Quick Capacitor Tester

A low-cost, handheld audio/visual unit that can identify short, open and working capacitors.

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On many occasions in the course of work at a small electronics shop, customers often ask if we could check a certain capacitor from their repair jobs to see if it is faulty or not.

If the capacitor is suspected short-circuit it can be easily checked using a multimeter on its Ohms range in the usual way, and although this gives an accurate indication of a short-circuit capacitor, it is a little slow, setting-up the range switch, adjusting the meter to read zero and holding the probes onto the leads of the capacitor under test. (Often a hopelessly clumsy procedure, especially if the leads of the capacitor have been cut short).

The open-circuit types are considerably more difficult to identify, as values from a few picofarads (pF) to one or two microfarads (uF) read the same on the multimeter test whether open-circuit or OK.

The best tester for a capacitor is, of course, a wide range capacitance meter, but these are by no means cheap and are not always available. What was needed was a cheap, handheld unit which could identify short, open and working capacitors quickly, and with a minimum of fuss. The following design not only does this, both audibly and visually, in a matter of seconds, but also gives some indication of leakage current, especially useful for electrolytic capacitors and also for diodes and transistor junctions.

Principle of Operation

The tester described here works by making the test capacitor part of an audio oscillator circuit. A good capacitor will enable the circuit to oscillate, an open or short circuit capacitor will not. The frequency of oscillation gives an indication of the capacitor value.

A second part of the circuit checks the oscillator output and indicates, via the LED, if a short circuited capacitor

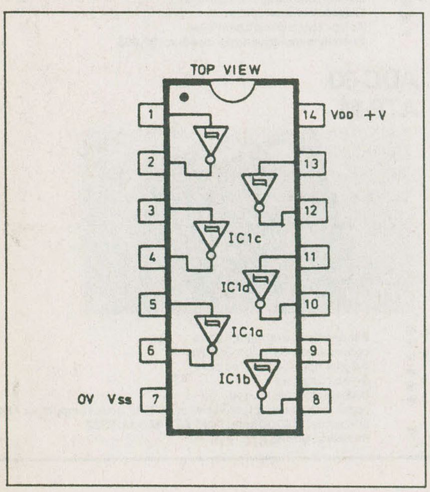

Fig. 1. The 4584 (40106) Hex Schmitt Trigger pinout details.

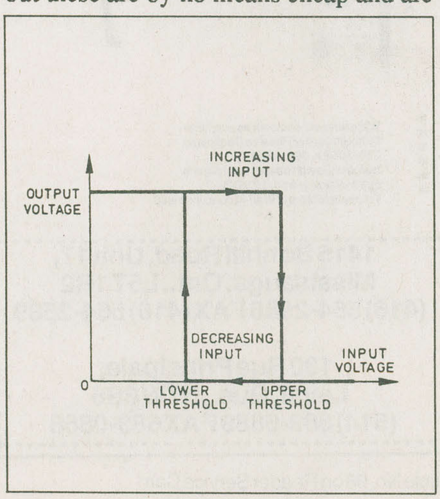

Fig. 2. Graph of the Schmitt trigger threshold levels.

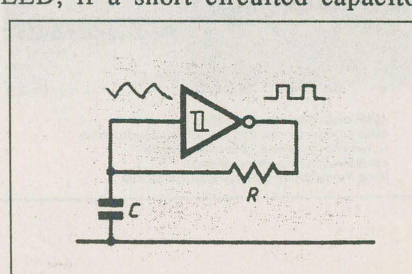

Fig. 3. Simplified Schmitt trigger inverter oscillator circuit.

prevents oscillation. To enable leakage currents to be measured a separate circuit that acts as a simple continuity tester has been added. The oscillator is a Schmitt-trigger oscillator built around one of six inverters on the 458 CMOS hex Schmitt trigger (Fig. 1).

