
THE "AVO" ELECTRONIC TEST UNIT.

THE

ELECTRONIC TEST UNIT

INTRODUCTION

The intention of this unit is that it should, when used with a suitable signal generator, such as the "AVO" Wide Range Signal Generator; and a Valve Voltmeter, such as the "AVO" Electronic Test Meter, considerably extend the utility of both instruments and convert the combination into a versatile radio test laboratory of sufficient accuracy for all normal purposes.

It consists essentially of an amplifier, aperiodic up to 2 Mc/s and tuned from 2—20 Mc/s having a flat amplification of 40 (within ±2-3 db) over the full frequency range. The internal variable condenser is accurately calibrated in $\mu\mu$F and is associated with low loss switching and terminal connections enabling the instrument to form the basis of an R.F. resonance test set for the determination of R.F. component losses, accurate condenser measurements at R.F., coil self capacity and inductance, etc. For the latter purpose, the instrument is directly calibrated in inductance for measurements over the range 0·5 μH—50 mH.

APPLICATIONS OF THE INSTRUMENT

AS A STRAIGHTFORWARD AMPLIFIER

With the input signal connected between the input socket and Earthy socket (both on the sub panel) and the output taken across the L & ⏚ terminals, the instrument is suitable either for extending the sensitivity of the Electronic Test Meter or as an amplifier with wide applications for A.C. measurement.

The amplification is aperiodic and within ± 2 or 3 db of 40 over the range 50 c/s—2 Mc/s with the range switch set at "50 c/s—2 Mc/s." (See Fig. 4).

With the range switch set at 2—5 Mc/s, 5—10 Mc/s, 10—20 Mc/s, (See Fig. 2) the amplifier is flatly tuned with equalised circuits and again gives an amplification of 40 ± 2 to 3 db over the range indicated. The maximum input the amplifier will accept at low distortion is 0·25 volt giving a maximum linear output voltage of 10 volts R.M.S.

The parallel input capacitance of the input sockets is approximately 15 pF and at 1 Mc/s the input loss resistance is of the order of 0·5 MΩ. This of course takes no account of lead capacitance but provided that a lower overall amplification can be accepted, the input capacitance can be considerably reduced by connecting the input to the leads via a small capacity of some 5-10 pF which will then be in series with the shunt input and lead capacitance.

The output impedance is relatively low being of the order of 7,000Ω thus enabling the instrument to be worked into valve voltmeter or oscillograph indicators of quite low impedance without error, although at audio frequencies the input impedance of the indicator should be of the order of ·75 MΩ or higher to avoid attenuation by the relatively small output feed condenser.

The amplification figure of 40 is chosen to combine with the scale markings on the A.C. ranges of the Electronic Test Meter. The latter is scaled 0—100 and 0—25 having an initial full scale sensitivity of 1V R.M.S. By utilising the 40 amplification of the Electronic Test Unit and setting the Electronic Test Meter to the 1V R.M.S. range, full scale sensitivity of 25 mV is obtained which is then easily read on the 0—25 scale marking.

AS A RADIO FREQUENCY RESONANCE TEST SET

With the range switch set to "QLC" the instrument is intended for use with a signal generator or other R.F. source as input signal and with a valve voltmeter connected across the terminals "VV". It then functions as a resonance test set in which the internal anode loads are ignored and the component under test and the calibrated variable condenser form the anode load, which is very lightly coupled to the amplifier valve by a capacity of only a few pF. The shunting effect of the amplifier on the load is thus virtually eliminated. (See Fig. 3).

TO MEASURE CAPACITY (0·5 $\mu\mu$F—900$\mu\mu$F)

The calibrated condenser should be set at 500 pF and the trimmer condenser set at 0. Then with any suitable coil connected across the "L" and earth terminals (the terminals "L" and "C" being strapped) the signal generator frequency is varied until resonance is shown on the valve voltmeter. With the capacity to be measured connected across the "C" and earth terminals the main calibrated variable, and if necessary, the incremental condensers are retuned for resonance, the difference between the new calibrated condenser setting and the original setting of 500 pF being the unknown capacitance. Any reading obtained on the incremental condenser is additive (+ or −) to the main calibrated condenser reading and thus acts as a vernier indication and also enables very small capacitances to be measured.

A similar test using the variable incremental condenser only will give the self capacitance of small trimmer condensers or other non-inductive components if they are connected in place of the unknown condenser.

