Project 151

Electronic ohmmeter features linear scale and high accuracy

Many workshop, laboratory and hobby applications require accurate measurement of resistor values or accurate matching of resistors of the same nominal value. This simple instrument fills the bill for the sort of measurement required.

THIS INSTRUMENT is a simple and inexpensive semi-precision ohmmeter that can be used to give accurate readings of resistance from a few tens of ohms to one megohm. The unit has four decade ranges covering 1k to 1M full scale and has a full scale accuracy of 2% if low tolerance range resistors are used.

Conventional moving coil ohmmeters have non-linear scales which typically cover two to four decade ranges of resistance value on a single scale. With such a range of resistance it is impossible to obtain an accurate reading, especially at the higher values. To measure resistance values with reasonable accuracy, the usual method is to use a Wheatstone Bridge, often very expensive and time consuming.

By contrast, this ohmmeter gives resistance readings on a linearly calibrated scale and covers only a single decade of resistance on each switched range. The instrument thus gives inherently more accurate readings of resistance than multimeter type ohmmeters.

The technique

The circuit consists of a voltage reference feeding an operational amplifier. The gain of the op-amp is set by the ratio of the range resistors, R3 to R6, to the feedback resistor, Rx. A moving-coil meter is connected to the output of the op-amp and the reading will be the reference voltage multiplied by the gain of the op-amp. Therefore, the reading is proportional to the gain of the op-amp which in turn is proportional to the value of Rx, the unknown resistor.

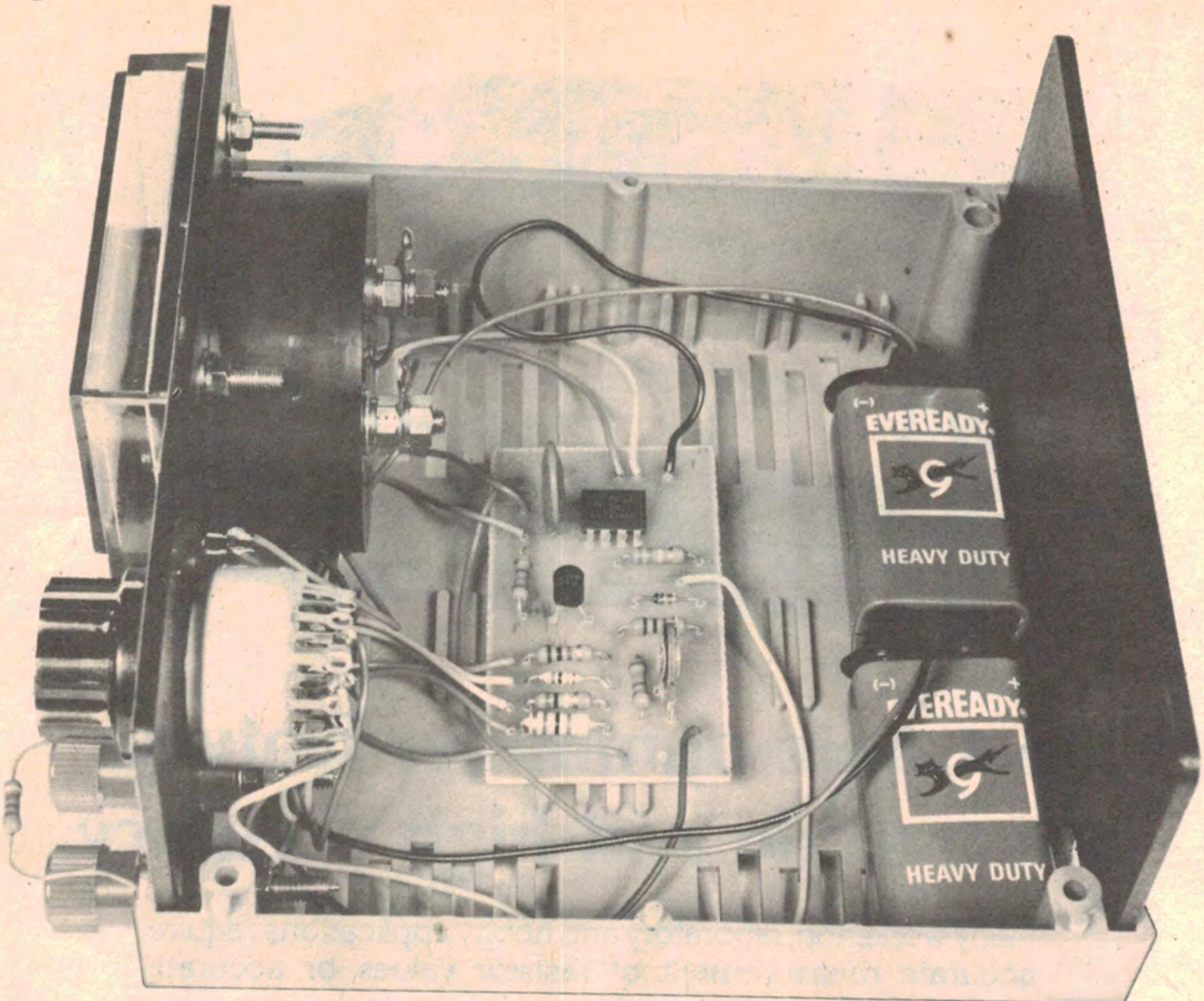
The op-amp we selected is a 301, used for its low input current. This ensures that the highest resistance range is not shunted by the input resistance of the op-amp causing inaccuracy at higher values. In fact a 10M range could be added but would not be accurate over about a few megs. The lowest resistance range is determined by the current capacity of the op-amp, reference supply, and the batteries.

