

**Practice on various analog and digital measuring instruments**

**Objectives:** At the end of this exercise you shall be able to

- connect various analog measuring instruments and measure electrical parameters
- connect various digital measuring instruments and measure electrical parameters.

Requirement	
<p><b>Tools / Instruments</b></p> <ul style="list-style-type: none"> <li>• MI voltmeter 0 - 500V (analog) - 1 No.</li> <li>• Digital voltmeter 0 - 500V - 1 No.</li> <li>• MI ammeter 0 - 30A (analog) - 1 No.</li> <li>• Digital ammeter 0 - 30A - 1 No.</li> <li>• Power factor meter 0.5 lag - 1 - 0.5 lead (Analog) - 1 No.</li> <li>• Digital power factor meter - 1 No.</li> <li>• Analog wattmeter 0-1500W - 1 No.</li> <li>• Digital wattmeter 0-1500W - 1 No.</li> <li>• Analog frequency meter 45-55HZ - 1 No.</li> <li>• Digital frequency meter 45-55HZ - 1 No.</li> </ul>	<p><b>Equipment / Machines</b></p> <ul style="list-style-type: none"> <li>• Squirrel cage Induction motor 3 phase, 440V, 5 HP - 1 No.</li> </ul> <p><b>Materials</b></p> <ul style="list-style-type: none"> <li>• Connecting leads - as reqd.</li> <li>• TPIC switch 16A, 500V - 1 No.</li> </ul>

**PROCEDURE**

**TASK 1: Measure the value of current, voltage, power factor, power and frequency by connecting respective analog meters in the circuit**

- 1 Identify the analog type of voltmeter, ammeter, wattmeter power factor meter and frequency meter from the given Figure Nos. 3 to 13.
- 2 Verify the range of analog voltmeter, ammeter wattmeter, powerfactor meter and frequency meter.
- 3 Connect the power supply with switch, fuse, analog meters and load as shown in Fig 1
- 4 Close the switch
- 5 Measure the corresponding values from the instruments and record the values in Table 1.
- 6 Switch off the Power Supply and disconnect the connection.

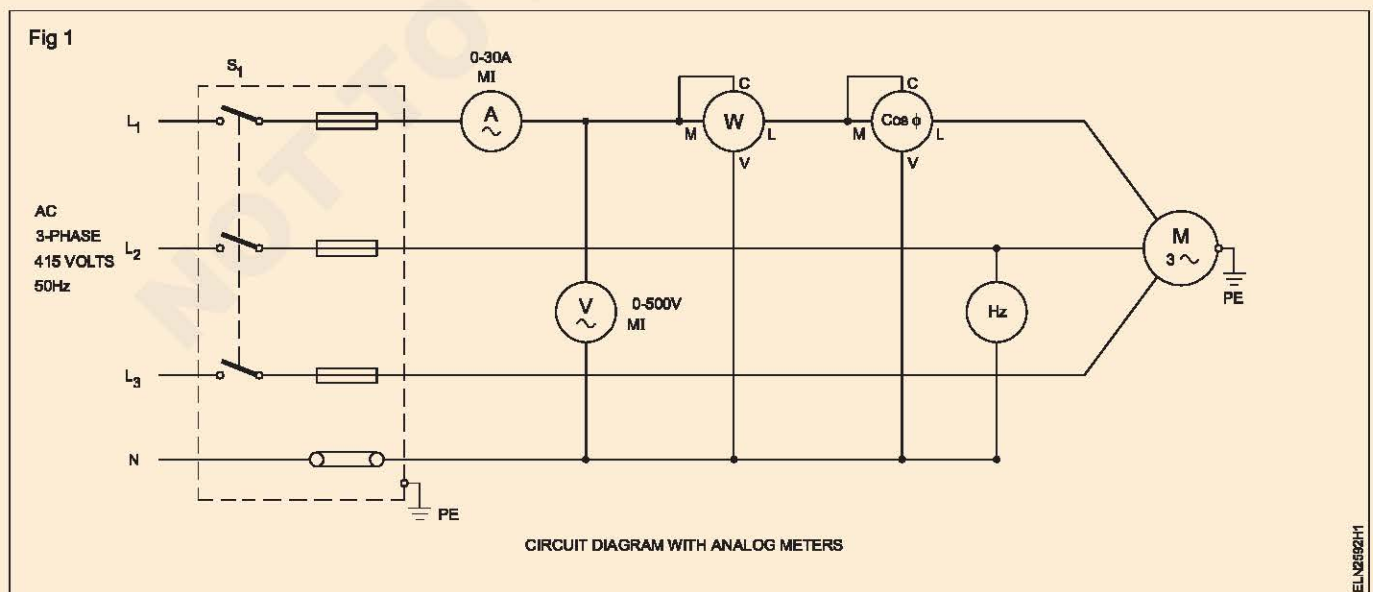


Table 1

Sl. No.	Meter	Reading
1	Voltmeter	
2	Ammeter	
3	Watt meter	
4	Power factor meter	
5	Frequency meter	

**TASK 2 : Measure the value of current, voltage, power factor, power and frequency by connecting respective digital meters in the circuit**

- 1 Identify the digital type of voltmeter, ammeter, wattmeter, power factor meter and frequency meter from the given figure nos. 3 to 13.
- 2 Verify the range of digital voltmeter, ammeter, wattmeter, power factor meter and frequency meter.
- 3 Connect the power supply with switch, fuse, digital meters and load as shown in Fig 2
- 4 Close the switch.
- 5 Measure the corresponding values from the instruments and record the values in Table - 2
- 6 Switch off the power supply and disconnect the connection.

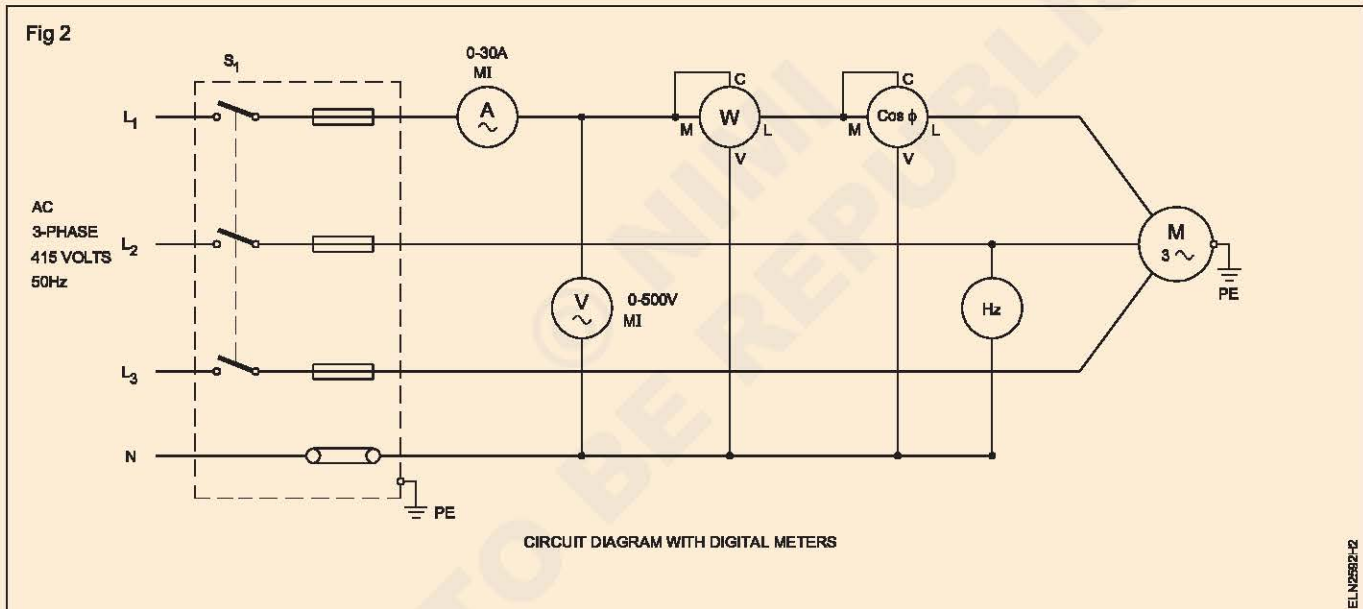


Table 2

Sl. No.	Meter	Reading
1	Voltmeter	
2	Ammeter	
3	Watt meter	
4	Power factor meter	
5	Frequency meter	

