Measure current, voltage and PF and determine the characteristics of the RL, R-C, R-L-C in AC series circuits

Objectives: At the end of this exercise, you shall be able to
- **measure the current, voltage, power and P.F in R-L series circuits**
- **measure the current voltage, power and P.F in R-C, series circuits**
- **measure the current voltage, P.F in R-L-C series circuits**
- **measure the power and P.F. in R-L-C series circuits.**

Requirements

Tools/Instruments

- MI voltmeter 0 - 300 V - 3 Nos.
- MI ammeter 0 - 1.5 A - 1 No.
- Wattmeter 250 V, 2.5 amps - 1 No.
- Power factor meter (0.5 lag to 0.5 lead) 250 volts, 2.5 amps - 1 No.

Equipment/Machines

- Auto transformer 0-270V/8A - 1 No.

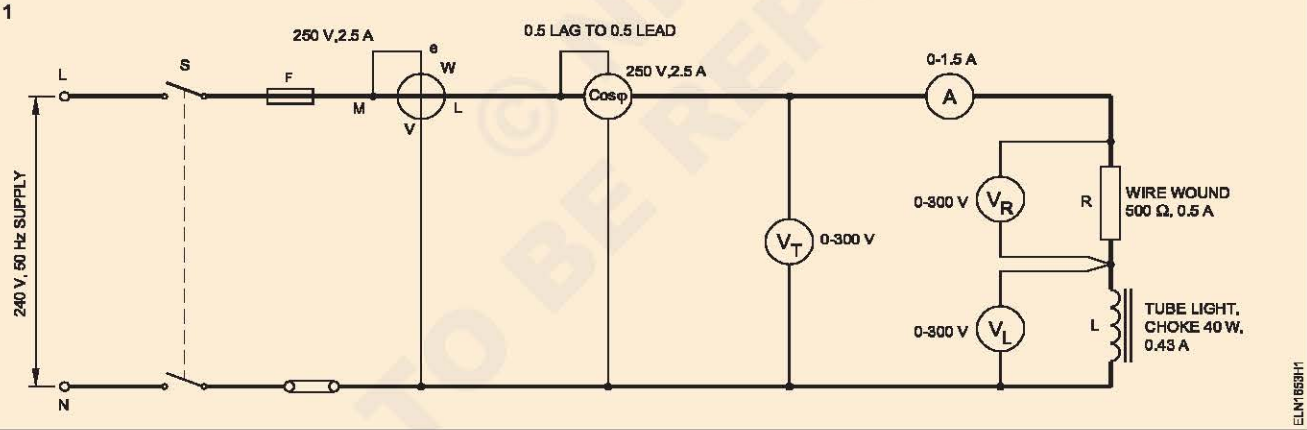
Materials

- Connecting cables - as reqd.
- Choke (tube light) 40 W, 0.43 A, 250 V - 1 No.
- I.C.D.P. switch - 16 amps, 250 volts - 1 No.
- Wire wound resistor 500Ω/0.5A - 1 No.
- Wire wound resistor 100Ω/1.5A - 1 No.
- Electrolytic capacitor 8μFd/400V - 1 No.
- Electrolytic 1μFd, 2μFd, 4μFd/400V - 1 No.each

PROCEDURE

TASK 1: **Measure the current, voltage, power and P.F in R-L series circuit**

Fig 1



1 Assemble the circuit by connecting instruments, resistor R, inductor L as in Fig 1. Switch ON the supply.

2 Measure the voltage V_R, V_L, supply voltage V_T and the circuit current and record in Table 1.

3 Read power (W_1) and power factor (cos ϕ) and record it in Table 1.

4 Calculate the apparent and the true power consumed in the circuit and compare them.

5 Calculate the power factor and compare it with the measured power factor.

6 Draw the vector diagram to add the voltage drops across R and L.

- Keep current as the reference vector.
- Select a suitable scale for the voltage.
- Draw the voltage vector (V_R) in-phase with current (I).
- Draw the voltage vector V_L leading-current I by 90°.
- Add vector V_R and V_L to get V_{T1}

7 Compare the above with the measured supply voltage.

8 Calculate the power factor from the true power and apparent power.

9 Compare the calculated power factor with the measured power factor.

10 Repeat the steps changing two values for the resistor and inductor and record them in Table 1 in columns 2 and 3.

11 Get it checked by the instructor.

Table 1

Measured value							Calculated value			
Sl. No.	Circuit current	Supply voltage	Power consumed (Wattmeter reading)	Voltage across resis-tance	Voltage across induc-tance	Power factor (reading of P.F. meter)	Vector addition of VR and VL	Difference in VT_1 and VT_2	Power consumed in circuit	Difference between measured & calculated power factor
	I	V_{T1}	W_1	V_R	V_L	$\cos\phi_1$	V_{T1}	$V_T - V_{T1}$	$W2 = V_T \times I \times \cos\phi_1$	$\cos\phi_1 - \cos\phi_2$

Conclusion

The difference between vector addition of V_R and V_L with respect to V_T is due to ______________________________

____

TASK 2: **Measure the current voltage, power and P.F in R-C series circuit**

1 Test the capacitor with an ohmmeter for its condition.

Discharge the capacitor before testing.

2 Check the value of the given resistance with a digital multimeter for its value.

Check the suitability of the selected wattmeter and P.F. meter with respect to the circuit specifications.

3 Construct the circuit as per diagram. (Fig 2) Keep the switch 'S' open.

Set the auto-transformer output to zero voltage.

4 Close switch 'S' and adjust the auto-transformer output voltage to 100V.

5 Measure the circuit current, voltage power consumed and power factor and note the readings in Table 2.

6 Calculate cosϕ and impedance.

7 Compare the calculated P.F with measured P.F.

8 Measure the voltages across R and C and note in Table 3.

9 Compare the arithmetical sum of V_R and V_C with the supply voltage and observe that this is a wrong procedure.

10 Add V_R and V_C by the vector method (graphically) selecting a suitable scale and compare with the measured supply voltage.

11 Adjust the output voltage to 200 V and repeat steps 5 to 10.

12 Get it checked by the instructor.

Fig 2

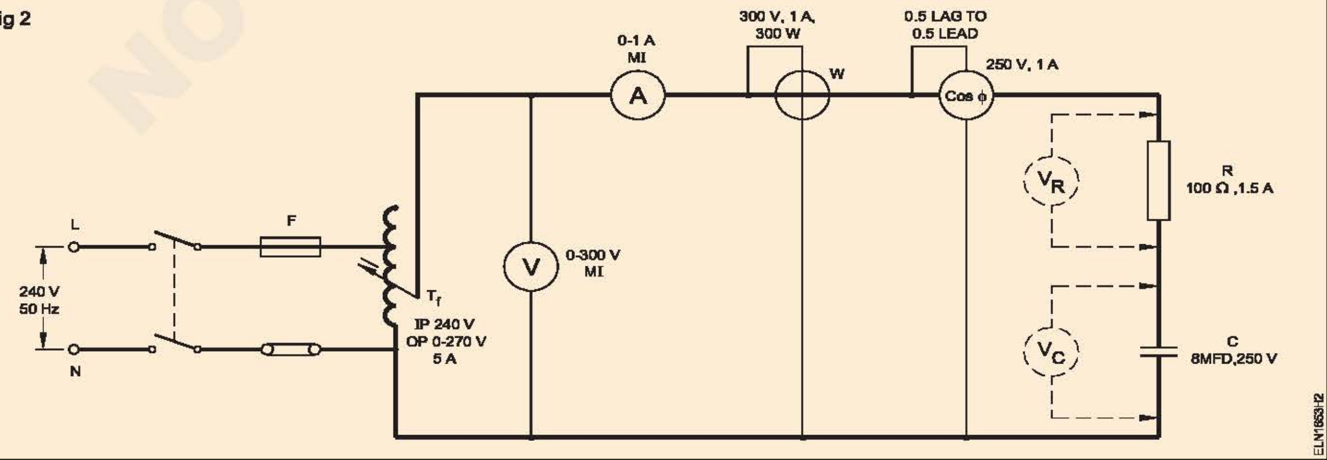


Table 2

Measured				Calculated	
V supply	I	W	PF	$PF = \frac{W}{VI}$	$Z = \frac{V}{I}$
100 V					
200 V					

Conclusion

____

Table 3

V supply	V_R	V_C	$V_R + V_C$ (Arithmetic)	$V_R + V_C$ (Vector)
100 V				
200 V				

— — — — — — — —

TASK 3: **Measure the current voltage, P.F, in R-L-C series circuit**

1 Assemble the circuit as per circuit diagram (Fig 3) with the instruments and components collected.

Before forming the circuit, confirm that the capacitor is discharged.

