

MODEL FR-4tr
FREQUENCY READOUT

operation • maintenance manual

**MODEL FR-4tr
FREQUENCY READOUT**

**e-tek
1028 Greene Street
Marietta, OH 45750
1-614-374-2280**

WARRANTY

Dear Customer:

Good performance is what you expect when you buy products from e-tek. We, too, are concerned about performance. That's why we offer the following 90 day warranty.

The warranty period starts one week after your equipment is shipped from the factory (or authorized distributor). This provides for ample shipping time so that the warranty will go into effect at approximately the same time you receive your unit.

During the warranty period, all component parts proven to be defective in materials or workmanship will be repaired or replaced at our expense, labor included. Please understand, however, that you must have a return authorization number from the factory before returning any equipment for service, and that you must pay for shipping to our repair service. In addition, a written description of the problem should be included to assure optimum service.

Naturally, our warranty cannot cover damage due to accidents, fires, floods, misuse, or acts of God.

A word on installation and operation. Please be sure to follow this manual carefully when installing and operating your unit. Oftentimes service problems can be avoided if the instructions are carefully observed.

We encourage you to keep this warranty explanation. You may never need it, but it's nice to know the protection is there.

Sincerely,

In order to validate your warranty, please fill out the registration form below and mail it to:

e-tak
1028 Greene Street
Marietta, Ohio 45750

NAME _____
STREET _____
CITY _____
STATE _____ ZIP _____
UNIT SERIAL NUMBER _____
DATE OF PURCHASE _____
COMMENTS:
FR4-tr

1.0 General Description

The model FR-4tr Readout was designed as a companion frequency readout for amateur radio equipment manufactured by R. L. Drake Company. Specifically, it is intended to interface directly with the TR-3, TR-4, TR-4C and TR-4CW series of transceivers. When interconnected with any of these units, the FR-4tr will provide both transmit and receive frequency displays, even on units with RIT.

While intended primarily for use at a fixed station, the FR-4tr Readout can be operated from mobile or portable power on all except the 10 meter band, since it utilizes a high accuracy crystal controlled time base.

2.0 Installation

2.1 Unpacking

The FR-4tr 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-4tr will provide years of dependable service in most 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 around the unit. We do not advise extending the cables supplied.

2.3 Connection to R. L. Drake transceivers

The following step-by-step procedure details the simple installation of the FR-4tr. While the attachment of the readout could be abbreviated further, full attention to the details will result in a reliable and professional looking modification to your rig which could easily be removed in the future.

1. Place a soft cloth over your workbench top and turn your transceiver upside down with the controls facing you (See Figure 1).
2. Remove the six black screws fastening the bottom to the unit and remove the bottom.
3. Locate the interface cable kit supplied with the FR-4tr and note that the end opposite the connector end consists of two cables, one longer than the other, held together with a white plastic anchor.

