Solid-state modulated RF test oscillator

compact design covers 455kHz-30MHz

This little modulated RF oscillator covers the range from 455kHz to 30MHz in four switched bands. It is compact, relatively easy to build and should be of interest to radio amateurs, servicemen, hobbyists and anyone requiring a reliable source of RF for alignment and other purposes.

by IAN POGSON

It is a long time since we last described a simple RF oscillator — 11 years in fact. The last one was in March 1968, so it is with some justification that we have been asked in recent times to present a new one.

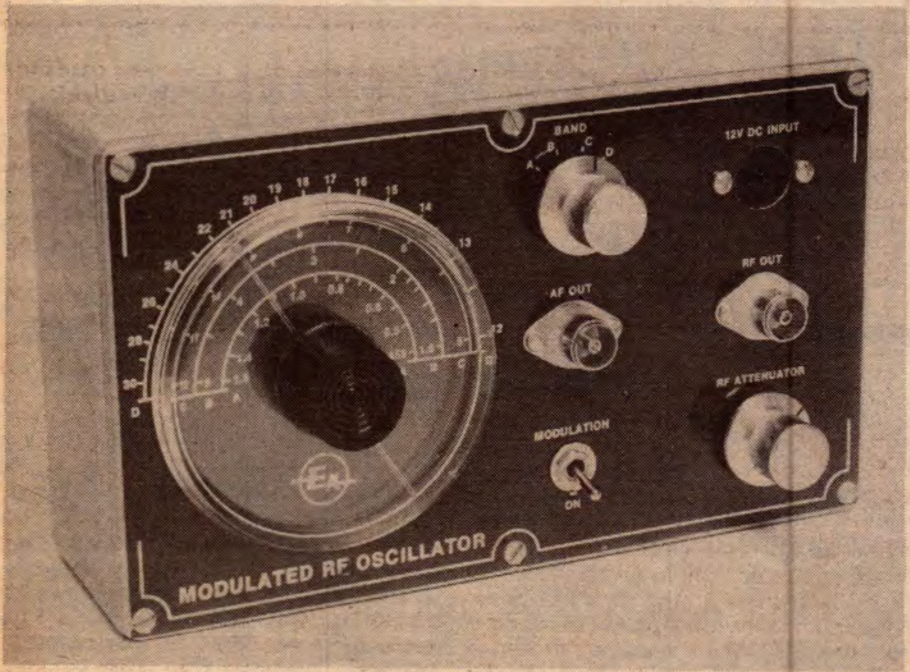
The March 1968 design as such has not dated dramatically, but due to the passage of time, the availability of parts has inevitably changed. As a result anyone interested in building this particular unit is likely to find problems. With this in mind, we have come up with what we think is a worthy successor, using parts which are currently in good supply.

The general approach we have used was to follow the same broad design, with a bandswitched RF oscillator followed by a buffer stage optionally modulated by the output of a fixed frequency audio oscillator. A simple attenuator controls the RF output. The output of the audio oscillator is also available separately from its own output socket. While operation has been arranged from an external mains derived power supply, it can also be operated from a battery source.

So that the RF output attenuator will have some real meaning, it has been necessary to consider the matter of RF leakage from the instrument. This is not an easy one to solve with a simple unit, but by using a diecast metal box and taking some other precautions, we have managed to keep leakage to a tolerable level. It should be realised that with a simple instrument such as this, it is not possible to make tests like absolute sensitivity measurements on receivers. But short of this, general alignment and adjustments can be made quite readily.

Let us now have a look at the circuit in more detail. The oscillator uses two JFETs in the source-coupled configuration, with feedback from the second drain to the first gate via a 4.7pF ceramic capacitor. The drain of the first JFET is grounded to RF, while the second one has a complex load consisting of a 10mH RF inductor in series with a 470uH RF inductor which is shunted with a 15k resistor. The two different values of inductor are used to help in maintaining a reasonably constant RF output across the range of interest. The shunting resistor is to avoid an unwanted resonance.

