VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the following:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual For

Electrical Circuits and Network

(313332)

Semester – III

(EE/EP)

"K-SCHEME"

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education, Mumbai
(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi, Bandra (East), Mumbai- 400051.
(Printed on July, 2024)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION, MUMBAI

Certificate

This is to certify that Mr. /Ms.…………………………………………….

Roll No. ……………………………of Third Semester of Diploma in …..…………………………..……………………………of Institute ………………………………………………………………………. (Code : ………) has completed the term work satisfactorily in course **Electrical Circuits and Network (313332)** for the academic year 20…….to 20…….. as prescribed in the curriculum.

Place: …………….. **Enrollment No: ……………….**

Date: ………………. **Exam Seat No: …………………**

Subject Teacher Head of department Principal

Seal of Institute

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering diploma programs with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher, instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through "chalk and duster" activity in the classroom situation. Accordingly, the "K" scheme laboratory manual development team designed the practical to focus on the outcomes, rather than the traditional age old practice of conducting practical to 'verify the theory" (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected. from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the Practical Significance, industry relevant skills, course level Learning outcomes and Relevant Affective Domains which serve key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

The basic aim of this course is develop skills to apply principle of single phase and three phase AC circuits and network theorems to analyze and solve simple electric circuit related problems.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Program Outcomes (POs) to be achieved through this course learning

- **PO 1. Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.
- **PO 2. Problem analysis:** Identify and analyse well-defined engineering problems using codified standard methods.
- **PO 3. Design/ development of solutions:** Design solutions for well-defined technical problems and assist with the design of system components or processes to meet specified needs.
- **PO 4. Engineering tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.
- **PO 5. Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
- **PO 6. Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
- **PO 7. Life-long learning:** Ability to analyse individual needs and engage in updating in the context of technological changes.

List of Relevant expected psychomotor domain Skills

This Lab manual intends to develop expected psychomotor domain skills of students. The skills mentioned below will be developed through the experiments performed in this Laboratory**.**

1. Ability to make connections.
2. To use the vocabulary of electrical network system.
3. To identify and measure the quantities using various measuring instruments.
4. Ability to adjust the components.

Practical-Course outcome matrix

COURSE LEVEL LEARNING OUTCOMES (COS)

1. CO1 – Analyze the parameters of single-phase AC series circuits.
2. CO2 - Analyze the parameters of single-phase AC parallel circuits.
3. CO3 - Analyze the parameters of polyphase AC circuits.
4. CO4 – Apply network reduction methods to solve DC circuits.
5. CO5 - Apply network theorems to solve basic electrical circuits.

Sr.No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5
1	Determination of the phase difference between A.C voltage and current in a given R-L series circuit by using dual trace oscilloscope.	✓	-	-	-	-
2	Determination of the phase difference between A.C voltage and current in a given R-C series circuit by using dual trace oscilloscope.	✓	-	-	-	-
3	Determination of the phase difference between A.C voltage and current in a given R-L-C series circuit by using dual trace oscilloscope.	✓	-	-	-	-
4	Determination of voltage, current and pf in a given R-L series circuit. Draw phasor diagram.	✓	-	-	-	-
5	Determination of active, reactive and apparent power consumed in given R-L series circuit.	✓	-	-	-	-
6	Determination of voltage, current and pf in a given R-C series circuit. Draw phasor diagram.	✓	-	-	-	-
7	Determination of active, reactive and apparent power consumed in a given R-C series circuit.	✓	-	-	-	-
8	Determination of voltage, current and pf in a given R-L-C series circuit. Draw phasor diagram.	✓	-	-	-	-
9	Determination of active, reactive and apparent power consumed in given R-L-C series circuit.	✓	-	-	-	-
10	Resonance in given R-L-C series circuit using variable frequency supply.	✓	-	-	-	-
11	Resonance in given R-L-C series circuit using variable inductor or capacitor.	✓	-	-	-	-
12	Determination of voltage, current, p.f., active, reactive and apparent power for given R-L-C parallel circuit.	-	✓	-	-	-
13	Resonance in given parallel R-L-C circuit using variable frequency supply or variable inductor and capacitor.	-	✓	-	-	-
14	Phase sequence of 3-phase supply system.	-	-	✓	-	-
15	Determination of line and phase quantities of voltage and current for balanced & unbalanced three phase star connected load. Draw phasor diagram.	-	-	✓	-	-

16	Determination of line and phase values of voltage and current for balanced & unbalanced three phase delta connected load. Draw phasor diagram.	-	-	✓	-	-
17	Determination of active, reactive, and apparent power for balanced three phase star connected inductive / capacitive load.	-	-	✓	-	-
18	Determination of active, reactive, and apparent power for balanced three phase delta connected inductive / capacitive load.	-	-	✓	-	-
19	Determination of active, reactive, and apparent power for unbalanced three phase star connected inductive / capacitive load.	-	-	✓	-	-
20	Determination of active, reactive, and apparent power for unbalanced three phase delta connected inductive / capacitive load.	-	-	✓	-	-
21	Verification of Mesh analysis method.	-	-	-	✓	-
22	Verification of Node analysis method.	-	-	-	✓	-
23	Verification of Superposition theorem.	-	-	-	-	✓
24	Verification of Thevenin’s theorem.	-	-	-	-	✓
25	Verification of Norton’s theorem.	-	-	-	-	✓
26	Verification of Maximum Power Transfer theorem.	-	-	-	-	✓
27	Verification of Superposition theorem for AC network.	-	-	-	-	✓

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each experiment
3. Involve students in performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
5. Teachers should give opportunity to students for hands on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
8. Finally give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.

Instructions for Students

1. Listen carefully the lecture given by teacher about subject, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make record all programs.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and gain confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual
6. Student shall refer technical magazines.
7. Student should develop habit to submit the practical’s on date and time.
8. Student should well prepare while submitting write-up of exercise.
9. Attach/paste separate papers wherever necessary.

Content Page

List of Practical's and Progressive Assessment Sheet

10	Resonance in given R-L-C series circuit using variable frequency supply.	70					
11	* Resonance in given R-L-C series circuit using variable inductor or capacitor.	77					
12	* Determination of voltage, current, p.f., active, reactive and apparent power for given R-L-C parallel circuit.	84					
13	Resonance in given parallel R-L-C circuit using variable frequency supply or variable inductor and capacitor.	92					
14	* Phase sequence of 3-phase supply system.	100					
15	* Determination of line and phase quantities of voltage and current for balanced & unbalanced three phase star connected load. Draw phasor diagram.	107					
16	* Determination of line and phase values of voltage and current for balanced & unbalanced three phase delta connected load. Draw phasor diagram.	114					
17	* Determination of active, reactive, and apparent power for balanced three phase star connected inductive / capacitive load.	121					
18	Determination of active, reactive, and apparent power for balanced three phase delta connected inductive / capacitive load.	127					
19	Determination of active, reactive, and apparent power for unbalanced three phase star connected inductive / capacitive load.	133					
20	Determination of active, reactive, and apparent power for unbalanced three phase delta connected inductive / capacitive load.	139					

21	* Verification of Mesh analysis method.	144						
22	* Verification of Node analysis method.	150						
23	* Verification of Superposition theorem.	156						
24	* Verification of Thevenin's theorem.	162						
25	* Verification of Norton's theorem.	167						
26	* Verification of Maximum Power Transfer theorem.	173						
27	* Verification of Superposition theorem for AC network.	178						
Total								

Note :

Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

Practical No. 1: Determination of the phase difference between A.C. voltage and current in a given R-L series circuit by using dual trace oscilloscope.

I Practical Significance:

In the industry environment Electrical Engineering Diploma graduate are expected to handle cathode ray oscilloscope (CRO) .In this experiment phase difference calculation using waveforms of voltage and current and its relation with frequency and time period is carried out . Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

LLO 1. Trace the output waveforms across R-L circuit to identify the phase difference and measure the amplitude.

LLO 2. Observe the nature of current with respect to voltage in R-L series circuit.

LLO 3. Operate various control of CRO

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

The phase difference or phase shift as it is also called of a sinusoidal waveform is the angle Φ (Greek letter Phi), in degrees or radians that the waveform has shifted from a certain reference point along the horizontal zero axis. In other words phase shift is the lateral difference between two or more waveform along a common axis and sinusoidal waveforms of the same frequency can have a phase difference.

The phase difference Φ of an alternating waveform can vary between 0 to its maximum timer period T of the waveform during one complete cycle and this can be anywhere along the horizontal axis between $\Phi = 0$ to 2π or $\Phi = 0$ to $360°$ depending upon the angular units used.

In these circuits, the phase angle by which the whole current lags the voltage is anywhere between 0 & 90 degrees.

A circuit that contains a pure resistance R ohms connected in series with a coil having a pure inductance of L (Henry) is known as **RL Series Circuit**. When an AC supply voltage V is applied, the current, I flows in the circuit.

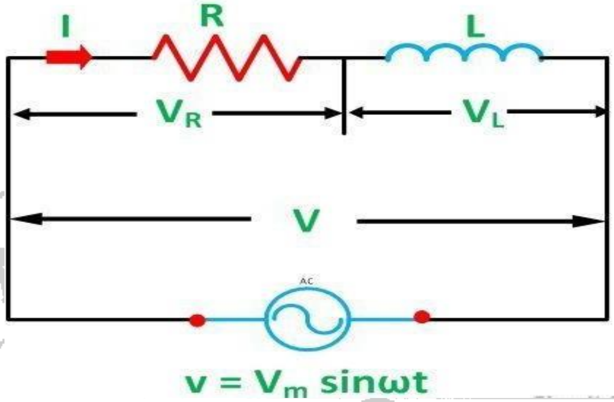

Fig. No. 1.1 Series R-L Circuit

Where,

V_R – voltage across the resistor R

V_L – voltage across the inductor L

V – Total voltage of the circuit

If the alternating voltage applied across the circuit is given by the equation:

$v = V m \sin\omega t$

The equation of current I is given as

$I = Im \sin(\omega t - \phi)$

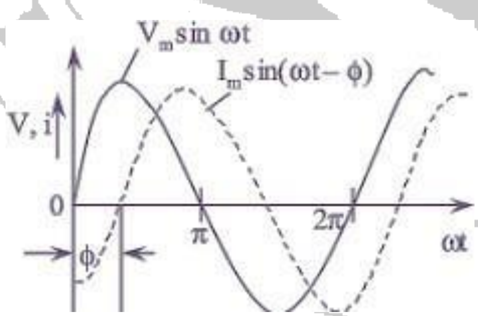

Fig. No. 1.2 Waveform of Circuit.

Waveform representation of supply voltage V and circuit current I, phase difference is ϕ. I is laggingbehind V by an angle of Φ

This is advantageous in applications where the removal of high-frequency noise is required. Smooth Current Transitions: Where high-frequency inductors repel changes in current, leading to smooth transitions in current inflow.

RL circuits are used in communication systems, radio wave transmitters, oscillator circuits, RF amplifiers, filtering circuits, variable tuned circuits, magnification of current and voltage, etc.

RL circuits are commonly used for the DC power supplies in the RF amplifiers where the conductors appear within the current and the block RF in the power supply. The circuits are also effective in terms of processing signals and marinating the filtering process of circuits in DC power.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

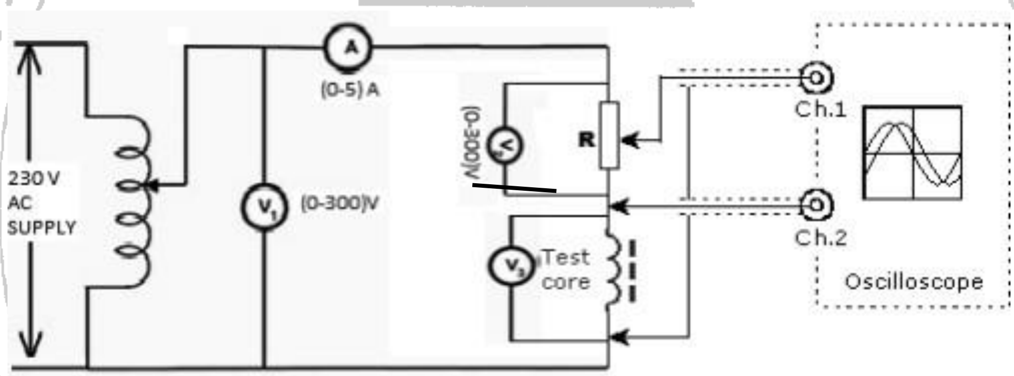

Fig. No. 1.2 Circuit Diagram of Series R-L circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable Inductor	1
3	Autotransformer	0-300 V	1
4	Voltmeter	Suitable Voltmeter	1
5	Ammeter	Suitable Ammeter	1
6	Multimeter	Suitable range	1
7	CRO	With 2 attenuator probes	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.
5. Ensure proper setting of CRO before use.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Connect the CRO for observing current and voltage waveform.
3. Repeat step 2 for different input voltages.
4. Plot the waveform.

XI Observations and calculations

1. Phase difference measured on CRO=

Sr. No.	V	I	Phase difference (From CRO)
1			
2			
3			

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Give current , voltage relation in R, L element.
2. Define Inductive reactance . write its equation.
3. Draw voltage triangle and impedance triangle for Series R-L circuit.
4. Write nature of power factor in series R-L series circuit.
5. What are the applications of RL circuits?

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 2: Determination of the phase difference between A.C. voltage and current in a given R-C series circuit by using dual trace oscilloscope.

I Practical Significance:

In the industry environment Electrical Engineering Diploma graduate are expected to handle cathode ray oscilloscope (CRO) .In this experiment phase difference calculation using waveforms of voltage and current and its relation with frequency and time period is carried out . Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

LLO 1. Trace the output waveforms across R-C circuit to identify the phase difference and measure the amplitude.

LLO 2. Observe the nature of current with respect to voltage in R-C series circuit.

LLO 3. Operate various control of CRO

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

The phase difference or phase shift as it is also called of a sinusoidal waveform is the angle Φ (Greek letter Phi), in degrees or radians that the waveform has shifted from a certain reference point along the horizontal zero axis. In other words phase shift is the lateral difference between two or more waveform along a common axis and sinusoidal waveforms of the same frequency can have a phase difference.

The phase difference Φ of an alternating waveform can vary between 0 to its maximum timer period T of the waveform during one complete cycle and this can be anywhere along the horizontal axis between $\Phi = 0$ to 2π or $\Phi = 0$ to $360°$ depending upon the angular units used.

In these circuits, the phase angle by which the whole current leads the voltage is anywhere between 0 & 90 degrees.

A circuit that contains pure resistance R ohms connected in series with a pure capacitor of capacitance C farads is known as **RC Series Circuit.** A sinusoidal voltage is applied and current I flows through the resistance (R) and the capacitance (C) of the circuit.

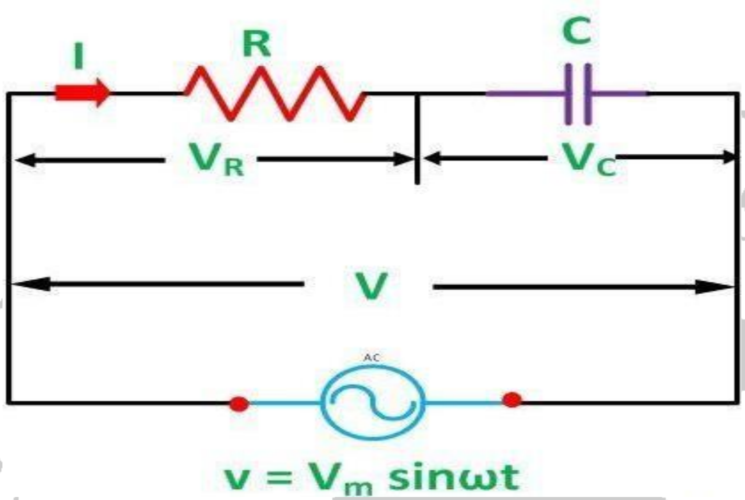

Fig. No. 2.1 Series R-C circuit

Where,

V_R – voltage across the resistor R

V_C – voltage across the inductor C

V – Total voltage of the circuit

If the alternating voltage applied across the circuit is given by the equation:

$v = V_m \sin\omega t$

The equation of current I is given as

$I = I_m \sin(\omega t + \phi)$

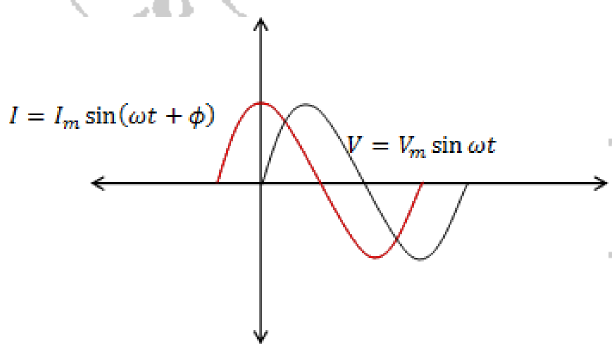

Fig. No. 2.1 Waveform of R-C series circuit

Waveform representation of supply voltage V and circuit current I, phase difference is ϕ.

I is leading V by an angle of Φ

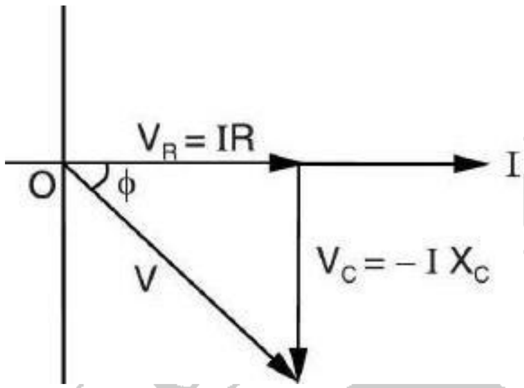

Fig. No. 2.3 Phasor diagram of Series R-C circuit

This is advantageous in applications where the removal of high-frequency noise is required. Smooth Current Transitions: Where high-frequency inductors repel changes in current, leading to smooth transitions in current inflow.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

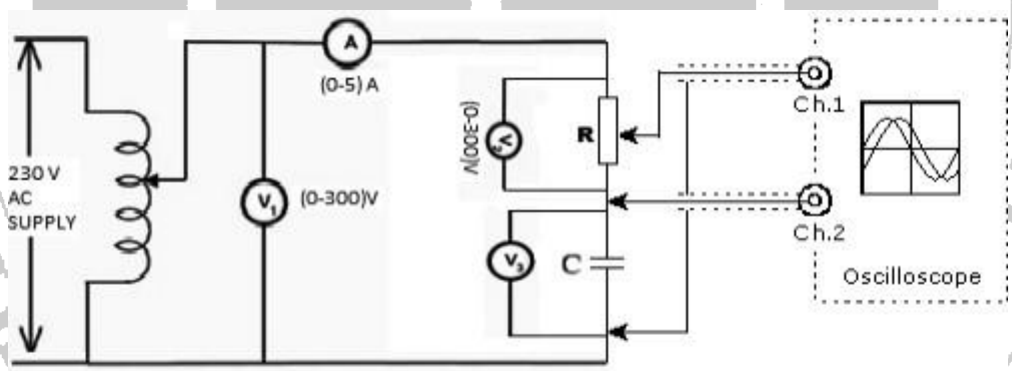

Fig. No. 2.4 Circuit diagram for Series R-C circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Capacitor	Suitable Inductor	1
3	Autotransformer	0-300 V	1
4	Voltmeter	Suitable Voltmeter	1
5	Ammeter	Suitable Ammeter	1
6	Multimeter	Suitable range	
7	CRO	With 2 attenuator probes	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.
5. Ensure proper setting of CRO before use.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Connect the CRO for observing current and voltage waveform.
3. Repeat step 2 for different input voltages.
4. Plot the waveform.

XI Observations and calculations

Phase difference measured on CRO=

Sr. No.	V	I	Phase difference (From CRO)
1			
2			
3			

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Give current , voltage relation in R, C element.
2. Define Capacitive reactance . write its equation.
3. Draw voltage triangle and impedance triangle for Series R-C circuit.
4. Write nature of power factor in series R-C series circuit.
5. What are the applications of RC circuits?

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 3: Determination of the phase difference between A.C. voltage and current in a given R-L-C series circuit by using dual trace oscilloscope.

I Practical Significance:

In the industry environment Electrical Engineering Diploma graduate are expected to handle cathode ray oscilloscope (CRO) .In this experiment phase difference calculation using waveforms of voltage and current and its relation with frequency and time period is carried out . Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

LLO 1. Trace the output waveforms across R-L-C circuit to identify the phase difference and measure the amplitude.

LLO 2. Observe the nature of current with respect to voltage for $X_L > X_C$ or $X_L < X_C$

LLO 3. Operate various controls of CRO

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

Thus far we have seen that the three basic passive components of Resistance, Inductance, and Capacitance have very different phase relationships to each other when connected to a sinusoidal alternating voltage. But we can connect these passive elements together to form a series RLC circuit in series with an applied voltage supply.

In a pure ohmic resistor the voltage waveforms are "in-phase" with the current. In a pure inductance the current waveform "lags" the voltage by 90^o, In a pure capacitance the current waveform "leads" the voltage by 90^o.

This Phase Difference, Φ depends upon the reactive value of the components being used and hopefully by now we know that reactance, (X) is zero if the circuit element is resistive, positive if the circuit element is inductive and negative if it is capacitive thus giving their resulting impedances as:

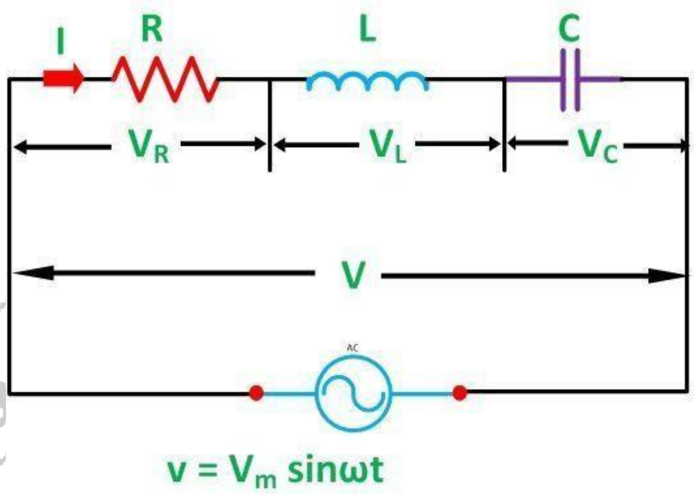

Fig. No. 3.1 Series R-L-C Circuit

Where,

V_R – voltage across the resistor R

V_L – voltage across the inductor L

V_C - Voltage across the Capacitor C

V – Total voltage of the circuit

The phasor diagram depends on the condition of magnitude of V_L and Vc which ultimately depends on values of X_L and Xc.

