TRW

RF SEMICONDUCTORS

CATALOG

1981

EUROPEAN EDITION

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INTRODUCTION

— SCOPE

This catalog is issued by TRW Composants Electroniques.
It provides complete information on all the TRW high-frequency transistors, modules and integrated circuits available from our plant in Bordeaux.

The book is up-dated in timely intervals in order reflect the latest developments of new products. It has proven to be an excellent aid and reference to numerous project and design ngineers.

— MARKET SEGMENTS

1) HF-SSB

Market

2 to 30 MHz, high power linear transmitters.

Products

12, 28 and 50 V up to 200 watt linear transistors.

2) MOBILE

Market

VHF (88 and 175 MHz) and UHF (470 MHz) transmitters for use in commercial and industrial mobile radio applications.

Products

7.5, 12 and 28 volts discrete transistors.
12 V power modules.

3) FM

Market

High power FM transmitters (88-108 MHz).

Products

High power transistors up to 175 W.

4) VHF/UHF BROADBAND

Market

Airbone and ground VHF/UHF transmitters — Navigation aids (ILS, VOR, GLIDE).

Products

Discrete and internally matched (JO) broadband transistors up to 100 watts.

5) SMALL SIGNAL

Market

Telecommunication, Instrumentation, General Purpose up to 1 200 MHz.

Products

- Transistors in plastic and ceramic packages with RF output voltages up to 122 dBuV (DIN 4 500 4 B).
- HYBRID Broadband amplifiers :
  1-500 MHz ; 50 to 100 Ohm
  40-900 MHz ; 50 to 100 Ohm
  Low noise and high linearity.

6) CATV

Market

Community Antenna Television Amplifiers — 40-300 MHz : 75 ohm
— 40-900 MHz : 75 ohm

Products

High performance HYBRID amplifiers for super linearity and cascadability.

7) TV TRANSPOSERS AND TRANSMITTERS

Market

Equipment for TV land coverage : transposers and transmitters.

Products

High power linear transistors specified in two bands : VHF 170 to 225 MHz, UHF 470 to 860 MHz.

8) MICROWAVE

Market

1 to 4 GHz transmitters.

Products

1 to 4 GHz discretes and internally matched (MRA) transistors specified as :
— Linear (common ermitter).
— Class C, Pulse (common base).
— Oscillators (common collector).

— TRW COMPOSANTS ELECTRONIQUES

This european facility was established in 1971 in order to provide optimum service to the european market. The advantages to our customers are numerous :

- MARKETING — TRW Bordeaux has an experienced team of product managers ready to discuss your needs and to serve your interests.
- MANUFACTURING — Most TRW products supplied by TRW Bordeaux are manufactured locally. The plant is equipped with the most modern machinery and has complete DC and RF testing facilities including highly specialized test stations for ultra-linear devices.

  Manufacture and stocking in Bordeaux assures quick response to our customers needs.
- QUALITY ASSURANCE — An independant Quality Assurance Department polices the design, manufacturing and testing procedures and guarantees the highest possible product quality.
- SPECIAL PRODUCTS — Should the products listed in this catalog fail to match your requirements exactly, there is always the possibility of a specially designed or modified device.

  Once we have defined what the transistor should be for your application. a specification will be written by you, reviewed by TRW and a special part number assigned. This procedure will insure proper operation of the devices in your equipment.
- APPLICATION ENGINEERING — One of the most important functions of TRW Bordeaux is the applications assistance which can be rendered promptly, efficiently and in a professional manner. The plant houses a well-equiped applications laboratory, which is staffed by RF engineers specialized in all areas of solid-state circuitry, applications and systems. Computer aided design is widely used.

In order to illustrate the level of expertise prevailing, some of the recent developments are listed below :

- **MOBILE**
  - 68-88 MHz — 100 W — 28 V Booster amplifiers.
  - 7.5 V broadband amplifier for portable radio.
- **VHF/UHF**
  - 100-400 MHz push-pull amplifier.
- **SMALL SIGNAL**
  - 1.5 volt — 40-960 MHz amplifier.
- **TV TRANSPOSERS AND TRANSMITTERS**
  - Band 4-5 — Broadband — 7 watt — 60 dB IMD.
  - Band 4-5 — Broadband — 12 watt — 60 dB IMD.
- **MICROWAVE**
  - Broadband microwave amplifier — 10 W up to 3 GHz.
  - MARISAT amplifier — 50 W at 1.6 GHz.
  - Common collector oscillator transistor up to 4 GHz.
- **FM**
  - High efficiency transistor.

QUALITY AT TRW

TRW RF components are renowned for quality and reliability. A consequence of such quality is the dominant position of TRW in European communication equipments.

The primary objective of TRW is « to provide products and services of the highest possible quality ». Lets us see how such goal is achieved in the TRW Bordeaux plant.

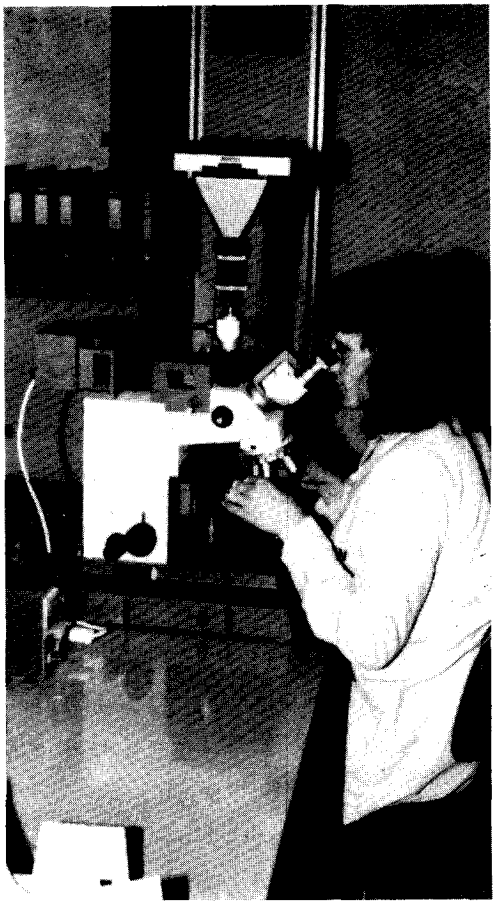
This quality objective is realised by a permanent control of material from the beginning of raw material in-coming inspection to the assembly lines and final delivery to customers (as shown on the manufacturing flow chart.

Quality dice lot

On arrival in the plant, each wafer is qualified by the evaluation of a sample of die, to measure quality of die solderability, wire bondability, DC and RF performances, current leakage, etc. and also to estimate the production yield we will achieve.

This wafer quality inspection has been recently further improved thanks to the scanning electronic microscopy. Since Jan. 1981, a SEM inspection is made on a 100 % basis for wafers intended for high reliability applications and on a sampling basis for all others.

The QA department can veto a wafer or a product at any stage of production if a failure is discovered.



Optical microscope inspection



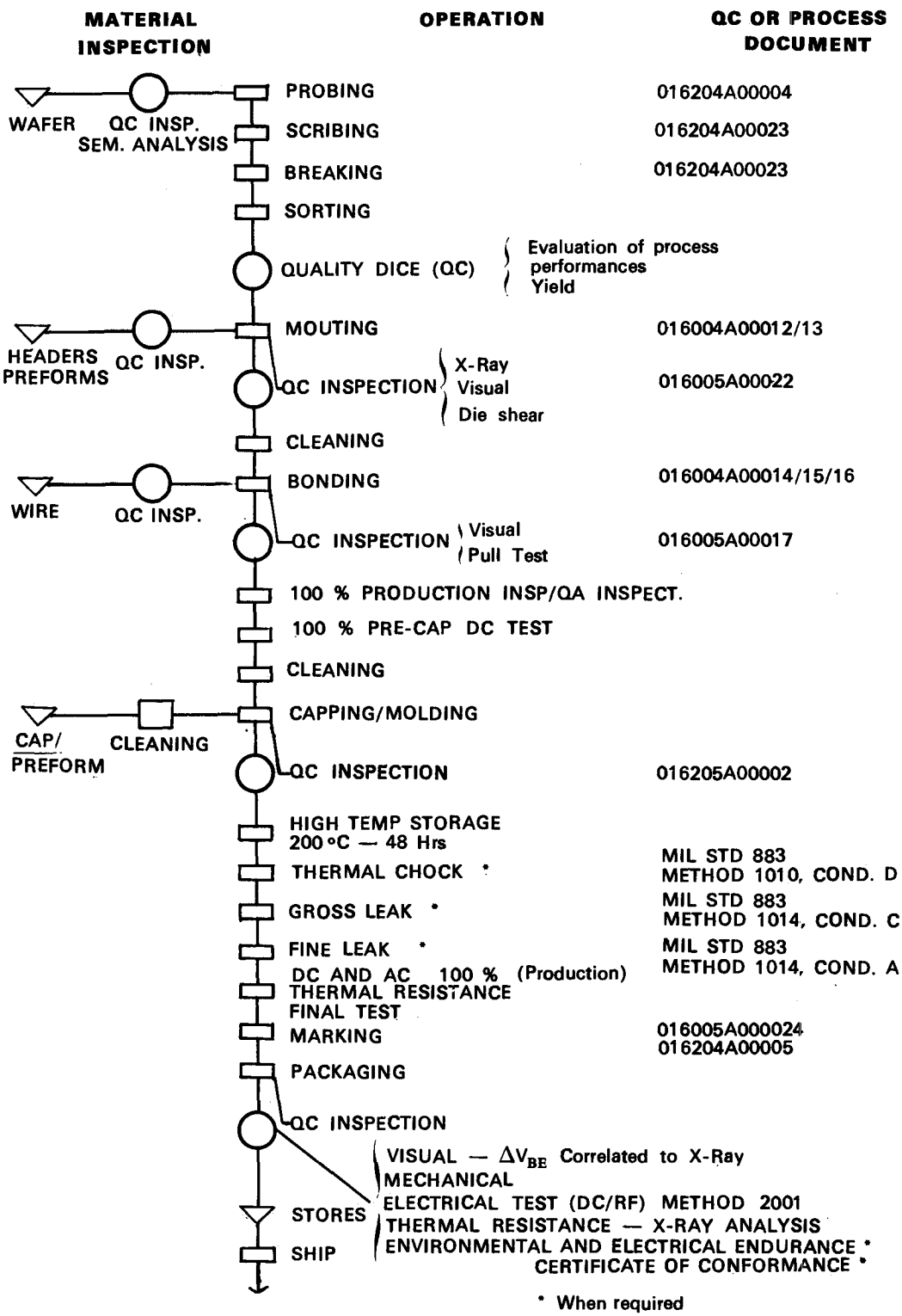
SEM wafer analysis

Assembly control — Quality lot card

During product assembly, die mounting and wire bonding machines are checked regurlarly every two hours to ensure that they are performing correctly.

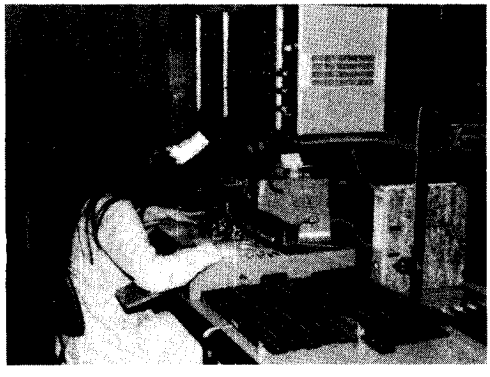
Q.A. visual inspection, destructive tests and wire strenght are noted on a quality card which accompagnies each production lot from the beginning to final inspection in Q.A. department.

MANUFACTURING FLOW CHART





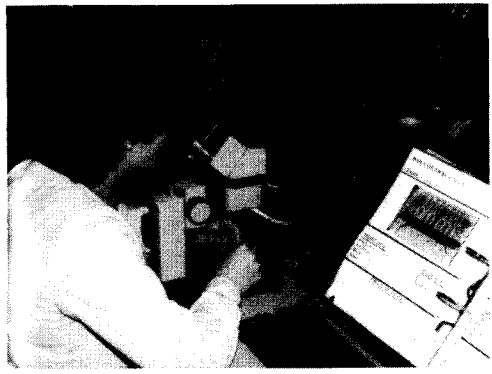
Hard soldering die bonding



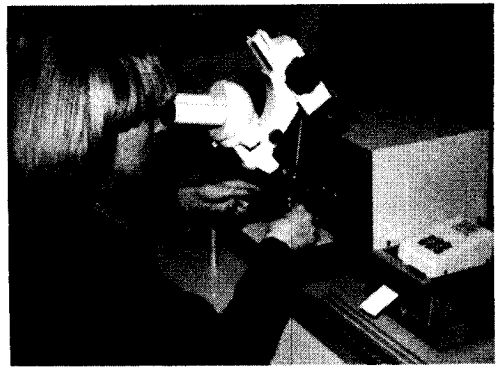
Wire bonding operation

X-Ray inspection

A good eutectic bond between the die and the header is fundamental, for the reliability of high power devices, so 2 years ago TRW Bordeaux introduced a X-Ray inspection of the die mounting operation. Depending on the method of construction of the transistor, either a 100 % or sampling only check is made on the quality of the die attach.



Soldering and visual inspection



Wire bonding pull test

100 % Thermal resistance for super high reliability

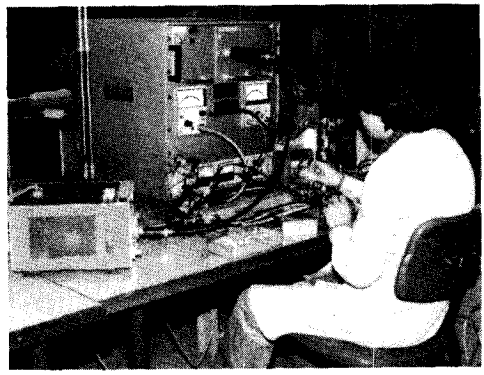
In order to assure a maximum reliability, TRW-Bordeaux introduced 3 years ago a ΔV_{BE} measurment which is related to the thermal resistance by the following formula

$$Rth_{JC} = \frac{I}{C} \frac{\Delta V_{BE}}{Pd}$$

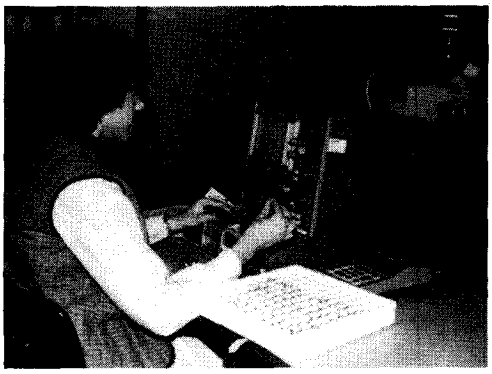
This ΔV_{BE} measurment which is performed on 100 % basis for all RF high power devices, is then correlated to a X-Ray analysis for each production lot in order to determine the maximum value of ΔV_{BE} authorized for a certain part number. This is the best way to make sure of perfection of the die mount.



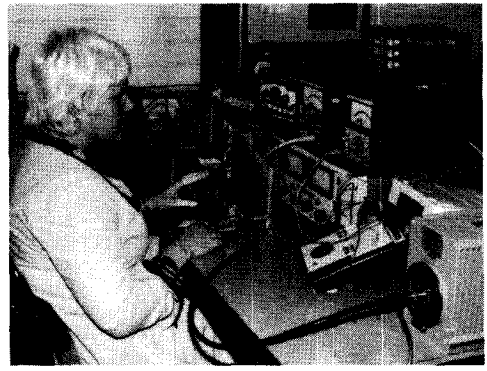
Die soldering X-Ray inspection.



Dynamic RF transistors testing



DC transistors final test inspection



Dynamic RF QA control

100 % visual inspection

All standart devices are 100 % visually inspected by production people prior to capping. High rel. components are submitted to a more stringent visual control under the responsability of the QA department with a high magnification microscope.

DC and RF testing

In order to assure the lowest possible failure level, each device is DC tested three times :

1. — Die probe prior to input
2. — prior to capping
3. — prior to final RF test.

All devices are then subjected to RF measurment on production line for conformity, to specification. After final production test and packaging, each lot passes to the quality department which tests again on a sample basis, DC and RF parameters. The percentage of pieces submitted to this final electrical control is 11 % for all discretes components and 18 % for hybrids circuits.

Reliability

The quality department is also responsible for reliability which is assured by several environmental and electrical tests which are made to devices during assembly operations or at the final test level.

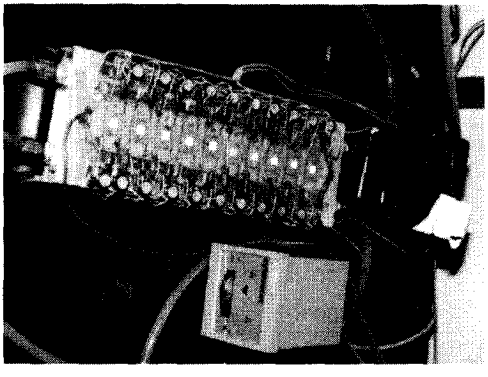
All moulded devices are subjected to a high Temperature DC test (+ 175°C) in to order remove any possible infant mortalities.

Other reliability tests include vibration, acceleration, thermal shock, humidity and DC or RF electrical endurance. These tests are performed either because of customer special requirement or as a routine reliability check.

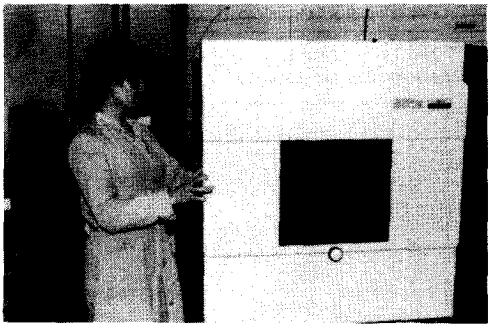
Many high power — high quality devices binlt in Bordeaux for professionnal applications have been already submitted to a 3 000 or 5 000 hours electrical endurance test. Reports are available on request.



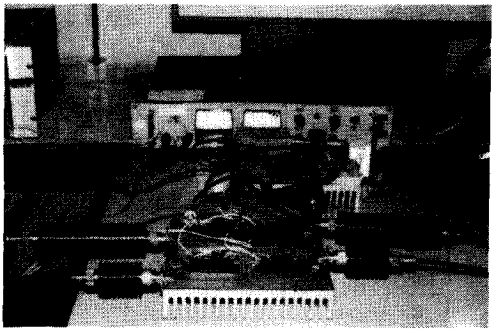
Acceleration test



DC burn-in life test



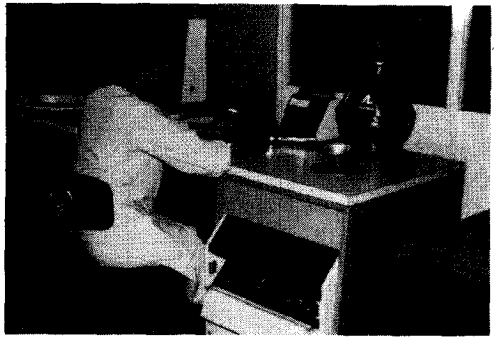
Environmental test



Fine leak test



Vibration test



RF burn-in life test

Quality Assurance Standart

TRW RF components are classified in three reliability classes depending on the level of screening needed to produce the quality and reliability required by each application as shown on table n° 1

RELIABILITY GRADE	APPLICATIONS
SH — Super High Reliability	— Space - system requiring super high reliability
H — High reliability	Military - Avionic - Systems requiring high reliability
I — Industrial	Industrial application - consumer

All class of transistor are screened in accordance to MIL STD 19 500/750/883 or CECC 50 007 or NFC 96 621 specification. However particular customer specification are also used as « a special customer requirement ».

TABLE A

SCREENING CONDITIONS

	TEST	METHOD	INSPECTION REQUIREMENT		
			SH	H	I
2	Precap. visual inspection	MILSTD 750-2072	100 %	100 %	100 %
3	High Rel. Prec. vis. insp.	TRW Specification	100 %	(1)	
4	Die-soldering X-Ray test	TRW specification	100 %	sampling	
5	Wire-bonding test	TRW specification	sampling	sampling	sampling
6	Precap. BV - test	CECC 50 000/4.3.4	100 %	100 %	100 %
9	DC Electrical Test BV_{CBO} BV_{CEO} BV_{EBO} I_{CBO} I_{CEO} I_{EBO} h_{FE}	CECC 50 000/4.3.4	100 %	100 %	100 %
11	RF test P_{out} - IMD - Ft. TOS	NFC 96.621	100 %	100 %	sampling
7	High storage	CECC 50 000/4.4.1	100 %	(1)	
8	Thermal Shock	CECC 50 000/4.4.4	100 %	(1)	
13	Vibration	CECC 50 000/4.4.6	100 %	(1)	
14	Acceleration	CECC 50 000/4.4.11	100 %	(1)	
10	Thermal Imped. (ΔV_{BE})	TRW Specification	100 %	100 %	
12	Ballast-Resist. control	TRW specification	100 %	sampling	
1	SEM wafer inspection	TRW specification	100 %	sampling	
15	Gross Leak	CECC 50 000/4.4.10/Qc only hermetic devices	100 %	100 %	sampling
16	Fine Leak	only hermetic devices CECC 50 000/4.4.10/Qk	100 %	100 %	
17	High temp. wire bonding test	only molded devices	100 %	sampling	
18	Electrical Endurance	NFC 96-621 CECC 50 000/4.5	100 %	sampling	
19	External - Visual - Mechanical	CECC 50 000/4.2.1	100 %	sampling	sampling
20	QA Final Inspection	TRW specification	sampling	sampling	sampling

(1) On special request.

TABLE B

QA INSPECTION — GROUP A

LOT PER LOT

EXAMINATION OR TEST	CONDITION	INSPECTION REQUIREMENT	
		sampling level	AQL
Sub-group A1			
Visual inspection - Dimen/hours	CECC 50 000/4.2.1	I	1,5
Sub-group A2			
Breakdown Voltage	CECC 50 000/4.3.4	II	0,4
Leakage current	CECC 50 000/4.3.4	II	0,4
h_{FE} — Cob	CECC 50 000/4.3.4	II	0,4
RF dynamic characteristic	NFC 96 621	I	1

TABLE C

QA — INSPECTION GROUP A & B

LOT PER LOT

EXAMINATION OR TEST	CONDITIONS	INSPECTION REQUIREMENT	
		sampling level	AQL
Sub-Group B2 to B5			
Solderability	CECC 50 000/4.4.7	S 4	1,5 %
Thermal shock (1)	CECC 50 000/4.4.4	S 4	1 %
Damp heat (1)	CECC 50 000/4.4.2	S 4	1,5 %
Gross leak	CECC 50 000/4.4.10.Qc	S 4	1 %
Fine leak	CECC 50 000/4.4.10.Qk	II	1 %
Sub-Group B8	CECC 50 000/4.5		
168 Hrs Electrical Endurance (1)	NFC 96 621	S 4	1,5 %
Sub-Group C3 to C6			
Tensile	CECC 50 000/4.4.9	I	1,5 %
Vibration (1)	CECC 50 000/4.4.6	I	1,5 %
Constant Acceleration (1)	CECC 50 000/4.4.11	I	1,5 %
Sub-Group C8	CECC 50 000/4.5		
1 000 Hrs Electrical Endurance (1)	NFC 96 621	S 4	1 %
Sub-Group C9			
High temp. storage (1)	CECC 50 000/4.4.1	S 4	1 %
Post measurment	$\Delta h_{FE} - \Delta I_{CBO}$		

(1) On special request from QA or from customes.

Part Number	Page	Application	Frequency	Power or gain (dB)	Supply Voltage (V)	Package
2 N 4429	I-383	MICROWAVE	1 GHz	1 W	28	TO 117
2 N 4430	I-383	MICROWAVE	1 GHz	2.5 W	28	TO 129
2 N 4431	I-383	MICROWAVE	1 GHz	5 W	28	TO 129
2 N 5589	B-33	MOBILE	175 MHz	3 W	13.6	380 SOE
2 N 5590	B-33	MOBILE	175 MHz	10 W	13.6	380 SOE
2 N 5591	B-33	MOBILE	175 MHz	25 W	13.6	380 SOE
2 N 6080	B-37	MOBILE	175 MHz	4 W	12.5	380 SOE
2 N 6081	B-37	MOBILE	175 MHz	15 W	12.5	380 SOE
2 N 6082	B-37	MOBILE	175 MHz	25 W	12.5	380 SOE
2 N 6083	B-37	MOBILE	175 MHz	30 W	12.5	380 SOE
BFR 91	E-210	SMALL SIGNAL	1 GHz	300 mV	5	T-PACK
BFR 96	E-214	SMALL SIGNAL	1 GHz	700 mV	12	T-PACK
CA 915	G-315	SMALL SIGNAL	1 GHz	60 dBmV	24	MVM
CA 915 TV	F-291	TV-BAND 1-5	1 GHz	150 mW	24	MVM
CA 2150	G-295	CATV	40-300 MHz	17 dB	24	CA
CA 2250	G-295	CATV	40-300 MHz	17 dB	24	CA
CA 2252	G-299	CATV	40-300 MHz	12 dB	24	CA
CA 2270 A	G-297	CATV	40-300 MHz	17 dB	24	CA
CA 2280	G-299	CATV	40-300 MHz	12 dB	24	CA
CA 2350 A	G-302	CATV	40-300 MHz	22 dB	24	CA
CA 2350 B	G-302	CATV	40-300 MHz	22 dB	24	CA
CA 2418	G-303	CATV	5-120 MHz	18 dB	24	CA
CA 2419	G-305	CATV	5-120 MHz	19 dB	24	CA
CA 2601 Bu	G-307	CATV	40-300 MHz	31 dB	24	CA
CA 2650	G-309	CATV	40-300 MHz	33 dB	24	CA
CA 2680	G-132	CATV	40-300 MHz	33 dB	24	CA
CA 2750	G-313	CATV	40-300 MHz	38 dB	24	CA
CA 2800	F-246	SMALL SIGNAL	10-400 MHz	17 dB/800 mW	24	CA
CA 2810	F-244	SMALL SIGNAL	10-350 MHz	33 dB/800 mW	24	CA
CA 2812	F-256	SMALL SIGNAL	1-520 MHz	30 dB	12	CA
CA 2818	F-258	SMALL SIGNAL	1-200 MHz	18 dB/800 mW	24	CA
CA 2820	F-262	SMALL SIGNAL	1-520 MHz	30 dB/400 mW	24	CA
CA 2830	F-266	SMALL SIGNAL	5-200 MHz	34 dB/1 W	24	CA
CA 2832	F-268	SMALL SIGNAL	1-200 MHz	35 dB/2 W	24	CA
CA 2840	F-270	SMALL SIGNAL	30-300 MHz	22 dB/1 W	24	CA
CA 2842	F-272	SMALL SIGNAL	30-300 MHz	22 dB/1 W	24	CA
CA 2850 R	F-274	SMALL SIGNAL	40-100 MHz	17 dB/250 mW	— 24	CA
CA 2851 R	F-276	SMALL SIGNAL	40-100 MHz	17 dB/250 mW	— 24	CA
CA 2870	F-278	SMALL SIGNAL	20-400 MHz	34 dB/400 mW	24	CA
CA 2875 R	F-282	SMALL SIGNAL	40-100 MHz	17 dB/310 mW	— 24	CA
CA 2876 R	F-284	SMALL SIGNAL	40-100 MHz	22 dB/100 mW	— 24	CA
CA 2880 R	F-286	SMALL SIGNAL	40-100 MHz	22 dB/100 mW	— 24	CA
CA 2899	F-288	RF-CHOKE	30 uH			
JO 2015 A	D-164	UHF, AM, FM	200-400 MHz	70 W	28	J-ZERO-C
JO 3015	B-134	MOBILE	450-512 MHz	15 W	12.5	J-ZERO-C
JO 3020	B-41	MOBILE	450-512 MHz	20 W	12.5	J-ZERO-C
JO 3037	B-44	MOBILE	450-512 MHz	37 W	12.5	J-ZERO-C
JO 3050	B-141	MOBILE	450-512 MHz	50 W	12.5	J-ZERO-C
JO 3055	B-45	MOBILE	450-512 MHz	55 W	12.5	J-ZERO-C
JO 3401	B-142	MOBILE	870 MHz	5 W	12.5	.230 F
JO 3402	B-142	MOBILE	870 MHz	18 W	12.5	.230 F
JO 3403	B-142	MOBILE	870 MHz	28 W	12.5	.230 F
JO 3404	B-142	MOBILE	870 MHz	45 W	12.5	.230 F
JO 4045	B-48	MOBILE	175 MHz	45 W	12.5	J-ZERO-C

Part Number	Page	Application	Frequency	Power or gain (dB)	Supply Voltage (V)	Package
JO 4070	B-52	MOBILE	175 MHz	70 W	12.5	J-ZERO-C
JO 4075	B-54	MOBILE	175 MHz	75 W	12.5	J-ZERO-C
JO 4080	B-56	MOBILE	175 MHz	80 W	12.5	J-ZERO-C
LNA 1100	F-290	SMALL SIGNAL	1 GHz	10 dB	10	TO 8
LN 2023-2	I-387	MICROW. LINEAR	2,2-3 GHz	2,3 W	16	GP 16
LN 2327-2	I-391	MICROW. LINEAR	2,3-2,7 GHz	2,3 W	16	GP 16
ML 20	B-57	MOBILE	68-88 MHz	20 W	12.5	MVM
MRA 0610-3	I-395	MICROW. CLASS C	0.6-1.0 GHz	3 W	28	MRA
MRA 0610-9	I-395	MICROW. CLASS C	0.6-1.0 GHz	9 W	28	MRA
MRA 0610-18	I-395	MICROW. CLASS C	0.6-1.0 GHz	18 W	28	MRA
MRA 0610-40	I-395	MICROW. CLASS C	0.6-1.0 GHz	40 W	28	MRA
MRA 1014-2	I-403	MICROW. CLASS C	1.0-1.4 GHz	2 W	28	MRA
MRA 1014-6	I-403	MICROW. CLASS C	1.0-1.4 GHz	6 W	28	MRA
MRA 1014-12	I-403	MICROW. CLASS C	1.0-1.4 GHz	12 W	28	MRA
MRA 1014-35	I-403	MICROW. CLASS C	1.0-1.4 GHz	35 W	28	MRA
MRA 1417-2	I-411	MICROW. CLASS C	1.4-1.7 GHz	2 W	28	MRA
MRA 1417-6	I-411	MICROW. CLASS C	1.4-1.7 GHz	6 W	28	MRA
MRA 1417-11	I-411	MICROW. CLASS C	1.4-1.7 GHz	11 W	28	MRA
MRA 1417-25	I-411	MICROW. CLASS C	1.4-1.7 GHz	25 W	28	MRA
MRA 1720-2	I-419	MICROW. CLASS C	1.7-2.0 GHz	2 W	28	MRA
MRA 1720-5	I-419	MICROW. CLASS C	1.7-2.0 GHz	5 W	28	MRA
MRA 1720-9	I-419	MICROW. CLASS C	1.7-2.0 GHz	9 W	28	MRA
MRA 1720-20	I-419	MICROW. CLASS C	1.7-2.0 GHz	20 W	28	MRA
MRAL 2023-1.5	I-427	MICROW. CLASS C	2.0-2.3 GHz	1.5 W	22	MRA
MRAL 2023-3	I-427	MICROW. CLASS C	2.0-2.3 GHz	3 W	22	MRA
MRAL 2023-6	I-427	MICROW. CLASS C	2.0-2.3 GHz	6 W	22	MRA
MRAL 2023-12	I-427	MICROW. CLASS C	2.0-2.3 GHz	12 W	22	MRA
MRAL 3742-2	I-435	MICROW. CLASS C	3.7-4.2 GHz	2 W	20	MRA 4
MRAL 3742-3.5	I-435	MICROW. CLASS C	3.7-4.2 GHz	3.5 W	20	MRA 4
MRAL 3742-6	I-435	MICROW. CLASS C	3.7-4.2 GHz	6 W	20	MRA 4
MV 20	B-59	MOBILE	140-175 MHz	20 W	12.5	MVM
MV 30	B-59	MOBILE	150-160 MHz	30 W	13.5	MVM
MX 7.5	B-63	MOBILE	400-512 MHz	7.5W	12.5	MXM
MX 12	B-63	MOBILE	400-512 MHz	12 W	12.5	MXM
MX 15	B-63	MOBILE	400-470 MHz	15 W	12.5	MXM
PT 8740	B-67	MOBILE	175 MHz	1.8 W	12.5	TO 39
PT 8809	B-70	MOBILE	470 MHz	2 W	12.5	280 SOE
PT 8810	B-70	MOBILE	470 MHz	5 W	12.5	280 SOE
PT 8811	B-70	MOBILE	470 MHz	10 W	12.5	280 SOE
PT 8828	B-74	MOBILE	175 MHz	9 W	12.5	380 SOE
PT 9700	D-168	UHF, FM, AM	400 MHz	1.5 W	28	280 SOE
PT 9701	D-168	UHF, FM, AM	400 MHz	4 W	28	280 SOE
PT 9702	D-168	UHF, FM, AM	400 MHz	20 W	28	280 SOE
PT 9703	D-168	UHF, FM, AM	400 MHz	10 W	28	280 SOE
PT 9704	D-168	UHF, FM, AM	400 MHz	30 W	28	289 SOE
PT 9704 A	D-168	UHF, FM, AM	400 MHz	30 W	28	280 SOE
PT 9730	D-176	VHF, FM, AM	175 MHz	4 W	28	380 SOE
PT 9731	D-176	VHF, FM, AM	175 MHz	25 W	28	380 SOE
PT 9732	D-176	VHF, FM, AM	175 MHz	8 W	28	380 SOE
PT 9733	D-176	VHF, FM, AM	175 MHz	50 W	28	380 SOE
PT 9734	D-176	VHF, FM, AM	175 MHz	15 W	28	380 SOE
PT 9780	A-12	SSB	2-30 MHz	100 W	28	500 SOE Flange

Part Number	Page	Application	Frequency	Power or gain (dB)	Supply Voltage (V)	Package
PT 9780 A	A-12	SSB	2-30 MHz	100 W	28	500 SOE Stud
PT 9783	A-12	SSB	2-30 MHz	50 W	28	380 SOE Flange
PT 9783 A	A-12	SSB	2-30 MHz	50 W	28	380 SOE Stud
PT 9784 A	A-5	SSB	2-30 MHz	75 W	12.5	380 SOE Flange
PT 9785	A-5	SSB	2-30 MHz	100 W	12.5	500 SOE Flange
PT 9787	A-12	SSB	2-30 MHz	8 W	28	380 SOE Flange
PT 9787 A	A-12	SSB	2-30 MHz	8 W	28	380 SOE Stud
PT 9788	A-12	SSB	2-30 WHz	20 W	28	380 SOE Flange
PT 9788 A	A-12	SSB	2-30 MHz	20 W	28	380 SOE Stud
PT 9790	A-20	SSB	2-30 MHz	150 W	50	500 SOE Flange
PT 9790 A	A-20	SSB	2-30 MHz	150 W	50	500 SOE 1/2 inch Stud
PT 9795 A	A-5	SSB	2-30 MHz	15 W	12.5	380 SOE
PT 9786	A-5	SSB	2-30 MHz	30 W	12.5	380 SOE Flange
PT 9797	A-5	SSB	2-30 MHz	50 W	12.5	380 SOE Flange
TP 210	B-78	MOBILE, PORTABLE	88 MHz	50 mW	7.5	T-PACK
TP 212	B-82	MOBILE, PORTABLE	88 MHz	5.0 W	7.5	280 SOE
TP 250	B-85	MOBILE, PORTABLE	470 MHz	10 mW	7.5	T-PACK
TP 251	B-88	MOBILE, PORTABLE	470 MHz	175 mW	7.5	200 SOE Studless
TP 252	B-91	MOBILE, PORTABLE	470 MHz	1.5	7.5	280 SOE
TP 393	E-215	SMALL SIGNAL	1 GHz	300 mV	5	T-PACK
TP 394	E-218	SMALL SIGNAL	1 GHz	700 mV	15	T-PACK
TP 491	E-221	SMALL SIGNAL	1 GHz	400 mV	5	T-PACK
TP 1045	B-94	MOBILE	88, 175, 470 MHz	2 W	12.5	280 SOE Studless
TP 2180	B-97	MOBILE	88 MHz	5 W	12.5	380 SOE
TP 2304	B-100	MOBILE	175 MHz	40 W	12.5	380 SOE
TP 2310	B-104	MOBILE	175 MHz	2.5 W	12.5	TO 39
TP 2312	B-107	MOBILE	175 MHz	2.75 W	12.5	TO 39-GE
TP 2314	B-110	MOBILE	175 MHz	4 W	12.5	TO 39-GE
TP 2320	B-113	MOBILE	175 MHz	17 W	12.5	380 SOE
TP 2330	B-117	MOBILE	175 MHz	30 W	12.5	380 SOE
TP 2404	B-120	VUF, FM, AM	175 MHz	50 W	28	500 SOE
TP 2405	B-123	VHF, FM, AM	175 MHz	90 W	27	500 SOE
TP 2500	B-126	MOBILE	175, 470 MHz	900, 350 mW	12.5	TO 46
TP 2503	B-129	MOBILE	175, 470 MHz	5 W	12.5	280 SOE Studless
TP 3093	E-223	SMALL SIGNAL	1 GHz	1 V	15	TO 39
TP 3097	E-227	SMALL SIGNAL	1 GHz	1 V	15	TO 117
TP 3098	E-230	SMALL SIGNAL	1 GHz	1 V	15	TO 117 C

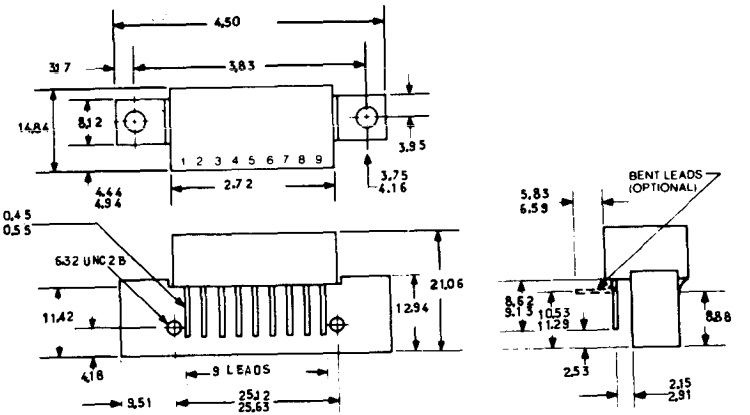
Part Number	Page	Application	Frequency	Power or gain (dB)	Supply Voltage (V)	Package
TP 3099	E-233	SMALL SIGNAL	1 GHz	1 V	15	200 SOE
TP 3400	E-236	SMALL SIGNAL	1 GHz	1.2 V	18	200 SOE
TP 5695	B-132	MOBILE	88 MHz	10 W	12.5	SOE 380
TP 9228	A-24	SSB	30 MHz	200 W	28	SOE 500 F
TP 9380	C-145	FM	108 MHz	75 W	28	SOE 500
TP 9381	C-148	FM	108 MHz	100 W	28	SOE 500
TP 9382	C-152	FM	108 MHz	175 W	28	SOE 500
TP 9383	C-156	FM	108 MHz	150 W	28	SOE 500
TP 9386	D-184	VHF	175 MHz	150 W	28	JO 500
TPM 401	D-187	BROADBAND V-UHF	100-400 MHz	1 W	20	SOE 180
TPM 405	D-191	BROADBAND V-UHF	100-400 MHz	5 W	20	SOE 280
TPM 425	D-195	BROADBAND V-UHF	100-400 MHz	25 W	20	SOE 280
TPM 4040	D-197	BROADBAND V-UHF	100-400 MHz	40 W	24	MRP 7
TPM 4100	D-201	BROADBAND V-UHF	100-400 MHz	100 W	28	MRP 7
TPS 175	B-135	MOBILE	175 MHz	20 W	12.5	TPS
TPS 470	B-132	MOBILE	470 MHz	20 W	12.5	TPS
TPV 364	H-320	TV BAND 3	225 MHz	10 W	25	SOE 380
TPV 375	H-324	TV BAND 3	225 MHz	14 W	28	SOE 500
TPV 376	H-328	TV BAND 3	225 MHz	30 W	28	SOE 500
TPV 385	H-336	TV BAND 3	225 MHz	14 W	28	JO 500
TPV 386	H-338	TV BAND 3	225 MHz	30 W	28	JO 500 S
TPV 394	H-332	TV BAND 3	225 MHz	5 W	28	SOE 280
TPV 3100	H-340	TV BAND 3	225 MHz	100 W	28	MRP 7
TPV 508	H-334	TV BAND 4-5	860 MHz	8 W	25	BMA-2
TPV 590	H-350	TV BAND 4-5	860 MHz	0.250 W	20	SOE 200
TPV 591	H-354	TV BAND 4-5	860 MHz	0.5 W	20	SOE 200
TPV 593	H-360	TV BAND 4-5	860 MHz	2 W	25	SOE 280
TPV 596	H-362	TV BAND 4-5	860 MHz	0.5 W	20	SOE 280
TPV 597	H-368	TV BAND 4-5	860 MHz	1 W	20	SOE 280
TPV 598	H-370	TV BAND 4-5	860 MHz	4 W	25	SOE 280
TPV 5051	H-374	TV BAND 4-5	860 MHz	50 W	28	BMA-2
TRW 2001	I-441	MICROW. CLASS C	2.0 GHz	1 W	28	HLP-8
TRW 2003	I-441	MICROW. CLASS C	2.0 GHz	3 W	28	HLP-8
TRW 2005	I-441	MICROW. CLASS C	2.0 GHz	5 W	28	HLP-8
TRW 2010	I-441	MICROW. CLASS C	2.0 GHz	10 W	28	HLP-8
TRW 2015	I-441	MICROW. CLASS C	2.0 GHz	15 W	28	HLP-11
TRW 2020	I-441	MICROW. CLASS C	2.0 GHz	20 W	28	HLP-11
TRW 2301	I-453	MICROW. CLASS C	2.3 GHz	1 W	22	HLP-8
TRW 2304	I-454	MICROW. CLASS C	2.3 GHz	4 W	22	HLP-8
TRW 2307	I-455	MICROW. CLASS C	2.3 GHz	7 W	22	HLP-8
TRW 3001	I-457	MICROW. CLASS C	3.0 GHz	1 W	28	HLP-8
TRW 3003	I-457	MICROW. CLASS C	3.0 GHz	3 W	28	HLP-8
TRW 3005	I-457	MICROW. CLASS C	3.0 GHz	5 W	28	HLP-8
TRW 4001	I-465	MICROW. CLASS C	4 GHz	1 W	20	HLP-8
TRW 4002	I-465	MICROW. CLASS C	4 GHz	2 W	20	HLP-8
TRW 4004	I-465	MICROW. CLASS C	4 GHz	4 W	20	HLP-8
TRW 52001	I-469	MICROW. CLASS A	2 GHz	1.5 W	20	TW 200
TRW 52101	I-469	MICROW. CLASS A	2 GHz	1.5 W	20	HLP-8 Flangeless

ALPHANUMERICAL INDEX

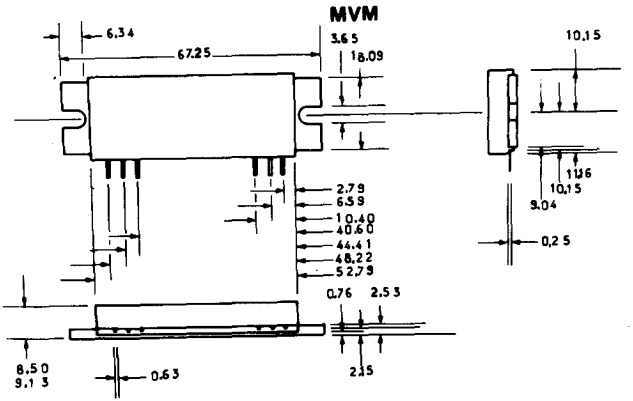
Part Number	Page	Application	Frequency	Power or gain (dB)	Supply Voltage (V)	Package
TRW 52102	I-473	MICROW. CLASS A	2 GHz	3.0 W	20	HLP-8 Flangeless
TRW 52104	I-477	MICROW. CLASS A	2 GHz	6.0 W	20	HLP-8 Flangeless
TRW 52601	I-469	MICROW. CLASS A	2 GHz	1.5 W	20	HLP-8
TRW 52602	I-473	MICROW. CLASS A	2 GHz	3.0 W	20	HLP-8
TRW 52604	I-477	MICROW. CLASS A	2 GHz	6.0 W	20	HLP-8
TRW 53001	I-481	MICROW. CLASS A	3 GHz	0.8 W	20	TW 200
TRW 53101	I-481	MICROW. CLASS A	3 GHz	0.8 W	20	HLP-8 Flangeless
TRW 53102	I-485	MICROW. CLASS A	3 GHz	1.6 W	20	HLP-8 Flangeless
TRW 53601	I-481	MICROW. CLASS A	3 GHz	0.8 W	20	HLP-8
TRW 53602	I-485	MICROW. CLASS A	3 GHz	1.6 W	20	HLP-8
TRW 54001	I-489	MICROW. CLASS A	4 GHz	0.5 W	20	TW 200
TRW 54101	I-489	MICROW. CLASS A	4 GHz	0.5 W	20	HLP-8 Flangeless
TRW 54601	I-489	MICROW. CLASS A	4 GHz	0.5 W	20	HLP-8
TRW 62601	I-493	MICR. OSCILLATOR	2 GHz	1.2 W	20	HLP-8
TRW 62602	I-497	MICR. OSCILLATOR	2 GHz	2 W	20	HLP-8
TRW 63601	I-501	MICR. OSCILLATOR	3 GHz	430 mW	20	HLP-8
TRW 63602	I-505	MICR. OSCILLATOR	3 GHz	850 mW	20	HLP-8
TRW 64601	I-509	MICR. OSCILLATOR	4 GHz	300 mW	20	HLP-8
TRW 64602	I-513	MICR. OSCILLATOR	4 GHz	600 mW	20	HLP-8

package designs (Dimensions Given in mm)

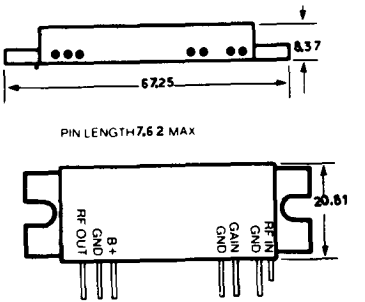
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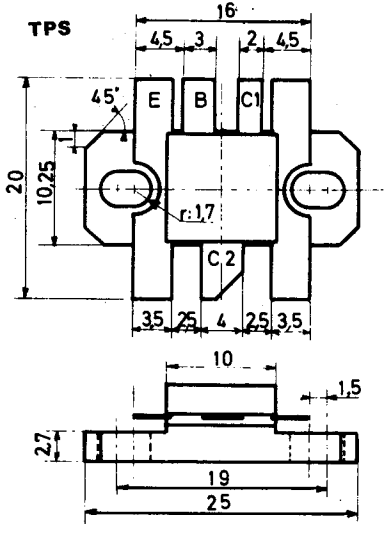
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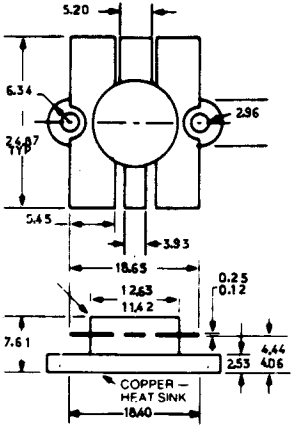
MXM



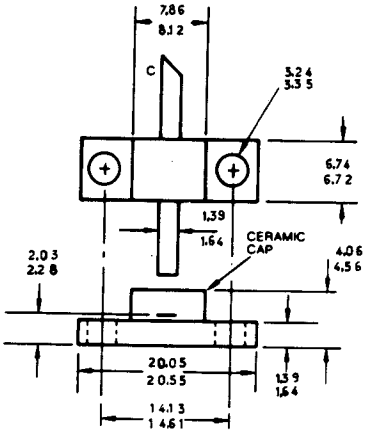
TPS



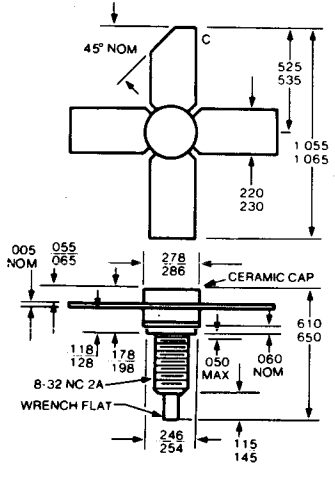
J-Zero-C



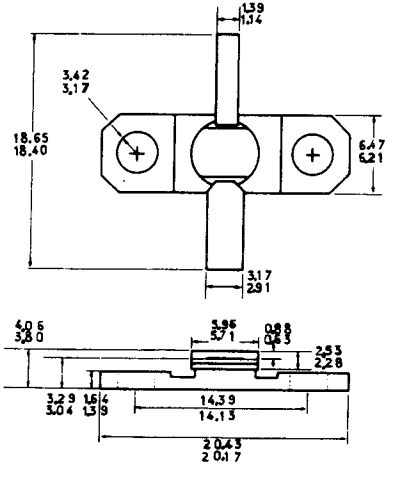
MRA



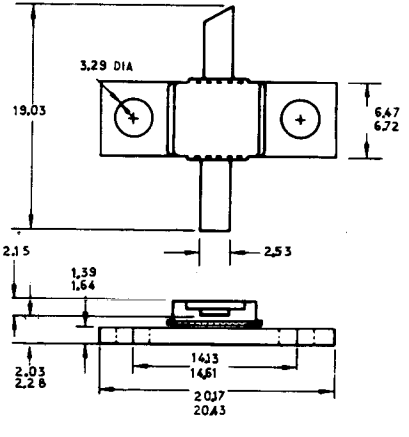
BMA 2



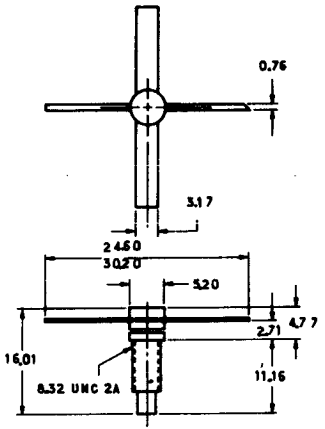
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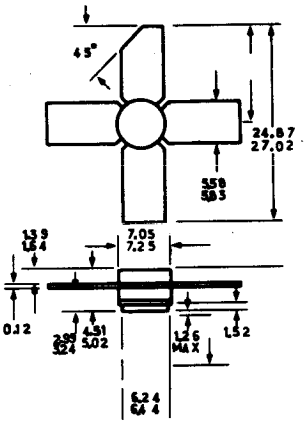
HLP-11



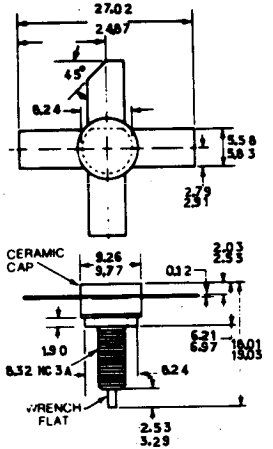
200 SOE



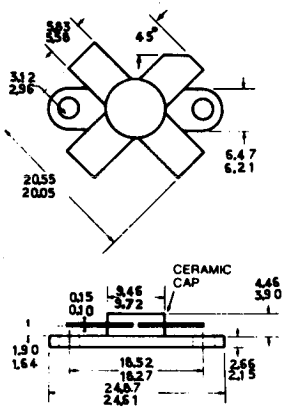
280 SOE/STUDLESS



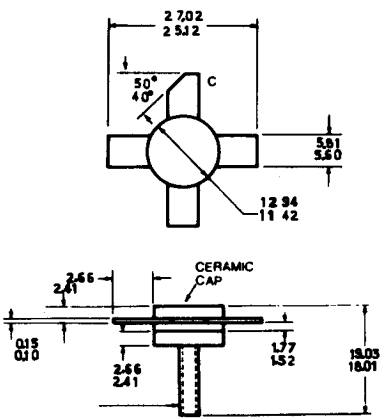
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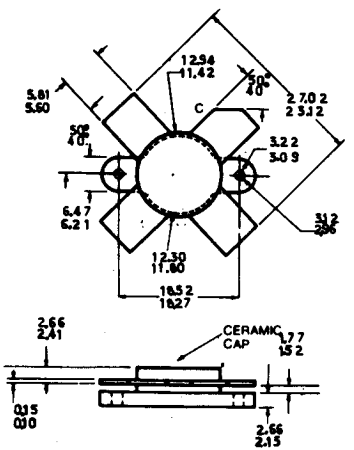
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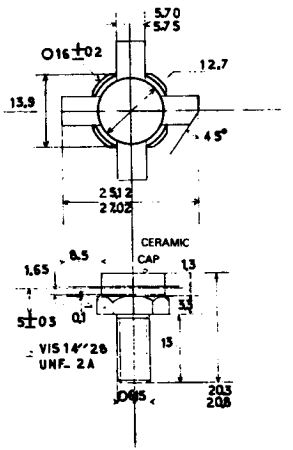
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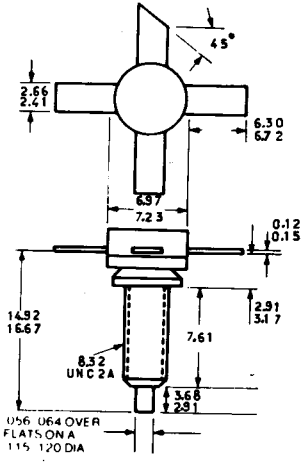
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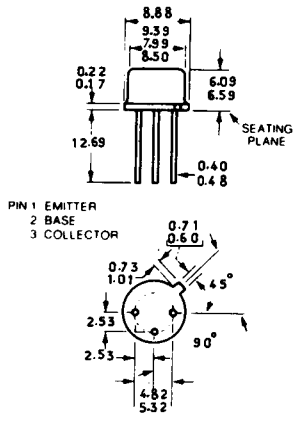
500 SOE 1/4" STUD



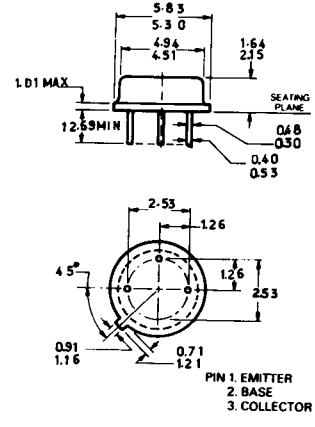
RT-3



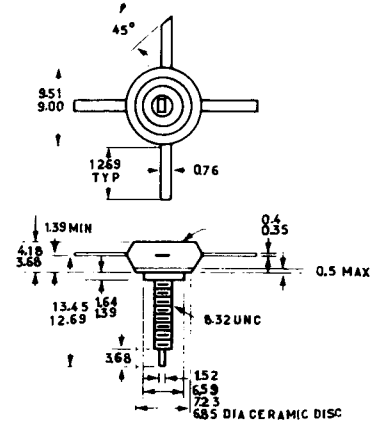
TO 39/TO 39 GE



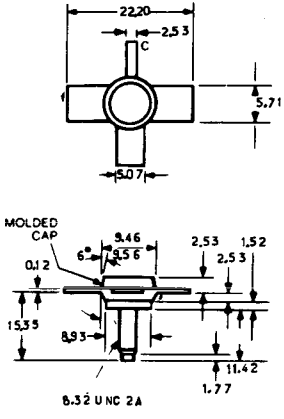
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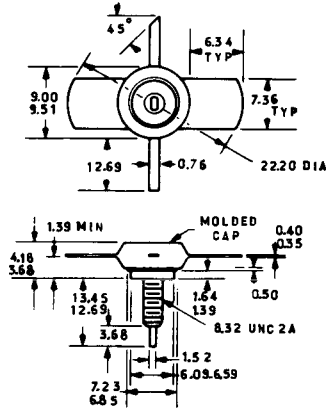
TO-117/TO-131



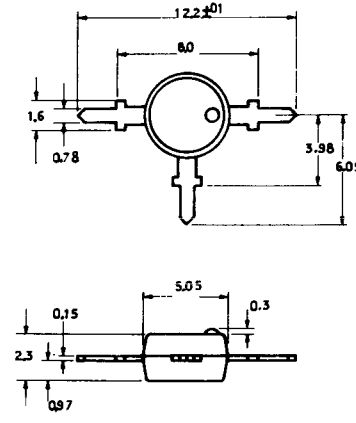
B-Band-2



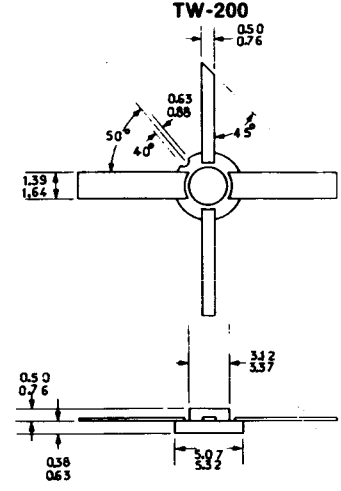
TO-129



T-PAK



TW-200



HF-SSB

HF — SSB POWER TRANSISTORS

PRODUCT SUMMARY

13,5 V - HF - SSB SERIES		PAGE
PT 9795/A	15 W PEP	**A-5**
PT 9796/A	30 W PEP	**A-5**
PT 9797/A	50 W PEP	**A-5**
PT 9784/A	75 W PEP	**A-5**
PT 9785	100 W PEP	**A-5**

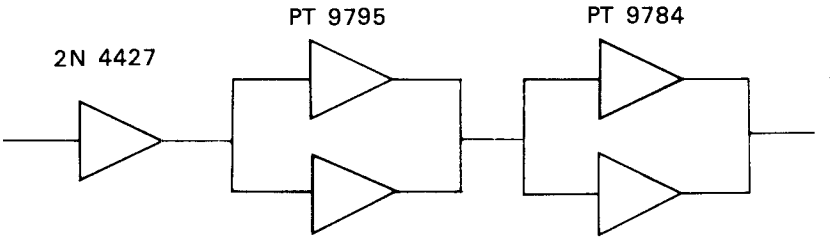
28 V - HF - SSB SERIES		
PT 9787/A	8 W PEP	**A-12**
PT 9788/A	20 W PEP	**A-12**
PT 9783/A	50 W PEP	**A-12**
PT 9780/A	100 W PEP	**A-12**
TP 9228	200 W PEP	**A-24**

50 V - HF - SSB SERIES		
PT 9790/A	150 W PEP	**A-20**

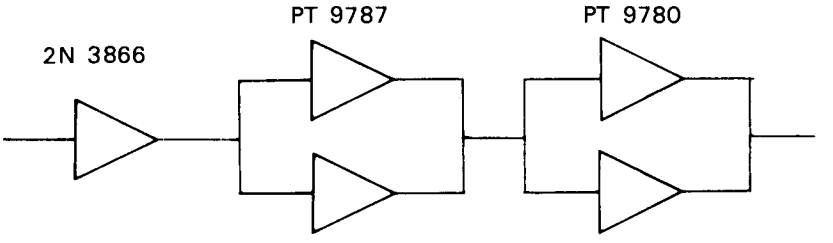
HF – SSB 1.5 – 30 MHz

LINE-UP SUGGESTIONS

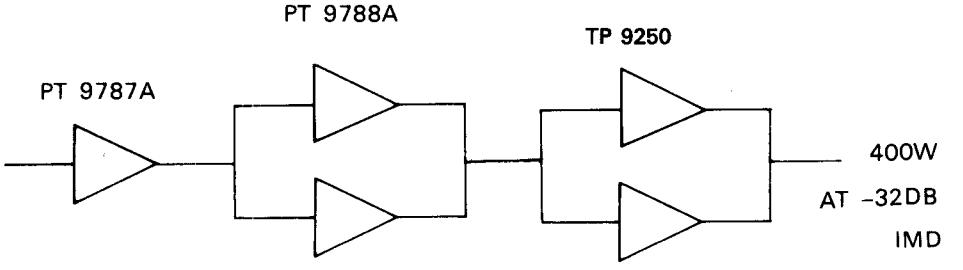
100 W – 12V – SSB RADIO FOR VEHICLE



100 W – 28 V – SSB RADIO – GROUND EQUIPEMENT



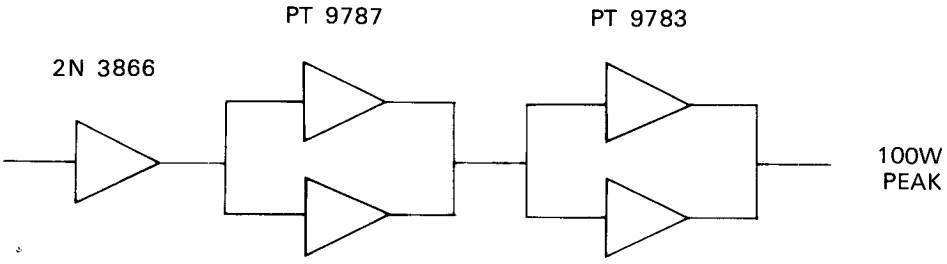
400 W – SSB TRANSMITTER – MILITARY OR MARINE



VHF

LINE-UP SUGGESTIONS

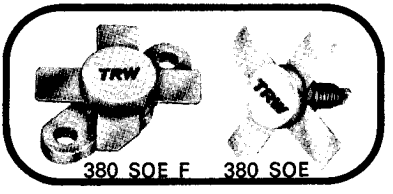
30-70 MHz - AM - 100W PEAK - TACTICAL RADIO



SSB Power Transistors

PT 9785 - 100 W
PT 9784/A - 75 W
PT 9797/A - 50 W
PT 9796/A - 30 W
PT 9795/A - 15 W
∞ VSWR

This Series features both high gain and high power, providing the desired power output with fewer devices. These power transistors are ballasted for ruggedness and will withstand infinite VSWR at all phase angles. A unique emitter structure provides high gain with wider emitter and base fingers resulting in high reliability. Ballast resistor design enables operation at Class A, AB and C. These rugged units are suitable for both narrow band and broadband HF communications and instrumentation service.



380 SOE F 380 SOE

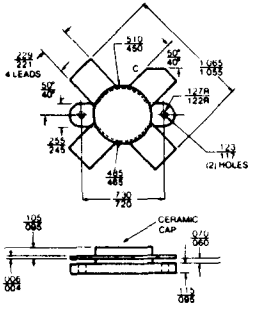
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	PT 9795/A	PT 9796/A	PT 9797/A	PT 9784/A	PT 9785	UNIT
D C TESTS	BV_{CBO}	Collector - Base Breakdown	I_C = 100 mA I_C = 200 mA	50	50	50	50	50	V Min
	BV_{EBO}	Emitter - Base Breakdown	I_E = 6 mA I_E = 10 mA	4.0	4.0	4.0	4.0	4.0	V Min
	I_{CES}	Collector - Emitter Cutoff Current	V_{CE} = 13,5 V	5	10	10	20	20	mA Max
	HF_E	DC Current Gain	V_{CE} = 5 V	25-150	25-150	25-150	20-100	20-100	—
	ΔHF_E	Matched Pairs	I_C = 1 A	Δ 10	Δ 10	Δ 10	Δ 5	Δ 5	—
R F TESTS	P_{out}	Dutput Power PEP	V_{CE} = 13,5 V P = 28 MHz	15	30	50	75	100	W PEP
	P_G	Power Gain	V_{CE} = 13.5 V F = 28 MHz P_{out} = Rated PEP	15	15	15	15	13	dB Min
	IMD	Intermodulation Distorsion	V_{CE} = 13.5 V F = 28 MHz P_{out} = Rated PEP	— 32	— 32	— 32	— 32	— 32	dB Max
	VSWR	Mismatch Tolerance	V_{CE} = 13.5 V F = 28 MHz P_{out} = Rated PEP	∞	∞	∞	∞	∞	—
THERMAL	Rth	Thermal Resistance Jonction to Heatsink (Including Contact)	V_{CE} = 13,5 V Pd = 6 W Pd = 18 W th = 40 °C Pd = 30 W Pd = 50 W Pd = 60 W	3,0	2,5	2,0	1,4	0,9	°C/W

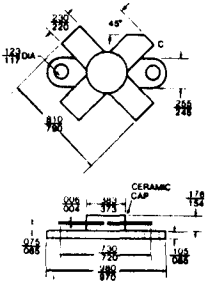
Absolute Maximum Ratings (T_{case} = 25 °C)

Part number	V_{CBO} V	V_{CEO} V	V_{CBO} V	$T_{storage}$ °C
PT 9795/A	50	20.0	4.0	— 65 to 200
PT 9796/A	50	20.0	4.0	— 65 to 200
PT 9797/A	50	20.0	4.0	— 65 to 200
PT 9784/A	50	20.0	4.0	— 65 to 200
PT 9785	50	20.0	4.0	— 65 to 200
The « A » suffix on part number denotes stud package				

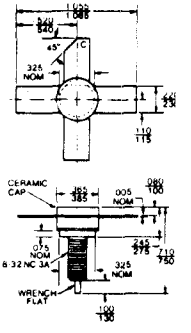
PT 9785



PT 9795
PT 9796
PT 9797
PT 9784



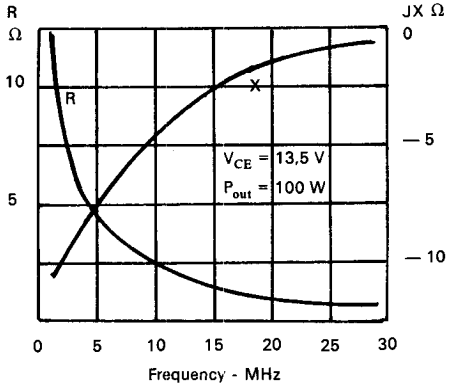
PT 9795 A
PT 9796 A
PT 9797 A
PT 9784 A



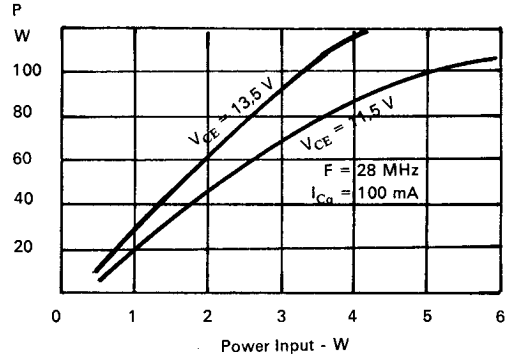
Mechanical Specifications

- Stud Torque, 10 in. lbs., max.
- Lead Soldering, 300°C, 15 sec. max.
- Lead Fatique, 3 bends @ 90°
- Flange Flatness, 0.0008 in. typ.

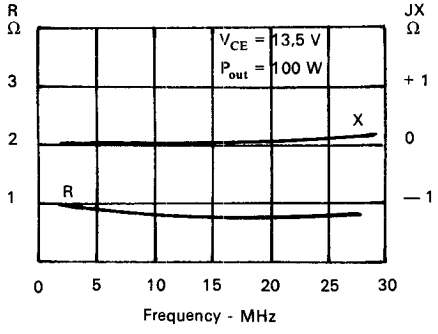
Series Input Impedance vs Frequency



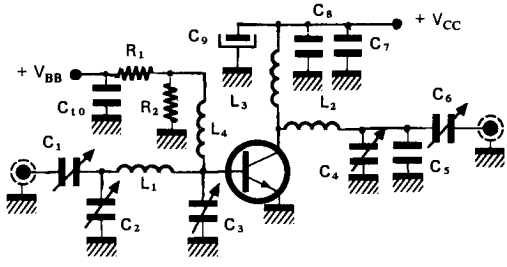
Power Output vs Power Input



Series Load Impedances vs Frequency



28 MHz Test Circuit



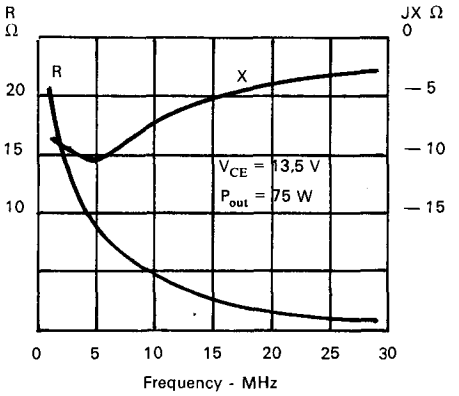
Test Circuit Ports List

C_1 ARCO 423 7-100 pF
C_2 ARCO 467 110-680 pF
C_3 ARCO 469 170-780 pF
C_4 ARCO 466 80-480 pF
C_5 400 pF UNELCO
C_6 ARCO 423 7-100 pF
C_7 1000 pF UNELCO
C_8 0,1 µF
C_9 470 µF Electrolytic
C_{10} 0,1 µF

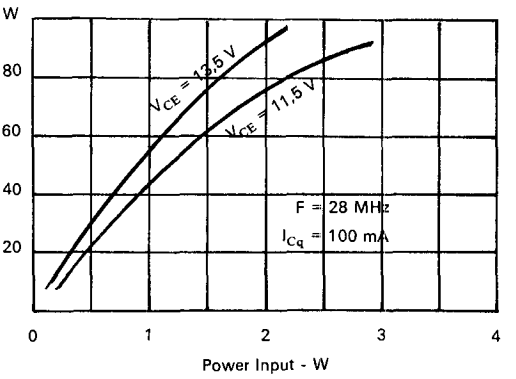
L_1 3 turns ⌀ 11 mm 1 mm wire L = 15 mm
L_2 3 turns ⌀ 15 mm 1,8 mm wire L = 20 mm
L_3 Sturns ⌀ 12 mm 1,8 mm wire
L_4 VK 200 ferrite choke

R_1 1,5 Ω
R_2 10 Ω/5 W

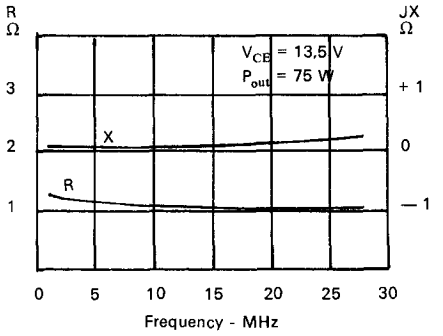
Series Input Impedance vs Frequency



Power Output vs Power Input



Series Load Impedance vs Frequency



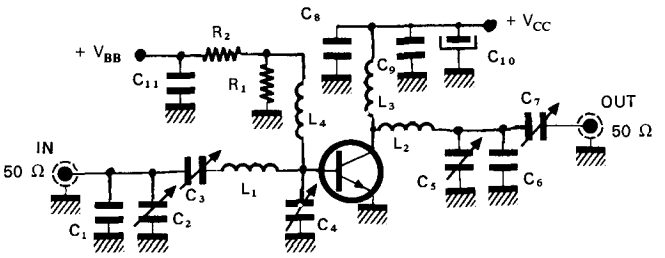
Test Circuit Parts List

L_1 3 turns ⌀ 12 mm 1,4 mm wire
L_2 2 turns ⌀ 13 mm 1,8 mm wire L = 10 mm
L_3 8 turns ⌀ 12 mm 1,2 mm wire
L_3 VK 200 ferrite choke

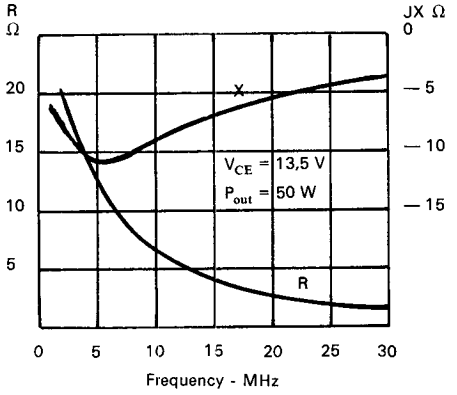
C_1 400 pF UNELCO
C_2 ARCO 427 55-300 pF
C_3 ARCO 469 170-780 pF
C_4 ARCO 469 170-780 pF
C_5 ARCO 427 55-300 pF
C_6 300 pF UNELCO
C_7 ARCO 425 24-200 pF
C_8 1000 pF UNELCO
C_9 0,1 µF
C_{10} 470 µF Electrolytic
C_{11} 0,1 µF

R_1 1,5 Ω
R_2 10 Ω/5 W

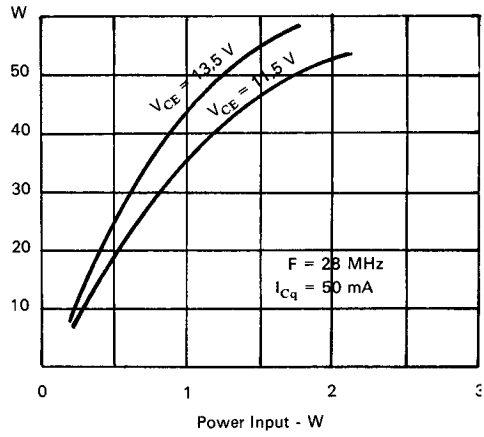
28 MHz Test Circuit



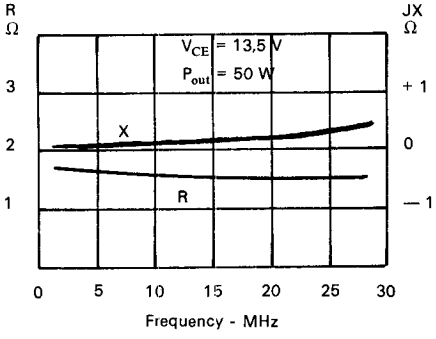
Series Input Impedance vs Frequency



Power Output vs Power Input



Series Load Impedance vs Frequency



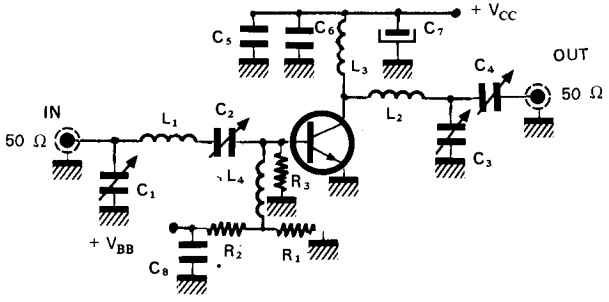
Test Circuit Parts List

L_1 3 turns ⌀ 10 mm 1,4 mm wire
L_2 3 turns ⌀ 10 mm 1,8 mm wire L = 13 mm
L_3 8 turns ⌀ 12 mm 1,2 mm wire
L_4 VK 200 ferrite choke

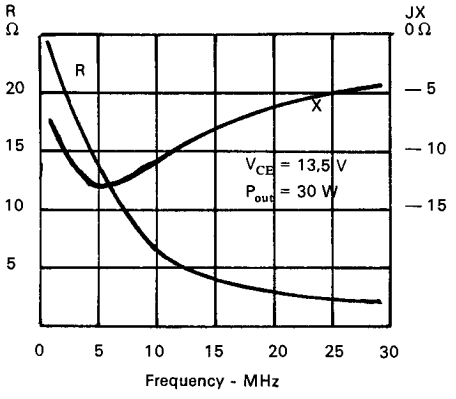
C_1 ARCO 427 55-300 pF + 400 pF UNELCO
C_2 ARCO 469 170-780 pF
C_3 ARCO 427 55-300 pF
C_4 ARCO 425 24-200 pF
C_5 1000 pF UNELCO
C_6 0,1 µF
C_7 470 µF Electrolytic
C_8 0,1 µF

R_1 1,5 Ω
R_2 10 Ω/5 W
R_3 39 Ω

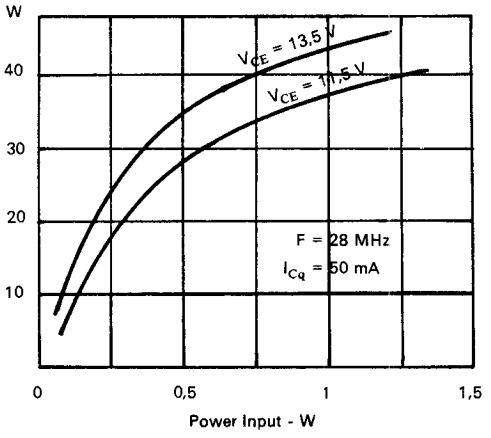
28 MHz Test Circuit



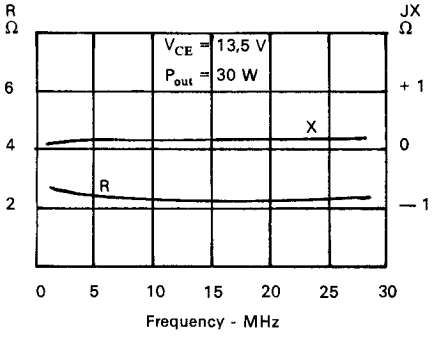
Series Input Impedance vs Frequency



Power Output vs Power Input



Series Load Impedance vs Frequency



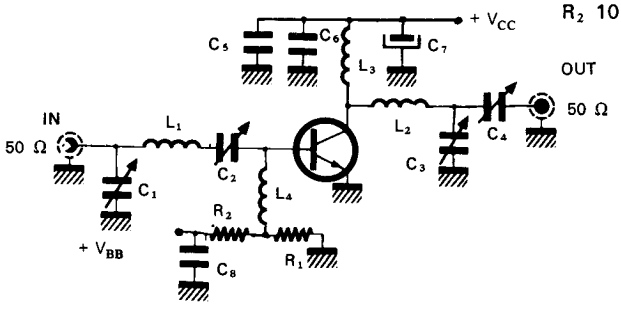
Test Circuit Parts List

L_1 4 turns ⌀ 12 mm 1 mm wire
L_2 4 turns ⌀ 12 mm wire L = 8 mm
L_3 10 turns ⌀ 12 mm 1 mm wire
L_4 VK 200 ferrite choke

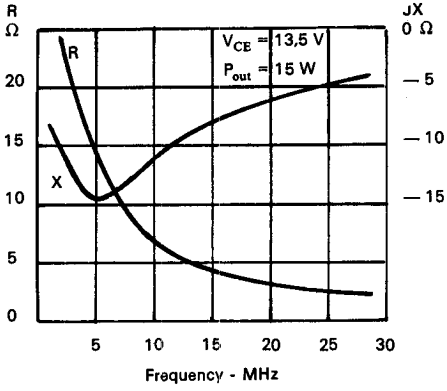
C_1 ARCO 469 170-780 pF + 200 pF UNELCO
C_2 ARCO 469 170-780 pF
C_3 ARCO 427 55-300 pF
C_4 ARCO 427 55-300 pF
C_5 1000 pF UNELCO
C_6 0,1 µF
C_7 50 µF Electrolytic
C_8 0,1 µF

R_1 1,5 Ω
R_2 10 Ω/5 W

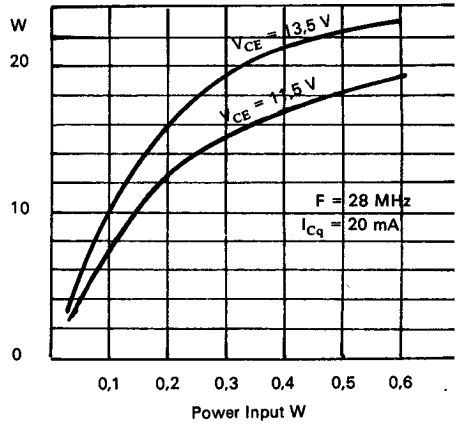
28 MHz Test Circuit



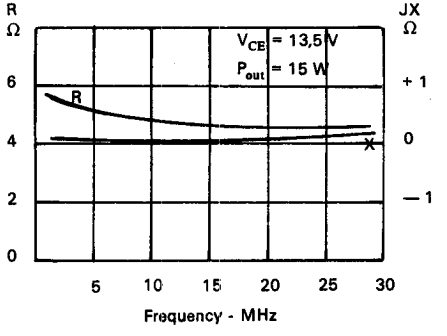
Series Input Impedance vs Frequency



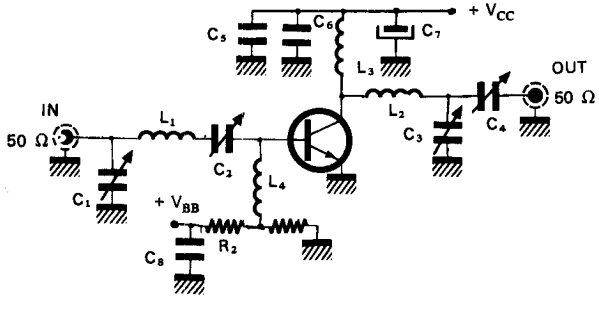
Power Output vs Power Input



Series Load Impedance vs Frequency



28 MHz Test Circuit



Test Circuit Parts List

C_1 ARCO 469 170-780 pF
C_2 ARCO 427 55-300 pF
C_3 ARCO 427 55-300 pF
C_4 ARCO 427 55-300 pF
C_5 1000 pF UNELCO
C_6 0,1 µF Disc
C_7 50 µF Electrolytic
C_8 0,1 µF

L_1 6 turns ⌀ 8 mm 1 mm wire
L_2 4 turns ⌀ 11 mm 1,2 mm wire
L_3 10 turns ⌀ 12 mm 1,2 mm wire
L_4 VK 200 ferrite choke

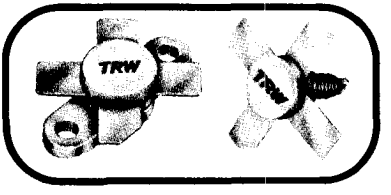
R_1 1,5 Ω
R_2 10 Ω/5 W

SSB Power Transistors

PT 9780/A - 100 W
PT 9783/A - 50 W
PT 9788/A - 20 W
PT 9787/A - 8 W
∞ VSWR

The PT 9780 SSB/VHF Series features both high gain and high power, providing the desired power output with fewer devices. These power transistors are ballasted for ruggedness and will withstand infinite VSWR at all phase angles. A unique emitter structure provides high gain with wider emitter and base fingers resulting in high reliability. Diffused ballast resistors design enables operation at Class A, AB, and C. These rugged units are suitable for both narrow band and broadband SSB and VHF communications and instrumentation service. They are suitable for the following applications :

2-30 MHz	SSB, FM, AM
2-76 MHz	SSB, FM, AM
2-100 MHz	Linear Class A, SSB, FM, AM



Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	CONDITIONS	PT 9787/A	PT 9788/A	PT9783/A	PT 9780/A	UNIT
D C Tests	BV_{CBO}	Collector to Base Breakdown Voltage	I_C = 100 mA, I_E = 0	70	70	70	70	V Min
	BV_{CEO}	Collector to Emitter Breakdown Voltage	I_C = 50 mA, I_B = 0	40	40	40	40	V Min
	I_{CES}	Collector - Emitter Cutoff Current	V_{CE} = 28 V	25	50	100	100	mA Max
	I_{EBO}	Emitter - Base Leakage Current	V_{BE} = 4 V	1.0	1.0	2.5	5.0	mA Max
	H_{FE}	D.C Current Gain	V_{CE} = 5 V	10-100	10-100	10-100	10-100	
	ΔH_{FE}	Matched Pairs	I_C = 1 A	Δ 5	Δ 5	Δ 5	Δ 5	
R F Tests	G_P	Power Gain	V_{CE} = 28 V, F = 28 MHz, P_{EP} 8 W / 20 W / 50 W / 100 W	14	14	14	14	dB Min
	IMD	Intermodulation Distortion	V_{CE} = 28 V, F = 28 MHz, P_{EP} 8 W / 20 W / 50 W / 100 W	— 32	— 32	— 32	— 32	dB Max
	VSWR	Mismatch Tolerance	V_{CE} = 28 V, F = 28 MHz, P_{EP} 8 W / 20 W / 50 W / 100 W	∞	∞	∞	∞	—

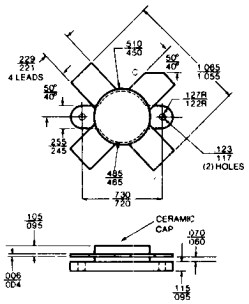
Absolute Maximum Ratings (T_{CASE} = 25°C)

Part Number*	V_{CBO} Volts	V_{CEO} Volts	V_{EBO} Volts	I_C Max Amps	P_T @ 25°C Watts	θ_{JC} °C/W	$T_{STORAGE}$ °C
PT9780	70	40	4.0	20.0	350	0.50	-65 to 200
PT9780A	70	40	4.0	20.0	250	0.70	-65 to 200
PT9783	70	40	4.0	10.0	175	1.0	-65 to 200
PT9783A	70	40	4.0	10.0	100	1.75	-65 to 200
PT9788/A	70	40	4.0	4.0	70	2.5	-65 to 200
PT9787/A	60	40	4.0	2.0	25	7.0	-65 to 200

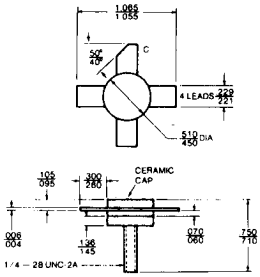
*The "A" suffix on part number denotes stud package.

Package Outlines

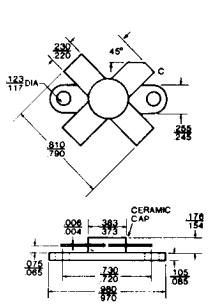
PT9780



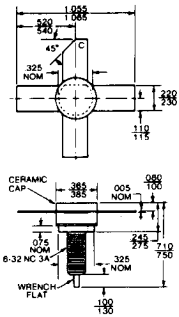
PT9780A



PT9783
PT9788
PT9787



PT9783A
PT9788A
PT9787A

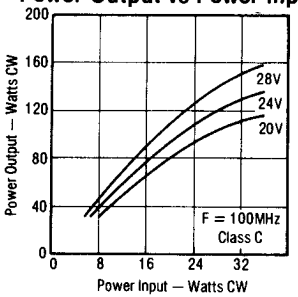


Mechanical Specifications

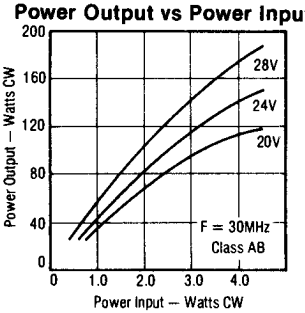
- Stud Torque, 10 in. lbs., max.
- Lead Soldering, 300°C, 15 sec. max.
- Lead Fatique, 3 bends @ 90°
- Flange Flatness, 0.0008 in. typ.

PT9780 and PT9780A

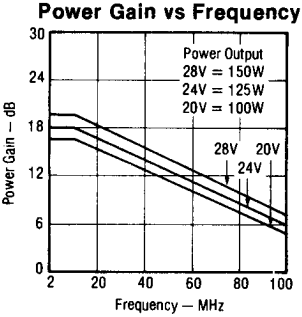
Power Output vs Power Input



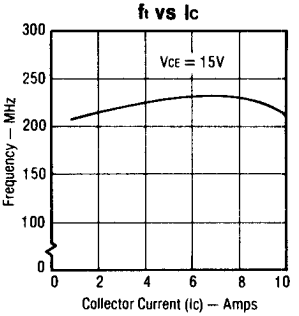
Power Output vs Power Input



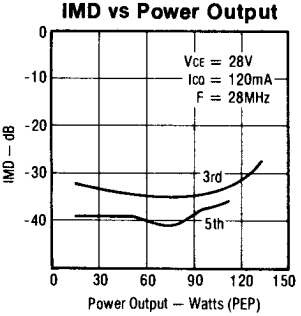
Power Gain vs Frequency



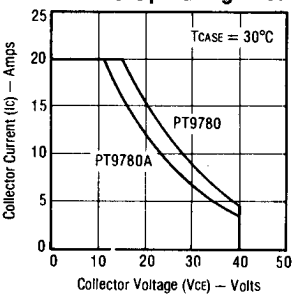
ft vs Ic



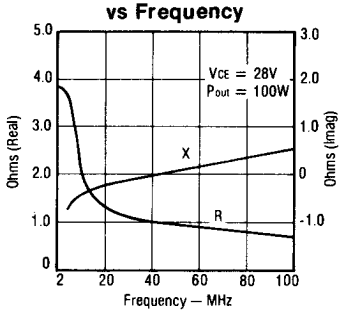
IMD vs Power Output



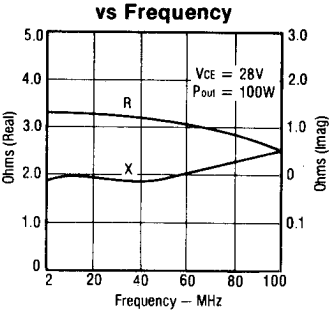
DC Safe Operating Area



Series Input Impedance vs Frequency

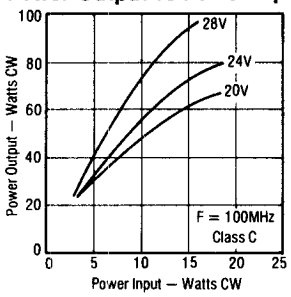


Series Load Impedance vs Frequency

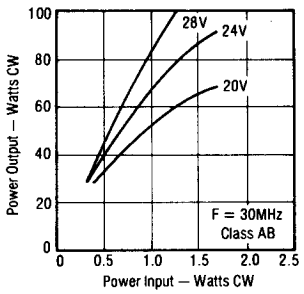


PT9783 and PT9783A

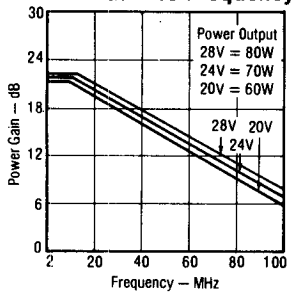
Power Output vs Power Input



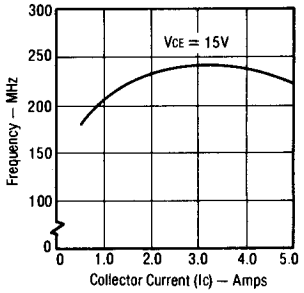
Power Output vs Power Input



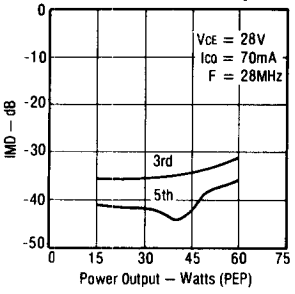
Power Gain vs Frequency



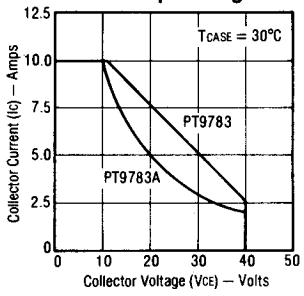
ft vs Ic



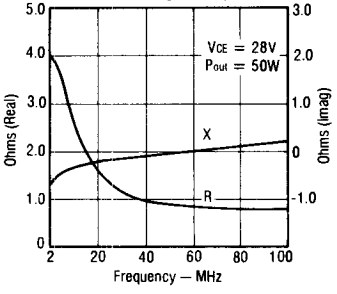
IMD vs Power Output



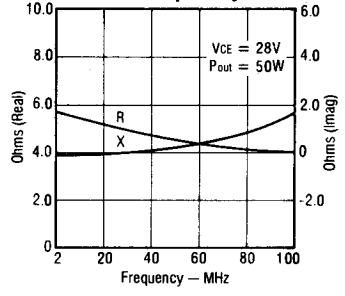
DC Safe Operating Area



Series Input Impedance vs Frequency

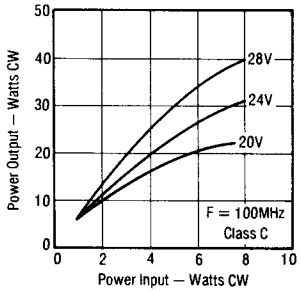


Series Load Impedance vs Frequency

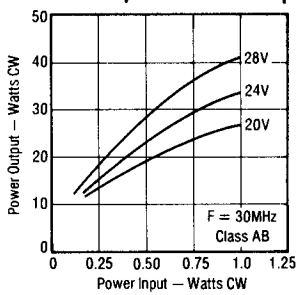


PT9788 and PT9788A

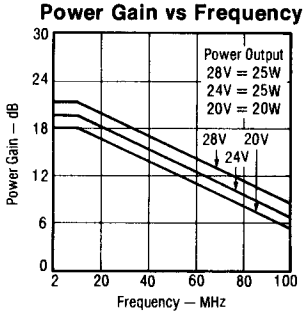
Power Output vs Power Input



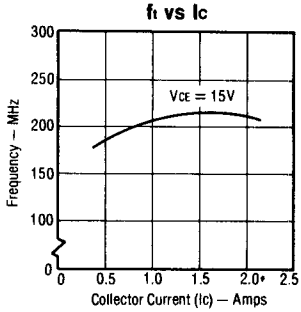
Power Output vs Power Input



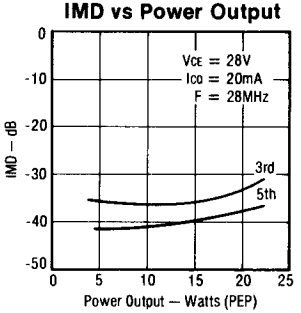
Power Gain vs Frequency



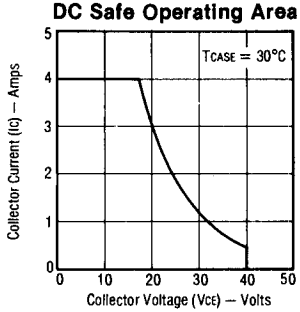
ft vs Ic



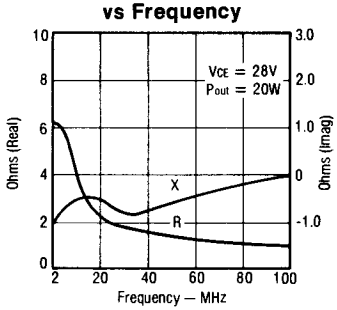
IMD vs Power Output



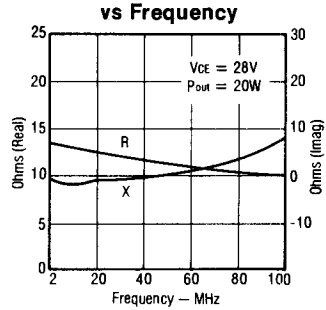
DC Safe Operating Area



Series Input Impedance vs Frequency

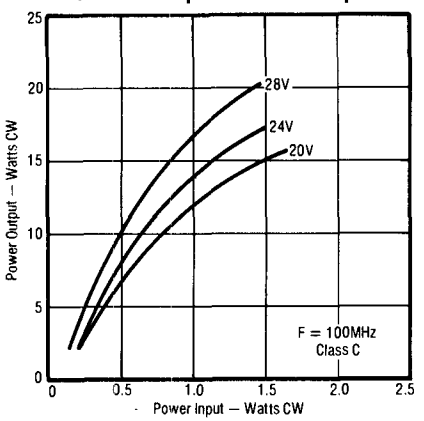


Series Load Impedance vs Frequency

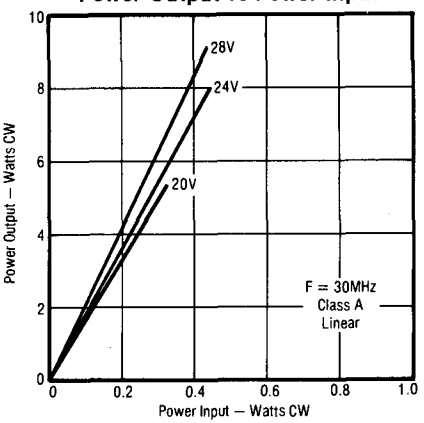


PT9787 and PT9787A

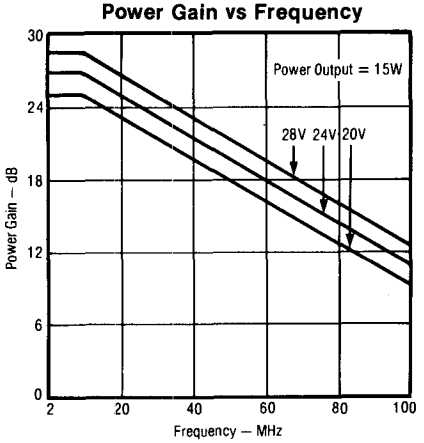
Power Output vs Power Input



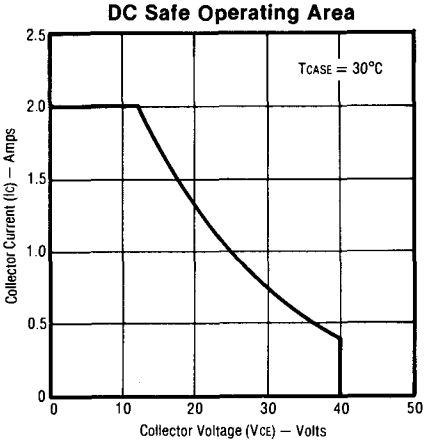
Power Output vs Power Input



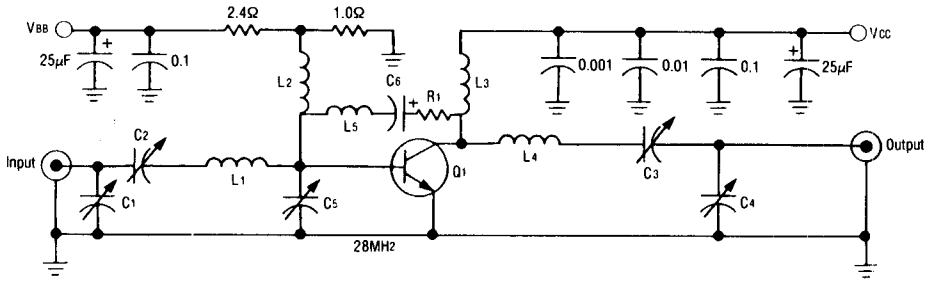
Power Gain vs Frequency



DC Safe Operating Area

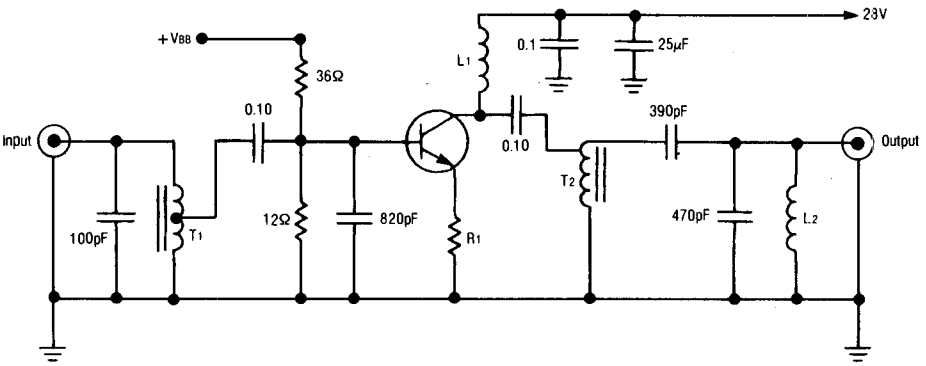


28MHz Test Circuit for PT9780/A, PT9783/A, PT9788/A



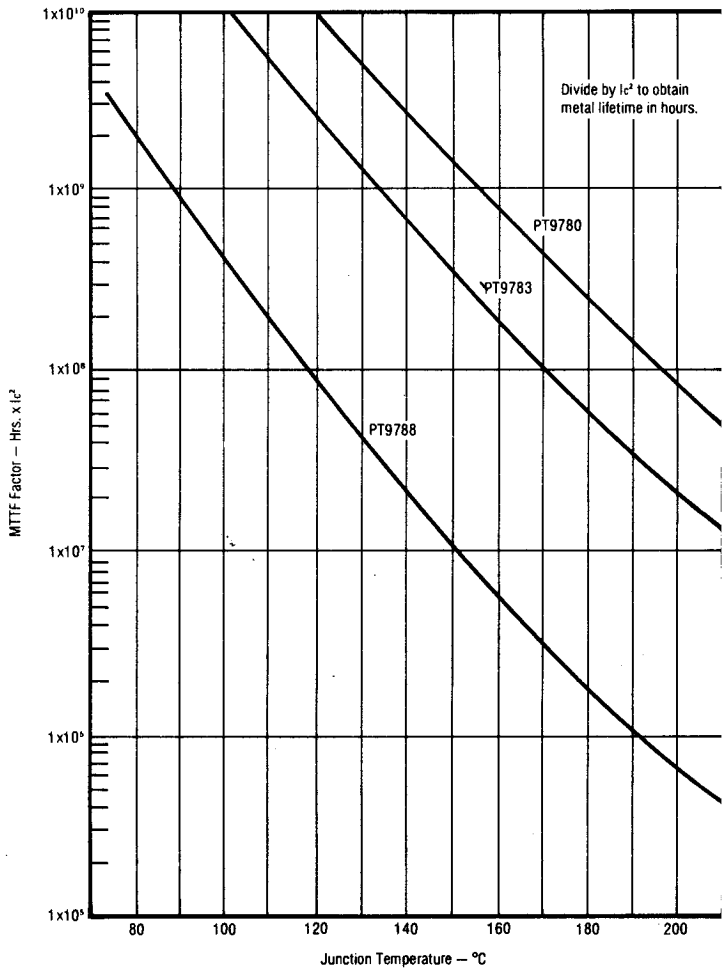
C_1	ARCO #467, 110-580pF
$C_{2,3,4}$	ARCO #466, 80-480pF
C_5	ARCO #469, 170-780pF
C_6	5µF, 50V ELE
R_1	50Ω, 2W
$L_{1,4}$	5 turns #14 tinned copper, 0.5" mean diameter, 1 equals 1.0"
L_2	10 turns #18AWG, 0.5" mean diameter
L_3	4 turns #20AWG through two Stackpole #23-1838 cores
L_5	6.8µH molded
V_{CC}	28V
V_{BB}	1.6 volts (Ic[Quies] = 100mA)

28MHz Test Circuit for PT9787 and PT9787A



R_1	1.0Ω on each emitter (0.5Ω)
T_1	6 turns, #22 wire tapped 2 turns from ground, on Fairrite Products #43 bead.
T_2	4 turns, #20 wire tapped 3½ turns from ground, on Fairrite Products #43 bead.
L_1	1.0µH
L_2	0.05µH

MTTF Factor
vs Junction Temperature

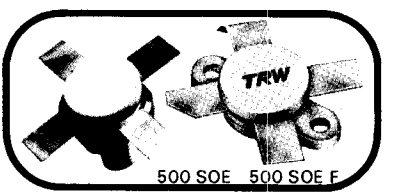


SSB POWER TRANSISTORS

The PT 9790 SSB/VHF Series features both high gain and high power, providing the desired power output with fewer devices. These power transistors are ballasted for ruggedness and will withstand infinite VSWR at all phase angles. A unique emitter structure provides high gain with wider emitter and base fingers resulting in high reliability. Diffused ballast resistor design enables operation at Class A, AB, and C. These rugged units are suitable for both narrow band and broadband SSB and VHF communications and instrumentation service. They are suitable for the following applications :

2-30 MHz	SSB, FM, AM
2-76 MHz	SSB, FM, AM
2-100 MHz	Linear Class A, SSB, FM, AM

HF - SSB
150 W - 50 V
∞ VSWR

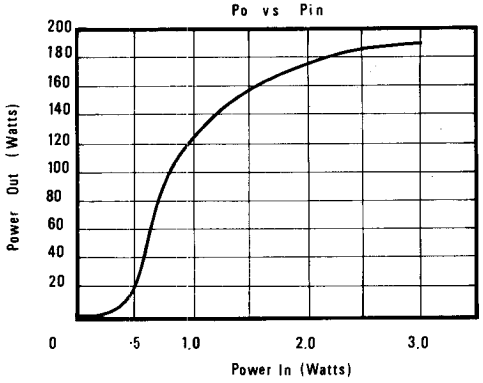


500 SOE 500 SOE F

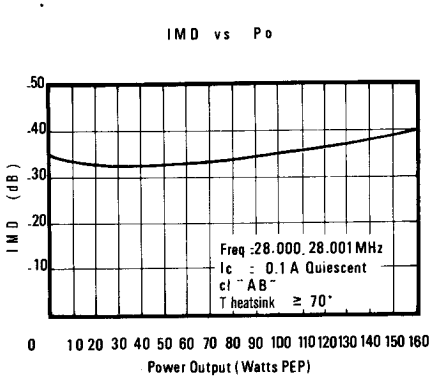
Electrical characteristics (25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Tests	BV_{CBO}	Collector - Base Breakdown	I_C = 100 mA I_E = 0	110			V
	BV_{CEO}	Collector - Emitter Breakdown	I_C = 100 mA I_B = 0	55			V
	BV_{CER}	Collector - Emitter Breakdown	I_C = 100 mA I_B = 0 R_{BE} = 10 Ω	110			V
	BV_{EBO}	Emitter - Base Breakdown	I_E = 20 mA I_C = 0	4.0			V
	H_{FE}	D.C Current Gain	V_{CE} = 6 V I_C = 1.4 A	15		50	
	ΔH_{FE}	Matched Pairs	V_{CE} = 6 V I_C = 1.4 A			Δ 5	
RF Tests	P_G	Power Gain	V_{CE} = 50 V F = 28 MHz P_{out} = 150 W	15	17		dB
	IMD	Intermodulation Distortion	V_{CE} = 50 V F = 28 MHz P_{out} = 150 W PEP		— 35	— 32	dB
	VSWR	Mismatch Tolerance	V_{CE} = 50 V F = 28 MHz P_{out} = 150 W PEP			∞ 3 sec any angle	
Operating	I_{Cmax}	Collector Current				20	A
	θ_{j-c}	Thermal Resistance Junction - Case				0.5	°C/W
	θ_{C-H}	Thermal Resistance Case - Case - Heatsink				0.2	°C/W
	T_{stg}	Storage Temperature		— 65		+ 200	°C

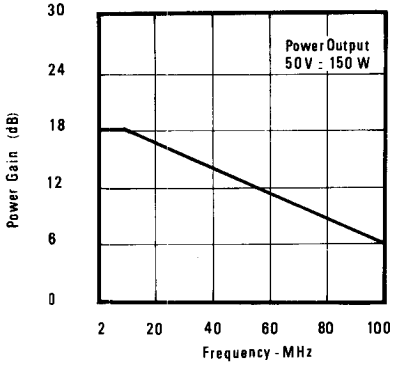
Power Out Put vs Power input



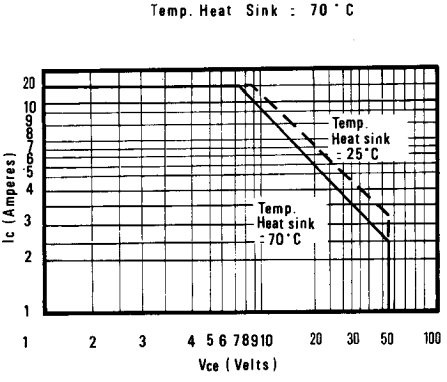
I M D vs Power Output



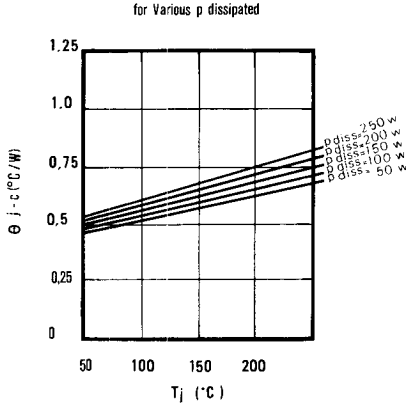
Power Gain vs Frequency



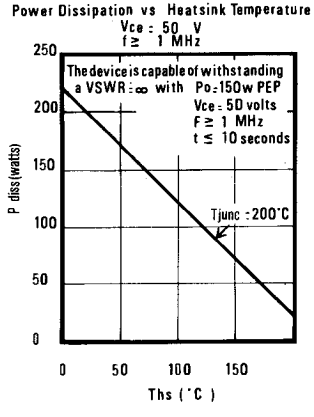
D.C. Safe Operating Area



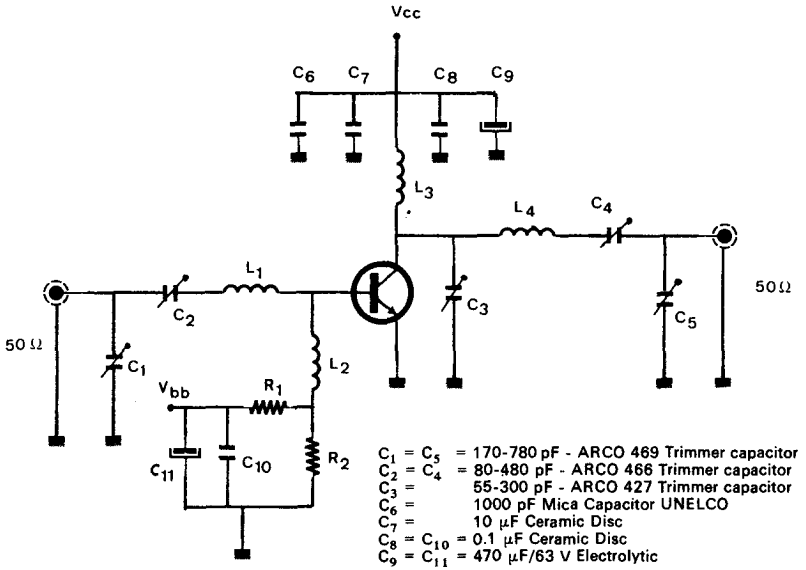
Thermal Resistance VS Junction Temperature



Power Dissipation vs Heatsink Temperature



28 MHz TEST CIRCUIT

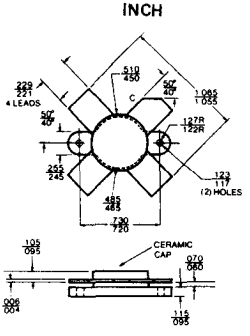


$C_1 = C_5$ = 170-780 pF - ARCO 469 Trimmer capacitor
$C_2 = C_4$ = 80-480 pF - ARCO 466 Trimmer capacitor
C_3 = 55-300 pF - ARCO 427 Trimmer capacitor
C_6 = 1000 pF Mica Capacitor UNELCO
C_7 = 10 µF Ceramic Disc
$C_8 = C_{10}$ = 0.1 µF Ceramic Disc
$C_9 = C_{11}$ = 470 µF/63 V Electrolytic

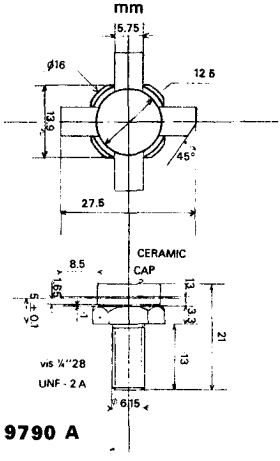
L_1 = 5 turns 15/10 mm Silvered wire - 10 mm I.D. - 25 mm length
L_2 = 10 turns 8/10 mm Enamelled wire - 10 mm I.D.
L_3 = 4 turns 12/10 mm Enamelled wire - 10 mm I.D. - 10 mm length
L_4 = 7 turns 15/10 mm Enamelled wire - 10 mm I.D. - 20 mm length

R_1 = 1 Ω - 2 W
R_2 = 2.7 Ω - 2 W

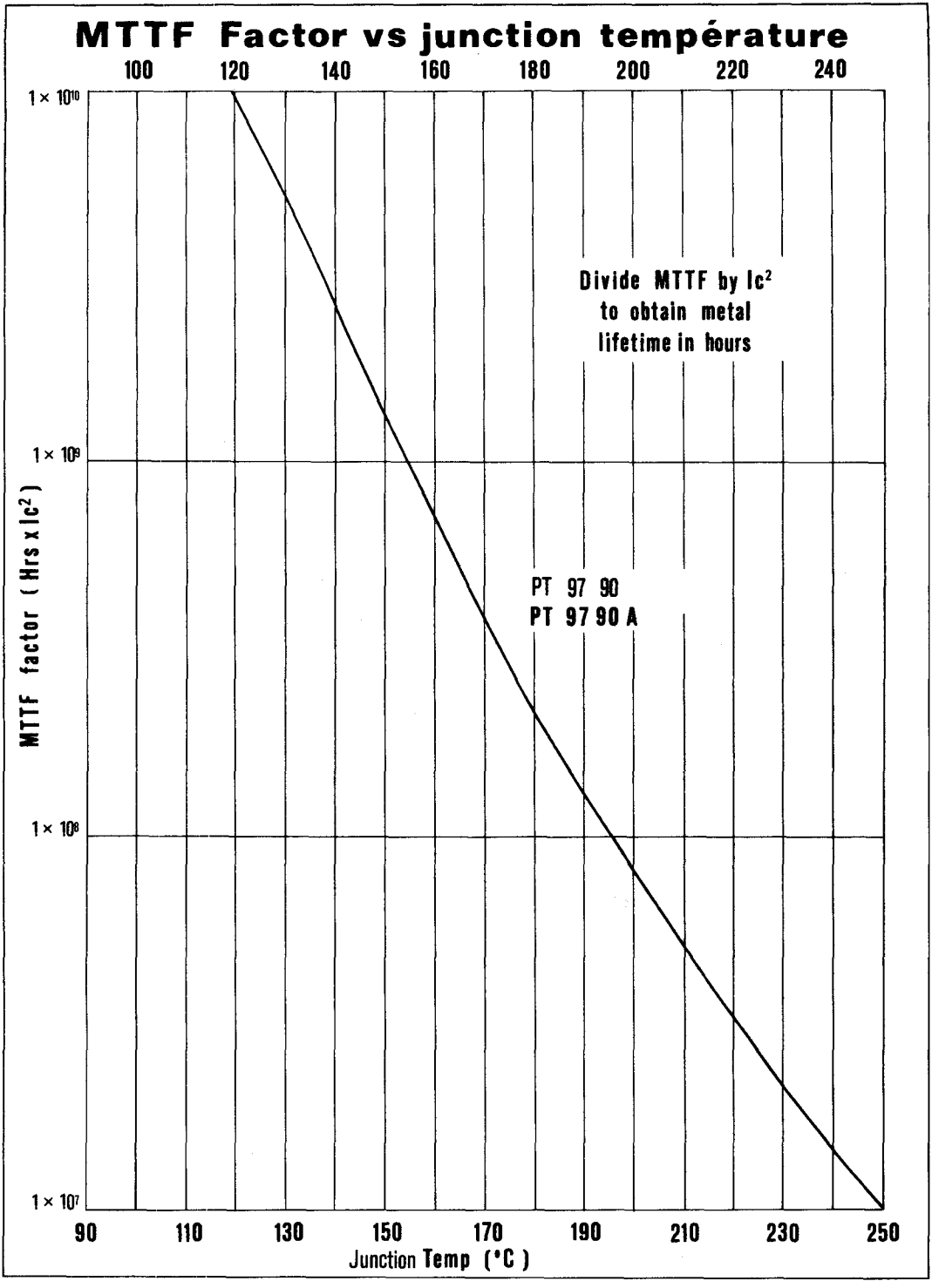
PACKAGE OUTLINE



PT 9790



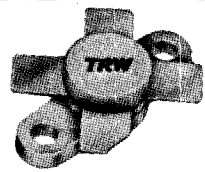
PT 9790 A


MTTF Factor vs junction température
100
120
140
160
180
200
220
240
1 × 10¹⁰
1 × 10⁹
1 × 10⁸
1 × 10⁷
MTTF factor (Hrs x Ic²)
Divide MTTF by Ic²
to obtain metal
lifetime in hours
PT 97 90
PT 97 90 A
90
110
130
150
170
190
210
230
250
Junction Temp (°C)

SSB Power Transistor

200 WATTS PEP
2-30 MHz 28 V

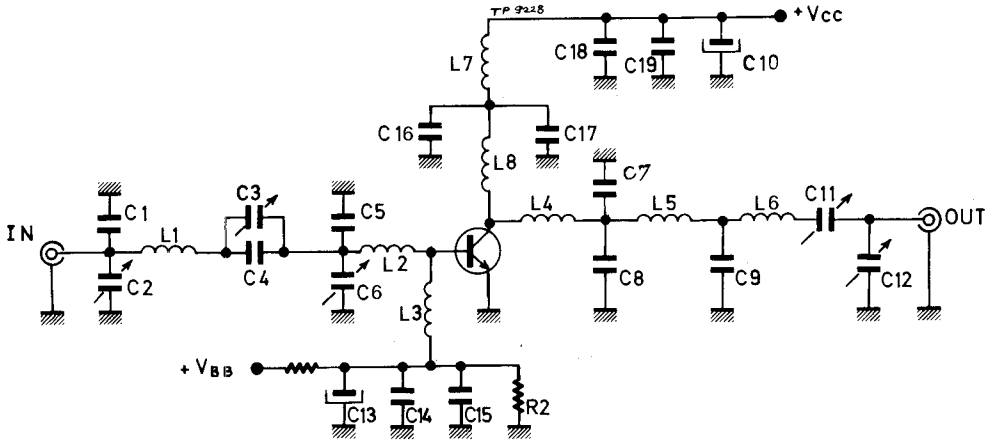
The TP 9228 transistor is intended for use in Marine, Military and Commercial high power SSB and CW RF transmitter designs. The combined die and package state-of-the-art technology enables reliable operation at elevated case temperatures.



Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown	I_E = 5 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown	I_C = 50 mA	35			V
	BV_{CES}	Collector - Emitter Breakdown	I_C = 100 mA	60			V
	I_{CES}	Collector - Emitter Leakage Current	V_{CE} = 25 V			10	mA
	H_{FE}	D.C Current Gain	V_{CE} = 10 V I_C = 1000 mA	20		150	
RF Test	G_P	RF Power Gain	V_{CE} = 28 V	15	16		dB
	η_C	Collector Efficiency	I_{CQ} = 100 mA	55			%
	IMD	Intermodulation Distorsion	F = 28 MHz		— 34	— 32	dB
	VSWR	Mismatch Tolerance	P_{out} = 200 W PEP	∞			—
	C_{OB}	Output Capacitance	V_{CB} = 28 V F = 1 MHz		430		pF
Thermal	θ_{JC}	Thermal Resistance Junction - Case				0.6	°C/W
	P_{max}	Power Dissipated				300	W
	T_{STG}	Storage Temperature		— 60		+ 200	°C

28 MHz TEST CIRCUIT
(narrow band)



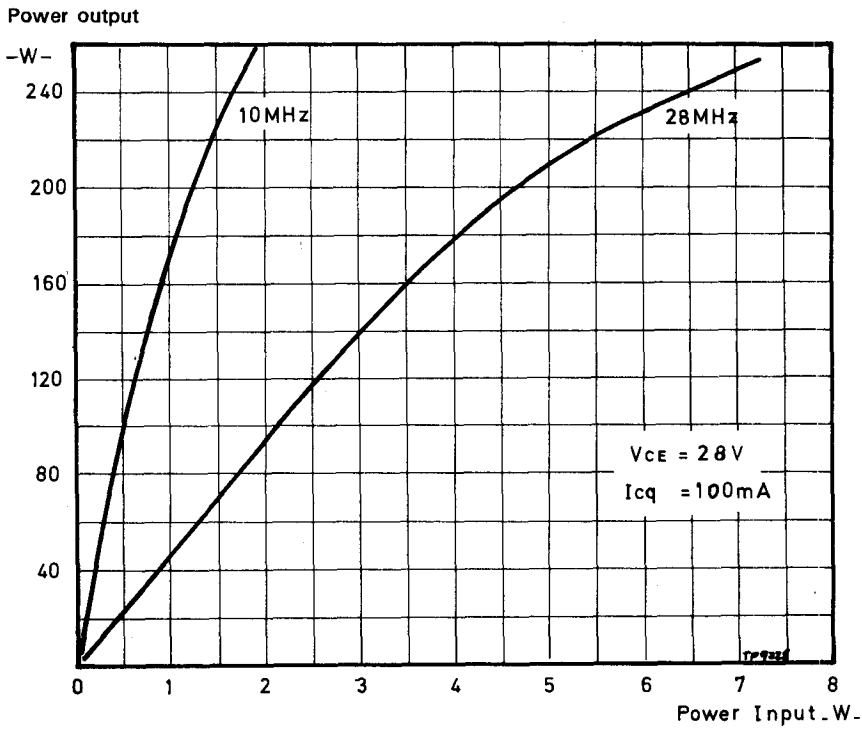
COMPONENT PARTS LIST

L_1 = 8turns ∅ 8 mm 1.4 mm wire
L_2 = 3 turns ∅ 10 mm 1.4 mm wire L = 7 mm
L_3 = 10 turns 0.8 mm wire on a 14 X 9 X 5 mm ferrite core (μ_i = 120)
L_4 = 2 turns ∅ 10 mm 1.4 mm wire L = 8 mm
L_5 = 3 turns ∅ 10 mm 1.4 mm wire L = 14 mm
L_6 = 6 turns ∅ 10 mm 1.4 mm wire
L_7 = 5 turns 1.4 mm wire on a 2 14 X 9 X 5 mm ferrite core (μ_i = 120)
L_8 = 7 turns ∅ 14 mm 1.8 mm wire L = 25 mm

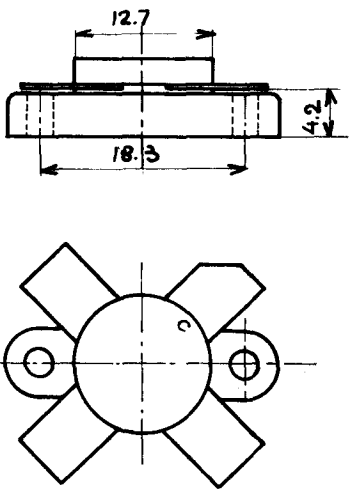
C_1 = 400 pF
C_2 = ARCO 469 170-780 pF
C_3 = ARCO 469
C_4 = 300 pF
C_5 = 200 pF
C_6 = ARCO 469
C_7 = 400 pF
C_8 = 500 pF
C_9 = 400 pF
C_{10} = 1000 uF
C_{11} = ARCO 469
C_{12} = ARCO 466 80-480 pF
C_{13} = 470 µF
C_{14} = 1000 pF
C_{15} = 0.1 µF
C_{16} = 1000 pF
C_{17} = 10 nF
C_{18} = 1000 pF
C_{19} = 0.1 µF

R_1 = 0,5 Ω 5 W
R_2 = 0,27 Ω 2 W

Typical Power Output vs Power Input



Package Outline (mm)



MOBILE

MOBILE

PRODUCT SUMMARY

P/N	FREQUENCY (MHz)	POWER OUTPUT (W)	GAIN (dB)	VOLTAGE (V)	PACKAGE	PAGE
TP 210	88	0.05		7.5	T-PACK	**B-78**
TP 212	88	5.0		7.5	280 SOE	**B-82**
TP 1045	88	1.5	11.8	9.5	280 SOE Studless	**B-94**
TP 2312	88	3	15.7	12.5	TO-39 GE	**B-107**
TP 2314	88	4	16	12.5	TO-39 GE	**B-110**
TP 5695	88	10	9.2	12.5	380 SOE	**B-132**
TP 2320	88	20	11.2	12.5	380 SOE	**B-113**
ML 20	68-88	20	21.2	12.5	MVM	**B-57**
TP 2304	88	40	7	12.5	380 SOE	**B-100**
TP 2180	88	80	7.0	12.5	J-ZERO-C	**B-97**
TP 1045	175	1.5	11.7	9.5	280 SOE Studless	**B-94**
TP 2503	175	5	11	9.5	280 SOE Studless	**B-129**
TP 2500	175	0.9	12.5	12.5	TO-46	**B-126**
PT 8740	175	1.8	12.5	12.5	TO-39	**B-67**
TP 2310	175	2.5	12	12.5	TO-39	**B-104**
TP 2312	175	2.75	15.3	12.5	TO-39 GE	**B-107**
TP 2314	175	4	12	12.5	TO-39 GE	**B-110**
2 N 6080	175	4	12	12.5	380 SOE	**B-37**
PT 8828	175	9	11.1	12.5	380 SOE	**B-74**
2 N 6081	175	15	6.4	12.5	380 SOE	**B-37**
PT 8811	175	15.0	10.0	12.5	280 SOE	**B-70**
TP 2320	175	17.0	8.2	12.5	380 SOE	**B-113**
TP 2330	175	30	10	12.5	380 SOE	**B-117**
MV 20	140-175	20	20	12.5	MVM	**B-59**
2 N 5589	175	3	8.2	13.6	380 SOE	**B-33**
2 N 5590	175	10	10	5.2	380 SOE	**B-33**
2 N 5591	175	25	4.4	13.6	380 SOE	**B-33**
2 N 6082	175	25	6.2	12.5	380 SOE	**B-37**
2 N 6083	175	30	5.7	12.5	380 SOE	**B-37**
MV 30	150-160	30	21.7	13.5	MVM	**B-59**
TPS 175	140-175	30	20.0	12.5	TPS	**B-135**
TP 2304	175	40	5.2	12.5	380 SOE	**B-100**
JO 4045	175	45	6.5	12.5	J-ZERO-C	**B-48**
JO 4070	175	70	5.9	12.5	J-ZERO-C	**B-52**
JO 4075	175	75	6.2	12.5	JO-C	**B-54**
JO 4080	175	80	7.3	12.5	JO-C	**B-56**
PT 9730	175	4	13	28	380 SOE	**D-167**
PT 9732	175	8	12	28	380 SOE	**D-176**
PT 9734	175	15	11.5	28	380 SOE	**D-176**
PT 9731	175	25	10	28	380 SOE	**D-176**
PT 9733	175	50	7.9	28	380 SOE	**D-176**
TP 2404	175	50	7.9	28	500 SOE	**B-120**
TP 2405	175	90	5.5	27	500 SOE	**B-123**

MOBILE
PRODUCT SUMMARY

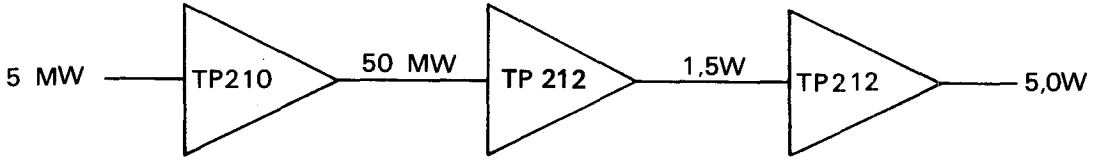
P/N	FREQUENCY (MHz)	POWER OUTPUT (W)	GAIN (dB)	VOLTAGE (V)	PACKAGE	PAGE
TP 250	470	0.01	10	7.5	T-PACK	**B-85**
TP 251	470	0.175	12.4	7.5	200 SOE Sutdless	**B-88**
TP 252	470	1.50	10	7.5	280 SOE	**B-91**
TP 2500	470	0.35	8.5	12.5	TO-46	**B-126**
TP 1045	470	2	10	12.5	280 SOE Studless	**B-94**
PT 8809	470	2	10	12.5	280 SOE	**B-70**
TP 2503	470	5	8.5	12.5	280 SOE Studless	**B-129**
PT 8810	470	5	8.5	12.5	280 SOE	**B-70**
MX 7.5	400-512	7.5	18.0	12.5	MXM	**B-63**
PT 8811	470	10	6	12.5	280 SOE	**B-70**
MX 12	400-512	12.0	19.0	12.5	MXM	**B-63**
MX 15	400-470	15.0	19.0	12.5	MXM	**B-63**
JO 3015	470	15	7.7	12.5	JO-C	**B-134**
JO 3020	470	20	7.5	12.5	JO-C	**B-41**
TPS 470	400-512	20 W	18.0	12.5	TPS	**B-132**
JO 3037	470	37	4.9	12.5	JO-C	**B-44**
JO 3050	470	50	5.8	12.5	JO-C	**B-141**
JO 3055	470	55	4.4	12.5	JO-C	**B-45**
PT 9700	400	1.5	11	28	280 SOE	**D-168**
PT 9701	400	4	9	28	280 SOE	**D-168**
PT 9703	400	10	9	28	280 SOE	**D-168**
PT 9702	400	20	7	28	280 SOE	**D-168**
PT 9704	400	30	6.3	28	280 SOE	**D-168**
PT 9704 A	400	30	7.8	28	280 SOE	**D-168**
JO 2015 A	400	70	8.4	28	J-ZERO-C	**D-164**
JO 3401	870	5	7.0	12.5	.230 F	**B-142**
JO 3402	870	18	6.5	12.5	.230 F	**B-142**
JO 3403	870	28	5.4	12.5	.230 F	**B-142**
JO 3404	870	45	4.8	12.5	.230 F	**B-142**

MOBILE

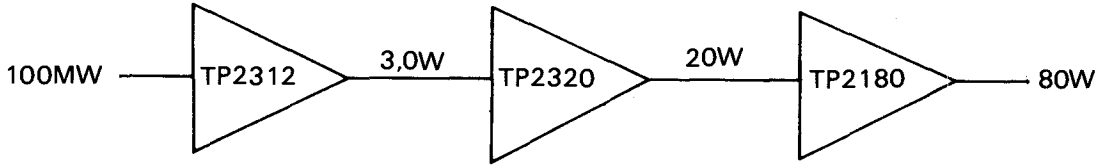
LINE-UP SUGGESTIONS

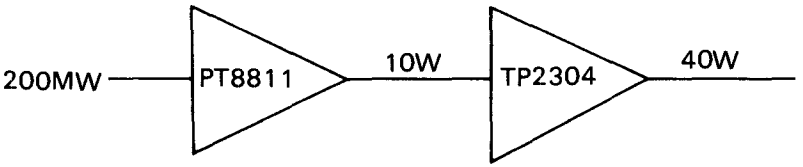
88 MHz

7.5V POCKETPHONES



12,5V POWER AMPLIFIER



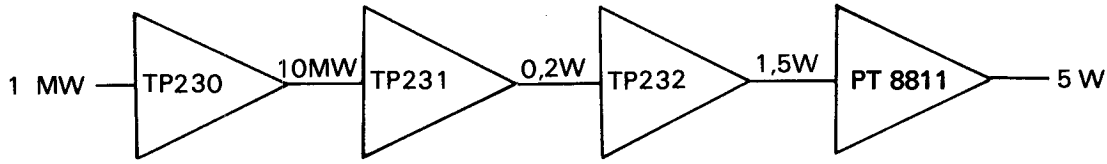


MOBILE

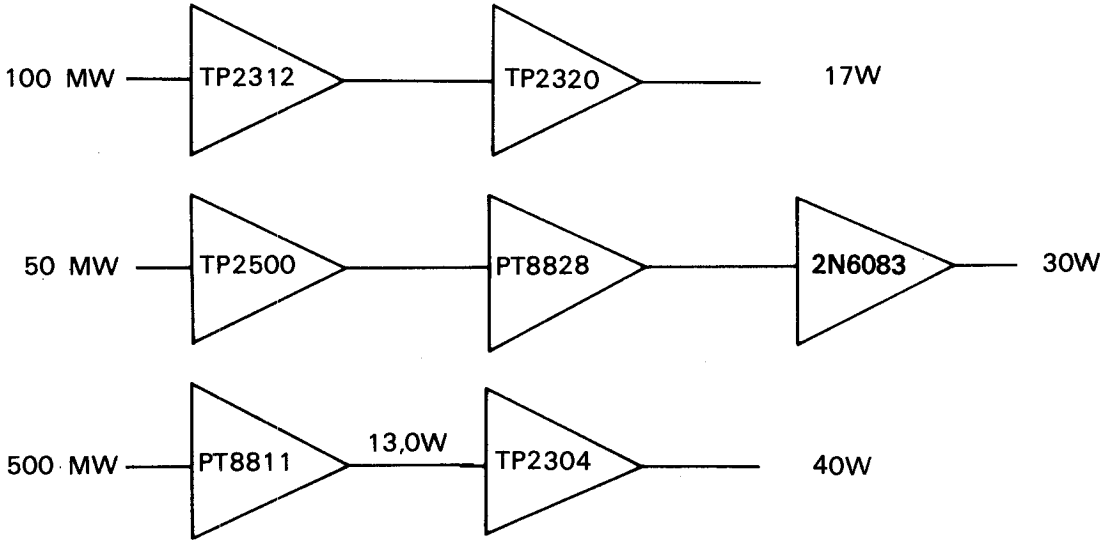
LINE-UP SUGGESTIONS

175 MHz

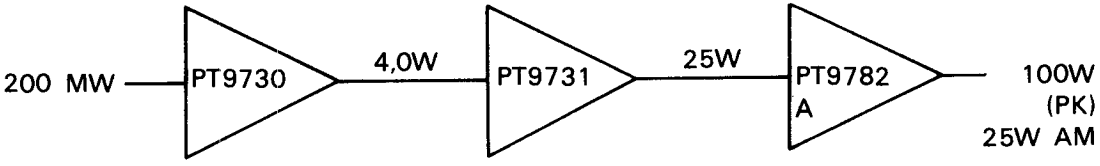
7,5V POCKETPHONES



12,5V POWER APLIFIERS



28V AM/FM POWER AMPLIFIER

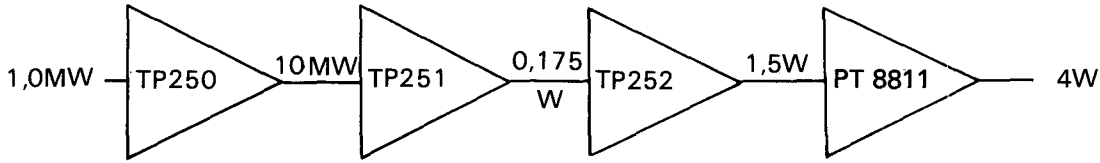


MOBILE

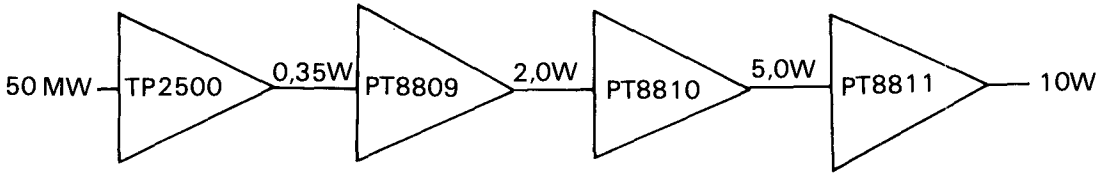
LINE-UP SUGGESTIONS

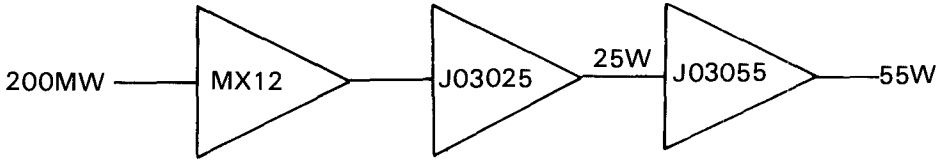
470 MHz

7,5V POCKETPHONES

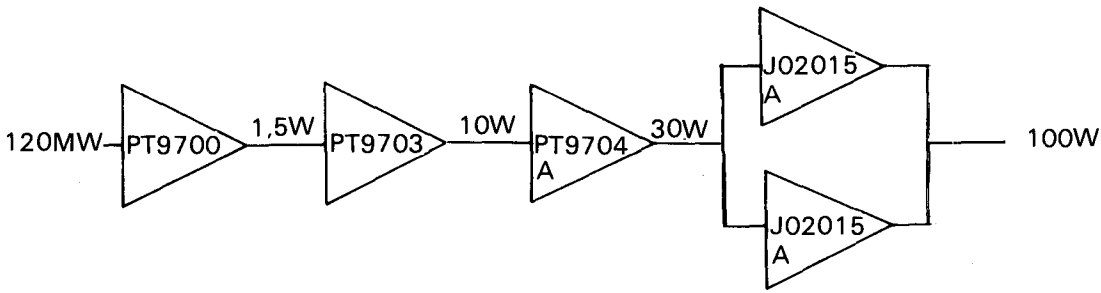


12,5V POWER AMPLIFIERS





28V POWER AMPLIFIER



TRW® SEMICONDUCTORS

2N 5589
2N 5590
2N 5591

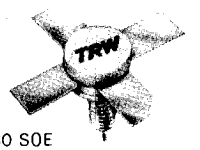
RF Power Transistors

3 W 10 W 25 W

175 MHz 13,6 V

The 2 N 5589... series is intended for use in 13.6 volts VHF amplifier applications.

These low cost rugged devices have an excellent performance and can achieve in excess of 25 W with as little as 350 mW drive power.



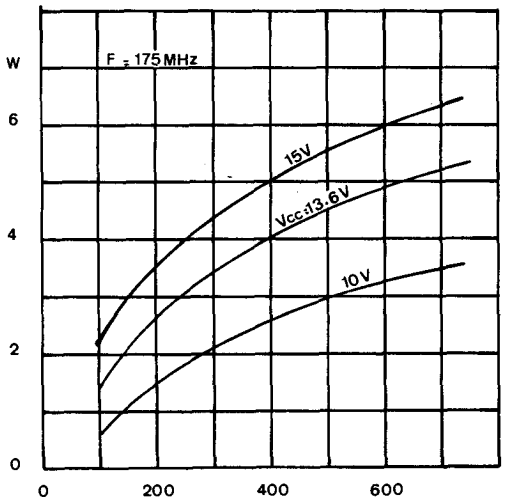
380 SOE

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	2N 5589	2N 5590	2N 5591	UNIT
DC Test	BV_{EBO}	Min Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0 I_E = 5 mA I_C = 0	4	4	4	V
	BV_{CEO}	Min Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0 I_C = 100 mA I_B = 0 I_C = 200 mA I_B = 0	18	18	18	V
	BV_{CBO}	Min Collector - Base Breakdown Voltage	I_C = 50 mA I_E = 0 I_C = 100 mA I_E = 0 I_C = 100 mA I_E = 0	36	36	36	V
	I_{CBO}	Max Collector Cutoff Current	V_{CB} = 15 V I_E = 0	1	1	1	mA
	H_{FE}	Min D.C Current Gain	V_{CE} = 5 V I_C = 100 mA V_{CE} = 5 V I_C = 250 mA V_{CE} = 5 V I_C = 500 mA	5	5	5	—
RF Test	P_{GAIN}	Min Power Gain	V_{CE} = 13.6 V P_{in} = 0.35 W P_{in} = 3 W F = 175 MHz P_{in} = 9 W	3	10	25	W
	η_i	Min Efficiency	V_{CE} = 13.6 V P_{out} = 3 W P_{out} = 10 W F = 175 MHz P_{out} = 25 W	50	50	50	%
	Z_{in}	Common Emitter Amplifier Typ Input Impedance	V_{CE} = 13.6 V P_{in} = 0.35 W P_{in} = 3 W F = 175 MHz P_{in} = 9 W	3.8 + j 1.8	2.3 + j 1.8	0.86 + j 1.13	Ω
	Z_{Load}	Common Emitter Amplifier Typ Load Impedance	V_{CE} = 13.6 V P_{out} = 3 W F = 175 MHz P_{out} = 10 W P_{out} = 25 W	21.9 + j 13.9	5.1 + j 1.2	3.45 + j 0.09	Ω
	C_{OB}	Max Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz I_E = 0	30	70	120	pF
Operating	I_C	Continous Collector Current		0.6	2	7	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C	12	8	2.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		← 65° to + 200 °C →			°C
	P_D	Power Dissipation	T_C = 25 °C	15	30	70	W

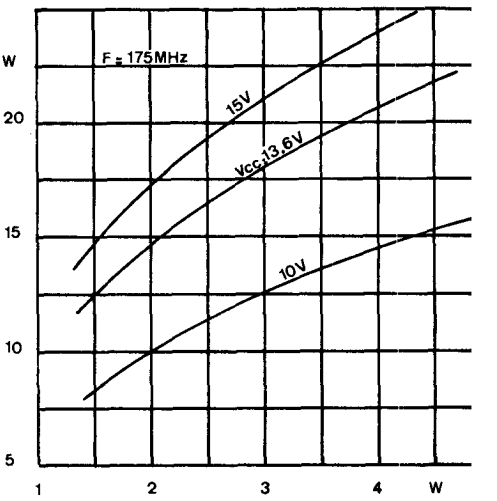
TYPICAL CHARACTERISTICS

Output Power vs Input Power and Voltage Supply

2 N 5589

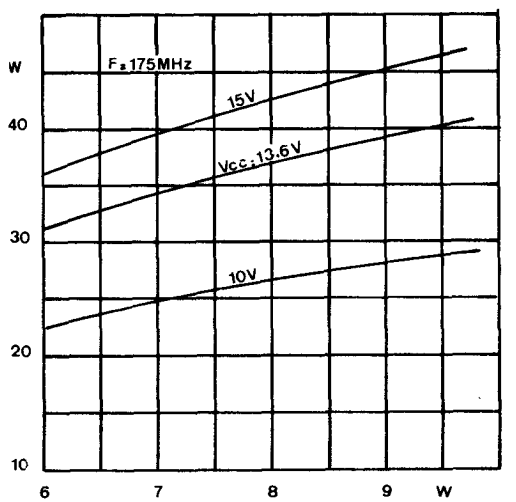


2 N 5590

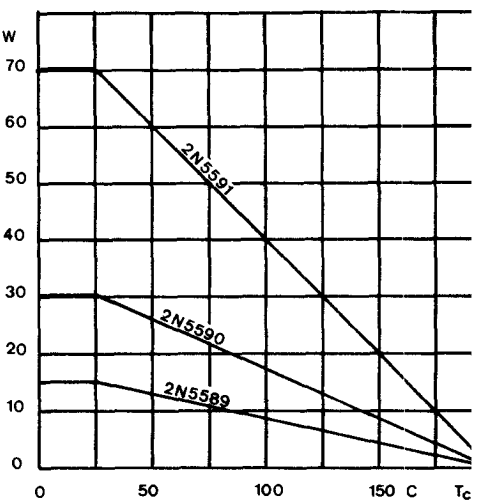


Output Power vs Input Power and Voltage Supply

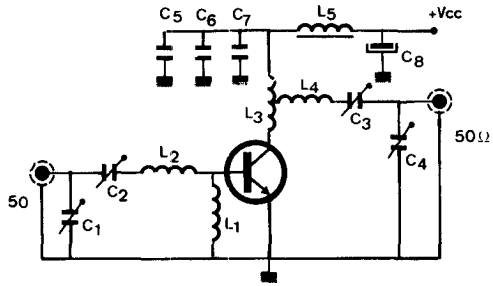
2 N 5591



Power - Temperature Derating Curve



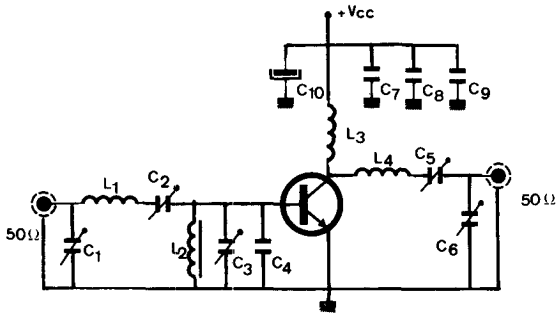
2 N 5589 TEST CIRCUIT



$C_1 = C_2 = C_3 = C_4$ = 3-70 pF trimmer capacitor ARCO 404
C_5 = 1400 pF mica capacitor UNELCO J101
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 47 µF/63 electrolytic

L_1 = 0.15 µH molded coil
L_2 = 3 turns 10/10 mm silvered wire 6 mm I.D.
L_3 = 3 turns 10/10 mm silvered wire 10 mm I.D.
L_4 = 3 turns 10/10 mm silvered wire 6 mm I.D.
L_5 = 2 turns on ferrite core

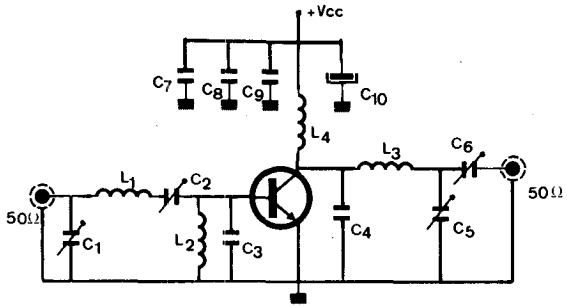
2 N 5590 TEST CIRCUIT



$C_1 = C_2 = C_5 = C_6$ = 7-100 pF trimmer capacitor ARCO 423
C_3 = 4-40 pF trimmer capacitor ARCO 403
C_4 = 100 pF mica capacitor UNELCO J101
C_7 = 1000 pF mica capacitor UNELCO J101
C_8 = 1000 pF ceramic disc
C_9 = 10 nF ceramic disc
C_{10} = 47 µF/63 V electrolytic

$L_1 = L_4$ = 2 turns - 12/10 mm silvered wire - 10 mm I.D.
L_2 = VK 200 - RTC
L_3 = 4 turns - 10/10 mm silvered wire - 10 mm I.D.

2 N 5591 TEST CIRCUIT

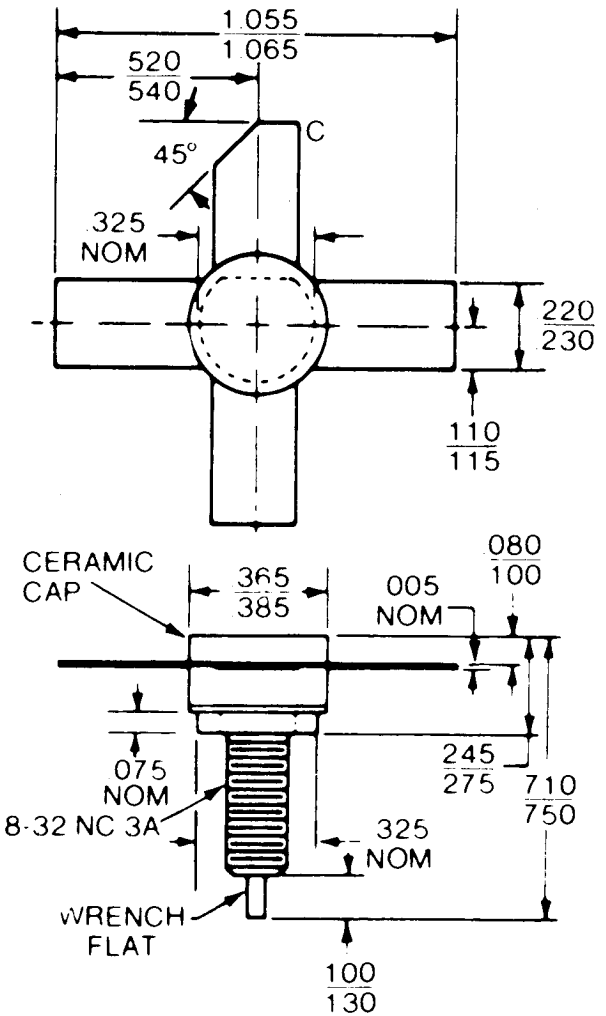


$C_1 = C_2 = C_5 = C_6$ = 7-100 pF trimmer capacitor ARCO 423
C_3 = 150 pF mica capacitor UNELCO J101
C_4 = 100 pF mica capacitor UNELCO J101
C_7 = 1000 pF mica capacitor UNELCO J101
C_8 = 10 nF ceramic disc
C_9 = 0.1 µF ceramic disc
C_{10} = 47 µF/63 V electrolytic

$L_1 = L_4$ = 3 turns 15/10 mm silvered wire 4 mm I.D.
L_2 = 0.47 µF molded coil
L_3 = 2 turns 15/10 mm silvered wire 4 mm I.D.

PACKAGE OUTLINE

.380 SOE



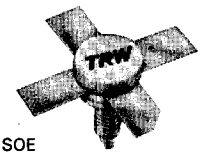
RF Power Transistor

2N 6080 4 W
2N 6081 15 W
2N 6082 25 W
2N 6083 30 W

175 MHz - 12.5 V

The 2 N 6080... series is intented for use in 12.5 volts VHF amplifier applications.

These low cost rugged devices have an excellent performance and can achieve in excess of 40 W with as little as 250 mW drive power.

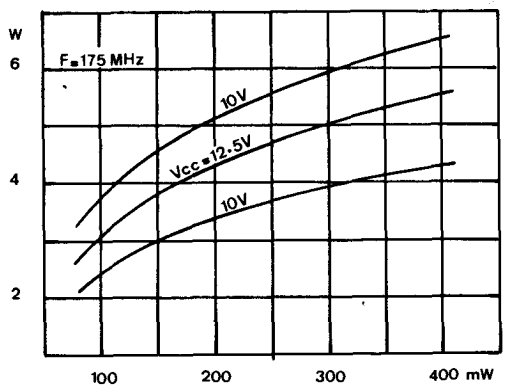


380 SOE

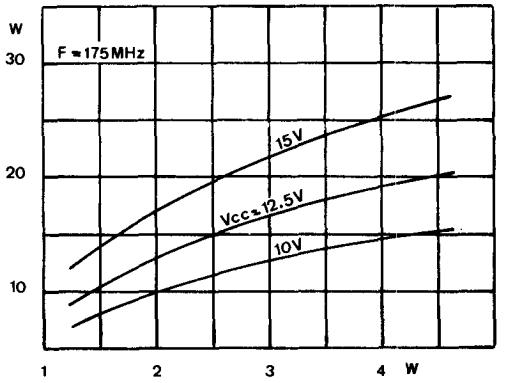
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	2N 6080	2N 6081	2N 6082	2N 6083	UNIT
DC Test	BV_{EBO}	Min. Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0 I_E = 2 mA I_C = 0 I_E = 5 mA I_C = 0 I_E = 10 mA I_C = 0	4	4	4	4	V
	BV_{CEO}	Min. Collector - Emitter Breakdown Voltage	I_C = 10 mA I_B = 0 I_C = 20 mA I_B = 0 I_C = 100 mA I_B = 0	18	18	18	18	V
	BV_{CBO}	Min. Collector - Base Breakdown Voltage	I_C = 5 mA I_E = 0 I_C = 10 mA I_E = 0 I_C = 15 mA I_E = 0 I_C = 20 mA I_E = 0	36	36	36	36	V
	I_{CBO}	Max. Collector Cutoff Current	V_{CB} = 15 V I_E = 0	0.25	0.5	1	1	mA
RF Test	H_{FE}	Min. DC Current Gain	V_{CE} = 5 V I_C = 0.25 A V_{CE} = 5 V I_C = 0.5 A V_{CE} = 5 V I_C = 1 A	5	5	5	5	—
	P_{GAIN}	Min. Power Gain	V_{CE} = 12.5 V P_{in} = 0.25 W F = 175 MHz P_{in} = 3.5 W P_{in} = 6 W P_{in} = 8 W P_{in} = 14 W	4	15	25	30	W
	η	Min. Efficiency	V_{CE} = 12.5 V P_{out} = 4 W F = 175 MHz P_{in} = 15 W P_{in} = 25 W P_{in} = 30 W P_{in} = 40 W	60	50	50	50	%
	C_{OB}	Max. Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz I_E = 0	20	85	130	130	pF
Operating	I_C	Continous Collector Current		1	2.5	5	7	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C	14.5	5.6	3.5	2.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65 °C to + 200 °C				°C
	P_D	Power Dissipation	T_C = 25 °C	12	31	50	70	W

Output Power vs Input Power and Voltage Supply

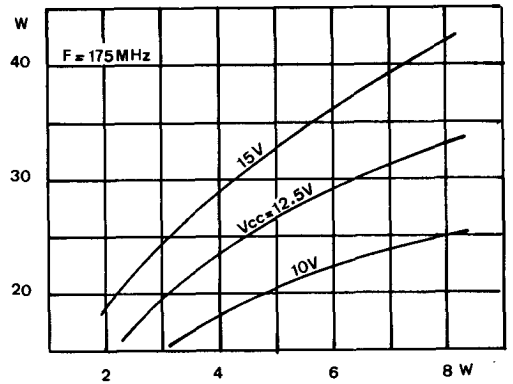
2 N 6080



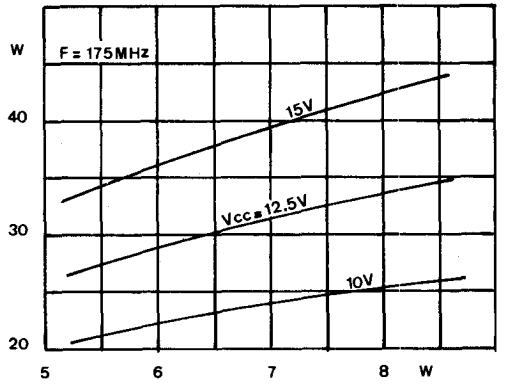
2 N 6081



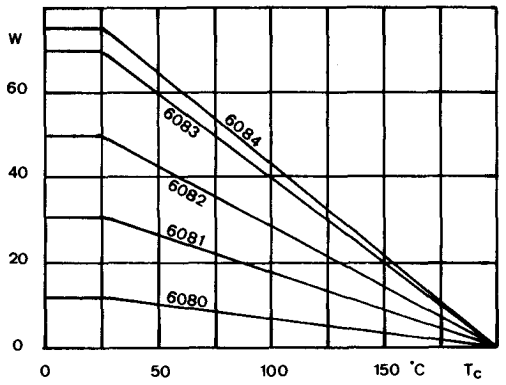
2 N 6082



2 N 6083

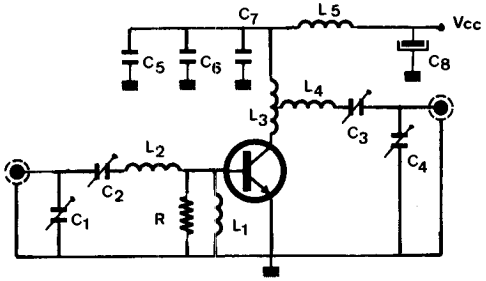


Power - Temperature Derating Curve



175 MHz TEST CIRCUIT

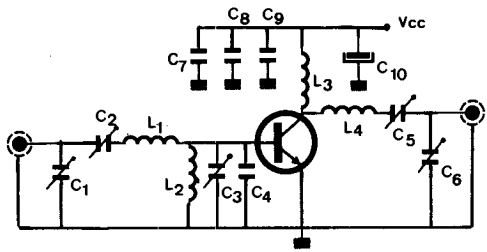
2 N 6080



$C_1 = C_2 = C_3 = C_4$ = 3-60 pF ARCO 404
C_5 = 1000 pF mica capacitor UNELCO J101
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 47 µF/63 V electrolytic

L_1 = 0.15 µH molded coil
L_2 = 3 turns 10/10 mm wire 6 mm I.D. 10 mm length
L_3 = 3 turns 10/10 mm wire 10 mm I.D. 12 mm length
L_4 = 3 turns 10/10 mm wire 6 mm I.D. 10 mm length
L_5 = 2 turns on ferrite core

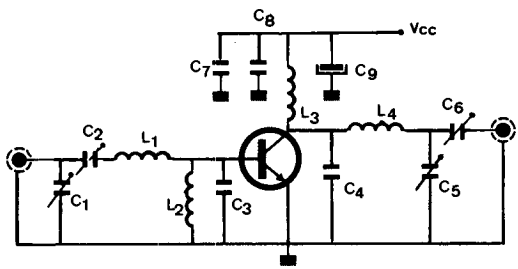
2 N 6081



$C_1 = C_2 = C_5 = C_6$ = 7-100 pF ARCO 423
C_3 = 4-40 pF ARCO 403
C_4 = 100 pF mica capacitor UNELCO J101
C_7 = 1000 pF mica capacitor UNELCO J101
C_8 = 1000 pF ceramic disc
C_9 = 10 nF ceramic disc
C_{10} = 47 µF/63 V electrolytic

$L_1 = L_4$ = 2 turns 12/10 mm wire 10 mm I.D.
L_2 = VK 200 RTC
L_3 = 4 turns 10/10 mm wire 10 mm I.D.

2 N 6082 - 2 N 6083



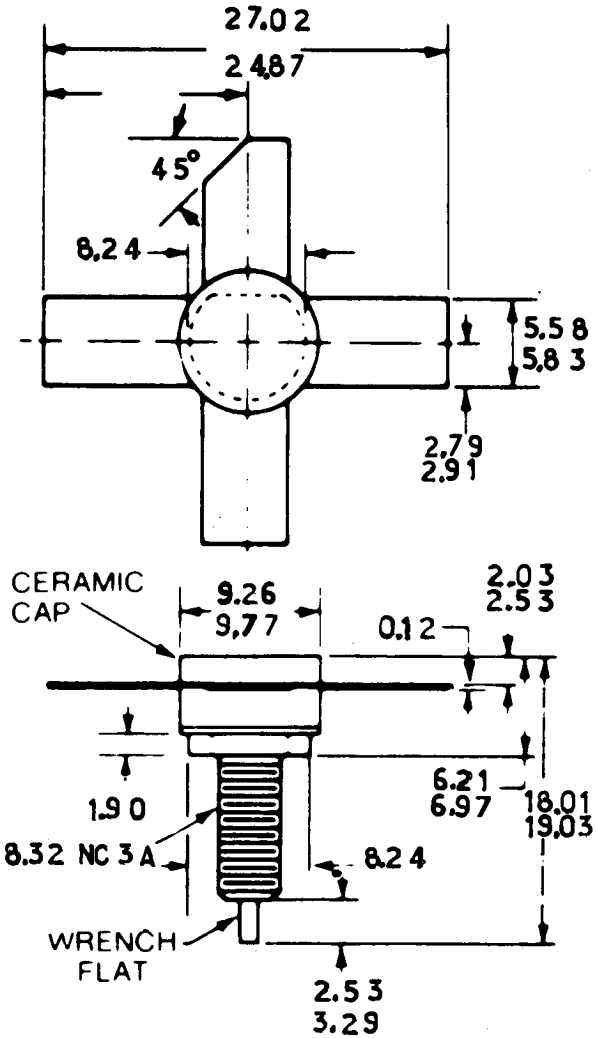
C_1 = 4-40 pF ARCO 403
$C_2 = C_5$ = 7-100 pF ARCO 423
C_3 = 200 pF mica capacitor UNELCO J101
C_4 = 150 pF mica capacitor UNELCO J101
C_6 = 7-200 pF ARCO 425
C_7 = 1000 pF mica capacitor UNELCO J101
C_8 = 0.1 µF ceramic disc
C_9 = 47 µF/63 V electrolytic

L_1 = 3 turns 15/10 mm silvered wire 6 mm I.D.
L_2 = 0.47 µH molded coil
L_3 = 6 turns 10/10 mm enameled wire wound on R_1
L_4 = 1 turn 15/10 mm silvered wire 6 mm I.D.

R_1 = 380 ohms 2 W carbon composition

PACKAGE OUTLINE

.380 SOE



UHF RF Power Transistor

The J-Zero 3020 is designed for UHF broadband applications covering the 450-512MHz frequency band. Designed for land mobile radio systems, it provides excellent gain and is extremely rugged.

20 Watt
450-512MHz
12.5V

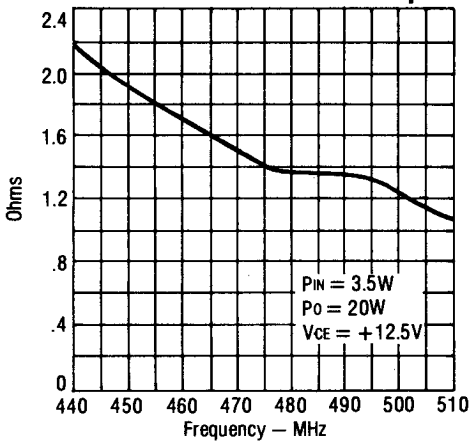


0.5 J-Zero Package

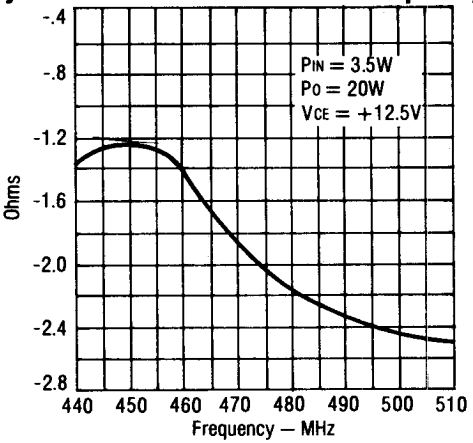
Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CBO}	Collector Base Voltage	I_C = 50mA	36			V
	BV_{CEO}	Collector Emitter Voltage	I_C = 50mA	16			V
	I_{CES}	Collector Emitter Leakage	V_{CE} = 12.5V			10	mA
	BV_{EBO}	Emitter Base Voltage	I_E = 5mA, I_C = 0	4			V
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	20	70	120	
RF TEST	P_{OUT}	Power Output	V_{CE} = 12.5V, f = 470MHz P_{IN} = 3.5W	20			W
	VSWR	Collector Load *Phase angle s varied > 360° during 3-second test	V_{CE} = 15.5V, f = 470MHz P_{IN} = 3.5W	∞:1			
	η	Collector Efficiency	At P_O = 20W		60		%
OPER.	$\theta_{j\text{-}c}$	Thermal Resistance	25°C Case		4.5		°C/W
	$T_{J(MAX)}$	Maximum Junction Temperature				200	°C
	T_{STG}	Storage Temperature		-55		150	°C
	$I_{C(MAX)}$	Maximum Collector Current	T_C = 25°C			3	A
	$P_{D(MAX)}$	Total Dissipation	T_C = 25°C			39	W

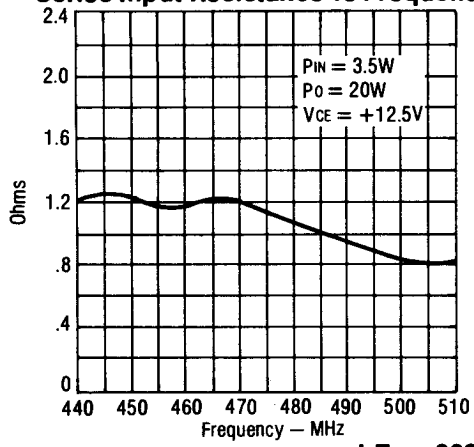
Series Load Resistance vs Frequency



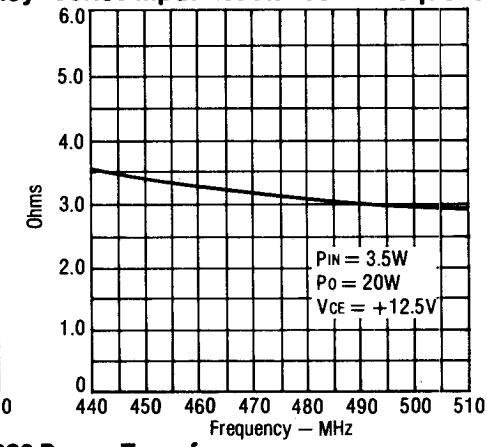
Series Load Reactance vs Frequency



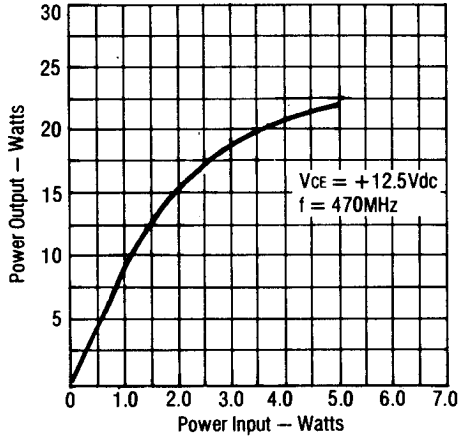
Series Input Resistance vs Frequency



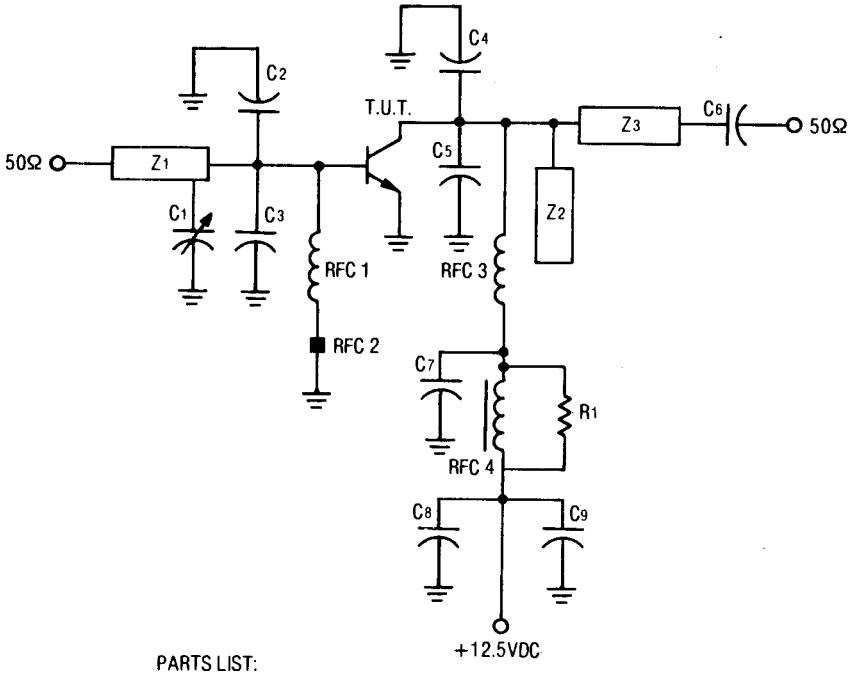
Series Input Reactance vs Frequency



J-Zero 3020 Power Transfer



TEST CIRCUIT



PARTS LIST:

C_1	1-10pf piston trimmer, located 0.4" from device end on Z_1.
$C_{2,4}$	30pf uncased mica capacitor.
C_3	20pf uncased mica capacitor.
C_5	40pf uncased mica capacitor.
C_6	30pf miniature uncased mica capacitor.
C_7	220pf uncased mica capacitor.
C_8	5μf @ 25 volts.
C_9	0.1μfD @ 50 volts disc ceramic.
RFC 1	6 T. #18 AWG., 1/4" dia., 1/2" long.
RFC 2	Ferrite bead.
RFC 3	4 T. #18 AWG., 3/8" dia.; 1/2" long.
RFC 4	3 T. #18 AWG. on 1/2" "H" toroid
R_1	10 ohms @ 1/2 watt.
Z_1	Microstripline, $Z_0 = 30$ ohms, W = 0.37", L = 3.02"
Z_2	Microstripline capacitor, $Z_0 = 24$ ohms, W = 0.46", L = 1.62
Z_3	Microstripline, $Z_0 = 20$ ohms, W = 0.56", L = 2.34"

Board material — 1/16" Teflon-glass

UHF RF Power Transistor

The J03037 is designed for UHF broadband applications covering the 450 - 512MHz frequency band. Designed for land mobile radio systems, it provides excellent gain and is extremely rugged.

37 Watts
450 - 512MHz
12.5 Volts



.500 J Zero

Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP	MAX	UNIT
DC TEST	BV_{CBO}	Collector-Base Voltage	I_C = 50mA	36			V
	BV_{CEO}	Collector-Emitter Voltage	I_C = 50mA	16			V
	BV_{EBO}	Emitter-Base Voltage	I_E = 5mA, I_C = 0	4			V
	I_{CES}	Collector Emitter Leakage	V_{CE} = +12.5Vdc		10		mA
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	20	70	120	
RF TEST	P_{OUT}	Power Output	V_{CE} = +12.5V, f = 470MHz P_{IN} = 12W	37			W
	VSWR	Collector Load	V_{CE} = +15.5V, f = 470MHz P_{IN} = 12W	∞:1			
		*Phase Angle	S varied > 360 degrees during 3 second test				
	η	Collector Efficiency	P_O = 37W, f = 470MHz		60		%
THERMAL	θ_{jc}	Thermal Resistance	25 deg C case		2.1		°C/W
	T_j Max	Maximum Junction Temperature				200	°C
	T_{stg}	Storage Temperature		-55		+150	°C
	$I_{C(MAX)}$	Maximum Collector Current	T_C = 25°C			5	A
	$P_{D(MAX)}$	Total Dissipation	T_C = 25°C			83	W

UHF RF Power Transistor

The J-Zero 3055 is designed for UHF broadband applications covering the 450-512MHz frquency band. Designed for land mobile radio systems, it provides excellent gain and is extremely rugged.

55 Watt
450-512MHz
12.5V

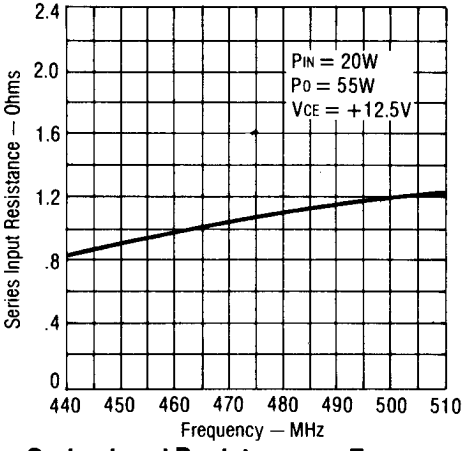


0.5 J-Zero Package

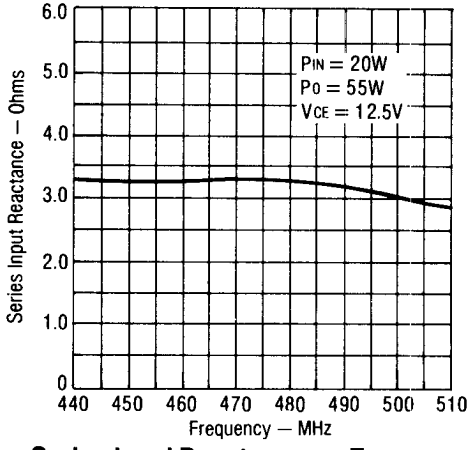
Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{CBO}	Collector Base Voltage	I_C = 50mA	36			V
	BV_{CEO}	Collector Emitter Voltage	I_C = 50mA	16			V
	I_{CES}	Collector Emitter Leakage	V_{CE} = 12.5V			20	mA
	BV_{EBO}	Emitter Base Voltage	I_E = 5mA, I_C = 0	4			V
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	20	70	120	
RF TEST	P_{OUT}	Power Output	V_{CE} = 12.5V, f = 470MHz P_{IN} = 20W	55			W
	VSWR	Collector Load *Phase angle s varied > 360° during 3-second test	V_{CE} = 15.5V, f = 470MHz P_{IN} = 20W	∞:1			
	η	Collector Efficiency	At P_O = 55W		60		%
DPER.	θ_{j-C}	Thermal Resistance	25°C Case		1.75		°C/W
	$T_{J(MAX)}$	Maximum Junction Temperature				200	°C
	T_{STG}	Storage Temperature		-55		150	°C
	$I_{C(MAX)}$	Maximum Collector Current	T_C = 25°C			8	A
	$P_{D(MAX)}$	Total Dissipation	T_C = 25°C			100	W

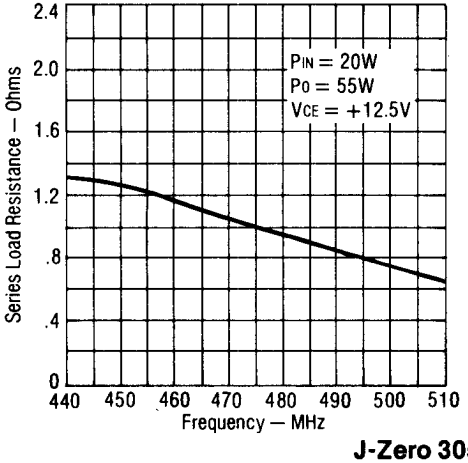
Series Input Resistance vs Frequency



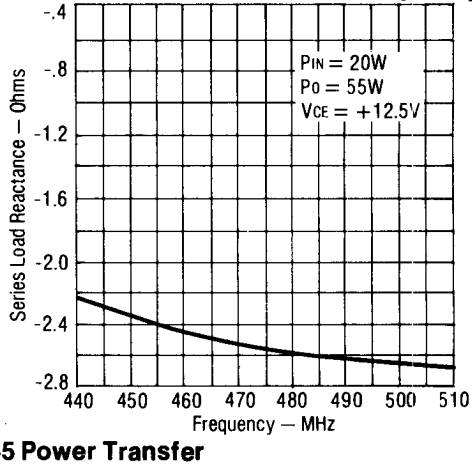
Series Input Reactance vs Frequency



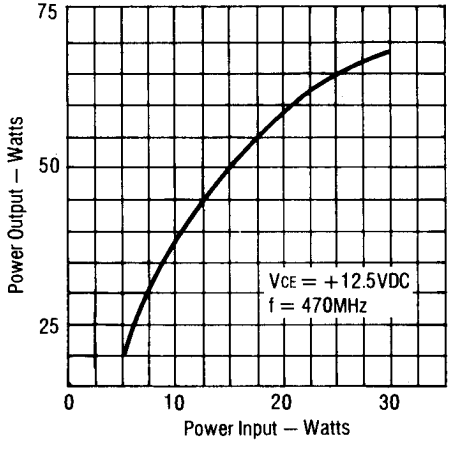
Series Load Resistance vs Frequency



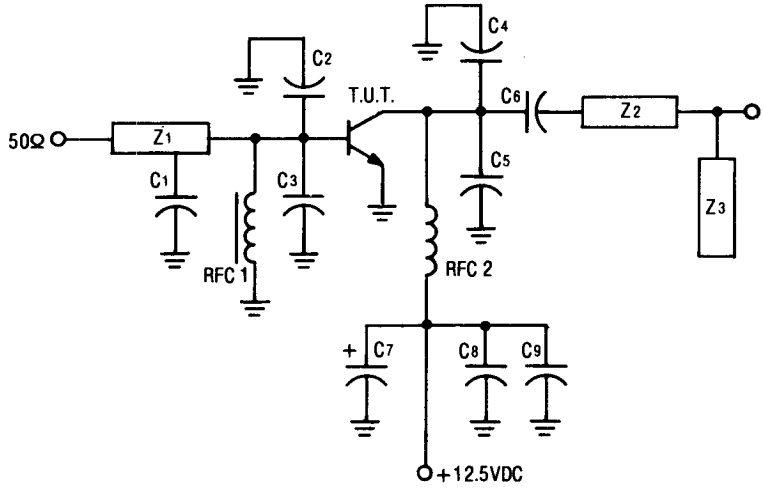
Series Load Reactance vs Frequency



J-Zero 3055 Power Transfer



TEST CIRCUIT



PARTS LIST:

C_1	1-10pf piston trimmer located 1.0" from device end on Z_1.
$C_{2,3,4,5}$	33pf uncased mica capacitor.
C_6	39pf uncased mica capacitor.
C_7	5μf @ 25 volts.
C_8	220pf uncased mica capacitor.
C_9	0.1μfD @ 50 volts disc ceramic.
RFC 1	VK200 choke
RFC 2	5 T. #18 AWG., 1/4" dia., 1/2" long.
Z_1	Microstripline, Z_0 = 45 ohms, W = 0.15", L = 2.05".
Z_2	Microstripline, Z_0 = 22 ohms, W = 0.425", L = 3.2".
Z_3	Microstripline Capacitor, Z_0 = 28 ohms, W = 0.25", L = 0.55".

Board material — 1/16" epoxy-glass.

RF Power Transistors

The JO 4045 utilizes internal impedance matching and is intended for land mobile applications with typical vehicular power supplies and operating over the 136-175MHz frequency range. The combination of diffused silicon ballasting, gold metalization, and low thermal resistance provide high reliability at low cost.

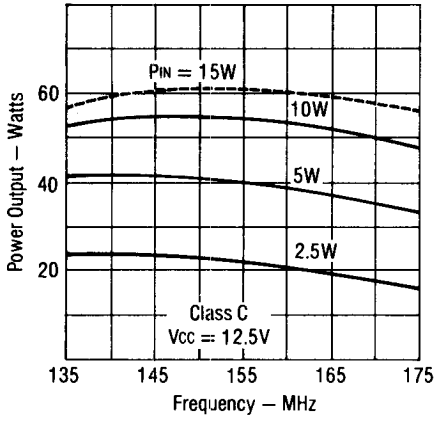
JO 4045 — 45 W
175MHz - 12.5V



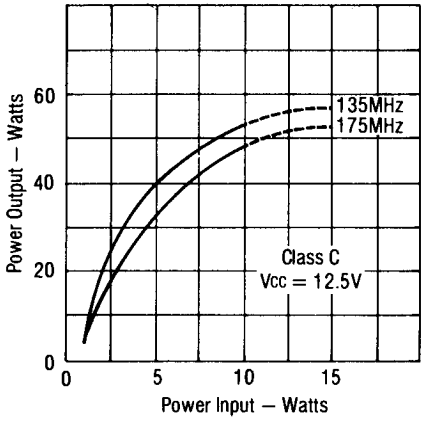
.500 J Zero

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP	MAX	UNIT
DC TEST	BV_{CES}	Collector-Emitter Breakdown Voltage	I_C = 50mA	36			Vdc
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_C = 5mA	4			Vdc
	I_{CES}	Collector Cutoff Current	V_{CE} = 15V			5	mAdc
	h_{FE}	DC Current Gain	V_{CE} = 5V, I_C = 1A	10		150	—
RF TEST	P_{OUT}	Power Output	V_{CE} = 12.5V, f = 175MHz P_{IN} = 10W	45			W
	P_{REF}	Power Reflected	V_{CE} = 12.5V, f = 175MHz P_{IN} = 10W			1.0	W
	Load VSWR	Load Mismatch Tolerance	V_{CE} = 15.5V, f = 175MHz P_{IN} = 10W	∞:1			VSWR
OPER.	$I_{C(MAX)}$	Collector Current	T_C = 25°C			6.5	A
	$P_{D(MAX)}$	Total Dissipation	T_C = 25°C			100	W
	T_{STG}	Operating and Storage Temperature		-65		150	°C
	$T_{J(MAX)}$	Junction Temperature			200		°C
	θ_{JC}	Thermal Resistance			1.75		°C/W

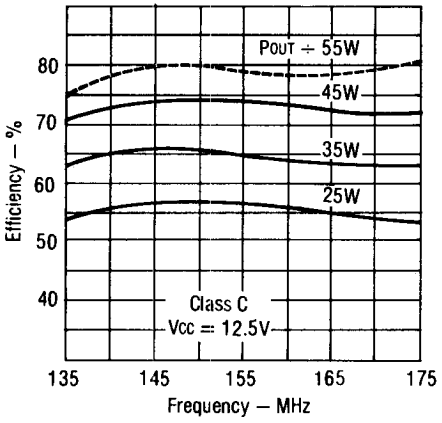
Broadband P(OUT) vs. Frequency



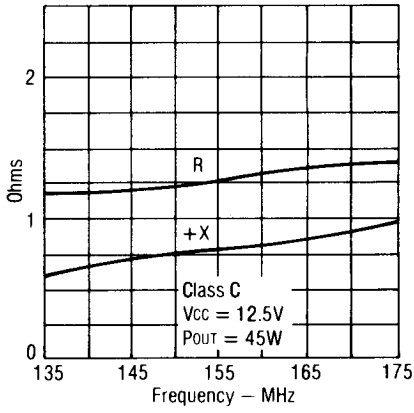
Broadband Power Transfer



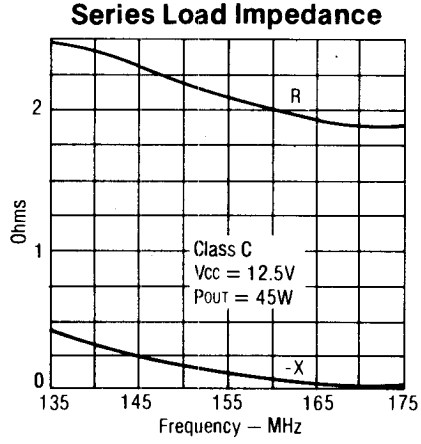
Broadband Collector Efficiency



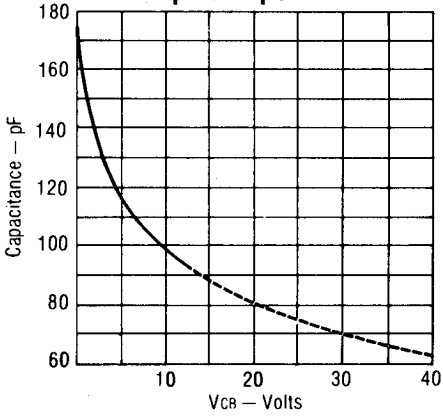
Series Input Impedance



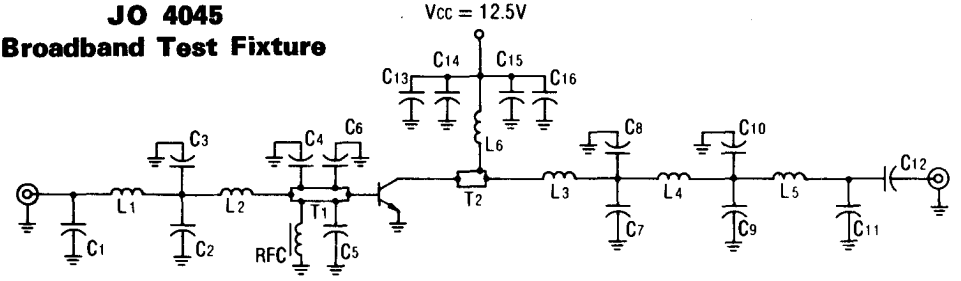
Series Load Impedance



Output Capacitance



JO 4045
Broadband Test Fixture

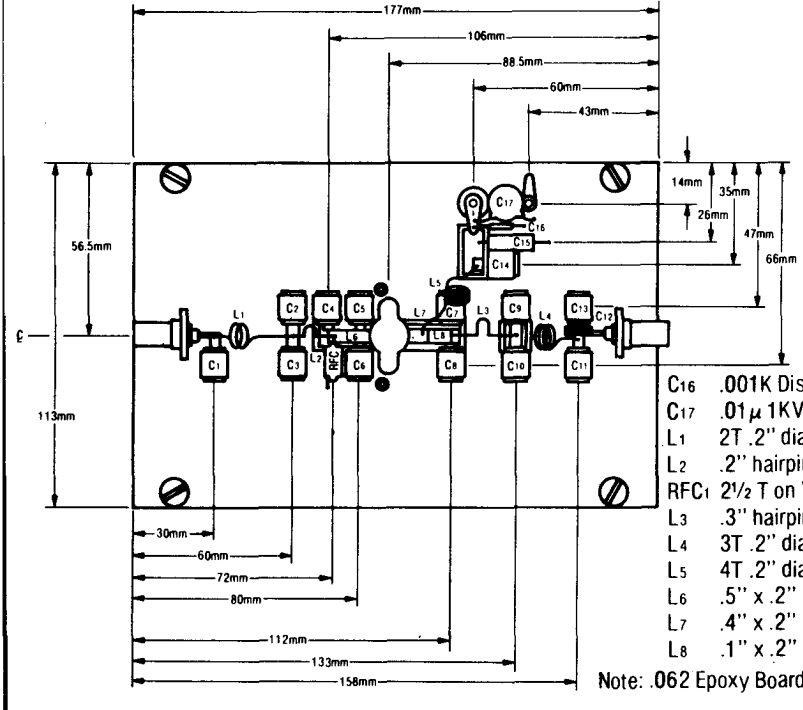


COMPONENTS LIST:

$C_{1,2}$	25pf
$C_{3,4}$	80pf
C_5	250pf
C_6	200pf
C_7	150pf
C_8	100pf
$C_{9,10}$	40pf
C_{11}	25pf
$C_{12,13}$	1000pf
C_{14}	.001μf
C_{15}	.01μf
C_{16}	25μf
L_1	2T 18 AWG .2" dia.
L_2	.2" hairpin .125" wide x .025 thick copper strip
L_3	.1" x .2" wide x .005" thick copper loop
L_4	.3" hairpin 18 AWG.
L_5	3 T. 18 AWG. .2" dia.
L_6	4 T. 18 AWG. .2" dia.
RFC	2½ T. on VK-211-07/38 ferrox cube
T_1	.2" width .5" length from package as ref.
T_2	.2" width .4" length from package as ref.

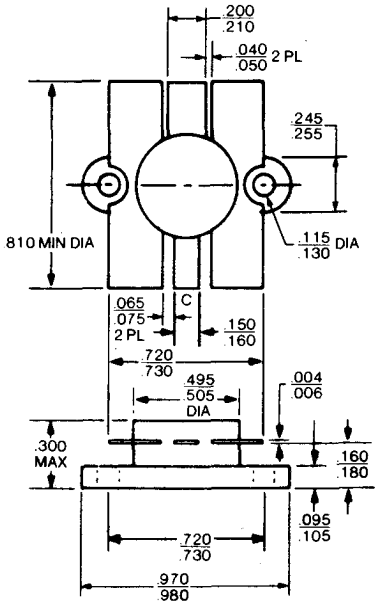
NOTES:

1. All capacitors in signal path are Underwood Electric Corp. Case Type J101.
2. Position C_5 and C_6 as close to pkg. as possible.



C_1	25pf
$C_{2,4}$	80pf
C_3	30pf
C_5	250pf
C_6	200pf
C_7	150pf
C_8	100pf
$C_{9,10}$	40pf
C_{11}	10pf
$C_{12,14}$	1000pf
C_{13}	15pf
C_{15}	5μf 25V
C_{16}	.001K Disc
C_{17}	.01μ 1KV Disc
L_1	2T .2" dia. 18 AWG .250" long
L_2	.2" hairpin .125" wide x .025 thick
RFC_1	2½ T on VK-211-07/3B ferrox cube
L_3	.3" hairpin #18 AWG
L_4	3T .2" dia. #10 AWG .500" long
L_5	4T .2" dia. #18 AWG .400 long
L_6	.5" x .2"
L_7	.4" x .2"
L_8	.1" x .2" wide x .005" thick

Note: .062 Epoxy Board Copper Clad -- 2 Sides


.200
.210
.040
.050 2 PL
.245
.255
.810 MIN DIA
.115
.130 DIA
.065
.075
2 PL
C
.150
.160
.720
.730
.495
.505
DIA
.004
.006
.300
MAX
.160
.180
.095
.105
.720
.730
.970
.980

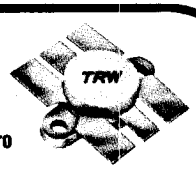
.500 J ZERO

VHF Power Transistor

- High gain, high efficiency, full band coverage
- Diffused silicon ballast resistors
- Passivated gold metalization

The JO4070 transistor is intended for land-mobile applications operating over the 136-175MHz frequency range with typical vehicular power supplies. The combination of diffused silicon ballasting, gold metalization and low thermal resistance provide high reliability at low cost.

136-175MHz
70 Watts
∞ VSWR at Full Rated Power,
15.5V

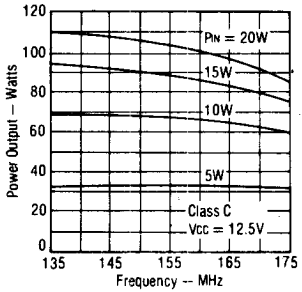


.500 J Zero

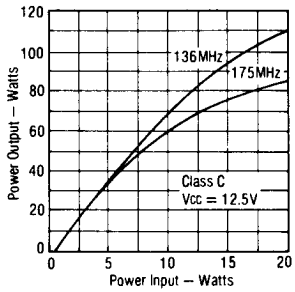
Electrical Characteristics (T_{FLANGE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX	UNIT
DC TEST	BV_{CBO}	Collector-Base Voltage	I_C = 50mA, I_E = 0	36			V
	BV_{CEO}	Collector-Emitter Voltage	I_C = 50mA, I_B = 0	16			V
	BV_{EBO}	Emitter-Base Voltage	I_E = 10mA, I_C = 0	4			V
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	10	80	200	
	I_{CES}	Collector-Emitter Leakage	V_{CE} = 15V			10	mA
RF TEST	P_{OUT}	Power Output	V_{CE} = 12.5V, f = 175MHz, P_{IN} = 18W	70	80		W
	P_{OUT}	Power Output	V_{CE} = 12.5V, f = 175MHz, P_{IN} = 15W		65		W
	$VSWR_L$	Load Mismatch Tolerance*	V_{CE} = 15.5V, f = 175MHz, P_{IN} = 18W	20:1			
OPER.	$P_{IN(MAX)}$	Maximum RF Input				25	W
	$P_{D(MAX)}$	Maximum Total Dissipation				233	W
	$V_{CC(MAX)}$	Collector Supply Voltage				16	V
	$I_{C(MAX)}$	Maximum Collector Current				17.5	A
	$T_{j(MAX)}$	Maximum Junction Temperature				+200	°C
	T_{STG}	Operating & Storage Temperature Range		-55		+150	°C
	θ_{J-F}	Thermal Resistance				0.75	°C/W

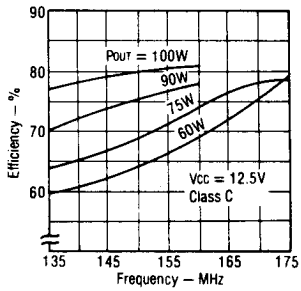
BROADBAND POUT VS. FREQUENCY



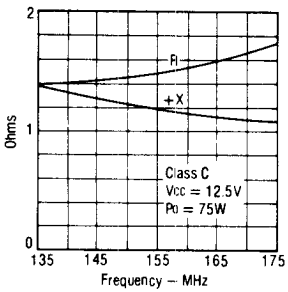
BROADBAND POWER TRANSFER



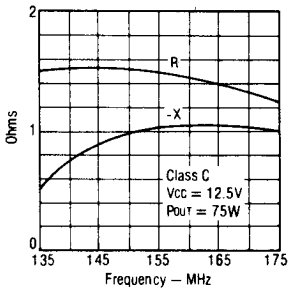
BROADBAND COLLECTOR EFFICIENCY



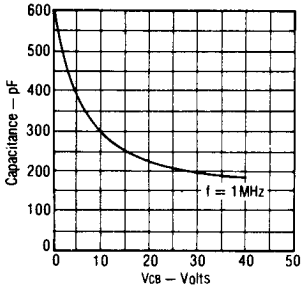
SERIES INPUT IMPEDANCE



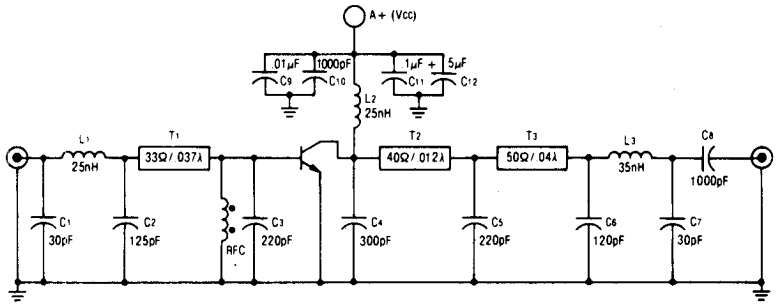
SERIES LOAD IMPEDANCE



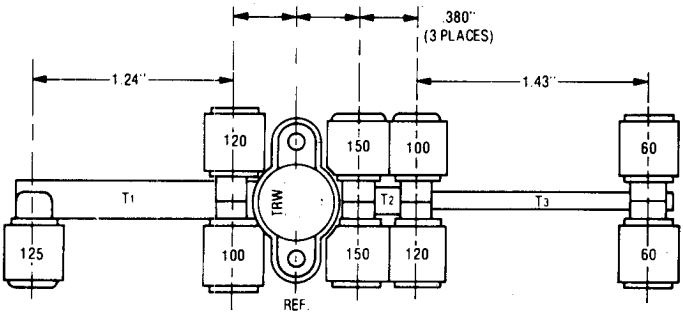
OUTPUT CAPACITANCE



BROADBAND TEST FIXTURE



LAYOUT OF CRITICAL SECTIONS



NOTES

1. All capacitors in signal path are Underwood Electric Corp., Case Type J101
2. L1: 3T, #16, 0.16 I.D., 0.25" Spacing
3. L2: 3T, #16, 0.16 I.D., 0.125" Spacing
4. L3: 4T, #16, 0.16 I.D., 0.125" Spacing
5. RFC: 2½T, #22 on Ferroxcube VK211-07/3B Bead
6. G10 P.C. Board, 1/16" Thick. Double Clad with 2 oz. Copper
7. Locate Metalized Thru-holes at all Shunt Capacitors
8. T1: 0.23" W, 1.75" L from REF. (33Ω, .037λ)
9. T2: 0.170" W, 0.85" L from REF. (40Ω, .012λ)
10. T3: 0.115"W, 1.5" L from T2 (50Ω, .04λ)
11. fREF = 155MHz

VHF Power Transistor

- High gain, high efficiency, full band coverage
- Diffused silicon ballast resistors
- Passivated gold metalization

The J04075 transistor is intended for land-mobile applications operating over the 136-175MHz frequency range with typical vehicular power supplies. The combination of diffused silicon ballasting, gold metalization and low thermal resistance provide high reliability at low cost.

136-175MHz
75 Watts
∞ VSWR at Full Rated Power, 15.5V

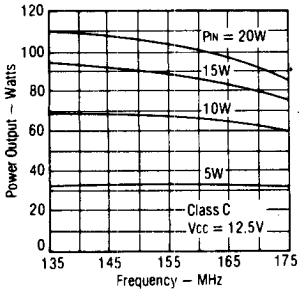


.500 J Zero

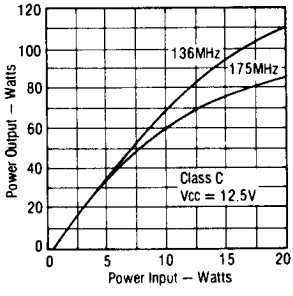
Electrical Characteristics (T_{FLANGE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX	UNIT
DC TEST	BV_{CBO}	Collector-Base Voltage	I_C = 50mA, I_E = 0	36			V
	BV_{CEO}	Collector-Emitter Voltage	I_C = 50mA, I_B = 0	16			V
	BV_{EBO}	Emitter-Base Voltage	I_E = 10mA, I_C = 0	4			V
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	10	80	200	
	I_{CES}	Collector-Emitter Leakage	V_{CE} = 15V			10	mA
RF TEST	P_{OUT}	Power Output	V_{CE} = 12.5V, f = 175MHz, P_{IN} = 18W	75	82		W
	P_{OUT}	Power Output	V_{CE} = 12.5V, f = 175MHz, P_{IN} = 15W		75		W
	$VSWR_L$	Load Mismatch Tolerance*	V_{CE} = 15.5V, f = 175MHz, P_{IN} = 18W	20:1			
OPER.	$P_{IN(MAX)}$	Maximum RF Input				25	W
	$P_{D(MAX)}$	Maximum Total Dissipation				233	W
	$V_{CC(MAX)}$	Collector Supply Voltage				16	V
	$I_{C(MAX)}$	Maximum Collector Current				17.5	A
	$T_{J(MAX)}$	Maximum Junction Temperature				+200	°C
	T_{STG}	Dperating & Storage Temperature Range		-55		+150	°C
	θ_{J-F}	Thermal Resistance				0.75	°C/W

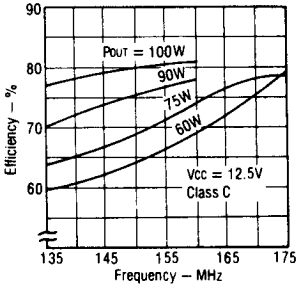
BROADBAND POUT VS. FREQUENCY



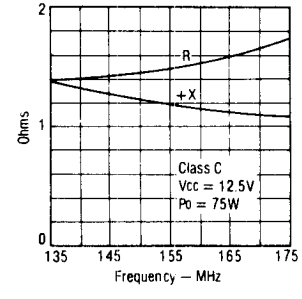
BROADBAND POWER TRANSFER



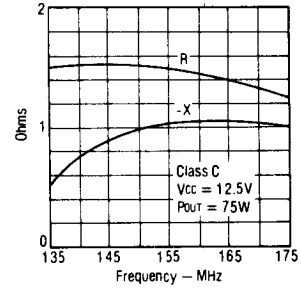
BROADBAND COLLECTOR EFFICIENCY



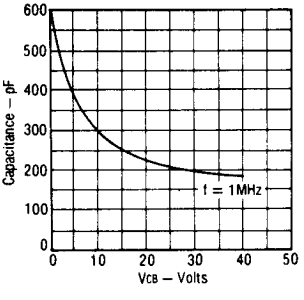
SERIES INPUT IMPEDANCE



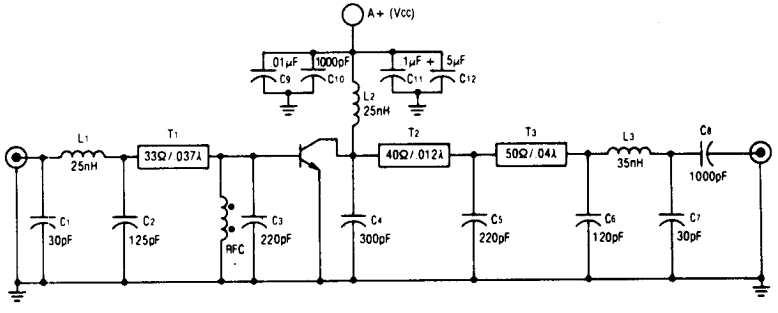
SERIES LOAD IMPEDANCE



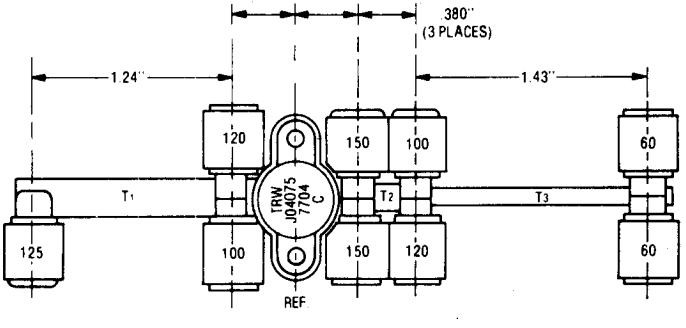
OUTPUT CAPACITANCE



BROADBAND TEST FIXTURE



LAYOUT OF CRITICAL SECTIONS



NOTES

1. All capacitors in signal path are Underwood Electric Corp., Case Type J101
2. L1: 3T, #16, 0.16 I.D., 0.25" Spacing
3. L2: 3T, #16, 0.16 I.D., 0.125" Spacing
4. L3: 4T, #16, 0.16 I.D., 0.125" Spacing
5. RFC: 2½T, #22 on Ferroxcube VK211-07/3B Bead
6. G10 P.C. Board, 1/16" Thick, Double Clad with 2 oz. Copper
7. Locate Metalized Thru-holes at all Shunt Capacitors
8. T1: 0.23" W, 1.75" L from REF. (33Ω, .037λ)
9. T2: 0.170" W, 0.85" L from REF. (40Ω, .012λ)
10. T3: 0.115"W, 1.5" L from T2 (50Ω, .04λ)
11. f_{REF} = 155MHz

- ∞ VSWR at Full Rated Power, 15.5V
- High Gain, High Efficiency, Full Band Coverage
- Diffused Silicon Ballast Resistors
- Passivated Gold Metalization

INTENDED APPLICATIONS

The J-Zero 4080 transistor is intended for land-mobile applications operating over the 136-175MHz frequency range with typical vehicular power supplies. The combination of diffused silicon ballasting, gold metalization and low thermal resistance provide high reliability at low cost.

80 Watt
150MHz
7.3dB Gain
13.5V



.500 J-Zero

Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 5mA, I_C = 0	4			V
	BV_{CED}	Collector-Emitter Breakdown Voltage	I_C = 50mA, I_B = 0	18			V
	BV_{CBD}	Collector-Base Breakdown Voltage	I_C = 50mA, I_E = 0	36			V
	I_{CES}	Collector Cutoff Current	V_{CE} = 15V, I_B = 0	5			mA
	h_{FE}	D.C. Current Gain	V_{CE} = 5V, I_C = 1A	10			–
RF TEST	P_{GAIN}	Power Gain	V_{CE} = 13.5V, f = 150MHz P_{IN} = 15W	80	88		W
	η	Efficiency	V_{CE} = 13.5V, f = 150MHz P_{IN} = 15W	60			%
	Load VSWR	Mismatch Tolerance	V_{CE} = 15.5V, f = 150MHz P_{IN} = 15W	∞:1			
	Z_{IN}	Common Emitter Amplifier Input Impedance	V_{CE} = 13.5V, f = 150MHz P_{IN} = 15W		0.35 +j 1.1		Ω
	Z_{LOAD}	Common Emitter Amplifier Load Impedance	V_{CE} = 13.5V, f = 150MHz P_{OUT} = 85W		1.1 -j 0.83		Ω
	C_{OB}	Collector-Base Capacitance	V_{CB} = 15V, f = 1MHz		250		pF
THERMAL	I_C	Continuous Collector Current				17	A
	$\theta_{j\text{-}C}$	Thermal Resistance	T_C = 25°C		1.25		°C/W
	T_{STG}	Storage Temperature		-65		150	°C
	P_D	Power Dissipation	T_C = 25°C			230	W

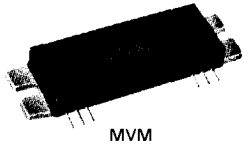
RF Power Module

68 - 88 MHz

20 W - 12,5 V

The ML modules are rugged power amplifier functions designed for battery powered mobile and marine applications in the 68-88 MHz band. The modules feature 50 Ω input and output impedances, highly repeatable broadband gain, and will withstand infinite load VSWR at 16 volts with overdrive and uncontrolled output power.

Compared to discrete components, these modules offer significant savings in size as well as cost of design, production and repair.

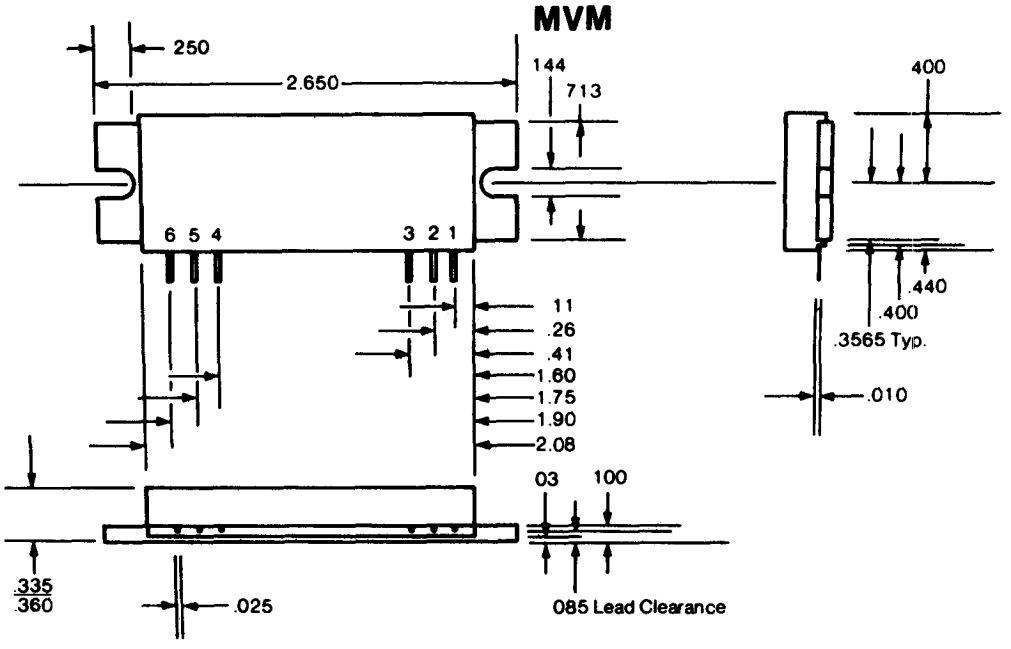


MVM

SPECIFICATIONS (T_{flange} = 25 °C, unless otherwise noted)

Characteristic	Test Conditions	ML 20	Units/Limit
Frequency Range		68-88	MHz
Supply Voltage, V_{CC}		12.5	Vdc, Nom.
Power Output	Rated V_{CC} Any In-Band Frequency $P_{in} \leq$ 0.15 watts	20	W, Min.
Efficiency	Rated P_o, V_{CC}	40	%, Min.
Harmonic Outputs	Rated P_o, V_{CC}	— 30	dB, Max.
Input Return Loss	Z_o = 50 Ω	— 10	dB, Max.
Output Impedance		50	Ω, Nom.
Quiescent Current	V_{CC} = 16 V, P_{in} = 0 W	0.1	Adc, Max.
Power Slump	Rated P_o, V_{CC} 25 °C — 30 °C to + 80 °C	1	dB, Max.
Load VSWR, 0-360° (Degradation)	V_{CC} = 16 V, P_{in} = 0.3 W Lowest Frequency	50 : 1	No Degradation
Load VSWR, 0-360° (Stability)	10 V $\leq V_{CC} \leq$ 16 V 0 < $P_{in} \leq$ 0.3 W Any In-Band Frequency	3 : 1	Min. Typ.
Temperature Range	Operating, T_{FLANGE}	— 30 + 100	°C Min. °C Max.

PACKAGE OUTLINE

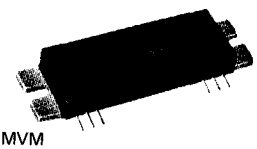


RF Power Modules

140 - 175 MHz
∞ VSWR @ 16 V

The MV modules are rugged power amplifier functions designed for battery powered mobile and marine applications in the 140-175 MHz band. The modules feature 50 Ω input and output impedances, highly repeatable broadband gain, and will withstand infinite load VSWR at 16 volts with overdrive and uncontrolled output power (typically more than 40 watts).

Compared to discrete components, these modules offer significant savings in size as well as cost of design, production and repair.

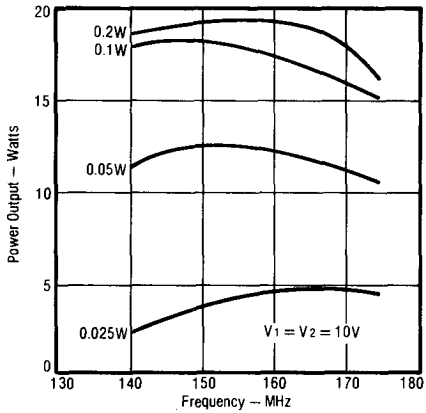


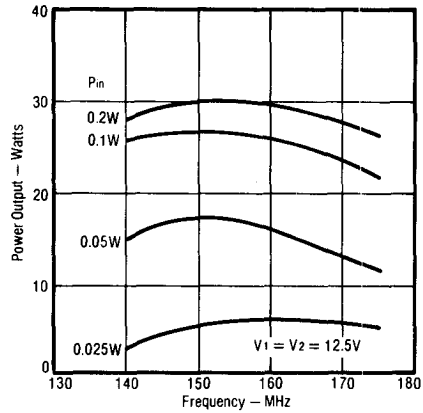
MVM

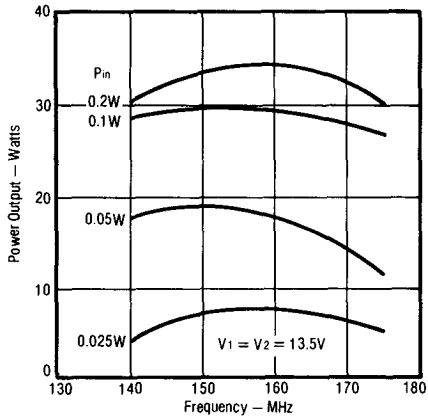
Electrical Characteristics (T_{flange} = 25 °C)

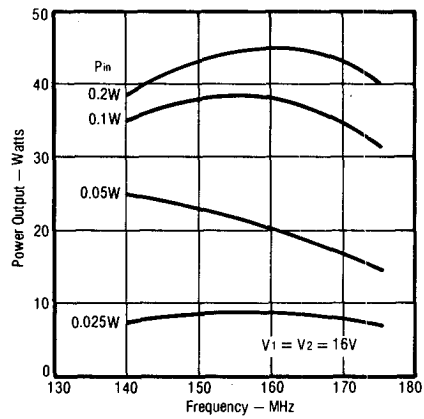
Characteristic	Test Conditions	MV20	MV30	Units/Limit
Frequency Range		140-175	150-160	MHz
Supply Voltage, V_{CC}		12.5	13.5	Vdc, Nom.
Power Output	Rated V_{CC} Any In-Band Frequency $P_{in} \leq 0.2$ Watts	20	30	W, Min.
Efficiency	Rated P_o, V_{CC}	40	50	%, Min.
Harmonic Outputs	Rated P_o, V_{CC}	— 35	— 40	dB, Max.
Input Return Loss	Z_o = 50 Ω	— 10	— 10	dB, Max.
Output Impedance		50	50	Ω, Nom.
Quiescent Current	V_{CC} = 16 V, P_{in} = 0 W	0.1	0.1	Adc, Max.
Power Slump	Rated P_o, V_{CC} 25 °C — 30 °C to + 80 °C	1.0	1.0	dB, Max.
Load VSWR, 0-360° (Degradation)	V_{CC} = 16 V, P_{in} = 0.3 W Lowest Frequency	20 : 1	20 : 1	No Degradation
Load VSWR, 0-360° (Stability)	10 V $\leq V_{CC} \leq$ 16 V 0 < $P_{in} \leq$ 0.3 W Any In-Band Frequency	3 : 1 5 : 1	3 : 1 5 : 1	Min. Typ.
Temperature Range	Operating, T_{FLANGE}	— 30 + 100	— 30 + 100	°C Min. °C Max.

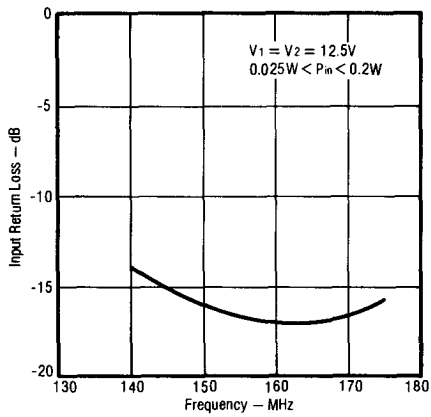
TYPICAL CHARACTERISTICS

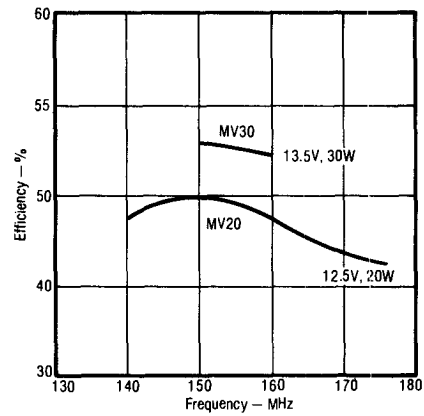


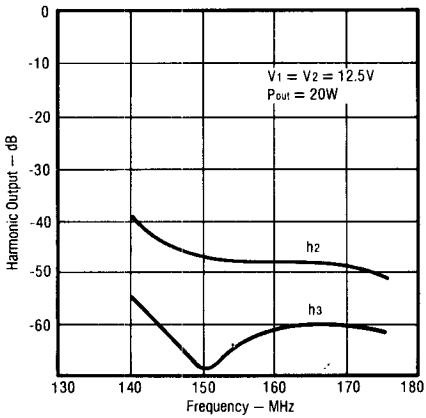


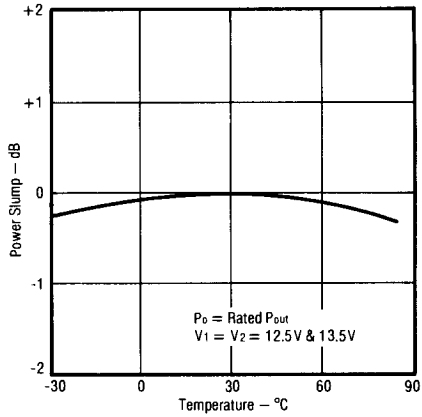


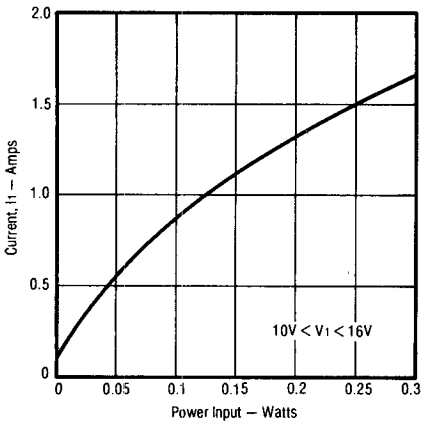


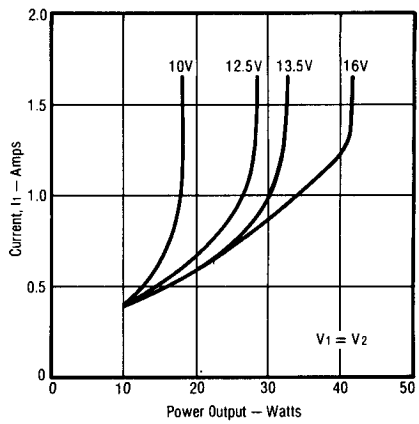


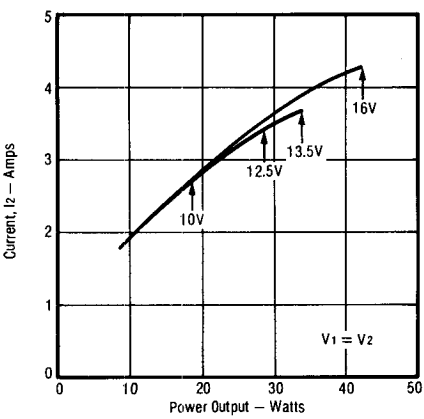


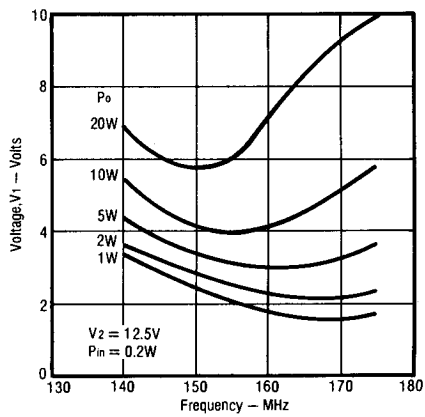

Harmonic Output – dB
0
-10
-20
-30
-40
-50
-60
$V_1 = V_2 = 12.5V$
$P_{out} = 20W$
h2
h3
130
140
150
160
170
180
Frequency – MHz


Power Slump – dB
+2
+1
0
-1
-2
P_o = Rated P_{out}
$V_1 = V_2$ = 12.5V & 13.5V
-30
0
30
60
90
Temperature – °C

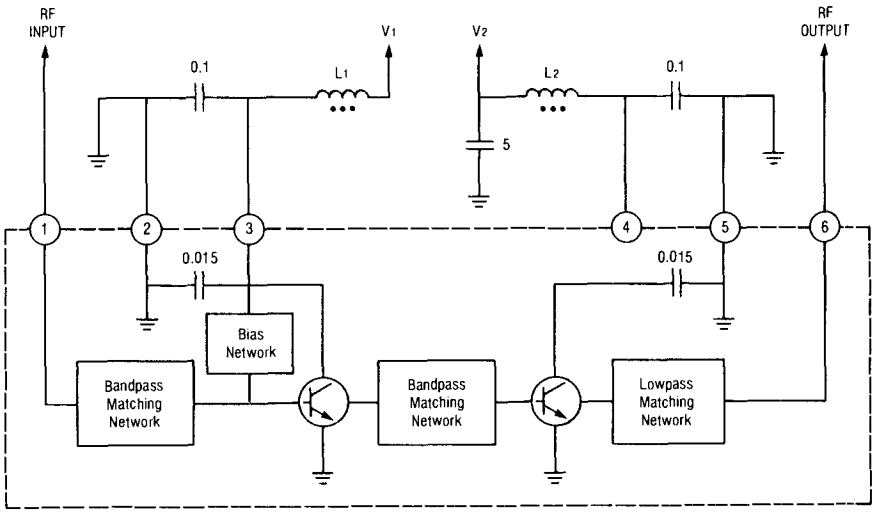

Current, I_1 – Amps
2.0
1.5
1.0
0.5
0
10V < V_1 < 16V
0
0.05
0.1
0.15
0.2
0.25
0.3
Power Input – Watts


Current, I_1 – Amps
2.0
1.5
1.0
0.5
0
10V
12.5V
13.5V
16V
$V_1 = V_2$
0
10
20
30
40
50
Power Output – Watts


Current, I_2 – Amps
5
4
3
2
1
0
16V
13.5V
12.5V
10V
$V_1 = V_2$
0
10
20
30
40
50
Power Output – Watts

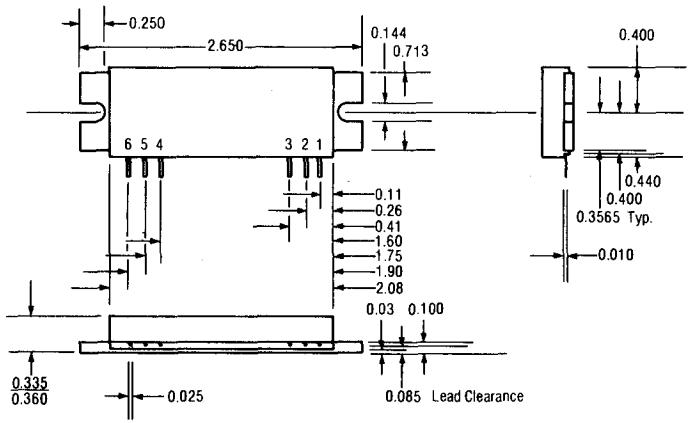

Voltage, V_1 – Volts
10
8
6
4
2
0
P_o
20W
10W
5W
2W
1W
V_2 = 12.5V
P_{in} = 0.2W
130
140
150
160
170
180
Frequency – MHz

CIRCUIT DIAGRAM FOR MV 20 AND MV 30



L1, L2: Ferroxcube VK211173B, 2½ turns
All capacitor values in μF

MVM PACKAGE OUTLINE



RF Power Modules

TRW's MX modules are rugged power amplifier functions designed for 12 volt broadband UHF applications. The modules feature 50 Ω input and output impedances, broadband gain, and can withstand infinite VSWR at 14 volts. They are stable under all operating conditions and provide excellent harmonic rejection. Using simple and inexpensive external circuitry, the modules also feature gain control capability, providing insensitivity to severe overdrive, surge voltages, and excessive currents induced by high VSWR levels.

