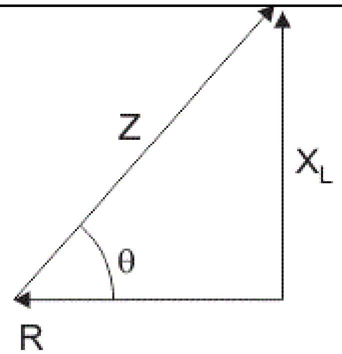
SUMMER– 19 EXAMINATION

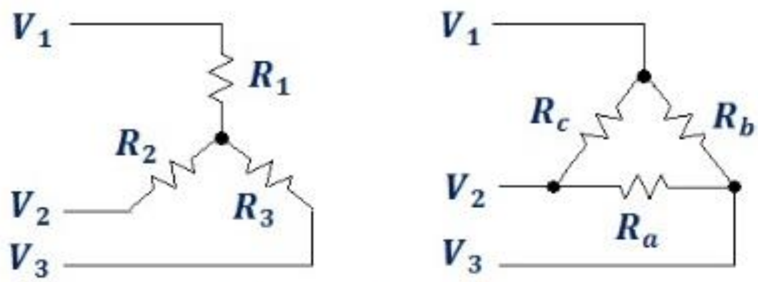
Subject Name: Electric circuits and network **Model Answer** **Subject Code:** 22330

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answers	Marking Scheme
1	**(A)**	**Attempt any FIVE of the following :**	**10- Total Marks**
	(a)	**Define impedance and reactance related to single phase AC series circuit. Give unit of both.**	**2M**
	Ans:	Impedance of single phase AC series circuit is defined as the net opposition offered to the flow of AC current by the combination of R, L and C. Unit of Impedance is Ω(Ohm). Reactance of single phase AC series circuit is defined as the opposition offered to the flow of AC current by either inductor(L) or capacitor(C). Unit of reactance is Ω(Ohm).	Each correct definition with its unit- 1M
	(b)	**Draw the impedance triangle for R-L series circuit.**	**2M**

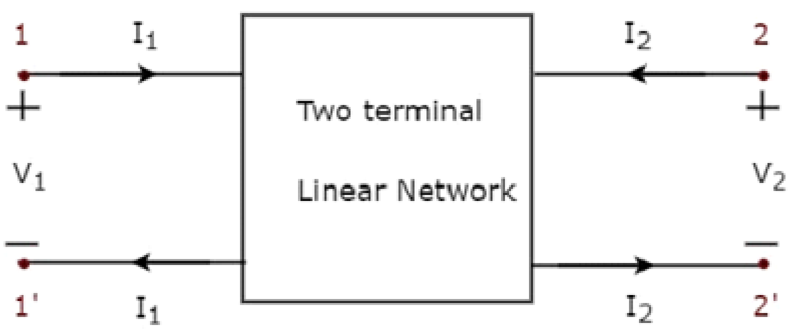
	Ans:	 **Fig. impedance triangle for R-L series circuit.**	impedance triangle-2M
	(c)	**State Q factor for parallel R.L.C. circuit.**	**2M**
	Ans:	Q factor for parallel R.L.C. circuit is defined as the current magnification provided at resonance. The magnitude of current flowing through inductor and capacitor is equal to Q times the input sinusoidal current I. As the parallel circuit magnifies the current it is also called as the current resonance circuit. OR The Quality factor of Parallel resonance RLC circuit is defined as the ratio of current circulating between its two branches to the line current drawn from the supply. Mathematically, $Q = RX_C$	Any correct definition-2M
	(d)	**Give four steps to solve nodel analysis.**	**2M**
	Ans:	four steps to solve nodal analysis- 1.all the nodes present in the network including the reference(ground) node)are identified and marked . The number of equations to be solved is given by (n-1) where n= no of independent nodes. 2. Mark all the branch currents. 3. Using KCL write current equation for each node in terms of node voltage and sources present. 4. The equations can be solved either simultaneously or by Cramer's rule to obtain various node voltages.	Each step - 1/2 M

