LABORATORY MANUAL

ELECTRICAL CIRCUIT ANALYSIS

B.Tech I YEAR SEM -II

A.Y: 2022-23

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INSTITUTE VISION

The aspiration is to emerge as a premier institution in technical education to produce
Competent engineers and management professionals contributing to Industry and Society.

INSTITUTE MISSION

The aspirations are fulfilled and continue to be fulfilled:

MI-1: By providing the student supporting systems:

To impart updated pedagogical techniques with supportive learning environment and state-of-the-art facilities.

MI-2: By training the students as per the industry needs:

To cultivate a culture of interdisciplinary approach, problem solving, innovative ecosystem, and entrepreneurship by facilitating critical thinking, teamwork, and research-driven activities with hands-on learning.

MI-3: By educating the students about society's needs:

To instill ethical, social, and environmental values through community engagement resulting in sustainable development of society.

DEPARTMENT VISION

The aspiration is to produce competent Electrical and Electronics Engineering Graduates capable of making valuable contributions in the field of Electrical and Electronics Engineering.

DEPARTMENT MISSION

MD-1:
Student Support Systems:
To equip students with advanced learning skills in Electrical and Electronics Engineering, while providing them with the necessary professional competencies to overcome future challenges.

MD-2:
Training the students as per the industry needs:
To facilitate the students to acquire interdisciplinary skills in renewable energy, electric Vehicles, and power electronics applications through practical knowledge and innovativeTechniques to meet evolving global challenges.

MD-3:
Educating the students, the needs of society:
To develop professional ethics, self-confidence, and leadership qualities among students.

ELECTRICAL CIRCUIT ANALYSIS LABORATORY

I B.Tech I/II -Semester

Prerequisites: ELECTRICAL CIRCUIT ANALYSIS

COURSE OBJECTIVES:

- To design electrical systems and analyze them by applying various Network Theorems
- To measure three phase Active and Reactive power.
- To understand the locus diagrams and concept of resonance.

COURSE OUTCOMES: After learning the contents of this paper the student must be able to

- Analyze complex DC and AC linear circuits
- Apply concepts of electrical circuits across engineering
- Evaluate response of a given network by using theorems.

Course Objectives	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
To design electrical systems and analyses them by applying various Network Theorems	2	1	2	2	2	2	2	1	1	1	2	3
To measure three phase Active and Reactive power	2	1	2	2	2	2	2	1	1	1	2	3
To understand the Locus diagrams and Concept of Resonance.	2	1	2	2	2	2	2	1	1	1	2	3

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Analyze complex DC And AC linear circuits.	2	1	2	2	2	2	2	1	2	1	2	3
Apply concepts of electrical circuits across engineering	2	1	2	2	2	2	2	1	2	1	2	3
Evaluate response of a given network by Using theorems.	2	1	2	2	2	2	2	1	2	1	2	3

INSTRUCTIONS TO THE STUDENTS

1. Students are required to attend all labs.
2. Students should work in a group of two in hardware laboratories and individually in computer laboratories.
3. While coming to the lab the student should bring the observation book, record, HB pencil, scale, eraser & sharpener.
4. Before coming to the lab, the student should go through the procedure of the lab experiments.
5. The student should utilize the prescribed time allotted for lab session properly to perform the experiment & to note down the readings.
6. The student should complete the circuit design, calculations (if necessary), and graph within the allotted time and should take the signature from faculty incharge of the laboratory.
7. If the experiment is not completed in the prescribed time, the pending work has to be done in the session(s) allotted for repetition only.
8. You will be expected to submit the completed record book according to the deadlines set up by your instructor.
9. For practical subjects there shall be a continuous evaluation during the semester for 25 sessional marks and 50 end examination marks. Of the 25 marks for internal, 15 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.
10. The end examination shall be conducted by the teacher concerned & another member of the staff of the same department.

Do’s and Don’ts

Do’s:

- Proper Dress Has to Be Maintained While Entering in The session.(Boys Tuckin And Shoes, Girls with Apron).
- Students Should Carry Observation Notes and manual Completed in All Aspects.
- Correct Specifications of The Equipment Have to Be Mentioned in The CircuitDiagram.
- Student Should Be Aware of Operating Equipment.
- Students Should Be at Their Concerned Exercise Table, Unnecessary Moment is Restricted.
- Student Should Follow the Indent Procedure to Receive and Deposit the Equipment from the session Store Room.
- After Completing the Connections Students Should Verify the Circuits by the session Instructor.
- The Readings Must Be Shown to The Lecturer In-Charge for Verification.
- Before Leaving the room , Students Must Ensure That All Switches Are in The Off Position and All the Connections Are Removed.
- All Patch Cords and Stools Should Be Placed at Their Original Positions.

Don’ts:

- **Don’t** Come Late to The session.
- **Don’t** Enter into The session with Golden Rings, Bracelets and Bangles.
- **Don’t** Make or Remove the Connections with Power On.
- **Don’t** Switch on The Supply Without Verifying by The Staff Member.
- **Don’t** Switch Off the Machine with Load.
- **Don’t** Leave the session Without the Permission of The Staff In- Charge

List Of Experiments
Out of fifteen conduct any

1. To draw the locus Diagrams of RL (R-Varying) and RC (R-Varying) Series Circuits.
2. Verification of Series and Parallel Resonance.
3. Determination of Time response of first order RL and RC circuit for periodic non –Sinusoidal inputs – Time Constant and Steady state error.
4. Determination of Two port network parameters – Z & Y parameters.
5. Determination of Two port network parameters – A, B, C, D parameters.
6. Determination of Co-efficient of Coupling and Separation of Self and Mutual Inductance in a Coupled Circuits.
7. Frequency domain analysis of Low-pass filters.
8. Frequency domain analysis of Band-pass filters.
9. Three Phase Transformer: Verification of Relationship between Voltages and Currents.(Star-Delta, Delta-Delta, Delta-star, Star-Star)
10. Harmonic Analysis of non-sinusoidal waveform signals using Harmonic Analyzer and plotting frequency spectrum.
11. Measurement of Active Power for Star and Delta connected balanced loads.
12. Measurement of Reactive Power for Star and Delta connected balanced loads.
13. Frequency domain analysis of High-pass filters.
14. Determination of Two port network parameters -Hybrid parameters.
15. Determination of Time response of first order RLC circuit for periodic non – sinusoidal Inputs – Time Constant and Steady state error.

BEYOND THE SYLLABUS

1. Transient response of series RL and RC circuits using dc excitation.
2. Resonance in series RLC circuit

CONTENTS

EXPERIMENT - 1

LOCUS DIAGRAMS FOR RL AND RC SERIES CIRCUITS

Aim:

To draw the locus diagram for series RL & RC circuits.

Apparatus Required:

S.NO	NAME	RANGE	QUANTITY
1	Ammeter	(0-1A) MI	1
2	Voltmeter	(0-75V) MI	1
3	1-ph Wattmeter	5A/150V/LPF	1
4	Capacitor	33 µF	1
5	Rheostat	250 Ohms / 2.5A	1
6	1-ph variac	240V / (0-270V)	1
7	Connecting wires	-----	Required

Circuit Diagram:

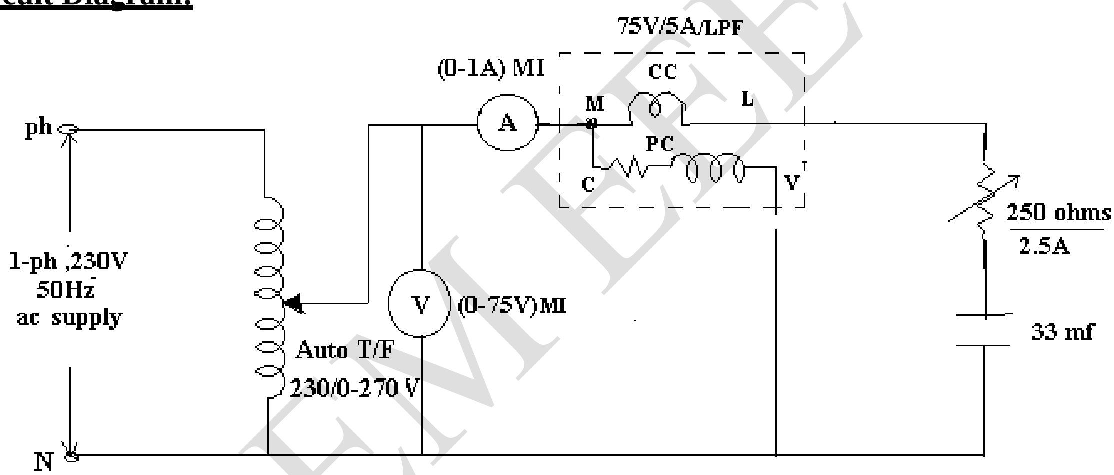


Fig 1

Theory:

The performance of ac circuits, when some of the parameters continuously vary over a wide range of values, with the aid of current locus diagrams. These diagrams not only provide a proper inside into the circuit behaviour, but it is also possible to predetermine the characteristics of certain circuits and ac machines (e.g. Transmission lines , Induction motors ..) , from such circle diagrams. Thus for a series circuit with R and L , if either of them is varied over a certain range, the current and the power input vary, and it is possible to ascertain the maximum values of current and power ,or evaluate the power factor from the locus diagram.

In this experiment the locus of series RC circuit , C is fixed and R is variable as shown in fig 2.

In this semi circles, Diameter of semicircle : V / Xc

Center : (0,V/ 2Xc)

Power factor : Cos 45^0 : 0.707

Procedure:

1. Make the connections as per the circuit diagram shown in fig1.
2. Keep the rheostat at maximum resistance position and switch on the supply.
3. Apply the source voltage Vs= 60V at constant value by using variac.
4. Vary the resistance in steps, note down the readings of ammeter, and wattmeter and tabulate the readings.
5. Calculate power factor and phase angle.

Calculations:

Power $W = V\ I\ \cos\Phi$

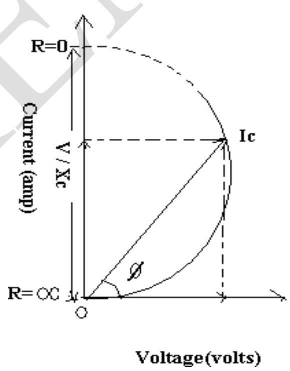
Power factor $\cos\Phi = \frac{W}{V\ I}$

Observation Table:

S.No	Vs (Volts)	Current (Amps)	W (watts)	P.F = CosΦ = W/VI	Φ = $\cos^{-1}$(W/VI)
1					
2					
3					
4					
5					
6					
7					
8					

Model Graph:

Plot the graph between Voltage vector (on X-=axis) and current vector (on y-axis) as shown below.



Result: .

Viva –Voice:-

1. The shape of the current locus in a circuit is generally
   a) Circle b) semi-circle c) ellipse d) parabola
2. What is the centroid of series RC circuit current locus?
3. What is the diameter of series RC circuit current locus?
4. Draw the current locus in series RL circuit when R is variable?
5. Draw the current locus in series RC circuit when C is variable?

Applications:

Series RL & RC circuits are used in

1. Filter circuits
2. Sensors
3. Transformers
4. Motors
5. Energy storage systems.

EXPERIMENT - 2

VERIFICATION OF SERIES RESONANCE & PARALLEL RESONANCE

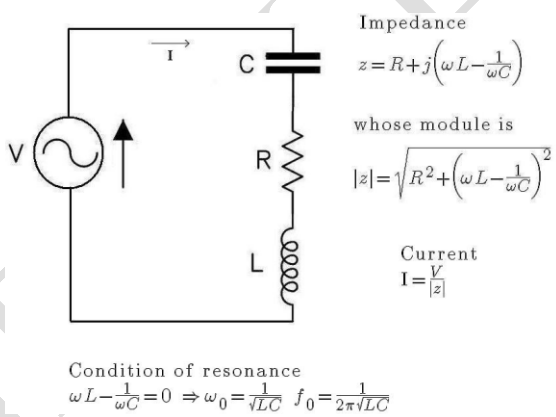
Aim:

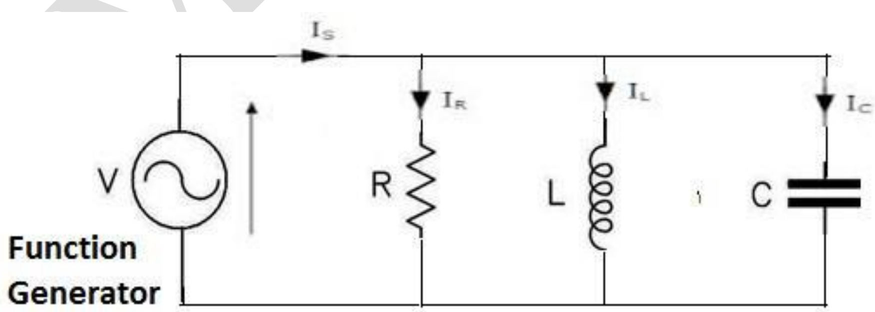
To verify resonant frequency, bandwidth and quality factor of RLC series and parallel resonant circuits.

Apparatus Required:

S.No	NAME	RANGE	TYPE	QUANTITY
1	Function Generator	(70-10000)Hz	-	1
2	Ammeter	(0-200)mA	MI	1
3	Decade Resistance Box	(0-1Mohms)	-	1
4	Decade Inductance Box	(0-100H)	-	1
5	Decade Capacitance Box	(0-100µF)	-	1
6	Connecting wires	-	-	Required

Theoritical Circuit Diagram For Series & Parallel Resonance:





Practical Circuit Diagram For Series Resonance:

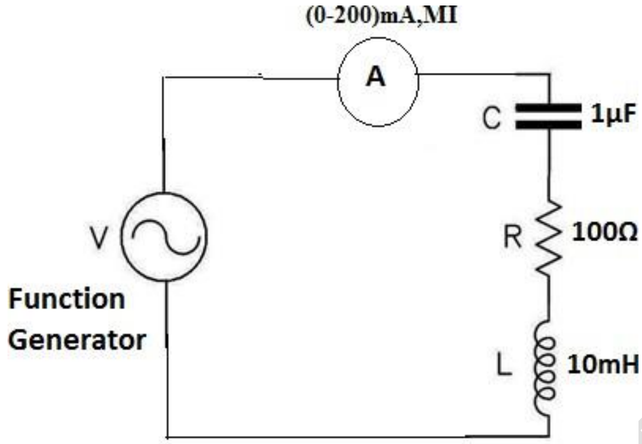


Fig.1

Practical Circuit Diagram For Parallel Resonance:

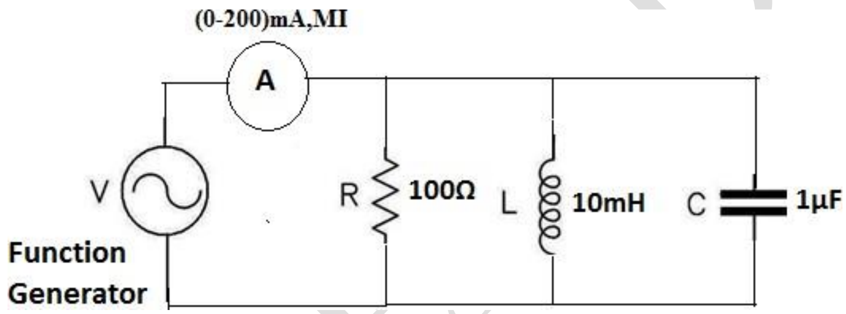


Fig.2

Theory:

An electrical circuit is said to undergo resonance when the net (total) current is in phase with the applied voltage. A circuit at resonance exhibits certain characteristic properties.

The frequency at which the resonance occurs in a circuit is called resonant frequency.

In series RLC circuit, the resonance occurs when

i) The net reactance in a circuit is zero. ($X_L = X_C$)
ii) The circuit impedance is equal to resistance in a circuit (Z = R)
iii) Current in phase with voltage
iv) Power factor is unity.
v) The current in a circuit is maximum.

Under resonance conditions, $X_L = X_C$ or $\omega L = 1 / \omega C$

$$\omega_o^2 = 1 / LC$$

$$\omega_o = \frac{1}{\sqrt{L\text{€}}} \quad \text{or} \quad f_o = \frac{1}{2\pi\sqrt{LC}}$$

In parallel resonance, the resonant frequency is same as the series resonance but the current in circuit is minimum and net suceptance is equal to zero.

Formulae:

a) Resonant frequency : $f_o = \frac{1}{2\pi\sqrt{LC}}$ Hz

b) Half power frequencies:

$f_1 = f_o - R/4\pi L$ Hz

$f_2 = f_o + R/4\pi L$ Hz

c) Band width:

$BW = f_2 - f_1$ (or) $R/2\pi L$

d) Q –factor: $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Procedure:

Series Resonance:

1. Make the connections as per the circuit diagram shown in fig1.
2. Apply the sinusoidal voltage of peak-peak value is 10V
3. Vary the frequency of sine wave between 100 Hz – 10000 Hz in steps, and note down the readings of ammeter.
4. Tabulate the readings in table1.

Parallel Resonance:

1. Make the connections are made as per the circuit diagram shown in fig2.
2. Apply the sinusoidal voltage of peak-peak value is 10V
3. Vary the frequency of sine wave between 100 Hz – 10000Hz in steps, and note down the readings of ammeter.
4. Tabulate the readings in table2.

