DIY KIT 95. 50MHZ 8-DIGIT FREQUENCY METER

This kit is a stand-alone frequency meter capable of measuring repetitive signals up to a frequency of 50MHz. It has two frequency ranges (15 and 50 MHz) as well as two sampling rates (0.1 and 1 second). Output is via an 8-digit LCD display. Nominal input impedance is 1MΩ.

The kit is supplied with a small plastic case complete with a screen-printed front panel. It requires a 9-to-12V DC power supply. A standard plug pack, centre positive, can be used. Current consumption is approximately 175mA. Case dimension: 13 x 7 x 4 cm.

The kit is constructed on two printed circuit boards (PCBs). One is double-sided, through-hole-plated and the other is single-sided. Both PCBs have a component overlay for ease of assembly. Protel Autotrax & Schematic were used to design the boards.

ASSEMBLY INSTRUCTIONS

Follow the component overlay on the PCBs for placement of components. Some components such as the transistors, FET and small signal diodes look the same so identify first them before starting. Take care with the metal film resistors – the color bands are difficult to distinguish. If in doubt use a meter to measure the resistance.

Interface Board

Assembly is straightforward. Start with the lowest height components (resistors, diodes, etc).

Note: There are five (5) links that need to be installed. These should be added **before** the IC sockets. Use the wire offcuts from the resistors as the links. Fix the 5V regulator and heatsink to the PCB using the nut and bolt provided. When inserting diodes D3-6, space them up from the PCB by about 3mm (1/8”). This will help with heat dissipation.

Display Board

The order in which components are fitted is critical. The following order is recommended:

1. Socket strip for the LCD display. Before soldering flip the board over and lay it on the table so that the socket strips are fully seated and vertical.
2. Resistors and diodes.
3. Resistor network RP1. The dot on one end of the body goes where the square is marked on the overlay.
4. The two 40-pin ICs, IC1 & IC2. These are soldered directly to the PCB. **Do not use IC sockets.**
5. The two 14-pin IC sockets for IC3 & IC4. Fit the ICs.
6. Capacitors. Note that the trimcap, C6, is mounted on the solder side of the board. This allows easy access for adjustment later on.
7. Crystal and transistor.
8. Bolt the three (3) 15mm brass spacers to the solder side of the display board. The three holes are located next to the 40-pin ICs.
9. Bolt the four (4) 10mm brass spacers to the component side of the display board. The four holes are located on each of the corners.
10. First identify which way around the LCD display is to be inserted into the socket strips. There is a small “dimple” at one end of the LCD. This end goes to the right side of the board, near where the LEDs will be fitted.
    Be careful when pushing the LCD into the socket strip. Make sure that the pins are all lined up in the holes. You will not be able to push all the pins in at once. Do one row at a time starting at one end. Apply even pressure along the row of pins until they are all in. **Excessive force could damage the LCD.** Keep watching for any pins starting to bend. Repeat for the other row.
11. Next is the LEDs. They have to be spaced up from the board so that they protrude slightly through the front panel. The easiest way to get the correct height is to use the front panel as a guide.
    Fit the LEDs into place but do not solder them in yet. Mount the front panel to the display board on the 10mm spacers and screw into place. Turn the assembly over onto a flat surface so that the front panel is down. Position the LEDs so that they drop through the holes in the front panel and solder them into place.
12. The only thing left to mount are the slide switches. Remove the front panel and insert the switches. Make sure they are sitting down against the PCB and evenly aligned with the overlay before soldering. It may be best to solder just one pin on each switch and then mount the front panel again. Check that the switch levers protrude through the front panel and slide freely without fouling. If all is well then solder the rest of the switch pins.

Putting it all together

Use the wiring diagram on the following page as a guide.

There are four wires that connect the two PCBs together, two power (X3,4) and two signal (X1,2). Cut and strip two pieces of wire 10cm (4”) long. Solder one end of each wire to pins X3 and X4 on the interface board. Cut and strip another two pieces 8cm (3”) long. Solder one end of each wire to pins X1 and X2 on the interface board

The other wires are for the DC input power and signal. Cut and strip four pieces of wire 9cm (3.5”) long. Solder one end of each wire to pins IN1, IN2, V1 and V2 on the interface board.

