

MODEL FR-4

FREQUENCY READOUT/COUNTER

**operation • maintenance
manual**

SPECIFICATIONS

FREQUENCY RANGE (RF INPUT): 50 KHZ to 50 MHZ

SENSITIVITY: Better than 100mv-RMS

INPUT IMPEDANCE: 1.0 Megohm in parallel with no greater than 35 pf.

TIME BASE FREQUENCY: 3.579600 MHz

TIME BASE TEMPERATURE STABILITY: ± 5 ppm, maximum in 20-30°C ambient

TIME BASE SETABILITY: ± 2 ppm

GATE INTERVAL: 100 msec.

DISPLAY SCHEME: Non-Flicker - Last Count Held in Memory

DISPLAY FORMAT: Six - 7-segment LED Readouts. LSD is 100 Hz.

POWER REQUIREMENTS: 105-130VAC, 60Hz or 12VDC with user supplied dropping resistor.

DIMENSIONS: 2-3/8H x 8-3/4D x 5W including feet.

CONTROLS: One three position switch OFF, COUNTER, READOUT (On back panel).

- a) COUNTER - unit performs as a standard frequency counter
- b) READOUT - unit corrects input for local oscillator offset and displays T/R frequency.

CONNECTORS: One RCA phono input (on back panel).

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1.0 General Description

The model FR-4 readout/counter was designed as a companion frequency readout for amateur equipment manufactured by R. L. Drake Company. Specifically, it is intended to interface directly with receivers R4, R4A, R4B, R4C; and transmitters T4, T4-X, T4-XB, T4-XC. With slight modification it will provide direct transmit and receive frequency readout with all Drake transceivers subject to limitations on the 80 meter band (see Section 5.2). Section 5.3 of this manual also provides information on use of the FR-4 with receivers and transmitters other than those manufactured by Drake.

In addition to use as a frequency readout, the model FR-4 is a high quality standard frequency counter when the switch on the back panel is set to the COUNTER position. In this mode, the FR-4 will count frequencies up to 50 MHz to the nearest 100 Hz. The addition of a prescaler permits the unit to go up to 500 MHz.

While intended primarily for use at a fixed station the FR-4 readout/counter can be operated on mobile or portable power since it utilizes a high accuracy crystal controlled time base.

2.0 Installation

2.1 Unpacking

The FR-4 should be carefully unpacked as soon as it is received. It is imperative that you report any damage immediately to the carrier who delivered it. Be sure to state the full extent of any damage.

2.2 Location

The FR-4 will provide many years of dependable service in almost any location or position. It is important, however, that the vent holes on the top and bottom not be blocked. DO NOT REMOVE THE FEET since air must be able to circulate freely across and up through the bottom.

2.3 Connection to R. L. Drake receivers and transmitters.

All of the Drake units for which the FR-4 is directly applicable provide direct access to the receive local oscillator or transmit oscillator via a phono connector on the chassis labeled INJ. Installation of the unit requires only that a cable be run from this INJ connector to the input connector on the FR-4. If the INJ connector on your unit is in use, it will be necessary to connect a "Y" adapter such as a Switchcraft No. 330FP1 or 330F1P1 between the unit and the remote accessory before connecting the FR-4. Figure 1 shows a typical installation using the R. L. Drake R-4B and T4-X.

Note: The INJ outputs on Drake units are reasonably high r.f. impedances and should not be heavily loaded. The high input impedance of the FR-4 is designed to be compatible, but not if excessively long cables are used. For this reason it is recommended that your FR-4 be located as close as possible to the rig such that short cables can be used.