Calculations:

R = 100ohms, L = 10mH, C = 1μF

a) Resonant frequency $f_o = \frac{1}{2\pi\sqrt{LC}}$ =------------ Hz

b) Half power frequencies

$f_1 = f_o - R/4\pi L$ = ------------Hz

$f_2 = f_o + R/4\pi L$ = ------------ Hz

c) Band width: $BW = f_2 - f_1$ (or) $R/2\pi L$ = ------------ Hz

d) Q –factor: = ----------

Tabular Column:

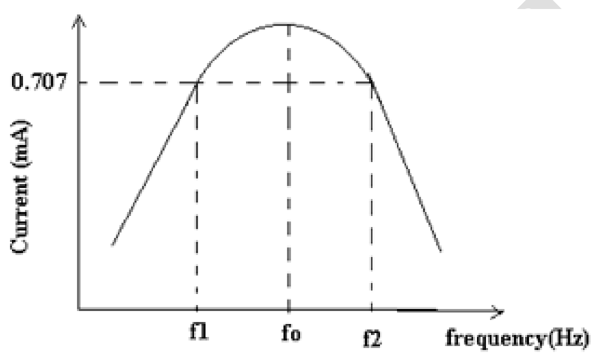
(Series resonance)

S.NO.	Frequency (Hz)	Current (mA)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

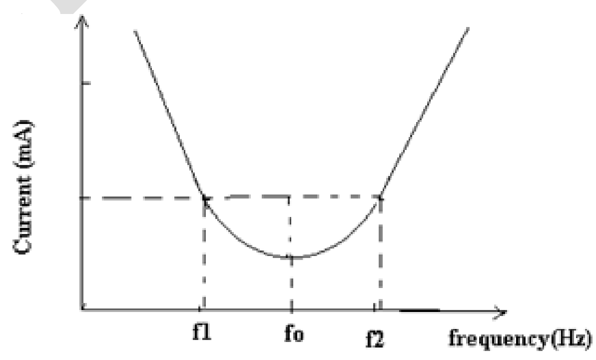
(Parallel resonance)

S.NO.	Frequency (Hz)	Current (mA)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Model Graph:



Series Resonance



Parellel Resonance

Precautions:

1. Avoid loose connections
2. Take readings without parallax error
3. Set the ammeter pointer at zero position

Result :

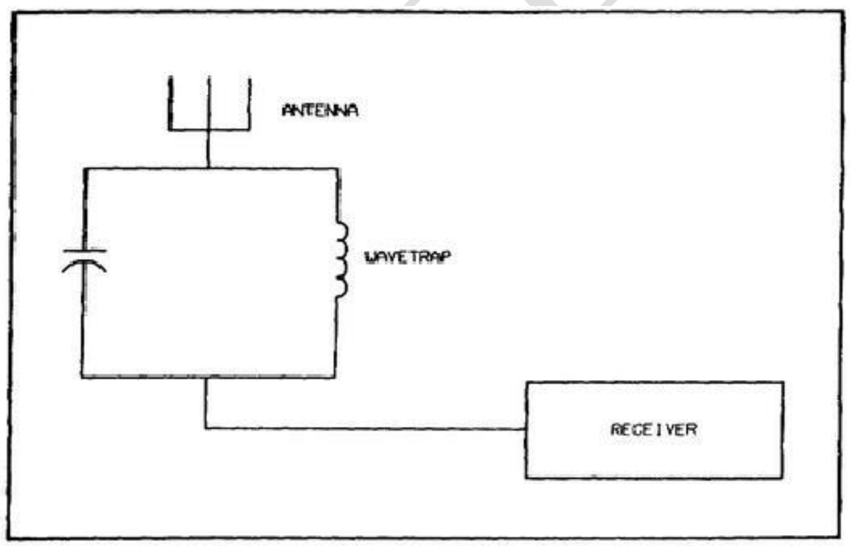
Viva-Voice:

1. Define resonance frequency.
2. What is the value of power factor in series RLC circuit under resonance condition?
3. Define Bandwidth?
4. Define Q-factor?
5. What is the value of current in parallel RLC circuit under resonance condition?

Applications:

The resonant RLC circuits has many applications like

1. Oscillator circuit, radio receivers and television sets are used for the tuning purpose
2. Since **resonance in series RLC circuit** occurs at particular frequency, so it is used for filtering and tuning purpose as it does not allow unwanted oscillations that would otherwise cause signal distortion, noise and damage to circuit to pass through it.
3. The series RLC circuit mainly involves in signal processing and communication system
4. The Series resonant LC circuit is used to provide voltage magnification
5. Since the parallel resonant circuit has a high impedance, it is often useful for rejecting undesired frequencies. An example is the wave trap, which is used to reject an undesired signal from a receiver.



Parallel Resonant Circuit Used as Wave Trap

6. Series and parallel LC circuit are used in induction heating.

EXPERIMENT – 3

DETERMINATION OF TIME RESPONSE OF FIRST ORDER RC AND RL NETWORK FOR NON- SINUSOIDAL INPUT

Aim:

To find the time response of first order RL & RC networks for periodic non-sinusoidal inputs and determination of time constant and steady state error.

Apparatus Required:

S.No	NAME	RANGE	TYPE	QUANTITY
1	Function Generator	(70-10000)Hz	-	1
2	C.R.O	-	MI	1
3	Decade Resistance Box	(0-1Mohms)	-	1
4	Decade Inductance Box	(0-100H)	-	1
5	Decade Capacitance Box	(0-100μF)	-	1
6	Connecting wires	-	-	Required

CIRCUIT Diagrams:

RL Circuit

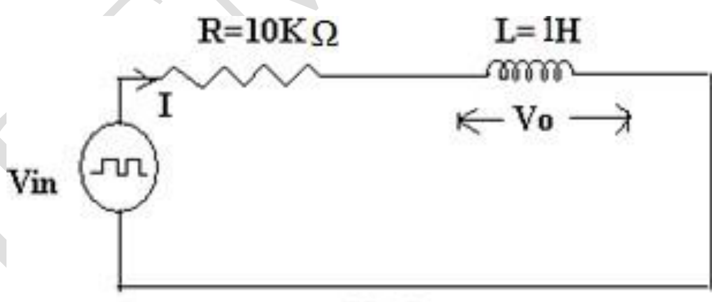


Fig 1

RC Circuit

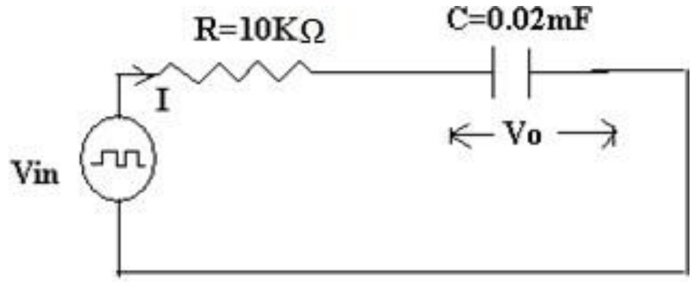


Fig 2

Theory:

For series RL circuit,

According to KVL; Vi(t) = Ri(t) + L di(t) / dt --- (1)

Vo(t) = L di(t) / dt --- (2)

Taking Laplace Transformation on both sides, Vi(s) = R I(s) + s L I(s)

Vo(s) = s L I(s)

TF = V(output) / V(input) = V(o) /V(i) = s L / [R + s L]

= s (L/R) / [1+ s (L/R)]

TF= sT / [1+ sT]

Where, T = Time constant of RL circuit = L / R (sec)

Similarly,

For series RC circuit, TF = 1 / (1 + s T)

Where, T = Time constant of RC circuit = RC (sec)

Procedure:

RL Circuit

1. Make the connections as per the circuit diagram shown in fig1.
2. Switch on the supply, and apply the square wave with peak value is 5V.
3. Note down the voltage waveform in CRO across an inductor.
4. Calculate the time constant and steady state error.

RC Circuit

1. Make the connections as per the circuit diagram shown in fig 2.
2. Switch on the supply, and apply the square wave with peak value is 5V.
3. Note down the voltage waveform in CRO across an inductor.
4. Calculate the time constant and steady state error.

Tabular Columns:

RL circuit

Vin (Volts)	Vo (Volts)	Time period (sec)	e_{ss} =Vin-Vout
5V			

RC circuit

Vin (Volts)	Vo (Volts)	Time period (sec)	e_{ss}=Vin-Vout
5V			

Calculations:-

For series RL circuit; R=10Kohms & L =1H

Time Constant T = L/R

= 1 / 10K = 0.1 msec.

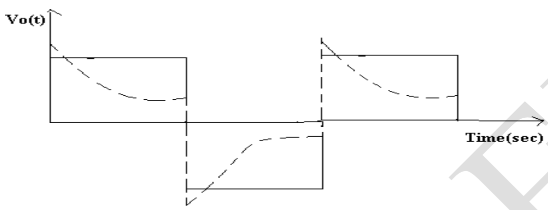
For series RC circuit; R=10Kohms & C =0.02 micro-F

Time Constant T = RC

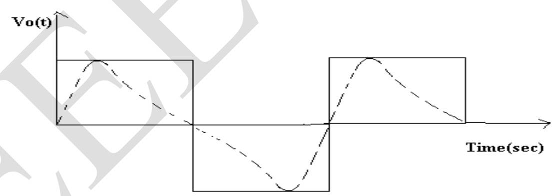
$= 10 \times 10^3 \times 0.02 \times 10^{-6} = 0.2$ msec

Model Graphs:

The output voltage waveforms across the inductor and capacitor as shown below.



RL Circuit



RC Circuit

Result:

Viva –Voice:

1. Define the Time constant for series RL circuit.
2. Define the Time constant for series RC circuit.
3. Define Steady state error.
4. Write the total impedance of series RL circuit under ac voltages.
5. What is the phase relation between I & V in series RC circuit.

Applications:

Series RL & RC circuits are used in

1. Filter circuits
2. Sensors
3. Transformers
4. Motors
5. Energy storage systems.

EXPERIMENT NO -4

DETERMINATION OF Z-PARAMETERS AND Y-PARAMETERS

Aim:

To verify Impedance (Z) and Admittance (Y) parameters of a two port network and Analytical verification.

Apparatus :

S.No	NAME	RANGE	TYPE	QUANTITY
1	Ammeter	(0- 200)mA	MC	2
2	Resistor	560Ω 470Ω 330Ω	-	1 1 1
3	Voltmeter	(0-30)V	MC	1
4	Breadboard Trainer system	-	-	1
5	Connecting Wires	-	-	Required number
6	Regulated Power Supply(R.P.S)	-	-	1

THEORETICAL CIRCUIT DIAGRAM:

For Z and Y Parameters:

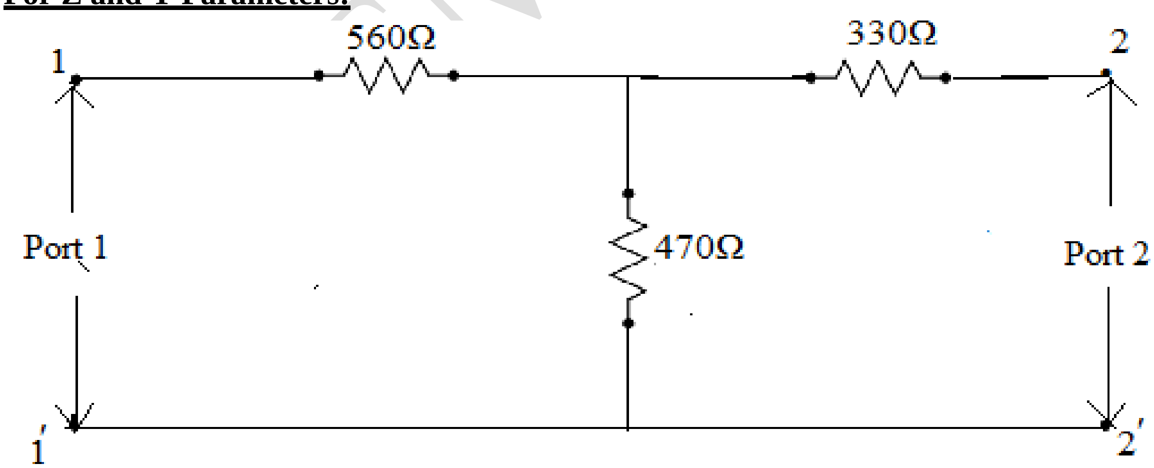


Fig.1

PRACTICAL CIRCUIT DIAGRAMS:
Impedance Parameters (Z):

Case 1: Open circuit second port(i.e making i_2=0)

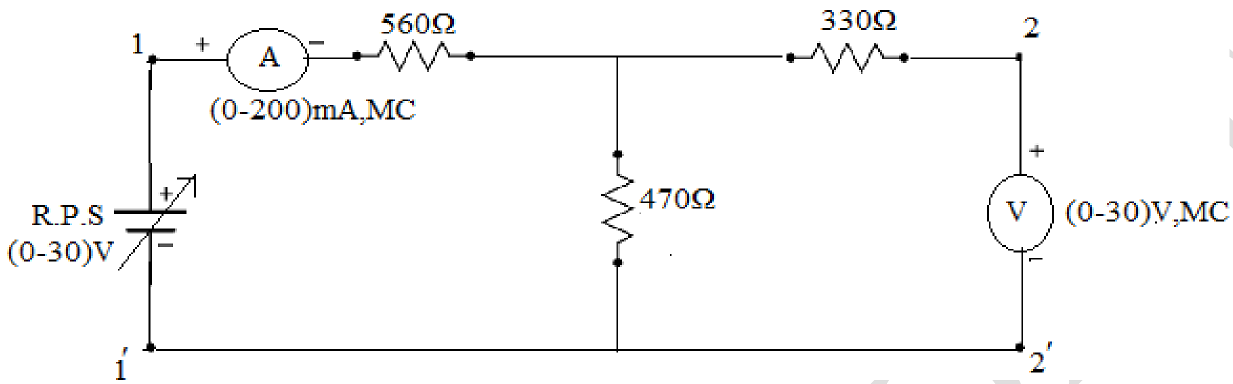


Fig.2

Case 2: Open circuit first port (i.e making i_1=0)

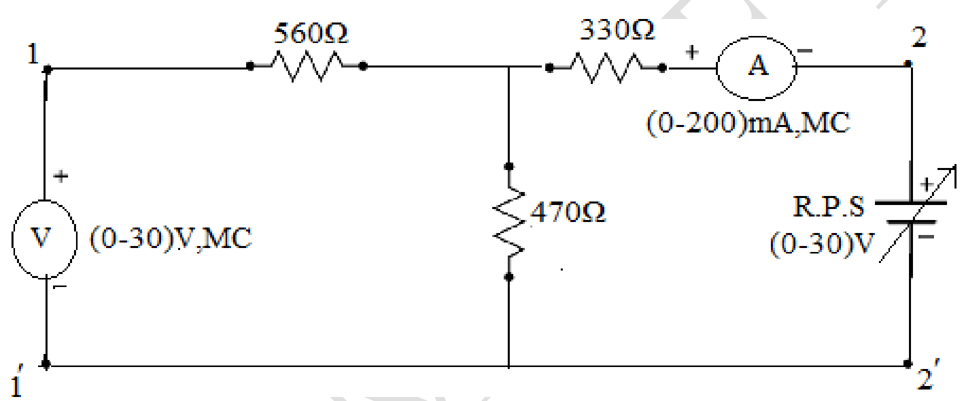


Fig.3

Admittance Parameters (Y):

Case 1: Short circuit second port (i.e making V_2=0)

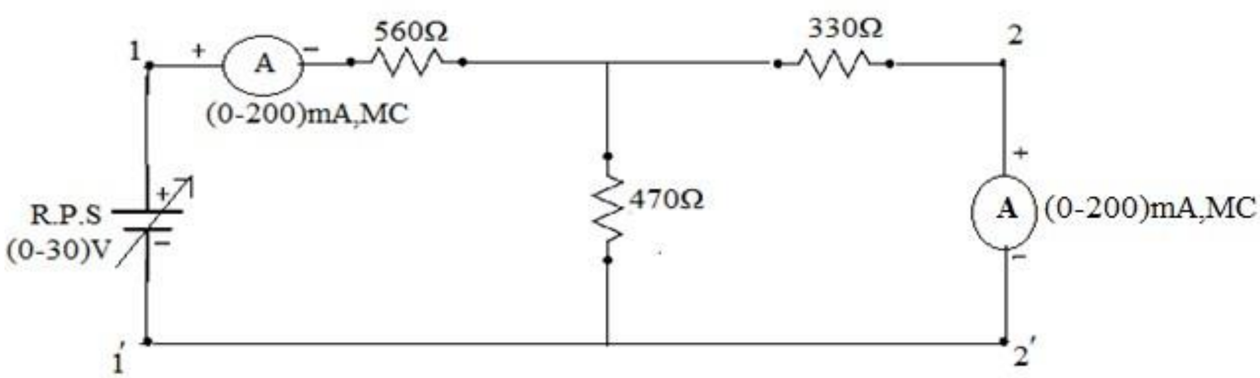


Fig.4

Case 2: Short circuit first port(i.emaking V_1=0)

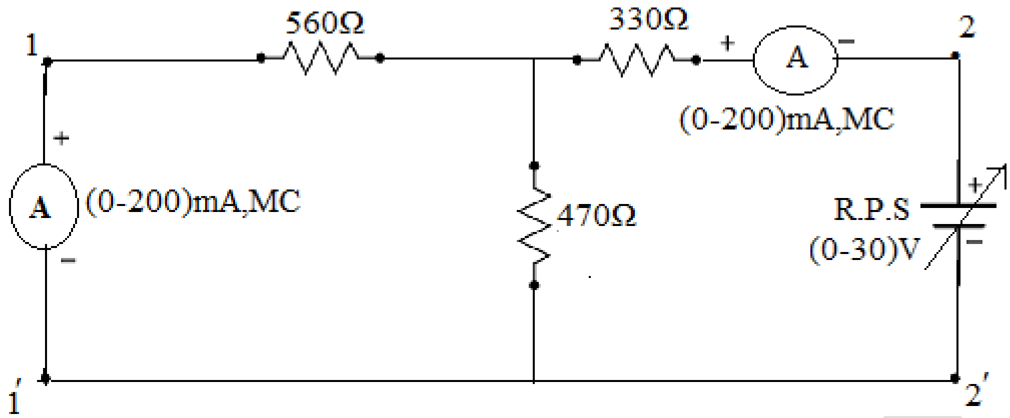


Fig.5

Theory:-

In a two port networks, the network parameters are Z , Y , ABCD , inverse ABCD, h & g-parameters.