2 Switch 'ON' the supply and adjust the auto-transformer until the voltmeter indicates 240 volts.

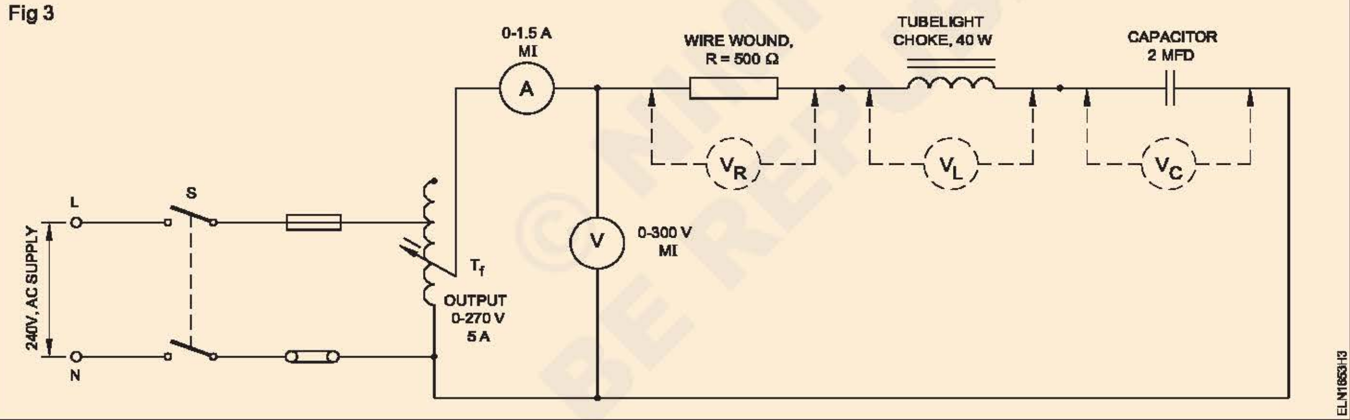
3 Measure the voltage across each element and note it in the Table 4.

Table 4

Supply	V_R	V_L	V_C	I
240 v				

4 Measure the current and note the same in Table 4. Switch off the circuit.

Fig 3



5 Draw the vector diagram (say 1cm = 50 V and 1cm = 0.1A) taking the current as the reference vector.

6 Determine the supply voltage from the vector diagram.

Supply voltage (vector sum) =.................V

Assumption: The resistance of the choke is negligible in this case.

7 Compare the value of the resultant vector voltage with reading of the voltmeter across the mains.

If the vector sum of voltages V_R V_C V_L is not exactly equal to the measured supply voltage, it may be due to---

- **observation error**
- **drawing of the vector diagram incorrectly**
- **assumptions made.**

8 Replace the capacitor with another value, say 8.0 MFD and repeat the steps 2 to 7.

9 Replace the capacitor with another value, say 1.0 MFD and repeat the steps 2 to 7.

10 **Result:** Total measured voltage is______________

____

11 Get it checked by the instructor.

Conclusion

A The voltage across individual component and total supply voltage______________

____

B The circuit current______________

____

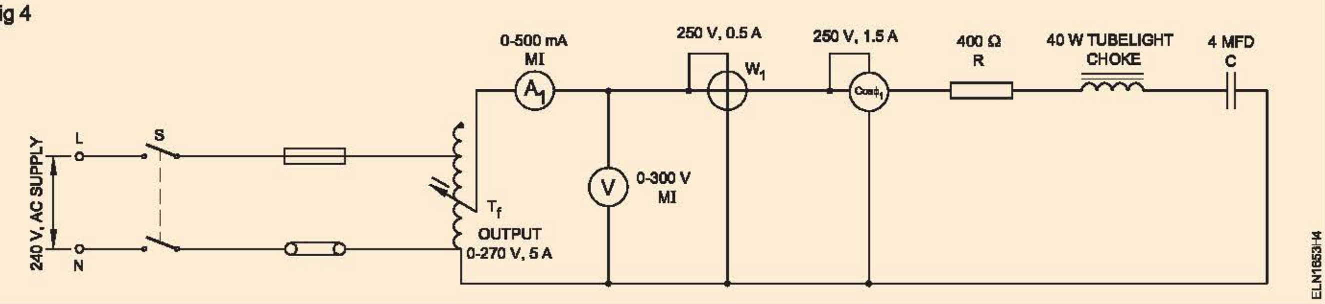
C The phase angle of current with supply voltage (from voltage vector)______________

— — — — — — — —

TASK 4: **Measure the power and P.F. in R-L-C series circuit**

1 Form the circuit as shown in Fig 4.

Fig 4



Discharge the capacitor. With an ohmmeter check the resistance for its value, the inductor for its continuity and the capacitor for leakage.

2 Set the auto-transformer to have zero output. Switch 'ON' the supply.

3 Gradually increase the output voltage until it is 100V.

4 Measure the corresponding current. Note down the readings in Table 5. Also read the Wattmeter and the power factor meter and record it in Table 5.

5 Calculate the apparent power from voltmeter and ammeter reading.

Apparent power = V x I in volt amp (VA)

6 Determine the power factor by using the formula and record it in Table 5.

$$\text{Cos } \phi = \frac{\text{True power}}{\text{Apparent power}}$$

7 Verify the measured power factor with the calculated power factor.

8 Increase the voltage to 200 volts and repeat steps 4 to 7.

Do not increase the voltage beyond 200V for this circuit.

9 Reduce the output voltage back to zero and switch off the supply.

10 Repeat the experiment (steps 2 to 9) with

i) the capacitor removed

ii) a 2 micro-farad capacitor connected

iii) a 8 micro-farad capacitor connected keeping the voltage at 200 V.

11 Compare the readings of the power factor in all the four cases. Record your observation.

12 **Result**

The change of the capacitor in the R-L-C series circuit for given R-L (value)

____

____

____

13 Get it checked by the instructor.

TABLE 5

Sl. No.	V Volt	I Amp.	W True power	AP = V xI in VA Apparent power	$\cos \phi = \frac{W}{AP}$	P.F. Meter reading	Capacitor value in MFD
1	100 V						8
2	200 V						4
3	200 V						0
4	200 V						2

Measure the resonance frequency in AC series circuit and determine its effect on the circuit

Objectives: At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC series circuit and circuit current**
- **plot a graph of frequency versus circuit current**
- **test the working of a series LC as a wave trap**
- **determine the effect of the resonance on the circuit.**

Requirements

Materials/Components

- General purpose Lug board - 1 No.
- Capacitor 0.1 µF - 1 No.
- Inductor coil, around 40mH (Use the solenoid coil made in Ex. 1.5.46) - 1 No.
- LED with holder - 1 No.
- Hook-up wires - as reqd.

Tools/Equipments/Instruments

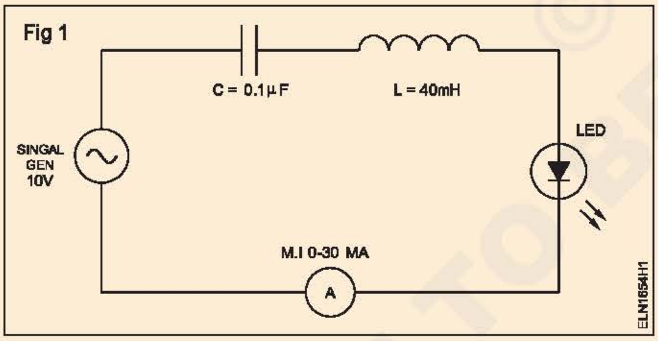
- Trainees kit - 1 No.
- CRO, 20 MHz - 1 No./batch
- Function generator - 1 No./batch
- MI Ammeter 0 - 30 mA - 1 No.

PROCEDURE

TASK 1: **Finding Resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple series resonance circuit. Connect instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit at different frequencies.

3 Calculate and record the resonance frequency of the series resonance circuit with known values of L and C

4 Set the output of the signal generator to $10V_{rms}$ and frequency to 1KHz. Record the current, I through the circuit in Table 1.

LED may not be glow or may be very dim, because the set frequency of 1 KHz may not be the resonance frequency of the circuit.

5 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes maximum (LED glows brightly).

This is the resonance frequency of the series resonance circuit because at series resonance, current I through the LC circuit will be maximum.

6 Compare and record the difference in the resonance frequency calculated in step 3 and that measured in step 5.

7 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

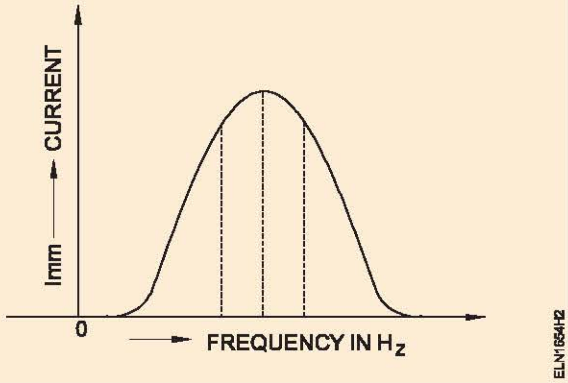
8 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC series circuit. (Fig 2)

9 It may appear as in Fig 2 working of the circuit, Record readings and plot the graph and get it checked by the instructor.

Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Current				

Fig 2



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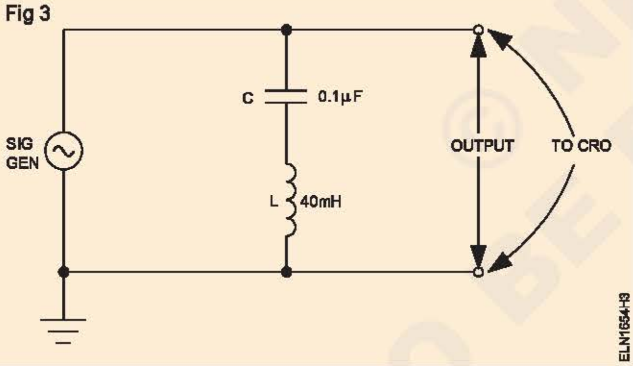
TASK 2: **To use series LC circuit as wave-trap to determine the effect on the circuit**

1 Using known values of L and C, make the circuit connections as in Fig 3.

Fig 3



2 Set the output of the signal generator to 3 volts, 50KHz, sine wave.

3 Increase the frequency till the output of the trap circuit is minimum. Record this frequency as the trap frequency and its the effect on the circuit.