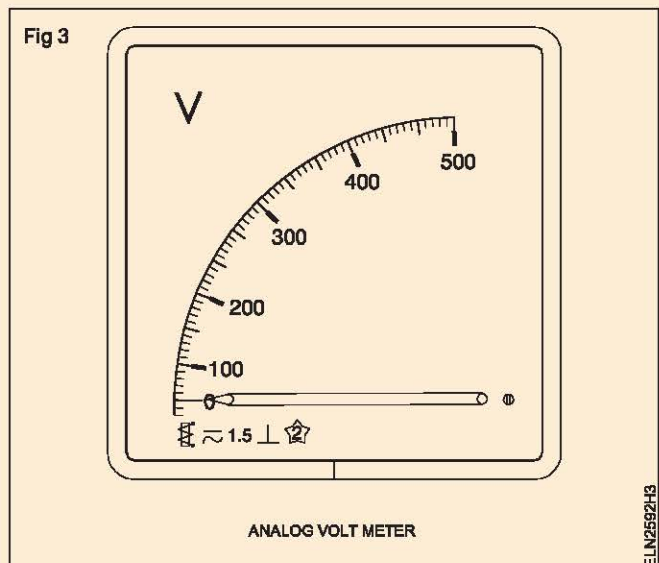
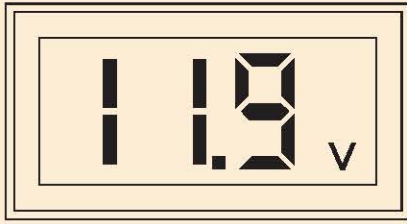


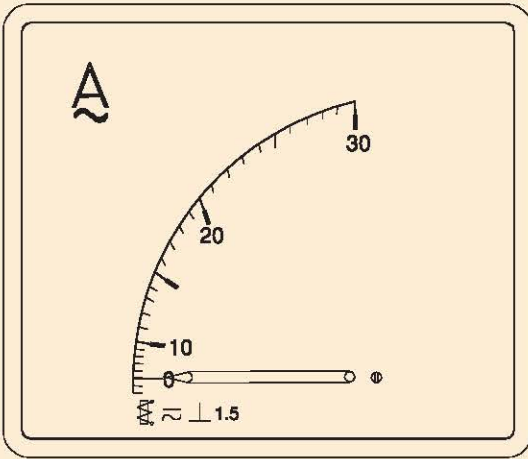
Fig 4



DIGITAL VOLT METER

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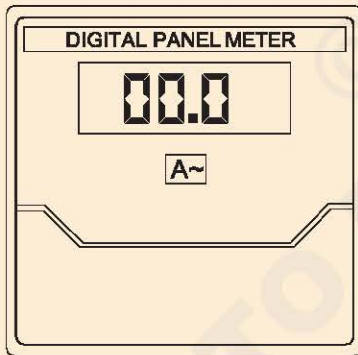
Fig 5



ANALOG AMMETER

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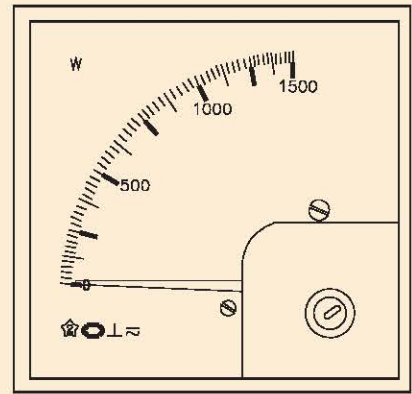
Fig 6



DIGITAL AMMETER

ELN2552H6

Fig 7



ANALOG WATT METER

ELN2552H7

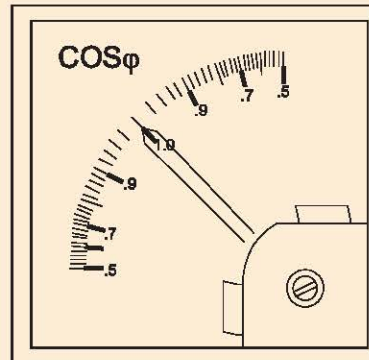
Fig 8



DIGITAL WATT METER

ELN2552H8

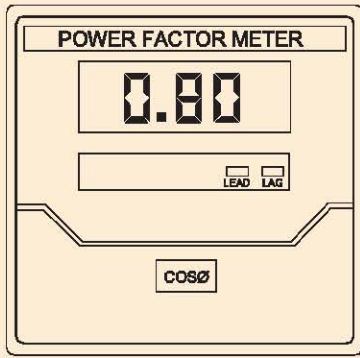
Fig 9



ANALOG POWER FACTOR METER

ELN2552H9

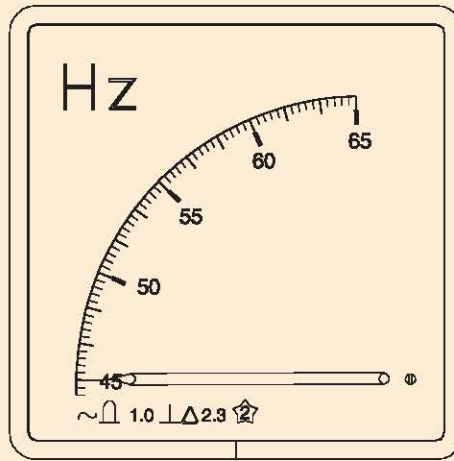
Fig 10



DIGITAL POWER FACTOR METER

ELN2592HA

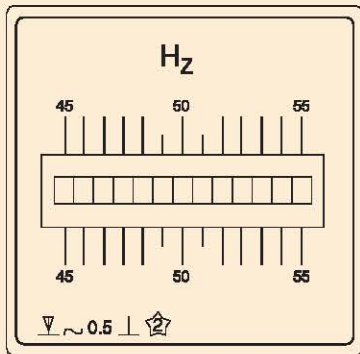
Fig 12



ANALOG FREQUENCY METER

ELN2592HC

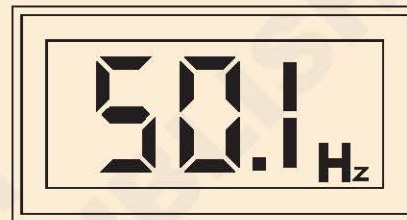
Fig 11



FREQUENCY METER

ELN2592HB

Fig 13



DIGITAL FREQUENCY METER

ELN2592HD

**Practice on measuring instrument in single and three phase circuit eg. multimeter, wattmeter, energy meter, phase sequence and frequency meter etc.**

**Objectives :** At the end of this exercise you shall be able to

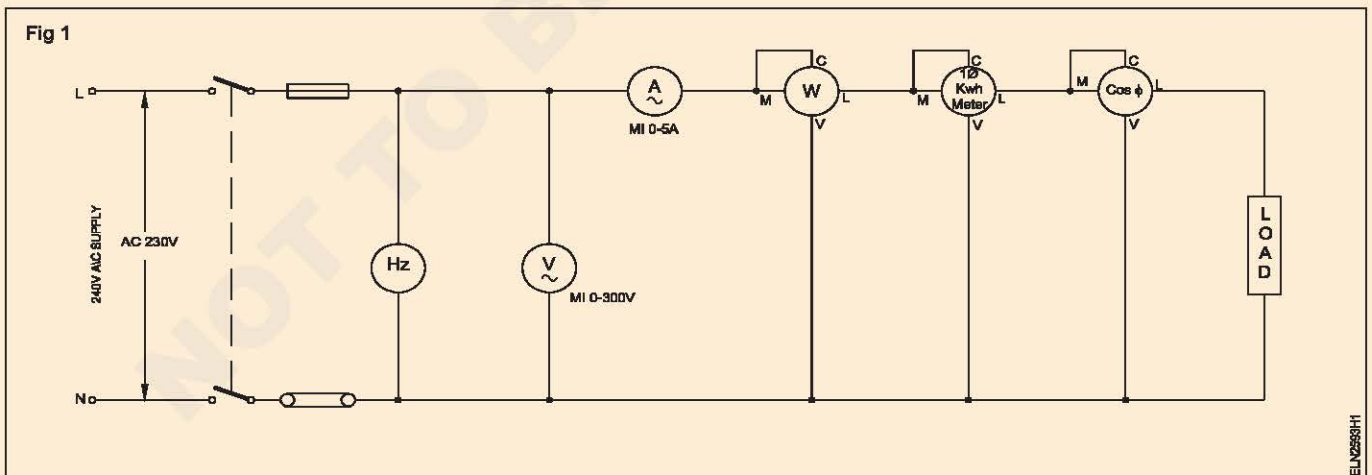
- connect voltmeter, ammeter, wattmeter, energy meter, frequency meter and power factor meter in single phase load
- connect voltmeter, ammeter, wattmeter, energy meter, frequency meter, power factor meter and phase sequence indicator in 3 phase balance load
- measure voltage, current, power, energy, frequency, power factor and record the values
- connect phase sequence meter to find the phase sequence.