Let us consider different cases:

Case (i): X_L > Xc

When $X_L > X_c$, Also $V_L > V_c$ (or) $IX_L > IX_c$

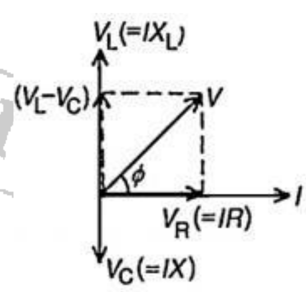

Fig. No. 3.2 Phasor Diagram for $X_L > X_c$

So, resultant of V_L and Vc will directed towards V_L i.e. leading current I. Hence I lags V i.e. current I will lags the resultant of V_L and Vc i.e. (V_L - Vc). The circuit is said to be inductive in nature.

V = Vm Sin wt i = Im Sin (wt - ϕ)

i.e I lags V by angle ϕ

Case (ii): X_L < Xc

When X_L < Xc Also V_L < Vc (or) IX_L < IXc

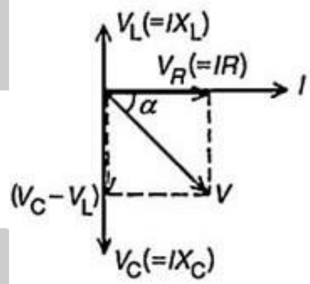

Fig. No. 3.3 Phasor Diagram for **X_L < Xc**

So, resultant of V_L and Vc will directed towards V_C i.e. leading current I. Hence I leads V i.e. current I will leads the resultant of V_L and Vc i.e. (V_C - VL). The circuit is said to be capacitive in nature.

V = Vm Sin wt i = Im Sin (wt + ϕ)

i.e I leads V by angle ϕ

Case(iii): X_L = Xc

When X_L = Xc

Also V_L = Vc (or) IX_L = IXc

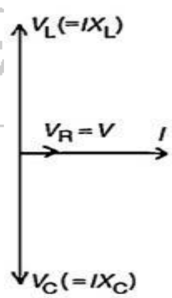

Fig. No. 3.3 Phasor Diagram for **X_L = Xc**

So V_L and Vc cancel each other and the resultant is zero. So $V = V_R$ in such a case, the circuit is purely resistive in nature.

RLC circuits have many applications as oscillator circuits. Radio receivers and television sets use them for tuning to select a narrow frequency range from ambient radio waves. In this role, the circuit is often referred to as a tuned circuit. An RLC circuit can be used as a band-pass filter, band-stop filter, low-pass filter or high-pass filter. The tuning application, for instance, is an example of band-pass filtering.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

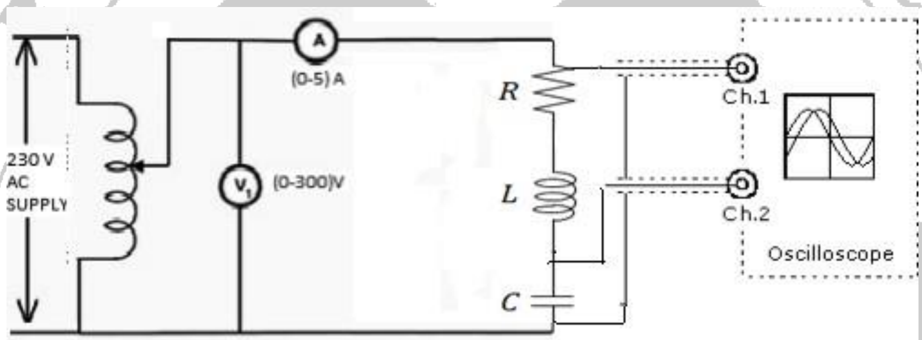

Fig. No. 3.4 Circuit Diagram For series R-L-C circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable Inductor	1
3	Capacitor	Suitable Capacitor	1
3	Autotransformer	0-300 V	1
4	Voltmeter	Suitable Voltmeter	1
5	Ammeter	Suitable Ammeter	1
6	Multimeter	Suitable range	
7	CRO	With 2 attenuator probes	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.
5. Ensure proper setting of CRO before use.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Connect the CRO for observing current and voltage waveform.
3. Repeat step 2 for different input voltages.
4. Plot the waveform.

XI Observations and calculations

Phase difference measured on CRO=

Sr. No.	V	I	Phase difference (From CRO)
1			
2			
3			

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Give current, voltage relation in R, L, C element.
2. What is the condition for resonance.
3. Define Resonance frequency. Write its equation.
4. Draw voltage triangle and impedance triangle for all three condition.
5. Write nature of power factor in series R-L-C series circuit for all three condition.
6. What are the applications of series RLC circuits?

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 4: Determination of voltage, current and power factor in a given R-L series circuit. Draw phasor diagram.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L series circuits. Therefore this practical will help you to acquire necessary AC series circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

Measure voltage , current and draw phasor diagram to find power factor and verify the same.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

A circuit that contains a pure resistance R ohms connected in series with a coil having a pure inductance of L (Henry) is known as **RL Series Circuit**. When an AC supply voltage V is applied, the current, I flows in the circuit.

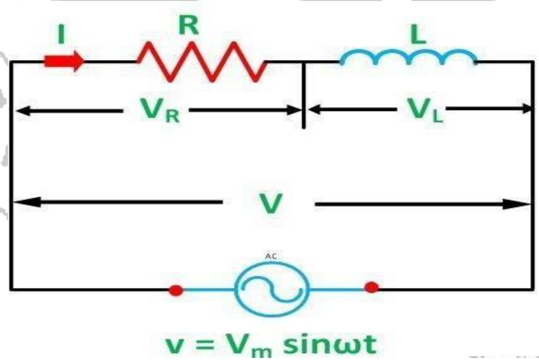

Fig. 4.1 Series R-L series Circuit

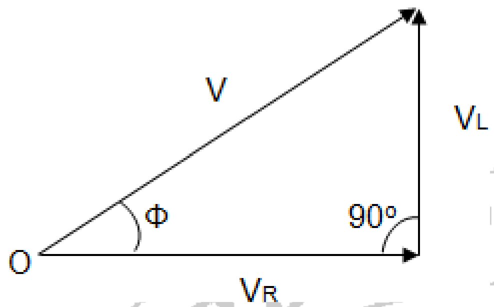

Fig. No. 4.2 Voltage Triangle for series R-L circuit

From the phasor diagram

$V^2 = (V_R)^2 + (V_L)^2$

$V = \sqrt{V_R^2 + V_L^2}$

$= \sqrt{(IR)^2 + (IX_L)^2}$

$= I\sqrt{R^2 + X_L^2}$

V = I. Z

Here,

V = r.m.s value of applied voltage

I = r.m.s. value of current

V_R = voltage drop across R = IR

V_L = voltage drop across L = IX_L

Z = Impedance of the circuit and it is measured in Ω ohms

$tan\ \phi = \frac{V_L}{V_R}$

$\phi = tan^{-1} \frac{X_L}{R}$

Here ϕ is known as phase angle

Voltage leads current by ϕ angle. In other words it can be said that current lags voltage by ϕ angle. Figure 6.8 shows the impedance triangle

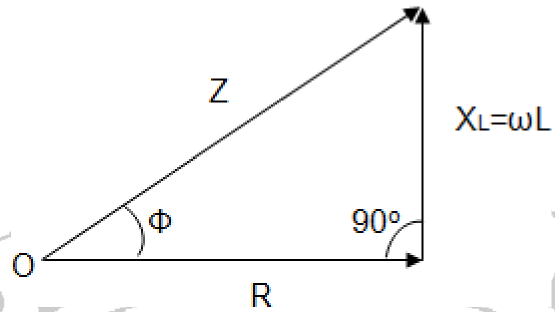

Fig. No. 4.3 Impedence triangle for a.c. series circuit

Impedance Z $= \sqrt{R^2 + X_L^2}$

$$Power\ factor = cos\ \phi = \frac{R}{Z}$$

Here, Z = Impedance and R = Resistance

X_L=Inductive reactance

ϕ = Phase angle

Cos ϕ = power factor of the circuit

VII Actual Circuit diagram used in laboratory with equipment Specifications:

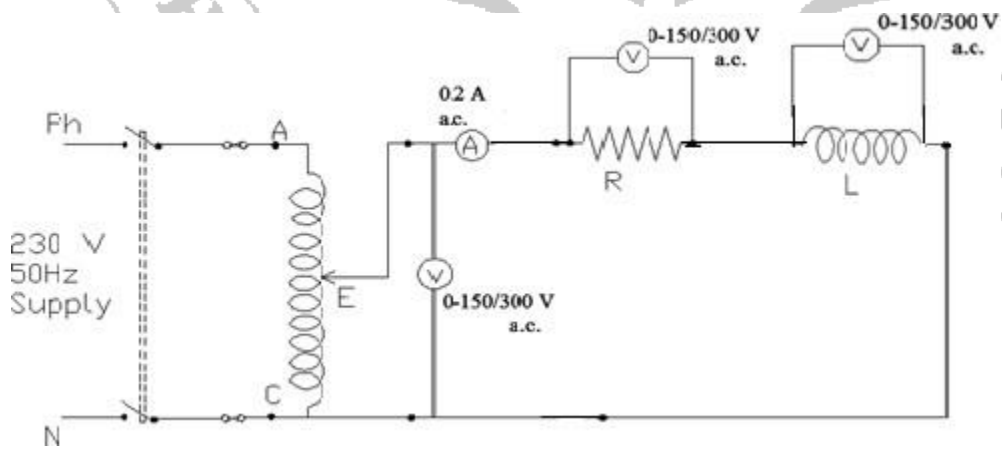

Fig. No. 4.4 circuit Diagram For series R-L circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable Inductor	1
3	Autotransformer	0-300 V	1
4	Voltmeter	Suitable Voltmeter	1
5	Ammeter	Suitable Ammeter	1
6	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage, current and voltage across R and L.
5. Repeat the procedure for different voltages.
6. Draw phasor diagram for all readings.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Current I (amp)	Voltage across resistance V_R volts	Voltage across choke coil V_L volts

Calculation table

Sr. No.	R=V_R/I	X_L=V_L/I	Z=V/I	Calculated Power factor cos ϕ = R/Z	Power factor from phasor diagram	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Draw voltage triangle and impedance triangle for Series R-L circuit.
2. Write nature of power factor in series R-L series circuit.
3. Draw waveform and phasor diagram for series R-L series circuit.
4. In series R-L circuit if resistance is 5 ohm and inductance is 0.01 H across 230 V , 50Hz supply Calculate circuit impedance , current and power factor of circuit.

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		Weightage
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 5: Determination of active, reactive and apparent power consumed in given R-L series circuit.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L series circuits. Therefore this practical will help you to acquire necessary AC series circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

Measure active power and calculate reactive and apparent power for R-L series circuit and verify the same.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

In single phase AC supply there are three types of power

Active Power (P)

Definition: The power which is actually consumed or utilised in an AC Circuit is called **True power** or **Active power** or **Real power**. It is measured in kilowatt (kW) or MW. It is the actual outcomes of the electrical system which runs the electric circuits or load.

Reactive Power (Q)

Definition: The power which flows back and forth that means it moves in both the directions in the circuit or reacts upon itself, is called **Reactive Power**. The reactive power is measured in kilo volt-ampere reactive (kVAR) or MVAR.

Apparent Power (S)

Definition: The product of root mean square (RMS) value of voltage and current is known as **Apparent Power**. This power is measured in kVA or MVA.

It has been seen that power is consumed only in resistance. A pure inductor and a pure capacitor do not consume any power since in a half cycle whatever power is received from the source by these components, the same power is returned to the source. This power which returns and flows in both the direction in the circuit, is called Reactive power. This reactive power does not perform any useful work in the circuit.

Apparent power S = VI

Real power, P = VI cos ϕ

Reactive power, Q = VI sin ϕ

What is a Power Triangle?

The power triangle is a right-angle triangle where Hypotenuse is the apparent power or true power (S), the Opposite side is the reactive power (Q) and the leftover Adjacent side is the active power or real power (P). These three parameters of AC circuits follow the Pythagoras' theorem as S2 =P2+Q2. The angle between P and S gives the Power Factor (or cos θ).

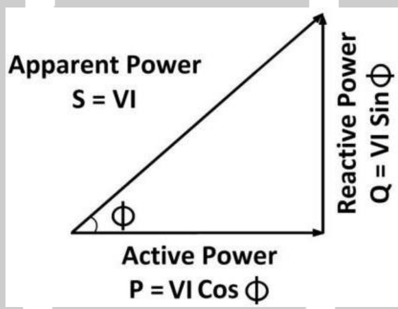

Fig. No. 5.1 Power Triangle

Uses of RL circuit are listed below: Communication systems. Signal Processing. Voltage/Current magnification. Radio wave transmitters. RF amplifiers. Resonant LC circuit. Variable tunes circuits. Oscillator circuits.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

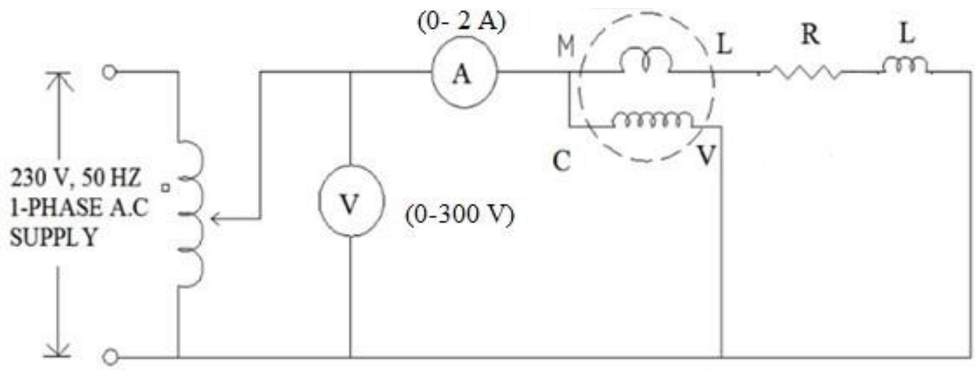

Fig. No. 5.2 Circuit Diagram for series R-L series circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable inductor	1
3	Autotransformer	1 Phase , 1 KVA , 0-300 V	1
4	Voltmeter	0-150/300V	1
5	Ammeter	0-1/2 Amp.	1
6	Wattmeter	5/10 Amp , 250/500V	1
7	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage, current and power .
5. Repeat the procedure for different voltages.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Current I(amp)	Power P (Watt)

Calculation table

Sr. No.	Power factor $\cos \phi = P/VI$	Phase angle (ϕ)	Reactive Power $Q = VI \sin \phi$ (VAR)	Apparent Power **S=VI (VA)**	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Draw impedance triangle and power triangle for Series R-L circuit.
2. Write equation of power factor in terms of power in series R-L circuit.
3. Draw power triangle with scale for any one reading.
4. In series R-L circuit if resistance is 15ohm and inductance is 0.1 H across 230 V , 50Hz supply Calculate circuit impedance , current , power factor , active power , reactive power and apparent power of circuit.

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		Weightage
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 6: Determination of voltage, current and power factor in a given R-C series circuit. Draw phasor diagram.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-C series circuits. Therefore this practical will help you to acquire necessary AC series circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

Measure voltage , current and draw phasor diagram to find power factor and verify the same.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

A circuit that contains a pure resistance R ohms connected in series with a pure capacitance of C (farad) is known as **RC Series Circuit**. When an AC supply voltage V is applied, the current, I flows in the circuit.

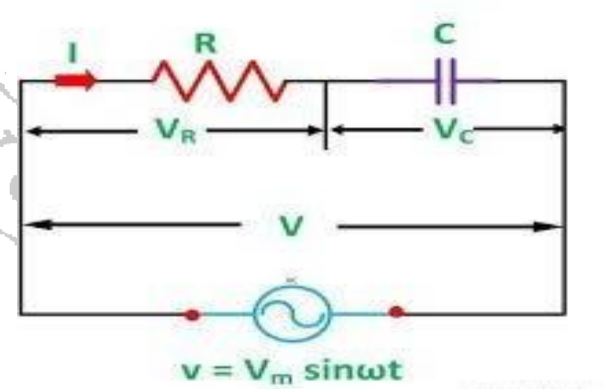

Fig. No. 6.1 Series R-C circuit

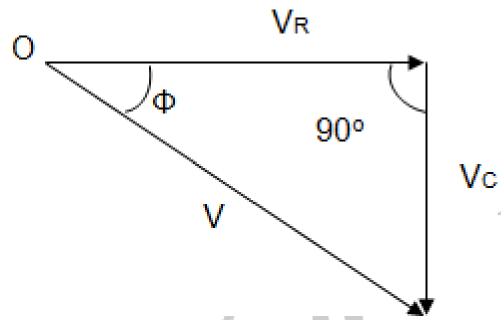

Fig. No. 6.2 Voltage Triangle series for R-C circuit

From the phasor diagram

$V^2 = (V_R)^2 + (-V_C)^2$

$V = \sqrt{V_R^2 + V_C^2}$

$= \sqrt{(IR)^2 + (IX_C)^2}$

$= I\sqrt{R^2 + X_c^2}$

V = I. Z

Here,

V = r.m.s value of applied voltage

I = r.m.s. value of current

V_R = Voltage drop across R = IR

V_C = Voltage drop across C = IX_C

Z = Impedance of the circuit and it is measured in ohms

$tan\ \phi = \frac{V_C}{V_R}$

$\tan\phi = \frac{IX_C}{IR} = \frac{X_C}{R}$

$\phi = tan^{-1}\frac{X_C}{R}$

Here ϕ is known as phase angle.

Current leads voltage by ϕ angle. In other word can be said that voltage lags current by ϕ angle.

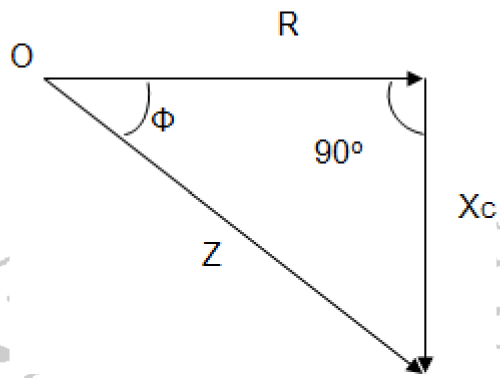

Fig. No. 6.3 Impedance triangle for a.c. series circuit

Impedance Z $= \sqrt{R^2 + X_C^2}$

Power factor $= \cos\phi = \frac{R}{Z}$

Here, Z = Impedance and R=Resistance

X_C = Capacitive reactance

$\cos\phi$ = Power factor of circuit

C = Capacitance

Power P = VI$\cos\phi$

Here,

V = r.m.s value of applied voltage

I = r.m.s. value of current

$\cos\phi$ = Power factor of circuit

VII Actual Circuit diagram used in laboratory with equipment Specifications:

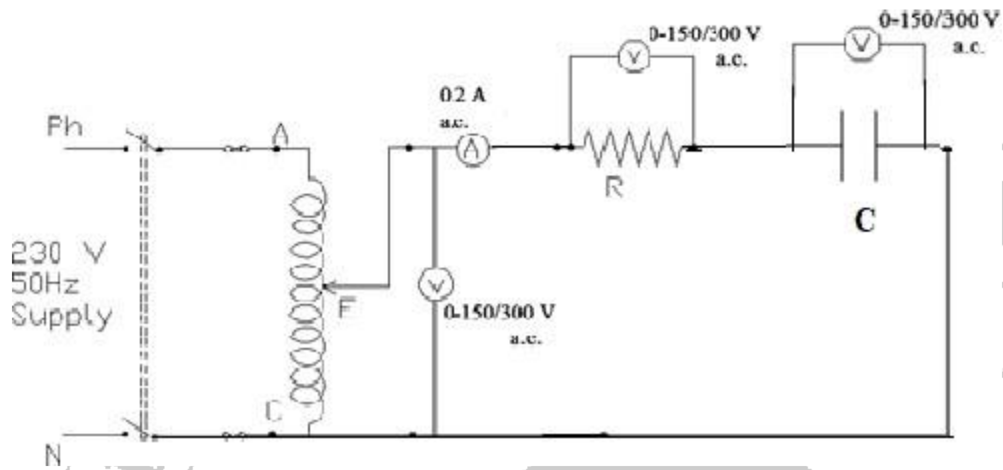

Fig. No. 6.4 Circuit Diagram for series R-C circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Capacitor	Suitable capacitor	1
3	Autotransformer	0-300 V	1
4	Voltmeter	Suitable Voltmeter	1
5	Ammeter	Suitable Ammeter	1
6	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage, current and voltage across R and C.
5. Repeat the procedure for different voltages.
6. Draw phasor diagram for all readings.

XI Observations table and calculations

Sr. No.	**Supply voltage V (volts)**	**Current I (amp)**	**Voltage across resistance V_R volts**	**Voltage across choke coil V_C volts**

Calculation table

Sr. No.	**R=V_R/I**	**X_C=V_C/I**	**Z=V/I**	**Calculated Power factor** $\cos \phi = R/Z$	**Power factor from phasor diagram**	**Remark**

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Draw voltage triangle and impedance triangle for Series R-C circuit.
2. Write nature of power factor in series R-C series circuit.
3. Draw waveform and phasor diagram for series R-C series circuit.
4. In series R-L circuit if resistance is 5 ohm and capacitance is 150 µF across 230 V , 50Hz supply Calculate circuit impedance , current and power factor of circuit.

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		Weightage
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 7: Determination of active, reactive and apparent power consumed in a power factor in a given R-C series circuit.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-C series circuits. Therefore this practical will help you to acquire necessary AC series circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

Measure active power and calculate reactive and apparent power for R-C series circuit and verify the same.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

A circuit that contains a pure resistance R ohms connected in series with a pure capacitance of C (farad) is known as **RC Series Circuit**. When an AC supply voltage V is applied, the current, I flows in the circuit.