At trap frequency, which is the resonance frequency of the Shunt connected LC circuit, the impedance of the circuit will be minimum and hence the voltage across the circuit will be minimum. Ideally, this should be zero. But, because of the internal resistance of the coil, the output voltage will not be zero but, will be minimum.

4 Get your work checked by the instructor.

LAB ASSIGNMENT: Change the value of the capacitor used in the LC circuit to 0.01µF and redo TASK 2 to find the new wave-trap frequency.

— — — — — — — —

Measure current, voltage and PF and determine the charactertics of R-L, R-C and R-L-C in AC parallel circuits

Objectives: At the end of this exercise you shall be able to
- **measure the current, voltage in R-L parallel circuit**
- **measure the current and voltage in each branch circuit of R-C parallel circuits**
- **determine the characteristics of R-L-C in parallel circuits.**

Requirements

Tools/Instruments
- Digital multimeter - 1 No.
- MI Ammeter 0 to 2 ampere (0-5A) - 2 Nos.
- MI Ammeter 0 to 3 amperes (0-5A) - 1 No.
- MI Voltmeter 0-250 V - 1 No.
- Frequency meter 50Hz/±5 - 1 No.

Equipment/Machines
- Auto-transformer - input 240 V - output 0 to 270 V, 8 amps - 1 No.
- Rheostar 400Ω/1A - 1 No.

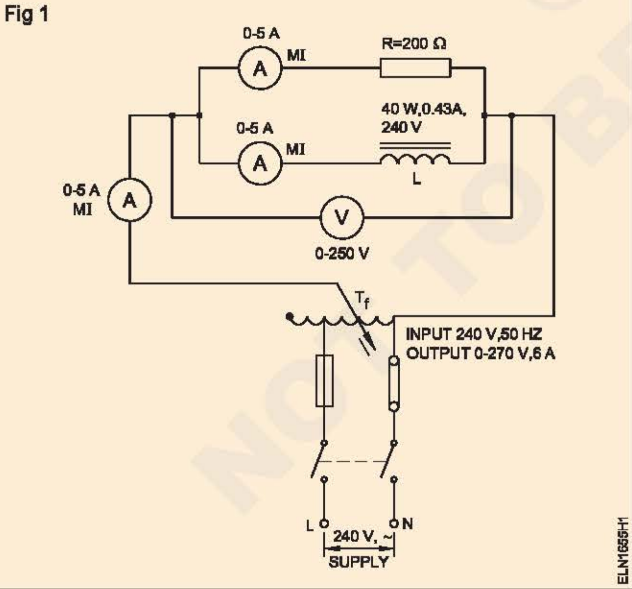
Materials
- Connecting cables - as reqd.
- I.C.D.P switch 250V, 16 A - 1 No.
- Wire wound resistor - 200 ohms - 1 No.
- Choke coil of 40 watts, 240V 50 Hz. tube light - 1 No.
- E.capacitor 8μFd/4μFd/400V - 1 each.
- E.capacitor 2μFd/400V - 1 each.

PROCEDURE

TASK 1: **Measure the current, voltage in R-L parallel circuit**

1 Assemble the circuit with the instruments, inductance coil and resistance. (Fig 1)

Fig 1



2 Set the auto-transformer output at zero position.

3 Switch 'ON' the supply and gradually increase the output voltage to 50V.

4 Measure the branch and total currents and record in Table 1. Repeat this step for different voltages say 100V, 125V, 150V, and 175V.

Table 1

Sl.No.	Measured				Graphical
	V	I_R	I_L	I_T	I_T Value
1	50				
2	100				
3	125				
4	150				
5	175				

5 Draw the vector diagram with suitable scale for currents taking voltage as reference vector in your practical record.

6 Determine the total current graphically.

The calculated values of total current and the actual measured value of current may vary due to instrument error, observational error and non-availability of pure inductance. Hence, about 5% error is permissible.

7 Compare the total current measured with the calculated value entered in table 2.

TABLE 2

Sl.No.	Measured value		Calculated value	
	V	I_T	$I_T = \sqrt{(I^2_R + I^2_L)}$	$Z = \frac{V}{I_T}$
1	50			
2	100			
3	125			
4	150			
5	175			

8 Find the Impedance of the circuit from the supply voltage and measured current. Calculate $Z = \frac{V}{I_T}$

Conclusion

Total current in an AC parallel circuit is the vector ______________ of $\mathbf{I}_R$ and $\mathbf{I}_L$ and not ______________ addition.

— — — — — — — — —

TASK 2: **Measure the current and voltage in each branch circuits of R-C parallel circuits**

1 Test the capacitor with an ohmmeter for its condition.

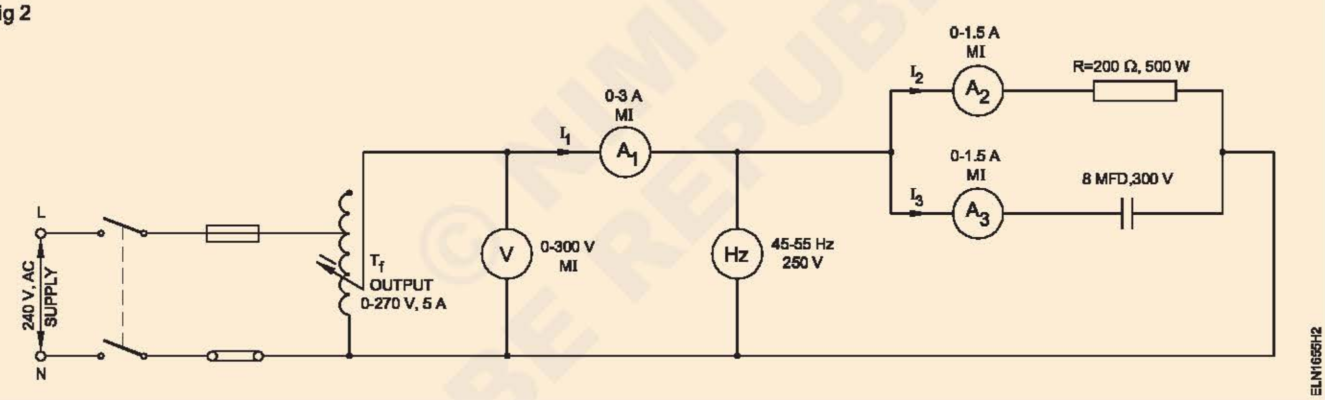
Discharge the capacitor before testing.

2 Test the resistor with an ohmmeter for its value.

6 Calculate the impedance 'Z' and record in Table 3.

7 Calculate the capacitive reactance ($X_c = V/I_3$) and record your result in Table 3.

Fig 2



3 Build the circuit as per diagram. (Fig 2) Keep the switch open. Set the auto-transformer to the minimum output voltage.

4 Switch ON the supply. Adjust the auto-transformer for an output voltage of 200V.

5 Record the frequency, voltage and the three ammeter readings in Table 3.

8 Calculate the capacitance from the values recorded in Table 3.

9 Establish that the arithmetical sum of the branch current is not equal to the main circuit current.

10 Graphically add the currents I_2 and I_3 and determine the value of I_1. Compare this value with the measured value.

Table 3

Sl.No.	V	f	I_1	I_2	I_3	$Z = \frac{V}{I_1}$	$X_C = \frac{V}{I_3}$	$C = \frac{1}{2\pi f X_c}$

11 Adjust the supply voltage to about 100 V and repeat steps 5 to 10.

Discharge the capacitor after the experiment.

12 Repeat the exercise for changed values of R and C in the circuit.

Conclusions

i The calculated value and the indicated value of the capacitor

ii The arithmetic sum of the branch current and the measured value of total current.

iii The vectorial sum of the branch currents and the measured value of the total current.

iv The determination of PF from the vector diagram

TASK 3 : Determine the characteristics of R-L-C in parallel circuits

1 Form the circuit as shown in Fig 3.

2 Repeat steps 2 to 12 of TASK 2 and record the readings in Table 4.

3 Compare the readings of the power factor in all the cases. Record your observations.

Conclusion

i Effect of change of supply voltage in R-L-C parallel circuit as regards power factor of circuit

ii Effect of change in capacitance in RLC parallel circuit.

Fig 3

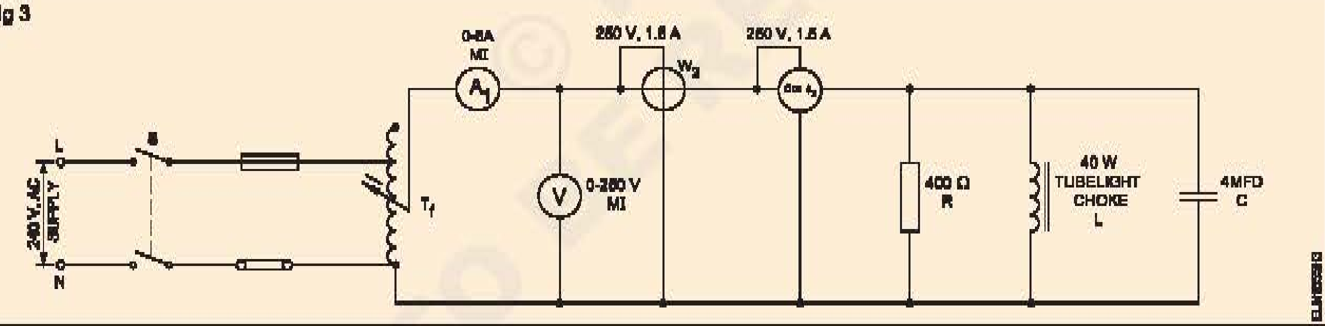


Table 4

Sl. No.	V Volt	I Amp.	W True power in Watt	AP = V xI Apparent power in VA	$\cos\phi = \frac{W}{AP}$	P.F. Meter reading	Capacitor value in µFD
1	100 V						4
2	200 V						4
3	200 V						0
4	200 V						2
5	200 V						3

Measure the resonance frequency in AC parallel circuit and determine its effects on the circuit

Objectives : At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC parallel circuit**
- **determine the circuit current for different frequencies**
- **plot a graph of frequency versus circuit current**
- **calculate the value of unknown C using LC parallel resonance**
- **determine the effect of LC parallel circuit on the circuit.**

Requirements

Tools/Equipment/Instruments

• Trainees kit	
• CRO, 20 MHz	- 1 No./batch
• Function generator	- 1 No./batch
• MI Ammeter 0-50mA	- 1 No.