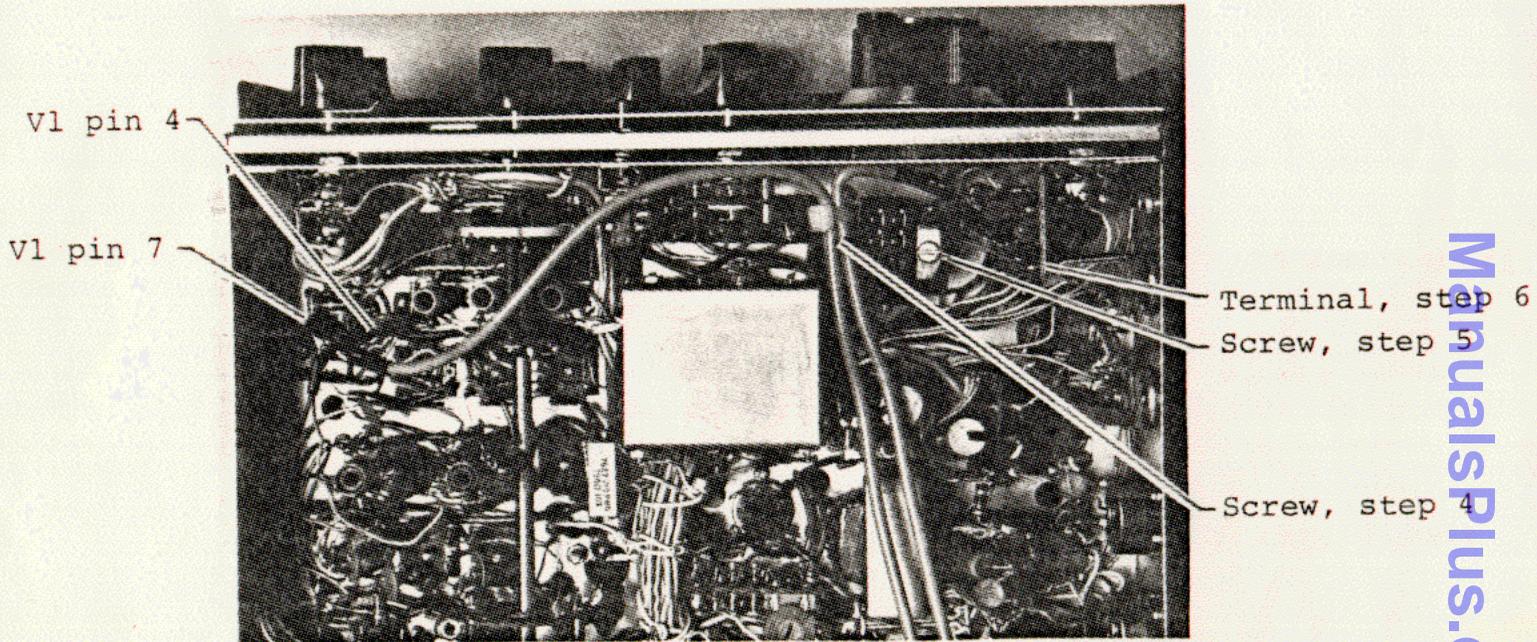


FIGURE 1 - Bottom of typical transceiver (TR-4cw)

4. Remove the long screw from the right of the VFO, ACCESSORY JACK in the transceiver, insert it through the plastic anchor and replace it. Dress the cables as shown in Figure 1 before tightening the screw.
5. Remove the long screw from the left of the VFO, ACCESSORY JACK, insert it through the ground lug on the short cable and replace the screw.
6. Locate the vertical circuit board just to the left of the VFO ACCESSORY JACK and solder the remaining wire from the short cable to the terminal which is connected to PIN 6 of that jack.
7. Now route the longer of the two cables as shown in the figure to tube V1. Solder the ground braid to pin 4 and the remaining wire to pin 7.
8. Insert the phono plugs through the rectangular cutout in the transceiver bottom and replace the six black screws.
9. Locate the transceiver in its normal operating position and place the FR-4tr within the cable length. Note that most users place the FR-4tr on top of the transceiver and route the cables across the bottom and up the back of the rig.
10. Plug the phono plug with the black band into the FR-4tr jack furthest from the line cord, and connect the remaining cable to the unused jack.

11. Connect the FR-4tr to a source of 105-130 VAC power and your installation is complete.

2.4 Grounding

Since the FR-4tr 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. Toward this end, the FR-4tr has been supplied with a ground post in the lower center of the back panel. If your frequency reading jumps during transmit, improper grounding is likely.

3.0 Operation

Once connected to your transceiver as indicated above, the FR-4tr is ready to read out frequency. After applying power to the transceiver and to the readout by placing the POWER switch in the up position, set the three position BAND switch in the proper position as indicated below:

<u>BAND</u>	<u>SWITCH POSITION</u>
10 m	Norm
15 m	Norm
20 m	20
40 m	Norm
80 m	80

Note that the readout will display a meaningless internal conversion number when the transceiver is off or until it warms up.

4.0 Theory of Operation

As indicated by the schematic diagram, Figure 2, your FR-4tr consists of four major sub-circuits. Each of these sections, the signal conditioners, time base, six decade counter and power supply will be discussed individually after a short section on the total system.

