Capacitor Tester

Check out those spare capacitors with this low cost instrument.

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Capacitors are very common components and appear in most electronic circuits. The value is usually marked on the body with either a type of colour code or expressed in alphanumeric form, for example, 223K – the value of this capacitor is explained at the end of the article. The markings are not always clear, however, and to make matters worse different manufacturers appear to use their own variations in expressing the value.

Since a multitester cannot be used to check capacitors, there is a need for an amateur instrument which can perform this function. Such meters that are available are usually expensive. The Capacitor Tester described here is less accurate than these but is more than adequate for amateur electronics work and may be constructed for a fraction of the cost.

The device operates from a small internal battery and, in occasional use, the life of this will be very long. The standby current requirement is 15mA approximately.

Operation

In use, the capacitor under test is connected to a pair of terminals (TB1 and TB2) on the side of the instrument. The unit is switched on and the range selected by means of a rotary switch. One of a row of green LEDs lights to indicate the chosen range.

A "push-to-test" button is now operated and a red LED flashes at the rate of about three per second, then goes off. This flash rate may be adjusted, within limits, to suit the user.

The number of flashes gives the value of the capacitor taking account of the range. Thus, with the range switch set to "10n", five flashes will indicate a value of 50nF. The ranges provided by the prototype unit are: 10nF; 1uF; 100uF; and 1000uF. When the value of a capacitor is completely unknown, the range is quickly found by trial and error.

Circuit Description

The complete circuit diagram for the Capacitor Tester is shown in Fig. 1. IC1 is a CMOS operational amplifier and, as such, has an exceptionally high input resistance – one million megohms approximately. The importance of this point will be explained later. The capacitor under test (C1) is connected to the input terminals TB1 and TB2. The purpose of capacitor C2 will also be explained later.

Assume that switch S2 (TEST) is in its relaxed (unpressed) state and that

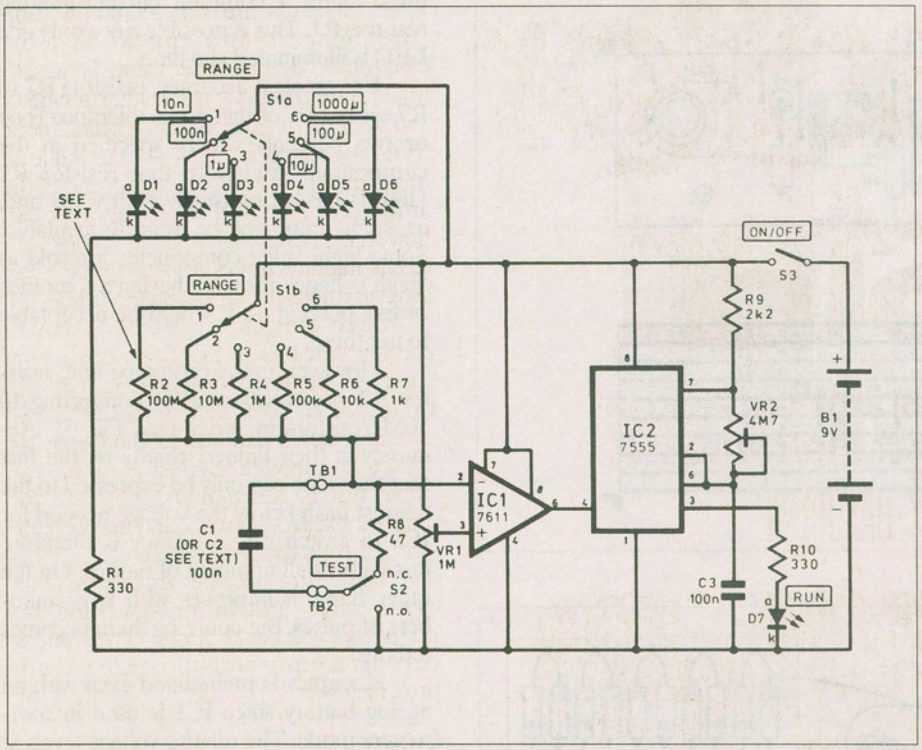


Fig. 1. Circuit diagram of the Capacitor Tester.

switch S3 (ON-OFF) is on. If capacitor C1 is charged for any reason, for example from a previous test, it will rapidly discharge through the normally-closed (n.c.) contacts of switch S2 and series resistor, R8. Resistor R8 is included to prevent large discharge currents which could damage S2 contacts especially where large-value capacitors were involved.

