14

Capacitance Bridge

A standard multimeter can be used to accurately measure resistor values, and can provide quick checks on other components such as diodes, transistors, and high value capacitors. The one major type of component which most multimeters are not equipped to test is low and medium value capacitors, say from a few picofarads to a few microfarads. Apart from checking for short circuits, an ordinary multimeter cannot check this type of component at all.

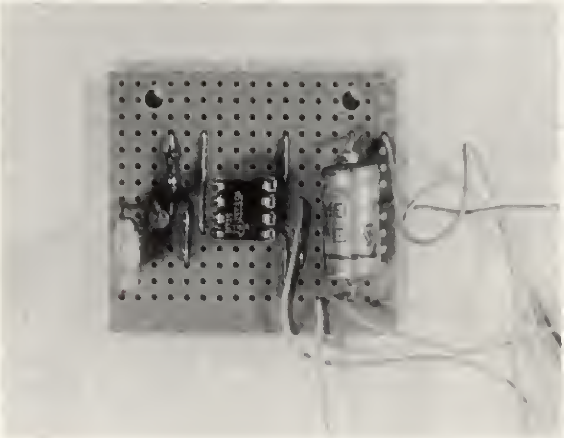

Figure 14.1

Capacitance bridge

This can be quite a serious drawback as capacitors form a substantial part of most constructional projects and sooner or later the constructor is likely to be faced with checking a doubtful capacitor, or measuring the value of one which has lost its value markings. A unit for measuring capacitance can also be invaluable when sorting through the popular bargain packs of assorted capacitors.

Some piece of capacitance measuring test gear is therefore a valuable addition to an electronics workshop, and probably the most simple way of obtaining accurate capacitance measurements is to use a capacitance bridge. A simple unit of this type is shown in Fig. 14.1. It has three ranges which provide coverage from 10pf to 10μF.

The circuit

The complete circuit diagram of the capacitance bridge is shown in Fig. 14.2. A bridge circuit is simply two potential divider circuits fed from a common signal source, and the output is taken from across the outputs of the potential dividers. This general arrangement is much used in electronics, and bridge circuits were employed in the multimeter sensitivity booster, flat battery warning light and thermometer projects which have already been featured.

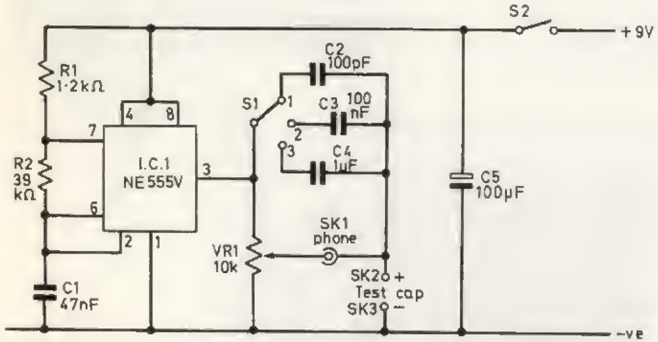

Figure 14.2

The circuit diagram of the capacitance bridge

In this circuit VR1 forms one side of the bridge and the other side is comprised of C2, C3 or C4 (according to the position of S1) and the capacitor under test. The input of the bridge is fed with an audio tone which is generated by the 555 timer i.c. (IC1) which is connected in the astable mode. The signal at the output of the bridge can be monitored using a crystal earpiece.

With S1 in the position shown, and a 100pF test capacitor connected to the circuit, at most settings of VR1 the audio tone will be produced from the earphone. However, with the slider of VR1 at about the centre of its track it will be possible to locate a setting where the tone is nulled.

The reason for this is quite simple: C2 and the test capacitor form a simple potential divider, and as they are of equal value, half the input signal voltage is produced at the output of this circuit. When the slider of VR1 is at the centre of its track it too produces an output equal to half the input signal voltage. Therefore, the voltage developed across the earphone must be zero since the two voltages to which it is connected rise and fall in unison. If the setting of VR1 is altered the bridge circuit will be unbalanced and there will be a higher voltage at one side of the bridge than appears at the other. This will cause a voltage to be developed across the earphone and the tone will be audible.

If the test capacitor has a higher value, say 1nF, then it will have a much lower impedance than C2 and the output from the right hand side of the bridge will be greatly reduced in consequence. The bridge can still be balanced of course, simply by taking the slider of VR1 down the track to the point where the two outputs match once again and the output tone is nulled.

A test capacitor of much lower value than C2, say 10pF, will have a much higher impedance than C2, and will cause a much increased output from the right hand section of the bridge. Again it is possible to balance the bridge, this time by taking the slider up towards the top of its track.

