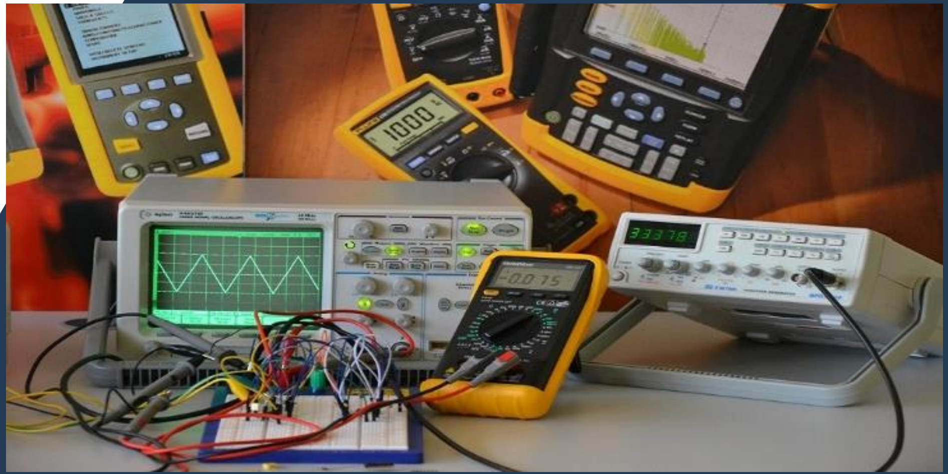
University of Global Village (UGV), Barishal

Electrical Circuits-II (Sessional)

Content of Laboratory Course



Prepared By

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University of Global Village (UGV)

BASIC COURSE INFORMATION

Course Title	Electrical Circuits-II Sessional
Course Code	EEE 0713-1204
Credits	01
CIE Marks	30
SEE Marks	20
Exam Hours	2 hours (Semester Final Exam)
Level	2nd Semester

Course Code: EEE 0713-1204 **Credits: 01**
Course Type: Sessional Course **CIE Marks: 30**
Exam Hours: 2 **SEE Marks: 20**

Course Learning Outcomes: at the end of this Course, the student will be able to -

CLO1	Demonstrate the characteristics of three phase system and transient response of RC and RL circuits.
CLO2	Apply resonance condition and find out the inductance and capacitance
CLO3	Investigate the phase sequence for a balanced and unbalanced system.
CLO4	Design of project and present it.

SL	Content of Course	Hrs	CLOs
1	Familiarization with equipment and observing different types of signals using oscilloscope and function generator in the Electrical circuit-II Lab.	5	CLO1
2	Draw the vector diagram of the RL-RC parallel circuit and verify Kirchhoff's current law (KCL) for AC circuits.	5	CLO1
3	Determine the value of an unknown resistance, capacitance, and inductance by measuring voltage current and power from the RLC series circuit.	10	CLO2
4	Observation of the resonance effect on RLC series circuits by varying frequency of the supply voltage	10	CLO2
5	Determination of the mutual inductance and equivalent impedance of a transformer	10	CLO2
6	Determination of the relationship between line voltage, phase voltage and line current in a balanced (У and Δ) system.	10	CLO1
7	Determination of the phase voltage of a three-phase unbalanced load.	10	CLO3
8	Measurement of 3-Φ Power & Power Factor by Two Wattmeter Method	10	CLO3
9	Power Factor Improvement using Capacitor Bank.	7	CLO4
10	Observation of the transient condition and find out the time constant in RC series circuit.	8	CLO1

Recommended Books:	
Introductory Circuit Analysis," 10th Edition	Robbert L. Boylestad
Fundamentals of Electric Circuits," 5th Edition	Charles K. Alexander and Mathew N.O. Sadiku
Electric Circuits," 7th Edition	J.W. Nilsson and S. Riedel

ASSESSMENT PATTERN	
CIE	**- Continuous Internal Evaluation (30 Marks)**
SEE-	**Semester End Examination (20 Marks)**
SEE-	**Semester End Examination (60 Marks) (should be converted in actual marks (20))**
Bloom's Category	**Tests**
Remember	**05**
Understand	**07**
Apply	**08**
Analyze	**07**
Evaluate	**08**
Create	**05**

CIE- Continuous Internal Evaluation (60 Marks) (should be converted in actual marks (30))

Bloom's Category Marks (out of 60)	Lab Final (30)	Lab Report (10)	Continuous lab performance (10)	Presentation & Viva (10)	External Participation in Curricular/Co-Curricular Activities (10)
Remember	05			02	Attendance 10
Understand	05	05	02	03	
Apply	05		02		
Analyze	05		02		
Evaluate	05	05	02		
Create				05	

Couse plan specifying content, CLOs, teaching learning and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Assessment Strategy	Corresponding CLOs
1	Familiarization with equipment and observing different types of signals using oscilloscope and function generator in the Electrical circuit-II Lab.	Lecture, discussion, Experiment	Quiz, Lab Test	CLO1
2-3	Draw the vector diagram of the RL-RC parallel circuit and verify Kirchhoff's current law (KCL) for AC circuits.	Oral Presentation, Project Exhibition	Lab Report Assessment, viva	CLO1
4-5	Determine the value of an unknown resistance, capacitance, and inductance by measuring voltage current and power from the RLC series circuit.	Presentation, Field visit	Skill Development Test	CLO2
6-7	Observation of the resonance effect on RLC series circuits by varying frequency of the supply voltage	Lecture, discussion, Experiment, Demonstration	Quiz, Lab Test	CLO2
8-9	Determination of the mutual inductance and equivalent impedance of a transformer	Oral Presentation, Project Exhibition	Lab Report Assessment, viva	CLO2
10-11	Determination of the relationship between line voltage, phase voltage and line current in a balanced (У and Δ) system.	Presentation, Field visit	Skill Development Test	CLO1
12-14	Determination of the phase voltage of a three-phase unbalanced load.	Lecture, discussion, Experiment	Quiz, Lab Test	CLO3

15	Measurement of 3-Φ Power & Power Factor by Two Wattmeter Method	Presentation, Field visit	Skill Development Test	CLO3
16	Power Factor Improvement using Capacitor Bank.	Lecture, discussion, Experiment	Quiz, Lab Test	CLO4
17	Observation of the transient condition and find out the time constant in RC series circuit.	Presentation, Field visit	Skill Development Test	CLO1

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Electrical Circuits-II (Sessional)

Preface

The *Electrical Circuit-II Sessional Lab Manual* has been meticulously developed to complement the theoretical knowledge acquired in the *Electrical Circuit-II* course. This manual serves as a practical guide for students to deepen their understanding of advanced circuit analysis and design principles, bridging the gap between theory and hands-on application.

The experiments included in this manual are designed to explore critical topics such as AC circuit analysis, resonance in RLC circuits, three-phase power systems, network theorems, transient responses in circuits, and the behavior of coupled inductors. By performing these experiments, students will gain insights into the functioning of electrical components, circuit behavior under various conditions, and the techniques required for effective circuit design and troubleshooting.

This lab manual emphasizes skill development in areas such as operating sophisticated electrical instruments (e.g., oscilloscopes, function generators, and multimeters), interpreting experimental data, and analyzing the results to draw meaningful conclusions. The *Electrical Circuit-II Sessional* course is a cornerstone of the Electrical and Electronics Engineering (EEE) curriculum. It prepares students for advanced studies in electrical engineering and equips them with the practical expertise required in modern engineering practices. The manual also emphasizes professional report writing, enabling students to document their findings clearly and concisely.

The authors would like to express their heartfelt gratitude to their colleagues for their invaluable contributions and support in preparing this manual. Inspiration and reference materials were drawn from renowned textbooks and resources, while diagrams and illustrations were curated from credible sources to enhance the clarity of the experiments.