Our main reasons for using the source coupled oscillator are that it is simple and allows the use of coils with only one winding and without a tapping. Four coils are required to cover the range. The lowest frequency coil is a ready wound one normally used in broadcast receivers, while the other three coils have to be wound; details are given in the table. Tuning is by



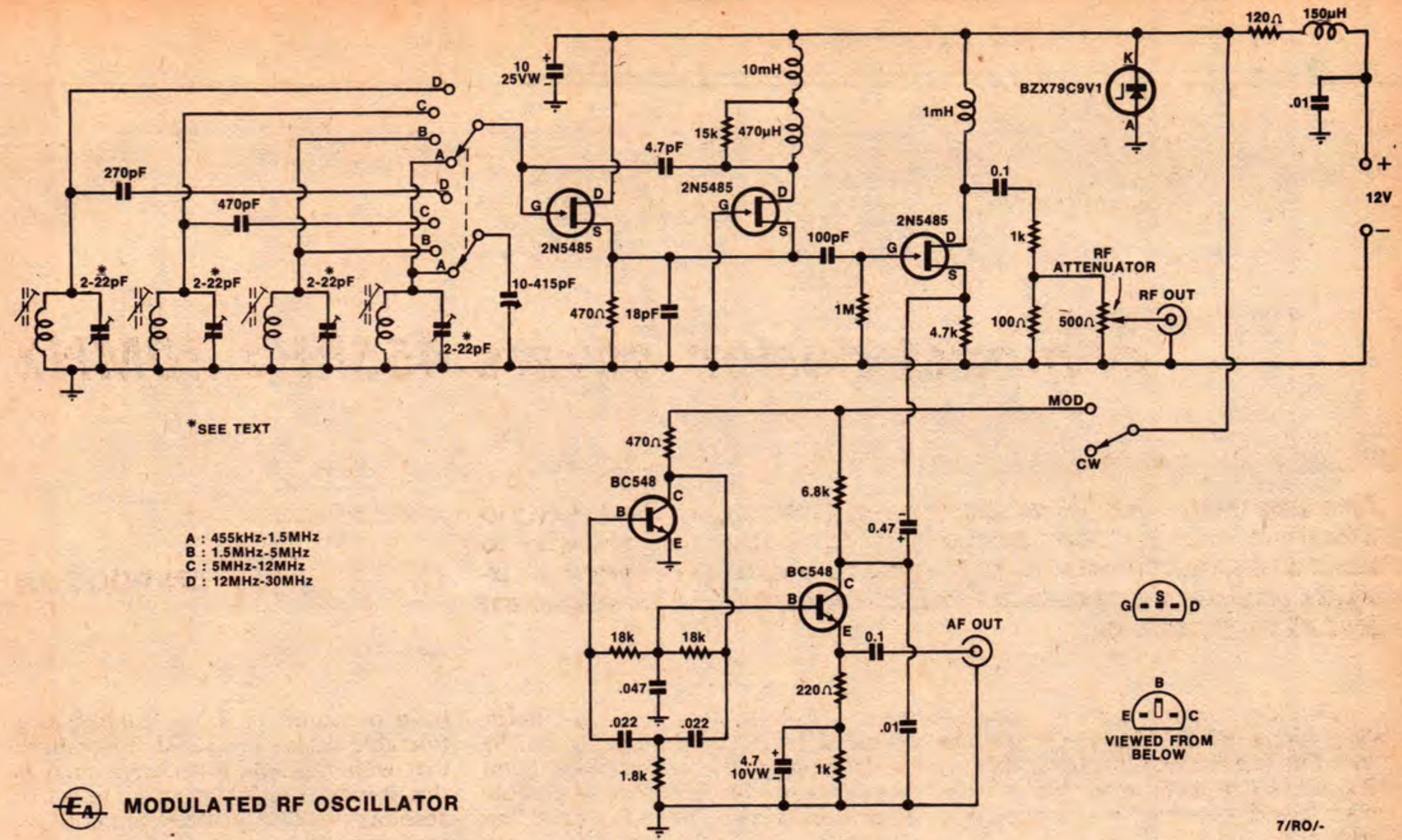
The prototype oscillator was built into a metal diecast box.

Estimated cost

We estimate that the current cost of parts for this project is approximately

$50

This includes sales tax.



MODULATED RF OSCILLATOR

means of a standard Roblan 10-415pF single gang capacitor and the two higher frequency bands are restricted by series capacitors of 470pF and 270pF to prevent them becoming too cramped. Adjustment for each band is by means of trimmers and the slugs in the coils.

Output from the oscillator is taken from the 470 ohm common source resistor via a 100pF capacitor to the gate of a third JFET, which performs the functions of buffer and modulated amplifier. The buffering function has the desirable effect of isolating the oscillator from the output, thereby reducing oscillator frequency shift due to varying output loading.