Open circuit parameters are Z-parameters, which can be defined by the following equation between the two ports.

Z-Parameters (or)Open Circuit Parameters(or) Impedance Parameters:

$V_1 = Z_{11} I_1 + Z_{12} I_2$ &

$V_2 = Z_{21} I_1 + Z_{22} I_2$

When the 2-2' port is open circuited, i.e. $I_2 = 0$, then

$Z_{11} = V_1/ I_1$ is called *"Open circuit input impedance."*

$Z_{21} = V_2 / I_1$ is called "*Open circuit forward transfer impedance.*"

When the 1-1' port is open circuited, i.e. $I_1 = 0$, then

$Z_{12} = V_1/I_2$ is called *"Open circuit backward transfer impedance."*

$Z_{22} = V_2 / I_2$ is called "*Open circuit Output impedance.*"

Y-parameters (or) Short circuit parameters(or)Admittance Parameters:

Short circuit parameters are Y-parameters, which can be defined by the following equation between the 2-ports.

$I_1 = Y_{11} V_1 + Y_{12} V_2$ &

$I_2 = Y_{21} V_1 + Y_{22} V_2$

When the 2-2' port is short circuited, i.e. $V_2 = 0$, then

$Y_{11} = I_1/ V_1$ is called *"Short circuit input admittance."*

$Y_{21} = I_2 / V_1$ is called "*Short circuit forward transfer admittance.*"

When the 1-1' port is open circuited, i.e. $V_1 = 0$, then

$Y_{12} = I_1/V_2$ is called *"Short circuit backward transfer admittance."*

$Y_{22} = I_2/V_2$ is called "*Short circuit Output admittance."*

Procedure:-

a) Z- Parameters:

1. Make the connections as per the circuit shown in figure 2.
2. Switch on the supply, and apply the Voltage V_s.
3. Note down the readings of supply voltage, ammeter and voltmeter, tabulate and calculate Z_{11} & Z_{21}.
4. Make the connections as per the circuit shown in figure 3.
5. Switch on the supply, and apply the Voltage Vs.
6. Note down the readings of supply voltage, ammeter and voltmeter, tabulate and calculate Z_{12} & Z_{22}.

b) Y-Parameters:

1. Make the connections as per the circuit shown in figure 4.
2. Switch on the supply, and apply the Voltage Vs.
3. Note down the readings of two ammeters and supply voltage, tabulate and calculate Y_{11} &Y_{21}.
4. Make the connections as per the circuit shown in figure 5.
5. Switch on the supply, and apply the Voltage Vs.
6. Note down the readings of two ammeters and supply voltage, tabulate and calculate Y_{12} &Y_{22}.

Tabular Column:

Z-Parameters

(i) $I_2 = 0$

V_1(Volts)	V_2(Volts)	I_1(mA)	$Z_{11} = V_1 / I_1$ (Ω)	$Z_{21} = V_2 / I_1$ (Ω)

(ii) $I_1 = 0$

V_1(Volts)	V_2(Volts)	I_2(mA)	$Z_{12} = V_1 / I_2$ (Ω)	$Z_{22} = V_2 / I_2$ (Ω)

Y-Parameters:

(i)$V_2 = 0$

V_1(Volts)	I_1(mA)	I_2 (mA)	$Y_{11} = I_1 / V_1$(℧)	$Y_{21} = I_2 / V_1$ (℧)

(ii) $V_1 = 0$

V_2 (Volts)	I_1(mA)	I_2 (mA)	$Y_{12} = I_1 / V_2$(℧)	$Y_{22} = I_2 / V_2$ (℧)

Precautions:

1. Avoid loose connections
2. Take readings without parallax error
3. Set the ammeter pointer at zero position

RESULT:

VIVA-VOICE:

1. Define Port.
2. Define 2-port network.
3. Define Z-parameters
4. Define Y-parameters.
5. Write the applications of 2-port networks

Applications:

1. These parameters are used to describe the electrical behavior of linear electrical networks.
2. They are also used to describe the small-signal (linearized) response of non-linear networks.

EXPERIMENT NO -5

DETERMINATION OF ABCD PARAMETERS & h-PARAMETERS

Aim:

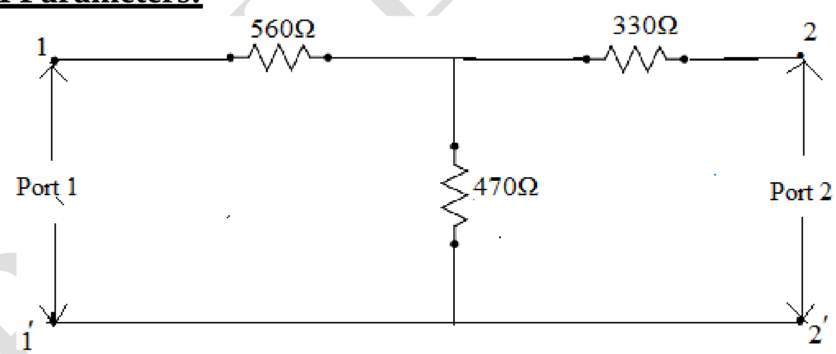
To determine ABCD and H-Parameters of a two port network and analytical verification

Apparatus:

S.No	NAME	RANGE	TYPE	QUANTITY
1	Ammeter	(0- 200)mA	MC	2
2	Resistor	560Ω 470Ω 330Ω	-	1 1 1
3	Voltmeter	(0-30)V	MC	1
4	Breadboard Trainer system	-	-	1
5	Connecting Wires	-	-	Required number
6	Regulated Power Supply(R.P.S)	-	-	1

THEORETICAL CIRCUIT DIAGRAM:

For ABCD and H Parameters:



ABCD Parameters:

Case 1: Open circuit second port(i.e making i_2=0)

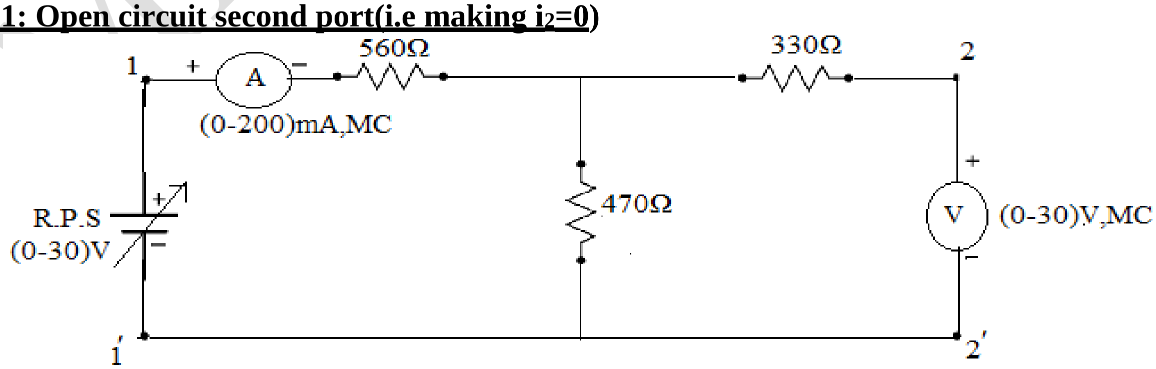


figure 1

Case 2: Short circuit second port(i.e making V_2=0)

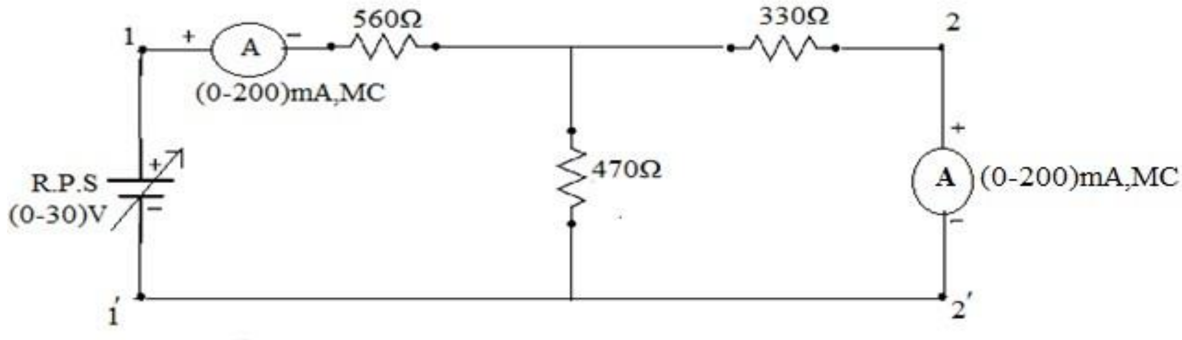


Figure2

H-Parameters:

Case 1: Short circuit second port(i.e making V_2=0)

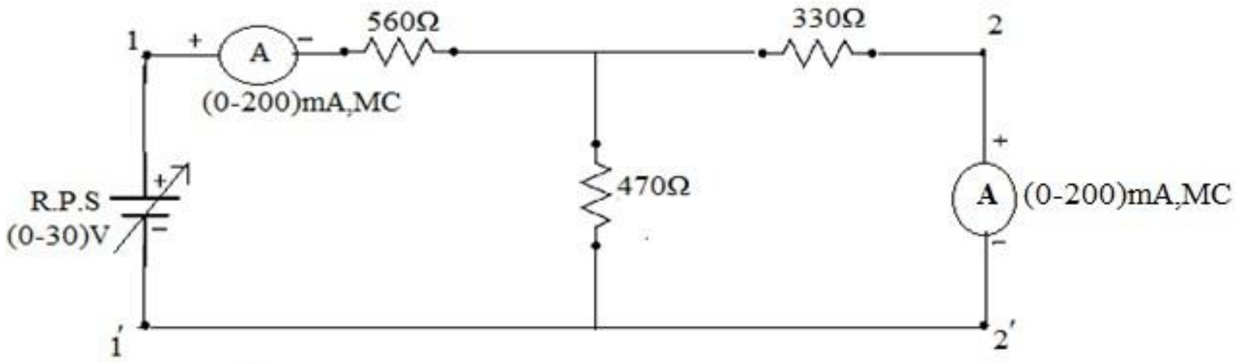


Figure 3

Case 2: Open circuit first port(i.e making i_1=0)

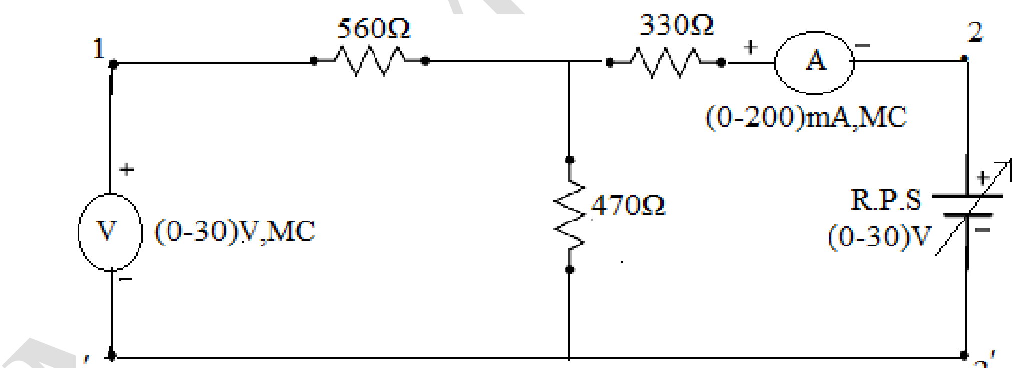


Figure 4

Theory:

In a two port networks, the network parameters are Z , Y , ABCD , inverse ABCD, h & g-parameters.

Transmission parameters can be defined by the following equation between the 2-ports.

$$V_1 = AV_2 - BI_2 \quad \&$$
$$I_1 = CV_2 - DI_2$$

When the 2-2’ port is open circuited, i.e. $I_2 = 0$, then

$A = V_1/V_2$ is called “Open circuit voltage gain.”

$C = I_1/V_2$ is called “Open circuit transfer admittance.”

When the 2-2’ port is open circuited, i.e. $V_2 = 0$, then

$-B = V_1/I_2$ is called “Short circuit transfer impedance.”

$-D = I_1/I_2$ is called “Short circuit Current gain.”

Hybrid parameters can be defined by the following equation between the 2-ports.

$V_1 = h_{11} I_1 + h_{12} V_2$ &

$I_2 = h_{21} I_1 + h_{22} V_2$

When the 2-2’ port is short circuited, i.e. $V_2 = 0$, then

$h_{11} = V_1/I_1$ is called “Short circuit input admittance.”

$h_{21} = I_2/I_1$ is called “Short circuit forward current gain.”

When the 1-1’ port is open circuited, i.e. $I_1 = 0$, then

$h_{12} = V_1/V_2$ is called “Open circuit reverse voltage gain.”

$h_{22} = I_2/V_2$ is called “Open circuit Output admittance.”

Procedure:

ABCD – Parameters:

1. Make the connections as per the circuit shown in figure 1.
2. Switch on the supply, and apply the Voltage Vs.
3. Note down the reading of Supply Voltage, ammeter and voltmeter, tabulate and calculate A& C.
4. Make the connections as per the circuit shown in figure 2.
5. Switch on the supply, and apply the Voltage Vs.
6. Note down the reading of two ammeters and Supply voltage, tabulate and calculate B& D.

arameters:

1. Make the connections as per the circuit shown in figure 3.
2. Switch on the supply, and apply the Voltage Vs.
3. Note down the readings of two ammeters and supply voltage, tabulate and calculate h_{11} & h_{21}.
4. Make the connections as per the circuit shown in figure 4.
5. Switch on the supply, and apply the Voltage Vs.
6. Note down the readings of supply voltage, ammeter and voltmeter, tabulate and calculate h_{12} & h_{22}.

Tabular Column:

ABCD Parameters:

When – $I_2 = 0$

V_1(Volts)	V_2(Volts)	I_1(mA)	$A = V_1 / V_2$	$C = I_1/V_2$(℧)

When $V_2 = 0$

V_1(Volts)	I_1(mA)	I_2 (mA)	$B = -V_1 / I_2 (\Omega)$	$D = -I_1 / I_2$

Hybrid Parameters (H):

When $V_2 = 0$

V_1(Volts)	I_1(mA)	I_2 (mA)	$h_{11} = V_1 / I_1 (\Omega)$	$h_{21} = I_2 / I_1$

When $I_1 = 0$

V_1(Volts)	V_2(Volts)	I_2(mA)	$h_{12} = V_1 / V_2$	$h_{22} = I_2 / V_2$ (℧)

Precautions:

1. Avoid loose connections
2. Take readings without parallax error
3. Set the ammeter pointer at zero position

Result :

Viva-Voice:

1. Define Transmission line parameters
2. Define Hybrid-parameters.
3. Write the applications of hybrid parameters
4. Write the applications of Transmission line parameters

Applications:

1. Power System Engineers use ABCD parameters extensively for the performance analysis of Transmission lines of any type - short, medium or long.
2. ABCD Parameters are used in the design of telephone systems, microwave networks, and radars.
3. ABCD parameters are extremely useful with cascaded linear passive networks (like multisection filters)
4. h parameters come in very handy when studying small signal equivalent models of transistors

EXPERIMENT - 6

MEASUREMENT OF ACTIVE POWER FOR STAR AND DELTA CONNECTED BALANCED LOAD

Aim:

To measure the active power for the given star and delta network.

Apparatus:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Auto Transformer	415V/(0-440), (0-20)A	3–Φ	01
02	U.P.F. Wattmeter	(150/300/600) (0-5/10)A	Dynamometer Type	01
03	L.P.F. Wattmeter	(150/300/600)V(0-5/10)A	Dynamometer Type	01
04	Ammeter	(0-10)A	MI	01
05	Voltmeter	(0-600)V	MI	01
06	Connecting Wires	------	------	As required

Theory:

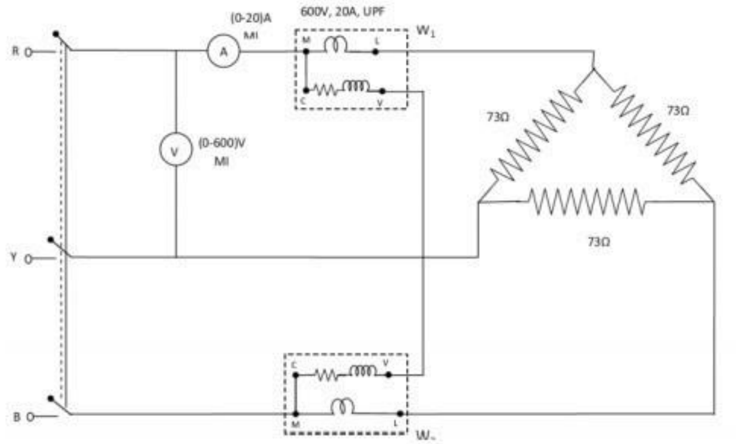
A three phase balanced voltage is applied on a balanced three phase load when the current in each of the phase lags by an angle Φ behind corresponding phase voltages. Current through current coil of $w_1=I_r$, current through current coil of $W_2=I_B$, while potential difference across voltage coil of $W_1=V_{RN}-V_{YN}=V_{RY}$(line voltage), and the potential difference across voltage coilof $W_2= V_{RN}-V_{YN}=V_{BY}$.Also, phase difference between I_R and V_{RY} is (300+ Φ).While that between I_B and V_{BY} is (300- Φ).Thus reading on wattmeter W_1 is given by $W_1=V_{RY}\ I_Y Cos(300+\Phi)$While reading on wattmeter W_2 is given by $W_2=V_{BY}I_B Cos(300-\Phi)$Since the load is balanced, $|I_R|=|I_Y|=|I_B|=I$ and $|V_{RY}|=|V_{BY}|=V_L$$W_1=V_L I Cos(300+\Phi)$$W_2=V_L I Cos(300-\Phi)$.

