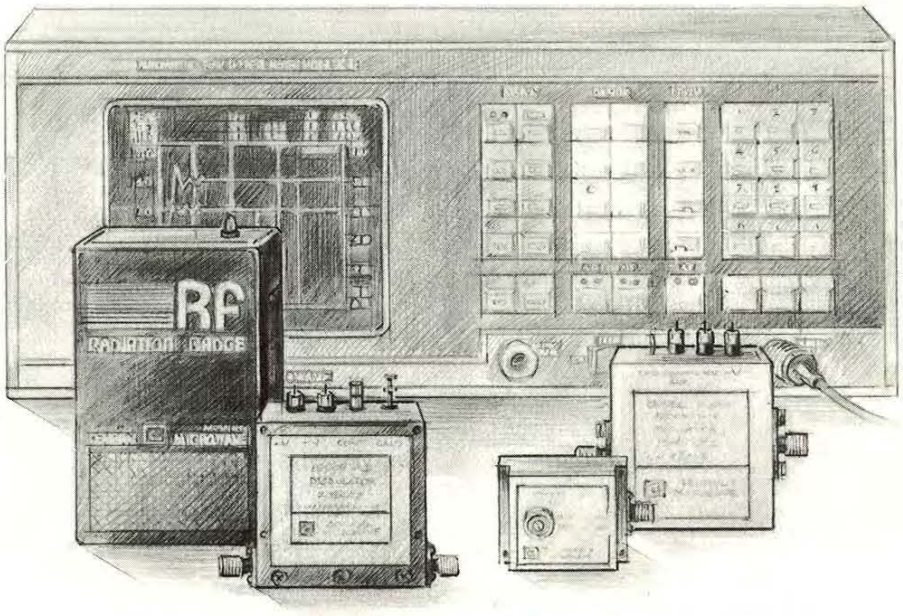
GENERAL MICROWAVE



FULL LINE CATALOG
COMPONENTS AND INSTRUMENTS

Ordering Information

1. Please order by model number, option number (where applicable), and product name.

   Telephone orders for standard catalog products will be accepted and processed immediately. However, shipment cannot be made until a confirming written order is received, either by means of a standard purchase order form or a TWX or FAX containing the following information as a minimum.

   Purchase order number.
   Ship to and bill to addresses.
   Description, model number and unit price.
   Name of authorized representative of purchasing department.
   Method of shipment.
   Amount of insurance on shipment.
   Sales/Use tax status of order.

   An order for special or modified catalog products cannot be processed prior to receipt of written authorization.

2. Address all purchase orders to:

   General Microwave Corporation (GMC)
   5500 New Horizons Blvd.
   Amityville, N.Y. 11701-1130

   or in care of our Engineering-Sales Representative in your area. Determination of prices, terms and conditions of sale, and final acceptance of orders are made only at the GMC factory.

3. Terms of payment for domestic orders are Net 30 days, subject to approval of credit. If credit has not been established, please provide payment in full or authorization to ship C.O.D. (certified or bank check only). All prices are FOB Amityville, New York and include packing to good commercial practice.

   NOTE: Title and risk of loss and damage pass to the purchaser when the shipment is accepted by a common carrier.

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5. The right to discontinue any item and to change specifications or prices at any time without notice is reserved.

6. The minimum order is $100, unless prepayment is received. The minimum line item charge is $10.

7. Unless specific instructions accompany the order, shipment is made via uninsured UPS or Parcel Post. Air freight shipments will be made FOB origin, freight charges collect.

8. Unless otherwise specified on the face of the order, overseas shipment will be made via air freight using a freight forwarder selected by GMC, with all charges, including forwarder, inland freight, air freight, insurance, consular and banking fees charged to the buyer's account.

9. Units returned for repair must be returned freight prepaid, FOB GMC factory. If warranty repair is applicable, the unit will be repaired and returned freight prepaid. If warranty repair is not applicable, the customer will be advised of the repair charges and his authorization to proceed awaited before any costs are incurred. Non-warranty repairs will be returned FOB Amityville, N.Y.

   Returns from outside the United States must be made free House/Free Domicile. Note that except where prior authorization has been received from the GMC factory, collect shipments will not be accepted by our receiving department.

10. GMC is obligated to process all orders based on their relative Defense Department priorities. Accordingly, all DO or DX ratings, as well as applicable government contract number(s), should be included on advance and confirming purchase orders.

11. Standard instruments or components returned for credit in a new and unused condition within 60 days after shipment will be accepted subject to a restocking charge of 15% of the selling price ($350 minimum).

12. Deliveries quoted are subject to prior sale.

13. Prices quoted are based on inspection at destination. If source inspection is desired, add $500/inspection day or 3% of the hardware price, whichever is greater.

14. Each unit will be accompanied by one copy of our standard operating instructions and will be tested in accordance with GMC's standard acceptance test procedure for the particular item. Unless specified in the schedule of items or services, no other data or special testing will be provided.

15. Quoted price is based on production and shipment in accord with GMC's most economical rate including accelerated and/or earlier delivery. GMC reserves the right to make partial shipments on a line item or quantity basis.

16. GMC will make its best efforts to ship on/before the promised delivery date. However, failure to do so will not be considered cause for cancellation or for claims arising therefrom.

17. Many of the products manufactured by General Microwave require U.S. Government Export Licenses prior to shipment abroad. Therefore, if the products are to be exported from the U.S. by purchaser or purchaser's agent, or if purchaser transfers title to anyone else who will export the products from the U.S., purchaser is hereby advised that a U.S. Government Export License may be required prior to shipment. All sales by General Microwave assume that the proper licenses are obtained by purchaser, purchaser's agent or transferee before the products are exported.

18. GMC is only authorized to collect taxes for the States of California, New York and Missouri, and will automatically add the appropriate sales/use taxes to our invoices unless advised to the contrary. In all other states, it is understood that buyer will pay any applicable taxes directly from his facility.

19. The following warranty applies:

EQUIPMENT WARRANTY

General Microwave Corporation warranties all parts of equipment of its manufacture to be free from defects caused by faulty material or poor workmanship. This warranty excludes electronic tubes, batteries, natural rubber and material normally consumed in operation unless such excepted items fail as a result of improper application by General Microwave.

Liability under this warranty is limited to the obligation to repair, or, at General Microwave's sole option, to replace without charge, FOB General Microwave's Plant, any part found to be defective under normal use and service within the time periods shown below, provided:

(1) General Microwave Corporation is promptly notified within the warranty period in writing upon discovery of such defects;

(2) The original parts or equipment are returned to General Microwave Corporation, transportation charges prepaid;

(3) General Microwave Corporation's examination shall disclose to its satisfaction that such defects have not been caused by abuse after delivery.

Warranties shall not apply to items which have been repaired or altered by others than General Microwave Corporation or its authorized agency.

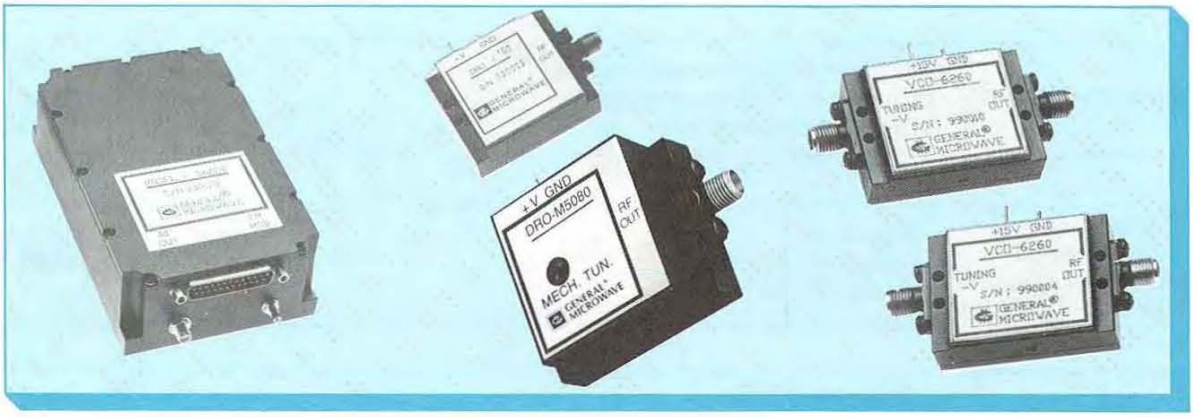
The period of warranty is one year after delivery of the instrument or component to the original purchaser.

The warranty period shall not include any period of time the unit or part fails to perform satisfactorily due to such defect, and any unit, part or component repaired or replaced by General Microwave pursuant to this warranty shall itself be guaranteed as specified above.

Contents

New Products

Oscillators 2-18 GHz



DTO's
Series 6000
(see page 158)

DRO's
Series 5000
(see page 161)

VCO's
Series 6000
(see page 159)

These high performance oscillators feature high speed, excellent frequency stability and superior phase-noise.

Microwave Radiation Hazard Meters

HAND-HELD
Survey Models
200 kHz-40 GHz

Featuring:
- Isotropic and Antisotropic Probes
- Wide Dynamic Range: 40 dB
- One Hand Operation

(see page 187)

POCKET-SIZED
Personal Warning Models
1-18 GHz

Model 60
User Adjustable Alarm
With Digital Readout
0-20 mW/cm²

Model 65
Factory Preset
1 mW/cm² and
5 mW/cm² Models

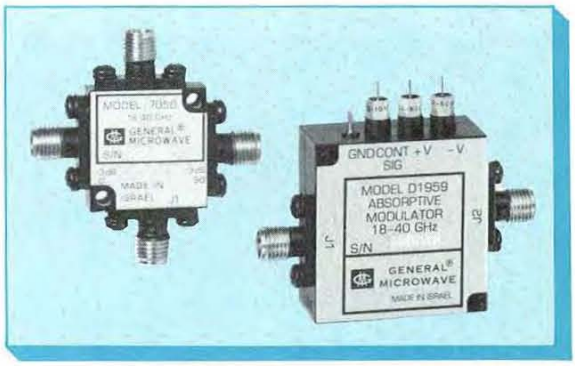
(see page 184)

New Products

ANALOG AND DIGITAL
I-Q Vector Modulators 0.5-18 GHz

Featuring independent control of amplitude (20 dB) and phase (360°)
71 Series 12-bit Digital Control
72 Series Analog Control
(see page 73)

BROADBAND
Millimeter Wave Components 18-40 GHz



- F90 Series SPST and SP2T Switches
- 7050 Quadrature Coupler
- 1959 Current Controlled Attenuator
- D1959 Voltage Controlled Attenuator

(see page 142)

ANALOG AND DIGITAL
Phase Invariant Attenuators 2-18 GHz

Series D197, Analog Control
Series 347, 8-Bit Digital Control
(see pages 37 and 61)

ANALOG AND DIGITAL
Multi-Octave Band 60 dB Attenuators 0.5-18 GHz

Series D196, Analog Control
Series 346, 8-Bit Digital Control
(see pages 31 and 58)

New Products HIGH REL HERMETICALLY-SEALED COMPONENTS

HIGH SPEED
0.5-6 GHz
63 dB Digital Attenuators
Switching Time: 30 nsec

6-Bit Control

Model H1980, 0.5-6 GHz
Model H1982, 2-6 GHz
(see page 40)

MINIATURIZED
2-18 GHz
Voltage Controlled
Attenuator
60 dB

Linear Control 10 dB/Volt

Model H1968
(see page 34)

These models are provided with removable SMA connectors.

BROADBAND
Power Limiters
1-18 GHz

Model 725, 10 mW Limiting
Model 726, 100 mW Limiting
(see page 151)

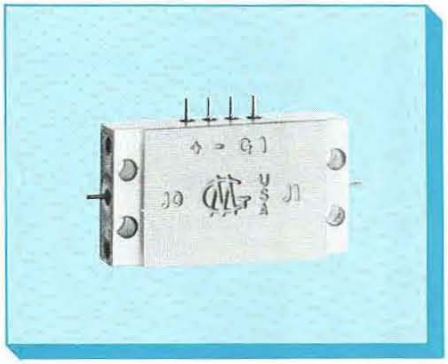
MINIATURIZED
6-18 GHz
60 dB Attenuators

8-Bit Digital Control and Analog Control

Model 3488, 500 nsec
Model 3488H, 200 nsec
(see page 64)

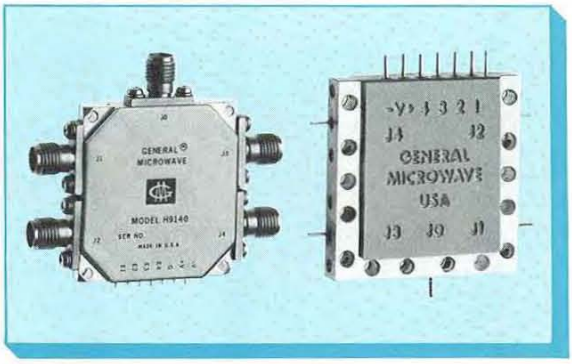
These models are provided with removable SMA connectors.

0.2-18 GHz Nonreflective SPST Switch and Pulse Modulator



Model HM192, 10 nsec
(see page 135)

1-18 GHz SPST-SP4T Switches

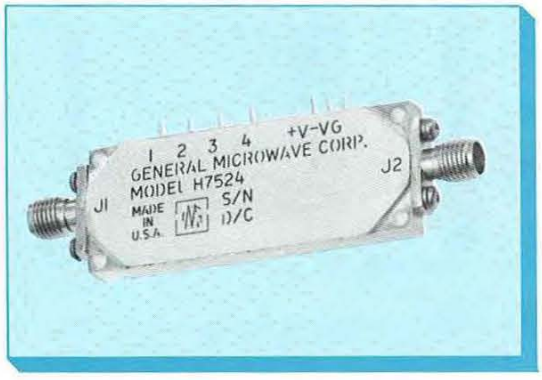


Series H and HM, 10 nsec
Reflective and Nonreflective Models
(see pages 137-141)

These parts are furnished as drop-in modules or provided with removable SMA connectors.

MINIATURIZED 360° Phase Shifters & Frequency Translators

4-8 GHz 4-Bit Control



Model H7524, 25 nsec
(see page 78)

6-18 GHz 8-Bit Control

Model 7928
(see page 84)

These parts provided with removable SMA connectors.

Model Number Index

Model Number Index (Cont)

Product Index

Solid State Control Components

The introduction of the PIN diode more than 30 years ago has led to the development of a large family of rf and microwave control components, including switches, attenuators, modulators, and phase shifters that have become essential elements of most modern microwave systems. Today, the types of PIN diodes available to the component designer is quite extensive and permits a choice of electrical characteristics such as junction capacitance, minority carrier lifetime, reverse voltage breakdown, saturation resistance and resistance vs. current law as well as mechanical format when selecting a diode for a particular application. While a complete treatment of the PIN diode will not be presented here, some of the more important relationships in diode characteristics are described below.[1]

The unique property of the PIN diode that makes it particularly suitable for control component use is that, in its useful operating frequency range, it behaves as a current variable resistor in its forward biased state. Depending upon the diode construction, this resistance can vary from as low as a few tenths of an ohm when the diode is fully ON to as high as 10,000 ohms with zero bias current applied. The PIN diode displays this behavior because, unlike P-N junction diodes, a thin layer of Intrinsic material is inserted between heavily doped layers of P and N material. When dc current flows through the diode, a stored charge is created in the I layer which establishes the conductance of the diode. The charge is in the form of holes and electrons which have a finite recombination time. As long as the period of any time-varying current is sufficiently short compared to this recombination time, there is effectively no modulation of the diode conductance and, ignoring parasitic reactances, the diode behaves as a pure resistor.

If we define a transition frequency f_o as

$$f_o = \frac{1}{2\pi\tau},$$

where τ is the minority carrier lifetime,

then for frequencies significantly below f_o, the PIN diode will behave as a P-N junction, rectifying the applied a-c signal. For frequencies well above f_o, the diode will behave as a linear resistor. The range of τ varies from as low as 10 nsec to as high as 5 μsec, and correspondingly f_o varies from about 16 MHz to 32 kHz.

The degree to which the PIN diode will rectify the a-c signal and thereby generate harmonic power depends not only on the minority carrier lifetime but upon the ratio of the a-c current to the applied d-c current. In general, as the applied signal power rises and the operating frequency decreases, diodes with long minority carrier lifetimes and high bias current are required for satisfactory operation. Unfortunately, such diodes exhibit relatively long switching time and low modulation rates.

When one uses a PIN diode in the microwave frequency range, parasitic reactances will have first order effects. The most important of these is the diode junction capacitance which limits the diode impedance in its back biased state. For low frequency diodes in chip format, employing relatively large junction areas, the junction capacitance is of the order of 0.2 to 1.0 pf. At the other extreme, beam lead diodes exhibit the lowest available junction capacity, ranging from 0.02 to 0.08 pf. For high frequency multi-throw switches, beam lead diodes are frequently employed at the common junction because of their small physical size and low junction capacity. Even with a capacitance as low as 0.02 pf, at a frequency of 18 GHz, the diode will have an impedance of only about 450 ohms in its back biased state due to this reactance. In similar manner, the intrinsic diode inductance as well as that of the connecting ribbons have a significant effect upon the frequency related behavior of the PIN diode.

The diode saturation resistance presents a loss mechanism in the rf and microwave circuit. This resistance can vary from a few tenths of an ohm in a chip diode, to as high as 5 ohms in a low-capacity beam lead diode. In general, there is an inverse relationship between diode junction capacity and saturation resistance. Therefore, in high frequency applications, where low capacity is generally required for best isolation and/or impedance match, higher insertion loss generally arises due to the loss attributed to the diodes.

In the sections that follow more detailed discussions are presented of the circuit topologies, design tradeoffs and performance characteristics of GMC's families of control components. GMC's large number of custom designs, which have evolved from these products, have not been included because of space limitations. Consultation with the factory is recommended for such requirements.

(1) *The reader interested in more information on this subject should consult one or more of the following references:*
"Microwave Semiconductor Engineering", J.F. White, Van Nostrand Reinhold Company, 1982.
"Microwave Semiconductor Control Devices", K.E. Mortenson, Microwave Journal, May 1964, pp 49-57.
"Fundamental Limitations in RF Switching and Phase Shifting Using Semiconductor Diodes", M.E. Hines," Proceedings of the IEEE, vol. 52, pp 697-708.
"Biasing and Driving Considerations for PIN Diode RF Switches and Modulators" Hewlett-Packard Applications Note 914, Jan. 1967.

Attenuators

General Microwave PIN diode attenuators cover the frequency range from 200 MHz to 40 GHz and are available in numerous configurations to permit the user to optimize system performance. Most designs are available with either analog or digital control, operating over octave or multi-octave bands with high or moderate switching speed characteristics.

ATTENUATOR TOPOLOGY

GMC PIN diode attenuators are designed with several different topologies, each of which has been selected to optimize certain performance characteristics. A brief discussion of these various topologies is presented below including a treatment of performance trade-offs.

SHUNT-MOUNTED REFLECTIVE ATTENUATOR

The simplest version of a PIN diode attenuator consists of one or more PIN diodes in shunt with a transmission line as shown in Fig. 1. This design provides a broadband reflective attenuator that can reach very high levels of attenuation, depending upon the number and electrical spacing of the diodes. While it generally has very low insertion loss and can operate at high switching rates, its usefulness is limited by the very large mismatch it presents in the attenuation state.

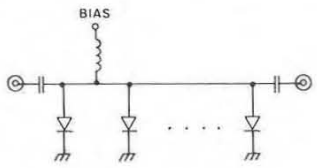


Fig. 1-Shunt mounted reflective attenuator

BALANCED ATTENUATOR

By placing identical shunt-mounted reflective attenuators between an appropriately connected pair of 3 dB quadrature hybrid couplers, a balanced attenuator is realized (see Fig. 2). The balanced attenuator has all the simplicity of the shunt-mounted reflective attenuator with the added feature of providing low VSWR under all conditions of attenuation. In addition, power handling is improved by 3 dB due to the power split of the input hybrid. This style of PIN diode attenuator offers simplicity, up to 3 to 1 bandwidth, moderately fast speed, and excellent linearity. Balanced attenuators are available from GMC covering the frequency range of 0.5 to 40.0 GHz.

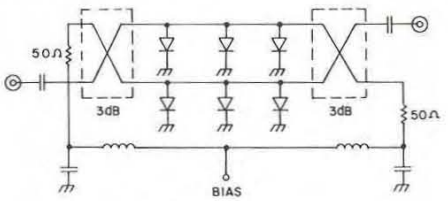


Fig. 2-Balanced attenuator

ARRAY ATTENUATOR

With the addition of terminating diode elements to the shunt-mounted reflective attenuators of Fig. 1, an attenuator can be realized with low VSWR that can operate over an octave band (see Fig. 3). By tapering the diode and transmission line impedance and adding multiple transformer sections it is possible to obtain good VSWR and attenuation characteristics over several octaves.

GMC employs array attenuators in a number of custom designs.

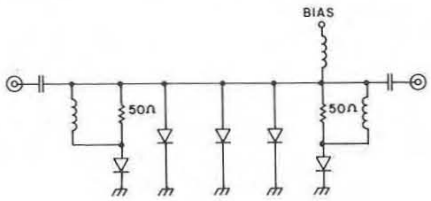


Fig. 3-Array attenuator

T-PAD AND π-PAD ATTENUATORS

The broadest frequency coverage available is obtained with some form of T-pad or π-pad attenuator. These are lumped element circuits which function in the microwave frequency range in essentially the same manner as they do at DC. Attenuation variation is obtained by simultaneously changing the bias current of the series and shunt diodes comprising the pads in a manner that assures constant impedance at all levels. Fig. 4 shows the basic configurations of both circuits. Only the T-pad configuration is used by GMC due to the difficulties in realizing sufficiently low stray reactances and short transmission line lengths in π-pad circuits for operation at higher microwave frequencies. Models of these attenuators cover the full frequency range from 0.2 to 18.0 GHz with excellent attenuation flatness and moderate switching speed.

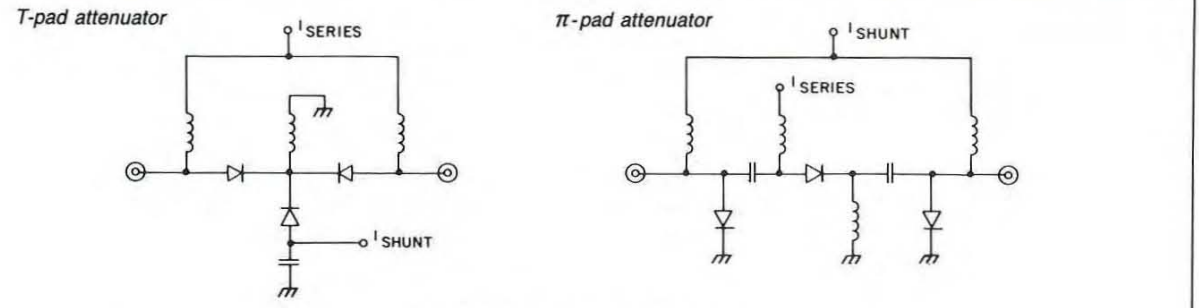


Fig. 4--Attenuator configurations

SWITCHED BIT ATTENUATORS

When an attenuator with a fast switching speed and high power handling capacity is required, the only option is to utilize a switched-bit attenuator. This attenuator combines one or more tandem pairs of SP2T switches with a zero loss connection between one pair of outputs and a fixed attenuator inserted in the other (see Fig. 5). In this configuration the PIN diodes are not used as variable resistors, but are switched between their forward and reversed biased states. This allows for much faster switching speed since high speed PIN diodes and drive circuitry can be used. In addition, it offers higher power handling capacity since the RF power is absorbed in the fixed attenuator(s), and not in the PIN diodes.

There are some disadvantages to this approach that may limit its usefulness. First, the minimum practical attenuation step size at microwave frequencies is about 0.5 dB due to interacting VSWR's as the bits are switched. These interactions may lead to a non-monotonic response as the attenuation is changed in increments of one LSB, i.e., the attenuation level may actually decrease when an increasing attenuation step is called for. Second, because of the RF circuit complexity, the cost of this attenuator is usually higher than other approaches. Finally, the incorporation of high speed switches may lead to excess video leakage.

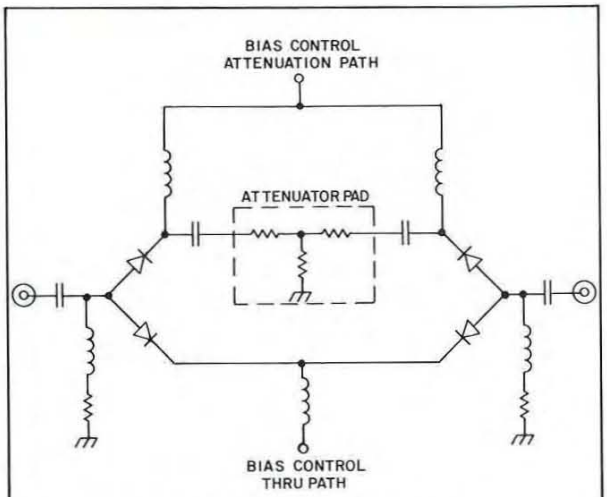


Fig. 5-Switched bit attenuator

PHASE INVARIANT ATTENUATORS

This specialized class of attenuators has the property that the insertion phase variation is minimized as the attenuation level is changed. A unique topology is employed by GMC to obtain this performance which is described in detail in a separate technical paper.[1] In all other respects they perform in a manner similar to the balanced attenuators described above.

DRIVER CONSIDERATIONS

All attenuators except for the switched bit variety are available with linearizing driver circuits with either analog or digital control inputs. In addition, many attenuators are available without the driver for those who choose to provide their own. Most digital attenuators are available with eight-bit TTL control which, for an attenuator with a nominal attenuation range of 60 dB, will provide a resolution of 0.25 dB. Some attenuators are available with a resolution of as low as 0.05 dB. Except for switched-bit designs, all PIN diode attenuators are analog in nature and thus their resolution is essentially limited by the DAC used in the driver circuit.

The driver circuit includes compensating elements to minimize the variation of attenuator with temperature. It also provides the proper source impedance and switching waveforms to optimize switching speed.

(1) *"Broadband Phase Invariant Attenuator", D. Adler and P. Maritato; 1988 IEEE MTTS Digest, pp 673-676. To obtain a copy of this paper, please write to Dept. C., General Microwave Corporation, 5500 New Horizons Blvd., Amityville, NY 11701.*

MONOTONICITY

In most applications it is imperative that the attenuator displays monotonic behavior as a function of the control input. Non-monotonic performance can occur in switched bit attenuators when interacting VSWR's are not properly compensated, or in digitally controlled analog attenuators when a non-monotonic condition exists in the MSB of the DAC. All GMC's attenuators are guaranteed monotonic.

PHASE SHIFT vs. ATTENUATION

All attenuators exhibit a variation in phase shift with attenuation level (AM/PM modulation). Fig. 6 shows typical phase shift variation as a function of attenuation for a number of GMC attenuator models. The phase shift is attributable to both the stray reactance of the PIN diodes as well as the lengths of transmission line interconnecting the diodes. While it is possible to minimize the AM/PM by careful design, it is not possible to eliminate it entirely. Where minimum change of phase with attenuation is a critical parameter, the use of GMC's line of Phase Invariant Attenuators described above should be considered.

HARMONICS AND INTERMODULATION PRODUCTS

All PIN diode control devices (i.e. attenuators, switches, phase shifters, and limiters) will generate harmonics and intermodulation products to some degree since PIN diodes are non-linear devices. When compared to digital switched-bit designs, analog PIN diode attenuators are more prone to generate spurious signals since the diodes function as current variable resistors and are typically operated at resistance levels where significant RF power is absorbed by the diode.

The levels of harmonic and intermodulation products generated by an attenuator are greatly dependent upon its design, the operating frequency, attenuation setting and input power level. Typical performance for a moderately fast attenuator i.e. 500 nsec switching speed, follows:

TYPICAL ATTENUATOR INTERCEPT POINTS

FREQUENCY	2nd ORDER INTERCEPT	3rd ORDER INTERCEPT
2.0 GHz	+35 dBm	+30 dBm
8.0 GHz	+40 dBm	+35 dBm

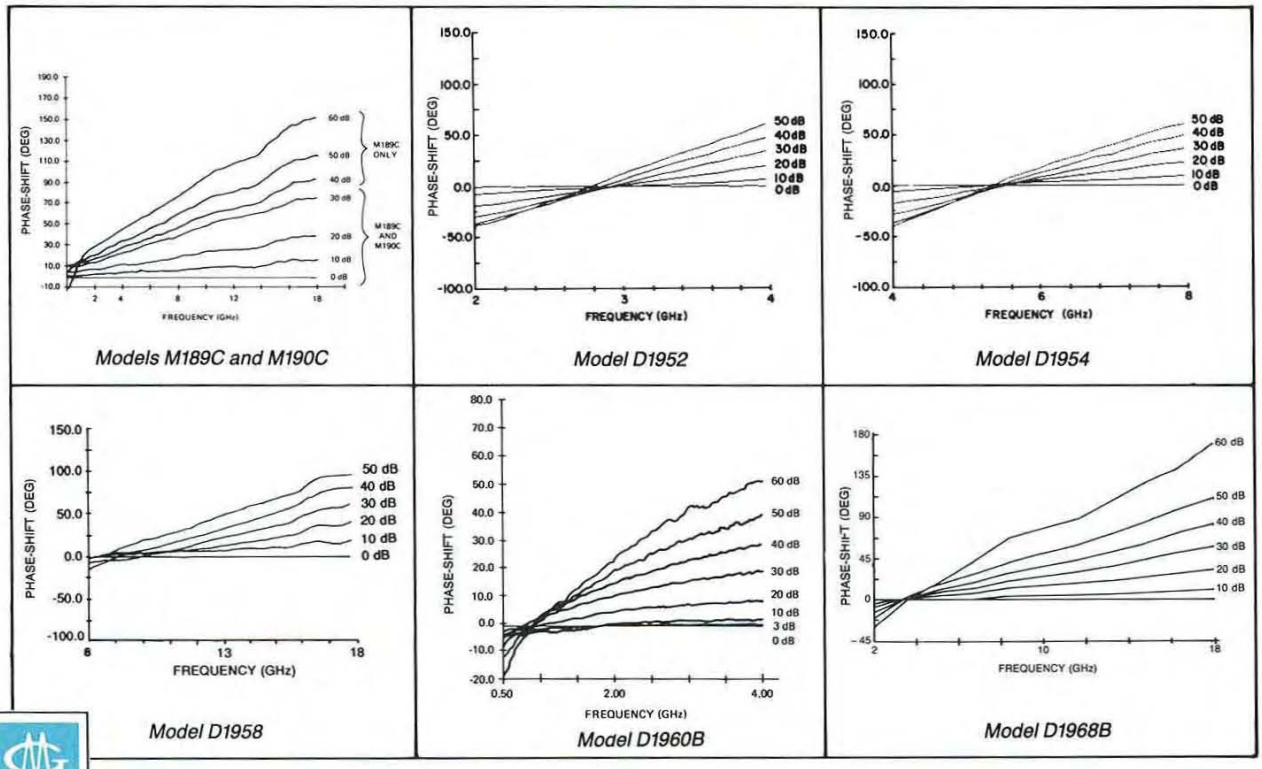


Fig. 6 Typical Phase vs. Attenuation

POWER HANDLING

The power handling of a PIN diode attenuator is dependent on its topology, biasing levels, and switching speed. The faster the attenuator, the lower the power handling capability. This catalog specifies both the maximum operating and the maximum survival levels. Maximum operating level is defined as that which will cause either a one dB compression of attenuation level or an out of specification condition. The survival levels are generally dependent on the maximum ratings of the semiconductors in the attenuator. Please consult the factory for special applications requiring higher operational power levels than those listed in this catalog.

DEFINITION OF PARAMETERS

MEAN ATTENUATION is the average of the maximum and minimum values of the attenuation over the specified frequency range for a given control signal.

ATTENUATION FLATNESS is the variation from the mean attenuation level over the specified frequency range. This is usually a function of the attenuation level, and is expressed in ± dB.

ATTENUATION ACCURACY is the maximum deviation of the mean attenuation from the programmed attenuation value expressed in dB when measured at +23 ±5°C.

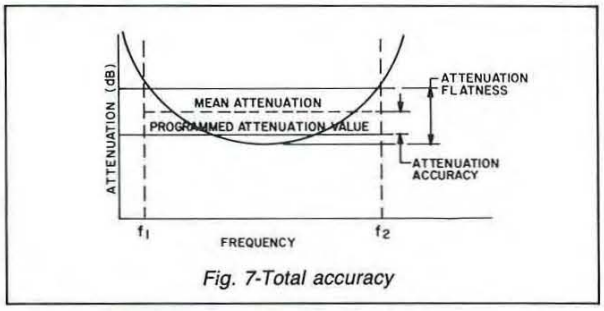


Fig. 7-Total accuracy

TOTAL ACCURACY is the sum of all the effects which contribute to the deviation from the programmed attenuation value. It includes the effects of attenuation accuracy, frequency variation and temperature, as shown in Fig. 7.

SWITCHING SPEED[2]

The following are the standard definitions of switching speed, as shown in Fig 8:

Rise Time is the transition time between the 10% and 90% points of the square-law detected RF power when the unit is switched from full OFF to full ON.

Fall Time is the transition between the 90% and 10% points of the square-law detected RF power when the unit is switched from full ON to full OFF.

(2) *For units without integrated drivers, the specifications apply to conditions when the attenuator is driven by an appropriately shaped switching waveform.*

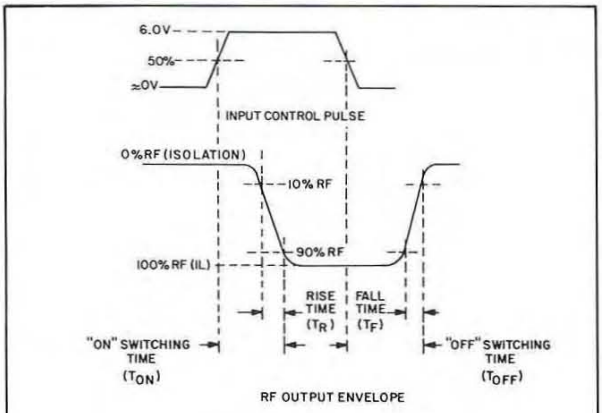


Fig. 8-Switching speed

On Time is the transition time between 50% of the input control signal to the 90% point of the square-law detected RF power when the unit is switched from full OFF to full ON.

Off Time is the transition time between 50% of the input control signal to the 10% point of the square-law detected RF power when the unit is switched from full ON to full OFF.

Note: Depending on the attenuator topology, there are differences in the behavior of the switching characteristics that may affect system performance. Switching speed is only specified to the 90% or 10% points of the detected RF signal, but the time the attenuator takes to reach final attenuation value or switch between different attenuation levels may be significantly longer.

MODULATION BANDWIDTH

Small Signal Bandwidth: With reference to a modulation frequency of 100 Hz and a modulation depth of ±3 dB at a quiescent level of −6 dB, the frequency at which the modulation depth decreases by 50% as measured with a square-law detector.

Large Signal Bandwidth: With reference to a modulation frequency of 100 Hz and a 100% modulation depth at a quiescent level of −6 dB, the frequency at which the modulation depth decreases by 50% as measured with a square-law detector.

TEMPERATURE COEFFICIENT is defined as the average rate of change of attenuation over the full operating temperature range of the unit under fixed bias conditions. It is expressed in dB/°C. Note that the attenuator temperature coefficient may vary with both temperature and programmed attenuation level.

Attenuator Selection Guide

ATTENUATORS AND MODULATORS

FREQUENCY RANGE (GHz) 0.2 0.5 1.0 2.0 4.0 8.0 12.4 18.0	ATTENUATION RANGE (dB)	MODEL	PAGE	COMMENTS
CONTINUOUSLY VARIABLE, CURRENT CONTROLLED, ABSORPTIVE ATTENUATORS				
0.2 — 18	35	M190C	16	Dual control, low power
	45	M186C		
	65	M189C		
0.2 — 12.4	35	LM190C	17	Dual control, low power
	40	LM186C		
	65	LM189C		
0.5 — 1	80	1950A	23	Single control
1 — 2	60	1951		
2 — 4	60	1952		
2.6 — 5.2	60	1953		
4 — 8	60	1954		
5 — 10	60	1955		
6 — 12	60	1956		
8 — 18	60	1958		
18 — 40	50	1959	143	
CONTINUOUSLY VARIABLE, VOLTAGE CONTROLLED, LINEARIZED ABSORPTIVE ATTENUATORS				
0.2 — 18	35	M190C/311	16	Separate driver and rf section, low power
	45	M186C/311		
	65	M189C/311		
0.2 — 12.4	35	LM190C/311	17	Separate driver and rf section, medium power
	40	LM186C/311		
	65	LM189C/311		
0.5 — 4	60	D1960B	31	Integrated driver and rf section
0.5 — 8	60	D1961B		
2 — 8	60	D1962B		
2 — 18	60	D1968B		
0.5 — 1	80	D1950A	27	
1 — 2	60	D1951		
2 — 4	60	D1952		
2.6 — 5.2	60	D1953		
4 — 8	60	D1954		
5 — 10	60	D1955		
6 — 12	60	D1956		
8 — 18	60	D1958		
18 — 40	50	D1959	143	
VOLTAGE CONTROLLED, HERMETICALLY SEALED, LINEARIZED ABSORPTIVE ATTENUATOR				
2 — 18	60	H1968	34	Integrated driver and rf section
VOLTAGE CONTROLLED, PHASE INVARIANT, LINEARIZED ATTENUATORS				
2 — 6	32	D1972	37	Integrated driver and rf section
4 — 12	32	D1974		
8 — 18	32	D1978		
HIGH SPEED ABSORPTIVE PULSE MODULATORS				
0.2 — 18	80	F192A	20	Integrated driver and rf section
0.2 — 18	80	HM192	135	Integrated driver and rf section, miniaturized, hermetically sealed

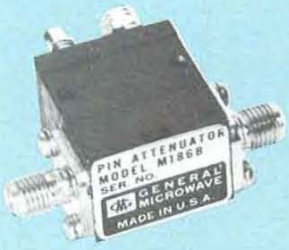
Attenuator Selection Guide (Con't)

ATTENUATORS AND MODULATORS (con't)

FREQUENCY RANGE (GHz) 0.2 0.5 1.0 2.0 4.0 8.0 12.4 18.0	ATTENUATION RANGE (dB)	MIN STEP SIZE (dB)	MODEL	PAGE	COMMENTS
DIGITALLY PROGRAMMABLE, HERMETICALLY SEALED, ABSORPTIVE ATTENUATORS					
0.5 — 6	63	1.0	H1980	40	Integrated driver and rf section
2 — 6	63	1.0	H1982		
DIGITALLY PROGRAMMABLE ABSORPTIVE ATTENUATORS, ULTRA-BROADBAND					
0.2 — 18	60	1	3250A	42	Integrated driver and rf section
DIGITALLY PROGRAMMABLE ABSORPTIVE ATTENUATORS, MULTI-OCTAVE BAND					
0.5 — 4	60	0.25	3460B	58	Integrated driver and rf section
0.5 — 8	60	0.25	3461B		
2 — 8	60	0.25	3462B		
2 — 18	60	0.25	3468B		
DIGITALLY PROGRAMMABLE, PHASE INVARIANT ATTENUATORS, MULTI-OCTAVE BAND					
2 — 6	32	0.125	3472	61	Integrated driver and rf section
4 — 12	32	0.125	3474		
8 — 18	32	0.125	3478		
DIGITALLY PROGRAMMABLE ABSORPTIVE ATTENUATORS, OCTAVE BAND					
0.5 — 1	80	0.05	3290A-80	45	Integrated driver and rf section
	80	0.25	3450	50	
1 — 2	120	0.1	3291-120	45	
	80	0.05	3291-80		
	60	0.25	3451, 3451H	50, 54	
2 — 4	120	0.1	3292-120	45	
	80	0.05	3292-80		
	60	0.25	3452, 3452H	50, 54	
2.6 — 5.2	120	0.1	3293-120	45	
	80	0.05	3293-80		
	60	0.25	3453, 3453H	50,54	
4 — 8	120	0.1	3294-120	45	
	80	0.05	3294-80		
	60	0.25	3454,3454H	50, 54	
5 — 10	120	0.1	3295-120	45	
	80	0.05	3295-80		
	60	0.25	3455, 3455H	50, 54	
6 — 12	120	0.1	3296-120	45	
	80	0.05	3296-80		
	60	0.25	3456, 3456H	50, 54	
8 — 18	120	0.1	3298-120	45	
	60	0.05	3298-60		
	60	0.25	3458, 3458H	50, 54	
DIGITALLY PROGRAMMABLE, MINIATURIZED, ABSOPTIVE ATTENUATORS, OCTAVE BAND					
8 — 18	60	0.25	3488, 3488H	64	integrated driver and rf section

Models M186C, M189C and M190C Ultra-Broadband PIN Diode Attenuator/Modulators

- **Absorptive**
- **0.2 to 18 GHz frequency range**
- **Attenuation range up to 65 dB**
- **Flatness as low as ±0.5 dB**



MODELS M186C, M189C AND M190C

This family of absorptive PIN diode attenuator/ modulators operates over the instantaneous frequency range of 0.2 to 18 GHz. Their multi-octave bandwidth makes tham highly suitable for wideband ECM and measurement systems.

The rf circuit consists of a T-pad arrangement of shunt and series diodes in a microstrip integrated circuit transmission line, as shown in figures 1 and 2 below, and a resistive low-loss bias line. The arrangement permits operation as a bilaterally-matched device at all attenuation levels by separately controlling the bias currents through the series and shunt diodes.

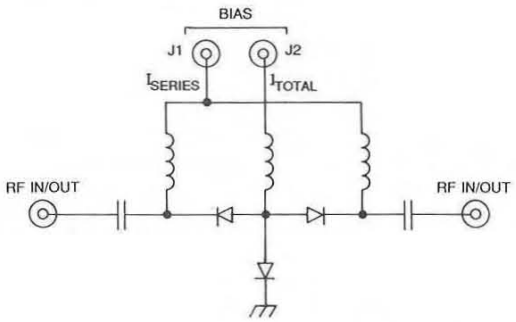


Fig. 1-Model M190C, schematic diagram (Model M189C consists of two such sections)

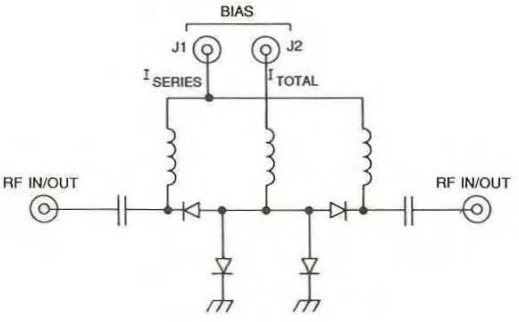


Fig. 2-Model M186C, schematic diagram

Models M186C, M189C and M190C Ultra-Broadband PIN Diode Attenuator/Modulators

Attenuation Levels

The Models M190C and M186C are rated for attenuation levels up to 35 and 45 dB, respectively. The Model M189C, which consists of the equivalent of two independently-controlled M190C attenuators in a single rf assembly, is rated up to 65 dB.

Power Ratings

Although all three models will survive input powers up to 2 watts from −65°C to +25°C, the maximum power levels at which they operate without performance degradation is limited to those shown in Fig. 5 on page 19. For higher power applications, the narrower band LM186C, LM189C and LM190C models are available.

Drivers

The proper levels of series and shunt diode currents required for operation as a matched attenuator can be provided by either the user's circuitry, or by the GMC Model 311 Driver. (See Fig. 4 on page 18 for typical Bias Current/Attenuation transfer curves.) The Model 311 provides voltage controlled linear attenuation with a nominal transfer function of 10 dB per volt for the Models M186C and M190C. For the Models M189C or LM189C, two Model 311 drivers are required and the transfer function is 20 dB per volt.

When attenuators are ordered with drivers, the assemblies are adjusted for optimum accuracy at 2 GHz. Optimization at customer-specified frequencies is available on special order.

For use As Reflective Switches

By reducing the series diode current to zero in the isolation state, these units can be operated as high-isolation reflective switches for low frequency applications. A typical response curve of the Model M816C operating in this mode is shown in Fig. 3 on page 18.

Specifications

MODEL NO.	CHARACTERISTIC	FREQUENCY (GHz) 0.2 to 8.0	8.0 to 12.4	12.4 to 18.0	MODEL NO.	CHARACTERISTIC	FREQUENCY (GHz) 0.2 to 8.0	8.0 to 12.4
M186C	Max Insertion Loss (dB)	1.8	2.2	3.0	LM186C	Max Insertion Loss (dB)	1.5	2.6
	Max VSWR	1.5	1.75	2.0		Max VSWR	1.5	1.75
	Min Attenuation (dB)	45(1)	45	45		Min Attenuation (dB)	40(2)	40
M189C	Max Insertion Loss (dB)	3.0	3.5	5.0	LM189C	Max Insertion Loss (dB)	2.5	3.5
	Max VSWR	1.75	2.0	2.0		Max VSWR	1.75	2.0
	Min Attenuation (dB)	65	65	55		Min Attenuation (dB)	60	55
M190C	Max Insertion Loss (dB)	1.8	2.2	3.0	LM190C	Max Insertion Loss (dB)	1.7	2.0
	Max VSWR	1.5	1.6	2.0		Max VSWR	1.75	2.0
	Min Attenuation (dB)	35	35	30		Min Attenuation (dB)	32	27

ATTEN. (dB)	FLATNESS (± dB) FREQUENCY (GHz) 0.2 to 8.0 M190C	M189C	LM190C	LM189C	0.2 to 12.4 M190C	M189C	LM190C	LM189C	12.4 to 18.0 M190C	M189C
10	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.7	1.0	1.0
20	0.5	0.5	0.5	0.5	1.0	1.0	1.2	1.2	1.0	1.0
30	0.7	0.7	1.0	1.0	1.5	1.5	2.0	2.0	1.0	1.5
40	—	1.0	—	1.0	—	1.5	—	2.0	—	1.5
50	—	1.0	—	1.5	—	1.5	—	2.0	—	1.5
60	—	1.0	—	2.0	—	1.5	—	2.5	—	1.5

(1) *Except 40 dB up to 2 GHz.*
(2) *Except 35 dB up to 2 GHz.*

Models M186C, M189C and M190C Specifications

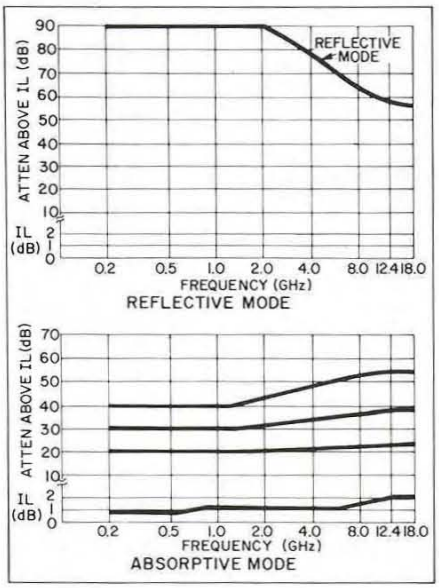


Fig. 3-Typical response curves of Model M186C

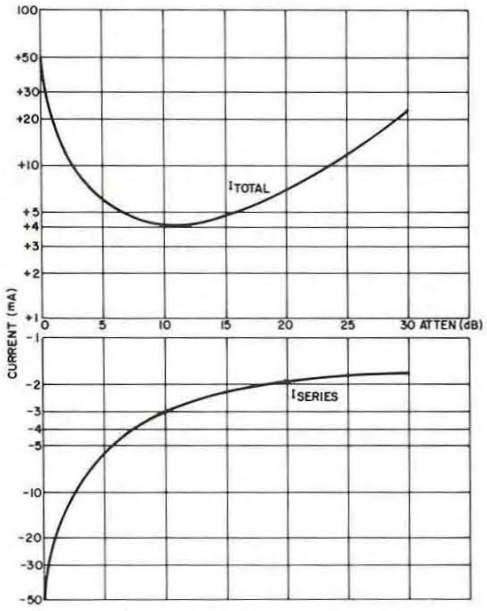


Fig. 4-Typical Models M186C and M190C bias current/attenuation transfer curves

PERFORMANCE CHARACTERISTICS

Power Handling Capability
Without Performance Degradation

M186C, M189C, M190C ..... Up to 100 mW cw or peak (see figure 5)

LM186C, LM189C, LM190C ..... 100 mW cw or peak

Survival Power (from −65°C to +25°C; see figure 6 for higher temperatures)

All units..... 2W average or peak (1μsec max pulse width)

Phase Shift..... See page 12

Typical Small Signal Bandwidth

M186C, M189C, M190C ..... 500 kHz

LM186C, LM189C, LM190C ..... 50 kHz

Bias Current Requirements (see figure 4)

M189C, LM189C .... ±100 mA max.

M186C, LM186C, M190C, LM190C ..... ±50 mA max.

ENVIRONMENTAL RATINGS (RF UNIT)

Operating Temperature Range... −65°C to +85°C

Non-Operating Temperature Range... −65°C to +125°C

Humidity..... MIL-STD-202F. Method 103B. Cond. B (96 hrs. at 95%)

Shock..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration..... MIL-STD-202F, Method 204D, Cond. B (.06″double amplitude or 15G, whichever is less)

Altitude..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

MODEL 311 CHARACTERISTICS[1]

Nominal Transfer Function..... 10 dB/volt

Accuracy at Calibration Frequency (2 GHz)..... ±1 dB starting from 5 dB above insertion loss

Typical Small Signal Bandwidth When Used With:

M186C, M189C, M190C..... 500 kHz

LM186C, LM189C, LM190C..... 50 kHz

Control Signal Input Voltage Range..... 0 to +5 volts dc

Control Signal Input Impedance..... 3 kohms (nominal)

(1) *Specifications listed are for each Model 311 Driver in use.*

Models M186C, M189C and M190C Specifications

MODEL 311 CHARACTERISTICS[1] (cont)

Switching Time . . . . . 100 μsec max

Power Supply Requirements . . . . . +15V ±0.1%, 125 mA
−15V ±0.1%, 125 mA

Operating Temperature Range . . . . . −55°C to +75°C

Non-Operating Temperature Range . . . . −55°C to +85°C

AVAILABLE OPTIONS (RF UNIT)

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male and one SMA female rf connector
33	EMI filter solder-type bias terminals
64A	SMB male control connector

(1) *Specifications listed are for each Model 311 Driver in use.*

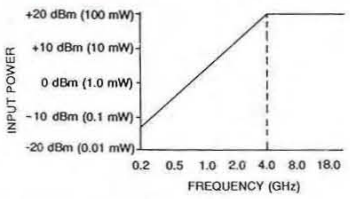


Fig. 5-Models M186C, M190C and M189C, maximum peak and average operating power without performance degradation

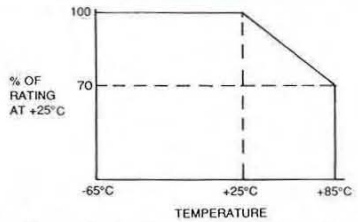
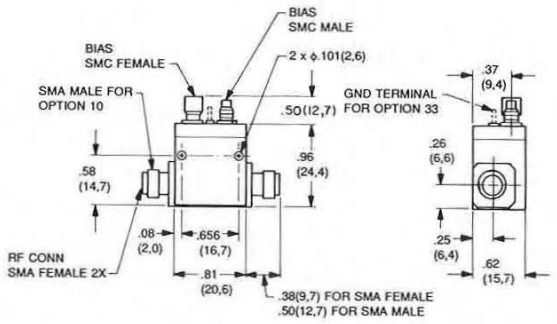
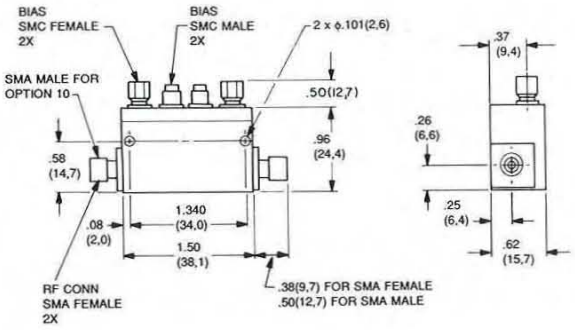


Fig. 6-Models M186C, LM186C, M189C, LM189C, M190C and LM190C, survival power derating factor

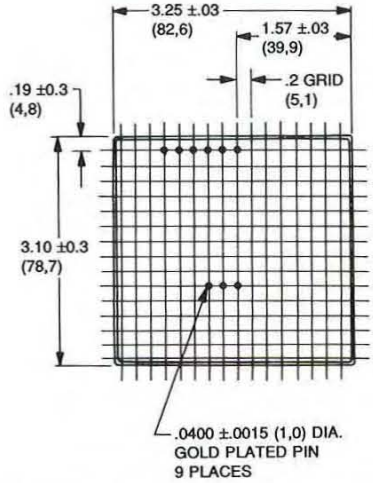
DIMENSIONS AND WEIGHTS

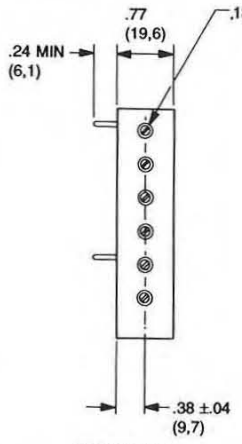


MODELS M186C, LM186C, M190C AND LM190C
Wt. 1 oz (28 gm) approx.

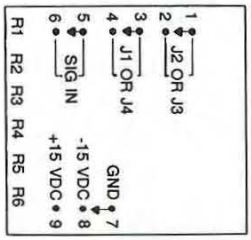


MODELS M189C AND LM189C
Wt. 2 oz. (57 gm) approx.





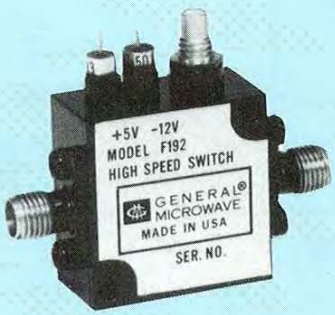
MODEL 311
Wt: 4 oz. (113 gm) approx.



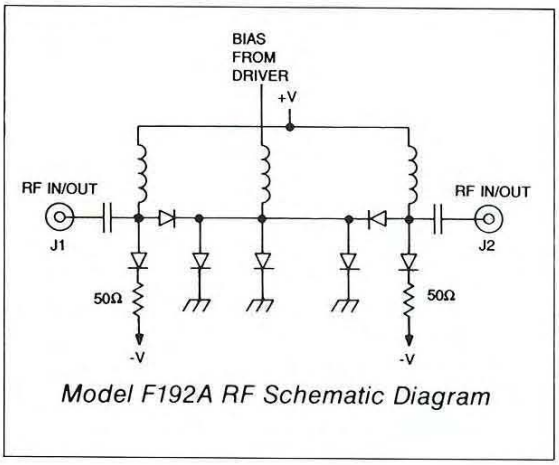
Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Model F192A Non-Reflective Ultra-Broadband High-Speed Pulse Modulator

- **High speed**
- **0.2 to 18 GHz frequency range**
- **80 dB isolation**
- **Low VSWR and insertion loss**
- **Small size, light weight**



The Model F192A is a high-speed non-reflective PIN diode pulse modulator with integrated driver. Operating over the instantaneous frequency range from 0.2 to 18 GHz, it provides a minimum isolation of 80 dB from 0.5 to 18 GHz, and 70 dB below 0.5 GHz. The rf design consists of an arrangement of shunt and series diodes in a microstrip integrated circuit transmission line as shown in the schematic diagram below.



Model F192A RF Schematic Diagram

The currents required to switch the unit ON or OFF and simultaneously maintain a bilateral 50-ohm impedance match in both states are provided by the integrated driver, which is controlled by an external logic signal.

Model F192A Specifications

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	FREQUENCY (GHz)				
	0.2 to 0.5	0.5 to 2.0	2.0 to 8.0	8.0 to 12.4	12.4 to 18.0
Min Isolation (dB)	70	80	80	80	80
Max Insertion Loss (dB)	2.0	2.0	2.5	3.0	3.5
VSWR (ON and OFF)	1.5	1.5	1.75	2.0	2.0

Switching Speed

Rise Time . . . . . 10 nsec. max.
Fall Time . . . . . 10 nsec. max.
ON Time . . . . . 30 nsec. max.
OFF Time . . . . . 15 nsec. max.

Power Handling Capability

Without Performance Degradation . . . . . 500 mW cw or peak
Survival Power . . . . . 1W average, 10W peak (1 μsec max. pulse width)

Power Supply Requirements

+5V ±5%, 90 mA
−12V ±5%, 75 mA

Control Characteristics

Control Input Impedance . . . . TTL, advanced Schottky, one-unit load. (A unit load is 0.6 mA sink current and 20μA source current.)
Control Logic . . . . Logic "0" (−0.3 to +0.8V) for switch ON and logic "1" (+2.0 to +5.0V) for switch OFF.

Model F192A Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . – 65°C to + 110°C

Non-Operating Temperature Range . . . . . – 65°C to + 125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

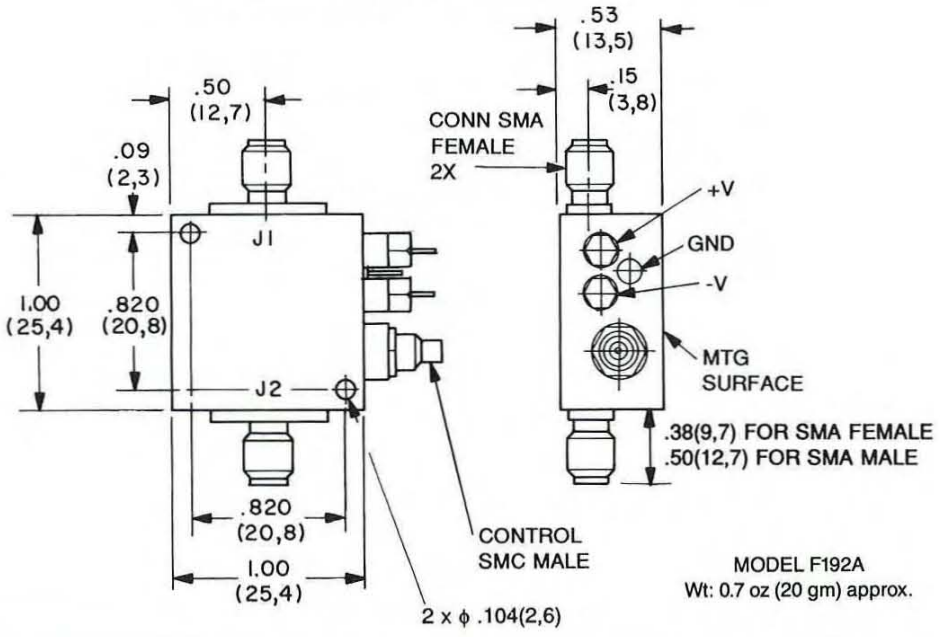
Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female control connector
7	Two SMA male rf connectors
9	Inverse control logic; logic "1" for switch ON and logic "0" for switch OFF
10	One SMA male (J1) and one SMA female (J2) rf connector
33	EMI filter solder-type control terminal
48	+5, –15V operation
64A	SMB male control connector

DIMENSIONS AND WEIGHT



MODEL F192A
Wt: 0.7 oz (20 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02: .XXX ± .005

Series 195 Octave-Band PIN Diode Attenuator/Modulators

SERIES 195

Series 195 current-controlled attenuator/modulators provide small size with greater than octave-bandwidth performance at low cost. All models except the 1950A provide a minimum of 60 dB of attenuation with fall times of 20 nsec max, and rise times ranging from 25 nsec max for the 1951 and 1952 to 125 nsec max for the 1956 and 1958. The 1950A provides a minimum of 80 dB of attenuation with a fall time of 50 nsec max and a rise time of 250 nsec max. These characteristics make this series suitable for a wide range of applications including level setting, complex amplitude modulation, pulse modulation and high-speed switching.

The eight models in the Series 195 encompass a frequency range from 0.5 to 18 GHz. All models except the 1950A are capable of extended bandwidth operation, typically 3:1, with only moderate degradation in performance at the band edges.

As shown in figures 1 and 2 below, the rf circuit employed in all models except the Model 1950A uses two shunt arrays of PIN diodes and two quadrature hybrid couplers. The quadrature hybrids are of a unique GMC microstrip design which are integrated with the diode arrays to yield a minimal package size. The rf circuit employed in the Model 1950A uses one shunt array of PIN diodes with input and output impedance matching circuits.

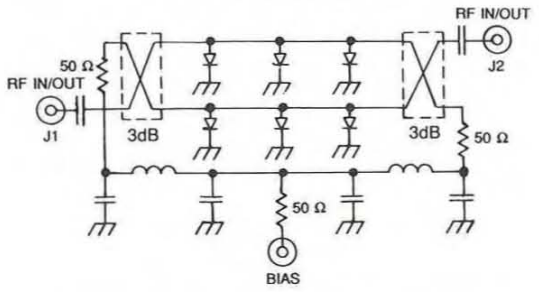


Fig. 1-Models 1951-1958, rf schematic diagram

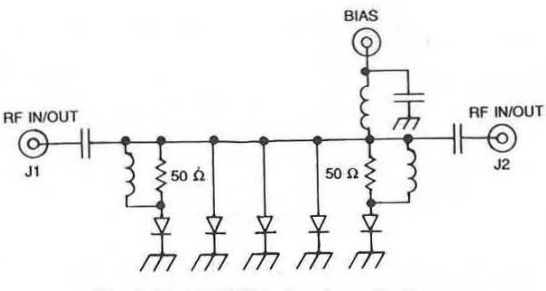
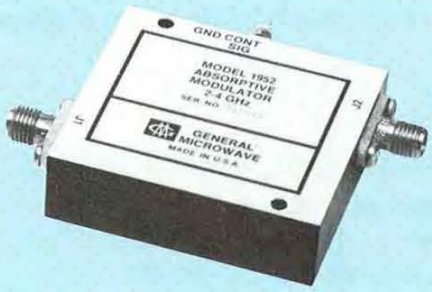
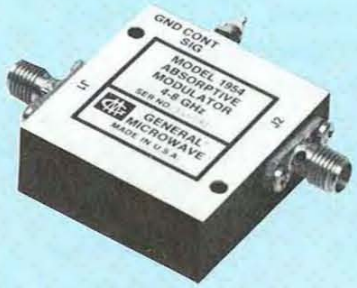


Fig. 2-Model 1950A, rf schematic diagram

- **Absorptive**
- **Current controlled**
- **0.5 to 18 GHz frequency range**
- **High performance MIC quadrature hybrid design**
- **High speed**





Series 195 Specifications

MODEL	FREQUENCY RANGE (GHz)	MAX. INSERTION LOSS (dB)	MAX. VSWR	FLATNESS (±dB) AT MEAN ATTENUATION LEVELS UP TO				
				10 dB	20 dB	40 dB	60 dB	80 dB
1950A	0.5 – 1.0	1.4	2.0	0.3	0.8	1.7	2.2	3.2
1951	1.0 – 2.0	1.3	1.5	0.3	0.8	1.5	1.6	
	0.75–2.25	1.4	2.0	0.5	1.4	3.0	3.5	
1952	2.0–4.0	1.5	1.5	0.3	0.8	1.5	1.6	
	1.5 – 4.5	1.6	2.0	0.5	1.4	3.0	3.5	
1953	2.6 – 5.2	1.7	1.6	0.3	0.8	1.5	1.6	
	1.95–5.85	1.8	2.1	0.5	1.4	3.0	3.5	
1954	4.0 – 8.0	2.0	1.7	0.3	0.8	1.5	1.6	
	3.0 – 9.0	2.1	2.2	0.5	1.4	3.0	3.5	
1955	5.0 –10.0	2.2	1.7	0.5	0.9	1.5	1.6	
	3.75 –11.25	2.3	2.2	0.7	1.4	3.0	3.5	
1956	6.0 – 12.0	2.3	1.8	0.7	1.0	1.5	1.6	
	4.5 – 13.5	2.4	2.2	0.9	1.5	3.0	3.5	
1958	8.0 – 18.0	2.5(1)	1.8(1)	0.7	1.0	1.5	1.6	
	6.0 – 18.0	2.5(1)	1.8(1)	0.9	1.5	3.0	3.5	

Note: Specifications for the extended frequency ranges are typical.

PERFORMANCE CHARACTERISTICS

Mean Attenuation Range
- 1950A . . . . . 80 dB
- All other units . . . . . 60 dB

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See page 12

Temperature Effects . . . . . See Fig. 3

Power Handling Capability

Without Performance Degradation
- 1950A, 1951 . . . . . 10 mW cw or peak
- All other units . . . . . 100 mW cw or peak

Survival Power (from −65°C to +25°C; see Fig. 4 for higher temperatures)
- All units . . . . . 1 W average
  25W peak (1 μsec max pulse width)

Switching Speed

Fall Time
- 1950A . . . . . 50 nsec max(2)
- All other units . . . . . 20 nsec max(2)

Rise Time
- 1950A . . . . . 250 nsec max
- All other units . . . . . 125 nsec max

Bias Current for Maximum Attenuation
- 1950A . . . . . 5 to 35 mA
- All other units . . . . . 15 to 70 mA

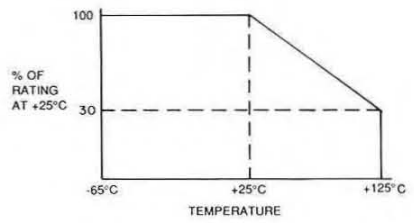


Fig. 4-Series 195 power derating factor

(1) *Except from 16 - 18 GHz where insertion loss is 3.5 dB max and VSWR is 2.0 max.*
(2) *For attenuation steps of 10 dB or more.*

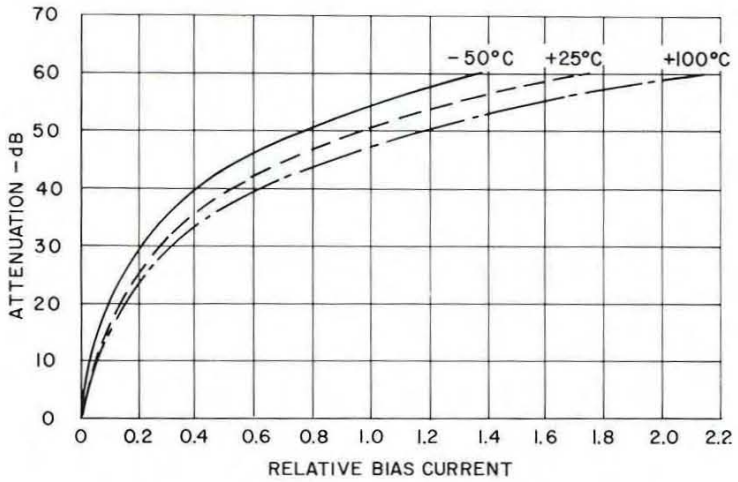


Fig. 3-Series 195, typical effects of temperature on attenuation

ENVIRONMENTAL RATINGS

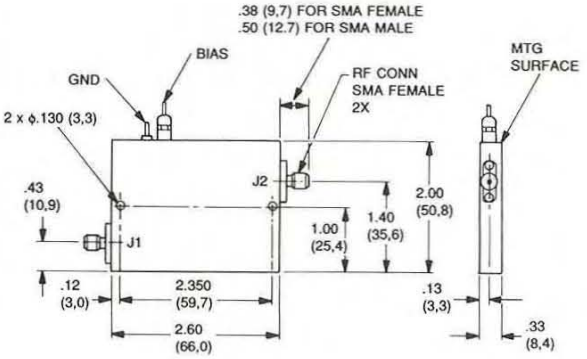
Operating Temperature Range	– 54 °C to + 125 °C
Non-Operating Temperature Range	– 65 °C to + 125 °C
Humidity	MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration	MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)
Altitude	MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling	MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

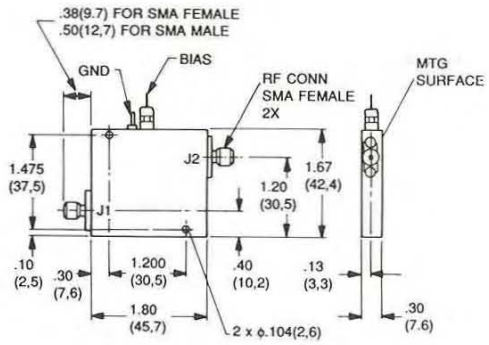
Option No.	Description
3	SMA female bias connector
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector
64	SMC male bias connector
64A	SMB male bias connector

Series 195 Specifications

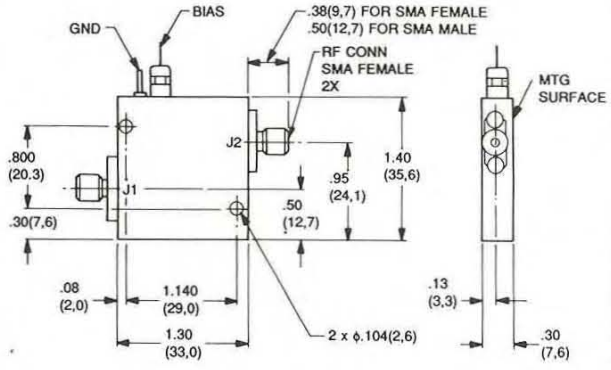
DIMENSIONS AND WEIGHTS



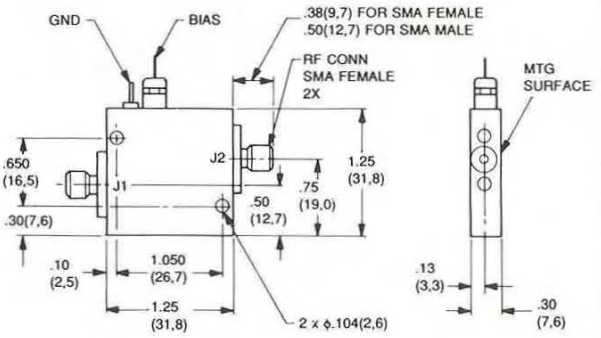
MODELS 1950A AND 1951
Wt: 3 oz. (85 gm) approx.



