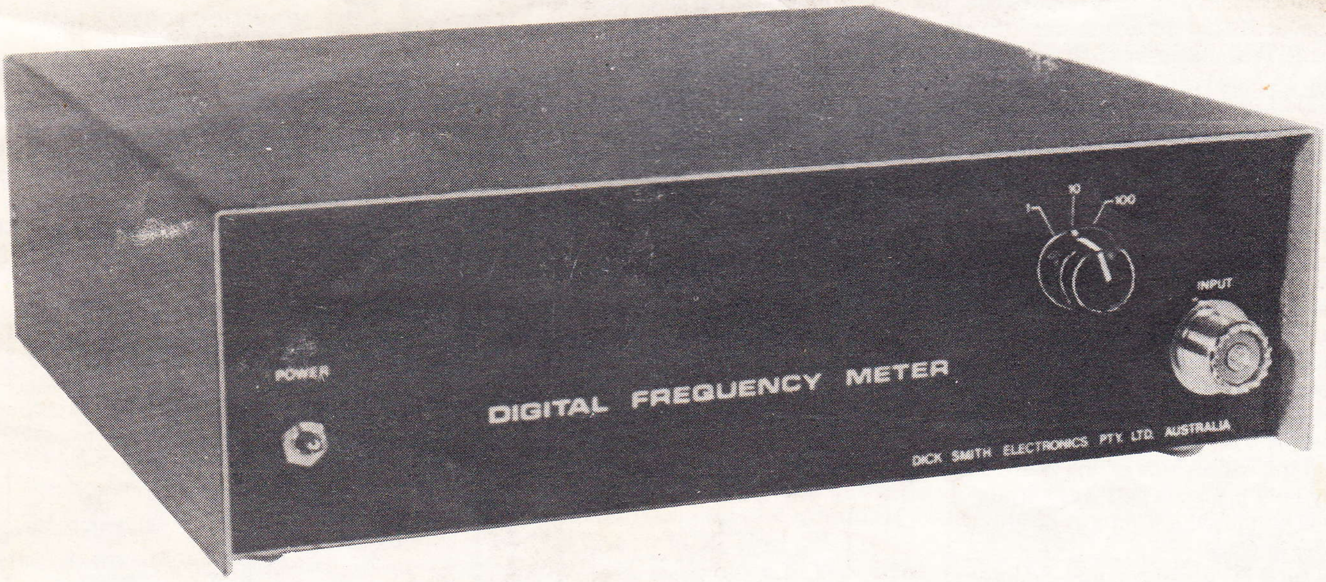
DICK SMITH
7 DIGIT FREQUENCY METER
EA PROJECT
KIT K-3436

200 MHz



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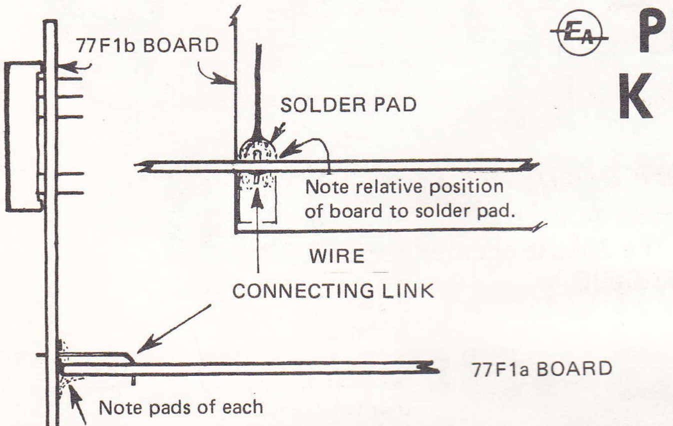
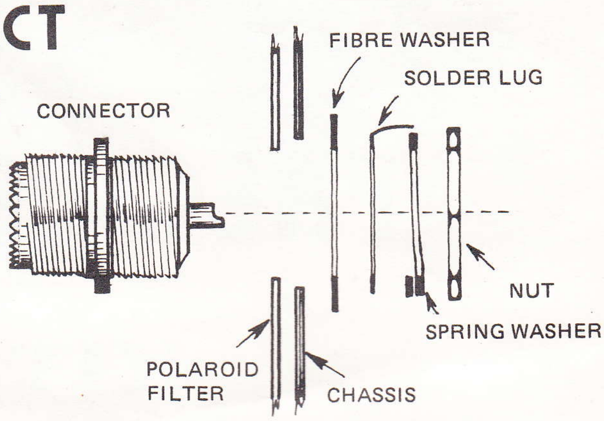


MOUNTING AND POSITION OF P.C. BOARDS



METHOD OF INSULATING U.H.F. PANEL SOCKET

ADDITIONAL NOTES TO ACCOMPANY YOUR DICK SMITH DELUXE DIGITAL FREQUENCY METER KIT — complete with pre-punched chassis and marvi-plate top.

This kit is completely operational to 20 MHz. If you require your counter to operate to 200MHz, simply purchase the optional 95H90 IC and solder into place. This IC is available from all our stores.

MOUNTING UHF SOCKET

The mounting sequence is as shown in the diagram. Before it is tightened, make sure the deluxe Polaroid filter is centred on the front panel. Tighten securely but not excessively.

MOUNTING IC POWER REGULATOR

Leave the mounting of this device until last. Take particular notice of the mounting arrangement. It is soldered in place before the PCB assembly is pushed onto the PCB mounts.
Push the 3 pins into the appropriate holes from the copper side of the board so that they only protrude half way through. While holding the IC in this position, solder in place.
The total PC board can now be located in position on the stand-offs.
Now bend the IC in position so it lies flat on the chassis and over the mounting hole. Secure in place with the screw & nut supplied. NOTE: If you intend to add the optional 12V wiring, this IC will have to be isolated with a mica washer, nylon screw and nut.