Thus total power P is given by

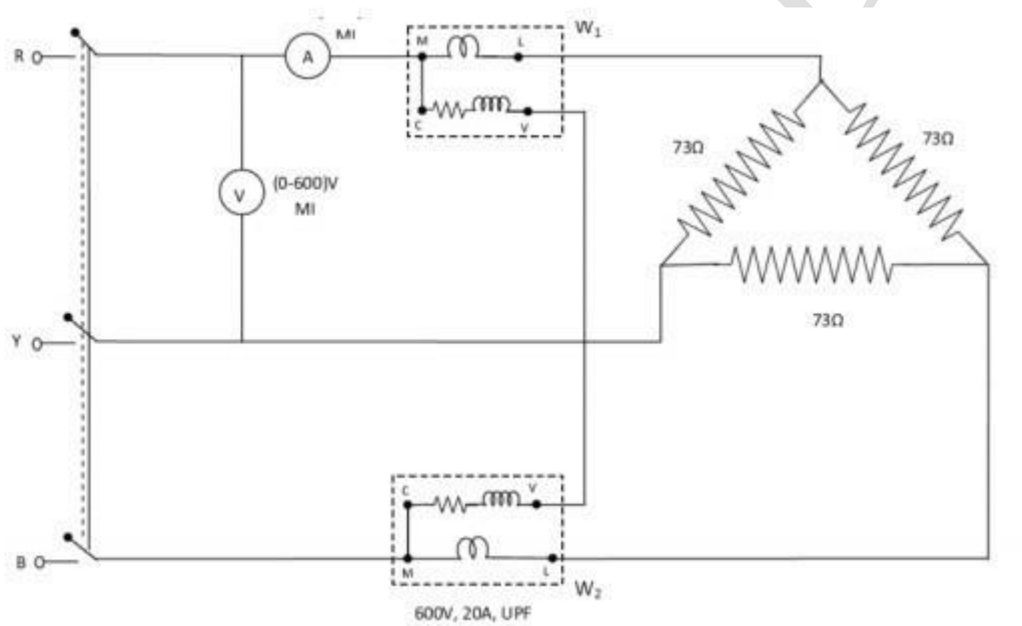
$$W= W_1 + W_2 = V_L I Cos(300+\Phi) + V_L I Cos(300-\Phi)$$
$$= V_L I[Cos(300+\Phi) + Cos(300-\Phi)]$$
$$= [\sqrt{3}/2 * 2Cos\ \Phi]V_L I = \sqrt{3} V_L I Cos\ \Phi$$

Circuit diagram:

Star connected load:



Delta connected load:



Procedure:

(Star connection):

1) Connect the circuit as shown in the figure.
2) Ammeter is connected in series with wattmeter whose other end is connected to one of the loads of the balanced loads.
3) The Y-phase is directly connected to one of the nodes of the 3-ph supply.
4) A wattmeter is connected across R-phase & Y-phase as shown in fig. The extreme of Bphase is connected to the third terminal of the balanced 3-ph load.
5) Another wattmeter is connected across Y & B phase, the extreme of B-phase is connected to the third terminal of the balanced three phases load.
6) Verify the connections before switching on the 3-ph power supply.

(Delta connection):

1) Connect the circuit as shown in the figure.
2) Ammeter is connected in series with wattmeter whose other end is connected to one of the loads of the balanced loads.
3) The Y-phase is directly connected to one of the nodes of the 3-ph supply.
4) A wattmeter is connected across Y & B phase, the extreme of B-phase is connected to the third terminal of the balanced 3-ph load.
5) Another wattmeter is connected across R & Yphase, the extreme of R-phase is connected to the third terminal of the balanced three phases load.
6) Verify the connections before switching on the 3-ph power supply.

Tabular Column:

S.No	Voltage V (Volts)	Line Current I_L (Amps) I	W_1 (Watts)	W_2 (Watts)	$W = W_1 + W_2$

Calculations:

For a star connected load

Line voltage(V_L) = VL/$3^{1/2}$

Line current(I_L) = I_L

$$Ø = \tan^{-1} 3^{1/2}(W_1-W_2)/(W_1+W_2)$$

$$P = 3^{1/2} V_L I_L \cos Ø$$

$$P = W_1+W_2$$

For a delta connected load

Line voltage(VL) = VL

Line current(IL) = $I_L/3^{1/2}$

$$Ø = \tan^{-1} 3^{1/2} (W1-W2)/(W1+W2)$$

$$P = 3^{1/2} V_L I_L \cos Ø$$

$$P = W_1+W_2$$

Precautions:

1. Avoid making loose connections.
2. Readings should be taken carefully without parallax error.

Result:

Viva-Voice:

1. Define active power, reactive power & apparent power.
2. Define power factor?
3. What are the different types of loads?
4. Write the equations of active power, reactive power & apparent power.

Applications:

1. Active power used to enhance voltage profile and improve the power factor.
2. To maintain voltage stability, high power factor and less transmission losses

EXPERIMENT - 7

MEASUREMENT OF REACTIVE POWER FOR STAR AND DELTA CONNECTED BALANCED LOADS

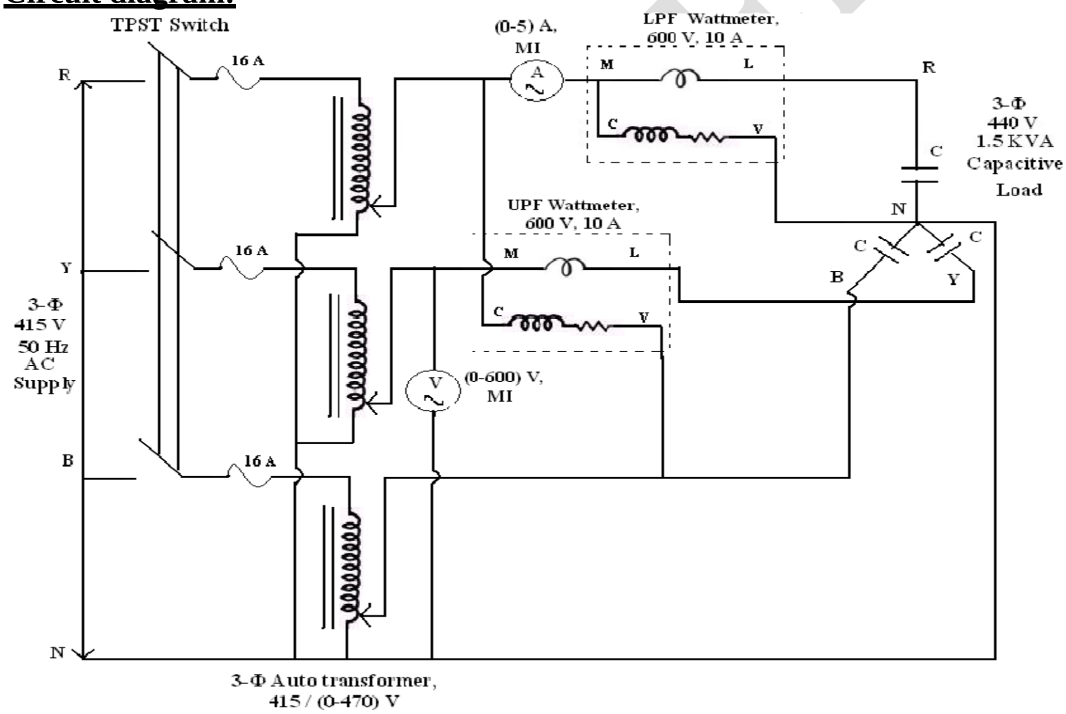
Aim:

To measure the total reactive power of a three phase balanced load using single phase wattmeter Method.

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Capacitive Load	440V, 1.5KVA	3–Φ	01
02	Auto Transformer	415V/(0-440), (0-20)A	3–Φ	01
03	U.P.F. Wattmeter	(150/300/600) (0-5/10)A	Dynamometer Type	01
04	L.P.F. Wattmeter	(150/300/600)V(0-5/10)A	Dynamometer Type	01
05	Ammeter	(0-10)A	MI	01
06	Voltmeter	(0-600)V	MI	01
07	Connecting Wires	------	------	As required

Circuit diagram:



Procedure:

1. Make the Connections as per circuit diagram.
2. Keep the 3-Phase Autotransformer is in minimum output position.
3. Switch on the supply and by slowly varying the autotransformer, rated value is applied to motor.
4. Note down the readings of Ammeter, Voltmeter, Wattmeter's readings (Wr & Wa)
5. After noting the values slowly decrease the Auto Transformer till Volt meter comes to zero voltage position, and switch of the supply.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage during starting.

Theoretical Calculations:

Ammeter reading = I_{ph} =

Voltmeter reading = V_{ph} =

Wattmeter reading (W_a) = Active power / Phase

Wattmeter reading (W_a) =

total active power = 3×Wa Total active power = 3VIcosϕ

= $3W_a$ Cosϕ = W_a / VI

$\sin^2\phi = 1 - \cos 2\phi$

Total calculated reactive power = W_{RC} = 3VISin ϕ

Total measured reactive power = 3Wr

Observation Table:

S.No	Voltage V (Volts)	Line Current I_L (Amps) I	W_1 (Watts)	W_2 (Watts)	W= $W_1 + W_2$

Result:

Viva-Voice:

1. Define active power, reactive power & apparent power.
2. Define power factor?
3. What are the different types of loads?
4. Write the equations of active power, reactive power & apparent power.

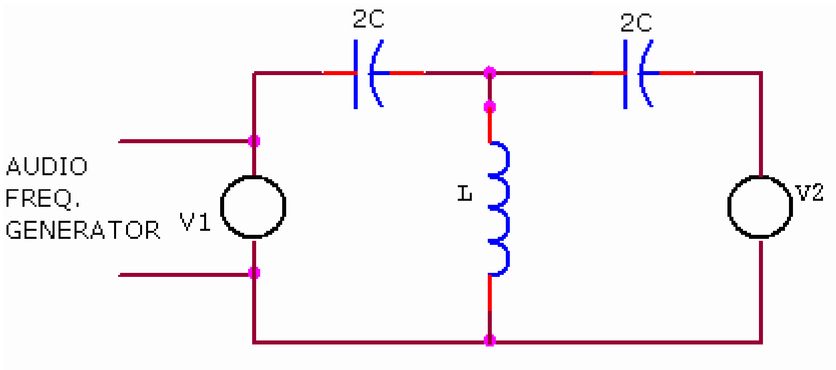
Applications:

1. Reactive power is essential to excite any electrical equipment. Once equipments are excited, equipments start to produce the real power. Without reactive power we can't produce the real power.
2. Reactive power used to enhance voltage profile and improve the power factor.

EXPERIMENT - 8
HIGH PASS FILTERS

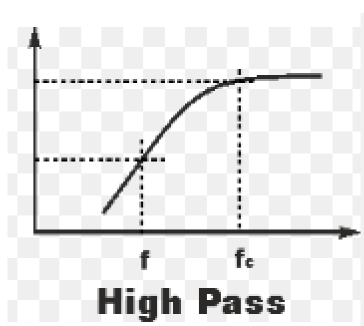
Introduction:
This Educational Trainer is a useful kit for the demonstration of Low pass & High pass, band pass & band reject Filters. This kit consists of wired circuitry of

HIGH PASS FILTER:



Procedure:
1) Connect trainer to the mains and switch on the power supply.
2) Measure the output voltage of Regulated Power Supply circuit i.e. + 12V and - 12V.
(Supplies are connected to the circuit internally, so external connection is not required)
3) Observe the output of AF Generator using CRO..
4) Connect one of the Resistor and capacitor provided on the board and calculate the cut off frequency using the formula
$$fc = 1/2\pi RC$$
5) Connect AF signal to the high pass filter circuit
6) Adjust the AF signal to required amplitude level.
7) By varying the AF signal frequency (keeping amplitude constant) in steps, note down the corresponding input and output voltages in tabular form.
8) Plot the graph between frequency vs gain.
9) Thus the high pass filter has a constant gain from low cut off frequency f_C to higher Frequencies, the gain is 0.707 below fc it decreases at a constant rate with an decrease in the frequency.

GRAPH:

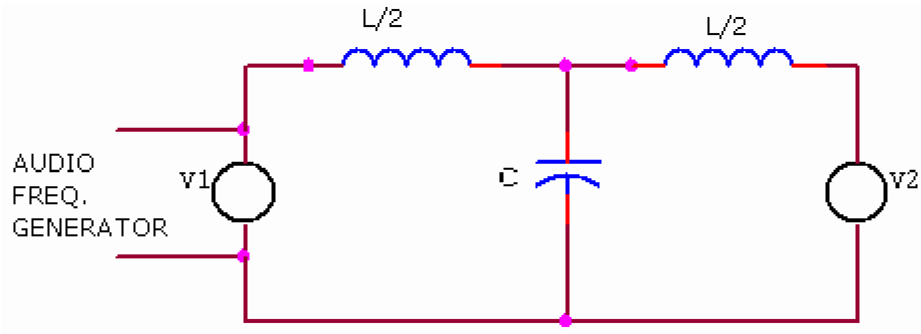


S.NO	Frequency (KHz)	I/P Voltage V1 (Volts)	O/P Voltage V2 (Volts)	$\alpha = 20 \log V2/V1$

EXPERIMENT - 9

LOW PASS FILTER

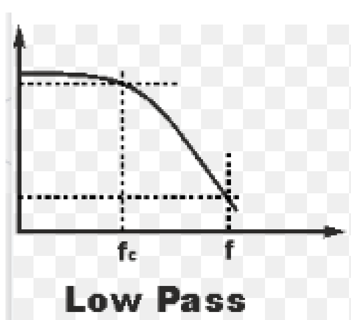
LOW PASS FILTER:



PROCEDURE:

1) Connect trainer to the mains and switch on the power supply.
2) Measure the output voltage of Regulated Power Supply circuit i.e. + 12V and - 12V. (Supplies are connected to the circuit internally, so external connection is required)
3) Observe the output AF Generator using CRO.
4) Connect one of the Resistor and capacitor provided on the board and calculate the cut off frequency using the formula $fc=1/2\pi RC$
5) Connect AF signal to the low pass filter circuit
6) Adjust the AF signal to required amplitude level.
7) By varying the AF signal frequency (keeping amplitude constant) in steps, note down the corresponding input and output voltages in tabular form.
8) Plot the graph between frequency vs gain.
9) Thus the low pass filter has a constant gain AF signal to the cut off Frequency fc. After fe it decreases at a constant rate with an increase in the frequency.

GRAPH:



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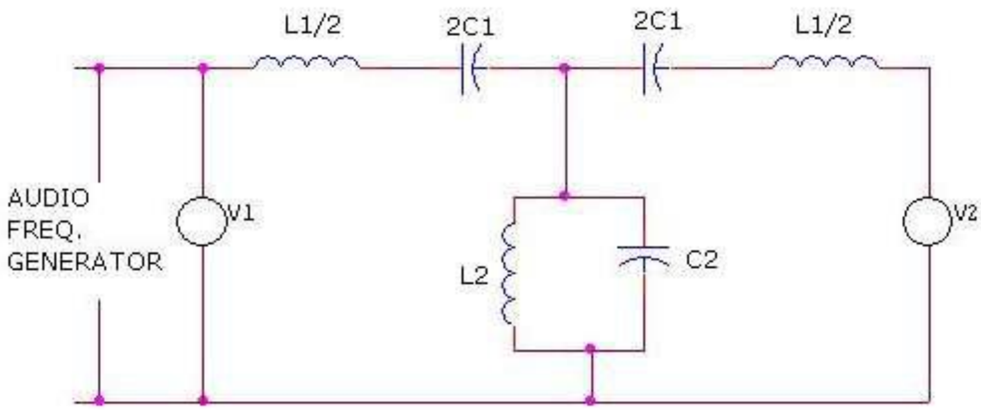
S.NO	Frequency (KHz)	I/P Voltage V1 (Volts)	O/P Voltage V2 (Volts)	α = 20 log V2/V1

EXPERIMENT - 10

BAND PASS FILTER

AIM: To study frequency response of Band pass filter

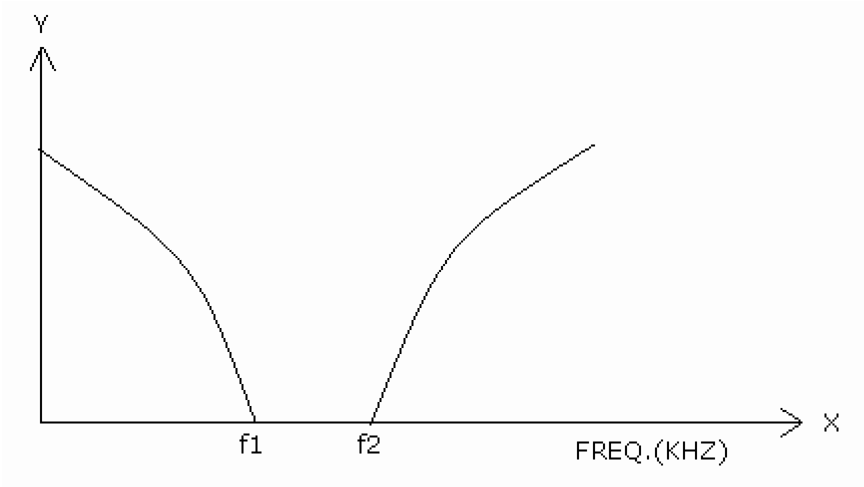
APPARATUS REQUIRED: Power Supply, Filter ckt. Kit, Resistances, Audio Frequency Generator, two Voltmeters.