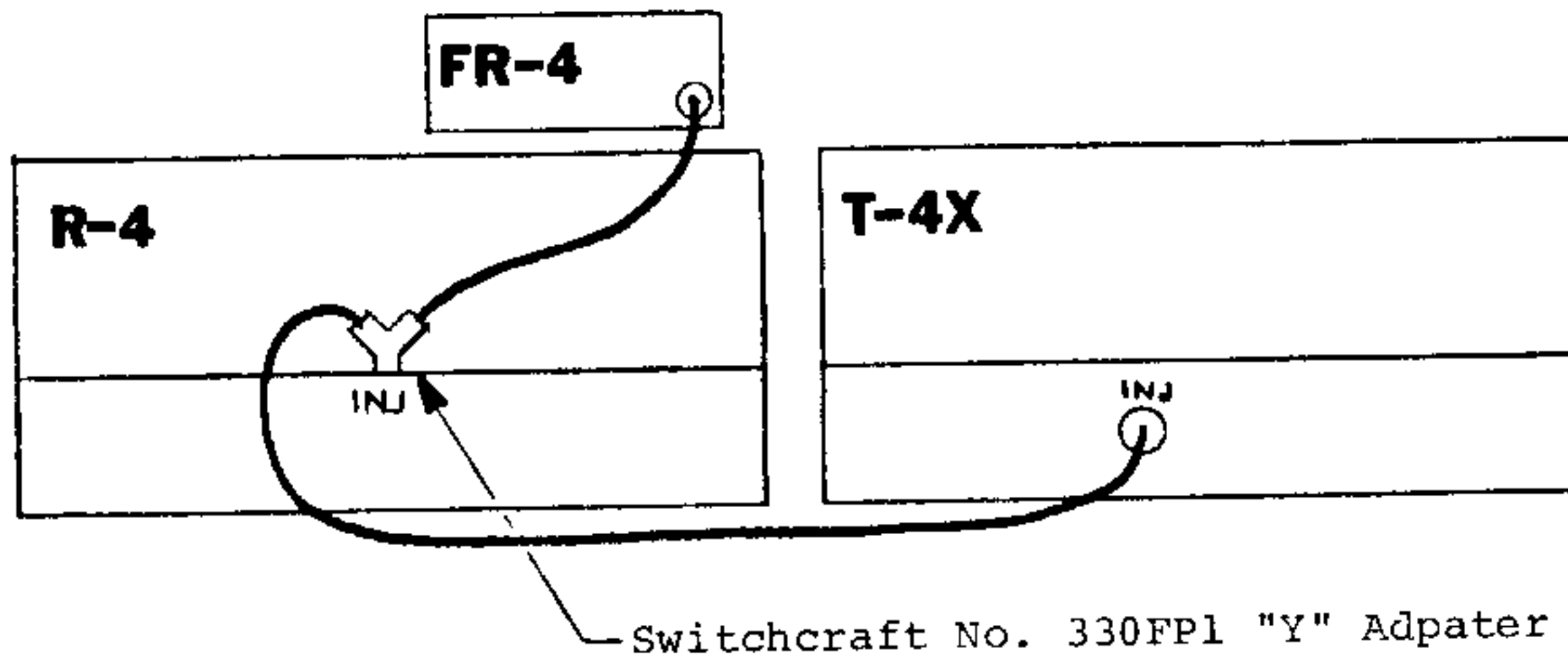


Figure 1 - Typical FR-4 Installation

2.4 Grounding

Since the FR-4 is a sensitive broadband frequency counter, it will respond to low level signals on its input. For this reason it is imperative that it be used with a properly grounded station set-up if it is to be unaffected by the r.f. field of the transmitter. If your FR-4 reading jumps while you are transmitting, a faulty ground system is likely.

3.0 Operation

3.1 As a frequency readout

Once connected to your station, whether it be a transceiver or separate transmitter and receiver, the FR-4 readout must be switched to the READOUT position utilizing the MODE switch on the back panel. This will apply power to the circuitry and cause the LED indicators to light. If your rig is not on, the readout will indicate 94.355. This is its internal conversion number. Once the rig is turned and properly adjusted for the band of interest the readout will immediately indicate the transmit or receive frequency.