The two boards can now be bolted together, with the Interface board fitted beneath the Display board.

Fit and solder the four wires, X1-4, from the Interface board to their corresponding points on the Display board. The wires are inserted on the solder side of the display board and soldered from the component side. Snip off any excess.

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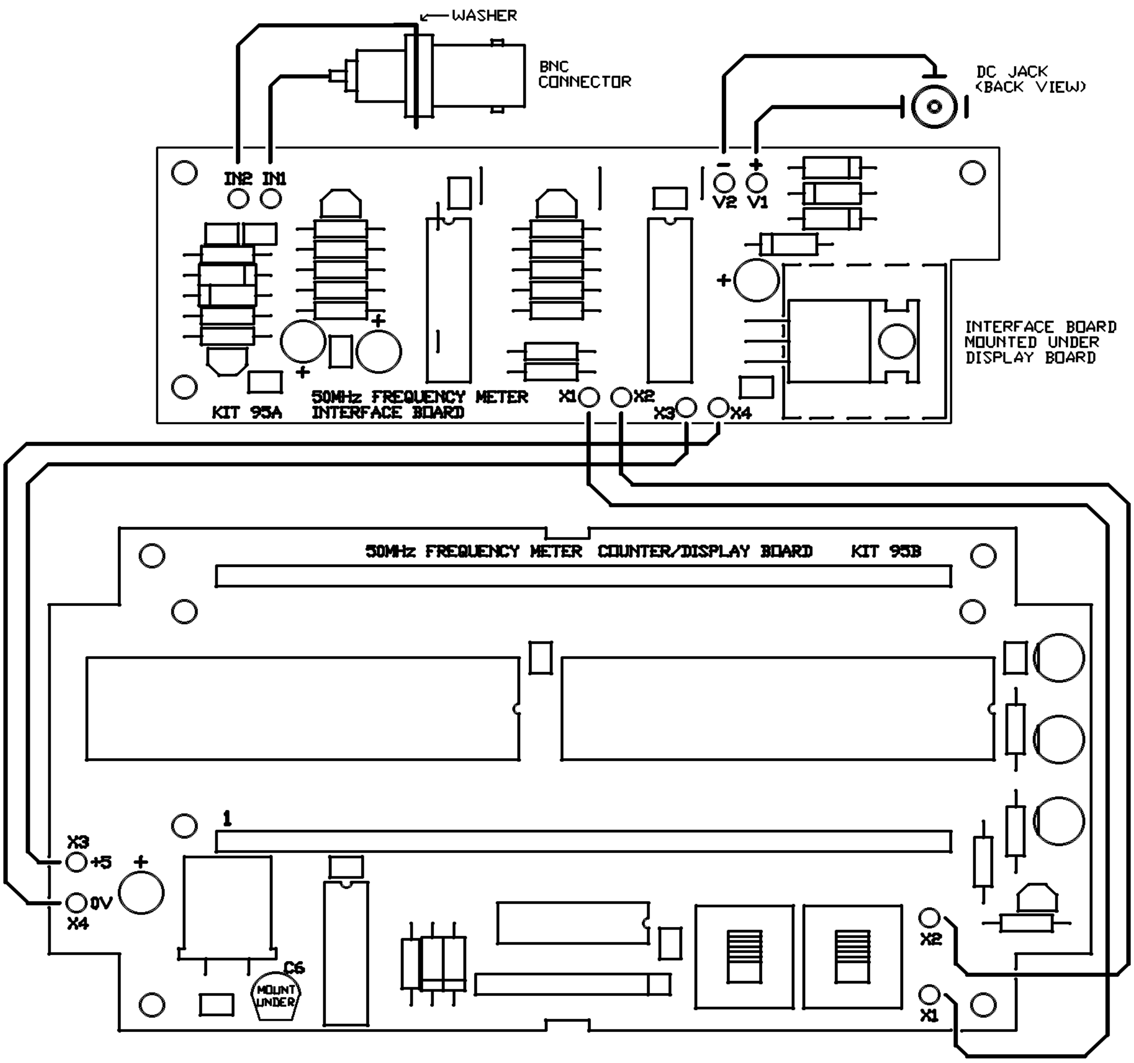