MODELS 1952 AND 1953
Wt: 2 oz. (57 gm) approx.



MODELS 1954, 1955 AND 1956
Wt: 1 oz. (28 gm) approx.



MODEL 1958
Wt: 1 oz. (28 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series D195 Octave-Band PIN Diode Attenuator/Modulators

With Integrated Drivers

SERIES D195

The Series D195 voltage-controlled linearized attenuator/modulators are integrated assemblies consisting of a Series 195 unit and a hybridized driver circuit which provides a nominal transfer function of 10 dB per volt. (See figure 1 below.)

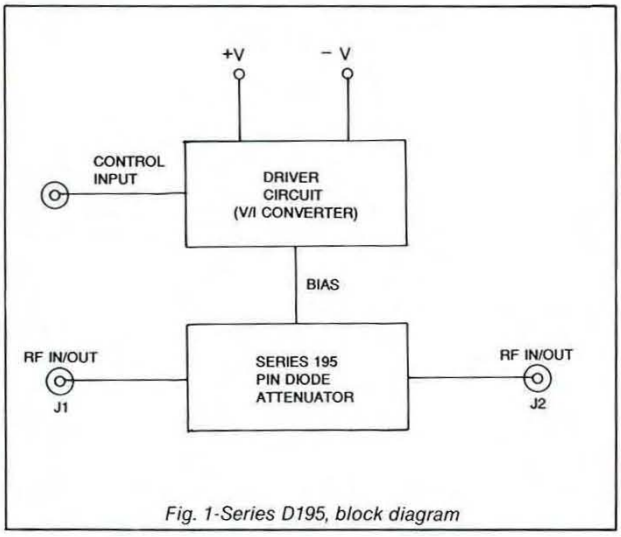


Fig. 1-Series D195, block diagram

All of the Series D195 units except the D1950A exhibit fall times of 20 nsec max and rise times of 1.5 μsec max for attenuation steps of 10 dB or more. For smaller excursions, the fall times can increase to several hundred nsec, while the rise times remain essentially unchanged. In applications where a rapid return to insertion loss from any level of attenuation is required, Option 59 is available. With this option, an external pulse is applied to trigger a high-speed reset circuit, and recovery times of 200 nsec max are obtained. Where use of an external reset pulse as described above is not feasible, an internal reset option (Option 58) is available which will automatically reset the unit to insertion loss within 200 nsec for a step of 50 dB or more.

The fall and rise time specifications for the D1950A are 500 nsec max and 10 μsec max, respectively. Options 58 and 59 are not available for this model.

- **Absorptive**
- **Linearized**
- **Frequency range: 0.5 to 18 GHz**
- **High performance MIC quadrature hybrid design**
- **High speed**

ALL UNITS IN THIS SERIES ARE EQUIPPED WITH INTEGRATED DRIVERS

Series D195 Specifications

MODEL	FREQUENCY RANGE (GHz)	MAX. INSERTION LOSS (dB)	MAX. VSWR	FLATNESS (± dB) AT MEAN ATTENUATION LEVELS UP TO				
				10 dB	20 dB	40 dB	60 dB	80 dB
D1950A	0.5 – 1.0	1.4	2.0	0.3	0.8	1.7	2.2	3.2
D1951	1.0 – 2.0	1.6	1.5	0.3	0.8	1.5	1.6	
	0.75–2.25	1.7	2.0	0.5	1.4	3.0	3.5	
D1952	2.0 – 4.0	1.8	1.5	0.3	0.8	1.5	1.6	
	1.5 – 4.5	1.9	2.0	0.5	1.4	3.0	3.5	
D1953	2.6 – 5.2	2.0	1.6	0.3	0.8	1.5	1.6	
	1.95–5.85	2.1	2.1	0.5	1.4	3.0	3.5	
D1954	4.0 – 8.0	2.4	1.7	0.3	0.8	1.5	1.6	
	3.0 – 9.0	2.5	2.2	0.5	1.4	3.0	3.5	
D1955	5.0 – 10.0	2.6	1.7	0.5	0.9	1.5	1.6	
	3.75 –11.25	2.7	2.2	0.7	1.4	3.0	3.5	
D1956	6.0 – 12.0	2.7	1.8	0.7	1.0	1.5	1.6	
	4.5 – 13.5	2.8	2.2	0.9	1.5	3.0	3.5	
D1958	8.0 – 18.0	3.0(1)	1.8(1)	0.7	1.0	1.5	1.6	
	6.0 – 18.0	3.0(1)	1.8(1)	0.9	1.5	3.0	3.5	

Note: Specifications for the extended frequency ranges are typical.

PERFORMANCE CHARACTERISTICS

Mean Attenuation Range
- D1950A . . . . . 80 dB
- All other units . . . . . 60 dB

Accuracy of Attenuation
- 0 to 30 dB . . . . . ± 0.5 dB
- > 30 to 50 dB . . . . . ± 1.0 dB
- > 50 to 60 dB . . . . . ± 1.5 dB
- > 60 to 80 dB . . . . . ± 2.0 dB (D1950A only)

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See page 12

Temperature Coefficient . . . . . ± 0.025 dB/°C

Power Handling Capability

Without Performance Degradation
- D1950A, D1951 . . . . . 10 mW cw or peak
- All other units . . . . . 100 mW cw or peak

Survival Power (from −65°C to +25°C; see figure 2 for higher temperatures)
- All units . . . . . 1 W average, 25 W peak (1 μsec max pulse width)

Switching Characteristics

Off Time
- D1950A . . . . . 600 nsec max
- All other units . . . . . 100 nsec max

On Time
- D1950A . . . . . 10 μsec max
- All other units . . . . . 1.6 μsec max

Fall Time
- D1950A . . . . . 500 nsec max
- All other units . . . . . 20 nsec max

Rise Time
- D1950A . . . . . 10 μsec max
- All other units . . . . . 1.5 μsec max

Nominal Control Voltage Characteristics

Range	Operating	Maximum
D1950A	0 to +8V	± 15V
All other units	0 to +6V	± 15V

Transfer Function . . . . 10 dB/volt

Input Impedance . . . . 10 Kohms(2)

Modulation Bandwidth

Small Signal
- D1950A . . . . . 25 kHz
- All other units . . . . 500 kHz

Large Signal
- D1950A . . . . . 5 kHz
- All Other Units . . . 50 kHz

Power Supply Requirements . . . . . +12V ± 5%, 100 mA; −12V ± 5%, 25 mA

Power Supply Rejection . . . . . Less than 0.1 dB/volt change in either supply

(1) *Except from 16 - 18 GHz where insertion loss is 4.0 dB max and VSWR is 2.0 max.*

ENVIRONMENTAL RATINGS

Operating Temperature Range	−54°C to +110°C
Non-Operating Temperature Range	−65°C to +125°C
Humidity	MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration	MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)
Altitude	MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling	MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female control connector
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector
58	Internally-generated reset to insertion loss (not available on D1950A)(1)
59	Externally-triggered reset to insertion loss (not available on D1950A)(2) (3)
61	20 dB/volt transfer function with 0 to +3V control signal input (+4V for the D1950A)
62	± 15 volt operation
64	SMC male control connector
64A	SMB male control connector

(1) *Where use of an Option 59 external reset pulse (see note 2 below) is not feasible, this option is available which will automatically sense the slope and magnitude of the control signal and reset the unit to the insertion loss state within 200 nsec for a step of 50 dB or more.*

(2) *An external terminal is provided for the user to apply a fast (10 nsec max rise time) positive-going 3-volt pulse at least 0.5 μsec wide to accelerate the return of the attenuator to the insertion loss state with the simultaneous lowering of the control signal to the zero voltage level. This reset can be accomplished within 200 nsec.*

(3) *The input impedance of units equipped with Option 59 is a circuit equivalent to approximately 50 pF in series with a parallel combination of 100 pF and 1000 ohms.*

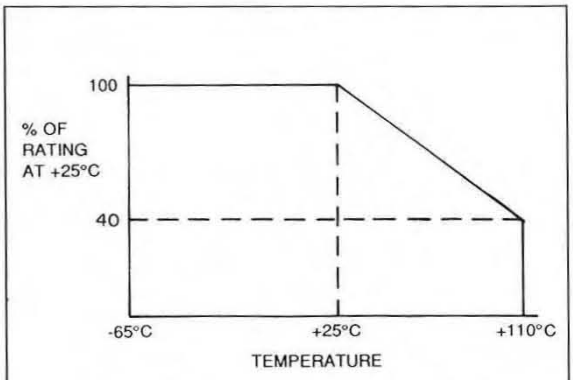
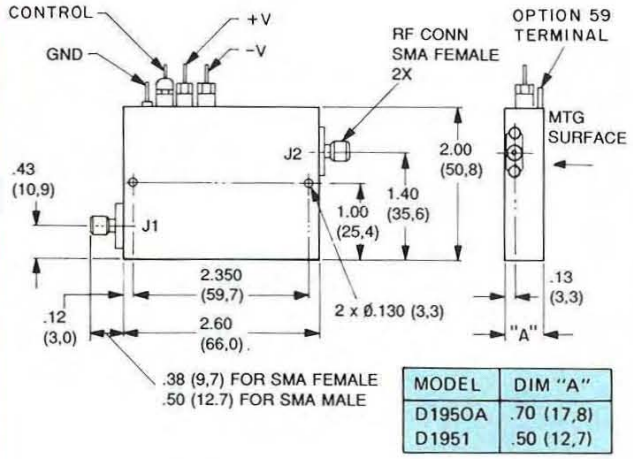


Fig. 2-Series D195, power derating factor

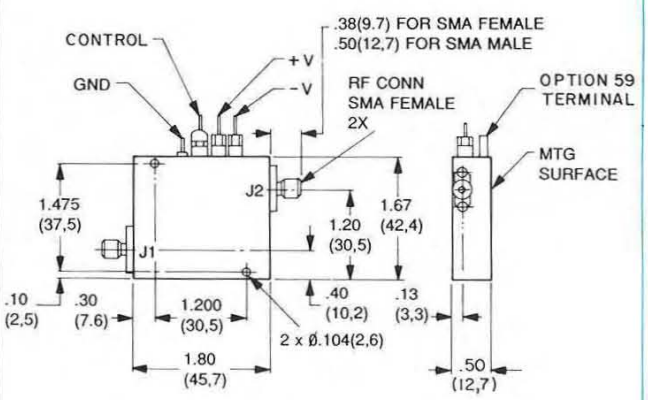
Series D195 Specifications

DIMENSIONS AND WEIGHTS

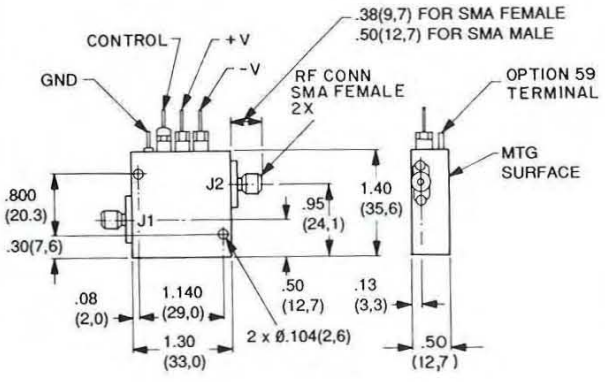


MODEL	DIM "A"
D1950A	.70 (17,8)
D1951	.50 (12,7)

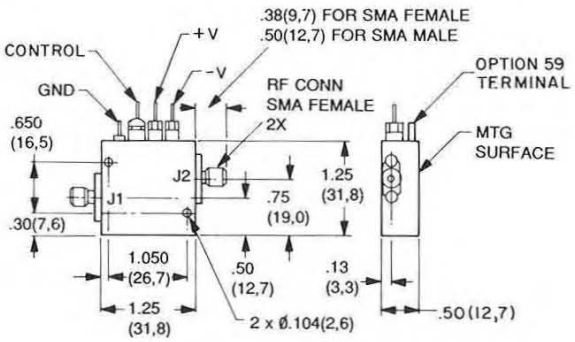
MODELS D1950A AND D1951
Wt: 3 oz. (85 gm) approx.



MODELS D1952 AND D1953
Wt: 2 oz. (57 gm) approx.



MODELS D1954, D1955 AND D1956
Wt: 1 oz. (28 gm) approx.



MODEL D1958
Wt: 1 oz. (28 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

D196 Series Multi-Octave PIN Diode Attenuators

With Integrated Drivers (0.5-18 GHz)

The D196 Series is a family of nonreflective voltage variable 60 dB PIN Diode Attenuators covering the frequency range from 0.5 GHz to 18 GHz in four overlapping multi-octave bands.

Each model in the Series is equipped with an integrated driver which controls the attenuation level at the rate of 10 dB/volt.

The RF circuit consists of two wide-band, T-pad attenuator sections connected in tandem. The driver circuit, which consists of a voltage-to-current converter and linearizing network, furnishes the proper series and shunt currents to control the attenuation value at the specified rate while simultaneously maintaining a bilateral match. See figs. 1 and 2.

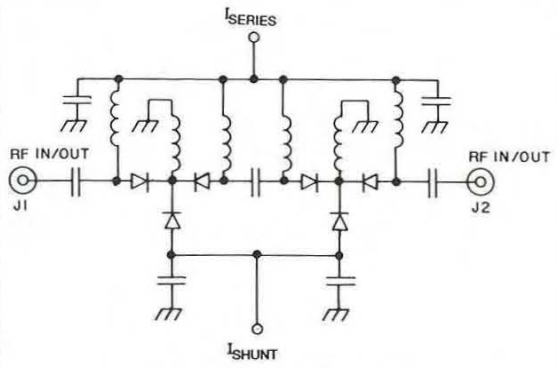


Fig. 1-Series D196, rf schematic diagram

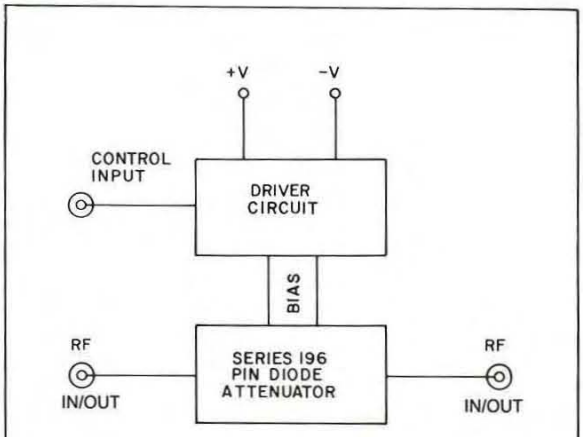


Fig. 2–Series D196 block diagram

- **Frequency range: 0.5 GHz-18 GHz in four overlapping bands**
- **Attenuation range: 60 dB**
- **Linear control: 10 dB/volt**
- **Low insertion loss**
- **Nonreflective**

All units in this series are equipped with integrated drivers

D196 Series Specifications

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	MODEL D1960B	MODEL D1961B	MODEL D1962B	MODEL D1968B
Frequency Range (GHz)	0.5-4	0.5-8	2-8	2-18
Mean Attenuation Range (dB)	60	60	60	60
Insertion Loss (dB) (max)	2.5	2.5 (0.5-4 GHz) 3.0 (4-8 GHz)	3.0	4.5
VSWR (max)	1.8	1.8	1.8	2.0
Flatness up to 20 dB **40 dB** **60 dB**	±0.5 dB ±0.75 dB ±1.0 dB	±0.75 dB ±1.0 dB ±1.5 dB	±0.75 dB ±1.0 dB ±1.5 dB	±1.0 dB ±1.25 dB ±3.0 dB

Mean Attenuation Range 60 dB

Accuracy of Attenuation
0-20 dB . . . . . ±1.0 dB
20-40 dB . . . . . ±1.5 dB
40-60 dB . . . . . ±2.0 dB

Monotonicity . . . . . Guaranteed
Phase Shift . . . . . See page 12

Temperature Coefficient . ±0.02 dB/°C

Power Handling Capability
Without Performance Degradation:
All Units . . . . . Up to 100 mW cw or peak (see Fig 3).
Survival Power
All Units . . . . . 2 W average or peak, from −65°C to +25°C (see Fig. 4 for higher temperatures).

Switching Characteristics
ON Time . . . . . 1.0 μsec max.
OFF Time . . . . . 0.5 μsec max.

Nominal Control Voltage Characteristics

Range
Operating . . . . . 0 to +6V
Maximum . . . . . ±15V

Transfer Function . . . . 10 dB/volt

Input Impedance . . . . . 10 kohms

Modulation Bandwidth
Small Signal . . . . . 20 kHz
Large Signal . . . . . 5 kHz

Power Supply Requirements . . . . . +12V ±5%, 70 mA
−12V ±5%, 50 mA

Power Supply Rejection . . . . . Less than 0.1 dB/volt change in either supply

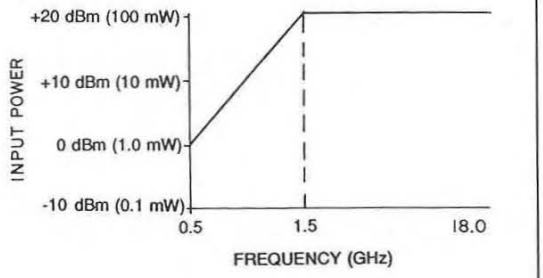


Fig. 3-Series D196, maximum peak and average operating power without performance degradation

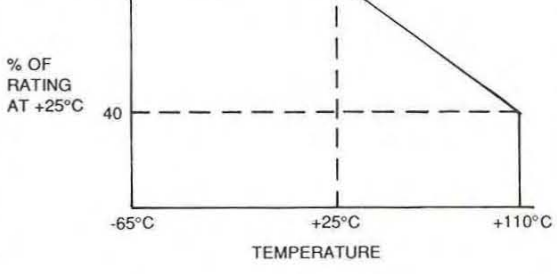


Fig. 4-Power derating factor

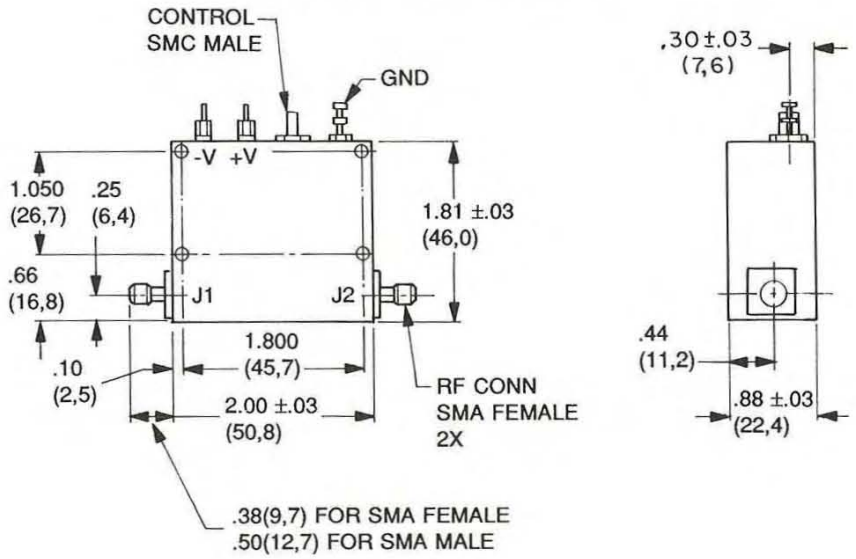
ENVIRONMENTAL RATINGS

Operating Temperature Range	−54°C to +110°C
Non-Operating Temperature Range	−65°C to +125°C
Humidity	MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration	MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)
Altitude	MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling	MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female control connectors
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector
33	EMI filter solder-type control terminal
61	20 dB/volt transfer function with 0 to +3V control signal input
62	± 15V operation
64A	SMB male control connector

DIMENSIONS AND WEIGHT



SERIES D196
Wt: 3 oz. (85 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Model H1968B
Hermetic PIN Diode Attenuator (2 to 18 GHz)

- **High reliability: hermetically-sealed**
- **Frequency range: 2-18 GHz**
- **Attenuation range: 60 dB**
- **Linear control: 10 dB/Volt**
- **Removeable SMA connectors: can be used as a drop-in module**

H1968B is a 2 to 18 GHz voltage-controlled PIN diode attenuator, with an attenuation range of 60 dB, in a 0.24″ thick hermetically-sealed configuration.

The RF circuit consists of two wide-band PIN diode T-pad attenuator sections connected in tandem. The integrated driver circuit provides the proper series and shunt currents to control the attenuation level at the rate of 10 dB/volt while simultaneously maintaining a bilateral match. See Fig. 1.

HERMETIC SEALING

The H1968B sealed assembly meets a 1×10^{-7} atm cc/sec leak rate specification.

The RF connectors may be replaced without compromising the integrity of the seal or removed to use the attenuator as a drop-in module.

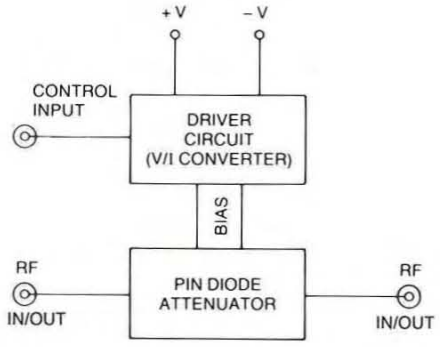


Fig. 1–Model H1968B block diagram.

H1968B Specifications

PERFORMANCE CHARACTERISTICS

Specifications	
Frequency Range (GHz)	2 to 18
Insertion Loss (dB) (max)	4.5
VSWR (max)	2.0
Flatness Up to 20 dB Up to 40 dB Up to 60 dB	 ±1.0 dB ±1.25 dB ±3.0 dB

Mean Attenuation Range . 60 dB

Accuracy of Attenuation
0-20 dB . . . . . ±1.0 dB
20-40 dB . . . . . ±1.5 dB
40-60 dB . . . . . ±2.0 dB

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See page 12

Temperature Coefficient . ±0.02 dB/°C

Power Handling Capability
Without Performance Degradation . . . . . 100 mW cw or peak
Survival Power . . . . . 2W average or peak (1 μsec max pulse width) from –65°C to +25°C (see Fig. 2 for higher temperatures)

Switching Time
On Time . . . . . 1.0 μsec
Off Time . . . . . 0.5 μsec

Nominal Control Voltage Characteristic Range
Operating . . . . . 0 to +6V
Maximum . . . . . ±15V

Transfer Function . . . . . 10 dB/volt

Input Impedance . . . . . 10 kohms

Power Supply Requirements . . . . . +12V ±5% @ 70 mA
–12V ±5% @ 50 mA

Power Supply Rejection . . . . . Less than 0.1 dB/volt change in either supply.

ENVIRONMENTAL RATINGS

Temperature Range
Operating . . . . . –65°C to +110°C

AVAILABLE OPTIONS

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male and one SMA female rf connector
49	High rel screening (See Table 1 on page 36)
62	±15V operation

AVAILABLE ACCESSORIES

Model	Spacer Plates
H1968B	19177-P3

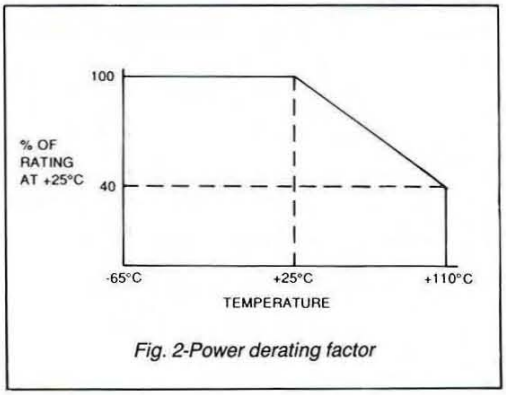


Fig. 2-Power derating factor

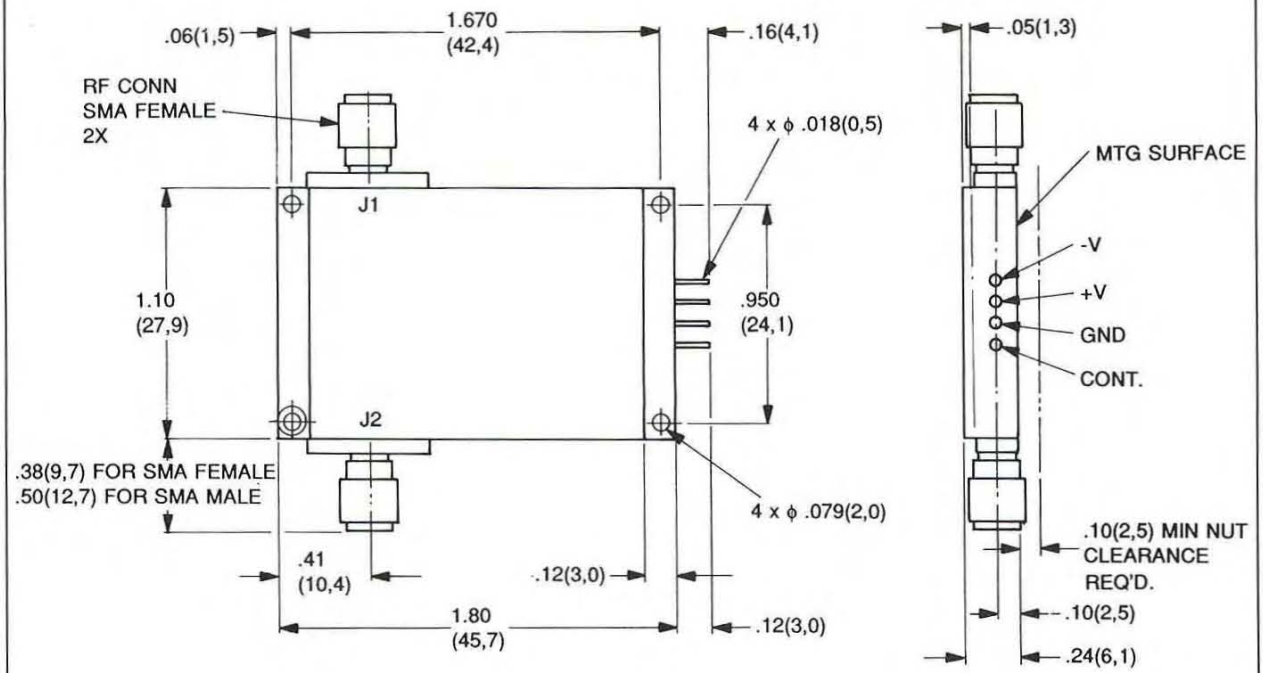
H1968B Specifications

TABLE 1: OPTION 49 HIGH REL SCREENING

General Microwave's hermetically-sealed components utilize rugged construction techniques and hermetic sealing to meet stringent military requirements for shock, vibration, temperature, altitude, humidity, and salt atmosphere. All hermetically-sealed parts may be ordered, if desired, with 100% screening in accord with the following:

Test	Method	Condition
Internal Visual	2017.3	—
Stabilization Bake	1008.2	C
Temperature Cycle	1010.5	C
Mechanical Shock	2002.3	B
Burn-In	1015.4	—
Leak	1014.2/.9	A1 & A2

DIMENSIONS AND WEIGHT



Weight: 3.5 oz. (99 gm) approx.

Dimensional tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Series D197 Voltage Controlled Phase Invariant Attenuators

The Series D197 voltage controlled PIN diode attenuators offer essentially phase free operation over a wide dynamic range in multi-octave frequency bands between 2 and 18 GHz. The attenuators utilize a unique double balanced arrangement of diodes and quadrature couplers to achieve the phase independent attenuation characteristic. Excellent temperature stability is maintained by employing a self-compensating biasing scheme. See Fig. 1.

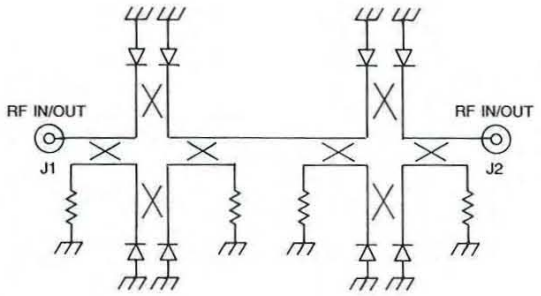
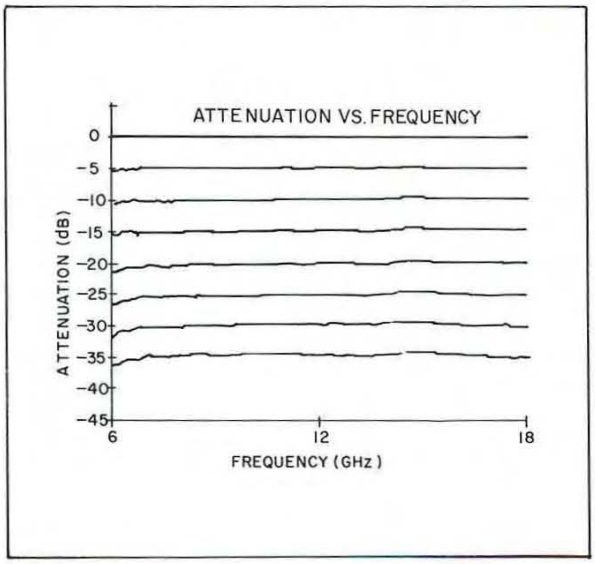
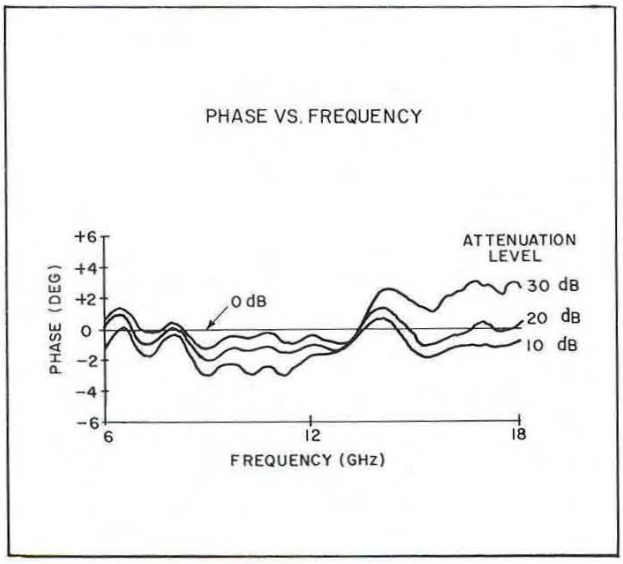


Fig. 1-RF schematic diagram

- **Low phase shift**
- **Frequency range: 2-18 GHz**
- **Nonreflective**
- **Attenuator range: to 45 dB**
- **Linearized control: 10 dB/V**
- **High speed**

TYPICAL PERFORMANCE





Series D197 Specifications

PERFORMANCE CHARACTERISTICS

MODEL	D1972	D1974	D1978
Frequency Range (GHz)	2-6	4-11	6-18
Mean Attenuation Range	32 dB		
Insertion Loss (Max)	4 dB	5 dB	5.5 dB
VSWR (Max)	2.0		
Accuracy of Attenuation 0 to 20 dB > 20 to 32 dB	± 1.0 dB ± 2.0 dB		
Amplitude Flatness 0 to 20 dB > 20 to 32 dB	± 0.4 dB ± 0.6 dB	± 0.4 dB ± 0.8 dB	± 0.8 dB(1) ± 1.3 dB(1)
Monotonicity	Guaranteed		
Phase Shift 0 to 20 dB > 20 to 32 dB	± 4° ± 8°	± 4° ± 8°	± 5° ± 10°
Control Voltage	0-3.2 V		
Control Input Impedance	10 kohms		
Transfer Function	10 dB/V		
On Time, Off Time	250 nsec		
Temperature Coefficient 0-20 dB > 20-32 dB	.01 dB/°C .03 dB/°C		
Max. RF Power Input (Operating)	100 mW		
Max. RF Power Input (Survival)	0.5 W		
Harmonic Distortion @ Pin = +10 dBm	−40 dBc	−50 dBc	−50 dBc
Power Supply Requirements	+15V ± 5% @ 200 mA −15V ± 5% @ 120 mA		

SPECIFICATIONS WITH EXTENDED RANGE OPTION (OPTION 45)

Mean Attenuation Range	45 dB		
Accuracy of Attenuation 0-20 dB > 20-32 dB > 32 dB	± 1.0 dB ± 2.0 dB ± 3.5 dB		
Amplitude Flatness 0 to 20 dB > 20 to 32 dB > 32 dB	± 0.4 dB ± 0.6 dB ± 1.5 dB	± 0.4 dB ± 0.8 dB ± 1.5 dB	± 0.8 dB(1) ± 1.3 dB(1) ± 2.0 dB
Phase Variation 0 to 20 dB > 20 to 32 dB > 32 dB	± 4° ± 8° ± 15°	± 4° ± 8° ± 20°	± 5° ± 10° ± 30°

(1) *Except from 8-18 GHz, flatness is ± 0.5 dB up to 20 dB, ± 1.0 dB up to 32 dB.*

Series D197 Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range ..... −54°C to +110°C

Non-Operating Temperature Range ..... −65°C to +125°C

Humidity ..... MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

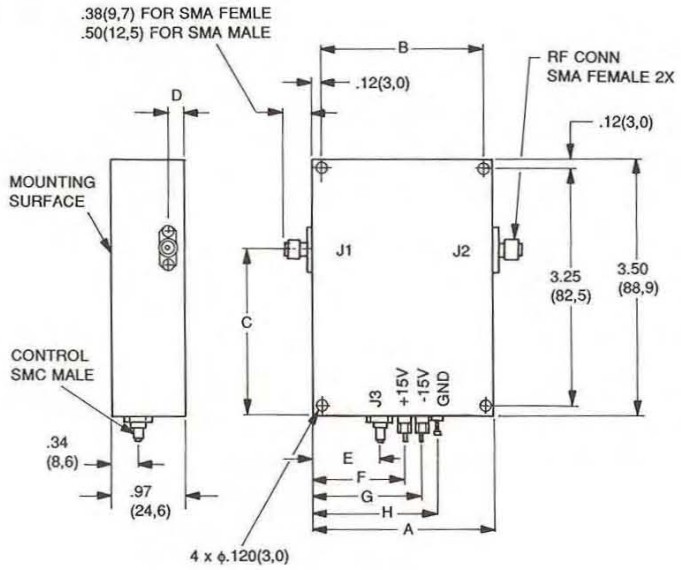
Altitude ..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling ..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector
45	Extended attenuation range to 45dB
65	±12V operation

DIMENSIONS AND WEIGHT



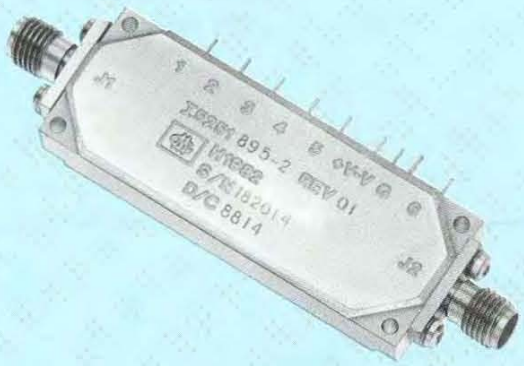
SERIES D197
Wt: 5 oz. (142 gm) approx.

MODEL	A	B	C	D	E	F	G	H
D1972	2.5 (63,5)	2.26 (57,4)	2.28 (57,9)	0.22 (5,6)	0.91 (23,1)	1.25 (31,7)	1.5 (38,1)	1.7 (43,2)
D1974	2.0 (50,8)	1.76 (44,7)	2.43 (61,7)	0.18 (4,6)	0.66 (16,8)	1.0 (25,4)	1.25 (31,7)	1.45 (36,8)
D1978	2.0 (50,8)	1.76 (44,7)	2.58 (65,5)	0.18 (4,6)	0.66 (16,8)	1.0 (25,4)	1.25 (31,7)	1.50 (38,1)

Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx ±.005

Series H198
6 Bit High Speed Digital Attenuators, 0.5-6 GHz

- **30 nSec switching time**
- **Up to 63 dB attenuation**
- **Hermetically-sealed; 0.24″ thick**
- **Guaranteed monotonic**



The Series H198 are hermetically sealed, high speed, digitally controlled switched bit attenuators. Attenuation changes are guaranteed to be monotonic over the entire frequency band and operating temperature range. Employing removable rf connectors, their small size and construction make these attenuators suitable for use as drop-in components for system integration or as conventional connectorized components.

Attenuation level is selected via six FAST TTL input control pins. The attenuators are protected against inadvertent power supply voltage reversals. See Fig. 1.

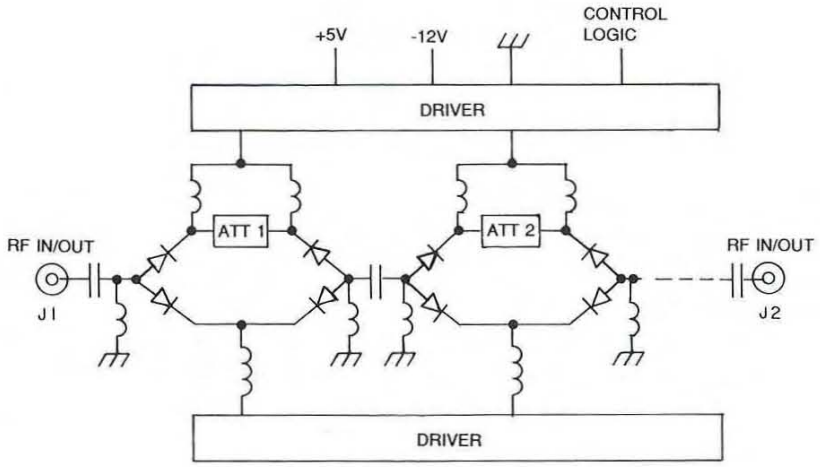


Fig. 1-Series H198 schematic diagram

Series H198 Specifications

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	H1980	H1982
Frequency Range (GHz)	0.5-6.0	2.0-6.0
Attenuation Range	63 dB	
Insertion Loss (Max)	5.0 dB	4.0 dB
VSWR (Max)	2.0:1	
Number of Bits	6	
Montonicity	Guaranteed	
Accuracy of Mean Attenuation	±0.5 dB: 0 to 31 dB ±1.0 dB: >31 to 63 dB	
Attenuation Flatness	±0.5 dB; 0 to 14 dB ±0.75 dB: >14 to 32 dB ±1.0 dB >32 to 63 dB	
Power Handling	+23 dBm cw	
Switching Time	30 nsec. (50% TTL to 1 dB of final value)	
Rise and Fall Time	<10 nsec	
Switch Rate	10 MHz (1)	
Control Logic	Logic "O" = Bit Off Logic "1" = Bit On	
Control Input	At Logic "O": −0.3 to +0.8V @ 1.2 mA At Logic "1": +2.0 to +5.0V @40 mA	
Power Supply	+5V ±5% @ 175 mA(2) −12V ±5% @ 150 mA	

(1) *Above 1 MHz, switching time will increase linearly to 35 nsec at 10 MHz.*

(2) *Above 1 MHz, current will increase to +5V @ 300 mA, −12V @ 250 mA at 10 MHz.*

ENVIRONMENTAL RATINGS

Temperature Range

Operating . . . . . −65°C to +110°C

AVAILABLE OPTIONS

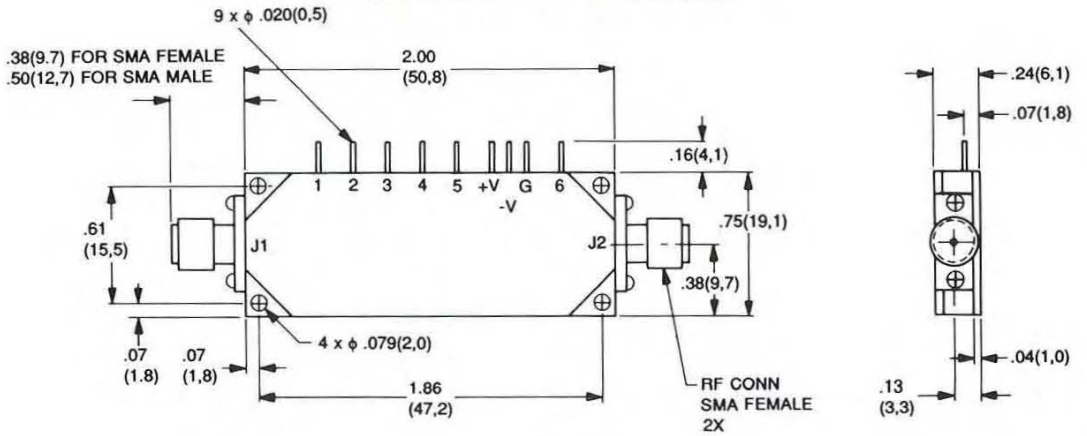
Option No.	Description
6A	31.5 dB range, 0.5 dB LSB (H1982 only)
7	Two SMA male rf Connectors
9	Inverse Control Logic
10	One SMA male and one SMA female rf connector
49	High Rel screening (see Table 1, page 36)

AVAILABLE ACCESSORIES

Model	Spacer Plates
H1980	19177-P2
H1982	19177-P2

PIN DESIGNATIONS	
PIN	FUNCTION
1	16 dB
2	8 dB
3	2 dB
4	4 dB
5	1 dB
6	32 dB
+V	+5V
−V	−12V
G	Ground

DIMENSIONS AND WEIGHT



SERIES H198
Wt: 0.8 oz (23 gm) approx

Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx±.005

Model 3250A Ultra-Broadband 6 Bit Digital PIN Diode Attenuator

- **Frequency range: 0.2 to 18 GHz**
- **Attenuation range: Up to 60 dB**
- **6 Bit Binary or BCD programming**
- **Absorptive**
- **Guaranteed Monotonicity**

The Model 3250A digitally programmable attenuator provides excellent performance characteristics over the frequency range of 0.2 to 18 GHz. Attenuation levels up to 60 dB are programmable in increments of 1 dB.

The unit is an integrated assembly of a dual T-pad PIN diode attenuator and a driver consisting of a D/A and an I/V Converter. See figures 1 and 2.

The Model 3250A operates as a bilaterally-matched device at all attenuation levels. It is supplied in a compact rugged package well-suited to military applications.

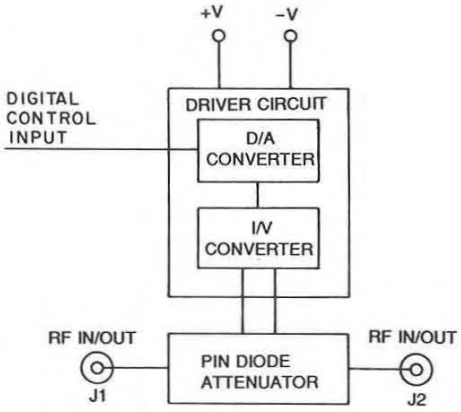


Fig. 1-Model 3250A, block diagram

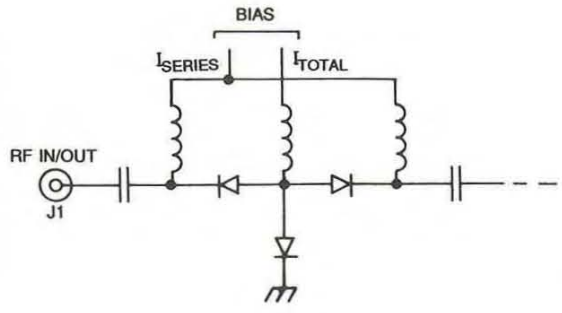


Fig. 2-Model 3250A, rf schematic diagram (unit consists of two such sections)

PERFORMANCE CHARACTERISTICS

Frequency Range . . . . . 0.2 to 18 GHz

Mean Attenuation Range
0.2 to 18 GHz . . . . . 60 dB

Insertion Loss (max.)
0.2 to 8 GHz . . . . . 3.5 dB
8 to 12.4 GHz . . . . . 4.0 dB
12.4 to 18 GHz . . . . . 5.0 dB

VSWR (max.)
0.2 to 8 GHz 1.75
8 to 18 GHz 2.0

Accuracy of Attenuation
0 to 30 dB . . . . . ±0.5 dB
31 to 50 dB . . . . . ±0.75 dB
51 to 60 dB . . . . . ±1.5 dB

Flatness of Attenuation
0 to 30 dB . . . . . ±1.0 dB
31 to 50 dB . . . . . ±1.5 dB
51 to 60 dB . . . . . ±3.0 dB

Temperature Coefficient . . . . . 0.02 dB/°C max

Power Handling Capability
Without Performance Degradation . . . . . Up to 100mW cw or peak (see Figure 3)
Survival Power . . . . . 2W average or peak (from −65°C to +25°C; see Figure 4 for higher temperatures)

Switching Time . . . . . 2 μsec max.

Programming . . . . . Positive true binary standard or BCD (Option 1). For complementary code, specify Option 2.

Minimum Attenuation Step 1.0 dB

Logic Input
Logic "0" (Bit Off) . . . . . −0.3 to +0.8 V@500 μA max
Logic "1" (Bit On) . . . . . +2.0 to +5.0 V@100 μA max

Power Supply
Requirements . . . . . +5V ±5%, 250 mA
+15V ±5%, 75 mA
−15V, ±5%, 75 mA

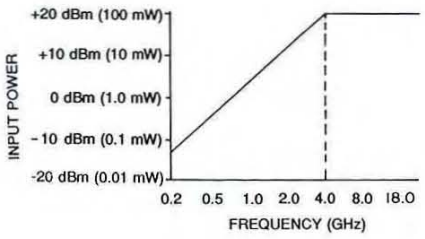


Fig. 3-Model 3250A, maximum peak and average operating power without performance degradation.

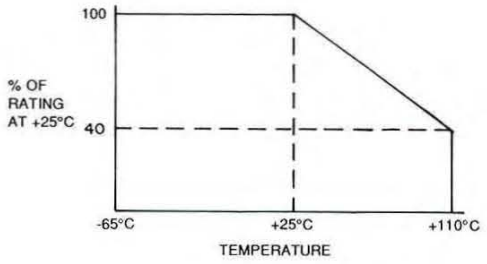


Fig. 4-Model 3250A survival power derating factor.

Model 3250A Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −54°C to 110°C

Non-Operating Temperature Range . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

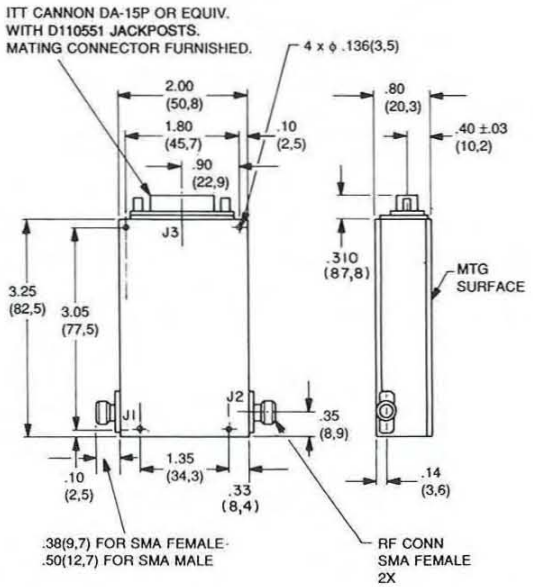
Option No.	Description
1	BCD programming (Binary is standard)
2	Complementary programming (positive true is standard)
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector

PIN FUNCTIONS		
PIN NO.	**BINARY**	**BCD (Opt. 1)**
1	SPARE	SPARE
2	SPARE	SPARE
3	+5V	+5V
4	DIGITAL & POWER GND	DIGITAL & POWER GND
5	GND	1 dB
6	GND	2 dB
7	1 dB	4 dB
8	2 dB	8 dB
9	4 dB	10 dB
10	8 dB	20 dB
11	16 dB	40 dB
12	32 dB	OPEN (NO CONNECTION)
13	+15V	+15V
14	−15V	−15V
15	SPARE	SPARE

ACCESSORY FURNISHED

Mating power/logic connector

DIMENSIONS AND WEIGHT



MODEL 3250A
Wt: 4 oz. (113 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ±.005

Series 329 Octave-Band 11 Bit Digital PIN Diode Attenuators

SERIES 329

The Series 329 programmable attenuators provide octave-band performance characteristics and wide programming flexibility. Attenuation ranges up to 120 dB and attenuation increments as low as 0.05 dB are available.

Each Series 329 unit is an integrated assembly of Series 195 units, and a driver circuit consisting of a D/A Converter and a precision V/I Converter (see page 23 and figure 1 below). This arrangement preserves the speed, reliability and monotonicity of the PIN diode attenuator and adds an extremely high degree of accuracy and design flexibility that permits selection of a virtually unlimited combination of dynamic range and attenuation interval. The rf characteristics of the Series 329 (e.g. - insertion loss, VSWR and flatness) are similar to the corresponding characteristics of the Series 195 unit employed.

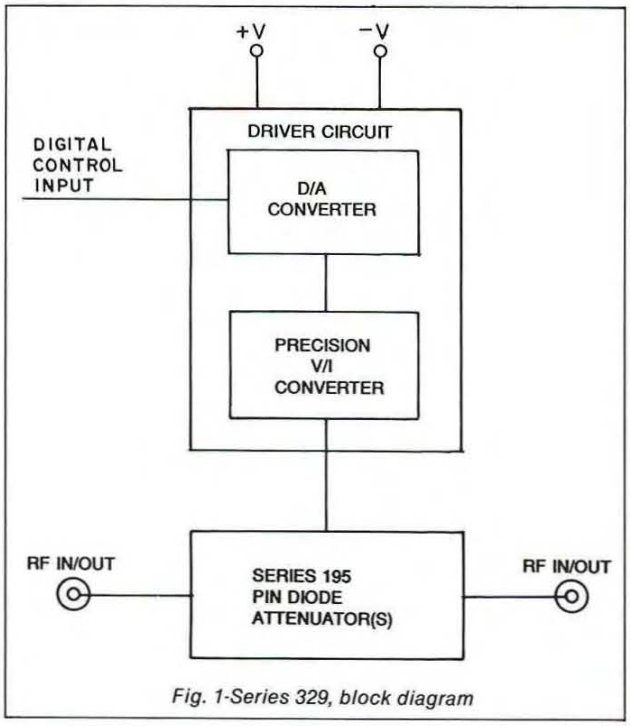


Fig. 1-Series 329, block diagram

- **Frequency range: 0.5 to 18 GHz**
- **Attenuation range: up to 120 dB**
- **Control: 11 bit binary or BCD**
- **Guaranteed monotonicity**
- **LSB: 0.05 dB**
- **Absorptive**

Series 329 Specifications

60/80 dB Series

MODEL	FREQUENCY RANGE (GHz)	MAX. INSERTION LOSS (dB)	MAX. VSWR	FLATNESS (±dB) AT MEAN ATTENUATION LEVELS UP TO				
				10 dB	20 dB	40 dB	60 dB	80 dB
3290A-80	0.5 – 1.0	1.4	2.0	0.3	0.8	1.7	2.2	3.2
3291-80	1.0 – 2.0	1.6	1.5	0.3	0.8	1.5	1.6	1.7
	0.75 – 2.25	1.7	2.0	0.5	1.4	3.0	3.5	3.6
3292-80	2.0 – 4.0	1.9	1.6	0.3	0.8	1.5	1.6	1.7
	1.5 – 4.5	2.0	2.2	0.5	1.4	3.0	3.5	3.6
3293-80	2.6 – 5.2	2.2	1.7	0.3	0.8	1.5	1.6	1.7
	1.95 – 5.85	2.3	2.3	0.5	1.4	3.0	3.5	3.6
3294-80	4.0 – 8.0	2.7	1.8	0.3	0.8	1.5	1.6	1.7
	3.0 – 9.0	2.8	2.4	0.5	1.4	3.0	3.5	3.6
3295-80	5.0 – 10.0	2.9	1.8	0.5	0.9	1.5	1.6	1.7
	3.75 – 11.25	3.0	2.4	0.7	1.4	3.0	3.5	3.6
3296-80	6.0 – 12.0	3.0	1.9	0.7	1.0	1.5	1.6	1.7
	4.5 – 13.5	3.1	2.4	0.9	1.5	3.0	3.5	3.6
3298-60	8.0 – 18.0	3.3(1)	1.9(1)	0.7	1.0	1.5	1.6	—
	6.0 – 18.0	3.3(1)	1.9(1)	0.9	1.5	3.0	3.5	—

Note: Specifications for the extended frequency ranges are typical.

120 dB Series

MODEL(2)	FREQUENCY RANGE (GHz)	MAX. INSERTION LOSS (dB)	MAX. VSWR	FLATNESS (±dB) AT MEAN ATTENUATION LEVELS UP TO						
				10 dB	20 dB	40 dB	60 dB	80 dB	100 dB	120 dB
3291-120	1.0 – 2.0	3.5	2.0	0.5	0.8	1.6	2.4	3.0	3.1	3.2
	0.75 – 2.25	3.7	2.5	0.7	1.4	3.0	4.5	6.0	6.7	7.0
3292-120	2.0 – 4.0	3.9	2.0	0.5	0.8	1.6	2.4	3.0	3.1	3.2
	1.5 – 4.5	4.1	2.5	0.7	1.4	3.0	4.5	6.0	6.7	7.0
3293-120	2.6 – 5.2	4.3	2.2	0.5	0.8	1.6	2.4	3.0	3.1	3.2
	1.95 – 5.85	4.5	2.6	0.7	1.4	3.0	4.5	6.0	6.7	7.0
3294-120	4.0 – 8.0	5.2	2.3	0.5	0.8	1.7	2.5	3.2	3.3	3.4
	3.0 – 9.0	5.4	2.7	0.7	1.4	3.0	4.6	6.2	6.9	7.2
3295-120	5.0 – 10.0	5.6	2.4	0.7	1.1	1.9	2.7	3.2	3.3	3.4
	3.75 – 11.25	5.8	2.8	1.2	1.7	3.2	4.8	6.3	7.0	7.2
3296-120	6.0 – 12.0	5.9	2.5	0.9	1.4	2.1	2.8	3.3	3.4	3.5
	4.5 – 13.5	6.1	2.9	1.5	2.0	3.5	5.0	6.4	7.0	7.2
3298-120	8.0 – 18.0	6.6(3)	2.5(3)	1.0	1.5	2.2	3.0	3.4	3.5	3.6
	6.0 – 18.0	6.6(3)	2.5(3)	1.5	2.0	3.5	5.0	6.4	7.1	7.4

Note: Specifications for the extended frequency ranges are typical.

(1) Except from 16 - 18 GHz where insertion loss is 4.2 dB max and VSWR is 2.2.

(2) Maximum attenuation in units with BCD option is 119 dB.

(3) Except from 16 - 18 GHz where insertion loss is 8.6 dB max and VSWR is 2.7.

PERFORMANCE CHARACTERISTICS

Mean Attenuation Range. Refer to model number suffix (e.g. - mean attenuation ranges of 3298-60 and 3298-120 are 60 dB and 120 dB, respectively)

Accuracy of Attenuation

60/80 dB units . . . . . ± (0.35 dB + 0.01 dB/dB)

120 dB units . . . . . ± (0.5 dB + 0.02 dB/dB)

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See page 12

Temperature Coefficient

60/80 dB units

0 to 10 dB . . . . . ± 0.01 dB/°C

>10 to 30 dB . . . . . ± 0.025 dB/°C

>30 to max attenuation . . . . . ± 0.05 dB/°C

120 dB units

0 to 20 dB . . . . . ± 0.02 dB/°C

>20 to 60 dB . . . . . ± 0.05 dB/°C

>60 to 120 dB . . . . . ± 0.1 dB/°C

Power Handling Capability

Without Performance Degradation

3290A and 3291 . . . . . 10 mW cw or peak

All other units . . . . . 100 mW cw or peak

Survival Power

All units . . . . . 1 W average, 25 W peak, 1 μsec max pulse width, from −25°C to +25°C, (see Fig. 2 for higher temperatures)

Power Supply Requirements

	+15V ±5%	−15V ±5%	+5V ±5%
60/80 dB units	100 mA	50 mA	50 mA
120 dB units	200 mA	100 mA	50 mA

Power Supply Rejection . . . . . Less than 0.1 dB/volt change in any supply

Switching Time

3298-60 . . . . . 2 μsec max

3298-120 . . . . . 3 μsec max

All other units . . . . . 10 μsec max

Programming . . . . . Positive true binary (standard) or BCD (Option 1). For complementary code, specify Option 2.

Minimum Attenuation Step

	60/80 dB units	120 dB units
Binary Units	0.05 dB	0.1 dB
BCD Units	0.2 dB	1.0 dB

Logic Input

Logic "0" (Bit Off) . . −0.3 to +0.8V @ −1.6 mA

Logic "1" (Bit On) . . +2.0 to +5.0V @ +40 μA

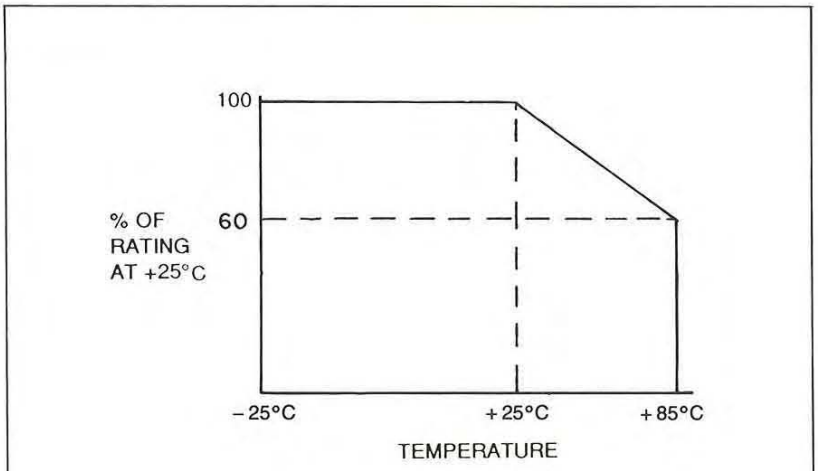


Fig. 2-Series 329, power derating factor

Series 329 Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range	−25 °C to +85 °C
Non-Operating Temperature Range	−54°C to +100°C
Humidity	MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration	MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)
Altitude	MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling	MIL-STD-202F, Method 107D, Cond. A, 5 cycles

ACCESSORY FURNISHED

Mating power/logic connector

AVAILABLE OPTIONS

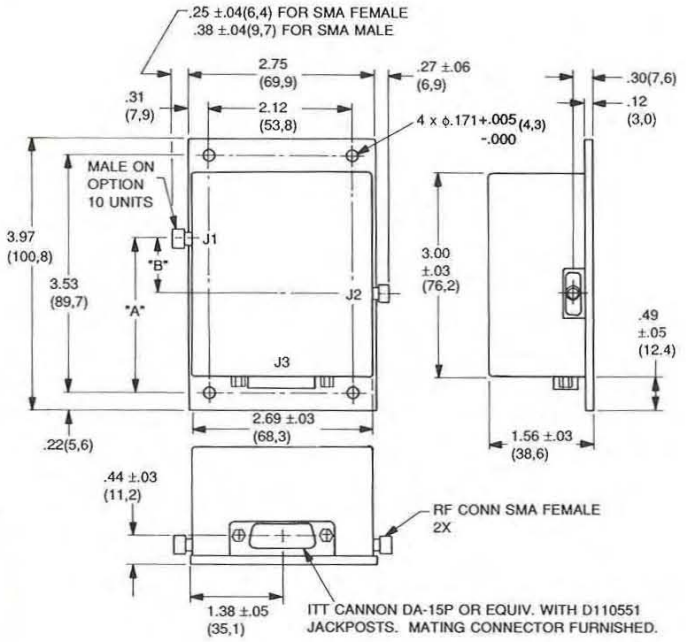
Option No.	Description
1	BCD programming (Binary is standard)
2	Complementary programming (Logic "0" is Bit On)
7	Two SMA male rf connectors (available only on 3290A-80, 3291-80 and all 120 dB units)
10	One SMA male and SMA female rf connector

DIMENSIONS AND WEIGHTS

PIN FUNCTIONS—60/80 dB SERIES		
PIN NO.	BINARY(1)	BCD(1)
1	0.1 dB	0.2 dB
2	0.2 dB	0.8 dB
3	+5V	+5V
4	GND	GND
5	0.4 dB	1 dB
6	0.8 dB	2 dB
7	1.6 dB	4 dB
8	3.2 dB	8 dB
9	6.4 dB	10 dB
10	12.8 dB	20 dB
11	25.6 dB	40 dB
12	51.2 dB	80 dB(1)
13	+15V	+15V
14	−15V	−15V
15	0.05 dB	0.4 dB

(1) *Model 3298-60 attenuation range is limited to 60 dB. Ground pin 12 in BCD version.*

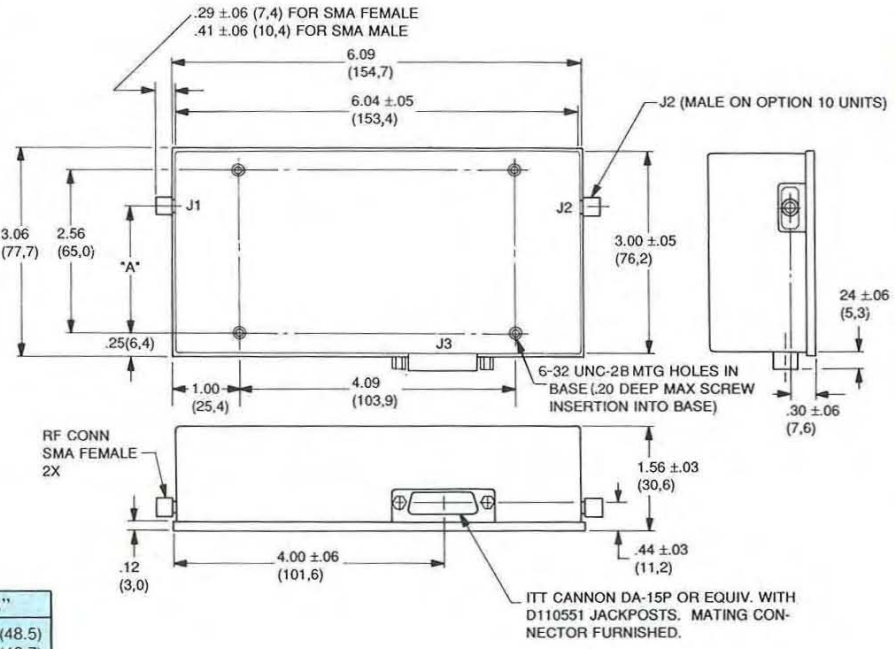
MODEL	APPROX. WT.	DIM "A"	DIM "B"
3290A-80	9 oz. (255 gm)	2.43 ±.03 (61,7)	.97 (24,6)
3291-80	9 oz. (255 gm)	2.43 ±.03 (61,7)	.97 (24,6)
3292-80	7 oz. (198 gm)	2.33 ±.03 (59,2)	.80 (20,3)
3293-80	7 oz. (198 gm)	2.33 ±.03 (59,2)	.80 (20,3)
3294-80	6 oz. (170 gm)	2.33 ±.03 (59,2)	.80 (20,3)
3295-80	6 oz. (170 gm)	2.33 ±.03 (59,2)	.80 (20,3)
3296-80	6 oz. (170 gm)	2.33 ±.03 (59,2)	.80 (20,3)
3298-60	6 oz. (170 gm)	2.33 ±.03 (59,2)	.80 (20,3)



PIN FUNCTIONS—120 dB SERIES		
PIN NO.	BINARY	BCD(2)
1	0.2 dB	N/C
2	0.4 dB	100 dB
3	+5V	+5V
4	GND	GND
5	0.8 dB	1 dB
6	1.6 dB	2 dB
7	3.2 dB	4 dB
8	6.4 dB	8 dB
9	12.8 dB	10 dB
10	25.6 dB	20 dB
11	51.2 dB	40 dB
12	102.4 dB	80 dB
13	+15V	+15V
14	−15V	−15V
15	0.1 dB	N/C

(2) *Maximum attenuation in units with BCD option is 119 dB.*

MODEL	APPROX. WT.	DIM "A"
3291-120	12 oz. (340 gm)	1.91 ± .06 (48.5)
3292-120	9 oz. (255 gm)	1.84 ± .06 (46.7)
3293-120	9 oz. (255 gm)	1.84 ± .06 (46.7)
3294-120	8 oz. (227 gm)	1.84 ± .06 (46.7)
3295-120	8 oz. (227 gm)	1.84 ± .06 (46.7)
3296-120	8 oz. (227 gm)	1.84 ± .06 (46.7)
3298-120	8 oz. (227 gm)	1.84 ± .06 (46.7)



Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx ±.005

Series 345 Miniature Octave-Band 8 Bit Digital PIN Diode Attenuators

- **Absorptive**
- **8 Bit binary or BCD programming**
- **Guaranteed monotonicity**
- **Frequency range: 0.5 to 18 GHz**

SERIES 345

The Series 345 programmable attenuators provide octave-band performance and wide programming flexibility in compact rugged packages well-suited to military applications. Attenuation ranges up to 60 dB are available (80 dB in the Model 3450) with attenuation increments as low as 0.25 dB.

Each Series 345 unit is an integrated assembly of one Series 195 attenuator and a driver circuit consisting of an 8-bit D/A Converter and a hybridized V/I Converter. This arrangement preserves the speed and reliability of the PIN diode attenuator and guarantees monotonicity and a high degree of accuracy. The rf characteristics of the Series 345 (e.g. - insertion loss, VSWR and flatness) are similar to the corresponding characteristics of the Series 195 attenuator employed. See Fig. 1.