It is our sincere hope that this manual will be a valuable asset for students, fostering a deeper understanding of electrical circuits and inspiring their journey toward becoming skilled engineers.

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ELECTRICAL CIRCUIT II

Laboratory Manual

Week 1

Experiment no.	**Name of Experiment**
01.	Familiarization with equipment and observing different types of signals using oscilloscope and function generator in the Electrical circuit-II Lab.
02.	Draw the vector diagram of the RL-RC parallel circuit and verify Kirchhoff's current law (KCL) for AC circuits.
03.	Determine the value of an unknown resistance, capacitance, inductance by measuring voltage current and power from the RLC series circuit.
04.	Observation of the resonance effect on RLC series circuits by varying frequency of the supply voltage.
05.	Determination of the mutual inductance and equivalent impedance of a transformer
06.	Determination of the relationship between line voltage, phase voltage and line current in a balanced (У and Δ) system.
07.	Determination of the phase voltage of a three-phase unbalanced load.
08.	Measurement of 3-Φ Power & Power Factor by Two Wattmeter Method.
09.	Power Factor Improvement using Capacitor Bank.
10.	Observation of the transient condition and find out the time constant in RC series circuit.

Experiment No: 1

Name of the experiment: Familiarization with equipment and observing different types of signals using oscilloscope and function generator in the Electrical circuit-II Lab.

Objectives:

1. To demonstrate the lab equipments and safety.
2. To of observe different types of alternating voltage in function generator
3. To observe a complex wave by using a function generator.

Name of Equipments:

1	Transformer	
2	Resistor	
3	Capacitor	
4	Inductor	
5	DC Power supply	
6	Variac	
6	Function Generator	
7	Oscilloscope	
8	Digital Multimeter	
9	AC voltmeter	
10	AC ammeter	
11	Wattmeter	

Procedures:

1) Firstly, Familiarize various Electrical circuit II lab equipment with proper explanation.

2) Secondly, Connect the function generator and generate sine waves and then connect it to the oscilloscope.
3) After that, from the oscilloscope observe waveshapes (sine wave, rectangular wave and triangular).
4) Connect Three function generator and observe a complex wave by following equation and draw waveshape from oscilloscope

$$V = 100\sin(\omega t) + 10\sin(2\omega t) + \sin(3\omega t)$$

Experimental Table:

For Sine wave:

No	Given frequency (Hz)	V_m(pk-pk) (V)	VPD (V)	T(P-P)	TPD (mS)	T(s)	f=1/T (Hz)

For Rectangular wave:

No	Given frequency (Hz)	V_m(pk-pk) (V)	VPD (V)	T(P-P)	TPD (mS)	T(s)	f=1/T (Hz)

For Triangular wave:

No	Given frequency (Hz)	V_m(pk-pk) (V)	VPD (V)	T(P-P)	TPD (mS)	T(s)	f=1/T (Hz)

Here, *VPD= Volt per division and *TPD= Time per division

Questions:

1. What are the differences between alternating current waveforms?
2. What causes a complex waveform?
3. What is the frequency of a complex?

Discussion:

Week 2-3

Experiment : 02

Name of the experiment: Draw the vector diagram of the RL-RC parallel circuit and verify Kirchhoff's current law (KCL).

Objectives:

1) To draw the vector diagram of RL-RC parallel circuit series circuit
2) To verify Kirchhoff's current law (KCL).

Required Equipments:

1	Variac	1
2	A.C Ammeter	2
3	Rheostat	1
4	Capacitor	1
5	Inductor	1

Theory:

In a parallel RLC circuit containing a resistor, an inductor and a capacitor the circuit current IS is the phasor sum made up of three components, IR, IL and IC with the supply voltage common to all three. Since the supply voltage is common to all three components it is used as the horizontal reference when constructing a current triangle. Parallel RLC networks can be analyzed using vector diagrams just the same as with series RLC circuits. However, the analysis of parallel RLC circuits is a little more mathematically difficult than for series RLC circuits when it contains two or more current branches. So an AC parallel circuit can be easily analyzed using the reciprocal of impedance called Admittance.

Table 1

Series Circuit	Parallel Circuit
Voltage, (V)	Current, (I)
Resistance, (R)	Conductance, (G)
Reactance, (X)	Susceptance, (B)
Impedance, (Z)	Admittance, (Y)

The real part is the reciprocal of resistance and is called Conductance, symbol Y while the imaginary part is the reciprocal of reactance and is called Susceptance, symbol B and expressed in complex form as: Y = G + jB with the duality between the two complex impedances being defined as table 1. As susceptance is the reciprocal of reactance, in an inductive circuit, inductive susceptance, BL will be negative in value and in a capacitive circuit, capacitive susceptance, BC will be positive in value.

Circuit Diagram:

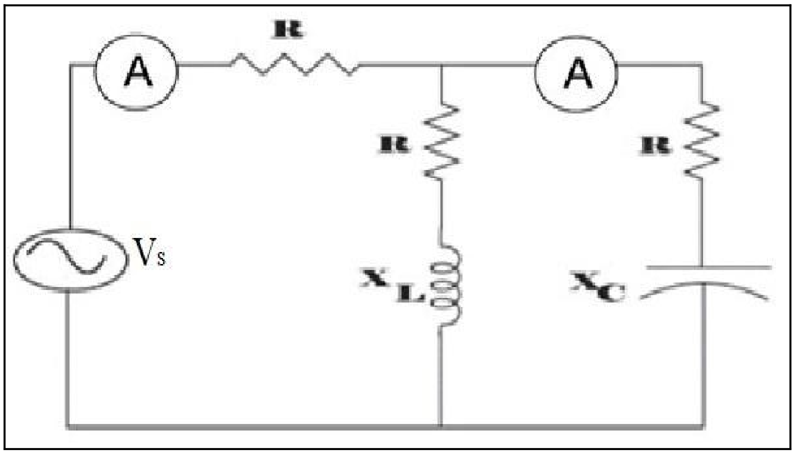


Figure 3: R-L and R-C parallel circuit

Procedure:

1. Connect the equipment's according to the figure 3
2. Fixed the supply voltage and record the ammeter reading & voltmeter reading
3. Put all the data in the table for different supply voltage
4. Then Calculate p.f. for all the data and draw the vector diagram for each reading.

Experimental Data Table:

Obs. No	Vs (V)	I (A)	I_2 (A)	V_R (V)	V_{RL} (V)	V_{XL} (V)	V_{RC} (V)	V_{XC} (V)	Power factor of R-L network portion	Power factor of R-C network portion	Overall Power factor (p.f)
1											
2											
3											
4											
5											

Calculation:

Calculate current through the R-L branch, $I_1 = I - I_2$ for every observation

Vector Diagram:

Questions:

1. How do you solve a parallel RC circuit?
2. Can an RC circuit be in parallel?

Discussion:

Week 4-5

Experiment :03

Name of the experiment: Determine the value of an unknown resistance, capacitance, inductance by measuring voltage current and power from RLC series circuit.

Objective: To find the value of an unknown resistance, capacitance, and inductance by using voltmeter, ammeter, and wattmeter.