Wiring Diagram

We are now ready to drill the mounting holes for the BNC connector and DC power jack. The positioning of the holes is critical so that the connectors do not touch the PCBs inside the case. Both connectors are mounted on the ends of the case. Looking from the front, the BNC connector mounts on the left side and the power jack on the right. Refer to the diagrams on page 4 for hole sizes and position details.

Fit the BNC connector and power jack into the holes and secure them.

All that remains is to connect the BNC connector and DC power jacks and fit the whole assembly into the case. The wires connected to IN1 and IN2 connect to the BNC input connector, with IN1 connecting to the centre pin. The wires connected to V1(+) and V2(-) connect to the power jack, with V1 connecting to the centre pin.

Proceed to the "**Testing**" and "**Calibration**" sections before final assembly.

Position the whole assembly into the case, making sure that the wires are clear of the heatsink. Use the four (4) self-tapping screws to secure it to the case.

TESTING

Before applying power, check your wiring and assembly very carefully. Make sure that polarity sensitive components such as diodes, transistors, ICs and electrolytic capacitors are inserted correctly.

If everything seems OK, connect a 9-to-12V DC plug pack to the power input socket. The LCD display should spring to life. The "Gate" LED should be flashing and one of the other two LEDs should also be on. With the signal input "floating" it is very likely that the display will show a random reading due to stray RF pickup.

If the unit appears "dead" then check the 5 volt output from the regulator. If there is no 5 volts there, check the input to the regulator. It should be greater than 7.5 volts. If there is no voltage there at all, check the polarity of the plug pack - it should be centre positive. Are diodes D3-6 inserted the right way around? It you get a reading but it is less than 7.5 volts then you may need a higher voltage plug pack or you may need to strap out some of the diodes. *See next section "Calibration" for details.*

If the voltage at the input to the regulator seems OK, then it is probable that there is a short from the 5 volt supply to ground. Disconnect the display board and check if that isolates the fault. Once you have determined which board has the fault, check it for shorts between the PCB tracks themselves. Look for solder "bridges" between component pins. If all still looks OK then start taking out the 100nF decoupling capacitors across each of the ICs. These have been known to go "short circuit". Another possibility is that the regulator is faulty, although this is unlikely.

If all seems well then the next thing to do is connect it to a repetitive signal source. A frequency generator or the calibration output of a CRO will do fine. Check that you get a reading on the display. If not, check the signal on X1 and X2, using either a CRO or a logic probe. If there is no signal on those pins then the fault is on the interface board.

CALIBRATION

The only calibration required is to adjust trimcap C6 to set the "gating" signal output of IC3. The easiest way of doing this is to measure the frequency of a known signal source, such as the timebase signal from a commercial counter or that from a crystal "calibrator". In either case, simply adjust C6 to produce the correct reading.

The only other "adjustment" is to set the input voltage to the regulator. The kit draws about 150-to-175mA. With a minimum voltage drop across the regulator of 2.5 volts, the regulator will dissipate between 350 and 450mW. Obviously a larger drop across the regulator will result in higher power dissipation.

In order to keep the power dissipation of the regulator to a minimum, a number of diodes (D3-6) have been added in series with the input. Each diode drops approximately 0.7 volts, for a total of 2.8 volts. This helps to reduce the input voltage to the regulator and therefore its power dissipation. Of course each diode will dissipate some of the power that would have been dissipated by the regulator.

