C/R METER

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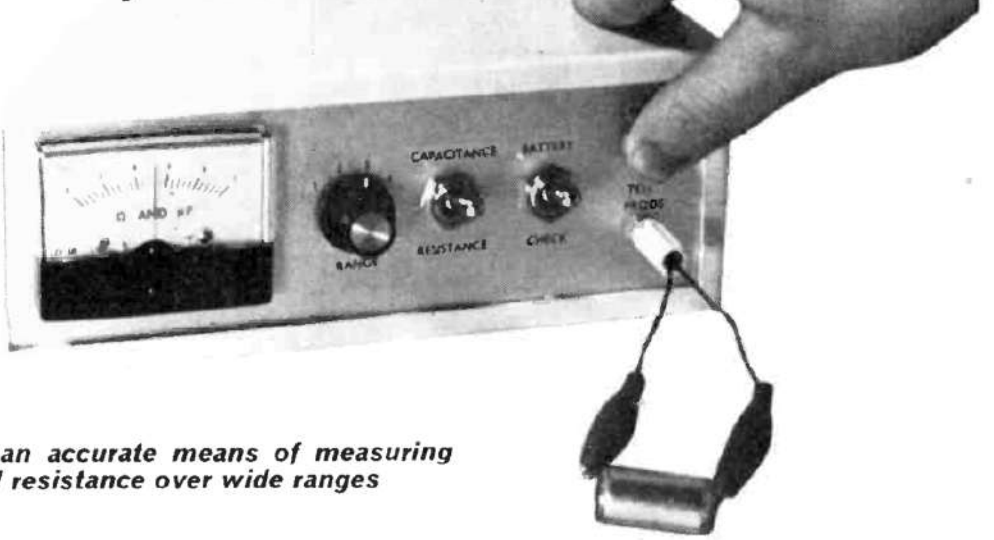


Fulfils the need for an accurate means of measuring capacitance and resistance over wide ranges

ONE of the most frustrating problems that the electronics enthusiast can encounter is to be faced with a capacitor of unknown value or a capacitor that is suspected of being faulty, without having available the appropriate test gear to perform the required measurement. Although a capacitance meter is likely to be required less often than the more important items of test gear, it can prove to be very useful and much used in the long term.

Problems can also arise when one wishes to make accurate resistance measurements, as many multimeters have only a couple of resistance ranges, and a logarithmic resistance scale that reads from right to left. Apart from being inconvenient to read, the accuracy on the resistance ranges of most multimeters is less than that obtained on the other ranges.

The device that forms the subject of this article has been designed to fill the need for a convenient and accurate way of measuring capacitance and resistance at low cost. Furthermore, it requires no external components for calibration, and the calibration process merely consists of adjusting four preset resistors (one for each range) for f.s.d. of the panel meter.

RANGES

The circuit does not merely consist of separate resistance and capacitance measuring circuits with the same meter being used to indicate the measured value, but achieves maximum economy by using the same basic circuit for both types of test.

Eight ranges are covered, four of resistance and four of capacitance. These are as follows:

Range	Resistance	Capacitance
1	0–10MΩ	0–1nF
2	0–1MΩ	0–10nF
3	0–100kΩ	0–100nF
4	0–10kΩ	0–1μF

These ranges permit the measurement of resistance between a few hundred ohms and 10 megohms, and capacitance between a few tens of picofarads and one

COMPONENTS . . .

Resistors

R1	10kΩ	R9	1 MΩ
R2	120kΩ	R10	100kΩ
R3	680Ω	R11	10kΩ
R4	5·6kΩ	VR12	4·7kΩ preset
R5	1kΩ	VR13	4·7kΩ preset
R6	4·7kΩ	VR14	4·7kΩ preset
R7	560Ω	VR15	4·7kΩ preset
R8	10MΩ (see text)		

All metal oxide 1 or 2% except presets

Capacitors

C1 100μF 10V elect.
C2 220nF type C280
C3 470nF type C280
C4 1μF
C5 100nF
C6 10nF
C7 1nF

Semiconductors

IC1 NE555V
IC2 NE555V
TR1 BC109

Switches

S1 D.p.d.t. toggle switch
S2 D.p.d.t. toggle switch (used as s.p.d.t.)
S3 4-way 3-pole standard wafer rotary switch
S4 Push-to-make release-to-break push button switch

Meter

ME1 1mA f.s.d. moving coil panel meter

Miscellaneous

Case about 205 × 140 × 75mm (Verobox type 75-1411D or similar). 3·5mm jack plug and socket, two crocodile clips or probe clips, materials to produce the p.c.b. PP7 battery and clips to suit, control knob, hardware.

microfarad. It thus covers by far the majority of values the amateur is likely to need to measure.