By marking the control knob of VR1 with a scale showing the positions at which various capacitance values balance the bridge, it is possible to use the unit to determine the value of an unmarked capacitor. It is merely necessary to connect the test capacitor, adjust VR1 for zero output from the earpiece, and then read the value off the scale. In theory the unit can be used to measure any capacitor, but in practice the values given in the example above represent the limits, as the scale would be excessively cramped outside these limits. However, the range of the unit can be extended by providing additional reference capacitors, and this is the purpose of C3 and C4. The unit has three measuring ranges which are as follows:

Range 1	10pF to 1nF
Range 2	1nF to 100nF
Range 3	100nF to 10μF

C5 provides supply decoupling and S2 is the on/off switch. The current consumption of the circuit is approximately 8mA.

Construction

Some of the components are mounted on a 0.1in pitch stripboard which has 14 copper strips by 17 holes, but C2 to C4 are mounted on S1, as shown in the wiring diagram of Fig. 14.3.

From the mechanical point of view construction should be perfectly straightforward, but it is recommended that a fairly large case constructed of a non-metallic material should be used. The large size is necessary to permit a large scale to be marked around the control knob of VR1.

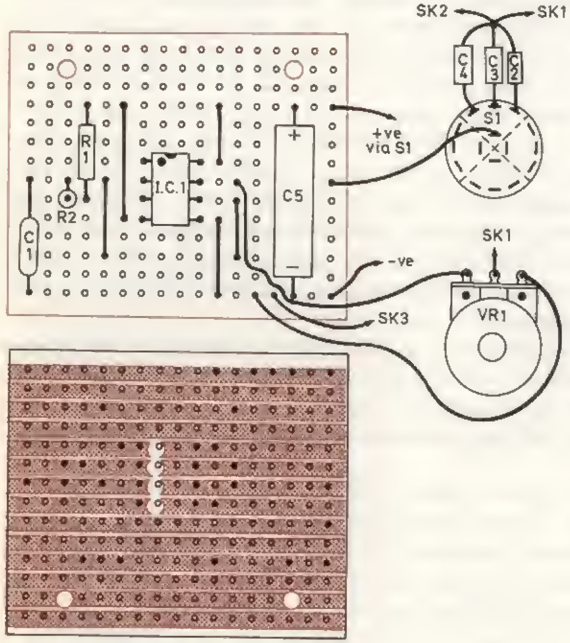

Figure 14.3

The 0.1in matrix stripboard layout and wiring of the capacitance bridge

Useful results can be obtained using a small scale, but this will place distinct limitations on the accuracy and resolution of the unit which is obviously far from ideal. A metal case should be avoided unless SK1 is either a socket of insulated construction, or steps are taken to insulate it from the case. No other wiring should be allowed to come into contact with the case. To do so could encourage stray capacitances and signal paths which could prevent a definite null from being obtained, particularly when measuring low value capacitors.

Calibration

In order to calibrate the unit it is necessary to have a number of capacitors of known value, and for optimum calibration accuracy these should all be close tolerance types. Provided C2 to C4 are all close tolerance capacitors it is not necessary to mark an individual scale for each range. A single scale marked '1' at the low value end (VR1 set anticlockwise) to '100' at the high value end with '10' at the centre will be quite suitable. This is obviously correct in terms of nF on Range 2, and is easily converted into an actual capacitance value on the other two ranges.

The scale is calibrated by connecting a capacitor to the unit, setting S1 to the appropriate range, adjusting VR1 for minimum signal from the earphone, and then marking the scale with the correct number at the point indicated by the pointer of the control knob for VR1. For instance, a 10nF component would provide the '10' calibration point with S1 set to Range 2. 10pF and 1nF components would provide the '1' and '100' calibration points respectively with S1 in the Range 1 position. Of course, it is not just a matter of marking in the centre and limits of the scale, and it must be calibrated at all the preferred values in the E12 series (1.2, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9, etc.). This is quite a long process, but it is worth doing well as a unit of this type can provide a high degree of accuracy despite the simplicity of the circuit.

When measuring electrolytic capacitors ensure that they are connected with the correct polarity (other types are nonpolarised and can be connected either way round). Do not use electrolytic types for calibrating the unit as these often have tolerances as high as +100% and –50%!

Components list for the capacitance bridge

Resistors	
R1	1.2kΩ miniature, ¼W, 5 or 10%
R2	39kΩ miniature, ¼W, 5 or 10%
VR1	10kΩ lin. wirewound
Capacitors	
C1	47nF type C280
C2	100pF close tolerance
C3	10nF close tolerance
C4	1μF close tolerance
C5	100μF, 10V
Switches	
S1	3-way 4-pole rotary type (only one pole used)
S2	S.P.S.T. toggle switch
Integrated circuit	
IC1	NE555V (or equivalent)
Miscellaneous	
0.1in matrix stripboard panel	
Case (preferably non-metallic, see text)	
3.5mm jack socket (SK1)	
Two wander sockets, one red and one black (SK2 and SK3)	
Crystal earpiece, control knob	
PP3 battery and connector to suit	
Wire, solder, etc.	