Depending on the output from the plug pack used, it may be necessary to strap out some of these diodes in order to lift the input voltage of the regulator to the minimum 7.5 volts required. This is easily done by soldering a small wire link on the solder side of the PCB beneath diodes D3, D4 and/or D5. Pads have been provided for this purpose.

Use the lowest voltage plug pack available which is capable of delivering the minimum 7.5 volts at the input of the regulator. A 9V plug pack should be fine.

CIRCUIT DESCRIPTION

The circuit has been divided into two sections, the Interface board and the Display/Counter board.

Interface Board

This section consists of two parts, a FET buffer stage (Q1) followed by a wideband preamp and squaring circuit, using an ECL triple line receiver (IC1).

Q1 is used to provide a high impedance input. Resistor R1 and diodes D1 and D2 form an input clipping circuit to protect the FET from damage due to large input signals. The diodes are type BAW62, which have high switching speeds and low parallel capacitance. Capacitor C1 is used to block DC. C2 provides high frequency compensation.

A word about the input impedance. This is nominally 1MΩ (R2) in parallel with about 10pF. This 10pF is made up of the capacitance of the FET and diodes D1 and D2. This capacitance affects the input impedance of the meter. The higher the input frequency the lower the capacitive reactance and therefore the lower the input impedance. At 50 MHz the capacitive reactance is only 318 ohms! This is the reason why commercial frequency meters have a separate input for measuring frequencies above 50 MHz, using prescaler chips that have a nominal input impedance of 50Ω. All high frequency circuits use 50Ω inpedance to minimise the effect of stray capacitance.

The first two stages of IC1 are configured as wideband amplifiers, while the third stage is configured as a Schmitt trigger with hysteresis. Transistors Q2 and Q3 act as level translators between the small output voltage swing from the ECL amplifier stage and the CMOS counting section.

The counters used (7224) will operate up to 15 MHz directly. However higher frequencies must be "prescaled" first. This is the function of IC3 (74F160), a BCD decade counter. An "F" series part was used here. These parts will work up to 100 MHz. IC3 divides-down the signal by ten, allowing frequencies above 15MHz to be measured. Of course, prescaling the input signal reduces the resolution of the meter to 10Hz.

The interface board also contains the power supply circuit. This is a standard 5 volt regulator with the usual input and output capacitors. A series of diodes on the input allow the voltage from the plug pack to be reduced before reaching the regulator. Diodes D3-5 can be strapped out to vary this input voltage. D6 cannot be strapped out and so provides protection for the regulator in case the input polarity is reversed.

Display/Counter Board

This is a classic textbook circuit straight out of the "Harris Semiconductor" data book. The circuit is based around an ICM7224, which is a 4 1/2 digit LCD Display counter. Two of these devices, IC1 and IC2, are used in series to provide an 8-digit counter.

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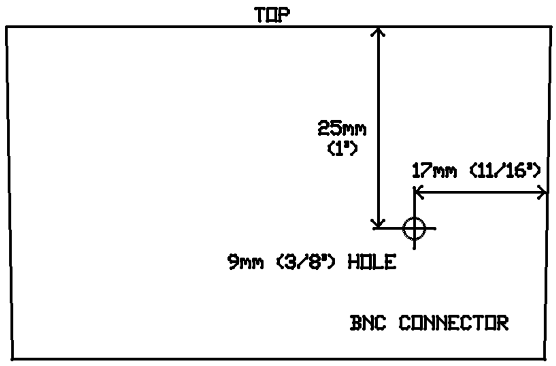
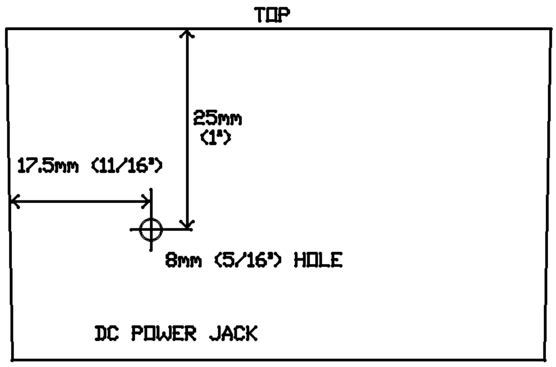
The counter is capable of direct static counting, guaranteed from DC to 15 MHz. At normal ambient temperatures it will typically count up to 25 MHz. The counter is controlled via three inputs, RESET, STORE and COUNT INHIBIT. These inputs are directly interfaced to IC3, an ICM7207A CMOS Timebase Generator.