If switch S2 is now pressed (test position) capacitor C1 charges from the supply through one of the range resistors R2 to R7, as determined by the setting of rotary switch S1b (RANGE), and S2 normally open (n.o.) contacts. The voltage across capacitor C1 therefore rises from zero towards the battery voltage. IC1 *inverting* input pin two, receives this voltage. Meanwhile, IC1 *non-inverting* input, pin three, receives a fixed voltage whose value is determined by the setting of preset potentiometer VR1 connected across the supply. While the voltage applied to the inverting input remains lower than applied to the non-inverting one, the op-amp will be on with its output, pin six, high (positive supply voltage). This will be the case when S2 is first pressed.

Astable

As the voltage across capacitor C1, hence at IC1 pin two rises, a time will come when the voltage at the non- inverting input is exceeded and IC1 switches off with pin six going low (negative supply voltage). The high or low voltage state of IC1 pin six is applied directly to IC2 reset input, pin four. IC2 and associated components are connected as an astable multivibrator and, while pin four is high this delivers squarewave pulses at its output (pin 3).

The rate at which pulses are produced is determined by R9, VR2 and C3. With the values specified this will be approximately three per second and adjustable within limits using preset VR2. Thus the LED connected to IC2 output, pin three, via current- limiting resistor, R10, will flash at this rate. When pin four is low, IC2 is inhibited and produces no pulses.

At the start of the test, LED D7 will flash but after a time dependent on the values of C1, R2 to R7 and VR1 the flashes will stop. With presets VR1 and VR2 correctly adjusted at the end of construction and with the values of R2 to R7 being accurately known (since they are close-tolerance components) the number of flashes is determined by C1 alone.

The capacitor C2 is a close-tolerance type which provides an accurately known reference value. This is connected to the terminals to enable accurate setting of potentiometer VR1 at the end of construction.

PARTS LIST

Resistors

R1,R10	330
R2,R3	10M (see text)
R4	1M
R5	100k
R6	10k
R7	1k
R8	47
R9	2k2

All 0.25W 1%, except R1, R8 and R10 may be 0.25W 5%

Potentiometers

VR1 ..... 1M sub-min. vertical trim
VR2 4M7 sub-min. horizontal trim

Capacitors

C2,C3 .... 100n 5%

Semiconductors

D1 to D6 .... 5mm green LED
D7 .... 5mm red LED
IC1 .... ICL7611 CMOS op amp.
IC2 ..... ICM7555 CMOS 555 timer

Miscellaneous

S1 2-pole 6-way rotary switch
S2 Push-button switch with single-pole change-over contacts
S3 SPST toggle switch

Stripboard, 0.1in. matrix size 30 holes x 9 strips; 8-pin DIP sockets; B1, 9V battery and connector; TB1, TB2 terminal posts (black and red); plastic box + ; wire; stranded connecting wire; self-adhesive plastic feet; solder, etc.

With switch S2 in its relaxed state, IC1 pin two is kept high through R2-R7 so the op.-amp will be off. This inhibits IC2 and D7 does not flash. The instant S2 is pressed, IC1 pin two goes low and flashes are delivered in the manner already described.

Range Indication

Switch S1 is a two-pole six-position rotary switch. S1b selects the range resistor as mentioned earlier. S1a operates one of six LEDs, D1 to D6 confirming the selected range – these could be omitted and the range marked around S1 control knob is desired. However, in such a case it would be wise to use an LED indicator to remind the user that the unit was switched on.

For the small cost involved, the green LEDs seemed worthwhile and were included in the prototype unit. Note that

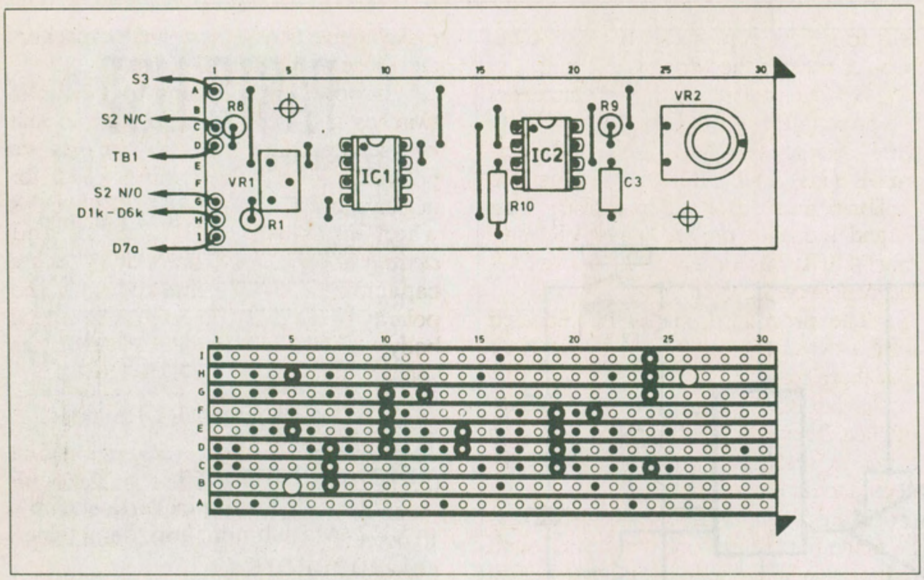


Fig. 2. Veroboard construction.