Although the Series 345 units are intended for use as digitally-programmable attenuators, they can also be used as current-controlled attenuator/modulators. Refer to the Notes following the Pin Functions table.

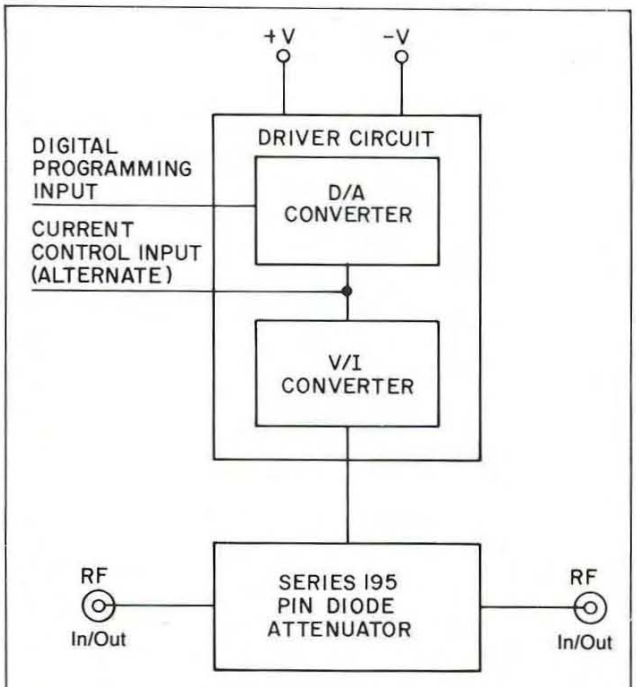


Fig. 1-Series 345, block diagram

MODEL	FREQUENCY RANGE (GHz)	MAX. INSERTION LOSS (dB)	MAX. VSWR	FLATNESS (± dB) AT MEAN ATTENUATION LEVELS UP TO				
				10 dB	20 dB	40 dB	60 dB	80 dB
3450	0.5 – 1.0	1.4	2.0	0.3	0.8	1.7	2.2	3.2
3451	1.0 – 2.0	1.6	1.5	0.3	0.8	1.5	1.6	
	0.75–2.25	1.7	2.0	0.5	1.4	3.0	3.5	
3452	2.0 – 4.0	1.8	1.5	0.3	0.8	1.5	1.6	
	1.5 – 4.5	1.9	2.0	0.5	1.4	3.0	3.5	
3453	2.6 – 5.2	2.0	1.6	0.3	0.8	1.5	1.6	
	1.95–5.85	2.1	2.1	0.5	1.4	3.0	3.5	
3454	4.0 – 8.0	2.4	1.7	0.3	0.8	1.5	1.6	
	3.0 – 9.0	2.5	2.2	0.5	1.4	3.0	3.5	
3455	5.0 – 10.0	2.6	1.7	0.5	0.9	1.5	1.6	
	3.75–11.25	2.7	2.2	0.7	1.4	3.0	3.5	
3456	6.0 – 12.0	2.7	1.8	0.7	1.0	1.5	1.6	
	4.5 – 13.5	2.8	2.2	0.9	1.5	3.0	3.5	
3458	8.0 – 18.0	3.0(1)	1.8(1)	0.7	1.0	1.5	1.6	
	6.0 – 18.0	3.0(1)	1.8(1)	0.9	1.5	3.0	3.5	

Note: Specifications for the extended frequency ranges are typical.

PERFORMANCE CHARACTERISTICS

Mean Attenuation Range

3450 . . . . . 80 dB(2)

All other units . . . . . 60 dB

Accuracy of Attenuation

0-30 dB . . . . . ± 0.5 dB
>30-50 dB . . . . . ± 1.0 dB
>50-60 dB . . . . . ± 1.5 dB
>60-80 dB . . . . . ± 2.0 dB (3450 only)

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See page 12

Temperature Coefficient . ± 0.03 dB/°C

Power Handling Capability

Without Performance Degradation
3450, 3451 . . . . . 10 mW cw or peak
All other units . . . . . 100 mW cw or peak

Survival Power (from −65°C to +25°C; see figure 2 for higher temperatures)
All units . . . . . 1 W average
25 W peak (1 μsec max pulse width)

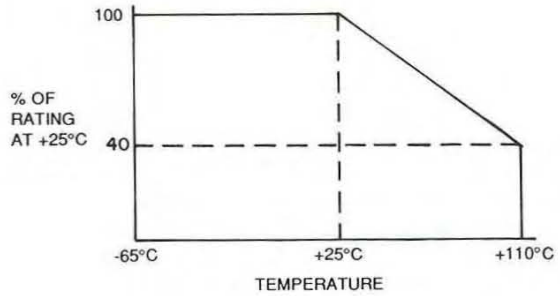


Fig. 2-Series 345H, Power derating factor

(1) *Except from 16 - 18 GHz where insertion loss is 4.0 dB max and VSWR is 2.0 max.*
(2) *Programmable range for 3450 Option 1 BCD units is 79 dB.*

Series 345 Specifications

PERFORMANCE CHARACTERISTICS (cont)

Switching Time
- 3450 . . . . . 10 μsec max
- All other units . . . . . 2 μsec max

Programming . . . . . Positive true binary (standard) or BCD (Option 1). For complementary code, specify Option 2. To interface with other logic families, please contact factory.

Minimum Attenuation Step
- Binary Units
  - 3450 . . . . . 0.5 dB
  - 3450 Option 5 . . . . . 0.25 dB
  - All other binary units . . . 0.25 dB
- BCD Units . . . . . 1.0 dB

Logic Input
- Logic "0" (Bit Off) . . . . −0.3 to +0.8V
- Logic "1" (Bit On) . . . . +2.0 to +5.0V
- Logic Input Current . . . 10 μA max

Nominal Control Current Characteristics

Range
- Binary Units
  - Standard 3450 . . . . . 0 to 1.28 mA
  - All other binary units . . . 0 to 2 mA
- BCD Units
  - Standard 3450 . . . . . 0 to 1.63 mA
  - All other BCD units . . . . 0 to 1.2 mA

Transfer Function
- Binary Units
  - Standard 3450 . . . . . 62.5 dB/mA
  - All other binary units . . . 30 dB/mA
- BCD Units
  - Standard 3450 . . . . . 48.5 dB/mA
  - All other BCD units . . . . 50 dB/mA

Input Impedance
- Binary Units
  - Standard 3450 . . . . . 6.25 Kohms
  - All other binary units . . . 3 Kohms
- BCD Units
  - Standard 3450 . . . . . 4.85 Kohms
  - All other BCD units . . . . 5 Kohms

Power Supply Requirements . . . . . + 12V ± 5%, 120 mA
− 12V ± 5%, 35 mA

Power Supply Rejection . . . . . Less than 0.1 dB/volt change in either supply

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −65°C to +110°C*

Non-Operating Temperature Range . . . . . −65°C. to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

ACCESSORY FURNISHED

Mating power/logic connector

AVAILABLE OPTIONS

Option No.	Description
1	BCD programming (Binary is standard)*
2	Complementary programming (logic "0" is Bit On)
5	3450 with mean attenuation range of 60 dB and minimum attenuation step of 0.25 dB
7	Two SMA male rf connectors (not available on 3458)
10	One SMA male (J1) and one SMA female (J2) rf connector (not available on 3458)
62	±15V operation

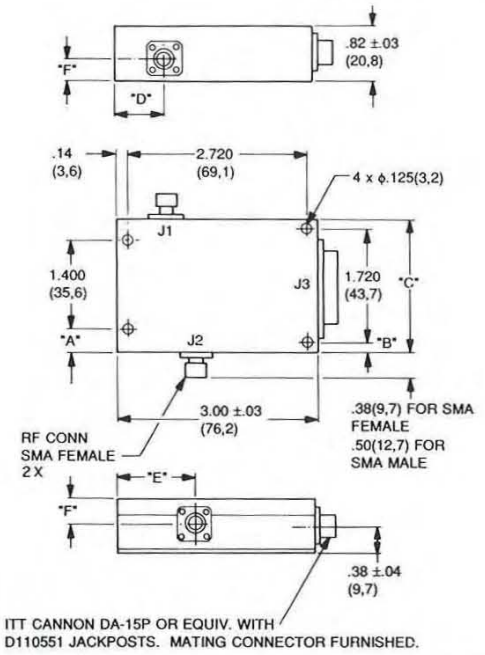
**Operating Temperature range of BCD units is limited to 0°C to +70°C.*

J3 PIN FUNCTIONS		
PIN NO	BINARY (Note 5)	BCD
1	GND (Note 2)	GND (Note 2)
2	ANALOG INPUT (Note 3)	ANALOG INPUT (Note 3)
3	NOT USED	NOT USED
4	GND	GND
5	0.25 dB (LSB)	1 dB (LSB)
6	0.5 dB	2 dB
7	1 dB	4 dB
8	2 dB	8 dB
9	4 dB	10 dB
10	8 dB	20 dB
11	16 dB	40 dB (MSB)
12	32 dB (MSB)	(Note 4)
13	+V	+V
14	−V	−V
15	NOT USED	NOT USED

Notes:

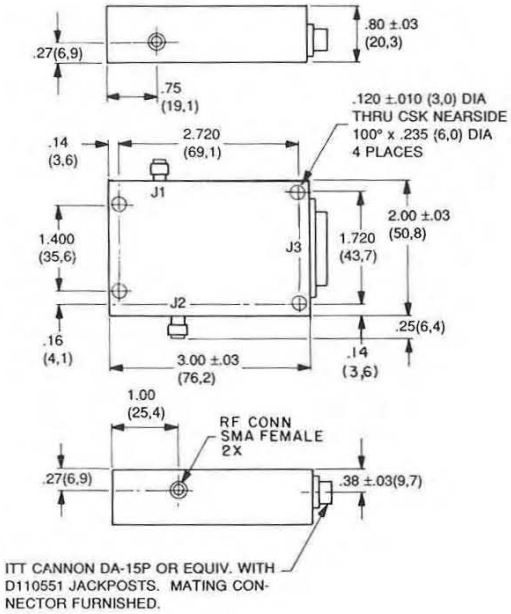
1. All unused logic inputs must be grounded.
2. For normal programming control, Pin 1 must be grounded or at logic "0." Application of logic "1" to Pin 1 overrides the digital input and sets the unit to insertion loss. For units with complementary programming (Option 2), the application of a logic "1" to Pin 1 sets the unit to high isolation (60 dB or greater).
3. Pin 2 is available to (a) monitor the D/A converter output, (b) apply a modulation signal from a current source, or (c) apply an independent analog signal for turn-on, turn-off or vernier attenuation levels.
4. For standard Option 1 BCD units, Pin 12 must be open or at logic "1." For units with complementary BCD programming (Options 1 and 2), Pin 12 must be grounded or at logic "0."
5. For standard Model 3450, LSB is 0.5 dB and MSB is 64 dB.

DIMENSIONS AND WEIGHTS



MODEL	DIM "A"	DIM "B"	DIM "C"	DIM "D"	DIM "E"	DIM "F"
3450	.58 (14,7)	.42 (10,7)	2.56 ± .03 (65,0)	.56 (14,2)	1.53 (38,9)	.31 (7,9)
3451	.58 (14,7)	.42 (10,7)	2.56 ± .03 (65,0)	.56 (14,2)	1.53 (38,9)	.29 (7,4)
3452,53	.30 (7,6)	.14 (3,6)	2.00 ± .03 (50,8)	.50 (12,7)	1.29 (32,8)	.34 (8,6)
3454,55,56	.30 (7,6)	.14 (3,6)	2.00 ± .03 (50,8)	.75 (19,1)	1.19 (30,2)	.34 (8,6)

MODELS 3450 THRU 3456
Wt: 4 oz. (113 gm) approx.



MODEL 3458
Wt: 4 oz. (113 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series 345H Miniature Octave-Band High-Speed 8 Bit Digital PIN Diode Attenuators

- **High speed**
- **Absorptive**
- **8 Bit binary or BCD programming**
- **Monotonicity guaranteed**
- **Frequency range: 1 to 18 GHz**

SERIES 345H

The Series 345H programmable attenuators provide octave-band performance and wide programming flexibility in compact rugged packages well-suited to military applications. Attenuation ranges up to 60 dB are available with attenuation increments as low as 0.25 dB.

Each Series 345H unit is an integrated assembly of one GMC Series 195 attenuator and a driver circuit consisting of an 8-bit D/A Converter and a hybridized V/I Converter. This arrangement preserves the speed and reliability of the PIN diode attenuator and guarantees monotonicity and a high degree of accuracy.

The Series 345H units are similar to the GMC Series 345 attenuators. The high-speed performance of the Series 345H units is achieved with some sacrifice of insertion loss. The other rf characteristics of the Series 345H (e.g.-VSWR and flatness) are similar to the corresponding characteristics of the Series 195 attenuator employed. See fig. 1.

Although the Series 345H units are intended for use as digitally-programmable attenuators, they can also be used as current-controlled attenuator/modulators. Refer to the Notes following the Pin Functions table.

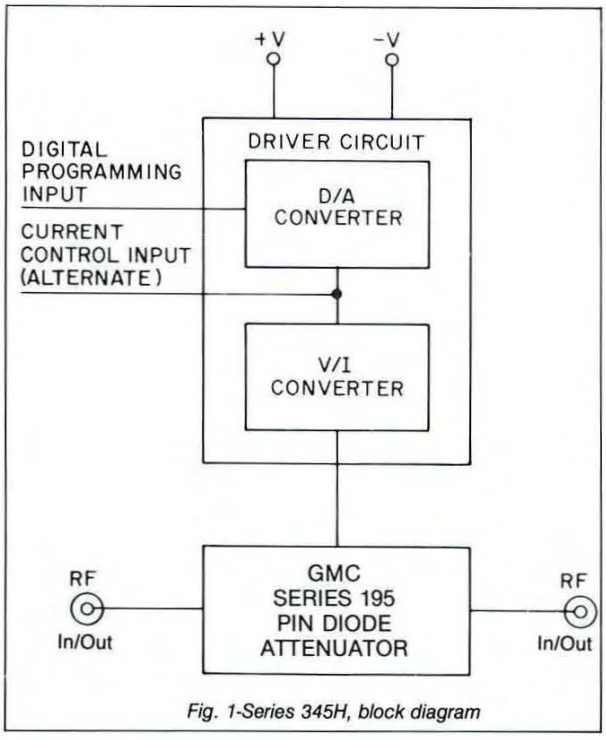


Fig. 1-Series 345H, block diagram

PERFORMANCE CHARACTERISTICS

MODEL	FREQUENCY RANGE (GHz)	MAX. INSERTION LOSS (dB)	MAX. VSWR	FLATNESS (±dB) AT MEAN ATTENUATION LEVELS UP TO			
				10 dB	20 dB	40 dB	60 dB
3451H	1.0 – 2.0	2.6	1.5	0.3	0.8	1.5	1.6
	0.75–2.25	2.7	2.0	0.5	1.4	3.0	3.5
3452H	2.0 – 4.0	2.8	1.5	0.3	0.8	1.5	1.6
	1.5 – 4.5	2.9	2.0	0.5	1.4	3.0	3.5
3453H	2.6 – 5.2	3.0	1.6	0.3	0.8	1.5	1.6
	1.95–5.85	3.1	2.1	0.5	1.4	3.0	3.5
3454H	4.0 – 8.0	3.4	1.7	0.3	0.8	1.5	1.6
	3.0 – 9.0	3.5	2.2	0.5	1.4	3.0	3.5
3455H	5.0 – 10.0	3.6	1.7	0.5	0.9	1.5	1.6
	3.75–11.25	3.7	2.2	0.7	1.4	3.0	3.5
3456H	6.0 – 12.0	3.7	1.8	0.7	1.0	1.5	1.6
	4.5 – 13.5	3.8	2.2	0.9	1.5	3.0	3.5
3458H	8.0 – 18.0	4.0[1]	1.8[1]	0.7	1.0	1.5	1.6
	6.0 – 18.0	4.0[1]	1.8[1]	0.9	1.5	3.0	3.5

Note: Specifications for the extended frequency ranges are typical.

Mean Attenuation Range 60dB

Accuracy of Attenuation

0-10 dB . . . . . ±0.75 dB
>10-30 dB . . . . . ±0.5 dB
>30-50 dB . . . . . ±1.0 dB
>50-60 dB . . . . . ±1.5 dB

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See page 12

Temperature Coefficient . ±0.03 dB/°C

Power Handling Capability

Without Performance Degradation
3451H . . . . . 10 mW cw or peak
All other units . . . . . 100 mW cw or peak

Survival Power (from −65°C to +25°C; see figure 2 for higher temperatures)

All units . . . . . 1 W average
25 W peak (1 μsec max pulse width)

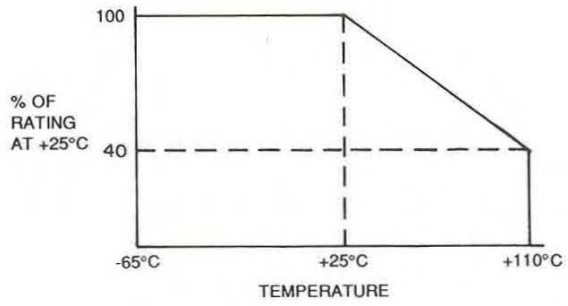


Fig. 2-Series 345, Power derating factor

[1] Except from 16 - 18 GHz where insertion loss is 5.0 dB max and VSWR is 2.0 max.

Series 345H Specifications

PERFORMANCE CHARACTERISTICS (cont)

Switching Time . . . . . 500 nsec max.

Programming . . . . . Positive true binary (standard) or BCD (Option 1). For complementary code, specify Option 2. To interface with other logic families, please contact factory.

Minimum Attenuation Step

Binary Units . . . . . 0.25 dB

BCD Units . . . . . 1.0 dB

Logic Input

Logic "0" (Bit Off) . . −0.3 to +0.8V
Logic "1" (Bit On) . . +2.0 to +5.0V
Logic Input Current . 10 μA max

Nominal Control Current Characteristics

Range

Binary Units . . . . . 0 to 4 mA
BCD Units . . . . . 0 to 1.2 mA

Transfer Function

Binary Units . . . . . 15 dB/mA
BCD Units . . . . . 50 dB/mA

Input Impedance

Binary Units . . . . . 1.5 Kohms
BCD Units . . . . . 5 Kohms

Power Supply Requirements . . . . . +12V ±5%, 120 mA
−12V ±5%, 45 mA

Power Supply Rejection . . . . . Less than 0.1 dB/volt change in either supply

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −65°C to +110°C*

Non-Operating Temperature Range . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

ACCESSORY FURNISHED

Mating power/logic connector

AVAILABLE OPTIONS

Option No.	Description
1	BCD programming (Binary is standard)*
2	Complementary programming (logic "0" is Bit On)
7	Two SMA male rf connectors (not available on 3458H)
10	One SMA male (J1) and one SMA female (J2) rf connector (not available on 3458H)
62	±15V operation

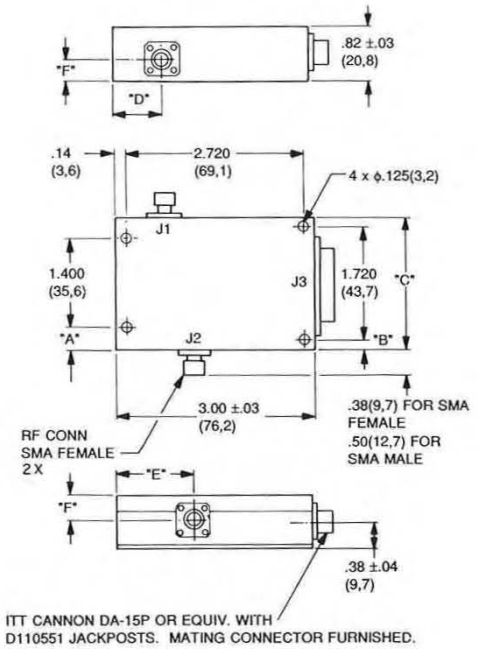
**Operating Temperature range of BCD units is limited to 0°C to +70°C.*

J3 PIN FUNCTIONS		
PIN NO	BINARY	BCD
1	GND (Note 2)	GND (Note 2)
2	ANALOG INPUT (Note 3)	ANALOG INPUT (Note 3)
3	NOT USED	NOT USED
4	GND	GND
5	0.25 dB (LSB)	1 dB (LSB)
6	0.5 dB	2 dB
7	1 dB	4 dB
8	2 dB	8 dB
9	4 dB	10 dB
10	8 dB	20 dB
11	16 dB	40 dB (MSB)
12	32 dB (MSB)	(Note 4)
13	+V	+V
14	−V	−V
15	NOT USED	NOT USED

Notes:

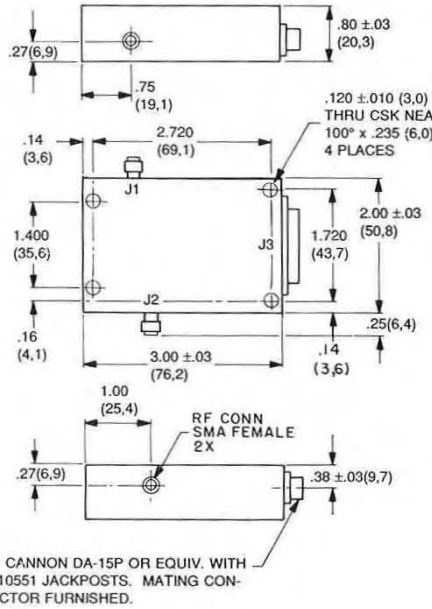
1. All unused logic inputs must be grounded.
2. For normal programming control, Pin 1 must be grounded or at logic "0". Application of logic "1" to Pin 1 overrides the digital input and sets the unit to insertion loss. For units with complementary programming (Option 2), the application of a logic "1" to Pin 1 sets the unit to high isolation (60 dB or greater).
3. Pin 2 is available to (a) monitor the D/A converter output, (b) apply a modulation signal from a current source, or (c) apply an independent analog signal for turn-on, turn-off or vernier attenuation levels.
4. For standard Option 1 BCD units, Pin 12 must be open or at logic "1". For units with complementary BCD programming (Options 1 and 2), Pin must be grounded or at logic "0".

DIMENSIONS AND WEIGHTS



MODELS 3451H THRU 3456H
Wt: 4 oz. (113 gm) approx.

MODEL	DIM "A"	DIM "B"	DIM "C"	DIM "D"	DIM "E"	DIM "F"
3451H	.58 (14,7)	.42 (10,7)	2.56 ±.03 (65,0)	.56 (14,2)	1.53 (38,9)	.29 (7,4)
3452H, 53H	.30 (7,6)	.14 (3,6)	2.00 ±.03 (50,8)	.50 (12,7)	1.29 (32,8)	.34 (8,6)
3454H,55H,56H	.30 (7,6)	.14 (3,6)	2.00 ±.03 (50,8)	.75 (19,1)	1.19 (30,2)	.34 (8,6)



MODEL 3458H
Wt: 4 oz. (113 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

346 Series Multi-Octave 8 Bit Digital PIN Diode Attenuators
(0.5-18 GHz)

- **Frequency range: 0.5 GHz-18 GHz in four overlapping ranges**
- **Attenuation range: 60 dB**
- **Programming: 8-Bit binary or BCD**
- **LSB: 0.25 dB**
- **Monotonicity: guaranteed**

The 346 Series is a family of nonreflective PIN diode attenuators, each programmable to 60 dB in attenuation steps as low as 0.25 dB, and covering the frequency range from 0.5 GHz to 18 GHz in four overlapping multi-octave bands.

Each model in the Series comprises an integrated assembly of a dual (current-controlled) PIN diode attenuator, and a driver circuit consisting of a D/A converter and a voltage-to-current converter (see Figure 1 below).

The RF circuit consists of two wide-band, T-pad attenuator sections in tandem. The levels of series and shunt currents required to maintain a bilateral match at all attenuation levels are provided by the driver.

This arrangement assures monotonicity over the operating band at all levels of attenuation and for any programmed attenuation step.

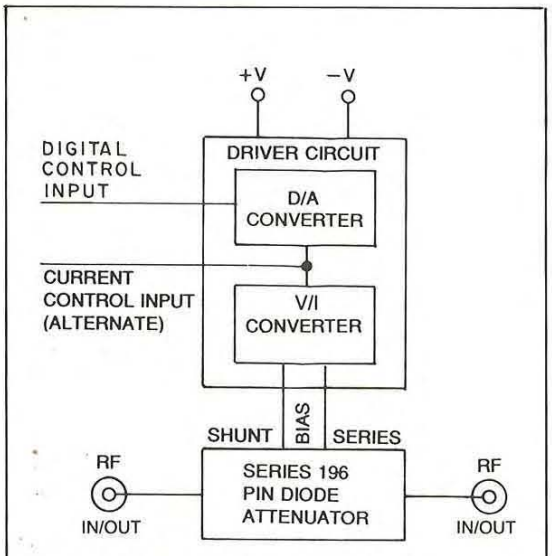


Fig. 1–Series 346, block diagram

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	MODEL 3460B	MODEL 3461B	MODEL 3462B	MODEL 3468B
Frequency Range (GHz)	0.5-4	0.5-8	2-8	2-18
Mean Attenuation Range (dB)	60	60	60	60
Insertion Loss (dB) (max)	2.5	2.5 (0.5-4 GHz) 3.0 (4-8 GHz)	3.0	4.5
VSWR (max)	1.8	1.8	1.8	2.0
Flatness up to 20 dB **40 dB** **60 dB**	±0.5 dB ±0.75 dB ±1.0 dB	±0.75 dB ±1.0 dB ±1.5 dB	±0.75 dB ±1.0 dB ±1.5 dB	±1.0 dB ±1.25 dB ±3.0 dB

Accuracy of Attenuation
0-20 dB . . . . . ±1.0 dB
20-40 dB . . . . . ±1.5 dB
40-60 dB . . . . . ±2.0 dB

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See page 12

Temperature Coefficient . ±0.02 dB/°C

Power Handling Capability
Without Performance Degradation
All Units . . . . . Up to 100 mW cw or peak (see figure 2).
Survival Power
All Units . . . . . 2 W average or peak, from −65°C to +25°C (see figure 3 for higher temperatures).

Switching Time
ON Time . . . . . 1.0 μsec. max.
OFF Time . . . . . 0.5 μsec. max.

Programming . . . . . Positive true binary (standard) or BCD (Option 1). For complementary code, specify Option 2. To interface with other logic families, please contact factory.

Minimum Attenuation Step
Binary Units . . . . . 0.25 dB
BCD Units . . . . . 1.0 dB

Logic Input
Logic "0" (Bit off) . . . −0.3 to +0.8V
Logic "1" (Bit on) . . . +2.0 to +5.0V
Input Current . . . . . 10 μA max.

Nominal Control Voltage Characteristics

Range
Binary Units . . . . . 0 to 2 mA
BCD Units . . . . . 0 to 1.2 mA

Transfer Function
Binary Units . . . . . 30 dB/mA
BCD Units . . . . . 50 dB/mA

Input Impedance
Binary Units . . . . . 3 kohms
BCD Units . . . . . 3 kohms

Power Supply Requirements . . . . . +12V ±5%, 80 mA
−12V ±5%, 60 mA

Power Supply Rejection . . . . . Less than 0.1 dB/volt change in either supply

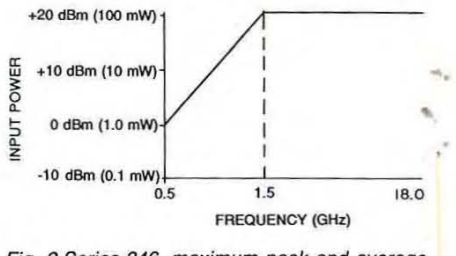


Fig. 2-Series 346, maximum peak and average operating power without performance degradation

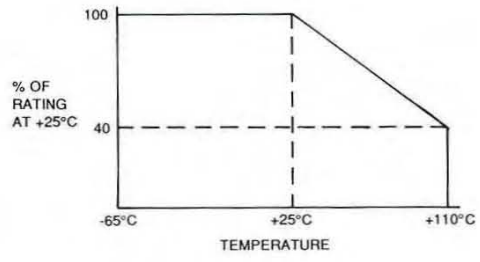


Fig. 3-Series 346, survival power derating factor

Series 346 Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range	−54°C to +110°C*
Non-Operating Temperature Range	−65°C to +125°C
Humidity	MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration	MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)
Altitude	MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling	MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
1	BCD programming (Binary is standard)*
2	Complementary programming (logic "0" is bit on)
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector
62	± 15V operation

**Operating temperature range of BCD units is limited to 0°C to +70°C.*

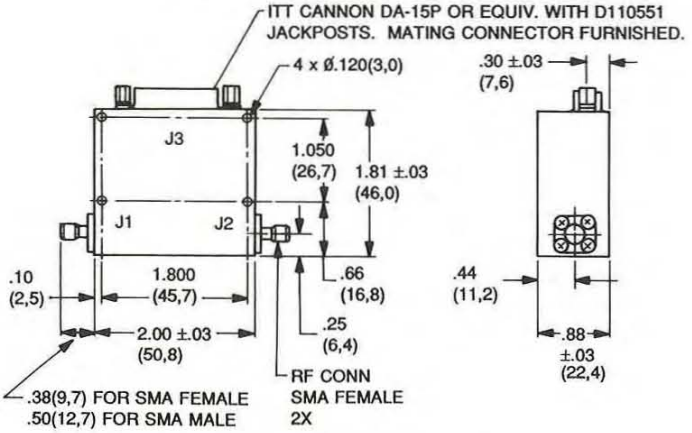
J3 PIN FUNCTIONS		
PIN NO.	**BINARY**	**BCD**
1	GND (Note 2)	GND (Note 2)
2	ANALOG INPUT (Note 3)	ANALOG INPUT (Note 3)
3	NOT USED	NOT USED
4	GND	GND
5	0.25 dB (LSB)	1 dB (LSB)
6	0.5 dB	2 dB
7	1 dB	4 dB
8	2 dB	8 dB
9	4 dB	10 dB
10	8 dB	20 dB
11	16 dB	40 dB (MSB)
12	32 dB (MSB)	(Note 4)
13	+V	+V
14	−V	−V
15	NOT USED	NOT USED

(1) *All unused logic inputs must be grounded.*
(2) *For normal programming control Pin 1 must be grounded or at logic "0". Application of logic "1" to Pin 1 overrides the digital input and sets the unit to insertion loss. For units with complementary programming (Option 2), the application of a logic "1" to Pin 1 sets the unit to high isolation (60 dB or greater).*
(3) *Pin 2 is available to (a) monitor the D/A converter output, (b) apply a modulation signal from a current source, or (c) apply an independent analog signal for turn-on, turn-off or vernier attenuation levels.*
(4) *For standard Option 1 BCD units, Pin 12 must be open or at logic "1". For units with complementary BCD programming (Options 1 and 2), Pin 12 must be grounded or at logic "0".*

ACCESSORY FURNISHED

Mating power/logic connector

DIMENSIONS AND WEIGHT



SERIES 346
Wt: 3 oz. (85 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series 347, 8 Bit Digital Phase Invariant Attenuators

The Series 347 digitally controlled PIN diode attenuators offer essentially phase free operation over a wide dynamic range in multi-octave frequency bands between 2 and 18 GHz. The attenuators utilize a unique double balanced arrangement of diodes and quadrature couplers to achieve the phase independent attenuation characteristic. Excellent temperature stability is maintained by employing a self-compensating biasing scheme. See Fig. 1.

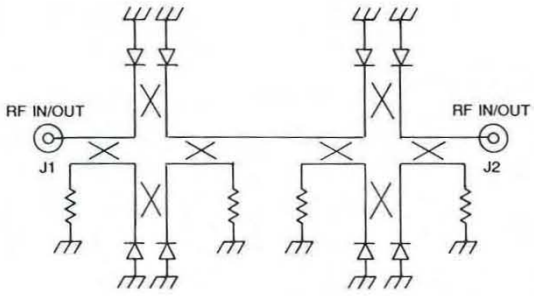
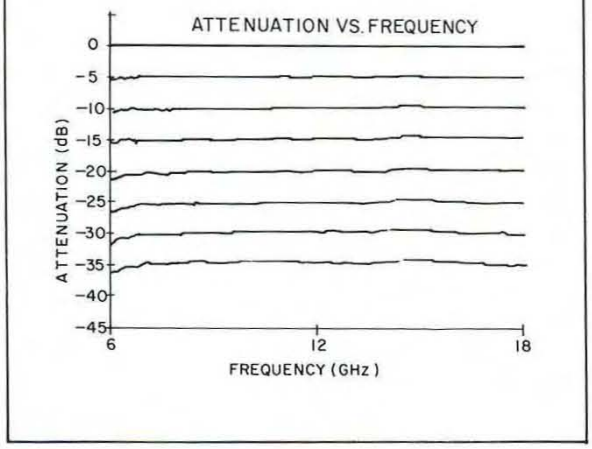
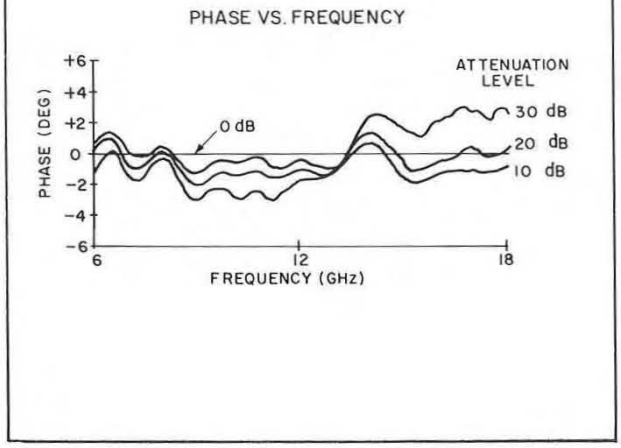


Fig. 1—RF schematic diagram

TYPICAL PERFORMANCE





Series 347 Specifications

PERFORMANCE CHARACTERISTICS

MODEL	3472	3474	3478
Frequency Range (GHz)	2-6	4-11	6-18
Mean Attenuation Range	32 dB		
Insertion Loss (Max)	4 dB	5 dB	5.5 dB
VSWR (Max)	2.0		
Accuracy of Attenuation	± 0.5 dB		
Amplitude Flatness 0 to 20 dB > 20 to 32 dB	± 0.4 dB ± 0.6 dB	± 0.4 dB ± 0.8 dB	± 0.8 dB(1) ± 1.3 dB(1)
Monotonicity	Guaranteed		
Phase Shift 0 to 20 dB > 20 to 32 dB	± 4° ± 8°	± 4° ± 8°	± 5° ± 10°
On Time, Off Time	350 nsec		
Temperature Coefficient	.02 dB/°C		
Max. RF Power Input (Operating)	100 mW		
Max. RF Power Input (Survival)	0.5 W		
Harmonic Distortion @ Pin = +10 dBm	−40 dBc	−50 dBc	−50 dBc
Control	8 bit TTL, 0.125 dB LSB		
Control Input Impedance	@ Logic "0" (−0.3 to +0.8 V), 500 μA max. @ Logic "1" (+2.0 to +5.0 V), 100 μA max.		
Logic Input	Logic "0" = Bit OFF; Logic "1" = Bit ON		
Power Supply Requirements	+5V ± 5% @ 325 mA +15V ± 5% @ 15 mA −15V ± 5% @ 70 mA		

SPECIFICATIONS WITH EXTENDED RANGE OPTION (OPTION 45)

Mean Attenuation Range	45 dB		
Accuracy of Attenuation	± 1.0 dB		
Amplitude Flatness 0 to 20 dB > 20 to 32 dB > 32 dB	± 0.4 dB ± 0.6 dB ± 1.5 dB	± 0.4 dB ± 0.8 dB ± 1.5 dB	± 0.8 dB(1) ± 1.3 dB(1) ± 2.0 dB
Phase Variation 0 to 20 dB > 20 to 32 dB > 32 dB	± 4° ± 8° ± 15°	± 4° ± 8° ± 20°	± 5° ± 10° ± 30°
Control	8 bit TTL, 0.176 dB LSB		

(1) *Except from 8-18 GHz, flatness is ± 0.5 dB up to 20 dB, ± 1.0 dB up to 32 dB.*

Series 347 Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . – 54°C to + 110°C

Non-Operating Temperature Range . . . . . – 65°C to + 125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

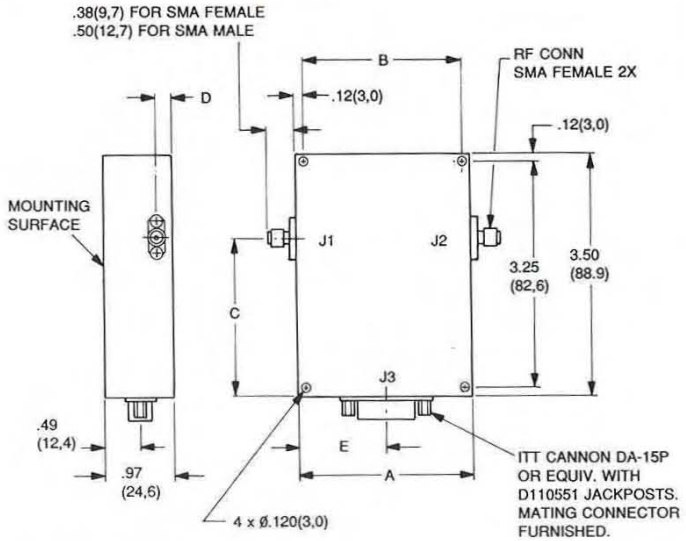
Option No.	Description
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector
45	Extended attenuation range to 45 dB
65	± 12V operation

ACCESSORY FURNISHED

Mating power/logic connector

DIMENSIONS AND WEIGHT

J3 PIN FUNCTIONS	
PIN NO.	BINARY
1	- – 15V
2	+ 15V
3	Internal Conn.
4	0.125 dB (LSB)
5	0.5 dB
6	4 dB
7	16 dB (MSB)
8	8 dB
9	GROUND
10	NOT USED
11	2 dB
12	0.25 dB
13	1 dB
14	NOT USED
15	+ 5V



SERIES 347
Wt. 5 oz. (142 gm) approx.

MODEL	A	B	C	D	E
3472	2.5 (63,5)	2.26 (57,4)	2.28 (57,9)	0.22 (5,6)	1.25 (31,7)
3474	2.0 (50,8)	1.76 (44,7)	2.43 (61.7)	0.18 (4,6)	1.0 (25,4)
3478	2.0 (50,8)	1.76 (44,7)	2.58 (65,5)	0.18 (4,6)	1.0 (25,4)

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Models 3488 and 3488H
8 Bit Digital/Analog Attenuators

- **6 to 18 GHz**
- **Digital/Analog**
- **8 Bit TTL**
- **Hermetically sealed**
- **Miniature**

MODELS 3488 AND 3488H

The Models 3488 and 3488H Digitally Programmable Attenuators provide greater than octave band performance in small hermetic packages ideally suited for high reliability applications. The 3488 offers moderate power handling capability (100 mW) at switching speeds less than 500 nsec while the 3488H offers 200 nsec switching speed at lower power. Attenuation of both series is 60 dB with monotonic 0.25 dB step resolution.

The attenuator is an integrated assembly of a sealed RF Microwave Integrated Circuit assembly and a sealed hybrid driver. Attenuation is controlled via a miniature 14 pin connector. See Fig. 1.

Although these units are primarily intended for use as digital attenuators, they can also be used as analog (voltage driven) attenuators or as combination analog/digital attenuators. (See note 4.)

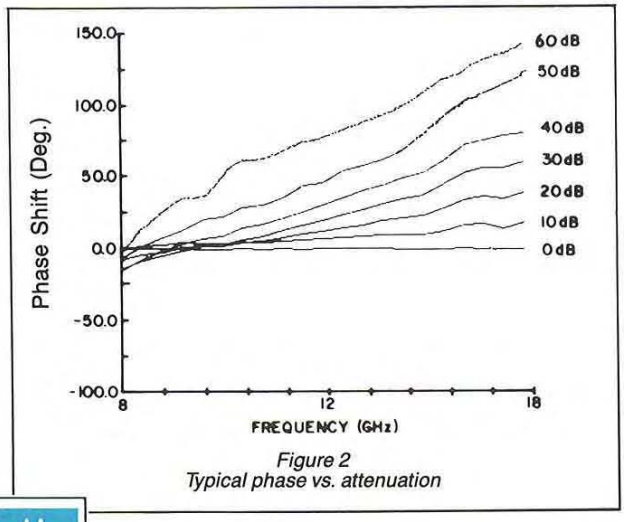


Figure 2
Typical phase vs. attenuation

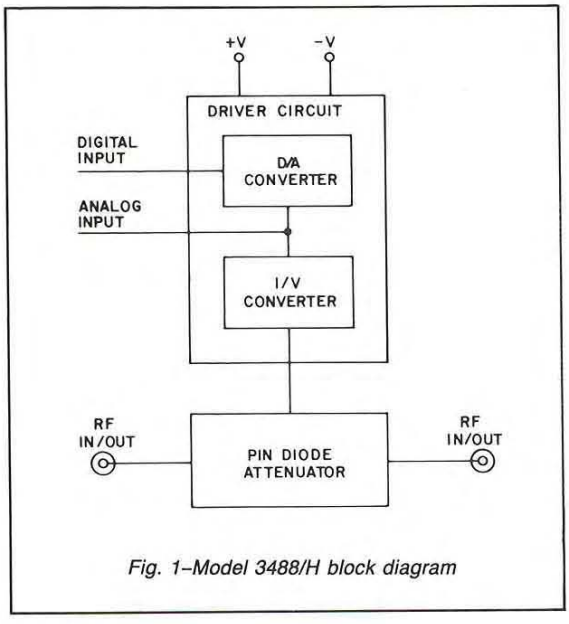


Fig. 1–Model 3488/H block diagram

Models 3488 and 3488H Specifications

PERFORMANCE CHARACTERISTICS

FREQUENCY RANGE (GHz)	MAX. INSERTION LOSS[1] (dB)	MAX VSWR[1]	FLATNESS (± dB) AT MEAN ATTENUATION LEVELS UP TO			
			10 dB	20 dB	40 dB	60 dB
8.0 - 18.0	3.0	1.8	0.7	1.0	1.5	1.6
6.0 - 18.0[2]	3.0	1.8	0.9	1.5	3.0	3.5

(1) *Except from 16-18 GHz where insertion loss is 4.0 dB max. and VSWR is 2.0 max.*
(2) *Specifications for the 6.0-18.0 GHz frequency range are typical.*

Mean Attenuation Range . . 60 dB

Accuracy of Attenuation . . . 0-30 dB ±0.5 dB
>30-50 dB ±1.0 dB
>50-60 dB ±1.5 dB

Monotonicity . . . . . Guaranteed

Phase Shift . . . . . See Fig. 2

Temperature Coefficient . . . ±0.02 dB/°C

Power Handling Capability Without Performance Degradation . . . . . 3488 100 mW cw or peak
3488H 10 mW cw or peak

Survival Power(from −65°C to +25°C, See Figure 3 for Higher Temperatures) . . . . . 1W average, 25W peak

Switching Time . . . . . (3488) 500 nsec max
(3488H) 200 nsec max

Programming: 8 Bit TTL . . . Positive true binary

Minimum Attenuation Step . 0.25 dB

Logic Input . . . . . Logic "0": −0.3 to +0.8V
Logic "1": +2.0 to +5.0V
Logic Input Current:
10 μA max

Analog Input Characteristics
Range . . . . . 0 to 6V
Transfer Function . . . . . 10 dB/V
Input Resistance . . . . . 6 Kohms

Power Supply Requirements . . . . . +12 to +15V, ±5%, 120 mA
−12 to −15V, ±5%, 50 mA

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −54°C to +110°C

Non-Operating Temperature Range . . . . . −65°C to +125°C

ACCESSORY FURNISHED

Mating power/logic connector

AVAILABLE OPTIONS

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male (J1), and one SMA female (J2) rf connector
49	High Rel screening (see Table 1, page 36)

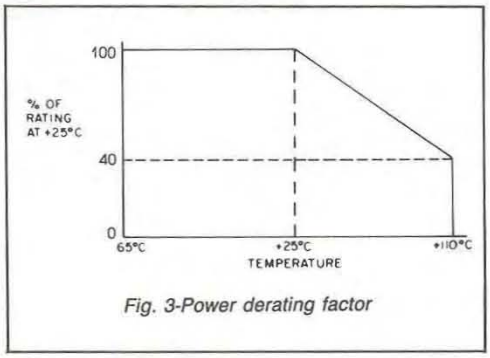
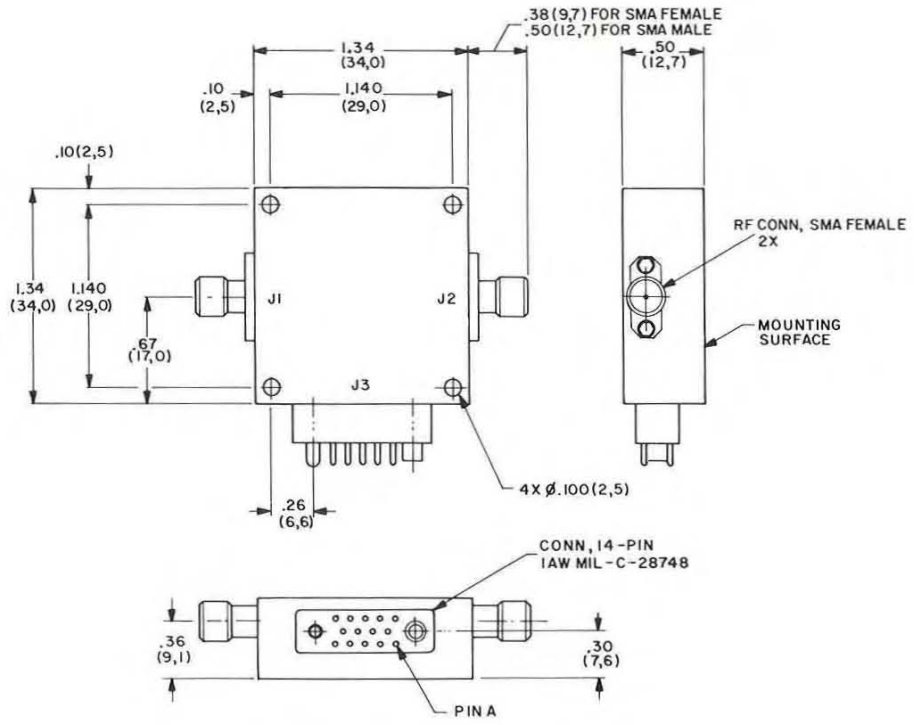


Fig. 3-Power derating factor

Models 3488 and 3488H Specifications

DIMENSIONS AND WEIGHT



MODEL 3488/H
Wt: 2.4 oz. (68 gm) approx.

J3 POWER/LOGIC CONNECTIONS	
PIN	**FUNCTIONS**
A	Digital/Power GND
B	Logic Control (NOte 2)
C	−12 to −15V
D	0.25 dB (LSB)
E	0.5 dB
F	1 dB
H	4 dB
J	2 dB
K	16 dB
L	32 dB (MSB)
M	+12 to +15V
N	8 dB
P	GND
R	Analog Input (Notes 3&4)

NOTES:

1. All unused logic inputs must be grounded.
2. For normal TTL programming control, PIN B must be grounded or at Logic 0. Application of Logic 1 to PIN B overrides the digital input and sets the unit to insertion loss. To interface with other logic families (e.g., CMOS, MTL , NMOS, etc...) contact factory.
3. For digital operation only, connect PIN R to PIN P.
4. To use the unit as a voltage controlled attenuator, apply a control voltage of 0 to +6V at PIN R. The slope of attenuation will be nominally 10 dB/V. For a non-zero source resistance (R_O) of up to 500 ohms, the attenuation error is approximately $-.0017 \cdot R_O \cdot V_{IN}$ dB and the slope will decrease by approximately 0.17 dB/V per 100 ohms of source resistance.

   Using the 348 Series attenuator as both a digital and analog control attenuator, the total attenuation ATT=10 $\cdot V_{IN}$ + programmed digital attenuation. The maximum attainable mean attenuation is 60 dB.

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Phase Shifters and I-Q Modulators

General Microwave offers a complete line of broadband phase shifters and I-Q modulators which span the frequency range from 0.5 to 18.0 GHz. These devices are available in several different topologies that allow the designer to choose among various performance characteristics that best suit his system needs. This catalog describes only our standard line of broadband phase shifter models. In addition to these, there are numerous special designs, employing a variety of phase shifter circuits, which GMC has utilized in custom applications.

PHASE SHIFTER FUNDAMENTALS

A variable phase shifter can be characterized as a linear two port device which alters the phase of its output signal in response to an external electrical command. (Mechanical phase shifters such as line stretchers or rotary waveguide phase shifters are not considered here.) Expressing this mathematically, with an input signal $\sin(\omega t)$, the output will be $A(n)\sin(\omega t + \Phi(n))$, where n is the programmed phase and A(n) is the insertion loss. The difference between the input phase and the output phase is the sum of the phase shift due to the propagation through the phase shifter plus the programmed phase shift.

The relative simplicity of the idea that any reactance placed in series or shunt with a transmission line will produce a phase shift has given rise to many different circuits over the years for use as phase shifters at microwave frequencies. Usually, for high speed applications, the controlling elements have been semiconductor devices such as PIN, Schottky and varactor diodes, whereas for high power requirements, when slower switching speed can be tolerated, ferrites are frequently employed. The final choice of a phase shifter network and control element will depend on the required bandwidth, insertion loss, switching speed, power handling, accuracy and resolution. In addition, a choice between analog and digital control must also be made.

A brief description of several of the more widely used phase shifter circuits follows.

SWITCHED BIT PHASE SHIFTERS

As the name implies, switched bit phase shifters are digitally controlled components. They are generally used where there are requirements for very high switching speed and moderate to high power handling capability. These attributes derive from the use of PIN diodes as switching elements which, for each bit, are used to select between one of two fixed networks which differ in phase shift by a predetermined amount. Typically an *n*-bit phase shifter will consist of *n* such elements in a tandem array, with the specific topology of each bit selected for optimum performance for its phase magnitude.

All switched bit phase shifters suffer from a common problem, i.e. varying VSWR interaction between the bits as the phase shift states are changed. These mismatch effects limit the phase resolution and accuracy of the phase shifter since they give rise to non-monotonic performance as the bit size begins to approach the interaction phase error. This problem becomes significantly more difficult for wide band and high frequency designs and usually limits practical phase shifters to a maximum of four bits.

General Microwave has produced a number of custom narrow and broadband switched bit phase shifters. Recently it has introduced as catalog items the Model H752 series, a broadband, high speed switched bit phase shifter which utilizes a proprietary "All-Pass" circuit as phase shift elements. A complete description of this design is available in a separate technical paper.[1] This topology achieves relatively constant phase shift performance over octave and greater bandwidths in a very compact format, especially as compared to the distributed transmission line approaches. As a result, the H752 series offers low insertion loss and high speed performance in a low profile, hermetic housing which makes it especially suitable for rugged military applications.

(1) *"Broadband Switched-Bit Phase Shifter Using All-Pass Networks", D. Adler and R. Popovich, 1991 IEEE MTT-S Digest, pp 265-268. To obtain a copy of this paper, please write to Dept. C., General Microwave Corporation, 5500 New Horizons Boulevard, Amityville, N.Y. 11701.*

Phase Shifters and I-Q Modulators

ANALOG PHASE SHIFTERS

Analog phase shifters are devices whose phase shift changes continuously as the control input is varied and therefore offer almost unlimited resolution with monotonic performance. The most commonly used semiconductor control devices used in analog microwave phase shifters are varactor diodes, which act as voltage controlled variable capacitors, and PIN diodes, which act as current controlled variable resistors. Schottky diodes and ferrite devices are also used as variable elements in analog phase shifters but the former suffer from limited power handling capability and matching difficulty in broadband networks whereas the latter are generally larger, require more bias power, and are relatively slow compared to semiconductor designs.

Among the more useful topologies for analog phase shifters are the loaded line design using lumped or distributed elements and the reflective design employing quadrature hybrids. One of the variants of the reflective phase shifter is the vector modulator, which in the particular embodiment used by General Microwave shows excellent performance over 3:1 bandwidths. This capability is especially useful in the design of frequency translators[2] and high resolution phase shifters for EW systems as well as in broadband simulators as I-Q modulators, where separate control of the quadrature components of the signal allow for independent adjustment of both phase and amplitude. General Microwave's Series 72 and 78 phase control components employ this design.

Analog phase shifters are readily convertible to digital control by the addition of suitable D/A converters and appropriate linearizing circuits. The Series 71, 77 and 79 digital phase shifters use this approach.

DEFINITION OF PARAMETERS

Phase Shift: The difference in phase angle of the exiting rf signal at a given frequency and phase shift setting referenced to the exiting signal at the same frequency with the phase shifter set to zero degree phase shift.

Temperature Coefficient: The average rate of change in phase shift, as referenced to the zero degree phase state, over the full operating temperature range of the unit. Expressed in degrees phase shift/°C.

PM/AM: The maximum peak-to-peak change in insertion loss of the phase shifter at any phase state over the full 360° phase range.

Accuracy: The maximum deviation in phase shift from the programmed phase shift over the operating frequency range when measured at room temperature.

Carrier Suppression: When the phase shifter is operated as a frequency translator, the minimum ratio of carrier output power to the translated carrier output power.

Sideband Suppression: When the phase shifter is operated as a frequency translator, the minimum ratio of any sideband output power to the translated carrier output power.

Switching Speed: The time interval from the 50% point of the TTL control signal to within 10° of final phase shift. This applies to a change in either direction between any two phase states which differ by more than 22.5°.

(2) *Phase shifters can be used to translate the frequency of an rf carrier by subjecting it to a linear time varying phase shift.*

Phase Shifters and I-Q Modulators Selection Guide

PHASE SHIFTERS/FREQUENCY TRANSLATORS
BI-PHASE MODULATORS
I.Q. VECTOR MODULATORS

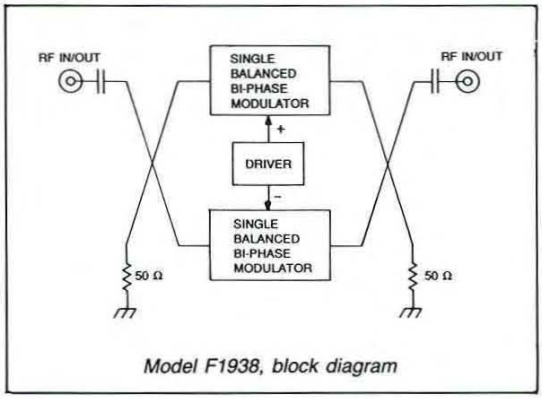
FREQUENCY RANGE (GHz) 0.5 2.0 4.0 6.0 8.0 12.0 18.0	MODEL	PAGE	COMMENTS
0.5 — 2.0	7720/7820	80	Phase shifter/Frequency translator, digital/analog
2.0 — 6.0	7722/7822		Phase shifter/Frequency translator, digital/analog
4.0 — 12.0	7724/7824		Phase shifter/Frequency translator, digital/analog
6.0 — 18.0	7728/7828		Phase shifter/Frequency translator, digital/analog
6.0 — 18.0	7928	84	Miniature Phase shifter/Frequency translator, Hermetically sealed, digital
4.0 — 8.0	H7524	78	Phase shifter/Frequency translator, Hermetically sealed, digital
6.0 — 18.0	F1938	70	Bi-Phase modulator
0.5 — 2.0	7120/7220	73	I.Q. Vector modulator, digital/analog
2.0 — 6.0	7122/7222		I.Q. Vector modulator, digital/analog
4.0 — 12.0	7124/7224		I.Q. Vector modulator, digital/analog
6.0 — 18.0	7128/7228		I.Q. Vector modulator, digital/analog

Model F1938
Bi-Phase Modulator
With Integrated Driver

- **Frequency range: 6-18 GHz**
- **Differental phase shift: 180° ± 10°**
- **High speed: 5 nsec (10-90% rf)**
- **Low VSWR and insertion loss**
- **Small size, light weight**

The Model F1938 is a high-speed 0° or 180° phase shifter that operates over the 6 to 18 GHz frequency range. It features a double-balanced design that provides excellent phase accuracy over its entire frequency range.

The rf design is shown below. The currents required to switch the unit between states are provided by the integrated driver, which is controlled by an external logic signal.



Model F1938, block diagram

Model F1938 Specifications

PERFORMANCE CHARACTERISTICS

Frequency Range . . . . . 6 to 18 GHz

Differential Phase Shift . . . . . 180° ± 10°

Switching Characteristics (1)

ON Time . . . . . 20 nsec. max.

OFF Time . . . . . 20 nsec max.

Rise Time . . . . . 5 nsec. max.

Fall Time . . . . . 5 nsec. max.

Insertion Loss . . . . . 3.0 dB max.

VSWR . . . . . 2.0 max.

Change of Insertion Loss With Phase Shift . . . . . 1.0 dB max.

Carrier Suppression . . . . . 20 dB min.

Modulation Rate . . . . . 10 MHz max.

Power Handling Capability

Without Performance Degradation . . . . . 1W cw or peak

Survival Power . . . . . 2W average, 25W peak (1 μsec max. pulse width)

Power Supply Requirements . . . . . +5V ± 5%, 65 mA
−12 to −15V, 20 mA

Control Characteristics

Control Input Impedance . . . . . Schottky TTL, two-unit load. (A unit load is 2 mA sink current and 50 μA source current.)

Control Logic . . . . . Alternate applications of logic "0" (−0.3 to +0.8V) and logic "1" (+2.0 to +5.0V) switches phase by 180°.

(1) *As measured with a phase bridge.*

Model F1938 Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range ..... −65° to +110°C

Non-Operating Temperature Range ..... −65° to +125°C

Humidity ..... MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

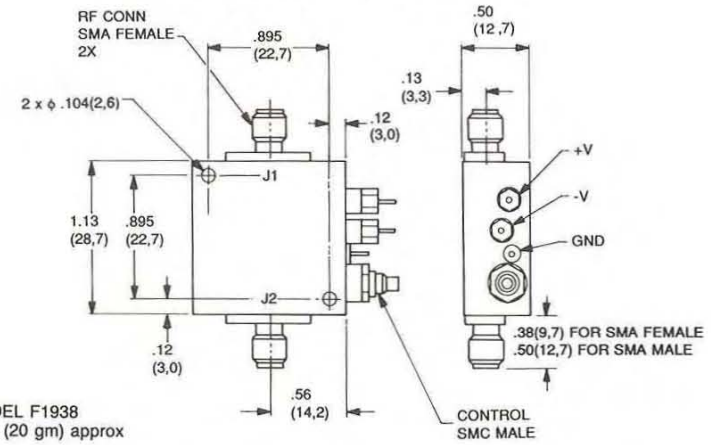
Altitude ..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling ... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female control connector
7	Two SMA male rf connectors
10	One SMA (J1) male and one SMA female (J2) rf connector
33	EMI filter solder-type control terminal
64A	SMB male control connector

DIMENSIONS AND WEIGHT



MODEL F1938
Wt: 0.7 oz (20 gm) approx

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series 71, 12 Bit Digital and Series 72 Analog I-Q Vector Modulators

Both Series comprise a family of four solid-state PIN diode I-Q Vector Modulators covering the frequency range from 0.5 to 18 GHz in four bands; 0.5 to 2 GHz, 2 to 6 GHz, 4 to 12 GHz and 6 to 18 GHz. See Fig. 1.

All models provide a full 360° range of phase shift and a minimum of 20 dB attenuation range at any frequency.

- **Simultaneous control of amplitude and phase**
- **0.5 to 18 GHz in four bands: 0.5 to 2 GHz; 2 to 6 GHz; 4 to 12 GHz; 6 to 18 GHz**
- **12 Bit digitally programmable (Series 71)**
- **Analog control (Series 72)**
- **High speed**
- **Guaranteed monotonicity**

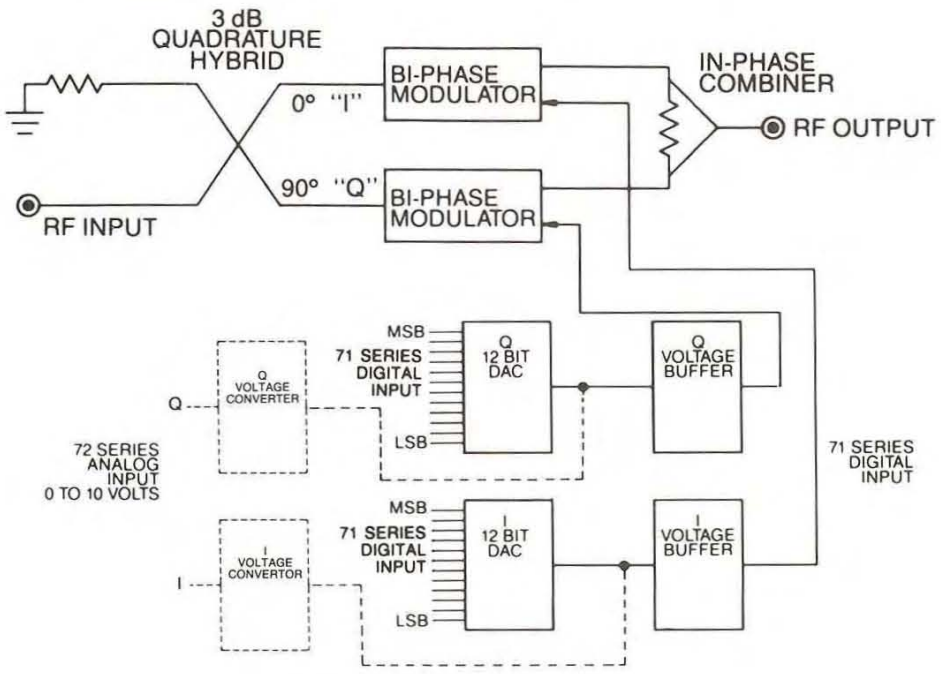


Fig. 1–Series 71, 72 Block Diagram

Series 71 12 Bit Digital and Series 72 Analog I-Q Vector Modulators

THEORY OF OPERATION

The block diagram of the I-Q Vector Modulator is shown in Figure 1. An RF signal incident on a 3 dB quadrature hybrid is divided into two equal outputs, with a 90° phase difference between them. The in-phase, or 0°, channel is designated the I channel and the Quadrature, or 90°, channel is designated the Q channel. Each signal passes through a bi-phase modulator which sets the 0° or 180° state and the attenuation level for both the I and Q paths. The outputs of the I and Q path are combined to yield the resultant vector which may fall anywhere within the bounded area shown in Figure 2. Any signal applied to the I-Q Vector Modulator can be shifted in phase and adjusted in amplitude by applying the following relationships:

1. Let the desired attenuation level = X dB and the desired phase shift = θ° (with respect to 0 dB and O° reference states).
2. The normalized output voltage magnitude is given by: $|V| = 10^{-(x/20)}$.
3. The values of the I and Q attenuator control inputs are then expressed as:

$$I = V \cos \theta$$

and

$$Q = V \sin \theta.$$

Figure 3 shows the nominal value of I and Q vs. either digital word (Series 71) or analog voltage (Series 72). Thus, to achieve an attenuation level of 3 dB with a phase offset of 112.5° (with respect of 0 dB and 0° reference states) the values of I and Q can be calculated as follows:

$$V = 10^{-(3/20)} = 0.707$$
$$I = 0.707 \cos (112.5°) = -0.27$$
$$Q = 0.707 \sin (112.5°) = +0.65$$

From Figure 3, the control inputs to yield the desired amplitude and phase are approximately:

Analog Units (72 Series)	Digital Units (71 Series)
I = 5.78 volts	100101000000
Q = 2.84 volts	010010001011

While these values for I and Q will yield an output signal whose amplitude and phase are close to the nominal values over the entire operating frequency range of the vector modulator, the use of an iterative measurement procedure will determine the I and Q inputs which exactly define the desired parameter at any selected frequency.

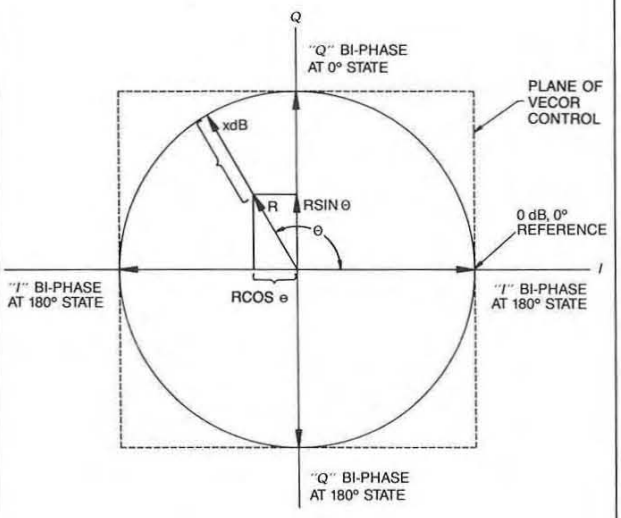


Fig. 2–I-Q Phase Relationship

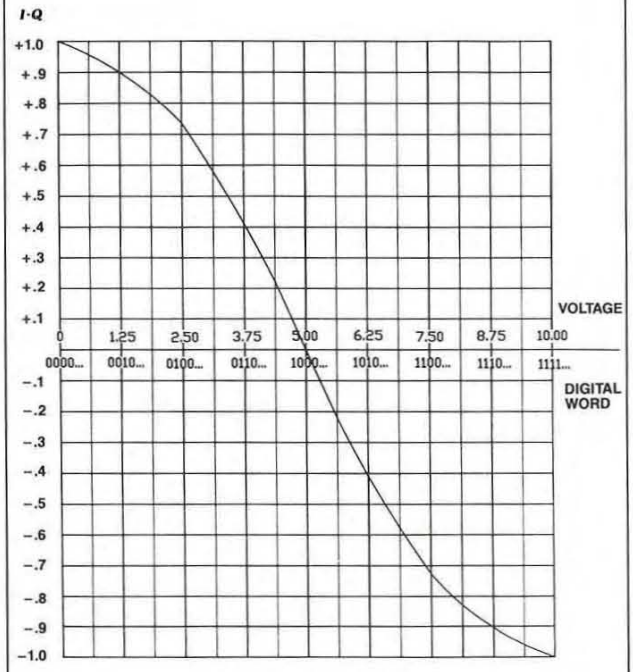


Fig. 3–I-Q vs Control Input

Series 71/72 Specifications

PERFORMANCE CHARACTERISTICS

MODEL	7120/7220	7122/7222	7124/7224	7128/7228
FREQUENCY	0.5-2.0 GHz	2.0-6.0 GHz	4.0-12.0 GHz	6.0-18.0 GHz
INSERTION LOSS (MAX)	13 dB	11 dB	12 dB	12 dB
VSWR (MAX)	1.6:1	1.8:1	1.8:1	2.0:1
POWER HANDLING WITHOUT PERFORMANCE DEGRADATION	+7 dBm	+20 dBm	+20 dBm	+20 dBm
SURVIVAL POWER (MAX)	1W			
ABSOLUTE INSERTION PHASE ACCURACY VS. FREQUENCY (MAX)	± 15°			
FINE GRAIN PHASE RIPPLE (50 MHz) (MAX)	2° pk-pk			
VARIATION OF PHASE VS. TEMPERATURE (MAX)	± 0.1 deg./°C			
VARIATION OF AMPLITUDE VS. TEMPERATURE (MAX)	0.02 dB/°C			
RESPONSE TIME (MAX)	0.5 μsec			
POWER SUPPLY	−12 to −15V @ 70 mA +12 to +15V @ 70 mA			
CONTROL INPUT 71 SERIES 72 SERIES	12 bit TTL for both I and Q inputs 0 to +10V dc for both I and Q inputs			
CONTROL INPUT IMPEDANCE 71 SERIES 72 SERIES	40 μA max 10 K ohms			

ENVIRONMENTAL RATINGS

Operating Temperature Range ..... −54°C to +100°C

Non-Operating Temperature Range ..... −65°C to +125°C

Humidity ..... MIL-STD-202F, Method 103B. Cond. B (96 hrs. at 95%)

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude ..... MIL-STD-202F, Method 105C. Cond. B (50,000 ft.)