The GATE signal from IC3 is inverted by Q1 and used to drive the COUNT INHIBIT input of IC2, the first counter in the chain. This signal can be set via the RANGE input to either 0.1 or 1 second. Q1 also drives the “Sample Rate” LED on the front panel.

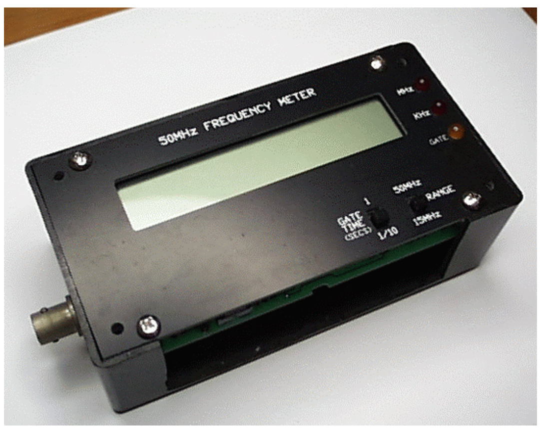
SW1 is the range switch. One half, SW1:B, is used to connect the direct or prescaled signal from the interface board to the counters. The other half, SW1:A, is used to drive the “KHz” or “MHz” LEDs of the front panel, as well as selecting the correct decimal point on the LCD display.

To light an LCD segment, it is necessary to supply a signal to it that is 180 degrees out of phase with the COM or backplane signal. The individual digit segments are driven directly by IC1 and IC2. The decimal points are driven by IC4, a quad dual-input exclusive NOR gate. The COM signal from the counters is commoned to one of each of the gate inputs. The other gate inputs are normally pulled high by RP1. A high input allows the COM signal to pass through unchanged. A low input causes the COM signal to become inverted on its output and therefore light the corresponding decimal point. The decimal point selected depends on the position of the two switches, SW1 and SW2.





DC Jack at LED end



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PARTS LIST - K95

GENERAL

Plastic case, 129 x 68 x 41 mm	1
BNC connector, panel mounting	1
2.5mm DC jack, panel mounting	1
Front panel, K95C	1
Metal spacer, 3mm tapped, 10mm long	4
Metal spacer, 3mm tapped, 15mm long	3
Flat washer, 3mm	4
3 x 6mm screws	14
Hookup wire, 2 colors, 30 inches of each color	

PARTS LIST - K95A
INTERFACE BOARD

Resistors (0.25W, 1%, Metal Film)		
12	R15	1
100	R14	1
180	R11	1
470	R6-9, R12,13	6
1K	R3-5, R10	4
10K	R1	1
1M	R2	1
Capacitors		
150pF ceramic	C2	1
100nF monoblock	C1, C4, C6-8, C10	6
10uF 16V tantalum	C3, C5	2
100uF 25V electro	C9	1
Semiconductors		
1N4004	D3-6	4
BAW62	D1,2	2
2N4258, PNP transistor (or PN3640)	Q2,3	2
2N5486, N channel FET	Q1	1
74F160 BCD decade counter	IC2	1
MC10116 ECL triple line receiver	IC1	1
7805 regulator, TO-220	IC3	1
Miscellaneous		
16-pin IC socket	IC1,2	2
K95A PCB		1
Heatsink for 7805 regulator		1
3 x 10mm screw & nut		1