Requirement	
<b>Tools/Instruments</b> <ul style="list-style-type: none"> <li>• Electrician Tool kit- 1 Set</li> <li>• MI voltmeter 0 - 300 v - 1 No.</li> <li>• MI Ammeter 0 - 5 A - 1 No.</li> <li>• wattmeter AC 0 - 1500 W - 1 No.</li> <li>• Energy meter 3<math>\phi</math> 4 15V - 1 No.</li> <li>• power factor meter 0 -5 leg-1 - 1 No.</li> <li>• Frequency of meter 0 - 50 Hz led - 1 No.</li> </ul>	<b>Equipment / Machines</b> <ul style="list-style-type: none"> <li>• Lamp load 1000W - 1 No.</li> </ul> <b>Materials</b> <ul style="list-style-type: none"> <li>• Fuse carrier - 5A - 1 No.</li> <li>• DPIC Switch 16A, 250v - 1 No.</li> <li>• 14 SWG copper wire - 0.5 kg.</li> <li>• Insulation tape 25 mm of 5 m - 1 roll</li> <li>• 1.5 mm<sup>2</sup> pvc copper wire - 5 m</li> <li>• TPIC switch 16A - 1 No.</li> </ul>

**PROCEDURE**

**TASK 1 : Connect voltmeter, ammeter, wattmeter single phase energy meter, power factor meter and frequency meter in single phase circuit**

- 1 Collect the required materials, meters and load.
- 2 Make necessary connections with meters and load as per circuit diagram (Fig 1)



**The current coil of the wattmeter, energy meter and P.F meter must be connected in series with load. Provide 5 Amps fuse in the fuse carrier.**

**If the wattmeter shows reverse direction interchange the connection of current coil**

- 3 Get the circuit approved by the instructor.
- 4 Switch 'ON' the power supply and observe deflections of the meters.
- 5 Note down the meter readings and enter in Table 1.
- 6 Switch "OFF" the power supply and disconnect the connection.

Table 1

Sl. No.	Ammeter reading (Amps)	Voltmeter reading (volts)	Wattmeter reading (watts)	Frequency meter (Hz)	Power factor meter (Cos $\phi$ )	Energy meter (kwh)

**TASK 2 : Connect voltmeter, ammeter, wattmeter, energy meter, frequency meter, power factor meter and phase sequence indicator in 3 phase circuit**

- 1 Collect the required materials, meters and load.
- 2 Make necessary connections with meters and load as per circuit diagram (Fig - 2)

**The current coil of the wattmeter, energy meter and P.F. meter must be connected in series with load. Provide 5 amps fuse in the fuse carrier.**

- 3 Get the circuit approved by the instructor.

- 4 Switch 'ON' the power supply and observe deflections of the meters.

**If the wattmeter shows reverse direction interchange the connection of current coil.**

- 5 Find out the phase sequence of the 3 phase supply.
- 6 Note down the meter reading and enter in Table - 2.
- 7 Switch 'OFF' the power supply and disconnect the connection.

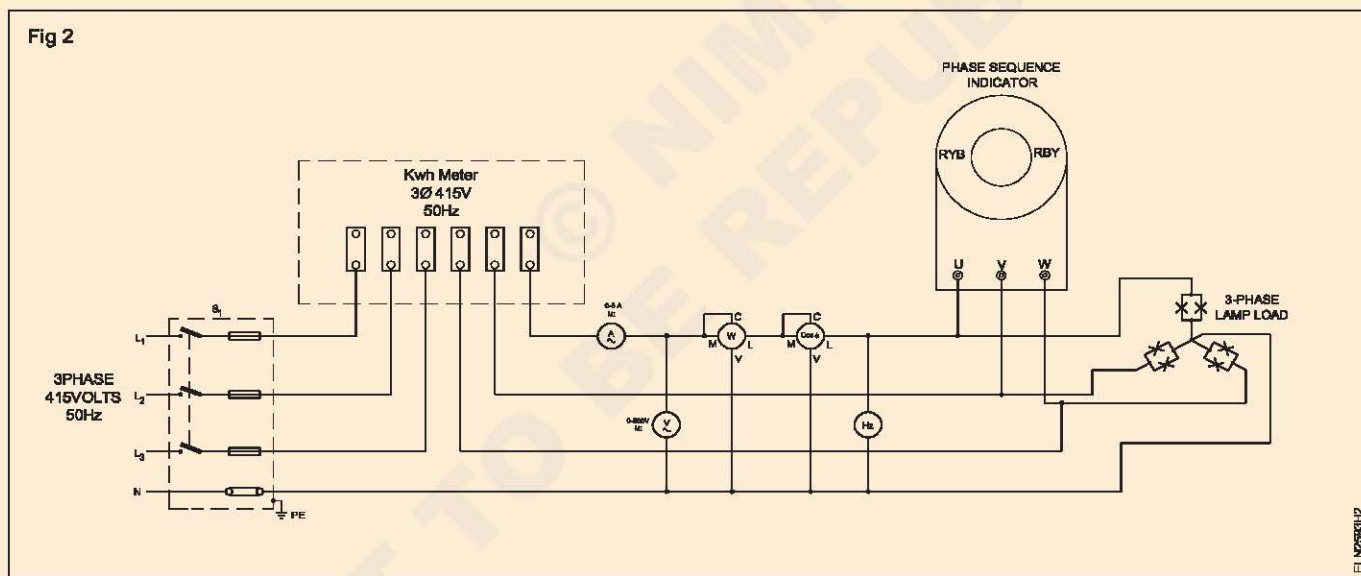


Table 2

Sl. No.	Ammeter reading (Amps)	Voltmeter reading (volts)	Wattmeter reading (watts)	Frequency meter (Hz)	Power factor meter (Cos $\phi$ )	Energy meter (kwh)	Phase sequence RY B / R BY

**Measure the power in 3-phase circuit using two wattmeter methods**

**Objectives :** At the end of this exercise you shall be able to

- connect two wattmeters in the circuit as per the given diagram
- measure the power and calculate the power factor.

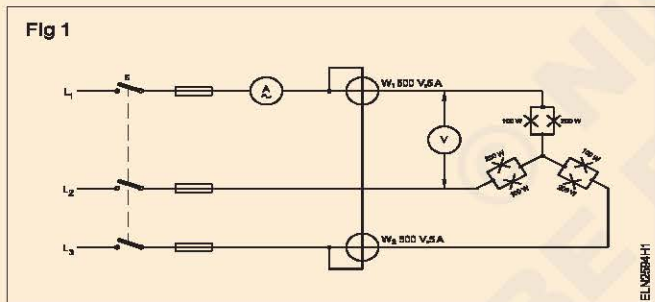
Requirements	
<b>Tools / Instruments</b>	<b>Materials</b>
<ul style="list-style-type: none"> <li>• Wattmeter 500V/5A, 3 KW - 2 Nos.</li> <li>• M.I. Voltmeter 0-500 V - 1 No.</li> <li>• M.I. Ammeter 0-5A - 1 No.</li> </ul>	<ul style="list-style-type: none"> <li>• 200W, 250V lamps - 3 Nos.</li> <li>• 100W, 250 lamps - 3 Nos.</li> <li>• Connecting leads - as reqd.</li> <li>• Pendant-holders 6A 250V - 6 Nos.</li> </ul>
<b>Equipment / Machines</b>	
<ul style="list-style-type: none"> <li>• 3-phase, 415V AC induction motor 3 HP - 1 No.</li> </ul>	

**PROCEDURE**

**TASK 1 : Measure the power in 3 phase circuit using two wattmeter method and calculate power factor**

- 1 Form the circuit as per the given circuit diagram. (Fig 1)

**Connect proper ranges of meters suitable for the given load.**



- 2 Switch 'ON' the 3-phase supply and observe for the proper deflection of wattmeters. If both wattmeters deflect properly, go to step 4, otherwise continue from step 3.
- 3 Switch 'OFF' the supply, if any one wattmeter deflects in the reverse direction. Change the connection of the potential coil of the reverse deflection wattmeter. Go to step 5.

- 4 Read wattmeters  $W_1$  &  $W_2$  and record in Table 1. Add the readings  $W_1$  and  $W_2$  and record the total power; go to step 6.
- 5 Switch on the supply and read the wattmeters  $W_1$  &  $W_2$ . Record the values in the Tables. Record the readings of the wattmeter with the changed potential coil as negative quantity.
- 6 Measure the 3-phase power for different load conditions specified below :
  - a  $L_1 = 500$  W bulb
  - $L_2 = 300$  W bulb
  - $L_3 = 200$  W bulb
  - b  $L_1, L_2, L_3$  water load to take a current of max. 3 amps
  - c Induction motor 3 HP on no load
  - d Induction motor 3-HP with load

**The instructor personally to connect the three-phase motor for proper running.**

- 7 Calculate the power factor in all the above cases and enter them in Table 1.
- 8 Get your work checked by Instructor.