		The current flowing through any element can be found out by substituting the value of node voltages in the relevant equation.	
	e)	**Write the formula for star to delta.**	**2M**
	Ans:	**The formula for star to delta** **Star to Delta (Y to Δ) Resistance Conversion Formula**  $R_a = \frac{R_1R_2+R_1R_3+R_2R_3}{R_1}$ $R_b = \frac{R_1R_2+R_1R_3+R_2R_3}{R_2}$ $R_c = \frac{R_1R_2+R_1R_3+R_2R_3}{R_3}$	Correct formula e with diagram-2M
	f)	**State Thevenin's theorem.**	**2M**
	Ans:	Any network containing active and/or passive elements and one or more dependent and/or independent voltage/or current sources can be replaced by an equivalent network containing a voltage source (Thevenin's equivalent voltage V_{TH} or V_{OC}) and a series resistance (called Thevenin's equivalent resistance R_{TH})where V_{TH} is the voltage measured across open terminals A and B and Rth is the resistance across same terminals A and B when all the sources are replaced by their internal resistances.	Stateme nt (2 Mark
	g)	**State the significance of two port network.**	**2M**
	Ans:	**The significance of two port network-**	2M

Any electrical network can be easily analyzed if it is represented with an equivalent model, which gives the relation between input and output variables. A two port network is a network having 2 ports. One port is used as input port and the other port is used as output port. These ports are called port1 and port2 respectively.

Once a network is represented in this equivalent form, the response of the network to signals applied to the ports can be calculated easily, without solving for all the internal voltages and currents in the network. It also allows similar circuits or devices to be compared easily.

A two port network representation is shown in the following figure.



Here, terminals 1 and 1' represent port1 and terminals 2 & 2' represent port2.

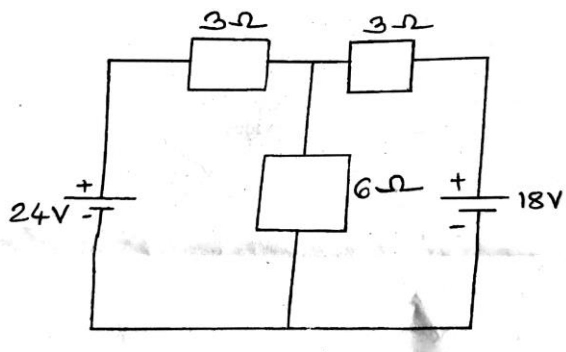
The common models that are used are referred to as z-parameters, y-parameters, h-parameters, g-parameters, and ABCD-parameters..

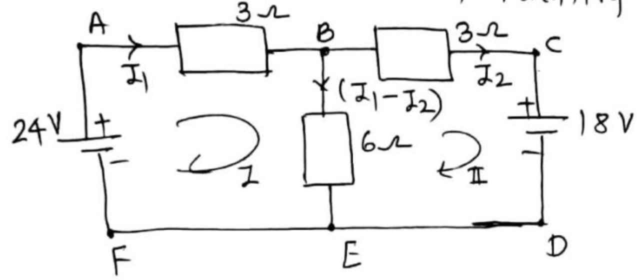
Q. No.	Sub Q. N.	Answers	Marking Scheme
2		**Attempt any THREE of the following:**	**12- Total Marks**
	a)	**An RC series circuit consists of R = 10Ω and C = 200 µf.it is connected across 250 V, 50Hz, 1 ϕ AC. Calculate the value of power consumed by the circuit.**	**4M**
	Ans:		1M –Xc, 1M-Z,