When the FR-4 is used with a separate transmitter and receiver its reading will be based on the signal in the cable connecting the two units (the injection cable). For this reason it will display both transmit and receive frequency when either the transmitter or receiver PTO is in control. When the mode switch is set to SEPARATE, however, it will read only the receive frequency. This, of course, is not a concern to the user since he can check his transmitting frequency by switching the mode switch to XMTR temporarily.

3.2 As a frequency counter

Your FR-4 is an excellent general purpose frequency counter when the MODE switch is set to the COUNTER position. Since it has very high input impedance, it can be connected to most any point in a circuit under test. Caution should be exercised to prevent high R. F. voltages from entering the unit. The unit should never be connected directly to the R. F. output of a transmitter under test. Oftentimes a small loop of wire will pick up enough energy to cause the unit to operate when checking a source of high RF power.

4.0 Theory of Operation

As indicated by the schematic diagram, Figure 2, your FR-4 consists of four major sub-circuits. Each of these sections', the signal conditioner, the time base, the six decade counter, and the power supply; will be covered in the following paragraphs.

4.1 Signal conditioner

Signals to be processed by the FR-4 are first amplified by FET Q_2 to enhance the sensitivity of the unit and to provide a high input impedance. This amplified signal is then applied to the base of Q_3 , a saturated high speed switching transistor. Since Q_3 is normally saturated, the amplified input signal need only be of sufficient amplitude to drive Q_3 out of conduction. This causes the collector of Q_3 to switch from ground to the positive supply at a rate equal to the input frequency.

The digital waveform generated by Q_3 is then applied to the input of U_3 where it is divided by 10. The conditioned input signal is therefore a pulse waveform whose period is ten times the period of the input frequency.

4.2 Time base

Integrated circuit, U_{22} is a combination crystal oscillator and divide by 59,660. This mask programmable device provides a precise 16.667 msec. waveform which is further processed by transistor stage Q_1 to provide sufficient digital drive to U_1 . U_1 is a divide by 12 circuit which produces a 200 msec. square waveform on pin 8, the GATE signal. The trailing edge of this signal is coupled with an RC network