PROCEDURE:

1) Connect trainer to the mains and switch on the power supply.
2) Measure the output voltage of Regulated Power Supply circuit i.e. + 12V and - 12V. (Supplies are connected to the circuit internally, so external connection is required)
3) Observe the output AF Generator using CRO.
4) Connect one of the Resistor and capacitor provided on the board and calculate the cut off frequency using the formula
   $fc=1/2\pi RC$
5) Connect AF signal to the low pass filter circuit
6) Adjust the AF signal to required amplitude level.
7) By varying the AF signal frequency (keeping amplitude constant) in steps, note down the corresponding input and output voltages in tabular form.
8) Plot the graph between frequency vs gain.
9) A band pass filter allows signals within a selected range of frequencies to be heard or decoded, While preventing signals at unwanted frequencies from getting through.

GRAPH:



OBSERVATION TABLE:

S.NO	Frequency (KHz)	I/P Voltage V1 (Volts)	O/P Voltage V2 (Volts)	α = 20 log V2/V1

EXPERIMENT - 11

DETERMINATION OF CO-EFFICIENT OF COUPLING AND SEPARATION OF SELF AND MUTUAL INDUCTANCE IN A COUPLED CIRCUIT.

AIM: To determine the self and mutual inductance of a given transformer and also determine the coefficient of Coupling.

APPARATUS:

S.NO	Name of the Equipment	Range	Type	Quantity
1	Ammeter	2A	MI	1
2	Voltmeter	300V (MI)and 0 -30V (MI)	MI	1
3	1-Phase Transformer	230V/115V, 3KVA		1
4	1-Phase Auto Transformer	230V/0-270V		1
5	Wattmeter	300v, 20A, LPF		1
6	Connecting Wires			

Theory:

When two inductors are located physically close to each other, a change in the current flowing in one inductor induces an emf in the other and vice-versa. This is due to the linking of one coil with the magnetic field produced by the other coil. The EMF in the second coil is proportional to the rate of change of flux linkages due to the change in the current in the first coil and the constant of proportionality is known as the mutual inductance. It is measured in Henry. Circuit Diagram:

Circuit diagram:

Case I:

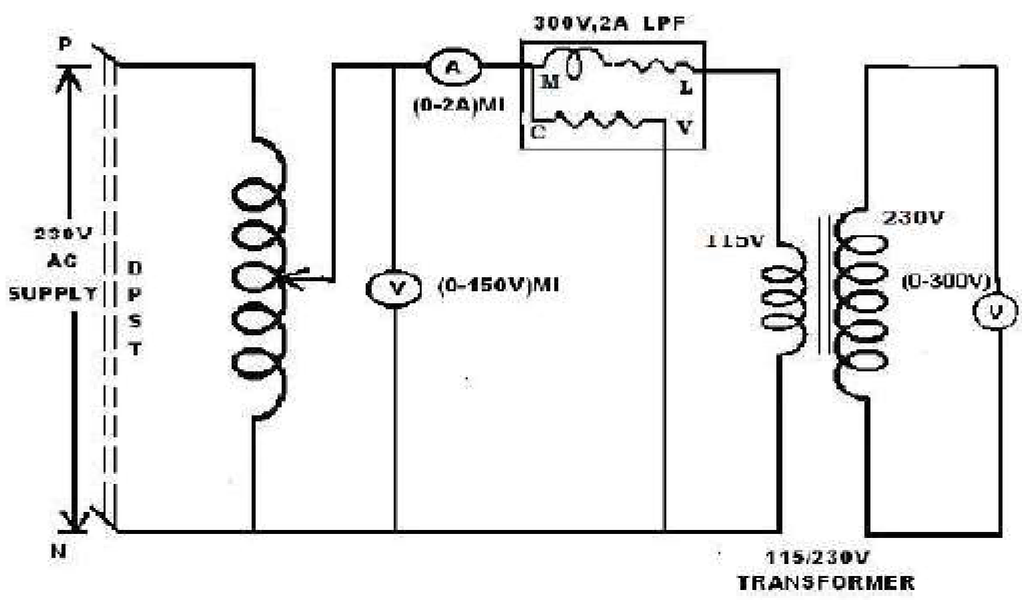
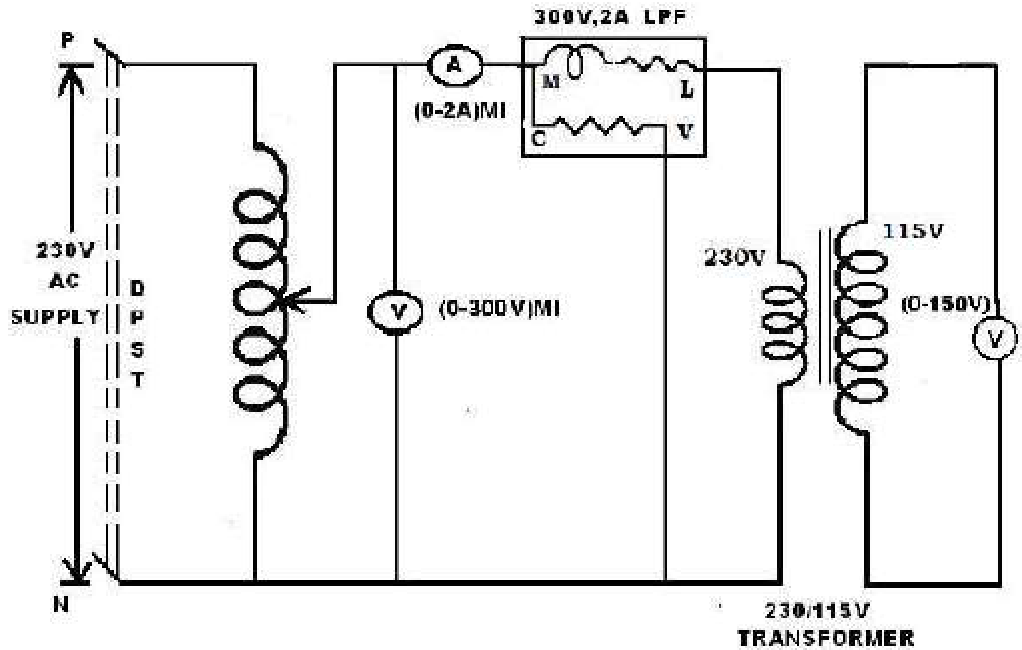


Fig. Self inductance of coil 1

Case II:



PROCEDURE:

Case I:

1. Make the connections as per the circuit diagram, and apply rated voltage to LV winding with the help of single phase auto transformer.

2. Note down the readings of ammeter(Io1) voltmeter(V1) and (E2); wattmeter reading (W1) in the tabular form.

3. Calculate

$W1 = V_1 I_{o1} \cos\Phi_{o1}$

$\cos \Phi_{o1} = W_1 / V_1 I_{o1}$

Magnetizing current, $I_{m1} = I_{o1} \sin \Phi_{o1}$

and $E2 = \omega M I_{m1}$ $M = E2/\omega I_{m1}$

$L_{LV} = V_1 / 2\pi f I_{m1}$ Henrys

Where V1 is the applied voltage.

Case II:

1. Make the connections as per the circuit diagram, and apply rated voltage to HV winding with the help of single phase auto transformer.

2. Note down the readings of ammeter, voltmeter and wattmeter reading in the tabular form.

3. Calculate $W_2 = V_2 I_{o2} \cos\Phi_{o2}$

$\cos \Phi_{o2} = W_2/V_2 I_{o2}$

Magnetizing current, $I_{m2} = I_{o2} \sin \Phi_{o2}$

and $E1 = \omega M I_{m2}$ $M = E_1/\omega I_{m2}$

4. Calculate

$L_{HV} = V_2 / 2\pi f I_{m2}$ Henrys

5. Now calculate the coefficient of coupling between two coils,

$K = M/\sqrt{L_{HV} L_{LV}}$

Readings and Calculations:

Case –I:

S.No.	**V_1**	**E_2**	**I_{o1}**	**W_{o1}**	**I_{m1}**	**L_{LV}**	**M**

Case –II:

S.No.	**V_2**	**E_1**	**I_{o2}**	**W_{o2}**	**I_{m2}**	**L_{HV}**	**M**

Sample Calculations:

Result: (to be written in the main laboratory record)

Discussion:

1. Define Mutual Inductance?

2. What does the value of coefficient of coupling indicate?

3. Explain the dot convention.

4. Which electrical device makes use of mutual inductance?

5. What is statically induced emf and what is dynamically induced emf.

EXPERIMENT - 12
HARMONIC ANALYSIS OF NON-SINUSOIDAL WAVEFORM SIGNALS USING HARMONIC ANALYZER AND PLOTTING SPECTRUM.

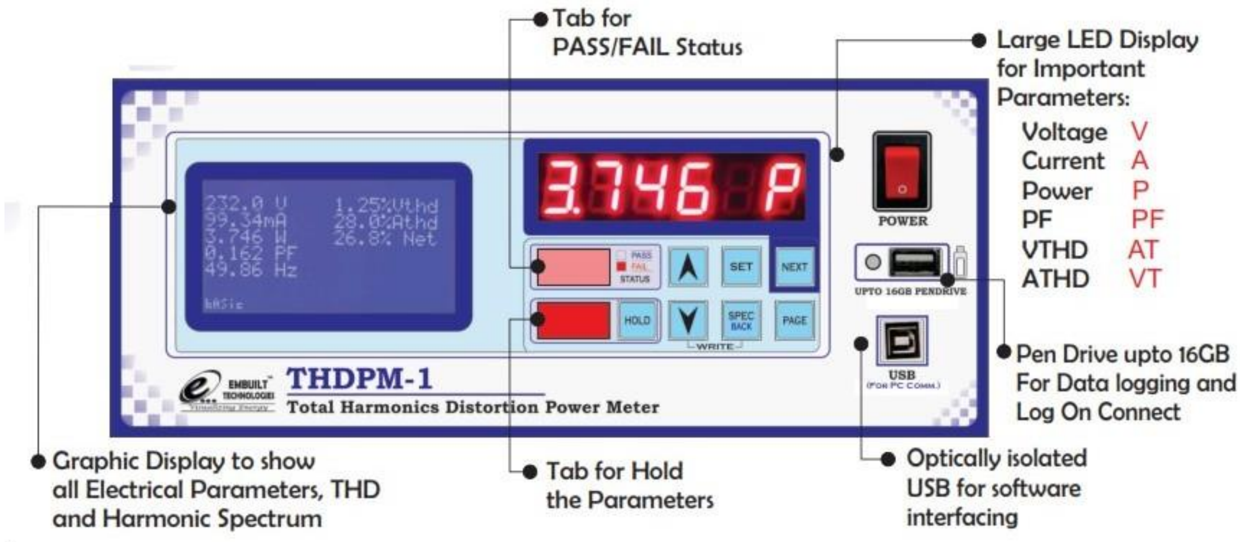
AIM:- Harmonic Analysis of non-sinusoidal waveform signals using Harmonic Analyzer and plotting spectrum.

APPARATUS REQUIRED:-

Si.No	Apparatus name	Qty
1	Harmonic Analyzer(THDPM – 1)	01
2	Test bench setup	**01**
3	LED bulb 5W	**01**
4	CFL Bulb 15W	**01**
	Connecting wires.	As required

THEORY:-

By using Total Harmonics Distortion Power Meter we can analyze the harmonics present in different types of electrical apparatus.



Harmonics can be analyzed for both Voltage and Current Waveforms. Up to 55th Harmonics can be seen on the THDPM-1 in tabulated and Bar Graph Form.

There are two types of Harmonics analysis done:

1. Testing the Harmonics of Incoming Voltage.

eg. Comparing the Harmonics of Square Wave Inverter and Sine Wave inverter

2. Testing the Harmonics of different loads. This is done in ideal conditions.

In non-Industrial environment, the Electricity Board harmonics are normally low and can be used for this type of experiments.

eg. Harmonics of a Bulb, Harmonics of a LED Bulb.

Technical Description:

Auxiliary Supply : 180 – 240 Volts

Input Voltage : 3V – 300 Volts

Current : 10mA – 2

AmpsFrequency 45-55 Hz

Measures up to 55th Harmonic

Accuracy Class: 0.2%

Voltage Harmonics

Current Harmonics

- **THDPM-1 is THD analyzer which measures up to 55^{th} harmonic.**
- **It provides Voltage and Current THD.**
- **It shows the net effect on THD due to load.**

➢ **It also shows following parameters**

- **Voltage**
- **Current**
- **Watt**
- **Frequency**
- **Power Factor**

➢ **It is useful for testing of LED Drivers, SMPS, CFL, CHOKES, Charger, AC to DC Converter, UPSetc.**