Impedance Triangle for series R-C circuit -

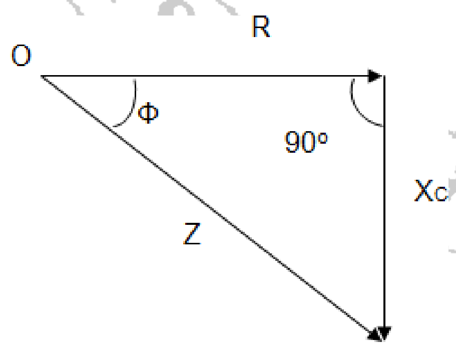

Fig No. 7.1 Impedance Triangle for series R-C circuit

Here, Z = Impedance and R=Resistance

X_C = Capacitive reactance

Cosϕ = Power factor of circuit

Power P = VICosϕ

Here , V = r.m.s value of applied voltage

I = r.m.s. value of current

Cosϕ = Power factor of circuit

In single phase AC supply there are three types of power

Active Power (P)

Definition: The power which is actually consumed or utilised in an AC Circuit is called **True power** or **Active power** or **Real power**. It is measured in kilowatt (kW) or MW. It is the actual outcomes of the electrical system which runs the electric circuits or load.

Reactive Power (Q)

Definition: The power which flows back and forth that means it moves in both the directions in the circuit or reacts upon itself, is called **Reactive Power**. The reactive power is measured in kilo volt-ampere reactive (kVAR) or MVAR.

Apparent Power (S)

Definition: The product of root mean square (RMS) value of voltage and current is known as **Apparent Power**. This power is measured in kVA or MVA.

Power Triangle for Series R-C circuit -

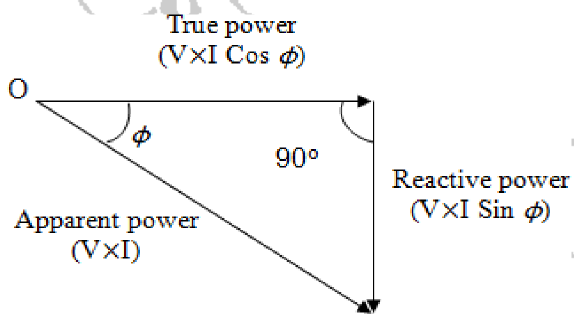

Fig. No. 7.2 Power Triangle for Series R-C circuit

Apparent power S = VI

Real power, $P = VI\cos\phi$

Reactive power, $Q = VI\sin\phi$

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

VII Actual Circuit diagram used in laboratory with equipment Specifications:

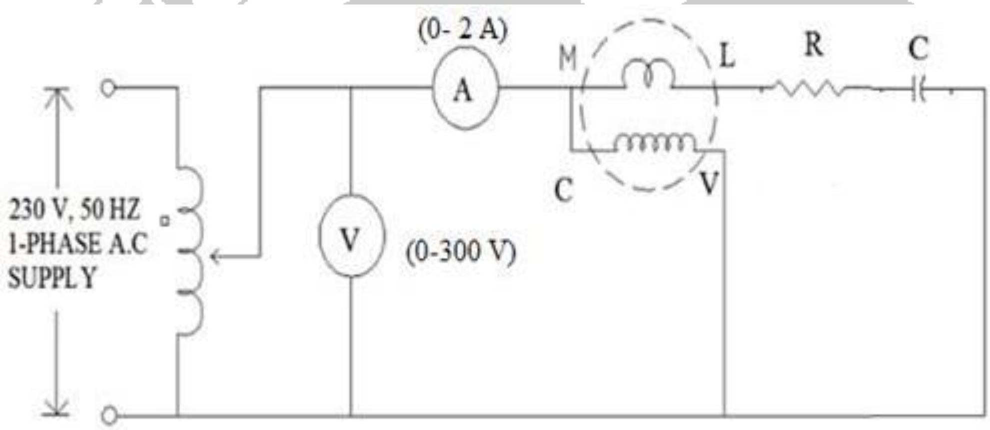

Fig. No. 7.3 Circuit diagram For series R-C circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Capacitor	Suitable capacitor	1
3	Autotransformer	1 Phase , 1 KVA , 0-300 V	1
4	Voltmeter	0-150/300V	1
5	Ammeter	0-1/2 Amp.	1
6	Wattmeter	5/10 Amp , 250/500V	1
7	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage, current and power .
5. Repeat the procedure for different voltages.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Current I(amp)	Power P (Watt)

Calculation table

Sr. No.	Power factor cos ϕ = P/VI	Phase angle (ϕ)	Reactive Power Q = VI sin ϕ (VAR)	Apparent Power S=VI (VA)	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Draw impedance triangle and power triangle for Series R-C circuit.
2. Draw power triangle with scale for any one reading.
3. Draw waveform and phasor diagram for series R-C series circuit.
4. In series R-L circuit if resistance is 5 ohm and capacitance is 200 μF across 230 V , 50Hz supply Calculate circuit impedance , current and power factor of circuit.

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		Weightage
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 8 : Determination of voltage, current and power factor in a given R-L-C series circuit. Draw phasor diagram.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L-C series circuits. Therefore this practical will help you to acquire necessary AC series circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

Measure voltage , current and draw phasor diagram to find power factor and verify the same.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

When the inductance L, resistance R and capacitor C are connected in series to an alternating source of voltage, then the circuit is called an RLC circuit. As they are connected in series, all of them will have the same amount of current flowing through them

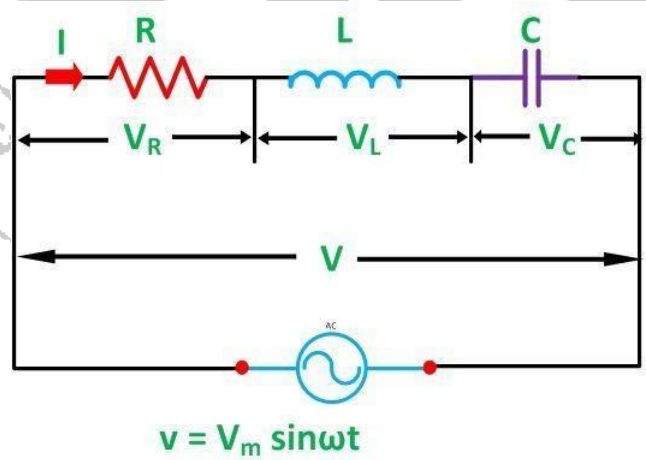

Fig. No. 8.1 Series R-L-C series circuit

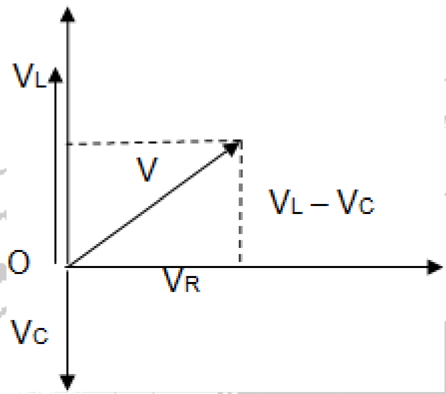

Fig. No. 8.2 Voltage Triangle for Series R-L-C circuit

The voltage drop across each element is given as:

a) Resistance (R) = V_R = IR (in phase with current I)

b) Inductance (L) = V_L = IX_L (leads current by 90^o)

c) Capacitance (C) = V_C = $I.X_C$(lags current by 90^o)

In the phasor diagram V_L is leading current I by 90^o and V_C is lagging current by 90o. So it is evident that V_L and V_C are at 180o to each other. In technical terms it is said to be 180o out of phase with each other. The circuit will behave like inductive or capacitive manner depending upon voltage drop V_L or V_C w.r.t current I.

From the phasor diagram:

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

$$= \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

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

$$V = I.Z$$

Where

Z = Impedance of the circuit which offers opposition to current flow.

$$tan\ \phi = \frac{V_L - V_C}{V_R}$$

Power factor:

$$cos\ \phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$$

Three cases of R-L-C Series Circuit

The equation for impedance is given as:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Case 1: When X_L>X_C

The term (X_L-X_C) is positive.

The circuit works as an R-L Series Circuit. Current lags behind voltage. Phase angle is positive. Power angle is positive. Power factor is lagging. Current flowing in circuit i,

$$i = I_m Sin(\omega t - \phi)$$

Case 2: When X_C>X_L

The term (X_L-X_C) is negative.

The circuit works as an R-C Series Circuit. Current leads over voltage. Phase angle is negative. Power factor is negative. The current flowing in the circuit i,

$$i = I_m Sin(\omega t + \phi)$$

Case 3: When X_L = X_C

The term (X_L-X_C) = 0.

The circuit works as pure resistance. Current is in phase with voltage. Phase angle is Zero. Power factor = 1. The current flowing in the circuit i,

$$i = I_m Sin\ \omega t$$

VII Actual Circuit diagram used in laboratory with equipment Specifications:

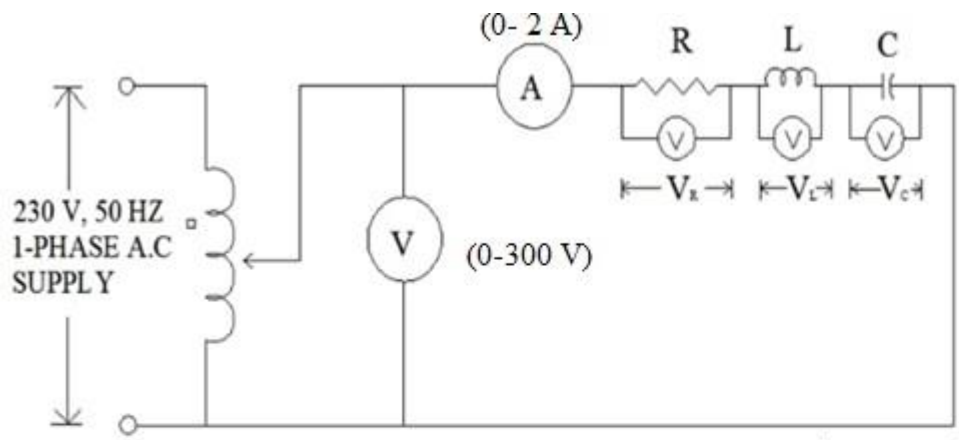

Fig. No. 8.3 Circuit Diagram for Series R-L-C series circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable Inductor	1
2	Capacitor	Suitable capacitor	1
3	Autotransformer	0-300 V	1
4	Voltmeter	Suitable Voltmeter	1
5	Ammeter	Suitable Ammeter	1
6	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage, current and voltage across R, L and C.
5. Repeat the procedure for different voltages.
6. Draw phasor diagram for all readings.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Current I(amp)	Voltage across resistance V_R volts	Voltage across inductance V_L volts	Voltage across capacitance V_C volts

Calculation table

Sr. No.	$R=V_R/I$	$X_L=V_L/I$	$X_C=V_C/I$	Z=V/I	Calculated Power factor $\cos\phi = R/Z$	Power factor from phasor diagram	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Draw voltage triangle and impedance triangle for condition i) $X_L > X_C$ ii) $X_C > X_L$
2. Write nature of power factor in series R-L-C series circuit for all conditions.
3. Draw waveform and phasor diagram for series R-L-C series circuit for all conditions.
4. In series R-L circuit if resistance is R=5 Ω , L=0.01 H , and C= 10 μF supplied with across 230 V, 50Hz supply Calculate circuit impedance , current and power factor of circuit.

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		Weightage
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 9: Determination of active ,reactive and apparent power consumed in a given R-L-C series circuit.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L-C series circuits. Therefore this practical will help you to acquire necessary AC series circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

Measure active power and calculate reactive and apparent power for R-L-C series circuit and verify the same.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

When the inductance L, resistance R and capacitor C are connected in series to an alternating source of voltage, then the circuit is called an RLC circuit. As they are connected in series, all of them will have the same amount of current flowing through them

In the RLC Series circuit

$\mathbf{X_L = 2\pi fL}$ and $\mathbf{X_C = 1/2\pi fC}$

When the AC voltage is applied through the RLC Series circuit the resulting current I flows through the circuit, and thus the voltage across each element will be:

1) $V_R = IR$ that is the voltage across the resistance R and is in phase with the current I.
2) $V_L = IX_L$ that is the voltage across the inductance L and it leads the current I by an angle of 90 degrees.
3) $V_C = IX_C$ that is the voltage across capacitor C and it lags the current I by an angle of 90 degrees.
4) Take current I as the reference as shown in the figure above
5) The voltage across the inductor L that is V_L is drawn leads the current I by a 90-degree angle.
6) The voltage across the capacitor c that is V_c is drawn lagging the current I by a 90-degree angle because in capacitive load the current leads the voltage by an angle of 90 degrees.

7) The two vector V_L and V_C are opposite to each other.

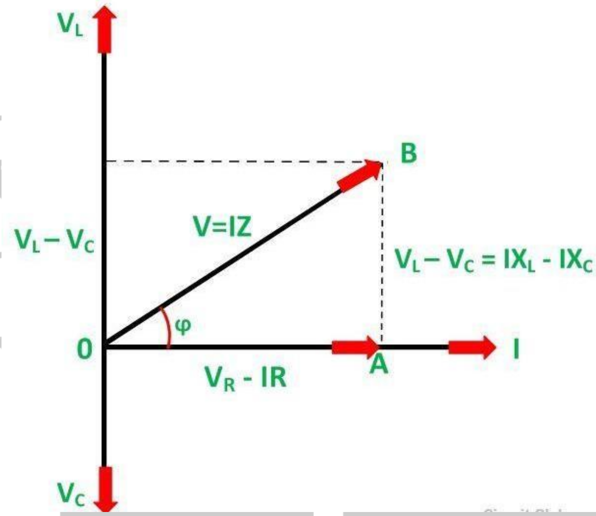

Fig. No. 9.1 Voltage Traingle for series R-L-C circuit

Power in RLC Series Circuit

The product of voltage and current is defined as power.

The three cases of RLC Series Circuit

1) When $X_L > X_C$, the phase angle ϕ is positive. The circuit behaves as RL series circuit in which the current lags behind the applied voltage and the power factor is lagging.
2) When $X_L < X_C$, the phase angle ϕ is negative, and the circuit acts as a series RC circuit in which the current leads the voltage by 90 degrees.
3) When $X_L = X_C$, the phase angle ϕ is zero, as a result, the circuit behaves like a purely resistive circuit. In this type of circuit, the current and voltage are in phase with each other. The value of the power factor is **unity**.

Impedance Triangle of RLC Series Circuit

When the quantities of the phasor diagram are divided by the common factor I then the right angle triangle is obtained known as impedance triangle. The impedance triangle of the RL series circuit, when ($X_L > X_C$) is shown below:

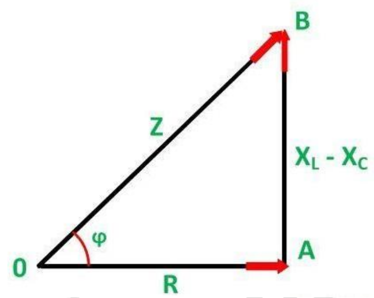

Fig. No. 9.2 Impedance Triangle for $X_L > X_C$

If the inductive reactance is greater than the capacitive reactance than the circuit reactance is inductive giving a **lagging phase angle**.

The equation for impedance is given as:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Impedance triangle is shown below when the circuit acts as an RC series circuit ($X_L < X_C$)

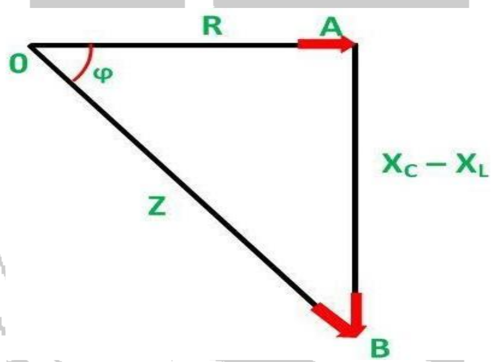

Fig. No. 9.3 Impedance Triangle for $X_L < X_C$

When the capacitive reactance is greater than the inductive reactance the overall circuit reactance acts as capacitive and the phase angle will be leading.

In single phase AC supply there are three types of power

Active Power (P)

Definition: The power which is actually consumed or utilised in an AC Circuit is called **True power** or **Active power** or **Real power**. It is measured in kilowatt (kW) or MW. It is the actual outcomes of the electrical system which runs the electric circuits or load.

Reactive Power (Q)

Definition: The power which flows back and forth that means it moves in both the directions in the circuit or reacts upon itself, is called **Reactive Power**. The reactive power is measured in kilo volt-ampere reactive (kVAR) or MVAR.

Apparent Power (S)

Definition: The product of root mean square (RMS) value of voltage and current is known as **Apparent Power**. This power is measured in kVA or MVA.

Apparent power S = VI

Real power, P = VI cos ϕ

Reactive power, Q = VI sin ϕ

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

VII Actual Circuit diagram used in laboratory with equipment Specifications:

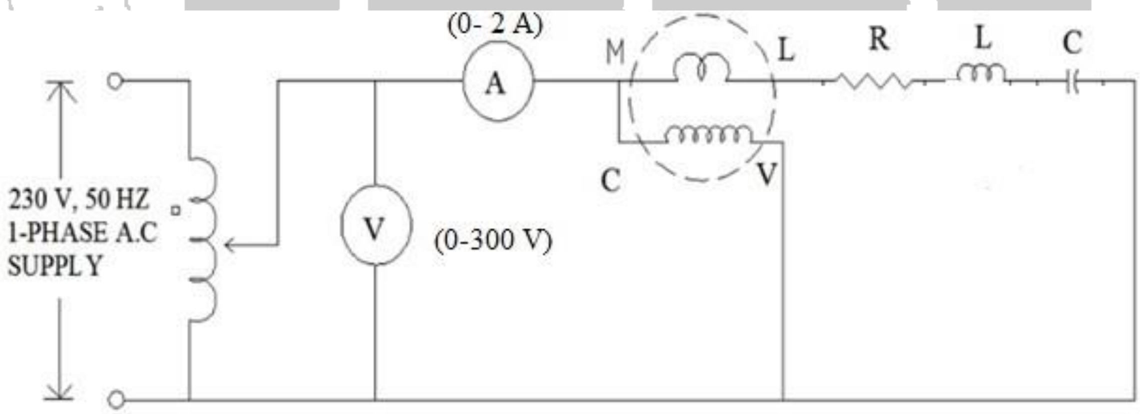

Fig. No. 9.4 Circuit Diagram for Series R-L-C circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable Inductor	1
3	Capacitor	Suitable capacitor	1
4	Autotransformer	1 Phase , 1 KVA , 0-300 V	1
5	Voltmeter	0-150/300V	1
6	Ammeter	0-1/2 Amp.	1
7	Wattmeter	5/10 Amp , 250/500V	1
8	Multimeter	Suitable range	1

IX Precautions to be followed:

1) All electrical connections should be neat and tight.
2) Check the power supply before connection.
3) Connect ammeter in series.
4) Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. Apply the voltage by using autotransformer.
4. Measure the voltage, current and power .
5. Repeat the procedure for different voltages.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Current I(amp)	Power P (Watt)

Calculation table

Sr. No.	Power factor cos ϕ = P/VI	Phase angle (ϕ)	Reactive Power Q = VI sin ϕ (VAR)	Apparent Power S=VI (VA)	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Write impedance equation for all three conditions in series R-L-C series circuit.
2. Draw power triangle with scale for any one reading.
3. Draw impedance triangle for i) $X_L > X_C$ ii) $X_L < X_C$
4. Write nature of power factor for series R-L-C series circuit in all three conditions.
5. A resistance of 100Ω, an inductance of 0.2 H and capacitance of 150 µF are connected in series across 230V, 50 Hz ac supply. Calculate the current drawn by the circuit, power factor of the circuit, its nature and power consumed by the circuit.

XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 10: Resonance in given R-L-C series circuit by using variable frequency supply.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L-C series resonance circuits. Therefore this practical will help you to acquire necessary resonance circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

LLO 1. Measure the resonant frequency and verify it by calculation.

LLO 2. Using variable frequency supply obtain resonant condition for R-L-C series circuit.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

In a series RLC circuit there becomes a frequency point were the inductive reactance of the inductor becomes equal in value to the capacitive reactance of the capacitor. In other words, $X_L = X_C$. The point at which this occurs is called the **Resonant Frequency** point, (f_r) of the circuit, and as we are analyzing a series RLC circuit this resonance frequency produces a **Series Resonance**.

Resonance:

The phenomenon of resonance in R-L-C series circuit is the condition at which the inductive and capacitive reactance's are equal, current in the circuit becomes maximum, impedance of the circuit is minimum, nature of the circuit is resistive, power factor of the circuit is unity and net reactance of the circuit is zero.

Properties of Series Resonance

1) Resonance occurs when $X_L = X_C$ and the imaginary part of the transfer function is zero.
2) At resonance the impedance of the circuit is equal to the resistance value as $Z = R$.
3) At low frequencies the series circuit is capacitive as: $X_C > X_L$, this gives the circuit a leading power factor.

4) At high frequencies the series circuit is inductive as: $X_L > X_C$, this gives the circuit a lagging power factor.
5) The high value of current at resonance produces very high values of voltage across the inductor and capacitor.

Resonant Frequency – For given value of resistance (R), inductance (L) and capacitance (C) the inductive reactance X_L becomes exactly equal to the capacitive reactance X_C only at one particular frequency , this frequency is called as resonant frequency and it is denoted by f_r

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

Series Resonance circuits are one of the most important circuits used electrical and electronic circuits. They can be found in various forms such as in AC mains filters, noise filters and also in radio and television tuning circuits producing a very selective tuning circuit for the receiving of the different frequency channels.