RF output is taken from the buffer's 1mH drain load, via a 0.1uF capacitor and a 1k resistor. This feeds the 500 ohm potentiometer, shunted with a 100 ohm resistor, which forms the output attenuator. The combination gives a source resistance of about 80 ohms. The maximum RF output varies somewhat over the full range, but it averages about 100mV.

The audio oscillator is a "twin-T" type using a BC548 bipolar transistor. A reasonably good sine wave is available from the .047uF capacitor and this is DC coupled into another BC548 transistor which acts as an amplifier and buffer. The output from the collector is fed via a 0.47uF tantalum capacitor to modulate the source of the 2N5485. This gives an approximate modulation level of 30%. Audio frequency output is taken from the 220 ohm emitter resistor of the BC548 amplifier. The audio frequency of the prototype was measured at 780Hz with an RMS level of 320mV.

Coil winding details:

Band A: Jabel type 7211 2nd RF bandpass coil, or equivalent.
Band B: 100 turns 36B&S enamel, 2 layers of 50 turns each close wound, separated with layer of tape, on Neosid 5mm former, with slug and can. (SMS type A assemblies, without ferrite ring and cup). Terminate on pins 1 and 2, corresponding with used positions on printed board.
Band C: Same as "B" but with 35 turns.
Band D: Same as "B" but with 15 turns 28B&S enamel.

A source of 12 to 14VDC is fed into the unit via the socket provided. At the socket is a .01uF ceramic bypass capacitor. This is followed by a 150uH RF inductor swung between the socket and the appropriate point on the printed board. These items are added to reduce the possibility of RF leakage via the DC supply leads. On the board are provided a 120 ohm resistor and a 9.1V zener diode. They provide voltage regulation for the unit, thereby reducing the possibility of frequency shift due to supply voltage variations.

It should be noted that if some readers may wish to supply the unit with a voltage higher than about 14V, then the 120 ohm resistor should be increased accordingly so as not to exceed the dissipation rating of the zener diode. The maximum power dissipation of the BZX79C9V1 zener diode is 400mW. The total current taken by the prototype was measured at 24mA.

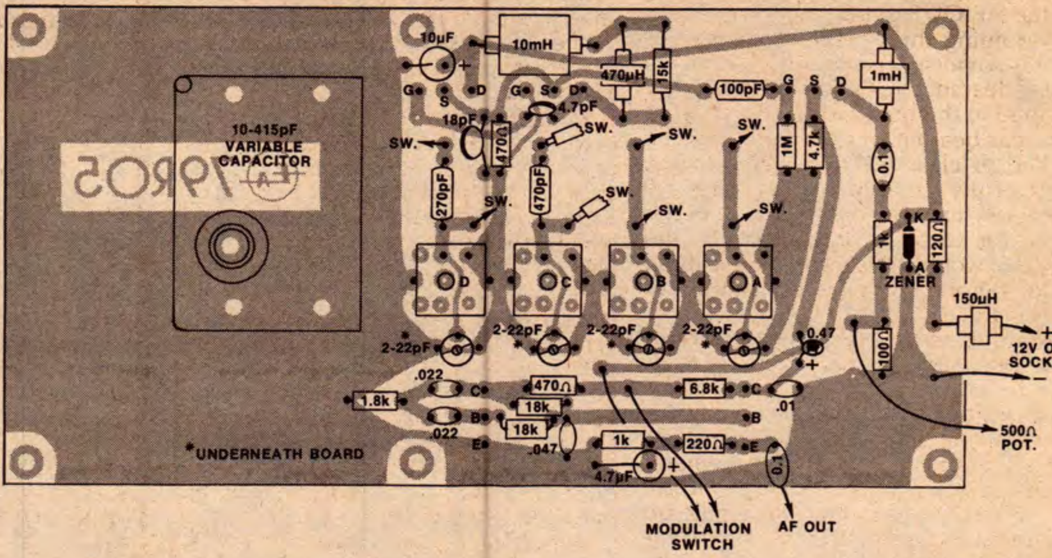
Earlier I mentioned that it has been necessary to design the new oscillator to suit the parts currently available. At the time of writing, all components are available but some items may need some clarification as regards the sources of supply. The diecast metal box is available from Dick Smith stores and may also be available from some other suppliers.

As usual, copies of the artworks for the printed board and the front panel label will be distributed to various suppliers and these items should be readily available.

The type 7211 coil, coil components, "Handspan" dial knob and the Roblan variable capacitor are all distributed by Watkin Wynne Pty Ltd, 32 Falcon Street, Crows Nest, NSW 2065. They may be obtained direct or through most other components stockists.

