GOVERNMENT POLYTECHNIC COLLEGE, NABARANGPUR

CIRCUIT AND SIMULATION LAB MANUAL

3rd SEM. ELECTRICAL ENGINEERING

Instruction manual

Verification of KCL & KVL

MODEL NO. ME 561D

An ISO CERTIFIED COMPANY

MARS

Mars EdPal Instruments Pvt. Ltd.

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INSTRUCTION MANUAL
FOR
VERIFICATION OF KCL AND KVL
(KIRCHHOFF'S CURRENT AND KIRCHHOFF'S VOLTAGE LAW)
MODEL NO. ME 561 & ME 561D

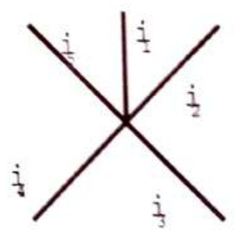
'MARS' made Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL) Apparatus has been designed to study and verify Kirchoff's Current Law & Kirchoff's Voltage Law.

The instrument comprises of the following built in parts:

1. DC Regulated power supply of 0-3V.
2. Four type of wire wound resistances each of 5 Watt(5Ω, 10Ω, 22Ω & 33Ω) are mounted on front panel.
3. Circuit for Kirchhoff's laws is engraved on front panel.
4. Two meters are provided on the front panel to measure corresponding Voltage & Current with connections brought out on sockets.

THEORY

In simple circuits,the resistance and potential difference are calculated with the help of ohms law.But in actual practice,we come across complicated circuits which contain a large number of resistances alongwith several sources of e.m.f. In such cases,the effective resistance and the e.m.f. can not be calculated easily from ohm's law.In order to solve such networks,Kirchhoff gave two laws which are known as Kirchhoff's laws.



First Law:

According to Kirchhoff's first law. "The algebriac sum of the various currents meeting at a junction in a closed electrical circuit is Zero.

$$i_1 - i_2 - i_3 + i_4 + i_5 = 0$$

or

$$i_1 + i_4 + i_5 = i_2 + i_3$$

Sign Convention:

The currents flowing towards a junction are taken as positive while the currents flowing away from the junction are taken as negative.Let us consider a junction 0.Where a number of conductors meet.i1 i2 are the currents flowing through them in the directions shown in Fig.(1).

Thus the total amount of current flowing into a junction must be equal to the total current flowing out of the junction. Clearly, according to this law, electric currentcannot accumulate at any point.Unlike charge,current cannot be stored.It must flow on.

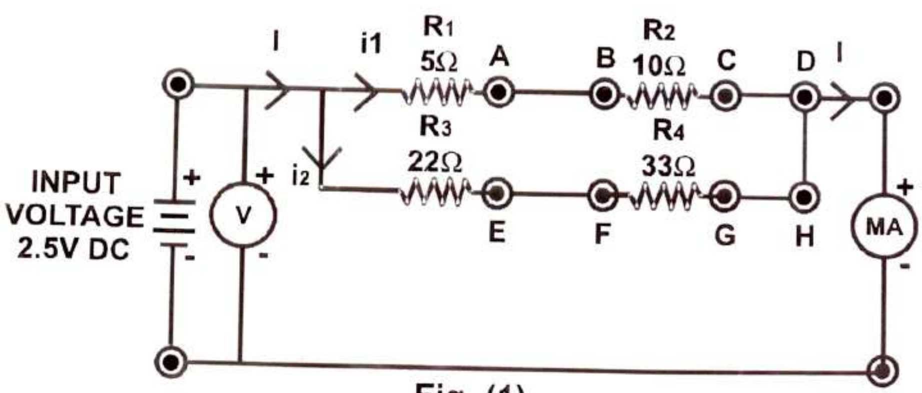


Fig. (1)

Second law:

According to second law,in a closed loop (closed circuit or mesh) the algebriac sum of the emfs is equal to the algebric sum of the products of the resistances and the respective currents flowing through them.

The distribution of currents in the circuit is shown in the diagram given below according to Kirchhoff's first law.

NOTE : Resistance tolerance is in ±10%.

PROCEDURE

NOTE : I denotes total input & total output current of the closed loop.i1 denotes current in the upper arm of the closed loop i.e.along R1 & R2.i2 denotes current in the lower arm of the closed loop i.e. along R3 & R4.

For KCL:

For calculation of i_1 current:

1. Connect the circuit as show in Fig.(1a) i.e.connect voltmeter across the positive to positive and negative to negative Current meter (mA) is connected to positive to positive and negative to negative.

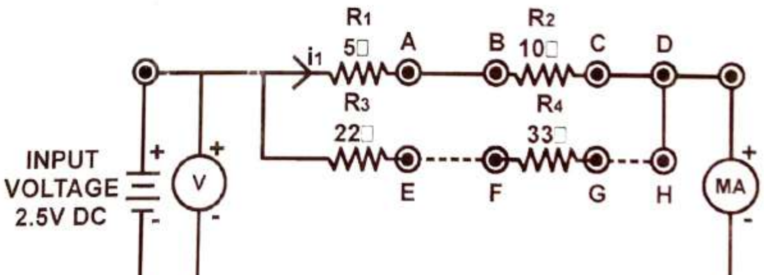


Fig. (1a)

0·16A

2. Set output voltage 2.5 volts and connect the input through patch cord.
3. Short the A and B or C and D point through patch cord.E and F or G and H point will be open.
4. Switch on the instrument and note down the current in (ma).

Applying Kirchhoff's second law to the closed mesh A B C D, We get

$R1\,i_1 + R2 i_1$	=	voltage
$(R1+R2)i_1$	=	voltage
i_1	=	V /(R1+R2) Amp.
i_1	=	?Amp (convert to miliamp.) (i1 x 1000 = mA)

Compare this calculated value to observed value at current meter.

Calculation of i_2 current:

1. Connect the circuit as show in Fig.(1b)i.e.connect voltmeter across the positive to positive and negative to negative Current meter (mA) is connected to positive to positive and negative to negative.

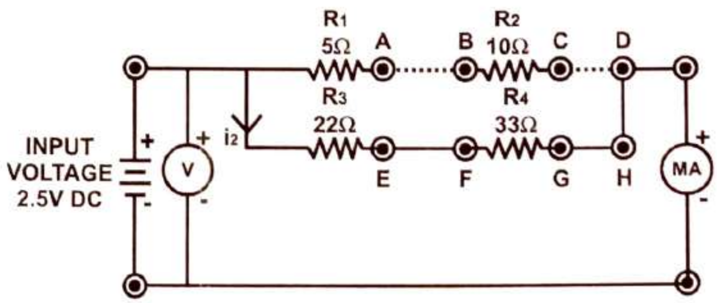


Fig.(1b)

0.04 A

2. Set output voltage 2.5 volts and connect the input through patch cord.
3. Short the E and F or G and H point through patch cord.A and B or C and D point will be open.
4. Switch ON the instrument and note down the current in (mA).

Applying Kirchhoff's second law to the closed mesh E F G H,We get

$R3\,i_2 + R4 i_2$	=	voltage
$(R3+R4)i_2$	=	voltage
i_2	=	V /(R3+R4) Amp.
i_2	=	?Amp (convert to miliamp.) (i2 x 1000 = mA).

Calculation of total Input current i:

Connect the circuit as shown in Fig.(1c) i.e. connect point A and B or C and D or E and F or G and H.

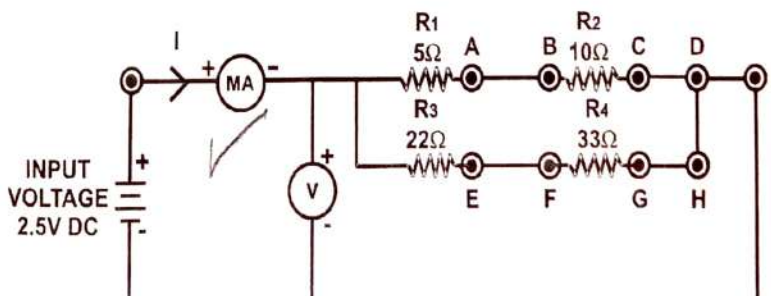


Fig.(1c)

Also connect current meter (mA) and voltmeter positive to positive and negative to negative.

Total Input Current, $i = i_1 + i_2$ convert the miliampere (i x 1000= mA)

Calculation of total Output current i:

Connect the circuit as shown in Fig.(1d) i.e. connect point A and B or C and D or E and F or G and H. Also connect current meter (mA) and voltmeter positive to positive and negative to negative.

Total Output Current, $i = i_1 + i_2$ convert the miliampere (i x 1000= mA)

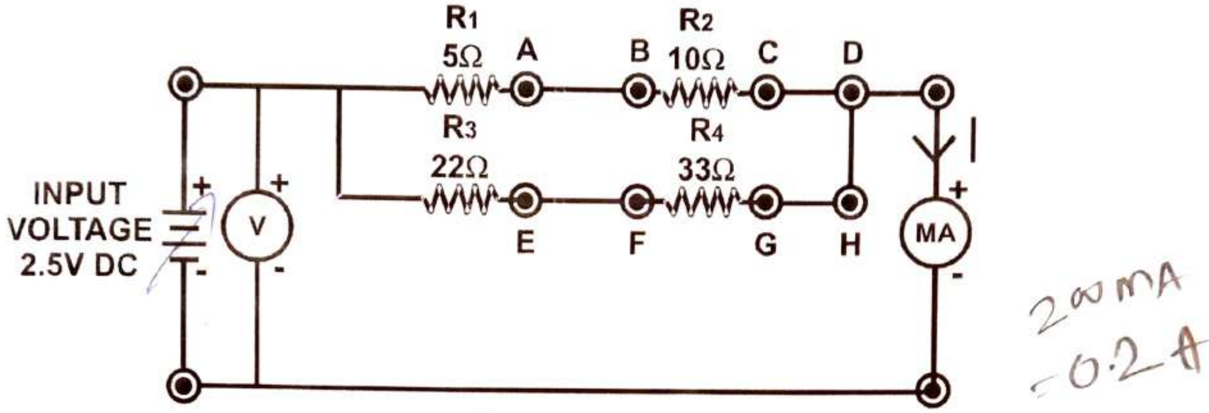


Fig. (1d)

Now Compare the total input current & the total output current. You will be observe that current entering in a junction= current leaving a junction.

For KVL:

For calculation of V_1 Voltage:

1. Connect the circuit as shown in Fig.(2a) i.e. connect voltmeter across voltmeter sockets & Current meter (mA) is connected in series between A & B.

