PROJECT DETAILS

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Topic ELECTRICAL ENGINEERING

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13/09/18

Experiment - 1

* **Objective** → To verify KCL and KVL by finding current through different branches of a circuit.

* **Apparatus required and build-in parts :-**

→ DC regulated power supply of 0-3 volts.
→ Four types of wire wound resistances (5 ω, 10 ω, 22 ω, 33 ω) pre-mounted behind the front panel.
→ Two round meters are mounted on front panel to measure corresponding voltage and current

* **Theory:-**

- **Kirchoff I law:** According to this, the algebraic sum of various currents meeting at a function is zero. Currents flowing towards the junction are taken as positive while flowing away from the junction are taken as positive while negative. The total current flowing into junction is equal to total current leaving.

- **Kirchoff II law:** According to this, the algebraic sum of emf's is equal to the algebraic sum of product of resistances and the respective current flowing through them.

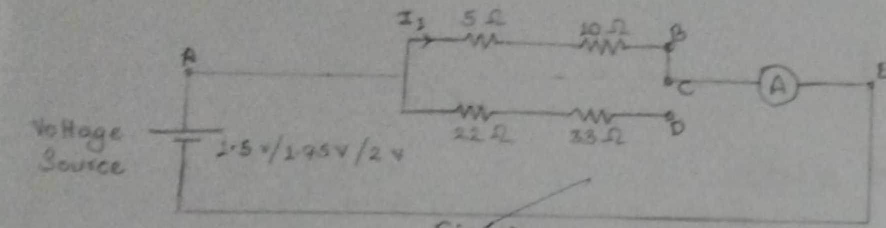


Fig (a)

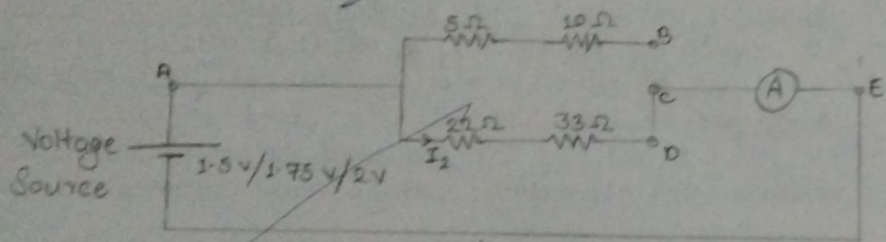


Fig (b)

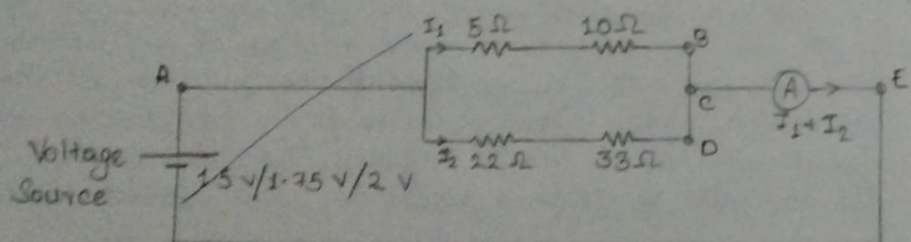


Fig (c)

Circuit Diagrams

Procedure :-

- **Calculation of current i_1:**
  Connect circuit as shown in fig (a) i.e, connect current meter (mA) across B & C as shown and C & D will remain open.
  Applying KVL in closed mesh ABCA,
  $\Rightarrow 5 i_1 + 10 i_1 = V$ volts (say)

- **Calculation of current i_2:**
  Connect circuit as in fig (b). i.e, connect current meter (mA) across C & D pts as shown while B & C will remain open.
  $\therefore 22 i_2 + 33 i_2 = V$ volts (say)

- **Calculation of current i:**
  Connect circuit as in fig (c) i.e, connect B, C & D and connect current meter (mA) between -ve terminal of battery and pt. C
  Total current $i = i_1 + i_2$

Standard Accessories :-

- 6 single point patchcords for interconnection.
- Instruction Manual.