The four trimmers are shown on the circuit as the 2-22pF Philips plastic dielectric type. This type may be used, but there are some alternative ceramic types currently easier to obtain and they are physically compatible, fitting

This component overlay diagram shows the PC board as viewed from the component side. Note that the trimmer capacitors (marked with an asterisk) are mounted on the copper side of the board.

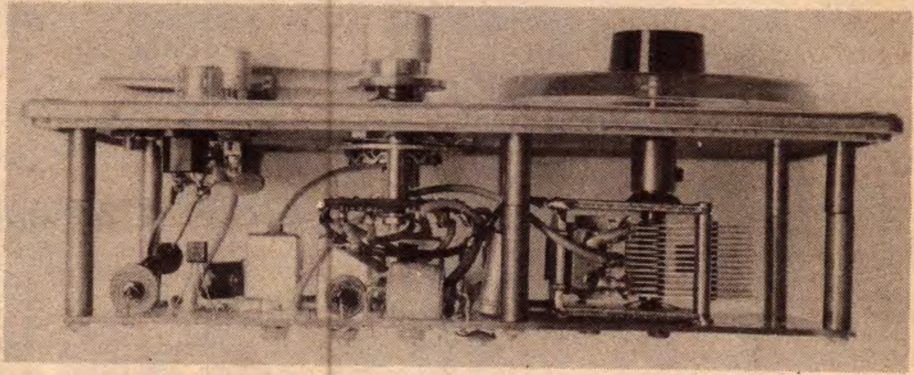


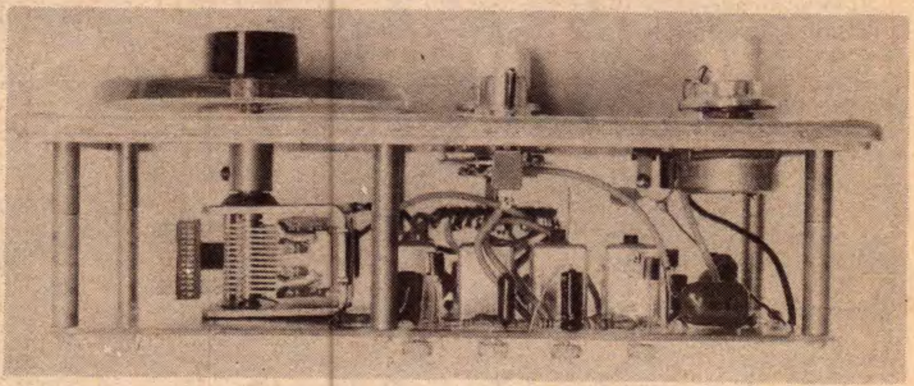
the board just the same as the Philips ones. However, the actual capacitance values available differ from the specified 2-22pF. In point of fact, we used ceramic 3.5-13pF units and these are available from Radio Despatch Service, 869 George Street, Sydney, NSW 2000. We understand that Dick Smith Electronics can also supply this type.

The rotary switch is a standard type and should be available from most stockists. The 500 ohm potentiometer is also a standard type, but it should be stressed that a carbon type should be used — not a wire wound one.

The coverage of each of the four ranges has been arrived at after some thought. It was found to be possible to get down to 455kHz with the available tuning capacitor and lowest-band coil, if the upper frequency was limited to 1500kHz. This was decided upon, with the second range starting at 1.5MHz and going to 5MHz. The third range covers from 5 to 12MHz and the fourth range, 12 to 30MHz.

Although we have taken some steps to reduce RF leakage, there is still a noticeable amount. I consider it largely due to leakage across the 500 ohm potentiometer, even when it is turned right off. Checked against a good quality signal generator, the leakage amounts to about 20uV.





These two views show the instrument as viewed from the top and the bottom, respectively. The PC board is stood off the front panel with brass spacers.

Construction, while it is not difficult, calls for a certain amount of care. The usual precautions should be taken with regard to soldering. A good hot, clean iron should be used, taking care to make good soldered joints, without overheating and possibly damaging vital components. All components should be checked that they are the correct ones before each is fixed on the board. Also, due regard should be given to polarities where this is applicable.

In addition to the above points to be observed, there are some other points more or less peculiar to this project which should also be observed. These points will be covered as we go along.

