Build this useful test instrument

Direct reading capacitance meter

Following on from our direct reading capacitance meter of about two years ago, here is an updated version which should be equally as useful as its predecessor and just as popular.

by IAN POGSON

In October 1976, we described a Direct Reading Capacitance Meter which became a very popular piece of test equipment. Because of its success, we decided to have another look at it with the idea of updating the design and making any improvements desirable in the light of intervening experience.

The original unit was not built on a printed board; instead, we made use of a piece of general-purpose DIP board. Obviously, it would make it neater and easier to build if we used a custom PCB and this is one improvement which is very worthwhile. Similarly the case which we used to house the original was quite a good one, but it is now rather expensive and so we looked around for a case which was more modestly priced but would do the job just as well. The ever popular "zippy box" filled the bill and this is what we have used for the new meter.

Another idea which seemed worth considering was to use a 100uA meter instead of the 50uA unit. This would give decade readings which would possibly be more in keeping with present day usage. However, investigations along these lines revealed that the system would not fully drive a 100uA movement, so that idea had to be passed over.

After our first unit was described one of our readers, Mr B. M. Byrne, of Indooroopilly, suggested some modifications in the light of his experiences with it; his suggestions were given in Circuit & Design Ideas for July, 1977. Interested readers may wish to refer to Mr Byrne's comments.

Our own experience in making up the new unit is that we have found that it was better to leave the resistor values as for the earlier circuit. It would seem that there are a number of hidden factors, possibly layout, etc, which can affect the two lower ranges. We have found that a very satisfactory way out of the problem is to add a couple of extra calibrating trimpots.

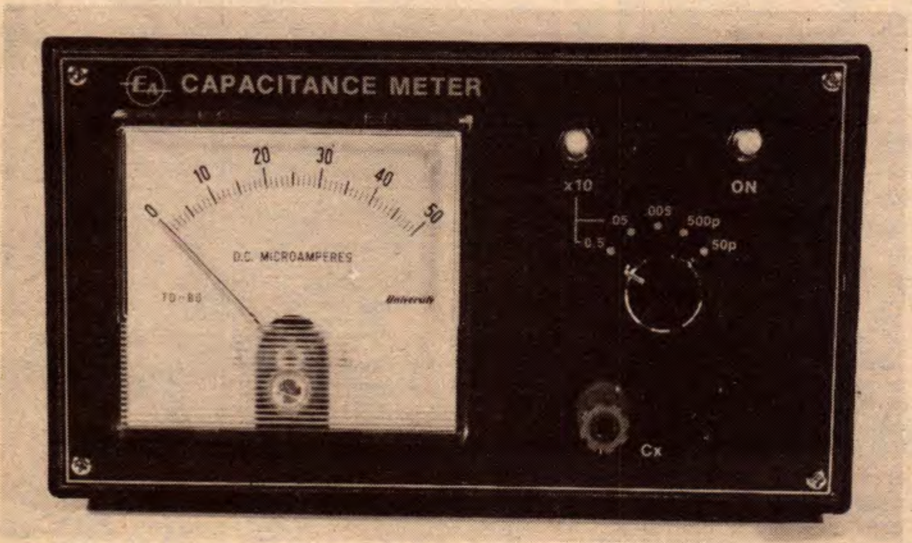
Modifications aside, this little capacitance meter is a most useful device for anyone making use of capacitors. Most of us have a box of assorted capacitors, some good, some doubtful and more than likely quite a number without any capacitance marking. For sorting out such a box of capacitors this capacitance meter is invaluable.

The unit effectively has six switched ranges. Capacitance measurements from as low as 1pF and up to 5uF are possible. Low values, below about 10pF, may be subject to a certain amount of inaccuracy. This is not unusual in simple types of capacitance measuring devices.