2. Set output voltage 2.5 volts and connect the input through patch cord.

3. Short C and D point through patch cord.E and F or G and H point will be open.

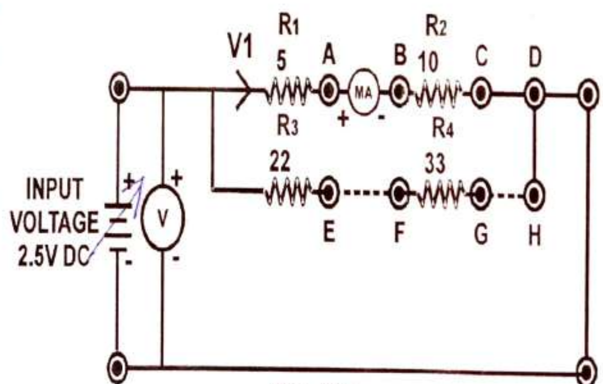


Fig. (2a)

4. Switch ON the instrument and note down the current in (ma).

5. Calculate voltage across 5Ω using ohms law i.e V=IR.

For calculation of V_2 Voltage:

1. Connect the circuit as shown in Fig.(2b) i.e. connect voltmeter across voltmeter sockets & Current meter (mA) is connected in series between C & D.
2. Set output voltage 2.5 volts and connect the input through patch cord.
3. Short A and B point through patch cord.E and F or G and H point will be open.
4. Switch ON the instrument and note down the current in (ma).
5. Calculate voltage across 10Ω using ohms law i.e V=IR.

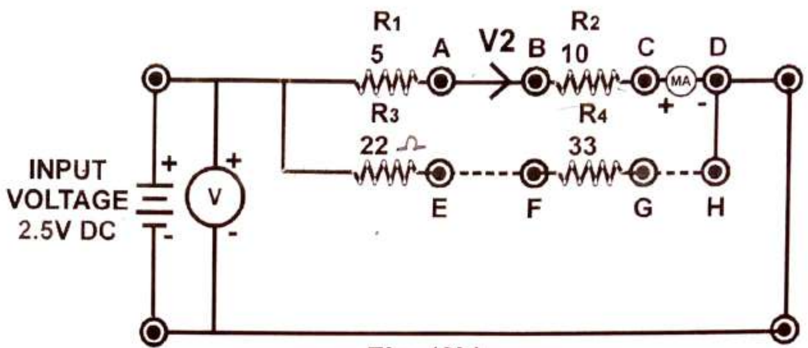


Fig. (2b)

Now add V1 & V2 & observe that there sum will be nearly = total input voltage (Approx. 2.5V) applied which verifies KVL.Similarly proceed for second arm i.e. across R3 & R4 for varifying KVL for second branch.

SAMPLE RESULTS

For KCL:

Calculation of i1:

$5i_1+10i_1$	=	2.5
$15i_1$	=	2.5
i_1	=	2.5 /15 Amp.
i_1	=	166.66 mA. (Calculated value)
	=	**160mA. (Observed value)**

Calculation of i2:

$22\, i_2 + 33\, i_2$	=	2.5
$55\, i_2$	=	2.5
i_2	=	2.5/55 amp
	=	45.45 mA. (Calculated Value)
	=	**45mA. (Observed Value)**

Calculation of Total Input & Output Current i:

Total Current	i	=	$i_1 + i_2$
	i	=	166.66 + 45.45
		=	212.11 mA (Calculated value)
		=	**205 mA (Observed value)**

Observe that total input & total output currents as observed from respective circuit diagrams 1(c) & 1(d) will be same i.e. current entering in a junction = current leaving a junction.

For KVL:

(A) Calculation of V1:

Input voltage applied = 2.5V (Observed value)

Current through 5Ω = 155mA

Therefore calculated voltage = V = IR

= 155mA x 5Ω

= 0.775V (Calculated value)

Calculation of V2:

Input voltage applied = 2.5V (Observed value)

Current through 10Ω = 155mA

Therefore calculated voltage = V = IR

= 155mA x 10Ω

= 1.55V (Calculated value)

Therefore voltage in the upper arm = 0.775+1.55 = 2.325V (Calculated value)

(B)Calculation of V1:

Input voltage applied = 2.5V (Observed value)

Current through 22Ω = 45mA

Therefore calculated voltage = V = IR

= 45mA x 22Ω

= 0.99V (Calculated value)

Calculation of V2:

Input voltage applied = 2.5V (Observed value)

Current through 33Ω = 45mA

Therefore calculated voltage = V = IR

= 45mA x 33Ω

= 1.485V

Therefore voltage in the lower arm = 0.99+1.485 = 2.475V (Calculated value)

STANDARD ACCESSORIES

1.	Single Point Patchcords for Interconnections.	-	10 Nos.
2.	Instruction Manual (DOC 561D).	-	01 Nos.
3.	Power Cord.	-	01 Nos.

Instruction manual

VERIFICATION OF THEVENIN'S & NORTON'S THEOREMS
MODEL NO.ME 590D-ii

An ISO CERTIFIED COMPANY

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INSTRUCTION MANUAL

FOR

VERIFICATION OF THEVENIN'S & NORTON'S THEOREMS

VERIFICATION OF THEVENIN'S & NORTON'S THEOREMS

Verification of Thevenin's & Norton's Theorems Apparatus has been designed to verify the different types of theorems such as:

1. Thevenin's Theorem.
2. Norton Theorem.

THE INSTRUMENT COMPRISES OF THE FOLLOWING BUILT IN PARTS:-

1. Fixed Output DC Regulated power supplies of 12V DC.
2. Two analog meters are mounted on the front panel to measure the value of Voltages and Currents.
3. Different types of resistances are also provided on the front panel.
4. Circuit diagrams for each theorem are printed on the front panel.

THEORY

Thevenin's Theorem:

Thevenin's Theorem states that current flowing through a load resistance R_L connected across any two terminals of a linear, active bilateral network is given by V_{OC} II (R_{th} + R_L), Where V_{OC} is the open circuit voltage (i.e. voltage across the two terminals when R_L is removed) and R_{th} is the internal resistance of the network as viewed back into the open circuited network when all voltage sources replaced by their internal resistance (if any).

How to Thevenize a Given Circuit?

1. Temporarily remove the resistance (called load resistance R_L) whose current is required.
2. Find the open circuit voltage V_{oc} which appears across the two terminals from where resistance has been removed. It is also called Thevenin's voltage V_{th}.

3. Compute the resistance of the whole network as looked into from these two terminals after all voltage sources have been removed leaving behind their internal resistances (if any). It is also called Thevenin's resistance R_{th}.

4. Replace the entire network by a single Thevenin's source, whose voltage is V_{th} and whose internal resistance is R_{th}.

5. Connect R_L back to its terminals from where it was previously removed.

6. Finally, Calculate the current flowing through R_L by using the equation:

$$I = V_{th} / (R_{th} + R_L).$$

Norton's Theorem:

Norton Theorem's states that any two terminal active network containing voltage sources and resistances when viewed from its output terminals, is equivalent to a constant current source(I_{SC}) and a parallel resistance(R_{NOR}). The constant current is equal to the current which would flow in a short circuit placed across the terminals & parallel resistance is the resistance of the network when viewed from these open circuited terminals after all voltage sources have been removed and replaced by their internal resistance(if any).

$$IL = \frac{Isc \times Rnor}{Rnor + RL}$$

PROCEDURE

For Thevenin's Theorem:

Find the current through RL as shown in Fig.(1) using Thevenin's Theorem.

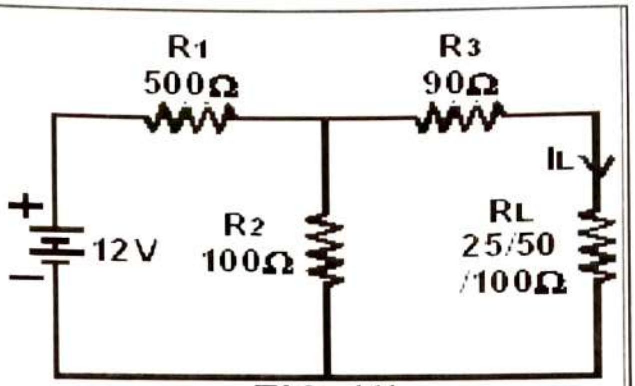

FIG. (1)

1. Connect the circuit as shown in Fig. (2) Through patch cords i.e. disconnect the load resistance (R_L) from output terminals and measure open circuit voltage(V_{th}) by connecting Voltmeter across points Z1 & Z2. Formula used to calculate the voltage drop across Z1 & Z2 is

$$V_{th} = R2 \times \frac{V}{R1 + R2}$$

$$V_{th} = 100\Omega \times 12V / 600\Omega = 2V$$

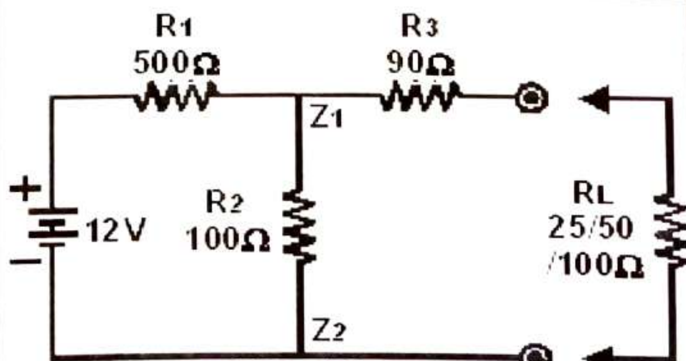

FIG. (2)

2. To measure the resistance across X & Y points, Disconnect voltage source (12V) and short the A & B points as shown in Fig. (3). Now connect DMM (Digital Multi Meter) across X & Y points, Set the mode of DMM at resistance and note down the value of resistance across X & Y points. Formula used to calculate the value of resistance (R_{th})

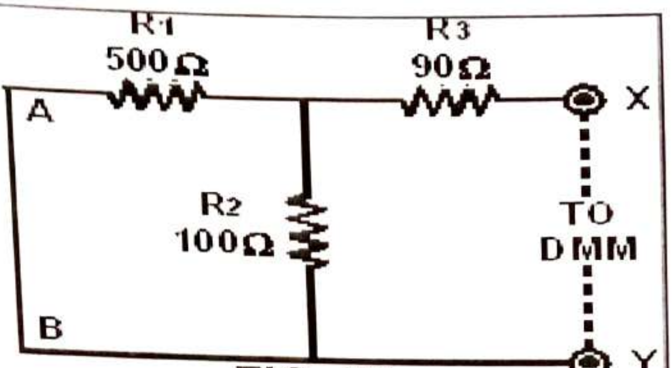

FIG. (3)

$$R_{th} = [R1 \parallel R2] + R3\ \Omega$$

$$R_{th} = [500 \times 100/(500 + 100)] + 90 = 173.3\Omega$$

3. To measure the current from load resistances RL (25/50/100Ω), connect the circuit as shown in Fig. (4) i.e. connect current meter in series of load resistance. Equivalent circuit for Fig.(4) is also shown by Fig. (5).