The difference between a standard inverter and a Schmitt trigger is important in this circuit, because it's the Schmitt trigger action which promotes the oscillation. A simple inverter gives an output which is the opposite logic level to that at its input. As the voltage on the input rises, the output will stay high until the input reaches the threshold level, at which point the output changes state and goes low. If the input voltage is now reduced the output will not go back to its high state until the input voltage has again reached the threshold level.

The important thing to remember is that a simple inverter has only one threshold level. The Schmitt trigger inverter however, is peculiar in that it has two threshold levels (see Fig.2). When the output reaches the upper threshold the output goes low in the usual way, but if the input voltage is now reduced, the output will not change state until the input has dropped to the lower threshold level.

In the simplifier oscillator circuit (Fig.3) we can see how the Schmitt trigger effect is utilized. As with all astable oscillator type circuits, we must first of all decide on the initial state of the circuits before we can describe its operation.

Let us assume to begin with that the capacitor, C, is discharged and that the output of the Schmitt trigger is therefore high. Capacitor C then begins to charge via resistor , R at a rate defined by the value of resistor R. When the voltage at C, and therefore at the input of the Schmitt trigger, reaches its upper threshold, the output goes low. The capacitor then discharges through R, until the voltage at the input has dropped to the lower threshold level, causing the output to change back to its high state once again.

The process then repeats and continues indefinitely. The output is therefore, a squarewave, and its frequency is determined by the values of C and R.

Circuit Description

The complete circuit diagram for the Quick Cap Tester is shown in Fig.4. There are two quite separate circuits in this design, each built around different parts of the same IC, so for clarity each section will de described individually.

The capacitor under test, Cx(a), is placed across one of three test pads and the common pad on the printed circuit board (PCB). Assuming that the capacitor is OK it completes the Schmitt oscillator, giving a squarewave output at pin 6 IC1a. This is buffered by the 1C1b to give a signal to drive the piezoelectric buzzer WD1.

The frequency varies according to which pad is chosen and the value of capacitor used. The series arrangement of resistors R1, R2 and R3 means that an audible note can be heard for a large range of different values of Cx(a). Resistor R4 protects the input by attempting to test a

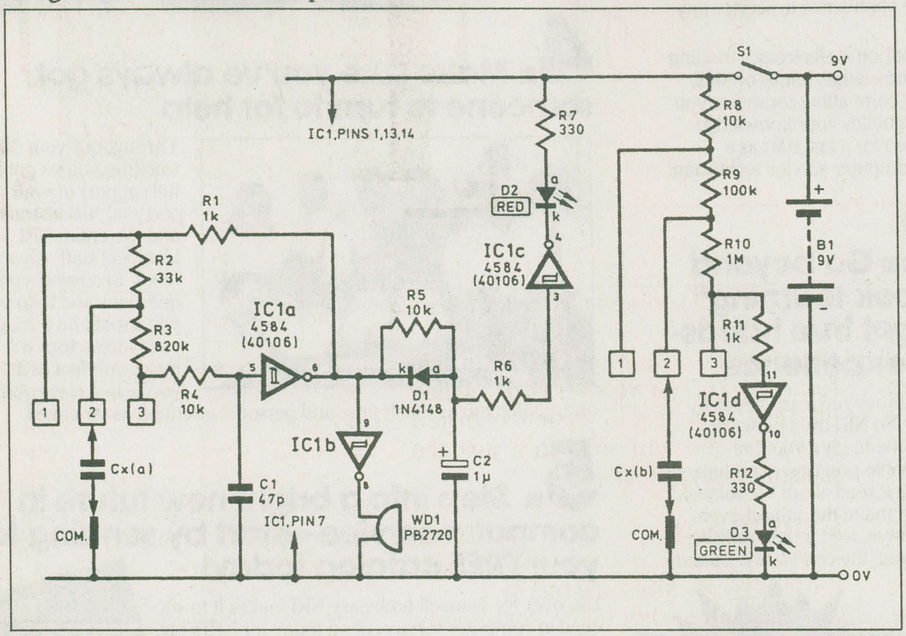

Fig. 4. Full circuit diagram for the tester.