Materials/Components

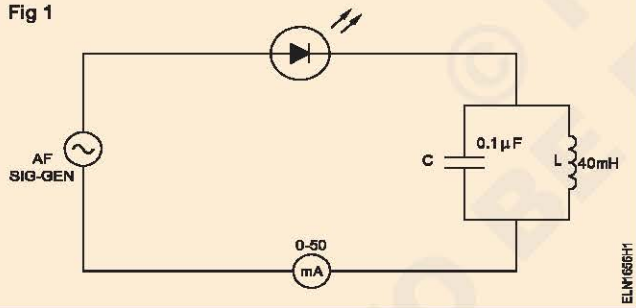
• General purpose Lug board	- 1 No.
• Capacitor 0.1 µF	- 1 No.
• Inductor coil, around 40mH	- 1 No.
(Use the solenoid coil made in unit 5)	- 1 No.
• LED with holder	- 1 No.
• Hook-up wires	- as reqd.

PROCEDURE

TASK 1: **Determine parallel resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple parallel resonance circuit. Connect the instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit for different frequencies.

2 Calculate and record the resonance frequency of the parallel resonance circuit from the value of L and C.

3 Set the output of the signal generator to $4V_{rms}$ and frequency to 1KHz in Table 1. Record the current, I through the circuit.

Ensure that the current through the circuit is around 10 to 12 mA and not more. If current flowing is more, reduce the output level of the signal generator. LED will glow at all frequencies except at the resonant frequency.

4 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes minimum (LED does not glow or glows very dimeter).

Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Current				

This is the resonance frequency of the parallel resonance circuit because at parallel resonance, current I through the parallel LC circuit will be minimum.

5 Compare and record the difference in the resonance frequency calculated in step 2 and that measured in step 4.

6 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

7 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC parallel circuit.

8 Get the working of the circuit, recorded readings and the graph checked by the instructor.

Measure power, energy for lagging and leading power factors in single phase circuits and compare the characteristics graphically

Objectives: At the end of this exercise you shall be able to
- **measure power and energy for lagging P.F.**
- **measure power and energy for leading P.F.**
- **draw a graph to compare lagging and leading P.F.**

Requirements

Tools and Instruments

- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V - 1 No.
- Wattmeter 250V/5A - 1 No.
- P.F. meter 250V/ 2A - 1 No.
- Variac 0-270/5A - 1 No.
- AC source 0-240V/5A - 1 No.
- Energy meter 5A 250 V - 1 No.
- Stop watch - 1 No.
- Lamp load 240 V/5A - 1KW - 1 No.

Materials

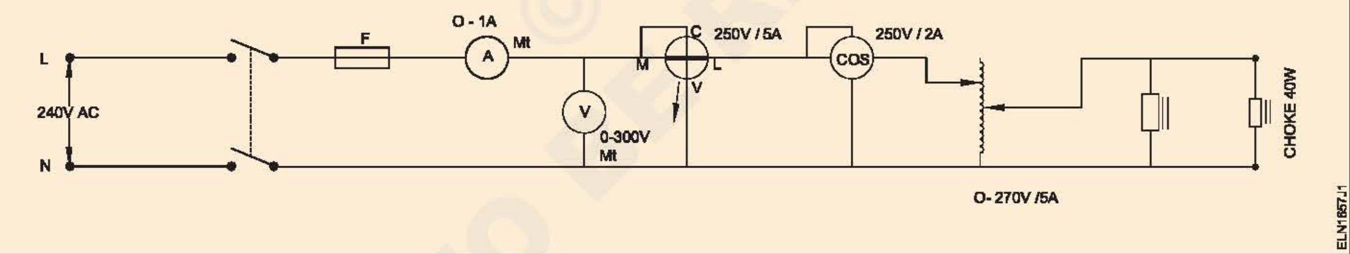
- Choke (T.L) 40W/250V - 2 Nos.
- Electrolytic capacitor, 2.5μFd/415V - 2 Nos.
- Connecting leads - as reqd.

PROCEDURE

TASK 1: **Measure the power for lagging P.F**

1 Assemble the circuit as shown in Fig 1.

Fig 1



2 Before giving supply disconnect one end of both the chokes and set the variac ouput voltage at 250V.

3 Switch 'ON' and note down the wattmeter and P.F. meter readings in Table 1.

4 Switch 'OFF' and connect one choke and record the readings (W and P.F.).

5 Switch 'OFF' and connect the second choke, record the readings in Table 1.

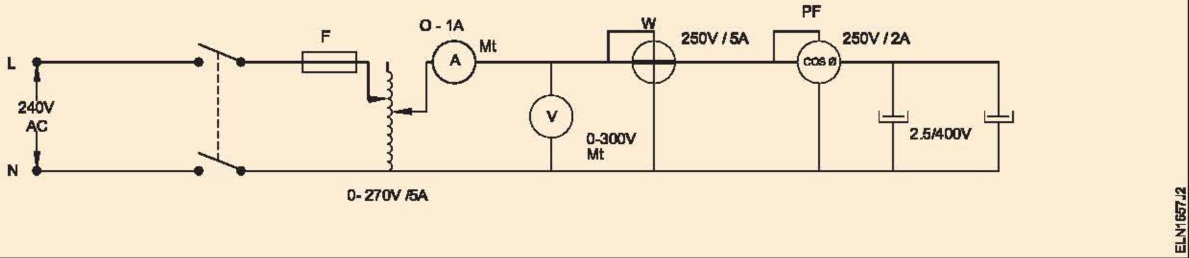
Table 1

S.No.	Voltage (V)	Current (I)	W (w)	PF +/- Lag/Lead	No. of Chokes
1					With one choke
2					With two chokes

TASK 2: **Measure the power for leading P.F.**

1 Switch 'OFF' and modify the circuit as shown in Fig 2.

Fig 2



2 Disconnect one end of both the capacitor and switch 'ON'. Record the W and P.F. reading in the Table 2.

3 Switch OFF and connect one capacitor and switch 'ON'. Record the W and P.F. reading in the Table 2.

4 Switch 'OFF' and connect second capacitor and switch 'ON'.

5 Record the W and P.F. reading in the Table 2.

Table 2

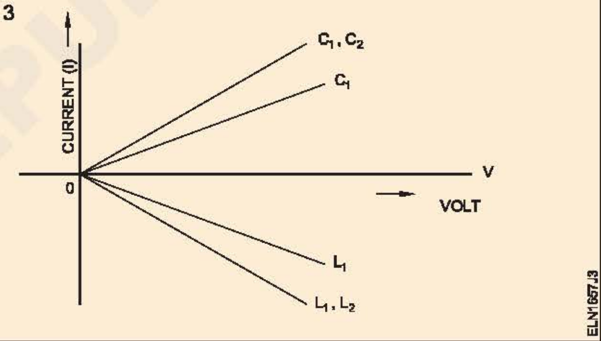
S.No.	Voltage V	Current I	W w	PF +/- lead/lag	Condition
1					With one capacitor
2					With two capacitor

6 Compile all the readings and plot a graph with volt to current for both leading and lagging PF.

Note: A sample graph is shown for reference. in Fig 3.

7 Get your work approved by the instructor.

Fig 3



TASK 3: **Measurement of energy with lagging and leading P.F.**

1 Identify the energy meter terminals - line and load, after removing the terminal cover.

Always mount the meter vertically.