MOUNTING RUBBER FEET

Your kit comes complete with adhesive rubber feet. Before these can be applied the chassis has to be cleaned. Apply a small amount of metho to a cloth and rub area of chassis close to each corner. Then remove the silicon backing from each foot and press into place.

DISPLAY BOARD MOUNTING

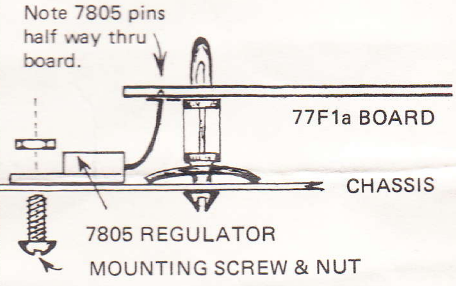
Note carefully the diagram and text on how to mount the 77f1b display board to the 77f1a board. Make sure these 2 boards are at right angles to each other before soldering all components.

OPTIONAL EXTERNAL 12V CONNECTIONS

When this wiring is used, the LM340T-5 or 7805 IC has to be isolated from the chassis. This is simply done by putting a mica washer between the device & the chassis. Secure in position with a nylon screw and nut.

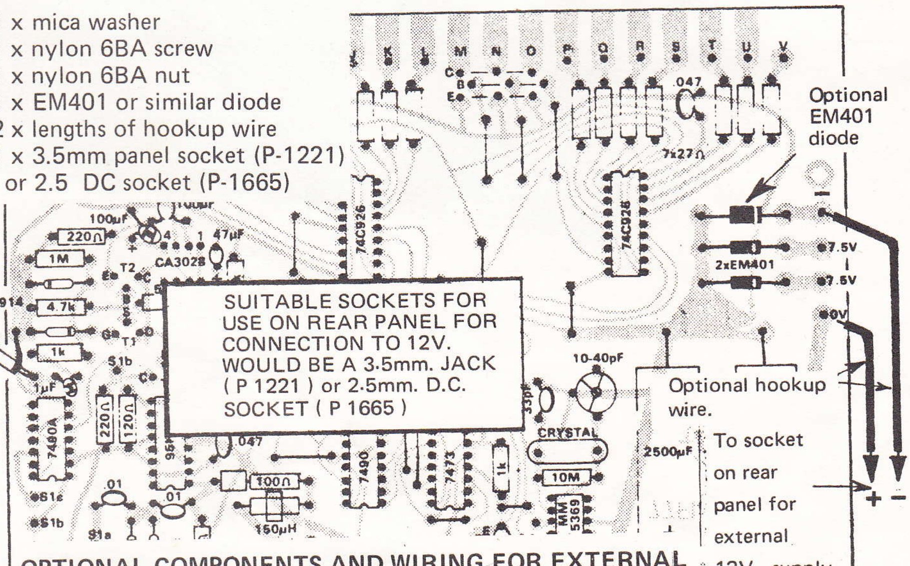
OPTIONAL PARTS REQUIRED FOR 12V EXTERNAL SUPPLY.

1 x mica washer
1 x nylon 6BA screw
1 x nylon 6BA nut
1 x EM401 or similar diode
2 x lengths of hookup wire
1 x 3.5mm panel socket (P-1221) or 2.5 DC socket (P-1665)



7805 REGULATOR MOUNTING

Insert diode in position shown (note polarity). Cut hookup wire to length. Mount socket on rear panel and connect to relevant position on PCB with the hookup wire.

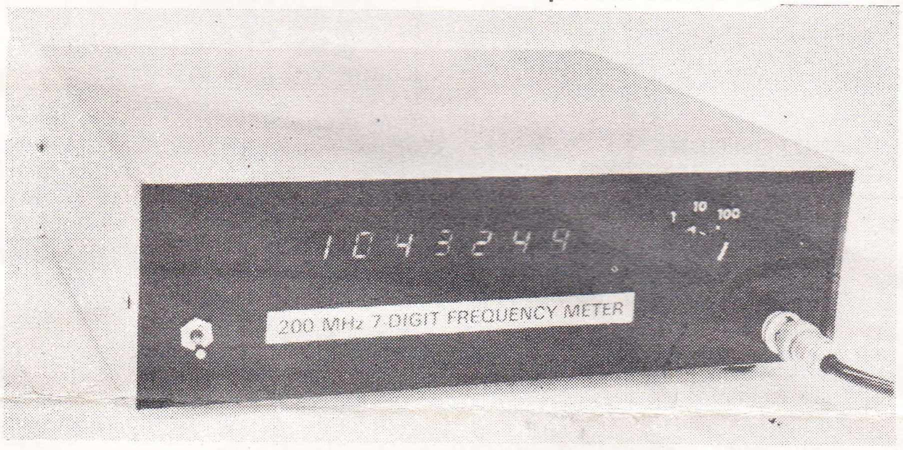


OPTIONAL COMPONENTS AND WIRING FOR EXTERNAL 12V. SUPPLY.

A low-cost digital frequency meter

. . . easily built unit is ideal for workshop and laboratory

This article is reprinted with the permission of Electronics Australia.
The text refers to the 200MHz counter construction. The 20MHz counter construction is the same except for the inclusion of the optional 95H90 IC.