Parts List

Resistors

R1,6,11 .... 1k
R2 .... 33k
R3 .... 820k
R4,5,8 .... 10k
R7,12 330
R9 .... 100k
R10 .... 1M
All .25W 5%

Capacitors

C1 .... 47p
C2 .... 1u50V

Semiconductors

D1 .... 1N4148, 1N914
D2 .... Red LED
D3 .... Green LED
IC1 .... 4584 or 40106

Miscellaneous

S1 .... SPST rocker switch
WD1 .... Piezo sounder
B1 .... 9V battery

Plastic case, PCB, 14-pin DIP socket, 9V battery clip, nuts, washers, etc.

charged-up capacitor. Capacitor C1 reduces the maximum frequency of oscillation to about 100kHz. This is because the nature of CMOS devices is such that they draw more current the more often their outputs change state. Without C1 the circuit oscillates merrily at about 8MHz causing considerable current drain, and possible interference problems.

It is also worth noting that the audio frequencies produced when this unit is being used are considerably less than the 100kHz produced when it is in its standby mode. This makes for an interesting paradox, a unit that uses less current when it's being used than when it isn't. So if you want to extend the battery life of your tester, use it as often as possible.

Returning to the circuit, when pin 6 of IC1a is oscillating, capacitor C2 attempts to charge up via resistor R5, but as soon as pin 6 goes momentarily low diode D1 becomes forward biased and quickly discharge C2. Thus, during oscillation C2 never charges to a high enough potential to operate the inverter at IC1c and the LED. D2 remains off.