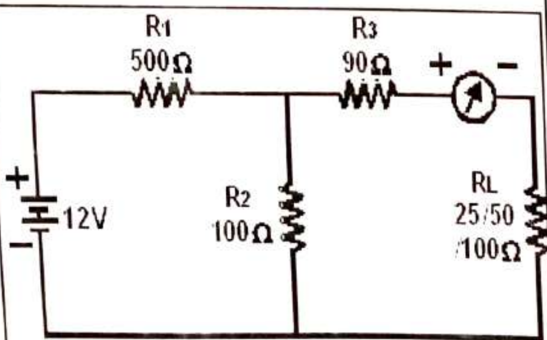

FIG. (4)

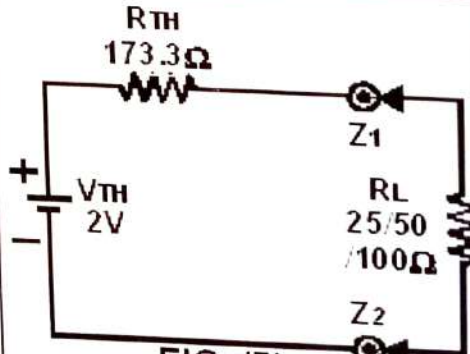

FIG. (5)

$$V_{th} = 2V$$
$$R_{th} = 173.4\,\Omega$$

For $R_L = 25\,\Omega$

$$\mathbf{I_L = \frac{V_{th}}{R_{th} + R_L} = 10mA}$$

$$I_L = 2 / (173.3 + 25) = 10mA$$

For

$$R_L = 50\,\Omega$$
$$I_L = 2 / (173.3 + 50) = 8.9\,mA$$
$$R_L = 100\,\Omega$$
$$I_L = 2 / (173.3 + 100) = 7.3\,mA$$

Compare the calculated values with observed value.

FOR NORTON'S THEOREM

Find the current through RL as shown in Fig. (6) Using Norton's Theorem.

1. Connect the circuit as shown in Fig. (7) Through patch cords i.e. disconnect the load resistance (R_L) from output terminals and connect current meter across X & Y points. Note down the short circuit current I_{SC}.

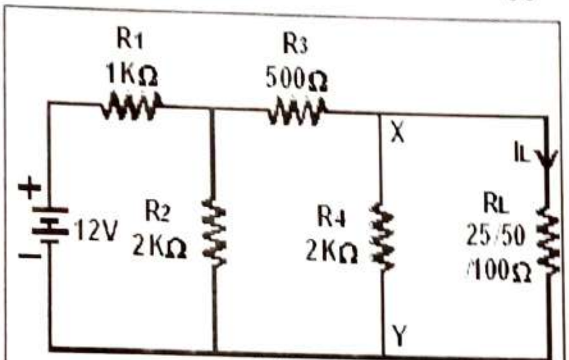

FIG. (6)

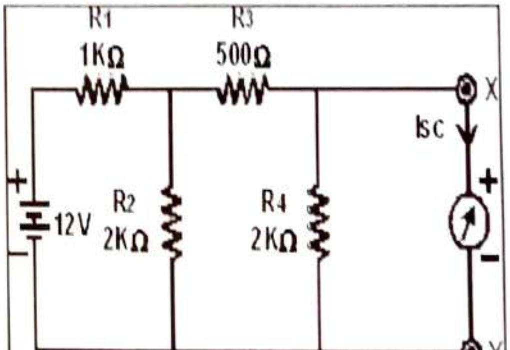

FIG. (7)

2. To measure the resistance across X & Y points, Disconnect voltage source (12V) and short the A & B points as shown in Fig. (8). Now connect DMM (Digital Multi Meter) across X & Y points, Set the mode of DMM at resistance and note down the value of resistance across X & Y points. Formula used to calculate the value of resistance (R_{NOR})

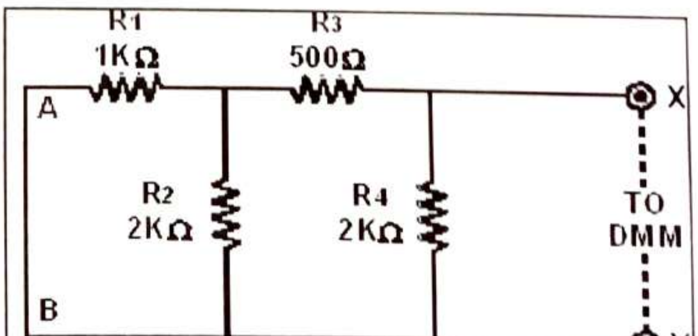

FIG. (8)

$$R_{NOR} = [R1 \parallel R2 + R3] \parallel R4\ \Omega$$

$$R_{NOR} = 737\Omega$$

Formula used to calculate short circuit current (I_{SC})

$$I_{SC} = \frac{V_{NOR}}{Rnor}$$

Where V_{NOR} is the open circuit voltage & is 5V.

$$I_{SC} = 5V/\,737\Omega = 6.78mA$$

3. To measure the current from load resistances RL (25/50/100Ω), connect the circuit as shown in Fig. (9) i.e. connect current meter of 25mA range in series of load resistance. Equivalent circuit for Fig.(9) is also shown by Fig. (10).

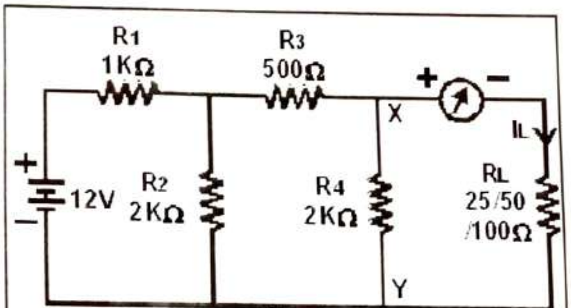

FIG. (9)

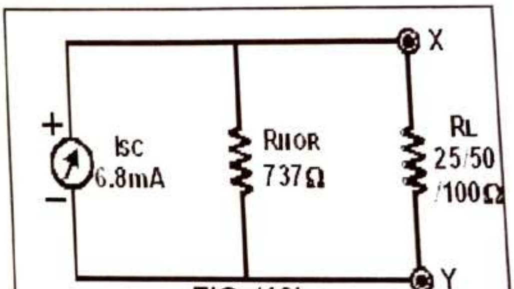

FIG. (10)

Now

$$I_{SC} = 6.78mA$$

$$R_{nor} = 737\ \Omega$$

$$For\ R_L = 25\ \Omega$$

$$I_L = 6.78\ x\ 737/\ 737\ +\ 25 = \ 6.55mA$$

For $R_L = 50$

$$IL = \frac{Isc \times Rnor}{Rnor+RL}$$

$$I_L = 6.78 \times 737/\,(737 + 50) = 6.34\ mA$$

$$\text{For } R_L = 100\Omega$$

$$I_L = 6.78\,x\,737/\,737 + 100 = 5.94mA$$

Compare the calculated values with observed value.

STANDARD ACCESSORIES

1. Single point (4mm) Patch cords for Interconnections. - 4 Nos.

2. Interconnect able (4mm) Patch cords for Interconnections - 3 Nos.

3. Power cord (Mains Cord). - 1 No.

4. Instruction Manual (DOC 590D-II). - 1 No.

OPTIONAL ACCESSORIES

1. 3½ Digit Digital Multi meter (Manual Range)(Model No. VC 203) - 01 No.

Instruction manual

VERIFICATION OF SUPER POSITION &MAXIMUM POWER TRANSFER THEOREMS

MODEL NO.ME 590D-i

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INSTRUCTION MANUAL
FOR
VERIFICATION OF SUPER POSITION &
MAXIMUM POWER TRANSFER THEOREMS
MODEL NO. ME 590D-I

`**MARS**`made Verification of Super Position & Maximum Power Transfer Theorems Apparatus has been designed to verify the different types of theorems such as :

1. Superposition Theorem.
2. Maximum Power Transfer Theorem.

The instrument comprises of the following built in parts :-

1. Fixed Output DC Regulated power supplies of 12V & 5V DC.

2. Two Analog meters are mounted on the front panel to measure the value of Voltages and Currents.

3. Different types of resistances are also provided on the front panel.

4. Circuit diagrams for each theorems are printed on the front panel.

THEORY

Superposition Theorem :-

Superposition Theorem states that in a network of linear resistances containing more than one sources of e.m.f, the current which flows at any point is the sum of all the currents which would flow at that point if each e.m.f source(Voltage source) were considered separately and all the other e.m.f sources replaced for the time being by resistances equal to their internal resistances (If any).

Maximum Power Transfer Theorem :-

When load is connected across a voltage source, power is transferred from the source to the load. The amount of power transferred will depend upon the load resistance. If load resistance R_L is made equal to the internal resistance R of the source, then maximum power is transferred to the load R_L. This is known as maximum power transfer theorem and can be stated as follows.

"Maximum power is transferred from a source to a load when the load resistance is made equal to the internal resistance of the source". This applies to DC as well as AC power.

APPLICATIONS :-

Electric power systems never operate for maximum power transfer because of low efficiency and high voltage drops between generated voltage and load. However, in the electronic circuits, maximum power transfer is usually desirable. For instance, in a public address system, it is desirable to have load (i.e. speaker) "Matched" to the amplifier so that there is maximum transference of power from the amplifier to the speaker. In such situations, efficiency is sacrificed at the cost of high power transfer.

PROCEDURE

For Super Position Theorem :-

Note :- Always switch OFF the Instrument when you are connecting any circuit, after that switch ON the Instrument. To measure the current from any branch/ resistance as shown in Figs. connect current meter in series of that branch/ resistance at a time. To note down the current from other branch/ resistance connect current meter in series of that particular branch/ resistance, while the previous current meter points should be shorted.

Find the current I_1, I_2 & I_3 as shown in Fig. (1) using Superposition Theorem.

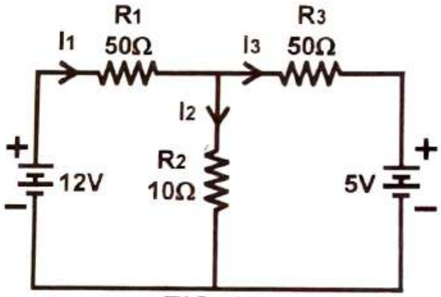

FIG. (1)

1. Connect the circuit as shown in Fig. (2) through patchcords. Consider only one voltage source at a time, first 12V.

2. Switch ON the instrument using ON/ OFF switch provided on the front panel.

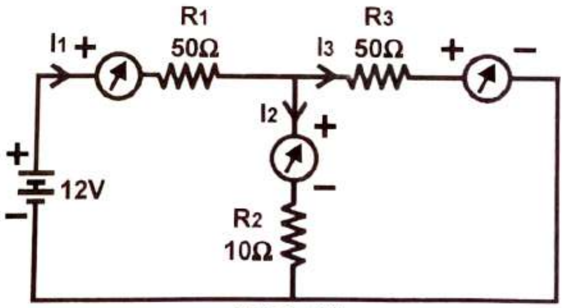

FIG. (2)

3. Note down currents I_1, I_2 & I_3 one by one by connecting current meter of 250mA range in series of resistances R1, R2 & R3.At this time other ammeter connections should be short.