With the recent release of several new CMOS integrated circuits in Australia, we have been able to produce a new high performance frequency meter with greatly simplified circuitry. Our latest design has seven digits and can measure up to 200MHz. It employs twelve integrated circuits and a handful of discrete components.

by LEO SIMPSON

Yet again, rapidly improving technology has enabled us to present a project which is considerably simpler and cheaper in real dollar terms than its predecessor. In 1970, we published a design for a 3½-digit 70MHz counter which employed a total of 43 IC's. That was superseded in December 1973 by a 4½-digit 200MHz design employing 24 IC s. And now with half that number of IC s, we present a 200MHz frequency meter with a seven-digit readout.

Apart from the seven-digit readout, almost every aspect of the new design is simpler than its 1973 predecessor. There are less controls, and assembly is more straightforward.

We hope the new styling will be popular too. The unit is housed in a low profile case measuring approximately 230 x 68 x 210mm (W x H x D). The front panel is made of red polaroid film which we assume suppliers will have screen-printed in white. When the unit is off, the front panel is dark and inscrutable, with no digits showing. When power is applied all digits are alight.

Brilliance of the readouts is quite high and adequate even in sunlit rooms, although readers might gain a different impression from the lead photo. Perhaps we should have had the photo retouched by an artist!

Some of the features of the new frequency meter are as follows: The range switch has only three positions—x1, x10 and x100. On the first range it will measure to above 3MHz. On the "x10" range measurements can be made to between 25 and 30MHz, depending on the input signal. And on the "x100" range measurements can be made to above 200MHz, again depending on the input signal amplitude.

The new design does not have leading zero blanking. While we regard LZB as a desirable feature, it was not possible to incorporate it in the present design.

No provision has been made for period counting or event counting under manual control. Nor is there any sensitivity adjustment. Measurements are restricted to a single low rate of one every two seconds, to keep the timebase circuitry simple and to eliminate timebase switching.

Input impedance of the meter on the "x1" and "x10" ranges is 1 megohm shunted by about 50pF. Sensitivity is about 50mV RMS or better from 10Hz to about 10MHz. On the "x100" range, the input impedance is 75 ohms or more and input sensitivity is 200mV RMS up to about 180MHz. A signal of 800mV P-P is required to guarantee operation to 220MHz and above. Minimum input frequency on the "x100" range is 1MHz.

Accuracy of the frequency meter will depend on the accuracy and stability of the crystal timebase. This can be expected to be within a few parts in 100,000. Resolution is 1Hz on the "x1" range, 10Hz on the "x10" range and 100Hz on the "x100" range.

Power consumption is fairly modest. Current drain is about 500 milliamps from the regulated 5V supply. The unit is normally powered from the 240VAC mains, but provision has been made on the PCB to power the unit from a 12V car battery via an isolating diode.

Our estimated cost for the unit is less than $120. When you consider that the 1973 design was worth about $140 and the extent of inflation since then, the projected cost for a kit of parts is a bargain in real dollar terms. And the nearest comparable frequency meter retails for many hundreds of dollars more!

Heart of the design is a pair of 74C926 CMOS 4-decade counters. These have been recently released by NS Electronics Pty Ltd.

Like many multi-function integrated circuits these days, the internal complexity is so great that the manufacturers do not bother to publish a schematic. The 74C926 contains virtually all the circuitry needed, apart from the timebase and

Frequency meter

display drivers, to make a four-digit frequency counter.

Contained in the chip are four decade counters (same function as the 7490 TTL decade counter), four 4-bit latches (equivalent to 16 flip-flops), BCD to seven segment decoders and drivers, plus an oscillator and multiplexing circuitry for the four digit driver transistors. Thus, even if the multiplexed output feature is not taken into account, the 74C926 is equivalent to eight IC s as used in our previous design.

It is appropriate to note at this stage that there are a number of competitive counter IC s, notably from Mostek, Ferranti and Intersil. Some of these may be better in some respects than the 74C926 but we regarded the National device as the best all round choice, especially when price, availability and compatibility is considered.

More about the 74C926 device later in the article.

Most of the timebase circuitry is contained within a single MOS integrated circuit, the MM5369N. This is described by National Semiconductors as a 17-stage programmable oscillator/divider. It can be programmed during manufacture to divide by a selected number between 10,000 and 98,000.

The particular device used by us is programmed to work with an American standard colour TV subcarrier crystal operating at 3.579545MHz. Output from the 5369 is 60Hz. This is a very economical method of obtaining a timebase since both the 5369 and the 3.58MHz crystal are quite cheap.

The 60Hz output from the 5369 is fed to a BC548 transistor to make it compatible with the following TTL stages. A 7473 dual JK flip-flop is interconnected to divide by three, to give 20Hz. This signal is then further divided by a 7490 decade divider to give a 2 Hertz square wave.

The 2Hz output from the timebase circuitry is interfaced with the 74C926 counters in what logic designers quaintly term a "housekeeping" circuit. The circuit consists of a 7473 dual JK flip-flop, a 7410 triple 3-input NAND gate and 3 Schmitt triggers in a 74LS14 hex trigger which are employed as inverters. The housekeeping circuit configuration is similar to that in our previous design.

Three different pulse trains are derived from the 2Hz timebase by the housekeeping circuitry, to control the 74C926s: One second pulses for gating and 250mS pulses for "reset" and "latch enable". Let us explain the term "latch enable".

As noted above, each 74C926 has four 4-bit latches. These are equivalent to a chain of flip-flops which are used to store the BCD count of the four decade counters. The latch information is used to drive the LED displays. Early frequency counters did not have latches and so the display was rapidly cycled during each count period. With latch circuitry the readout is constant if the input frequency is constant—there is no blinking or flickering.

So the "latch enable" pulse is the command to the 74C926 to transfer the BCD count from the decade counters to the 4-bit latches.