Required Equipments:

1	Variac	1
2	A.C Ammeter	1
3	Resistor	1
4	Capacitor	1
5	Inductor	1
6	Wattmeter	1

Theory:

Individual Voltage Vectors,

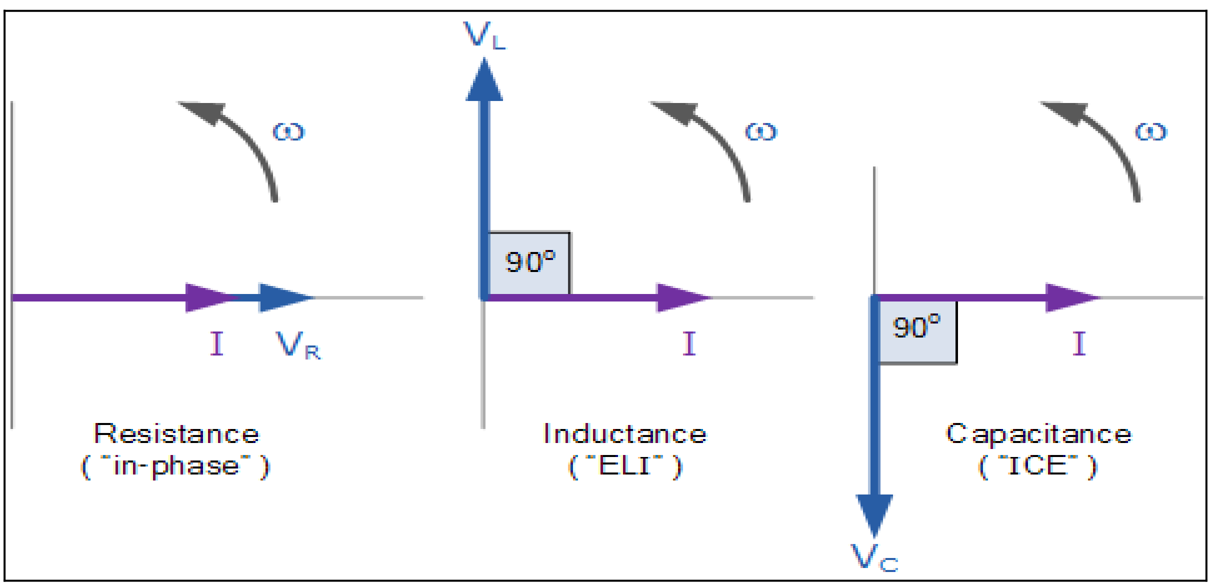


Figure 4: Phasor diagram for Resistance, inductance, and capacitance

Instantaneous Voltages for a Series RLC Circuit

$$\text{KVL:} \quad V_S - V_R - V_L - V_C = 0$$

$$V_S - IR - L\frac{di}{dt} - \frac{Q}{C} = 0$$

$$\therefore V_S = IR + L\frac{di}{dt} + \frac{Q}{C}$$

The phasor diagram for a series RLC circuit is produced by combining together the three individual phasors above and adding these voltages vectorially. Since the current flowing through the circuit is common to all three circuit elements, we can use this as the reference vector with the three voltage vectors drawn relative to this at their corresponding angles. The resulting vector V_S is obtained by adding together two of the vectors, V_L and V_C and then adding this sum to the remaining vector V_R. The resulting angle obtained between VS and i will be the circuits phase angle as shown below.

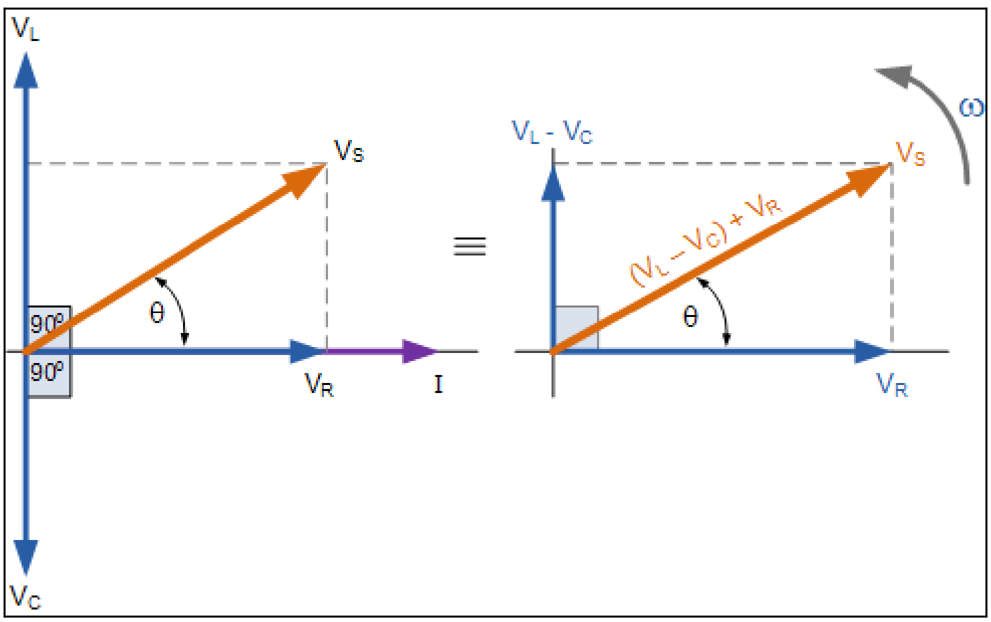


Figure 5: Phasor Diagram for a Series RLC Circuit

Voltage Triangle for a Series RLC Circuit,

$$V_S^2 = V_R^2 + (V_L - V_C)^2$$

$$V_S = \sqrt{V_R^2 + (V_L - V_C)^2}$$

The voltage across each component can also be described mathematically according to the current flowing through, and the voltage across each element as.

$$V_R = iR\sin(\omega t + 0^0) = i.R$$

$$V_L = iX_L\sin(\omega t + 90^0) = i.j\omega L$$

$$V_C = iX_C\sin(\omega t - 90^0) = i.\frac{1}{j\omega C}$$

By substituting these values into the Pythagoras equation above for the voltage triangle will give us:

$$V_R = I.R \qquad V_L = I.X_L \qquad V_C = I.X_C$$

$$V_S = \sqrt{(I.R)^2 + (I.X_L - I.X_C)^2}$$

$$V_S = I.\sqrt{R^2 + (X_L - X_C)^2}$$

$$\therefore V_S = I \times Z \qquad \text{where: } Z = \sqrt{R^2 + \left(X_L - X_C\right)^2}$$

The Impedance of a Series RLC Circuit:

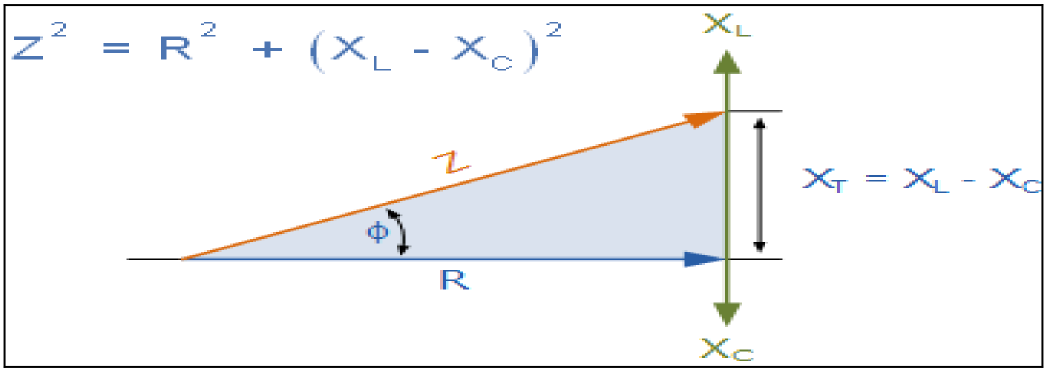


Figure 6: The Impedance Triangle for a Series RLC Circuit

$$\text{Impedance, } Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

The phase angle, θ between the source voltage, VS and the current, i is the same as for the angle between Z and R in the impedance triangle. This phase angle may be positive or negative in value depending on whether the source voltage leads or lags the circuit current and can be calculated mathematically from the ohmic values of the impedance triangle as:

$$\cos\phi = \frac{R}{Z} \qquad \sin\phi = \frac{X_L - X_C}{Z} \qquad \tan\phi = \frac{X_L - X_C}{R}$$