4. Compare the observe current readings to calculated current values.

Formula used to calculate the currents :

According to Fig.(2), total resistance of the circuit is

R_T = 50Ω II 10Ω + 50Ω (Where II represents parallel sign)

R_T = 50Ω + 8.33Ω = 58.33Ω

Therefore current

$I_1 = I_T$ (I_T = Total current)

$I_T = V/R_T$

$I_T = 12V / 58.33\Omega = 205.7\ mA$

$I_1 = 205.7mA$

$I_3 = 205.7 \times 10 / 60 = 34.2\ mA$

$I_2 = I_1 - I_3 = 171.4\ mA$

Therefore for Fig.(2)

$I_1 = 205.7\ mA$

$I_2 = 171.4\ mA$

$I_3 = 34.2\ mA$

5. Now Connect the circuit as shown in Fig. (3) through patchcords. Consider only one voltage source at a time, second 5V.

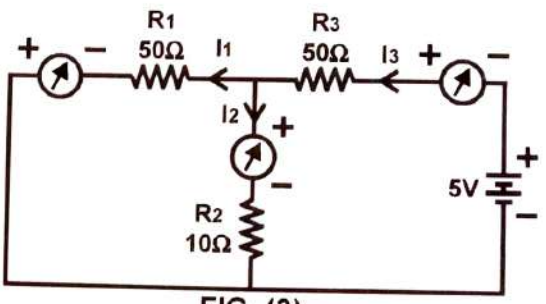

FIG. (3)

6. Switch ON the instrument using ON/ OFF switch provided on the front panel.

7. Note down currents I_1, I_2 & I_3 one by one by connecting current meter of 250mA range in series of resistances R1, R2 & R3.

8 Compare the observe current readings to calculated current values.

Formula used to calculate the currents :

According to Fig.(3), total resistance of the circuit is :

$R_T = 50\Omega \parallel 10\Omega + 50\Omega$ (Where II represents parallel sign)

$R_T = 50\Omega + 8.33\Omega = 58.33\Omega$

Therefore current

$I'3 = I_T$ (I_T = Total current)

Current $I_T = I'_3 = V/R_T$

$I'_3 = 5V/58.33 = 85.7mA$

$I'_3 = I_T = 85.7\ mA$

$I'_2 = \frac{85.7 \times 50}{50 + 10} = 71.4\ mA$

$I'_1 = 85.7 - 71.4 = 14.3\ mA$

Therefore current for Fig (3)

I'_1 = 14.3 mA

I'_2 = 71.4 mA

I'_3 = 85.7 mA

9 Connect the circuit as shown in Fig. (1) to measure Nett algebraic sum of Current when both the voltage sources (12V & 5V) Connected simultaneously.

10 Note down currents I_1, I_2 & I_3 one by one by connecting current meter of 250mA range in series of resistances R1, R2 & R3.

11 Compare the observed current readings to calculated current values.
Formula used to calculate the currents I_1, I_2 & I_3 :

Current through resistance R1 = $I_1 = I_1 - I'_1$ = 205.7- 14.3 = 191.4 mA
Current through resistance R2 = $I_2 = I_2 - I'_2$ = 171.4+ 71.4 = 242.8 mA
Current through resistance R3 = $I_3 = I_3 - I'_3$ = 85.7 - 34.2 = 51.5 mA

12 We can also observe the voltage drop across each resistance by connecting voltmeter across each resistance. Formula used to calculate the voltage drop across each resistance is :

When source voltage is 12 V only :-

Voltage drop across R1 :

VR1 = I_1 x R1 = 205.7 mA x 50 = 10.28V

Voltage drop across R2 :

VR2 = I_2 x R2 = 171.4 x 10 = 1.71V

Voltage drop across R3 :

VR3 = I_3 x R3 = 34.2 x 50 = 1.71V

When source is 5 volts only :-

VR1 = I'_1 x R1 = 14.3 x 50 = 0.71V

VR2 = I'_2 x R2 = 71.4 x 10 = 0.71V

VR3 = I'_3 x R3 = 85.7 x 50 = 4.2V

When Both the Sources Connected Simultaneously :-

$VR1 = I_1 \times R1 = 191.4 \times 50 = 9.5V$

$VR2 = I_2 \times R2 = 242.8 \times 10 = 2.4V$

$VR3 = I_3 \times R3 = 51.5 \times 50 = 2.5V$

At low voltages Analog voltmeter may show error in readings because of its low impedance, So it is good to use a multimeter to note down the lower voltage readings.

For Maximum Power Transfer Theorem :-

1. Connect the circuit as shown in Fig. (15) through patchcords.

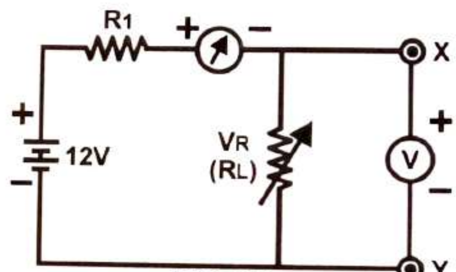

FIG. (5)

2. Connect resistance R = 500Ω & also set the load resistance value (VR or RL) to 500Ω by using good quality DMM (Digital Multi Meter). Connect currentmeter & voltmeter in the circuit provided on the front panel.

3. Note down the voltage & current and calculate the output power by using formula : Pout = Voltage x Current (V I)

4. Now increase & decrease the value of load resistance (VR) in small steps and Every time note down the corresponding value of voltage and current. Calculate output power for each reading and note down the observation in Table No. (1).

R	R_L (VR)	Volatge (V)	Current (I)	P_{OUT} = V I

TABLE No. (1)

5. We will observed that at a particular point when load resistance (VR) is made equal to the value of R (i.e. internal resistance of a source) maximum power is transferred from source to load. Draw a graph between output power and load resistance as shown in Fig. (6) by taking VR (R_L) along X-axis & P_{out} along Y-axis.

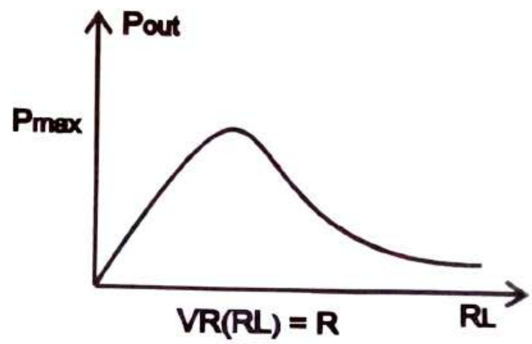

FIG. (6)

6. Repeat steps 2 to 5 for other values of R_1.

STANDARD ACCESSORIES

Singlepoint (4mm) Patchcords for Interconnections.	-	8 Nos.
Interconnectable (4mm) Patchcords for Interconnections	-	2 Nos.
Power Cord (Mains Cord).	-	1 No.
Instruction Manual (DOC 590D-I).	-	1 No.

OPTIONAL ACCESSORIES

3½ Digit Digital Multimeter (Manual Range) (Model No. VC 203)	-	1 No.

Instruction manual

Charging Discharging
of RC & RL circuit

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or Send the Email on : sales@marsedpal.com

INSTRUCTION MANUAL

FOR

CHARGING & DISCHARGING OF

RC & RL CIRCUIT

(ME-973)

CHARGING & DISCHARGING OF RC & RL CIRCUIT

"**MARS**" made RC & RL Trainer Kit which has been designed to Study charging and discharging of RC and RL circuit using oscilloscope and measure time constant value.

THEORY:

STEP RESPONSE OF A CIRCUIT

Step response of a circuit means behavior of the circuit when all of sudden some excitation of the circuit is changed to a new constant value or some component configuration is changed. Suppose the voltage applied to the circuit is given by $\upsilon(t) = V\ u\ (t)$ where u(t) is unit step function. In This case, behaviors of the circuit i.e. current flowing the circuit w.r.t. time for t> 0 is known as step response of the circuit

STEP RESPONSE OF SERIES R-L CIRCUIT

Consider The Series R-L Circuit as shown in Figure 1 which is initially

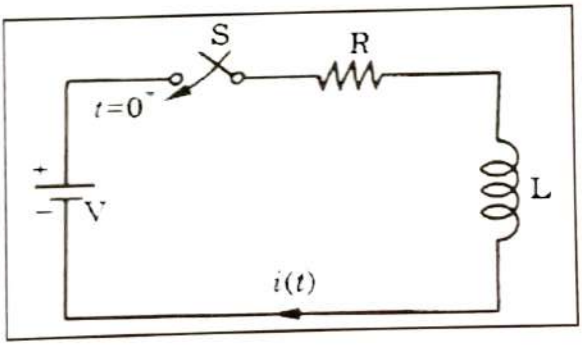


Figure 1: Series R-L Circuit

At t>0 the equation for the circuit can be written

$$V = Ri\,(t) + L\,\frac{di(t)}{dt}$$

Taking Laplace on both sides, we get

$$\frac{V}{s} = R\,I(s) + L\,[s\,I(s) - i(0-)]$$

Since Inductors is initially de-energized, hence i(0-) = 0

Thus. $$\frac{V}{s} = R\,I(s) + sL\,I(s)$$

or $$I(s) = \frac{V}{s(R+sL)} = \frac{V/L}{s\left(s+\frac{R}{L}\right)}$$

To Convert in To Partial Fraction from Let

$$\frac{V/L}{s\left(s+\frac{R}{L}\right)} = \frac{A}{s} + \frac{B}{s+\frac{R}{L}}$$

$$\Rightarrow \quad V/L = A\left(s+\frac{R}{L}\right) + Bs$$

Putting $s = 0$ we get $A = V/R$

Putting $s = -\frac{R}{L}$ we get $B = -V/R$

Using These Values of A & B, We Can Write

$$I(s) = \frac{V/R}{s} - \frac{V/R}{s+\frac{R}{L}} = \frac{V}{R}\cdot\frac{1}{s} - \frac{V}{R}\cdot\frac{1}{s+\frac{R}{L}}$$

Taking Laplace Inverse on Both Sides, We Get

$$i(t) = \frac{V}{R} - \frac{V}{R} e^{-\frac{R}{L}t} \quad \text{as } \pounds^{-1}\left(\frac{1}{s+a}\right) = e^{at}$$

STEP RESPONSE OF SERIES R-C CIRCUIT

Consider the series R-C Circuit as Shown in Fig 2. At t $\leq$ 0 The Capacitor is fully discharge at t = 0+, Switch S is closed.