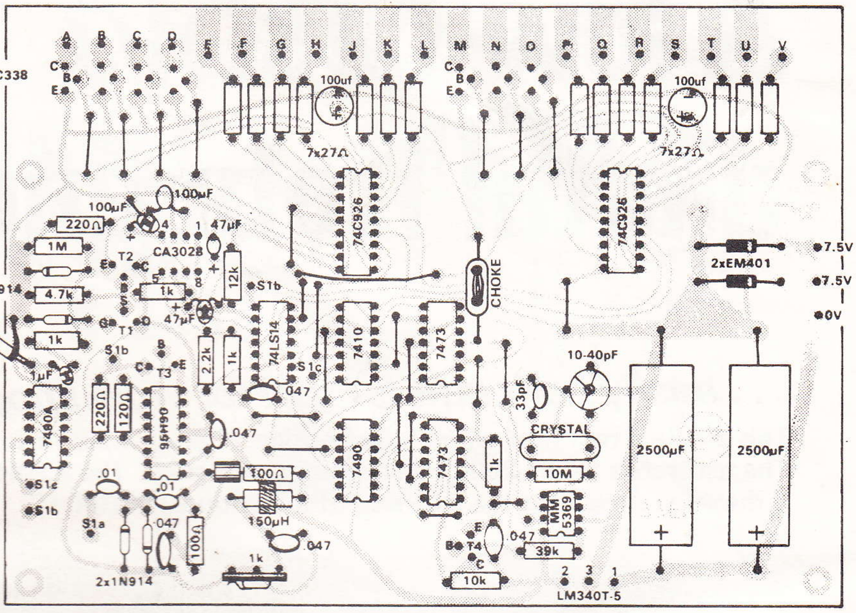
The basic measurement cycle takes two seconds. In the first second, gate 1 of the 7410 is turned on by the second flip-flop in the 7473 to allow a one second burst of input signal to be fed to the clock input (pin 12) of the first 74C926. The first 74C926 counts the first four decades (to 9999) and generates "carry out" pulses to allow the second 74C926 to count the following decades.

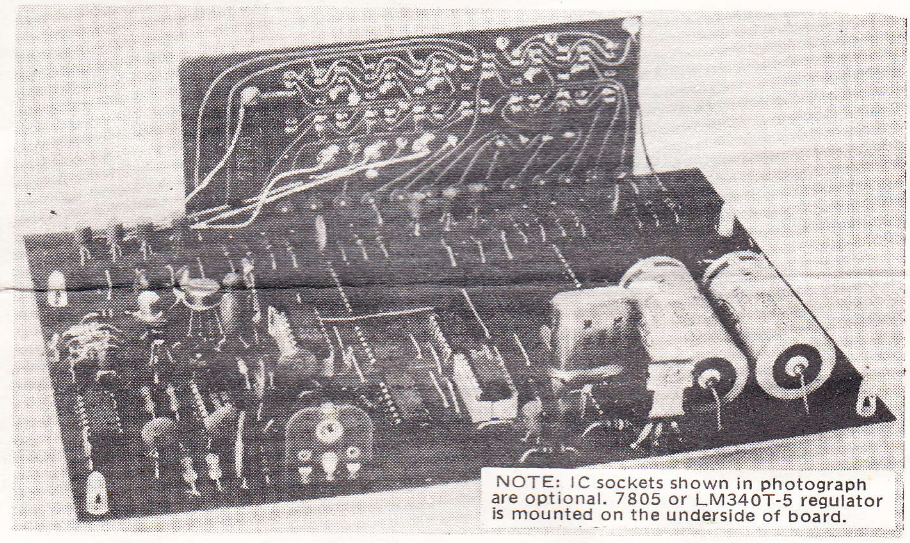
During the third half-second of the 2-second measurement period a 250mS pulse is delivered to pins 5 of both 74C926s to transfer the BCD count into the latches. Then in the last half-second another 250mS pulse is fed to pins 13 of the 74C926s to reset the counters to zero.

So the display is updated once every two seconds.