Circuit Diagram:

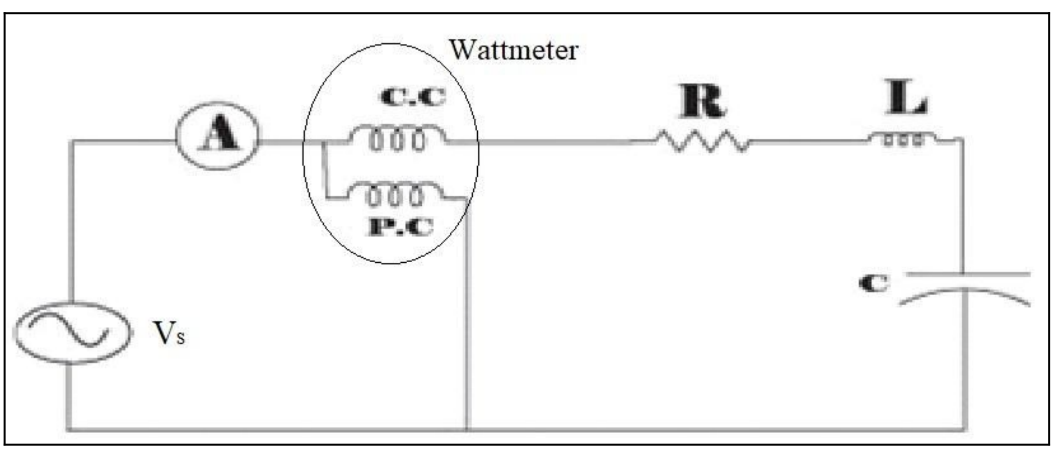


Figure 7: RLC series circuit with ammeter, voltmeter and wattmeter

Procedure:

1. Connect the equipments according to figure 7.
2. Fixed the supply voltage and record the ammeter reading & voltage meter reading
3. Record the the wattmeter reading
4. Put all the data in the table for different supply voltage
5. Then Calculate the values of resistor (R), inductor (L), capacitor (C) from the recorded data.

Experimental Data Table:

No	Vs (V)	I (A)	W (watt)	Power factor (P.f)	V_R (V)	V_{XL} (V)	V_{XC} (V)	R (Ω)	X_L (Ω)	X_C (Ω)
1										
2										
3										
4										

Calculation:

Questions:

1. How do you calculate power in an RLC circuit?
2. How do you find the power factor of a series circuit?

Discussion:

Week 6-7

Name of the experiment: Observation of the resonance effect on RLC series circuit by varying frequency of the supply voltage.

Objective: To observe the resonance effect on RLC series circuit.

Equipment's:

1	A.C Ammeter	1
2	Digital Multimeter	1
3	Rheostat	1
4	Capacitor	1
5	Inductor	1
6	Function Generator	1

Theory:

Resonance in AC circuits implies a special frequency determined by the values of the resistance , capacitance , and inductance . For series resonance the condition of resonance is straightforward, and it is characterized by minimum impedance and zero phase.

The resonance of a series RLC circuit occurs when the inductive and capacitive reactances are equal in magnitude but cancel each other because they are 180 degrees apart in phase. The sharp minimum in impedance which occurs is useful in tuning applications. The sharpness of the minimum depends on the value of R and is characterized by the "Q" of the circuit.

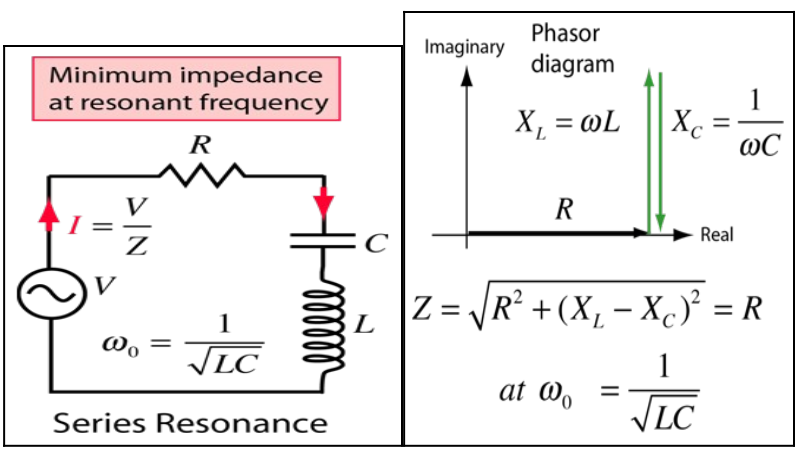


Figure 8: Resonance of RLC series circuit

Resonance occurred when

$X_L = X_C$

Then resonance frequency becomes

$$f_{0=¿¿}\ \frac{1}{2\pi\sqrt{\square}}$$

Circuit Diagram:

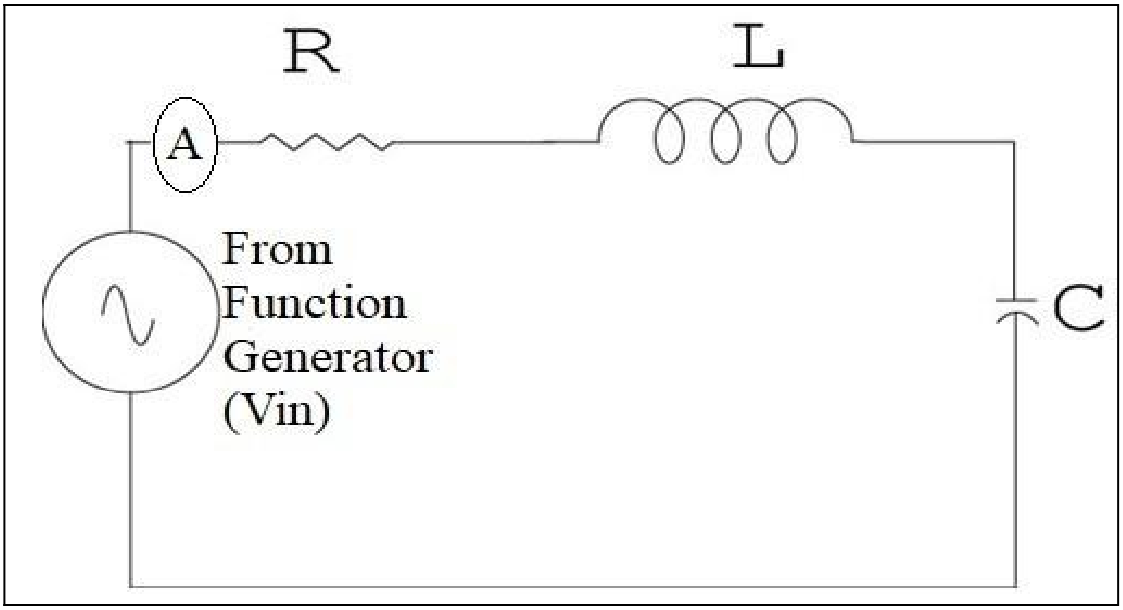


Figure 9: RLC series circuit with ammeter, voltmeter and wattmeter

Procedure:

1. Connect the circuit according to the figure 9
2. Calculate circuit resonance frequency (f_0) using $X_L = X_C$
3. Vary the frequency of supply voltage and record the values of I, V_R, V_L and V_c before resonance frequency (f_0) occurred.
4. Record the values of I, V_R, V_L and V_C at resonance frequency (f_0).
5. Vary the frequency of supply voltage and record the values of I, V_R, V_L and V_c after resonance frequency (f_0) occurred.
6. Draw the resonance curve by using the values from experimental data table.