Table 1

Type of Load	Wattmeter $W_1$	Wattmeter $W_2$	Total $W_1 + W_2$	Calculated Power factor $\text{Cos } \theta$
				$\text{Cos } \theta$
1				
2				
3				
4				
5				

Conclusion: \_\_\_\_\_

**Measure power factor in three phase circuit by using power factor meter and verify the same with voltmeter, ammeter and wattmeter readings**

**Objectives:** At the end of this exercise you shall be able to

- connect a single phase P.F. meter in 3-phase balanced load and read the P.F
- verify the P.F. by voltmeter, ammeter and wattmeter readings and determine the error
- connect the capacitor bank in the 3-phase circuit and measure the P.F.

**Requirements**

**Tools / Instruments**

- Single phase P.F. meter 250V/ 500V, 5A/ 10A - 1 Set
- Wattmeter 250/500V, 5A/10A 1500W - 1 Nos.
- M.I Ammeter 0-5 A/ 10A - 1 No.
- M.I Voltmeter 0-300V/ 600V - 1 No.
- Insulated combination plier 200mm - 1 No.
- Insulated screwdriver 200mm - 1 No.

**Equipment / Machines**

- 3-phase induction motor 415V 2.25 KW (with loading arrangement) - 1 No.
- Power factor improving capacitor bank single phase 250V, 50 Hz 1kvar - 1 Set
- 3 Phase lamp load 3 KW 415 V 50 Hz - 1 No.

**Materials**

- PVC insulated copper cable 2.5 sq. mm 650 V - grade - 20 m
- T.P.I.C. switch 16A, 500V - 2 Nos.

**PROCEDURE**

1 Collect the meters and the 3-phase lamp load.

**The lamp load should have equal wattage in all the three phases.**

2 Make necessary connections of the meters and load as per circuit diagram - Fig 1.

**Connect the current coils of wattmeter and P.F. meter in series with load.**

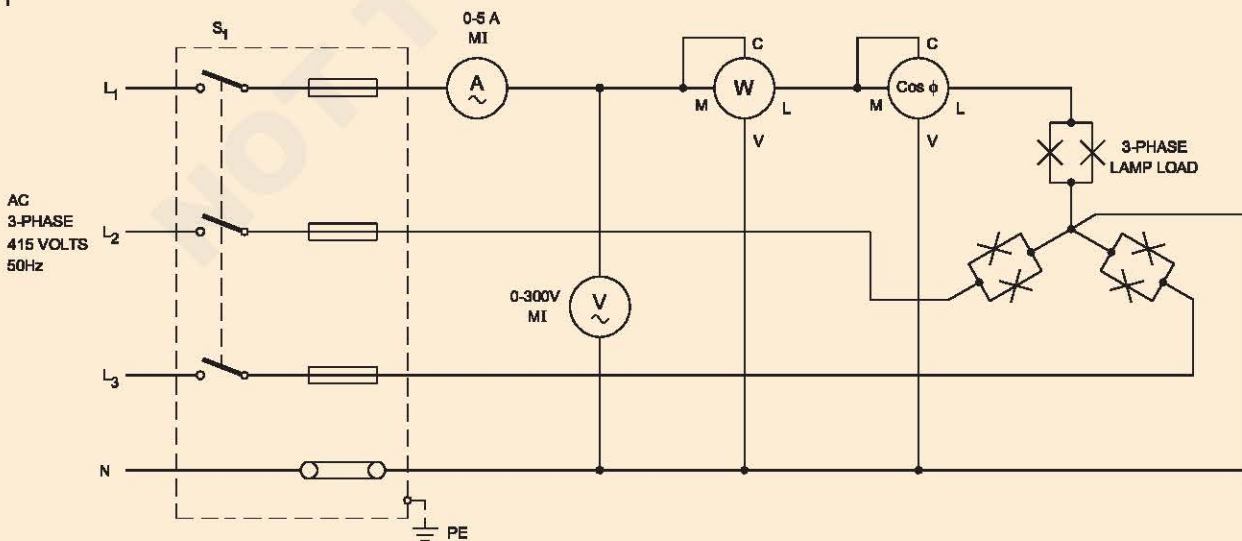
3 Get the circuit approved by the instructor.

4 Switch 'ON' the power supply momentarily observe deflections of all the meters. Keep the switch closed if nothing is abnormal.

5 Equally load all the three phases and note down the meter readings and enter in Table 1.

6 Switch 'OFF' the power supply.

Fig 1



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Table 1

Load condition	Ammeter reading in Amps. ( $I_{ph}$ )	Volt-meter reading in Volts ( $E_{ph}$ )	3-phase apparent power in watts $3 \times E_{ph} \times I_{ph}$	Wattmeter reading in Watts W	3-phase power $W \times 3$	Calculated value of P.F. $P.F. = \frac{W \times 3}{3 \times E_{ph} \times I_{ph}}$	P.F. measured value	Remarks
Resistive load								
Motor without load								
Motor without load but with capacitor								
Motor with load								
Motor with load and with capacitor								

**If P.F. meter shows leading P.F. for inductive load, switch 'off' the supply and interchange current coil connections of the P.F. meter.**

7 Determine the power factor by using the formula,

$$P.F. = \frac{W \times 3}{3 \times E_{ph} \times I_{ph}}$$

Where W- Wattmeter reading (power in one phase)

$E_{ph}$  - Phase voltage

$I_{ph}$  - Phase current (Also equal to line current)

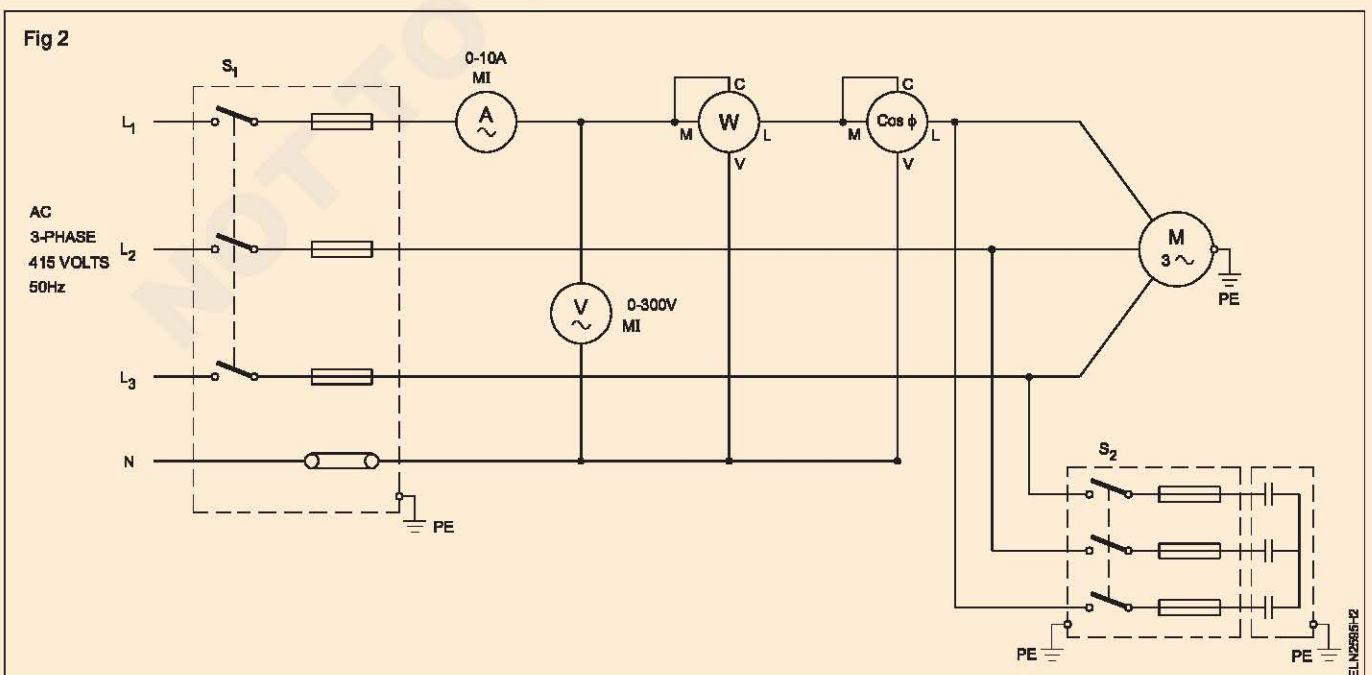
8 Compare the calculated power factor and power factor meter reading and write your observation.

Observation \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

9 Show the readings to your instructor for approval.

10 Disconnect the lamp load and connect the 3 phase induction motor with P.F. improving capacitor as shown in Fig 2.

11 Ensure that the range of current coil in wattmeter and P.F. meter are well higher than the load current of the connected load.