For capacitance measurements above 450 pF, the capacitance switch should be set to C × 2 and the above procedure adopted, the effective swing of the calibrated condenser now being 100 pF to 1,000 pF instead of 50—500 pF on the C × 1 range. Note that the reading of the incremental condenser is *not* doubled on this range.

TO MEASURE COIL SELF CAPACITANCE

For coils of relatively large inductance say 100 μH upwards, the above arrangement should be set to resonance at a suitably high frequency on the generator with a coil of about 1 μH between "L" and earth terminals and with the internal calibrated condenser set at say 100 pF. The coil of which the self capacity is to be determined is then connected across the "C" and Earth terminals. Since the inductance of the test coil is very high in comparison with the tuning inductance, the effect from this source will be negligible and the coil self capacity then acts simply as a shunt capacitance. If resonance is now re-established by the incremental condenser, the variation of this condenser will give the coil self capacitance.

Alternatively for coils of low inductance, resonance should be established with the unknown coil across the "L" and Earth terminals at a reading on the calibrated condenser of 50 pF. If the frequency of resonance in this condition is "f", the generator should next be set at half the frequency (·5f) and the new reading of the calibrated variable condenser for resonance noted. If the two condenser readings are C_1 (50 pF) and C_2 the coil self capacitance will be given by:—

$$\text{Self capacitance} = \frac{C_2 - 4C_1}{3}\,\text{pF}$$

TO MEASURE COIL INDUCTANCE

First estimate the coil self capacitance or determine it as above. Then remove an equivalent capacity from circuit by setting the incremental condenser to a value of pF equal to the coil self capacity. The Generator is then set to a suitable frequency as given below, and resonance established with the coil to be measured across the "L" and Earth terminals, and the calibrated variable condenser.

It will be noted that the variable condenser dial is calibrated in μH from 50—500. The resonance readings of the condenser read on this scale in conjunction with the multiplying factors as given below will give the inductance of the coil under test.

For inductance readings between 5 mH and 50 mH set the signal generator frequency to 100 Kc/s.
For inductance between 500 μH and 5 mH set the signal generator frequency to 316 Kc/s.
For inductance between 50 μH and 500 μH set signal generator to 1,000 Kc/s.
For inductance between 5 μH and 50 μH set signal generator to 3·16 Mc/s.
For inductance from 0·5 μH to 5 μH set signal generator to 10 Mc/s.

TO MEASURE RADIO FREQUENCY LOSS AND "Q"

In order to obtain a measure of the "Q" of a coil, the latter is connected to the "L" and Earth terminals, the incremental condenser set at zero and with the required frequency set on the signal generator, resonance is established by tuning the calibrated variable condenser (on the Cx1 range only). The valve volt meter reading "V" at resonance is noted, also "C", the capacitance reading of the calibrated variable. Then without disturbing any other control, retune the circuit by the incremental condenser until the valve voltmeter shows ·707 "V." Note ΔC, the change in capacitance indicated by the incremental condenser. The "Q" of the coil (which will be in error by any parallel losses exhibited by the valve voltmeter and other parts of the circuit) is given by $\frac{C}{\Delta C}$

For "Q" readings of about 200, the answer may be low by a factor of say 10—20% depending on the input losses of the valve voltmeter, but for "Q" values of the order of 100—120 downwards, an accuracy better than 10% should be obtained. Losses of condensers, the radio frequency resistance of high resistances etc., may be estimated by measuring a high "Q" coil as above, and then shunting the component under test across the "C" and Earth terminals and noting the change in effective "Q" of the circuit.

THE ADJUSTMENT OF TUNED AND COUPLED CIRCUITS IN SITU

As resonance measurements are made with one side of both condenser and coil "Earthy" this arrangement is particularly applicable to the adjustment of tuned circuits "in SITU", thus enabling the rapid determination of the performance of IF transformers and band pass circuits, alignment of R.F. and oscillator circuits, etc., with the radio receiver, or other apparatus with which they are associated, in an inoperative condition.