Experimental Data table:

Obs. No	Frequency, f (Hz)	V_{in} (V)	I (A)	V_R (V)	V_L (V)	V_C (V)
1						
2						
3						
4						

Calculation:

Calculate the resonance frequency, $f_{0=\text{¿¿}}\frac{1}{2\pi\sqrt{\square}}$

Graph:

Draw the resonance curve for RLC series circuit

Questions:

1. What is RLC series resonance?
2. What happens in resonance in RLC circuit?

Discussion:

Experiment No. 05

Week 8-9

Name of the experiment: Determination of the mutual inductance and equivalent impedance

Objective: To Determine the mutual inductance and equivalent impedance

Required Equipments:

1	Variac	1
2	A.C Ammeter	1
3.	Transformer	1

Theory:

Mutual Inductance between the two coils is defined as the property of the coil due to which it opposes the change of current in the other coil, or you can say in the neighboring coil. When the current in the neighboring coil changes, the flux sets up in the coil and because of this, changing flux emf is induced in the coil called Mutually Induced emf and the phenomenon is known as Mutual Inductance. Determining the Mutual Inductance between the two coils, the following expression is used

$$e_m = M\frac{dI_1}{dt}$$

or

$$M = \frac{e_m}{dI_1/dt} \ldots\ldots\ldots(1)$$

This expression is used when the magnitude of mutually induced emf in the coil and the rate of change of current in the neighbouring coil is known. Mutual inductance can also be expressed in another way as shown below

$$e_m = M\frac{dI_1}{dt} = \frac{d}{dt}(MI_1) \ldots\ldots (2) \text{ also}$$

$$e_m = N_2\frac{d\varphi_{12}}{dt} = \frac{d}{dt}(N_2\varphi_{12}) \ldots\ldots\ldots(3)$$

Equating equation (2) and (3) you will get

$$MI_1 = N_2\varphi_{12} \text{ Or } M = \frac{N_2\varphi_{12}}{I_1} \text{ Henry}$$

The above expression is used when the flux linkage ($N_2\varphi_{12}$) of one coil due to the current (I_1) flowing through the other coil are known. The value of Mutual Inductance (M) depends upon the following factors

- Number of turns in the secondary or neighboring coil
- Cross-sectional area
- Closeness of the two coils

Mutual Coupling in the Magnetic Circuit:

When on a magnetic core, two or more than two coils are wound, the coils are said to be mutually coupled. The current, when passed in any of the coils wound around the magnetic core, produces flux which links all the coils together and also the one in which current is passed. Hence, there will be both self-induced emf and mutual induced emf in each of the coils. The best example of the mutual inductance is the transformer, which works on the principle of Faraday's Law of Electromagnetic Induction. Faraday's law of electromagnetic induction states that "the magnitude of voltage is directly proportional to the rate of change of flux." which is explained in the topic Faraday's Law of Electromagnetic Induction.

Procedure:

Part A:
Connect the circuit according to figure 10-a and take reading of following table .

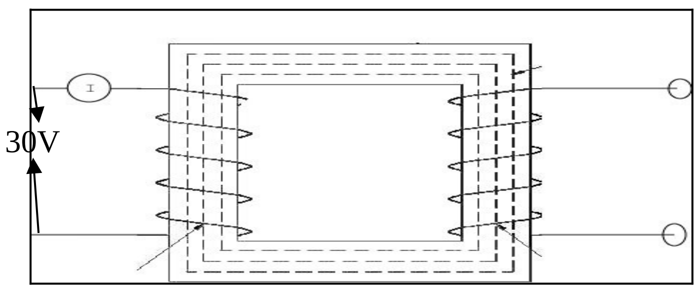


Figure 10-a

Experimental Data Table:

V_1(volt)	I_1(A)	$Z_1(\Omega)$	$R_1(\Omega)$	$L_1(\Omega)$

Part B:

Connect the circuit according to figure 10-b and take reading of following table.

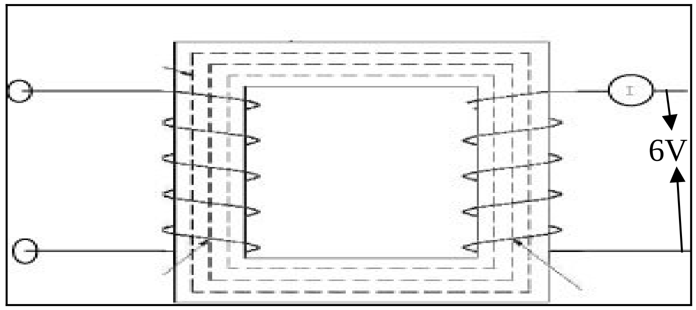


Figure 10-b

Experimental Data Table:

V_2(volt)	I_2(A)	$Z_2(\Omega)$	$R_2(\Omega)$	$L_2(\Omega)$

Part C:

Connect the circuit according to figure 10-c and take reading of following table .

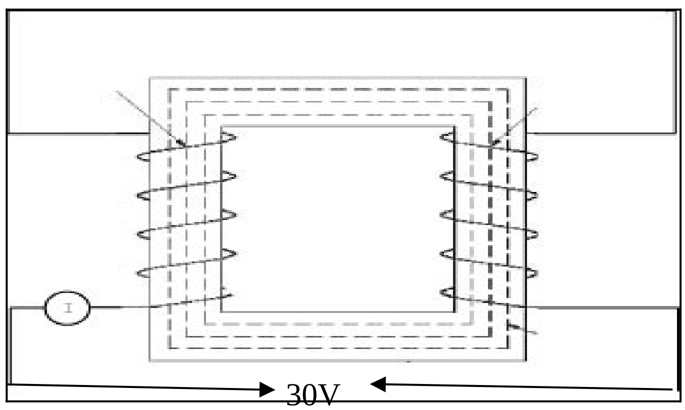


Figure 10-c

Experimental Data Table:

V_3(volt)	I_3(A)	$Z_3(\Omega)$	$R_3(\Omega)$	$L_3(\Omega)$

Part D:

Connect the circuit according to the figure 10-d and take reading of following table.

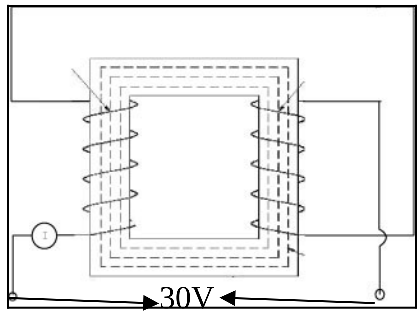


Figure 10-d

Experimental Data Table:

V_4(volt)	I_4(A)	Z_4(Ω)	R_4(Ω)	L_4(Ω)

Part E:

Connect the circuit according to figure 10-e and take reading of following table.

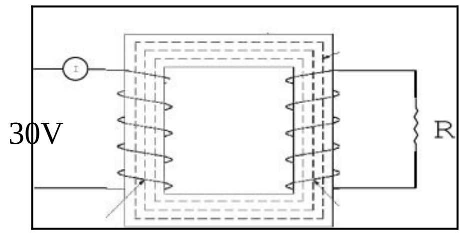


Figure 10-e

Experimental Data Table:

V_5(volt)	I_5(A)	Z_5(Ω)	R_5(Ω)	L_5(Ω)

Questions:

1. What is mutual inductance and self-inductance?
2. What is mutual inductance in circuit theory?

Discussion:

Experiment 06

Week 10-11

Name of the experiment: Determination of the relationship between line voltage, phase voltage and line current in a balanced (У and Δ) system.

