OPERATION:

Operation of the CT-250 is very elementary. Simply connect your input signal to the proper input jack (10MHz, 60MHz or 2.5GHz) and select the range and gate time. All switches are mounted on the front panel in easy view of the tuner. A description of the front panel controls are as follows:

Power

- OFF Turns the counter off.
- ON Turns the counter on.
- HOLD Stops the clock signals to the counter circuits and holds the count that is displayed.

Gate

- 0.1 SEC position selects a 1/10 second gate period. The gate period is the time interval over which input pulses are counted. The faster gate period allows a faster updated count at the expense of less resolution.
- 1.0 SEC position selects a 1 second gate period. This position is used when better resolution is required.
- 10 SEC position selects a 10 second gate period. This position is used only when extreme accuracy is required and a long term, stable signal is available. NOTE On the 2.5GHZ range, actual gate times are 2.5 times longer.

Range

- 10MHz position is used when input signals are connected to the 10MHz, 60MHz input jack. The counter will then count up to 10MHz with 0.1Hz resolution (10 second gate).
- 60MHz position is used when the input signals are connected to the 10MHz, 60MHz input jack. The counter will then count up to 60MHz with 1.0Hz resolution (10 second gate).
- 2.5GHz position is used when the input signals are connected to the 2.5GHz input jack. The counter will then count up to 2.5GHz with 10Hz resolution (10 second gate). Gate times on the 2.5GHz range are 2.5 times longer than indicated.

Gate Light

Indicates when the counter is actually measuring input signals. The gate light gives a visual indication of gate time and counter operation. It is extremely useful when using the longer gate times.

THEORY OF OPERATION:

General: Regardless of the type or complexity of a frequency counter, all instruments measure frequency by counting input pulses with respect to known frequency or time base. The time base generates a precisely controlled time interval, selectable to be one (1) second or one-tenth (1/10) of a second. During this period, the counter is enabled and input pulses counted. When the time period is up, the number of pulses counted is then displayed. A long gate period allows more pulses to be counted. The more pulses counted, the better the resolution. The limiting factors governing resolution are the number of digits in the display and the tolerable gate period. Usually 1.0Hz is the best resolution practical for an easy to read count. Of course it is not always necessary to read frequency to a hertz or wait for a one (1) second count. By selecting a shorter gate period, you can reduce the display update time and get a faster reading display, but at the expense of poorer resolution.

Detailed Theory: The UHF and VHF inputs have been kept separate to increase the input sensitivity by eliminating switching losses. The UHF signals are fed through J1 into U1 (the first divider stage) then to Q1 (a wave shaping transistor stage). From there the signal is sent to U3 (the counter IC).

The VHF input is much different because it must be of a very high impedance. The signal is fed through J2 past CR3 and CR4 input protection diodes to the gate of Q2; FET. The combination of the FET and Q3 bootstrap bipolar transistor follower provides the high impedance required. The signal is then sent to the three stage line amp (U4). This IC is an ECL device that limits and shapes the signal. Transistor Q4 then converts the ECL level to a TTL level signal that the rest of the counter requires. The input to U2 divided is selected by the range switch. Its input can come from the UHF section (U1) or the VHF section (Q4). If the 10MHz mode has been selected, U2 is bypassed completely and the signal is sent directly to U3 the counter IC.

The time base for U3 is supplied by Y1 and Y2 and their associated components. The counter IC will use whichever time base that has been selected. The counter IC generates all its own housekeeping functions such as multiplex, strobe, gate and reset signals. A logic circuit inside the counter IC senses the scanned readout signals (D0 through D7) as well as the input to pin 14 (the gate select input). By comparing these inputs, the counter IC generates the selected gate time. The decimal point is displayed the same way. A logic circuit inside the IC looks at the scanned outputs (D0 through D7) and compares this with the signals selected by S2.

The power supply uses a simple bridge rectifier circuit that will accept an AC or DC input. Regulator VR1 provides a stable 5v power source while R28 and CR12 provide the charging current for the nicads (if used). Capacitors C15 and C16 provide added filtering.