Calibration of the instrument is achieved by adjusting the trimpot for correct reading with a known resistance.

Construction

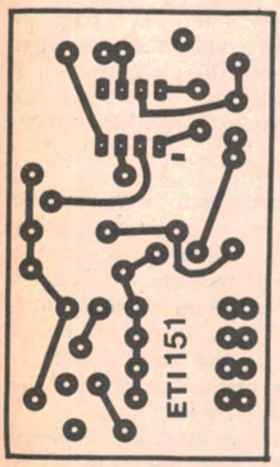
The ohmmeter can either be constructed as a completely contained unit, with its own moving-coil meter, as we have done, or it can be built as an add-on to an existing multimeter having a 1mA dc current range. As the meter is the most expensive part the latter method is by far the cheapest way of doing it.

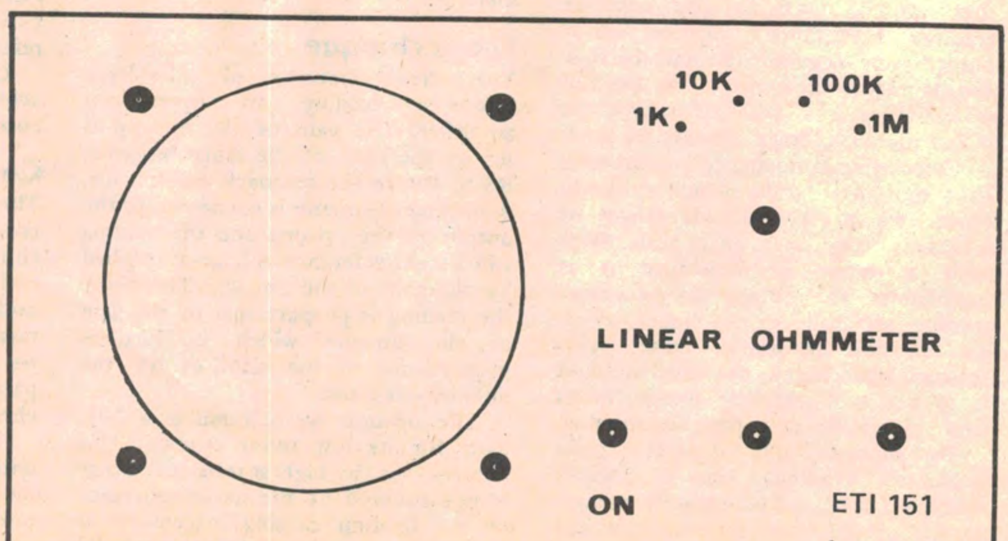
The construction is straightforward with all the minor components mounted on a pc board. Take care with the polarity of the zener diode. The 301 op-amp cannot be substituted by a ▶