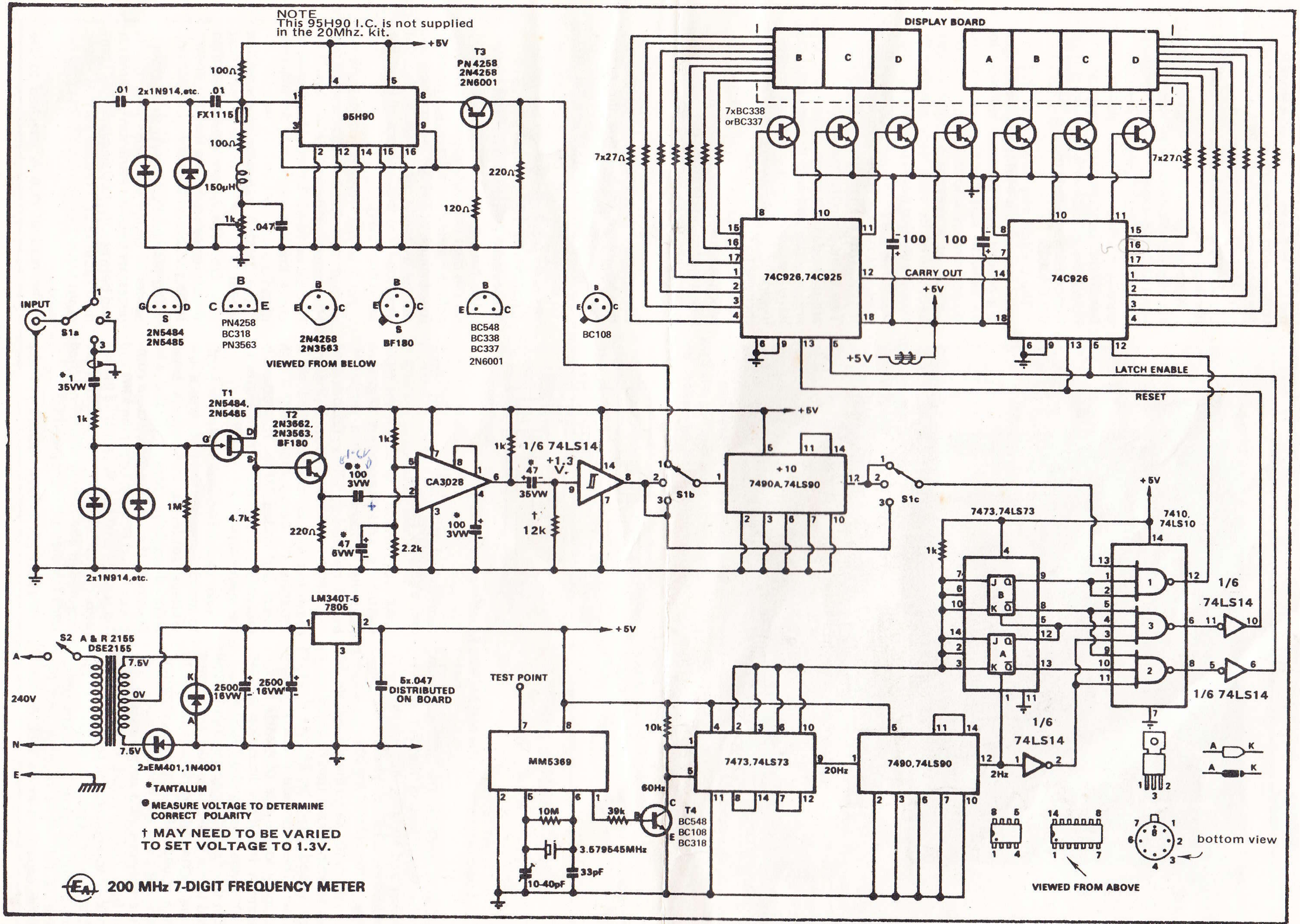
Notice that the second 74C926 only drives 3 digits instead of 4. We have omitted the fourth digit, because the 74C926 typical maximum count rate of between 3 and 4MHz plus the one second gating time mean the maximum count cannot go beyond 4,000,000—well within the capacity of seven display digits.

The front end of the new design consists of a FET, an NPN emitter-follower, a CA3028 RF amplifier and one section of the 74LS14 hex Schmitt trig. The FET provides an input impedance of 1 megohm. The NPN emitter-follower combines with the FET to provide a very low source impedance to drive the

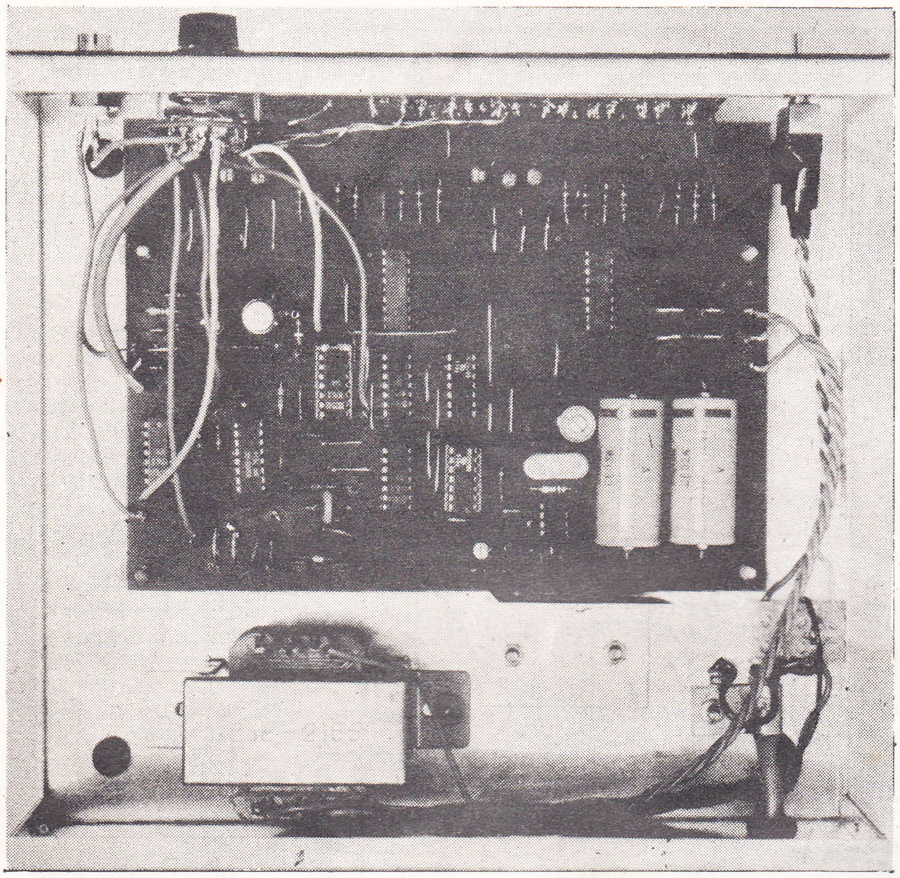


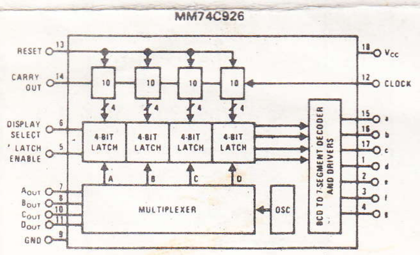


At top is the component layout for the main PC board. Above shows the completed board assembly with the display board soldered in position and wired.