The concept of driving a circuit in its resonant frequency is found in various applications. In an oscillator, a parallel LC is used as a tank-circuit, which is driven in its resonant frequency. The result is a continuous series of steady, oscillating clock pulses that drive components like microcontrollers and communication ICs.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

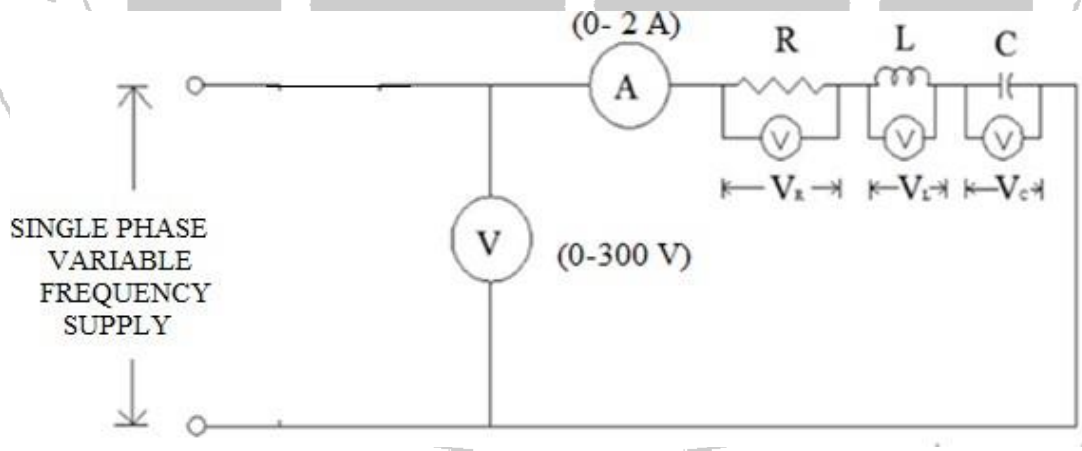

Fig. No. 10.1 Circuit Diagram for Series R-L-C circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable variable Inductor	1
3	Capacitor	Suitable capacitor	1
4	Variable Frequency Generator	Suitable range	1
5	Voltmeter	0-150/300V	1
6	Ammeter	0-1/2 Amp.	1
7	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. Capacitor should be discharged before and after use.
4. Measure the voltage, current , V_R , V_L, V_C by varying supply frequency V_L=V_C

XI Observations table and calculations

Sr. No.	Supply voltage V(volts)	Current I (amp)	Voltage across Resistance (V_R) volts	Voltage across Inductance (V_L) volts	Voltage across Capacitance (V_C) volts

Calculation table

Sr. No.	Impedance $Z = V/I$ Ω	Resistance $R = V_R / I$ Ω	Inductive Reactance (X_L) Ω	Capacitive Reactance (X_C) Ω	Phase angle (ϕ) from phasor diagram	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. What is meant by Resonance in series R-L-C circuit .
2. Define Resonant frequency and derive its equation.
3. State any four properties of series resonance.
4. Draw the curve showing variation of R , X_L , X_C , Z and Current with frequency .
5. Define Q-factor .

XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 11: Resonance in given R-L-C series circuit using variable inductor or capacitor.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L-C series resonance circuits. Therefore this practical will help you to acquire necessary resonance circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC series circuits.

IV Laboratory Learning Outcome(s)

LLO 1. Measure the inductance and capacitance to obtain the resonant condition.

LLO 2. Measure current , Voltage and draw vector diagram to obtain power factor at resonance in series R-L-C series circuit.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

In a series RLC circuit there becomes a frequency point were the inductive reactance of the inductor becomes equal in value to the capacitive reactance of the capacitor. In other words, $X_L = X_C$. The point at which this occurs is called the **Resonant Frequency** point, (f_r) of the circuit, and as we are analyzing a series RLC circuit this resonance frequency produces a **Series Resonance**.

Resonance:

The phenomenon of resonance in R-L-C series circuit is the condition at which the inductive and capacitive reactance's are equal, current in the circuit becomes maximum, impedance of the circuit is minimum, nature of the circuit is resistive, power factor of the circuit is unity and net reactance of the circuit is zero.

Series Resonance circuits are one of the most important circuits used electrical and electronic circuits. They can be found in various forms such as in AC mains filters, noise filters and also in radio and television tuning circuits producing a very selective tuning circuit for the receiving of the different frequency channels.

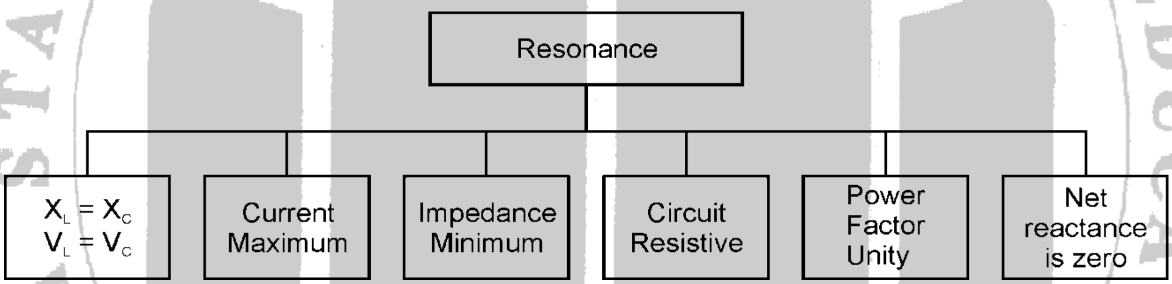
$\mathbf{X_L = 2\pi fL}$ and $\mathbf{X_C = 1/2\pi fC}$

1) Resonance occurs when $X_L = X_C$ and the imaginary part of the transfer function is zero.
2) At resonance the impedance of the circuit is equal to the resistance value as Z = R.
3) At low frequencies the series circuit is capacitive as: $X_C > X_L$, this gives the circuit a leading power factor.
4) At high frequencies the series circuit is inductive as: $X_L > X_C$, this gives the circuit a lagging power factor.
5) The high value of current at resonance produces very high values of voltage across the inductor and capacitor.

Resonant Frequency – For given value of resistance (R), inductance (L) and capacitance (C) the inductive reactance X_L becomes exactly equal to the capacitive reactance X_C only at one particular frequency , this frequency is called as resonant frequency and it is denoted by f_r

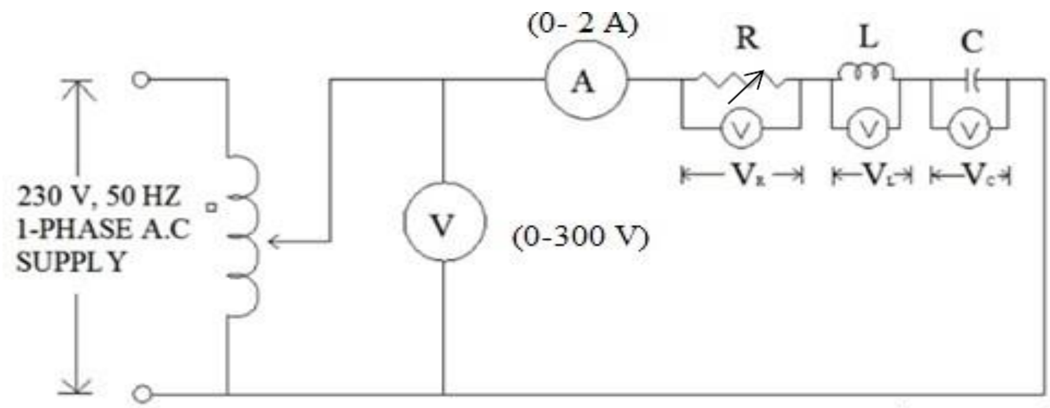
$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

Concept Structure:



The concept of driving a circuit in its resonant frequency is found in various applications. In an oscillator, a parallel LC is used as a tank-circuit, which is driven in its resonant frequency. The result is a continuous series of steady, oscillating clock pulses that drive components like microcontrollers and communication ICs.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable variable Inductor	1
3	Capacitor	Suitable capacitor	1
4	Autotransformer	1 Phase , 1 KVA , 0-300 V	1
5	Voltmeter	0-150/300V	1
6	Ammeter	0-1/2 Amp.	1
7	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage, current , V_R , V_L, V_C by varying inductor till you get V_L=V_C
5. Reduce the autotransformer voltage gradually to zero and switch off the supply.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Current I(amp)	Voltage across Resistance (V_R) volts	Voltage across Inductance (V_L) volts	Voltage across Capacitance (V_C) volts

Calculation table

Sr. No.	Impedance $Z= V/I$ Ω	Resistance $R= V_R/ I$ Ω	Inductive Reactance (X_L) Ω	Capacitive Reactance (X_C) Ω	Phase angle (ϕ) from phasor diagram	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. What is meant by Resonance in series R-L-C circuit .
2. Define Resonant frequency and derive its equation.
3. Draw the curve showing variation of R , X_L , X_C , Z and Current with frequency .
4. Draw the phasor diagram at resonance.
5. Write application of series resonance circuit

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XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 12 : Determination of voltage, current, power factor , active, reactive and apparent power for given R-L-C parallel circuit.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L-C parallel circuits. Therefore this practical will help you to acquire necessary AC parallel circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC parallel circuits.

IV Laboratory Learning Outcome(s)

LLO 1 Measure voltage, current and draw phasor diagram to find pf and verify the same.

LLO 2 Measure active power and calculate reactive and apparent power for R-L-C parallel circuit and verify the same.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

In the above parallel RLC circuit, we can see that the supply voltage, V_S is common to all three components whilst the supply current I_S consists of three parts. The current flowing through the resistor, I_R, the current flowing through the inductor, I_L and the current through the capacitor, I_C.

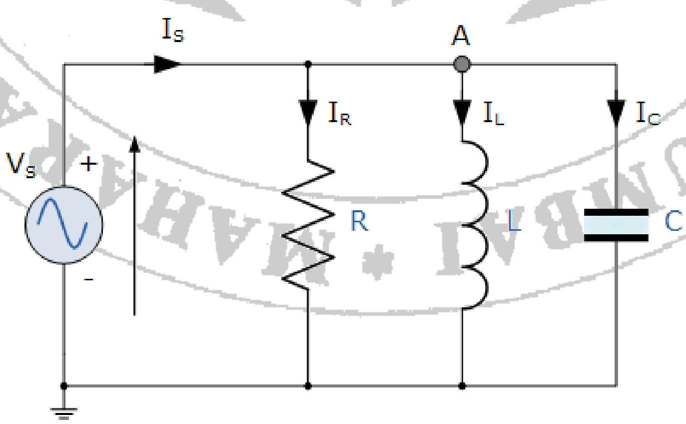

Fig. No. 12.1 Parallel R-L-C circuit

Like the series RLC circuit, we can solve this circuit using the phasor or vector method but this time the vector diagram will have the voltage as its reference with the three current vectors plotted with respect to the voltage. The phasor diagram for a parallel RLC circuit is produced by combining together the three individual phasors for each component and adding the currents vectorially.

Since the voltage across the circuit is common to all three circuit elements we can use this as the reference vector with the three current vectors drawn relative to this at their corresponding angles. The resulting vector current I_S is obtained by adding together two of the vectors, I_L and I_C and then adding this sum to the remaining vector I_R. The resulting angle obtained between V and I_S will be the circuits phase angle as shown below.

Phasor Diagram for a Parallel RLC Circuit

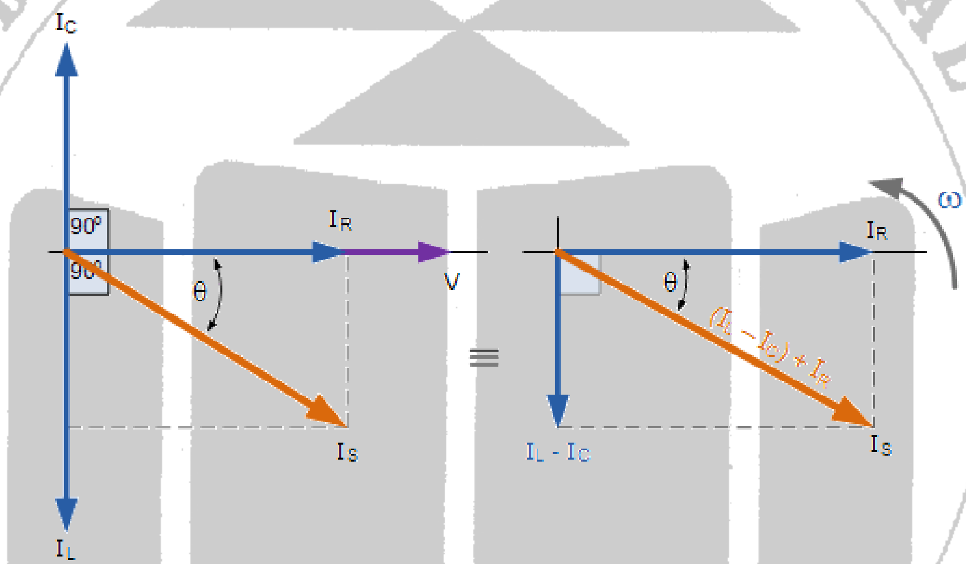

Fig. No. 12.2 Phasor Diagram for a Parallel RLC Circuit

Sr.No	Series Circuit	Parallel Circuit
1	Resistance, (R)	Conductance, (G)
2	Reactance, (X)	Susceptance, (B)
3	Impedance, (Z)	Admittance, (Y)

Admittance is the reciprocal of impedance given the symbol, Y. Like impedance, it is a complex quantity consisting of a real part and an imaginary part. The real part is the reciprocal of resistance and is called **Conductance**, symbol Y. 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 impedance's being defined as:

As susceptance is the reciprocal of reactance, in an inductive circuit, inductive susceptance, B_L will be negative in value and in a capacitive circuit, capacitive susceptance, B_C will be positive in value. The exact opposite to X_L and X_C respectively.

We have seen so far that series and parallel RLC circuits contain both capacitive reactance and inductive reactance within the same circuit. If we vary the frequency across these circuits there must become a point where the capacitive reactance value equals that of the inductive reactance and therefore, $X_C = X_L$.

RLC circuits have countless applications outside of being filters. For example, RLC circuits are used for voltage magnification and parallel RLC circuits can be used for current magnification. Another use for RLC circuits is in induction heating.

RLC circuits have many applications as oscillator circuit. Radio receivers and television sets use them for tuning to select a narrow frequency range from ambient radio waves. In this role, the circuit is often referred to as a tuned circuit.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

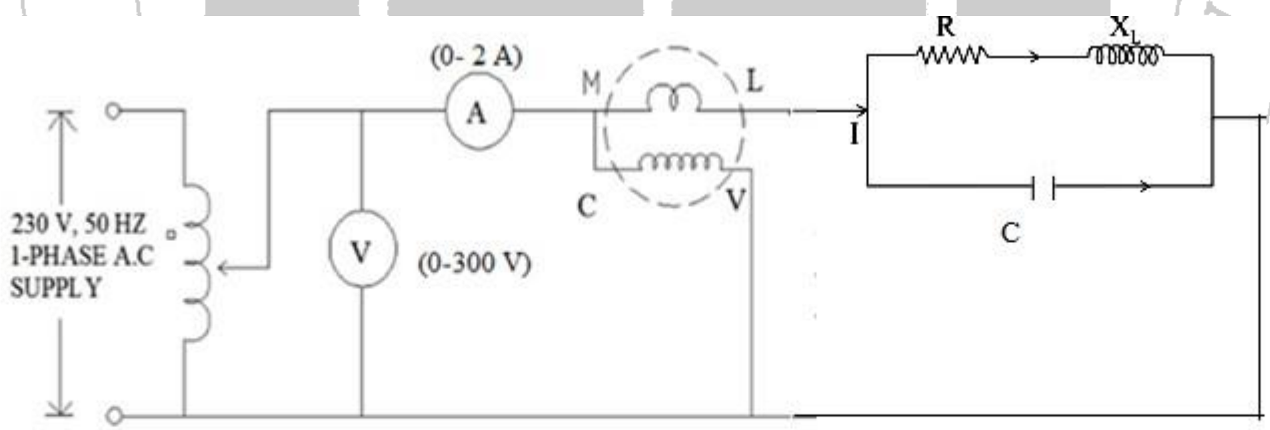

Fig. No. 12.3 Circuit Diagram Parallel Circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable Inductor	1
3	Capacitor	Suitable capacitor	1
4	Autotransformer	1 Phase , 1 KVA , 0-300 V	1
5	Voltmeter	0-150/300V	1
6	Ammeter	0-1/2 Amp.	1
7	Wattmeter	5/10 Amp , 250/500V	1
8	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Measure the voltage, current and Power.
5. Repeat the procedure for different voltages.
6. Draw phasor diagram for all readings.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Current I(amp)	Power P (Watt)

Calculation table

Sr. No.	Power factor $\cos \phi = P/VI$	Phase angle (ϕ)	Reactive Power $Q = VI \sin \phi$ (VAR)	Apparent Power $S = VI$ (VA)	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. State the purpose and application of parallel circuit.
2. Draw phasor diagram for parallel R-L-C circuit.
3. Define Q-factor for parallel circuit.
4. Define Current Magnification. Derive its equation.

XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 13: Resonance in given parallel R-L-C circuit using variable frequency supply or inductor and capacitor.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to measure basic parameters like voltage, frequency, time period etc. for R-L-C parallel resonance circuits. Therefore this practical will help you to acquire necessary resonance circuits skills.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of single-phase AC parallel circuits.

IV Laboratory Learning Outcome(s)

LLO 1. Measure the resonant frequency and verify it by calculation.

LLO 2. Obtain resonant condition for R-L-C parallel circuit by varying frequency or inductance and capacitance

LLO 3. Measure current , Voltage and draw vector diagram to obtain power factor at resonance in R-L-C parallel circuit.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

Parallel Resonance means when the circuit current is in phase with the applied voltage of an AC circuit containing an inductor and a capacitor connected together in parallel.

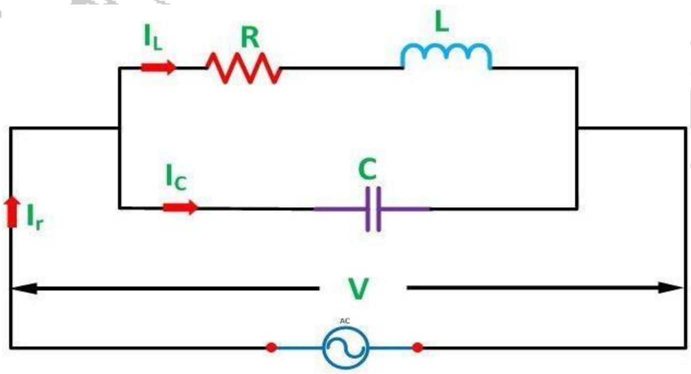

Fig. No. 13.1 Parallel Circuit

Consider an Inductor of L Henry having some resistance of R ohms connected in parallel with a capacitor of capacitance C farads. A supply voltage of V volts is connected across these elements. The circuit current Ir will only be in phase with the supply voltage when the following condition given below in the equation is satisfied.

$$I_C = I_L \, Sin\varphi_L$$

Frequency at Resonance Condition in Parallel resonance Circuit

The value of inductive reactance $\mathbf{X_L = 2\pi fL}$ and capacitive reactance $\mathbf{X_C = 1/2\pi fC}$ can be changed by changing the supply frequency. As the frequency increases, the value of X_L and consequently the value of Z_L increases. As a result, there is a decrease in the magnitude of current I_2 and this I_2 current lags behind the voltage V.

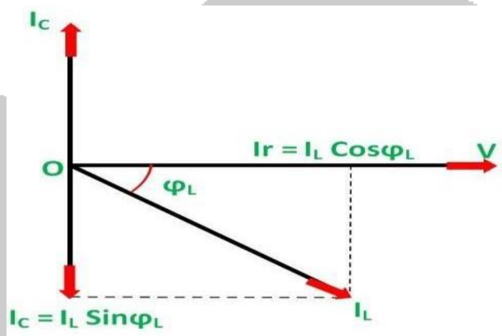

Fig. 13.2 Phasor Diagram

On the other hand, the value of capacitive reactance decreases and consequently the value of I_C increases.

At some frequency, f_r called resonance frequency.

$$f_r = \frac{1}{2\pi L} = \sqrt{\frac{L}{C} - R^2} = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

If R is very small as compared to L, then resonant frequency will be

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

The following **conclusions** are made from the above discussion about the **Parallel Resonance.**

1) The circuit impedance is purely resistive because there is no frequency term present in it. If the value of inductance, capacitance and resistance is in Henry, Farads and Ohm then the value of circuit impedance Z_r will be in Ohms.
2) The value of Zr will be very high because the ratio L/C is very large at parallel resonance.
3) The value of circuit current, Ir = V/Zr is very small because the value of Zr is very high.
4) The current flowing through the capacitor and the coil is much greater than the line current because the impedance of each branch is quite lower than that of circuit impedance Zr.

Since the parallel resonant circuit can draw a very small current and power from the mains, therefore, it is also called as **Rejector Circuit.**

VII Actual Circuit diagram used in laboratory with equipment Specifications:

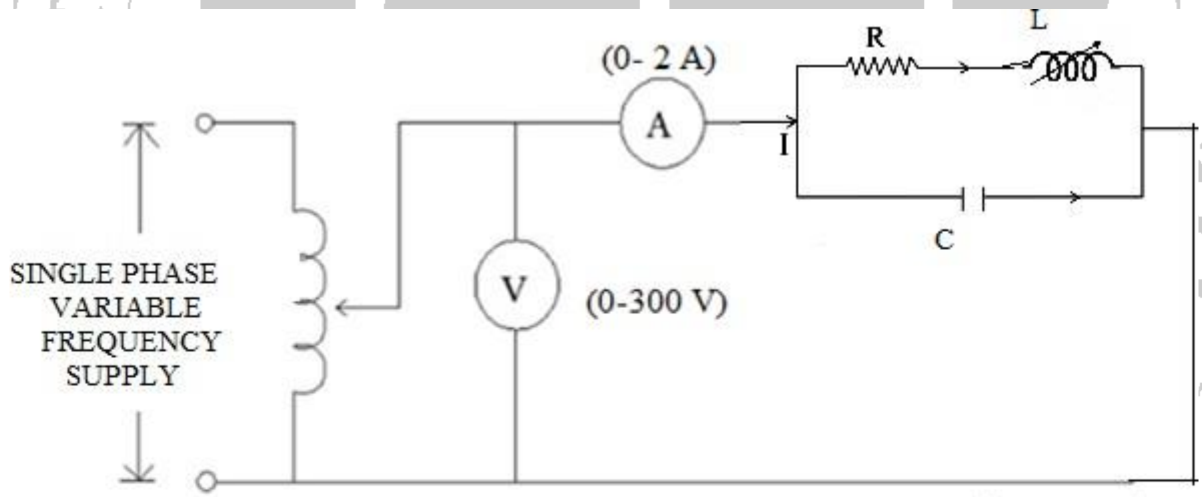

Fig. No. 13.3 Circuit Diagram for parallel circuit

VIII Required Resources/apparatus/equipment with specification:

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Rheostat	Suitable Rheostat	1
2	Inductor	Suitable variable Inductor	1
3	Capacitor	Suitable capacitor	1
4	Autotransformer	1 Phase , 1 KVA , 0-300 V	1
5	Voltmeter	0-150/300V	1
6	Ammeter	0-1/2 Amp.	1
7	Multimeter	Suitable range	1

IX Precautions to be followed:

1. All electrical connections should be neat and tight.
2. Check the power supply before connection.
3. Connect ammeter in series.
4. Connect voltmeter in parallel.