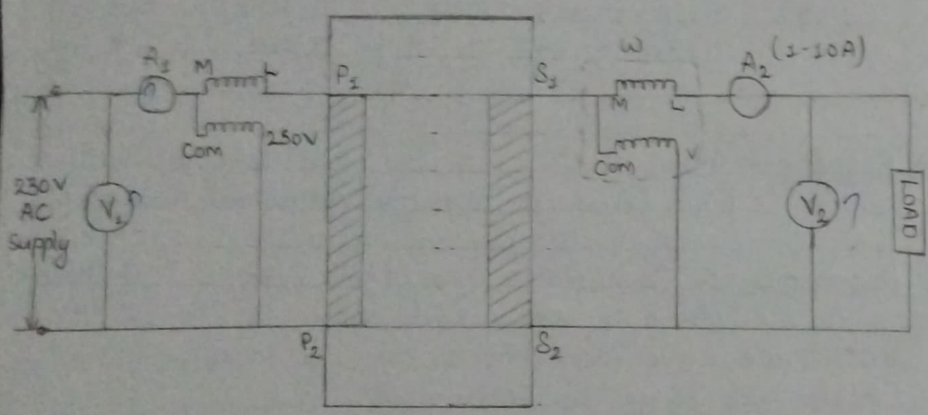
* Observations:-

Sr. No.	Voltage (in V)	i_1 (A)	i_2 (A)	i (in Amp) Ideal	Observed	% error
1.)	1.5	0.099	0.025	0.127	0.124	1.5 %
2.)	1.75	0.116	0.029	0.148	0.144	2.7 %
3.)	2.0	0.132	0.034	0.169	0.164	2.9 %

* **Result:-** Above readings verify that total current $i = i_1 + i_2$ (currents through individual branches).

* **Precautions:-** Connections should be pledged out before changing connectivity from BC to CD to BCD. Make sure connections are not loose. Check zero error of instruments.

$$\%\ \text{error} = \frac{i(\text{ideal}) - i(\text{observed})}{i(\text{ideal})} \times 100$$



<u>Circuit Diagram</u>

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Experiment -2

- **Objective:-** Measurement of efficiency of a single phase transformer by load test.

- **Apparatus required:-** AC ammeter, 2 wattmeters, 1 single phase transformer, lamp road in series with inductor, switch, connecting wires.

- **Theory:-** Efficiency of transformer is given by:

$$\eta = \frac{\text{output power}}{\text{input power}} \times 100$$

→ The method of determination of transformer efficiency by direct measurement output power & input power does not give accurate results, as power losses are quite low (of order of 1-4%). The difference b/w the readings of output and input instruments is then so small than an instrument error as low as 0.5% would cause an error of order of 15-20% in the power losses.

→ Further, it is inconvenient & costly to have necessary loading devices of correct currents and voltage ratings and power factor to load the transformer. There is also a wastage of large amount of power and no information is available from such test about proportion of copper and iron losses.

Calculations :-

(1) $\eta = \frac{320}{360} \times 100 = 88.88\ \%$

(2) $\eta = \frac{420}{460} \times 100 = 91.30\ \%$

(3) $\eta = \frac{520}{560} \times 100 = 92.85\ \%$

(4) $\eta = \frac{620}{680} \times 100 = 91.17\ \%$

(5) $\eta = \frac{720}{780} \times 100 = 92.30\ \%$

[Efficiency $(\eta) = \frac{W_2}{W_1} \times 100$]

Procedure :-

- Connect the circuit as shown in the figure
- Loads, wattmeters & ammeters are connected to primary & secondary terminals of transformer.
- The supply is switched on through DPIC switch
- Reading of input, output power & current are noted for different values of loads.

Observations:-

Sr. No.	Input Power (W_1)	Output Power (W_2)	Current (I)	Efficiency $= \frac{W_2}{W_1} \times 100$
(1)	360	320	2.7	88.88 %
(2)	460	420	3.6	91.30 %
(3)	560	520	4.5	92.85 %
(4)	680	620	5.4	91.17 %
(5)	780	720	6.3	92.30 %