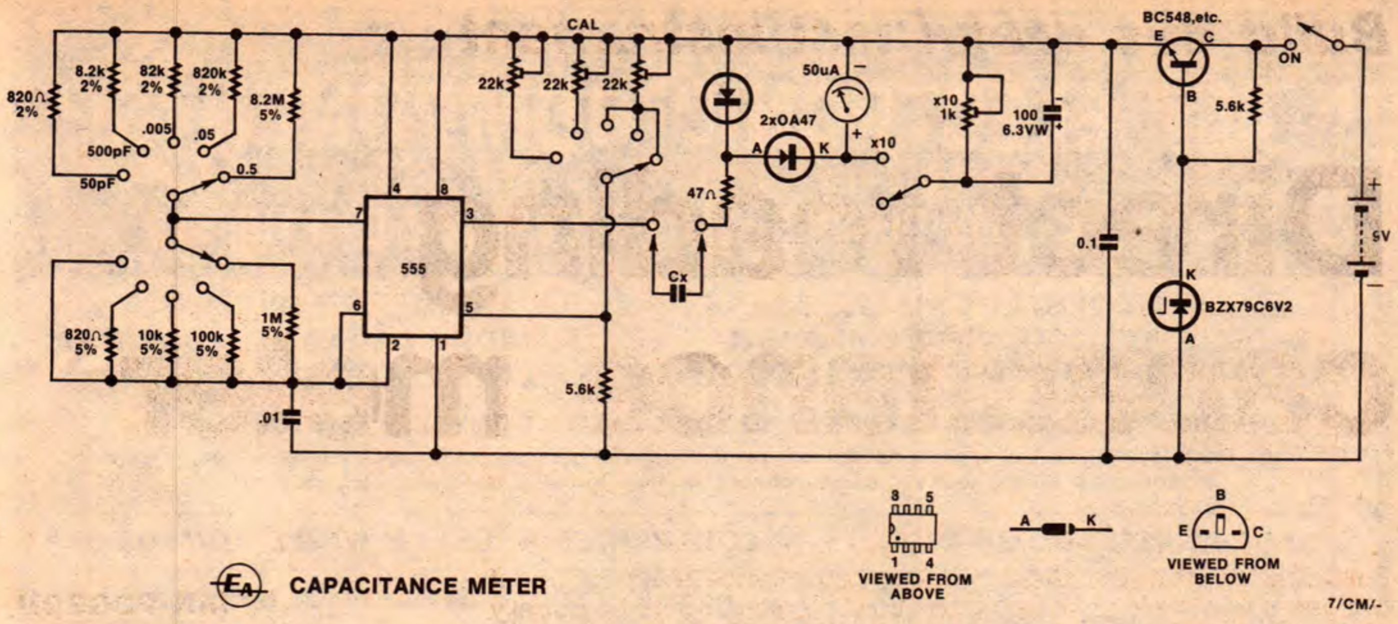
In addition to measuring ordinary capacitors, it is possible to measure electrolytics as there is a potential difference between the two terminals amounting to a volt or two. The polarity must be observed of course. Also, this potential difference makes it possible to measure the reverse biased capacitance of diodes, at the voltage appearing across the terminals. This is not all. Such other capacitance measurements as the junctions of transistors, coaxial cable, etc may also be made.

As may be seen from the circuit and pictures, the device is quite simple. It follows that the cost is quite modest by current standards. The operation of the circuit centres on the very popular 555 timer IC. I will give a very short description of the operation, but for readers who would like to go into this at greater depth, I suggest that you refer to the original article by Mr Willcox, in the May 1976 issue of "Television".

The two resistors selected by the



A low-cost plastic "zippy" case was used to house the prototype.



CAPACITANCE METER

range switch, together with the .01uF capacitor and part of the 555 timer, form an oscillator. After undergoing switching in other parts of the 555 timer the output emerges at pin 3 in the form of pulses. One part of the pulse is discharged through capacitor Cx, via the diode to the supply rail. The other part of the pulse discharges through the other diode and the meter. These pulses are integrated by the meter and give a reading in accordance with the capacitance Cx.

Calibration is achieved by adjusting the three 22k trimpots. One is common to the three highest ranges and need only be adjusted on one of those ranges. The other two trimpots are used for the two lower ranges, giving separate adjustments for each.

In the earlier version of the capacitance meter we specified close tolerance resistors for the oscillator ranges. The need still applies for the three highest ranges, as they are controlled by one calibrating trimpot. However, the other two ranges may not need such close tolerance resistors, as separate adjustment is provided for each. We have retained the close tolerance resistors on the circuit diagram and in the parts list, but readers may decide whether or not they adhere strictly to these.