All ranges have a forward reading linear scale.

OPERATION

The circuit is based on two NE555V timer i.c.s. Fig. 1 shows the complete circuit diagram of the unit.

IC1 is used in the astable mode, and C2 is continually being charged via R2 and discharged through R3. As R3 has a much lower value than R2, the discharge time is considerably shorter than the charge time.

The output of IC1 is developed across R4, and the voltage at pin 3 of IC1 is high while C2 is charging, and low while it is discharging. A series of very brief negative pulses are thus produced by IC1 and fed via C3 to the input of IC2. The astable operates at the fairly low frequency of about 50Hz.

The meter circuit is not fed direct from the output of IC2, as the peak output voltage of this varies with fluctuations in the supply voltage. It is important in the interest of accuracy that the average output voltage across the meter is dependent upon the monostable pulse length, so R5, R6, R7, and TR1 are used to form a shunt regulation circuit, and they clip the output pulses at approximately +4V. TR1 is used as an amplified diode, and this gives a much higher degree of stabilisation than using a low voltage Zener diode.

Varying the supply voltage from a little over 9V to 7·5V (the approximate range covered by a 9V battery during its useful lifetime) was found to have a slight but insignificant effect upon the accuracy of the unit.

CAPACITANCE MEASUREMENT

In the capacitance measuring role, S1 connects a reference resistor into circuit and connects the test