X Procedure

1. Connect the circuit as per circuit diagram.
2. Set rheostat at maximum position.
3. By using autotransformer apply the voltage.
4. Record the readings V, I, I_L and le by varying input frequency or inductance or capacitance gradually, till you get minimum current.
5. Reduce the autotransformer voltage gradually to zero and switch off the supply.
6. Draw the phasor diagram.

XI Observations table and calculations

Sr. No.	Supply voltage V (volts)	Total current I (amp)	Current Through R-L branch I_L	Current Through capacitor branch I_C	Voltage across Resistance (V_R) volts	Voltage across Inductance (V_L) volts	Voltage across Capacitance (V_C) volts

Calculation table

Sr. No.	Impedance Z= V/I Ω	Resistance $R= V_R/ I$ Ω	Inductive Reactance (X_L) Ω	Capacitive Reactance (X_C) Ω	Phase angle (ϕ) from phasor diagram	Remark

XII Results:

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XIII Interpretation of results:

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. What is meant by Resonance in parallel R-L-C circuit .
2. Draw phasor diagram under resonance.
3. State the purpose and applications of parallel resonance circuit.
4. Compare Series and parallel resonance.

XVI References/Suggestions for further reading:

1. **https://nptel.ac.in/**
2. www.electrical4u.com
3. www.howstuffworks.com
4. www.electricaltechnology.org

XVII Assessment Scheme:

Performance indicators		**Weightage**
Process related (60%)		**15 Marks**
1	Handling of the components	10 %
2	Identification of component	20 %
3	Measuring value using suitable instrument	20 %
4	Working in team	10 %
Product related (40%)		**10 Marks**
5	Calculate theoretical values of given component	10 %
6	Interpretation of result	05 %
7	Conclusions	05 %
8	Practical related questions	15 %
9	Submitting the journal in time	05%
	Total	100 %

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 14: Phase sequence of 3-phase supply system.

I Practical Significance:

Direction of rotation of three phase motors solely depends upon the phase sequence of supply. Getting the phase sequence wrong can have devastating consequences for plants and machinery with serious implication for machine safety. From motors running backwards through to cooling or lubrication systems underperforming, one wrong connection can lead to a major maintenance headache. This device is essential for checking phase sequences to ensure the proper functioning of phase supplies.

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of polyphase AC circuits.

IV Laboratory Learning Outcome(s)

Identify phase sequence of the three phase supply system and draw the waveforms.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

The phase sequence indicator detects the correct sequence in a three-phase AC network, with a nominal voltage of 100 to 600 V, own consumption of 1.2 VA, and a frequency of 50 or 60 Hz.

There are two types of phase sequence indicators:

(i) Rotating type (ii) Static type.

(1) **Rotating type.** The principle of working of these meters is like that of 3 phase induction motors.

They consist of three coils mounted 120° apart in space. The three ends of the coils are brought out and connected to three terminals marked RYB as shown in Fig. 14.1 The coils are star connected and are excited by the supply whose phase sequence is to be determined. An aluminium disc is mounted on the top of the coils. The coils produce a rotating magnetic field and eddy emfs are induced in the disc. These emfs cause eddy currents to flow in the aluminium disc. A torque is produced with the interaction of the eddy currents with the field. The disc revolves because of the torque and the direction of rotation depends upon the phase sequence of the supply.

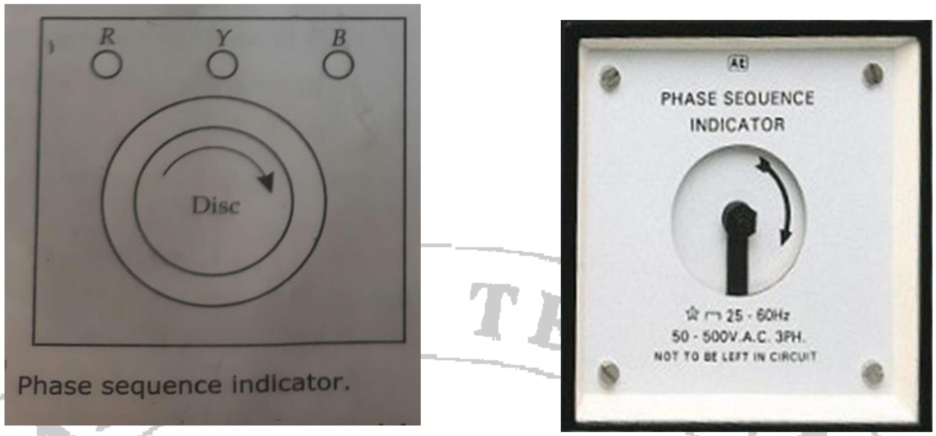


Figure 14.1 Phase Sequence Indicator

An arrow indicates the direction of the rotation of the disc. If the direction of the rotation is the same as that indicated by the arrow head, the phase sequence of the supply is the same as marked on the terminals of the instrument. However, if the disc revolves opposite to the direction indicated by the arrowhead, the sequence of the supply is opposite to that marked on the terminals.

(ii) **Static type.** One arrangement consists of two lamps and an inductor as shown in Figure 14.2(a). When the phase sequence is RYB, lamp 2 will be dim and lamp 2 will glow brightly. If the phase sequence is RBY, lamp 1 will glow brightly and lamp 2 will be dim.

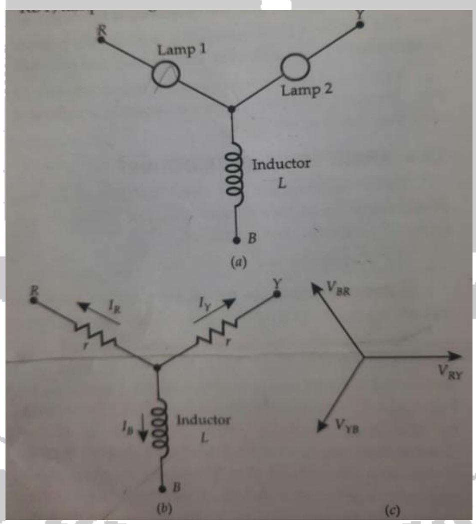


Figure 14.2 Static Type Indicator

The principle of operation may be understood from the following analysis. Assume that the phase sequence is RYB and that phasor relations of voltages V_{RY}, V_{YB} and V_{BR} are as shown in Figure 14.2(c).

$V_{RY} = V(1+j0)$, $V_{YB} = V(-0.5-j0.866)$

$V_{BR} = V(-0.5+j0.866)$.

Assume the currents to be as shown in Fig. 14.2(b) that is:

$I_R+I_Y+I_B = 0$

From Figs. 13.25(b) and (c),

VRY+Iyr-I_Rr=0

$V_{YB}+I_R\ jX_L$-Iyr = 0

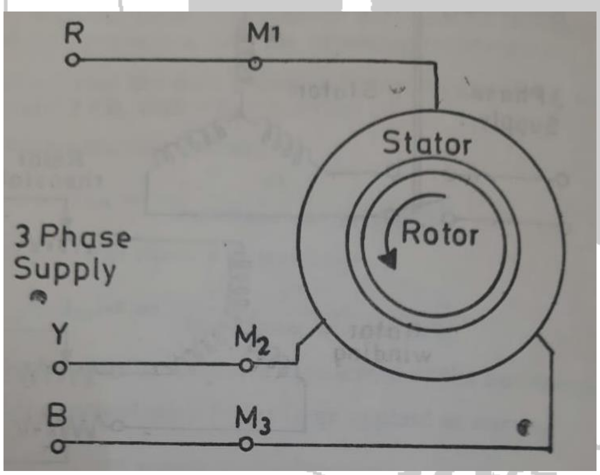
After solving it mathematically for Ir and Iy, we get ,

$I_R/\ I_Y=0.27$

Thus, the voltage drop across lamp 1 (Ir) is only 27% of that across lamp 2 (i.e., ly = 0.27 Ip r). Thus if the phase sequence is RYB lamp 1 glows dimly while lamp 2 glows brightly.

It can be shown that, if the inductor is replaced by a capacitor of such value that Xc = Xl. The ratio Ip/ly is 3.7, which means in this case lamp' 1 glows brightly and lamp 2 glows dimly if the phase sequence is RYB.

VII Actual Circuit diagram used in laboratory with equipment Specifications:



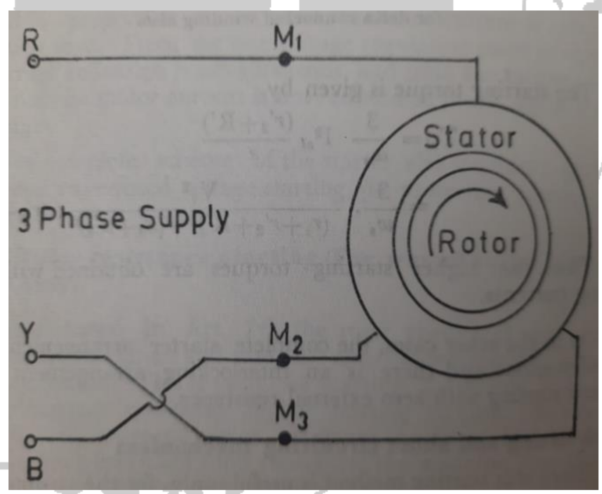


Figure 14.3

Course teacher will guide students to connect Phase sequence indicator as per availability in the laboratory

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Three phase variac	5KVA OR Suitable Three phase variac	1	
2	Three phase Induction motor	3-phase, 3HP,415V OR Suitable Three phase motor	1	
3	Phase sequence indicator of any type	Operating Voltage : 50V to 500V AC Frequency : 25 Hz to 60 Hz. Operating Temp : -10°C to 55°C	1	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don’t touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Set the autotransformer output voltage zero.
3. Switch “On” three phase supply.
4. Gradually increase the voltage with the help of autotransformer just enough to rotate the motor.
5. Note the direction of rotation of motor.
6. Reduce the autotransformer voltage to zero and switch “OFF” the supply.
7. Exchange the connections of motor for R and Y phase “OR” Y and B phase.
8. Repeat Step No.2 to Step No.6
9. Draw two separate waveforms showing phase sequences.

XI Observation table

S.No	Phase Sequence	Direction of rotation of Motor
1	R-Y-B	
2	R-B-Y	

XII Result(s)

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XII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. State the names of types of phase sequence indicator.
2. Describe working principle of rotating type phase sequence indicator.
3. Phase sequence indicator rotates clockwise for phase sequence of RYB. In which direction phase sequence indicator will rotate if phase sequence is i) BRY ii) YRB.

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XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 15: Determination of line and phase values of voltage and current for balanced & unbalanced three phase star connected load. Draw phasor diagram.

I Practical Significance:

In a three phase circuit loads can be connected in balanced star and delta mode. It is necessary to formulate voltage and current relations for the system parameters for testing, calculations and interpretations. Therefore this practical will help you acquire necessary polyphase circuit skills.

In the industry ,Electrical Engineering diploma graduate are expected to understand three phase circuit. In practice, large power applications (synchronous machines & Transformers, Transmission line) use three phase systems.

Three phase electrical supply systems have become popular due to the following advantages:

• The three - phase systems are most economical from the point of view of generation, transmission, distribution and utilization. If a given volume of material can handle P watts of power in a single-phase system, it can handle (1.5 x P) watts of power in a three phase system.

• Performance: Three-phase generators and motors run smoothly, with no torque pulsations, unlike single phase machines

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems

III Course Level Learning Outcome(s)

Analyze the parameters of polyphase AC circuits.

IV Laboratory Learning Outcome(s)

LLO 1 Measure line and phase values for both balance and unbalance star connected load.

LLO 2 Draw phasor diagram with the help of phase values and verify the line values.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

Three phase balanced supply:- Three phase supply is said to be a balance supply if the magnitude of three voltages is equal and displace from each other by 120°. For balanced three phase supply phasor sum of three voltages is zero.

Balanced Load: - Load is generally given by impedance in Ω. Three phase load is said to be

a balanced load if the impedance of each phase is equal in magnitude and having phase angle. (i.e.,$Z_{R=}$ Z_Y = Z_B=Z<Ø)

Line voltage: - The voltage between any two phases is known as line voltage (V_L). (Example: V_{RY}, V_{YB}, V_{BR}).

Phase voltage: - The voltage between any phase with respect to neutral is known as phase voltage (V_{PH}). (Example: V_{RN}, V_{YN}, V_{BN} or V_R, V_y, V_B).

In the **Star Connection**, the similar ends (either start or finish) of the three windings are connected to a common point called star or neutral point. The three-line conductors run from the remaining three free terminals called **line conductors**.

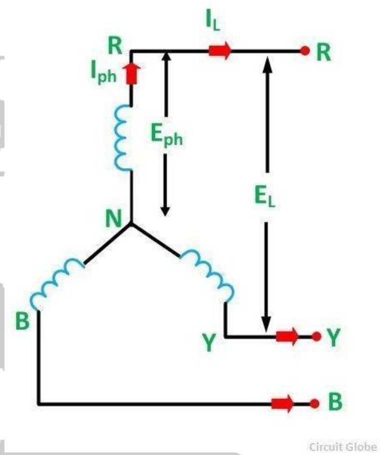

Figure 15.1 Star Network

in star connection line voltage is root 3 times of phase voltage.

$$\text{Line voltage} = \sqrt{3} \text{ x Phase voltage}$$

$$E_L = \sqrt{3}\, E_{ph}$$

The same current flows through phase winding as well as in the line conductor as it is connected in series with the phase winding.

$$I_R = I_Y = I_B = I_L$$

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.

Usually, Star Connection is used in both transmission and distribution networks (with either single phase supply or three – phase. Delta Connection is generally used in distribution networks. Since insulation required is less, Star Connection can be used for long distances.

VII. Actual Circuit Diagram used in laboratory with related equipment rating:

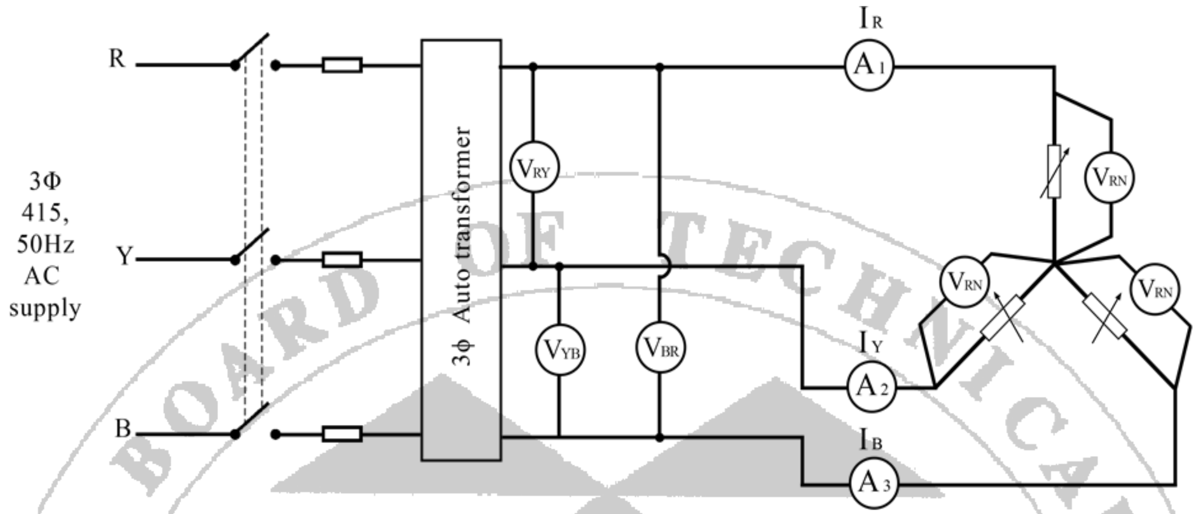

Figure 15.2 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Three phase variac	5KVA OR Suitable Three phase variac	1	
2	Three phase load	3-phase, Resistive,5kW,415V OR Suitable Three phase load	1	
3	Ammeter	MI type :AC/DC ,0-5-10Amp,0-2.5 Amp,0-0.5-1Amp OR Suitable Ammeters	3	
4	Voltmeter	MI Type: AC/DC, 0-150/300V,0-250/500,0-75/150V OR Suitable Voltmeters	6	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don’t touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.
4. Make sure that lamps are in “OFF” position before switching ON the supply.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Set the autotransformer output voltage zero.
3. Switch "ON" three phase supply.
4. Set the supply voltage and record the readings of ammeters, voltmeters and power factor meter for V_L, I_L, V_{PH}, I_{PH}
5. Switch "ON" the lamps of load gradually .Make sure the three phase load is balanced.
6. Take different readings without exceeding the current limits.
7. Repeat the readings for unbalanced load.

XI Observation table for Balanced star connected load

Sr.No.	Line Voltage			Phase Voltage			Phase Current= Line Current		
	V_{RY}	V_{YB}	V_{BR}	V_R	V_Y	V_B	I_R	I_Y	I_B
1									
2									
3									

Observation table for Unbalanced star connected load

Sr.No.	Line Voltage			Phase Voltage			Phase Current= Line Current		
	V_{RY}	V_{YB}	V_{BR}	V_R	V_Y	V_B	I_R	I_Y	I_B
1									
2									
3									

Calculations:

For phase values of Voltage for **Balanced** Load :

$\frac{VRY}{\sqrt{3}} = \_\_V$, $\frac{VYB}{\sqrt{3}} = \_\_\_V$, $\frac{VBR}{\sqrt{3}} = \_\_\_V$

For phase values of Voltage for **Unbalanced** Load :

$\frac{VRY}{\sqrt{3}} = V$, $\frac{VYB}{\sqrt{3}} = V$, $\frac{VBR}{\sqrt{3}} = V$

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Give reason, factors, probable errors if $\frac{I}{\sqrt{3}}$. Is not exactly equal to I_{PH}
2. What will be the value of neutral current for three phase star connected balanced load?
3. What will happen if one of the branches gets disconnected?
4. Sate applications where delta connection is used?
5. In three phase unbalanced load, current in all the three phases is not same. Give reason

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XVI References/Suggestions for further reading:

1. www.electrical4u.com
2. www.howstuffworks.com
3. www.electricaltechnology.org
4. https://nptel.ac.in/
5. https://vlab.amrita.edu
6. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

	Performance Indicators	Weightage
Process Related : 15 Marks		**60 %**
1	**Handling of the components**	**10%**
2	**Identification of components**	**20%**
3	**Measuring value using suitable instrument**	**20%**
4	**Working in teams**	**10%**
Product Related: 10 Marks		**40%**
5	**Calculated theoretical values of given component**	**10%**
6	**Interpretation of result**	**05%**
7	**Conclusions**	**05%**
8	**Practical related questions**	**15%**
9	**Submitting the journal in time**	**05%**
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 16: Determination of line and phase values of voltage and current for balanced & unbalanced three phase delta connected load. Draw phasor diagram.

I Practical Significance:

In a three phase circuit loads can be connected in balanced star and delta mode. It is necessary to formulate voltage and current relations for system parameters for testing, calculations and interpretations. Therefore this practical will help you to acquire necessary polyphase circuit skills.

In the industry environment Electrical Engineering diploma graduate are expected to understand three phase circuit. In practice, large power applications (synchronous machines & Transformers, Transmission line) use three phase systems.

Three phase electrical supply systems have become popular due to the following advantages:

• The three - phase systems are most economical from the point of view of generation, transmission, distribution and utilization. If a given volume of material can handle P watts of power in a single-phase system, it can handle (1.5 x P) watts of power in a three phase system.

• Performance of three-phase generators and motors run smoothly, with no torque pulsations, unlike single phase machines

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry

III Course Level Learning Outcome(s)

Analyze the parameters of polyphase AC circuits.

IV Laboratory Learning Outcome(s)

LLO 1 Measure line and phase values for both balance and unbalance delta connected load.

LLO 2 Draw phasor diagram with the help of phase values and verify the line values.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

Three phase balanced supply:- Three phase supply is said to be a balance supply if the magnitude of three voltages is equal and displace from each other by 120°. For balanced three phase supply phasor sum of three voltages is zero.

Balanced Load: - Load is generally given by impedance in Ω. Three phase load is said to be a balanced load if the impedance of each phase is equal in magnitude and having phase angle. (i.e.,$Z_{R=}$- $\bar{Z}_Y = \bar{Z}_B = \bar{Z}<Ø$)

Line voltage: - The voltage between any two phases is known as line voltage (V_L). (Example: V_{RY}, V_{YB}, V_{BR}).

Phase voltage: - The voltage between any phase with respect to neutral is known as phase voltage (V_{PH}). (Example: V_{RN}, V_{YN}, V_{BN} or V_R, Vy, V_B).

The delta in a three-phase system is formed by connecting one end of the winding to the starting end of other winding and the connections are continued to form a closed loop. The star in the three-phase system is formed by connecting one end of all three impedances are connected together.

In **Delta (Δ) or Mesh connection**, the finished terminal of one winding is connected to start terminal of the other phase and so on which gives a closed circuit. The three-line conductors are run from the three junctions of the mesh called **Line Conductors**.

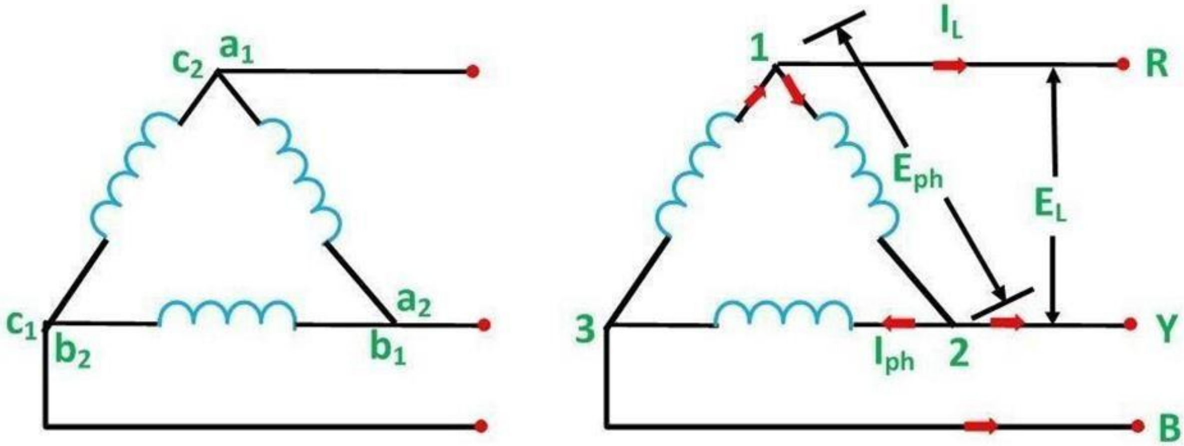

Figure 16.1 Delta circuit

To obtain the **delta connections**, a_2 is connected with b_1, b_2 is connected with c_1 and c_2 is connected with a_1 as shown in the above figure. The three conductors R, Y and B are running from the three junctions known as **Line Conductors**.