Compared to discrete components, these modules offer significant savings in size as well as in design, production, and repair costs.

POWER OUTPUT
16 W ∞ VSWR



MXM

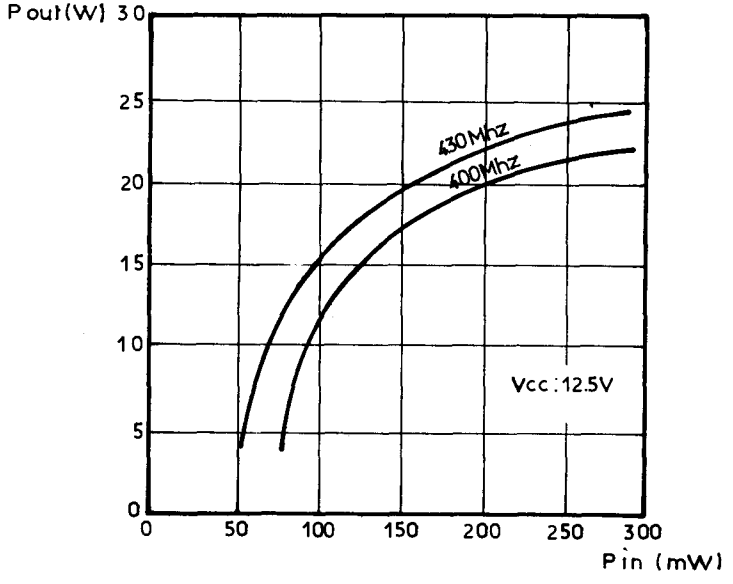
Electrical Characteristics (T_{flange} = 25 °C)

Characteristics	Test Conditions	MX 7.5	MX 12	MX 15	Unit
Frequency Ranges	-1 -3 -4	400-430 430-470 470-512	400-430 430-470 470-512	400-430 430-470 —	MHz
Supply Voltage		12.5	12.5	12.5	Vdc nominal
Power Gain	$P_{in} \leqslant$ 125 mW $P_{in} \leqslant$ 150 mW $P_{in} \leqslant$ 200 mW	7.5	12	15	W
Efficiency	Rated P_0	33	35	35	% min.
Harmonic Content	Rated P_0	— 30	— 30	— 30	dB min.
Load VSWR	14 V, 10 W, low frequency 14 V, 14 W, low frequency 14 V, 16 W, low frequency	∞ : 1	∞ : 1	∞ : 1	
Power Derating	— 30 °C to + 70 °C	2	2	2	dB max.
Stability	Any frequency	0-16 0-200 10	0-16 0-250 14	0-16 0-300 16	Vdc mW W max.
Input Impedance Return Loss		50 — 10	50 — 10	50 — 10	Ω nominal dB max.
Output Impedance		50	50	50	Ω nominal
φ JF		4	4	4	°C/W Typical
Operating Mode		C	C	C	Class
Temperature Range	Operating	— 30 + 100	— 30 + 100	— 30 + 100	°C min. °C max.
Gain Control Range	Operating	10	10	10	dB min.

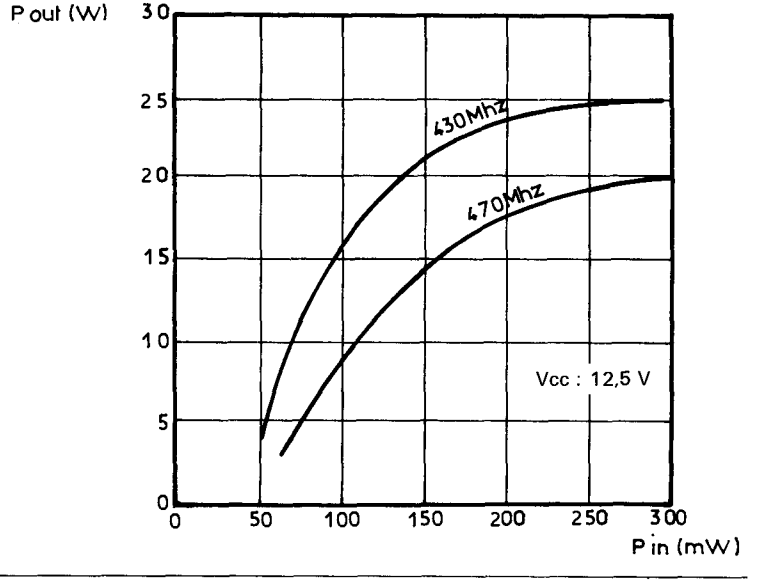
TYPICAL CHARACTERISTICS

Output Power vs Input Power

MX 15-1

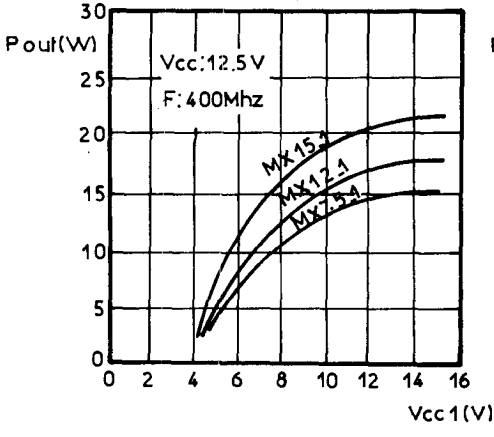


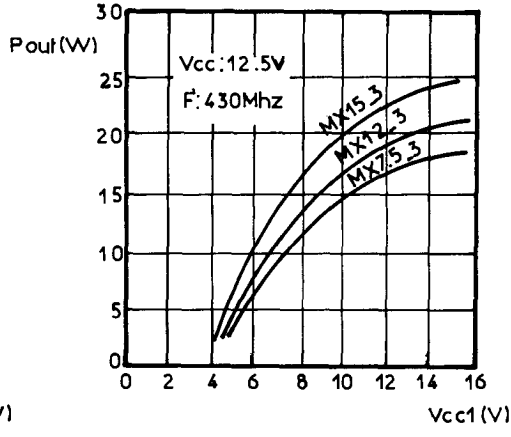
MX 15-3



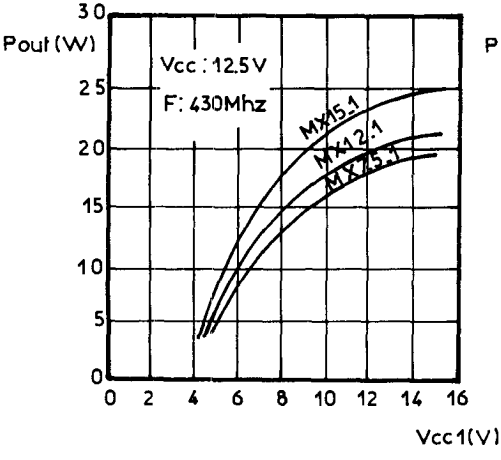
TYPICAL CHARACTERISTICS

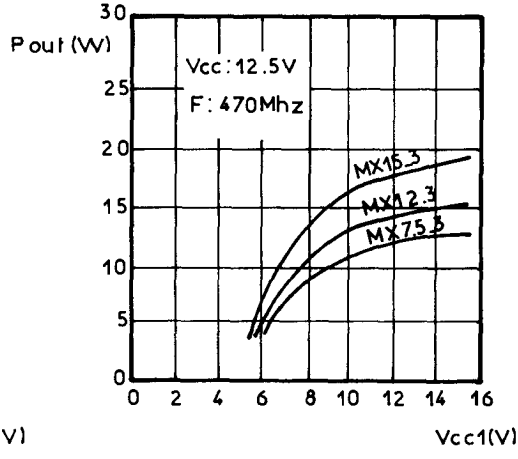
Output Power vs Gain voltage





Output Power vs Gain voltage



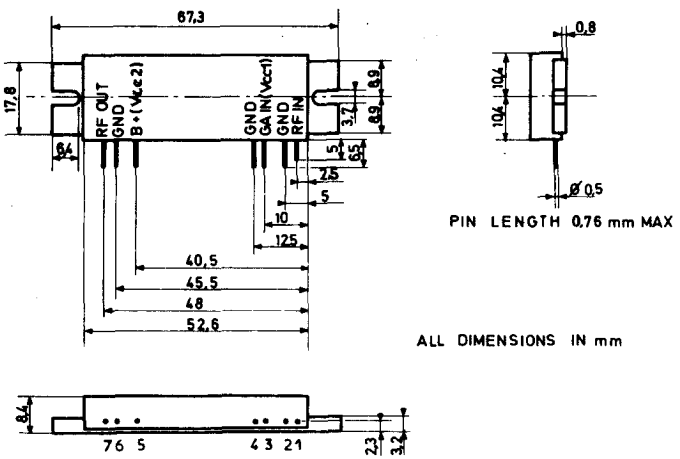


Pin = 200 mW (**MX 15**)
Pin = 150 mW (**MX 12**)
Pin = 125 mW (**MX 7.5**)

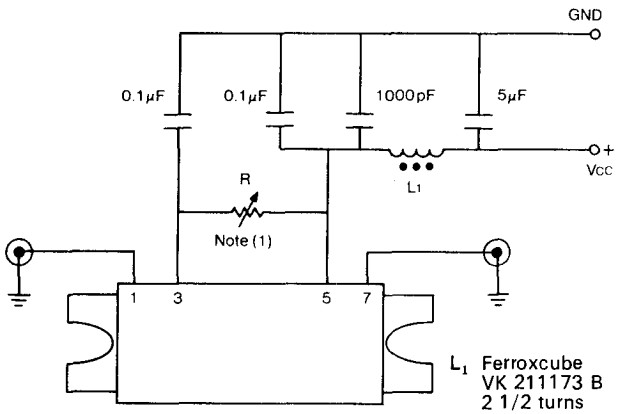
Absolute Maximum Rating (T_{flange} = 25 °C)

Characteristics	MX 7.5	MX 12	MX 15
Power Output	10 W	14 W	16 W
Power Input	200 mW	250 mW	300 mW
Supply Voltage	16 V	16 V	16 V
Total Current	3 A	4 A	4.5 A
Storage Temperature	—30° C to + 100 °C	—30 °C to + 100 °C	—30 °C to + 100 °C

MX MODULES PACKAGES



APPLICATION OF TRW AMPLIFIER MODULES



L_1 Ferroxcube VK 211173 B 2 1/2 turns

Notes

1. Adjust R for rated P_0 at V_{CC} = 12.5 V R value will be 0-100 ohms. P_{in} should be set at rated value.
2. When adjusted as in Note 1, the MX series can be operated at up to 16 volts when the output is terminated in a nominal load of 50 ohms (3 : 1 max. VSWR) or up to 14 volts when the output is terminated in an " infinite " VSWR, any phase angle.

RF Power Transistor

2 W - 470 MHz
12.5 V

The PT 8740 is designed for use in 12.5 V UHF and VHF applications and is ideally suited for use in the predriver or driver stage of a power amplifier.



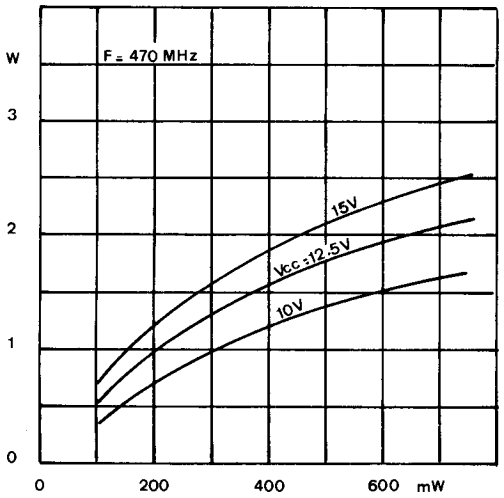
TO 39

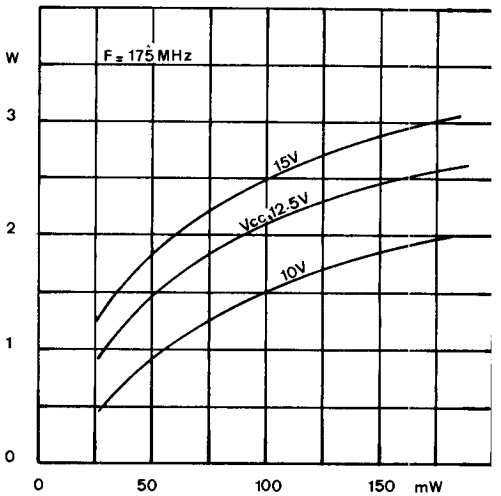
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	18			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA I_E = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 10 V I_C = 100 mA	15		150	—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.7 W V_{CE} = 12.5 V F = 175 MHz P_{in} = 0.1 W	2 1.8			W
	η_c	Efficiency	V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W	60			%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.7 W V_{CE} = 12.5 V F = 175 MHz P_{in} = 0.1 W		4.31 — j 1.88 5.06 — j 9.62		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 470 MHz V_{CE} = 12.5 V F = 175 MHz P_{out} = 1.8 W		21.1 + j 7.39 22.3 + j 31.36		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz			12	pF
Operating	I_C	Continous Collector Current				0.5	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			50	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			3.5	W

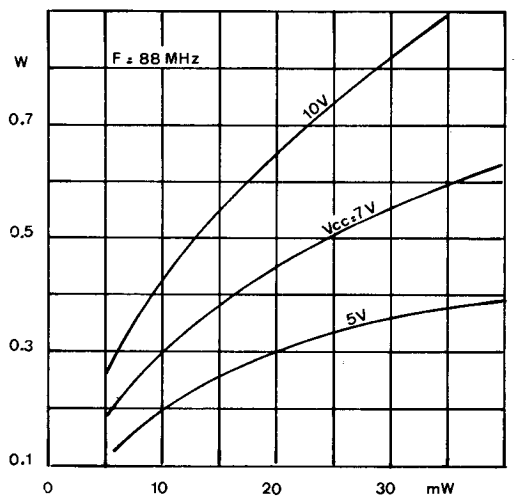
TYPICAL CHARACTERISTICS

Power Output vs Input Power and Voltage Supply

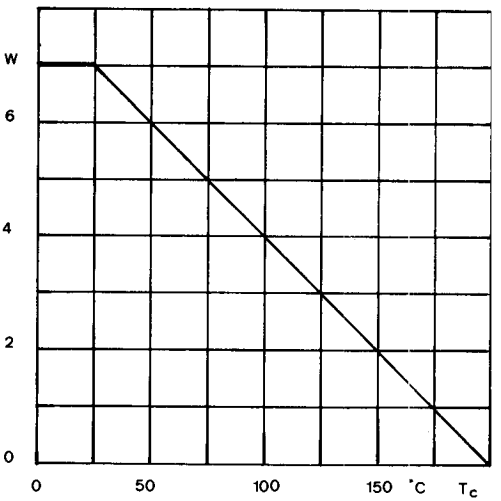




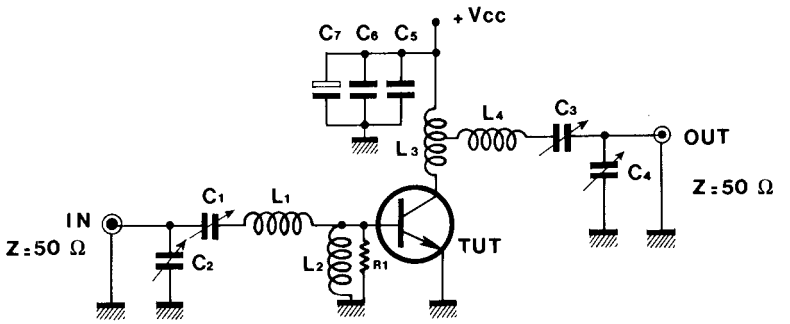
Power Output vs Input Power and Voltage Supply



Power - Temperature Derating Curve

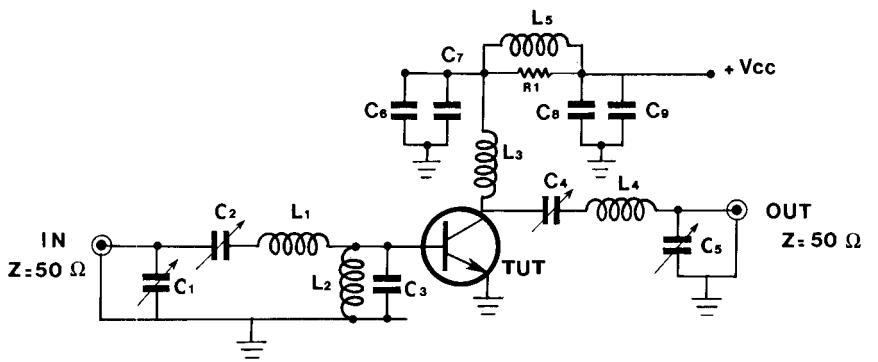


175 MHz AMPLIFIER-POWER OUTPUT TEST CIRCUIT



C_1-C_2-C_3-C_4 = 7.60 pF trimmer capacitor ARCO 404
C_5 = 1000 pF ceramic disc
C_6 = 10 nF ceramic disc
C_7 = 47 µF electrolytic
L_1 = 2 1/2 turns 10/10 mm wire - 1 cm I.D. - 1 cm length
L_2 = 1 µH molded coil
L_3 = 3 turns 10/10 mm wire - 1 cm I.D. - 1,5 cm length center tapped
L_4 = 2 1/2 turns 10/10 mm wire - 1 cm I.D. - 1 cm length
R_1 = 47 ohms 1/2 W carbon composition

470 MHz AMPLIFIER-POWER OUTPUT TEST CIRCUIT



C_1 = 1,5-20 pF trimmer capacitor ARCO 402
C_2-C_4 = 7-60 pF trimmer capacitor ARCO 404
C_5 = 4-40 pF trimmer capacitor ARCO 403
C_3 = 20 pF ceramic disc
C_6-C_8 = 1000 pF silver mica capacitor
C_7-C_9 = 10 nF ceramic disc
L_1 = 3 mm × 12 mm copper strip
L_2 = 0.15 µH molded coil
L_3 = 2 turns 4/10 mm wire - 3 mm I.D.
L_4 = 5 mm × 15 mm copper strip
L_5 = 10 turns 4/10 mm wire on R1
R_1 = Resistor 20 ohms 1/2 W carbon composition

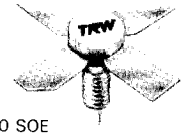
TRW® SEMICONDUCTORS

RF Power Transistors

PT 8809 2 W
PT 8810 5 W
PT 8811 10 W

470 MHz - 12.5 V

The PT 8809, 10 and 11 are designed for 12.5 volt, UHF applications. Power output is usable to the top of their ratings and they are able to withstand infinite VSWR at all phase angles at rated output power.



280 SOE

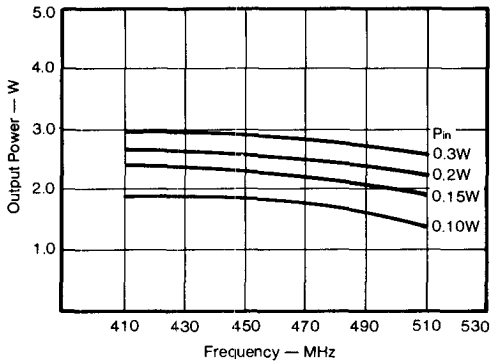
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	PT 8809	PT 8810	PT 8811	UNIT
DC Test	BV_{EBO}	Min. Emitter - Base Breakdown	I_E = 1 mA, I_C = 0 I_E = 2 mA, I_C = 0 I_E = 5 mA, I_C = 0	4	4	4	V
	BV_{CES}	Min. Collector - Emitter Breakdown	I_C = 5 mA, V_{BE} = 0 I_C = 10 mA, V_{BE} = 0 I_C = 20 mA, V_{BE} = 0	36	36	36	V
	BV_{CEO}	Min. Collector - Emitter Breakdown	I_C = 25 mA, I_B = 0 I_C = 50 mA, I_B = 0	16	16	16	V
	I_{CBO}	Max. Collector Cutoff Current	V_{CB} = 15 V, I_E = 0	1	1	2	mA
	H_{FE}	Min. D.C Current Gain	V_{CE} = 5 V, I_C = 100 mA V_{CE} = 5 V, I_C = 200 mA V_{CE} = 5 V, I_C = 500 mA	20	20	20	—
RF Test	P_{GAIN}	Min. Power Gain	V_{CE} = 12.5 V, F = 470 MHz, P_{in} = 0.2 W P_{in} = 0.7 W P_{in} = 2.5 W	2	5	10	W
	η_i	Min. Collector Efficiency	V_{CE} = 12.5 V, F = 470 MHz, P_{out} = 2 W P_{out} = 5 W P_{out} = 10 W	60	55	55	%
	VSWR	Mismatch Tolerance	V_{CE} = 12.5 V, F = 470 MHz, P_{out} = 2 W P_{out} = 5 W P_{out} = 10 W	∞ : 1	∞ : 1	∞ : 1	
	C_{OB}	Max. Collector - Base Capacitance	V_{CB} = 15 V, F = 1 MHz, I_E = 0	8	17	30	pF
Operating	I_C	Continous Collector Current		0.75	1.7	3.4	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C	10	5	3.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65° to + 200°			°C
	P_D	Power Dissipation	T_C = 25 °C	17.5	35	50	W

TYPICAL POWER GAIN PERFORMANCE IN BROADBND CIRCUIT

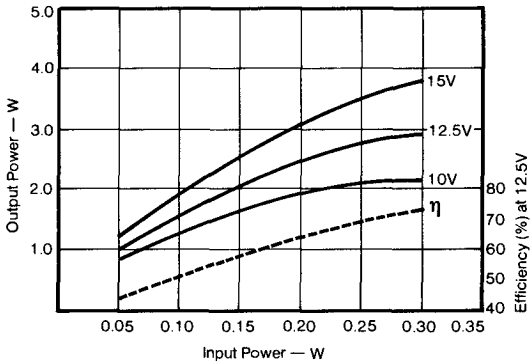
Power Output Frequency
V_{CE} = 12.5 V

PT 8809

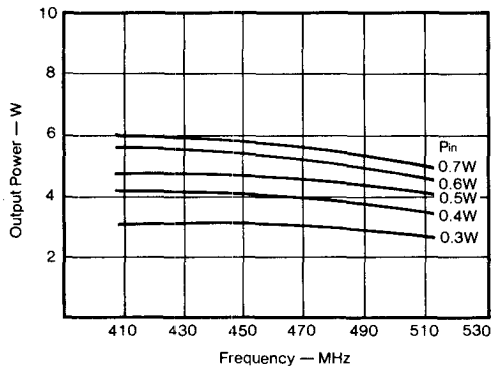


Power Output vs Power Input
f = 470 MHz

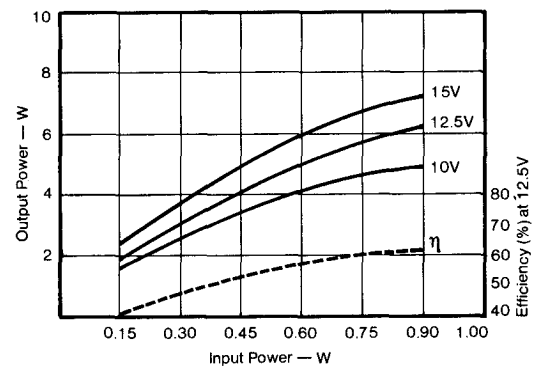
PT 8809



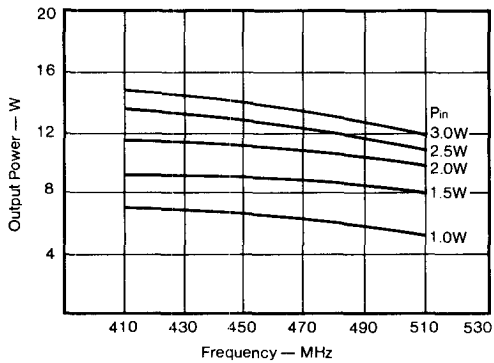
PT 8810



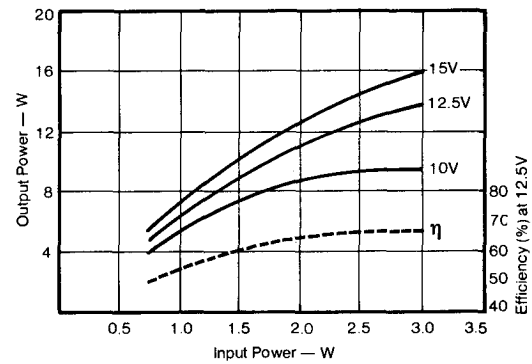
PT 8810



PT 8811



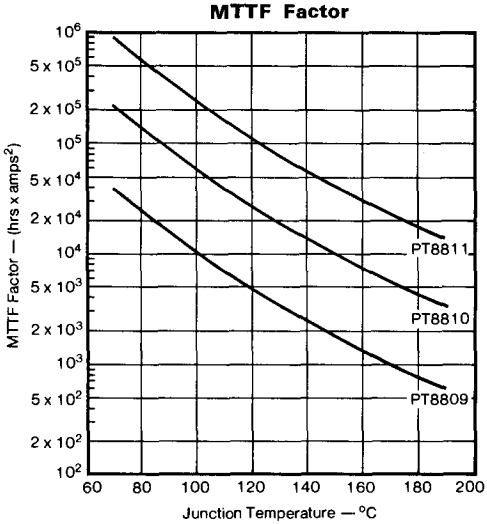
PT 8811



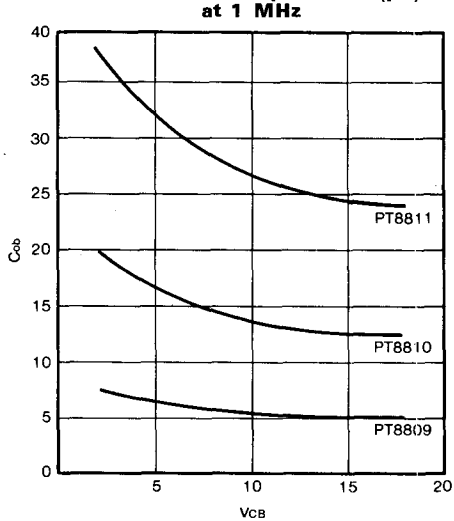
DEVICE IMPEDANCE PARAMETERS AT 12.5 V AND RATED INPUT POWER

DEVICE	FREQUENCY (MHz)	Z_n (Ω)	Z_{out} (Ω)
PT 8809	410	1.70 + j 1.92	15.7 — j 20.4
	430	1.79 + j 2.09	15.5 — j 19.7
	450	1.87 + j 2.26	15.4 — j 18.9
	470	1.96 + j 2.44	15.2 — j 18.2
	490	2.03 + j 2.61	15.1 — j 17.5
	510	2.11 + j 2.77	14.9 — j 16.7
PT 8810	410	1.49 + j 2.60	9.95 — j 6.20
	430	1.52 + j 2.90	9.80 — j 6.05
	450	1.56 + j 3.20	9.65 — j 5.90
	470	1.60 + j 3.50	9.55 — j 5.75
	490	1.63 + j 3.80	9.40 — j 5.60
	510	1.67 + j 4.10	9.30 — j 5.45
PT 8811	410	1.25 + j 2.65	6.00 — j 1.70
	430	1.24 + j 2.77	5.85 — j 1.64
	450	1.23 + j 2.89	5.70 — j 1.58
	470	1.22 + j 3.00	5.55 — j 1.62
	490	1.21 + j 3.12	5.40 — j 1.46
	510	1.20 + j 3.24	5.25 — j 1.40

MTTF Factor



Collector Base Capacitance (pF) at 1 MHz



MTTF factor is derived from calculations based on metal migration theory. The following example will serve to demonstrate the use of the MTTF factor charts shown above. Consider the PT 8810 operating at 470 MHz under normal conditions.

$$P_0 = 5\ W$$
$$V_C = 12.5\ V$$
$$P_{in} = 0.6\ W$$
$$\eta = 60\ \%$$

From this we calculate $I_C = 0.67$ A; therefore, the total power dissipated is 4 watts.

The junction temperature can then be calculated from :

$$T_j = T_{stud} + Pd \times \theta_{jC}$$

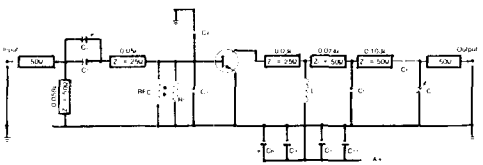
In this example $P_d \times \theta_{jC}$ is 20 °C.

For a stud temperature of 100 °C, T_j is 120 °C. From the chart above, we find the PT 8810 has an MTTF factor of 2.75×10^4 hours amps^2 at 120 °C. We calculate MTTF as follows :

$$MTTF = \frac{2.75 \times 10^4\ \text{hrs.amps}^2}{(0.67\ \text{amps})^2}$$

$$MTTF = 61{,}300\ \text{hours}$$

PT 8809 TEST CIRCUIT
BROADBAND (450-510 MHz)

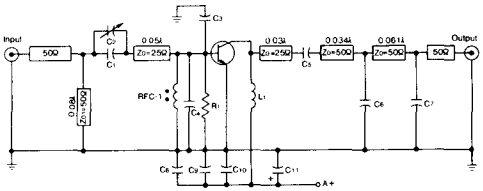


COMPONENT AND MATERIAL LIST

C_1	3.9 pF, ceramic chip
$C_{2,7}$	0.8-10 pF, Voltronics AP 10, variable
$C_{3,4}$	27 pF, ceramic chip
C_5	15 pF, ceramic chip
C_6	470 pF, ceramic chip
C_8	5 µF, electrolytic
C_9	1000 pF, Underwood
C_{10}	0.1 µF, disc-ceramic
C_{11}	0.1 µF, disc-ceramic
L_1	2 turns # 22 enameled, 0.1" I.D.
R_1	270 Ω, 1/2 watt, carbon
RFC_1	2 1/2 turns # 22 AWG on Ferroxcube VK 211/17-4 B

All transmission lines reference at 480 MHz

PT 8810 TEST CIRCUIT
BROADBAND (450-510 MHz)

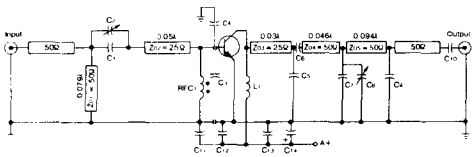


COMPONENT AND MATERIAL LIST

C_1	3.9 pF, ceramic chip
C_2	0.8-10 pF, Voltronics AP 10, variable
$C_{3,4}$	25 pF, ceramic chip
C_5	1500 pF, ceramic chip
C_6	10 pF, Underwood
C_7	5 pF, Underwood
C_8	0.01 µF, disc-ceramic
C_9	0.10 µF, disc-ceramic
C_{10}	1000 pF, Underwood
C_{11}	5 µF, electrolytic
L_1	4 turns, # 22 enameled, 0.1" I.D.
R_1	750 Ω, 1/2 watt, carbon
RFC_1	2 1/2 turns # 22 AWG on Ferroxcube VK 211/17-4 B

All transmission lines reference at 480 MHz

PT 8811 TEST CIRCUIT
BROADBAND (450-510 MHz)

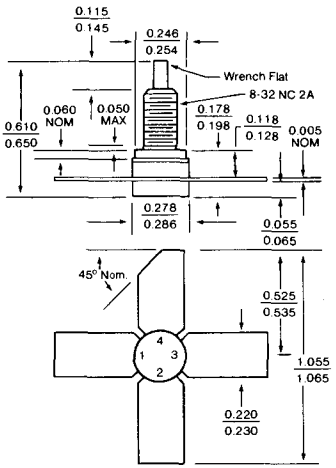


COMPONENT AND MATERIAL LIST

C_1	3.9 pF, ceramic chip
$C_{2,8}$	0.8-10 pF, Voltronics AP 10, variable
$C_{3,4}$	27 pF, ceramic chip
C_5	20 pF, Underwood
C_6	81 pF, ceramic chip
C_7	10 pF, Underwood
C_9	5 pF, Underwood
C_{10}	470 pF, ceramic chip
C_{11}	1000 pF, Underwood
C_{12}	0.1 µF, disc-ceramic
C_{13}	0.01 µF, disc-ceramic
C_{14}	5 µF, electrolytic
L_1	4 turns, # 22 enameled, 0.1" I.D.
RFC_1	2 1/2 turns # 22 AWG on Ferroxcube VK 211/17-4 B

All transmission lines reference at 480 MHz

CASE OUTLINE



To convert inches to millimeters multiply by 25.4

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

RF TRANSISTOR

10 W - 175 MHz
12,5 V

NPN SILICON

Designed for 12.5 V VHF amplifiers. Class B or C operation.

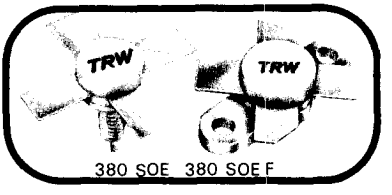
12.5 V characteristics :

Output power 175 MHz - 9 W min.

Minimum gain at 175 MHz - 11 dB.

Available in either stud or flange package.

Power output useable to the top ratings and capable of whithstanding infinite VSWR at all phase angles at rated output power.

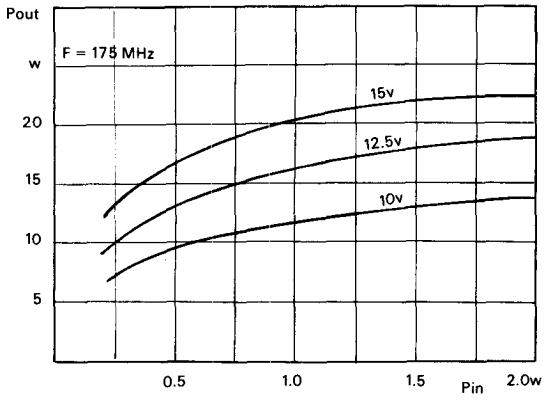


380 SOE 380 SOE F

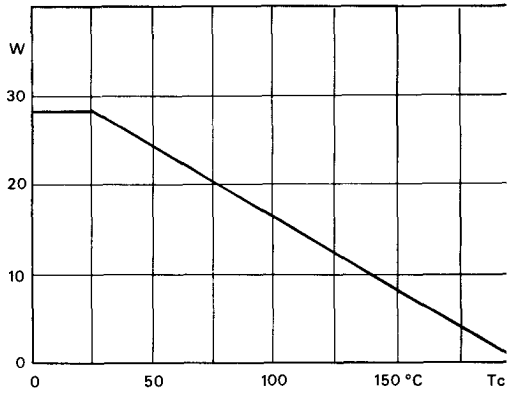
Electrical Characteristics (T_{Flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA I_E = 0	36			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			2	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 500 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V P_{in} = 0.7 W F = 175 MHz	9			W
	η	Efficiency	V_{CE} = 12.5 V P_{out} = 9 W F = 175 MHz	60			%
	Load VSWR	Mismatch Tolerance	V_{CE} = 12.5 V P_{out} = 9 W F = 175 MHz		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V P_{in} = 0.7 W F = 175 MHz		1.8 _ j 0.1		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V P_{out} = 9 W F = 175 MHz		8.29 + j 2.55		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz			30	pF
Operating	I_C	Continous Collector Current				3.4	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			3.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			50	W

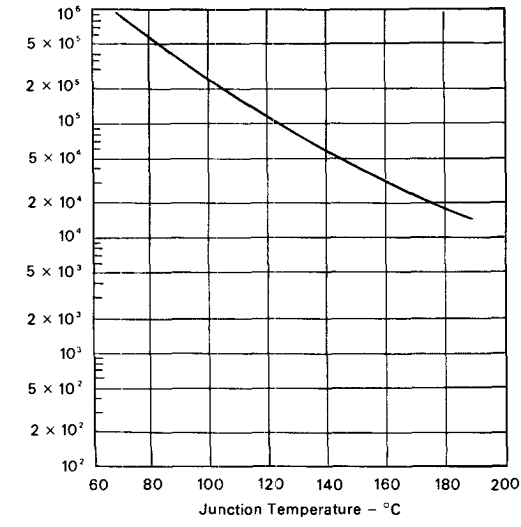
Typical characteristics



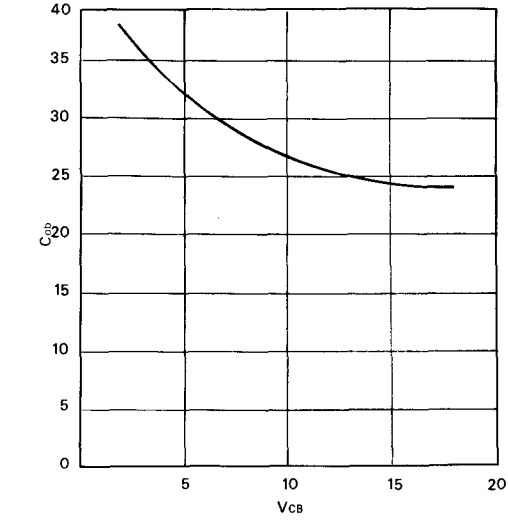
Power - Temperature Derating Curve



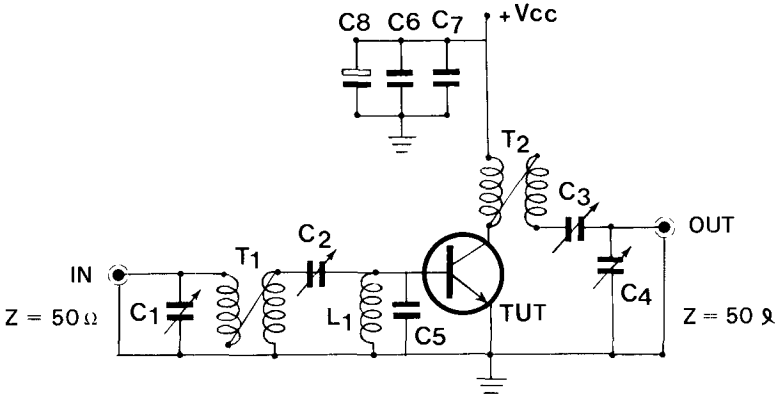
MTTF Factor



Collector Base Capacitance (pF) at 1 MHz



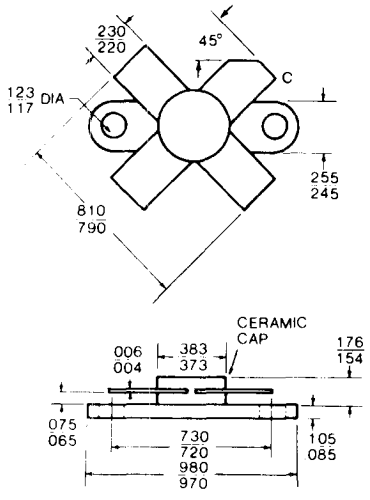
175 MHz - POWER OUTPUT TEST CIRCUIT



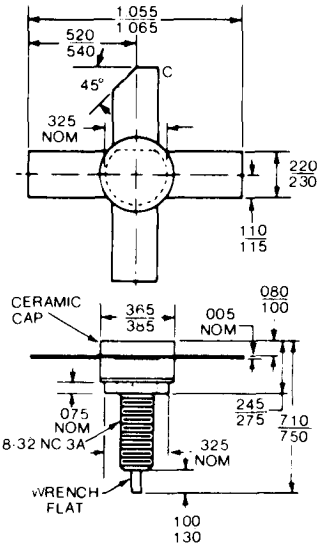
C_1-C_2-C_4 = 7-100 pF Trimmer Capacitor ARCO 423
C_3 = 24-200 pF Trimmer Capacitor ARCO 425
C_5 = 150 pF Silvered Mica Capacitor. Low Inductance
C_6 = 1000 pF Silvered Mica Capacitor
C_7 = 1000 pF Ceramic Disc
C_8 = 47 μF/63 V Electrolytic
L_1 = 10 μH Molded Coil
T_1-T_2 = Transmission Line Transformers 2 wires 8/10 mm Twisted - 5 cm length

PACKAGE OUTLINE

.380 SOE F



.380 SOE

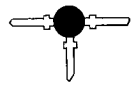


7.5 Volts Transistor

88 MHz

19 dB GAIN

Using the most recent TRW technology, this T-Pack transistor has been specifically designed and characterized as a high gain 7.5 V VHF device. It is ideally suited for use in pocketphone applications where low battery voltage is used.

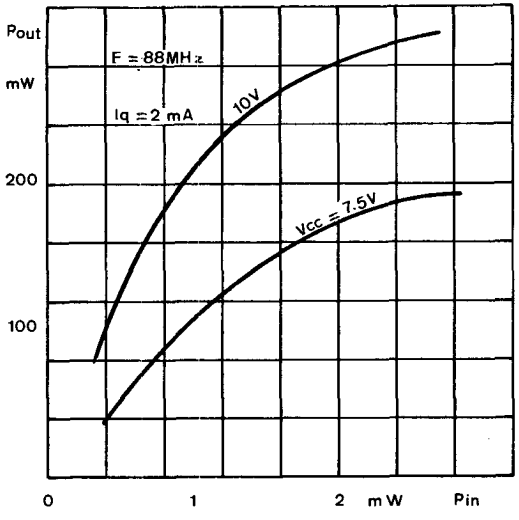


T - PACK

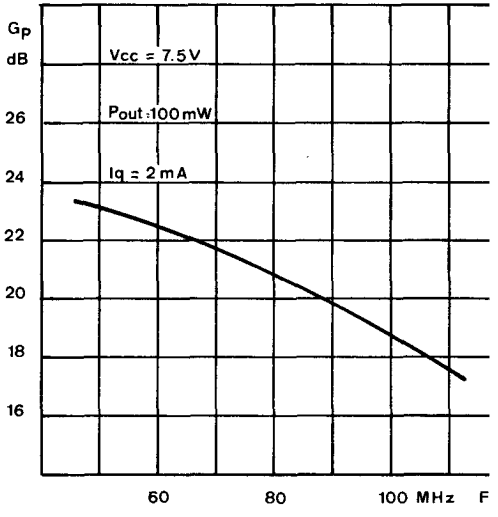
Preliminary

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 0.1 mA I_C = 0	3			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 10 mA I_B = 0	20			V
	BV_{CER}	Collector Emitter Breakdown Voltage	I_C = 10 mA R_{BE} = 10 Ω	25			V
	BV_{CEO}	Collector Base Breakdown Voltage	I_C = 1 mA I_E = 0	30			V
	H_{FE}	DC Current Gain	V_{CE} = 10 V I_C = 40 mA	15			—
RF TEST	P_{GAIN}	Power Gain	V_{CE} = 7.5 V I_C = 2 mA P_{in} = 1 mW F = 88 MHz	80			mW
	F_T	Cutoff Frequency	V_{CE} = 10 V I_C = 40 mA F = 100 MHz		2		GHz
	G_{Umax}	Maximum unilaterilized Gain	V_{CE} = 10 V I_C = 40 mA F = 100 MHz		26		dB
	S_{21}	Forward Gain 50 Ω/50 Ω	V_{CE} = 10 V I_C = 40 mA F = 100 MHz		24		dB
	C_{ob}	Collector Base Capacitance	V_{CB} = 10 V F = 1 MHz		2.5		pF
OPERATING THERMAL	I_{Cmax}	Maximum Collector Current				200	mA
	P_T	Dissipated Power	T_{case} = 50 °C			0.6	W
	T_{STG}	Storage Temperature		— 65°		+ 200	°C
	T_J	Junction Temperature					

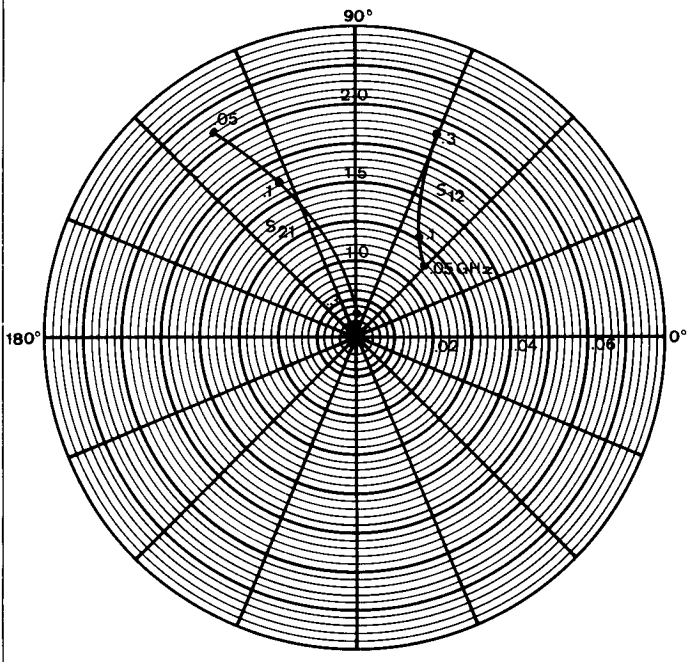
Output Power vs Frequency and Voltage Supply



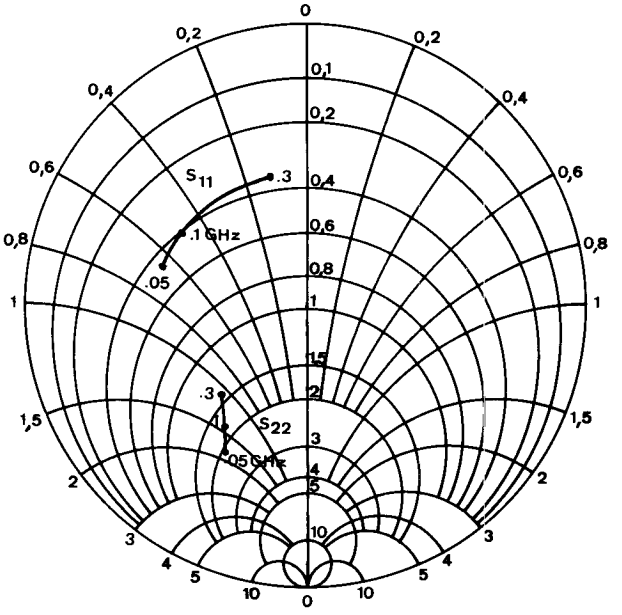
Power Gain vs Frequency



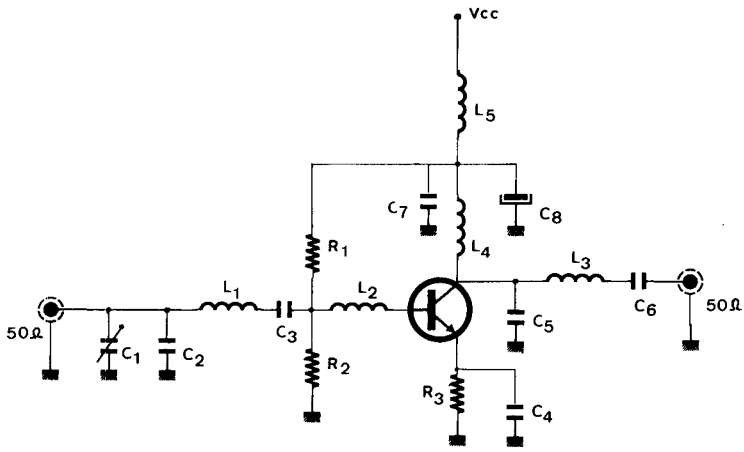
S21 - S12 Parameters vs Frequency
V_{CE} = 10 V - I_C = 40 mA



S11 - S22 Parameters vs Frequency
V_{CE} = 10 V - I_C = 40 mA



88 MHz Test Circuit



C_1 = 6-60 pF Trimmer Capacitor
C_2 = 22 pF Ceramic
C_3 = 180 pF Ceramic
C_4 = C_7 = 1 nF Ceramic
C_5 = 18 pF
C_6 = 220 pF
C_8 = 1 μF Electrolytic

L_1 = L_2 = 0.1 μH Molded Coil
L_3 = 0.18 μH Molded Coil
L_4 = 0.22 μH Molded Coil
L_5 = 1.2 μH Molded Coil

R_1 = 680 Ω Carbon composition
R_2 = 56 Ω Carbon composition
R_3 = 4.7 Ω Carbon composition

7.5 Volts Transistor

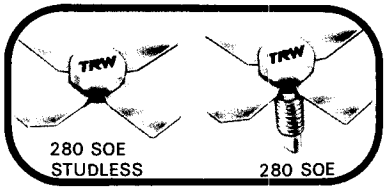
88 MHz

1.5 WATTS

13 dB GAIN

Using the latest in TRW technology, this device has been specifically designed and characterized for 7.5 V operation.

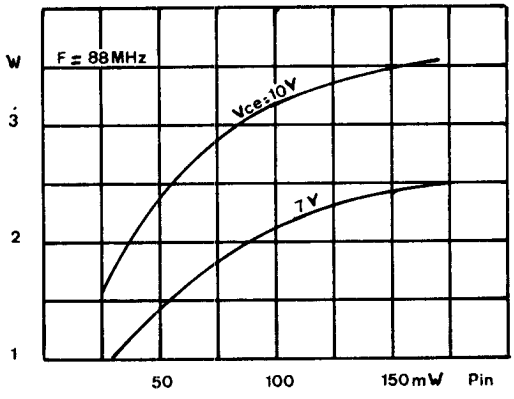
It is ideally suited for use in pocketphone where low battery voltage is used.



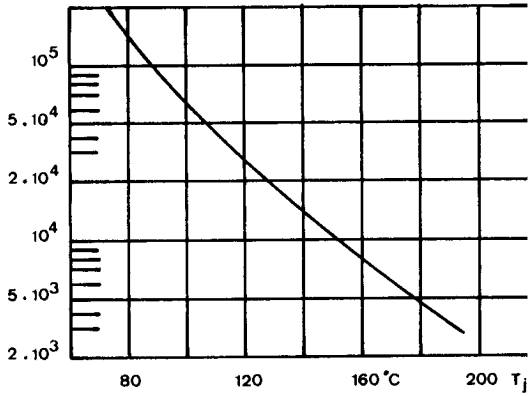
Preliminary Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 2 mA I_C = 0	4			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 10 mA I_E = 0	36			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 200 mA	20			—
RF TEST	P_{GAIN}	Power Gain	V_{CE} = 7.5 V F = 88 MHz P_{in} = 0.075 W	1.5			W
	η	Efficiency	V_{CE} = 7.5 V F = 88 MHz P_{out} = 1.5 W	50	all phase angles : 1		%
	Load VSWR	Mismatch Tolerance	V_{CE} = 10 V F = 88 MHz P_{out} = 1.5 W				
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 7.5 V F = 88 MHz P_{in} = 0.075 W		2.54 — j 3.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 7.5 V F = 88 MHz P_{out} = 1.5 W		21.38 + j 10.3		Ω
	C_{OB}	Collector Base Capacitance	V_{CB} = 15 V F = 1 MHz		13	17	pF
OPERATING THERMAL	I_C	Continuous Collector Current				1.7	A
	$\theta_{j.C}$	Thermal Resistance	T_C = 25 °C			10	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			17.5	W

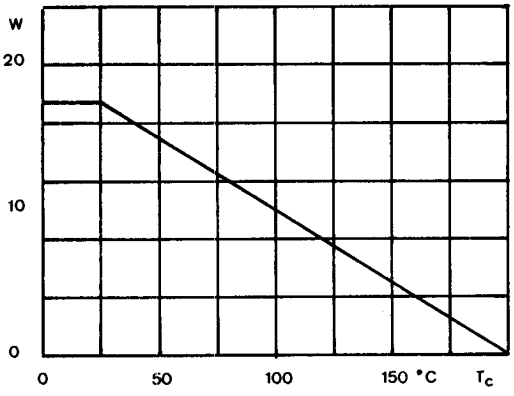
Output Power vs Input Power and Voltage Supply



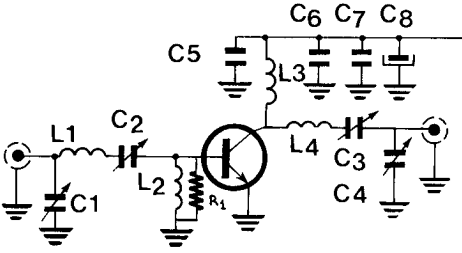
MTTF Factor vs Junction Temperature



Power - Temperature Operating Curve



88 MHz TEST CIRCUIT



$C_1 = C_2 = C_3$ = 24-200 pF ARCO 425
C_4 = 7-100 pF ARCO 423
C_5 = 1000 pF mica capacitor UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 100 µF/35 V electrolytic

$L_1 = L_4$ = 4 turns 14 AWG 1/2″ I.D.
L_2 = 0.47 µH
L_3 = 6 turns 14 AWG 1/2″ I.D. Close Wound

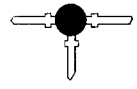
R_1 = 47 ohms

7.5 Volts Transistor

400 - 512 MHz

12 dB GAIN

Using the most recent TRW technology, this T-Pack transistor has been specifically designed and characterized as a high gain 7.5 V VHF device. It is ideally suited for use in pocketphone applications where low battery voltage is used.

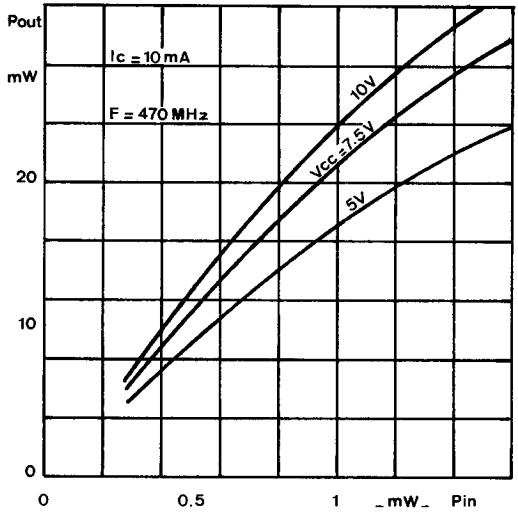


T - PACK

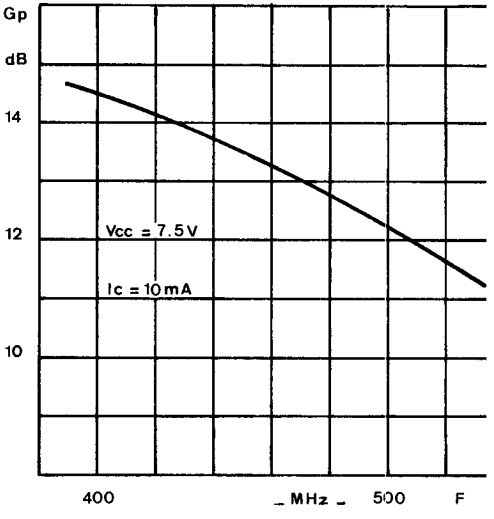
Preliminary

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 0.1 mA	I_C = 0	3			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 10 mA	I_B = 0	18			V
	BV_{CER}	Collector Emitter Breakdown Voltage	I_C = 10 mA	R_{BE} = 10 Ω	25			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 1 mA	I_E = 0	30			V
	H_{FE}	DC Current Gain	V_{CE} = 10 V	I_C = 40 mA	15			—
RF TEST	P_{GAIN}	Power Gain	V_{CE} = 7.5 V I_C = 10 mA	P_{in} = 1 mW F = 470 MHz	15			mW
	F_T	Cut-off Frequency	V_{CE} = 10 V I_C = 40 mA	F = 500 MHz		2.5		GHz
	$G_{U\ max}$	Maximum Unilaterilized Gain	V_{CE} = 10 V I_C = 40 mA	F = 500 MHz		14		dB
	S_{21}	Forward Gain 50 Ω/50 Ω	V_{CE} = 10 V I_C = 40 mA	F = 500 MHz		12.5		dB
	C_{ob}	Collector Base Capacitance	V_{CB} = 10 V	F = 1 MHz		2.5		pF
OPERATING	$I_{C\ max}$	Maximum Collector Current					200	mA
	P_T	Dissipated Power	T_{case} = 50 °C				0.6	W
	T_{STG}	Storage Temperature			— 65		+ 200	°C
	T_J	Junction Temperature						

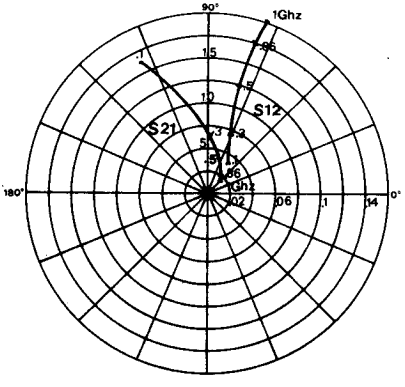
Output Power vs Input Power and Voltage Supply



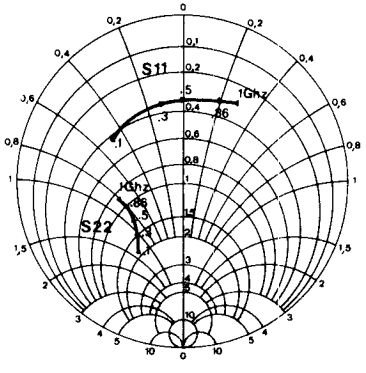
Power Gain vs Frequency



S21 - S12 Parameters vs Frequency
V_{CE} = 10 V - I_C = 40 mA

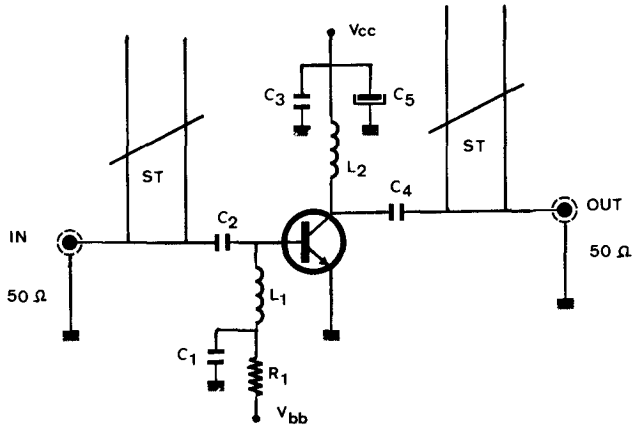


S11 - S22 Parameters vs Frequency
V_{CE} = 10 V - I_C = 40 mA



TYPICAL VALUE

Test Circuit 400-512 MHz



$L_1 = L_2 = 0.33\ \mu H$ Molded coil
$C_1 = C_2 = C_3 = C_4 = 1000$ pF Ceramic chip
$C_5 = 10\ \mu F/25$ V Electrolytic
$R_1 = 10\ k\Omega$ 1/2 W Carbon composition
ST = Stub tuner

7.5 Volts Transistor

400 - 512 MHz
0.2 Watts
13 dB Gain

The latest in the TRW RF transistor, this device has been specifically designed and characterized for 7.5 V operation. It is ideally suited for use in pocketphones where low battery voltage is used.

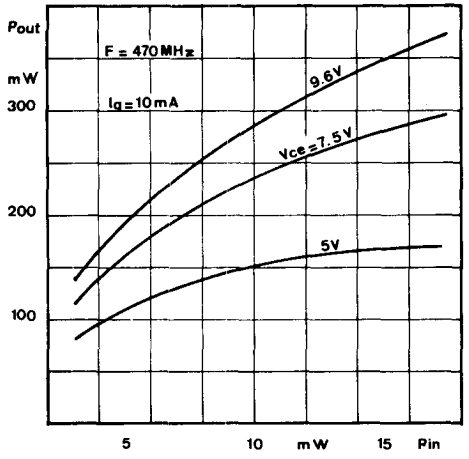


200 SOE STUDLESS

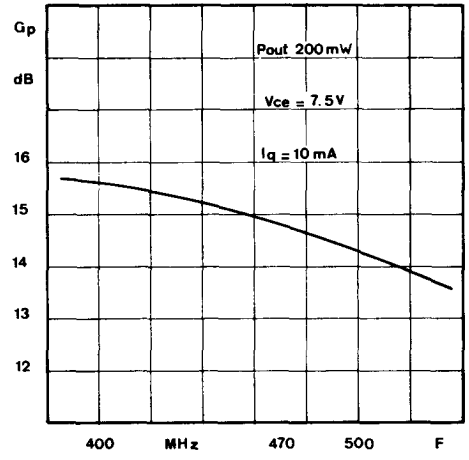
PRELIMINARY

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 5 mA I_B = 0	18			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA I_E = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			0.5	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 50 mA	20			—
RF Test	P_{GAIN}	Power Gain	F = 470 MHz Iq = 10 mA V_{CE} = 7.5 V P_{in} = 10 mW V_{CE} = 9.6 V P_{in} = 10 mW	0.175 0.200	0.230 0.290		W
	η	Efficiency	F = 470 MHz Iq = 10 mA V_{CE} = 7.5 V Rated Output Power	35	40		%
	Z_{in}	Common Emitter Amplifier Input Impedance	F = 470 MHz AB Class V_{CE} = 7.5 V P_{in} = 10 mW		5 + j 0.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	F = 470 MHz AB Class V_{CE} = 7.5 V P_{out} = 0.2 W		47 + j 45		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 10 V F = 1 MHz		1.6	2.5	pF
Operating	I_C	Continous Collector Current				0.2	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			60	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			2.9	W

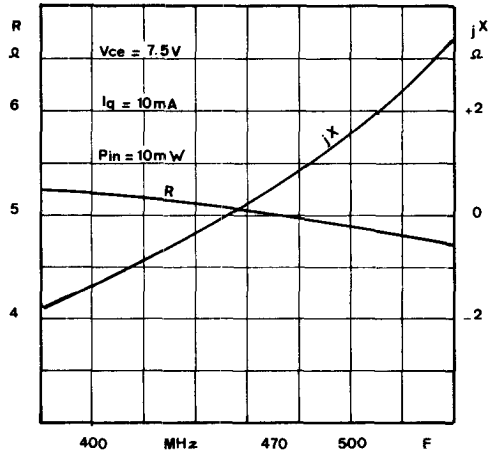
Output Power vs Input Power and V_{CE}



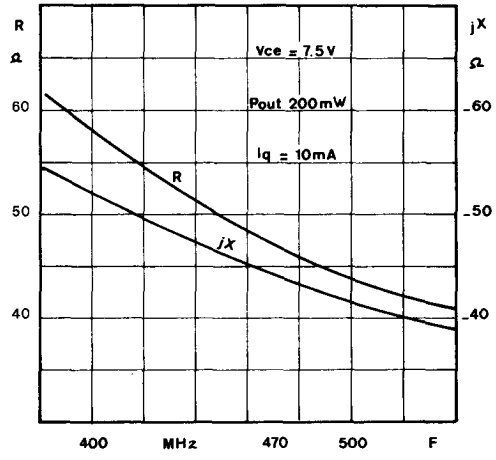
Power Gain vs Frequency



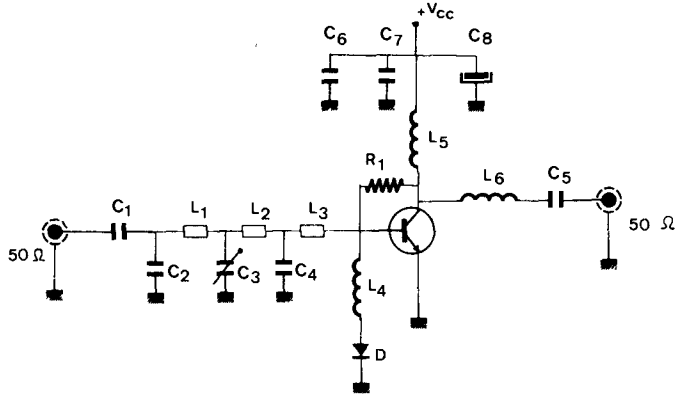
Input Impedance vs Frequency



Output Impedance vs Frequency



400-512 MHz TEST CIRCUIT



C_1 = 27 pF Ceramic 632 RTC
C_2 = 8.2 pF Ceramic 632 RTC
C_3 = 3-20 pF Trimmer Capacitor
C_4 = 22 pF Ceramic 632 RTC
$C_5 = C_6$ = 1000 pF Ceramic 629 RTC
C_7 = 10 nF Ceramic 629 RTC
C_8 = 10 µF/25 V Electrolytic

L_1 = Stripline Z_0 = 70 ohms l = 0.061 λ
L_2 = Stripline Z_0 = 70 ohms l = 0.026 λ
L_3 = Stripline Z_0 = 50 ohms l = 0.031 λ
} F_{REF} = 480 MHz

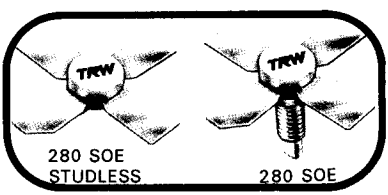
$L_4 = L_5$ = 0.15 µH Molded Coil
L_6 = 3 turns - Silvered Wire 6/10 mm - 4 mm I.D - 8 mm length
R_1 = 5 10 Ω Carbon Composition 1/4 W

7.5 Volts Transistor

400 - 512 MHz
1.5 Watts
10 dB Gain

The latest in the TRW RF transistor, this device has been specifically designed and characterized for 7.5 V operation.

It is ideally suited for use in pocketphone where low battery voltage is used.

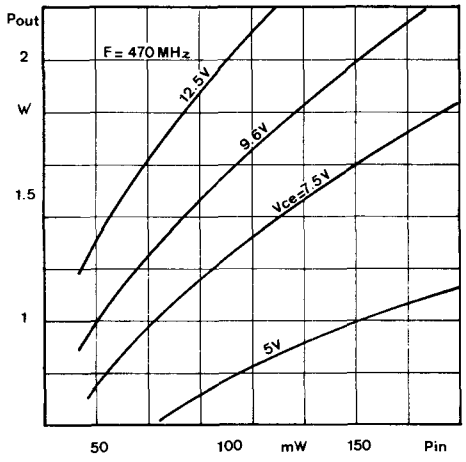


280 SOE STUDLESS — 280 SOE

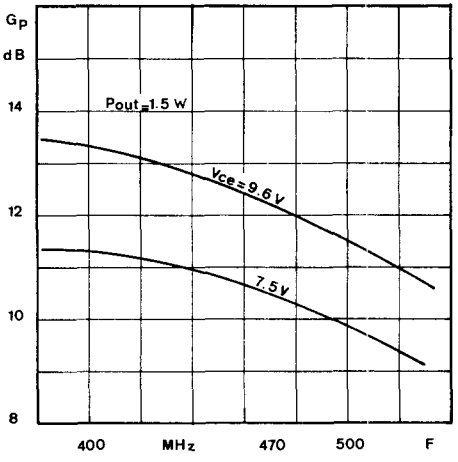
PRELIMINARY

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA I_B = 0	14			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 5 mA I_E = 0	30			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			0.5	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 100 mA	20			—
RF Test	P_{GAIN}	Power Gain	F = 470 MHz V_{CE} = 7.5 V P_{in} = 175 mW V_{CE} = 9.6 V P_{in} = 150 mW	1.5 1.5	1.8 2		W
	η	Efficiency	F = 470 MHz V_{CE} = 7.5 V P_{out} = 1.5 W	50	60		%
	Load VSWR	Mismatch Tolerance	F = 470 MHz V_{CE} = 10 V P_{out} = 1.5 W		∞ : 1 All phases		
	Z_{in}	Common Emitter Amplifier Input Impedance	F = 470 MHz V_{CE} = 7.5 V P_{in} = 150 mW		1.8 + j 3.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	F = 470 MHz V_{CE} = 7.5 V P_{out} = 1.5 W		11 + j 6		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 10 V F = 1 MHz		5.5	7	pF
Operating	I_C	Continous Collector Current				1	A
	θ_{j-c}	Thermal Resistance	T_C = 25 °C			10	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			17.5	W

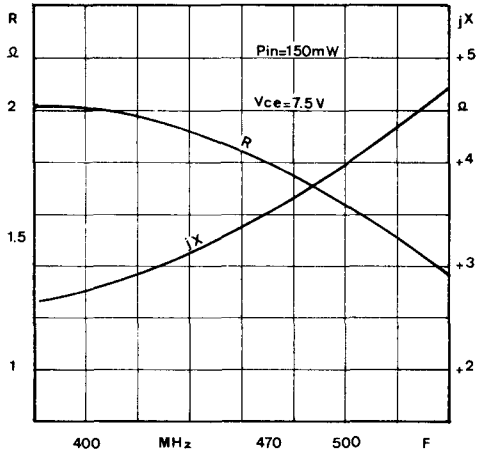
Output Power vs Input Power and V_{CE}



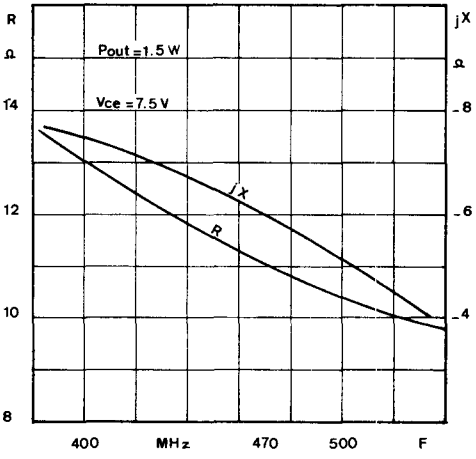
Power Gain vs Frequency and V_{CE}



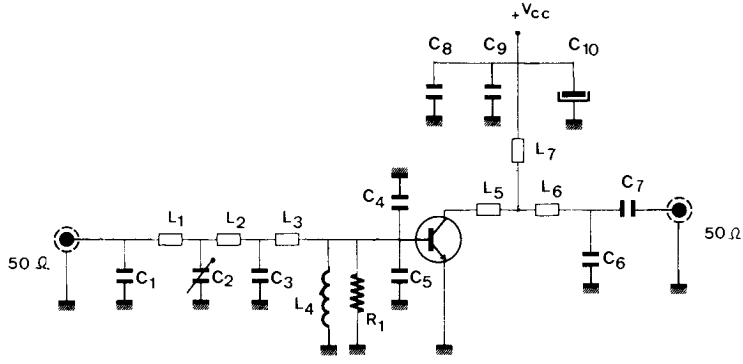
Input Impedance vs Frequency



Output Impedance vs Frequency



400-512 MHz TEST CIRCUIT



C_1 = 4.7 pF Ceramic 632 RTC
C_2 = 2-10 pF Trimmer Capacitor
C_3 = 15 pF Ceramic 632 RTC
$C_4 = C_5$ = 39 pF Ceramic Chip ATC
C_6 = 10 pF Ceramic Chip ATC
$C_7 = C_8$ = 1000 pF Ceramic 629 RTC
C_9 = 10 nF Ceramic 629 RTC
C_{10} = 10 µF/25 V Electrolytic

L_1 =	Stripline	Z_0 = 70 ohms	l = 0.032 λ	F_{REF} = 480 MHz
L_2 =	Stripline	Z_0 = 70 ohms	l = 0.029 λ	
L_3 =	Stripline	Z_0 = 25 ohms	l = 0.031 λ	
L_5 =	Stripline	Z_0 = 25 ohms	l = 0.006 λ	
L_6 =	Stripline	Z_0 = 70 ohms	l = 0.052 λ	
L_7 =	Stripline	Z_0 = 70 ohms	l = 0.064 λ	

L_4 = 0.15 µH Molded Coil

R_1 = 47 ohms Carbon Composition - 1/4 W

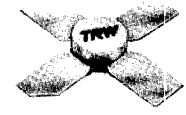
RF Power Transistor

2 W - 470 MHz
12.5 V

The TP 1045 is designed for 12.5 V VHF and UHF amplifiers.

Its high gain at reduced voltage and stripline package make it suitable for use in pocketphone applications.

The power output is useable to the top of its ratings and it is able to withstand an infinite VSWR at all phase angles at rated output power.

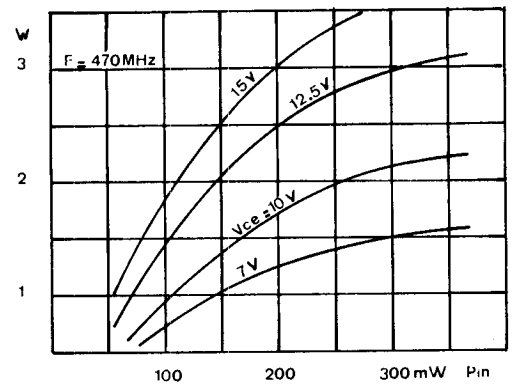


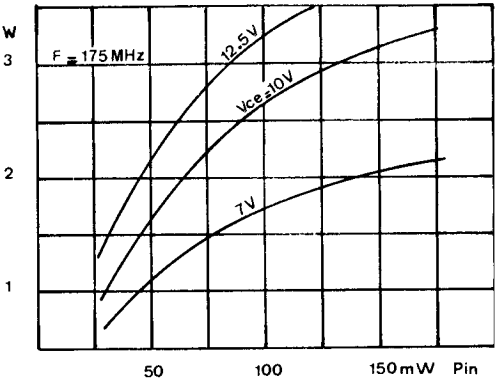
280 SOE STUDLESS

Electrical Characteristics (T_{case} = 25 °C)

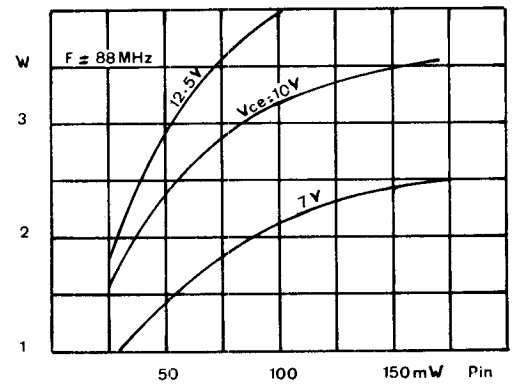
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 25 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Beakdown Voltage	I_C = 5 mA I_E = 0	36			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 100 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.2 W V_{CE} = 9.5 V F = 175 MHz P_{in} = 0.1 W V_{CE} = 9.5 V F = 88 MHz P_{in} = 0.1 W	2 1.5 1.5	 2.2 2.9		W
	η	Efficiency	V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W	60			%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.2 W		1.96 + j 2.44		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W		15.2 + j 18.2		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		5	8	pF
Operating	I_C	Continous Collector Current				0.75	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			12	°C/W
	T_{STG} T_j	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			14.5	W

Output Power vs Input Power and Voltage Supply

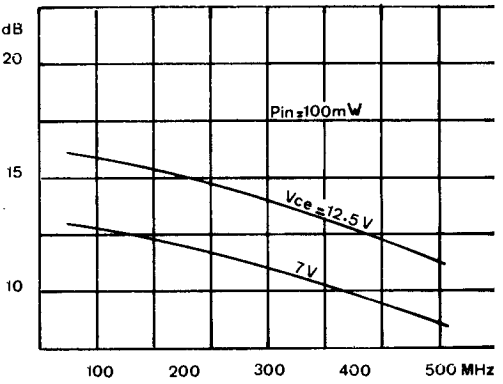




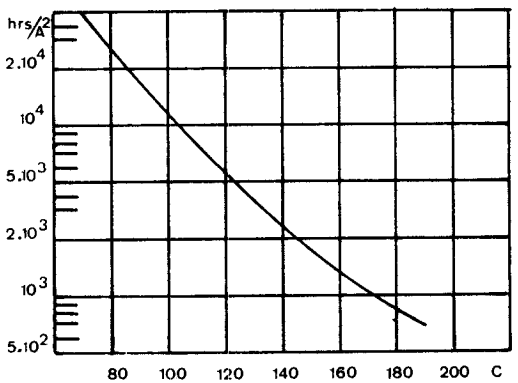
Output Power vs Input Power and Voltage Supply



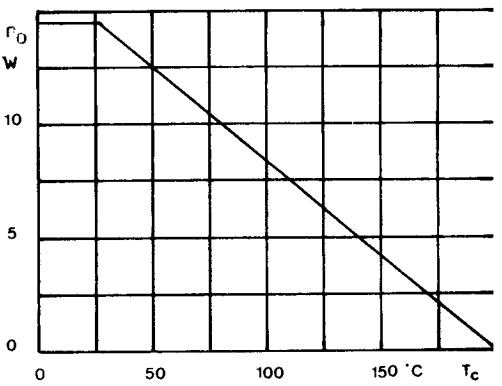
Power Gain vs Frequency and Voltage Supply



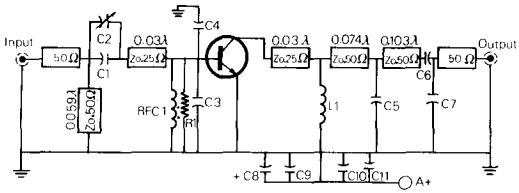
MTTF Factor vs Junction Temperature



Power - Temperature Derating Curve



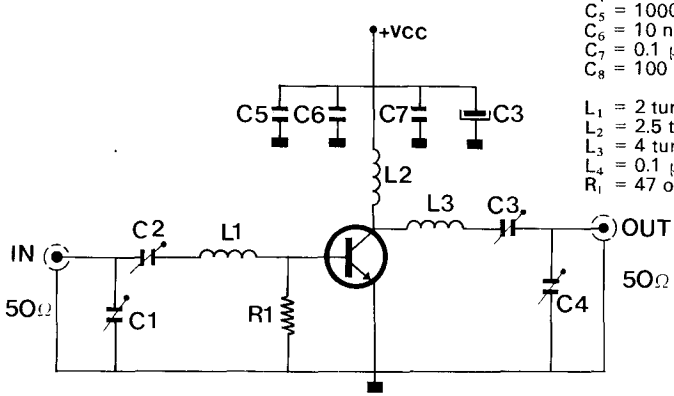
TEST CIRCUIT BROADBAND (450-510 MHz)



COMPONENT AND MATERIAL LIST

C_1 3.9 pF, ceramic chip
C_2, C_7 0.8-10 pF, Vol ronics AP 10, variable
C_3, C_4 27 pF, ceramic chip
C_5 15 pF, ceramic chip
C_6 470 pF, ceramic chip
C_8 5 µF, electrolytic
C_9 1000 pF, Underwood
C_{10} 0.1 µF, disc-ceramic
C_{11} 0.01 µF, disc-ceramic
L_1 2 turns # 22 enameled, 0.1" I.D.
R_1 270 Ω, ½ watt, carbon
RFC-1 2 ½ turns # 22 AWG on Ferroxcube VK211/17-4B
All transmission lines reference at 480 MHz

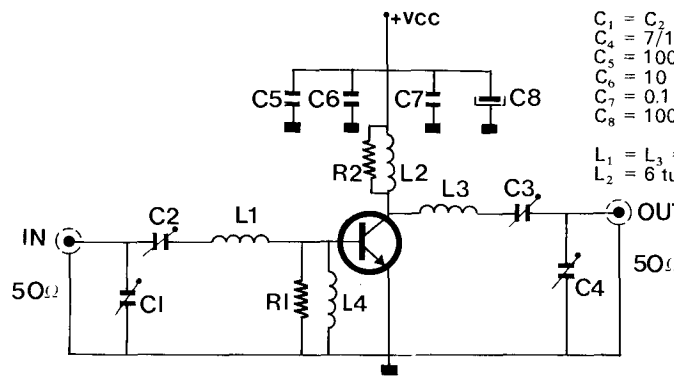
175 MHz TEST CIRCUIT



C_1 = 2-60 pF ARCO 404
C_2 = 24-200 pF ARCO 425
C_3 = 7-100 pF ARCO 425
C_4 = 4-40 pF ARCO 423
C_5 = 1000 pF UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 100 µF/35 V electrolytic

L_1 = 2 turns - 8/10 mm wire - 4 mm I.D.
L_2 = 2.5 turns - 8/10 mm wire on ferrite core
L_3 = 4 turns - 8/10 mm wire - 4 mm I.D.
L_4 = 0.1 µH Molded Coil
R_1 = 47 ohms - 1/2 W carbon

88 MHz TEST CIRCUIT



C_1 = C_2 = C_3 = 24/200 pF ARCO 425
C_4 = 7/100 pF ARCO 423
C_5 = 1000 pF UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 nF ceramic disc
C_8 = 100 µF/35 V electrolytic

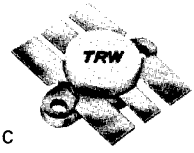
L_1 = L_3 = 4 turns 14 AWG - 1/2" I.D.
L_2 = 6 turns - 14 AWG - 1/2" I.D. close wound

RF Power Transistor

80 W - 12.5 V
88 MHz

The TP 2180 is designed for use in 12.5 V VHF amplifiers operating under class A, B or C conditions.

Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to be used at its maximum ratings and be able to withstand an infinite VSWR at all phase angles.



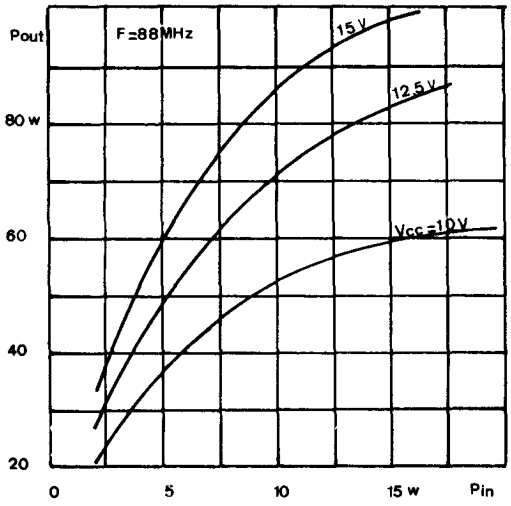
J zéro C

Electrical Characteristics (T_{case} = 25 °C)

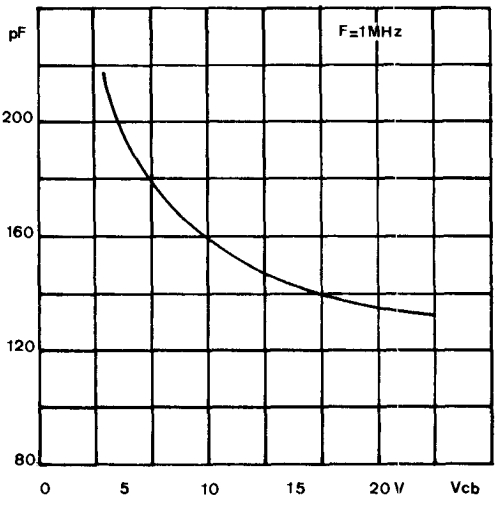
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 200 mA I_B = 0	18			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 100 mA I_E = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 20 V I_E = 0			5	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	10			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 88 MHz P_{in} = 16 W	80			W
	η	Efficiency	V_{CE} = 12.5 V F = 88 MHz P_{out} = 80 W	60	70		%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 88 MHz P_{out} = 8 0W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 88 MHz P_{in} = 16 W		0.3 — j 0.4		Ω
	Z_{Load}	Common Emitter Amplifier Loac Impedance	V_{CE} = 12.5 V F = 88 MHz P_{out} = 80 W		0.6+j 0.44		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz			180	pF
Operating	I_C	Continous Collector Current				16	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			1.25	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			140	W

TYPICAL CHARACTERISTICS

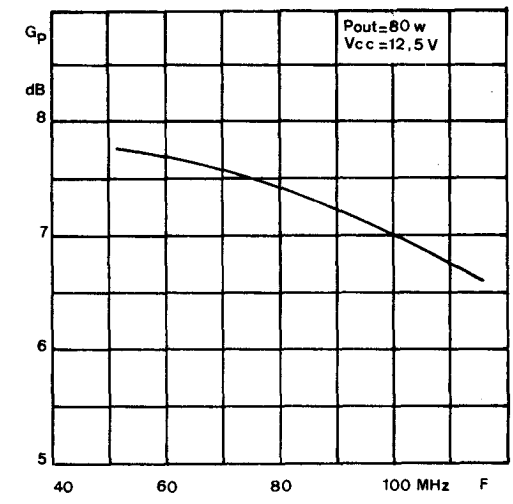
Output power vs input power and voltage supply



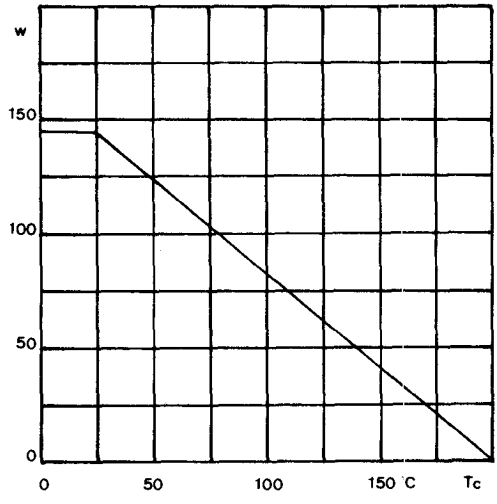
Collector base capacitance



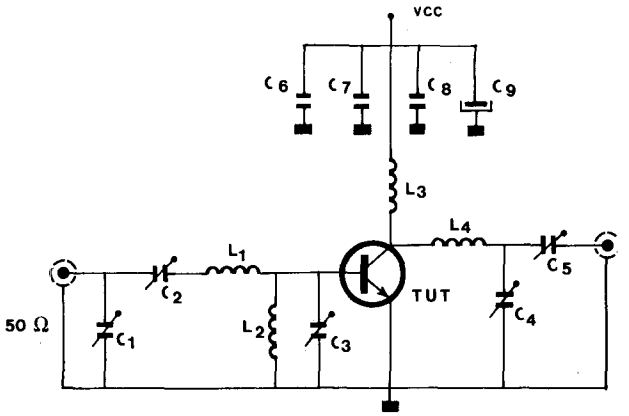
Power gain vs frequency



Power - Temperature operating curve



88 MHz TEST CIRCUIT



$C_1 = C_4$ = 24-200 pF trimmer capacitor ARCO 425
$C_2 = C_3$ = 55-300 pF trimmer capacitor ARCO 427
C_5 = 7-100 pF trimmer capacitor ARCO 423
C_6 = 1000 pF mica capacitor UNELCO
C_7 = 10 nF ceramic disc
C_8 = 0.1 µF ceramic disc
C_9 = 470 µF/40 V

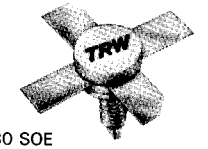
L_1 = 3 turns - 12/10 mm silvered wire - 5 mm I.O.
L_2 = 0.68 µH molded coil
L_3 = 5 turns - 12/10 mm silvered wire - 12 mm I.O.
L_4 = 1 turn - 12/10 mm silvered wire - 6 mm I.O.

RF Power Transistor

40 W - 175 MHz
12.5 V

The TP 2304 is designed for use in 12.5 V VHF amplifiers operating under class A, B or C conditions.

Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to be used at its maximum ratings and be able to withstand an infinite VSWR at all phase angles.



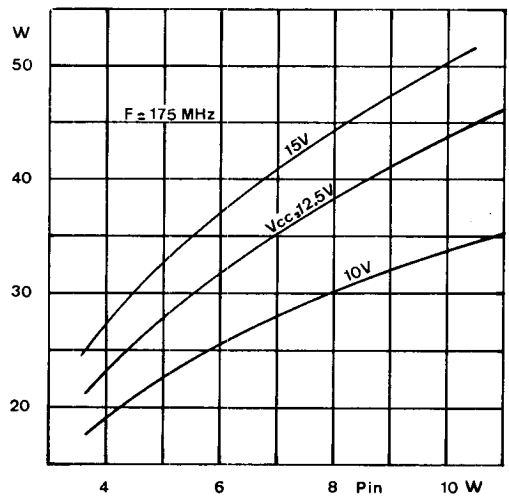
380 SOE

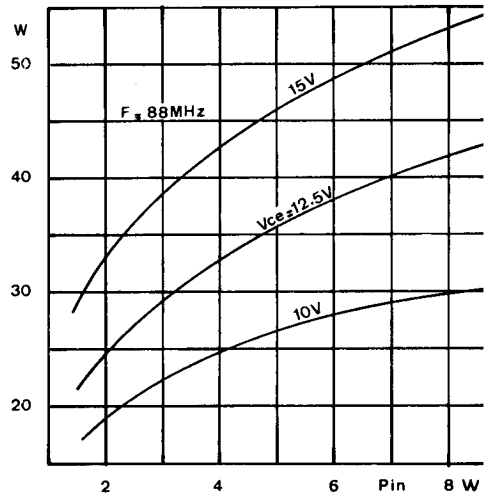
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	18			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA I_E = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			2	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	10			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 12 W V_{CE} = 12.5 V F = 88 MHz P_{in} = 8 W	40 40			W
	η	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 40 W	60			%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 40 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 10 W		1.5 + j 1.6		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 40 W		2.25+j0.1		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz		70	100	pF
Operating	I_C	Continous Collector Current				8	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			2.2	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			80	W

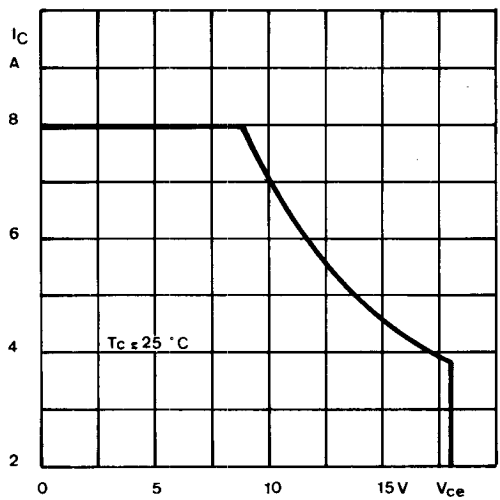
TYPICAL CHARACTERISTICS

Output Power vs Input Power and Voltage Supply

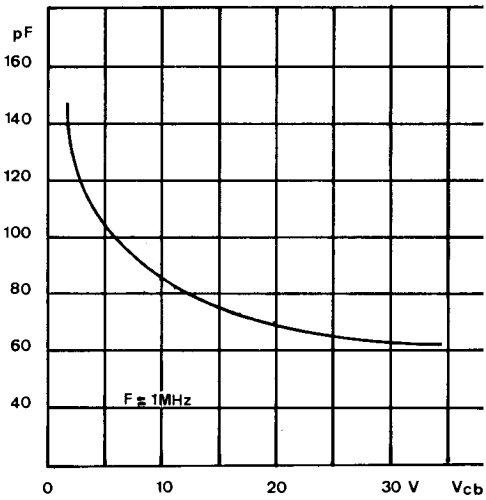




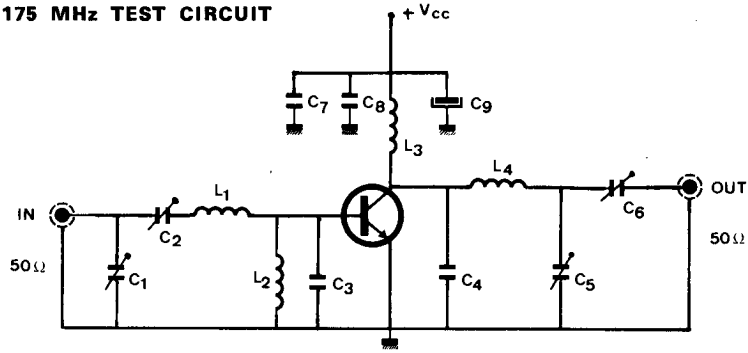
Safe Operating Area



Collector Base Capacitance



175 MHz TEST CIRCUIT



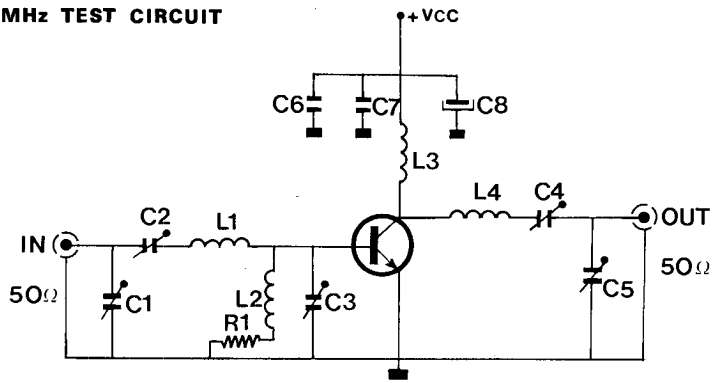
C_1 = ARCO 403 trimmer capacitor
C_2 = C_5 = ARCO 423 trimmer capacitor
C_3 = 200 pF mica capacitor UNELCO
C_4 = 150 pF mica capacitor UNELCO
C_6 = ARCO 425 trimmer capacitor
C_7 = 1000 pF mica capacitor UNELCO
C_8 = 0.1 µF ceramic disc
C_9 = 47 µF/63 V electrolytic

L_1 = 3 turns 15/10 mm silvered wire 6 mm I.D.
L_2 = 0.47 µH molded coil
L_3 = 6 turns 10/10 mm enameled wire wound on R_1

L_4 = 1 turns 15/10 mm silvered wire 6 mm I.D.

R_1 = 380 ohms 2 W carbon composition

88 MHz TEST CIRCUIT

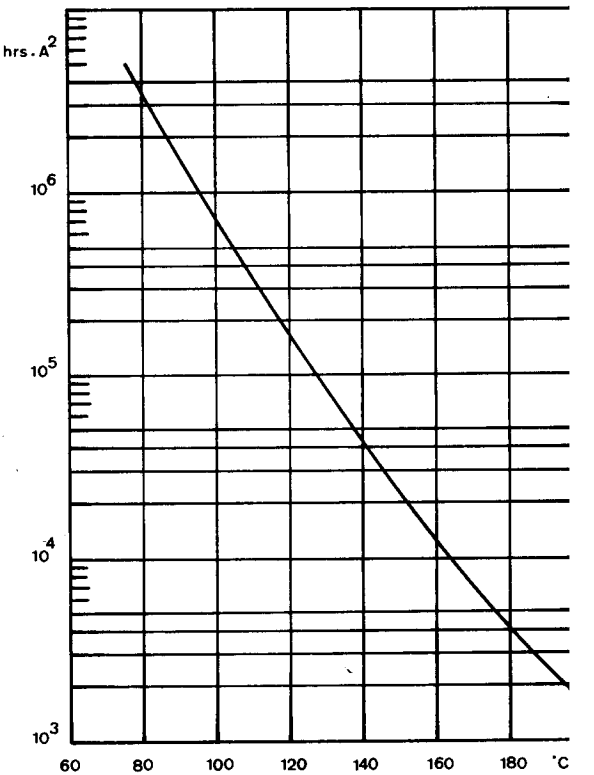


C_1 = C_4 = ARCO 425 24-200 pF trimmer capacitor
C_2 = ARCO 423 7-100 pF trimmer capacitor
C_3 = C_5 = ARCO 427 55-300 pF trimmer capacitor
C_6 = 1000 pF mica capacitor
C_7 = 10 nF ceramic
C_8 = 100 µF/35 V electrolytic

L_1 = 5 turns ≠ 14 AWG 3/8" I.D.
L_2 = 1 µH
L_3 = 9 turns ≠ 16 AWG 5/16" I.D.
L_4 = 4 turns ≠ 14 AWG 3/8" I.D.

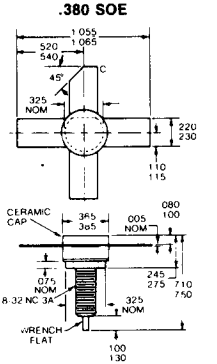
R_1 = 2.4 Ω

MTTF Factor vs Junction Temperature



PACKAGE OUTLINE

.380 SOE



RF Power Transistor

2.5 W - 175 MHz
12.5 V

The TP 2310 is designed for use in 12.5 V VHF applications and is ideally suited for use in the predriver or driver stage of a power amplifier where high gain is required.



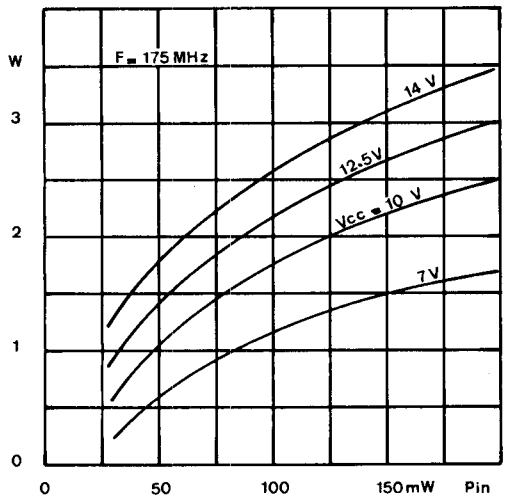
TO 39

Electrical Characteristics (T_{case} = 25 °C)

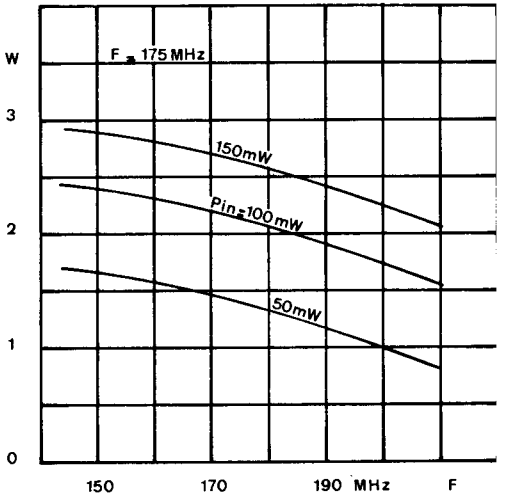
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 25 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdwon Voltage	I_C = 5 mA I_E = 0	35			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 100 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 150 mW	2.5			W
	η_c	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 25 W				%
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 150 mW		1.41 —j 10.62		Ω
	Z_{Load}	Common Emitter Amplifier Loac Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 2.5 W		38.3 + j 28.8		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		5	7	pF
Operating	I_C	Continous Collector Current				0.7	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			23.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			7.5	W

TYPICAL CHARACTERISTICS

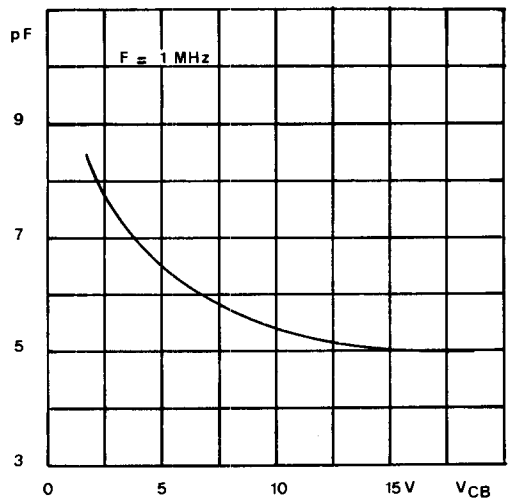
Output Power vs Input Power and Voltage Supply



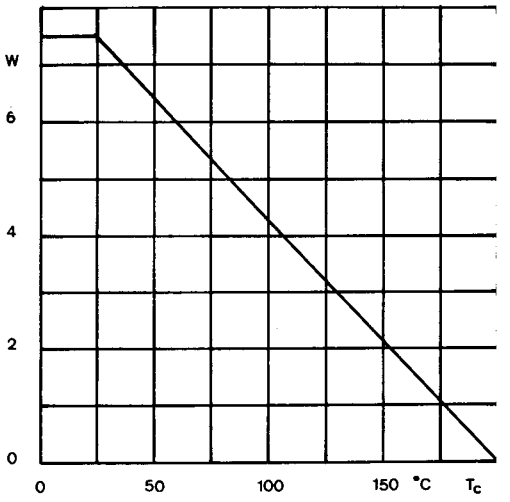
Output Power vs Frequency and Input Power



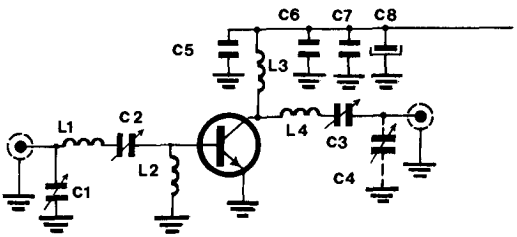
Collector Base Capacitance



Power - Temperature Derating Curve



POWER GAIN TEST CIRCUIT



COMPONENTS

C_1-C_2-C_3	24/200 pF ≠ trimmer capacitor
C_4	7/100 pF trimmer capacitor
C_5	1000 pF
C_6	10000 pF
C_7	0.1 µF
C_8	100 µF/35 V
L_1-L_4	4 turns ≠ 14 AWG 1/2" I.D.
L_2	0.47 µH
L_3	6 turns 14 AWG 1/2" I.D. close wound

RF Power Transistor

3 W - 175 MHz
12.5 V

The TP 2312 is designed for 6 V to 12 V VHF applications and is intended for class A, B or C medium power amplifiers, frequency multioliers or oscillator circuits.

Its grounded emitter construction gives excellent thermal dissipation and the ability of providing further heatsinking where necessary the case also acts as a good RF screen.

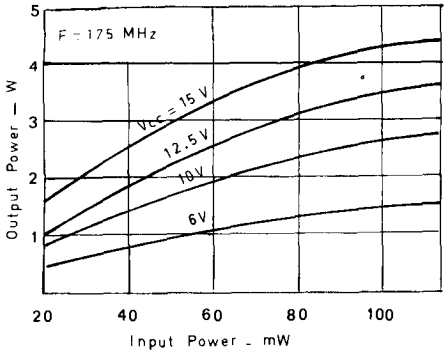
This device features high gain and an infinite VSWR rating at all phase angles at rated power output.

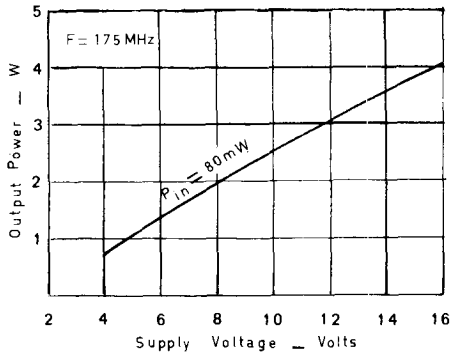


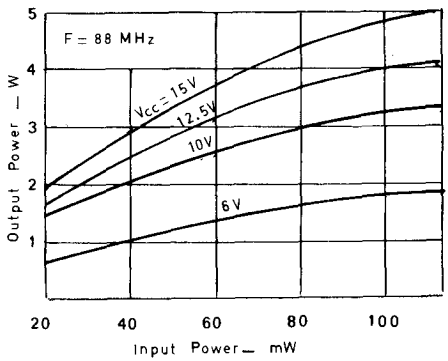
TO 39 GE

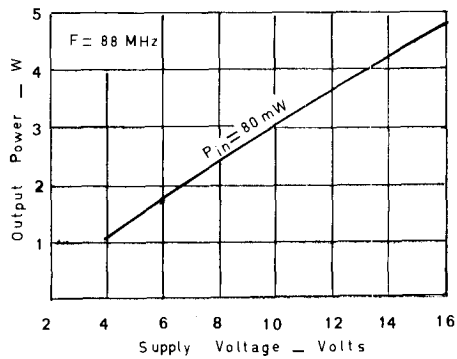
Electrical Characteristics (T_{case} = 25 °C)

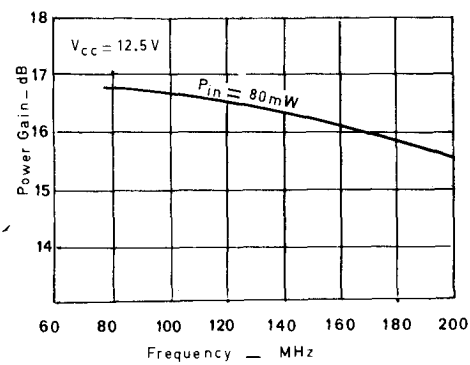
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 25 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 5 mA I_E = 0	35			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 100 mA	20	70		—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 80 mW V_{CE} = 6 V F = 175 MHz P_{in} = 80 mW V_{CE} = 12.5 V F = 88 MHz P_{in} = 80 mW	2.75 1 3	3 1.3 3.5		W
	η_i	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 3 W	60	68		%
	Load VSWR	Mismatch Tolerance	All Phase Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 2.75 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 80 mW F = 88 MHz		2.9 + j 4.36 2.94 — j 7.67		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 3 W F = 88 MHz		25.1 + j 10.2 29 + j 18.4		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz		5.5	7	pF
Operating	I_C	Continous Collector Current				0.7	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			25	°C/W
	T_{STG}	Storage Temperature and Junction Temperature	-	— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			7	W

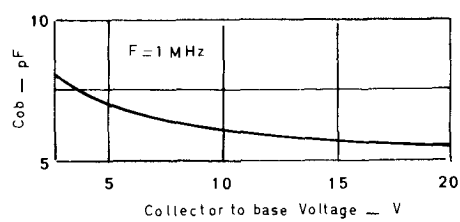


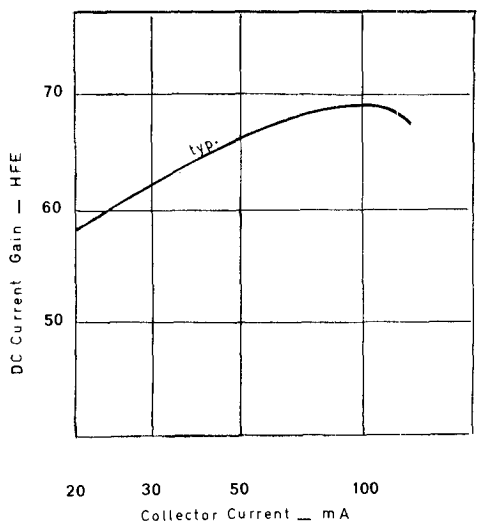






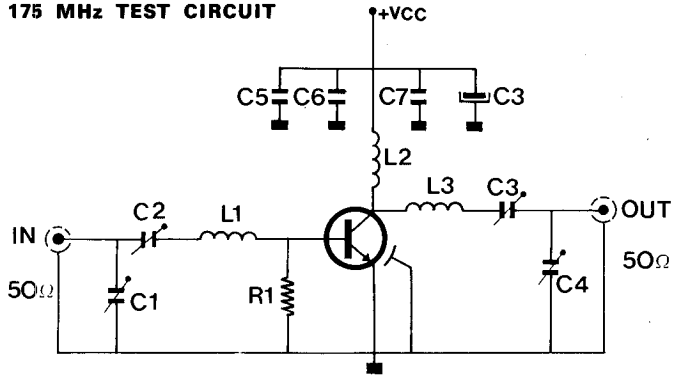






NOTA : TYPICAL CHARACTERISTICS

175 MHz TEST CIRCUIT



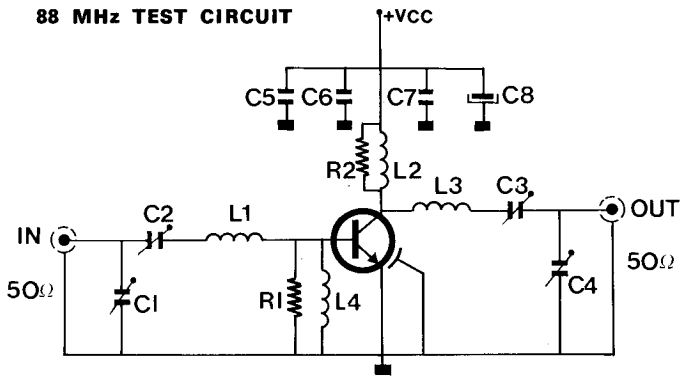
$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 47 µF electrolytic

$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.

R_1 = 47 ohms - 1/2 W - carbon composition

NOTA : CASE MUST BE GROUNDED

88 MHz TEST CIRCUIT



$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 47 µF electrolytic

$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_4 = 0.45 µH - molded coil
R_1 = 47 ohms - 1/2 W

R_2 = 220 ohms - 1/2 W

NOTA : CASE MUST BE GROUNDED

RF Power Transistor

4 W - 175 MHz
12.5 V

The TP 2314 is designed for 6 V to 12 V VHF applications and is intended for class A, B or C medium power amplifiers, frequency multipliers or oscillator circuits.

Its grounded emitter constructions gives excellent thermal dissipation and the ability of providing further heatsinking where necessary.

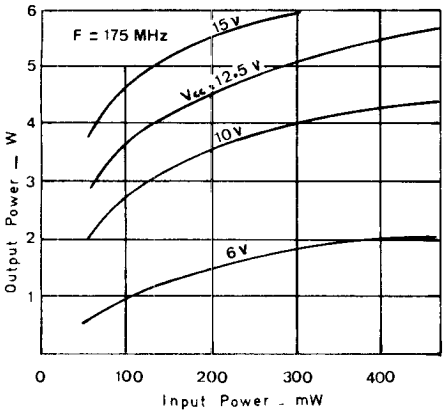
The case also acts as a good RF screen this device features high gain and an infinite VSWR rating at all phase angles at rated power output.

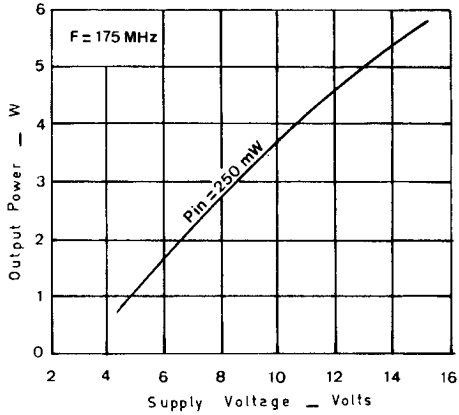


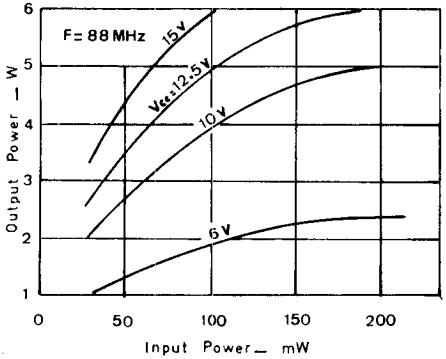
TO 39 GE

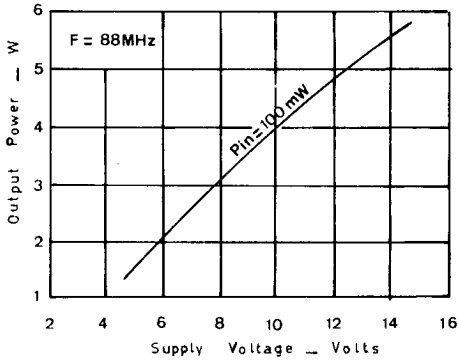
Electrical Characteristics (T_{case} = 25 °C)

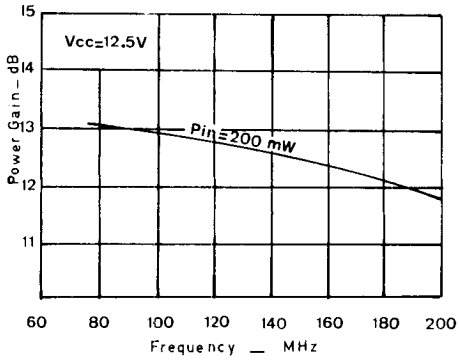
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdwon Voltage	I_E = 2 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA I_E = 0	36			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 200 mA	20	40		—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 250 mW V_{CE} = 6 V F = 175 MHz P_{in} = 250 mW V_{CE} = 12.5 V F = 88 MHz P_{in} = 250 mW	4 1 4	4.8 1.6 4.8		W
	η_i	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 4 W	55	64		%
	Load VSWR	Mismatch Tolerance	All Phase Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 4 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 250 mW F = 88 MHz		4.33 — j 3.69 4.5 — j 4.8		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 4 W F = 88 MHz		15.96 + j 4.13 18.74 + j 6.44		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz		12	15	pF
Operating	I_C	Continous Collector Current				1	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			20	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			8	W

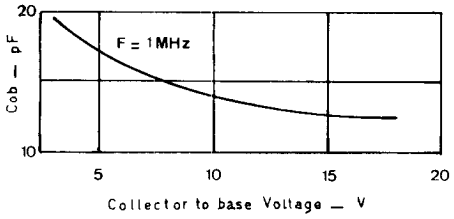


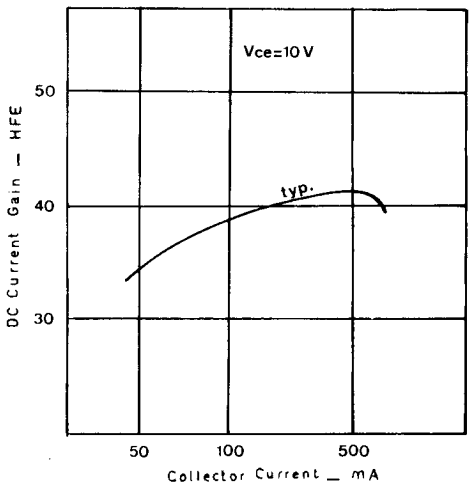






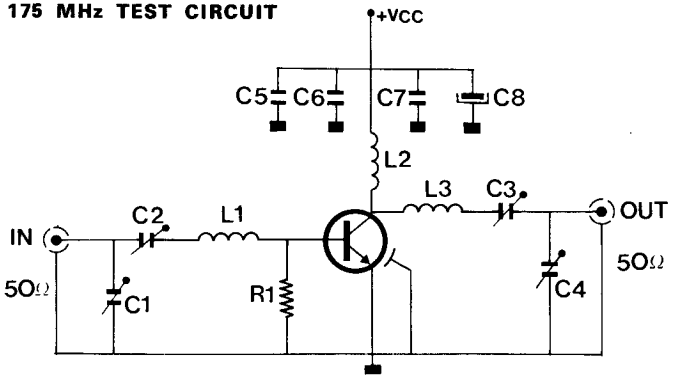






NOTA : TYPICAL CHARACTERISTICS

175 MHz TEST CIRCUIT



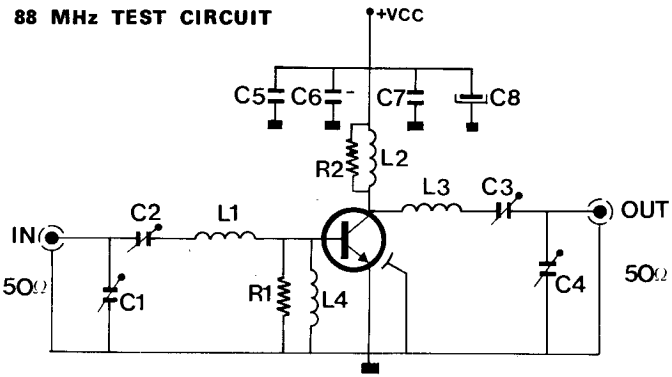
$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 47 µF electrolytic

$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.

R_1 = 47 ohms - 1/2 W - carbon composition

NOTA : CASE MUST BE GROUNDED

88 MHz TEST CIRCUIT



$C_1 = C_2 = C_3 = C_4$ = ARCO 404 7-60 pF trimmer capacitor
C_5 = 1000 pF mica capacitor
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 47 µF electrolytic
$L_1 = L_3$ = 2.5 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_2 = 3 turns - silvered wire ⌀ 1.5 mm - 10 mm I.D.
L_4 = 0.47 µF - molded coil
R_1 = 47 ohms - 1/2 W
R_2 = 220 ohms - 1/2 W

NOTA : CASE MUST BE GROUNDED

RF Power Transistor

20 W - 175 MHz

12.5 V

The TP 2320 is designed for use in 12.5 V VHF amplifiers operating under class A, B or C conditions.

Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to be used at its maximum ratings and be able to withstand an infinite VSWR at all phase angles.



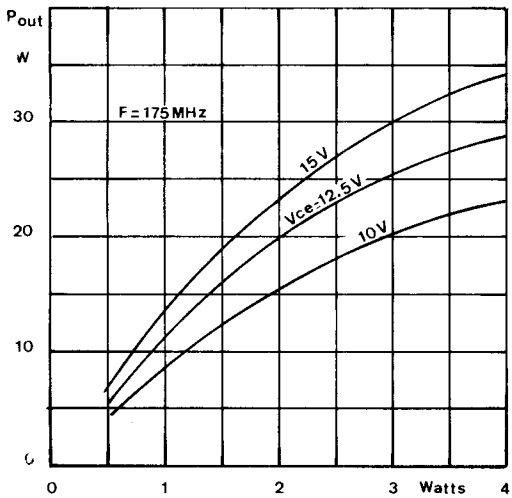
380 SOE

Electrical Characteristics (T_{CASE} = 25 °C)

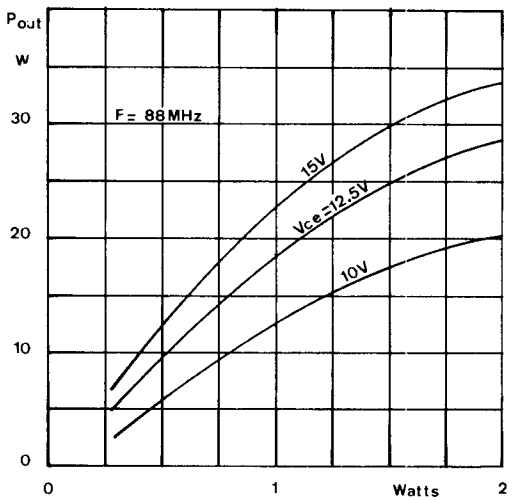
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	18			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA I_E = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			2	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 500 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 175 MHz P_{in} = 3 W V_{CE} = 12.5 V F = 88 MHz P_{in} = 1.5 W	17 17	20 20		W
	η	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 20 W	50			%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 17 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{in} = 3 W		2 + j 1.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 20 W		4.2 + j 0.7		Ω
	C_{OB}	Collector - Base Capacitance	V_{CE} = 20 V F = 1 MHz I_E = 0		55	70	pF
Operating	I_C	Continous Collector Current				6	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			3.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		+200°	°C
	P_D	Power Dissipation	T_C = 25 °C			50	W

TYPICAL CHARACTERISTICS

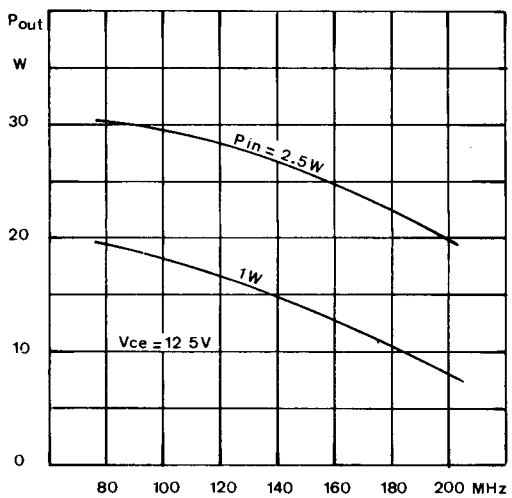
Output power vs input power and voltage supply



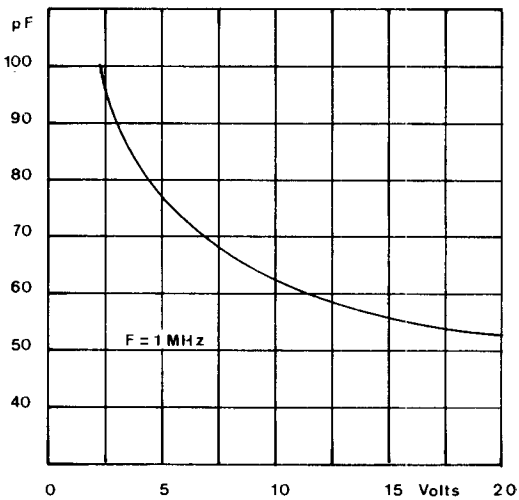
Output power vs input power and voltage supply



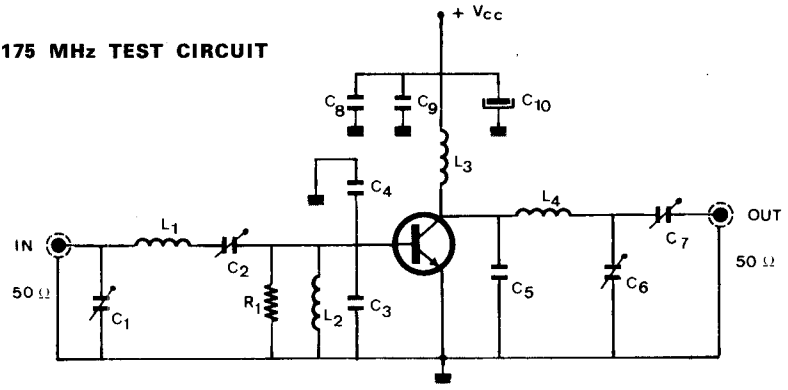
Output power vs frequency and input power



Coll. base capacitance



175 MHz TEST CIRCUIT



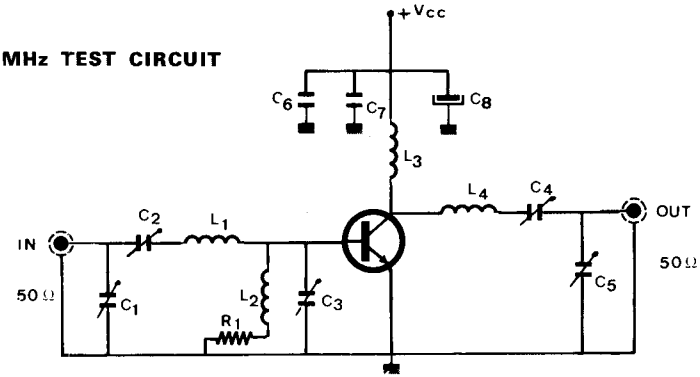
C_1 = ARCO 423 - 7-100 pF trimmer capacitor
C_2 = ARCO 423
C_3 = C_4 = 80 pF mica capacitor UNELCO
C_5 = 100 pF mica capacitor UNELCO
C_6 = C_7 = ARCO 423
C_8 = 1000 pF mica capacitor UNELCO
C_9 = 1000 pF ceramic disc
C_{10} = 47 µF electrolytic

L_1 = 3 turns 12/10 mm silvered wire - 6 mm I.D.

L_2 = 1 µH molded coil
L_3 = 3 turns 12/10 mm silvered wire - 6 mm I.D.
L_4 = 2 turns 12/10 mm silvered wire - 6 mm I.D.

R_1 = 150 ohms

88 MHz TEST CIRCUIT

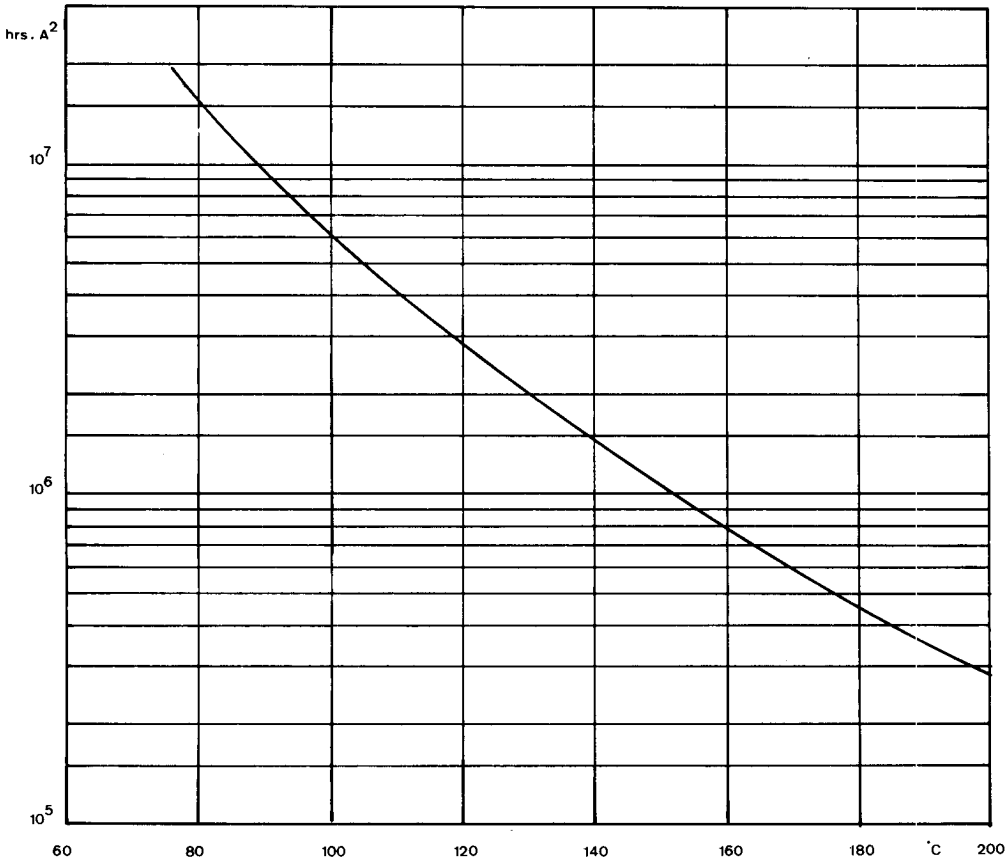


C_1 = C_4 = ARCO 425 24-200 pF trimmer capacitor
C_2 = ARCO 423 7-100 pF trimmer capacitor
C_3 = C_5 = ARCO 427 55-300 pF trimmer capacitor
C_6 = 1000 pF mica capacitor
C_7 = 10 nF ceramic
C_8 = 100 µF/35 V electrolytic

L_1 5 turns ≠ 14 AWG 3/8" ID
L_2 1 µH
L_3 9 turns ≠ 16 AWG 5/16" ID
L_4 4 turns ≠ 14 AWG 3/8" ID

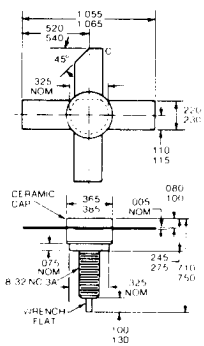
R_1 2.4 Ω

MTTF factor vs junction temperature



PACKAGE OUTLINE

.380 SOE



PRELIMINARY

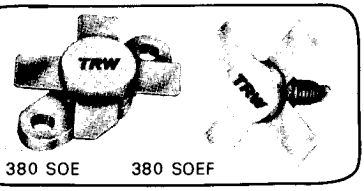
RF Power Transistor

30 W - 10 DB

175 MHz - 12,5 V

The TP 2330 is device intended for use in VHF transmitter output stages where a high gain is necessary.

Using the latest in technology and manufacturing processes from TRW, excellent gain and high saturated output power has been achieved enabling a 30 W transmitter to be designed using only a TO 39 as driver.



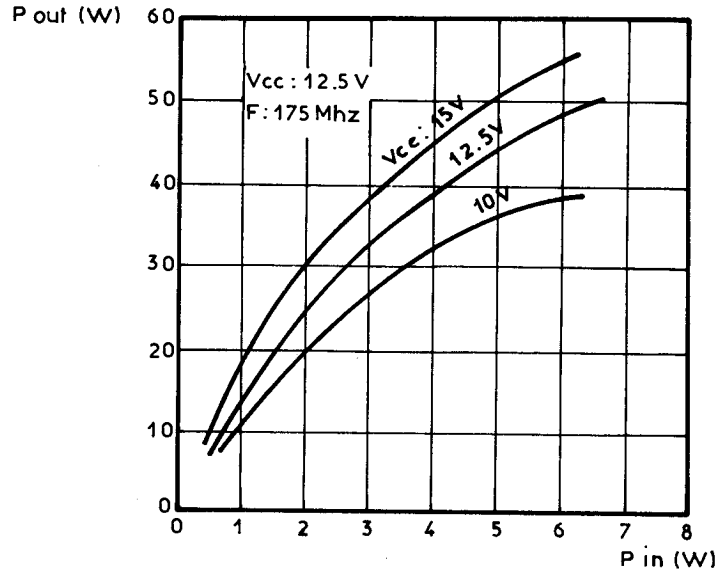
380 SOE 380 SOEF

Electrical Characteristics (T_{case} = 25 °C)

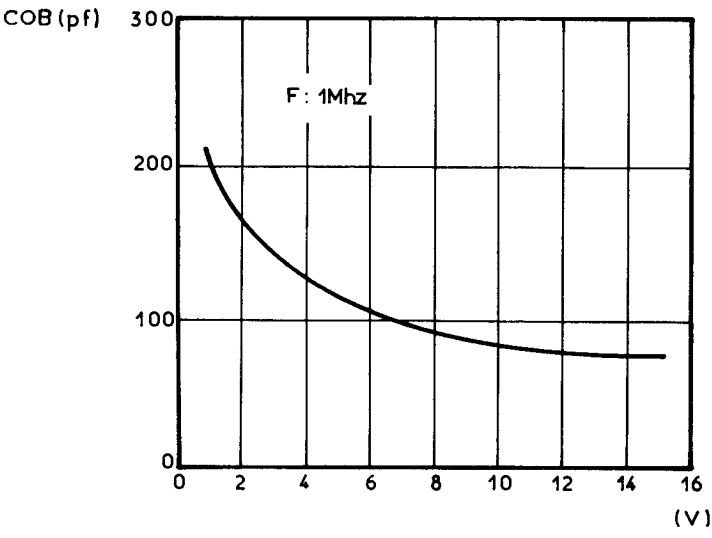
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_c = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_c = 50 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_c = 50 mA I_E = 0	36			V
	I_{CES}	Collector - Emitter Cutoff - Current	V_{CE} = 15 V			10	mA
	H_{FE}	DC Current Gain	V_{CE} = 5 V I_c = 1 A	20		150	
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V P_{in} = 3 W F = 175 MHz P_{in} = 3.8 W (F)	30 30			W
	η_i	Efficiency	V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W	60			%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W		1.05 + j 0.5		
	Z_{LOAD}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 175 MHz P_{out} = 30 W		2.7 + j 0.2		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		70	100	pF
	I_c	Continuous Collector Current				8	A
Thermal	θ_{j-c}	Thermal Resistance	T_c = 25 °C			2.2	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65		+ 200	°C
	P_D	Power Dissipation	T_C = 25 °C			80	W

TYPICAL CHARACTERISTICS

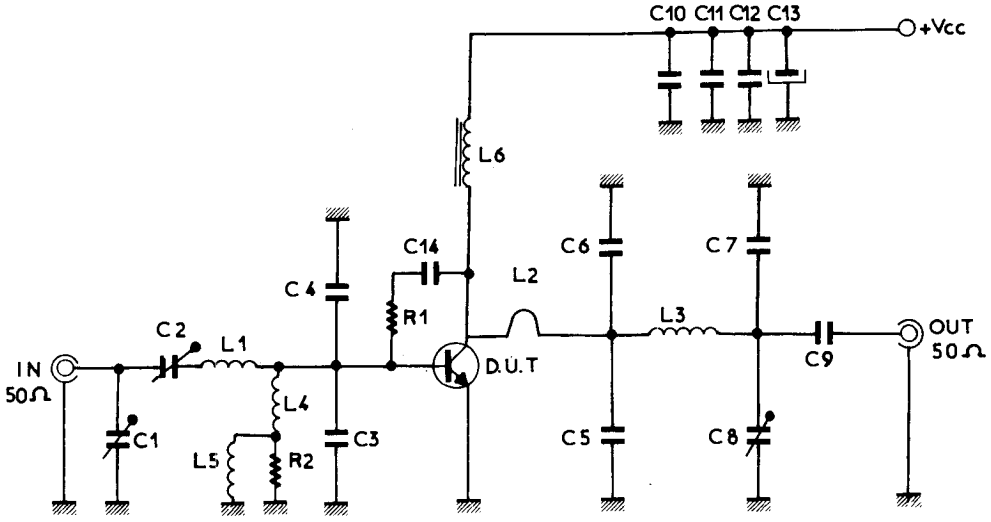
TP 2330 Output Power vs Frequency



Collector base capacitance vs voltage



TP 2330 (F) 175 MHz test circuit



Components List

$C_1 = C_2$	=	100 pF ARCO 423 trimmer capacitor
C_3	=	200 pF UNELCO mica capacitor
C_4	=	150 pF UNELCO mica capacitor
C_5	=	120 pF UNELCO mica capacitor
C_6	=	100 pF UNELCO mica capacitor
C_7	=	25 pF UNELCO mica capacitor
C_8	=	40 pF ARCO 403 trimmer capacitor
C_9	=	1 000 pF ceramic disc capacitor
C_{10}	=	1 000 pF UNELCO mica capacitor
$C_{11} = C_{14}$	=	100 nF ceramic capacitor
C_{12}	=	10 nF ceramic capacitor
C_{13}	=	47 µF 25 V electrolytic capacitor

L_1	= 3 turns — 1 mm enameled wire. ID = 6 mm
L_2	= Copper lead 8 × 6 mm
L_3	= 1.5 mm wire — 30 mm length
L_4	= 6 turns — 1 mm enameled wire. ID = 6 mm
L_5	= 10 uH molded coil
L_6	= 8 turns enameled wire wound on ferrite core 4C6 9 × 15 mm. ur = 120

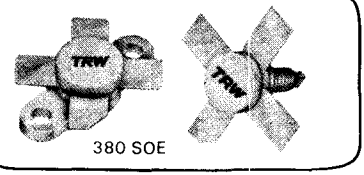
R_1	= 100 Ω 1 W Carbon composition resistor.
R_2	= 10 Ω 1/2 W Carbon composition resistor

RF Power Transistor

50 W - 175 MHz
28 V

The TP 2404 is designed for use in 28 V FM or 12.5 V AM VHF amplifiers operating under class A, B or C conditions.

Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to be used at its maximum ratings and be able to withstand an infinite VSWR at all phase angles.

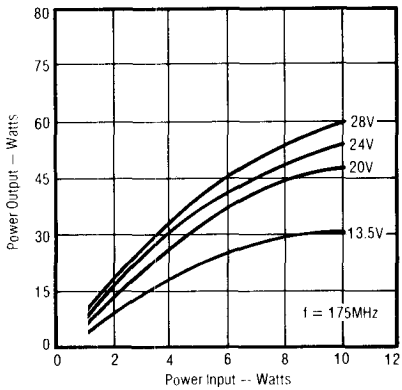


380 SOE

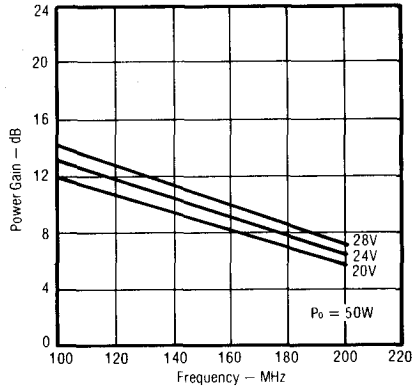
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 25 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 100 mA I_B = 0	35			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 100 mA I_E = 0	65			V
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	10			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 28 V F = 175 MHz P_{in} = 9 W	50			W
	η	Efficiency	V_{CE} = 28 V F = 175 MHz P_{out} = 50 W	65	70		%
	Load VSWR	Mismatch Tolerance	All phases Angles V_{CE} = 28 F F = 175 MHz P_{out} = 50 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 28 V F = 175 MHz P_{in} = 9 W		1 + j 1.3		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 28 V F = 175 MHz P_{out} = 50 W		8 + j 3		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz			90	pF
Operating	I_C	Continous Collector Current				8	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			1.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			115	W

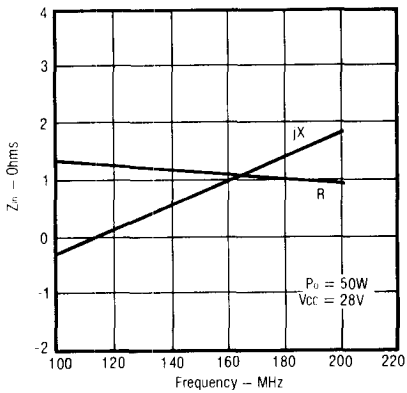
Power Output vs Power Input



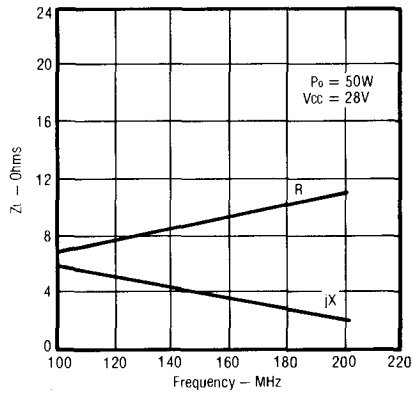
Power Gain vs Frequency



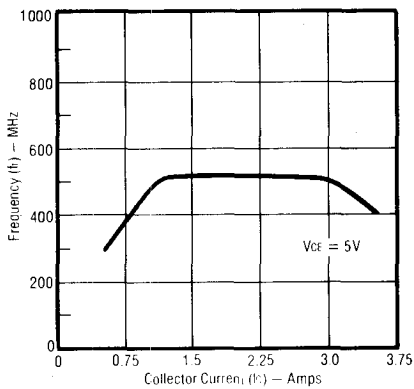
Series Input Impedance vs Frequency



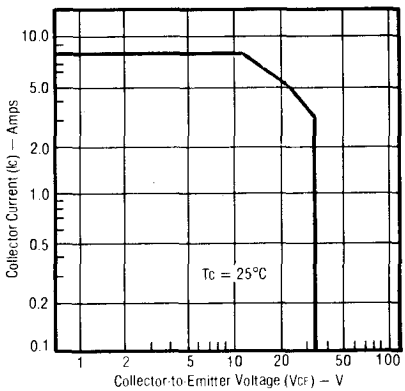
Series Load Impedance vs Frequency



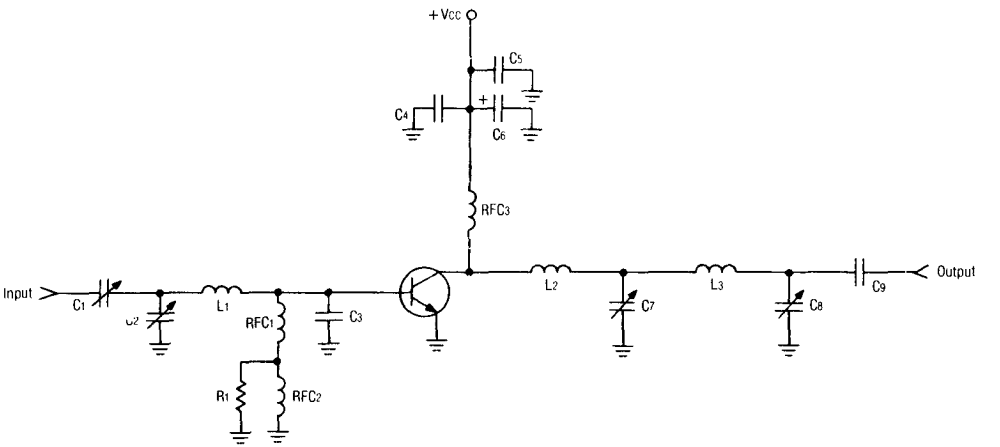
f_t vs I_C



Safe Operating Area



175 MHz TEST CIRCUIT



$C_{1,2,8}$ 8-60 pF ARCO # 404
C_3 150 pF UNELCO
C_4 500 pF UNELCO
C_5 0.1 mF disc capacitor
C_6 5 mF 50 V electrolytic
C_7 5-80 pF ARCO # 462
C_9 0.001 mF disc capacitor
L_1 1 turn, 0.1" wide by 0.02" thick copper strip, 5/16" I.D.

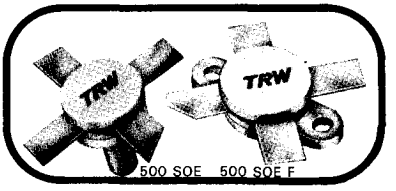
L_2 U-shaped copper strip, 0.1" wide by 0.02" wide thick
0.25" high by 0.675" long
L_3 1-1/2 turns, 0.1" wide by 0.02" thick copper strip, 5/16" I.D.
R_1 10 ohms, 0.5 W carbon resistor
RFC_1 150 nH molded inductor
RFC_2 10.000 nH molded inductor
RFC_3 4 turns # 16 AWG, 5/16" I.D.

RF Power Transistor

90 W - 175 MHz
27 V

The TP 2405 is designed for use in 28 V FM and 12.5 V AM VHF amplifiers operating under class A, B or C conditions.

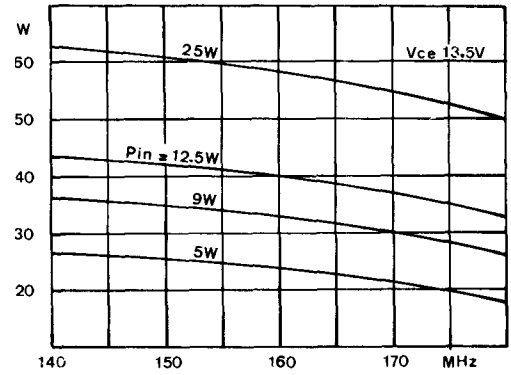
Its construction which incorporates gold metalization and diffused ballast resistors for longer life, enables the part to withstand an infinite VSWR at all phase angles.



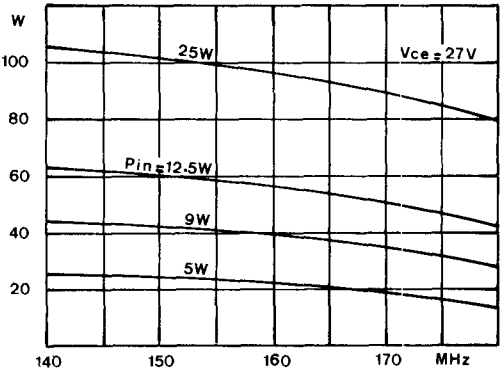
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 100 mA I_B = 0	35			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 100 mA I_E = 0	65			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 30 V I_E = 0			2	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 3 A	10			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 27 V F = 150 MHz P_{in} = 25 W V_{CE} = 27 V F = 150 MHz P_{in} = 12.5 W V_{CE} = 13.5 V F = 150 MHz P_{in} = 9 W	90 45 22.5	100 50 25		W
	η_i	Efficiency	V_{CE} = 27 V F = 150 MHz P_{out} = 100 W	60			%
	Load VSWR	Mismatch Tolerance	V_{CE} = 27 V P_{out} = 75 W All Phases F = 150 MHz P_{out} = 100 W		∞ : 1 10 : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 27 V F = 150 MHz P_{in} = 25 W		1 + j 5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 27 V F = 150 MHz P_{out} = 100 W		3 + j 1		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		115	150	pF
Operating	I_C	Continous Collector Current				10	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			1.25	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			140	W

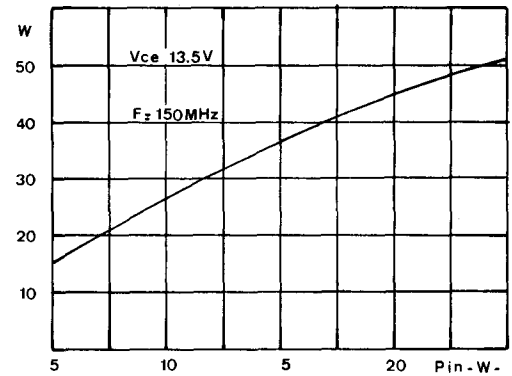
Output Power vs Frequency and Input Power



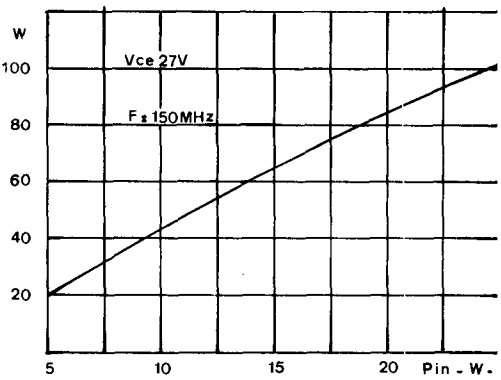
Output Power vs Frequency and Input Power



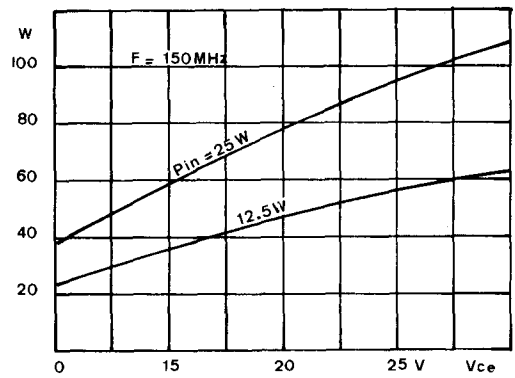
Output Power vs Input Power



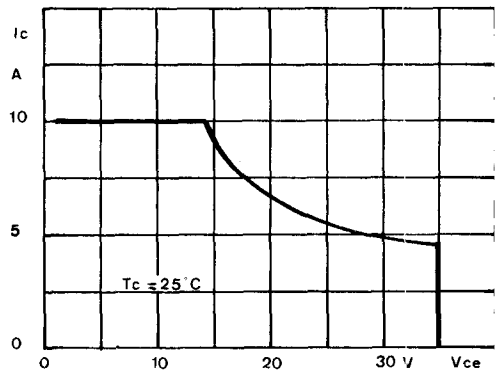
Output Power vs Input Power



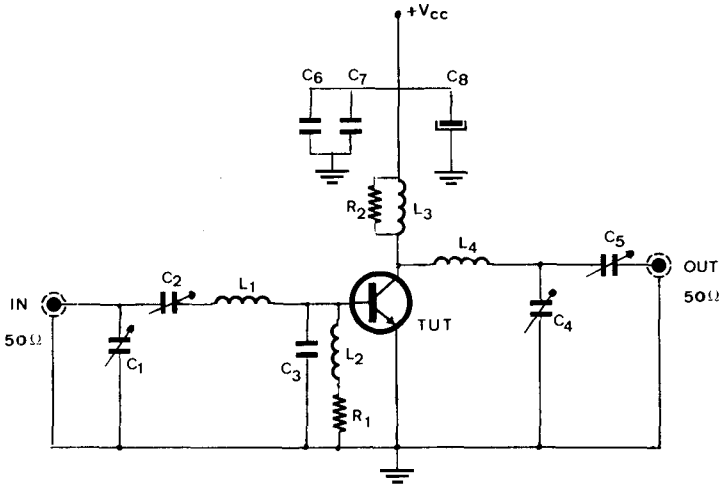
Output Power vs Voltage Supply and Input Power



Safe Operating Area



150 MHz TEST CIRCUIT SCHEMATIC



C_1 = C_4 = trimmer capacitor ARCO 423
C_2 = trimmer capacitor ARCO 425
C_3 = 250 pF mica capacitor UNELCO
C_5 = trimmer capacitor ARCO 404
C_6 = 1000 pF ceramic capacitor
C_7 = 10 nF ceramic capacitor
C_8 = 47 μF/63 V electrolytic

L_1 = 2 turns silvered wire 15/10 mm - 6 mm I.D.
L_2 = 0.15 μH molded coil
L_3 = 10 turns enameled wire 8/10 mm woud on R2
L_4 = copper strip 2 mm × 30 mm

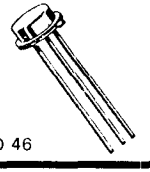
R_1 = 2.7 ohms 1/2 W carbon composition
R_2 = 1 K ohms 2 W carbon composition

RF Power Transistor

470 MHz - 12 V

The TP 2500 has been especially designed for use in 12,5 V VHF and UHF amplifiers where size is of prime importance.

Its low profile TO 46 and high gain makes it ideally suited for use in pocketphone and portable instrument applications.

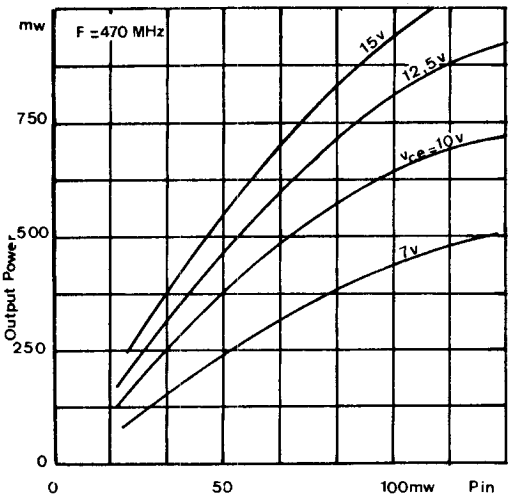


TO 46

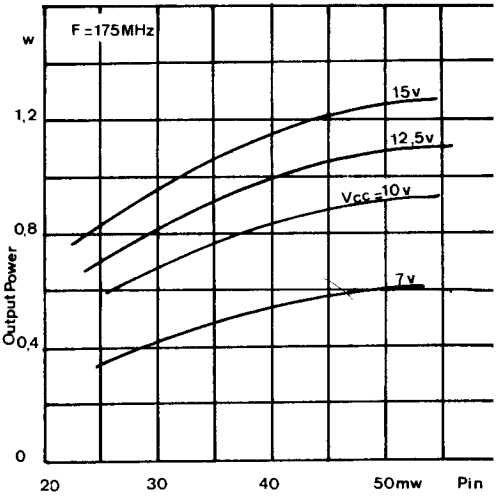
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 25 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown	I_C = 5 mA I_E = 0	35			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_B = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 100 mA	20	70		—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V P_{in} = 50 mW F = 470 MHz F = 175 MHz	0.35 0.9			W
	η_i	Efficiency	V_{CE} = 12.5 V F = 470 MHz P_{out} = 400 mW	60	70		%
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V P_{in} = 50 mW F = 470 MHz F = 175 MHz		4.35 + j 5.22 4.15 — j 3.76		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V P_{out} = 400 mW F = 470 MHz F = 175 MHz		26 + j 47.4 42.5 — j 68		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		5	7	pF
Operating	I_C	Continous Collector Current				0.7	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			87.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			2	W

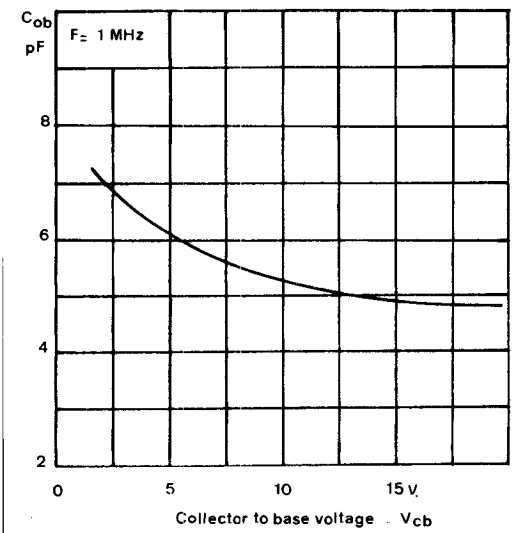
Output Power vs Input Power and Voltage Supply (AT 470 MHz)



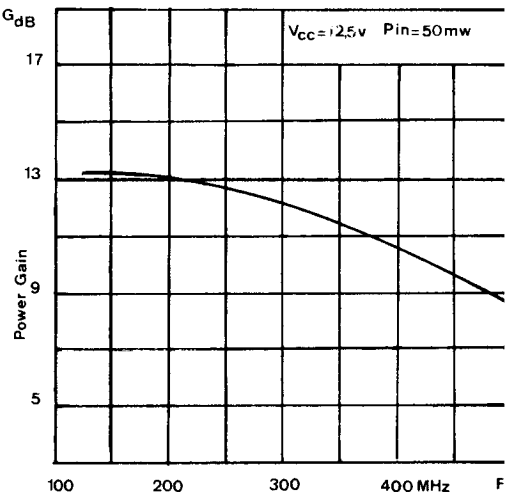
Output Power vs Input Power and Voltage Supply (AT 175 MHz)



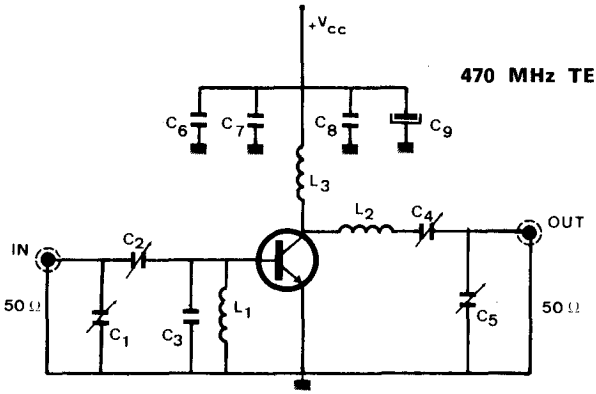
Collector Base Capacitance



Output Power vs Frequency

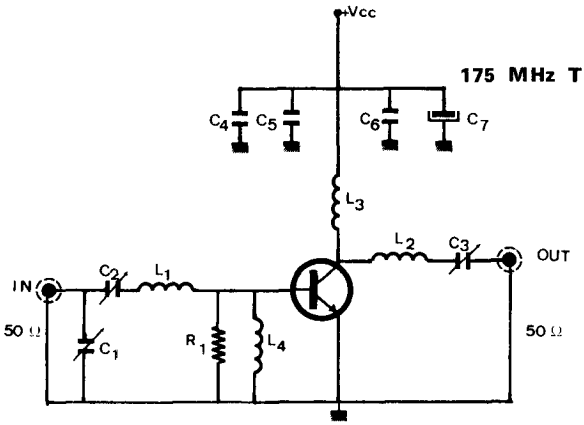


470 MHz TEST CIRCUIT



L_1 molded coil - 0,1 µH
L_2 = 1 turn silvered wire ⌀ 0.3 mm - 4 mm I.D.
L_3 = 2.5 turns silvered wire ⌀ 0.3 mm - 4 mm I.D.
C_1 = C_4 = ARCO 402 - 1.5-20 pF - trimmer capacitor
C_2 = ARCO 403 - 4-40 pF - trimmer capacitor
C_5 = ARCO 400 - 0.9-7 pF - trimmer capacitor
C_3 = Chip ATC - 39 pF
C_6 = 1000 pF - mica capacitor
C_7 = 680 nF - ceramic disc
C_8 = 0.1 µF - ceramic disc
C_9 = 10 µF - electrolytic

175 MHz TEST CIRCUIT



L_1 = 2 turns silvered wire - ⌀ 0.8 mm - 6 mm I.D.
L_2 = 4 turns silvered wire - ⌀ 0.8 mm - 6 mm I.D.
L_3 = 3 turns silvered wire - ⌀ 0.8 mm - 6 mm I.D.
L_4 = molded coil - 0.1 µH
R_1 = 22 ohms - 1/2 W - carbon composition
C_1 = C_2 = ARCO 425 - 24-200 pF - trimmer capacitor
C_3 = ARCO 427 - 55-300 pF - trimmer capacitor
C_4 = 1000 pF - mica capacitor
C_5 = 10 nF - ceramic disc
C_6 = 0.1 µF - ceramic disc
C_7 = 10 µF - electrolytic

RF Power Transistor

5 W - 470 MHz
12.5 V

The TP 2503 is designed for 12.5 V VHF and UHF amplifiers.

Its high gain at reduced voltage and stripline package make it suitable for use in pocketphone applications.

The power output is useable to the top of its ratings and it is able to withstand an infinite VSWR at all phase angles at rated output power.

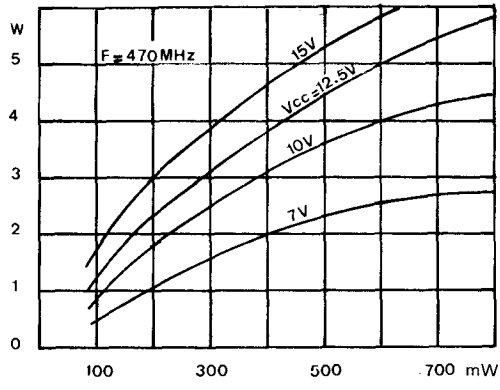


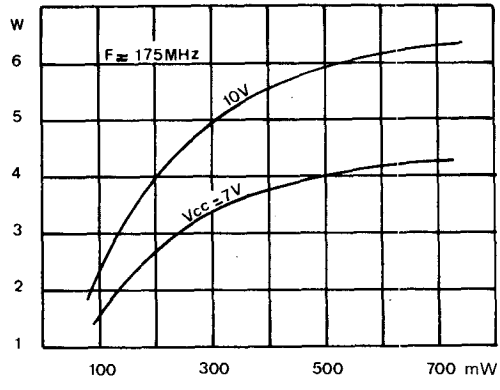
280 SOE STUDLESS

Electrical Characteristics (T_{case} = 25 °C)

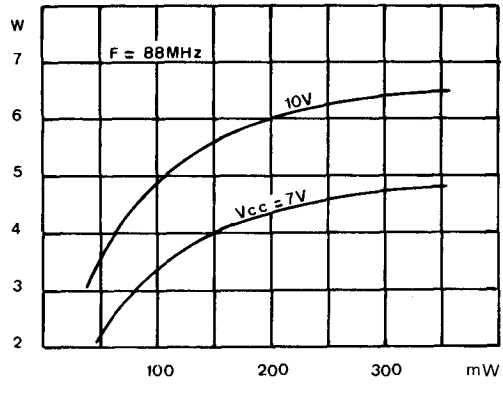
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 2 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	16			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA I_E = 0	36			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			1	mA
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 200 mA	20			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.7 W V_{CE} = 9.5 V F = 175 MHz P_{in} = 0.4 W V_{CE} = 9.5 V F = 88 MHz P_{in} = 0.2 W	5 5 5	5.5 5.5 6		W
	η	Efficiency	V_{CE} = 12.5 V F = 470 MHz P_{out} = 2 W	55			%
	Load VSWR	Mismatch Tolerance	All Phases Angles V_{CE} = 12.5 V F = 470 MHz P_{out} = 5 W		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V F = 470 MHz P_{in} = 0.7 W		1.6 + j 3.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V F = 470 MHz P_{out} = 5 W		9.55 + j 5.75		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		13	17	pF
Operating	I_C	Continous Collector Current				1.7	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			10	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			17.5	W

Output Power vs Input Power and Voltage Supply

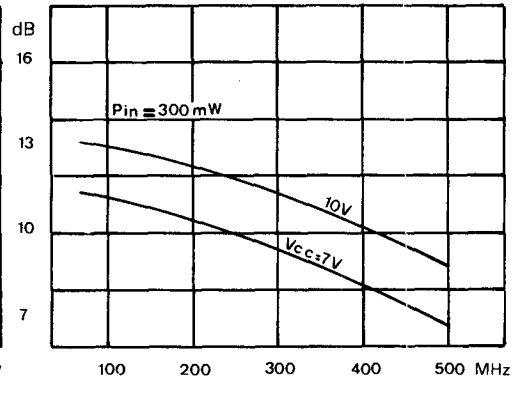




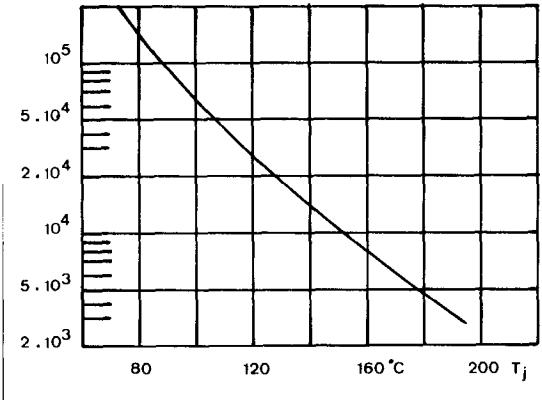
Output Power vs Input Power and Voltage Supply



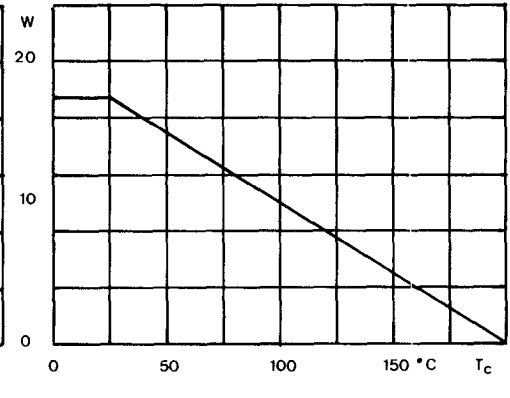
Power Gain vs Frequency and Voltage Supply



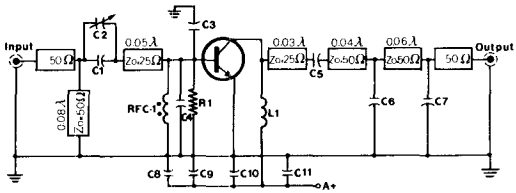
MTTF Factor vs Junction Temperature



Power - Temperature Operating Curve



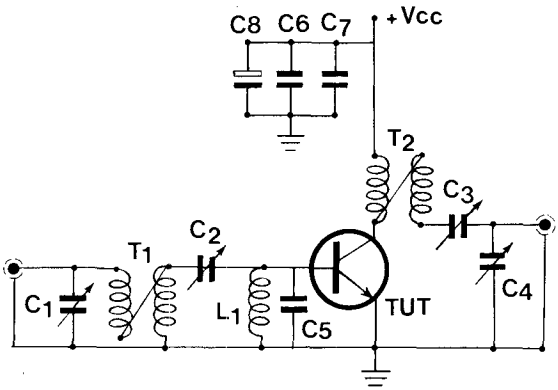
TEST CIRCUIT BROADBAND (450-510 MHz)



COMPONENT AND MATERIAL LIST

C_1 3,9 pF, ceramic chip
C_2 0.8-10 pF, Voltronics AP 10, variable
C_3, C_4 25 pF, ceramic chip
C_5 1500 pF, ceramic chip
C_6 10 pF, Underwood
C_7 5 pF, Underwood
C_8 0.01 µF, disc-ceramic
C_9 0.10 µF, disc-ceramic
C_{10} 1000 pF, Underwood
C_{11} 5 µF, electrolytic
L_1 4 turns, # 22 enameled, 0.1" I.D.
R_1 750 Ω, ½ watt, carbon
RFC-1 2½ turns # 22 AWG on Ferroxcube VK211/17-4B
All transmission lines reference at 480 MHz

175 MHz TEST CIRCUIT

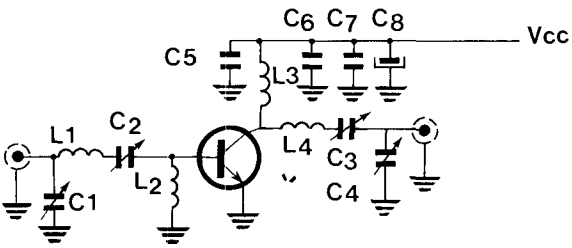


$C_1 = C_2 = C_4$ = 7-100 pF ARCO 423
C_3 = 24-200 pF ARCO 425
C_5 = 150 pF mica capacitor UNELCO
C_6 = 1000 pF mica capacitor UNELCO
C_7 = 10 nF ceramic disc
C_8 = 47 µF/63 V electrolytic

L_1 = 10 µH Molded Coil

$T_1 = T_2$ = Transmission Line Transformers 2 wires 8/10 mm twisted - 5 cm length

88 MHz TEST CIRCUIT



$C_1 = C_2 = C_3$ = 24-200 pF ARCO 425
C_4 = 7-100 pF ARCO 423
C_5 = 1000 pF mica capacitor UNELCO
C_6 = 10 nF ceramic disc
C_7 = 0.1 µF ceramic disc
C_8 = 100 µF/35 V electrolytic

$L_1 = L_4$ = 4 turns 14 AWG 1/2" I.D.
L_2 = 0.47 µH
L_3 = 6 turns 14 AWG 1/2" I.D. Close Wound

RF TRANSISTOR

10 W - 88 MHz - 12 V

NPN SILICON

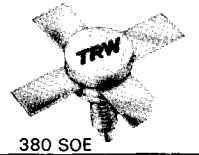
Designed for 12.5 V VHF amplifiers. Class B or C operation.

12.5 V characteristics :

Output power 88 MHz - 8 W min.

Minimum gain at 88 MHz - 10 dB.

Power output useable to the top ratings and capable of withstanding infinite VSWR at all phase angles.

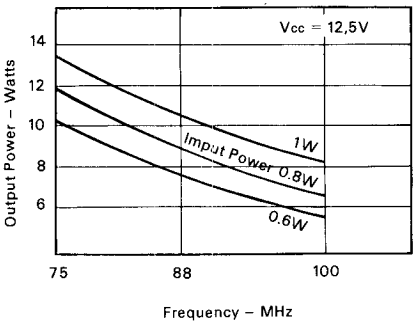


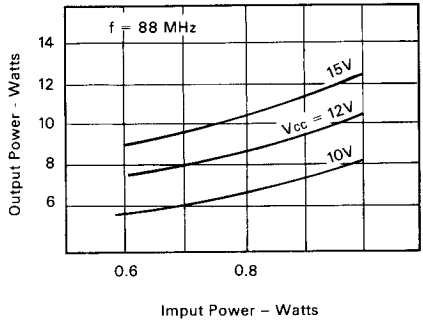
380 SOE

Electrical Characteristics (T_{flange} = 25 °C)

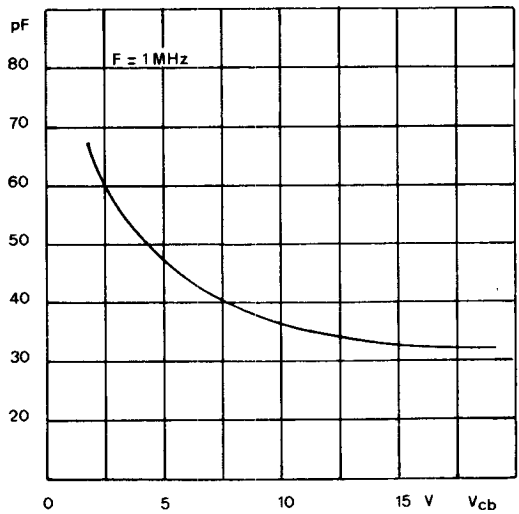
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_B = 1 mA I_C = 0	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA I_B = 0	20			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 3 mA I_E = 0	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 15 V I_E = 0			2	mA
	H_{FE}	D.C Current Gain	V_{CE} = 10 V I_C = 100 mA	15			—
RF Test	P_{GAIN}	Power Gain	V_{CE} = 12.5 V P_{in} = 1.2 W F = 88 MHz	10			W
	η	Efficiency	V_{CE} = 12.5 V P_{out} = 20 W F = 88 MHz	60			%
	Load VSWR	Mismatch Tolerance	V_{CE} = 12.5 V P_{out} = 10 W F = 88 MHz		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CE} = 12.5 V P_{in} = 1.2 W F = 88 MHz		4 + j 1.5		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CE} = 12.5 V P_{out} = 10 W F = 88 MHz		6.48 + j 0.88		Ω
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V F = 1 MHz		35	50	pF
Operating	I_C	Continous Collector Current				2	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			7	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65°		200°	°C
	P_D	Power Dissipation	T_C = 25 °C			25	W

Typical RF Characteristics

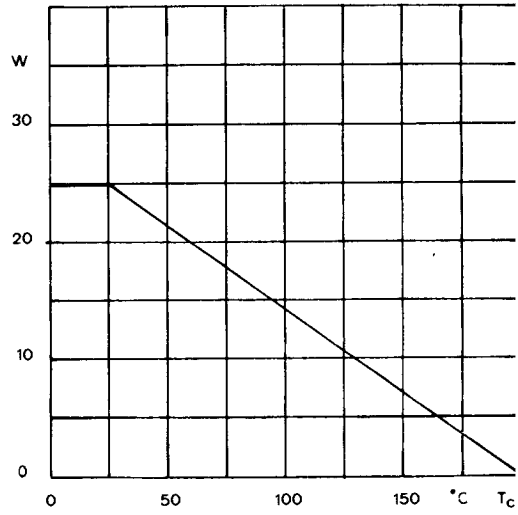




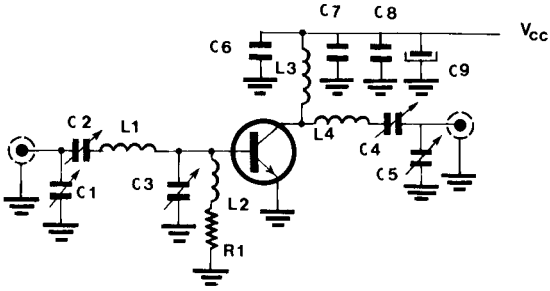
Collector Base capacitance



Power - Temperature Derating Curve



88 MHz TEST CIRCUIT



C_1-C_4 = 24/200 pF Trimmer capacitor
C_2 = 7/100 pF Trimmer capacitor
C_3-C_5 = 55/300 pF Trimmer capacitor
C_6 = 1000 pF
C_7 = 10000 pF
C_8 = 0,1 μF
C_9 = 100 μF/35 V

L_1 = 5 turns # 14 AWG 3/8" ID
L_2 = 1 μH
L_3 = 9 turns # 16 AWG 5/16" ID
L_4 = 4 turns # 14 AWG 3/8" ID

R_1 = 2,4 Ω

PRELIMINARY

RF Power Transistor

30 W - 175 MHz
12,5 V
20 DB GAIN

The TPS 175 is one of a new generation of Mobile devices which aim to simplify the design of mobile radio transmitters.
This device, which offers the user a 2 stage high gain broadband amplifier, is no more that the standard size transistor package, allows the user a much greater design flexibility than when using a module in that he has control over the input and output matching networks and can thus optimize performance at the desired operating point.

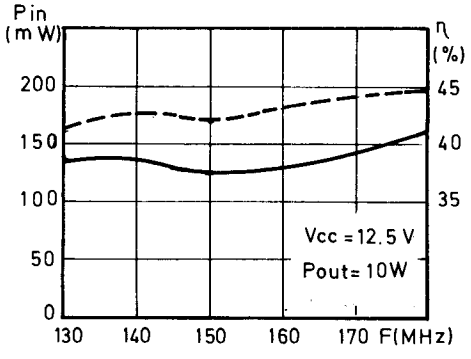


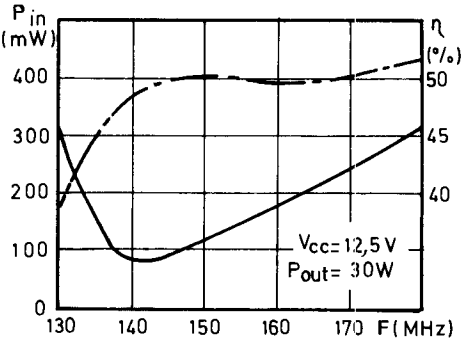
TPS 175

Electrical Characteristics (T_{case} = 25 °C)

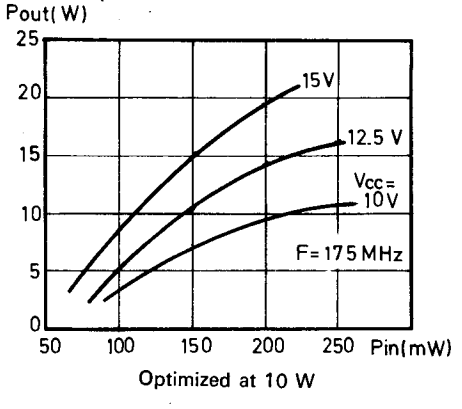
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA I_C = 0	4			V
	BV_{C1EO}	Collector 1 - Emitter Breakdown Voltage	I_{C1} = 50 mA I_B = 0	16			V
	BV_{C1BO}	Collector 1 - Base Breakdown Voltage	I_{C1} = 20 mA I_E = 0	36			V
	BV_{C2ES}	Collector 2 - Emitter Breakdown Voltage	I_{C2} = 50 mA	40			V
	I_{C1BO}	Collector 1 - Cutoff Current	V_{C1B} = 15 V I_E = 0			2	mA
	H_{FE1}	D.C. Current Gain B.C1.E	V_{C1E} = 5 V I_{C1} = 500 mA	20			—
RF TEST	P_G	Power Gain	V_{CC} = 12.5 V P_{in} = 0.3 W F = 175 MHz	30			W
	η	Efficiency	V_{CC} = 12.5 V P_{out} = 30 W F = 175 MHz	40	45		%
	Load VSWR	Mismatch Tolerance	V_{CC} = 12.5 V P_{out} = 30 W F = 175 MHz All phase angles		∞ : 1		
	Z_{in}	Common Emitter Amplifier Input Impedance	V_{CC} = 12.5 V P_{in} = 0.3 W F = 175 MHz		2.5 — j 0.3		Ω
	Z_{Load}	Common Emitter Amplifier Load Impedance	V_{CC} = 12.5 V P_{out} = 30 W F = 175 MHz		2.0 + j 2.0		Ω
THERMAL	I_{C1}	Continuous Collector 1 Current				3.4	A
	I_{C2}	Continuous Collector 2 Current				8	A
	θ_{j-c}	Hot Spot Thermal Resistance	T_C = 25 °C			2.2	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65		+ 200	°C/W
	P_D	Total Power Dissipation	T_C = 25 °C			130	W

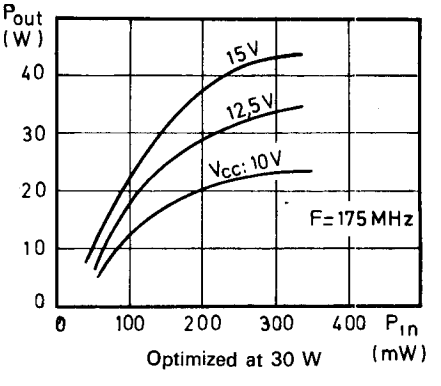
——— Input Power vs Frequency
- - - - - - Efficiency vs Frenquency





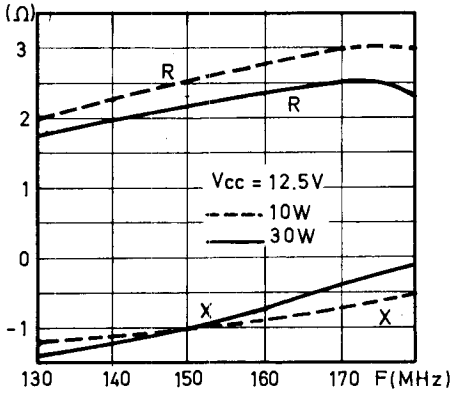
Output Power vs Input Power and Supply Voltage



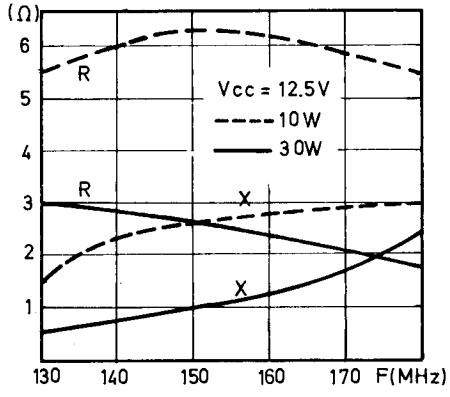


Typical Values

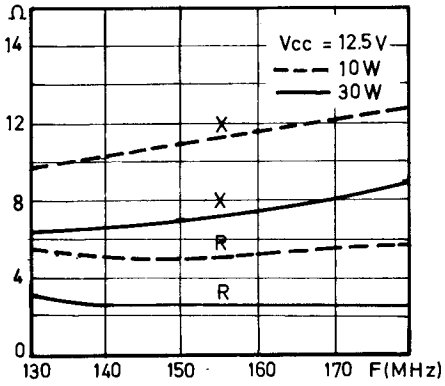
Series Input Impedance vs Frequency



Series Output Load Impedance vs Frequency

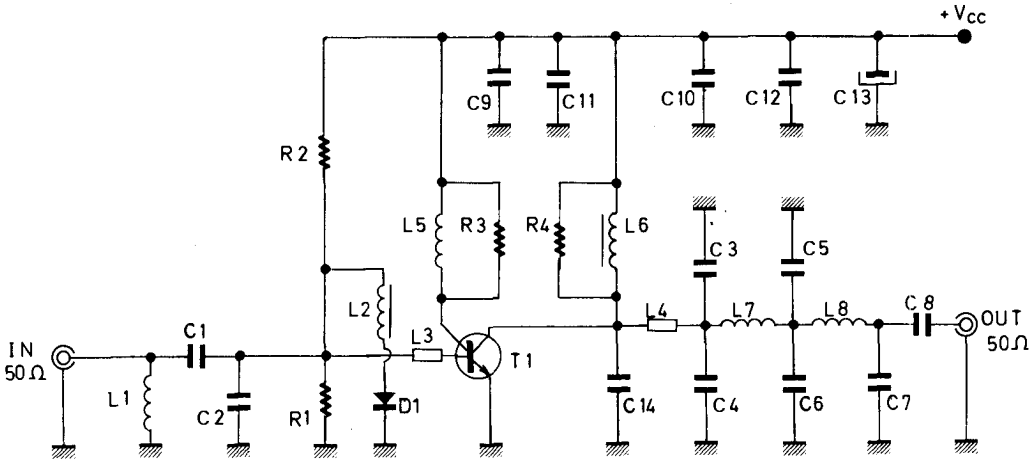


Serie CI Load Impedance vs Frequency



Typical Values

30 Watts Broadband Test Circuit (140-175 MHz)



C_1	=	47 pF chip
C_2	=	150 pF chip
C_3	=	82 pF chip
C_4	=	100 pF chip
C_5	=	62 pF chip
C_6	=	39 pF chip
C_7	=	30 pF chip
C_8	=	1000 pF chip
$C_9 = C_{10}$	=	1 nF ceramic
$C_{11} = C_{12}$	=	10 nF ceramic
C_{13}	=	10 µF/25 V electrolytic
C_{14}	=	15 pF ceramic

L_1	= 2 turns - 8/10 mm enameled wire - 4 mm I.D.
L_2	= 3 turns - 3/10 mm wire wound on a ferrite core
L_3	= Stripline Z_0 = 50 Ω - 15 mm - ε_r = 4.2
L_4	= Stripline Z_0 = 50 Ω - 18 mm - ε_r = 4.2
L_5	= 1 turn - 8/10 mm enameled wire - 4 mm I.D.
L_6	= Choke coil VK 200 RTC
L_7	= 1 turn - 8/10 mm enameled wire - 4 mm I.D.
L_8	= 3 turns - 8/10 mm enameled wire - 4 mm I.D.

R_1	= 18 Ohms 1/4 W carbon composition
R_2	= 240 Ohms 1 W carbon composition
R_3	= 3.3 Ohms 1/2 W carbon composition
R_4	= 240 Ohms 1/2 W carbon composition
T_1	= TPS 175 TRW transistor
D_1	= IN 4001 Si diode

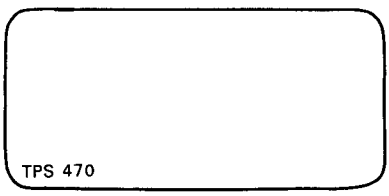
PRELIMINARY

RF Power Transistor

20 W - 400-512 MHz
12,5 V
18 dB GAIN MIN.

The TPS 470 is one of a new generation of Mobile devices which aim to simplify the design of mobile radio transmitters.

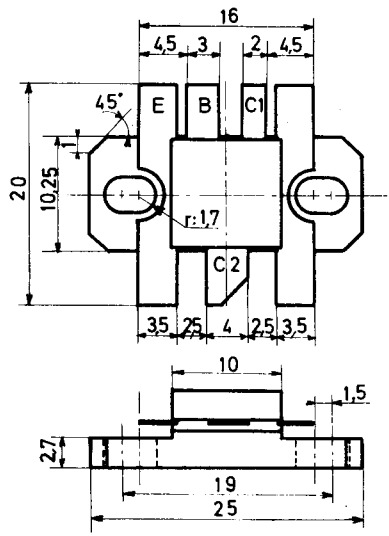
This device, which offers the user a 2 stage high gain broadband amplifier, in no more than the standard size transistor package, allows a much greater design flexibility than when using a module in that he has control over the input and output matching networks and can thus optimize performance at the desired operating point.

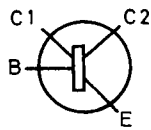


Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 2 mA I_c = 0	4			V
	BV_{C1EO}	Collector 1 - Emitter Breakdown Voltage	I_{c1} = 50 mA I_B = 0	16			V
	BV_{C1BO}	Collector 1 - Base Breakdown Voltage	I_{c1} = 10 mA I_E = 0	36			V
	BV_{C2ES}	Collector 2 - Emitter Breakdown Voltage	I_{c2} = 50 mA	36			V
	I_{c1BO}	Collector 1 - Cutoff Current	V_{c1B} = 15 V I_E = 0			1	mA
	H_{FE1}	DC Current Gain B.C_1.E	V_{CE1} = 5 V I_{c1} = 200 mA	20			—
RF Test	P_G	Power Gain	V_{cc} = 12.5 V F = 470 MHz P_{in} = 0.3 W	20			W
	η	Efficiency	V_{cc} = 12.5 V F = 470 MHz P_{out} = 20 W		45		%
	Load VSWR	Mismatch Tolerance	V_{cc} = 12.5 V F = 470 MHz P_{out} = 20 W All phase angles		∞ : 1		

Package Outline





FORTHCOMING PRODUCTS

UHF

410-512 MHz, COMMON EMITTER, 12.5 V

	FREQ. (MHz)	P out (W)	P in (W)	Gain dB	Package
JO 3015	470	15	2.5	7.7	500 Jϕ
JO 3050	470	50	13	5.8	500 Jϕ

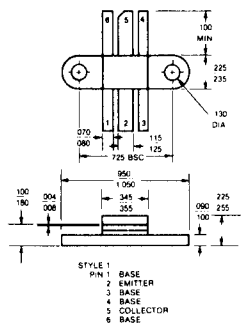
FORTHCOMING PRODUCTS

900 MHz

806-870 MHz, COMMON BASE, 12.5 V

	FREQ. (MHz)	P out (W)	P in (W)	Gain (dB)	Package		
JO3401	870	5.0	1.0	7.0	.230 F		
JO3402	870	18.0	4.0	6.5	.230 F		
JO3403	870	28.0	8.0	5.4	.230 F		
JO3404	870	45.0	15.0	4.8	.230 F		

.230 F



FM

FM TRANSMITTERS

PRODUCT SUMMARY

P/N	OUTPUT POWER at 108 MHz (W)	GAIN DB	PAGE
TP 9380	75	10.3	**C-145**
TP 9381	100	7.4	**C-148**
TP 9382	175	6.4	**C-152**
TP 9383	150	9.2	**C-156**

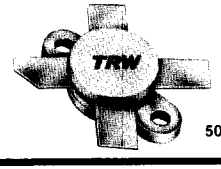
FM Power Transistor

PRELIMINARY DATA SHEET

75 W
108 MHz - 28 V
HIGH GAIN
RF POWER TRANSISTOR
NPN SILICON

The TP 9380 is designed for use in the new generation of VHF-FM broadcast transmitters operating from a 28 V supply in class A, B or C.

Its construction, which now incorporates the new standard TRW process of gold metallization and diffused ballast resistors, ensures a long operational life even when run at its maximum ratings.

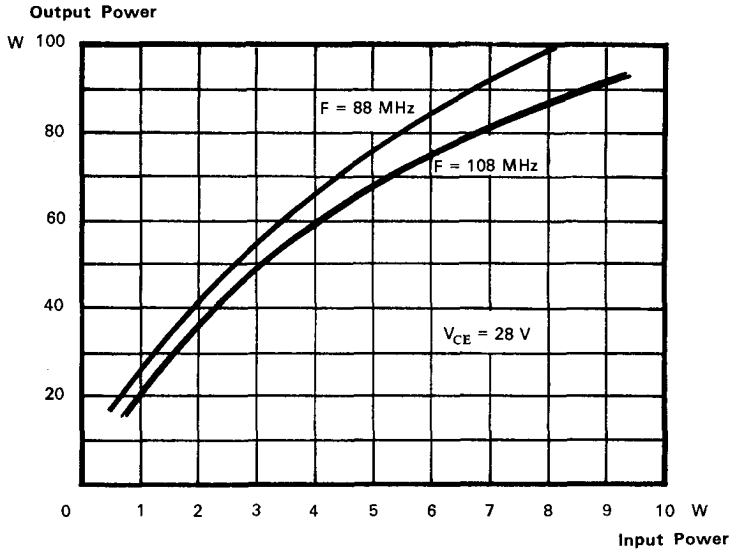


500 SOE F

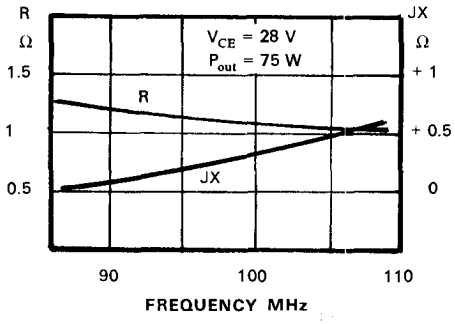
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 Ω	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	H_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 1 A	20		150	—
RF TEST	P_G	RF Power Gain	V_{CE} = 28 V P_{in} = 7 W F = 108 MHz	75			W
	η_C	Collector Efficiency	V_{CE} = 28 V P_{out} = 75 W F = 108 MHz	70	75		%
	C_{OB}	Output Capacitance	V_{CB} = 30 V F = 1 MHz			85	pF
	VSWR	Mismatch Tolerance (All phases)	V_{CE} = 28 V P_{out} = 75 W F = 108 MHz All phases	4 : 1			—
THERMAL	I_C	Maximum Collector Current				10	A
	θ_{jc}	Thermal Resistance Junction Case	T case = 70 °C			1.5	°C/W
	θ_{CH}	Thermal Resistance Case Heatsink				0.25	°C/W
	P_S	Power Dissipated	T heatsink = 25 °C			100	W
	T_{STG}	Storage and Junction Temperature		— 65		+ 200	°C

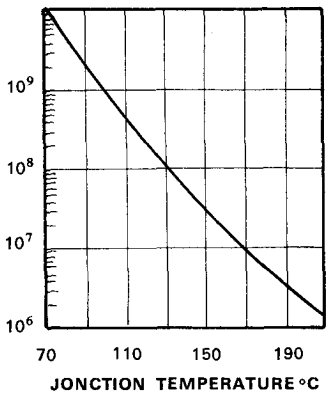
TYPICAL POWER OUTPUT vs POWER INPUT



SERIES INPUT IMPEDANCE vs FREQUENCY

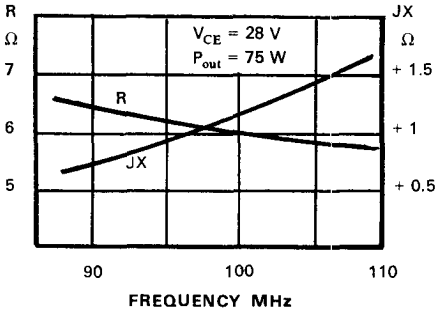


MTTF FACTOR vs Tj

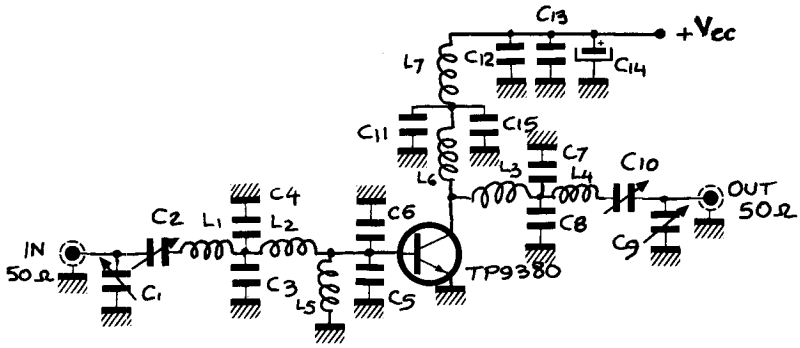


DIVIDE BY Ic2 TD DBTAIN METAL LIFETIME IN HDURS

SERIES LOAD IMPEDANCE vs FREQUENCY



88-108 MHz NARROW BAND TEST FIXTURE



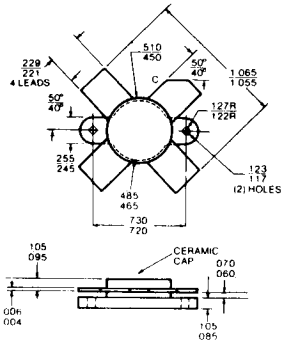
C_1 Arco 425 Variable capacitor (24 - 200 pF).
C_2 Arco 425 Variable capacitor (24 - 200 pF).
C_3 60 pF UNELCO.
C_4 60 pF UNELCO (108 MHz).
100 pF UNELCO (88 MHz).
C_5 330 pF chip capacitor (closed to the transistor).
C_6 330 pF chip capacitor (closed to the transistor).
C_7 40 pF UNELCO.
C_8 40 pF UNELCO (108 MHz).
80 pF UNELCO (88 MHz).
C_9 Arco 423 variable capacitor (7 - 100 pF).
C_{10} Arco 425 variable capacitor (24 - 200 pF).
C_{11} 1 000 pF UNELCO.
C_{12} 1 000 pF UNELCO.
C_{13} 0.1 µF disc capacitor.
C_{14} 100 µF/40 V capacitor.
C_{15} 10 nF disc capacitor.

L_1 3 turns ID = 6 mm 1 mm wire.
L_2 « Hair pin » made with a 1.4 mm wire L = 15 mm
L_3 « Hair pin » made with a 2 mm wire L = 20 mm for 108 MHz.
« Hair pin » made with a 2 mm wire L = 30 mm for 88 MHz.
L_4 3 turns ID = 8 mm 1.4 mm wire.
L_5 0.7 µH chocke.
L_6 6 turns ID = 6 mm 1.2 mm wire L = 15 mm.
L_7 4 turns 1.2 mm wire on ferrite.

Use an ultra flat heatsink.

Use a few of silicon thermal grease.

PACKAGE
500 SOE F



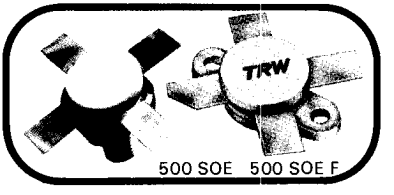
FM Power Transistor

PRELIMINARY DATA SHEET

The TP 9381 is designed for use in the new generation of VHF-FM broadcast transmitters operating from a 28 V supply in class A, B, or C.

Its construction, which now incorporates the new standard TRW process of gold metallization and diffused ballast resistors ensures a long operational life even when run at its maximum ratings.

100 W
108 MHz
28 V
RF POWER
NPN SILICON



500 SOE 500 SOE F

Electrical Characteristics (T_{case} = 25 °C)

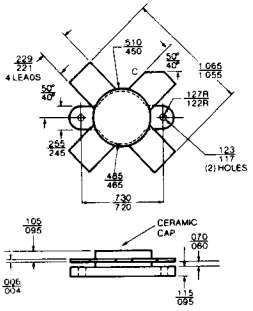
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 5 mA	4			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CES}	Collector Emitter Breakdown Voltage	I_C = 100 mA Emitter base short circuited	60			V
	I_{CES}	Collector cut off current	V_{CE} = 25 V			10	mA
	h_{FE}	DC current gain	V_{CE} = 10 V I_C = 1 A	20		150	—
RF TEST	P_{out}	Commun Emitter Amplifier output power	V_{CE} = 28 V P_{in} = 18 W F = 108 MHz	100			W
	η_C	Collector Efficiency	V_{CE} = 28 V P_{out} = 100 W F = 108 MHz	75			%
	C_{ob}	Output Capacitance	V_{CB} = 28 V F = 1 MHz			200	pF
	VSWR	Voltage Standing wave ratio	V_{CE} = 28 V P_{out} = 100 W F = 108 MHz All phases	∞			—
THERMAL	$Rth_{J.C}$	Thermal Resistance Junction - Case	Pd = 80 W t = 25 °C t = 70 °C		0,85 1	1,1	°C/W °C/W
	$Rth_{C.H}$	Thermal Resistance Case - Heatsink			0,15		°C/W

Absolute Maximum Ratings

Emitter Base Voltage	V_{EB}	4 V
Collector Emitter Voltage	V_{CE}	35 V
Collector Base Voltage	V_{CB}	60 V
Collector current	I_C	12 A
Total device power dissipation t_{case} = 25 °C	P_d	150 W
Storage and Junction temperature	T_{STG}	— 65 to 200 °C

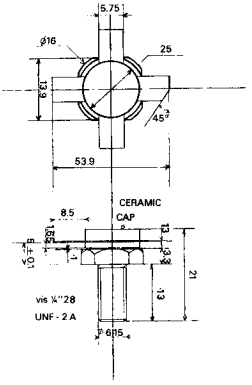
TP 9381

500 SOE F



TP 9381 A

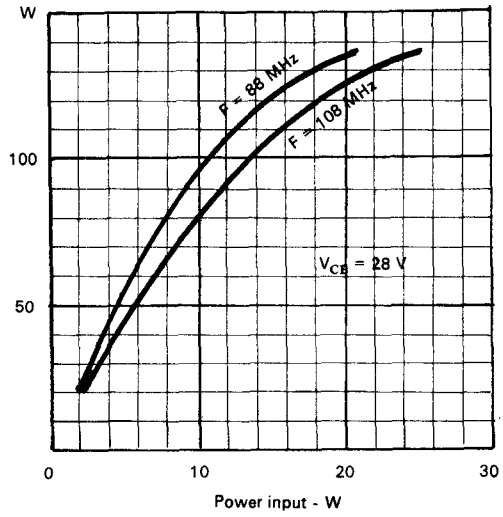
500 SOE 1/4 STUD



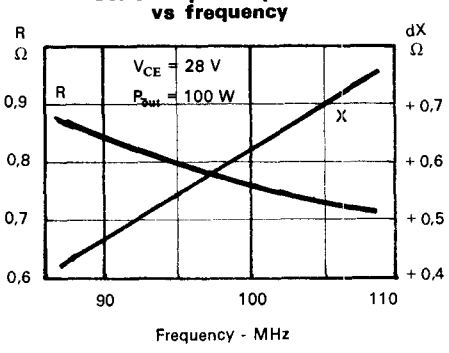
Stud torque :
min 21 kg.cm
max 25 kg.cm

Use ultra flat heat sink. Make stud hole as small as possible. Use a few of silicon grease.

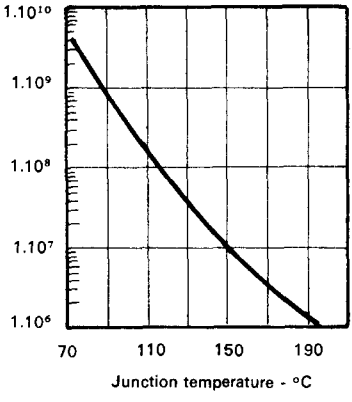
Power Output vs Power Input



Series Input Impedance vs frequency

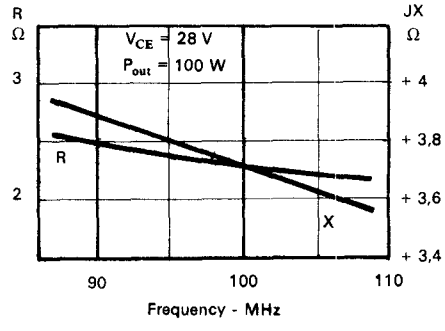


MTTF Factor vsTj

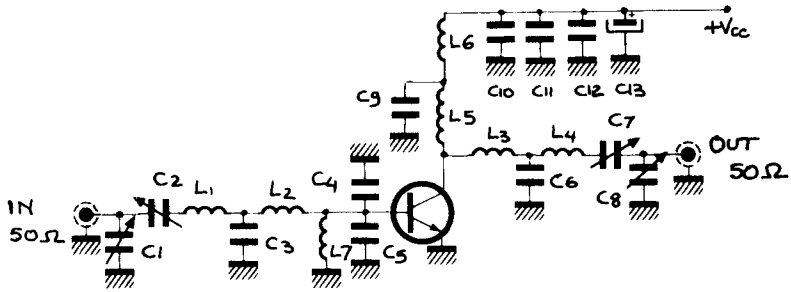


Divide by I_C^2 to obtain metal lifetime in hours

Series load Impedance vs frequency



Test Circuit 88-108 MHz
Narrow band



C_1 ARCO 425 Variable capacitor 24-200 pF
C_2 ARCO 425
C_3 150 pF UNELCO
C_4 470 pF Chip capacitor (very close to the transistor) ATC
C_5 470 pF Chip capacitor (very close to the transistor) ATC
C_6 300 pF UNELCO
C_7 ARCO 425
C_8 ARCO 425
C_9 1000 pF UNELCO
C_{10} 1000 pF UNELCO
C_{11} 10000 pF
C_{12} 0.1 μF
C_{13} 100 μF/40 V electrolytic

L_1 3 turns 6 mm ID 1.2 mm wire
L_2 2 cm wire 1.2 mm Ω (hair pin)
L_3 1.2 cm wire 1.2 mm Ω (hair pin)
L_4 3 turns 6 mm ID 1.2 mm wire
L_5 6 turns 8 mm ID 1.5 mm wire
L_6 6 turns 1.5 mm wire on ferrite core
L_7 10 μH chocke

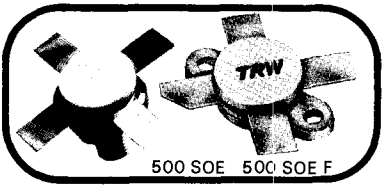
FM Power Transistor

PRELIMINARY DATA SHEET

175 W
108 MHz 28 V
HIGH POWER RF
TRANSISTOR
NPN SILICON

The TP 9382 is designed for use in new generation of VHF-FM broadcast transmitters operating from a 28 V supply in class A, B, or C.

Its construction, which incorporates the now standard TRW process of gold metallization and diffused ballast resistors, ensures a long operational life even when run at its maximum ratings.



500 SOE 500 SOE F

Electrical Characteristics (T_{case} = 25 °C)

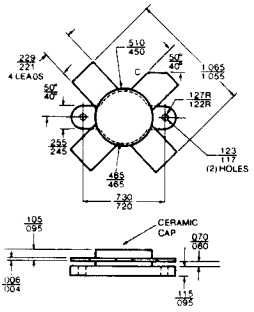
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 10 mA	4			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 100 mA	35			V
	BV_{CES}	Collector Emitter Breakdown Voltage	I_C = 200 mA Emitter Base Short circuited	60			V
	I_{CES}	Collector cutoff current	V_{CE} = 25 V			20	mA
	h_{FE}	DC current gain	V_{CE} = 10 V I_C = 1 A	20		150	—
RF TEST	P_{out}	Commun Emitter Amplifier Output power	V_{CE} = 28 V P_{in} = 40 W F = 108 MHz	175			W
	η_C	Collector Efficiency	V_{CE} = 28 V P_{out} = 175 W F = 108 MHz	75			%
	C_{ob}	Output Capacitance	V_{CB} = 28 V F = 1 MHz			380	pF
	VSWR	Voltage Standing Wave Ratio	V_{CE} = 28 V P_{out} = 175 W F = 108 MHz				—
THERMAL	$Rth_{J.C}$	Thermal Resistance Junction - Case	Pd = 100 W t = 25 °C t = 70 °C		0,5 0,6	0,7	°C/W
	$Rth_{C.H}$	Thermal Resistance Case - Heatsink			0,15		°C/W

Absolute Maximum Ratings

Emitter Base Voltage	V_{EB}	4 V
Collector Emitter Voltage	V_{CE}	35 V
Collector Base Voltage	V_{CB}	60 V
Collector Current	I_C	24 A
Total device Power dissipation (t_{case} = 25 °C)	P_d	250 W
Storage and Junction temperature	$T°_S$	— 65 to 200 °C

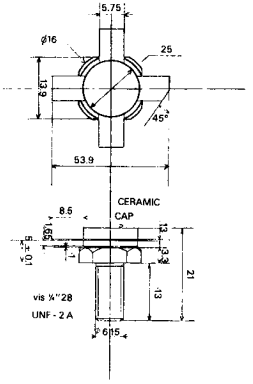
TP 9382

500 SOE F



TP 9382 A

500 SOE 1/4 STUD



TP 9382/A

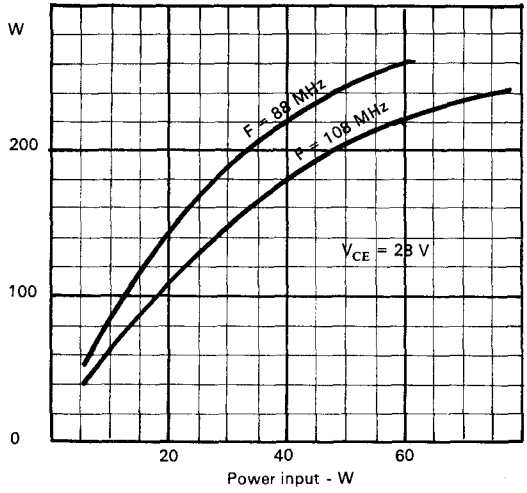
Stud torque :

min 21 kg.cm

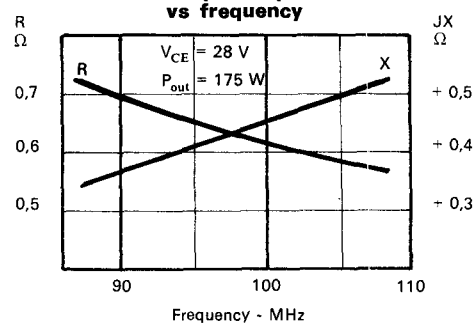
max 25 kg.cm

Use ultra flat heat sink. Make stud hole as small as possible. Use a few of silicon grease.

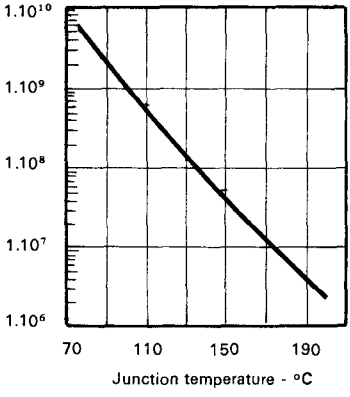
Power Output vs Power Input



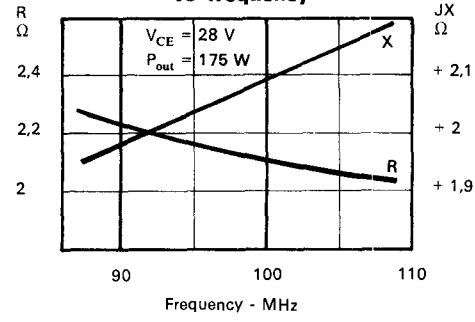
Series Input Impedance vs frequency



MTTF factor vs Tj

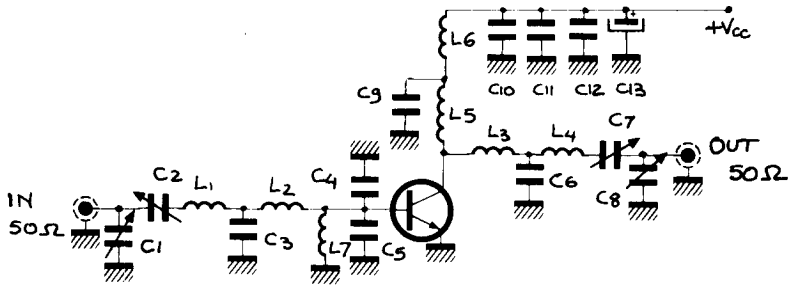


Series load Impedance vs frequency



Divide by Ic^2 to obtain metal lifetime in hours.

Test Circuit 88-108 MHz
Narrow band



C_1 ARCO 425 Variable capacitor 24-200 pF
C_2 ARCO 425
C_3 150 pF UNELCO
C_4 470 pF Chip capacitor (very close to the transistor) ATC
C_5 470 pF Chip capacitor (very close to the transistor) ATC
C_6 300 pF UNELCO
C_7 ARCO 425
C_8 ARCO 425
C_9 1000 pF UNELCO
C_{10} 1000 pF UNELCO
C_{11} 10000 pF
C_{12} 0.1 μF
C_{13} 100 μF/40 V electrolytic

L_1 3 turns 6 mm ID 1.2 mm wire
L_2 2 cm wire 1.2 mm Ω (hair pin)
L_3 1.2 cm wire 1.2 mm Ω (hair pin)
L_4 3 turns 6 mm ID 1.2 mm wire
L_5 6 turns 8 mm ID 1.5 mm wire
L_6 6 turns 1.5 mm wire on ferrite core
L_7 10 μH chocke

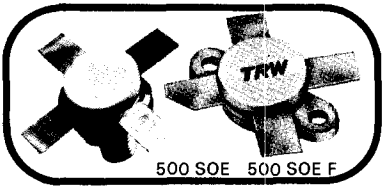
FM Power Transistor

PRELIMINARY DATA SHEET

150 W
108 MHz 28 V
HIGH GAIN
RF POWER
TRANSISTOR
NPN SILICON

The TP 9383 is designed for use in the new generation of VHF-FM broadcast trasmitters operating from a 28 V supply in class A, B, or C.

Its construction, which now incorporates the new standard TRW process of gold metallization and diffused ballast resistors, ensures a long operational life even when run at its maximum ratings.



500 SOE 500 SOE F

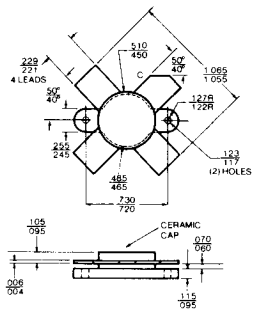
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 20 mA	4			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 100 mA	25			V
	BV_{CER}	Collector Emitter Breakdown Voltage	I_C = 100 mA R_{BE} = 10 Ω	55			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 100 mA	60			V
	h_{FE}	DC current gain	V_{CE} = 5 V I_C = 1 A	20		150	—
RF TEST	P_{out}	Commun Emitter Amplifier output power	V_{CE} = 28 V P_{in} = 18 W F = 108 MHz	150			W
	η_C	Collector Efficiency	V_{CE} = 28 V P_{out} = 150 W F = 108 MHz	70	75		%
	C_{ob}	Output Capacitance	V_{CB} = 28 V F = 1 MHz			150	pF
	VSWR	Voltage Standing wave Ratio	V_{CE} = 28 V P_{out} = 100 W F = 108 MHz P_{out} = 150 W All phases	∞ 4 : 1			— —
THERMAL	$Rth_{J.C}$	Thermal Resistance Junction - Case	Pd = 100 W t = 25 °C t = 70 °C		0,75 0,9	1	°C/W
	$Rth_{C.H}$	Thermal Resistance Case - Heatsink			0,15		°C/W

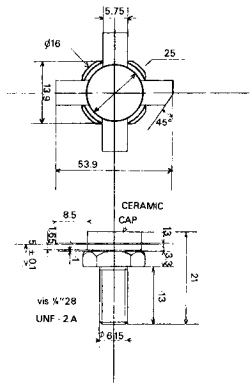
Absolute Maximum Ratings

Emitter Base Voltage	V_{EB}	4 V
Collector Emitter Voltage	V_{CE}	35 V
Collector Base Voltage	V_{CB}	60 V
Collector Current	I_C	16 A
Total device power dissipation t_{case} = 25 °C	P_d	150 W
Storage and junction temperature	T_{STG}	— 65 to + 200 °C

TP 9383
500 SOE Flange



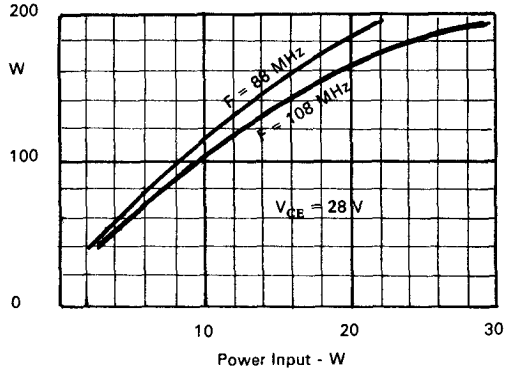
TP 9383 A
500 SOE 1/4" Stud



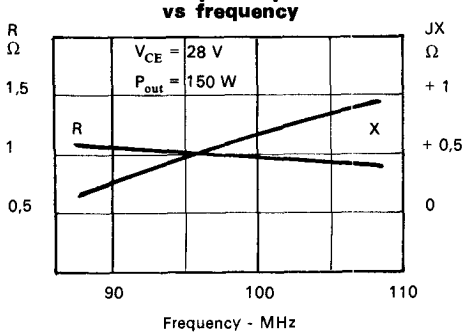
Stud Torque :
Min : 21 kg.cm
Max : 25 kg.cm

Use ultra flat heatsink. Make Stud hole as small as possible.
Use a few of silicon grease.

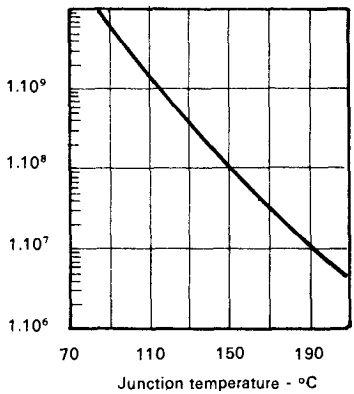
Power Output vs Power Input



Series Input Impedance vs frequency

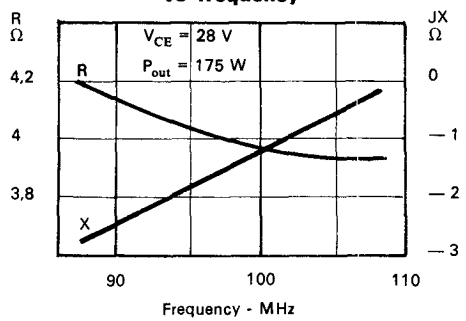


MTTF factor vs Tj

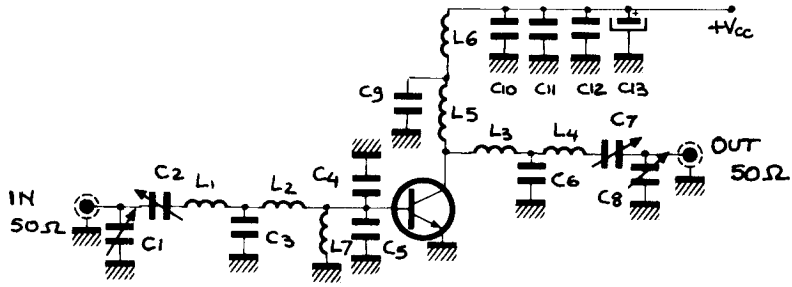


Divide by Ic^2 to obtain metal lifetime in hours.