Here, wattmeter is used at 250 V & 10 A supply of current

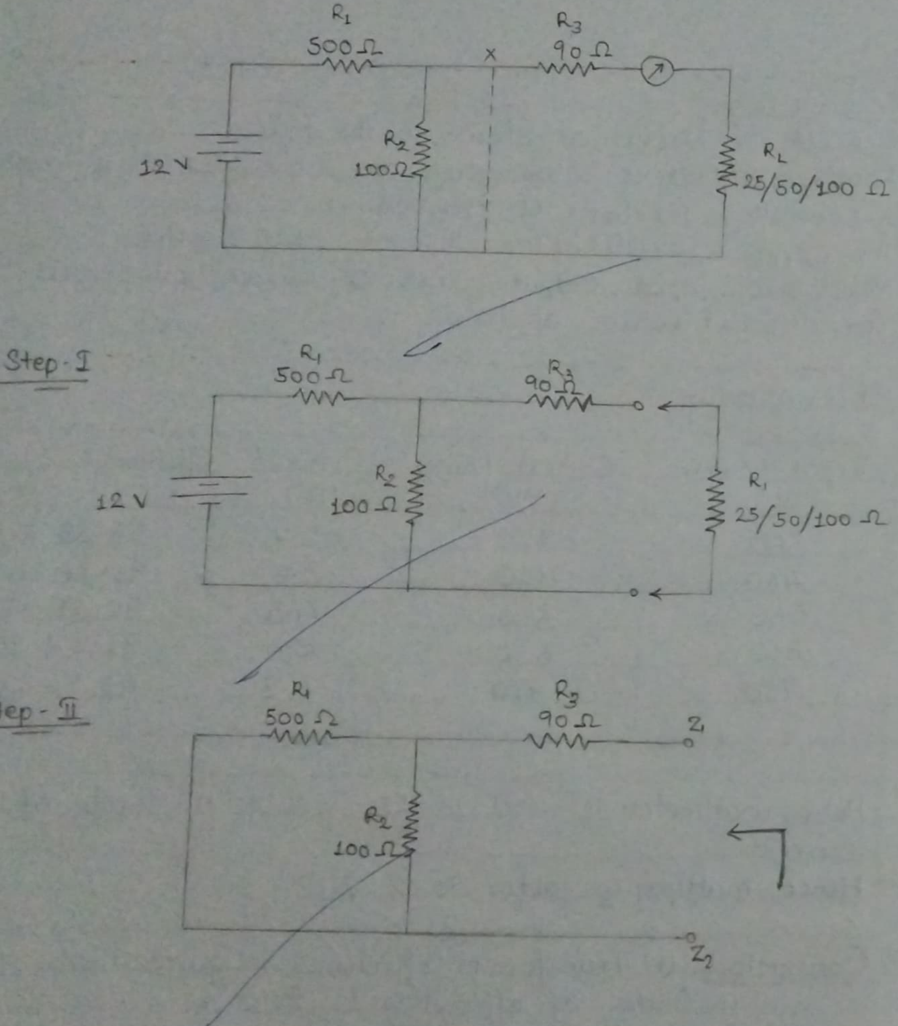
Hence, multiplying factor is 2.

Conclusion:-

(i) Transformer efficiency is quite high

(ii) Order of efficiency is 91.3 %

(iii) Power factor on primary & secondary sides are almost same



Circuit Diagrams

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Experiment - 3

⊛ **Objective** :- To verify Thevenin's theorem.

⊛ **Apparatus used** :- DC regulated power supply of 12 V. An instrument with two :-

(i) Ammeter (0 - 5 A)
(ii) Voltmeter (0 - 10 V)
(iii) Resistors
(iv) Connecting wires.

⊛ **Theory** :-

⊙ **Thevenin's Theorem** → Accoring to this, if any linear bilateral network containing one or more voltage source can be replaced by a single voltage source whose values is equal to the open circuit voltage at output terminal, with a series thevenin's resistance. The thevenin resistance is equal to the effective resistance looking back from the output terminal by removing the load resistance.

⊛ **Procedure** :-

- The battery E_1 of 12 V and resistances R_1, R_2 & R_3, load resistance R_L, voltmeter V and ammeter A are connected as in figure.
- Keys K_1, K_2 & K_3 are closed; readings of ammeter A giving current flowing through load resistance R_L.