PARTS LIST - K95B
DISPLAY/COUNTER BOARD

Resistors (0.25W, 1%, Metal Film)		
390	R3	1
470	R1,2	2
10K	R4,5	2
10K 9P8R ‘A’ RESNET	RP1	1
Capacitors		
39pF ceramic	C5	1
100nF monoblock	C1-4	4
10-68pF trimcap	C6	1
10uF 16V electro	C7	1
Semiconductors		
1N4148	D1,2	2
BC547B	Q1	1
ICM7224IPL 4 1/2 digit LCD Display Counter	IC1,2	2
ICM7207A CMOS Timebase Generator	IC3	1
74HC266 Quad 2-inpt exclusive NOR gate	IC4	1
LED, 5mm Red	L1,2	2
LED, 5mm Green	L3	1
Miscellaneous		
Crystal, 5.24288MHz	Y1	1
Slide switch, DPDT C&K, 1201-M2-C	SW1,2	2
8-digit display Varitronix, VI-804-DP-RC	DISPLAY	1
14-pin IC socket	IC3,4	2
34-way socket strip	for LCD display	2

REFERENCES

The Internet is the place to get references and any sort of technical data.

Data sheets for the ICM7224 and ICM7207A are available from the Harris Semiconductor web site at:-

“http://www.semi.harris.com”

Data for the 74HC266 and 74F160 can be found in any TTL data book. Functionally they are identical to the LS series of parts except that the “F” series part will operate at much higher frequencies.

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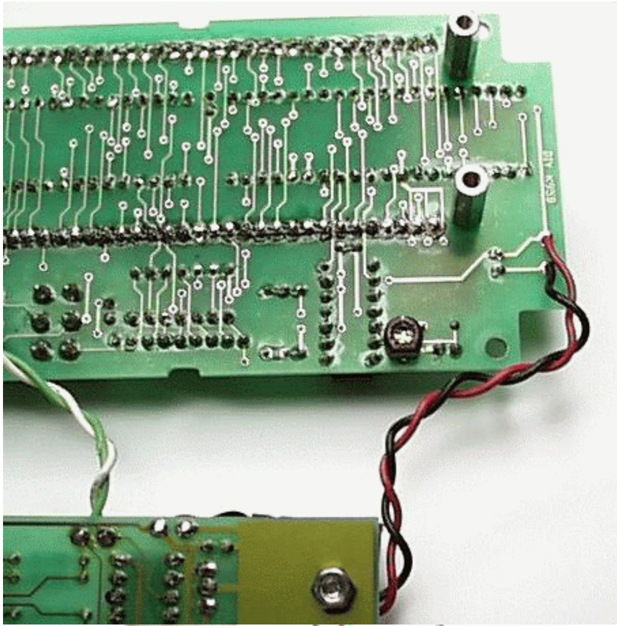

