Lab Notes

An occasional series in which we discuss interesting circuit techniques, circuits we have tried in our own laboratory but not developed as a project, practical notes on projects, measurement techniques for hobbyists etc.

Getting the best from the ETI-140 1GHz DFM

SINCE IT WAS described in the March and April 1978 issues, this project has been very popular, reportedly many hundreds have been built.

The design has proved very sound, although some constructors have reported minor problems. This is gratifying considering the complexity of the project.

Here are a number of hints and tips to help you get the best from your instrument.

Minor errata

We should get this out of the way first.

In the table on page 87 of the March 1978 issue, the connections for IC42 should show pins 4 and 5 connected to the +5V rail, while pin 12 goes to OV (zero volts).

On the circuit diagram, p. 90 of the March 1978 issue, the reset output of IC37 (pin 5) is incorrectly labelled "Reset Button". This button actually connects to IC41 (a debounce circuit). The overlay is correct.

Crystal oscillator

The oscillator stability is the main limitation on ultimate performance, as would be expected. Experience indicates that, despite the crystal oven (which works quite well), temperature changes affecting the 74LS00 oscillator/driver affect the frequency of oscillation, limiting the accuracy to a few parts per million.

This is quite satisfactory for many purposes, but, where greater accuracy is required, particularly where the full display facilities are to be used to best advantage, then an 'add-on' high stability oscillator is recommended (see following notes).

It may be found that some crystals will not 'behave' in the circuit as published. The solution lies in tailoring some of the oscillator components to suit the crystal used.

For starters, R58 and R59 may be adjusted to give the correct drive level to the crystal. Reliable starting and improved stability result from a little 'juggling' of these resistors. Not all crystals have the same characteristics.

Too high or too low a drive level may cause unreliable starting and possible harmonic or sub-harmonic oscillation. (e.g. rather than the oscillator operating on 4 MHz as intended, it may produce 8 MHz or 2 MHz). In addition, too low a drive level increases frequency drift. The correct level is best found experimentally if you experience trouble in this department.

Note that capacitor C3 is a bypass intended to suppress harmonic operation of the oscillator. However, with some crystals it may bring about sub-harmonic oscillation!

From experience, some crystals require R58 and R59 to be 470 ohms and C3 to be left out for best operation of the oscillator/driver. Still others need these resistors to be at least 1k, C3 being retained in this case.

Additionally, it has been noted that the value of C4 may need to be increased to achieve correct operation on **frequency** and **period** modes. A value of 330 pF is suggested as a starting point.

Longer gate times

The standard gating time of one second (1.6 S on prescale) is a good compromise between accuracy and reading delay, chosen to suit the majority of applications envisaged for this instrument. Longer gating times of 10 seconds, or even 100 seconds, can be provided by adding extra stages to the divider chain. This is desirable at lower frequencies where resolution is the important factor.

If the extra stages are connected at the output of IC31 (pin 9), the range of the **time** and **period** functions will be increased, but, at the same time the resolution will be reduced. Low power Shottky devices — 74LS90s — are recommended. Note that CMOS 4518s require buffering to drive the 74S10, and are therefore impractical.

Sensitivity control

If you find it disconcerting that the **sensitivity** control operates opposite to the convention; i.e. maximum sensitivity is obtained when the control is wound fully anti-clockwise, this can be reversed as follows:

On the pc board cut the track connecting the centre pin of RV1 and connect the centre pin of the pot to the opposite pin instead.

For many applications, a linear pot will provide a more 'controlled' rate of attenuation.

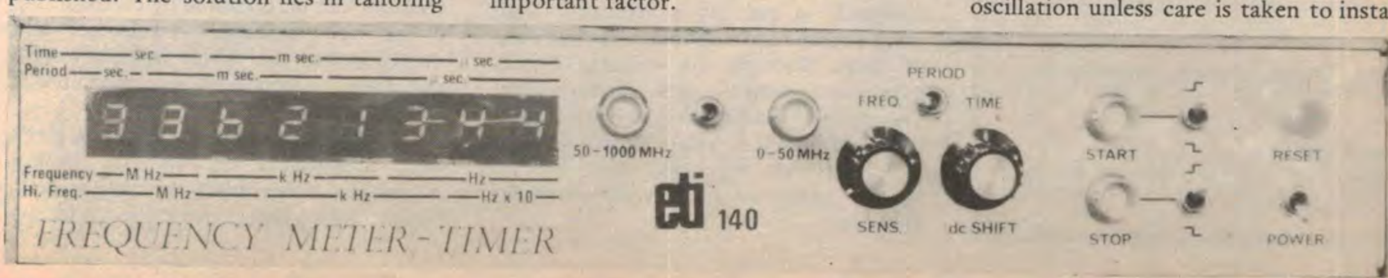
Note that the **DC shift** control is 'off' when it is centred.

Prescaler pointers

Constructers should follow stringent RF construction practices in order to avoid problems with the prescaler — particularly around the OM335.

Earth paths are critical at UHF. All components should be soldered both above and below the board where indicated, especially the earth leads of the OM335. This IC should mount right down on the pc board. Some ceramic material may need to be *carefully* scraped away from the pins at the component's body to enable successful soldering to the pins on the top side of the pc board.

As the OM335 provides a lot of gain in a small space the stage will tend to be unstable at best, breaking into oscillation unless care is taken to install ▶



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it correctly. If you experience instability problems, check the above points first. Then, adding an extension to the tinplate shield running alongside the OM335 (refer to the photographs in the original article). These measures should be completely effective.