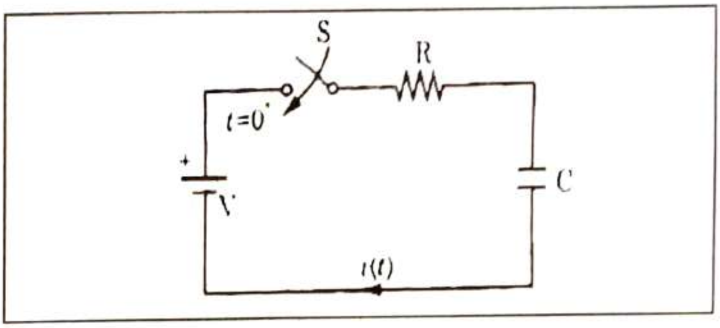


Figure 2: Series R-C Circuit

Thus, The excitation to the circuit is V, u (t) and is step type in nature At t > 0, the equation for the circuit can be written as

$$V = Ri(t) + \frac{1}{C}\int i\,dt$$

Taking Laplace on Both sides, We Get

$$\frac{V}{s} = RI(s) + \frac{1}{C}\left[\frac{I(s)}{s} + \frac{1}{s}\int i\,dt\Big|_{0+}\right] = \frac{I(s)}{sC} + \frac{v_0}{s} + RI(s)$$

Where υ_0 is initial voltage across the capacitor and since at starting capacitor is fully discharged, Hence $\upsilon_0 = 0$

$$\frac{V}{s} = RI(s) + \frac{I(s)}{sC} = \left(R + \frac{1}{sC}\right) I(s)$$

$$\Rightarrow \quad I(s) = \frac{V}{s\left(R + \frac{1}{sC}\right)} = \frac{V/R}{s + \frac{1}{RC}} = \frac{V}{R} \frac{1}{s + \left(\frac{1}{RC}\right)}$$

Taking Laplace inverse on Both sides:

$$i(t) = \frac{V}{R} e^{-\frac{1}{RC}t} \qquad \text{as } \mathcal{L}^{-1}\left(\frac{1}{s+a}\right) = e^{-at}$$

Here, RC Is Called time constant (τ) of the circuit.

PROCEDURE

FOR RC CIRCUIT

1. Connect square input signal at sockets (Red & Black) marked with RC circuit input provided on front panel in "RC Network" circuit with the help of patch cords. Set signal to any frequency (say 100 Hz by external multimeter).
2. Connect desired value of C (0.1/0.2/0.3 uF) and R (1K/2K/3K) in circuit by shorting dotted lines with Patch Cords.
3. Connect an external C.R.O. across the output sockets (Red & Black) marked as "OUTPUT" provided on front panel in circuit and observe the waveform on C.R.O.
4. Change the Value of R & C & Observe change in response on CRO.

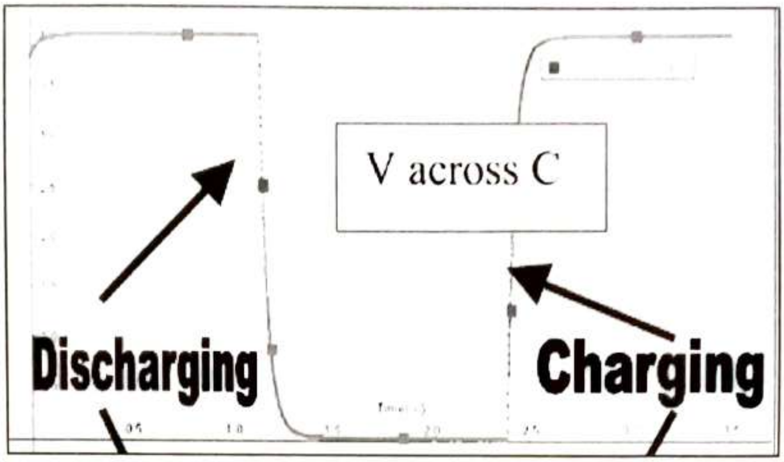
FOR RL CIRCUIT

1. Connect square input signal at sockets (Red & Black) marked with RL circuit input provided on front panel in "RL Network" circuit with the help of patch cords. Set signal to any frequency (say 100 Hz by external multimeter).
2. Connect desired value of L (1/5/10 H) and R (1K/2K/3K) in circuit by shorting dotted lines with Patch Cords.
3. Connect an external C.R.O. across the output sockets (Red & Black) marked as "OUTPUT" provided on front panel in circuit and observe the waveform on C.R.O.
4. Change the Value of R & L & Observe change in response on CRO.

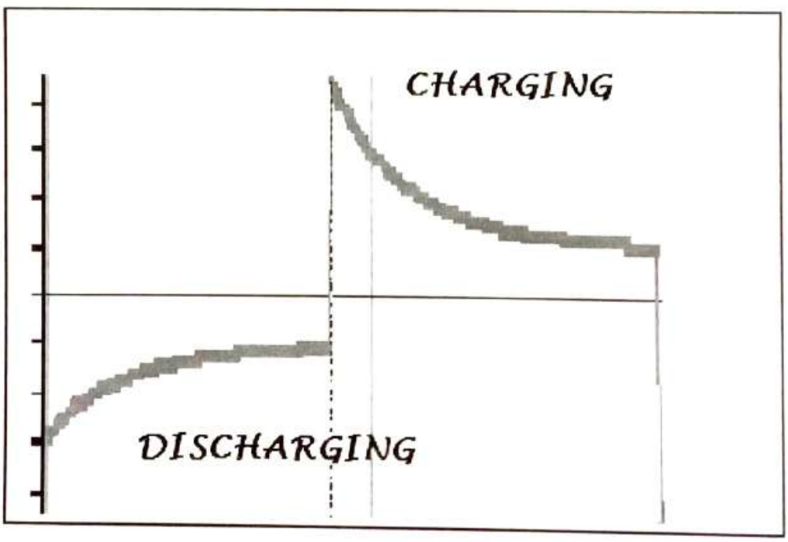
OBSERVATIONS:

Observe the response on CRO for RC & RL Circuit with different values of R, L & C.

FOR RC CIRCUIT, SAMPLE WAVEFORM IS SHOWN:



FOR RL CIRCUIT, SAMPLE WAVEFORM IS SHOWN:



TIME CONSTANT:

FOR RC CIRCUIT:

R ($K\Omega$)	C (μF)	TIME CONSTANT ($\tau = RC$)
1	0.1	
	0.2	
	0.3	
2	0.1	
	0.2	
	0.3	
3	0.1	
	0.2	
	0.3	

FOR RL CIRCUIT:

IF L = 1H, R_L = 500 ohm

IF L = 5H, R_L = 1.3 Kohm

IF L = 10H, R_L = 2 Kohm

TOTAL RESISTANCE OF CIRCUIT, $R= R_1+ R_L$

R1 ($K\Omega$)	L (H)	TIME CONSTANT ($\tau = \frac{L}{R}$)
1	1	
	5	
	10	
2	1	
	5	
	10	
3	1	
	5	
	10	

NOTE: YOU CAN MEASURE THE VOLTAGE AND CURRENT WITH THE HELP OF EXTERNAL MULTIMETER.

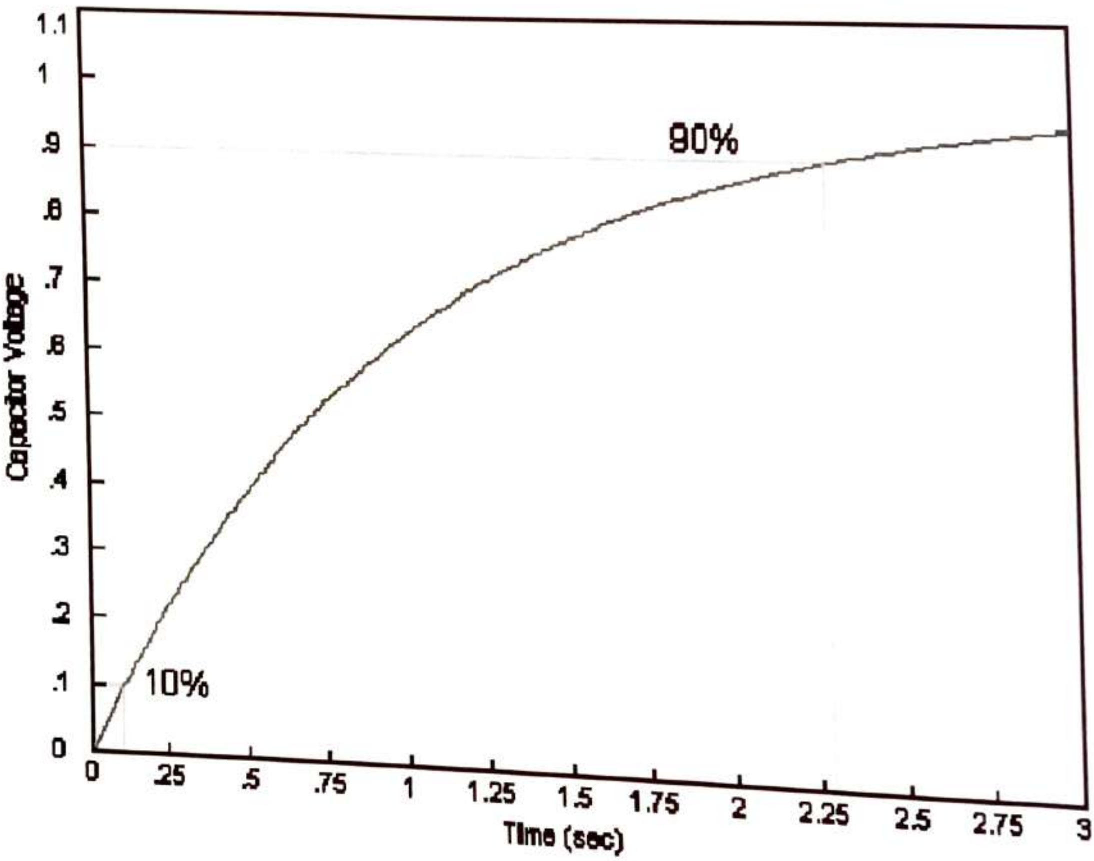
FOR RISE TIME:

The response of an RC circuit to a voltage step of amplitude V_0, starting at time t=0 can be characterized by the time constant τ= R.C [s].

$v(t) = V_0(1 - e^{-t/\tau})$ for $t \geq 0$

At the time $t = \tau$ the voltage rises to a value given by $V_0(1-e^{-1})$. This is about 63% of the full value V_0. It takes approximately 4 more time constants to reach the full value to a good degree of accuracy. The definition of rise time is "that time taken for a linear network's output to rise from 10% to 90% of its final value when stimulated by a step input".

It is easy to measure on an oscilloscope OR you may draw the waveform on graph paper.