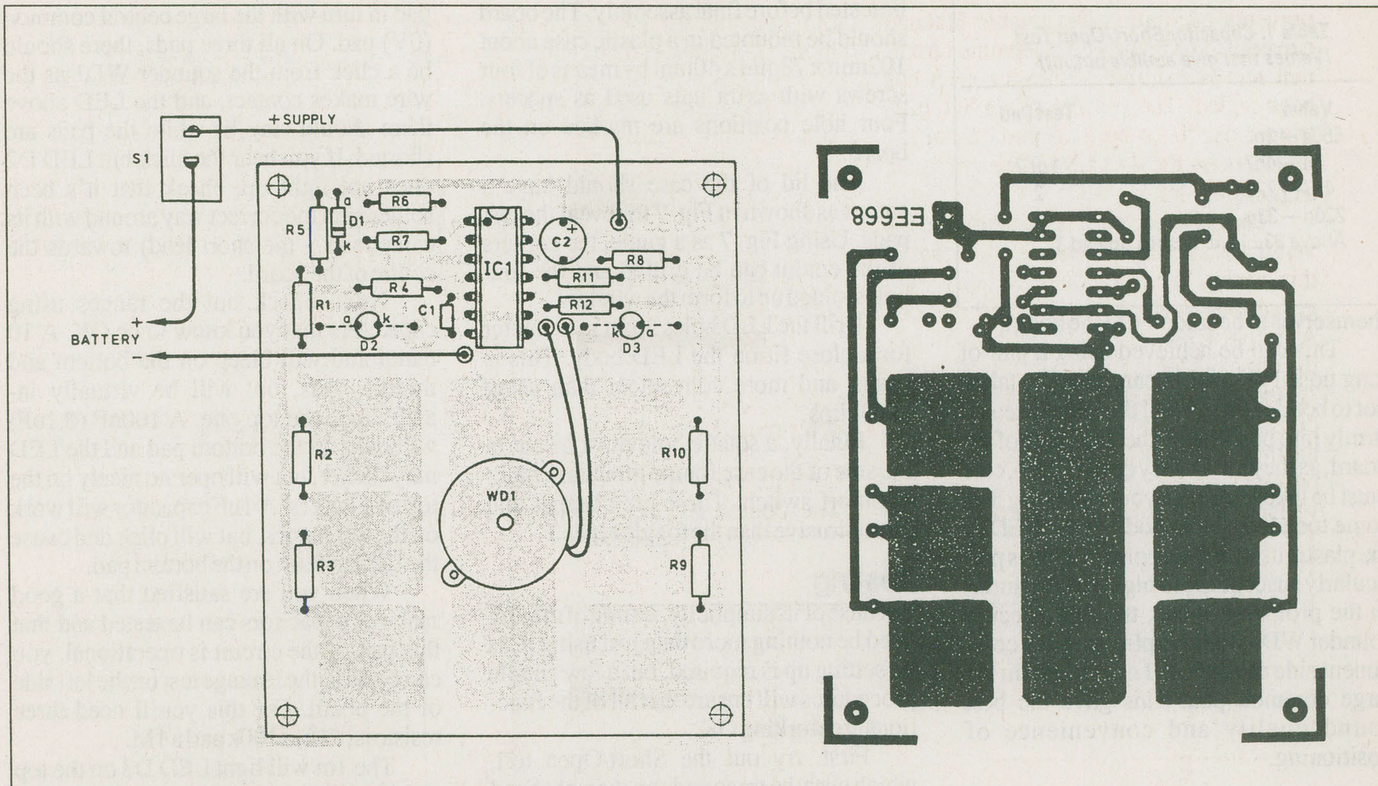

Fig.5. PCB laout and foil side pattern. The diodes D2 and D3 are mounted on the track side.

If short-circuit is placed between any of the test-pads and the OV, pin 6 will go high for long enough to charge capacitor C2 to the upper threshold of IC1c and the short circuit indicator D2 will light. At very low frequencies, caused by large values of capacitors being tested, the LED may flicker or flash on and off as the capacitor charges and discharges. This is easily distinguishable from the result given by an actual short-circuit capacitor.

Leakage

The second part of the circuit is the leakage current test. The capacitor under test is placed across another set of test-pads (1,2,3) in a similar way. Initially the input to IC1d is held high by resistors R8, R9 and R10, and therefore the LED D3 is off. If the capacitor (or diode or transistor junction) leaks more current down to ground (OV) than that initially flowing through the combinations of R8, R9 and R10, the input to IC1d will be pulled low, causing the LED D3 to light.

The series arrangement of resistors R8, R9 and R10, with the tap- offs to the three pads (1,2,3) means that different leakages can be measured (approx. 4uA, 40uA and 400uA with the resistor values given). Large value electrolytics, which look like a short-circuit when they are charging up will cause the LED D3 to light for a couple of seconds or more depending on the value used. When charged however, the unit indicated just the remaining leakage current.

Construction

The component layout and full size copper foil master pattern is shown in Fig.5.

Assembly should be reasonably trouble-free as there are very few components and no wire links. Provided all of the visual precautions are taken, diode D1 and the LEDs are the correct way around, and the polarity of capacitor C2 is carefully observed the unit should work first time.

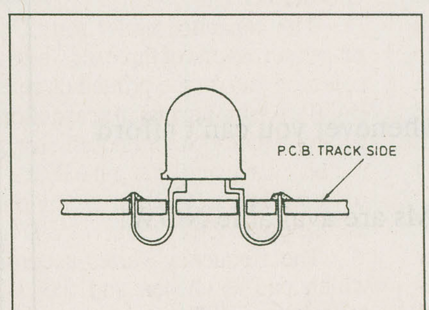

Fig. 6. The leads of diodes D2 and D3 are passed through one set of holes and soldered to adjacent pads.

The only difficulty some constructors may have is in the somewhat unconventional mounting of the LEDs D2 and D3, see Fig.6. Because the large pads on the track side of the board are used as the test pads, the LEDs need to be mounted on the track side with the legs or leads going through the board and looped back on

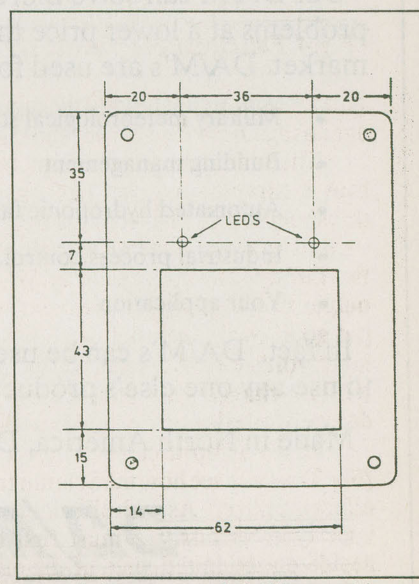

Fig. 7. Front panel drilling guide and details of the test pad circuit.