200 MHz 7-DIGIT FREQUENCY METER





Logic diagrams for the MM74C926 four decade counters.

CA3028 RF amplifier. The latter makes up for the signal loss in the FET source-follower and NPN emitter-follower and provides the extra gain to allow the signal to toggle the Schmitt trigger.

On the "x10" range the signal from the 7414 Schmitt trigger (pin 8) is fed via a high speed 7490 or 74LS90 decade divider. These decade dividers have a maximum toggle rate of 40MHz so the maximum frequency limitation on the "x10" range is set by the 74LS14.

On the "x100" range the input signal is fed to the 95H90 prescaler and thence to the 7490A/74LS90 decade divider to give a resultant division of one hundred. The 95H90 prescaler is very similar to that in the previous 1973 design except that the bias circuitry has been slightly modified to improve the sensitivity.

The power supply is simple. A 15V centre tapped secondary transformer drives a full wave rectifier and two 2500uF capacitors in parallel. A three-terminal plastic pack regulator then derives the 5V rail.

All of the circuitry, apart from the input switching and the seven segment readouts, is mounted on a single PC board measuring 178 x 127mm and coded 77F1a. The seven segment readouts are accommodated on a separate PC board measuring 118 x 55mm and coded 77F1b. This board is mounted and secured at right angles to the main board.

Take care when making solder joints to avoid damaging the PCB. Use a low wattage soldering iron with a small chisel-shaped bit. Mount all the wire links first. Then mount the discrete components and PC pins. Leave the 5369 and 74C926 ICs until last. Note that all the ICs with the exception of the 74C926s are oriented in one direction—with notched ends towards the rear of the PCB.

We have not found it necessary to take any special precautions when soldering the CMOS ICs except to use a small low voltage iron. If you are worried, connect the soldering iron to the PCB earth pattern with a jumper lead and then solder the supply and earth pins of the CMOS ICs first.

Notes about some of the components are appropriate here. Polarity of the 1uF input tantalum capacitor is unimportant. The NPN emitter-follower must be a transistor with a very high value of gain-bandwidth product (Ft), otherwise the output impedance will increase at high frequencies and thus reduce the gain of the CA3028.

The CA3028 may be supplied in a circular can or an 8-lead minidip package. If a circular type, the leads will have to be bent to suit the copper pattern. (Experimenters who may wish to use the CA3028 as a preamp in other circuits because of its very wide bandwidth should note that because of the low supply voltage and cascode connection it does not have a linear transfer characteristic. That is immaterial in this circuit.) Two of the Schmitt trigs. in the 74LS14 are unused. Their inputs (pins 3 and 13) are grounded and outputs (pins 4 and 12) have no connection. The 12k resistor from pin 9 of the 74LS14 may have to be changed to another value to bring the input voltage down to around 1.3volts which is between the positive and negative thresholds of the device. This maximises the sensitivity of the circuit.

Low power Schottky ICs may be substituted for TTL ICs if available. This has the advantage of lowering the power consumption. The devices in question are 74LS10, 74LS14, 74LS73 and 74LS90.

To achieve the high speed capability of the pulse shaping circuit following the CA3028 it has been found a 74LS14 is necessary for maximum performance.

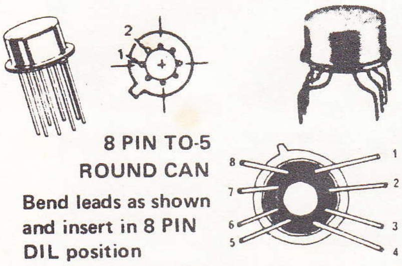
We have specified BC338 (or BC337) for the digit drivers because of their low collector saturation voltage. It is possible to substitute BC548 but the readouts will not be as bright and there is also the likelihood that they will not all have the same brightness.

Pin 7 of the MM5369N is a buffered output for the 3.5MHz oscillator. However it is of no real use in calibration. It could be handy for troubleshooting to check that the oscillator is actually running.

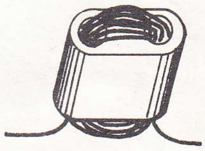
The 2N4258 transistor following the 95H90 is a very high speed switching type. Do not subtitute types other than those suggested, unless they are known to be suitable for high speed operation.

The readout PCB is easy to assemble. Solder in all the wire links first. This is necessary because some run underneath and between the LED displays. Any common cathode LED display such as Monsanto MAN-7 or Litronix DL-704 may be used.

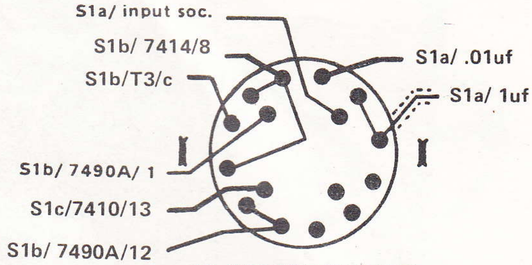
The readout PCB is attached to the



CA3028 (bottom view)



CHOKE
Wind on 6 turns of the fine hookup wire supplied.



S1 SWITCH WIRING
(REAR VIEW)

main PCB by soldering the line of pads together on both. There is a line of holes along the bottom edge of the readout PCB. These should be lined up with the top surface of the main PCB by means of a couple of wire links running between the boards. Set the boards at right angles, and run a fillet of solder between each set of matching pads on the boards. One of the photographs illustrates the method.