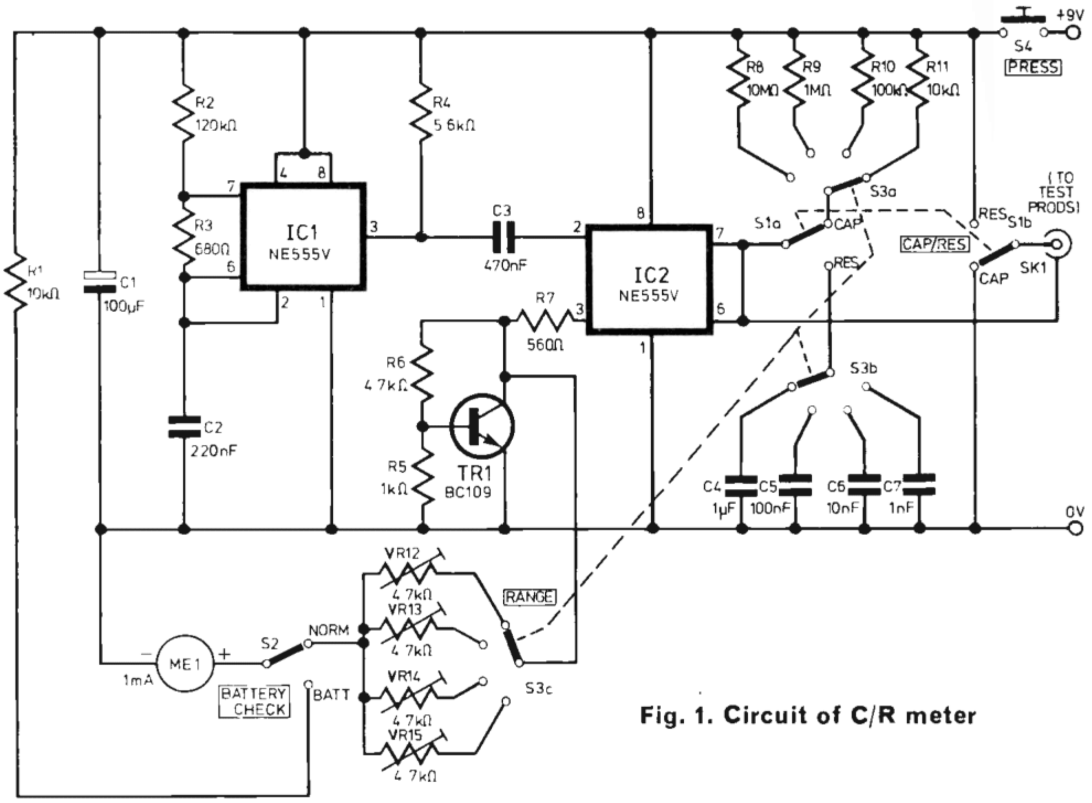


Fig. 1. Circuit of C/R meter

IC2 is used in the monostable mode. Here the device produces a positive output pulse at pin 3 after a negative trigger pulse has been received at pin 2. The length of the pulse is determined by the values given to the timing resistor and capacitor. When the circuit is in the capacitance measuring mode the timing capacitor is the capacitor under test, and the timing resistor is an internal component of the device. When used to measure resistance the opposite is true.

OUTPUT STABILISATION

There is a linear relationship between the length of the output pulse and the values of the timing components. The output of the meter circuit is fed to a meter which responds to the average output voltage of the monostable.

prods between the negative supply rail and pins 6–7 of IC2. There are actually four reference resistors (R8 to R11) giving four capacitance ranges, S3 being used to switch in the resistor for the desired range.

With S3 in the position shown, R11 is switched into circuit and the unit has a range of 0–1 microfarad. With a 1 microfarad capacitor connected across the test terminals each output pulse from the monostable ends shortly before the next pulse from the astable is received. This gives the astable and monostable output waveforms shown in Figs. 2(a) and 2(b) respectively. The meter circuit sensitivity is adjusted using VR12 to give f.s.d. of the meter with a 1 microfarad capacitor in circuit.

If a lower value capacitor, say 0·5 microfarad is now connected, the length of monostable output pulses will be halved. This gives the output waveform shown in Fig. 2(c). The meter reads the average output voltage which will obviously be half its previous level.

It will be apparent from this that the meter reading is linearly proportional to the value of the test capacitance. Each time S3a is moved a position to the right the reference resistance is raised by a factor of ten times, and so only one tenth of the capacitance is required across the test terminals to provide f.s.d. of the meter. The unit thus obtains its four capacitance ranges of 0–1nF, 10nF, 100nF, and 1μF.

RESISTANCE RANGES

When used in the resistance mode the circuit operates in the same basic manner, except it is now the timing resistor that is the test component and the timing capacitor that is an internal part of the unit. S1 switches the reference resistors out of circuit and the reference capacitors into circuit, and switches one test prod from the negative to the positive supply.

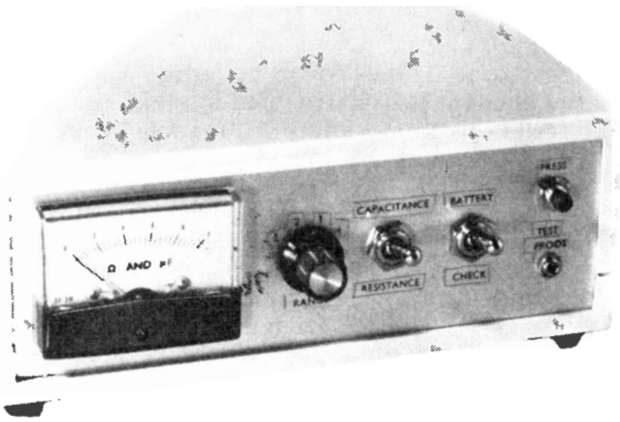
As we have already seen, with a microfarad timing capacitor in circuit a timing resistance of 10 kilohm produces f.s.d. of the meter. Lowering the resistance across the test terminals reduces the monostable pulse length proportionately, and gives a lower reading on the meter. Again there is a linear relationship between the value of the test component and the meter reading, and of course the scale is forward reading. The same basic circuit can thus be used for the measurement of both resistance and capacitance. Four switched reference capacitors (C4 to C7) provide four resistance ranges.

The power is not supplied to the circuit until S4 is depressed. A normal on/off switch is not used as when S1 is in the "Resistance" position and no resistor is connected across the test prods, the meter would be deflected beyond f.s.d. if the power was connected. This problem is solved by using a pushbutton for the on/off switch, as this is not closed until the component under test has been connected to the test prods.