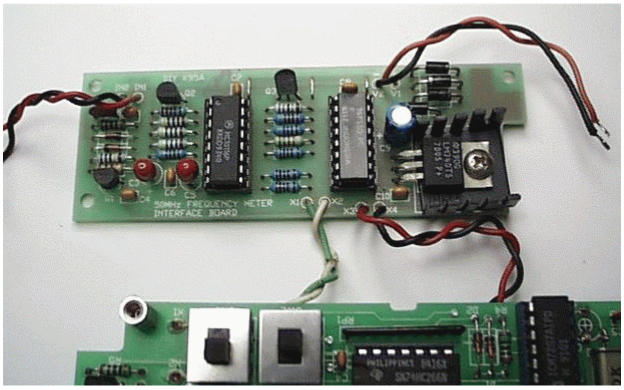

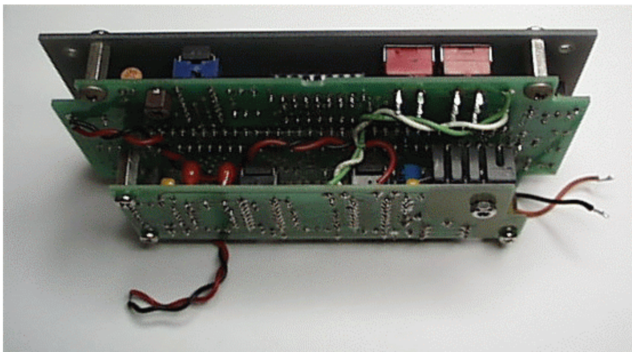

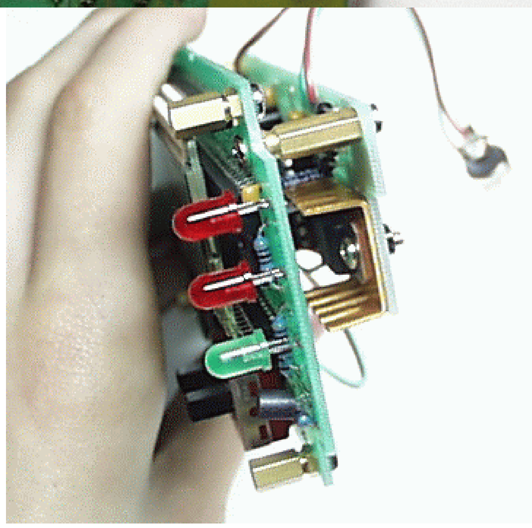

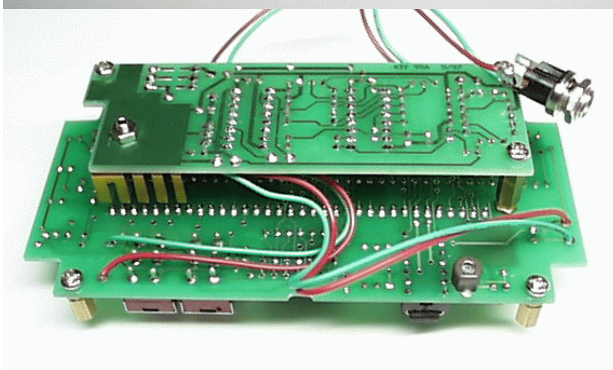

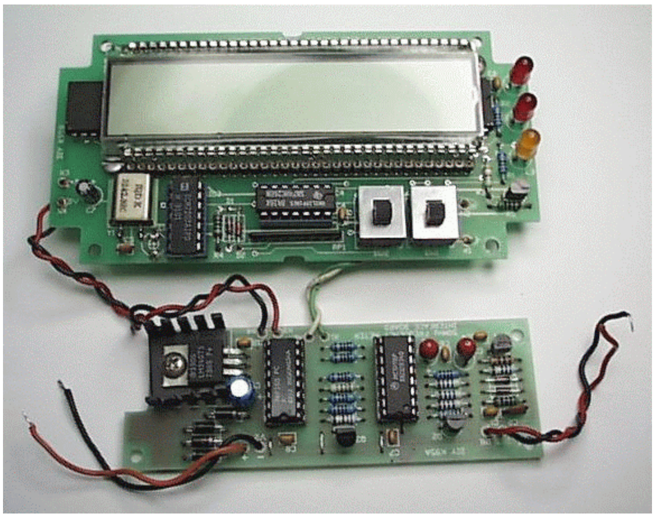