Temp. Cycling ..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

ACCESSORY FUNISHED

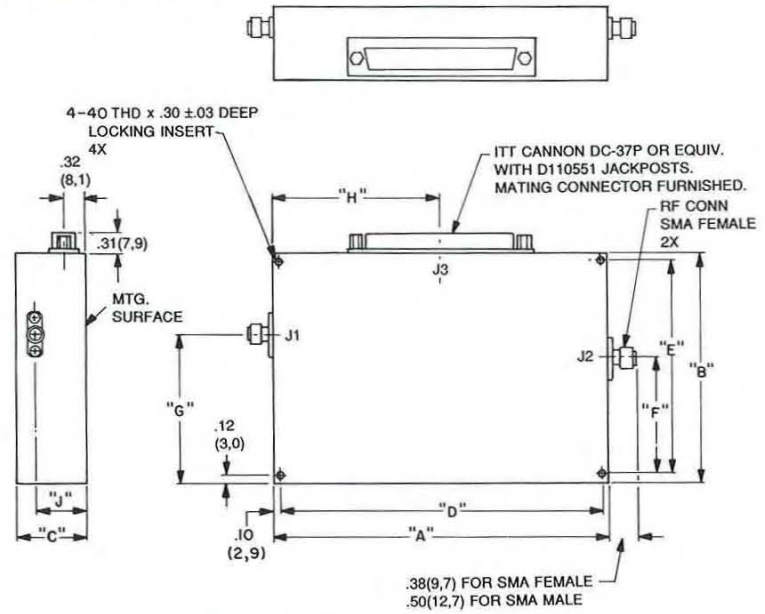
Mating power/control connector (Series 71 only)

AVAILABLE OPTIONS

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector

Series 71/72 Specifications

DIMENSIONS AND WEIGHTS



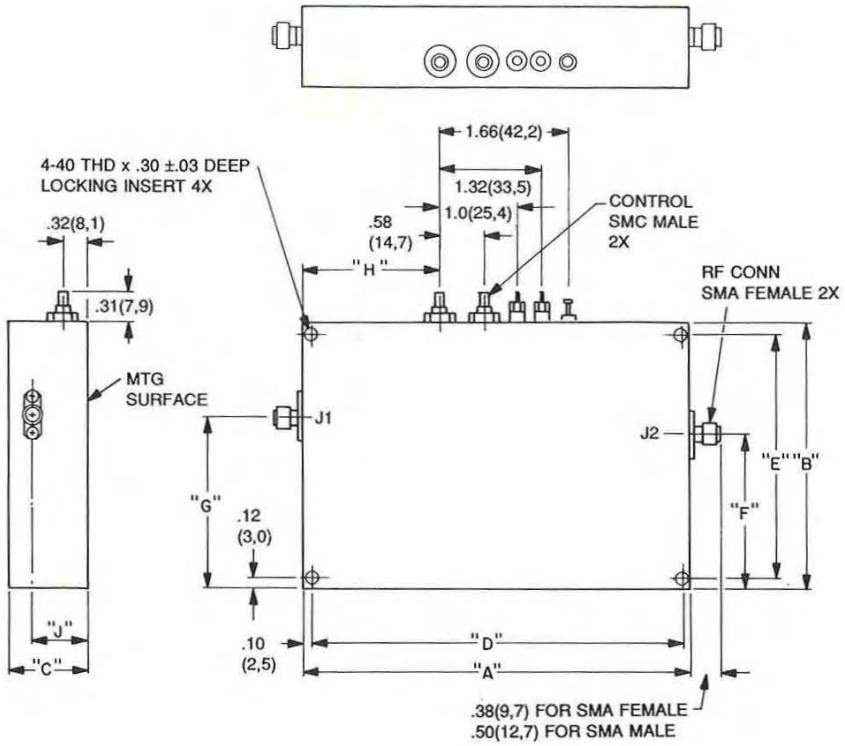
MODEL	A	B	C	D	E	F	G	H	J
7120	4.95 ± .03 (125,7)	3.38 ± .03 (85,9)	1.02 (25,9)	4.75 ± .01 (120,7)	3.12 ± .01 (79.2)	2.62 (66,5)	1.69 (42,9)	2.48 (62,9)	.73 (18,5)
7122	3.25 ± .03 (82,6)	3.25 ± .03 (82,6)	.85 (21.6)	3.05 ± .01 (77,5)	3.00 ± .01 (76,2)	1.63 (41,4)	1.99 (50,5)	1.63 (41,4)	.68 (17.3)
7124							1.83 (46,5)		
7128	3.00 ± .03 (76,2)	3.00 ± .03 (76,2)	.96 (24,4)	2.80 ± .01 (71,1)	2.75 ± .01 (69,9)	1.50 (38,1)	1.63 (41,4)	1.50 (38,1)	.76 (19,3)

J3 PIN FUNCTIONS			
PIN	FUNCTION	PIN	FUNCTION
1	1-5	20	1-4
2	1-6	21	1-7
3	1-8	22	1-3
4	1-9	23	1-2
5	1-10	24	1-1 (LSB)
6	1-11	25	1-12 (MSB)
7	N/C	26	N/C
8	+ 12 to + 15V	27	N/C
9	GND	28	GND
10	GND	29	N/C
11	– 12 to – 15V	30	N/C
12	Q-3	31	N/C
13	Q-2	32	Q-4
14	Q-1 (LSB)	33	N/C
15	Q-5	34	N/C
16	Q-6	35	Q-12 (MSB)
17	Q-7	36	Q-11
18	Q-8	37	Q-10
19	Q-9		

MODEL	WEIGHT (APPROX)
7120	9 oz. (255 gm)
7122	6 oz. (170 gm)
7124	6 oz. (170 gm)
7128	5 oz. (142 gm)

Dimensional tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

DIMENSIONS AND WEIGHTS



MODEL	A	B	C	D	E	F	G	H	J
7220	4.95 ± .03 (125,7)	3.38 ± .03 (85,9)	1.02 (25,9)	4.75 ± .01 (120,6)	3.12 ± .01 (79,2)	2.62 (66,5)	1.69 (42,9)	1.75 (44,5)	.73 (18,5)
7222	3.25 ± .03 (82,6)	3.25 ± .03 (82,6)	.85 (21,6)	3.05 ± .01 (77,5)	3.00 ± .01 (76,2)	1.63 (41,4)	1.99 (50,5)	.90 (22,9)	.68 (17,3)
7224							1.83 (46,4)		
7228	3.00 ± .03 (76,2)	3.00 ± .03 (76,2)	.96 (24,4)	2.80 ± .01 (71,1)	2.75 ± .01 (69,9)	1.50 (38,1)	1.63 (41,4)	.78 (19,8)	.76 (19,3)

MODEL	WEIGHT (APPROX)
7220	10 oz. (283 gm)
7222	7 oz. (198 gm)
7224	7 oz. (198 gm)
7228	6 oz. (170 gm)

Dimensional tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Model H7524 High Speed, 4 Bit Phase Shifter/Frequency Translator

- **4-8 GHz**
- **25 nsec switching speed**
- **4-Bit, 0-337.5° phase shift range**
- **0.24″ thick**
- **Hermetically sealed**
- **Guaranteed monotonicity**

The Model H7524 is a hermetically sealed, high speed, digitally controlled switched bit phase shifter. Broadband, constant, differential phase shift is obtained by switching between two unbalanced all-pass filter networks. See Figs. 1, 2 and 3.

Phase shift changes are guaranteed to be monotonic over the entire frequency band and operating temperature range. Employing removable rf connectors, the small size and contruction of the Model H7524 make it suitable for use as a drop-in component for system integration or as a conventional connectorized component.

Phase shift is selected via four FAST TTL input control pins. The unit is protected against inadvertent power supply voltage reversals.

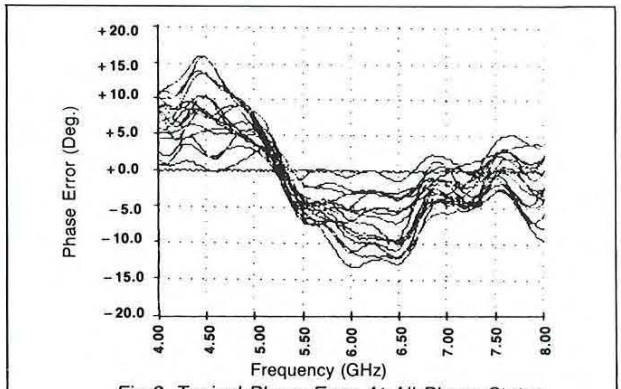


Fig 2. Typical Phase Error At All Phase States

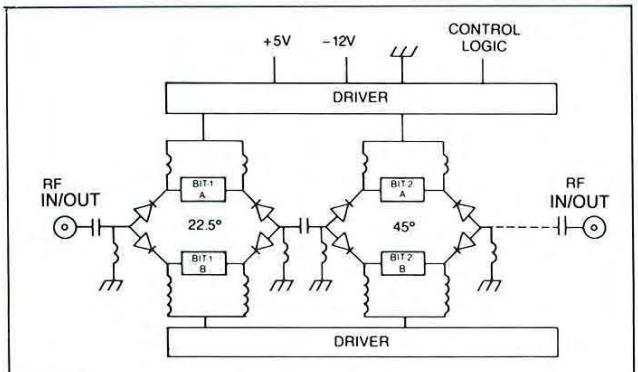


Fig 1. H7524 Schematic Diagram

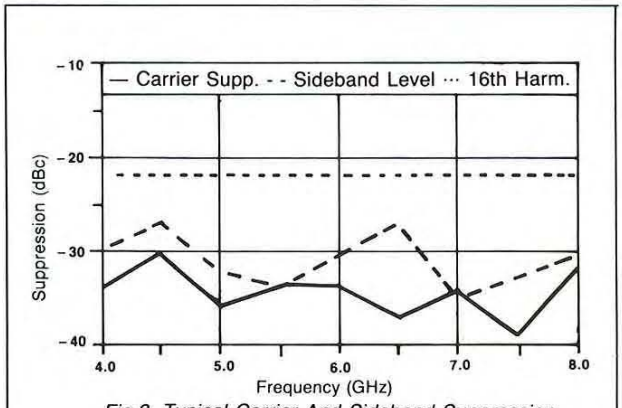


Fig 3. Typical Carrier And Sideband Suppression

Model H7524 Specifications

PHASE SHIFTER SPECIFICATIONS

FREQUENCY RANGE (GHz)	INSERTION LOSS (Max.)	VSWR (Max.)	ACCURACY (Max.)	PM/AM (Max.)
4 to 8	7 dB	2.0:1	±18° PEAK ±8° RMS	±1.0 dB

FREQUENCY TRANSLATOR (SERRODYNING) SPECIFICATIONS

TRANSLATION RATE	CARRIER SUPPRESSION (Min.)	SIDEBAND[1] SUPPRESSION (Min.)	CONVERSION LOSS (Max.)
0 to 2 MHz	25 dB	25 dB	6.0 dB

PERFORMANCE CHARACTERISTICS

Phase Shift:
Range . . . . . 0° to 337.5°

Control Input . . . . . 4 Bit TTL
Bit Weights . . . . . 22.5°, 45°, 90° & 180°
Logic "0" . . . . . Insertion Phase (−0.3 to +0.8V@1.2 mA)
Logic "1" . . . . . Positive Phase Shift (+2.0 to +5.0V@40 μA)

Switching Time . . . . . 25 nsec (max)

Harmonics . . . . . −30 dBc

Power Handling Capability (CW) . . . . . +23 dBm

Power Supply[2] . . . . . +5V ±5%, 170 mA
−12V ±5%, 130 mA

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −54°C to +110°C

Non-Operating Temperature Range . . . . . −65°C to +125°C

AVAILABLE OPTIONS

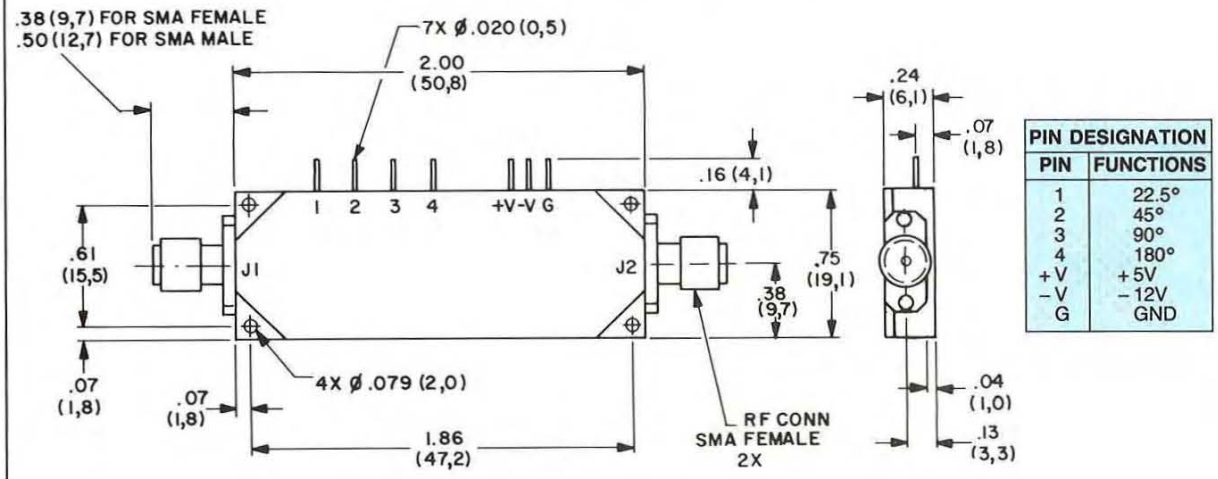
Option No.	Description
7	Two SMA male rf connectors
9	Inverse logic
10	One SMA (J1) male and one SMA (J2) female rf connector
49	High Rel screening (See table 1, page 36)

AVAILABLE ACCESSORY

Model	Spacer Plates
H7524	19177-P2

(1) *Except 22 dBc for the 16th harmonic*
(2) *Above 1 MHz translation rate (LSB @ 16 MHz rep rate) the power supply current will increase to +5.0V at 325mA, −12V at 275mA, at 2 MHz.*

DIMENSIONS AND WEIGHT



PIN DESIGNATION	
PIN	FUNCTIONS
1	22.5°
2	45°
3	90°
4	180°
+V	+5V
−V	−12V
G	GND

MODEL H7524 Wt: 0.8 oz (23gm) approx.

Dimensional Tolerances: unless otherwise indicated: .xx ± .02; .xxx ± .005

Series 77, 8 Bit Digital And Series 78 Analog 360° Phase Shifters & Frequency Translators

- **0.5 to 18 GHz in four bands: 0.5 to 2 GHz; 2 to 6 GHz; 4 to 12 GHz; 6 to 18 GHz**
- **8 Bit digitally programmable (Series 77)**
- **Analog control (Series 77)**
- **High speed**
- **Guaranteed monotonicity**

Both Series, 77 and 78, comprise a family of eight solid-state PIN diode phase shifters covering the frequency range from 0.5 to 18 GHz in four bands; 0.5 to 2 GHz, 2 to 6 GHz, 4 to 12 GHz and 6 to 18 GHz.

All models provide a full 360° range of phase shift and may also be used for frequency translation applications.

Each unit is an integrated assembly of an rf vector modulator and a driver circuit, consisting of an 8-bit D/A converter and a voltage buffer in the Series 77 digital units (see Fig. 1A) and a voltage converter and buffer in the Series 78 analog configuration (see Fig. 1B).

The voltage buffer in the Series 78 consists of an A/D converter followed by a D/A converter and converts a continuous analog input voltage into discrete steps of 1.41°.

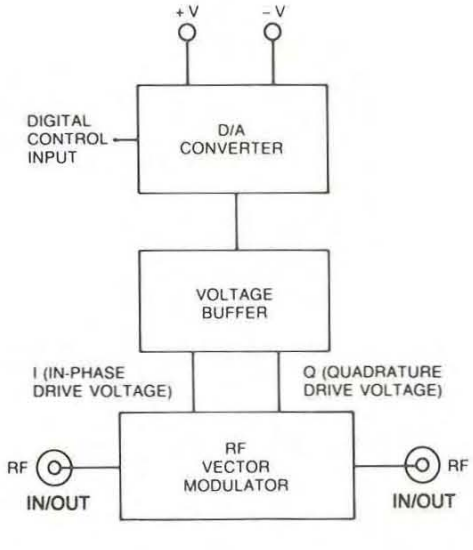


Fig. 1A—Series 77, Block Diagram

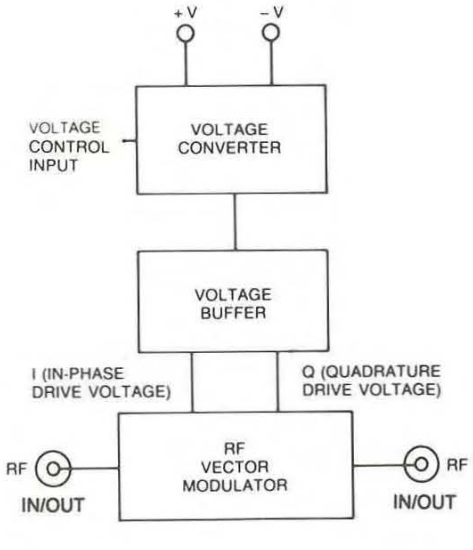


Fig. 1B—Series 78, Block Diagram

Phase Shift
Phase shift is achieved utilizing the rf vector modulator approach shown in Fig. 2. The 3 dB hybrid coupler divides the rf signal into two quadrature components which are then modulated in proportion to the sine and cosine of the desired phase shift. The signals are then combined in-phase to yield the phase-shifted output.

Excellent phase accuracy and PM/AM performance (see Figs. 4 and 5) are achieved by using linearized double balanced modulators. In their main operating bands, phase accuracy is better than ± 10° up to 10 GHz and ± 12° to 18 GHz. This phase accuracy can be extended to cover the band edges by using a built-in frequency correction circuit. Switching speed is better than 500 nsec.

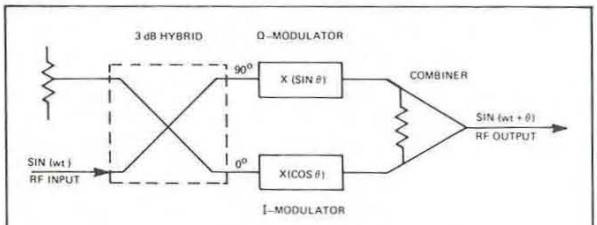


Fig. 2-RF vector modulator

Frequency Translation (Serrodyning)
Special attention in the design of the units has been paid to those characteristics which affect their performance as frequency translators. These include minimizing PM-to-AM conversion, use of high slew rate drivers, and optimizing phase shift linearity with applied signal. As a result, carrier and sideband suppression levels of over 25 and 20 dB, respectively, are obtained in the main bands. The same carrier and sideband performance can be realized over the full stretch band when the internal frequency correction circuit is employed.

See Fig. 3 for input voltage control requirements for Series 77 and 78 when used as a frequency translator.

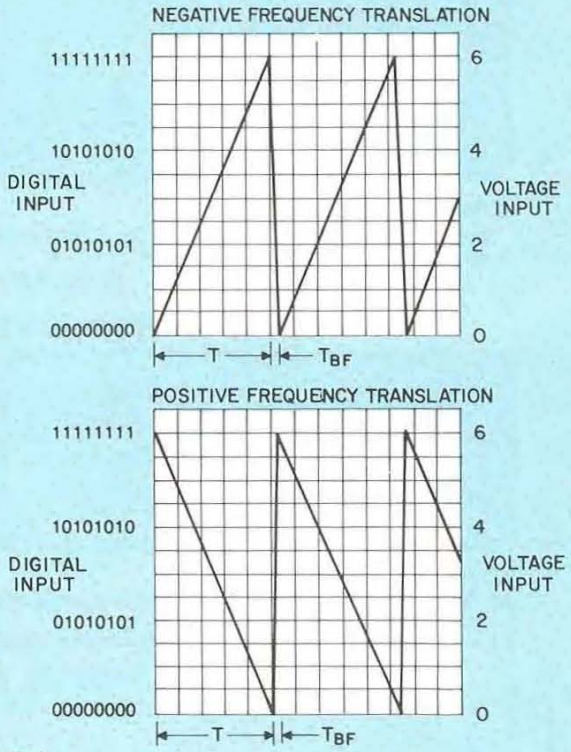
On special order, frequency translators can be provided for operation over reduced bandwidths with suppression levels of up to 35 dB. Consult the factory for special requirements.

PERFORMANCE CHARACTERISTICS

SERIES 77

Control . . . . . 8 bit TTL
Logic Input
Logic "0" (Bit OFF) . . . . . −0.3 to +0.8V @ 500 μA max
Logic "1" (Bit ON) . . . . . +2.0 to +5.0V @ 100 μA max
Power Supply . . . . . +5V at 250mA
+12 to +15V @ 50 mA max
−12 to −15V @ 35mA max

Fig. 3-Series 77 and Series 78 input requirements



NOTES:
T_{BF} should be less than 1% of T to achieve specified carrier and sideband suppression.

Translation Rate = $\frac{1}{T + T_{BF}}$

SERIES 78

Control Voltage . . . . . 0 to +6V
Sensitivity . . . . . 23.4 mV/LSB
Resolution . . . . . 1.41°
Step Uncertainty . . . . . 0.7° max, 0.3° typ.
Input Resistance . . . . . 2K ohms
Power Supply . . . . . +5V at 300mA
+12 to +15V at 125mA
−12 to −15V at 50 mA

COMMON TO BOTH SERIES 77 & 78

Power Handling Capability
Without Performance
Degradation . . . . . +20 dBm (+7 dBm for 7720, 7820)
Survival . . . . . +30 dBm
Harmonics . . . . . −30 dBc
Phase Variation . . . . . 0.1°/°C

Series 77/78 Specifications

PHASE SHIFTER SPECIFICATIONS

MODEL NOS.	FREQUENCY RANGE (GHz)	INSERTION LOSS (Max.)	VSWR (Max.)	ACCURACY[1] (Max.)	PM/AM (Max.)
7720 & 7820	Main Band 0.7-1.6 Stretch Band 0.5-2.0	11.5 dB 13.0 dB	1.75	±10° ±15°	±1.1 dB ±2.5 dB
7722 & 7822	Main Band 2.6-5.2 Stretch Band 2.0-6.0	10.0 dB 11.0 dB	1.6	±10° ±15°	±1.1 dB ±1.5 dB
7724 & 7824	Main Band 4.5-10.5 Stretch Band 4.0-12.0	10.5 dB 12.0 dB	1.8	±10° ±15°	±1.1 dB ±2.0 dB
7728 & 7828	Main Band 8.0-18.0 Stretch Band 6.0-18.0	12.0 dB	2.0	±12° ±15°	±1.1 dB ±2.0 dB

OTHER SPECIFICATIONS

Switching Speed (50% TTL to within 10° of Final Phase Value): 500 nsec Max.
Minimum phase shift range:
Series 77:360° in 256 Steps (8-bit) *Series 78:360° @ 60°/Volt*

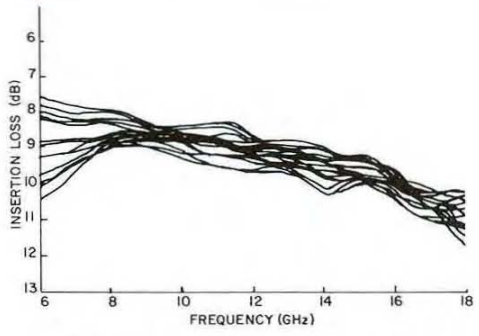
FREQUENCY TRANSLATOR SPECIFICATIONS

TRANSLATION RATE (Min.)	CARRIER[1] SUPPRESSION (Min.)	SIDE BAND[1] SUPPRESSION (Min.)	INSERTION LOSS VARIATION (Max.) with translation rate:
0 to 500 kHz[2]	Main Band: 25 dB Stretch Band: 18 dB	Main Band: 20 dB Stretch Band: 15 dB	200 kHz: 1 dB 500 kHz: 3 dB

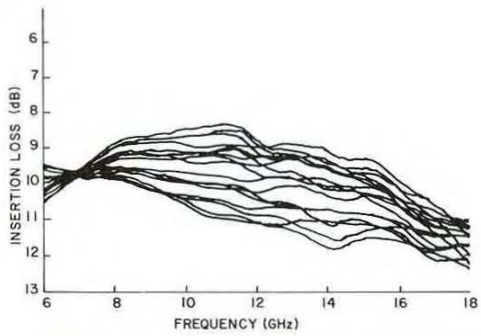
NOTES:

(1) *Main band specifications apply if 1 bit TTL logic signal is provided indicating whether input rf signal is in main-band or band-edge.*
(2) *All specifications are met using only the five most significant bits on the 77 series.*

TYPICAL PERFORMANCE



PM/AM over the full operating band.



PM/AM with frequency correction circuit selected.

Figure 4

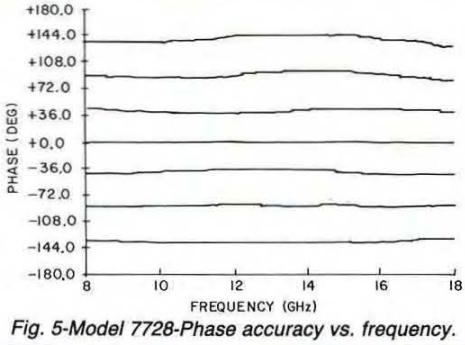


Fig. 5-Model 7728-Phase accuracy vs. frequency.

Series 77/78 Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range ..... –54°C to +100°C

Non-Operating Temperature Range ..... –65°C to +125°C

Humidity ..... MIL-STD-202F, Method 103B. Cond. B (96 hrs. at 95%)

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude ..... MIL-STD-202F, Method 105C. Cond. B (50,000 ft.)

Temp. Cycling ..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

ACCESSORY FURNISHED

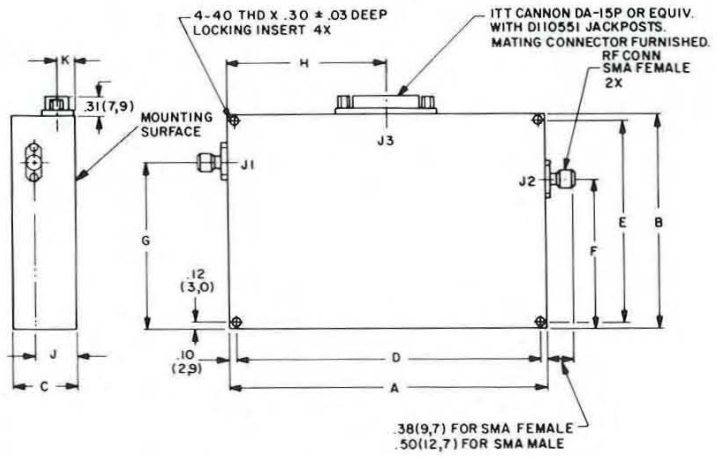
Mating power/control connector

AVAILABLE OPTIONS

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male (J1) and one SMA female (J2) rf connector

J3 PIN FUNCTIONS		
	Function	
Pin No.	Series 77	Series 78
1	–12V to –15V	–12V to –15V
2	+12V to +15V	+12V to +15V
3	Freq. Correction Circuit Select "0" = Band Edge	Freq. Correction Circuit Select "0" = Band Edge
4	1.4° (LSB)	Not Used
5	5.6°	Not Used
6	45.0°	Not Used
7	180.0° (MSB)	Not Used
8	90.0°	Not Used
9	Ground	Ground (Sig)
10	Not Used	Ground (Pwr)
11	22.5°	Not Used
12	2.8°	Not Used
13	11.3°	Not Used
14	Not Used	Control Voltage
15	+5V	+5V

DIMENSIONS AND WEIGHTS



MODEL	A	B	C	D	E	F	G	H	J	K	WEIGHT (APPROX)
7720	4.95 ± .03	3.38 ± .03	1.02 (25,9)	4.75 ± .01	3.12 ± .01	2.62	1.69	2.48	.73 (18,5)	.32 (8,1)	13 oz. (369 gm)
7820	(125,7)	(85,9)	1.48 (37,6)	(120,7)	(79.2)	(66,5)	(42,9)	(62,9)	1.18 (30,0)	.78 (19,8)	15 oz. (425 gm)
7722	3.25 ± .03	3.25 ± .03	.80 (20,3)	3.05 ± .01	3.00 ± .01	1.63	1.99 (50,5)	1.63	.66 (16,8)	.32 (8,1)	6 oz. (170 gm)
7822			1.21 (30,7)						1.07 (27,2)	.72 (18,3)	7 oz. (198 gm)
7724	(82,6)	(82,6)	.80 (20,3)	(77,5)	(76,2)	(41,4)	1.83 (46,5)	(41,4)	.66 (16,8)	.32 (8,1)	6 oz. (170 gm)
7824			1.21 (30,7)						1.07 (27,2)	.72 (18,3)	7 oz. (198 gm)
7728	2.50 ± .03	3.00 ± .03	.88 (22,4)	2.30 ± .01	2.75 ± .01	1.50	1.63	1.25	.71 (18,0)	.39 (9,9)	4 oz. (113 gm)
7828	(63,5)	(76,2)	1.19 (30,2)	(58,4)	(69,9)	(38,1)	(41,4)	(31,8)	1.02 (25,9)	.69 (17,6)	7.5 oz. (213 gm)

Dimension tolerances, unless otherwise indicated: .xx ± .02; xxx ± .005

Model 7928 Miniaturized 8 Bit 360° Phase Shifter/Frequency Translator

- **6 to 18 GHz**
- **360° range**
- **High speed**
- **Digitally programmable (8 Bits)**
- **Guaranteed monotonicity**
- **Hermetically Sealed**
- **Miniaturized: less than 1.5 in³**

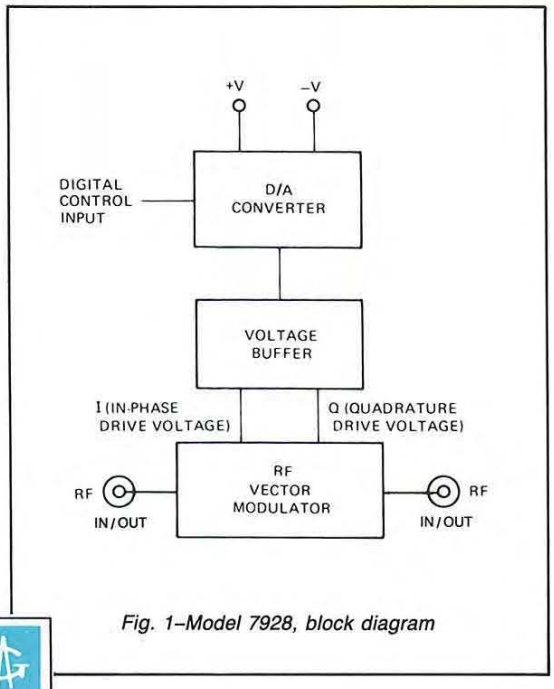


Fig. 1–Model 7928, block diagram

The Model 7928 is a miniaturized, hermetically sealed PIN diode phase shifter covering the frequency range from 6 to 18 GHz providing a full 360° range of variable phase shift. It can also be used to perform frequency translation.

The unit is an integrated assembly of an rf vector modulator and a driver circuit consisting of an 8-bit D/A converter and a voltage buffer. See Figure 1.

PHASE SHIFT

Phase shifting is achieved utilizing the rf vector modulator approach shown in Figure 2. The 3-dB hybrid coupler divides the rf signal into two quadrature components which are then biased in proportion to the sine and cosine of the desired phase shift. The signals are then combined in-phase to yield desired output.

ACCURACY

Improved phase accuracy and PM/AM performance are achieved by using double-balanced bi-phase linear amplitude modulators. In the main operating band, overall phase accuracy is better than 12°. The same phase accuracy can be achieved at the band edges by using a built-in frequency correction circuit.

Switching speed is better than 500 nsec.

FREQUENCY TRANSLATION (SERRODYNING)

In the design of the Model 7928 special attention has been paid to those characteristics which affect its performance as a frequency translator. These include minimizing PM-to-AM conversion, use of high slew rate drivers, and optimizing phase shift linearity with applied signal. As a result, carrier and sideband suppression levels of over 25 and 20 dB, respectively, are obtained in the main band. The same carrier and sideband performance can be realized over the full stretch band when the internal frequency correction circuit is employed. See Fig. 3 for input control requirements.

On special order, frequency translators can be provided for operation over reduced bandwidths with suppression levels of up to 40dB. Consult the factory for such requirements.

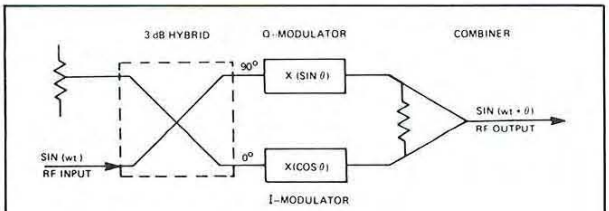


Figure 2. Rf Vector Modulator

Model 7928 Specifications

PHASE SHIFTER SPECIFICATIONS

FREQUENCY RANGE (GHz)	INSERTION LOSS (Max.)	VSWR (Max.)	ACCURACY[1] (Max.)	PM/AM (Max.)
Main Band 8.0-18.0 Stretch Band 6.0-18.0	12.0 dB	2.0:1	±12° ±15°	±1.1dB ±2.0dB

FREQUENCY TRANSLATOR SPECIFICATIONS

TRANSLATION RATE (Min.)	CARRIER[1] SUPPRESSION (Min.)	SIDE BAND SUPPRESSION (Min.)	INSERTION LOSS VARIATION (Max.) with translation rate:
0 to 500 kHz[2]	Main Band: 25 dB Stretch Band 18 dB	Main Band: 20 dB Stretch Band: 15 dB	200 kHz: 1 dB 500 kHz: 3 dB

(1) *Main band specifications apply if 1 bit TTL logic signal is provided indicating whether input rf signal is in main band or band edge.*
(2) *All specifications are met using only the five most significant bits on the Model 7928.*

PERFORMANCE CHARACTERISTICS

Phase Shift
Range . . . . . 360° in 256 steps
Variation . . . . . 0.1°/°C
Control Input . . . . . 8 Bit TTL
Switching Speed (50% TTL to within 10° of Final Phase Value) . . . . . 500 nsec max
Harmonics . . . . . −30 dBc

Power Handling Capability
Without Performance Degradation . . . . . +20 dBm
Survival Power . . . . . +30 dBm

Power Supply Requirements . . . . . +5V ±5%, 250mA
+12 to +15V ±5%, 50mA
−12 to −15V ±5%, 35mA

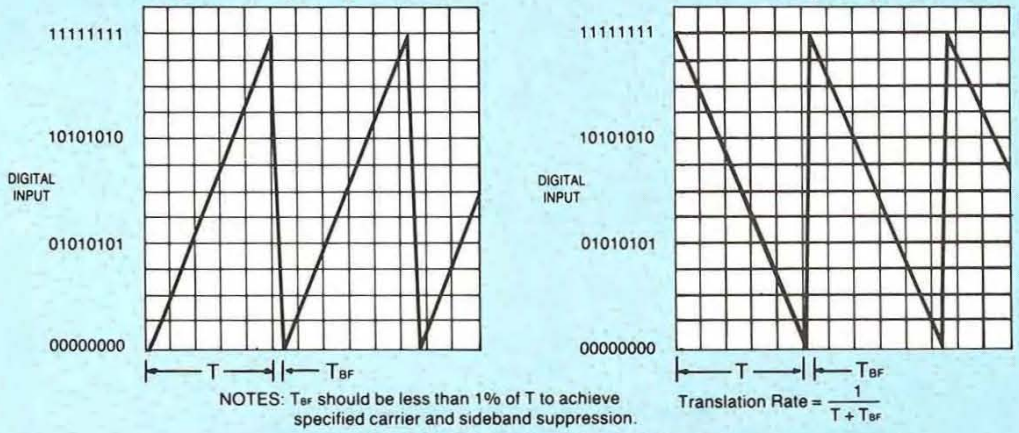


Fig. 3–Model 7928 Control input requirements

Model 7928 Specifications

ACCESSORY FURNISHED

Mating power/logic connector

ENVIRONMENTAL RATINGS

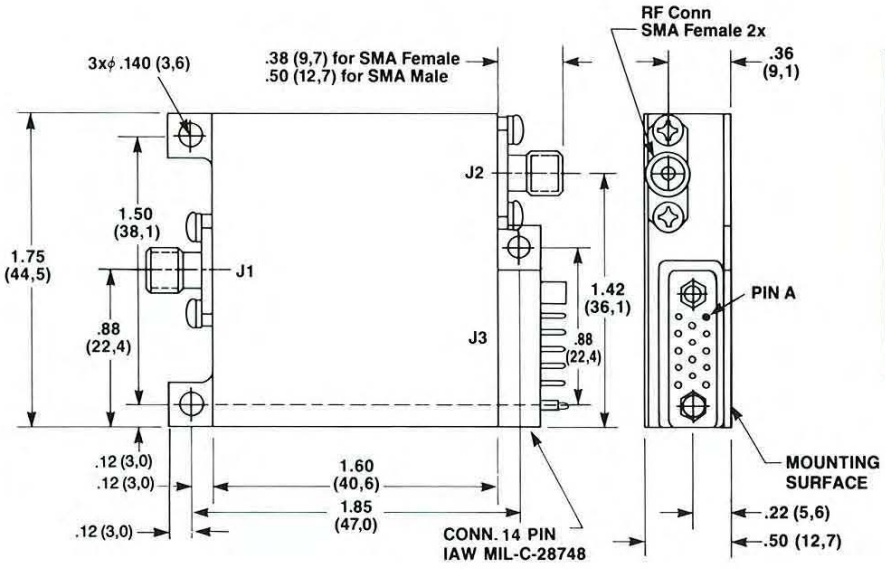
Operating Temperature
Range ..... −54°C to +110°C

Non-Operating Temperature
Range ..... −65°C to +125°C

AVAILABLE OPTIONS

Option No.	Description
7	Two SMA male rf connectors
10	One SMA male (J1), and one SMA female (J2) rf connector
49	High Rel screening (see Table 1, page 36)

DIMENSIONS AND WEIGHT



MODEL 7928	PIN FUNCTIONS
PIN	FUNCTION
A	Ground
B	+5V
C	−12 to −15V
D	1.4° (LSB)
E	2.8°
F	5.6°
H	22.5°
J	11.3°
K	90°
L	180° (MSB
M	+12 to +15V
N	45°
P	GND
R	Freq. Correction Circuit Select "0" = Band Edge

Model 7928 Wt. 3.0 oz (85g) approx.
Dimensional Tolerances: unless otherwise indicated: xx ±.02; .xxx ±.005

General Microwave switches cover the frequency range from 100 MHz to 40 GHz and are available in various topologies ranging from single-pole single-throw (SPST) to single-pole seven-throw (SP7T) in both reflective and non-reflective configurations.

SWITCH TOPOLOGY

There are two fundamental methods of connecting PIN diodes to a transmission line to provide a switching function: in series with the transmission line so that RF power is conducted when the PIN diode is forward biased and reflected when reverse biased; or in shunt with the transmission line so that the RF power is conducted when the diode is reverse biased and reflected when forward biased. A simple reflective SPST switch can be designed utilizing one or more PIN diodes in either configuration as shown in Fig. 1.

A multi-throw switch essentially consists of a combination of SPST switches connected to a common junction and biased so that each switch port can be enabled individually. The common junction of the switch must be designed to minimize the resistive and reactive loading presented by the OFF ports in order to obtain low insertion loss and VSWR for the ON port. There are two basic methods of realizing a multi-throw switch common junction for optimum performance over a broad frequency range. The first employs series mounted PIN diodes connected to the common junction. A path is selected by forward biasing its series diode and simultaneously reverse biasing all the other diodes. This provides the desired low-loss path for the ON port with a minimum of loading from the OFF ports. The second method utilizes shunt mounted PIN diodes located a quarter wavelength from the junction. The diode(s) of the selected ON port is reverse biased while the OFF ports are forward biased to create a short circuit across the transmission line. As a result of the quarter wavelength spacing, the short circuits are transformed to open circuits at the junction. By proper choice of transmission line impedances and minimization of stray reactance it is possible to construct a switch of this type with low insertion loss and VSWR over a three to one bandwidth. The schematic diagrams for both switches are shown in Fig. 2.

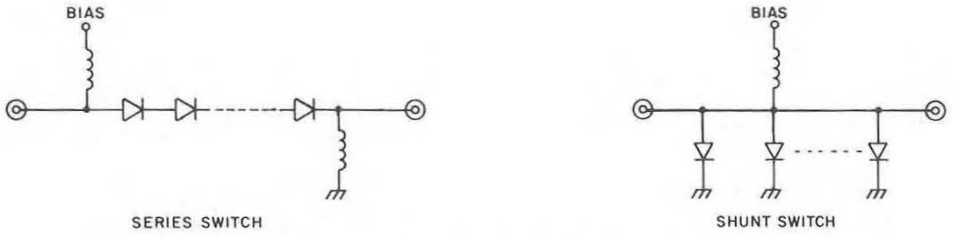


Fig. 1-Reflective SPST switch

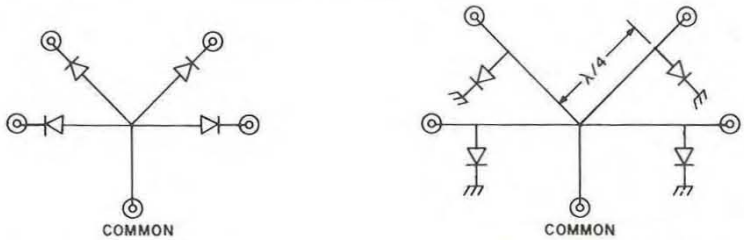


Fig. 2-Schematic diagrams of multi-throw switches

ABSORPTIVE SWITCHES

It is often desirable to have a PIN diode switch present a low VSWR in its OFF position as well as in its ON state in order to maintain desired system performance. General Microwave offers a complete line of single and multi-throw absorptive switches which incorporate 50Ω terminations in each of the output ports. Fig. 3 shows the schematic diagrams of the two versions of absorptive (also known as non-reflective or terminated) switches employed by GMC. The shunt termination is used in GMC's "all-series" configured absorptive switches which have a suffix ending in "T" or "W". This style of absorptive switch offers the minimum penalty in insertion loss due to the addition of the terminating elements. The series termination is used in GMC's high speed "series-shunt" configured absorptive switches since it provides the optimum in switching performance.

The common port of the standard absorptive multi-throw switches in the GMC catalog will be reflective in the special circumstance when all ports are turned OFF. If there is a need for this port to remain matched under these conditions, this can be realized either by employing an additional port to which an external termination is connected or, in a custom design, by providing automatic connection of an internal termination to the common port.

DEFINITION OF PARAMETERS

INSERTION LOSS is the maximum loss measured in a 50 ohm system when only a single port of the switch is in the ON state.

ISOLATION is the ratio of the power level when the switch port is ON to the power level measured when the switch port is OFF. In a multi-throw switch the isolation is measured with one of the other ports turned ON and terminated in 50 ohms.

VSWR is defined for the input and output ports of the selected ON path. For those switches with a "T", "W", or "HT" suffix, the VSWR is also defined for the OFF state.

VIDEO LEAKAGE

Video leakage refers to the spurious signals present at the RF ports of the switch when it is switched without an RF signal present. These signals arise from the waveforms generated by the switch driver and, in particular, from the leading edge voltage spike required for high speed switching of PIN diodes. When measured in a 50 ohm system, the magnitude of the video leakage can be as much as several volts. The frequency content is concentrated in the band below 200 MHz although measurable levels for high speed switches are observed as high as 6.0 GHz. The magnitude of the video leakage can be reduced significantly by the inclusion of high pass or "video filters"(1) in the switch, but the high frequency energy which falls within the passband of the switch can be eliminated only by using a slower speed switch.

HARMONIC AND INTERMODULATION PRODUCTS

All PIN diode switches generate harmonics and intermodulation products since the PIN diodes are fundamentally non-linear devices. The magnitude of these spurious signals is typically small in a switch since the diodes are usually either in their saturated forward biased state or in their reversed biased state. The physics of the PIN diode cause a cut-off frequency phenomena such that the level of harmonics and intermods greatly increase at low frequencies. These levels will vary with the minority carrier lifetime of the diode. Thus, a high speed switch operating below 500 MHz may have a second order intercept point of 35 dBm, while a slow switch operating at 8 GHz will have a second order intercept point of 70 dBm. Typical performance is as follows:

TYPICAL SWITCH INTERCEPT POINTS

SWITCH	FREQUENCY	2nd ORDER INTERCEPT	3rd ORDER INTERCEPT
HIGH SPEED	2.0 GHz	+50 dBm	+40 dBm
LOW SPEED	2.0 GHZ	+65 dBm	+50 dBm

Since these levels vary significantly with frequency, switching speed, and RF topology, please consult the factory for specific needs in this area.

(1) *For switches with internal video filters, specify Option 41, or Option 42, or Option 43. These filters reduce the leakage to less than 100 mV peak-to-peak, measured looking into a 100 MHz bandwidth in a 50-ohm system.*

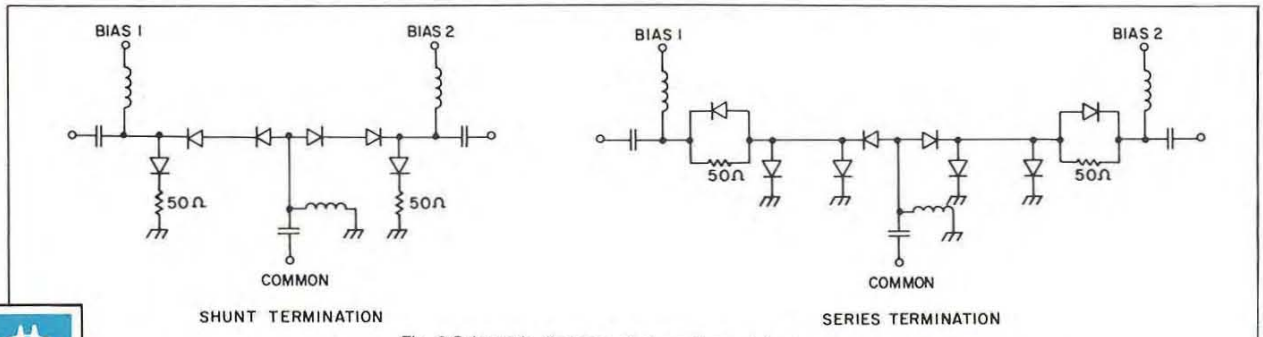


Fig. 3-Schematic diagrams of absorptive switches

SWITCHING SPEED[2]

Port-To-Port Switching is the interval from the time the RF power level at the off-going port drops to 90% of its original value to the time the RF power level in the on-going port rises to 90% of its final value. See Fig. 4.

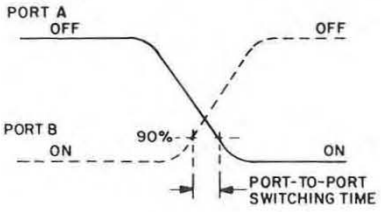


Fig. 4-Port-to-port switching speed definition

Rise Time is measured between the 10% and 90% points of the square-law detected RF power when the unit is switched from full OFF to full ON. See Fig. 5.

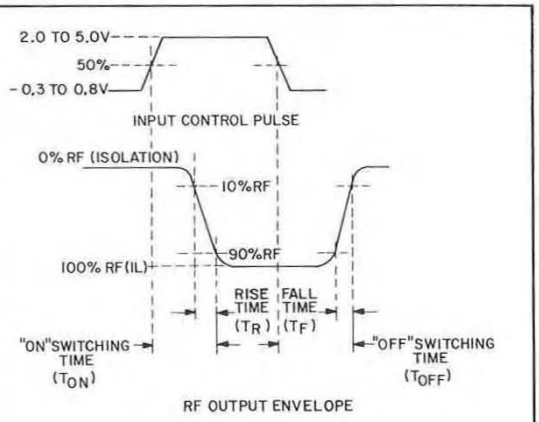


Fig. 5-Switching speed definition

Fall Time is the time between the 90% and 10% points of the square-law detected RF power when the unit is switched from full ON to full OFF.

On Time is measured from the 50% level of the input control signal to the 90% point of the square-law detected RF power when the unit is switched from full OFF to full ON.

Off Time is measured from the 50% level of the input control signal to the 10% point of the square-law detected RF power when the unit is switched from full ON to full OFF.

In addition to the above definitions, the following information about switching performance may be useful to the system designer.

Switching To Isolation - Although catalog switching speed specifications are usually defined to the 10% level of detected RF (equivalent to 10 dB isolation), the user of a switch may be more interested in the time the switch requires to reach rated isolation. This latter time is strongly dependent on the topology of the switch. For all-shunt mounted or combination series and shunt mounted topologies, the time to reach final isolation is usually less than twice the fall time. For an all-series topology, the time to reach final isolation may be as much as ten times the fall time.

Switching To Insertion Loss - For multi-throw switches, the ON time depends on whether the switch is being operated in a commutating or single port mode. In the former mode, switching speed is slower than in the latter due to the loading effect at the junction of the port turning OFF. All switching speed measurements at GMC are performed in the commutating mode.

PHASE AND AMPLITUDE MATCHING

Switches are available on a custom basis with phase and/or amplitude matching. Matching can be either between ports of a switch, between like ports on different switches, or a combination of the two. The uniformity of broadband catalog switches is quite good and is usually better than ±0.75 dB and ±15 degrees over the entire operating frequency of the switch. Please consult the factory for special requirements.

POWER HANDLING

The power handling of PIN diode switches is dependent on the RF topology, forward and reverse biasing levels, and speed of the switch. This catalog addresses both the maximum operating power levels and the survival limits of the components. Maximum operating limits are usually set at the power level which will cause the reversed biased diodes to begin conduction and thereby degrade the insertion loss, VSWR, or isolation of the switch. The survival power limits are based on the maximum ratings of the semiconductors in the switch. For special applications, significantly higher operational power levels can be provided, particularly for narrow band requirements. Please consult the factory for specific applications.

(2) *For a unit without an integrated driver, the specifications apply to conditions when it is driven by an appropriately shaped switching waveform.*

Switch Selection Guide

SWITCHES WITH INTEGRATED DRIVERS

FREQUENCY RANGE (GHz) 0.1 0.2 0.5 1 2 4 8 12.4 18	MODEL OR SERIES	PAGE	COMMENTS
REFLECTIVE SPST SWITCHES			
0.1 — 18	DM86, FM86	96	Ultra-broadband, low insertion loss
0.1 — 18	DM86H, FM86H	96	Ultra-broadband, high-speed
1 — 18	F91	99	Minature broadband
0.2 — 4	F9214A	99	Minature broadband
1 — 18	H9114	137	Hermetically sealed, low profile
1 — 18	HM9114	137	Hermetically sealed, drop-in module
NON-REFLECTIVE SPST SWITCHES			
0.2 — 18	HM192	135	Hermetically sealed, ultra-broadband
0.2 — 18	F192A	93	Ultra-broadband
REFLECTIVE SP2T SWITCHES			
0.2 — 18	DM870	102	Ultra-broadband
1 — 18	F91, G91	108	Miniature broadband
1 — 18	F91H	108	Miniature broadband, high-speed
0.2 — 4	F92, G92	108	Miniature broadband
1.5 — 4.5	F892	105	Octave-brand, high-speed
3 — 9	F892	105	Octave-brand, high-speed
6 — 18	F892	105	Octave-brand, high-speed
1 — 18	H9120H	138	Hermetically sealed, low profile
1 — 18	HM9120H	138	Hermetically sealed, drop-in module
NON-REFLECTIVE SP2T AND TRANSFER SWITCHES			
1 — 18	F91T, F91W, G91T, G91W	108	Miniature broadband
1 — 18	F91HT	108	Miniature broadband, high-speed
0.2 — 4	F92T, G92T	108	Miniature broadband
0.5 — 18	F940H	113	Broadband transfer switch
1 — 18	H9120HT	138	Hermetically sealed, low profile
1 — 18	HM9120HT	138	Hermetically sealed, drop-in module
REFLECTIVE SP3T SWITCHES			
1 — 18	F91, G91,	116	Miniature broadband
1 — 18	F91H	116	Miniature broadband, high-speed
0.2 — 4	F92, G92	116	Miniature broadband
1 — 18	H9130H	139	Hermetically sealed, low profile
1 — 18	HM9130H	139	Hermetically sealed, drop-in module
NON-REFLECTIVE SP3T SWITCHES			
1 — 18	F91T, F91W, G91T, G92W	116	Miniature broadband
1 — 18	F91HT	116	Miniature broadband, high-speed
0.2 — 4	F92T, G92T	116	Miniature broadband
1 — 18	H9130HT	139	Hermetically sealed, low profile
1 — 18	HM9130HT	139	Hermetically sealed, drop-in module
REFLECTIVE SP4T SWITCHES			
1 — 18	F91, G91,	120	Miniature broadband
1 — 18	F91H	120	Miniature broadband, high-speed
0.2 — 4	F92, G92	120	Miniature broadband
1 — 18	H9140H	140	Hermetically sealed, low profile
1 — 18	HM9140H	140	Hermetically sealed, drop-in module

Switch Selection Guide (Cont.)

SWITCHES WITH INTEGRATED DRIVERS (con't)

FREQUENCY RANGE (GHz) 0.1 0.2 0.5 1 2 4 8 12.4 18	MODEL OR SERIES	PAGE	COMMENTS
NON-REFLECTIVE SP4T SWITCHES			
1 — 18	F91T, F91W, G91T, G91W	120	Miniature broadband
1 — 18	F91HT		Miniature broadband, high-speed
0.2 — 4	F92T, G92T		Miniature broadband
1 — 18	H9140HT	140	Hermetically sealed, low profile
1 — 18	HM9140HT		Hermetically sealed, drop-in module
REFLECTIVE SP5T SWITCHES			
1 — 18	F91, G91,	124	Miniature broadband
0.2 — 4	F92, G92		
NON-REFLECTIVE SP5T SWITCHES			
1 — 18	F91T, F91W, G91T, G91W	124	Miniature broadband
0.2 — 4	F92T, G92T		
REFLECTIVE SP6T SWITCHES			
1 — 18	F91, G91,	127	Miniature broadband
0.2 — 4	F92, G92		
NON-REFLECTIVE SP6T SWITCHES			
1 — 18	F91T, F91W, G91T, G91W	127	Miniature broadband
0.2 — 4	F92T, G92T		
REFLECTIVE SP7T SWITCHES			
1 — 18	F91, G91,	130	Miniature broadband
0.2 — 4	F92, G92		
NON-REFLECTIVE SP7T SWITCHES			
1 — 18	F91T, F91W, G91T, G91W	130	Miniature broadband
0.2 — 4	F92T, G92T		

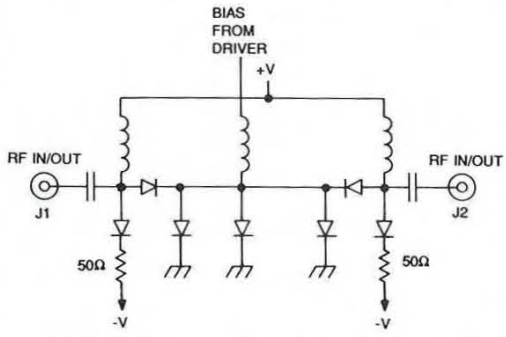
Switch Selection Guide (Cont.)

SWITCHES WITHOUT INTEGRATED DRIVERS

FREQUENCY RANGE (GHz) 0.1 0.2 0.5 1 2 4 8 12.4 18	MODEL OR SERIES	PAGE	COMMENTS
REFLECTIVE SPST SWITCHES			
0.1 — 18	M86	96	Ultra-broadband, low insertion loss
	M86H		Ultra-broadband, high-speed
1 — 18	91	99	Minature broadband
0.2 — 4	9214		
REFLECTIVE SP2T SWITCHES			
0.2 — 18	M870	102	Ultra-broadband
1 — 18	91	108	Miniature broadband
	91H		Miniature broadband, high-speed
0.2 — 4	92		Miniature broadband
NON-REFLECTIVE SP2T SWITCHES			
1 — 18	91T, 91W	108	Miniature broadband
	91HT		Miniature broadband, high-speed
0.2 — 4	92T		Miniature broadband
REFLECTIVE SP3T SWITCHES			
1 — 18	91	116	Miniature broadband
	91H		Miniature broadband, high-speed
0.2 — 4	92		Miniature broadband
NON-REFLECTIVE SP3T SWITCHES			
1 — 18	91T, 91W	116	Miniature broadband
	91HT		Miniature broadband, high-speed
0.2 — 4	92T		Miniature broadband
REFLECTIVE SP4T SWITCHES			
1 — 18	91	120	Miniature broadband
	91H		Miniature broadband, high-speed
0.2 — 4	92		Miniature broadband
NON-REFLECTIVE SP4T SWITCHES			
1 — 18	91T, 91W	120	Miniature broadband
	91HT		Miniature broadband, high-speed
0.2 — 4	92T		Miniature broadband
REFLECTIVE SP5T SWITCHES			
1 — 18	91	124	Minature broadband
0.2 — 4	92		
NON-REFLECTIVE SP5T SWITCHES			
1 — 18	91T, 91W	124	Minature broadband
0.2 — 4	92T		
REFLECTIVE SP6T SWITCHES			
1 — 18	91	127	Minature broadband
0.2 — 4	92		
NON-REFLECTIVE SP6T SWITCHES			
1 — 18	91T, 91W	127	Minature broadband
0.2 — 4	92T		
REFLECTIVE SP7T SWITCHES			
1 — 18	91	130	Minature broadband
0.2 — 4	92		
NON-REFLECTIVE SP7T SWITCHES			
1 — 18	91T, 91W	130	Minature broadband
0.2 — 4	92T		

Model F192A Non-Reflective Ultra-Broadband High-Speed SPST Switch

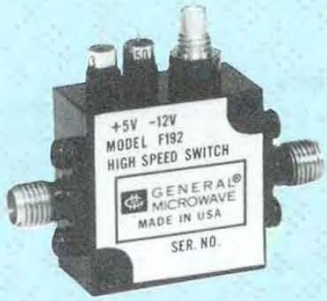
The Model F192A is a high-speed non-reflective PIN diode SPST switch with integrated driver. Operating over the instantaneous frequency range from 0.2 to 18 GHz, it provides a minimum isolation of 80 dB from 0.5 to 18 GHz, and 70 dB below 0.5 GHz. The rf design consists of an arrangement of shunt and series diodes in a microstrip integrated circuit transmission line as shown in the schematic diagram below.



Model F192A RF Schematic Diagram

The currents required to switch the unit ON or OFF and simultaneously maintain a bilateral 50-ohm impedance match in both states are provided by the integrated driver, which is controlled by an external logic signal.

- **High speed**
- **0.2 to 18 GHz frequency range**
- **80 dB isolation**
- **Low VSWR and insertion loss**
- **Small size, light weight**



Model F192A Specifications

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	FREQUENCY (GHz)				
	0.2 to 0.5	0.5 to 2.0	2.0 to 8.0	8.0 to 12.4	12.4 to 18.0
Min Isolation (dB)	70	80	80	80	80
Max Insertion Loss (dB)	2.0	2.0	2.5	3.0	3.5
VSWR (ON and OFF)	1.5	1.5	1.75	2.0	2.0

Switching Speed

Rise Time . . . . . 10 nsec. max.
Fall Time . . . . . 10 nsec. max.
ON Time . . . . . 30 nsec. max.
OFF Time . . . . . 15 nsec. max.

Power Handling Capability

Without Performance Degradation . . . . . 500 mW cw or peak
Survival Power . . . . . 1W average, 10W peak (1 μsec max. pulse width)

Power Supply Requirements

+5V ±5%, 90 mA
−12V ±5%, 75 mA

Control Characteristics

Control Input Impedance . . . . TTL, advanced Schottky, one-unit load. (A unit load is 0.6 mA sink current and 20μA source current.)
Control Logic . . . . Logic "0" (−0.3 to +0.8V) for switch ON and logic "1" (+2.0 to +5.0V) for switch OFF.

Model F192A Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −65°C to +110°C

Non-Operating Temperature Range . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

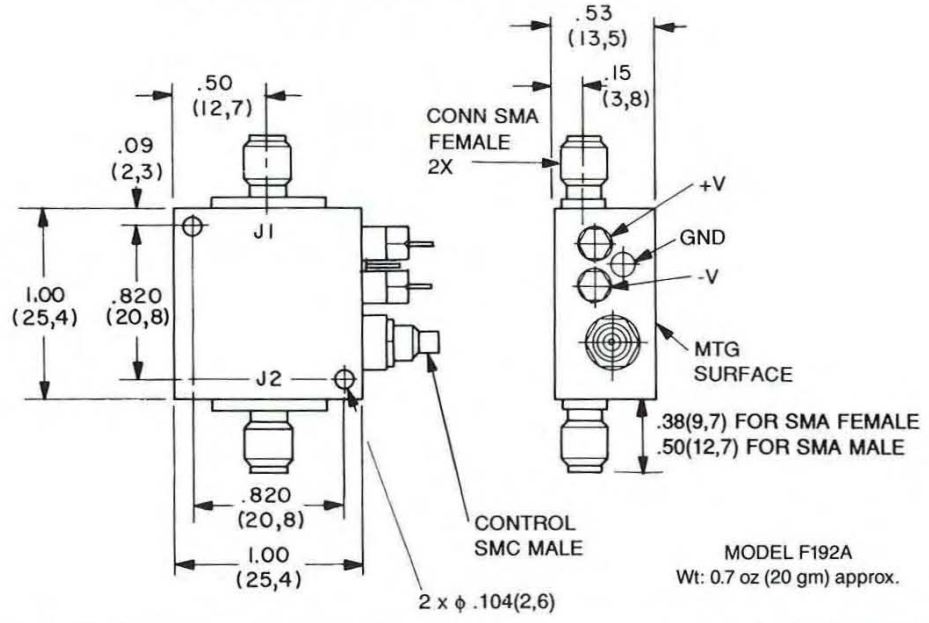
Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female control connector
7	Two SMA male rf connectors
9	Inverse control logic; logic "1" for switch ON and logic "0" for switch OFF
10	One SMA male (J1) and one SMA female (J2) rf connector
33	EMI filter solder-type control terminal
48	+5, −15V operation
64A	SMB male control connector

DIMENSIONS AND WEIGHT



MODEL F192A
Wt: 0.7 oz (20 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

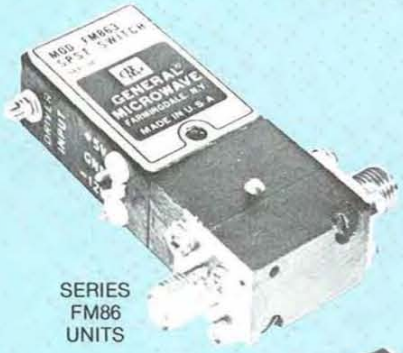
Series 86
Ultra-Broadband SPST Switches

- **Frequency range: 0.1 to 18 GHz**
- **Low VSWR and insertion loss**
- **Up to 80 dB isolation**
- **As fast as 10 nsec rise and fall times**
- **Small size, light weight**

DRIVERLESS UNITS

M862B

M864B



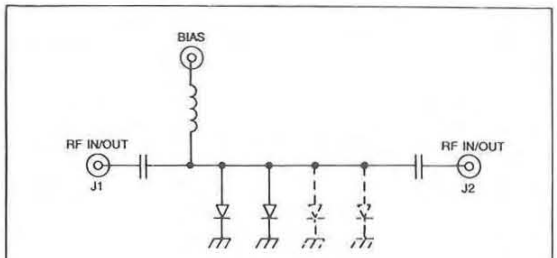
SERIES FM86 UNITS

UNITS WITH INTEGRATED DRIVERS

SERIES DM86 UNITS

SERIES M86

The Series M86 is a diverse group of high performance broadband SPST switches. Included are two low insertion loss models and four high speed models, all of which operate up to 18 GHz. Each model features an integrated circuit assembly of up to four PIN diodes mounted in a microstrip transmission line as well as a resistive bias line that contributes to the broadband low-loss performance. The circuit configuration is shown below. By applying positive current to the bias terminal, the diodes are biased to low resistances and the switch is OFF. With zero or negative voltage at the bias terminal, the diodes are biased to high resistances and the switch is ON.



Rf Schematic diagram

Low Insertion Loss Models

Models M862B and M864B operate over the frequency range from 0.1 to 18 GHz. They exhibit nominal isolation characteristics of 45 and 80 dB at 18 GHz, respectively, with maximum rise and fall times of 50 nanoseconds.

High Speed Models

For higher speed requirements, Models M862BH and M864BH are available. These operate from 0.5 to 18 GHz and feature maximum rise and fall times of 10 nanoseconds. Optional Models M862BH-25 and M864BH-25 operate from 0.1 to 18 GHz with maximum rise and fall times of 20 nanoseconds.

SERIES DM86 AND FM86

The Series DM86 and FM86 switches are the same as the corresponding Series M86 models except the units are equipped with integrated drivers. DM86 switches are powered by ± 15 volt supplies; FM86 units are powered by +5 and −12 to −15 volt supplies. The proper current required to switch the unit ON or OFF is provided by the driver, which is controlled by an external logic signal.

MODEL NO.[3]		CHARACTERISTIC	FREQUENCY (GHz)					
			0.1 to 1.0	1.0 to 2.0	2.0 to 4.0	4.0 to 8.0	8.0 to 12.4	12.4 to 18.0
LOW INSERTION LOSS MODELS	M862B DM862C FM862C	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	30 1.0 1.3	36 1.0 1.3	40 1.0 1.3	45 1.0 1.6	45 1.5 1.75	45 2.0 1.75
	M864B DM864C FM864C	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	37 1.0 1.4	60 1.0 1.4	74 1.0 1.4	80 1.3 1.7	80 1.8 1.75	80 2.5 2.2
HIGH SPEED MODELS[1]	M862BH DM862CH FM862CH	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	30 1.0 1.3	36 1.0 1.3	40 1.0 1.5	45 1.0 1.7	45 1.5 2.0	45 2.3 2.2
	M864BH DM864CH FM864CH	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	37 1.0 1.4	60 1.0 1.4	74 1.0 1.5	80 1.3 1.7	80 1.8 2.0	80 2.8 2.2

PERFORMANCE CHARACTERISTICS

Switching Characteristics[2]

	High Speed Models	Low Loss Models
Rise Time	10 nsec max.	20 nsec max.
Fall Time	10 nsec max.	20 nsec max.
ON Time	20 nsec max.	50 nsec max.
OFF Time	20 nsec max.	30 nsec max.
Repetition Rate	20 MHz max.	10 MHz max.