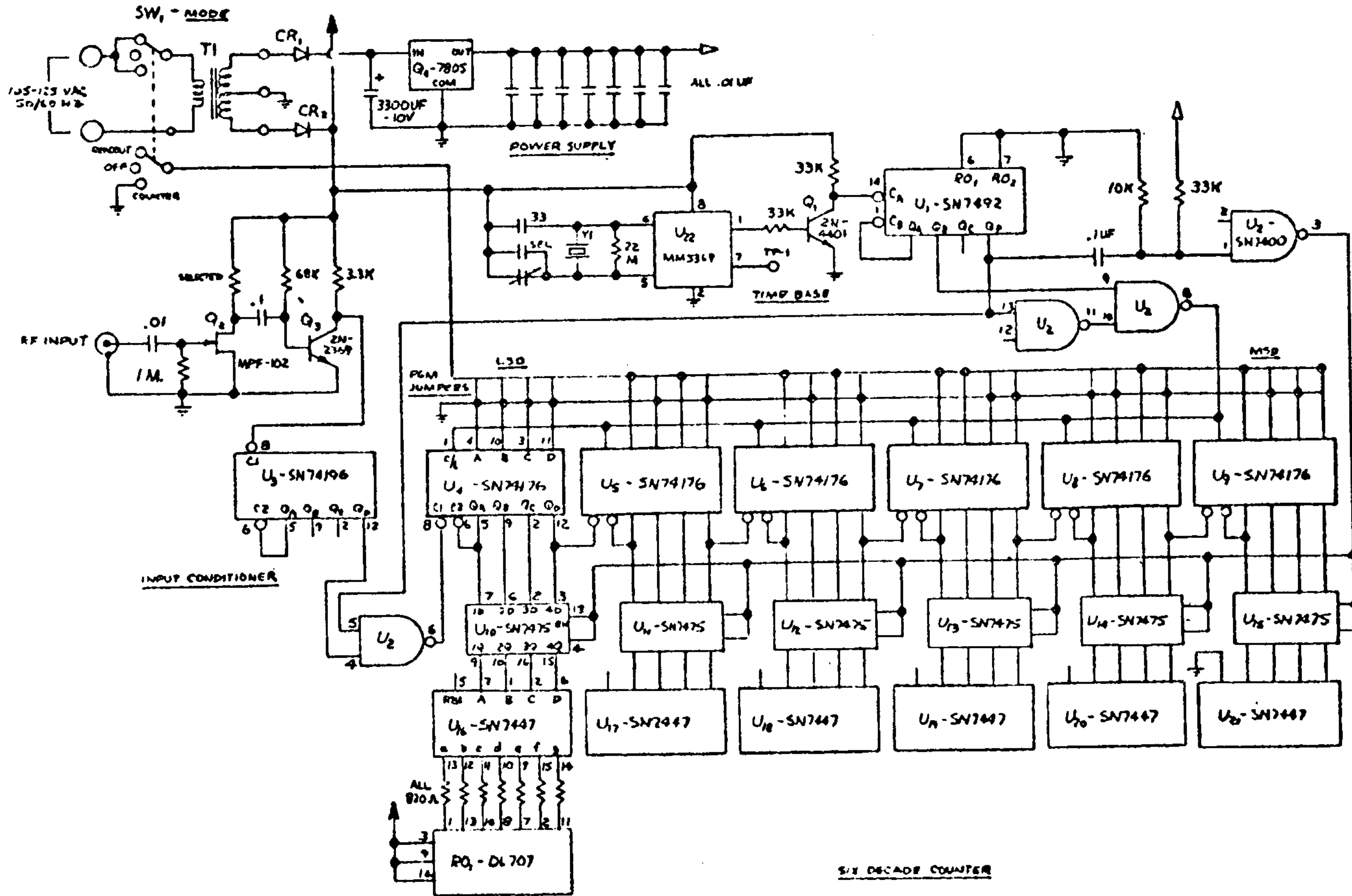


FIGURE 2 - FR-4 CIRCUITRY

4.2 Time Base (Cont'd)

to U₂ where it is inverted and emerges as a low impedance narrow pulse in sync with the end of the GATE interval. This signal is called the MEMORY STROBE.

The signal entering U₂ pin 13 is inverted and applied to pin 10 of the same integrated circuit. When ANDed with the wave form on U₁ pin 11, an output is produced on pin 8 which goes low after the GATE AND MEMORY STROBE and returns to its normal high state before the GATE occurs at the beginning of another cycle. The signal is the PRESET signal for the counter.

4.3 Six decade counter

All of the remaining integrated circuits are utilized in the six decade counter. In fact, one section of U₂ is also involved to gate the signal into the counter at the proper time. The processed input signal from U₃ is combined with the GATE signal from the time base to provide periodic, precise 100 msec. samples of the input to the first decade counter U₄. Each time U₄ counts ten pulses on its input, U₅ pulses the third counter, etc. This process continues until the 100 msec. GATE interval is over. When the gate has closed, each counter will remember the number of pulses it counted and present them on its outputs as a binary number.

The next row of integrated circuits U₁₀ through U₁₅ serve as a second memory for each of the counters. This is necessary to permit the readouts to continue displaying while the counters are cleared for the next count cycle. The

4.3 Six decade counter (cont'd)

MEMORY STROBE signal from the time base causes these auxiliary memories to read and store the binary number presented to them by the counters.

These binary numbers are fed next to integrated circuits U16 through U21, where they are decoded into seven lines for each of the seven segments of the digital readouts RO₁, through RO₆. Thus each readout displays the number of pulses counted by its respective counter on the last count.