- 12 Keep the capacitor switch in OFF condition. Switch ON the power supply and observe the deflection of the meters.
- 13 Record the meter readings in Table 1 for the load conditions shown in Table 1.
- 14 Switch 'OFF' the power supply and disconnect the connection.
- 15 Calculate the power factor in each case and compare with the measured P.F.

- 16 Observe the P.F. each load condition and write your observations.

Observation \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- 17 Show the readings and observation to your instructor for approval.

**Consider the multiplying factor of the wattmeter which depends on the range of watt meter with respect to current and voltage ranges and C.C. and P.C. range selected. The reading of the wattmeter should be multiplied with the multiplying factor to get the actual power.**

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**Measure electrical parameters using tong tester in three phase circuit**

**Objectives:** At the end of this exercise you shall be able to

- select a suitable range in tong testers to measure the different electrical parameters
- measure the AC volt, DC volt and frequency
- measure the AC current
- measure kW, KVA, PF and phase angle in AC circuit
- measure resistance
- measure capacitance
- measure AC and DC micro ampere.

Requirement			
<b>Tools / Instruments</b>		<b>Equipment / Machines</b>	
• Tong - tester	- 1 No.	• Single phase lamp load	- 1 Set
		• Welding Transformer	- 1 No.
		• 3 phase Induction motor 3 HP 440V, with suitable load	- 1 Set

**PROCEDURE**

**TASK 1 : Measure the AC and DC voltage and frequency**

**The operating instruction given below is for one particular tong Tester. Some other model Tong Testers are also be available in market. Follow the operating instructions accordingly**

- 1 Set the rotary switch to the 'V' Position.
- 2 Insert the test leads into the input Jack (Black to COM and Red to V)
- 3 Connect the test leads in parallel to the measured circuit.
- 4 The meter will automatically switch to ACV or DCV display.
- 5 The meter will automatically select the appropriate range.
- 6 Read the voltage and frequency values displayed on the LCD and note down in Table (Fig 1)

**TASK 2 : Measure current in AC circuit**

- 1 Set the rotary switch to the 'A' position.
- 2 Press the trigger to open the jaw and fully enclose the conductor to be measured.
- 3 The clamp will automatically select the appropriate range
- 4 Read the current values displayed on the LCD and note down in Table (Fig 1).

**No gap is allowed between the two half Jaws**

**TASK 3 : Measure AC kW, KVA, PF and  $\phi$  (phase angle)**

- 1 Set the rotary switch to the KW / KVA Position
- 2 Insert the test leads into the input Jack. (Black to COM and Red to V)
- 3 Connect the Black lead COM to the neutral line.
- 4 Connect the Red lead 'V' to power line and clamp the same conductor where V (red) terminal is connected.
- 5 The power clamp will automatically select the appropriate range.
- 6 Read the watt and HP values displayed on the LCD and note down in Table.
- 7 Press range button to display required parameters.
- 8 For 3 phase 3 wire balanced load system, insert 3 plug in adapter in terminals " COM" and "V". Connect three crocodile clips to appropriate phase (R, Y and B) 3 phase power = 3 x meter indication (Fig 1).

$$PF = \frac{KW}{KVA} = \cos\theta$$

**TASK 4 : Measurement of Resistance**

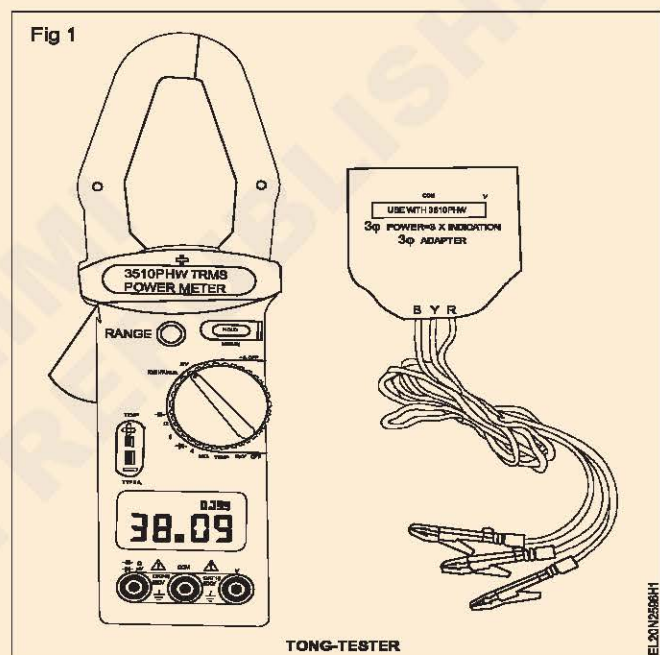
- 1 Before taking resistance measurement, make sure the circuit is not live and discharge any capacitor present in the circuit.
- 2 Set the rotary switch to the  $\Omega$  or M  $\Omega$  range.
- 3 Insert the test leads into the input jack.  
(Black to com and red to  $\Omega$  )
- 4 Connect the test leads to the circuit being measured and read the displayed value.
- 5 Note down the reading in Table.

**TASK 5 : Measurement of capacitance**

- 1 Insert the test leads into the input Jacks (Black to COM and Red to
- 2 Set the rotary switch to the “—|—” Positon.
- 3 Connect the rotary test lead to the anode side and black test lead to the cathode side of the capacitor being tested
- 4 Read capacitance value on LCD and note it in Table.

**TASK 6 : AC + DC Micro Ampere measurement**

- 1 Set the rotary switch is “ $\approx \mu A$ ” position.
- 2 Insert the test leads into the input Jack (Black to COM and Red to  $\mu A$ ) (Fig 1)
- 3 Connect the meter in series the with the circuit being measured and read the displayed value and note down the reading in Table.



Table

Sl. No.	Measurement	Reading 1	Reading 2
1	AC voltage		
2	DC voltage		
3	Frequency		
4	KW		
5	KVA		
6	PF		
7	Phase angle		
8	Resistance		
9	Capacitance		
10	AC Micro Ampere		
11	DC micro Ampere		

**Demonstrate smart meter, its physical components and communication components**

- Objectives:** At the end of this exercise you shall be able to
- read and interpret the name plate details of smart electrical meter
  - identify physical components
  - identify communication components.

Requirements			
Tools / Instruments		Materials	
• Electrician tool kit	- 1 Set	• Connecting leads	-1 No.
• Smart energy meter	- 1 No.	• Pencil	- 1 No.
		• Drawing sheet	- 1 No.

**PROCEDURE**

- 1 Take one smart meter (Fig 1) and note down the name plate details in Table 1.
- 2 Inspect physical components and study the application and note down.



Table 1

Name	
Sl.No.	
Voltage	
Current	
Frequency	
Type	
Model	

Physical components		Application
Sl.No.	Name	
1		
2		
3		
4		
5		

- 3 Find out the communication components and read its application and note down.

Communication components		Application
Sl.No.	Name	
1		
2		
3		
4		
5		

- 4 Discuss your findings with your instructor and verify the doubts.

**Perform meter readings, install and diagnose smart meters**

**Objectives:** At the end of this exercise you shall be able to

- connect a smart energy meter in the supply
- take readings of smart energy meter
- operate communication components.

<b>Requirements</b>			
<b>Tools / Instruments</b>			
• Electrician tool kit	- 1 Set	• Watt meter 5A 1500W	- 1 No.
• Smart energy meter with communication components	- 1 No.	<b>Materials</b>	
• Resistive load	- 1 No.	• Connecting leads	- as reqd.
• Volt meter 0-300v M.I	- 1 No.	• ICDP main switch	- 1 No.
• Ammeter 0-5A	- 1 No.		

**PROCEDURE**

- 1 Read and note down the name plate details of smart energy meter in Table 1.

Table 1

Name	
Sl.No.	
Voltage	
Current	
Frequency	
Type	
Model	

- 2 Connect the smart meter as for the circuit diagram. (Fig 1)



**Terminals screws of energy meter should be tightened gently.**

- 3 Switch on the power supply and resistive load.
- 4 Note down the initial readings in Table 2.
- 5 Wait for half-an-hour and note down the final reading in Table 2.
- 6 Use communication components and note down the readings for the same time with same load and enter in table 2.
- 7 Compare both readings.
- 8 Show the readings to your instructor and clarify your doubts.