In the bottom row of oscillator resistors it may be seen that three of them relate by a factor of 10, but the fourth resistor is reduced to 820 ohms and the fifth position is reduced to a link. These are due to the effective resistance presented by the IC at pin 7.

To increase the top range measurement of 0.5uF by a factor of 10, a shunt in the form of a 1k trimpot is switched across the meter. Due to the low frequency of the oscillator on the top range the pointer of the meter is inclined to "jitter", so a 100uF electrolytic capacitor is also switched across the meter to eliminate this effect. Of course, when switching out the x10 facility, the jittering effect remains on the top range. It is not serious, but if you wish, the next lower range may be selected and the x10 switch added, again resulting in a 0.5uF range but with smooth meter operation.

To maintain accuracy of measurement, it is necessary to keep the supply voltage at a steady value. To this end, we have used a simple voltage regulator consisting of a 6.2V zener diode and a BC548 (or similar) transistor. It was found that this arrangement was slightly unstable under certain conditions and the 0.1uF bypass capacitor was added to cure this tendency.

The supply for our unit is derived from a small 9V battery, regulated as just described. If you wish to operate the unit from the mains, then the battery may be replaced by a suitable transformer, rectifier diodes and a large value electrolytic capacitor. However, we are of the opinion that this type of unit is better supplied by a battery, thus giving greater freedom and flexibility.

The matter of components can present problems in availability but there should be little or no trouble with this

LIST OF COMPONENT PARTS

1 Zippy box, 196mm x 113mm x 60mm
1 Printed circuit board, 89mm x 76mm, code 78CII
1 50uA Meter, 86mm x 78mm (see text for alternative)
1 Rotary switch, 2 sections 2-pole 5-position
2 Miniature toggle switches, SPDT
1 Knob
2 Terminals type D64, 1-red 1-black
2 Banana plugs
2 Crocodile clips
1 9V battery No 2362
1 555 IC 8-pin DIL
1 IC socket, 8-pin DIL (optional)
1 BC548 transistor or similar
1 Zener diode BZX79C6V2
2 OA47 germanium diodes

RESISTORS
(½ watt)
1 47 ohms
1 820 ohms 2%
1 820 ohms 5%
2 5.6k
1 8.2k 2%
1 10k 5%
1 82k 2%
1 100k 5%
1 820k 2%
1 1M 5%
1 8.2M 5%
1 1k Philips miniature trimpot, horizontal mounting
3 22k Philips miniature trimpots, horizontal mounting

CAPACITORS
1 .01uF greencap
1 0.1uF greencap
1 100uF 6.3VW electrolytic

MISCELLANEOUS
Hookup wire, solder, solder lugs, clips for battery.

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used in the prototype. Components with higher ratings may generally be used provided they are physically compatible. Components with lower ratings may also be used in some cases, provided the ratings are not exceeded.

Direct reading capacitance meter

project. The zippy box is available from Dick Smith Electronics stores and many other suppliers. As usual, copies of the artworks for the printed board and the front panel label will be distributed to various suppliers and these items should be readily available.

If you wish to make your own printed board and front panel label, we can supply the usual dyeline transparencies through the Information Centre.