In the normal COUNTER position of the FR-4, the PRESET signal from the time base causes all of the counter circuits to go to zero. Since this signal occurs before the GATE interval, the counters always begin with zero and count up. Once they have stopped counting, the MEMORY STROBE presents the count to the readouts before the counters are cleared.

When counting the local oscillator of a radio receiver, however, it is necessary to correct the counter for the offset between the local oscillator and the received signal. This offset, of course, must be equal to the IF frequency of the receiver. In the case of the applicable R.L. Drake units, the IF frequency is 5.645 MHz. If a correction were not made for this offset, the readouts would display a frequency 5.645 MHz too high.

Rather than mathematically subtracting 56,450 from the decade counters, the FR-4 corrects the reading by starting the counters that number of pulses below zero. In other words, when the MODE switch is set to the READOUT position,

4.3 Six decade counter (cont'd)

the first 56,450 pulse to enter the six decade counter merely serve to clock it up to zero. In fact, when in the READOUT mode, the PRESET signal actually causes the number 943,550 to be set into the counters.

4.4 Power supply

The power supply section of the FR-4 is a conventional full wave center-tapped design. Unregulated d.c. between 7 and 9 volts is present on the positive end of C₁. This voltage powers the LED readouts, the time base and the input circuitry. The regulator, Q₄, provides 5 volts at very low ripple for all of the integrated circuits. It is normal for this regulator to be warm to the touch since it can dissipate up to 2.5 Watts in this configuration.

5.0 Conversion to other offset frequencies

The offset frequency programmed in your FR-4 when shipped is 5.645 MHz. This frequency, however, can be easily re-programmed since jumpers are provided for the purpose.

5.1 Re-programming the FR-4

Re-programming the FR-4 consists of moving the program jumpers on the counter IC's. This, in effect, changes the number which is added to or subtracted from the frequency measured by the counter. This digital mathematics is accomplished by either starting the counter below zero by the number of

5.1 Re-programming the FR-4 (cont'd)

counts to be subtracted or above zero if addition is to be performed. A step-by-step procedure is shown below:

1. Express the receiver first i.f. frequency in MHz and move the decimal point four places to the right.
EXAMPLE: 9.0 MHz becomes 90,000
2. If your receiver's local oscillator frequency is below the received station the number obtained in step 1 is the OFFSET NUMBER. If the local oscillator in your receiver runs above the receive frequency you must subtract the number obtained in step 1 from 1,000,000.
EXAMPLE: 9.0 MHz i.f., local osc. above station
 $1,000,000 - 90,000 = 910,000$
3. Program the number derived in step 2 as shown by Figure 3.
EXAMPLE: To program 910,000, program 9 in U₉, 1 in U₈ and 0 in U₄ through U₇ as shown. When completed, all i.c.'s should have pins 4, 10, 3, and 11 grounded except pins 4 and 11 on U₉ and pin 4 on U₈ which should go to the mode switch.

5.2 Use with Drake transceivers

The frequency scheme utilized in Drake transceivers is radically different than in the separate transmitters and receivers. The most significant problem for the FR-4 owner is the fact the local oscillator tunes backward on the 80 meter band only.

FIGURE 3 - PROGRAMMING THE FR-4

U ₄ to U ₉ PGM JUMPERS				
NO. TO BE PROGRAMMED	PIN 4	PIN 10	PIN 3	PIN 11
0	G	G	G	G
1	S	G	G	G
2	G	S	G	G
3	S	S	G	G
4	G	G	S	G
5	S	G	S	G
6	G	S	S	G
7	S	S	S	G
8	G	G	G	S
9	S	G	G	S

U ₄ to U ₉ WEIGHTS	
DIGIT WEIGHT	I.C. NUMBER
10 ⁰	U ₄
10 ¹	U ₅
10 ²	U ₆
10 ³	U ₇
10 ⁴	U ₈
10 ⁵	U ₉

Hook G to ground and S to MODE switch

EXAMPLE: To program an offset of 9.0 Mhz

1. Divide 9,000,000 by 100 to get 90,000.
2. Subtract this from 1,000,000.

$$\begin{array}{r} 1,000,000 \\ - 90,000 \\ \hline \end{array}$$

3. According to tables, program 9 in U₉, 1 in U₈ and 0 in U₄ through U₇

5.2 Use with Drake transceivers (cont'd)

This means that when the unit is re-programmed the user will have to subtract the reading from 100 MHz to get the actual frequency.