4.1 General

R. L. Drake transceivers utilize three distinct frequency mixing schemes in producing the desired transmit and receive signals. The particular mixing approach used at any given time is based on the amateur band selected. Each of these mixing arrangements will be discussed separately below:

1	U1	SN74196N	50MHz Presettable BCD Counter
2	U2	SN74176N	35MHz Presettable BCD Counter
3	U3	MM5369	Oscillator/Divider
4	U4	MC14518BP	CMOS Dual Up-Counters
5	U5	CD4011BE	CMOS Quad NAND Gate
6	U6	CD4011BE	CMOS Quad NAND Gate
7	U7	MC14510BP	CMOS Up/Down Counter
8	U8	MC14510BP	CMOS Up/Down Counter
9	U9	MC14510BP	CMOS Up/Down Counter
10	U10	MC14510BP	CMOS Up/Down Counter
11	U11	MC14510BP	CMOS Up/Down Counter
12	U12	CD4001BE	CMOS Quad NOR Gate
13	U13	CD4511AE	CMOS Latch/Decoder/Driver
14	U14	CD4511AE	CMOS Latch/Decoder/Driver
15	U15	CD4511AE	CMOS Latch/Decoder/Driver
16	U16	CD4511AE	CMOS Latch/Decoder/Driver
17	U17	CD4511AE	CMOS Latch/Decoder/Driver
18	U18	CD4511AE	CMOS Latch/Decoder/Driver
19	R01	DL-702	7 Segment LED Readout
20	R02	DL-702	7 Segment LED Readout
21	R03	DL-702	7 Segment LED Readout
22	R04	DL-702	7 Segment LED Readout
23	R05	DL-702	7 Segment LED Readout
24	R06	DL-702	7 Segment LED Readout
25	Q1	2N2369	NPN Transistor
26	Q2	2N2369	NPN Transistor
27	Q3	2N2369	NPN Transistor
28	Q4	2N5485	N Channel JFET
29	Q5	2N4401	NPN GP Transistor
30	Q6	2N4401	NPN GP Transistor
31	Q7	2N2369	NPN Transistor
32	CR1	1N4001	Rectifier, 50V, 1A
33	CR2	1N4001	Rectifier, 50V, 1A
34	CR3	1N4733	Diode, zener, .5.1V.
35	CR4	1N914	Diode, silicon, GP
36	CR5	1N914	Diode, silicon, GP
37	CR6	1N914	Diode, silicon, GP

38	C1	Capacitor, disc, .01UF/25V
39	C2	Capacitor, disc, .01UF/25V
40	C3	Capacitor, disc, .01UF/25V
41	C4	Capacitor, disc, .1UF/25V
42	C5	Capacitor, disc, .01UF/25V
43	C6	Capacitor, disc, .01UF/25V
44	C7	Capacitor, disc, .1UF/25V
45	C8	Capacitor, disc, .001UF/1KV
46	C9	Capacitor, disc, .001UF/1KV
47	C10	Capacitor, disc, 55pf NPO
48	C11	Capacitor, disc, selected
49	C12	Capacitor, variable
50	C13	Capacitor, electrolytic, 4700UF/25V
51	C14	Capacitor, disc, .01UF/25V
52	X1	Crystal, quartz, 3579.545kHz
53	R1	Resistor, $\frac{1}{4}$ W, 10%, 100ohms
54	R2	Resistor, $\frac{1}{4}$ W, 10%, 1000ohms
55	R3	Resistor, $\frac{1}{4}$ W, 10%, 4700ohms
56	R4	Resistor, $\frac{1}{4}$ W, 10%, 470ohms
57	R5	Resistor, $\frac{1}{4}$ W, 10%, 4700ohms
58	R6	Resistor, $\frac{1}{4}$ W, 10%, 33K
59	R7	Resistor, $\frac{1}{4}$ W, 10%, 1000ohms
60	R8	Resistor, $\frac{1}{4}$ W, 10%, 100ohms
61	R9	Resistor, $\frac{1}{4}$ W, 10%, 100ohms
62	R10	Resistor, $\frac{1}{4}$ W, 10%, 1000ohms
63	R11	Resistor, $\frac{1}{4}$ W, 10%, 68K
64	R12	Resistor, $\frac{1}{4}$ W, 10%, 3300ohms
65	R13	Resistor, $\frac{1}{4}$ W, 10%, 1 M
66	R14	Resistor, $\frac{1}{4}$ W, 10%, 4700ohms
67	R15	Resistor, $\frac{1}{4}$ W, 10%, 4700ohms
68	R16	Resistor, $\frac{1}{4}$ W, 10%, 33K
69	R17	Resistor, $\frac{1}{4}$ W, 10%, 47K
70	R18	Resistor, $\frac{1}{2}$ W, 10%, 22 M
71	R19	Resistor, $\frac{1}{4}$ W, 10%, 1000ohms
72	R20	Resistor, $\frac{1}{4}$ W, 10%, 47K
73	R21	Resistor, $\frac{1}{4}$ W, 10%, 47K
74	R22	Resistor, $\frac{1}{4}$ W, 10%, 47K
75	R25	Resistor, 2W, 10%, 82ohms
76	R26-69	Resistor, $\frac{1}{4}$ W, 10%, 1500ohms