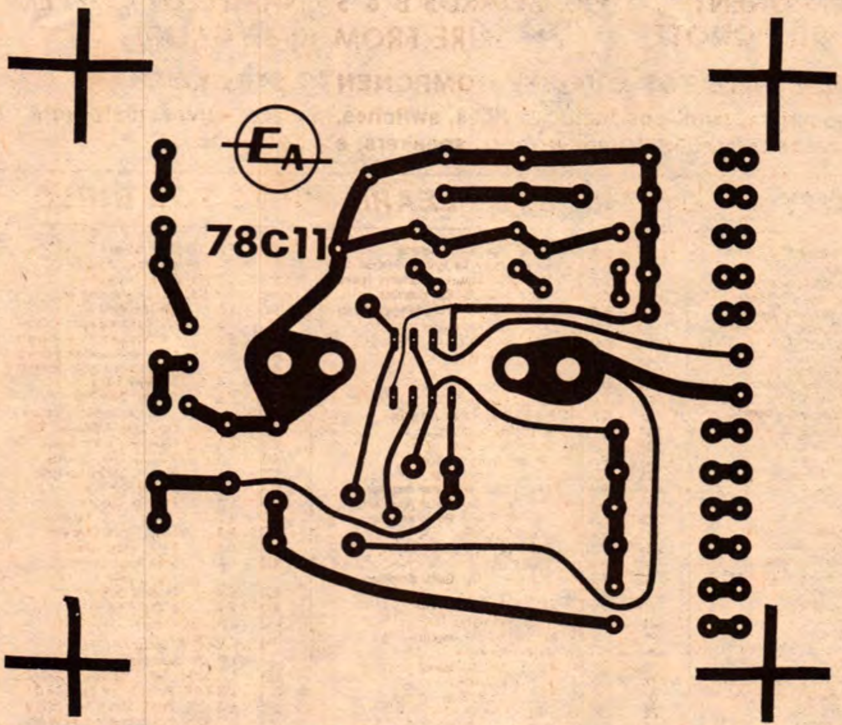
The meter which we have used on the prototype is one imported by University Graham and it should be available through most components sellers. On the other hand Dick Smith Electronics offer a much smaller meter which would also do the job. Naturally, if you elect to use this smaller meter but still use the same box, then the different mounting requirements will have to be taken into account. The terminal centres on the back of the small meter are closer than for the larger meter, but we have provided for this on the printed board.

The close tolerance resistors for the prototype were obtained from Radio Despatch Service, but these should also be available from most components sellers. OA47 or similar gold bonded germanium diodes are required, but supplies of these seem to be readily available.

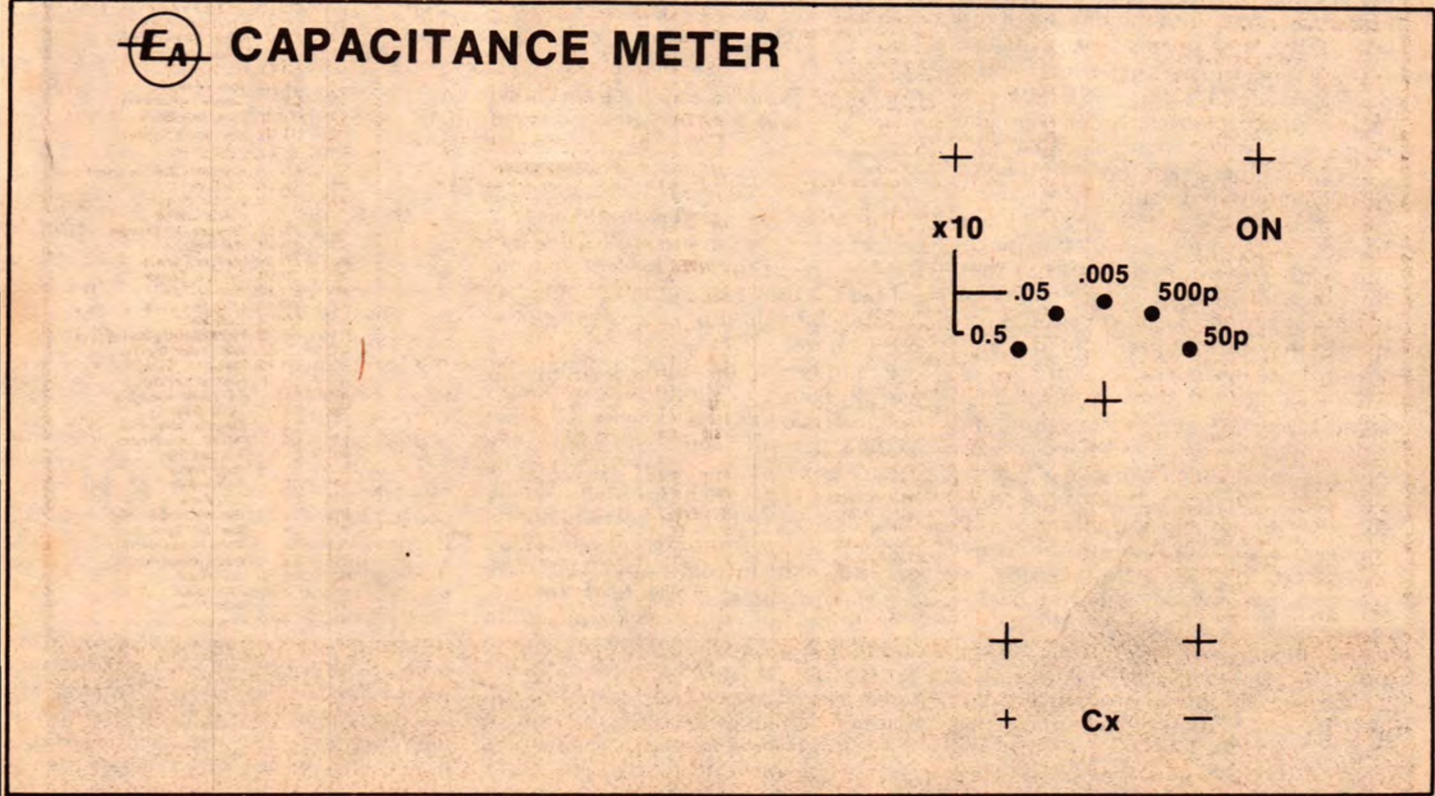
Construction is quite straightforward and should present no difficulties. Most of the components are accommodated on the PCB and this in turn is mounted on the back of the meter by means of the two terminals. The range selector switch, the two toggle switches and two terminals are mounted on the front panel. The battery is accommodated on the bottom of the box at one end.