Table 2

S. No.	Mode	Initial reading	Final reading	Consumption
1	Direct			
2	Through Communication Components			

Practice for range extension and calibration of various measuring instruments

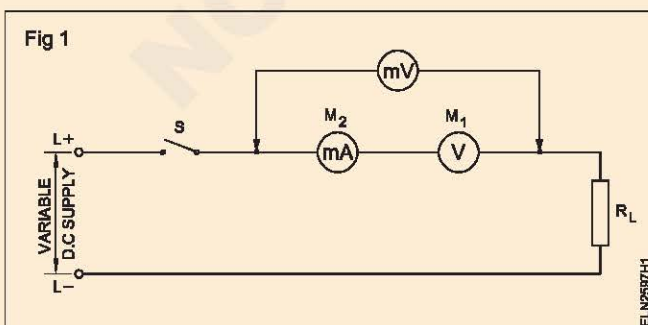
- Objectives:** At the end of this exercise you shall be able to
- extend MC 0-15V voltmeter range to MC 0-30V voltmeter
  - extend MC 500 milli ammeter range to MC 2.5 ampere
  - extend MC 500 milli ammeter range to MC5 ampere
  - extend MC 100 milli ammeter range to MC1 ampere
  - calibrate MC 0-50V voltmeter
  - calibrate MI 0-300V voltmeter
  - calibrate MC 0-500 m.A. ammeter
  - calibrate MI 0-1 A ammeter.

Requirements			
<b>Tools / Instruments</b>		<b>Equipment/Machines</b>	
• Electrician's Tool Kit	- 1 Set	• Variable D.C. power supply 0-50V	- 1 No.
• Combination pliers 150mm	- 1 No.	• Standard resistors for multipliers (Decade resistance box in 5 decades 1, 10, 100, 1000, 10000) OR	- 3 Nos.
• Wire stripper 150 mm	- 1 No.	Variable tubular wire wound resistors	
• Electric soldering iron 230V 35W	- 1 No.	• Battery 12V 100 A H	- 1 No.
• MC milli voltmeter 0-50mV	- 2 Nos.	• Variac 0-300V/5A	- 1 No.
• MC milli ammeter 0-10mA	- 1 No.	<b>Materials</b>	
• M C Voltmeter 0-15V	- 1 No.	• Potentiometer 10k 2W	- 1 No.
• MC Ammeter 0-500 m.A	- 1 No.	• Resistor 1K 2W	- 1 No.
• MC Voltmeter 0-100 m V	- 1 No.	• Resin core solder	- as reqd.
• MC Voltmeter 0-1V	- 1 No.	• Connecting leads	- as reqd.
• Ohmmeter or multimeter	- 1 No.	• Copper wire 18 SWG	- as reqd.
• MC Voltmeter 0-50V	- 1 No.	• Nichrome wire 18 SWG	- 1/2 m
• Digital Voltmeter	- 1 No.		
• M.I. Voltmeter 0-300V	- 1 No.		
• M I Ammeter 0-1A	- 1 No.		
• Rheostat 100Ω/5W	- 1 No.		

PROCEDURE

TASK 1 : Extension MC 0-15V voltmeter range to MC 0-30V voltmeter

- 1 Remove the cover of the MC 0-15V Voltmeter, examine and disconnect the series resistance, if any.
- 2 Connect the moving coil ends to the meter terminals and close the cover.
- 3 Form the circuit as shown in Fig 1.
- 4 Close the switch; gradually increase the DC voltage until full scale deflection is achieved in  $M_1$  (voltmeter under test).
- 5 Record the reading of  $M_2$  and then the voltage drop across  $M_1$  at full scale deflection in Table 1.
- 6 Open the switch and disconnect the circuit.
- 7 Calculate the M C resistance of  $M_1$  using Ohm's Law and record in Table 1.



**Keep the switch open and the variable DC supply at minimum level.**

Table 1

Reading of $M_2$ at f.s.d. of $M_1$	Voltage drops across $M_1$ at f.s.d.	Resistance of MC of $M_1$
1	2	3

- 8 Calculate the resistance of the multiplier for the proposed range (say 0-30V) using the formula

Multiplier resistance =

$$\frac{\text{Proposed range of voltage-Voltage drop across MC at FSD}}{\text{MC current at FSD}}$$

9 Calculate the multiplying factor (M.F.) by the formula

$$MF = \frac{\text{Proposed voltmeter range}}{\text{Voltage drop across MC at FSD}}$$

10 Select the standard resistance suitable for the value of the multiplier resistance calculated in step 8 and connect them all in series with meter  $M_1$ .

11 Form the circuit as shown in Fig 2, keeping the switch open.

**Keep the variable D C Supply at minimum level.**

12 Close the switch and increase the voltage gradually to get exact divisions in standard voltmeter  $M_3$ .

13 Record the readings of  $M_1$  and  $M_3$  in Table 2 for each setting (in  $M_3$ ) until  $M_1$  reaches the full scale deflection.

14 Open the switch and disconnect the circuit.

15 Calculate the actual voltage using ' $M_1$  reading' and the 'Multiplying factor' of the multiplier connected.

16 Calculate the error using the formula given below and record in Table 2.

Error = standard meter - calculated voltage from the reading of  $M_1$

**In case of non-availability of wire-wound resistors of different values of suitable wattage to form the multiplier resistance, you may make use of wire-wound tubular variable resistance for laboratory use and verify the working of the instrument in the extended range.**

**Set the value of variable wire-wound resistance exactly equal to the multiplier resistance using the Wheatstone bridge.**

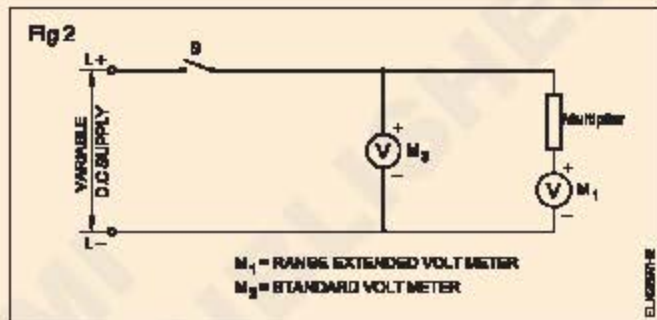


Table 2

SI No	Reading of $M_3$	Reading of $M_1$	Multiplying factor M.F.	Voltage = $M_1 \times MF$	Error (Col.2)-(Col.5)
1	2	3	4	5	6

### TASK 2 : Extension of M.C 500 milliammeter range to 2.5 amperes

1 Connect the 0-500mA range milliammeter as shown in Fig 3 to the variable DC power supply. If a variable DC power supply is not available, make connections to a battery as shown in the circuit Fig 4.

2 Set the output voltage to the circuit at the minimum and close the switch S.

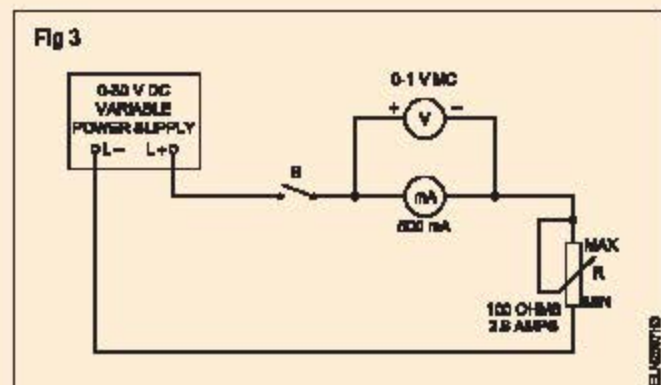
3 Gradually increase the voltage until the milliammeter reads full scale deflection.

4 Observe and record the reading of the voltmeter and ammeter in Table 3. The measuring element indicates full scale deflection at  $V_1 = \underline{\hspace{2cm}} \text{ V}$

$$I_1 = \underline{\hspace{2cm}} \text{ A.}$$

5 Open the switch S and disconnect the circuit elements.

6 Calculate the shunt resistance  $R_{sh}$ .



$$R_{sh} = \frac{V_i}{I_{sh}}$$

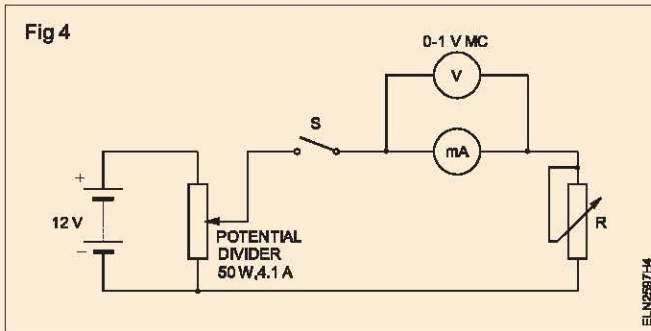
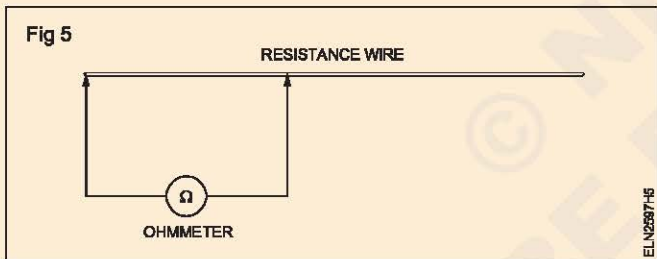


Table - 3

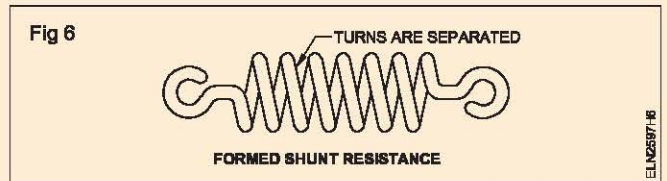
Voltmeter reading in Volts	Ammeter reading in Amps.