Calculations :-

(1) $I_{TH} = \frac{1.83}{175.96 + 25} = \underline{9.10 mA}$

$\% \text{ error} = \frac{|9.1 - 9.1|}{9.1} \times 100 = \underline{0\%}$

(2) $I_{TH} = \frac{1.83}{175.96 + 50} = \underline{8.12 \text{ mA}}$

$\% \text{ error} = \frac{|8.12 - 8.10|}{8.12} \times 100 = \underline{0.25\%}$

(3) $I_{TH} = \frac{1.83}{175.96 + 100} = \underline{6.67 \text{ mA}}$

$\% \text{ error} = \frac{|(6.67 - 6.63)|}{6.67} \times 100 = \underline{0.60\%}$

I_L is noted and also voltage across load resistance R_L is measured by voltmeter.

- Now, load resistance R_L is removed by opening key K_3 and voltage across terminals A & B is measured by a D.C voltmeter. This is an open-circuit voltage V_{OC} (or Thevenin voltage V_{TH})
- Now, terminals A & B are short circuited by closing key K_4 and reading of ammeter is noted down. This is the short circuit current I_{SC}. The thevenin resistance, R_{TH} is given by $\frac{V_{OC}}{I_{SC}}$. Load current, $I_L = \frac{V_{TH}}{R_{TH} + R_L}$

Observations:-

$V_{OC} = V_{TH} = 1.83 \text{ V}$

I_{SC} = current through branch OC = 10.40 mA

$R_{TH} = \frac{V_{TH}}{I_{SC}} = \frac{1.83}{10.4} \times 10^3 = 175.96 \ \Omega$

$\boxed{R_{TH} = 175.96 \ \Omega}$

Sr. No.	R_L [Load resistance] (Ω)	I_L [Current through load] (mA)	I_L^{th} [Thevenin current] (mA)	% Error
(1)	25	9.10	9.10	0%
(2)	50	8.10	8.12	0.25%
(3)	100	6.63	6.67	0.60%

Conclusion:- Thevenin's theorem is verified.

Precautions:-

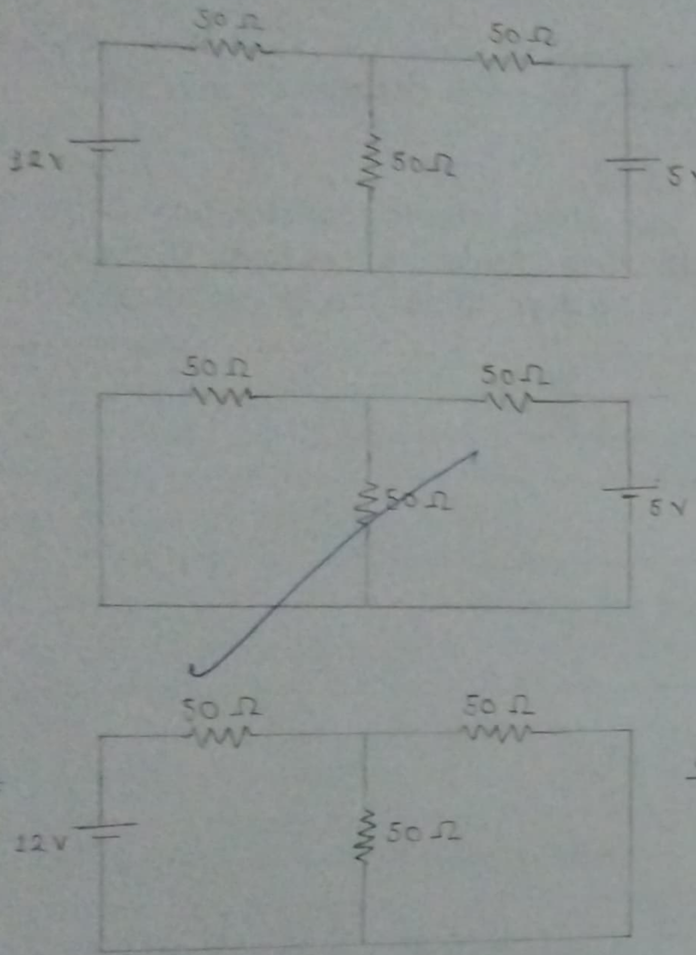
(i) All the connections should be neat and clean and tight
(ii) Emf of battery should be constant.
(iii) All the connecting wire should be of uniform thickness.