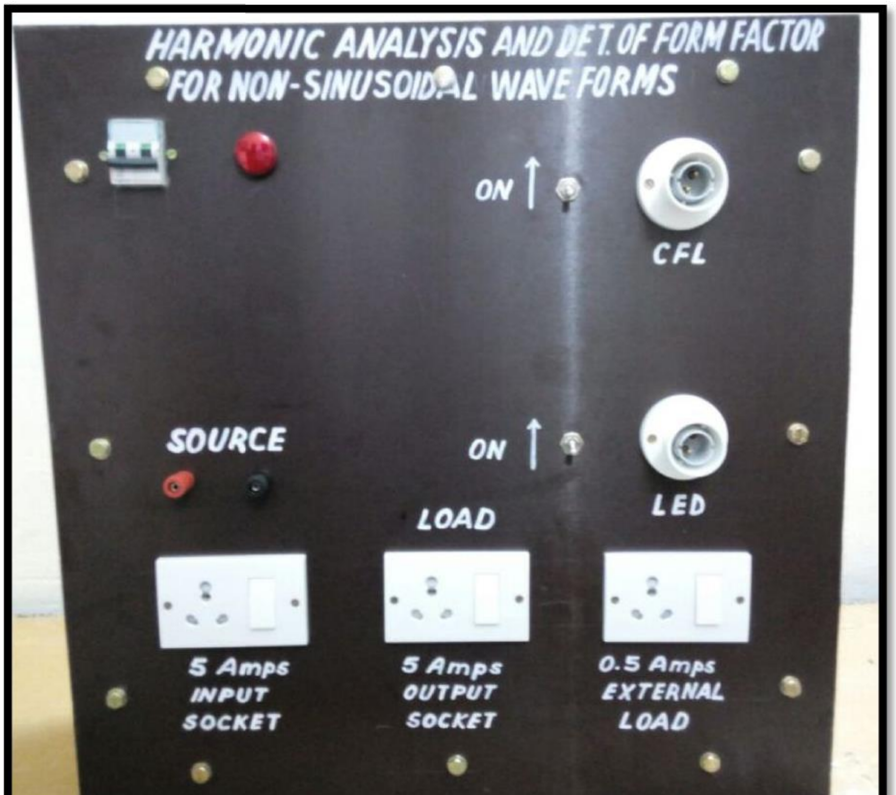


Fig 1: Panel View

TEST BENCH SETUP

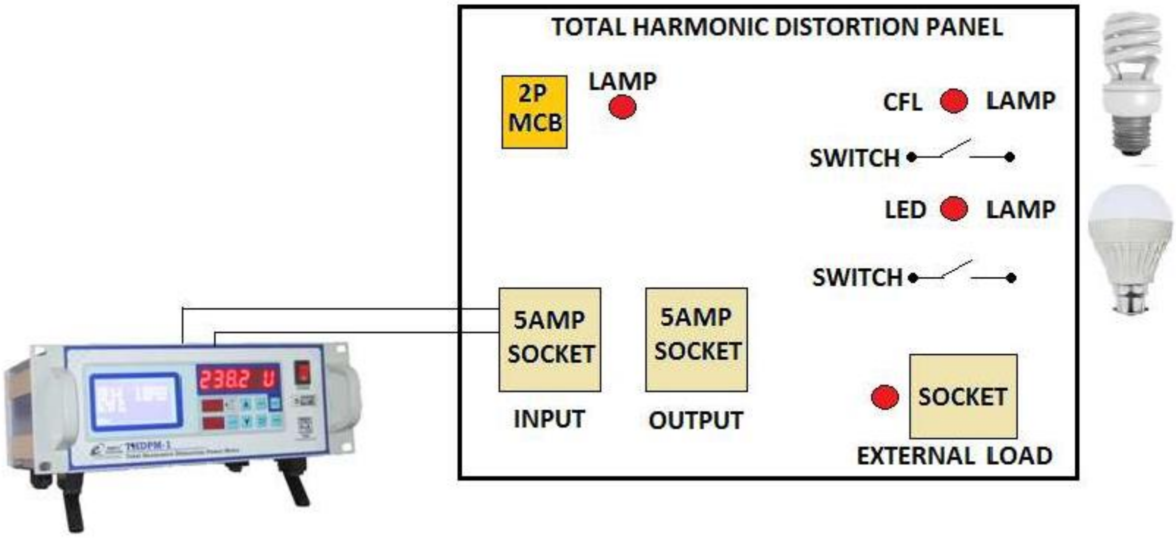


Fig 2: Test bench setup

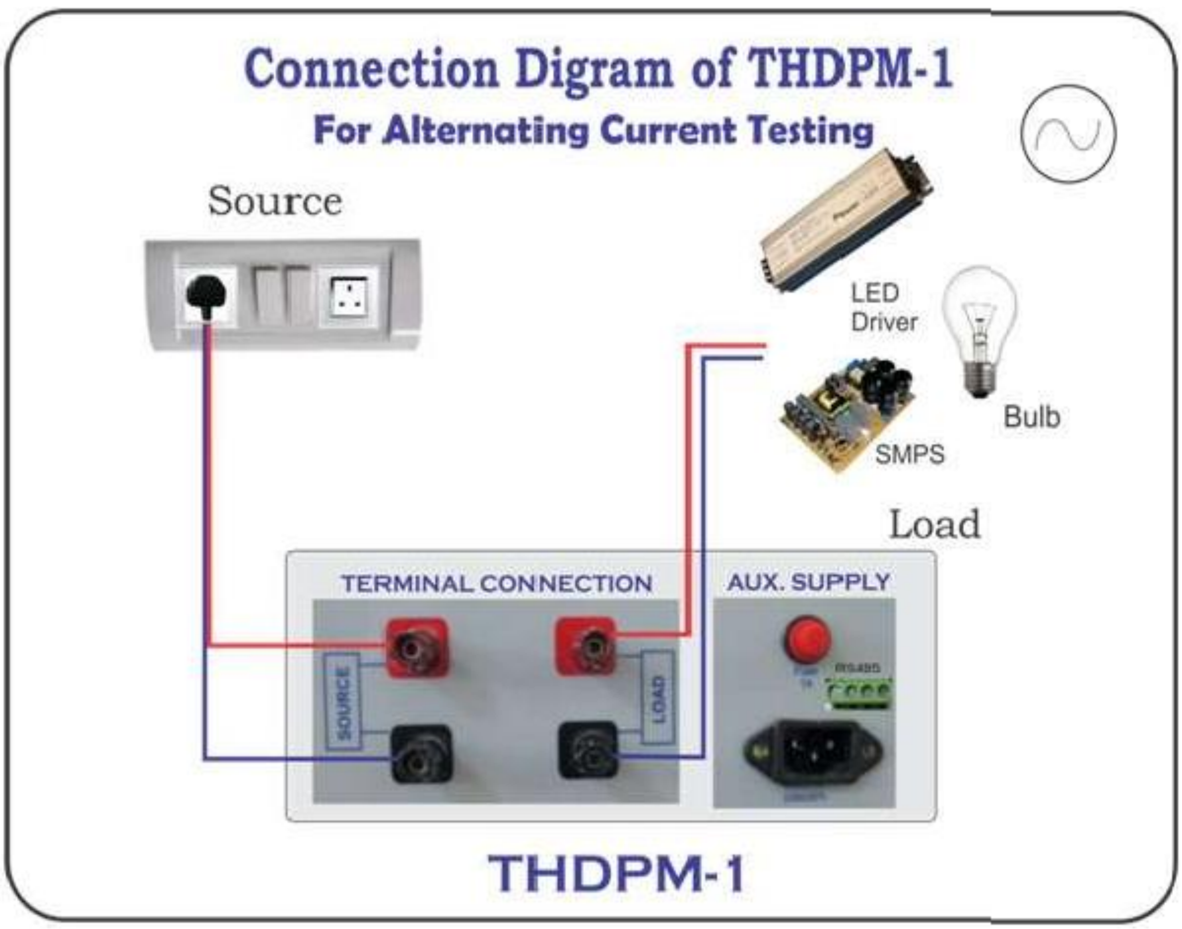


Fig 3: Circuit Diagram

PROCEDURE:-

For Experiment No: 1

HARMONIC ANALYSIS OF NON-SINUSOIDAL WAVEFORM SIGNALS USING HARMONICANALYZER AND PLOTTING SPECTRUM.

1. Switch ON the Harmonic Analyzer kit.
2. Connect the Circuit as per the circuit diagram as shown in fig.
3. Connect the source terminals of Harmonic Analyzer to source terminals provided on the panel.
4. Connect the Load terminals of Harmonic Analyzer to Load terminals provided on the panel.
5. Now, switch ON CFL bulb using switch provided.
6. Observe the readings displayed on Harmonic Analyzer kit main page.
7. Note down the voltage Harmonics and $\boldsymbol{V_{THD}}$ % level.
8. Note down the Current Harmonics and $\boldsymbol{A_{THD}}$ % level.
9. Tabulate the readings in tabular column.
10. Observe the Harmonic Spectrum graph displayed on Harmonic Analyzer kit.
11. Repeat the above procedure for LED bulb also.
12. Repeat the above procedure for CFL and LED bulb combination.

For Experiment No: 2

DETERMINATION OF FORM FACTOR FOR NON-SINUSOIDAL WAVEFORM

1. Switch ON the Harmonic Analyzer kit.
2. Connect the Circuit as per the circuit diagram as shown in fig.
3. Connect the source terminals of Harmonic Analyzer to source terminals provided on the panel.
4. Connect the Load terminals of Harmonic Analyzer to Load terminals provided on the panel.
5. Now, switch ON CFL/LED bulb using switch provided.
6. Observe the Form factor and crest factor displayed on Harmonic Analyzer.
7. Using the formula determine the form factor and note down the readings.

FOR DETERMINATION OF FORM FACTOR:

Peak Value (V_{pk}) = Reading taken from THD meter.

RMS Value (V_{rms}) = V_{pk} x 0.707

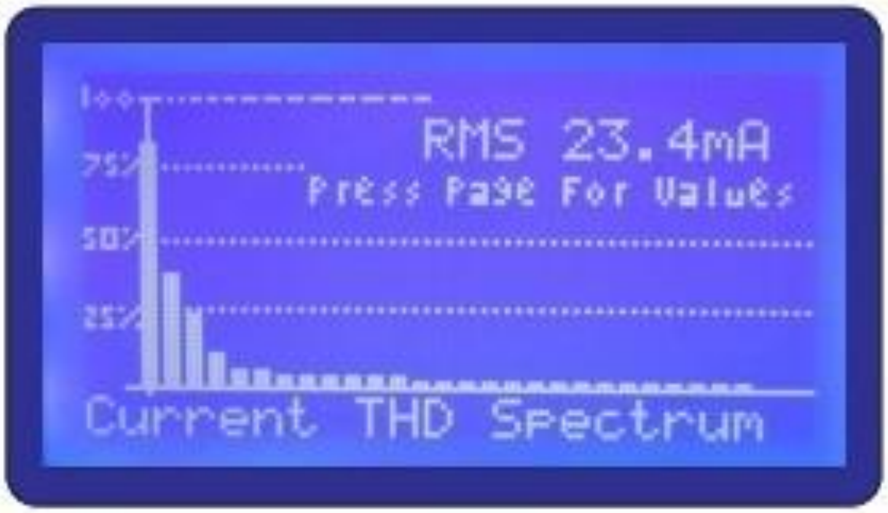
Average Value (V_{avg}) = V_{pk} x 0.637

$$\text{Crest Factor} = \text{Peak / RMS} = \frac{V_{pk}}{V_{pk} \times 0.707} = 1.414$$

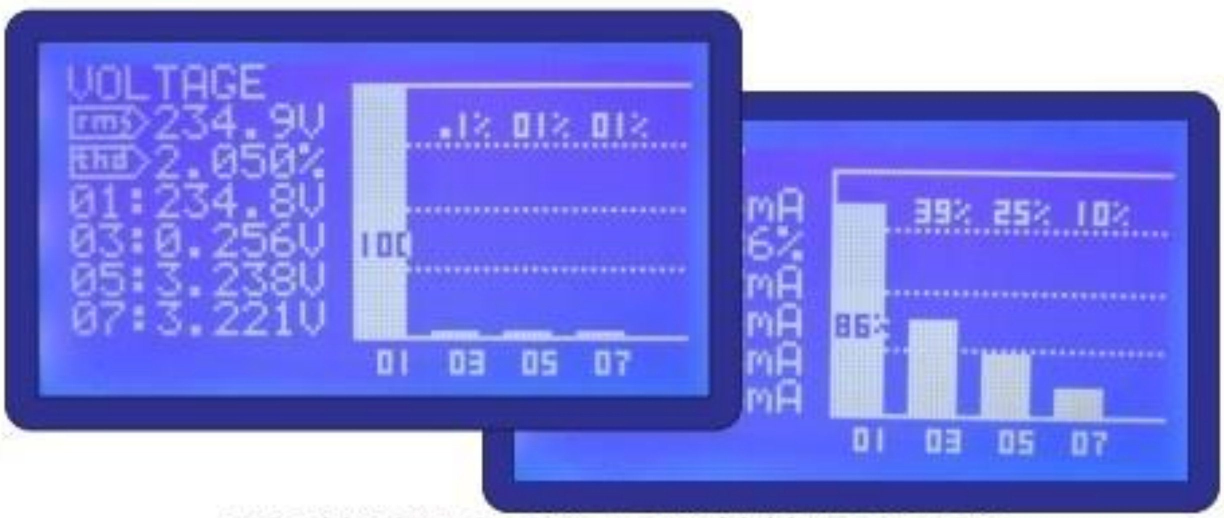
$$\text{Form Factor} = \text{RMS/ Avg} = \frac{V_{pk} \times 0.637}{V_{pk} \times 0.707} = 1.1098$$

MAIN PAGE

- Voltage, Current, Wattage, PF,Frequency
- Voltage THD, Current THD
- Net Effect of load on THD
- Model number
- Pass/Fail status

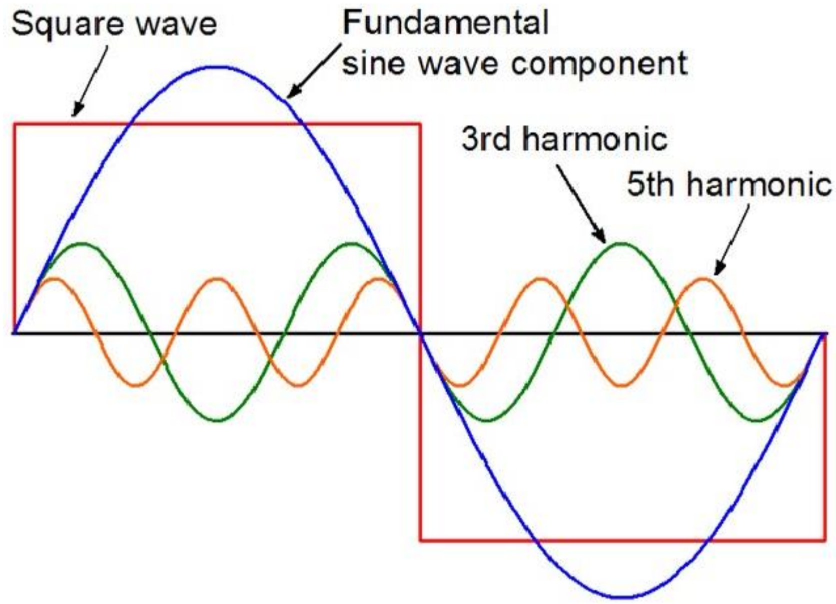


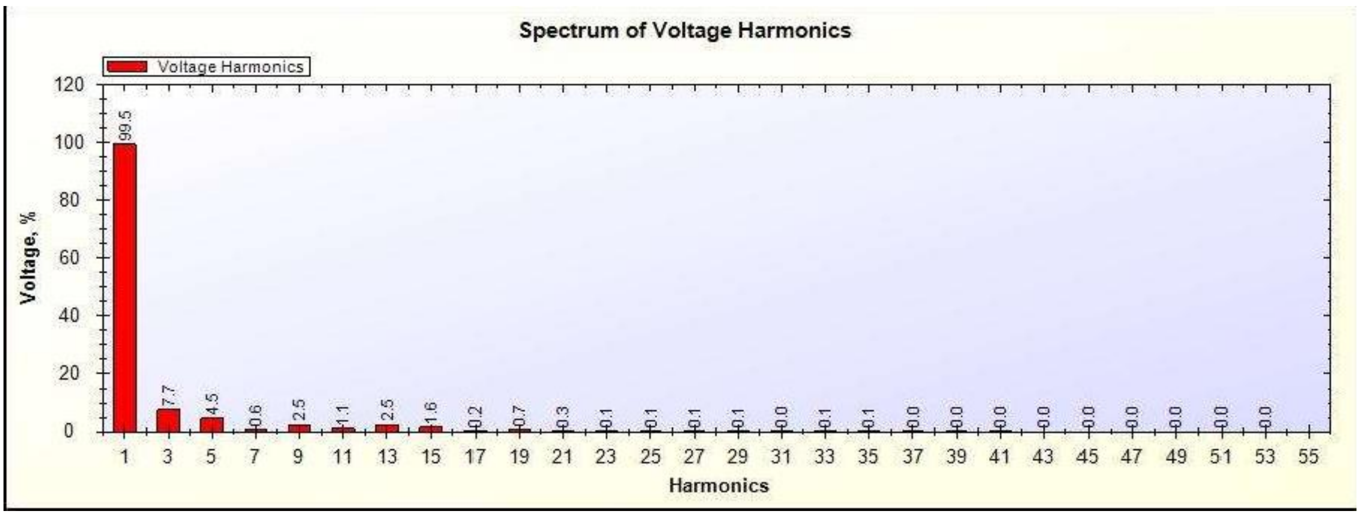
GRAPHICAL HARMONIC SPECTRUM VIEW



VOLTAGE & CURRENT THD PAGE

- RMS Value
- Total Harmonic Distortion
- Upto 55th order of Voltage/Current Harmonics





READINGS FROM THE THD METER:

Voltage and Current Harmonics up to 55th Harmonics

OBSERVATION TABLES:-

Voltage:	
Current:	
Power:	
Power Factor:	
Frequency:	
V_{THD} **%:**	
A_{THD} **%:**	

Exp. 1

Type of load: LED bulb. (Voltage and Current Harmonics up to 55th Harmonics)

Harmonics	Voltage THD	Voltage THD %

Harmonics	Current THD	Current THD %

Exp. 2

Type of load: CFL bulb. (Voltage and Current Harmonics up to 55th Harmonics)

Harmonics	Voltage THD	Voltage THD %

Harmonics	Current THD	Current THD %

Exp. 3

Type of load: CFL & LED bulb. (Voltage and Current Harmonics up to 55th Harmonics)

Harmonics	Voltage THD	Voltage THD %

Harmonics	Current THD	Current THD %

For Experiment No: 2

- **DETERMINATION OF FORM FACTOR FOR NON-SINUSOIDAL WAVEFORM**

FOR DETERMINATION OF FORM FACTOR:

Peak Value (V_{pk}) = Reading taken from THD meter.

RMS Value (V_{rms}) = $V_{pk} \times 0.707$

Average Value (V_{avg}) = $V_{pk} \times 0.637$

$$\text{Crest Factor} = \text{Peak / RMS} = \frac{V_{pk}}{V_{pk} \times 0.707} = 1.414$$

$$\text{Form Factor} = \text{RMS/ Avg} = \frac{V_{pk} \times 0.637}{V_{pk} \times 0.707} = 1.1098$$

EXPERIMENT - 13

THREE PHASE TRANSFORMER

II) VERIFICATION OF RELATIONSHIP BETWEEN VOLTAGES AND CURRENTS (STAR-DELTA, DELTA-DELTA, DELTA-STAR, STAR-STAR)

AIM: To verify the relationship between Voltages and Currents of a given 3-ϕ Transformer

(STAR- DELTA, DELTA-DELTA, DELTA-STAR, STAR-STAR)

APPARATUS REQUIRED:

S.NO	Name of the equipment	Rating/Range	Type	Quantity
1	Three phase Transformer	3000VA, 240/415:138/240,∆/Y	AC	1
2	Three Phase Auto Transformer	415/(0-600)V	AC	1
3	Voltmeters	(0-600)V	MI	3
4	Ammeters	(0-20)A	MI	3
5	Connecting Wires	-------		Required Number

THEORY & PROCEDURE:

Four common ways of connecting transformer windings to form a three-phase transformer are: delta-delta, Star-Star (wye-wye) ,delta-Star(wye) and Star(wye)-delta as shown in figure below. In order to set up a wye connection, first connect the three components (windings) together at a common point for interconnection with the neutral wire, then connect the other end of each component in turn to the three line wires. To set up a delta connection, connect the first component in series with the second, the second in series with the third and the third in series with the first to close the delta loop. The three line wires are then separately connected to each of the junction nodes in the delta loop.