HOW TO USE YOUR COUNTER:

Using your counter is usually just as easy as connecting the signal to the input jack and counting. However, is some instances, such as noisy signals or low frequencies, care must be taken in applying the signal to the counter. The counter not only has a high input impedance but also high sensitivity. Noise accompanying the desired signal may fall within the counter's sensitivity and frequency limits and be counted. This signal plus noise input is amplified and counted within the instrument and produces a jittery, unstable display. The solution to this problem is to attenuate the signal plus noise to the level where the noise is below the counter threshold. A scope x10 probe is ideal for this purpose. An easily constructed probe of this type is described later on.

Another problem area is ringing at the counter input. Consider the coax cable from the signal to be measured to the input jack, it's a transmission line just like your antenna coax on a transmitter. Being such, a standing wave phenomenon can occur if impedances are mismatched. If a signal from low impedance source is presented to the coax cable, and the cable is connected to the high impedance counter input, the signal will be mismatched. This mismatch will cause the signal to reflect from the input and return, again causing an unstable display.

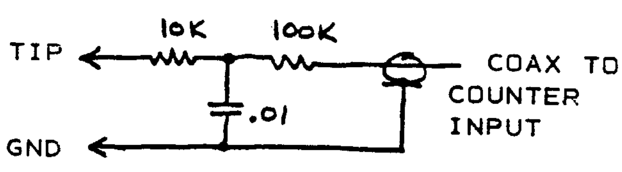
Yet another consideration is that of ground loops. If your counter probe is grounded to the circuit to be measured, and the counter case is also grounded (whether physically or induced) a ground current along the cable can exist. This ground current will produce a voltage which, if it is AC, will be counted.

Fortunately, most of these problems are easily solved by thoughtful selection of coupling the input signal. This involves determining just what sort of signal you are attempting to measure.

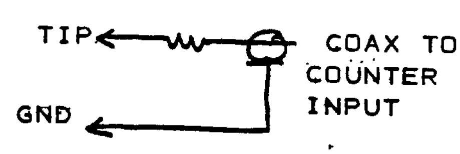
For Low Frequency Measurement (less than 20KHz):

Low frequency measurements are usually upset by excessive noise riding on the input signal, ground loops or ringing. Even though you may feel the signal is very "clean", the counter can count up to VHF and noises or ringing will be counted. The use of a low pass filter will prevent any high frequency noise or ringing being presented to the counter input. Preventing a ground loop is not quite as easy as using a different probe. Generally, providing a ground path other than the probe's ground will solve the problem. Two simple low pass probes are shown below:

LOW PASS PROBES



2 POLE FILTER



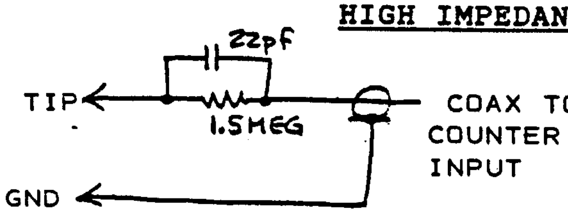
1 POLE FILTER

Coax may be RG-58 or RG-174 3 - 8 feet in length.

For General Use (20KHz to 60MHz):

The majority of signal measurements are usually within this range. Ringing and noise are the chief culprits in measurement. The only way to counteract these undesirables is to damp the ringing and/or attenuate the noise (along with the signal too, unfortunately). A simple x10 scope probe works well to attenuate noise as well as providing a less loading probe. If the noise is at a 10mv level and signal at 1v, the x10 probe will reduce the noise to 1mv and the signal to 100mv, thus noise is out of the counter's sensitivity range while the desired signal is not. The x10 probe (or high impedance probe) will generally damp out ringing. Another benefit of the high impedance probe is that it does not load the circuit being measured by the input cable's capacitance. This is especially important when measuring oscillators or amplifiers. A simple high impedance probe is shown below:

HIGH IMPEDANCE PROBE



ATTENUATION ≈ 3db

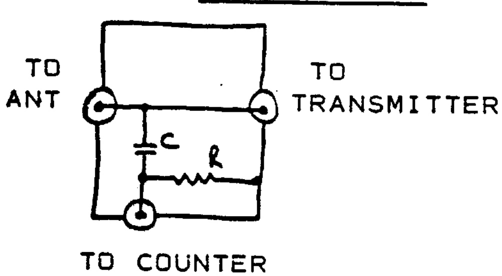
FLATNESS ≈ -3db @ 30MHz

LOADING ≈ 15pf

For Direct Transmitter Measurement:

Measuring a transmitter requires coupling enough transmitter energy into the counter for a stable count and not so much as to exceed the counter's safe input. For VHF work, a small 18" whip antenna will generally pick up a transmitter from 5 to 10 feet away. Direct connection to the transmitter can be made via a coupling box or pick up loop. The pick up loop is simply a few turns of wire wrapped around the transmitter's antenna coax and fed to the counter. The coupling box requires breaking into the transmitter's antenna coax. See schematic below:

COUPLING BOX

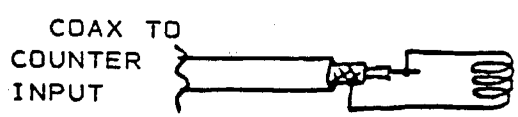


MOUNT 3 COAX CONNECTORS IN A SMALL METAL MINI-BOX. THIS INSURES SHIELDING

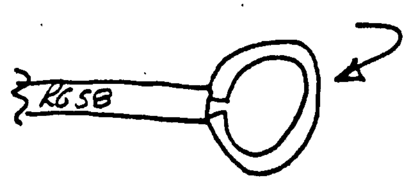
FOR: 2 - 50MHz C=10pf R=51Ω

50 - 450MHz C=2pf R=51Ω

SNIFFER LOOP

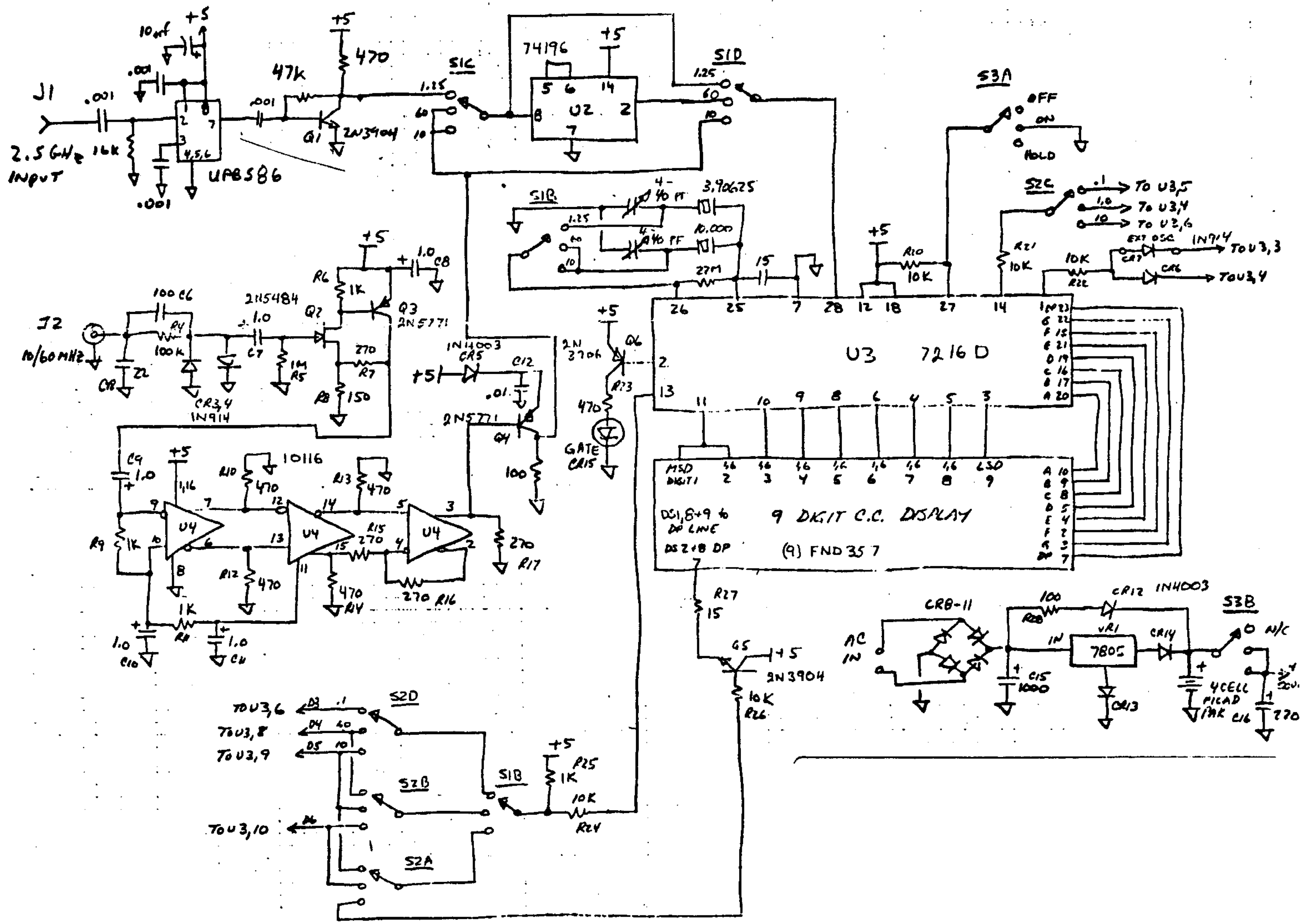


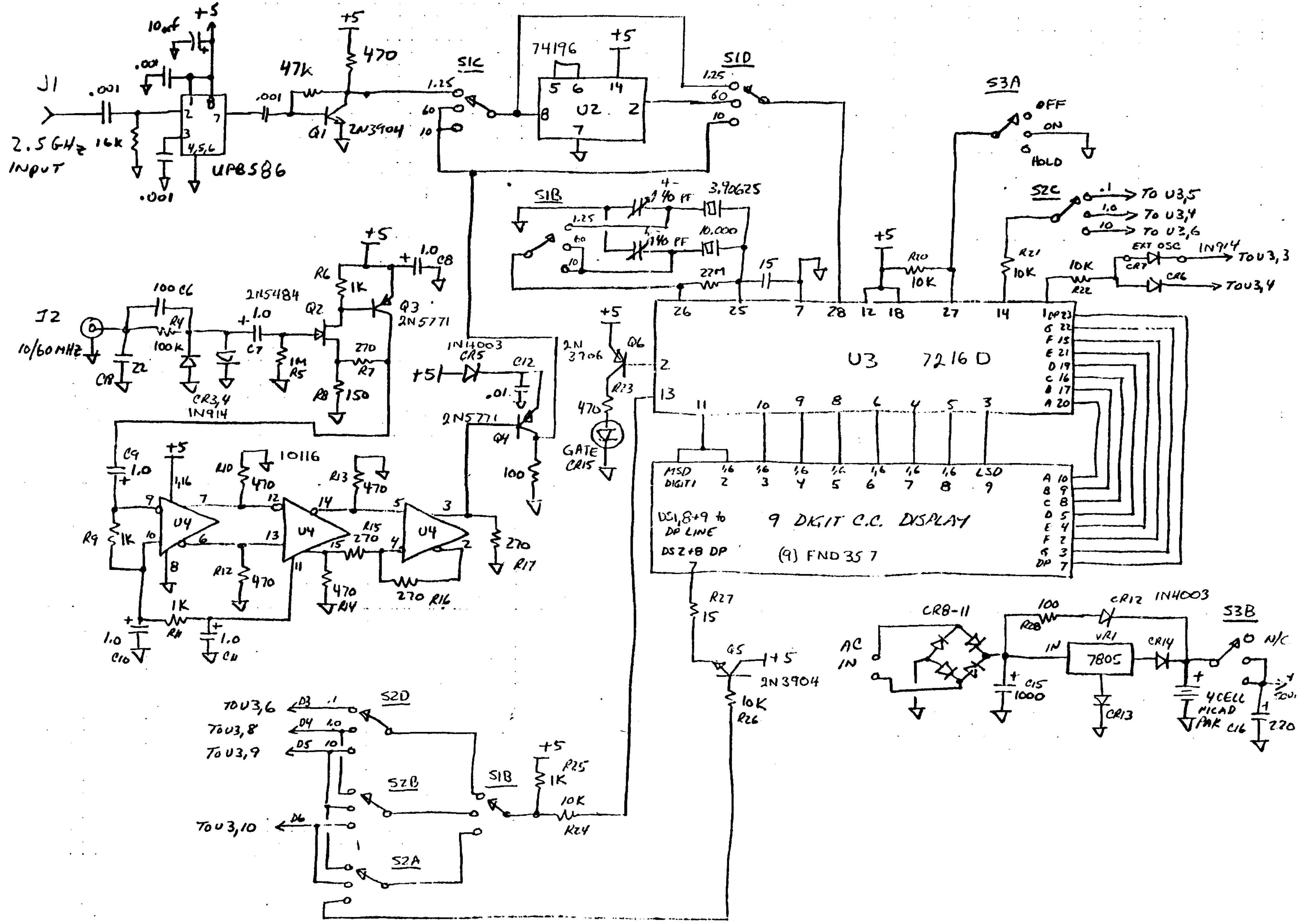
COIL IS ABOUT 3 TURNS OF #22 WIRE ON 1/2 INCH DIAMETER. ENCLOSE WIRE AND CABLE IN SHRINK TUBING FOR A NEAT FINISHED LOOK



For Counting UHF and Microwave Frequencies:

The CT uses the UPB565 prescaler. This device is very sensitive and can be damaged by excessive input levels. To avoid damaging this part, it is best to keep the maximum input level below 300mv (2 milliwatts). Exceeding this level can cause error in the displayed frequency or damage to the prescaler.