The voltage across the shunt resistance is then equal to  $V_i$ . The current  $I_{sh}$  in the shunt resistance is the difference between the end value of the measuring range  $I = 2.5A$  and the current in the measuring element  $I_i$ . ie.  $I_{sh} = I - I_i$ .

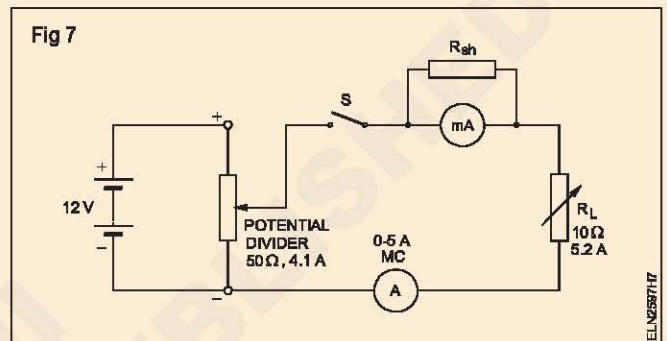
- 7 Measure the exact length of the Manganin wire that has a resistance equal to  $R_{sh}$  as shown in Fig 5, using an ohmmeter and go to step 9.



- 9 Cut the wire 1 cm greater in length than measured.
- 10 Coil the wire with eye formation at both ends. Exercise care to see the excess length of 1 cm is used for eye formation at the ends. (Fig 6)



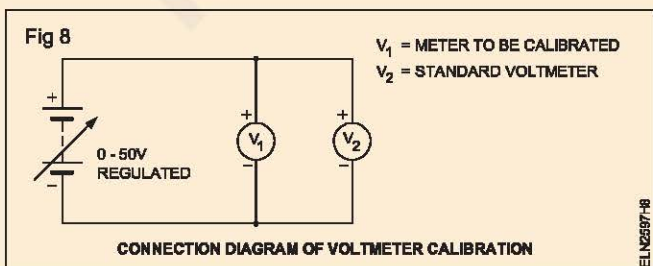
- 11 Connect the coiled wire as shunt across the terminals of the milliammeter.
- 12 Set up the circuit according to the circuit diagram. (Fig 7)



- 13 Adjust the variable load resistance  $R_L$  to 4 ohms.
- 14 Switch on the power and adjust the output voltage to circuit, equal to 10V. Observe the ammeter deflection.
- 15 Read the value of current 'I'.
- 16 Verify that the readings shown are in amperes by inserting a 5A ammeter in series.

### TASK 3 : Calibrate a 0-50V MC type voltmeter

- 1 Check and set the pointer of the meter under calibration to read zero (mechanical zero setting).
- 2 Connect the 0-50V meter to be calibrated and a standard digital voltmeter across a regulated DC power supply as shown in the Fig 8.
- 3 With the output of the adjustable DC PSU set to zero Volt, get the connections checked by your instructor.



- 4 Increase the output voltage of the DC PSU such that the standard meter ( $V_2$ ) reads 5V (1/10th of the range of the meter under calibration.).
- 5 Record the corresponding voltage reading of the meter under calibration ( $V_1$ ) in Table 4
- 6 From the readings of the standard meter and the reading shown by the meter under calibration, find the % of error in the meter under calibration as given in Table 4
- 7 Repeat steps 4,5 and 6 to find the % error at different readings of the meter under calibration as given in Table 4
- 8 From the % error found at different readings, calculate and record the average % error of the meter under calibration.
- 9 Get your work checked by the instructor.

Table 4

Type of meter :

Range :

Sl. No.	PSU output volts	Voltmeter readings in volts		error ( $V_2 - V_1$ )	% of error $\frac{V_2 - V_1}{V_2} \times 100$
		Standard $V_2$	undercalibration $V$		
1	5	5			
2	10	10			
3	20	20			
4	30	30			
5	40	40			
6	50	50			

$$\text{Average \% error} = \frac{\text{Total \% error}}{\text{No. of reading}}$$

#### TASK 4 : Calibrate a 0-500mA MC type ammeter

- 1 Check and set the pointer of the meter under calibration to read zero (mechanical zero setting).
- 2 Connect the given 0-500mA DC meter to be calibrated and a standard digital DC Ammeter for some range across the output of a regulated DC power supply via a rheostat as shown in the Fig 9.
- 3 Set the Rheostat to its half resistance position and set the output of DC PSU to zero volts. Get the wired circuit checked by your instructor.
- 4 Increase the output of the PSU slowly till the standard ammeter ( $A_2$ ) read 500 mA (full scale value of the ammeter under calibration ( $A_1$ )).
- 5 Adjust the rheostat such that the standard ammeter ( $A_2$ ) reads 450mA (decrease in current equivalent to 1/10 of the full range of the meter under calibration).
- 6 Record the corresponding reading on the ammeter ( $A_1$ ) under calibration in Table 5.
- 7 From the readings of the standard meter and the reading shown by the meter under calibration, find the % of error in the meter under calibration using the formula given in Table 5.
- 8 Repeat step 5 & 7 for the values given in Table 3 to cover the complete range of the ammeter under calibration.
- 9 From the % error found at different readings, calculate and record the average % error of the meter under calibration.
- 10 Get your work checked by the instructor.
- 11 Paste a slip on the calibrated meter indicating date of calibration and average % error.

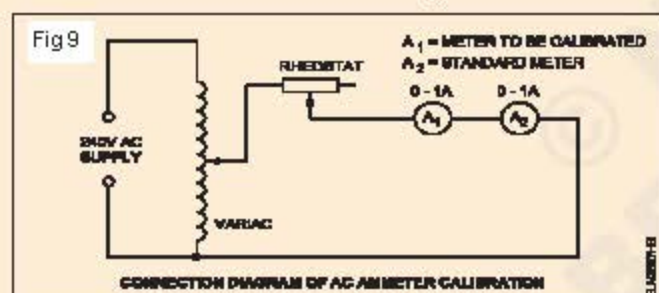


Table 5

Sl.No	Ammeter reading in mA		Error ( $I_2 - I_1$ )	% of error $\frac{(I_2 - I_1)}{I_2} \times 100$
	Standard $I_2$	Undercalibration $I_1$		
1	50			
2	150			
3	250			
4	350			
5	450			
6	500			

$$\text{Average \% error} = \frac{\text{Total \% error}}{\text{No. of reading}}$$

**Determine errors in resistance measurement by voltage drop method**

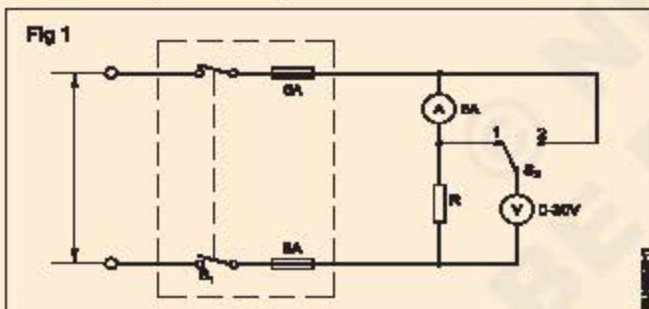
**Objectives:** At the end of this exercise you shall be able to

- determine errors in resistance measurement by voltage drop method
- connect suitably the voltmeter and ammeter to minimize measurement errors.

Requirement	
<b>Tools/Instruments</b>	
• Insulated cutting pliers 150 mm	- 1 No.
• Screwdriver 150 mm	- 1 No.
• Connector screwdriver 100 mm	- 1 No.
• 0-30V mC panel type voltmeter	- 1 No.
• Multimeter	- 1 No.
• 0-5 amps ammeter, P.M.M.C type	- 1 No.
• Ohmmeter, Shunt type 0-100 ohms	- 1 No.
<b>Equipment / Machines</b>	
• 24V DC power supply unit	- 1 No.
• Rheostat 10 ohms, 20 ohms and 50 ohms 4A capacity each	- 1 No.
<b>Materials</b>	
• DPST knife switch 16 A	- 1 No.
• SPDT knife switch 16A	- 1 No.
• 5A fuse wire	- 1 No.
• P.V.C. cable 48/0.2mm	- 10 m
• Glass cartridge fuse with holder 100 mA	- as reqd.