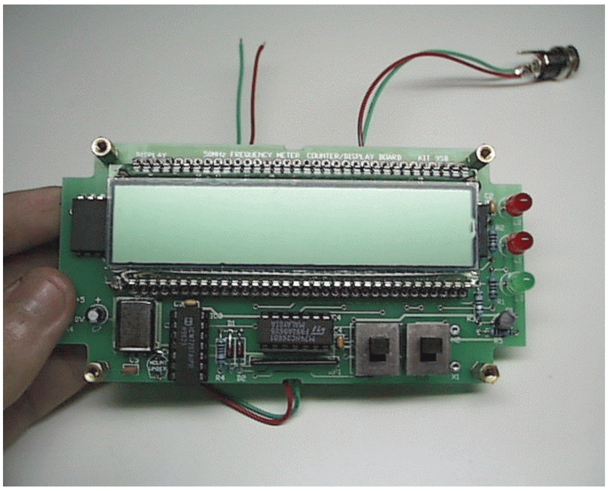

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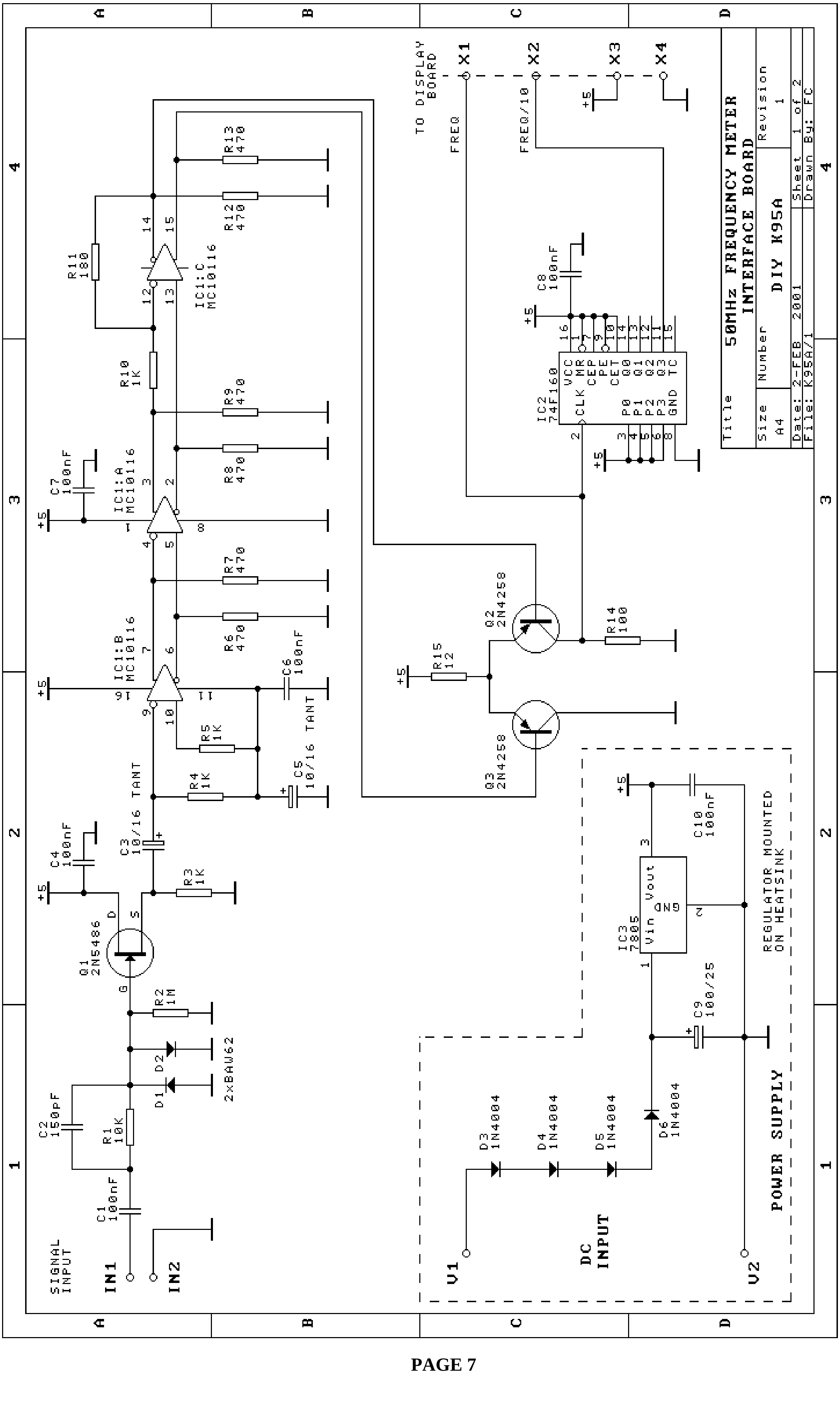

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