J1
2.5 GHz INPUT
.001
16K
UPB586
10uf
+5
47K
470
Q1
2N3904
S1C
1.25
60
10
74196
U2
S1D
S3A
OFF
ON
HOLD
S1B
4-140 PF
3.90625
10.000
22M
15
S2C
TO U3,5
TO U3,4
TO U3,6
EXT OSC
1N914
TO U3,3
TO U3,4
R10
10K
R21
R22
J2
10/60 MHZ
100 C6
R4
100K
CR3,4
1N914
C7
1.0
1M
R5
2N5484
Q2
R6
1K
Q3
2N5771
C8
270
R7
R8
150
1N4003
CR5
C12
.01
2N5771
Q4
100
2N 3706
Q6
R23
470
GATE
CR15
U3
7216 D
MSD DIGIT 1
LSD
9 DIGIT C.C. DISPLAY
(9) FND 357
DS1,8+9 to DP LINE
DS 2+8 DP
C9
10116
U4
R9
R10
R12
R13
R15
R16
R17
R14
R11
1.0
C10
C11
R27
Q5
2N3904
R26
R25
R24
S2D
S2B
S2A
TO U3,6
TO U3,8
TO U3,9
TO U3,10
D3
D4
D5
D6
CR8-11
AC IN
C15
1000
R28
CR12
1N4003
VR1
7805
IN
CR13
CR14
S3B
N/C
4 CELL NICAD PAK
C16
220