Objective: To determine the relationship between line voltage, phase voltage and line current in a balanced (У and Δ) system.

Required Equipments:

1	Ac power supply power supply (3φ)	1
2	A.C ammeter	3
3	Multimeter	1
4.	Bulbs (60W)	3

Theory:

Star Connection:

In star connection, there is four wire, three wires are phase wire and fourth is neutral which is taken from the star point. Star connection is preferred for long distance power transmission because it is having the neutral point. In this we need to come to the concept of balanced and unbalanced current in power system. When equal current will flow through all the three phases, then it is called as balanced current. And when the current will not be equal in any of the phase, then it is unbalanced current. In this case, during balanced condition there will be no current flowing through the neutral line and hence there is no use of the neutral terminal. But when there will be unbalanced current flowing in the three-phase circuit, neutral is having a vital role. It will take the unbalanced current through to the ground and protect the transformer. Unbalanced current affects transformer and it may also cause damage to the transformer and for this star connection is preferred for long distance transmission.

The star connection is shown below-

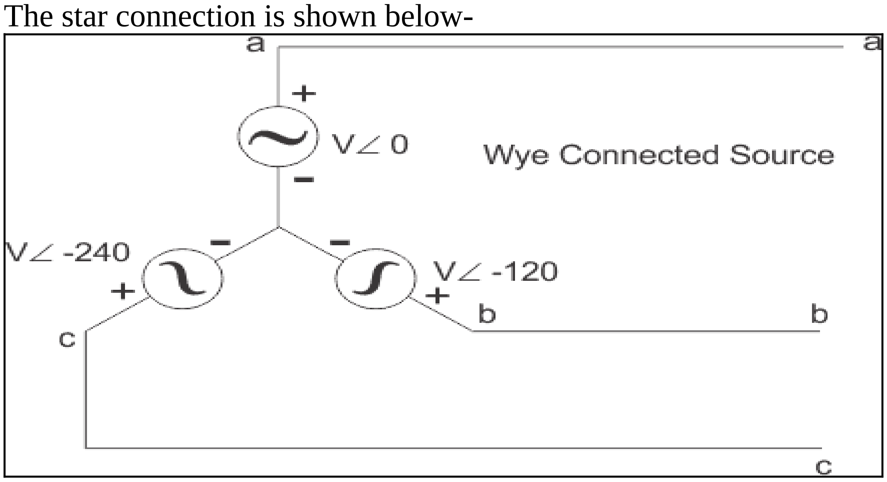


Figure 11: Three Phase Y system

In star connection, the line voltage is √3 times of phase voltage. Line voltage is the voltage between two phases in three phase circuit and phase voltage is the voltage between one phase to the neutral line. And the current is same for both line and phase. It is shown as expression below

$$\boxed{E_{Line} = \sqrt{3}E_{phase} \ and \ I_{Line} = I_{Phase}}$$

Delta Connection:

In delta connection, there is three wires alone and no neutral terminal is taken. Normally delta connection is preferred for short distance due to the problem of unbalanced current in the circuit. The figure is shown below for delta connection. In the load station, ground can be used as neutral path if required.

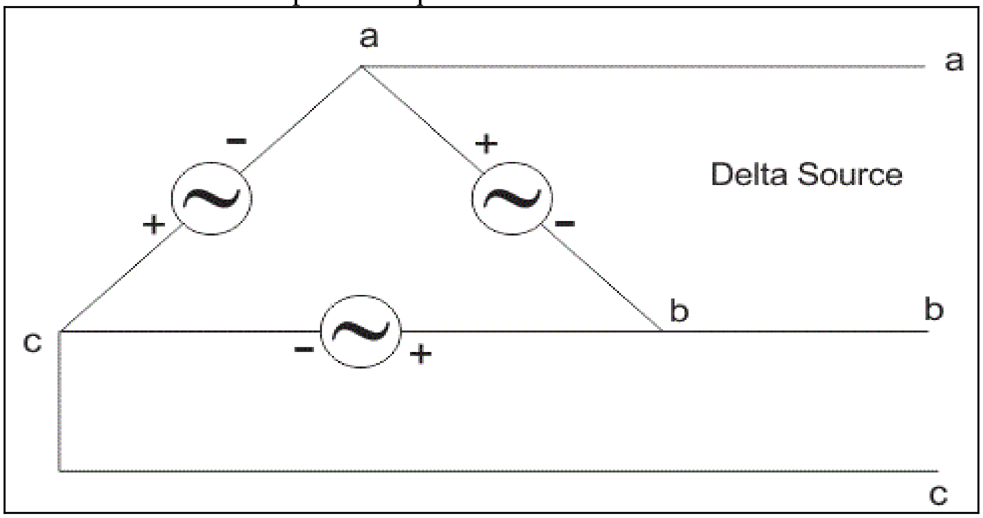


Figure 12: Three Phase Δ system

In delta connection, the line voltage is the same as that of phase voltage. And the line current is √3 times of phase current. It is shown as expression below,

$$\boxed{E_{Line} = E_{phase} \ and \ I_{Line} = \sqrt{3}I_{Phase}}$$

Circuit Diagram:

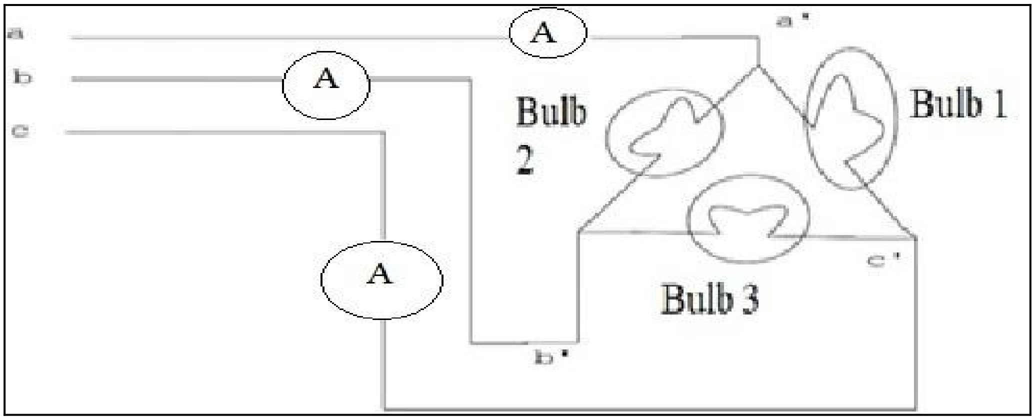


Figure 13: Three Phase balanced Δ system

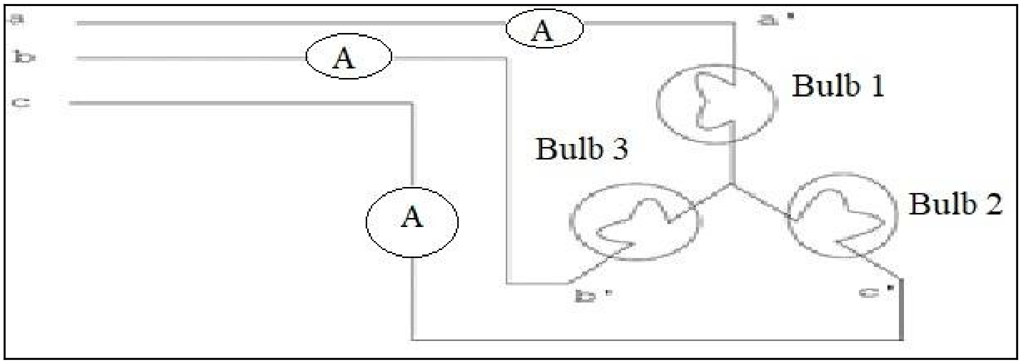


Figure 14: Three Phase balanced Y system

Procedure:

1. Connect the equipment's according to figure 13 and figure 14.
2. Fixed the supply voltage 100V.
3. Then collect reading of line currents, phase currents, line voltages & phase voltages for both Δ and Y systems
4. Draw the vector diagram.