The current flowing through each phase is called **Phase Current (Iph)**, and the current flowing through each line conductor is called **Line Current (IL).**

The voltage across each phase is called **Phase Voltage (Eph)**, and the voltage across two line conductors iscalled **Line Voltage (EL).**

Relation between Phase Voltage and Line Voltage in Delta Connection

$$E_{RY} = E_{YB} = E_{BR} = E_L$$

In delta connection, line voltage is equal to phase voltage.

Relation between Phase Current and Line Current in Delta Connection

In delta connection line current is root three times of phase current.

$$\text{Line Current} = \sqrt{3} \times \text{Phase Current}$$

$$I_L = \sqrt{3} I_{ph}$$

In a Delta Connection, the Line and Phase Voltages are same and hence, more insulation is required for individual phases. Usually, Star Connection is used in both transmission and distribution networks (with either single phase supply or three – phase. Delta Connection is generally used in distribution networks

Three Phase balanced network are used in the power industry for the reason of economy and performance. Three phase generators and motors run smoothly, with no torque pulsation, unlike single phase machine. In addition balanced three phase system may be operated as three or four wire systems, which much less copper needed for the power delivered as compared with three single phase systems.

VII. Actual Circuit Diagram used in laboratory with related equipment rating

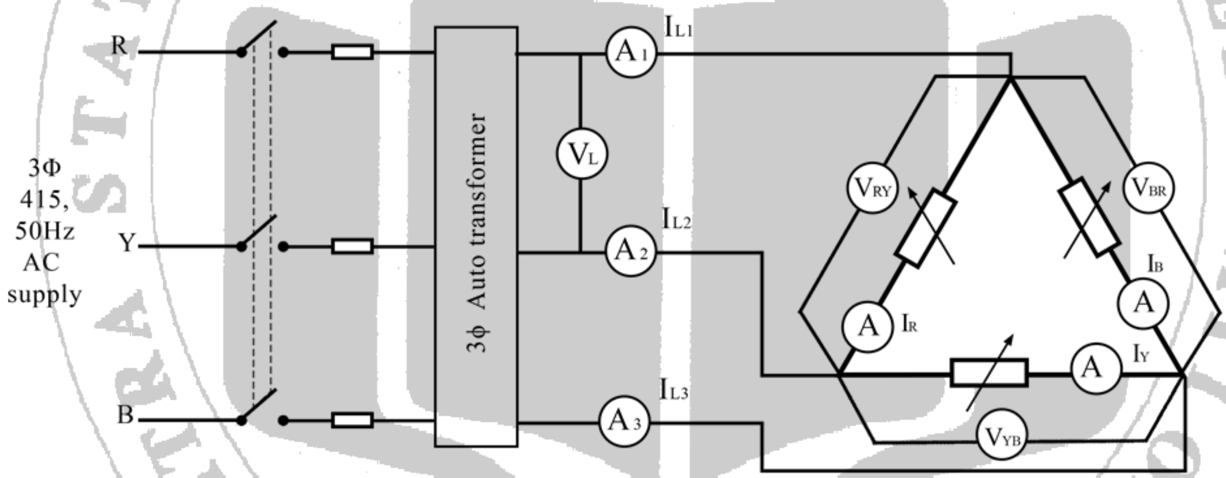

Figure-16.2 Circuit Diagram for Delta connection

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Three phase variac	5KVA OR Suitable Three phase variac	1	
2	Three phase load	3-phase, Resistive,5kW,415V OR Suitable Three phase load	1	
3	Ammeter	MI type :AC/DC ,0-5-10Amp,0-2.5 Amp,0-0.5-1Amp OR Suitable Ammeters	6	
4	Voltmeter	MI Type: AC/DC, 0-150/300V,0-250/500,0-75/150V	3	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don't touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.
4. Make sure that lamps are in "OFF" position before switching ON the supply.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Set the autotransformer output voltage zero.
3. Switch "ON" three phase supply.
4. Set the supply voltage and record the readings of ammeters, voltmeters and power factor meter for V_L, I_L, V_{PH}, I_{PH}
5. Switch "ON" the lamps of load gradually .Make sure the three phase load is balanced.
6. Take different readings without exceeding the current limits.
7. Repeat the readings for unbalanced load.

XI Observation table for Balanced delta connected load

Sr.No.	Phase Voltage			Phase Current			Line Current		
	V_R	V_Y	V_B	I_R	I_Y	I_B	I_{L1}	I_{L2}	I_{L3}
1									
2									
3									

Observation table for Unbalanced delta connected load

Sr.No.	Phase Voltage			Phase Current			Line Current		
	V_R	V_Y	V_B	I_R	I_Y	I_B	I_{L1}	I_{L2}	I_{L3}
1									
2									
3									

Calculations:

For phase values of current for **Balanced Load**:

$\frac{A1}{\sqrt{3}} = \_\_A$, $\frac{A2}{\sqrt{3}} = \_\_A$, $\frac{3}{\sqrt{3}} = \_\_A$

For phase values of current for **Unbalanced Load**:

$\frac{A1}{\sqrt{3}} = \_\_A$, $\frac{A2}{\sqrt{3}} = \_\_A$, $\frac{3}{\sqrt{3}} = \_\_A$

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Give reason, factors, probable errors if $\frac{L}{\sqrt{3}}$ Is not exactly equal to V_{PH}
2. What will be the value of neutral current for three phase star connected balanced load?
3. What will happen if one of the fuses of the circuit blows?
4. Sate applications where star connection is used?
5. In three phase unbalanced delta connected load, voltage in all the three phase is not same. Give reason

XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 17: Determination of active, reactive, and apparent power for balanced three phase star connected inductive/capacitive load.

I Practical Significance:

In a three phase circuit loads can be connected in balanced star and delta mode. Power consumed by any circuit decides the economy of the system. Therefore this practical will help you to acquire necessary skills to calculate useful power in polyphase circuit.

In the industry environment Electrical Engineering diploma graduate are expected to understand three phase circuit. In practice, large power applications (synchronous machines & Transformers, Transmission line) use three phase systems.

Three phase electrical supply systems have become popular due to the following advantages:

• The three - phase systems are most economical from the point of view of generation, transmission, distribution and utilization. If a given volume of material can handle P watts of power in a single-phase system, it can handle (1.5 x P) watts of power in a three phase system.

• Performance of three-phase generators and motors run smoothly, with no torque pulsations, unlike single phase machines

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of polyphase AC circuits.

IV Laboratory Learning Outcome(s)

LLO Measure active, reactive and apparent power for balanced three phase star connected inductive /capacitive load.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

To measure power in a 3-phase system, it would seem necessary to use three wattmeters, each connected to neutral for a common terminal, and each responding to a line-to-neutral voltage and a line current. One would then add up the powers indicated on each wattmeter. Analysis of such a circuit shows that one wattmeter is redundant, hence the two-wattmeter method of measuring 3-phase power was developed for three wire systems. This method is satisfactory even if the loads are unbalanced. It is necessary to connect the wattmeters taking into account the polarity of their coils. When the current enters the marked terminal of the current coil and the voltage positive is connected to the marked terminal of the voltage coil, the reading represents power absorbed. In that case the algebraic sum of the wattmeters determines the total load power. In reactive circuits it may be necessary to reverse the current coil of one wattmeter in order to get an upscale deflection. This reading is taken as negative when the total power is determined algebraically.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

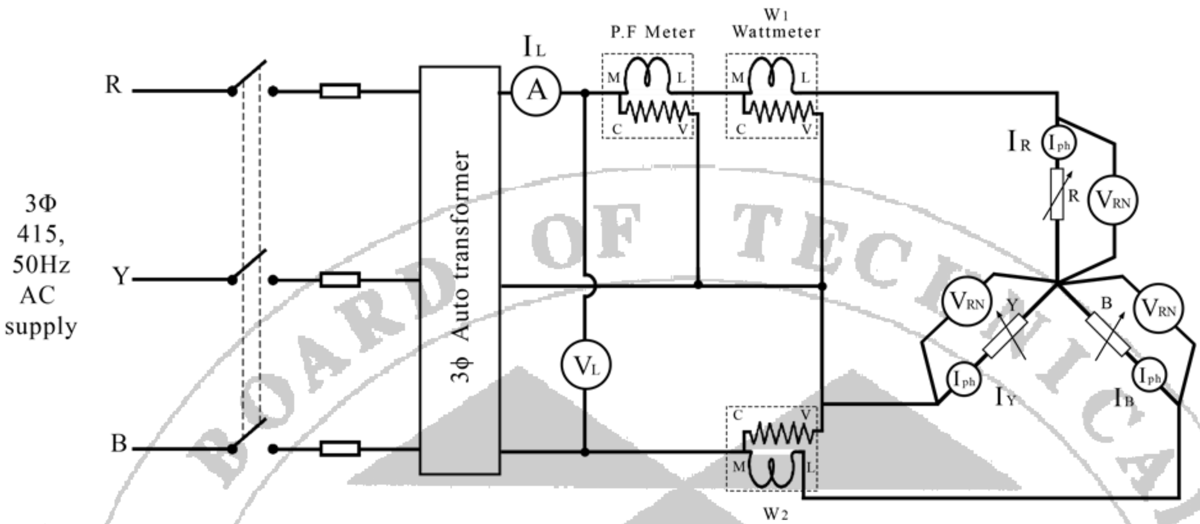

Figure-17.1 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

S. No.	Particulars	Specification	Quantity	Remark
1	Three phase variac	5KVA OR Suitable Three phase variac	1	
2	Three phase load	3-phase, Inductive/Capacitive ,5kW,415V OR Suitable Three phase load	1	
3	Ammeter	MI type :AC/DC ,0-5-10Amp,0-2.5 Amp,0-0.5-1Amp OR Suitable Ammeters	4	
4	Voltmeter	MI Type: AC/DC, 0-150/300V,0-250/500,0-75/150V OR Suitable Voltmeters	4	
5	Wattmeter	Wattmeter: Single Phase 2.5/5 Amp, 200/400V,Single Phase5/10Amp,250/500V	2	
6	Power Factor meter	Power Factor meter	1	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don’t touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.
4. Make sure that lamps are in “OFF” position before switching ON the supply.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Set the autotransformer output voltage zero.
3. Switch “On” three phase supply.
4. Set the supply voltage , and record the readings of ammeters, voltmeters ,Wattmers and power factor meter for V_L, I_L, V_{PH}, I_{PH}, W_1, W_2 , Cos Ø
5. Switch “ON” the lamps of load gradually .Make sure the three phase load is balanced.
6. Take different readings without exceeding the current limits.

XI Observation table

Sr. No	Line voltage V_L	Line current I_L	V_{RN}	V_{YN}	V_{BN}	I_R	I_Y	I_B	W_1	W_2	Cos Ø
1											
2											
3											

- Average of Phase currents= ______A
- Average of Phase Voltages=_______V

Sr.No.	Average of the three phase currents measured in above table (I_{PH})	Ratio I_L/I_{PH}	Average of the three phase voltages measured in above table (V_{PH})	Ratio V_L/V_{PH}	Active power P	Reactive power Q	Apparent power S
1							
2							
3							

XII Result(s)

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XII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Name methods to measure power in three phase circuit.
2. Define active power and state its significance.
3. Define apparent power and state its significance.
4. Define reactive power and state its significance

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XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 18: Determination of active, reactive, and apparent power for balanced three phase delta connected inductive/capacitive load.

I Practical Significance:

In a three phase circuit loads can be connected in balanced star and delta mode. Power consumed by any circuit decides the economy of the system. Therefore this practical will help you to acquire necessary skills to calculate useful power in polyphase circuit.

In the industry environment Electrical Engineering diploma graduate are expected to understand three phase circuit. In practice, large power applications (synchronous machines & Transformers, Transmission line) use three phase systems.

Three phase electrical supply systems have become popular due to the following advantages:

• The three - phase systems are most economical from the point of view of generation, transmission, distribution and utilization. If a given volume of material can handle P watts of power in a single-phase system, it can handle (1.5 x P) watts of power in a three phase system.

• Performance of three-phase generators and motors run smoothly, with no torque pulsations, unlike single phase machines

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of polyphase AC circuits.

IV Laboratory Learning Outcome(s)

Measure active, reactive and apparent power for balanced three phase star connected inductive /capacitive load.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

To measure power in a 3-phase system, it would seem necessary to use three wattmeters, each connected to neutral for a common terminal, and each responding to a line-to-neutral voltage and a line current. One would then add up the powers indicated on each wattmeter. Analysis of such a circuit shows that one wattmeter is redundant, hence the two-wattmeter method of measuring 3-phase power was developed for three wire systems. This method is satisfactory even if the loads are unbalanced. It is necessary to connect the wattmeters taking into account the polarity of their coils. When the current enters the marked terminal of the current coil and the voltage positive is connected to the marked terminal of the voltage coil, the reading represents power absorbed. In that case the algebraic sum of the wattmeters determines the total load power. In reactive circuits it

may be necessary to reverse the current coil of one wattmeter in order to get an upscale deflection. This reading is taken as negative when the total power is determined algebraically.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

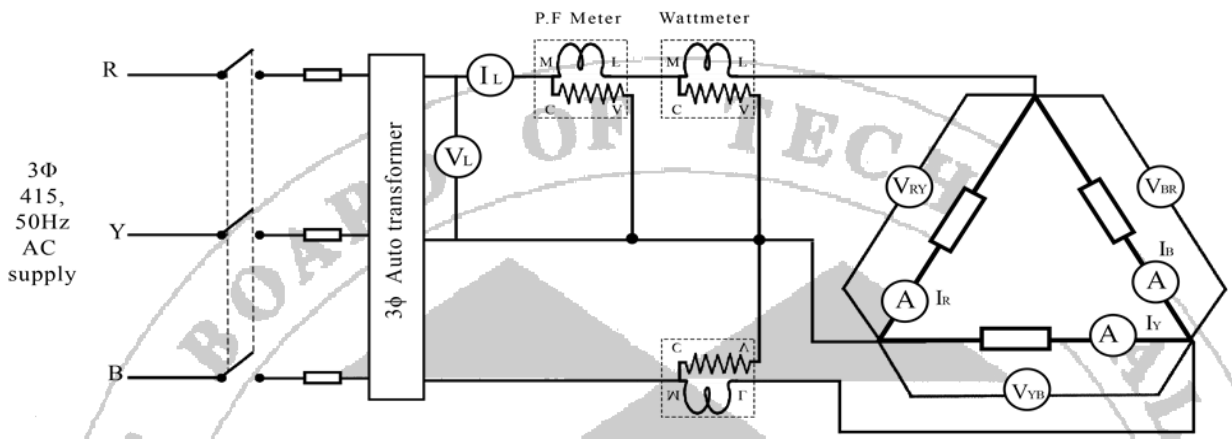

Figure-18.1 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Three phase variac	5KVA OR Suitable Three phase variac	1	
2	Three phase load	3-phase, Inductive/Capacitive ,5kW,415V OR Suitable Three phase load	1	
3	Ammeter	MI type :AC/DC ,0-5-10Amp,0-2.5 Amp,0-0.5-1Amp OR Suitable Ammeters	4	
4	Voltmeter	MI Type: AC/DC, 0-150/300V,0-250/500,0-75/150V OR Suitable Voltmeters	4	
5	Wattmeter	Wattmeter: Single Phase 2.5/5 Amp, 200/400V,Single Phase5/10Amp,250/500V	2	
6	Power Factor meter	Power Factor meter	1	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don't touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.
4. Make sure that lamps are in "OFF" position before switching ON the supply.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Set the autotransformer output voltage zero.
3. Switch "On" three phase supply.
4. Set the supply voltage , and record the readings of ammeters, voltmeters , Wattmers and power factor meter for V_L, I_L, V_{PH}, I_{PH}, W_1, W_2 , Cos Ø
5. Switch "ON" the lamps of load gradually .Make sure the three phase load is balanced.
6. Take different readings without exceeding the current limits.

XI Observation table

Sr.No.	Line voltage V_L	Line current I_L	V_{RY}	V_{YB}	V_{BR}	I_R	I_Y	I_B	W_1	W_2	Cos Ø
1											
2											
3											

Average of Phase currents= _____A

Average of Phase Voltages=______V

Sr.No.	Average of the three phase currents measured in above table (I_{PH})	Ratio I_L/I_{PH}	Average of the three phase voltages measured in above table (V_{PH})	Ratio V_L/V_{PH}	Active power P	Reactive power Q	Apparent power S
1							
2							
3							

XIIResult(s)

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XII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Name method used commonly to measure three phase power.
2. Draw phasor diagram for three phase delta connected inductive load.
3. Draw phasor diagram for three phase star Capacitive load.

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Space for Phasor Diagrams:

XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 19: Determination of active, reactive, and apparent power for unbalanced three phase star connected inductive/capacitive load.

I Practical Significance:

In a three phase circuit loads can be connected in balanced star and delta mode. Power consumed by any circuit decides the economy of the system. Therefore this practical will help you to acquire necessary skills to calculate useful power in polyphase circuit.

In the industry environment Electrical Engineering diploma graduate are expected to understand three phase circuit. In practice, large power applications (synchronous machines & Transformers, Transmission line) use three phase systems.

Three phase electrical supply systems have become popular due to the following advantages:

• The three - phase systems are most economical from the point of view of generation, transmission, distribution and utilization. If a given volume of material can handle P watts of power in a single-phase system, it can handle (1.5 x P) watts of power in a three phase system.

• Performance of three-phase generators and motors run smoothly, with no torque pulsations, unlike single phase machines

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of polyphase AC circuits.

IV Laboratory Learning Outcome(s)

Measure active, reactive and apparent power for balanced three phase star connected inductive /capacitive load.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

To measure power in a 3-phase system, it would seem necessary to use three wattmeters, each connected to neutral for a common terminal, and each responding to a line-to-neutral voltage and a line current. One would then add up the powers indicated on each wattmeter. Analysis of such a circuit shows that one wattmeter is redundant, hence the two-wattmeter method of measuring 3-phase power was developed for three wire systems. This method is satisfactory even if the loads are unbalanced. It is necessary to connect the wattmeters taking into account the polarity of their coils. When the current enters the marked terminal of the current coil and the voltage positive is connected to the marked terminal of the voltage coil, the reading represents power absorbed. In that case the algebraic sum of the wattmeters determines the total load power. In reactive circuits it

may be necessary to reverse the current coil of one wattmeter in order to get an upscale deflection. This reading is taken as negative when the total power is determined algebraically.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

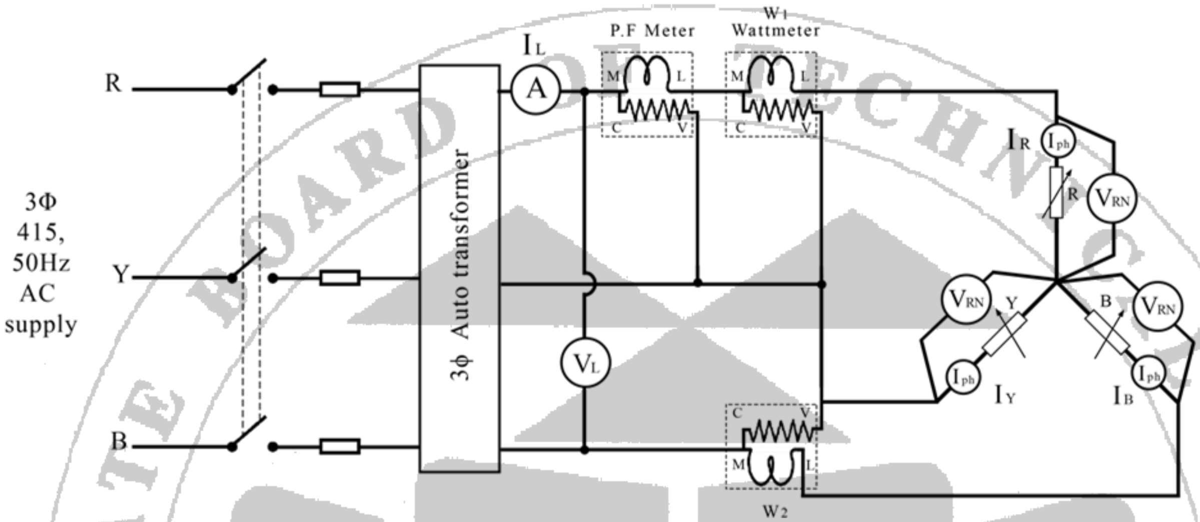

Figure-19.1 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

Sr. **No.**	**Particulars**	**Specification**	**Quantity**	**Remark**
1	Three phase variac	5KVA OR Suitable Three phase variac	1	
2	Three phase load	3-phase, Inductive/Capacitive ,5kW,415V OR Suitable Three phase load	1	
3	Ammeter	MI type :AC/DC ,0-5-10Amp,0-2.5 Amp,0-0.5-1Amp OR Suitable Ammeters	4	
4	Voltmeter	MI Type: AC/DC, 0-150/300V,0-250/500,0-75/150V OR Suitable Voltmeters	4	
5	Wattmeter	Wattmeter: Single Phase 2.5/5 Amp, 200/400V,Single Phase5/10Amp,250/500V	2	
6	Power Factor meter	Power Factor Meter:10A, 300V	1	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don't touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.
4. Make sure that lamps are in "OFF" position before switching ON the supply.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Set the autotransformer output voltage zero.
3. Switch "On" three phase supply.
4. Set the supply voltage , and record the readings of ammeters, voltmeters ,Wattmers and power factor meter for V_L, I_L,V_{PH},I_{PH},W_1,W_2 , Cos Ø
5. Switch "ON" the lamps of load gradually .Make sure the three phase load is unbalanced.
6. Take different readings without exceeding the current limits.