It is a good idea to wind the three higher-band coils before going ahead with the main assembly. Details for the coils are given in the table. The windings should be done such that the windings are mechanically stable. They should be wound firmly and fixed with some paraffin wax or cellulose lacquer. Termination of the windings should coincide with the connections on the printed board. When the coils have been wound, they are fitted into the can and the can crimped to hold the coil in place.

Assembly of the board is next. It is generally best to start with the small components first, gradually working up to the larger ones. It is important to note that the four trimmers are mounted on the copper side of the board. Also, the 150uH RF choke should be left off for the time being. This also applies to the 0.1uF capacitor at the AF OUT point.

Mounting the variable capacitor requires some special attention. Firstly, a large clearance hole must be drilled or reamed in the board to clear the nut of the rear bearing. Also, a hole must be drilled to clear the rivet head on the back of the capacitor. These holes are necessary to allow the back face of the capacitor to sit on the board. By the way, it would be better to drill these holes before starting the assembly of the board.

Another consideration when mounting the variable capacitor relates to its spindle lining up with the centre of the hole in the front panel. It may be necessary to use some washers to do some judicious packing here and there, to achieve this condition. Finally, it will be necessary to shorten the spindle on the variable capacitor and fit an extension shaft, also cut to length as required.

Having taken the board assembly this far, with the variable capacitor left off to allow easier handling for some further operations, the brass spacers may be fitted. You will notice that we have six spacers 1in long and another six ¾in long. The reason for this is that we needed six spacers 1¾in long but these were not readily available. (If you are able to make your own then so much the better.) The spacers were joined together with some ½in Whitworth screws with the heads removed. These were used as joiners by inserting half of the thread into one end each of a 1in and a ¾in spacer. The joined spacers are then screwed to the printed board.

We will assume that the front panel is ready with all holes drilled. The rotary bandswitch may be mounted and put aside for the moment. Now fix hookup wires to each of the points of the board which have to go to the switch. You have the option as to whether you use both holes with leads from pin 2 of coils for bands A and B, or use a jumper across the switch lugs and only use one of the points on the board. Also, shielded leads, using insulated audio type coaxial cable, should be used for band C. This is done to prevent "suckout" from the adjacent band D, with consequent upsetting of the oscillator at the particular frequency.

Now offer the front panel with switch to the spacers and use the two middle spacers to screw the board to the panel for the next operation. The leads from the board have to be cut to length and soldered to the lugs of the switch. This is a bit tricky, but by giving each lead some thought and working out the order in which they are terminated, it may be done without any great problems.

It is important that the leads be kept

PARTS LIST

1 Diecast aluminium box 190mm x 60mm x 110mm.
1. Lettered front panel (see text).
1 Handspan dial knob
2 Knobs
2 Belling Lee coaxial sockets
1 2-pin speaker socket.
1 2-pin plug for above.
1 Miniature SPDT toggle switch.
1 2-pole 5-position rotary switch
1 500 ohm linear potentiometer.
6 Brass spacers, 1in long tapped ⅛in Whitworth
6 Brass spacers, ¾in long tapped ⅛in Whitworth
1 Printed circuit board 178mm x 89mm, code 79R05.
1 Roblan 10-415pF single gang capacitor
1 150uH RF inductor.
1 470uH RF inductor.
1 1mH inductor.
1 10mH RF inductor.
1 Jabel type 7211 2nd RF bandpass coil
3 Neosid coil former assemblies, SMS type A.
3 2N5485 transistors
2 BC548 transistors
1 BZX79C9V1 zener diode

CAPACITORS
1 4.7pF NPO ceramic
1 18pF NPO ceramic
4 2-22pF Philips trimmers (see text).
1 100pF polystyrene.
1 270pF polystyrene.
1 470pF polystyrene.
2 .01uf greencap.
2 .022uF greencap
1 .047uF greencap
2 0.1uF greencap
1 0.47uF 35VW tantalum
1 4.7uF 10VW electrolytic
1 10uF 25VW electrolytic

RESISTORS (½ watt)
1 x 100 ohm, 1 x 120 ohm, 1 x 220 ohm, 2 x 470 ohm, 2 x 1k, 1 x 1.8k, 1 x 4.7k, 1 x 6.8k, 1 x 15k, 2 x 18k, 1 x 1M.

MISCELLANEOUS
Hookup wire, solder, solder lugs, audio type coax cable, screws, nuts, enamelled wire for coils.

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used in the prototype. Components with higher ratings may generally be used provided they are physically compatible. Components with lower ratings may also be used in some cases, provided the ratings are not exceeded.

as short as possible. The shielded leads are only earthed at the switch end. Connect the shields together with a piece of hookup wire and then run from the connection nearest the variable capacitor position, with another piece of hookup wire, which will be soldered to the frame of the variable capacitor later on.