The second concern when re-programming the FR-4 for use with a transceiver is the fact that the 20 meter injection frequency is 9.0 MHz below the receiving frequency while all other bands use an injection frequency 9.0 MHz above the received station. This means that one offset must be programmed for the 10, 15, and 40 meter bands and a second offset utilized for 20 meters. These offsets can then be selected with the READOUT/COUNTER switch on the back panel.

Applying the information in the previous section (5.1) of this manual provides for the two required OFFSET NUMBERS. For the 10, 15, and 40 meter bands where the injection frequency is above the received station by 9.0 MHz, the OFFSET NUMBER is 910,000. For 20 meters only, this number becomes 90,000.

In re-programming for the transceiver it will be noted that the last four digits are 0000 in both numbers. In other words, the program pins for i.c.'s U₄ through U₇ should all be grounded.

Counter U₈ must be switchable between the number 9 and 1 by the mode switch. This means that pin 4 must never be grounded and that pin 11 must go to ground for 910,000 (10, 15, and 20). This can be accomplished by hooking U₈ pin 11 to the unused

5.2 Use with Drake transceivers (cont'd)

terminal on the mode switch and removing the jumper on pin 4 so that it floats high. Pin 3 on U_g must now go to ground.

This change in programming is easily accomplished by following the procedure below:

1. Cut the jumper between U_g pin 3 and U₉ pin 11.
2. Ground U_g pin 3.
3. Cut the ground jumper on U_g pin 4.
4. Remove wire coming from mode switch at program bus end and reconnect it to U₉ pin 4.
5. Add a wire from U_g pin 11 to the unused terminal on the mode switch.

Adding the required connector to your transceiver is done by the following steps:

1. Remove the bottom cover.
2. Connect the center conductor of a shielded cable with a suitable connector (such as a Switchcraft 25AF84) to pin 8 of tube V3a.
3. Select a nearby chassis ground for the shield.
4. Replace the bottom cover with the added cable passing through the rectangular remote VFO connector hole.
5. Connect the FR-4 to this new connector.

5.3 Use with other amateur or communications receivers

The FR-4 can be readily programmed to operate with any receiver which utilizes a non-inverted local oscillator within the frequency and amplitude limits of the unit. (See SPECIFICATIONS) That is, if your receiver's local oscillator increases in frequency as you tune to stations operating on higher frequencies, and if the oscillator is never greater than 50 MHz and of sufficient amplitude, the FR-4 will work. Since the input impedance of the FR-4 is so high and 100 mv. RMS is sufficient, there are only a few receivers not compatible with the FR-4 once the proper offset frequency is programmed.

6.0 Calibration

When shipped from the factory your FR-4 has been adjusted to within ± 2 ppm. For most amateur applications, this is sufficiently accurate, and should not change significantly with time. If, however, you wish to calibrate the unit, there are two easy methods available.

If you have a frequency counter of known accuracy, you can adjust the FR-4 time base by connecting the counter to TP-1 in Figure 4. Adjust the FREQ. CAL. control for a reading of 3.579600 MHz. Do not adjust it to the frequency printed on the crystal.

If you do not have a counter, it is a simple matter to tune your receiver to a broadcast station whose frequency is known. Of course, WWV or CHU are excellent if you can tune them. Once the station is precisely centered in your most selective filter, adjust the FR-4 FREQ. CAL. to make the reading agree with the assigned frequency of the station.