BATTERY CHECK

Current consumption is about 10 milliamps, but as power is only drawn while a reading is being taken, an ordinary 9V radio type battery (PP7, etc.) can be used to power the unit and will have virtually its shelf life.

When the battery voltage does drop due to ageing, misleading results could be obtained and there is the danger of the battery leaking and damaging the unit. A



battery check circuit has therefore been included. This uses S2 and R1, and with S2 in the "Check" position the meter is connected across the supply rails via R1. The meter then has a f.s.d. sensitivity of about 10V, and can be used to check that the loaded supply voltage is satisfactory.

CONSTRUCTION

Many of the components are mounted on a printed circuit board that measures 86 × 56mm. Details of this are shown in Fig. 3.

There is quite a large amount of point to point wiring to the components on the front panel. When this has been completed the p.c.b. is mounted on the base of the cabinet behind S1, S2 and S3 using three 6BA or M3 bolts, and spacers to hold it a little way clear of the bottom of the case.

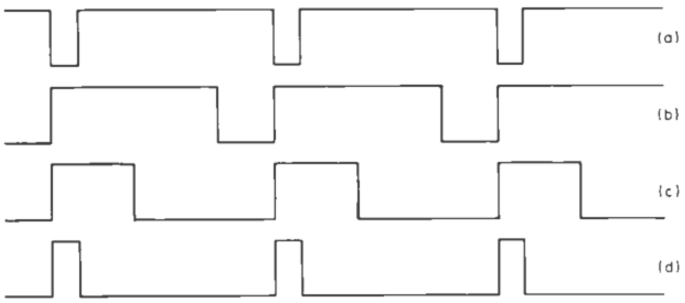


Fig. 2. (a) Output from the astable circuit, brief negative pulses to trigger the monostable (b) the waveform across the meter at f.s.d. (c) the waveform across the meter at half f.s.d. (d) the waveform across the meter at $\frac{1}{10}$th f.s.d.