Having got the switch wired up, the rest is quite easy. The switch should now be unscrewed from the front panel and allowed to be supported by the leads for the time being. The front panel is now removed from the stand-offs.

Mount the two coaxial sockets, the DC input socket, the toggle switch and the potentiometer on the panel. Put a solder lug under the nut which holds the DC input socket nearest the switch. A .01uF ceramic capacitor is connected between the lug and the +12V terminal on the socket. Also, a lug is fitted under the nut of the RF OUT socket which is nearest the end of the panel. This lug is soldered directly to the nearest lug on the 500 ohm potentiometer. Then another solder lug is used to make the connection between the centre conductor of the coax socket to the centre lug of the potentiometer.

Before proceeding with the connections between the board and the panel components just dealt with, the variable capacitor should be installed. First of all the spindle should be shortened so that when the boss of the extension spindle is fitted it will just touch the body of the capacitor, although a slight clearance should be observed when finally fitted. By temporarily fitting the panel, the length of the extension spindle required to suit the handspan knob may be found. The spindle should then be cut to this length.

At this stage, the variable capacitor should be mounted permanently on the board, making whatever adjustments which may be necessary to ensure that the spindle passes through the centre of the hole in the front panel. With the front panel in position, you should have a clearance between the end of the extension spindle boss and the inside face of the panel of between 1 and 2mm. It is necessary to make electrical contact at this point between the boss and the panel. We took a flat washer and dished it so that when it was dropped over the spindle and the front panel fixed in place, the washer should make a sliding contact as required.

With the variable capacitor installed, the rest of the leads from the board to the components on the panel may be added. In the case of the AF output, a 0.1uF capacitor is run between the board and the socket, while a 150uH RF inductor is run from the +12V DC input socket to the board. Another point is that the -12V DC lug on the socket is connected to the earth point on the board, as shown in the wiring diagram.

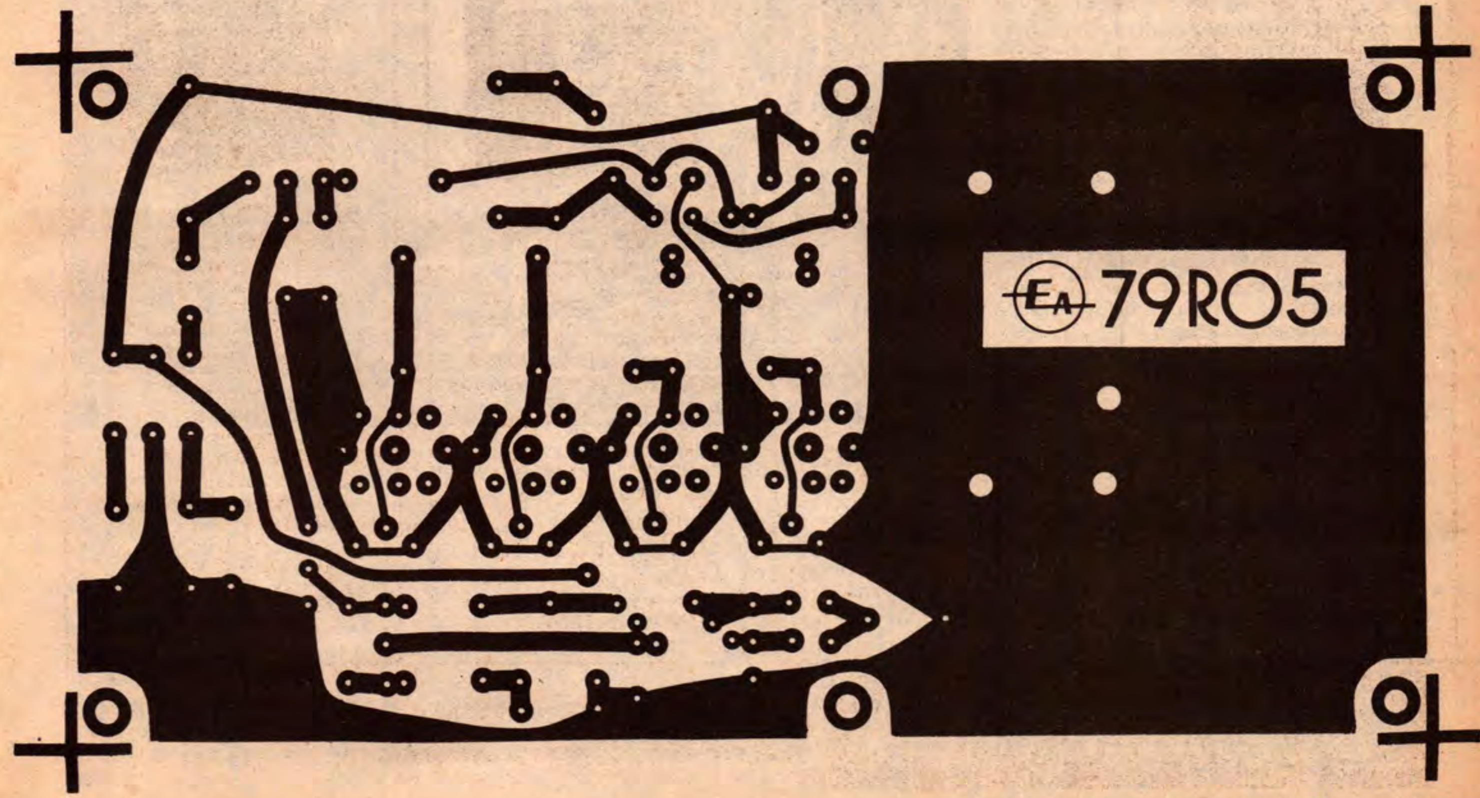
With the instrument completed, a power supply is needed. Any suitable source of 12 to 14V DC should be satisfactory. It is a good idea to shield the positive lead and some audio type coaxial lead will achieve this. This precaution should help to keep RF leakage to a minimum.