In case of the RC network, the 10% level is reached after T1 time constants and the 90% after T2 time constants; thus the rise time is (T2 – T1) time constants.

RISE TIME= (T2-T1)*τ

STANDARD ACCESSORIES:

1. Single Point Patch cords for Interconnections (4mm)	:	05 No.
2. Double point patch cords for Interconnections (4mm)	:	02 No.
3. Power cord	:	01 No.
4. Instruction Manual	:	01 No.

OPTIONAL ACCESSORIES:

1. CATHODE RAY OSCILLOSCOPE	:	01 No.
2. DIGITAL MULTIMETER	:	01 No.

Instruction manual

'T' type Passive Low Pass,
High Pass, Band Pass &
Band Stop filters

MODEL NO. ME 961

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or Send the Email on : sales@marsedpal.com

INSTRUCTION MANUAL
FOR
"T" TYPE PASSIVE LOW PASS, HIGH PASS, BAND PASS & BAND STOP FILTERS
MODEL NO. ME 961

'**MARS**' made Passive Filter circuits has been designed to study the characteristics of Passive Filters.

The instrument comprises of the following built in parts:

1. Circuit diagram for all the filters are printed on the front panel and components are mounted behind the front panel.

2. Sockets are mounted on the front panel to connect the Function Generator across input signal & CRO across output.

THEORY

A filter is an electrical network that can transmit signals within a specified frequency range. This frequency range is called pass band and other frequency band where the signals are suppressed is called attenuation band or stop band. The frequency that seprates the pass and attenuation bands is known as cut-off frequency. There may also be two cut off frequencies in the entire zone of operation of the filter. The cut off frequency is usually symbolised as f_c in case its value is unique or by f_1 and f_2 in case the cut off frequencies are more than one (f_1 indicates lower cut off while the f_2 indicates higher cut off frequency).

An ideal filter would transmit signals under the pass band frequencies without attenuation and completely suppress the signal with attenuation band of frequencies with a sharp cut off profile. Practical filters do not ideally transmit the pass band signal unattenuated due to absorption, reflection or due to other loss. This results in loss of signal power. Also, the filters do not completely suppress the signal in attenuation bands. In passive filters, the circuit components -capacitor and inductor -are arranged in different circuit configurations to make the passive filter.

PROPERTIES OF FILTER :

The chief properties of a passive filter section are generally characterised by the following properties -

a **Characteristic impedance.** The characteristic impedance (Z_0) of a filter matches with the circuit to which it is connected throughout the pass band This prevents reflection loss in the combination Special attention must be taken for choosing a filter,so that it can be inserted into a given line or between two pieces of equipment

b **Pass band characteristic.** The filter should have minimum attenuation in its pass band range and high attenuation in the stop band range.The degree of attenuation is generally expressed by the attenuation constant α, its unit being Neper or decibel.

c **Cut off frequency characteristic.** The filter should possess frequency distinguishing property in the pass band or stop band.It should be capable of identifying lower as well as higher cut off frequency for transmitting signals through it. The transition frequency region between the pass and stop band must be very small. In real life,ideal filters are difficult to be implemented.However,attempts are being made to fabricate filters having characteristics in close proximity of ideal filters.

USE OF FILTERS

Filters are frequently used in numerous fields of electrical and electronic engineering.The filter being a frequency selecting device,it can be utilised for selecting a particular band or frequency from a wide range of frequency spectrum. In voice frequency telegraphy,multichannel communication is possible by utilising a number of band pass filters with different pass bands. In telephony or radio and TV broadcasting, several numbers of informations are transmitted by modulating different carrier frequencies which can be received by utilising filter circuits In radio receivers,intermediate carrier frequency selection is also possible by using filters in the communication network. In AM detection, high pass filters (HPF) are generally used in order to separate carrier frequency signal from the audio frequency. Many filters are used in various stages in TV receivers,where they can be used for producing intermediate combined sound and picture carrier frequency and then can separate sound carrier from the composite video signal. It also selects horizontal and vertical synchronising pulses from the composite video signal in addition to separating colour signals. In audio amplifiers,filters are used to reduce harmonic distortion and voice rejection. In regulated power supply units, filters are used to provide smooth DC output from AC input. In many electronic measuring equipments,filters are used to study particular band of frequencies. Different instruments/equipments may be protected using filter circuits.In electrical engineering, LPF and HPF (Low Pass Filter and High Pass Filter) are utilised in order to eliminate the undesired frequency components resulting from thyristor controlled circuits.

Filters may be classified as :

A Low Pass Filters (LPF)

B High Pass Filters (HPF)

C Band Pass Filters (BPF)

D Band Stop Filter (BSF) or Band Elimination Filter (BEF)

A. **Low Pass Filter (LPF)**

It is the simplest type of filter which allows all frequencies upto the specified cut off frequency to pass through band and attenuates all the other frequencies above the cut off frequency. Cut off frequency demarcates the pass band and the stop band.

B. **High Pass Filter (HPF)** :

Simply speaking, a high pass filter is the reverse of a low pass filter. This filter attenuates all frequency below the cut off frequency and allows to pass other frequencies above the cut off frequency.

C. **Band Pass Filter (BPF)** :

A band pass filter allows transmission of a limited band of frequencies ($f_2 - f_1$) and rejects all other frequencies below or above frequency band. A band pass filter has series tuned circuit in series arm and parallel tuned circuit in the shunt arm.

D. **Band Stop Filter (BSF)** :

A band elimination or band stop filter rejects transmission of a limited band of frequencies but it allows transmission of all other frequencies.

PROCEDURE

Low Pass Filter (Design for cut-off Frequency of 7.5KHz) :

1. Study the circuit configuration for Low Pass Filter printed on the front panel carefully.

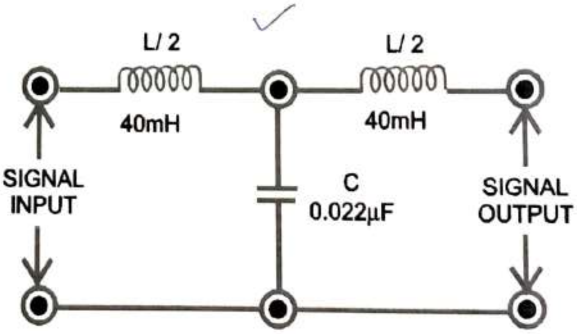

FIG. (1)

2. Connect the output of Audio Frequency Function Generator across signal input of Low Pass Filter.
3. Set the output of Audio Frequency Function Generator at Sine Wave of 2V peak to peak amplitude, 100Hz frequency.
4. Connect CRO (Cathode Ray Oscilloscope) across signal output sockets of the filter.
5. Switch ON both the instruments i.e, Function Generator & CRO.
6. Increase the frequency of Function Generator towards 10kHz range in small steps and note down output voltage on CRO everytime. You wil observe on the CRO that below 7.5kHz frequencies, the filter passes input signal completely (i e, output voltage amplitude will remain 2V peak to peak or more than 2V peak to peak). But after 7.5kHz frequency the filter will starts to attenuate or supress the output signal amplitude

(Signal amplitude reduces from 2V peak to peak amplitude) This frequency where the filter circuit starts to attenuate the signal is known as the cut-off frequency. Note down all the observation in Table No. (1).

Sr No	Frequency	Input Voltage V_{IN}	Output Voltage V_{OUT}	Gain=$20\log_{10} V_{OUT}/V_{IN}$
1				
2				
3				
4				
5				
6				
-				

OBSERVATION TABLE NO. 1

7 Plot the graph between output Voltage & Frequency or output gain vs frequency as shown in Fig. (1a)

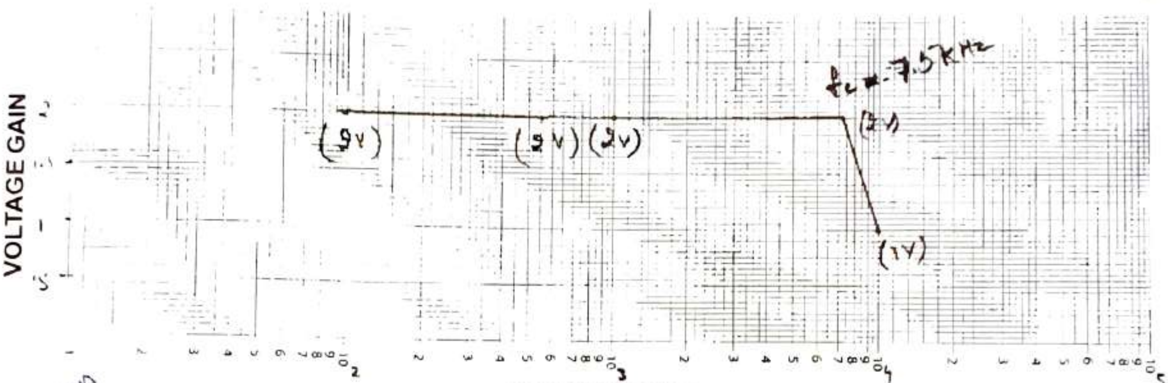

FIG. (1a)

Calculation

Formula used to calculate the cut-off frequency (fc) is

$$fc = 1/\pi\ (LC)^{1/2}$$

$$= 1/\ 3.14\ [(80 \times 10^{-3})\ (0.022 \times 10^{-6})]^{1/2}\ Hz$$

$$= 7.58\ kHz$$

The nominal design impedance (R0) is given as

$$Ro = (L/C)^{1/2}$$

$$= [(80 \times 10^{-3}) / (0.022 \times 10^{-6})]^{1/2}\ \Omega$$

$$= 1.907\ k\Omega$$

PROCEDURE

High Pass Filter (Design for cut-off Frequency of 10.7KHz) :

1. Study the circuit configuration for High Pass Filter printed on the front panel carefully.

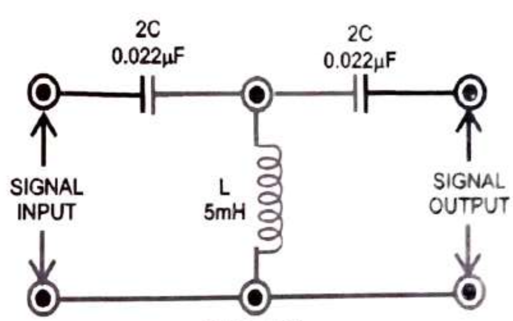

FIG. (2)

2. Connect the output of Audio Frequency Function Generator across signal input of High Pass Filter

3. Set the output of Audio Frequency Function Generator at Sine Wave of 2V peak to peak amplitude, 1kHz frequency

4. Connect CRO (Cathode Ray Oscilloscope) across signal output sockets of the filter.

5. Switch ON both the instruments i.e, Function Generator & CRO.

6. Increase the frequency of Function Generator towards 10kHz range in small steps and note down output voltage on CRO everytime.