80 Meters - The transmit or receive frequency is simply the difference between 9.0 MHz (the receive i.f. and/or the transmit oscillator) and the PTO, since the crystal oscillator portion of the pre-mixer system is not used. Therefore, operation at the low end of the band corresponds to the high end of the PTO. As an example, the PTO would be at 5.5 MHz for operation at 3.5 MHz. ($9.0 - 5.5 = 3.5$).

20 Meters - The transmit or receive frequency is the sum of 9.0 MHz and the PTO. As in the case of 80 M operation, the crystal oscillation is not used. In this situation, however, operation at the high end of the band corresponds to the highest PTO frequency. As an example, the PTO frequency would be 5.5 MHz for operation on 14.5 MHz. ($9.0 + 5.5 = 14.5$)

10, 15, and 40 Meters - The transmit or receive frequency is derived by first subtracting the PTO from the crystal oscillator and then subtracting 9.0 MHz from that result. As in the case of 80 M operation, the PTO will be at its high frequency end for operation at the low end of the band. Note that the crystal frequencies used are 21.5 MHz (40 M), 35.5 MHz (15 M) and 42.5, 43.0, 43.6 MHz (10 M). As an example, operation at 21.5 MHz would utilize the 35.5 MHz crystal and the PTO at 5.0 MHz. ($35.5 - 5.0 = 30.5$), ($30.5 - 9.0 = 21.5$)

These frequency generation characteristics are the key to the design theory of the FR-4tr. Just as your transceiver operates in three different modes based on bands, so too does the readout unit. The following three paragraphs detail the operation of the FR-4tr.

- 80 Meters - Load 090000 into counter, gate the PTO signal divided by 10 into the counter for 100 msec with the counter set to count down. As an example, operation at 3.746 MHz (PTO at 5.254) would be equivalent to 52,540 counts down from a starting point of 90,000 for a difference of 37,460 counts, which when gated to the display and latched would read 3.7460 MHz.
- 20 Meters - Load 090000 into counter, gate the PTO signal divided by 10 into the counter for 100 msec with the counter set to count up. As an example, operation at 14.322 MHz (PTO at 5.322 MHz) would be equivalent to 53,220 counts up from a starting point of 90,000 for a sum of 143,220 counts, which when gated to the display and latched would read 14.3220 MHz.
- 10,15, and 40 Meters - Load 910000 into counter, gate the crystal oscillator divided by 10 into the counter for 100 msec with the counter set to count up, wait 100 msec, gate the PTO signal divided by 10 into the counter set to count down. As an example operation at 21.386 MHz (PTO at 5.114 MHz, crystal at 35.5 MHz) would be equivalent to 355,000 counts up from a starting point of 910,000

which after overflowing the counter, would result in 265,000. Gating the PTO signal into the counter set to count down would subtract 51,140 counts from this 265,000 producing a result of 213,860 counts, which when gated to the display and latched would read 21.3860 MHz.

4.2 High Frequency Input Circuit (XTAL. IN)

After a.c. coupling by capacitor C1, signals entering this input are amplified by transistor Q1, before being a.c. coupled by C4 to the base of transistor Q2. Note that diode CR4 clamps the negative level of the amplified signal to 600 mv. Since R4, the collector resistor of Q2 is returned to the +5 volt supply, the output of this stage is a 5 volt high square wave.