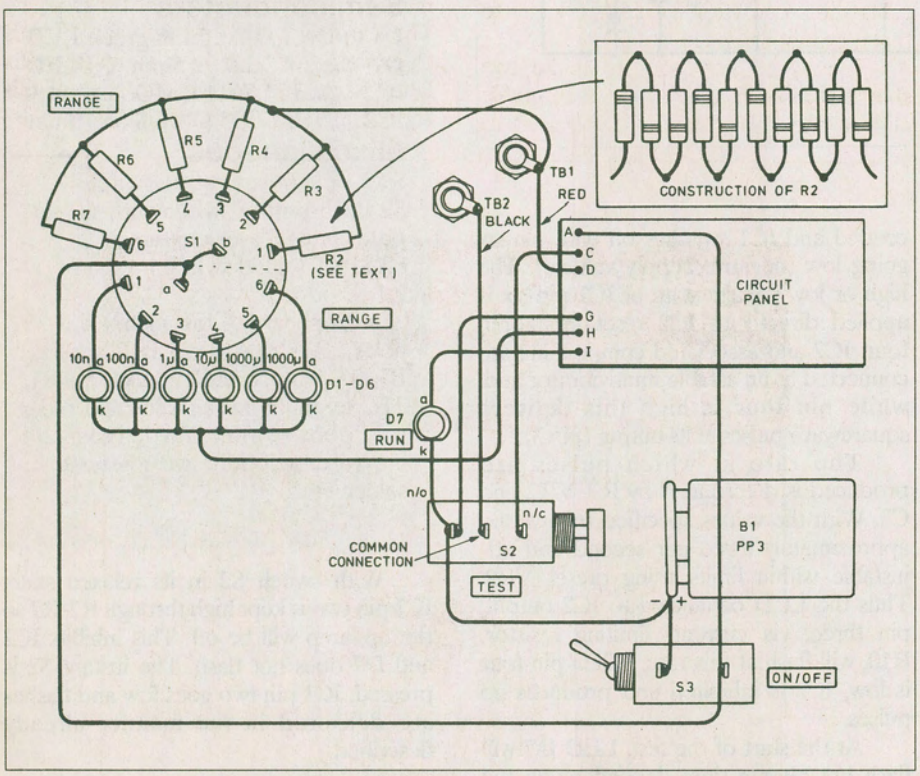
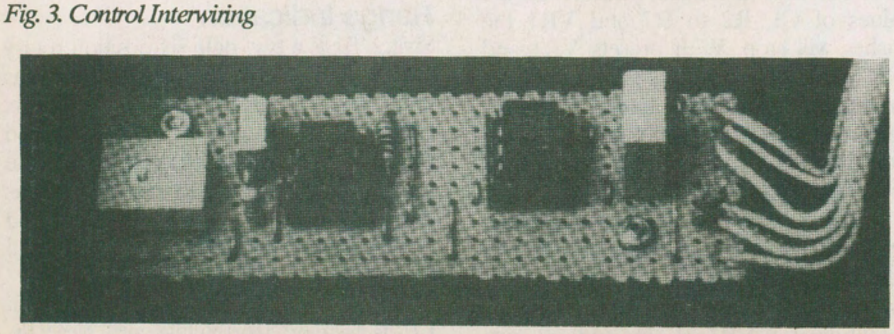


Fig. 3. Control Interwiring



these share a common current-limiting resistor, R1. This is possible since only one LED is illuminated at a time.

For greatest accuracy, resistors R2 to R7 should be of the close- tolerance (one or two percent) variety specified in the components list. Note that resistor R2 (100M) has an unusually high value and, as such, may not be readily available. Some high- value components are sold as "high voltage" resistors having a tolerance of five percent – it would be acceptable to use these.

However, in the prototype unit, resistor R2 was constructed by connecting 10 10M resistors in series (see Fig. 3). Accuracy is then limited chiefly by the fact that the value can only be expressed to the nearest flash below the voltage needed for IC2 to switch off. Accuracy is therefore less with small numbers of flashes. On the other hand, it improves with large numbers of pulses, but counting them becomes tedious.