A convenient power source is the Ferguson Power Point Adaptor, type PPA9DC. With the load involved here this unit gives between 12 and 14V into the oscillator. An equivalent Plug Pak made by A & R Transformers should also be satisfactory, although we have not tried one at this stage.

Preliminary checks should be made to ensure that all is well before switching on. After switching on the power supply, it should then be established that the unit is working properly by listening on a suitable receiver. Assuming that signals may be heard at various frequencies on the receiver, the instrument is ready to be calibrated.

If you are fortunate enough to have access to a frequency counter or a well-calibrated RF signal generator, then either could be used for calibration. An alternative method, and one which is possibly not so accurate, is to calibrate against the dial on a broadcast and short wave receiver.

Below is an actual size reproduction of the PC pattern.



RF oscillator

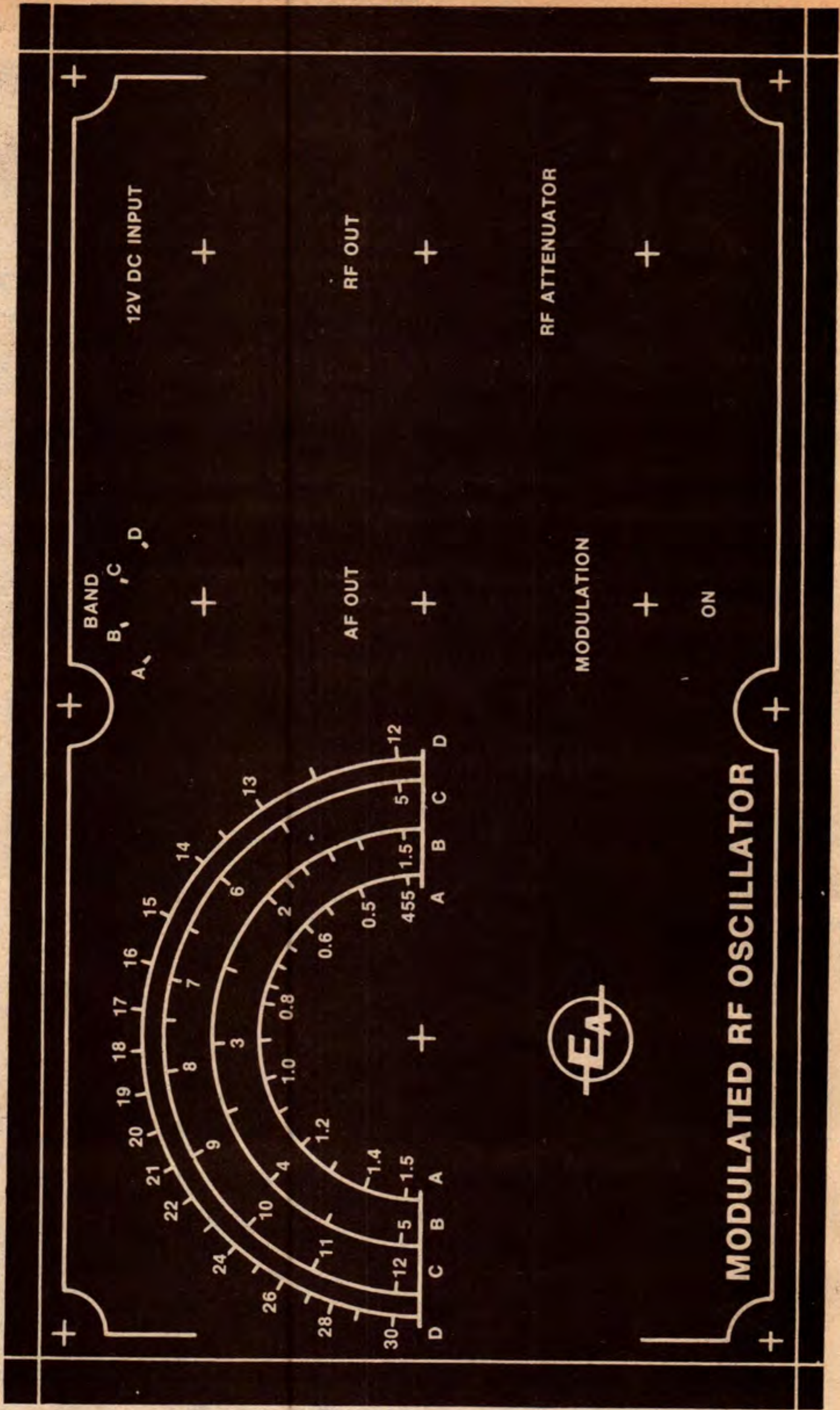
For the purposes of calibration we will assume that you are using a copy of the front panel used on the prototype, with its calibration markings. Before starting the calibration process, make sure that the line on the dial knob is lined up with the scale base line, with the capacitor fully meshed.

All calibrations must be carried out by taking readings with the unit in its box — the panel fixing screws are omitted for this operation. The unit must be removed from its box each time to make adjustments to the appropriate slug or trimmer. The reason for this inconvenience is that no holes have been provided in the box to gain access to these adjustments, in order to keep RF leakage to a minimum.

To calibrate with a frequency counter, turn the modulation off and feed the output of the oscillator into the counter. Start with the low frequency end of band "A" and set the oscillator dial to 455kHz. The slug in the appropriate coil is adjusted until the correct reading is obtained. Now set the dial to the other end of the band, to 1.5MHz, and adjust the appropriate trimmer until the correct reading is obtained. This process must be repeated at each end of the band until both readings are correct. The three subsequent bands are treated in the same way.