The procedure is as follows:—

(*a*) For single tuned circuits—separate R.F. or local oscillator elements of ganged tuning circuits, wave traps tuned filters, etc.—proceed as for "Q" measurements with signal generator signal into input terminals and valve voltmeter across terminals V.V. Then connect "Earthy" terminal of Electronic Test Unit to chassis of receiver (through a condenser if chassis is operative and live to mains) and connect "L" terminal to the "live" (fixed) plates of the variable condenser. Then at any one setting of the variable gang condenser (or tuning dial associated therewith), tune the signal generator until resonance is shown. This will show the frequency of resonance of the tuned circuit in question which may be compared with its nominal calibrated frequency. In the case of local oscillator circuits of superhets, the frequency shown on the signal generator should be compared with the nominal calibrated frequency plus the intermediate frequency of the set. Adjustments may thus be easily made on individual tuned circuits so that the dial calibration and tracking is maintained throughout the frequency range on all ganged circuits involved. For this test the "L" and "C" terminals are not shorted.

In the case of double tuned circuits i.e. band pass I.F. transformer, etc., having a self contained trimmer condenser, a similar set-up is adopted, but in this case the "V.V." terminals are not used. The hot side of the primary of the transformer (or anode of the valve to which it is connected) is connected to the "L" terminal of the Electronic Test Unit, and the secondary circuit (or grid of subsequent I.F. valve and Earth) is connected directly to the valve voltmeter.

If the signal generator is now tuned through resonance as shown on the "V.V.", adjustments to the I.F. transformer trimmers for correct frequency calibration may be made, whilst a plot of the "V.V." characteristic obtained when tuning the signal generator through the nominal resonance frequency of the I.F. transformer will show its overall band pass characteristic, and enable band width to be measured and corrected.

A similar performance can of course be adopted on an intermediate frequency transformer or other tuned circuit as a separate component not connected into a receiver.

GENERAL NOTES

(*a*) When making voltage measurements across high frequency tuned circuits or across resistive anode loads in radio amplifiers or any other instance where the input capacitance of the measuring device has to be kept to a minimum in order to avoid disturbing circuit conditions, it is evident that even the 6-7 pF input capacitance of a valve voltmeter can cause trouble. This can in some instances be overcome by reducing the effective input capacitance of the valve voltmeter by feeding it through a condenser of say 1 pF. Such an arrangement will however, reduce the effective sensitivity of the valve voltmeter by the ratio of the feed capacitance (1 pF) to the shunt capacitance of voltmeter and leads (say 10 pF). Since the minimum useful direct indication on a valve voltmeter is about ·15-·2 Volts RMS, this means that the voltage to be measured must be at least 1·5 volts for a reasonable indication. The Electronic Test Unit can appreciably simplify matters in this direction by inserting it between the measuring points and the valve voltmeter. Provided that the measuring leads between the source and the Electronic Test Unit are kept short and of low capacitance (say 5 pF) and assuming an input capacitance at the Electronic Test Unit terminals of 15 pF, a total shunt capacitance of about 20 pF is applied across the source to be measured. If now this is fed by a small capacitance of 1 pF applied directly at the hot measuring point, the capacitance attenuation is 1:20. Since the Electronic Test Unit has an amplification of 40 (app.) however, there is still a step up of 2:1 between the source and the valve voltmeter allowing the effective measurement of voltages less than ·1V RMS at an effective input capacitance of about 1 pF—a much more satisfactory arrangement.

A similar procedure can be adopted where it is necessary to use shielded cable or long leads between the measuring instrument and the source, for the total lead and Electronic Test Unit input capacitance can be increased to 40 pF, and with a series capacitance of 1 pF the original valve voltmeter sensitivity will be maintained.

A further useful feature of this arrangement is that the effective shunt resistive losses of the measuring circuit are also considerably reduced thereby.

(*b*) When using the resonance test combination with the Electronic Test Unit on ranges "QLC" it is always wise to reduce the signal input to the minimum that will give a useful indication on the valve voltmeter. When dealing with circuits of reasonably high "Q", the attenuated output of the signal generator having a maximum value of 50 mV will usually suffice; with low "Q" circuits, it may be necessary to have an input signal from the generator greater than 50 mV, in which case the signal generator force output should be used. As this has no attenuator however, it can easily be attenuated to a suitable value by interposing a small fixed condenser or trimmer having a value of say 5—20 pF in series with the high level signal input load.

(*c*) When attempting to measure or compare very low inductances, it must be realised that the minimum calibrated value of 0·5 μH does not take into account the distributed wiring inductance both internal and external.