This makes the majority of connections to the display PCB. There are five wires left to be run to the display PCB from the main PCB. This completes the PCB assembly.

Now assemble the chassis hardware. Solder the mains leads to the power transformer, tape them and bolt the transformer to the chassis.

Loosen the clicker plate of the input switch before installing it so that it can be easily operated with a small knob. Also cut the shaft to length before installation.

The screen printed panel should be located on the front of the chassis using the toggle switch, rotary switch and UHF socket as location guides. When the panel is lined up square with the top and sides, the switches and socket can be tightened firmly but not excessively. Remember the UHF socket is insulated, make sure it is in the centre of the mounting hole.

The three-core mains cord should be passed through a grommetted hole in the rear of the chassis and anchored with a cord clamp. Terminate the earth wire to a solder lug on the chassis. Terminate the active and neutral conductors plus the wires to the transformer primary and the mains switch to a three-way insulated terminal block.

With chassis assembly complete, fit Richco supports to the PCB and mount it in the chassis. Alternatively, use screws and nuts to support the PCB 10mm off the chassis. Attach the regulator to its heatsink and run the wires to the input switch. Run the wires as shown in the photo. Do not attempt to lace the wiring into a neat cable form or run the wires close together as this will cause faulty

PARTS LIST

MAIN PCB ASSEMBLY

1 PCB, 77F1a, 178 x 127mm
1 3.58MHz crystal
11 PC pins
1 150uH RF choke
1 FX115 ferrite bead
SEMICONDUCTORS
2 74C926 4-digit counters

1 95H90 ECL prescaler (optional)
1 CA3028 RF cascode/differential amplifier
1 MM5369N oscillator/divider
1 74LS90 or 7490A high-speed decade counter
1 7490 decade counter
2 7473 dual JK flip-flop
1 74LS14 hex schmitt trigger (LS only)
1 7410 3-input NAND gate
1 7805 or LM340T/5 5V/1A regulator
7 BC338, BC337, NPN transistor
1 BC548, BC108, BC318 NPN transistor
1 PN4258, 2N4258, 2N6001 PNP high speed switching transistor
1 2N3563, 2N3662, BF180 NPN RF transistor
1 2N5484 or similar VHF FET
4 1N914 (1N4148) signal diodes
2 1N4001, EM401, EM402, EM404, silicon diodes.

CAPACITORS
2 2500uF/ electrolytic
2 100uF/ tantalum electrolytic
2 47uF/ tantalum electrolytic
1 1uF/ tantalum electrolytic
5 .047uF ceramic
2 .01uF/ ceramic
1 33pF NPO ceramic
1 10-40pf ceramic trimmer
2 100uf RB electrolytic caps
RESISTORS
¼ or ½W,
1 x 10M, 1 x 1M, 1 x 39k, 1 x 10k,
1 x 12k, 1 x 4.7k, 1 x 2.2k, 4 x 1k,
2 x 220 ohms, 1 x 120 ohms,
2 x 100 ohms, 14 x 47 ohms,
1 x 1k trimpot

READOUT PCB ASSEMBLY

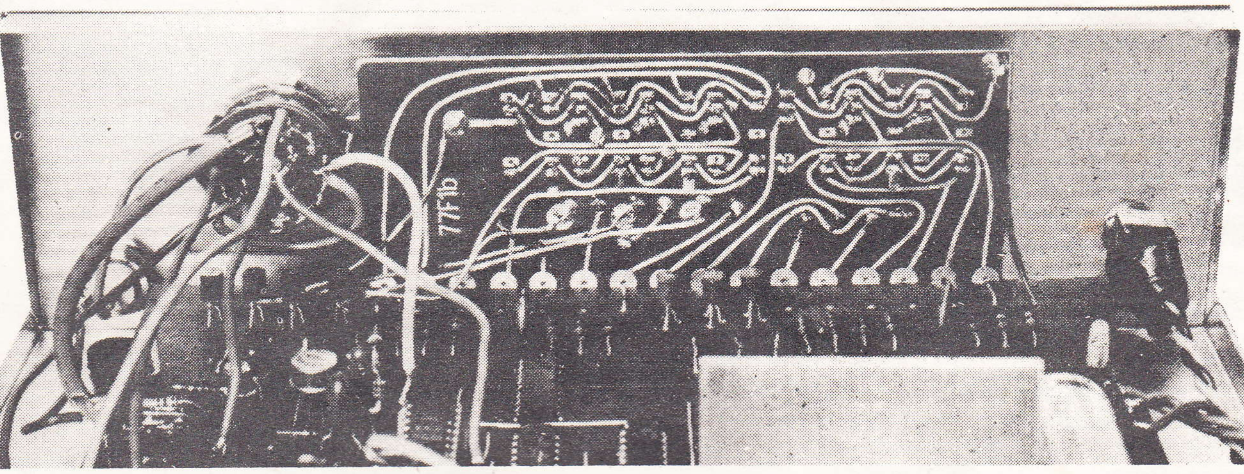
1 PC board, 77F1b, 118 x 55mm
7 seven-segment common cathode LED display, Monsanto MAN-7, Litronix DL-704 or equivalent

