Winner of the EA-Parameters project competition

Audio impedance meter

Part 2

Last month, we detailed the performance characteristics of this new audio impedance meter, and described the circuit. In this second article we present the constructional details, and describe how the completed instrument is used.

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The only part of the circuit left to describe is the power supply, which consists of two type 216 9V batteries, and double-pole switch S4. The writer originally intended the power supply to be 9 volts total, so that a package supply could be used, but there was insufficient AC drive to the coupling transformer at this voltage. The drain from each battery is close to 8mA so, unless the unit is left switched on for long periods, the batteries will last a good while. Rechargeable cells in this size are now available if you are prepared to pay the price.

The instrument is built in a 196 x 112 x 60mm plastic box with aluminium panel, and both are easy to drill, ream, or file. A Scotchcal panel can be made from the panel drawing (Fig. 5a). The components, aside from panel controls, meter, batteries terminals and three resistors, are mounted on a 55mm x 155mm PCB. Fibreglass is the preferred material for this board since insulation resistance, particularly around the inputs to ICs 3 and 4, should be as high as possible.

The PCB is attached on the front panel with two angle brackets and the board mounting has been arranged to keep the leads from S2 to the multiplier resistors to a minimum length. The angle brackets are in turn attached to the front panel by machine screws, one of which must be countersunk to clear the potentiometer knob. Put a solder lug under one of these brackets, and run a wire to the PCB earth strip, to earth the front panel. The measuring terminals are mounted in the left-hand end of the box, in line with the front panel marks, on ¾in centres to accommodate a 2-pin banana plug.

The oscillator frequency switch, and input jack for the signal generator, are mounted in the right-hand end of the box. This allows the oscillator to be deleted without altering the panel layout. The prototype employed Dymo labels for the frequency selection, but a Scotchcal label could be made from Fig. 5b.

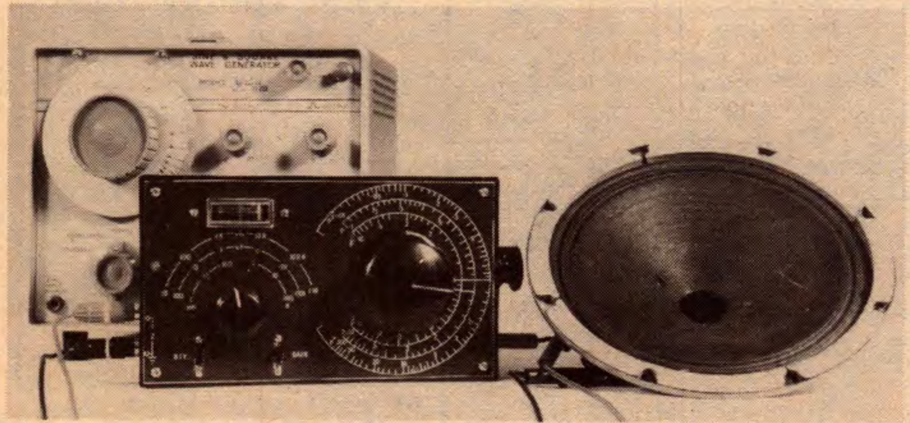
If the gain potentiometer option is preferred, simply drill a hole for the pot. shaft, using the centre of the gain switch cutout as the drilling point. The panel lettering is arranged to allow the lettering "HI" and "LO" to be obscured by the pot. knob. Because of the gain control options, resistors R15, R16 and R17 are not on the PCB; they are mounted on a small lug strip, which is secured to the front panel by slipping the strip mounting lug under the switch mounting flange, and putting the switch screw through both.

For the gain pot., the only resistor to be accommodated is R17, and this can be soldered between the pot. lug and the pot. case, care being taken to ensure that the case is earthed to the front panel. If in doubt, run an earth wire from the case to the PCB. The batteries can be held in the bottom of the plastic case by a small bracket made of aluminium strip.

In an effort to be a little different, the ratio dial pointer is made from a pin, fastened to the underside of the knob skirt with contact cement. Make sure the shaft of the pin is accurately aligned with the white pointer line on the knob. If desired the pointer could be made from a scrap of perspex with a line scribed on it.

Take care with the assembly of ratio pot. P4, because the accuracy of the instrument depends on it. The dial pointer must align accurately with the end stop marks on the dials, and the pot. shaft must be absolutely concentric with the dial scale. Check this by noting whether the tip of the pointer remains concentric with the scale as the knob is rotated. Take care also with the wiring from the PCB to the various switches.

The leads from S2 to the multiplier resistors R7 to R12, the trimpot P6, and the trimmer C12, must be kept as short as possible. It is also desirable that the leads to the switch S1 be kept short, although trouble will be experienced in fitting S1 into the case if these leads are



Typical test set-up using the new instrument. Here the impedance of a loudspeaker is being measured at various frequencies provided by an audio oscillator.

cut to the bare minimum. An average length of 50 to 70mm seems a reasonable compromise.