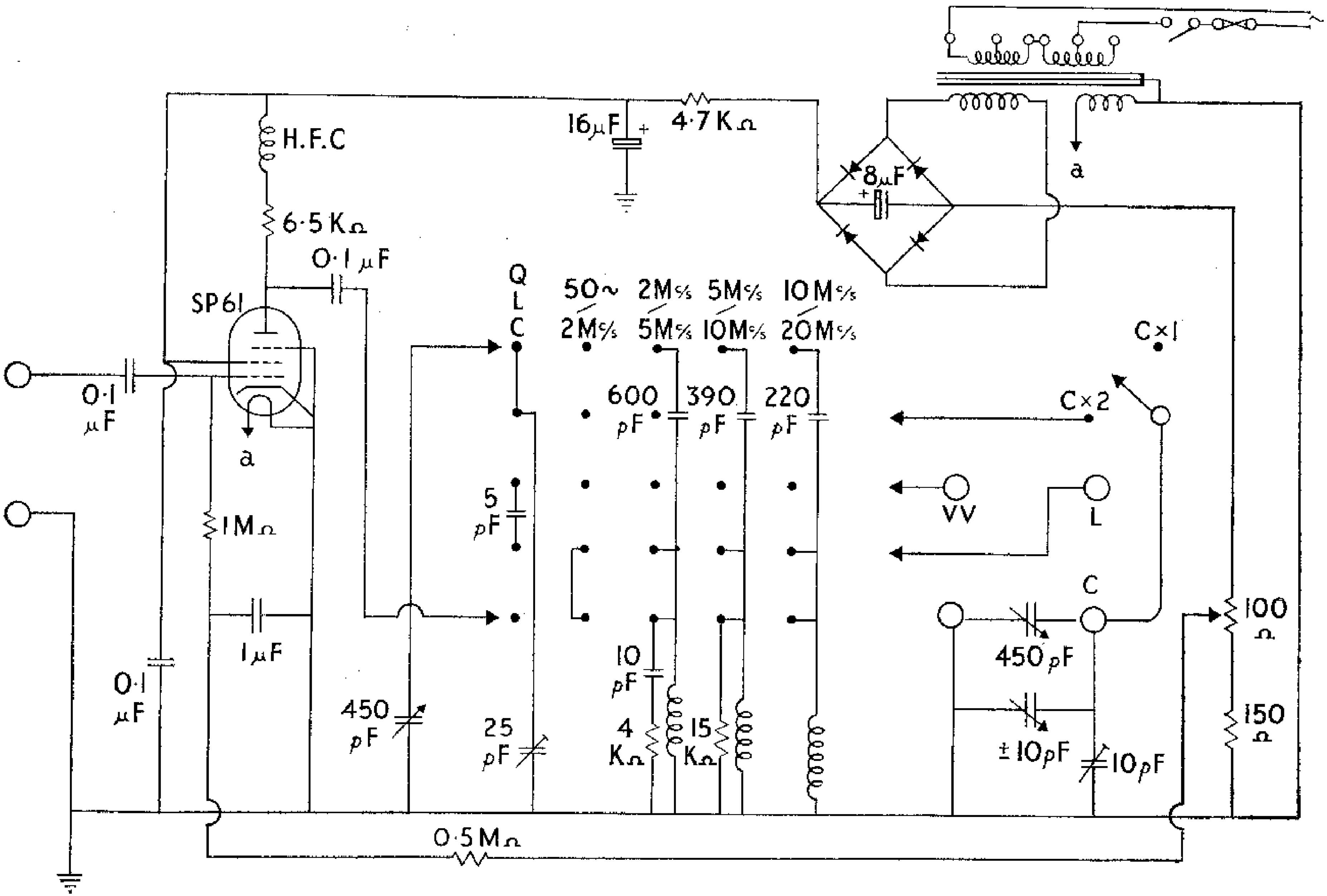


Fig. 1—CIRCUIT DIAGRAM OF THE "AVO" ELECTRONIC TEST UNIT.