Accuracy is maintained even with an ageing battery since IC1 is used in *comparator* mode. The relative voltage levels at pins two and three do not depend on the battery voltage so will always occur at the same time. Eventually, however, the battery will reach such a poor state of charge that it will fail to operate the LEDs effectively and it will be obvious when battery replacement is due.

The high input resistance of IC1 is important since, otherwise, appreciable current would flow into the IC with less current available to charge the capacitor under test. This would lead to considerable inaccuracy especially with small value capacitors.

Construction

Construction is based on a main circuit panel made from 0.1 in. matrix stripboard size 30 holes x 9 strips. The component layout and underside details are shown in Fig. 2. Cut this to size, drill the two fixing holes and make all track breaks and inter-strip links as indicated.

Solder all on-board components into position but do not insert the ICs in their holders until the end of construction. Note that C2 (calibration capacitor) is not soldered into the circuit – it is not used until the end of construction.

After a careful check for errors – particularly for accidental "bridging" of adjacent copper tracks, solder 15cm pieces of light-duty stranded connecting wire to strips A,C,D,G,H and I along the left-hand side of the panel. Use of rainbow ribbon cable here will keep the wiring neat and prevent errors. Set VR1 and VR2 sliding contacts to approximately mid-track position.

Prepare "resistor" R2 (100m) by connecting 10 off 10M resistors in series (see Fig. 3) unless a single component of this value is available. Solder R2 to R7 to rotary switch S1 contacts as indicated in Fig. 3.

Drill holes in the lid of the case for the switches and LEDs. Drill two holes in one of the case sides, for the terminals TB1 and TB2, and in the base for the circuit board. Attach all remaining components and complete the internal wiring paying attention to the polarities of all LEDs. The LEDs should be a tight push fit in the holes and secured, if necessary, with a dab of quick-setting epoxy resin adhesive.

Again, it is a good idea to use ribbon cable between switch S1 connections and the green LEDs. Note the link wire between S1a and S1b moving contacts and the common (k) connection at D1 to D6.

When wiring the terminals, note that TB1 is colored RED and connected to strip D on the circuit board. TB2 is BLACK and connected to switch S2 moving contact.

Remove the ICs from their special protective packing and, without touching the pins, insert them into their sockets with the correct orientation. Care must be taken in handling the ICs since they are CMOS devices and can be damages by static charge which may exist on the body.

Attach the circuit board to the base of the box using the holes drilled for the purpose, small fixings and short stand-off insulators. Connect the battery and secure it to the base of the unit using an adhesive fixing pad. Fit a control knob to switch S1 and self-adhesive plastic feet to the base of the case to prevent scratching of the work surface by the protruding bolt heads.

Testing and Calibration

For the initial test, bridge the terminals TB1 and TB2 with a short piece of connecting wire. Check operation of the green (RANGE) LEDs, D1 to D6, by switching on S3 and rotating switch S1 through all its positions. Each LED should light in the correct sequence with D7 remaining off.

Press S2 and, keeping it pressed, check that D7 flashes. Adjust preset VR2 to obtain three flashes per second (clockwise adjustment increase the number). It is possible to choose a slightly different rate to suit the user. Note that if any LED fails to light it is probably because it has been connected the wrong way round.

Now transfer attention to adjustment of the preset VR1. Set the range switch S1 to "10n". Remove the wire bridging the terminals (TB1 and TB2) and connect the "calibration capacitor" C2 in its place. Press S2 and, keeping it pressed, adjust VR1 until exactly 10 flashes are given – clockwise adjustment decrease the number.

The procedure should be repeated until a consistent result is obtained. Note that there may be some slight eccentricity in the last flash – this is of no consequence. The instrument should now give accurate results for any capacitor connected to the test terminals.

An occasional calibration check may be made but the prototype unit was found to maintain its accuracy over a long period of time. It would be wise to tape the calibration capacitor inside the case so that it cannot become lost.

It may be necessary to make two short test leads each with a small crocodile clip at one end. These will be used to make connections to very small capacitors and those with rigid end wires.

It now only remains to label the switches and LEDs and to put the unit into service. Note that the terminals are polarized – red for positive, black for negative and it is important to observe this when measuring the value of and *electrolytic* capacitor. The body of such a capacitor is clearly marked with the polarity – the end connected to the metal body – being the negative. Note that its voltage rating should not be *less* than 9V.

Capacitor Value

The value of the capacitor mentioned at the beginning of the article is 22,000 pF (22nF or 0.022uF) with a tolerance of +/-10 percent. This is arrived at in the following way.

The first two digits give the first two numbers of the value – in this case, 22. The third digit gives the number of zeros to express the value in picofarads. Suffix letter K means that the tolerance of this capacitor is +/-10 percent. ■