Table 1: Capacitor Short/Open Test (Values that give audible output)

Value	Test Pad
560p—1n	1
1n—4n7	1 or 2
4n7—220n	2
220n—33μ	3
Above 33μ l.e.d. flashes on Pad 3	

themselves to be soldered to the board.

This can be achieved using a pair of long nosed pliers, but care must be taken not to bend the legs until the LED is seated firmly into position on the track side of the board, as they break very easily. Also, care must be taken not to let your soldering iron come too close to the body of the LED as the plastic used in their construction is particularly susceptible to high temperatures. In the prototype mode, the piezoelectric sounder WD1 was also placed on the component side of the board over a hole in the large common pad. This gave the best sound quality and convenience of positioning.

Case

The whole board when completed should be tested before final assembly. The board should be mounted in a plastic case about 102mm x 78mm x 40mm by means of four screws with extra nuts used as spacers. Four hole positions are marked on the board.

The lid of the case should have a cutout as shown in Fig. 7 to reveal the test pads. Using Fig. 7 as a guide, the corners of the cutout can be drilled and the four holes joined up to form the window.

Drill the LED holes 3mm in diameter for a close fit on the LED body. This is neater and more convenient than using LED clips.

Finally, a square hole must be cut in the side of the case for the miniature rocker on/off switch. These are cheaper and less obtrusive than the toggle types.

Testing

Because of its simplicity, testing of the unit need be nothing more than just using it, as no setting up is required, but a few simple procedures will ensure that all of the functions are working OK.

First, try out the Short/Open test, which uses the three pads on the right hand side of the PCB as you look at it from the front. Use a piece of wire to short out each pad in turn with the large central common (0V) pad. On all three pads, there should be a click from the sounder WD1 as the wire makes contact, and the LED above them should stay lit while the pads are shorted. If you hear the click but LED D2 does not light up, check that it's been soldered in the correct way around with its cathode (k - the short lead) towards the centre of the board.

Next, check out the ranges using capacitors that you know to be OK. A 10 nanofarad will bleep on the bottom and middle pads, but will be virtually inaudible on the top one. A 100nF (0.1uF) will buzz on the bottom pad and the LED may flicker, but will operate nicely on the top two ranges. A 1uF capacitor will work on the top ranges, but will click and cause the LED to flash on the bottom pad.

When you are satisfied that a good range of capacitors can be tested and that this part of the circuit is operational, you can go on to the leakage test on the left side of the board. For this you'll need three resistors, a 1k, a 100k and a 1M.

The 1m will light LED D3 on the top pad (4uA) but not on the others. The 100k will light it on the top and middle (400uA) ranges and the 1k will light it on all ranges, as will a short circuit. Again, if D3 fails to light, see that its cathode is toward the centre of the board.

In the event that you can get nothing at all from your unit, check for solder bridges, etc., and with a multimeter check the obvious points for power; for example pins 1, 13, and 14 of IC1 should be at 9V (supply voltage) and pin 7 should be at 0V, as should the common (ground) pad.

In Use

After a little time using the tester, you quickly get to know how to interpret results. The current leakage detector side speaks for itself. The top pad detects leaks up to 4uA, the middle up to 40uA and the top to 400uA.

On the Short/Open test, Table 1 may help you to get used to the different ranges, though it does not take long to try your test capacitor on all ranges.

Conclusion

The tester has been invaluable in the component shop, not only for testing capacitors, but also the leakage current in diodes and transistor junctions. On another note, the budding electronics experimenter may want to try to use the remaining two Schmitt trigger inverters on the 4584 IC for other tests or facilities. ■