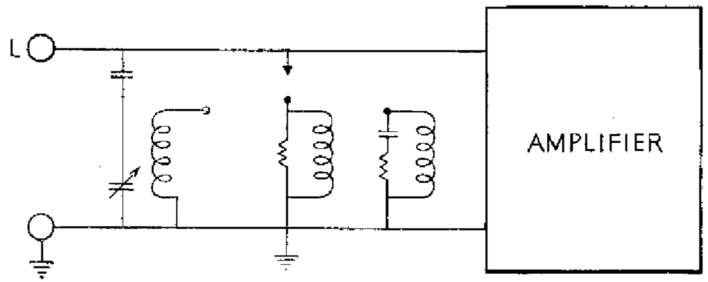


Fig. 2

THE TEST UNIT USED AS AN EQUALISED TUNED AMPLIFIER FROM 2Mc/s TO 20Mc/s.

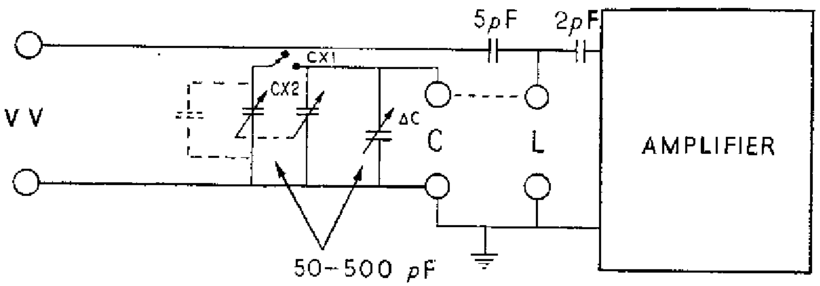
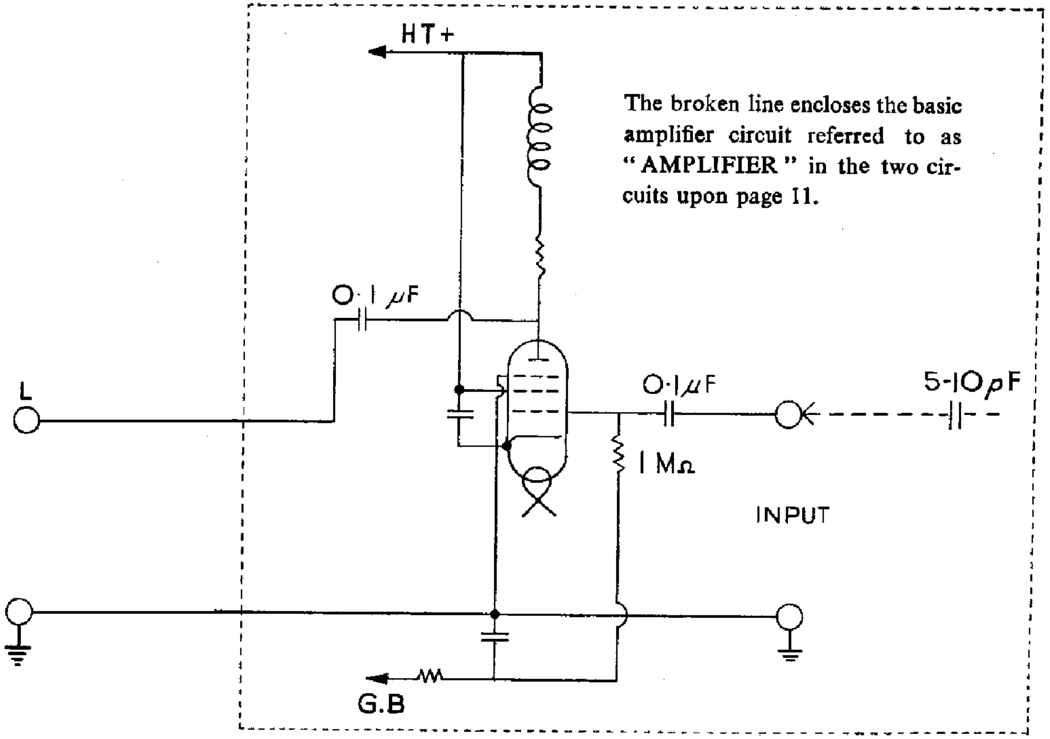


Fig. 3

THE TEST UNIT USED AS A RADIO FREQUENCY RESONANCE TEST SET



The broken line encloses the basic amplifier circuit referred to as "AMPLIFIER" in the two circuits upon page 11.

Fig. 4

THE TEST UNIT USED AS AN APERIODIC AMPLIFIER FROM 50c/s TO 2Mc/s.