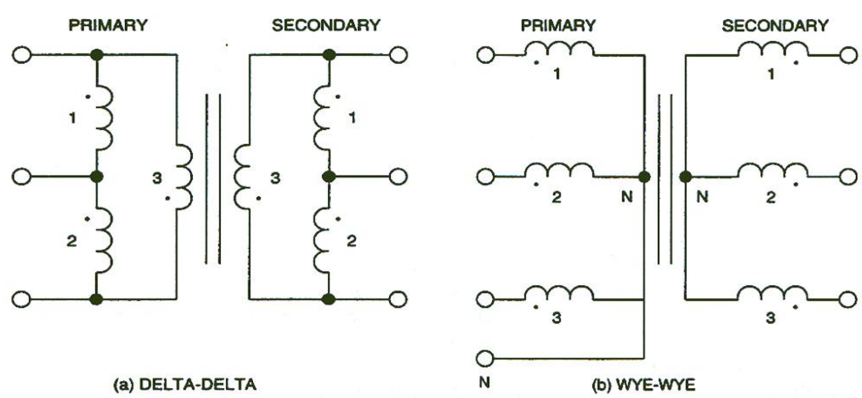


Fig1: Delta-Delta and Star(Wye)-Star(Wye)Connections

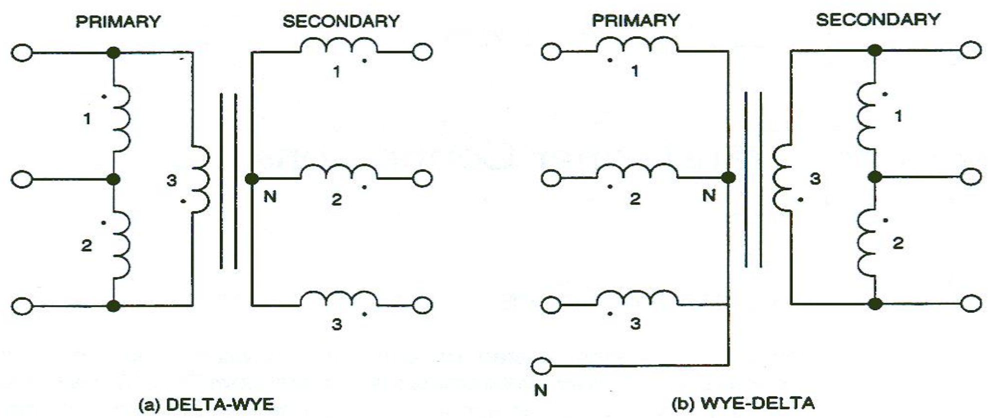


Figure 5-2 Delta-Star(Wye) and Star(Wye)-Delta Connections

Before a three-phase transformer is put into service, the phase relationship must be verified. For a wye configuration, the line voltages at the secondary windings must all be √3 times greater than the corresponding phase voltages. If not, winding connections must be reversed. To verify that the phase relationships are correct for a wye configuration, the voltage between two windings (E_{AB}) is measured as shown in **Figure 5-3 (a)** to confirm that it is √3 times greater than the line-to-neutral voltage across either winding (for example E_{AN}). The voltages between the third winding and the others (E_{BC} and E_{CA}) are then measured to confirm that they are also √3 times greater than the phase voltage (E_{AN}) as shown in **Figure 5-3 (b).**

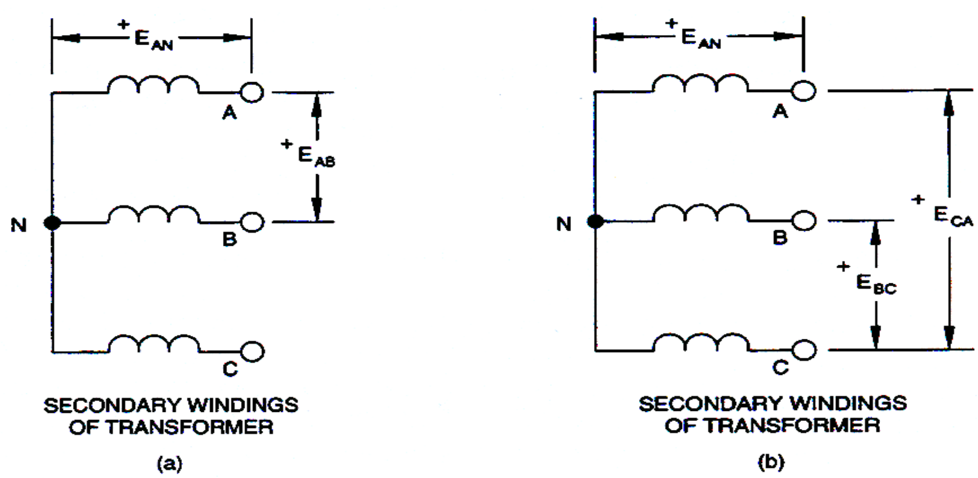


Figure 5-3 Confirming Phase Relationships in a Wye-Connected Secondary

For a delta configuration, the line voltages at the secondary windings must all be equal. If not, winding connections must be reversed. To verify that phase relationships are correct for a delta configuration, the voltage across two series-connected windings (E_{CA}) is measured as shown in **Figure 5-4 (a)** to confirm that it equals the voltage across either winding (E_{AB} and E_{BC}). The third winding is then connected in series, and the voltage across the series combination of the three windings is measured to confirm that it is zero before delta is closed, as shown in **Figure 5-4 (b)**. This is extremely important for a delta configuration because a very high short-circuits current will flow if the voltage within the delta is not equal to zero when it is closed.

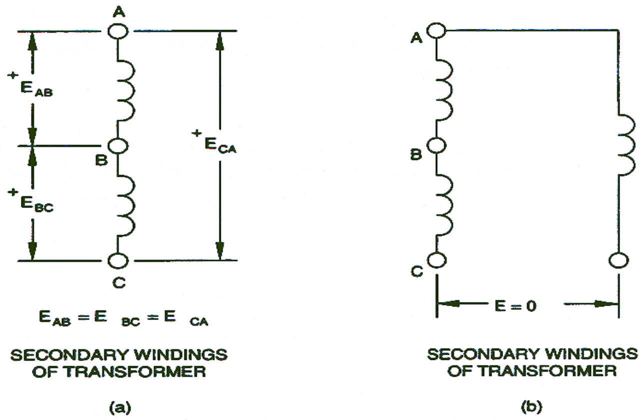


Figure 5-4 Confirming that the Delta Voltage Equals Zero.

TABULAR COLUMN:

Type of connections	Primary Voltage		Secondary Voltage		Voltage Ratio
	Line	Phase	Line	Phase	
Delta/Star					
Star/Star					
Star/Delta					
Delta/Delta					

RESULT:

APPLICATIONS:

1. Distribute power at high voltage
2. Eliminate double wiring
3. Operate 120 volt equipment from power circuits
4. Isolate electrical circuits

5. Separately establish branch circuits

6. Provide 3 wire secondary circuits

7. Buck Boost connexion

8. Provide electrostatic shielding for transient noise protection

VIVA-VOCE QUESTIONS:

1. Can Single Phase Transformers be used for Three Phase applications?
2. What is tertiary winding? What is Three Winding Transformer? What are its advantages?
3. Which transformer connections are more feasible to use in the distribution ends

EXPERIMENT - 14

THREE PHASE TRANSFORMER

II) VERIFICATION OF RELATIONSHIP BETWEEN VOLTAGES AND CURRENTS (STAR- DELTA, DELTA-DELTA, DELTA-STAR, STAR-STAR)

AIM: To verify the Relationship between Voltages and Currents of 3 ph transformer (Star-Delta, Delta-Delta, Delta-star, Star-Star)

APPARATUS REQUIRED:

Sl.No	Equipment name	quantity
01	Digital voltmeter (0-500VAC)	02
02	Digital ammeter (0-20 AAC)	02
03	3 Ph auto transformer	01
04	3 Ph transformer	01
05	Balanced resistive load	01
06	Connecting wires.	As Required

CIRCUIT DIAGRAM: (For STAR and STAR Configuration)

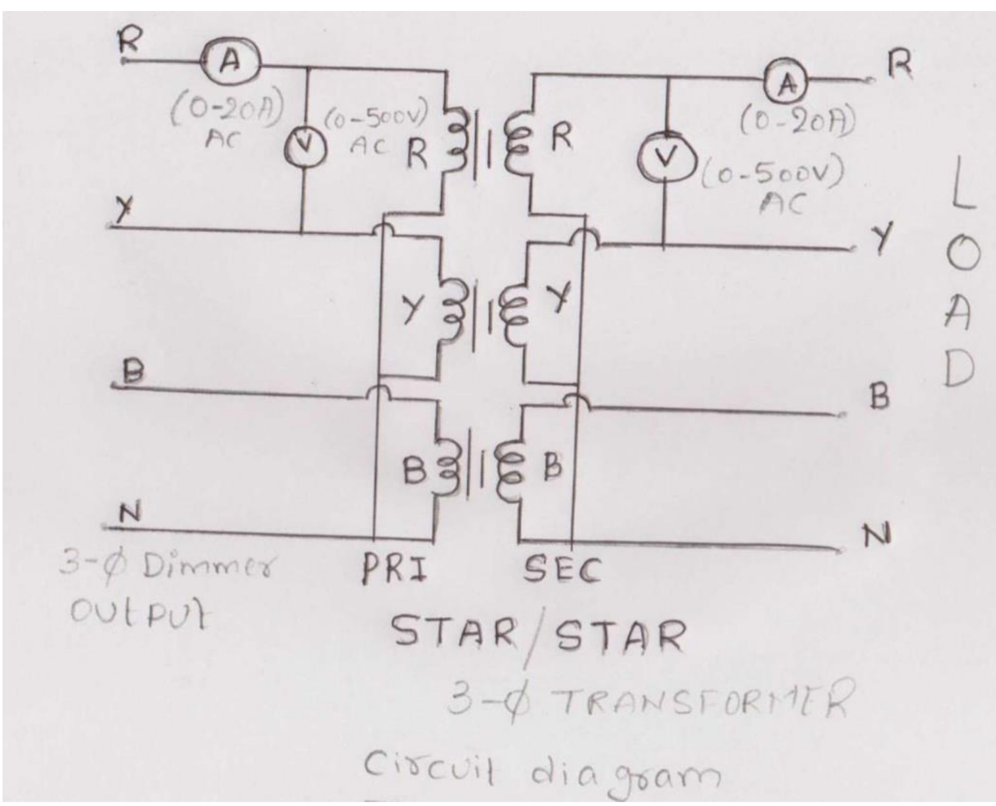


Fig 1

CIRCUIT DIAGRAM: (For DELTA and DELTA Configuration)

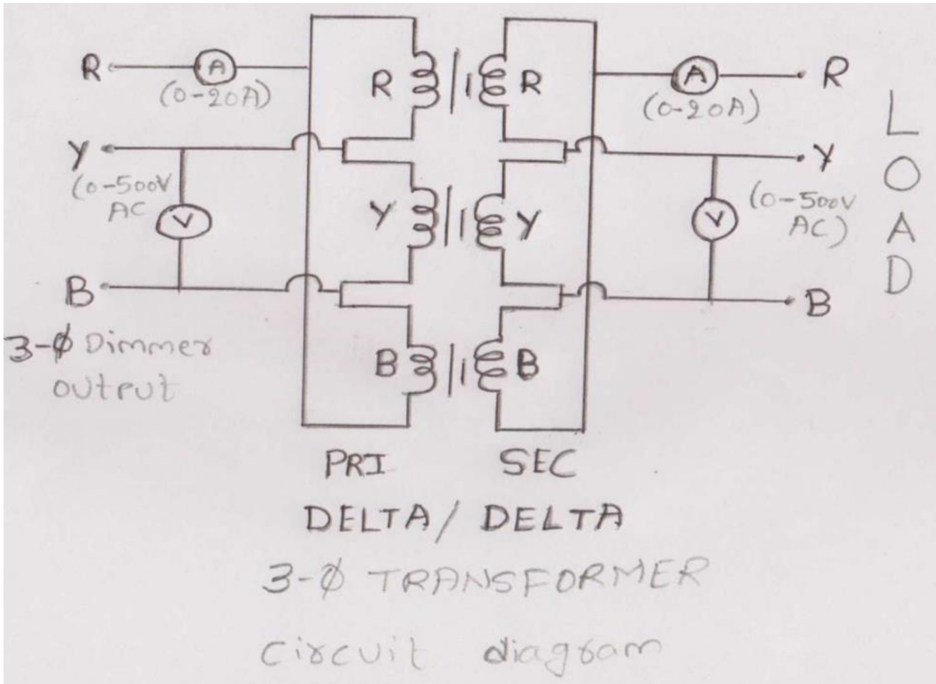


Fig 2

CIRCUIT DIAGRAM: (For DELTA and STAR Configuration)

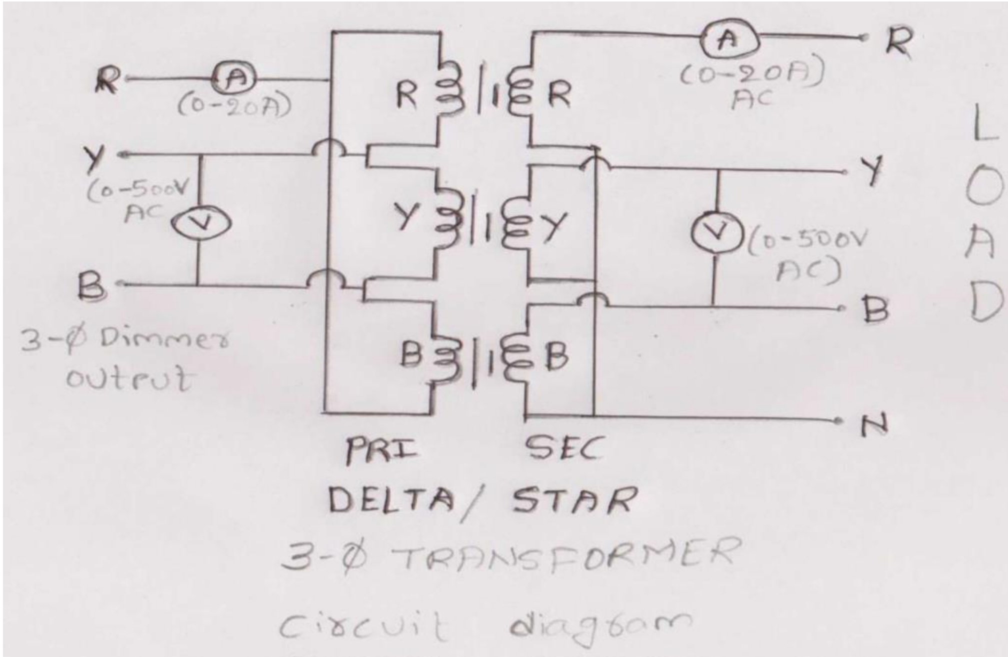


Fig 3

CIRCUIT DIAGRAM: (For STAR and DELTA Configuration)

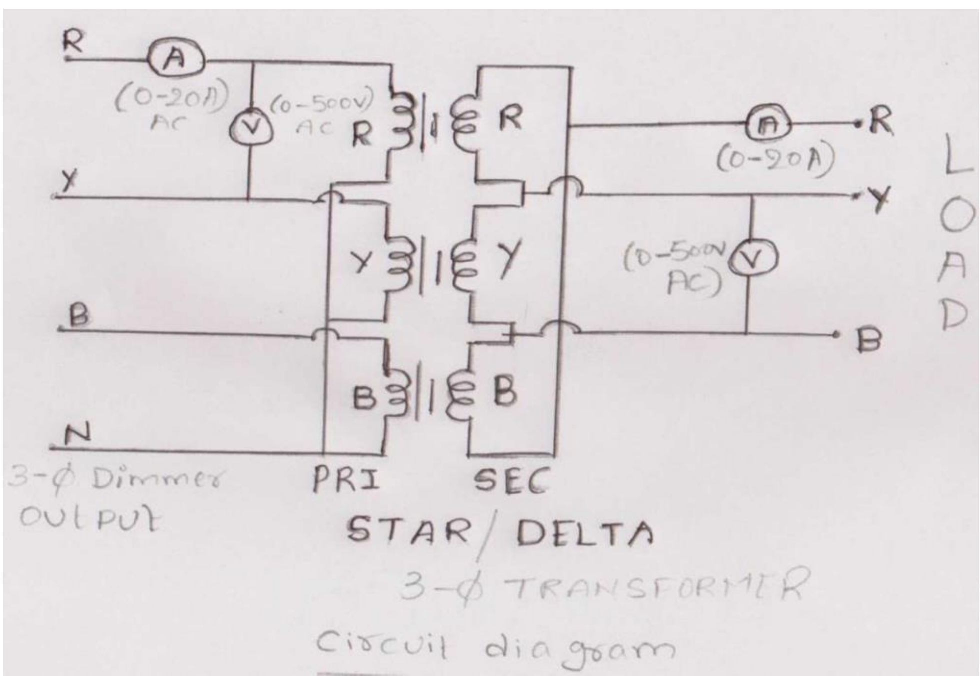


Fig 4

PROCEDURE: (For Balanced connected Loads)

1. Make the connections as per the circuit diagram.(fig 1)
2. Connect the supply to the STAR connected load through all meters as per the circuit diagram.
3. Switch ON the MCB.
4. Apply Voltage using Three Phase dimmerstat up to 400Volts.
5. Note down the Readings of voltmeter, ammeter.
6. Switch OFF the STAR Connected load.
7. Tabulate the readings.
8. Repeat the same procedure for (fig 2,3,4) remaining configurations.

OBSERVATIONS:

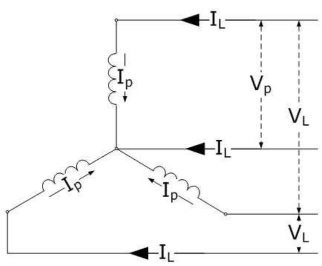
	PRIMARY		SECONDARY	
Transformer Configuration	VOLTAGE (L-L)	CURRENT	VOLTAGE (L-L)	CURRENT
STAR/STAR				
DELTA/DELTA				
DELTA/STAR				
STAR/DELTA				

CALCULATIONS:

Star Connection

$$I_L = I_p$$

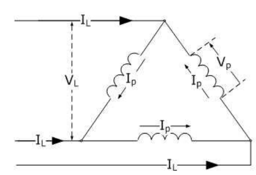
$$V_L = \sqrt{3} \times V_p$$



Delta Connection

$$V_L = V_P$$

$$I_L = \sqrt{3} \times I_P$$



RESULT:

EXPERIMENT – 15

DETERMINATION OF TWO PORT NETWORK PARAMETERS -HYBRID PARAMETERS.

Aim: To calculate and verify Hybrid parameters of two-port network.

APPARATUS : Breadboard, Batteries or DC regulated power supply, Resistors, Digital multimeter, Connecting wires, Alligator clips.

THEORY:
h-Parameters of Two Port Network are also called hybrid parameters. These parameters are very useful in constructing models for transistors.

These parameters are obtained by expressing voltage at input port and the current at output port in terms of the current at the input port and the voltage at the output port.

We will get the following set of two equations by considering the variables V1 & I2 as dependent and I1 & V2 as independent.

In equation form, above relations can be written as,

$V1=h11I1+h12V2$ …(1)

$I2=h21I1+h22V2$ …(2)

The coefficients of independent variables, I1 and V2, are called as h-parameters.

Figure 1: Two-port network

In matrix form the above equations can be written as,

Verify Hybrid Parameters of Two-port Network
Assuming the short circuit condition at the output terminal, we get V2 = 0

Now putting V2 = 0 in (1), we get

V1 = h11I1

∴h11 = (V1 / I1)

Similarly, putting V2 = 0 in (2), we get

I2 = h21I1

∴ h21 = (I2 / I1)

Again, assuming input port of the two-port network to be open circuited, the input voltage will be zero i.e. I1 = 0

Now putting I1 = 0 in (1), we get

V1 = h12V2

∴ h12 = (V1 / V2)

Similarly putting I1 = 0 in (3), we get

I2 = h22V2

∴ h22 = (I2 / V2)

Thus, there are four h parameter for a two-port or four-terminal network. Their values are tabulated below.

h_{11}	(V_1 / I_1)	Condition: Output port of the two-port network is short circuited i.e. V2 = 0
h_{12}	I_2/I_1	
h_{21}	V_1/V_2	Condition: Input port of the two-port network is open circuited i.e. I1 = 0
h_{22}	(I_2 / V_2)	

The individual h-parameters are defined as follows,

$h_{11} = (V_1 / I_1)$ AT $V_2 = 0$

$h_{12} = (I_2/I_1)$ AT $V_2 = 0$

$h_{21} = (V_1/V_2)$ AT $I_1 = 0$

$h_{22} = (I_2 / V_2)$ AT $I_1 = 0$

The parameters, h12 and h21, do not have any units, since those are dimension-less. The units of parameters, h11 and h22, are Ohm and Mho respectively.

All above parameters are having different units such as ohm for short circuit impedance and mho for open circuit output admittance, the name of the parameter is hybrid parameter.

CIRCUIT DIAGRAM:

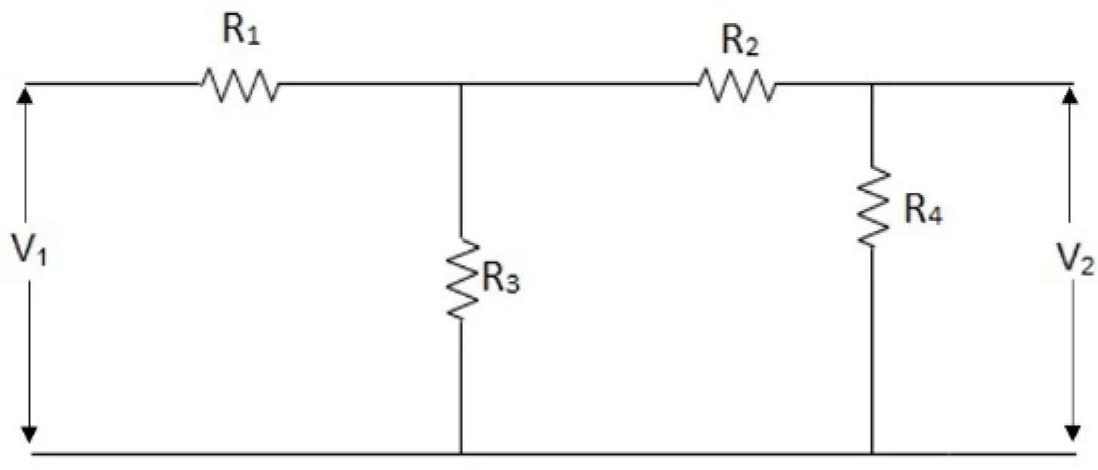


Figure : Circuit diagram for experimental set-up of H-Parameters

PROCEDURE:

1. Connect the circuit as shown in figure 2.
2. First short the output port (port 2) and supply 10V to input port (port 1). Measure output current and input current using multi-meter.
3. Secondly, open circuit input port and supply 5V to output port. Measure input and output voltages and output current using multi-meter.
4. Calculate the values of h-parameters using respective formulas (Shown in calculation section).
5. Switch ‘OFF’ the supply after taking the readings.

PRECAUTIONS:

1. Before circuit connection working condition of all the components must be checked.
2. All the connection should be tight.
3. Ammeter must be connected in series while voltmeter must be connected in parallel to the components (resistors).
4. The electrical current should not flow the circuit for long time, otherwise its temperature will increase and the result will be affected.

OBSERVATION TABLE:

V_1	I_1	I_2	V_1	V_2	I_2

Calculations
For Practical Values:

(a) When output is short circuited i.e. V2 = 0

h11 = V1 / I1 = ___ Ω

h21 = I2 / I1 = ___

(b) When input is open circuited i.e. I1 = 0

h12 = V1 / V2 = ___

h22 = I2 / V2 = ___ mho

For Theoretical Values:

[Use any method to calculate h-parameters]

h11 = ____ Ω

h21 = ____

h12 = ____

h22 = ____mho

RESULT:

Parameter	h_{11}	h_{12}	h_{21}	h_{22}
Theoretical				
Practical				

EXPERIMENT – 1

TRANSIENT RESPONSE OF SERIES RL AND RC CIRCUITS USING DC EXCITATON

AIM: To construct RL & RC transient circuit and to draw the transient curves.

APPARATUS REQUIRED:

S.NO.	NAME OF THE EQUIPMENT	RANGE	TYPE	QTY.
1.	RPS	(0-30)V	DC	1
2.	Ammeter	(0-10)mA	MC	1
3.	Voltmeter	(0-10)V	MC	1
4.	Resistor	10 K	-	3
5.	Capacitor	1000 µ F	-	1
6.	Bread board	-	-	1
7.	Connecting wires	-	Single strand	As required

THEORY:

Electrical devices are controlled by switches which are closed to connect supply to the device, or opened in order to disconnect the supply to the device. The switching operation will change the current and voltage in the device. The purely resistive devices will allow instantaneous change in current and voltage.

An inductive device will not allow sudden change in current and capacitance device will not allow sudden change in voltage. Hence when switching operation is performed in inductive and capacitive devices, the current & voltage in device will take a certain time to change from pre switching value to steady state value after switching. This phenomenon is known as transient. The study of switching condition in the circuit is called transient analysis.The state of the circuit from instant of switching to attainment of steady state is called transient state. The time duration from the instant of switching till the steady state is called transient period. The current & voltage of circuit elements duringtransient period is called transient response.

FORMULA:

Time constant of RC circuit = RC

Time constant of RL circuit = L/R

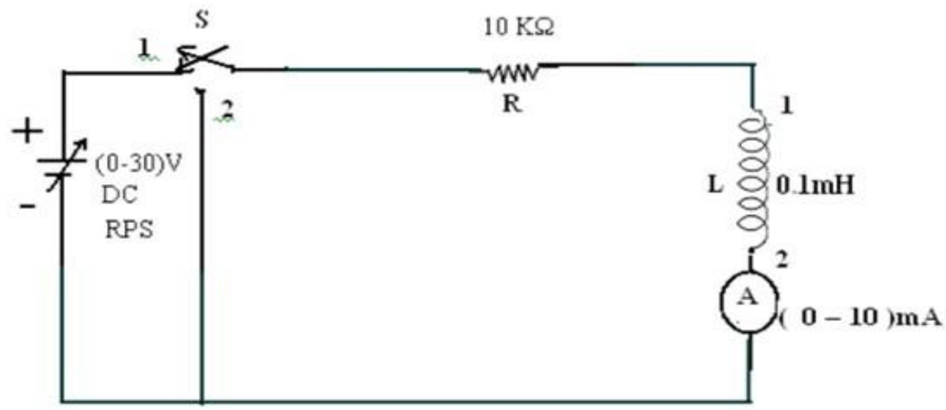
PROCEDURE:

- ❖ Connections are made as per the circuit diagram.

- Before switching ON the power supply the switch S should be in off position
- Now switch ON the power supply and change the switch to ON position.

CIRCUIT DIAGRAM:

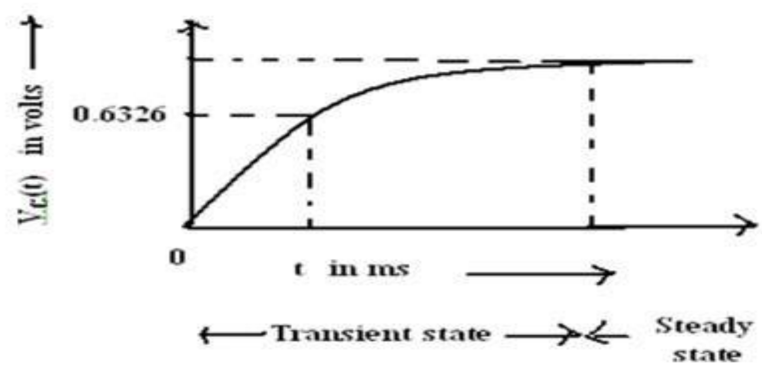
RL CIRCUIT:



TABULATION:

S.NO.	TIME (msec)	CHARGING CURRENT (I) A	DISCHARGING CURRENT (I) A

MODEL GRAPH:



TABULATION:

CHARGING:

S.NO.	TIME (msec)	VOLTAGE ACROSS 'C' (volts)	CURRENT THROUGH 'C' (mA)

MODEL CALCULATION & ANALYSIS:

TABULATION:

DISCHARGING:

S.NO.	TIME (msec)	VOLTAGE ACROSS 'C' (volts)	CURRENT THROUGH 'C' (mA)

RESULT:
Thus the transient response of RL & RC circuit for DC input was verified.

VIVA VOICE QUESTIONS:

1. Define steady state response
2. Define transient response
3. Why transient occurs in electric circuits
4. Define time constant of RL circuit
5. Define time constant of RC circuit
6. Voltage across capacitor cannot change instantaneously. Justify
7. Current through an inductor cannot change instantaneously. Justify.

APPLICATIONS:

RC, RL and LC circuits are essential building blocks in many circuit applications.

1. For example, RC and RL circuits are commonly used as filters (taking advantage of the fact that capacitors tend to pass high frequency signals but block low frequency signals, while the opposite is true for inductors).

2. They are also useful for electrical signal processing, for example, taking the derivative or integral of an electrical signal. The LC circuit is a simple example of an electrical "oscillator" or resonance circuit and is a common component in circuits used for amplifiers, radio tuning, etc.

EXPERIMENT NO- 2

RESONANCE IN SERIES RLC CIRCUIT

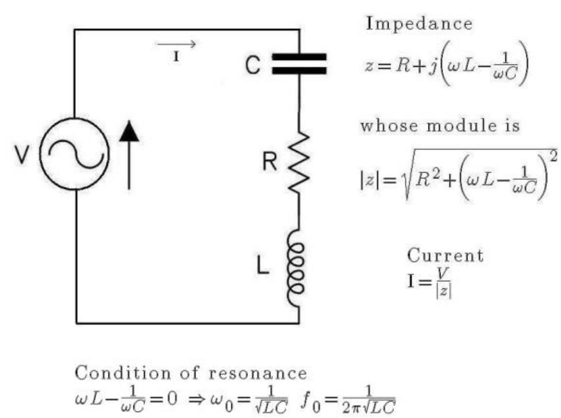
AIM:

To verify resonant frequency, bandwidth and quality factor of RLC series resonant circuits.

APPARATUS REQUIRED:

S.No	NAME	RANGE	TYPE	QUANTITY
1	Function Generator	(70-10000)Hz	-	1
2	Ammeter	(0-200)mA	MI	1
3	Decade Resistance Box	(0-1Mohms)	-	1
4	Decade Inductance Box	(0-100H)	-	1
5	Decade Capacitance Box	(0-100µF)	-	1
6	Connecting wires	-	-	Required

Theoritical Circuit Diagram For Series Resonance:



Practical Circuit Diagram For Series Resonance:

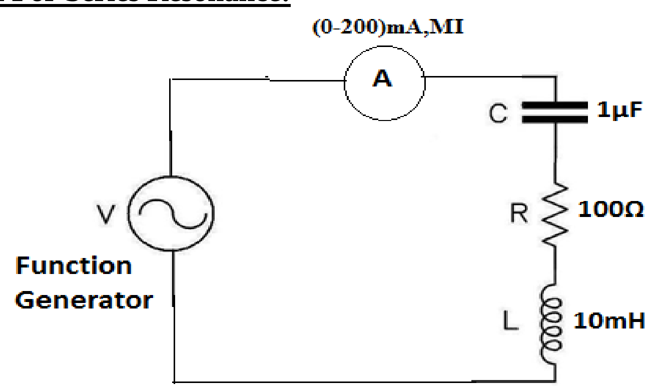


Fig.1

THEORY:

An electrical circuit is said to undergo resonance when the net (total) current is in phase with the applied voltage. A circuit at resonance exhibits certain characteristic properties.

The frequency at which the resonance occurs in a circuit is called resonant frequency.

In series RLC circuit, the resonance occurs when

i) The net reactance in a circuit is zero. ($X_L = X_C$)

ii) The circuit impedance is equal to resistance in a circuit (Z = R)

iii) Current in phase with voltage

iv) Power factor is unity.

v) The current in a circuit is maximum.

UNDER RESONANCE CONDITIONS,

$X_L = X_C$ *or* $\omega L = 1 / \omega C$

$$\omega_o^2 = 1 / LC$$

$$\omega_o = \frac{1}{\sqrt{LC}} \quad \text{or} \quad f_o = \frac{1}{2\pi\sqrt{LC}}$$

In parallel resonance, the resonant frequency is same as the series resonance but the current in circuit is minimum and net suceptance is equal to zero.

Formulae:

a) Resonant frequency: $f_o = \frac{1}{2\pi\sqrt{LC}}$ Hz

b) Half power frequencies:

$f_1 = f_o - R/ 4\pi L$ Hz

$f_2 = f_o + R/ 4\pi L$ Hz

c) Band width:

$BW = f_2 - f_1$ (or) $R/ 2\pi L$

d) Q –factor: $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

PROCEDURE:

SERIES RESONANCE:

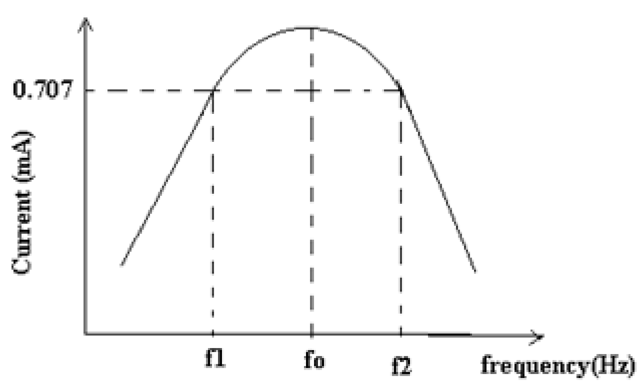
1. Make the connections as per the circuit diagram shown in fig1.
2. Apply the sinusoidal voltage of peak-peak value is 10V
3. Vary the frequency of sine wave between 100 Hz – 10000 Hz in steps, and note down the readings of ammeter.
4. Tabulate the readings in table1.

TABULAR COLUMN:

(SERIES RESONANCE)

S.NO.	***Frequency (Hz)***	***Current (mA)***
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Model Graph:



Series Resonance

PRECAUTIONS:

1. Avoid loose connections
2. Take readings without parallax error
3. Set the ammeter pointer at zero position

RESULT :

-

VIVA-VOCE QUESTIONS:

1. Define resonance frequency.
2. What is the value of power factor in series RLC circuit under resonance condition?
3. Define Bandwidth?
4. Define Q-factor?

APPLICATIONS:

The resonant RLC circuits has many applications like

1. Oscillator circuit, radio receivers and television sets are used for the tuning purpose
2. Since **resonance in series RLC circuit** occurs at particular frequency, so it is used for filtering and tuning purpose as it does not allow unwanted oscillations that would otherwise cause signal distortion, noise and damage to circuit to pass through it.
3. The series RLC circuit mainly involves in signal processing and communication system
4. The Series resonant LC circuit is used to provide voltage magnification