Integrated circuit U1, an SN74196 is a TTL divide by 10 when connected as shown. Note that transistor Q3 serves as a means of gating and clearing the counter when a digital high is applied to resistor R6. The output of U1 is therefore a 5 volt digital pulse at one tenth the frequency of the transceiver's premixer crystal oscillator.

4.3 Low Frequency Input Circuit (PTO IN)

FET, Q4 serves to increase the amplitude of the PTO signal before it is coupled via capacitor Q7 to the base of transistor Q5. Transistor Q5, integrated circuit U2 and gating transistor Q6 form an analogous circuit to Q2, U1 and Q3 as discussed in Section 4.2 above. Note that due to its lower frequency of operation, integrated circuit U2 is a SN74176.

- 4.4 Integrated circuit U3 is a combination crystal oscillator and divide by 59,660. This mask programmable device utilizes a 3.579 MHz quartz crystal, X1 in conjunction with fixed capacitors C10, C11 and variable capacitor C12 to generate the basic time base, which is then divided down to produce a precise 60 Hz square wave output.

Gates U5 (pins 1,2,3 and 4,5,6) in conjunction with the first half of U4, provide a digital divide by six pulse waveform for injection into the second half of U4. This 100 msec period on U4-pin 9 is then divided by four in a binary arrangement producing a total counter logic cycle of 400 msec. This 400 msec cycle is subdivided by gates U5, U6 and U12 such that U6-3 is low only from 0 to 100 msec and U6-4 is low between 200 and 300 msec. These signals produce the gating for XTAL IN and PTO IN respectively.

The combination of capacitor C8, resistor R20 and U6 (pins 11,12 and 13) serves to detect the rising edge of the PTO IN gate (300 msec)

and produce a narrow negative giving pulse a U6-11 which is used to latch the data into the readout driver i.c.'s U13 through U18. Note that capacitor C9 and resistor R17 detect the trailing edge of this latch pulse, producing a second, delayed, narrow pulse used to preset each of the counter i.c.'s through U11.

4.5 Modified Six Decade Counter

Transistor Q7 serves to shift the 5 volt TTL output of either U1 or U2 to a 15 volt level for clocking of the CMOS counters. Note that diodes CR5 and CR6 gate the appropriate input counter into the six-decade divider chain.

In operation, pulses entering up-down counter U7 cause it to increment either up or down (depending on the state of pin 10) until its binary outputs are at 9 (1001) when counting up, or 1 (0001) when counting down at which time it passes the next pulse out of its carry out (CO) terminal to the next decade and increments (or decrements) to 0(0000). This process continues such that each counter passes its output to the next one down the line. When the 100 msec counting period is over, pins 2, 14, 11 and 6 on each counter will present, in binary coded decimal (BCD) form, the number of counts it received either up or down, added to or subtracted from its starting point.

Because the FR-4tr is designed to be used with only Drake transceivers, it is possible to eliminate some pulse propagation problems in the counter chain by substituting a gating arrangement for the final (most significant) counter i.c.. This gating matrix generates either a blank, or one, or a two depending on the state of the band switch, and the last actual counter output. Table 2 below indicates the output of this matrix for various input possibilities.

BAND SWITCH	U-11 OUTPUT	BCD INPUT TO U18	MSD
80	3(0011)	1100	Blank
40(Norm)	7(0111)	1100	Blank
20	4(0100)	0001	1
15	1(0001)	0010	2
10	8/9(1000/1001)	0010	2

Counter i.c.'s U2 through U11 are preset by first placing the number to be preset on pins 3, 13, 12 and 4 in BCD data form and then pulsing the PE terminal, pin 1. Since U7 through U11 have all these preset terminals grounded, application of this pulse will cause a 0 to be set up as the starting count. Note that U11, however,

is preset with either a 1(0001) or a 9(1001) depending on the setting of the band switch.

Readout drivers U13 through U18 accept BCD data from the counters through pins 6, 2, 1 and 7. When the LE terminal, pin 5, is high the input data is stored and presented to the decoded/driver via the seven segment outputs. Pin 5, when set low and returned high causes the i.c. to read the input again and latch it. Note that these i.c.'s are designed to blank the readout for binary inputs above 9(1001).