CHASSIS & HARDWARE

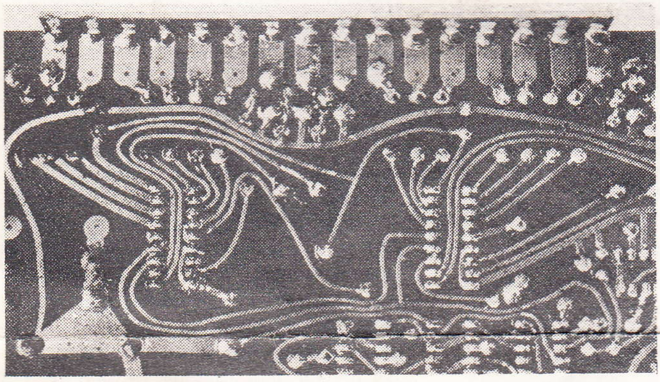
1 deluxe metal case & marviplate cover
1 fully screened Polaroid red filter

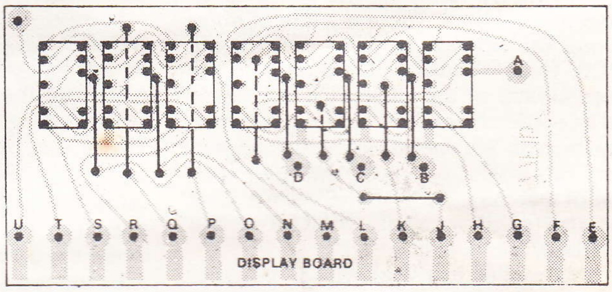
1 knob
1 SPST miniature toggle switch
1 4 pole three-position switch
1 power transformer, 15V centre-tapped at 1 amp DC; A&R 2155, DSE 2155
1 ferrite balun former for choke.
4 rubber feet
4 Richco 10mm high PCB supports
1 solder lug
1 three-pin mains plug and three-core flex
1 mains cord clamp and grommet
1 three-way insulated terminal block

Miscellaneous: screws, nuts, lock-washers, short length of shielded cable, hook-up wire, tinned copper wire, insulation tape, solder, etc.
Note: Capacitors and resistors with higher ratings may be used if physically compatible. Other substitutions, unless mentioned in the text, are not recommended.



A close-up view of the wiring behind the front panel. Note that the short length of shielded cable from the range switch is earthed only at the PC board, and not at the switch itself. Tape the mains switch to avoid the possibility of shock.





Photograph at left illustrates how the display PC board is soldered to the main PC board. Above is the component overlay pattern for the display board.

operation. Note the short length of shielded cable from the input switch, which should not be omitted.

Check wiring and apply power, then quickly check the 5V rail to make sure that all is well. The LEDS should show zeros, except for the least significant digit which may show "1". The 12k resistor associated with the 74LS14 should be adjusted as noted above. If too low a value is used it may prejudice the sensitivity and may result in random readings on the least significant digit.

Now adjust the 1k pot for optimum sensitivity of the 95H90 prescaler. Feed in a VHF signal at 100MHz or higher and adjust the pot until a stable reading can be obtained with the smallest input signal. With too small a signal the reading will drop from its correct value and vary randomly—or it may drop to zero. With optimum sensitivity the 95H90 becomes sensitive to random noise and will show a random reading on the last three digits with no signal applied.

When the pot has been adjusted for maximum sensitivity the 95H90 will run quite warm to the touch. This is normal.

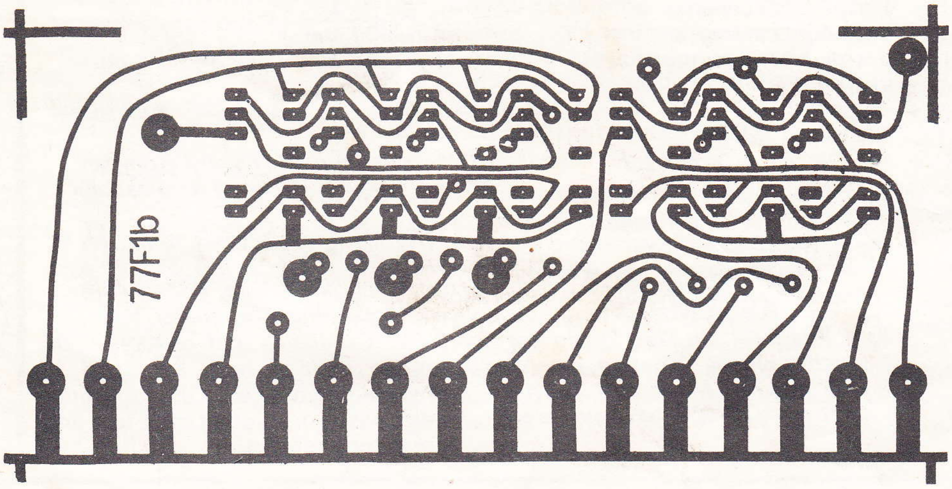
Calibration presents a problem. However without calibration the unit will have a typical accuracy of .01% ±1 count, which should be adequate for most applications. The easiest method is to calibrate the meter by making comparison measurements with a frequency counter of known accuracy. That is how we did it.

There are two other methods, neither of which we have tried. One is to use a crystal set tuned to a strong broadcast station and measure the signal when there is no modulation. This may be difficult and selectivity may present problems, but it could be worth trying.

The other method is to use a signal generator and a broadcast or short-wave receiver. Set the generator for zero beat against a station of known frequency (and precision). Then measure the output of the signal generator.

For the best result, the calibration should be carried out only after the counter has been on for an hour or so, to stablise its temperature. If the receiver is fitted with an "S" meter, this can be used to get closer to the true zero beat condition than if the audio output is used alone. The idea is to try and get the needle of the meter swinging as slowly as possible.

A brief note about using the frequency meter. A signal too high in frequency or insufficient in amplitude may result in a false reading or zero. The tip off is to watch the 2nd and 3rd most significant digits. If these vary, it is miscounting.



Here is an actual size reproduction of the display board pattern.