**PROCEDURE**

- 1 Form the circuit as shown in Fig 1. (Use only high sensitivity voltmeter.)



- 2 Measure the value of resistor R and enter the measured value in Table 1.
- 3 Switch on the supply keeping switch S<sub>2</sub> at position 1, across the resistor only. Read the voltmeter and ammeter and record the readings in Table 1 switch off the circuit.

- 4 Calculate the resistance value from the measured quantities using the formula  $R = V/I$ , and enter the values in Table 1.
- 5 Change switch S<sub>2</sub> to position 2, across the resistor and ammeter. Read and record the voltage and the current.
- 6 Repeat step 4 for these values.
- 7 Calculate and enter the error occurred in the measurement of resistance by using the formula

$$\% \text{ error} = \frac{(R_{2cal} - R_{2mes}) \times 100}{R_{2mes}}$$

- 8 Repeat the same procedure for different values of R as given in Table 1.

Table 1

Resistance value			Voltmeter connected across	Voltage	Current	Calculated value of resistance $R = V/I$	% error = $\frac{(R_{2cal} - R_{2mes}) \times 100}{R_{2mes}}$
Sl No.	Marked $R_{Mar}$	Measured $R_{Mes}$ ohms					
1	10		R only				
			R & A				
2	20		R only				
			R & A				
3	50		R only				
			R & A				

**Test single phase energy meter for its errors**

**Objectives :** At the end of this exercise you shall be able to

- identify the creeping in energy meter
- test the energy meter for starting current error
- select suitable loading arrangements for determining errors in energy meters
- determine the percentage error in an energy meter.

**Requirements**

**Tools/Instruments**

- Electrician's Tool Kit - 1 No.
- Single phase energy meter 5A 250 V 50HZ - 1 No.
- Voltmeter MI 0 - 300V - 1 No.
- Ammeter MI 0 - 5 A - 1 No.
- Power factor meter 240 V 5 A 50 Hz - 1 No.
- Ammeter MI 0 - 50mA - 1 No.

**Equipment/Machines**

- Single phase capacitor motor with brake load 240V 50 Hz AC 1/2 kW - 1 No.
- Lamp load single phase 250 V 50 Hz 1.25 kW - 1 No.
- Auto-transformer 0 to 270V 8A 50 Hz - 1 No.

**Materials**

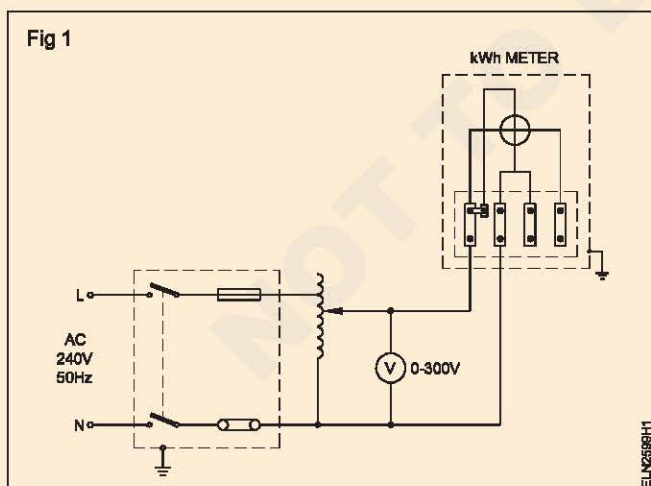
- Electric bulb 5 W 240 V with holder - 1 No.
- PVC insulated cable 1.5 sq. mm 250 V grade - 10 m

**PROCEDURE**

**Adjustment of errors inside the energy meter is beyond the scope of this course as it requires costly equipment like rotating sub-standard meter etc. Hence the simplified method of finding errors only is included here.**

**TASK 1 : Check the energy meter at no load (to find the creeping error)**

- 1 Connect the energy meter through an auto-transformer as shown in Fig 1.
- 2 Vary the input voltage to the energy meter between 80% and 110% of the rated voltage of the energy meter.



**For an energy meter rating of 240 Volts the input voltage is between 192 V to 264 V. Observe, if the meter disc is rotating or not. The load should not be connected or the load switch should be 'off' during the observation period.**

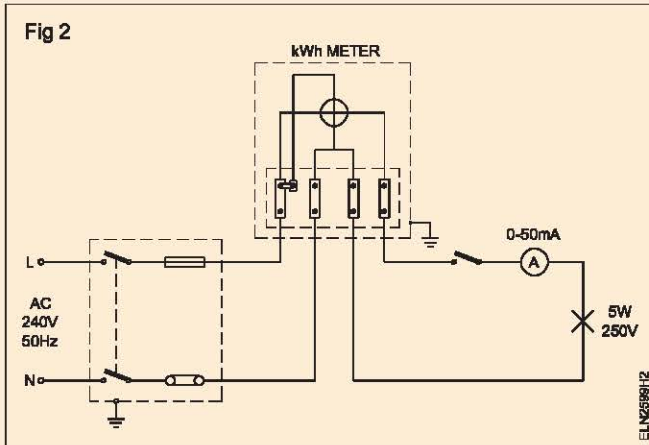
- 3 Write your observations correlating your findings from the above experiments with the recommendation given in IS 722.

**OBSERVATION**

**As per IS 722 (Part I) 1977 the meter shall not make a complete revolution at any voltage between 80% and 110% of the reference voltage.**

**TASK 2: Task for starting current error in energy meter**

- 1 Connect low load (5 W lamp) as shown in Fig 2.
- 2 Switch on the load and observe the meter rotation.
- 3 Write your observations, correlating your finding from the above experiment with the recommendation given in IS 722 (Part III).



OBSERVATION

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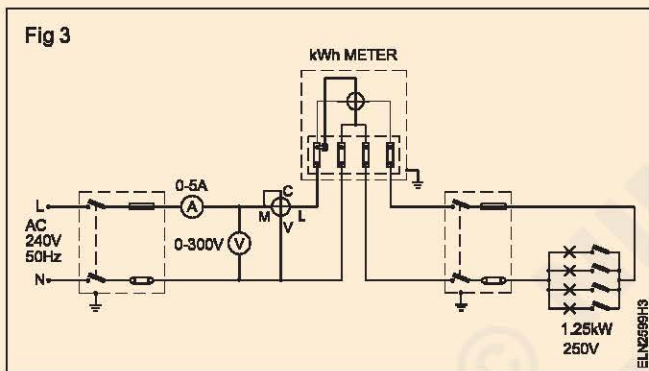


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**As per IS 722 (Part II) 1977 the starting current shall be 0.5% of the rated basic current across = 1 for dial and pointer type register whereas for drum type register it will be 0.75%. For meters provided with reverse stop the values will be 1% and 1.5% respectively.**

**TASK 3 : Task for percentage error in single phase energy meter**

- 1 Make the connections as shown in Fig 3 with the lamp load.



- 2 Switch 'ON' the lamps so that 25% of the rated current of energy meter flows in the circuit.
- 3 Tabulate the voltmeter, ammeter and P.F. meter readings in Table 1.
- 4 Keeping the load constant, count the number of revolutions of the energy meter disc for 2 minutes (120 seconds) and record the same in Table 1.

- 5 Calculate the true energy by using the formula

$$\text{True energy} = \frac{E \times I \times \cos \phi \times t}{1000 \times 3600} \text{ kWh}$$

where 't' is the time in seconds.

- 6 Calculate the energy registered (recorded) by the meter using the formula

$$\text{Recorded energy} = \frac{\text{No. of revolutions}}{\text{Meter constant}} \text{ kWh} = \frac{N}{K} = \text{kWh}$$

- 7 Find the error using the formula  
Error = Recorded energy - True energy.
- 8 Calculate the percentage error, using the formula

$$\text{Percentage error} = \frac{R - A}{A} \times 100$$

where R = Energy registered by the meter

A = True energy.

Table 1

Sl. No.	Load reading	Voltmeter reading	Ammeter reading	P.F. meter reading	Time in Sec	True energy	Revolution counted N	Meter constant K	Recorded energy	% error
1	Resistive									
2	25%									
3	50%									
4	75%									
4	100%									
1	Inductive									
2	25%									
3	50%									
3	75%									
4	100%									

Repeat the working steps from 2 to 8 for 50%, 75%, 100% resistive and inductive loads and enter in Table 1.

For inductive load, make the connection as shown in Fig 4.

For checking the proper registraion of energy, verify the readings through initial and final reading differences recorded in the energy meter. As per I.S. 722 (Part III) 1977, the percentage error shall not exceed  $\pm 2\%$ , both at unity power factor and at 0.5 lagging.

If the above errors are beyond the limitation prescribed in I.S., take action for calibration of the energy meter at the meter testing department attached to the electricity board.

Fig 4