2 Associate the circuit diagram (inside) with the terminal markings of the instrument.

3 Connect the energy meter terminals (line and load) in the circuit as shown in Fig 4.

4 Note the meter constant from the nameplate of the energy meter. (Fig 5)

5 Record the initial meter readings.

6 Switch ON the circuit with load.

7 Record the reading after 30 minutes in Table 3.

Fig 4

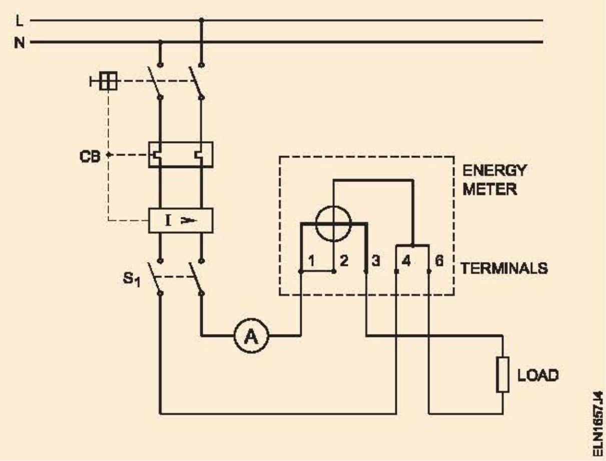


Fig 5

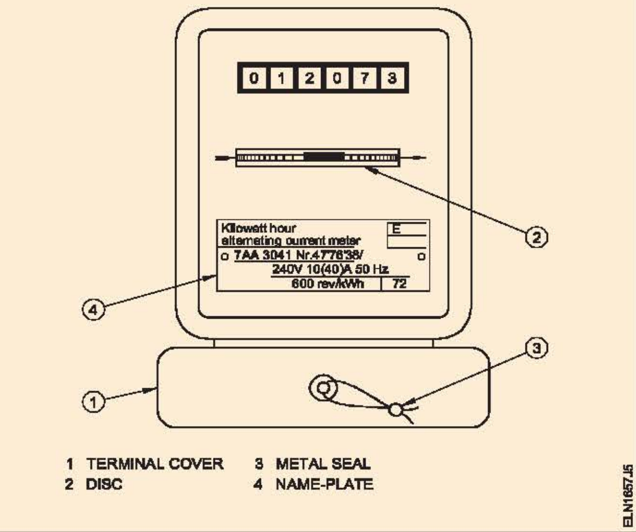


Table 3

Sl. No.	Volt (V)	Current (I)	Meter constant	Time (Secs)	Energy	
					Wh (Measured)	Wh (Calculated)

8 Connect the inductive load (Lagging power factor) and record the reading (Fig 6) in Table 4

9 Calculate the energy for lagging PF.

Fig 6

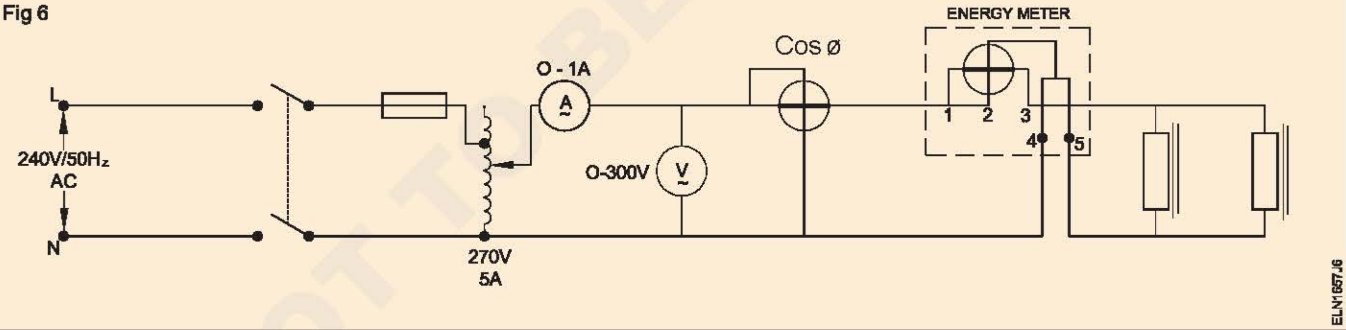


Table 4

Sl. No.	Volt (V)	Current (I)	W	Meter constant	Time (Secs)	Energy	
						Wh (Calculated)	Wh (Measured)

9 Switch Off the power and remove the inductive load.

10 Connect the capacitive, reactance (Fig 7) load and record the reading in Table 5.

Fig 7

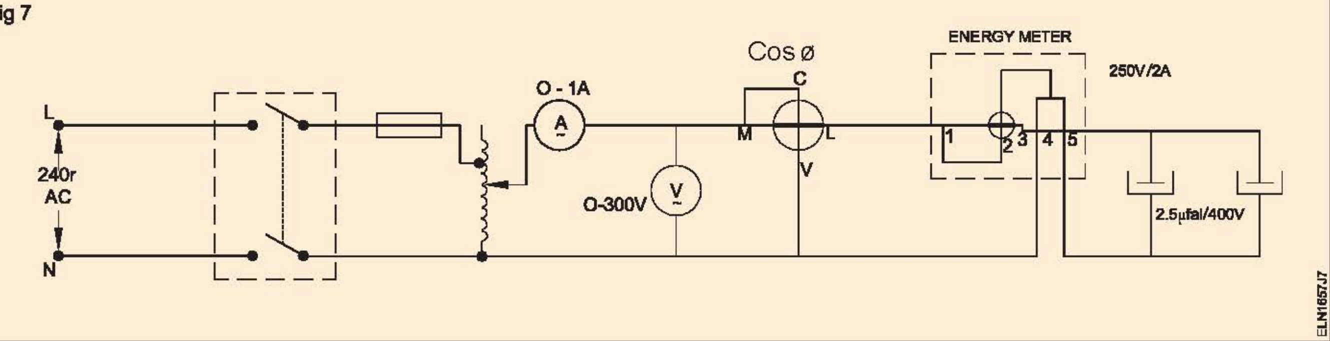


Table 5

Sl. No.	Volt (V)	Current (I)	W	Meter constant	Time (Secs)	Energy	
						Wh (Calculated)	Wh (Measured)

11 Calculate the energy for leading P.F. compile all the values and record the findings.

12 Plot the graph for lagging and leading P.F. for energy with respect to load current in the space provided

13 Get it checked by the instructor.

Result :

Space for Graph

Measure current, voltage, power, energy and power factor in 3 phase circuits

Objectives: At the end of this exercise, you shall be able to
- **connect voltmeter, ammeter, wattmeter and power factor meter and 3 phase energy meter in 3 phase circuits**
- **measure the voltage, current, power and power factor and 3 energy in 3 phase circuits with lamp load**
- **measure the voltage, current, power and P.F and energy in 3 phase circuits with inductive lead (Induction motor).**

Requirements

Tools and Instruments

- Insulated screw driver 200 mm - 1 No.
- Insulated cutting plier 150 mm - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- M.I Ammeter 0-5A/10A - 1 No.
- Wattmeter 250V/500V, 5A/10A - 1 No.
- Power Factor meter 415V/20A - 1 No.
- 3 phase 4 wire energy meter 415V/20A - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 50 Hz, 5 HP (3.75 KW) - 1 No.
- 3-phase lamp load 100 W - 6 Nos.

Materials

- PVC insulated copper cable 2.5 mm^2 650V grade TPIC 16A/500V - 20 m.
- 200 Watt/250V, lamps - 6 hrs.

PROCEDURE

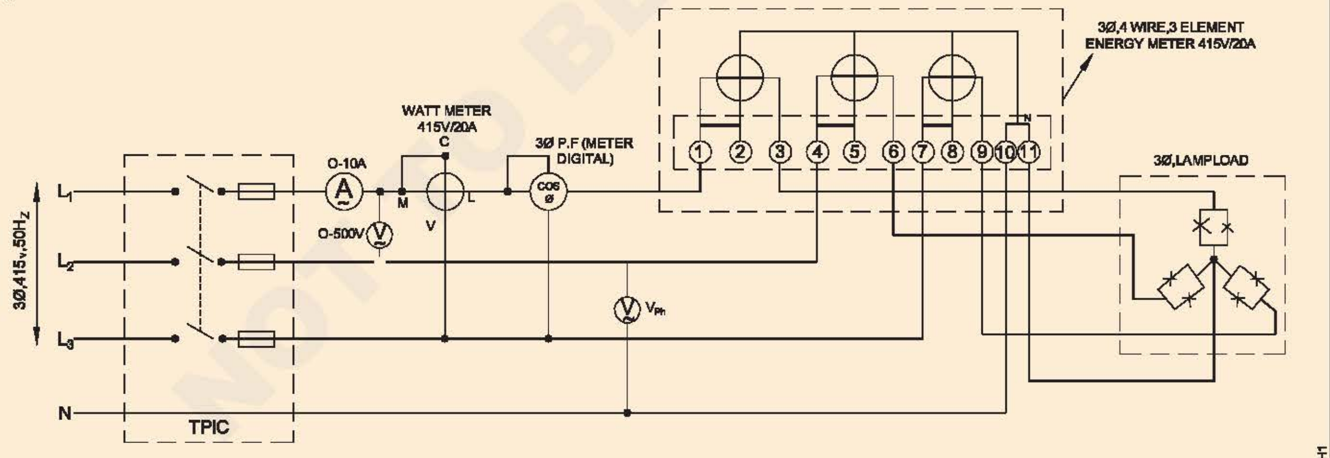
TASK 1: **Measure three phase current, voltage, power and power factor in 3 phase circuit with lamp load**

1 Select and collect the proper range of meters and lamp load for 3 phase circuit.

The lamp load should have equal wattage in all three phases

3 Switch 'ON' the power supply momentarily after getting the approval of the instructor and observe all the meter deflections. Keep the switch closed if nothing is abnormal.

Fig 1



CIRCUIT DIAGRAM FOR MEASURING OF VOLTAGE, CURRENT,POWER,ENERGY AND P.F IN 3 PHASE CIRCUIT

ELN1658H1

2 Make the connections of the meters and load as per the circuit diagram (Fig 1).

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

4 Note down the initial reading of the energy meter.

5 Note down the meter readings and enter in Table 1.

6 Keep the load in 'ON' position for at least 10 minutes and then note and record the final reading and calculate the energy consumption (i.e) F.R - I.R.