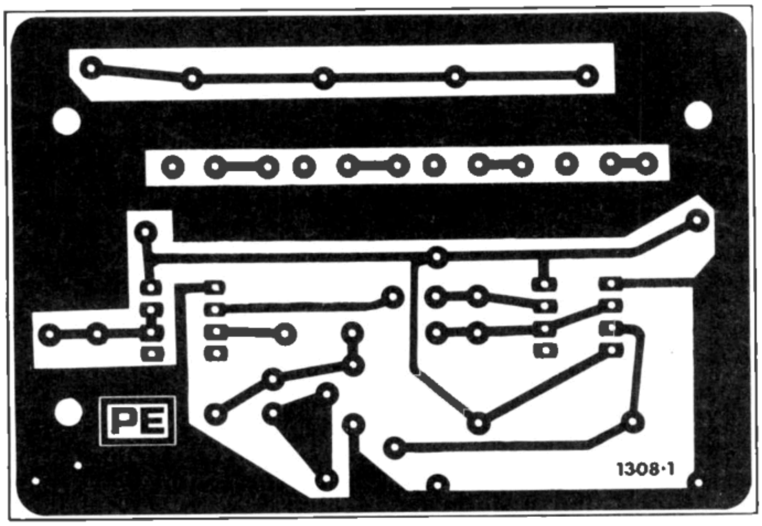


Fig. 3. Printed board track pattern shown full size

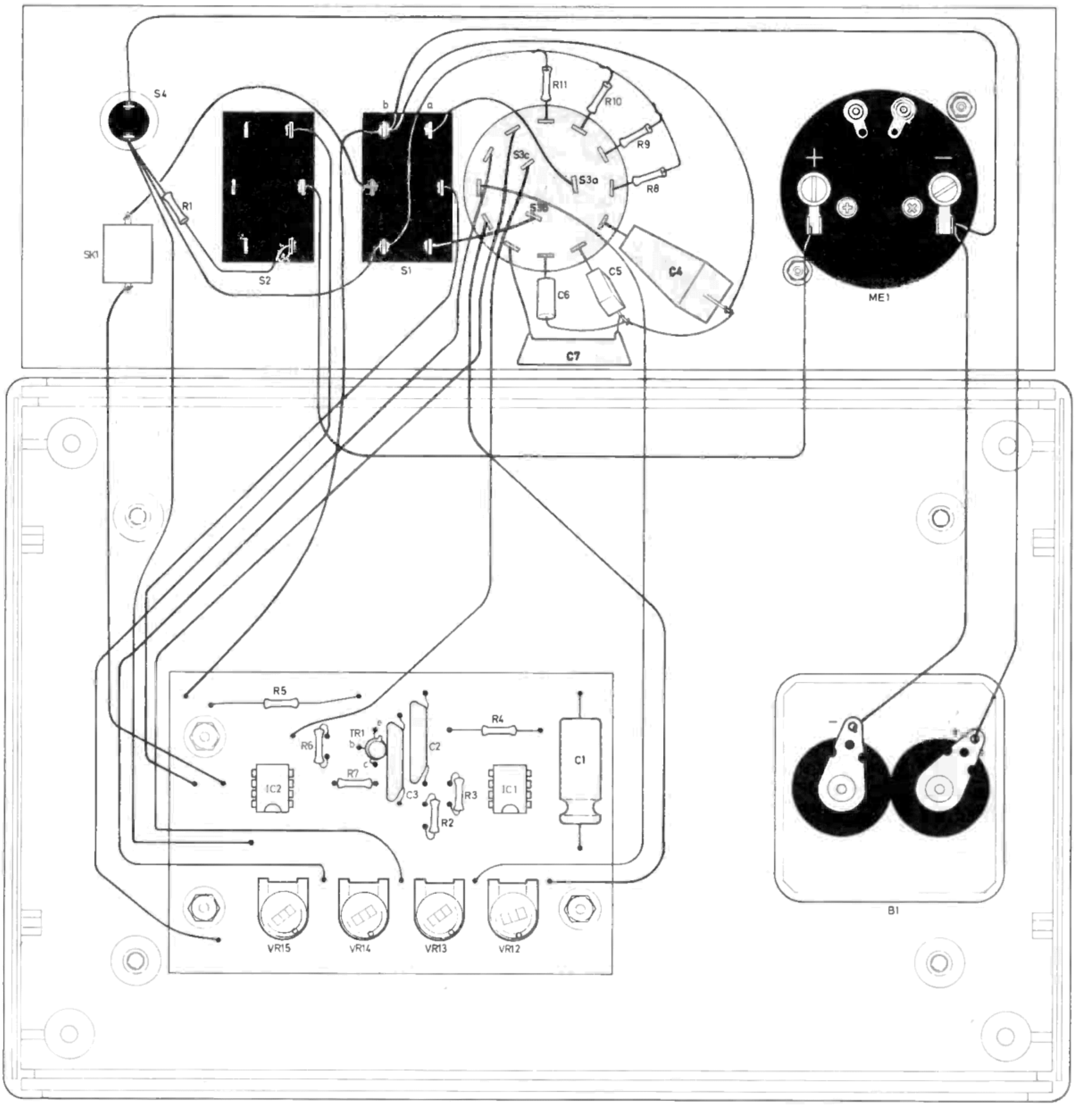


Fig. 4. Board assembly and complete interwiring details for unit

ADJUSTMENT AND USE

A set of test leads are required, and these consist of a couple of 100mm lengths of insulated wire each terminated in a 3·5mm jack plug at one end and a crocodile clip at the other.

At the outsetVR12–VR15 are all adjusted to insert maximum resistance into circuit (fully clockwise). Temporarily connect the centre tags of S3a and S3b together. Mechanically zero the meter, turn the unit on, and set S3 to position 1. The meter should give a large positive indication and then VR15 is adjusted to give precisely f.s.d. of the meter. Then switch S3 to the other three switch positions, and use the appropriate preset resistor to produce f.s.d. of the meter in each switch position.

COMPONENTS

This method of calibration uses the internal timing components as the calibration standards. It is therefore important that these components have close tolerances as it is the precision of their values that largely determines the accuracy of the finished unit.

The resistors should have tolerances of 1 or 2 per cent, and the capacitors tolerances of between 1 and 5 per cent, according to availability. The smaller the tolerance of these components the better.

R8 can be a 5 per cent type as this is the closest tolerance in which this value would seem to be available. Alternatively it can be made up from several 1 or 2 per cent types connected in series to provide the required value of 10 megohms. ★