Series load impedance vs frequency



Test circuit 88-108 MHz
Narrow band



C_1 ARCO 425 Variable capacitor 24-200 pF
C_2 ARCO 425
C_3 150 pF UNELCO
C_4 470 pF Chip capacitor (very close to the transistor) ATC
C_5 470 pF Chip capacitor (very close to the transistor) ATC
C_6 300 pF UNELCO
C_7 ARCO 425
C_8 ARCO 425
C_9 1000 pF UNELCO
C_{10} 1000 pF UNELCO
C_{11} 10000 pF
C_{12} 0.1 µF
C_{13} 100 µF/40 V electrolytic

L_1 3 turns 6 mm ID 1.2 mm wire
L_2 2 cm wire 1.2 mm Ω (hair pin)
L_3 1.2 cm wire 1.2 mm Ω (hair pin)
L_4 3 turns 6 mm ID 1.2 mm wire
L_5 6 turns 8 mm ID 1.5 mm wire
L_6 6 turns 1.5 mm wire on ferrite core
L_7 10 µF chocke

VHF/UHF BROADBAND

VHF AND UHF BROADBAND POWER TRANSISTORS

PRODUCT SUMMARY

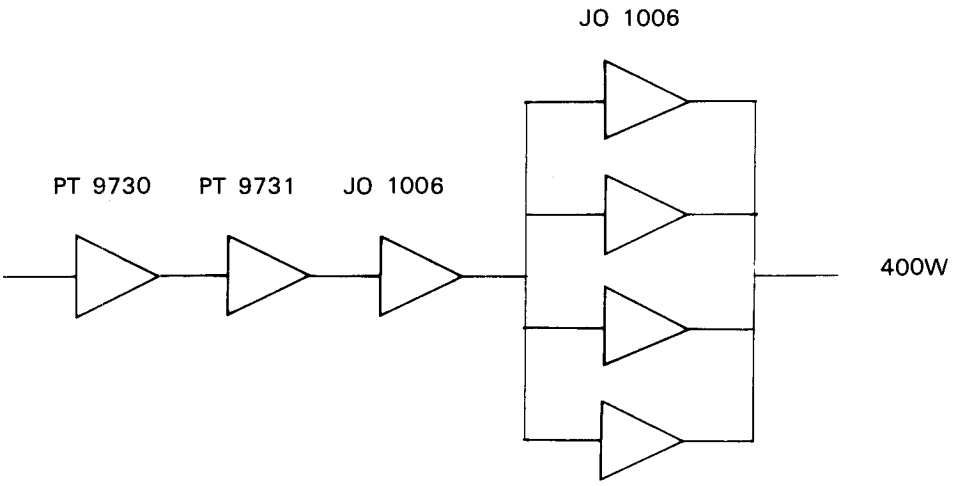
VHF BROADBAND TRANSISTORS — 28 V — 175 MHz		PAGE
PT 9730	4 W	**D-176**
PT 9732	8 W	**D-176**
PT 9734	15 W	**D-176**
PT 9731	25 W	**D-176**
PT 9733	50 W	**D-176**
TP 9383	150 W	**C-156**
TP 9386	150 W	**D-184**

UHF BROADBAND TRANSISTORS — 28 V — 400 MHz		
PT 9700	1.5 W	**D-168**
PT 9701	4 W	**D-168**
PT 9703	10 W	**D-168**
PT 9702	20 W	**D-168**
PT 9704 A	30 W	**D-168**
TPM 401	1 W	**D-187**
TPM 405	5 W	**D-191**
TPM 425	25 W	**D-195**
JO 2015 A	70 W	**D-164**

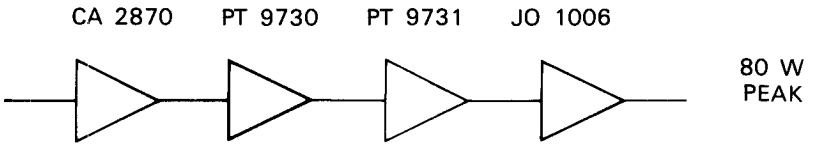
VHF/UHF ULTRA BROADBAND		
TPM 4040	40 W	**D-197**
TPM 4100	100 W	**D-201**

VHF - UHF
LINE-UP SUGGESTIONS

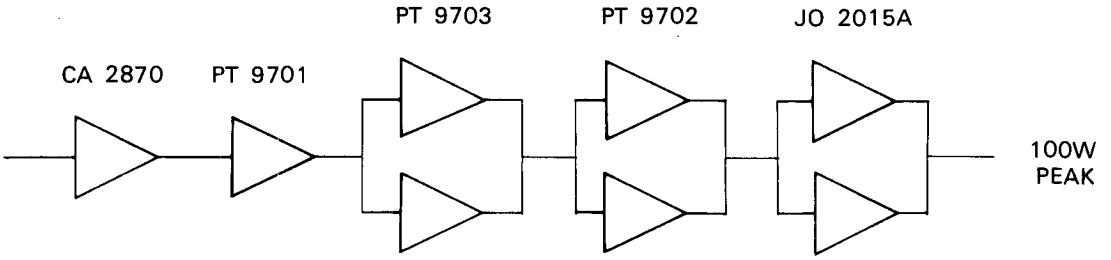
108-118 MHz - FM - 400W



118-156 MHz - AM - 80W PEAK - AIRCRAFT



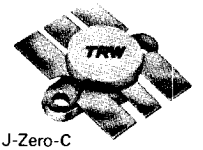
225-400 MHz - AM - 100W PEAK - AIRCRAFT TACTICAL RADIO



UHF POWER TRANSISTOR

BROAD BAND
225 - 400 MHz
70 W - 28 V
∞ VSWR

The JO 2015 A is an internally matched NPN silicon UHF power transistor. Its multicell design allows optimum heat dissipation and operating efficiency. A slotted-grid finger structure assures uniform current injection. Ruggedability and long-term reliability is guaranteed by unique, diffused silicon ballasting resistors coupled with TRW's refractory-gold-passivated metalization system.

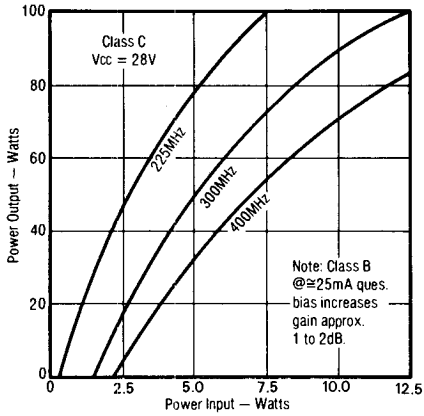


J-Zero-C

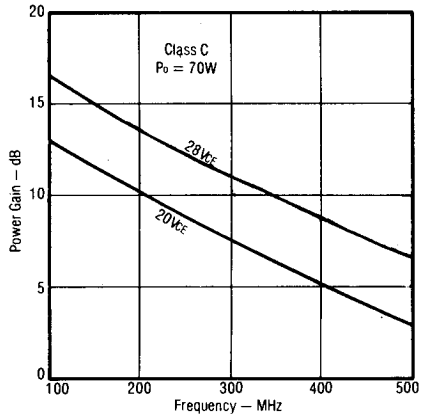
Electrical Characteristics (25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100 mA	65 Vdc Min
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 5.0 mA	3.5 Vdc Min
	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 50 mA	30 Vdc Min
	VSWR	Mismatch Tolerance	V_{CE} = 28 V, f = 400 MHz, P_o = 70 W	∞ (All Angles)
	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz	80 pF Max
	h_{FE}	DC Current Gain	V_{CE} = 10 V, I_C = 1 A	10-100
R F Tests	P_{gain}	Power Gain, CW Broadband	V_{CE} = 28 V, P_o = 50 W f = 225-400 MHz	10 dB Min
	P_{sat}	Saturated Power Output	V_{CE} = 28 V, f = 400 MHz	70 W Min
	η	Narrowband Collector Efficiency	V_{CE} = 28, f = 400 MHz, P_o = 70 W	55 % Min
Operating	T_{stg}	Max Storage Temperature		— 65 °C to + 200 °C
	θ_{jC}	Thermal Resistance	25 °C	1.25 °C/W
	I_C	Continuous Collector Current	V_{CE} = 10 V	10 A Max

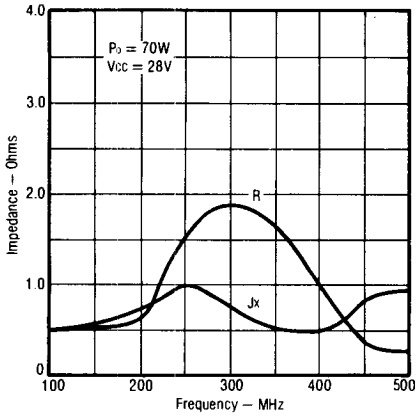
Power Output vs Power Input



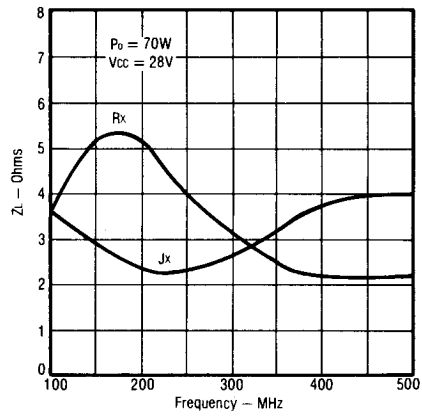
Power Gain vs Frequency



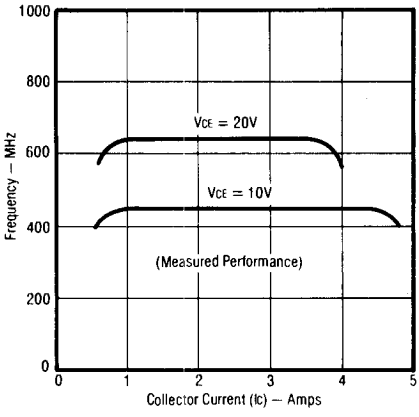
Series Input Impedance vs Frequency



Series Load Impedance vs Frequency



ft vs Ic



Safe Operating Area

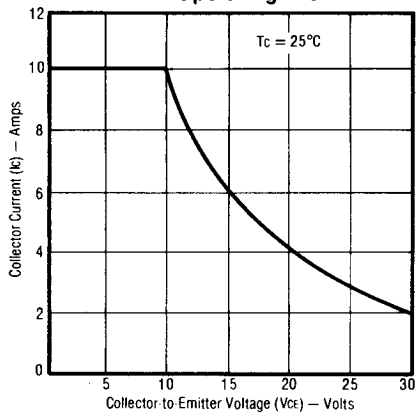
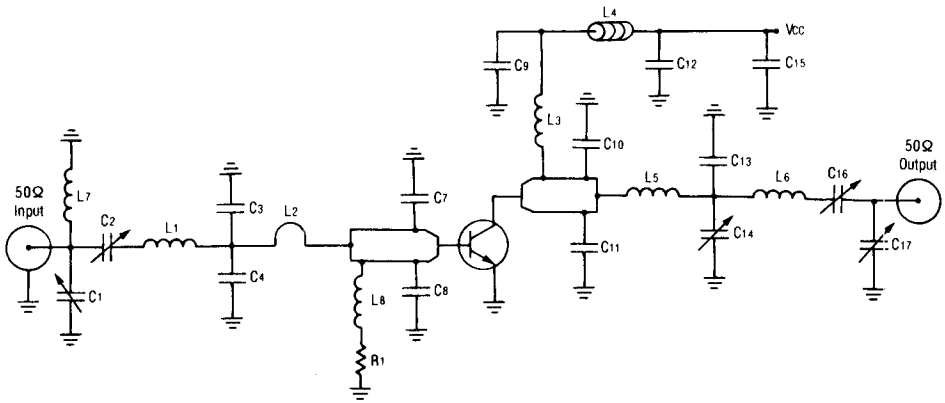


Figure 1. Narrowband Test Circuit



$C_{1,2,14,17}$	1.5-20pF ARCO #402	L_1	2 turns #22AWG, 0.1" form
$C_{3,4}$	10pF UNELCO	L_2	0.2" hairpin, 0.1" wide ribbon
$C_{7,8}$	60pF UNELCO	L_3	#22AWG, 1" diameter
$C_{10,11}$	40pF UNELCO	L_4	3 Ferrite beads on #22AWG
C_{13}	15pF UNELCO	L_5	#22AWG, 0.25" hairpin
$C_{9,12}$	1000pF UNELCO	L_6	1 turn #22AWG, 0.1" form
C_{15}	5μF electrolytic	L_7	6 turns #22AWG, 0.1" form
C_{16}	8-60pF ARCO #404	L_8	8 turns #22AWG, 0.1" form

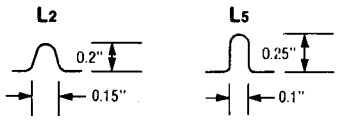
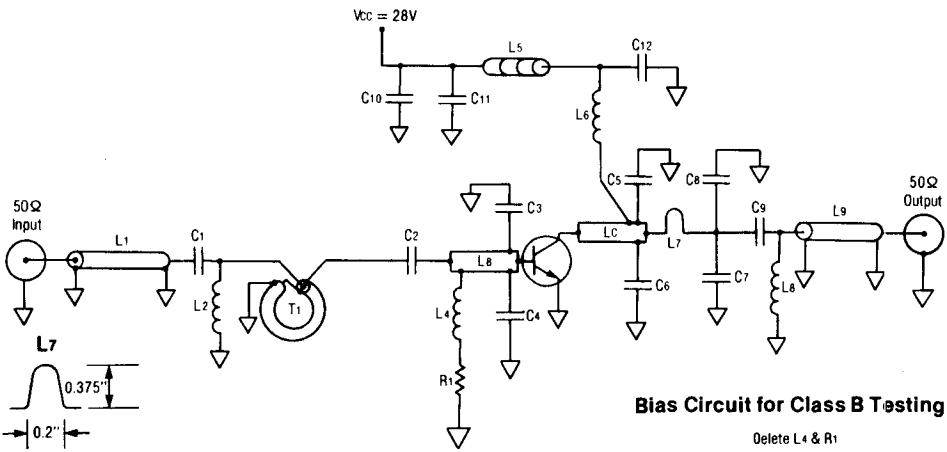


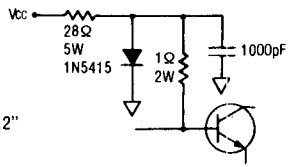
Figure 2. 70 Watt Broadband Test Circuit (225-400MHz)



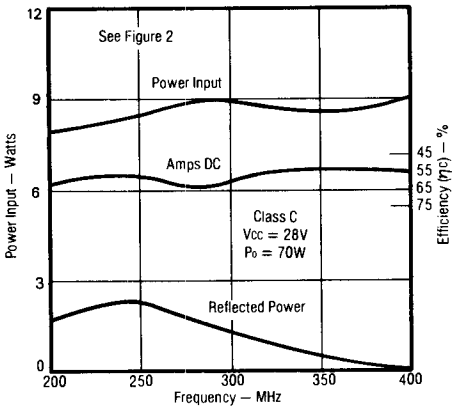
C_1	20pF JFD	$L_{2,4}$	4 turns #20AWG, 0.125" form
C_2	68pF JFD	L_5	3 Ferrite beads
$C_{3,4}$	60pF UNELCO	L_6	#20AWG, 1" diameter
$C_{5,6}$	40pF UNELCO	L_7	3/8" hairpin
$C_{7,9}$	15pF UNELCO	L_8	3 turns #20AWG, 0.125" form
C_8	10pF UNELCO	L_8	Base Inductance Pad, 0.5" x 0.2"
C_{10}	5μF electrolytic	L_C	Collector Inductance Pad, 0.5" x 0.2"
$C_{11,12}$	1000pF UNELCO	R_1	0.5Ω, 1W
$L_{1,9}$	50Ω semirigid (length to suit circuit)	T_1	1", 25Ω semirigid coax

Bias Circuit for Class B Testing

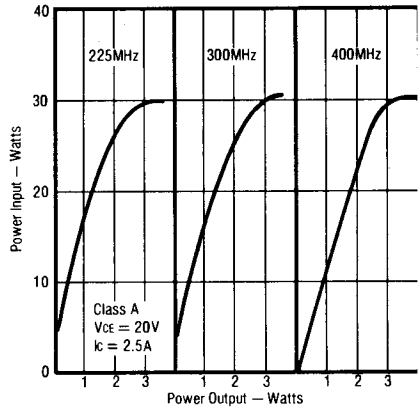
Delete L_4 & R_1



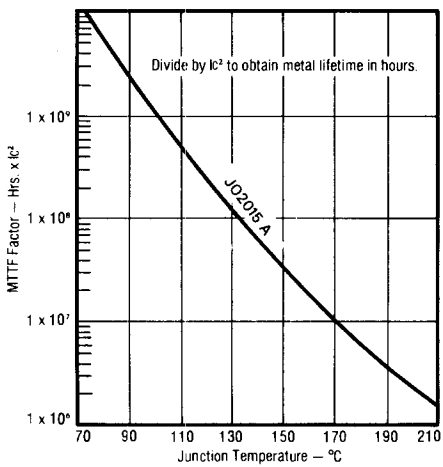
70W Broadband Performance



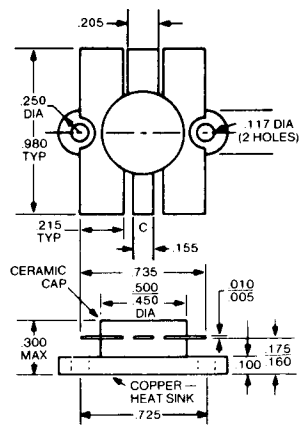
Typical Class A Linear Transfer Characteristics



MTTF Factor vs T_j



J-Zero-C Package Outline



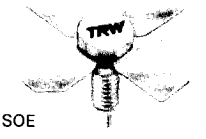
TRW® SEMICONDUCTORS

UHF Power Transistors

PT 9700	1.5 W
PT 9701	4 W
PT 9703	10 W
PT 9702	20 W
PT 9704	30 W
PT 9704A	30 W

400 MHz - 28 V

The PT 9700 UHF Series features both high gain and high power, providing the desired power output with fewer devices. Microwave cellular geometries processed for UHF application provide both high performance and ruggedness. Diffused ballast resistors in the higher power units enable these devices to withstand infinite VSWR at all phase angles. Ballast resistor design enables operation at Class A, AB and C. These rugged units are suitable for both narrow band and broad band UHF communications and instrumentation service. All are gold metalized for long life and incorporate ceramic stripline packages.



280 SOE

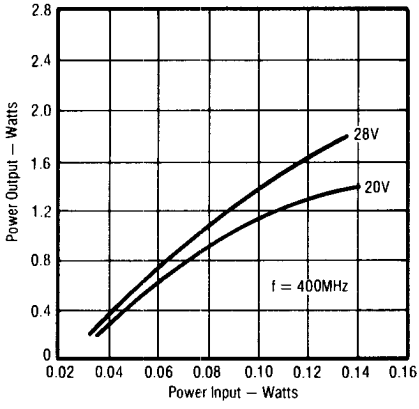
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	PT 9700	PT 9701	PT 9703	PT 9702	PT 9704 PT 9704A	UNIT
DC Test	BV_{EBO}	Min. Emitter - Base Breakdown	I_E = 0.1 mA I_C = 0 I_E = 1 mA I_C = 0 I_E = 2 mA I_C = 0	3.5	4	4	4	4	V
	BV_{CES}	Min. Collector - Emitter Breakdown	I_C = 1 mA V_{BE} = 0 I_C = 10 mA V_{BE} = 0 I_C = 20 mA V_{BE} = 0	55	55	55	55	55	V
	BV_{CEO}	Min. Collector - Emitter Breakdown	I_C = 20 mA I_B = 0 I_C = 50 mA I_B = 0	35	30	30	30	30	V
	I_{CES}	Max. Collector - Emitter Cutoff Current	V_{CE} = 30 V	0.25	5	5	10	10	mA
	H_{FE}	Min. D.C Current Gain	I_C = 0.1 A V_{CE} = 5 V	20-150	10-150	10-150	10-150	10-150	—
RF Test	P_{GAIN}	Min. Power Gain	V_{CE} = 28 V P_{in} = 0.12 W P_{in} = 0.5 W P_{in} = 1.25 W F = 400 MHz P_{in} = 4 W P_{in} = 5 W	1.5	4	10	20	30*	W
	η_i	Min. Collector Efficiency	V_{CE} = 28 V Rated F = 400 MHz Output Power	55	55	60	60	60	%
	VSWR	Mismatch Tolerance	V_{CE} = 28 V Rated F = 400 MHz Output Power	∞	∞	∞	∞	∞	
	P_{SAT}	Typical Saturated Power Output	V_{CE} = 28 V F = 400 MHz	2	7	15	25	35	W
	C_{OB}	Max. Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz I_E = 0	3.5	14	14	22	35	pF
Operating	I_C	Continous Collector Current		0.5	0.75	1.25	2	5	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C	35	17.5	8.8	4.4	2.5	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65 to + 200					°C
	P_D	Power Dissipation	T_C = 25 °C	5	10	20	40	70	W

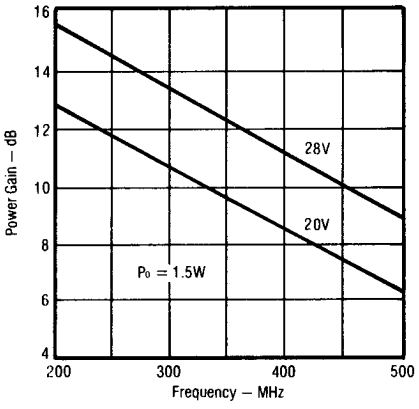
* PT 9704 Power Gain = 6.3 dB at 400 MHz - Power Out/Power in = 30 W/7 W

PT 9700 — 1.5 Watts

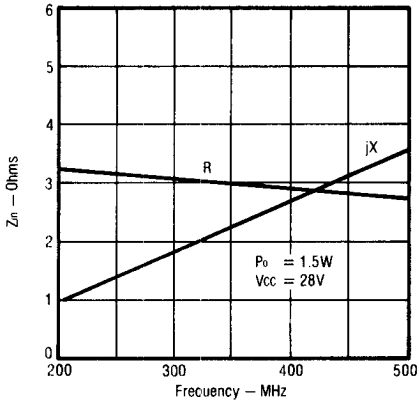
Power Output vs Power Input



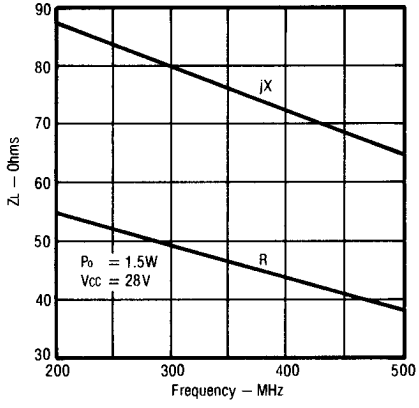
Power Gain vs Frequency



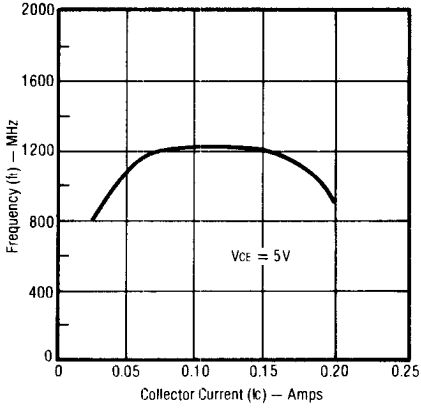
Series Input Impedance vs Frequency



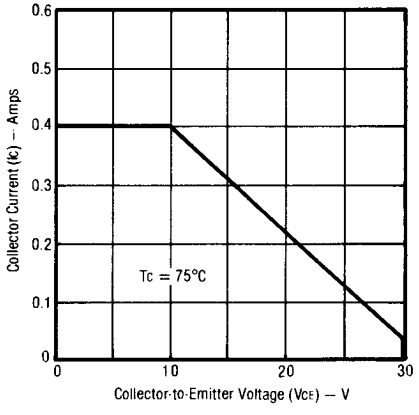
Series Load Impedance vs Frequency



f_t vs I_C

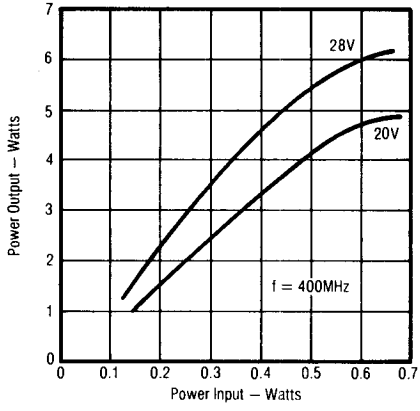


Safe Operating Area

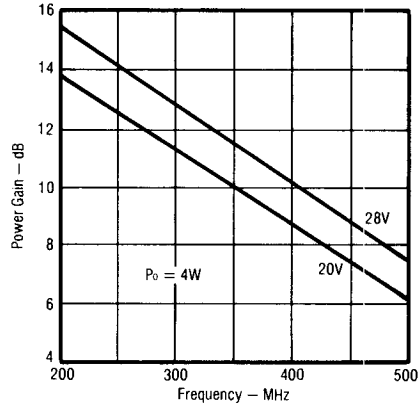


PT 9701 — 4 Watts

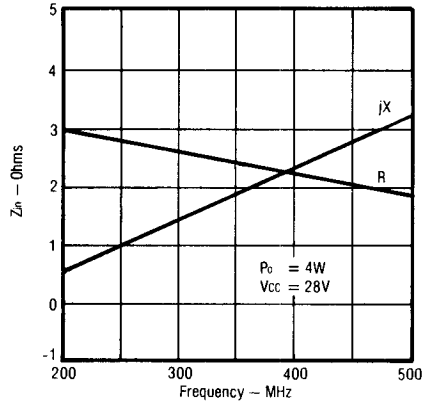
Power Output vs Power Input



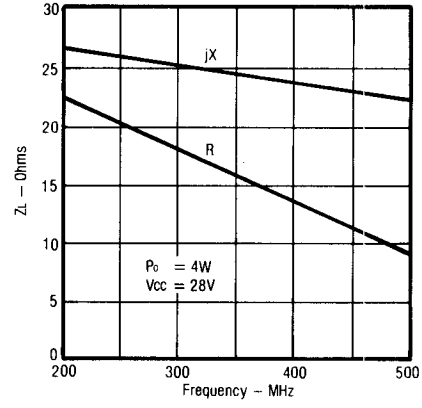
Power Gain vs Frequency



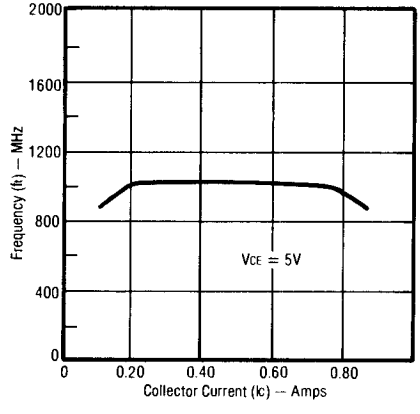
Series Input Impedance vs Frequency



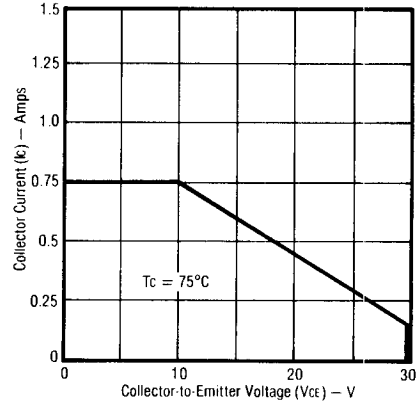
Series Load Impedance vs Frequency



f_t vs I_C

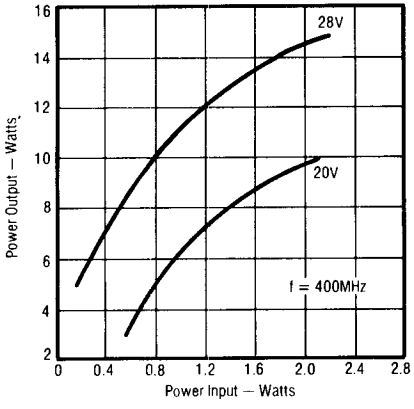


Safe Operating Area

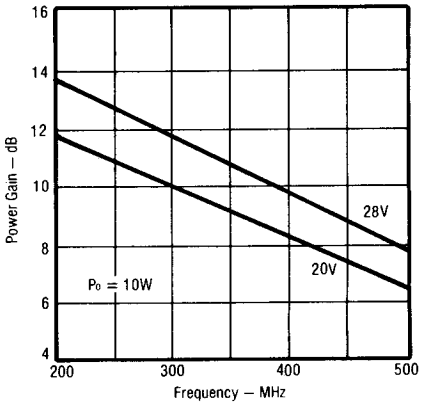


PT 9703 — 10 Watts

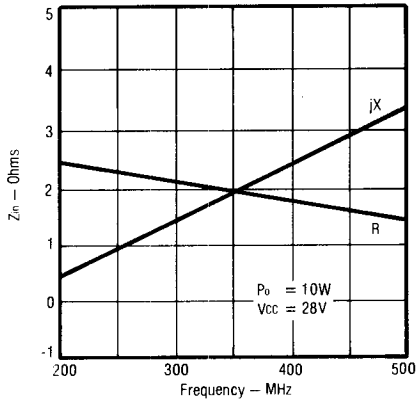
Power Output vs Power Input



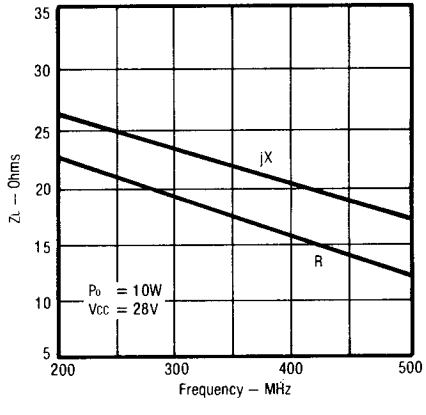
Power Gain vs Frequency



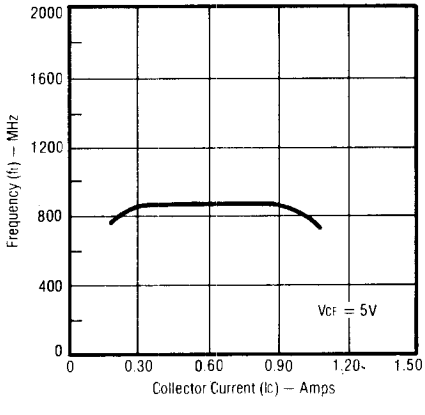
Series Input Impedance vs Frequency



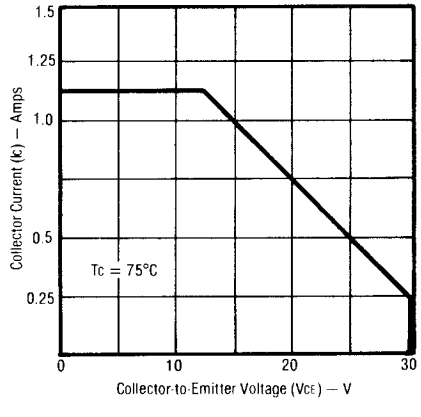
Series Load Impedance vs Frequency



f_t vs I_C

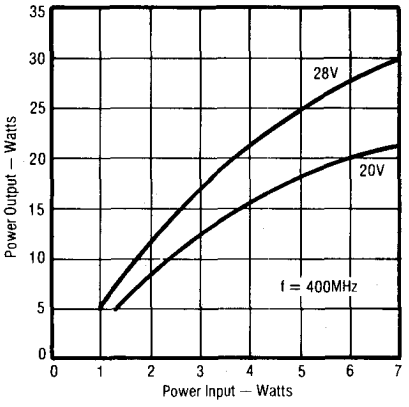


Safe Operating Area

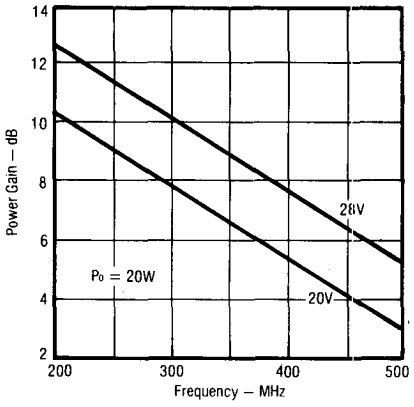


PT 9702 — 20 Watts

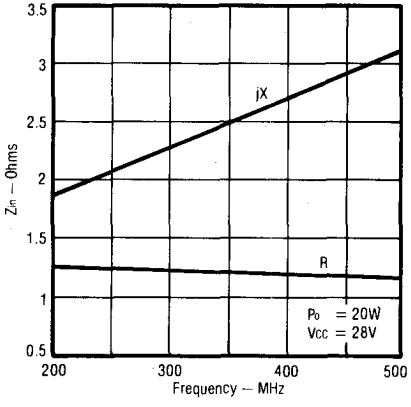
Power Output vs Power Input



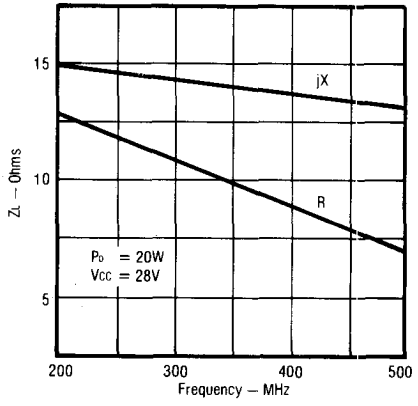
Power Gain vs Frequency



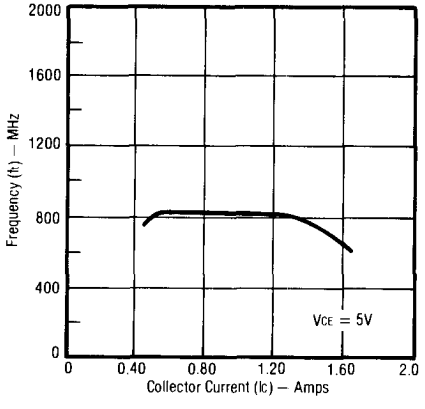
Series Input Impedance vs Frequency



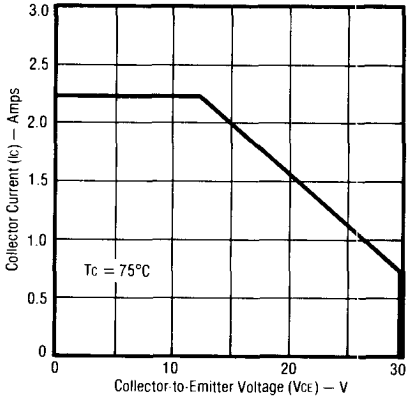
Series Load Impedance vs Frequency



f_t vs I_C

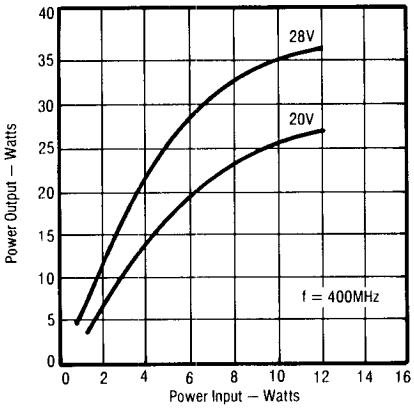


Safe Operating Area

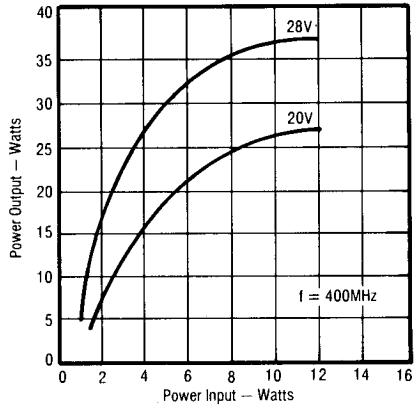


PT 9704 and PT 9704 A — 30 Watts

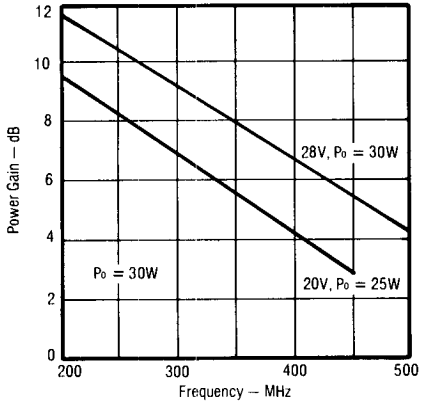
PT 9704 Power Output vs Power Input



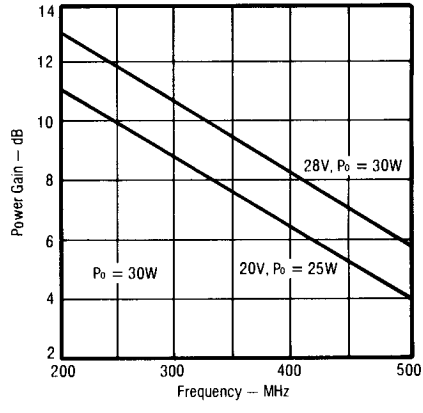
PT 9704 A Power Output vs Power Input



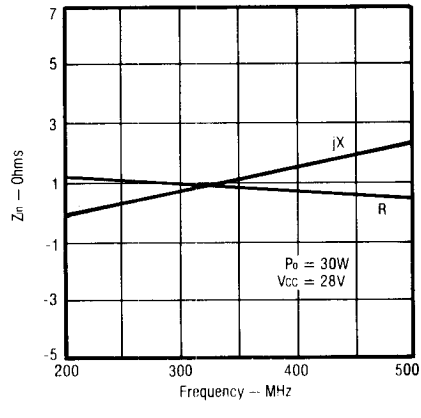
PT 9704 Power Gain vs Frequency



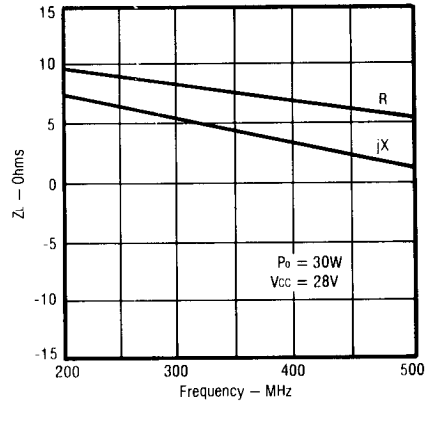
PT 9704 A Power Gain vs Frequency



PT 9704 and PT 9704 A Series Input Impedance vs Frequency



PT 9704 and PT 9704 A Series Load Impedance vs Frequency

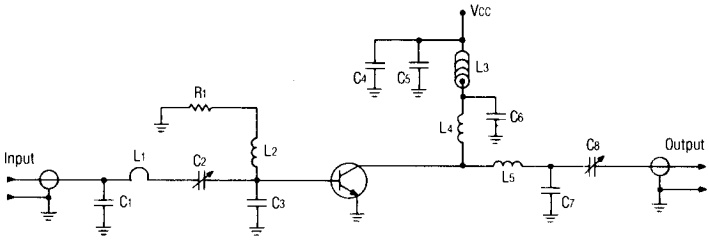


PT 9700, 400 MHz TEST CIRCUIT

$C_{1,7,8}$ 0.9-7pF ARCO #400
C_2 3-35pF ARCO #403
C_3 30pF UNELCO
$C_{4,6}$ 1000pF UNELCO
C_5 1000µF electrolytic

L_1 1 loop #22AWG, 3/4"
$L_{2,5}$ 4 turns #22AWG, 0.1" I.D.
L_3 3 Ferrite beads
L_4 6 turns #22AWG, 0.1" I.D.

R_1 1 ohm, 1/4 watt carbon resistor

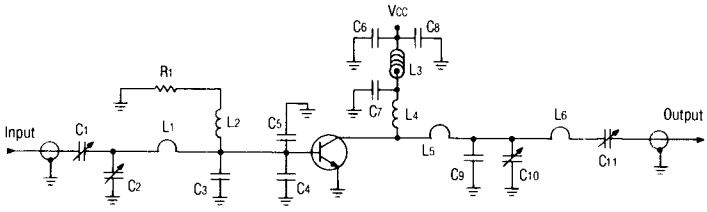


PT 9701 and PT 9703, 400 MHz TEST CIRCUIT

C_1 3-35pF ARCO #403
$C_{2,10}$ 0.9-7pF ARCO #400
$C_{3,9}$ 10pF UNELCO
$C_{4,5}$ 30pF UNELCO
$C_{6,7}$ 1000pF UNELCO
C_8 100µF electrolytic
C_{11} 0-18pF ARCO #402

L_1 #22AWG, 1/2"
L_2 4 turns #22AWG, 0.1" I.D.
L_3 3 Ferrite beads
L_4 2 turns #22AWG, 0.1" I.D.
L_5 #22AWG, 0.5" hairpin
L_6 3 turns #22AWG, 0.1" I.D.

R_1 1 ohm, 1/4 watt carbon resistor

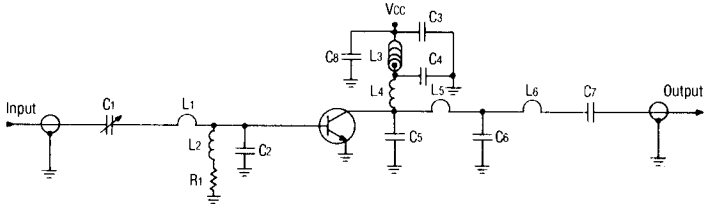


PT 9702, 400 MHz TEST CIRCUIT

C_1 1.5-20pF ARCO #402
C_2 40pF UNELCO
C_3 1000pF UNELCO
C_4 1000pF UNELCO
$C_{5,6}$ 20pF UNELCO
C_7 30pF dipped mica
C_8 100µF electrolytic

L_1 #22AWG, 0.6"
L_2 4 turns #22AWG, 0.125 I.D.
L_3 3 Ferrite beads
L_4 3 turns #22AWG, 0.125 I.D.
L_5 #22AWG, 0.5" hairpin
L_6 #22AWG, 0.3" hairpin

R_1 1 ohm, 1/4 watt carbon resistor

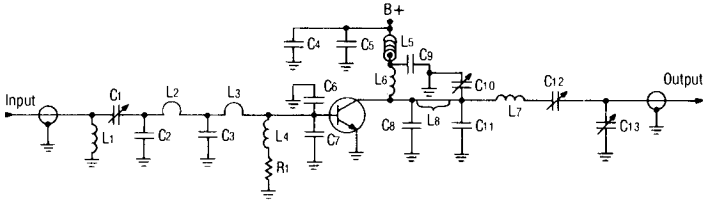


PT 9704 and PT 9704 A, 400 MHz TEST CIRCUIT

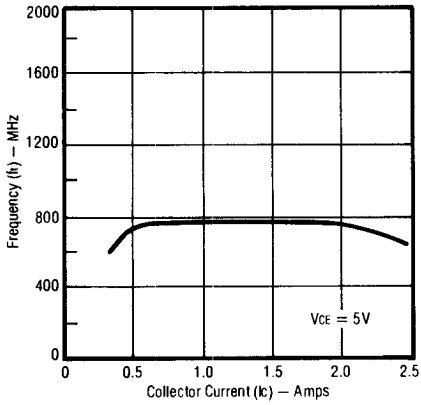
$C_{1,12}$ 1.5-20pF ARCO #402
C_2 15pF UNELCO
$C_{3,6,7}$ 30pF UNELCO
$C_{4,9}$ 1000pF UNELCO
C_5 100µF electrolytic
C_8 35pF UNELCO
$C_{10,13}$ 0.9-7pF ARCO #400
C_{11} 10pF UNELCO

L_1 6 turns #22AWG, 1/8" I.D.
L_2 #22AWG, 3/8" hairpin
L_3 1/8" by 1/4" strap
L_4 2 turns on resistor lead
L_5 3 Ferrite beads
$L_{6,7}$ 2 turns #22AWG, 1/8" I.D.
L_8 #22AWG, 0.3"

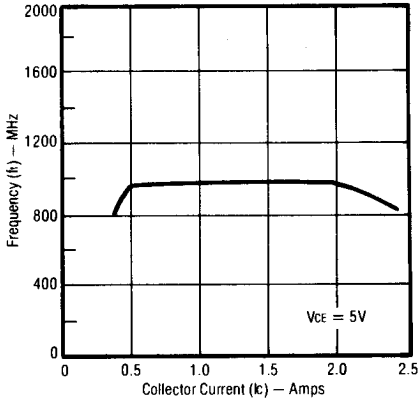
R_1 1 ohm, 1/2 watt carbon resistor



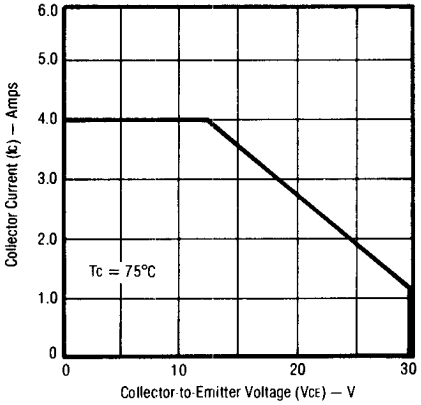
PT 9704 f_t vs I_C



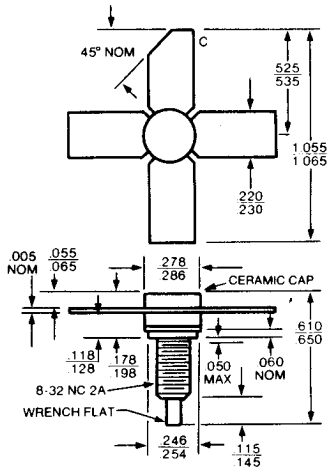
PT 9704 A f_t vs I_C



PT 9704 and PT 9704 A Safe Operating Area

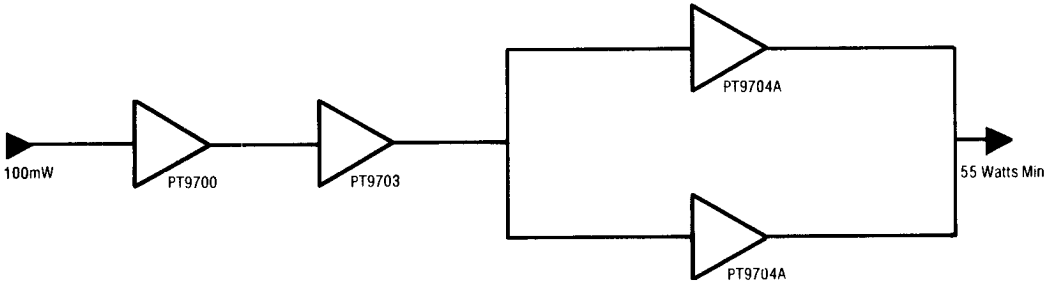


Package Outline



To convert inches to millimeters multiply by 2.54

Typical Application
55 Watt UHF 28 V Power Amplifier
225-400 MHz



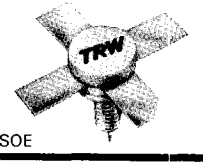
TRW® SEMICONDUCTORS

VHF Power Transistors

PT 9730	4 W
PT 9732	8 W
PT 9734	15 W
PT 9731	25 W
PT 9733	50 W

175 MHz - 28 V

The PT9730 VHF Series feature both high gain and high power, providing the desired power output with fewer devices. These power transistors are ballasted for ruggedness and will withstand infinite VSWR at all phase angles. A unique emitter structure provides high gain with wider emitter and base fingers resulting in high reliability. Ballast resistor design enables operation at Class A, AB, and C. These rugged units are suitable for both narrow band and broadband VHF communications and instrumentation service.



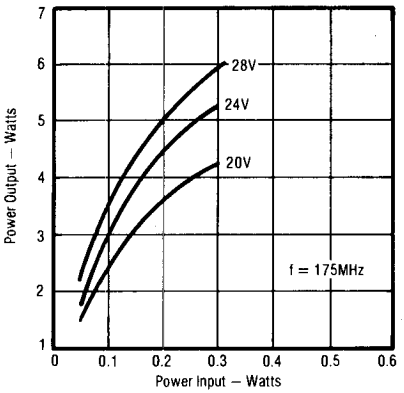
380 SOE

Electrical Characteristics (T_{flange} = 25 °C)

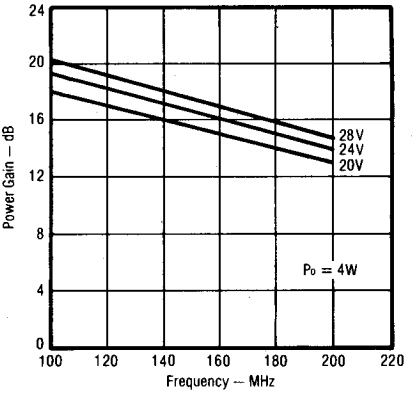
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	PT 9730	PT 9732	PT 9734	PT 9731	PT 9733	UNIT
DC Test	BV_{EBO}	Min. Emitter - Base Breakdown	I_E = 1 mA I_C = 0	4	4	4	4	4	V
	BV_{CES}	Min. Collector - Emitter Breakdown	I_C = 50 mA V_{BE} = 0	60	60	60	60	60	V
	BV_{CEO}	Min. Collector - Emitter Breakdown	I_C = 25 mA I_B = 0	35	35	35	35	35	V
	I_{CES}	Max. Collector - Emitter Cutoff Current	V_{CE} = 25 V	0.5	0.5	0.75	1	2	mA
	H_{FE}	Min. D.C Current Gain	I_C = 500 mA V_{CE} = 10 V	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	—
RF Test	P_{GAIN}	Min. Power Gain	V_{CE} = 28 V F = 175 MHz P_{in} = 0.2 W / P_{in} = 0.6 W / P_{in} = 1 W / P_{in} = 2.5 W / P_{in} = 10 W	4	8	15	25	50	W
	η	Min. Collector Efficiency	V_{CE} = 28 V F = 175 MHz Rated Output Power	60	60	60	60	60	%
	VSWR	Mismatch Tolerance	V_{CE} = 28 V F = 175 MHz Rated Output Power	∞	∞	∞	∞	∞	
	P_{SAT}	Min. Saturated Power Output	V_{CE} = 28 V F = 175 MHz	6	10	18	30	60	W
	C_{OB}	Max. Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz I_E = 0	12	18	24	40	90	pF
Operating	I_C	Continous Collector Current		1	1.25	2.5	4	8	A
	θ_{j-C}	Thermal Resistance	T_C = 25 °C	17.5	8.8	5.8	3.9	2.1	°C/W
	T_{STG}	Storage Temperature and Junction Temperature		— 65 to + 200					°C
	P_D	Power Dissipation	T_C = 25 °C	10	20	30	45	85	W

PT 9730 — 4 Watts

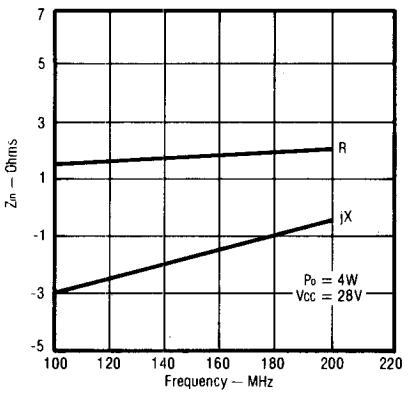
Power Output vs Power Input



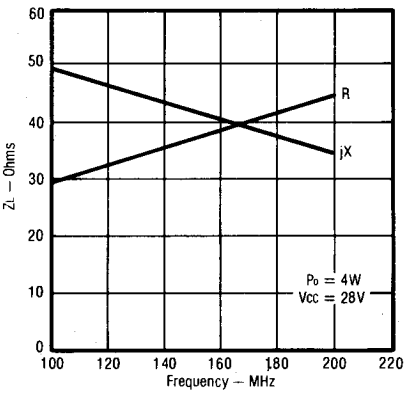
Power Gain vs Frequency



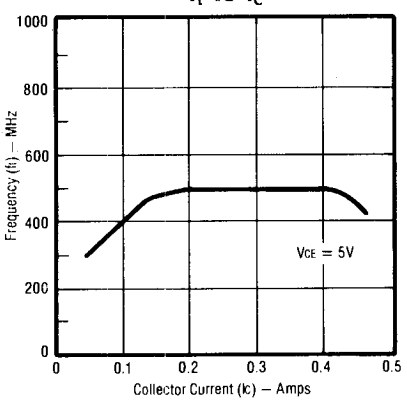
Series Input Impedance vs Frequency



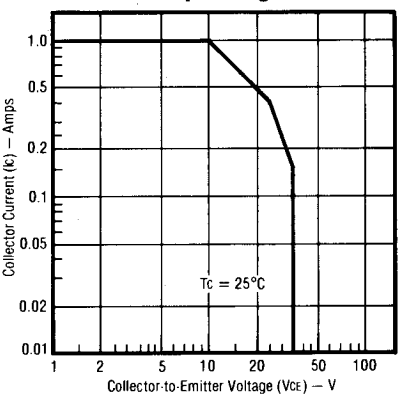
Series Load Impedance vs Frequency



f_t vs I_C

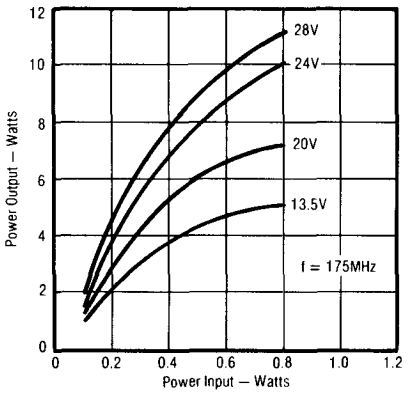


Safe Operating Area

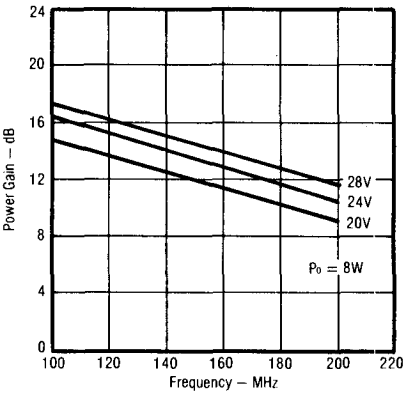


PT 9732 — 8 Watts

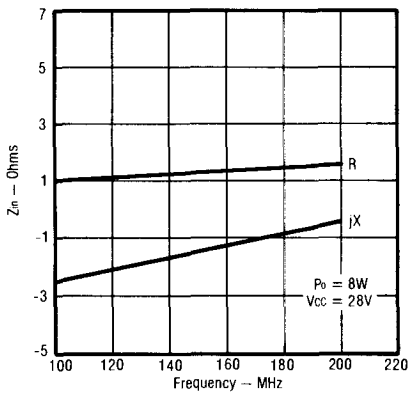
Power Output vs Power Input



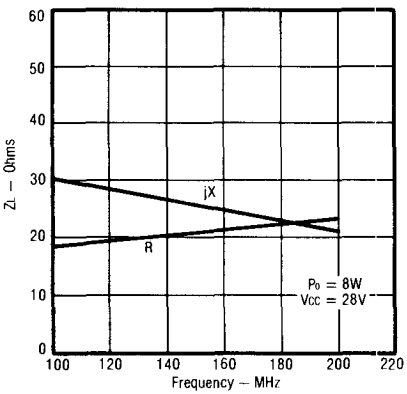
Power Gain vs Frequency



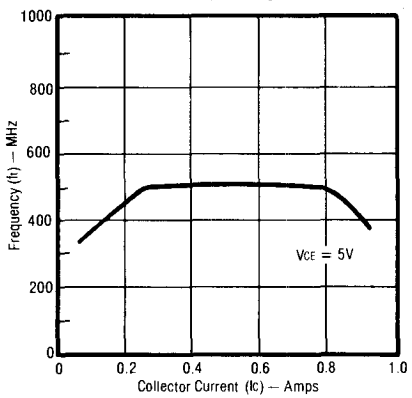
Series Input Impedance vs Frequency



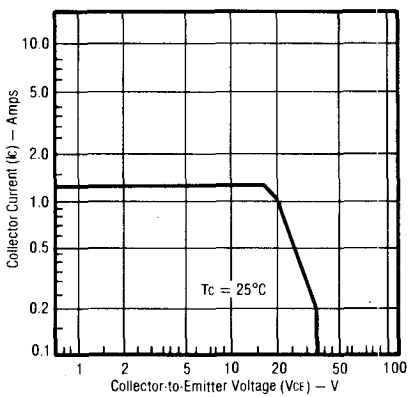
Series Load Impedance vs Frequency



f_t vs I_C

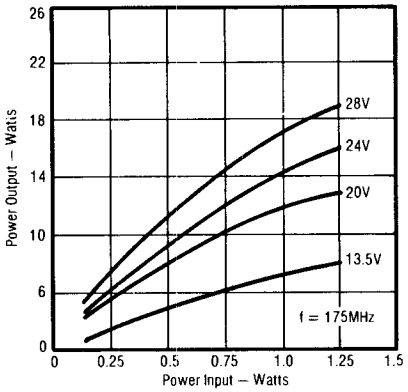


Safe Operating Area

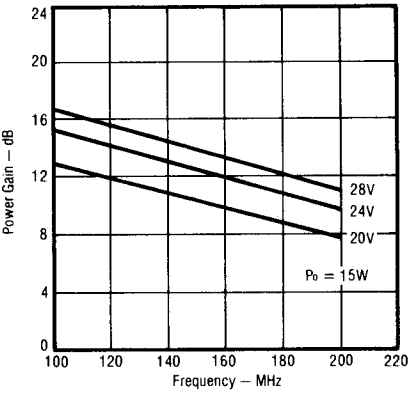


PT 9734 — 15 Watts

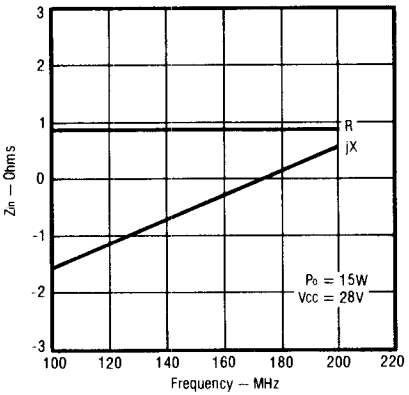
Power Output vs Power Input



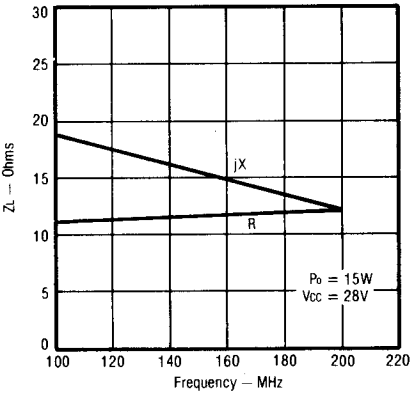
Power Gain vs Frequency



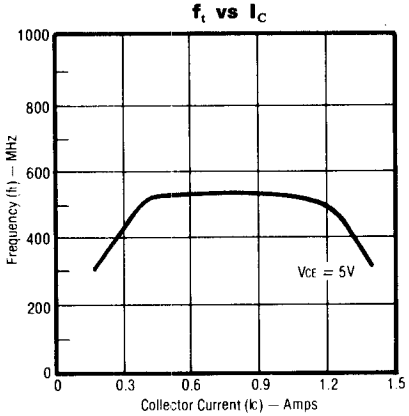
Series Input Impedance vs Frequency



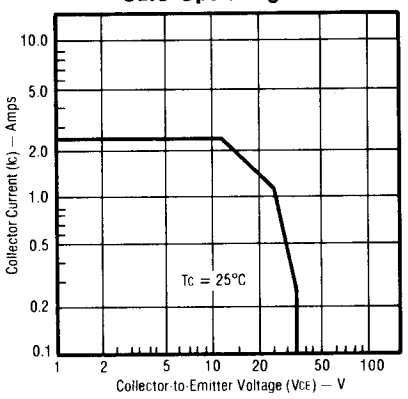
Series Load Impedance vs Frequency



f_t vs I_C

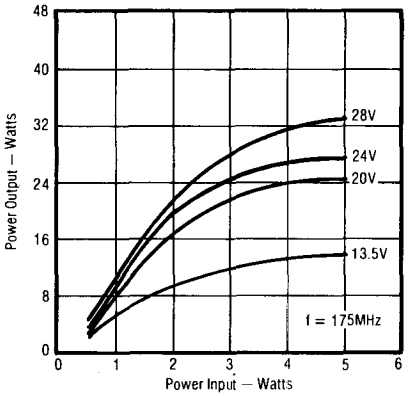


Safe Operating Area

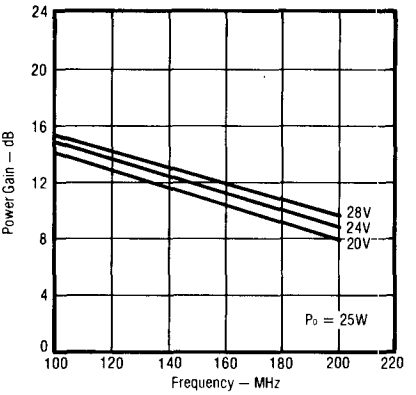


PT 9731 — 25 Watts

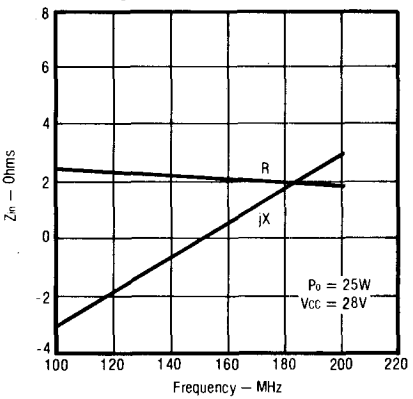
Power Output vs Power Input



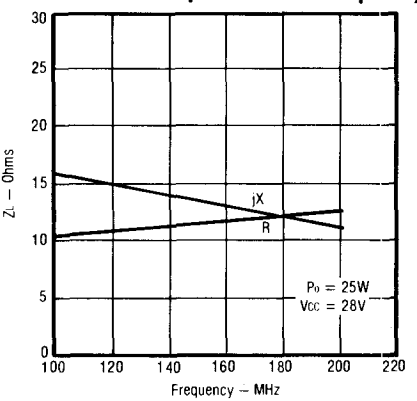
Power Gain vs Frequency



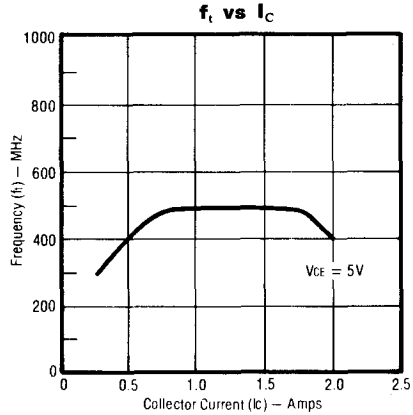
Series Input Impedance vs Frequency



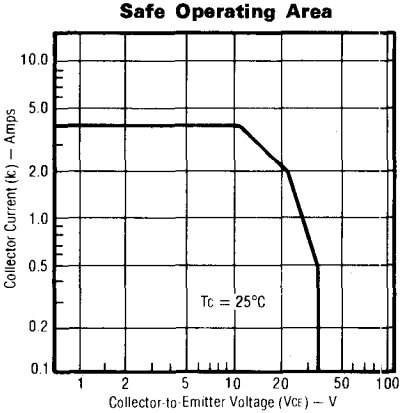
Series Load Impedance vs Frequency



f_t vs I_C

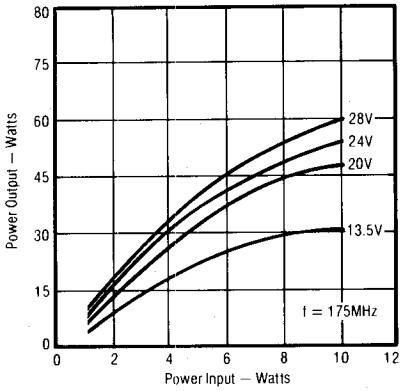


Safe Operating Area

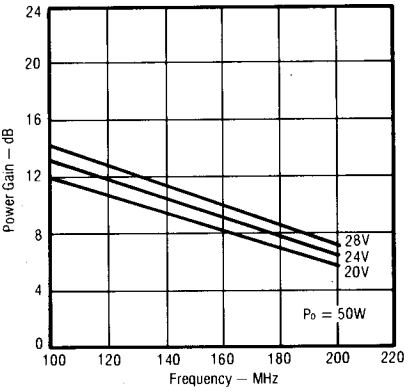


PT 9733 — 50 Watts

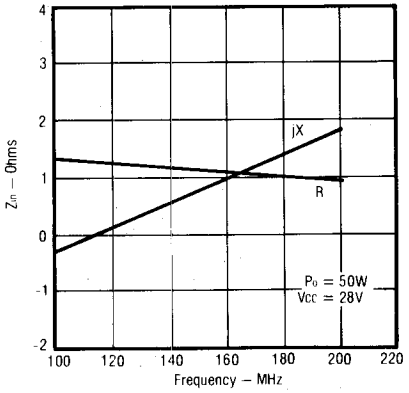
Power Output vs Power Input



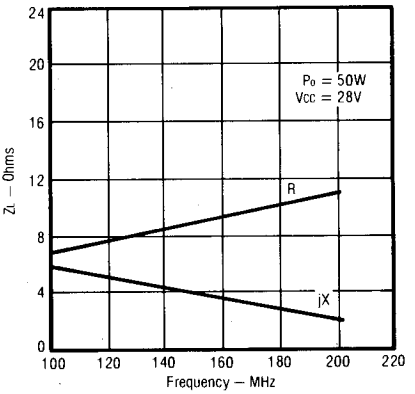
Power Gain vs Frequency



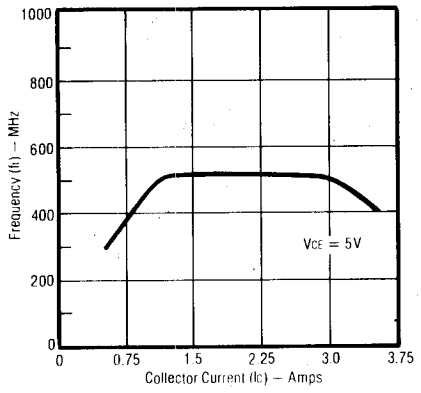
Series Input Impedance vs Frequency



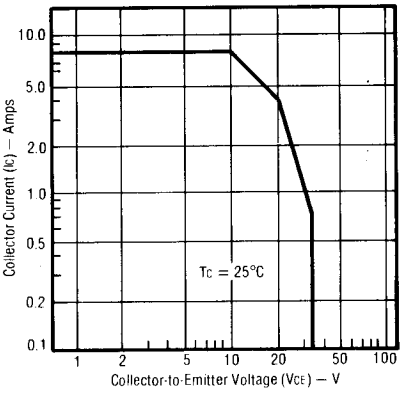
Series Load Impedance vs Frequency



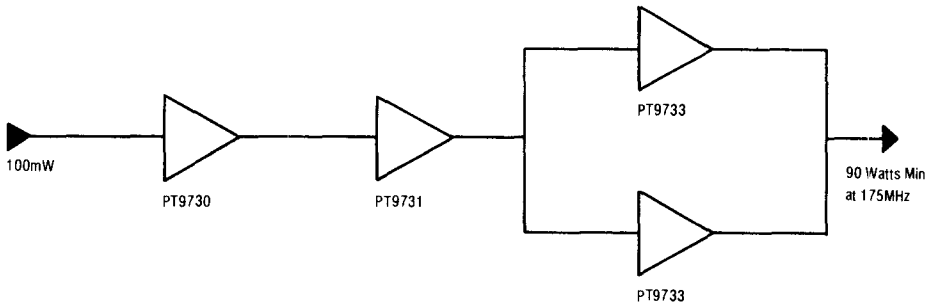
f_t vs t_C



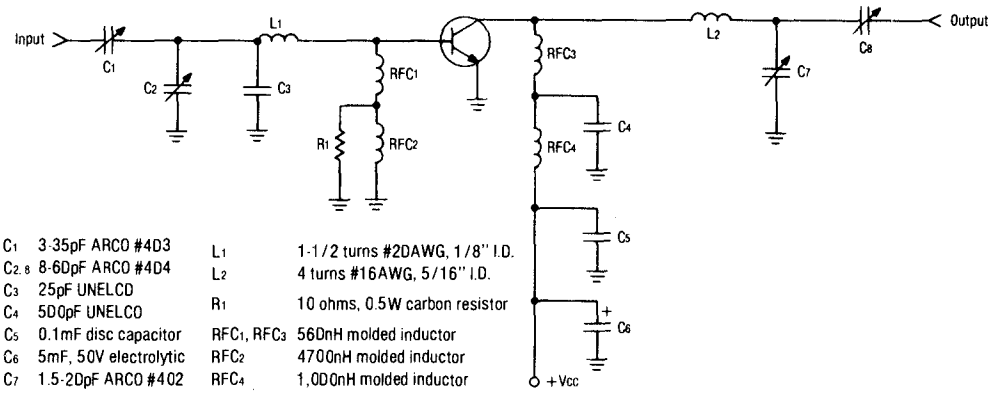
Safe Operating Area



TYPICAL APPLICATION
90 Watt VHF 28 V Power Amplifier

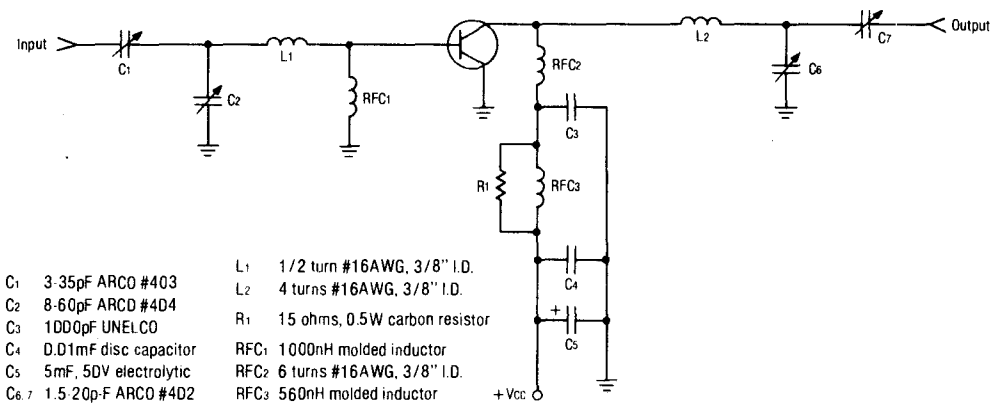


PT 9730 and PT 9732 175 MHz TEST CIRCUIT



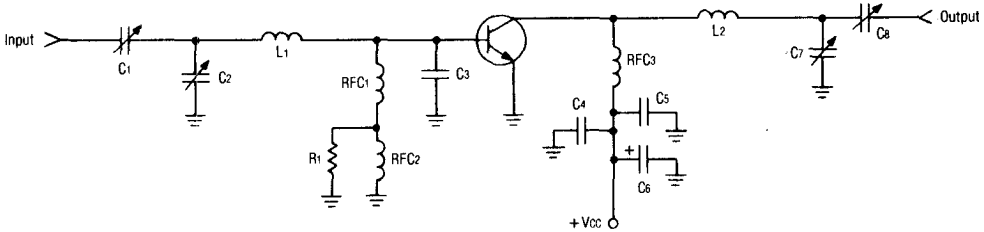
C_1	3-35pF ARCO #4D3	L_1	1-1/2 turns #2DAWG, 1/8" I.D.
$C_{2,8}$	8-60pF ARCO #4D4	L_2	4 turns #16AWG, 5/16" I.D.
C_3	25pF UNELCO	R_1	10 ohms, 0.5W carbon resistor
C_4	5D0pF UNELCO	RFC_1, RFC_3	56DnH molded inductor
C_5	0.1mF disc capacitor	RFC_2	4700nH molded inductor
C_6	5mF, 50V electrolytic	RFC_4	1,0D0nH molded inductor
C_7	1.5-2Dp-F ARCO #402		

PT 9734 175 MHz TEST CIRCUIT



C_1	3-35pF ARCO #403	L_1	1/2 turn #16AWG, 3/8" I.D.
C_2	8-60pF ARCD #4D4	L_2	4 turns #16AWG, 3/8" I.D.
C_3	1DD0pF UNELCO	R_1	15 ohms, 0.5W carbon resistor
C_4	D.D1mF disc capacitor	RFC_1	1000nH molded inductor
C_5	5mF, 5DV electrolytic	RFC_2	6 turns #16AWG, 3/8" I.D.
$C_{6,7}$	1.5-20p-F ARCO #4D2	RFC_3	560nH molded inductor

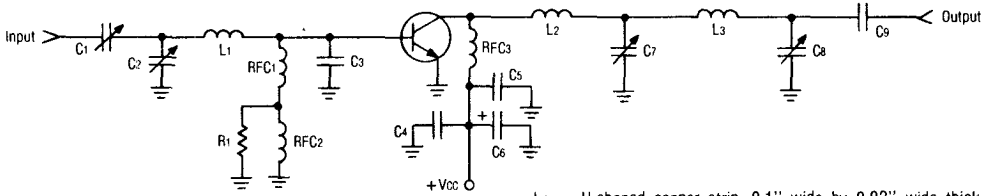
PT 9731 175 MHz TEST CIRCUIT



C1, 8 7-100pF ARCO #423
C2 8-60pF ARCO #404
C3 90pF UNELCO
C4 1000pF UNELCO
C5 0.1mF disc capacitor
C6 5mF, 50V electrolytic
C7 5-80pF ARCO #462

L1 2 turns, 0.1" wide by 0.02" thick copper strip, 1/4" I.D.
L2 4 turns, 0.1" wide by 0.02" thick copper strip, 1/4" I.D.
R1 10 ohms, 0.5W carbon resistor
RFC1 150nH molded inductor
RFC2 10,000nH molded inductor
RFC3 4 turns #16AWG, 5/16" I.D.

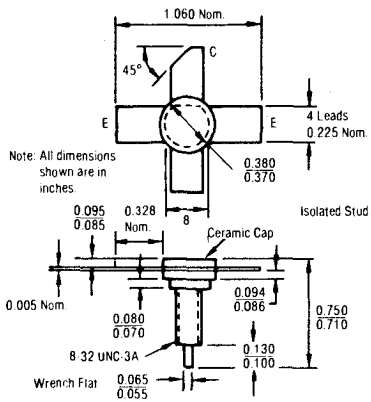
PT 9733 175 MHz TEST CIRCUIT



C1, 2, 8 8-60pF ARCO #404
C3 150pF UNELCO
C4 500pF UNELCO
C5 0.1mF disc capacitor
C6 5mF, 50V electrolytic
C7 5-80pF ARCO #462
C9 0.001mF disc capacitor

L1 1 turn, 0.1" wide by 0.02" thick copper strip, 5/16" I.D.
L2 U-shaped copper strip, 0.1" wide by 0.02" wide thick, 0.25" high by 0.675" long
L3 1-1/2 turns, 0.1" wide by 0.02" thick copper strip, 5/16" I.D.
R1 10 ohms, 0.5W carbon resistor
RFC1 150nH molded inductor
RFC2 10,000nH molded inductor
RFC3 4 turns #16AWG, 5/16" I.D.

PACKAGE OUTLINE



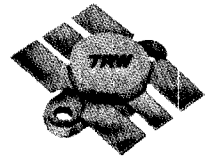
PRELIMINARY DATA SHEET

VHF Power Transistor

The TP 9386 is designed for use in the new generation of VHF transmitters. It operates in class A, B or C from a 28 V supply.

Its construction, which now incorporates the new standard TRW process of gold metallisation and diffused ballast resistors, ensures a long operational life even when run at its maximum ratings.

150 W
100 - 175 MHz
HIGH GAIN
RF POWER TRANSISTOR
SILICON

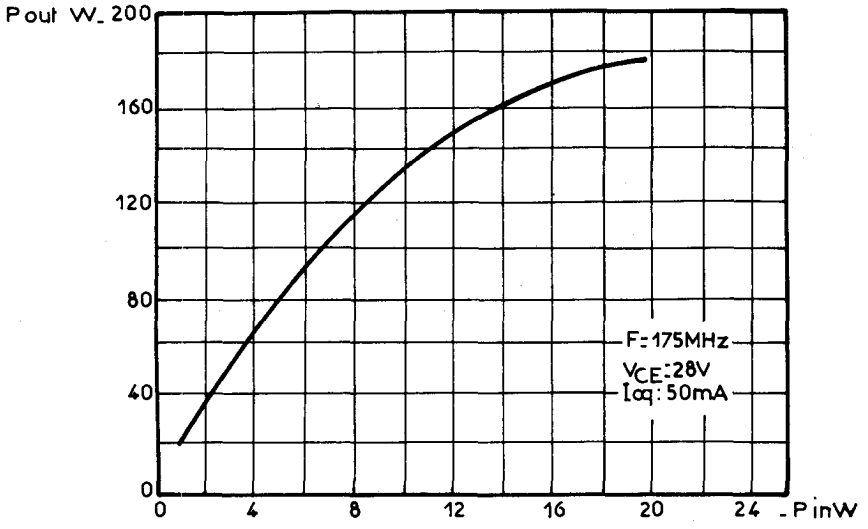


JØ 500

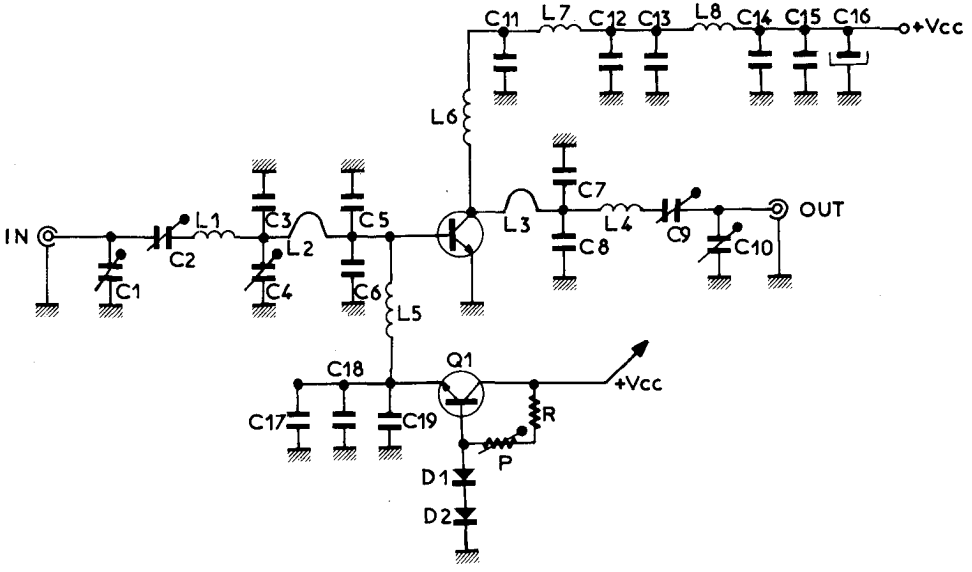
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 20 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 Ω	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	h_{FE}	D.C Current Gain	V_{CE} = 5V I_C = 1 A	15		150	—
RF Test	P_{out}	Common Emitter Amplifier output power	V_{CE} = 28 V I_{cq} = 50 mA F = 175 MHz P_{in} = 15 W	150			W
	η_c	Collector Efficiency	V_{CE} = 28 V I_{cq} = 50 mA F = 175 MHz P_{out} = 150 W	60			%
	C_{ob}	Output Capacitance	V_{CB} = 28 V F = 1 MHz			150	pF
Thermal	P_d	Maximum Power dissipation				250	W
	I_c	Maximum Collector Current				15	A
	R_{thjc}	Thermal resistance Junction case				0,7	°C/W

TYPICAL POWER OUTPUT VERSUS POWER INPUT



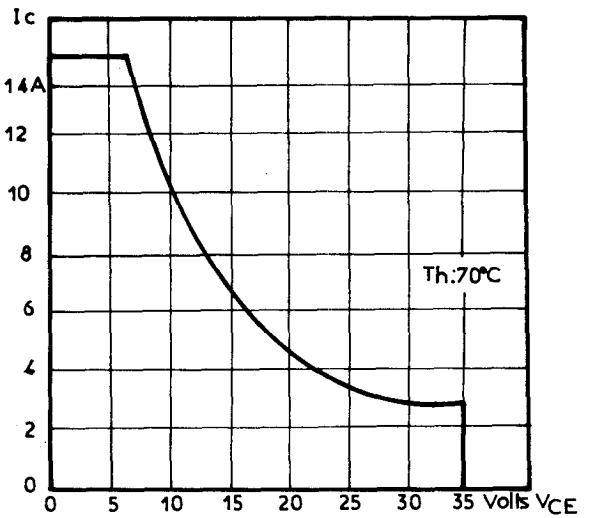
TEST FIXTURE (Narrow band)



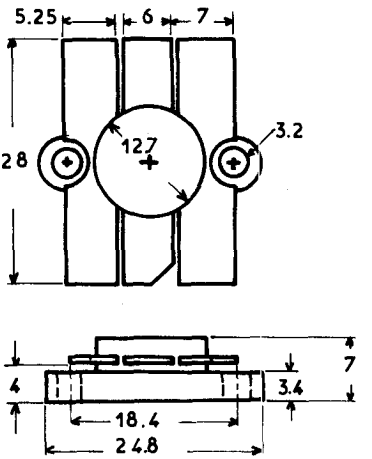
COMPONENTS PART LIST

C_1 C_2	ARCO 403	
C_3	30 pF	
C_4	ARCO 404	
C_5 C_6	80 pF	
C_7 C_8	100 pF	
C_9 C_{10}	ARCO 425	(24-200 pF)
C_{11} C_{12} C_{14} C_{17}	1 000 pF	
C_{13} C_{15} C_{18}	10 nF	
C_{16} C_{19}	47 µF	
L_1	2turns	ø 8 mm 1 mm wire
L_2	Hair pin	Copper foil 15 × 3 mm 0,3 mm thick
L_3	Hair pin	Copper foil 12 × 5 mm 0,3 mm thick
L_4	3 turns	ø 5 mm 1,5 mm wire
L_5	10 turns	ø 5 mm 0,5 mm wire
L_6	3 turns	ø 6 mm 1,5 mm wire
L_7	3 turns	ø 6 mm 1,5 mm wire
L_8	10 turns	1 mm wire on core (µi = 120)
R	1,5 Ω	1/2 W
P	5 KΩ	
D_1 D_2	IN 4007	
Q_1	BD 135	

DC SAFE OPERATING AREA



PACKAGE



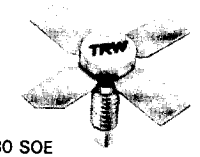
Dimensions given in mm

UHF Power Transistor

100 - 400 MHz
1 W 20 V
16 dB GAIN
NARROW BAND
GOLD RELIABILITY

The TM 401 is a NPN gold metallized transistor using diffused emitter ballast resistor design for operation in class A, B or C conditions.

The high gain reduces the need for complex broadband circuits and is ideally suited for 100-400 MHz broadband amplifier applications.



280 SOE

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 0.3 mA	3.5			V
	BV_{CER}	Collector Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 20 mA	50			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 20 mA	24			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 1 mA	45			V
	I_{CBO}	Collector Base Leakage	V_{CB} = 28 V			0.4	mA
	h_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 100 mA	20		120	
RF TEST	P_G	Power Gain Class A Broad Band	F = 400 MHz V_{CE} = 20 V I_E = 200 mA P_O = .5 W	13			dB
	P_{sat}	Broad Band Min Saturated Output Power Class A	F = 400 MHz V_{CE} = 20 V I_E = 200 mA	1.3			W
	VSWR	Mismatch Tolerance	F_O = 400 MHz V_{CE} = 20 V I_C = 220 mA P_{out} = 1.0 WCW		∞		
	C_{ob}	Collector Base Capacitance	V_{CB} = 24 V F = 1 MHz			5	pF
	F_T	Cutoff Frequency	V_{CE} = 20 V I_E = 200 mA	2.2			GHz
THERMAL	I_C	Maximum Collector Current				0.7	A
	$\theta_{j.C}$	Thermal Resistance Junction Case	T_{case} = 70 °C			20	°C/W
	P_T	Power Dissipation	T_{case} = 25 °C			8.75	W
	T_{STG} T_J	Storage temperature Junction temperature		— 65		+ 200	°C

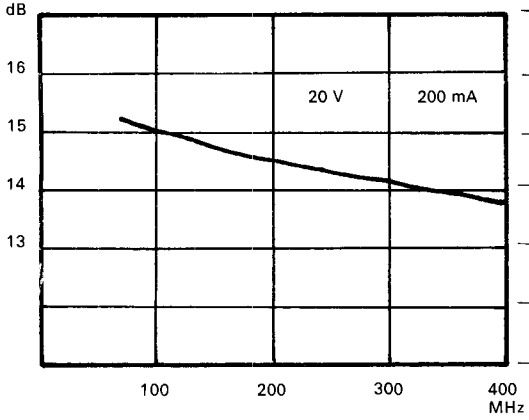
V_{CE} = 20 V - I_C = 200 mA - Class A

POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl°
100 MHz	0.67	203°	12.6	112°	0.037	32°	0.41	— 90°
200 MHz	0.78	186°	7.6	93°	0.042	31°	0.33	— 122°
300 MHz	0.79	183°	5.5	82.5°	0.047	30°	0.34	— 135°
400 MHz	0.78	170°	4.21	72°	0.053	30°	0.34	— 137°
500 MHz	0.76	165°	3.39	66°	0.061	35°	0.33	— 138°

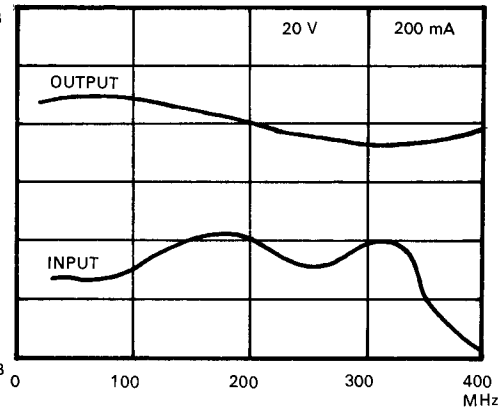
100-400 MHz AMPLIFIER PERFORMANCES

Class A **20 V** **200 mA**

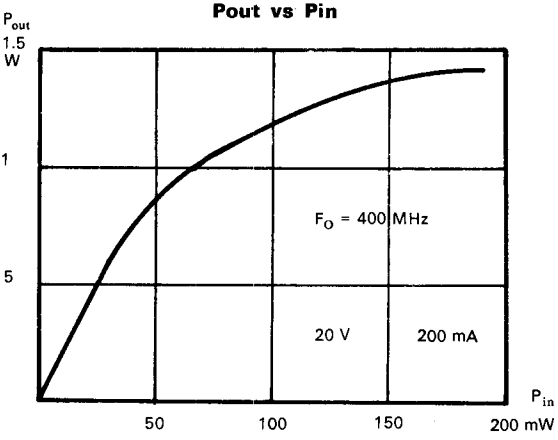
Small Signal Gain Variation



Input and Output VSWR

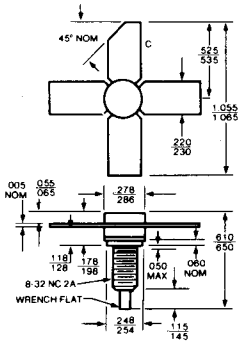


Pout vs Pin

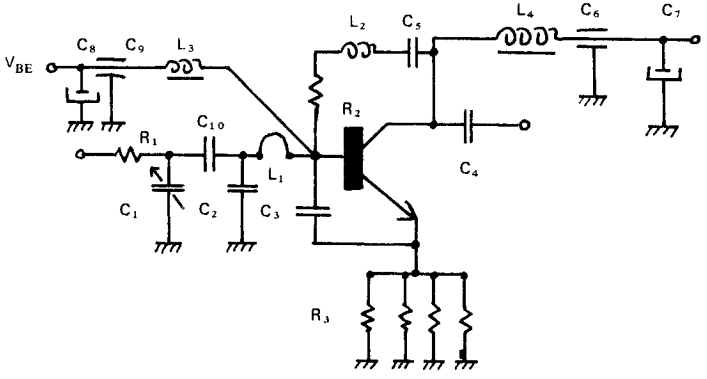


Package

.280 SOE



1 W - 100-400 MHz Class A AMPLIFIER



C_1 = 1-9 pF variable RTC
C_2 = 8.2 pF RTC C 330
C_3 = 2 × 2.2 pF RTC C 632
C_4 = 10 nF RTC C 331
C_5 = C_{10} = 1 nF C 331
C_6 = C_9 = 1 nF by-pass
C_7 = C_8 = 10 µF 25 V

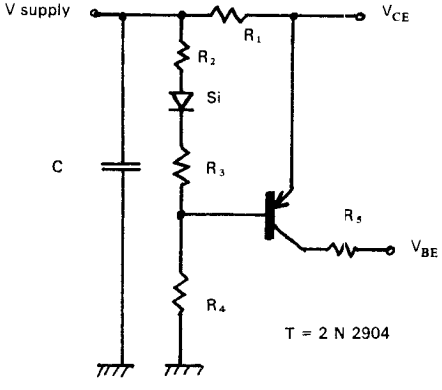
R_1 = 15 Ω carbon composition
R_2 = 300 Ω carbon composition
R_3 = 4 × 3.9 Ω 1/4 W
Carbon composition

L_1 = 5 mm × 5 mm wire 5/10 mm

L_2 = 4 turns ID 4 mm wire 5/10 mm

L_3 = L_4 = choke

Bias Circuit



R_1 = 11 Ω 1/2 W
R_2 = 500 Ω
R_3 = 220 Ω
R_4 = 4.7 kΩ
R_5 = 22 Ω

Preliminary

UHF Power Transistor

5 W - 400 MHz

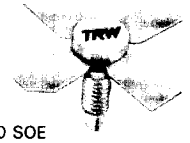
16 dB GAIN

GOLD RELIABILITY

The TPM 405 is a NPN gold metallized transistor using diffused emitter ballast resistors for operation at class A, AB and C.

Its high gain reduces the complexity of the broadband stages and make the TPM 405 ideal for 100-400 MHz applications.

A 100-400 MHz push-pull amplifier is described in the two last pages of this data sheet.



2B0 SOE

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CER}	Collector Emitter Breakdown Voltage	I_C = 40 mA R_{BE} = 10 Ω	50			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 2 mA	45			V
	I_{CBO}	Collector Base Leakage	V_{CB} = 28 V			0.450	mA
	h_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 200 mA	20		120	
RF TEST	P_{GAIN}	Power Gain Class AB	V_{CE} = 24 V P_{out} = 5 W F_O = 400 MHz I_Q = 50 mA	16			dB
	η	Min Collector Efficiency	V_{CE} = 24 V P_{out} = 5 W F_O = 400 MHz I_Q = 50 mA	50			%
	VSWR	Mismatch Tolerance	V_{CE} = 24 V P_{out} = 3 W F_O = 400 MHz I_Q = 50 mA		∞		
	P_{SAT}	Min Saturated Power output	V_{CE} = 24 V F_O = 400 MHz I_Q = 50 mA	7			W
	C_{ob}	Collector Base Capacitance	V_{CB} = 24 V F = 1 MHz			7	pF
THERMAL	I_C	Maximum Collector Current				1.4	A
	$\theta_{J.C}$	Thermal Resistance Junction Case	T_{case} = 70 °C			9.5	°C/W
	T_{STG} T_j	Storage and Junction Temperature		— 65 °C		+ 200	°C

CLASS A - V_{CE} = 20 V - I_C = 440 mA - Small Signal

POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Asgl°	Magn	Angl°
100 MHz	0.871	190	6.130	108	0.028	17	0.537	205
200 MHz	0.902	182	4.9	90	.03	18	0.562	191
300 MHz	0.907	178	3.35	80	0.033	20	0.562	189
400 MHz	0.902	175	2.66	72	0.035	22	0.562	188
500 MHz	0.905	175	2.21	71	0.034	30	.540	192

Large Signal Impedances

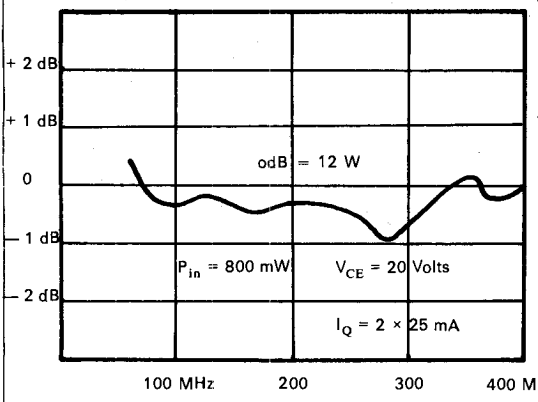
Class AB I_Q = 50 mA F_O = 400 MHz

P_{out} = 5 W V_{CE} = 20 V

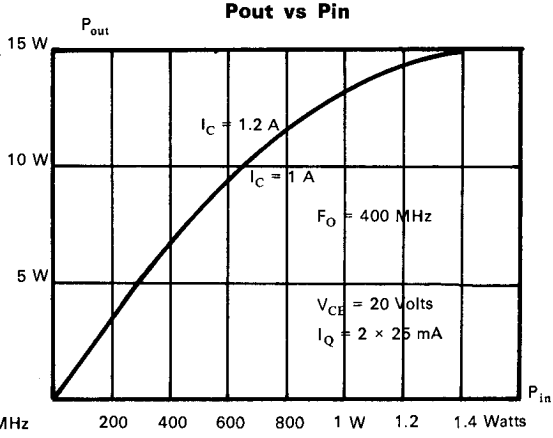
Z_{in}	Z_{out}
(1,5 — J 1) ohm	(15,5 — J 21,4) ohm

PUSH-PULL PERFORMANCES

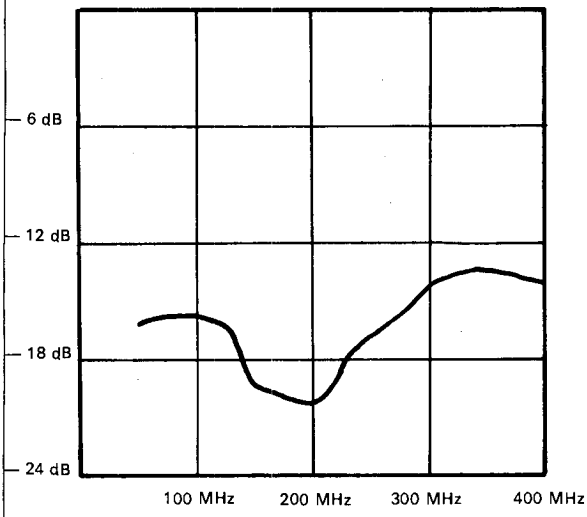
Pout vs Frequency



Pout vs Pin

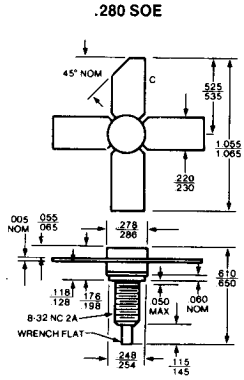


Input Return Loss

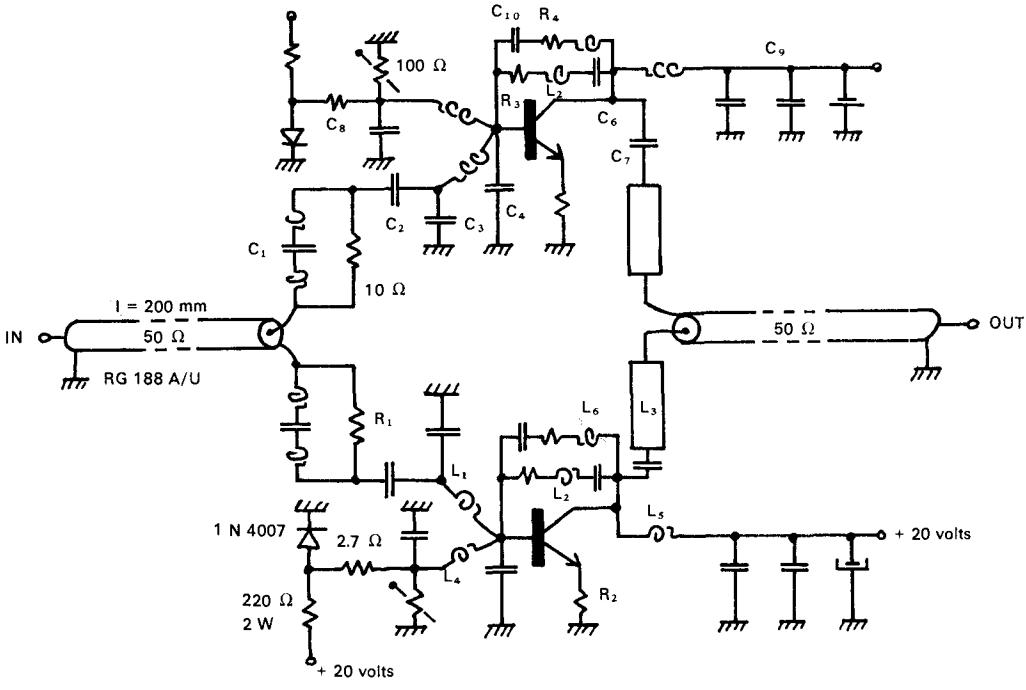


PACKAGE

.280 SOE



PUSH-PULL AMPLIFIER 100-400 MHz



L_1 : 1/2 turn  5 mm 5/10 mm
5 mm

L_2 : 6 turns ⌀ 3 mm 5/10 mm
L_3 : 25 Ω line 2 % λg at 400 MHz
L_4 : Moiled coil .47 µF
L_5 : Moiled coil 4.7 µH
L_6 : 17 turns ⌀ 3 mm 5/10 mm

C_1 : 27 pF C 300 RTC with 12 mm leads
C_2 : C_7 = 10 nF chip
C_3 : 27 pF ATC 100 A
C_4 : 2 × 1.3 pF ATC 100 A
C_6 : C_{10} = 10 nF RTC C 331
C_8 : C_9 = 1 nF + 10 nF + 0.1 µF + 10 µF decoupling

R_1 = 10 Ω 1/4 W carbon
R_2 = 4 × 1 Ω 1/4 W carbon
R_3 = R_4 = 300 Ω 1/4 W carbon

PRELIMINARY

UHF Power Transistor

25 W - 400 MHz
9 dB GAIN

GOLD RELIABILITY

The TPM 425 is a high gain UHF transistor which has been specially designed for use in 100-400 MHz broadband amplifiers.

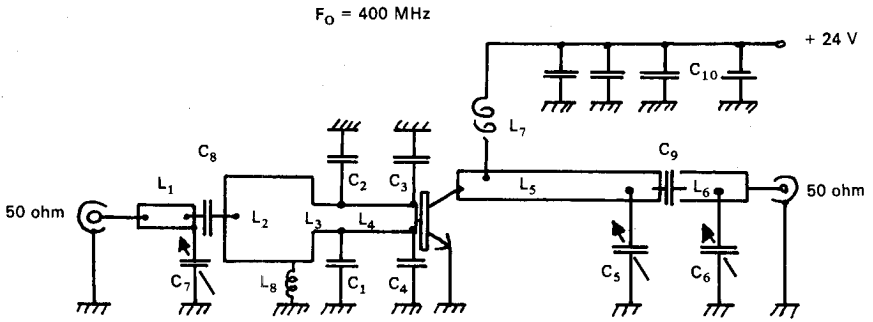
Its construction utilizes the new standard, gold metallization and diffused emitter ballast resistors, allowing class A, B or C operation and a high degree of ruggedability.



280 SOE

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 3 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_E = 20 mA	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA	45			V
	H_{FE}	D.C Current Gain	V_{CE} = 20 V I_C = 500 mA	10			
RF TEST	P_{out}	Power Output	V_{CE} = 24 V F_O = 400 MHz P_{in} = 3 W	25			W
	η_C	Collector Efficiency	V_{CE} = 24 V F_O = 400 MHz P_{out} = 25 W	60	70		%
	C_{OB}	Collector - Base Capacitance	V_{CE} = 24 V F = 1 MHz			20	pF
	I_C	Maximum Collector Current				2	A
THERMAL	θ_{J-C}	Thermal Resistance Junction - Case	T_{case} = 25 °C			5	°C/W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C



L_1 = 50 ohm line
L_2 = 22 ohm line 3 % λg at 400 MHz
L_3 = 30 ohm line 0.5 % λg at 400 MHz
L_4 = 30 ohm line 1 % λg at 400 MHz
L_5 = 50 ohm line 5.5 % λg at 400 MHz
L_6 = 50 ohm line 3.5 % λg at 400 MHz

L_7 = 2 turns — ID 7 mm — wire 1 mm
L_8 = 0.68 μH - Molded — RFC

C_1 = C_2 = 18 pF — ATC — 100 A
C_3 = C_4 = 10 pF — ATC — 100 A
C_5 = AT 5501 — 1-20 pF — Tekelec
C_6 = C_7 = AT 5601 — 1-30 pF — Tekelec
C_8 = C_9 = 1 nF
C_{10} = 1 nF + 10 nF + .1 μF + 10 μF Decoupling.

POLAR S-PARAMETERS 50 OHM SYSTEM

FREQ. MHz	S 11		S 21		S 12		S 22	
	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl
100	0.957	181	3.89	99	0.019	35	0.707	190
200	0.957	178	1.97	95	0.019	45	0.724	186
300	0.957	176	1.29	75	0.025	45	0.741	184
400	0.957	174	1.06	68	0.032	50	0.749	184
500	0.957	172	0.86	63	0.035	57	0.746	183

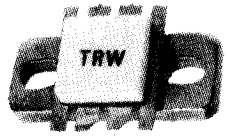
V_{CE} = 25 V I_C = 850 mA

PRELIMINARY DATA SHEET

40 W
30 - 400 MHz
28 V
RF POWER
PUSH-PULL TRANSISTOR
NPN SILICON

The TPM 4040 is an internally matched transistor on a push-pull package specially designed for multioctave bandwith high gain and power applications. Its internal matching and package configuration lead to high input and output impedances.

Multicell die design and ultra thin beryllium oxide header allow optimum heat dissipation and operating efficiency. Long term reliability and ruggedness are garanteed by diffused silicon ballast resistors and the TRW gold metallization process.

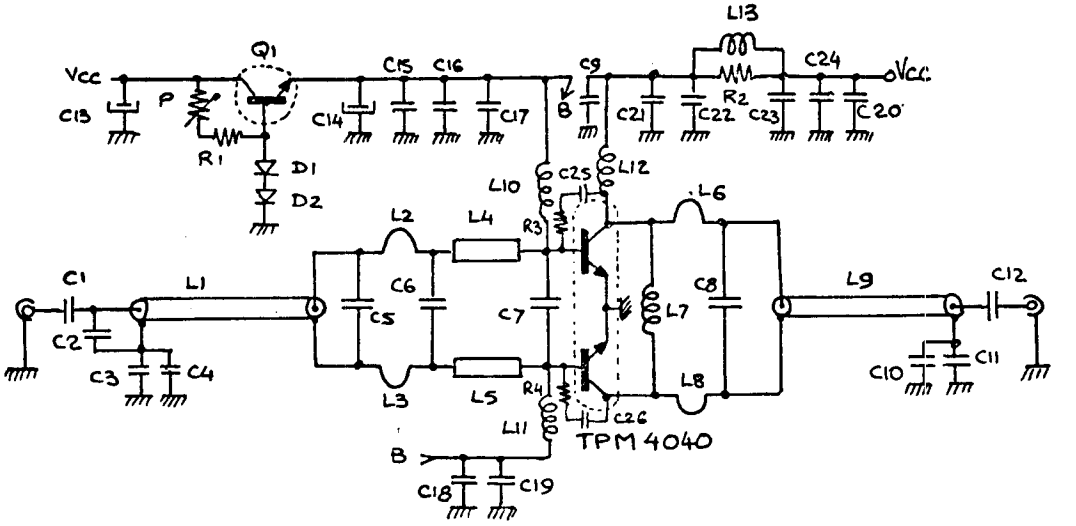


MRP7 Push-pull package.

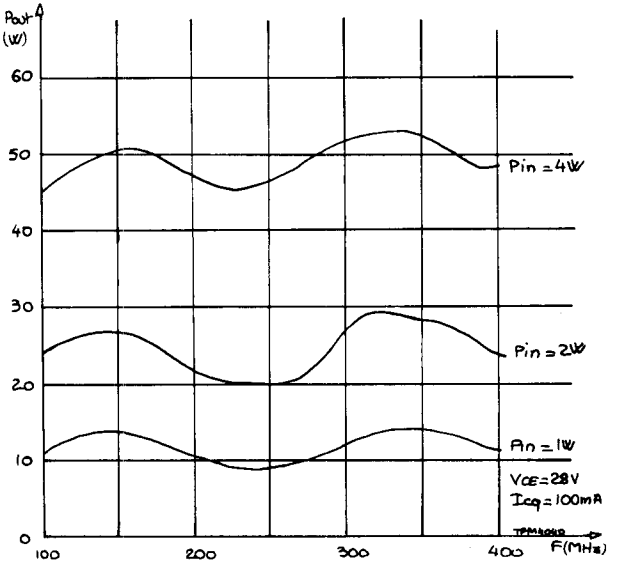
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emetter - Base Breakdown Voltage	I_E = 6 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 40 mA	30			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA	45			V
	H_{FE}	D.C. Current Gain	V_{CE} = 20 I_C = 500 mA	10			—
RF Test	P_G	RF Power Gain	V_{CE} = 28 V	10			dB
	η_C	Collector Efficiency	F = 400 MHz	50			%
	VSWR	Mismatch Tolerance	P_{out} = 40 W I_{cq} = 2 X 50 mA	∞			—
	C_{OB}	Collector - Base Capacitance (Each Side)	V_{CB} = 28 V F = 1 MHz			20	pF
Thermal	θ_{JC}	Thermal Resistance Junction Case	$T°_{case}$ = 70 °C			2	°C/W
	P_D	Power dissipated	$T°_{case}$ = 70 °C			65	W

100-MHz 40 W AMPLIFIER (Class AB)



Typical Pout vs Pin, F

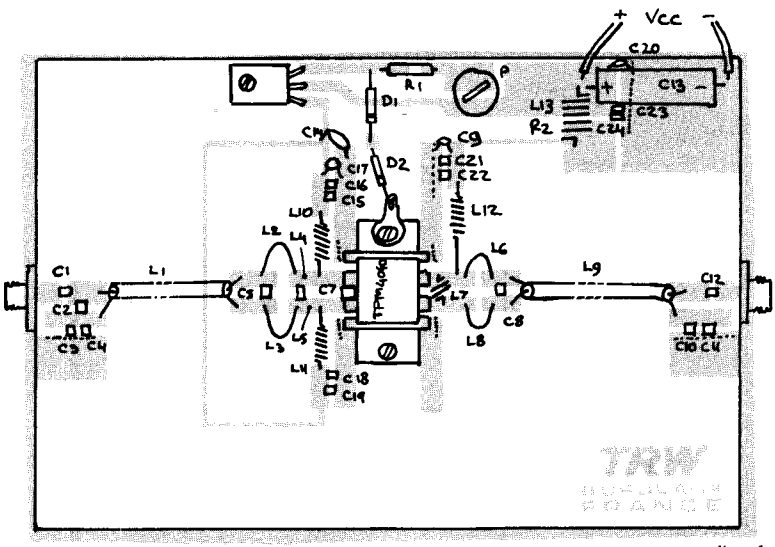


COMPONENTS PART LIST

C_1, C_6, C_{12}	= 39 pF chip capacitor
C_2	= 3.9 pF chip capacitor
C_3, C_{10}, C_{15}, C_{18}, C_{21}, C_{23}	= 1000 pF chip capacitor
C_4, C_{11}, C_{16}, C_{19}, C_{22}, C_{24}	= 15 nF chip capacitor
C_5	= 22 pF chip capacitor
C_7	= 68 pF chip capacitor
C_8	= 15 pF chip capacitor
C_{25}, C_{26}	= 10 nF ceramic disc capacitor
C_{14}	= 10 µF/ 5 V Electrolytic capacitor
C_{13}	= 100 µF/40 V Electrolic capacitor
C_9, C_{13}, C_{17}, C_{20}	= 0.1 µF Tantal
L_1, L_9	= 100 mm, 50 ohms teflon coaxial cable
L_2, L_3	= hair pin L = 17 mm, 0.8 mm wire
L_4, L_5	= 6 mm X 3 mm line on substrate
L_6, L_8	= hair pin L = 12 mm, 0.8 mm wire
L_7	= 3 turns ∅ 5 mm, 0.8 mm wire
L_{10}, L_{11}, L_{12}	= 15 turns ∅ 3 mm 0.5 mm craneled wire
L_{13}	= 6 turns ∅ 5 mm 1.2 mm wire
R_1	= 1.2 K ohms 1/2 W
R_2	= 15 ohms 1/2 W
R_3, R_4	= 1 K ohms 1/4 W
D_1, D_2	= 1 N 4007 or equivalent
Q_1	= BD 135 or equivalent

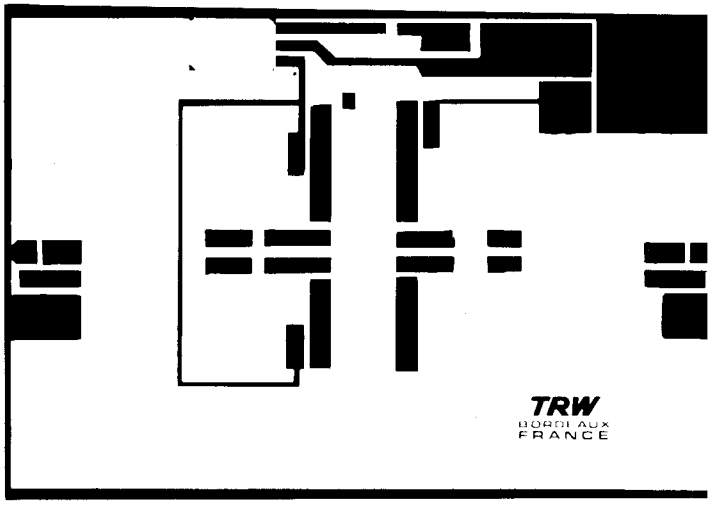
Substrate : teflon glass 1/50"

COMPONENTS LAYOUT

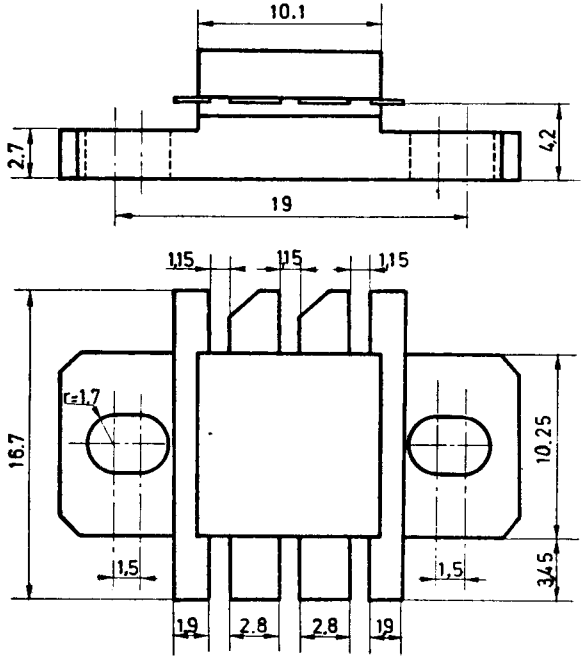


- - - - - = grounding foil

PRINTED CIRCUIT BOARD



PACKAGE

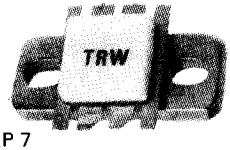


Push-Pull Transistor

PRELIMINARY DATA SHEET

The TPM 4100 is an internally matched transistor on a push-pull package specially designed for multioctave bandwidth high power applications. Its internal matching and package configuration lead to high input and output impedances. Multicell die design and ultra thin beryllium oxide header allow optimum heat dissipation and operating efficiency. Long term reliability and ruggedness are garanteed by diffused silicon ballast resistors and the TRW gold metallization process.

100 W
100 - 400 MHz
28 V
RF POWER
PUSH-PULL TRANSISTOR
NPN SILICON

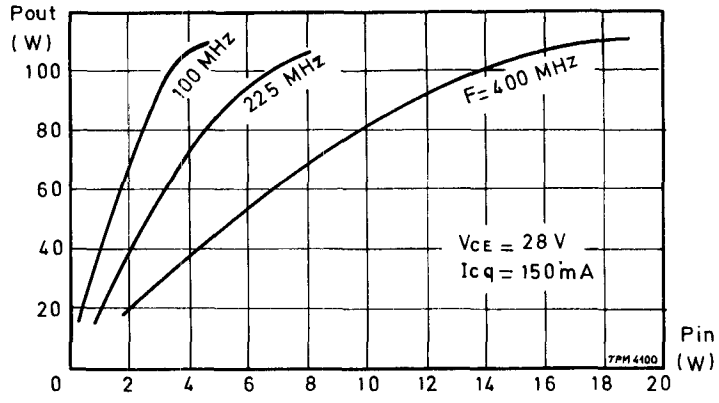


MRP 7

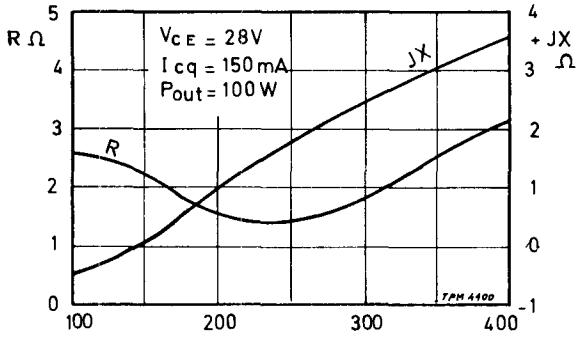
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA	3.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	30			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 100 mA	65			V
	H_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 1 A	20		150	—
RF TEST	P_G	Power Gain	V_{CE} = 28 V P_{out} = 100 W F = 400 MHz I_{CQ} = 150 mA	7.5			dB
	η_C	Collector Efficiency	V_{CE} = 28 V P_{out} = 100 W F = 400 MHz I_{CQ} = 150 mA	50			%
	C_{OB}	Collector Base Capacitance (each side)	V_{CB} = 28 V F = 1 MHz		60	70	pF
THERMAL	P_D	Maximal Total Dissipation	t_C = 25 °C			175	W
	I_C	Maximal Collector Current (each side)				10	A
	R_{TH}	Thermal Resistance Junction Heatsink	Theatsink = 60 °C P_D = 100 W Including contact			1	°C/W

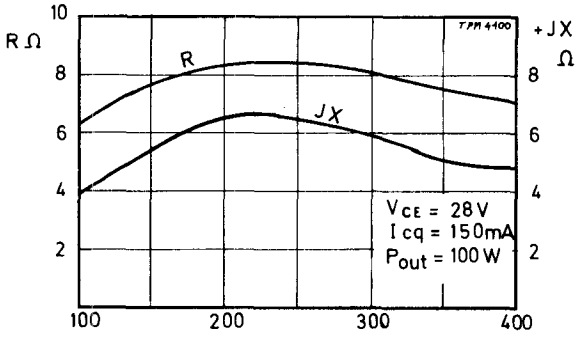
Typical Power Output vs Power Input vs Frequency



Typical Series Input Impedance vs Frequency Base to Base



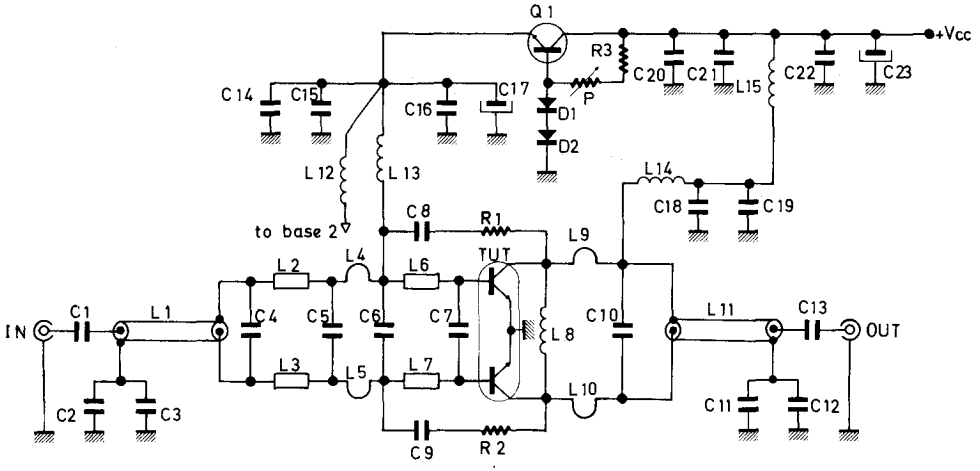
Typical Series Load Impedance vs Frequency Collector to Collector



— All these values are given in push-pull configuration

— I_{cq} = 150 mA is total quiescent current.

400 MHz TEST CIRCUIT



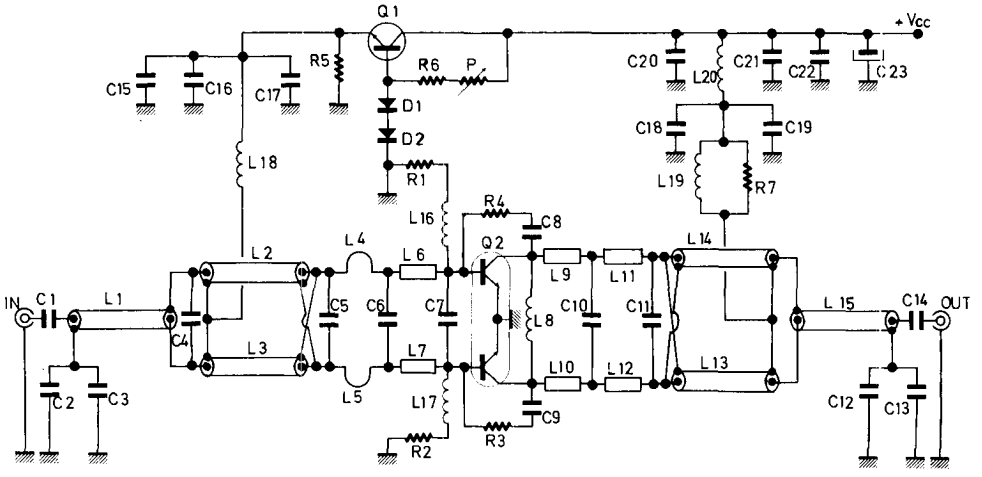
Test Fixture Components List

C_1, C_{13}	=	39 pF chip capacitor
C_2, C_{11}, C_{14}, C_{18}, C_{20}	=	1000 pF chip
C_3, C_{12}, C_{15}, C_{19}, C_{21}	=	15 nF chip
C_4	=	27 pF chip
C_5	=	33 pF chip
C_6	=	47 pF chip
C_7	=	68 pF chip
C_8, C_9	=	10 nF disc
C_{10}	=	47 pF
C_{16}, C_{22}	=	0.1 µF tantal
C_{17}	=	47 µF/10 V
C_{23}	=	100 µF/40 V
L_1, L_{11}	=	λ/4 (13 cm) 25 Ω coaxial cable (teflon)
L_2, L_3	=	7 × 3 mm line on substrate
L_4, L_5	=	Hair pin L = 4 mm 0,8 mm wire
L_6, L_7	=	7 × 3 mm line on substrate
L_8	=	4 turns ∅ 5 mm 1 mm wire
L_9 L_{10}	=	Hair pin L = 6 mm 1 mm wire
L_{12}, L_{13}	=	0.15 µH molded inductor
L_{14}	=	6 turns ∅ 5 mm 1 mm wire
L_{15}	=	6 turns 1 mm wire on a µ = 120 ferrite core
D_1, D_2	=	IN 4007
Q_1	=	BD 135
R_1, R_2	=	330 Ω 1/2 W
R_3	=	2 KΩ 1/2 W
P	=	5 KΩ
Substrate		Teflon glass 1/50"

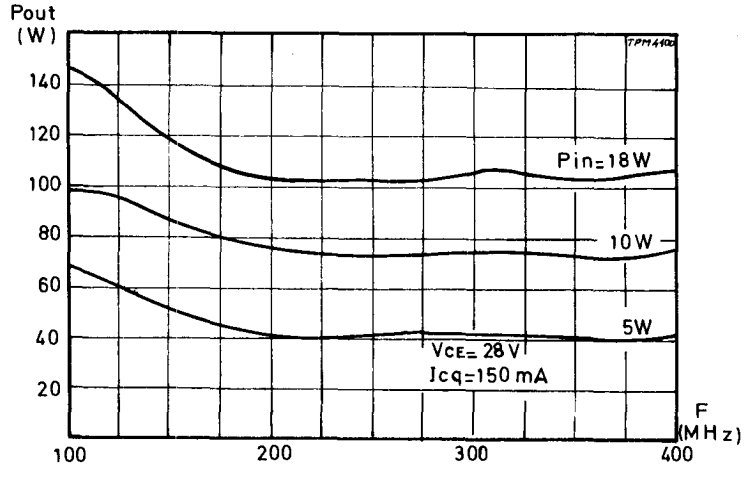
TYPICAL APPLICATION

BROAD BAND AMPLIFIER

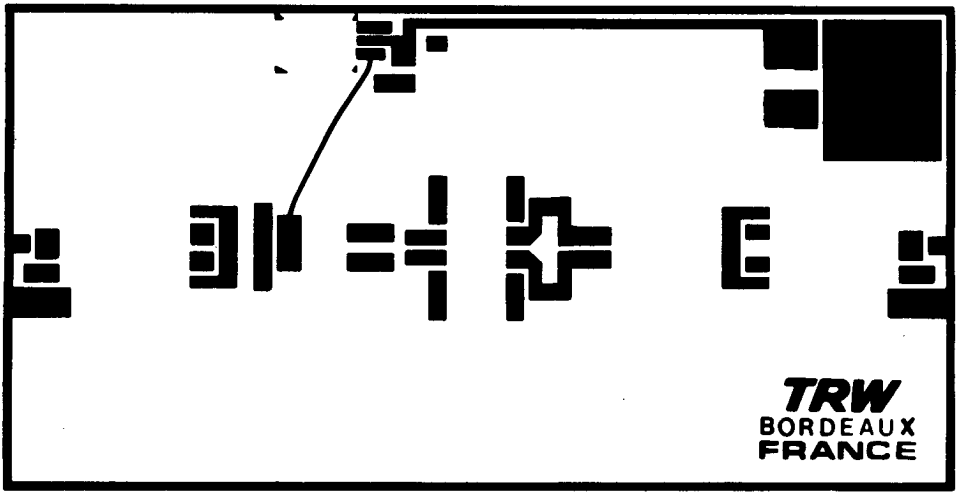
100 W 100-400 MHz 28 V Class AB (Icq = 150 mA)



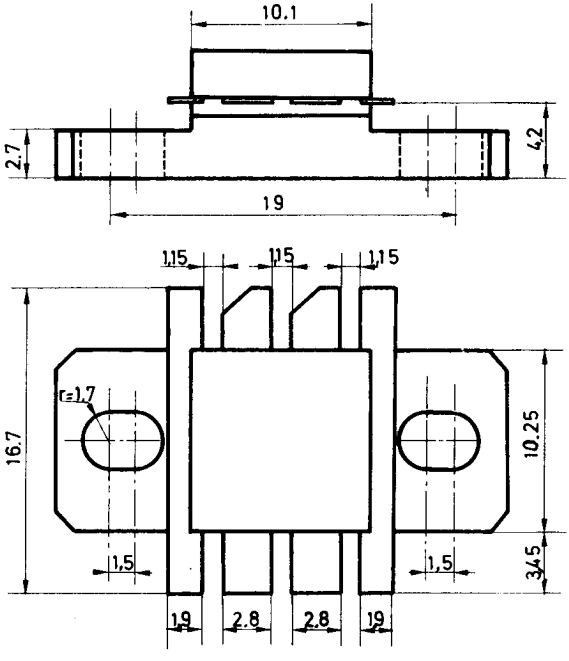
Typical Power Output vs Frequency Power Input



Printed Circuit board (full scale)



Package Outline



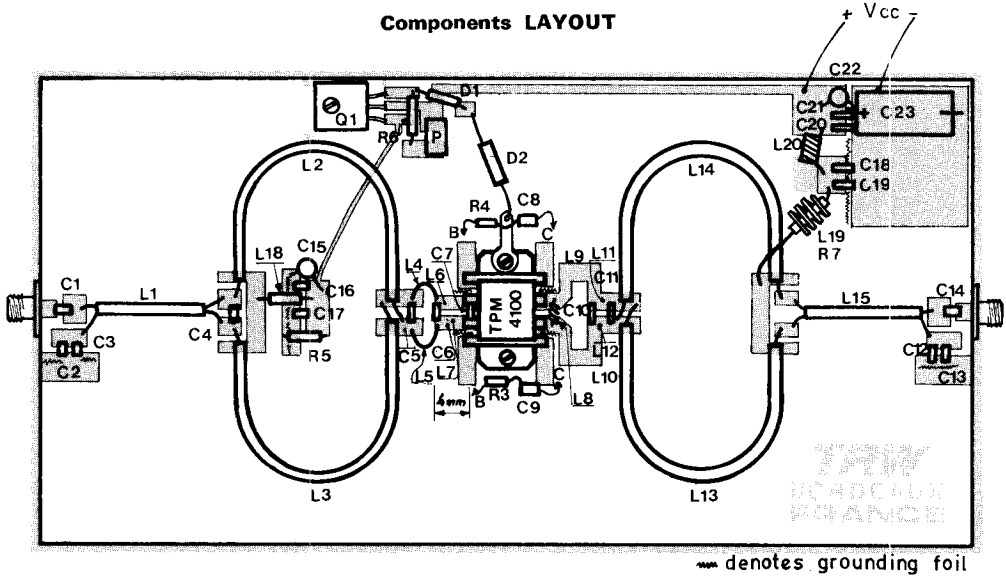
dimensions in Millimeters

Components Part List

C_1, C_{14}	39 pF chip	R_1, R_2	10 Ω 1/2 W
C_2, C_{12}, C_{15}, C_{18}, C_{20}	1000 pF	R_3, R_4	330 Ω 1/2 W
C_3, C_{13}, C_{16}, C_{19}, C_{21}	15 nF chip	R_5	33 Ω 1/4 W
C_4	3.6 pF chip	R_6	1.5 KΩ 1/2 W
C_5	27 + 22 pF	R_7	15 Ω 1/2 W
C_6	47 pF		
C_7	47 + 22 pF	Q_1	BD 135
C_8, C_9	10 nF ceramic disc	Q_2	TPM 4100
C_{10}	15 pF		
C_{11}	22 pF	D_1, D_2	IN 4007
C_{17}, C_{22}	0.1 µF tantal	Substrate	Teflon glass 1/50"
C_{23}	100 µF/40 V		

L_1, L_{15}	75 mm, 50 Ω coaxial cable (Teflon)
L_2, L_3, L_{14}, L_{13}	65 mm, 25 Ω coaxial cable (Teflon)
L_4, L_5	Hair pin, L = 4 mm, 0.8 mm wire
L_6, L_7	L = 6 mm × 2.5 mm on substrate
L_8	4 turns ⌀ 4 mm, L = 5 mm, 0.8 mm wire
L_9, L_{10}	L = 20 mm × 2.5 mm on substrate
L_{11}, L_{12}	L = 5 mm × 3 mm on substrate
L_{16}, L_{17}	0.1 µH molded inductor
L_{18}	0.47 µH molded inductor
L_{19}	6 turns, ⌀ 6 mm, 1 mm wire

Components LAYOUT



SMALL SIGNAL "DISCRETES"

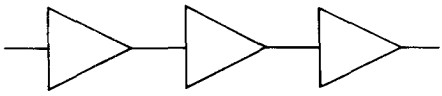
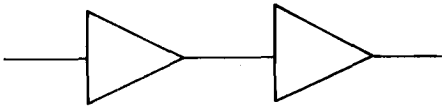
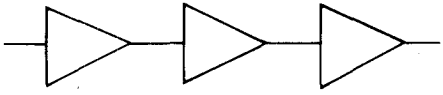
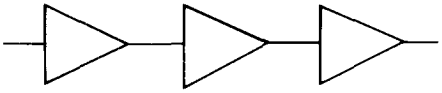
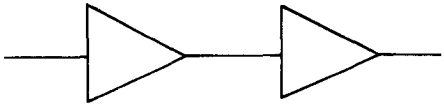
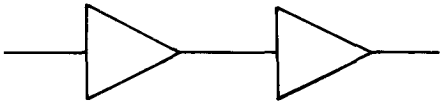
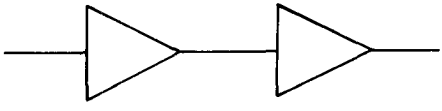
PRODUCT SUMMARY

P/N	PACKAGE	OUTPUT VOLTAGE (mV)	GAIN (S_{21}) at 500 MHz (dB)	PAGE
BFR 91	T-PACK	300	16.0	**E-210**
BFR 96	T-PACK	600	13.0	**E-214**
TP 393	T-PACK	300	14.0	**E-215**
TP 394	T-PACK	700	12.5	**E-218**
TP 491	T-PACK	300	14.8	**E-221**
TP 3093	TO 39	700	8.5	**E-223**
TP 3097	TO 117	700	12.5	**E-227**
TP 3098	TO 117 C	700	11.5	**E-230**
TP 3099	SOE 200	700	14.0	**E-233**
TP 3400	SOE 200	1 200	14.0	**E-236**

SMALL SIGNAL

LINE-UP SUGGESTIONS

40-900 MHz

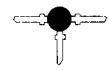
DISCRETES	GAIN (dB)	THIRD ORDER OUTPUT (mV)	NOISE FIGURE (dB)
3 × TP 393 	24	250	3.5
2 × TP 491 	18	300	2.0
TP 491 TP 491 TP 394 	24	700	2.0
BFR 91 BFR 91 BFR 96 	27	700	1.5
BFR 96 TP 3099 	17	900	
BFR 96 TP 3097 	15	1 000	
TP 3098 TP 3400 	20	1 200	

UHF Linear Transistor

1.2 DB NOISE FIGURE
AT 500 MHz
5 GHz FT
HIGH OUTPUT
HIGH GAIN

The BFR 91 is a gold metallized NPN Silicon transistor specifically designed for low noise, high frequency broadband operation, which is mounted in T-pack for high volume low cost applications. These characteristics make it an ideal for low noise, intermediate level MATV/CATV amplifiers from 40 to 860 MHz.

The BFR 91 has applications in low noise receivers and mixers up to 2.5 GHz in radio or cable communication, doppler radards and instrumentation equipments.

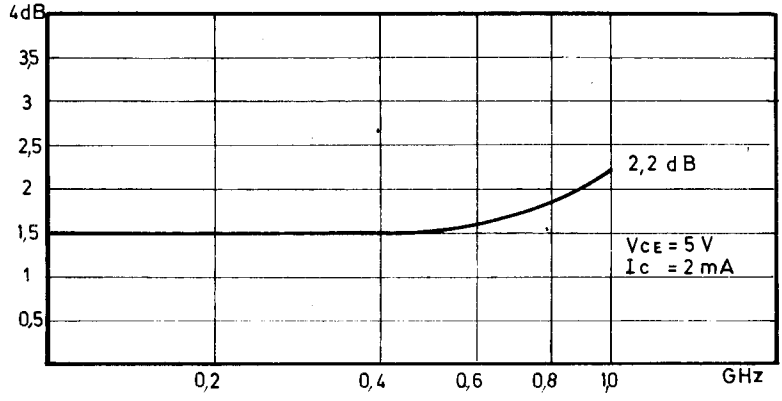


T-PACK

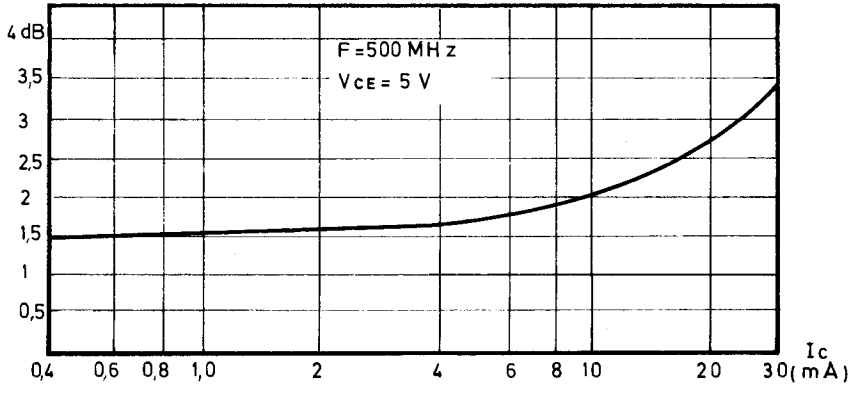
Electrical Characteristics (T_{case} = 25 °C)

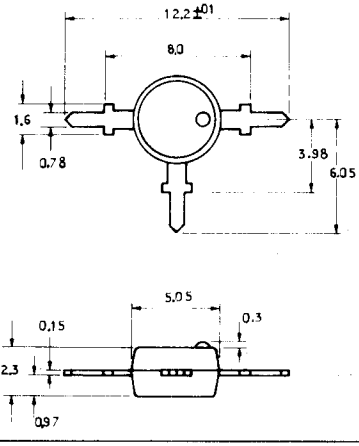
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	2.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_E = 1.0 mA	12			V
	BV_{CBO}	Collector - Base Breakdown Breakdown Voltage	I_C = 0.1 mA	15			V
	I_{CBO}	Collector Base Leakage	V_{CB} = 5 V		1		µA
	H_{FE}	D.C. Current Gain	V_{CE} = 5 V I_E = 30 mA	25		250	dB
RF TEST	N_F	Noise Figure	I_C = 2 mA V_{CE} = 5 V F = 500 MHz		1.2		dB
	F_T	Cutoff Frequency	I_C = 30 mA V_{CE} = 5 V F = 500 MHz		5		GHz
	G_{Amax}	Maximum Available Gain	I_C = 30 mA V_{CE} = 5 V F = 500 MHz		18		dB
	$\|S_{21}\|$	Forward Gain 50 ohms/50 ohms	I_C = 30 mA V_{CE} = 5 V F = 500 MHz		16		dB
	IMD	Intermodulation Distortion 3 tone — DIN 45004/B F = 500 MHz R_{Load} = 75 ohms	I_C = 30 mA V_{CE} = 5 V F = 500 MHz R_L = 75 Ω V_p = 300 mV			— 60	dB
	C_{OB}	Collector Base Capacitance	V_{CB} = 10 V F = 1 MHz		0.8		pF
THERMAL	I_{Cmax}	Maximum Collector Current				50	mA
		Dissipated Power				300	mW
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_J	Junction Temperature					

Noise Figure vs Frequency

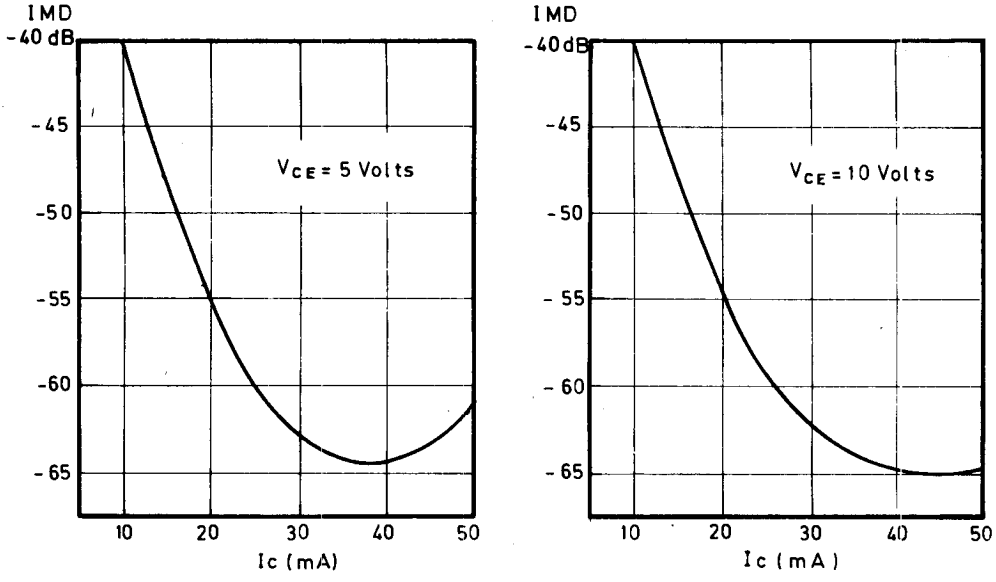


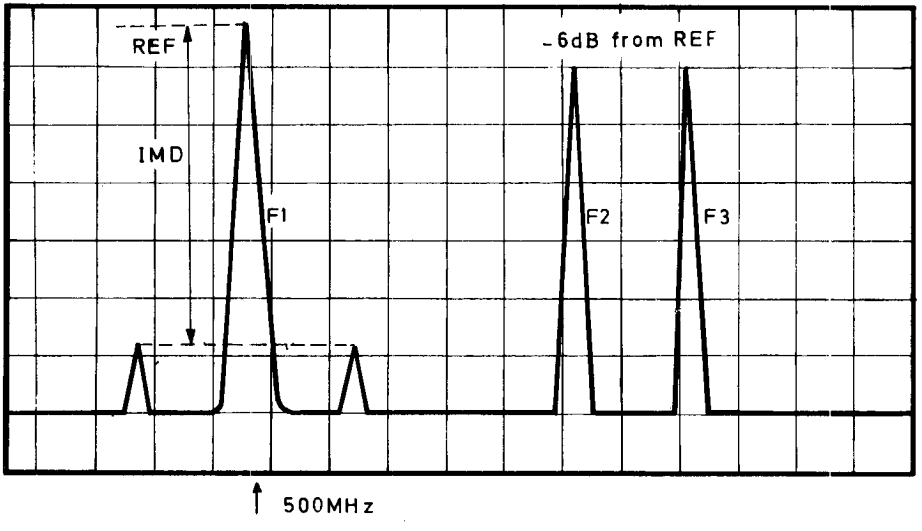
Noise Figure vs Collector Current





Intermodulation Distortion





Intermodulation Distortion Test

POLAR S-PARAMETERS IN 50 OHMS SYSTEM

V_{CE} = 5 V I_C = 30 mA

FREQ.	S 11		S 21		S 12		S 22	
	magn	angl	magn	angl	magn	angl	magn	angl
500	0.13	— 135	7.	81.	0.06	72.0	0.46	— 26
1000	0.15	— 166	3.76	60.0	0.0123	64.0	0.42	— 38

S PARAMETERS Vs I_C

f = 500 MHz	S 11		S 21		S 12		S 22	
	magn	angl	magn	angl	magn	angl	magn	angl
5	0.5	— 98	4	99	0.06	56	0.62	— 32
10	0.27	— 115	6	89	0.06	64	0.53	— 30
20	0.14	— 126	6.9	83	0.06	70	0.48	— 27
30	0.13	— 135	7	81	0.06	72	0.46	— 26
40	0.13	— 143	7	80	0.06	74	0.46	— 25

LARGE SIGNAL IMPEDANCES

V_{CE} = 5 V I_C = 30 mA

500 MHz

$Z_1 = 18 - j\,5$

$Z_0 = 100 - j\,105$

1000 MHz

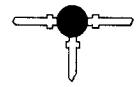
$Z_1 = 9.5 + j\,7$

$Z_0 = 50 - j\,125$

UHF Linear Transistor

The BFR 96 is a NPN transistor gold metallized for reliability. Its high output power compatible with the power dissipation of a T-Pack make it an ideal candidate for high level MATV-CATV broadband amplification.

HIGH OUTPUT
0.6 V at -60 dB IMD
HIGH GAIN 16 dB
4.5 GHz f_T



T-Pack

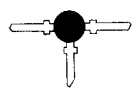
Electrical Characteristics (T_{case} = 25 °C)

SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	3			V
BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	15			V
BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	20			V
I_{CBO}	Collector - Base Leakage	V_{CB} = 10 V		1		µA
h_{FE}	D.C. Current Gain	V_{CE} = 10 V I_C = 40 mA	25			
N_F	Noise Figure	V_{CE} = 10 V I_C = 4 mA f = 500 MHz		3.3		dB
f_T	Cutoff Frequency	V_{CE} = 10 V I_C = 40 mA f = 500 MHz		4.5		GHz
G_{Umax}	Maximum Unilaterilized Gain	V_{CE} = 10 V I_C = 40 mA f = 500 MHz		16		dB
S_{21}	Forward Gain 50 Ω/50 Ω	V_{CE} = 10 V I_C = 40 mA f = 500 MHz		13		dB
I_{MD}	Intermod. Distort 3 tone Din 45004/B F = 500 MHz R_{Load} = 75 ohms	V_{CE} = 10 V I_C = 40 mA V_{out} = 600 mV		— 60		dB
C_{OB}	Collector - Base Capacitance	V_{CB} = 10 V f = 1 MHz		2.5		pF
I_{Cmax}	Maximum Collector Current				70	mA
P_T	Dissipated Power				500	mW
T_{STG}	Storage Temperature		— 65		+ 200	°C
T_j	Junction Temperature					

UHF LINEAR TRANSISTOR

The TP 393 is a gold metallized NPN silicon transistor specifically designed for low noise, high frequency broadband operation. It is mounted in T-pack for high volume low cost applications. These characteristics make it an ideal choice for low noise, intermediate level **MATV/CATV** amplifiers from **40 to 860 MHz** TP 393 has applications in low noise **receivers** and **mixers** up to **2.5 GHz** in radio or cable communication, doppler radars and instrumentation equipment.

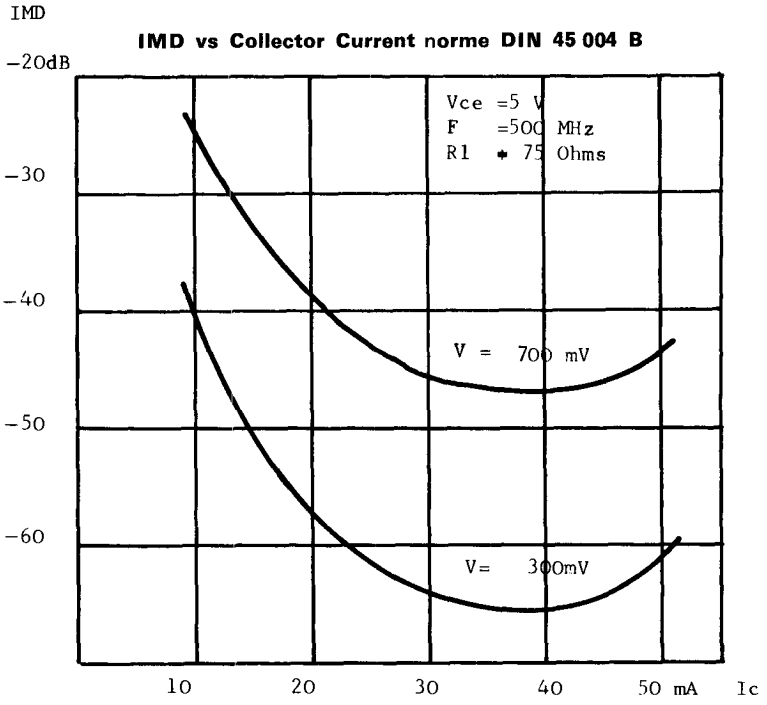
2 DB NOISE FIGURE
AT 500 MHz
3 GHz FT
HIGH OUTPUT



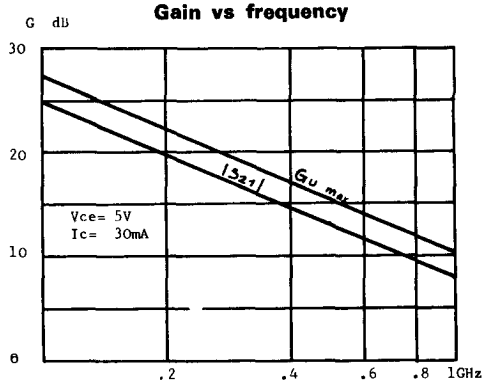
T - PACK

Electrical Characteristics (T_{CASE} = 25 °C)

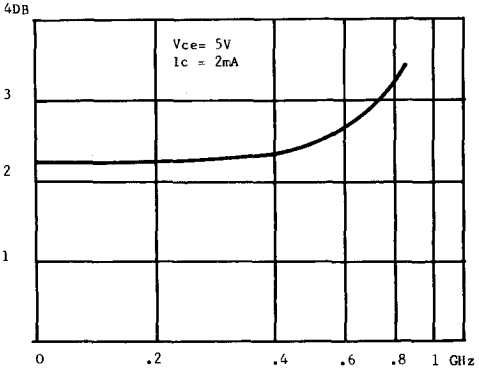
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	2.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	14			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 0.1 mA	25			V
	h_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 30 mA	25			
RF Test	NF	Noise Figure	V_{CE} = 5 V I_C = 2 mA F = 500 MHz		2	2.5	dB
	f_T	Cutoff Frequency	V_{CE} = 5 V I_C = 30 mA F = 500 MHz	2.8	3.0		GHz
	G_{Umax}	Maximum Unilaterilized Gain	V_{CE} = 5 V I_C = 30 mA F = 500 MHz	15	15.5		dB
	S_{21}	Forward Gain 50Ω/50 Ω	V_{CE} = 5 V I_C = 30 mA F = 500 MHz		14		dB
	IMD	Intermodulation Distortion 3 Tone - Din 45004/B F = 500 MHz R_{LOAD} = 75 ohms	V_{CE} = 5 V V_{out} = 300 mV I_C = 30 mA V_{out} = 700 mV		— 60 — 45		dB dB
	C_{OB}	Collector - Base Capacitance	V_{CB} = 5 V f = 1 MHz		0.7		pF
Operating Thermal	I_{Cmax}	Maximum Collector Current				50	mA
	P_T	Dissipated Power				250	mW
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_j	Junction Temperature				150	°C


IMD
IMD vs Collector Current norme DIN 45 004 B
-20dB
-30
-40
-50
-60
Vce =5 V
F =500 MHz
R1 = 75 Ohms
V = 700 mV
V= 300mV
10
20
30
40
50 mA
Ic

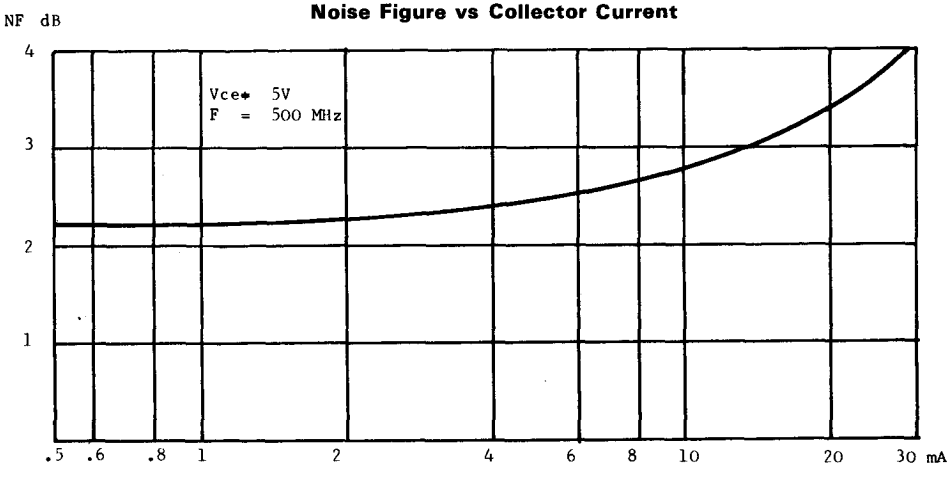
Gain vs frequency



Noise Figure vs Frequency



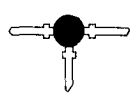
Noise Figure vs Collector Current



UHF LINEAR TRANSISTOR

HIGH OUTPUT
AT LOW COST
0,7 V AT - 62 DB IMD
GOLD RELIABILITY
2,5 GHZ FT

The TP 394 is a NPN transistor, gold metallized for reliability, using diffused ballast resistors for super linearity at currents compatible with the power dissipation capability of a T-Pack. TP 394 is the ideal candidate for up to **0.8 V** (DIN 45004/B) **MATV** amplifiers from **40 to 860 MHz.** The TP 394 has applications in driver stages of 12 volts VHF/UHF transmitters and broadband instrumentation equipment.

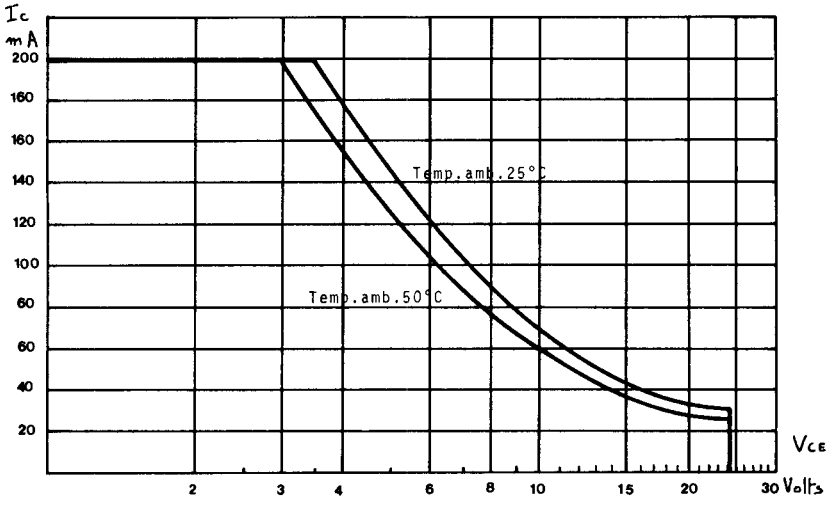


T - PACK

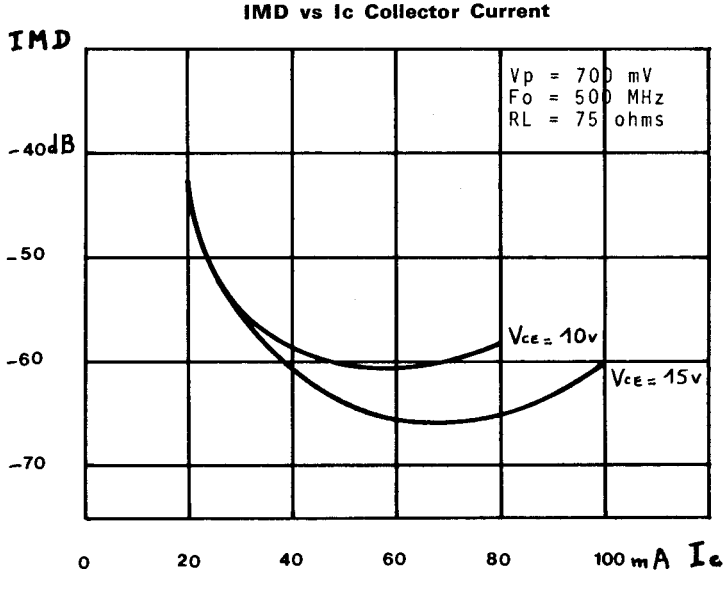
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	3			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	20			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 10 mA R_{BE} = 10 ohms	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	30			V
	h_{FE}	D.C Current Gain	V_{CE} = 10 V I_C = 40 mA	15			
R F Test	NF	Noise Figure	V_{CE} = 10 V I_C = 20 mA F = 500 MHz		3.5		dB
	f_T	Cutoff Frequency	V_{CE} = 10 V I_C = 40 mA F = 500 MHz		2.5		GHz
	G_{Umax}	Maximum Unilaterilized Gain	V_{CE} = 10 V I_C = 40 mA F = 500 MHz		14		dB
	[S 21]	Forward Gain 50 Ω/50 Ω	V_{CE} = 10 V I_C = 40 mA F = 500 MHz		12.5		dB
	IMD	Intermodulation Distortion 3 Tone - DIN 45004/B F = 500 MHz R_{Load} = 75 ohms	V_{CE} = 10 V V_{out} = 700 mV I_C = 60 mA		— 62		dB
	C_{OB}	Collector - Base Capacitance	V_{CB} = 10 V f = 1 MHz		2.5		pF
Thermal	I_{Cmax}	Maximum Collector Current				200	mA
	P_T	Dissipated Power	T_{CASE} = 50 °C			0.6	W
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_J	Junction Temperature					

Safe Operating Area

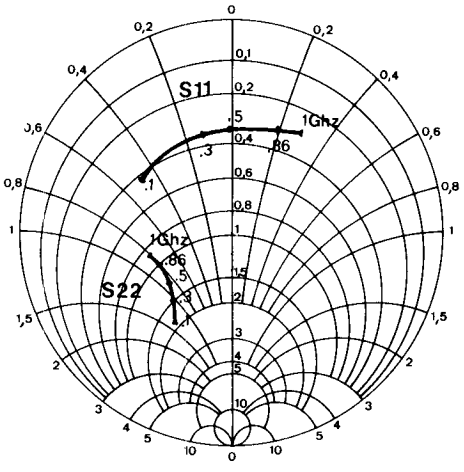


IMD vs Ic Collector Current



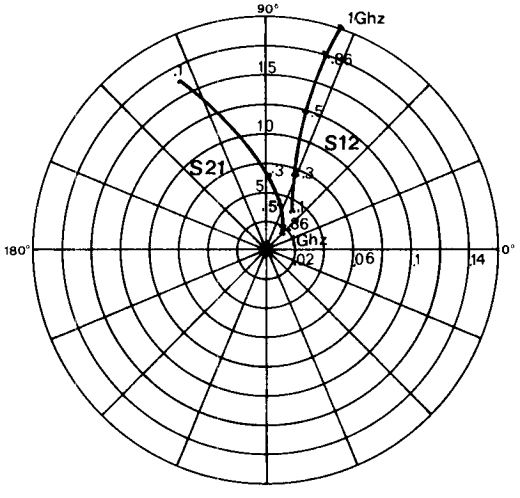
S11 - S22 Parameters vs Frequency

V_{CE} = 10 V - I_C = 40 mA



S21 - S12 Parameters vs Frequency

V_{CE} = 10 V - I_C = 40 mA

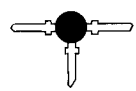


UHF LINEAR TRANSISTOR

1.6 DB NOISE FIGURE
AT 500 MHz
3.5 GHz FT
HIGH OUTPUT

The TP 491 is a gold metallized NPN silicon transistor specifically designed for low noise, high frequency broadband operation, which is mounted in T-pack for high volume low cost applications. These characteristics make it an ideal for low noise, intermediate level **MATV/ CATV** amplifiers from **40 to 860 MHz.**

TP 491 has applications in low noise **receivers** and **mixers** up to **2.5 GHz** in radio or cable communication, doppler radars and instrumentation equipments.

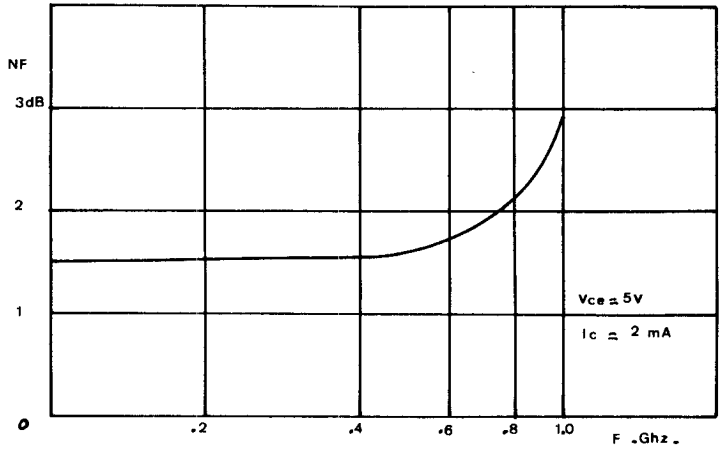


T - PACK

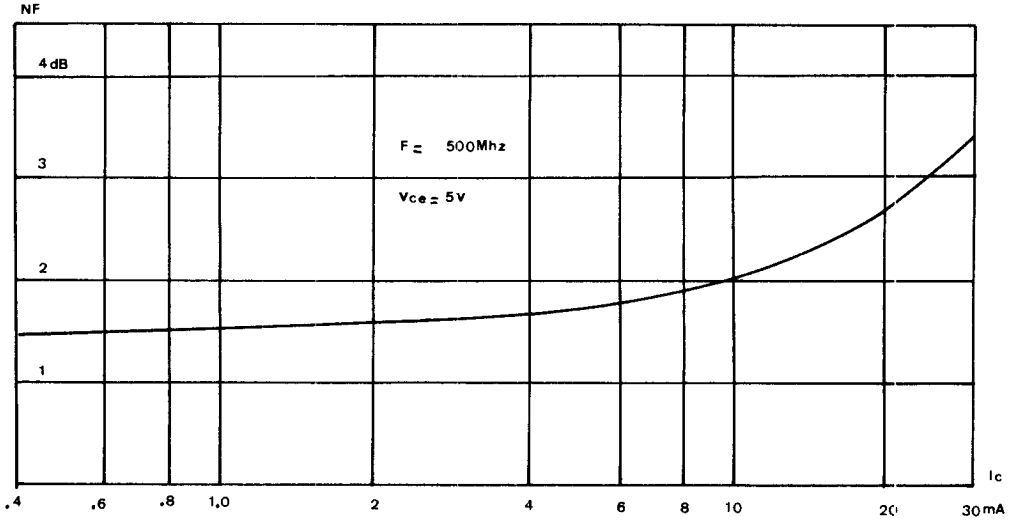
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	2.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	14			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 0.1 mA	25			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 20 V		10		µA
	h_{FE}	D.C. Current Gain	V_{CE} = 1 V I_C = 2 mA	25			
RF Test	NF	Noise Figure	V_{CE} = 5 V I_C = 2 mA F = 500 MHz		1.6	2.0	dB
	f_T	Cutoff Frequency	V_{CE} = 5 V I_C = 30 mA F = 500 MHz		3.2		GHz
	G_{Umax}	Maximum Unilaterilized Gain	V_{CE} = 5 V I_C = 30 mA F = 500 MHz		16.4		dB
	$\|S_{21}\|$	Forward Gain 50 Ω/50 Ω	V_{CE} = 5 V I_C = 30 mA F = 500 MHz		14.8		dB
	IMD	Intermodulation Distortion 3 Tone - Din 45004/B F = 500 MHz R_{LOAD} = 75 ohms	V_{CE} = 5 V I_C = 30 mA V_{out} = 300 mV			— 60	dB
			V_{CE} = 5 V I_C = 30 mA V_{out} = 700 mV			— 45	dB
	C_{OB}	Collector - Base Capacitance	V_{CB} = 5 V f = 1 MHz		0.8		pF
Thermal	I_{Cmax}	Maximum Collector Current				50	mA
	P_T	Dissipated Power				300	mW
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_J	Junction Temperature					

Noise Figure vs Frequency



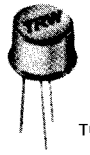
Noise Figure vs Collector Current



UHF LINEAR TRANSISTOR

The TP 3093 is an NPN silicon transistor using gold metallization and diffused emitter ballast resistors for long term reliability. Its mains characteristics are high output level, low noise figure and high Ft. These features make TP 3093 an ideal candidate for broadband linear amplifier up to 1 GHz (MATV), oscillators, mixers, multipliers and others.

3 GHz FT
1 volt output DIN 45004 B
3,5 dB NF at 500 MHz

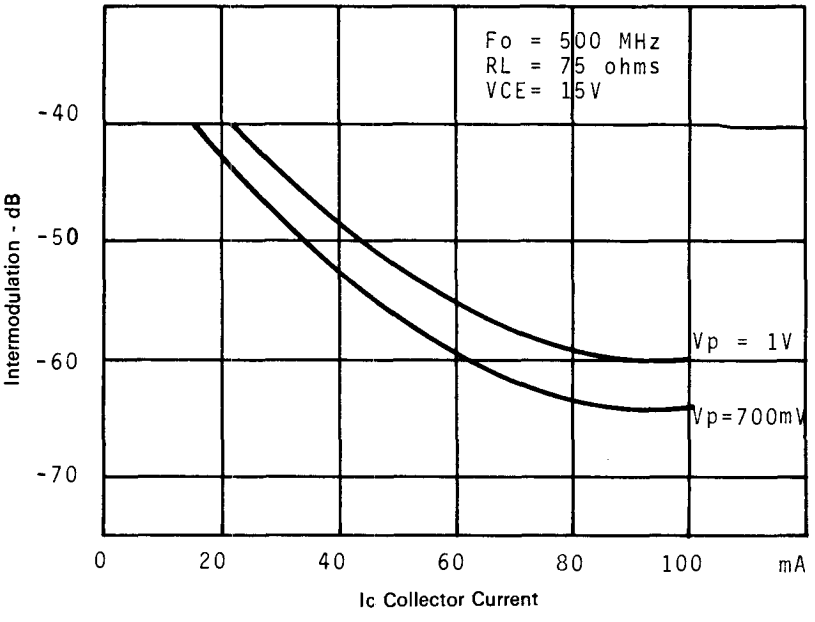


TO 39

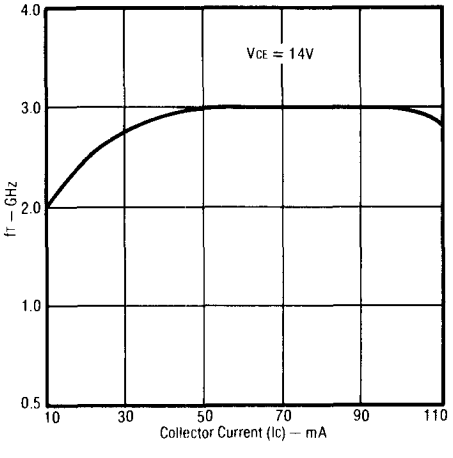
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	3			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	20			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	30			V
	h_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 50 mA	20			
RF Test	NF	Noise Figure	V_{CE} = 15 V I_C = 20 mA F = 500 MHz		3.5		dB
	f_T	Cutoff Frequency	V_{CE} = 15 V I_C = 50 mA F = 500 MHz		3		GHz
	G_{Umax}	Maximum Unilaterilized Gain	V_{CE} = 15 V I_C = 50 mA F = 500 MHz		9.5		dB
	$\|S_{21}\|$	Forward Gain 50 Ω/50 Ω	V_{CE} = 15 V I_C = 50 mA F = 500 MHz		8.5		dB
	IMD	Intermodulation Distortion 3 Tone - DIN 45004/B F = 500 MHz R_{Load} = 75 ohms	V_{CE} = 15 V V_{out} = 700 mV I_C = 60 mA V_{out} = 1000 mV		— 65 — 56		dB dB
	C_{OB}	Collector - Base Capacitance	V_{CB} = 15 V f = 1 MHz			3	pF
Thermal	I_{Cmax}	Maximum Collector Current			200		mA
	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 25 °C		50°		°C/W
	P_T	Dissipated Power	T_{CASE} = 25 °C		3.5		W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

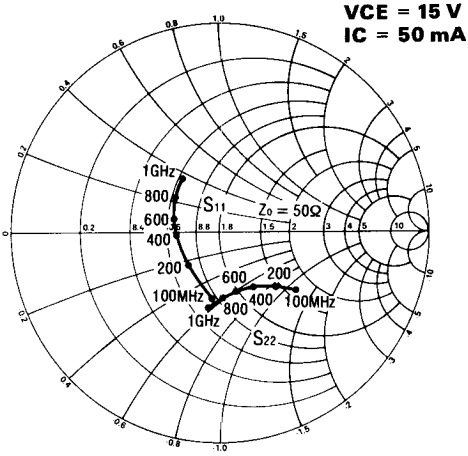
DIN 45004 B IMD VS Ic Collector Current



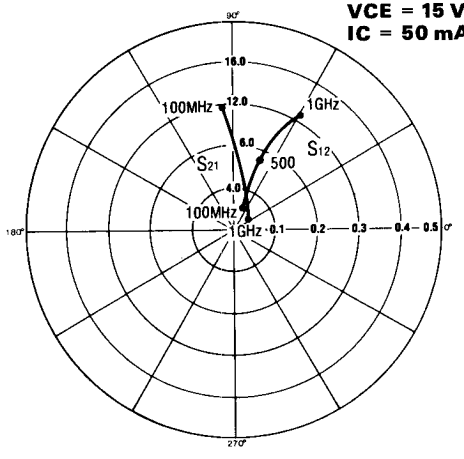
Cutoff Frequency



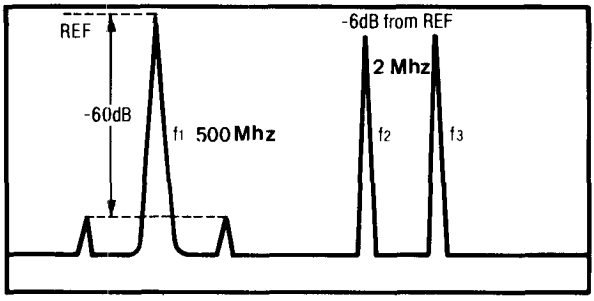
S 22 - S 11 Parameters vs Frequency



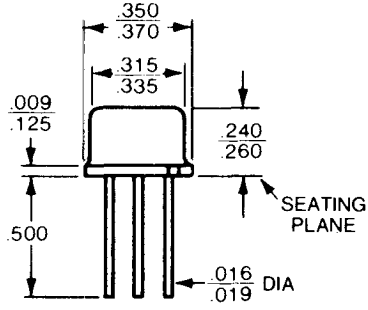
S 21 - S 12 Parameters vs Frequency



Intermodulation Distortion Test

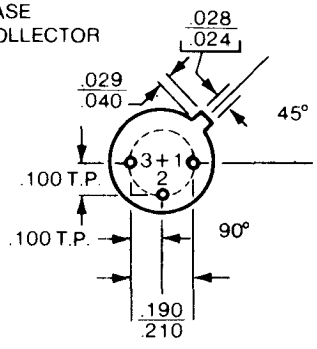


Package Outline
TO-39



PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIMENSIONS IN INCHES

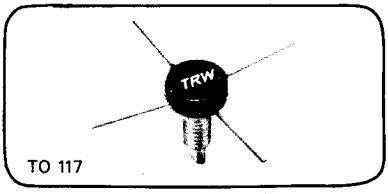


UHF Linear Transistor

The TP 3097 is a NPN-transistor, goldmetallized for reliability. It uses diffused emitter ballast resistors for high linearity.

Its transition frequency of 3 GHz provides super performances in applications like MATV and CATV amplifiers up to 1 GHz.

MATV / CATV
40 - 860 MHz
HIGH LINEARITY
120 dBuV
DIN 45004 B

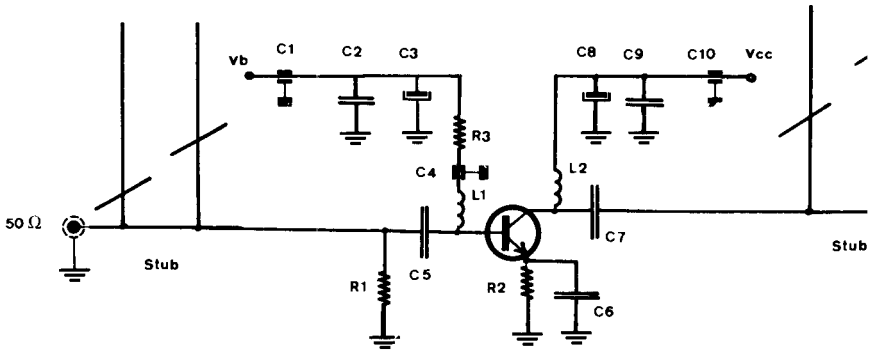


TO 117

Electrical Characteristics (T_{case} = 25 °C)

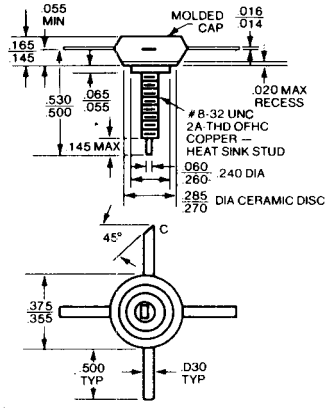
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Voltage	I_e = 0.1 mA	3.0			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_c = 10 mA	22.0			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_c = 1.0 mA	30.0			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_c = 10 mA R_{be} = 10 Ω	25.0			V
	I_{CBO}	Collector - Base Leakage	V_{cb} = 15 V			0,2	mA
	h_{FE}	D.C Current Gain	V_{ce} = 10 V I_c = 90 mA	25			
	I_{cmax}	Maximum Collector Current				200	mA
RF Test	$\|S_{21}\|$	Forward Gain (50 Ohms)	V_{ce} = 15 V I_c = 100 mA f = 500 MHz	12.0	12.5		dB
	f_T	Cutoff Frequency	V_{ce} = 15 V I_c = 100 mA f = 500 MHz		3.0		GHz
	I_{MD}	Intermodulation Dis ; DIN 45 004 B at 500 MHz and 75 Ω Termination	V_{ce} = 15 V I_C = 100 mA V_{out} = 700 mV		—66	— 65	dB
	N_F	Noise Figure	V_{ce} = 15 V I_c = 40 mA f = 500 MHz			4	dB
Thermal	θ_{jc}	Thermal Resistance Junction - Case	T_{case} = 25 °C			35	K/W
	P_T	Dissipation Power				5.0	W
	T_{STG}	Storage Temperature					
	T_J	Junction Temperature		— 65		200	°C

IMD AND NF TEST CIRCUIT AT 500 MHz



$L_{1,2}$	0.1 nH molded coil
$C_{1,4,10}$	1000 pF by pass
$C_{2,9}$	470 pF ceramic disc
$C_{5,7}$	220 pF ceramic chip
$C_{3,8}$	47 µF 40 V electrolytic
C_6	2 × 220 pF chip one at each emitter lead
R_1	100 ohms 1/4 W carbon resistor
R_2	39 ohms 1/4 W carbon resistor
R_3	1.5 K ohms 1/4 W carbon resistor

TO-117
Package Outline

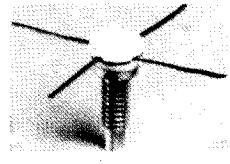


UHF Linear Transistor

HIGH OUTPUT
1 V (DIN 45004/B)
200 MW (DIN 45004/K)
10 DB GAIN AT 860 MHz
GOLD RELIABILITY

The TP 3098 is a NPN transistor gold metallized for reliability.

It uses diffused emitter ballast resistors for super linearity, The transistion frequency of 3 GHz makes these transistor ideal for UHF broadband linear amplification such as in high level 1 VOLT MATV Amplifiers up to 860 MHz or low power 200 mW TV TRANSPOSER stages.

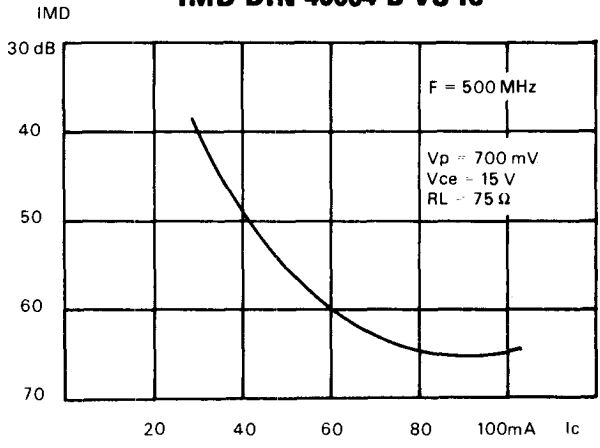


TO 117 C.

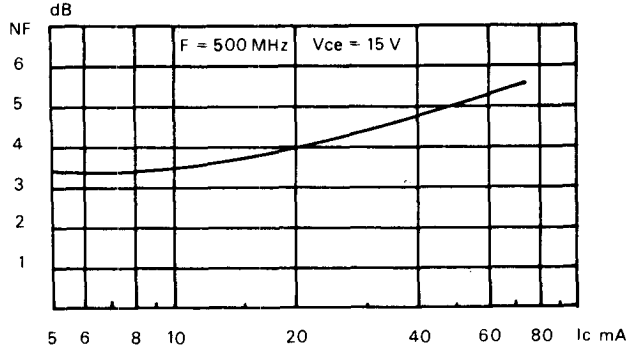
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{BEO}	Emitter - Base Breakdown Voltage	I_E = 0.1 mA	3.0			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	20			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 10 mA R R_{BE} = 10	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	30			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 15 V			0.2	mA
	H_{FE}	D.C. Current Gain	V_{CE} = 10 V I_C = 90 mA	60			
RF Test	N_F	Noise Figure	V_{CE} = 15 V I_C = 40 mA F = 500 MHz			6.5	dB
	F_T	Cutoff Frequency	V_{CE} = 15 V I_C = 100 mA F = 500 MHz		2.6		GHz
	G_{Umax}	Maximum Gain	V_{CE} = 15 V I_C = 100 mA F = 500 MHz		13.5		dB
	$\|S_{21}\|$	Forward Gain 50 ohms/50 ohms	V_{CE} = 15 V I_C = 100 mA F = 500 MHz		11.5		dB
	IMD	Intermodulation Distortion 3 tone — DIN 45004/B F = 500 MHz R_{Load} = 75 ohms	V_{CE} = 15 V V_{out} = 700 mV I_C = 100 mA		— 65	— 60	dB
	C_{OB}	Collector Base Capacitance	V_{CB} = 10 V F = 1 MHz		2.5		pF
Thermal	I_{Cmax}	Maximum Collector Current				200	mA
	O_{JC}	Thermal Resistance	T_{case} = 25 °C			35	°C/W
	P_T	Dissipated Power				5.0	W
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_J	Junction Temperature					

IMD DIN 45004 B VS Ic

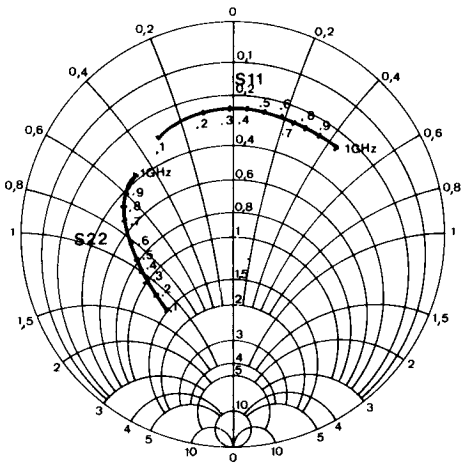


Noise Figure vs Collector current



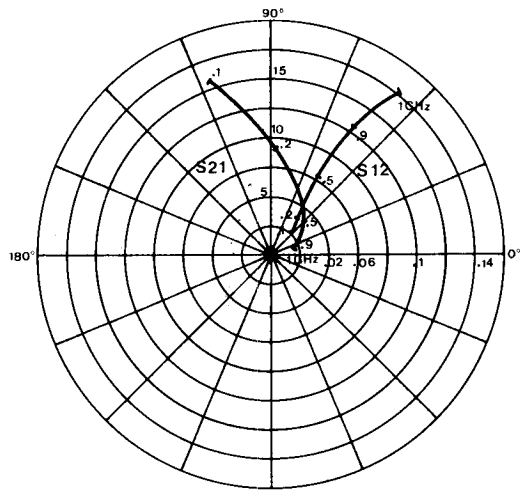
S11 and S22 vs Frequency

V_{CE} = 15 V - I_C = 100 mA

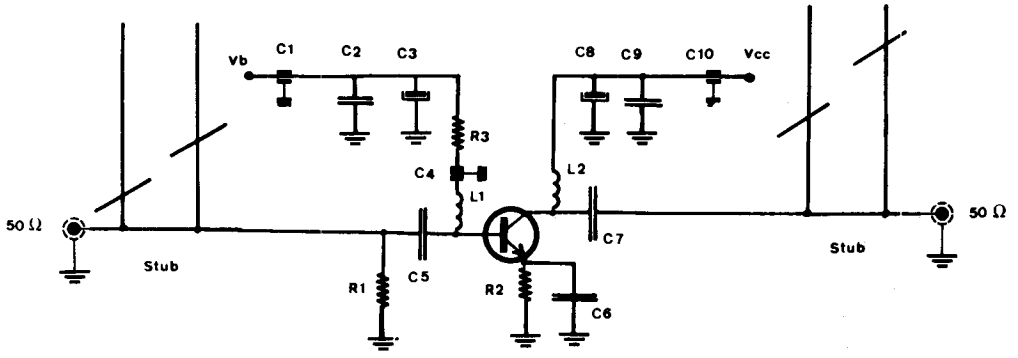


S21 - S 12 Parameters vs Frequency

V_{CE} = 15 V - I_C = 100 mA

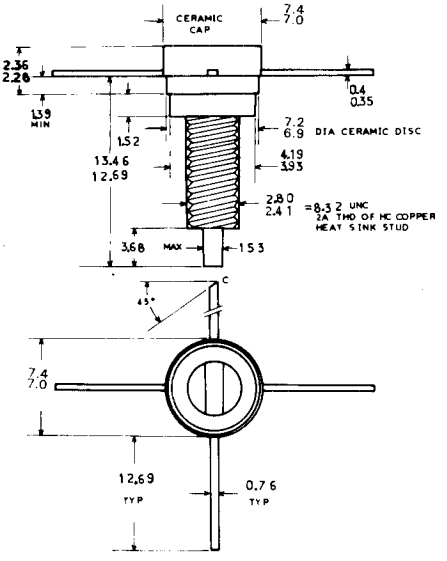


IMD AND NF TEST CIRCUIT AT 500 MHz



$L_{1,2}$	0.1 nH molded coil
$C_{1,4,10}$	1000 pF by pass
$C_{2,9}$	470 pF ceramic disc
$C_{5,7}$	220 pF ceramic chip
$C_{3,8}$	47 µF 40 V electrolytic
C_6	2 × 220 pF chip one at each emitter lead
R_1	100 ohms 1/4 W carbon resistor
R_2	39 ohms 1/4 W carbon resistor
R_3	1.5 K ohms 1/4 W carbon resistor

Package Outline To 117 G

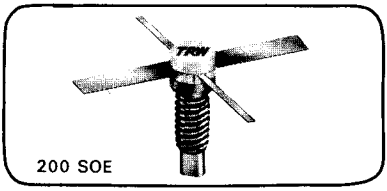


UHF Linear Transistor

HIGH OUTPUT
1 V (DIN 45004/B)
200 mW (DIN 45004/K)
10 DB GAIN AT 860 MHz
GOLD RELIABILITY

The TP 3099 is NPN transistor gold metallized for reliability

It uses diffused emitter ballast resistors for super linearity, The transistion frequency of 3 GHz make these transistor ideal for UHF broadband linear amplification such as in high level 1 Volt MATV Amplifiers up to 860 MHz or low power 200 mW TV TRANSPOSER stages.

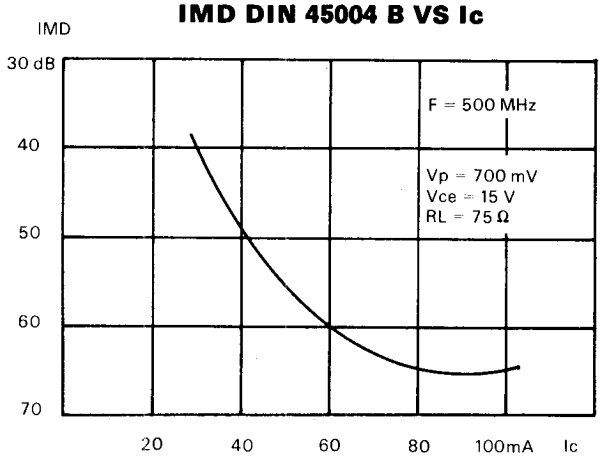


200 SOE

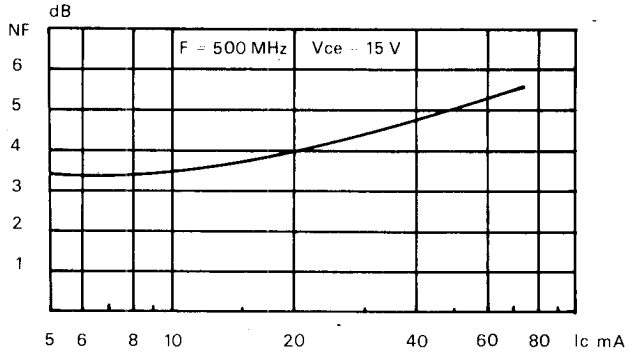
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_e = 0.1 mA	3.0			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_c = 10 mA	20			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_c = 10 mA R_{be} = 10 Ohms	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_c = 1 mA	30			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 15 V			0.2	mA
	h_{FE}	D.C Current Gain	V_{ce} = 10 V I_c = 90 mA	60			
RF Test	N_F	Noise Figure	V_{ce} = 15 V I_c = 40 mA f = 500 MHz			6.5	dB
	f_T	Cutoff Frequency	V_{ce} = 15 V I_c = 100 mA f = 500 MHz		2.6		GHz
	GU_{max}	Maximum Unilaterilized Gain	V_{ce} = 15 V I_c = 100 mA f = 500 MHz		15		dB
	$\|S_{21}\|$	Forward Gain 50 Ohms/50 Ohms	V_{ce} = 15 V I_c = 100 mA f = 500 MHz		14		dB
	I_{MD}	Intermodulation Dist. 3 Tone Din 45 004/B F = 500 MHz R_{load} = 75 Ohms	V_{ce} = 15 V V_{out} = 700 mV I_c = 100 mA		— 65	— 60	dB
	C_{OB}	Collector - Base Capacitance	V_{cb} = 10 V f = 1 MHz		2.5		pF
Operating	$I_{c\,max}$	Maximum Collector Current				200	mA
	O_{jc}	Thermal Resistance	T_{case} = 25 °C			35	°C/W
	P_T	Dissipation Power				5.0	W
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_j	Junction Temperature					

IMD DIN 45004 B VS Ic

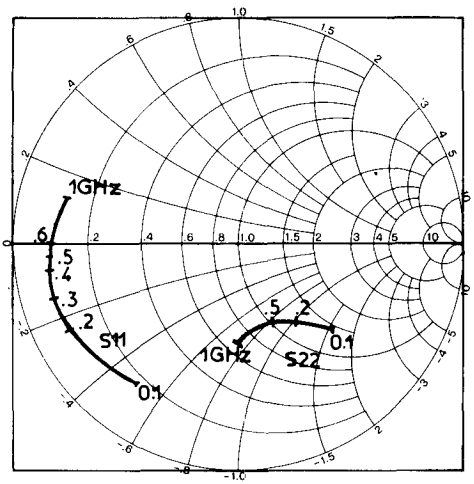


Noise Figure vs Collector current



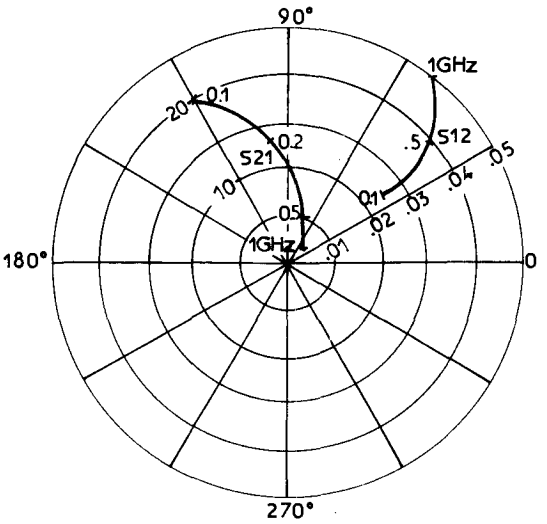
S11 and S22 vs Frequency

V_{ce} = 15 V I_c = 100 mA



S21 and S12 vs Frequency

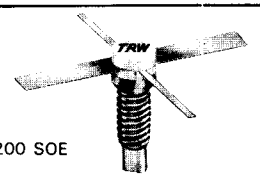
V_{ce} = 15 V I_c = 100 mA



MATV AMPLIFIER
1.2 V (DIN 45004/B)
13.5 DB AT 860 MHz

The TP 3400 is a NPN transistor gold metallized for reliability.

The transition frequency of 3 GHz make this transistor a high gain — high output power part ideal for MATV — CATV linear amplification over the band 40-900 MHz.

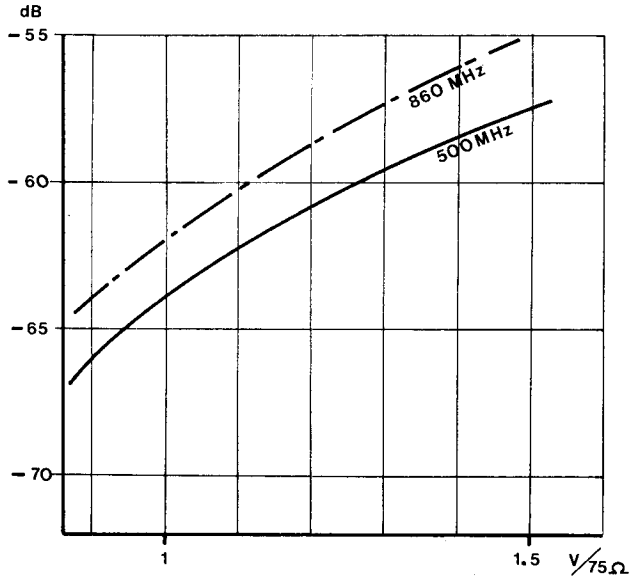


200 SOE

Electrical Characteristics (T_{case} = 25 °C)

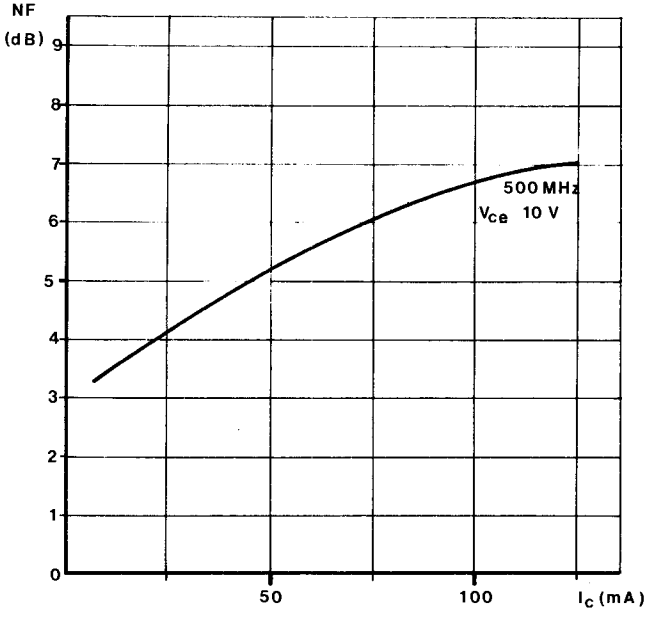
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	20			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 10 mA	40			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
	H_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 100 mA	20		150	
RF TEST	IMD	Intermodulation Distortion 3 Tone - Din 45004/B R_{Load} = 75 ohms	F = 860 MHz I_C = 125 mA V_{CE} = 18 V V_{out} = 1.2 V		— 60		dB
	P_G	Power Gain		13.5			dB
	N_F	Noise Figure	V_{CE} = 10 V I_C = 125 mA F = 500 MHz		7		
	C_{OB}	Collector Base Capacitance	V_{CB} = 20 V F = 1 MHz			3	pF
	F_T	Cutoff Frequency	V_{CE} = 18 V I_E = 125 mA	2.5			GHz
THERMAL	I_C	Maximum Collector Current				0.4	A
	θ_{j-c}	Thermal Resistance Junction Case	T Heatsink 70 °C			30	°C/W
	T_J T_{STG}	Maximun Junction and Storage Temperature		— 65		200	°C/W

IMD (Din 45004 B) vs Output Voltage



V_{ce} 18 V I_C 125 mA

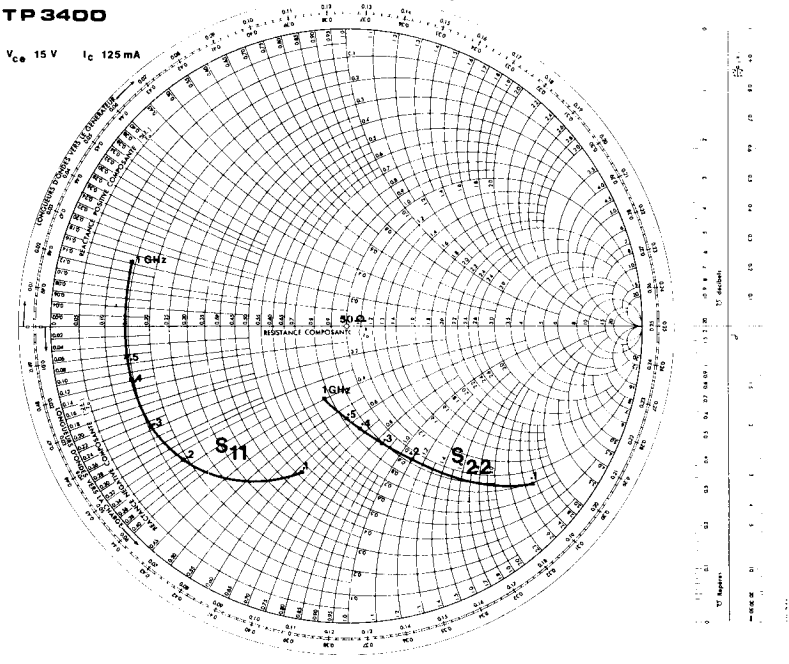
Noise Figure vs Collector Current



S PARAMETER

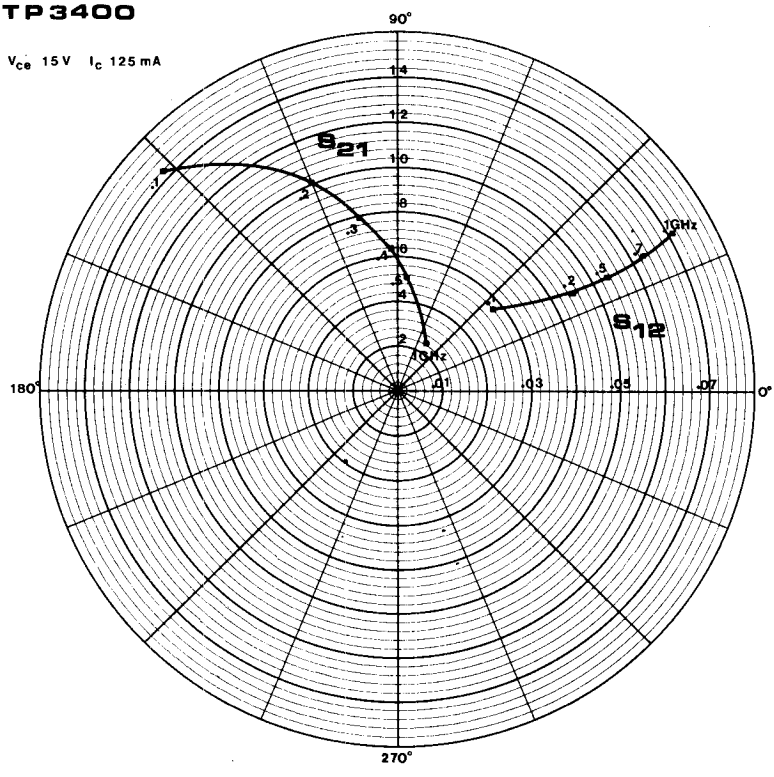
TP3400

V_{ce} 15 V I_C 125 mA

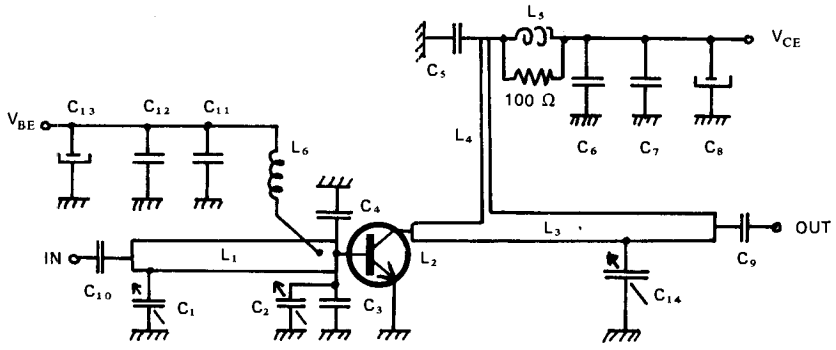


TP3400

V_{ce} 15 V I_C 125 mA



V_{CE} = 18 V **I_C = 125 mA** **F = 860 MHz**

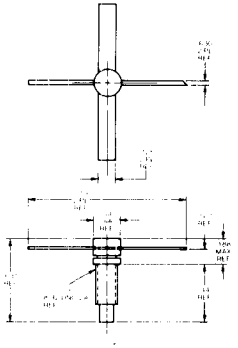


L_1 = 50 Ω line l = 10 % λg at 860 MHz
L_2 = 100 Ω line l = 12 % λg at 860 MHz
L_3 = 50 Ω line l = 7 % λg at 860 MHz
L_4 = 120 Ω line l = 10 % λg at 860 MHz
L_5 = 6 turns ID 3 mm wire .5 mm
L_6 = 6 turns ID 3 mm wire .5 mm

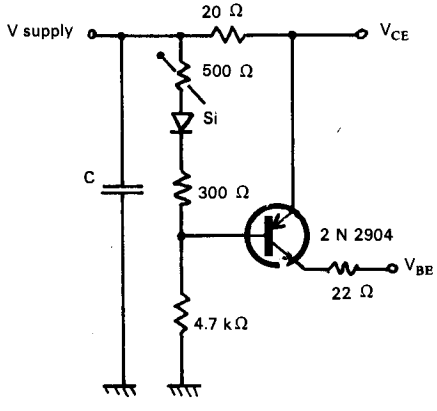
C_1 = C_2 = C_{14} = variable AIRTRONIC C max 4.7 pF AT 7275
C_3 = C_4 = ATC chip 10 pF
C_5 = 680 pF ATC chip
C_6 = C_{11} = 1 nF
C_7 = C_{12} = 10 nF
C_8 = 10 µF 63 V
C_{13} = 10 µF 25 V
C_9 = C_{10} = 1 nF chip

Package

.200 SOE STUD



C = 1 µF + .1 µF + 10 nF



Bias Circuit

SMALL SIGNAL

" HYBRID AMPLIFIERS "

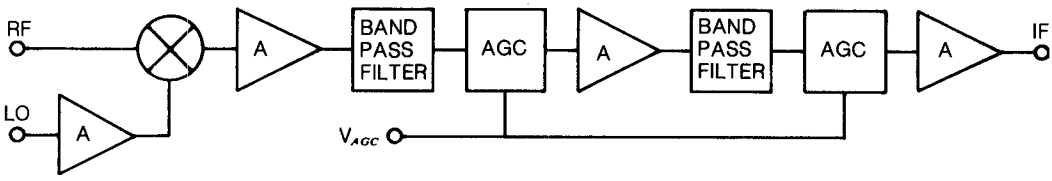
SMALL SIGNAL - HYBRIDS

PRODUCT SUMMARY

P/N	BANDWIDTH (MHz)	GAIN (dB)	1 DB COMPRESSION OUTPUT POWER (mW)	Vcc (V)	
CA 2800	10-400	17	800	24	**F-246**
CA 2810	10-350	33	800	28	**F-244**
CA 2810/F	10-350	33	800	24	**F-254**
CA 2812	1-520	30	250	12	**F-256**
CA 2818	1-200	18	800	24	**F-258**
CA 2820	1-520	30	400	24	**F-262**
CA 2830	5-200	34	1 000	24	**F-266**
CA 2832	1-200	35	2 000	24	**F-268**
CA 2840	30-300	22	1 000	24	**F-270**
CA 2842	30-300	22	1 000	24	**F-272**
CA 2850 R	40-100	17	250	— 24	**F-274**
CA 2851 R	40-100	17	250	— 24	**F-276**
CA 2870	20-400	34	400	24	**F-278**
CA 2875 R	40-100	17	310	— 24	**F-282**
CA 2876 R	40-100	22	100	— 24	**F-284**
CA 2880 R	40-100	22	100	— 24	**F-286**
CA 2899	RF-CHOKE	30 µH			**F-288**
LNA 1110	40-900	10	+ 2 dBm	10	**F-290**
CA 915 TV	40-900	17	150 mW ; Psync.	24	**F-291**

SMALL SIGNAL HYBRIDS LINE UP SUGGESTIONS

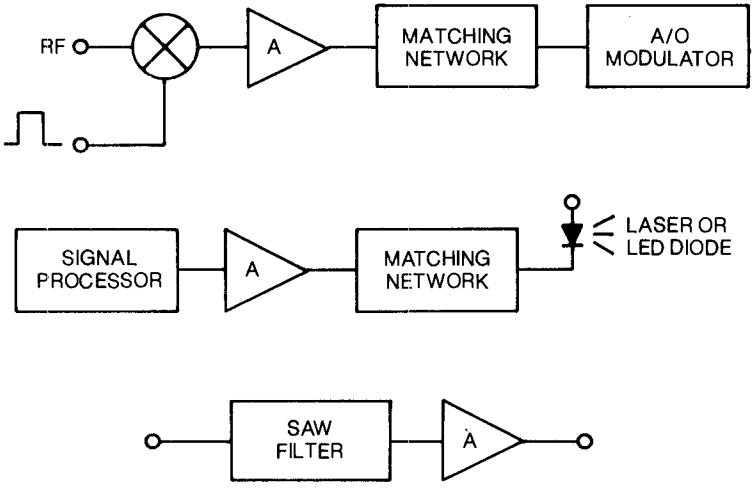
HIGH PERFORMANCE RECEIVER APPLICATIONS



APPLICATIONS

- **LINEAR IF AMPLIFIER**
- **BUFFER AMP FOR HIGH LEVEL MIXER**
- **REPEATER AMPLIFIER FOR FIBER OR COAXIAL CABLE COMMUNICATIONS**
- **HIGH DENSITY PACKAGING**

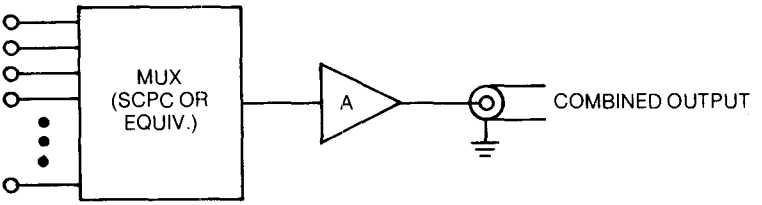
ELECTRO/OPTICAL EQUIPMENT, SAW APPLICATIONS, FIBER OPTIC APPLICATIONS



APPLICATIONS

- **ACOUSTO-OPTIC MODULATORS**
- **FIBER OPTIC LASER/LED DRIVERS**
- **SAW FILTER AMPLIFIERS**
- **DRIVERS FOR CHARGE COUPLED DEVICES**
- **SUITABLE FOR ANALOG OR DIGITAL MODULATION, ALL TYPES OF WAVEFORMS**

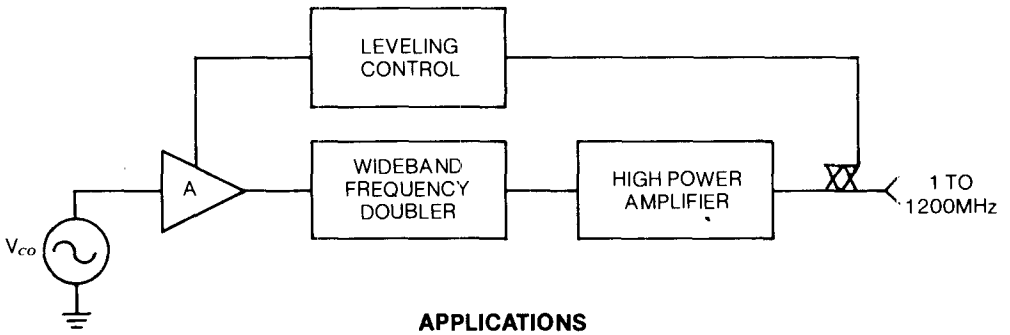
SATELLITE COMMUNICATIONS EQUIPMENT



APPLICATIONS

- **LINEAR POWER AMPLIFIER FOR FM, DIGITAL, DATA, OR VOICE CHANNELS**
- **DRIVER FOR EXTENDED LENGTHS OF COAX**

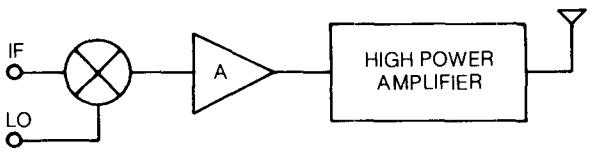
RAOAR/ECM



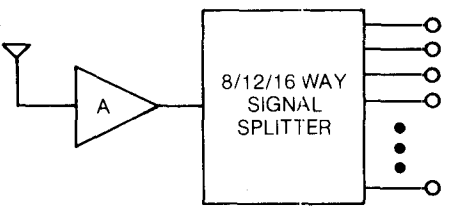
APPLICATIONS

- **DME, TACAN, IFF APPLICATIONS**
- **RADAR, ECM, DRONE APPLICATIONS**
- **BROADBAND SWEPT INSTRUMENTATION**
- **HF THROUGH UHF TRANSMITTER DRIVERS**

RADIO COMMUNICATIONS



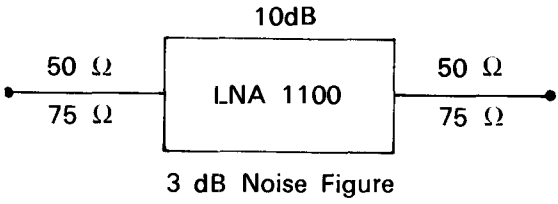
MULTI-PORT DISTRIBUTION



APPLICATIONS

- **HF, VHF, UHF FREQUENCY RANGE**
- **AM OR FM TRANSMISSION**
- **COMMERCIAL OR MILITARY EQUIPMENT**
- **N-WAY POWER SPLITTER**

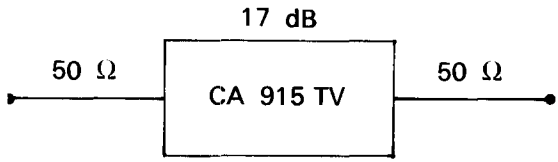
HYBRIDS (40-900 MHz)



3 dB Noise Figure

Low noise headend amplifier for

- TRANSPOSER
- RECEIVER
- INSTRUMENTATION
- LOW NOISE APPLICATIONS



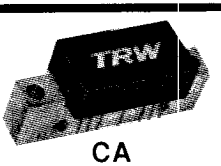
Driver amplifier for

- TRANSPOSER
- TRANSMITTER
- HIGH LINEARITY RF-APPLICATIONS

Wide Bandwidth Linear Hybrid Amplifier

The CA2800 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. Units are designed for wide bandwidth linear operation in 50 to 100 ohm systems. This hybrid provides excellent gain stability with temperature and very low distortion due to push-pull amplifier circuitry. This module is recommended for wide bandwidth, low noise and linear applications.

- Instantaneous Bandwidth, 10-400MHz
- 17dB Gain
- 400mW PEP @ -32dB IMD

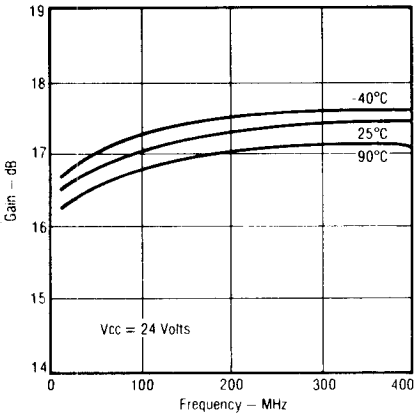


CA

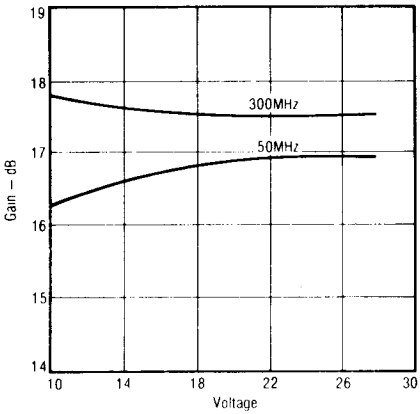
Electrical Characteristics For 50Ω Systems (T_{CASE} = 25°C and 24V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	VALUE
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage		28V
	P_{IN}	RF Power Input		+16dBm
	T_{ST}	Storage Temperature		-40°C to +100°C
	T_{OP}	Operating Temperature		-20°C to +90°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = 25°C and 24V)	P_G	Power Gain	f = 50MHz	17 ± 0.75dB
	NF	Noise Figure, Broadband	f = 60MHz f = 300MHz	5.0dB Typ 8.5dB Typ
	I_{TO}	Third Order Intercept, See Figure 1	f = 300MHz	+44dBm Typ
	VSWR	Input/Output VSWR for 50Ω Systems	f = 10-400MHz	2:1 Typ
	I_{CC}	Supply Current	24V	220mA Max
	P_O	Power Output — 1dB Compression	f = 200MHz	800mW
	P_{RI}	Reverse Isolation	f = 10-400MHz	25dB Typ
	FR	Frequency Response	f = 30-300MHz f = 10-400MHz	± 0.5dB Max ± 1dB Max
	dso	Second Harmonic Distortion	Tone at 10mW f = 10-300MHz	-66dB Typ
	PEP	Peak Envelope Power for Two Tone Distortion Test See Figure 1	f = 10-300MHz at -32dB	400mW Typ

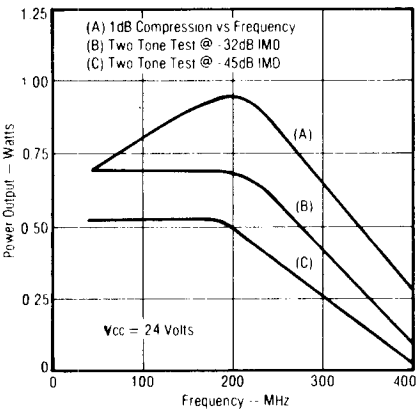
Gain vs Frequency



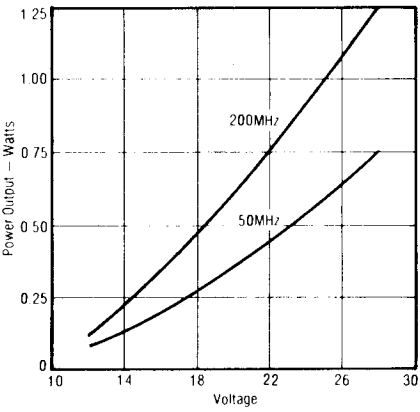
Gain vs Voltage



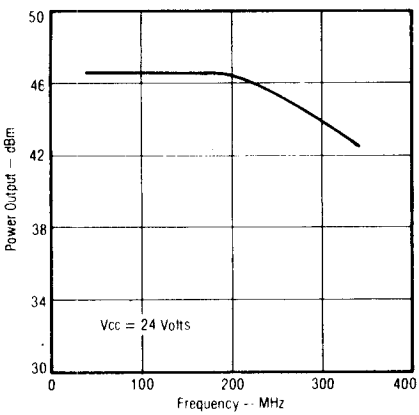
Power Output vs Frequency



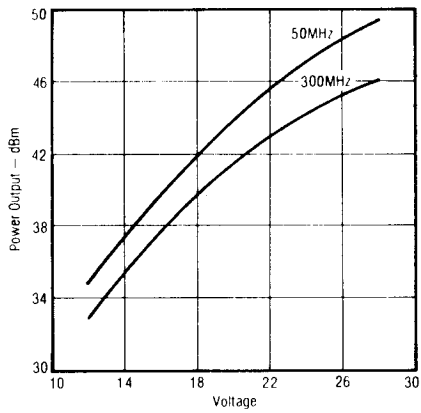
1dB Compression vs Voltage



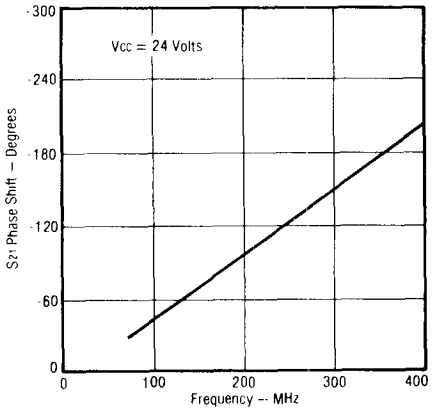
Third Order Intercept vs Frequency



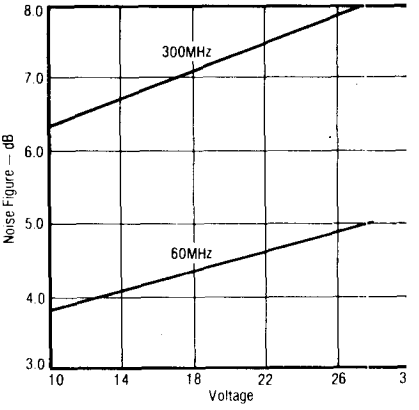
Third Order Intercept vs Voltage



Phase Shift vs Frequency



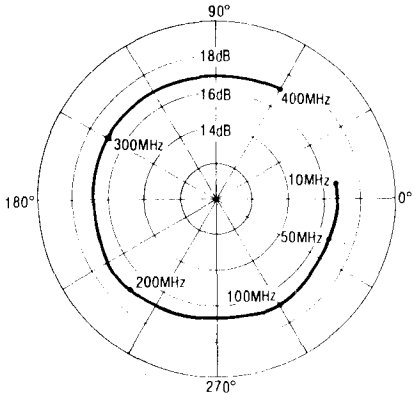
Noise Figure vs Voltage



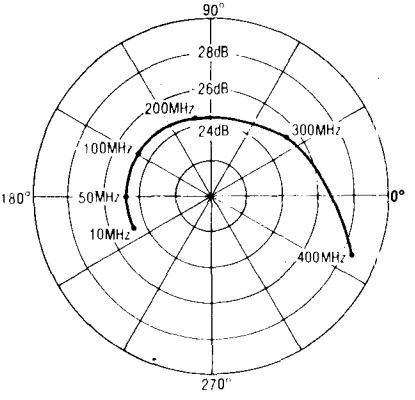
S-Parameters

Vcc = 24V, Zo = 50Ω

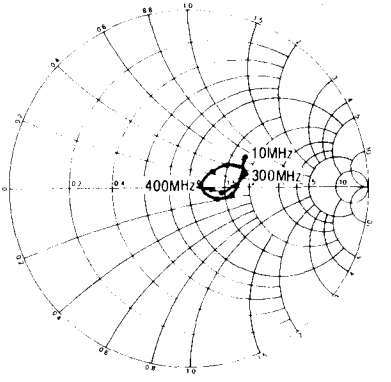
S21



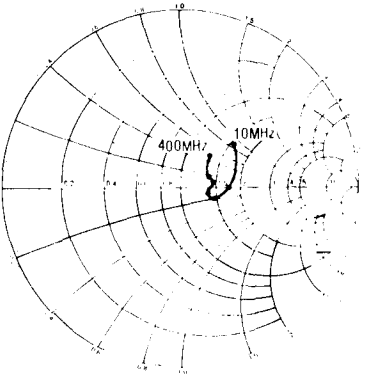
S12



S11



S22



CA Package Outline

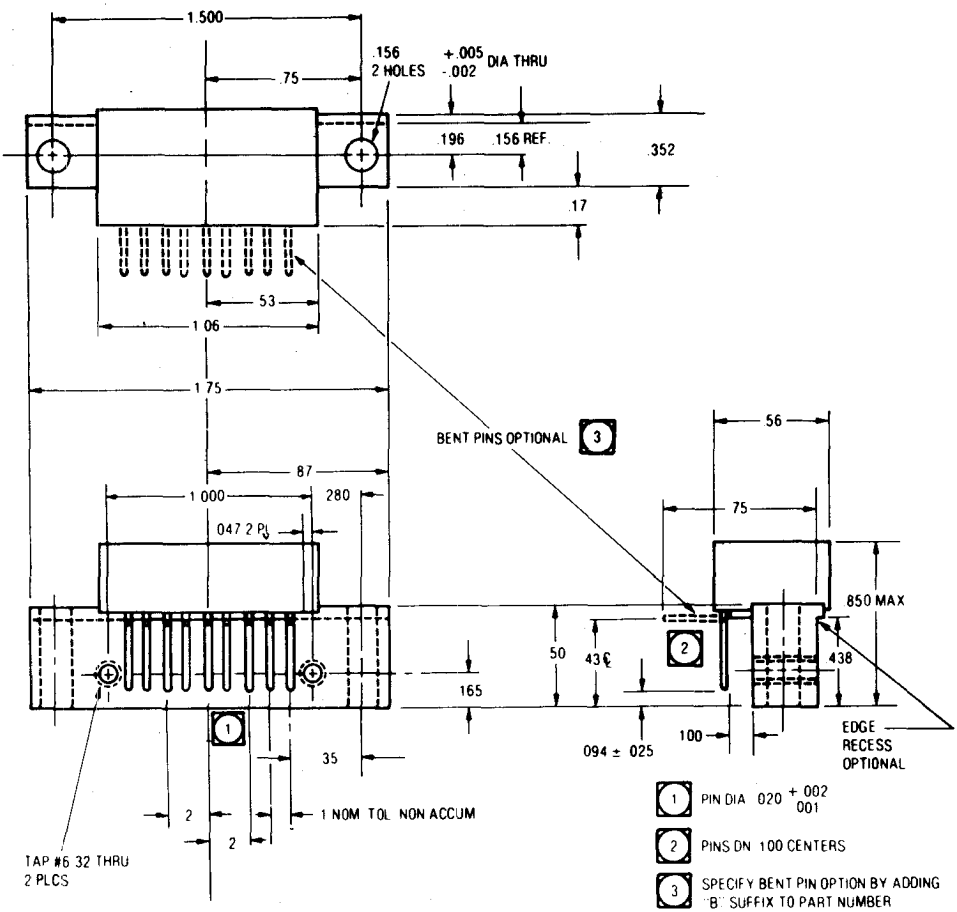
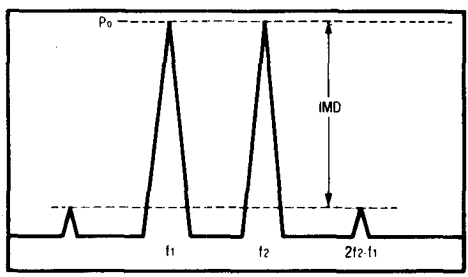


FIGURE 1. INTERMODULATION TEST



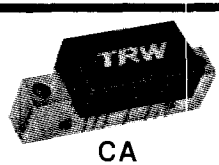
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X P_o @ IMD = -32dB

Wide Bandwidth Linear Hybrid Amplifier

The CA2810 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. Units are designed for wide bandwidth linear operation in 50 to 100 ohm systems. This hybrid provides excellent gain stability with temperature and very low distortion due to push-pull amplifier circuitry. This module is recommended for wide bandwidth, low noise and linear applications.