4.6 Power Supply

Primary power at 115 volts is processed by the transformer T1, diodes CR1 and CR 2 and capacitor C13 into approximately 16 volts d.c. power for use by all the CMOS i.c.'s and the six LED readouts. Two watt resistor R25 and zener diode CR3 provide a regulated 5 volt supply for the two TTL high speed counters.

5.0 Calibration

When shipped from the factory, your FR-4tr 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, or if you wish to calibrate out any error which might exist in the crystals or filters of your transceiver, the following procedure is recommended.

First tune in a station of known frequency such as CHU at 7.335 MHz.
Then tune trimmer capacitor C12 for a correct reading on that station.
Figure 3 shows the location of this adjustment.

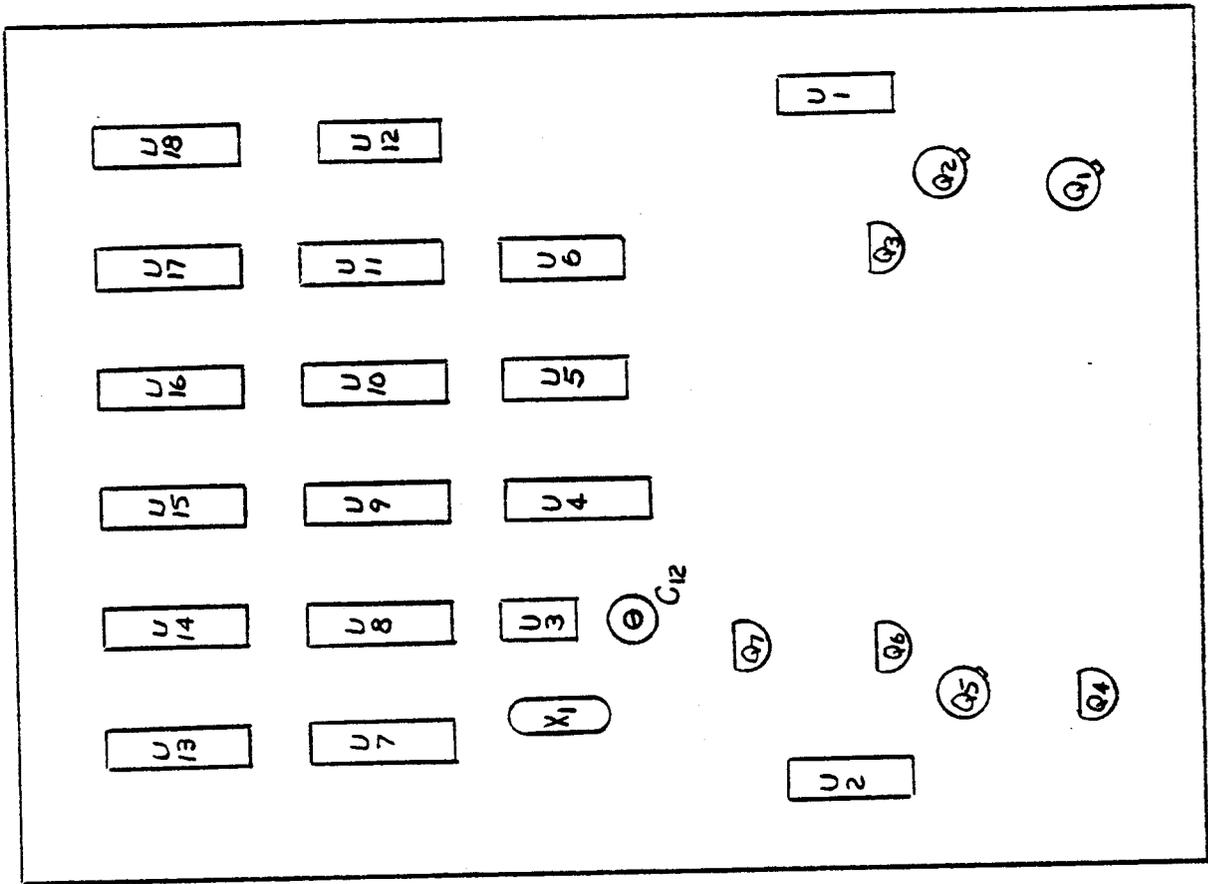


Figure 3 - FR-4tr Parts Layout