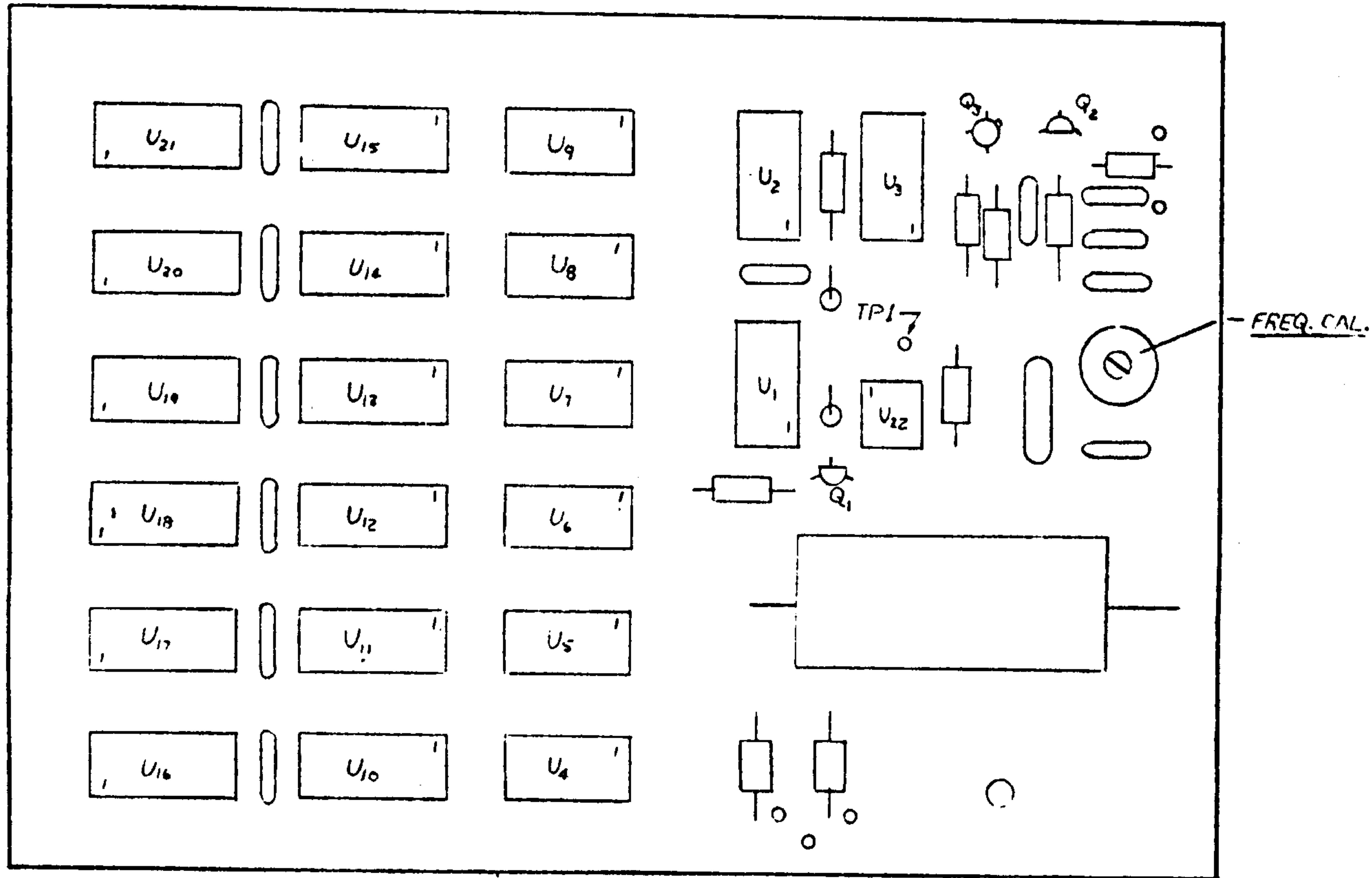


Figure 4 - Calibration Test Point and Control Location