XI Observation table

Sr.No.	Line voltage V_L	Line current I_L	V_{RN}	V_{YN}	V_{BN}	I_R	I_Y	I_B	W_1	W_2	Cos Ø
1											
2											
3											

- Average of Phase currents= _____A
- Average of Phase Voltages=______V

Sr.No.	Average of the three phase currents measured in above table (I_{PH})	Ratio I_L/I_{PH}	Average of the three phase voltages measured in above table (V_{PH})	Ratio V_L/V_{PH}	Active power P	Reactive power Q	Apparent power S
1							
2							
3							

XII Result(s)

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XII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Write equation to calculate active power in three phase power. Also mention its unit.
2. Write equation to calculate reactive power in three phase power. Also mention its unit.
3. Write equation to calculate apparent power in three phase power. Also mention its unit.

XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 20: Determination of active, reactive, and apparent power for unbalanced three phase Delta connected inductive/capacitive load.

I Practical Significance:

In a three phase circuit loads can be connected in balanced star and delta mode. Power consumed by any circuit decides the economy of the system. Therefore this practical will help you to acquire necessary skills to calculate useful power in polyphase circuits.

In the industry environment Electrical Engineering diploma graduate are expected to understand three phase circuit. In practice, large power applications (synchronous machines & Transformers, Transmission line) use three phase systems.

Three phase electrical supply systems have become popular due to the following advantages:

• The three - phase systems are most economical from the point of view of generation, transmission, distribution and utilization. If a given volume of material can handle P watts of power in a single-phase system, it can handle (1.5 x P) watts of power in a three phase system.

• Performance of three-phase generators and motors run smoothly, with no torque pulsations, unlike single phase machines

II Industry/Employer Expected Outcome(s)

Diagnose and rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Analyze the parameters of polyphase AC circuits.

IV Laboratory Learning Outcome(s)

Measure active, reactive and apparent power for balanced three phase star connected inductive /capacitive load.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

To measure power in a 3-phase system, it would seem necessary to use three wattmeters, each connected to neutral for a common terminal, and each responding to a line-to-neutral voltage and a line current. One would then add up the powers indicated on each wattmeter. Analysis of such a circuit shows that one wattmeter is redundant, hence the two-wattmeter method of measuring 3-phase power was developed for three wire systems. This method is satisfactory even if the loads are unbalanced. It is necessary to connect the wattmeters taking into account the polarity of their coils. When the current enters the marked terminal of the current coil and the voltage positive is connected to the marked terminal of the voltage coil, the reading represents power absorbed. In that case the algebraic sum of the wattmeters determines the total load power. In reactive circuits it

may be necessary to reverse the current coil of one wattmeter in order to get an upscale deflection. This reading is taken as negative when the total power is determined algebraically.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

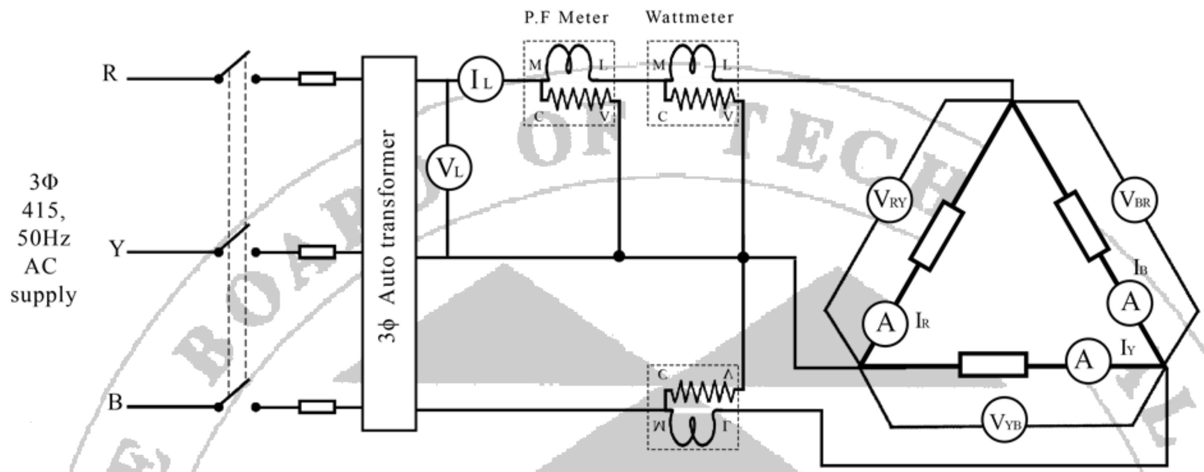

Figure-20.1 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Three phase variac	5KVA OR Suitable Three phase variac	1	
2	Three phase load	3-phase, Inductive/Capacitive ,5kW,415V OR Suitable Three phase load	1	
3	Ammeter	MI type :AC/DC ,0-5-10Amp,0-2.5 Amp,0-0.5-1Amp OR Suitable Ammeters	4	
4	Voltmeter	MI Type: AC/DC, 0-150/300V,0-250/500,0-75/150V OR Suitable Voltmeters	4	
5	Wattmeter	Wattmeter: Single Phase 2.5/5 Amp, 200/400V,Single Phase5/10Amp,250/500V	2	
6	Power Factor meter	Power Factor meter	1	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don't touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.
4. Make sure that lamps are in "OFF" position before switching ON the supply.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Set the autotransformer output voltage zero.
3. Switch "On" three phase supply.
4. Set the supply voltage , and record the readings of ammeters, voltmeters ,Wattmers and power factor meter for V_L, I_L,V_{PH},I_{PH},W_1,W_2 , Cos Ø
5. Switch "ON" the lamps of load gradually .Make sure the three phase load is unbalanced.
6. Take different readings without exceeding the current limits.

XI Observation table

Sr.No.	Line voltage V_L	Line current I_L	V_{RN}	V_{YN}	V_{BN}	I_R	I_Y	I_B	W_1	W_2	Cos Ø
1											
2											
3											

- Average of Phase currents= _____A
- Average of Phase Voltages=_______V

Sr.No.	Average of the three phase currents measured in above table (I_{PH})	Ratio I_L/I_{PH}	Average of the three phase voltages measured in above table (V_{PH})	Ratio V_L/V_{PH}	Active power P	Reactive power Q	Apparent power S
1							
2							
3							

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Write formula to convert three phase star connected balanced load to convert to equivalent delta connected load.

2. Write formula to covert three phase delta connected balanced load to convert to equivalent star connected load.

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XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theor

XVII Assessment Table

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 21: Verification of Mesh analysis.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to understand the network analysis. The Electrical circuit for different systems involves a number of branches. Measurement of current, & voltage across a branch is required for analysis of electrical networks. These parameters can be calculated using Mesh Analysis of the given circuit. This experiment will help you to verify the theoretically obtained current through a branch using mesh analysis.

II Industry/Employer Expected Outcome(s)

Diagnose and Rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Apply network reduction methods to solve DC circuits

IV Laboratory Learning Outcome(s)

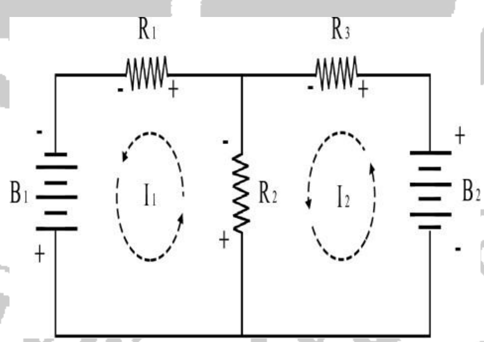
Measure current through the branch for given electric network and verify by applying mesh analysis.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

In this method of analysis, Kirchhoffs Voltage Law is applied to a closed loop network. Mesh equations in terms of mesh currents can be written. By solving simultaneous linear equations for multiple meshes, current through particular branch can be found out.



Mesh equations:

$$(I_1 - I_2)R_2 + I_1 * R_1 - B_1 = 0$$

$$I_2 * R_3 - (I_1 - I_2)R_2 - B_2 = 0$$

Simplified

$$(R_1 + R_2)I_1 - R_2 * I_2 = B1$$

$$-R_2 * I_1 + (R2+R_3)I_2 = B2$$

VII Actual Circuit diagram used in laboratory with equipment Specifications:

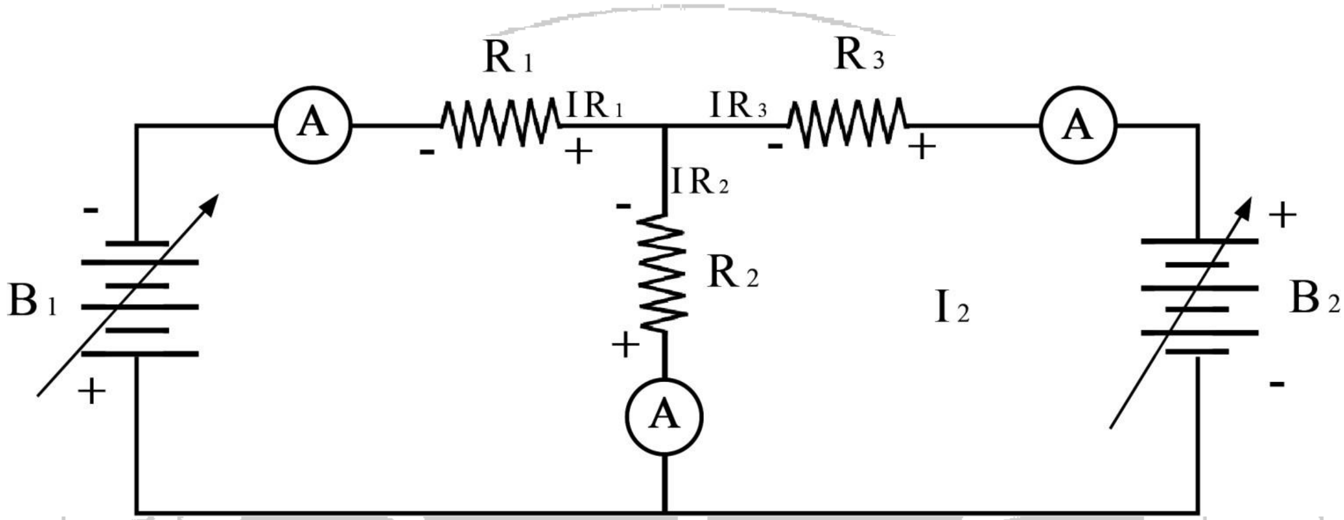


Figure-21.2 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

S.No.	Particulars	Specification	Quantity	Remark
1	DC Regulated power supply	0-30V, 0-100mA	1	
2	Trainer Kit	Trainer Kit for verification of Superposition Theorem as per circuit diagram	1	
3	Multimeter	Suitable Multimeter	1	

IX Precautions to be followed:

1. Ensure the power switch is in "OFF" condition initially.
2. Check the proper range and mode of the multimeter as ammeter and voltmeter.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Switch ON the both voltage sources B_1 and B_2
3. Set V_{B1} and V_{B2} at predefined values.

4. Note down the corresponding multimeter readings I1, I2, and I3 .
5. Change the values of V_{B1} and V_{B2} to get one more reading.
6. Reduce the supply voltage to zero and switch "OFF" the supply.

XI Observation table

Sr. No	Measurement					Calculation by Mesh analysis		
	V_{B1}	V_{B2}	I_{R1}	I_{R2}	I_{R3}	I_{R1}	I_{R2}	I_{R3}
1								
2								

Calculations: Write Kirchhoffs Voltage Equations for the meshes. Simplify the equations. Write the equations in matrix form & find the values of mesh currents and branch current.

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XII Result(s)

1. Observed value of current through branch I_{R2} =
2. Calculated value of current through branch I_{R2} =

XIII Interpretation of results

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XIV Conclusion and recommendation

XV Practical related questions (Provide space for answers)

1. Write steps of mesh analysis of electrical networks.
2. Explain when mesh analysis method is suitable for analysis of network.
3. What are the limitations of mesh analysis?
4. State Kirchhoffs voltage law. Define voltage drop and voltage rise with example.

XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 22: Verification of Nodal analysis.

I Practical Significance:

In the industry environment Electrical Engineering diploma graduate are expected to understand the network analysis. The Electrical circuit for different systems involves a number of branches. Measurement of current & voltage across a branch is required for analysis of electrical networks. These parameters can be calculated using nodal analysis of the given circuit. This experiment will help you to verify the theoretically obtained voltage across a branch using nodal analysis.

II Industry/Employer Expected Outcome(s)

Diagnose and Rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Apply network reduction methods to solve DC circuits

IV Laboratory Learning Outcome(s)

Measure current through the branch for given electric network and verify by applying nodal analysis.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background (With diagrams if required)

The method of nodal analysis is mainly based on Kirchhoffs current law. Every junction point in a network where three or more branches meet is called a node. One of the node is regarded as the reference node or datum node or zero potential node. The potentials of the other nodes are then assumed with respect to this arbitrarily chosen zero potential node. The potential equations are then written for all the nodes using Kirchhoff's current law. Similar to mesh analysis, this method also reduced the number of independent equations to be solved. If n is the number of independent nodes, the number of simultaneous equations to be solved becomes (n-1). To determine the node potentials and thereafter, the branch currents can be calculated.

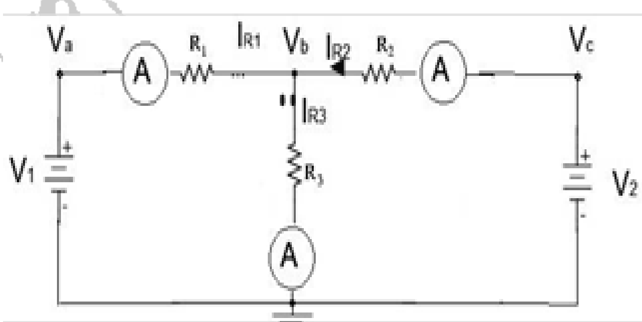

Figure-22.1 KCL diagram

Apply KCL at node b,

$I_{R1}+I_{R2}=I_{R3}$, $[(Va-Vb)/R_1]+[(Vc-Vb)/R_2]=Vb/R_3$.-------- (1)

In this circuit diagram the value of node potential Va is V_1 and node potential V_b is V_2. In equation (1) only one unknown variable is V_b. The unknown node potential V_b is obtained by solving equation (1).

VII Actual Circuit diagram used in laboratory with equipment Specifications:

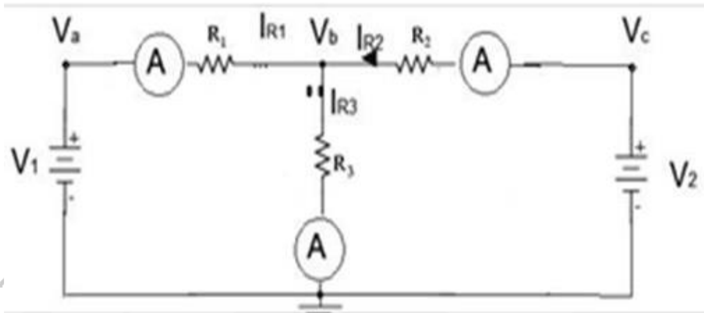

Figure-22.2 Circuit diagram

VIII Required Resources/apparatus/equipment with specification:

S.No.	Particulars	Specification	Quantity	Remark
1	DC Regulated power supply	0-30V, 0-100mA	1	
2	Trainer Kit	Trainer Kit for verification of Superposition Theorem as per circuit diagram	1	
3	Multimeter	Suitable Multimeter	1	

IX Precautions to be followed:

1. Ensure the power switch is in "OFF" condition initially.

2. Check the proper range and mode of the multimeter as ammeter and voltmeter.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Switch ON the both voltage sources B_1 and B_2
3. Set V_{B1} and V_{B2} at predefined values.
4. Note down the corresponding multimeter readings I1, I2, and I3 and potentials at different nodes.
5. Change the values of V_{B1} and V_{B2} to get one more reading.
6. Reduce the supply voltage to zero and switch "OFF" the supply.

XI Observation table

Sr. No	Measurement					Calculation by Mesh analysis				
	V_a	V_b	V_c	V_{R3}	I_{R3}	V_a	V_b	V_c	V_{R3}	I_{R3}
1										
2										

Calculations: Write Kirchhoffs Current Equations for the nodes. Simplify the equations. Write the equations in matrix form & find the values of mesh currents and branch current.

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XII Result(s)

1. Observed value of current through branch I_{R3} =
2. Calculated value of current through branch I_{R3} =

XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Write steps of nodal analysis of electrical networks.
2. Explain when nodal analysis method is suitable for analysis of network.
3. What are the limitations of nodal analysis?
4. Write difference between mesh and nodal analysis.

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XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Assessment Table

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
1	Calculated theoretical values of given component	10%
2	Interpretation of result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	Product Related (10)	Total (25)	

Practical No. 23: Verification of Superposition Theorem.

I Practical Significance:

The Electrical & Electronic circuit for different systems involves a number of branches. Many a times as per the requirement, measurement of current, voltage across a branch is required. These parameters of the circuit can be calculated using Superposition theorem in a network having more than one sources. This experiment will help you to verify the theoretically obtained current through a branch using superposition theorem.

II Industry/Employer Expected Outcome(s)

Diagnose and Rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Apply network theorems to solve basic electrical circuits.

IV Laboratory Learning Outcome(s)

LLO 1 Measure current through the branch for a given DC electric network and

verify by applying superposition theorem.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

Superposing theorem:

For a linear system the response (voltage or current) in any branch of a bilateral circuit having more than one independent source, equals the algebraic sum of the responses caused by each independent sources acting alone, where all the other independent sources are replaced by their internal impedances.

Deactivation of sources

1. Voltage source is deactivated by short circuit it leaving behind its internal impedance if any.
2. Current source is deactivated by open circuit it leaving behind its internal impedance if any.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

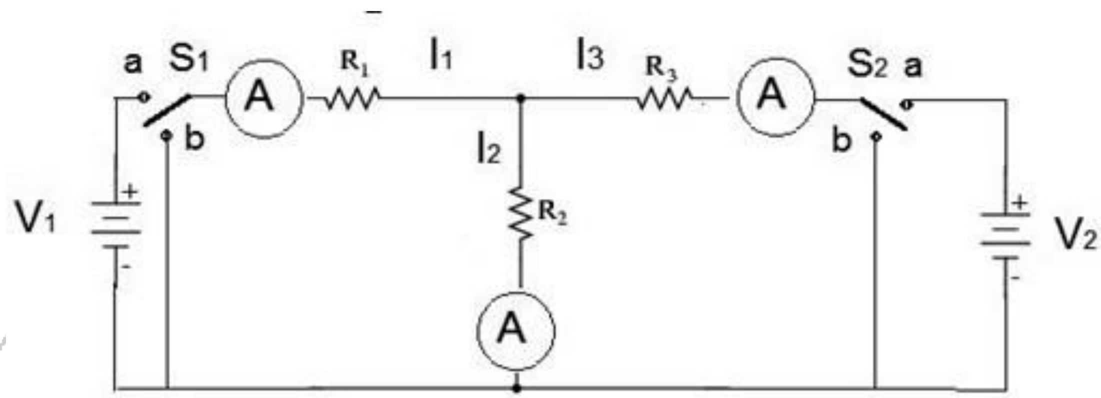

Figure-23.1 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

S.No.	Particulars	Specification	Quantity	Remark
1	DC Regulated power supply	0-30V, 0-100mA	1	
2	Trainer Kit	Trainer Kit for verification of Superposition Theorem as per circuit diagram	1	
3	Multimeter	Suitable Multimeter	1	

IX Precautions to be followed:

1. Ensure the power switch is in "OFF" condition initially.
2. Check the proper range and mode of the multimeter as ammeter and voltmeter.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Switch ON voltage source V_1 by connecting switch S_1 to 'a' and note down the corresponding multimeter readings $I_{1'}$, $I_{2'}$ and I_3'. (Short circuit voltage source V_2 by connecting switch S_2 to 'b').
3. Reduce the supply voltage to zero and switch "OFF" V_1.
4. Now, Switch "ON" voltage source V_2 by connecting switch S_2 to 'a' and note down the corresponding multimeter readings $I_{1''}$, $I_{2''}$ and $I_{3''}$ (Short circuit voltage source V_1 by connecting switch S_1 to 'b').

5. Switch ON the both voltage sources V_1 and V_2 and note down the corresponding multimeter readings I_1, I_2, and I_3 .
6. Reduce the supply voltage to zero and switch "OFF" V_2.
7. .Algebraically add the currents in steps 4 and 6 above and compare with current In step 7 above to verify the theorem.

XI Observation Table: (and Calculations) (use blank sheet provided if space not sufficient)

S. No	Observed									Calculated								
	Voltage source V_1 ON			Voltage source V_2 ON			Both Voltage source V_1 & V_2 ON			Voltage source V_1 ON			Voltage source V_2 ON			Both Voltage source V_1 & V_2 ON		
	I_1'	I_2'	I_3'	I_1''	I_2''	I_3''	I_1	I_2	I_3	I_1'	I_2'	I_3'	I_1''	I_2''	I_3''	I_1	I_2	I_3
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Calculations:-

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions

1 State the limitations of superposition theorem.

2 Can superposition theorem be applied to a circuit containing one AC and one DC source?

3 Write steps to solve the given DC circuit using Superposition Theorem.

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XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	Product Related (10)	Total (25)	

Practical No. 24: Verification of Thevenin's Theorem.

I Practical Significance:

The Electrical & Electronic circuit for different systems involves a number of branches. Many a times as per the requirement, measurement of current, voltage across a branch is required. These parameters of the circuit can be calculated using Thevenin's theorem in a network .

The Thevenin's equivalent circuit is used to represent any network of linear sources and impedances at a given frequency. Norton's theorem and its dual, Thévenin's theorem, are widely used for circuit analysis simplification and to study circuit's initial-condition and steady-state response.

This experiment will help you to verify the theoretically obtained current through a branch using Thevenin's theorem.

II Industry/Employer Expected Outcome(s)

Diagnose and Rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Apply network theorems to solve basic electrical circuits.

IV Laboratory Learning Outcome(s)

LLO1: Measure Thevenin's equivalent circuit parameters for a given DC circuit and verify by applying Thevenin's theorem.

LLO2:Draw Thevenin's equivalent Circuit and Verify the load current.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

Statement of Thevenin's theorem: Any linear, bilateral electrical network having open terminals A & B (by removing load resistance) can be replaced by a single voltage source of V_{TH} in series with a single resistance R_{TH}. Where, V_{TH} is the voltage obtained across the open terminals A & B. The resistance R_{TH} is the equivalent resistance of the network measured between open terminals A & B, with all sources replaced by their internal resistances.