The 'Maximum input' of 200 mVac specified for the ETI 140 refers to the input impedance of 75 ohms. Above this level the input protection diodes reduce the impedance. Specified maximum input to the OM335 itself is about 2.5 V. The diodes will protect it from most overloads, but to retain system impedance during measurements and to give the maximum overload safety margin, input level should be kept well below the specified maximum.

Fortunately, the sensitivity is so high, at least 20 mV at 50 MHz and improving with increasing frequency, that for most applications direct connection to a circuit is not necessary and a small pickup loop on the end of a coax lead is all that is required to obtain an adequate measurement.

Displays

The DL707 display specified is an industry standard and can be obtained under a variety of part numbers. Some of these, for example, are:
MAN72A
745-0017
TIL312
5082-7610
5082-7650

Some constructors who used the XAN3062 display, substituted for the DL707, found them unreliable. If DL707s are unavailable, any of the above may be substituted.

Power supply

Do not be bothered (. . . my little chicken – as the fairy story goes) that the transformer specified (Ferguson PL18/20VA) gets quite hot. This is not because it is overloaded, rather it is designed to run at a relatively high temperature. It conducts a fair amount of heat through the chassis, which, naturally enough, gets quite warm. The internal temperature remains within tolerable limits. If you're worried about it, either run the unit with the lid slightly raised or put ventilation holes in the lid.

General tips

When attaching the external wiring to the pc board, a little extra length will allow the board to be pivoted forward to allow access to the underside for service. Not shown in Figure 8 (April 78 issue, p.79) is an extra connection from point 'E' to the main board. The type 8168 pushbutton switch specified for PB1 has not been available for some time, due to production problems we are told. Type 8121 may be substituted. The connections are different but, referring to figures 8 and 16 in the April 1978 issue and the markings on the switch, correct wiring is readily ascertained.

When troubleshooting

The apparent complexity of the instrument may make the task of servicing or debugging seem daunting. However, if the unit is treated in its separate sections it becomes fairly straightforward.

Firstly, it is essential that the unit not be switched on without the earth lead from the chassis to the pc board earth pattern or the 9582 (IC42) will be damaged. If a prescaler is fitted the earth should go from a lug under the prescaler input socket to the earth pattern of the prescaler board – use a short, heavy lead.

A divider probe must be used when checking operation of the ECL devices with a CRO, otherwise oscillation may result. A 'x10' probe is recommended, but should not be used on the ECL/TTL translator.

Note that it is normal of ICs 42 to 45 and 47 to 49 to run hot.

Exercise care when removing ICs from the board to avoid damage. The safest way in the absence of special equipment is to use a solder sucker or 'solder wick' to remove solder.

Add-on crystal oscillator

Improved short-term and long-term stability can be obtained by constructing a separate oscillator and buffer and incorporating the whole assembly with the oven components suggested in the article on ETI 140.

A suitable oscillator circuit is given here. Capacitors C1 and C2 should be either silver mica or polystyrene types. Exact value is not critical and one value either side of those specified may be used. The two 10n (0.01 uF) bypass capacitors should be ceramic types. The output capacitor from the collector is best chosen by experiment, depending on the buffer used. More on this later.

The 2k2 resistor marked 'Rf' determines the level of feedback, and to a certain extent, affects the ultimate stability as it isolates the crystal from the active device and the load. It should be chosen such that reliable starting is obtained, with the highest tolerable value. One standard value lower than that determined by experiment for reliable oscillator starting is the best bet. Note that it may take some seconds for the oscillator output to appear and rise to maximum level following switch on with this circuit.

The 5-60 pF trimmer is used to set the frequency exactly. A miniature Philips film trimmer or (if you have the space) a mica compression trimmer should be used.

A CMOS Schmitt trigger, to provide logic level output, is recommended as a buffer. The coupling capacitor from the oscillator collector should be chosen to be as small a value as possible, consistent with reliable operation of the Schmitt trigger. A value of 100 pF is a good place to start.

All these measures isolate the crystal from the cruel vicissitudes of the 'outside world'.

The crystal, oscillator components, buffer and oven components should all be mounted in a thermally-insulated container – polystyrene foam blocks are ideal, as mentioned previously. The crystal should be mechanically (and thus thermally) connected to the oven components as detailed in the original article. Having some thermal linkage to the other components is also a good idea, however, this is left to the individual constructor's ingenuity.

Output from the buffer can be taken direct to the divider chain.

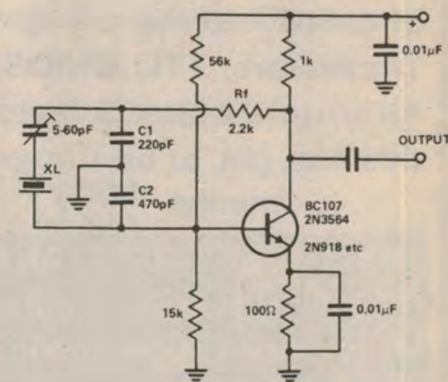
Only common and +5 V supply are the other connections necessary.

Crystal specifications

No specifications were given in the original article for the crystal. Not all crystals are the same. The following set of specifications is recommended.

Frequency:
 4.0000 MHz
Manufacturing tolerance:
 +/- 20 ppm
Temperature tolerance:
 +/- 20 ppm,
 -10 to +55°C
 (or 0 to +60°C)
Load capacitance:
 32 pF (or 30 pF)

The crystal can be obtained in either the HC6/U (13 mm pin spacing) or the smaller HC18/U package – the latter is preferred for space reasons. Either pins or flying leads may be ordered for the crystal connections. ●



The assistance and cooperation of John Rileagh, of JR Components, in preparing these notes on the ETI 140 DFM is greatly appreciated.