Sr. No.	Frequency	Input Voltage V_{IN}	Output Voltage V_{OUT}	Gain=$20\log_{10} V_{OUT}/V_{IN}$
1				
2				
3				
4				
5				
6.				
-				

OBSERVATION TABLE NO. 2

At frequency range approximate 10.7KHz, you wil observe that the output amplitude of the signal on CRO approches to input signal voltage i.e, 2V peak to peak. It means the filter starts to pass the signals of frequencies above 10kHz(i.e, output voltage amplitude will remain 2V peak to peak or more than 2V peak to peak). But before 10 kHz frequency the filter will supress or attenuates the input signal. Note down all the observation in Table No. (2).

7. Plot the graph between output Voltage & Frequency or output gain vs frequency as shown in Fig. (2a).

Calculation

Formula used to calculate the

Voltage gain = V_{OUT}/V_{IN}

Formula used to calculate the cut-off frequency (fc) is

$$f_c = 1/\ 4\pi\ (LC)^{1/2}$$

$$= 1/\ 4 \times 3.14\ (5 \times 10^{-3})\ (0.011 \times 10^{-6})^{1/2}\ \text{Hz}$$

$$= 10.73\text{KHz}$$

VOLT GAIN (V)

The nominal design impedance (R_0) is given as

$$R_0 = (L/C)^{1/2}$$

$$= [(5 \times 10^{-3})/(0.011 \times 10^{-6})]$$

$$= 674\Omega$$

Band Pass Filter (Design for cut-off Frequency of 3-6KHz) :

1. Study the circuit configuration for Band Pass Filter printed on the front panel carefully.

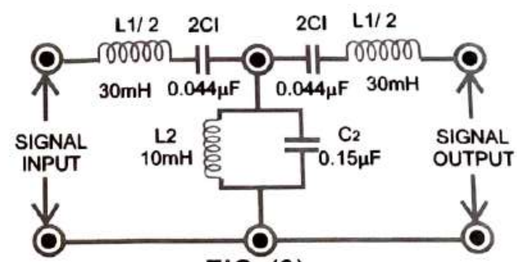

FIG. (3)

2. Connect the output of Audio Frequency Function Generator across signal input of Band Pass Filter.

3. Set the output of Audio Frequency Function Generator at Sine Wave of 2V peak to peak amplitude, 1kHz frequency.

4. Connect CRO (Cathode Ray Oscilloscope) across signal output sockets of the filter.

5. Switch ON both the instruments i.e, Function Generator & CRO.

6. Increase the frequency of Function Generator towards 10kHz range in small steps and note down output voltage on CRO everytime.

   At frequency range approximate 3-6kHz, you wil observe that the output amplitude of the signal on CRO approches to input signal voltage i.e, 2V peak to peak. It means the filter starts to pass the signals of frequencies between 3-6kHz (i.e, output voltage amplitude will remain 2V peak to peak or more than 2V peak to peak). But before 3kHz and after 6kHz the amplitude of output will remain less than input signal i.e, 2V peak to peak. It means that filter attenuates the signal of frequenceis less than 3kHz and more than 6kHz. Note down all the observation in Table No. (3).

Sr. No.	Frequency	Input Voltage V_{IN}	Output Voltage V_{OUT}	Gain=$20\log_{10} V_{OUT}/V_{IN}$
1				
2				
3				
4				
5				
6.				
-				

OBSERVATION TABLE NO. 3

7. Plot the graph between output Voltage Gain & Frequency as shown in Fig. (3a).

Formula used to calculate the Voltage gain = V_{OUT} / V_{IN}

Formula used to calculate Resonant Frequency

$$f_r = (f1 \times f2)^{1/2}$$
$$= (3kHz \times 6kHz)^{1/2}$$
$$= (4.24kHz)$$

FIG. (3a)

Band Stop Filter (Design for cut-off Frequency of 2-5KHz) :

1. Study the circuit configuration for Band Stop Filter printed on the front panel carefully.

2. Connect the output of Audio Frequency Function Generator across signal input of Band Stop Filter.

3. Set the output of Audio Frequency Function Generator at Sine Wave of 2V peak to peak amplitude, 100Hz frequency

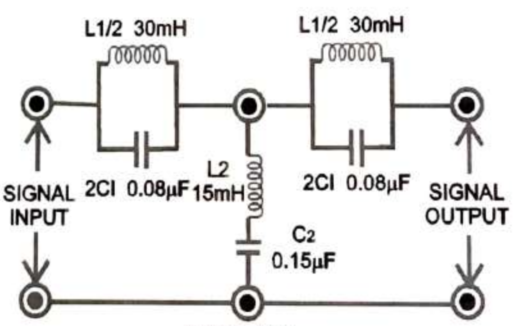

FIG. (4)

4. Connect CRO (Cathode Ray Oscilloscope) across signal output sockets of the filter.

5. Switch ON both the instruments i.e, Function Generator & CRO.

6. Increase the frequency of Function Generator towards 10kHz range in small steps and note down output voltage on CRO everytime

Sr No.	Frequency	Input Voltage V_{IN}	Output Voltage V_{OUT}	Gain=20log$_{10}$ V_{OUT}/V_{IN}
1				
2				
3				
4				
5				
6				
-				

OBSERVATION TABLE NO. 4

At frequency range approximate 2-5kHz, you wil observe that the output amplitude of the signal on CRO falls down from input signal i.e. 2V peak to peak. It means the filter starts to attenuate the signals of frequencies between 2-5kHz range. But before 2kHz and after 5kHz, this filter passes the input signal completely (Amplitude of output will remain 2V peak to peak or more than 2V peak to peak). Note down all the observation in Table No. (4).

7 Plot the graph between output Voltage & Frequency or output gain vs frequency.

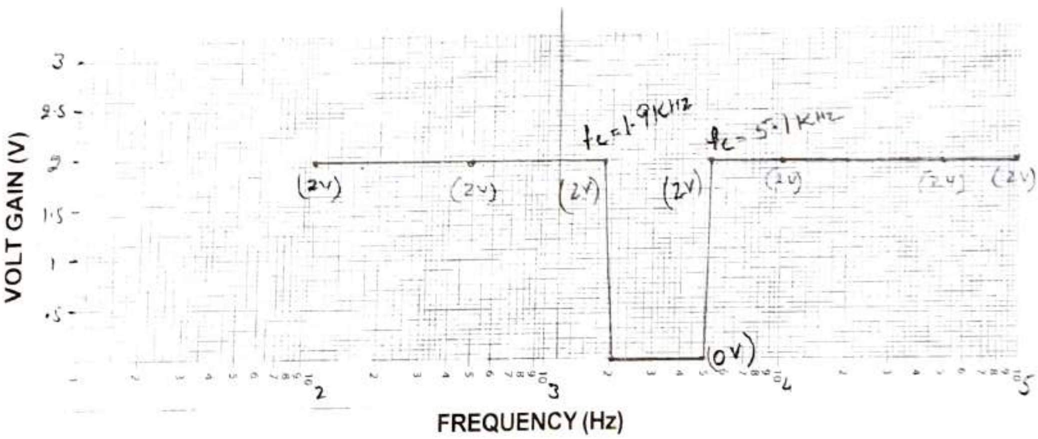

FIG. (4a)

STANDARD ACCESSORIES

1 Singlepoint (4mm) Patchcords for Interconnections. - 4 Nos.

2 Instruction Manual (DOC 961). - 1 No.

OPTIONAL ACCESSORIES

1 Audio Frequency Function Generator (Model No. ME 250). - 1 No.

2 Cathode Ray Oscilloscop (CRO), 20MHz. (Model No. ME 3020) - 1 No.

Instruction manual

LCR Resonance Apparatus With builtin Sine wave Oscillator

MODEL NO ME 571D

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Mars EdPal Instruments Pvt. Ltd.

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INSTRUCTION MANUAL
FOR
L C R RESONANCE APPARATUS
With Built In Sine Wave Oscillator
MODEL NO. ME 571D

"**MARS**" made LCR Resonance Circuit Appartus has been designed to study the phenomenon of Resonance in LCR Series & Parallel circuits.

The instrument comprises of the following built in parts :

1 The output of six resistances (from 50 Ohm to 200 Ohm) & six capacitors (from 0.1μF to 0.6μF) is available across sockets and can be selected by using band switches.

2. Two inductance of 30mH mounted inside the cabinet & connection brought out on sockets.

3 Two AC moving coil meters to measure corresponding voltage & current.

4 Built in Sine wave oscillator of 100Hz to 100kHz.

THEORY

There are circuits, which are used in radio equipments, to select and amplify particular frequency. Such amplifiers which are used to amplify selected frequency called Tuned Amplifier. These amplifiers used a tuned circuit (A L, R, C Network or Tank Circuit) for selection of a particular frequency. The selected frequency depends upon resonance frequency of tuned circuit. Therefore it is important to study the phenomenon of Resonance in AC circuit.

Before all that, let we name the electronic components involved in Resonance. Inductor is an electronic component opposis the change of current. The ability of Inductor with which it opposes the change of current through it is known as its inductance, it is denoted by (L) and measured in Henry (H) after the name Joseph Henry. The amount of opposition offered by Inductor is measured in terms of reactance called Inductive reactance and denoted by

$$X_L = \omega L$$

Similarly capacitors are electronics component which provide easy path to highly change current & appose slowly changing current and capacitance is property of capacitors by virtue of which they let the highly changing current easily. It is denoted by "C" & measured in farad. The amount of easyness offered by capacitor to changing (varying) amount is measured in terms of capacitive reactance (Xc)

$$Xc = 1 / \omega c$$

Last one is Resistance, resistance is electronic component which appose the flow of (Direct & Alternating) current through it, the ability of resistor to appose the flow of current is known of resistance, denoted by "R" and measured in ohm (Ω)

RESONANCE :

The phenomenon of resonance occurs only in AC circuits containing Inductance (L) and Capacitance (C). The circuit also contain Resistance (R) which may be the effective resistance of the coil itself or a resistance deliberately introduced into the circuit to create some desired results.

The circuit containing the above parameters may behave as an inductive circuit or capacitive circuit when connected across an AC supply. However, when the supply frequency is such that inductance reactance is equal to capacitive reactance (i.e, $X_L = X_C$), the circuit behaves as a pure resistive circuit and current supplied to the circuit is in phase with the supply voltage. This phenomenon is called resonance and the frequency at which this phenomenon occurs is called resonant frequency.

Thus, the phenomenon by which in an AC circuit, at a particular frequency, inductive reactance becomes equal to capacitive reactance is called **Resonance** and the frequency at which this phenomenon occurs is called **Resonant Frequency**.

The components L & C may be connected in series or in parallel, according they are known as series resonance circuit and parallel resonance circuit respectively.