Step-I

Short Circuit 12 V battery

Step-II

Short Circuit 5 V battery



Circuit Diagrams

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Experiment - 4

⊛ **Objective:-** Verification of Superposition theorem

⊛ **Apparatus Used:-**

(i) 12 V DC regulated power supply.
(ii) 5 V DC regulated power supply.
(iii) Two meters are mounted on the front panel to measure value of voltage and current.
(iv) Circuit diagram engraved on front panel.

⊛ **Theory:-** In the linear resistance networks, connecting two or more voltage sources, the current through any element may be determined by adding together algebraically the currents produced by each source acting along when all the extra voltage sources are replaced by their internal resistance, the terminals to which it was connected are joined together.

⊛ **Procedure:-**

(i) Take 2 batteries E_1 of 12 V and E_2 of 5 V. First, short circuit the battery of 12 V and note down the reading of current I_1 in middle wire.
(ii) Now, short circuit the battery of 5 V and again note down the reading of current I_2 in middle wire.
(iii) Now, add currents I_1 & I_2.

Calculation :-

$I = I_1 + I_2$

$= 0.169 + 0.072 = 0.241$

$\% \text{ error} = \frac{|0.242 - 0.241|}{0.242} \times 100 = 0.41\%$

Observation Table :-

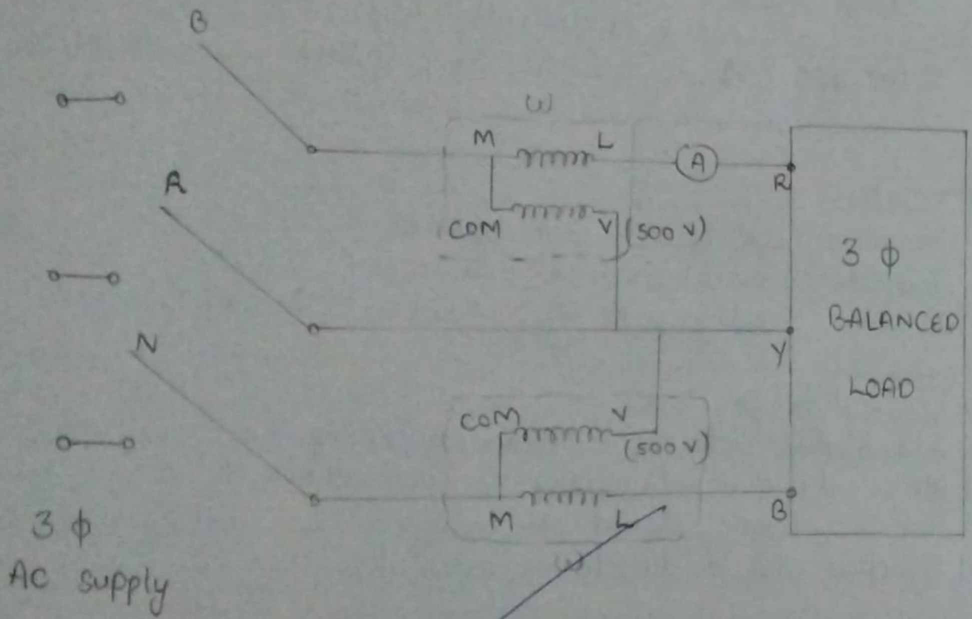
Sr. No.	I_1	I_2	$I_1 + I_2$ (Theoretical)	$I_1 + I_2$ (Experimental)	% Error
-	0.169	0.072	0.242	0.241	0.41 %

Result :-

Ammeter reading with both sources = 0.242
Ammeter reading with 12 V source = 0.169
Ammeter reading with 5 V source = 0.072

Precautions :-

(1) Check the instrument before performing the experiment.
(2) Make the connection properly and check it.
(3) The connection should be tight.
(4) Reading should be taken carefully.



Circuit Diagram

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Experiment - 5

Object :- Measurement of power in a three phase circuit by two wattmeter method and determination of its power factor.

Apparatus :- Dynamometer type wattmeter, voltmeter, ammeter, 3-phase balanced load, connecting wires.

Procedure :-

(1) Make the connections as shown in the circuit diagram
(2) Take the ammeter and voltmeter readings
(3) Note the wattmeter readings by varying the load.