Table 1

Load	Line Voltage V_L	Phase Voltage V_{ph}	Line Current I_L	Phase Current I_{PH}	Power in Watt	Power factor	Initial reading in energy meter	Final reading after 10 min in energy meter F.R	Energy consumption F.R - I.R in KWh
Lamp load for 100W									
Lamp load for 200W									
3 ϕ Ind. meter load									

7 Swtich 'OFF' the power supply.

8 Replace the 100 Watt lamp with 200W lamp load.

9 Repeat steps 3 to 6 and record the readings in Table 1.

10 Switch 'OFF' power supply and disconnect the lamp load and connect 3 phase induction motor 3.75 KW/ 4.5V/50 Hz to the circuit.

11 Repeat steps 3 to 6 and record the readings in Table 1.

12 Get it checked by the instructor.

— — — — — — — —

Practice improvement of PF by use of capacitor in three phase circuit

Objectives: At the end of this exercise you shall be able to
- **connect 3 phase balanced inductive load and measure the P.F.**
- **connect 3 phase capacitor bank to inductive load and measure the P.F.**
- **calculate and record the improvement of P.F, after connecting the capacitor bank.**

Requirements

Tools and Instruments

- Insulated combination pliers 200 mm - 1 No.
- Insulated screwdriver 200 mm - 1 No.
- 3 ϕ P.F. meter 240V/440V ; - 1 No.
- Wattmeter 250/500 V, 5A/10A - 2 Nos.
- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- Power factor improving capacitor bank 3 phase 415V, 1.5 KVAR - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 2.25 KW (with loading arrangement) - 1 No.
- 3-phase lamp load 0-3KW - 1 No.

Materials

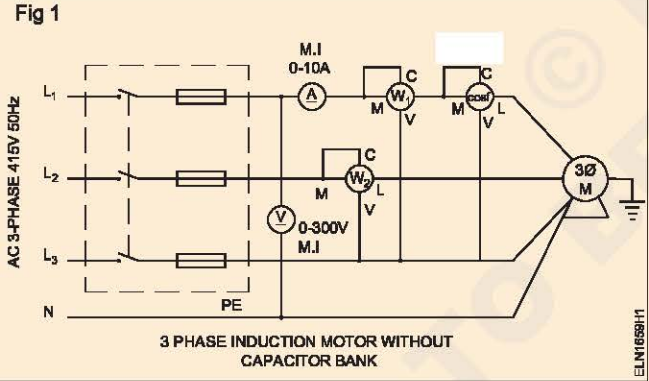
- PVC insulated copper cable 2.5 Sq, MM, 650V grade - 20 m.
- T.P.I.C.Switch 16A, 500V - 2 Nos.

PROCEDURE

TASK 1: **Connect 3 phase unbalanced inductive load and measure the P.F.**

1 Connect two Wattmeters P.F. meter, voltmeter and ammeter to 3 phase motor as shown in Fig 1.

Fig 1

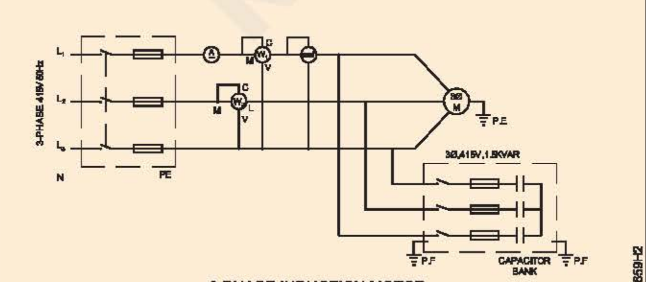


3 PHASE INDUCTION MOTOR WITHOUT CAPACITOR BANK

2 Get the connection checked by the instructor.

3 Switch 'ON' and load the motor to 60% of its load capacity and note the readings in Table 1.

Fig 2



3 PHASE INDUCTION MOTOR WITH CAPACITOR BANK

4 Switch OFF and connect the capacitor bank as shown in Fig 2.

5 Switch ON and adjust 60% of the load and verify the readings as in step 3. The readings will be same.

6 Switch ON the capacitor bank and record the readings in Table 1 for the load conditions.

7 Calculate the P.F. in each case using the following formula.

a) P.F. calculated 1 = cos φ = $= \frac{W_1 + W_2}{3E_{PH} I_{PH}}$

b) P.F. calculated 2 = Cos θ where the angle θ is derived from the formula $\tan\theta = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$

8 Enter the values in Table 1. Determine the percentage of error.

$$\%\,error = \frac{(\text{Calculated P.F.} - \text{Measured P.F.}) \times 100}{\text{Calculated P.F}}$$

Write your conclusion and reasons for if any.

9 Get it checked by your instructor.

Table 1

Condition	Ammeter reading I_{PH}	Voltmeter reading E_{PH}	3-phase apparent power in volt amperes $3 \times E_{PH} \times I_{PH}$	Wattmeter reading W_1 watts	Wattmeter reading W_2 watts	3-phase true power $W_1 + W_2$	P.F. Calculated 1 Cos φ (P.F) $= \frac{W_1 + W_2}{3E_{PH} I_{PH}}$	P.F. Calculated 2	P.F. measured	Percentage of error
Motor with load										
Motor with load and capacitor bank										

Conclusion:

After connecting the capacitor bank, the effect in value of P.F. is ____________________

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Ascertain use of neutral by identifying wires of a 3-phase 4 wire system and find the phase sequence using phase sequence meter

Objectives: At the end of this exercise, you shall be able to
- **test the phase wire and identify neutral with the use of test lamp**
- **identify, check and confirm the neutral wire with a meter**
- **connect and verify the phase sequence with 3-phase sequence meter.**

Requirements

Tools and Equipment

- Connector/Screw driver 100 mm - 1 No.
- Combination plier 150 mm - 1 No.
- Test lamp (40W/250V) - 2 Nos.
- Voltmeter 0-600V M.I. - 1 No.
- Phase sequence meter - 1 No.

Materials

- Connecting wires - as reqd.

PROCEDURE

TASK 1: **Test the phase line and identify the neutral with the use of test lamp**

1 Prepare a test lamp by connecting two lamps in series.

2 Mark the terminals as 1, 2, 3 and 4 and connect one lead of lamp to the marked 1 and other lead to the earth point provided in the frame as shown in Fig 1 and record the condition of lamp in Table 1.

Fig 1

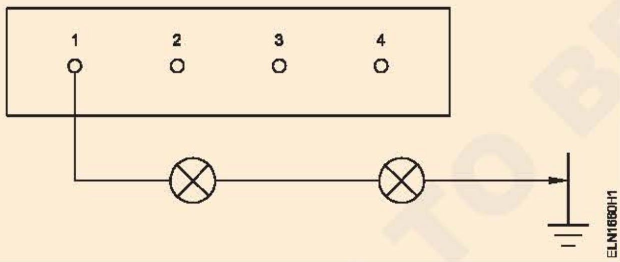


Table 1

Terminals	Glowing	Not glowing
1 to E		
2 to E		
3 to E		
4 to E		

3 Repeat the above step for other terminals 2, 3 and 4 and record the conditions in Table 1.

4 Mark the terminal where the lamp is not glowing as neutral. (N)

> **The three terminals at which the test lamp glows are the phase leads.**

5 Connect one lead, No:4 (Identified as N) and connect the other lead of test lamp to 1, 2, 3. (Fig 2). Record the glow condition of the lamp in Table 2.

Fig 2

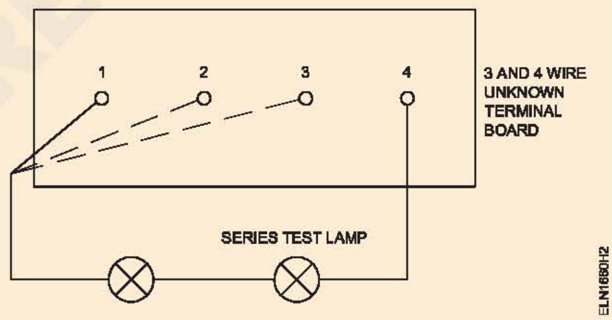


Table 2

Sl.No.	Terminals	Lamp condition	
		Glowing	Not glowing
1	4 - 1		
2	4 - 2		
3	4 - 3		
	1 - 2		
	1 - 3		
	2 - 3		

6 Refer to Table 2, mark the terminals where the lamp is glowing dim as neutral. If the lamp glows bright in the other three terminals i.e. 1-2, 1-3, 2-3 are phase terminal

7 Repeat steps 1 to 5 by replacing lamps in series by connecting the voltmeter (0-600v) and record the readings in Table 3 as shown in Fig 3.