Analysis :

A. SERIES RESONANCE :

Resonance Frequency :-

In series resonance circuit, R,L & C are connected in series across an AC source as shown in Fig. (1) at a given frequency

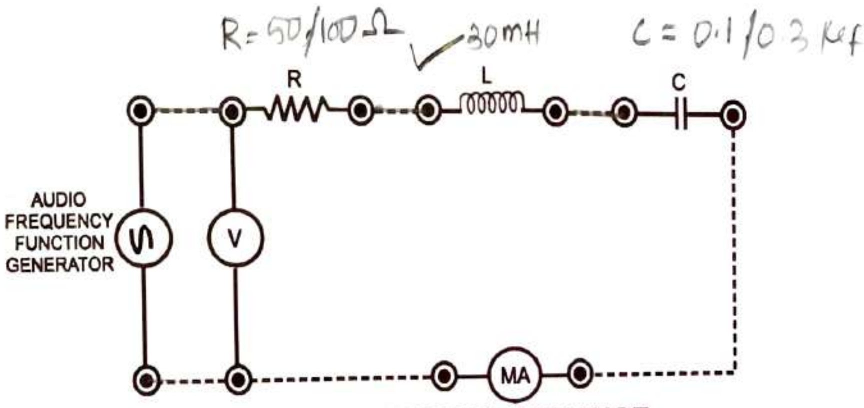

FIG. (1) SERIES RESONANCE

$$X_L = \omega_L \qquad \text{(i)}$$

$$X_C = 1/\omega_C \qquad \text{(ii)}$$

where $\omega = 2\pi/T = 2\pi f$

At resonance (w =wr) $X_L = X_C \qquad \text{(iii)}$

Putting (i) (ii) in (iii) at

$$\omega = \omega r$$
$$\omega_{rL} = 1/\ \omega_{rC}$$
$$\omega_r^2 = 1/LC$$
$$\omega_r = 1/(LC)^{½}$$
$$f_r = ½\pi\ (LC)^{½}$$

Quality Factor : -

The rates of voltage drop across L or C to the voltage drop across R at series resonance is called Quality Factor. It is also called figure of merit at resonance maximum current (Ir) flows through L & R.

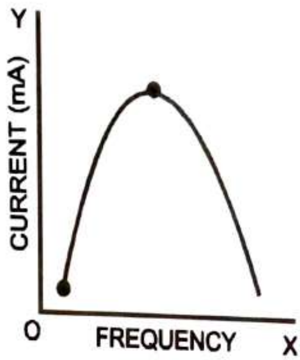

FIG. (2)
SERIES RESONANCE CURVE

Voltage drop across "L" = $I_r X_L$

Voltage drop across "R" = $I_r R$

$$Q = X_L / R = \omega_{rL} / R = 2\pi f_{rL} / R$$

Graphical Representation (Resonance Curve) :-

The curve plotted between current flowing in circuit and supply frequency called **Resonance Curve.**

In series resonance at resonance frequency the circuit impedance is minimum and hence the current drawn by the circuit is maximum. The magnitude of current decreases as frequency deviates from Fr on otherside. The resonance curve for series resonance is shown in the Fig. (2).

B. PARALLEL RESONANCE :

Parallel Frequency :-

In parallel resonance an inductive reactance and a capacitive reactance are connected in parallel, as shown in the Fig. (3).

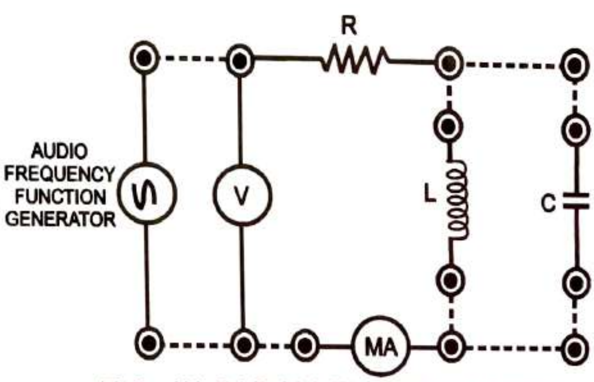

FIG. (3) PARALLEL RESONANCE

Analysis :

Phaser diagram for parallel resonance is shown in figure.

Resonance will occur when reactive component of inductor current "I_L" = ILsinθ will cancel out current in capacitor branch "I_C" i.e,

$$I_C = I_L \sin\theta$$
$$I_C = V / X_{C'}$$
$$I_L = V / X_L$$
$$\sin\theta = X_L / Z_L$$

where X_L is Inductive reactance

Z_L is total impedance of inductor with it's resistance.

Quality Factor :-

The most important characteristic of a parallel tuned circuit is it's property of selectivity Sharpness of esonance curve denotes it's selectivity and sharpness depends upon resistance "R" in circuit, smaller the curve more shaper the Resonance Curve

$$Q = (2\pi f_r L) / R$$

Graphical Representation (Resonance Curve) :-

Impedance at resonance frequency i.e, is very high, therefore the current flowing in circuit is very small at resonant frequency. Its value increases rapidly when frequency changed above or below the resonant frequency. For low value R curve is sharp (i.e, high quality factor) higher the value of R, less shaper the curve this implies small value of quality factor.

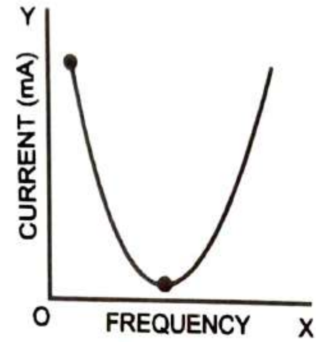

FIG. (4)
PARALLEL RESONANCE CURVE

We know Inductance (L) is property of inductors by virtue of which they oppose the change of current/ through them. The amount of by which they oppose the current flowing through them is measured in terms of reactance called Inductive reactance and denoted by

$(X_L F, \omega L = 2\pi fL)$ ———— (i)

Similarly Capacitance (C) is property of capacitors by virtue of which they oppose change of current through them, the extent to which they oppose is measured in term of reactance called Capacitive reactance.

$(XC)\ (1/wC = 1/2\pi fC)$ ———— (ii)

We can see term eqn. (i) X_L L this implies that inductive reactance is 'zero' for DC and increases as rate of change of Voltage/ Current increases (i.e, Frequency 'f' increases).

Eqn. (ii) shows that capacitive reactance is inversely proportional to the frequency (Rate of change in Voltage / Current), capacitor offers very high reactance to slowly changing voltage/ current (i.e, reactance to DC voltage or current because DC has 'zero' frequency) That is why, DC can't flow through capacitors.

Besides all that inductors have some increases Resistance (R), it is effective resistance of coil self the property of material of Inductor. Sometime a resistor is delibrately in produced to have some desired effect 'C' to increase or decrease Quality Factor 'Q'.

R, L, C can be connected in two configuration as shown in Fig. (1) & (2) called series resonant and parallel resonant circuit. These circuit may behave as inductive or capacitive circuit. It depends upon the frequency of input signal at high frequencies. Inductive reactance is higher than capacitive resonance, so circuit behave as inductive circuit, where as at lower frequencies capacitive reactance is higher then inductive reactance (X_L) therefore circuit behaves as capacitive circuit.

However there is some frequency at which circuit is neither inductiive norcapacitive at this frequency inductive reactance and then circuit behaves as purely resistive circuit This phenomenon is called RESOSNANCE and the frequency at which resosnance occure called resonance frequency and is denoted as f_r

At resosnce	X_L	=	X_C	———— (iii)
We know	X_L	=	ωL	———— (iv)
	X_C	=	$1/\omega_C$	———— (v)
	ω	=	$2\pi/T = 2\pi f$	———— (vi)

Putting (ii) & (iii) in (i) at $\omega = \omega_r$

$$\omega L = 1/\omega C$$

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

$$\omega_r = 1/(\pi LC)^{½}$$

$$2\pi f_r = 1/(LC)^{½}$$

$$fr = 1/2\pi (LC)^{½}$$

Quality Factor may be defined the voltage magnification that the circuit produces at resonance.

$$\text{Voltage Magnification} = \frac{\text{Voltage Drop across LRC}}{\text{Voltage across R (VI)}}$$

At resonance voltage across inductor and capacitor as same

$$IX_2 = IX_C$$

$$\text{Voltage across R} = IR$$

$$\text{Voltage Magnification} = IX_L/IR = X_L/R = \omega_r L/R$$

$$w1 (L/R) = 2\pi f_r L/R = 2\pi L/R.\ 1/2\pi (LC)^{½} = 1/R (LC)^{½}$$

Graphical Representation (Resonance Curve) :

We can make a RLC circuit to resonate (i) by keeping frequency constant and varying supply frequency. We will keep the applied voltage LC constant and will vary input signal.

Fig. (2) shows resonance curve for Series RLC circuit.

Fig (4) shows resonance curve for parallel circuit. Current varies inversly with variation in impedance, for parallel combination of RLC impedance is maximum at resonance frequency and hence current is minimum at resonance and in increase on both scale of resonance frequency.

PROCEDURE

Series Resonance:

1. Connect the circuit as shown in Figure (1) i.e, R = 50Ω , L = 30mH, C = 0.1μF
2. Adjust the Sine Wave signal of oscillator at 3V r.m.s., 1kHz.
3. Increase the frequency of signal upto 10kHz and note down the corresponding value of frequency and current. Record the observations in Table No. (1). The frequency where current start decreasing is known as resonance frequency.

S.NO.	FREQUENCY	CURRENT	VOLTAGE
1.			
2.			
3.			
4.			
5.			

TABLE (1)

Formula used to calculate resonance frequency is :

$$f = 1/2\pi(LC)^{1/2}$$

and formula used to calculate quality factor is :

$$\text{Quality Factor (Q)} = (L/C)^{1/2}/R$$

4. Repeat steps 1 -3 for different values of R & C.
5. Plot a graph between Frequency v/s Current as shown in Fig. (3).

Parallel Resonance :

1. Connect the circuit as shown in Figure (3) i.e, R = 50Ω , L = 30mH, C = 0.1μF.
2. Adjust the Sine Wave signal of oscillator at 3V r.m.s,1kHz.
3. Increase the frequency of signal upto 10kHz and note down the corresponding value of frequency and current. Record the observations in Table No. (2). The frequency where current start increasing is known as resonance frequency.

S.NO.	FREQUENCY	CURRENT	VOLTAGE
1.			
2.			
3.			
4.			
5.			

TABLE (2)

Formula used to calculate resonance frequency is :

$$f = 1/2\pi\ (LC)^{1/2}$$

and formula used to calculate quality factor is :

$$\text{Quality Factor (Q)} = (L/C)^{1/2}/R$$

4. Repeat steps 1 -3 for different values of R & C.
5. Plot a graph between frequency V/S current as shown in Fig. (4).

STANDARD ACCESSORIES

1.	Single point (4mm) Patchcords for interconnections.	-	10 Nos.
2.	Instruction Manual (DOC 571D).	-	01 No.
3.	Powerchord	-	01 No