The lead from the PCB to the hot side of the test terminals should also be kept as short as possible. The writer first wired this in shielded cable, but found that the cable capacitance affected the calibration severely at high frequencies. Use small-diameter hookup wire for this lead.

Coming now to the calibration and use of the meter, the first step is to set the oscillator gain pot. This is best done using an oscilloscope. With S1 set to F1, put the probe on the output of IC1, and adjust P1 until oscillation just occurs, with little or no visible distortion. Switch to F2, and again check the waveform. If an oscilloscope is not available, simply turn on the meter with the Z terminals open circuit, and set P1 on minimum gain. (Pot. moving contact at earth end.) Slowly increase P1 until the meter deflects suddenly to one side. Check that the meter deflects on both F1 and F2. If not, increase the setting of P1 a little.

Next, set the buffer amplifier gain. Put a resistor across the Z terminals, and roughly balance the meter. With the oscilloscope probe on the hot Z terminal, adjust P2 for maximum output without visible clipping of the waveform. Without an oscilloscope, put a resistor across the Z terminals, and adjust the controls until the meter is nearly, but not quite, balanced. Now adjust P2 for minimum meter deflection, then slowly increase it again while watching the meter. A point will be reached at which the meter deflection will remain constant despite increases in P2. Set P2 just below this point.

If the oscillator has been omitted, a slightly different procedure is required. Adjust P2 for minimum gain (minimum meter deflection or oscilloscope signal), then slowly advance the signal generator output control, until waveform clipping occurs or meter deflection ceases. Back the output off a little and note the output control setting. This will be the maximum permissible level, and will give the most linear calibration, although voltages less than this can be used.

Now for the ratio dial calibration. You will need three close-tolerance resistors with values of 100 ohms, 10 kilohms, and 1 megohm. Put the 100 ohm resistor across the Z terminals and set Rm to the 1 kilohm position. Set the ratio dial to 0.1 on the P scale and adjust P5 to null the meter. (If the null occurs at the other end of the scale, reverse the end connections to P4, then repeat the adjustment.) Now put the 10 kilohm resistor across the terminals, turn the dial to 10.0, and adjust P3 to null the meter. This may upset the 100 ohm adjustment a little, so repeat these steps several times.

All that remains is calibration of the 1 megohm range, which is best done using a signal generator. Before beginning the calibration, the signal generator output voltage must be set as described above. With the 1 megohm resistor across the Z terminals, adjust the signal generator to 100Hz, switch to the 1 megohm range and set the ratio dial to 1. Adjust P6 until the meter nulls. Set the signal generator to 10kHz and adjust C12 to null the meter again. If the meter will not null, reduce the frequency to 5kHz and re-adjust C12. If a signal generator is unavailable, set P6 in the F1 position and C12 in the F2 position. Your Meter is now calibrated.

RESISTANCE MEASUREMENT: Simply place the unknown resistor across the Z terminals, and adjust the multiplier switch and ratio pot. dial until the meter nulls. Read the value from the resistance scale on the multiplier, and the P scale on the pot.

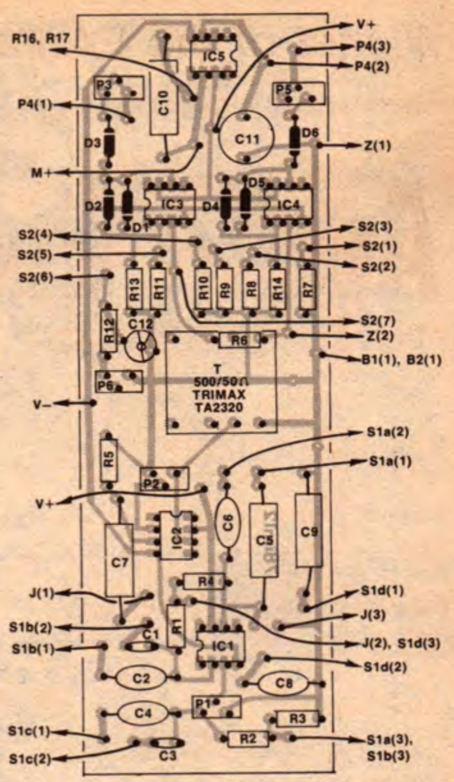
Example:
The multiplier switch is set to 1 kilohm. The ratio dial reads 0.3 on the P scale. The resistance value is 1 kilohm x 0.3 = 300 ohms.

Either F1 or F2 may be used, or any signal generator frequency from 10Hz to 10kHz. For extreme high and low resistance, consult calibration charts.