- **Instantaneous Bandwidth, 10-350MHz**
- **33dB Gain**
- **Power Output, 800mW**

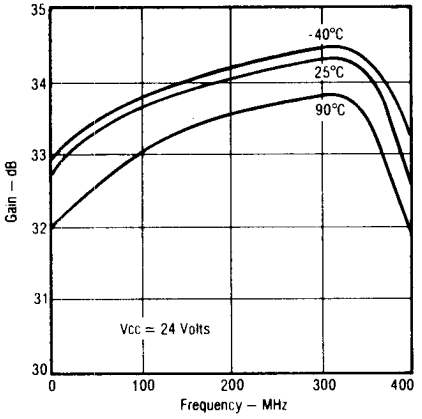


CA

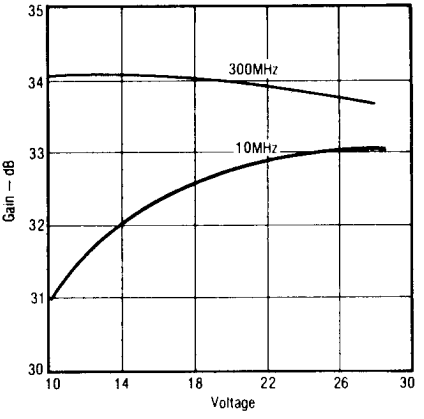
Electrical Characteristics For 50Ω Systems (T_{CASE} = 25°C and 24V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	VALUE
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage		28V
	P_{IN}	RF Power Input		+5dBm
	T_{ST}	Storage Temperature		-40°C to +100°C
	T_{OP}	Operating Temperature		-20°C to +90°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = 25°C and 24V)	P_G	Power Gain	f = 50MHz	33 ± 1dB
	NF	Noise Figure, Broadband	f = 60MHz f = 300MHz	4.5dB Typ 8.0dB Typ
	ITO	Third Order Intercept, See Figure 1	f = 300MHz	+43dBm Typ
	VSWR	Input/Output VSWR for 50Ω Systems	f = 10-350MHz	2:1 Typ
	I_{CC}	Supply Current	24V	330mA Max
	P_O	Power Output — 1dB Compression	f = 200MHz	800mW
	P_{HI}	Reverse Isolation	f = 10-350MHz	40dB Typ
	F_R	Frequency Response	f = 30-300MHz f = 10-350MHz	± 1.0dB Max ± 1.5dB Max
	dso	Second Harmonic Distortion	Tone at 10mW f2H = 10-300MHz	-66dB Typ
	PEP	Peak Envelope Power for Two Tone Distortion Test See Figure 1	f = 10-300MHz at -32dB	400mW Typ

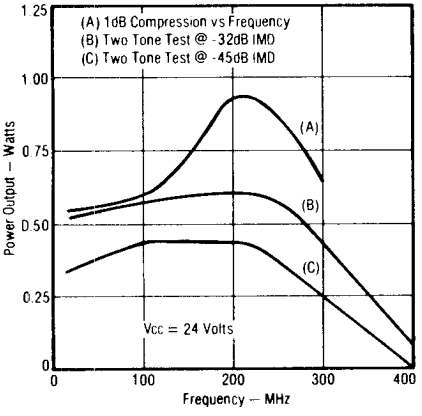
Gain vs Frequency



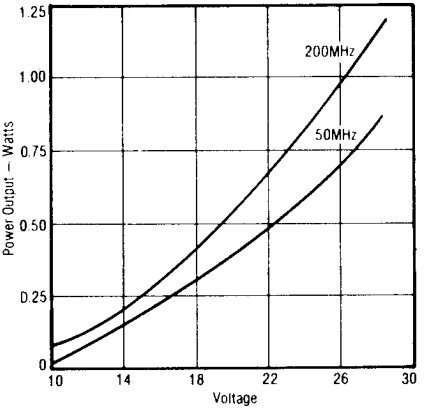
Gain vs Voltage -



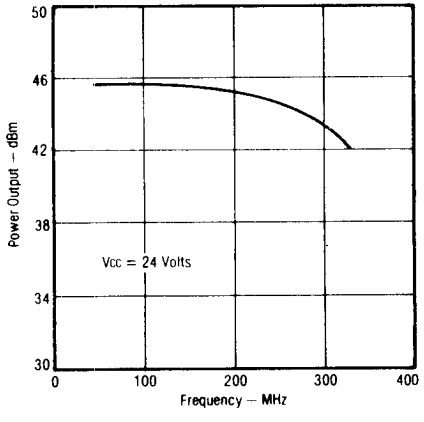
Power Output vs Frequency



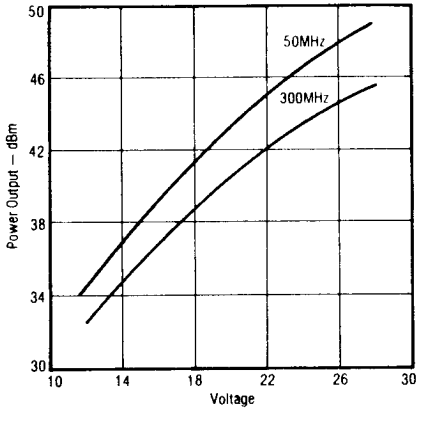
1dB Compression vs Voltage



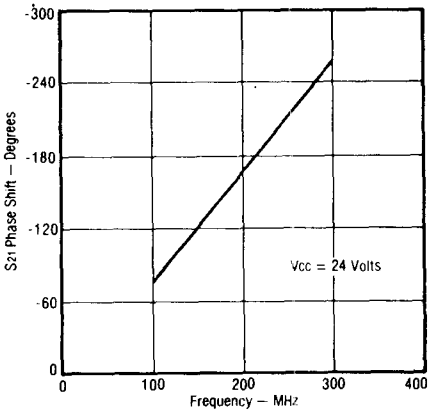
Third Order Intercept vs Frequency



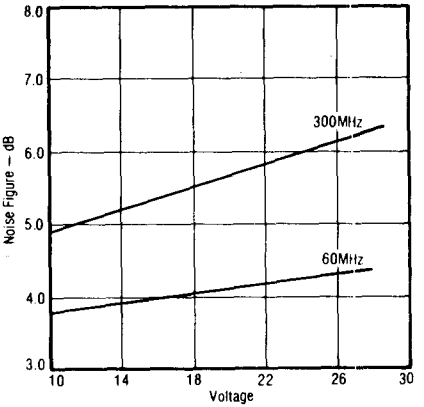
Third Order Intercept vs Voltage



Phase Shift vs Frequency



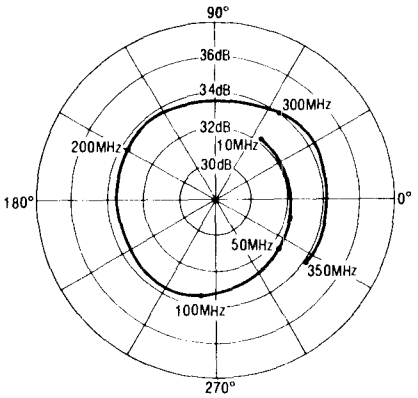
Noise Figure vs Voltage



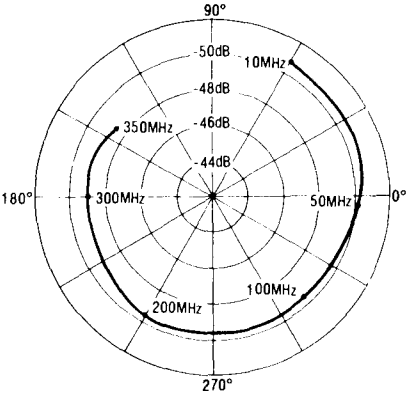
S-Parameters

Vcc = 24V, Zo = 50Ω

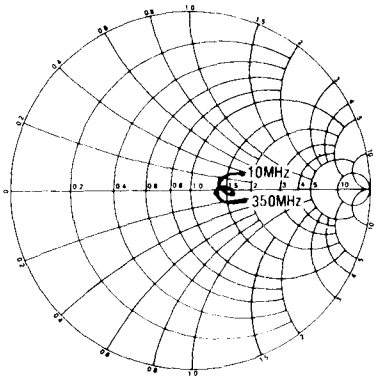
S21



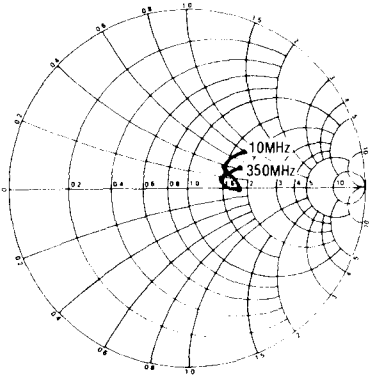
S12



S11



S22



PACKAGE OUTLINE

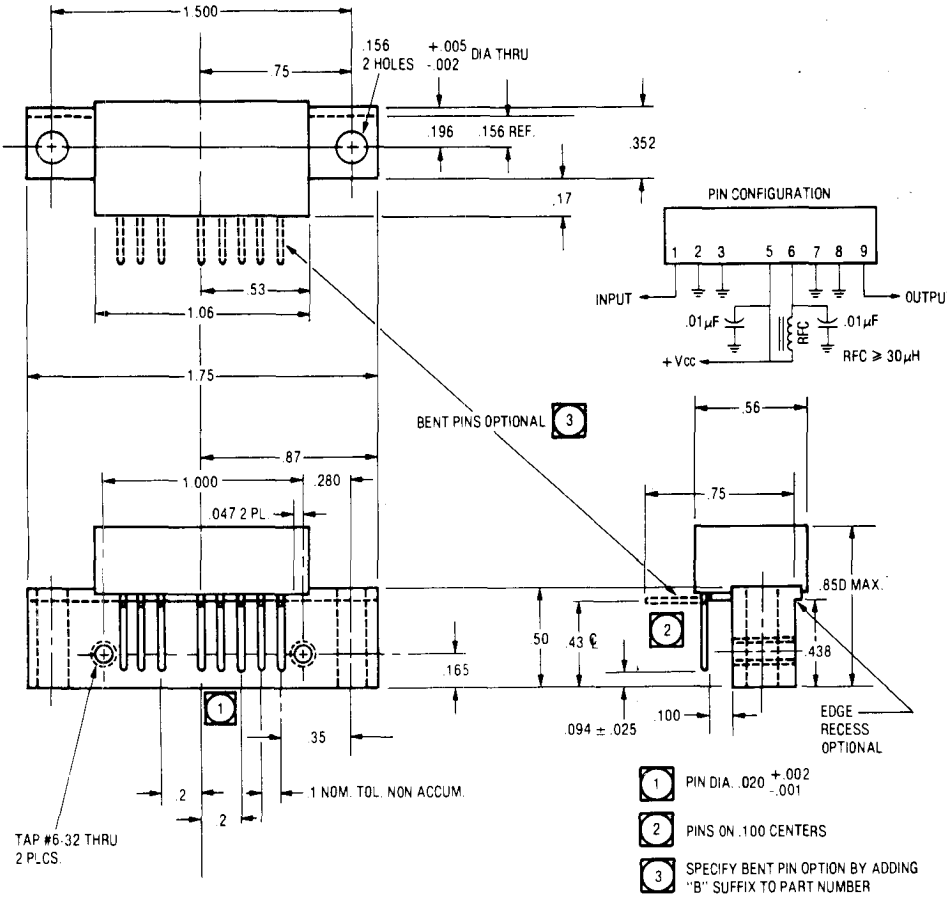
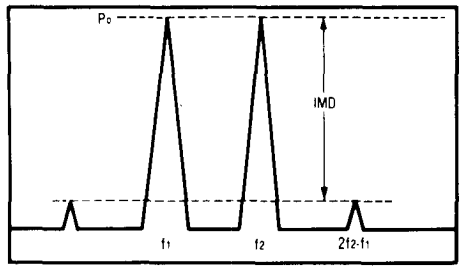


FIGURE 1. INTERMODULATION TEST



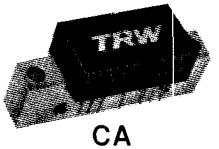
$$ITO = P_O + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X P_O @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- High performance 75 ohm IF amplifier for satellite communications
- Local oscillator buffer amp for high level mixer
- Linear driver/repeater amplifier for 75 ohm cable communications systems
- ± 10V to ± 15V supply

- **Wide Dynamic Range: +43dBm Third Order Intercept**
- **33dBk Gain, 10-350MHz**
- **Low Noise Figure**

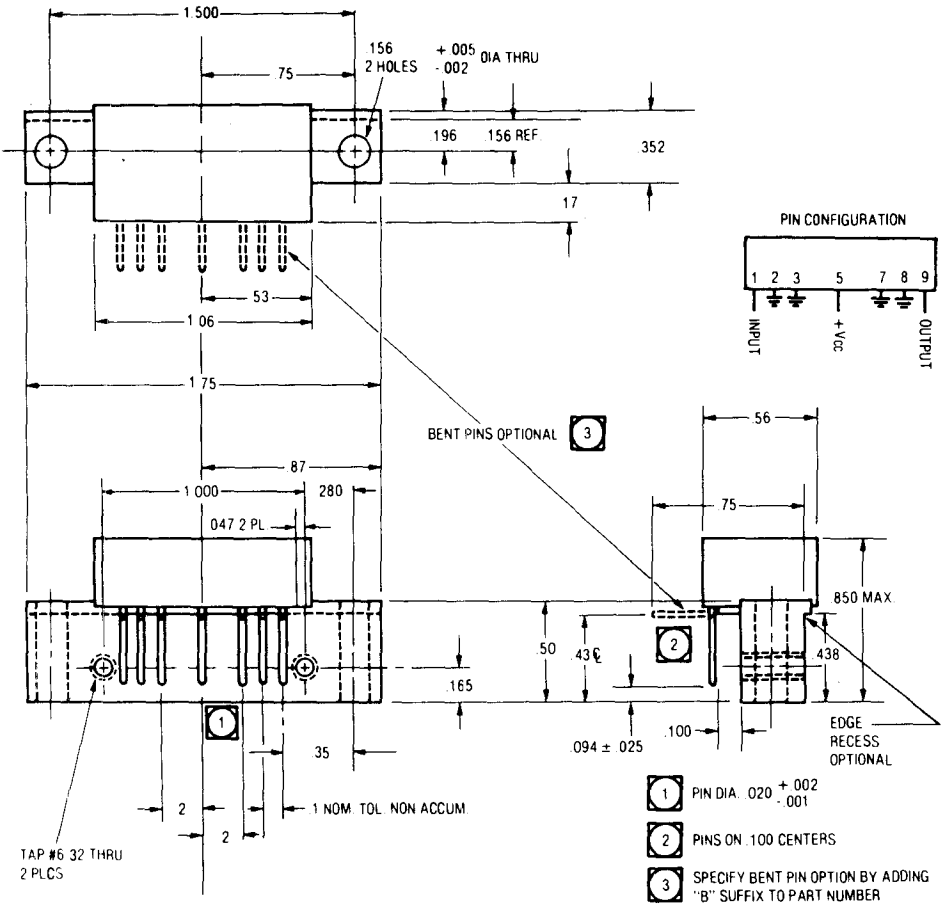


CA

Electrical Characteristics For 75Ω Systems (T_{CASE} = +25°C and ± 12V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage			± 12	± 15	volts
	P_{IN}	RF Power Input				+5	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 75Ω SYSTEMS (T_{CASE} = +25°C and ± 12V)	P_G	Power Gain	f = 100MHz	32	33.5	35	dB
	F_R	Frequency Response	f = 10-350MHz	–	± 1.0	± 1.5	dB
	P_O	Power Output, 1dB Compression	f = 200MHz	–	800	–	mW
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 10-300MHz @ -32dB IMD	–	400	–	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 300MHz	+42	+43	–	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 10mW f_{2H} = 300MHz	–	-66	–	dB
	NF	Noise Figure, Broadband	f = 70MHz	–	4.5	–	dB
	RL	Input/Output Return Loss (75Ω)	f = 40-300MHz	18	–	–	dB
	I_{CC}	Supply Current	± 12V	270	300	330	mA

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

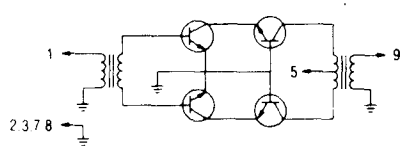
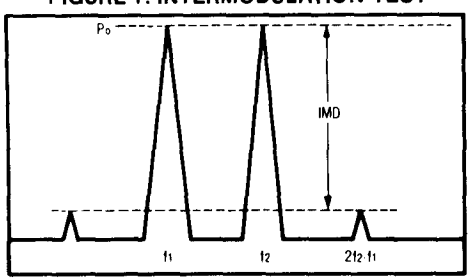


FIGURE 1. INTERMODULATION TEST



$$ITO = P_o + \frac{IMO}{2} \text{ @ } IMO > 60dB$$

$$PEP = 4X\ P_o \text{ @ } IMO = -32dB$$

Wide Bandwidth Linear Hybrid Amplifier

- Low cost single ended design
- Unconditional stability under all mismatch conditions

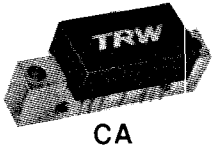
The CA2812 is a high-reliability thin-film hybrid amplifier utilizing an all gold metallization system. Units are designed for widest bandwidth linear operation in 50 ohm systems. The linear class A bias enables the CA2812 to drive highly reactive loads at large signal levels over its frequency range. Low end frequency response can be extended to 500KHz by increasing the value of the external RF chokes. This module is recommended for wide bandwidth, low cost and linear applications in 25 to 75 ohm systems over a wide range of supply voltages.

Instantaneous Bandwidth, 1-520MHz

30dB Gain

Power Output, 250mW Minimum

Optimized for 12 Volt Operation

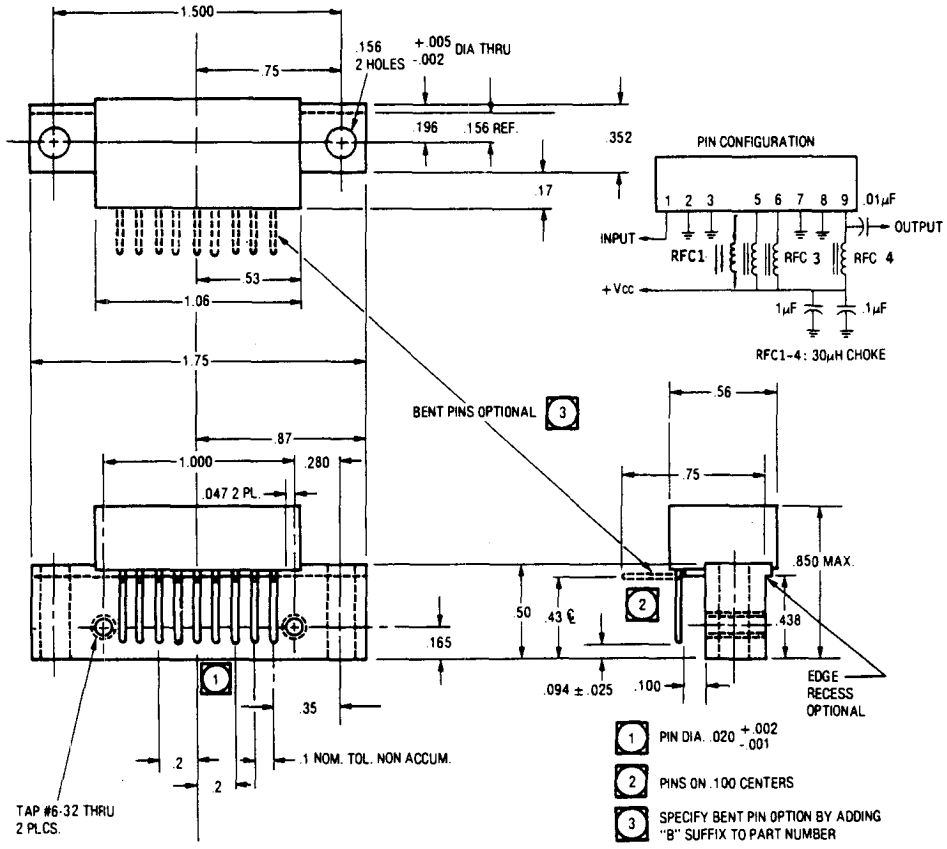


CA

Electrical Characteristics For 50Ω Systems (T_{CASE} = 25°C and 12V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
MAX RATINGS	V_{CC}	Supply Voltage				18	volts
	P_{IN}	RF Power Input				+10	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS	P_G	Power Gain	f = 100MHz	29	30	31	dB
	NF	Noise Figure, Broadband	f = 30MHz f = 500MHz	— —	5.5 8	7 10	dB
	I_{TO}	Third Order Intercept, See Figure 1	f = 520MHz	+32	+34	—	dBm
	VSWR	Input VSWR for 50 Ohm Systems Output VSWR for 50 Ohm Systems	f = 1-520MHz	—	1.5:1 1.8:1	2.0:1 2.0:1	N/A
	I_{CC}	Supply Current	12V	300	330	360	mA
	P_O	Power Output — 1dB Compression	f = 1-520MHz	250	300	—	mW
	P_{RI}	Reverse Isolation	f = 1-520MHz	49	52	—	dB
	F_R	Frequency Response	f = 1-520MHz	—	± 0.8	± 1.5	dB
	d_{SO}	Second Harmonic Distortion	P_O = 10mW f_{2H} = 1-520MHz	-40	-50	—	dB

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

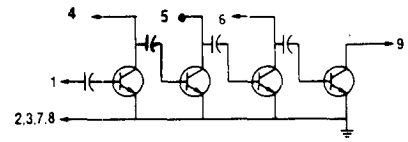
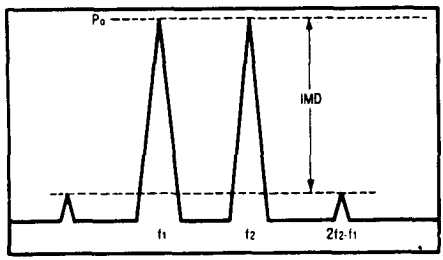


FIGURE 1. INTERMODULATION TEST



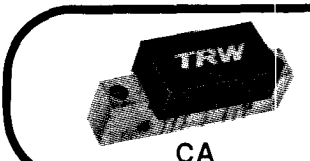
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X Po @ IMD = -32dB

Wide Bandwidth Linear Hybrid Amplifier

The CA2818 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. This hybrid provides excellent gain stability and very low distortion due to push-pull amplifier circuitry. The CA2818 is recommended for driver applications requiring high power capability and for "gain blocks" that demand maximum linearity. Excellent performance can be obtained with a supply voltage from 12 to 28 volts. For 75 ohm performance, refer to CATV equivalent model CA2418.

- **Instantaneous Bandwidth, 1-200MHz**
- **18.5dB Gain**
- **Power Output, 800mW**



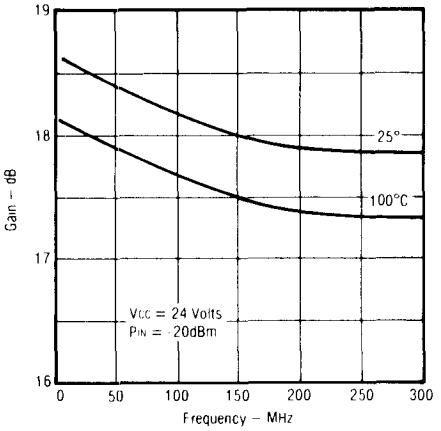
CA

Electrical Characteristics For 50Ω Systems *(T_{CASE} = 25°C and 24V)

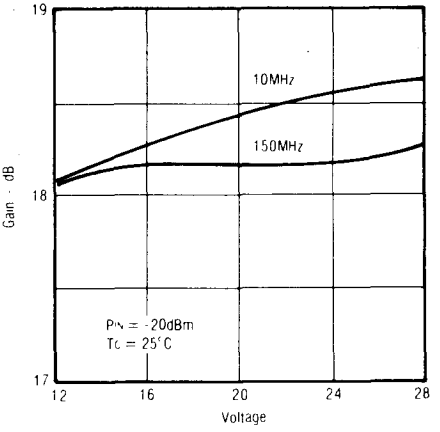
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				28	volts
	P_{IN}	RF Power Input				+14	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS *(T_{CASE} = 25°C and 24V)	*P_G	Power Gain	f = 50MHz	17.75	18.5	19.25	dB
	NF	Noise Figure, Broadband	f = 30MHz f = 150MHz	— —	4.5 5.5	6.0 7.0	dB
	I_{TO}	Third Order Intercept, See Figure 1	f = 150MHz	+44	+47	—	dBm
	VSWR	Input/Output VSWR for 50Ω Systems Input/Output VSWR for 75Ω Systems	f = 1-200MHz	— —	1.7:1 1.2:1	2.0:1 1.3:1	N/A
	I_{CC}	Supply Current	24V	190	205	220	mA
	P_O	Power Output — 1dB Compression	f = 150MHz	800	900	—	mW
	P_{RI}	Reverse Isolation	f = 1-200MHz	—	25	—	dB
	F_R	Frequency Response	f = 5-150MHz f = 1-200MHz	— —	± 0.2 ± 0.5	± 0.5 ± 1.0	dB
	d_{SO}	Second Harmonic Distortion	P_O = 100mW f_{2H} = 1-200MHz	-55	-60	—	dB
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 1-200MHz at -32dB	600	800	—	mW

*Except for VSWR as noted.

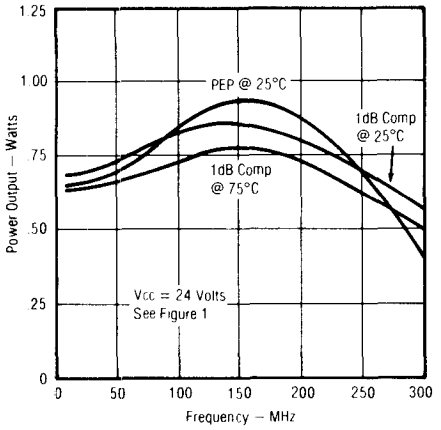
GAIN VS. FREQUENCY



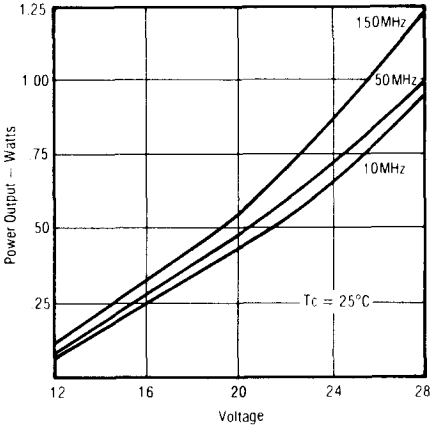
GAIN VS. VOLTAGE



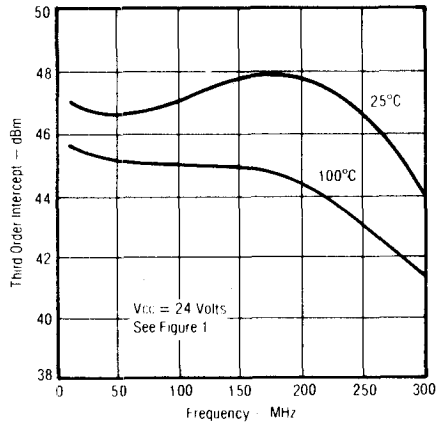
POWER OUTPUT VS. FREQUENCY



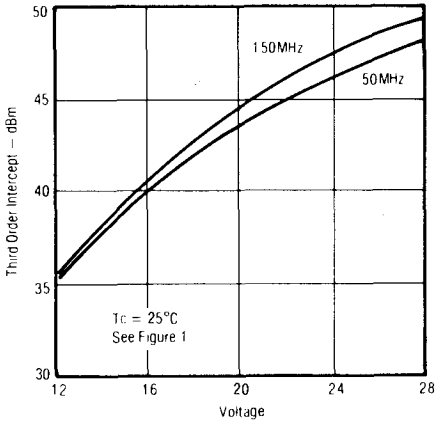
1dB COMPRESSION VS. VOLTAGE



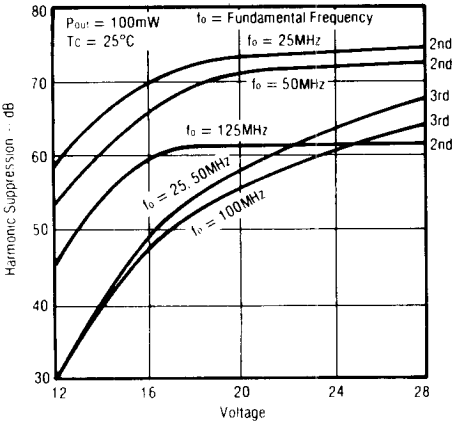
THIRD ORDER INTERCEPT VS. FREQUENCY



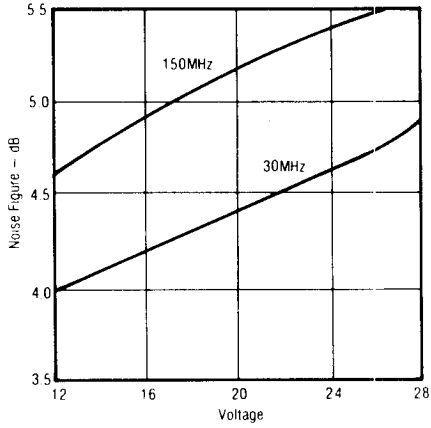
THIRD ORDER INTERCEPT VS. VOLTAGE



SECOND AND THIRD HARMONIC SUPPRESSION VS. VOLTAGE



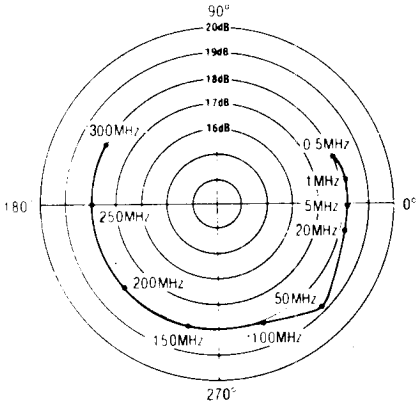
NOISE FIGURE VS. VOLTAGE



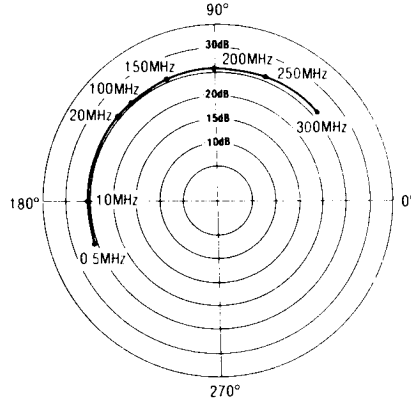
S-PARAMETERS

Zo = 50Ω, Vcc = 24V

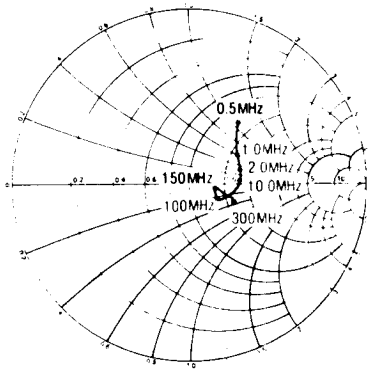
S21



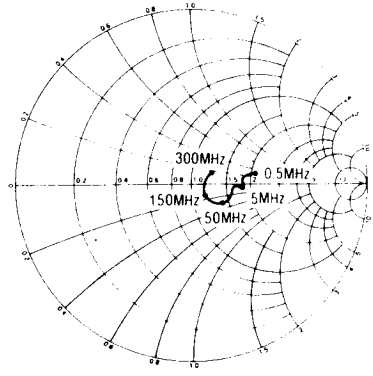
S12



S11



S22



PACKAGE OUTLINE

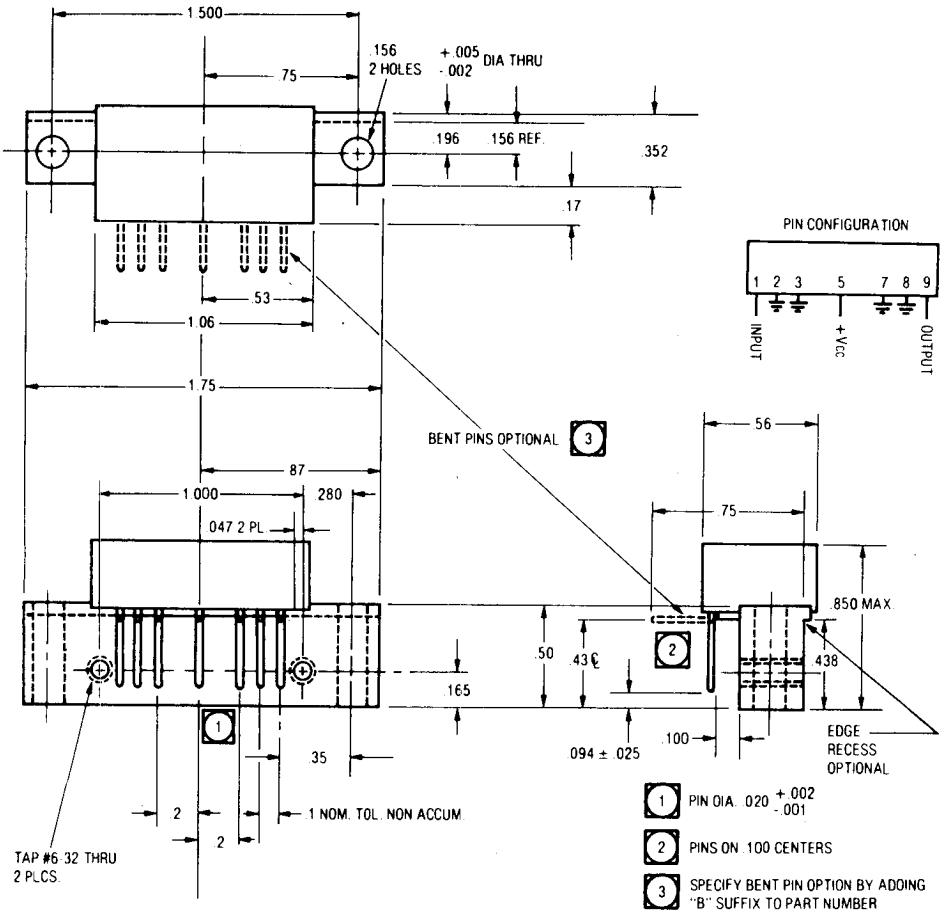
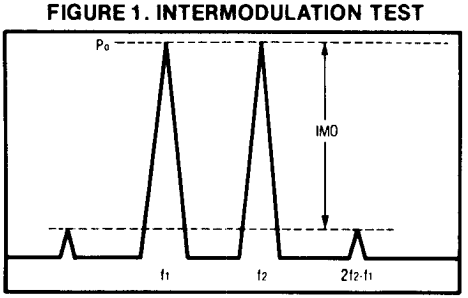


FIGURE 1. INTERMODULATION TEST



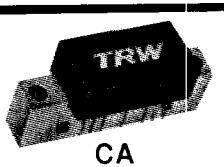
$$ITO = P_o + \frac{IMO}{2} \text{ @ } IMO > 60dB$$

$$PEP = 4X\ P_o \text{ @ } IMD = -32dB$$

Wide Bandwidth Linear Hybrid Amplifier

The CA2820 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system. Units are designed for widest bandwidth linear operation in 50 ohm systems. The linear class A bias enables the CA2820 to drive highly reactive loads at large signal levels over its frequency range. Low end frequency response can be extended to 500KHz by increasing the value of the external RF chokes. This module is recommended for wide bandwidth, low cost and linear applications in 25 to 75 ohm systems over a wide range of supply voltages.

- **Instantaneous Bandwidth, 1-520MHz**
- **30dB Gain**
- **Power Output, 400mW Minimum**

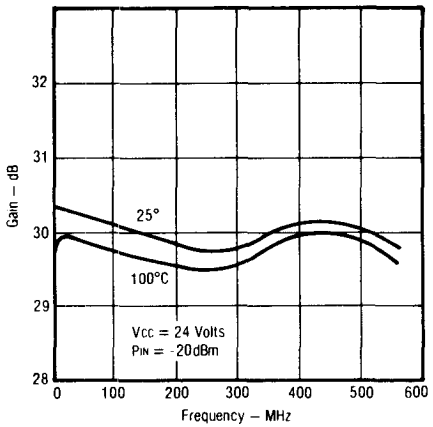


CA

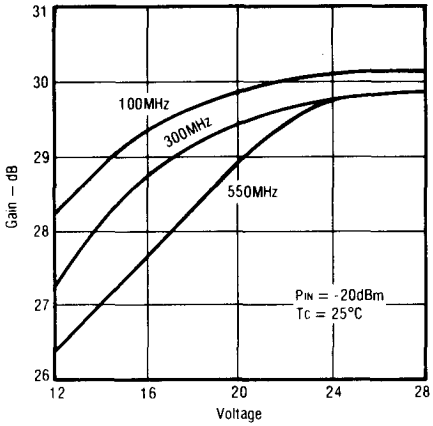
Electrical Characteristics For 50Ω Systems (T_{CASE} = 25°C and 24V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				28	volts
	P_{IN}	RF Power Input				+10	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = 25°C and 24V)	P_G	Power Gain	f = 100MHz	29	30	31	dB
	NF	Noise Figure, Broadband	f = 30MHz f = 500MHz	— —	6.0 8.3	8 10	dB
	I_{P3}	Third Order Intercept, See Figure 1	f = 520MHz	+35	+37	—	dBm
	VSWR	Input VSWR for 50 Ohm Systems Output VSWR for 50 Ohm Systems	f = 1-520MHz	—	1.5:1 1.8:1	2.0:1 2.0:1	N/A
	I_{CC}	Supply Current	24V	300	330	360	mA
	P_O	Power Output — 1dB Compression	f = 1-520MHz	400	440	—	mW
	P_R	Reverse Isolation	f = 1-520MHz	49	52	—	dB
	FR	Frequency Response	f = 1-520MHz	—	± 0.8	± 1.5	dB
	d_{50}	Second Harmonic Distortion	P_O = 10mW f_{2H} = 1-520MHz	-45	-55	—	dB
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 1-520MHz at -32dB	300	400	—	mW

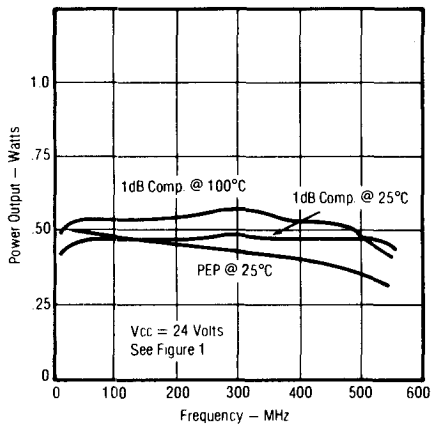
GAIN VS. FREQUENCY



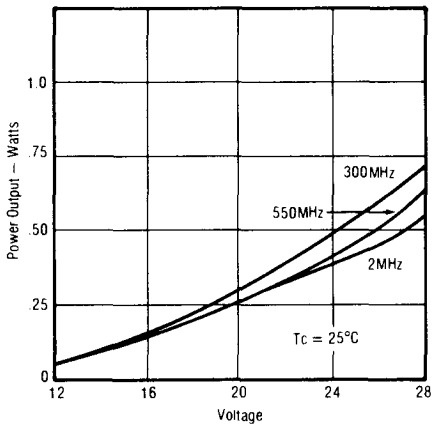
GAIN VS. VOLTAGE



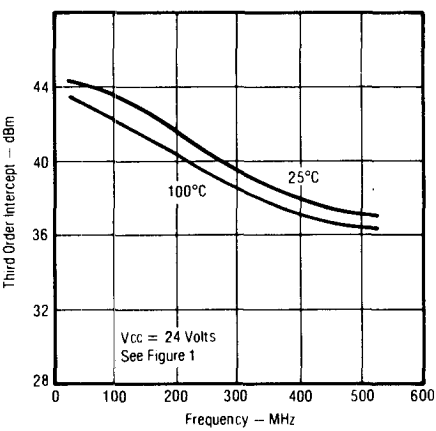
POWER OUTPUT VS. FREQUENCY



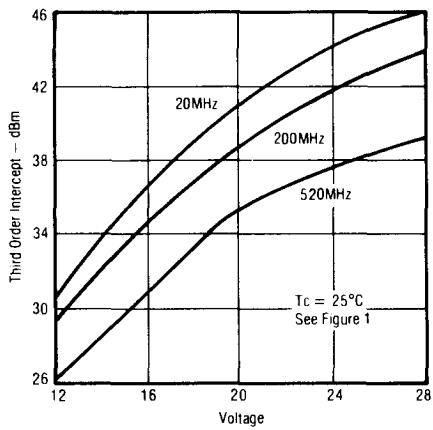
1dB COMPRESSION VS. VOLTAGE



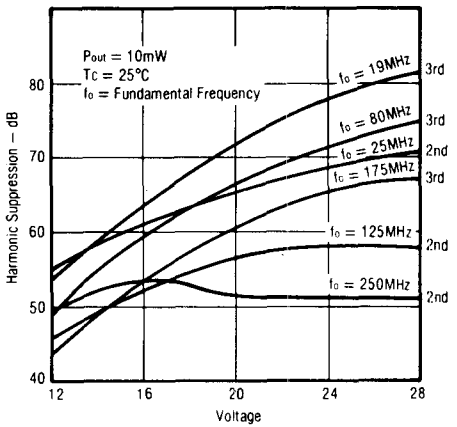
THIRD ORDER INTERCEPT VS. FREQUENCY



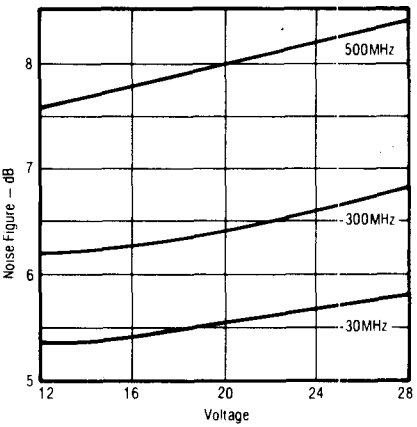
THIRD ORDER INTERCEPT VS. VOLTAGE



SECOND AND THIRD HARMONIC SUPPRESSION VS. VOLTAGE



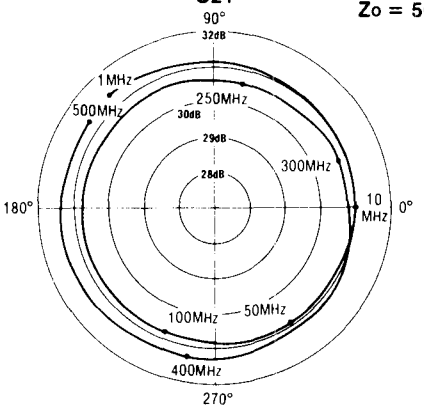
NOISE FIGURE VS. VOLTAGE



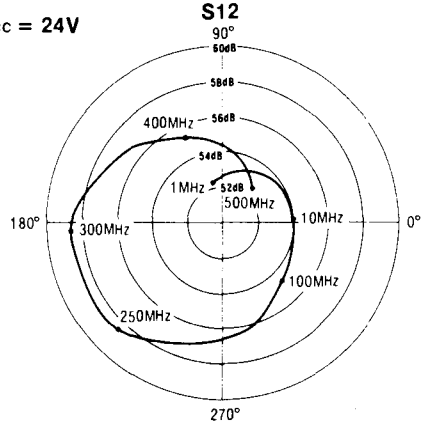
S-PARAMETERS

Zo = 50Ω, Vcc = 24V

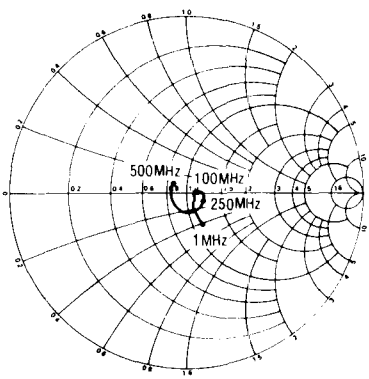
S21



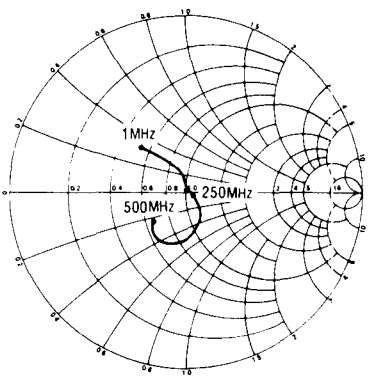
S12



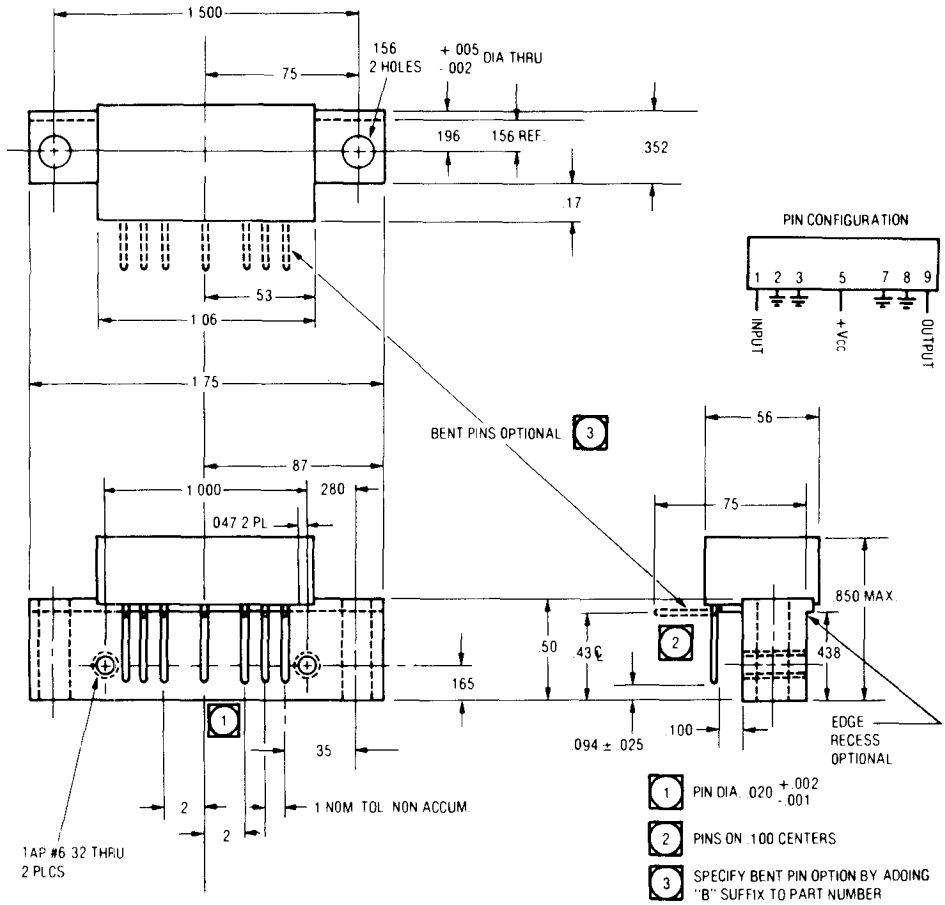
S11



S22



PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

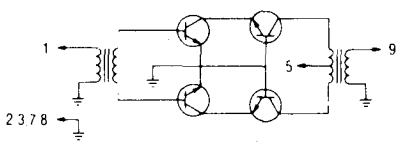
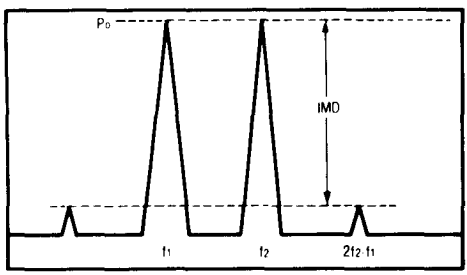


FIGURE 1. INTERMODULATION TEST



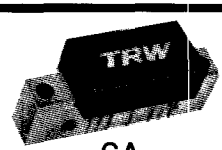
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X P_o @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- Wide dynamic range: +46dBm third order intercept
- Unconditional stability under all load conditions
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- Transmitter driver for HF, VHF communications radios
- Fiber optic driver for laser/L.E.D. diodes
- Driver for acousto-optic modulators
- High performance linear amplifier for all types of analog/digital waveforms

- **High Gain (34.5dB), Low Distortion (Push-pull Circuitry)**
- **1W Output Power at 28V**



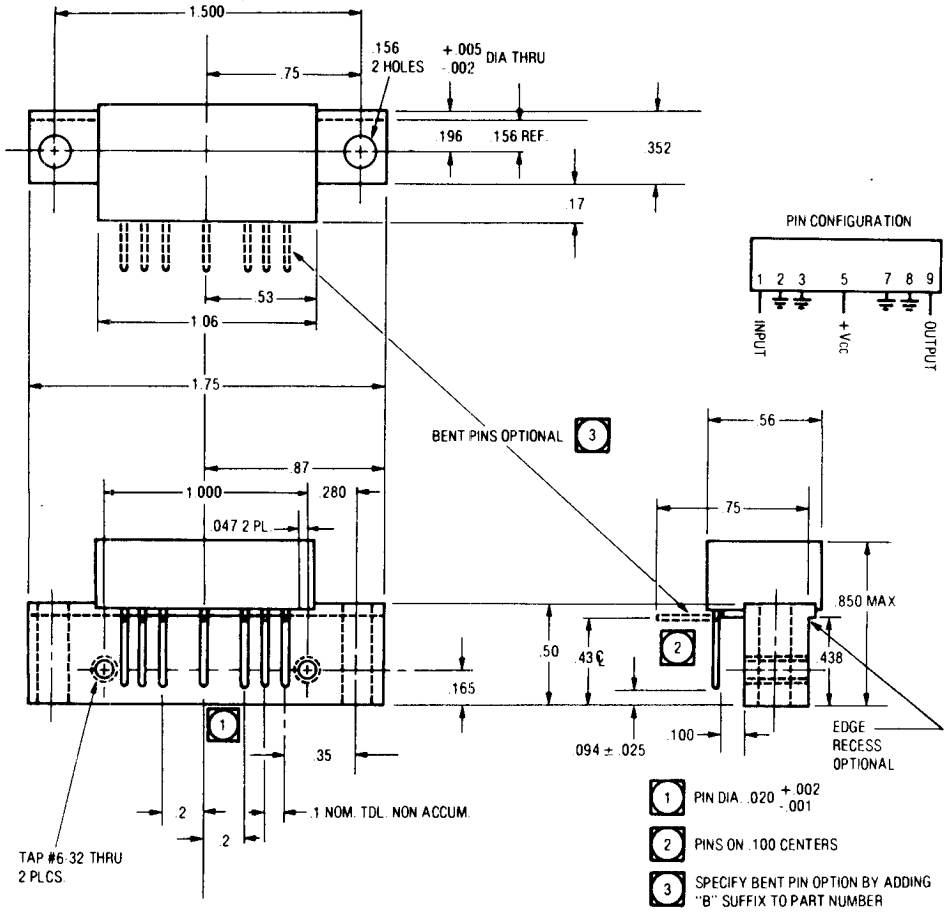
CA

Electrical Characteristics For 50Ω Systems (T_{CASE} = +25°C and +24V*)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP	MAX	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				+28	volts
	P_{IN}	RF Power Input				+5	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = +25°C and +24V*)	P_G	Power Gain	f = 100MHz	33.5	34.5	35.5	dB
	F_R	Frequency Response	f = 5-200MHz	—	± 0.5	± 1.0	dB
	P_O	Power Output, 1dB Compression	f = 5-200MHz	+28	+29	—	dBm
	P_O	Power Output, 1dB Compression, V_{CC} = 28V	f = 5-200MHz	+30	+31	—	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 5-200MHz @ -32dB IMD	600	800	—	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 200MHz	+44	+46	—	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2H} = 150MHz	-50	-60	—	dB
	NF	Noise Figure, Broadband	f = 200MHz	—	4.7	5.5	dB
	VSWR	Input/Output VSWR (50Ω)	f = 5-200MHz	—	1.5:1	2.0:1	N/A
	I_{CC}	Supply Current	24V	270	300	330	mA

*Except for power output as noted.

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

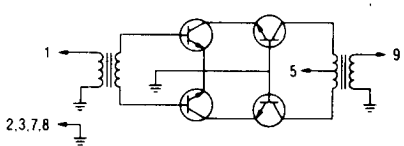
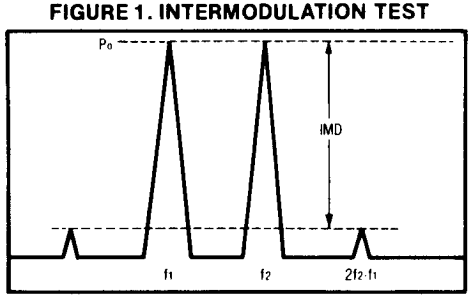


FIGURE 1. INTERMODULATION TEST



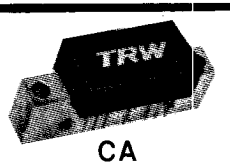
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X Po @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- High gain (35.5dB), low distortion (push-pull circuitry)
- 2W output power at 28V
- Wide dynamic range: +47dBm third order intercept
- Unconditional stability under all load conditions
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- Transmitter driver for HF, VHF communications radios
- Fiber optic driver for laser/L.E.D. diodes
- Driver for acousto-optic modulators
- High performance linear amplifier for all types of analog/digital waveforms

- **High Gain — 35.5dB**
- **Low Distortion**
- **2W Output @ 28V**

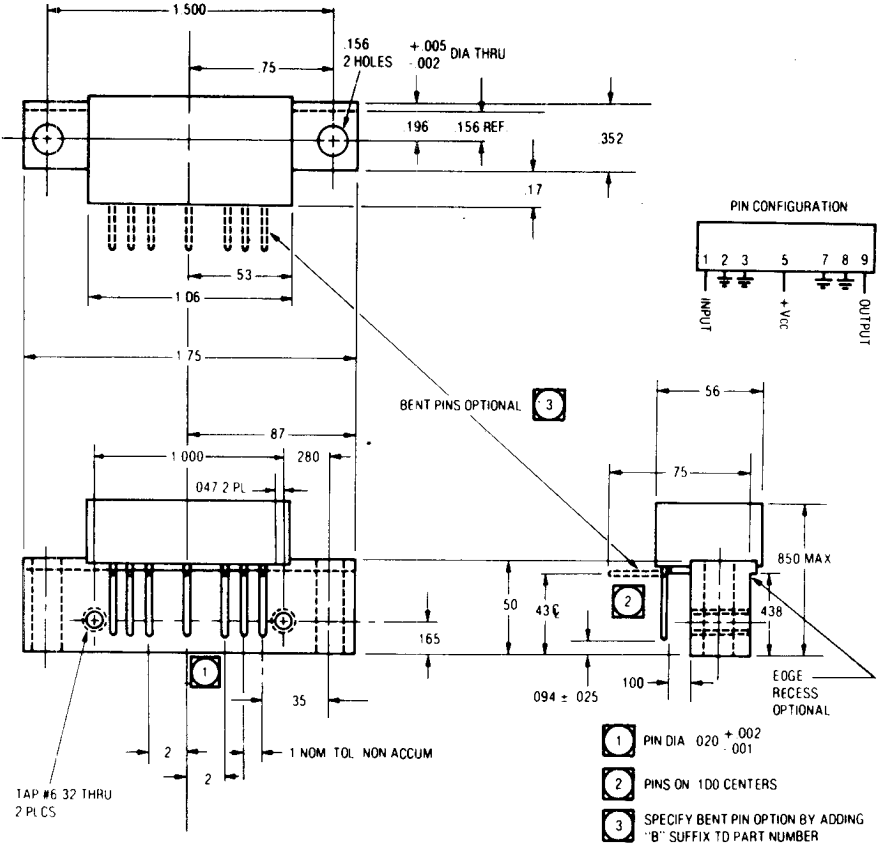


CA

Electrical Characteristics For 50Ω Systems (T_{CASE} = +25°C and +28V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				+30	volts
	P_{IN}	RF Power Input				+15	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = +25°C and +28V)	P_G	Power Gain	f = 100MHz	34.0	35.5	37.0	dB
	F_R	Frequency Response	f = 1-200MHz	—	± 0.5	± 1.0	dB
	P_O	Power Output, 1dB Compression	f = 1-200MHz	+31	+32	—	dBm
	P_O	Power Output, 1dB Compression	f = 150MHz	—	+33	—	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 1-200MHz @ -32dB IMD	—	900	—	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 200MHz	+45	+47	—	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{CH} = 150MHz	-60	-70	—	dB
	NF	Noise Figure, Broadband	f = 200MHz	—	6	7	dB
	VSWR	Input/Output VSWR (50Ω)	f = 1-200MHz	—	1.5:1	2.0:1	N/A
	I_{CC}	Supply Current	28V	400	435	470	mA

CA2832
PACKAGE OUTLINE



PIN CONFIGURATION

FUNCTIONAL SCHEMATIC

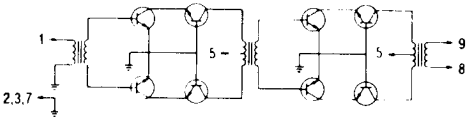
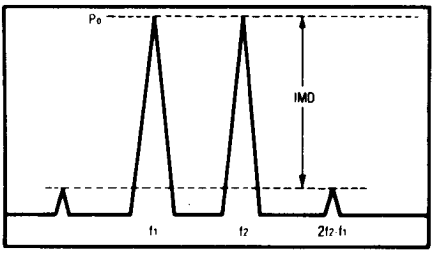


FIGURE 1. INTERMODULATION TEST



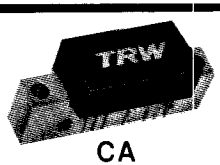
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X Po @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- Unconditional stability under all load conditions
- All gold (monometallic) metallization system featuring gold transistor die with diffused ballast resistors for the ultimate in reliability
- Local oscillator buffer amp for high level mixer
- 75 ohm IF post amplifier
- High performance linear amplifier for all types of analog/digital waveforms

- **22dB Gain, Low Distortion (Push-pull Circuitry)**
- **1W Output Power at 28V**
- **Matched for 75Ω Applications**



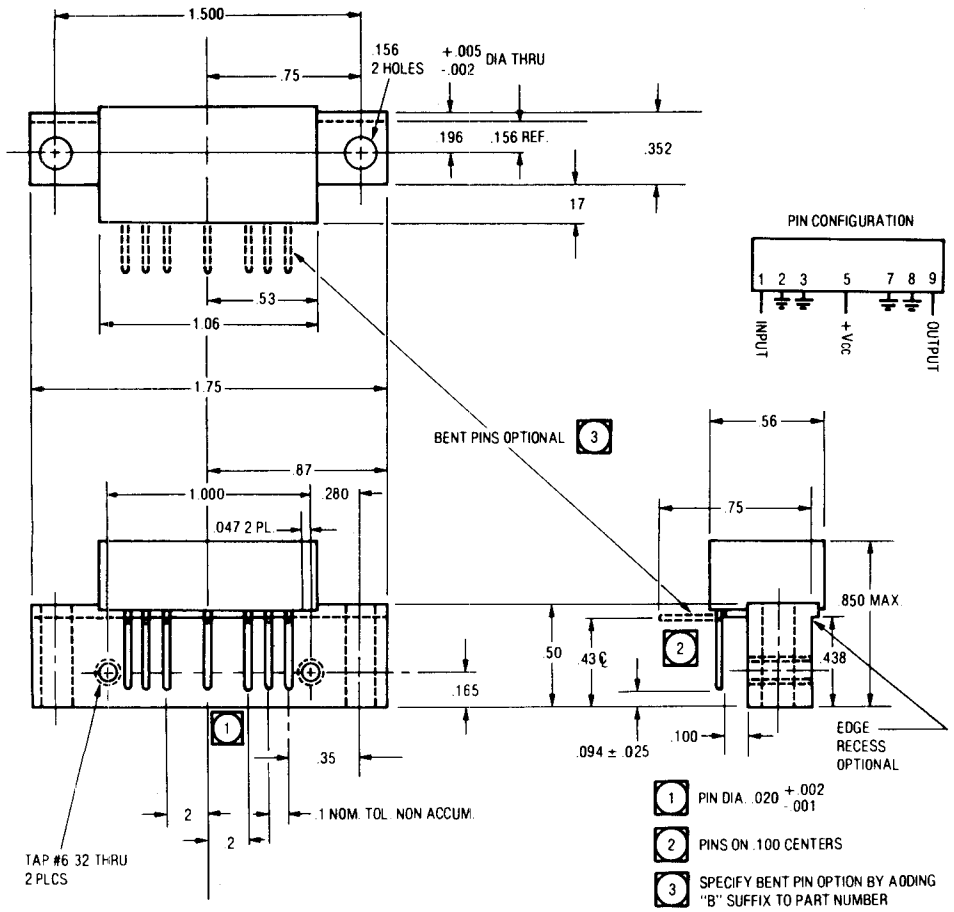
CA

Electrical Characteristics For 75Ω Systems (T_{CASE} = +25°C and +24V*)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				+28	volts
	P_{IN}	RF Power Input				+4	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 75Ω SYSTEMS (T_{CASE} = +25°C and +24V*)	P_G	Power Gain	f = 100MHz	21	22	23	dB
	F_R	Frequency Response	f = 30-300MHz	–	±0.5	±1.0	dB
	P_O	Power Output, 1dB Compression	f = 30-200MHz	+29	+30	–	dBm
	P_O	Power Output, 1dB Compression, V_{CC} = 28V	f = 30-200MHz	+30	+31	–	dBm
	P_{EP}	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 200MHz @ -32dB IMD	550	650	–	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 30-300MHz	+43	+46	–	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2H} = 150MHz	-50	–	–	dB
	NF	Noise Figure, Broadband	f = 100MHz	–	5	6	dB
	VSWR	Input/Output VSWR (75Ω)	f = 30-300MHz	–	1.2:1	1.3:1	N/A
	I_{CC}	Supply Current	24V	210	230	250	mA

*Except for power output as noted.

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

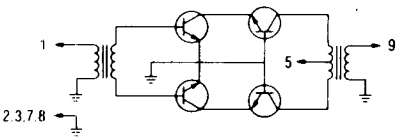
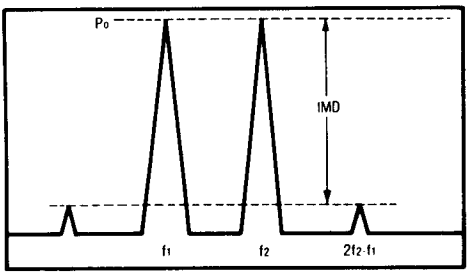


FIGURE 1. INTERMODULATION TEST



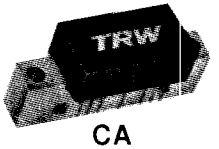
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X Po @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- Insensitive to load variations: unconditionally stable
- Wide dynamic range: +46dBm third order intercept
- Low distortion (push-pull circuitry)
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- Transmitter driver for VHF radios (AM/FM)
- Fiber optic driver for laser/L.E.D. diodes
- Driver for acousto-optic modulators
- High performance linear amplifier for all types of analog/digital waveforms

- **1.2W Output Power at 28V from 30-200MHz**
- **22dB Gain, 30-300MHz**
- **Matched for 50Ω Applications**



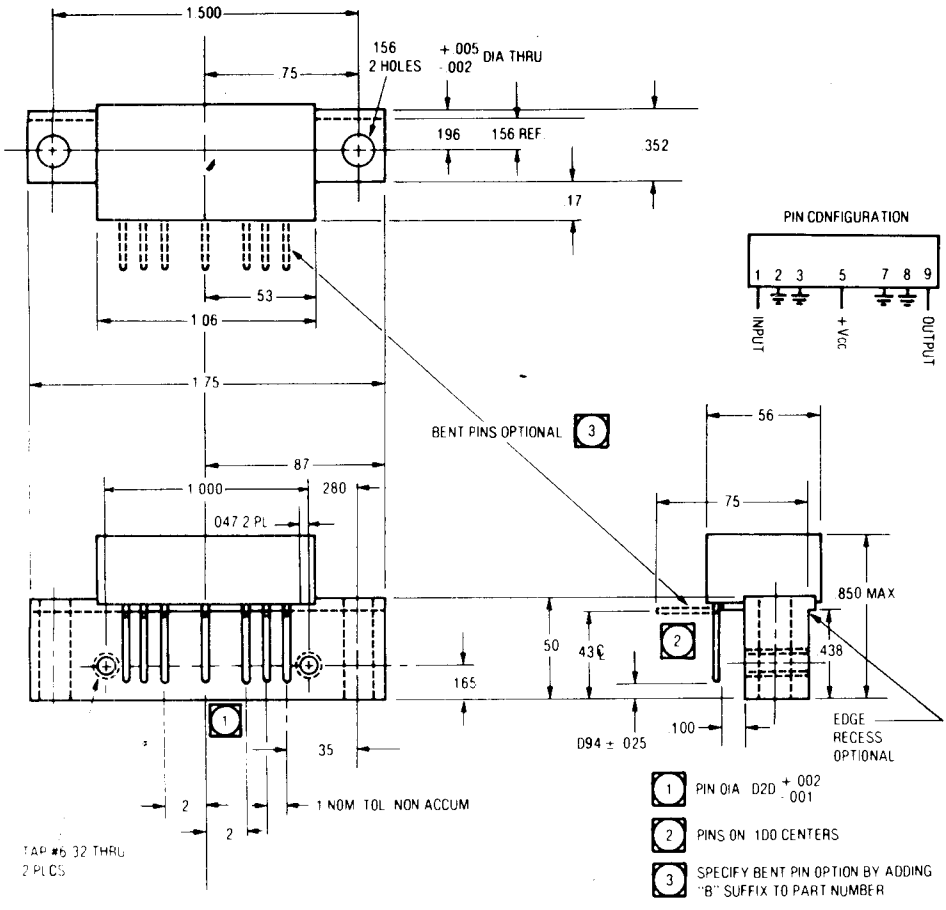
CA

Electrical Characteristics For 50Ω Systems (T_{CASE} = +25°C and +24V*)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				+28	volts
	P_{IN}	RF Power Input				+14	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = +25°C and +24V*)	P_G	Power Gain	f = 100MHz	21	22	23	dB
	F_R	Frequency Response	f = 30-300MHz	—	± 0.5	± 1.0	dB
	P_O	Power Output, 1dB Compression, V_{CC} = 28V	f = 30-200MHz f = 200-300MHz	+31 +28	+32 +29	— —	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 200MHz @ -32dB IMD	550	650	—	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 30-300MHz	+43	+46	—	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2H} = 300MHz	-50	—	—	dB
	NF	Noise Figure, Broadband	f = 100MHz	—	5	6	dB
	VSWR	Input/Output VSWR (50Ω)	f = 30-200MHz f = 200-300MHz	— —	— —	1.3:1 1.5:1	N/A
	I_{CC}	Supply Current	24V	210	230	250	mA

*Except for power output as noted.

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

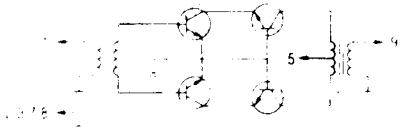
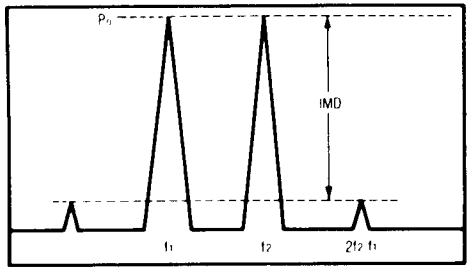


FIGURE 1. INTERMODULATION TEST



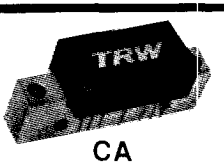
$$IIP3 = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X P_o @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- Low noise figure (push-pull cascode circuit)
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- High performance 50 ohm IF amplifier
- Local oscillator buffer amp for high level mixer
- Linear driver/repeater amplifier for 50 ohm cable communications systems
- -15V to -24V supply

- **Low Power Consumption**
- **Wide Dynamic Range: +40dBm Third Order Intercept**
- **Low VSWR for 50Ω Systems**

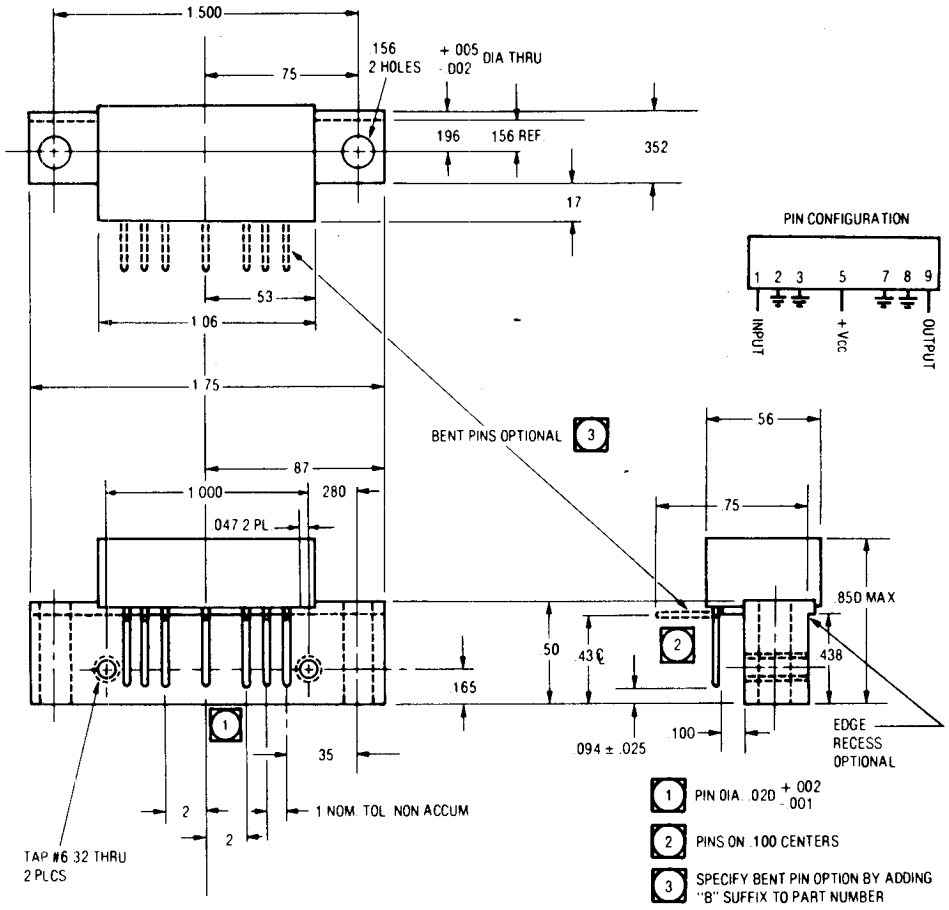


CA

Electrical Characteristics For 50Ω Systems (T_{CASE} = +25°C and -19V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				-23	volts
	P_{IN}	RF Power Input				+14	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE}=+25°C and -19V)	P_G	Power Gain	f = 100MHz	17.0	17.5	18.0	dB
	F_R	Frequency Response	f = 40-100MHz	—	±0.1	±0.2	dB
	P_O	Power Output, 1dB Compression	f = 40-100MHz	+24	+25	—	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 40-100MHz @ -32dB IMD	250	300	—	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 70MHz	+37	+40	—	dBm
	d_{SO}	Second Harmonic Suppression	P_O = +24dBm f_{2H} = 100MHz	—	-40	—	dB
	NF	Noise Figure, Broadband	f = 70MHz	—	4.5	5.0	dB
	VSWR	Input/Output VSWR (50Ω)	f = 40-100MHz	—	1.2:1	1.3:1	N/A
	I_{CC}	Supply Current	-19V	110	125	140	mA

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

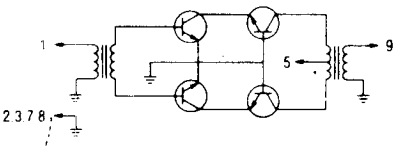
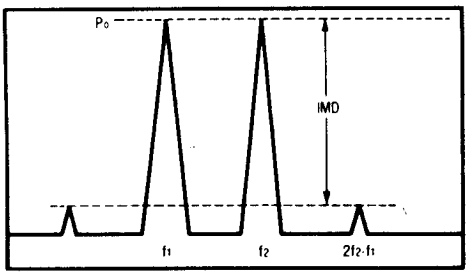


FIGURE 1. INTERMODULATION TEST



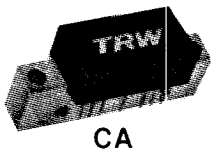
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X Po @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- Low VSWR for 50Ω systems
- Low noise figure (push-pull cascode circuit)
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- High density packaging
- High performance 50 ohm IF amplifier
- Local oscillator buffer amp for high level mixer
- Linear driver/repeater amplifier for 50 ohm cable communications systems
- -15V to -24V supply

- **Low Profile Package**
- **Low Power Consumption**
- **Wide Dynamic Range: +40dBm Third Order Intercept**

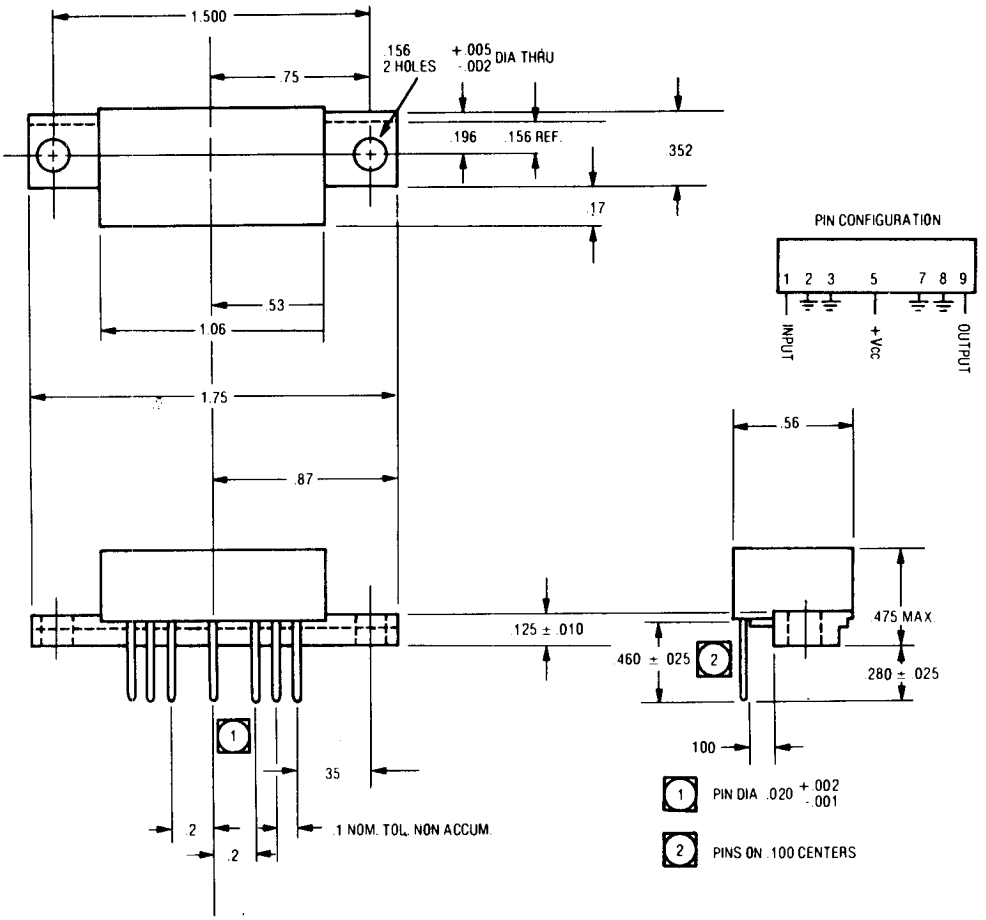


CA

Electrical Characteristics For 50Ω Systems (T_{CASE} = +25°C and -19V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				-28	volts
	P_{IN}	RF Power Input				+14	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} +25°C and -19V)	P_G	Power Gain	f = 100MHz	17.0	17.5	18.0	dB
	F_R	Frequency Response	f = 40-100MHz	–	± 0.1	± 0.2	dB
	P_O	Power Output, 1dB Compression	f = 40-100MHz	+24	+25	–	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 40-100MHz @ -32dB IMD	250	300	–	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 70MHz	+37	+40	–	dBm
	d_{SO}	Second Harmonic Suppression	P_O = +24dBm f_{2H} = 100MHz	–	-40	–	dB
	NF	Noise Figure, Broadband	f = 70MHz	–	4.5	5.0	dB
	VSWR	Input/Output VSWR (50Ω)	f = 40-100MHz	–	1.2:1	1.3:1	N/A
	I_{CC}	Supply Current	-19V	110	125	140	mA

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

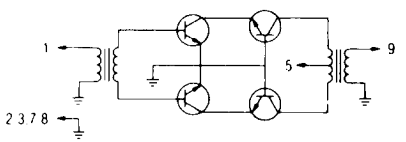
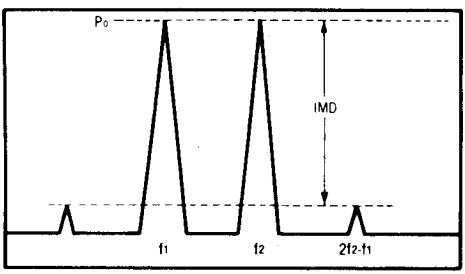


FIGURE 1. INTERMODULATION TEST



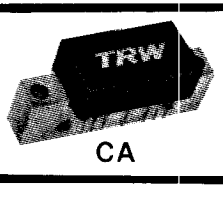
$$ITO = Po + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X Po @ IMD = -32dB

Wide Bandwidth Linear Hybrid Amplifier

The CA2870 is a high-reliability thin-film hybrid amplifier utilizing an all gold metalization system with built-in provisions for amplitude leveling. The circuit covers the 20-400MHz frequency range. Two B+ inputs, one for the preamplifier and one for the final stage, provide a convenient means of RF leveling by variation of the final stage B+ voltage. Load variations on the preceding stage are kept to a minimum by this provision. Although the uncorrected flatness of this module is superb (±0.5dB typical), the leveling provisions provide convenient means of correcting for the frequency response of succeeding stages and injection of AM modulation. This module finds wide application in military and industrial service as gain blocks in RF amplifiers for VHF and UHF transmitters.

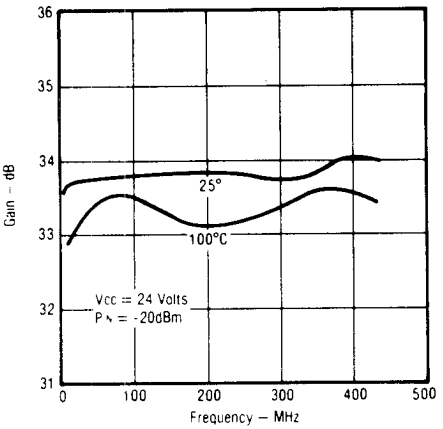
- **Instantaneous Bandwidth, 20-400MHz**
- **34dB Gain**
- **Power Output, 400mW Minimum**



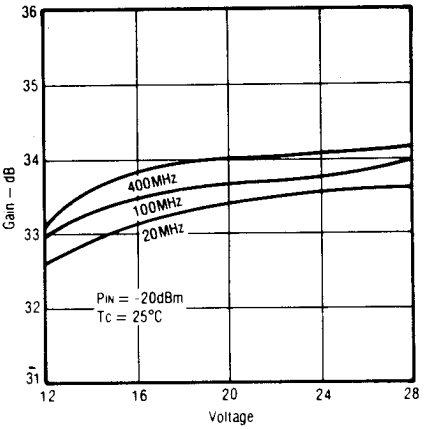
Electrical Characteristics For 50Ω Systems (T_{CASE} = +25°C and 24V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				+28	volts
	P_{IN}	RF Power Input				+5	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 50Ω SYSTEMS (T_{CASE} = 25°C and 24V)	P_G	Power Gain	f = 100MHz	32.5	34	35.5	dB
	F_R	Frequency Response	f = 20-400MHz	—	± 0.5	± 1.0	dB
	P_O	Power Output — 1dB Compression	f = 225MHz f = 400MHz	800 400	850 500	-- --	mW
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 20-400MHz @ -32dB	400	500	--	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 300MHz	+42	+45	--	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2H} = 20-400MHz	-45	-52	--	dB
	NF	Noise Figure, Broadband	f = 30MHz f = 400MHz	— —	4.5 7.5	6.0 8.5	dB
	P_{RI}	Reverse Isolation	f = 20-400MHz	45	48	--	dB
	VSWR	Input VSWR for 50 Ohm Systems Output VSWR for 50 Ohm Systems	f = 20-400MHz	— —	1.5:1 1.8:1	2.0:1 2.0:1	N/A
	I_{CC}	Supply Current	24V	270	300	330	mA

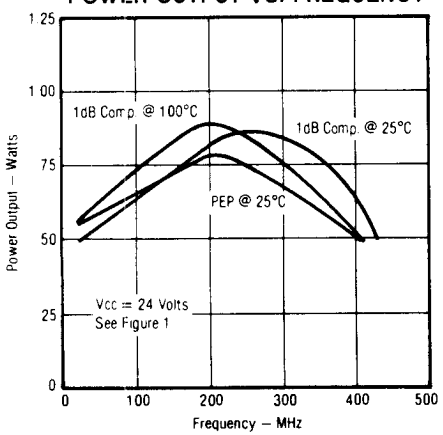
GAIN VS. FREQUENCY



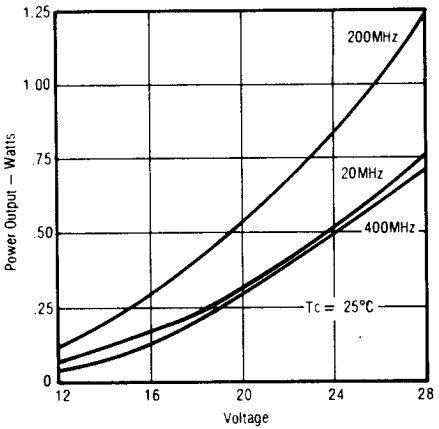
GAIN VS. VOLTAGE



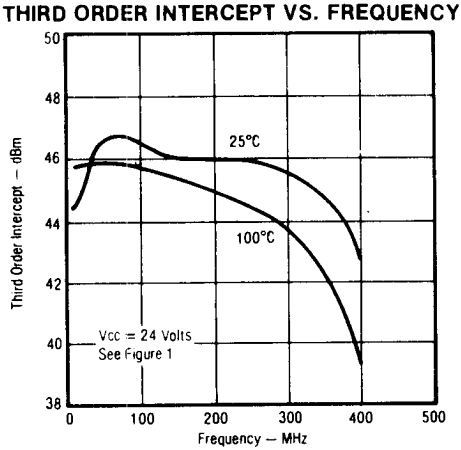
POWER OUTPUT VS. FREQUENCY



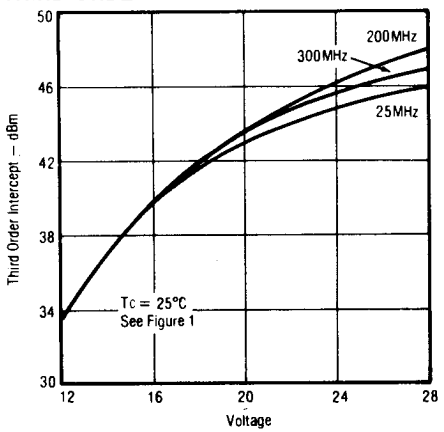
1dB COMPRESSION VS. VOLTAGE



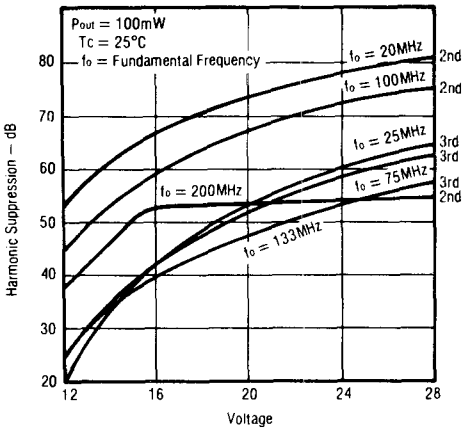
THIRD ORDER INTERCEPT VS. FREQUENCY



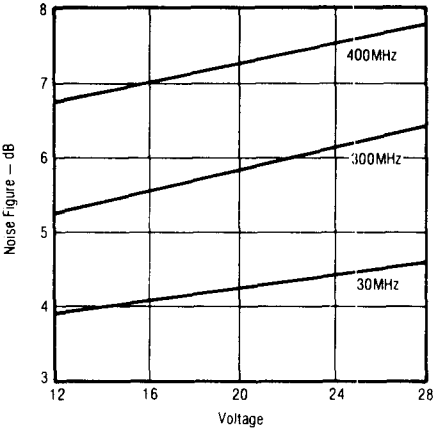
THIRD ORDER INTERCEPT VS. VOLTAGE



SECOND AND THIRD HARMONIC SUPPRESSION VS. VOLTAGE



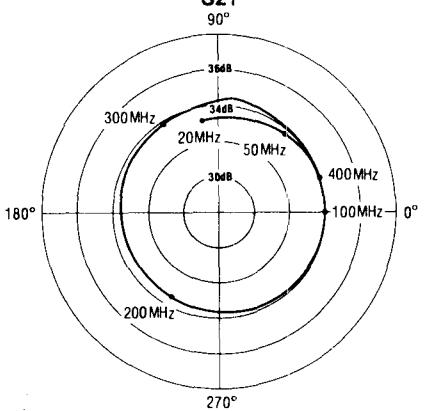
NOISE FIGURE VS. VOLTAGE



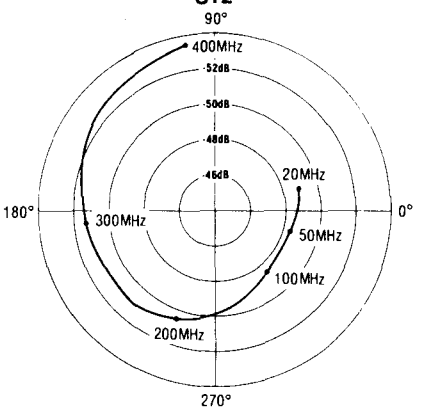
S-PARAMETERS

Zo = 50Ω, Vcc = 24V

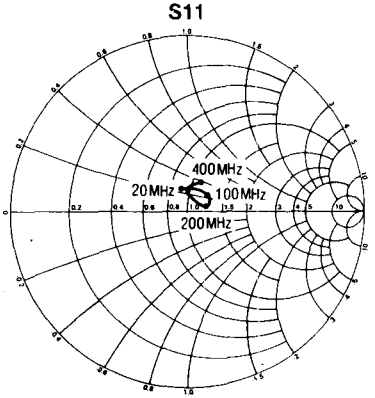
S21



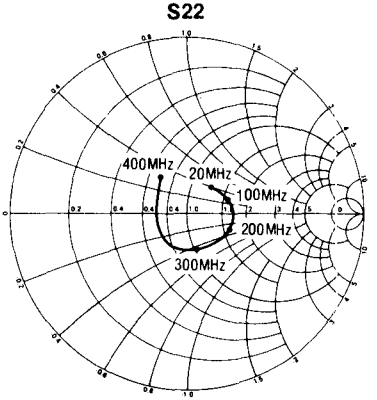
S12



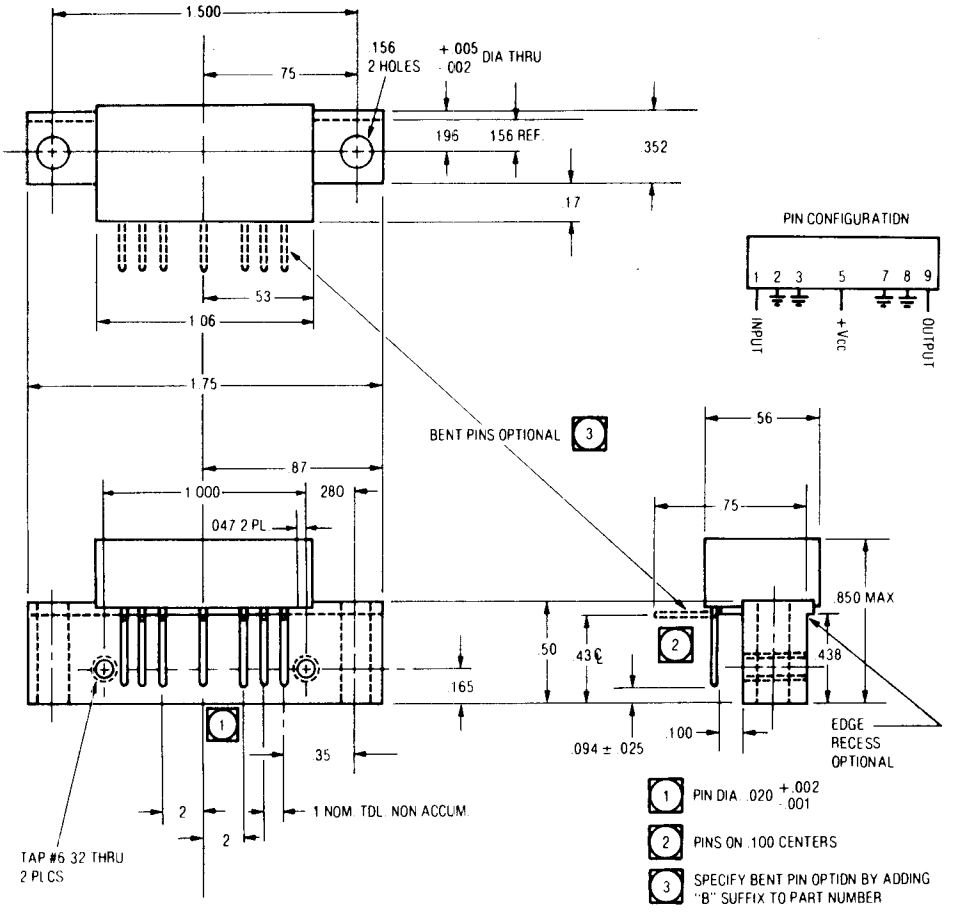
S11



S22



PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

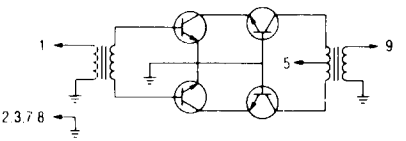
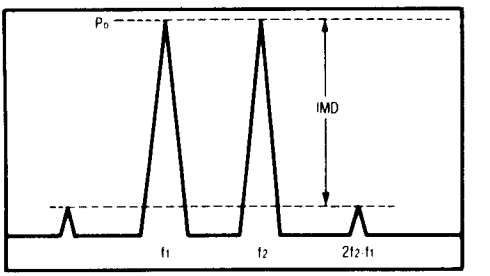


FIGURE 1. INTERMODULATION TEST



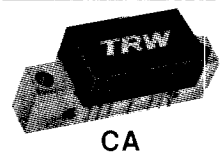
$$IIO = P_O + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X P_O @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- Wide dynamic range: +43dBm third order intercept
- Excellent match at input/output: lowest VSWR
- Low noise figure (push-pull cascode circuit)
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
  High performance 75 ohm IF amplifier
- Local oscillator buffer amp for high level mixer
- Linear driver/repeater amplifier for 75 ohm cable communications systems
- -15V to -24V supply

- **+43dBm Third Order Intercept**
- **Lowest VSWR**
- **Low Noise Figure**

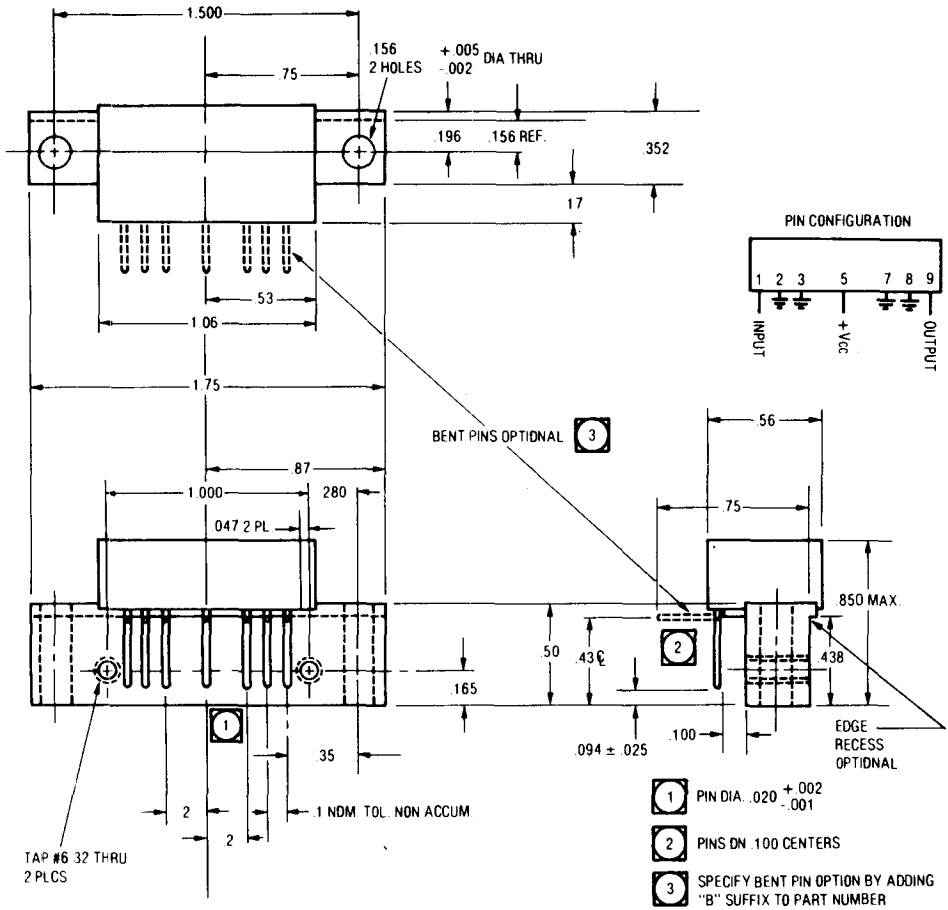


CA

Electrical Characteristics For 75Ω Systems (T_{CASE} = +25°C and +19V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				-28	volts
	P_{IN}	RF Power Input				+14	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 75Ω SYSTEMS (T_{CASE} = +25°C and +19V)	P_G	Power Gain	f = 100MHz	17.0	17.5	18.0	dB
	F_R	Frequency Response	f = 40-100MHz	—	± 0.1	± 0.2	dB
	P_O	Power Output, 1dB Compression	f = 40-100MHz	+25	+26	—	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 40-100MHz @ -32dB IMD	250	300	—	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 70MHz	+42	+43	—	dBm
	d_{SO}	Second Harmonic Suppression	P_O = +24dBm f_{2H} = 100MHz	—	-40	—	dB
	NF	Noise Figure, Broadband	f = 70MHz	—	4.5	5.0	dB
	RL	Input/Output Return Loss (75Ω)	f = 40-100MHz	30	—	—	N/A
	I_{CC}	Supply Current	-19V	140	155	170	mA

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

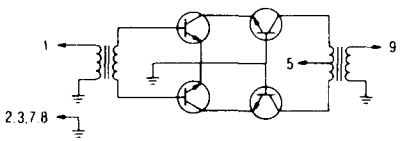
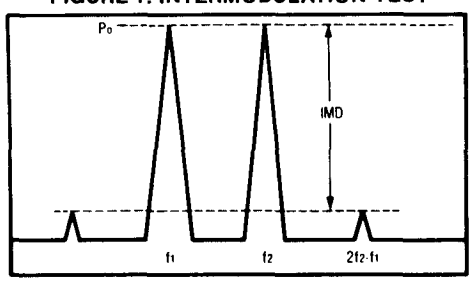


FIGURE 1. INTERMODULATION TEST



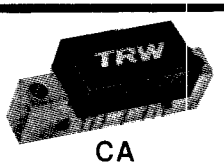
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X P_o @ IMD = -32dB

Thin Film RF Linear Hybrid Amplifier

- +36dBm third order intercept
- Low VSWR for 75Ω systems
- Push-pull cascode circuit
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- Low noise 75Ω IF amplifier
- High performance linear amplifier for signal levels below 100mW
- Linear amplifier applications requiring low current consumption
- -15V to -24V supply

- **1.5W DC Power Consumption**
- **3dB Noise Figure**
- **22dB Gain, Low Distortion**

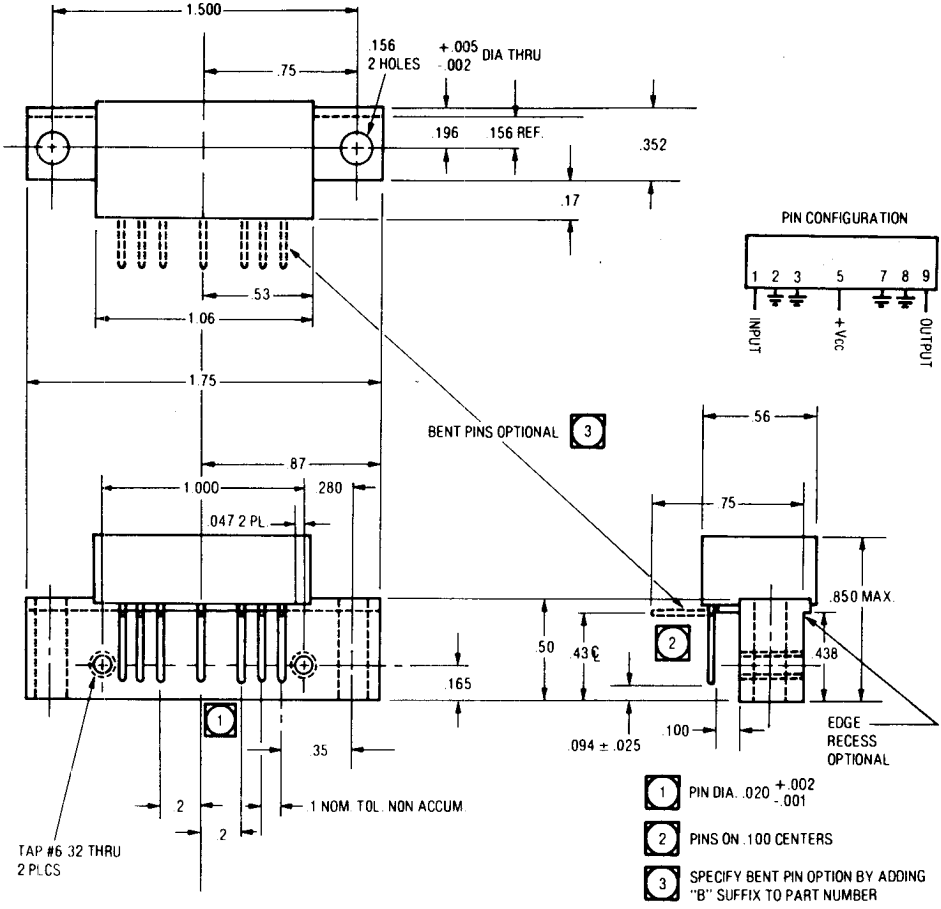


CA

Electrical Characteristics For 75Ω Systems (T_{CASE} = +25°C and -19V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				-28	volts
	P_{IN}	RF Power Input				+14	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 75Ω SYSTEMS (T_{CASE} = +25°C and -19V)	P_G	Power Gain	f = 100MHz	21.25	22	22.75	dB
	F_R	Frequency Response	f = 40-100MHz	—	± 0.1	± 0.3	dB
	P_O	Power Output, 1dB Compression	f = 40-100MHz	+20	+22	—	dBm
	PEP	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 40-100MHz @ -32dB IMO	100	175	—	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 70MHz	+33	+36	—	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2H} = 100MHz	-45	-50	—	dB
	NF	Noise Figure, Broadband	f = 70MHz	—	3.0	3.5	dB
	VSWR	Input/Output VSWR (75Ω)	f = 40-100MHz	—	1.1:1	1.2:1	N/A
	I_{CC}	Supply Current	-19V	65	73	80	mA

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

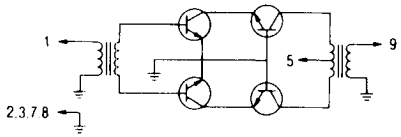
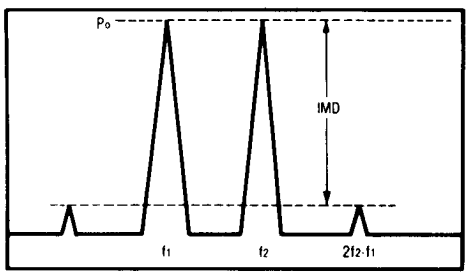


FIGURE 1. INTERMODULATION TEST



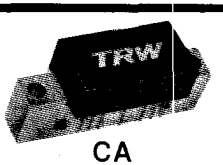
$$ITO = P_o + \frac{IMD}{2} \text{ @ IMD} > 60dB$$

PEP = 4X Po @ IMO = -32dB

Thin Film RF Linear Hybrid Amplifier

- 22dB gain, low distortion
- +36dBm third order intercept
- Low VSWR for 75Ω systems
- Push-pull cascode circuit
- All gold (monometallic) metallization system featuring gold transistor die with diffused emitter ballast resistors for the ultimate in reliability
- High density packaging
- Low noise 75Ω IF amplifier
- High performance linear amplifier for signal levels below 100mW
- Linear amplifier applications requiring low current consumption
- -15V to -24V supply

- **Low Profile Package**
- **1.5W DC Power Consumption**
- **3dB Noise Figure**

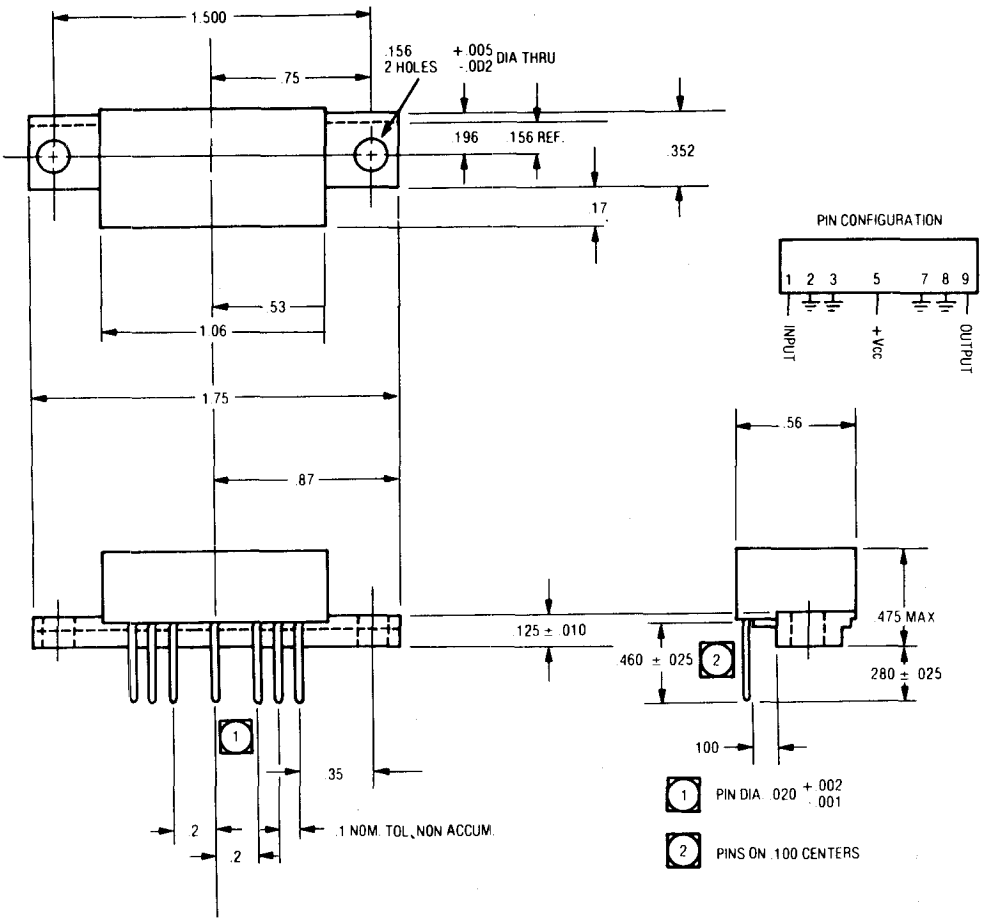


CA

Electrical Characteristics For 75Ω Systems (T_{CASE} = +25°C and -19V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage				-23	volts
	P_{IN}	RF Power Input				+14	dBm
	T_{ST}	Storage Temperature		-55		+125	°C
	T_{OP}	Operating Temperature		-40		+100	°C
ELECTRICAL CHARACTERISTICS FOR 75Ω SYSTEMS (T_{CASE} = +25°C and -19V)	P_G	Power Gain	f = 100MHz	21.25	22	22.75	dB
	F_R	Frequency Response	f = 40-100MHz	–	± 0.1	± 0.3	dB
	P_O	Power Output, 1dB Compression	f = 40-100MHz	+20	+22	–	dBm
	PE^{3}	Peak Envelope Power for Two Tone Distortion Test, See Figure 1	f = 40-100MHz @ -32dB IMO	100	175	–	mW
	I_{TO}	Third Order Intercept, See Figure 1	f = 70MHz	+33	+36	–	dBm
	d_{SO}	Second Harmonic Suppression	P_O = 100mW f_{2H} = 100MHz	-45	-50	–	dB
	NF	Noise Figure, Broadband	f = 70MHz	–	3.0	3.5	dB
	VSWR	Input/Output VSWR (75Ω)	f = 40-100MHz	–	1.1:1	1.2:1	N/A
	I_{CC}	Supply Current	19V	65	73	80	mA

PACKAGE OUTLINE



FUNCTIONAL SCHEMATIC

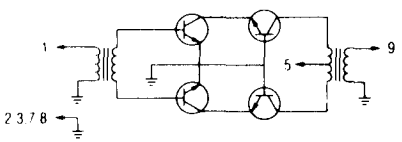
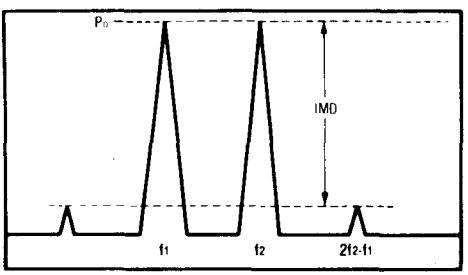


FIGURE 1. INTERMODULATION TEST



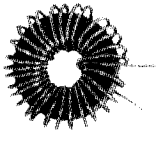
$$ITO = Po + \frac{IMD}{2} \text{ @ } IMD > 60dB$$

PEP = 4X Po @ IMD = -32dB

Broadband RF Choke

TRW Model CA2899 is a broadband, high impedance choke (RFC) required as an external component for models CA2812 (4 each), CA2820 (3 each), and CA2870 (1 each) RF Linear Hybrid Amplifiers (not sold as a separate item). For construction details refer to Application Note "Mechanical and Thermal Considerations in Using TRW RF Linear Hybrid Amplifiers".

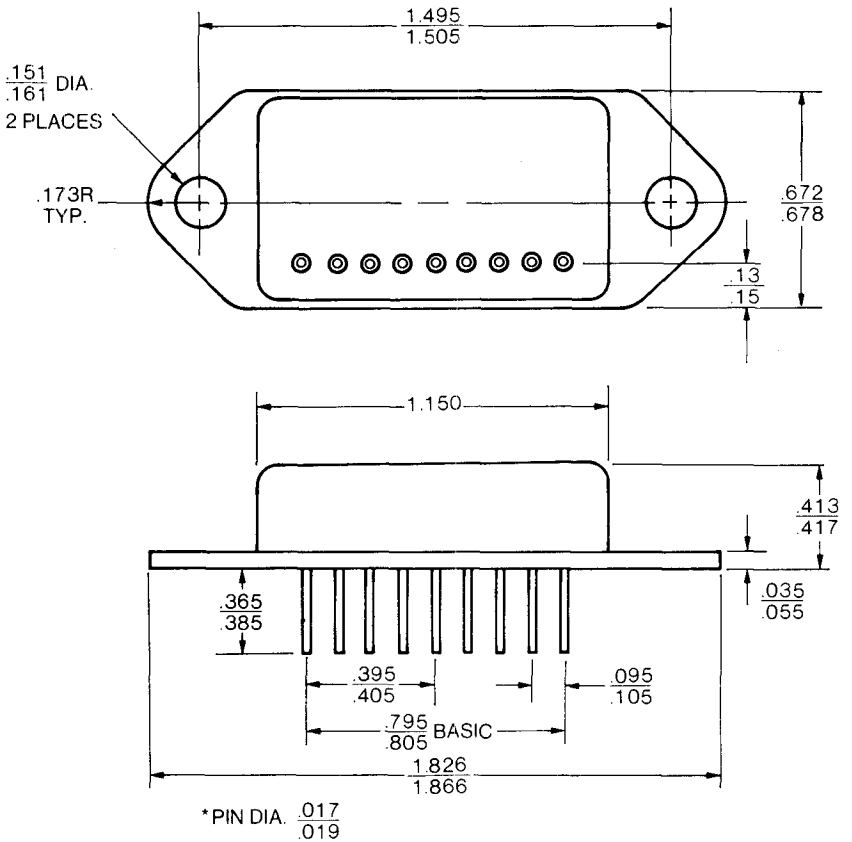
- **LOW COST**
- **30μH RFC**
- **0.5 AMP CAPACITY**



Electrical Characteristics (T_{CASE} = 25°C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	R	DC Resistance	I = 100mA	–	.001	–	Ω
RF TEST	L	Inductance	f = 1MHz	–	30	–	μH

NEW HERMETIC PACKAGE



- All units 100% tested for hermeticity.
- Now available for all TRW RF linear hybrid amplifiers!
- Electrical performance remains unchanged!
- Specify hermetic package option by adding "H" suffix to part number.

PRELIMINARY DATA SHEET

WIDE BANDWIDTH
Low Noise - Hybrid Amplifier

10 DB GAIN
40 - 900 MHz
3 DB NOISE FIGURE

The LNA 1100 is a 50 ohm low noise amplifier ideal for broadband preamplification.

All bias, matching and decoupling components are included in a small TO 8 package.

TO. 8

Electrical Characteristics (T_{case} = 25 °C)

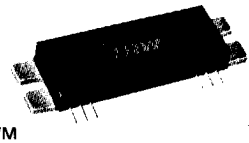
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	V_S	Supply Voltage			+ 10		V
	J_S	Supply Current			10		mA
RF TEST	G_P	Gain	f = 40 — 900 MHz	9.5	10.0	10.5	dB
	IMD	DIN 45004 B	(worst case)	94			dBuV
	P_O	Power Out	1 dB — Compression	+ 2			dBm
	NF	Noise Figure	at 500 MHz 900 MHz		3 4	3.5 4.5	dB dB
	I/ORL	Input - Output Returnloss	50 ohm	— 14			dB
THERMAL	T_{STG}	Storage Temperature		— 40		+ 100	°C
	T_{OP}	Operating Temperature		— 20		+ 90	°C

CA 915 TV

The CA 915 TV is a 50 ohm hybrid amplifier for high linear TV amplification in the entire 40-860 MHz band.

It is an ideal candidate for applications like. TV — TRANSPOSER — TRANSMITTER.

17 DB
40 - 900 MHz
150 mW PSYNC
- 60 DB IMD



MVM

PRELIMINARY

Electrical Characteristiscs (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	V_S	Supply Voltage		—	+ 24	—	mA
	I_S	Supply current		—	250	—	mA
RF TEST	G_P	Power Gain	40 — 900 MHz	16	17	18	dB
	IMD	Intermodulation Distortion Vision Carrier = Ref. 8 dB Sound Carrier = Ref. 7 dB Sideband Carrier=Ref. 16 dB	P_{SYNC} = 150 mW (—7 ; —17 ; —8) (dB)			— 60	dB
	I_{RL}	Input Return Loss	50 ohms Reference	10			dB
	O_{RL}	Output Return Loss	50 ohms Reference	10			dB
THERMAL	T_{STG}	Storage Temperature	Base Plate	— 40		+ 100	°C
	T_{OP}	Operation Temperature	Base Plate	— 20		+ 90	°C


CATV

CATV HYBRIDS

PRODUCT SUMMARY

P/N	GAIN DB	POWER OUTPUT DIN 45004 B	PAGE
CA 2150/CA 2250	17	61/63.5 dBmV	**G-295**
CA 2252/CA 2280	12	63.5/65 dBmV	**G-299**
CA 2270/A	17	65 dBmV	**G-297**
CA 2350 A/CA 2350 B	22	61/63.5 dBmV	**G-302**
CA 2418 (5-120 MHz)	18	—	**G-303**
CA 2419 (5-50 MHz)	19	67 dBmV	**G-305**
CA 260/BU	31	—	**G-307**
CA 2650	33	63 dBmV	**G-310**
CA 2680	33	64 dBmV	**G-312**
CA 2750	39	64 dBmV	**G-313**
CA 915 (40-900 MHz)	17 dB	60 dBmV	**G-315**

CATV Hybrid Amplifiers

The CA 2150 and CA 2250 amplifiers are thin film hybrid gain blocks using gold metallized transistors for long term reliability. They are specifically designed for the rigid requirements of the 75 ohm CATV mainline operation. The dual push-pull circuit configuration and the state of the art transistors provide unique noise figure and distortion characteristics, which combined with the flat, « signature » free frequency response allow for cascadability.

17 dB, GOLD
INPUT, OUTPUT
LOW LEVEL MAINLINE
HIGH LEVEL BRIDGER



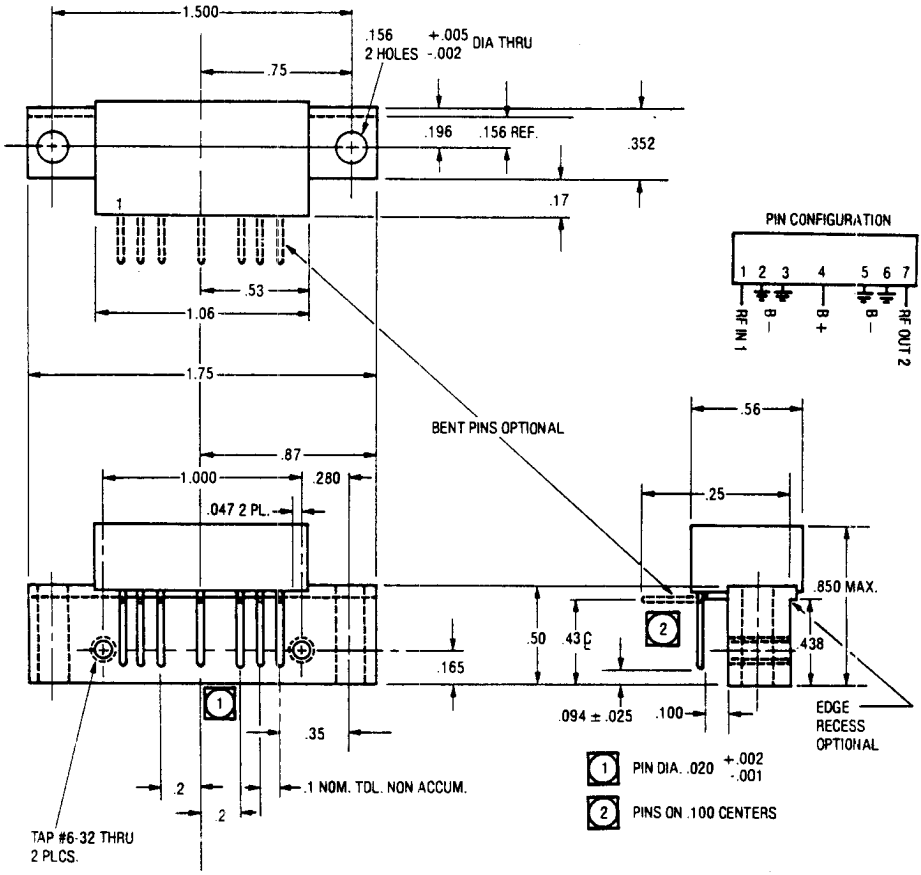
CA

Electrical Characteristics (T_{case} = 25 °C)

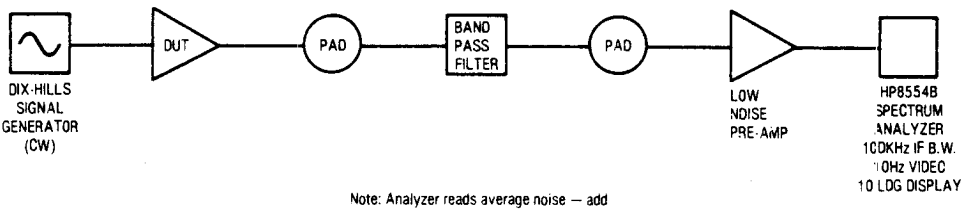
PARAMETERS	CA 2150	CA 2250
Gain 50 MHz	17.1 ± 0.5 dB	17.1 ± 0.5 dB
Frequency Response	40-300 MHz (± 0.1 dB)	40-300 MHz (± 0.1 dB)
Slope Cable Equivalent	+ 0 to + 1.0 dB	+ 0 to + 1.0 dB
Output Capability		
— 57 dB X-MOD NCTA		
12 Channel Flat	52.0 dBmV	54.5 dBmV
20 Channel Flat	49.5 dBmV	52.0 dBmV
35 Channel Flat	47.0 dBmV	49.5 dBmV
Second Order Beat + 50 dBmV (Channels 2, 13, R)	— 68 dB	— 70 dB
Triple Beat DIN 45004 B		
220 MHz	63 dBmV	65.5 dBmV
300 MHz	61 dBmV	63.5 dBmV
Signal to Triple Beat Noise*		
35 Channel Flat 46 dBmV		
On Channel 13	— 62 dB	— 67 dB
On Channel W	— 59 dB	— 64 dB
Noise Figure		
200 MHz	6.5 dB Max.	7.0 dB Max.
300 MHz	7.5 dB Max.	8.0 dB Max.
Return Loss Input/Output	20 dB Minimum	20 dB Minimum
Return Loss Derate with Freq.	1 dB per Octave	1 dB per Octave
Power Requirement	160 mA (TYP) 24 Vdc	200 mA (TYP) 24 Vdc
Operating Temperature (Sink)	— 20 °C to + 90 °C	— 20 °C to + 90 °C
Storage Temperature	— 40 °C to + 100 °C	— 40 °C to + 100 °C

* See Test Procedure

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise — add 2.5dB to noise level for RMS value.

CATV-KTV Hybrid Amplifiers

The CA 2270 and CA 2270 A amplifiers are thin film hybrid gain blocks using gold metallized transistors for long term reliability. They are specifically designed for the rigid requirements of the 75 ohm CATV mainline operation. The dual push-pull circuit configuration and the state of the art transistors provide unique noise figure and distortion characteristics, which combined with the flat, « signature » free frequency response allow for cascadability.

17 dB, GOLD
INPUT, OUTPUT
LOW NOISE
HIGH LEVEL

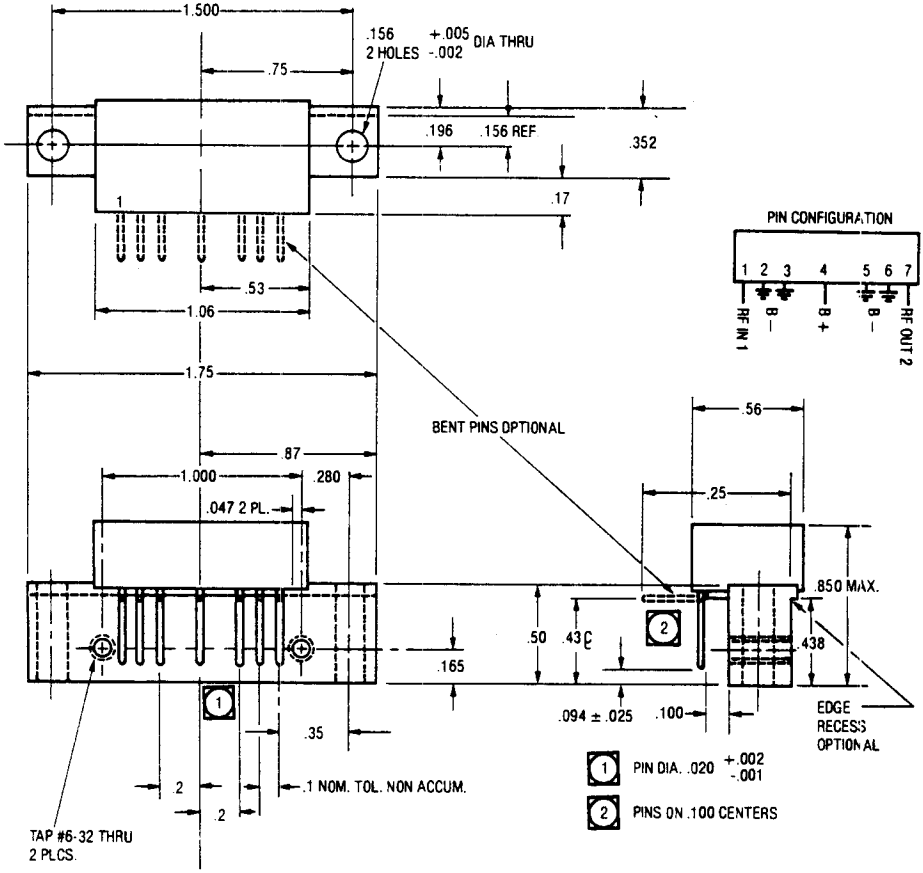


CA

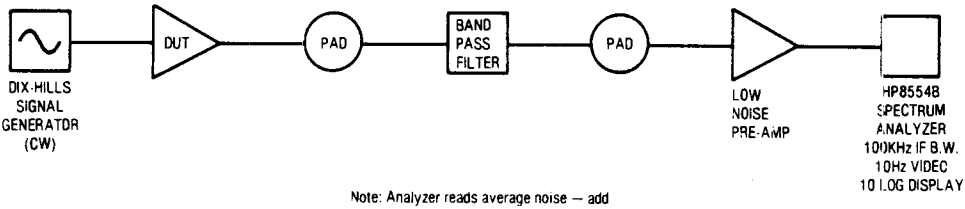
Electrical Characteristics (T_{CASE} = 25 °C)

PARAMETERS	CA 2270	CA 2270 A
Gain 50 MHz	17.1 ± 0.4 dB	17.1 ± 0.4 dB
300 MHz	17.6 ± 0.4 dB	17.6 ± 0.4 dB
Frequency Response	40-300 MHz (± 0.1 dB)	40-300 MHz (± 0.1 dB)
Slope Cable Equivalent	+ 0.2 to + 0.8 dB	+ 0.2 to + 0.8 dB
Second Order Beat + 50 dBmV (Channels 2, 13, R)	— 70 dB	— 70 dB
Triple Beat DIN 45004 B 300 MHz	65 dBmV	65 dBmV
Noise Figure 300 MHz	7.0 dB Max.	6.0 dB Max.
Return Loss Input/Output	20 dB Minimum	20 dB Minimum
Return Loss Derate with Freq.	1 dB per Octave	1 dB per Octave
Power Requirement	200 mA (TYP) 24 Vdc	200 mA (TYP) 24 Vdc
Operating Temperature (Sink)	— 20 °C to + 90 °C	— 20 °C to + 90 °C
Storage Temperature	— 40 °C to + 100 °C	— 40 °C to + 100 °C

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise — add 2.5dB to noise level for RMS value.

CATV Hybrid Amplifiers

12 dB GOLD
INPUT, OUTPUT
LOW NOISE
HIGH LEVEL

The CA 2280 and CA 2252 amplifiers are thin film hybrid gain blocks using gold metallized transistors for long term reliability. They are specifically designed for the rigid requirements of the 75 ohm CATV mainline operation. The dual push-pull circuit configuration and the state of the art transistors provide unique noise figure and distortion characteristics, which combined with the flat, « signature » free frequency response allow for cascadability.



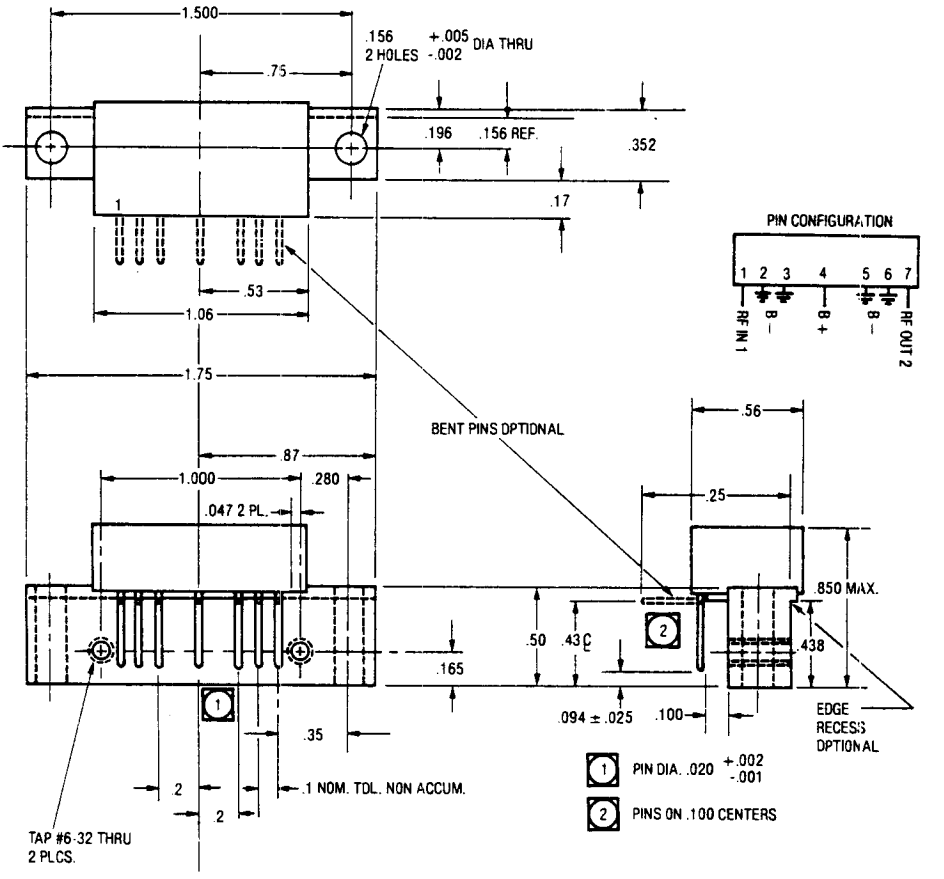
CA

Electrical Characteristics (T_{case} = 25 °C)

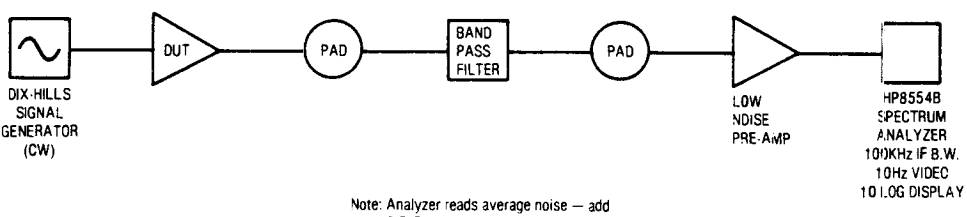
PARAMETERS	CA 2280	CA 2252
Gain 50 MHz	12.4 ± 0.4 dB	12.5 ± 0.5 dB
300 MHz	12.9 ± 0.4 dB	
Frequency Response	40-300 MHz (± 0.1 dB)	40-300 MHz (± 0.2 dB)
Slope Cable Equivalent	+ 0.2 to + 0.8 dB	+ 0.5 to + 1.5 dB
Output Capability		
— 57 dB X-MOD		
12 Channel Flat		54.5 dBmV
20 Channel Flat		52.0 dBmV
32 Channel Flat		50.0 dBmV
Second Order Beat 50 dBmV (Channels 2, 13, R)	— 70 dB	— 70 dB
Triple Beat DIN 45004 B		
220 MHz		65.5 dBmV
300 MHz	65 dBmV	63.5 dBmV
Signal to Triple Beat Noise*		
35 Channel Flat 46 dBmV		
On Channel 13		— 67 dB
On Channel W		— 64 dB
Noise Figure (Channel 13)		8.0 dB Max.
(Channel W)	7.0 dB Max.	9.0 dB Max.
Return Loss Input/Output	20 dB Min.	20 dB Min.
Return Loss Derate with Freq.	1 dB per Octave	1 dB per Octave
Power Requirements	200 mA (TYP) 24 Vdc	200 mA (TYP) 24 Vdc
Operating Temperature (Sink)	— 20 °C to + 90 °C	— 20 °C to + 90 °C
Storage Temperature	— 40 °C to + 100 °C	— 40 °C to + 100 °C

* See Test Procedure

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise — add 2.5dB to noise level for RMS value.

CATV Hybrid Amplifiers

The CA 2350 A and CA 2350 B amplifiers are thin film hybrid gain blocks using gold metallized transistors for long term reliability. They are specifically designed for the rigid requirements of the 75 ohm CATV mainline operation. The dual push-pull circuit configuration and the state of the art transistors provide unique noise figure and distortion characteristics, which combined with the flat, « signature » free frequency response allow for cascadability.

22 dB
INPUT, OUTPUT
MAINLINE, DISTRIBUTION
GOLD RELIABILITY



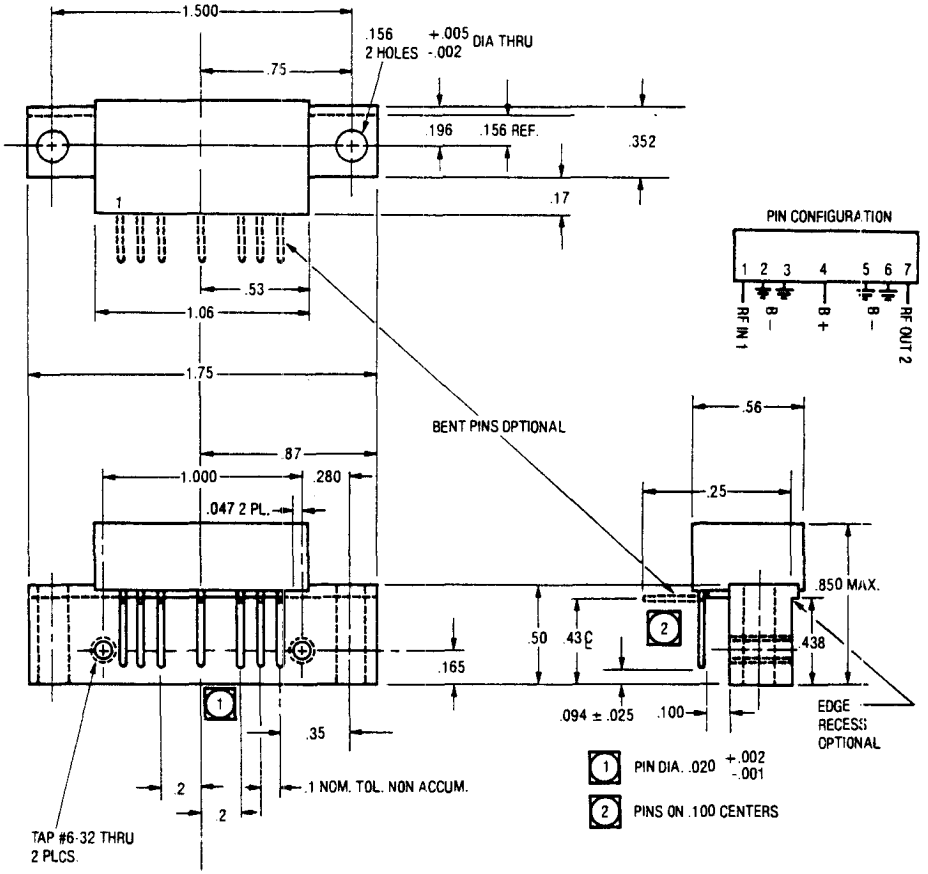
CA

Electrical Characteristics (T_{case} = 25 °C)

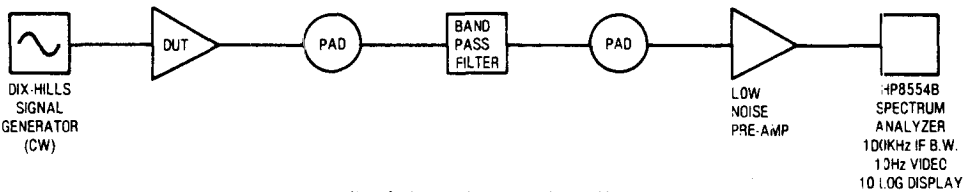
PARAMETERS	CA 2350 A	CA 2350 B
Gain 50 MHz	22.0 ± .6 dB	22.0 ± .6 dB
Frequency Response	40-300 MHz (± 0.2 dB)	40-300 MHz (± 0.2 dB)
Slope Cable Equivalent	+ 0.0 to 1.0 dB	+ 0.0 to + 1.0 dB
Output Capability		
— 57 dB X-MOD NCTA		
12 Channel Flat	52.0 dBmV	54.5 dBmV
20 Channel Flat	49.5 dBmV	52.0 dBmV
32 Channel Flat	47.5 dBmV	50.0 dBmV
Second Order Beat 50 dBmV (Channels 2, 13, R)	— 64 dB	— 66 dB
Triple Beat DIN 45004 B		
200 MHz	63 dBmV	65 dBmV
300 MHz	61 dBmV	63 dBmV
Signal to Triple Beat Noise*		
35 Channel Flat 46 dBmV		
On Channel 13	— 62 dB	— 67 dB
On Channel W	— 59 dB	— 64 dB
Noise Figure (200 MHz)	5.5 dB Max.	6.5 dB Max.
(300 MHz)	6.5 dB Max.	7.5 dB Max.
Return Loss Input/Output	20 dB Minimum	20 dB Minimum
Return Loss Derate with Frequency	1 dB per Octave	1 dB per Octave
Power Requirements	180 mA (TYP) 24 Vdc	220 mA (TYP) 24 Vdc
Operating Temperature (Sink)	— 20 °C to + 90 °C	— 20 °C to + 90 °C
Storage Temperature	— 40 °C to + 100 °C	— 40 °C to + 100 °C

* See Test Procedure

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise — add 2.5dB to noise level for RMS value.

CATV Hybrid Amplifier

The CA 2418 amplifier is a thin film hybrid gain block using gold metallized transistors for long term reliability. It is specifically designed for the rigid requirements of the 75 ohm CATV mainline reverse path operation. The dual push-pull circuit configuration and the state of the art transistors provide unique noise figure and distortion characteristics, which combined with the flat, « signature » free frequency response allows for cascadability.

18 dB GAIN
5-120 MHz
REVERSE AMPLIFIER
GOLD RELIABILITY

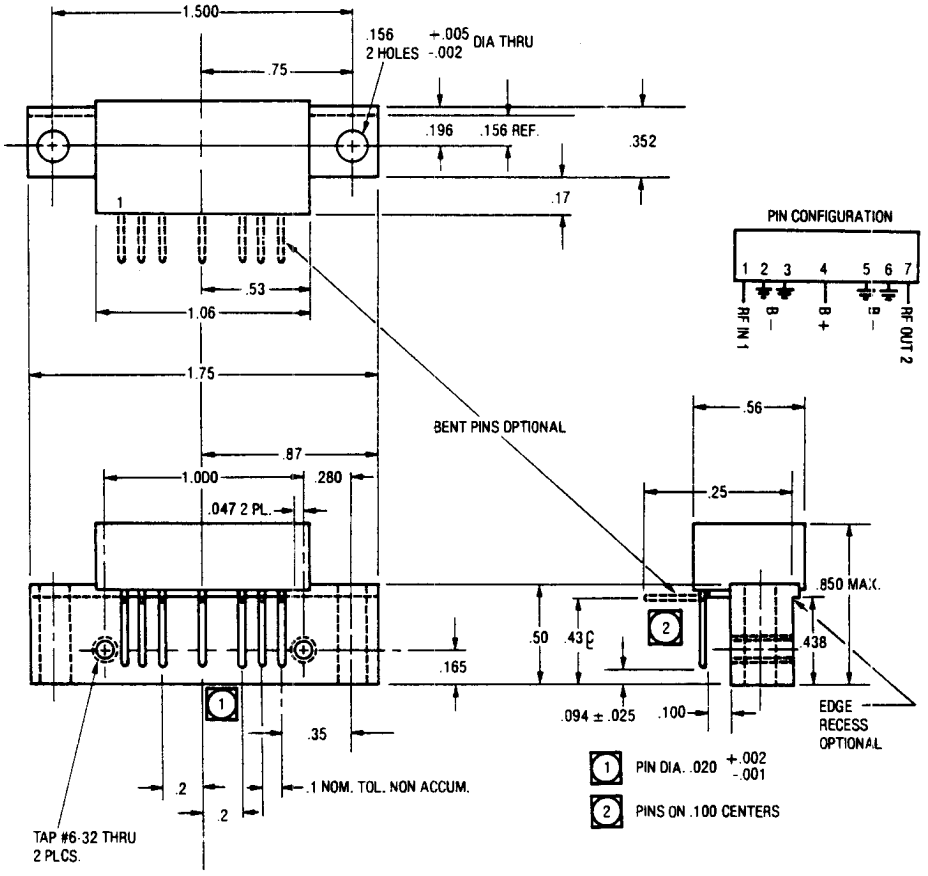


CA

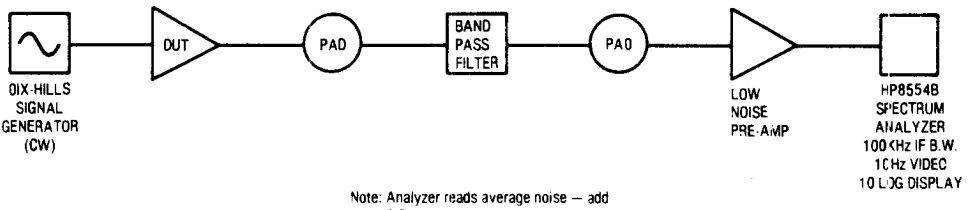
Electrical Characteristics (T_{case} = 25 °C)

PARAMETERS	CA 2418
Gain 100 MHz	18.5 ± 0.5 dB
Frequency Response	5 — 120 MHz (± 0.25 dB)
Slope Cable Equivalent	+ 0.2 to — 0.5
Output Capability — DIN 45004 B	67 dB mV
Second Order Beat 50 dBmV	— 72 dB
Triple Beat 50 dBmV	— 84 dB
Noise Figure (100 MHz)	6.5 dB
Return Loss Input/Output	20 dB Minimum
Power Requirement	200 mA (TYP) 24 Vdc
Operating Temperature (Sink)	— 20 °C to + 100 °C
Storage Temperature	— 40 °C to + 100 °C

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise — add 2.5dB to noise level for RMS value.

CATV Hybrid Amplifiers

The CA 2419 amplifier is a thin film hybrid gain block using gold metallized transistors for long term reliability. It is specifically designed for the rigid requirements of the 75 ohm CATV mainline reverse path operation. The dual push-pull circuit configuration and the state of the art transistors provide unique noise figure and distortion characteristics, which combined with the flat, « signature » free frequency response allows for cascadability.

19 dB GAIN
5-50 MHz
REVERSE AMPLIFIER
GOLD RELIABILITY

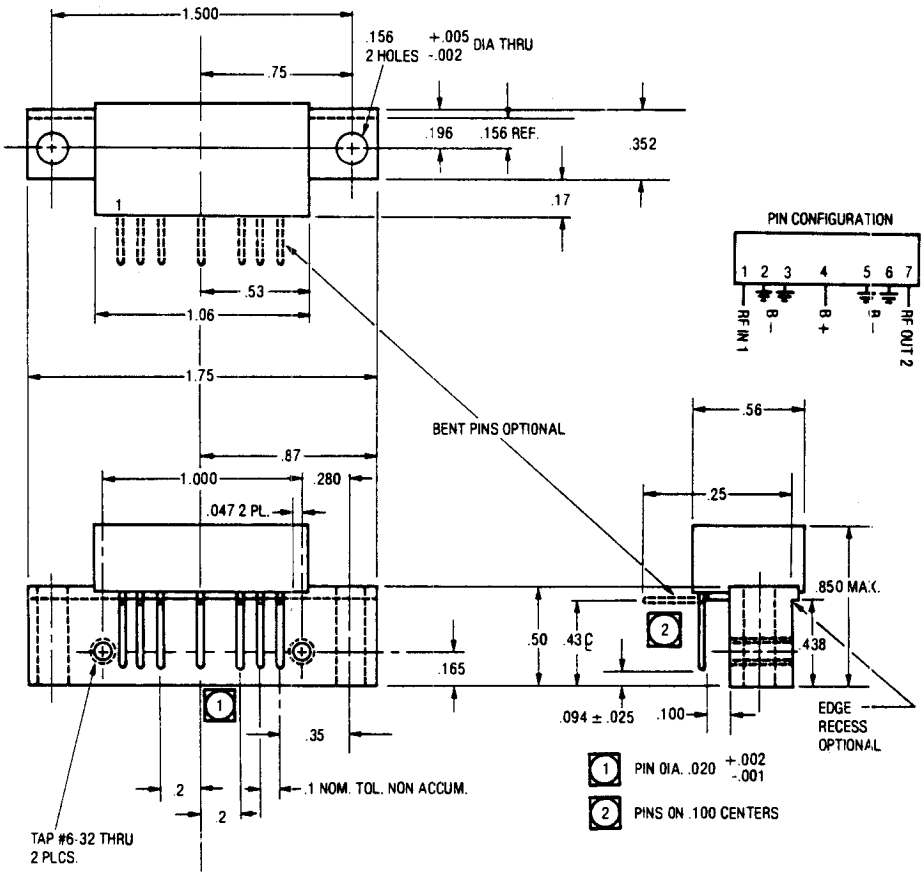


CA

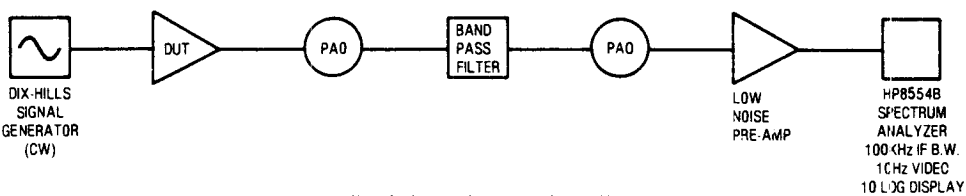
Electrical Characteristics (T_{case} = 25 °C)

PARAMETERS	CA 2419
Gain 5 MHz	19 ± 0.5 dB
Frequency Response	5 — 50 MHz (± 0.15 dB)
Slope Cable Equivalent	+ 0.2 to — 0.2
Output Capability — DIN 45004 B	67 dBmV
Second Order Beat 50 dBmV	— 72 dB
Triple Beat 50 dBmV	— 84 dB
Noise Figure (100 MHz)	6.5 dB
Return Loss Input/Output	23 dB Minimum
Power Requirement	200 mA (TYP) 24 Vdc
Operating Temperature (Sink)	— 20 °C to + 100 °C
Storage Temperature	— 40 °C to + 100 °C

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT

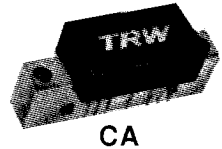


Note: Analyzer reads average noise — add 2.5dB to noise level for RMS value.

CATV Amplifier

The CA2601BU amplifier is a thin film hybrid gain block manufactured with a gold monometallic process for high reliability. The true push-pull configuration and the typical flatness of the units in 75 Ohm systems provide excellent performance for line extender and small system trunk line applications. The amplifier has a nominal gain of 31dB. The CA2601BU is divided into two sections to permit the use of interstage gain and tilt controls or filtering in case of high output single channel "strip amplifier" or "pre-amplifier" applications. Designed for 24 volt operation, they will give satisfactory performance down to 20 volts. With its improved distortion parameters as a result of improved gold transistors, it is intended as a direct replacement for the CA601BU.

- **31dB Gain**
- **Low Distortion**
- **High Output Capability**
- **Low Noise Figure**

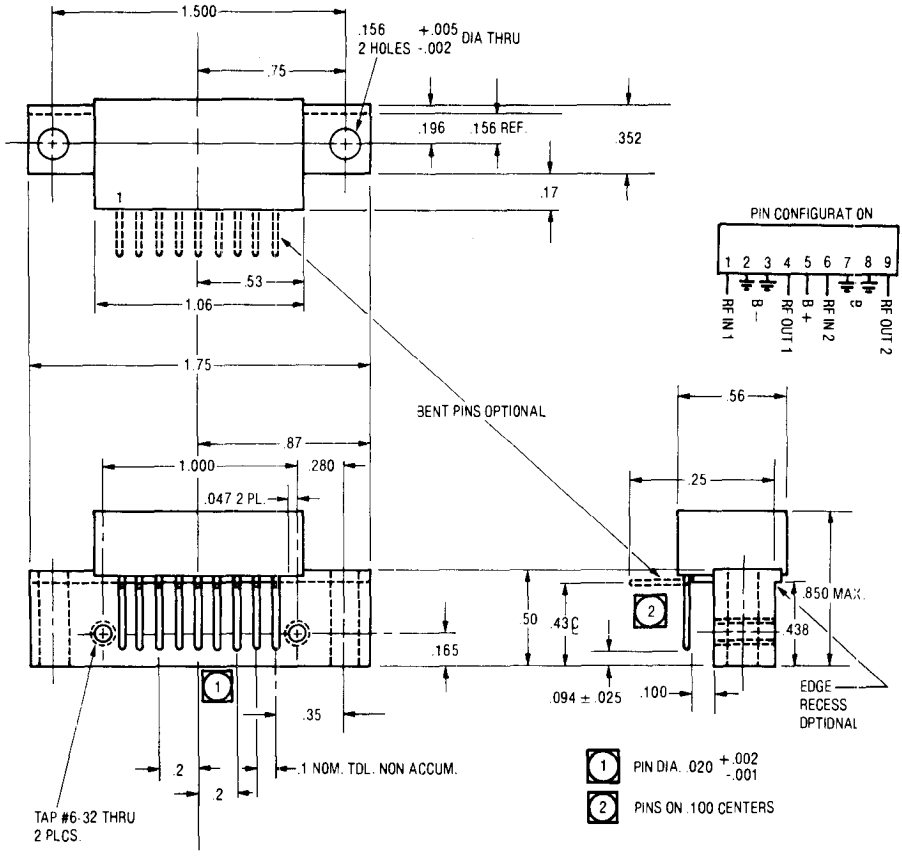


CA

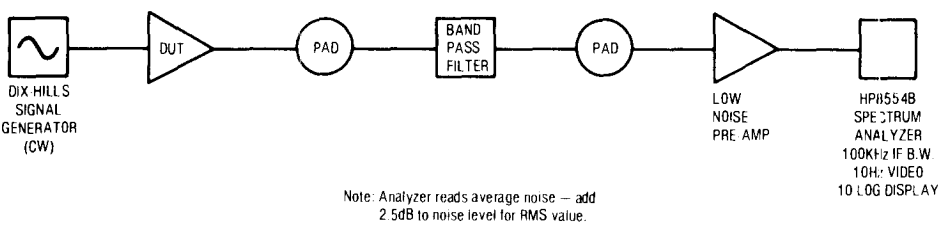
Electrical Characteristics For 75Ω Systems (T_{CASE} 25°C, V_{CC} = 24V)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	VALUE
ABSOLUTE MAX. RATINGS	V_{CC}	Supply Voltage		24V
	P_{IN}	RF Power Input		+50dBmV
	T_{ST}	Storage Temperature		-40°C to +100°C
	T_{OP}	Operating Temperature		-20°C to +100°C
ELECTRICAL CHARACTERISTICS FOR 75Ω SYSTEMS (T_{CASE} = 25°C and 24V)	Gain	Gain	50MHz	31.0 ± 1dB
	B.W.	Frequency Response		40-300MHz ± 0.5dB
	S.C.E.	Slope Cable Equivalent		+0.5 to +1.5dB
	X-Mod	Output Capability @ -57dB NCTA	12 CH Flat 20 CH Flat 35 CH Flat	52.0dBmV 49.5dBmV 47.0dBmV
	S.O.	Second Order Beat @ 50dBmV	CH 2, 13, R	-62dB
	T.B.	Triple Beat @ 50dBmV	F1 ± F2 ± F3 on 13 F1 ± F2 ± F3 on W	-75dB -72dB
	C.T.B. *See back for test procedure	Composite Triple Beat, 35 Channels Flat @ 46dBmV	CH 13 CH W	-60
	N.F.	Noise Figure	CH W	11dB Max.
	R.L.	Return Loss Input/Output	2pF Pin 1 — Gound	18dB Min.
	P. Req.	Power Requirement	24Vdc	270mA (Typ)

PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise – add 2.5dB to noise level for RMS value.

CATV Hybrid Amplifiers

33 dB
HIGH OUTPUT
DISTRIBUTION
GOLD RELIABILITY

The CA 2650 amplifier is a thin film hybrid gain block using gold metallized transistors for long term reliability. It is specifically designed for the rigid requirements of the 75 ohm CATV distribution operation. The four stages push-pull configuration and the state of the art transistors allow its use as high gain distribution amplifier with optimum cross-modulation and intermodulation distortion performances.



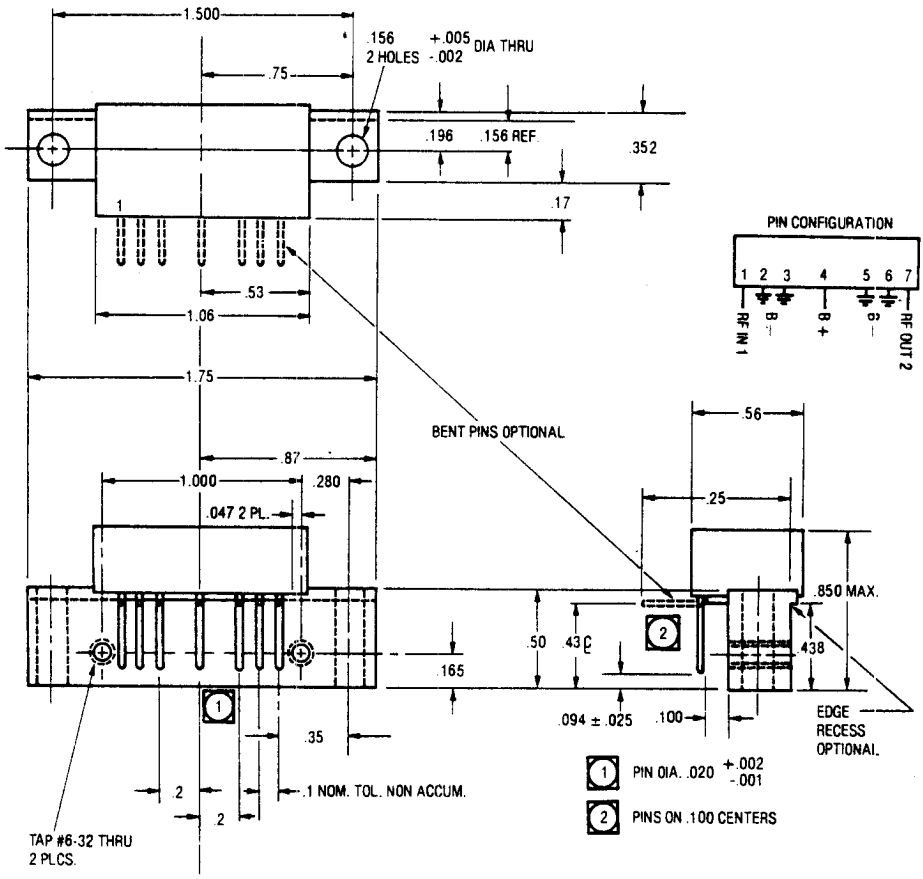
CA

Electrical Characteristics (T_{case} = 25 °C)

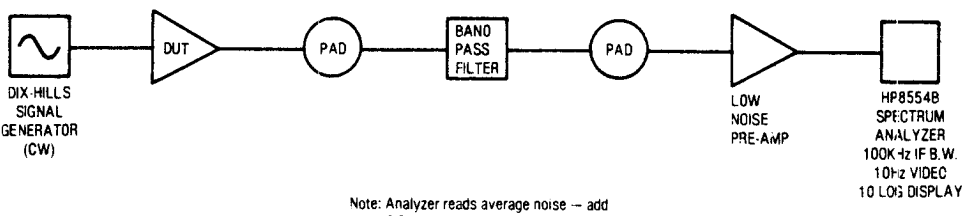
PARAMETERS	CA 2650
Gain 50 MHz	33.5 ± 1.0 dB
Frequency Response	40-300 MHz (± 0.3 dB)
Slope Cable Equivalent	+ 0.5 to + 1.5 dB
Output Capability	
— 57 dB X-MOD NCTA	
12 Channel Flat	53.5 dBmV
20 Channel Flat	51.0 dBmV
35 Channel Flat	48.5 dBmV
Second Order Beat 50 dBmV (Channels 2, 13, R)	— 68 dB
Triple Beat DIN 45004 B	
200 MHz	64.5 dBmV
300 MHz	63 dBmV
Signal to Triple Beat Noise*	
35 Channel Flat 46 dBmV	
On Channel 13	— 65 dB
On Channel W	— 63 dB
Noise Figure	
200 MHz	6 dB Max.
300 MHz	7 dB Max.
Return Loss Input/Output	20 dB Minimum
Return Loss Derate with Frequency	1 dB per Octave
Power Requirements	290 mA (TYP) 24 Vdc
Operating Temperature (Sink)	— 20 °C to + 90 °C
Storage Temperature	— 40 °C to + 100 °C

* See Test Procedure

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



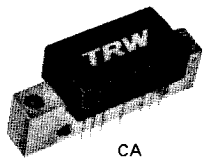
Note: Analyzer reads average noise – add 2.5dB to noise level for RMS value.

CATV Hybrid Amplifier

PRELIMINARY

The CA 2680 is a thin film hybrid gain block manufactured with a gold monometallic process for high reliablity. It features interstage accessability for gain control circuitry or filtering and extraordinary flatness and linearity. The CA 2680 has push-pull circuitry throughout giving it superior dynamic range, excellent flatness and making it a practical choice for economy trunk amplifiers and line extenders where up to 6 dB of interstage loss is tolerable. Typical performance for the preamp section is specified and facility for phase inversion is provided via the balanced output pins.

33,5 DB GAIN
HIGH OUTPUT
LOW NOISE

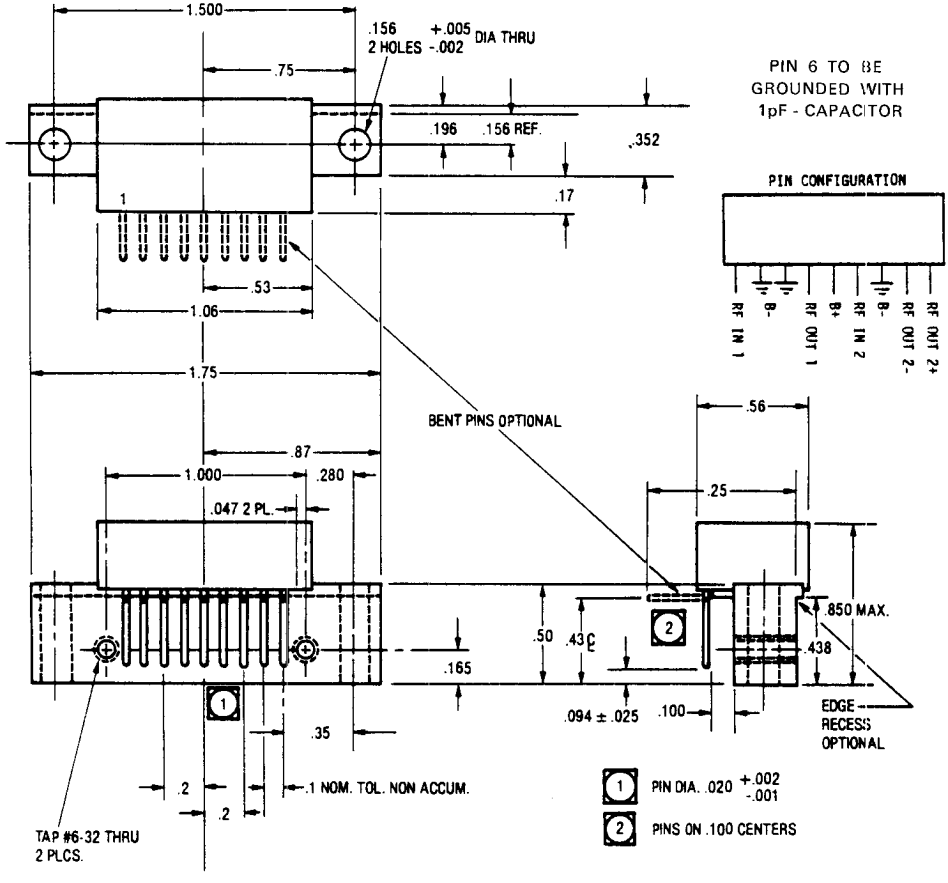


CA

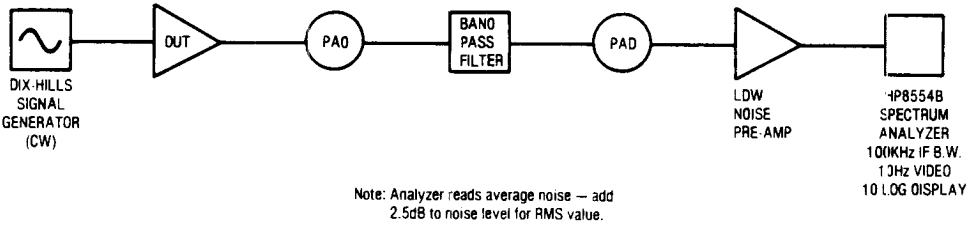
Electrical Characteristics (T_{case} = 25 °C)

PARAMETERS	OVERALL (MAX)
Gain 50 MHz	33.5 ± 1 dB
300 MHz	34.5 ± 1 dB
Frequency Response	± 0.3 dB
Slope Cable Equivalent	+ 0.5 to 1.5 dB
Output Capability	
— 57 dB X-MOD NCTA	
12 Channel Flat	54.5 dBmV
20 Channel Flat	52.0 dBmV
35 Channel Flat	49.5 dBmV
Second Order Beat 50 dBmV	
(Channels 2, 13, R)	— 66 dB
Triple Beat DIN 45004 B	
200 MHz	65.5 dBmV
300 MHz	64.0 dBmV
Composite Triple Beat Output at — 60 dB	
On Channel 13	+ 49 dBmV
On Channel W	+ 48 dBmV
Noise Figure	
200 MHz	5 dB
300 MHz	6.5 dB
Return Loss Input/Output — 1 dB/Octave Oeterior	20 dB
Power Requirements	330 mA
Operating Temperature	— 20 °C to + 90 °C
Storage Temperature	— 40 °C to + 100 °C

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise – add 2.5dB to noise level for RMS value.

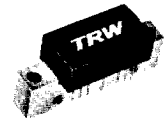
CATV Hybrid Amplifier

PRELIMINARY

The CA 2750 amplifier is optimized for 75 Ω CATV applications where signature free flat response, excellent impedance match and low distortion and noise figure are required.

High reliability is achieved through a monometalic gold assembly process using state-of-art gold transistors. These hybrids utilizing push-pull circuitry provide low distortion and superior thermal stability.

38 dB GAIN
ALL GOLD DIE
CHARACTERIZED FOR ALL CATV PARAMETERS
LOW DISTORTION, HIGH OUTPUT CAPABILITY
LOW NOISE FIGURE



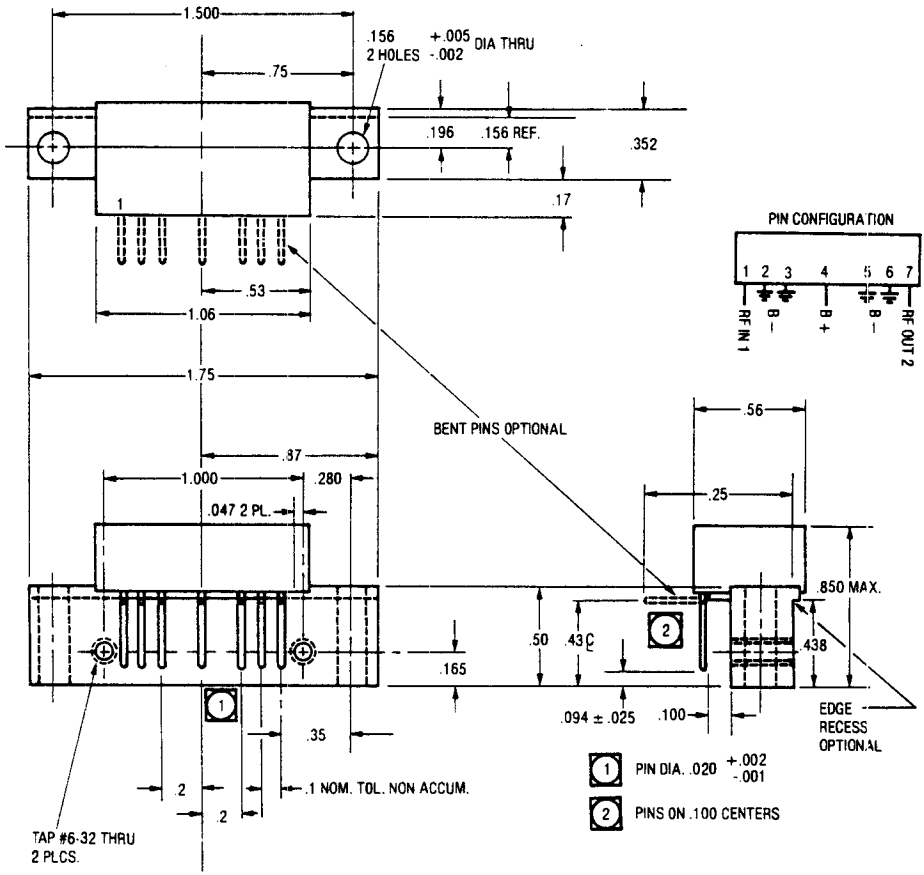
CA

Electrical Characteristics (T_{case} = 25 °C)

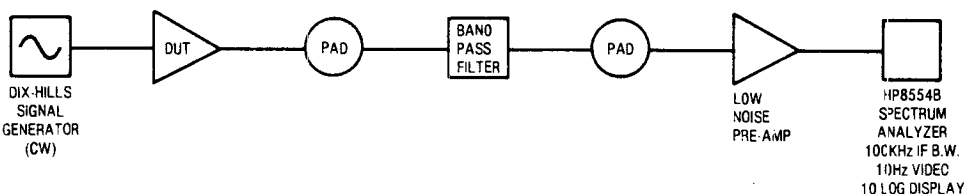
PARAMETERS	CA 2750
Gain 50 MHz	39 ± 1.5
Frequency Response	40 - 300 MHz ± 0.4 dB
Slope Cable Equivalent	0 to 1.5 dB
Output Capability	
— 57 dB X-MOD NCTA	
12 channel Flat	54.5 dBmV
20 channel Flat	52 dBmV
35 channel Flat	49.5 dBmV
Second Order Beat 50 dBmV (channels 2, 13, R)	– 65 dB
Triple Beat DIN 45004 B	
200 MHz	65.5 dBmV
300 MHz	64 dBmV
Signal to Triple Beat Noise * 35 channel Flat 46 dBmV	
on channel 13	— 66 dB
on channel W	— 64 dB
Return Loss Input/Output	16 dB Minimum
Noise Figure	6.5 dB
Power Requirements	320 mA Typ
Operating Temperature (sink)	— 20 °C to + 90 °C
Storage Temperature	— 40 °C to + 100 °C

* See Test Procedure

CA PACKAGE OUTLINE



COMPOSITE TRIPLE BEAT



Note: Analyzer reads average noise — add 2.5dB to noise level for RMS value.

PRELIMINARY

VHF/UHF Hybrid

The CA 915 is a 75 ohm hybrid amplifier for V/UHF - CATV - DISTRIBUTION NETWORKS. Outstanding second order and third order (DIN 45004 B) performances are achieved through.

PUSH - PULL TECHNIQUE

17 DB GAIN
40 - 900 MHz
ULTRALINEAR



MVM

PRELIMINARY

Electrical Characteristics (Theatsink = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	V_S	Supply Voltage			+ 24		V
	J_S	Supply Current			250		mA
RF Test	G_P	Gain	F = 40 — 900 MHz	16.5	17.0	17.5	dB
	D_{SO}	Second Order	at 50 dBmV OUT	— 66			dB
	IMD	DIN 45004 B	(worst case)	120			dBuV
	NF	Noise Figure	(worst case)			9	dB
	I_{RL}	Input Return Loss	75 ohm	15			dB
	O_{RL}	Output Return Loss	75 ohm	15			dB
Thermal	T_{STG}	Storage Temperature		— 40		+ 100	°C
	T_{OP}	Operation Temperature		— 20		+ 90	°C

TV TRANSPOSERS AND TRANSMITTERS

PRODUCT SUMMARY

	P/N	CLASS	POWER (W)	LIN.* (dB)	GAIN (dB)	PACKAGE	PAGE
BAND 3							
170-230 MHz	TPV 394	A	5	— 58	15	SOE 280	**H-332**
	TPV 364	A	10	— 54	10	SOE 380	**H-320**
	TPV 375	A	14	— 55	8.5	SOE 500	**H-324**
	TPV 385	A	14	— 53	14	J⌀ 500	**H-336**
	TPV 376	A	30	— 53	7.5	SOE 500	**H-328**
	TPV 386	A	30	— 51	11	J⌀ 500 S	**H-338**
	TPV 3100	AB	100	1	11	MRP 7	**H-340**
BAND 4-5							
470-860 MHz	TPV 590	A	0.250	— 60	14	SOE 200	**H-350**
	TPV 591	A	0.5	— 60	13	SOE 200	**H-354**
	TPV 596	A	0.5	— 60	12	SOE 280	**H-362**
	TPV 597	A	1	— 60	11	SOE 280	**H-368**
	TPV 593	A	2	— 60	8.5	SOE 280	**H-360**
	TPV 598	A	4	— 60	7	SOE 280	**H-370**
	TPV 508	A	8	— 58	7.5	BMA 2	**H-344**
	TPV 5051	AB	50	1	6	BMA 2	**H-374**

* 1 — DEVICES IN CLASS A = 3 TONES TEST — VISION — 8 dB, SOUND — 7 dB, SIBEDAND — 17 dB.
2 — DEVICES IN CLASS AB = GAIN COMPRESSION.

TV TRANSPOSERS AND TRANSMITTERS

LINE-UP SUGGESTIONS

CONTACT TRW APPLICATION ASSISTANCE

Avenue de la Jallère

33300 BORDEAUX-LAC

Tél. : (56) 90.92.26

Telex : 570179F

Telefax : (56) 39.93.14

VHF LINEAR TRANSISTOR

TV TRANSPOSER AND TRANSMITTER BAND 3 10 W AT - 55 DB IMD 10 DB GAIN

The TPV 364 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. This transistor is designed for high power band 3 TV transposers and transmitters.

The TPV 364 is used in the final stages of 20 W transposers or in the driver stages of 100 W plus transposers and transmitters. Its high gain allows to reduce the complexity of lower power stages.

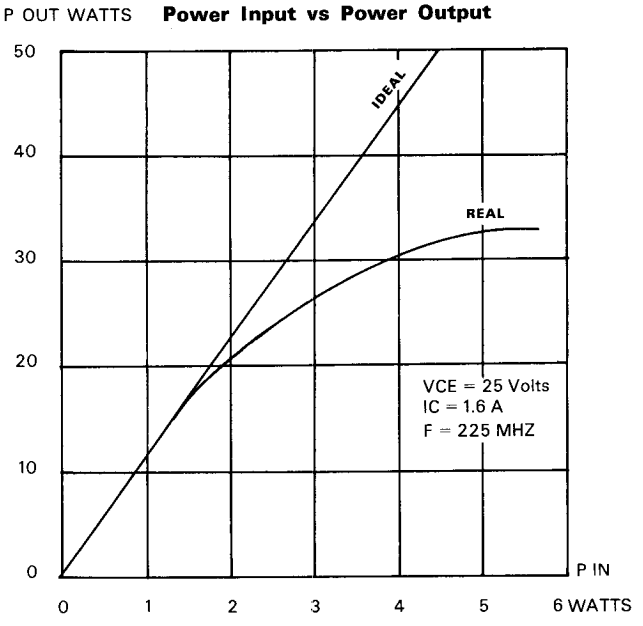


380 SOE

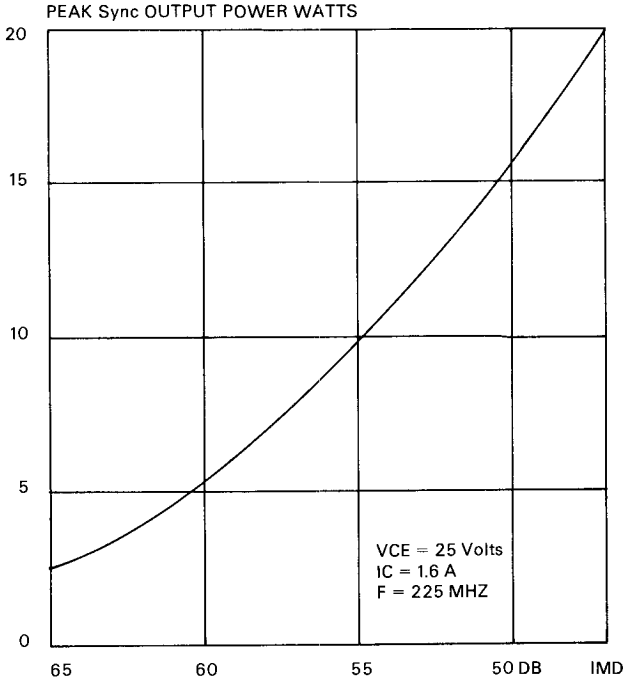
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 ohms	65			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	h_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	20		120	
RF Test	IDM_1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 225 MHz V_{CE} = 25 V I_E = 1.6 A P_{REF} = 10 W			- 54	dB
	IMD 2	Idem	F = 225 MHz V_{CE} = 25 V I_E = 1.6 A P_{REF} = 15 W			— 52	dB
	P_G	Power Gain 10 REF	F = 225 MHz V_{CE} = 25 V I_E = 1.6 A	10			dB
	VSWR	Mismatch Tolerance	P_{REF} = 20 W F = 225 MHz V_{CE} = 25 V I_E = 1.6 A P_{REF} = 15 W		∞		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		58	85	pF
Thermal	I_C	Maximum collector current				9	A
	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			2.0	°C/W
	θ_{CH}	Thermal Resistance Case - Heatsink				0.5	°C/W
	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			70	W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

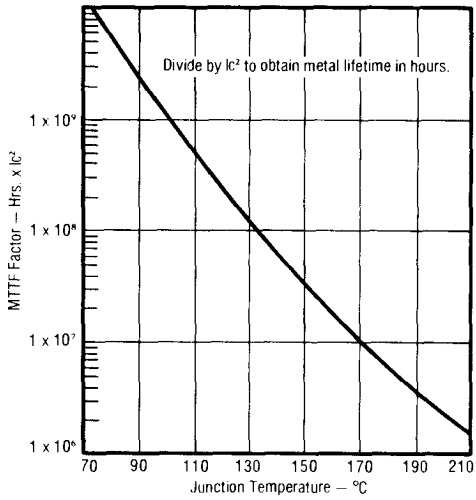
Power Input vs Power Output



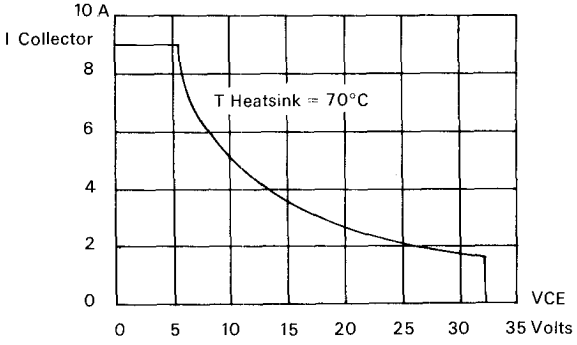
IMD vs Peak Sync Output Power



MTTF Factor vs Tj

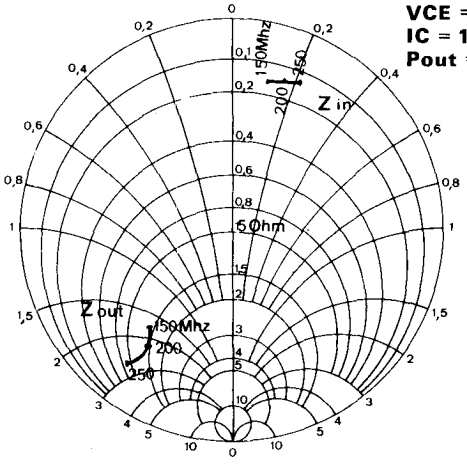


Safe Operating Area

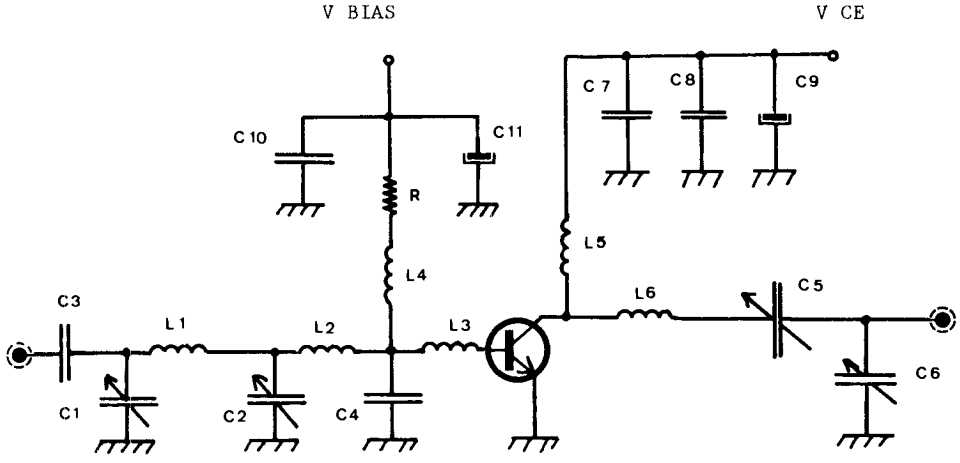


Large Signal Impedances vs Frequency

VCE = 25 V
IC = 1.6 A
Pout = 15 W peak



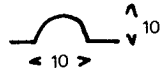
TEST CIRCUIT FOR 225 MHz



C_1 ARCO 403
$C_{2,6}$ ARCO 404
C_5 ARCO 423
$C_{3,7}$ chip capacitor 470 pF
C_4 UNELCO-capacitor 80 pF
$C_{8,10}$ UNELCO-capacitor 1000 pF
$C_{9,11}$ 100 µF electrolytic - 63 V

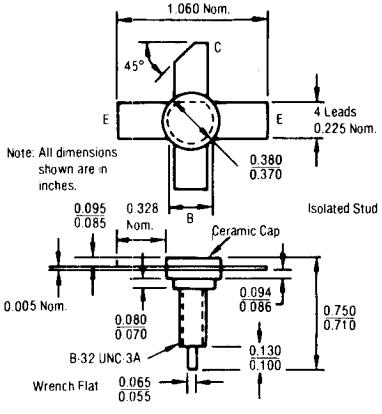
R 4.7 ohms - 1/2 W

L_1 1.5 turns closely wound - Cu wire 1 mm - I.D. 5 mm
L_2 2.5 cm - 50 ohms line
L_3 length of the base lead
L_6 Cu wire 1.5 mm

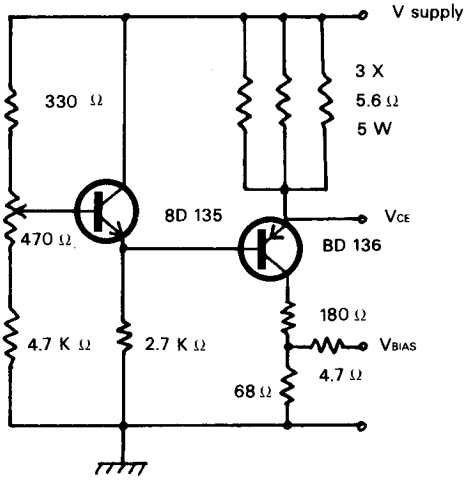


L_5 3 cm - 50 ohms line
L_4 5 turns closely wound - Cu wire 8 mm - I.D. 5 mm

380 SOE



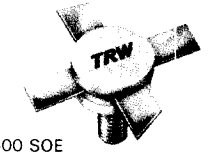
BIAS CIRCUIT



VHF LINEAR TRANSISTOR

TV TRANSPOSER
AND TRANSMITTER
BAND 3
20 W AT - 51 DB IMD
14 W AT - 55 DB IMD
HIGH SATURATION POWER

The TPV 375 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. The TPV 375 is specifically designed for **high power band 3. TV transposers and transmitters amplifiers.** Due to its high saturation power (over 70 watts), the TPV 375 shows good linearity characteristics at powers over 25 W. This performance allows to build a 50 W transposer using 2 TPV 375 in parallel with linearity correction circuit.

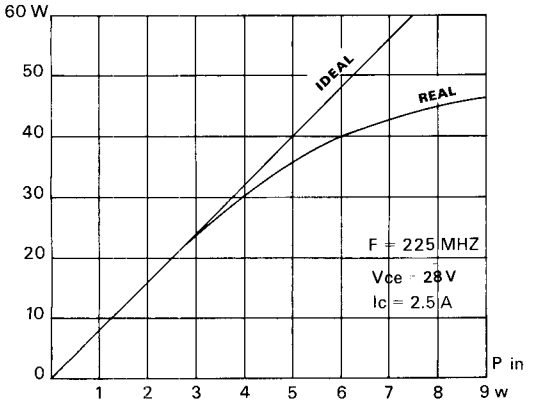


500 SOE

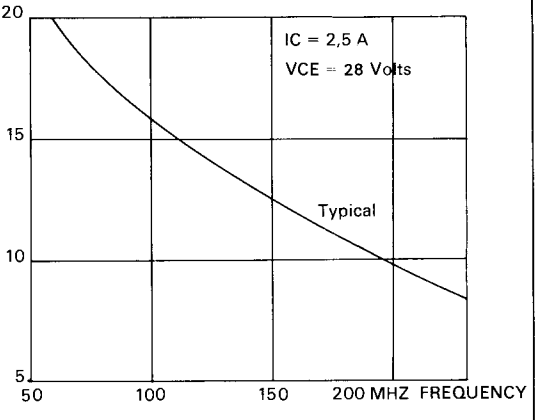
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 ohms	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	h_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 1000 mA	20		120	
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 225 MHz V_{CE} = 28 V I_E = 2.5 A P_{REF} = 14 W			— 55	dB
	IMD 2	Idem	F = 225 MHz V_{CE} = 28 V I_E = 2.5 A P_{REF} = 20 W			— 51	dB
	P_G	Power Gain	F = 225 MHz V_{CE} = 28 V I_E = 2.5 A P_{REF} = 20 W	8	9		dB
	VSWR	Mismatch Tolerance	F = 225 MHz V_{CE} = 28 V I_E = 2.5 A P_{REF} = 20 W		∞		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		58	85	pF
Thermal	I_C	Maximum Collector Current				10	A
	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			1.5	°C/W
	θ_{CH}	Thermal Resistance Case - Heatsink				0.25	°C/W
	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			100	W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

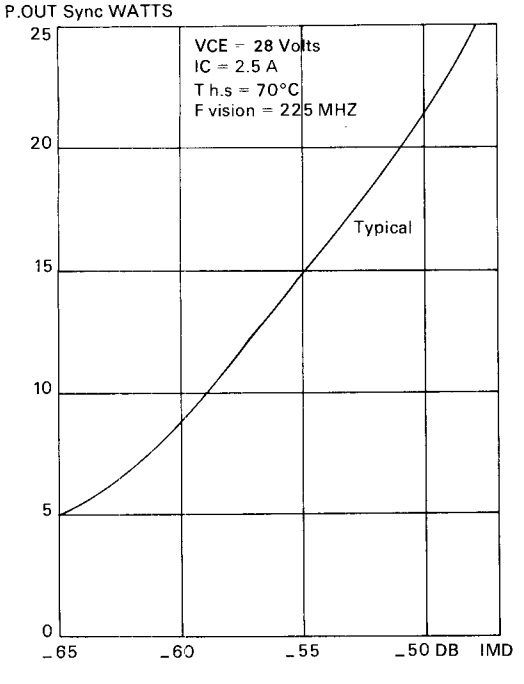
Power Output vs Power Input



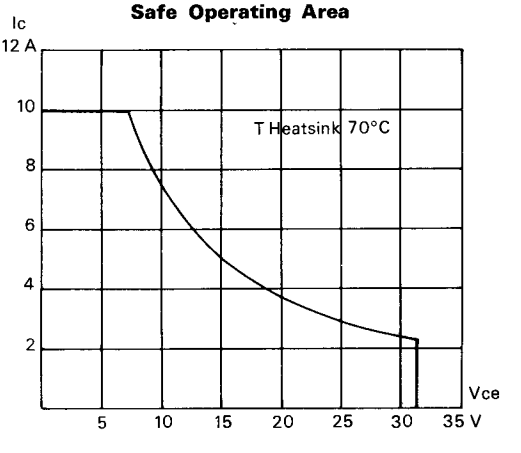
Power Gain vs Frequency



Intermodulation Distortion vs Peak Sync Power

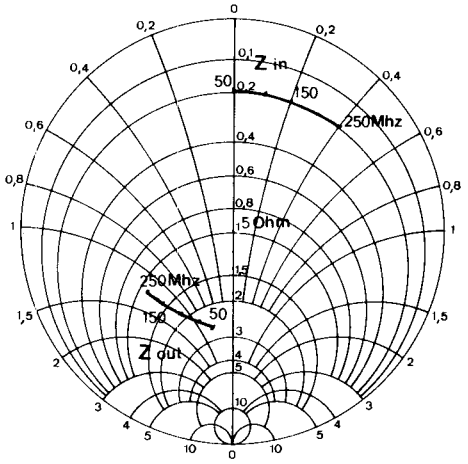


Safe Operating Area

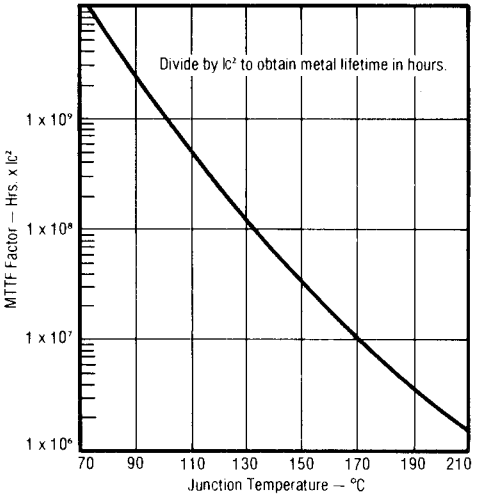


Large signal Impedances vs Frequency

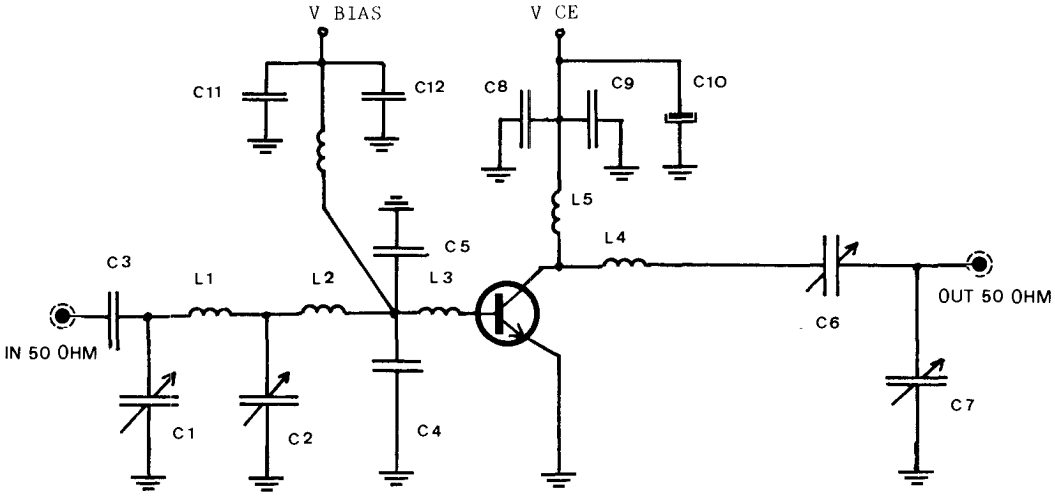
V_{CE} = 28 V - I_C = 2.5 A



MTTF Factor vs Tj

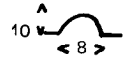


TEST CIRCUIT FOR F = 225 MHz



$C_{1,7}$ ARCO 403
C_2 ARCO 404
$C_{3,8}$ chip capacitor 470 pF
$C_{4,5}$ UNELCO 80 pF
C_6 ARCO 423
$C_{9,11}$ UNELCO 1000 pF
C_{10} 470 µF electrolytic
C_{12} 10 nF

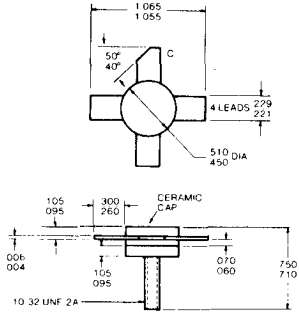
L_1 1.5 turns closely wound. Cu wire 0.7 mm I.D. 4.5 mm
L_2 2.1 cm - 50 ohms - line
L_3 length of the base lead
L_4 Cu wire 1.6 mm



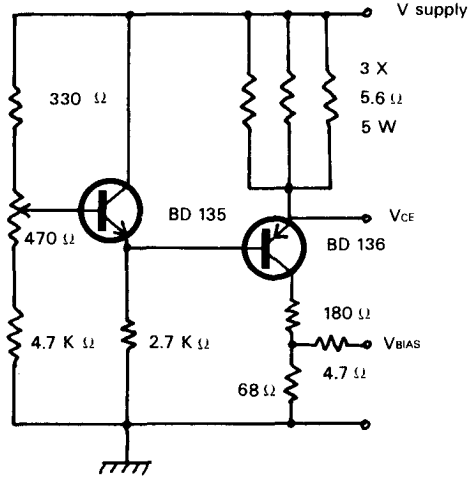
L_5 3.5 cm - 50 ohms line
L_6 4 turns closely wound Cu wire 0.8 mm I.D. 4.5 mm

PACKAGE OUTLINE

.500 SOE



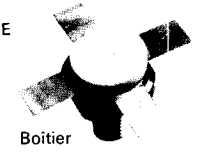
BIAS CIRCUIT



UHF LINEAR TRANSISTOR

TPV 376 is a gold metallized NPN silicon transistor using high value diffused emitter ballast resistors. It is packaged in a low thermal resistance header. A combination of state of the art die mounting technique and on-line 100 percent thermal resistance testing ensures unsurpassed long term reliability. The above features make TPV 376 the highest Power transistor available for **class A and class AB band 3 TV transmitters and transposers** applications.

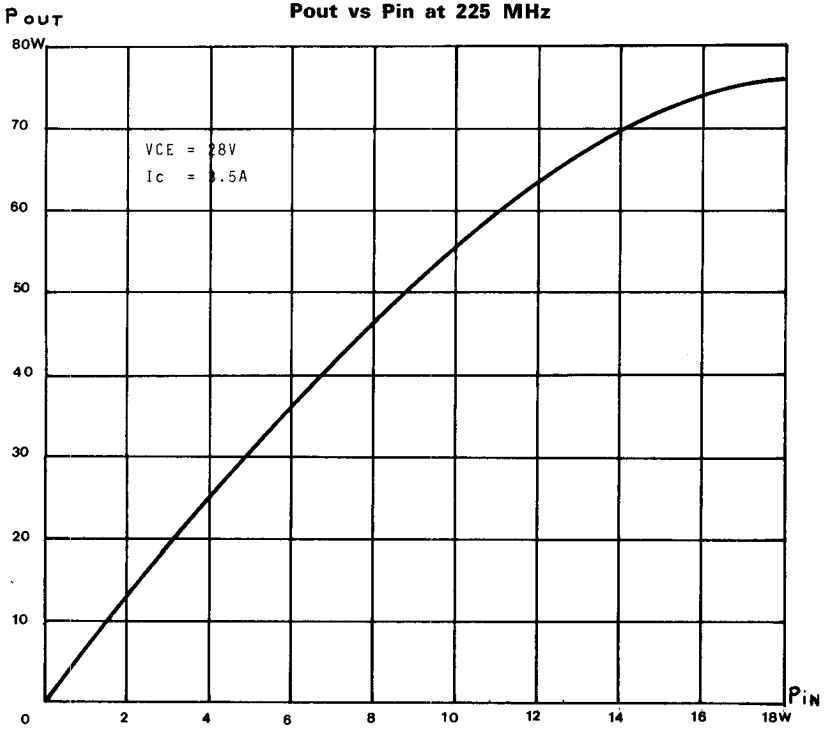
Band 3
30 W at - 53 dB IMD
8 dB gain
CLASS A or AB

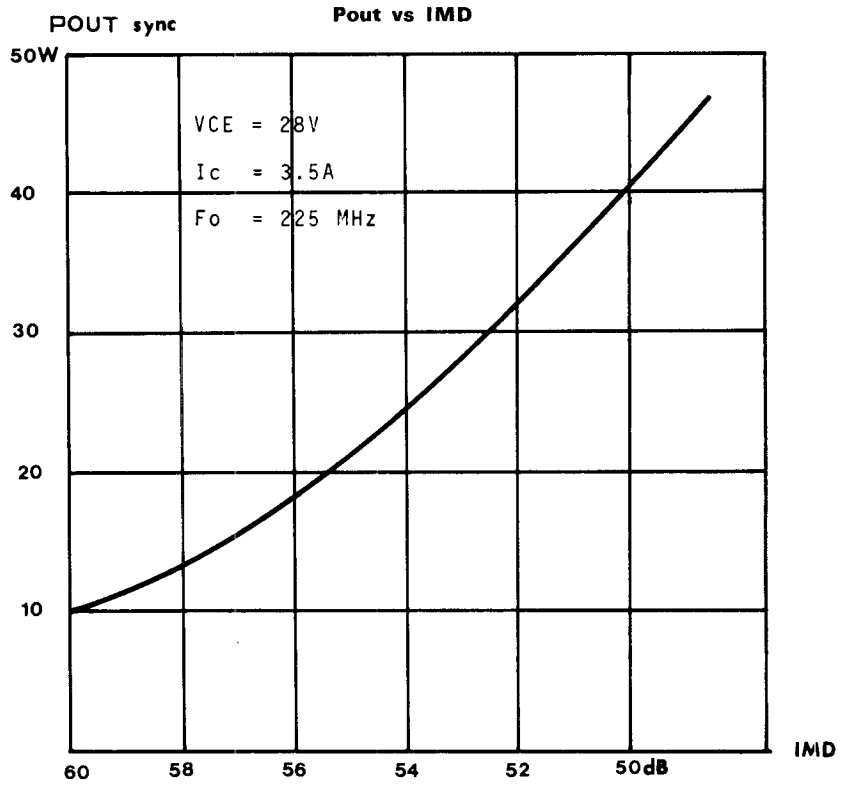


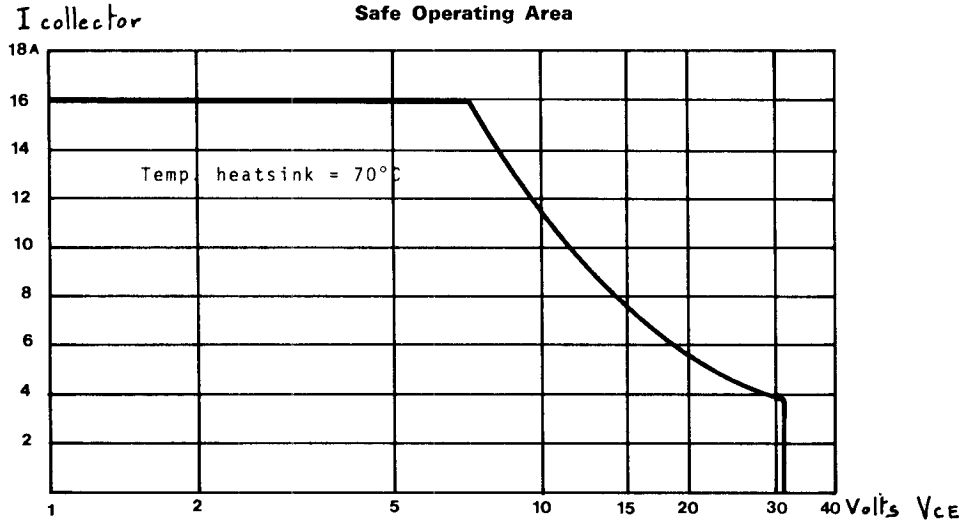
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 20 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 100 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 100 mA R_{BE} = 10 ohms	60			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 100 mA	65			V
	h_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1000 mA	20		120	
R F Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband = Reference - 16 dB	F = 225 MHz V_{CE} = 28 V I_E = 3.5 A P_{REF} = 30 W			- 53	dB
	P_G	Power Gain	F = 225 MHz V_{CE} = 28 V I_E = 3.5 A P_{REF} = 20 W	7.5		8	dB
	VSWR	Mismatch Tolerance	F = 225 MHz V_{CE} = 28 V I_E = 3.5 A P_{REF} = 20 W	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		100	150	pF
Thermal	I_C	Maximum Collector Current			16		A
	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C		0.9	1	°C/W
	θ_{CH}	Thermal Resistance Case - Heatsink			0.15		°C/W
	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C		150		W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

Pout vs Pin at 225 MHz

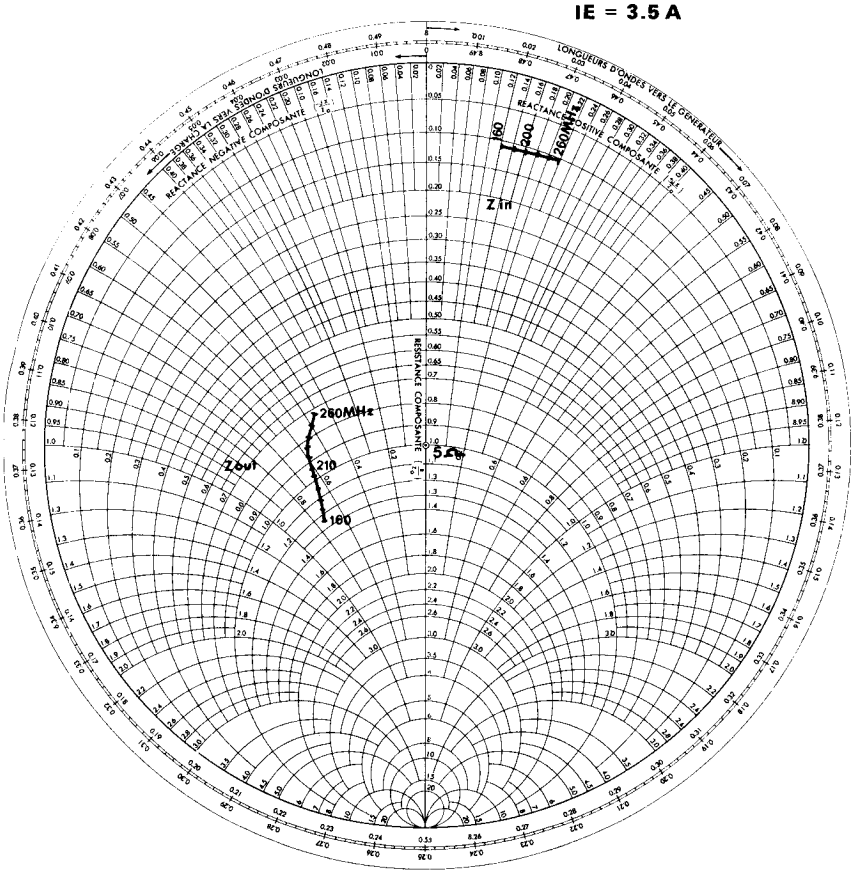



POUT sync
Pout vs IMD
50W
40
30
20
10
VCE = 28V
Ic = 3.5A
Fo = 225 MHz
60
58
56
54
52
50dB
IMD


I collector
Safe Operating Area
18A
16
14
12
10
8
6
4
2
Temp. heatsink = 70°C
1
2
5
10
15
20
30
40 Volts VCE

Large Signal Zout Zin

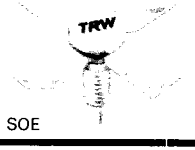
VCE = 28 V
IE = 3.5 A



VHF LINEAR TRANSISTOR

TV TRANSPOSER AND TRANSMITTER BAND 3 5 W AT - 58 DB IMD 16 DB GAIN

The TPV 394 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. This transistor is designed for **medium power band 3 TV transposers.** The TPV 394 is used in the output stage of 10 W transposers or in the driver stages of higher power transposers and transmitters. Its exceptional **high gain** reduces the complexity of driver stages.

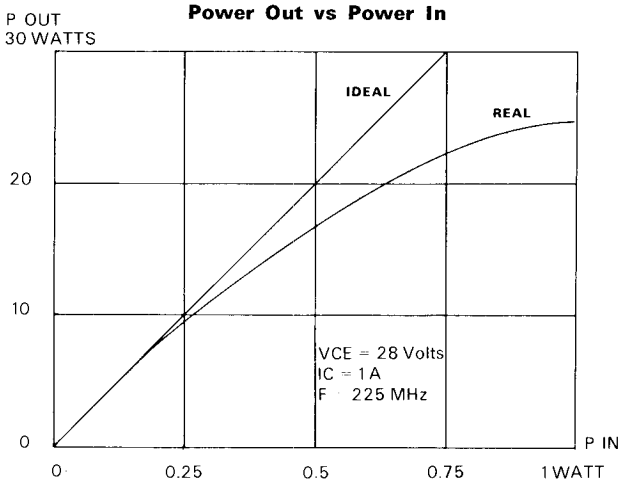


280 SOE

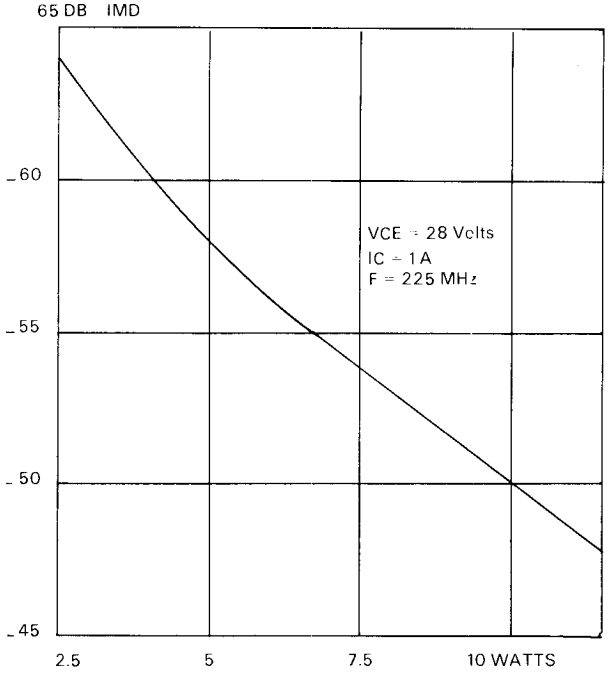
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 2 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	30			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10 ohms	55			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA	55			V
	h_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 100 mA	10			
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 225 MHz V_{CE} = 28 V I_E = 1 A P_{REF} = 5 W			— 53	dB
	IMD 2	Idem	F = 225 MHz V_{CE} = 28 V I_E = 1 A P_{REF} = 10 W			— 50	dB
	P_G	Power Gain	F = 225 MHz V_{CE} = 28 V I_E = 1 A P_{REF} = 5 W	15	16		dB
	VSWR	Mismatch Tolerance	F = 225 MHz V_{CE} = 28 V I_E = 1 A P_{REF} = 5 W		∞		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz			35	pF
Thermal	I_C	Maximum Collector Current				4	A
	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			2.5	°C/W
	θ_{CH}	Thermal Resistance Case - Heatsink				1.0	°C/W
	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			50	W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

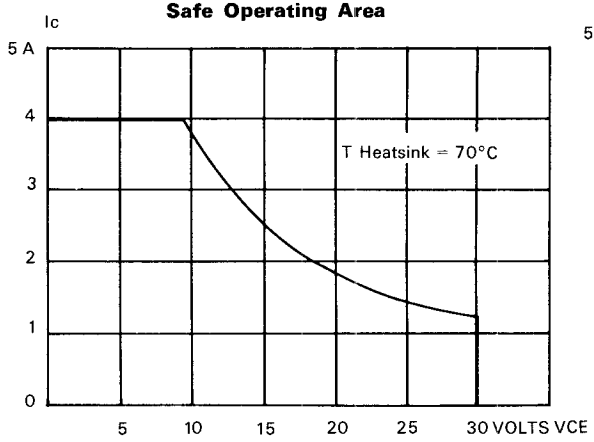
Power Out vs Power In



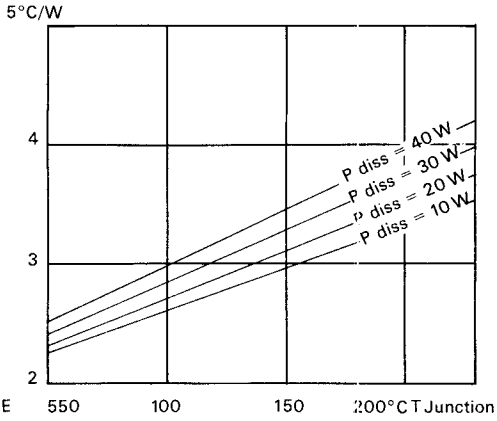
Intermodulation Distortion vs Power Out



Safe Operating Area

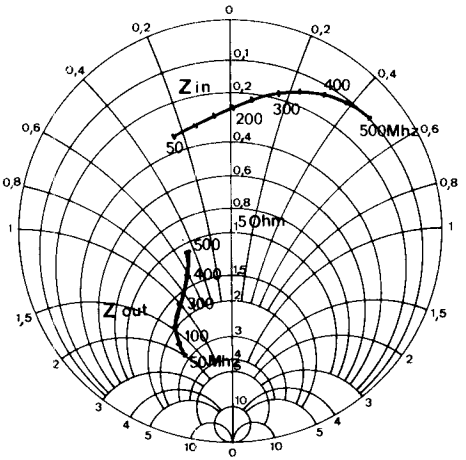


Thermal Resistance Junction Heatsink vs Temperature of Junction for Various Power's Dissipated

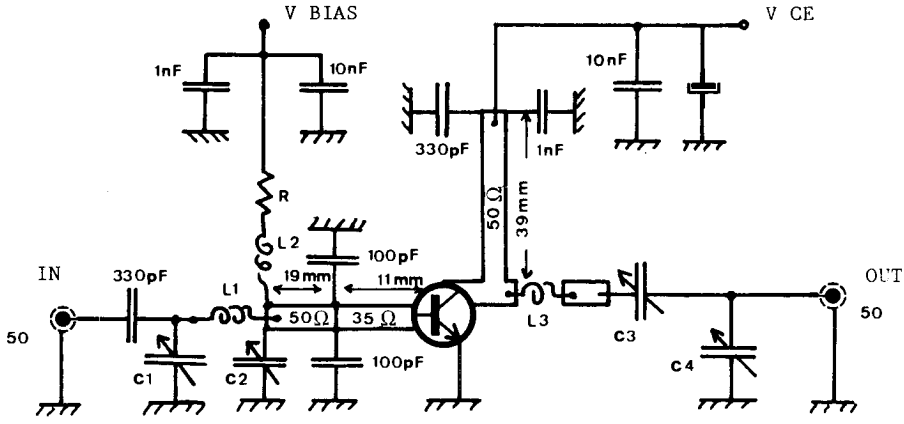


Large Signal Impedances vs Frequency

V_{CE} = 28 V - I_C = 1 A



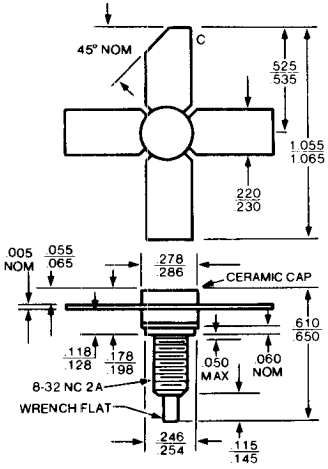
TEST CIRCUIT AT F = 225 MHz



Lines are printed on G 10 epoxy glass material

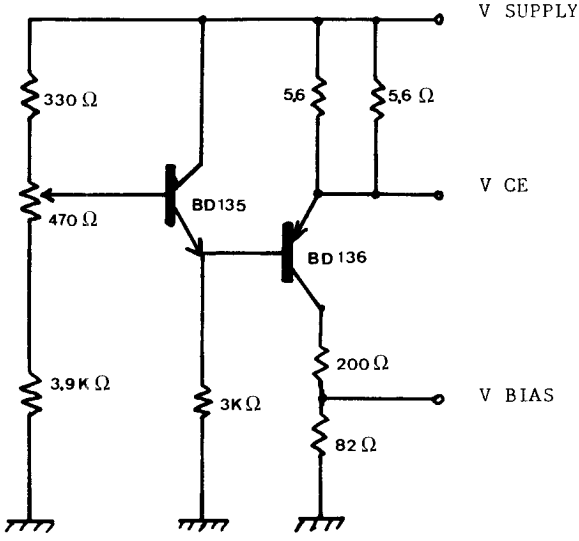
$C_{1,4}$ ARCO 403
C_2 ARCO 404
C_3 ARCO 423
L_1 1 turn 1/2 I.D. = 5 mm
L_2 RFC 10 turns I.D. = 5 mm
L_3 1.5 mm shaped :

Package Outline



To convert inches to millimeters multiply by 2.54.

CLASS A BIAS CIRCUIT



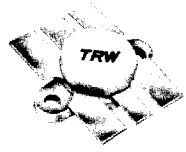
UHF Linear Transistor

PRELIMINARY

The TPV 385 is a NPN gold metallized transistor using diffused ballast resistors for super linearity. The TPV385 is specifically designed for high power band III TV transposers and transmitters amplifiers. Due to its very high gain, the number of transistors per line-up is reduced.

Its internal matching makes easier a band III broadband circuit.

TV TRANSPOSER AND TRANSMITTER BAND 3 14 DB GAIN 14 W AT -53 DB

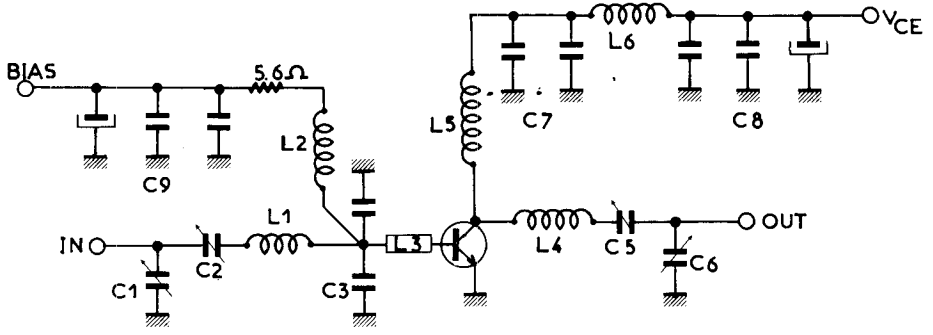


JΦ 500

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 10 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 10	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1 A	20		100	
RF Test	IMD	Intermodulation Distortion 3 tone vision = — 8 dB sound = — 7 dB sideband = — 16 dB	F_O = 225 MHz V_{CE} = 28 V I_E = 2.5 A			— 53	dB
	P_G	Power Gain	P_{REF} = 14 W	14	15		dB
	VSWR	Mismatch Tolerance			∞		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		65	85	pF
Thermal	I_C	Maximum Collector Current				10	A
	θ_{JC}	Thermal Resistance Junction Case	T_{case} = 70 °C			1.5	°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

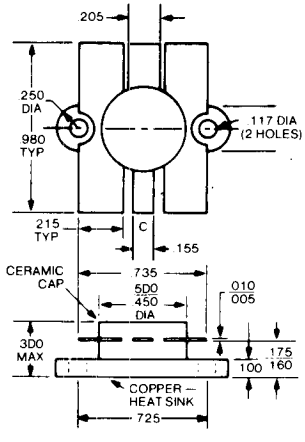
TEST CIRCUIT a 225 MHz CLASS A

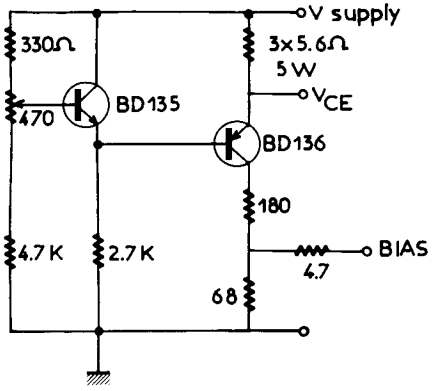


$C_1 = C_6$ = ARCO 404
$C_2 = C_5$ = ARCO 423
$C_3 = C_4$ = UNELCO 80 pF
C_7 = 1 nF + 47 nF
$C_8 = C_9$ = 1 nF + 0.1 µF + 47 µF

L_1 = 2 turns - ID 6 mm - wire 1 mm
L_1 = 1 turn - ID 10 mm - wire 1 mm
L_2 = 6 turns - ID 6 mm - wire .6 mm
L_3 = base inductance PAD - L = 10 mm W = 5 mm
L_5 = 1 turn - ID 6 mm - wire 1.5 mm
L_6 = 2 turns on ferrite core - wire 1.5 mm

J-Zero-C Package Outline





UHF Linear Transistor

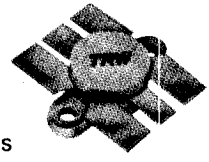
PRELIMINARY

TPV 386 is an internally matched transistor on a very low thermal resistance package, designed for high gain, high output power Band 3 TV transmitters and transposers applications.

The combination of multicell die design, optimum matching techniques, ultra thin beryllium layer header, 100 % linearity and thermal tests have led to what is undoubtly the most powerful available device for class A and AB TV amplification.

Long term reliability and ruggedness are guaranteed by diffused silicon ballast resistors and the TRW gold metallization process.