Fig 3

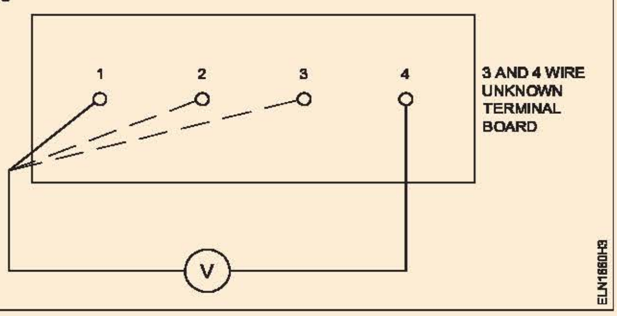


Table 3

Sl.No.	Test terminals	Voltage	
		High	Low
1	4 - 1		
2	4 - 2		
3	4 - 3		
4	1 - 2		
5	1 - 3		
6	2 - 3		

— — — — — — — —

TASK 2: **Identify the phase sequence in 3-phase 4 wire system by using phase sequence meter**

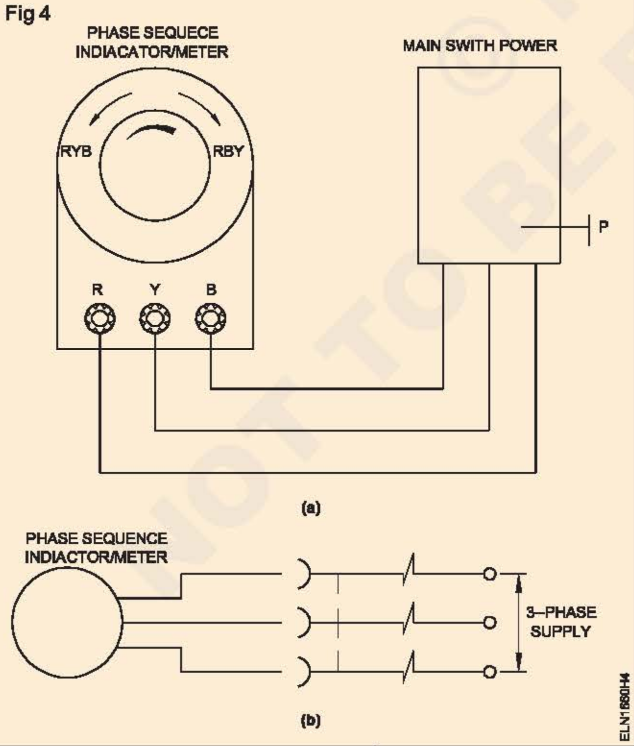
1 Read and record the marking of the phase sequence indicator direction: (Fig 4)

RYB Sequence } Arrow marking to be indicated
RBY Sequence }

Arrow in clockwise - ↱

Arrow in anti-clockwise - ↶

Fig 4



Rotation	Remarks
Same as arrow of the disc	
Opposite to the arrow of disc	

2 Switch 'OFF' the supply and connect the corresponding terminals (R, Y & B) to the phase sequence Indicator .

3 Mark leads as I, II, III. Connect them, such that I is connected to R, II to Y, III to B,

You can connect any lead (phase) to any terminal in the sequence indicator.

4 Switch 'ON' and observe the rotation of the disc and record the direction of rotation.

5 If the direction is anticlockwise switch 'OFF' the supply and interchange the terminals 1 and 2. Switch 'ON' and see that the rotation is reversed.

6 Mark the leads corresponding to the letters on the Phase Sequence Meter. (PSM)

If you connect any wire to any terminal, the disc will rotate anticlockwise if the RYB sequence is reversed, and it will be in the clockwise direction when RYB is connected in sequence.

7 Get it checked by your instructor.

— — — — — — — — —

Determine effect of broken neutral wire in three phase four wire system

Objectives: At the end of this exercise you shall be able to
- **check the effect of broken neutral wire in 3-phase 4 wire system.**

Requirements

Tools and Instruments

- Combination plier 150 mm - 1 No.
- Connector screw driver 150 mm - 3 Nos.
- Three phase test board with netural link - 1 No.
- Lamp 40/240 V - 3 Nos.
- M.I Voltmeter 0-600V - 1 No.
- M.I Ammeter 0-5A - 3 Nos.
- Line tester 500V/5A - 1 No.

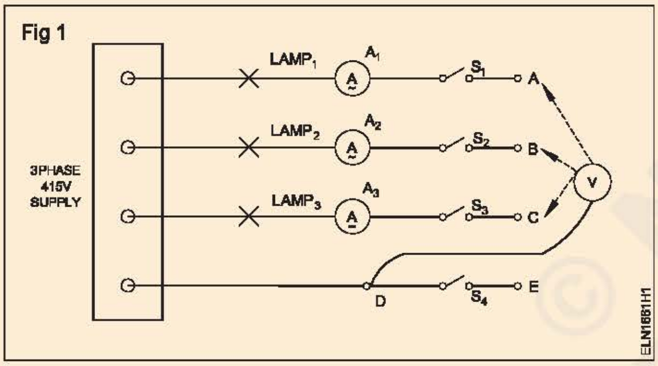
Materials

- Connecting wires -as reqd.
- ON-OFF switch - 4 Nos.

PROCEDURE

1 Connect the circuit as shown in Fig 1.

Fig 1



2 Switch 'OFF' all the switches S_1, S_2,S_3,S_4 and switch ON the 3-phase supply.

3 Check whether the lamps are glowing. Lamps do not glow

4 Switch 'OFF' 3-phase supply. Connect the terminal 'B to D', 'C to D' and 'A to E'

5 Switch 'ON' 3-phase supply. Switch 'ON' S_1, S_2, S_3. Switch 'OFF' S_4. Check if the lamps are glowing. Record all the readings in the Table 1. (L_1 will not glow L_2 and L_3 will glow - Step 2)

6. Switch 'OFF' 3-phase supply. Link 'B-E'. Follow the step 3 in Table - 1. Record the readings

7. Repeat the above step while linking 'C-E' (step 4 in Table 1). Record all the readings

It is evident that when neutral is broken the current does not flow So lamp will not glow, even though supply is available.

Table 1

S. No.	Switch position	A_1	A_2	A_3	V_1	V_2	V_3	Links	Links
1	S_1,S_2, S_3, S_4 OFF	0	0	0	0	0	0	–	–
2	S_1,S_2, S_3 ON S_4 OFF	0			0			A - E	B to D C to D
3	S_1,S_2, S_3 ON S_4 OFF		0			0		B - E	A to D C to D
4	S_1,S_2, S_3 ON S_4 OFF			0			0	C - E	A to D B to D

Determine the relationship between Line and Phase values for star and delta connections

Objectives: At the end of this exercise you shall be able to
- **verify the relationship between Line and Phase values in star connection**
- **verify the relationship between Line and Phase values in delta connection.**

Requirements

Tools/Instruments

- Screw driver 150 mm - 1 No.
- Combination plier 150 mm - 1 No.
- M.I Ammeter type 0-1 amp - 2 Nos.
- M.I Voltmeter type 0-500V - 2 Nos.
- ICTPN switch 16A 500V - 1 No.

Materials

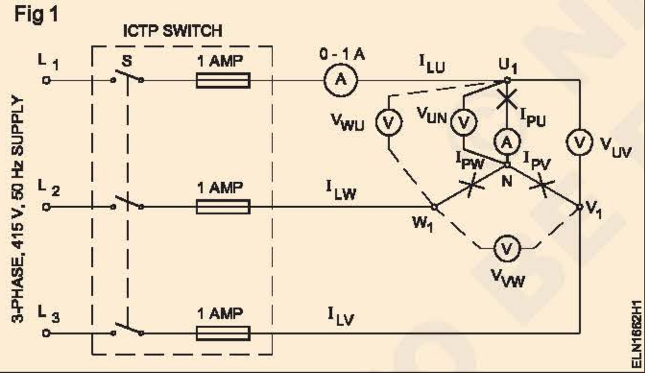
- Connecting leads - as reqd.
- Lamp BC - 40W 240V - 6 Nos.
- 100W 240V - 6 Nos.
- 200W 240V - 6 Nos.

PROCEDURE

TASK 1: **Verify the relationship between Line and Phase values in star connection of three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 1) with one lamp each connected to all the 3 phases (40/100/200 W).

Fig 1



2 Identify the 3-phase (L_1, L_2, L_3) and neutral (N) of supply terminals.

3 Switch 'ON' the 3-phase supply.

4 Measure the line voltage V_{UV} by placing the voltmeter leads between the two lines and enter the reading in Table 1.

5 Repeat for the other line voltages V_{VW}, V_{WU}.

6 Measure the phase voltages by placing the voltmeter leads between one line and star point N, and enter the readings in Table 1.

7 Measure the Line and Phase current and enter the readings in Table 1.

Switch 'OFF' supply before effecting any change in load.

8 Repeat steps 3 to 7 for different loads.

9 Calculate the ratio between the Line voltage and Phase voltage.

$$\frac{V_{UV}}{V_{UN}} =$$

$$\frac{V_{VW}}{V_{VN}} =$$

$$\frac{V_{WU}}{V_{WN}} =$$

10 Verify the ratio between Line current and Phase current, i.e.

$$\frac{I_{LU}}{I_{PU}} = \frac{I_{LV}}{I_{PV}} = \frac{I_{LW}}{I_{PW}} =$$

11 Get it checked by the instructor.

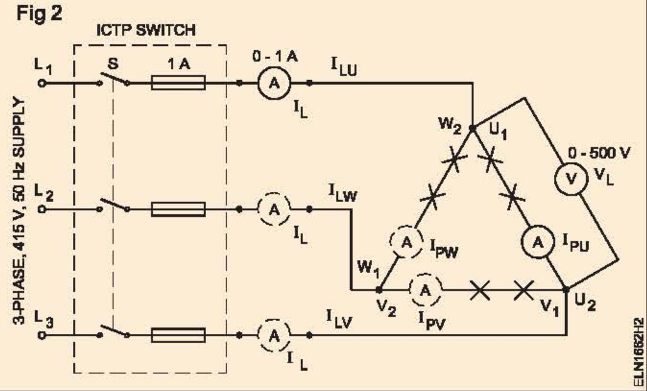
Table 1

Sl. No.	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{UV}	V_{VW}	V_{WU}	V_{UN}	V_{VN}	V_{WN}	I_U	I_V	I_W	I_{UN}	I_{VN}	I_{WN}
1	40W												
2	100W												
3	200W												

TASK 2: **Verify the relationship between Line and Phase values in delta connection in three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 2) Two lamp in series to be connected between two phases of same voltage.