Experimental Data Table:

For balanced Δ system

Obs. No.	Line voltages	Phase voltages	Line Current I_L	Phase current I_P
1. for V_{ab}				
2. for V_{bc}				
3. for V_{ca}				

For balanced Y system

Obs. No.	Line voltages	Phase voltages	Line Current I_L	Phase current I_P
1. for V_{ab}				
2. for V_{bc}				
3. for V_{ca}				

Vector Diagram:

Questions:

1. What is a balanced three phase system?
2. What is the difference between star and delta connection in three phase system?

Discussion:

Week 12-14

Experiment 07

Name of the experiment: Determination of the phase voltage of a three-phase unbalanced load.

Objective: To determine the phase voltage of a three-phase unbalanced load.

Required Equipments:

1	3 phase AC power supply	1
2	A.C Ammeter	1
3.	Rheostat	3
4.	Capacitor	1
5.	Inductor	1
6.	Bulb 60W	1
7	Digital Multimeter	1

Theory:

An unbalanced system is caused by two possible situations: (1) the source voltages are not equal in magnitude and/or differ in phase by angles that are unequal, or (2) load impedances are unequal. Thus, an unbalanced system is due to unbalanced voltage sources or an unbalanced load. To simplify the analysis, we will assume balanced source voltages, but an unbalanced load. Unbalanced three-phase systems are solved by the direct application of mesh and nodal analysis. Figure 15 shows an example of an unbalanced three-phase system that consists of balanced source voltages (not shown in the figure) and an unbalanced Y-connected load (shown in the figure).

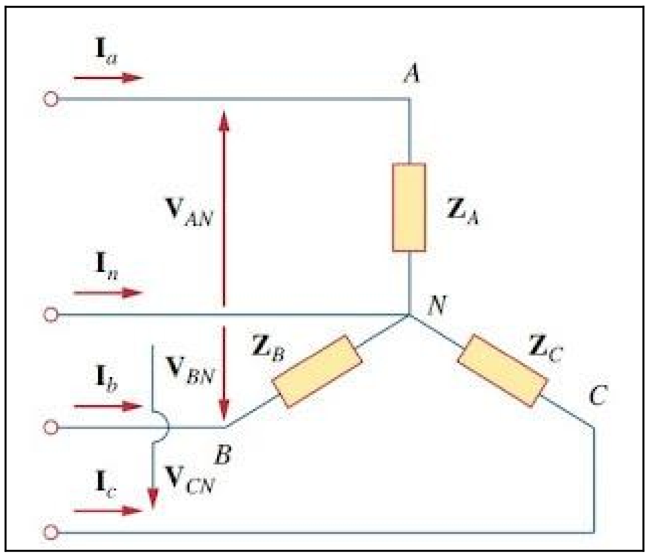


Figure 15. Unbalanced three-phase Y-connected load

Since the load is unbalanced, ZA, ZB, and ZC are not equal. The line currents are determined by Ohm's law as

$$\mathbf{I}_a = \frac{\mathbf{V}_{AN}}{\mathbf{Z}_A}, \qquad \mathbf{I}_b = \frac{\mathbf{V}_{BN}}{\mathbf{Z}_B}, \qquad \mathbf{I}_c = \frac{\mathbf{V}_{CN}}{\mathbf{Z}_C}$$

This set of unbalanced line currents produces current in the neutral line, which is not zero as in a balanced system. Applying KCL at node N gives the neutral line current as

$$\mathbf{I}_n = -(\mathbf{I}_a + \mathbf{I}_b + \mathbf{I}_c)$$

In a three-wire system where the neutral line is absent, we can still find the line currents Ia, Ib, and Ic using mesh analysis. A node N, KCL must be satisfied so that Ia + Ib + Ic = 0 in this case. The same could be done for a Δ-Y, Y-Δ, or Δ-Δ three-wire system. As mentioned earlier, in long-distance power transmission, conductors in multiples of three (multiple three-wire systems) are used, with the earth itself acting as the neutral conductor. To calculate power in an unbalanced three-phase system requires that we find the power in each phase. The total power is not simply three times the power in one phase but the sum of the powers in the three phases.

Circuit Diagram:

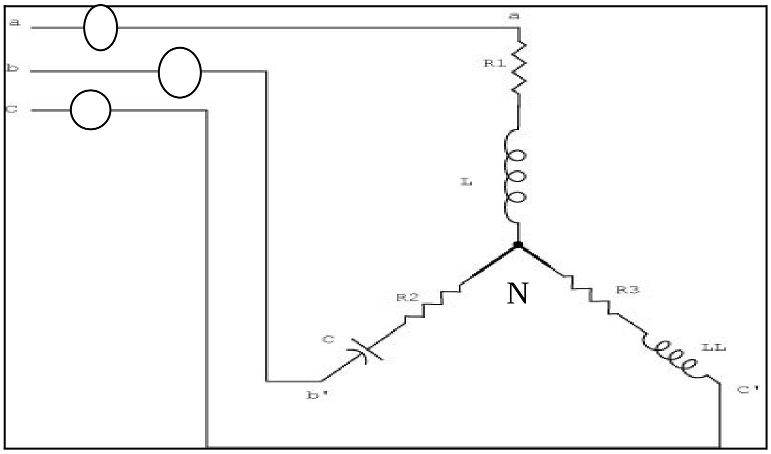


Figure 16: Three Phase unbalanced system

Procedure:

1. Connect the Circuit according to the figure 16.
2. Then provide the supply voltage from three phase power supply.
3. Vary the supply voltage and record phase voltages, line voltages, voltage across resistive load, phase currents and line currents

Experimental Data Table:

Obs. No.	V_{L-L} (V)	V_{R1} (V)	$I_{aa`}$ (A)	V_{R2} (V)	$I_{bb`}$ (A)	V_{R3} (V)	$I_{cc`}$ (A)	$V_{a`N}$ (V)	$V_{b`N}$ (V)	$V_{c`N}$ (V)
1										
2										
3										
4										

Calculation:

Vector diagram:

Questions:

1. What is an unbalanced three phase system?
2. What happen if there three phase powers unbalanced?
3. How do you solve an unbalanced three phase circuit?

Discussion:

Week 15

Experiment :08

Name of the experiment: Measurement of 3-Φ Power & Power Factor by Two Wattmeter Method.

Objective:

1. To measure the power of three phase system by using 2-wattmeter method
2. To calculate the power factor of the load from the reading of two wattmeter.

Required Equipments:

1.	Wattmeter		2
2.	Digital Multimeter		1
3.	Bulb	60W, 100W	3
4.	Inductor	1 H	3

Theory:

The power delivered to a three-phase, three-wire Δ- or Y-connected balanced or unbalanced load can be found by using only two wattmeter if the proper connection is used and if the wattmeter readings are interpreted properly. The basic connection of this two-wattmeter method is shown in the figure below. One end of each potential coil is connected to the same line. The current coils are then placed in the remaining lines. The total power delivered to the load is the algebraic sum of the two wattmeter readings. For a balanced load, we will consider two methods for determining whether the total power is the sum or the difference of the two wattmeter readings.