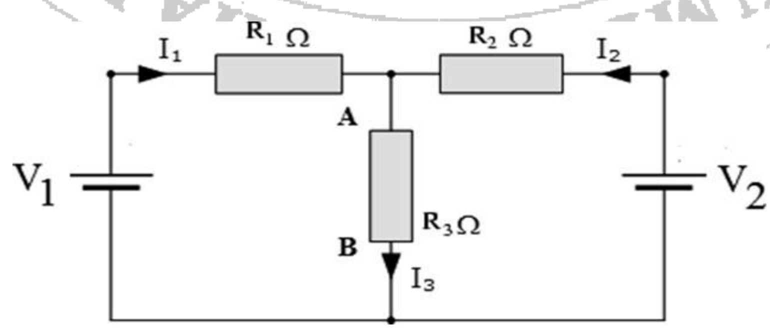

Figure-24.1 Thevenin's theorem Diagram

VII Actual Circuit diagram used in laboratory with equipment Specifications:

Circuit for measurement of V_{TH}:

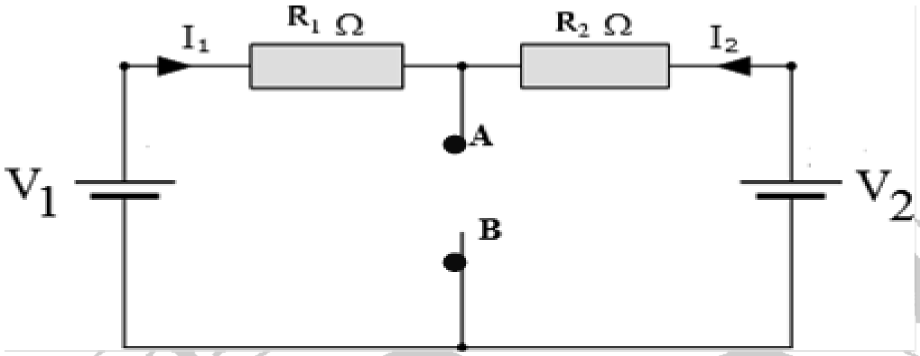

Figure-24.2 Calculation of V_{TH}

Circuit for measurement of R_{TH}:

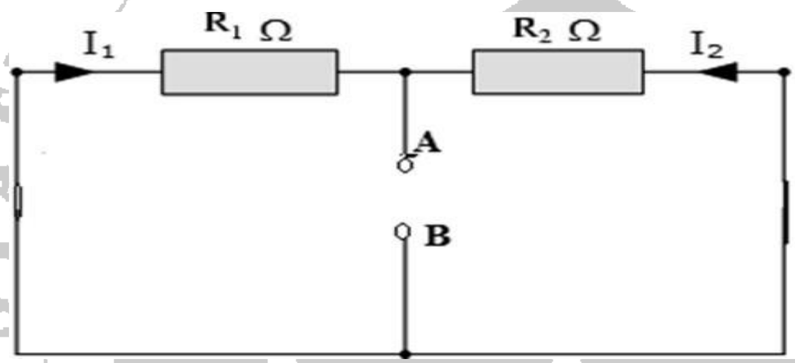

Figure-24.3 Calculation of R_{TH}

VIII Required Resources/apparatus/equipment with specification:

S.No.	Particulars	Specification	Quantity	Remark
1	DC Regulated power supply	0-30V, 0-100mA	1	
2	Trainer Kit	Trainer Kit for verification of Thevenin's Theorem as per circuit diagram	1	
3	Multimeter	Suitable Multimeter	1	

IX Precautions to be followed:

1) Ensure the power switch is in "OFF" condition initially.
2) Check the proper range and mode of the multimeter as ammeter and voltmeter.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Remove load resistance R3 through terminals A & B
3. Switch "ON" both voltage sources V_1 and V2 and note down the voltage across the open terminals A and B (i.e. V_{TH}). As shown in figure 2.
4. Remove both voltage sources and replace by internal resistances (short circuit the terminal) and measure the resistance between open terminals A and B (i.e. R_{TH}). As shown in figure 3
5. Calculate the current in resistance R_3 by using observed V_{TH} and R_{TH}, $I_{R3} = V_{TH}/(R_{TH} + R_3)$.
6. Switch off the supply.
7. Verify theorem by calculating the values.

XI Observation Table: (and Calculations) (use blank sheet provided if space not sufficient)

Sr.no.	**Observed**			**Calculated**		
	V_{TH} Volts	R_{TH} Ω	$I_{R3} = V_{TH}/(R_{TH} + R_3)$ Amp	V_{TH} Volts	R_{TH} Ω	$IR3 = V_{TH}/(R_{TH} + R_3)$ Amp
1						

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. State the necessity of Theorems in electrical circuit.
2. How will you overcome the problem of overload of DC power supply?
3. Can we perform the experiment with ac supply also? Justify

XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 25: Verification of Norton's Theorem.

I Practical Significance:

The Electrical & Electronic circuit for different systems involves a number of branches. Many a times as per the requirement, measurement of current, voltage across a branch is required. These parameters of the circuit can be calculated using Norton's theorem in a network .

The Norton equivalent circuit is used to represent any network of linear sources and impedances at a given frequency. Norton's theorem and its dual, Thévenin's theorem, are widely used for circuit analysis simplification and to study circuit's initial-condition and steady-state response.

This experiment will help you to verify the theoretically obtained current through a branch using Norton's theorem.

II Industry/Employer Expected Outcome(s)

Diagnose and Rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Apply network theorems to solve basic electrical circuits.

IV Laboratory Learning Outcome(s)

LLO 1 Measure Norton's equivalent circuit parameters for a given DC circuit and verify by applying Norton's theorem.

LLO2:Draw Norton's equivalent Circuit and Verify the load current.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

Statement of Norton's theorem:

Any linear bilateral network having two terminals A & B of load can be replaced by a current source of a current I_N in parallel with a resistance R_N. The current source I_N is equal to the current that would flow through AB when A & B are short circuited. The resistance R_N is the resistance of the network measured between A & B with load removed & the all sources are replaced by their internal resistances.

VII Actual Circuit diagram used in laboratory with equipment Specifications:

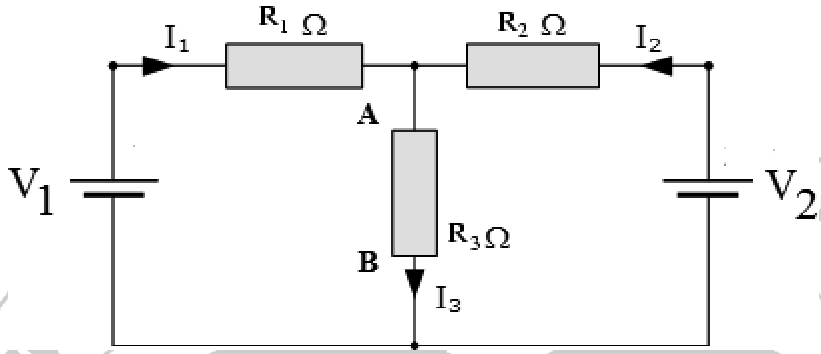

Figure-25.1 Circuit Diagram

Circuit for measurement of I_N:

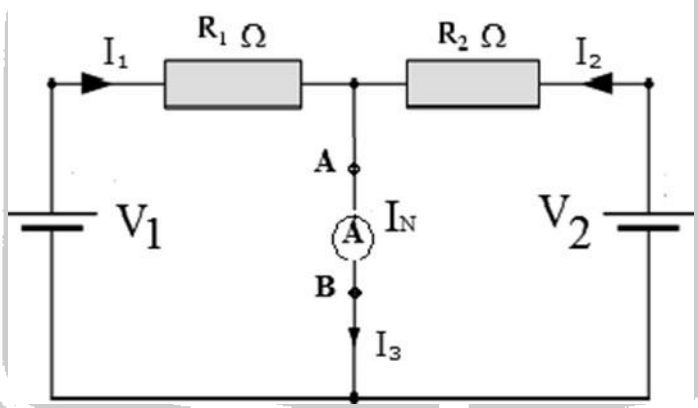

Figure-25.2 Measurement of I_N

Circuit for measurement of $R_N = R_{TH}$:

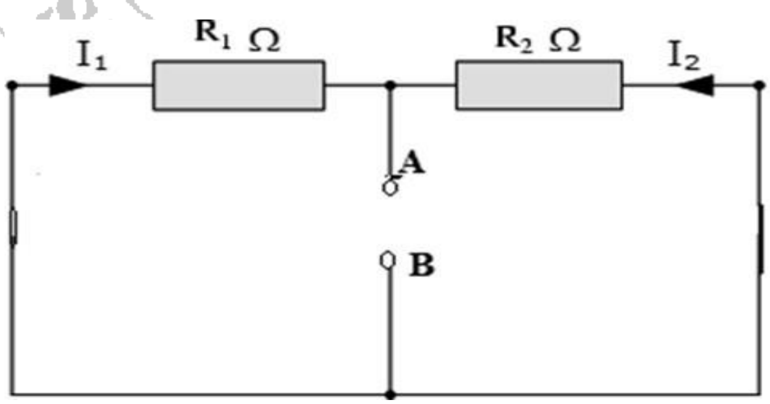

Figure-25.3 Measurement of $R_N = R_{TH}$

VIII Required Resources/apparatus/equipment with specification:

S.No.	Particulars	Specification	Quantity	Remark
1	DC Regulated power supply	0-30V, 0-100mA	1	
2	Trainer Kit	Trainer Kit for verification of Norton's Theorem as per circuit diagram	1	
3	Multimeter	Suitable Multimeter	1	

IX Precautions to be followed:

1. Ensure the power switch is in "OFF" condition initially.
2. Check the proper range and mode of the multimeter as ammeter and voltmeter.

X Procedure

1. Connect the circuit as shown in circuit diagram of figure 2.
2. Remove load resistance R3 & short circuit terminals A & B through ammeter.
3. Switch "ON" both voltage sources V_1 and V_2 and note down the current through the short terminals A and B (i.e.I_N)- As shown in figure 2.
4. Remove both voltage sources by internal resistances or short circuits the terminal of its and measure the resistance between open terminals A and B (i.e. R_N)- As shown in figure 3
5. Calculate the current in resistance R_3 by using observed value of I_N and R_N.

   $I_L = I_3 = I_N \text{ X } R_N/ (R_N+R_3)$.
6. Calculate the current in resistance R_3 by using Norton's theorem.
7. Switch off the supply.
8. Verify theorem using calculated values.

XI Observation Table: (and Calculations) (use blank sheet provided if space not sufficient)

Sr.no.	Observed			Calculated		
	I_N (Amps)	R_N Ω	IR_3 (Amps)	I_N (Amps)	R_N Ω	$IR_3 = I_N * R_N / (R_3+R_N)$ (Amps)
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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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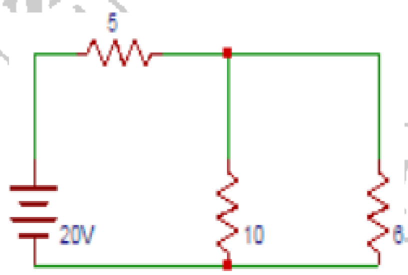
XV Practical related questions (Provide space for answers)

1. Find the voltage drop across 6Ω resistor using Norton's theorem in the circuit shown below.



2. Write applications of Norton's Theorem.
3. How to convert Norton's Circuit to Thevenin's Circuit.

XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Suggested Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 26: Verification of Maximum Power Transfer Theorem.

I Practical Significance:

The maximum power is delivered through the load in a circuit when the resistance of the load is equal to the resistance of the available source. To design economical electrical and electronic circuits this theorem is useful as it gives optimum value of load/source resistance to transfer power from source to load.

Efficiency takes into account the ratio of the dissipated power in the load divided by the source power, on the other hand the maximum power transfer considers only the magnitude of the dissipated power.

II Industry/Employer Expected Outcome(s)

Diagnose and Rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Apply network theorems to solve basic electrical circuits.

IV Laboratory Learning Outcome(s)

LLO 1 Measure load resistance to transfer maximum power for a given DC circuit and verify by applying maximum power transfer theorem.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

It states that, maximum power is absorbed by the load from the source when the load resistance (R_L) is equal to the internal resistance (R_I) of the source.

Power absorbed by the load (PL) will be maximum when $R_I = R_L$

- Total power Supplied by the Source $P = P_I + P_L$
- Power loss in the internal resistance of source $P_I = I_2 * I_2 * _{RI}$
- Power absorbed by the load $P_L = I_2 * R_I$ (as $R_I = R_L$) i.e. efficiency= 50%

VII Actual Circuit diagram used in laboratory with equipment Specifications:

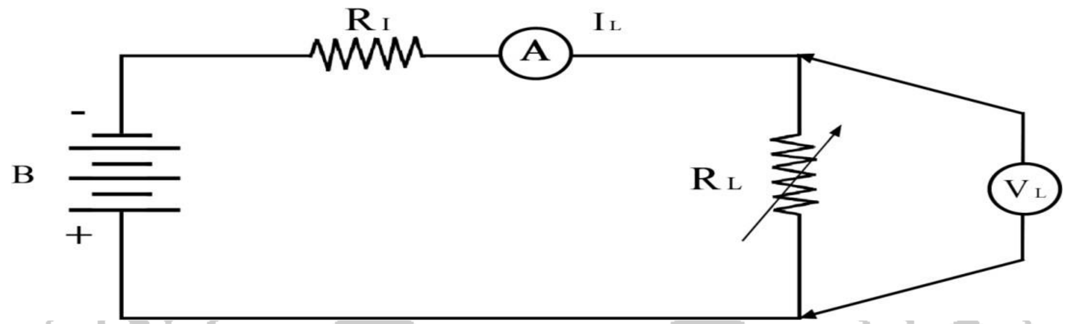


Figure-26.1 Circuit Diagram

VIII Required Resources/apparatus/equipment with specification:

S.No.	Particulars	Specification	Quantity	Remark
1	DC Regulated power supply	0-30V, 0-100mA	1	
2	Trainer Kit	Trainer Kit for verification of Maximum Power Transfer Theorem as per circuit diagram	1	
3	Multimeter	Suitable Multimeter	1	

IX Precautions to be followed:

1. Ensure the power switch is in "OFF" condition initially.
2. Check the proper range and mode of the multimeter as ammeter and voltmeter.

X Procedure

1) Make the connections as shown in circuit diagram.
2) Set the supply voltage to its rated value
3) Switch ON the supply.
4) Record the readings current and voltage across load by varying the load resistance R_L.
5) Switch OFF the supply

6) Perform the necessary calculations.

7) Plot the graph between load resistance R_L and powers absorbed by the load P_L and determine the value of load resistance for maximum power transfer from graph.

XI Observation Table: (and Calculations) (use blank sheet provided if space not sufficient)

Sr. No.	Measured Values at R_i= ---Ω		Calculated Values	
	Current through load resistance I_L(Amp)	Voltage across load resistance V_L (Volts)	Load resistance $R_L=V_L/I_L$ Ohms	Power absorbed by load resistance $P_L=I_L^2*R_L$ Watts
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XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. Prove that the efficiency is 50% under maximum power transfer condition.
2. State the purpose and applications of maximum power transfer theorem.
3. Under what situation maximum power transfer theorem is not applicable? Give reasons.

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XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 27: Verification of Superposition Theorem for AC network.

I Practical Significance:

The Electrical & Electronic circuit for different systems involves a number of branches. Many a times as per the requirement, measurement of current, voltage across a branch is required. These parameters of the circuit can be calculated using Superposition theorem in a network having more than one sources. This experiment will help you to verify the theoretically obtained current through a branch using superposition theorem.

II Industry/Employer Expected Outcome(s)

Diagnose and Rectify simple electric circuit and network related problems in industry.

III Course Level Learning Outcome(s)

Apply network theorems to solve basic electrical circuits.

IV Laboratory Learning Outcome(s)

LLO 1 Measure current through the branch for a given AC electric network and

verify by applying superposition theorem.

V Relevant Affective Domain related outcome(s)

Follow safety electrical rules for safe practices.

VI Relevant Theoretical Background

Superposing theorem:

For a linear system the response (voltage or current) in any branch of a bilateral circuit having more than one independent source, equals the algebraic sum of the responses caused by each independent sources acting alone, where all the other independent sources are replaced by their internal impedances.

Deactivation of sources

1. Voltage source is deactivated by short circuit it leaving behind its internal impedance if any.
2. Current source is deactivated by open circuit it leaving behind its internal impedance if any.

The theorem is applicable to linear networks (time varying or time invariant) consisting of independent sources, linear dependent sources, linear passive elements (resistors, inductors, capacitors) and linear transformers.

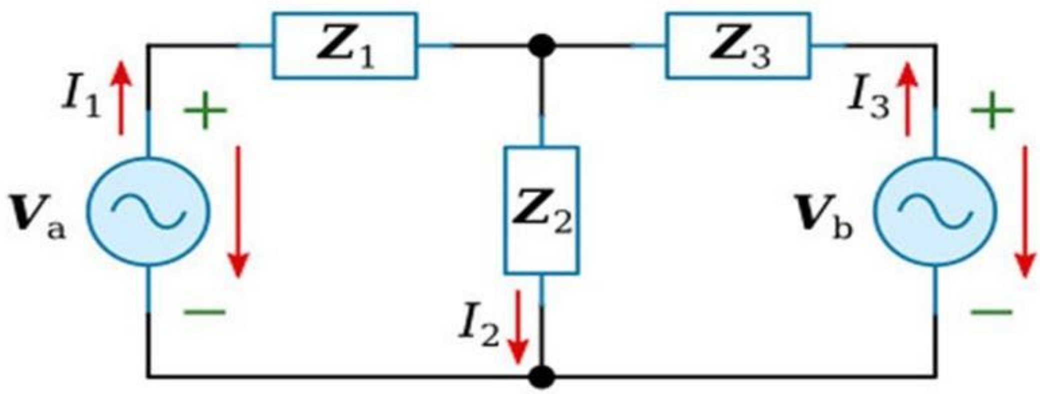

Figure-27.1 Circuit Diagram

VII Actual Circuit diagram used in laboratory :

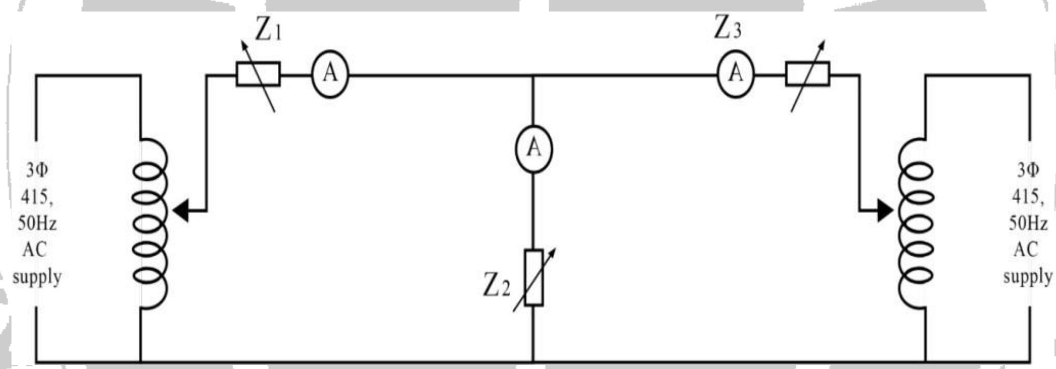

Figure-27.2 Actual Circuit diagram

VIII Required Resources/apparatus/equipment with specification:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Dimmer	Dimmer- 1-phase,1KVA,230V	1	
2	Rheostat	18Ω-10A/250Ω-2A/500Ω-1A/720Ω-0.8A or Suitable range	3	
3	Inductor	1.3H or Suitable Range	1	
4	Capacitor	10µF,250V or suitable range	1	
5	Ammeter	0-/1A/2A/5A/10A Or any Suitable Range	3	

IX Precautions to be followed:

1. Avoid loose connections.
2. Don't touch wire with wet hands.
3. Make sure that autotransformer is at zero Voltage position before switching ON the supply.
4. Ensure the power switch is in "OFF" condition initially.

X Procedure

1. Connect the circuit as shown in circuit diagram.
2. Switch ON voltage source V_1 and note down the corresponding ammeter readings I_1', I_2' and I_3'. (Short circuit voltage source V_2).
3. Reduce the supply voltage to zero and switch "OFF" V_1.
4. Now, Switch "ON" voltage source V_2 note down the corresponding ammeter readings I_1'', I_2'' and I_3'' (Short circuit voltage source V_1).
5. Switch ON both voltage sources V_1 and V_2 and note down the corresponding ammeter readings I_1, I_2, and I3 .
6. Reduce the supply voltage to zero and switch "OFF" V_1 & V_2.
7. Phasor addition of the currents in steps 2 and 4 above and compare with current In step 5 above to verify the theorem.

XI Observation Table: (and Calculations) (use blank sheet provided if space not sufficient)

sr. **No**	**Observed**									**Calculated**								
	Voltage source V_1 ON			Voltage source V_2 ON			Both Voltage source V_1 & V_2 ON			Voltage source V_1 ON			Voltage source V_2 ON			Both Voltage source V_1 & V_2 ON		
	I_1'	I_2'	I_3'	I_1''	I_2''	I_3''	I_1	I_2	I_3	I_1'	I_2'	I_3'	I_1''	I_2''	I_3''	I_1	I_2	I_3
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Calculations:-

XII Result(s)

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XIII Interpretation of results

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XIV Conclusion and recommendation

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XV Practical related questions (Provide space for answers)

1. State the difference between treatment of Superposition theorem applied for AC and DC Supply for calculation of current through the circuit.
2. Write steps to solve the given AC network using Superposition
3. When removing a current source, its value is set to zero. This is done by replacing the current source with an ______

   a) Light bulb b)Short circuit c)Open circuit d)Resistor
4. Superposition theorem is valid for

   a) Linear circuits b) Non-linear circuits c) Both linear and non-linear circuits

   1. None of the options

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XVI References/Suggestions for further reading:

1. www.howstuffworks.com
2. www.electricaltechnology.org
3. https://nptel.ac.in/
4. https://vlab.amrita.edu
5. www.nptelvideos.in/electrical engineering/circuit theory

XVII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusions	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	