Power Handling Capability

Without Performance Degradation

Without Integrated Drivers . . . . . 1W cw or peak[4]

With Integrated Drivers . . . . . 1W cw or peak

Survival Power . . . . . 2W average, 75W peak (1 μsec max pulse width)

(1) *Models shown operate from 0.5 to 18 GHz. The addition of Option 25 to these models permits operation from 0.1 to 18 GHz, with max. rise and fall times of 20 nanoseconds.*

(2) *For driverless units, shaped current pulses must be provided by the user.*

(3) *Models prefixed with "DM" or "FM" are equipped with integrated TTL-compatible drivers; models prefixed with "M" only are current-controlled units and are furnished without drivers.*

(4) *5W cw or peak with −20V back bias.*

Series 86 Specifications

Power Supply Requirements

Driverless Units

For rated isolation: +35 mA
For rated insertion loss: −10V

Units With Integrated Drivers

All DM86 Units: +15V ±2%, 70 mA
−15V ±5%, 20 mA
All FM86 Units: +5VDC ±5%, 65 mA
−12 to −15V, 20 mA

Control Characteristics

Units With Integrated Drivers

Control Input Impedance . . . . . TTL, advanced Schottky one-unit load. (A unit load is 0.6 mA sink current and 20 μA source current.)

Control Logic
Series DM86 . . . . . Logic "0" (−0.3 to +0.8V) for switch OFF and logic "1" (+2.0 to +5.0V) for switch ON.

Series FM86 . . . . . Logic "0" (−0.3 to +0.8V) for switch ON and logic "1" (+2.0 to +5.0V) for switch OFF.

ENVIRONMENTAL RATINGS

Operating Temperature Range:
Series M86 . . . . . −65°C to +125°C
Series DM86 . . . . . −65°C to +85°C
Series FM86 . . . . . −65°C to +110°C

ENVIRONMENTAL RATINGS (Con't)

Non-Operating Temperature Range: . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

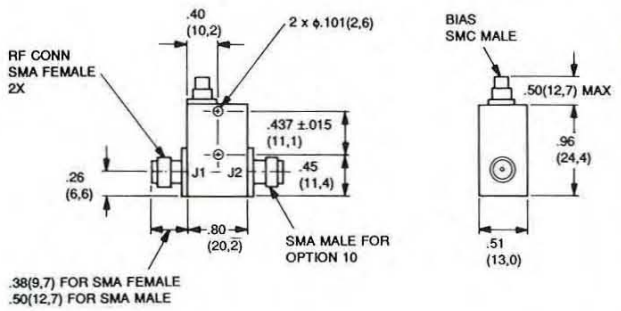
Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

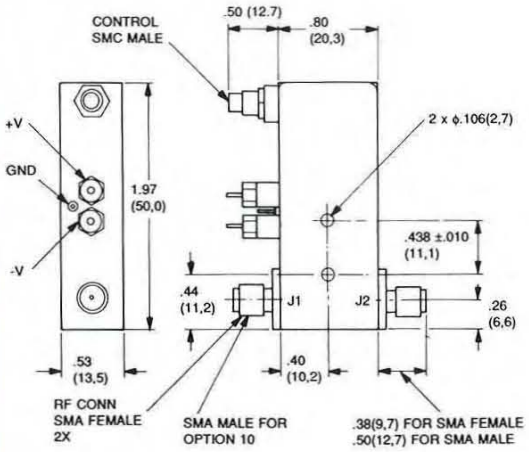
Option No.	Description
3	SMA female bias/control connector
7	Two SMA male rf connectors
9	Inverse control logic (Not applicable to Series M86)
10	One SMA male and one SMA female rf connector
20*	One unit load control input impedance
25	0.1 to 18 GHz range, 20 nsec rise and fall times (available only on high-speed models)
33	EMI filter solder-type bias/control terminal
64A	SMB male bias/control connector

**Not applicable to Series M86; standard in Series FM86 (need not be specified when ordering); all Series DM86 units are furnished with this option unless otherwise specified by customer. Other options, such as 50 ohms to ground, are available on special order.*

DIMENSIONS AND WEIGHTS



SERIES M86
Wt: 1 oz. (28 gm) approx.



SERIES DM86 AND FM86
Wt: 2 oz. (57 gm) approx.

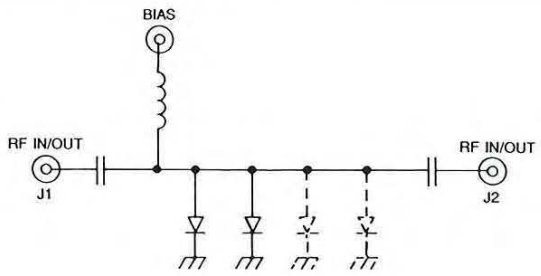
Dimensional Tolerances, unless otherwise indicated: .XX ±.02; .XXX ±.005

Series 91 and 92
Miniature Broadband SPST Switches

SERIES 91 AND 92

Series 91 and 92 switches provide high performance characteristics over a multi-octave range. Series 91 models cover the frequency range of 1 to 18 GHz, while Series 92 models cover the range from 0.2 to 4.0 GHz. These miniature switches measure only 0.75 × 0.69 × 0.38 inches.

Both series use an integrated circuit assembly of up to four PIN diodes mounted in a microstrip transmission line. The circuit configuration is shown below.



Rf schematic diagram

Application of a positive current to the bias terminal switches the unit OFF since the diodes are biased to a low resistance value. With zero or negative voltage at the bias terminal, the diodes are biased to high resistances and the unit is switched ON. Maximum rise and fall times are less than 10 nsec.

SERIES F91 AND F92

The Series F91 and F92 switches are the same as the corresponding Series 91 and 92 models except the units are equipped with integrated drivers, and the dimensions of the units are 0.75 × 0.75 × 0.38 inches. The proper current required to switch the unit ON or OFF is provided by the integral driver which requires +5 and −12 to −15 volt power supplies and is controlled by an external logic signal.

- **Frequency range (Series 91): 1 to 18 GHz**
- **Frequency range (Series 92): 0.2 to 4 GHz**
- **Low VSWR and insertion loss**
- **Up to 80 dB isolation**
- **Less than 10 nsec rise and fall time**
- **Miniature size, light weight**

F9114A

UNITS WITH INTEGRATED DRIVERS

F9214A

9112

DRIVERLESS UNITS

9212

Series 91 and 92 SPST Switches Specifications

PERFORMANCE CHARACTERISTICS

MODEL NO.[1]	CHARACTERISTIC	FREQUENCY (GHz) 0.2 to 0.5	0.5 to 1.0	1.0 to 2.0	2.0 to 4.0	4.0 to 8.0	8.0 to 12.4	12.4 to 18.0
9112, F9112A	Min Isolation (dB)	—	—	36	40	45	45	45
	Max Insertion Loss (dB)	—	—	0.8	0.8	0.9	1.1	1.8
	Max VSWR (ON)	—	—	1.3	1.3	1.6	1.75	1.75
9114, F9114A	Min Isolation (dB)	—	—	60	74	80	80	80
	Max Insertion Loss (dB)	—	—	0.9	0.9	1.0	1.6	2.5
	Max VSWR (ON)	—	—	1.4	1.4	1.75	1.75	2.0
9214, F9214A	Min Isolation (dB)	40	45	50	50	—	—	—
	Max Insertion Loss (dB)	1.0	1.0	1.0	1.0	—	—	—
	Max VSWR (ON)	1.5	1.5	1.5	1.5	—	—	—

Switching Speed[2]

Rise TIme..... 10 nsec max.
Fall Time..... 10 nsec max.
On Time..... 20 nsec max.
Off Time..... 20 nsec max.
Repetition Rate..... 20 MHz max.

Power Supply Requirements

Driverless Units

For rated isolation: +35 mA
For rated insertion loss: −10V

Units With Integrated Drivers

+5V ±5%, 65 mA
−12 to −15V, 20 mA

Power Handling Capability

Without Performance Degradation
Without integrated drivers
1W cw or peak[3]

With integrated drivers
1W cw or peak

Survival Power..... 2W average, 75W peak (1 μsec max. pulse width)

Control Characteristics

Control Input Impedance..... TTL, two-unit load. (A unit load is 1.6 mA sink current and 40 μA source current.)

Control Logic..... Logic "0" (−0.3 to +0.8V) for switch ON and logic "1" (+2.0 to +5.0V) for switch OFF.

(1) *Models prefixed with "F" are equipped with integrated TTL-compatible drivers; models without the "F" prefix are current-controlled units and are furnished without drivers.*
(2) *For driverless units, shaped current pulses must be provided by the user.*
(3) *2W cw or peak with −20V back bias.*

Series 91 and 92 SPST Switches Specifications

ENVIRONMENTAL RATINGS

Operating Temperature Range:
Series 91 and 92 . . . −65°C to +125°C
Series F91 and F92 . −65°C to +110°C

Non-Operating Temperature Range . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

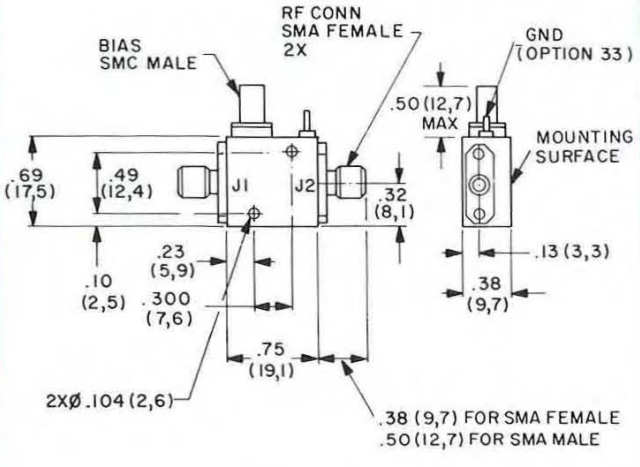
Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

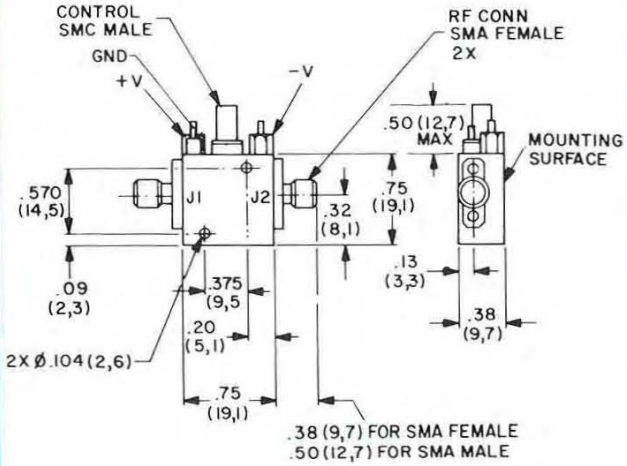
AVAILABLE OPTIONS

Option No.	Description
3	SMA female bias/control connector
7	Two SMA male rf connectors
9	Inverse control logic; logic "0" for switch OFF, logic "1" for switch ON (Not applicable to Series 91/92)
10	One SMA male (J1) and one SMA female (J2) rf connector
33	EMI filter solder-type bias/control terminal
41	Internal video filter, port J1 only
42	Internal video filter, port J2 only
43	Internal video filter, both ports
64A	SMB male bias/control connector

DIMENSIONS AND WEIGHTS



SERIES 91 AND 92
Wt: .39 oz. (11 gm) approx.



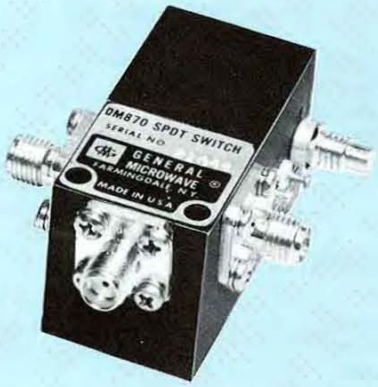
SERIES F91 AND F92
Wt: .43 oz. (12 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ±.02; .XXX ±.005

Models M870 and DM870
Ultra-Broadband SP2T Switches

- **Frequency range: 0.2 to 18 GHz**
- **Low VSWR and insertion loss**
- **Up to 60 dB isolation**
- **Small size, light weight**

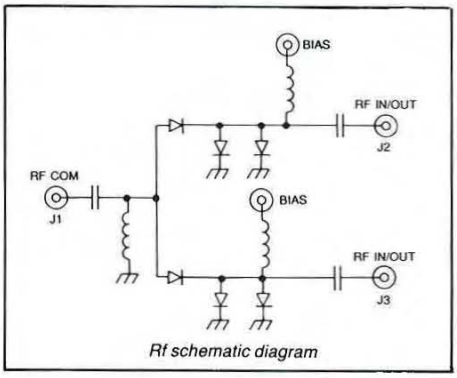
M870 (DRIVERLESS)



DM870
(WITH INTEGRATED
DRIVER)

MODEL M870

Model M870 is a high-performance broadband single-pole two-throw switch that operates over the full instantaneous bandwidth of 0.2 to 18 GHz. Design features include an integrated circuit assembly of PIN diodes mounted in a microstrip transmission line as well as a resistive bias line that contributes to the broadband low-loss performance. The circuit configuration of the Model M870 is shown below.



Rf schematic diagram

By applying positive current to a bias terminal, the associated port is OFF since the corresponding shunt diodes are biased to a low resistance and the series diode to a high resistance. With negative current at the bias terminal, the converse conditions are established and the port is ON. Since bias terminals are individually available for both ports, the user has the option of operating with either or both ports ON or OFF.

MODEL DM870

The Model DM870 is the same as the Model M870 except it is equipped with an integrated driver that is powered by + 15 and − 12 to − 15 volt supplies. The proper currents required to switch the ports ON or OFF are provided by the driver, which is controlled by external logic signals. Standard units are wired so that one port is biased ON and the other OFF at all times. See AVAILABLE OPTIONS for independent port control.

Models M870 and DM870 Specifications

MODEL NO. (2)	CHARACTERISTIC	FREQUENCY (GHz)			
		0.2 to 4.0	4.0 to 8.0	8.0 to 12.4	12.4 to 18.0
M870 DM870	Min Isolation (dB)	60	55	55	55
	Max Insertion Loss (dB)	1.5	1.5	1.75	2.2
	Max VSWR (ON)	1.5	1.75	1.75	2.0

PERFORMANCE CHARACTERISTICS

Switching Speed (port to port) . . . . . 2 μsec max.(1)

Power Handling Capability

Without Performance Degradation . . 1W cw or peak

Survival Power . . . . . 1W average, 75W peak (1 μsec max. pulse width)

Power Supply Requirements

MODEL M870

Bias current required at each port for rated isolation and insertion loss(3)

Port OFF . . . . . +30 mA

Port ON . . . . . −30 mA

MODEL DM870 (For one port ON)

+5V ±2%, 65 mA

−12 to −15V, 65 mA

Control Characteristics

MODEL DM870

Control Input Impedance . . TTL, low power Schottky, two unit load. (A unit load is 0.8 mA sink current and 40 μA source current.)

Control Logic . . . . . One port ON and one port OFF. Logic "0" (−0.3 to +0.8V) connects J1 to J3. Logic "1" (+2.0 to +5.0V) connects J1 to J2.

(1) *Switching speed, defined as the interval between the instant the rf power level in the port switched OFF drops to 90% of its original value and the instant the rf power level in the port switched ON rises to 90% of its final value, is rated for ports driven by shaped current pulses. For the Model DM870, the pulses are provided by the integrated driver. For the Model M870, the pulses must be provided by the user.*

(2) *DM870 is equipped with an integrated TTL compatible driver; M870 is a current-controlled unit that is furnished without a driver.*

(3) *For operation of Models M870 with more than one port ON, total negative current must be limited to −40 mA. Do not apply more than 75 mA to any OFF port or more than −40 mA to any ON port.*

Models M870 and DM870 Specifications

ENVIRONMENTAL RATINGS

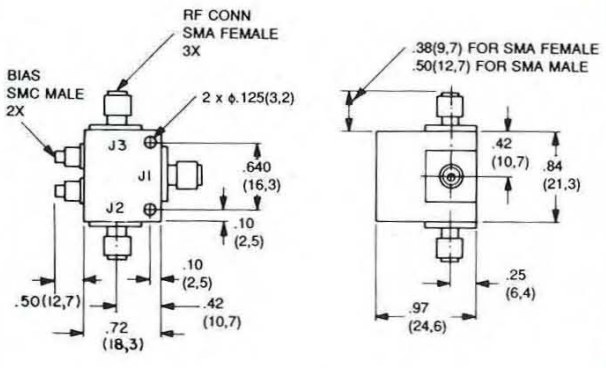
Operating Temperature Range	
Model M870	−65 °C to +125 °C
Model DM870	−65 °C to +110 °C
Non-Operating Temperature Range	−65 °C to +125 °C
Humidity	MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration	MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)
Altitude	MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling	MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

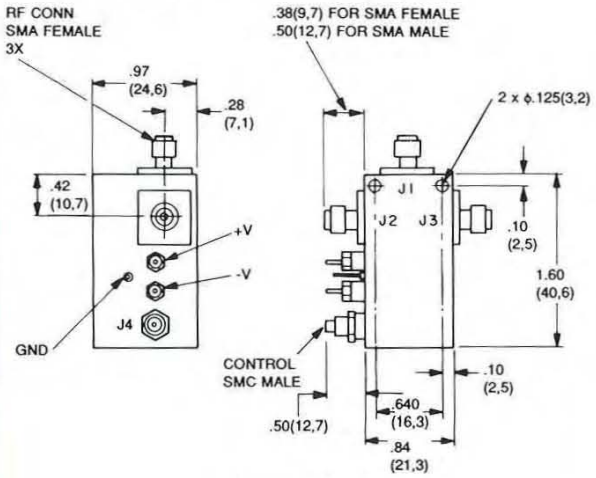
Option No.	Description
7	SMA male rf connectors
7A	J1 SMA male; J2 and J3 SMA female
7B	J1 SMA female; J2 and J3 SMA male
9	Inverse control logic; logic "0" for port ON and logic "1" for port OFF (available only in conjunction with Option 22)
20(1)	Two unit load control input impedance
22	Individual port control (DM 870 only — one unit load); logic "0" for port OFF and logic "1" for port ON. Also available with logic "0" for port ON and logic "1" for port OFF (Specify Option 9)
33	EMI Filter solder-type bias/control terminal
64A	SMB male bias/control connector

(1) *Not applicable to Model M870. All Models DM870 are furnished with this option unless otherwise specified by customer. Other options, such as 50 ohms to ground, are available on special order.*

DIMENSIONS AND WEIGHTS



MODEL M870
Wt: 1.5 oz. (43 gm) approx.



MODEL DM870
Wt: 2.5 oz (71 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series F892
High-Speed Octave-Band SP2T Switches

SERIES F892

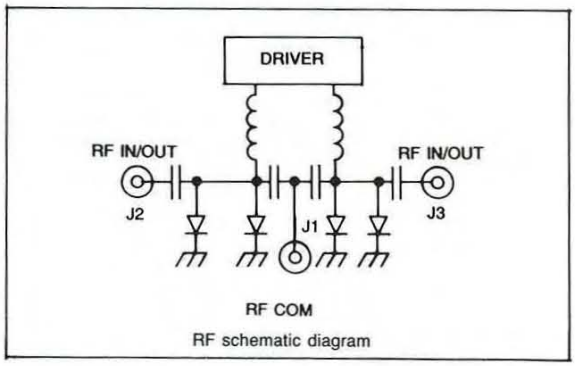
Series F892 high speed switches with integrated drivers are low-cost units that have been engineered to meet the need of microwave system designers for fast switching devices in small packages.

2 To 18 GHz Frequency Range

Frequency coverage from 2 to 18 GHz is provided by the three models in the Series: Model F8922 (2-4 GHz), Model F8924 (4-8 GHz) and Model F8928 (8-18 GHz). Each model is capable of extended bandwidth operation, typically 3:1, with only moderate degradation in performance at the band edges, as shown in the specifications on page 106.

Fast Switching Shunt Design

All models are optimally designed, with respect to their size, for low VSWR and insertion loss. As shown in the schematic below, a pure shunt design is used for the most practical realization of fast switching action. Although the use of a pure shunt mode imposes certain bandwidth limitations, frequency coverage in excess of octave bands has been maintained.



RF schematic diagram

The proper currents required to switch ports ON or OFF are provided by the integrated drivers which are controlled by external logic signals.

- **Low Cost**
- **S, C and X-U band models**
- **10 nsec rise and fall times**
- **Up to 60 dB isolation**
- **As low as 1.0 dB insertion loss**


F8928


F8924


F8922

THE THREE UNITS IN THIS SERIES ARE EQUIPPED WITH INTEGRATED DRIVERS

Series F892 Specifications

PERFORMANCE CHARACTERISTICS

MODEL NO.	FREQUENCY RANGE (GHz)	INSERTION LOSS, MAX. (dB)	ISOLATION MIN. (dB)	VSWR MAX. (ON)
F8922	2-4	1.0	60	1.5
	1.5-4.5	2.0	55	2.0
F8924	4-8	1.4	50	1.5
	3-9	2.3	45	2.2
F8928	8-18	2.3	45(2)	2.2
	6-18	2.5	45(2)	2.5

Switching Characteristics

Rise Time . . . . . 10 nsec max.
Fall Time . . . . . 10 nsec max.

ON Time . . . . . 35 nsec max.
OFF Time . . . . . 30 nsec max.

Repetition rate . . . . . 10 MHz max.

Power Handling Capability

Without Performance Degradation . . . . . 2W cw or peak(1)

Survival Power . . . . . 2W average, 75W peak (1 μsec max pulse width)

Control Characteristics

Control Input Impedance . . . . . Schottky TTL, one-unit load. (A unit load is 2.0 mA sink current and 50 μA source current.)

Control Logic . . . . . Logic "0" (−0.3 to +0.8V) for port ON and logic "1" (+2.0 to +5.0V) for port OFF

Power Supply Requirements

(For one port ON) . . . +5V ±5%, 65 mA
−12 to −15V(1), 2 mA

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −65°C to +110°C

Non-Operating Temperature Range . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

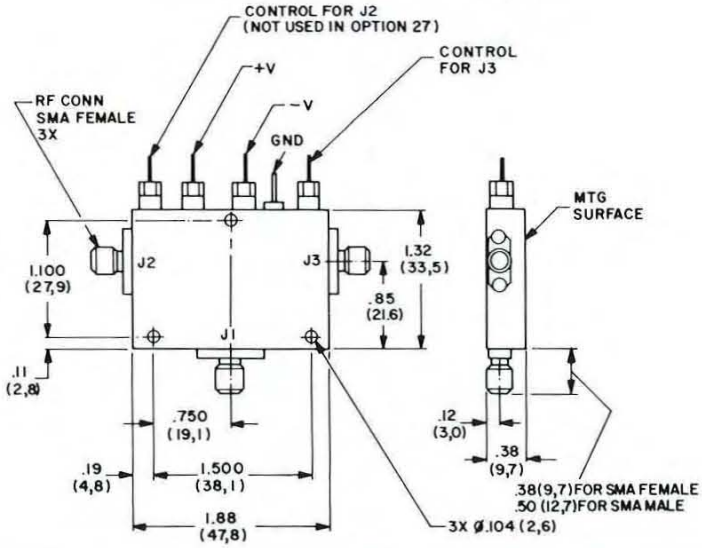
AVAILABLE OPTIONS

Option No.	Description
3	SMA female control connectors
7	SMA male rf connectors
7A	J1 SMA male; J2 and J3 SMA female
7B	J1 SMA female; J2 and J3 SMA male
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON
27	Single-port toggle control; logic "0" connects J1 to J2
62	±15V operation
64	SMC male control connectors
64A	SMB male control connectors
65	±12V operation

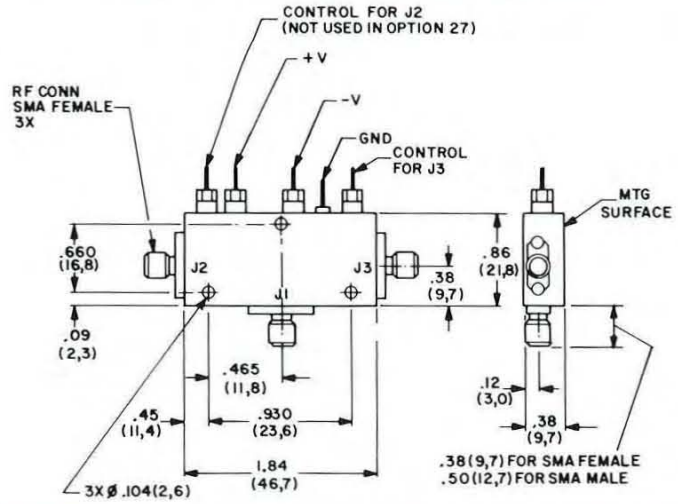
(1) With −15V power supply. Reduces to 1.5W with −12V power supply. Units can be operated at higher input power levels with some increase in switching time when −30V power supply is used.
(2) Isolation 40 dB above 16 GHz.

DIMENSIONS AND WEIGHTS

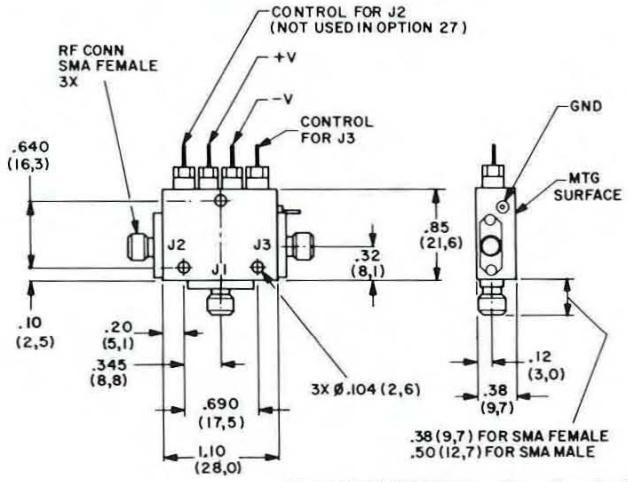
MODEL F8922
Wt: 1.5 oz. (43 gm) approx.



MODEL F8924
Wt: 1 oz. (28 gm) approx.



MODEL F8928
Wt: 1 oz. (28 gm) approx.



Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx ±.005

Series 91 and 92
Miniature Broadband SP2T Switches

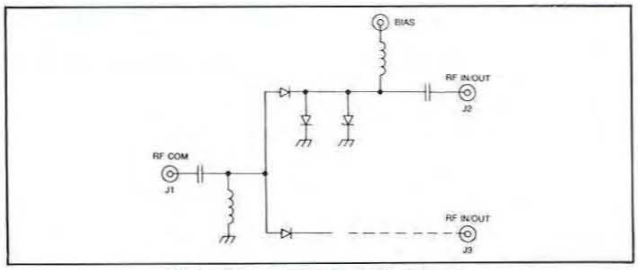
- **Frequency range (Series 91): 1 to 18 GHz**
- **Frequency range (Series 92): 0.2 to 4 GHz**
- **Rise and fall times as fast as 10 nsec**
- **Reflective and nonreflective models**
- **Low VSWR and insertion loss**
- **Miniature size, light weight**

F9120
(WITH INTEGRATED DRIVER)

9120-500
(DRIVERLESS)

MODELS 9120-500 AND 9220-500

These switches provide high-performance characteristics over a multi-octave frequency range. Model 9120-500 covers the frequency range of 1 to 18 GHz; Model 9220-500 covers the frequency range of 0.2 to 4 GHz. Both models use an integrated circuit assembly of a series-shunt configuration of PIN diodes mounted in a microstrip transmission line as shown below.



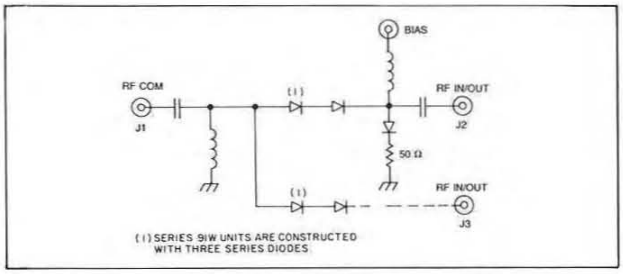
Series 91 and 92 schematic diagram

Port Control

By applying positive current to a bias terminal, the associated port is OFF since the corresponding shunt diodes are biased to a low resistance and the series diode to a high resistance. With negative current at the bias terminal, the converse conditions are established and the port is ON. Since bias terminals are individually available for both ports, the user has the option of any combination of ports ON or OFF.

MODELS 9120T-500, 9120W-500 AND 9220T-500

These switches are non-reflective versions of the switches described above. They are constructed in the configuration shown below.



Series 91T, 92T and 91W schematic diagram

When positive current is applied, the port is OFF since the associated series diodes are back-biased to a high resistance. At the same time, the corresponding shunt diode is biased to a low resistance, and the impedance at the port is then effectively that of the 50 ohm resistor in series with the shunt diode.

When applying negative current, the converse conditions are established and the port is ON.

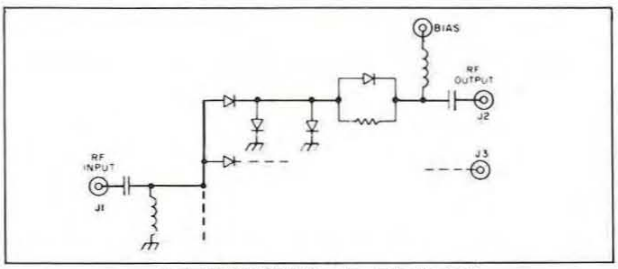
Note that when all output ports are OFF, a high VSWR will be present at the common port.

MODEL 9120AH-500

This switch has the same circuit topology as the 9120-500 except it is equipped with high-speed diodes to achieve rise and fall times of 10 nsec.

MODEL 9120AHT-500

This switch is similar to the 9120AH-500 except it includes a terminating network as shown below.



Model 9120AHT-500 schematic diagram

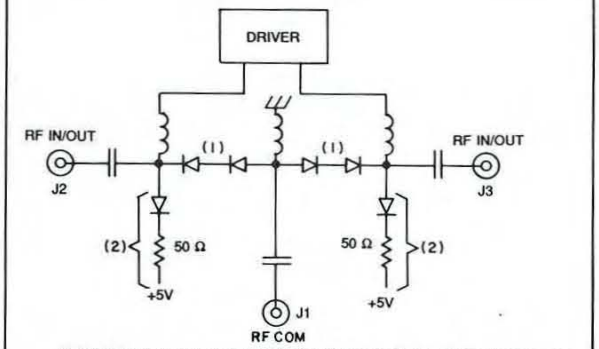
SERIES F91/F92

The Series F91/F92 units are the same as the Series 91/92 units except they are equipped with integrated drivers that are powered by +5 and −12 to −15 V supplies. The proper currents required to switch the ports ON or OFF are provided by the drivers, which are controlled by external control signals. Standard units are wired so that a port is ON with the application of a logic "0" control signal.

Series 91 and 92
Miniature Broadband SP2T Switches

SERIES G91 and G92

Operating from +5 and +15V power supplies only, the G-series switches provide high performance characteristics at relatively high speeds over multi-octave frequency ranges. The series includes low insertion loss and high isolation models in both reflective and non-reflective configurations. Series G91 units cover the frequency range of 1 to 18 GHz; Series G92 units cover the frequency range of 0.2 to 4 GHz. The design is based on an integrated circuit assembly of PIN diodes mounted in a microstrip transmission line as shown below. The currents required to switch the ports ON or OFF are provided by the integrated driver, which is controlled by external TTL logic signals.



(1) SERIES G91W UNITS ARE CONSTRUCTED WITH THREE SERIES DIODES.
(2) DELETE FOR UNITS WITHOUT "T" OR "W" SUFFIX.

Model G9120( ), rf schematic diagram

SERIES G91T/G92T and G91W

These switches are non-reflective versions of the switches described above.

- **Frequency range (Series G91): 1 to 18 GHz**
- **Frequency range (Series G92): 0.2 to 4 GHz**
- **Rise times as fast as 75 nsec**
- **Reflective and nonreflective models**
- **Low VSWR and insertion loss**
- **Up to 60 dB isolation**
- **Positive dc supplies only**
- **Miniature size, light weight**

MODEL G9120

Series 91 and 92 SP2T Switches Specifications

MODEL NO. (1)	CHARACTERISTIC	FREQUENCY (GHz)					
		0.2-1	1-2	2-4	4-8	8-12.4	12.4-18
9120-500 **F9120**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.1 1.75	60 1.1 1.75	60 1.4 1.75	60 2.0 1.75	50 2.5 2.0
G9120	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.8 1.5	60 1.8 1.5	60 1.8 1.5	60 2.2 1.5	50 2.5 2.0
9220-500 **F9220**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.5 1.5	60 1.5 1.5	60 1.5 1.5	– – –	– – –	– – –
G9220	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.8 1.5	60 1.8 1.5	60 1.8 1.5	– – –	– – –	– – –
9120T-500 **F9120T** **G9120T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	50 1.2 1.5	50 1.2 1.5	50 1.5 1.5	45 1.5 1.5	40 2.2 2.0
9220T-500 **F9220T** **G9220T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	60 1.2 1.5	60 1.2 1.5	60 1.2 1.5	– – –	– – –	– – –
9120W-500 **F9120W** **G9120W**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	60 1.8 1.5	60 1.8 1.5	60 1.8 1.5	60 2.2 1.5	55 2.5 2.0
9120AH-500 **F9120AH**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.1 1.75	60 1.1 1.75	60 1.4 1.75	60 2.0 1.75	50 2.5 2.0
9120AHT-500 **F9120AHT**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON) Max VSWR (OFF)	– – – –	60 1.3 1.75 1.75	60 1.3 1.75 1.75	60 1.7 1.9 2.0	60 2.5 2.0 2.2	50 3.0 2.0 2.3

PERFORMANCE CHARACTERISTICS

Power Handling Capability

Without Performance Degradation
- Units without "T" or "W" suffix: 1W cw or peak
- Units with "T" or "W" suffix
  - Input to any "OFF" port: 100 mW cw or peak
  - Input to any "ON" port: 1W cw or peak
  - Input to common port: 1W cw or peak

Survival Power
- Units without "T" or "W" suffix: 1W average, 75W peak (1 μsec max. pulse width)
- Units with "T" or "W" suffix
  - Input to any "OFF" port : 1W average, 10W peak (1 μsec max. pulse width)
  - Input to any "ON" port: 1W average, 75W peak (1 μsec max. pulse width)
  - Input to common port: 1W average, 75W peak (1 μsec max. pulse width)

(1) *Models prefixed with "F" or "G" are equipped with integrated TTL-compatible drivers; models without the "F" or "G" prefix are current-controlled units and are furnished without drivers; models suffixed with "T" or "W" are non-reflective except a high VSWR will be present at the common port if all other ports are OFF; models suffixed with "H" are high-speed units.*

Switching Characteristics(1)

SERIES 91/F91/F92

Units without "H" suffix
ON time . . . . . 500 nsec max.
OFF time . . . . . 500 nsec max.

Units with "H" suffix
Rise time . . . . . 10 nsec max.
Fall time . . . . . 10 nsec max.
ON time . . . . . 25 nsec max.
OFF time . . . . . 20 nsec max.
Repetition rate . . . . . 20 MHz max.

SERIES G91/G92
ON time . . . . . 250 nsec max.
OFF time . . . . . 250 nsec max.

Power Supply Requirements

SERIES 91/92/F91/F92

Driverless Units

Bias current required at each port for rated isolation and insertion loss

PORT OFF
Units without "H" suffix . . . +50mA
Units with "H" suffix . . . . . +30mA

PORT ON
Units without "H" suffix . . . −50mA
Units with "H" suffix . . . . . −35mA

Units With Integrated Drivers

(For one port ON)	+5V ±5%	−12 to −15V
Units Without "H" Suffix	65 mA	65 mA
Units With "H" Suffix	60 mA	50 mA
Units With "HT" Suffix	80 mA	50 mA

SERIES G91/G92
(For one Port ON)
+5V ±5%, 100 mA
+15V ±5%, 30 mA

(1) *For driverless units, shaped current pulses must be provided by user.*

Control Characteristics

SERIES 91/92/F91/F92

Units With Integrated Drivers

Control Input Impedance
Units without "H" suffix . . . TTL, low power Schottky, one unit load. (A unit load is 0.8 mA sink current and 40 μA source current.)

Units with "H" suffix . . . . . TTL, advanced Schottky, one unit load. (A unit load is 0.6 mA sink current and 20 μA source current.)

Control Logic . . . . . Logic "0" (−0.3 to +0.8 V) for port ON and logic "1" (+2.0 to +5.0 V) for port OFF.

SERIES G91/G92

Control Input Impedance . . Schottky TTL, one unit load. (A unit load is 2.0 mA sink current and 50 μA source current.)

Control Logic . . . . . Logic "0" (−0.3 to +0.8 V) for port ON and logic "1" (+2.0 to +5.0 V) for port OFF.

Series 91 and 92 SP2T Switches Specifications

ENVIRONMENTAL RATINGS

Temperature Range

Units With Integrated Drivers

Operating ..... −65°C to +110°C

Non-Operating ..... −65°C to +125°C

Driverless Units

Operating and Non-Operating ..... −65°C to +125°C

Humidity ..... MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

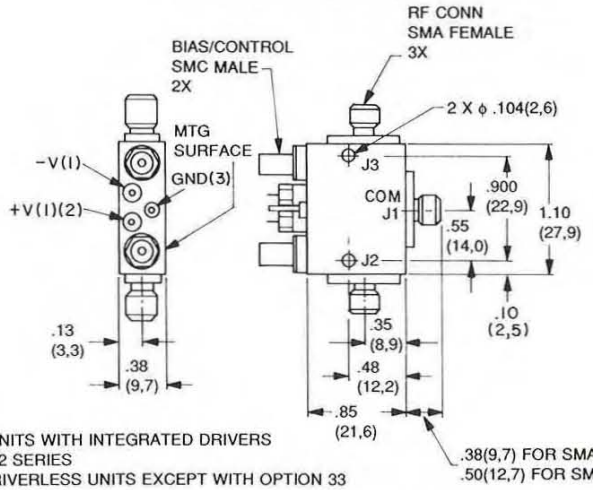
Altitude ..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling ..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female bias/control connectors
7	J1, J2 and J3 SMA male
7A	J1 SMA male; J2 and J3 SMA female
7B	J1 SMA female; J2 and J3 SMA male
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON (Not applicable to Series 91/92)
27	Single-port toggle control; logic "0" connects J1 to J2 (Not applicable to Series 91/92)
33	EMI filter solder-type bias/control terminals
41	Internal video filter, common port only
42	Internal video filter, output ports only
43	Internal video filter, all ports
64A	SMB male bias/control connectors

DIMENSIONS AND WEIGHT



SERIES 91/92/F91/F92/G91/G92
Wt: .75 oz. (21 gm) approx.

(1) USED ONLY ON UNITS WITH INTEGRATED DRIVERS
(2) +15V FOR G91/G92 SERIES
(3) NOT USED ON DRIVERLESS UNITS EXCEPT WITH OPTION 33

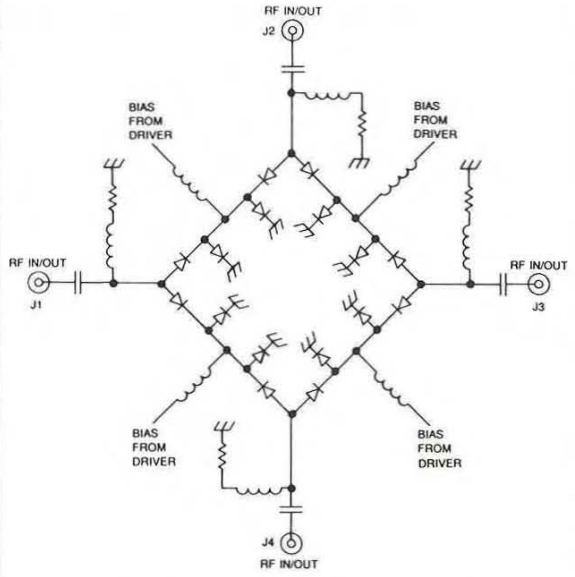
Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Model F940H
Broadband Transfer Switch

With Integrated Driver

MODEL F940H

Model F940H is a high-performance broadband transfer switch that operates over the full instantaneous bandwidth of 0.5 to 18 GHz with ON and OFF times of 30 nsec. Design features include an integrated circuit assembly of PIN diodes mounted in a microstrip transmission line as well as a resistive bias line that contributes to the broadband low-loss performance. The circuit configuration of the Model F940H is shown below.



Model F940H Schematic Diagram

The Model F940H is equipped with an integrated driver that is powered by +5 and −12 volt supplies. The proper currents required to switch the ports ON or OFF are provided by the driver, which is controlled by external logic signals.

- **Frequency range: 0.5 to 18 GHz**
- **Low VSWR and insertion loss**
- **Isolation: up to 60 dB**
- **Small size, light weight**

Model F940H Specifications

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	FREQUENCY (GHz)		
	0.5 to 8.0	8.0 to 12.4	12.4 to 18.0
Min Isolation (dB)	60	55	50
Max Insertion Loss (dB)	2.0	2.5	3.0
Max VSWR	1.75	1.75	2.0

Switching Time
ON Time . . . . . 30 nsec max
OFF Time . . . . . 30 nsec max

Power Handling Capability
Without Performance Degradation . . . . . 500 mW cw or peak
Survival Power . . . . . 1W average, 75W peak (1 μsec max pulse width)

Power Supply Requirements

+5V ±5%, 100 mA
−12V ±5%, 60 mA

Control Characteristics

Control Input Impedance . . . . . Schottky TTL, two unit loads. (A unit load is 2 mA sink current and 50 μA source current.)

Control Logic . . . . . Logic "O" (−0.3 to +0.8V) connects J1 to J2 and J3 to J4. Logic "1" (+2.0 to +5.0V) connects J1 to J4 and J2 to J3.

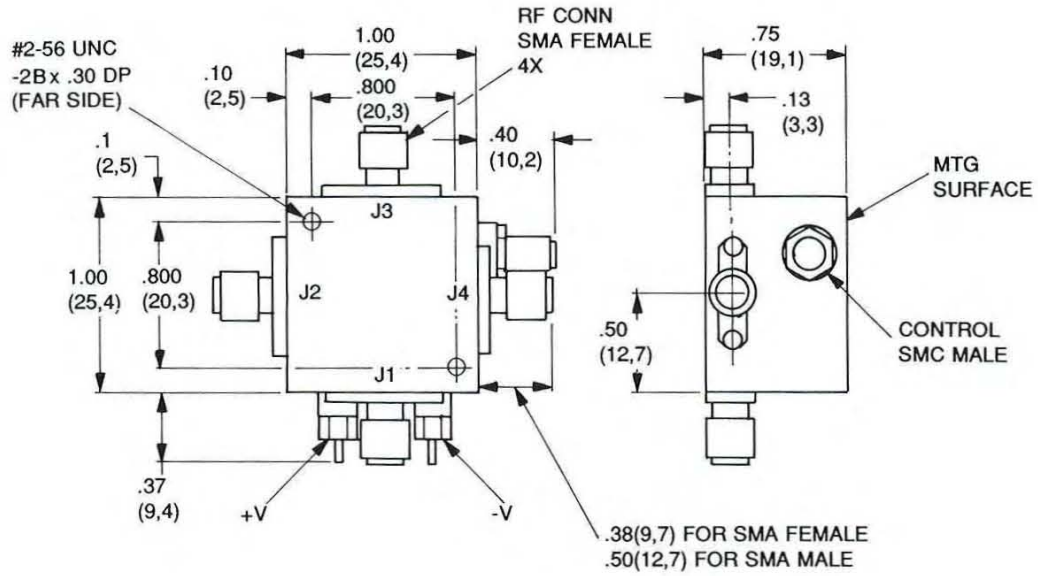
ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . −65°C to +110°C
Non-Operating Temperature Range . . . . . −65°C to +125°C
Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)
Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
7	SMA male rf connectors
9	Inverse control logic; logic "0" connects J1 to J4 and J2 to J3, and logic "1" connects J1 to J2 and J3 to J4
33	EMI filter solder-type control terminal
64A	SMB male control connector

DIMENSIONS AND WEIGHT



MODEL F940H
Wt: 1.1 oz (31 gm) approx.

Dimensional Tolerances, unless otherwise indicated: . xx ± .02; .xxx ± .005

Series 91 and 92
Miniature Broadband SP3T Switches

- **Frequency range (Series 91): 1 to 18 GHz**
- **Frequency range (Series 92): 0.2 to 4 GHz**
- **Rise and fall times as fast as 10 nsec**
- **Reflective and nonreflective models**
- **Low VSWR and insertion loss**
- **Isolation: up to 60 dB**
- **Miniature size, light weight**

9130-500 (DRIVERLESS)

F9130
(WITH INTEGRATED
DRIVER)

MODELS 9130-500 AND 9230-500

These switches provide high-performance characteristics over a multi-octave frequency range. The Model 9130-500 covers the 1 to 18 GHz frequency range while the Model 9230-500 covers the 0.2 to 4 GHz range. This description and operation are the same as that for the Models 9120-500 and 9220-500 SP2T switches.

MODELS 9130T-500, 9130W-500 AND 9230T-500

These switches are non-reflective versions of the switches described above.

MODELS 9130AH-500 AND 9130AHT-500

These switches are the same as the 9120AH-500 and 9120AHT-500 except for the number of ports.

SERIES F91 AND F92

The Series F91 and F92 switches are the same as the corresponding Series 91 and 92 models, except the units are equipped with integrated drivers.

SERIES G91 AND G92

These switches are the same as the Series G91 and G92 SP2T switches except for the number of ports.

Series 91 and 92 SP3T Switches Specifications

MODEL NO. (1)	CHARACTERISTIC	FREQUENCY (GHz)					
		0.2-1	1-2	2-4	4-8	8-12.4	12.4-18
9130-500 **F9130**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.5 1.75	60 1.5 1.75	60 1.5 1.75	60 2.0 1.75	50 2.5 2.0
G9130	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.8 1.5	60 1.8 1.5	60 2.0 1.7	60 2.5 1.7	50 2.8 2.0
9230-500 **F9230**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.5 1.5	60 1.5 1.5	60 1.5 1.5	– – –	– – –	– – –
G9230	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.8 1.5	60 1.8 1.5	60 1.8 1.5	– – –	– – –	– – –
9130T-500 **F9130T** **G9130T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	50 1.4 1.5	50 1.4 1.5	45 1.6 1.7	40 1.8 1.7	40 2.5 2.0
9230T-500 **F9230T** **G9230T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	60 1.2 1.5	60 1.2 1.5	50 1.4 1.5	– – –	– – –	– – –
9130W-500 **F9130W** **G9130W**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	60 1.8 1.5	60 1.8 1.5	60 2.0 1.7	60 2.5 1.7	55 2.8 2.0
9130AH-500 **F9130AH**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.2 1.75	60 1.2 1.75	60 1.5 1.75	60 2.0 1.75	50 2.6 2.0
9130AHT-500 **F9130AHT**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON) Max VSWR (OFF)	– – – –	60 1.6 1.75 1.75	60 1.6 1.75 1.75	60 1.8 1.9 2.0	60 2.5 2.0 2.2	50 3.3 2.0 2.3

PERFORMANCE CHARACTERISTICS

Power Handling Capability

Without Performance Degradation
- Units without "T" or "W" suffix: 1W cw or peak
- Units with "T" or "W" suffix
  - Input to any "OFF" port: 100 mW cw or peak
  - Input to any "ON" port: 1W cw or peak
  - Input to common port: 1W cw or peak

Survival Power
- Units without "T" or "W" suffix: 1W average, 75W peak (1 μsec max. pulse width)
- Units with "T" or "W" suffix
  - Input to any "OFF" port : 1W average, 10W peak (1 μsec max. pulse width)
  - Input to any "ON" port: 1W average, 75W peak (1 μsec max. pulse width)
  - Input to common port: 1W average, 75W peak (1 μsec max. pulse width)

(1) *Models prefixed with "F" or "G" are equipped with integrated TTL-compatible drivers; models without the "F" or "G" prefix are current-controlled units and are furnished without drivers; models suffixed with "T" or "W" are non-reflective except a high VSWR will be present at the common port if all other ports are OFF; models suffixed with "H" are high-speed units.*

Series 91 and 92 SP3T Switches Specifications

Switching Characteristics[1]

SERIES 91/92/F91/F92

Units without "H" suffix

ON time . . . . . 500 nsec max.
OFF time . . . . . 500 nsec max.

Units with "H" suffix

Rise time . . . . . 10 nsec max.
Fall time . . . . . 10 nsec max.
ON time . . . . . 25 nsec max.
OFF time . . . . . 20 nsec max.
Repetition rate . . . . . 20 MHz max.

SERIES G91/G92

ON time . . . . . 250 nsec max.
OFF time . . . . . 250 nsec max.

Power Supply Requirements

SERIES 91/92/F91/F92

Driverless Units

Bias current required at each port for rated isolation and insertion loss

Port OFF
Units without "H" suffix . . . . . + 50 mA
Units with "H" suffix . . . . . + 30 mA
Port ON
Units without "H" suffix . . . . . – 50 mA
Units with "H" suffix . . . . . – 35 mA

Units With Integrated Drivers

(For one port ON)

	+5V ±5%	–12 to –15V
Units Without "H" Suffix	130 mA	60 mA
Units With "H" Suffix	75 mA	55 mA
Units With "HT" Suffix	105 mA	55 mA

SERIES G91/G92
(For one port ON)
+5V ±5%, 100 mA
+15V ±5%, 40 mA

(1) *For driverless units, shaped current pulses must be provided by user.*

Control Characteristics

SERIES 91/92/F91/F92

Units With Integrated Drivers

Control Input Impedance

Units without "H" suffix . . . TTL, low power Schottky, one unit load. (A unit load is 0.8 mA sink current and 40 υA source current.)

Units with "H" suffix . . . . . TTL, advanced Schottky, one unit load. (A unit load is 0.6 mA sink current and 20 μA source current.)

Control Logic . . . . . Logic "0" (–0.3 to +0.8 V) for port ON and logic "1" (+2.0 to +5.0 V) for port OFF.

SERIES G91/G92

Control Input Impedance . . Schottky TTL, one unit load. (A unit load is 2.0 mA sink current and 50 μA source current.)

Control Logic . . . . . Logic "0" (–0.3 to +0.8 V) for port ON and logic "1" (+2.0 to +5.0 V) for port OFF.

Series 91 and 92 SP3T Switches Specifications

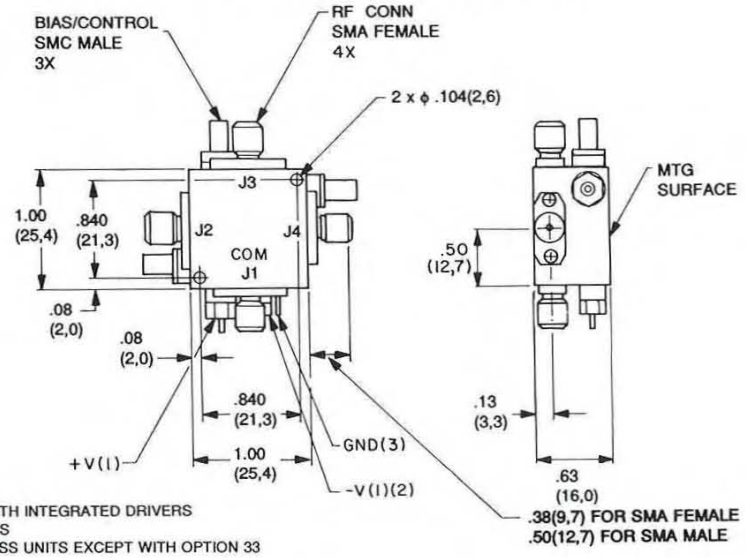
ENVIRONMENTAL RATINGS

Temperature Range	
Units With Integrated Drivers	
Operating	−65°C to +110°C
Non-Operating	−65°C to +125°C
Driverless Units Operating and Non-Operating	−65°C to +125°C
Humidity	MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)
Shock	MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)
Vibration	MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)
Altitude	MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)
Temp. Cycling	MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female bias/control connectors
7	SMA male rf connectors
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON (Not applicable to Series 91/92)
33	EMI-filter solder-type bias/control terminals
41	Internal video filter, common port only
42	Internal video filter, output ports only
43	Internal video filter, all ports
64A	SMB male bias/control connectors

DIMENSIONS AND WEIGHT



(1) USED ONLY ON UNITS WITH INTEGRATED DRIVERS
(2) +15V FOR G91/G92 SERIES
(3) NOT USED ON DRIVERLESS UNITS EXCEPT WITH OPTION 33

MODELS 91/92/F91/F92/G91/G92
Wt: 1.1 oz. (31 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series 91 and 92
Miniature Broadband SP4T Switches

- **Frequency range (Series 91): 1 to 18 GHz**
- **Frequency range (Series 92): 0.2 to 4 GHz**
- **Rise and fall times as fast as 10 nsec**
- **Reflective and nonreflective models**
- **Low VSWR and insertion loss**
- **Isolation: up to 60 dB**
- **Miniature size, light weight**

F9140
(WITH INTEGRATED DRIVER)

9140-500
(DRIVERLESS)

MODELS 9140-500 AND 9240-500

These switches provide high-performance characteristics over a multi-octave frequency range. Model 9140-500 covers the 1 to 18 GHz frequency range while the Model 9240-500 covers the 0.2 to 4 GHz range. Their description and operation are the same as that for the Models 9120-500 and 9220-500 SP2T switches.

MODELS 9140T-500, 9140W-500 AND 9240T-500

These switches are nonreflective versions of the switches described above.

MODELS 9140AH-500 AND 9140AHT-500

These switches are the same as the 9120AH-500 and the 9120AHT-500 except for the number of ports.

SERIES F91 AND F92

The Series F91 and F92 switches are the same as the corresponding Series 91 and 92 models except the units are equipped with integrated drivers.

SERIES G91 AND G92

These switches are the same as the Series G91 and G92 SP2T switches except for the number of ports.

Series 91 and 92 SP4T Switches Specifications

MODEL NO. (1)	CHARACTERISTIC	FREQUENCY (GHz)					
		0.2-1	1-2	2-4	4-8	8-12.4	12.4-18
9140-500 **F9140**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.4 1.75	60 1.4 1.75	60 1.5 1.75	60 2.0 1.75	50 2.8 2.0
G9140	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 2.0 1.5	60 2.0 1.5	60 2.2 1.7	60 2.7 1.7	50 3.0 2.0
9240-500 **F9240**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.5 1.6	60 1.5 1.6	60 1.5 1.6	– – –	– – –	– – –
G9240	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 2.0 1.5	60 2.0 1.5	60 2.0 1.5	– – –	– – –	– – –
9140T-500 **F9140T** **G9140T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	50 1.5 1.5	50 1.5 1.5	45 1.7 1.7	40 2.0 1.7	40 2.5 2.0
9240T-500 **F9240T** **G9240T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	60 1.3 1.5	60 1.3 1.5	50 1.5 1.5	– – –	– – –	– – –
9140W-500 **F9140W** **G9140W**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	60 2.0 1.5	60 2.0 1.5	60 2.2 1.7	60 2.7 1.7	55 3.0 2.0
9140AH-500 **F9140AH**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.4 1.75	60 1.4 1.75	60 1.8 1.75	60 2.5 2.0	50 3.3 2.0
9140AHT-500 **F9140AHT**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON) Max VSWR (OFF)	– – – –	60 1.6 1.75 1.75	60 1.6 1.75 1.75	60 2.1 1.9 2.0	60 2.7 2.0 2.2	50 3.6 2.0 2.3

PERFORMANCE CHARACTERISTICS

Power Handling Capability

Without Performance Degradation
- Units without "T" or "W" suffix: 1W cw or peak
- Units with "T" or "W" suffix
  - Input to any "OFF" port: 100 mW cw or peak
  - Input to any "ON" port: 1W cw or peak
  - Input to common port: 1W cw or peak

Survival Power
- Units without "T" or "W" suffix: 1W average, 75W peak (1 μsec max. pulse width)
- Units with "T" or "W" suffix
  - Input to any "OFF" port : 1W average, 10W peak (1 μsec max. pulse width)
  - Input to any "ON" port: 1W average, 75W peak (1 μsec max. pulse width)
  - Input to common port: 1W average, 75W peak (1 μsec max. pulse width)

(1) *Models prefixed with "F" or "G" are equipped with integrated TTL-compatible drivers; models without the "F" or "G" prefix are current-controlled units and are furnished without drivers; models suffixed with "T" or "W" are non-reflective except a high VSWR will be present at the common port if all other ports are OFF; models suffixed with "H" are high-speed units.*

Series 91 and 92 SP4T Switches Specifications

Switching Characteristics[1]

SERIES 91/92/F91/F92

Units without "H" suffix

ON time . . . . . 500 nsec max.
OFF time . . . . . 500 nsec max.

Units with "H" suffix

Rise time . . . . . 10 nsec max.
Fall time . . . . . 10 nsec max.
ON time . . . . . 25 nsec max.
OFF time . . . . . 20 nsec max.

SERIES G91/G92

ON time . . . . . 250 nsec max.
OFF time . . . . . 250 nsec max.

Power Supply Requirements

SERIES 91/92/F91/F92

Driverless Units

Bias current required at each port for rated isolation and insertion loss

Port OFF

Units without "H" suffix . . . . . +50 mA
Units with "H" suffix . . . . . +30 mA

Port ON

Units without "H" suffix . . . . . −50 mA
Units with "H" suffix . . . . . −35 mA

Units With Integrated Drivers

(For one port ON)

	+5V ±5%	−12 to −15V
Units Without "H" Suffix	190 mA	60 mA
Units With "H" Suffix	95 mA	60 mA
Units With "HT" Suffix	135 mA	60 mA

SERIES G91/G92

(For one port ON)

+5V ±5%, 150 mA
+15V ±5%, 50 mA

(1) *For driverless units, spiked current pulses must be provided by user.*

Control Characteristics

SERIES 91/92/F91/F92

Units With Integrated Drivers

Control Input Impedance

Units without "H" suffix . . . TTL, low power Schottky, one unit load. (A unit load is 0.8 mA sink current and 40 μA source current.)

Units with "H" suffix . . . . . TTL, advanced Schottky, one unit load. (A unit load is 0.6 mA sink current and 20 μA source current.)

Control Logic . . . . . Logic "0" (−0.3 to +0.8 V) for port ON and logic "1" (+2.0 to +5.0 V) for port OFF.

SERIES G91/G92

Control Input Impedance . . Schottky TTL, one unit load. (A unit load is 2.0 mA sink current and 50 μA source current.)

Control Logic . . . . . Logic "0" (−0.3 to +0.8 V) for port ON and logic "1" (+2.0 to +5.0 V) for port OFF.

Series 91 and 92 SP4T Switches Specifications

ENVIRONMENTAL RATINGS

Temperature Range

Units With Integrated Drivers

Operating ..... −65°C to +110°C

Non-Operating ..... −65°C to +125°C

Driverless Units

Operating and Non-Operating ..... −65°C to +125°C

Humidity ..... MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

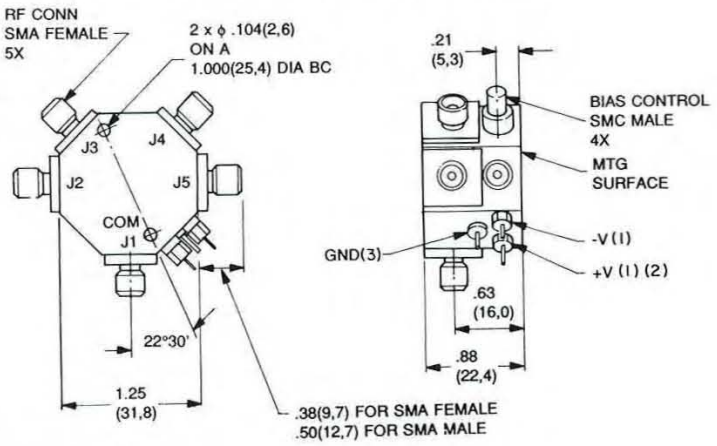
Altitude ..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling ..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female bias/control connectors
7	SMA male rf connectors
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON (Not applicable to Series 91, 92)
33	EMI-filter solder-type bias/control terminals
41	Internal video filter, common port only
42	Internal video filter, output ports only
43	Internal video filter, all ports
64A	SMB male bias/control connectors

DIMENSIONS AND WEIGHT



(1) USED ONLY ON UNITS WITH INTEGRATED DRIVERS
(2) +15V FOR G91/G92 SERIES
(3) NOT USED ON DRIVERLESS UNITS EXCEPT WITH OPTION 33

MODELS 91/92/F91/F92/G91/G92
Wt. 2 oz. (57 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series 91 and 92
Miniature Broadband SP5T Switches

- **Frequency range (Series 91): 1 to 18 GHz**
- **Frequency range (Series 92): 0.2 to 4 GHz**
- **Reflective and nonreflective models**
- **Low VSWR and insertion loss**
- **Isolation: up to 60 dB**
- **Miniature size, light weight**

F9150
(WITH INTEGRATED
DRIVER)

9150-500 (DRIVERLESS)

MODELS 9150-500 AND 9250-500

These switches provide high-performance characteristics over a multi-octave frequency range. The Model 9150-500 covers the 1 to 18 GHz frequency range while the Model 9250-500 covers the 0.2 to 4 GHz range. This description and operation are the same as that for the Models 9120-500 and 9220-500 SP2T switches.

MODELS 9150T-500, 9150W-500 AND 9250T-500

These switches are non-reflective versions of the switches described above.

SERIES F91 AND F92

The Series F91 and F92 switches are the same as the corresponding Series 91 and 92 models, except the units are equipped with integrated drivers.

SERIES G91 AND G92

These switches are the same as the Series G91 and G92 SP2T switches except for the number of ports.

Series 91 and 92 SP5T Switches Specifications

MODEL NO. (1)	CHARACTERISTIC	FREQUENCY (GHz)					
		0.2-1	1-2	2-4	4-8	8-12.4	12.4-18
9150-500 **F9150**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.5 1.5	60 1.5 1.5	55 1.5 1.75	50 2.0 1.75	50 3.0 2.0
G9150	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 2.2 1.5	60 2.2 1.5	60 2.4 1.8	60 3.0 2.0	50 3.3 2.2
9250-500 **F9250**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.5 1.6	60 1.5 1.6	60 1.5 1.6	– – –	– – –	– – –
G9250	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 2.2 1.5	60 2.2 1.5	60 2.2 1.5	– – –	– – –	– – –
9150T-500 **F9150T** **G9150T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	50 1.5 1.5	50 1.5 1.5	45 2.0 1.7	40 2.5 2.0	40 3.0 2.2
9250T-500 **F9250T** **G9250T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	60 1.4 1.5	60 1.4 1.5	50 1.5 1.5	– – –	– – –	– – –
9150W-500 **F9150W** **G9150W**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	60 2.2 1.5	60 2.2 1.5	60 2.4 1.8	60 3.0 2.0	55 3.3 2.2

PERFORMANCE CHARACTERISTICS

Power Handling Capability

Without Performance Degradation
- Units without "T" or "W" suffix: 1W cw or peak
- Units with "T" or "W" suffix
  - Input to any "OFF" port: 100 mW cw or peak
  - Input to any "ON" port: 1W cw or peak
  - Input to common port: 1W cw or peak

Survival Power
- Units without "T" or "W" suffix: 1W average, 75W peak (1 μsec max. pulse width)
- Units with "T" or "W" suffix
  - Input to any "OFF" port : 1W average, 10W peak (1 μsec max. pulse width)
  - Input to any "ON" port: 1W average, 75W peak (1 μsec max. pulse width)
  - Input to common port: 1W average, 75W peak (1 μsec max. pulse width)

Switching Time(2)

SERIES 91/92/F91/F92

ON time..... 500 nsec max.
OFF time..... 500 nsec. max.

SERIES G91/G92

ON time..... 250 nsec max.
OFF time..... 250 nsec max.

(1) *Models prefixed with "F" or "G" are equipped with integrated TTL-compatible drivers; models without the "F" or "G" prefix are current-controlled units and are furnished without drivers; models suffixed with "T" or "W" are non-reflective except a high VSWR will be present at the common port if all other ports are OFF.*

(2) *For driverless units, shaped current pulses must be provided by the user.*

Series 91 and 92 SP5T Switches Specifications

Power Supply Requirements

SERIES 91/92/F91/F92
Driverless Units

Bias current required at each port for rated isolation and insertion loss

Port OFF . . . . . +50 mA
Port ON . . . . . −50 mA

Units With Integrated Drivers

(For one port ON) . . . . . +5V ±5%, 250 mA
−12 to −15V, 60 mA

SERIES G91/G92

(For one port ON) . . . . . +5V ±5%, 150 mA
+15V ±5%, 60 mA

Control Characteristics

SERIES 91/92/F91/F92
Units With Integrated Drivers

Control Input Impedance . . TTL, low power Schottky, one unit load. (A unit load is 0.8 mA sink current and 40 μA source current.)

Control Logic . . . . . Logic "O" (−0.3 to +0.8V) for port ON and logic "1" (+2.0 to +5.0V) for port OFF.

SERIES G91/G92

Control Input Impedance . . Schottky TTL, one unit load. (A unit load is 2.0 mA sink current and 50 μA source current.)

Control Logic . . . . . Logic "O" (−0.3 to +0.8V) for port ON and logic "1" (+2.0 to +5.0V) for port OFF.

ENVIRONMENTAL RATINGS

Temperature Range
Units With Integrated Drivers
Operating . . . . . −65°C to +110°C
Non-Operating . . . . . −65°C to +125°C
Driverless Units
Operating and Non-Operating . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

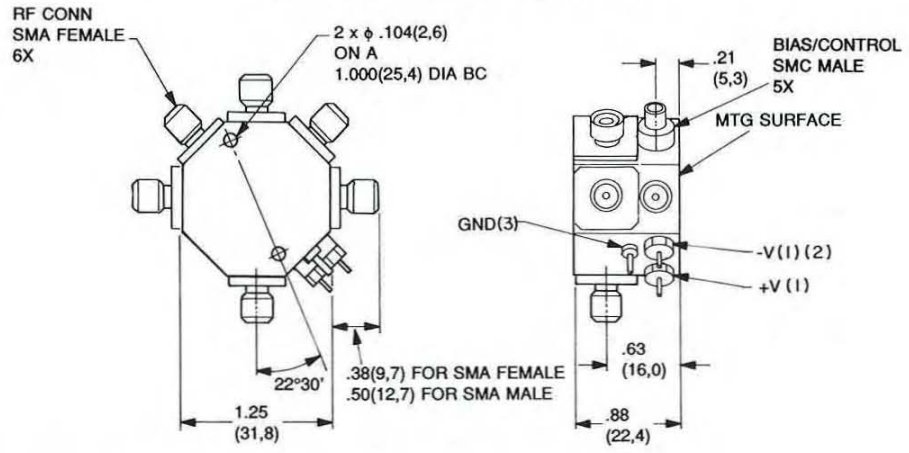
Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female bias/control connectors
7	SMA male rf connectors
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON (Not applicable to Series 91, 92)
33	EMI filter solder-type bias/control terminals
41	Internal video filter, common port only
42	Internal video filter, output ports only
43	Internal video filter, all ports
64A	SMB male bias/control connectors

DIMENSIONS AND WEIGHT



(1) USED ONLY ON UNITS WITH INTEGRATED DRIVERS
(2) +15V FOR G91/G92 SERIES
(3) NOT USED ON DRIVERLESS UNITS EXCEPT WITH OPTION 33

MODELS 91/92/F91/F92/G91/G92
Wt: 2 oz. (57 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series 91 and 92
Miniature Broadband SP6T Switches

MODELS 9160-500 AND 9260-500

These switches provide high-performance characteristics over a multi-octave frequency range. Model 9160-500 covers the 1 to 18 GHz frequency range while the Model 9260-500 covers the 0.2 to 4 GHz range. Their description and operation are the same as that for the Models 9120-500 and 9220-500 SP2T switches.

MODELS 9160T-500, 9160W-500 AND 9260T-500

These switches are non-reflective versions of the switches described above.

SERIES F91 AND F92

The Series F91 and F92 switches are the same as the corresponding Series 91 and 92 models, except the units are equipped with integrated drivers.