Observation Table :-

Sr. No.	Ammeter reading (A)	Power W_1 (watt)	Power W_2 (watt)	Total Power $P = W_1 + W_2$	Power Factor
(1)	4.5	240	280	520	0.9912
(2)	6.6	320	360	680	0.9982
(3)	6.9	340	460	800	0.9889

Calculations :—

$$\cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}\,(\omega_1 \sim \omega_2)}{\omega_1 + W_2}\right)\right]$$

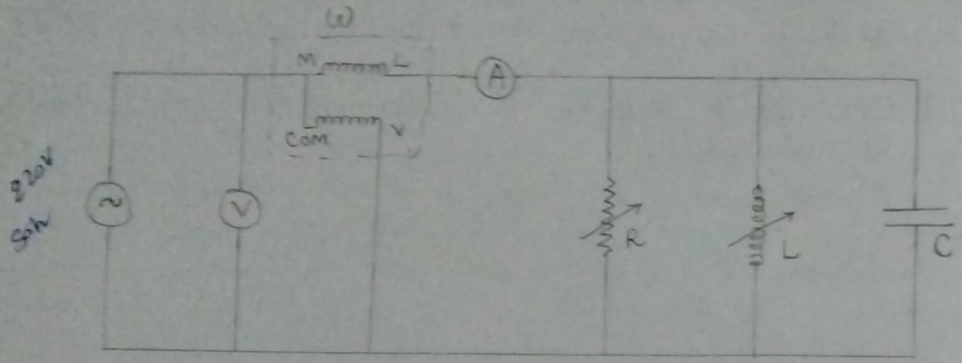
(1) $\cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}\times 40}{520}\right)\right] = 0.9912$

(2) $\cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}\times 40}{680}\right)\right] = 0.9982$

(3) $\cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}\times 120}{800}\right)\right] = 0.9889$

Precautions and Sources of error:-

(1) Connections should be tight and clean.
(2) Safety equipment should be used to prevent one from getting shock (gloves).
(3) Open the switches carefully.
(4) Readings in ammeters should not exceed current ratings of wattmeter
(5) With negative deflection in wattmeter connections should be reversed.



Circuit Diagram

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Experiment - 6

* **Object**:- Measurement and verification of power and power factor in a single phase AC series circuit and study of improvement of power factor using capacitor.

* **Apparatus Used**:-
Ammeter, Voltmeter, Wattmeter, Connecting wires and Capacitor.
Rating?

* **Theory**:- Real Power (P) in a single-phase AC series inductive circuit is measured by a wattmeter.
P = reading of wattmeter × multiplying factor.

For measurement of power factor,

$$\cos\phi = \frac{P\ (real)}{V \times i}$$

* **Procedure**:-

→ Ammeter, Wattmeter, Voltmeter and ~~resistive~~ loads must be connected as shown in the circuit diagram. Initially, capacitor must not be connected.

→ Now, switch on the supply and obtain the readings in

→ voltmeter, ammeter and wattmeter.

Now, switch off the supply and connect the capacitor.

Calculations :-

⇒ Actual Power

P = Readings in wattmeter × Multiplying factor

$\therefore P_1 = 2 \times 420 = 840 \text{ W}$

$P_2 = 2 \times 420 = 840 \text{ W}$

⇒ Power Factor

$$(\cos\phi)_{\text{with } C} = \frac{840}{240 \times 4} = 0.875$$

$$(\cos\phi)_{\text{without } C} = \frac{840}{240 \times 4.4} = 0.7955$$

→ Switch on the supply and again note the readings of ammeter, wattmeter and voltmeter. Switch off the supply now.