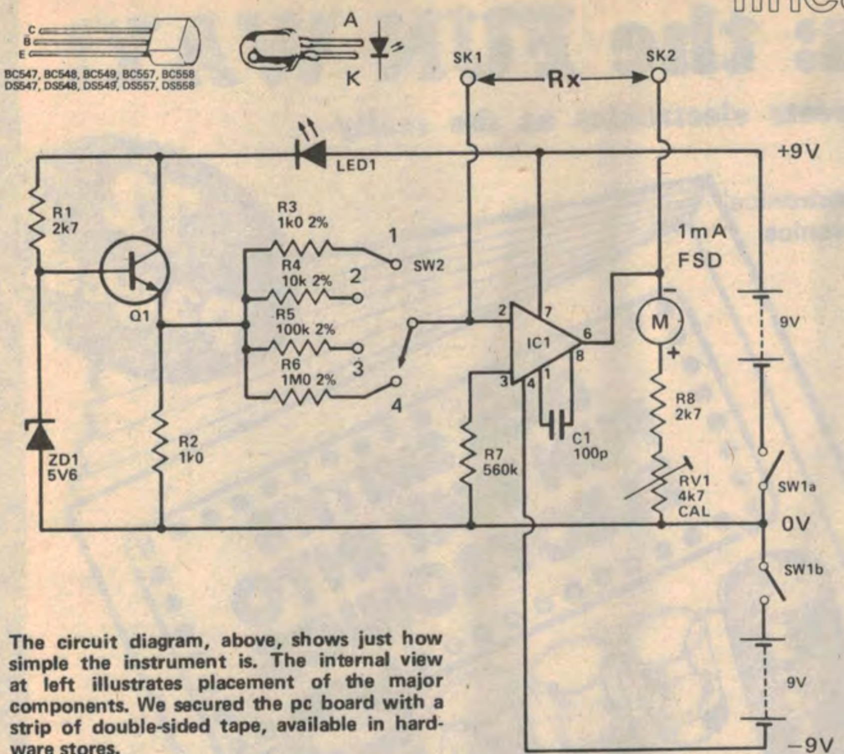
741 as it has been selected for its low input current. The overall accuracy of the instrument is determined by the tolerance of the range resistors (R3 to R6) and the accuracy of the meter. If 1% or 2% resistors are used the accuracy of the instrument will be about two percent. See Shoparound for a list of suppliers with close tolerance resistors.

When the pc board assembly is complete, fit the board into the box and complete the wiring to the major components. We used a common plastic case, identical to the one used for the Linear Scale Frequency Meter in the December issue. If you are making an add-on version of the meter, fit a couple of screw terminals in place of the meter





RIGHT: Front panel artwork. Scotchcal overlays will be available from Radio Despatch Service in Sydney.



The circuit diagram, above, shows just how simple the instrument is. The internal view at left illustrates placement of the major components. We secured the pc board with a strip of double-sided tape, available in hardware stores.

for connection to your multimeter.

We used a 'Lorlin' range switch made by C&K. These switches start out life as a two-pole six-position switch and are easily changed to four position by moving round a small metal ring beneath the securing nut. Only one pole is used. In this way, C&K have come up with a single switch which can be changed to suit your own needs.

If your supplier stocks this switch he will show you how to adjust it. Any other single-pole four-position switch will do just as well.

Calibration

When construction is complete, switch the unit on and check that the LED lights up. If it doesn't, check the wiring and the polarity of the LED. When all is well connect an accurately known resistor (having a value within the range of the instrument) across the terminals and adjust the trimpot for the correct reading. The unit is then ready for use and should not require further calibration. You could purchase a 1k, 1% resistor specifically for this purpose. ●

HOW IT WORKS – ETI 151

The linear scale ohmmeter circuit is divided into two parts: a reference voltage generator and a readout unit that indicates the value of the resistor under test. The reference voltage generator section of the circuit comprises zener diode ZD1, transistor Q1, and resistors R1 and R2. The action of these components is such that a stable reference of about 5V is developed across R2. This reference voltage is fed to the op-amp resistance-indicating circuit via range resistors R3 to R6.

The op-amp is wired as an inverting dc amplifier, with the 1 mA meter and R8-RV1 forming a voltmeter across its output, and with the op-amp gain determined by the relative values of ranging resistors R3 to R6 and by the negative feedback resistor Rx. RV1 is adjusted so that the meter reads full scale when Rx has the same value as the selected range resistor. Under this condition the op-amp circuit has a voltage gain of precisely unity. Since the values of the reference voltage and the ranging resistors are fixed, the reading of the meter is directly proportional to the value of Rx, and the circuit thus functions as a linear-scale ohmmeter and has a full scale value equal to the value of the selected range resistor.

PARTS LIST - ETI 151

Resistors all ½W
(* See text)

R1	2k7 5%
R2	1k 5%
R3	1k*
R4	10k*
R5	100k*
R6	1M*
R7	560k 5%
RV1	5k minimum vertical trim pot

Capacitors

C1	100p ceramic

Semiconductors

LED1	TIL220 red LED or similar
ZD1	5V1 400mW zener diode
Q1	BC109, BC549, or similar
IC1	301 op amp

Miscellaneous

SW1	DPDT minimum toggle switch
SW2	one pole four position wafer switch
M1	1mA FSD meter 60 mm square, University TD66 or similar
SK1, SK2	screw terminals

ETI 151 pc board, two 9V batteries (type 216) and battery clips, plastic case 130 mm x 130 mm x 75 mm, knob.