IMPEDANCE MEASUREMENT: Place the unknown impedance across Z, and adjust the dial for balance, using the ohms scale and P scale as above. Use a signal generator if the impedance at a particular frequency is desired.

INDUCTANCE MEASUREMENT: The 2-frequency measurement of inductance is, with a little practice, easier to do than to describe. Follow these steps:

a. Turn the oscillator switch to F2, or adjust the signal generator to 1590Hz.
b. Adjust the dials for a null setting, and read the value on the P^2 scale.
c. Turn the oscillator switch to F1, or adjust the signal generator to 159Hz.
d. Again null the meter, and read the value of P^2. If it is necessary to change the multiplier switch to obtain the second null, repeat steps (a) to (d), using the next higher or lower position of Rm, as required.
e. Subtract the reading obtained in (d) from the reading obtained in (b). Turn the knob to this value on the P^2 scale.
f. Read the value under the pointer on the P scale.
g. Multiply this number by the inductance reading on the multiplier scale.
Example:
Reading at F2 — The multiplier switch is set to 10 henries. The ratio dial reads 6 on the P^2 scale.
Reading at F1 — The multiplier switch is set to 10 henries. The ratio dial reads 2 on the P^2 scale.
Subtract 2 from 6: 6 - 2 = 4.
Turn the dial to P^2 = 4.

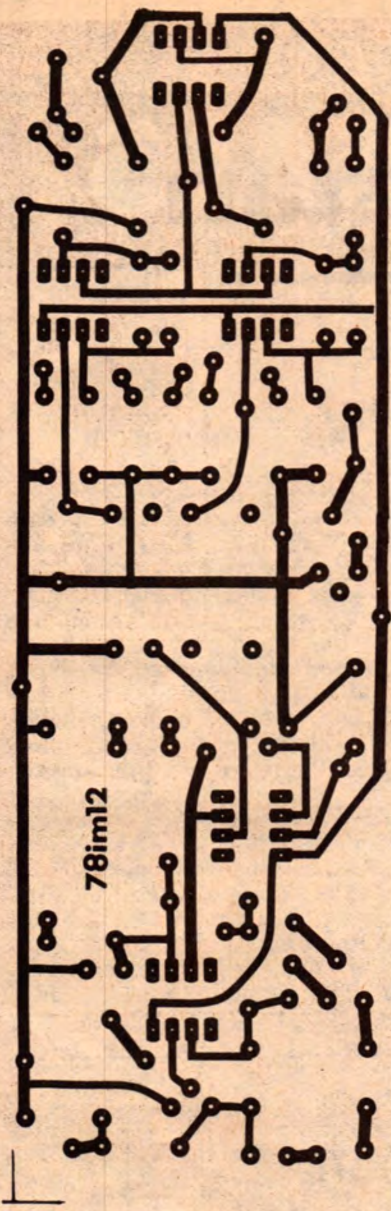


Layout of components on the PC board. Note that resistor R6 is soldered directly across the transformer terminals.

Read the corresponding point on the P scale. P = 2. Therefore the value of the inductance is 10 henries x 2 = 20 henries.

CAPACITANCE MEASUREMENTS: For capacitors with negligible leakage, which is the usual case, follow these steps:

a. Turn the oscillator to F1, or adjust the signal generator to 159Hz.
b. Adjust the dials for a null setting, and read the value on the 1/P scale.
c. Then the value of the capacitor can be read from the capacitance scale on the multiplier, and the 1/P scale on the pot.
Example:
The multiplier switch is set to 10 uF.
The ratio dial reads 0.2 on the 1/P scale.
The capacitance or value is 10uF x 0.2 = 2uF.
If leakage is suspected, repeat (a) and (b) above, reading the value on the P^2 scale. Then proceed as follows:—
d. Turn to F2, or set the signal generator to 1590Hz.
e. Null the meter, and again read the value of P^2.
f. Subtract the second reading from the first, and set the dial to the resultant, on the P^2 scale.
g. Read the value under the pointer on the 1/P scale, and multiply it by the capacitance reading on Rm.



Actual size reproductions of the PC pattern and the front and side panels.