Observations:-

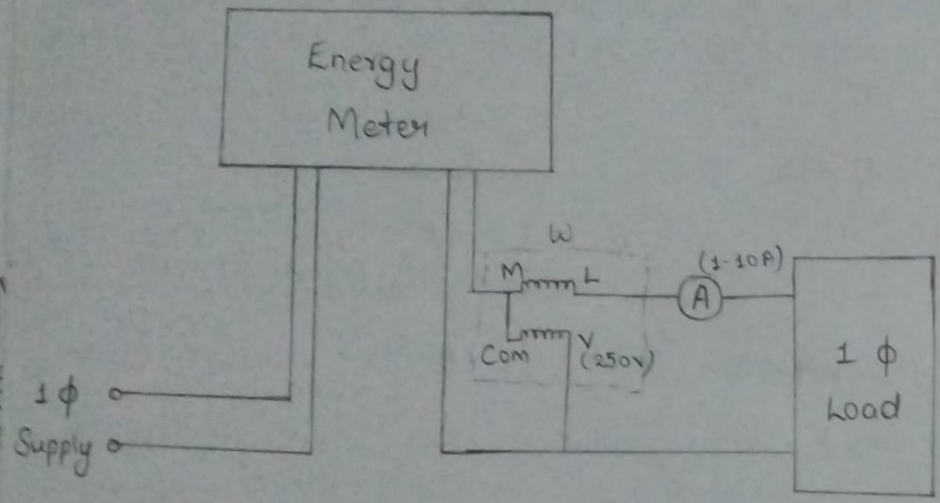
Sr. No		Input Voltage	Input Current	Input Power	Calculated Power Factor.
(1.)	With Capacitor	240	4	2 × 420 = 840 W	0.875 ~~0.7955~~
(2.)	Without Capacitor	240	4.4	2 × 420 = 840 W	0.7955

Result:-

Power consumed by the circuit remains unchanged on connecting capacitor C across the load but the power factor improves.

Precautions:-

(1.) All connections should be proper and tight.
(2.) The current in ammeter should not exceed over the safe range.
(3.) Supply must be switched on in presence of the lab instructor.



Circuit Diagram

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Experiment - 7

Object:- To measure energy by a single phase energy meter and determine error.

Apparatus Used:- Single phase energy meter, wattmeter, ammeter, one phase load, connecting wires, stopwatch, etc

Theory:- Energy meter is an integrating instrument which is used to record the energy consumed by the load during a given time period. Energy meter is also known as watt-hour meter. Electrical energy is measured in kilowatt hour by this energy meter. The no of revolutions made by energy meter is directly propotional to the energy consumed by wattmeter.

Procedure:-

- Ammeter, voltmeter, wattmeter and energy meter, and load are connected to a single phase AC supply through an auto transformer.
- Energy is switched on. Auto transformer is adjusted to provide rated voltage.
- Now the load is switched on and the one phase resistive load is set to 750 Ω and stop watch is started.
- The time corresponding to nine complete revolutions of disc is noted.

Calculations:-

(I) Energy Consumption indicated by Energy meter.

900 revolutions correspond to 1 KWH energy

9 revolutions correspond to $\frac{9}{900} = 0.01$ kWH

$= 3600$0 Ws energy

(II) Actual Energy Consumption

E = Wattmeter Reading × Time Duration (Ws)

(1) $E_1 = 840 \times 57.8 = 40{,}152$ Ws

(2) $E_2 = 960 \times 39.7 = 38{,}112$ Ws

(3) $E_3 = 1160 \times 31.8 = 36{,}888$ Ws

(III) Error Calculation

$$\%\ \text{Error} = \frac{|\text{Actual energy} - \text{Energy in energy meter}|}{\text{Actual energy}} \times 100$$

(1) $\%\ E_1 = \frac{|40152 - 36000|}{40152} \times 100 = 11.5\ \%$

(2) $\%\ E_2 = \frac{|38112 - 36000|}{38112} \times 100 = 5.8\ \%$

(3) $\%\ E_3 = \frac{|36888 - 36000|}{36888} \times 100 = 2.4\ \%$

Observations:-

(1) Number of phase - Single
(2) Voltage - 230 V
(3) Frequency - 50 Hz
(4) Current Rating - 10 A
(5) Energy meter Constant - 900 rev/KWH
(6) Multiplying factor of wattmeter - 4

Observation Table:-

Sr. No	No of Revolutions	Time Duration (s)	Wattmeter Reading (W)	Ammeter Reading (A)
(1)	9	47.8	210 × 4 = 840	2.8
(2)	9	39.7	240 × 4 = 960	3
(3)	9	31.8	290 × 4 = 1160	4.1

Result:-

If energy consumption indicated by energy meter is higher than actual energy consumption, the meter is running fast and if small, than meter is running slow.

Precautions:-

(1) Power should be put on in presence of the lab instructor.
(2) All connecting load wires should be tight.
(3) Proper current & voltage range must be selected before putting equipments in circuit.
(4) Take observations carefully.