The usual precautions should be observed. Care should be taken to make good soldered joints and not to overheat the components in the process. Also, it is important to observe the polarity of such components as diodes, transistors, electrolytic capacitors and the IC. With regard to the IC, we used a socket for it but if you wish, it may be dispensed with providing care is taken when soldering it in place.

Having completed the assembly of



Here are actual size reproductions of the PC pattern and front panel artwork.



the printed board, it should be carefully checked to make sure that there are no errors or omissions. Leads of hookup wire should now be soldered to all points on the board, with sufficient length in each case so that they will reach the external destination point. When wiring the range switch for the resistors, I used different colours of wire for each range with the same colour for the two sides of the switch. This makes wiring and subsequent tracing easier.

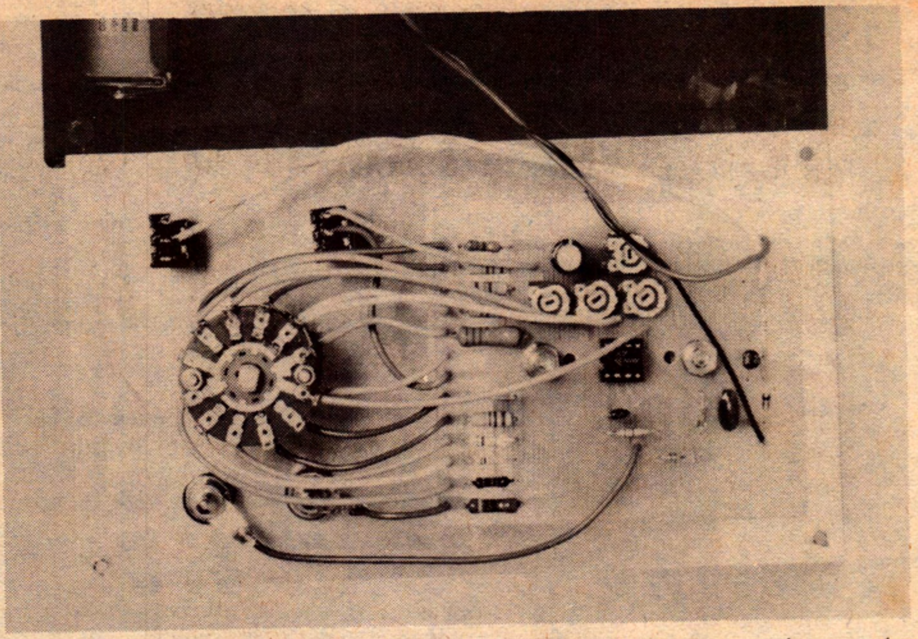
The meter may now be fixed to the front panel and the printed board assembly may be screwed to it. The switches and terminals may also be fixed to the panel prior to doing all the interwiring.