Circuit Diagram:

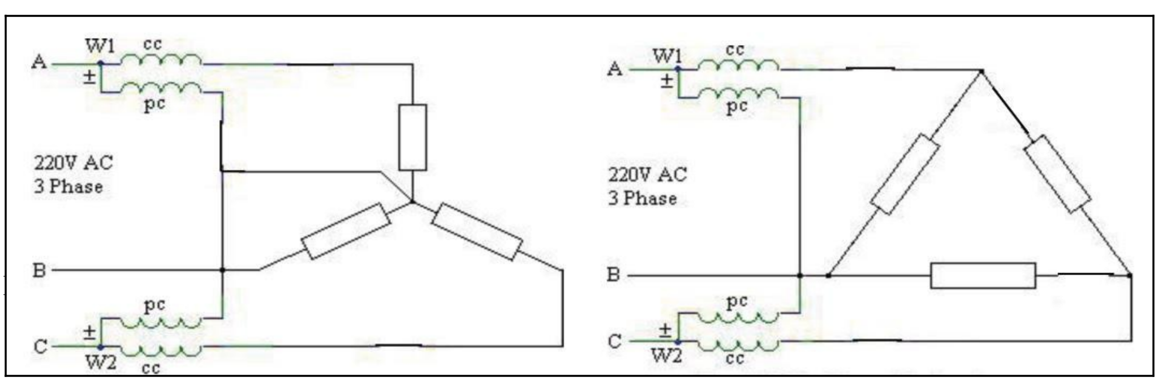


Figure 17: Three Phase power measurement of delta and wye system

Procedure:

1. Connect the equipment according to the figure 17.
2. Vary the three-phase voltage and record the values of power from two wattmeter for every change
3. Calculate power factor of the three-phase system.

Experimental data table:

Obs. No.	W1 (Watt)	W2 (Watt)	P= W1+W2 (Watt)	Power factor $cos\Phi$ = cos ¿tan^-1[√3ostan^-1[$\sqrt{3}(\frac{W1-W2}{W1+W2})$]]
1				
2				
3				
4				
5				
6				
7				
8				

Questions:

1. How can we measure three phase powers?
2. Why do we use two wattmeter methods for measuring three phase power measurement?

Discussion:

Experiment 09

Name of the experiment: Power Factor Improvement using Capacitor Bank.

Objective: To demonstrate the use of a capacitor for the power factor improvement.

Required Equipments:

1.	AC ammeter	0-10 A	1
2.	AC Voltmeter	0-500 V	1
3.	Wattmeter		1
4.	Multimeter		1
5.	Capacitor	3.5 μF, 2.5 μF	2
6.	Magnetic ballasts	1 H	1

Theory:

For fixed power and voltage, the load current is inversely proportional to the power factor. Lower the power factor, higher the load current and vice-versa. At lower power factor the KVA rating of the equipment has to be made more, making the equipment larger and expensive. Moreover, to transmit or distribute a fixed amount of power, the conductor size has to be greater at low power factor. Consequently, more I2R losses result. Therefore, low power factor is objectionable in the power system. The low power factor is mainly due to the fact that most of the industrial loads are inductive and therefore take lagging currents. In order to improve the power factor, some elements or devices taking leading current should be connected in parallel with the load. One of such elements could be capacitor bank. In this experiment, study will be made on a power factor improvement (PFI) plant controlled by manually where capacitor bank switches are turned ON and OFF according to the power factor such that nearly standard power factor is achieved.

Circuit Diagram:

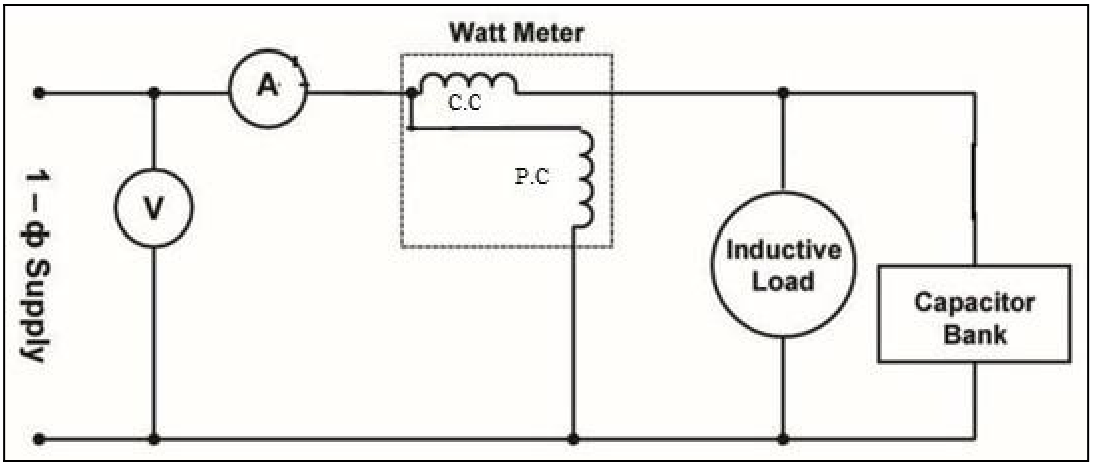


Figure 18: Power factor improvement circuit

Procedure:

1. Connect the equipment according to the figure 18.
2. Switch on the power supply and record the values of voltage, current and power without connecting capacitor.
3. Then connect the capacitor and record the record the values of voltage, current and power
4. Change the value of capacitor and record the record the values of voltage, current and power

Experimental data table:

Without Capacitor

Obs. No.	V (Volt)	I (Amps)	W (Watt)	Power factor P.F = P/VI
1.				
2.				

With Capacitor

Obs. No.	V (Volt)	I (Amps)	W (Watt)	Capacitor value	Power factor P.F= P/VI
1.					
2.					

Calculation:

Find out improvement of power factor, by using following equation for every observation

Power factor (with capacitor) - Power factor (without capacitor)

Questions:

1. Why is capacitor used for power factor improvement?
2. How does a power factor correction capacitor work?

Discussion:

Week 17

Experiment 10:

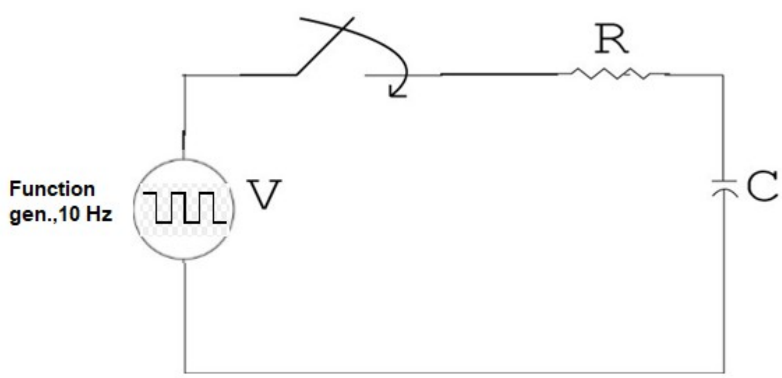
Name of the experiment: Observation of the transient condition and find out the time constant in RC series circuit.

Objective: To observe the transient condition and find out the time constant in RC series circuit.

Equipment's:

1	Function generator	1
2	Multimeter	1
3	Resistor	1
4.	Capacitor	1

Circuit Diagram:



Procedure:

1. Connect the Circuit as given above.
2. Supply 10Hz square wave from function generator.
3. Observe the waveshape across C using an oscilloscope.
4. Now draw the curve for t vs V_R and t vs $V_{C.}$

Data Table:

No	Vs	T (sec)	V_R (v)	V_C (v)
1				
2				
3				
….. 20				

Vector Diagrams:

Discussion: