



# Analysis of the Production of an Analogue Capacitance Meter

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**Abstract:** As a prelude to instrumentation, a work study was carried out on the available Electrical/Electronic instruments in the laboratories. This study analyses the configuration of the Electrical/Electronic instruments in existence and the processes involved in constructing an analogue capacitance meter. A method analysis was performed on the design of capacitance meter and calibration of this meter. This study also established an order of comparison in voltmeter and ammeter that will vary directly as the capacitance of the capacitor.

**Keywords:** Capacitor, resistor, integrated circuit (I.C), frequency, time, duty circle.

## 1. Introduction

In practical electronics, it is necessary to measure the basic parameters of a circuit, that is, voltage, current, resistance, capacitance and inductance. Every component has its own tolerance. Components value can change drastically due to various defects. So for trouble shooting, a method of measuring the component values is absolutely essential. It is the only way to pinpoint the defective components. These measuring instruments are called meter.

Although the human sense can detect defective passive and active components that are burnt, they are completely unsuited for detection or measurement of Electrical and Electronic quantities.

These instruments that respond to Electrical/Electronic quantities and display these responses in a form suitable for human interpretation are required. Of the many Electrical quantities of interest to engineers and scientists, some of the instruments among others that have been designed and available to measure some of these quantities are:

- i. Ammeter:- This is an instrument used to measure the electric current flow in a circuit. Current is measured in Ampere (A).
- ii. Voltmeter:- This is used to measure the voltage drop or potential difference across any resistance or load within a circuit. Voltage is measured in volts (V).
- iii. Ohmmeter:- This is used to measure the value of resistor. Resistance is measured in ohm ( $\Omega$ ).
- iv. Multimeter:- This is a multipurpose made meter which is used to measure electrical quantities like current, resistance and potential difference both d.c. and a.c.
- v. Wattmeter:- this is used to measure electrical power fed to a load. Power is measured in watt (W).

- vi. Capacitance Meter:- This is used to measure the value of the capacitors. Capacitance is measured in Farad (F), microfarad ( $\mu$ F) pico farad (pF) etc.

Of the above mentioned meters, the capacitance meter is very scarce even it is not available in some electronics laboratories. Ohmmeter is used instead of the capacitance meter to test the capacitor whether it is good or bad by the spindle deflection and returning back to its original position immediately after deflection. But this instrument cannot measure precisely the value of a capacitor.

## 2. Materials and Methods

### 2.1 Theoretical Consideration

The combination of  $R_A$ ,  $R_B$  and  $C_{ext}$  as connected in the circuit (fig1) served to generate a frequency of 10KHz to the timer. The frequency of oscillation was given by: Theraja, (2003)

$$f = \frac{1.44}{(R_A + 2R_B)C_{ext}} \quad (1)$$

$$\text{Then } R_A + 2R_B = \frac{1.44}{fC_{ext}} \quad (2)$$

By selecting carefully  $R_A$  and  $R_B$  the duty cycle of the output can be adjusted. Since  $C_{ext}$  charges through  $R_A$  and  $R_B$  and discharges through  $R_B$  only, duty cycles approaching a minimum of 50% could be achieved if  $R_B \gg R_A$  so that charging and discharging times were approximately equal. The time that the output will discharge from  $1/3V_{cc}$  to  $2/3V_{cc}$  is:

$$T_1 = 0.693(R_A + R_B) C_{ext} \quad (3)$$

$$\text{Also, } T_2 = 0.693R_B C_{ext} \quad (4)$$

$$\text{Then, total time, } T = T_1 + T_2 \quad (5)$$

$$\text{Also, } f = \frac{1}{T} \quad (6)$$

$$\text{The duty cycle} = \frac{T_1}{T} \quad (7)$$

$$= \frac{T_1}{T_1 + T_2} \text{ ----- (8)}$$

Substituting equations (3) and (4) in equation (8) gives

$$\text{The duty cycle} = \frac{0.693(R_A + R_B)C_{ext}}{0.693(R_A + R_B)C_{ext} + 0.693R_B C_{ext}} \text{ ----- (9)}$$

$$= \frac{R_A + R_B}{R_A + 2R_B} \text{ ----- (10)}$$

This Duty cycle should be expressed as a percentage

**2.2 Capacitance Meter Circuit**

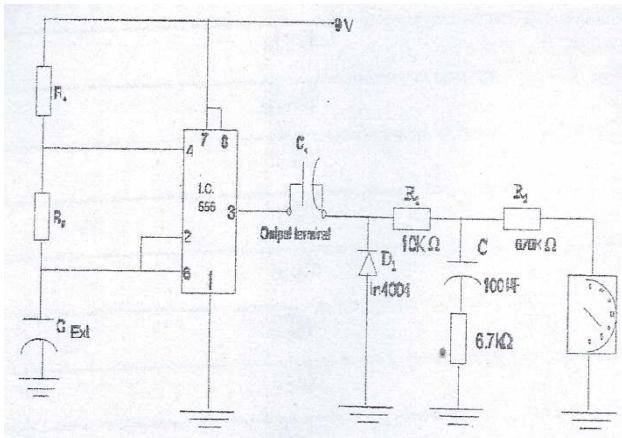


Figure 1 shows the circuit diagram of an analogue capacitance meter. Each of the components was soldered on a clean and dust free vero board. The output of the circuit was connected to an ammeter and in turn connected to a voltmeter. Then some capacitors were tested and corresponding ammeter and voltmeter reading were recorded as shown in Table 1 and 2.

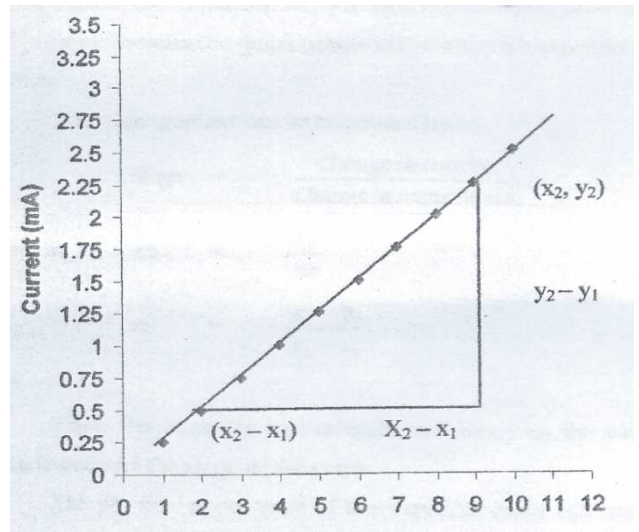
**Table 1:** Relationship between capacitance and current

Capacitor (µF)	Current (mA)
1	0.25
2	0.50
3.	0.75
4	1.00
5.	1.25
6.	1.45
7	1.70
8.	1.90
9.	2.15
10.	2.50
22	4.50
44	9.25
66	13.50

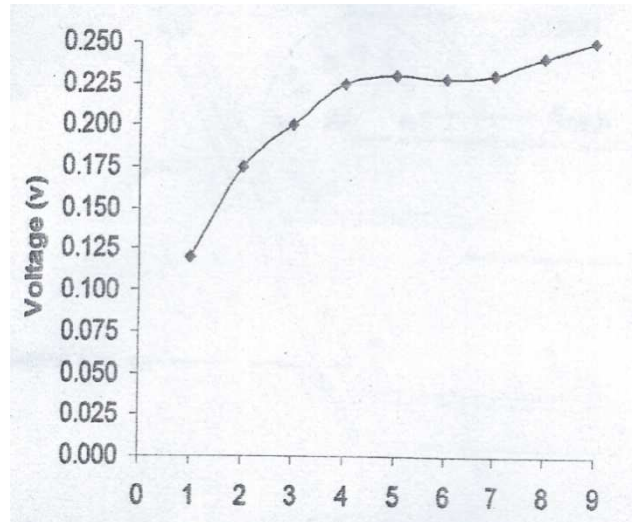
**Table 2.** Relationship between capacitance and voltage

Capacitance (µF)	Voltage (V)
1	0.130
2	0.180
3	0.200
4	0.230
5	0.238
6	0.239
7	0.240
8	0.245
9	0.250

The graph of the two relationships i.e. capacitance and current, and capacitance and voltage were drawn as shown in Figure 2 and Figure 3.



**Figure 2:** Graph of current versus capacitance.



**Figure 3:** Graph of voltage versus capacitance

**3. Result and Discussion**

The graphs of fig2 and fig 3 show the way each quantity varies as capacitance of the capacitor. It was from here that we discovered that Ammeter suit this purpose because the graph of the relationship between capacitance and current is linear.

Then the gradient can be calculated using:

$$\text{Slope} = \frac{\text{Change in current}}{\text{Change in capacitance}}$$

Therefore,

$$m = \frac{\Delta y}{\Delta x}$$

$$m = \frac{y_2 - y_1}{x_2 - x_1} \text{ ----- (11)}$$

Then, the ammeter was re-calibrated based on the values of the capacitors being tested and the slope of the graph. The physical appearance of this capacitor meter box made by plank is shown in Figure 4.

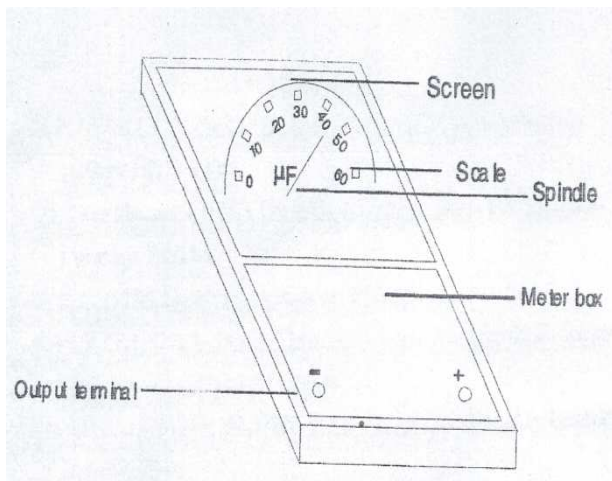


Figure 4: Capacitance meter box

#### Specification

Range: 10 ranges with full scale value from  $0\mu\text{F}$  to  $60\mu\text{F}$   
 Accuracy: 0.5% of full scale  
 Display: Analogue  
 Power source: Single standard 9V battery (NEDA 1604)  
 Battery life: 6 hours  
 Operating temperature:  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$   
 Dimension: 12 x 22 x 9cm

#### 4. Conclusion

The human senses and ohmmeter can only detect whether the capacitor is burnt or defective but cannot determine the actual value of the capacitor. Therefore, comparing the ohmmeter with this newly designed capacitance meter, it shows that the capacitance meter is better and very important in determining whether the capacitor is good or bad and at the same time useful in determining the actual value of the capacitor.

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#### Nomenclature

$R_A, R_B$	voltage divider resistors
$V_{cc}$	voltage source
I.C. 555	Integrated circuit 555 timer
$C_{ext}$	External capacitor
$D_1$	Diode
$R_1, R_2, R_3$	esistors
$C$	Capacitor
$C_x$	Unknown capacitor value
$f$	frequency
$T_1$	Charging Time
$T_2$	Discharging Time
$T$	Total time.