TV TRANSPOSER & TRANSMITTER BAND 3 CLASS A OR AB 12 DB GAIN

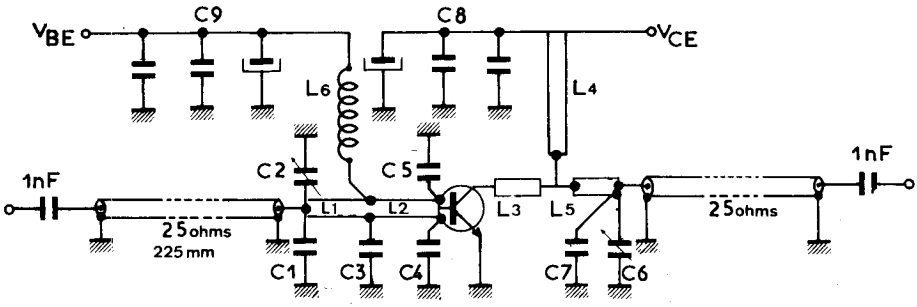


JΦ 500 S

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 20 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 100 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 100 mA R_{BE} = 10 Ω	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	H_{FE}	D.C Current Gain	V_{CE} = 5 V I_C = 1 A	20		100	
RF Test	Class A	Intermodulation Distortion 3 tone vision = — 8 dB sound = — 7 dB sideband = — 16 dB	F = 225 MHz V_{CE} = 28 V I_E = 3.5 A P_{REF} = 30 W		— 53	— 51	dB
		Power Gain		11	12		dB
		Mismatch Tolerance			∞		
	Class AB	1 dB Compression Point CW	V_{CE} = 28 V I_Q = 200 mA F = 225 MHz	90			W
	C_{OB}	Collector - Base Capacitance	V_{CB} = 30 V F = 1 MHz		130	150	pF
Thermal	I_C	Maximum Collector Current				16	A
	θ_{JC}	Thermal Resistance Junction Base	T_{case} = 70 °C		0.7	1	°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

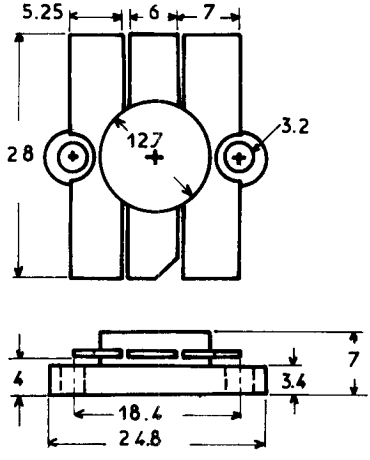
TEST CIRCUIT DIAGRAM



C_1 = 2 X 47 pF ATC 100 A
C_2 = 22 pF ATC 100 A
C_3 = 2 X 33 pF ATC 100 A
$C_4 = C_5$ = 220 pF ATC 100 B
C_6 = 7-60 pF ARCO 404
C_7 = 100 pF ATC 100 A
$C_8 = C_9$ = 220 pF ATC 100 B + 1 nF + 10 nF + 2 x .1 μF + 100 μF

L_1 = 30 Ω Line (W = 7 mm ; L = 10 mm) époxy ε_r = 4.1
L_2 = 30 Ω Line (W = 7 mm ; L = 11 mm) époxy ε_r = 4.1
L_3 = 35 Ω Line (W = 6 mm ; L = 5 mm) époxy ε_r = 4.1
L_4 = 8 X 3 mm COPPER STRIP .3 mm THICKNESS
L_5 = 6 X 3 mm COPPER STRIP .3 mm THICKNESS
L_6 = 3 turns closely wound - copper wire .6 mm ID 3 mm

PACKAGE



Dimensions given in mm

PRELIMINARY

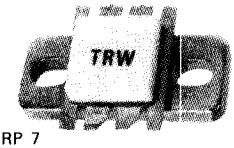
VHF Linear Power Transistor

BAND 3
TV TRANSMITTER
HIGH GAIN
CLASS A.B.
PUSH-PULL TRANSISTOR

TPV 3100 is a gold metallized NPN silicon push-pull transistor packaged on a very low thermal resistance header.

The use of high value diffused emitter ballast resistors, state of the art die mounting technology and 100 % mechanical thermal and electrical test ensures long term reliability. This device combines very high gain, easy circuit design, ruggedness and linearity.

It is an ideal candidate for VHF Band 3 vision only or sound amplifiers.



MRP 7

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
EACH SIDE DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 5 mA	3.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 50 mA	35			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 50 mA R_{BE} = 15 Ω	60			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 50 mA	65			V
	H_{FE}	D.C. Current Gain	V_{CE} = 28 V I_C = 0.5 A	20	150		
RF TEST	P_G	Power Gain	V_{CE} = 28 V	11			dB
	G_C	Gain Compression	P_{out} = 100 W			1	dB
	η_C	Collector Efficiency	IQ = 2 × 100 mA F_o = 225 MHz	70		1	dB %
	C_{OB}	Collector Base Capacitance each side	V_{CB} = 28 V F = 1 MHz		60		pF
THERMAL	I_C	Maximum Collector Current each side				8	A
	θ_{j-c}	D.C. Thermal Resistance Junction Case	T_{case} 70 °C			1.2	°C/W
	T_{STG}	Storage Température		— 65		+ 200	°C

LARGE SIGNAL IMPEDANCES

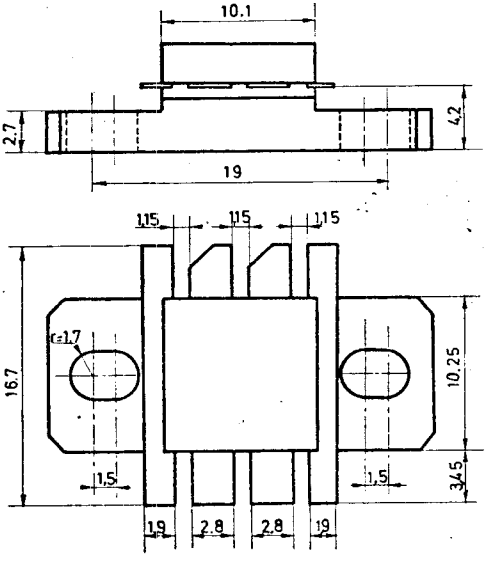
FREQUENCY (MHz)	Z_{in} (Ω)	Z_{Load} (Ω)
170	1.25 + j 0.5	10 + j 10
200	0.9 + j 0.9	9.5 + j 7
230	1 + j 2	6.5 + j 6.5

NOTES : V_{CE} = 28 Volts I_q = 2 × 100 mA P_{out} = 100 W

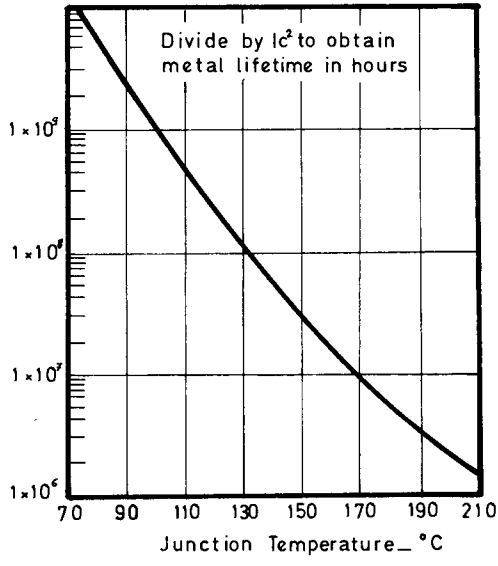
— Z_{in} values to get optimum input return loss

— Z_{Load} values to get optimum output power and efficiency

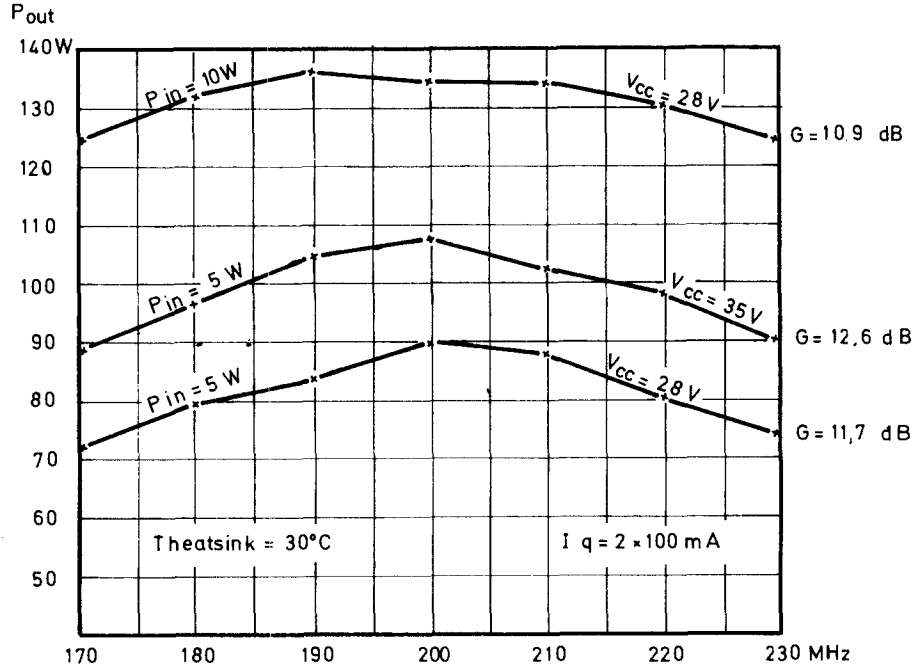
Package Outline



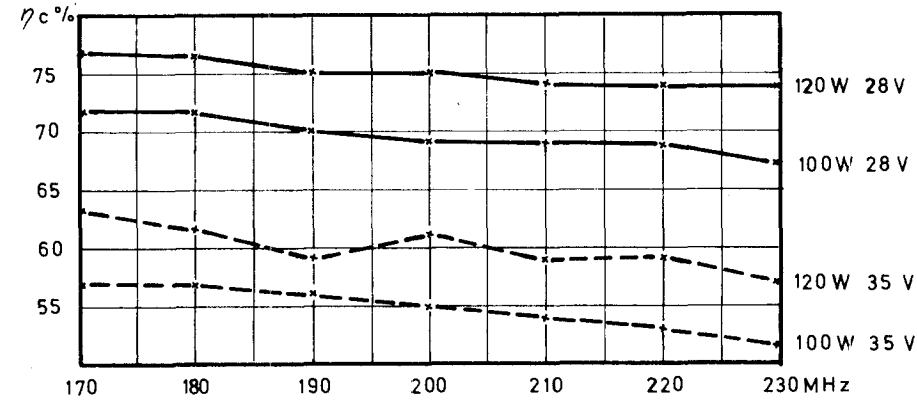
MTTF vs Junction Temperature



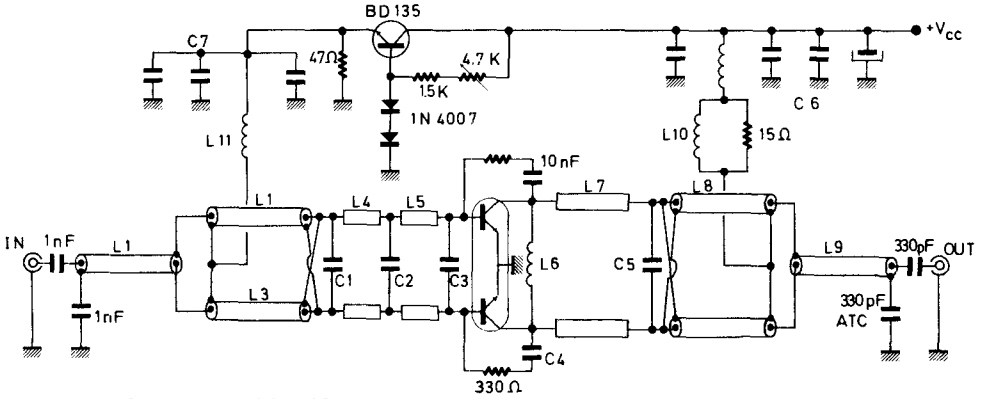
Typical Performances Class AB



Collector Efficiency vs Frequency



170-230 MHz BROADBAND AMPLIFIER CLASS AB

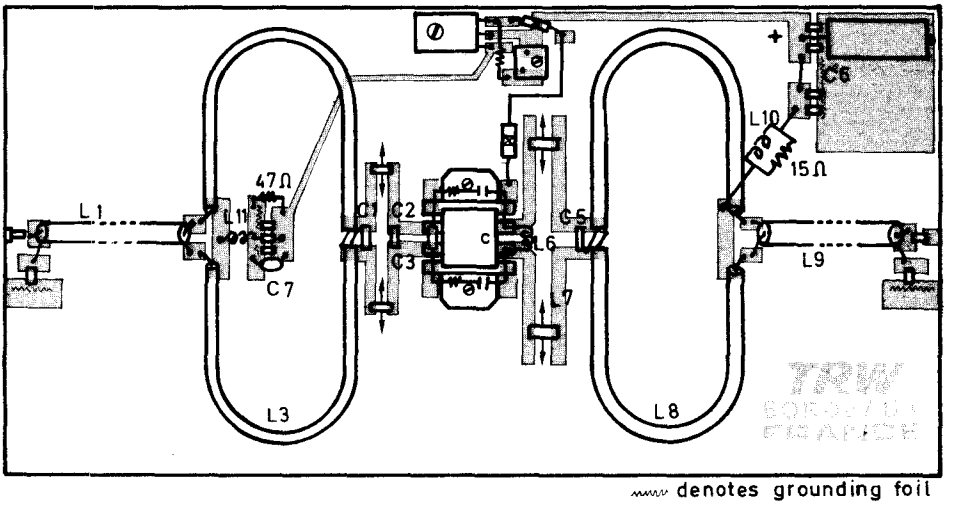


L_1 = L_9 = 50 ohms coaxial 1 = 80 mm
L_2 = L_3 = L_8 = 25 ohms coaxial cable or semi-rigid 1 = 80 mm
L_4 = 40 ohms line 2.5 % of λg 225 MHz or 1 = 23 mm sub 1/50 inch teflon glass
L_5 = 40 ohms line 65 % λg 225 MHz or 1 = 6 mm
L_6 = 3 turns ID 4 mm wire 1 mm ∅ leads 5 mm long
L_7 = 40 line 3.5 % λg 225 MHz or 1 = 32 mm 1/50 teflon glass
L_{10} = 11 turns ID 4 mm wire 1 mm ∅
L_{11} = .22 µH molded inductor

C_1 = 68 pF ATC 100B
C_2 = 100 pF ATC 100B
C_3 = 220 pF ATC 100B
C_5 = 27 pF + 33 pF ATC 100A
C_6 = C_7 = 1 nF + 10 nF + .1 µF + ELECTROLYTIC

L_4 has to be adjusted for Gain
L_6 and L_7 have to be adjusted for the best lead

Components Layout



denotes grounding foil

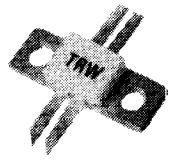
UHF Linear Transistor

The TPV 508 is a push-pull device incorporating gold metallized dice and diffused emitter ballast resistors for linearity and ruggedness.

The chip design using microwave techniques provides over 7.5 dB gain at 860 MHz.

The TPV 508 is specifically designed for high power Band 4 & 5 TV transposers and solid state transmitters.

TV TRANSPOSERS
BAND 4 & 5
8 W
7.5 DB GAIN
GOLD RELIABILITY

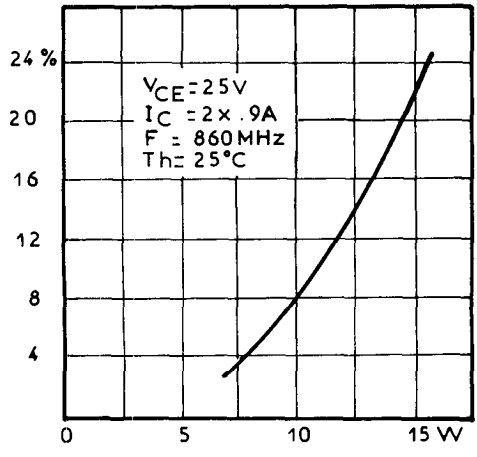


BMA-2

Electrical Characteristics (T_{case} = 25 °C)

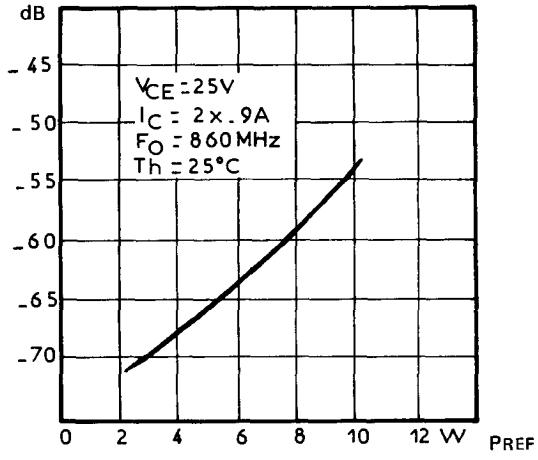
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test each side	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 3 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 40 mA	28			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA	45			V
	H_{FE}	D.C Current Gain	V_{CE} = 20 V I_C = 500 mA	10			
RF Test	I_{MD}	Intermodulation distortion 3 tones (-8-7-16)	F = 860 MHz V_{CE} = 25 V I_C = 2 X .9 A Pref. = 8 W			— 58	dB
	P_G	Power Gain		7.5	8		dB
	C_{OB}	Collector - Base Capacitance each side			17.5	20	pF
Thermal	θ_{JC}	Thermal Resistance Junction Case	— high resolution — T_{case} = 70 °C — D.C dissipation			2.5	°C/W
	θ_{CH}	Thermal Resistance Case heatsink			0.2		°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

Cross-mod* vs Output Power



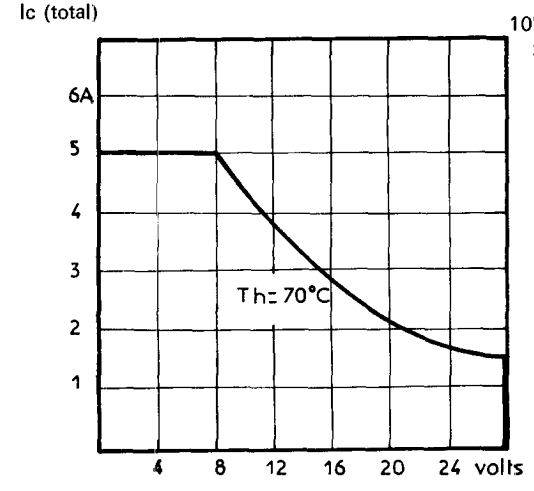
* Cross-mod : Δ % sound (— 7 dB)
— vision O ——→ PEAK

IMD* vs Output Power

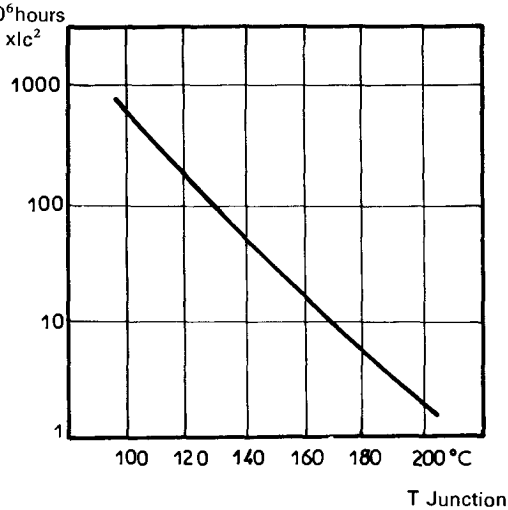


* IMD : 3 tones — 7 dB, — 8 dB, — 16 dB

DC Safe Operating Area

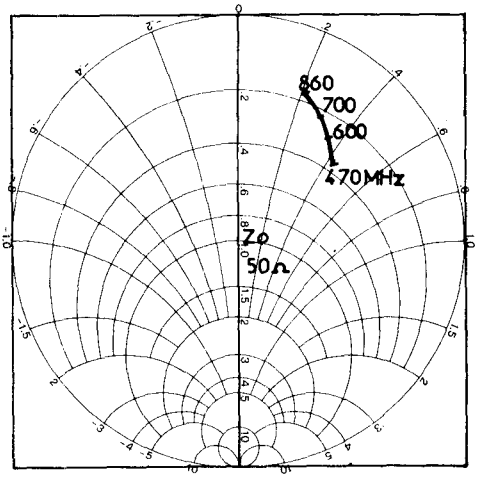


MTTF vs Junction Temperature



Z LOAD FOR BEST IMD (8 W) and CROSS-MODULATION (12 W)

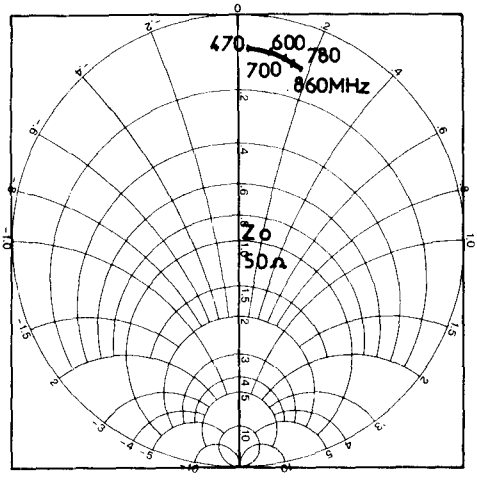
Collector to collector



V_{CE} = 25 V
I_C = 2 X C.9 A

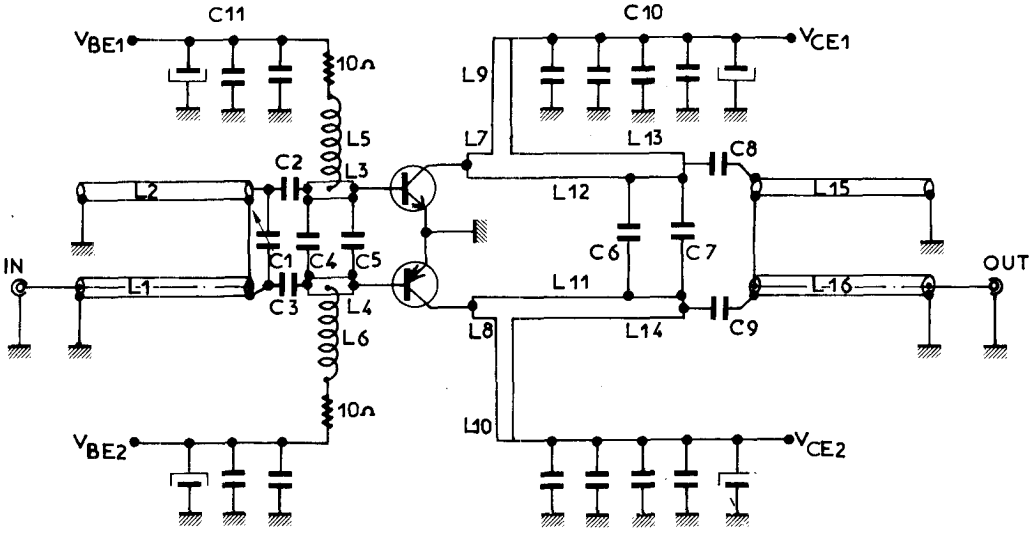
ZIN FOR BEST INPUT VSWR

Base to base



V_{CE} = 25 V
I_C = 2 X 0.9 A

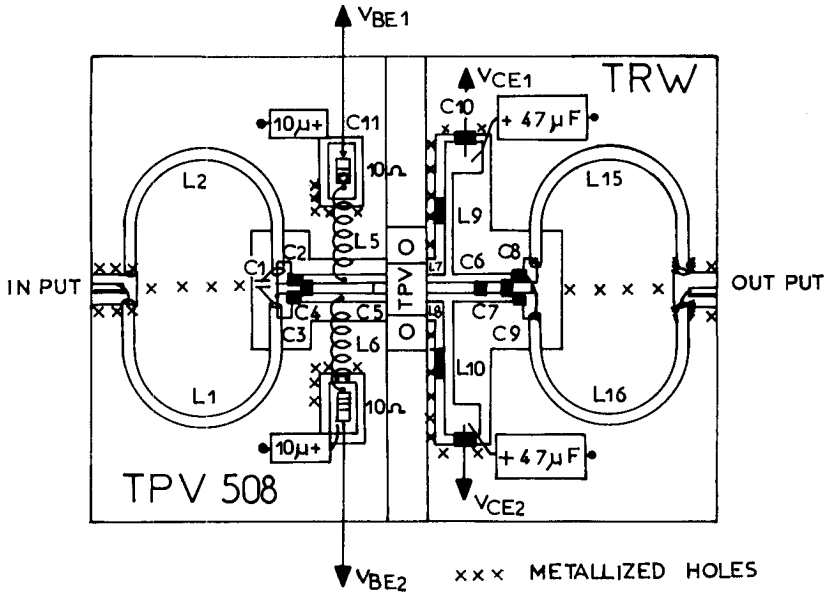
TPV 508 BROADBAND AMPLIFIER 470-860 MHz
Class A

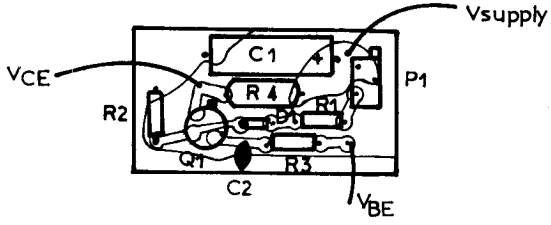


$L_1 = L_2 = L_{15} = L_{16}$	=	60 mm of 50 Ω - 2.2 mm semi rigid coax
$L_3 = L_4$	=	50 Ω line - 5.5 % λ g at 860 MHz
$L_5 = L_6$	=	3 turns ID 2 mm
$L_7 = L_8$	=	50 Ω line - 1.5 % λ g at 860 MHz
$L_9 = L_{10}$	=	50 Ω line - 4.9 % λ g at 860 MHz
$L_{11} = L_{12}$	=	50 Ω line - 2 % λ g at 860 MHz
$L_{13} = L_{14}$	=	50 Ω line - 1.5 % λ g at 860 MHz
C_1	=	.5 — 4.5 pF GIGATRIM TRIMMER
$C_2 = C_3$	=	27 pF ATC 100 A
C_4	=	6.8 pF ATC 100 A
C_5	=	18 pF ATC 100 A
C_6	=	3.3 pF ATC 100 A
C_7	=	4.7 pF ATC 100 A
$C_8 = C_9$	=	27 pF ATC 100 A
C_{10}	=	+ 330 pF ATC 100 B + 1 nF + 10 nF + 47 μF
C_{11}	=	1 nF + 10 nF + 10 μF

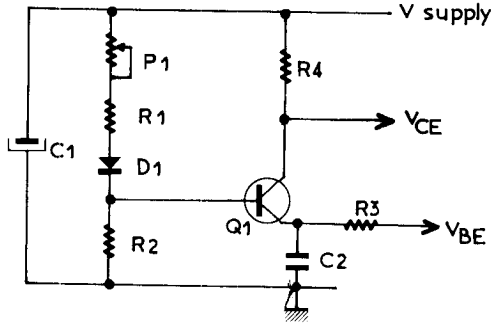
470-860 MHz BROADBAND AMPLIFIER

Class A





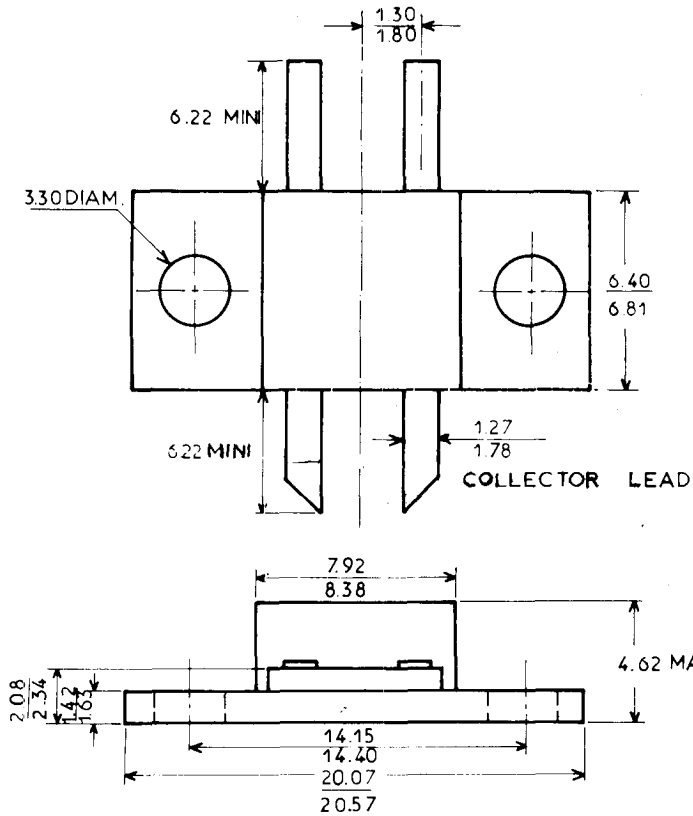
BIAS



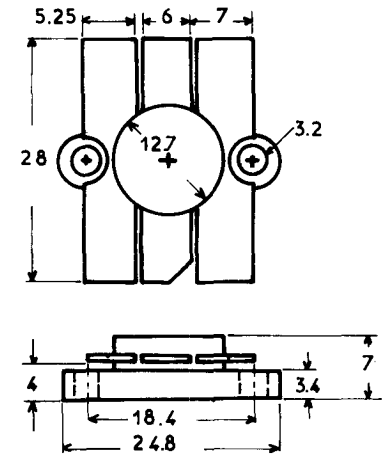
PART LIST

C_1 = 100 MF	R_2 = 5.6 KΩ	D_1 = 1 N 4148
C_2 = 10 nF	R_3 = 100 Ω	Q_1 = 2 N 2904
R_1 = 150 Ω	R_4 = 2.7 Ω 2 W.	P_1 = 1 K Ω

PACKAGE OUTLINE



PACKAGE



Dimensions given in mm

Preliminary

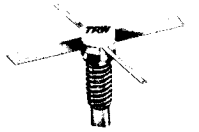
UHF Linear Transistor

TV TRANSPOSER
0.25 W - BAND 5
14 dB GAIN at 860 MHz

GOLD RELIABILITY

The TPV 590 is a NPN gold metallized transistor using emitter ballast resistors for super linearity. The fine chip geometry gives typical gain in excess of 14 dB at 860 MHz.

These characteristics make TPV 590 an ideal candidate for very efficient low power stages in UHF transposers applications.



.200 SOE

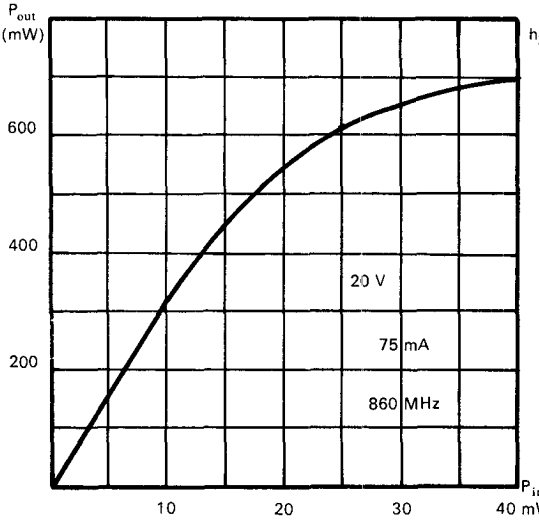
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CEO}	Collector Emitter Breakdown Voltage	I_C = 10 mA	24			V
	BV_{CBO}	Collector Base Breakdown Voltage	I_C = 1 mA	45			V
	BV_{CER}	Collector Emitter Breakdown Voltage	R_{BE} = 10 I_C = 10 mA	50			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
	H_{FE}	DC Current Gain	V_{CE} = 5 V I_C = 100 mA	20		120	
RF TEST	I_{MD}	Intermodulation Distortion — 8 dB — 16 dB — 7 dB	F = 860 MHz V_{CE} = 20 V I_E = 75 mA P_{ref} = 0.25 W		— 60	— 58	dB
	P_G	Power Gain		14	14.5		dB
	VSWR	Mismatch Tolerance			∞		
	C_{ob}	Collector Base Capacitance	V_{CB} = 20 V F = 1 MHz			3	pF
	F_T	Cutoff Frequency	V_{CE} = 20 V I_E = 75 mA	3			GHz
THERMAL	I_C	Maximum Collector Current				.4	A
	θ_{JF}	Thermal Resistance Junction Heatsink	Theatsink = 70 °C			30	°C/W
	T_J T_{STG}	Max Junction and Storage Temper		— 65		+ 200	°C

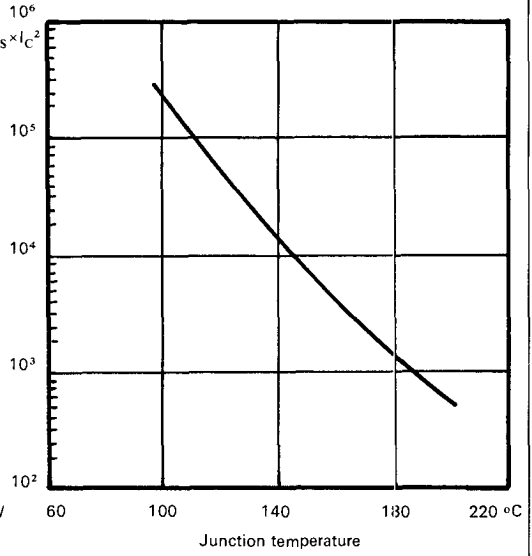
TPV 590 V_{CE} = **20 V** I_C = **100 mA**

POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl°
100 MHz	0.613	226°	17.78	126°	0.0199	35°	0.530	320°
200 MHz	0.732	203°	12.88	103°	0.028	33°	0.316	305°
300 MHz	0.767	192.5°	9.22	93°	0.029	33°	0.266	297°
400 MHz	0.767	185°	6.91	84°	0.033	33°	0.266	295°
500 MHz	0.754	179.5°	5.16	79°	0.033	38°	0.266	300°
600 MHz	0.776	174°	4.67	72°	0.035	42°	0.237	300°
700 MHz	0.776	170°	4.02	66°	0.039	43°	0.237	290°
800 MHz	0.767	167°	3.34	61°	0.044	44°	0.266	285°
900 MHz	0.767	163°	3.16	56°	0.047	44°	0.237	290°
1 GHz	0.776	160°	2.786	52°	0.053	45°	0.266	280°

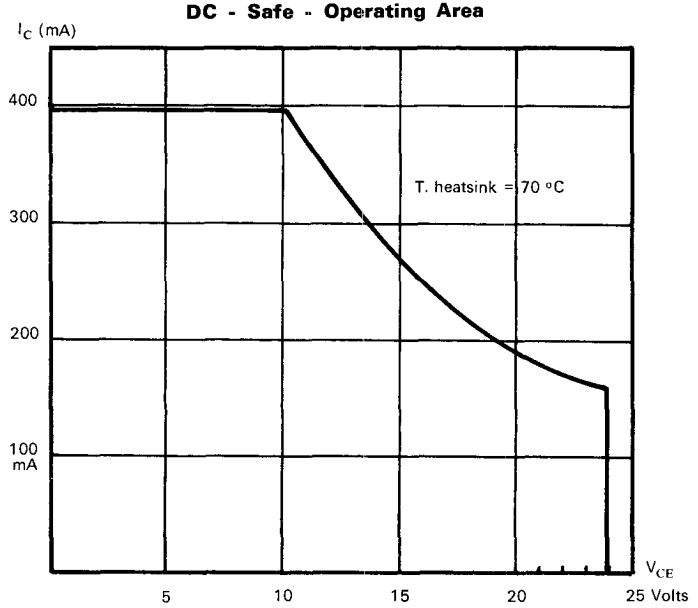
Power Output vs Power Input



MTTF Factor vs Junction Temperature

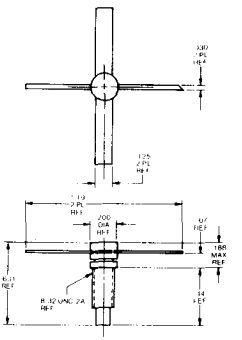


DC - Safe - Operating Area

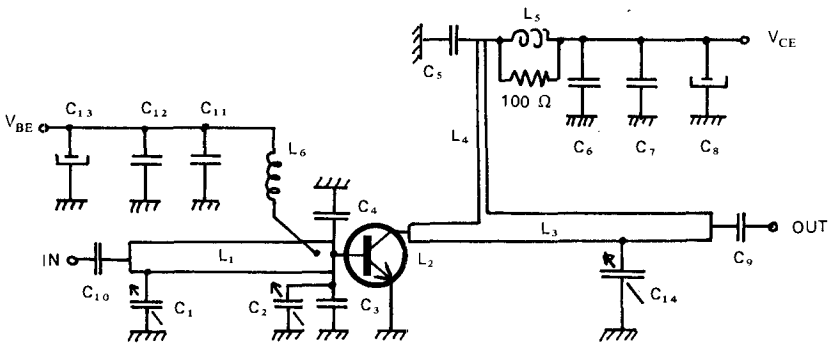


Package

.200 SOE STUD

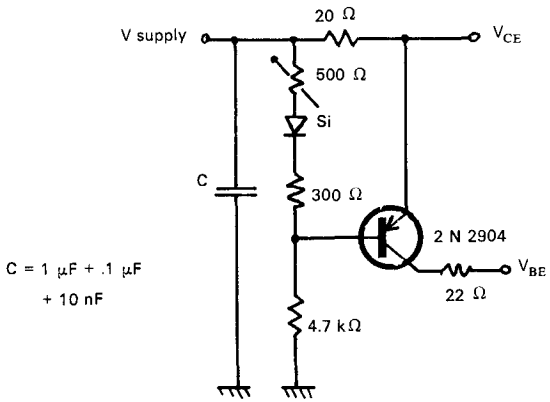


V_{CE} = 20 V **I_C = 75 mA** **F_O = 860 MHz**



L_1 : 50 Ω line l = 10 % λg at 860 MHz
L_2 : 100 Ω line l = 12 % λg at 860 MHz
L_3 : 50 Ω line l = 7 % λg at 860 MHz
L_4 : 120 Ω line l = 10 % λg at 860 MHz
L_5 : 6 turns ID 3 mm wire .5 mm
L_6 : 6 turns ID 3 mm wire .5 mm

$C_1 = C_2 = C_{14}$ = variable AIRTRONIC C max 4.7 pF AT 7275
$C_3 = C_4$ = ATC chip 10 pF
C_5 = 680 pF ATC chip
$C_6 = C_{11}$ = 1 nF
$C_7 = C_{12}$ = 10 nF
C_8 = 10 μF 63 V
C_{13} = 10 μF 25 V
$C_9 = C_{10}$ = 1 nF chip



Bias Circuit

PRELIMINARY

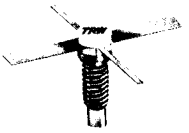
UHF Linear Transistor

The TPV 591 is a NPN gold metallized transistor using diffused emitter ballast resistors.

The sophisticated chip geometry allows the TPV 591 to expand the gain-efficiency frontier.

Its characteristics make the TPV 591 the best device available for very efficient low power stages in UHF transposers applications.

TV TRANSPOSER
0.5 W BAND 5
14 dB GAIN AT 860 MHz
HIGH EFFICIENCY
GOLD RELIABILITY



200 SOE

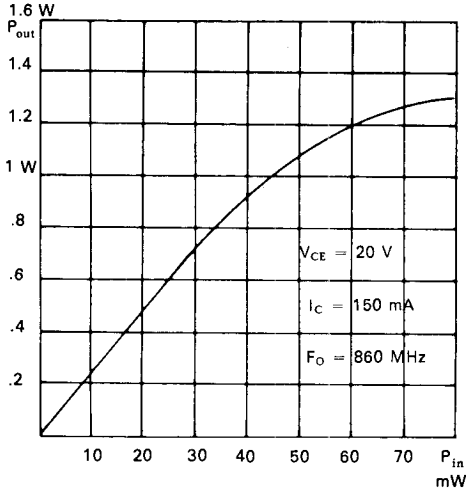
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	24			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 20 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.5	mA
	H_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 200 mA	20		120	
RF TEST	IMD	Intermodulation Distortion — 8 dB, — 16 dB, — 7 dB	F_O = 860 MHz		— 60	— 58	dB
	P_G	Power Gain	V_{CE} = 20 V I_C = 150 mA	13	14		dB
	VSWR	Mismatch tolerance	P_{REF} = 0.5 W		∞		
	F_T	Cutoff Frequency	V_{CE} = 20 V I_E = 75 mA	3			GHz
	C_{OB}	Collector - Base Capacitance	V_{CB} = 20 V F = 1 MHz			5.5	pF
THERMAL	I_C	Maximum Collector Current				.8	A
	θ_{JF}	Thermal Resistance Junction - Heatsink	$T_{Heatsink}$ = 70 °C			16	°C/W
	T_J T_{STG}	Maximum Junction and Storage Temperature		— 65		+ 200	°C

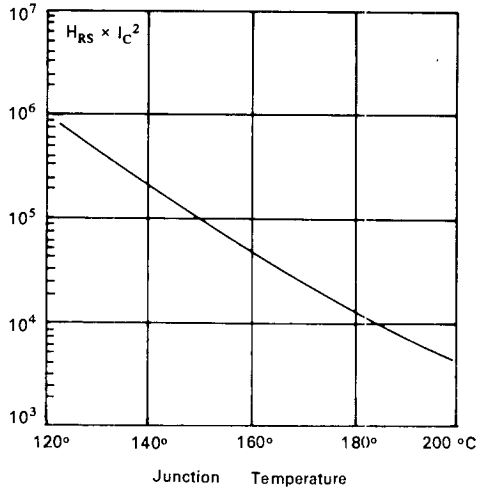
V_{CE} = 20 V I_C = 150 mA

POLAR S-PARAMETERS IN 50 OHM SYSTEM								
F	S 11		S 21		S 12		S 22	
MHz	Magn	Angl°	Magn	Angl°	Magn	Angl°	Magn	Angl°
100	0.733	190	13.8	117	0.025	27	0.365	280
200	0.841	187	8.13	100	0.028	27	0.266	241
300	0.861	181	5.62	88	0.033	27	0.266	241
400	0.861	177	4.27	79	0.035	30	0.282	225
500	0.861	173	3.47	72	0.040	36	0.282	225
600	0.865	169	2.82	68	0.045	36	0.282	218
700	0.865	167	2.44	61	0.045	37	0.316	214
800	0.866	163	2.15	54	0.050	40	0.316	216
860	0.866	162	2.03	54	0.050	43	0.331	218
900	0.866	160	1.94	52	0.053	44	0.331	217
1 000	0.876	158	1.66	46	0.056	44	0.376	214

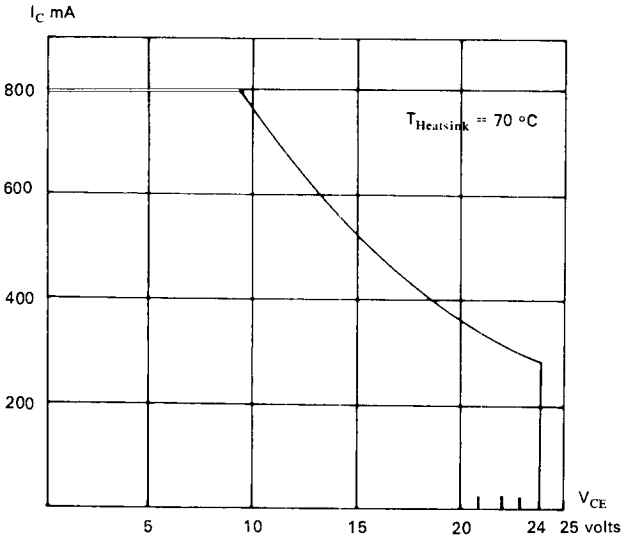
Power Output vs Power Input



MTTF Factor vs Junction Temperature

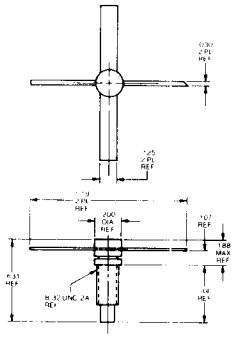


D.C Safe Operating Area

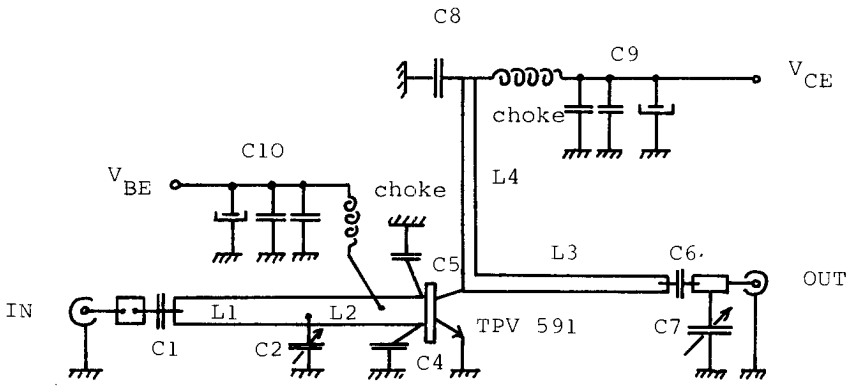


Package

.200 SOE STUD



F_o = 860 MHz — V_{CE} = 20 V — I_C = 150 mA

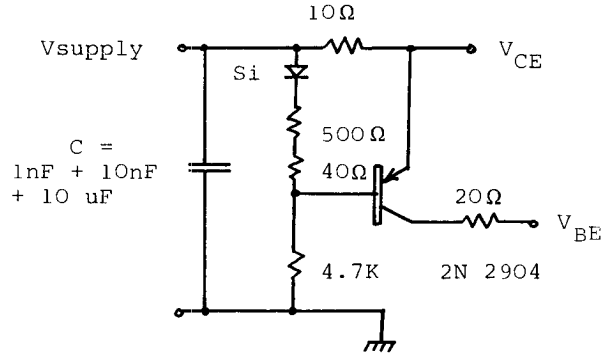


$C_1 = C_6$ = 1 nF
$C_2 = C_7$ = Variable Airtronic AT 7285 - max. 2.5 pF
C_4 = ATC 100 A 10 pF
C_5 = ATC 100 A 6.8 pF + 4.7 pF
C_8 = 1 nF
$C_9 = C_{10}$ = 1 nF + 10 nF + 10 μF

Choke : 8 turns — ID 6 mm — wire .5 mm

L_1 = 50 line — ℓ = 10 % λg at 860 MHz
L_2 = 50 line — ℓ = 5 % λg at 860 MHz
L_3 = 80 line — ℓ = 13 % λg at 860 MHz
L_4 = 100 line — ℓ = 8 % λg at 860 MHz

BIAS CIRCUIT



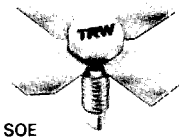
PRELIMINARY DATA SHEET

UHF Linear Transistor

The TPV 593 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity.

Its characteristics make the TPV 593 the best device available for very efficient medium power stages in UHF transposers applications.

TV TRANSPOSER
BAND 4 & 5
9 dB GAIN
2 W



280 SOE

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 80 mA	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA	45			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA	4			V
	H_{FE}	D.C. Current Gain	V_{CE} = 20 V I_C = 250 mA	10			—
RF TEST	IMD	Intermodulation distortion vision = — 8 dB sound = — 7 dB Sideband = — 16 dB	F = 860 MHz P_{REF} = 2 W V_{CE} = 25 V I_C = 450 mA			— 60	dB
	P_G	Power Gain		8.5	9		dB
	C_{OB}	Collector Base Capacitance	V_{CB} = 25 V F = 1 MHz			10	pF
THERMAL	θ_{j-c}	Thermal Resistance Junction Case	T_{case} 70 °C			11	°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C
	T_J	Junction Temperature		— 65		+ 200	°C

POLAR « S » PARAMETERS IN 50 OHMS SYSTEM

F	S11		S21		S12		S22		S21	K
MHz	MAGN	ANGL	MAGN	ANGL	MAGN	ANGL	MAGN	ANGL	dB	FACTOR
470	0.93	170°	1.5	63	0.04	50°	0.55	— 166°	3.52	1.01
650	0.93	165°	1.06	50	0.05	54°	0.60	— 169°	0.51	1.04
860	0.92	162°	0.79	38	0.06	54°	0.65	— 169°	— 2	1.15

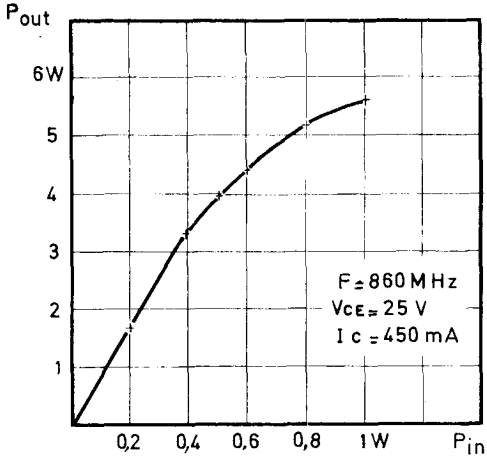
NOTE : V_{CE} = 25 Volts — I_C = 450 mA — Class A

POLAR COORDINATES OF SIMULTANEOUS CONJUGATE MATCH IN 50 OHMS SYSTEM

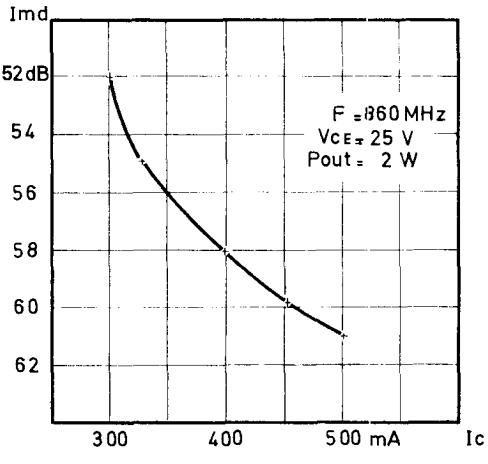
F	SOURCE REFL. COEFF.		LOAD REFL. COEFF.		G MAX
MHz	MAGN	ANGLE	MAGN	ANGLE	dB
470	0.99	— 173°	0.91	124°	15.2
650	0.99	— 168°	0.83	134°	12.0
860	0.95	— 165°	0.79	146°	9.2

NOTE : V_{CE} = 25 Volts — I_C = 450 mA — Class A

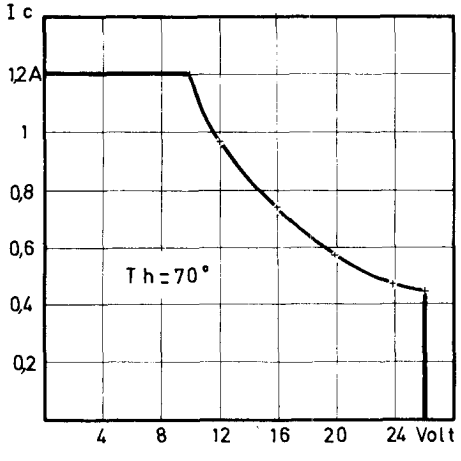
Output Power vs Input Power



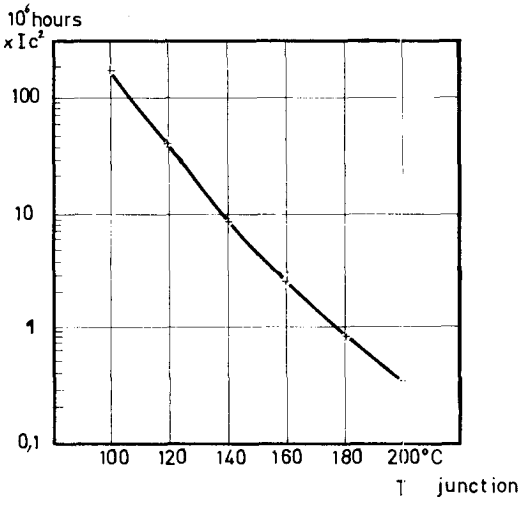
IMD vs Collector Current



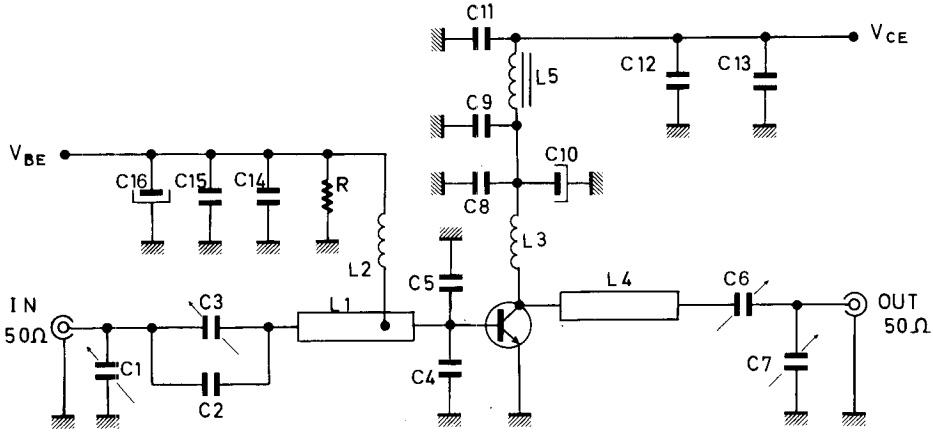
DC Safe Operating Area



MTTF vs Junction Temperature



TEST CIRCUIT AT 860 MHz

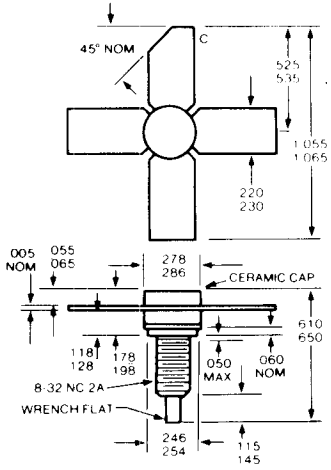


Components Part List

C_1 = AIR TRIMMER AT 5201 0.8 - 10 pF TEKELEC
C_2 = CHIP ATC 4.7 pF
C_3 = AIR TRIMMER AT 5751 0.6 - 6 pF TEKELEC
C_4 = C_5 = CHIP ATC 3.3 pF
C_6 = C_7 = AIR TRIMMER AT 5501 1 - 20 pF TEKELEC
C_8 = C_{13} = C_{14} = 1 nF CHIP CAPACITOR
C_9 = C_{11} = C_{15} = 10 nF RTC
C_{12} = 0.1 µF RTC
C_{10} = C_{16} = 10 µF 63 V electrolytic

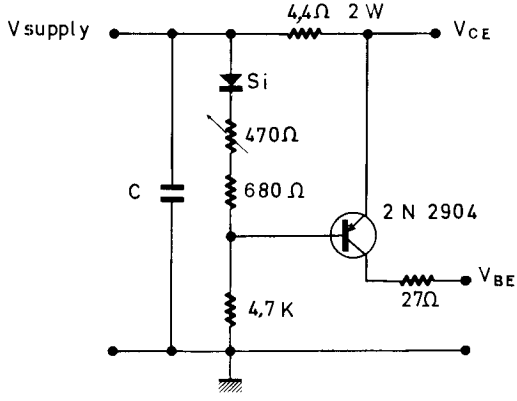
L_1 = 30 Ω line 1 = 6.5 % λg
L_2 = choke 0.47 µH
L_3 = 1 turn - ID 6 mm - wire 10/10
L_4 = 30 Ω line 1 = 19 % λg
L_5 = 8 turns on a CN 20 FERRITE BEAD - CERAMICL - MAGNETICS
R = 43 Ω 1/4 Watt

Package Outline



To convert inches to millimeters multiply by 2.54

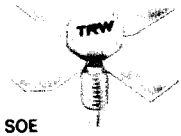
Class a Bias Circuit



UHF LINEAR TRANSISTOR

TV TRANSPOSER
0.5 W BAND 5
MATV 1.5 V - 860 MHz
12 DB GAIN
GOLD RELIABILITY

The TPV 596 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity. The chip design using microwave techniques provides more than 12 dB gain at 860 MHz thereby reducing the complexity of the lower amplifier stages. The TPV 596 is specifically designed for very high output **1.5 volt MATV** amplifier up to 860 MHz and **500 mW band 5 TV transposers** stages.

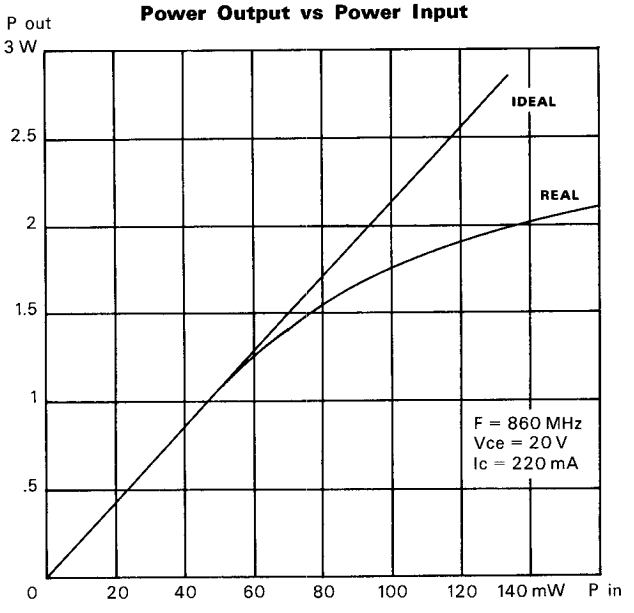


280 SOE

Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	24			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 20 mA R_{BE} = 10 ohms	50			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1 mA	45			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.45	mA
	h_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 100 mA	20		120	
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 1 W			— 50	dB
	IMD 2	Idem	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 0.5 W		— 60	— 58	dB
	P_G	Power Gain	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 1 W	11.5	12		dB
	VSWR	Mismatch Tolerance	F = 860 MHz V_{CE} = 20 V I_E = 0.22 A P_{REF} = 1 W		∞		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz			5	pF
	f_T	Cutoff Frequency	V_{CE} = 20 V I_E = 220 mA	2.2	2.5		GHz
Thermal	I_C	Maximum Collector Current				0.7	A
	θ_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			20	°C/W
	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			8.75	W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

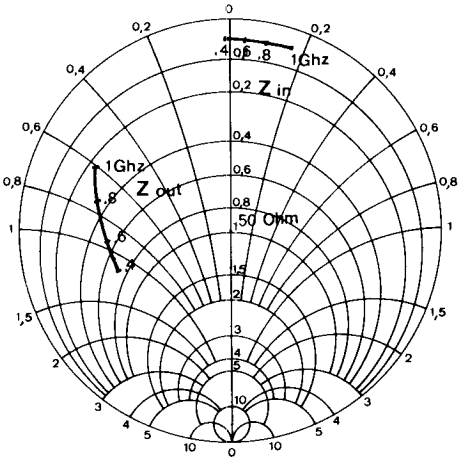
Power Output vs Power Input



LARGE SIGNAL IMPEDANCES

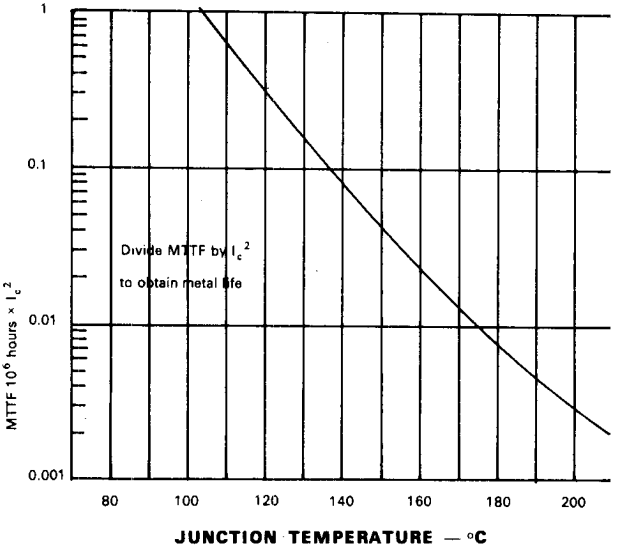
Vce = 20 v

Ic = 220 mA

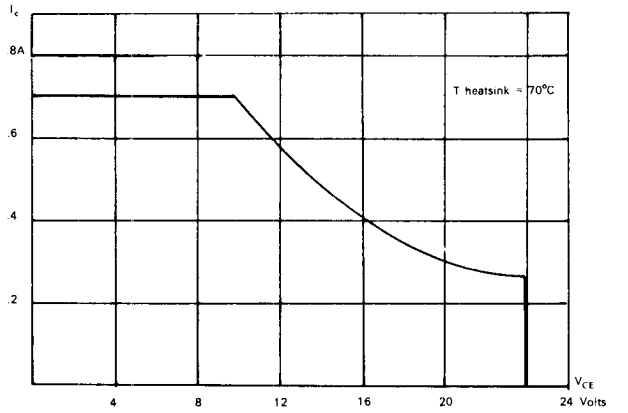


MTTF FACTOR vs

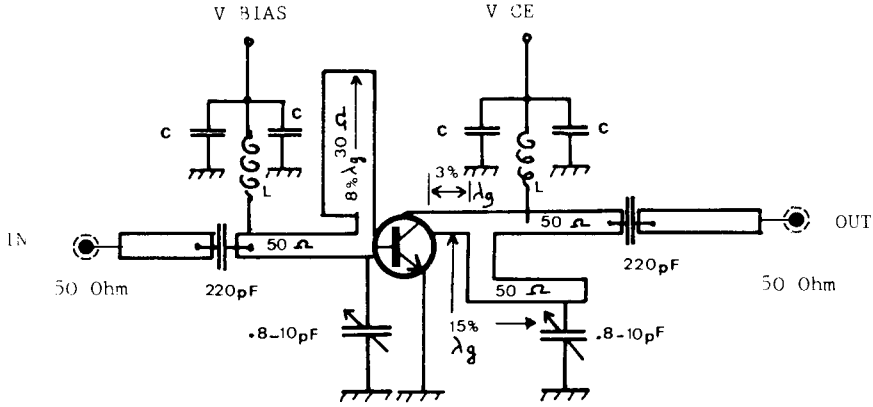
JUNCTION TEMPERATURE



DC-SAFE OPERATING AREA



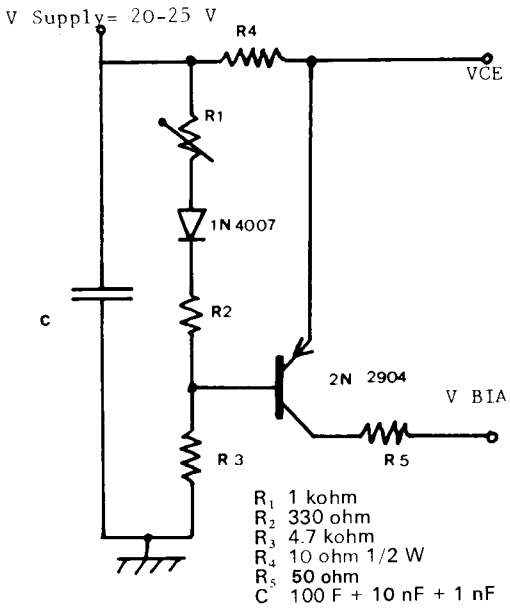
TEST CIRCUIT AT 860 MHz



L = 6 turns ID = 1 mm Wire diameter = 0.6 mm

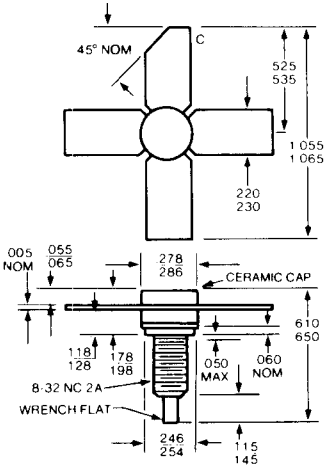
The lengths are given for F = 860 MHz

CLASS A BIAS CIRCUIT



R_1 1 kohm
R_2 330 ohm
R_3 4.7 kohm
R_4 10 ohm 1/2 W
R_5 50 ohm
C 100 F + 10 nF + 1 nF

Package Outline

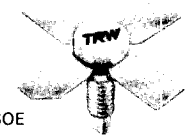


To convert inches to millimeters multiply by 2.54

UHF LINEAR TRANSISTOR

TV TRANSPOSER
BAND 5
1 W
11 DB GAIN
GOLD RELIABILITY

The TPV 597 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity. The chip design using microwave techniques provides more than 11 dB gain at 860 MHz thereby reducing the complexity of the lower amplifier stages. The TPV 597 is specifically designed for **1 W - band 5 - TV transposers** stages.

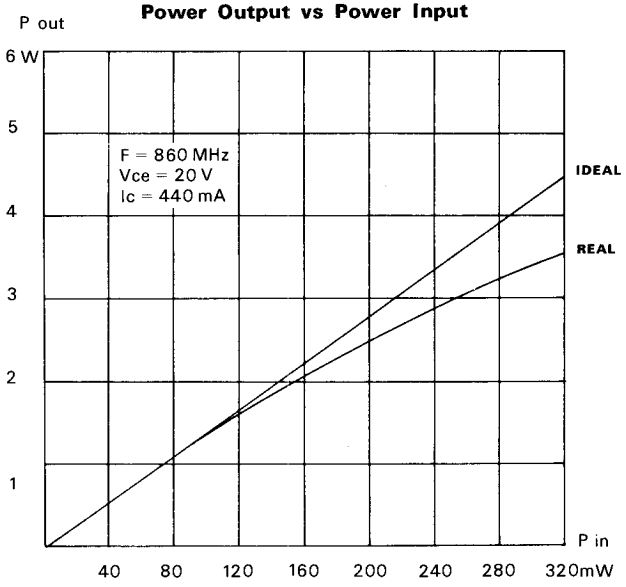


280 SOE

Electrical Characteristics (T_{flange} = 25 °C)

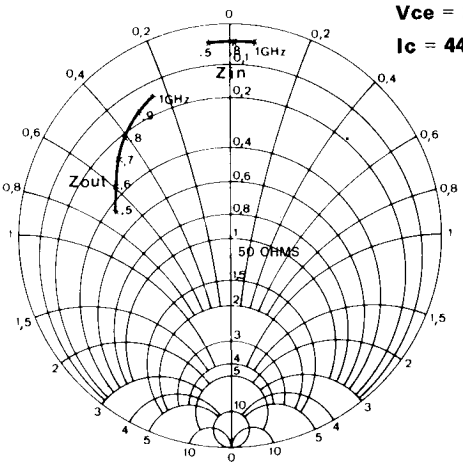
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 40 mA	24			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 40 mA R_{BE} = 10 ohms	50			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA	45			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.45	mA
	h_{FE}	D.C. Current Gain	V_{CE} = 5 V I_C = 200 mA	15		120	
RF Test	IMD 1	Intermodulation Distortion - 3 Tone Vision Carrier = Reference - 8 dB Sound Carrier = Reference - 7 dB Sideband Carrier = Reference - 16 dB	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 1 W		— 60	— 58	dB
	IMD 2	Idem	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 2 W			— 51	dB
	P_G	Power Gain	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 1 W	10.5	11		dB
	VSWR	Mismatch Tolerance	F = 860 MHz V_{CE} = 20 V I_E = 0.44 A P_{REF} = 2 W		∞		
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F = 1 MHz			7	pF
	f_T	Cutoff Frequency	V_{CE} = 20 V I_E = 440 mA	2.2	2.5		GHz
Thermal	I_C	Maximum Collector Current				1.4	A
	0_{JC}	Thermal Resistance Junction - Case	T_{CASE} = 70 °C			9	°C/W
	P_T	Dissipated Power	$T_{HEATSINK}$ = 25 °C			19	W
	T_{STG} T_J	Storage Temperature Junction Temperature		— 65		+ 200	°C

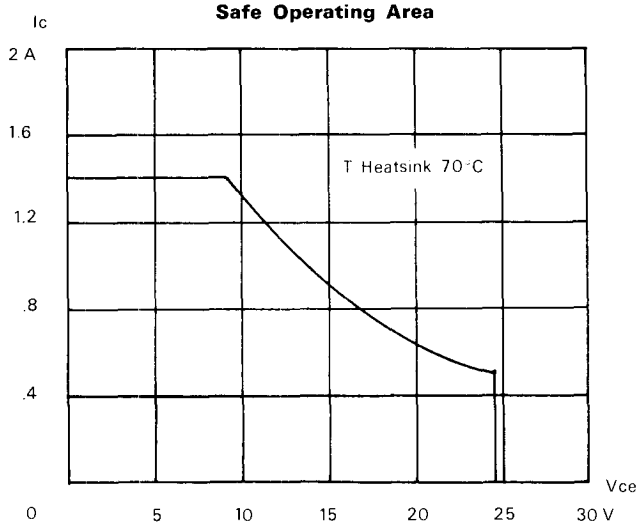
Power Output vs Power Input

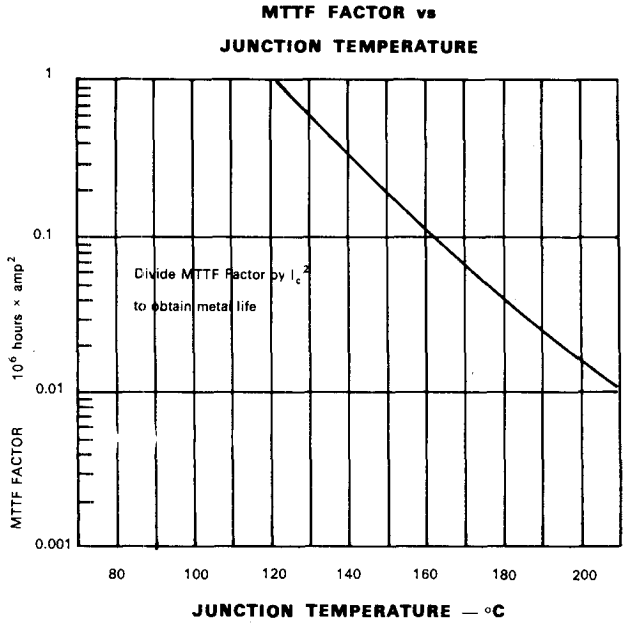


LARGE SIGNAL IMPEDANCES

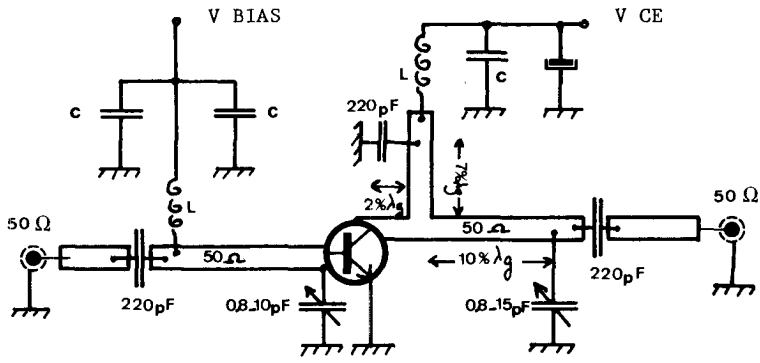
Vce = 20 v
Ic = 440 mA




Safe Operating Area
Ic
2 A
1.6
1.2
.8
.4
0
T Heatsink 70°C
Vce
5
10
15
20
25
30 V

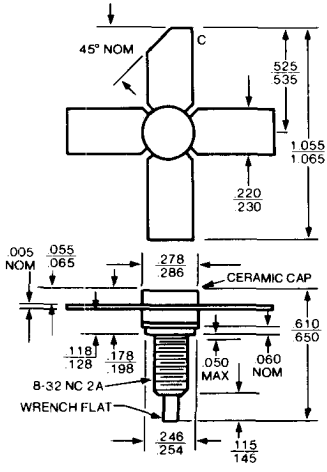

MTTF FACTOR vs
JUNCTION TEMPERATURE
1
0.1
0.01
0.001
MTTF FACTOR
10^6 hours × amp^2
Divide MTTF Factor by Ic^2
to obtain metal life
80
100
120
140
160
180
200
JUNCTION TEMPERATURE — °C

TEST CIRCUIT AT 860 MHz



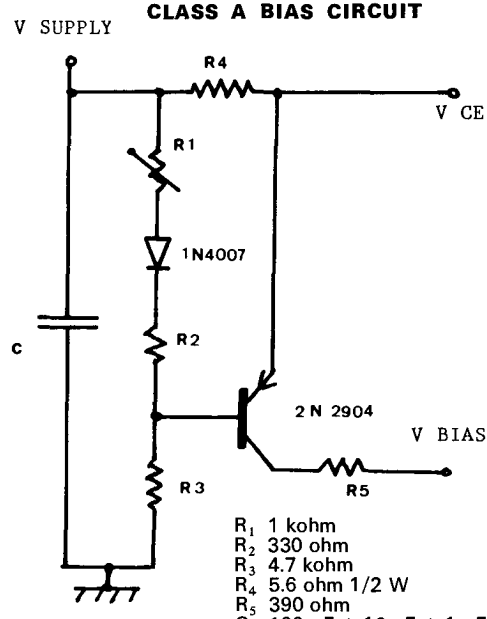
L = 6 turns ID = 1 mm Wire diameter = 0.6 mm
The lengths are given for F = 860 MHz

Package Outline



To convert inches to millimeters multiply by 2.54.

CLASS A BIAS CIRCUIT



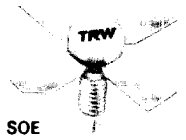
R_1 1 kohm
R_2 330 ohm
R_3 4.7 kohm
R_4 5.6 ohm 1/2 W
R_5 390 ohm
C 100 µF + 10 nF + 1 nF

UHF Linear Transistor

TV TRANSPOSER
BAND 4 & 5
4 W
7 dB GAIN

The TPV 598 is a NPN gold metallized transistor using diffused emitter ballast resistors for super linearity. The chip design using microwave techniques provides over 7 dB gain at 860 MHz.

The TPV 598 is specifically designed for high power band 4 and 5 TV Transposers.



280 SOE

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1 mA	4			V
	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	25			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 10 mA	45			V
	H_{FE}	D.C. Current Gain	V_{CE} = 20 V I_C = 500 mA	10			
RF TEST	IMD	Intermodulation distortion 3 tones : — 8 dB vision — 7 dB sound — 16 dB Sideband	F = 860 MHz V_{CE} = 25 V I_C = 850 mA			— 60	dB
	P_G	Power Gain	P_{REF} = 4 W	7			dB
	C_{OB}	Collector Base Capacitance	V_{CB} = 25 V F = 1 MHz			20	pF
	F_T	Cutoff Frequency	V_{CE} = 25 V I_C = 850 mA		2		GHz
THERMAL	θ_{JC}	Thermal Resistance Junction Case	DC Dissipation Average Temperature T_{case} = 70 °C			5	°C/W
	θ_{JC}	Thermal Resistance Junction Case	High Resolution DC Dissipation T_{case} = 70 °C			6.2	°C/W
	θ_{CH}	Thermal Resistance Case Heatsink			0.4		°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

POLAR S PARAMETERS IN 50 OHMS SYSTEM

F	S 11		S 21		S 12		S 22	
	MAGN	ANGL	MAGN	ANGL	MAGN	ANGL	MAGN	ANGL
100	0.957	181	3.89	99	0.019	35	0.707	190
200	0.957	178	1.97	95	0.019	45	0.724	186
300	0.957	176	1.29	75	0.025	45	0.741	184
400	0.957	174	1.065	68	0.032	50	0.749	184
500	0.957	173	0.86	63	0.035	57	0.746	183
600	0.959	171	0.692	56	0.040	59	0.759	182
700	0.957	170	0.596	49	0.045	59	0.767	182
800	0.955	168	0.537	45	0.050	63	0.785	181
900	0.955	166	0.501	45	0.056	63	0.776	180
1000	0.955	164	0.409	36	0.063	61	0.813	180

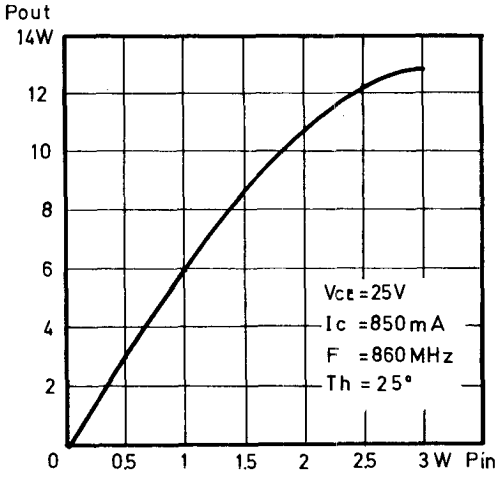
NOTE : V_{CE} = 25 Volts I_C = 850 mA

LARGE SIGNAL IMPEDANCES

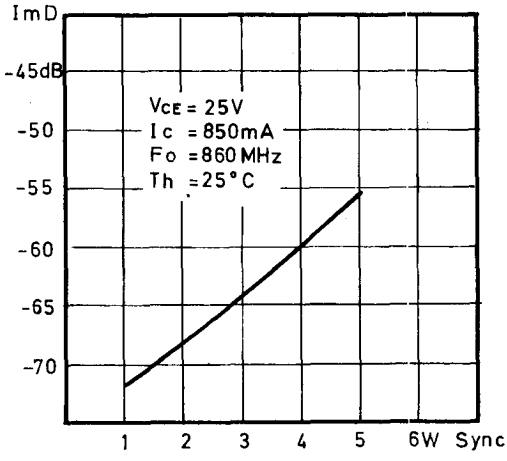
FREQUENCY (MHz)	Z_{in} (Ohms)	Z_{Load} (Ohms)
470	.63 + j .9	11.25 + j 11
550	.63 + j 1.2	8.75 + j 10.5
650	.6 + j 1.5	7 + j 10
750	.5 + j 1.75	6 + j 9.5
860	.45 + j 2.15	3.5 + j 7.5

NOTES : — Z_{in} = Values to get optimum input return loss and gain.
— Z_{Load} = Values to get optimum IMD at 5 W Sync.

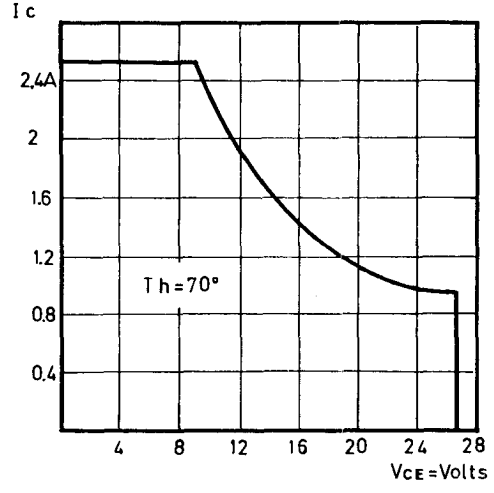
Output Power vs Input Power



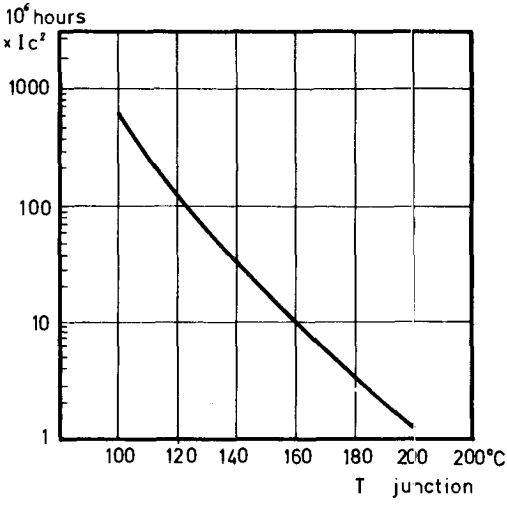
IMD vs Collector Current



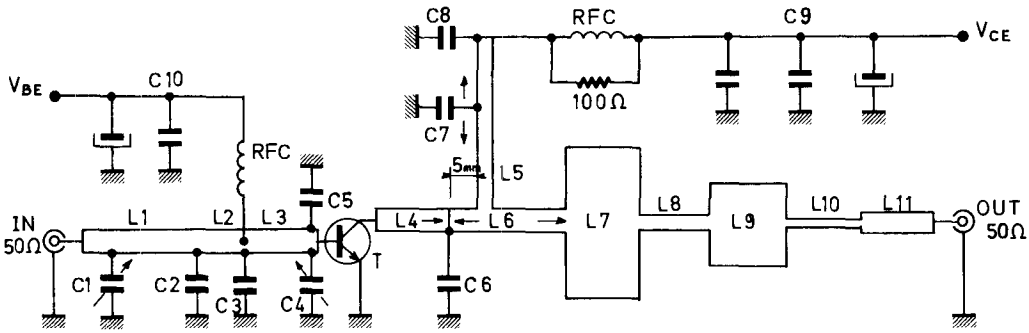
DC Safe Operating Area



MTTF vs Junction Temperature



BROADBAND TEST CIRCUIT

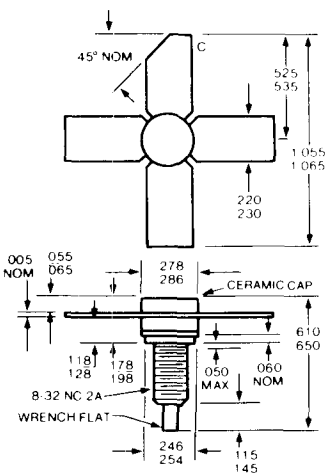


C_1 = VARIABLE .5 - 4.7 pF AIRTRONIC
C_2 = C_3 = ATC 4.7 pF
C_4 = ATC 10 pF + VARIABLE .5 - 4.7 pF AIRTRONIC
C_5 = ATC 10 pF + ATC 5.6 pF
C_6 = ATC 18 pF + .5 - 4.7 pF VARIABLE AIRTRONIC
C_7 = 470 pF CHIP CAPACITOR
C_8 = 1 nF + 10 nF DECOUPLING
C_9 = 1 nF + 10 nF + .1 μF + 10 μF
C_{10} = 10 nF + 1 μF + 10 μF

RFC = 8 turns ID 2.5 mm Wire = .5 mm

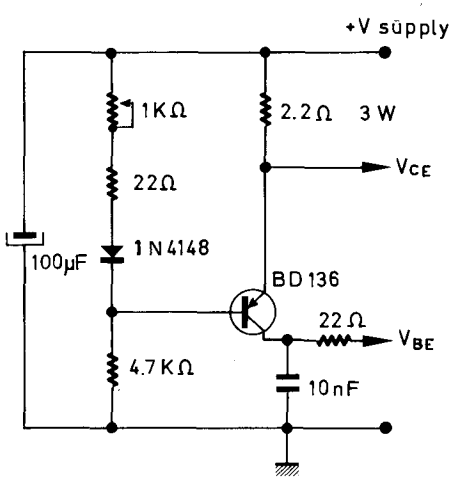
L_1 = 50 Ω line 6.2 % λg at 860 MHz
L_2 = 50 Ω line 4.2 % λg at 760 MHz
L_3 = 50 Ω line 4.9 % λg at 860 MHz
L_4 = 20 Ω line 6.5 % λg at 860 MHz
L_5 = 50 Ω line 5 % λg at 860 MHz
L_6 = 20 Ω line 9.5 % λg at 860 MHz
L_7 = 4 Ω line 8 % λg at 860 MHz
L_8 = 55 Ω line 7.5 % λg at 860 MHz
L_9 = 7.5 Ω line 8 % λg at 860 MHz
L_{10} = 100 Ω line 8 % λg at 860 MHz
L_{11} = 20 Ω line 8 % λg at 860 MHz

Package Outline



To convert inches to millimeters multiply by 2.54

Class a Bias Circuit



PRELIMINARY

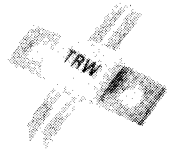
UHF Linear Transistor

TV TRANSMITTER BAND 4 & 5 50 W CLASS AB PUSH-PULL GOLD RELIABILITY

The TPV 5051 is a push-pull device incorporating gold metallized dice and diffused emitter ballast resistors for linearity and ruggedness.

It provides 6.5 dB gain at 50 W and 860 MHz.

The TPV 5051 is specifically designed for high power vision only TV amplifiers operating in Bands IV or V.



BMA-2

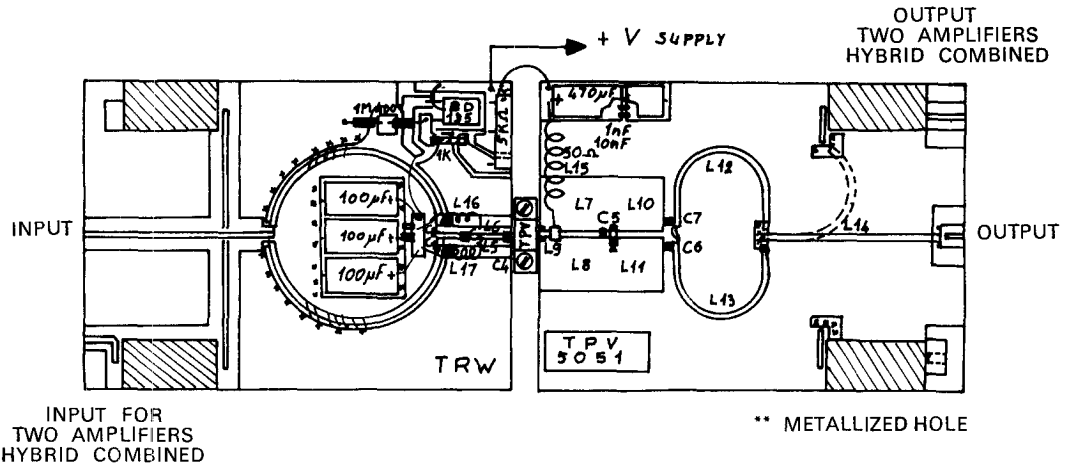
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test each side	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 6 mA	4			V
	BV_{ECO}	Collector Emitter Breakdown Voltage	I_C = 40 mA	30			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 20 mA	45			V
	H_{FE}	D.C Current Gain	V_{CE} = 20 V I_C = 800 mA	10			
RF Test	P_G	Power Gain	V_{CE} = 28 V I_q = 2 X 100 mA F = 860 MHz P_{out} = 50 W	6.5	7		dB
	η_C	Collector Efficiency		45	50		%
Thermal	Cob/Side	Collector - Base Capitance	V_{CB} = 28 V F = 1 MHz			40	pF
	θ_{JC}	Thermal Resistance Junction - Case	— High resolution — T_{case} = 70 °C — Rated output power			1.8	°C/W
	θ_{CH}	Thermal Resistance Case Heatsink			0.2		°C/W
	T_{STG}	Storage Temperature		— 65		+ 200	°C

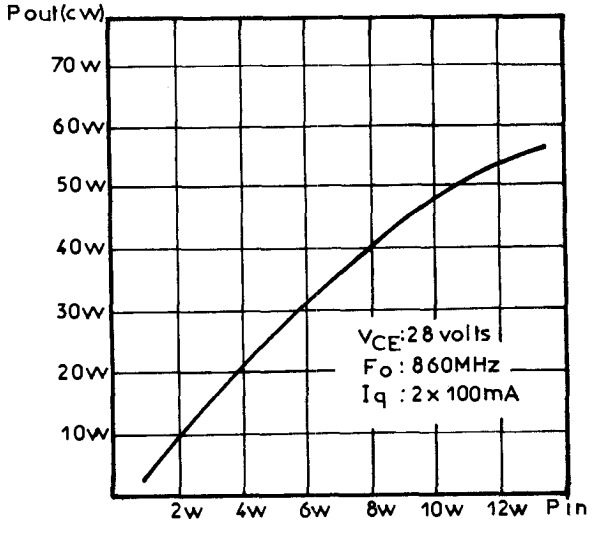
TYPICAL APPLICATION

600-860 MHz BROADBAND AMPLIFIER CLASS A-B

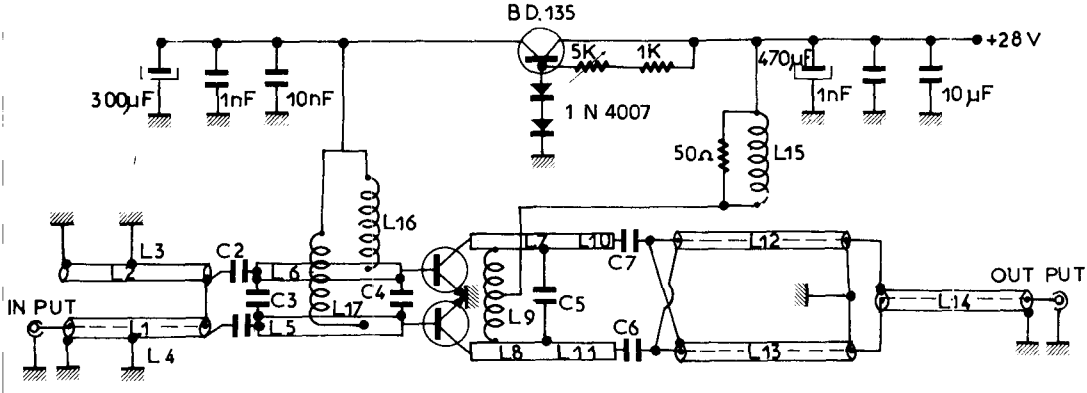
CIRCUIT LAYOUT



TYPICAL OUTPUT POWER US INPUT POWER



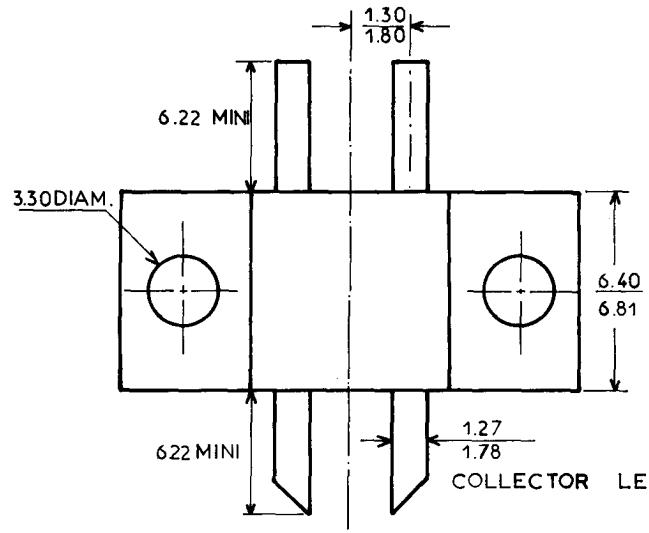
600-860 MHz CIRCUIT DIAGRAM

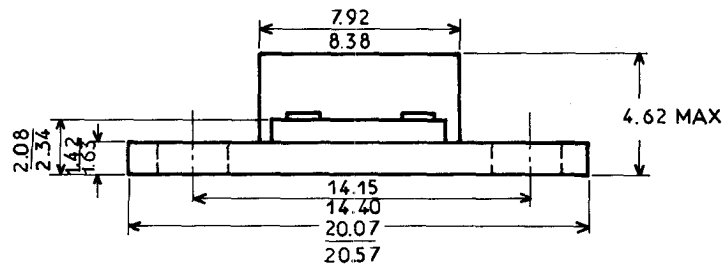


$L_1 = L_2$ = 70 mm of 50 Ω semi rigid coax — ∅ 2.2 mm
$L_3 = L_4$ = 50 Ω micro-strip line — 17 % λ g at 860 MHz
$L_5 = L_6$ = 40 Ω micro-strip line — 6 % λ g at 860 MHz
$L_7 = L_8$ = 10 Ω micro-strip line — 6 % λ g at 860 MHz
L_9 = 2 mm, 6 mm, 2 mm — cooper ribbon
$L_{10} = L_{11}$ = 12 Ω micro-strip line — 6 % λ g at 860 MHz
$L_{12} = L_{13}$ = 25 Ω semi-rigid — 50 mm long
L_{14} = 50 Ω semi-rigid — 47 mm long

$C_1 = C_2$ = 8.2 pF ATC 100 A
C_3 = 2.2 pF ATC 100 A + .5 — 4.5 pF GIGATRIM TRIMMER
C_4 = 12 pF + 4.7 pF ATC 100 A
C_5 = 10 pF ATC 100 A + .5 — 4.5 pF GIGATRIM TRIMMER
$C_6 = C_7$ = 100 pF ATC 100 A
L_{15} = 3 turns — wire 1 mm — ID 5 mm
$L_{16} = L_{17}$ = 6 turns — wire .5 mm — ID 2 mm

PACKAGE OUTLINE





DIMENSIONS GIVEN IN mm

MICROWAVE

MICROWAVE POWER TRANSISTORS

PRODUCT SUMMARY

LINEAR MICROWAVE TRANSISTORS			PAGE
TRW 52601/602/604	2 GHz	TO 6 W	I-469 à 477
TRW 53601/602	3 GHz	0,8 AND 1,6 W	I-481 à 485
TRW 54601	4 GHz	0,5 W	I-489

MICROWAVE OSCILLATOR TRANSISTORS			
TRW 62601	2 GHz	1.2 W	I-493
TRW 62602	2 GHz	2 W	I-497
TRW 63601	3 GHz	430 mW	I-501
TRW 63602	3 GHz	850 mW	I-505
TRW 64601	4 GHz	300 mW	I-509
TRW 64602	4 GHz	600 mW	I-513

LINEAR BROADBAND FOR DIGITAL LINKS			
LN 2023-2	2-2.3 GHz	2 W at 1 dB compression	I-387
LN 2327-2	2.3-2.7 GHz	2 W	I-391

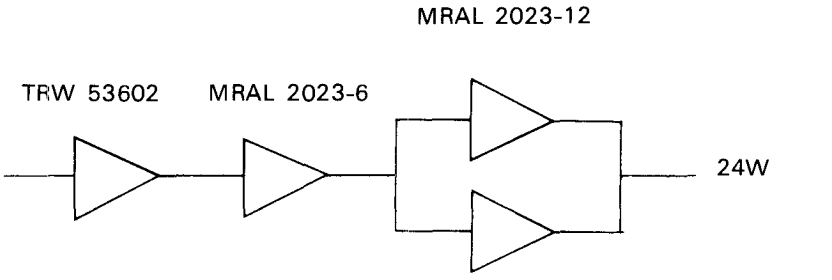
MICROWAVE POWER TRANSISTORS			
2 N 4429/4430/4431	1 GHz	TO 5 W	I-383
TRW 2001/03/05/10/15/20	2 GHz	TO 20 W	I-441
TRW 2301/04/07	2.3 GHz	TO 7 W	I-453 à 455
TRW 2001/03/05	3 GHz	TO 5 W	I-457
TRW 4001/02/04	4 GHz	TO 4 W	I-465

BROADBAND MICRO AMP'S			
MRA 0610-SERIES	0.6-1.0 GHz	TO 40 W	I-395
MRA 1014-SERIES	1.0-1.4 GHz	TO 35 W	I-403
MRA 1417-SERIES	1.4-1.7 GHz	TO 25 W	I-412
MRA 1720-SERIES	1.7-2.0 GHz	TO 20 W	I-419
MRAL 2023-SERIES	2.0-2.3 GHz	TO 12 W	I-427
MRAL 3742-SERIES	2.3-2.7 GHz	TO 12 W	I-435

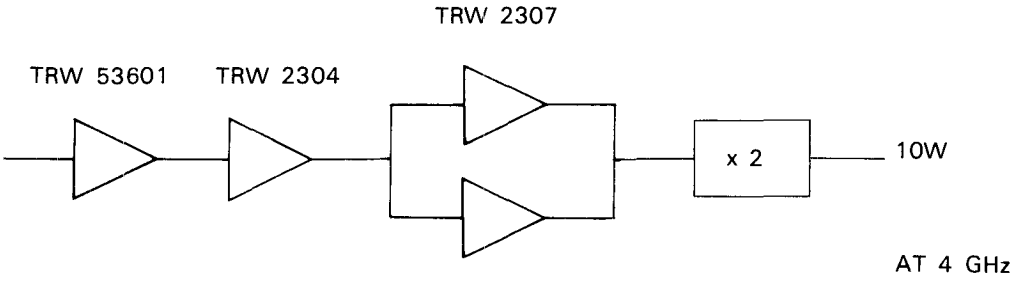
MICROWAVE

LINE-UP SUGGESTIONS

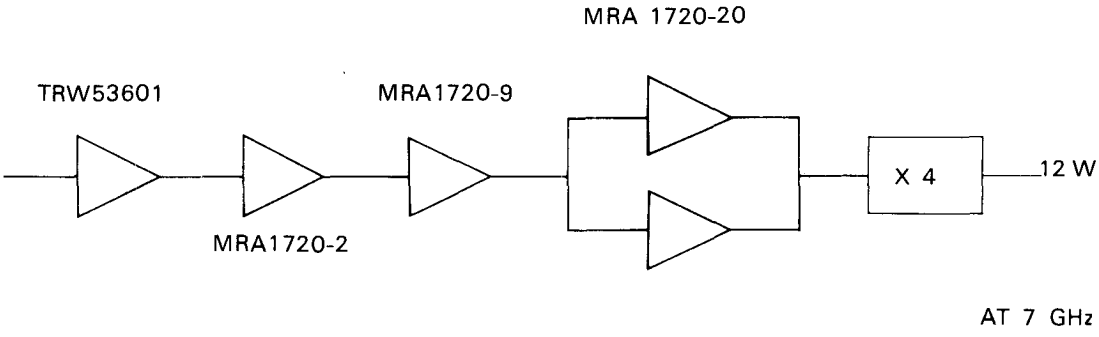
2 GHz FUNDAMENTAL



4 GHz MULTIPLICATION



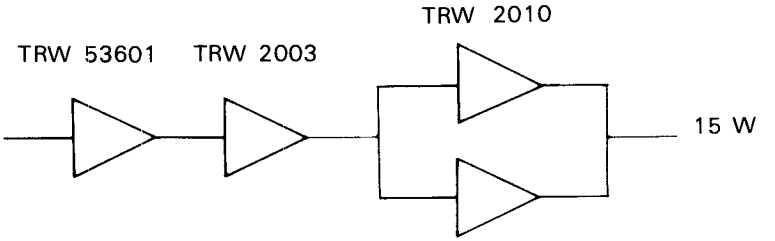
7 GHz MULTIPLICATION



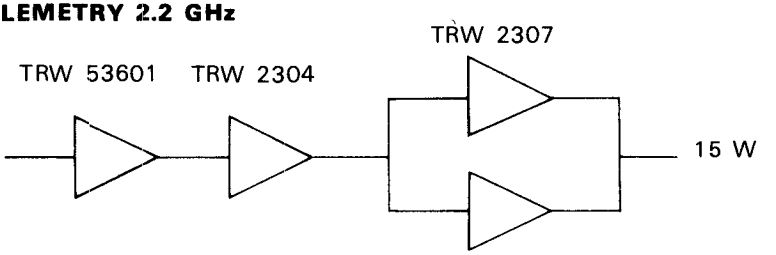
MICROWAVE

LINE-UP SUGGESTIONS

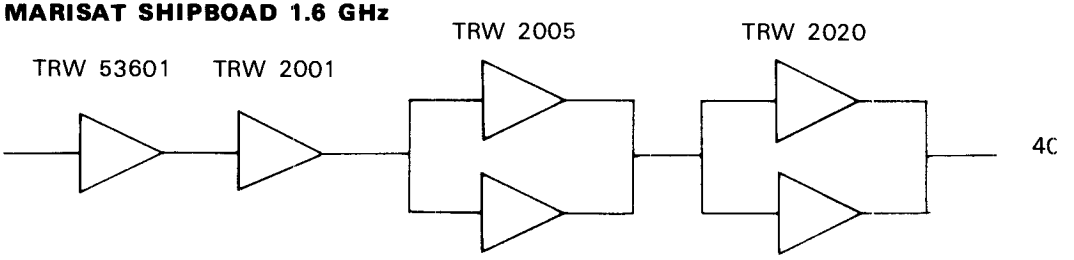
L BAND TELEMETRY 1.4 GHz



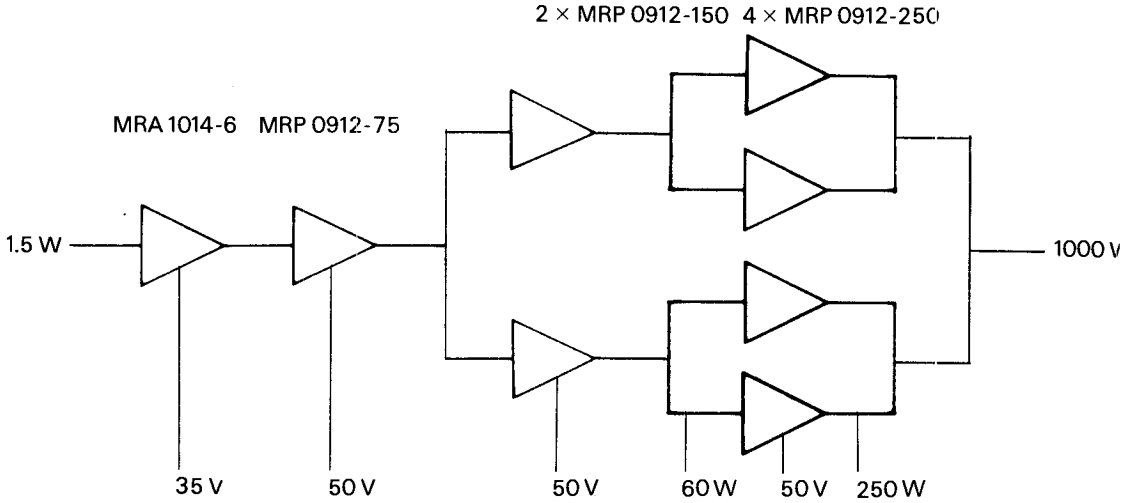
S BAND TELEMETRY 2.2 GHz



MARISAT SHIPBOAD 1.6 GHz



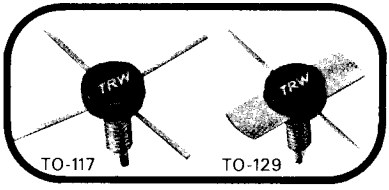
DME - TACAN AIRCRAFT 960 - 1215 MHz - 1 kW



Microwave Power Transistors

2 N 4429 - 1 W
2 N 4430 - 3 W
2 N 4431 - 5 W

These are the first series of high power gigahertz transistors introduced in 1966 and in continuous production since that time.

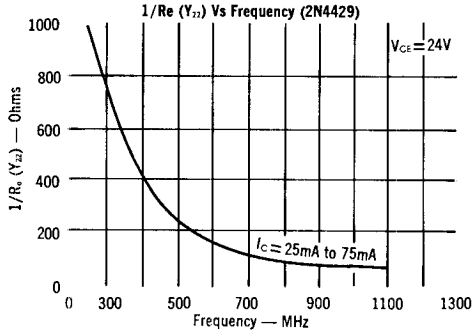


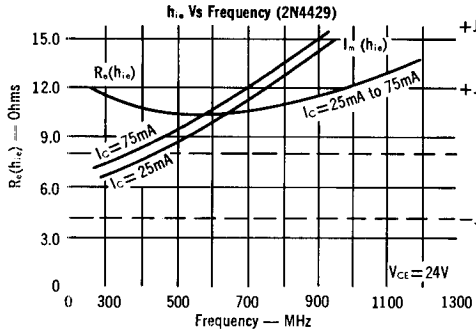
Electrical Characteristics (T_{stud} = 25 °C)

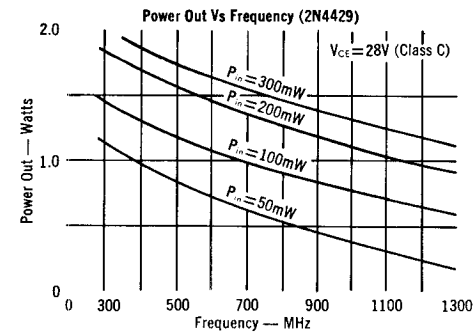
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS		2N4431 Min.	2N4431 Max.	2N4430 Min.	2N4430 Max.	2N4429 Min.	2N4429 Max.
DC Tests	I_{CEX}	Collector Cutoff Current	V_{CE} = 55 V	V_{BE} = — 1.5 V		4.0 mA		2.0 mA		1.0 mA
	V_{CEO}	Collector to Emitter Voltage	I_C = 50 mA I_C = 20 mA	I_b = 0 I_b = 0	40 V		40 V		35 V	
	V_{CER}	Collector to Emitter Voltage	R = 10 Ω R = 10 Ω	I_C = 50 mA I_C = 20 mA	55 V		55 V		55 V	
	V_{EBO}	Emitter to Base Voltage	I_e = 0.50 mA I_e = 0.20 mA I_e = 0.10 mA		3.5 V		3.5 V		3.5 V	
	h_{FE}	DC Current Gain	V_{CE} = 5 V V_{CE} = 5 V	I_C = 100 mA I_C = 50 mA	20	200	20	200	20	200
RF Tests	f_t	Gain-Bandwidth Product Measured at 200 MHz	V_{CE} = 20 V V_{CE} = 20 V	I_C = 100 mA I_C = 50 mA	600 MHz		600 MHz		700 MHz	
	C_{ob}	Collector to Base Capacitance	V_{CB} = 28 V	f = 1.0 MHz		10 pF		5.0 pF		3.5 pF
	P_{out}	Power Output V_{CE} = 28 Volts n = Collector Efficiency > 35 %	f = 1000 MHz f = 1000 MHz f = 1000 MHz	P_{in} = 1.57 W P_{in} = 750 mW P_{in} = 300 mW	5.0 W		2.5 W		1.0 W	
Operating	I_C	Continuous Collector Current			2.0 A		1.0 A		425 mA	
	P_T	Total Dissipation at 25 °C Stud			18 W		10 W		5.0 W	
	θ_{JC}	Thermal Resistance (Junction to Stud)			9.7 °C/W		17.5 °C/W		35 °C/W	
	T_{stg}	Storage Temperature			— 65 to 200 °C		— 65 to 200 °C		— 65 to 200 °C	
	T_J	Junction Temperature			— 65 to 200 °C		— 65 to 200 °C		— 65 to 200 °C	

Typical Performance Characteristics

2 N 4429

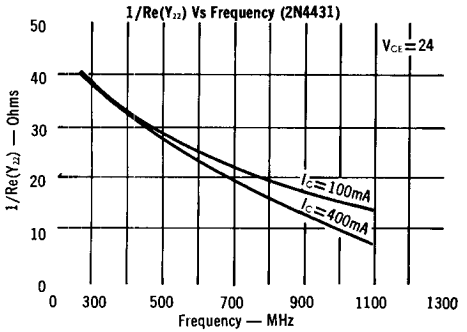


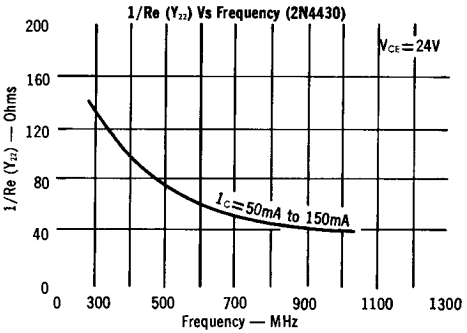


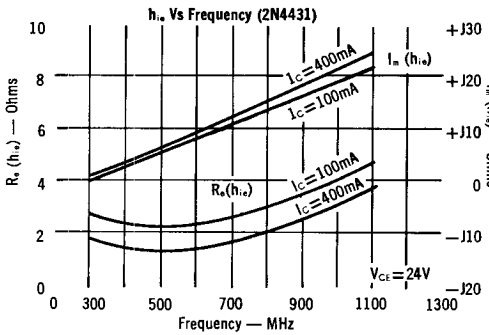


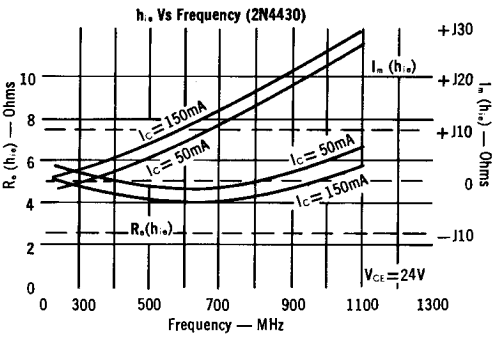
Typical Performance Characteristics

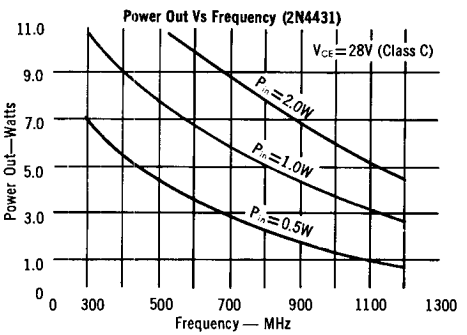
2 N 4431/2 N 4430

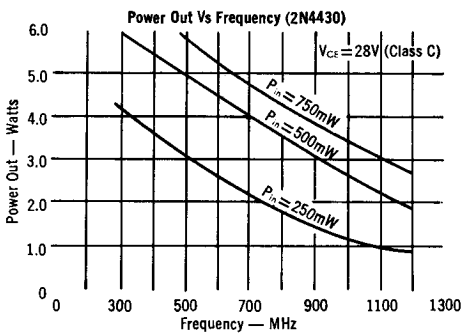






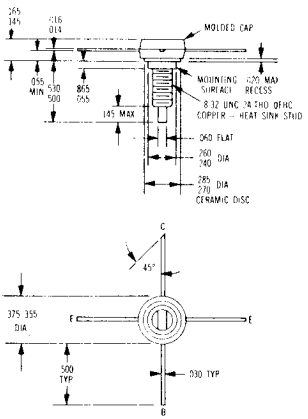




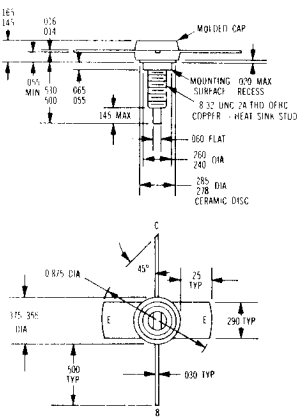


Case Drawings and Test Circuits

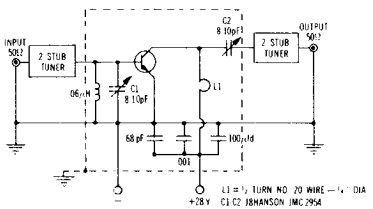
UHF Low Profile Package (2N4429)



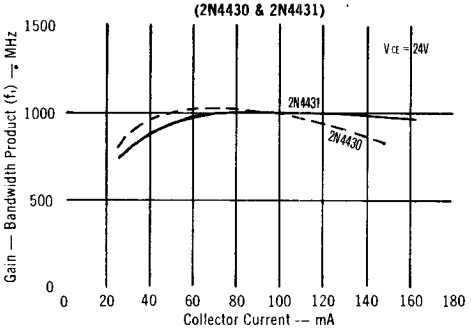
UHF Stripline Package (2N4431/2N4430)



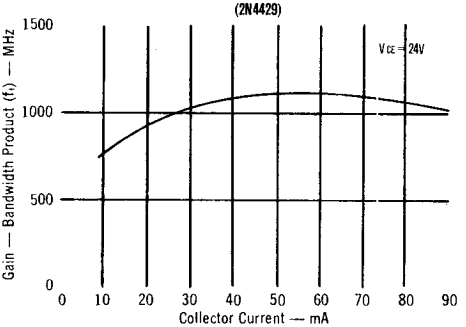
1.0 GHz Test Circuit (2N4431/2N4430/2N4429)



Gain — Bandwidth Product Vs Collector Current (2N4430 & 2N4431)



Gain — Bandwidth Product Vs Collector Current (2N4429)



PRELIMINARY

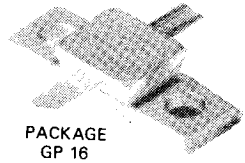
Microwave Linear Transistor

The LN 2023-2 is a broadband class AB device designed for Telecommunication and Radio Relay Industries.

The LN 2023-2 is housed in an hermetic package with internal input and output matching structure.

The transistor cells are gold metallized, the emitters are ballasted with diffused resistors, the base and the emitter are ion-implanted for high gain, a base depletion ring is used for higher breakdown voltage, and the low resistivity graded EPI configuration allows high saturated output power and efficiency.

BROADBAND CLASS AB TRANSISTOR



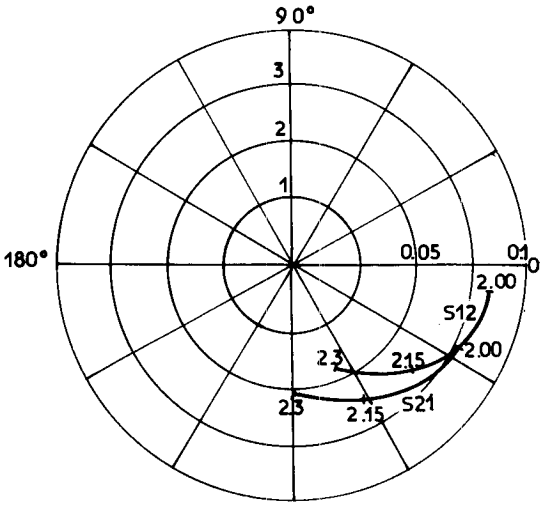
PACKAGE GP 16

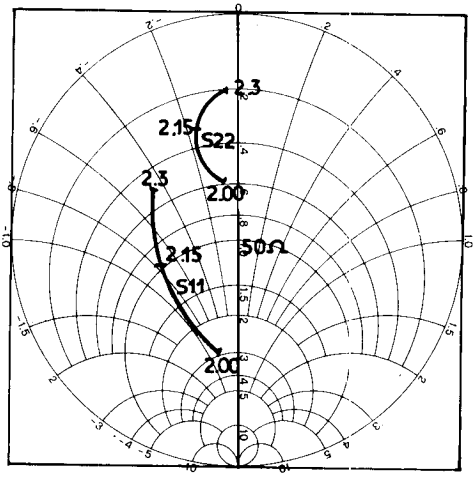
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_c = 20 mA	20			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_c = 2 mA	40			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_e = 1 mA	3.5			V
	I_{CBO}	Collector Cutoff Current	I_c = 0, V_{Ce} = 20 V			4	mA
	h_{FE}	Forward Current Transfer Ratio.	V_{ce} = 5 V, 100 mA	5			
RF Test	P_{out}	Minimum Broadband Output Power	V_{ce} = 16 V, I_c = 20 mA P_{in} = 200 W F = 2.0 — 2.3 GHz	1			W
	P_{1dB}	Minimum Broadband Out-power at 1_{dB} compression	V_{ce} = 16, I_c = 20 mA P_{in} = 550 mW F = 2.0 — 2.3 GHz	2.3			W
	η_C	Broadband Collector Efficiency	V_{ce} = 16 V, I_c = 20 mA P_{in} = 550 mW F = 2.0 — 2.3 GHz	40			%
	L_R	Max. Broadband Return loss in Recomm. Circuit	V_{ce} = 16 V, I_c = 20 mA P_{in} = 650 mW F = 2.0 — 2.3 GHz			— 8	dB
Thermal	I_C	Max. Collector Current				0.6	A
	P_{diss}	Dissip. Power	T_{case} = 75 °C			6.5	W
	θ_{jc}		T_{case} = 100 °C			16	°C/W
	T_{STG}			— 65		200	°C

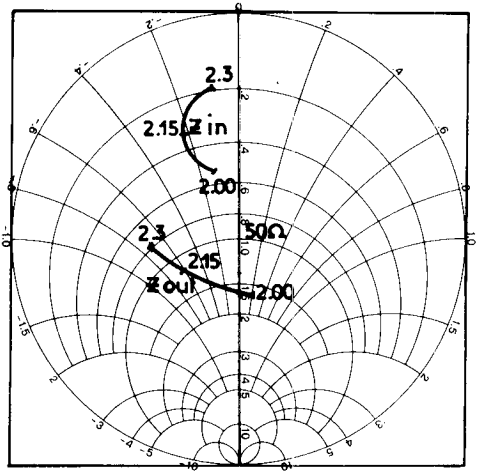
S — PARAMETERS

V_{ce} = 15 V I_c = 100 mA

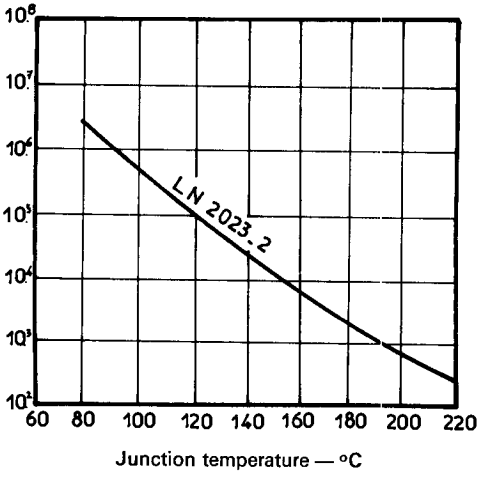




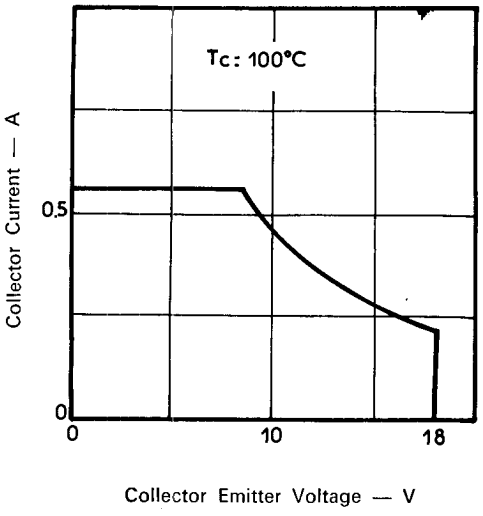
Impedance Data



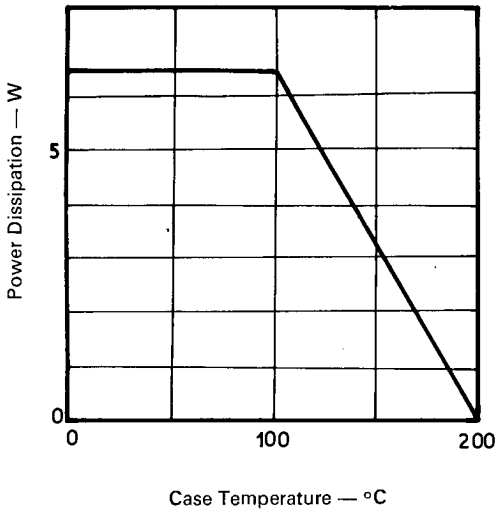
MTTF Factor
(normalized to 1 × Amp.^{2})



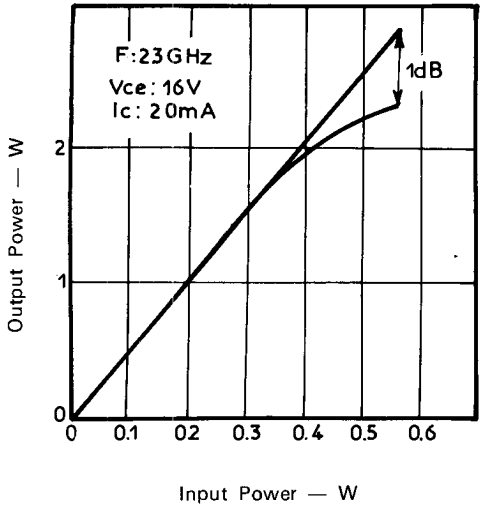
Safe Operating Area



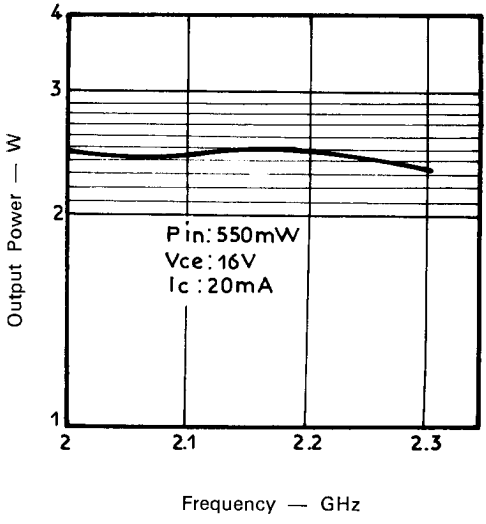
Dissipation Derating Curve



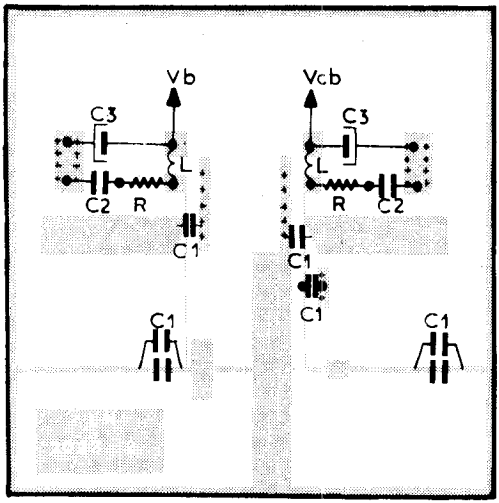
Output Power vs Input Power



Ouput Power vs Frequency

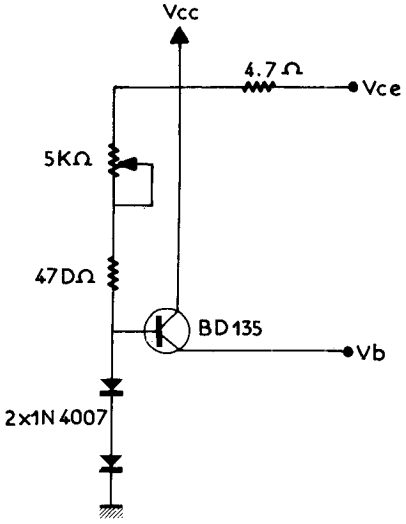


TEST CIRCUIT BOARD
2.0 — 2.3 GHz

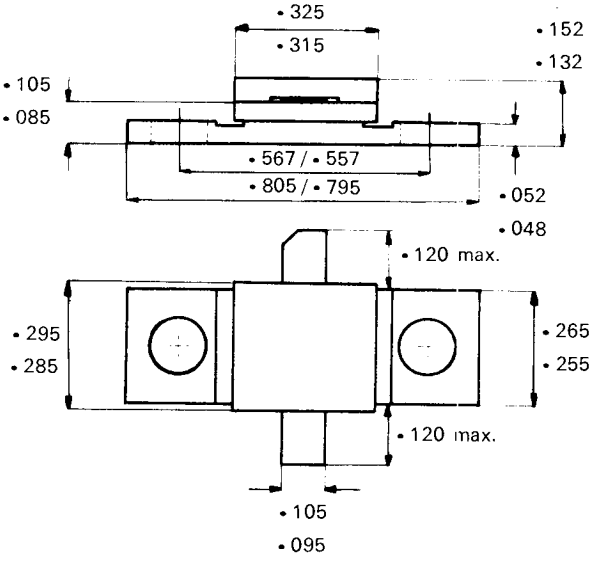


C_1 = 100 pF chip (ATC 100 A Capacitor)
C_2 = .250 μ chip capacitor
C_3 = 43 μ F »
L = RF choke 6 turns.
R = 10 Ohms
\+ Foil Wrap or plate around to ground plane.

Class AB Bias Circuit



Package GP 16



PRELIMINARY

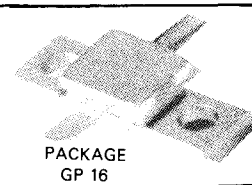
Microwave Linear Transistor

BROADBAND CLASS AB TRANSISTOR

The LN 2327-2 is a broadband class AB device designed for Telecommunication and Radio Relay Industries.

The LN 2327-2 is housed in an hermetic package with internal input and output matching structure.

The transistor cells are gold metallized, the emitters are ballasted with diffused resistors, the base and the emitter are ion-implanted for high gain, a base depletion ring is used for higher breakdown voltage, and the low resistivity graded EPI configuration allows high saturated output power and efficiency.



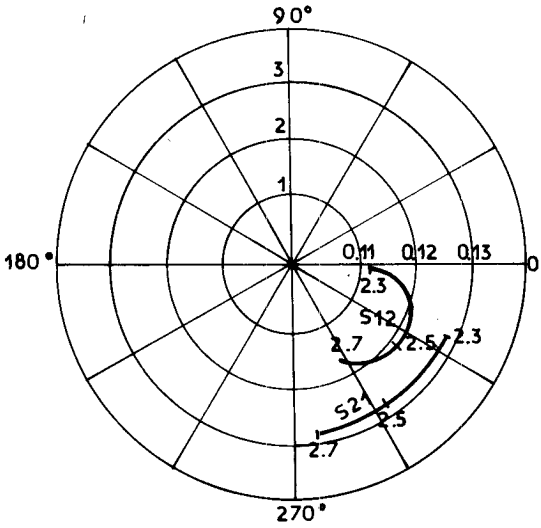
PACKAGE
GP 16

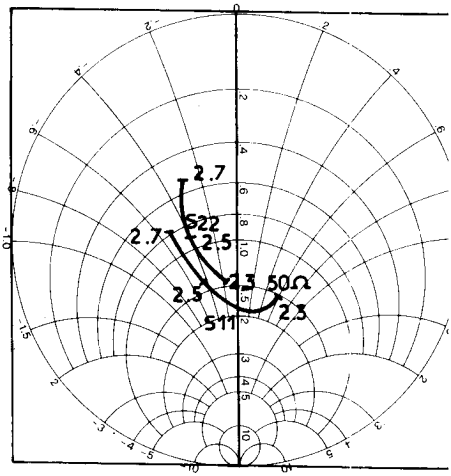
Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_c = 20 mA	20			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_c = 2 mA	40			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_e = 1 mA	3.5			V
	I_{CBO}	Collector Cutoff Current	I_e = 0, V_{ce} = 20 V			4	mA
	h_{FE}	Forward Current Transfer Ratio	V_{ce} = 5 V, 100 mA	5			
RF Test	P_{out}	Minimum Broadband Output Power	V_{ce} = 16 V, I_c = 20 mA P_{in} = 220 mW F = 2.3 — 2.7 GHz	1			W
	P_{1dB}	Minimum Broadband Out-power at 1_{dB} compression	V_{ce} = 16 V, I_c = 20 mA P_{in} = 650 mW F = 2.3 — 2.7 GHz	2.3			W
	η_c	Broadband Collector Efficiency	V_{ce} = 16 V, I_c = 20 mA P_{in} = 650mW F = 2.3 — 2.7 GHz	35			%
	L_R	Max. Broadband Return loss in Recomm. Circuit	V_{ce} = 16 V, I_c = 20 mA P_{in} = 650 mW F = 2.3 — 2.7 GHz			— 8	dB
Thermal	I_c	Maximum Collector Current				0.6	A
	P_{diss}	Dissip. Power	T_{case} = 75 °C			6.5	W
	θ_{jc}		T_{case} = 100 °C			16	°C/W
	T_{STG}			— 65		200	°C

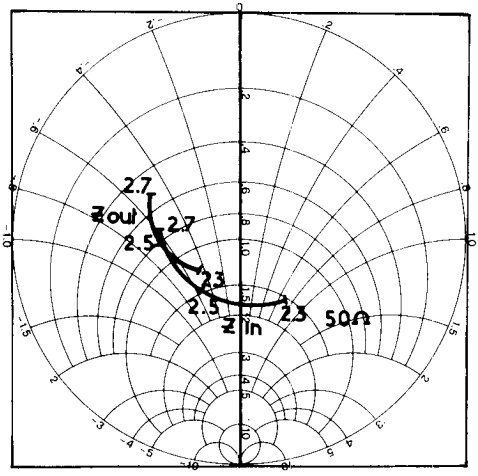
S — PARAMETERS

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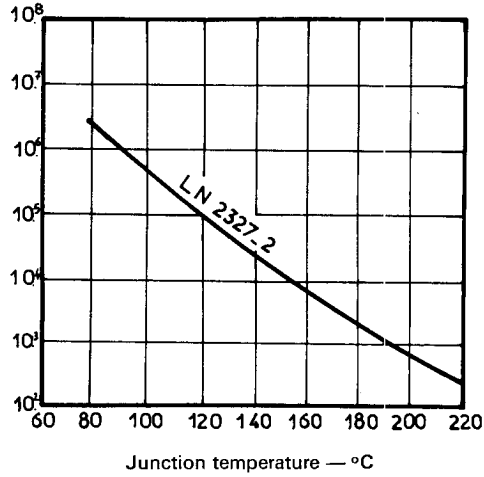




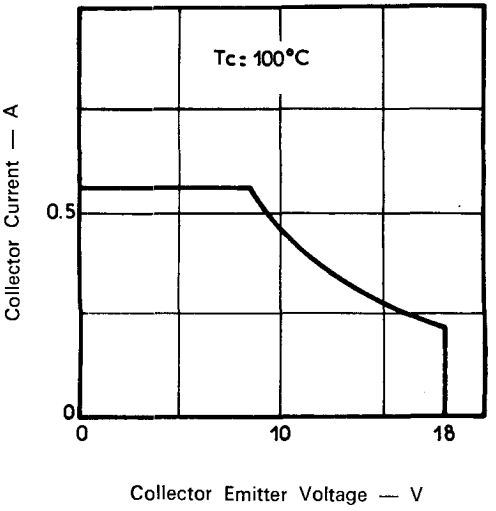
Impedance Data



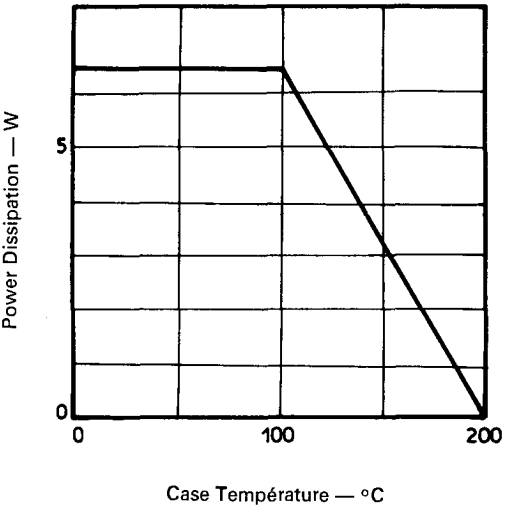
MTTF Factor (normalized to 1 × Amp.^{2})



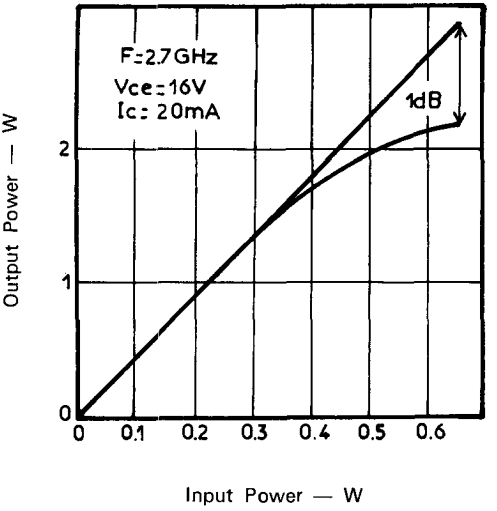
Safe Operating Area



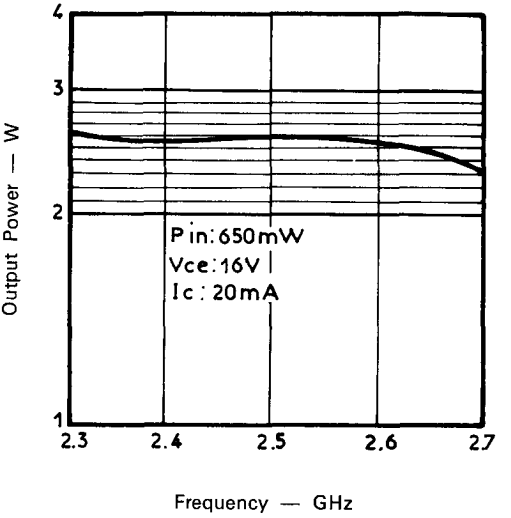
Dissipation Derating Curve



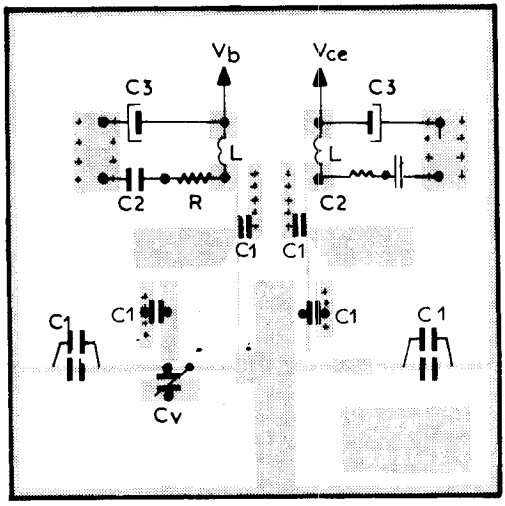
Ouput Power vs Input Power



Output Power vs Frequency

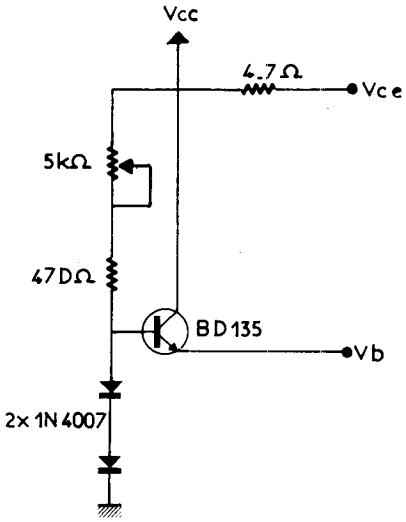


TEST CIRCUIT BOARD
2.3 — 2.7 GHz

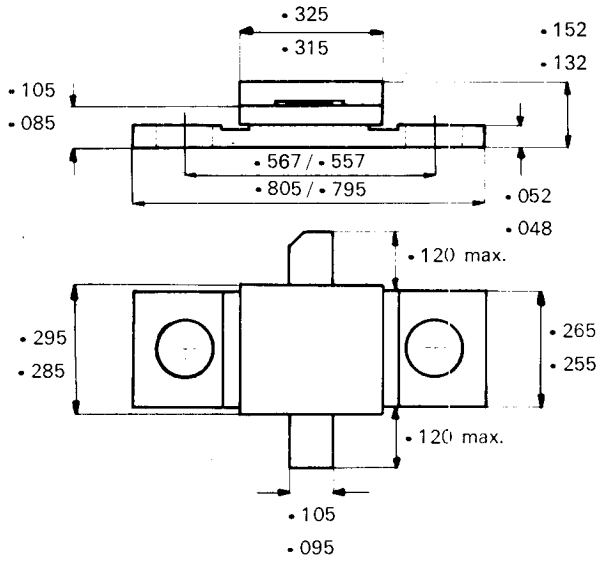


C_1 = 100 pF chip (ATC 100 A Capacitor)
C_2 = .250 µ chip capacitor
C_3 = 43 µ F »
L = RF choke 6 turns.
R = 10 Ohms
+ Foil Wrap or plate around to ground plane.

Class AB Bias Circuit



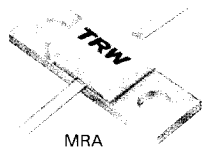
Package GP 16



MICROAMP

MRA 0610-3
MRA 0610-9
MRA 0610-18
MRA 0610-40

- 3-9-18-40 Watts
- Broadband 600-1000 MHz
- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data



MRA

Electrical Characteristics (T_{flange} = 25 °C)

Symbol	Characteristic	MRA0610-3	MRA0610-9	MRA0610-18	MRA0610-40
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 60 mA 50 V Min	I_C = 100 mA 50 V Min	I_C = 200 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_B = 0.5 mA 3.5 V Min	I_B = 1.25 mA 3.5 V Min	I_E = 2.5 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA	V_{CB} = 28 V 1.5 mA	V_{CB} = 28 V 2.5 mA	V_{CB} = 28 V 5.0 mA
		V_{CB} = 45 V 1.0 mA	V_{CB} = 45 V 3.0 mA	V_{CB} = 45 V 5.0 mA	V_{CB} = 45 V 10.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.5 A	5.0 A	10.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.3 A 10-100	I_C = 0.5 A 10-100	I_C = 1.0 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	6 °C/W	4 °C/W	2.5 °C/W
P_o	Min Broadband Power Output	3.0 W	9.0 W	18.0 W	40.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	10 pF	14 pF	28 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 3.0 W 7.8 dB	P_o = 9.0 W 7.8 dB	P_o = 18.0 W 7.8 dB	P_o = 40.0 W 7.0 dB
MTTF	Metal Failure Factor Hrs × Amps^2 T_j = 150 °C*	60,692	546,227	1,517,298	6,069,192
η_c	Min Broadband Collector Efficiency	P_o = 3.0 W 50 %	P_o = 9.0 W 55 %	P_o = 18.0 W 55 %	P_o = 40.0 W 55 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* Based on Black's equation and using φ = 0.96 EV, $\beta = 1.07 \times 10^{-12}$ for unpassivated Au. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, inc. (US ≠ 3,713,006).

The TRW MRA0610 series offers a complete family of broadband, high-gain transistors for applications in the 600-1000MHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA0610 series is intended for use in a variety of military and industrial applications including ECM, radio relay and the "960" mobile band for fixed station use.

The smooth, broadband transfer characteristics of the MRA0610 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 3, 9, 18 and 40 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as 10KW/CM², extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA0610 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA0610 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

METALIZATION AND RELIABILITY

Metal migration is the main concern when considering a metal system. In fine geometry devices such as microwave transistors, the use of aluminum having sufficiently large grain size to provide an activation energy equal to that of gold is not possible since geometrical definition would be impossible. In order to adequately define small geometries, one must use aluminum with a grain size (1 micron or less) which has a very unattractive activation energy. Activation energy has an exponential relationship to metal migration.

A fair comparison of two metal systems (aluminum versus gold) would be to construct the same transistor using both metal systems and calculate the anticipated metal failure point using Black's equation. The following example is based upon the same transistor cell as is used in the TRW MRA0610 series.

Junction Temperature	Times Improvement of MTTF with Gold vs Aluminum
100°C	691
125°C	370
150°C	168
175°C	56
200°C	30

For this reason, TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRA0610 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

Parasitic reactances (primarily due to the package) become increasingly more significant past 200MHz and impose severe limitations on band width past 1GHz. Additionally, the real component of input Z(R_{bb}) becomes smaller as higher drive power and higher power outputs are achieved.

Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

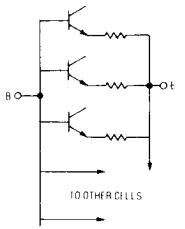


Figure 1. Elementary Method of Cell Combining

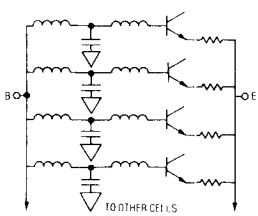


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

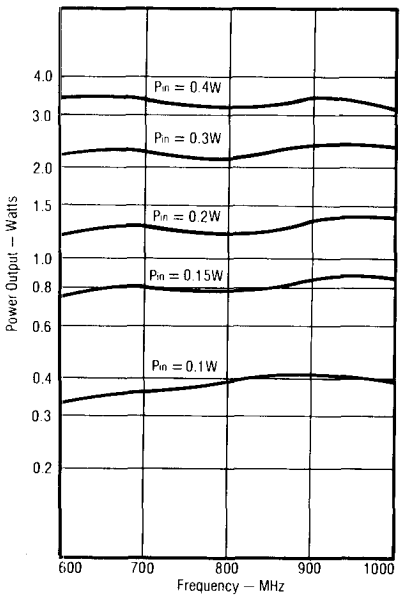
Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

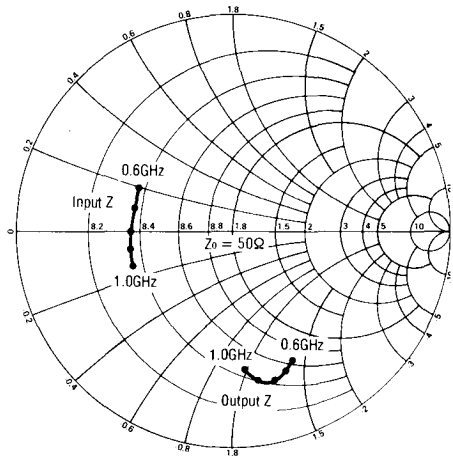
*TRW U.S. Patent #3,713,006

MRA0610-3 — 3 WATTS BROADBAND

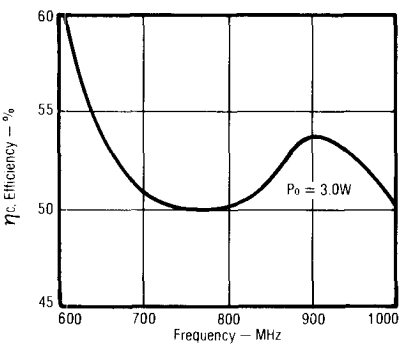
Typical Power Output vs Frequency



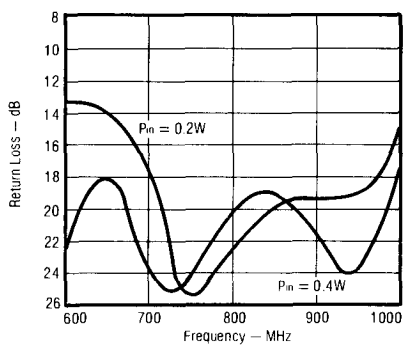
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

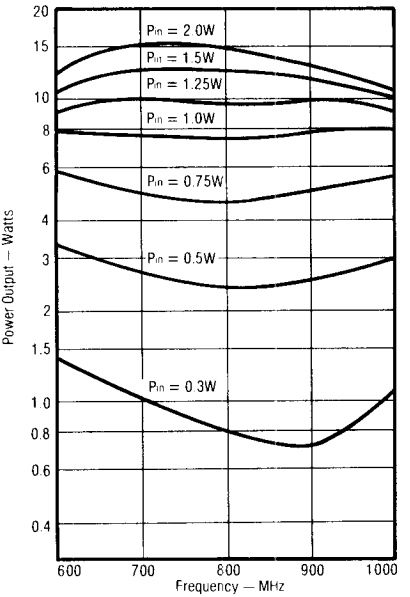


Typical Return Loss vs Frequency

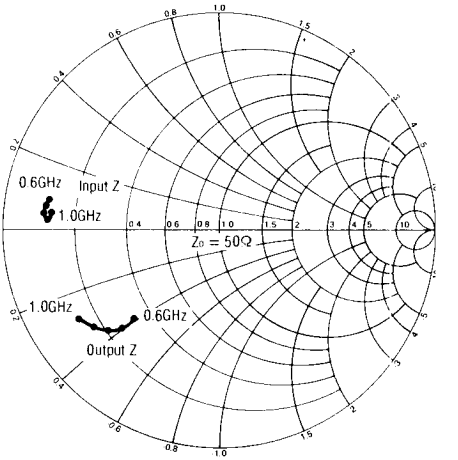


MRA0610-9 — 9 WATTS BROADBAND

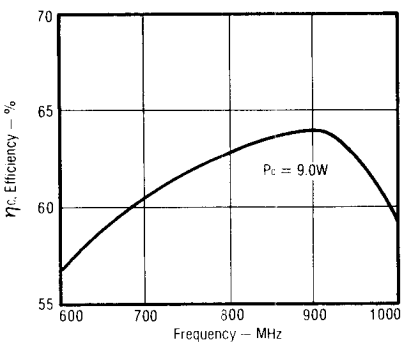
Typical Power Output vs Frequency



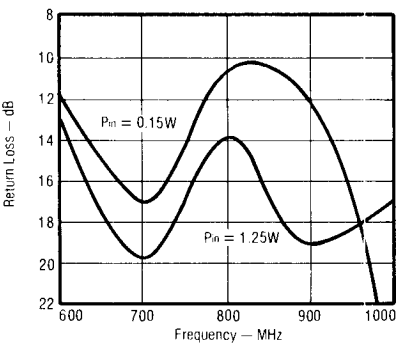
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

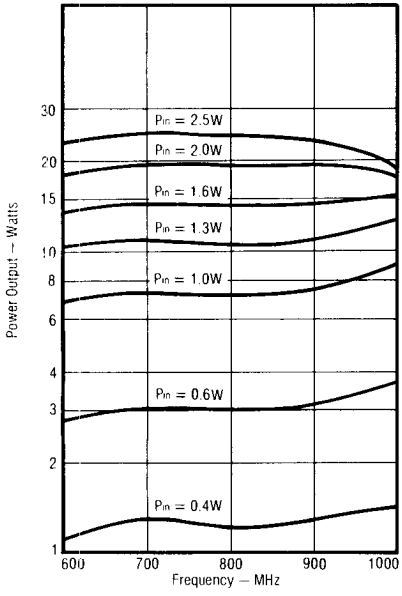


Typical Return Loss vs Frequency

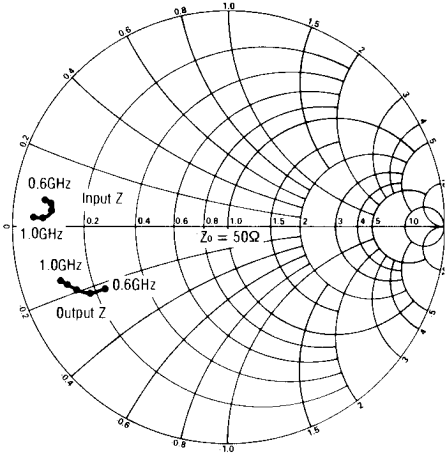


MRA0610-18 — 18 WATTS BROADBAND

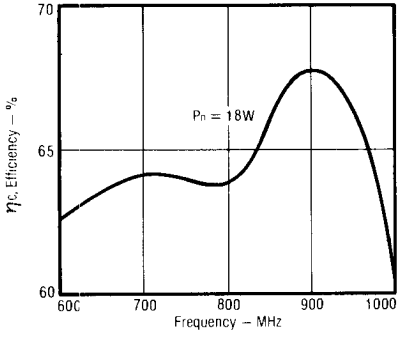
Typical Power Output vs Frequency



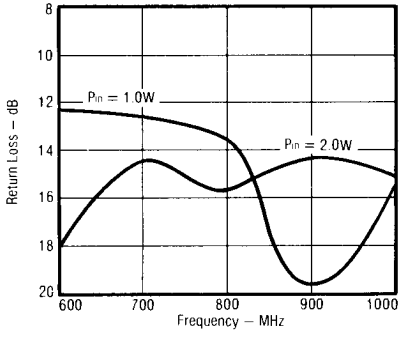
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

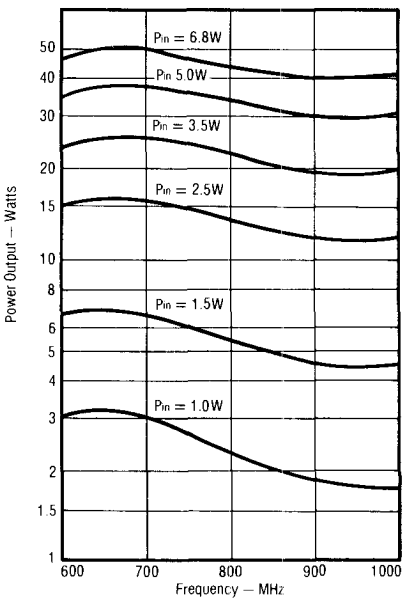


Typical Return Loss vs Frequency

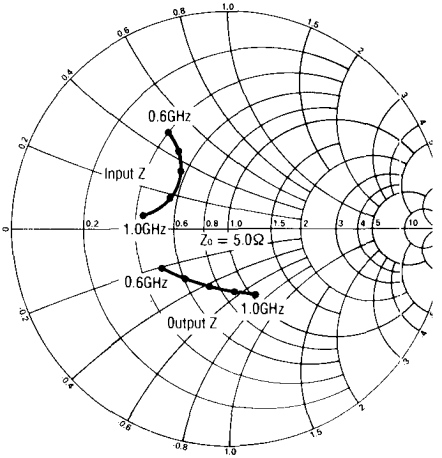


MRA0610-40 — 40 WATTS BROADBAND

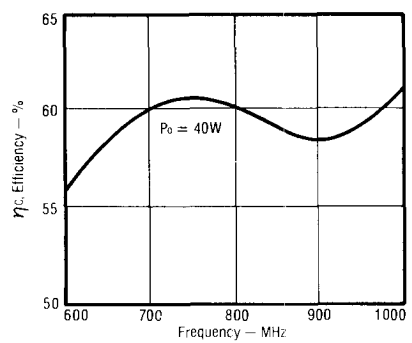
Typical Power Output vs Frequency



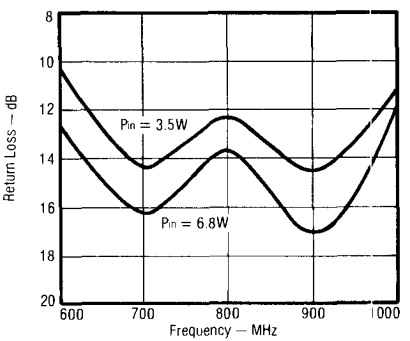
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

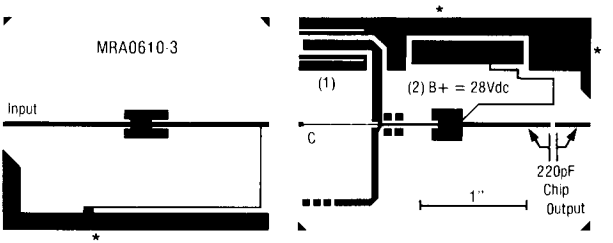


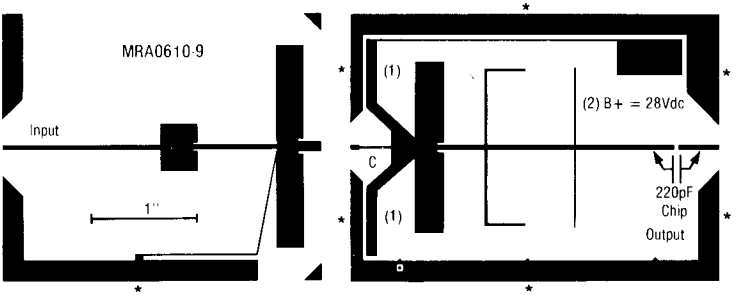
Typical Return Loss vs Frequency

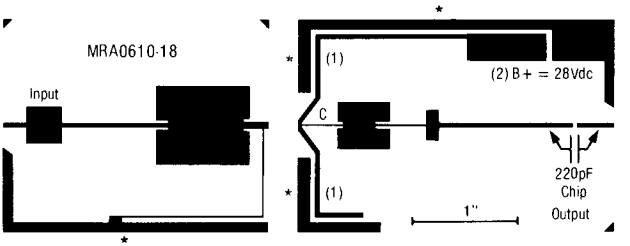


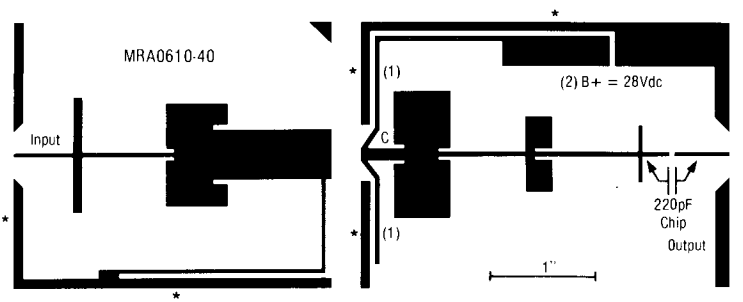
TEST CIRCUIT BOARDS FOR MRA0610 SERIES

NOTE: Scale is not 1:1.









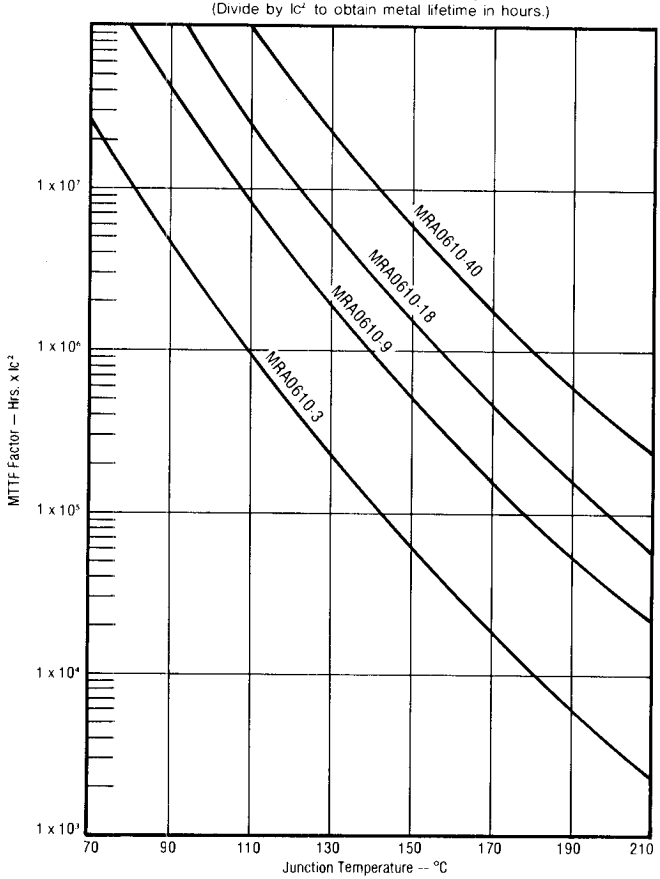
*Foil wrap or plate around to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

(1) Bypass capacitor to ground for shunt inductor (220pF chip).

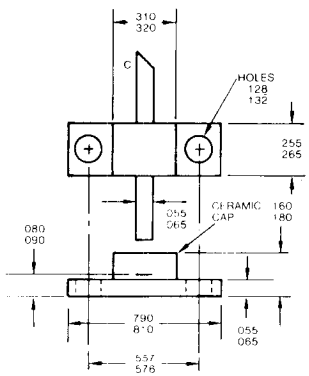
(2) Use B+ bypass of 0.01 and 1μF capacitors at this point.

MTTF FACTOR vs T_j

(Divide by I_C^2 to obtain metal lifetime in hours.)



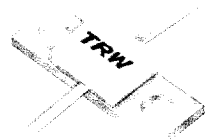
MRA Series Package



MICROAMP

- 2-6-12-35 Watts
- Broadband 1000-1400 MHz
- Internally Compensated*
- Gold Metalized
- Diffused Ballast Resistors
- MTTF Data

MRA 1014-2
MRA 1014-6
MRA 1014-12
MRA 1014-35



MRA

Electrical Characteristics (T_{flange} = 25 °C)

Symbol	Characteristic	MRA1014-2	MRA1014-6	MRA1014-12	MRA1014-35
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 40 mA 50 V Min	I_C = 80 mA 50 V Min	I_C = 200 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_E = 0.5 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.5 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA	V_{CB} = 28 V 1.0 mA	V_{CB} = 28 V 2.0 mA	V_{CB} = 28 V 5.0 mA
		V_{CB} = 45 V 1.0 mA	V_{CB} = 45 V 2.0 mA	V_{CB} = 45 V 4.0 mA	V_{CB} = 45 V 10.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.5 A	5.0 A	10.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.2 A 10-100	I_C = 0.4 A 10-100	I_C = 1.0 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	8 °C/W	4.5 °C/W	2 °C/W
P_o	Min Broadband Power Output	3.0 W	6.0 W	12.0 W	35.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	8 pF	12 pF	28 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 2.0 W 8.2 dB	P_o = 6.0 W 7.4 dB	P_o = 12.0 W 7.8 dB	P_o = 35.0 W 7.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 2.0 W 45 %	P_o = 6.0 W 50 %	P_o = 12.0 W 50 %	P_o = 35.0 W 50 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US # 3,713,006).

The TRW MRA1014 series offers a complete family of broadband, high-gain transistors for applications in the 1000-1400MHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA1014 series is intended for use in a variety of military and industrial applications including ECM, radio relay and telemetry for fixed station use.

The smooth, broadband transfer characteristics of the MRA1014 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Device output power levels of 2, 6, 12 and 35 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA1014 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA1014 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

METALIZATION AND RELIABILITY

Metal migration is the main concern when considering a metal system. In fine geometry devices common to all microwave transistors, the use of aluminum having sufficiently large grain size to provide an activation energy equal to that of gold is not possible since geometrical definition would be impossible. In order to adequately define small geometries, one must use aluminum with a grain size (1 micron or less) which has a very unattractive activation energy. Activation energy has an exponential relationship to metal migration.

A fair comparison of two metal systems (aluminum versus gold) would be to construct the same transistor using both metal systems and calculate the anticipated metal failure point using Black's equation. The following example is based upon the same transistor cell as is used in the TRW MRA1014 series.

Junction Temperature	Times Improvement of MTTF with Gold vs Aluminum
100°C	691
125°C	370
150°C	168
175°C	56
200°C	30

For this very obvious reason TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRA1D14 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

Parasitic reactances (primarily due to the package) become increasingly more significant past 200MHz and impose severe limitations on band width past 1GHz. Additionally, the real component of input $Z(R_{bb})$ becomes smaller as higher drive power and higher power outputs are achieved.

Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

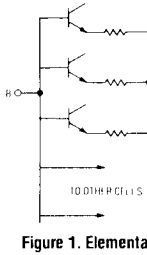


Figure 1. Elementary Method of Cell Combining

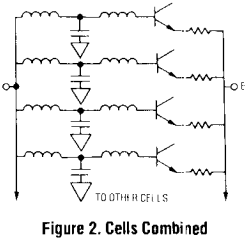


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

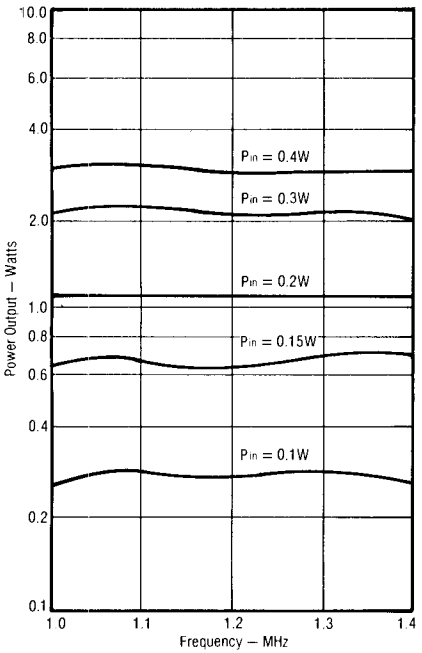
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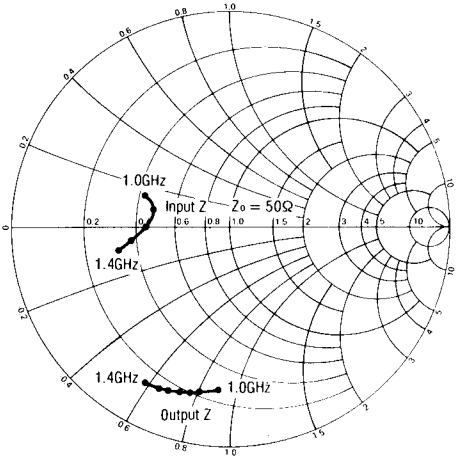
*TRW U.S. Patent #3,713,006

MRA1014-2 — 2 WATTS BROADBAND

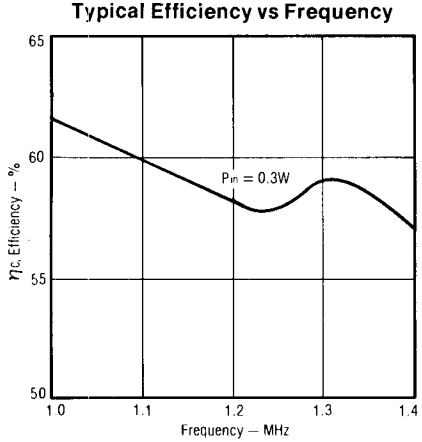
Typical Power Output vs Frequency



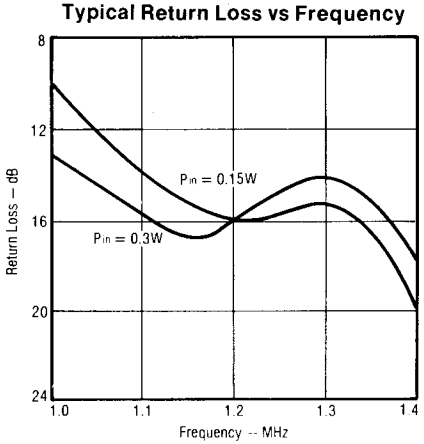
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

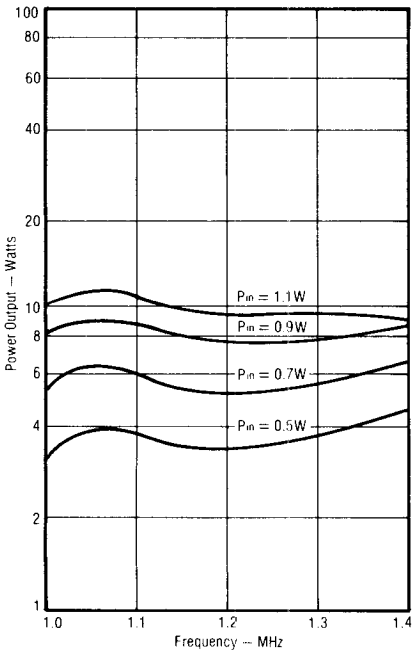


Typical Return Loss vs Frequency

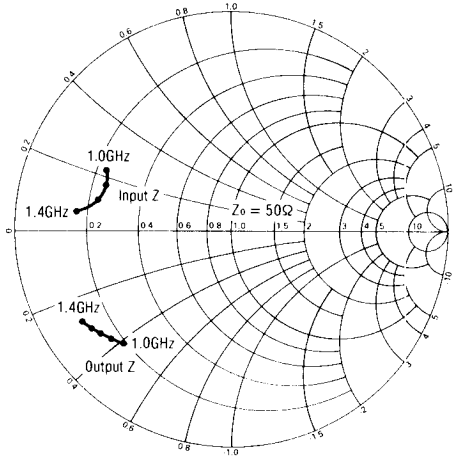


MRA1014-6 — 6 WATTS BROADBAND

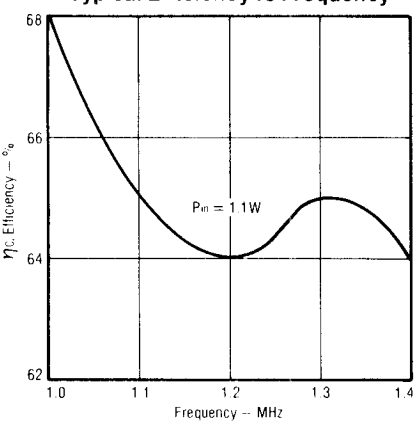
Typical Power Output vs Frequency



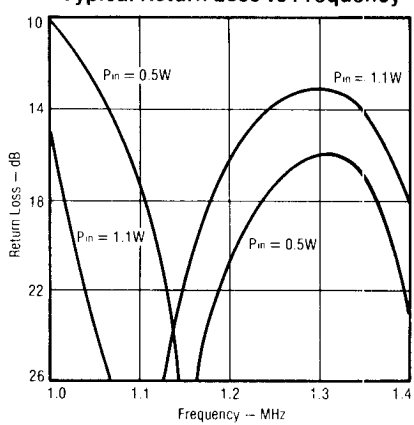
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

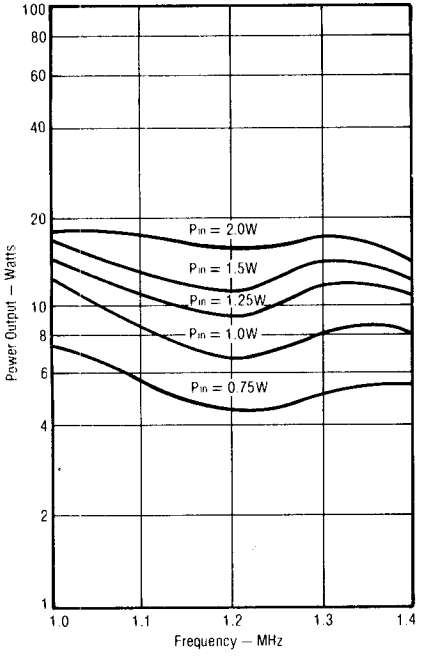


Typical Return Loss vs Frequency

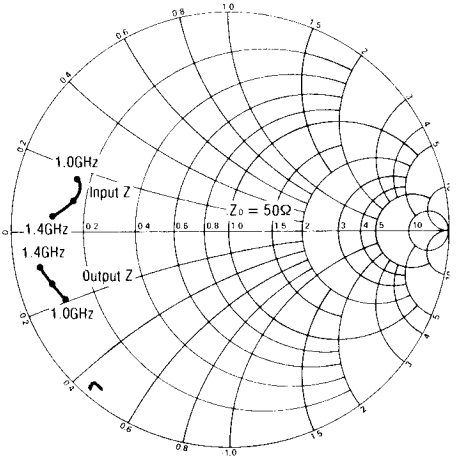


MRA1014-12 — 12 WATTS BROADBAND

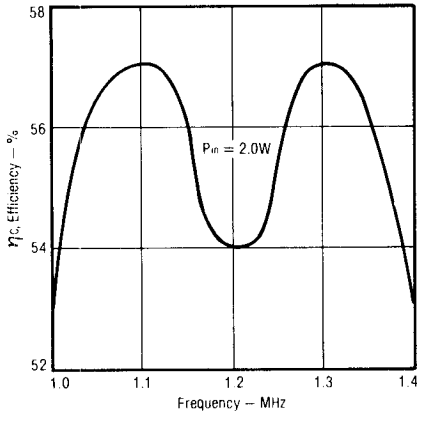
Typical Power Output vs Frequency



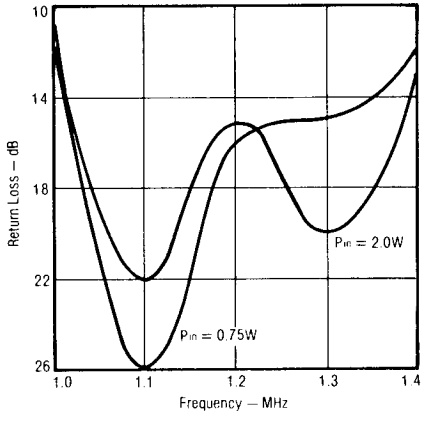
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

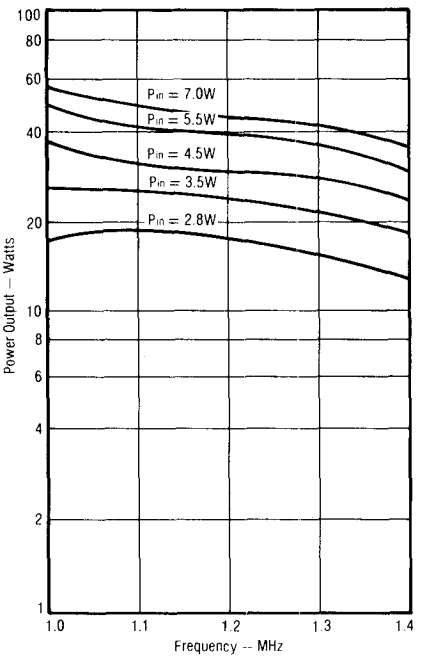


Typical Return Loss vs Frequency

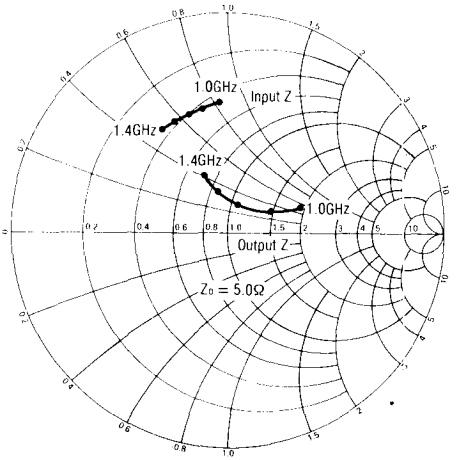


MRA1014-35 — 35 WATTS BROADBAND

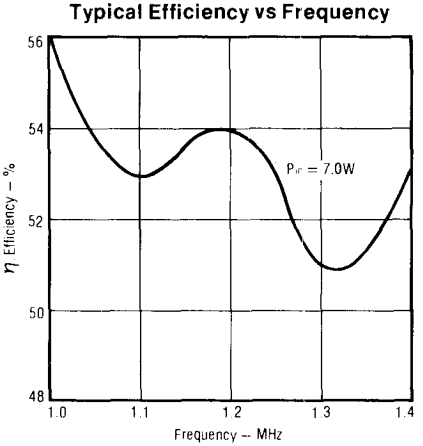
Typical Power Output vs Frequency



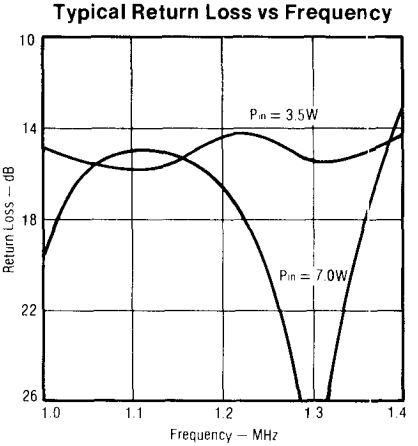
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

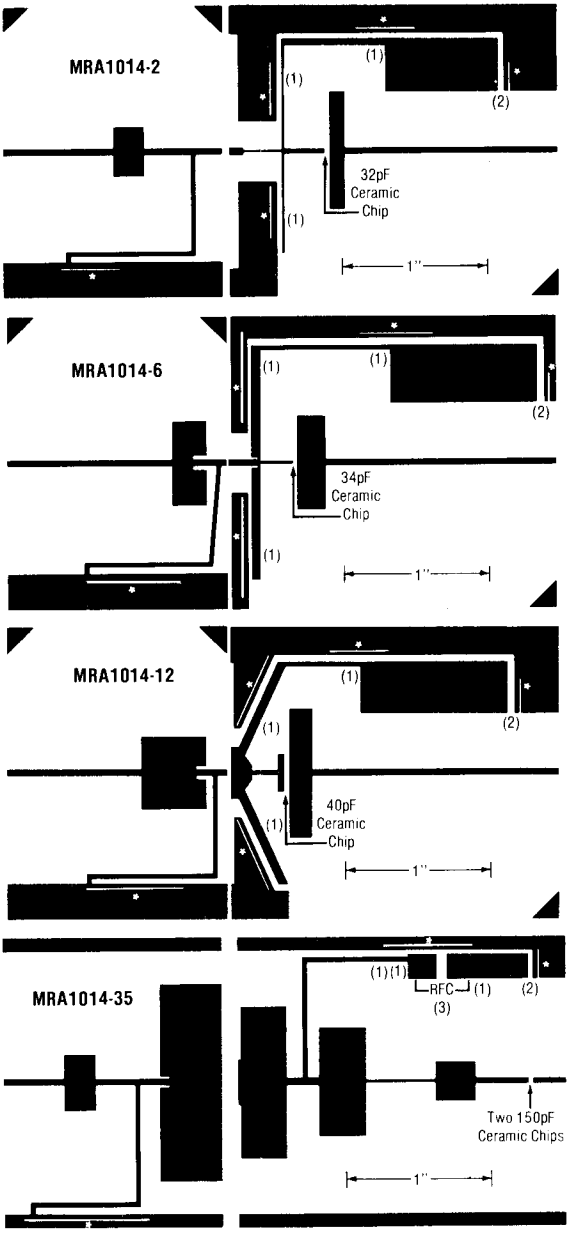


Typical Return Loss vs Frequency



TEST CIRCUIT BOARDS FOR MRA1014 SERIES

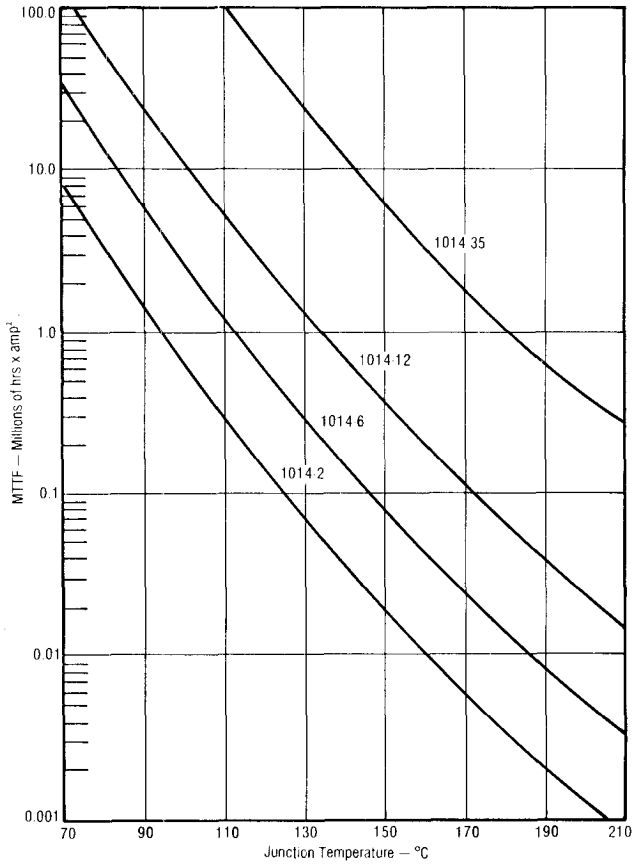
NOTE: Scale is not 1:1.



*Foil wrap or plate around to ground plane. Board material 0.020 inch glass teflon $\varepsilon_r = 2.55$.
(1) Bypass capacitor to ground (150pF chip).
(2) Use B+ bypass of 0.01 and 1μF capacitors at this point.
(3) 10 turns #20 enamel close wound on 0.040 mandril.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRA1014-12 Conditions

where:

$P_o = 12W$
$P_{in} = 2W$
$V_{CC} = 28V$
$\eta_C = 50\%$
$T_{flange} = 70°C$

$$I_C \cong I_E = \frac{100\,P_o}{\eta_C \times V_{CC}} = 0.857A$$

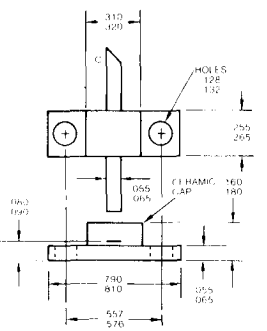
$$P_{diss} = P_{in} + V_{CC}\,I_C - P_o = 14.0W$$

$$T_{junc} = T_{flange} + \theta_F \times P_{diss} = 133°C$$

$$MTTF = \frac{1.2 \times 10^6 \text{ hrs amp}^2}{I_C^2} = 1{,}400{,}200 \text{ hrs}$$

$$= 159 \text{ yrs}$$

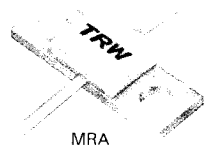
MRA Series Package



MICROAMP

- **2-6-11-25 Watts**
- **Broadband 1400-1700 MHz**
- **Internally Compensated***
- **Gold Metalized**
- **Diffused Ballast Resistors**
- **MTTF Data**

MRA 1417-2
MRA 1417-6
MRA 1417-11
MRA 1417-25



MRA

Electrical Characteristics at T_{flange} = 25 °C

Symbol	Characteristic	MRA1417-2	MRA1417-6	MRA1417-11	MRA1417-25
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 40 mA 50 V Min	I_C = 80 mA 50 V Min	I_C = 160 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_E = 0.5 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.0 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA	V_{CB} = 28 V 1.0 mA	V_{CB} = 28 V 2.0 mA	V_{CB} = 28 V 4.0 mA
		V_{CB} = 45 V 1.0 mA	V_{CB} = 45 V 2.0 mA	V_{CB} = 45 V 4.0 mA	V_{CB} = 45 V 8.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.5 A	1.0 A	4.0 A	8.0 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-100	I_C = 0.2 A 10-100	I_C = 0.4 A 10-100	I_C = 0.8 A 10-100
θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	8 °C/W	4.5 °C/W	2.5 °C/W
P_o	Min Broadband Power Output	2.0 W	6.0 W	11.0 W	25.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	8 pF	12 pF	24 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 2.0 W 8.0 dB	P_o = 6.0 W 7.4 dB	P_o = 11.0 W 7.4 dB	P_o = 25.0 W 7.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 2.0 W 40 %	P_o = 6.0 W 45 %	P_o = 11.0 W 45 %	P_o = 25.0 W 45 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* Based on Black's Equation and using φ = 0.96 EV, $\beta = 1.07 \times 10^{-12}$ for unpassivated A_u. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US # 3,713,006).

The TRW MRA1417 series offers a complete family of broadband, high-gain transistors for applications in the 1.4-1.7GHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRA1417 series is intended for use in a variety of military and industrial applications including ECM, radio relay and telemetry.

The smooth, broadband transfer characteristics of the MRA1417 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

Oevice output power levels of 2, 6, 11 and 25 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

Microwave transistor devices are universally constructed using multiple cell combinations for higher power. A number of advantages are obtained using the cellular concept including better thermal balance and the ability to adjust power output capability using more or less cells to construct a device. Unless proper ballasting techniques are employed, some difficulty can be encountered in the act of combining cells. Ballasting makes cell combining practical. The alternative to ballasted cells is an operator-dependent assembly technique called "contour-bonding." Herein, bond wires of varying lengths are employed to adjust inductance and thereby achieve the expected balance. TRW has decided in favor of ballasting rather than contour-bonding because it is a controlled, repeatable and totally reliable technique.

While ballasting is desirable, certain techniques for creating ballast resistors in fine geometry microwave transistors have proven unreliable. Such an example is "metal" ballast resistors. Such resistors are incorporated by introducing an exposed section of barrier metal between the emitter finger and feeder bar. This type of resistor, of necessity, lies on top of an oxide layer. Because the metal resistor is required to dissipate as much as $10KW/CM^2$, extreme temperatures are generated in the resistor material. With this construction there is no adequate means of removing heat from the metal resistor. Therefore, the ballast resistor undergoes radical changes in physical dimension during its operating profile. This results in separation from the oxide layer or micro-cracking, or both.

Given that ballasting is desirable, a better solution, **diffused ballast resistors**, is incorporated in the MRA1417 series. Several advantages accrue from this approach. It is integral in the silicon carrier, has the same coefficient of expansion and is heat sinked. Experience has shown that the diffused ballast resistor has none of the metal resistor disadvantages, yet offers an additional advantage. In the MRA1417 series, the diffused resistor is designed to current limit (because of limited carriers) before destructive current levels at the junction occur. Diffused ballast resistors are definitely superior in performance and reliability. Test data is available to verify this fact.

METALIZATION AND RELIABILITY

Metal migration is the main concern when considering a metal system. In fine geometry devices common to all microwave transistors, the use of aluminum having sufficiently large grain size to provide an activation energy equal to that of gold is not possible since geometrical definition would be impossible. In order to adequately define small geometries, one must use aluminum with a grain size (1 micron or less) which has a very unattractive activation energy. Activation energy has an exponential relationship to metal migration.

A fair comparison of two metal systems (aluminum versus gold) would be to construct the same transistor using both metal systems and calculate the anticipated metal failure point using Black's equation. The following example is based upon the same transistor cell as is used in the TRW MRA1417 series.

Junction Temperature	Times Improvement of MTTF with Gold vs Aluminum
100°C	691
125°C	370
150°C	168
175°C	56
200°C	30

For this very obvious reason TRW RF Semiconductors uses a gold metalization system on all microwave transistors including the MRA1417 series.

TRW'S PATENTED* MICroAMP

Since power microwave transistors became feasible, the bandwidth limiting problem of excessively high input "Q's" has vexed the solid state microwave amplifier designer.

Parasitic reactances (primarily due to the package) become increasingly more significant past 200MHz and impose severe limitations on band width past 1GHz. Additionally, the real component of input $Z(R_{bb})$ becomes smaller as higher drive power and higher power outputs are achieved.

Microwave power transistors generally employ several emitter ballasted cells in parallel to obtain power outputs required with the small cell geometry necessary to realize a microwave transistor. Figure 1 shows the schematic representation of such a device.

Note that all components of the input impedance are in parallel, which compounds the "Q" and bandwidth problem as more cells are used to achieve power, or the operating frequency is raised (or both). Figure 2 illustrates a more acceptable solution which combines inputs after an impedance transformation at the input of each device cell. It is convenient to do this all or partially within the package.

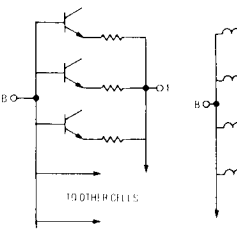


Figure 1. Elementary Method of Cell Combining

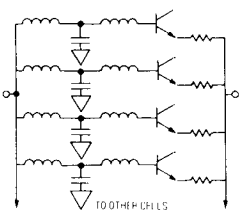


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

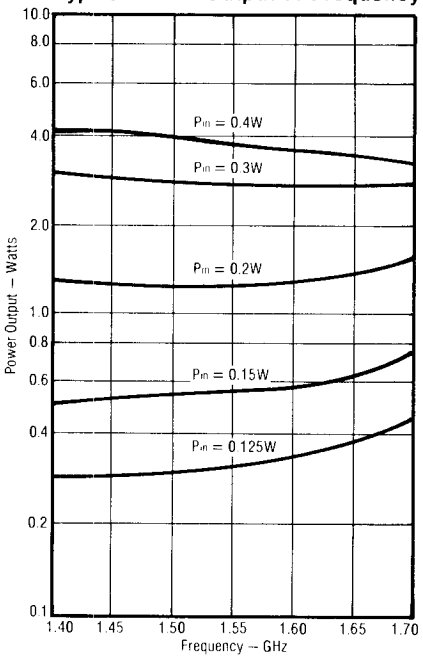
Because of the nature of source impedance driving the transistor cell (essentially a voltage source), as much as 10dB additional usable dynamic range without noticeably altering bandwidth or tuning is possible with the MICroAMP.

Additional gain and bandwidth advantage can be obtained by operation of the MICroAMP device cells in a common base configuration. The devices described therein are so configured.

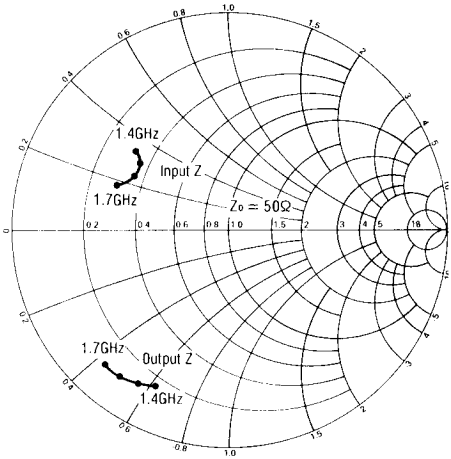
*TRW U.S. Patent #3,713,006

MRA1417-2 — 2 WATTS BROADBAND

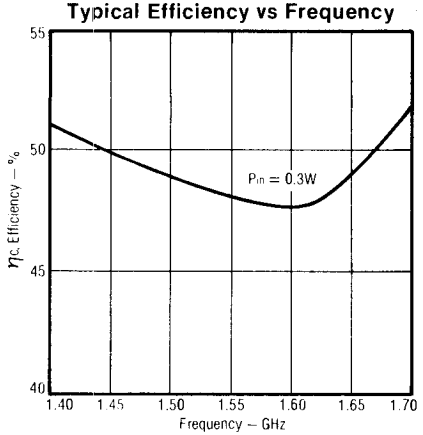
Typical Power Output vs Frequency



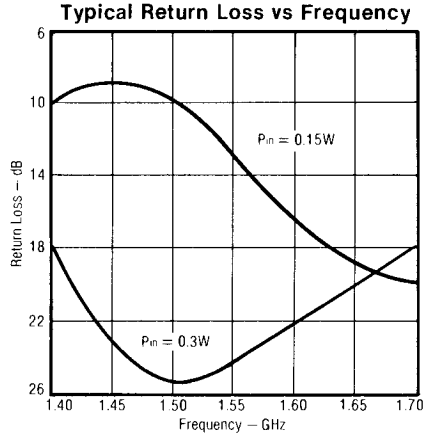
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

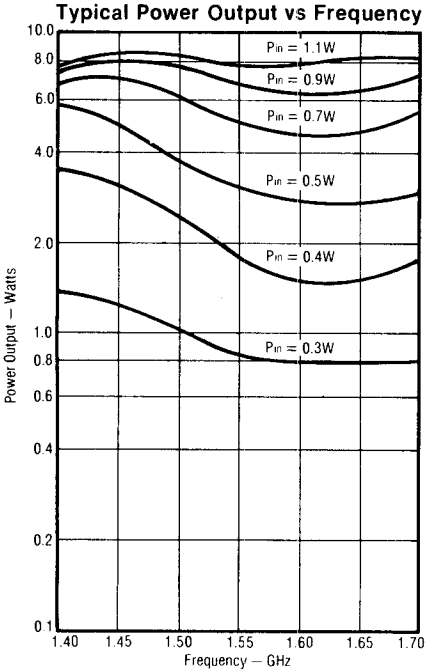


Typical Return Loss vs Frequency

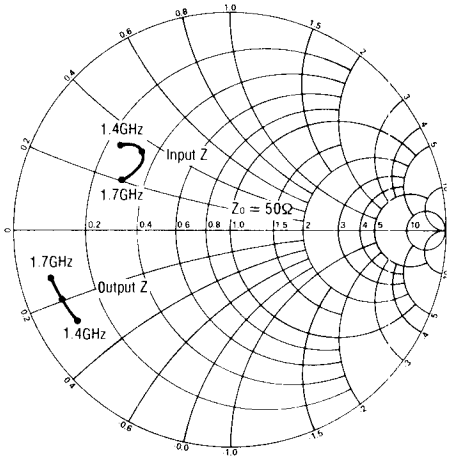


MRA1417-6 — 6 WATTS BROADBAND

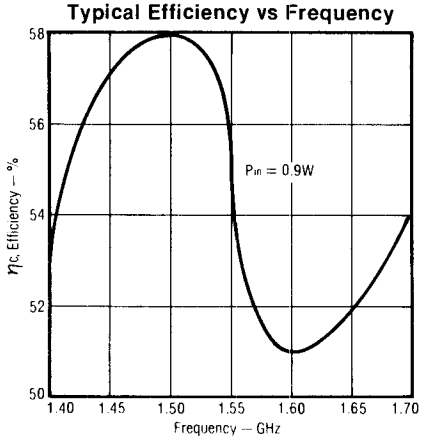
Typical Power Output vs Frequency



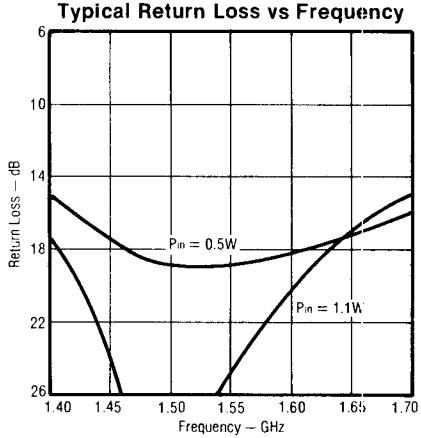
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

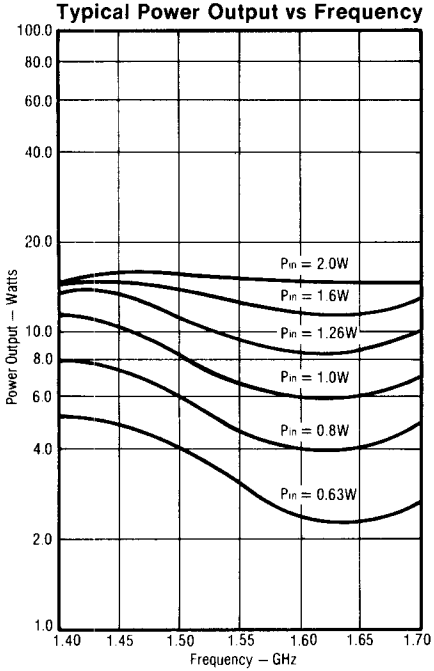


Typical Return Loss vs Frequency

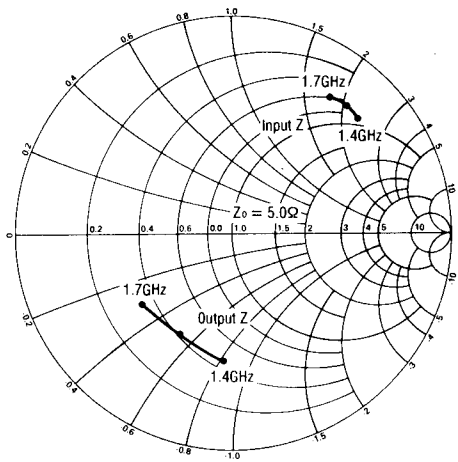


MRA1417-11 — 11 WATTS BROADBAND

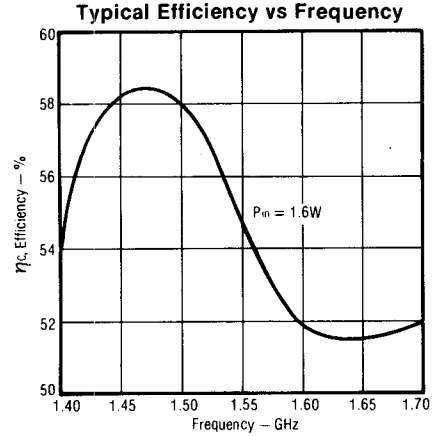
Typical Power Output vs Frequency



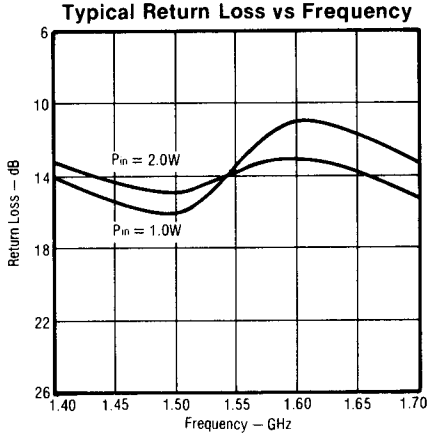
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

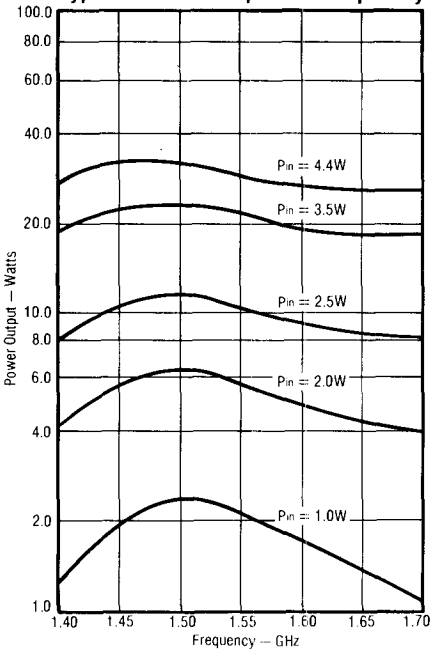


Typical Return Loss vs Frequency

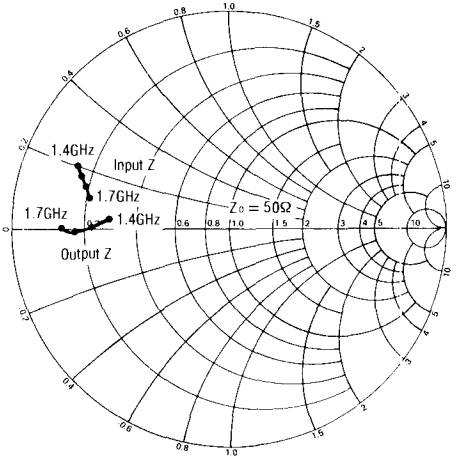


MRA1417-25 — 25 WATTS BROADBAND

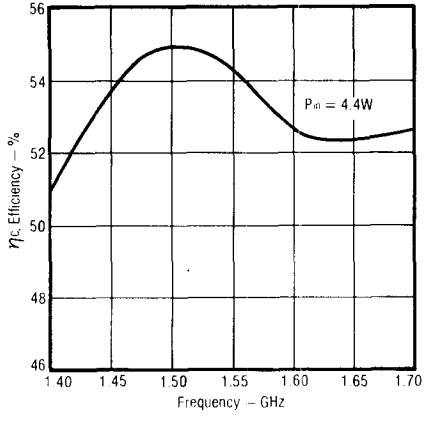
Typical Power Output vs Frequency



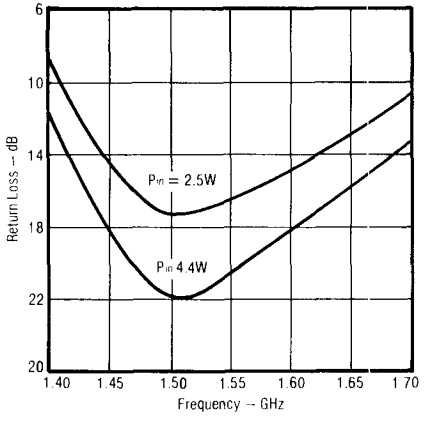
Impedance Data
Vcc = 28V



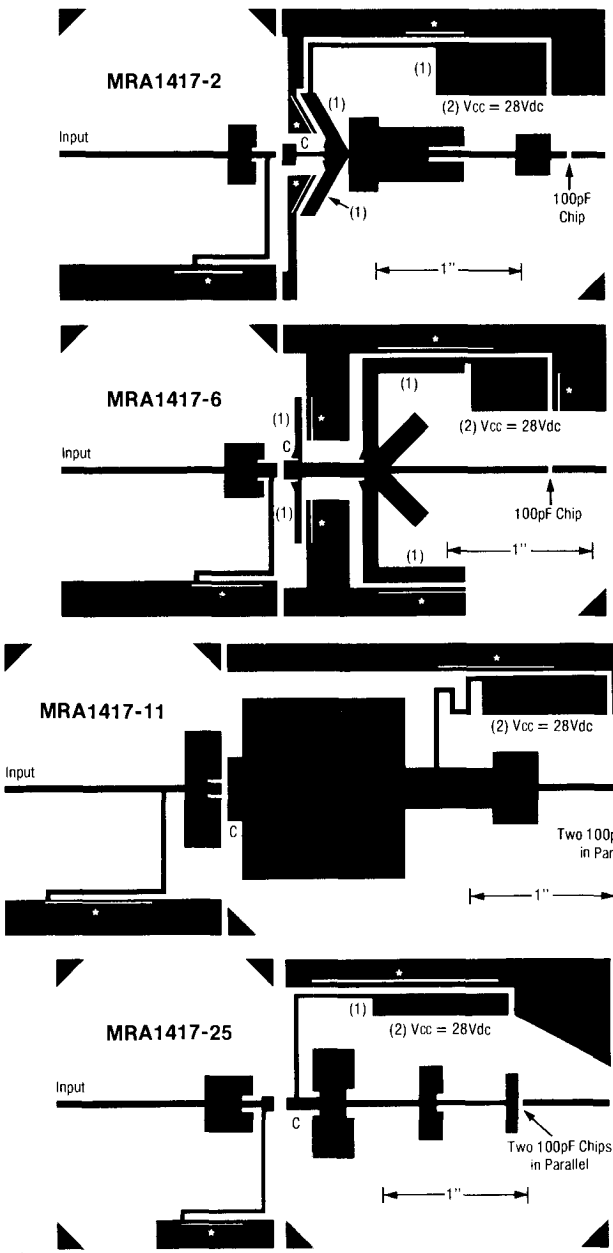
Typical Efficiency vs Frequency



Typical Return Loss vs Frequency



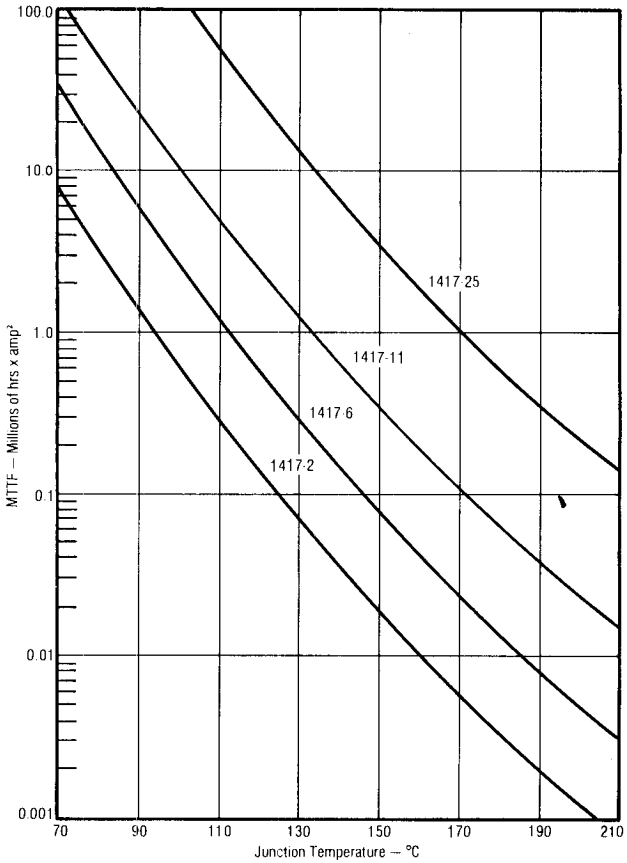
TEST CIRCUIT BOARDS FOR MRA1417 SERIES



*Foil wrap or plate around to ground plane.
(1) Bypass capacitor to ground (220pF chip).
(2) Use Vcc bypass of 220pF chip, 0.1μF chip and 5μF.
Board material 0.020 inch glass-teflon Er = 2.55.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRA1417-11 Conditions

where:

$P_o = 11W$

$P_{in} = 2W$

$V_{CC} = 28V$

$\eta_C = 45\%$

$T_{flange} = 70°C$

$$I_C \cong I_E = \frac{P_o}{\eta_C \times V_{CC}} = 0.873A$$

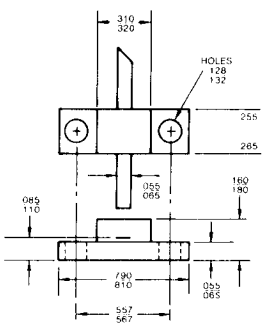
$$P_{diss} = P_{in} + V_{CC}\ I_C - P_o = 15.4W$$

$$T_{junc} = T_{flange} + \theta_{JF} \times P_{diss} = 132°C$$

$$MTTF = \frac{1.1 \times 10^6 \text{ hrs amp}^2}{I_C^2} = 1{,}443{,}328 \text{ hrs}$$

$$= 164 \text{ yrs}$$

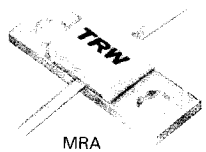
MRA Series Package



MICROAMP

- **2-5-9-20 Watts**
- **Broadband 1700-2000 MHz**
- **Internally Compensated***
- **Gold Metalized**
- **Diffused Ballast Resistors**
- **MTTF Data**

MRA 1720-2
MRA 1720-5
MRA 1720-9
MRA 1720-20



MRA

Electrical Characteristics at T_{flange} = 25 °C

Symbol	Characteristic	MRA1720-2	MRA1720-5	MRA1720-9	MRA1720-20
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 20 mA 50 V Min	I_C = 40 mA 50 V Min	I_C = 80 mA 50 V Min	I_C = 160 mA 50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA 3.5 V Min	I_E = 0.5 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.0 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 28 V 0.5 mA	V_{CB} = 28 V 1.0 mA	V_{CB} = 28 V 2.0 mA	V_{CB} = 28 V 4.0 mA
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θ_{jF}	Thermal Resistance Junction to Flange	15 °C/W	8 °C/W	4.5 °C/W	2.5 °C/W
P_o	Min Broadband Power Output	2.0 W	5.0 W	9.0 W	20.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 28 V, f = 1 MHz	4.5 pF	8 pF	12 pF	24 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 28 V	P_o = 2.0 W 7.5 dB	P_o = 5.0 W 6.5 dB	P_o = 9.0 W 6.5 dB	P_o = 20.0 W 6.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 2.0 W 35 %	P_o = 5.0 W 40 %	P_o = 9.0 W 40 %	P_o = 20.0 W 40 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, Inc. (US # 3,713,006).

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Device output power levels of 2, 5, 9 and 20 watts allow a wide choice of lineup configurations. Excellent device-to-device phase tracking characteristics permit hybrid combination for higher powers with negligible combining loss.

Complete data and broadband circuitry, suitable to photograph for circuit boards, are contained herein.

DIFFUSED BALLASTING AND RELIABILITY

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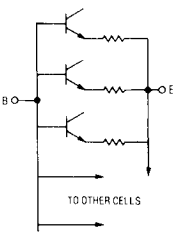


Figure 1. Elementary Method of Cell Combining

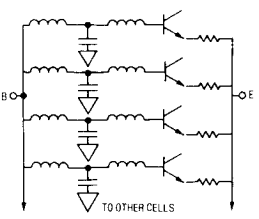


Figure 2. Cells Combined with Transformers

Correct input circuitry design can yield a device which is broadbandable over a broad range of frequencies (40 percent or more).

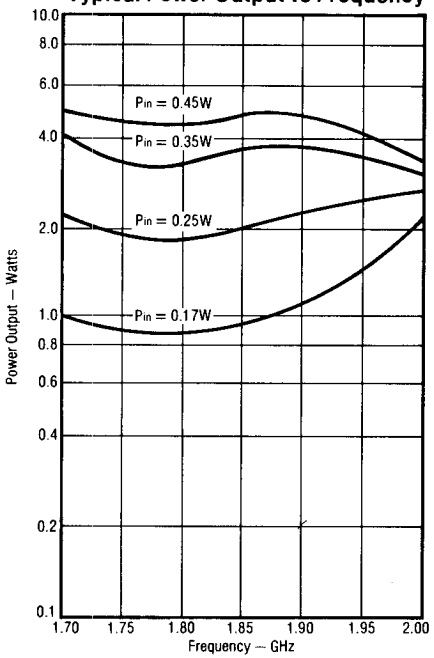
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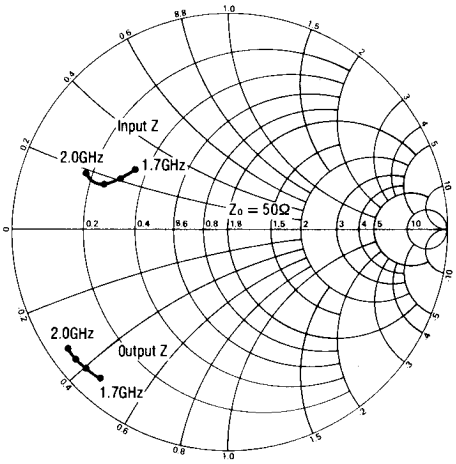
*TRW U.S. Patent #3,713,006

MRA 1720-2 WATTS BROADBAND

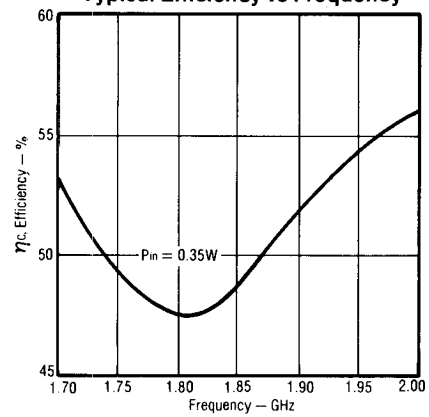
Typical Power Output vs Frequency



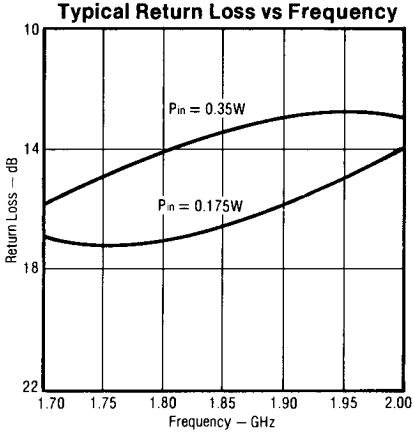
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

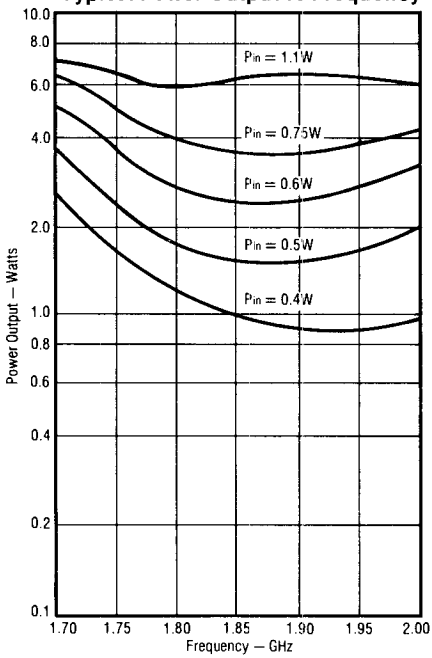


Typical Return Loss vs Frequency

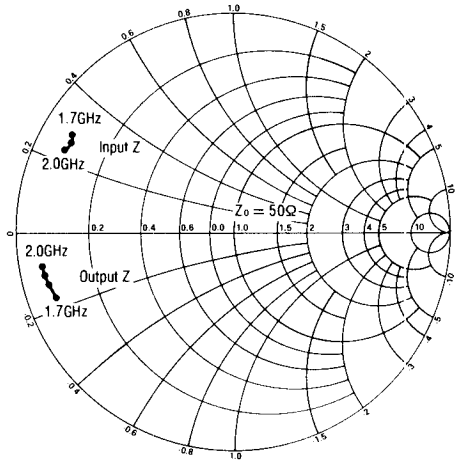


MRA 1720-5 — 5 WATTS BROADBAND

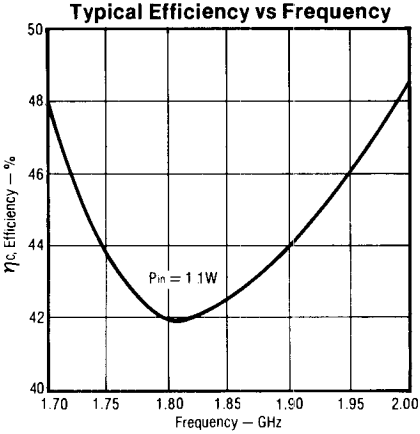
Typical Power Output vs Frequency



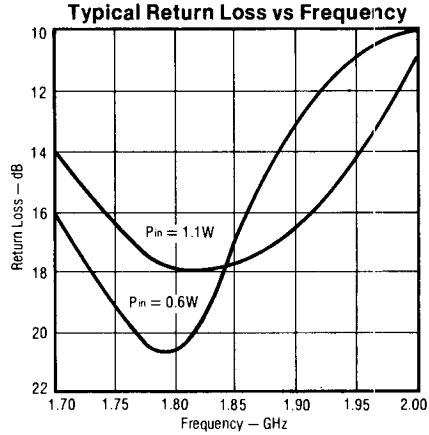
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

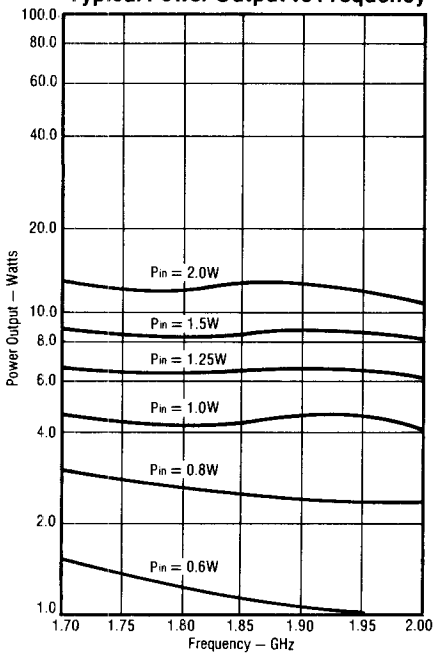


Typical Return Loss vs Frequency

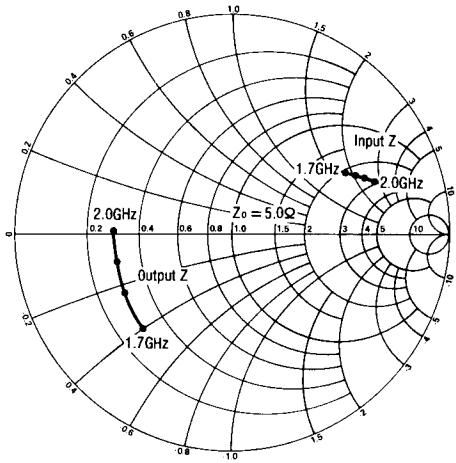


MRA 1720-9 — 9 WATTS BROADBAND

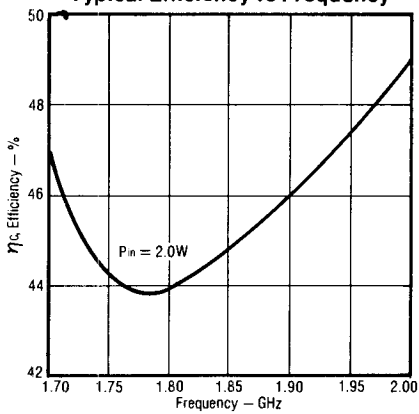
Typical Power Output vs Frequency



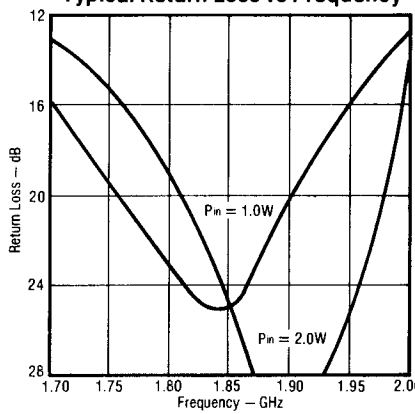
Impedance Data
Vcc = 28V



Typical Efficiency vs Frequency

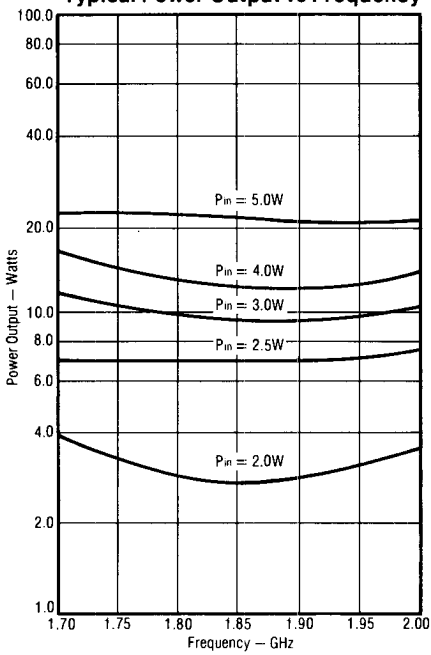


Typical Return Loss vs Frequency

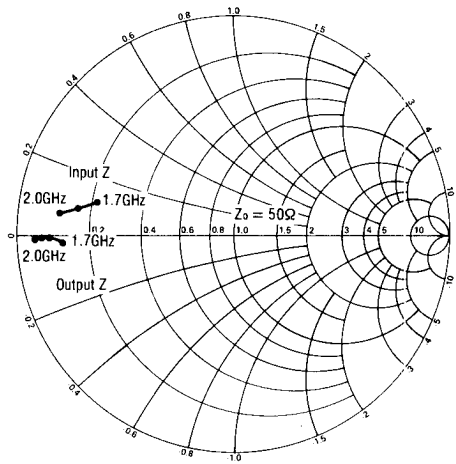


MRA 1720-20 — 20 WATTS BROADBAND

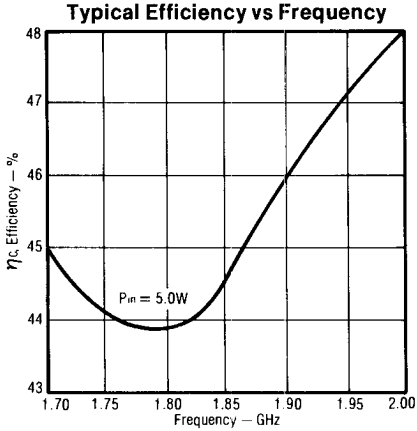
Typical Power Output vs Frequency



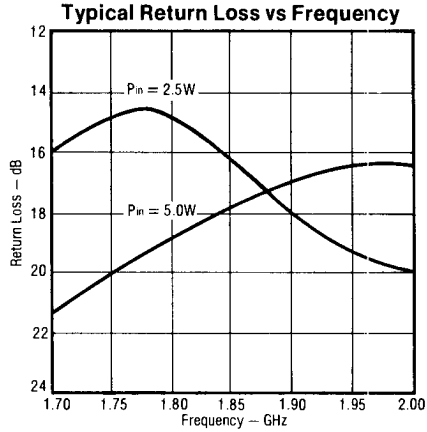
Impedance Data
Vcc = 28V



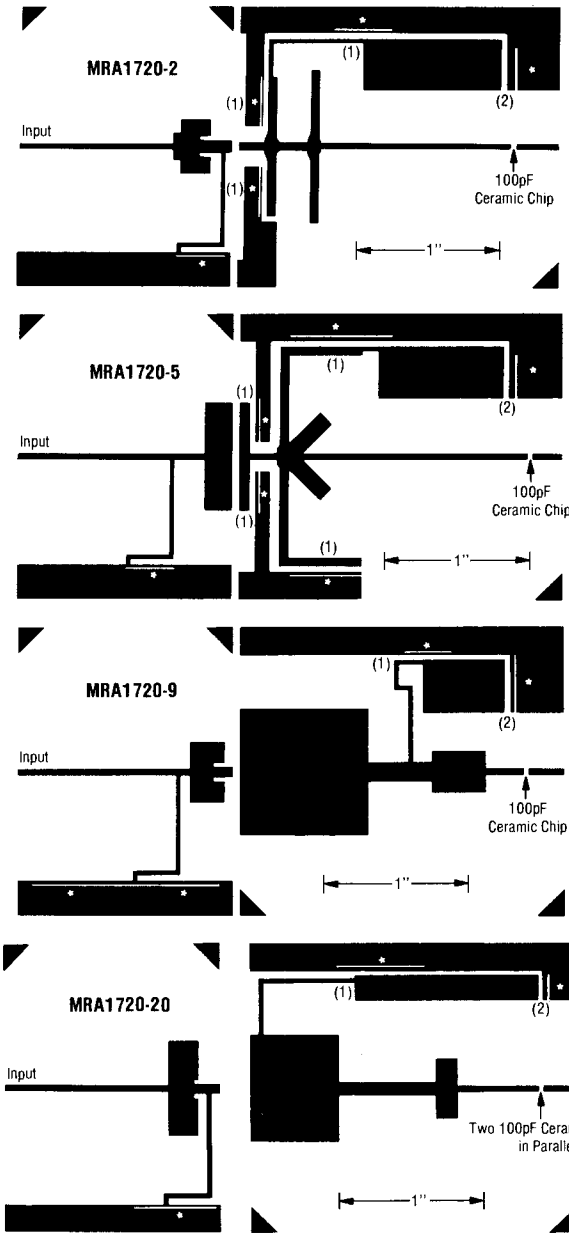
Typical Efficiency vs Frequency



Typical Return Loss vs Frequency



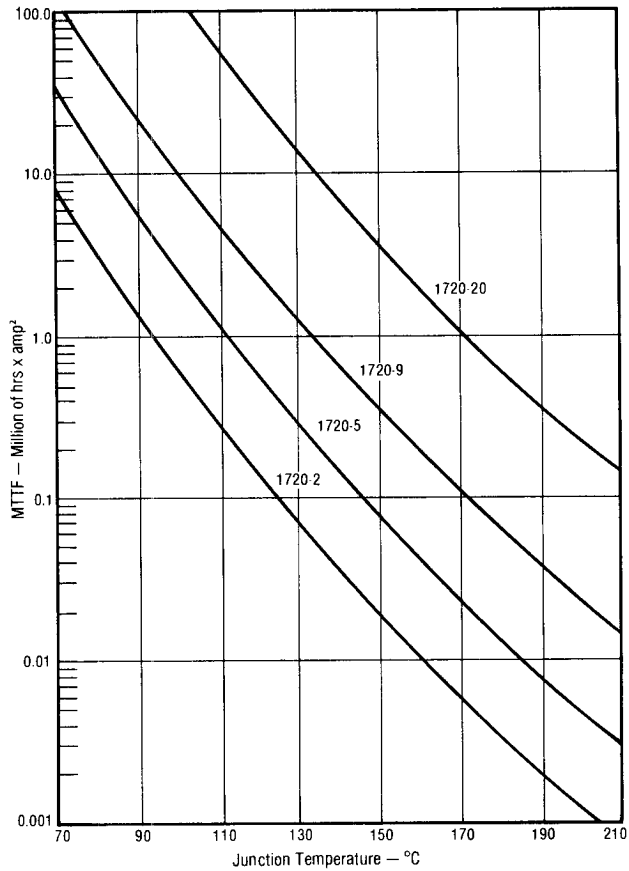
TEST CIRCUIT BOARDS FOR MRA1720 SERIES



*Foil wrap or plate around to ground plane.
(1) Bypass capacitor to ground (100pF ceramic chip).
(2) Use Vcc bypass of 100pF chip, 0.1μF chip and 5μF.
Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRA1720-9 Conditions

where:

$P_o = 9W$

$P_{in} = 2W$

$V_{CC} = 28V$

$\eta_C = 40\%$

$T_{flange} = 70°C$

$$I_C \cong I_E = \frac{100\,P_o}{\eta_C \times V_{CC}} = 0.800A$$

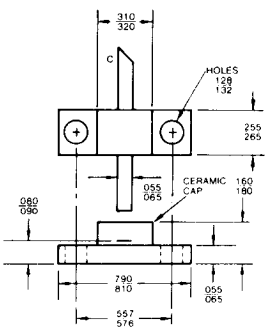
$$P_{diss} = P_{in} + V_{CC}\ I_C - P_o = 15.4W$$

$$T_{junc} = T_{flange} + \theta_{jF} \times P_{diss} = 139.3°C$$

$$MTTF = \frac{0.7 \times 10^5 \text{ hrs amp}^2}{I_C^2} = 109{,}380 \text{ hrs}$$

$$= 12.46 \text{ yrs}$$

MRA Series Package



MICROAMP

MRAL 2023-1.5
MRAL 2023-3
MRAL 2023-6
MRAL 2023-12

- **1.5-3-6-12 Watts, 22 V Operation**
- **Broadband 2000-2300 MHz**
- **Internally Compensated***
- **Gold Metalized**
- **Diffused Ballast Resistors**
- **MTTF Data**



MRA

Electrical Characteristics at T_{flange} = 25 °C

Symbol	Characteristic	MRAL2023-1.5	MRAL2023-3	MRAL2023-6	MRAL2023-12
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 10 mA 42 V Min	I_C = 20 mA 42 V Min	I_C = 50 mA 42 V Min	I_C = 100 mA 42 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.2 mA 3.5 V Min	I_E = 0.4 mA 3.5 V Min	I_E = 1.0 mA 3.5 V Min	I_E = 2.0 mA 3.5 V Min
I_{CBO}	Collector Cutoff Current I_E = 0	V_{CB} = 22 V 0.25 mA	V_{CB} = 22 V 0.5 mA	V_{CB} = 22 V 1.25 mA	V_{CB} = 22 V 2.5 mA
		V_{CB} = 38 V 0.5 mA	V_{CB} = 38 V 1.0 mA	V_{CB} = 38 V 2.5 mA	V_{CB} = 38 V 5.0 mA
I_C	Max Continuous Collector Current V_{CE} = 4 V	0.25 A	0.5 A	1.25 A	2.5 A
h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V	I_C = 0.1 A 10-90	I_C = 0.2 A 10-90	I_C = 0.5 A 10-90	I_C = 1.0 A 10-90
θ_{jF}	Thermal Resistance Junction to Flange	30 °C/W	16 °C/W	8 °C/W	4.5 °C/W
P_o	Min Broadband Power Output	1.5 W	3.0 W	6.0 W	12.0 W
C_{ob}	Max Collector-Base Capacitance V_{CB} = 22 V, f = 1 MHz	3.5 pF	5 pF	10 pF	18 pF
$P_{G(dB)}$	Min Power Gain in dB V_{CB} = 22 V	P_o = 1.5 W 8.0 dB	P_o = 3.0 W 8.0 dB	P_o = 6.0 W 7.0 dB	P_o = 12.0 W 7.0 dB
η_c	Min Broadband Collector Efficiency	P_o = 1.5 W 35 %	P_o = 3.0 W 40 %	P_o = 6.0 W 40 %	P_o = 12.0 W 40 %
T_j & T_{STG}	Maximum Junction and Storage Temperatures : — 65 to + 200 °C				

* Based on Black's Equation and using φ = .96 EV, $\beta = 1.07 \times 10^{-12}$ for unpassivated A_u. Empirical data indicates a 3-10 times improvement for glass passivated units. These units are glass passivated.

* The concept of input and/or output matching using MOS capacitors, wire bonds and other techniques is patented by TRW, In. (US # 3,713,006).

The TRW MRAL2023 series offers a complete family of broadband, high-gain transistors for applications in the 2.0-2.3GHz band.

Using internal compensation (a patented* technique developed and first offered for sale by TRW), the MRAL2023 series is intended for use in a variety of military and industrial applications including ECM, radio relay and telemetry.

The smooth, broadband transfer characteristics of the MRAL2023 series makes it attractive for semi-linear applications without the need for bias. Power leveling within a broad range can be accomplished simply through control of low-level drive, thus eliminating brute force control of collector voltage.

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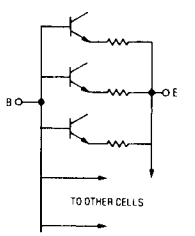


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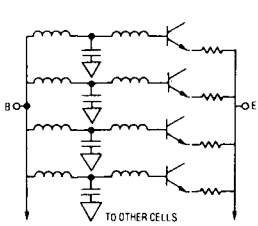


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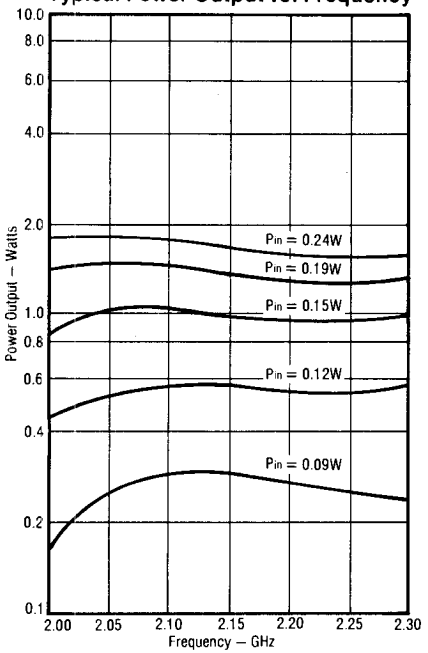
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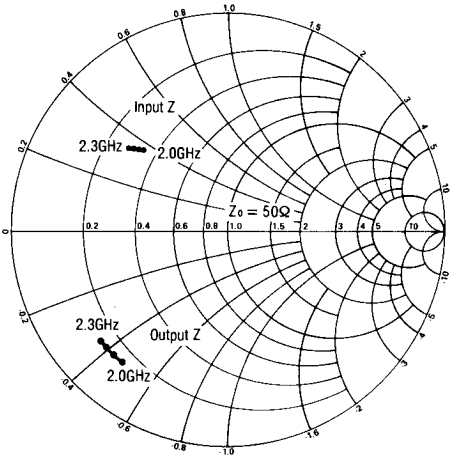
*TRW U.S. Patent #3,713,006

MRAL2023-1.5 WATTS BROADBAND

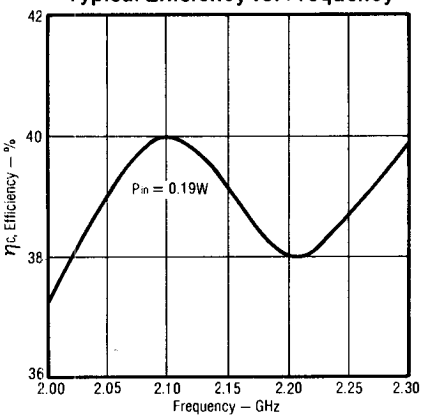
Typical Power Output vs. Frequency



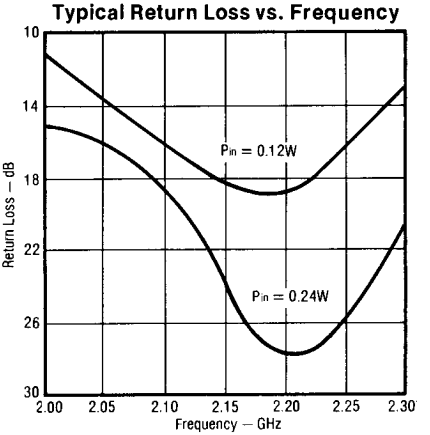
Impedance Data
Vcc = 22V



Typical Efficiency vs. Frequency

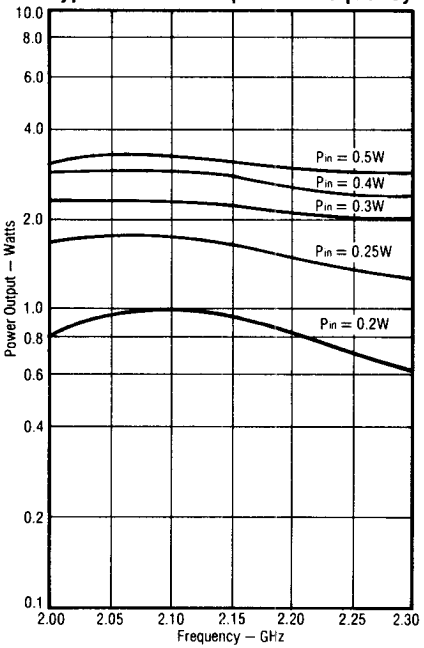


Typical Return Loss vs. Frequency

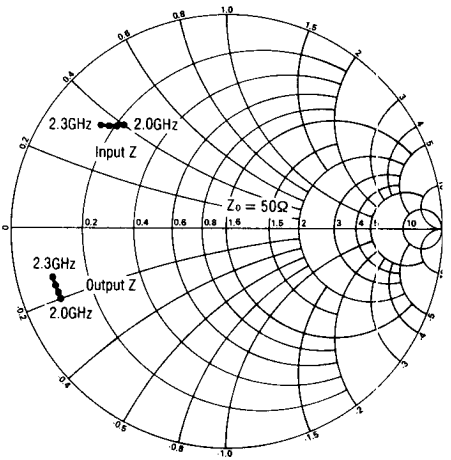


MRAL2023-3 — 3 WATTS BROADBAND

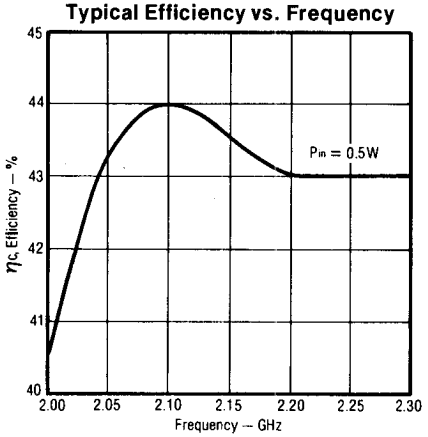
Typical Power Output vs. Frequency



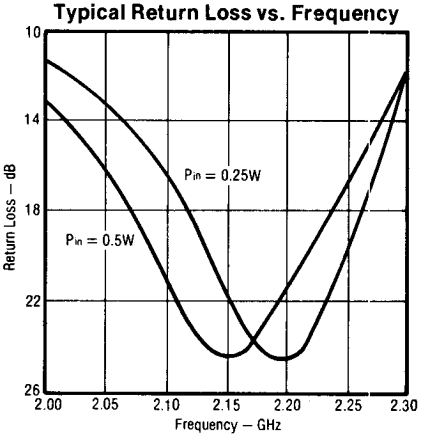
Impedance Data
Vcc = 22V



Typical Efficiency vs. Frequency

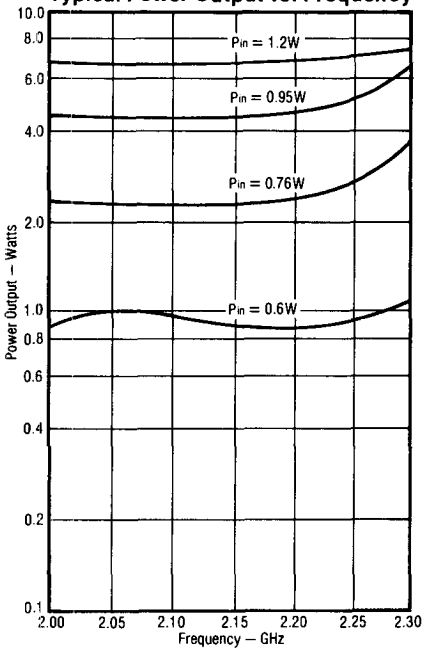


Typical Return Loss vs. Frequency

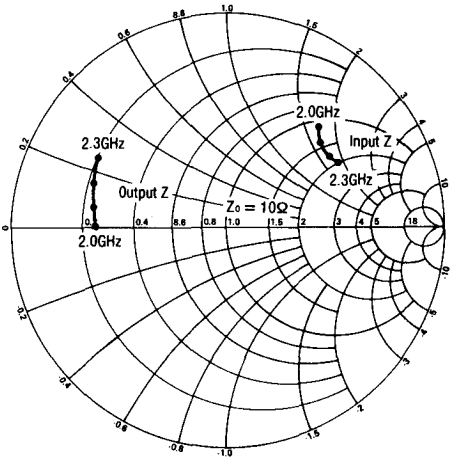


MRAL2023-6 — 6 WATTS BROADBAND

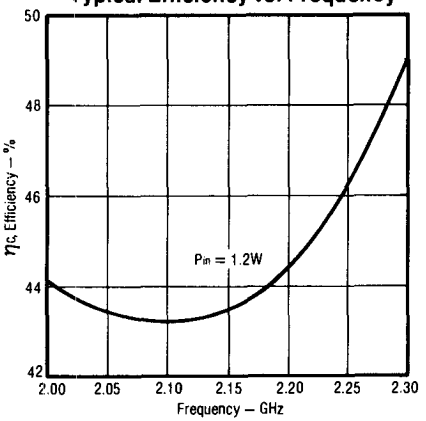
Typical Power Output vs. Frequency



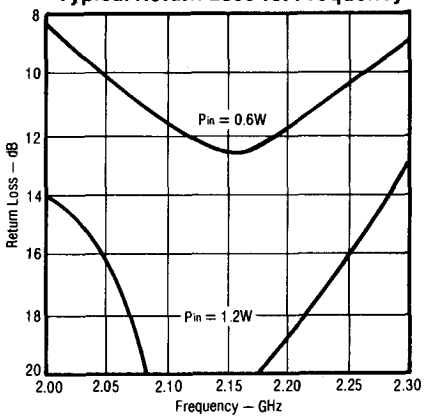
Impedance Data
Vcc = 22V



Typical Efficiency vs. Frequency

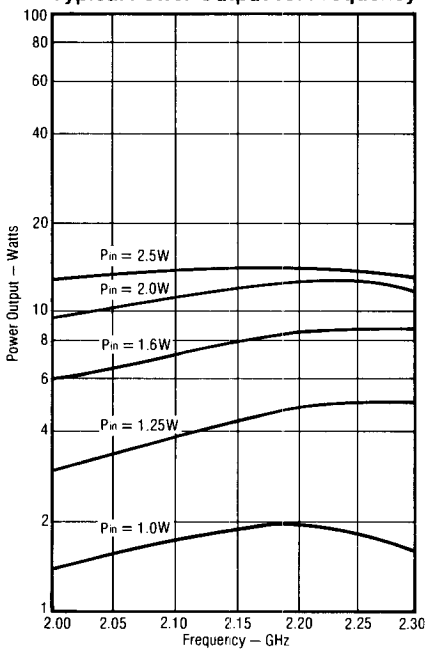


Typical Return Loss vs. Frequency

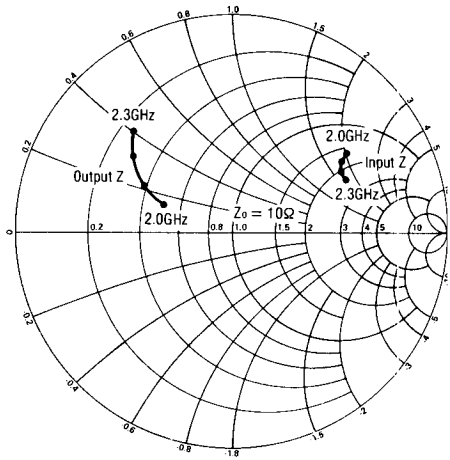


MRAL2023-12 — 12 WATTS BROADBAND

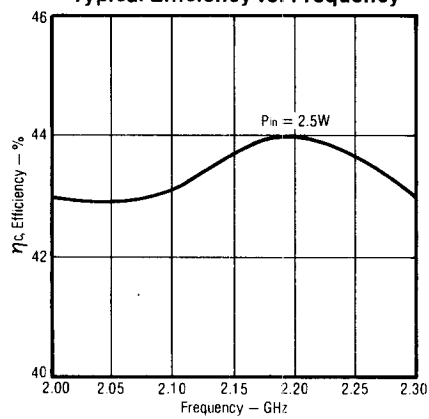
Typical Power Output vs. Frequency



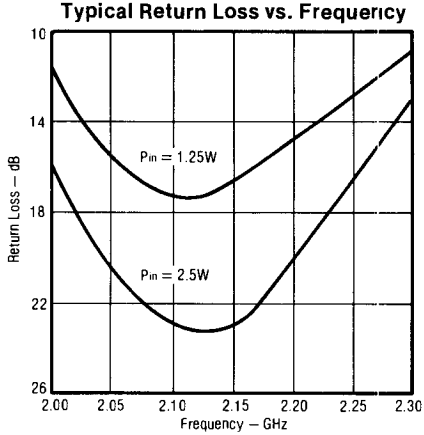
Impedance Data
Vcc = 22V



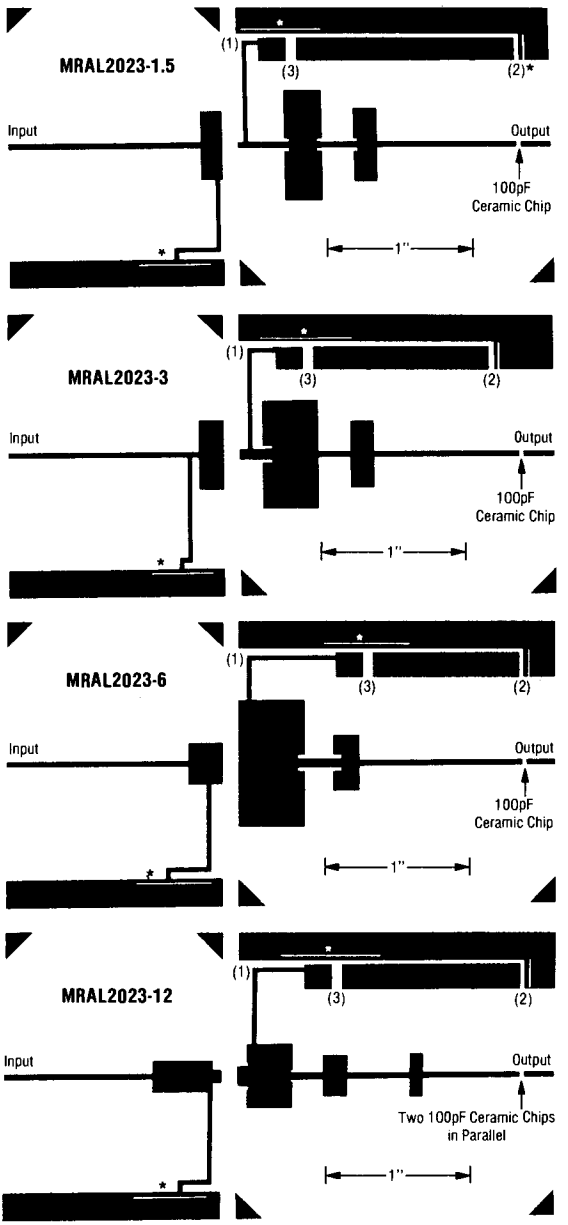
Typical Efficiency vs. Frequency



Typical Return Loss vs. Frequency



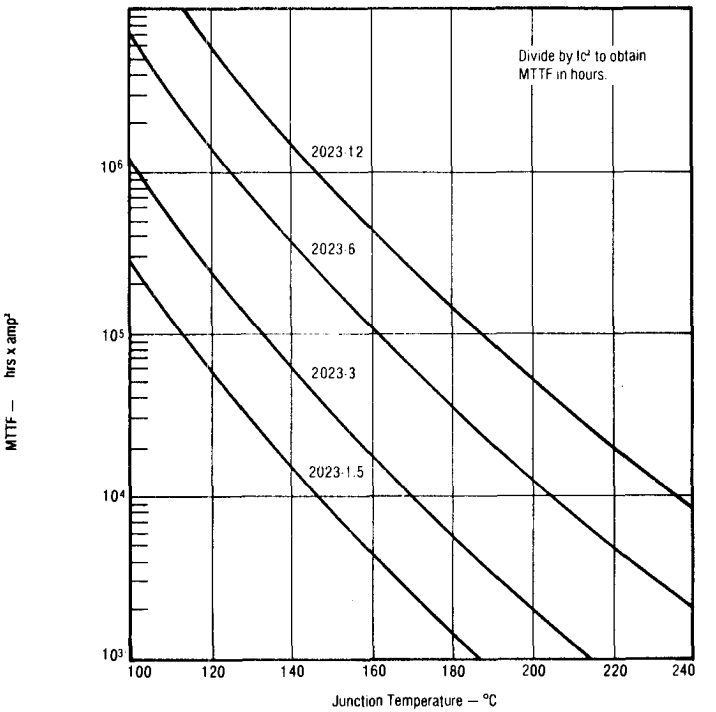
TEST CIRCUIT BOARDS FOR MRAL2023 SERIES



*Foil wrap or plate around to ground plane.
(1) Bypass capacitor to ground (100pF ceramic chip).
(2) Use Vcc bypass of 100pF chip, 0.1μF chip and 5μF.
(3) RF choke 10 turns #28 enam. close bound.
Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

MTTF FACTOR (Normalized to 1 Ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included below.



Example of MTTF for MRAL2023 Conditions

where:

$P_o = 12W$

$P_{in} = 2.4W$

$V_{CC} = 22V$

$\eta_C = 40\%$

$T_{flange} = 70°C$

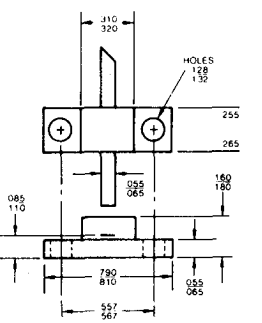
$$I_C \cong I_E = \frac{100\,P_o}{\eta_C \times V_{CC}} = 1.36A$$

$$P_{diss} = P_{in} + V_{CC}\,I_C - P_o = 20.40W$$

$$T_{junc} = T_{flange} + \theta_{JF} \times P_{diss} = 161.4°C$$

$$MTTF = \frac{4.3 \times 10^5 \text{ hrs amp}^2}{I_C^2} = 232{,}482 \text{ hrs} = 26.5 \text{ yrs}$$

MRA Series Package



TRW SEMICONDUCTORS

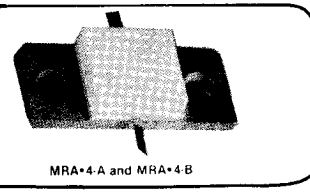
MRAL 3742 Series

MICROAMP

MRAL 3742-2
MRAL 3742-3.5
MRAL 3742-6

Guaranteed Performance — Characteristics

- Broadband 3.7-4.2 GHz
- 2, 3.5, 5.8 Watts, 20V Operation
- 5.5, 5.4, 5.1 dB Gain
- 25 % Broadband Collector Efficiency
- Input Internally Pre-Matched
- Output Internally Matched

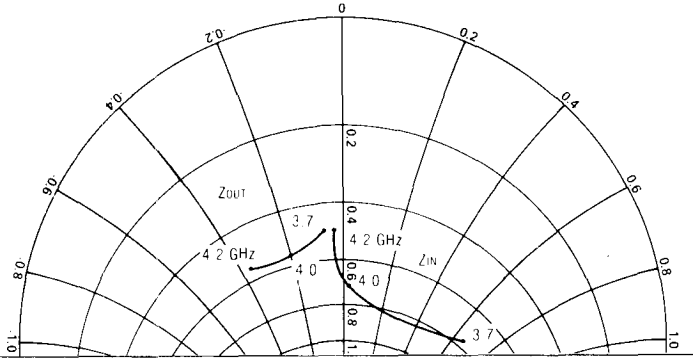


MRA•4-A and MRA•4-B

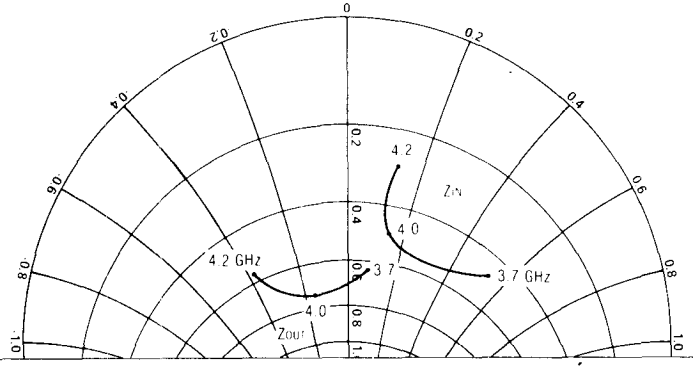
Electrical Characteristics at T_{flange} = 25 °C

	SYMBOL	CHARACTERISTICS	MRAL 3742-2	MRAL 3742-3.5	MRAL 3742-6
DC Test	BV_{CES}	Collector - Emitter Breakdown Voltage	35 V Min. I_C = 10 mA	35 V Min. I_C = 10 mA	35 V Min. I_C = 10 mA
	BV_{EBO}	Emitter - Base Breakdown Voltage	3.5 V Min. *at* I_E = 10 mA	3.5 V Min. *at* I_E = 10 mA	3.5 V Min. I_E = 10 mA
	I_{CBO}	Collector Cutoff Current I_E = 0 ; V_{CB} = 20 V	2 mA Max.	4 mA Max.	7 mA Max.
	h_{FE}	Forward Current Transfer Ratio V_{CE} = 5 V ; I_C = 100 mA	5 Min.	5 Min.	5 Min.
Operating	I_C	Maximum Continuous Collector Current	6 A.	1.2 A	1.8 A
	θ_{JF}	Thermal Resistance Junction to Flange Infra-red Measurement at 25 °C Flange	17 °C/W Max.	10 °C/W Max.	6 °C/W Max.
RF Test	P_{out}	Broadband Value V_{CB} = 18 V V_{CB} = 20 V (Test Voltage) V_{CB} = 22 V	TYP. MIN. 1.7 W 2.2 W 2.0 W 2.5 W *at* P_{in} = .56 W 3.7-4.2 GHz	TYP. MIN. 3.0 W 3.8 W 3.5 W 4.5 W *at* P_{in} = 1 W 3.7-4.2 GHz	TYP. MIN. 5.1 W 6.2 W 5.8 W 6.6 W *at* P_{in} = 1.8 W 3.7-4.2 GHz
	G	Minimum Broadband Power Gain V_{CE} = 20 V	5.5 dB	5.4 dB	5.1 dB
	η_C	Broadband Collector Efficiency V_{CB} = 18 V V_{CB} = 20 V (Test Voltage) V_{CB} = 22 V	TYP. MIN. 32 % 30 % 25 % 27 % *at* P_{in} = .56 W 3.4-7.2 GHz	TYP. MIN. 32 % 30 % 25 % 27 % *at* P_{in} = 1 W 3.7-4.2 GHz	TYP. MIN. 32 % 30 % 25 % 27 % *at* P_{in} = 1.8 W 3.7-4.2 GHz
	L_R	Maximum Broadband Return Loss in Recommended Circuit	— 8.5 dB *at* P_{in} = .56 W 3.7-4.2 GHz	— 8.5 dB *at* P_{in} = 1 W 3.7-4.2 GHz	— 8.5 dB *at* P_{in} = 1.8 W 3.7-4.2 GHz
	VSWR	Mismatch Tolerance V_{CB} = 20 V and Tested at F = 3.7 and F = 4.2 GHz	3 : 1 P_{out} = 2 W	3 : 1 P_{out} = 3.5 W	3 : 1 P_{out} = 5.8 W

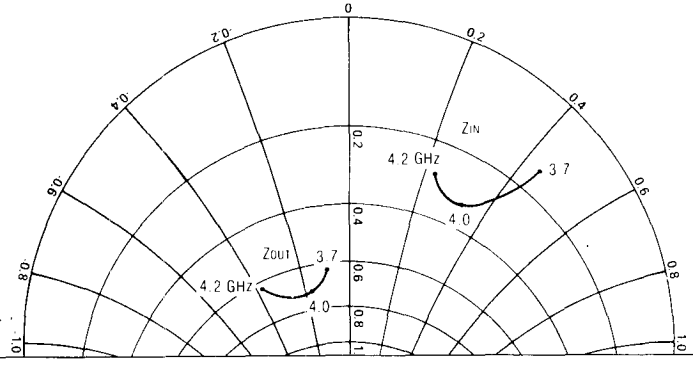
IMPEDANCE DATA (Zo = 50Ω)
MRAL 3742-2
VCB = 20V



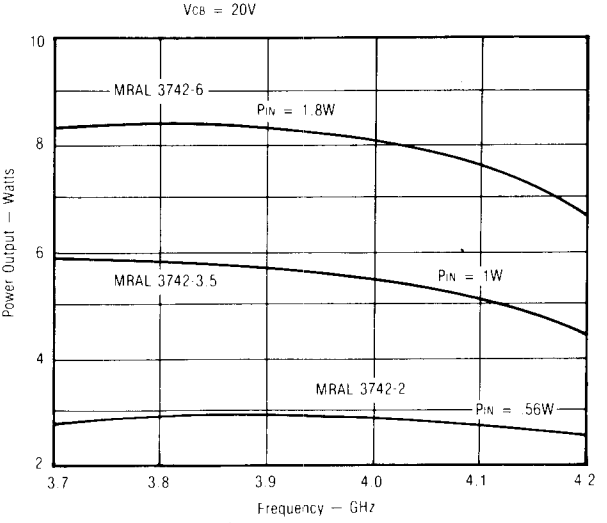
IMPEDANCE DATA (Zo = 50Ω)
MRAL 3742-3.5
VCB = 20V



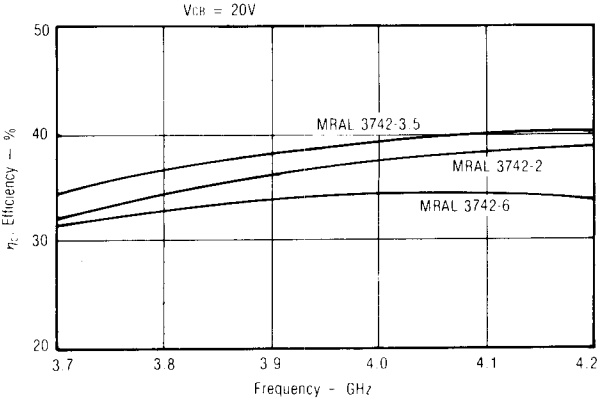
IMPEDANCE DATA (Zo = 50Ω)
MRAL 3742-6
VCB = 20V



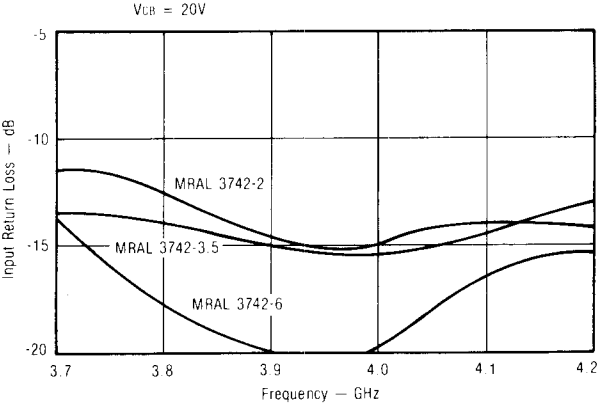
Typical Power Output vs. Frequency



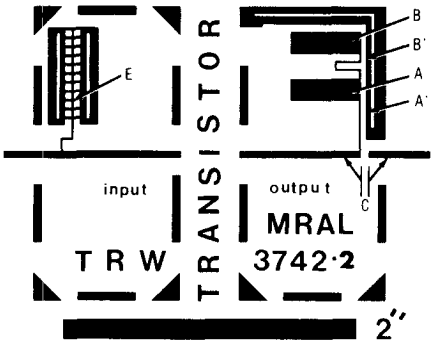
Typical Collector Efficiency vs. Frequency

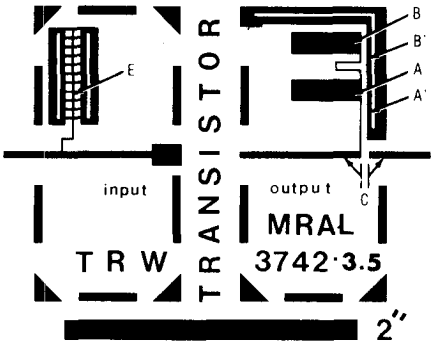


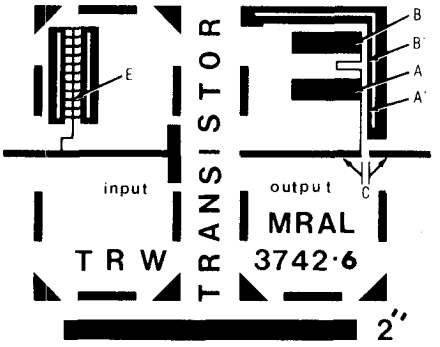
Typical Input Return Loss vs. Frequency



P.C. BOARD LAYOUT FOR MRAL 3742 SERIES







▬: Cut slot through insert shim brass and solder to both sides of circuit board.

AA': Connect 27pF ceramic chip capacitor.

C: 27pF ceramic chip capacitor.

BB': Connect 100pF and .1μF ceramic chip capacitor and 27μF electrolytic capacitor.

B: Connect the positive supply.

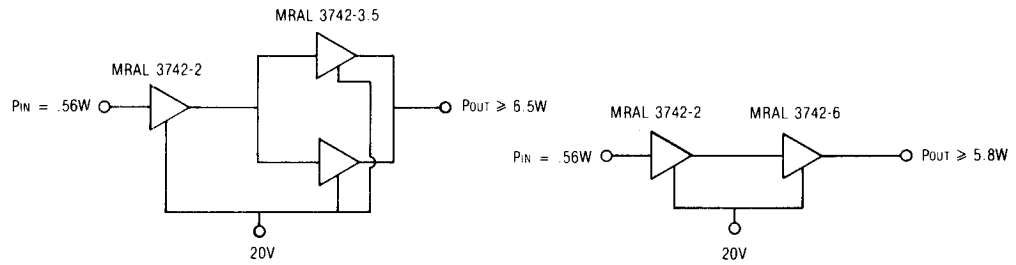
B': Connect the ground supply.

E: Cut the strips to have the best input match.

Board Material: 20 Mils glass-teflon; ε_r = 2.55; dielectric thickness = 18 mils.

LINE-UP SUGGESTIONS

3.7-4.2 GHz - 6W - Radio Relay Amplifier.



The MRAL 3742 Series offers high **broadband** performance transistors which are suited to radio relay and other applications in 3.7-4.2 GHz region.

The input impedance can be easily matched to 50 Ω and the output impedance is internally matched to 50 Ω. The output circuit utilizes a direct shunt inductor technique resulting in excellent RF stability. In order to obtain 500 MHz bandwidth with good performance a monolithic shunt inductor (MSL) is used for the output circuit of the 3.5 W and 6 W transistors.

The transistor cells are gold metallized, the emitters are ballasted with diffused resistors, the base and the emitter are ion-implanted for high gain, a base depletion ring is used for higher breakdown voltage, and the low resistivity graded EPI configuration allows high saturated output power and efficiency.

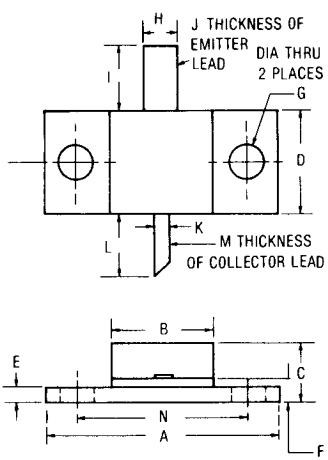
This series can be used in Class B when linearity or higher gain is required.

This series is housed in a 400 square mil. package.

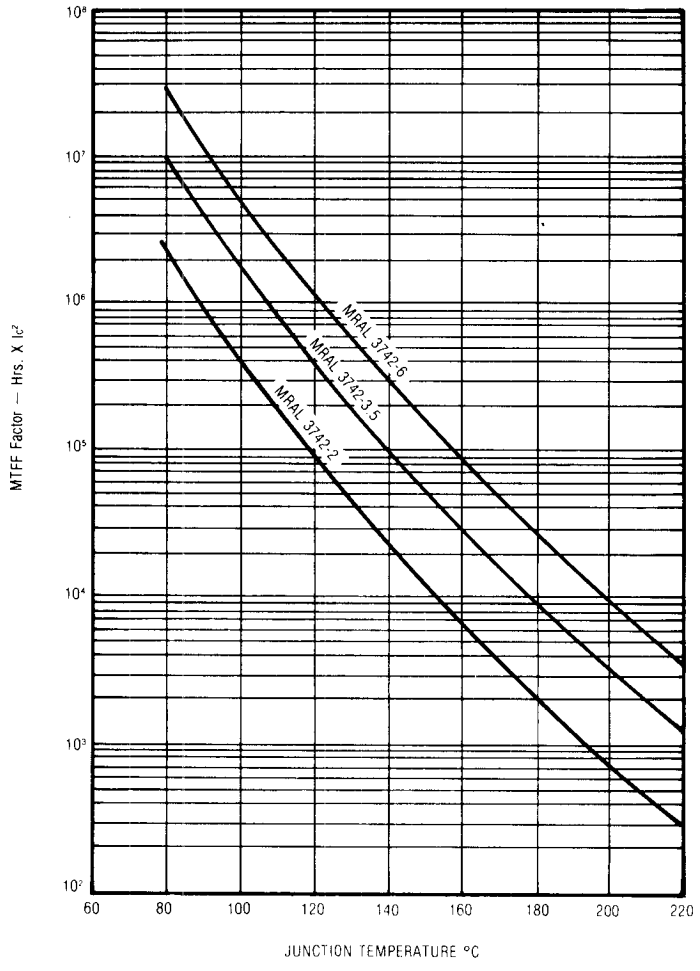
PACKAGE MRA 4

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.892	.908	22.66	23.06
B	.394	.406	10.01	10.31
C	—	.220	—	5.588
D	.400	.405	10.16	10.29
E	.060	.064	1.524	1.626
F	.082	.094	2.083	2.388
G	.127	.133	3.226	3.378
H1*	.026	.036	0.660	0.914
H2*	.050	.070	1.270	1.778
I	.150	—	3.810	—
J1*	.001	.003	0.025	0.076
J2*	.002	.007	0.051	0.178
K	.026	.036	0.660	0.914
L	.150	—	3.810	—
M	.001	.003	0.038	0.076
N	.640	.660	16.25	16.77

* H1, J1: MRAL 3742-2 ONLY
H2, J2: MRAL 3742-3.5 AND MRAL 3742-6



MTTF FACTOR VS. TJ
(DIVIDE BY I_C^2 TO OBTAIN LIFETIME IN HOURS)



EXAMPLE OF MTTF FOR MRAL 3742-3.5. CONDITIONS ARE :

P_O = 4W $\quad ic \cong I_E = \dfrac{P_O}{(\eta c)\,(V_{CB})} = 667A$

P_{IN} = 1W $\quad P_{diss} = P_{IN} + V_{cc}I_C - P_O = 10.3W$

V_{CB} = 20V

ηc = 30 % $\quad T_{JUNC} = T_{FLANGE} + \theta_{JF} \times P_{DISS} = 153\ °C$

T_{FLANGE} = 50 °C $\quad MTTC = \dfrac{4 \times 10^4}{667^2} = 89{,}910$ HRS. $= 10.3$ YRS.

TRW® SEMICONDUCTORS

SUPER 2 GHz Series

Microwave Power Transistors

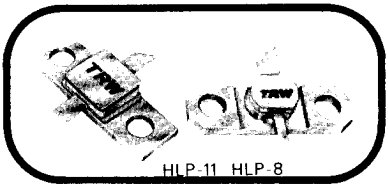
The TRW « Super 2 GHz » series is the first group of 2 GHz, common base devices offering unqualified tolerance of **complete mismatch** (∞ VSWR, any phase) conditions. This feature is particularly desirable in military and space applications where multi-million dollar investments (and even human lives) can be jeopardized by device failure.

The « Super 2 GHz » series is characterized to 2.3 GHz and is priced to be attractive in industrial service. All units are **gold metalized** for longevity and resistance to metal migration. They are emitter ballasted with heat sinked, diffused, rather than deposited metal resistors. This series is housed in TRW's true hermetic, MIL acceptable, HLP package. The package is available with or without flange.

The « Super 2 GHz » series can be adapted readily to circuits designed around older, less reliable devices with a minimum of circuit adjustment. They are mechanically interchangeable with other similar 2 GHz devices.

TRW 2001	1 W, 9 dB
TRW 2003	3 W, 8 dB
TRW 2005	5 W, 8 dB
TRW 2010	10 W, 6 dB
TRW 2015	15 W, 6 dB
TRW 2020	20 W, 5.2 dB

∞ VSWR



HLP-11 HLP-8

Electrical Characteristics (T_{CASE} = 25 °C)

Mechanical Specifications

The following are mechanical specifications for this transistor.

Dimensions : Per outline drawing.

Solderability : Per MIL-STD-750.

Marking : Per MIL-S-19500, « TRW », 4-digit date code, type number.

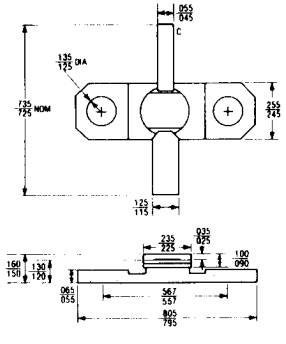
Hermaticity : Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration : Per MIL-STD-750, 20.000 G in any plane.

Bond Pull : Per MIL-STD-750, 3 grams min.

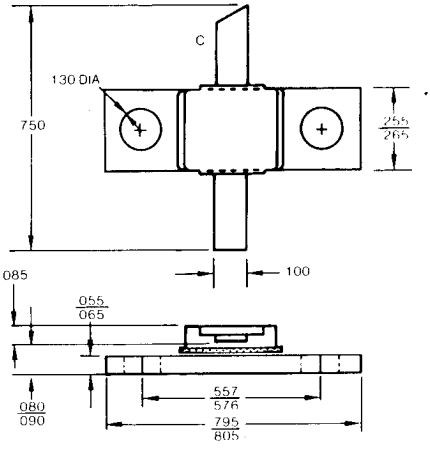
Package : A glass-free, brazed ceramic package assuring long-term integrity of hermetic seals.
HLP-11
HLP-8 Leads of KOVAR base material with minimum 60 micro-inches of gold plating.

HLP-8 Normal Package



Flangeless HLP-8
Specify « F » Suffix

HLP-11 Package



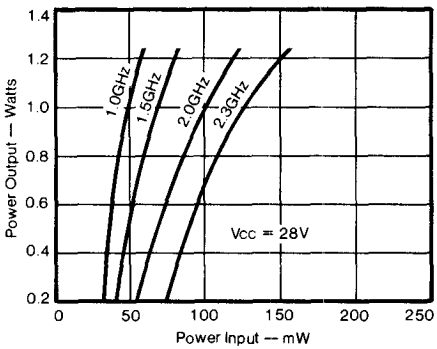
Flangeless HLP-11
Specify « F » Suffix

TRW 2001

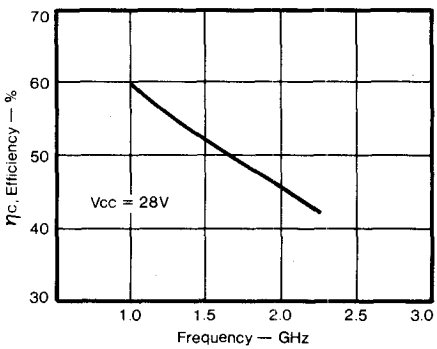
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Conditon	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 10mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1mA I_C = 0	4.0V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	500μA 1mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	0.250A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 100mA	10-120
θ_{jF}	Thermal Resistance (Junction to Flange)	—	28°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	3.0pF
P_O	Power Output @ 2000MHz	P_{in} = 0.125W	1W Min
$P_{O(sat)}$	Power Output @ 2300MHz Power Output @ 1500MHz Power Output @ 1000MHz	V_{CE} = 28Vdc	1.0W (Typ) 1.2W (Typ) 1.3W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_O = 1.0W	9dB Min
VSWR	Mismatch Tolerance @ Vcc = 28V	P_O = 1.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	4,661
η_C	Collector Efficiency (Min)	P_O = 1.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

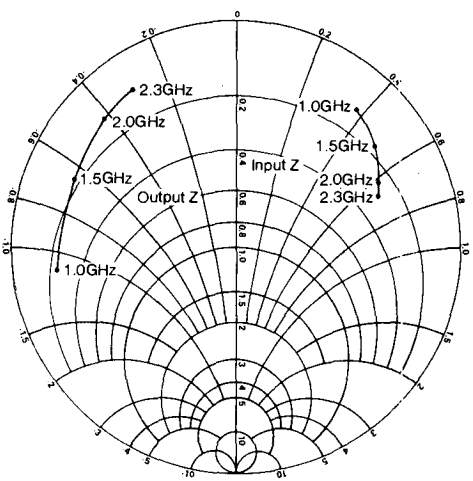
Typical Transfer Characteristics Versus Frequency



Typical η_C Versus Frequency



Impedance Data Vcc = 28V



PC BOARD LAYOUT FOR TRW 2001 TEST CIRCUITS

PART DETAILS

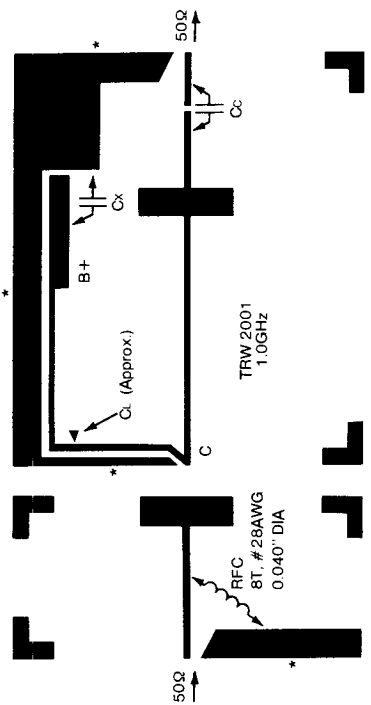
* = Foil-wrap asterisked edge to ground plane

C_C = 220pF chip on all circuits

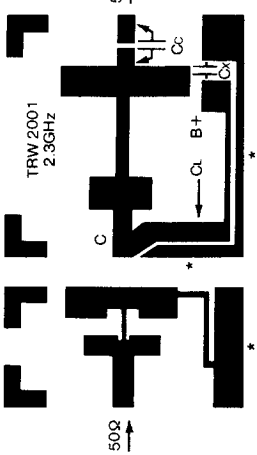
C_X = A combination of two 220pF chips, one 0.1 chip and a 25µF tantalum capacitor (35V min)

C_L = Used as an AC bypass on the shunt inductor line (220pF chip) whose position can be varied

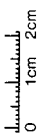
RFC = 1000MHz . . . . . 8 turns, # 28AWG, 0.040 dia
RFC = 1500MHz . . . . . 6 turns, # 28AWG, 0.040 dia
RFC = 2000 and 2300MHz . . . . 4 turns, # 28AWG, 0.040 dia



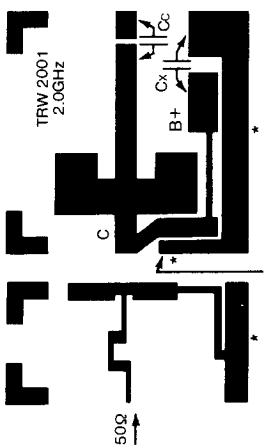
Board Material = 0.020" Glass-Teflon ε_r = 2.55



Board Material = 0.062" Glass-Teflon ε_r = 2.55







Board Material = 0.062" Glass-Teflon ε_r = 2.55

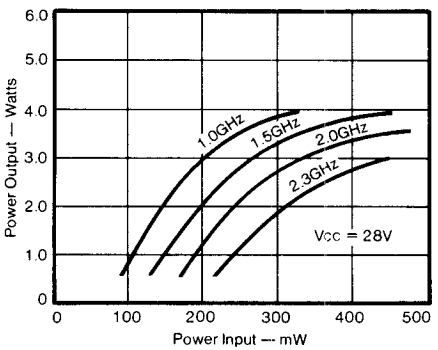
Board Material = 0.062" Glass-Teflon ε_r = 2.55

TRW 2003

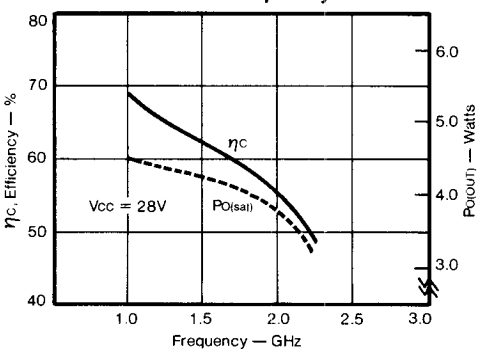
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Conditon	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 20mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25mA I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 2BV I_E = 0 V_{CB} = 45V	500μA 1mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	0.50A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 100mA	10-100
θ_{JF}	Thermal Resistance (Junction to Flange)	—	15°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	5.0pF
P_o	Power Output @ 2000MHz	P_{in} = 0.47W	3.0W Min
$P_{o(sat)}$	Power Output @ 2300MHz	V_{CE} = 28Vdc	3.0W (Typ)
	Power Output @ 1500MHz		3.7W (Typ)
	Power Output @ 1000MHz		4.0W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_o = 3.0W	8dB Min
VSWR	Mismatch Tolerance @ Vcc = 28V	P_o = 3.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	20,300
η_C	Collector Efficiency (Min)	P_o = 3.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

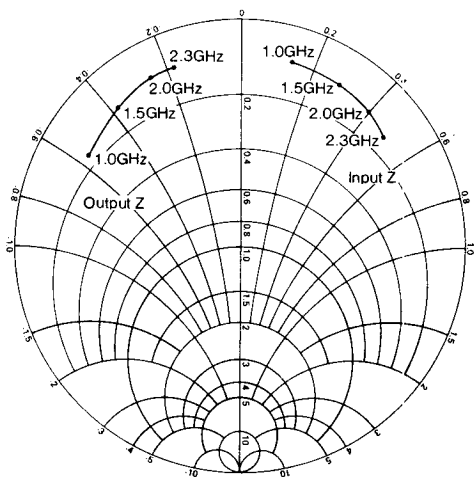
Typical Transfer Characterics Versus Frequency



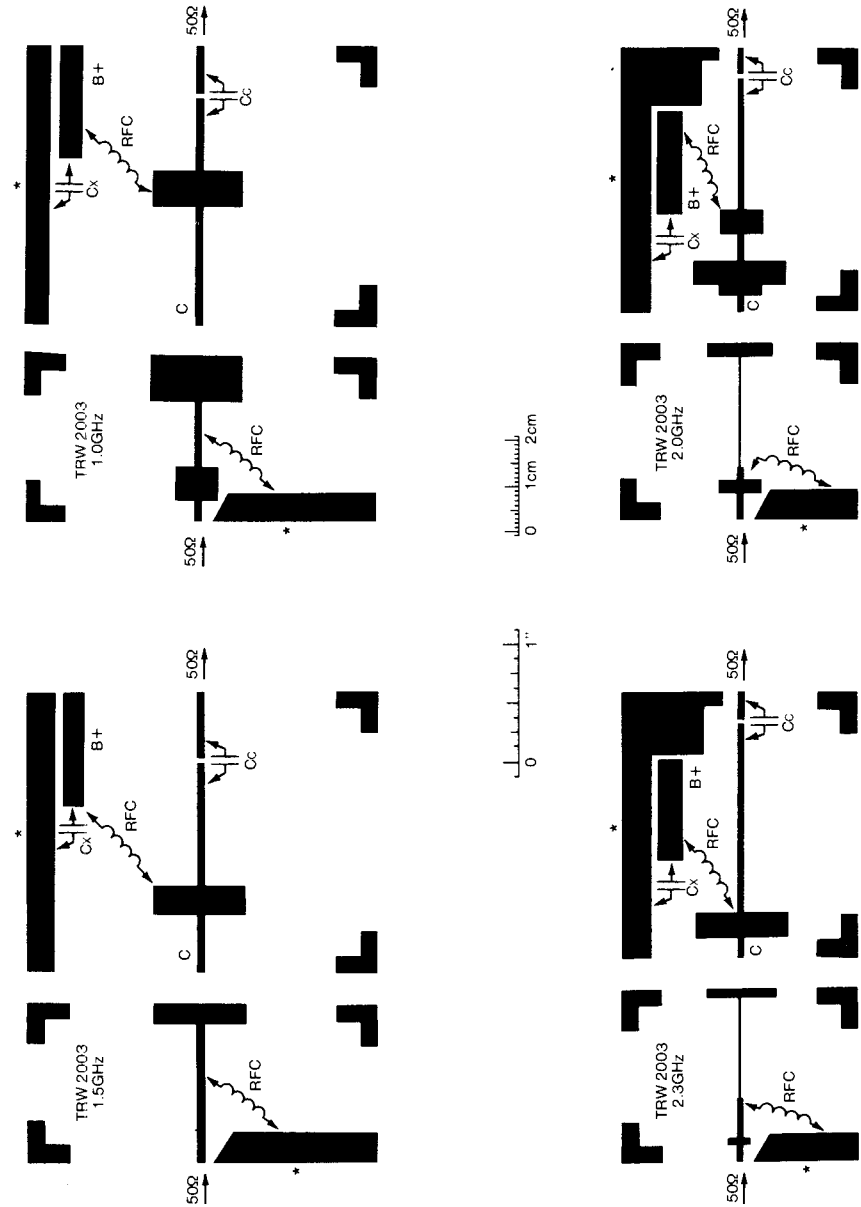
Typical η_C, Power Output Versus Frequency



Impedance Data Vcc = 28V



PC BOARD LAYOUT FOR TRW 2003 TEST CIRCUITS



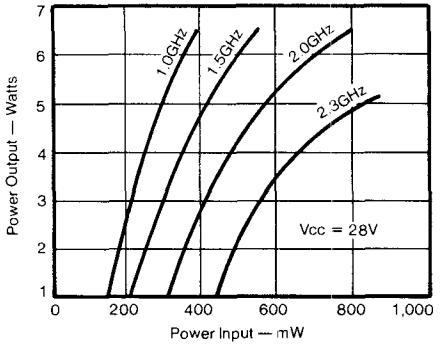
See page 3 for parts details

TRW 2005

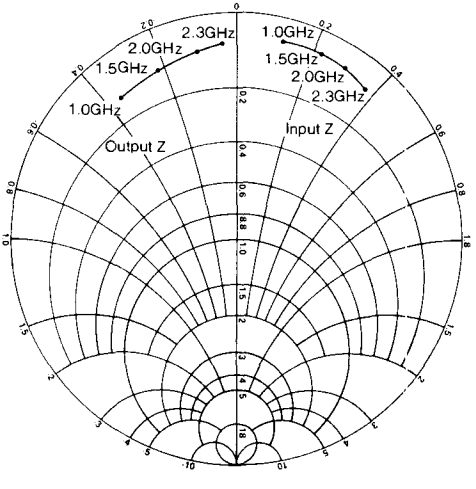
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Conditon	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 40mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.5mA I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	500μA 2mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	1.0A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 200mA	10-100
θ_{j-F}	Thermal Resistance (Junction to Flange)	—	8.5°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	7.0pF
P_o	Power Output @ 2000MHz	P_{in} = 0.80W	5W Min
$P_{o(sat)}$	Power Output @ 2300MHz	V_{CE} = 28Vdc	5.0W (Typ)
	Power Output @ 1500MHz		6.5W (Typ)
	Power Output @ 1000MHz		7.5W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_o = 5.0W	8dB Min
VSWR	Mismatch Tolerance @ Vcc = 28V	P_o = 5.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	81,200
η_C	Collector Efficiency (Min)	P_o = 5.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

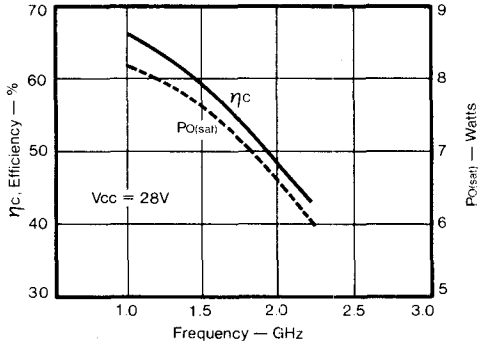
Typical Transfer Characteristics Versus Frequency



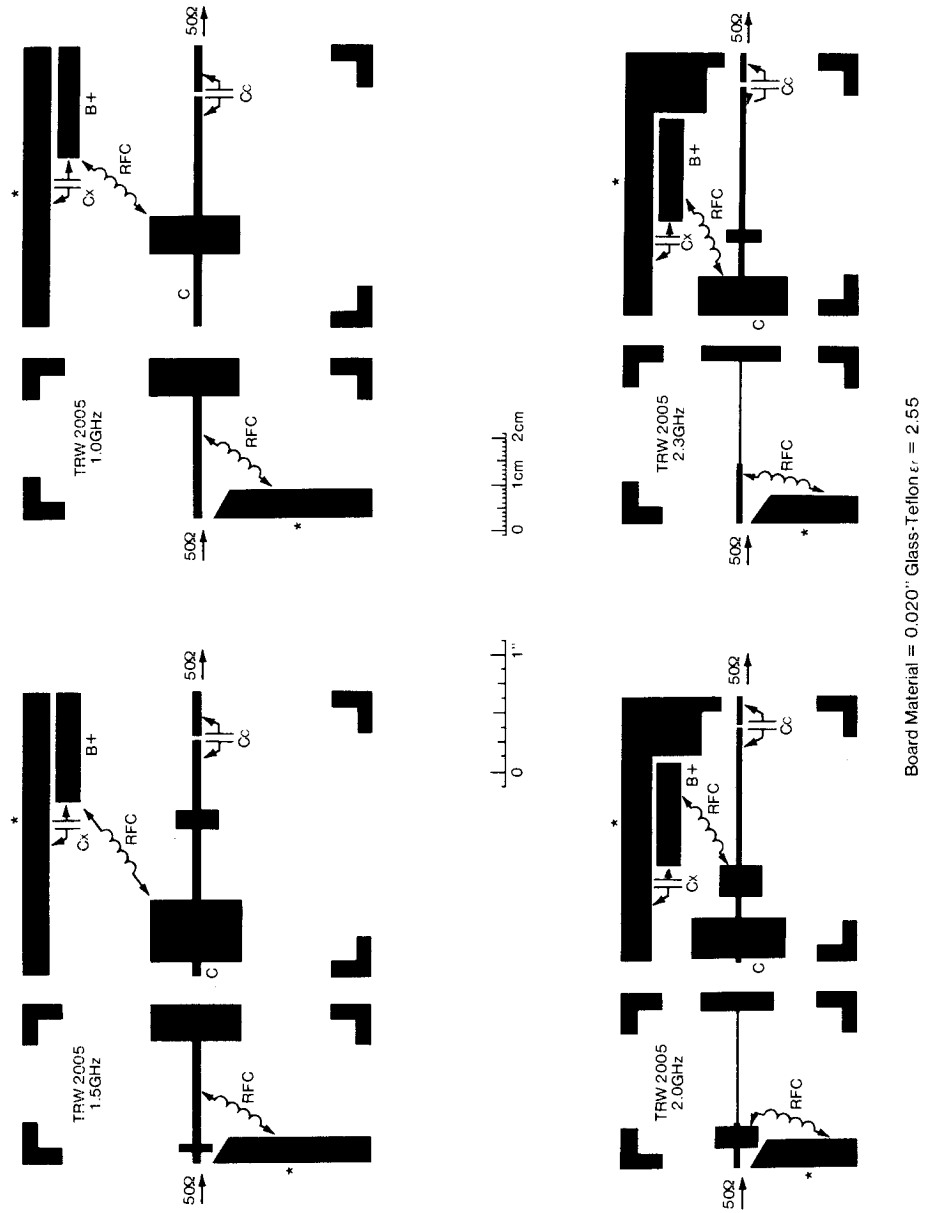
Impedance Data Vcc = 28V



Typical η_C, Power Output Versus Frequency



PC BOARD LAYOUT FOR TRW 2005 TEST CIRCUITS



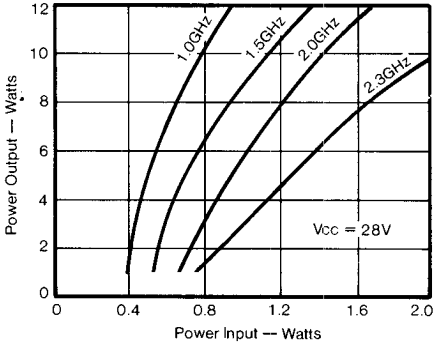
See page 3 for parts details

TRW 2010

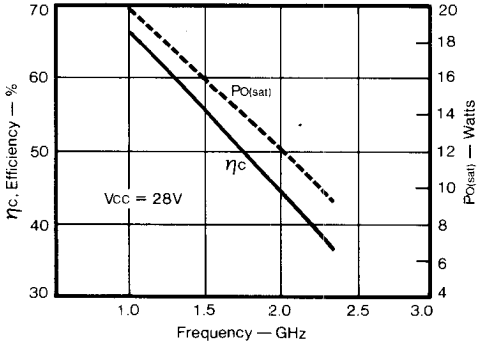
Electrical Characteristics (T_{flange} = 25°C)

Symbol	Characteristic	Conditon	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 80mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0mA I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	500μA 4mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	2.0A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 400mA	10-100
θ_{JF}	Thermal Resistance (Junction to Flange)	—	6°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	12.0pF
P_o	Power Output @ 2000MHz	P_{in} = 2.5W	10.0W Min
$P_{o(sat)}$	Power Output @ 2300MHz	V_{CE} = 28Vdc	10.0W (Typ)
	Power Output @ 1500MHz		13.0W (Typ)
	Power Output @ 1000MHz		15.0W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_o = 10W	6dB Min
VSWR	Mismatch Tolerance @ V_{CC} = 28V	P_o = 10.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	324,800
η_C	Collector Efficiency (Min)	P_o = 10.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperatures	-65 to 200°C	

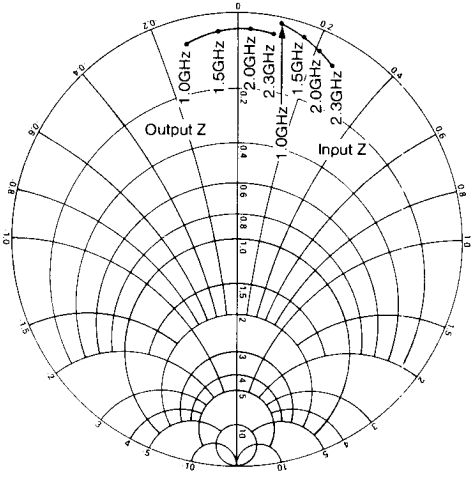
Typical Transfer Characteristics Versus Frequency



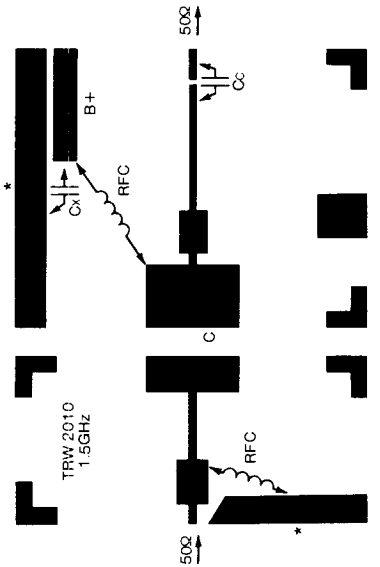
Typical η_C, Power Output Versus Frequency

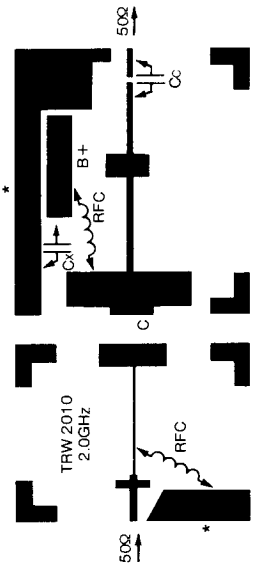


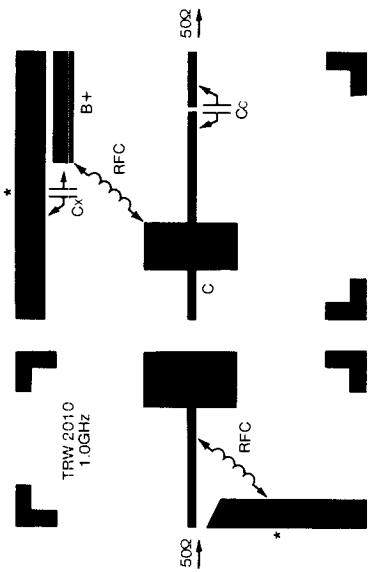
Impedance Data Vcc = 28V

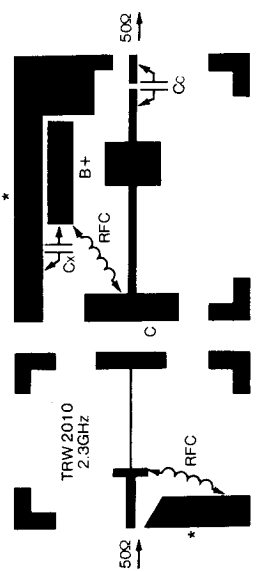


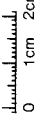
PC BOARD LAYOUT FOR TRW 2010 TEST CIRCUITS

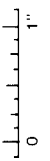












Board Material = 0.020" Glass-Teflon $\varepsilon_r = 2.55$

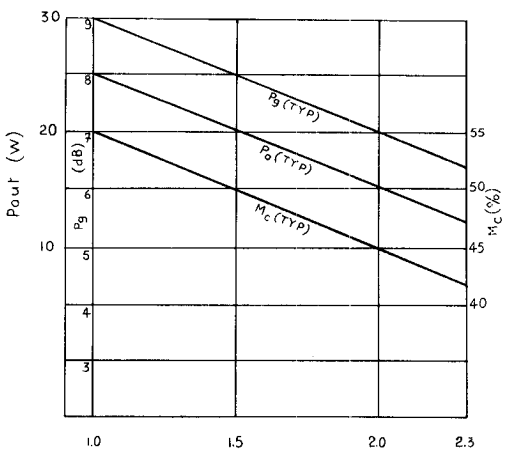
See page 3 for parts details

TRW 2015

Electrical Characteristics (T_{FLANGE} = 25°C)

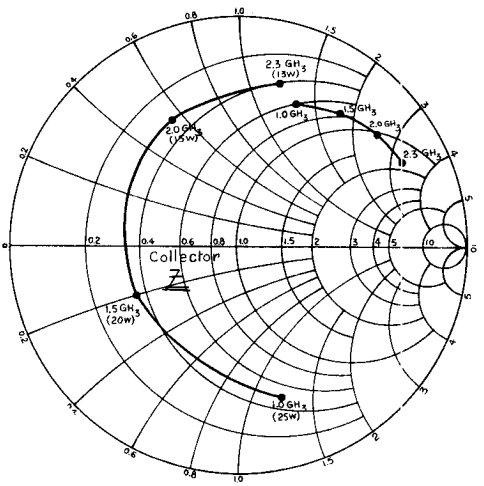
Symbol	Characteristic	Condition	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 120 mA	50 V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1,5 mA I_C = 0	3.5 V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V I_E = 0	1.0 mA Max
I_C	Continuous Collector Current (Max)	V_{CE} = 4 V	3.0 A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 600 mA	10-100
θ_{jF}	Thermal Resistance (Junction to Flange)	--	4 °C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28 V	21 pF
P_o	Power Output 2000 MHz	P_{in} = 3.75 W	15.0 W Min
$P_{o(sat)}$	Power Output 1500 MHz	V_{CE} = 28 V	22 W Typ
	Power Output 1000 MHz		30 W Typ
P_{gain}	Power Gain (dB) 2000 MHz	P_o = 15 W	6 dB Min
VSWR	Mismatch Tolerance V_{CC} = 28 V	P_o = 15 W f = 2 GHz	∞
MTTF	Mean Time-to-Metal Failure (Hrs × Amps^2)	T_j = 150 °C	780,000
η_C	Collector Efficiency (Min)	P_o = 15 W f = 2 GHz	40 %
T_j & T_{stg}	Max Junction and Storage Temperature	— 65 °C to + 200 °C	

Typical Performance Characteristics



Impedance Data

Vcc = 28V Zo = 5.0Ω

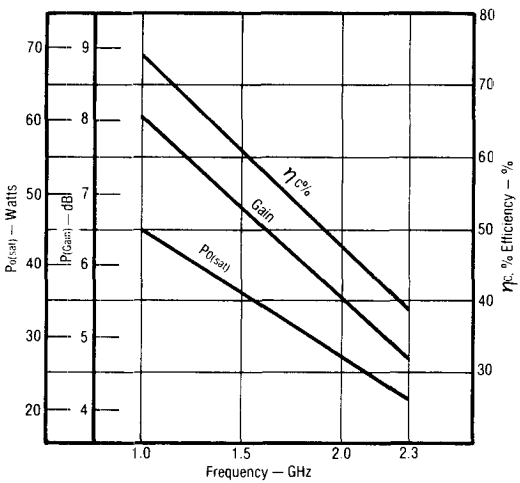


TRW 2020

Electrical Characteristics (T_{FLANGE} = 25°C)

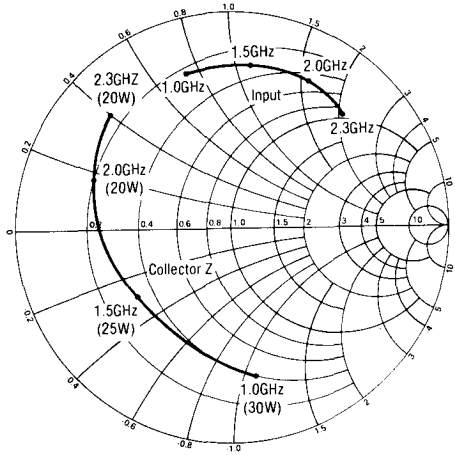
Symbol	Characteristic	Condition	Value
BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10Ω	I_C = 160mA	50V Min
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 2.0mA I_C = 0	3.5V Min
I_{CBO}	Collector Cutoff Current	V_{CB} = 28V I_E = 0 V_{CB} = 45V	1.0mA 8mA
I_C	Continuous Collector Current (Max)	V_{CE} = 4V	4.0A
h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5V I_C = 800mA	10-100
θ_{jF}	Thermal Resistance (Junction to Flange)	–	3°C/W
C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 28V	24.0pF
P_O	Power Output @ 2000MHz	P_{in} = 6.0W	20.0W Min
$P_{O(sat)}$	Power Output @ 1500MHz	V_{CE} = 28Vdc	30.0W (Typ)
	Power Output @ 1000MHz		40.0W (Typ)
P_{gain}	Power Gain (dB) @ 2000MHz	P_O = 20W	5.2dB Min
VSWR	Mismatch Tolerance @ V_{CC} = 28V	P_O = 20.0W f = 2.0GHz	∞
MTTF	Mean-Time-to-Metal Failure (Hrs x Amps²)	T_j = 150°C	1,588,000
η_C	Collector Efficiency (Min)	P_O = 20.0W f = 2.0GHz	40%
T_j & T_{stg}	Max Junction and Storage Temperature	-65 to 200°C	

Typical Performance Characteristics



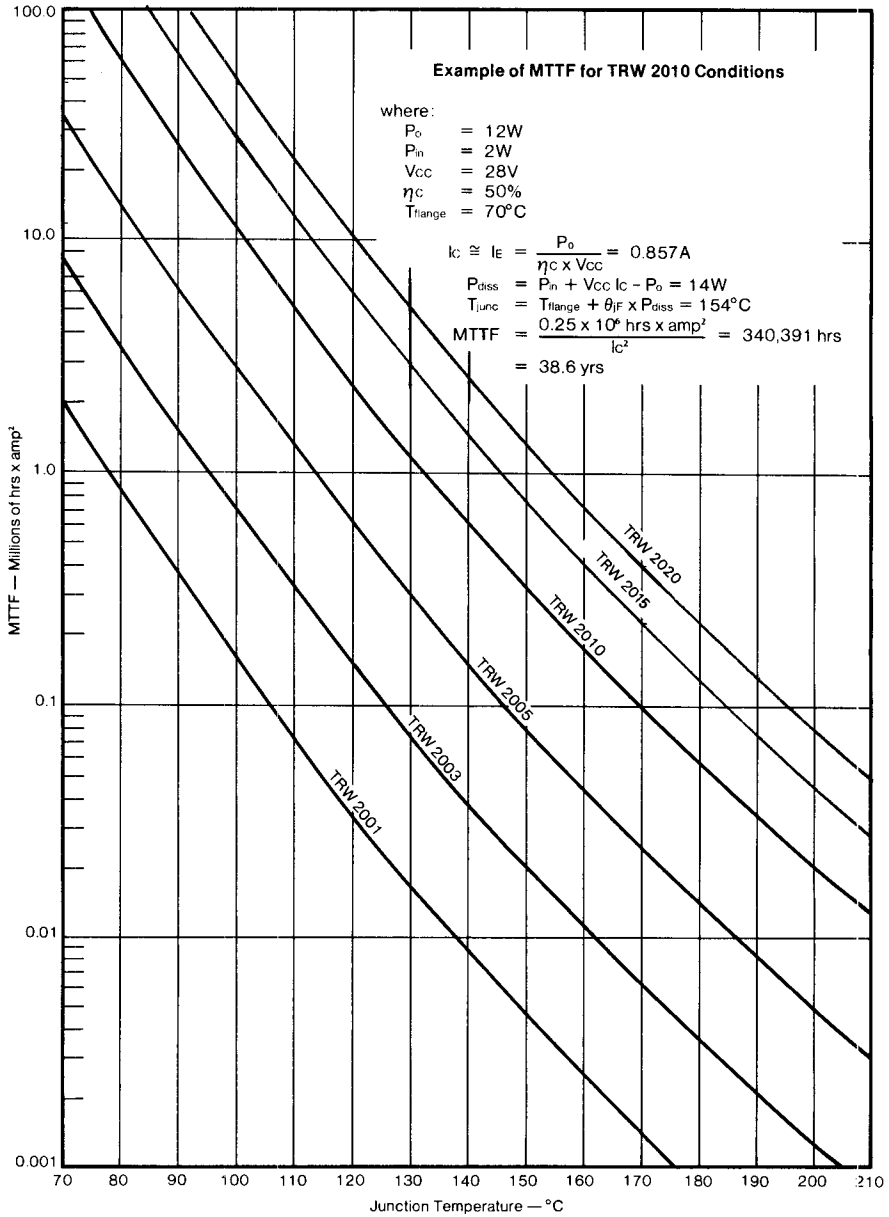
Impedance Data

V_{CC} = 28V Z_O = 5.0Ω



MTTF FACTOR (Normalized to 1 ampere² Continuous Duty)

The graph shown below displays MTTF in hours x ampere² emitter current for each of the "Super 2GHz" devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included on the graph.



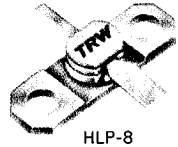
Microwave Power Transistor

Latest in the TRW « Super 2 GHz » Series, the TRW 2301 offers a sturdy transistor which is ideally suited to space, military, radio relay and other applications in the 1 to 3.0 GHz region.

The device is capable of withstanding any mismatch load condition at any phase angle up to, and including, open and short circuit (∞ **VSWR**) under full rated conditions. The unit is **gold metalized,** thereby eliminating metal migration problems common with aluminum parts (metal failure predictions are included herein). Further, the transistor is emitter ballasted with **diffused silicon resistors** rather than deposited metal film resistors for reliability and ruggedness.

The TRW 2301 is housed in the HLP-8, glass-free, **full hermetic** package which is available with or without mouning flange. Full mechanical specifications are guaranteed.

2.3 GHz
1.5 W - 20 V
∞ VSWR



HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 50 mA	42 V Min
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0 mA I_c = 0	3.5 V Min
	I_{CBO}	Collector Cutoff Current	V_{CB} = 22 V I_E = 0	0.5 mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 100 mA	10-120
R F Tests	C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 20 V	4 pF
	P_o	Power Output	f = 2.3 GHz V_{CE} = 20 V V_{CE} = 24 V	1.5 W Min 2 W Typ
	P_{gain}	Power Gain (dB)	f = 2.3 GHz P_o = 1.5 W V_{CE} = 20 V	8.0 dB Min
	VSWR	Mismatch Tolerance	P_o = 1.5 W f = 2.3 GHz V_{CE} = 20 V	∞
	η_C	Collector Efficiency	P_o = 1.5 W f = 2.3 GHz V_{CE} = 20 V	40 % Min
Operating	T_j & T_{stg}	Max Junction and Storage Temperature	— 65 to + 200 °C	
	θ_{jF}	Thermal Resistance		35 °C/W
	I_C	Continuous Collector Current	V_{CE} = 5 V	0.5 A Max

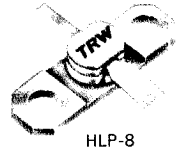
Transistor Microwave Power

Latest in the TRW « Super 2 GHz » Series, the TRW 2304 offers a sturdy transistor which is ideally suited to space, military, radio relay and other applications in the 1 to 3.0 GHz region.

The device is capable of withstanding any mismatch load condition at any phase angle up to, and including, open and short circuit (∞ **VSWR**) under full rated conditions. The unit is **gold metalized,** thereby eliminating metal migration problems common with aluminum parts (metal failure predictions are included herein). Further, the transistor is emitter ballasted with **diffused silicon resistors** rather than deposited metal film resistors for reliability and ruggedness.

The TRW 2304 is housed in the HLP-8, glass-free, **full hermetic** package which is available with or without mounting flange. Full mechanical specifications are guaranteed.

2.3 GHz
4 W - 20 V
∞ VSWR



HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 50 mA	42 V Min
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5 V Min
	I_{CBO}	Collector Cutoff Current	V_{CB} = 22 V I_E = 0	0.75 mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 250 mA	10-120
R F Tests	C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 20 V	7 pF
	P_o	Power Output	f = 2.3 GHz V_{CE} = 20 V V_{CE} = 24 V	4 W Min 5 W Typ
	P_{gain}	Power Gain (dB)	f = 2.3 GHz P_o = 4 W V_{CE} = 20 V	8.0 dB Min
	VSWR	Mismatch Tolerance	P_o = 4 W f = 2.3 GHz V_{CE} = 20 V	∞
	η_C	Collector Efficiency	P_o = 4 W f = 2.3 GHz V_{CE} = 20 V	40 % Min
Operating	T_j & T_{stg}	Max Junction and Storage Temperature	— 65 to + 200 °C	
	θ_{jF}	Thermal Resistance		17 °C/W
	I_C	Continuous Collector Current	V_{CE} = 5 V	1.5 A Max

Microwave Power Transistor

Latest in the TRW « Super 2 GHz » Series, the TRW 2307 offers a sturdy transistor which is ideally suited to space, military, radio relay and other applications in the 1 to 3.0 GHz region.

The device is capable of withstanding any mismatch load condition at any phase angle up to, and including, open and short circuit (∞**VSWR**) under full rated conditions. The unit is **gold metalized,** thereby eliminating metal migration problems common with aluminum parts (metal failure predictions are included herein). Further, the transistor is emitter ballasted with **diffused silicon resistors** rather than deposited metal film resistors for reliability and ruggedness.

The TRW 2307 is housed in the HLP-8, glass free, **full hermetic** package which is available with or without mounting flange. Full mechanical specifications are guaranteed.

2.3 GHz
7 W - 20 V
∞ VSWR

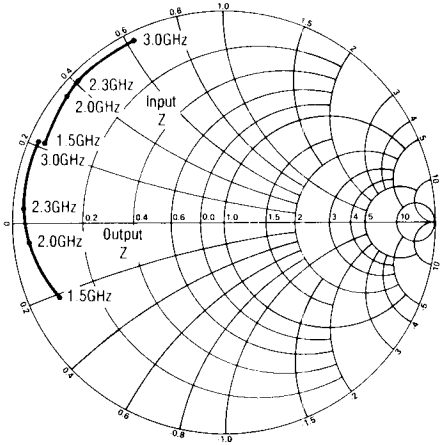


HLP-8

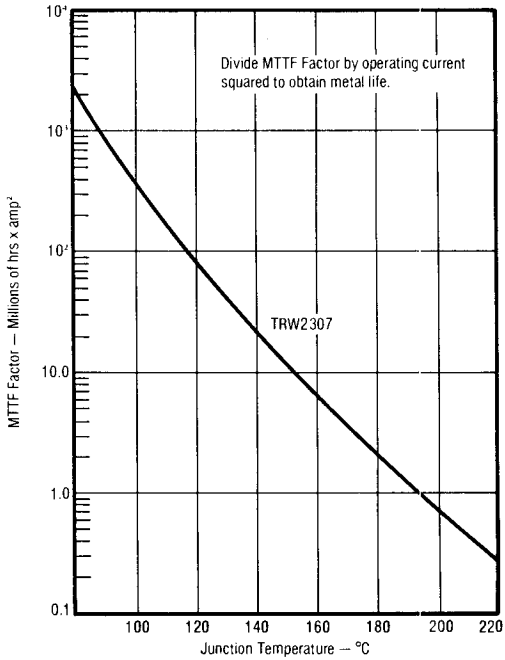
Electrical Characteristics (T_{flange} = 25 °C)

	Symbol	Characteristics	Condition	Value
D C Tests	BV_{CER}	Collector-Base Breakdown Voltage R_{BE} = 10 Ω	I_C = 50 mA	42 V Min
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5 V Min
	I_{CBO}	Collector Cutoff Current	V_{CB} = 22 V I_E = 0 V_{CB} = 38 V	1.25 mA 2.5 mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 500 mA	10-120
R F Tests	C_{OB}	Collector-Base Capacitance (Max)	V_{CB} = 20 V	10 pF
	P_o	Power Output	f = 2.3 GHz V_{CE} = 20 V V_{CE} = 24 V	7.0 W Min 9.0 W Min
	P_{gain}	Power Gain (dB)	f = 2.3 GHz P_o = 7.0 W V_{CE} = 20 V	8.4 dB Min
	VSWR	Mismatch Tolerance	P_o = 7.0 W f = 2.3 GHz V_{CE} = 20 V	∞
	η_C	Collector Efficiency	P_o = 7.0 W f = 2.3 GHz V_{CE} = 20 V	40 % Min
Operating	T & T_{stg}	Max Junction and Storage Temperature	— 65 to + 200 °C	
	θ_{jF}	Thermal Resistance		8.5 °C/W
	I_C	Continuous Collector Current	V_{CE} = 5 V	2.5 A Max

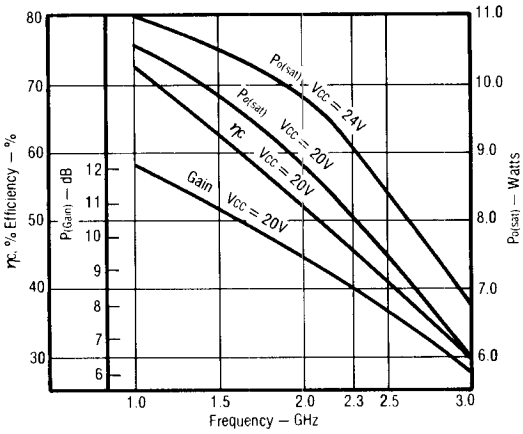
Impedance Data
Vcc = 20V



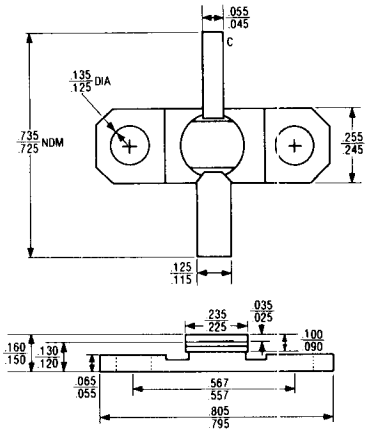
Metal Failure



Typical Performance Characteristics



HLP-8 Package



Mechanical Specifications

The following are mechanical specifications for this transistor.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A glass-free, brazed ceramic package assuring long-term integrity of hermetic seals. Leads of HLP-8, KOVAR base material with minimum 60 microinches of gold plating.

TRW® SEMICONDUCTORS

SUPER 3 GHz SERIES

This data describes TRW's SUPER 3GHz transistors. The etchless gold die metallization, the diffused ballast resistors, and the avalanche protection are available exclusively from TRW.

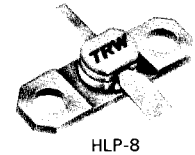
∞ VSWR Tolerance. A TRW first. Every SUPER 3GHz transistor is tested to guarantee each device is capable of withstanding all mismatch conditions (any magnitude, any phase angle). This guarantee precludes costly failures due to an inadvertent impedance mismatch in the laboratory, on the production line or in the field. A 100% production line test for ∞ VSWR capability also assures the die mount integrity. This is not possible with less rugged transistors.

Diffused Ballast Resistors. Another TRW first. Only TRW offers this major technological advance in microwave transistors (patents pending). High resistance ballast resistors are diffused directly into the silicon die totally avoiding the primary failure mechanism of peeling and microcracking associated with conventional thin film, metal ballast resistors. Also, diffused ballasting safely allows much higher resistance values to be achieved (25Ω-100Ω) than does thin film metal ballasting (8Ω-10Ω). Higher ballast levels preclude "hot spotting" since near perfect finger-to-finger and cell-to-cell current sharing is realized. The positive temperature coefficient of the diffused resistor further equalizes uneven temperature distribution.

Avalanche Protection. Yet another TRW first. TRW's exclusive avalanche protection mechanism (patent pending) precludes the failure mode not handled by ballasting alone — secondary breakdown. The voltage across the transistor junction is never allowed to reach breakdown. The P-N diode of the ballast resistor is diffused to avalanche several volts less than the transistor junctions. Under severe mismatch conditions when voltages in excess of breakdown occur, the diode conducts the full avalanche current, thus, protecting the transistor junction. True "full-circle" VSWR protection is achieved with these devices.

Gold Die Metallization. One more TRW first. TRW's etchless, gold metallization process (patent pending) provides exact finger definition. This process is capable of defining sub-micron finger spacing in the interdigitated geometry even though the cross sectional dimension of each gold finger is deeper than it is wide. The etchless process precludes finger scalloping characteristic of all etching processes and eliminates resultant current crowding where metal fingers are necked down. With TRW's gold die metallization original design values are not compromised in the manufacturing process for the primary wear-out mechanism in RF transistors — metal migration. Thus, TRW's etchless, gold metallization system not only capitalizes on the vast improvement in electromigration properties of gold over aluminum but it also assures that the metal lifetime design criteria is retained in the manufacturing process. This achievement cannot be accomplished with any etch-dependent metal system.

TRW 3001 - 1 W
TRW 3003 - 3 W
TRW 3005 - 5 W
∞ VSWR

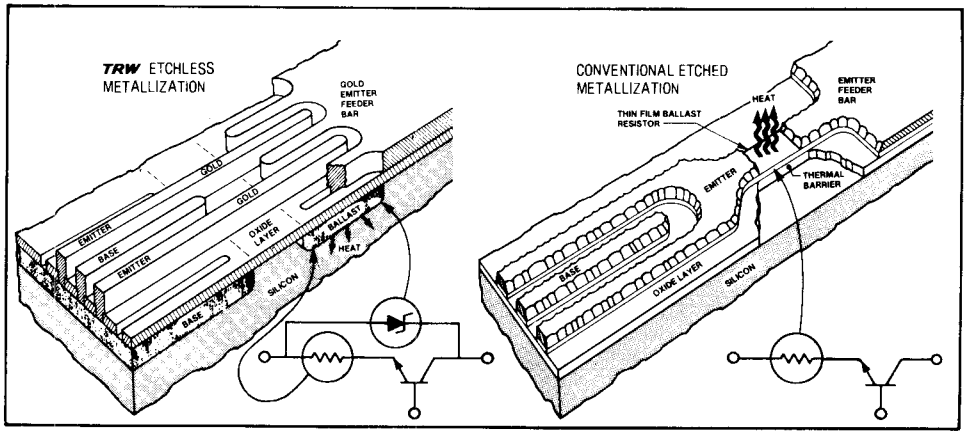


HLP-8

Mono-Metal System. TRW's use of gold metallized die, gold wire bonds, and gold package metal on all SUPER 3GHz transistors precludes intermetallic formations and resultant failures. Gold bonding wire does not work-harden and is thousands of times more resistant to fatigue than is the more brittle aluminum wire alternative. Fatigue tests have verified that TRW's thermal-compression bonding technique provides bond-to-pad mechanical integrity, not possible with aluminum, ultra-sonic bonding systems.

Mil-Package. The Space Qualified HLP-8 is a fully hermetic, glass-free, co-fired ceramic package. It is available with or without a flange.

TRW DIFFUSED BALLAST RESISTORS WITH ETCHLESS GOLD METALLIZATION VS. CONVENTIONAL THIN FILM BALLAST RESISTORS WITH ETCHED METALLIZATION

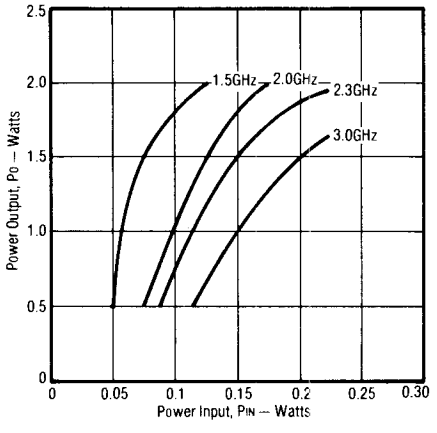


Electrical Characteristics (T_{case} = 25 °C)

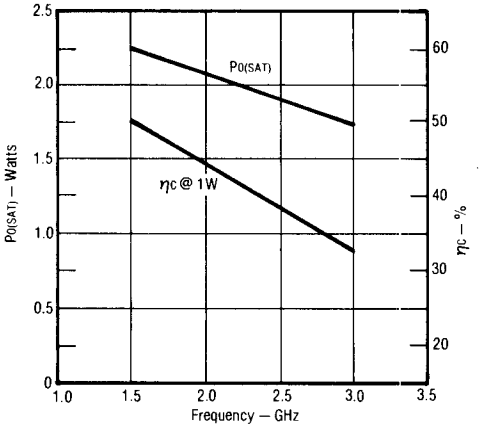
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA b	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 10 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.5	mA
	H_{FE}	DC Current Gain	V_{CB} = 5.0 V I_C = 100 mA	10		120	
RF TEST	P_{gain}	Power Gain	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	7.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 1.0 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		3.5	4.0	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			35	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

TYPICAL CHARACTERISTICS

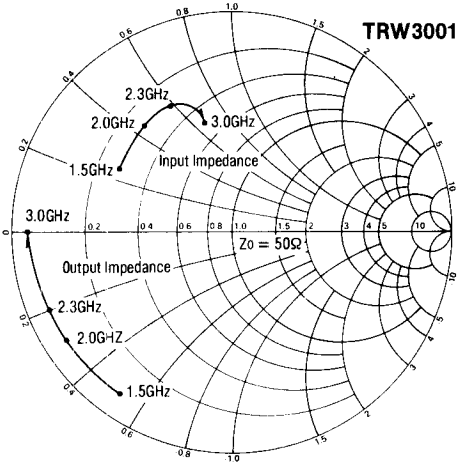
TRW3001

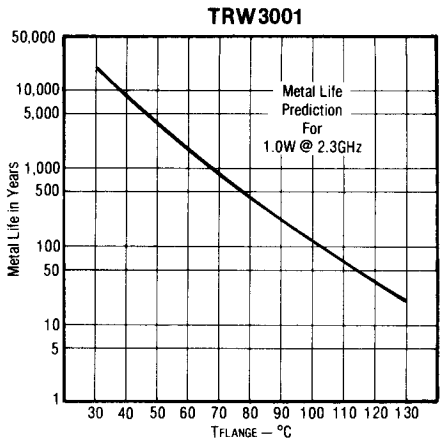


TRW3001

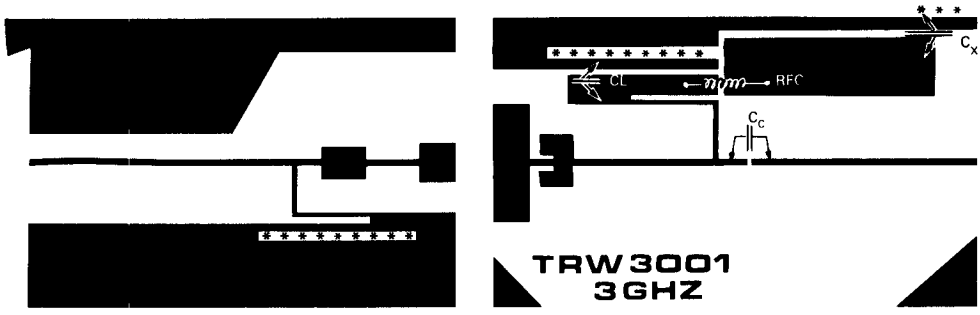


TYPICAL CHARACTERISTICS





PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

Board material ≃ 0.020" Glass teflon (ε_r = 2.55).

* = Foil wrap asterisked edge to ground plane.

C_C = 100 pF chip.

C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 μF.

C_L = 100 pF chip capacitor. The capacitor position can be tuned.

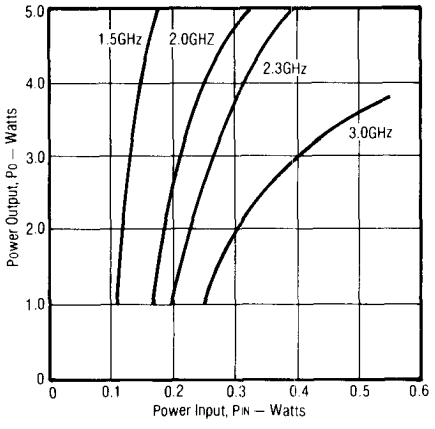
R_{FC} = 8 turns # 28AWG, 0.010 dia.

Electrical Characteristics (T_{case} = 25 °C)

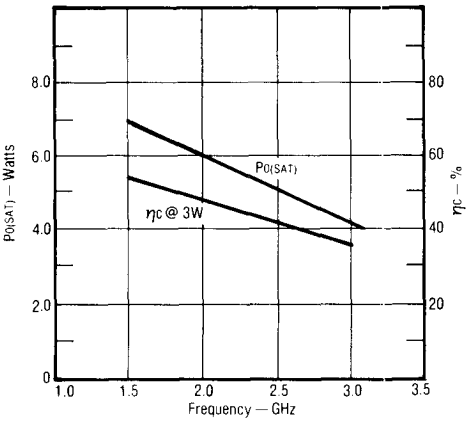
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 3.0 mA	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 30.0 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			0.75	mA
RF TEST	H_{FE}	DC Current Gain	V_{CE} = 5.0 V I_C = 300 mA	10		120	
	P_{Gain}	Power Gain	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	6.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 3.0 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz		5.7	7.0	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			17	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

TYPICAL CHARACTERISTICS

TRW3003

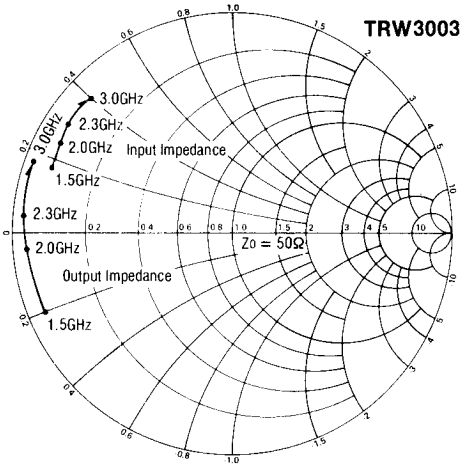


TRW3003

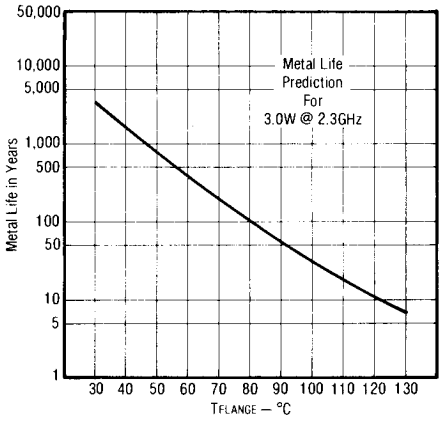


TYPICAL CHARACTERISTICS

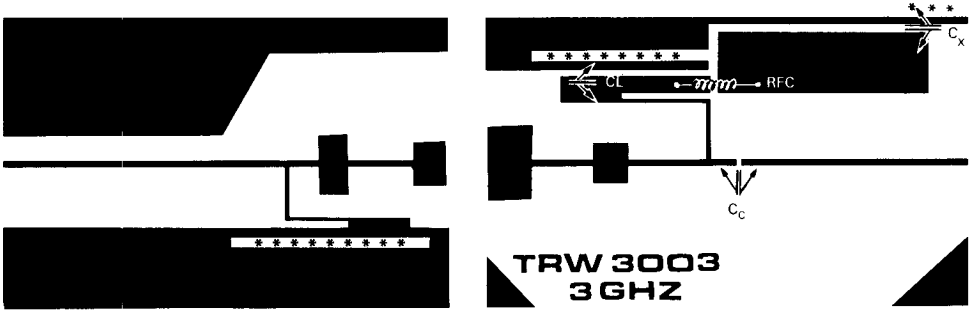
TRW3003



TRW3003



PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

Board material : 0.020″ Glass Teflon (ε_r = 2.55)

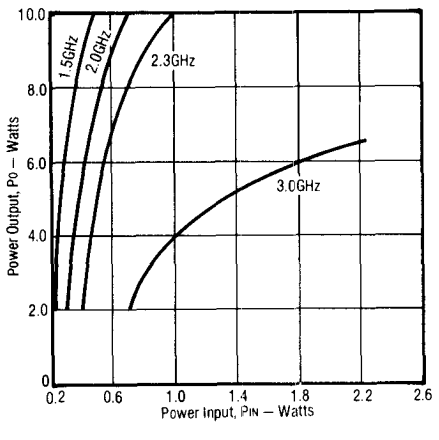
* = Foil wrap asterisked edge to ground plane.
C_C = 100 pF chip.
C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 μF.
C_L = 100 pF chip capacitor. The capacitor position can be tuned.
R_{FC} = 8 turns # 28AWG, 0.010 dia.

Electrical Characteristics (T_{case} = 25 °C)

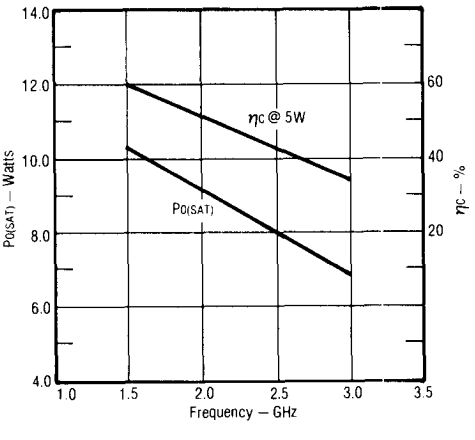
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 1.0 mA I_C = 0	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 5.0 mA	45			V
	BV_{CES}	Collector - Emitter Breakdown Voltage (EB Shorted)	I_C = 50.0 mA	50			V
	I_{CBO}	Collector - Base Leakage	V_{CB} = 28 V			1.25	mA
RF TEST	H_{FE}	DG Current Gain	V_{CE} = 5.0 V I_C = 500 mA	10		120	
	P_{Gain}	Power Gain	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	5.0			dB
	η_C	Collector Efficiency	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	30			%
	VSWR	Mismatch Tolerance (Without Damage)	F_O = 3 GHz P_O = 5 W V_{CC} = 28 V	∞			
	C_{OB}	Collector - Base Capacitance	V_{CB} = 28 V F_O = 1 MHz	8.4		10	pF
THERMAL	θ_{JC}	Thermal Impedance Junction to Case	—			8.5	°C/W
	T_{STG} & T_J	Junction & Storage Temperature Range	—	— 65		+ 200	°C

TYPICAL CHARACTERISTICS

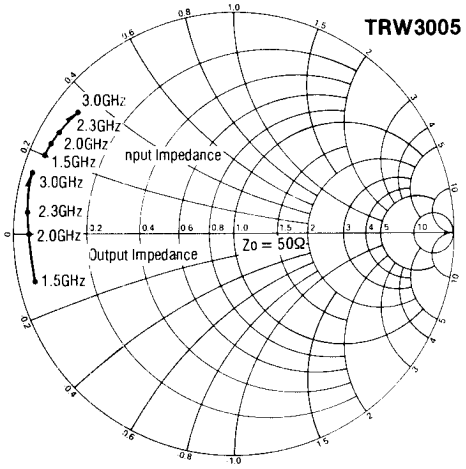
TRW3005

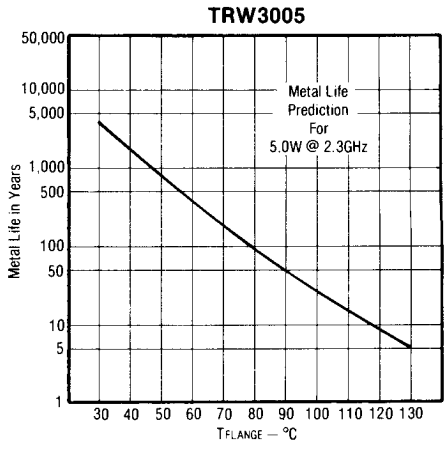


TRW3005

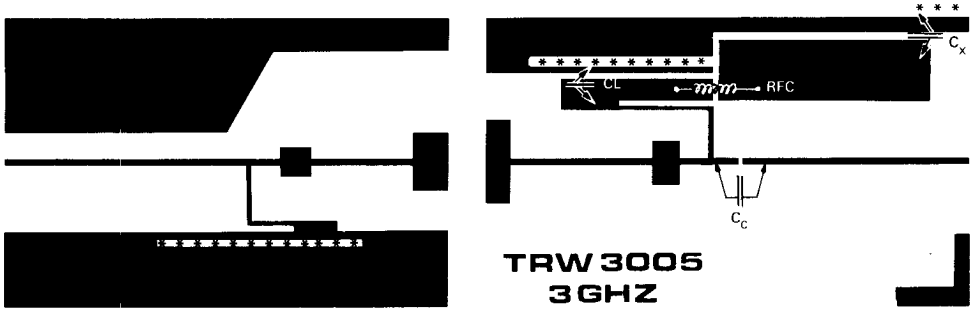


TYPICAL CHARACTERISTICS





PC BOARD LAYOUT F = 3 GHz



1 inch = 19,48 mm

PARTS DETAILS

Board material : 0.020" Glass Teflon (ε_r = 2.55)

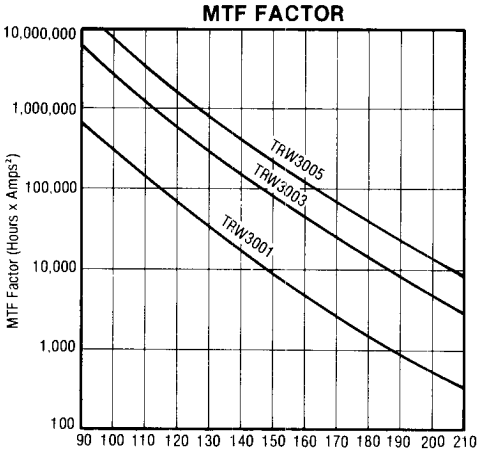
* = Foil wrap asterisked edge to ground plane.

C_C = 100 pF chip.

C_X = 100 pF, 1 nF, 10 nF chip capacitors and 10 µF.

C_L = 100 pF chip capacitor. The capacitor position can be tuned.

R_{FC} = 8 turns # 28AWG, 0.010 dia.



MTTF FACTOR

(Normalized to 1 ampere² Continuous Duty)

The graph shown displays MTTF in hours x ampere² emitter current for each of the 3 GHz devices. Life tests at elevated temperatures have correlated to better than ± 10 % to the theoretical prediction for metal failure. **CAUTION** ε A calculation is required to obtain actual metal life. Sample MTTF calculations based on operating conditions are shown below.

Junction Temperature — °C

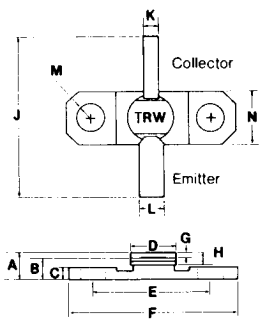
To calculate metal lifetime under any set of conditions, obtain actual data or estimate from typical performance curves. Solve for T_J (°C):

(1) $$T_J = \theta_{JF}\left(\frac{P_{OUT} \times 100}{\eta_C\,\%} + P_{IN} - P_{OUT}\right) + T_{FLANGE}$$

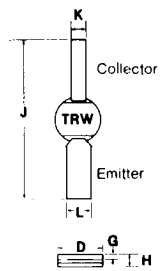
Enter graph of MTF factor vs. T_J. Obtain MTF factor. Calculate metal life by:

(2) $$\text{Metal Life in Hours} = \frac{\text{MTF Factor}}{I_C^2\,(\text{Amps})}$$

HLP-8 Normal Package



Flangeless HLP-8 (Specify « F » Suffix)



Mechanical Dimensions

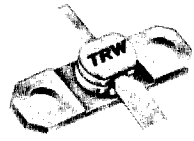
Dimension	U.S. (Inches ± 0.005)	Metric (Centimeters ± 0.0127)
A	0.155	0.3937
B	0.125	0.3175
C	0.060	0.1524
D	0.230	0.5842
E	0.562	1.4270
F	0.800	2.030
G	0.030	0.0762
H	0.095	0.2413
J	0.730 nom	1.85 nom
K	0.050	0.127
L	0.120	0.3048
M	0.130 dia	0.3302 dia
N	0.250	0.6350

Microwave Power Transistors

The TRW « super 4 GHz » series offer a complete family of high gain common base devices, intended for use in a variety of military and industrial applications such as TELEMETRY, ECM, and RADIO-RELAYS.

The transistor cells are gold metallized, the emitters are ballasted with diffused resistors, the base and the emitter are ion-implanted for high gain, a base depletion ring is used for higher breakdown voltage and the low resistivity graded EPI configuration allows high saturated output power and efficiency.

TRW 4001 - 1,3 W - 7,2 DB
TRW 4002 - 2,6 W - 7,0 DB
TRW 4004 - 4,5 W - 5,8 DB
AT 3,5 GHz



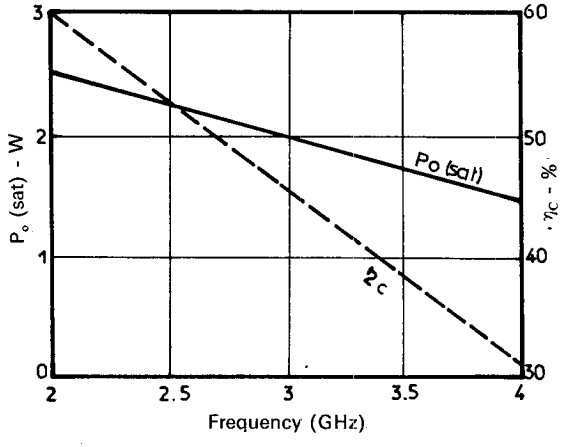
HLP 8

Electrical Characteristics (T_{case} = 25 °C)

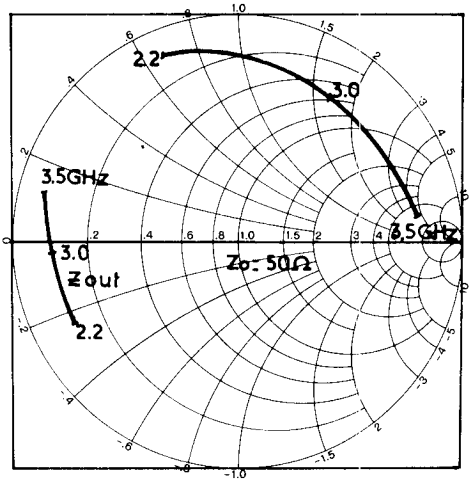
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	TRW 4001	TRW 4002	TRW 4004	UNIT
DC Test	BV_{CES}	Collector - Base Breakdown Voltage	I_c = 10 mA	35	35	35	V (min)
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_e = 10 mA	3,5	3,5	3,5	V (min)
	I_{CBO}	Collector Cutoff Current	I_e = 0 V_{cb} = 20 V	1	2	4	mA (max)
	h_{FE}	Forward Current Transfer Ratio.	V_{ce} = 5 V I_c = 100 mA	5	5	5	Min
RF Test	C_{OB}	Collector Base Capacitance	V_{ce} = 20 V F = 1 MHz	4,5	5,6	9	pF (max)
	P_{out}	Output Power	V_{cb} = 20 V P_{in} = .25 W	1,3			
			P_{in} = .52 W		2,6		
			F = 3.5 GHz P_{in} = 1.2 W			4,5	
	η_C	Collector Efficiency	V_{cb} = 20 V F = 3,5 GHz at rated P out	33	32	30	%
	VSWR	Mismatch Tolerance	V_{cb} = 20 V F = 3,5 GHz at rated P out	3 : 1	3 : 1	3 : 1	
Operating	I_c	Maximum Continuous Collector Current	V_{ce} = 5 V	300	600	1 200	mA (max)
	θ_{jc}	Thermal Resistance	T_F = 25 °C	40	20	10	°C/W max
	T_{SGT}	Maximum Storage		— 65		+ 200	°C

TRW 4001

Typical η_C, power output versus frequency

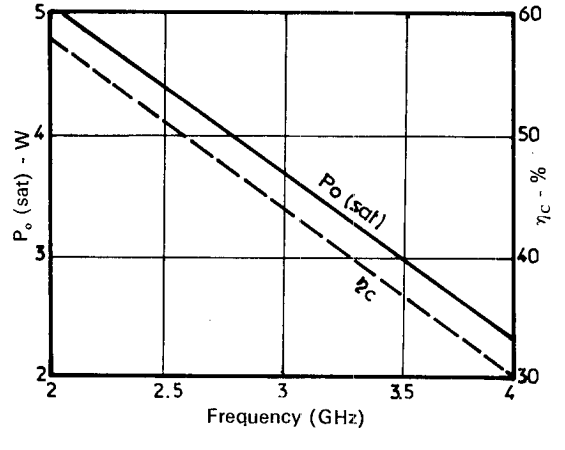


Impedance data
V_{BC} = 20 V

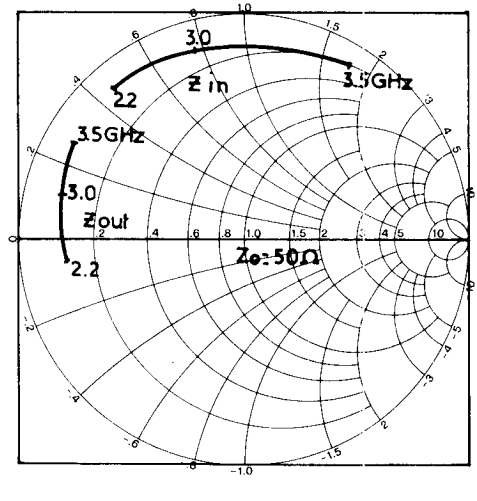


TRW 4002

Typical η_C, power output versus frequency

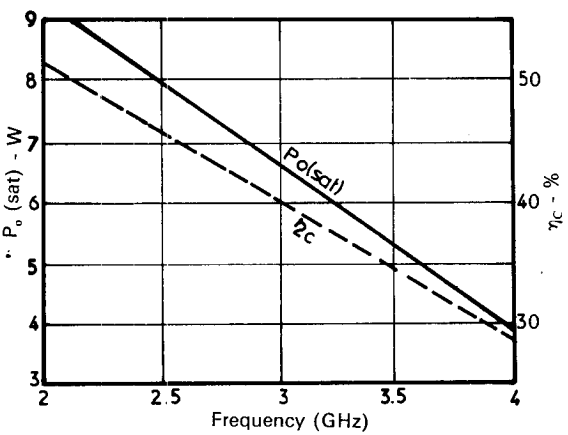


Impedance data
V_{CB} = 20 V

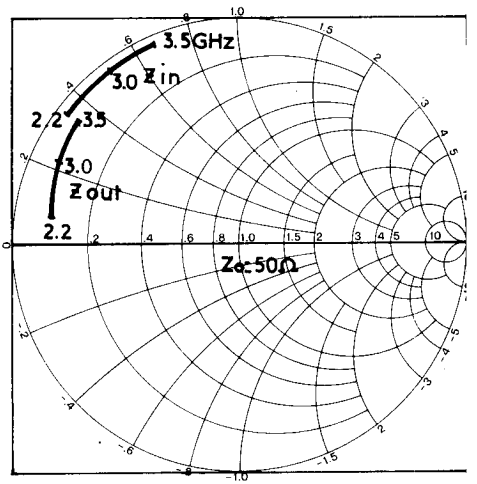


TRW 4004

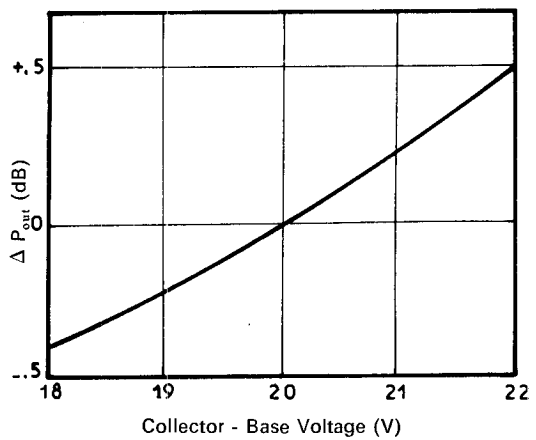
Typical η_C, power output versus frequency



Impedance data
V_{CB} = 20 V



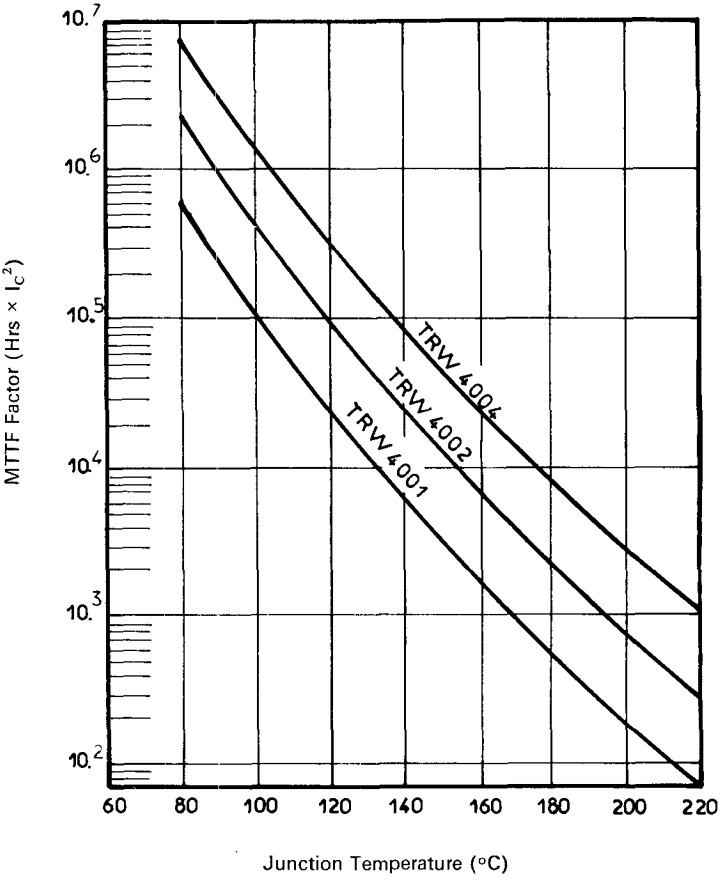
Power output at 3.5 GHz vs collector - base voltage



Conditions

TRW 4001 : P_{in} = 200 mW
TRW 4002 : P_{in} = 420 mW
TRW 4004 : P_{in} = 100 W

MTTF FACTOR



Divide by I_C^2 to obtain life time in hours

Microwave Linear Transistors

The TRW linear devices described herein are medium signal (1.5 watt), common emitter, diffused ballasted, **gold metalized** microwave transistors characterized for Class « A » service.

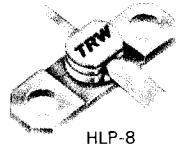
Because of TRW's proprietary ballasting and other protection techniques, no special techniques are required to protect these devices from arbitrary terminations up to infinite VSWR (any phase) so long as the transistors are attached properly to an adequate heat sink.

These transistors are useful for a variety of Military and industrial applications. They are available in TRW's HLP-8 flange package (TRW 52601), the HLP-8 flangeless (TRW 52101) and the new TW-200 symmetrically opposed emitter stripline package (TRW 52001).

Particular attention is directed to the ultralinear properties of these transistors and the guaranteed specification in accordance with DIN-45004.

Complete mechanical and electrical data are contained herein.

1.5 W
2 GHz
CLASS "A"



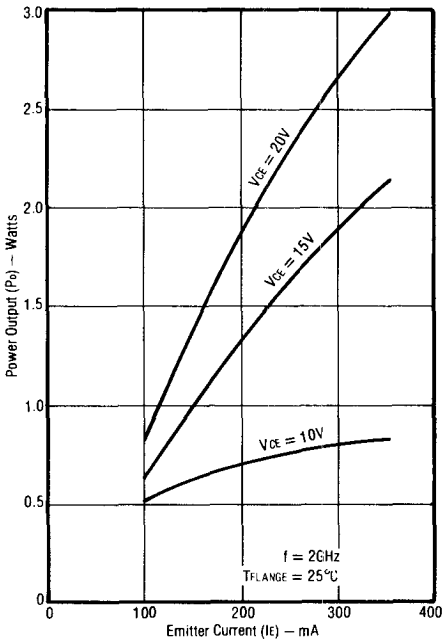
HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

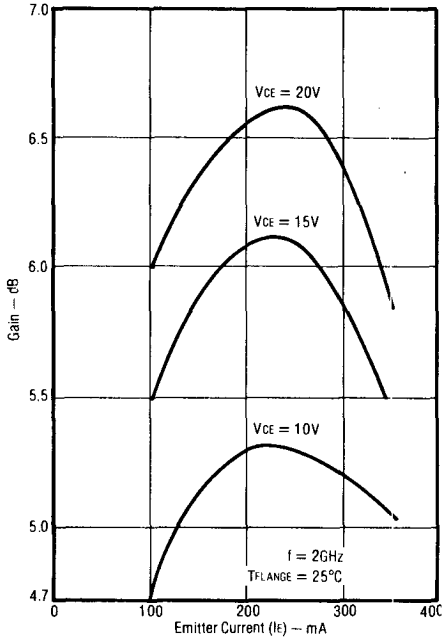
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Tests	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 20 mA	24			V
	BV_{CER}	Collector-Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 20 mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.125	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 100 mA	20		120	—
R F Tests	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz			5	pF
	P_o	Power Output	V_{CE} = 20 V, I_E = 220 mA f = 2.0 GHz, P_{in} = 0.375 W	1.5			W
	f_t	Frequency Cutoff	V_{CE} = 20 V, I_E = 220 mA	2.7	3.0		GHz
	VSWR	Mismatch Tolerance	P_o = 1.5 W, I_E = 220 mA, V_{CE} = 20 V	∞			
	IMD	Third Order intermodulation Distortion (Reference to Either Tone)	V_{CE} = 20 V, I_E = 220 mA f = 2.0 GHz, $P_{o(PEP)}$ = 1.5 W Tones at 2.05 GHz and 2.1 GHz			— 30	dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20 V, I_E = 150 mA f = 1.0 GHz, P_{REF} = 0.5 W			— 60	dB
Operating	T_j & T_{stg}	Max Junction and Storage Temperature		— 65		+ 200	°C
	θ_{jC}	Thermal Resistance	T_C = 25 °C			15	°C/W

ELECTRICAL CHARACTERISTICS
TRW52001, TRW52101, TRW52601

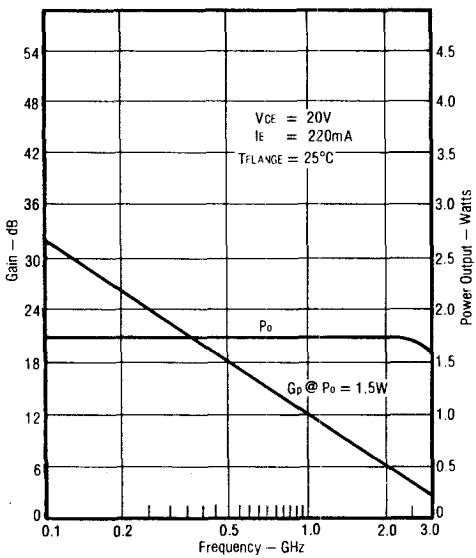
1dB Compression Point vs. Emitter Current



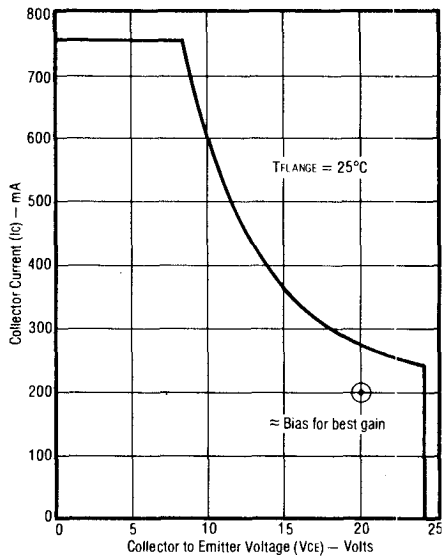
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency

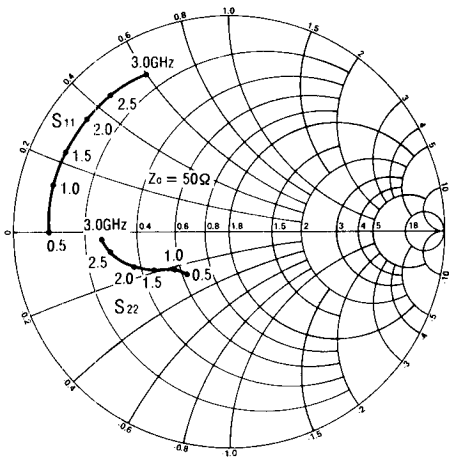


Safe Operating Area

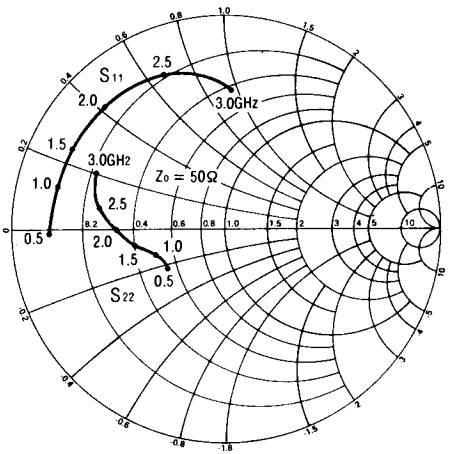


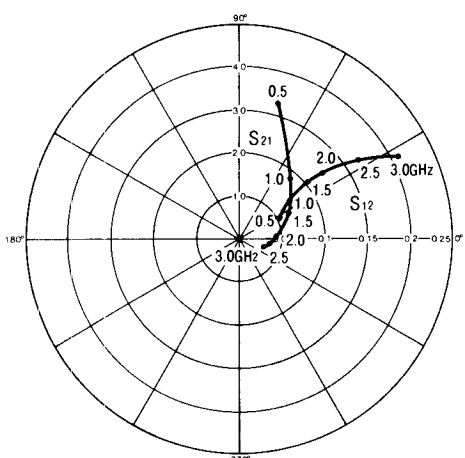
S-PARAMETERS
V_{CE} = 20V, I_E = 220mA, T_{FLANGE} = 25°C

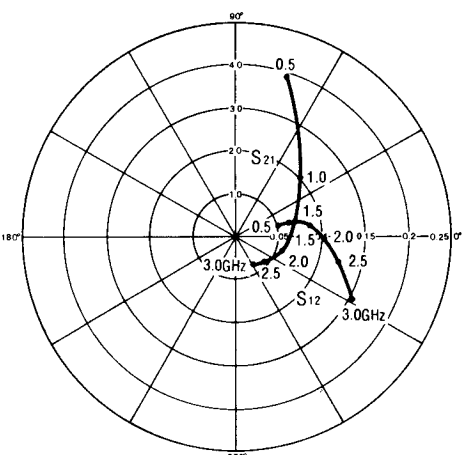
TRW52001



TRW52101, TRW52601

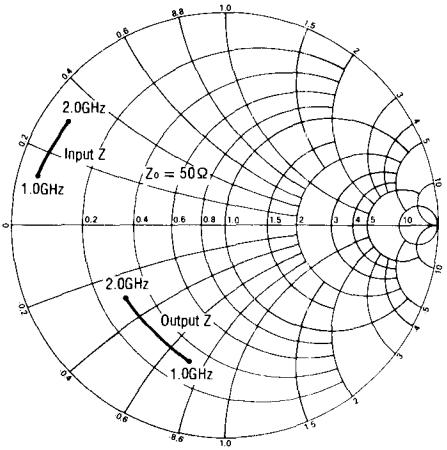




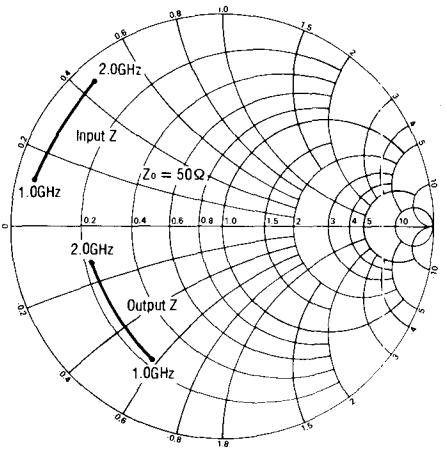


LARGE SIGNAL IMPEDANCE DATA
V_{CE} = 20V, I_E = 220mA, T_{FLANGE} = 25°C

TRW52001

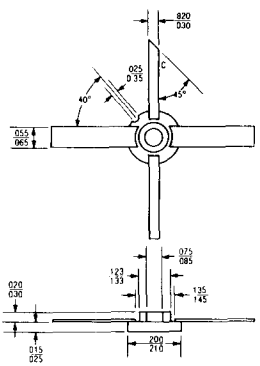


TRW52101, TRW52601

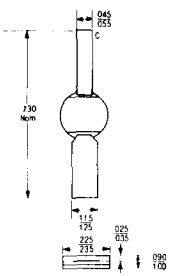


Package Outlines

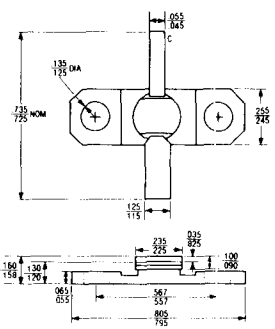
TRW52001



TRW52101



TRW52601



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Lead Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Microwave Linear Transistors

The TRW linear devices described herein are medium signal (3.0 watt), common emitter, diffused ballasted **gold metalized** microwave transistors characterized for Class « A » service.

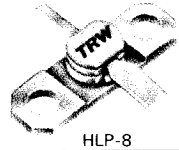
Because of TRW's proprietary ballasting and other protection techniques, no special techniques are required to protect these devices from arbitrary terminations up to infinite VSWR (any phase) so long as the transistors are attached properly to an adequate heat sink.

These transistors are useful for a variety of Military and industrial applications. They are available in TRW's HLP-8 flange package (TRW 52602), the HLP-8 flangeless (TRW 52102).

Particular attention is directed to the ultralinear properties of these transistors and the guaranteed specification in accordance with DIN-45004.

Complete mechanical and electrical data are contained herein.

3 W
2 GHz
CLASS "A"



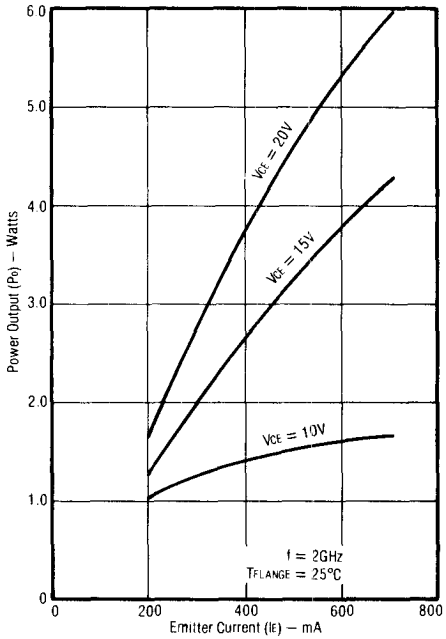
HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

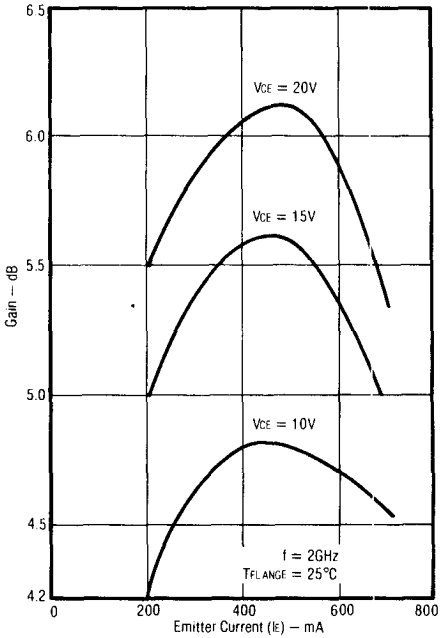
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Tests	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 40 mA	24			V
	BV_{CER}	Collector-Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 40 mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.50 mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 2.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 200 mA	20		120	—
R F Tests	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz			7	pF
	P_o	Power Output	V_{CE} = 20 V, I_E = 440 mA f = 2.0 GHz, P_{in} = 0.75 W	3.0			W
	f_t	Frequency Cutoff	V_{CE} = 20 V, I_E = 440 mA	2.7	3.0		GHz
	VSWR	Mismatch Tolerance	P_o = 3.0 W, I_E = 440 mA, V_{CE} = 20 V	∞			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20 V, I_E = 440 mA $P_{o(PEP)}$ = 3.0 W Tones at 2.000 GHz and 2.005 GHz			— 30	dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20 V, I_E = 300 mA f = 1.0 GHz, P_{REF} = 1.0 W			— 60	dB
Operating	T_j & T_{stg}	Max Junction and Storage Temperature		— 65		+ 200	°C
	θ_{j-c}	Thermal Resistance	25 °C			8.5	°C/W

ELECTRICAL CHARACTERISTICS

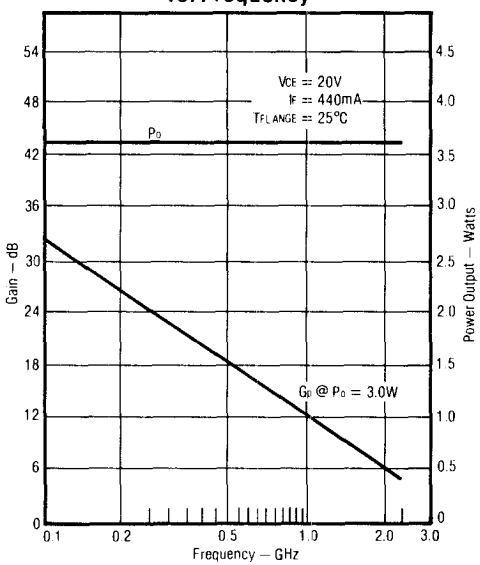
1dB Compression Point vs. Emitter Current



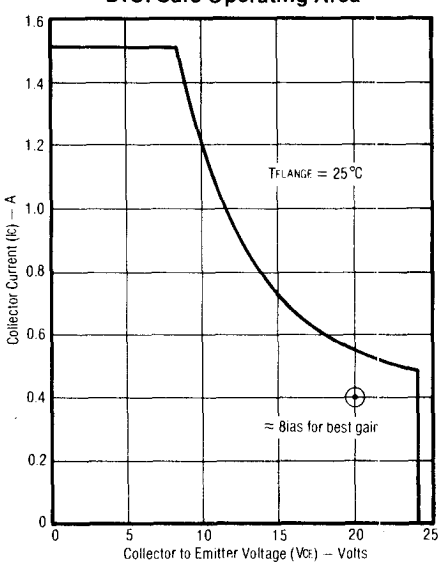
Gain vs. Emitter Current



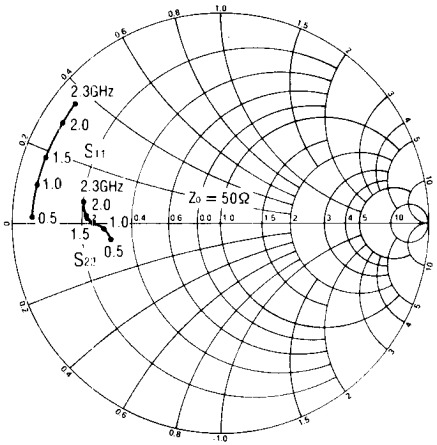
Gain and 1dB Compressed Power vs. Frequency

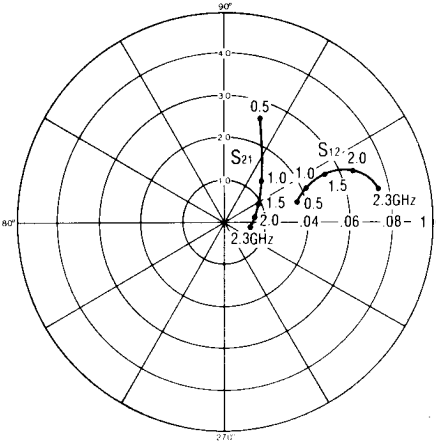


D.C. Safe Operating Area

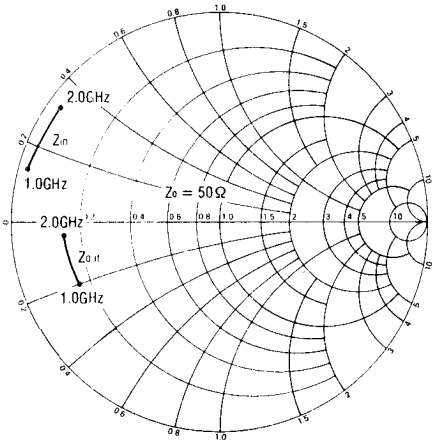


S-PARAMETERS
V_{CE} = 20V, I_E = 440mA, T_{FLANGE} = 25°C

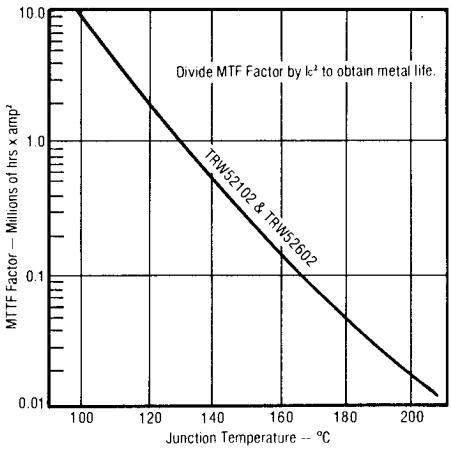




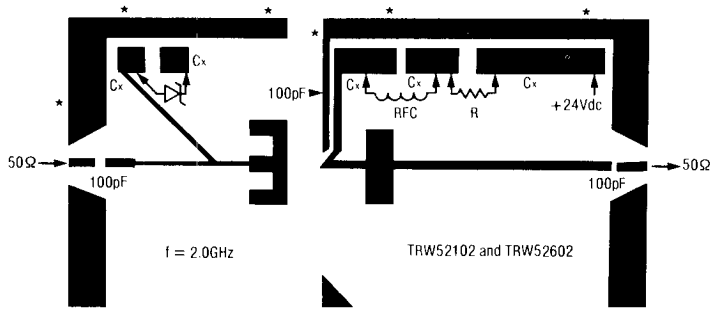
Large Signal Impedance Data



MTTF Factor vs. Junction Temperature



TEST CIRCUIT BOARD FOR TRW52102 AND TRW52602



Parts Details

* = Foil-wrap asterisked edge to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

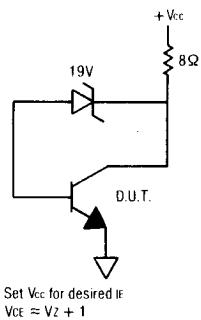
C_x = 100pF and 0.1pF chip

Zener Diode = 19V, 1W

RFC = 8 turns, #28A.W.G., 0.040 diameter

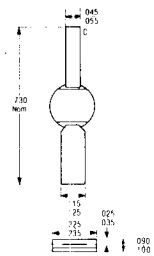
R = 8Ω, 2W

Self-Regulating Bias Circuit

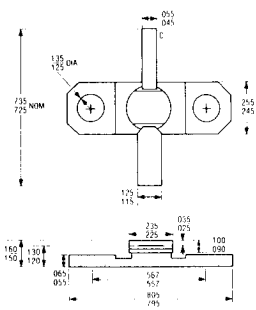


Package Outlines

TRW52102



TRW52602



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Microwave Linear Transistors

The TRW linear devices described herein are medium signal (6.0 watt), common emitter, diffused ballasted, **gold metalized** microwave transistors characterized for Class « A » service.

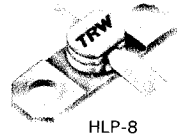
Because of TRW's proprietary ballasting and other protection techniques, no special techniques are required to protect these devices from arbitrary terminations up to VSWR 3 : 1 so long as the transistors are attached properly to an adequate heat sink.

These transistors are useful for a variety of Military and industrial applications. They are available in TRW's HLP-8 flange package (TRW 52604), the HLP-8 flangeless (TRW 52104).

Particular attention is directed to the ultralinear properties of these transistors and the guaranteed specification in accordance with DIN-45004.

Complete mechanical and electrical data are contained herein.

6 W
2 GHz
CLASS "A"



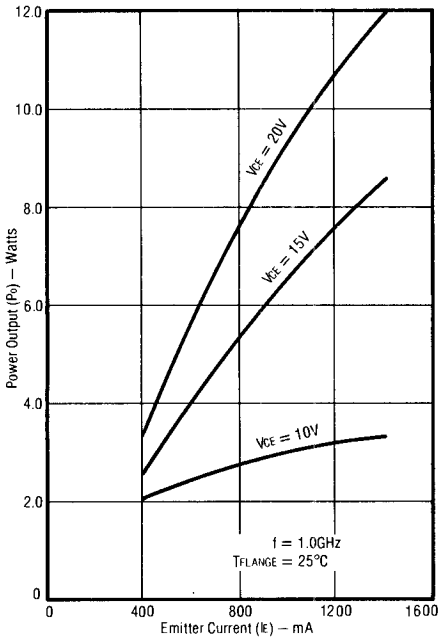
HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

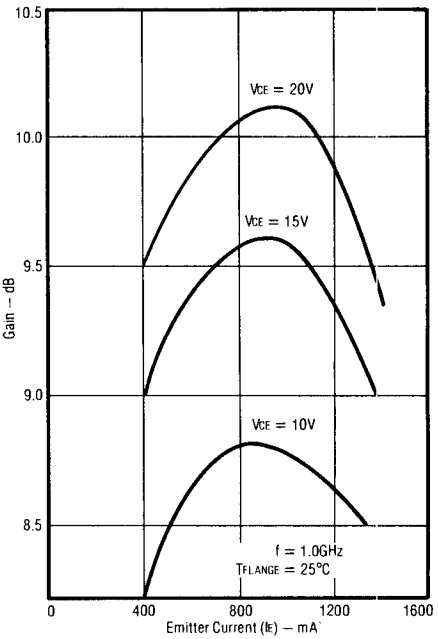
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Tests	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 80 mA	24			V
	BV_{CER}	Collector-Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 80 mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 1.0 mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 4.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.5	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 400 mA	20		120	—
R F Tests	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz			12	pF
	P_o	Power Output	V_{CE} = 20 V, I_E = 880 mA f = 1.0 GHz, P_{in} = 0.600 W	6.0			W
	f_t	Frequency Cutoff	V_{CE} = 20 V, I_E = 880 mA	2.4	2.6		GHz
	VSWR	Mismatch Tolerance	P_o = 5.0 W, I_E = 600 mA, V_{CE} = 20 V	3:1			
	IMD	Third Order Intermodulation Distortion	V_{CE} = 20 V, I_E = 880 mA $P_{o(PEP)}$ = 6.0 W Tones at 1.000 GHz and 1.005 GHz			— 30	dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20 V, I_E = 600 mA f = 1.0 GHz, P_{REF} = 2.0 W			— 60	dB
Opérating	T_j & T_{stg}	Max Junction and Storage Temperature		— 65		+ 200	°C
	θ_{j-C}	Thermal Resistance	P_o = 5 W, V_{CE} = 20 V, I_E = 880 mA			6.0	°C/W

ELECTRICAL CHARACTERISTICS

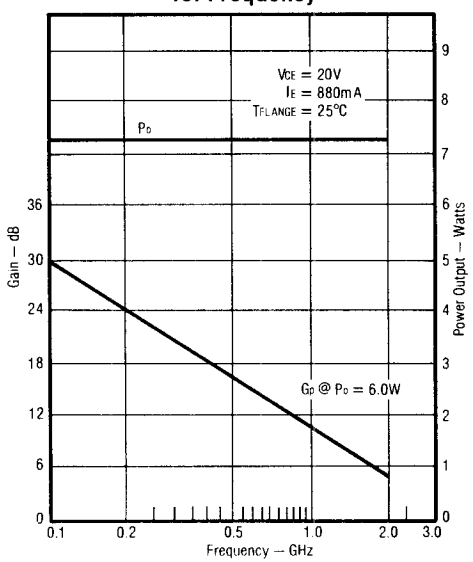
1dB Compression Point vs. Emitter Current



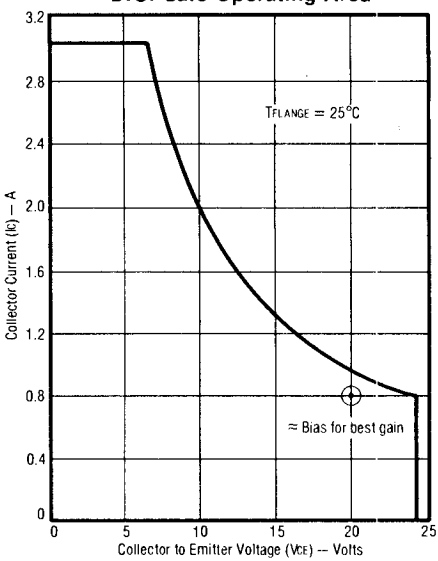
Gain vs. Emitter Current



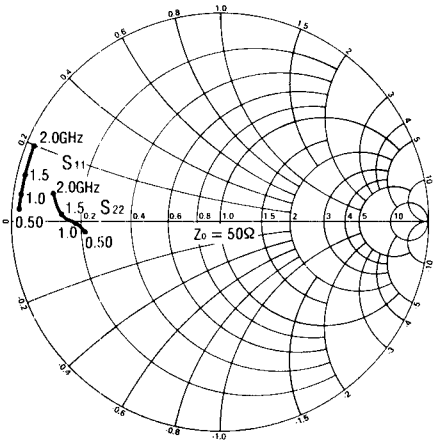
Gain and 1dB Compressed Power vs. Frequency

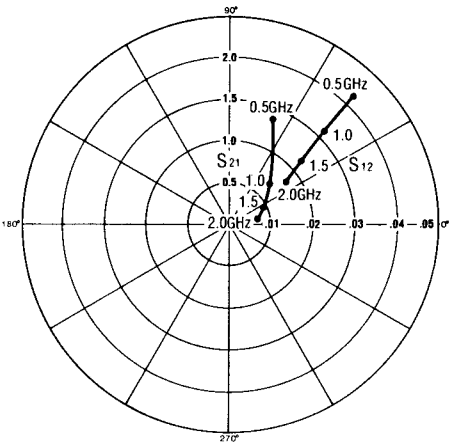


D.C. Safe Operating Area

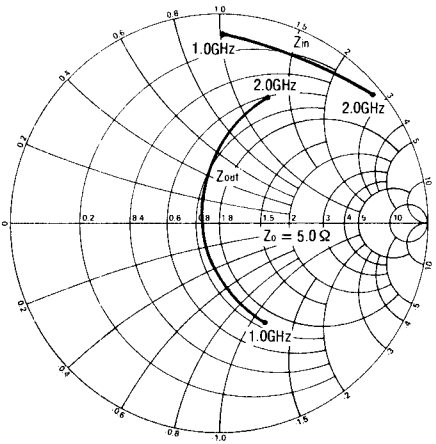


S-Parameters
V_{CE} = 20V, I_E = 880mA, T_{FLANGE} = 25°C

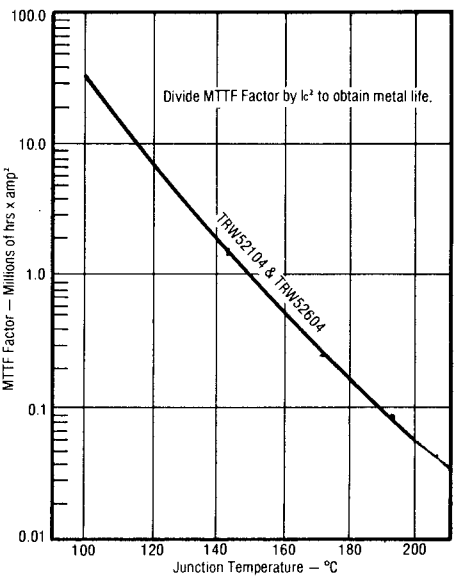




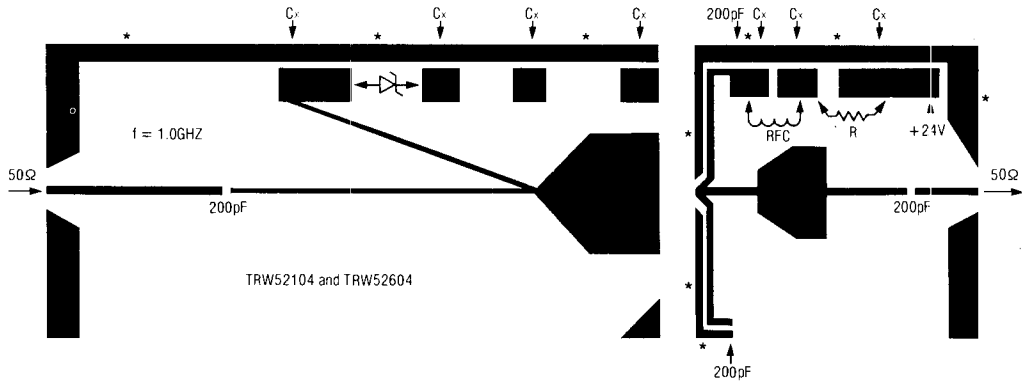
Large Signal Impedance Data



MTTF Factor vs. Junction Temperature



TEST CIRCUIT BOARD FOR TRW52104 AND TRW52604



Parts Details

* = Foil-wrap asterisked edge to ground plane. Board material 0.020 inch glass teflon $\varepsilon r = 2.55$.

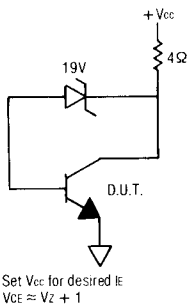
C_x = 100pF and 0.1μF chip

Zener Diode = 19V, 1W

RFC = 8 turns, #28A.W.G., 0.040 diameter

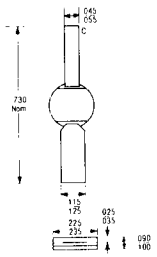
R = 4Ω, 4W

Self-Regulating Bias Circuit

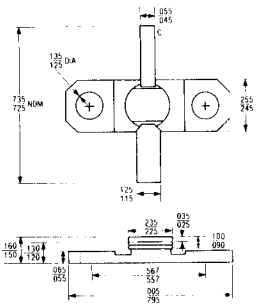


Package Outlines

TRW52104



TRW52604



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring ong-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Microwave Linear Transistors

The TRW linear devices described herein are medium signal (0.8 watt), common emitter, diffused ballasted, **gold metalized** microwave transistors characterized for Class « A » service.

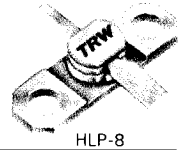
Because of TRW's proprietary ballasting and other protection techniques, no special techniques are required to protect these devices from arbitrary terminations up to infinite VSWR (any phase) so long as the transistors are attached properly to an adequate heat sink.

These transistors are useful for a variety of Military and industrial applications. They are available in TRW's HLP-8 flange package (TRW 53601), the HLP-8 flangeless (TRW 53101) and the new TW-200 symmetrically opposed emitter stripline package (TRW 53001).

Particular attention is directed to the ultralinear properties of these transistors and the guaranteed specification in accordance with DIN-45004.

Complete mechanical and electrical data are contained herein.

0.8 W
3 GHz
CLASS "A"



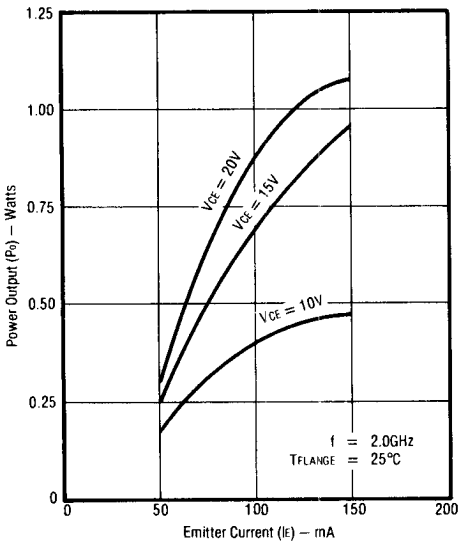
HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

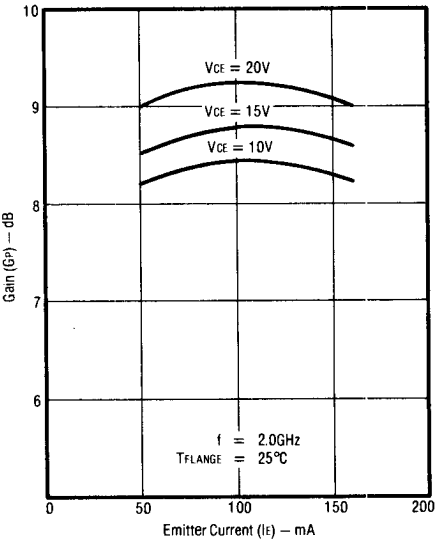
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Tests	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 10 mA	24			V
	BV_{CER}	Collector-Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 10 mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 100 mA	20		120	—
R F Tests	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz			3.5	pF
	P_o	Power Output	V_{CE} = 20 V, I_E = 120 mA f = 2.0 GHz, P_{in} = 0.113 W	0.8			W
	f_t	Frequency Cutoff	V_{CE} = 20 V, I_E = 120 mA	3.0	3.3		GHz
	VSWR	Mismatch Tolerance	P_o = 0.8 W, I_E = 120 mA, V_{CE} = 20 V	∞			
	IMD	Third Order Intermodulation Distortion (Reference to Either Tone)	V_{CE} = 20 V, I_E = 120 mA $P_{o(PEP)}$ = 0.8 W Tones at 2.000 GHz and 2.005 GHz			— 30	dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20 V, I_E = 75 mA f = 1.0 GHz, P_{REF} = 0.25 W			— 60	dB
Operating	T_j & T_{stg}	Max Junction and Storage Temperature		— 65		+ 200	°C
	θ_{jF}	Thermal Resistance	T_C = 25 °C			31	°C/W

Electrical Characteristics
TRW53001, TRW53101, TRW53601

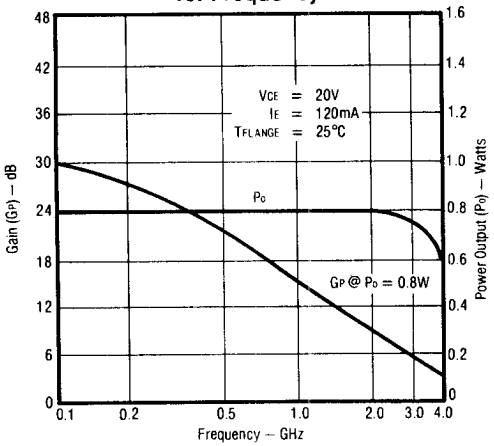
1dB Compression Point vs. Emitter Current



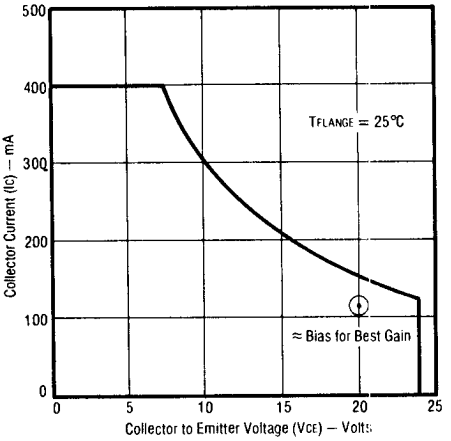
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency



D.C. Safe Operating Area



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

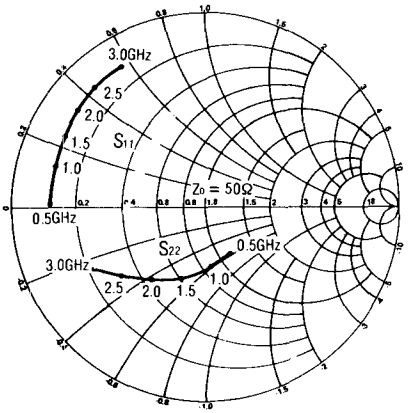
Acceleration: Per MIL-STD-750, 20,000G in any plane.

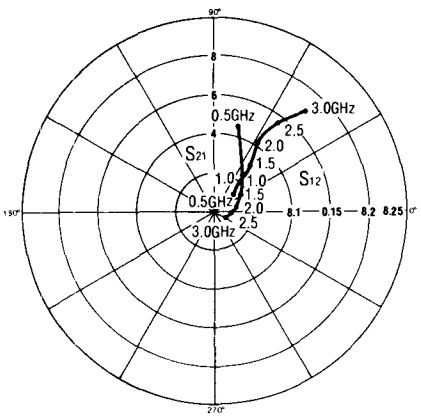
Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

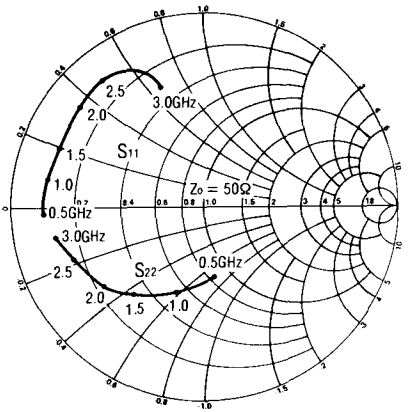
S-Parameters
V_{CE} = 20V, I_E = 120mA, T_{FLANGE} = 25°C

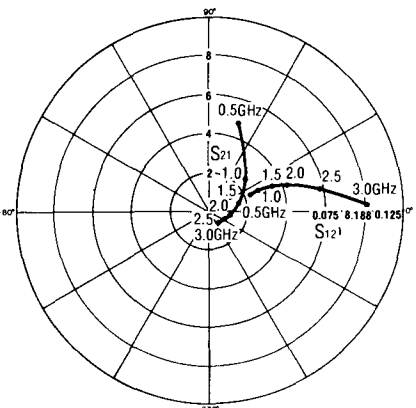
TRW53001



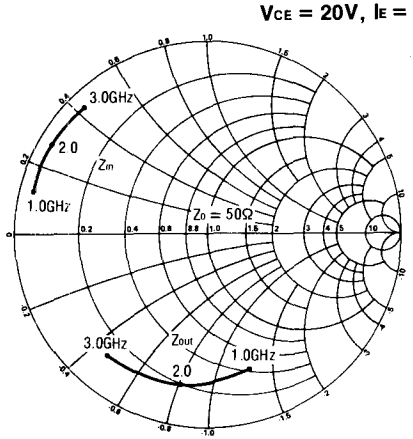


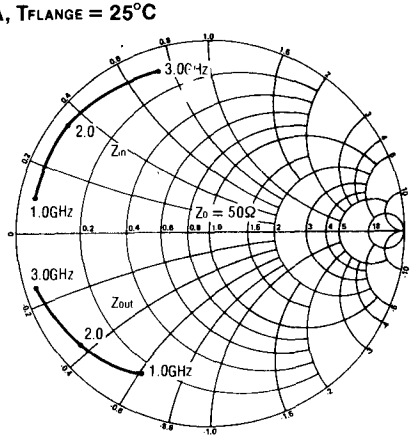
TRW53101, TRW53601



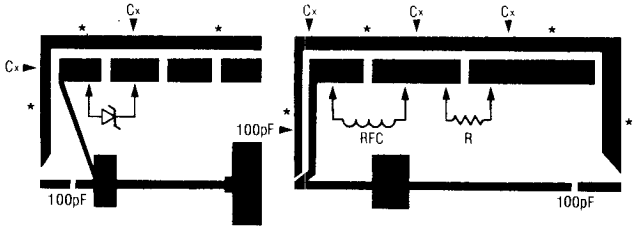


Large Signal Impedance Data
V_{CE} = 20V, I_E = 120mA, T_{FLANGE} = 25°C





Test Circuit Board For TRW53001, TRW53101 AND TRW53601



f = 2GHz

TRW53001, TRW53101 and TRW53601

Parts Details

* = Foil-wrap asterisked edge to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

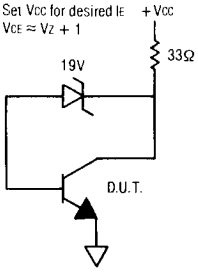
C_x = 100pF and 0.1μF chip

Zener Diode = 19V, 1W

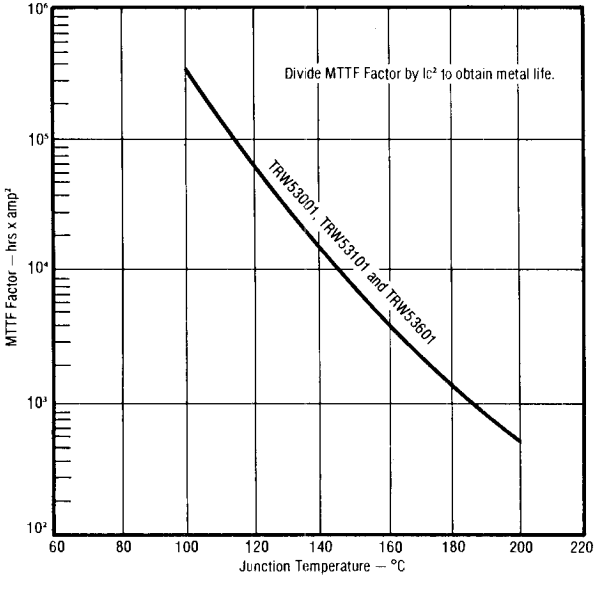
RFC = 8 turns, #28A.W.G., 0.040 diameter

R = 33Ω, 1W

Self-Regulating Bias Circuit

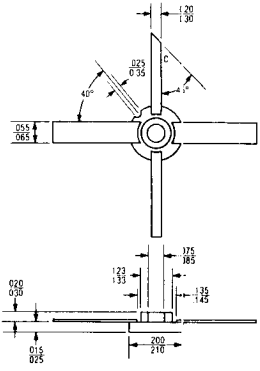


MTTF Factor vs. Junction Temperature

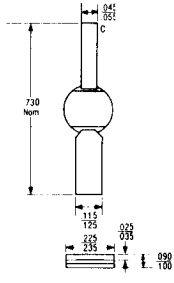


Package Outlines

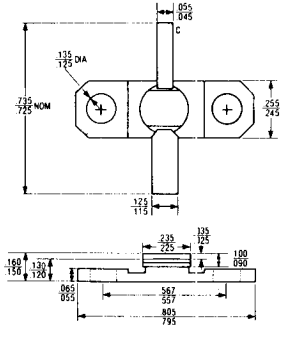
TRW53001



TRW53101



TRW53601



Microwave Linear Transistors

The TRW linear devices described herein are medium signal (1.6 watt), common emitter, diffused ballasted, **gold metalized** microwave transistors characterized for Class « A » service.

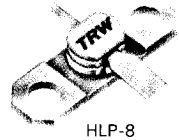
Because of TRW's proprietary ballasting and other protection techniques, no special techniques are required to protect these devices from arbitrary terminations up to infinite VSWR (any phase) so long as the transistors are attached properly to an adequate heat sink.

These transistors are useful for a variety of Military and industrial applications. They are available in TRW's HLP-8 flange package (TRW 53602), the HLP-8 flangeless (TRW 53102).

Particular attention is directed to the ultralinear properties of these transistors and the guaranteed specification in accordance with DIN-45004.

Complete mechanical and electrical data are contained herein.

1.6 W
3 GHz
CLASS "A"



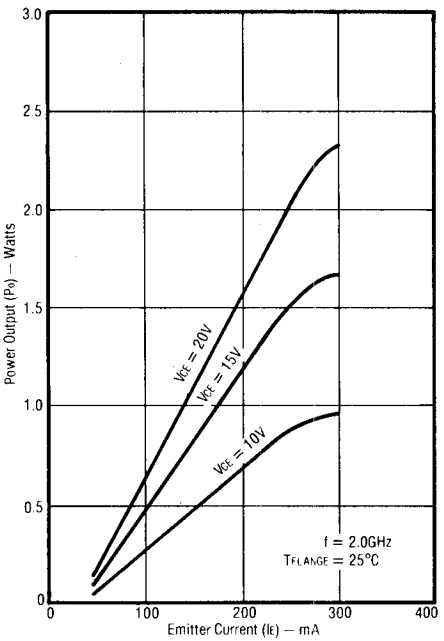
HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

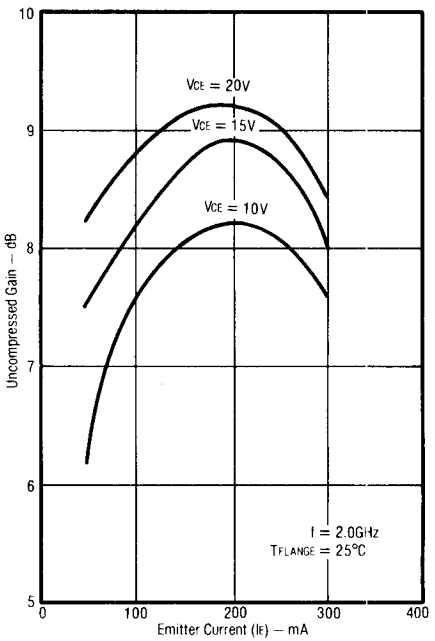
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Tests	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 20 mA	24			V
	BV_{CER}	Collector-Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 20 mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.50 mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 2.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.5	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 200 mA	20		120	—
R F Tests	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz			5.5	pF
	P_o	Power Output	V_{CE} = 20 V, I_E = 230 mA f = 2.0 GHz, P_{in} = 0.253 W	1.6			W
	f_t	Frequency Cutoff	V_{CE} = 20 V, I_E = 230 mA	3.0	3.3		GHz
	VSWR	Mismatch Tolerance	P_o = 1.6 W, I_E = 230 mA, V_{CE} = 20 V	∞			
	IMD	Third Order Intermodulation Distortion (Reference to Either Tone)	V_{CE} = 20 V, I_E = 230 mA $P_{o(PEP)}$ = 1.6 W Tones at 2.000 GHz and 2.005 GHz			— 30	dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20 V, I_E = 150 mA f = 1.0 GHz, P_{REF} = 0.5 W			— 60	dB
Operating	T_j & T_{stg}	Max Junction and Storage Temperature		— 65		+ 200	°C
	θ_{j-C}	Thermal Resistance	T_C = 25 °C			17	°C/W

ELECTRICAL CHARACTERISTICS

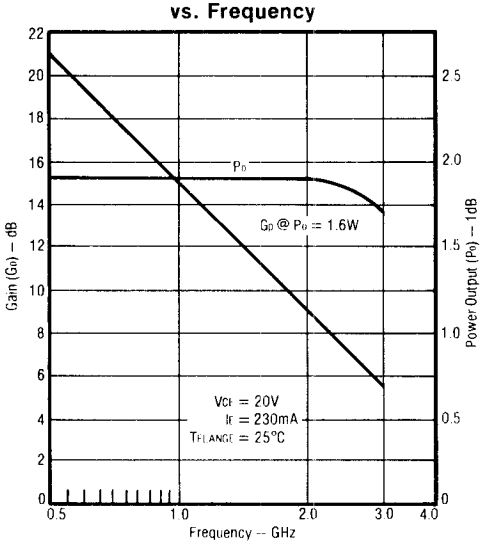
1dB Compression Point vs. Emitter Current



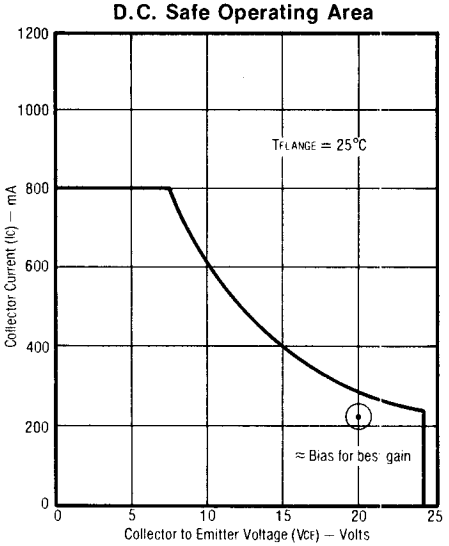
Gain vs. Emitter Current



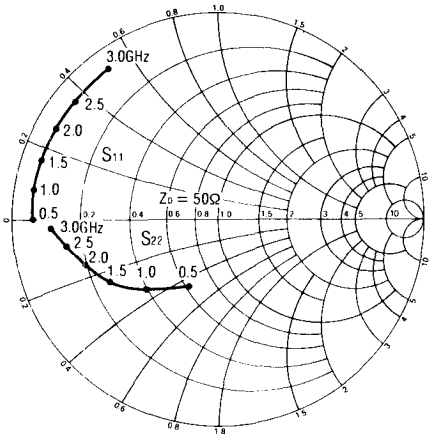
Gain and 1dB Compressed Power vs. Frequency

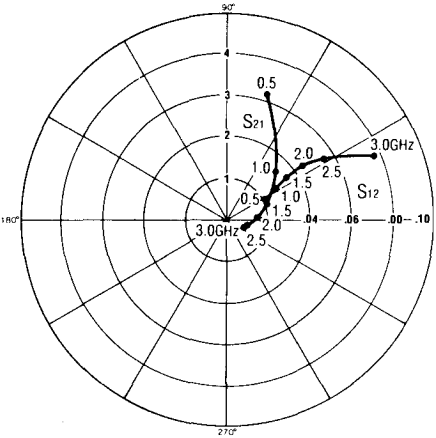


D.C. Safe Operating Area

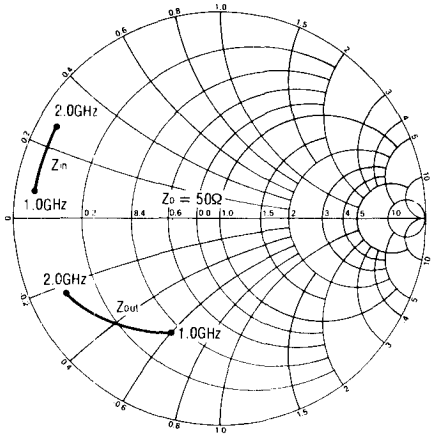


S-PARAMETERS
V_{CE} = 20V, I_E = 230mA, T_{FLANGE} = 25°C

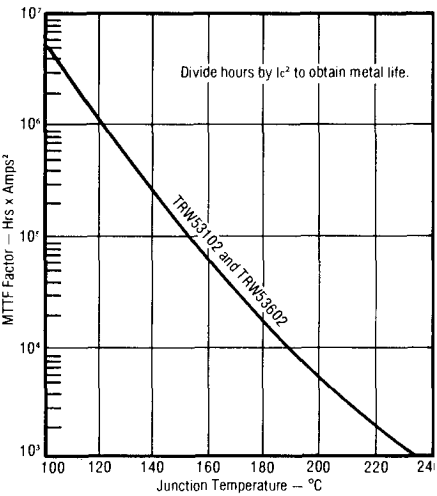




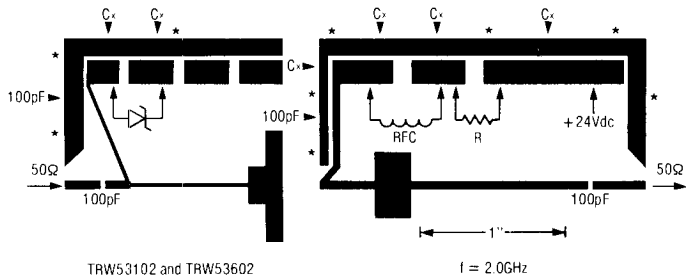
Large Signal Impedance Data



MTTF Factor vs. Junction Temperature



TEST CIRCUIT BOARD FOR TRW53102 AND TRW53602



Parts Details

* = Foil-wrap asterisked edge to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

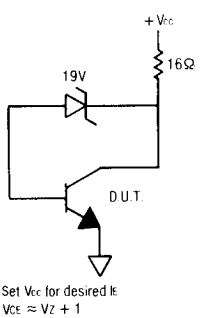
C_x = 100pF and 0.1μF chip

Zener Diode = 19V, 1W

RFC = 8 turns, #28A.W.G., 0.040 diameter

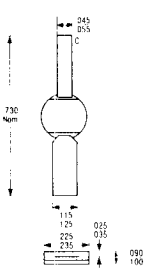
R = 16Ω, 2W

Self-Regulating Bias Circuit

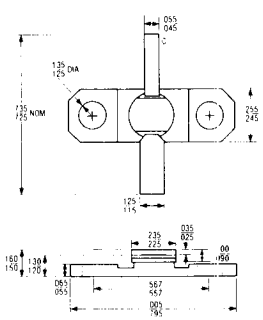


Package Outlines

TRW53102



TRW53602



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4-digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

Bond Pull: Per MIL-STD-750, 3 grams min.

Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Microwave Linear Transistors

The TRW linear devices described herein are medium signal (0.5 watt), common emitter, diffused ballasted, **gold metalized** microwave transistors characterized for Class « A » service.

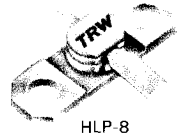
Because of TRW's proprietary ballasting and other protection techniques, no special techniques are required to protect these devices from arbitrary terminations up to infinite VSWR (any phase) so long as the transistors are attached properly to an adequate heat sink.

These transistors are useful for a variety of Military and industrial applications. They are available in TRW's HLP-8 flange package (TRW 54601), the HLP-8 flangeless (TRW 54101) and the new TW-200 symmetrically opposed emitter stripline package (TRW 54001).

Particular attention is directed to the ultralinear properties of these transistors and the guaranteed specification in accordance with DIN-45004.

Complete mechanical and electrical data are contained herein.

0.5 W
4 GHz
CLASS "A"



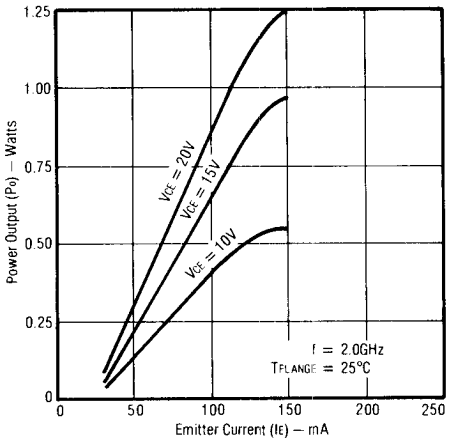
HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

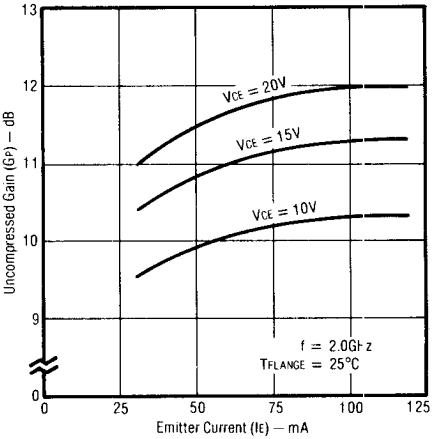
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Tests	BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 10 mA	24			V
	BV_{CER}	Collector-Emitter Brekdown Voltage	R_{BE} = 10 Ω, I_C = 10 mA	50			V
	BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 100 mA	20		120	—
R F Tests	C_{ob}	Collector-Base Capacitance	V_{CB} = 28 V, f = 1 MHz			3.5	pF
	P_o	Power Output, V_{CE} = 20 V, I_E = 120 mA	TRW 54101, 54601 f = 2.0 GHz, P_{in} = 0.040 W f = 4.0 GHz, P_{in} = 0.125 W	0.5	0.5		W W
			TRW 54001 f = 2.0 GHz, P_{in} = 0.063 W f = 4.0 GHz, P_{in} = 0.158 W	0.5	0.5		W W
	f_t	Frequency Cutoff	V_{CE} = 20 V, I_C = 120 mA	4.0	4.5		GHz
	VSWR	Mismatch Tolerance	P_o = 0.5 W, I_E = 120 mA, V_{CE} = 20 V	∞			
	IMD	Third Order Intermodulation Distortion (Reference to Either Tone)	V_{CE} = 20 V, I_E = 120 mA $P_{o(PEP)}$ = 0.5 W Tones at 2.000 GHz and 2.005 GHz			— 30	dB
	$IMD_{(TV)}$	Intermodulation per DIN-45004/K	V_{CE} = 20 V, I_E = 75 mA f = 1.0 GHz, P_{REF} = 0.15 W			— 60	dB
Opérating	T_j & T_{stg}	Max Junction and Storage Temperature		— 65		+ 200	°C
	θ_{j-c}	Thermal Resistance	T_C = 25 °C			40	°C/W

Electrical Characteristics
TRW54001, TRW54101, TRW54601

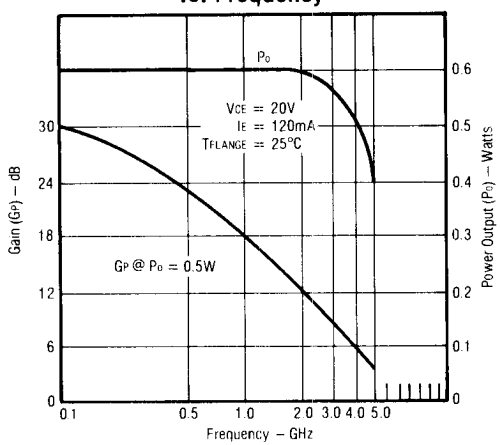
1dB Compression Point vs. Emitter Current



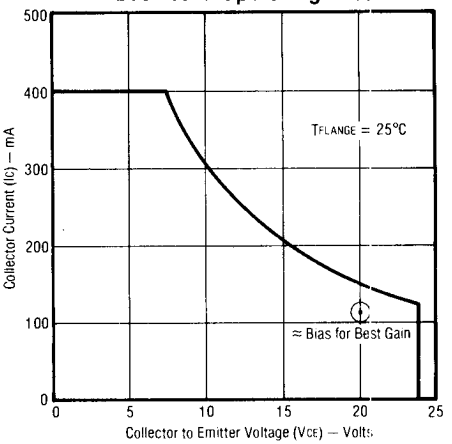
Gain vs. Emitter Current



Gain and 1dB Compressed Power vs. Frequency



D.C. Safe Operating Area



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions: Per outline drawing.

Solderability: Per MIL-STD-750.

Marking: Per MIL-S-19500, "TRW," 4 digit date code, type number.

Hermaticity: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)

Acceleration: Per MIL-STD-750, 20,000G in any plane.

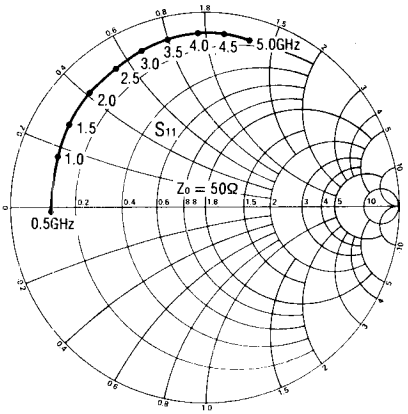
Bond Pull: Per MIL-STD-750, 3 grams min.

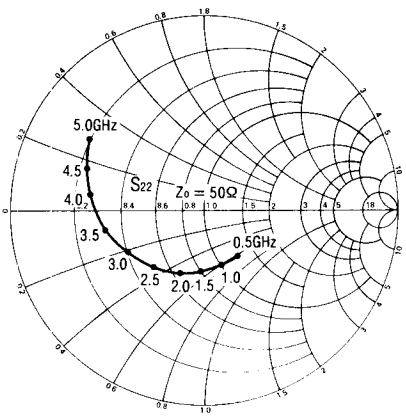
Package: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

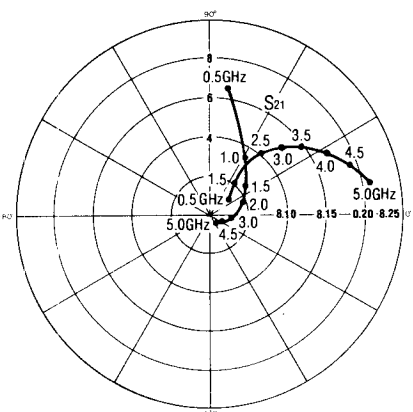
S-Parameters

V_{CE} = 20V, I_E = 120mA, T_{FLANGE} = 25°C

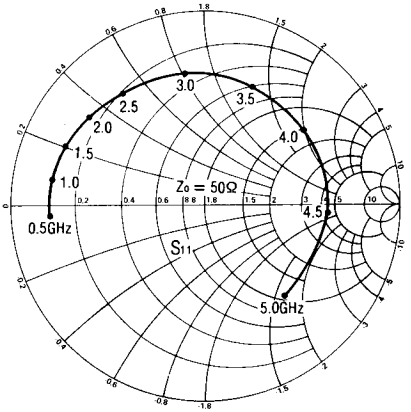
TRW54001

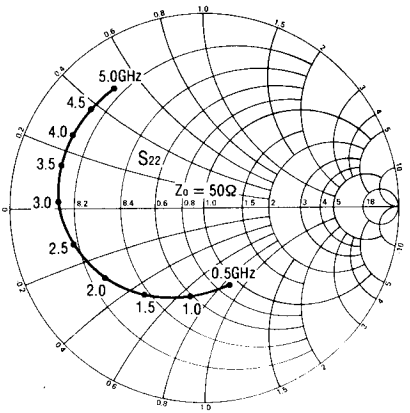


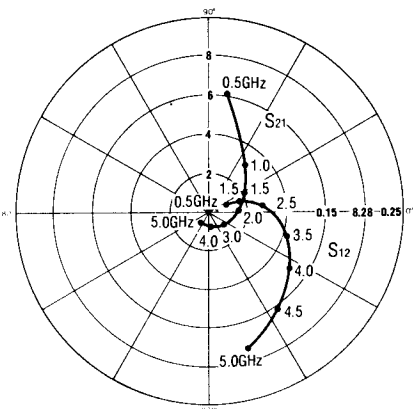




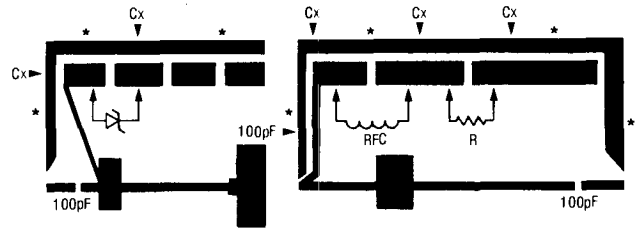
TRW54101, TRW54601







Test Circuit Board For TRW54101 and TRW54601



f = 2GHz

TRW54101 and TRW54601

Parts Details

* = Foil-wrap asterisked edge to ground plane. Board material 0.020 inch glass-teflon $\varepsilon_r = 2.55$.

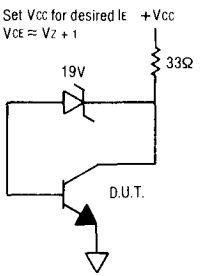
C_x = 100pF and 0.1μF chip

Zener Diode = 19V, 1W

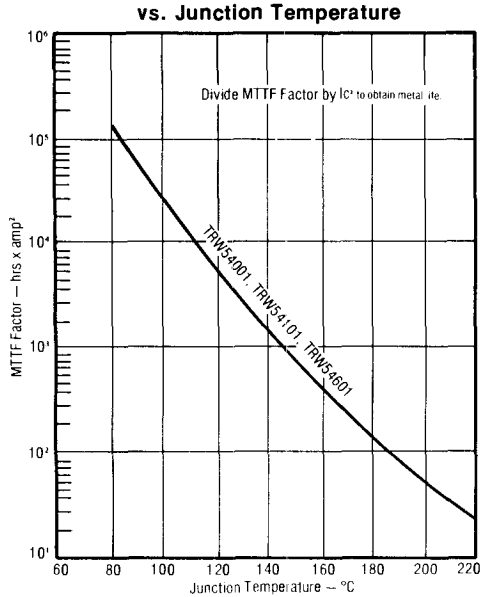
RFC = 8 turns, #28A.W.G., 0.040 diameter

R = 33Ω, 1W

Self-Regulating Bias Circuit

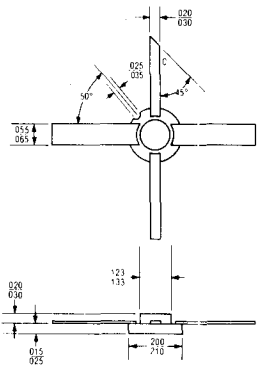


MTTF Factor vs. Junction Temperature

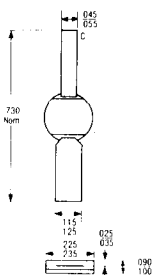


Package Outlines

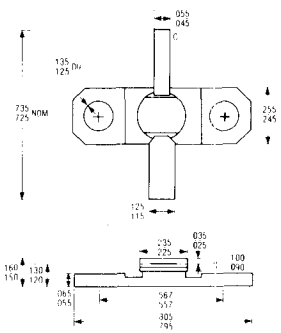
TRW54001



TRW54101



TRW54601



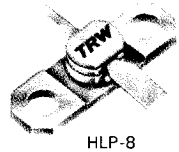
Microwave Power oscillators Transistors

Up to 3 GHz
1.2 W at 2.5 GHz
∞ VSWR

The TRW 62601 is designed for use up to 3 GHz with a typical Pout of 1.2 W at 2.5 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

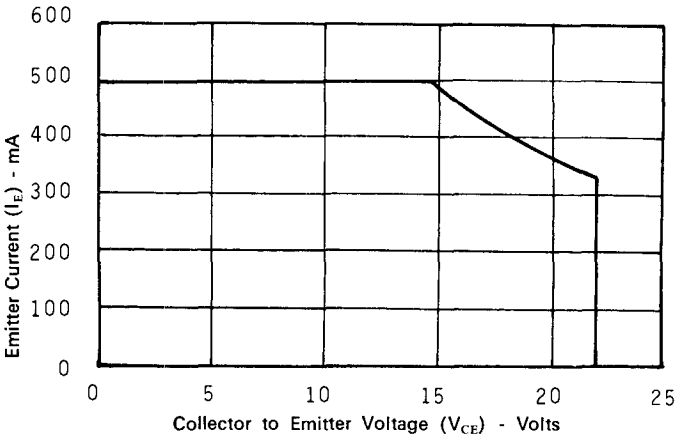


HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

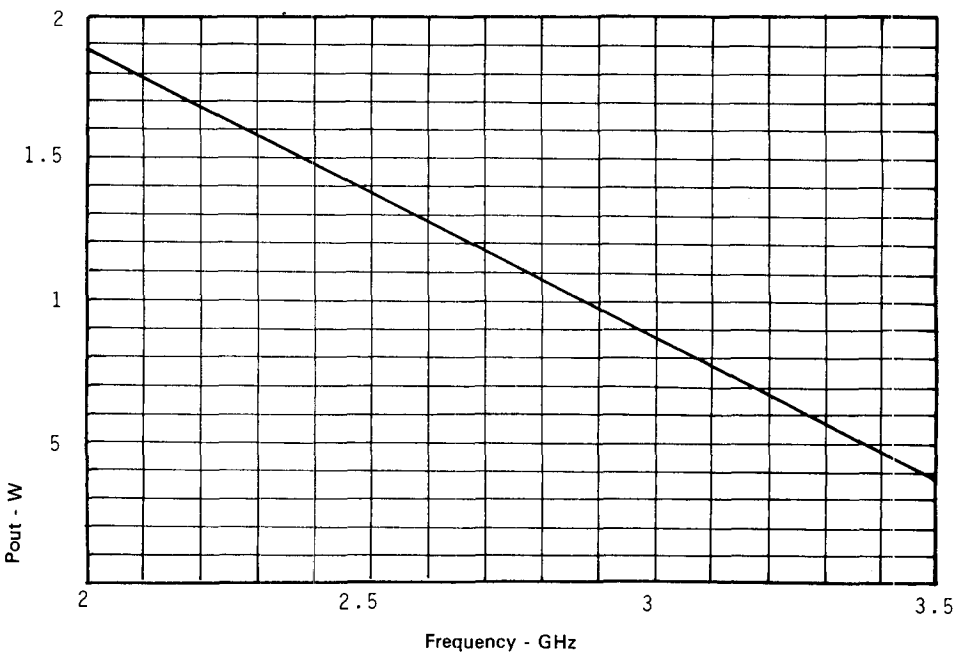
	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	22			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 20 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28			0.125	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 100 mA	20		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V, F = 1 MHz			5.0	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V, I_E = 220 mA	2.7	3.0		GHz
	P_o	Power output	F = 2.0 GHz, V_{CE} = 20 V, I_E = 220 mA	1.25			W
	VSWR	Mismatch Tolerance	P_o = 1.25 W, V_{CE} = 20 V, I_E = 220 mA		∞ : 1		
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				15	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

D.C. Safe Operating Area



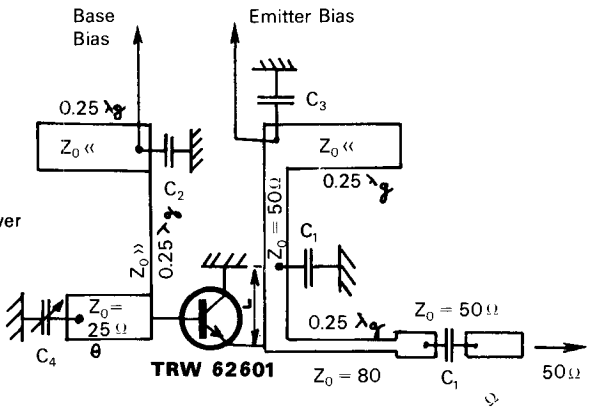
Output Power vs. Frequency

(V_{CE} = 20 V, I_E = 220 mA)

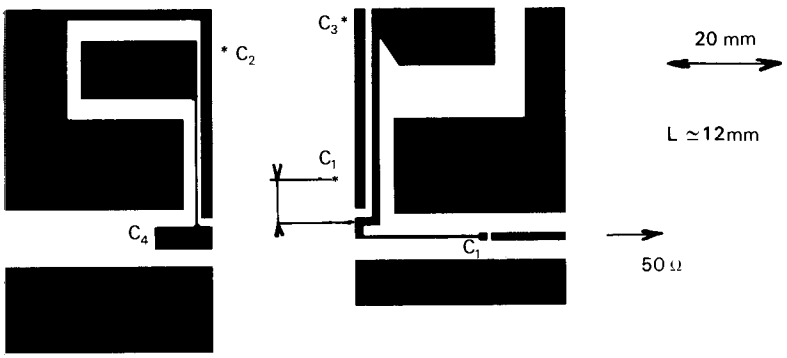


C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 µF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power
θ = 0.115 λg for Fo = 2.3 GHz
θ = 0.06 λg for Fo = 3 GHz

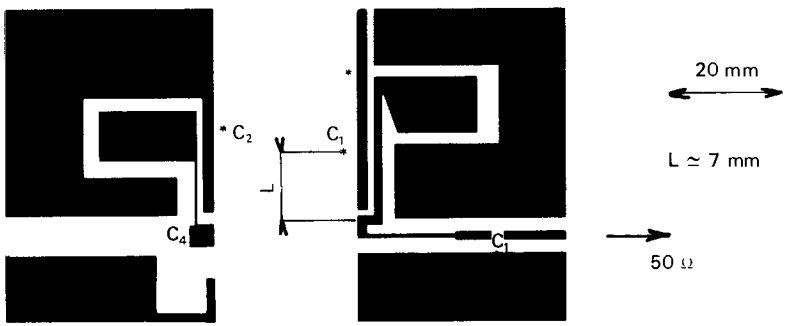
TEST CIRCUIT



PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)



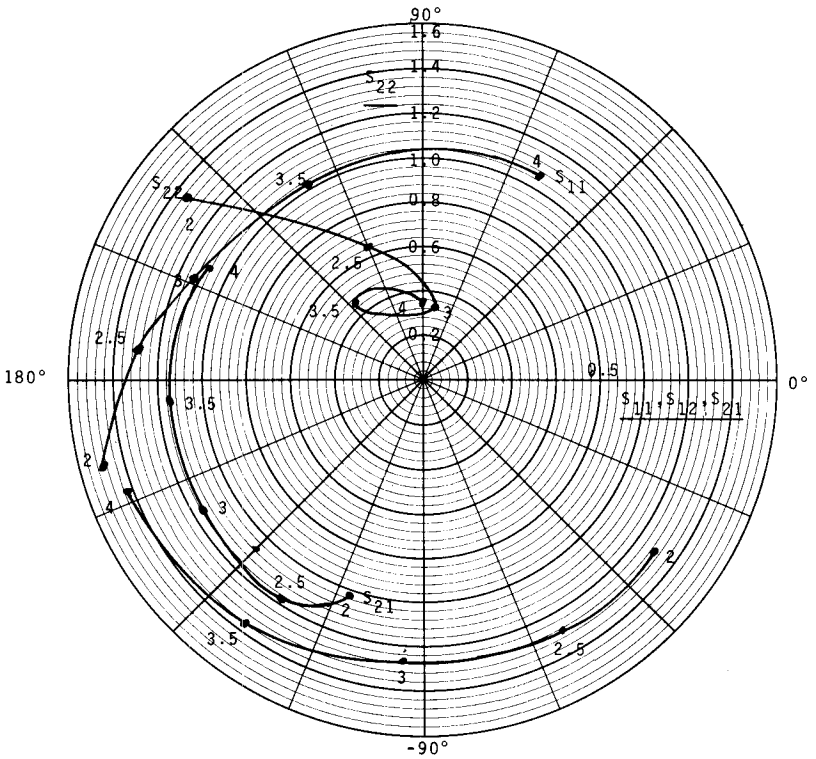
PC Board Layout for Fo = 3 GHz (BW = 500 MHz)



* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 220 mA)

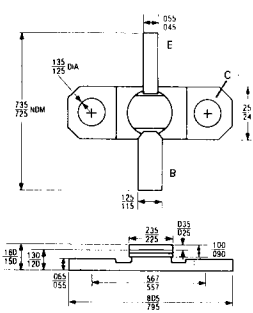


Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions:	Per outline drawing.
Solderability:	Per MIL-STD-750.
Marking:	Per MIL-S-19500, "TRW," 4-digit date code, type number.
Hermaticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Package Outlines



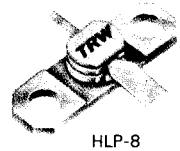
Microwave Power oscillator Transistors

Up to 3 GHz
2 W at 2.5 GHz
∞ VSWR

The TRW 62602 is designed for use upt to 3 GHz with a typical Pout of 2 W at 2.5 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

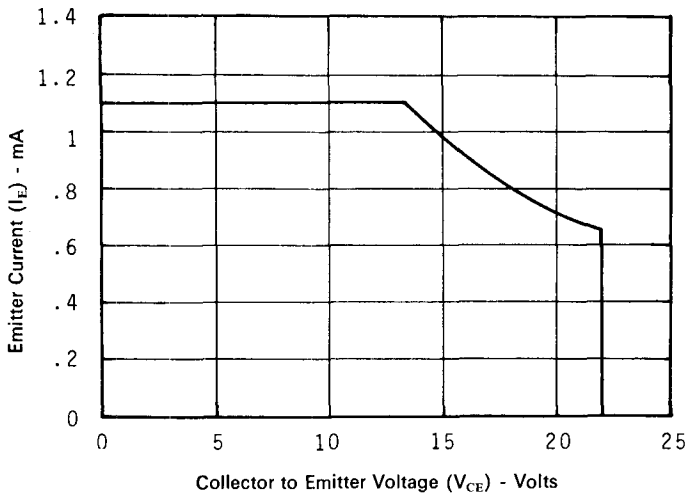


HLP-8

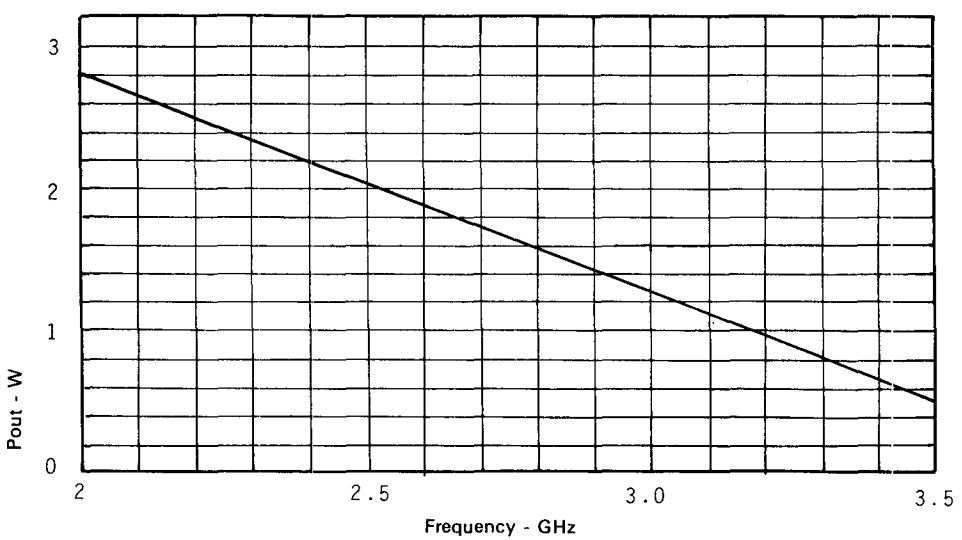
Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 40 mA	22			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 40 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 200 mA	20		120	
RF Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V, F = 1 MHz			7.0	pF
	F_T	Frequency Cutoff	V_{CE} = 2.0 GHz I_E = 440 mA	2.7	3.0		GHz
	P_o	Power output	F = 2.00 GHz V_{CE} = 20 V, I_E = 440 mA	2.5			W
	VSWR	Mismutch Tolerance	P_o = 2.5 W V_{CE} = 20 V, I_E = 440 mA		∞ : 1		
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				8.5	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

D.C. Safe Operating Area

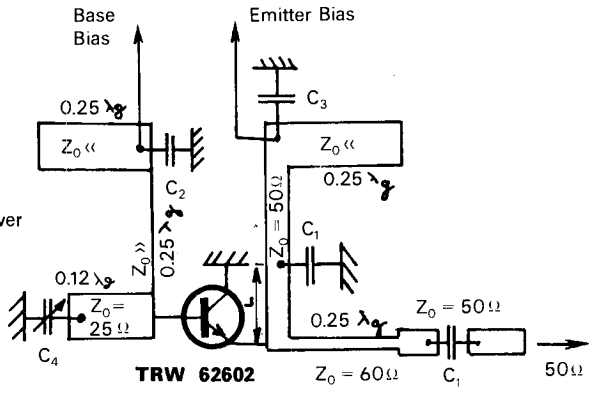


Output Power vs. Frequency
(V_{CE} = 20 V, I_E = 440 mA)

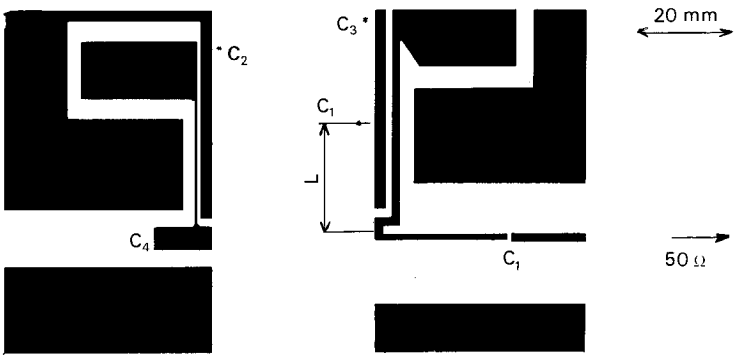


TEST CIRCUIT

C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 µF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power



PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)

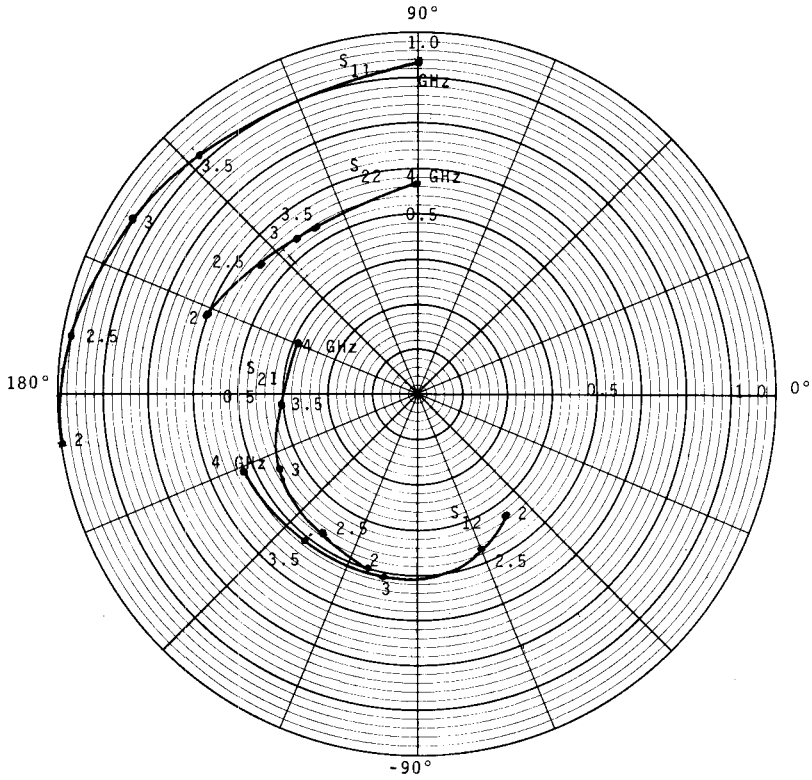


* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

For F = 2 GHz L = 24 mm
F = 2.3 GHz L = 19 mm
F = 2.5 GHz L = 14 mm

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 440 mA)

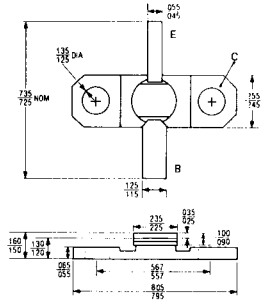


Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions:	Per outline drawing.
Solderability:	Per MIL-STD-750.
Marking:	Per MIL-S-19500, "TRW," 4-digit date code, type number.
Hermaticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

PACKAGE OUTLINE



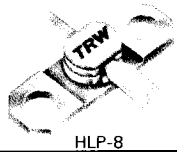
Microwave Power oscillator Transistors

Up to 3.5 GHz
430 mW at 3 GHz
∞ VSWR

The TRW 63601 is designed for use up to 3.5 GHz with a typical Pout of 430 mW at 3 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.



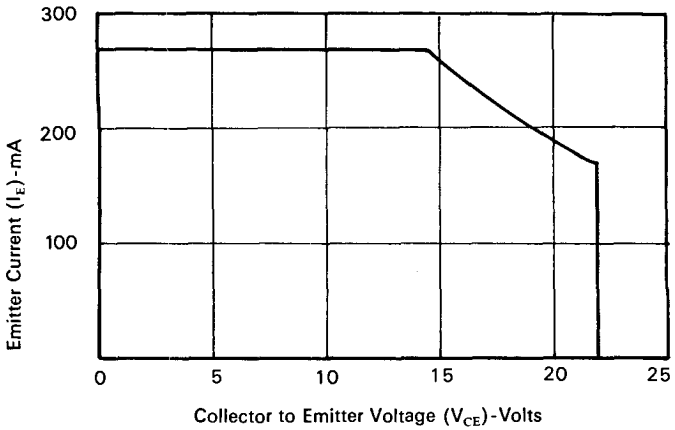
HLP-8

Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	22			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω I_C = 10 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.250	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V I_C = 100 mA	20		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V F = 1 MHz			3.5	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V I_E = 120 mA	3.0	3.3		GHz
	P_o	Power output	F = 2.3 GHz V_{CE} = 20 V I_E = 120 mA	0.6			W
	VSWR	Mismatch Tolerance	P_o = 0.6 W V_{CE} = 20 V I_E = 120 mA		∞ : 1		
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				32	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

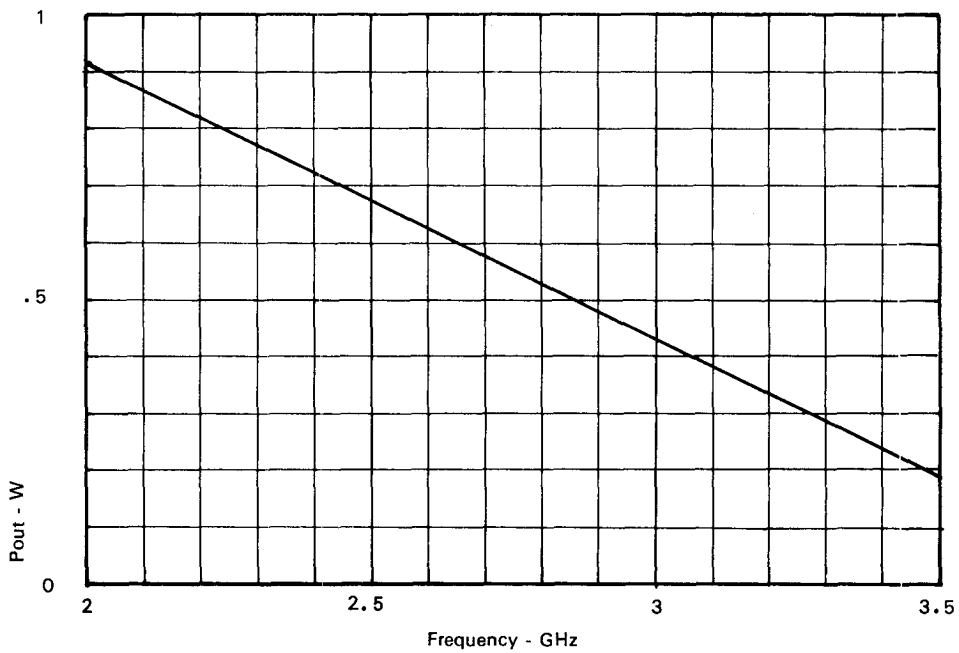
D.C. Safe Operating Area

T_{flange} = **75** °C



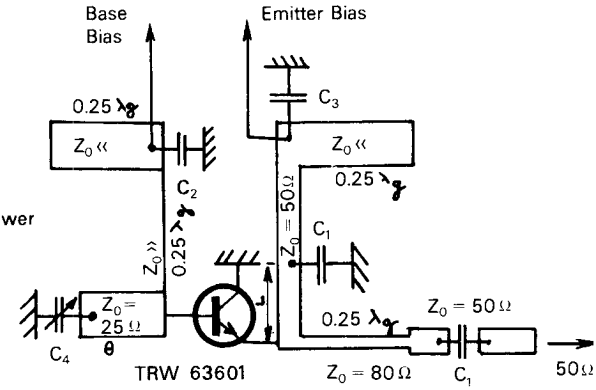
Output Power vs. Frequency

(V_{CE} = 20 V, I_E = 120 mA)

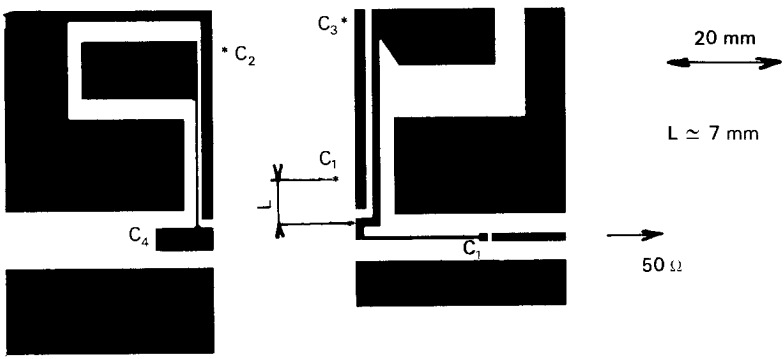


C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 µF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power
θ = 0.115 λg for Fo = 2.3 GHz
θ = 0.06 λg for Fo = 3 GHz

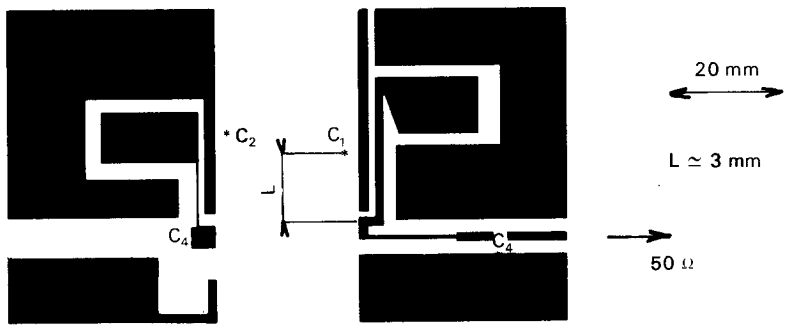
TEST CIRCUIT



PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)



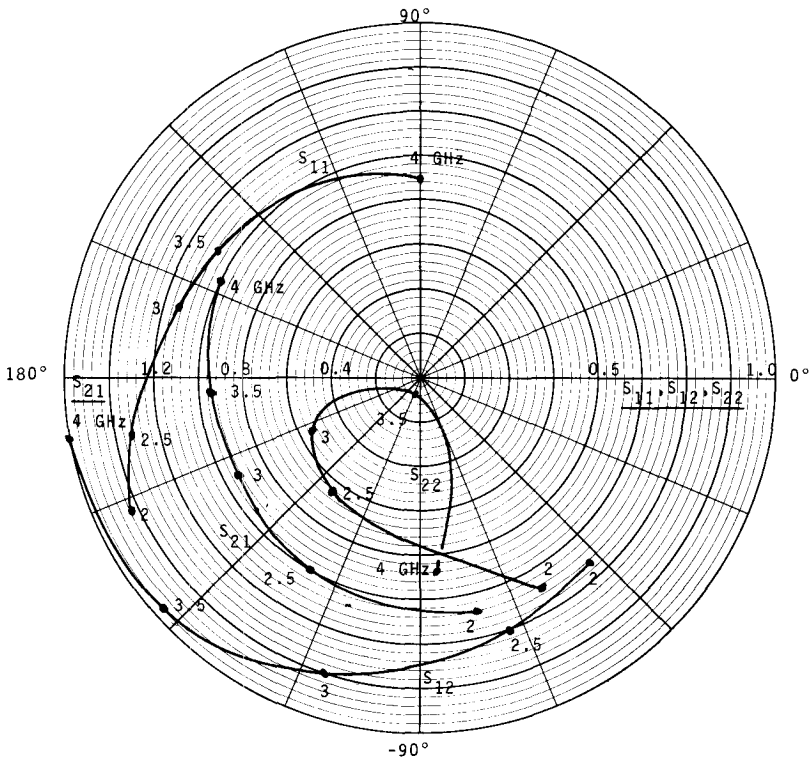
PC Board Layout for Fo = 3 GHz (BW = 500 MHz)



* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 120 mA)

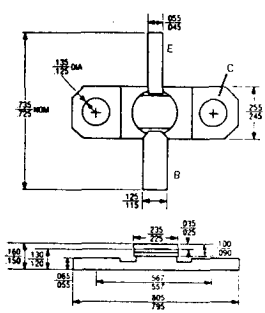


Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions:	Per outline drawing.
Solderability:	Per MIL-STD-750.
Marking:	Per MIL-S-19500, "TRW," 4-digit date code, type number.
Hermaticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Package Outlines



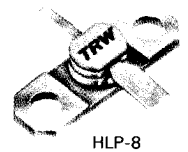
Microwave Power Transistors

Up to 3.5 GHz
850 mW at 3 GHz
∞ VSWR

The TRW 63602 is designed for use up to 3.5 GHz with a typical Pout of 850 mW at 3 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

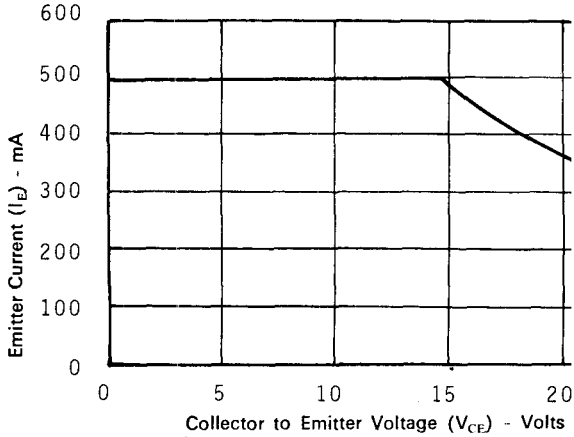


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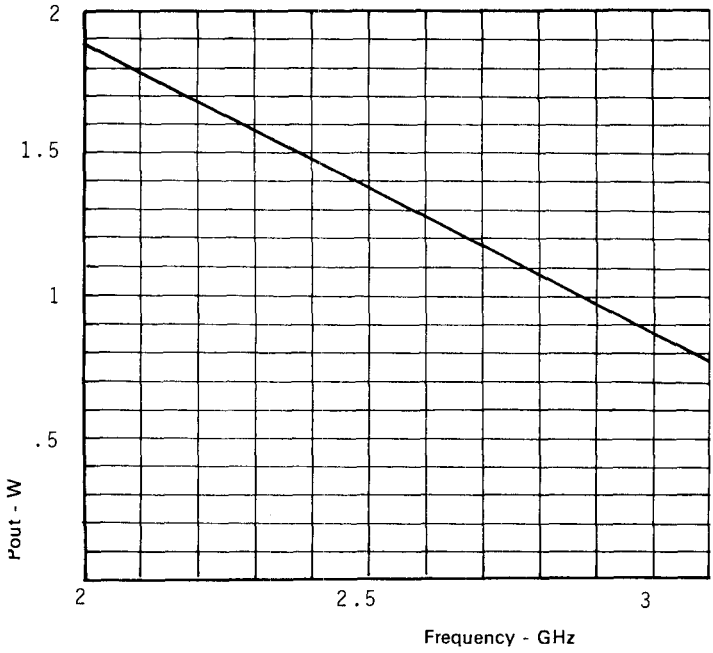
Electrical Characteristics (T_{flange} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	22			V
	BV_{CER}	Collector - Emitter Breakdwon Voltage	R_{BE} = 10 Ω, I_C = 20 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28 V			0.5	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 200 mA	20		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V, F = 1 MHz			5.5	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V, I_E = 230 mA	3	3.3		GHz
	P_o	Power output	F = 2.3 GHz, V_{CE} = 20 V, I_E = 230 mA	1.2			W
	VSWR	Mismatch Tolerance	P_o = 1.2 W, V_{CE} = 20 V, I_E = 230 mA			∞ : 1	
Operating	θ_{jF}	Thermal Resistance (junction to Flange)				17	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		200	°C

D.C. Safe Operating Area

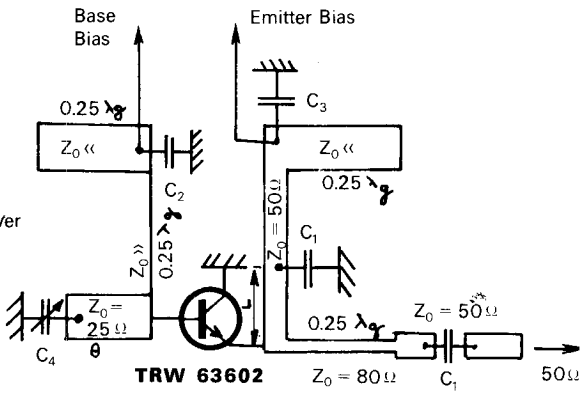


Output Power vs. Frequency
(V_{CE} = 20 V, I_E = 230 mA)

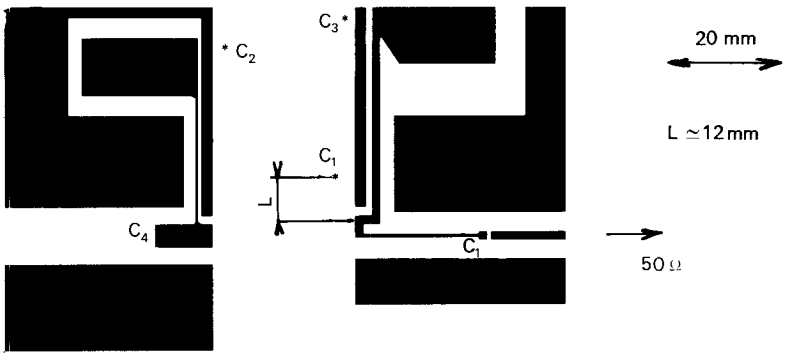


C_1: 220 pF (chip)
C_2: 220 pF (chip) + 10 nF
C_3: 220 pF (chip) + 10 nF + 10 µF
C_4: 0.6-4.5 pF (Frequency tuning)
L : adjust to obtain the maximum output power
θ = 0.115 λg for Fo = 2.3 GHz
θ = 0.06 λg for Fo = 3 GHz

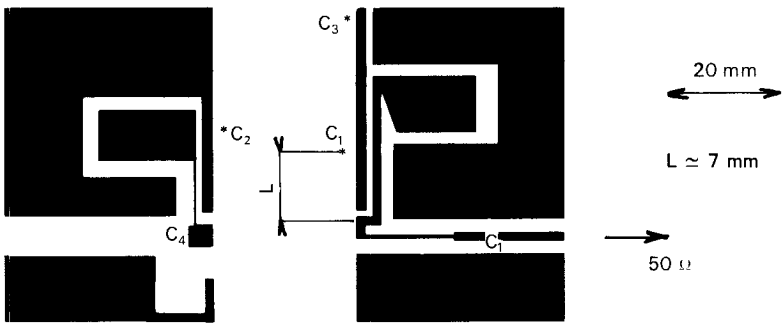
TEST CIRCUIT



PC Board Layout for Fo = 2.3 GHz (BW = 500 MHz)



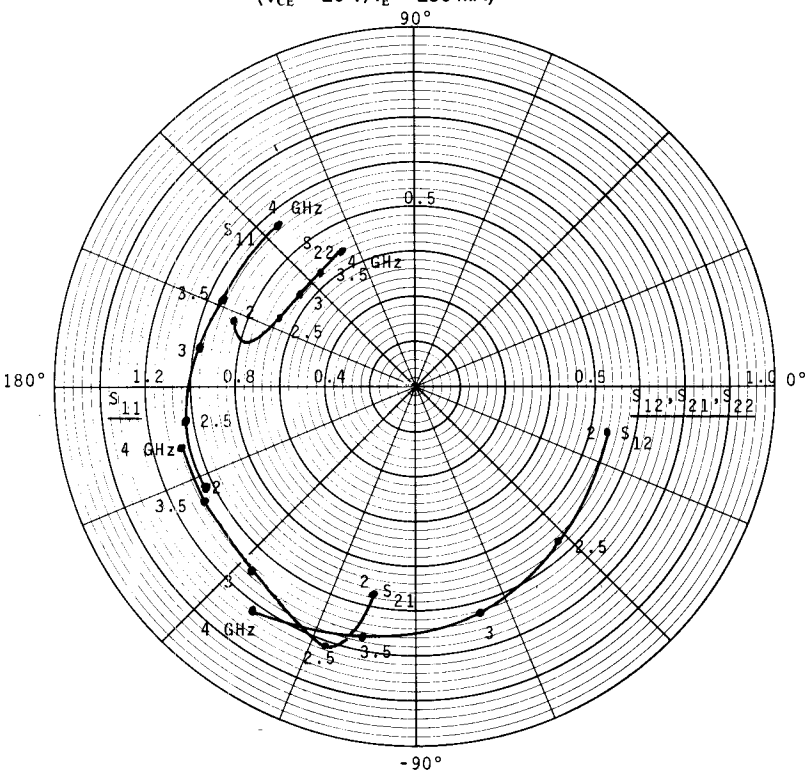
PC Board Layout for Fo = 3 GHz (BW = 500 MHz)



* Foil-wrap asterisked edge to ground plane.
Board material :- 0.020" Glass teflon (Er = 2.55)
Adjust L to obtain the maximum output power

Small Signal S-Parameters

(V_{CE} = 20 V, I_E = 230 mA)

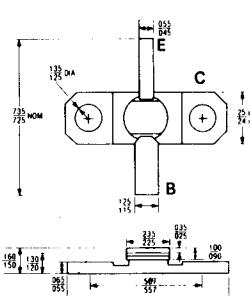


Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions:	Per outline drawing.
Solderability:	Per MIL-STD-750.
Marking:	Per MIL-S-19500, "TRW," 4-digit date code, type number.
Hermaticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Package Outlines



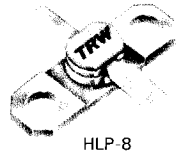
Microwave Power oscillator Transistors

Up to 5 GHz
350 mW at 4 GHz
∞ VSWR

The TRW 64601 is designed for use up to 5 GHz with a typical Pout of 350 mW at 4 GHz.

TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.



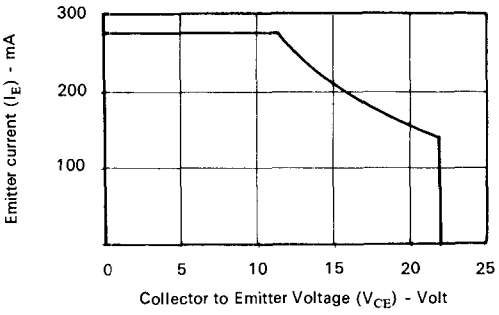
HLP-8

Electrical Characteristics (T_{CASE} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
D C Test	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 10 mA	22			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	R_{BE} = 10 Ω, I_C = 10 mA	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.25 mA	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 1.0 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CB} = 28			0.25	mA
	h_{FE}	Forward Current Transfer Ratio	V_{CE} = 5.0 V, I_C = 100 mA	20		120	
R F Test	C_{ob}	Collector Base Capacitance	V_{CB} = 28 V, F = 1 MHz			3.5	pF
	F_T	Frequency Cutoff	V_{CE} = 20 V, I_E = 120 mA	4.0	4.5		GHz
	P_o	Power output	F = 4 GHz, V_{CE} = 20 V, I_E = 120 mA	0.300	0.350		W
	VSWR	Mismatch Tolerance	P_o = 0.300 W, V_{CE} = 20 V, I_E = 120 mA		∞ : 1		
Operating	θ_{JF}	Thermal Resistance (junction to Flange)				40	°C/W
	T_{STG}	Max Junction and Storage Temperature		— 65		100	°C

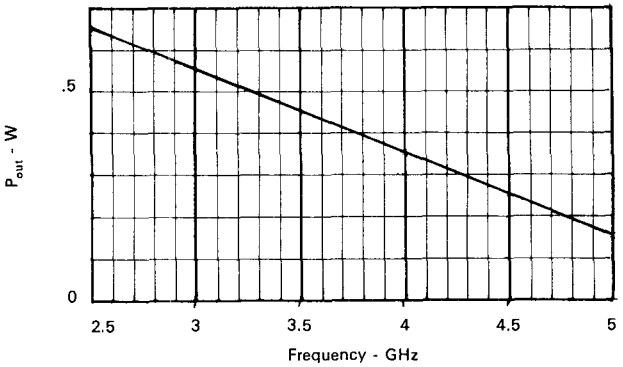
DC Safe Operating Area

T_{Flange} = 75 °C



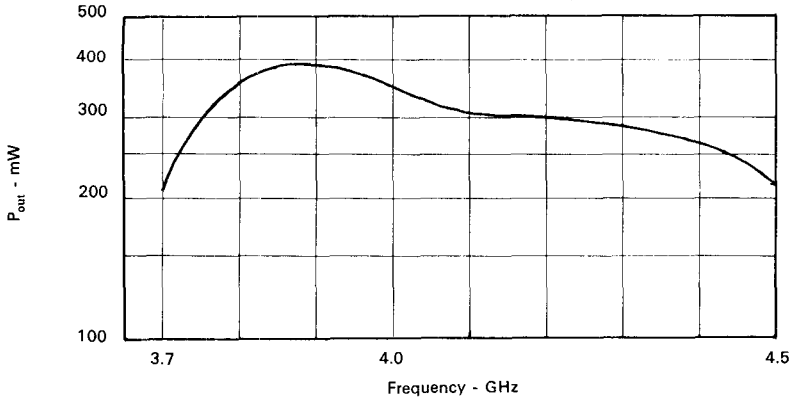
Output Power V_S Frequency

(V_{CE} = 20 V, I_E = 120 mA)



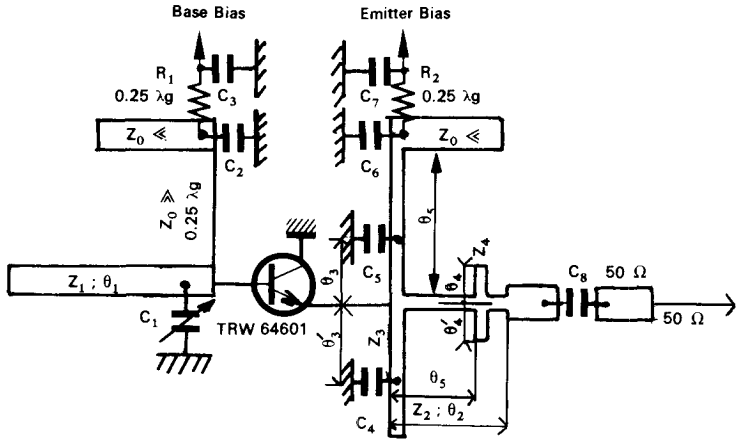
P_{out} V_S Frequency with a Fixed tuned output circuit

Oscillator circuit : TF; V_{CE} = 20 V; I_E = 120 mA



Test circuit

F_0 = 4 GHz



$Z_1 = 23.5\ \Omega$ $\theta_1 = 0.52\ \lambda g$

$Z_2 = 80/67\ \Omega$ $\theta_2 = 0.25\ \lambda g$

$Z_3 = 50\ \Omega$ { $\theta_3 = 0.095\ \lambda g$; $\theta'_3 = 0.140\ \lambda g$ Adjust θ_3 and θ_3 to obtain the maximum output power

$Z_4 = 62\ \Omega$ $\theta_4 = 0.05\ \lambda g$

$\theta_5 = 0.18\ \lambda g$

$R_1 = 160\ \Omega$

$R_2 = 1\ \Omega$

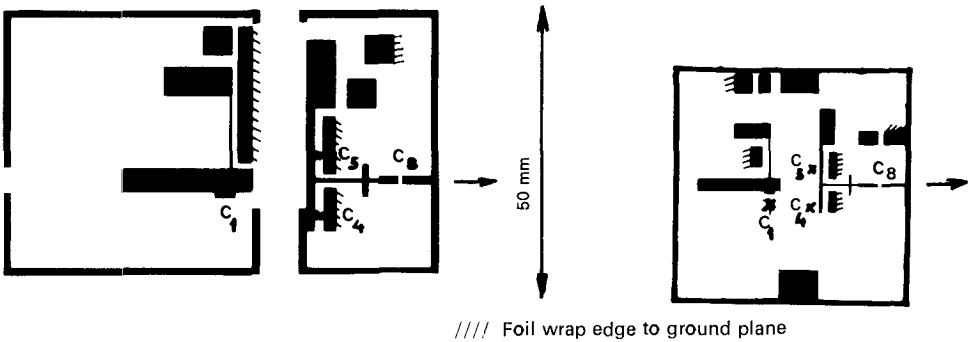
$C_1 = 0.4 - 2.5$ pF

$C_2 = C_6 = 100$ pF (chip) + 10 nF

$C_3 = C_7 = 10$ nF

$C_4 = C_5 = C_8 = 33$ pF (chip)

P_C Board layout For F_0 = 4 GHz (BW = 700 MHz)

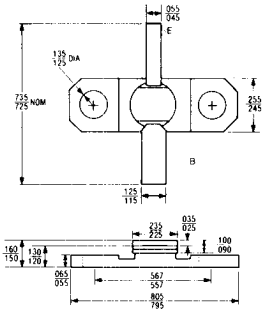


//// Foil wrap edge to ground plane

Board Material : 0.020″ Glass teflon;
$E_r = 2.55$

Board Material : 0.025″
Epsilan 10 ; $E_r = 10.2$

Package Outlines



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions:	Per outline drawing.
Solderability:	Per MIL-STD-750.
Marking:	Per MIL-S-19500, "TRW," 4-digit date code, type number.
Hermaticity:	Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak. (Available on special order screened to 10^{-8} atmospheres.)
Acceleration:	Per MIL-STD-750, 20,000G in any plane.
Bond Pull:	Per MIL-STD-750, 3 grams min.
Package:	A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

Microwave Power Oscillator Transistor

PRELIMINARY

The TRW 64602 is designed for use up to 5 GHz with a typical P_{out} of 650 mW at 4 GHz.

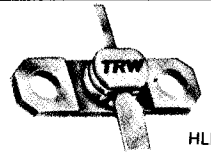
TRW oscillator devices are commun collector, diffused ballasted, gold metalized microwave transistors characterized for Power oscillator applications.

Their construction enables these devices to be able to withstand an infinite VSWR at any phase and at operating conditions.

UP TO 4 GHz

650 mW AT 4 GHz

∞ VSWR



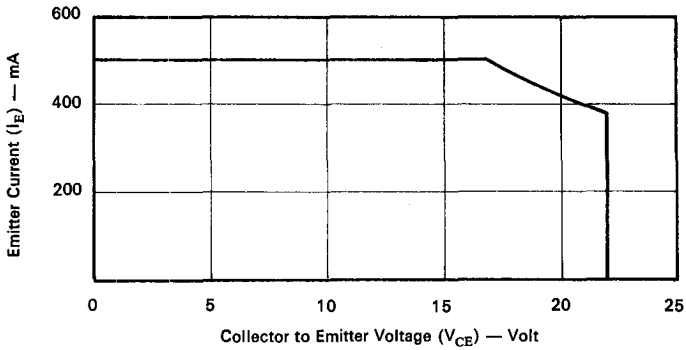
HLP-8

Electrical Characteristics (T_{case} = 25 °C)

	SYMBOL	CHARACTERISTICS	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC TEST	BV_{CEO}	Collector - Emitter Breakdown Voltage	I_C = 20 mA	22			V
	BV_{CER}	Collector - Emitter Breakdown Voltage	I_C = 20 mA R_{BE} = 10 Ω	50			V
	BV_{EBO}	Emitter - Base Breakdown Voltage	I_E = 0.5 V	3.5			V
	BV_{CBO}	Collector - Base Breakdown Voltage	I_C = 2 mA	45			V
	I_{CBO}	Collector Cutoff Current	V_{CE} = 28 V			0.5	mA
RF TEST	H_{FE}	Forward Current Transfer Ratio	V_{CE} = 5 V I_C = 200 mA	20		120	
	C_{OB}	Collector Base Capacitance	V_{CB} = 28 V F = 1 MHz			5.5	pF
	P_o	Power output	V_{CE} = 20 V F = 4 GHz I_C = 240 mA	550	650		mW
	VSWR	Mismatch Tolerance	V_{CB} = 20 V F = 4 GHz I_C = 240 mA		∞ : 1		
THERMAL	θ_{JF}	Thermal Resistance Junction to Flange				20	°C/W
	T_{STG} & T_J	Max Junction & Storage Temperature		— 65		+ 200	°C

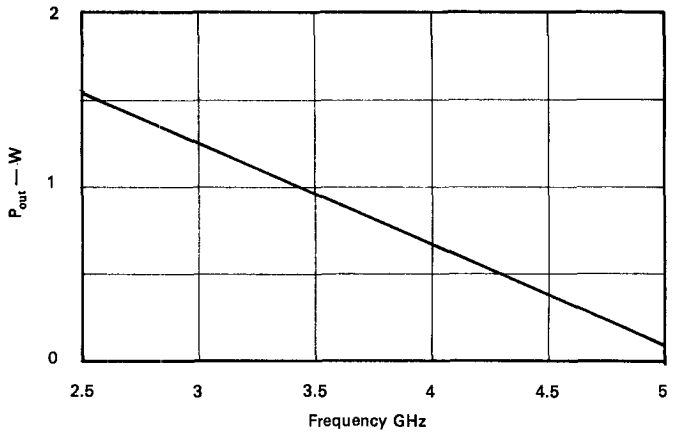
DC Safe Operating Area

T_{flange} = 75 °C

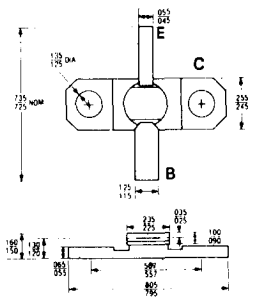


Output Power vs Frequency

(V_{CE} = 20 V, I_E = 240 mA)



Package Outlines



Mechanical Specifications

The following are mechanical specifications for this transistor series.

Dimensions	: Per outline drawing.
Solderablility	: Per MIL-STD-750.
Marking	: Per MIL-S-19500, « TRW », 4-digit date code, type number.
Hermaticity	: Per MIL-STD-750, 10^{-7} atmospheres gross and fine leak (Available on special order screened to 10^{-8} atmospheres.)
Acceleration	: Per MIL-STD-750, 20.000G in any plane.
Bond Pull	: Per MIL-STD-750, 3 grams min.
Package	: A brazed ceramic package assuring long-term integrity of hermetic seals. Leads of KOVAR base material with minimum 60 microinches of gold plating.

APPLICATION NOTES

RF Transistor Reliability

Reliability and MTF -- The Long and Short of It

Mean Time for Failure in microwave power transistors is increasing by the introduction of new designs and improved metallization systems. Here is a review of both long-term and short-term reliability problems and how they can be dealt with.

ALONG with the development of high power microwave transistors has been a determined effort by the major transistor houses to improve device short and long-term reliability. Short-term reliability allows a device to withstand electrical or environmental abuse for brief periods of time, such as infinite VSWR. Long-term reliability on the other hand is the ability of a device to take adverse conditions for an extended period of time, such as elevated ambience or non-optimum load conditions.

Several factors enter into the determination of microwave transistor reliability. Among the most important are

- a device design that minimizes thermal stresses and current densities (both conductive to premature and long-term failure modes).
- silicon and junction passivation integrity.
- metallization ruggedness as to thermal, electrochemical corrosion, silicon dissolution, oxide reduction, and electromigration effects.
- and a package design that provides a hermetic, low parasitic, and maximum heat dissipation environment.

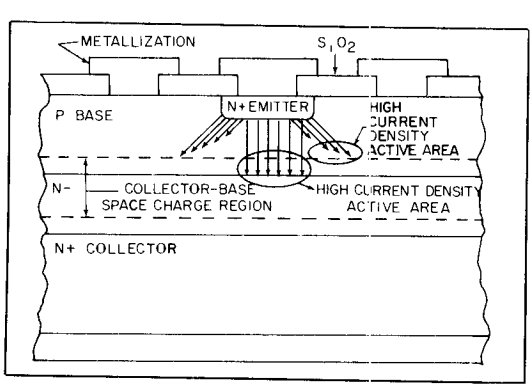
Short-term failure—forward bias

When a microwave power transistor fails under short-term stress conditions, it is invariably caused by intense localized heating at the emitter-base or collector-base junction. This heating culminates in a localized melting of the contacting metallization and the silicon crystal, resulting in catastrophic failure. These stress conditions usually occur from a high VSWR presented to the device by non-optimum load conditions.

Either low voltage and high current, high voltage and low current, or intermediate current-voltage combinations can occur, depending on the magnitude and phase angle of the VSWR. Most high power microwave transistors are operated in a common-base, class C mode. When a voltage swing exceeds specific voltage ratings, large avalanche currents flow in the device causing high power dissipation and localized heating. If the load termination allows a low-voltage, high-current state to occur, equally destructive localized heating results.

Forward-bias secondary breakdown occurs whenever a device is heavily biased into the active region and large emitter and collector currents flow (Fig. 1a). Under these conditions, a large transverse voltage drop occurs in the base region under the emitter. As a result large base current components de-bias the emitter-base junctions in their central portions such that only the periphery of these junctions are active, causing high amounts of heat to be generated. Should the load termination be such that avalanche conditions prevail, the multiplication further aggravates the already present current and power density stresses.

The severity of localized heating depends both on the current drive and applied voltage. For a given current level, increases in V_{CE} cause higher power densities in the collector-base junction, resulting in higher temperatures. Increases in current drive cause equally deleterious effects for a given V_{CE} bias level, since higher current levels further diminish the useful emitter-base active area due to base-current de-biasing effects. As a result, localized power densities are increased and with the available areas decreased, the local thermal impedances cause inordinate temperature



1(a). Cross section of a typical epitaxial, planar diffused junction transistor shows current flow under hard forward bias conditions at corners of emitter-base junction. **(b) Collector-base forward-bias,** or emitter-base reverse bias causes emitter-collector current to be localized in the center of the emitter-base junction (color tint).

Mike Flahie, Microwave Engineer, TRW Semiconductor Division, Lawndale, Calif.

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rises to occur. Unfortunately, these temperature rises are degenerative: i.e., as a particular junction becomes hot, the more current it will draw; as it draws more current the hotter it becomes.

Emitter-base junction de-biasing is directly proportional to the frequency and power of a transistor. High frequency devices demand narrow basewidths, relatively high base-sheet resistances, and high collector-base voltages.

Saturated secondary breakdown

Reverse-bias can be equally fatal to a device. Here current flows through the device under either emitter-base reverse-bias conditions, or hard, high-current, collector-base forward-bias conditions. Under either condition, base current direction is reversed causing emitter-collector current to be localized in the central portion of the emitter-base junction (Fig. 1b). Reduced area and periphery result in high local impedances.

When both conditions exist, the effect can be even more disastrous. Hard avalanche reverse-bias of an emitter-base junction results in a temporary emitter-collector current gain degradation.[1] A doubly-fatal condition results: current gain is reduced; hence, the next current-drive cycle faces deteriorated gain—the cycle is clearly degenerative. The degeneration of junction properties can be avoided via internal device current-limiting techniques.

Packaging integrity important

Long-term failure modes are characterized by gradual deterioration of device performance levels due to junction, contacting metallization (including wire and die bonds), or package degradation effects. The processes are both degenerative and cumulative, and lead to eventual catastrophic failure.

A transistor package provides a protective environment, low thermal impedance, low parasitic and a mechanically rugged housing for a chip. It should only minimally detract from the intrinsic device capability. Compromises are usually the case: i.e., device performance is usually sacrificed in order to provide reliable performance. Package integrity, such as the quality of the isolating dielectric (e.g. BeO), lead connection layout, and overall package construction usually result in a 1-2 dB power degradation. This results from both high thermal impedances and high parasitic losses presented by the housing.

Major reliability problems involved in the package assembly process are

- die bonding of the chip to the package
- wire bond leads from the package to the chip
- hermeticity of the assembled package
- voids between the header and die
- voids in the heat sinking base of the header
- and cracking of the die during both the die and wire bonding operations.

Assuming total package integrity, two critical variables that influence both the short and long term reliability of a microwave power transistor are the quality of the die bond to the header and the external lead bonding. Faulty die bonding leads to voids between the die and its heat sink. These voids in turn lead to poor thermal conductance areas, creating local device "hot spots." This leads to localized thermal runaway, causing eventual destruction of the device.

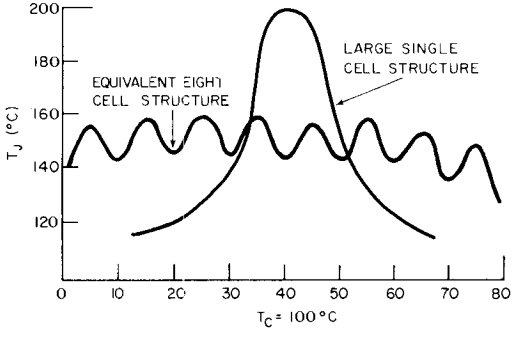
Faulty lead bonding can have a similar result If a lead is shorter or longer than the other corresponding leads, or presents a localized high impedance due to poor contact, phase differences result in non-uniform rf current distribution.

Hot spots and multi-cell design

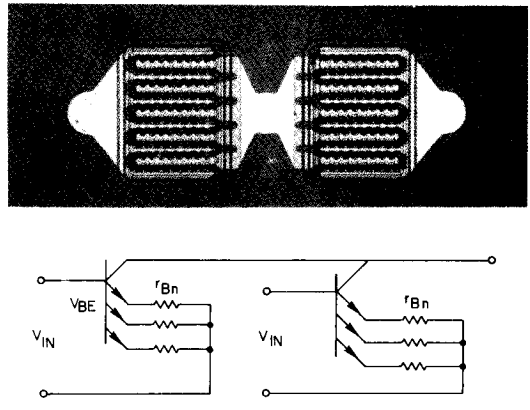
Microwave power transistor design is predicted on two main criteria:

- sufficient collector-base junction area and periphery to manage the heat generated; dc to rf conversion efficiencies are only 30-60%.
- and, extremely fine geometries to maximize emitter-periphery to base-area ratios.

(continued on next page)



2. The temperature profile across the surface of a large area microwave transistor can be distributed by using a multi-cell construction.



3. Cell-pair of an emitter ballasted, TRW 5 W, 3 GHz transistor and schematic. Darker areas are the refractory ballast resistor material.

To attain higher power at microwave frequencies by using larger collector-base junction areas has historically ended in a situation of diminishing returns. Less output power is observed as the collector-base junction area is increased above a critical level, although the device emitter periphery/base area ratio, f_t, and base periphery figure of merits are maintained. Further, large collector-base area devices are more prone to premature failure than their lower power, scaled down "equivalents." This results because large area devices exhibit grossly non-uniform current and temperature distributions (Fig. 2) where a temperature gradient of approximately 4°C/mil exists from the center of the die to the edge.[2] As a result only a small fraction of the available active device area is used for power conversion. Cooler portions receive less drive current, for a fixed emitter-base voltage bias level, due to the exponential relationship between current, voltage, and temperature of a forward biased junction:

$$I_E = CT^{1.4}\, e^{(-1/KT)(E_g - qV_{BE})} \qquad (1)$$

where

E_g = Energy gap for silicon doping.
q = charge electron.
V_{BE} = base emitter bias voltage.
C = constant.
T = temperature – °K.

The percentage increase in emitter current per °C is obtained by the differentiating Eq. 1 with respect to temperature, holding V_{BE} constant:

$$\frac{1}{I_E}\left(\frac{dI_E}{dT}\right) = \frac{1}{T}\,[1.4 + (E_g - q\,V_{BE})/KT] \qquad (2)$$

When operating near 300°K (room temperature), and a forward bias $V_{BE} = 1$ V, Eq. 2 predicts

$$\frac{1}{I_E}\left(\frac{dI_E}{dT}\right) = 1.75\%/°C \qquad (3)$$

Hence, a difference in temperature of 20°C can result in a percentage current difference of nearly 35%. Further, since

$$\frac{1}{I_E}\left(\frac{dI_E}{dT}\right) = \frac{1}{I_E}\left(\frac{dI_E}{dx}\right)\left(\frac{dx}{dT}\right) \qquad (4)$$

then

$$\frac{1}{I_E}\left(\frac{dI_E}{dx}\right) = \frac{1}{T}\left(\frac{dT}{dx}\right)[1.4 + (E_g - q\,V_{BE})/KT] \qquad (5)$$

Equation 5 means that large percentage thermal gradients are accompanied by large percentage current gradients.

To avoid hot spots the collector-base junction area is usually divided into paralleled "cells," (Fig. 2). However, paralleling multiple cells presents difficulties. Phase differences associated with package parasitics and physical die dimensions cause major problems at gigahertz frequencies. These phase differences can result in unequal power drive to the individual cells resulting in situations equally as dangerous to device reliability as poor device area layout.

Emitter ballasting, where discrete resistive elements are introduced in series with the emitter contact metallization, greatly reduces these drive input non-uniformities, and increases the device ruggedness to secondary breakdown effects. Emitter ballasting works as follows: If a given emitter-base junction site becomes excessively heated and tries to draw more than its proportionate share of drive current, the series resistance will divide the input voltage in accordance with the IR drop demanded by the relative impedance levels of both the series resistance and the emitter-base junction site involved (Fig. 3).

For a dual-celled, emitter-ballasted device, the emitter current at any site is

$$I_E = I_S\,(e^{q(V_{BE}/KT} - 1) \qquad (6)$$

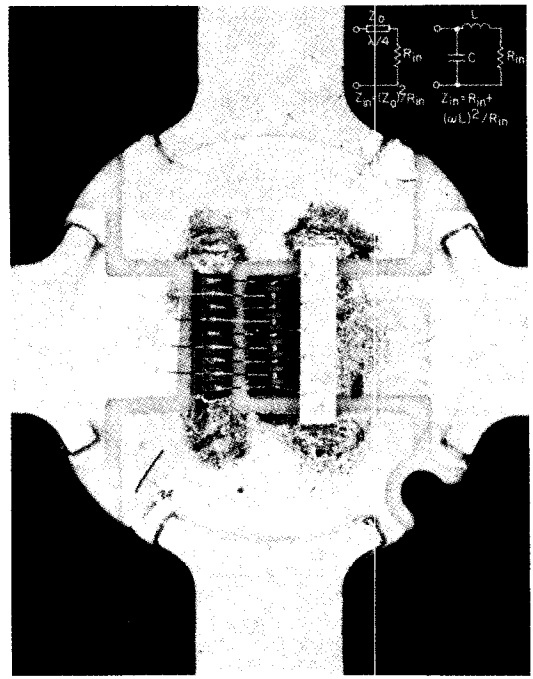
But

$$V_{BE} = V_{IN} - I_E r_B \qquad (7)$$

Hence

$$I_E = I_S\,(e^{q(V_{IN} - I_E r_B/KT)} - 1) \qquad (8)$$

In other words, for a constant V_{IN} applied across the emitter-base junction and ballast network, local increases in I_E due to temperature cause a rise in the local $I_E r_B$ drop, resulting in less V_{BE} voltage drive. The ballast resistor thus stabilizes any endangered site. Although the ballast resistors are in series with the load, their effect on the rf performance of the device can be minimized. The resultant total value is $R_T = 1 \Big/ \sum_n (1/r_{Bn})$ which is usually small. Further, increases in



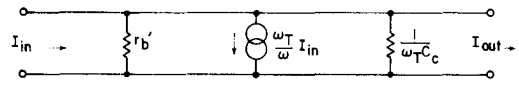
4. Matching sections given by $Z_{in} = R_{in} + (\omega L)^2/R_{in}$ consist of lead wire inductances and discrete SiO_2/Si capacitance elements.

saturation voltage for the paralleled ballast resistors are also minimal, since the $I_E R_T$ drop is on the order of a few hundreds of millivolts. One additional advantage of multicellular construction is it increases the total amount of collector-base junction periphery for a given total-required base area. This increase in periphery decreases the total thermal impedance of the device, since θ_{jc} is inversely proportional to base periphery.

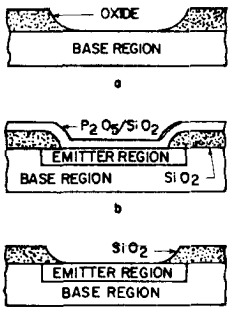
Further improvements in device reliability and performance are obtainable with in-package, discrete element, impedance matching schemes (Fig. 4). Should for any reason an emitter-ballasted transistor present a low input impedance not controlled by emitter-ballasting at any given cell, an impedance inverting network can be provided to reflect this low impedance input into a high impedance input. Should R_{in} decrease due to either phase differences in the input drive, or localized heating, Z_{in} increases inversely (Fig. 4) limiting the amount of power delivered to the misbehaving site.

Transistor equivalent circuit

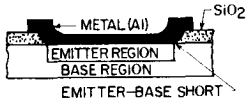
Transistor unilateral gain (that gain obtained when a device is designed with a lossless network and matched at both ports) can be approximated by:[2]



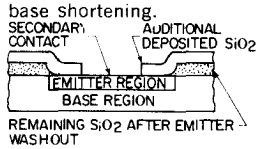
5. Simplified equivalent circuit of a transistor—$r_b C_c$ is minimized for maximum frequency.



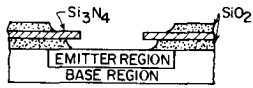
6. "Emitter-washout" effects are shown in (a) before emitter diffusion, (b) after, and (c) after emitter diffusion and emitter-washout.



7. Metal-oxide reduction effects result in emitter-base shortening.



8. By disposition an additional layer onto the wafer, secondary contacts, narrower in width may be defined over the emitter diffusion sites.



9. A silicon-nitride shelf technique diminishes the "emitter-washout" hazard.

$$G(f) \approx \frac{G(0)}{[1 + G^2(0)\ (f/f_{max})^4]^{1/2}} \quad (9)$$

For $G^2(0)\ (f/f_{max})^4 >> 1$, $G(f) \approx (f_{max}/f)^2$. The maximum frequency of oscillation of a transistor, f_{max}, is the frequency for which power gain drops to unity. For the simplified transistor equivalent circuit of (Fig. 5) the real part of the input conductance is $1/r_b'$; the real part of the output conductance is approximately $\omega_T C_c$, and current gain $|h_{fe}| = \omega_T/\omega$. The gain of the equivalent circuit given by (Fig. 5) is then

$$G(f) = \frac{P_{out}}{P_{IN}} \approx \frac{I^2_{OUT}\ (1/Re\,(Y_{OUT}))}{4\,I^2_{IN}\ (1/Re\,(Y_{IN})} \quad (10)$$

Hence,

$$G(f) \approx \frac{f_T}{8\,\pi\,f^2\,r_b\,C_c} \quad (11)$$

For $f = f_{max}$, $G(f) = 1$, hence

$$f_{max} = \frac{f_T}{8\,\pi\,r_b'\,C_c} \quad (12)$$

To achieve high gain at a particular frequency, f_T must be maximized, and the $r_b'C_c$ product minimized. For a simple interdigitated device, r_b, the base spreading resistance is approximated by

$$r_b' \approx \frac{R_{BS}}{2L_E N_E} \quad (13)$$

where

R_B = base sheet resistivity, in $\Omega/\square$
S = emitter to base contact spacing
L_E = emitter contact length
N_E = total number of emitter contacts

and

$2L_E N_E$ = total emitter periphery, E_P.

C_c is the collector- base junction capacitance (neglecting fringing and other parasitic capacitances), and its magnitude is given by

$$C_c = \frac{\epsilon_o\,\epsilon\,A_B}{X_D} \quad (14)$$

where

ϵ_o = permittivity to free space
ϵ = relative dielectric constant of silicon
A_B = collector-base junction area
X_D = depletion width at a given value of V_{CE} or V_{CB}.

Therefore the $r_b'C_c$ product is approximately

$$r_b'C_c \approx \frac{\epsilon\,\epsilon_o\,R_B\,S A_B}{X_D\,E_P} \quad (15)$$

For a fixed frequency, base sheet resistivity, and voltage, transistor gain depends on

$$G \approx \frac{f_T}{S}\left(\frac{E_P}{B_A}\right) \quad (16)$$

Hence most transistor geometries are designed to maximize the E_P/B_A (emitter-periphery to base area) ratio, and minimize the emitter to base contact spacings. f_T is given by the following

$$f_T = \Big[\ 2\,\pi\,[r_E(C_E + C_c + C_X) + W^2/2.43D + X_D/2\,V_S + r_c'\,C_c]\ \Big]^{-1} \quad (17)$$

where

$r_E = \frac{KT}{qI_E}$

C_E = emitter-base junction capacitance given by $\epsilon \epsilon_o A_E/X_E$

C_C = collector-base junction capacitance

C_X = parasitic capacitances

W = metallurgical basewidth

D = diffusion constant of minority carriers in the base

X_D = collector-base junction depletion width

V_S = saturated limiting velocity of majority carriers in the collector-base depletion region

r_C = parasitic collector region resistance

K = Boltzmann's constant

T = temperature in °K

I_E = emitter current

A_E = emitter area

X_E = emitter base, junction depletion width.

To maximize f_T, consistent with the highest operating emitter current the following must be minimized:

- emitter-base junction de-biasing and base-widening effects (which cause gain degradation)
- emitter-base and collector-base junction areas
- metallurgical basewidths
- collector-base junction voltage, and
- parasitic series collector resistance.

The capacitances are minimized by device geometries that maximize the E_P/B_A ratios, and minimize the emitter and base contact areas. Base widths are minimized by using the shallowest feasible collector-base and emitter-base junction depths. Emitter current capability is extended by minimal r_b' and maximal emitter periphery.

Contact geometries and emitter washout

Three distinct transistor contact geometries to meet these requirements are presently used: interdigitated, overlay, and mesh, or matrix types. (These are discussed in a subsequent article; pp. 46-51). Due to the requirements of shallow-diffused junctions, a high integrity passivation and contact definition scheme is required. Some contact geometries employ "emitter-washout" to define the final contact to the emitter-base junction sites.

"Emitter-washout is the practice of chemically removing the resultant thin P_2O_5/SiO_2 layer over the emitter contact sites after the emitter diffusion step (Fig. 6). The thin SiO_2 layer that remains can present a reliability hazard if the metallization used reduces this oxide layer under high temperature. A classic example is the aluminum-silicon oxide reaction that leads to emitter-base junction degradation and eventual failure (Fig. 7).[4] "Second-contact" schemes can minimize this hazard by replacing the oxide removed during the washout process with an additional layer of SiO_2, (Fig. 8).

Silicon-nitride layer can also diminish the "emitter-washout" hazard because it is more immune to metallization reduction effects. Since it also has a lower etch rate than silicon oxide in the silicon-oxide etchant, its thickness is relatively unaltered and a protective silicon nitride "shelf" remains over the emitter-base junction site (Fig. 9).

All three emitter-base junction site contacting techniques are used in interdigitated, overlay, and mesh geometry transistor. Their ultimate reliability depends both on the shallowness of the emitter-base junction sites, and the metallization system employed.

Metal migration—how and why[5]

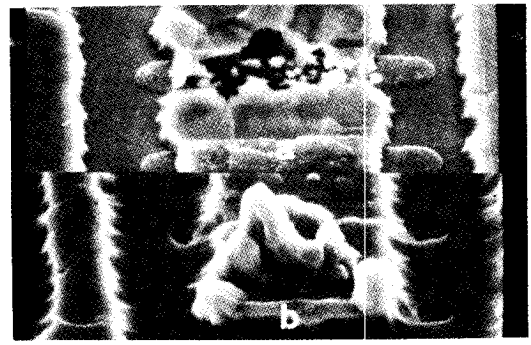
Aluminum has long been used for semiconductor devices because of its distinct advantages and properties:

- low bulk resistivity ($\rho \approx 2.7\ \mu\ \Omega$-cm)
- excellent adherence to Si and SiO_2
- ease of evaporation
- low cost
- low resistance ohmic contact to heavily doped n and p-type Si
- amenability to chemical pattern delineation.

However, it has several limitations:

- susceptibility to current induced electromigration forming voids and hillocks.
- Interactions with both Si and SiO_2 lead to contact embrittlement, loss of adhesion, dissolution of Si into Al in the active areas, void formation, and contact opens and shorts.
- Intermetallic compound formation with gold lead wires leading to poor adhesion, high contact resistance, and eventual contact failure.
- Difficulty in delineating fine line geometries due to its non-isotropic etch characteristics and crystalline structure.
- Oxide step coverage problems.
- Severe electroylic-corrosion susceptibility.

The most stringent requirement to be met by an alternate metallization system is it be highly resistant to current induced metal mass migration. This phenomena poses the most severe hazard to long term reliability, as it is the pre-



10(a) Void formation is accelerated by high temperatures which actlvate metal ions and high current densities. Hence, more electrons are available to collide with the activated ions and impart momentum to them. **(b) Hillocks** are the result of a net mass transport and build-up toward the anodics end of the film (RCA photo).

dominant failure mechanism even when operating within safe-area regimes. The next most stringent requirement is short term ruggedness under junction high temperature conditions. It must not interact with either the SiO_2 passivation layers or the Si contact areas to cause junction degradation.

At a given temperature, a certain equilibrium concentration of vacancies exists in all metal films. Self diffusion of metal ions throughout the film arise due to the metal ions being thermally activated into adjacent vacancies from their normal lattice sites. In the absence of external forces, the metal in diffusion is isotropic and results in no net accumulation or depletion of mass in any given site. With an electric field, however, the thermally activated metal ions experience a force due to their charge resulting in an ion flux toward the cathodic end of the film (Fig. 10). In addition the electric field will cause electron scattering off the activated ions and impart momentum to them, inducing an ion flux toward the anodic end of the film. In good conductors, the momentum exchange force dominates the electrostatic force and results in a net mass transport toward the anodic end of the film. Voids can also be formed at the negative terminals, eventually resulting in contact opens. Void formation is accelerated by high temperatures and high current densities, i.e., above 150 C and 10^6 A/cm^2.

Although more detailed analyses of electromigration effects are available,[5,6,7,8,9] Black's simplified theory describes this phenomena and provides insight into the main variables influencing the Median Time to Failure (MTF).[3]

$$\mathrm{MTF} = \left(\frac{W \cdot t}{CJ^2}\right) e^{\phi/KT} \qquad (18)$$

where

W = stripe width of the metallization
t = stripe thickness of the metallization
J = current density
ϕ = activation energy for diffusion of the metal
K = Boltzmann's constant
T = temperature in °K
C = constant depending on degree of film crystallinity, resistivity, ion mass, density and stripe geometry.

Figure 11 (in color tint) shows the expected best case MTF for a small grained aluminum stripe 1 μ thick × 2.54 μ wide, with a current density of 10^6 Amps/cm^2. Other expected MTF's for various current densities, temperatures, and a 10^{-7} cm^2 cross sectional area are also shown.

To increase the MTF of devices, three options exist:

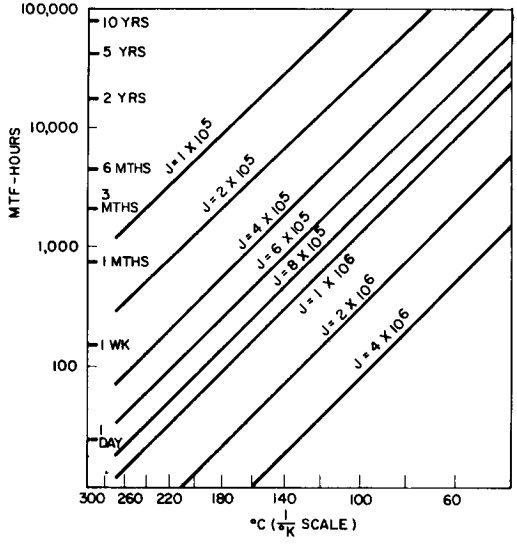
- Reduce the current density and temperature.
- Select a metal system with a higher activation energy and higher mass.
- Alter a basic aluminum system to increase the activation energy and decrease the pre-exponential constant.

Utilization of a new metal system, or altering of the basic aluminum system has been the option generally exercised by the industry (see pp. 54 through 58). However, a system providing higher resistance to electromigration effects may not satisfy temperature, corrosion resistance, oxide step coverage, adhesion, and production capability criteria previously discussed.

Three basic techniques have shown to retard electromigration effects in aluminum: (1) the addition of a small percentage of Cu (~ 4% by wt), (2) the use of a glass passivation layer over large grained aluminum, and (3) the addition of a small amount of Si (~ 0.3%).

The addition of a small percentage of Cu to Al results in an activation energy of approximately 0.6 eV (essentially the same as pure Al) but at current densities of 4×10^6 Amps/cm^2 and at temperatures from 100°C to 200°C, the improvement in MTF was found to be approximately 100. This increase in MTF is attributed to a change of the pre-exponential constant in Eq. 18.[9] However, copper junction poisoning presents a reliability risk. Silicon diodes and NPN transistors, power aged at temperatures of 100-200°C, and at current densities of 10^4 to 10^5 Amps/cm^2 degrade in less than 24 hours due to softening of the emitter base junction. Similar units stored at the same temperature but without power dissipation remained intact. This may be explained in terms of Cu atoms drifting to the junction under the influence of an electric field.[10]

The addition of a glass passivation layer over large grained aluminum has been reported to result in an activation energy of approximately 0.56 eV, and a J^2 MTF factor of approximately



11. MFT decreases rapidly as temperature and current density increase as shown on this log scale.

9×10^{11} hours $(A/cm^2)^2$ at 200°C, as contrasted to a J^2 MTF product of 6×10^{13} hours $(A/cm^2)^2$ for unpassivated, small grained Al (activation energy = 0.48 eV) at 200°C. This represents a factor of 15 lifetime improvement.[11]

The addition of a small percentage of Si (~ 0.3% by wt.) has also been reported to result in a lower activation energy than Al, i.e., 0.32 eV versus 0.55 eV, but with a times-ten improvement in lifetime, at 180°C and a current density of 2×10^6 A/cm^2.[12]

Gold metallization systems

Refractory-gold metallization systems provide the most drastic increase in electromigration resistance, as well as interfacial layer metallurgical stability.[11,15,16] In these systems, the gold layer serves as the primary conductive layer, and the refractory layers provide adhesion and a barrier layer to prevent Au-Si eutectic formation (which occurs at ~ 370°C). Several composite systems are presently used: Ni-Cr/W/Au, PtSi/Ti/Pt/Au, PtSi/Mo/Au, PtSi/W/Au, and PtSi/Ti/W/Au.

PtSi primary layers provide low ohmic contact resistance[20] and are formed in excess of 500°C without evidence of emitter-base junction degradation effects. Even in extremely shallow junctions, i.e. $\leq 0.2\ \mu$, the Pt + Si → PtSi reaction is limited. The refractory layers exhibit minimal SiO_2 reduction effects and almost no silicon dissolution effects. Refractory layers are efficient barriers to Au-Si reactions due to the absences of refractory-gold intermetallics.

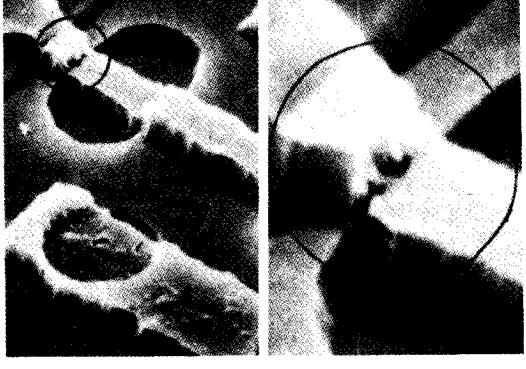
Due to the extreme melting temperatures of refractory metals, evaporation techniques are not usually used. Instead, rf sputter deposition methods are used which allow precise deposition control as well as excellent oxide step coverage. Reliability problems presented by thin metallization over oxide steps are eliminated (Fig. 13).

The corrosion resistance properties of Al-Au, Al-Al, Mo-Au, Ti-Pt-Au, W-Au, and Ti: W-Au are summarized in the Table.[14] ••

Table: Temperature/Humidity/Bias testing of various metal systems of unencapsulated test transistors*

Metal System	% Cumulative Failure/ in no. hours
Al-(Au wire)	100%/100 hours
Al-(Al wire)	100%/100 hours
Mo-Au-(Au wire)	100%/100 hours
Ti-Pt-Au-(Au wire)	0%/>1000 hours
W-Au-(Au wire)	96%/250 hours
(10%)Ti:w-Au-(Au wire)	93%/1000 hours**

* Test Conditions: 85°C, 85% relative humidity.
V_{CB} = +6 V, V_{BB} = +2 V, grounded base.
**At 55°C/70% relative humidity, 4%/1000 hours.



12. Poor step coverage can result with an evaporated aluminum metallization which gives rise to regions of extremely high current densities and eventually failure.



13. Gold metallization provides good step coverage as shown in these 6000 times photomicrographs. The cross-section of the rf sputtered gold strip has no discontinuities.

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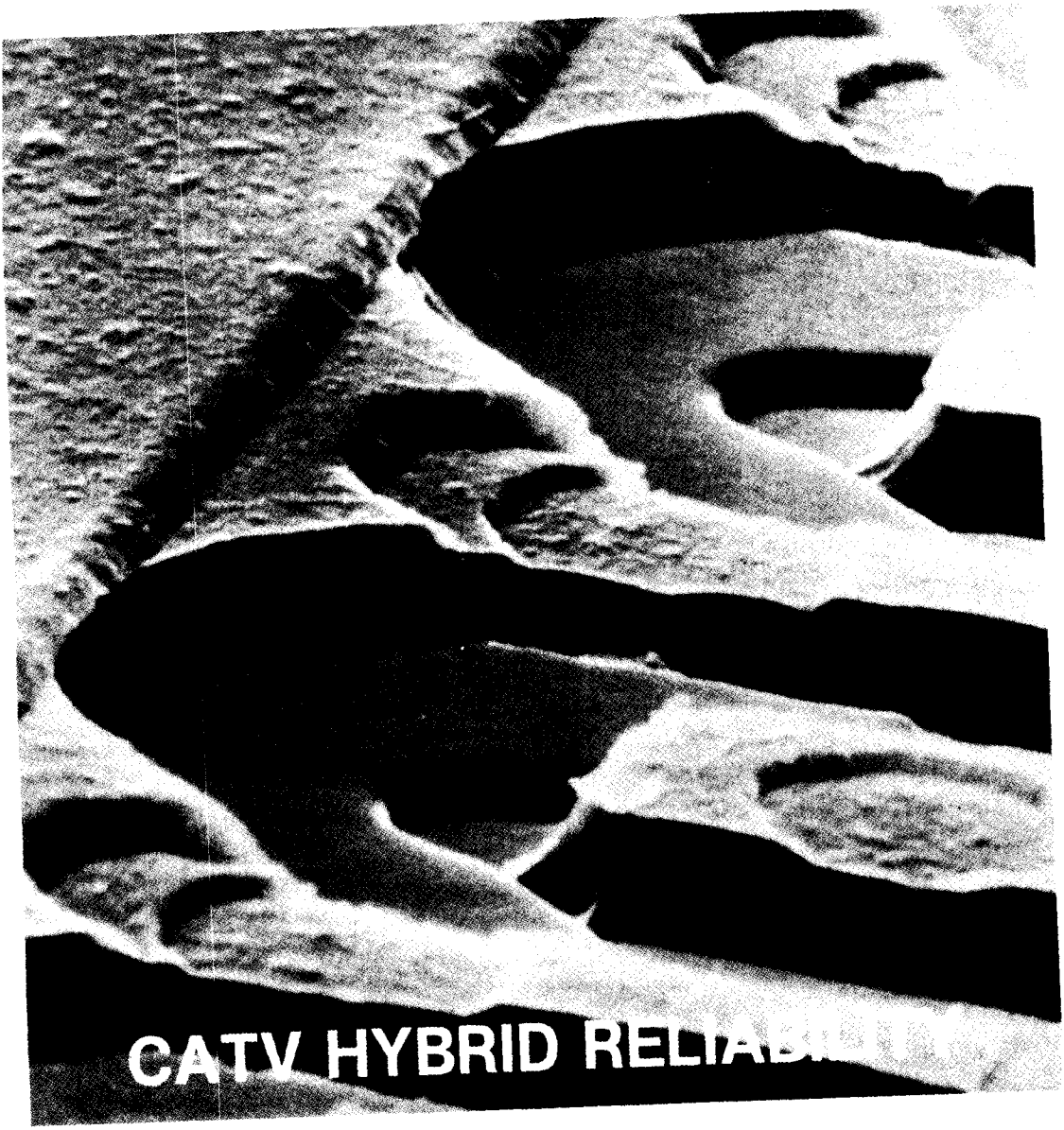
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CATV HYBRID

350,000 Units in the Field with Over 3,000,000,000 Hours

RELIABILITY

Performance is important, so is price. However, if the product is not reliable the equipment manufacturers and the system operator have a lot more to lose than dollars or performance. It costs several times the initial price of a hybrid to replace a failed unit in the field and the downtime is not appreciated by the subscribers. TRW RF Semiconductors understands more than price/performance tradeoffs. We understand reliability.

This brochure briefly outlines some of the reliability considerations in designing and building hybrid amplifiers and describes the ongoing programs that will assure a continuation of what is now the best semiconductor record in the industry.

Through five-years experience building hybrids and 20 years building transistors, TRW RF Semiconductors has built up an expertise that shows. When a problem does arise, we react, we learn and we continually improve the product.

HISTORY OF THE CATV MODULE

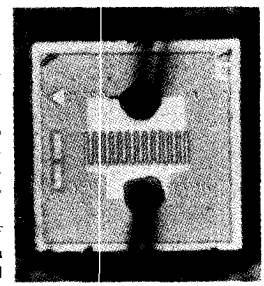
The history of the CATV module at TRW RF Semiconductors has been one of change. Our present products are a result of a well-controlled, evolutionary process. All process changes must be qualified and tested before they are put into production. The original product was a good one, but we are constantly searching for ways to improve the performance and reliability.

We changed to unglazed alumina substrates to improve metal adhesion and resistance to resistor cracking with overvoltage. This also lowered the die temperature (T_j) by 10°C. We instituted a solder reflow process that attaches all components in one step. With the implementation of this more controllable and more reliable system, the pins are soldered directly to the substrate eliminating the swage operation. The die heat spreaders are also reflow soldered instead of the old inductive heating technique. We changed from silver plated pins which were subject to oxidation, to gold-plated copper pins which are stiffer and easier to solder.

Other improvements have followed in quick succession. The aluminum heat sinks were nickel-plated to eliminate long term oxidation at the substrate interface. A copper metallization layer was inserted under the gold surface metal to improve component solderability. We also began securing all transformers to the substrate to better maintain tuned performance.

THE TRANSISTOR DIE

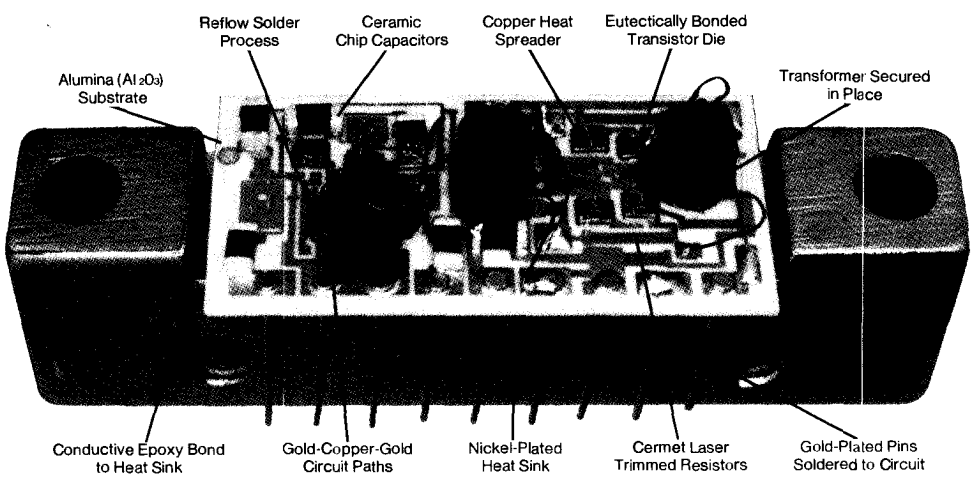
The transistor die is the heart of the hybrid amplifier. With four to eight devices per circuit, the transistor limits performance and is the most critical to proper circuit operation. However, when properly manufactured and surrounded by optimized circuitry, these devices have an MTF in excess of 100 years. Two well known failure mechanisms are metal migration and excessive power.



Transistor die with wire bonds on hybrid

METAL MIGRATION

This phenomenon is the predominant failure mechanism in transistors even when operating within "safe" areas. It is a function of time, temperature and current density.



At a given temperature, an equilibrium concentration of vacancies exist in all metal films. Self diffusion of metal ions throughout the film arise due to the metal ions being thermally activated into adjacent vacancies. In the absence of external forces, this ion diffusion is isotropic and results in no depletion or build-up of mass in any particular area. In the presence of an electric field, however, the metal ions experience a force due to their charge. This results in an ion flux toward the cathodic end of the film. The electric field will also cause electron scattering of the activated ions and impart momentum to them. This induces an ion flux toward the anodic end of the film. The momentum exchange force dominates the electrostatic force and results in a net mass transport toward the anodic end of the film, eventually resulting in open circuits. This void formation is accelerated by high-temperature and high-current densities.

Aluminum possesses certain properties which make it desirable for semiconductor applications such as cost and ease of evaporation. However, aluminum has exhibited a susceptibility to this phenomenon of electromigration above the current densities of 10^6 amps/cm^2. The current density in our present products is 6×10^4 amps/cm^2 which is more than an order of magnitude below this danger area.

EXCESSIVE POWER

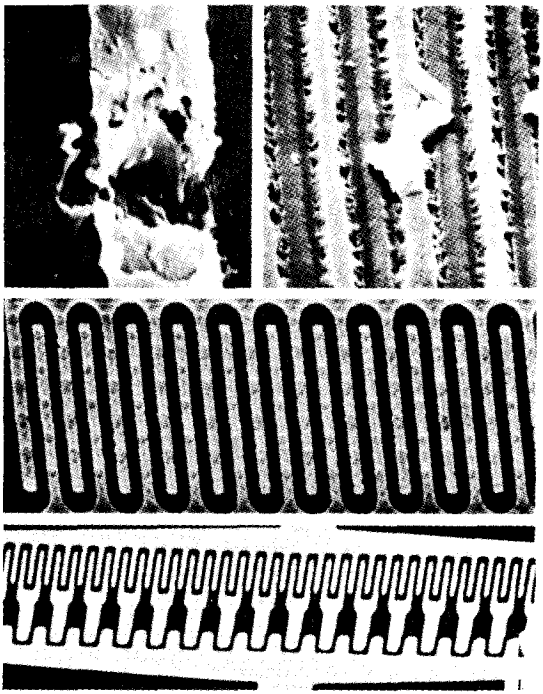
Power handling capability is the second mechanism and is in many cases not the primary cause. A circuit resistor failure, a power supply failure, improper heat sinking, or a severe transient can cause a transistor failure no matter how ruggedly a device is designed. Any semiconductor device will fail if enough power is supplied. A combination of heat and high-current densities cause thermal runaway. Too much power virtually destroys the device.

The industry standard for the maximum temperature a transistor device can be operated, with a reasonable lifetime, is 200°C at the semiconductor junction. On the TRW RF Semiconductor hybrid circuit the hottest transistor die will be less than 150°C at 90°C sink temperature, thus ensuring a large margin of safety.

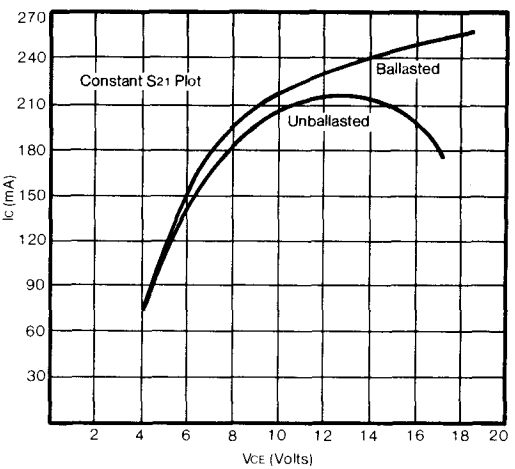
Aluminum metal systems currently used by CATV semiconductor manufacturers have performance limitations because of the nature of the aluminum process. Generally, the higher performance is pushed, the more reliability is sacrificed. To transcend this performance/reliability barrier, TRW RF Semiconductors is introducing a gold metallization technology. This proprietary process has been developed over the past three years. This technique plus diffused emitter ballasting resistors allows improved performance and reliability. The TRW RF Semiconductors gold metallization process achieves finer geometry as shown below. The designer now has the flexibility to use geometries impossible with aluminum devices.

GOLD METALLIZATION

Gold also has a minimum improved lifetime of ten times under severe testing conditions. The diffused emitter ballasting resistors thermally stabilize the device preventing hot spots. These resistors are current limiting; therefore, the device can handle much more power in a smaller area than a non-ballasted device. The graph below shows S_{21} plots on the I-V plane for a ballasted versus non-ballasted device demonstrating the superior power handling of the ballasted device. All this means better performance *and* reliability in CATV equipment.



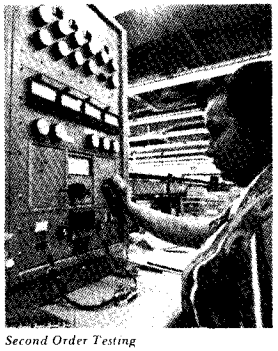
Top left: Circuit break due to migration. Top right: Metal migration. Middle: Aluminum device. Bottom: Gold device.



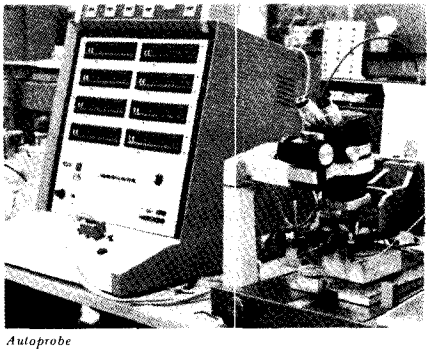


Gold Transistor Metallization Chamber





Second Order Testing



Autoprobe

DESIGN AND MANUFACTURING

The TRW RF Semiconductors hybrid is designed and manufactured with materials and techniques chosen because of their reliable history in the demanding CATV environment and many years of military/aerospace and commercial usage. All process improvements are thoroughly evaluated in pilot line production and qualification tested before they are released to production.

DESIGN

The design has steadily evolved from a thermal, mechanical and performance aspect. With the help of an infrared-scanning microscope, the thermal profile can be optimized to give best performance at conservative die temperatures. This ensures long transistor life. Mechanical improvements provide protection against thermal and mechanical shock as well as environmental elements such as moisture and corrosion. These changes were made while also improving performance.

COMPONENTS

The hybrid circuit is built on an alumina (Al_2O_3) *substrate*. This white, hard substance is ideally suited for the thin-film circuit process. It electrically isolates, is thermally conductive, and can be manufactured smooth enough to allow precision deposition of the resistors (chromium and silicon oxide) and circuit paths (gold and copper).

The heart of the hybrid is the *transistor die* which is manufactured for ruggedness as well as performance. The hybrid transistors are a product of nine years experience in supplying the CATV industry.

The *pins* are gold plated for solderability and corrosion resistance and the chip *capacitors* are an industry standard component. *Transformers* are of a proven design with years of field operation, and the *heat sink* is nickel-plated providing good conductivity and corrosion resistance.

THE MANUFACTURING PROCESS

Thin Film Fabrication

The hybrid amplifier starts in the sputtering chamber where cermet (for the resistors) and then gold (for the conductors) are kinetically deposited on the alumina substrate by bombarding a target of the desired material with an argon plasma. Each of four special sputtering chambers process 850 circuits at a time. After sputtering, the circuits undergo a series of photo-etch and plate-up operations. The resistors and circuit paths are outlined and selectively etched to form the desired conductor-resistor pattern. These circuit paths are then plated with a copper-gold sandwich to provide good solderability and corrosion resistance. The finished circuit is visually inspected and sent to laser trim.

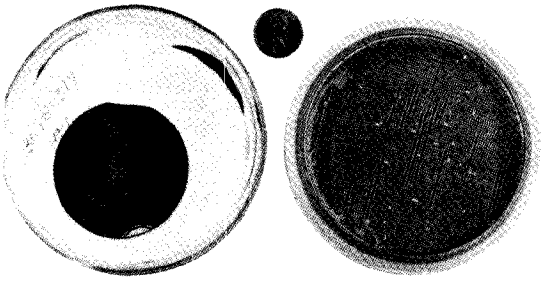
A computer-controlled laser trims the value of each resistor to better than one-percent tolerance. Each circuit, containing up to 27 resistors, can be trimmed in less than three seconds.

Transistor Fabrication

Using the latest diffusion and automatic handling equipment, the transistors take 30 process steps and several weeks to complete. After 100-percent testing for DC parameters and sample RF testing for distortion parameters, the transistors are eutectically bonded to heat spreaders. These spreaders reduce thermal impedance when mounted on the substrate and aid in efficient heat transfer to the heat sink.

Hybrid Assembly

Solder paste is silk-screened onto the thin film circuit only on the transistor and capacitor bonding pads. These components are mounted and held into place by the paste containing flux and

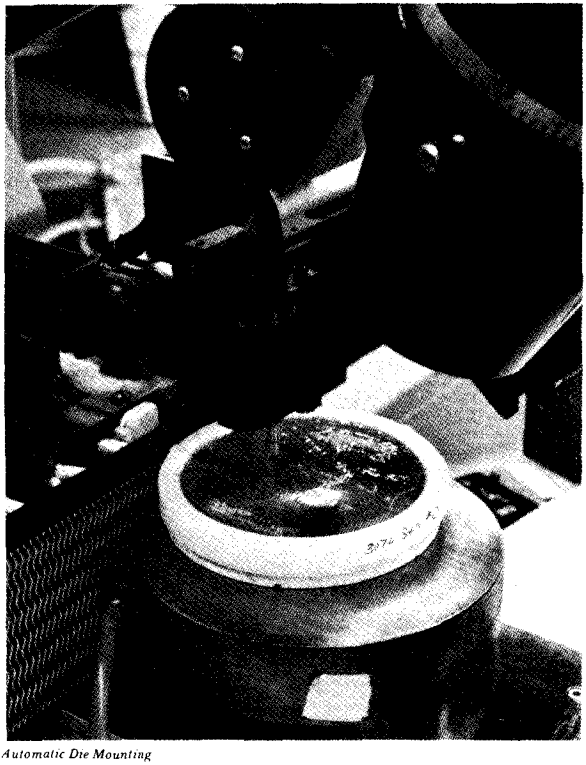


Transistor Wafer: 1) after autoprobe; 2) ready to mount

Laser Trimmer



Final Test



Automatic Die Mounting

solder particles in suspension. After the pins are dropped into place the circuit is ready for solder reflow.

The solder reflow process heats the substrate at a precise temperature and for a precise time. The solder particles melt and "reflow" attaching the transistors, capacitors and pins with uniform solder connections. Soldering the pins directly to the circuit paths eliminates up to 18 wire bonds.

After visual inspection the units are wire bonded. One-mil aluminum wires are ultrasonically attached to make the base and emitter connections to the circuit conductors. Other bonds are added for tuning purposes.

The heat sinks are individually numbered for traceability and are attached to the substrate with conductive epoxy. The epoxy is a thermal and electrical conductor between the heat sink and the gold ground plane on the back side of the circuit.

The transformers are secured to the circuit and the leads are soldered to the circuit conductors. The die is given a protective coating to prevent any possible micro particle contamination. The hybrid amplifier is now RF operable and ready to be tuned for response, flatness and match. Response is achieved by pulling combinations of wire bonds which changes the circuit inductance. Match is achieved by positioning the transformer leads. The units are capped, sealed with epoxy and marked.

TEMPERATURE CYCLING AND BURN-IN

A 100-percent temperature cycle and burn-in follow to ensure only the best products go to our customers. Temperature cycling tests the mechanical integrity of the circuit. All parts are cycled six times from +90°C to -10°C allowing 30 minutes soak at each temperature extreme. Power burn-in then follows temperature cycle. All units are mounted in burn-in fixtures and powered at 24V for eight hours at 115°C sink. The amplifiers are retested for changes during burn-in, packaged and then inspected by Quality Control before shipment.

TESTING

A large part of the hybrid construction process is testing which starts with incoming inspection and ends with final Quality Control sampling and inspection.

To assure performance and reliability, the transistor die are subjected to rigorous testing before being mounted on the circuit. The silicon wafer containing about 6000 individual transistors are autoprobed. The autoprobe performs eight DC tests on each transistor and marks out any not meeting the standards. A sample is taken from each wafer and mounted on headers for full DC and RF testing. If the sample passes, 20 hybrid amplifiers are built from this wafer and RF tested for all the distortion parameters (second order, x-modulation, triple beat and noise). If these units pass, the wafer is approved for production. Since each amplifier has its own number stamped on the heat sink, the transistors on each amplifier can be traced back to the original wafer. A sample from this wafer can be examined two years later, if necessary.

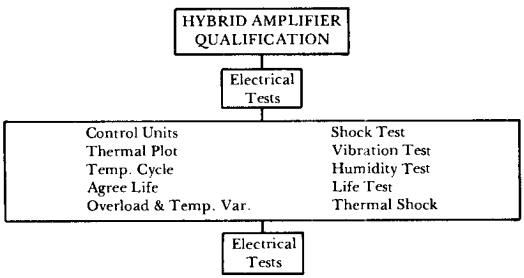
After the transistor die are mounted on the heat spreaders, each one is visually and electrically tested to assure that no damage was done during mounting.

Before the completed amplifiers are tuned for match and response, they are 100 percent tested for second-order distortion and DC current. This test shows whether the circuit is balanced and performing correctly. After temperature cycle and burn-in, this test is repeated on all units. Match and response are rechecked on a sample basis.

Finally the completed hybrid amplifiers are tested by Quality Control on a 0.65 AQL sample for match, response, gain, second-order distortion and DC current. The mechanical configuration is also checked on this sample.

NEW PRODUCT QUALIFICATION

All new designs and significant product variations must be subjected to, and successfully pass, a rigorous reliability qualification program before the device is approved for production. A testing diagram taken from our Reliability Test Plan is shown below. These tests are done according to MIL-STD-883.



PROCESS CONTROLS

HYBRID TRACEABILITY

AT TRW RF Semiconductors a history of all hybrid circuits is kept. This allows a check of all process steps. Traceability is maintained from circuit metallization to final testing and includes the particular die lot which was used for any specific circuit.

In addition to traceability, which is primarily a production and engineering aid, there are several Quality Control steps which help to ensure all products are manufactured in a well-controlled production line.

DIE MOUNT QUALIFICATION

CATV transistors are mounted on heat spreaders with a high-speed automatic machine. To ensure the quality of this high-speed operation, regular quality control checks are made on the quality and strength of the bonds.

REFLOW QUALIFICATION

A daily QC check is made of the solder reflow process which solders the individual components to the circuit. Both a visual inspection and shear-strength test are made to test the process.

LASER QUALIFICATION

All resistors in CATV hybrids are adjusted to value by a YAG-laser resistor trimming system. This system is checked regularly by Quality Control to ensure that the product being generated is within the required specifications. In addition, a continuous production monitor assures proper laser performance.

WIRE-BOND QUALIFICATION

Wire bonding is a process which must be carefully controlled because of the many parameters which affect the quality of the bonds. The Quality Control group at TRW RF Semiconductors performs two separate bonding checks on a periodic basis. The first check is a bondability test to ensure that the metal itself is bondable. This is performed on each lot of material. The second test checks the bonding machines for proper operation. This test is performed every two hours and accomplished by measuring the force necessary to separate a bond from the circuit.

QA AUDITING SYSTEM

There are many Quality Control check points throughout the CATV hybrid process. To ensure complete tests and inspections, the Quality Assurance Department performs a periodic audit of each inspection point and issues a report on that audit.

ENVIRONMENTAL AND RELIABILITY TEST CAPABILITIES

The 100 percent temperature cycling and full-power burn-in is a normal part of the production process. The other tests outlined below are used for qualification of new products or processes.

TEMPERATURE CYCLE

CATV hybrids are temperature cycled from +90°C to -10°C for six one-hour cycles.

POWER BURN-IN

CATV hybrids are burned-in at 115°C case for eight hours under normal DC operating conditions.

POWER CYCLING

The power cycling test is one which attempts to duplicate, as closely as possible, the actual operating conditions under which a module should operate. The test fixture consists of a mounting board which can be heated or cooled. One method of operation would be to apply power (DC and RF) to a unit then apply heat for a given time. The power and heat may then be switched off and the part quickly cooled to begin another cycle.

LIQUID-TO-LIQUID THERMAL SHOCK

This test determines the resistance of a circuit to sudden extreme temperature changes. The test is conducted by immersing the unit in a low temperature liquid, then transferring it to a high-temperature liquid. The transfer is kept as short as possible. The immersion time may be any length but is usually 15 minutes.

HUMIDITY TESTS

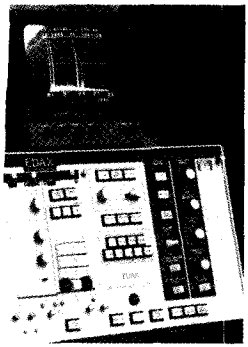
This test is intended to determine the resistance of a unit to a humid environment, and may be conducted with or without power applied. A typical test would subject the unit to a temperature cycle of 25°C to 65°C while exposed to a humidity of 95 percent.

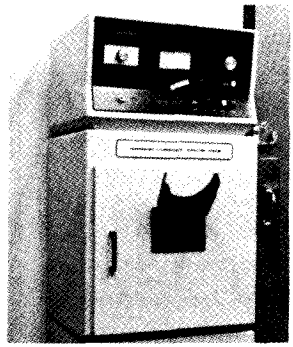
MECHANICAL SHOCK

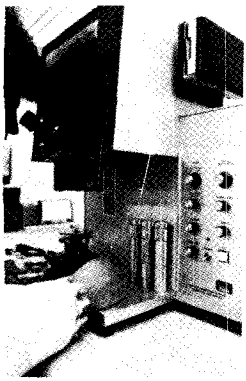
The purpose of this test is to determine the resistance of a unit to severe shock. Our environmental laboratory has the capability of exposing units to a 10,000G shock for a duration of 0.2 micro-seconds.

Burn-In Racks

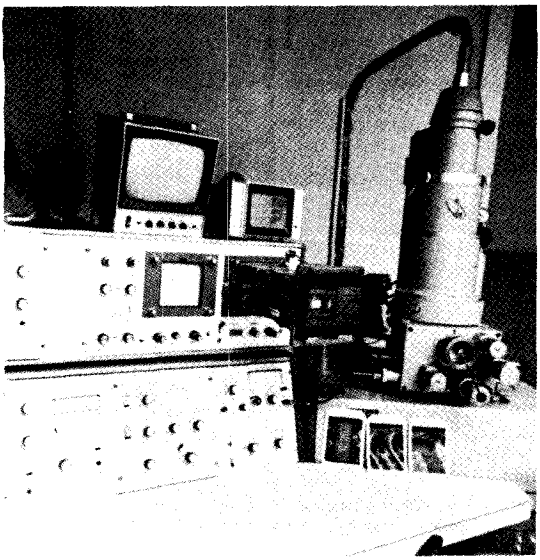












Top left: X-ray Dispersion Analyzer
Top right: X-ray System
Middle left: Infrared Scanning Microscope
Middle right: Scan of Hybrid Push-Pull Section
Directly above: Scanning Electron Microscope
Right: SEM Photograph of Transistor



VARIABLE FREQUENCY VIBRATION

This is a destructive test which is performed for the purpose of determining the effect on component parts of vibration in the specified frequency range. TRW RF Semiconductors has the facilities for performing this test in the 20 to 20,000Hz frequency range.

X-RAY

The QA laboratory has the capability of taking and developing X-ray exposures of hybrid circuits and discrete transistors. This is a very valuable tool for detecting voids in solder or eutectic bonds.

INFRARED MICROSCOPY

The ability to examine a circuit thermally under operating conditions is absolutely necessary when designing a new product or testing a new process. We utilize an infrared microscanner for evaluation of new products from the standpoint of thermal resistance and operating temperature. Resolution of 0.0005 inch can be achieved.

SCANNING ELECTRON MICROSCOPY

The SEM, which is part of the QA Reliability Physics Laboratory, is used in all facets of product analysis at TRW RF Semiconductors. This instrument allows us to closely examine hybrid microcircuits and transistors not possible with optical techniques.

DISPERSIVE X-RAY ANALYSIS

This capability, which is a feature of the SEM, allows us to make a microprobe to determine the chemical composition of a sample. This is accomplished by detection of secondary emission X-rays which possess characteristic energies. The relative quantity and location of elements may then be displayed on the CRT.

TRANSISTOR LIFE TESTING

Each new transistor considered for use in a hybrid amplifier undergoes a series of extensive reliability life tests. The new gold devices are now being subjected to the following tests:

1. Operating Life Test: 20 volts, 150mA, with T_j = 200°C for 1000 HRS.
2. High-Temperature Reverse Bias: V_{CB} = 26 volts, T_A = 100°C for 1000 HRS.
3. High-Temperature Storage: 400°C for 1000 HRS.
4. Humidity Test: 90% relative humidity over temperature excursion at 25°C to 65°C for 1000 HRS.

HYBRID LIFE TESTING

Hybrid life testing plays an important role in hybrid development. These tests, continually run under worst case conditions (95°C ambient), provide valuable data which can be used to identify potential problem areas. All units are inspected and tested after 24, 100, 250, 500, 1000 and then every 1000 hours. Typically, there are always 100 to 300 units of each type under test. Failures are carefully analyzed to determine corrective action needed in the components, process, quality control or design. This program has allowed us to supply a product that has an excellent record in the field.

Since we shipped our first hybrid in 1970, over 350,000 TRW RF Semiconductor hybrids have been put into the field and have accumulated over 3-billion operating hours.* While accurate figures on field failures are difficult to obtain, based on customer inputs we estimate the failure rate to be less than 1% per year.

WARRANTY

Details of the warranty policy are contained in a separate warranty document.

**Based on (1) 4-month delay from time we ship until units are put in field and (2) 720 hours per month.*

RELIABILITY CONSIDERATIONS IN DESIGN AND USE OF RF INTEGRATED CIRCUITS

By
JAMES HUMPHREY
and
GEORGE LUETTGENAU
TRW Semiconductors
February 5, 1976

ABSTRACT

Reliability is a major factor in the profitability of CATV Systems.

In spite of its proportionally low cost, the RF integrated circuit figures prominently in the overall reliability picture. This complex and important function is located at strategic points in the system.

Fortunately, modern design and manufacturing technology, which draws extensively from resources generated by military and space activities, assures a degree of reliability which is compatible with the most stringent requirements.

Transistor chips are the most vital elements of the RF integrated circuit. Low noise and distortion require state-of-the-art transistor structures. Gold metallization, thermal equilibrium by means of diffused balancing resistors, as well as automated process control have resulted in transistor lifetimes of over 100 years.

One of the inherent reliability advantages of IC's is the reduced number of interconnects. The full benefit of this characteristic is achieved through the use of gold conduction paths in conjunction with gold wire bonding. Perhaps the single most dangerous enemy of high reliability is excessive heat. Careful, computer-aided circuit design coupled with thermally sound, stress-free mechanical construction guarantee structural integrity and safe operating temperatures under all practical conditions. Infrared scanning helps verify the achievement of design goals.

Abuse or abnormal stresses may counteract the best of reliability. In order to avoid problems, the user must control the electrical, thermal, and mechanical environment surrounding the RF IC. Much progress in this respect has been made by the equipment industry.

INTRODUCTION

Reliability considerations are becoming increasingly important in the operation of CATV Systems, requiring an absorption of military and aerospace reliability technology into the CATV business. Market surveys show a large number of MSO's and consultants consider reliability as a major item in equipment selection.

A definition of major reliability terms is important along with an introduction to microcircuit reliability tools (both hardware and software).

An overview discussion of Physics of Construction involved with the die and interconnects must be presented.

DEFINITIONS

R = Reliability

Reliability is related to the probability that an item will perform a defined task satisfactorily for a specified length of time, when used for the purpose intended, and under conditions for which it was designed to operate.

Failure

Failure is a detected cessation of ability to perform a specified function within previously established limits in the area of interest.

(a) Dead on arrival
(b) Infant mortalities
(c) Lifetime failure rates (random)
(d) End of life (wearout)

MTBF (Mean Time Between Failures)

The total measured operating time of a population of equipment, divided by the total number of failures within the population during the measured period of time.

Average Life

The mean value for a normal distribution of lives, and generally, it applies to failures resulting from wearout.

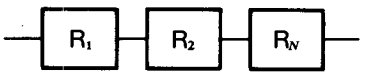
BASIC RELIABILITY EQUATION

$$R = e^{-t/m} = e^{-\lambda t}$$

Where: R = Reliability or probability of success
t = Mission time in hours
m = MTBF in hours = $\frac{\text{hours}}{\text{failures}}$
λ = Failure rate = $\frac{1}{\text{MTBF}} = \frac{\text{failures}}{\text{hours}}$

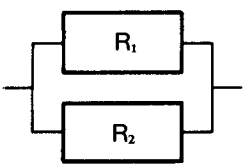
SYSTEM RELIABILITY

1. When components are in series, failure of any one of the components will result in failure of the system.



Then: $R_{SYSTEM} = R_1 \times R_2 \times R_3 \times \text{---} R_N$
$\lambda_{SYSTEM} = \lambda_1 + \lambda_2 + \lambda_3 + \text{---} \lambda_N$

2. When the same components are in parallel (redundancy) neglecting, for simplicity, the decision-making device, the switchover function and the fail safe requirements:



$$R_{SYSTEM} = R_1 + R_2 - (R_1 R_2)$$

RELIABILITY CURVE

The following curve represents the typical condition of operational reliability.

RELIABILITY PREDICTION ALGORITHM

The military has put considerable money and time into the study of reliability. One very useful military document is Military Handbook 217B, *Reliability Prediction of Electronic Equipment*. This handbook shows how to develop failure rate predictions by the use of mathematical models based on years of data collection by military agencies. A discussion of the interaction of components in the model is very useful in gaining an understanding of the overall subject.

PART FAILURE RATE MODEL λ_p

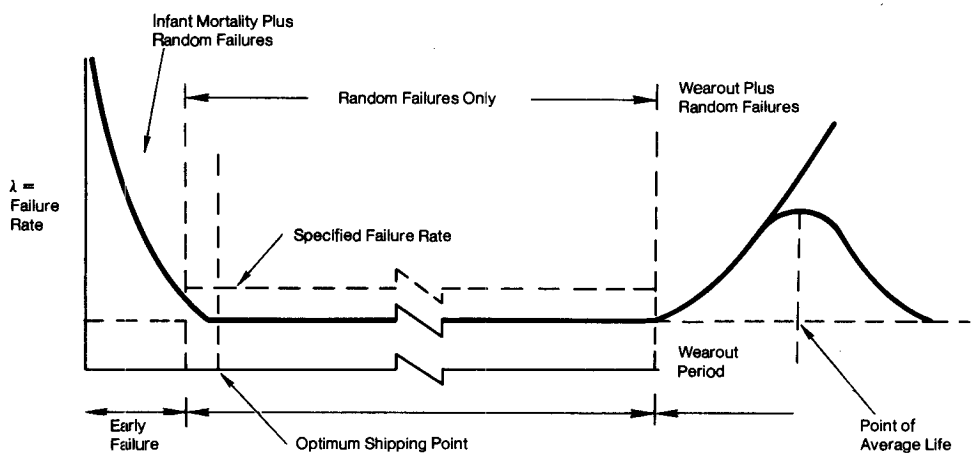
$$\lambda_p = \lambda_b (\pi_T \times \pi_E \times \pi_Q \times \pi_F \times \pi_M)$$

Where: λ_p = Part failures in failures per 10^6 hrs.
λ_b = Base failure rate
π_T = Temperature adjustment factor
π_E = Environmental adjustment factor
π_Q = Adjustment factor based on quality
π_F = Adjustment factor for circuit function
= 0.8 for digital hybrids
= 1.0 for linear hybrids
= 1.1 for combination hybrids
π_M = Adjustment factor for maturity of product

BASE FAILURE RATE MODEL λ_b

$\lambda_b = \lambda_S + A_c\lambda_c + \Sigma\lambda_{RT}N_{RT}$ (Substrate contribution)
$+ \Sigma\lambda_{DC}N_{DC}$ (Attached components contributions)
$+ \lambda_{PF}\pi_{PF}$ (Package contributions)

Where: λ_b = Base failure rate in failures/10^6 hr.
λ_S = Failure rate due to the substrate and film processing
$A_c\lambda_c$ = Failure rate contributions due to network complexity and substrate area which includes:
(a) Number of lead terminations
(b) Number of film resistors
(c) Number of discrete chip devices
(d) Type of film (thin versus thick)



$\Sigma\lambda_{RT}N_{RT}$ = The sum of the failure rates for each resistor as a function of the required resistance tolerance

$\Sigma\lambda_{DC}N_{DC}$ = The sum of the attached device failure rates for semiconductors and capacitors

$\lambda_{PF}\pi_{PF}$ = The hybrid package failure adjusted to include material and style

PHYSICS OF CONSTRUCTION

Following the enumeration and identification of symbols used in reliability algorithms, a discussion of the major microelectronic components with respect to their reliability contributions is in order:

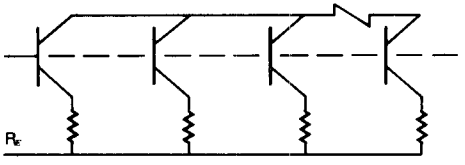
TRANSISTORS

The transistor die is the heart of the hybrid amplifier. With four to eight devices per circuit, the transistor determines performance and is most critical to proper circuit operation.

During the last few years users have witnessed major advances in the performance of linear broadband transistors. Often, efforts to improve one characteristic have adverse effects on other desirable features. For instance, distortion may be bettered by thinning the epitaxial collector region. This, however, leads to sensitivity to voltage transients and other abnormal operating conditions. Therefore, devices with outstanding performance in one area are prone to weakness in others. Computer-aided device design coupled with volume production and tight process controls have resulted in transistors in which all essential features are in proper balance.

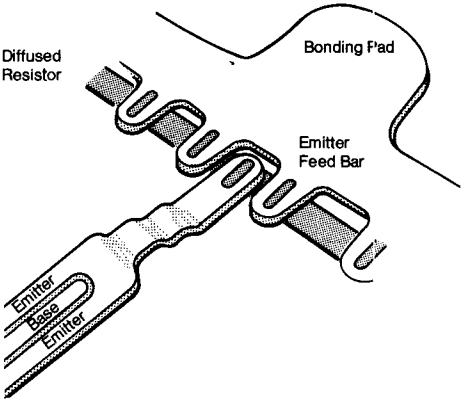
High f_T is generally recognized as an important factor in achieving wide bandwidth and uniform distortion characteristics. Gigahertz transistors, which are now being used, have very delicate patterns, involving micron and submicron tolerances. They also occupy sizable areas on the silicon wafer, since watt-sized powers have to be handled. It is only realistic to expect that all parts of the overall transistor structure are not perfectly alike, but rather resemble the parallel configuration of many, slightly differing, small devices, as shown in the figure.

Ballast Resistors

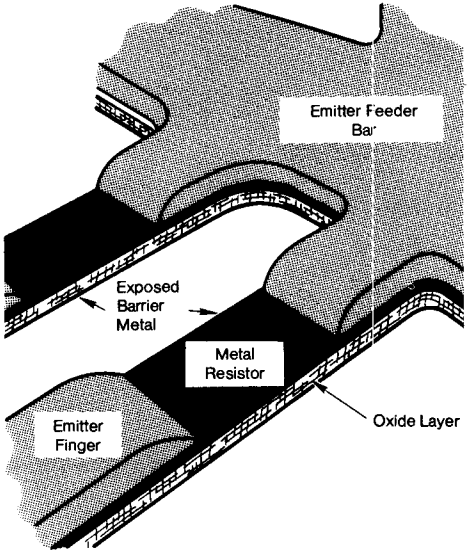


It is also apparent that the entire transistor geometry cannot be tightly thermally coupled within itself, therefore giving rise to the possibility of small sub-areas of the transistor assuming different values of temperature than others. This possible problem can be effectively combatted by adding emitter balancing resistors to the device. Ideally each emitter-site or finger should have its own resistor. This goal is easily realized in interdigitated structures. Film or diffused monolithic resistors may be used. From a process and reliability point of view, diffused resistors are preferred because they avoid the silicon-oxide barrier which has a very high thermal resistance.

Diffused Ballasting System (Only one emitter contact shown)



Metal Film Ballast Resistor



METAL MIGRATION

Some time ago a serious failure mechanism, associated with GHz transistors, was discovered. The metallization stripes of such devices, as mentioned earlier, are only a few microns wide. The metal thickness is, because of

fabrication limitations, of similar dimensions. Consequently, the current density in these stripes is quite high, often reading hundreds of thousands of amperes per cm^2 of cross-section. Under these circumstances, metal migration may occur. With such large numbers of electrons flowing in such crowded space, the probability of collisions with thermally activated metal ions is great. The ions are propelled in the direction of electron current flow causing, in the long run, the metal to move, forming hillocks, whiskers and voids. The lifetime of a transistor is a function of three things: the current density, the temperature, and the type and consistency of metallization.

Not much leeway exists in reducing the current density (unless f_T is sacrificed). Changing from aluminum to gold extends the life at least by an order of magnitude. At high temperatures the difference is even more pronounced. At 150°C, the time to metal failure for gold metallization microwave transistors is in excess of 10^6 hours = 114 years. While this number is quite comforting, one is not at liberty to treat the subject of transistor chip heatsinking too lightly. A proven method for removing heat while at the same time obtaining a solid mechanical mount, has been to employ a heatspreader between the silicon chip and the IC substrate. Automatic mounting stations are used to eutectic collet mount the chip to indexed leadframes. Tight control of pressure and scrub sequence result in defect free attachment. Although one may employ other methods of heatsinking, e.g. beryllium oxide substrates for part of the circuit, the added mechanical complexity and the reduced freedom of optimal circuit layout presently outweight the minor advantages resulting from a reduction in transistor temperature.

INTERCONNECTS

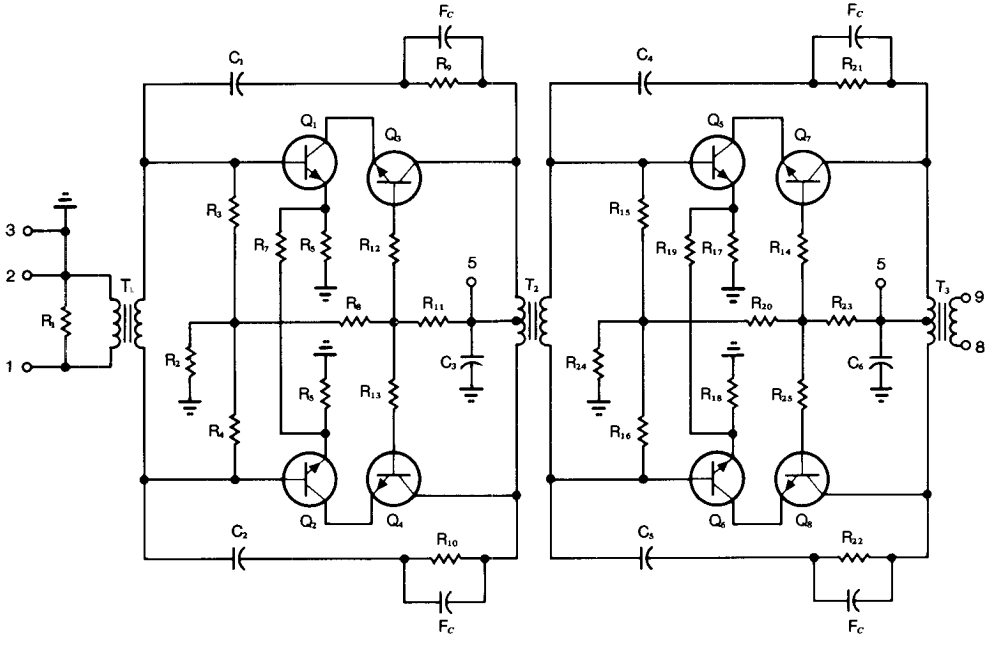
One of the most important parts of hybrid circuits is the interconnect system. The ability to reduce the number, control the quality, and test them by screening complete functions, is one of the major advantages of hybrid circuits over more conventional approaches. Constant improvement in the mechanical and metallurgical systems have drastically improved reliability.

An analysis of the schematic on the standard 33dB Hybrid Amplifier will illustrate the point:

Comparing hybrid versus discrete techniques, one can show the following:

1. For each transistor used, a minimum of three interconnects corresponding to the solder joints at the PC board are eliminated.
2. For each capacitor used, a minimum of two interconnects are eliminated.
3. For each film resistor used, a minimum of four interconnects are eliminated corresponding to the connection to the resistor body and the connection to the PC board.
4. Transformer interconnects will be the same for hybrid or discrete.

33dB Gain Block



The increase in interconnects in building 33dB of gain in discrete form over the same circuit in hybrid form is:

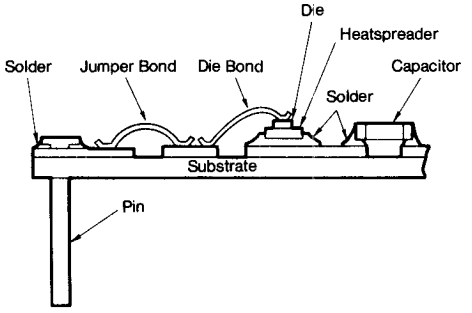
Add due to transistors	=	24
Add due to chip capacitors	=	12
Add due to resistors	=	100
Add due to transformers	=	0
Less due to hybrid jumpers	=	-4
Less due to active pins	=	-5
		127 Additional interconnects per 33dB function

MIL Handbook 217B also discusses the reduction in reliability of printed circuit boards as a direct multiple of the holes required. Eighty-one additional holes are involved in making one discrete amplifier.

Having the interconnects made early in the manufacturing sequence, before the subsequent series of tests and inspections, has beneficial influence on end equipment reliability.

The complete functional system including interconnects is tested, screened and Q.C. sampled many times before it even meets up with the PC board in the manufacturers subsystem.

Interconnects



COMPONENT MOUNT

The transistor heatspreaders, chip capacitors and pin connections are soldered to the metallization pattern on the substrate surface. This process is completed in a tightly controlled solder reflow furnace.

Due to the fact that the units are processed in an inert atmosphere and thoroughly cleaned and inspected early in the production process, workmanship problems are greatly reduced.

BONDS

Wire bonding was a major reliability issue for years.

Aluminum has been one of the most widely used bonding systems in the hybrid industry for many years. The main reason for this is that ultrasonic aluminum systems bond at room temperature and, hence, do not interfere with other hybrid assembly processes.

Gold thermal compression ball bonding has been a reliable standard process in the semiconductor industry for years. However, the requirement for 300°C bonding temperatures have kept this technique out of most hybrids. The recent changeover to all gold hybrids prompted the development of a compatible low temperature gold wire bonding system which by far out-performs aluminum.

Advantages of Aluminum Bonds

Low temperature process
Compatible with Al die metal
Low cost
High speed
Easy to loop (stiff)

Disadvantages of Aluminum Bonds

Degrades with time/temperature
Kirkendall voiding
Intermetallic formation with gold
Brittle and subject to cracks
Difficult to screen
Difficult to control

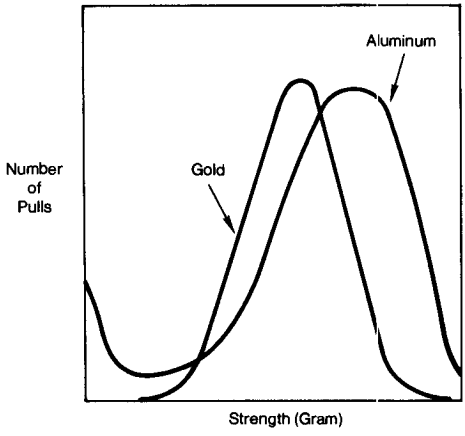
Advantages of Gold Bonding

Compatible with gold die and substrate
Strength stable with time/temperature
Malleable — not subject to cracking
Easier to control process

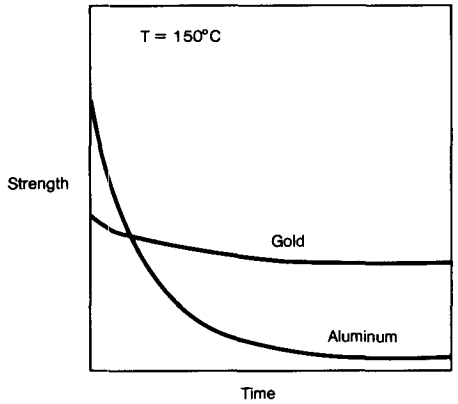
Disadvantages of Gold Bonding

More expensive
More deformation at bond foot
Hard to form loops

Histogram of Gold Versus Aluminum Bond Strengths



Strength Versus Time on Gold Versus Aluminum Wire



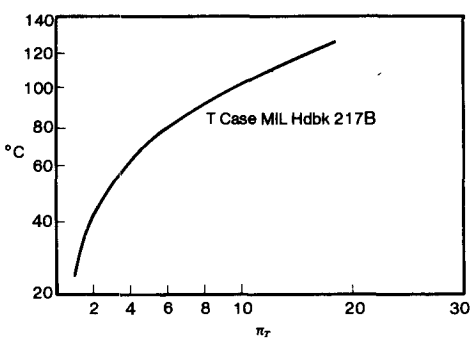
RELIABILITY ADJUSTMENT FACTORS

Following is a discussion of the "π adjustment factors" in MIL Handbook 217B. These relate to the external influences on hybrid circuit reliability.

TEMPERATURE ADJUSTMENT FACTOR π_T

Operating temperature is one of the most important factors in reliability. As can be seen by the curve shown, great reliability improvements can be obtained by lowering the case temperature.

Failure Rate Multiplier Due to Temperature



This curve shows that a hybrid circuit, operating at a case temperature of 100°C, has four times the failure rate as the same circuit run at 50°C.

ENVIRONMENTAL ADJUSTMENT FACTOR π_E

This adjustment factor is based on the service environmental conditions that the part will be exposed to during operation.

π_E, Environmental Factor Based on Environmental Service Conditions

Environment	Symbol	π_E
Ground, Benign	G_B	0.2
Space Flight	S_F	0.2
Ground Fixed	G_F	1.0
Airborne, Inhabited	A_I	4.0
Naval, Sheltered	N_S	4.0
Ground, Mobile	G_M	4.0
Naval, Unsheltered	N_U	5.0
Airborne, Uninhabited	A_U	6.0
Missile, Launch	M_L	10.0

The question is where does CATV fit into this table. Mechanical and thermal casting designs are extremely important in protecting the RF IC from the external environment conditions. Still, wide variations in system placement introduce a swing factor for environmental effects, which will cause π_E for CATV to fall between 1.0 and 5.0.

The user must strive to keep the components as close to laboratory zero as possible.

MATURITY ADJUSTMENT FACTOR π_M

The failure rate predicted by this mechanical model can be expected to increase by a factor of (π_M = 10) under any one of the following conditions:

(a) New device in initial production.
(b) Where major changes in design or processes have occurred.
(c) Where there has been an extended interruption in production or a change in line personnel (radical expansion).

The factor of 10 can be expected to apply until conditions and controls have stabilized. This period can extend for as much as 6 months of continuous production.

This maturity factor is extremely important. The industry has used over 400,000 CATV modules since the first module was shipped in 1970. Since that time we have constantly improved and refined the IC. Optimum reliability is an evolutionary process depending on time, volume, defect analysis and feedback to fine tune the product and eliminate defects.

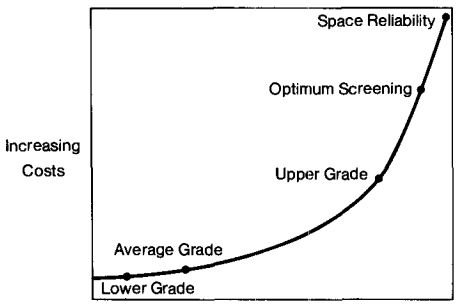
QUALITY ADJUSTMENT FACTOR π_Q

This is the adjustment factor based on the quality grade of the product. This factor modifies the reliability levels by the different quality levels specified in MIL STD 883, *Test Methods and Procedures for Microelectronics.* These levels take into account different screening levels, qualification levels and quality conformance inspection requirements for the specified class.

	π_Q
MIL STD 883 Class A	0.5
MIL STD 883 Class B	1.0
Vendor Equivalent Class B	5.0
MIL STD 883 Class C	30.0
Commercial with Screening	50.0
Commercial (No Screening)	75.0

A study of the MIL STD 883 Quality Requirements allow a very important discussion of cost versus reliability. As could be expected the test, manpower, equipment, time and paperwork go up rapidly as the MIL STD Grade is increased. A relative plot of this relationship is shown below:

Cost Versus Reliability



Many of the MIL Standard Military requirements seem unimportant in influencing CATV reliability. However, the cost versus reliability curve is real and the equipment supplier can make choices as to the type of reliability he is willing to pay for.

EQUIPMENT

It takes a massive capital investment in order to meet the manufacturing requirements for the CATV industry. The volume, quality and performance standards required have caused us to constantly reinvest for the future. Many of the invested dollars are for equipments for which the return on investment is subjective.

SCANNING ELECTRON MICROSCOPE

This instrument allows very high magnification of surface conditions not available with optical methods. Magnifications up to 100,000 times are possible with the SEM.

DISPERSIVE X-RAY ANALYSIS

This capability, which is a feature of the SEM, allows us to make a microprobe to determine the chemical composition of a sample. This is accomplished by detection of secondary emission x-rays which possess characteristic energies. The relative quantity and location of elements may then be displayed on the CRT.

VARIABLE FREQUENCY VIBRATION

This is a destructive test which is performed for the purpose of determining the effect on component parts of vibration in the specified frequency range.

X-RAY

This is a very valuable tool for detecting voids in solder or eutectic bonds.

INFRARED MICROSCOPY

The ability to examine a circuit thermally under operating conditions is absolutely necessary when designing a new product or testing a new process. The infrared microscanner is used for evaluation of new products from the standpoint of thermal resistance and operating temperature. Resolution of 0.0005 inch can be achieved.

CONCLUSIONS

- Many reliability tools are available today both in equipments for evaluation of reliability and in analytical tools such as MIL Handbook 217B for predictions of reliability.
- Hybrid circuits offer massive reliability leverage due to:
  (a) Reduction of Interconnects
  (b) Ability to control quality by screening
  (c) Large volume of complex standard functions are easier to control
- Case temperature is very important for reliability
- A monometallic system, i.e., gold die metallization and gold wire bonding are optimum for reliability.
- Reliability can be improved by adding quality cost to the module process. This increased cost may easily be returned due to the lower failure rate.

ACKNOWLEDGEMENTS

The authors wish to thank Al Bird, TRW Systems Group, Redondo Beach, California, for his technical guidance.

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MOUNTING OF STUDDED RF POWER TRANSISTORS

I) Preparing of heat-sink

The majority of thermal energy generated in the chip is dissipated downward to the heat sink through the package in a circular cone et 45° from the bottom of the chip (See drawing).

Since efficiency, power gain and life expetency is inversly proportional to the chip temperature, care must be taken in getting the most heat transferred from the package to the heat-sink.

A) The hole in the heat-sink for the transistor stud must not be larger than absolutely necessary, i.e. : Nr 8-32 UNC-2 A stud, Nr. 10-32 UNC-2 A studs, etc.

B) Do not chamfer hole, but remove any burr left by drill with a file — to keep as much of the heat sink as possible in direct contact with the header flange.

C) Keep the heat-sink which is in direct contact with the header flange as flat as possible and clean of any foreign material.

II) Mounting the transistor.

The transistor leads are not made to give mechanical support nor should they be used in holding the transistor when screwing the nut down :

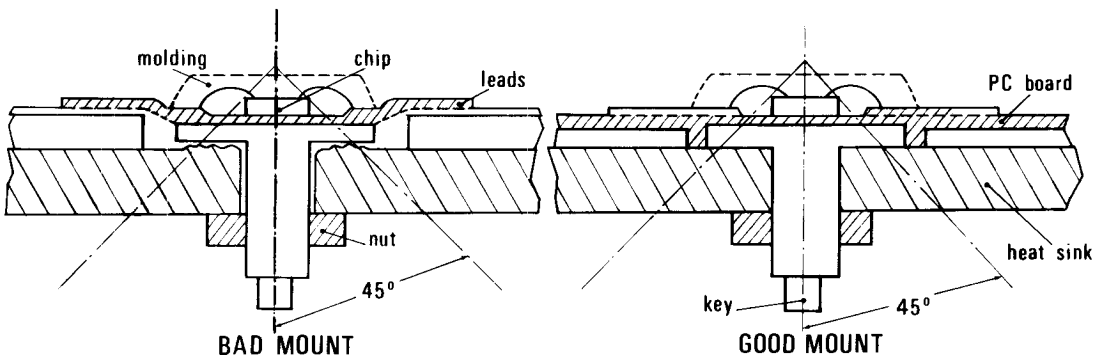
A) Make sure the distance from the flange of the header to the bottom of the electrical leads is observed (See drawing).

B) Coat the heat-sink surface with a small amount of thermal contact grease.

C) Put transistor in place making sure emitter, base and collector are aligned property.

D) Lock the nut into place with 10 in.pound (± 10 %) (9 kg.cm) torque by holding transistor in place with fingers or by gripping the key provided on the studd of the transistor with a tool.

E) The solder leads into place.



MOUNTING OF FLANGE RF POWER TRANSISTORS

I. Preparation of heat sink

To ensure maximum heat transfer from the transistor to the heat sink it is imperative that the heat sink be made as flat as possible. Ideally one should target for a flatness of the mounting surface to 0.02 mm by careful machining.

It is also important to ensure that the fixing holes do not have any burrs around them, which may prevent the transistor from sitting firmly on the heat sink.

II. **Mounting proceedure**

A) Prior to mounting, the transistor flange should be lapped to 0.01 mm flatness using a 400 grit carborundum paper on a flat surface, and then cleaned of any small particles.

B) Apply the absolute minimum of thermal grease to the flange base of the transistor and then rub lightly on a flat surface to remove any excess. TOO MUCH THERMAL GREASE IS WORSE THAN USING NONE.

C) Bolt the transistor in place using the appropriate screws plan washers and lock washers.

If at any time it is found necessary to remove the transistor and then replace it once more in the circuit, the device should be lapped again before mounting. This will be necessary since the flange will almost certainly have been distorted by mounting and removal.

MOUNTING OF RF POWER MODULES - (MOBILE MX/MV)

A similar proceedure to that for the mounting of lange transistors should be adhered to. However the degree of flatness to be acheived is as follows.

a) Heat sink - 0.1 mm.

b) Module - This is already delivered to a flatness guaranteed to be better than 0.15 mm.

Again, the absolute minimum of heat sink compound should be used.

A study of the advantages of GOLD METALLIZATION in the manufacture of microwave transistors

M. FLAHIE - M. WEISS

ABSTRACT

The development of a high reliability metallization system for R.F. power transistors has been TRW Semiconductor's continuing primary R&D and Manufacturing priority.

This priority, of course, is a necessary part of TRWS' goal to sustain its leadership in R.F. power transistors by continually advancing the state-of-the-art in power and frequency.

This report summarizes the reasons for TRWS' commitment to a GOLD metallization system for the manufacture of high power microwave transistors.

The conclusions are that the GOLD metallization system is superior to ALUMINIUM systems in the following respects :

* Electromigration resistance
* Temperature stability
* Corrosion resistance
* Mechanical strength
* Oxide step coverage
* Manufacturability

SECTION 1 - ELECTROMIGRATION

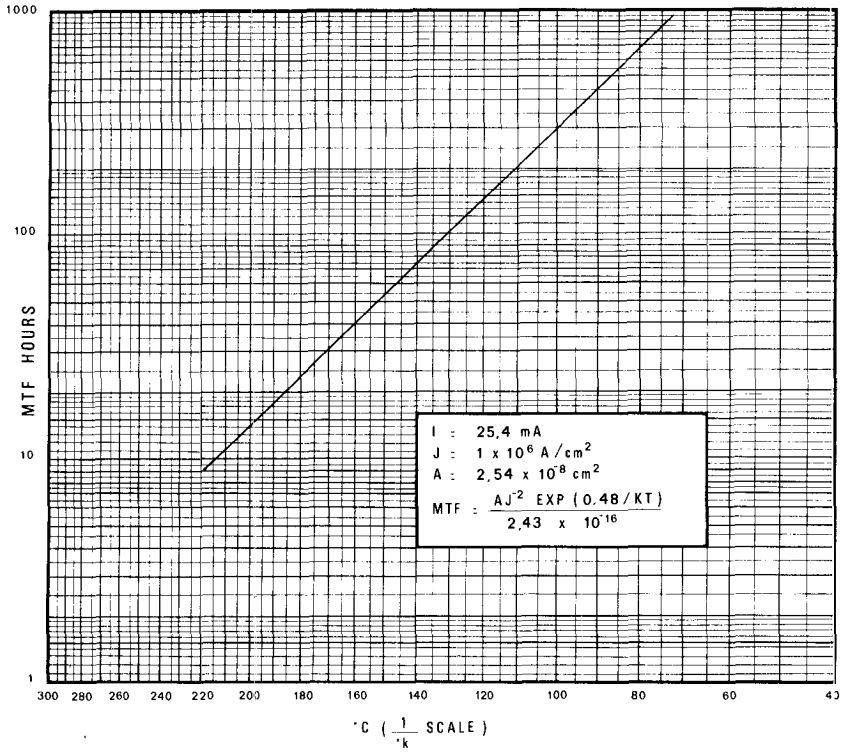
The phenomena of electromigration occurs as follows (1). For any given temperature, a certain equilibrium concentration of vacancies exists in all metal films. Self diffusion of metal ions throughout the film will arise due to the metal ions being thermally activated from their normal lattice sites into adjacent vacancies. In the absence of any external forces, the metal ion diffusion will be isotropic and will result in no net accumulation or depletion of mass in any given site. Upon the application of an electric field, however, the thermally activated metal ions will experience a force due to their charge and the electric field inducting an ion flux toward the cathodic end of the film. In addition, the conduction flow of electrons in the metal due to the electric field will cause electron scattering off the activated ions and impart momentum to them inducing an ion flux toward the anodic end of the film. In good conductors, the momentum exchange force dominates the electrostatic force. This results in a net mass transport toward the anodic end of the film.

In the case of device interconnections, the ne tflux of mass due to momentum transfer causes void formation at the negative terminals. This void formation causes eventual contact opens resulting in destruction of the device. Void formation, hence, device failure, is accelerated by high temperatures (i.e., more metal ions will be activated) and high current densities (i.e., more electrons will collide with the activated ions and impart more momentum to them).

A simplified theory, Black (1), describing this phenomena provides the following expression for Median Time before Failure of device interconnections :

$$MTF = \frac{\omega . t\, e^{\phi/KT}}{CJ^2}$$

where ω = Stripe width
t = Stripe thickness
J = Current density
ϕ = Activation energy for self diffusion of the metal
K = Boltzmann's constant
T = Temperature in °K
C = Constant depending on degree of film crystallinity, resistivity, ion mass, density and stripe geometry.



TEMPERATURE IN °C
MTF for a 1 μ × 2.54 μ
ALUMINIUM STRIPE

Figure 1

ALUMINIUM SYSTEM

Figure 1 shows the expected best case MTF for an ALUMINUM stripe 1 μ thick by 2.54 μ wide, with a current density of 10^6 amps/cm^2 at various temperatures.

Figure 2 shows the effect of current density and temperature on life time of small crystallite ALUMINUM, Black (1).

GOLD SYSTEM

In order to incresse the MTF of devices, two options exist :

1. Reduction of current density and/or device temperature.
2. Selection of a metal with a higher activation energy and higher mass (since electromigration is a momentum transfer process between the conduction electrons and metal ions thermally activated out of the crystal lattice).

Current density reduction cannot always be exercised due to device performance limitations (i.e., prerequisite geometry for frequency response considerations, etc.). Reducing the thermal stresses is possible ; however, practical limits still make critical demands on the metallization. Utilization of a metal with a higher mass and activation energy is the remaining approach to incressing MTF.

GOLD is preferred as the main conductor due to its high activation energy for self-diffusion, high mass and density, resistance to oxidation and corrosion, facility of chemical pattern delineation, and ease of lead wire bonding. Unfortunately, GOLD cannot be used as single layer metallization system due to its poor adherence to both Si and SiO_2, and the low Au-Si eutectic temperature of 367 °C. To prevent the GOLD from alloying with the silicon, a barrier metal layer must be employed.

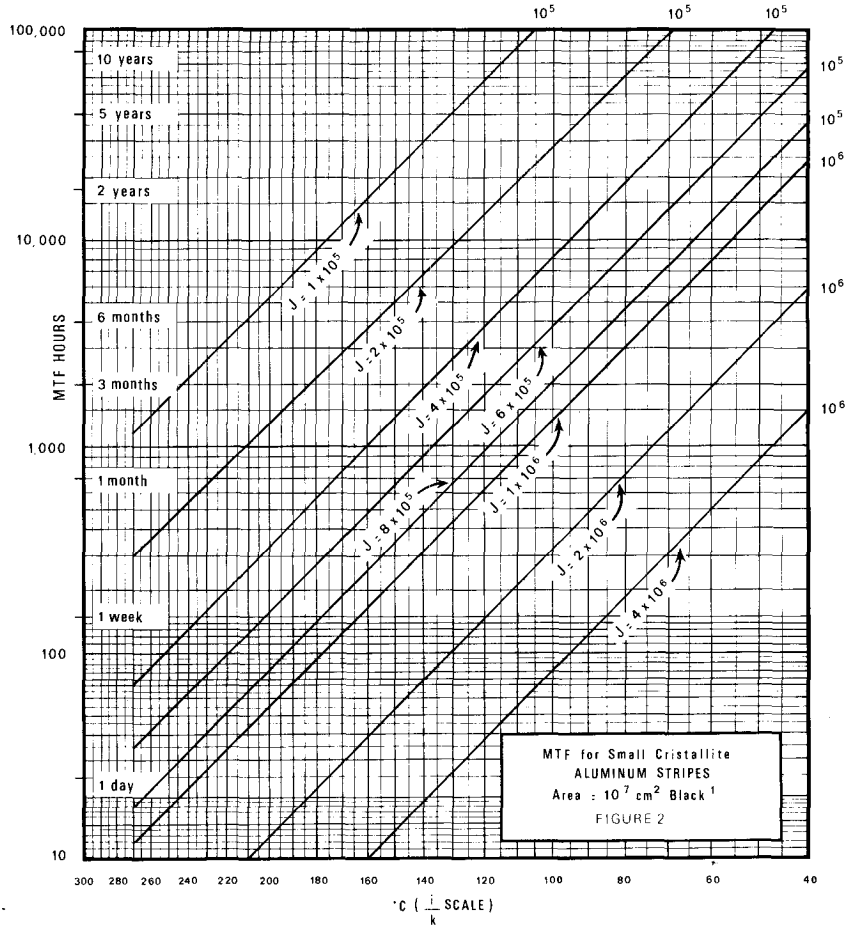


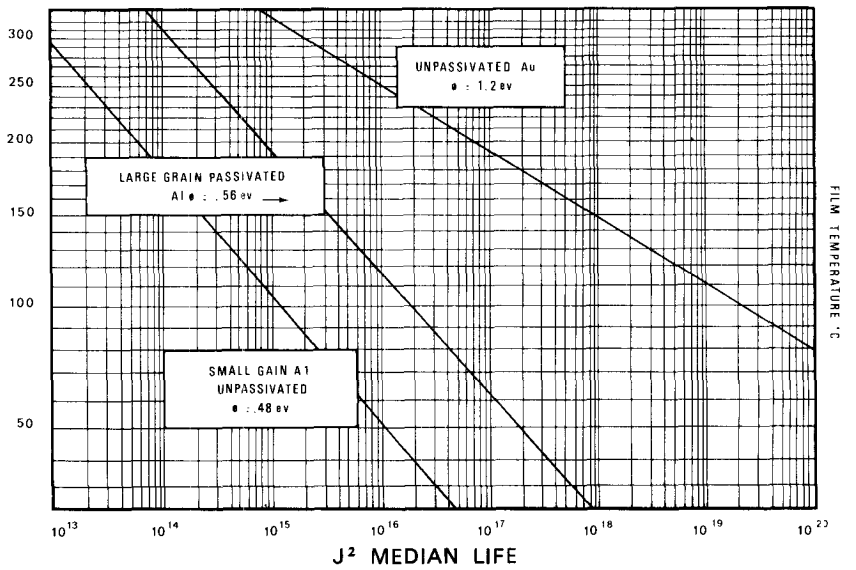
FIGURE 2

The composite system PtSi-Ti-TUNGSTEN-GOLD* meets all the aforementioned requirements for a superior metallization system. PtSi is used to provide a stable, ohmic contact to silicon. The TUNGSTEN layer is also used as a barrier against GOLD diffusion into, and eutectic alloying with Si, as well as to provide adhesion of the GOLD to silicon and SiO_2. Extensive investigation and life testing of the GOLD composite system has been done by TRW Semiconductors and others.

The following discussion, figures, and tables (sections 1-5) are a summary of these investigations.

Figure 3 compares unpassivated small grain ALUMINUM and passivated large grain ALUMINUM to unpassivated TUNGSTEN-GOLD composite metallization.

The lifetime improvement for GOLD vs. ALUMINUM is dramatic, as shown in Table I. For example, the improvement is nearly two orders of magnitude in lifetime for GOLD vs. large grain ALUMINUM (passivated), even at an extreme of 200 °C, and over three orders of improvement at 100 °C. The data used to compile Figure 3 and Table I was obtained by accelerating the failure with high currents being passed through 0.5 mil by 13.5 mil dog bones (2) and using actual transistor structures (7).



* First developed by Texas Instruments and described in U.S. Patents 3,575,570 and 3,601,666 and U.K. Patent 1,265,896.

Temperature	Median lifetime improvement	
	Gold vs. Small grain Aluminum Un-passivated	Gold vs. Large grain Aluminum Passivated
200	1,250 times	88 times
150	4,750 times	264 times
100	17,000 times	1150 times

Table I

A life test under severe conditions is under way at TRW. Identically processed, actual transistors made by both ALUMINUM and GOLD processes are base-emitter forward biased such that Tj = 200 °C and $J = 1.4 \times 10^6$ A/cm^2. After 197 hours, 50 % of the ALUMINUM transistors had failed. At 272 hours, all had failed due to open metallization.

At this writing the GOLD units have survived over 9000 hours of testing without degradation (as evidenced by regular power, gain, and leakage tests). This establishes 30 times life improvement for GOLD over ALUMINUM (a mathmatical model indicates 100 times) as a minimum.

Keep in mind that test is a severe, accelerated life

test and does not indicate that acceptable lifetimes cannot be realized from ALUMINUM in lower frequency, larger geometry devices. GOLD appears necessary in microwave, sub-micron geometry devices.

SECTION 2 - TEMPERATURE STABILITY

Temperature stability involves two areas of interest. The first and most important is the silicon-metal ohmic (non-rectifying) contact; secondly, is the formation of intermetallics or solid-solubility.

SILICON-METAL CONTACT

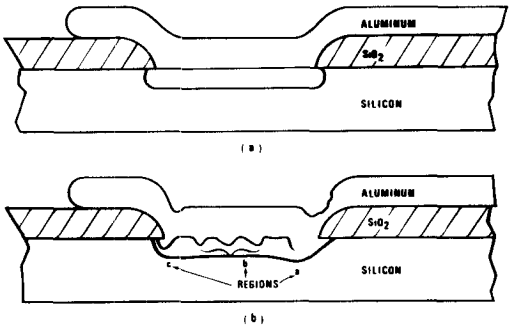
Previously (section 1) it was shown that transistors fail as « open » due to electromigration. In this section, it will be shown how transistors fails as base-emitter « shorts » due to alloying of silicon with the contacting metallization.

ALUMINUM SYSTEM

Again, the problem is most severe with ALUMINUM. Figure 4 illustrates the etch-pit that forms when ALUMINUM is alloyed with silicon (caused by dissolution (1) of silicon into ALUMINUM). The alloying rate at 400 °C is .021 angstrom/minute. Three gigahertz transistors have emitter diffusion depths of 3000-4000 angstroms.

Therefore, in 100 hours of operation under a hot-spot condition of 400 °C, the transistor will fail as an emitter-base short. Output power will have degraded over time due to the even increasing base-emitter leakage.

E-B SHORTS DUE TO SINTERING OF Al INTO CONTACTS



	Temp. (°C)	Å/Min.
Silicon etch pit formation by : (a) As deposited	400	.021
(b) After alloying	500	6.36
	600	520.86

Figure 4
TYPICAL ALLOYING RATES OF Al INTO Si

At practical microwave device operating temperatures (150 °C) and practical current density (1×10^5 A/cm^2), the calculated lifetime of ALUMINUM is limited to slightly over two years.

However, it is not uncommon with microwave geometries to have current densities of 2×10^5 A/cm^2, again at 150 °C, the ALUMINUM lifetime in this case is limited to 5,500 hours or approximately 7.5 months.

Therefore, ALUMINUM metallization is deemed unsatisfactory for fine geometry device applications which approach the above conditions, expecially those requiring practical lifetimes of over six months, and all high reliability applications.

GOLD SYSTEM

The GOLD composite metallization has lower alloying rates as shown in Table II (2).

PtSi is used at TRW as the ohmic contact. Pt is sputtered on to the silicon, then PtSi, is formed at greater than 500 °C for times much in excess required to complete the reaction. Excess Pt, which was not exposed to silicon, is then etched away chemically. PtSi contacts are much less resistive than alloyed ALUMINUM contacts, thus reducing power loss.

With the use of TUNGSTEN to contact the Si-PtSi surface, a very stable connection is achieved which eliminates any etch-pit formation due to hot-spots.

ALUMINUM SYSTEM

« Although the alloying times given for Al in Table II were obtained without the use of a PtSi contact layer (450 °C), it was found that a reaction occurred between the two materials which caused alloying in slightly more than thirty minutes » (2).

INTERMETALLIC FORMATION

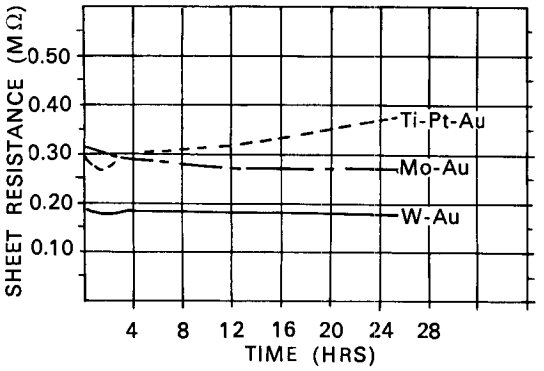
Osborne, et al (2) investigated the change in contact resistance for various GOLD systems. This is shown in Figure 5. PtSi formed the preohmic contact. Again, the TUNGSTEN-GOLD composite is the most stable.

TIME TO ALLOY JUNCTIONS AT 450 °C AND 550 °C (2)

Metal \ Test	450 °C	550 °C
Al	20 min.	—
Mo-Au	3.5 hr.	40 min.
Ti-Pt-Au	5.0 hr.	50 min.
W-Au	4.5 hr.	50 min.

Table II

SHEET RESISTANCE CHANGE AT 450°C IN N_2 (2)



CORROSION LIFETIME FOR Al, Mo-Au, Ti-Pt-Au, AND W-Au* (2)

Metal \ Test	85-85	98-98	Comments
Al**	4.5 hrs.	1.5 hrs.	Electro-chemical dissolution negative terminal
Mo-Au	—	25 hrs.	Mo-corrosion
Ti-Pt-Au	18 hrs.	4 hrs.	Au-deplating from positive terminal
W-Au	16 hrs.	3 hrs.	

* All tests were conducted with 3 V dc bias.

** Unpassivated. Osborne, et al (2).

Table III

SECTION 3 - ELECTROLYTIC CORROSION

Osborne, et al (2) investigated electrolytic corrosion for Al, Mo-Au, Ti-Pt-Au, and W-Au as shown in Table III.

Two test condition were used; (1) 85 °C - 85 % Relative Humidity, and (2) 98 °C - 98 % Relative Humidity. In each case, the test samples were two parallel 0.3 mil width stripes separated by 0.9 mils. A bias voltage of 3 Vdc was applied across the two stripes under the above test conditions.

ALUMINUM SYSTEM

The ALUMINUM samples under test exhibited electro-chemical dissolution of ALUMINUM on the nagative stripe while the positive biased side was nearly unchanged. Passivated ALUMINUM (6000 Å SiO_2) was also tested with observance of the same reaction at the exposed bonding pad areas.

Biasing was shown to accelerate the ALUMINUM corrosion. In ten hours at 98 °C - 98 % R.H. no signs of corrosion was observed. However, with 3 Vdc bias applied (98 °C - 98 % R.H.), severe corrosion was observed in one and a half hours.

GOLD SYSTEM

GOLD deplating from the positively to the negatively biased stripe was the limiting parameter for the TUNGSTEN-GOLD system (also for Ti-Pt-Au).

The time required for this failure is much longer than for ALUMINUM.

« The apparent differences in lifetime between Au on PtSi vs. Au on W as shown in Table III was attributed to a difference in surface topology of the GOLD resulting from different deposition conditions rather than any inherent effect of the underlying metallization » (2).

SECTION 4 - ADHESION

Adhesion of the metal system to SiO_2 and Si is of a major importance to the mechanical and electrical reliability of any transistor.

Pull strengths of thermo-compression wire bonds were used to obtain a quantitative determination of adhesion (2).

Figures 6 and 7 show the gaussian distribution of bond failures. The GOLD metallization systems all tend to show higher average wire pull strengths with GOLD wire than ALUMINUM with GOLD wire (2).

Similar tests conducted at TRW Semiconductors on the PtSi-Ti-TUNGSTEN GOLD compared to ALUMINUM, also show higher average strength for GOLD vs. ALUMINUM (GOLD wire thermal-compression bonds).

WIRE BOND PULL STRENGTH
AL METAL
(Osborne, et al (2))

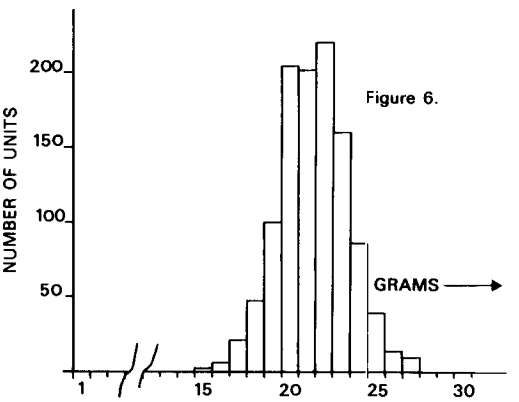


Figure 6.

WIRE-BOND PULL STRENGTH
W-Au METAL
(Osborne, et al (2))

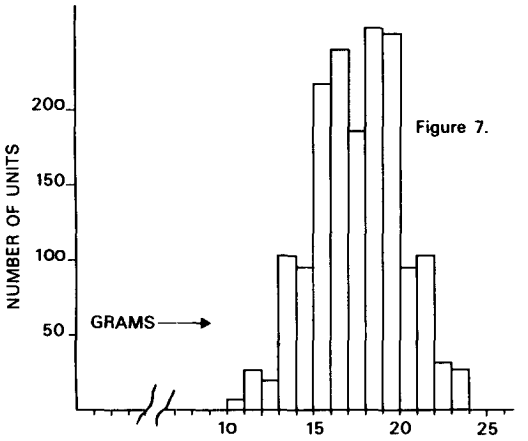


Figure 7.

SECTION 5 - PROCESSING ADVANTAGES OF GOLD SYSTEMS COMPARED TO ALUMINUM

The reliability of all metal systems depends not only on those factors discussed in the previous sections, but the following three processing factors :

1. **Deposition reproductibility,**
2. **Etchability** to define metal geometries, and
3. **Oxide step coverage,** the ability to cover oxide steps without decrease of metal thickness or cracking.

The method of deposition makes the greatest difference between the quality factors of GOLD and ALUMINUM metallizations.

SPUTTERING is used at TRW Semiconductors for the PtSi-Ti-TUNGSTEN GOLD system, where vacuum evaporation is the industry-wide method to deposit ALUMINUM.

VACUUM EVAPORATION of ALUMINUM is accomplished via electron beam or resistive heating of the ALUMINUM to its vaporization temperature.

ALUMINUM SYSTEM

A point source for the ALUMINUM is used and since the mean free path of the ALUMINUM particle is long before collision, the wafer substrate must be rotated through all possible angles to achieve perfect coverage of all oxide steps. In practice, only an approximation to this ideal requirement is possible (see Figure 8).

OXIDE STEP COVERAGE
ALUMINUM VACUUM EVAPORATION

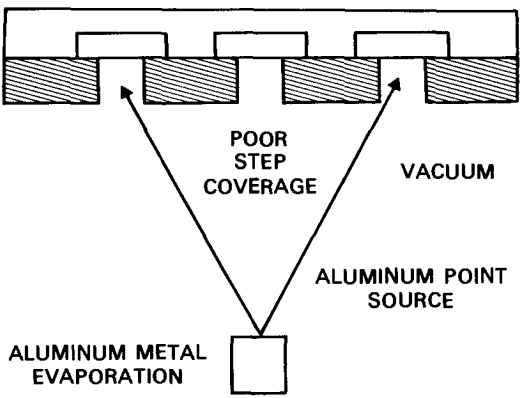


Figure 8.

This process problem alone is sufficient to justify an improved technique, but the task is only made impossible when the many difficult to control process variables are considered. A complete discussion of these process variables is beyond the scope of this paper ; however, the impact on reliability of these process variables and problems is the subject of the Goddard Space Flight Center Specification S-311-P-12A entitled, « Scanning Electron Microscope inspection of Semiconductor Device Metallization, Specification for ».

Figure 9 shows a SEM photograph of an oxide step coverage problem with ALUMINUM.

Etchability of ALUMINUM is a problem which has been solved for large geometries, but is still (even though it has wide usage) a major process reliability problem with small geometry microwave transistors.

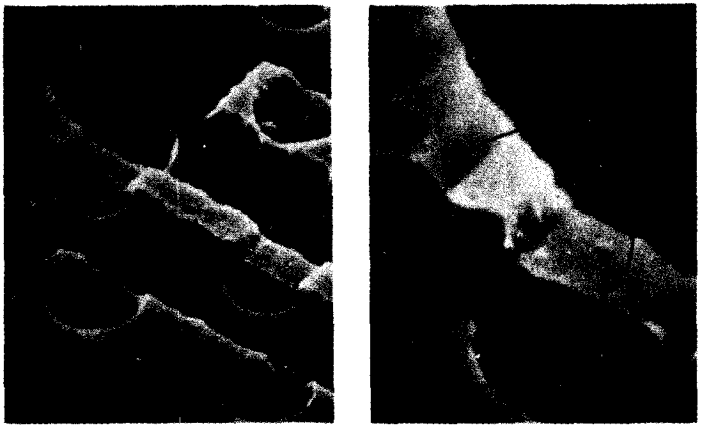


Figure 9

Photomicrographs of a transistor with ALUMINUM metallization showing poor step coverage. The blowup (6000 X) shows a typical step with poor continuity in metallization. This gives rise to regions of extremely high current densities and the resultant failures.



Figure 10 A

6000 X photomicrograph of a GOLD metallized transistor section. Note the uniform metallization without discontinuities.

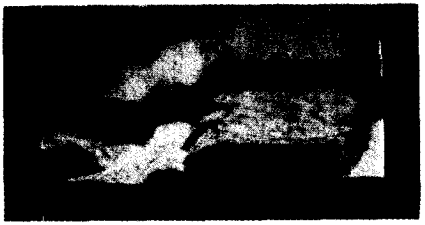


Figure 10 B

Cross section photomicrograph of a GOLD metallized stripe showing uniform stripe thickness.

GOLD SYSTEM

The sputtering and etching processes used for PtSiTi-TUNGSTEN-GOLD (at TRW Semiconductors) solves these process-reliability problems.

Sputtering to deposit the metals is done in a high purity-inert gas atmosphere under pressure where the mean free path to collision of the metal particle is short.

The infinite number of metal particle to gas molecule collisions cause the metal to impinge on the wafer substrate surface at every possible angle. All oxide steps are easily and reproducibly covered (both sides of the substrate could be coated at one time!). Figure 10 shows a portion of the TRW 5 watt - 3 GHz transistor.

This picture demonstrates that etchability is no longer a problem with the proprietary processes developed by TRW Semiconductors.

Sputtered PtSiTi-TUNGSTEN-GOLD forms the metallization. Step coverage and etchability is seen to be ideal, even though the device structure would be nearly impossible to process with ALUMINUM.

CONCLUSION

* TRW has Adapted the PtSiTi-TUNGSTEN-GOLD metallization system to solve the reliability problems which exist with ALUMINUM metallizations.
* The reliability problems with ALUMINUM are generally confined to R.F. power transistors designed for operation **above** 750 MHz.
* PtSiTi-TUNGSTEN-GOLD metallization system removes the question of metal-reliability with microwave R.F. transistors.
* SUMMARY OF TEST RESULTS :

Section 1 - ELECTROMIGRATION

Median lifetimes of transistor metallization can be improved over 17,000 times over ALUMINUM by using GOLD systems.

Section 2 - TEMPERATURE STABILITY

PtSi-W contacts to silicon have more than 100 times the stability of ALUMINUM contacts.

Section 3 - ELECTROLYTIC CORROSION

PtSiTi-TUNGSTEN-GOLD is over 3 1/2 times more corrosion resistant than ALUMINUM.

Section 4 - ADHESION

PtSiTi-TUNGSTEN-GOLD has better adhesion to Si and SiO_2 than ALUMINUM.

Section 5 - PROCESSING ADVANTAGES OF GOLD METAL SYSTEMS

1. GOLD metal systems are more reproducible.
2. GOLD metal systems have improved etchability.
3. GOLD metal systems, sputter-deposited, solve all oxide step coverage problems.

The conclusion to be found within this report is :

* **PtSiTi-TUNGSTEN-GOLD** is a reliable, reproducible, and highly manufacturable metallization system which can increase the reliability (lifetime) of any R.F. power transistor, especially microwave transistors which are designed for operation above 750 MHz.

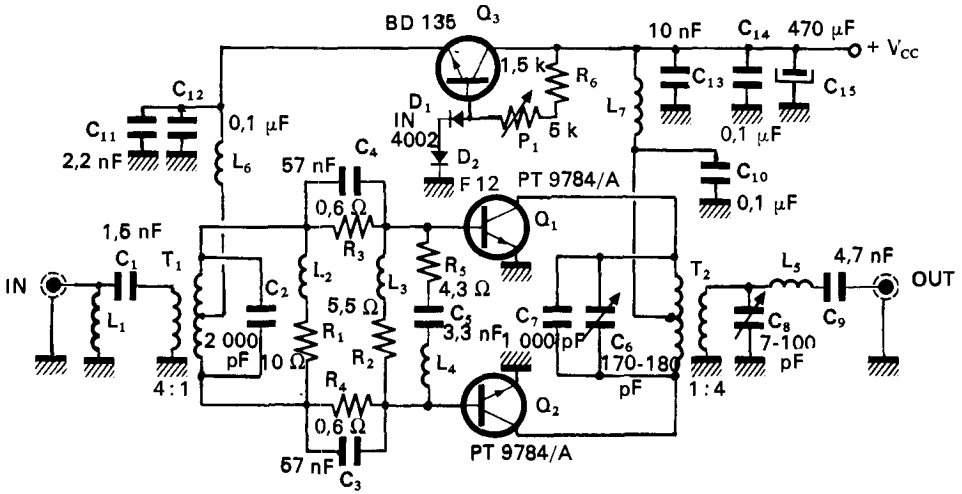
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5. W. W. Lee, and Daniel Oblas, *Argon Concentration in Tungsten Films Deposited by dc Sputtering*, p. 128, J. Vac. Sci. and Tech. Vol 7, No. 1, January/February 1970.
6. E. M. Ruggiero, *Ohmic Contacts Consisting of a First Level of Molybdenum-Gold Mixture of Gold and Vanadlum and a second Level of Molybdenum-Gold*, Patent 3,434,020, March 18, 1969.
7. TRW Semi conductors Test Data.

150 WATT LINEAR AMPLIFIER
2 TO 28 MHz, 13.5 VOLT D.C.

This application note describes the design of a push-pull linear 150 W solid state power amplifier intended for SSB transmitter applications.
The broadband amplifier operates directly from a 13.5 V DC source and covers the 2 — 28 MHz band.

The circuit calculation, the major performance characteristics and the complete construction details are presented.
Devices used : Two PT 9784/A.



1. — BASIC AMPLIFIER SPECIFICATION

V_{CE} = 13.5 V

Bandwidth : 2 to 28 MHz

Pgain at 150 W : 15 ± 1.3 dB

IMD at 28 MHz and 150 W PEP ⩽ — 30 dB

INPUT VSWR ⩽ 1.6 : 1

2. — GENERAL DESIGN CONSIDERATION

The principal aims were :

— employ a relatively simple solution permitting us to obtain optimal performance from two PT 9784/A,

— use components available on European market.

In order to comply with ourself imposed criteria, we chose a push-pull configuration to improve even harmonic suppression and to simplify the matching problems due to very low input and output transistor impedances.

In push-pull configuration, the transistor input or output impedances are in series, making the required transformation ratio one quarter of that required for parallel operation.
We also chose a ferrite manufacturer whose product is freely available on the European market.

The circuit calculation was made as follows :

— choice of the input and output transformer ratio,

— choice of the transformer type,

— estimation of the transformer volumes,

— calculation of the transformer compensation,

— calculation of an input network between the input transformer and the transistors to match 2 Zin to 3 Ω and to stabilize the gain-frequency characteristic.

The figure 1 shows the schematic of the amplifier.

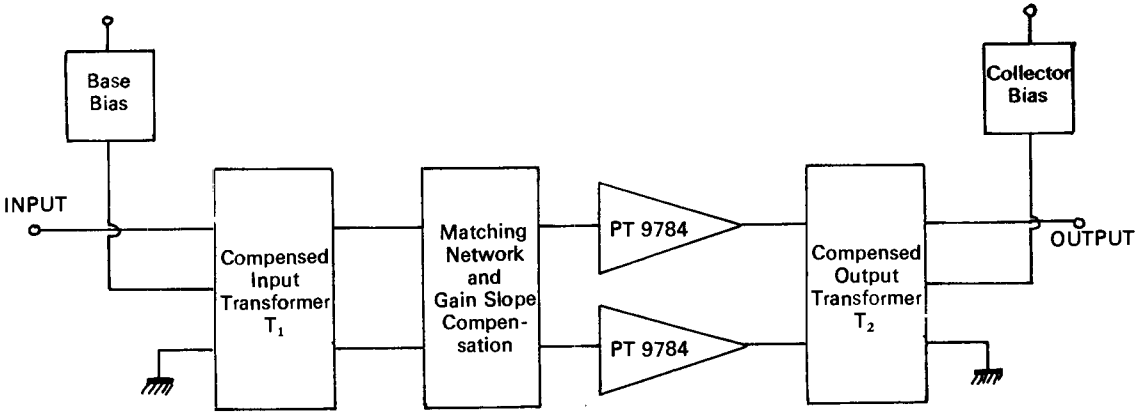


Fig. 1

3. — IMPEDANCE TRANSFORMATION CHOICE

3. — 1. Input voltage transformation ratio

Zin = R + JX (Ω) typical values :

F (MHz)	2	5	10	15	20	25	30
R (Ω)	15	8	5	3	2	1.5	1.2
X (Ω)	— 8	— 11	— 7.5	— 5	— 4	— 3.5	— 3

In order to obtain a good match at high frequency, we consider Zin at 25 MHz. The real part at this frequency is 1.5 Ω, which means for a push-pull configuration the real part is 3 Ω between the two bases.

The voltage transformation ratio is determined by :

$$n = \sqrt{\frac{50}{3}} \simeq 4 \qquad \boxed{n_{IN} = 4}$$

3. — 2. Output voltage transformation ratio

The transistor equivalent output circuit is :

With :

$C_C \simeq 270$ pF

$$R_C = \frac{(V_{CC} - V_{sat})^2}{2\,P_o}$$

Where :

- V_{CC} : collector supply voltage = 13.5 V
- V_{sat} : RF saturation voltage = 1.0 V
- P_o : Output power for one transistor = 75 W
- $R_C \simeq 1.1\ \Omega$

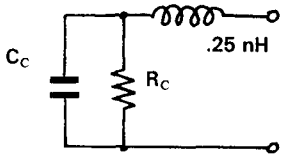


Fig 2.

The output transformer matches 2 Z_{out} to 50 Ω for push-pull configuration. The voltage transformation ratio is defined by :

$$n = \sqrt{\frac{50}{2.2}} = 4.7 \simeq 5$$

In fact we found empirically that the best ratio is n = 4.

$$n_{out} = 4$$

4. — TRANSFORMER TYPES USED

Since the input and output voltage transformation ratios are 4, we can use the small pratical transformer show by figures 3 and 4.

The low impedance winding always consists of one turn, which limits the available impedance transformation ratio to 1, 4, 9...

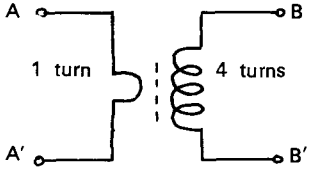


Fig. 3.

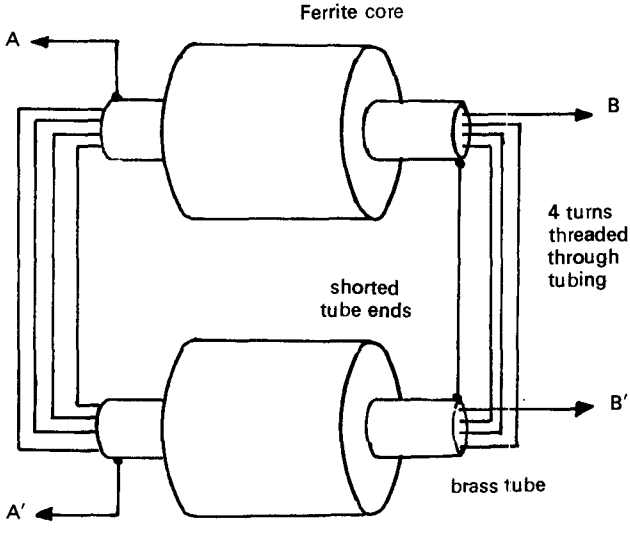


Fig. 4.

5. — TRANSFORMER VOLUME ESTIMATION

5. — 1. **Output transformer**

Ferrite used : 4 C 6 material made by RTC.
Reference : Tore 14/9/5 — 4 C 6
4322 020 97 180

$\mu_r = 120 \pm 20\ \%$

Toroid dimensions.

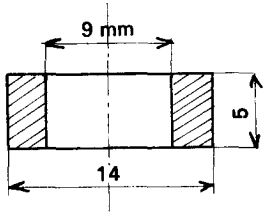


Fig. 5.

The primary inductance can be calculated with the following formula :

$$L_p = \mu_o \mu_r n^2 \frac{S}{l} \qquad (5\text{-}1\text{-}1)$$

Where :

- L_p : inductance (H)
- $\mu_o = 4 \pi 10^{-7}$
- μ_r : Relative permeability
- s : ferrite cross section (m^2)
- l : average lenght of the lines force (m)
- n : number of turns.

The value of L_p must be chosen high, but not higher than really necessary, because otherwise the performance at the high end of the band will be degraded.

We take :

$$2 \pi L_p F \text{ min} \simeq 3 R$$

in which :

- R : load impedance = 50 Ω
- F mini = 2 MHz

$$L_p = \frac{150}{2 \pi 2\, 10^6} = 12\ \mu H$$

The ferrite cross section is :

$$S = Nh \frac{(D - d)}{2}$$

in which N is the number of toroids.

$$S = N\, 5\, 10^{-3}\, 2.5\, 10^{-3} = 1.25\, 10^{-5}\, N\ (m^2)$$

From 5 — 1 — 1 we can calculate N :

$$N = \frac{L_p l}{\mu_o \mu_r n^2\, 1.25\, 10^{-5}} = \frac{12\, 10^{-6}\, 36.1\, 10^{-3}}{4 \pi 10^{-7}\, 120\, 16\, 12.5\, 10^{-5}}$$

$N \simeq 14$ toroids.

In fact we use 16 cores, which gives :

$$Lp = 13.7\ \mu H \quad \text{and} \quad S = 2\, 10^{-4}\ (m^2)$$

The highest toroid losses occur in this case at 2 MHz under large signal conditions. RTC give the power loss density, i.e. the power loss related to the unit of volume versus the maximum induction and the frequency. The maximum induction $\hat{B}$ can be calculated with the following formula :

$$\hat{B} = \frac{\hat{V}}{2 \pi FSn} \qquad (5\text{-}1\text{-}2)$$

in which :

- $\hat{B}$: maximum induction (T)
- S : ferrite cross section (m^2)
- n : number of turns
- $\hat{V}$: maximum value of voltage accross n turns (V)
- F : frequency

$\hat{V}$ is given by :

$$\hat{V} = \sqrt{2 P_o R_L} \qquad (5\text{-}1\text{-}3)$$

where :

- P_o : output power
- $R_L = 50\ \Omega$

$$\hat{V} = \sqrt{2\ 150\ 50} = 122.5\ V$$

$$\hat{B} = \frac{122.5}{2 \pi\ 2\ 10^6\ 2\ 10^{-4}\ 4} = 1.2\ 10^{-2}\ T$$

for $\hat{B}$ = 12 mT and F = 2 MHz the power loss density is $2\ 10^2$ mW.cm^{-3}.

The ferrite volume is :

$$v = \frac{\pi}{4} (D^2 - d^2)\ hN = \frac{\pi}{4} (14^2 - 9^2)\ 5\ 16\ 10^{-3} = 7.2\ cm^3$$

This gives a loss α :

$$\alpha = 2\ 10^2\ 7.2 = 1440\ mW \text{ or } \frac{1.4}{150} = 1\ \%$$

This 0.05 dB loss in the ferrite is acceptable.

5. — 2. **Input transformer**

Ferrite used : 4 C 6 material made by RTC
Reference : Tore 9/6/3 — 4 C 6
4322 020 97170

$\mu_r = 120 \pm 20\ \%$

Toroid dimensions.

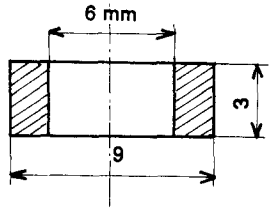


Fig. 6.

In order to reduce the transformer dimensions we use a transformer with a primary inductance at 2 MHz given by :

$$2 \pi L_p F \text{ mini} \simeq R_s \qquad (5\text{-}2\text{-}1) \qquad \text{where } R_s = 50\ \Omega$$

this inductance is compensated at low frequencies by the following circuit (figure 7) :

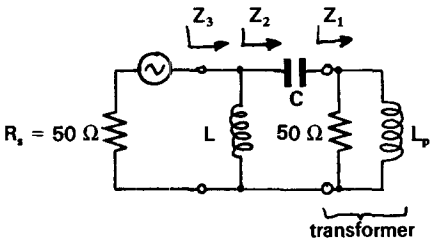


Fig. 7.

Smith chart :

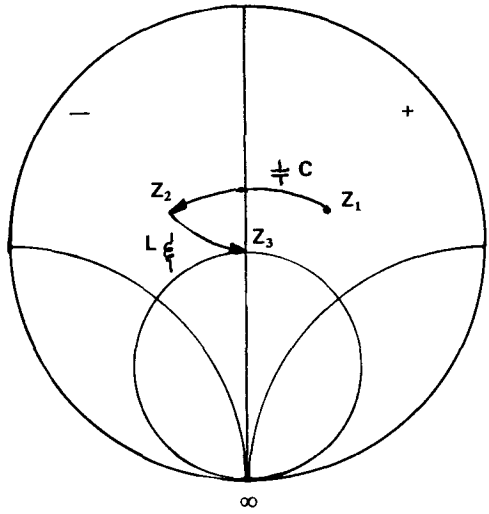


Fig. 8.

From 5-2-1 :

$$L_p \simeq \frac{50}{2\,\pi\,2\,10^6} = 4\ \mu\,H$$

The ferrite cross section S is :

$$S = N\,\frac{D - d}{2}\,h = N\,1.5\,10^{-3}\,3\,10^{-3} = 4.5\,N\,10^{-6}\ (m^2)$$

where N is the number of toroids.

The average length of the line force l is :

$$l = \pi\,\frac{D + d}{2} = \pi\,7.5\,10^{-3} = 23.6\,10^{-3}\ (m)$$

N can be calculated from 5-1-1 :

$$N = \frac{L_p l}{\mu_o\,\mu_r\,n^2\,4.5\,10^{-6}} = \frac{4\,10^{-6}\,23.6\,10^{-3}}{4\,\pi\,10^{-7}\,120\,16\,4.5\,10^{-6}}$$

$N = 8.7 \simeq 9$.

In fact we use $N = 10$ toroids, which means :

$$L_p = 4.6\ \mu H$$

By using the same reasoning and formula as the output transformer :

$P_{in} \simeq 3$ W at 2 MHz

$$\hat{V} = \sqrt{2\,P_{in}\,R} = \sqrt{2\ .\ 3\ .\ 50} = 17.3\ V$$

$$\hat{B} = \frac{\hat{V}}{2\,\pi\,FSn} = \frac{17.3}{2\,\pi\,2\,10^6\,4.5\,10^{-5}\,4} = 7.6\,10^{-3}\ T$$

for $\hat{B} = 8$ mT and F = 2 MHz the power loss density is 70 mW·cm^{-3}.

The ferrite volume is:

$$v = \frac{\pi}{4}(D^2 - d^2)\, hN = \frac{\pi}{4}(9^2 - 6^2)\, 3\, 10\, 10^{-3} = 1\ cm^3$$

This gives a loss α :

$$\alpha = 70 \times 1 = 70\ mW \text{ or } \frac{70}{3000} = 2.3\ \%$$

This 0.1 dB loss in the ferrite is acceptable.

6. — OUTPUT CIRCUIT

Figure 9 shows the RF equivalent output circuit :

— Resistor AA, capacitor AA and inductor BB are the equivalent circuit to 2 Zout in series.

— Capacitor CC, capacitor EE and inductor FF are the transformer HF compensation.

— Capacitor FF is for low frequency compensation.

— The transformer is a black box described by its S-parameters.

The compensation elements are optimized with the aid of an analysis and optimization computer programme COMPACT.

Figure 10 shows the programme with final values and the final analysis :

The maximum output VSWR is lower than 1.6 : I.

ELEMENTS		CALC. VALUE	EMPIRICAL VALUE
CC	CAP (pF)	1474	1000 + 100/700*
EE	CAP (pF)	136	20/100*
FF	IND (nH)	256	90
	CAP (pF)	2993	4700

* variable capacitor.

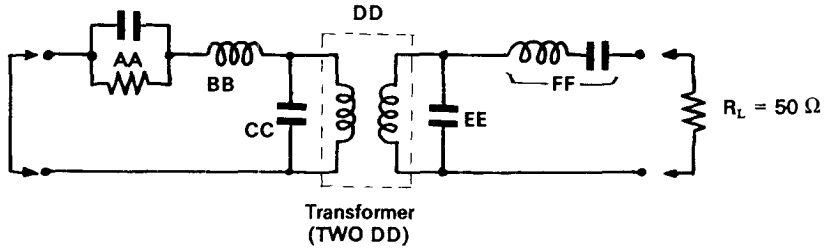


Fig. 9.

OUTPUT CIRCUIT

COMPACT PROGRAM

```
PRC  AA SE   3.000        135.0
IND  BB SE    .5000
CAP  CC PA — 1474.
TWØ  DD S1 — 50.00
CAP  EE PA — 136.0
SLC  FF SE — 251.4       — 2993.
CAX  AA FF
PRI  AA ØR   50.00
END

2  5  10  15  20  25  30
END

.909 176.5  .409   26    .390   20.5  .881   57.5
.884 177    .449    9.5  .435   10    .877   23
.884 176    .458    2    .439    2    .865    9
.877 174.5  .460 —  2.5  .437 —  1.5  .858    3
.884 173    .453 —  6    .439 —  4    .871 —  0.5
.885 172    .453 —  8    .437 —  6.5  .870 —  4.
.886 170    .456 — 10    .432 —  9    .867 —  8
END

1
0 1 0 0
END
```

DEFINITIONS + INTERCONNECTIONS

THE ELEMENT VALUES ARE THE FINAL VALUES

FREQUENCY (MHz)

POLAR S-PARAMETERS FOR THE TRANSFORMER (TWØDD)

OPTIMIZATION DATA

FINAL ANALYSIS

ØUTPUT REFL. CØEF. AND VSWR IN 50.ØHM SYSTEM WITH 0.0ØHM SOURCE

F (MHZ)	RHØ (MAGN. < ANGLE)		VSWR	RET L/G (DB)	Z (R + JX) ØHM	
2.000	0.107	— 167.8	1.24 : 1	— 19.08	40.46	— 1.85
5.000	0.051	— 24.1	1.11 : 1	— 25.79	54.86	2.31
10.000	0.053	59.3	1.11 : 1	— 25.57	52.54	4.77
15.000	0.076	52.0	1.16 : 1	— 22.44	54.46	6.52
20.000	0.107	27.5	1.24 : 1	— 19.41	60.15	6.02
25.000	0.047	— 9.8	1.10 : 1	— 26.62	54.81	— 0.88
30.000	0.232	— 148.8	1.60 : 1	— 12.68	32.60	— 8.30

Fig. 10.

7. — INPUT CIRCUIT

Figure 11 shows the RF equivalent input circuit :

— IMP JJ is the two transistor input impedances in series,

— inductor AA and capacitor BB are for transformer compensation at low frequency,

— capacitor DD is for high frequency transformer compensation,

— circuits EE, FF, GG and HH have two functions :

- form a selective attenuator with 3 Ω input impedance to stabilize the gain-frequency characteristic ;
- match the two transistors input impedance which are in series to 3 Ω, with the minimum of loss at the highest frequency.

Figure 12 shows the programme with final values and the final analysis : the maximum input VSWR is lower than 1.6 : 1.

ELEMENTS		CAL. VALUE	EMPIRICAL VALUE
AA	IND (nH)	5732	4000
BB	CAP (pF)	1294	1680
DD	CAP (pF)	1146	2000
EE	RES (Ω)	13.4	10
	IND (nH)	189	200
FF	RES (Ω)	1.3	1.2
	CAP (pF)	33350	57000
GG	RES (Ω)	7.2	5.5
	IND (nH)	93.3	95
HH	RES (Ω)	6.8	4.3
	IND (nH)	31.5	45
	CAP (pF)	3040	3300

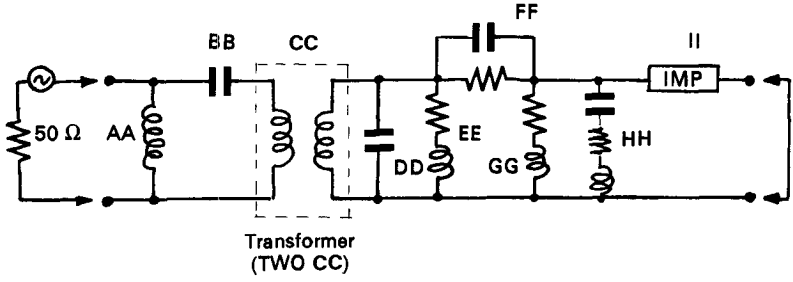


Fig. 11.

INPUT CIRCUIT

COMPACT PROGRAM

```
IND   AA  PA  — 5732.
CAP   BB  SE  — 1294.
TWØ   CC  S1     50.00
CAP   DD  PA  — 1146.
SRL   FE  PA  — 13.43      — 189.0
PRC   FF  SE  — 1.325      — .3335 E + 05
SRL   GG  PA  — 7.161      — 93.26
SRX   HH  PA  — 6.817      — 01.50        — 3040.
IMP   II  SE
CAX   AA  II
PRI   AA  IR     50.00
END
```

DEFINITIONS + INTERCONNECTIONS

THE ELEMENT VALUES ARE THE FINAL VALUES

```
2 5 10 15 20 25 30
END
```

FREQUENCY (MHz)

```
.917 87.5  .321 — 139  .337 — 139  .949 176
.891 41.5  .414 — 161  .428 — 161  .909 177
.868 19    .430 — 172  .452 — 172  .891 176
.863 11    .437 — 176  .453 — 177  .883 172
.861  6.5  .439 — 179  .455  180   .883 175
.854  2.5  .441  178   .452  177   .884 174
.852  0    .445  175   .443  175   .885 174
END
```

POLAR S-PARAMETERS FOR THE TRANSFORMER (TWØ CC)

```
30  — 16
16  — 22
10  — 15
 6  — 10
 4  —  8
 3  —  7
2.4 —  6
END
```

2 ZIN IN SERIES R + JX (Ω)

```
1
0 1 0 0
END
```

OPTIMIZATION DATA

FINAL ANALYSIS

INPUT REFL. CØEF. AND VSWR IN 50. ØHM SYSTEM WITH 0.0 ØHM LØAD

F (MHZ)	RHØ (MAGN<ANGLE)		VSWR	RET L/G (DB)	Z (R + JX) ØHM	
2.000	0.129	— 93.6	1.30 : 1	— 17.79	47.60	— 12.46
5.000	0.186	55.7	1.46 : 1	— 14.60	58.51	13.64
10.000	0.108	45.6	1.24 : 1	— 19.36	57.41	8.93
15.000	0.248	74.0	1.66 : 1	— 12.10	50.76	25.80
20.000	0.083	48.6	1.18 : 1	— 21.66	55.32	6.91
25.000	0.054	87.5	1.11 : 1	— 25.33	49.95	5.42
30.000	0.115	159.0	1.26 : 1	— 18.78	40.18	3.35

Fig 12.

8. — BIAS CIRCUIT

The transistors which heat up during operation, need a thermally compensated bias current.

The circuit used is an emitter follower giving a low output resistance, in which the base voltage is fixed through a thermally variable component : a diode.

The diode is thermally connected with the heatsink (D2).

D1 is needed to compensate the VBE of the transistor.

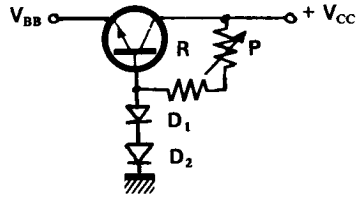


Fig. 13.

With the potentiometer, we adjust the current through the diodes, changing the voltage accross them.

We could have made a more sophisticated circuit, but this one is enough for our purpose.

9. — AMPLIFIER PERFORMANCES

The test set up used is the following (figure 14) :

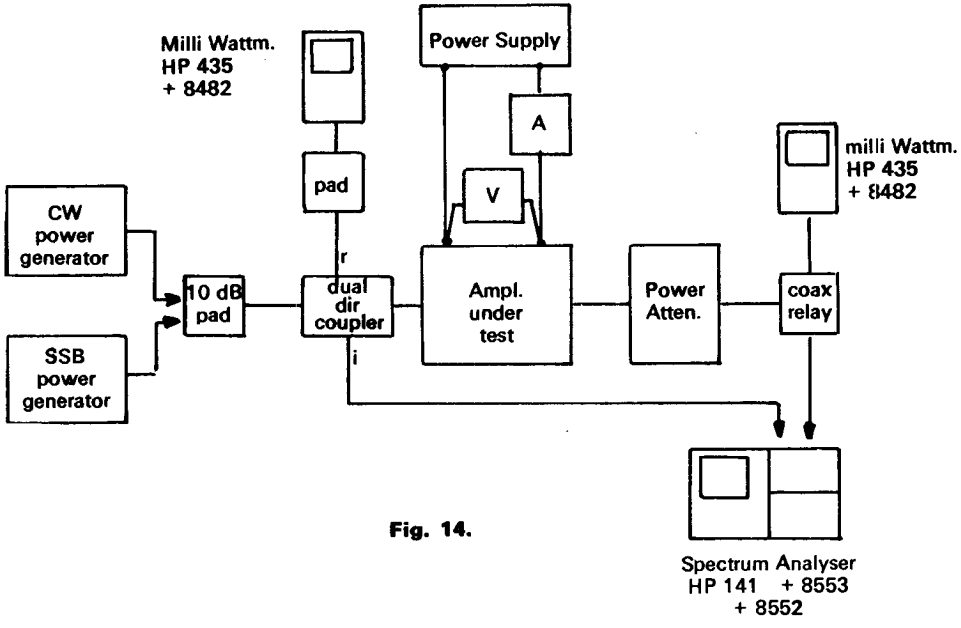


Fig. 14.

The performances are given in the following figures :

Power output versus frequency	: Figure 15
Input VSWR versus frequency	: Figure 16
IMD versus power output	: Figure 17
Gain output versus power input and frequency	: Figure 18

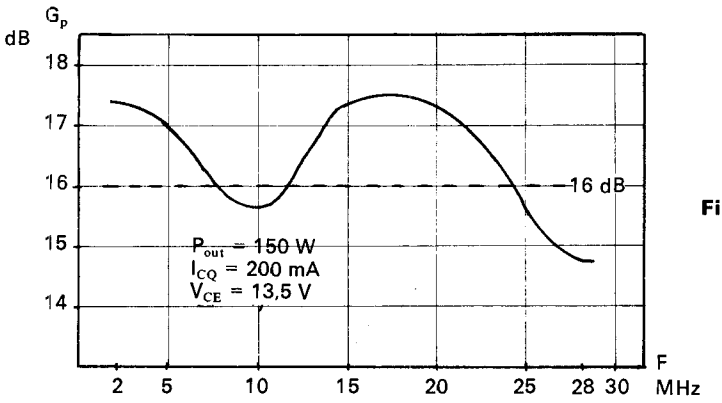


Fig. 15.

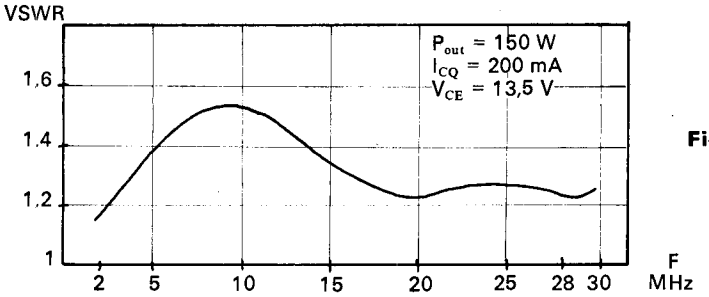


Fig. 16.

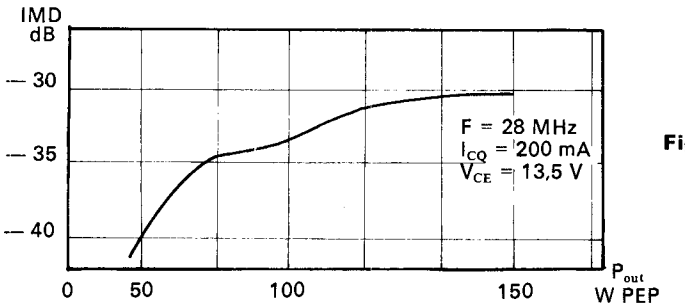


Fig. 17.

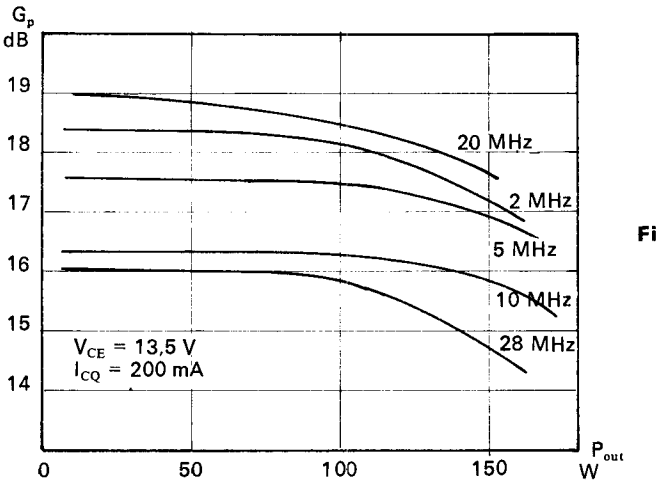


Fig. 18.

AMPLIFIER SCHEMATIC

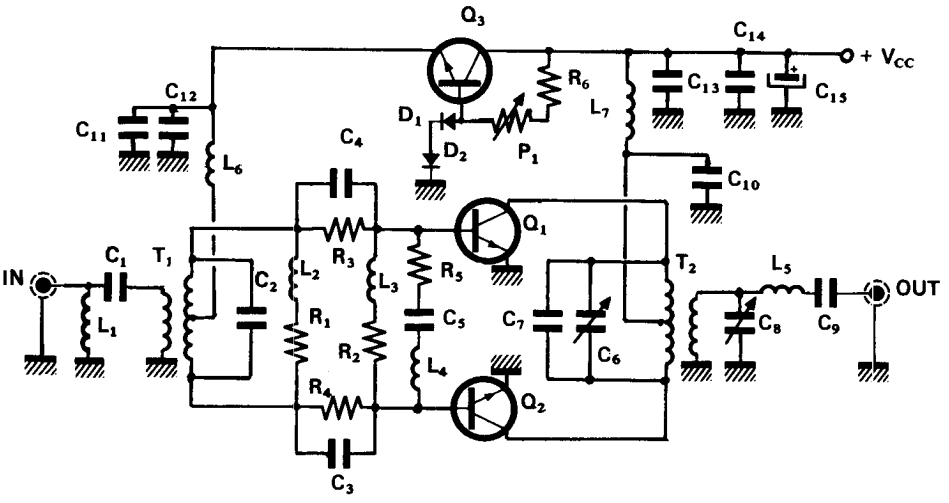


Fig. 19.

COMPONENTS PART LIST

CAPACITORS

C 1	1000 pF + 560 pF	
C 2	1000 pF + 1000 pF	
C 3	47 nF + 10 nF	
C 4	47 nF + 10 nF	
C 5	3300 pF	
C 6	ARCO 469	170 — 780 pF
C 7	1000 pF Mica	
C 8	ARCO 423	7 — 100 pF
C 9	4700 pF	
C 10	0.1 μ F	
C 11	2200 pF	
C 12	0.1 μ F	
C 13	10 nF	
C 14	0.1 μ F	
C 15	470 μ F/25 V	

RESISTORS

R 1	10 Ω made by 20 Ω + 20 Ω ½ W in parallel
R 2	5.5 Ω made by 10 Ω + 12 Ω ½ W in parallel
R 3	0.6 Ω made by 1.2 Ω + 1.2 Ω ½ W in parallel
R 4	0.6 Ω made by 1.2 Ω + 1.2 Ω ½ W in parallel
R 5	4.3 Ω 1/2 W
R 6	1.5 K Ω ½ W
P 1	2 K Ω

SEMICONDUCTORS

D 1	1N 4002
D 2	F 12 metallic case (cathode to case)
Q 1	PT 9784/A
Q 2	PT 9784/A
Q 3	BD 135

INDUCTORS

L1	15 turns 0.5 mm wire wound on a ferrite core same as used for T1		
L2	6 turns ⌀ 7 mm	0.8 mm wire	
L3	4 turns ⌀ 7 mm	1 mm wire	
L4	4 turns ⌀ 6 mm	0.8 mm wire	6 mm length
L5	4 turns ⌀ 8 mm	1.4 mm wire	9 mm length
L6	1 μ H molded choke		
L7	10 turns 1.4 mm wire wound on a ferrite core same as used for T 2.		

TRANSFORMERS

Refer to figure 20 for complete view of the transformers.

T 1

PRIMARY : 2 times 5 ferrite cores 9 × 6 × 3 mm μ_r = 120 material 4 C 6 reference RTC 4322 020 97170, on 2 brass tubes ⌀ 5 mm, 22 mm length, with a 10 × 20 mm PCB piece on each side (figure 21).

SECONDARY : 4 turns of 0.5 mm² insulated wire wound through the 2 brass tubes.

T 2

PRIMARY : 2 times 8 ferrite cores 14 × 9 × 5 mm μ_r = 120 material 4 C 6 reference RTC 4322 020 97180 on 2 brass tubes ⌀ 8 mm, 49 mm lenght, with a 15 × 30 mm PCB piece on each side (figure 22).

SECONDARY : 4 turns of 1.8 mm² insulated wire wound through the 2 brass tubes.

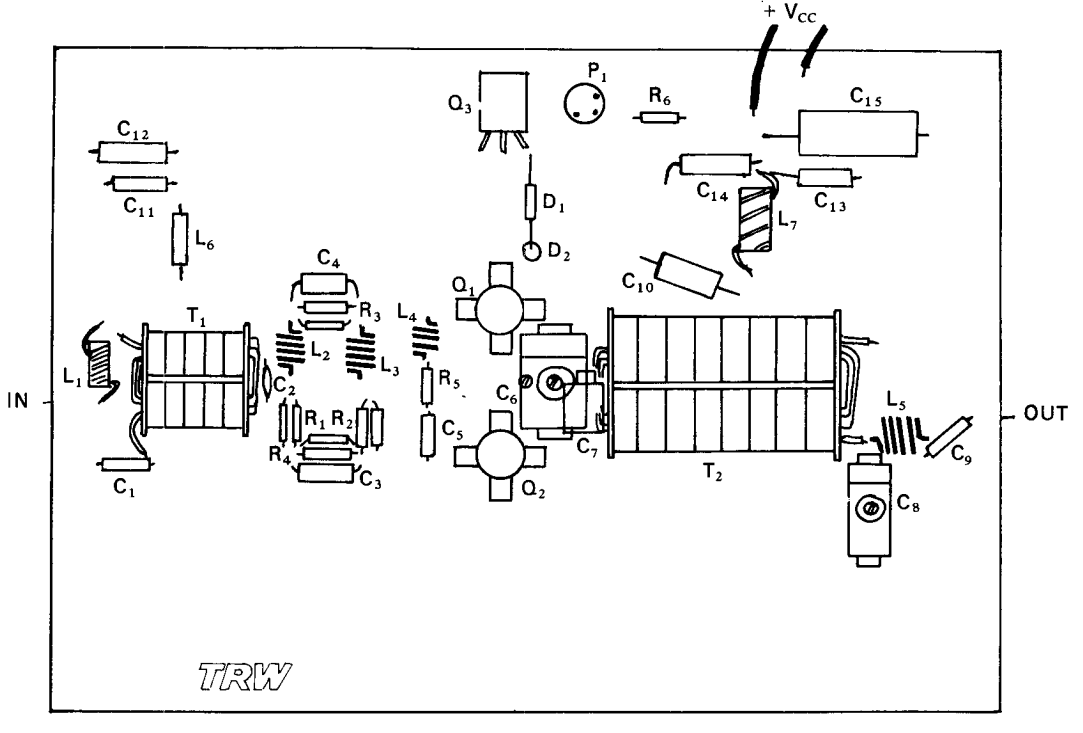


Fig. 24

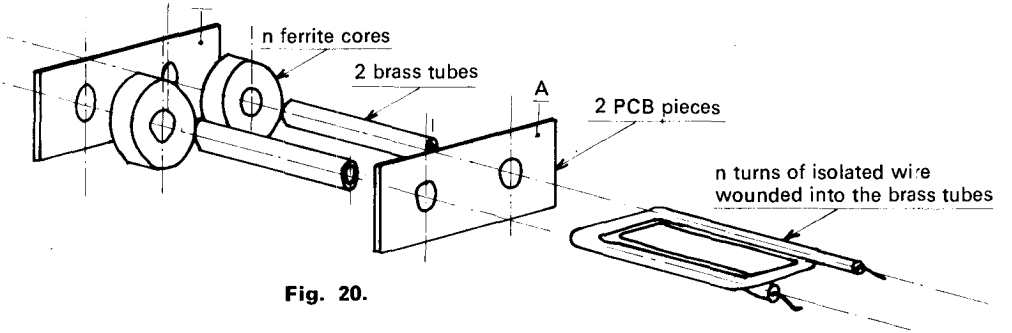
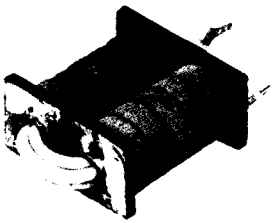


Fig. 20.



INPUT TRANSFORMER

PARTS A AND B FOR T1 (INPUT)

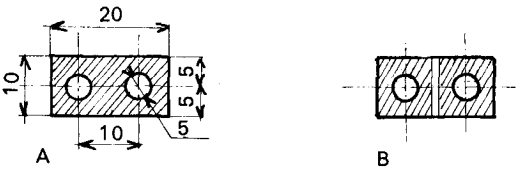
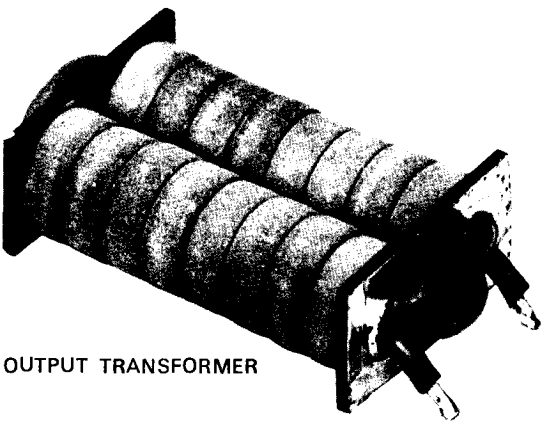


Fig. 21.



OUTPUT TRANSFORMER

PARTS A AND B FOR T2 (OUTPUT)

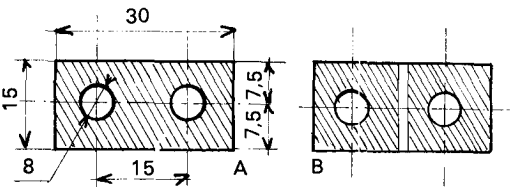
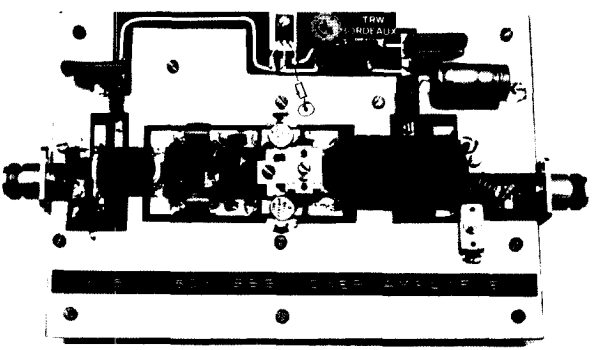


Fig. 22.



PRINTED CIRCUIT
FULL SCALE

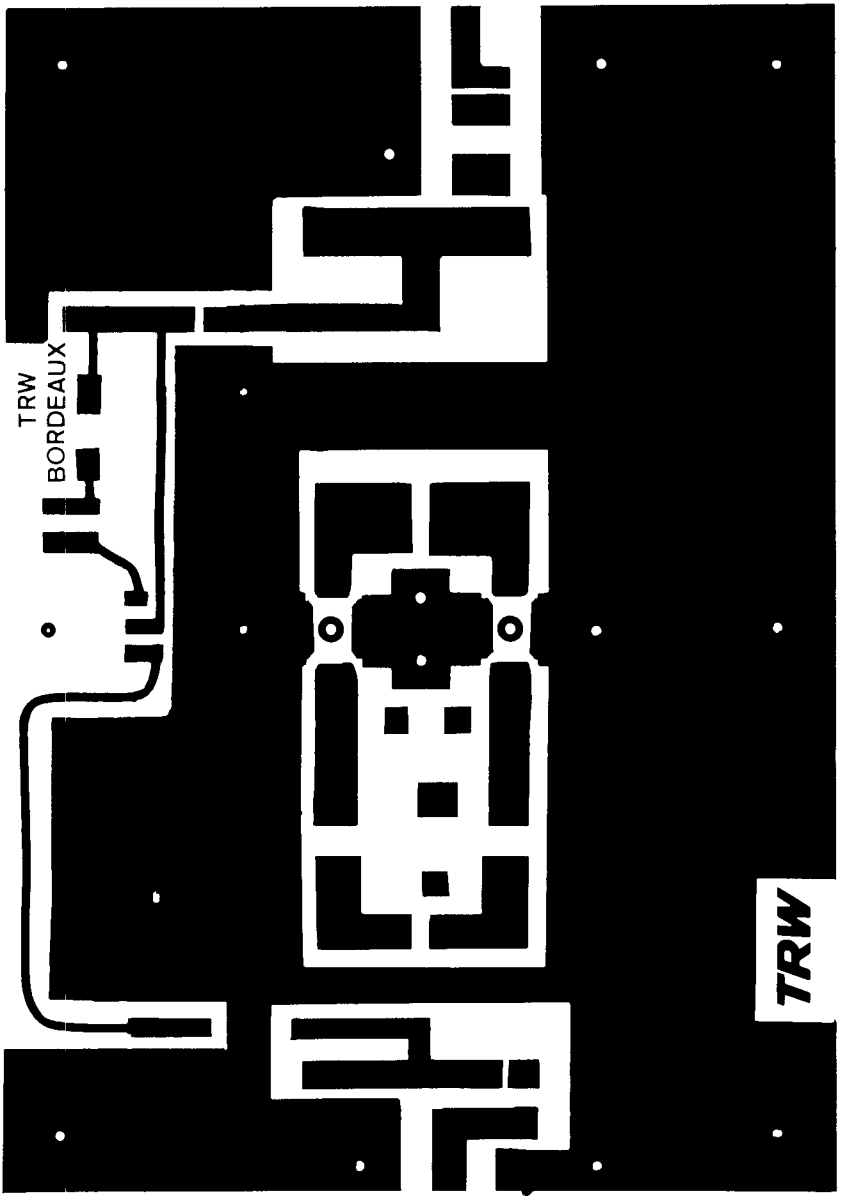
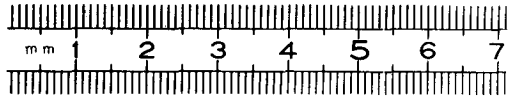


Fig. 23.

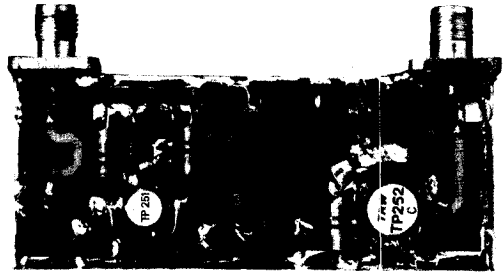
TRW® SEMICONDUCTORS

APPLICATION NOTE N° 7



7.5V - BROADBAND AMPLIFIER

- 1,5 Watts - 20 dB - - 400 - 512 MHz -



Introduction

For portable FM equipment, it is necessary to design RF power amplifiers supplied by low voltage batteries. The typical voltages used are 7.5 V to 9.6 V. Output power required is about 1.5 watts out of the amplifier. The most important problem is to provide very good efficiency in order to have a longer battery operating time. Small size is also required.

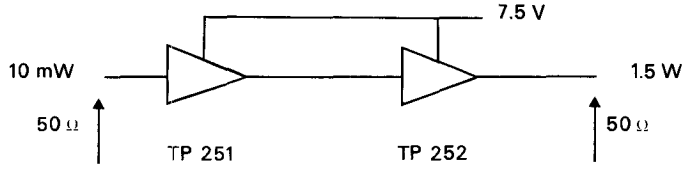
General design considerations

The design of a broadband power amplifier that will operate from a 7.5 V source and provide 1.5 W output with 50 % typical efficiency requires that careful attention be paid to impedance matching.

Performance constraints :

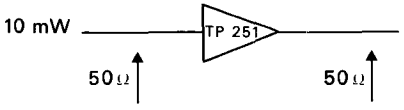
V_{CC} = 7.5 V.
P_{out} = 1.5 watts min. with 20 dB gain.
Frequency range = 400-512 MHz broadband.
Efficiency = 40 % min. 45 % to 50 % typical.
Input return loss = — 10 dB max.
Input and output load impedance = 50 ohms.

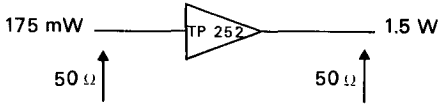
TRW's new 7.5 V transistor family offers the capability of meeting this specification with only 2 stages.



Looking at the TP 251 data sheet we can see that the real part of the output impedance is ≃ 50 ohms for 175 mW output.

For this reason we have taken the approach of designing the matching networks around each device such that each transistor is matched 50 Ω in/50 Ω out. This gives us the added advantage that, during early design, each stage may be looked at on an individual basis.





Analysis and optimization of circuits was made by computer (compact program).

Example of calculation

Since it is necessary to have a very good efficiency, as one example, we will describe the design of the output matching for the final stage TP 252.

The TP 252 data sheet gives us :

Frequency	Z_{out} (Ω)	
400 MHz	13 — j 7.5	V_{CC} = 7.5 V
470 MHz	11 — j 6	
520 MHz	10 — j 4.5	P_{out} = 1.5 W

In order to facilitate easy connection of the transistor collector lead to the circuit, it is necessary to start with a short length of line with sufficient width. For this reason a stripline L_{11} (Z_0 = 25 Ω, l = 4 mm for εr = 1) is connected at the output of the TP 252 (fig. 1). The resulting transformation of the output impedance is the following :

$$Z = \begin{matrix} f^- \text{ 400 MHz} \\ f_0 \text{ 470 MHz} \\ f^+ \text{ 520 MHz} \end{matrix} \quad \begin{matrix} 12.75 - j\,6.82\ (\Omega) \\ 10.81 - j\,5.15\ (\Omega) \\ 9.86 - j\,3.55\ (\Omega) \end{matrix}$$

After normalization to Z_0 = 70 Ω (We have chosen 70 ohms transmission line in order to realize a small mechanical size). Fig. 2.

$$z_1 = \begin{matrix} f^- \text{ 400 MHz} \\ f_0 \text{ 470 MHz} \\ f^+ \text{ 520 MHz} \end{matrix} \quad \begin{matrix} 0.18 - j\,0.1 \\ 0.15 - j\,0.07 \\ 0.14 - j\,0.05 \end{matrix} \quad \text{or} \quad y_1 = \begin{matrix} 4.24 + j\,2.35 \\ 5.30 + j\,2.51 \\ 6.31 + j\,2.30 \end{matrix} \quad \text{with} \quad Y_0 = \frac{1}{70}\,\mho$$

If we connect in parallel an admittance value — j 2.51 this improves the real impedance at f_0.
The Smith chart shows this is possible using a line L_{12} (Z_0 = 70 Ω - l = 0.06 λ) connected in parallel and with short circuit termination - fig. 2.

$$y_1 \rightarrow y_2 = \begin{matrix} 4.24 - j\,0.68\ f^- \\ 5.30 + j\,0\quad f_0 \\ 6.31 + j\,0.03\ f^+ \end{matrix}$$

For f_0, the intersection with the circle y = 1.4 — jX is possible if we connect a line L_{13} (Z_0 = 70 Ω, l = 0.052 λ).

$$y_2 \rightarrow y_3 = \begin{matrix} 1.60 - j\,1.94\ f^- \\ 1.41 - j\,2.18\ f_0 \\ 1.09 - j\,2.21\ f^+ \end{matrix}$$

Admittance C_{11} y = j 2.18, Y = 31 mV (10.5 pF for f_0 = 470 MHz) completes the matching to y = 1.4 or Z = 50 Ω.

$$y_3 \rightarrow y_4 = \begin{matrix} 1.60 - j\,0.12\ f^- \\ 1.41 + j\,0\quad f_0 \\ 1.09 + j\,0.17\ f^+ \end{matrix} \qquad Y_0 = \frac{1}{70}\,\mho$$

After normalization to Z_0 = 50 ohms, we can write :

$$z_4 = \begin{matrix} f^- = 400 \text{ MHz} \\ f_0 = 470 \text{ MHz} \\ f^+ = 520 \text{ MHz} \end{matrix} \quad \begin{matrix} 0.87 + j\,0.066 \\ 1 + j\,0 \\ 1.25 - j\,0.19 \end{matrix} \quad \text{or} \quad Z_4 = \begin{matrix} 43.5 - j\,3.3\ (\Omega) \\ 50 + j\,0\ (\Omega) \\ 63.5 - j\,9.5\ (\Omega) \end{matrix}$$

The final circuit is the following :

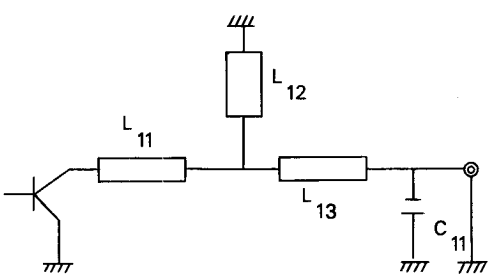


Fig. 1

L_{11} Z_0 = 25 Ω l = 0.006 λ εr = 1
L_{12} Z_0 = 70 Ω l = 0.06 λ εr = 1
L_{13} Z_0 = 70 Ω l = 0.052 λ εr = 1
F_{REF} = 470 MHz
C_{11} = 10.5 pF

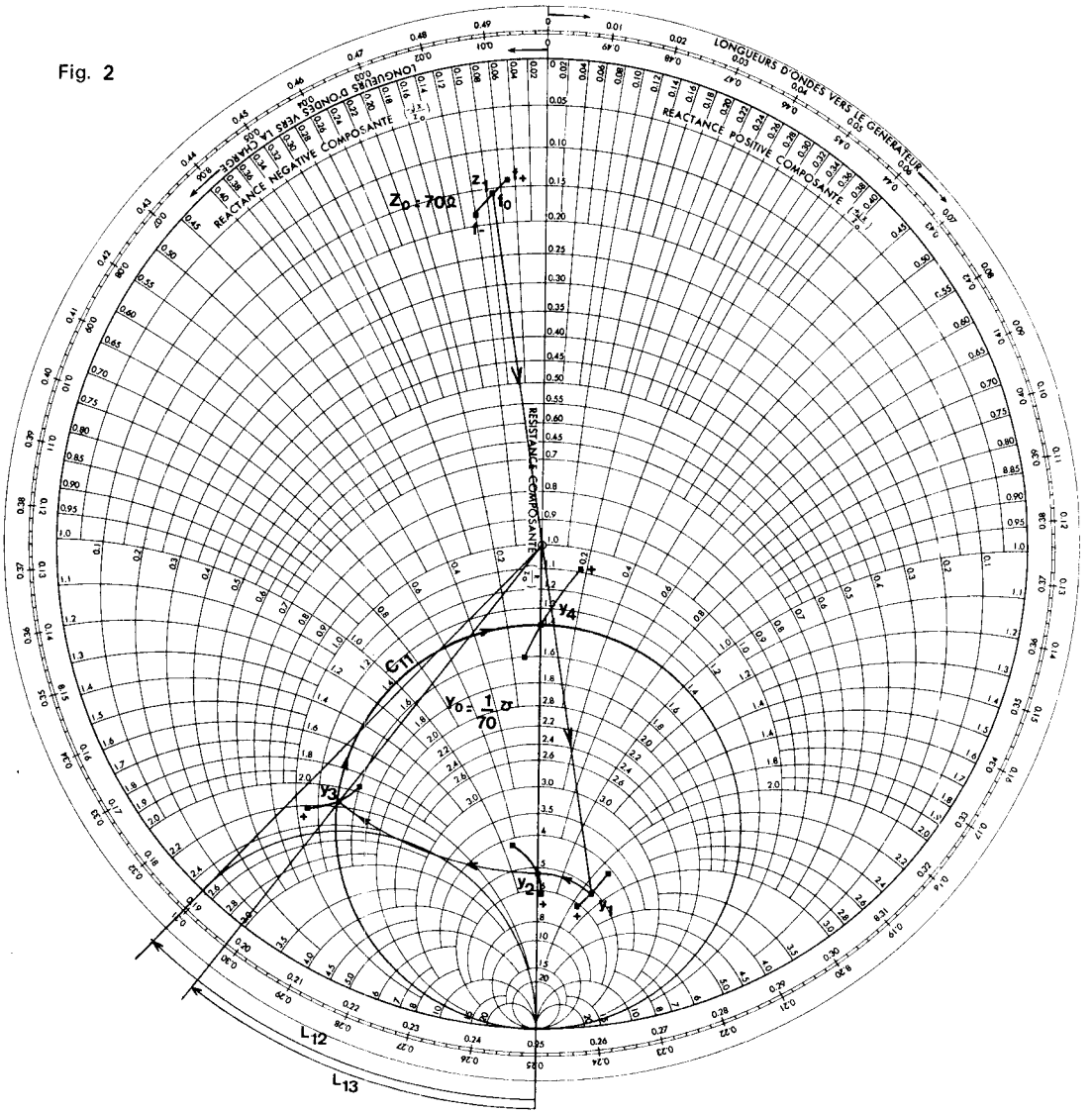
Analysis of this circuit by computer gives the following results :

Output refl. coef. and VSWR in 50. ohm system

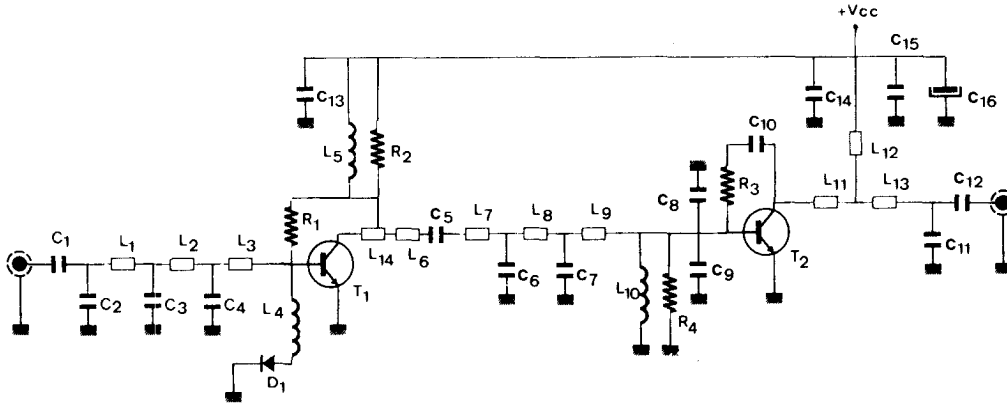
F (MHz)	Rho (magn. < angle)	VSWR	Ret L/G (dB)	Z (R + jX) ohm
400.000	0.067 150.2	1.14 : 1	— 23.47	44.4 3.0
470.000	0.002 — 172.2	1.00 : 1	— 53.25	49.8 -- 0.0
520.000	0.149 — 37.9	1.35 : 1	— 16.56	62.1 -- 11.6

N.B. — • Line L_{12} is a convenient point to supply the transistor but it is necessary to realize a good RF short circuit at this end.
• L_{12} provides a low load impedance for the transistor at low frequencies (stability).
• The good matching over the frequency range ensures that we acheive optimum efficiency.

Fig. 2



SCHEMATIC



List of components

C_1 = 27 pF Ceramic 632 RTC
C_2 = 8.2 pF Ceramic 632 RTC
C_3 = 18 pF Ceramic 632 RTC
C_4 = 22 pF Ceramic 632 RTC
$C_5 = C_{10} = C_{12} = C_{13} = C_{14}$ = 1 nF Ceramic 629 RTC
C_6 = 12 pF Ceramic 632 RTC
C_7 = 15 pF Ceramic 632 RTC
$C_8 = C_9$ = 39 pF Ceramic Chip ATC
C_{11} = 10 pF Ceramic Chip ATC
C_{15} = 10 nF Ceramic 629 RTC
C_{16} = 10 µF/25 V Electrolytic

D_1 = 1 N 4001

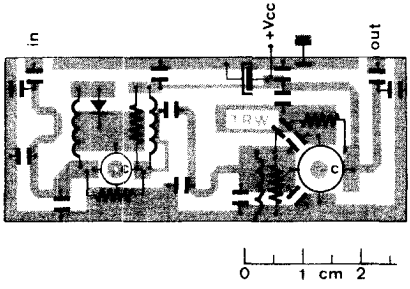
T_1 = TP 251 TRW
T_2 = TP 252 TRW

L_1 = Stripline Z_0 = 70 ohms 0.061 λ
L_2 = Stripline Z_0 = 70 ohms 0.026 λ
L_3 = Stripline Z_0 = 50 ohms 0.031 λ
$L_4 = L_5 = L_{10}$ = 0.15 µH Molded Coil
L_6 = Stripline Z_0 = 100 ohms 0.045 λ
L_7 = Stripline Z_0 = 70 ohms 0.043 λ
L_8 = Stripline Z_0 = 70 ohms 0.041 λ
L_9 = Stripline Z_0 = 25 ohms 0.031 λ
L_{11} = Stripline Z_0 = 25 ohms 0.006 λ
L_{12} = Stripline Z_0 = 70 ohms 0.064 λ
L_{13} = Stripline Z_0 = 70 ohms 0.052 λ
L_{14} = Stripline Z_0 = 50 ohms 0.009 λ

F_{REF} = 480 MHz

R_1 = 510 ohms 1/4 W carbon composition
R_2 = 270 ohms 1/4 W carbon composition
R_3 = 150 ohms 1/4 W carbon composition
R_4 = 10 ohms 1/4 W carbon composition

Example of realisation with epoxy glass substrate



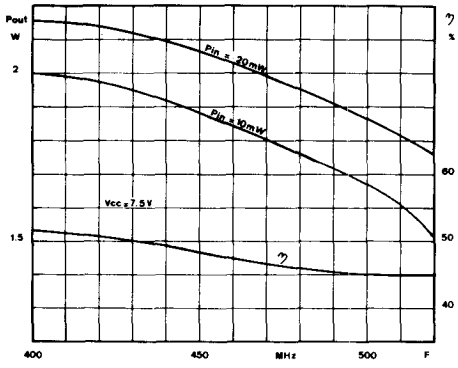
(h = 1/16" and εr = 4.1)

Edge of the PC board must bemetallized and it is necessary to locate plated through holes underneath the emitter leads of transistors.

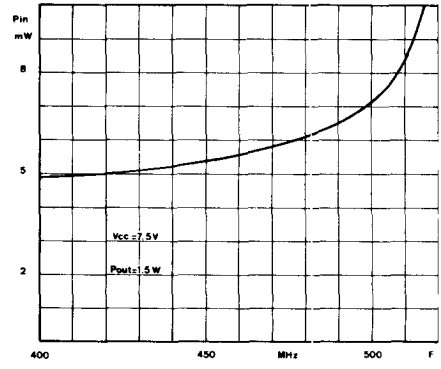
Components are mounted on the circuit side.

TYPICAL RESULTS

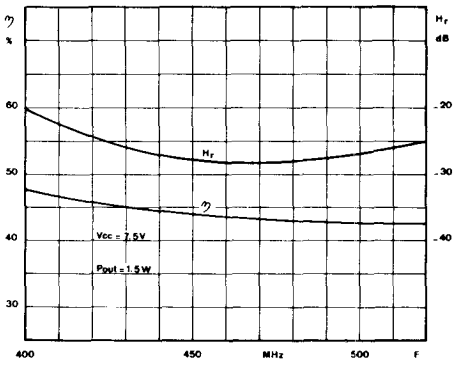
Output Power vs Frequency and Input Power



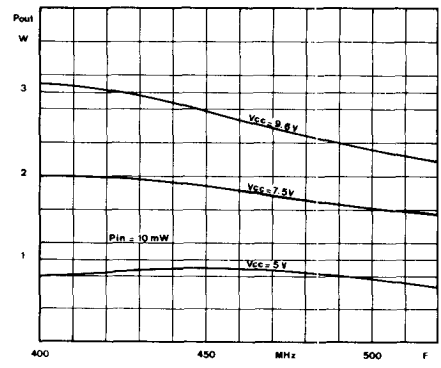
Input Power vs Frequency for 1.5 watts Output



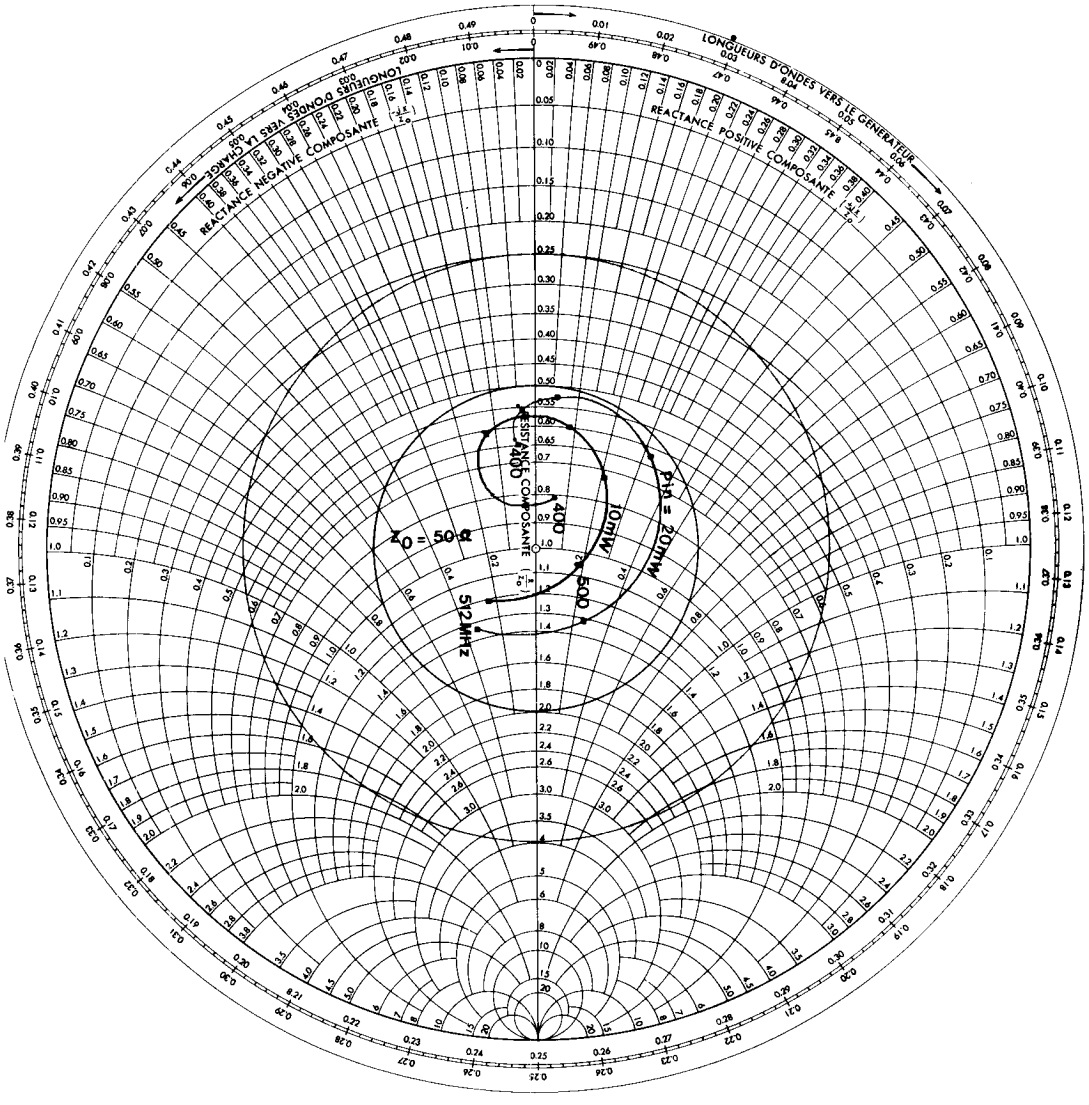
Efficiency and Harmonic Rejection vs Frequency



Output Power vs Frequency and Voltage Supply



Input Impedance vs Frequency and Input Power



Stability

To improve stability with VSWR at the output, it is necessary to put resistor (R_1 and R_3) between collector and base of transistors. In this condition, it is possible to guarantee stability with 3 : 1 VSWR all phases.

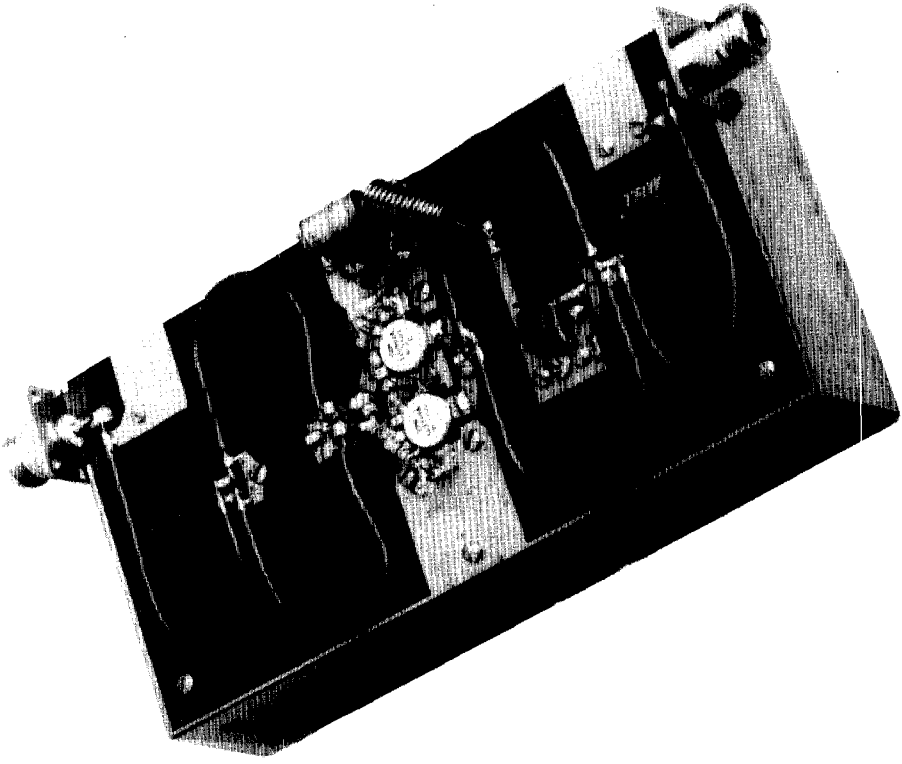
$5\ V \leqslant V_{CC} \leqslant 10\ V$ $\qquad$ P_{in} 0 to 20 mW

TRW SEMICONDUCTORS

APPLICATION NOTE
N° 8

SOLID STATE POWER AMPLIFIER

300 W FM



BROADBAND 88 – 108 MHz

INTRODUCTION

High efficiency multikilowat FM transmitters with full solid state amplifiers are possible today. The power amplifier of these transmitters should be made by multiparalleling of a basic building block amplifier. This building block should have a high output power and a high gain, a good collector efficiency, broad-band (88-108 MHz) frequency response and a simple, reproducible and reliable circuit design. This application note describes an FM building block amplifier that meets the requirements mentioned above and that can be successfully incorporated to a number of amplifier architectures.

The amplifier has been developed with a pair of TP 9383 transistors in push-pull configuration. TP 9383 is a double diffused silicon epitaxial transistor that makes use of gold metallization and diffused ballast resistors for long operationg life and ruggedness. Its basic specifications are :

V_{CC} = 28 V ; η = 75 % at 108 MHz and 150 W output power

G = 9 dB , Po = 150 W

DESIGN CONSIDERATIONS

When designing an FM amplifier the total efficiency must be the first goal.

Overall efficiency is the combination of good collect efficiency and high gain. To get a good collector efficiency the transistors must be operated in class C and the load impedance should match the transistors output impedance at the operation power level. Class C amplifiers are non-linear units. The harmonic content of the output signal of this type of amplifiers can be very high and their power wasted with an important reduction in the efficiency.

This fact made adventageous the use of balanced amplifiers. In such circuit arrangement all the even harmonic are largely suppressed and the waste of power minimized. Push-pull amplifiers have also the additional advantages of connecting in series for RF operation the input and output impedance of the 2 transistors. That makes considerably easier to match the input and output impedances of the transistor pair. However, as the impedance transformation is lower, the RF power losses are smaller and the gain and efficiency higher.

Another important consideration in the design of an FM amplifier is the ruggedness of the amplifier. FM transmitters are often operated 24 hours per day and sometimes remotly controlled and in difficult access sites. The operating point of the transistors should be choosen in a conservative way and the heat properly evacuated. A thermo switch should be incorporated to the system. The amplifier must also be able to withstand output VSWR. Although all transmitters use to incorporate VSWR protection in their interlocky systems, the amplifier must be designed with the capability of supporting VSWR of 3.1 as a minimum. This point can be very determinent when considering that on a high efficiency circuit the collector voltage swing can be close to 3 times the collector supply voltage.

CIRCUIT DESCRIPTION

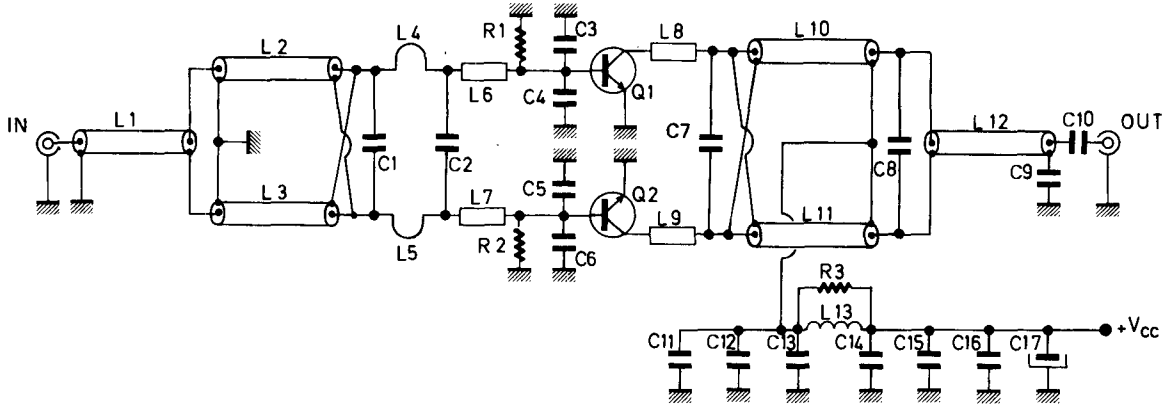
Circuit schematic is given in the Figure 1. At the amplifier input there is a two section balun. The first section, L_1, consists of a short lenght ($\simeq \lambda/20$) of 50 Ω coaxial semirigid cable. The outer conductor of the coaxial cable is grounded at the input side and floates at the output.

The second section of the balun consists of two identical coaxial cables, L_2 and L_3, of the same lenght that L_1 but with 25 Ω characteristic impedance. The ends of these two coaxials are interconnected in series at the input side (thus offering 50 Ω impedance to L_1) and in parallel at the output of the section.

The combined balanced impedance will be therefore 12.5 Ω at the output of the balun. The input impedance of the transistor pair Q_1 and Q_2 is transformed to 12.5 Ω (2 $\times$ 6.25) with the LC network represented in the schematic.

If this balun is well charged by 2 $\times$ 6.25 Ω it is well capable of multioctave operation. However in this case the LC network that transform the impedances of the transistor pair has been optimized only between 88 and 108 MHz.

A similar balun circuit is used at the output of the amplifier. The main difference with the input balun is that the coaxial cables are also used in the collect biasing circuit. Care has been taken with the decoupling of the collect bias in order to avoid low frequency oscillations. The collect impedance is higher than the base impedance and therefore the LC output transforming network is very simple, only L_8, L_9 and C_7.



88-108 MHz; 300 W 28 V

BROADBAND POWER AMPLIFIER FM

Figure 1

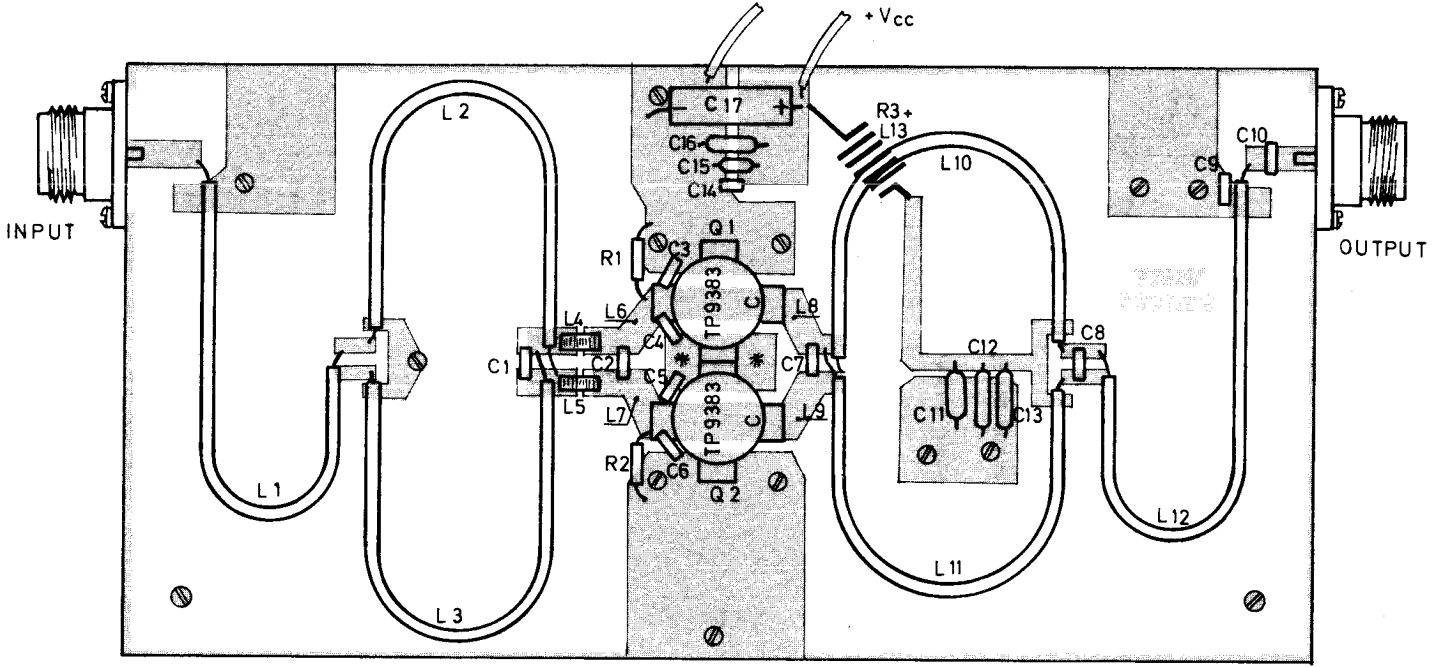
COMPONENTS LIST

C_1	= 120 + 80 pF Chip capacitor ATC 100 B
C_2	= 220 pF Chip capacitor ATC 100 B
C_3, C_4, C_5, C_6	= 470 pF Chip capacitor ATC 100 B
C_7	= 100 pF Chip capacitor ATC 100 B
C_8	= 27 pF Chip capacitor ATC 100 B
C_9, C_{10}, C_{11}, C_{14}	= 1 000 pF Disc capacitor
C_{12}, C_{15}	= 10 nF
C_{13}, C_{16}	= 0,1 µF
C_{17}	= 1 000 µF/63 V Electrolytic

L_1	= 50 Ω coaxial cable ⌀ 3,2 mm (Teflon) L = 110 mm
L_2, L_3	= 25 Ω coaxial cable ⌀ 3,2 mm (Teflon) L = 110 mm
L_4 L_5	= Hair pin : copper foil 18 × 3 mm 0,3 mm thickness
L_6, L_7	= Line on substrate : 15 × 5 mm
L_8, L_9	= Line on substrate : 10 × 5 mm
L_{10}, L_{11}	= 25 Ω coaxial cable ⌀ 5 mm (Teflon) L = 110 mm
L_{12}	= 50 Ω coaxial cable ⌀ 5 mm (Teflon) L = 110 mm
L_{13}	= 15 turns ⌀ 8 mm 1,4 mm wire

R_1, R_2	= 22 Ω 1/2 W
R_3	= 47 Ω 2 W

Q_1, Q_2	= TP 9383

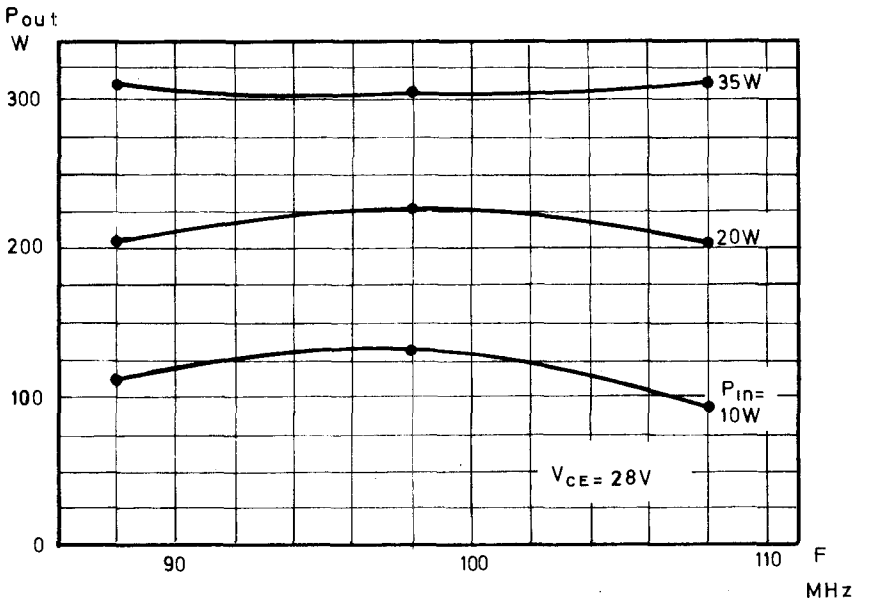


* Grouding eyelet.

Epoxy glass dual side coated

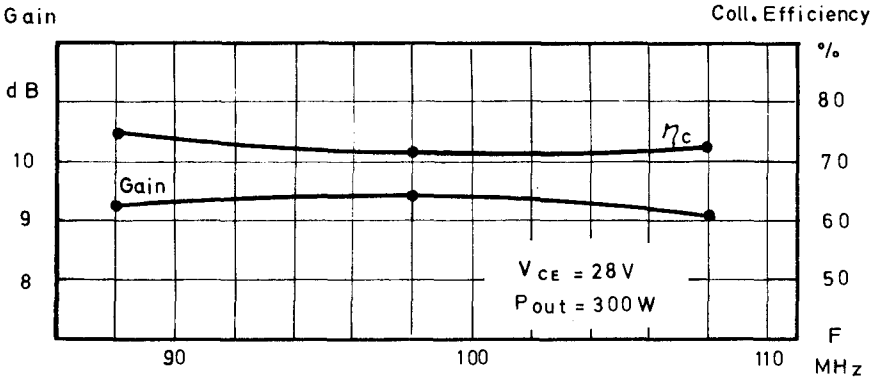
Figure 2

J 574



Pin/Pout

Figure 3



Gain and Efficiency

Figure 4

A BROADBAND AMPLIFIER FOR MATV APPLICATIONS
200 mV; 40-860 MHz

This note describes the performance of a broadband 200 mV three stage linear amplifier designed for service in the band 40-860 MHz as MATV amplifier.

DEVICES USED

Three TP 491 (T-pack)

BASIC SPECIFICATION

Frequency range : 40-860 MHz
Gain : 29.5 $\pm$ 1.8 dB
Noise figure : 6 dB at 500 MHz
Input and output impedances : 75 Ω
VSWR input $\leqslant$ 3 : 1
VSWR output $\leqslant$ 1.7 : 1
IMD* $\leqslant$ — 60 dB at 200 mV and 500 MHz
Supply voltage : 12 V
Supply current : 70 mA
* DIN 45004/B

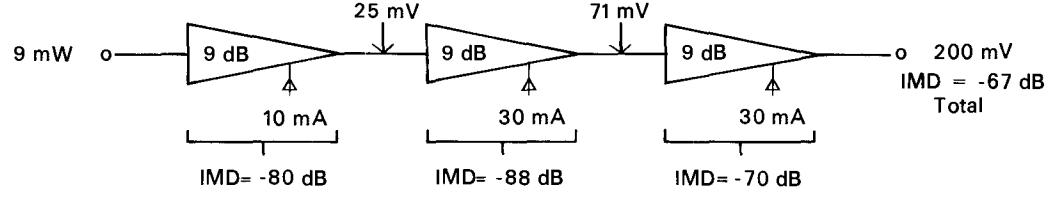
GENERAL CONSIDERATIONS

The aim was to design a low cost broadband amplifier for MATV using the TP 491 (T-pack) transistor. With a typical gain of 11.5 dB for the TP 491 at 860 MHz, we can expect for a broadband amplifier using negative feedback to stabilize the gain over the bandwidth, about 9 dB per stage. This gives about 27 d B for the total amplifier. The collector currents of the two last stages were chosen to obtain good distortion performance (I_E = 30 mA) and the first stage current was chosen as a compromise between noise figure and distortion (I_E = 10 mA) :

at 10 mA : — NF = 2 dB (with optimum noise source impedance).
— IMD = — 80 dB for 25 mV output voltage.

From the IMD versus Ic curve on the data sheet and using the approximate rule that the IMD/output power slope is 2 dB/1 dB, we can estimate the IMD at 500 MHz of each stage and then by adding the IMD vectors (they have the same phase for the 3rd order distortion) we can estimate the total IMD at 500 MHz.

$IMD_{Total} = 20 \log (10^{-80/20} + 10^{-88/20} + 10^{-70/20}) = -67$ dB



In order to obtain a good IMD performance we have tried to optimize the output VSWR for each stage.

The noise figure is not easy to estimate since :

— the amplifier is not optimized for noise but to have a relatively good input match, which means the noise source impedance is not optimized,

— the negative feedback is achieved using resistors which increases the noise figure.

If a low noise figure is required without IMD consideration, we must modify the first stage by reducing the current which should be optimized for noise performance.

AMPLIFIER DESIGN

The amplifier consists of three identical basic stages called CC on figure 1, using shunt feedback and serie feedback to stabilize the gain-frequency characteristic, and single matching networks for the input, inter-stage and output matching.

The calculation using the S-parameters of TP 491, was done with the aid of a computer and the COMPACT program, which is an analysis and optimization program for passive and active circuits. The program, the final values and the final analysis are shown in figures 1, 2 and 3.

The difficulty with this kind of amplifier is that we use lumped elements up to 860 MHz. Unfortunately their behaviour above 500 MHz tends to deviate from the theoretical, which means we have to optimize the more critical elements empirically.

Figure 8 shows the empirical schematic.

Figure 3 shows the difference between calculated and empirical values.

Calculated gain : see figure 4

Calculated Zin : see figure 5

Calculated Zout : see figure 6

AMPLIFIER PERFORMANCE

- Gain versus frequency : Figure 4
- Input impedance : Figure 5
- Output impedance : Figure 6
- NF at 500 MHz : 6 dB
- IMD versus output voltage : Figure 7
- Bias conditions : Vcc = 12 V I_{Total} = 70 mA

TECHNOLOGY AND LAYOUT CONSIDERATIONS

Epoxy-glass 1/16 inch (Er = 4.1) is used as board material but no transmission line is used and the substrate can therefore be changed without changing the PC board layout.

- Schematic : Figure 8
- PC board layout : Figure 9

RF EQUIVALENT CIRCUIT FOR COMPACT PROGRAM

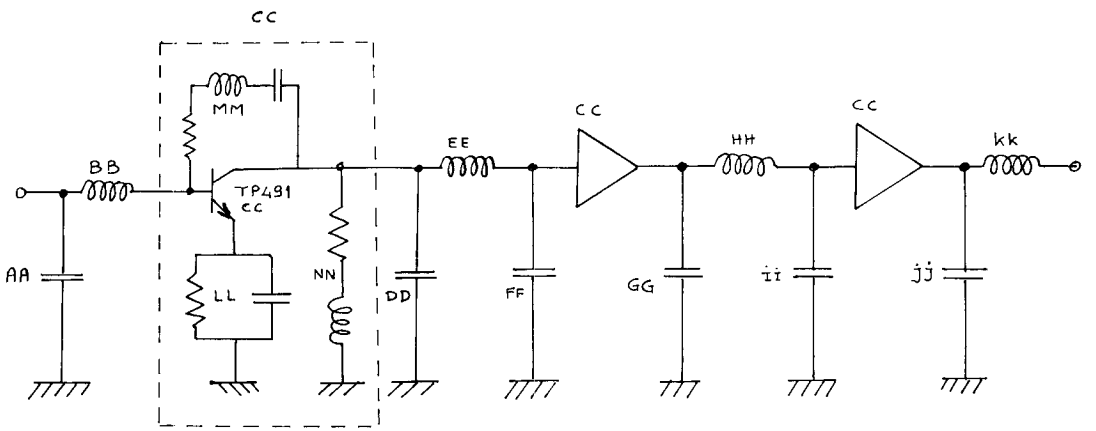


Figure 1

COMPACT PROGRAM

```
CAP  AA   PA   — 4.038
IND  BB   SE   — 6.694
TWØ CC   S1     50.00
PRC  LL   PA   — 9.448      — 12.24
SER  CC   LL
SRX  MM  SE   — 265.9        4.300       56.00
PAR  CC   MM
SRL  NN   PA     91.00       120.0
CAS  CC   NN
CAP  DD   PA     1.400
IND  EE   SE     4.400
CAP  FF   PA     3.200
CAS  FF   CC
CAP  GG   PA     1.800
IND  HH   SE    28.10
CAP  II   PA     1.700
CAS  II   CC
CAP  JJ   PA   — 2.594
IND  KK   SE   — 6.709
CAX  AA   KK
PRI  AA   S1     75.00
END
```

CIRCUIT DEFINITION
(— : variables)

```
40  100  200  500  750  900
END
```

FREQUENCY (MHz)

```
.599 320 28.5  105  .0113 61 .75   330
.450 278 17.78 122  .0159 63 .66   342
.333 225 11.09 105  .0224 65 .517  341
.267 196 5.37  76   .0562 68 .5119 335
.271 176 4.08  71   .0768 66 .515  329
.279 164 3.31  68.5 .0891 65 .517  325
END
```

POLAR S-PARAMETERS
FOR TWO CC (TP 491)

```
1
10  10  1  29
END
```

OPTIMIZATION DATA

VARIABLES	GRADIENTS
(1) : 4.03804	(1) : .213757
(2) : 6.69433	(2) : .126163E-01
(3) : 9.44751	(3) : — 1.20523
(4) : 12.2431	(4) : .472764
(5) : 265.861	(5) : 1.02654
(6) : 2.59366	(6) : .605981E-02
(7) : 6.70918	(7) : .131875

ERR. F. = 2.651

SEARCH INTERRUPTED, **FINAL ANALYSIS FOLLOW**

POLAR S-PARAMETERS IN 75.0 OHM SYSTEM

FREQ.	S11 (MAGN<ANGL)	S21 (MAGN<ANGL)	S12 (MAGN<ANGL)	S22 (MAGN<ANGL)	S21 DB	K FACT.
40.00	0.13 < — 122	30.38 < 124.4	0.002 < 28.1	0.31 < 179	29.65	6.48
100.00	0.19 < — 135	25.34 < 125.9	0.003 < — 0.4	0.28 < 170	28.08	6.20
200.00	0.19 < — 133	30.51 < 65.7	0.003 < — 42.2	0.30 < — 167	29.69	4.47
500.00	0.64 < — 148	27.23 < — 111.5	0.002 < — 117.7	0.39 < 89	28.70	4.77
750.00	0.56 < 159	30.05 < 150.6	0.003 < — 153.2	0.13 < 15	29.56	4.45
900.00	0.23 < 15	26.15 < 41.3	0.004 < 144.5	0.18 < — 156	28.35	4.77

Figure 2

ELEMENT VALUES

		Calc. Value	Empirical Value
AA	pF	4.0	1.8
BB	nH	6.7	5 + parasitic
CC	Transistor	TP 491	TP 491
LL	Ω	9.4	10
	pF	12.2	13.8
MM	Ω	266	300
	nH	4.3	10 + parasitic
	pF	56	56
NN	Ω	91	91
	nH	120	120
DD	pF	1.4	1.8
EE	nH	4.4	10 + parasitic
FF	pF	3.2	1.2
GG	pF	1.8	0
HH	nH	28.1	2 + parasitic
II	pF	1.7	2.7
JJ	pF	2.6	1.2
KK	nH	6.7	10 + parasitic

Figure 3

GAIN VS FREQUENCY

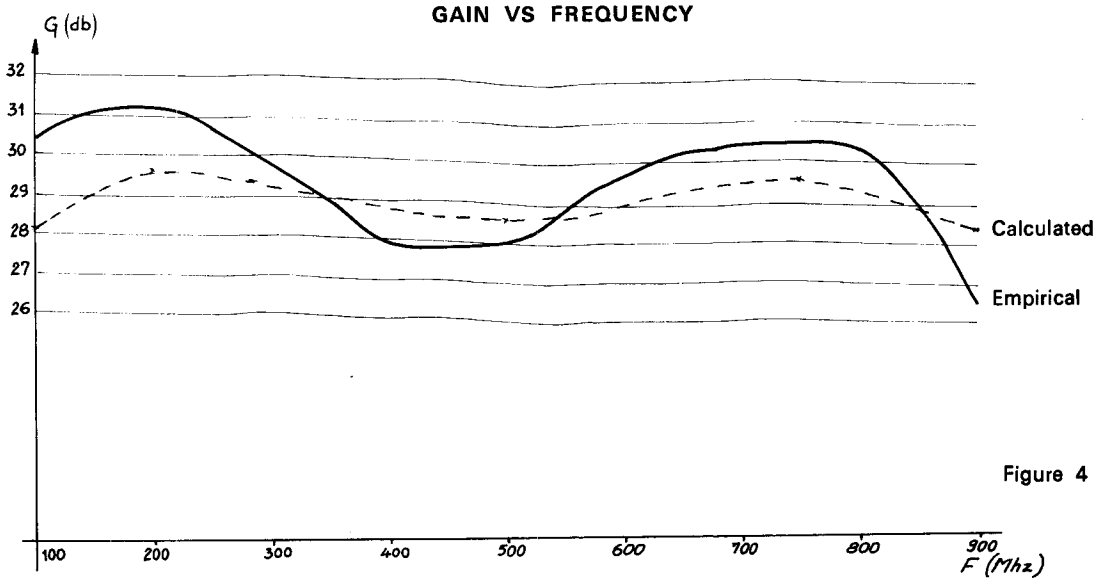


Figure 4

INPUT IMPEDANCE

Empirical value

Calculated value

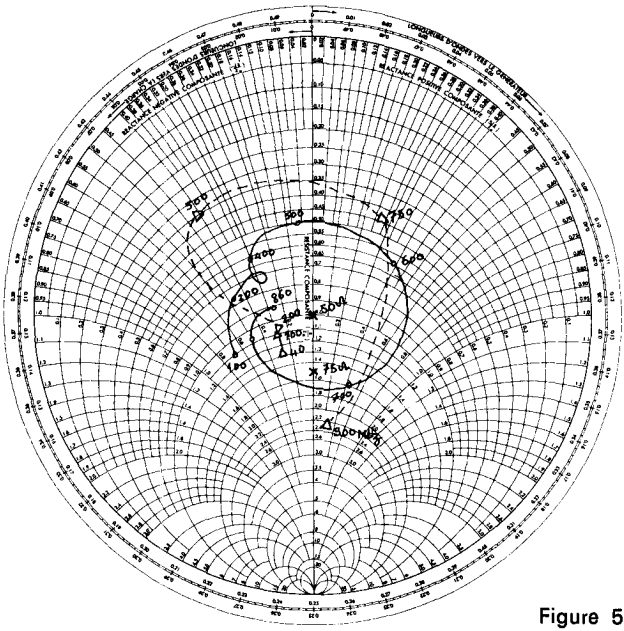


Figure 5

OUTPUT IMPEDANCE

Empirical value

Calculated value

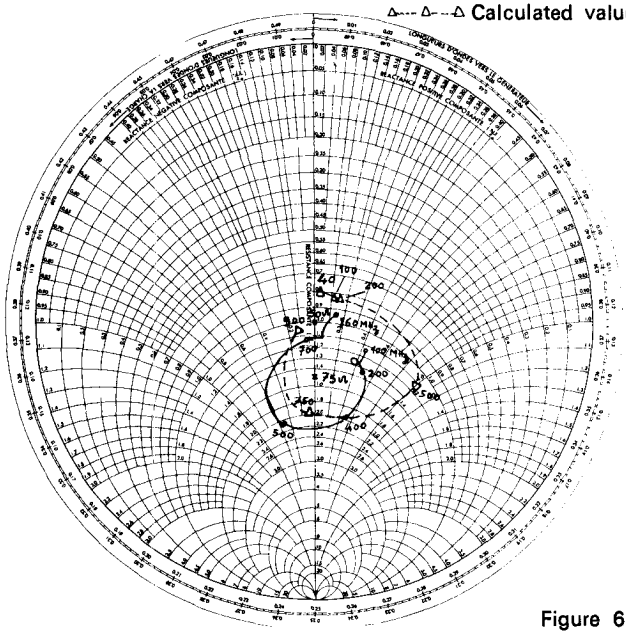
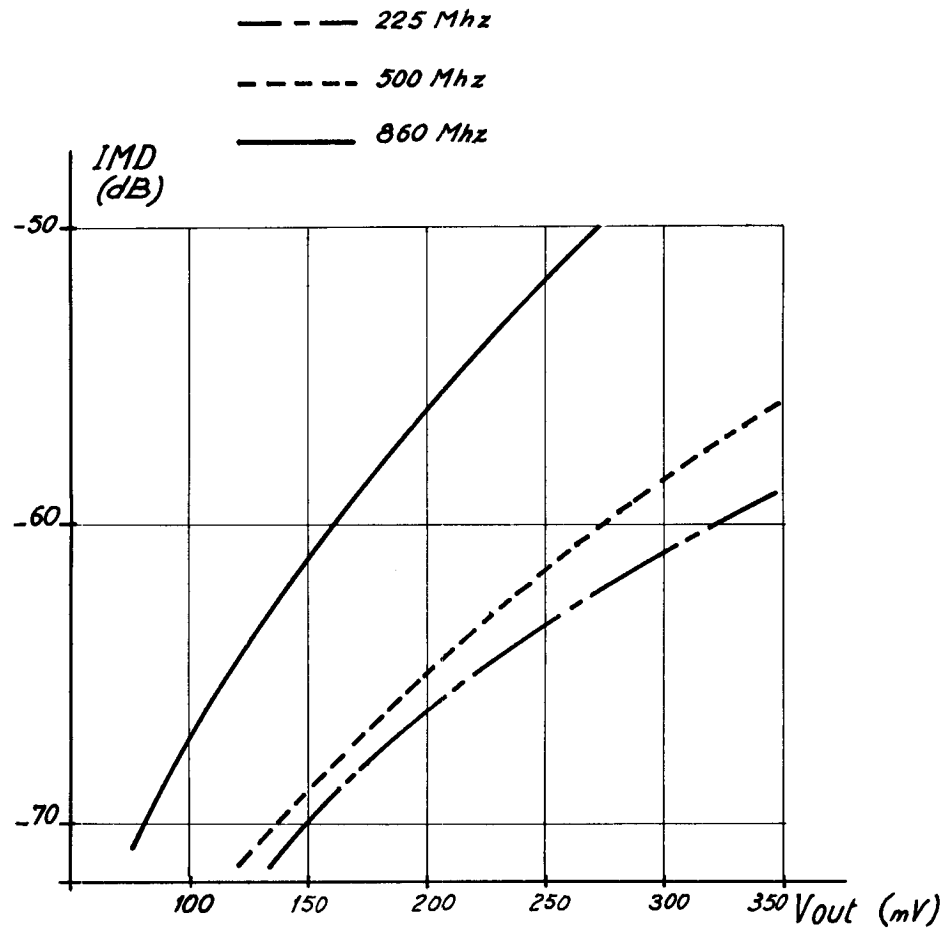
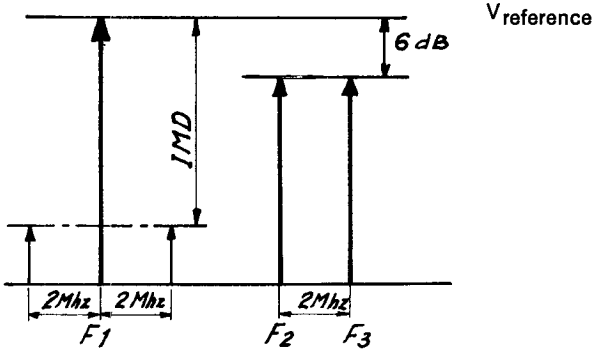


Figure 6

IMD* VS FREQUENCY AND OUTPUT VOLTAGE



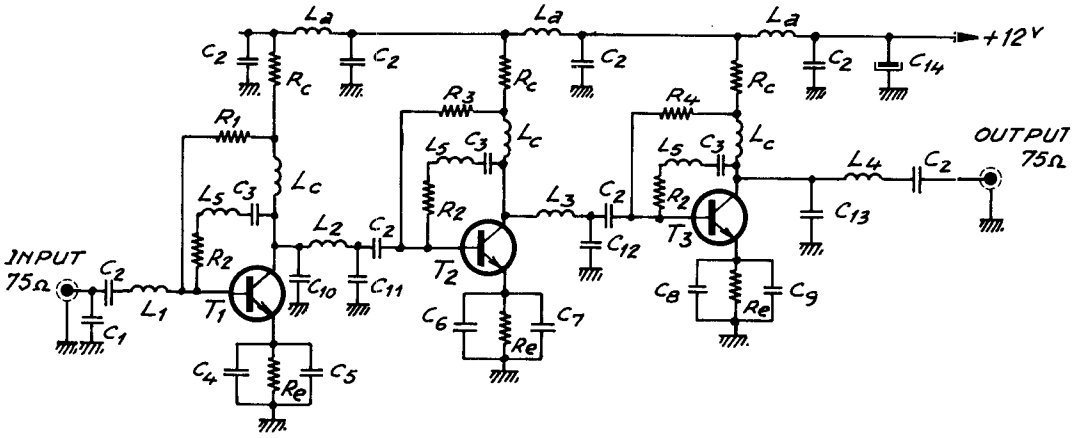
* DIN 45004 B



TRW-CE

Figure 7

DIAGRAM CIRCUIT



R_e	10 Ω 1/4 W metal-film resistor
R_c	91 Ω 1/4 carbon-composition
R_1	100 kΩ 1/4 W carbon-composition
R_2	300 Ω 1/4 W carbon-composition
R_3	33 kΩ 1/4 W carbon-composition

Capacitor-ceramic

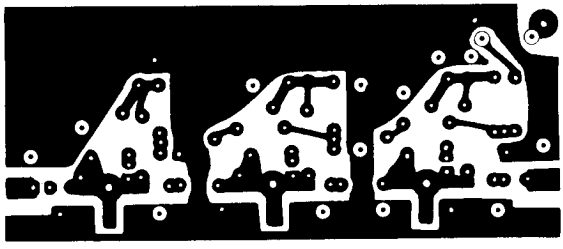
C_1	1.8 pf C632 RTC
C_2	10 nf C629 RTC
C_3	56 pf C632 RTC
$C_4C_6C_8$	8.2 pf C632 RTC
C_5C_7	5.6 pf C632 RTC
C_9	6.8 pf C632 RTC
C_{10}	1.8 pf C632 RTC
$C_{11}C_{13}$	1.2 pf C632 RTC
C_{12}	2.7 pf C632 RTC
C_{14}	50 µf 25 volts

L_1	1 turn 5/10 mm Cu ID 4 mm 5 nh
$L_2L_4L_5$	2 turns 5/10 mm Cu ID 3 mm 10 nH
L_5	1/2 turn 5/10 mm Cu ID 3 mm 2 nH
L_a	0.33 µH molded coil
L_c	120 nH 14 turns 7/10 enameled wire ID 3 mm

$T_1.T_2.T_3$ TP 491 TRW-CE

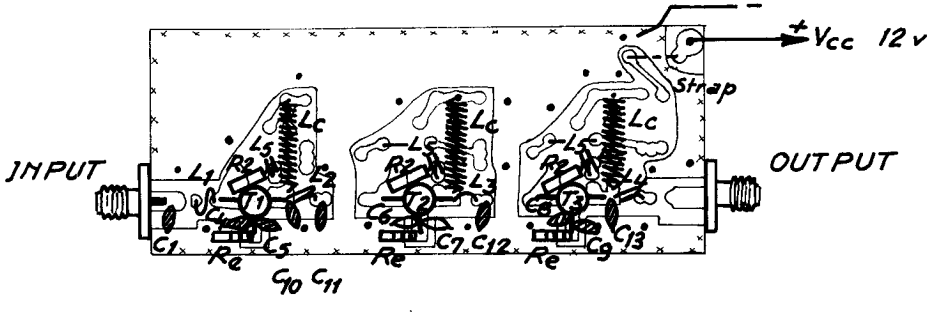
Figure 8

PC BOARD LAYOUT



COMPONENT LAYOUT

Topside



BOARD MATERIAL : EPOXY GLASS (G 10) 1/16 inch $\varepsilon_r \simeq 4.2$

● Strap between the planes. **** Foil wrap or plate around to ground plane.

Back side

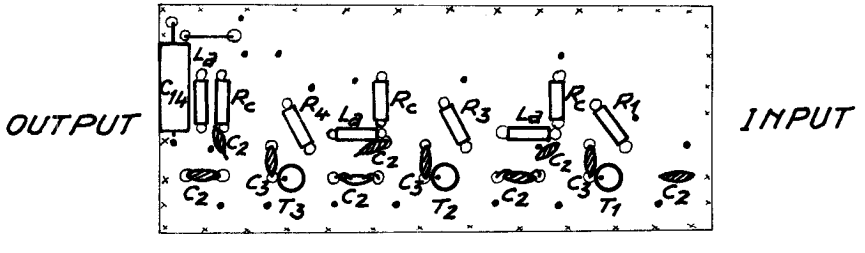


Figure 9

1.2 V, 40-900 MHz BROADBAND AMPLIFIER WITH THE TP 3400 TRANSISTOR

INTRODUCTION

This application note describes a single stage broadband amplifier incorporating the TP 3400 transistor. The amplifier will deliver 1.2 V output signal from 40 to 900 MHz at an intermodulation level* of — 60 dB or less. The gain is 9.5 dB ± 0.5 dB. Although the amplifier has been designed for MATV use, its simplicity and versatility makes it suitable for use in many other applications. The circuit construction is straight forward and only standard components have been used.

TP 3400

The TP 3400 is a NPN gold metallized transistor with a transition frequency of more than 3 GHz. The transistor is housed in a SOE 200 package.

The TRW gold metallization process used on the manufacture of this transistor is etchless, providing exact finger definition with submicron resolution and avoids the finger scalloping characteristic of all etching processes, which eliminates therefore current crowding where metal fingers are necked down. Moreover this gold process improves on all the benefits of gold over aluminium regarding electromigration.

The TP 3400 also incorporates diffused ballast resistors. High resistance ballast resistors are diffused directly into the silicon avoiding therefore all the reliability problem associated with conventional thin film, metal ballast resistors. In addition the P-N diode of the ballast resistor is diffused to avalanche at a lower voltage than the transistor, thus protecting effectively the transistor against VSWR or transient damage. A diagram illustrating the above mentioned technological characteristic is given in fig. 1.

TRW DIFFUSED BALLAST RESISTORS WITH ETCHLESS GOLD METALLIZATION VS. **CONVENTIONAL THIN FILM BALLAST RESISTORS WITH ETCHED METALLIZATION**

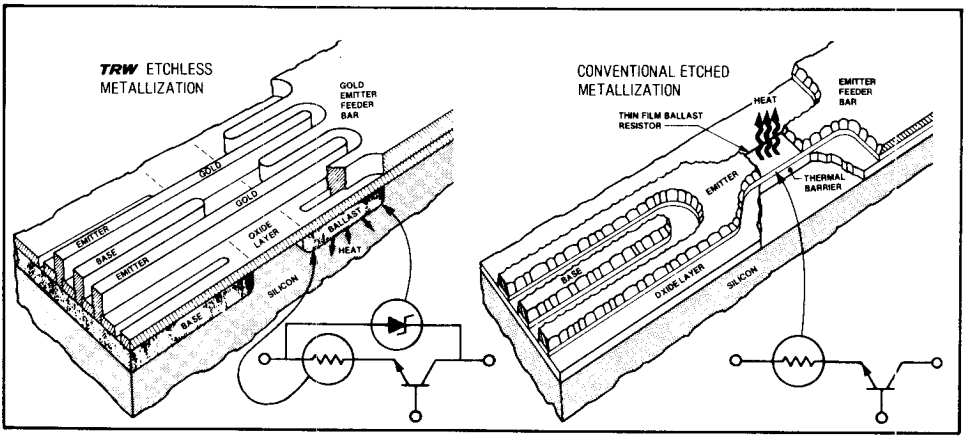


Figure 1

(*) Intermodulation measured with a test procedure in accordance with DIN 45004/B.

AMPLIFIER DESIGN

a) Calculations

The amplifier configuration choosen is given in figure 2. A combination of series and shunt feedback compensates the frequency gain slope of the transistor. Transmission line inductors are used on the shunt feedback network. The resistor in series with the base will improve the input VSWR at the cost of some gain, but this gain decrease is partially compensated by the fact that less series feddback is necessary in this way.

The calculation and optimization of the circuit was carried out with the aid of a computer using the COMPACT program. The program, the optimization data and the final expected results are given in table. 1. The expected gain is 9.5 dB plus/minus 0.5 dB, the amplifier is unconditionally stable over the required frequency range and input and output impedance matchings could be considered correct.

b) Amplifier assembly

Final amplifier is shown in fig. 3. The component values are given in table 2. The amplifier was built on standard Epoxy glass double clad printed circuit board and all the components are commonly used types. The resistors are carbon-composition type. Care was taken with all ground returns, made by wrapping copper foil between both planes. Plated trough holes may also be used. PC board and component layouts are given in figures 4 and 5 respectively.

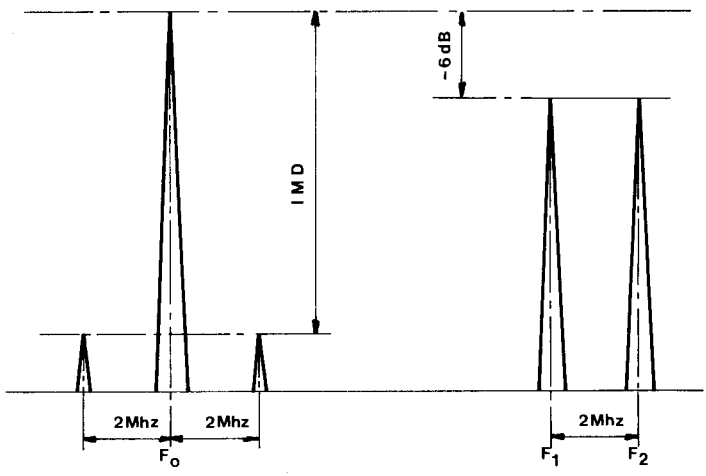
RESULTS

Several TP 3400 transistors, covering all the accepted production spread, were used and no significant differences in the amplifier performance were recorded.

Input and output matching are given in figures 6 and 7. Gain versus frequency is given in figure 8. It is similar to that calculated.

Figure 9 shows its behaviour as an MATV amplifier, measured according to the DIN 45004B test procedure. The — 60 dB IMD level is attained at 1.2 volt, 75 output.

INTERMODULATION MEASUREMENT ACCORDING DIN 45004/B



COMPACT PROGRAM **Table 1**

```
MET   AA   ZZ
CAP   AA   PA   — 2.078
TRL   BB   SE     65.00      — 19.96      1.000
RES   CC   SE   — 12.44
TRL   DD   SE     65.00      — 18.35      1.000
CAP   EE   PA   — 2.101
TWO   HH   SI     50.00
CAS   EE   HH
RES   II   PA   — 6.759
SER   EE   II
CAP   JJ   PA   — .8989
SRL   KK   PA     35.00        1000.
TRL   LL   SE     65.00      — 10.15      1.000
CAX   JJ   LL
CAS   EE   JJ
RES   MM   SE   — 204.7
TRL   NN   SE     65.00      — 7.229      1.000
CAS   MM   NN
PAR   EE   MM
TRL   FF   SE     65.00      — 14.60      1.000
CAP   GG   PA   — .9557
CAX   AA   GG
PRI   AA   SI     50.00
END
```

CIRCUIT DEFINITION

```
100  200  300  400  500  600  700  800  900
END
```

FREQUENCY (MHz)

```
.61  226  17.8  126  .0200  35  .53  320
.73  203  12.9  103  .0282  33  .32  305
.77  192  9.23   93  .0299  33  .27  297
.75  185  6.92   84  .0335  33  .27  295
.75  179  5.15   79  .0335  38  .27  300
.78  174  4.68   72  .0355  42  .24  300
.77  167  3.34   61  .0447  44  .27  285
.77  163  3.16   56  .0473  44  .24  290
END
```

POLAR S PARAMETERS FOR TWO HH (TP 3400)

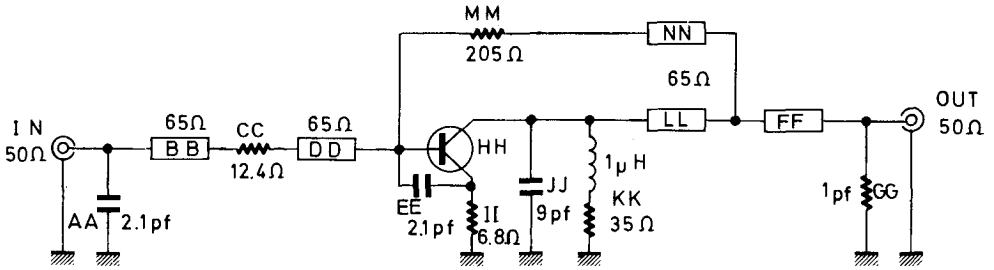
```
.5
10  10  1  10
END
```

OPTIMIZATION DATA

POLAR S-PARAMETERS IN 50.0 OHM SYSTEM

FREQ.	S11 (MAGN	ANGL)	S21 (MAGN	ANGL)	S12 (MAGN	ANGL)	S22 (MAGN	ANGL)	S21 dB	K FACT.
100.00	0.09	— 132	2.99	157.1	0.139	— 10.7	0.16	149	9.52	1.38
200.00	0.11	— 140	3.14	135.2	0.139	— 21.5	0.16	141	9.94	1.33
300.00	0.13	— 152	3.13	113.4	0.136	— 32.7	0.11	128	9.91	1.36
400.00	0.15	— 166	3.14	89.7	0.133	— 43.6	0.03	86	9.94	1.38
500.00	0.15	166	2.94	64.2	0.128	— 53.5	0.07	— 52	9.37	1.49
600.00	0.15	140	3.15	43.9	0.126	— 63.6	0.10	— 68	9.96	1.42
700.00	0.15	99	3.18	20.0	0.127	— 72.3	0.16	— 99	10.05	1.37
800.00	0.20	51	2.95	— 6.8	0.128	— 80.8	0.25	— 120	9.38	1.34
900.00	0.26	18	3.06	— 29.3	0.128	— 93.0	0.25	— 125	9.78	1.22

TP 3400 Amplifier 40-900 MHz



$9.4 \leqslant G \leqslant 10.1$ dB INPUT VSWR $\leqslant 1.8 : 1$
OUTPUT VSWR $\leqslant 1.7 : 1$

Figure 2

List of Components **Table 2**

C_1 = capacitor ceramic 2.8 pF 632 RTC
C_2 = capacitor chip 10 nF Eurofarad
C_3 = capacitor chip 8.2 pF Vitramon
C_4 = capacitor chip 2.2 pF Vitramon
C_5, C_7 = capacitor chip 1 nF Eurofarad
C_6, C_8 = capacitor chip 10 nF Eurofarad
C_9 = capacitor chip 22 pF Vitramon
C_{10} = capacitor chip 10 nF Eurofarad
C_{11} = capacitor electrolytic 25 MF 25 V

L_1 = 8 turns 5/10 mm Cu ID 2.5 mm
L_2 = printed 5 nH
L_3 = printed stripline 75 ohms 11.5 mm
L_4 = printed stripline 75 ohms 11 mm
L_5 = printed stripline 75 ohms 25 mm
F_1 = ferrite bead 1200082 TRW

R_1 = resistor 12 ohms 1/4 W carbon composition
R_2 = resistor 4.7 ohms 1/4 W carbon composition
R_3, R_4 = resistor 10 ohms 1/4 W carbon composition
R_5 = resistor 8.2 kohms 1/4 W carbon composition
R_6 = resistor 240 ohms 1/4 W carbon composition
R_7 = resistor 12 ohms 1/2 W carbon composition

T = transistor TRW TP 3400

Board Material

Epoxy glass (G 10) 1/16 inch $E_R = 4.2$

CIRCUIT DIAGRAM

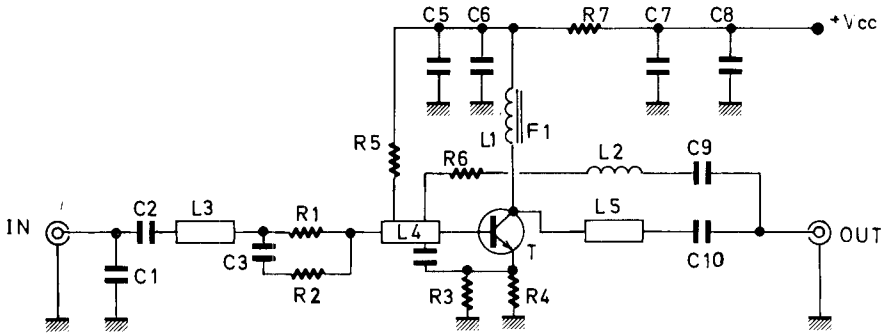


Figure 3

PC Board Layout

Epoxy glass (G 10)

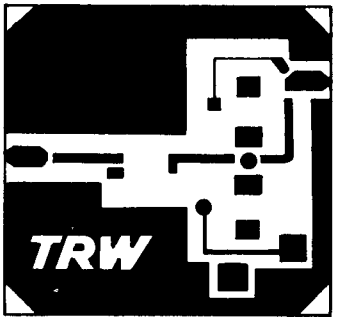
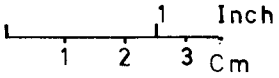


Figure 4



Component Layout

Double sided

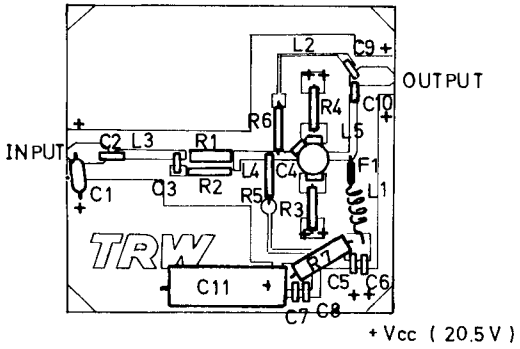


Figure 5

+++ FOIL WRAP OR PLATE AROUND PLANE

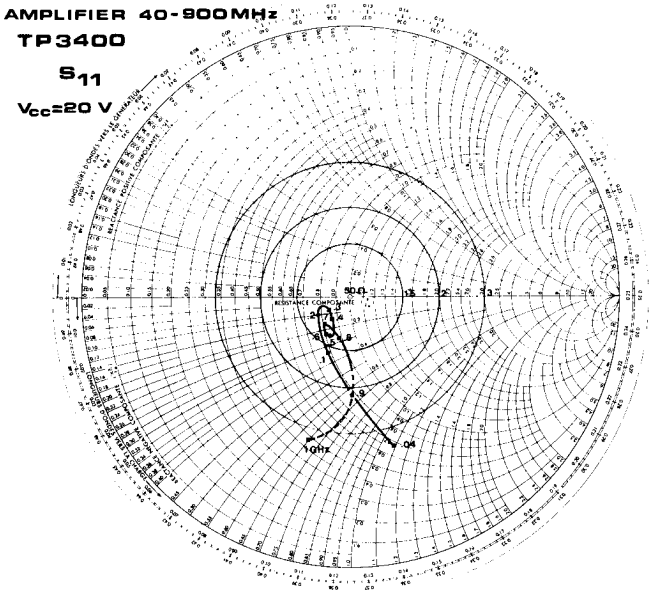


Figure 6

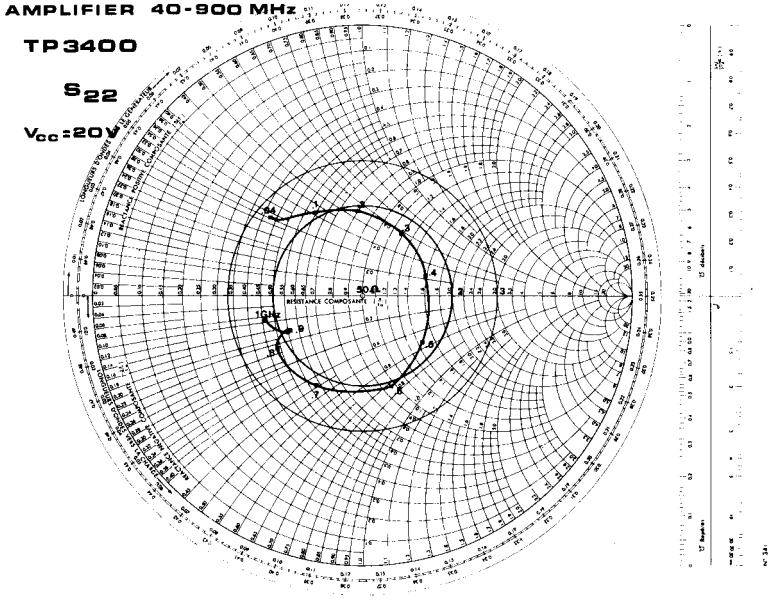
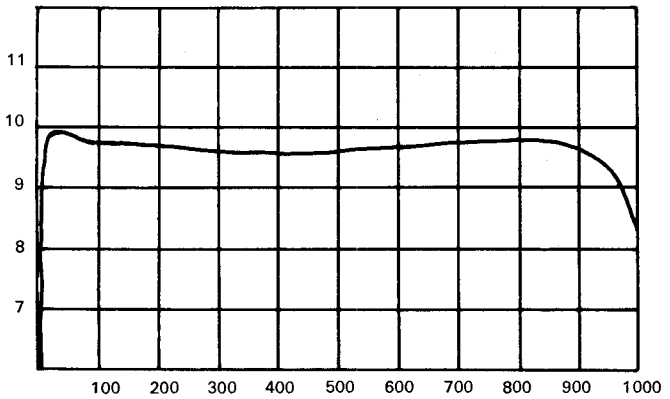


Figure 7

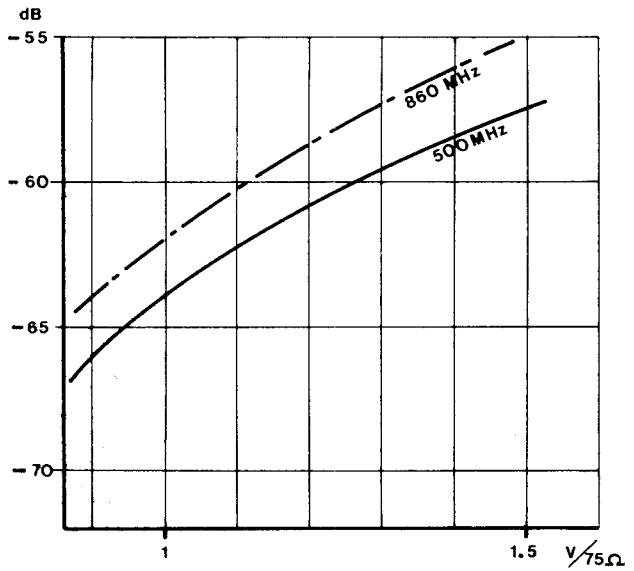
Gain vs Frequency



Vcc = 20.5 V.
Vce = 18 V.
Ic = 125 mA.

Figure 8

IMD (Din 45004 B) vs Output Voltage



V_{ce} 18 V I_C 125 mA

Figure 9

35/50 WATT BROADBAND (160-240 MHz)

PUSH-PULL TV AMPLIFIER BAND III

This note describes the performance of a broadband ultra linear push pull amplifier designed for service in band III TV transposers and transmitters.

Devices used : two TPV 375.

Basic amplifier specifications :

IMD (1) = — 51 dB at P_o = 35 W
IMD (1) = — 48 dB at P_o = 50 W
V_{ce} = 28 volts ; Total = 4.4 A
P_{gain} = 10 dB
input VSWR : < 1.6
output VSWR : < 1.5

(1) vision carrier — 8 dB, sound carrier — 7 dB, sideband signal — 16 dB.

General design Consideration

The principal aims were :

— employ a relatively simple solution permitting us to obtain the optimal performances from TWO TPV 375.

— simplify the design and reduce the cost.

The main consideration was to obtain the maximum output power with the best IMD over the band. To obtain this requirement the output match and losses must be the best possible in all the band.

The second consideration was to obtain the maximum gain by reducing the input matching circuit losses to a minimum.

These factors led us to choose matching circuits using quarter-wavelength transformers at the input and output which permit us to :

— reduce the load and source impedances to low values with low losses

— couple two transistors in a push pull configuration.

Because the output and input transistor impedances are in series, due to the push-pull configuration, the required transformation ratio is one half of that required for a single ended stage.

The first approach for the circuit calculation was made from the input and output impedances given in the TPV 375 data sheet and matched to the proper impedance levels using a smith chart. The element values were then optimized with the aid of «COMPACT » program.

Amplifier Design

The basic block diagram for the amplifier is shown in Figure 1 and the circuit schematic is shown in Figure 2.

The input and output circuits are each composed of two networks : a quarter-wavelength transformer-balun and a matching network.

The quarter-wavelength transformer impedances have been chosen to be easily built using microstrip technology.

Input circuit

The input circuit is shown in Figure 3 and the input impedances are shown in Smith Chart 1.

The low transistor input impedances are transformed into higher impedances near the real axe by capacitors FF.

The (EE, DD) series elements and (CC, BB) parallel elements collapse the amplifier input impedances around 8,5 Ω.

Since the devices can be considered in series at this point the impedance is doubled to 17 Ω. The quarter-wavelength transformer balun (AA) completes the match to 50 Ω.

The transformation ratio is 2.8 : 1.

The maximum theoritical input VSWR is 1.80 : 1 and the maximum experimental VSWR is 1.60 : 1.

Output circuit

The output circuit is shown in Figure 4 and the output impedances on Smith Chart. II. Since the output impedances are higher than the input impedances, the output matching network is simpler and the quarter-wavelength transformer ratio is lower.

The inductors aid the matching but primarily provide for good stability at the low frequencies, and are used for collector bias. The output quarter-wave-length transformer ratio is 1.6 : 1.

The maximum theoritical VSWR is 1.16 : 1 and the maximum experimental VSWR is 1.44 : 1.

Amplifier Performances

— IMD versus output power : Figure 5

— Input and output return loss and VSWR = Figure 6

— Gain versus frequency : see Figure 7

— 1 dB gain point compression : 70 W

— Bias conditions : V_{ce} = 28 V ; Total = 4.4 A.

Technology and layout considerations

The epoxy-Glass 1/16 inch (ε_r = 4.1) is used as board material except for the input and ouput transformers.

The glass - Teflon 1/50 inch (ε_r = 2.55) is used for the transformers (see the details Figure 8).

We have considered for a microstrip line that after W (Width) from the conductor strip edge the fields are negligible and we can size the ground conductor to be 3 W without perturbing the propagation. This kind of transformer has the following characteristics :

— We can have any impedance values within realizable min-max limits.

— The vertical dimensions are small and the mechanical realibility is good.

— Good repeatibility.

The bias circuits are included with RF circuits in order to give a compact amplifier : Figures 10 and 11 show the layouts and the Figure 12 the physical layout of the push-pull amplifier.

Combined pairs of push-pull Amplifiers

— In general several push-pull amplifiers are used for the final stage of the TV transmitter amplifiers.

They can be combined by pair with quadrature combiners (see block diagram Figure 9).

The advantage of using this kind of coupler is that the input and output VSWR become good (> 20 dB rtn. loss) in comparison with the relatively high original VSWR of the push-pull amplifier.

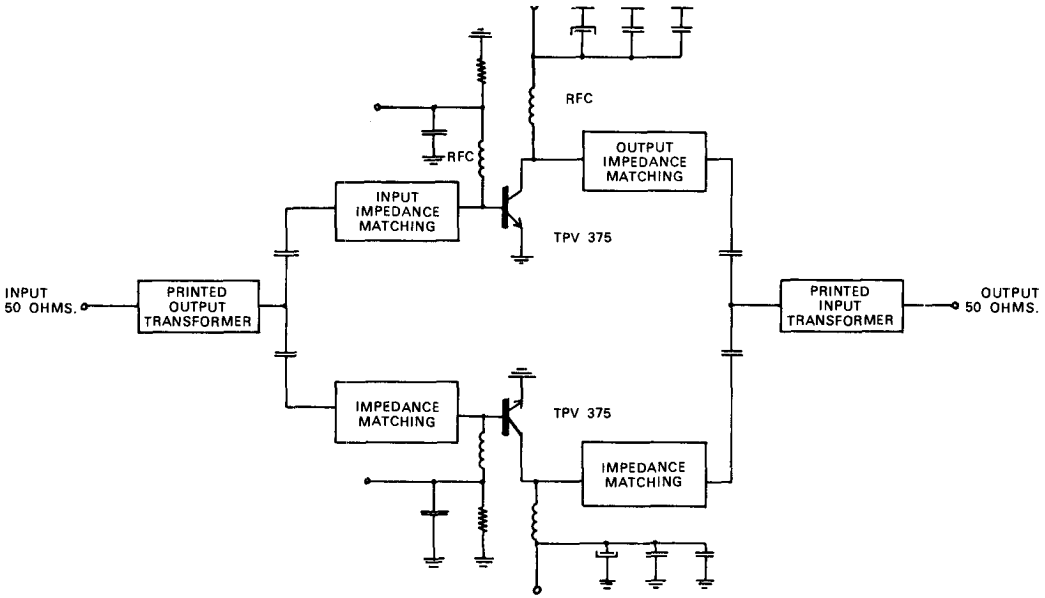
General Conclusions

— Pushpull techniques simplify the required circuitry and associated losses.

— The problems associated with 3 dB hybrids in cascade — insertion loss and imbalance — when four devices in parallel are required are minimized.

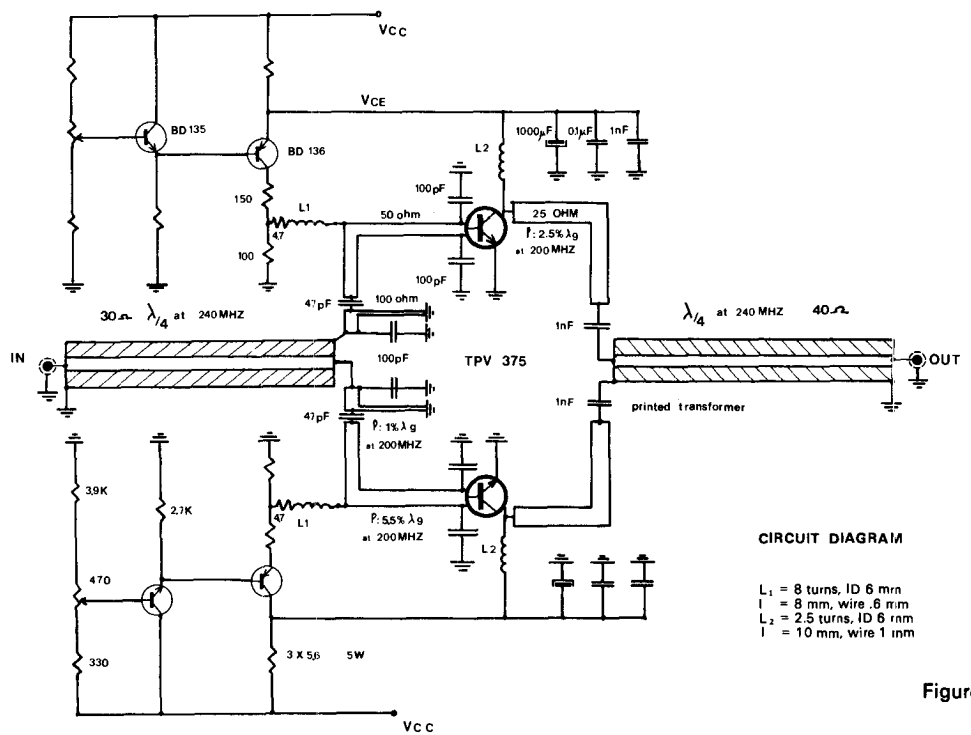
— With additional effort both the input and output VSWR could be improved to 1.2 : 1.

— Good repeatability in production without variable components being required.



PUSH-PULL CIRCUIT

Figure 1



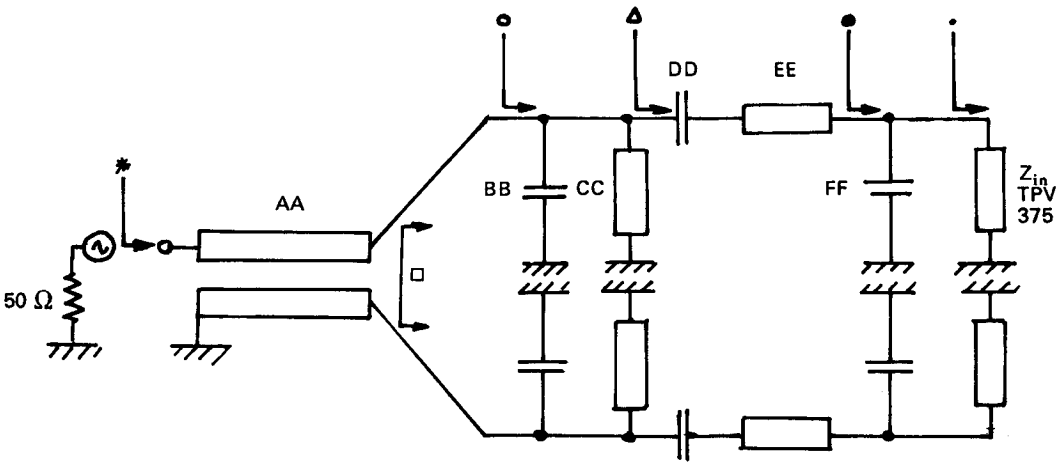
CIRCUIT DIAGRAM

L_1 = 8 turns, ID 6 mm
l = 8 mm, wire .6 mm
L_2 = 2.5 turns, ID 6 mm
l = 10 mm, wire 1 mm

Figure 2

INPUT CIRCUIT

On the smith chart the impedances are represented by :



	AA		BB	CC		DD	EE		FF
	Z_0 (Ω)	L* (mm)	(pF)	Z_0 (Ω)	L* (mm)	(pF)	Z_0 (Ω)	L* (mm)	(pF)
Calc. value	30	313	139	100	11.3	47	50	80.8	238
Empirical value	30	313	100	100	15.0	47	50	82.5	200

* L is given for $\varepsilon_r = 1$

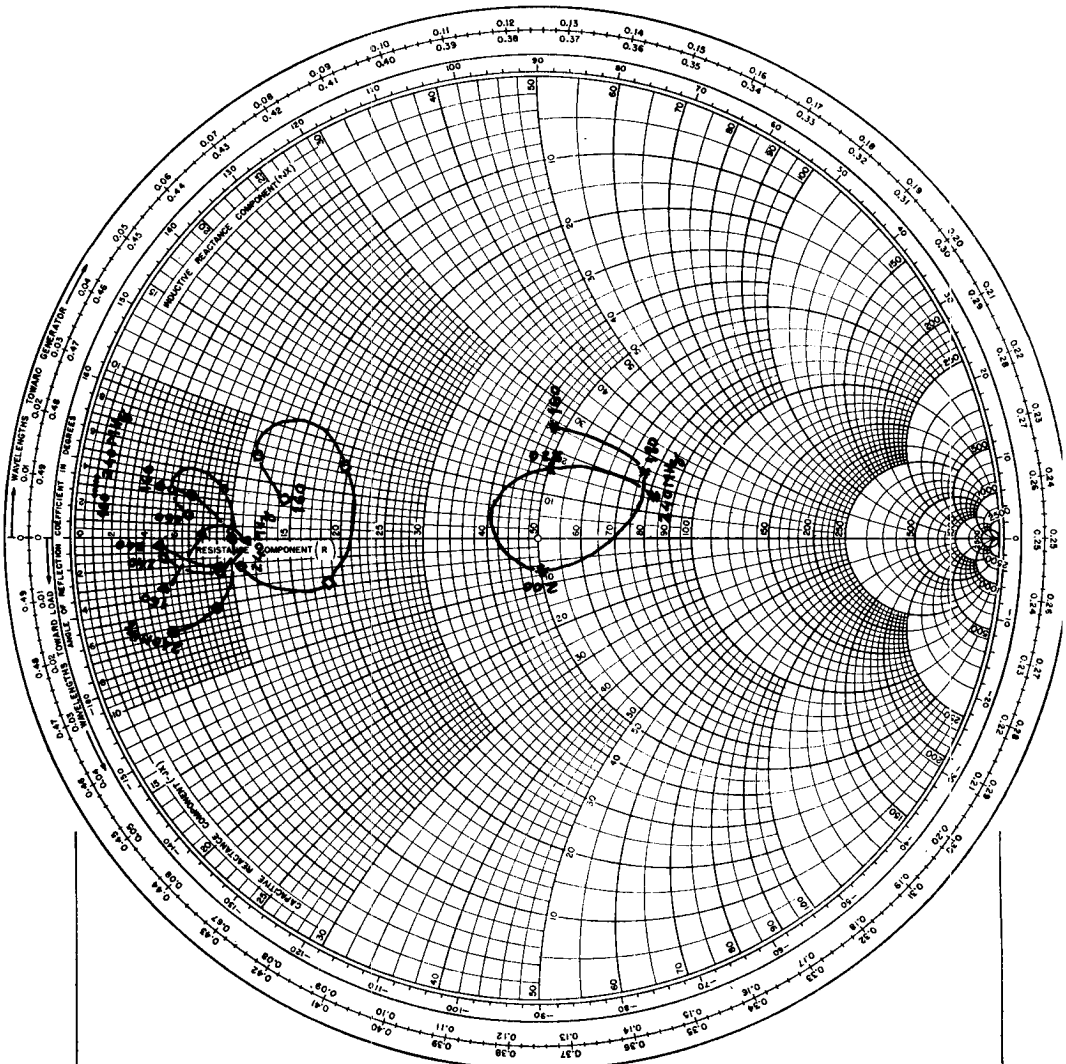
Figure 3

TITLE

INPUT CIRCUIT

DATE

IMPEDANCE COORDINATES—50-OHM CHARACTERISTIC IMPEDANCE



SMITH CHART I

RADIALLY SCALED PARAMETERS

STANDING WAVE VOL. IN DB RATIO

TRANSM. LOSS DB STEPS

LOSS COEFF.

TOWARD GENERATOR →

← TOWARD LOAD

REFLECTION COEFF. VOL. IN DB

REFLECTION LOSS IN DB PWR. RATIO

CENTER

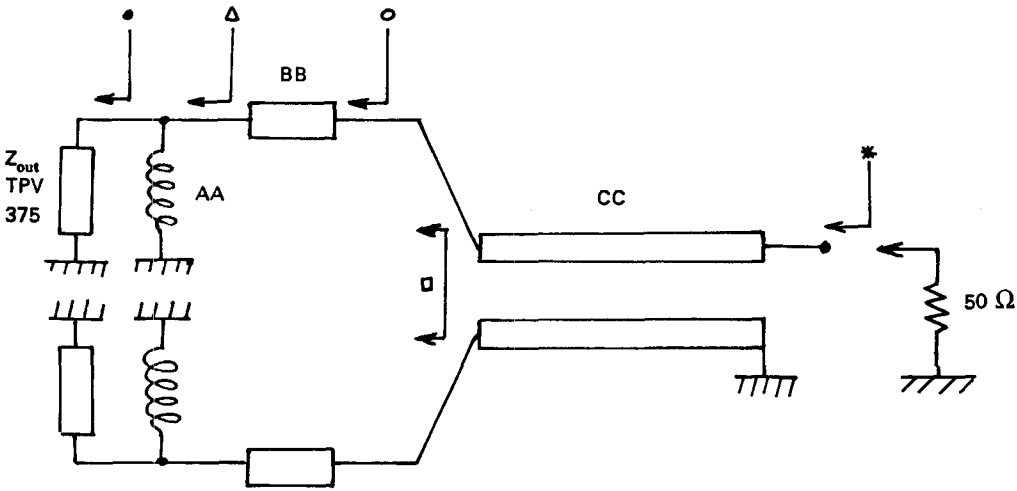
Electronics - VOL. 17, NO. 1, PP. 130-133, 318-325, JAN. 1944

GENERAL RADIO COMPANY
WEST CONCORD, MASS.

FORM 5301-7569Z
Printed in USA

OUPUT CIRCUIT

On the smith chart the impedances are represented by :



	AA	BB		CC	
	(nH)	Z_o (Ω)	L* (mm)	Z_o (Ω)	L* (mm)
Calc. value	11.7	21.6	37.5	33	312.5
Empirical value	53.1	25.0	37.5	40	312.5

* L is given for $\varepsilon_r = 1$

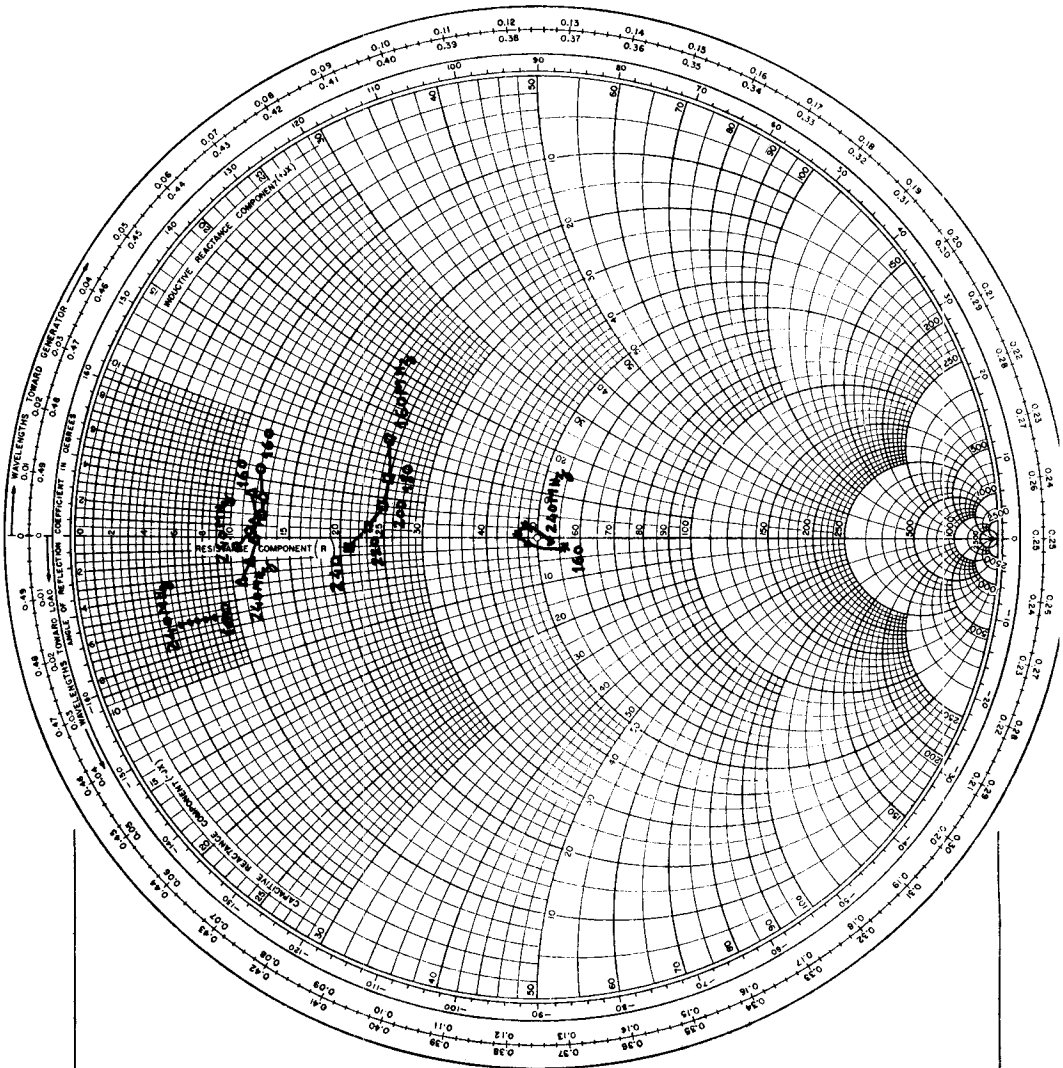
Figure 4

TITLE

OUTPUT CIRCUIT

DATE

IMPEDANCE COORDINATES—50-OHM CHARACTERISTIC IMPEDANCE



Electronics · VOL. 17, NO. 1, PP. 130-133, 318-325, JAN. 1944

GENERAL RADIO COMPANY
WEST CONCORD, MASS.

FORM 5301-7569Z
Printed in USA

IMD VERSUS OUTPUT POWER

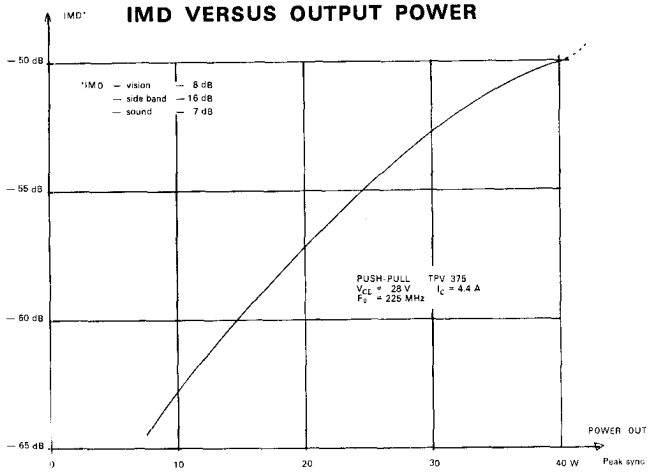


Figure 5

INPUT AND OUTPUT RETURN LOSS Vs FREQUENCY

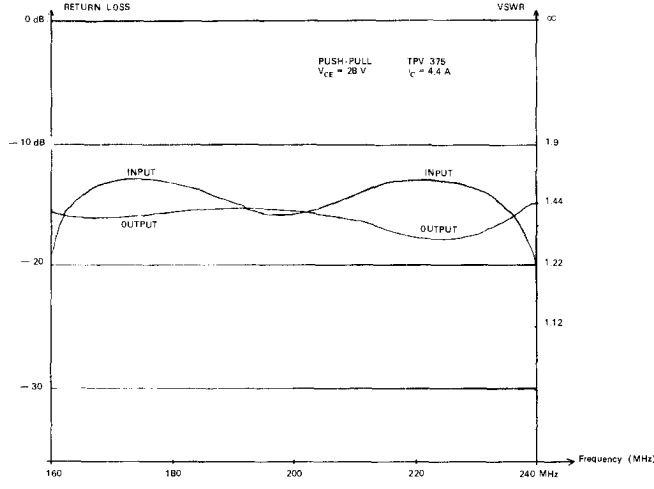


Figure 6

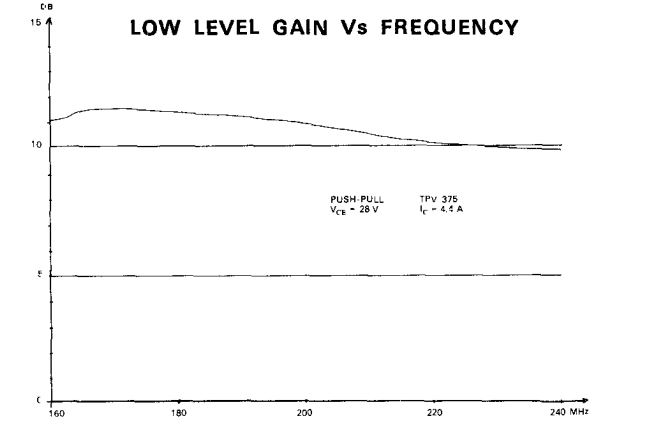
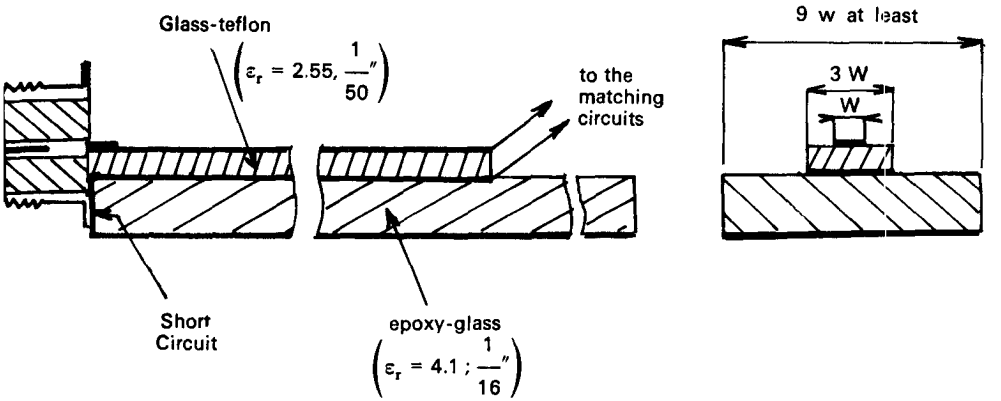


Figure 7

QUATER WAVELENGTH BALUN



EQUIVALENT CIRCUIT

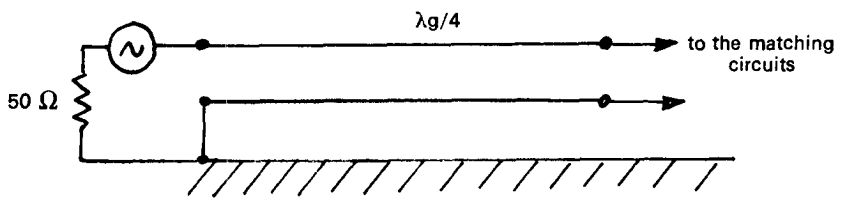


Figure 8

COMBINED PAIR OF PUSH-PULL AMPLIFIERS

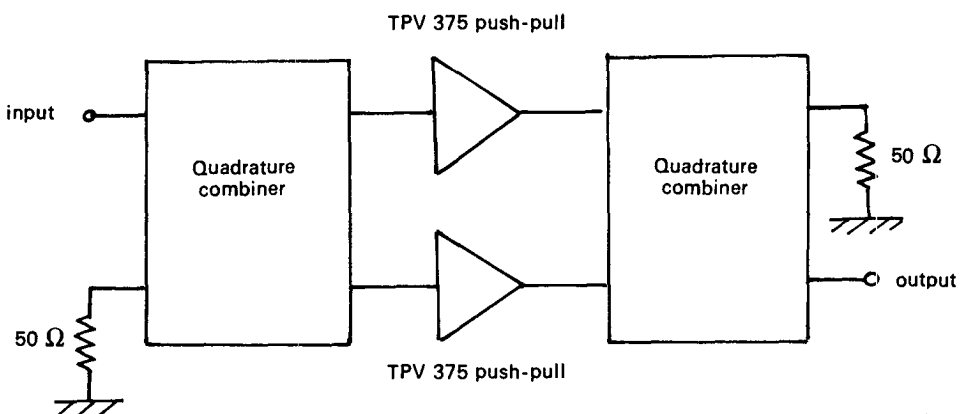


Figure 9

PC BOARD LAYOUT FOR INPUT AND OUTPUT QUATER-WAVELENGHT TRANSFORMER

Board material : glass teflon ; 1/50 inch ; $\varepsilon_r = 2.55$

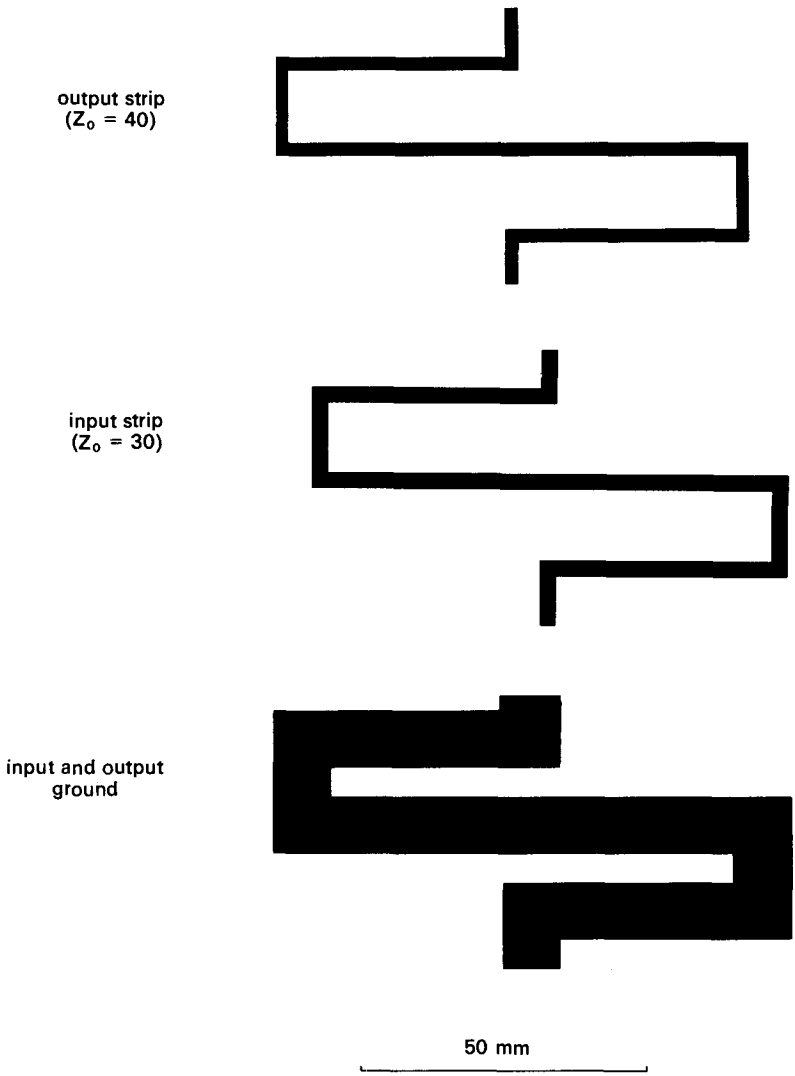


Figure 11

PC BOARD LAYOUT

Board material : epoxy-glass ; 1/16 inch ; ε_r = 4.1

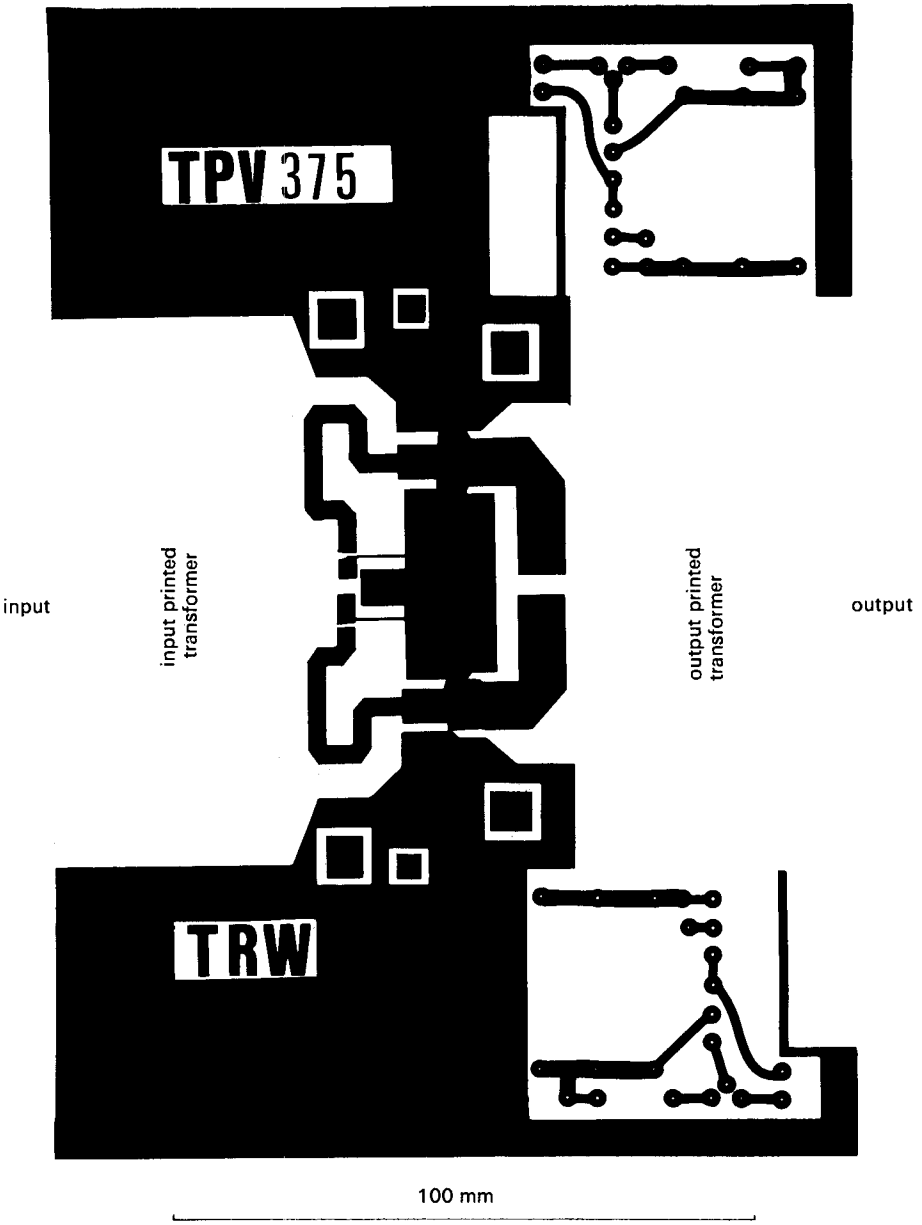


Figure 10

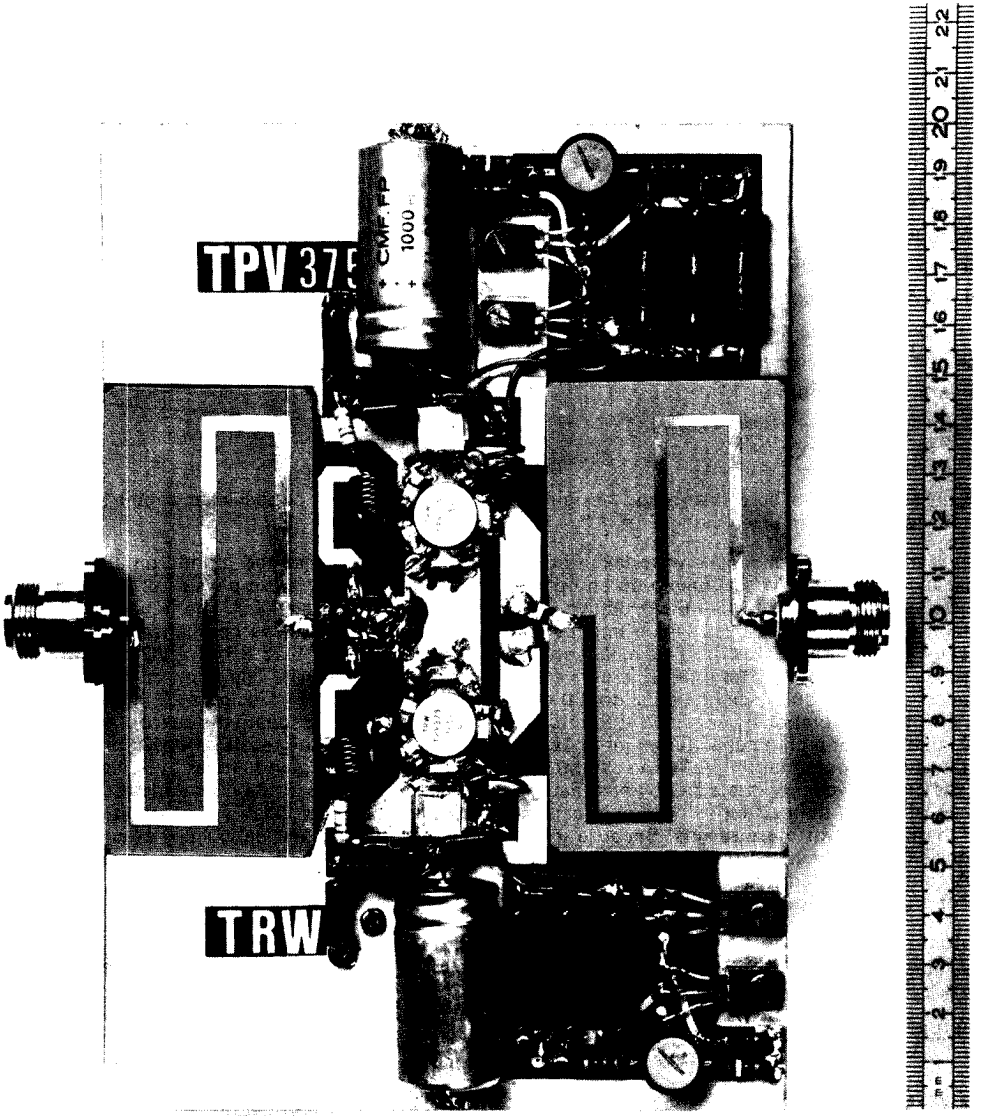


Figure 12

TV TRANSPOSERS BAND IV & V

P_0 = 0.5 W/1.0 W

This note describes the performance of a broadband (470-860 MHz) ultra linear amplifier designed for service in band IV and V T.V. transposers.
Device used :

TPV 596.

Basic specs :

I.M.D. — 60 dB max. at Po = 0.5 watts
Vce = 20 volts ; Ic = 200 mA
Pgain = 11.5 dB min.

The approach used is intended to be straight forward and inexpensive as follows.

1) The load line be defined to provide the correct match for peak power (P. sync).
2) The VSWR at the collector be less than 2 : 1.
3) The input match be designed to provide flat gain with decreasing frequency.
4) Use computer aided design.
5) Use a three tone norm

Pvision = — 8 dB
Psound = — 7 dB
Psideband = — 16 dB

6) Circuit realization to be a distributed design built upon teflon glass copper clad circuit boards. However the design will be analized using Er = 1.0.

The input and output impedances were taken from the TPV 596 data sheet and plotted on a smith chart. First consider the input. To have flat gain with an optimum collector load, the basic physics of a class « A » biased device defines a gain slope of — 6 dB/octave which must be compensated for. The band of interest is 470-860 MHz which is .915 octaves which implies that 5.25 dB of gain must be compensated for if the device is perfectly matched at 860 MHz. This means that a transmission loss of 5.25 dB or a VSWR of 11.0 : 1 must be employed at 470 MHz. The input Z is converted to Y on smith chart (I). The point at 860 MHz will intersect the constant conductance line equal to 1.0 (20 m℧) if it is rotated 0.14 λ using a 20 m℧ (50 Ω) transmission line. After this rotation a capacitive stub or chip capacitor is used to resonate the susceptance at 860 MHz ; A capacitive stub or a chip capacitor equal to 16.7 pF can be used, and the result is shown on Smith chart (I). It is interesting to note that the VSWR vs : frequency can be adjusted for gain flatness by selecting an optimum Zo for the capacitive stub. It is also obvious that the locus of impedances at the circuit input can very between the locus of points defined by using a chip capacitor, and the imaginary axis by using a stub with Zo = ∞. Graph (II) is a plot of these results. Because infinite isolation doesn't exist between the output and input of any transistor, and because the required network is very simple, the input circuit will be optimized empirically. A computed aided circuit will be defined for the output only. It is also indicated that a combination chip capacitor and stub may provide the best results.

The output circuit considerations were first determined using a smith chart approach. It must be clearly understood that computer optimization is only as good as the circuit configuration and associated computer instructions.

The approach follows :

Smith Chart (II)

1) The device output impedances are first converted to admittances and plotted as the conjugate (Y load).
2) In order to allow easy collector lead soldering a Zo = 50 Ω, 3 mm long transmission line is used. Since the Smith chart is normalized to 20 m℧ (50 Ω) we can rotate toward the load directly as the chart is configured.
3) Since the balance of the circuit used Yo = 10 m℧ (100 Ω) we next normalize the chart to 10 m℧. 100 Ω transmission line was chosen as a good compromise between physical length requirements and ease of realization on Teflon Glass.
4) The next element, a shorted shunt transmission line less than λ/4 in length reduces the imaginary part by moving each point of admittance along a line of constant conductance. The length was chosen to locate the lowest frequency point (400 MHz) near the real axis so that the locus of points would be more equally distributed about a 2.0 : 1 VSWR circle.

5) The resultant locus of points are then rotated with a 10 mℨ (100 Ω) transmission line to a degree which locates the admittance point of 860 MHz near the line of constant conductance equal to 2.0 on Smith Chart (II). This conductance is exactly equal to 20 mℨ since the chart is normalized to 10 mℨ.

6) The final step is to use a parallel resonant circuit which will reduce the imaginary pacts at both the upper and lower frequencies.

The following approach was used to calculate the element values for the antiresonant circuit.

By observation of the smith chart it was decided to place the 460 and 860 MHz points on or just inside the 2.0 : 1 VSWR circle.

It then follows that

$$\text{at } f_1 = 460 \text{ MHz} \qquad W_1C - \frac{1}{W_1L} = -0.4$$

$$\text{at } f_2 = 860 \text{ MHz} \qquad W_2C - \frac{1}{W_2L} = 1{,}7$$

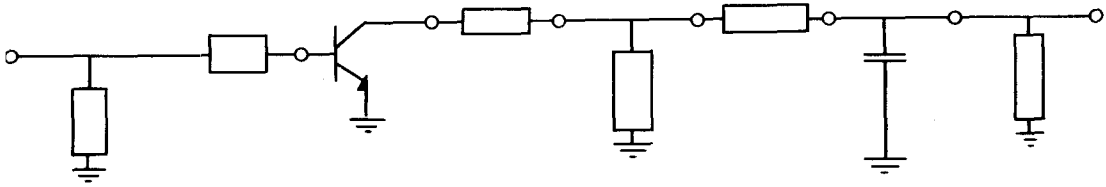
The 2 equations with 2 unknows are solved with the following result.

L = 0,189 nHy
C = 496.11 pFd

since we are normalized to 10 m ℨ

Lactual = 0.189/.01 nH = 18.9 nHy
Cactual = 496.11 × 0.1 pF = 4.96 pFd

7) The result is normalized to 20 mℨ with the final result shown.



Zo	10 Ω	50 Ω	TPV 596	50 Ω	100 Ω	100 Ω		100 Ω
Calc. Value	45.7 mm	3.78 mm		3 mm	76.1 mm	29,3 mm	4.9 pF	50.4 mm
Empirical Value	8.5 48.8 mm	1.5 mm	Opti- mized Value	3 mm	98.8 mm	39.62	5.5 pF	61.6 mm

Graph (III) shows the various VSWR calculated compared to the theoretical best curve and the actual VSWR measured.

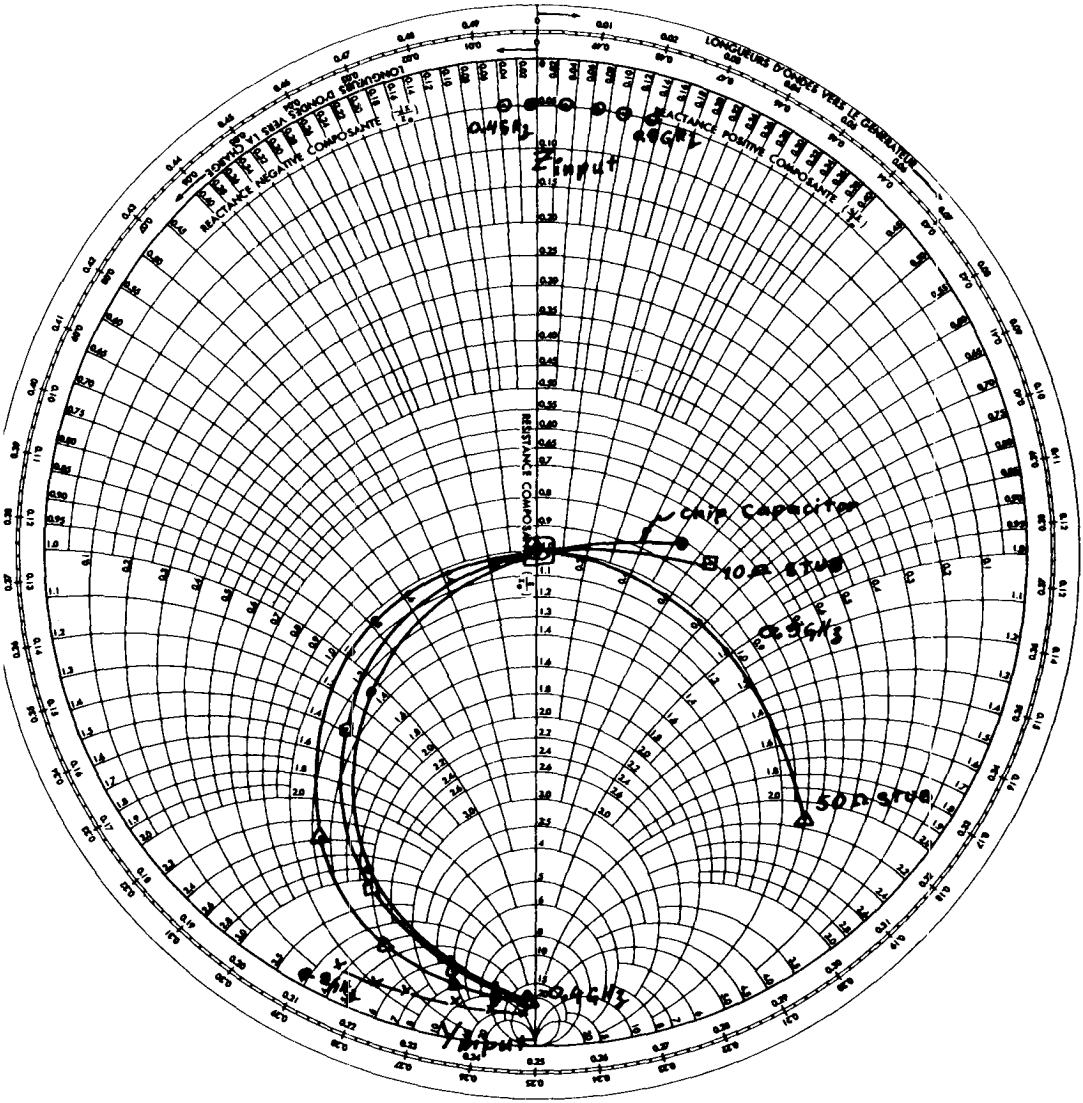
Graph (IV) shows the collector load VSWR for the calculated, optimized, and actual result.

Graph (V) is a plot of the single ended amplifier results taken with a network analyzer. No component losses were considered for the theoritical and optimized analysis. The final circuit was also optimized empirically from 470-860 MHz using a network analyzer.

The following results are a summary of performance, bias conditions circuit configuration and recommended hybrid adaptation.

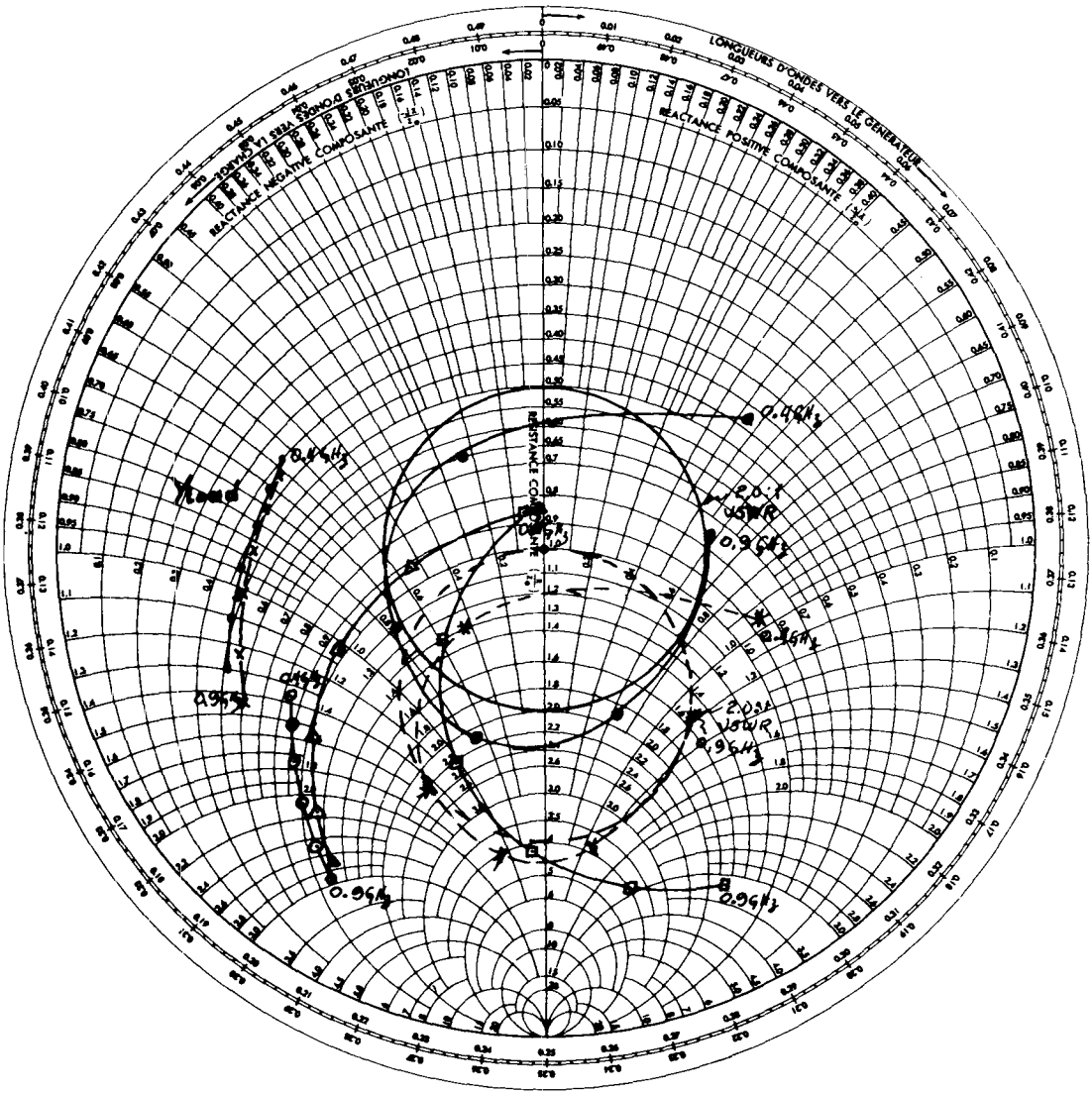
SMITH CHART (I)

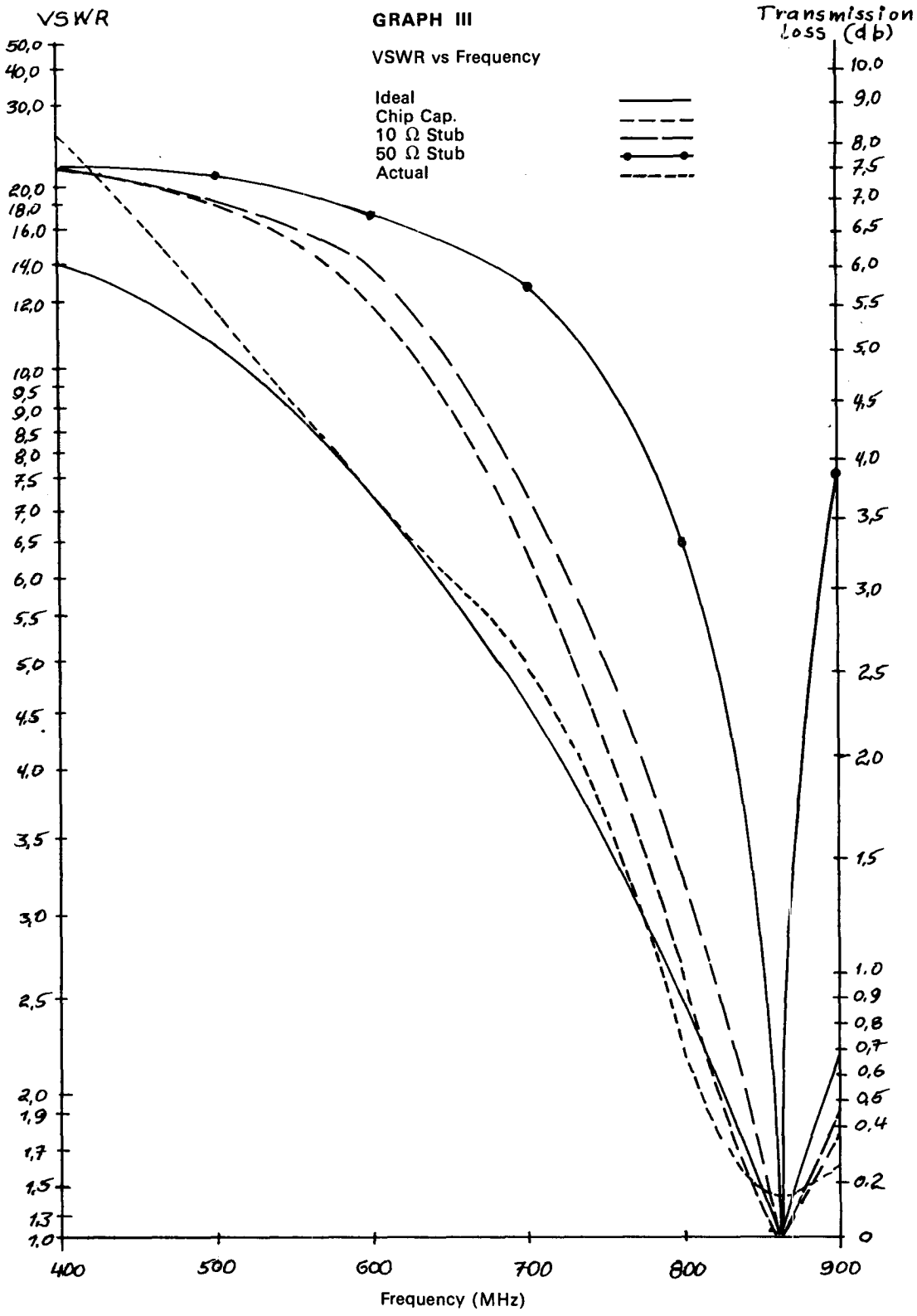
starting Imp.
rotated Adm.
final Adm. ω/Chip Cap.
final Adm. ω/10 Ω Stub
final Adm. ω/50 Ω Stub



SMITH CHART (II)

starting Adm.
50 Ω rotation
100 Ω translation
equiv. shunt Ind.
100 Ω rotation
parallel L-C
final Adm. 50 Ω translation

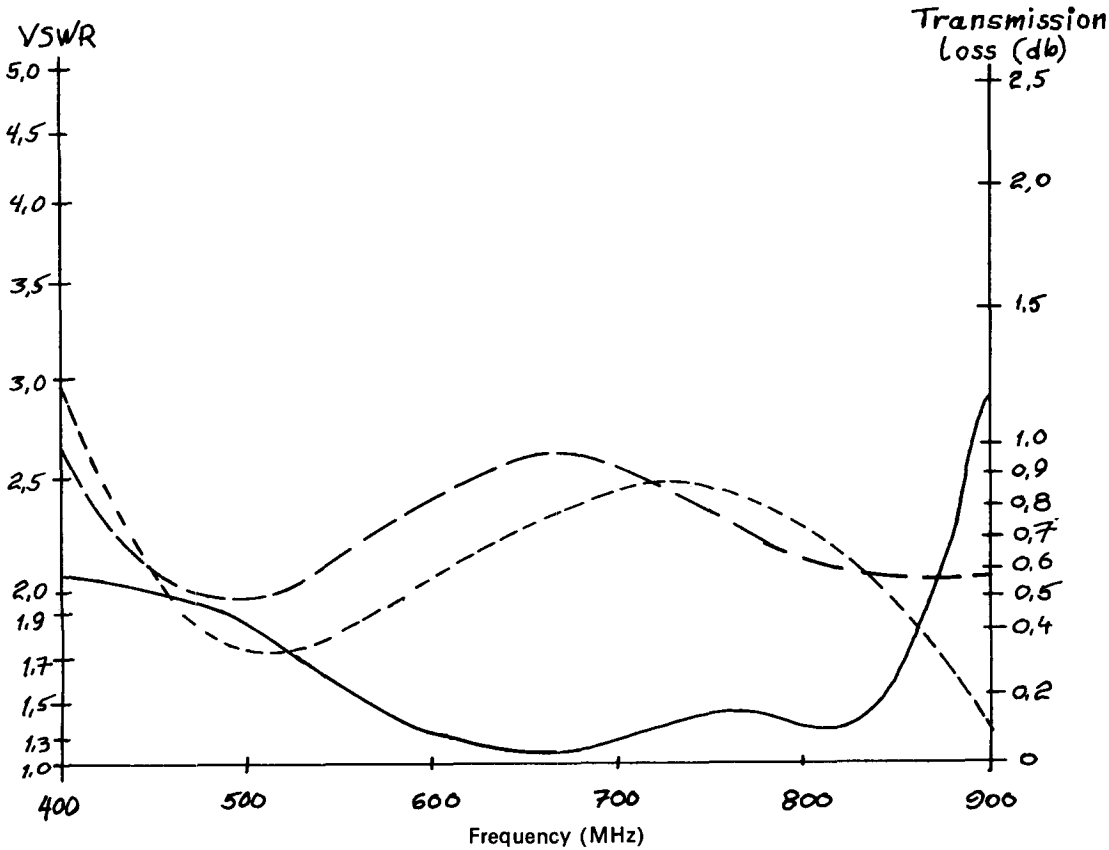



VSWR
GRAPH III
VSWR vs Frequency
Ideal
Chip Cap.
10 Ω Stub
50 Ω Stub
Actual
Transmission Loss (db)
50,0
40,0
30,0
20,0
18,0
16,0
14,0
12,0
10,0
9,5
9,0
8,5
8,0
7,5
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,9
1,7
1,5
1,3
1.0
10.0
9,0
8,0
7,5
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1.0
0,9
0,8
0,7
0,6
0,5
0,4
0,2
0
400
500
600
700
800
900
Frequency (MHz)

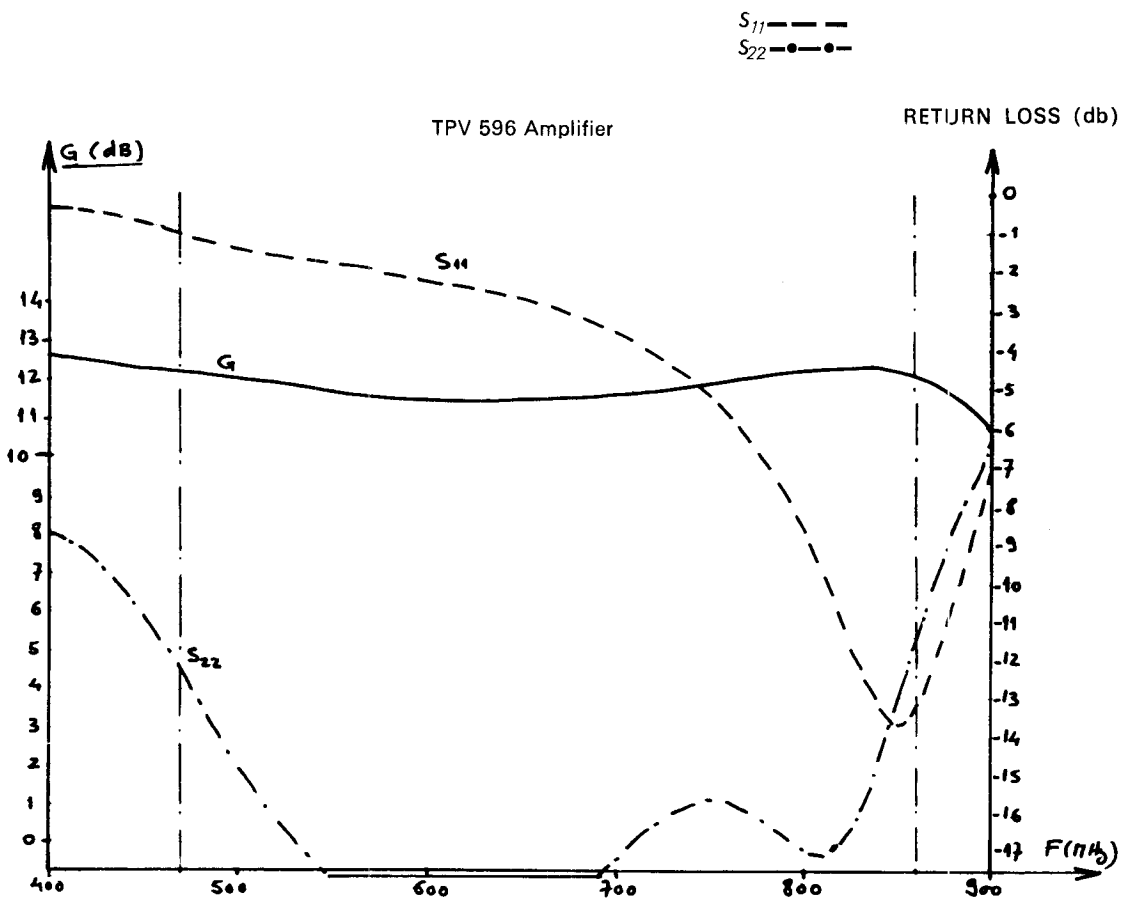
GRAPH IV

VSWR vs : Frequency

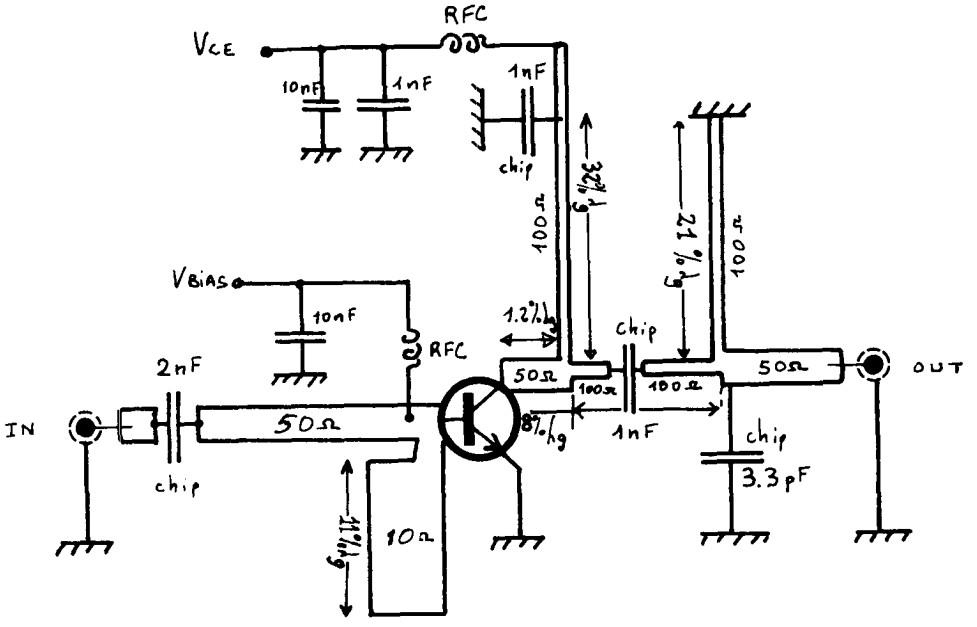
Preoptimization
Postoptimization
Measured



GRAPH V

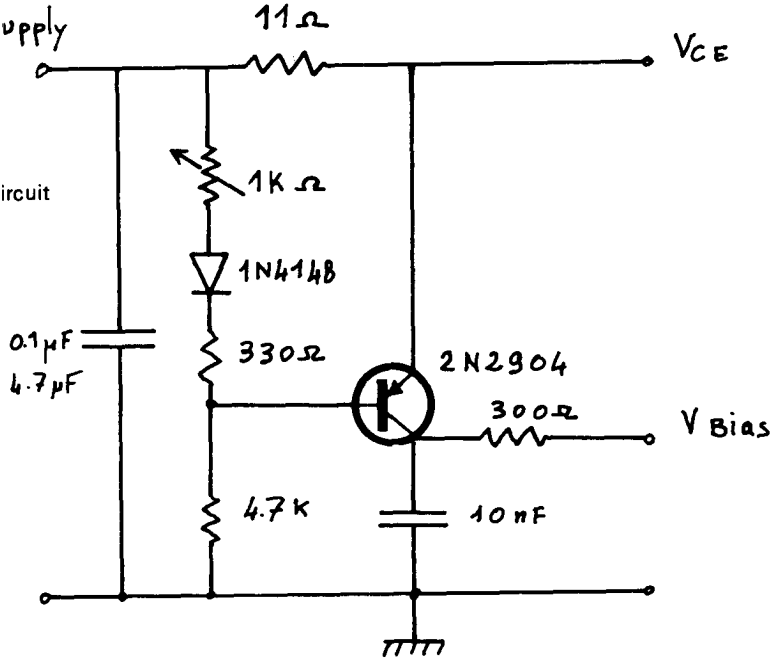

S_{11}
S_{22}
TPV 596 Amplifier
RETURN LOSS (db)
G (dB)
S11
G
S22
F(MHz)
400
500
600
700
800
900

470-860 MHz class A with TPV 596



V_{CE} = 20 V - I_C = 220 mA
F_0 = 860 MHz - WAVELENGTH (λg) at 860 MHz
(material : Glass teflon εr = 2.55 - 1/16″ used by TRW)

Class A bias circuit



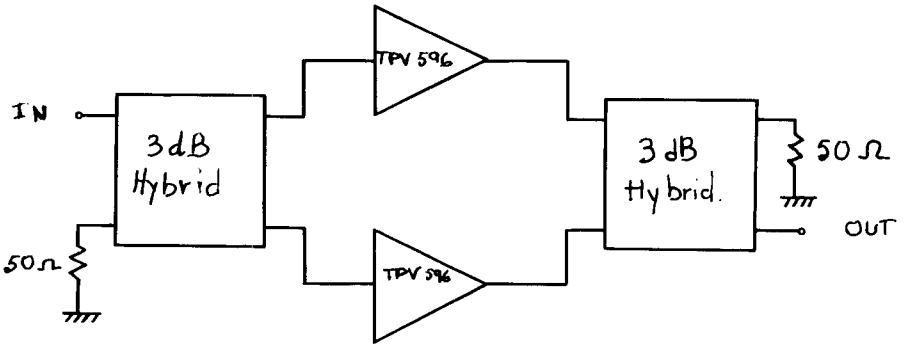
TPV 596 BROADBAND AMPLIFIER

FREQUENCY RANGE	: 470 MHz-860 MHz
POWER OUTPUT AT	: — 60 dB IMD* $\geqslant$ 0.5 W
POWER GAIN	: 11.5 $\leqslant$ G $\leqslant$ 12.7 dB
INPUT RETURN LOSS*	: < — 1 dB
OUTPUT RETURN LOSS	: < — 11 dB
VOLTAGE SUPPLY	: ~ 23 V (V_{CE} = 20 V)
TOTAL CURRENT	: 220 mA

*IMD : Vision : — 8 dB ; Sound carried : — 7 dB ; Side band : — 16 dB

RECOMMENDED CONFIGURATION

*INPUT RETURN LOSS : This amplifier must be used by two connected together with two 3 dB quadrature hybrids to have a balance amplifier with a good input VSWR.



*3 dB - 90° Hybrid coupler from
— AMAREN 10 264-3
— SAGE wireline 3 dB Hybrid 4450 900

IMD VS OUTPUT FOR A SINGLE STAGE
VCE = 20 V-220 mA

F = 860 MHz ; Vision = — 8 dB ; Sound Carrier = — 7 dB ; Sideband = — 16 dB

Pout (W)	0.25 W	0.5 W	1 W
IMD (dB)	— 67 dB	— 61 dB	— 55 dB

F = 860 MHz ; IMD DIN 45004/B
RL = 75 ohms

1.5 V/75 ohms	IMD = — 66 dB
2 V/75 ohms	IMD = — 60 dB

1 W/2 W BROADBAND TV AMPLIFIER BAND IV & V

This note describes the performance of a broadband (470-860 MHz) ultra linear amplifier designed for service in band IV and V T.V. transposers.

Device used : TPV 597

Basic specifications

IMD (1) = — 60 dB at P_o = 1 W
V_{ce} = 20 V; I_e = 440 mA
P_{gain} = 11.5 dB.

(1) Vision carrier — 8 dB, sound carrier — 7 dB, sideband signal — 16 dB.

General design considerations

In general to obtain a flat gain for broadband amplifiers which use transistors with about — 6 dB power gain variation per octave we can use two techniques :

— feedback technique (eg emitter resistor and a negative feedback with a selective circuit between the collector and the base),

— or reflect the input or the output power selectivly to have an insertion loss of 6 dB per octave with 0 dB for the highest frequency.
(There is also another technique which uses a selective attenuator).

With the feedback technique we can have a good input and output match. With the second technique we need to reflect the input power and have a good output match in order to obtain a good IMD. It means the input VSWR is very high for the low frequencies.

The second solution is simpler than the first and if we use two amplifiers connected together with 3 dB quadrature hybrids to have a balanced amplifier this inconvenience disappears. We have chosen for this amplifier this second solution. For the larger broadband amplifier (eg 170-860 MHz) this solution must be rejected and the only acceptable solution is to use the feedback technique.

Amplifier design

The first approach for the circuit calculation was made by using the Smith Chart from the input and output impedances given in the TPV 597 data sheet to have, at the input, a reflected power so that the gain will be flat and at the output to obtain the best match possible.

INPUT VSWR VERSUS FREQUENCY TO OBTAIN A FLAT GAIN :

The power gain can be approximated by :

$$G \simeq \left(\frac{F_{max}}{F}\right)^2$$

F_{max} is the frequency for which power gain drops to unity.

The transmission loss due to the input reflection is :

$$\alpha = 1 - |\rho|^2$$

ρ is the reflection coefficient.

To have $G\alpha$ constant we must have :

$$G\alpha \simeq \left(\frac{F_{max}}{F}\right)^2 [1 - |\rho|^2] = G_H = \left(\frac{F_{max}}{F_H}\right)^2$$

G_H is the gain at the highest frequency used (F_H)

or

$$|\rho| \simeq \left[1 - \left(\frac{F}{F_H}\right)^2\right]^{1/2}$$

$$VSWR = \frac{1 + |\rho|}{1 - |\rho|} \simeq \frac{1 + \left[1 - \left(\frac{F}{F_H}\right)^2\right]^{1/2}}{1 - \left[1 - \left(\frac{F}{F_H}\right)^2\right]^{1/2}}$$

Figure 1 shows the theoritical VSWR versus frequency with an insertion loss of 0 dB (implies $\rho = 0$) for 860 MHz.

We have defined the input circuit from the TPV 597 input impedance to have an input VSWR as close as possible to this curve, and have assumed that output circuit losses versus frequency is negligeable.

After we have calculated separatly the input and the output circuits, we optimized some of the parameters by means of the global amplifier and the TPV 597 S-parameters, with the COMPACT Program.

— RF equivalent circuit : Figure 2
— Program : Figure 3
— Calculated gain and empirical gain : Figure 4
— Calculated and empirical input VSWR : Figure 5
— Calculated and empirical output VSWR : Figure 6

Amplifier Performance

— IMD versus output power : Figure 7
— IMD versus frequency : Figure 7'
— Input return loss and VSWR : Figure 5
— Output return loss and VSWR : Figure 6
— Gain versus frequency : Figure 4
— Bias conditions : V_{ce} = 20 V ; I_c = 440 mA

Technology and layout considerations

— The glass Teflon 1/16 inch (ε_r = 2.55) is used as board material. This substrat is soldered to the heat sink to have a good contact and repeatable results.

Figure 8 shows the circuit diagram and the bias circuit ; figure 9 shows the PC board layout.

Combined - Transistor Stage

In many instance the power output requirements of transposers exceed the capability of a single transistor, which forces the designer to use combinations of transistors. They can be combined by pair with quadrature combiners (See figure 10). Since quadrature combiners have the ability to channel the reflected power from the amplifier into the fourth port of the combiner it means the input and output VSWR become very low (VSWR $<$ 1.2). The power gain is reduced due to the couplers insertion loss by 0.6 dB. Coupler imbalance should also be taken into account as causing some IMD degration.

INPUT VSWR

$$\text{VSWR} = \frac{1 + \left|1 - \left(\frac{F}{F_H}\right)^2\right|^{1/2}}{1 - \left|1 - \left(\frac{F}{F_H}\right)^2\right|^{1/2}}$$

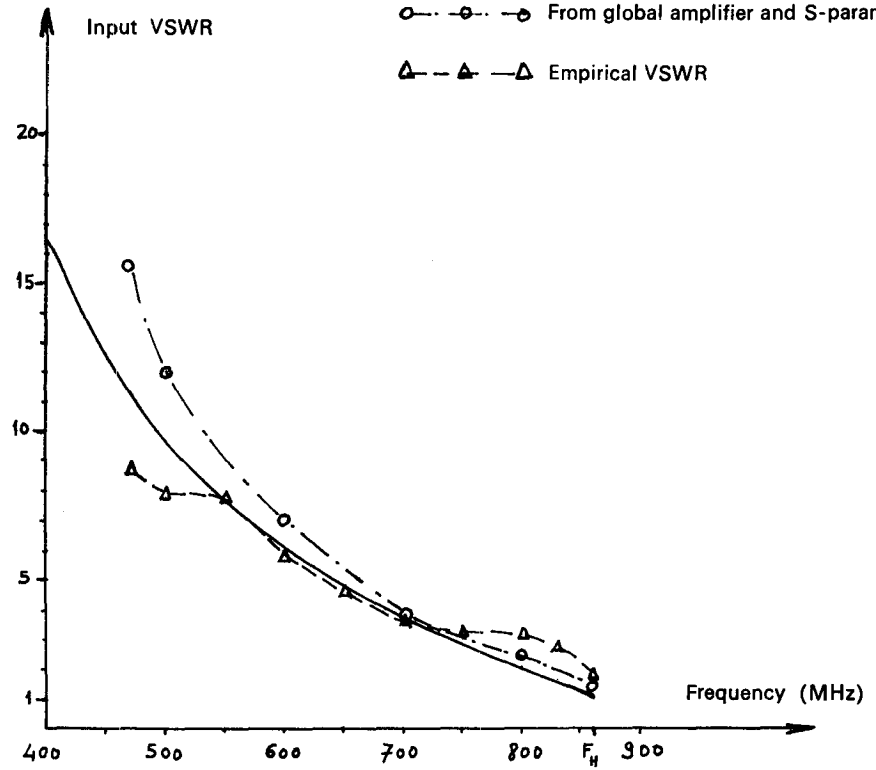
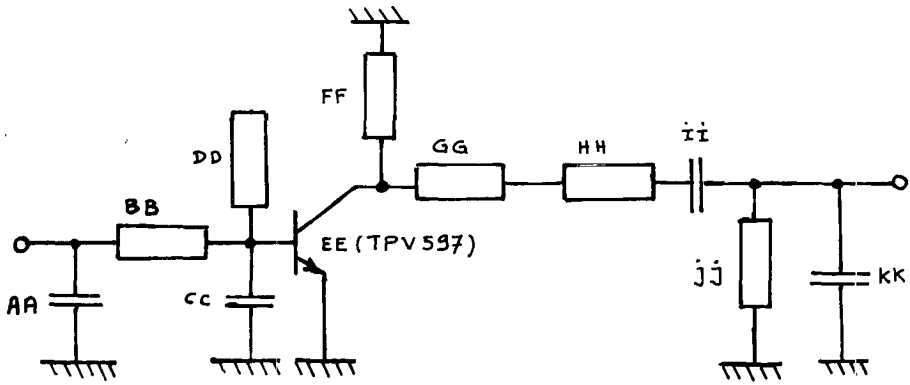


Figure 1

RF EQUIVALENT CIRCUIT FOR COMPACT PROGRAM



	AA	BB		CC	DD		FF	
	pF	Z_0 (Ω)	L (mm)	pF	Z_0 (Ω)	L (mm)	Z_0 (Ω)	L (mm)
Calc. value	4.5	50	32.0	29.3	25	14	50	72.2
Empirical value	4.7	50	45.4	10.0	25	14	50	34.9

	GG		HH		II	JJ		KK
	Z_0 (Ω)	L (mm)	Z_0 (Ω)	L (mm)	pF	Z_0 (Ω)	L (mm)	pF
Calc. value	110	28.4	45	14	5.1	75	50	3.5
Empirical value	110	27.9	45	14	3.9	75	38.4	3.3

L are given for $\varepsilon_r = 1$.

Figure 2

```
MET  AA ZZ
CAP  AA PA   — 4.61
TRL  BB SE   50  — 41.64  1
CAP  CC PA   — 25.39
ØST  DD PA   25  14  1
TWØ  EE S1   50
SST  FF PA   50  — 63.43  1
TRL  GG SE   110  28.44  1
TRL  HH SE   45  14  1
CAP  II  SE  — 5.134
SST  JJ PA   75  49.98  1
CAP  KK PA   — 4.129
CAX  AA KK
PRI  AA SI   50
END
```

CIRCUIT DEFINITION

```
470  500  600  700
800  860
END
```

FREQUENCY (MHz)

```
.92  176  2.38  72  .033  31  .55  — 166
.91  175  2.21  71  .034  33  .54  — 167
.93  171  1.80  63  .037  34  .56  — 170
.93  170  1.57  59  .039  36  .59  — 168
.92  169  1.40  54  .043  38  .58  — 165
.91  167  1.30  52  .045  40  .58  — 166
END
```

POLAR S PARAMETERS FOR TWØ EE (TPV 597)

```
.5
0  100  1  12
100  100  2  12
END
```

OPTIMIZATION DATA

VARIABLES (—)

(1) : 4.51899
(2) : 32.0136
(3) : 29.2938
(4) : 72.2399
(5) : 5.16145
(6) : 3.53445
ERR. F. = 7.809

GRADIENTS

(1) : — .894864
(2) : .704452E-01
(3) : 2.69282
(4) : .287748
(5) : 1.68585
(6) : — .267730

HOW MANY ITERATIONS BEFORE NEXT STOP? , 0 ' RESULTS IN FINAL ANALYSIS.
WANT INTERMEDIATE PRINTS (YES = 1' NO = 0)? TYPE TWO NUMBERS : (I, J) : 0
SEARCH INTERRUPTED, **FINAL ANALYSIS FOLLOWS** :

POLAR S-PARAMETERS IN 50.0 OHM SYSTEM

FREQ.	S11 (MAGN < ANGL)	S21 (MAGN < ANGL)	S12 (MAGN < ANGL)	S22 (MAGN < ANGL)	S21 DB	K FACT.
470.00	0.88 < 134	3.53 < 86.3	0.049 < 45.3	0.11 < 105	10.97	0.75
500.00	0.85 < 128	3.46 < 68.4	0.053 < 30.4	0.12 < 109	10.79	0.90
600.00	0.75 < 92	4.19 < 12.2	0.086 < — 16.8	0.05 < 5	12.45	0.78
700.00	0.59 < 55	4.48 < — 39.2	0.111 < — 62.2	0.19 < — 127	13.02	0.78
800.00	0.43 < 11	4.34 < — 93.2	0.133 < — 109.2	0.26 < 180	12.75	0.86
860.00	0.20 < — 44	4.08 < — 135.2	0.141 < — 147.2	0.26 < 114	12.22	1.01

Figure 3

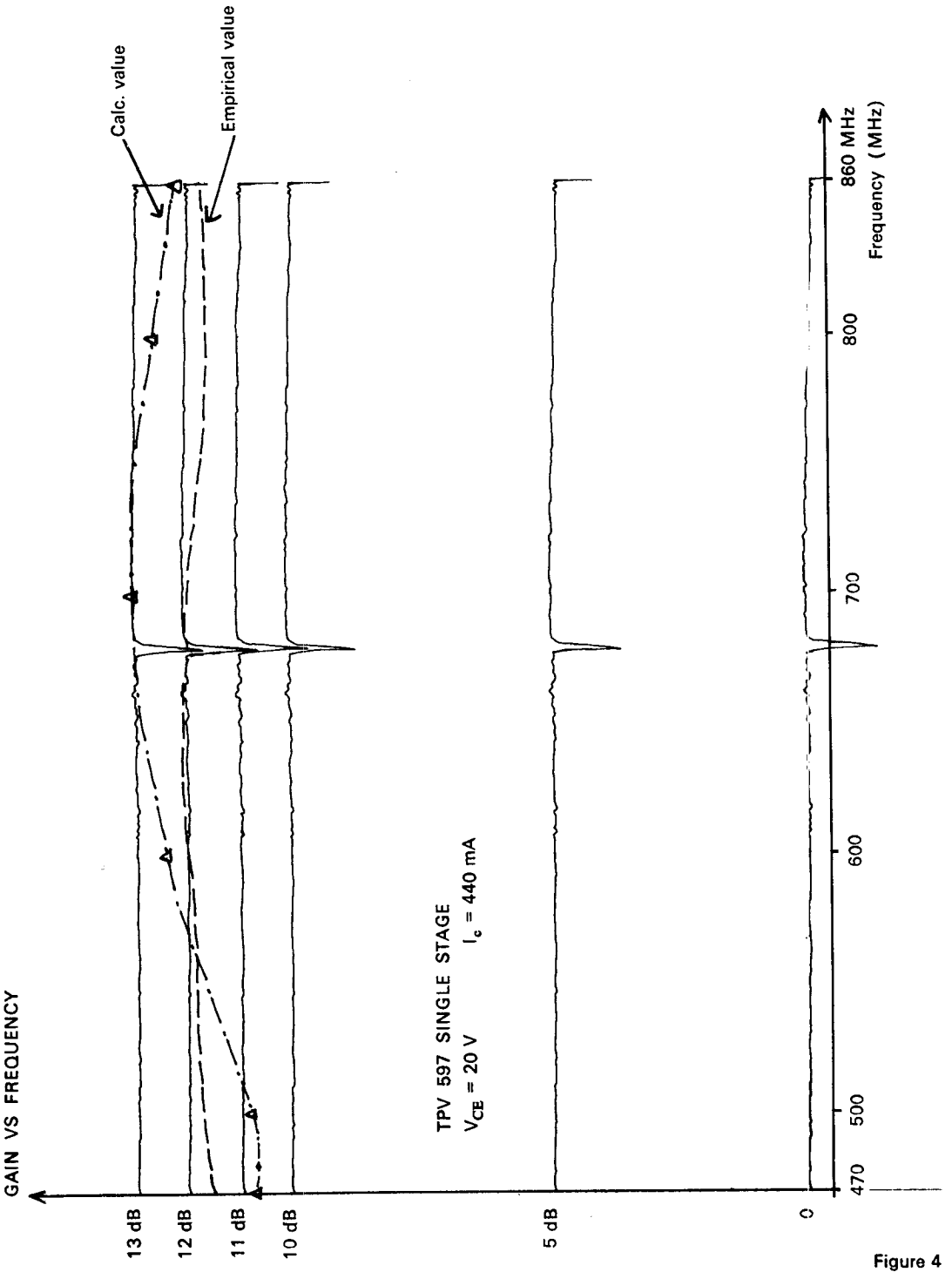

GAIN VS FREQUENCY
Calc. value
Empirical value
13 dB
12 dB
11 dB
10 dB
5 dB
0
TPV 597 SINGLE STAGE
V_{CE} = 20 V
I_c = 440 mA
470
500
600
700
800
860 MHz
Frequency (MHz)

Figure 4

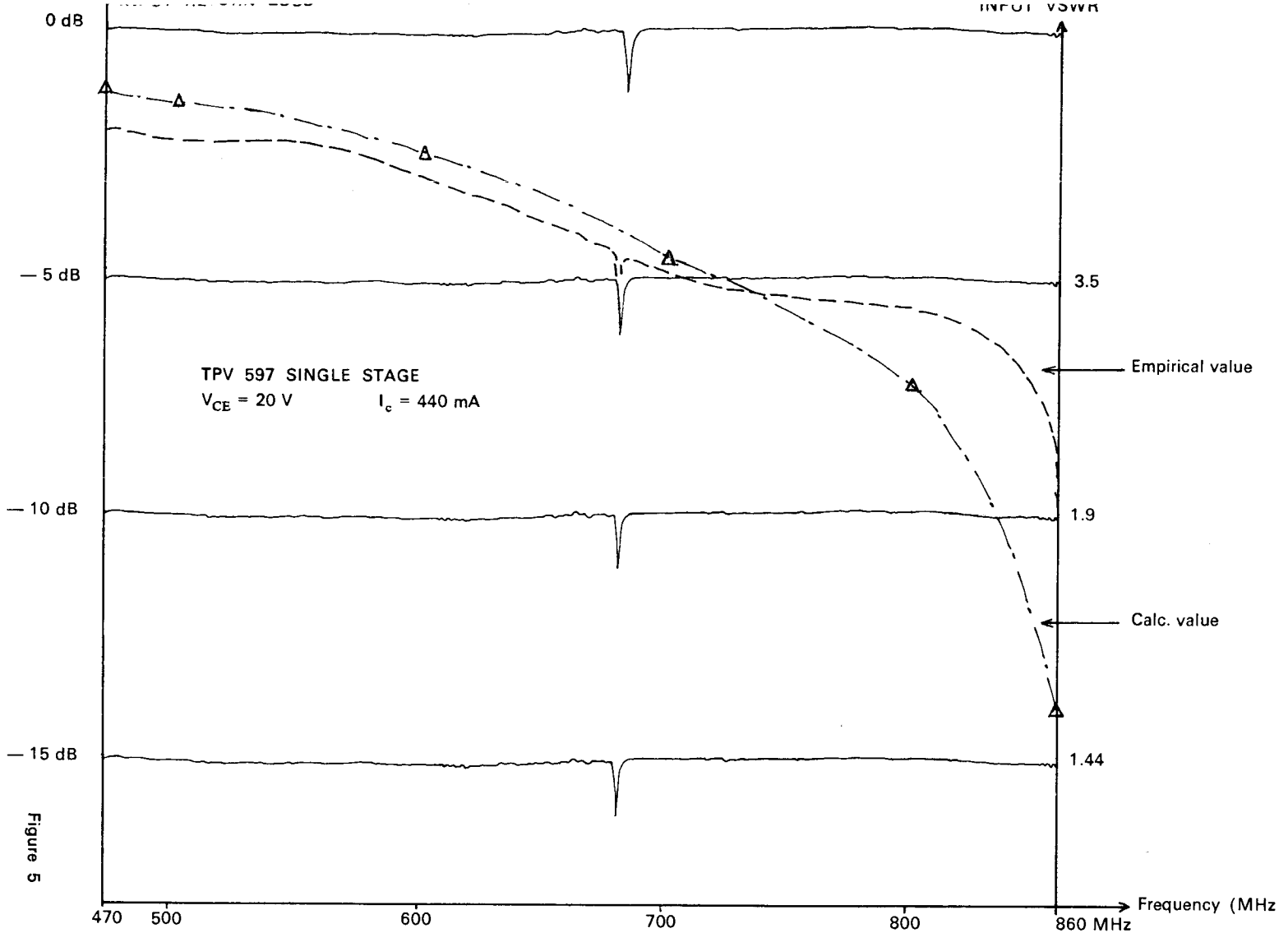


Figure 5

J 619

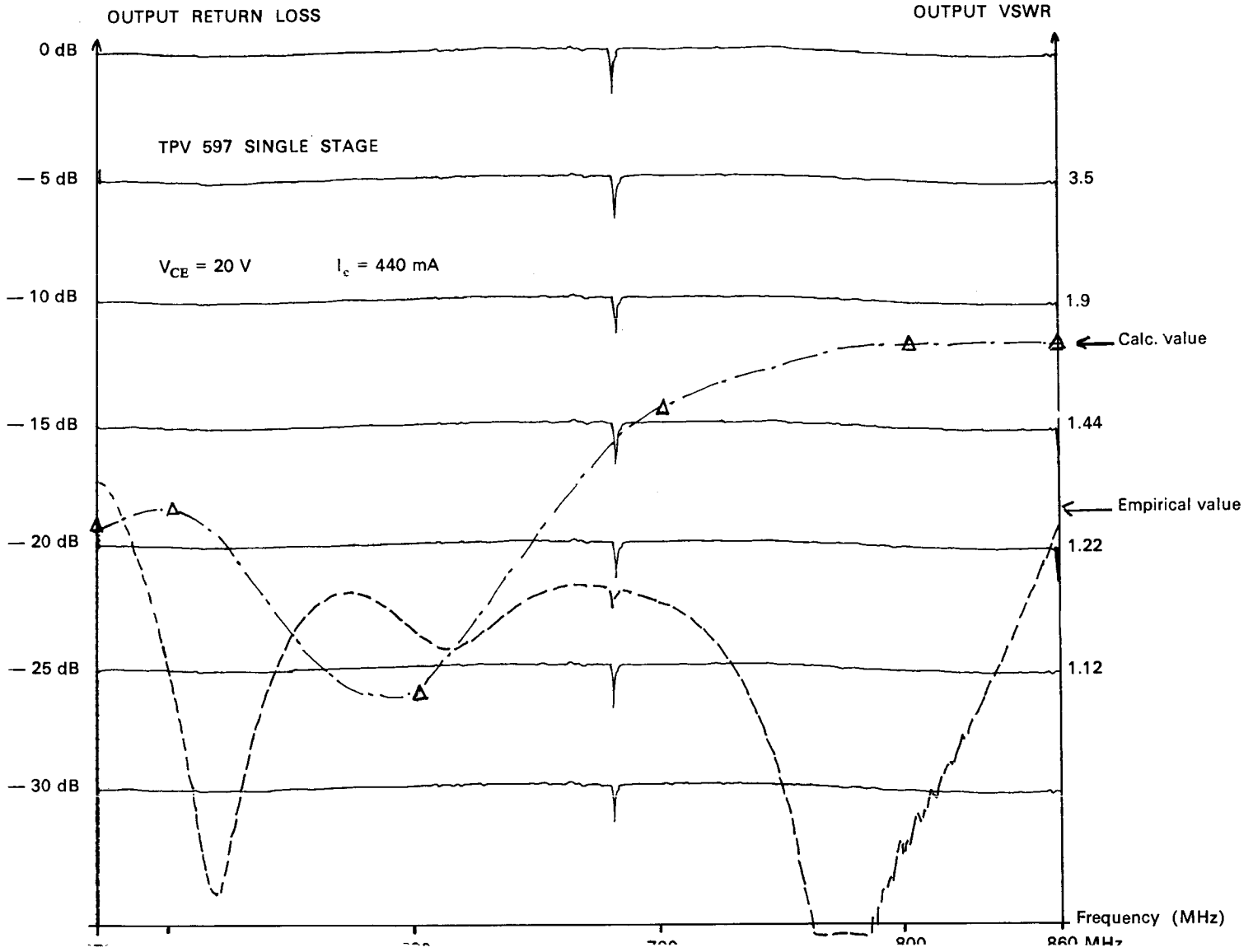

OUTPUT RETURN LOSS
OUTPUT VSWR
0 dB
— 5 dB
— 10 dB
— 15 dB
— 20 dB
— 25 dB
— 30 dB
TPV 597 SINGLE STAGE
V_{CE} = 20 V
I_c = 440 mA
3.5
1.9
Calc. value
1.44
Empirical value
1.22
1.12
Frequency (MHz)
800
860 MHz

Figure 6

IMD VS PEAK SYNCH OUTPUT

TPV 597 Single Stage

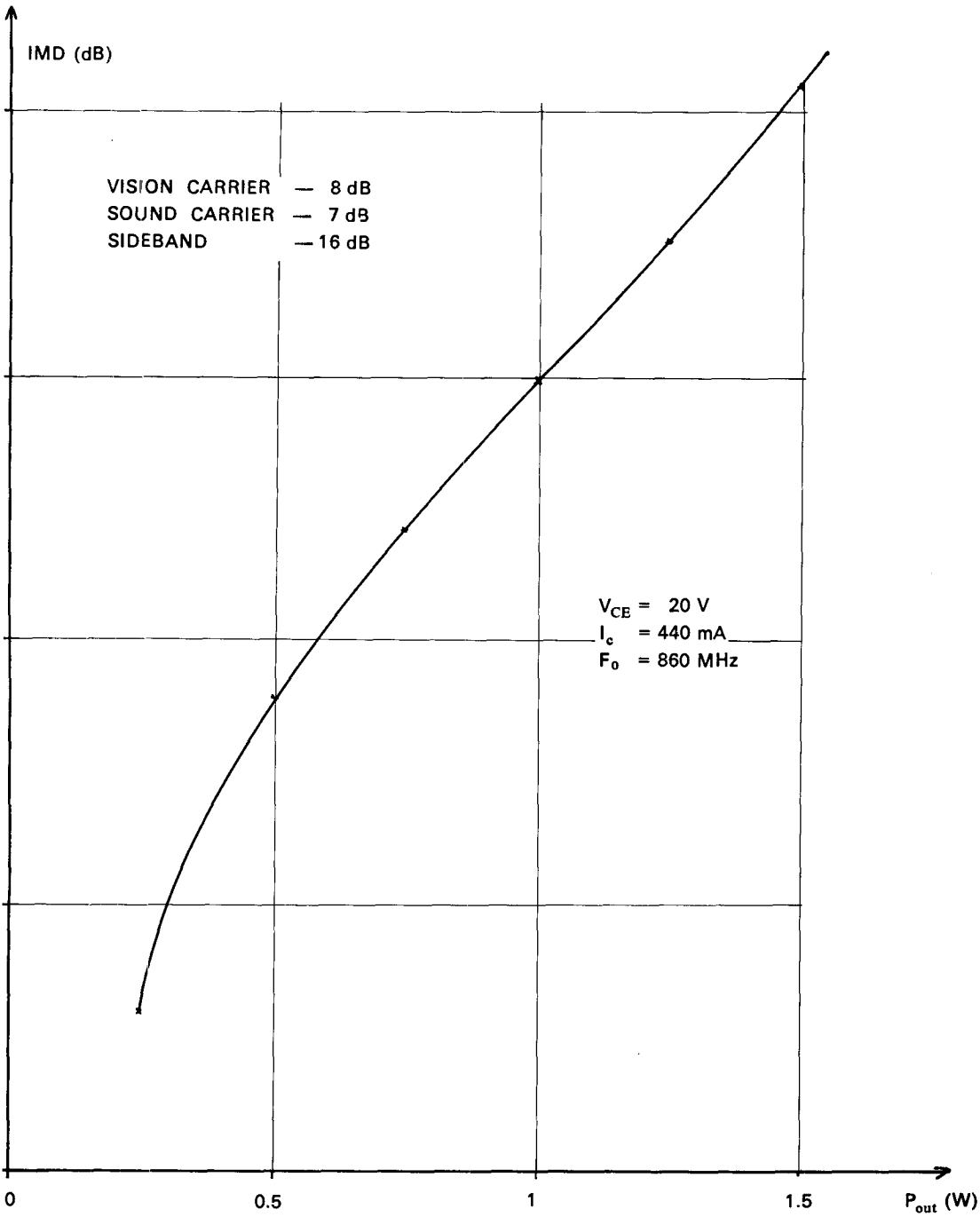


Figure 7

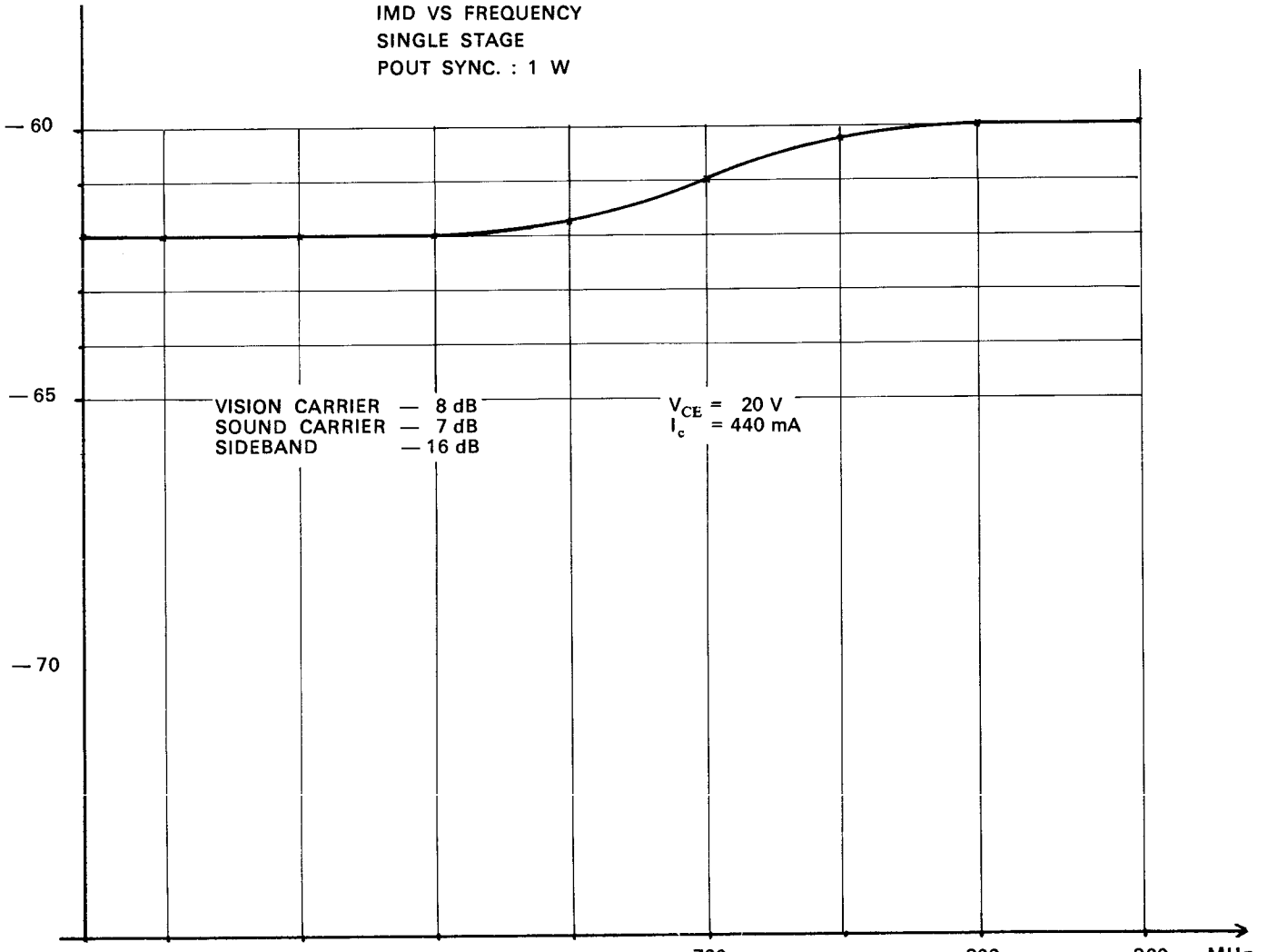
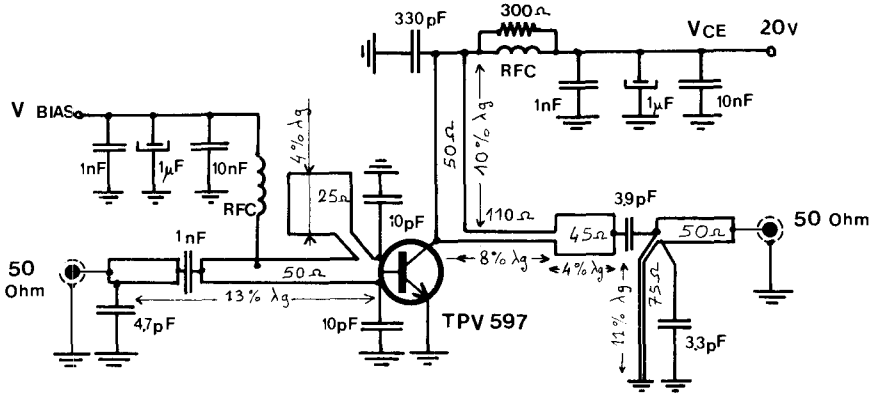

IMD VS FREQUENCY
SINGLE STAGE
POUT SYNC. : 1 W
— 60
— 65
— 70
VISION CARRIER — 8 dB
SOUND CARRIER — 7 dB
SIDEBAND — 16 dB
V_{CE} = 20 V
I_c = 440 mA
700
800
860
MHz

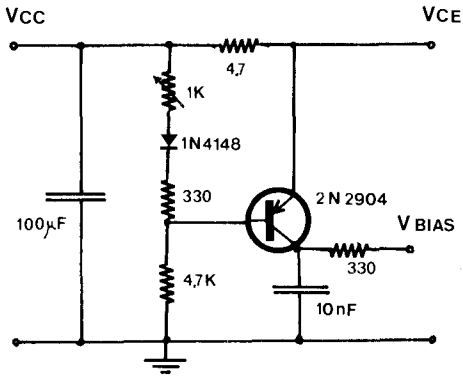
Figure 7.

DIAGRAM CIRCUIT



Lengths are given at F_o = 860 MHz $\left(\lambda g = \frac{3.10^8}{F_o \sqrt{\varepsilon_{eff}}}\right)$

Glass teflon E_r = 2.55 1/16" used by TRW.

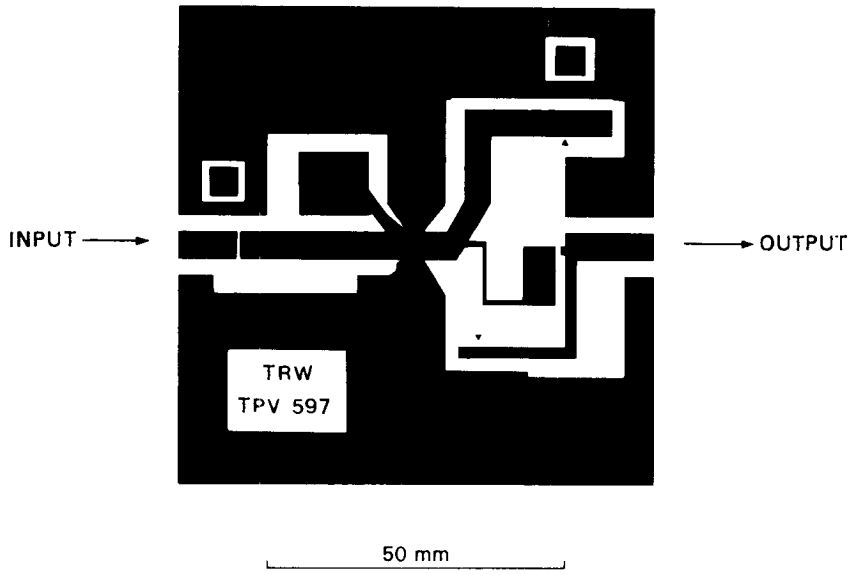


CLASS A BIAS CIRCUIT

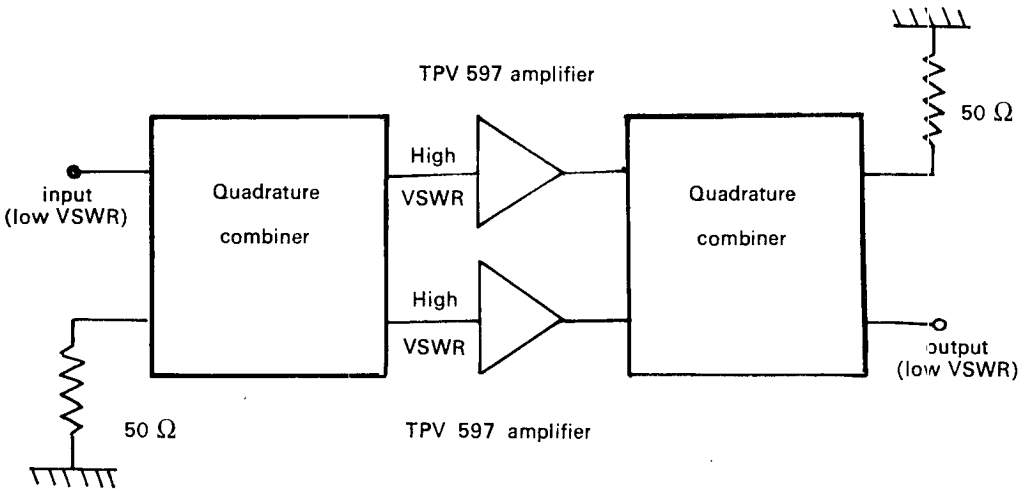
Figure 8

PC BOARD LAYOUT

Board material : Glass Teflon ; 1/16 inch ; ε_r = 2.55



TWO BROADBAND AMPLIFIERS COMBINED WITH QUADRATURE COMBINERS



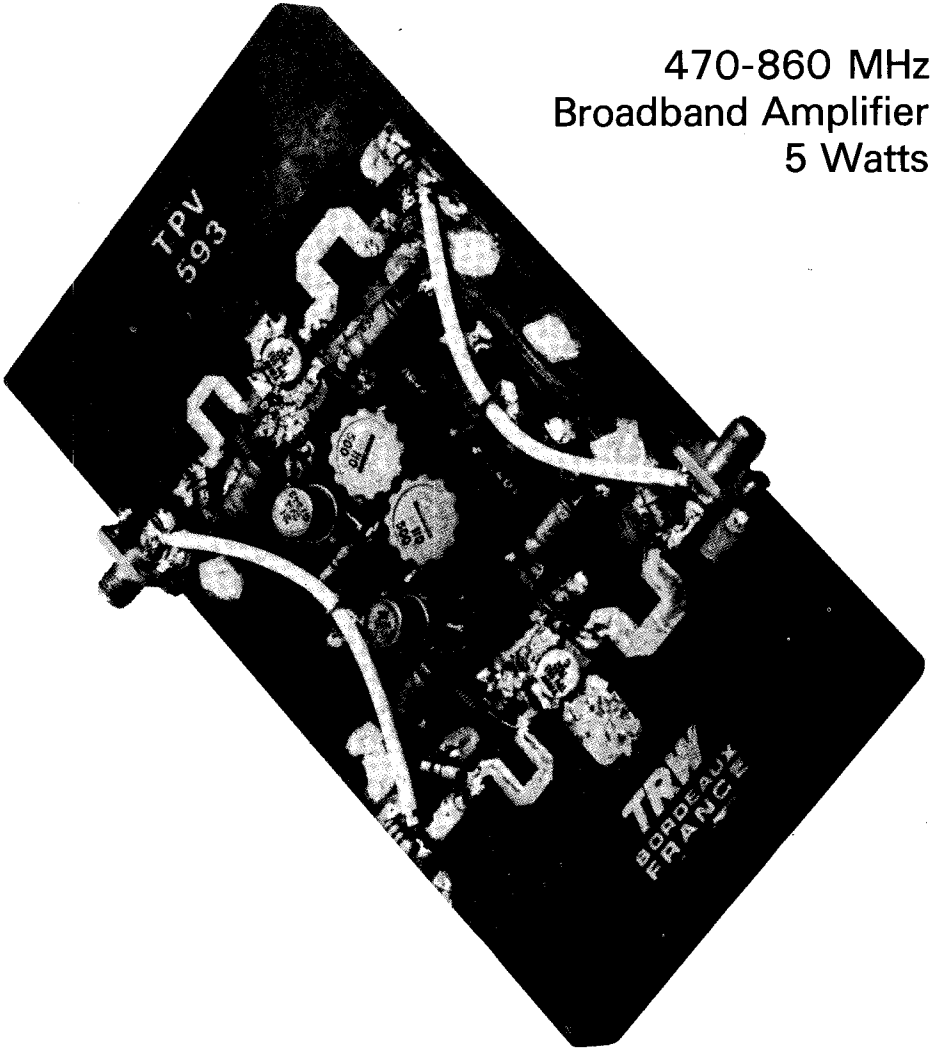
The 3 dB quadrature combiners can be supplied by :

— ANAREN (10 264-3)
— SAGE wireline (4450900)

Figure 10

TRW SEMICONDUCTORS

APPLICATION NOTE
N° 14



470-860 MHz Broadband Amplifier 5 Watts

5 W UHF TV TRANSPOSER AMPLIFIER WITH TWO TPV 593 TRANSISTORS

INTRODUCTION

This application note describes an ultralinear broadband (470-860 MHz) amplifier, developed for TV transposer applications. The amplifier incorporates two TPV 593 transistors.

Each transistor is used to build a separate broadband amplifier. The two identical amplifiers are later combined with 3 dB hybrids.

The TPV 593 transistor has been developed for TV class A application. It incorporates gold metallization and diffused ballast resistors for ruggedness and linearity. Its DC current consumption is very low and makes it a good candidate for solar cell powered systems. Its basic specifications are :

V_{CC} = 25 V I_C = 450 mA

G = 9 dB at 860 MHz

IMD = — 60 dB at 860 MHz and 2 W output

The S parameters of the TPV 593 are given in the table below.

POLAR S-PARAMETERS IN 50.0 OHM SYSTEM

FREQ.	S11 (MAGN ANGL)	S21 (MAGN ANGL)	S12 (MAGN ANGL)	S22 (MAGN ANGL)	S21 dB	K FACT·
470.00	0.93 170	1.50 63.0	0.040 50.0	0.55 — 166	3.52	1.01
650.00	0.93 165	1.06 50.0	0.050 54.0	0.60 — 169	0.51	1.04
860.00	0.92 162	0.79 38.0	0.056 54.0	0.65 — 169	— 2.00	1.15

POLAR COORDINATES OF SIMULTANEOUS CONJUGATE MATCH

F MHz	SOURCE REFL. COEFF. MAGN. ANGLE	LOAD REFL. COEFF. MAGN. ANGLE	Gmax dB
470.0	0.99 — 173	0.91 124	15.23
650.0	0.97 — 168	0.83 134	12.01
860.0	0.95 — 165	0.79 146	9.16

DESIGN CONSIDERATIONS

Two identical single transistor class A amplifiers will be combined with 3 dB couplers. First the design of a single amplifier will be considered.

From the analysis of the variation of the TPV 593 S21 parameter with the frequency it may be seen that there is a difference of 5.52 dB between 470 and 860 MHz. If a flat gain is required this gain slope has to be compensated. The compensation can be implemented in two ways :

a) By placing a selective attenuator at the input of the transistor amplifier, with an insertion loss minimum at 860 MHz and wich increases to 5.52 dB at 470 MHz. The insertion loss increase should compensate the transistor gain slope.

b) By selective mistmatch at the input of the transistor. The input circuit will provide impedance matching at 860 MHz, in order to get a gain as close as possible to the GA max. Frequency dependent mistmatch will compensate the gain slope. At 470 MHz a VSWR as high as 11 : I will be necessary. It has been proved that impedance mistmatch at the base terminal of a transistor power amplifier do not modify the linearity behaviour of the device.

As it was decided to combine two amplifiers with 3 dB couplers the method b) was selected. 50 ohms 3 dB hybrid couplers when used with two identical loads provide a good VSWR at the common terminal even if the loads differ from 50 ohms. The reflected energy is dissipated as the 50 ohms load connected to the fourth terminal of the coupler. The coupler behaves as a selective attenuator. Figure 1 shows the amplifier arrangement. The use of a 3 dB coupler to split the input signal makes almost compulsory the use of the same type of circuit at the output.

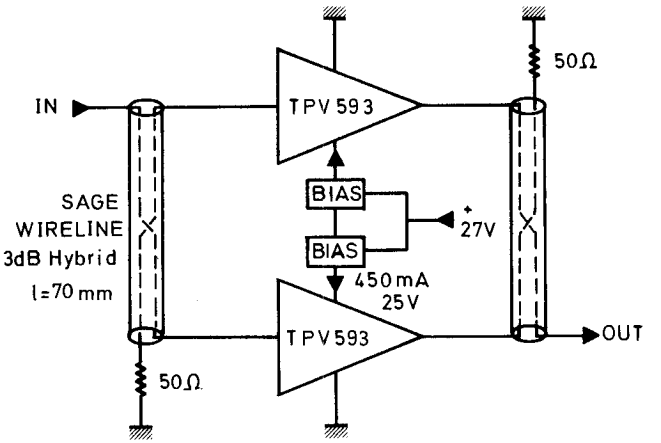


Figure 1

The amplifier must be as linear as possible over the complete UHF band. A transistor power amplifier usually requires impedance matching at the collector side for optimum intermodulation. Therefore the output circuitry has been designed for impedance matching all over the bands IV and V.

COMPONENTS PART LIST

L_1, L_2, L_6 = 50 ohms Line
L_3 = 65 line 11 % g at 860 MHz
L_4 = 50 line 1.5 % g at 860 MHz
L_5 = 50 line 17 % g at 860 MHz
L_7 = 7 turns ID 2 mm - Closely Wound - wire .5 mm

L_8 = 10 mm (5 mm wire 1 mm)

C_1, C_5 = Variable Airtronic at 7275, .8-4.5 pF
C_2 = 6.8 pF ATC 100 A
C_3, C_4 = 10 pF ATC 100 A
C_6, C_7 = 1 nF + 10 nF + .1 µF + 10 µF

Board Material : 1/16" Teflon Fiberglass

CIRCUIT DESCRIPTION

The circuit of a simple amplifier is given in Figure 2.

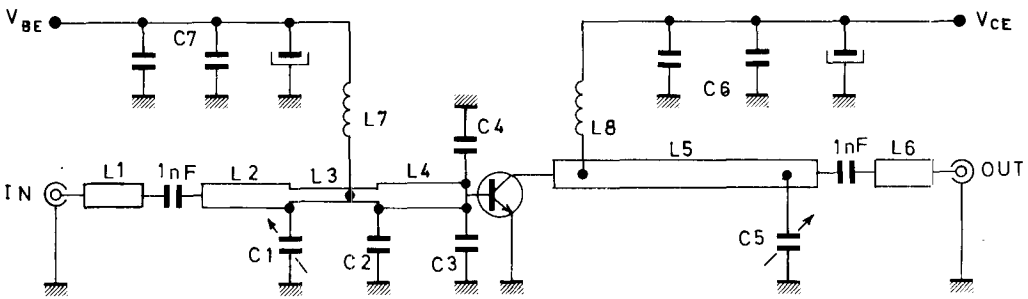


Figure 2

The input circuit consist of a three section low pass type matching network. To minimize power losses all the inpedance transformations are made at a low Q level. Variable capacitor C_1 is adjusted for optimum VSWR at 860 MHz. The tuning is straight forward and only a small retouch is necessary after the collector tuning.

The very constant S22 of the TPV 593 transistor makes extremely simple to match the collector to a 50 ohms load. L_8 tunes the output capacitance of the device and is determinant for good matching at the low end of the band. Only one low pass section is necessary. Capacitor C_5, variable, allows a good shaping of the output VSWR. Collector tuning should be done after tuning the input.

The bias control circuitry is classical and is given in figure 3.

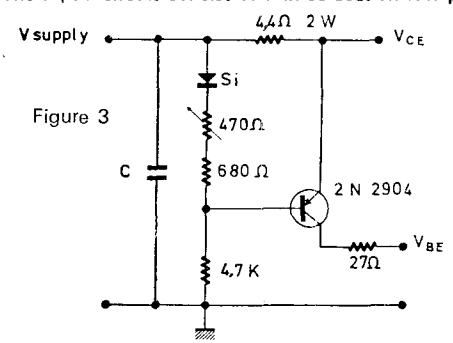


Figure 3

CONSTRUCTIONAL DETAILS

The printing circuit board lay-out of the complete amplifier is given in figure 4. Considerate attention should be paid to the ground returns. Platted through holes have been used to ensure low emitter inductance. Wrapped foils ensure proper grounding of parallel capacitors and connectors.

The couplers have been made with parallel wire cable.

This solution is as inexpensive as straigh forward.

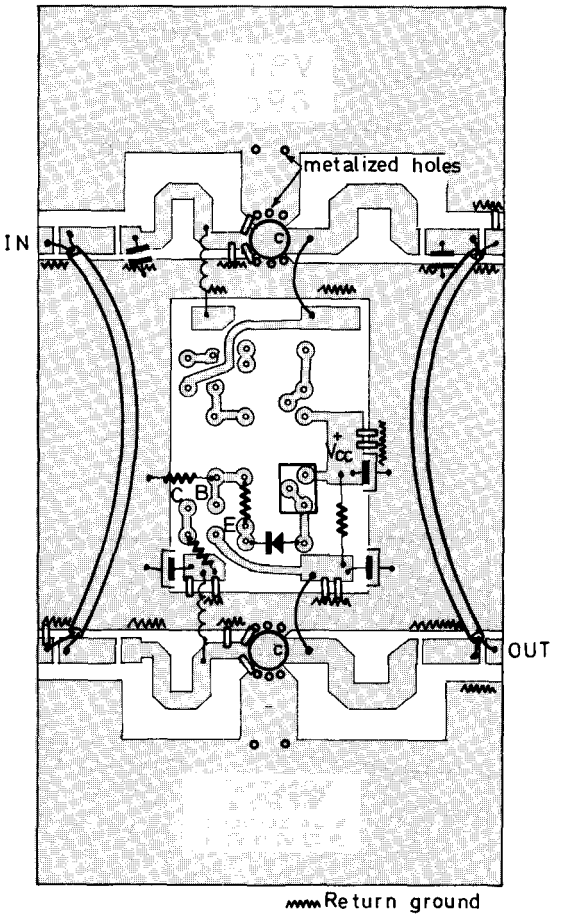


Figure 4

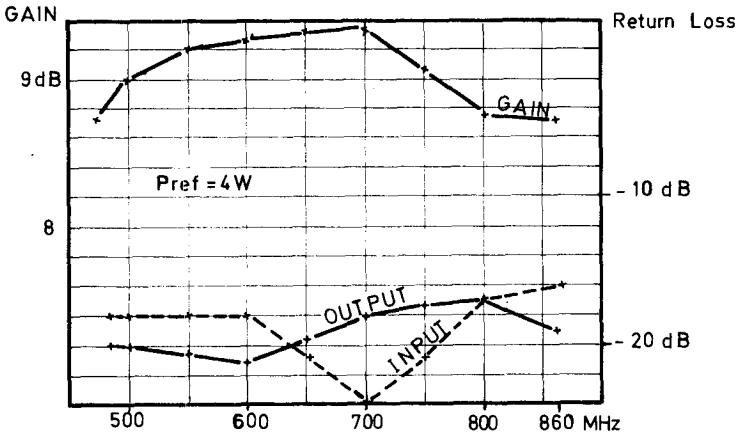


Figure 5

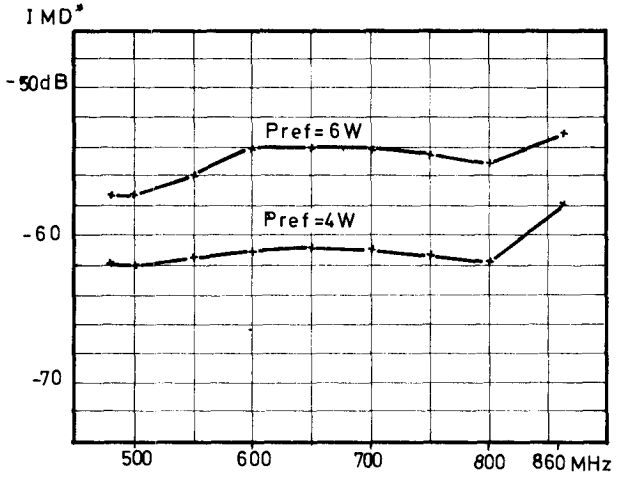
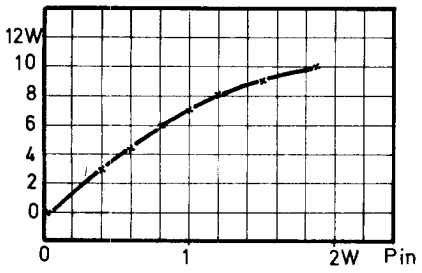
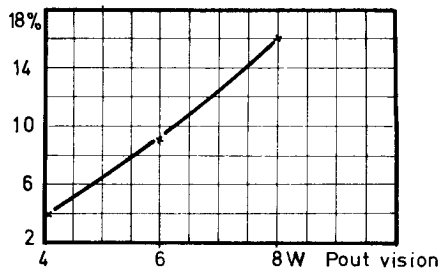


Figure 6

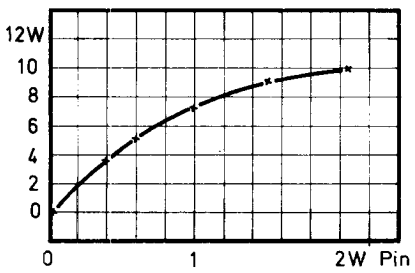
Output Power vs Input Power **Vision to Sound Cross Modulation**

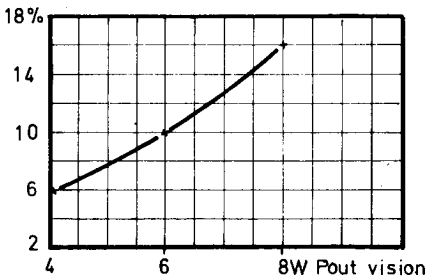
470 MHz



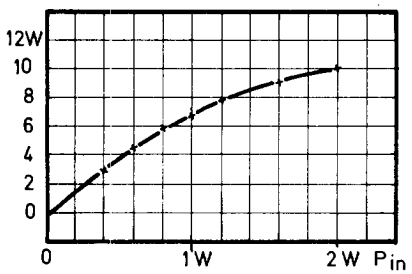


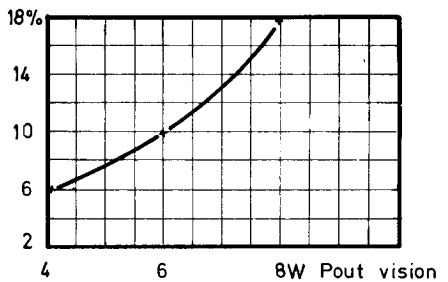
650 MHz





860 MHz





NOTA : Δ % of sound carrier (— 7 dB)
when vision carrier is switch ON/OFF

Figure 7

MEASUREMENTS

The measurements results have been summarized in table. 2.

Figure 5 shows the frequency response of the amplifier as well as the input and output match. Figure 6 displays the linearity (IMD test ; — 8, — 16, — 7 dB) of the amplifier. Static transfer curves are given in the figure 7 that shows also the vision to sound cross modulation of the amplifier.

TABLE 2

TYPICAL RESULTS

BANDWIDTH	: 470 - 860 MHz
GAIN	: 8.7 dB min.
IMD * at — 4 W	: — 58 dB
— 5 W	: — 56 dB
INPUT RETURN LOSS	: — 16 dB
OUTPUT RETURN LOSS	: — 17 dB
BIAS CONDITIONS	: V_{CE} = 25 V ; I_C = 2 × 450 mA

* IMD : SOUND = REF. — 7 dB
VISION = REF. — 8 dB
SIDEBAND = REF. — 16 dB

CONCLUSION

A high performance amplifier has been described as an example of the possibilities offered to the designer by the TPV 593. In particular the amplifier combines excellent frequency response and linearity with high efficient use of the DC power. This circuit may be of interest for output stages of low power TV transposers or drivers of higher power units.

Match impedances in microwave amplifiers

and you're on the way to successful solid-state designs. Here's how to analyze input/output factors and to create a practical design.

The key to successful solid-state microwave power-amplifier design is impedance matching.

In any high-frequency power-amplifier design, improper impedance matching will degrade stability and reduce circuit efficiency. At microwave frequencies, this consideration is even more critical, since the transistor's bond-wire inductance and base-to-collector capacitance become significant elements in input/output impedance network design.

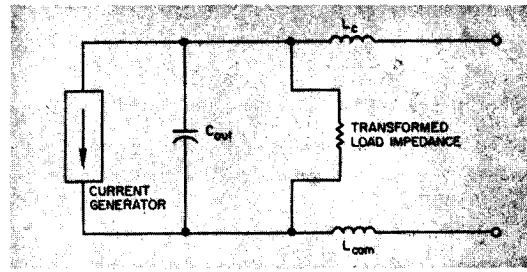
In selecting a suitable transistor, therefore, keep in mind that the input and output impedances are critical along with power output, gain and efficiency.

Unless the selected transistor is used at frequencies that are much lower than the maximum operating frequency, the input impedance is largely inductive with a small real part. The large inductance is due to bond wires that connect the transistor chip to the input lead of the package and to the common-element bond wires. The small real part of the input impedance is due to the large geometries required to generate high power at high frequencies; the base bulk resistance may be the predominant part of the real input impedance.

Use microstrip stubs at input network

The first and most important step in designing the input matching network for the selected device is to provide a shunt capacitance that will resonate the inductive component of the input impedance. This step forms the low-pass matching section of the network and should provide the smallest possible transformed impedance. To minimize the inductive component, the input and common-element lead lengths must be kept short.

The resonating capacitance is generally best provided by a microstrip stub. In some cases the stub producing the required capacitance is so large that a practical circuit size cannot be realized. It is best then to distribute as much of this capacitance as is physically practical and to provide the balance with high-quality chip capacitors.



1. **In this output equivalent circuit,** capacitance C_{OUT} is almost equal to the selected transistor's collector-to-base capacitance C_{ob}.

The first section of the impedance matching network is extremely important because it can degrade the stability of the amplifier if it is not well designed. Depending on the design frequency of the amplifier and the transistor selected, the resonated real impedance can range from less than 50 Ω to much higher. When it is below 50 Ω, an additional low-pass matching section can be conveniently added to achieve the required 50-Ω impedance at the input.

The higher-impedance case presents a special problem if microstrip techniques are used to build the matching network. The problem occurs because the resonated impedance may be as high as 300 Ω. Reducing this to 50 Ω by use of a low-pass network configuration requires a series-transmission line that will behave as an inductor. The rule of thumb is that the characteristic impedance of the transmission line must be at least twice the higher impedance before such behavior results. Examination of the accompanying table shows that characteristic impedance lines of greater than 100 Ω are very narrow. Narrow transmission lines (less than 0.01-inch wide) should be avoided wherever possible, because repeatability of width dimensions is poor. Also, the loss in a narrow line may become excessive. A better solution is to use a quarter-wave transmission-line transformer with a characteristic impedance

Roger DeBloois, Senior Applications Engineer, TRW Semiconductors, Lawndale, Calif. 90260.

equal to the square root of the 50-Ω impedance product: $Z_o = \sqrt{50\, Z_R}$.

Make output bandwidth wider than input

The output impedance of a microwave power transistor is usually defined as the conjugate of the load impedance required to achieve the device performance. A typical output equivalent circuit is shown in Fig. 1. The capacitance C_{out} is nearly equal to the collector-base capacitance C_{ob} specified for the selected transistor. L_c is the inductance of the bond wires used to bridge from the collector metallization area to the package output lead, and L_{com} represents the inductive effects of the common element bond wires.

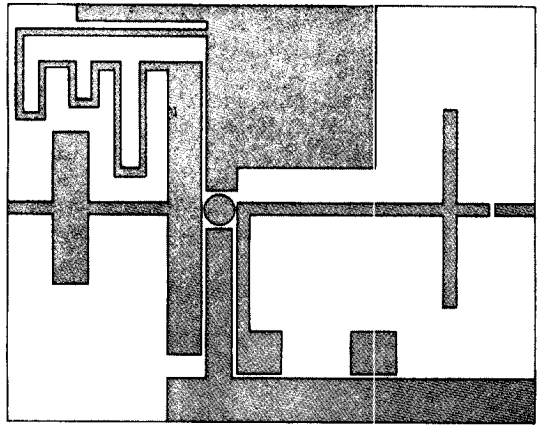
For correct operation of the transistor, the ultimate load impedance must be transformed to a real impedance across the current generator. This real impedance is determined by

$$R_L = \frac{[V_{cc} - V_{ce}\,(sat)]^2}{2P_{out}}.$$

The load impedance presented to the package terminals will contain the real impedance at the current generator, transformed to a lower value by the low-pass L section formed by C_{out} and the parasitic inductances L_c and L_{com}. Usually the reactive part of the load impedance is made inductive to tune out the residual capacitance of the device.

The output matching network should be designed so it has greater bandwidth than the input matching network. Providing a good collector match, both above and below the design frequency, ensures that the input power will be reflected before the collector VSWR rises to values that endanger the transistor. In this way the transistor is protected from off-frequency operation. The amount of additional bandwidth required for protection of the transistor depends on the ruggedness of the transistor used. The manufacturer's specifications for VSWR tolerance and input Q can be a guide for determining the bandwidth requirements of the input matching network.

One technique for obtaining the required bandwidth is to resonate a portion of the capacitive



2. **With this typical microwave amplifier breadboard layout,** the entire board can be soldered to a metal plate to provide a path for thermal cooling.

reactance of the transistor output impedance with a shunt inductor. The shunt inductor can also be used to feed the collector supply voltage to the transistor. Additional transformation may be obtained from a low-pass matching section. By adjusting the amount of shunt inductance and rematching with the low-pass section, the designer can create a truly broadband output match.

Don't overlook base and collector paths

In addition to matching the device impedances, direct-current paths must be provided to the base and collector of the transistor. The collector path is provided by the shorted stub in the impedance-matching network. The base path requires the addition of a choke from the base to ground. The choke can be a lumped element or a distributed shorted stub of sufficient impedance to be negligible in the circuit. A quarter-wavelength stub is ideal. The narrowest practical line should be selected. In addition a dc blocking capacitor is required in the collector circuit. Also needed is a bypass capacitor to provide the proper ac shorting point for the inductive stub in the col-

Microstrip Z_0 and velocity factor vs width-to-height (W/H) ratio.

(Prepared by Don Schulz, Applications Engineer, TRW)

W/H	Air K = 1.0		Teflon K = 2.55		Epoxy K = 4.25		Alumina K = 9.6	
	Z_o	V_P	Z_o	V_P	Z_o	V_P	Z_o	V_P
0.630	168.425	1.000	110.683	0.657	87.986	0.522	60.977	0.362
0.695	161.878	1.000	106.258	0.656	84.414	0.521	58.441	0.361
0.766	155.370	1.000	101.865	0.656	80.870	0.521	55.927	0.360
0.844	148.909	1.000	97.509	0.655	77.360	0.520	53.440	0.359
0.931	142.506	1.000	93.199	0.654	73.888	0.518	50.985	0.358
1.026	136.171	1.000	88.941	0.653	70.463	0.517	48.566	0.357
1.131	129.916	1.000	84.745	0.652	67.090	0.516	46.187	0.356
1.247	123.753	1.000	80.616	0.651	63.775	0.515	43.853	0.354
1.375	117.692	1.000	76.565	0.651	60.524	0.514	41.568	0.353
1.516	111.746	1.000	72.597	0.650	57.345	0.513	39.337	0.352
1.672	105.926	1.000	68.721	0.649	54.243	0.512	37.164	0.351
1.843	100.242	1.000	64.944	0.648	51.223	0.511	35.053	0.350
2.032	94.706	1.000	61.273	0.647	48.291	0.510	33.007	0.349
2.240	89.327	1.000	57.714	0.646	45.451	0.509	31.030	0.347
2.470	84.115	1.000	54.271	0.645	42.709	0.508	29.123	0.346
2.723	79.076	1.000	50.951	0.644	40.066	0.507	27.289	0.345
3.002	74.218	1.000	47.757	0.643	37.527	0.506	25.531	0.344
3.310	69.546	1.000	44.692	0.643	35.094	0.505	23.849	0.343
3.649	65.065	1.000	41.759	0.642	32.768	0.504	22.244	0.342
4.023	60.779	1.000	38.959	0.641	30.550	0.503	20.716	0.341
4.435	56.689	1.000	36.292	0.640	28.440	0.502	19.266	0.340
4.890	52.796	1.000	33.760	0.639	26.439	0.501	17.892	0.339
5.391	49.100	1.000	31.360	0.639	24.544	0.500	16.594	0.338
5.944	45.600	1.000	29.091	0.638	22.755	0.499	15.370	0.337
6.553	42.291	1.000	26.952	0.637	21.069	0.498	14.218	0.336
7.224	39.173	1.000	24.938	0.637	19.485	0.497	13.138	0.335
7.965	36.233	1.000	23.047	0.636	17.998	0.497	12.125	0.335
8.781	33.484	1.000	21.275	0.635	16.606	0.496	11.179	0.334
9.681	30.904	1.000	19.618	0.635	15.305	0.495	10.295	0.333
10.674	28.491	1.000	18.071	0.634	14.091	0.495	9.472	0.332
11.768	26.240	1.000	16.629	0.634	12.961	0.494	8.707	0.332
12.974	24.143	1.000	15.288	0.633	11.911	0.493	7.996	0.331
14.304	22.192	1.000	14.043	0.633	10.937	0.493	7.338	0.331
15.770	20.381	1.000	12.888	0.632	10.033	0.492	6.728	0.330
17.387	18.702	1.000	11.818	0.632	9.198	0.492	6.164	0.330
19.169	17.148	1.000	10.830	0.632	8.425	0.491	5.644	0.329
21.133	15.172	1.000	9.917	0.631	7.713	0.491	5.164	0.329
23.300	14.385	1.000	9.074	0.631	7.056	0.490	4.722	0.328
25.688	13.162	1.000	8.299	0.630	6.451	0.490	4.315	0.328

Table continued

W/H	Air K = 1.0 Z_o	Air K = 1.0 V_p	Teflon K = 2.55 Z_o	Teflon K = 2.55 V_p	Epoxy K = 4.25 Z_o	Epoxy K = 4.25 V_p	Alumina K = 9.6 Z_o	Alumina K = 9.6 V_p
28.321	12.036	1.000	7.585	0.630	5.894	0.490	3.942	0.327
31.224	10.999	1.000	6.929	0.630	5.383	0.489	3.598	0.327
34.424	10.047	1.000	6.326	0.630	4.914	0.489	3.284	0.327
37.953	9.172	1.000	5.773	0.629	4.483	0.489	2.995	0.327
41.843	8.370	1.000	5.266	0.629	4.089	0.489	2.731	0.326
46.132	7.634	1.000	4.801	0.629	3.727	0.488	2.489	0.326
50.860	6.960	1.000	4.376	0.629	3.397	0.488	2.267	0.326
56.073	6.343	1.000	3.987	0.629	3.094	0.488	2.065	0.326
61.821	5.779	1.000	3.632	0.628	2.818	0.488	1.880	0.325
68.157	5.264	1.000	3.307	0.628	2.566	0.487	1.711	0.325
75.144	4.792	1.000	3.010	0.628	2.335	0.487	1.557	0.325
82.846	4.362	1.000	2.739	0.628	2.125	0.487	1.417	0.325
91.337	3.969	1.000	2.492	0.628	1.933	0.487	1.289	0.325
100.700	3.611	1.000	2.267	0.628	1.758	0.487	1.172	0.324

lector-matching network.

Selection of a blocking capacitor is relatively straightforward. The capacitor should be chosen to provide low loss at the operating frequency while maintaining the capacitance at a value that inhibits low-frequency oscillation. The latter is caused by the series capacitor's tendency to display rising reactance with decreasing frequency.

Blocking capacitors must be large enough to preserve coupling characteristics down to a frequency where the shunt-feed chokes can effectively short the respective port to ground. Coupling capacitors should not be excessively large, or they may produce as much as 1-dB loss in gain with a corresponding decrease in efficiency in the case of collector coupling capacitors. The Q of the coupling capacitor determines the acceptable range of capacitance values and is generally inversely related to capacitance.

Bypass capacitors are selected by analysis of the same considerations as those for blocking capacitors. A large bypass capacitor (tantalum or electrolytic), placed from the dc feedpoint to ground, prevents tendencies toward low-frequency oscillation in the circuit. Also, it may be necessary to add smaller bypass capacitors to preserve stability over a wide range of frequencies.

Adjust for bandwidth and physical dimensions

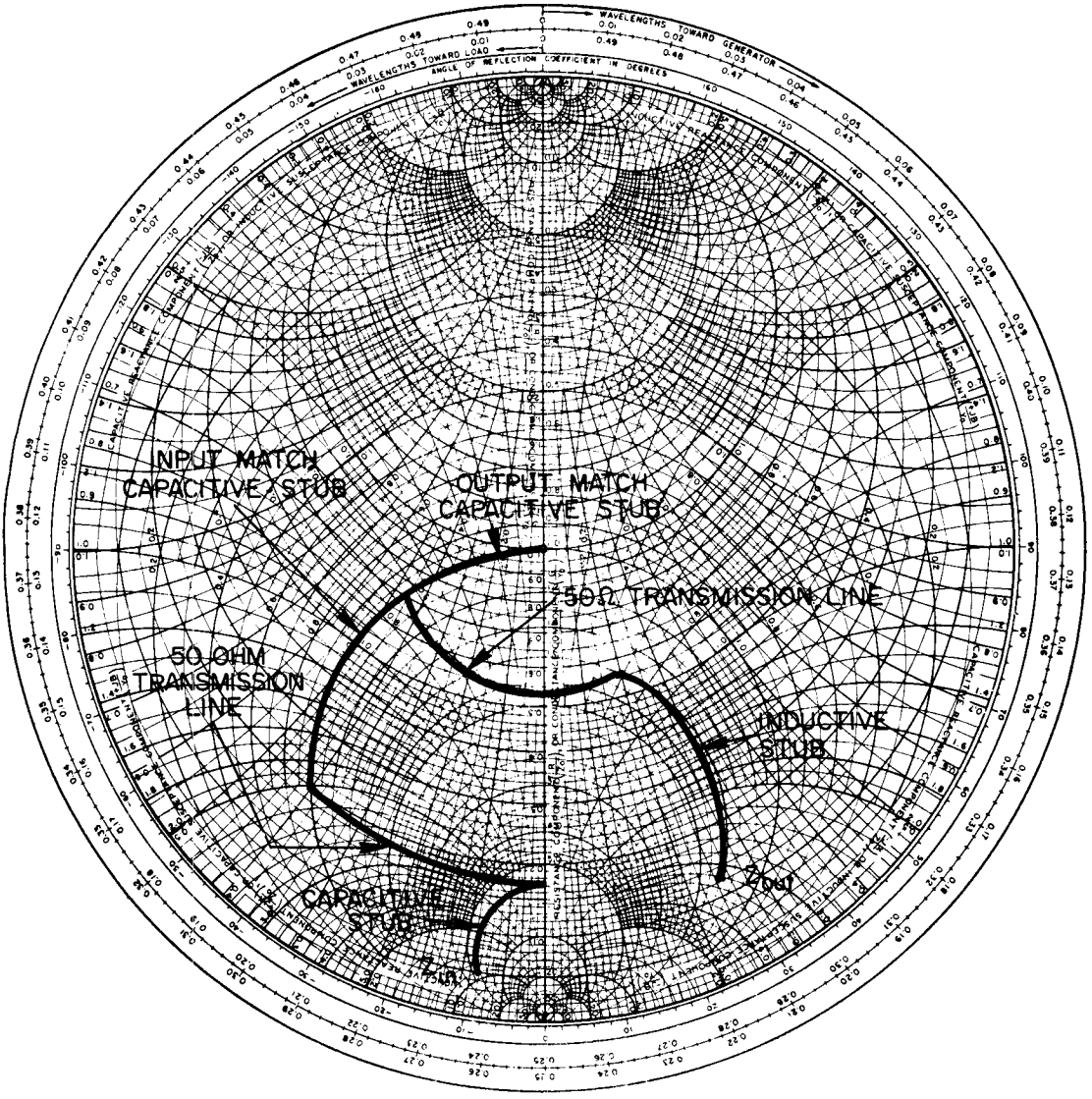
The circuit design may be adjusted quickly for bandwidth requirements through use of a computer optimization program such as Magic, offered by University Computing of Dallas, Tex. When that step is finished, electrical dimensions must be converted to physical dimensions.

At this point in the design sequence, the dielectric material must be chosen. Three commonly used materials are Teflon fiberglass, epoxy fiberglass and alumina. Above 500 MHz, epoxy fiberglass exhibits too many losses to be a good choice. Teflon fiberglass can be used up to several gigahertz; it has reasonable dielectric losses and is easy to process. Alumina, a ceramic, offers a high dielectric constant, good dimensional consistency and small circuit geometry.

When plastic materials are used, it's a good practice to measure the material thickness and dielectric constant, because variations are common. In a recent test the dielectric constant of a sheet of epoxy fiberglass material was measured at 4.55 at 1 MHz and 4.25 at 500 MHz. If the manufacturer's value of 5.5 had been used for the design of matching networks, considerable error would have resulted.

The physical dimensions of the matching circuitry may be calculated from the data in the table. The line lengths are scaled by the velocity factor, which is equal to $Z_o/Z_{o(air)}$ in air for a constant width-to-height ratio, W/H.

The final design of a typical breadboard microwave amplifier is shown in Fig. 2. The ground areas on the top of the board are connected to the microstrip ground plane by 2-mil-thick foil wrapped around the edges of the board and the areas directly under the emitter leads of the transistor. The foil is secured to the top and bot-



3. **The immittance chart,** with values specified for the design example, indicates the necessary inductive and capacitive stubs. Impedance transformations are achieved by 50-Ω series-transmission lines.

tom surfaces with solder. Plating may be used for production units. The entire board can be soldered to a metal plate to allow connector mounting and to provide a thermal path for the heat generated by the transistor.

The initial tune-up of the amplifier matching circuits can be expedited by use of a network analyzer and a precision load on the input or output connector. The circuit can be adjusted to match the nominal impedances supplied by the transistor manufacturer. Distributed stubs are purposely made longer than necessary and are adjusted to the correct length by trimming of the foil on the capacitive stubs. The inductive stub in the output network is adjusted by positioning of the bypass capacitor along the stub and the adjacent ground plane.

This procedure results in a load line that is fairly close to optimum. A transistor can now be inserted in the circuit and the collector matching network readjusted for maximum collector efficiency. Stub tuners are used to match the amplifier input impedance, so that only one variable at a time need be considered. Initially it may be necessary to operate the transistor at reduced collector voltage and power output to avoid

excessive stress. When maximum efficiency is obtained, the stub tuner is removed and the input network adjusted for minimum input VSWR.

Now let's design an impedance-matching circuit

Let's consider a practical example of a procedure for the design of impedance-matching circuitry. The sample circuit uses a TRW 2N5596 at 700 MHz as the active device.

Specifications for the completed amplifier are:

$$\begin{aligned} Z_{in} &= 50\ \Omega, \\ Z_{out} &= 50\ \Omega, \\ P_{out} &= 20\ W, \\ G_p &= 7\ dB, \\ \eta &= 55\%\ \text{minimum}. \end{aligned}$$

Specifications for the TRW 2N5596 are:

$$\begin{aligned} P_{out} &= 20\ W \text{ at } 1\ GHz, \\ \eta &= 55\% \text{ minimum at } 1\ GHz, \\ G_p &= 5\ dB \text{ minimum at } 1\ GHz, \\ Z_{in} &= 2.5 + J4.0 \text{ at } 700\ MHz, \\ Z_{out} &= 6.0 - J12.5 \text{ at } 700\ MHz. \end{aligned}$$

In practice, the gain of a common-emitter amplifier decreases at a rate of 4 to 5 dB per octave. The 2N5596 at 700 MHz produces about 7 dB of gain. Therefore approximately 4 W of drive will be required to produce 20 W of output power. The collector efficiency can be expected to increase at the lower frequency, but it is difficult to estimate because it is a complex phenomenon. Manufacturers' curves of typical behavior are useful. Output power will not increase significantly with the decreased frequency.

The efficiency-frequency relationship depends on device f_T and ballasting. Heavily ballasted transistors tend to give increased efficiency as frequency is decreased. However, they level out at a lower efficiency than a nonballasted part because of I^2R losses in ballast resistors. The average increase in efficiency as a result of decreasing frequency is about 20% per octave. Values from 10 to 40% per octave have been measured.

The initial phase of the design is best accomplished on an immittance chart. The chart with appropriate values indicated for the sample design is shown in Fig. 3. The input match is achieved when the input impedance is resonated with a capacitive susceptance of 0.18 mhos. This susceptance is realized by use of a pair of capacitive microstrip stubs. Each stub must exhibit a reactance of $2 \times 1/0.18$ mhos, or 11.1 Ω. The length of the stub may be calculated by

$$\tan \Theta = \frac{Z_o}{X_c}.$$

For ease of adjustment, the length of the stubs should be less than 60 degrees. Because capacitive reactance is a tangential function, the reactive variations per unit length become increasingly severe past 60 degrees. It is better to decrease Z_o rather than to use longer stubs to achieve higher capacitance. Therefore $Z_o \leqq 1.732\ X_c \leqq 19.24\ \Omega$. Because it is easier to shorten a microstrip stub than to lengthen it, the Z_o of 15 Ω, for example, provides sufficient adjustment range to accommodate device variations.

The next step is to transform the resonated impedance to 50 Ω. This is accomplished by a series-transmission line with a characteristic impedance of 50 Ω. From Fig. 3, we see that the length of this line can be directly determined to be 0.062 wavelengths, or 22.3 degrees, long. A capacitive susceptance of 0.040 mhos completes the transformation. Again, a pair of capacitive stubs will provide the susceptance. For ease of converting the design to microstrip dimensions, it is convenient to choose a Z_o for the second stub that is equal to that selected for the first. Therefore:

$$\tan \Theta = \frac{Z_o}{X_c} = \frac{15}{50} = 0.3,$$
$$\text{or } \Theta = 16.7 \text{ degrees}.$$

In this case the length chosen is 20 degrees to allow for some adjustment.

The output match is achieved by partial resonating of the device's output impedance with an inductive susceptance. While the amount of susceptance chosen is arbitrary at this point, the output network bandwidth is affected by the value. From Fig. 3, we can determine that 0.05 mhos is required for the first matching element. This susceptance is achieved by use of a shorted microstrip stub. The length of the stub may be calculated from the equation

$$\tan \Theta = \frac{X_L}{Z_o}.$$

If Z_o of the stub is arbitrarily chosen to be 50 Ω,

$$\tan \Theta = \frac{20}{50} = 0.4,$$
$$\Theta = 21.8 \text{ degrees}.$$

Again, the stub is made somewhat longer because it can be adjusted by sliding the chip capacitor (ac short) up or down the line length. The remaining transformation is achieved by a 50-Ω series-transmission line of 0.15 wavelengths (54 degrees long) and a capacitive susceptance of 0.014 mhos. Selecting a pair of 50-ohm microstrip lines to provide the susceptance requires a stub length of

$$X_c = 2 \times \frac{1}{0.014} = 143\ \Omega.$$
$$\tan = \frac{Z_o}{X_c} = \frac{50}{143} = 0.350 = 19.3 \text{ degrees}.$$

A stub length of 25 degrees will provide an adequate allowance for adjustment of the circuit. ■■

Three Balun Designs For Push-Pull Amplifiers

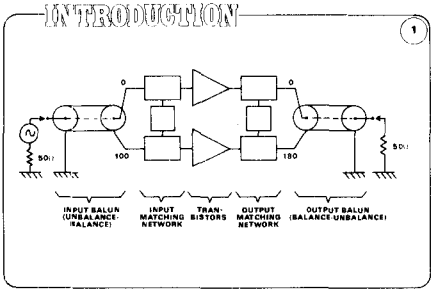
SINGLE RF power transistors seldom satisfy today's design criteria; several devices in separate packages,[1] or in the same package (balanced, push-pull or dual transistors), must be coupled to obtain the required amplifier output power. Since high-power transistors have very low impedance, designers are challenged to match combined devices to a load. They often choose the push-pull technique because it allows the input and output impedances of transistors to be connected in series for RF operation.

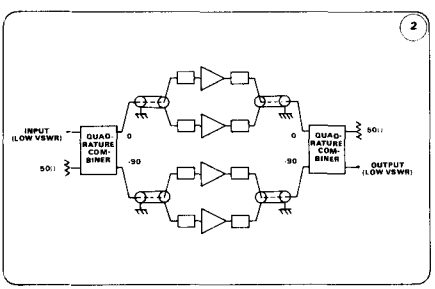
Balun-transformers provide the key to push-pull design, but they have not been as conspicuous in microwave circuits as at lower frequencies. Ferrite baluns[2] have been applied up to 30 MHz; others incorporating coaxial transmission lines operate in the 30-to-400-MHz range.[3]

The success of these two balun types should prompt the microwave designer to ask if balun-transformers can be included in circuits for frequencies above 400 MHz. Theory and experimental results lead to the emphatic answer: yes! Not only will baluns function at microwave frequencies, but a special balun can be designed in microstrip form that avoids the inherent connection problems of coax.

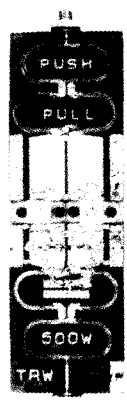
On the next six pages, you will observe the development of three balun-transformers—culminating with the microstrip version. None of the baluns was tuned nor were the parasitic elements compensated. In this way, the deviation of the experimental baluns from their theoretical performance could be evaluated more easily. The frequency limitations imposed by the parasitic elements also were observed more clearly.

INTRODUCTION





1. A balun transforms a balanced system that is symmetrical (with respect to ground) to an unbalanced system with one side grounded. Without balun-transformers, the minimum device impedance (real) that can be matched to 50 ohms with acceptable bandwidth and loss is approximately 0.5 ohms. The key to increasing the transistors' output power is reducing this impedance ratio. Although 3-dB hybrid combiners can double the maximum power output, they lower the matching ratio to only 50:1. Balun transformers can reduce the original 100:1 ratio to 6.25:1 or less. The design offers other advantages: the baluns and associated matching circuits have greater bandwidth, lower losses, and reduced even-harmonic levels.



A 500-W push-pull amplifier for DME band.

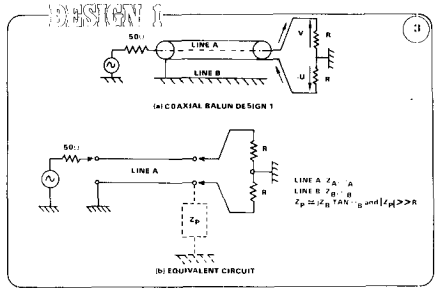
2. Baluns are not free of disadvantages. Coupling a pair of push-pull amplifiers with 3-dB hybrids avoids (for four-transistor circuits) one of these: the higher broadband VSWRs of balun-transformers. A second disadvantage, the lack of isolation between the two transistors in each push-pull configuration, is outweighed by the advantages of the balun design in reducing the critical impedance ratio.

3. In this simple balun that uses a coaxial transmission line, the grounded outer conductor makes an unbalanced termination, and the floating end makes a balanced termination. Charge conservation requires that the currents on the center and the outer conductors maintain equal magnitudes and a 180-degree phase relationship at any point along the line. By properly choosing the length and characteristic impedance, this balun can be designed to match devices to their loads. In the case shown, if $\emptyset_A = 90$ degrees, the matching condition is:

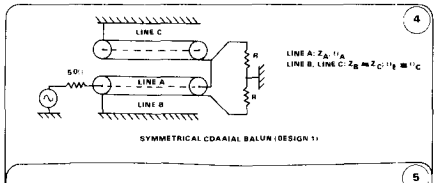


Experimental version of a simple balun using coaxial lines.

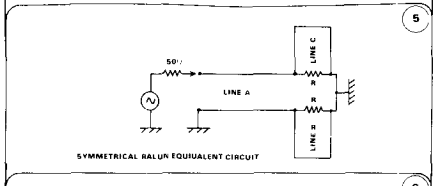
$$Z_A^2 = 2xRx50.$$



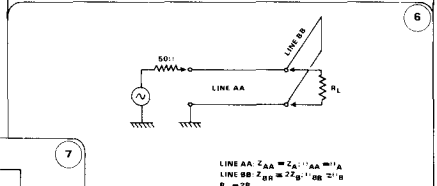
4. By adding a second coaxial line, the basic balun can be made perfectly symmetrical. In this symmetrical coaxial balun, the bandwidth (in terms of the input VSWR) is limited by the transformation ratio, 50/2R, and the leakages, which are represented by lines B and C. If Z_A = 50 ohms and R = 25 ohms, the bandwidth is constrained only by the leakages.

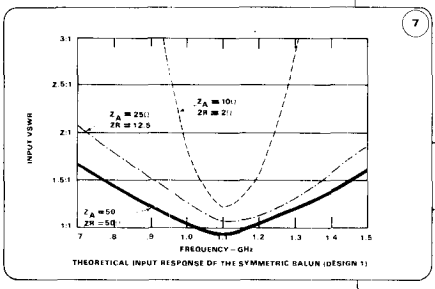


5. The equivalent circuit for the symmetrical balun shows the effect of the leakages (lines B and C) on its performance. A broadband balun can be obtained by using a relatively high characteristic impedance for these leakage lines. In theory, the construction of the baluns insures perfect balance.

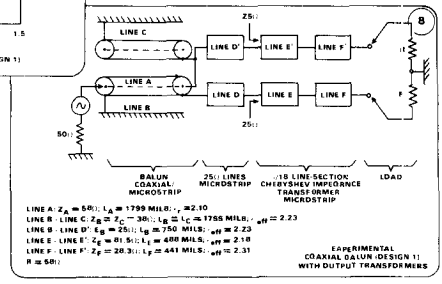


6. The symmetric balun's input equivalent circuit further simplifies its configuration and allows the input VSWR to be calculated.[4] In this design, line A has a characteristic impedance of Z_A = 50 ohms, a length of L_A = 1799 mils, and a dielectric constant (relative) of ϵ_r = 2.10. For lines B and C, Z_0 = 30 ohms, L = 1799 mils, and ϵ_{eff} = 2.23.

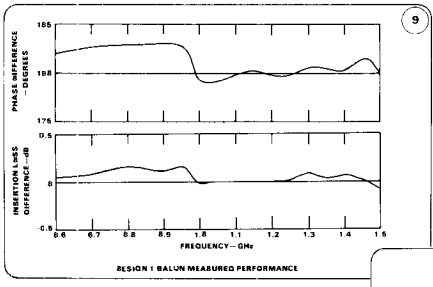




7. The theoretical input VSWR has been calculated for 50-ohm values of Z_A and 2R, and for two other sets of values for these parameters. The performance of an experimental balun will be compared with these theoretical results.

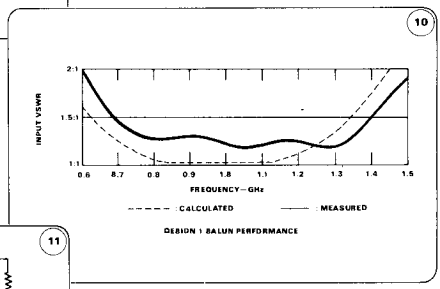


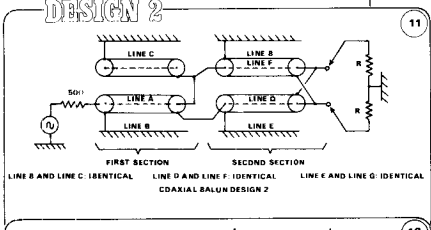
8. Two λ/16 line-section Chebyshev impedance transformers match the experimental balun to a 50-ohm measurement system. The balun was tested from 0.6 to 1.5 GHz.



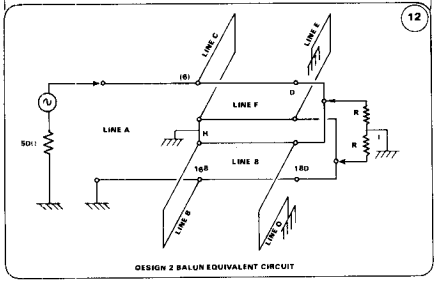
9. The measured phase difference and insertion loss difference, which indicate the maximum unbalance for the Design 1 experimental balun, are 3 degrees and 0.2 dB, respectively.

10. The maximum VSWR measured for the first design is 1.5:1. Note the comparison between the calculated and measured response. The performance shown can be considered valid for amplifier applications up to an octave range.

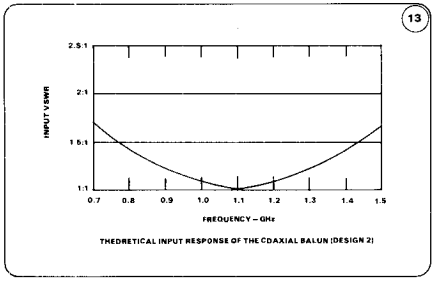




11. The second balun design adds two identical coax lines to the simple balun just described. The inputs of the identical lines are connected in series to the output of the first balun. By putting their outputs in parallel, the final output becomes symmetrical. The output impedance is halved.



12. The equivalent circuit for the Design 2 balun indicates that its bandwidth, in terms of input VSWR, is limited by the transformation ratios of the first and second sections and the leakages represented by lines B, C, E, and G. If the balun is designed with Z_A = 50 ohms, and $Z_D = Z_F$ = 25 ohms, and if the load, 2R, is set at 2×6.25 ohms, all of the transmission lines will be connected to their characteristic impedances. In this case, the bandwidth will be limited by the leakage alone, and a broadband balun can be obtained by choosing lines B, C, E, and G with relatively high impedance and λ/4 length for the center frequency. The balun achieves a transformation from 50 ohms to twice 6.25 ohms without causing a standing wave in the coaxial cables.

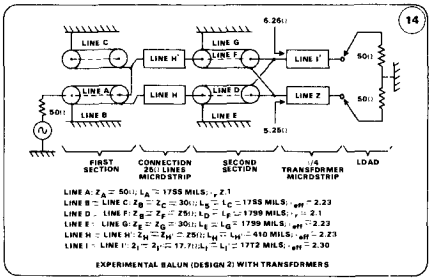


13. The performance of the Design 2 balun can be calculated using its equivalent circuit. The calculated VSWR shows a response very close to the simple coaxial balun (Fig. 10) because the new second section has four times the bandwidth of the first section. This design and its two companions are intended to have octave bandwidths centered at 1.1 GHz, the central frequency used in distance measuring equipment (DME, 1.025 to 1.150 GHz) and tactical air navigation (TACAN, 0.960 to 1.215 GHz). For line A: Z_A = 50 ohms, L_A = 1799 mils, ϵ_r = 2.10; lines B, C, E, and G: Z_B = 30 ohms, L = 1799 mils, ϵ_{eff} = 2.23; lines E and F: Z_E = 25 ohms, L = 1799 mils, ϵ_r = 2.10.



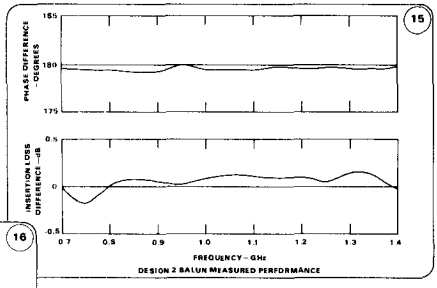
Two-section balun often used in the 100-to-400 MHz range.

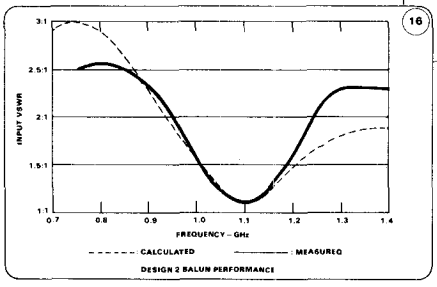
14. Two λ/4 transformers match the experimental two-section coaxial balun's 6.25-ohm impedance to the 50-ohm load. Although these transformers drastically reduce the bandwidth (in terms of the VSWR), they don't affect the balance.



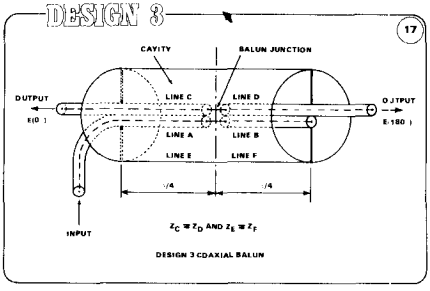
15. The measured phase difference and measured insertion loss difference are plotted for the two-section coaxial balun (Design 2). The maximum unbalances for these two measurements over the octave bandwidth are 1 degree and 0.2 dB.

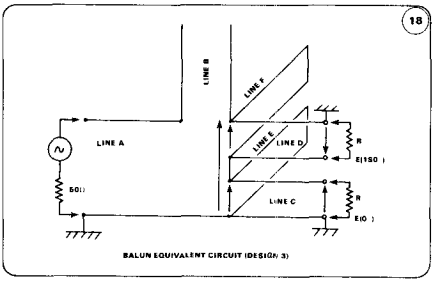
16. The calculated and measured values for the input VSWR for the Design 2 balun show close agreement between the experimental and predicted performances. This indicates that the parasitic inductors at the connections are negligible to at least 1.4 GHz. Moreover, the balun has excellent balance to 1.4 GHz and achieves the 4:1 transformation without causing a standing wave in the coaxial line. Despite the many excellent qualities of the Design 1 and Design 2 baluns, the necessary coaxial line connection limits them to approximately 2 GHz.





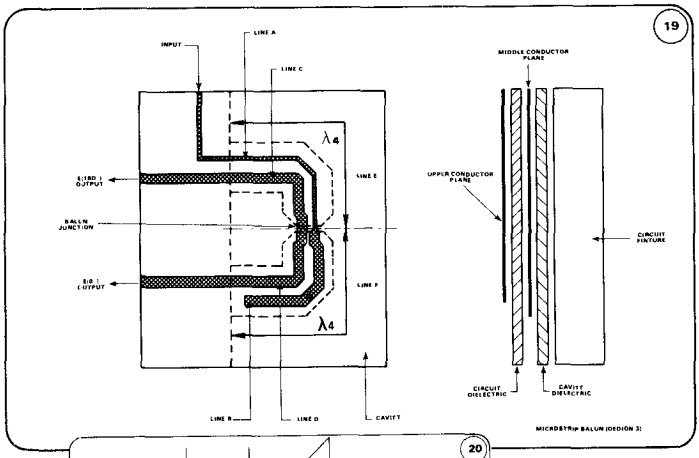
17. The problems associated with the previous coaxial baluns can be reduced or eliminated by using a balun that allows a microstrip coplanar arrangement of the input and output lines, which greatly simplifies the connections to the amplifier. This balun[5] consists of an input line, A, connected in series to three elements in the center of the half-wavelength cavity: a reactive open-circuit stub, B, and the λ/4 output lines, C and D.

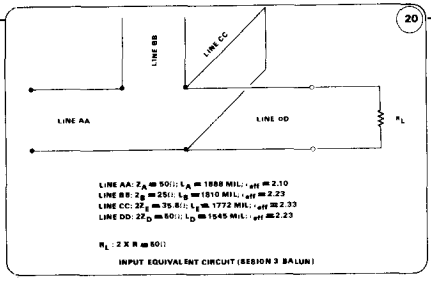




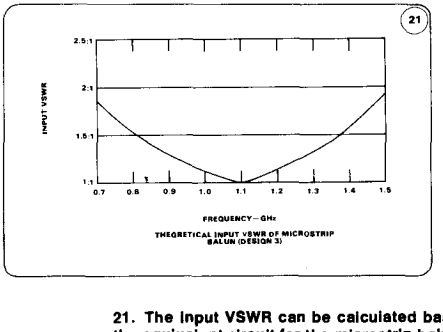
18. The equivalent circuit of the Design 3 coaxial version balun shows lines C and D connected to place their input signals in antiphase, thereby producing two antiphase signals at their outputs. Transmission line impedances and lengths are optimized to achieve the correct input/output transformation ratio and a good match across the desired bandwidth. If only one frequency or a narrow bandwidth is desired, and all lengths are λ/4, the matching condition $Z_A^2/50 = 2Z_C^2/R$, will occur. In this case, Z_E ($Z_E = Z_F$) and Z_B have no significance except for loss.

19. The coplanar arrangement of input and output lines can be accomplished with microstrip technology. The uppermost conductor plane contains input line A, output lines C and D, and the open stub B. Coupling between these lines is avoided by separating them by at least one line width. The middle conductor carries the ground plane for the lines. To avoid radiation loss, the center conductor must extend at least one line width to either side of the upper plane circuit line. The balun resonant cavity is formed by the region between the middle and the lower conductor planes. A hole for the cavity is cut in the circuit fixture, filled with dielectric, and covered with the middle conductor plane. The end-to-end length of the cavity is nominally a half-wavelength at midband. To avoid disturbance of the field distribution, the cavity width must be at least three times the width of the middle conductor plane. The arms of the balun cavity are folded to produce two parallel and proximate output transmission lines. This configuration is more suited to coupling two transistors than the original layout in which the two outputs were on opposite sides (Fig. 17).





20. The input equivalent circuit for the microstrip version of the Design 3 balun allows its theoretical performance to be calculated. The design parameters shown provide a microstrip circuit that can be compared with the coaxial baluns of Design 1 and Design 2. Transmission line A and lines C and D are loaded by their characteristic impedances—in this case, 50 and 25 ohms. The cavity and the stub impose the principal frequency limitation. The impedances of these elements are dictated by the properties of the available dielectric substrates (glass-Teflon 0.020 and 0.0625 inches thick).

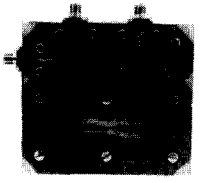


21. The input VSWR can be calculated based on the equivalent circuit for the microstrip balun. For a one-octave bandwidth, the input VSWR is lower than 1.75:1. This calculated performance is similar to that of the two previous balun designs. The design of the microstrip has theoretically perfect balance.

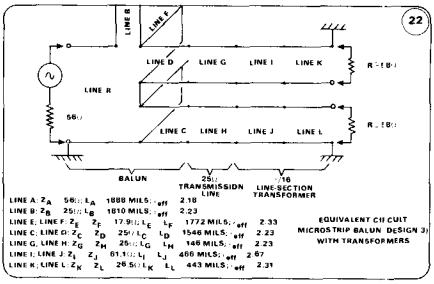
References

1. "35/50 Watt Broadband (160-240 MHz) Push-Pull TV Amplifier Band III," TRW Application Note, TRW RF Semiconductors Catalog No. 97, p. 84AN.
2. "150 W Linear Amplifier 2 to 28 MHz, 13.5 Volt DC," TRW Application Note, TRW RF Semiconductors Catalog No. 97, p. 108AN.
3. TRW Application Notes on the TPM-4100 (100 W, 100 - 400 MHz); the TPM-4040 (40 W, 100 - 400 MHz); the TPV-3100 (110 W, Band III); and the TPV-5050 (50 W, UHF), available from TRW RF Semiconductors.
4. The program used for the circuit calculation was COMPACT (Computerized Optimization of Microwave Passive and Active Circuits).
5. Gordon J. Laughlin, "New Impedance-Matched Wideband Balun and Magic Tee," *IEEE Transactions: Microwave Theory and Technology*, Vol. MTT-24, No. 3, (March 1976).

22. The equivalent circuit of the microstrip balun shows it during performance measurements with λ/16 matching lines. The experimental model uses 18-mil glass-Teflon (ϵ_r = 2.55) for the tap circuits and 62.5 mil glass-Teflon for the cavity. Balance properties were measured with a 50-ohm system, which was transformed to 25 ohms by the λ/16 line-section Chebyshev impedance transformers, which have a bandwidth from 0.960 to 1.215 GHz.

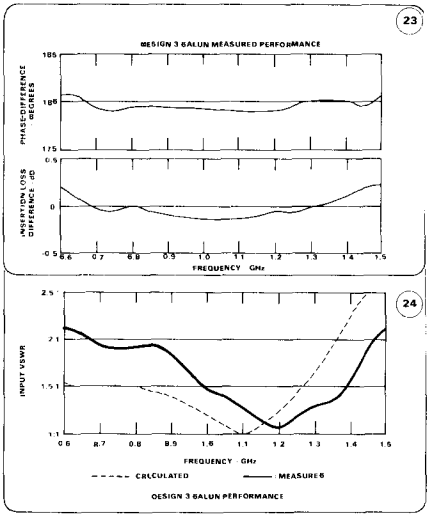


The experimental microstrip balun showing the uppermost conductor plane.



23. The unbalance between output ports for a one-octave bandwidth is shown in the measured 1.5-degree maximum phase difference and 0.15-dB maximum insertion loss difference.

24. The central frequency is 10 percent higher than expected, but response is close to the calculated values if relative frequency is considered. If the output transformers and their effect on input VSWR are disregarded, an octave bandwidth with a maximum input VSWR of around 2.0:1 can be obtained. The 100-MHz shift between the two curves may be caused by the improper determination of the folded cavity's electrical length. Similar calculation inaccuracies may arise from effects at the balun junction and from the electrical length of the stub. As in the calculated response, the experimental microstrip balun performs comparably to the two coaxial designs.



25. The similarity in the performance of the three balun designs within the considered frequency bands indicates that the parasitic elements do not significantly affect the theoretical properties. The frequency limit is higher than 1.5 GHz for all three. In the 0.960-to-1.215-GHz bandwidth (TACAN and DME applications), each performed with satisfactory balance. The table compares the main characteristics of the balun designs.

The phase differences (±1.5 degrees) for all three baluns are similar to those experienced with the miniature 3-dB hybrid couplers that are normally used to combine transistors for microwave balanced amplifiers. But the insertion loss differences of the baluns are better—0.2 dB for a one-octave bandwidth compared with 0.5 dB.

The physically simple microstrip balun eliminates the connection problem inherent in coaxial designs: physical variances that breed standing waves and unbalance. Microstripping the transmission lines allows a designer to choose any value of characteristic impedance of the lines. Consequently, the microstrip balun is both more manageable and more controllable.

Since the balun load impedance will vary with frequency, the best results will be obtained by simultaneously optimizing the balun parameters with those of the matching network. The transistor's internal prematching network must be considered.••

SUMMARY

Performance of the Three Balun Designs 25

Type of balun	Balun loads, R (ohms)	Maximum experimental unbalance for one-octave bandwidth		Theoretical input VSWR for:	
		Δφ(°)	ΔMAG (dB)	960-1215 MHz	One-octave bandwidth
Coaxial I (Design 1)	25	3	0.2	1.15:1	1.6:1
Coaxial II (Design 2)	6.25	1	0.2	1.15:1	1.6:1
Microstrip (Design 3)	25	1.5	0.2	1.20:1	1.8:1

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