You may run into a problem up on the higher frequencies, where there may not be enough output from the oscillator to give a reliable reading on the counter. This may generally be avoided by taking the output temporarily from the junction of the 1mH RF inductor and the drain of the 2N5485.

If you wish to do the calibrating against a good RF signal generator, then a receiver covering the full range will be required. The RF generator output and the output of the oscillator will need to be loosely coupled into the aerial terminal of the receiver. This will need to be determined experimentally. The RF generator is set to the wanted frequency and tuned on the receiver. The oscillator, also set to the wanted frequency is adjusted with the slugs and trimmers in turn, until zero beat is obtained. The overall procedure is then the same as for the frequency counter.



Here is an actual size reproduction of the front panel.

Before proceeding, there is one point which must be considered with the above method. Very few receivers can be tuned to 455kHz and the method of calibrating 455kHz against such a receiver is to use the second harmonic. The receiver is tuned to twice 455kHz, or 910kHz and the 455kHz point is calibrated in this way.

To calibrate against a receiver, similar to the one mentioned above, the slugs and trimmers of the oscillator should be adjusted as previously described, so that the calibrations on the oscillator dial correspond with those on the receiver. To make sure that you are tuned to the signal from the oscillator, the modulation may be switched on and off to give this assurance.

When using a receiver for calibration purposes, it will more than likely be a superheterodyne. This being the case the possibility of errors due to "image" responses should not be overlooked. The two receiver responses are separated by twice the IF of the receiver. In the usual case of a 455kHz IF, the two responses will be 910kHz apart. The true or wanted response is usually that which corresponds to the lower oscillator frequency, or the higher of the two receiver dial readings.