SERIES G91 AND G92

These switches are the same as the Series G91 and G92 SP2T switches except for the number of ports.

- **Frequency range (Series 91): 1 to 18 GHz**
- **Frequency range (Series 92): 0.2 to 4 GHz**
- **Reflective and nonreflective models**
- **Low VSWR and insertion loss**
- **Isolation: up to 60 dB**
- **Miniature size, light weight**

F9160
(WITH INTEGRATED
DRIVER)

9160-500 (DRIVERLESS)

Series 91 and 92 SP6T Switches Specifications

MODEL NO. (1)	CHARACTERISTIC	FREQUENCY (GHz)					
		0.2-1	1-2	2-4	4-8	8-12.4	12.4-18
9160-500 **F9160**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.6 1.6	60 1.6 1.6	55 1.8 1.9	50 2.2 2.0	50 3.4 2.2
G9160	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 2.2 1.6	60 2.2 1.6	60 2.6 2.0	60 3.2 2.2	50 3.5 2.3
9260-500 **F9260**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.5 1.6	60 1.5 1.6	60 1.5 1.6	– – –	– – –	– – –
G9260	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 2.2 1.6	60 2.2 1.6	60 2.2 1.6	– – –	– – –	– – –
9160T-500 **F9160T** **G9160T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	50 1.5 1.6	50 1.5 1.6	45 2.2 1.8	40 2.7 2.0	40 3.2 2.2
9260T-500 **F9260T** **G9260T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	60 1.5 1.5	60 1.5 1.5	50 1.5 1.6	– – –	– – –	– – –
9160W-500 **F9160W** **G9160W**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	60 2.2 1.6	60 2.2 1.6	60 2.6 2.0	60 3.2 2.2	55 3.5 2.3

PERFORMANCE CHARACTERISTICS

Power Handling Capability

Without Performance Degradation
- Units without "T" or "W" suffix: 1W cw or peak
- Units with "T" or "W" suffix
  - Input to any "OFF" port: 100 mW cw or peak
  - Input to any "ON" port: 1W cw or peak
  - Input to common port: 1W cw or peak

Survival Power
- Units without "T" or "W" suffix: 1W average, 75W peak (1 μsec max. pulse width)
- Units with "T" or "W" suffix
  - Input to any "OFF" port: 1W average, 10W peak (1 μsec max. pulse width)
  - Input to any "ON" port: 1W average, 75W peak (1 μsec max. pulse width)
  - Input to common port: 1W average, 75W peak (1 μsec pulse width)

Switching Time(2)

SERIES 91/92/F91/F92

ON time..... 500 nsec max.
OFF time..... 500 nsec max.

SERIES G91/G92

ON time..... 250 nsec max.
OFF time..... 250 nsec max.

(1) *Models prefixed with "F" or "G" are equipped with integrated TTL-compatible drivers; models without the "F" or "G" prefix are current-controlled units and are furnished without drivers; models suffixed with "T" or "W" are non-reflective except a high VSWR will be present at the common port if all other ports are OFF.*

(2) *For driverless units, shaped current pulses must be provided by the user.*

Series 91 and 92 SP6T Switches Specifications

Power Supply Requirements

SERIES 91/92/F91/F92
Driverless Units
Bias current required at each port for rated isolation and insertion loss
Port OFF . . . . . , +50 mA
Port ON . . . . . −50 mA

Units With Integrated Drivers
(For one port ON) . . . . . +5V ±5%, 315 mA
−12 to −15V, 60 mA

SERIES G91/G92
(For one port ON) . . . . . +5V ±5%, 150 mA
+15V ±5%, 70 mA

Control Characteristics

Series 91/92/F91/F92
Units With Integrated Drivers

Control Logic . . . . . Logic "O" (−0.3 to +0.8V) for port ON and logic "1" (+2.0 to +5.0V) for port OFF.

Control Input Impedance . . . . . TTL, low power Schottky one unit load. (A unit load is 0.8 mA sink current and 40 μA source current).

Series G91/G92

Control Logic . . . . . Logic "O" (−0.3 to +0.8V) for port ON and logic "1" (+2.0 to +5.0V) for port OFF.

Control Input Impedance . . . . . Schottky TTL, one unit load (A unit load is 2.0 mA sink current and 50 μA source current).

ENVIRONMENTAL RATINGS

Temperature Range
Units With Integrated Drivers
Operating . . . . . −65°C to +110°C
Non-Operating . . . . . −65°C to +125°C
Driverless Units
Operating and Non-Operating . . . . . −65°C to +125°C

Humidity . . . . . MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock . . . . . MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration . . . . . MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

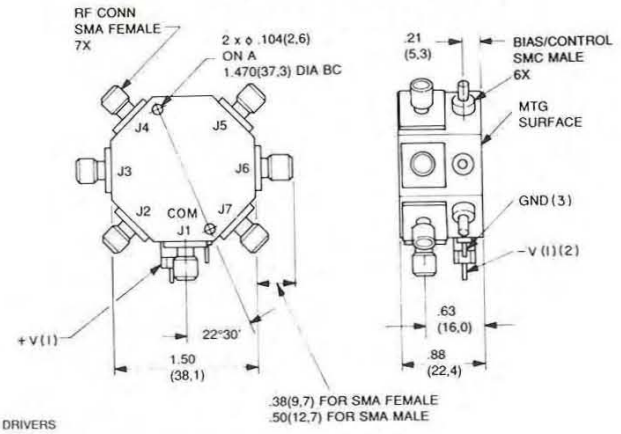
Altitude . . . . . MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling . . . . . MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female bias/control connectors
7	SMA male rf connectors
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON (Not applicable to Series 91/92)
33	EMI filter solder-type bias/control terminals
41	Internal video filter, common port only
42	Internal video filter, output ports only
43	Internal video filter, all ports
64A	SMB male bias/control connectors

DIMENSIONS AND WEIGHT



(1) USED ONLY ON UNITS WITH INTEGRATED DRIVERS
(2) +15V FOR G91/G92 SERIES
(3) NOT USED ON DRIVERLESS UNITS EXCEPT WITH OPTION 33

MODELS 91/92/F91/F92/G91/G92
Wt: 2.9 oz. (82 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

Series 91 and 92
Miniature Broadband SP7T Switches

- **Frequency range (Series 91): 1 to 18 GHz**
- **Frequency range (Series 92): 0.2 to 4 GHz**
- **Reflective and nonreflective models**
- **Low VSWR and insertion loss**
- **Isolation: up to 60 dB**
- **Miniature size, light weight**

F9170
(WITH INTEGRATED
DRIVER)

9170-500 (DRIVERLESS)

MODELS 9170-500 AND 9270-500

These switches provide high-performance characteristics over a multi-octave frequency range. Model 9170-500 covers the 1 to 18 GHz frequency range while the Model 9270-500 covers the 0.2 to 4 GHz range. Their description and operation are the same as that for the Models 9120-500 and 9220-500 SP2T switches.

MODELS 9170T-500, 9170W-500 AND 9270T-500

These switches are non-reflective versions of the switches described above.

SERIES F91 AND F92

The Series F91 and F92 switches are the same as the corresponding Series 91 and 92 models, except the units are equipped with integrated drivers.

SERIES G91 AND G92

These switches are the same as the Series G91 and G92 SP2T switches except for the number of ports.

Series 91 and 92 SP7T Switches Specifications

MODEL NO.(1)	CHARACTERISTIC	FREQUENCY (GHz)					
		0.2-1	1-2	2-4	4-8	8-12.4	12.4-18
9170-500 **F9170**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 1.75 1.75	60 1.75 1.75	55 2.0 2.0	50 2.6 2.2	50 3.8 2.4
G9170	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	– – –	60 2.2 1.7	60 2.2 1.7	60 2.8 2.2	60 3.5 2.2	50 3.8 2.4
9270-500 **F9270**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 1.5 1.6	60 1.5 1.6	60 1.5 1.6	– – –	– – –	– – –
G9270	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	60 2.2 1.7	60 2.2 1.7	60 2.2 1.7	– – –	– – –	– – –
9170T-500 **F9170T** **G9170T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	50 1.5 1.7	50 1.5 1.7	45 2.4 2.0	40 3.0 2.2	40 3.5 2.4
9270T-500 **F9270T** **G9270T**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	60 1.5 1.5	60 1.5 1.5	50 1.5 1.7	– – –	– – –	– – –
9170W-500 **F9170W** **G9170W**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON or OFF)	– – –	60 2.2 1.7	60 2.2 1.7	60 2.8 2.2	60 3.5 2.2	55 3.8 2.4

PERFORMANCE CHARACTERISTICS

Power Handling Capability

Without Performance Degradation
- Units without "T" or "W" suffix: 1W cw or peak
- Units with "T" or "W" suffix
  - Input to any "OFF" port: 100 mW cw or peak
  - Input to any "ON" port: 1W cw or peak
  - Input to common port: 1W cw or peak

Survival Power
- Units without "T" or "W" suffix: 1W average, 75W peak (1 μsec max. pulse width)
- Units with "T" or "W" suffix
  - Input to any "OFF" port : 1W average, 10W peak (1 μsec max. pulse width)
  - Input to any "ON" port: 1W average, 75W peak (1 μsec max. pulse width)
  - Input to common port: 1W average, 75W peak (1 μsec max. pulse width)

Switching Time(2)

SERIES 91/92/F91/F92

ON time..... 500 nsec max.
OFF time..... 500 nsec max.

SERIES G91/G92

ON time..... 250 nsec max.
OFF time..... 250 nsec max.

(1) *Models prefixed with "F" or "G" are equipped with integrated TTL-compatible drivers; models without the "F" or "G" prefix are current-controlled units and are furnished without drivers; models suffixed with "T" or "W" are non-reflective except a high VSWR will be present at the common port if all other ports are OFF.*

(2) *For driverless units, shaped current pulses must be provided by the user.*

Series 91 and 92 SP7T Switches Specifications

Power Supply Requirements

SERIES 91/92/F91/F92

Driverless Units

Bias current required at each port for rated isolation and insertion loss

Port OFF ..... +50 mA
Port ON ..... −50 mA

Units With Integrated Drivers

(For one port ON)..... +5V ±5%, 375 mA
−12 to −15V, 60 mA

SERIES G91/G92

(For one port ON)..... +5V ±5%, 190 mA
+15V ±5%, 70 mA

Control Characteristics

SERIES 91/92/F91/F92

Units With Integrated Drivers

Control Input Impedance .. TTL, low power Schottky, one unit load. (A unit load is 0.8 mA sink current and 40 μA source current.)

Control Logic..... Logic "O" (−0.3 to +0.8V) for port ON and logic "1" (+2.0 to +5.0V) for port OFF.

SERIES G91/G92

Control Input Impedance .. Schottky TTL, one unit load. (A unit load is 2.0 mA sink current and 50 μA source current.)

Control Logic..... Logic "O" (−0.3 to +0.8V) for port ON and logic "1" (+2.0 to +5.0V) for port OFF.

ENVIRONMENTAL RATINGS

Temperature Range

Units With Integrated Drivers

Operating ..... −65°C to +110°C
Non-Operating ..... −65°C to +125°C

Driverless Units
Operating and Non-Operating ..... −65°C to +125°C

Humidity ..... MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06″ double amplitude or 15G, whichever is less)

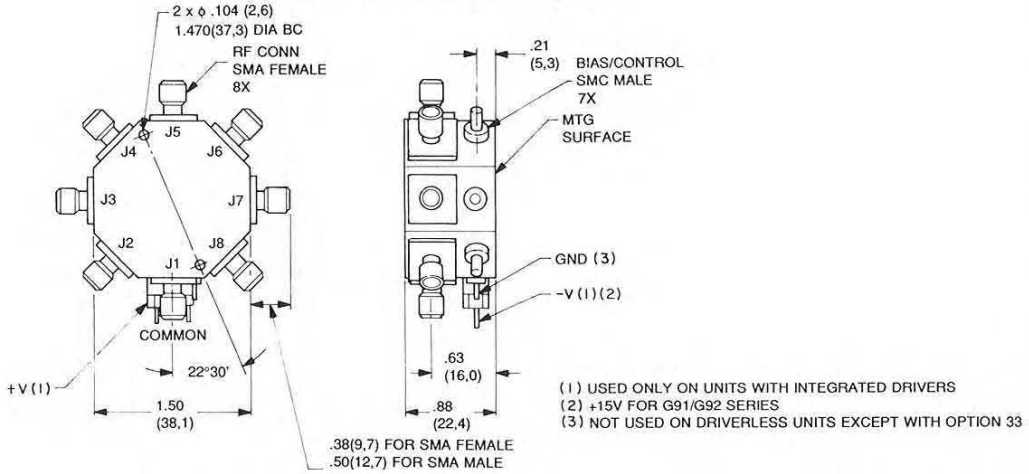
Altitude..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

AVAILABLE OPTIONS

Option No.	Description
3	SMA female bias/control connectors
7	SMA male rf connectors
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON (Not applicable to Series 91, 92)
33	EMI filter solder-type bias/control terminals
41	Internal video filter, common port only
42	Internal video filter, output ports only
43	Internal video filter, all ports
64A	SMB male bias/control connectors

DIMENSIONS AND WEIGHT



(1) USED ONLY ON UNITS WITH INTEGRATED DRIVERS
(2) +15V FOR G91/G92 SERIES
(3) NOT USED ON DRIVERLESS UNITS EXCEPT WITH OPTION 33

MODELS 91/92/F91/F92/G91/G92
Wt: 2.9 oz. (82 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .XX ± .02; .XXX ± .005

H91 Series, HM91 Series Hermetically-Sealed SPST Thru SP4T Switches

Both H91 and HM91 Series consist of a family of high-speed high-isolation hermetically sealed switches with integrated drivers that operate over the frequency range from 1 to 18 GHz.

These switches employ sealed glass-to-metal feed-thrus and are designed to meet stringent environmental conditions.

The H Series switches are equipped with removeable SMA female RF connectors permitting field replaceability or integration as drop-in modules. Package area and volume are minimized and overall thickness, with the built-in driver, is only 0.24".

The HM Series switches are supplied without connectors and are primarily intended for use as system drop-in modules. Additional mounting holes around each RF connector ensure optimum RF performance over the entire operating frequency range.

The H91 and HM91 family consists of a reflective SPST and SP2T, SP3T, SP4T switches in both reflective and nonreflective configurations.

On all switches, the dc and control ports are located in line on one wall of the module above the RF connection level. This makes the switches ideally suitable for printed-circuit type mounting.

SPST SWITCH

The models H9114 and HM9114 SPST switch consists of a shunt array of four PIN diodes in a microstrip transmission line (See Fig. 1).

Application of a positive current (by the driver) biases the diodes to a low resistance value, and switches the unit OFF. When the diodes are reverse biased to a high resistance, the unit is switched ON.

REFLECTIVE MULTI-THROW SWITCHES

All models in this group use an integrated assembly of PIN diodes mounted in a microstrip transmission line in a series-shunt arrangement as shown in Fig. 2.

When positive current is applied by the driver, the associated port is OFF since the corresponding shunt diodes are biased to a low resistance and the series diode to a high resistance. With negative current, the converse conditions are established and the port is ON.

- **Replaceable SMA Connectors**
- **Low Profile: 0.24" thickness with integrated TTL-compatible driver**
- **High Speed, High Isolation**
- **Low VSWR, Low Insertion Loss**
- **Nonreflective and Reflective Models**

H91 — LOW PROFILE CONNECTORIZED SWITCHES

- **TTL-Compatible Driver: Built-in**
- **Effective Mounting Thickness 0.16"**
- **High Speed, High Isolation**
- **Nonreflective and Reflective Models**
- **Low Insertion Loss, Low VSWR**

HM91 — DROP-IN SWITCH MODULES

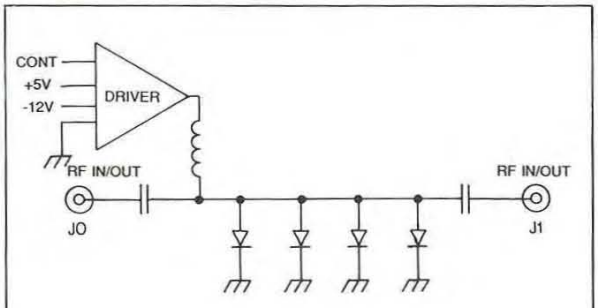


Fig. 1-Single throw switch schematic diagram.

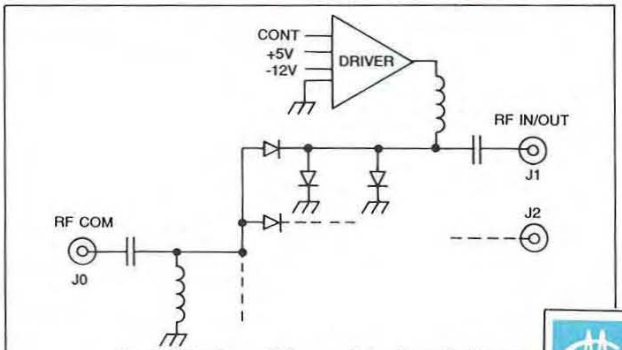


Fig. 2-Reflective multi-throw switch schematic diagram.

H91 Series, HM91 Series Hermetically-Sealed SPST Thru SP4T Switches

NON REFLECTIVE MULTI-THROW SWITCHES

The circuit arrangement for this series is shown in Figure 3.

When positive current is applied the port is turned OFF. All the series diodes in that port are reverse-biased and the impedance at the output of the port is then effectively that of the 50-ohm resistor.

SWITCHING SPEED

All models exhibit transition times of less than 10 nanoseconds between 10% and 90% or 90% and 10% of the RF power.

ON time, the time from 50% point of the TTL command to the 90% level of the detected RF, is less than 25 nanoseconds for all models; OFF time, from the 50% point of the TTL command to the 10% level of the detected RF, is less than 20 nanoseconds.

HERMETIC SEALING

All switches are housed in enclosures using sealed glass-to-metal "feedthru" connectors for true hermeticity.

Covers are welded to the main block in an inert atmosphere, and the final assembly will not leak at a rate in excess of 1 x 10^{-7} atm cc/sec He.

MOUNTING

To facilitate mounting the H Series switches on a flat surface, 0.060" spacers are available to provide clearance for the SMA coupling nut.

Connector kits enabling the user to mount SMA female connectors on the HM Series switches for use in that configuration, or to verify performance, are available as optional accessories.

Each kit also includes an appropriate mounting spacer which permits the switch module to be mounted on a flat surface, while providing proper clearance for mating SMA male connectors.

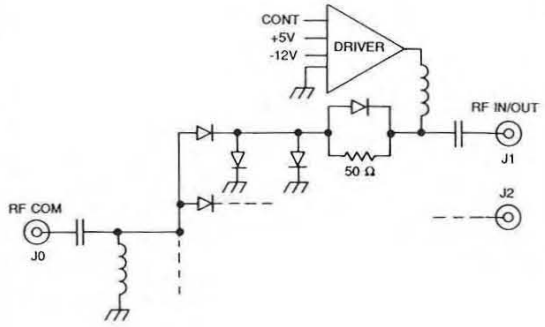


Fig. 3-Non-reflective multi-throw switch schematic diagram.

UNIQUE CONFIGURATION

The HM91 Switch Module Series offers several unique constructional features.

0.16" EFFECTIVE MOUNTING THICKNESS: While the overall thickness of the modules is 0.24", the thickness where the mounting holes are located is only 0.16", minimizing mounting hardware protrusion.

EXTRA MOUNTING HOLES: All switch modules are designed with mounting holes on both sides of each RF port to assure good ground continuity. In addition, four extra mounting holes are provided so that the module can be mounted when used with connectors.

RF AND CONTROL PORTS: The SP3T configurations (HM9130H and HM9130HT), offer the user the added flexibility of being able to specify the positions of three output ports.

Model HM192 Non-Reflective Ultra-Broadband High-Speed SPST Switch Module

The Model HM192 is a hermetically sealed, high speed, non-reflective SPST PIN diode switch with integrated driver. The switch is designed for use as a drop-in module but can be used as a conventional connectorized component when equipped with removable SMA connectors. Operating over the instantaneous frequency range from 0.2 to 18 GHz, it provides a minimum isolation of 80 dB from 0.5 to 18 GHz. The switch consists of an internal driver and an arrangement of shunt and series diodes in a microstrip integrated circuit transmission line as shown in Fig. 1.

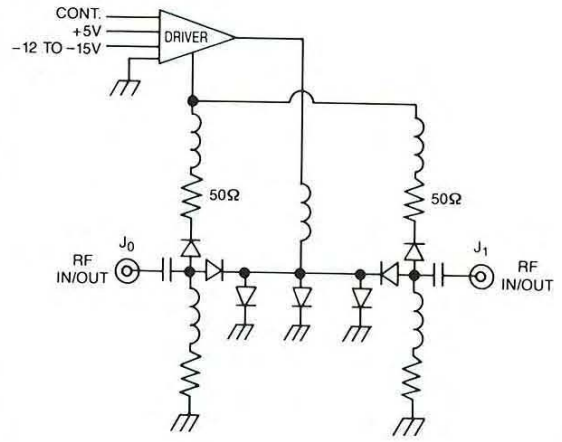
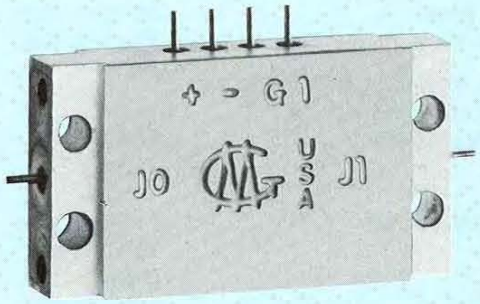


Fig. 1 — Model HM192 Schematic Diagram

- **High speed; 10 nsec**
- **Frequency range: 0.2 to 18 GHz**
- **80 dB isolation**
- **Low VSWR and insertion loss**
- **0.24 inch thick**
- **Hermetically sealed**



Model HM192 Specifications

PERFORMANCE CHARACTERISTICS

CHARACTERISTIC	FREQUENCY (GHz)				
	0.2 to 0.5	0.5 to 2.0	2.0 to 8.0	8.0 to 12.4	12.4 to 18.0
Min Isolation (dB)	35	80	80	80	80
Max Insertion Loss (dB)	2.0	2.0	2.5	3.0	3.5
VSWR (ON and OFF)	1.5	1.5	1.75	2.0	2.0

Switching Characteristics

Rise Time . . . . . 10 nsec. max
Fall Time . . . . . 10 nsec. max
ON Time . . . . . 30 nsec. max
OFF Time . . . . . 15 nsec. max

Power Handling Capability

Without Performance Degradation . . . . . 500 mW cw or peak

Survival Power . . . . . 1 W average, 10 W peak (1 μsec max pulse width)

Control Characteristics

Control Input Impedance . . . . . TTL, Advanced Schottky, Two-unit load. (A unit load is 0.6 mA sink current and 20 μA source current)

Control Logic
Logic "O" . . . . . (–0.3 to +0.8V) for switch ON
Logic "1" . . . . . (+2.0 to +5.0V) for switch OFF.

Power Supply Requirements(1) . . . . . +5V ±5%, 50 mA
–12 to –15V
±5%, 50 mA

ENVIRONMENTAL RATINGS

Operating Temperature Range . . . . . –65°C to +125°C

AVAILABLE OPTIONS

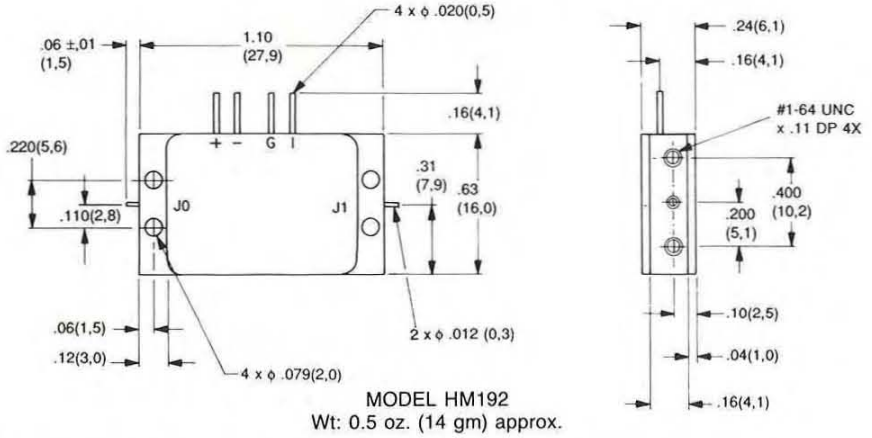
Option No.	Description
9	Inverse control logic; logic "1" for switch ON and logic "O" for switch OFF.
49	High Rel screening (see Table 1 page x)

AVAILABLE ACCESSORIES

CK-1 Connector Kit:
Two female connectors, spacers and mounting hardware.

(1) *Up to 1 MHz switching rate. At 10 MHz, +V and –V @ 125 mA each.*

DIMENSIONS AND WEIGHT

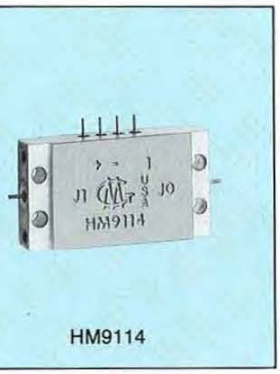


MODEL HM192
Wt: 0.5 oz. (14 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Models H9114, HM9114
Hermetically Sealed SPST Switches

H9114



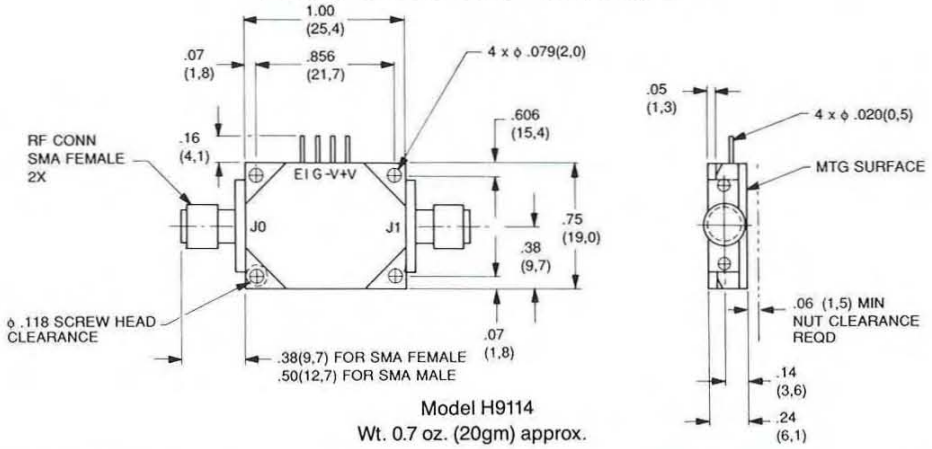
HM9114

PERFORMANCE CHARACTERISTICS[1]

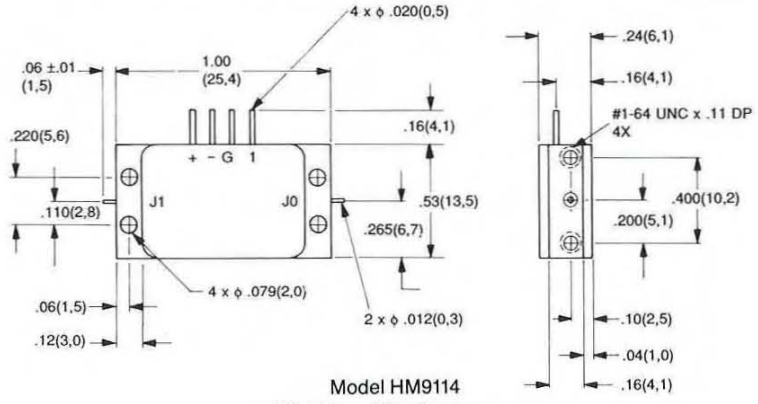
MODEL NO.	CHARACTERISTIC	FREQUENCY (GHz)				
		1.0-2.0	2.0-4.0	4.0-8.0	8.0-12.4	12.4-18.0
H9114 **HM9114**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR: (On position)	60 0.9 1.4	74 0.9 1.4	80 1.2 1.75	80 1.6 1.75	80 2.5 2.0

(1) *For Switching Speed, Power Handling and other specifications, see page 141.*

DIMENSIONS AND WEIGHTS



Model H9114
Wt. 0.7 oz. (20gm) approx.

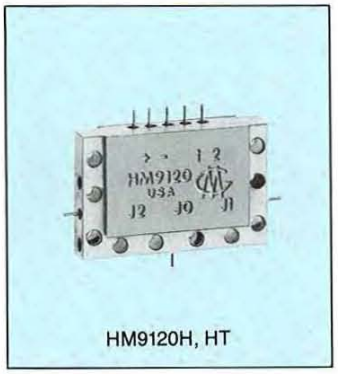


Model HM9114
Wt. 0.4 oz. (11gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Models H9120H, HM9120H, H9120HT, HM9120HT Hermetically Sealed SP2T Switches

H9120H, HT



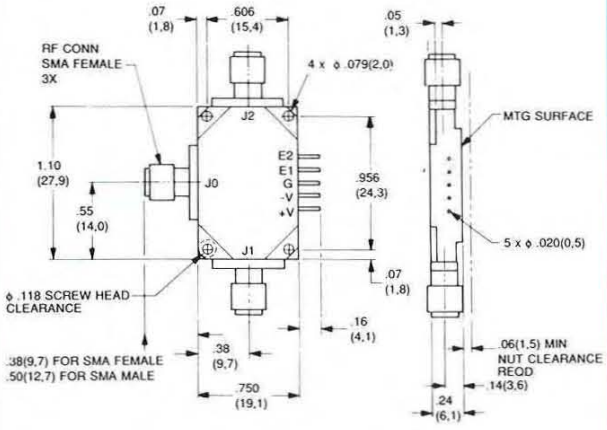
HM9120H, HT

PERFORMANCE CHARACTERISTICS[1]

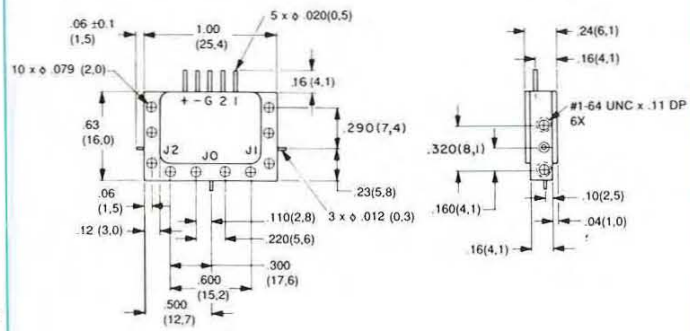
MODEL NO.	CHARACTERISTIC	FREQUENCY (GHz)			
		1-4	4-8	8-12.4	12.4-18
H9120H HM9120H	Min Isolation (dB)	60	60	60	50
	Max Insertion Loss (dB)	1.1	1.4	2.0	2.5
	Max VSWR: (On position)	1.75	1.75	1.75	2.0
H9120HT HM9120HT (NONREFLECTIVE)	Min Isolation (dB)	60	60	60	50
	Max Insertion Loss (dB)	1.3	1.7	2.5	3.0
	Max VSWR: Port ON	1.75	1.9	2.0	2.0
	Max VSWR: Port OFF	1.75	2.0	2.2	2.3

(1) *For Switching Speed, Power Handling and other specifications, see page 141.*

DIMENSIONS AND WEIGHTS



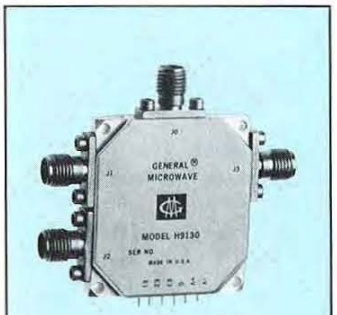
Model H9120H, HT
Wt. 0.8 oz. (23gm) approx.



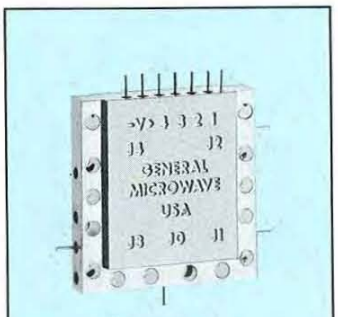
Model HM9120H, HT
Wt. 0.4 oz. (11gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx ±.005

Models H9130H, HM9130H, H9130HT, HM9130HT Hermetically Sealed SP3T Switches



H9130H, HT



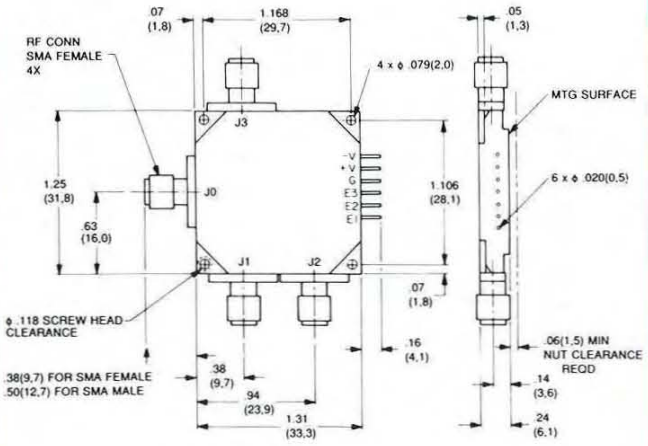
HM9130H, HT

PERFORMANCE CHARACTERISTICS[1]

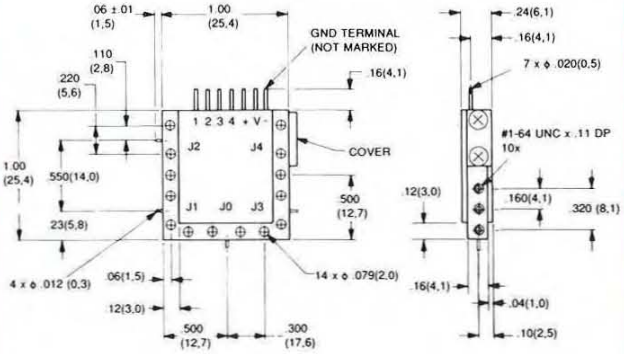
MODEL NO.	CHARACTERISTIC	FREQUENCY (GHz)			
		1-4	4-8	8-12.4	12.4-18
H9130H HM9130H	Min Isolation (dB)	60	60	60	50
	Max Insertion Loss (dB)	1.2	1.5	2.0	2.6
	Max VSWR: (On position)	1.75	1.75	1.75	2.0
H9130HT HM9130HT (NONREFLECTIVE)	Min Isolation (dB)	60	60	60	50
	Max Insertion Loss (dB)	1.4	1.8	2.5	3.3
	Max VSWR: Port ON	1.75	1.9	2.0	2.0
	Max VSWR: Port OFF	1.75	2.0	2.2	2.3

(1) *For Switching Speed, Power Handling and other specifications, see page 141.*

DIMENSIONS AND WEIGHTS



Model H9130H, HT
Wt. 1.4 oz. (40gm) approx.

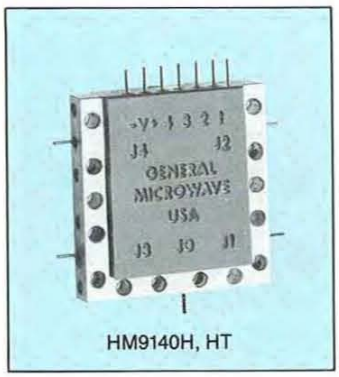


Model HM9130H, HT
Wt. 0.65 oz. (18gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ±02; .xxx ±.005

Models H9140H, HM9140H, H9140HT, HM9140HT
Hermetically Sealed SP4T Switches

H9140H, HT



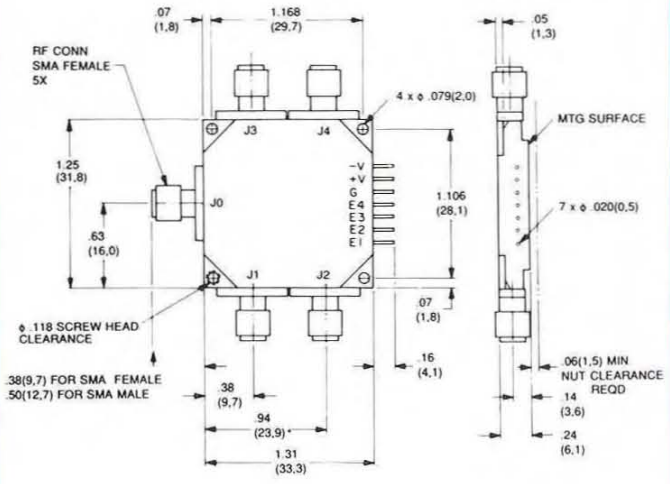
HM9140H, HT

PERFORMANCE CHARACTERISTICS[1]

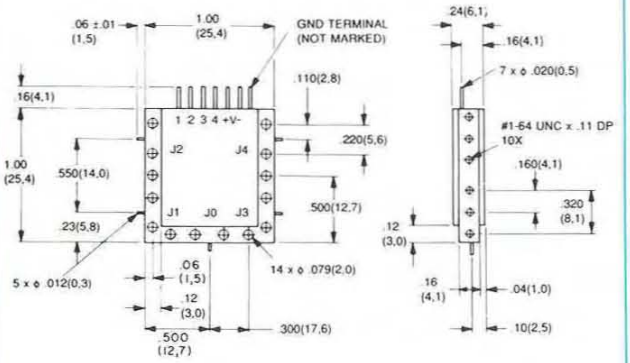
MODEL NO.	CHARACTERISTIC	FREQUENCY (GHz)			
		1-4	4-8	8-12.4	12.4-18
H9140H **HM9140H**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR: (On position)	60 1.4 1.75	60 1.5 1.75	60 2.0 1.75	50 2.8 2.0
H9140HT **HM9140HT** **(NONREFLECTIVE)**	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR: Port ON Max VSWR: Port OFF	60 1.6 1.75 1.75	60 1.8 1.9 2.0	60 2.5 2.0 2.2	50 3.3 2.0 2.3

(1) *For Switching Speed, Power Handling and other specifications, see page 141.*

DIMENSIONS AND WEIGHTS



Model H9140H, HT
Wt. 1.5 oz. (43gm) approx.



Model HM9140H, HT
Wt. 0.65 oz. (18gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx ±.005

PERFORMANCE CHARACTERISTICS

Power Handling Capability

Without Performance Degradation

All Reflective
Switches . . . . . 1W cw or peak

All Non Reflective Switches

Input to any "OFF" port: 100 mW cw or peak
Input to any "ON" port: 1W cw or peak
Input to common port: 1W cw or peak

Survival Power

SPST Switches . . . . 2W average, 75W peak (1μsec max pulse width)

Reflective Multi-Throw
Switches . . . . . 1W average, 75W peak (1μsec max. pulse width)

Non Reflective Multi-Throw Switches

Input to any "OFF" port: 1W average, 10W peak (1 μsec max pulse width)
Input to any "ON" port; 1W average 75W peak (1μsec max pulse width)
Input to common port: 1W average 75W peak (1μsec max pulse width)

Switching Speed (All Models)

Rise time . . . . . 10 nsec max
Fall time . . . . . 10 nsec max
ON time . . . . . 25 nsec max
Except SPST Switch . . 20 nsec max
OFF time . . . . . 20 nsec max
Max Repetition Rate is 20 MHz.

Power Supply Requirements

MODEL	+5V ±5%	−12 to −15V
H9114 HM9114	65 mA	20 mA
FOR ONE PORT ON		
H9120H HM9120H	60 mA	50 mA
H9120HT HM9120HT	80 mA	50 mA
H9130H HM9130H	75 mA	55 mA
H9130HT HM9130HT	105 mA	55 mA
H9140H HM9140H	95 mA	60 mA
H9140HT HM9140HT	135 mA	60 mA

CONTROL CHARACTERISTICS

Units With Integrated Drivers

Control Input Impedance

TTL, advanced Schottky, one unit load.
(A unit load is 0.6 mA sink current and 20 μA source current).

Control Logic

Logic "0" (−0.3 to +0.8 V) for port ON.
Logic "1" (+2.0 to +5.0 V) for port OFF.

ENVIRONMENTAL RATINGS

Temperature Range

Operating . . . . . −65°C to +125°C

AVAILABLE OPTIONS

Option No.	Description
7	SMA male rf connectors (H series only)
7A	J1 SMA male; J2 and J3 SMA female
7B	J1 SMA female; J2 and J3 SMA male
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON.
10	One SMA male (J0) and one SMA female (J1) rf connector. (H9114 only)
27	Single-port toggle control. Logic "0" connects J0 to J1. Control can be applied to either terminal 1 or 2. (SP2T models only)
41	Internal video filter, common port only
42	Internal video filter, output ports only
43	Internal video filter, all ports
49	High Rel screening (see Table 1, page 36)

AVAILABLE ACCESSORIES

Model	Spacer Plates
H9114	17244-P1
H9120H, HT	17244-P1
H9130H, HT	17244-P3
H9140H, HT	17244-P3

Model	Model[1]
HM9114	CK-1
HM9120H, HT	CK-2
HM9130H, HT	CK-3
HM9140H, HT	CK-4

[1] Each kit includes a set of mounting spacers, one female connector for each RF port and mounting hardware.

Millimeter Wave Components, 18-40 GHz

D7050

F9021

F9014

D1959

SPST & SP2T F90 SERIES SWITCHES

General Microwave millimeter wave switches are available in SPST and SP2T models in a variety of topologies and configurations, e.g., with current-controlled switching, or with integrated TTL-compatible voltage drivers, and in both low insertion loss and high isolation models.

All switch models in the series operate over the frequency range from 18-40 GHz; each is capable of handling cw or peak powers up to 1W without performance degradation, and features rise and fall times of less than 10 ns.

CURRENT- & VOLTAGE-CONTROLLED ATTENUATORS

General Microwave wideband millimeter-wave attenuators are available in two configurations.

Model 1959 is current-controlled, while the Model D1959, which incorporates a hybrid driver, is voltage-controlled with a linearized transfer function of 10 dB per volt.

Each of the two models operates over the full frequency range from 18-40 GHz with a dynamic attenuation range of 50 dB.

QUADRATURE COUPLER

The Model 7050 3-dB Quadrature Coupler is a 4-port single-section Hopfer coupler which operates over the frequency range from 18-40 GHz. It features low insertion loss, high isolation, and excellent amplitude and phase balance.

Models 1959, D1959
Millimeter Wave PIN Diode Attenuator/Modulator

MODEL 1959

The Model 1959 is a current-controlled attenuator/modulator that provides a minimum of 50 dB of attenuation over the frequency range of 18 to 40 GHz.

As shown in figure 1 below, the rf circuit uses two shunt arrays of PIN diodes and two quadrature hybrid couplers. The quadrature hybrids are of a unique GMC microstrip design which are integrated with the diode arrays to yield a minimal package size.

MODEL D1959

The Model D1959 voltage-controlled linearized attenuator/modulator is an integrated assembly of a Model 1959 and a hybridized driver circuit which provides a nominal transfer function of 10 dB per volt. (See figure 2 below.)

- **Absorptive**
- **Current or voltage controlled**
- **18 to 40 GHz frequency range**
- **High performance MIC quadrature hybrid design**
- **High speed**

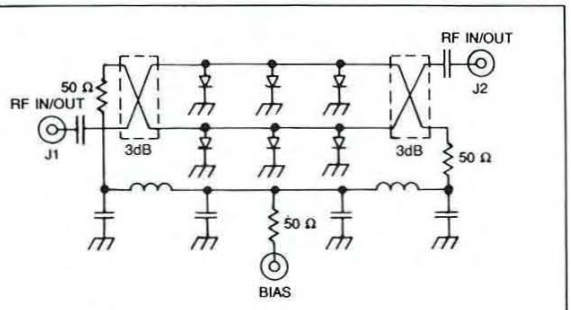


Fig. 1—Model 1959, rf schematic diagram

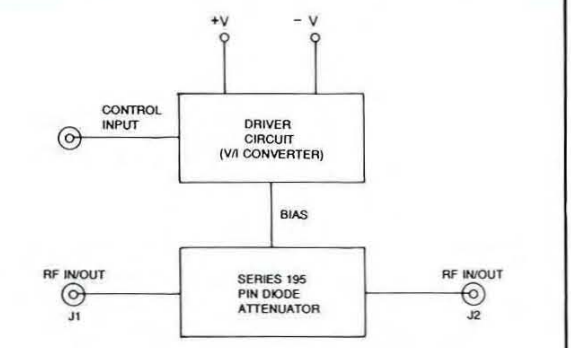


Fig. 2—Model D1959, block diagram

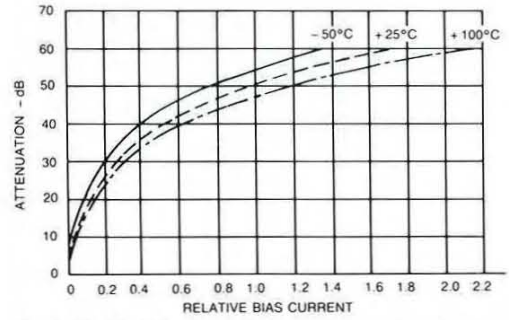


Fig. 3—Model 1959, typical effects of temperature on attenuation.

Models 1959, D1959 Specifications

PERFORMANCE CHARACTERISTICS

MODEL	FREQUENCY RANGE (GHz)	MAX INSERTION LOSS (dB)	MAX VSWR	FLATNESS (± dB) AT MEAN ATTENUATION LEVELS UP TO			
				10 dB	20 dB	40 dB	50 dB
1959	18-26.5	3.6	2.2	1.3	2.2	3.4	4.0
	26.5-36	4.1					
	36-40	4.7					
D1959	18-26.5	4.1	2.2				
	26.5-36	4.6					
	36-40	5.2					

COMMON TO BOTH MODELS 1959 and D1959

Mean Attenuation
Range . . . . . 50 dB
Monotonicity . . . . . Guaranteed
Power Handling Capability
Without Performance Degradation . . . . . 10 mW cw or peak
Survival Power . . . . . 0.2W average, 5W peak (1 μsec max pulse width)

MODEL 1959
Rise and Fall Times
Rise Time . . . . . 75 nsec max
Fall Time . . . . . 20 nsec max (1)
Bias Current for Maximum Attenuation . . . . . 15 to 70 mA
Temperature Effects . . . See figure 3

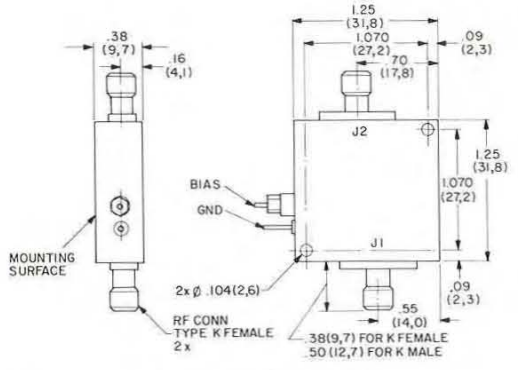
MODEL D1959
Accuracy of Attenuation
0 to 30 dB . . . . . ±0.5 dB
30 to 50 dB . . . . . ±1.0 dB
Temperature Coefficient . . . . . ±0.025 dB/°C
Switching Characteristics
On Time . . . . . 300 nsec
Off Time . . . . . 30 nsec max(1)
Nominal Control Voltage Characteristics
Operating . . . . . 0 to +5V
Transfer Function . . . . . 10 dB/volt
Input Impedance . . . . . 10 Kohms
Modulation Bandwidth
Small Signal . . . . . 5 MHz
Large Signal . . . . . 2 MHz
Power Supply Requirements . . . . . +12V ±5%, 100 mA
−12V ±5%, 20 mA
Power Supply Rejection . . . . . Less than 0.1 dB/Volt change in either supply

ENVIRONMENTAL RATINGS AND AVAILABLE OPTIONS

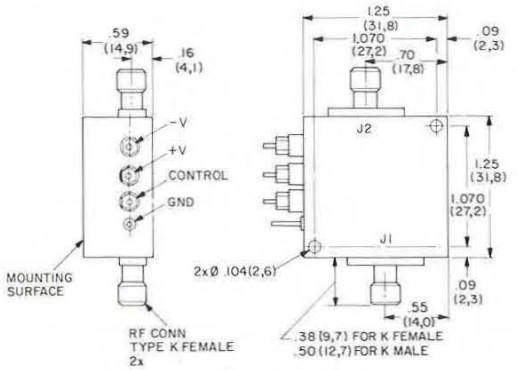
See page 150.

(1) *For attenuation steps of 10 dB or more*

DIMENSIONS AND WEIGHTS



MODEL 1959
Wt: .8 oz. (23 gm) approx.



MODEL D1959
Wt: 1 oz. (28 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Series 90
Millimeter Wave SPST Switches

SERIES 90

Series 90 switches provide high performance characteristics over the frequency range of 18 to 40 GHz. These miniature switches measure only .75″ x .95″ x .42″.

The series uses an integrated circuit assembly of up to four PIN diodes mounted in a microstrip transmission line. The circuit configuration is shown in Fig. 1, below.

Application of a positive current to the bias terminal switches the unit OFF since the diodes are biased to a low resistance value. With zero or negative voltage at the bias terminal, the diodes are biased to a high resistance and the unit is switched ON.

SERIES F90

The Series F90 switches are the same as the corresponding Series 90 models except the units are equipped with integrated drivers as shown in Fig. 2.

The proper current required to switch the unit ON or OFF is provided by the integral driver which is controlled by an external logic signal. Maximum rise and fall times are less than 10 nsec.

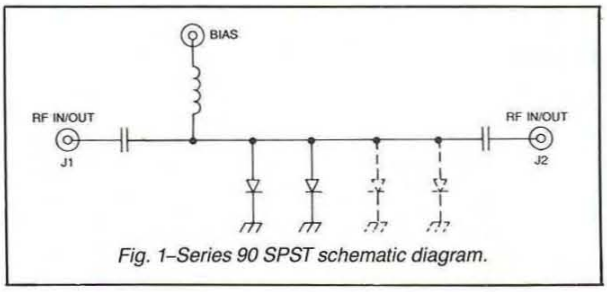


Fig. 1–Series 90 SPST schematic diagram.

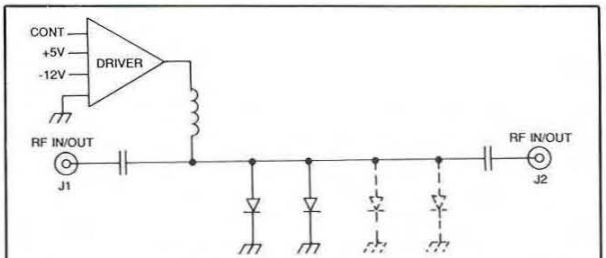


Fig. 2–Series F90 SPST schematic diagram.

- **18 to 40 GHz frequency range**
- **Low VSWR and insertion loss**
- **Up to 75 dB isolation**
- **Less than 10 nsec rise and fall times**

Series 90 SPST Switches Specifications

PERFORMANCE CHARACTERISTICS

MODEL NO.(1)	CHARACTERISTIC	FREQUENCY (GHz) 18-26.5	26.5-40
9012, F9012	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	35 2.2 2.0	30 2.7 2.2
9013, F9013	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	55 2.5 2.0	50 3.0 2.2
9014, F9014	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	75 2.8 2.2	70 3.5 2.2

Rise and Fall Times . . . . . 10 nsec max
Switching Time . . . . . 20 nsec max
Repetition Rate . . . . . 20 MHz max

Power Handling Capability
Without Performance Degradation . . . . . 1W cw or peak
Survival Power . . . . . 2W average, 75W peak (1 μsec max pulse width)

POWER SUPPLY REQUIREMENTS

Driverless Units
For rated isolation . . . . . +35 mA
For rated insertion loss . −10V

Units With Integrated Drivers . . . . . +5V ±2%, 65 mA
−12 to −15V, 20 mA

CONTROL CHARACTERISTICS

Control Input Impedance . . . . . TTL, advanced Schottky, one unit load. (A unit load is 0.6 mA sink current and 20 μA source current.)

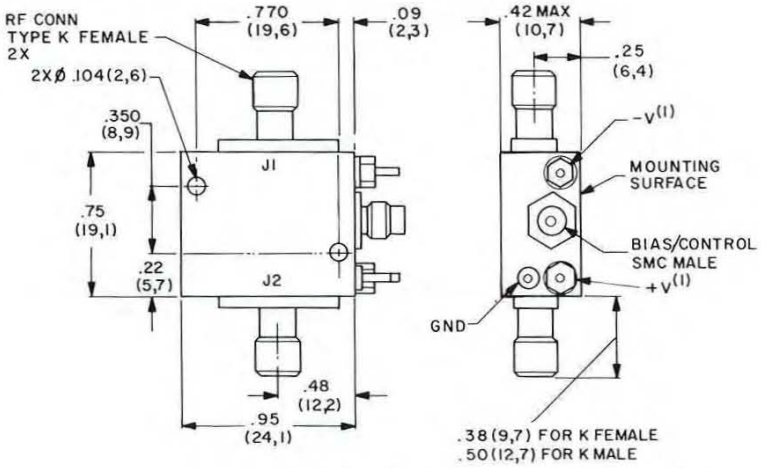
Control Logic . . . . . Logic "0" (−0.3 to +0.8 V) for switch ON and Logic "1" (+2.0 to +5.0 V) for switch OFF.

ENVIRONMENTAL RATINGS AND AVAILABLE OPTIONS

See page 150

(1)*Models prefixed with "F" are equipped with integrated TTL-compatible drivers; models without the "F" prefix are current-controlled units and are furnished without drivers.*

DIMENSIONS & WEIGHT



(1) USED ONLY ON UNITS WITH INTEGRATED DRIVERS
Series 90/F90
Wt: .6 oz. (17 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx ±.005

Series 90
Millimeter Wave SP2T Switches

REFLECTIVE SP2T SWITCHES

Series 90 SP2T switches use an integrated assembly of PIN diodes mounted in a microstrip transmission line in a series-shunt arrangement as shown in Figure 1.

When applying positive current (by the driver), the associated port is OFF since the corresponding shunt diodes are biased to a low resistance and the series diode to a high resistance. With negative current at the bias terminal converse conditions are established and the port is ON. All models are supplied with integrated drivers. Standard units are supplied with logic that turns a port ON with the application of a logic "0" control signal. Maximum rise and fall times are less than 10 nsec.

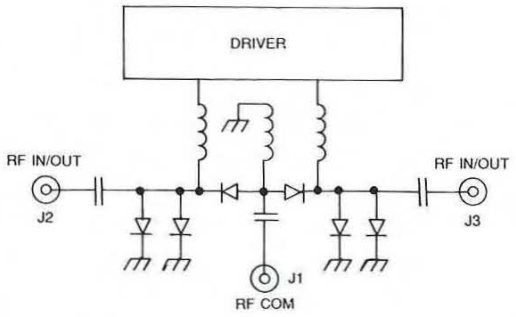


Fig. 1—Series F90 SPDT schematic diagram

- **18 to 40 GHz frequency range**
- **Rise and fall times less than 10 nsec**
- **Low VSWR and insertion loss**
- **Up to 65 dB isolation**

Series 90 SP2T Switches Specifications

PERFORMANCE CHARACTERISTICS

MODEL NO.	CHARACTERISTIC	FREQUENCY (GHz) 18 - 26.5	FREQUENCY (GHz) 26.5 - 40
F9021	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	30 3.0 2.1	20 3.6 2.3
F9022	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	45 3.2 2.2	40 4.0 2.3
F9023	Min Isolation (dB) Max Insertion Loss (dB) Max VSWR (ON)	65 3.5 2.3	55 4.5 2.5

Rise and Fall Times . . . . . 10 nsec max
Switching Time . . . . . 25 nsec max
Repetition Rate . . . . . 20 MHz max

Power Handling Capability
Without Performance Degradation . . . . . 1W cw or peak
Survival Power . . . . . 1W average, 75W peak (1 μsec max pulse width)

Power Supply Requirements . . . . . +5V ±2%, 75 mA
−12 to −15V, 50 mA

CONTROL CHARACTERISTICS

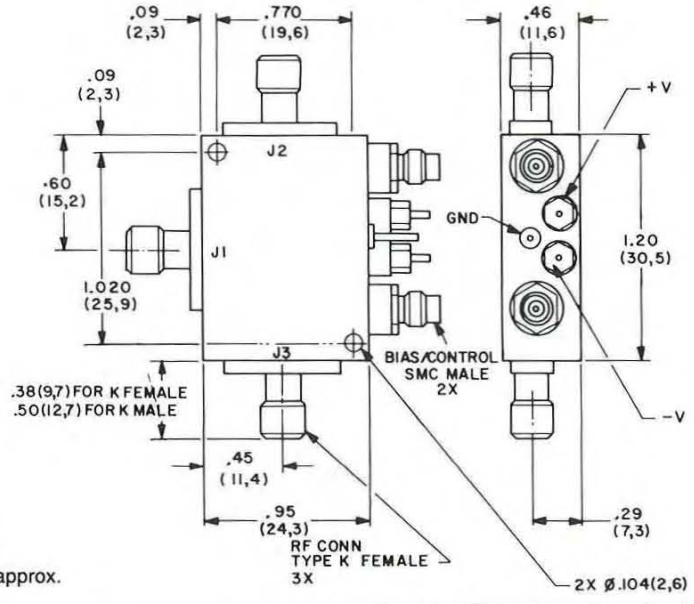
Control Input Impedance . . . . . TTL, advanced Schottky, one unit load. (A unit load is 0.6 mA sink current and 20 μA source current.)

Control Logic . . . . . Logic "0" (−0.3 to +0.8 V) for port ON and Logic "1" (+2.0 to +5.0 V) for port OFF.

ENVIRONMENTAL RATINGS AND AVAILABLE OPTIONS

See page 150

DIMENSIONS AND WEIGHT



SERIES F90
Wt: 1 oz. (28 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Model 7050 Millimeter Wave 3 dB Quadrature Coupler

The 3 dB Quadrature Coupler is a four port device covering the frequency range of 18 to 40 GHz. The coupler design is a single section Hopfer coupler which has been optimized to perform in the millimeter frequency range. See Fig. 1. It offers excellent amplitude and phase balance as well as low loss and high isolation. The 3 dB Quadrature Coupler utilizes removable connectors for easy integration into coaxial millimeter wave systems.

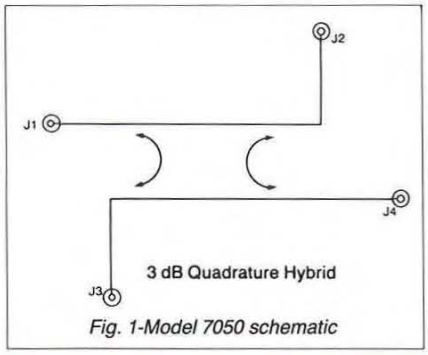
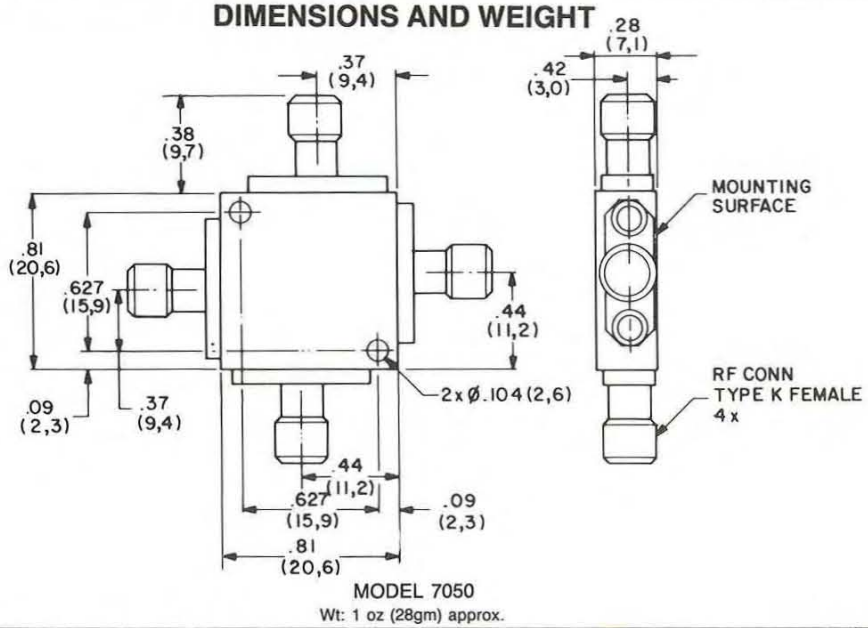


Fig. 1-Model 7050 schematic

- **Frequency range: 18-40 GHz**
- **Low insertion loss**
- **High isolation**
- **Removable connectors**

SPECIFICATIONS	
Frequency (GHz)	18-40
Min Isolation (dB)	14
Max Insertion Loss (dB)	1.5
Max VSWR	1.8
Amplitude Balance (dB)	±1.7
Phase Balance (deg)	±10
Power Handling, operating and survival, cw or peak	2W

DIMENSIONS AND WEIGHT



MODEL 7050
Wt: 1 oz (28gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ±.02; .xxx ±.005

Millimeter Wave Component Specifications

ENVIRONMENTAL AND OPTIONS

ENVIRONMENTAL RATINGS

Operating Temperature Range
- **Series 90**
  - With Drivers ..... −65°C to +110°C
  - Without Drivers .... −65°C to +125°C
- **Model 1959** ..... −54°C to +125°C
- **Model D1959** ..... −54°C to +110°C
- **Model 7050** ..... −65°C to +125°C

Non-Operating Temperature Range ..... −65°C to +125°C

Humidity ..... MIL-STD-202F, Method 103B, Cond. B (96 hrs. at 95%)

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude ..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling ..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

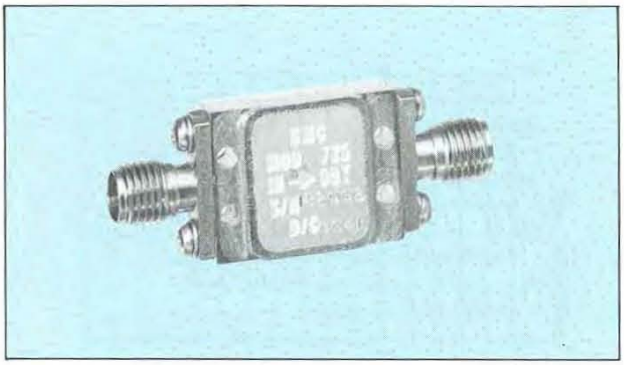
AVAILABLE OPTIONS		MODEL			
Option No.	Description	1959 Current-Controlled Attenuator	D1959 Voltage-Controlled Attenuator	9012, 9013, 9014 F9012, F9013, F9014 SPST Switches	F9021, F9022, F9023 SP2T Switches
3	SMA female bias/control connectors	✓	✓	✓	✓
7	Type K male rf connectors	✓	✓	✓	✓
7A	J1 type K male; J2 and J3 type K female				✓
7B	J1 type K female; J2 and J3 type K male				✓
9	Inverse control logic; logic "0" for port OFF and logic "1" for port ON(1)			✓	✓
10	One type K male (J1) and one type K female (J2) rf connector	✓	✓	✓	
27	Single-port toggle control; logic "0" connects J1 to J2				✓
33	EMI filter solder-type bias/control terminals			✓	✓
61	20 dB/volt transfer function with 0 to +3V control signal input		✓		
62	± 15 volts operation		✓		
64	SMC male bias/control connectors	✓	✓		
64A	SMB male bias/control connectors	✓	✓	✓	✓

(1) *Not applicable for units without drivers.*

Models 725 and 726
Broadband Low and Medium Power Limiters

Models 725 and 726 broadband limiters are designed for low and medium power applications. The low power limiter Model 725 covers the frequency range of 1 to 18 GHz and limits up to input power levels of 3 watts cw and 100 watts peak. The medium power limiter Model 726 covers the frequency range of 2 to 18 GHz and provides limiting up to input power levels of 10 watts cw and 200 watts peak.

Typical limiting curves for each model are shown in figures 1 and 2. Both limiters are supplied in hermetically sealed packages with removable SMA connectors and are suitable for use as drop-in modules.



PERFORMANCE CHARACTERISTICS

MODEL NO.	CHARACTERISTICS	FREQUENCY (GHz)		
725	LOW POWER LIMITER	1-4	4-12.4	12.4-18
	Max Insertion Loss (dB)	0.7	1.3	2.0
	Max VSWR	1.75	2.0	2.0

726	MEDIUM POWER LIMITER	2-8	8-12.4	12.4-18
	Max Insertion Loss (dB)	1.2	1.8	2.0
	Max VSWR	1.6	2.0	2.0

CHARACTERISTICS	MODEL 725	MODEL 726
Max Leakage Power	@ Pin = 3 watt cw: 90 mW	@ Pin = 10 watts cw: 100 mW
	@ Pin = 100 watts peak: 100 mW	@ Pin = 200 watts peak: 100 mW
Limiting Threshold	10 mW min. (1 dB Compression)	10 mW min. (1 dB Compression)
Spike Leakage	0.25 erg max.	0.5 erg max.
Recovery Time	10 nsec. max to 1 dB of I.L.	100 nsec. max. to 1 dB of I.L.
Peak Power Handling	100 W peak with 1 μsec. pulse width and 0.01 duty cycle	200 W peak with 1 μsec. pulse width and 0.02 duty cycle
CW Power Handling	3 watts	10 watts

AVAILABLE OPTIONS

Option No.	Description
49	High Rel screening (see Table 1, page 36)

ENVIRONMENTAL RATINGS

Temperature Range
Operating . . . . . – 65°C to + 110°C

Models 725 and 726 Specifications

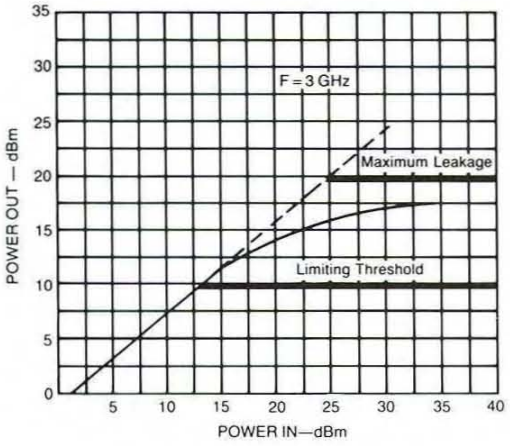


Fig. 1—Model 725 power in vs. power out

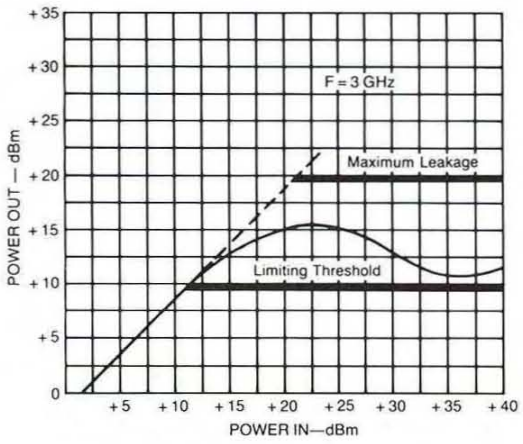


Fig. 2—Model 726 power in vs. power out

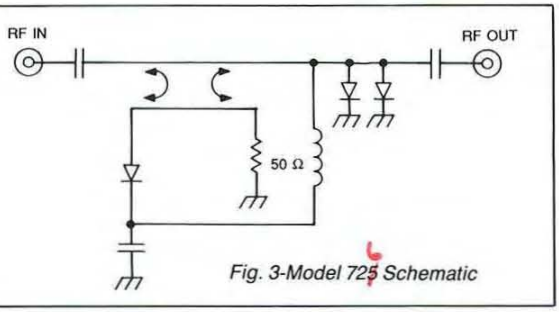


Fig. 3-Model 725 Schematic

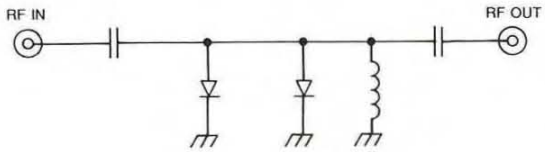
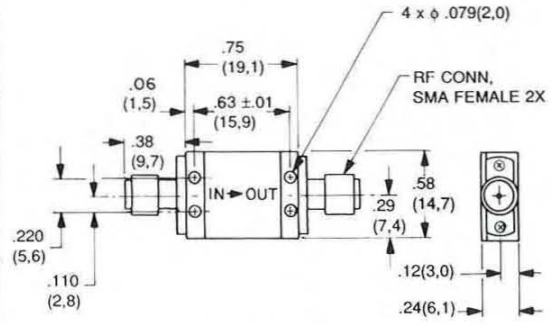
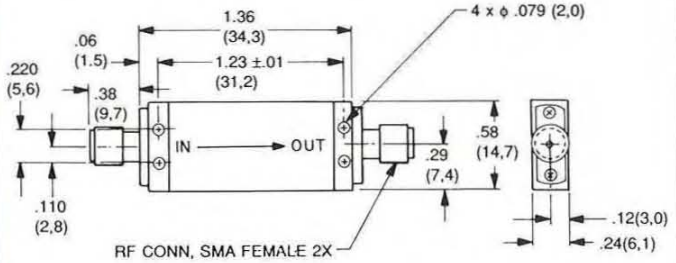


Fig. 4-Model 726 Schematic

DIMENSIONS AND WEIGHTS



MODEL 725
Weight: 0.5 oz. (14 gm) Approx.