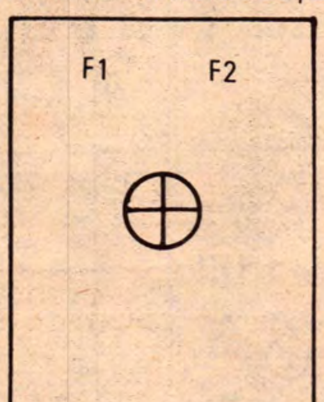


FIG. 5b

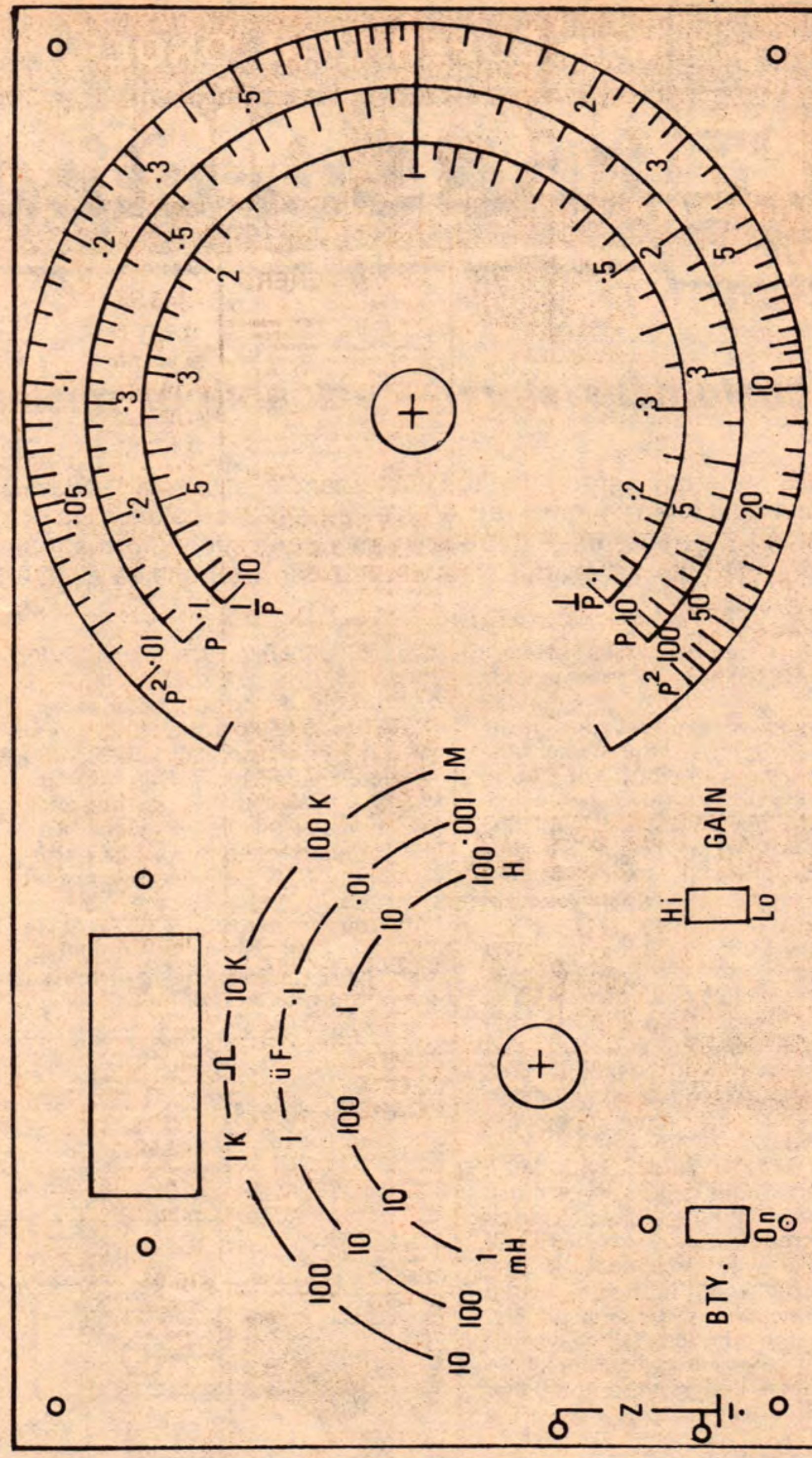


FIG. 5a

Example:—
Reading at F1 — The multiplier is set to 0.1uF. The ratio dial reads 1.0 on the P^2 scale.
Reading at F2 — The multiplier is set to 0.1uF. The ratio dial reads 0.2 on the P^2 scale.
Subtract 0.2 from 1.0: 1—0.2 = 0.8.
Turn the diai to P^2 = 0.8.
The corresponding point on the 1/P scale is 1.1.
Then the value of the capacitor is 0.1uF x 1.1 = 0.11uF.

RESONANT FREQUENCY MEASUREMENT: Using the signal generator, adjust its frequency to give the highest impedance reading for a parallel L-C tuned circuit, or the lowest impedance for a series L-C tuned circuit.

References

1 "Measurement of Iron-cored Inductances", Radiotron Designers Handbook, 4th Edition, P. 250.

2 "Easy-to-Build R-L-C Bridge", Electronics Australia, P. 40, Vol. 39 No. 12 March 1978.

3 Unpublished contribution for "Circuit and Design Ideas", titled "Improved R-C Oscillator", from the writer, to Electronics Australia.