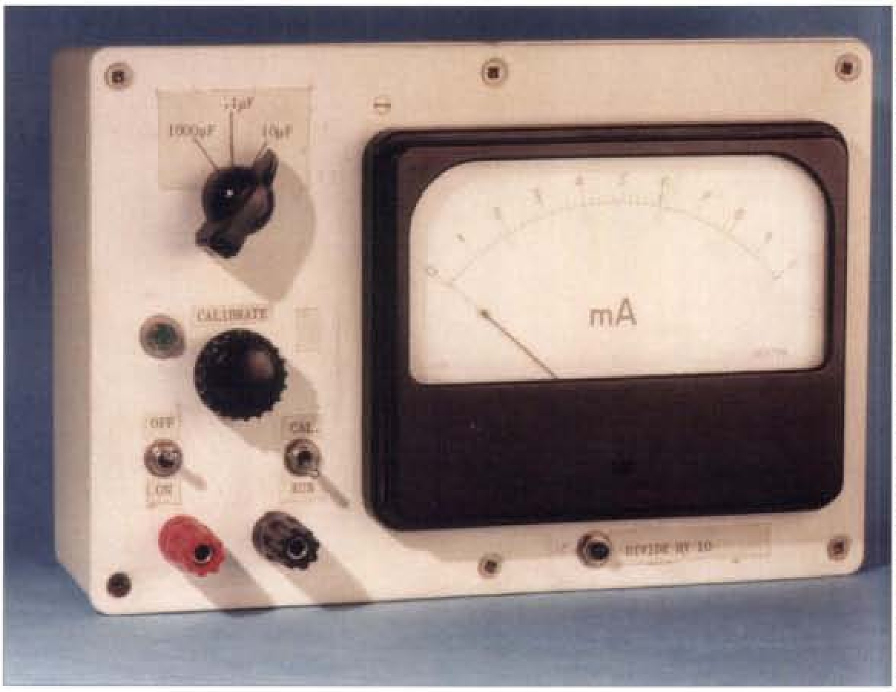
An easy to build...

SIMPLE CAPACITANCE METER

James Brett G0TFP presents an easy to build instrument to directly read capacitance in the range of 1pF to 10μF.



Before I start describing the project, let's take a (very quick) look at the theory involved. The reactance of capacitor C is $1/(2\pi fC)$. If we substitute in the current equation for Xc we get that the current, $I = E2\pi fC$. In other words the current is directly proportional to the capacity if E and f are kept constant.

In this design, the frequency source is a squarewave but this doesn't matter. All repetitive waveforms are made up from a fundamental sinewave and a succession of harmonic sinewaves. The fact that there are many sinewaves of different frequency but remaining in the same relative phase relationship doesn't matter so long as the result remains constant. This means that the current will still be in direct proportion to the capacity.

The Circuit

Now we've briefly examined the theory, it's time to look at the circuit that's shown in the diagram of **Fig. 1**. The heart of this simple capacitance meter is IC1, the ever popular timer chip 555, which is configured to run as asymmetrical oscillator, with the 'clock' frequency set by the selection of C1, C2 or C3 and series resistor chain R1/2/3. The frequencies involved are approximately 480kHz for position 1, 4.8kHz for position 2 and 48Hz for position 3.

The output level from IC1 pin 3 is fed through either, the 'capacitor on test' or the range-selected 'standard' capacitor. The standard capacitor allows a calibration setting for the meter circuit. Overall, the accuracy is as good as the tolerance of the three standard calibration capacitors and the readability of the meter scale.

The bridge rectifier arrangement of D1 to D4, enables the d.c. moving coil meter to read the mean value of the alternating current being passed through the circuit. The meter has a 1mA movement but is shunted to enable it to read 10mA full scale. So, when S3 is pressed, the meter reading represents a capacitance value that is one tenth of the scale reading.

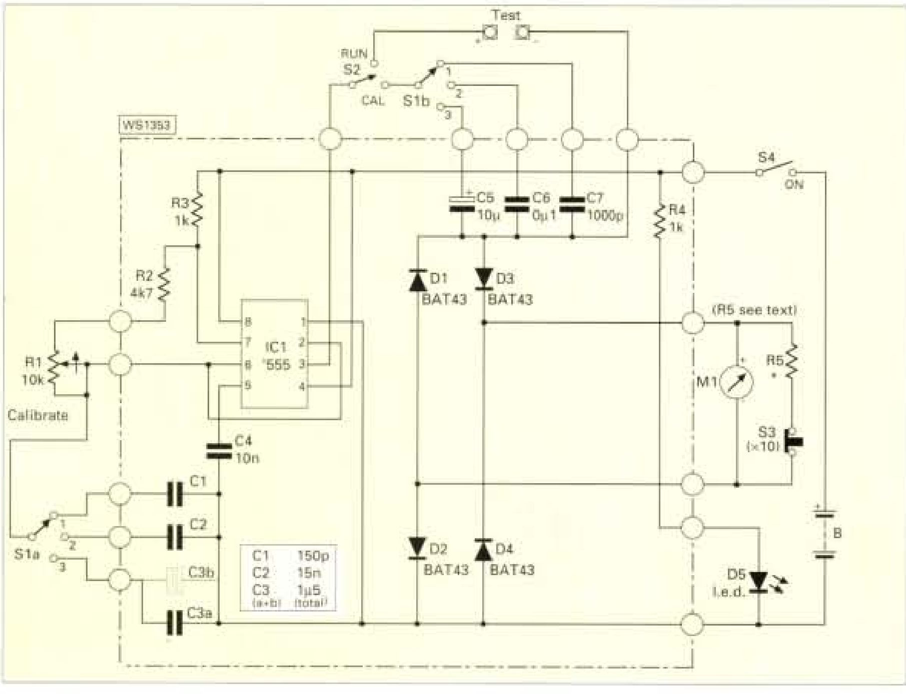


Fig. 1: The circuit diagram of the simple, but effective capacitance meter.

Construction & Layout

The construction is quite simple and the layout is not critical. Most of the components are wired on the strip board as shown in **Fig. 2**. A fairly large space is left for the capacitors as the sizes will depend on the types selected. Due to the comparative difficulty of obtaining 1.5μF non-electrolytic capacitors provision is made for the two

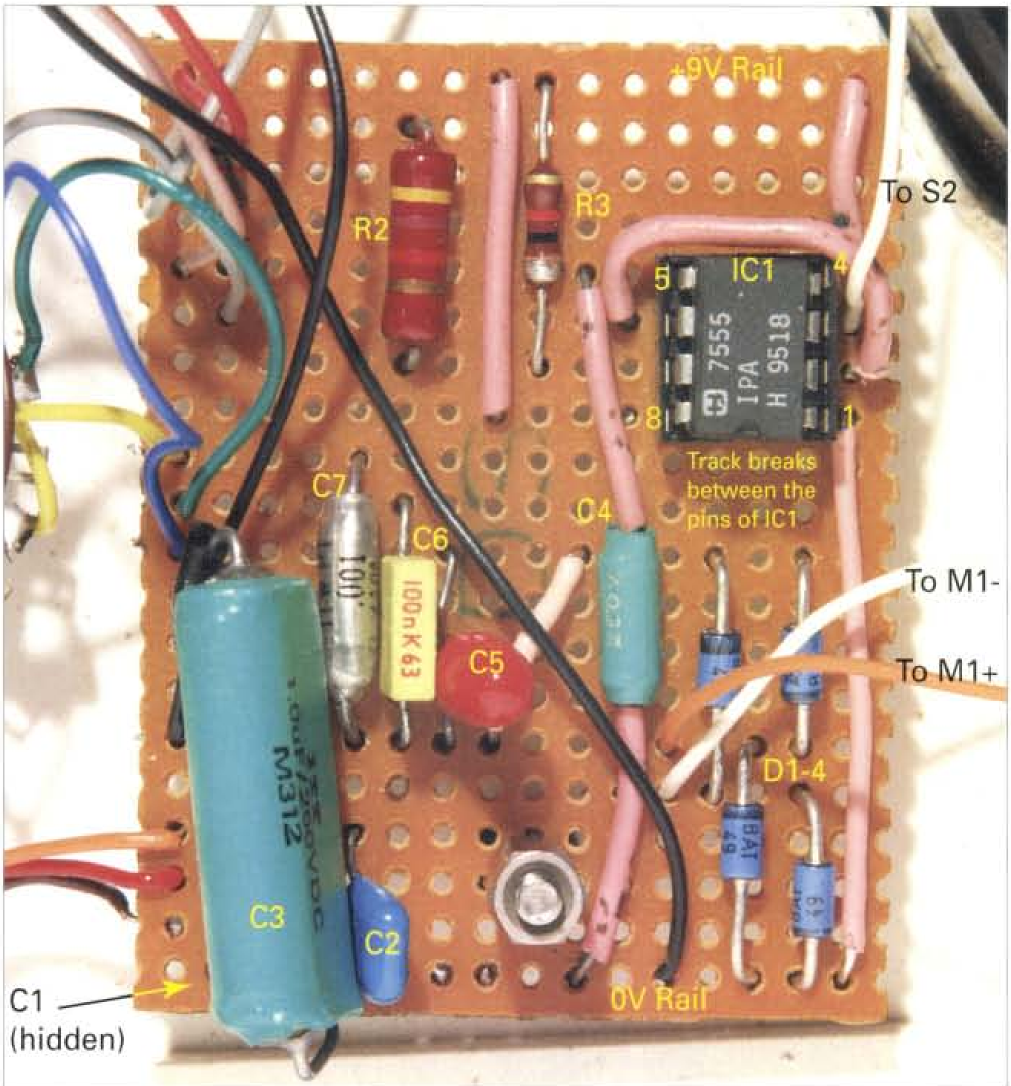


Fig. 2: Most of the electronic components are mounted on a small piece of Veroboard. Don't forget to cut the tracks between the pins of IC1 before soldering it in place. The tracks run horizontally on the small piece of Veroboard.

lesser values in parallel.

The wires from the circuit board to S2 and S1b should be kept fairly short and separated to avoid excessive stray capacity. The layout of my prototype is shown in the photograph of **Fig. 3**.

Since the 555 is generating a fairly high frequency squarewave, a very high level of harmonics will be present. In keeping with current EMC practice, a metal box is recommended to prevent any possible radiation of interference.

Select a suitable layout to suit the size of the meter and box an example as shown with components mounted on the lid. For convenience, R5 is mounted between the meter terminal and S3. The circuit board is mounted where convenient, and near switch S2.

The accuracy of the measurements are wholly dependent on the tolerance of the capacitors C6, C7 and C8 which are used for calibration. Good quality and close tolerance capacitors

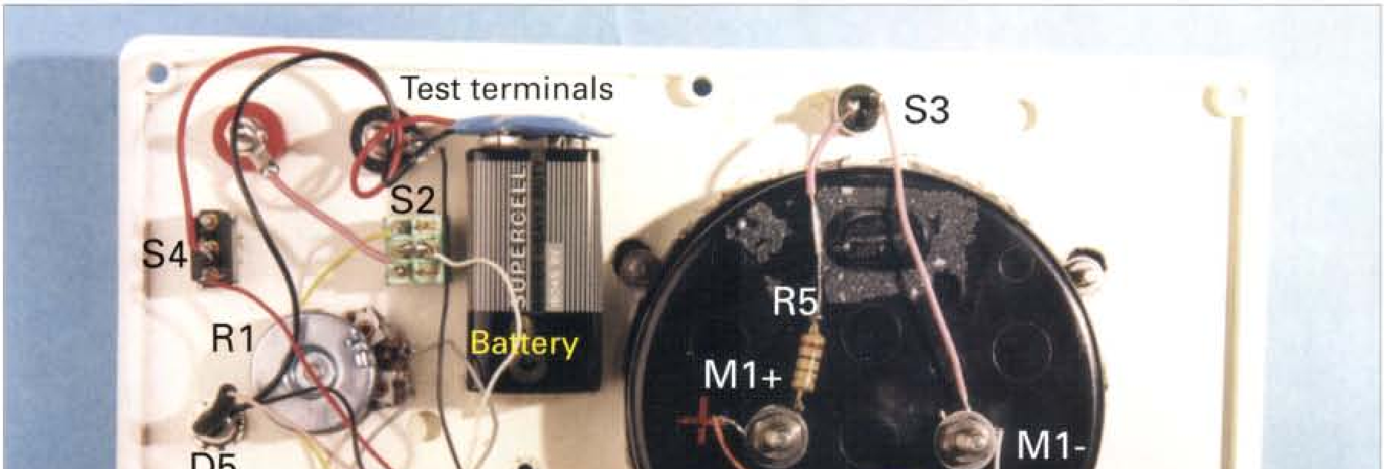


Fig. 3: The layout of Jim Brett's prototype capacitance meter. Yours may vary from this as desired, but try to keep all wiring as short as possible.

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should obviously be selected.

Since the battery will not be changed very often, it can be held to the side of the box by double-sided tape or a simple bent strip bolted to the box. (Alternatively, you could use a cheap battery holder).

Careful Check

Now, after a careful wiring check, let's look at the operation and calibration. Fit the battery but before switching on, ensure that S3 is in the closed position if a non-return switch or button hasn't been used. Set R1 fully anti-clockwise and S2 to the 'CAL' position and S1 to position 1.

Switch on and the meter should read somewhere in the upper half of the scale. Adjust R1 to bring the meter to full scale. The meter is now calibrated to read 1000pF (1nF) full scale.

Couple a capacitor of several hundred picofarads but less than 1000pF to the **TEST** terminals and switch S2 to **RUN**. The meter will now indicate directly the value of the test capacitor and C8.

Change the capacitor to be tested for one or less than 100pF and operate (open) S3 which now divides the full scale capacitance reading by 10. The direct reading will now be given (but remember to allow for the tolerances!).

In use (if the value of capacitor to be measured is totally unknown, start with the higher range first. As each range is selected the calibration operation must be carried out first.

Well, that's it - a working capacitance meter. Now you should never be caught out wondering what the value of that capacitor 'out of the junkbox' is - ever again!

PW

Shopping List

Resistors

1k	2	R3, R4
4k7	1	R2
a.o.t.	1	R5 adjust on test. This will vary with the meter full scale current and resistance
Chassis mounted rotary (lin)		
10k	1	R1

Capacitor (all 10V d.c. working or greater)

150pF	1	C1
10nF	1	C4
15nF	1	C2
1.5µF		C3 (may be made up from two or more capacitors)
Close tolerance units		
1000pF	1	C7
100nF	1	C6
Tantalum close tolerance		
10µF	1	C7

Semiconductors

NE555	1	IC1
BAT43	4	D1, D2, D3, D4
LED	1	1D5

Miscellaneous

Strip board 20 holes × 16 holes, metal box, size to suit meter and panel components, 1mA moving coil meter, potentiometer knob, test terminals, 8-pin socket, 9V PP3 battery and battery snap.