MODEL 726
Weight: 0.7 oz (20 gm) Approx.

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Solid State Oscillators

Modern microwave oscillators utilize a solid state device, such as a transistor or diode, together with a resonant circuit and matching network, to convert dc power to microwave power at a specified frequency. A simplified block diagram of a microwave oscillator is shown in Fig. 1. By appropriate choice of these elements, oscillators may be designed for an extremely wide range of applications. In addition, low frequency digital and analog control circuitry may be incorporated to provide further flexibility.

General Microwave offers a catalog line of high-performance voltage-controlled oscillators (VCO's), digitally-tuned oscillators (DTO's) and dielectric resonator oscillators (DRO's) in the 2-18 GHz frequency range. In addition, many custom oscillators have been developed for various applications.

VCO's

The GMC line of VCO's covers the 2-18 GHz frequency range in octave (2-4, 2.6-5.2 and 4-8 GHz) and half-octave (8-12 and 12-18 GHz) bands. The major features of the VCO's are fast settling time, low phase noise and excellent frequency stabilty. A simplified block diagram is shown in Fig. 2. For optimum performance, the active element used is a silicon bipolar transistor. (This is in lieu of GaAs FETs which typically exhibits 10-20 dB poorer phase noise performance. Although GaAs FETs have extremely low noise in amplifier applications, they suffer from high 1/f noise, which is upconverted in the non-linear oscillator to phase noise near the carrier.) To vary the frequency of the oscillator, a high-Q silicon hyperabrupt varactor is utilized. The capacitance-voltage characteristic is specified to provide as nearly linear frequency vs. voltage tuning curve as possible. In practice, good linearity can only be realized over a small portion of the tuning range because of parasitic reactances present in the physical circuit and the bipolar transistor. Typical ratios of maximum to minimum frequency vs. voltage sensitivity for an octave band are 2:1, and are specified at 3:1. GaAs varactors, although having higher Q's than silicon varactors, suffer from long-term charging effects as well as relatively poor thermal conductivity. Silicon varactors are therefore mandatory in high-speed applications requiring settling times of the order of several hundred nanoseconds and low post-tuning-drift.

To minimize pulling effects on the oscillator frequency due to variations in the external load, attenuator pads followed by buffer amplifiers are incorporated at the oscillator output. Voltage regulators are also included to minimize the effect of variations in the power supply voltage on both oscillator frequency and power level. Finally, filtering is provided to reduce the harmonic content of the output signal.

Of particular note is GMC's 8-12 GHz VCO, which utilizes a high performance transistor operating in the fundamental, rather than the doubling push-push

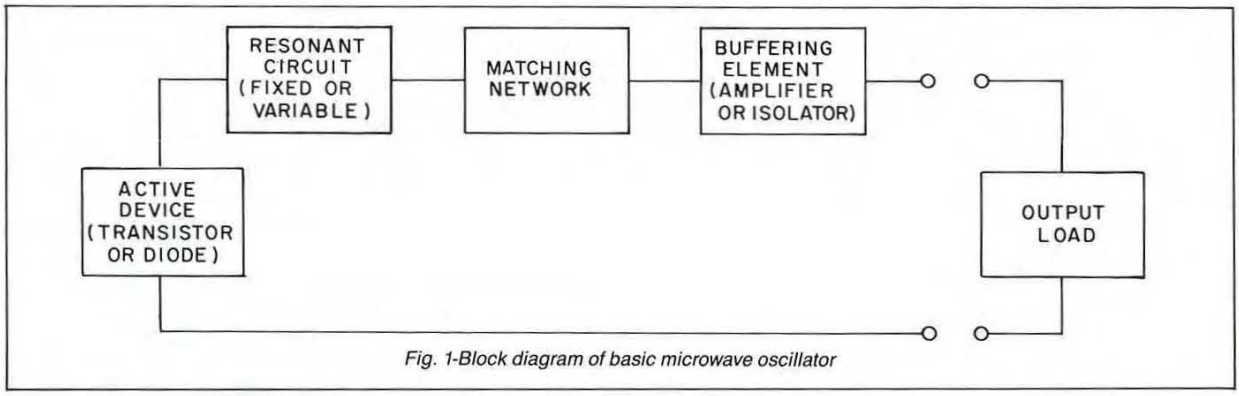


Fig. 1-Block diagram of basic microwave oscillator

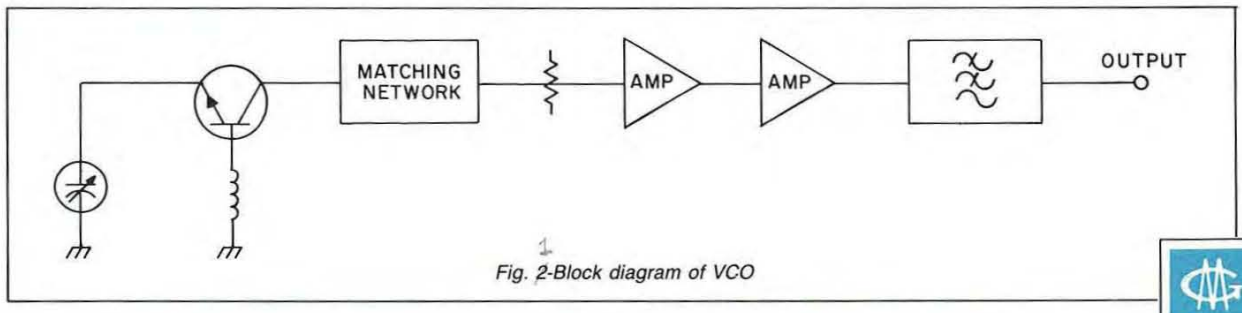


Fig. 2-Block diagram of VCO

mode. This mode of operation eliminates all $(2n + 1)f_o/2$ frequencies in the output spectrum. The second harmonic signal is filtered to less than −50 dBc typically, and −40 dBc maximum.

Because fundamental mode oscillation is not currently achievable with available solid state devices in the 12-18 GHz band, the doubling push-push approach, shown schematically in Fig. 3, is used. Thus, for example, for a 12 GHz output frequency, each oscillator is designed to operate at 6 GHz. If the structure were perfectly symmetrical, all odd harmonics of 6 GHz would be suppressed, and only even harmonics would be present in the output spectrum. By suitable filtering, an essentially pure 12 GHz output signal could be obtained. In practice, imperfect symmetry results in $f_o/2$ and $3f_o/2$ signals, which are filtered to the extent possible. (For the case of a 12 GHz output signal, the undesired $3f_o/2$ signal at 18 GHz cannot be filtered since it is within the 12-18 GHz frequency range of the VCO.)

DTO's

GMC offers a line of DTO's covering the 2-18 GHz frequency range based upon its catalog line of VCO's. The DTO provides the desired output frequency in response to a digital control signal. A block diagram of the DTO is shown in Fig. 4. By appropriate design of the electronic circuitry, settling times of less than 300 nanoseconds are achieved. To obtain a frequency accuracy of the order of ±0.1%, including the effects of temperature, the VCO is proportionally-heated and the electronic circuitry temperature-compensated. A latch mode is provided as a standard feature.

To enable analog frequency modulation of the DTO for jamming and other applications, a separate frequency modulation port is provided. Since the slope of the frequency vs. voltage curve of the VCO varies over the band, compensation is required to obtain a relatively constant deviation bandwidth. Compensation to within ±5% is achieved by utilizing a PROM to vary the attenuation applied to the modulating signal. The DTO may be frequency modulated at rates of greater than 20 MHz.

In general, DTO's tend to be tailored to the overall requirements of the system in which they are used. Among the custom designs GMC has developed are high-speed multi-band units with frequency coverage from C to Ku band.

DRO's

Over the past decade, the DRO has become the oscillator of choice for fixed-frequency applications requiring high stability and low phase noise. GMC offers a high-performance line of DRO's in the 5-18 GHz frequency range featuring 1 ppm/°C frequency stability over a wide temperature range. A high-Q temperature-stable dielectric resonator is used as the key element in the passive resonant circuit.

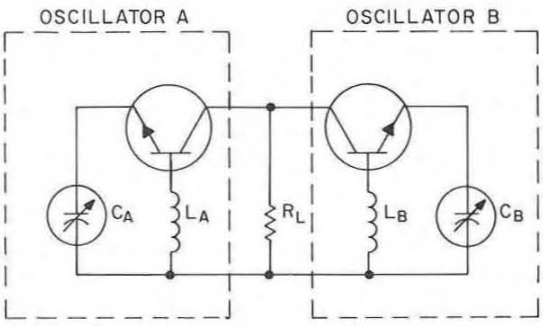


Fig. 3-Schematic diagram of Push-Push Oscillator

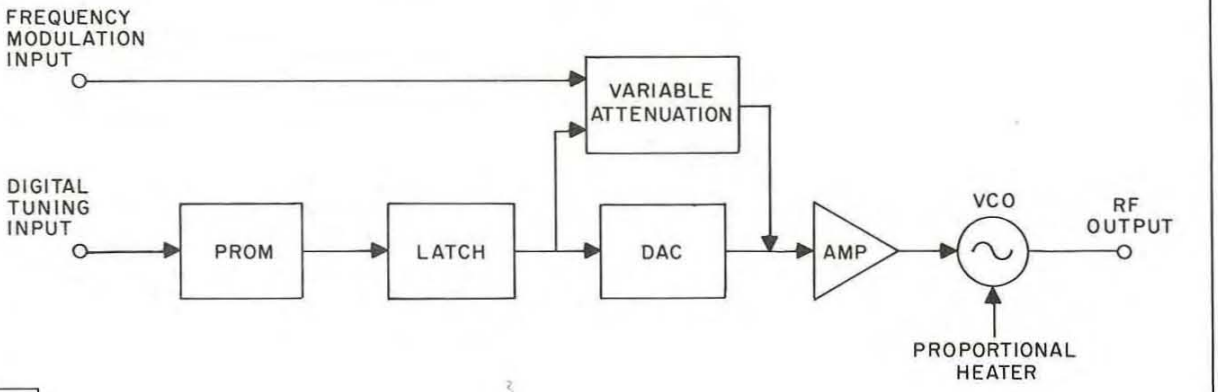


Fig. 4-Block diagram of DTO

The dielectric resonator is weakly coupled to maximize the loaded Q of the circuit, thereby minimizing the frequency variation over temperature, phase noise, and frequency pulling and pushing. A series feedback topology is chosen for best overall performance, as shown in Fig. 5. GaAs FETs are used as the active device in the 8-18 GHz range, and silicon bipolar transistors in the 5-8 GHz range. Buffer amplifiers and voltage regulators are included as standard features to further reduce the frequency variations due to variations in the load and supply voltages, respectively. GMC's "M" series of DRO's includes a mechanical tuning element which permits the user to vary the frequency of the DRO over a narrow band.

DEFINITION OF PARAMETERS

Frequency Settling/Post-Tuning Drift: The maximum deviation in frequency at a given time, following a change in tuning command, relative to the frequency one second after the change in tuning command. The worst-case condition usually occurs for frequency steps from one end of the band to the other. (Results of a typical measurement are shown in Fig. 6.) Settling time usually refers to the response up to several hundred microseconds, while post-tuning-drift usually refers to the variation from several hundred microseconds to as long as several hours.

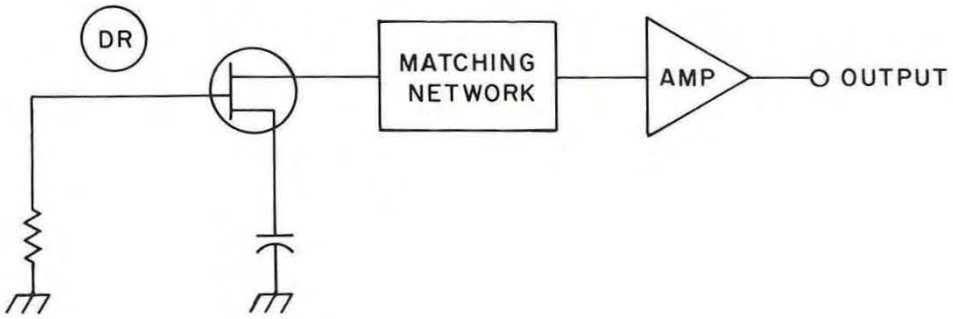


Fig. 5-Schematic diagram of DRO

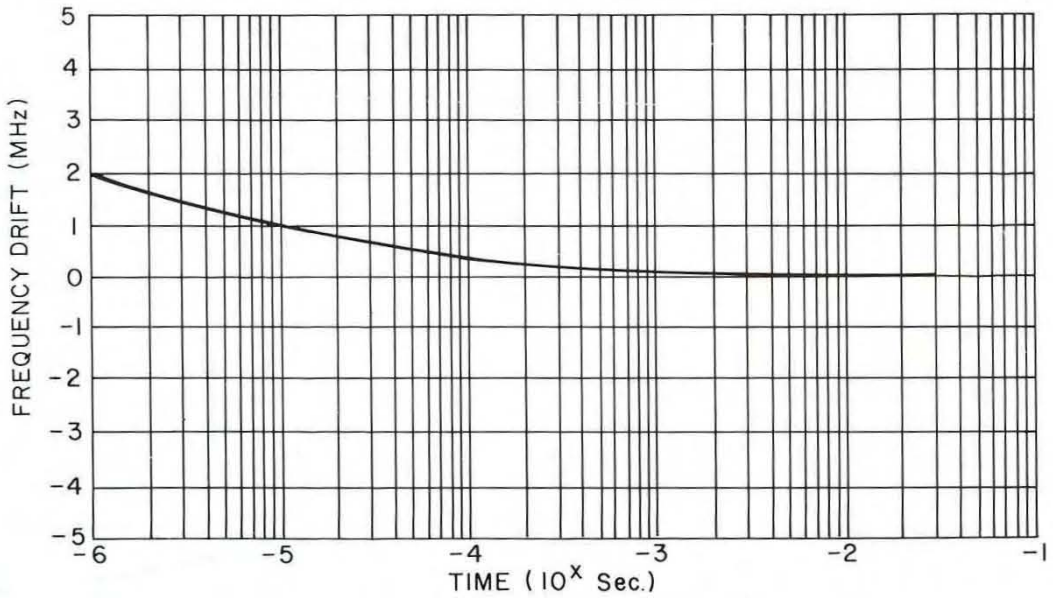


Fig. 6-Measured settling time of 8-12 GHz VCO

Modulation Sensitivity Ratio: The ratio between the maximum and minimum slopes of the frequency vs. voltage tuning curve of a VCO over its frequency band. (For a DTO, this is defined at the FM modulation port.)

Frequency Deviation Bandwidth: The peak-peak frequency deviation obtained for a given peak-peak voltage swing at the modulation port of a VCO or DTO.

Modulation Bandwidth: The modulation frequency at which the frequency deviation bandwidth of a VCO or DTO decreases by 3 dB relative to the deviation bandwidth at low frequencies.

Phase Noise: The sideband noise level at a given deviation, f_m, from the oscillator frequency, relative to the carrier power level and normalized to a bandwidth of 1 Hz. Typical measured DRO phase noise versus frequency deviation is shown in Fig. 7. From 10 kHz to 100 kHz, the phase noise of a VCO or DRO has a nominal $1/f_m^3$ dependence. Thus, as shown in the figure, the phase noise at 100 kHz is approximately 30 dB lower than that at 10 kHz.

Residual FM: The peak-peak frequency deviation of an oscillator at its −3 dBc points, when measured on a spectrum analyzer with a resolution bandwidth of 1 kHz. (See Fig. 8).

Temperature Stability: The total oscillator frequency variation over the rated operating temperature, usually expressed in ppm/°C.

Pulling: The maximum variation in oscillator frequency, relative to its frequency when operating with a matched load, when the output load is rotated through a full 360° phase change. The peak-peak variation in oscillator frequency is approximately twice the pulling figure defined above. By using the following approximate formula, the pulling figure may be scaled as a function of the VSWR:

$$\Delta f_{\text{peak-peak}} = \frac{f_o}{2Q_{EXT}} (S - 1/S)$$

where f_o is the oscillator frequency, Q_{EXT} is the external Q of the circuit, and S is the load VSWR.

Pushing: The incremental change in oscillator frequency that results from an incremental change in power supply voltage.

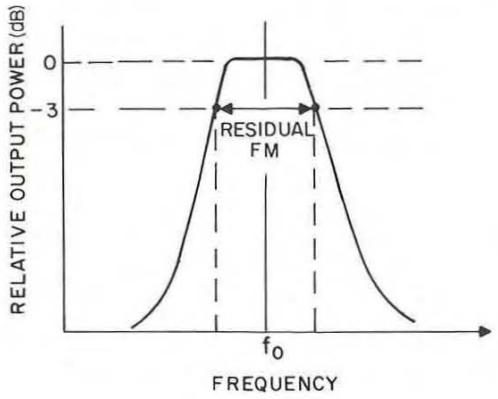


Fig. 8-Residual FM

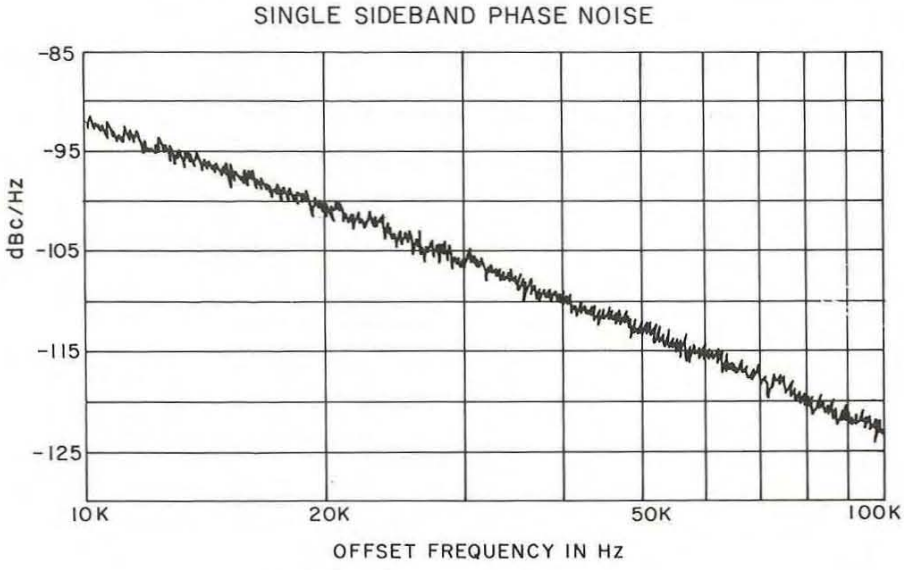


Fig. 7-Measured phase noise of 12 GHz DRO

Oscillator Selection Guide

PERFORMANCE HIGHLIGHTS (at 18 GHz)[1]

High Speed: ..... ± 12 MHz within 300 nsec

Low Post Tuning Drift: ..... ±3 MHz within 1 μsec

Accuracy: (Including Temperature) ..... ±12 MHz max

Wide Modulation Bandwidth: ..... 20 MHz min

DTO — DIGITALLY TUNED OSCILLATORS

STANDARD DTOs[2]

MODEL	FREQUENCY RANGE (GHz)
D6020	2.0 to 4.0
D6026	2.6 to 5.2
D6040	4.0 to 8.0
D6080	8.0 to 12.0
D6120	12.0 to 18.0

2-18 GHz

High Speed: ..... ≤ ±10 MHz within 50 nsec

Low Post Tuning Drift: ..... ≤ ±3 MHz within 1 μsec

SUPERIOR FREQUENCY STABILITY:

Over Temperature .... ≤ 75 PPM/°C typ

Load Pulling (VSWR=2:1) ..... 1 MHz max

VCO — VOLTAGE CONTROLLED OSCILLATORS

STANDARD VCOs[2]

MODEL	FREQUENCY RANGE (GHz)
V6020	2.0 to 4.0
V6026	2.6 to 5.2
V6040	4.0 to 8.0
V6080	8.0 to 12.0
V6120	12.0 to 18.0

2-18 GHz

EXCELLENT FREQUENCY STABILITY:

Over Temperature: ... 1 PPM/°C max

Load Pulling ..... 150 kHz max

Power Supply Pushing 4 kHz/ V max

SUPERIOR PHASE NOISE: (dBc/Hz)

at 10 kHz Offset ..... −85 dBc max

at 100 kHz Offset ..... −115 dBc typ

DRO — DIELECTRIC RESONATOR OSCILLATORS

STANDARD DROs[2]

MODEL	FREQUENCY RANGE (GHz)
F5080	5.000 to 7.999
M5080	5.000 to 7.999
F5120	8.000 to 11.999
M5120	8.000 to 11.999
F5180	12.000 to 18.000
M5180	12.000 to 18.000

5-18 GHz

NOTES: **1.** *Specifications improve at lower frequency.* **2.***Custom designs available upon request.*

DTO Specifications

PARAMETER	MODEL				
	D6020	D6026	D6040	D6080	D6120
FREQUENCY RANGE (GHz)	2-4	2.6-5.2	4-8	8-12	12-18
ACCURACY, Incl. temp. (MHz)	±4	±6	±8		±12
FREQUENCY SETTLING[1], max (MHz) within 300 nsec	±4	±6	±8		±12
within 1μsec	±1		±2		±3
MODULATION Bandwidth, min (MHz)	DC to 20				
Sensitivity variation, max	±5%				
Frequency deviation bandwidth, min @ 2V P-P (MHz)	200	260	400		600
RF POWER Output, min (dBm)	+10				
Variation, incl. temp.and freq. max (dB)	±1.5		±2.0		
RESIDUAL FM, P-P @ −3 dBc (kHz)	50	75	100		150
HARMONICS, max (dBc)	−15			−40	−30
f/2, 3f/2, max (dBc)	N/A				−25
SPURIOUS, max (dBc)	−60				
PULLING, VSWR 2:1 max (MHz)	1				
PUSHING, max (kHz/V)	250				
NOMINAL LSB[4] (MHz)	0.5		1.0		1.5
MONOTONICITY	Guaranteed				
TURN ON TIME, (minutes) to specified accuracy @ +25°C	2				
to specified accuracy @ −54°C	5				
CONNECTORS Control/Power	25 pin, D type male[2]				
RF output	SMA female				
FM input	SMC male				
POWER SUPPLY REQUIREMENT Voltage @ Current	+15V ±0.5V @ 200 mA max −15V ±0.5V @ 100 mA max +5V ±0.5V @ 300 mA max +28V −4 V, +2V@ 1000 mA max				
Turn-on current @ 28 volts	3 amps max				
ENVIRONMENTAL[3] Operating temperature (°C)	−54 to +85				
Storage temperature (°C)	−54 to +125				
MECHANICAL DIMENSIONS Inches	5.67 x 3.55 x 1.69				
Millimeters	144.0 x 90.2 x 42.9				

(1) *Δf relative to f after 1 sec.*
(2) *Mating connector furnished*
(3) *RF section and driver components hermetically sealed.*
(4) *12 Bit TTL input*

VCO Specifications

PARAMETER	MODEL V6020	V6026	V6040	V6080	V6120
FREQUENCY RANGE (GHz)	2-4	2.6-5.2	4-8	8-12	12-18
FREQUENCY SETTLING[1], max (MHz)					
within 50 nsec			±8		±10
within 200 nsec		±3		±4	±5
within 1μsec		±1		±2	±3
MODULATION					
Bandwidth, min (MHz)			100		
Sensitivity ratio, max			3:1		
RF POWER					
Output, min (dBm)			+10		
Variation, Incl. temp. and freq. max (dB)		±2.5		±3.0	
PHASE NOISE, max (dBc/Hz)					
@ 100 kHz offset		−95	−90	−85	−85
HARMONICS, max (dBc)		−15		−40	−30
f/2, 3f/2, max (dBc)			N/A		−25
SPURIOUS, max (dBc)			−60		
TEMPERATURE STABILITY, typ (PPM/°C)			~~75~~ 100		
PULLING, VSWR 2:1 max (MHz)			1		
PUSHING, max (kHz/V)			250		
CONNECTORS					
Power supply			Solder terminal		
Tuning voltage			SMA female		
RF output			SMA female		
POWER SUPPLY REQUIREMENT					
Voltage (Vdc)			+15 ±0.5		
Current, max (mA)		150	~~200~~ 150		250
Tuning voltage (Vdc)		0 to +20		0 to +15	
INPUT CAPACITANCE, nominal (pF)			~~25~~ 30		
ENVIRONMENTAL[2]					
Operating temperature (°C)			−54 to +85		
Storage temperature (°C)			−54 to +125		
MECHANICAL DIMENSIONS					
Inches			1.79×1.10×0.45		2.19×1.10×0.45
Millimeters			45,5×27,9×11,4		55,6×27,9×11,4

(1) *Δf relative to f after 1 sec.*
(2) *RF section and driver components hermetically sealed.*

AVAILABLE OPTIONS

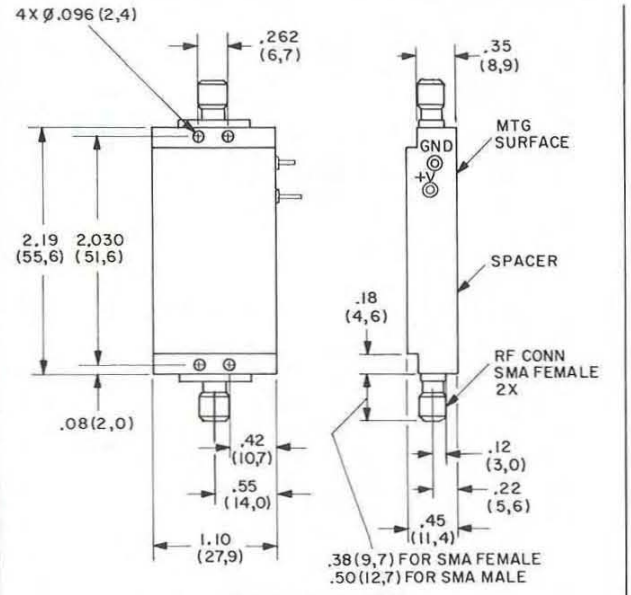
Option No.	Description
2	Drop-In module configuration
49A	High Rel screening (see Table 1 to the right)

TABLE 1: OPTION 49A HIGH REL SCREENING

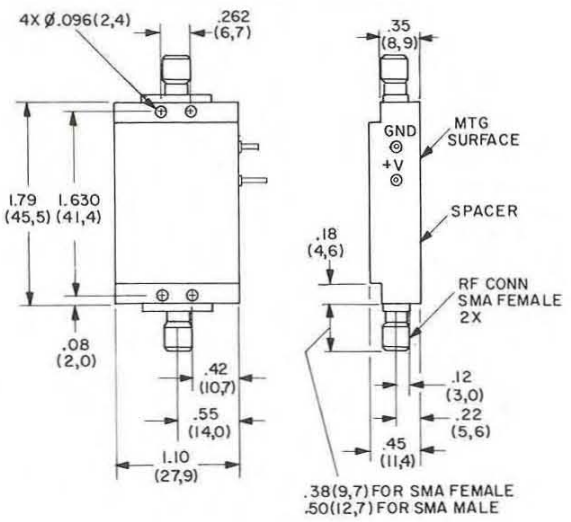
General Microwave's hermetically-sealed components utilize rugged construction techniques and hermetic sealing to meet stringent military requirements for shock, vibration, temperature, altitude, humidity, and salt atmosphere. All hermetically-sealed parts may be ordered, if desired, with 100% screening in accord with the following:

TEST	METHOD	CONDITION
Internal Visual	2017.3	—
Stabilization Bake	1008.2	C
Temperature Cycle	1010.5	B
Mechanical Shock	2002.3	A
Burn-In	1015.4	—
Leak	1014.2/.9	A1 & A2

DTO/VCO Specifications



MODEL V6120 VCO
Wt: 1.94 oz. (55 gm) approx.

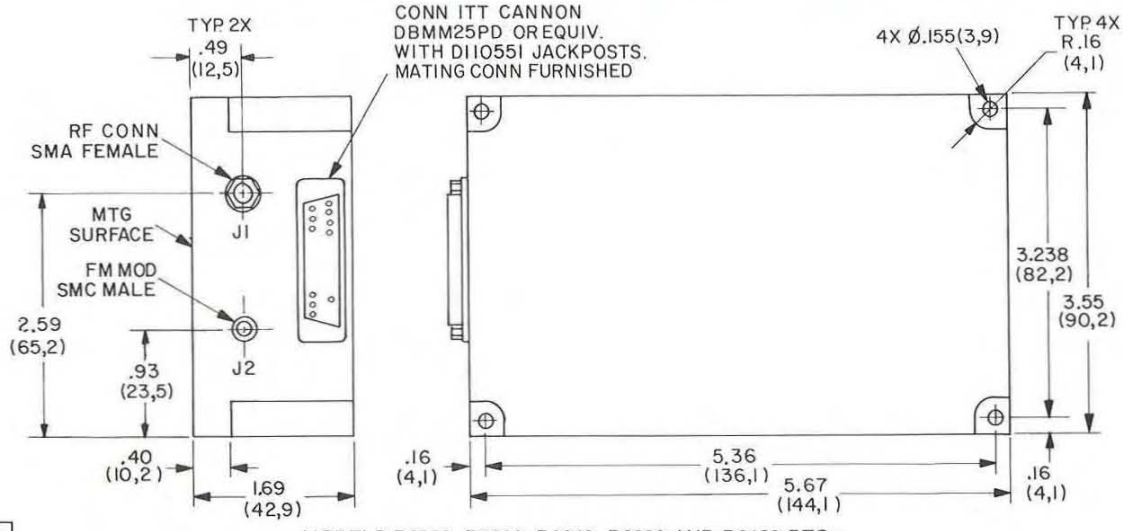


MODELS V6020, V6026, V6040 AND V6080 VCOs
Wt: 1.27 oz. (36 gm) approx.

CONTROL/POWER CONNECTOR	
Pin. No.	Function
1	+28 V
2	+28 V
3	Temp. monitor thermistor (VCO)
4	Tuning word Bit 1 (LSB)
5	" " Bit 3
6	" " Bit 5
7	" " Bit 7
8	" " Bit 9
9	" " Bit 11
10	Not used
11	+5V (digital)
12	+15V (analog)
13	Analog ground

CONTROL/POWER CONNECTOR	
Pin. No.	Function
14	+28 V (return)
15	+28 V (return)
16	Not used
17	Tuning word Bit 2
18	" " Bit 4
19	" " Bit 6
20	" " Bit 8
21	" " Bit 10
22	" " Bit 12 (MSB)
23	Latch[1]
24	Digital ground
25	−15V (analog)

(1) *Logic "0" to latch input word.*
Logic "1" to unlatch input word.



MODELS D6020, D6026, D6040, D6080 AND D6120 DTOs
Wt: 23.1 oz. (655 gm) approx.

Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

DRO Specifications

PARAMETER	MODEL					
	F5080	M5080	F5120	M5120	F5180	M5180
TYPE	Fixed Tuned	Mechanically Tuned	Fixed Tuned	Mechanically Tuned	Fixed Tuned	Mechanically Tuned
FREQUENCY RANGE (GHz)	5.000-7.999		8.000-11.999		12.000-18.000	
MECHANICAL TUNING RANGE, min (MHz)	None	± 5 MHz	None	± 10 MHz	None	± 15 MHz
RF POWER OUTPUT, min (dBm)	+13				+10	
With OPTION 1	+10		+13		+10	
Variation, incl. temp. and freq. max (dB)	± 1.0	± 1.5	± 1.0	± 1.5	± 1.0	± 1.5
PHASE NOISE (dBc/Hz) at 10 kHz offset max	−105		−90		−85	
at 100 kHz offset typ	−130		−120		−115	
2nd HARMONIC, max (dBc)	−25		−25		−25	
SPURIOUS, max (dBc)	−70		−70		−70	
TEMPERATURE STABILITY, max (PPM/°C)	1	2	1	2	1	2
PULLING, VSWR 1.5:1 max (MHz)	0.05	0.075	0.1	0.15	0.15	0.2
With OPTION 1	0.75	1.000	1.0	1.50	1.50	2.0
PUSHING, max (kHz/V)	2		2		4	
CONNECTORS Power Supply	Solder terminal					
RF Output	SMA female					
POWER SUPPLY REQUIREMENT Voltage (Vdc)	+15 to +18		+12 to +18			
Current, max (mA)	150					
With OPTION 1	75		60			
ENVIRONMENTAL[1] Operating temperature (°C)	−54 to +85					
Storage temperature (°C)	−54 to +125					
MECHANICAL DIMENSIONS Inches	2.09×1.54×0.97	2.09×1.54×1.13	1.77×1.40×0.75	1.77×1.40×0.91	1.54×1.18×0.62	1.54×1.18×0.77
(Millimeters)	(53,1×39,1×24,6)	(53,1×39,1×28,7)	(45,0×35,6×19,1)	(45,0×35,6×23,1)	(39,1×30,0×15,7)	(39,1×30,0×19,6)

(1) *RF section and deliver components hermetically sealed.*

HOW TO SPECIFY

1. Specify frequency range.
2. Specify mechanically tuned (M) or fixed tuned (F)
3. Specify Model, i.e., F5080 is a FIXED TUNED DRO with an operating frequency between 5 and 7.999 GHz
4. Specify desired operating frequency (can be specified to a resolution of 1 MHz, i.e., 6038 MHz)

AVAILABLE OPTIONS

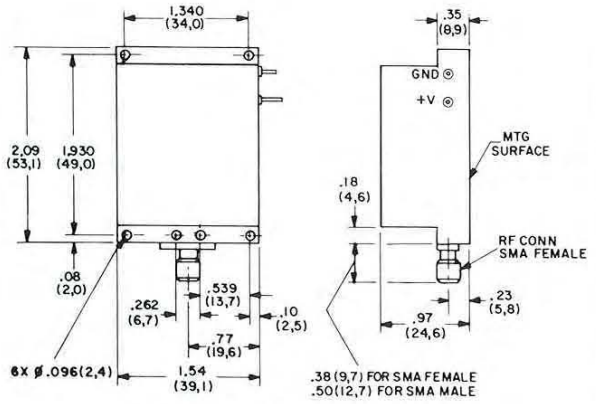
Option No.	Description
1	Lower cost model available with reduced output power and increased pulling effect
2	Drop-in module configuration
49A	High Rel screening

(see Table 1, page 159)

DRO Specifications

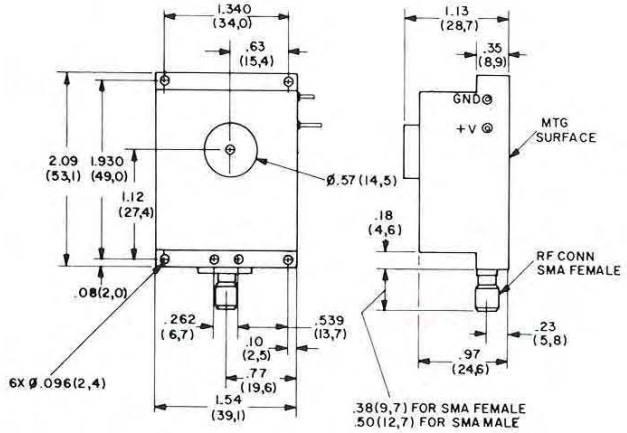
DIMENSIONS AND WEIGHTS

F5080



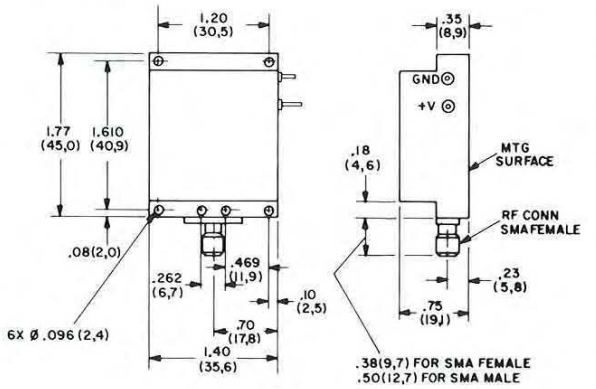
Wt: 2.75 oz. (78 gm) approx.

M5080



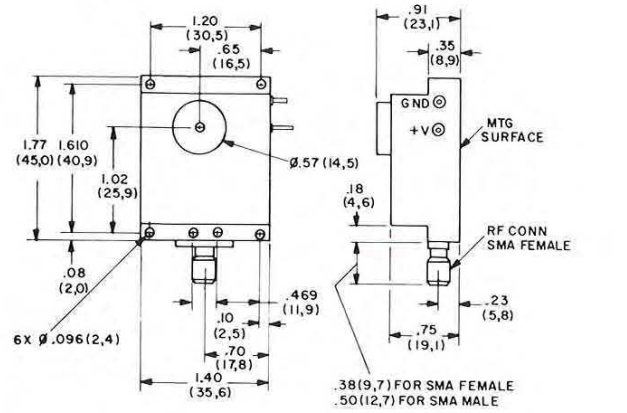
Wt: 2.93 oz. (83 gm) approx.

F5120



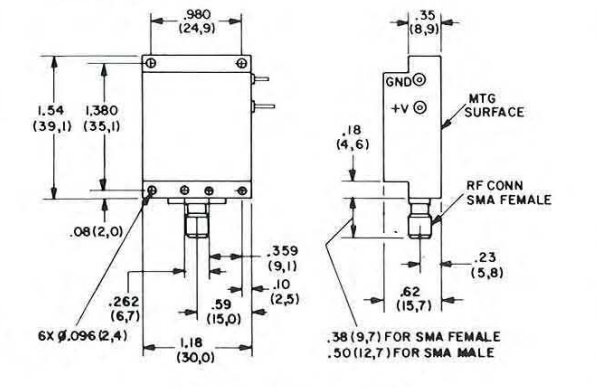
Wt: 1.94 oz. (55 gm) approx.

M5120



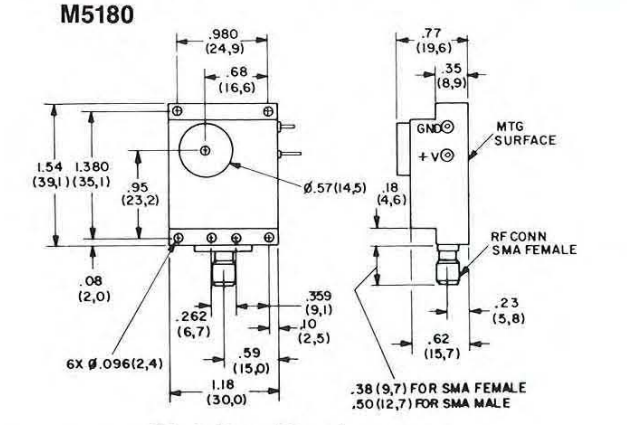
Wt. 2.12 oz. (60 gm) approx.

F5180



Wt: 1.3 oz. (37 gm) approx.

M5180



Wt: 1.48 oz. (42 gm) approx.

SERIES 5000
Dimensional Tolerances, unless otherwise indicated: .xx ± .02; .xxx ± .005

Power Measuring Instruments

General Microwave has an extensive product line of power measuring instruments including thermoelectric average power monitors and crystal detector peak power meters, covering the frequency range of 10 MHz to 40 GHz, in both coaxial and waveguide configurations.

POWER MONITORS

Power Monitors are typically employed in fixed installations for the continuous measurement of system power. Incorporating both the rf detector and an instrumentation amplifier, they offer cost-effective flexible solutions to high accuracy and wide dynamic range power measurements in reliable efficient packages.

The power head design uses thin-film metallic loads to absorb incident rf power. By constructing the rf load as a bi-metallic element, vacuum-deposited on a thin dielectric substrate, pairs of thermoelectric junctions are created. Half of the junctions are thermally "sinked" to the transmission line conductors, while the others are located within the air space between. These latter junctions constitute almost the entire calorimetric mass, enabling high sensitivity and fast response time.

The absorption of rf power by the load creates a temperature difference between the hot and cold junctions that gives rise to a thermoelectric emf. By keeping this temperature differential small, the load acts as a true square-law (rms) device, producing a dc output voltage directly proportional to the absorbed power. This voltage is applied to the monitor amplifier which provides a user-selectable current or voltage output in three remotely selectable 10 dB ranges for a total 30 dB dynamic range.

The Models N425, N426, and N427 Power Monitors cover the frequency range of 0.01 to 12.4 GHz with full scale powers of 1, 10 and 100 mW respectively. The Models N445 and N446 units cover the range of 0.01 to 18 GHz with full scale powers of 10 and 100 mW respectively. Power monitors in waveguide configurations covering the X, U, K and A waveguide bands are also available.

ERRORS AND WHAT TO DO ABOUT THEM

The numerous sources of errors present in the measurement of microwave power can make an accurate measurement a somewhat daunting task. The errors associated with a power measuring device include its frequency response, mismatch, linearity, square-law response and noise and drift. With respect to the former, each GMC power monitor is furnished with calibration data defining its CAL FACTOR (1) as a function of frequency. (CAL FACTOR is the normalized response of the power monitor relative to its performance at 1 GHz and includes the effects of detector inefficiency as well as the mismatch loss when operating with a matched source.) For GMC power monitors CAL FACTORS typically run about 93% at 12 GHz and 91% at 18 GHz. Errors due to linearity and square-law response for GMC power monitors are usually less than 1% for the former and negligible for the latter.

Another major contributor to the measurement uncertainty is the mismatch error. As stated above, the CAL FACTOR is a correction to be applied when measuring a matched source. If the source is mismatched, inter-reflections between the source and the power monitor produce an additional error whose magnitude is a function of the complex impedance of both the source and load. Because these data vary with frequency and are usually not available, one usually assumes the worst case condition which can be obtained from commonly available mismatch charts or tables.

The contribution of noise and drift to the measurement accuracy is obviously a function of the power level being measured. For GMC Power Monitors, noise and drift are rated from 0.02% to 0.035% and 0.025%/°C to 0.035%/°C of full scale, respectively, on the least sensitive range, increasing proportionally on the more sensitive ranges. For most practical purposes, these effects can be ignored for measurements made over the upper 10dB of the monitor's range.

PEAK POWER METERS

Although laboratory methods for the measurement of peak power were developed many years ago, it is only recently that practical commercial instrumentation for that purpose have become available. In the absence of a direct reading peak power meter, it has been the practice to use average power meters and derive the peak power from the duty cycle. This procedure was subject to significant uncertainty not only because of the variability of the pulse repetition frequency but because the exact shape of the pulse was difficult to characterize.

Using a combination of broadband Schottky detectors and high speed digital signal processing, GMC brought to market its Model 478, the first commercial digital peak power meter. This instrument is a single channel instrument capable of not only measuring the peak power of a pulse at any point along its envelope, but also can measure pulse width, rise and fall times and pulse period. These data are all presented digitally together with a CRT graphical presentation of the pulse on a linear or logarithmic scale.

(1) *Cal factor, or calibration factor is the ratio of the substitution audio power to the total incident rf power required to produce equal dc output voltages from the tft power head.*

The two channel Model 490 performs the same measurements with the further enhancements of full color display, automatic parameter measurements, multiple stored menus, and comparative measurements between the two input channels. Both instruments have full IEEE-488 bus compatibility.

The power heads employed with the Model 478 and Model 490 Peak Power Meters employ low barrier Schottky detectors which are subject to the same sources of error as those described in the section above, i.e. frequency response, square-law response, linearity and temperature dependence. Whereas in the case of the thermoelectric detectors used in the power monitors, these characteristics are essentially independent of each other, this is generally not the case with Schottky detectors. As a result, each peak power detector used with the Models 478 and 490 is individually calibrated for all parameters as a function of frequency and the data are stored in an EEPROM for use in the measurement process. Whenever a power head is changed, the EEPROM, mounted either in the power head or the instrument is changed as well.

Diode detectors are inherently temperature dependant, especially when resistively loaded to achieve a wide video bandwidth. The Models 436, 438 and 439 power heads maintain their diode detectors at constant temperatures to eliminate the temperature drift error.

Power Measuring Instruments Selection Guide

PEAK POWER METERS

MODEL	DESCRIPTION	PAGE
478A	Single Channel, Automatic Peak Power Meter	171
490	Dual Channel, Automatic Peak Power Meter	166

POWER HEADS (for Model 478A)

MODEL	FREQUENCY RANGE[1] GHz	RISE/FALL TIME nsec	CONNECTOR RF	PAGE
N436A	0.75-18.0	10	TYPE N	171
M438A	0.75-26.5	10	TYPE K	
MK438A	0.75-40.0	10	TYPE K	

POWER HEADS (for Model 490)

MODEL	FREQUENCY RANGE[1] GHz	RISE/FALL TIME nsec	CONNECTOR RF	PAGE
N439	0.75-18.0	10	TYPE N	169
M439	0.75-26.5	10	TYPE K	
MK439	0.75-40.0	10	TYPE K	
A439	26.5-40.0	10	UG-599U	

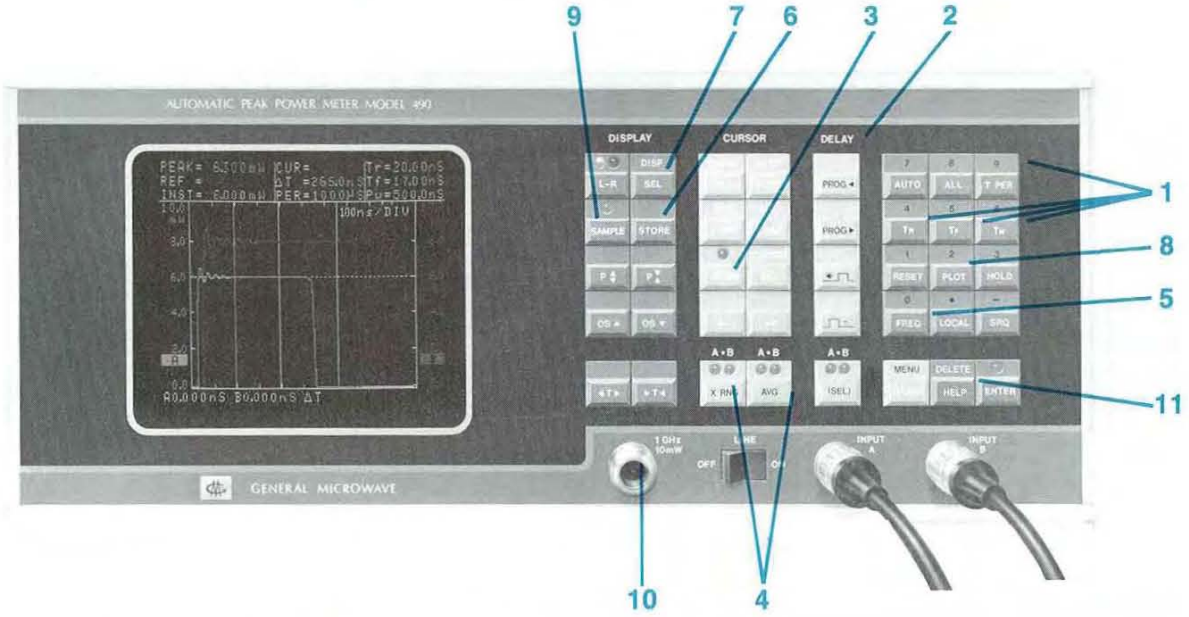
POWER MONITORS

MODEL	FREQUENCY RANGE GHz	POWER RANGE		ACCURACY	PAGE
		dBm	mW		
N425D	0.01-12.4	−10 to +10	0.1 to 10	± 1%	175
N426D	0.01-12.4	0 to +20	1 to 100	± 1%	
N427D	0.01-12.4	−20 to 0	0.01 to 1	± 1%	
N445B	0.01-18.0	−20 to +10	0.1 to 10	± 1%	
N446B	0.01-18.0	0 to +20	1 to 100	± 1%	

(1) *Optional lower frequencies available.*

Model 490 Automatic Peak

MODEL 490 PEAK POWER METER



HELP SCREENS

HELP SCREENS PROVIDE INFORMATION FOR ALL OF THE MODEL 490 KEY FUNCTIONS

Power Meter Features

1. Pulse parameter measurements can be made without the need for manually positioning cursors. The Model 490 Automatic Peak Power Meter will calculate and display the pulse rise time, fall time, pulse width or period, each with single key command from the keyboard. If all four parameters are desired, a single key command is available for that as well. There is also a manual cursor system available for instances when nonstandard definitions of pulse parameters are required. Pulse parameters are per IEEE standard definitions.

2. Trigger delay: The trigger delay value in the 490 can be applied to each of the two traces individually or to both simultaneously. This allows individual alignment of pulses relative to each other or delay measurements between pulses. Delay values are displayed on the screen for each input. Convenient delay controls are provided using either left/right keys or numeric input to adjust the trace position. Desired changes in delay values may be entered during measurements from the keyboard.

3. Normalization: Pulse comparison is most convenient to perform when the pulses to be compared are displayed at the same amplitude. The NORM key permits the operator to normalize automatically the pulse selected to the other pulse shown on the display.

4. Noise reduction: The 490 uses both digital and analog noise reduction techniques, which can be used either individually or together and can be selectively applied to either or both of the input signals. The digital averaging mode permits selection through the keyboard of up to 999 sweeps of the trace to be averaged for enhancement of the signal-to-noise ratio. Where the measured pulse response is such that the 10 nanosecond response of the 490 is not required, the extended range function may be used. This reduces the system video bandwidth resulting in reduced noise and additional dynamic range.

5. The computations and correction for frequency and amplitude compensation for the power head response are automatically applied by entering the operating frequency into the keyboard. The power meter receives the frequency and amplitude profile of the power head from an EEPROM in the power head. If the operating frequency is entered, the meter will automatically compute and output the corrected power values.

6. Pulse trace storage is another feature of the 490. A pulse can be measured and stored, available to be displayed by a keyboard command, for comparison to a new signal being measured as a second trace. Adjustments can then be made on the new pulse with easy comparisons to the stored pulse.

7. Using the A/B mode makes gain or loss measurements simple to perform in either linear or logarithmic units. In the linear mode the 490 indicates the gain/loss as a ratio: in the logarithmic mode it is indicated in + or – dB.

8. For hard copy data, the 490 contains an output to a digital plotter. When the plotter key is depressed, all of the data on the screen, which includes the dual trace display and header information, is fed to a digital plotter for a permanent record of the measured data.

9. Short Sweep Cycle (SAMPLE key): The number of sample points per sweep can be selected from 1 to 201. Reducing the number of sample points results in more rapid updating of the display, thereby enabling higher speed system operation. Using this feature together with an external trigger and appropriate trigger delay value will permit a measurement to be made on a single pulse.

10. Provides a 1 GHz 10 mW CW signal at the front panel for performance verification.

11. A **Help Mode** feature has been added to the Model 490 Automatic Peak Power Meter. This feature provides information for all the 490 key functions. To access the Help Mode from the 490 Graph Mode, depress the Help/Delete key. The Help Mode Index listing will then be displayed. For additional listings, depress the cursor arrow (►) key. Enter the desired index number to the keyboard and depress the enter key. The selected item will then be defined on the 490 CRT. This feature permits the operator to verify any 490 key function and quickly return to the Graph Mode of operation without disturbing previously set test parameters.

Model 490 Dual Input, Dual Trace Automatic Peak Power Meter

No other power meter can offer you these features:

- **Help Mode:**
  A **Help Mode** feature has been added to the Model 490 Automatic Peak Power Meter. This feature provides information for all of the 490 key functions.
- **Automatic Operation:**
  Automatically selects optimal time base and power range.
- **Dual Trace Operation:**
  Presents pulse waveforms of two traces on a calibrated graphic display.
- **Power Measurements:**
  Automatically measures and digitally displays peak and instantaneous power values on linear or logarithmic scales.
- **Automatic Pulse Parameter Measurements:**
  Measures rise time, fall time, pulse width and period with a single command.
- **7" Color CRT Display:**
  Utilizes 3 colors to provide a clear presentation of both measured waveforms.
- **Intelligent Power Head:**
  Supplies power meter with appropriate frequency compensation and square law correction values along with the measurement data. May be field calibrated.
- **Trace Storage:**
  Can store and display a pulse trace while viewing a second incoming trace.
- **GPIB Programmability:**
  All instrument functions may be controlled via a GPIB interface making completely automatic signal acquisition and analysis available.
- **Performance Verification:**
  Instrument is furnished with a built-in 1 GHz reference oscillator.

The Model 490 Automatic Peak Power Meter with its associated Model N439, M439, MK439, or A439 Power Head produces a flexible, powerful, versatile, accurate and simple to use instrument.

The capability of measuring peak power and presenting on a CRT both the calibrated microwave pulse and a digital display of measured power values was an innovative design concept first introduced with General Microwave's Model 478 Automatic Peak Power Meter. This concept has been further enhanced in the Model 490, to permit two pulses to be displayed on a calibrated graph along with the measured values for an analysis of each pulse. These units offer simultaneous viewing and pulse analysis of two microwave signals with pulse widths as small as 15 nanoseconds. The pulses may be derived from the dual power head inputs or from one input and a stored reference.

The Model 490 is equipped with a three color CRT display on which each pulse is displayed in a separate color providing an unambiguous presentation of both traces. Pulse parameters such as rise and fall time, pulse width and period can be measured automatically with the touch of a single button eliminating the uncertainty of manually selecting reference power levels. Gain and loss measurements, in either linear or logarithmic units, are performed automatically using the A/B ratio mode.

The instrument has the capability of storing user programmed setup menus, which permit rapid access to as many as eight frequently used, desired test conditions. Total control of all of the features of the instrument may be exercised via the keyboard or via the IEEE-488 General Purpose Interface Bus (GPIB).

The power heads contain an EEPROM which automatically supplies the power meter with the appropriate linearity and frequency correction data. The EEPROMs are field programmable and permit field calibration of the power heads through the power meter keyboard or the GPIB.

Model 490 Specifications

POWER RANGE:
Normal Range: . . . . –20 to +15 dBm with N439
–14 to +15 dBm with M439, MK439, A439
Extended Range: . . –30 to +15 dBm with N439
–24 to +15 dBm with M439, MK439, A439

PULSE WIDTH:
Normal Range: . . . . 15 nsec to 1 sec and CW
Extended Range: . . 1.5μsec to 1 sec and CW

VIDEO BANDWIDTH AND RISE/FALL TIME (10-90%/90-10%)[1]:
Normal Range: . . . . 35 MHz, 10 nsec
Extended Range: . . 500 kHz, 700 nsec

FREQUENCY RANGE:
0.75 to 18 GHz with N439
0.75 to 40 GHz with MK 439
0.75 to 26.5 GHz with M439
26.5 to 40 GHz with A439

ACCURACY:
See figure 1

MAXIMUM SAFE INPUT POWER:
+20 dBm CW, +30 dBm peak (1μsec max pulse width, 1% duty cycle)

FREQUENCY RESPONSE:
Compensated: . . . . ±0.1 dB to 18 GHz
±0.3 dB to 26.5 GHz (M439, MK439)
±0.3 dB to 40 GHz (MK439)
±0.3 dB 26.5 to 40 GHz (A439)
Uncompensated: . . ±0.3 dB to 8 GHz
±0.5 dB to 18 GHz
±1.0 dB to 26.5 GHz (M439, MK439)
±1.5 dB to 40 GHz (MK439)
±1.8 dB 26.5 to 40 GHz (A439)

INPUT IMPEDANCE:
Coaxial models 50 ohms nominal

VSWR:
N439 . . . . . 1.2:1 to 8 GHz
1.4:1 to 18 GHz
M439, MK439 . . . . . 1.2:1 to 8 GHz
1:35:1 to 18 GHz
1.7:1 to 26.5 GHz
MK439 . . . . . 2.0:1 to 40 GHz
A439 . . . . . 1.44:1 26.5 to 40 GHz

POWER SCALE RANGE:
From 0.1 to 20 dBm (or dB)/division or 1μW to 2 MW/division in a 1-2-5 sequence.

RELATIVE OFFSET RANGE:
From –99.99 to +99.99 dB

TIME BASE RANGE:
From 10 nsec/division to 100 msec/division in a 1-2-5 sequence

TIME MEASUREMENT ACCURACY:
Dependent on Ts (Ts = trigger to sample time)
When: 1 nanosec ≤ Ts ≤ 1 microsec
Then: Accuracy = .005% or 2 nsec, whichever is greater
When: 1 microsec < Ts ≤ 1 second
Then: Accuracy = .005% or 10 nsec, whichever is greater

TRIGGER DELAY RANGE:
From 1 nsec to 1 sec with resolution of 1 nsec

EXTERNAL TRIGGER REQUIREMENTS:
50 ohm Input: . . . . . +1.5 V to +5 V into 50 ohms
300 nsec rise time max
TTL Input: . . . . . 10 unit load positive pulse

NOMINAL MEASUREMENT TIME:
2 sec[2] per trace

INTERNAL TRIGGER LEVEL RANGE:
Normal Range: . . . . –10 to +15 dBm (N439)
– 5 to +15 dBm (M439, MK439, A439)
Extended Range: . . –20 to +15 dBm (N439)
–15 to +15 dBm (M439, MK439, A439)

DISPLAY:
7″ CRT with liquid crystal color shutter. Graph area is 201 horizontal by 151 vertical cells which are organized into 10 horizontal and 5 vertical major divisions.

DISPLAY OFFSET RANGE:
Up to 2 MW or 0 to +100 dBm (or dB)

DISPLAY MODES:
Single or Dual Alternate Trace. Input A, Input B, Memory, A/B or A/Memory

(1) *See description of Power Head Options.*
(2) *At 201 samples per sweep in Manual mode; faster at lower number of samples; slower in Automatic mode or with wide or low repetition rate pulses.*

Model 490 Specifications

REFERENCE OSCILLATOR:
Frequency: . . . . . 1 GHz ± 3%
Power Level: . . . . . 10 mW ± 1%
Connector: . . . . . Type N

SAMPLES:
Selectable up to 201 per sweep.

IEEE-488 GPIB:
Programmability: Unit is fully programmable via an IEEE-488 GPIB data bus, to receive commands from a controller and transmit measured data to other instruments on the bus.

Function Subsets: SR1, SH1, AH1, T6, TEO, L4, LEO, RL1, PPO, DC1 and DT1 are implemented.

PLOTTER OUTPUT:
Outputs all data on screen via the GPIB interface using HPGL

SET UP MENUS:
Eight user defined set up menus

PRE-PROGRAMMED TIME PARAMETER MEASUREMENT FUNCTIONS:
Rise time, fall time, pulse width and pulse period

VIDEO OUTPUT:
Real time buffered output: 750 mV full scale into 50 ohms.

OPERATING TEMPERATURE RANGE:
+15 to +35°C

POWER REQUIREMENTS:
100, 120, 220 or 240 VAC, +5%, –10%, 48 to 63 Hz; 150 Watts

POWER HEAD CONNECTOR:
N439 . . . . . Type N, male
M439, MK439 . . . . . K CONNECTOR male SMA compatible.
A439 . . . . . UG-599/U

NOMINAL DIMENSIONS:
Model 490: . . . . . 7.0″ (177.8mm) High x 17.0″ (431.8mm) Wide x 18″ (457.2mm) Long excluding projections

Model N439: . . . . . 1.75″ (44.5 mm) dia x 3.20″ (81.3mm) long (including RF connector) and cable

Models M439/MK439: . . . . . 1.75″ (44.5mm) dia x 2.65″ (67.3mm) long (including RF connector) and cable

Model A439: . . . . . 2.00″ (50.8mm) dia x 5.08″ (129.0mm) long (including waveguides and isolator) plus cable

WEIGHT:
Model 490 . . . . . 0.5 lbs. (18.4 kg)
Models
M439/MK439 . . . . . 9.2 oz. (260 g)
Model N439 . . . . . 9.5 oz. (269 g)
Model A439 . . . . . 21 oz (594 g)

POWER METER OPTIONS:
Model 490R: . . . . . 19″ Rack Mount Configuration
Option 01: . . . . . Rear Panel Power Head Inputs
Option 05: . . . . . Rear Panel Reference Oscillator Output

POWER HEAD OPTIONS:

OPTION	START FREQ.	FREQUENCY RANGE			VIDEO BANDWIDTH	RISE/FALL TIMES
		N439	M439	MK439		
02	100 MHz	18 GHz	26.5 GHz	40 GHz	4.7 MHz	75 nsec
03	500 MHz	18 GHz	26.5 GHz	40 GHz	23 MHz	15 nsec
15	70 MHz	18 GHz	26.5 GHz	40 GHz	3.3 MHz	107 nsec

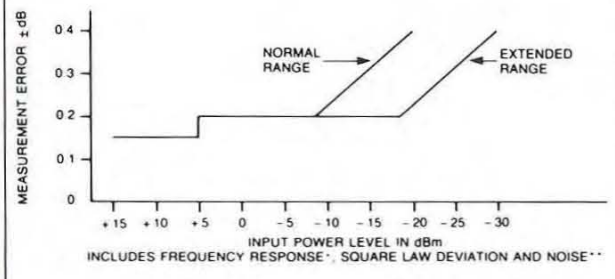


Fig. 1A-Model 490/N439 accuracy

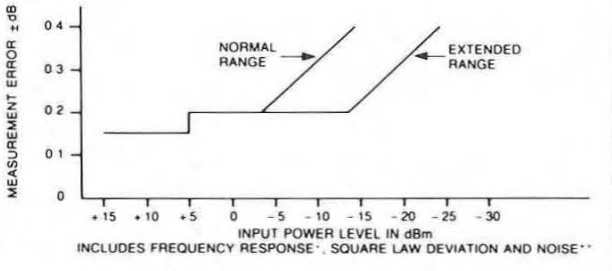


Fig. 1B-Model 490/M439, 490/MK439, 490/A439 accuracy

* Assumes that operating frequency has been entered into instrument ** In digital averaging mode with 100 averages

Model 478A
Automatic Peak Power Meter

INTRODUCTION

The Model 478A Automatic Peak Power Meter, with its associated Model N436A, M438A or MK438A Power Head, is a powerful and flexible instrument designed to measure and display the characteristics of pulsed microwave signals. In addition to offering significant improvements in accuracy, sensitivity and video bandwidth, the instrument offers full programmability via an IEEE-488 GPIB data bus for use with computer based automatic test systems.

POWER METER

Operating with a microprocessor-based sampled data system, the power meter digitizes the detected input signal and creates a composite representation of that signal. All operations may be controlled locally through a front panel keyboard with measurement parameters selected from an initiating menu, or remotely via the GPIB interface. In the Automatic mode of operation, the input is displayed on a calibrated graph with machine-selected time base and power scales. The Model 478A is designed to be calibrated and maintained in the field. RF calibration can be verified using CW standards. An internal test routine is included to facilitate test and circuit calibration, and the time base is automatically calibrated against a crystal-controlled clock each time the power meter is turned on.

POWER HEADS

The Models N436A, M438A and MK438A are temperature-compensated power heads that employ low-barrier Schottky diode detectors mounted on a thin-film substrate. A matching circuit optimizes both the VSWR and frequency sensitivity. The standard power head is furnished with a five foot cable. Other lengths are available on special order.

Each power head is supplied with a customized ROM to be installed in the Model 478A which then compensates for the individual power head square-law deviation and frequency response characteristics.

APPLICATIONS

In addition to the absolute measurement in linear (watts) or logarithmic (dB) units of peak power, referred to the input of the power head, the Model 478A can be used in the following measurement procedures:

- **Relative power measurements (in dB mode):** To make gain or loss measurements with respect to an arbitrary reference.
- **Measurement of transient and steady state VSWR:** To characterize system performance under "hot switching" as well as "dwell" intervals.
- **Measurement of a selected pulse in a repetitive burst:** Trigger delay can be preset to select any pulse train for display with optimum resolution.
- **Measurement through directional couplers or other lossy devices:** By using the Relative Offset feature, the de-coupling factor is added to the measured levels to provide a correctly scaled power indication.
- **Measurement of power versus frequency:** The unit can be configured in conjunction with suitable external test equipment to display the frequency response characteristics of pulsed or CW signals.

Model 478A Features

- **Automatic Operation:**
  The time base and power scale are automatically selected to characterize and obtain the best presentation of the pulse being measured.
- **Manual Operation:**
  The keyboard control permits selection of the desired time base and power scale.
- **Built-In Display:**
  A 7″ CRT presents a calibrated display of the detected signal as well as an alpha-numeric readout of amplitude and time. Peak power and instantaneous power values are digitally displayed at up to three different selectable times in either linear or logarithmic units by the use of a novel three-cursor system. Pulse rise and fall times, pulse width and pulse period are also digitally displayed via a time interval measurement between selectable pulse power levels.
- **Menu Mode:**
  A prompted menu permits selection of Automatic or Manual operation, trigger source, Trigger Delay, internal trigger level, time base, power scale, Relative Offset, Display Offset, Normal or Extended Range, local or remote IEEE-488 GPIB operation, and operating frequency for optimum accuracy compensation.
- **Frequency and Amplitude Compensation:**
  The Model 478A automatically corrects for square-law deviation and frequency response characteristics of the power head at the operating frequency.
- **Short-Sweep Cycle:**
  The number of sample points per sweep can be selected from 1 to 201. Reducing the number of sample points results in more rapid updating of the display, thereby enabling higher-speed system operation.
- **Digital Averaging:**
  Enhances low level signal-to-noise ratio by a factor of up to 10:1.
- **Relative Offset:**
  Automatically scales display to compensate for external gain or loss.
- **Display Offset:**
  Permits a vertical shifting of the display for more detailed examination of the measured pulse.
- **Trigger Select:**
  Gives choice of internal or external triggers or CW operation in both Automatic and Manual modes.
- **Trigger Delay:**
  Delayed trigger capability provides pulse sampling flexibility.
- **Hold Mode:**
  Retains display for further analysis after signal input has been removed.
- **Video Output:**
  Provides real time-buffered output of the detected waveform via rear BNC connector.
- **X-Y Recorder Output:**
  Provides horizontal and vertical outputs and pen lift command; associated switch compensates for a variety of recorder characteristics.
- **IEEE-488 GPIB Programmability:**
  Permits use of unit as part of an IEEE-488 GPIB system to receive commands from a controller and transmit measured data to other instruments on the bus.
- **Overload indication:**
  Automatically indicates that input to power head has exceeded +15 dBm.