On the range switch, I used the wafer nearest to the panel for the two sets of resistors. The other wafer also has two sections but only one is used. The three calibrating trimpots are wired to this section, one trimpot being used for the three highest ranges and a trimpot each for the other two ranges.

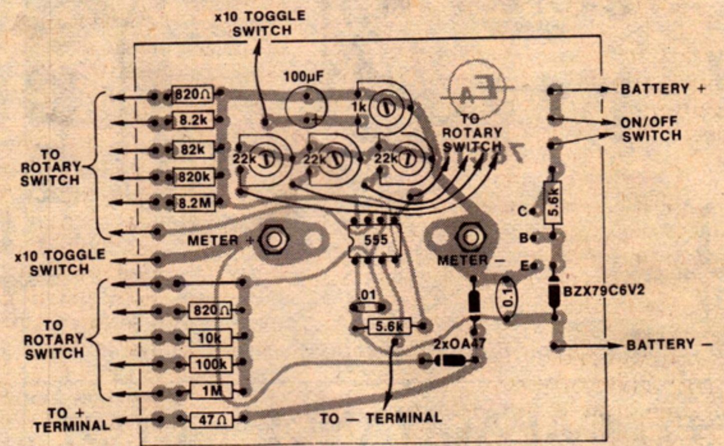
The leads to the two test terminals should be taken as directly as possible, but they should also be kept away from other near objects and from each other. This will keep stray capacitance to a minimum, which could become significant on the lowest range. Having done the external wiring it is a good idea to check over it before proceeding.

With all the rest of the unit now completed, you will find that the battery will just fit nicely into the bottom of the box at the end nearest the switches. Also, as an extra facility, I made up a pair of crocodile clips with plugs attached. I obtained a pair of clips and dispensed with one handle insulator in each case. I then soldered a short piece of 16 gauge tinned copper wire to each one. The clips were then screwed to banana plugs with the insulating pieces removed. The finished items can then be plugged into the tops of the terminals as required. Of course the terminals may be used without the clips when this is more convenient.

To calibrate the meter, you will need some capacitors of suitable values and close tolerance. You will need at least one capacitor which will give a close to full scale reading on one of the three highest ranges, preferably not the highest range because of the wider tolerance in the 8.2M resistor. A capacitor of say, .047uF or .0047uF would be satisfactory. With the capacitor in place, the three 22k trimpots set to mid travel and the range switch set to the appropriate range, switch on and adjust the trimpot so that the correct reading is given on the meter. The other two ranges controlled by this trimpot should also be correct.



Inside view of the prototype showing how the PC board is mounted across the meter terminals. Note routing of leads to the two test terminals.



The component overlay diagram shows the PC board as viewed from the component side. Take care to ensure correct orientation of polarised components.

The other two ranges should also be calibrated in the same way. A 470pF and a 47pF capacitor could be used to calibrate the respective ranges as before, by adjusting the appropriate 22k trimpot.

In addition to the above calibrations, we still have to calibrate the x10 multiplier. To do this, the range switch is set to the 0 to 0.5uF range. You will need a capacitor of known value close to the maximum scale reading of 5uF. The 1k trimpot is set so that the reading on the meter scale corresponds with the value of the calibrating capacitor. The capacitance meter is now ready for use.

In using the meter, one precaution should always be taken. Before adding a capacitor to the Cx terminals, the range switch should be rotated to the extreme left or 0 to 0.5uF position. If this is not done and a large capacitor is connected to the terminals, the meter will be "slammed", which is a practice which should be avoided as much as possible. Another point which should be noted is that the x10 multiplier should only be used with the 0 to 0.5uF and the 0 to .05uF ranges. Errors could be experienced with the lower ranges.

It should also be noted that there is a small zero error on the lowest range. Without the clips plugged in, the prototype gives a zero error reading of 1.5pF and with the clips plugged in the error increases to about 1.8pF. Very low capacitance measurements are subject to some error, particularly below about 10pF. However, experience will soon establish what these errors are and they may be allowed for.

It can be an interesting procedure to take a handful of capacitors, including some electrolytics, diodes, transistors, coaxial cable, etc, and make some measurements. This will soon show just how useful our little capacitance meter can be.