Fig 2



2 Switch ON the 3-phase supply. Measure the line voltages by connecting the voltmeter leads between two of the terminals U_1, V_1, W_1.

3 Measure the phase voltage by placing the voltmeter leads across the lamps, i.e. U_1, U_2 or V_1, V_2 or W_1, W_2.

4 Record the Line voltages and Phase voltages measured, under the appropriate column in Table 2.

5 Measure the Line and Phase currents and enter the readings in Table 2.

An ammeter connected between supply and load indicates Line current. An ammeter connected in series with single load (two lamps in series) indicates Phase current.

6 Repeat steps 2 to 5 for different loads.

Switch off the supply before effecting any change in the load.

7 Verify the relationship between Line and Phase value of current and voltage. Enter in Table 3.

Result

In star : Line current and Phase current are ________

whereas Line voltage =________ x Phase voltage.

In delta :Line voltage and Phase voltages are ________

whereas Line current =________ x Phase current.

8 Get it checked by the instructor..

Table 2

Sl. No.	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{U1V1}	V_{V1W1}	V_{W1U1}	V_{U1U2}	V_{V1V2}	V_{W1W2}	I_U	I_V	I_W	I_{U1U2}	I_{V1V2}	I_{W1W2}
1	40W												
2	100W												
3	200W												

Table 3

Load	$\frac{V_{U_1V_1}}{V_{U_1U_2}}$	$\frac{V_{V_1W_1}}{V_{V_1V_2}}$	$\frac{V_{W_1U_1}}{V_{W_1W_2}}$	$\frac{I_{LU}}{I_{PU}}$	$\frac{I_{LV}}{I_{PV}}$	$\frac{I_{LW}}{I_{PW}}$
40W						
100W						
200W						

Measure the power of 3-phase circuit for balanced and unbalanced loads

Objectives: At the end of this exercise, you shall be able to
- **identify and connect the terminals of a single-phase Wattmeter**
- **connect single wattmeter in star, balanced load and measure the power**
- **connect two wattmeters in the circuit as per the given diagram**
- **connect two wattmeters in unbalanced, star-connected load and measure the power**
- **identify and connect 3-phase wattmeter and measure the power in star.**

Requirements

Tools/Instruments

- Single-phase wattmeter 250V/5A - 1 No.
- Wattmeter 500V/5A - 2 Nos.
- PF meter, single phase 250V,5A - 1 No.
- Voltmeter 0-500 V M.I. - 1 No.
- Ammeter 0-5A M.I. - 1 No.

Equipment/Machines

- 3-phase, 415V AC induction motor
  3 HP coupled with DC generator - 1 No.

Materials

- 200W, 250V lamps - 3 Nos.
- 100W, 250V lamps - 3 Nos.
- Capacitor 400V AC 4 MFD - 2 Nos.
- Connecting leads - as reqd.
- Pendent-holders 6A 250V - 6 Nos.

PROCEDURE

TASK 1: **Connect balanced load in star and measure the power with one single element Wattmeter**

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

Connect proper voltage and current ranges of Wattmeters suitable to the given load.

2 Switch ON the 3-phase supply and read the wattmeter and record the wattmeter readings in Table 1.

3 Measure the power in the other two phases by connecting the wattmeter in turns and record the redings.

4 Total the readings of the wattmeters and check its confirmity with the calculated total power.

5 Repeat steps 1 to 4 for different load conditions.

Fig 1

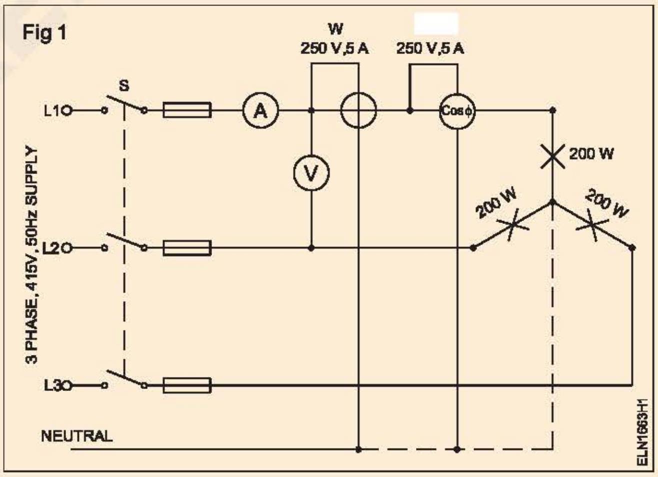


Table 1

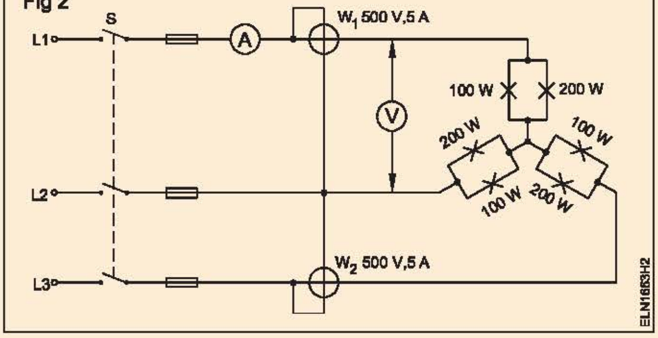
Type of Load	Wattmeter connected in the line						Calculated Total power	Total power = Total of three wattmeter readings
	W_{L1}	W_{L2}	W_{L3}	V_L	I_L	P.F	$W = \sqrt{3}\, V_L I_L \cos\theta$	$W_{L1} + W_{L2} + W_{L3} = W$
1								
2								
3								
4								

TASk 2: **Power measurement by two-wattmeter method in 3-phase unbalanced load**

1 Form the circuit as per the given circuit diagram. (Fig 2)

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

Fig 2



2 Switch 'ON' the 3-phase supply and check whether the deflection of wattmeter is correct. 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 the wattmeters W_1 and W_2 and record in Table 2. 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 and W_2. Record the values in the Table. 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 = 100 W bulb parallel 4 MFD capacitor

L_3 = 200 W bulb

b) Water load to take a current maximum of 3 amps.

c) Induction motor 3 HP on no load

d) Induction motor 3 HP with load

> **The instructor may connect the three-phase motor to ensure it is running properly.**

7 Calculate the power factor in all the above cases and enter them in Table 2.

8 Get it checked by the instructor.

Table 2

Type of Load	Wattmeter W_1	Wattmeter W_2	Total $W_1 + W_2$	Calculated Power factor Cos θ $\tan\theta = \sqrt{3}\dfrac{W_1 - W_2}{W_1 + W_2}$ Determine Cos θ
1				
2				
3				
4				
5				

Conclusion : ____

— — — — — — — —

Measure current and voltage of two phases in case of one phase is short-circuited in three phase four wire system and compare with healthy system

Objectives: At the end of this exercise, you shall be able to
- **connect and test the circuit**
- **measure the current and voltage in healthy conditions**
- **check the condition of the two phase, when one phase is overloaded/short-circuited**
- **record the current and voltage in both conditions.**

Requirements

Tools/Instruments

- M.I Ammeter 0-10A - 2 Nos.
- M.I Ammeter 0-20A - 1No.
- M.I Voltmeter 0-300V - 3 Nos.
- Load 1500W/ 240V - 4 Nos.
- 3 Phase supply board 3φ, 4 wire - 1 No.

Materials

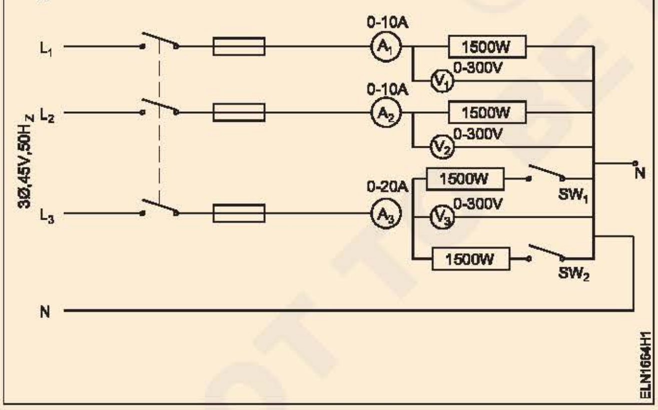
- S.P. switch 240V/16A - 2 Nos.
- Connecting wires - as reqd.
- TPIC - 415V/16A - 1 No.

PROCEDURE

We cannot manually make a short circuit in the phase line as it is dangerous and it may trip the circuit. In order to make a short circuit condition load current is doubled in one phase.

1 Connect the circuit as per the diagram shown in Fig 1.

Fig 1



2 Switch 'ON' the 3 Phase supply and ON the switch SW_1. Record the current and voltage the tabular column.

3 Switch 'OFF' the 3 Phase in supply and SW_2 switch 'ON'.

4 Switch 'ON' the 3 Phase supply and record the readings of the current and voltage in the tabular column.

5 Switch 'OFF' all the supply lines, and disconnect the wiring and return all the materials and equipment.

6 Get it checked by the instructor.

Conclusion : ______________________________

Table 1

Sl.No.	SW_1 - ON	SW_1 - ON & SW_2 ON			
1	A_1 V_1	A_1		V_1	
2	A_2 V_2	A_2		V_2	
3	A_3 V_3	A_3		V_3	