Model 478A Specifications

POWER RANGE:
Normal Range: . . . . –20 to +15 dBm with N436A
–14 to +15 dBm with M438A, MK438A
Extended Range: . . –30 to +15 dBm with N436A
–24 to +15 dBm with M438A, MK438A

PULSE WIDTH:
Normal Range: . . . . 15 nsec to 1 sec and CW
Extended Range: . . 1.5 μsec to 1 sec and CW

VIDEO BANDWIDTH AND RISE/FALL TIMES (10-90%/190-10%)(1)
Normal Range: . . . . 35 MHz, 10 nsec
Extended Range: . . 500 kHz, 700 nsec

FREQUENCY RANGE(1):
0.75 to 18 GHz with N436A
0.75 to 26.5 GHz with M438A
0.75 to 40.0 GHz with MK438A

ACCURACY:
See Fig. 1

MAXIMUM SAFE INPUT POWER:
+20 dBm CW, +30 dBm peak (1 μsec max pulse width, 1% duty cycle)

FREQUENCY RESPONSE
Compensated: . . . . ±0.1 dB to 18 GHz
±0.3 dB to 26.5 GHz (M438A, MK438A)
±0.3 dB to 40.0 GHz (MK438A)
Uncompensated: . . ±0.3 dB to 8 GHz
±0.5 dB to 18 GHz
±1.0 dB to 26.5 GHz (M438A, MK438A)
±1.5 dB to 40.0 GHz (MK438A)

INPUT IMPEDANCE:
50 ohms nominal

VSWR
N436A: . . . . . 1.2:1 to 8 GHz
1.4:1 to 18 GHz
M438A: . . . . . 1.2:1 to 8 GHz
MK438A: . . . . . 1.35:1 to 18 GHz
1.7:1 to 26.5 GHz
2.0:1 to 40.0 GHz

POWER SCALE RANGE:
From 0.1 to 20 dBm (or dB)/division of 1 μW to 2MW/division in a 1-2-5 sequence

RELATIVE OFFSET RANGE:
From –99.99 to +99.99 dB

TIME BASE RANGE:
From 10 nsec/division to 100 msec/division in a 1-2-5 sequence

TRIGGER DELAY RANGE:
From 1 nsec to 1 sec with resolution of 1 nsec

EXTERNAL TRIGGER REQUIREMENTS:
+1.5V to +5V pulse into 50 ohms

TRIGGER DELAY UNCERTAINTY
For delays up to
1 μsec: . . . . . 2 nsec max.
For delays above
1 μsec: . . . . . 10 nsec max

INTERNAL TRIGGER LEVEL RANGE:
Normal Range: . . . . –15 to +15 dBm with N436A
–10 to +15 dBm with M438A, MK438A
Extended Range: . . –25 to +15 dBm with N436A
–20 to +15 dBm with M438A, MK438A

NOMINAL MEASUREMENT TIME:
2 seconds(2)

SELF-CONTAINED DISPLAY:
Built-in 7″ CRT. Graph area is 201 horizontal by 151 vertical cells, which are organized into 10 horizontal and 5 vertical major divisions

DISPLAY OFFSET RANGE:
Up to 2 MW or 0 to +100 dBm (or dB).

SAMPLES:
Selectable up to 201 per sweep.

IEEE-488 GPIB

Progammability: Unit is fully programmable via an IEEE-488 GPIB data bus to receive commands from a controller and transmit measured data to other instruments on the bus.

Function Subsets: SRI, SHI, AHI, T6, TEO, L4, LEO, RLI, PPO, DCI and DTI are implemented

Video Output: Real time buffered output; nominal 375 mV full scale into 50 ohms.

X-Y Recorder Output: Horizontal and vertical outputs of +10V full scale and pen lift command via contact closure.

OPERATING TEMPERATURE RANGE:
+15 to +35°C

(1) *See description of Options 02 and 03.*
(2) *At 201 samples per sweep in Manual mode; faster at lower number of samples; slower in Automatic mode or with wide or low repetition rate pulses.*

Model 478A Specifications

POWER REQUIREMENTS:
100, 120, 220 or 240 VAC, +5%, –10%;
48 to 63 Hz; 150 watts

POWER HEAD CONNECTOR
N436A: . . . . . Type N, male
M438A, MK438A: . . Type K, male
SMA compatible.

NOMINAL DIMENSIONS
Model 478A: . . . . . 7.0″ (177.8mm) H x 17.0″ (431.8mm) Wide x 18″ (457.2mm) Long excluding projections

Model N436A: . . . . . 1.27″ (32.3 mm) dia x 3.01″ (76.5mm) long (including RF connector) plus 5-foot umbilical cable assembly.

Models
M438A, MK438A: . . 1.25″ (31.8 mm) dia x 2.50″ (63.5 mm) long (including RF connector) plus 5-foot umbilical cable assembly.

WEIGHT:
Model 478A: . . . . . 39.5 lbs. (17.9 kg)
Model N436A: . . . . . 9.0 oz. (255 gm)
Models
M438A/MK438A: . . 8.7 oz. (247 gm)

POWER METER OPTIONS
Model 478AR: . . . . . 19″ Rack Mount Configuration

Option 01: . . . . . Rear Panel Power Head Input

POWER HEAD OPTIONS
Option 02: . . . . . Frequency range: 100 MHz to 18 GHz for N436A, 26.5 GHz for M438A or 40 GHz for MK438A
Video Bandwidth: 4.7 MHz
Rise/Fall Times: 75 nsec

Option 03: . . . . . Frequency range: 500 MHz to 18 GHz for N436A, 26.5 GHz for M438A or 40 GHz for MK438A
Video Bandwith: 23 MHz
Rise/Fall Times: 15 nsec

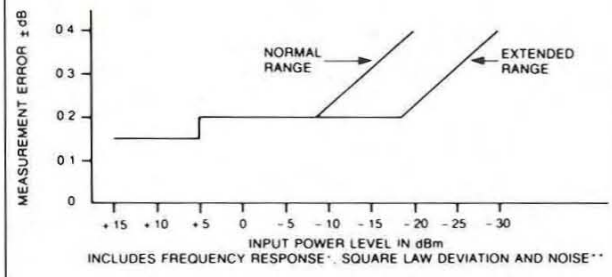


Fig. 1A-Model 478A/N436A accuracy

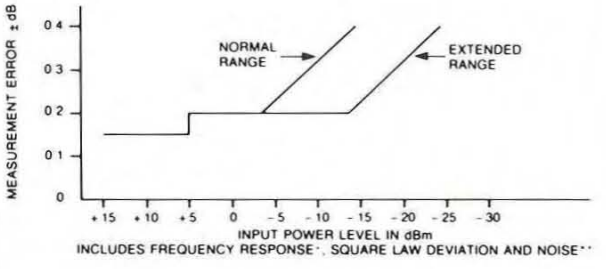


Fig. 1B-Model 478A/M438A, MK438A accuracy

* Assumes that operating frequency has been entered into instrument ** In digital averaging mode with 100 averages

Models N445B, N446B, N425D, N426D, N427D Integrated Thermoelectric Power Monitors

These power monitors are compact, integrated assemblies of thermoelectric power sensors and dc amplifiers specially designed for system power monitoring at local or remote locations. Small size and light weight make them ideal for difficult systems packaging requirements, and choice of readout type and location is flexible—all this is accomplished without sacrificing high accuracy, excellent stability or economy.

Modulated, pulsed, or cw signals from 0.01 to 18 GHz are measured over a 30 dB dynamic range covered in three convenient decade steps. Power levels as low as − 30 dBm (1μW) and as high as + 20 dBm (100 mW) can be measured. Provisions for remote range selection and zero setting are included.

The monitor output is a dc analog signal which may be connected to readouts in either a constant current or constant voltage mode, directly scaleable in milliwatts. The constant current output is 1 milliampere full scale, and the constant voltage output is adjustable up to − 10 volts full scale. For remote readout distances up to many hundreds of feet, the constant current connection provides a stable reading free from errors caused by long wire resistance values. Where the readout device is a voltmeter, or for such applications as sweep generator leveling, the constant voltage mode of operation is available.

The carefully designed amplifier section, when combined with the excellent stability of the thermoelectric power sensor, assures exceptionally low noise and drift. A wide operating temperature range of − 55°C to + 85°C is also featured.

The Type N rf connector conforms to MIL-C-39012, and the dc and signal output connector mates with a furnished MS3116E plug connector. Rugged construction is featured throughout.

- **Amplifier and power sensor in a single, compact package**
- **0.01 to 18 GHz frequency range**
- **30 dB dynamic power range**
- **± 1% accuracy**
- **− 55°C to + 85°C temperature range**
- **0.02% F.S. (p-p) noise**
- **0.005% F.S./°C drift**

Models N445B, N446B: 0.01 to 18 GHz

Models N425D, N426D, N427D: 0.01 to 12.4 GHz

ACCESSORIES

TOOL KIT MODEL TK-1

The Model TK-1 contains all the special tools necessary for field replacement of tft elements in all GMC integrated thermoelectric power monitors.

TK-1

Models N445B, N446B, N425D, N426D, N427D Specifications

MODEL	N445B		N446B		N425D		N426D		N427D	
Frequency Range	0.01 to 18 GHz				0.01 to 12.4 GHz					
Full Scale Ranges:	dBm	mW	dBm	mW	dBm	mW	dBm	mW	dBm	mW
Range 1	+10	10	+20	100	+10	10	+20	100	0	1
Range 2	0	1	+10	10	0	1	+10	10	−10	0.1
Range 3	−10	0.1	0	1	−10	0.1	0	1	−20	0.01
Input Impedance	50 ohms									
Max. VSWR	1.35[1] to 10 GHz; 1.6 from 10 GHz to 18 GHz				1.5[2]					
Accuracy[3]	± 1% of full scale									
Operating Temperature Range	−54°C to +85°C[7]		−54°C to +85°C[8]		−54°C to +85°C[7]		−54°C to +85°C[8]		−54°C to +85°C[9]	
Zero Drift[4]	0.005% F.S./°C								0.01% F.S./°C	
Noise[4]	0.02% F.S. (p-p)								0.035% F.S. (p-p)	
Element Temperature Sensitivity	0.1%/°C									
Field-Replaceable Elements	TL-4A		TL-5		TL-0B		TL-1B		TL-2B	
CW Overload Rating[6]	300%		200%		300%					
Max. Pulse Energy at +25°C (Wμsec)	5		30		15		150		1.5	
Max. Pulse Power at +25°C (W)	1		15		3		30		0.3	
Max. Pulse Duration at +25°C (μsec)[5]	5		2		5					
Max. dc Voltage (volts)	10		30		10		30		3	
Output: Current Mode	1 mA full scale, each range									
Output: Voltage Mode	−10 volts full scale (maximum), each range									
Power Supply Requirements	± 6V to ± 18V, 10 mA, 0.1% regulation									
Weight	8 oz. (227 gm.)									

ENVIRONMENTAL RATINGS

Shock ..... MIL-STD-202F, Method 213B, Cond. B (75G, 6 msec)

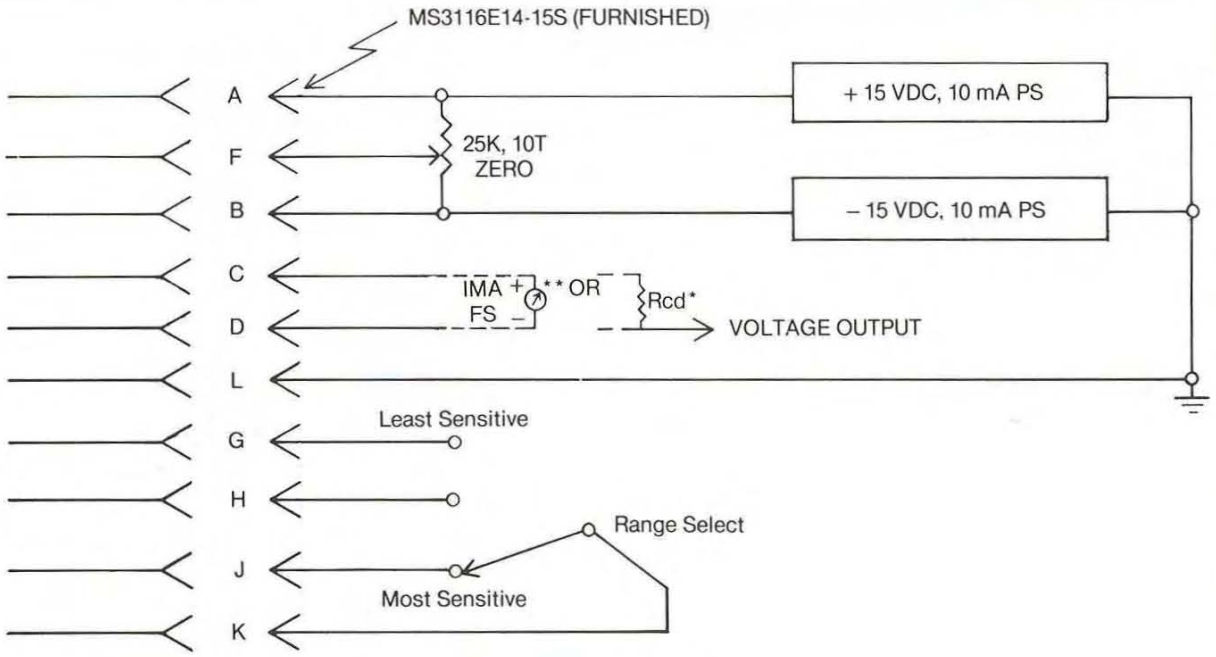
Vibration ..... MIL-STD-202F, Method 204D, Cond. B (.06" double amplitude or 15G, whichever is less)

Altitude ..... MIL-STD-202F, Method 105C, Cond. B (50,000 ft.)

Temp. Cycling ..... MIL-STD-202F, Method 107D, Cond. A, 5 cycles

(1) *Except in the range from 0.010 to 0.015 GHz, where VSWR may rise to 1.5.*
(2) *Except in the range from 0.010 to 0.015 GHz, where VSWR may rise to 1.75.*
(3) *Excluding RF calibration error.*
(4) *On least sensitive range. Proportionately more on lower power ranges.*
(5) *At maximum pulse power.*
(6) *While the units will take overloads for short periods of time, extended periods of operation at overload levels may result in permanent change in the element characteristics or even burnout. Maximum care should be exercised to avoid such an occurrence.*
(7) *Derate at 0.2 mW/°C from +60°C to +85°C.*
(8) *Derate at 1.4 mW/°C from +50°C to +85°C.*
(9) *Derate at 0.02 mW/°C from +60°C to +85°C.*

Models N445B, N446B, N425D, N426D, N427D Specifications



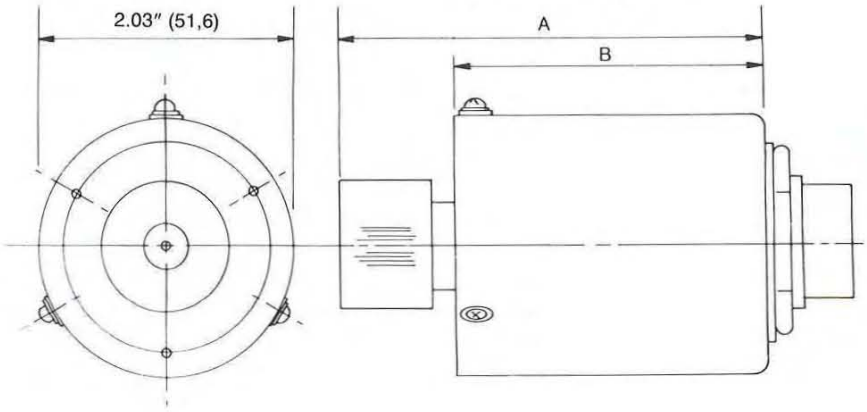
PIN	N445B, N425D	N446B, N426D	N427D
G	+10 dBm	+20 dBm	0 dBm
H	0 dBm	+10 dBm	–10 dBm
J	–10 dBm	0 dBm	–20 dBm

* When voltage output is used, connect resistor (Rcd) between pins C and D. Output between pins D and L will be –1 Volt per 1000 ohms of resistance of Rcd with a maximum value of –10V (i.e. –10,000 ohms). Simultaneous use of voltage and current modes is also possible.

** Any number of 1 mA meters may be connected in series provided total pins C-D loop resistance does not exceed 10,000 ohms.

TYPICAL SET-UP FOR OPERATION

DIMENSIONS



Unit	Dimensions	
	A	B
N445B, N446B	3.60″ (91,4)	2.60″ (66,0)
N425D, N426D, N427D	4.34″ (110,2)	3.10″ (78,7)

Radiation Hazard Measuring Systems

INTRODUCTION

General Microwave RAHAM™ Radiation Hazard Meters detect and measure potentially hazardous non-ionizing electromagnetic energy radiating from rf and microwave sources. They are designed to monitor a wide variety of systems — military, industrial and commercial — which may expose personnel to such conditions. Typical of these are microwave ovens, medical equipment, radar installations, microwave heaters and dryers, communication systems, and electronic warfare systems.

This tutorial provides introductory material to personnel with a working knowledge of elementary electromagnetic theory. It contains an interpretation of safety standards, reviews the meaning of different units of measurement and outlines the design concepts used in General Microwave instruments.

The determination of a safe electromagnetic radiation level is a complex matter. During the past two decades a number of U.S. and foreign governmental and independent standardization committees have promulgated such standards. Their diversity reflects the complex nature of the problems involved. In establishing safety levels, consideration must be given to a large number of physical and biological factors, including frequency of radiation, ratio of energies stored in the local electric and magnetic fields, polarization, relative location of grounded surfaces, modulation characteristics of the field as well as the exposure time. These efforts to establish appropriate safety levels have spurred a whole field of analytical tools and biological studies.[1]

The three common units of measurement for characterizing electromagnetic energy are power density in mW/cm^2, electric field ("E-field") in V/m and magnetic field ("H-field") in A/m. At sufficiently large distances from the source of radiation, the E-field and H-field components have a fixed mathematical relationship. Thus, the measurement of any one of these units in free space is sufficient to determine the radiation level and derive the other two. At frequencies nominally above 1 GHz, most radiation fields are of this character, known as the free space condition. The free space relationships are given in the following table:

TABLE 1

To convert:	
power density P in mW/cm^2 to electric field E in V/m:	$E=61.4\sqrt{P}$
power density P in mW/cm^2 to magnetic field H in A/m:	$H=0.163\sqrt{P}$

In most cases, to fully characterize electromagnetic energy at lower frequencies i.e. below 1 GHz, both E-field and H-field components need to be known. Some standards below 300 MHz, have a separate safety level for each field component. In such instances, the E-field safety levels are the more stringent of the two. Thus measuring E-field alone is usually sufficient to determine if a safe radiation level is present. However, there may exist conditions, particularly in the proximity of large metal surfaces, or within conducting coils, where the propagating electromagnetic energy is stored predominantly in the H-field.

ANSI AND NRPB STANDARDS

Among the more widely accepted safety standards are those established by the American National Standards Institute ("ANSI"), C95.1-1991, and the National Radiological Protection Board ("NRPB"), NRPB-G11, of the United Kingdom. The current E-field safety levels contained in these standards are shown in Fig. 1 in terms of equivalent power density in mW/cm^2. Each of the two standards establishes different safety limits for the general public and industrial environments. Of particular significance is the 10 to 300 MHz frequency range, where the limits are most stringent, especially for the general public, and are set to an equivalent power density of 0.2 mW/cm^2. At higher frequencies, the limits are as high as 10 mW/cm^2, whereas at frequencies below 3 MHz, the limits are set to 100 mW/cm^2.

For general applications, a radiation meter should operate over a frequency bandwidth of many decades and be capable of measuring power density levels from below 0.2 mW/cm^2 to above 100 mW/cm^2. General Microwave produces a series of broadband Radiation Hazard Meters, a number of which span more than five decades of frequency with 40 dB dynamic range. Other products are designed for narrower ranges of operation to suit specific applications more economically.

THE RELATIONSHIP OF ELECTRIC AND MAGNETIC FIELDS TO POWER DENSITY

An electromagnetic field has a complex time-space relationship between its electric and magnetic components. Although it is beyond the scope of this tutorial to define this relationship generally, it should be useful to present the specific case of free space electromagnetic radiation, in which the relationship reduces to a relatively simple form.

(1) *A comprehensive review of these issues is presented in "Biological Effects and Medical Applications of Electromagnetic Energy", OM P. Gandhi, Editor, Prentice-Hall, 1990.*

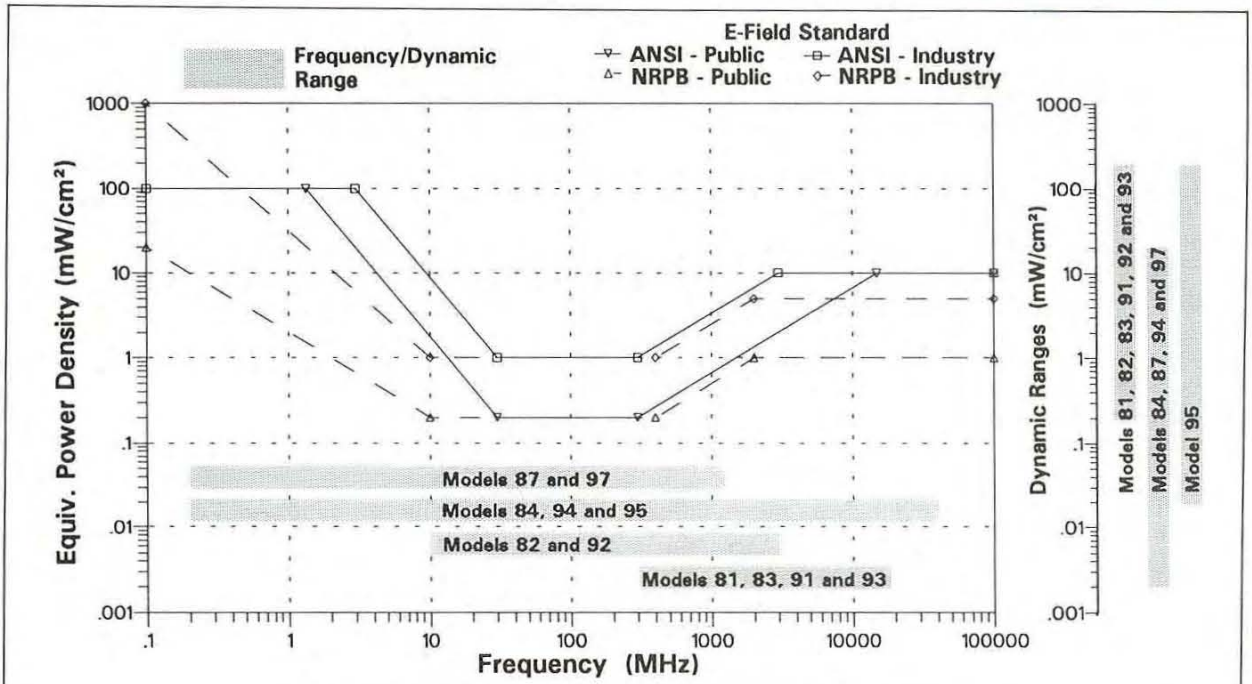


Fig. 1-1991 ANSI (U.S.) and 1988 NRPB (U.K.) E-Field Safety Standards

The E-field and H-field vectors of a radiated electromagnetic wave in free space are perpendicular with respect to each other in a plane transverse to the direction of propagation, as illustrated in Fig. 2.

At *any given time*, the magnitudes of both field components vary sinusoidally along the direction of propagation, with a periodicity corresponding to the wavelength λ, and are spatially invariant in the transverse direction. Conversely, at *a fixed position*, the amplitudes of the field components vary sinusoidally at the rate of the transmitting frequency f. The frequency f and the wavelength λ are related via the free space velocity c_o of the propagating wave by

$$c_o = \lambda_{cm} f_{GHz} = 30\text{cm/nsec}$$

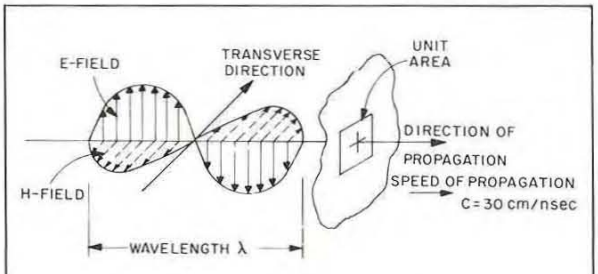


Fig. 2-E- and H-Field Relationships of an Electromagnetic Wave in Free Space

The magnitudes of the field components are related through the free space impedance Z_{sp}

$$Z_{sp} = \frac{|E|}{|H|} = 120\,\pi$$

In general, the incident power density is derived by integrating the magnitude of the E-field and H-field vector product over a unit area in the transverse plane. In the free space case, the magnitude of the field components can be directly related to the incident power density P_{inc} by

$$P_{inc} = \underset{\text{transverse plane}}{\iint} |E \times H|\, dS = \frac{|E|^2}{Z_{sp}} = |H|^2 Z_{sp}$$

All RAHAM instruments include a display calibrated in units of incident power density. Historically, this has been the most common method of defining potentially hazardous fields. However, RAHAM probes do not measure this quantity directly, but rather are designed to measure the magnitude of the electric field and display the result in equivalent incident power density using the free space relationship described above. The E-field measurement is preferred to an H-field measurement since it permits the realization of products with broader frequency and dynamic ranges.

Radiation Hazard Measuring Systems

The relative significance of the E-field and H-field as a biological hazard has been extensively studied by many workers in the field. There is still considerable on-going research and investigation of biological response to non-ionizing radiation exposure. For further information, the reader can consult the reference cited above as well as many other sources.

SENSOR DESIGN

General Microwave radiation meters employ electric field sensors, made of narrow conductive or resistive strips. Conceptually, their theory of operation can be analyzed by the "short dipole" method or "long resistive strip" method, respectively. These are illustrated in Fig. 3.

The former method, Fig. 3a, is employed at frequencies whose wavelength λ is much greater than the dipole length L. The key characteristic of this method is that the magnitude of the induced current has a triangular distribution along the dipole. The peak current at the center of the dipole is proportional to the frequency, ω, of the electromagnetic signal. Since the phase of the E-field lags the phase of the induced current by 90°, there is, nominally, no absorbed energy by the dipole. Instead some of the incident energy is reflected through the displacement current, whose distribution is complementary to that of the induced current. RAHAM sensors of this type are designed to reflect less than 5% of the incident power within the capture area of the dipole ($\approx L^2$). As long as the dc resistance of the short dipole is lower then the associated antenna reactance, the induced current distribution is not affected. (A resistive strip that meets this criterion will also operate in this mode.)

The "long resistive strip" method, Fig. 3b, used at frequencies where the strip length L is comparable to or greater than the wavelength λ, is characterized by a virtually uniform distribution of the magnitude of the induced current along the length of the strip. This current is in phase with the E-field and consequenly dissipates some energy along its length. All RAHAM resistive strip sensors have been designed to absorb about 5% of the incident power within their capture area.

General Microwave has pioneered the resistive strip antenna design. Additional details of this design can be found in papers published by Hopfer[2] and Hopfer and Adler[3].

DETECTION PROCESS

One important requirement of a sensor design is that it must minimally perturb the measured rf field. For this reason the sensor is usually separated from the instrumentation and connected via high resistance feed lines. Because the rf currents cannot travel along such feed lines efficiently, the induced current is confined to the sensor where it is converted to a dc voltage. General Microwave employs either a thermocouple array or a Schottky diode as detecting elements. These are illustrated in Fig. 4.

The thermocouple array, shown in Fig. 4a, is comprised of alternate thin film segments of thermoelectrically dissimilar metals, forming a long resistive strip. The thin film array is mounted between a pair of thermally conductive dielectric wafers to enhance the detector sensitivity. As a result of the power dissipated by the induced rf current, a thermal gradient arises across each thermocouple junction. By keeping the temperature differential small, the detector acts as a true rms device, thus producing a dc output voltage directly proportional to the rms value of the induced current which in turn is

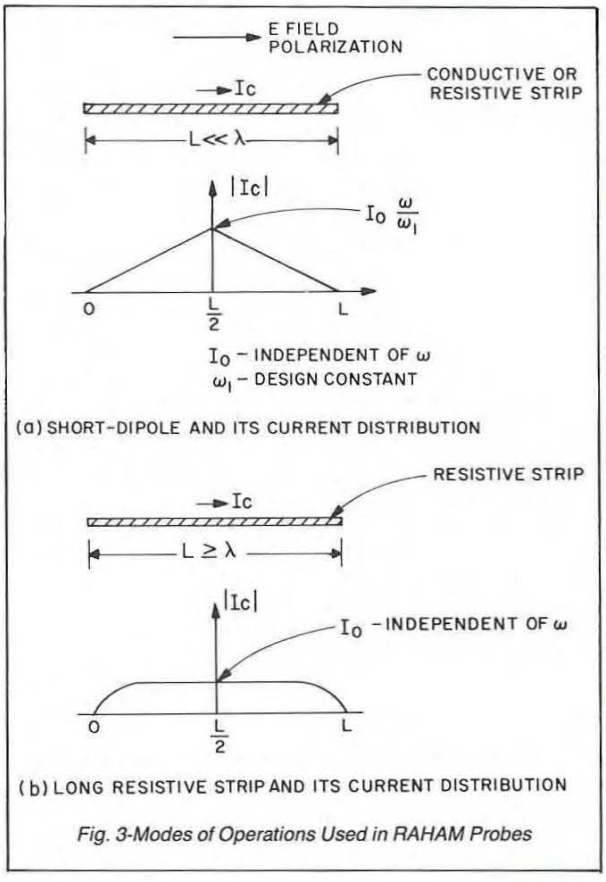


Fig. 3-Modes of Operations Used in RAHAM Probes

(2) *"The Design of Broad-Band Resistive Radiation Probes", S. Hopfer; Nov. 1972 IEEE Trans IM-21, pp 416-421.*

(3) *"An Ultra Broad-Band (200 KHz-26 GHz) High-Sensitivity Probe", S. Hopfer and D. Adler; Dec. 1980 IEEE Trans. Vol IM-29, pp 445-451.*

To obtain a copy of these papers, please write to Dept. C., General Microwave Corporation, 5500 New Horizons Blvd., Amityville, NY 11701.

proportional to the incident power density. This scheme is applicable above 300 MHz and is used in RAHAM probe Models 81, 83, 91 and 93.

Models 82, 87, 92 and 97 use the short dipole method of Fig. 3a. To compensate for the frequency dependence of the induced current, a sufficiently large capacitance C_s is inserted at the dipole center, parallel to the high impedance Schottky diode, illustrated in Fig. 4b. Since the reactance across C_s is inversely proportional to ω, the resulting rf voltage across the diode remains constant. By keeping this rf voltage within the square law range of the Schottky diode, a frequency independent dc voltage proportional to $|E|^2$ is generated. This scheme is useful only up to about 3 GHz.

Models 84, 94 and 95 employ a similar scheme, except a resistance R_s is added in series with capacitance C_s in the shunt network as seen in Fig. 4c. The addition of the resistance R_s provides a frequency independent rf voltage at higher frequencies, which is limited only by the parasitic inductance and capacitance associated with the detection circuit at high frequencies.

DIRECTIONAL RESPONSE

In a typical environment, information about the polarization of the electric field is usually not available. In an orthogonal x-y-z- system, the magnitude of the electric field E is related to its three axial components E_x, E_y and E_z by

$$|E|^2 = |E_x|^2 + |E_y|^2 + |E_z|^2$$

An isotropic probe design employes a set of three sensors arranged in an orthogonal x-y-z configuration. Since each sensor produces a dc voltage proportional to the square of the magnitude of the projected component, the sum of all three voltages results in an output proportional to $|E|^2$ and, therefore, to the power density, P_{inc}, regardless of the probe orientation. All RAHAM probes employ this isotropic arrangement except Models 81, 82, 91 and 92.

In those applications where the direction of propagation is known, an orthogonal arrangement of two sensors is sufficient to measure the field, as long as the E-field is polarized in the plane of the sensors. This is the design approach used in the anisotropic Models 81, 82, 91 and 92.

Other factors may affect the directional response of a multi-sensor probe, such as scattering due to the sensors, the dc summing network, feed lines, the mechanical arrangement housing the probe assembly and linearity errors. In practice, the summing network, feed line and housing are the most demanding aspects of an effective probe design.

LINEARITY ISSUES

Useful dynamic range is limited by linearity errors inherent in the detection process. The thermocouple array displays a near-intrinsic square-law response up to its burnout level. In addition, because of its relatively slow response time, it is insensitive to modulation including very low duty cycle signals such as are found in many radar systems. Unfortunately, it is limited in sensitivity and for practical purposes cannot be operated at frequencies below 300 MHz.

Schottky diodes exhibit a significantly more limited square-law range and may give rise to substantial errors when measuring fields with a low duty cycle. RAHAM probes using Schottky diodes have been designed to allow a maximum of 1 dB linearity error in cw fields. However, in those cases where the measured field is modulated, the magnitude of this error may increase considerably giving rise to an indicated power density lower than the actual value.

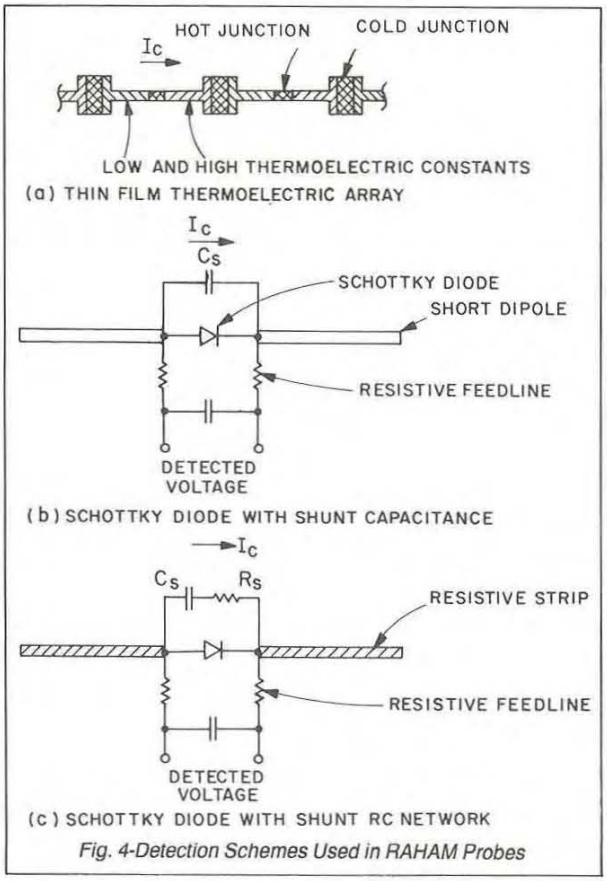


Fig. 4-Detection Schemes Used in RAHAM Probes

Radiation Hazard Measuring Systems

FREQUENCY AND DYNAMIC RANGE

Both the frequency and dynamic range of broadband RAHAM probes produced by General Microwave make them suitable for a number of applications. Some may require the measurement of high power fields over a narrow frequency range, while in other cases broad frequency range at low power level must be monitored. To compare the capabilities of various RAHAM probes to the most widely used safety standards, the frequency and dynamic ranges[4] of each model are superimposed on the ANSI and NRPB safety limit curves in Fig. 1.

The isotropic Models 83 and 93 and anisotropic Models 81 and 91, provide coverage from 300 MHz up to 18 GHz from 0.2 to 200 mW/cm^2. These models are specifically suitable for low duty cycle fields and environments with multiple sources such as communication systems and electronic warfare systems.

The anisotropic Models 82 and 92 are low cost units covering 10 MHz to 3 GHz, which covers a number of common applications such as medical equipment, microwave heaters and dryers as well as microwave ovens. In all these instances the source of the radiation is known; thus the anisotropic design is adequate.

Isotropic Models 84 and 94 cover over 17 octaves in frequency range and are capable of measuring fields as low as 0.002 mW/cm^2. They are suitable for general surveillance, safety verification of general public and industrial sites as well as measurement of low level interference fields. Due to their high sensitivity, they may also be suitable for EMI and EMC applications.

Model 95 is similar to Model 94, except its maximum power range is extended 10 dB and its sensitivity is reduced by 10 dB. The high level 200 mW/cm^2 range suits this model for stronger field applications that may exist at industrial and military sites. As seen in Fig. 1, this product is capable of measurements within all ANSI and NRPB safety levels over its 200 KHz to 40 GHz frequency range.

Models 87 and 97 are low frequency, low cost versions of Models 84 and 94 respectively. Their upper frequency is limited to 1.2 GHz.

INSTRUMENTATION

All General Microwave RAHAMs consist of a power density meter, one or more probes, an extension cable, and a carrying case, and all are portable and battery operated. The probe output is applied to a high gain, low noise, solid-state amplifier which is packaged in an instrument case with a self-contained meter calibrated to read power density directly.

In normal operation, the user has the option of mounting the probe directly on the power density meter or interconnecting the probe and meter with the extension cable. While the directly connected probe offers convenient one-hand operation, the extension cable allows the operator greater flexibility in probing for radiation fields in awkward or less accessible locations. It also permits him to more readily shield himself in potentially hazardous radiation fields.

Models 1, 2, 3, and 12 utilize Meter 481B and Probes 81A, 82 and 83A. Models 4C and 7 utilize Meter 484 and Probes 84C and 87.

The RAHAM Models 10, 20, 30, 40, 50 and 70 comprise the latest line of Radiation Hazard Measuring Systems. These units employ a new and more versatile instrument, the Model 495, which is capable of utilizing both isotropic and anisotropic probes over a wide dynamic range. All of these systems are supplied with a battery charger and a carrying case.

PERSONAL DOSIMETERS

The most recent addition to the radiation hazard meter product line of General Microwave is a series of battery-powered pocket size personal dosimeters, the Models 60, 65-1 and 65-5 RF Badges. These units, which are intended to be carried in a shirt or jacket pocket or clipped to one's clothes or belt, continuously monitor the area in which the user works and produce an audible and visual alarm whenever the electromagnetic field exceeds a preset level.

The rf detector, which is the same in all three models of the RF Badge, consists of an orthogonal pair of thermocouple arrays similar to those used in the isotropic Models 83 and 93. Anisotropy is limited to E-fields with a component normal to the broad face of the instruments, and should normally not prove to be a limitation, especially if the user is in motion. The instrumentation is housed within the assembly and is well shielded to minimize interaction with the rf detectors.

The Model 65 only provides an alarm level which is factory preset to 1 mW/cm^2 and 5 mW/cm^2 for the Model 65-1 and 65-5 respectively. The Model 60 not only permits the user to set the alarm to any level within the operating range of the instrument, but it also provides a direct readout of either instantaneous power density or the power density averaged over the preceding six minutes. All RF Badge models employ continuous built-in self testing to warn the user of an equipment malfunction.

(4) *The dynamic range shown is from the maximum rated operating power to 10% of full scale of the most sensitive range.*

Radiation Hazard Measuring Systems Selection Guide

RF BADGE: PERSONAL DOSIMETERS

MODEL	FREQUENCY RANGE	POWER RANGE mW/cm²	RESPONSE	PAGE
60	1-18 GHz	0.1 to 20	Directional	184
65-1	1-18 GHz	1	Directional	
65-5	1-18 GHz	5	Directional	

HIGH PERFORMANCE MODELS

- **Ultra-broad frequency range**
- **Instantaneous and 6 minute average measurements**
- **Hazard level alarms**
- **One hand operation**
- **Low weight, small size**
- **Battery/line operation**

MODEL	FREQUENCY RANGE	POWER RANGE mW/cm²	RESPONSE	PAGE
10	300 MHz - 18 GHz	0.2 to 200	Directional	187
20	10 MHz - 3 GHz	0.2 to 200	Directional	
30	300 MHz - 18 GHz	0.2 to 200	Isotropic	
40	200 kHz - 40 GHz	0.002 to 20	Isotropic	
50	200 kHz - 40 GHz	0.02 to 200	Isotropic	
70	200 kHz - 1.2 GHz	0.002 to 20	Isotropic	

ECONOMY MODELS

- **Broad frequency range**
- **Instantaneous measurements**
- **Wide dynamic range: 40 dB**
- **One hand operation**
- **Small size, rugged construction**
- **Battery operated**

MODEL	FREQUENCY RANGE	POWER RANGE mW/cm²	RESPONSE	PAGE
1	300 MHz - 18 GHz	0.2 to 200	Directional	190
2	10 MHz - 3 GHz	0.2 to 200	Directional	
3	300 MHz - 18 GHz	0.2 to 200	Isotropic	
4C	200 kHz - 26 GHz	0.002 to 20	Isotropic	
7	200 kHz - 1.2 GHz	0.002 to 20	Isotropic	
12	10 MHz - 18 GHz	0.2 to 200	Directional	

Model 60 And Model 65 RF/Microwave Radiation Badges

The Model 60 and Model 65 RF Badges are battery operated instruments, which instantaneously detect, measure and warn the wearer of exposure to potentially hazardous microwave radiation levels.

Coverage is continuous from 1 to 18 GHz. The units feature built-in circuitry which runs a self-diagnostic test everytime they are switched on. And, they continually self-test to maintain reliable performance. The Badges are false alarm-free, regardless of the power level set.

Both models are equipped with high intensity LED indicators and audible alarms which turn on, latch, and continue flashing and sounding to warn of excessive radiation. All units are furnished with an earplug for use in a high noise environment.

They are intended for use by personnel working at installations purposefully broadcasting or capable of accidentally leaking hazardous levels of RF/Microwave radiation.

MODEL 60: USER ADJUSTABLE

The Model 60 enables the user to set the alarm warning level anywhere in the range from 0.2-20 mW/cm^2. In addition, the user can choose either of two measurement modes: instantaneous exposure level or a 6-minute average measurement. Both modes are displayed on a 3-digit LCD panel along with a 10-segment bar graph normalized to the selected alarm level.

MODEL 65: FACTORY PRESET

The Model 65 is available in two versions differing only in their factory-preset warning levels:

Model 65-1 1 mW/cm^2
Model 65-5 5 mW/cm^2

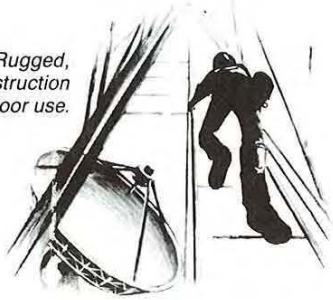
TYPICAL APPLICATIONS:

• Radar Sites • Microwave Communications Towers • Satellite Earth Terminal Uplinks • Airborne/ Shipborne/Ground-Based Installations with High Power Microwave Systems.

Hands-free operation

Furnished with ear plug so you can hear alarm in noisy environments.

Continuous coverage from 1-18 GHz.



Rugged, drip-proof construction for outdoor use.

Model 60 And Model 65
RF/Microwave Radiation Badges

MODEL 60

Built-In Test Functions	• Automatically self-tests when switched on • Signals whenever battery is low • Signals whenever instrument is faulty
Measurement Modes	• Instantaneous exposure level • 6-minute average exposure level
Alarm Levels	• User adjustable from 0.2 mW/cm^2 to 20 mW/cm^2

Visual Displays	• Light flashes when alarm level is exceeded
	• Flash rate varies with intensity of exposure
	• LCD display
	  • Indicates level to 20 mW/cm^2
	  • Flashes when alarm level is exceeded
	  • Signals low battery
	  • Signals instrument fault
	•Bar graph constantly indicates exposure as a percent of preset alarm level

Audible Signals	• Beeps when alarm level is exceeded • Beep rate varies with intensity of exposure • Beeps to indicate low battery • Continuous signal indicates instrument fault

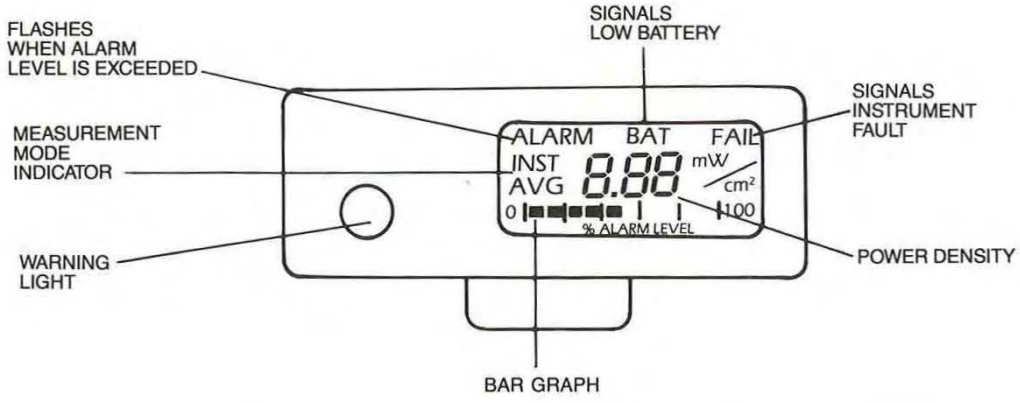
MODEL 65

Built-In Test Functions	• Automatically self-tests when switched on • Signals whenever battery is low • Signals whenever instrument is faulty
Measurement Mode	• Instantaneous exposure level

Alarm Levels	• Two factory preset models
	  • 1 mW/cm^2 (Model 65-1)
	  • 5 mW/cm^2 (Model 65-5)

Visual Displays	• Light flashes when alarm level is exceeded • Flash rate varies with intensity of exposure • Flashes to indicate low battery • Continuous light indicates instrument fault
Audible Signals	• Beeps when alarm level is exceeded • Beep rate varies with intensity of exposure • Beeps to indicate low battery • Continuous signal indicates instrument fault

Model 60 Display Features

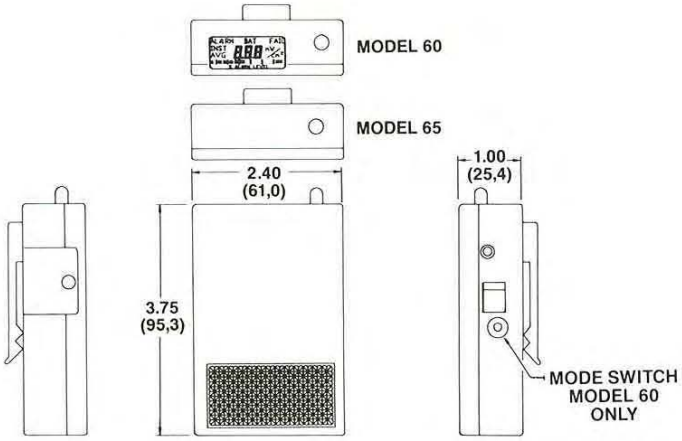


Model 60 and Model 65 Specifications

MODEL 60	SPECIFICATION
FREQUENCY RANGE:	1-18 GHz
POWER DENSITY RANGE:	0.01 to 20 mW/cm^2
ALARM ACCURACY:	± 1.5 dB
HALF POWER BEAM WIDTH:	
Horizontally Polarized	90°
Vertically Polarized	180°
RF DETECTOR:	True RMS
AVERAGE POWER OVERLOAD:	0.5 W/cm^2
PEAK POWER OVERLOAD:	30 W/cm^2
PULSE ENERGY DENSITY OVERLOAD:	150 W-μsec/cm^2
POWER DENSITY INDICATORS:	a) 3 digit LCD b) Bar Graph
MEASUREMENT MODES:	a) Instantaneous Pwr Density b) 6 Minute Average Power Density
BAR GRAPH DISPLAY:	Percent of Set Alarm Level
ALARM LEVEL SETTING:	0.2 to 20 mW/cm^2
ALARM SIGNALS:	a) Flashing LCD Indicator b) Flashing LED c) Audible Beep
BUILT IN TEST:	Continuous
BULT IN TEST FUNCTIONS:	a) Detector Fault b) Low Battery
TEMPERATURE RANGE:	
Operating	−10°C to +50°C
Non-Operating	−40°C to +65°C
BATTERY:	
Type	DL2450B, Lithium
Life	1000 hours
SIZE: inches	2.40 x 3.75 x 1.00
mm	61,0 x 95,3 x 25,4
WEIGHT: oz	6
gm	170
ACCESSORIES:	1) Earphone 2) Carrying Case

MODEL 65	SPECIFICATION
FREQUENCY RANGE:	1-18 GHz
ALARM LEVEL:	
Model 65-1	1 mW/cm^2
Model 65-5	5 mW/cm^2
ALARM ACCURACY:	± 1.5 dB
HALF POWER BEAM WIDTH:	
Horizontally Polarized	90°
Vertically Polarized	180°
RF DETECTOR:	True RMS
AVERAGE POWER OVERLOAD:	0.5 W/cm^2
PEAK POWER OVERLOAD:	30 W/cm^2
PULSE ENERGY DENSITY OVERLOAD:	150 W-μsec/cm^2
ALARM SIGNALS:	a) Flashing LED b) Audible Beep
BUILT IN TEST:	Continuous
BUILT IN TEST FUNCTIONS:	a) Detector Fault b) Low Battery
TEMPERATURE RANGE:	
Operating	−10°C to +50°C
Non-Operating	−40°C to +65°C
BATTERY (2 ea.)	
Type	DL2032B, Lithium
Life	1000 hours
SIZE: inches	2.40 x 3.75 x 1.00
mm	61,0 x 95,3 x 25,4
WEIGHT: oz	6
gm	170
ACCESSORIES:	1) Earphone 2) Carrying Case

DIMENSIONS



Models 10, 20, 30, 40, 50, 70 High Performance RAHAM® Radiation Hazard Meters

- **Ultra-broad frequency range in a single probe: 200 kHz-40 GHz**
- **Wide dynamic range: 40 dB**
- **One hand operation**
- **Low weight: 2.1 lbs. (meter and probe)**

The RAHAM Models 10, 20, 30, 40, 50 and 70 comprise the latest line of Radiation Hazard Measuring Systems. These systems consist of a probe, a power density meter, and an extension cable. They are portable, battery operated instruments that detect and measure potentially hazardous electromagnetic radiation from rf and microwave sources. These units employ a new and more versatile power density meter, the Model 495, which is capable of utilizing both isotropic and anisotropic probes over a wide dynamic range.

All RAHAM systems are supplied with a battery charger and a carrying case.

In addition, an optional portable test source, Model 309, is available for use with all of these units (except Model 70).

Models 10, 20, 30, 40, 50, 70 High Performance RAHAM® Radiation Hazard Meters

POWER DENSITY METER, MODEL 495

The Model 495 has a six minute power density averaging function which automatically computes and displays the average exposure measurement over the six minute period required by safety standards. In addition, it has built-in local and remote alarms, a peak hold mode, probe calibration factor control, normal and slow meter response control and a recorder output for remote measurements.

The following is a brief description of instrument functions:

- **Three operational modes**
  NORMAL — for direct reading of power density
  PEAK — for recording the maximum power density
  AVERAGE — for automatically computing and displaying the average power density over a six minute period. This value is updated every 90 seconds.
- **Range**
  40 dB with the Models 40, 50 or 70
  30 dB with the Models 10, 20 or 30
- **Built-in alarm system alerts operator when power density exceeds the selected level**
  LOCAL — Audible alarm
  REMOTE — Logic state signal change
- **Cal. Factor control**
  When the frequency of the radiating source is known, setting this control corrects for the frequency response of the probe.
- **Response time control**
  When the rf field is changing, this control provides improved readability by adjusting the instrument bandwidth.
  NORMAL — 1.5 seconds
  SLOW — 3 seconds
- **Power source**
  PORTABLE — operates for 50 hours on rechargeable batteries. The battery condition is conveniently checked on the front panel meter.
  STATIONARY — can be operated using 115/230 VAC. Instrument may be operated continuously on the battery charger.
- **Push To Zero**
  Zeroing the meter on the most sensitive range assures a zero for all ranges.
- **Recorder output**
  Provides a 100mV full scale signal for chart recording or for interfacing with a digital voltmeter.

ISOTROPIC AND ANISOTROPIC PROBES, MODELS 91, 92, 93, 94, 95 AND 97

Depending on which probe is utilized with the Model 495 Power Density Meter, the radiation hazard measuring system can provide isotropic or anisotropic response, up to 40 dB dynamic range, over a 200 kHz to 40 GHz frequency range. The probes are color coordinated with the meter range selector switch to indicate applicable measurement range. Each probe is calibrated over its frequency range and a frequency response profile is supplied with the unit.

RAHAM SYSTEM	POWER DENSITY METER	PROBE
Model 10: 0.3 to 18 GHz 0.2 to 200 mW/cm^2 anisotropic response	Model 495	Model 91
Model 20: 0.01 to 3 GHz 0.2 to 200 mW/cm^2 anisotropic response	Model 495	Model 92
Model 30: 0.3 to 18 GHz 0.2 to 200 mW/cm^2 isotropic response	Model 495	Model 93
Model 40: 200 kHz to 40 GHz 0.002 to 20 mW/cm^2 isotropic response, Ultra Broadband, High Sensitivity	Model 495	Model 94
Model 50: 200 kHz to 40 GHz 0.02 to 200 mW/cm^2 isotropic response Ultra Broadband, High Power	Model 495	Model 95
Model 70: 200 kHz to 1.2 GHz 0.002 to 20 mW/cm^2 isotropic response Broadband, High Sensitivity	Model 495	Model 97

MODEL 309 RAHAM TEST SOURCE

The Model 309 RAHAM Test Source provides a convenient means for verifying the operational performance of a RAHAM system. The Model 309 is portable, battery operated and can be conveniently housed within the RAHAM carrying case.*

The RAHAM Test source generates an X-band field (approximately 10.5 GHz) within a resonant chamber. At the probe location, an equivalent power density of 1 mW/CM^2 is established.

**Models 10, 20, 30, 40 and 50 only.*

Models 10, 20, 30, 40, 50, 70 Specifications

CHARACTERISTIC	MODEL 10	MODEL 20	MODEL 30	MODEL 40	MODEL 50	MODEL 70
FREQUENCY RANGE	0.3 to 18 GHz	0.01 to 3 GHz	0.3 to 18 GHz	200 kHz to 40 GHz	200 kHz to 40 GHz	200 kHz to 1.2 GHz
POWER DENSITY RANGE	30 dB			40 dB		
METER MODEL	495			495		
FULL SCALE READING	2,20,200 mW/cm²			0.02,0.2,2,20 mW/cm²	0.2,2,20,200 mW/cm²	0.02,0.2,2,20 mW/cm²
FREQUENCY SENSITIVITY	± 2.5 dB, 1 to 18 GHz −1 to −8 dB, 0.3 to 1 GHz	± 1.25 dB, 0.01 to 1.2 GHz +2.5 dB, −0 dB, 1.2 to 3.0 GHz	± 1.5 dB, 1 to 18 GHz +0 to −3 dB, 0.3 to 1 GHz	± 1.5 dB, 200 kHz to 26 GHz +2 to −2 dB, 200 kHz to 40 GHz		± 1 dB, 3 to 300 MHz ± 2 dB, 200 kHz to 1.2 GHz
PROBE MODEL	91	92	93	94	95	97
CALIBRATION ACCURACY	± 0.5 dB					
CALIBRATION FREQUENCIES(1)	0.3, 1.2, 2.45, 3.8, 8, 12, 18 GHz	0.01, 0.027, 0.1, 0.3, 1.2, 2.45, 3 GHz	0.3, 1.2, 2.45, 3.8, 8, 12, 18 GHz	0.2, 2, 27, 100, 300 MHz 1.2, 2.45, 3.8, 8, 12, 18, 26, 33, 40 GHz		.2, 2, 27, 100, 300 MHz 1.2 GHz
AVERAGE POWER OVERLOAD(2)	0.5W/cm(2)	1W/cm(2)	0.5W/cm(2)	1W/cm(2)		
PEAK POWER OVERLOAD(2)	30W/cm(2)			100W/cm(2)		
PULSE ENERGY DENSITY OVERLOAD(2)	150W-μsec/cm(2)			300W-μsec/cm(2)		
POLARIZATION	ANISOTROPIC		ISOTROPIC			
ELLIPTICITY(3)	± 0.75 dB	± 0.5 dB(4)				
ISOTROPY	—		RESPONSE varies ± 1.0 dB maximum for energy incident from any direction except from/through the handle.			
NOISE (max) MOST SENSITIVE RANGE	1% P-P			3% P-P	1% P-P	3% P-P
RESPONSE TIME (Nominal) Normal: Slow:	1.5 Seconds 3 Seconds					
CAL FACTOR RANGE	0.5 to 2.0					
POWER DENSITY AVERAGE	Meter indicates the power density as averaged over a 6 minute interval. The reading is updated at a 90 second rate.					
PEAK HOLD	Meter indicates peak value of measured power density until manually reset.					
ALARM	Audible alarm sounds and remote alarm operates when meter reading exceeds alarm preset level.					
RECORDER OUTPUT	0.100 volts full scale into minimum resistance of 100K ohms.					
BATTERY/LINE OPERATION	50 hours on built in rechargeable batteries. Operates from 115/230 VAC with supplied charger/adaptor. Battery status checked on meter.					
OPERATING TEMPERATURE RANGE	0°C to +55°C					
SIZE: POWER DENSITY METER EACH PROBE CABLE ASSEMBLY CARRYING CASE MODEL 309	 6″ x 4.75″ x 6.75″ (152 x 121 x 171mm) 14″ long x 2.75″ max. dia. (355 x 70mm) 4′ long (1.22m) 15.5″ x 12.25″ x 6.25″ (394 x 311 x 159mm) 6.1″ x 3.4″ x 3.2″ (155 x 86 x 81mm)					
WEIGHT (APPROX) METER & PROBE CARRYING CASE & ACCESSORIES MODEL 309	 2.1 lbs (1.0 kg) 8.0 lbs (3.6 kg) 1.3 lbs (0.6 kg)					

(1) *Special Calibration Frequencies Available Upon Request*
(2) *At 25°C*
(3) *Maximum change in sensitivity due to rotation about an axis through the handle*
(4) *For models 40 and 50, above 18 GHz, ellipticity may rise to ± 0.75 dB*

Models 1, 2, 3, 4C, 7 and 12
RAHAM® Radiation Hazard Meters

General Microwave RAHAM Radiation Hazard Meters detect and measure potentially hazardous electromagnetic energy radiating from RF and microwave sources. They are designed to monitor a wide variety of systems—military, industrial and commercial—which may expose personnel to such conditions. Typical of these are microwave ovens, medical equipment, radar installations, microwave heaters and dryers, communication systems, and electronic warfare systems.

All General Microwave RAHAMs consist of a power density meter, one or more probes, an extension cable, and a carrying case, and all are portable and battery operated.

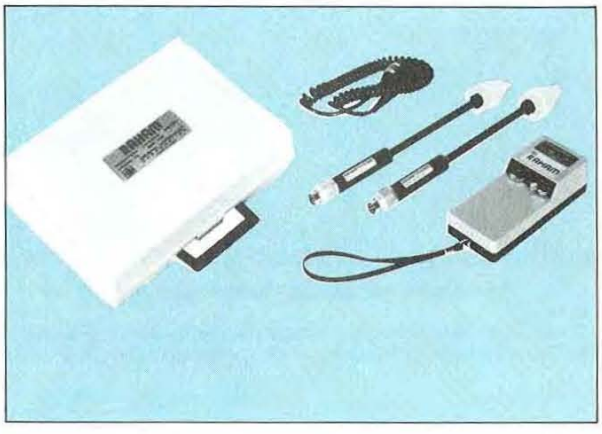
The probe output is applied to a battery powered, high gain, low noise, solid-state amplifier. The amplifier is packaged in an instrument case with a self-contained meter which is calibrated to read power density directly.

In normal operation, the user has the option of mounting the proble directly on the power density meter or interconnecting the probe and meter with the extension cable. While the directly connected probe offers convenient one-hand operation, the extension cable allows the operator greater flexibility in probing for radiation fields in awkward or less accessible locations. It also permits him to shield himself in potentially hazardous radiation fields.

Models 1, 2, 3 and 12 utilize Meter 481B and Probes 81A, 82 and 83A.

Models 4C and 7 utilize Meter 484 and Probes 84C and 87.

In addition, an optional portable test source, Model 309, is available for use with all of these units (except Model 7).



Models 1, 2, 3, 4C, 7 and 12 Specifications

CHARACTERISTIC	MODEL 1	MODEL 2	MODEL 12	MODEL 3	MODEL 4C	MODEL 7
FREQUENCY RANGE	0.3 to 18 GHz	0.01 to 3 GHz	0.01 to 18 GHz	0.3 to 18 GHz	200 kHz to 26 GHz	200 kHz to 1.2 GHz
POWER DENSITY RANGE	30 dB				40 dB	
METER MODEL	481B				484	
FULL SCALE READING	2, 20, 200 mW/cm²				0.02, 0.2, 2, 20 mW/cm²	
FREQUENCY SENSITIVITY	± 2.5 dB, 1 to 18 GHz −1 to −8 dB, 0.3 to 1 GHz	± 1.25 dB, 0.01 to 1.2 GHz, +2.5 dB, −0 dB, 1.2 to 3.0 GHz	0.01 to 3 GHz (same as 82) 0.3 to 18 GHz (same as 81A)	± 1.5 dB, 1 to 18GHz +0 to −3 dB, 0.3 to 1 GHz	± 1.5 db 200 kHz to 26 GHz	± 1 dB, 3 to 300 MHz ± 2 dB, 200 kHz to 1.2 GHz
PROBE MODEL	81A	82	81A & 82	83A	84C	87
CALIBRATION ACCURACY	± 0.5 dB					
CALIBRATION FREQUENCIES(1)	0.3, 1.2, 2.45, 3.8, 8, 12, 18 GHz	0.01, 0.027, 0.1, 0.3, 1.2, 2.45, 3 GHz	0.01, 0.027, 0.1, 0.3, 1.2, 2.45, 3.0, 3.8, 8, 12, 18 GHz	0.3, 1.2, 2.45, 3.8, 8, 12, 18 GHz	0.2, 2, 27, 100, 300 MHz 1.2, 2.45, 3.8, 8, 12, 18, 26 GHz	.2, 2, 27, 100, 300 MHz 1.2 GHz
AVERAGE POWER OVERLOAD(2)	0.5W/cm(2)	1W/cm(2)	81A-0.5W/cm(2) 82-1W/cm(2)	0.5W/cm(2)	1W/cm(2)	
PEAK POWER OVERLOAD(2)	30W/cm(2)				100W/cm(2)	
PULSE ENERGY DENSITY OVERLOAD(2)	150W-μsec/cm(2)				300W-μsec/cm(2)	
POLARIZATION	ANISOTROPIC			ISOTROPIC		
ELLIPTICITY(3)	± 0.75 dB	± 0.5 dB	same as 81A same as 82	± 0.5 dB(4)		
ISOTROPY	—			RESPONSE varies ± 1.0 dB maximum for energy incident from any direction except from/through the handle.		
NOISE (max) MOST SENSITIVE RANGE	1% P-P				3% P-P	
RESPONSE TIME (Nominal)	1.5 SECONDS					
BATTERY OPERATION	500 Hours expendable			900 Hours expendable		
RECORDER OUTPUT	0.124 volt full scale into a minimum resistance of 100 K ohms					
OPERATING TEMPERATURE RANGE	0°C to 55°C					
SIZE: POWER DENSITY METER EACH PROBE CABLE ASSEMBLY CARRY CASE	2.50″ x 1.63″ x 6.38″ (64 x 41 x 162mm) 14.00″ max length x 2.75″ max diameter (356 x 70mm) 4′ long (1.22m) 15.5″ x 12.25″ x 4.75″ (394 x 311 x 120mm)					
WEIGHT (APPROX) METER & PROBE PLUS CARRYING CASE & ACCESSORIES	1.1 lbs (0.5 kg) 5.4 lbs (2.45 kg)					

(1) *Special Calibration Frequencies Available Upon Request*
(2) *At 25°C*
(3) *Maximum change in sensitivity due to rotation about an axis through the handle*
(4) *For Model 4C, above 18 GHz, ellipticity may rise to ± 0.75 dB*

Domestic Sales Representatives

1. Saber Associates
   PO Box 5990
   Huntsville, AL 35814
   Tel: 1-800-327-0853
   Fax: 407-725-0578

2. RF Associates North, Inc.
   800 San Antonio Road
   Palo Alto, CA 94303
   Tel: 415-494-3331
   Fax: 415-857-0351

3. RF Associates Inc.
   2127A Sawtelle Blvd.
   Los Angeles, CA 90025
   Tel: 213-478-1586
   Fax: 213-478-1580

4. Saber Associates
   PO Box 1599
   Melbourne, FL 32902
   Tel: 1-800-432-6288
   Fax: 407-725-0578

5. Cain-Forlaw Co., Inc.
   25677 Hillview Ct.
   Mundelein, IL 60060
   Tel: 708-540-9962
   Fax: 708-540-9974

6. Microwave Marketing
   655 Boston Road
   Suite 2B
   Billerica, MA 01821
   Tel: 508-667-1440
   Fax: 508-667-1946

7. E.F. Technical Sales
   60 Northfield Ave.
   W. Orange, NJ 07052
   Tel: 201-731-7203
   Fax: 201-731-8058

8. E.F. Technical Sales
   79 Express Street
   Plainview, NY 11803
   Tel: 516-942-7400
   Fax: 516-942-7404

9. Saber Asscciates
   PO Box 826
   Clayton, NC 27520
   Tel: 1-800-327-0853
   Fax: 407-725-0578

10. Cain-Forlaw Co.
    223 St. Pierre
    Worthington, OH 43085
    Tel: 614-436-3004
    Fax: 614-436-3097

11. Beta Sales
    428 Pennsylvania Ave.
    Ft. Washington, PA 19034
    Tel: 215-643-6650
    Fax: 215-643-6651

12. Saber Associates
    PO Box 563
    Lawrenceville, GA 30246
    Tel: 1-800-327-0853
    Fax: 407-725-0578

13. Cain & Company
    2750 Northaven Road
    Suite 105
    Dallas, TX 75229
    Tel: 214-247-3901
    Fax: 214-243-4683

14. Saltech
    10320 Route 99
    Ellicott City, MD 21043
    Tel: 301-461-7350
    Fax: 301-461-1679

15. Technical Concepts Corp.
    8415 Datapoint Drive
    Suite 1060
    San Antonio, TX 78229
    Tel: 512-616-0000
    Fax: 512-616-0001

16. Herb Bass Associates
    5225 N. 51st. Street
    Boulder, CO 80301
    Tel: 303-530-7509
    Fax: 303-530-7510

17. Herb Bass Associates
    2406 Wood Hollow Way
    Bountiful, UT 84010
    Tel: 801-295-7100

18. KJS Marketing
    Cedar Rapids, IA
    Tel: 319-395-7500
    Fax: 314-245-6860

19. KJS Marketing
    12131 Dorsett Road
    Suite 124
    Maryland Heights, MO 63043
    Tel: 314-770-1412
    Fax: 314-770-1316

20. KJS Marketing
    12117 West 76th Street
    Suite 101
    Lenexa, KS 66216
    Tel: 913-962-1795
    Fax: 913-962-9722

21. Technical Component Sales
    167 Frontenac Heights
    Rochester, NY 14617
    Tel: 716-342-2406
    Fax: 716-266-1835

22. Blackhart Associates
    6120 N. Desert Foothills Drive
    Tuscon, AZ 85743
    Tel: 602-579-0399
    Fax: 602-579-0098

23. RF Associates Inc.
    10 Buccaneer Way
    Coronado, CA 92118
    Tel: 619-575-9011
    Fax: 619-575-0257

International Sales Representatives

To place orders and for information about our microwave instruments and components, please contact your local representative.

Pour toute commande ou information sur nos composants et nos instruments de haute qualité pour ondes centimétriques, veuillez contacter votre représentant local.

Wenn sie bauteile und instrumente von höchster qualitat für mikrowellen benötigen, wenden sie sich bitten an uns.

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