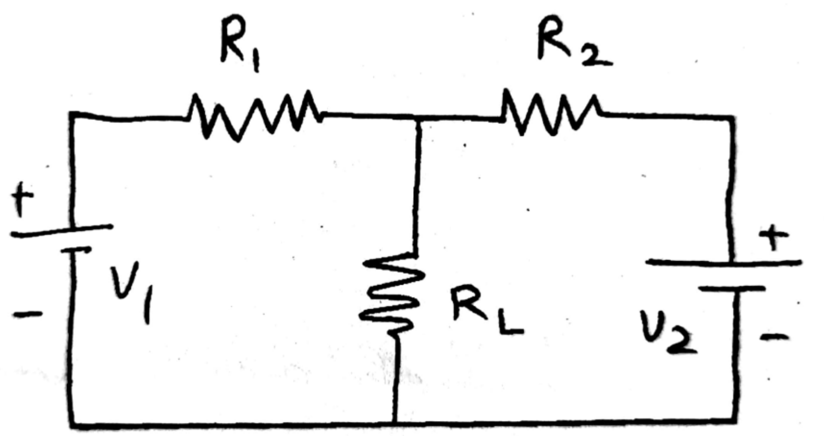
		Solution –: Given –: $R = 10\Omega$, $C = 200\mu F$, $V = 250V$, $f = 50Hz$ Capacitive Reactance, X_C :– $X_C = \frac{1}{2\pi f C}$ $= \frac{1}{2\times\pi\times 50\times 200\times 10^{-6}}$ $\therefore X_C = 15.91\ \Omega$ $\therefore$ Impedence Z: – $\therefore \|Z\| = \sqrt{R^2+X_C^2} = \sqrt{10^2+(15.91)^2}$ $\therefore \|Z\| = 18.79\ \Omega$ Now, the total current I: $\therefore I = \frac{V}{Z} = \frac{250}{18.79} = 13.30\ A$ Power Factor, $\cos\phi = \frac{R}{Z} = \frac{10}{18.79}$ $\therefore$ P.F. $= \cos\phi = 0.53$ (leading) And, the value of power consumed by the circuit is P:– $P = V \cdot I \cos\phi$ $= 250 \times 13.30 \times 0.53$ $\therefore P = 1762.25$ watt OR $\therefore P = 1.7622$ Kwatt 	1M- Power Factor, 1M- Power consumed
	b)	**Describe the procedure to tune the given electrical circuit using the principles of resonance.**	**4M**
	Ans:	An electrical circuit can be tuned to resonant frequency in any one of the following ways:	**4M**

SUMMER– 19 EXAMINATION

Subject Name: Electric circuits and network **Model Answer** **Subject Code: 22330**

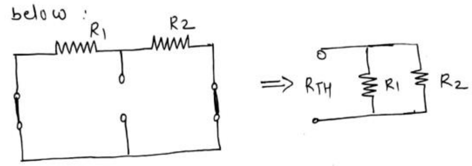
		i)If the circuit parameters like resistance ,inductance and capacitance are of fixed value,the resonant frequency is calculated .Then by connecting a function generator, the input frequency can be varied till the circuit is tuned to the desired resonant frequency. ii)If the circuit is to be tuned to a particular frequency, and the frequency of the supply cannot be varied, then by using either a variable capacitor or variable inductor, the variable element can be varied till the circuit is tuned to the desired resonant frequency.	
	c)	**Find the current in 6Ω resistor in the circuit shown in Fig. No. 1 using mesh analysis.**  **Fig. No. 1**	**4M**

	Ans:	Step 1 :- Name the nodes and identify the loops :-  Step 2 :- Equation for loop I (ABEFA) :- Apply KVL, $24 - 3I_1 - 6(I_1 - I_2) = 0$ $-3I_1 - 6I_1 + 6I_2 = -24$ $-9I_1 + 6I_2 = -24$ $\therefore 9I_1 - 6I_2 = 24$ ——— (1) Step 3 :- Equation for loop II (BCDEB) :- $-3I_2 - 18 - 6(I_2 - I_1) = 0$ $-3I_2 - 6I_2 + 6I_1 = 18$ $6I_1 - 9I_2 = 18$ ——— (2) Solving equation (1) and (2) by Determinant Method $D = \begin{vmatrix} 9 & -6 \\ 6 & -9 \end{vmatrix} = (-9)\times 9 - [(-6)\times 6] = -81 + 36$ $\therefore D = -45$ $D_1 = \begin{bmatrix} 24 & -6 \\ 18 & -9 \end{bmatrix} = 24 \times (-9) - [(-6)\times 18] = -216 + 108$ $\therefore D_1 = -108$ $D_2 = \begin{bmatrix} 9 & 24 \\ 6 & 18 \end{bmatrix} = 9 \times 18 - (24 \times 6) = 162 - 144$ $\therefore D_2 = 18$ $\therefore I_1 = \frac{D_1}{D} = \frac{-108}{-45} = 2.4\ A$ $I_2 = \frac{D_2}{D} = \frac{18}{-45} = -0.4\ A$ $\therefore$ The current in 6Ω resistor is $(I_1 - I_2)$ $= 2.4 - (-0.4)$ $= 2.8\ A$	½ M- each equation 1M for I_1, 1M for I_2, 1M for current through 6 ohm resistor

	d)	**Find the value of R_L so that maximum power will transfer from source to it . also write equation for P_{MAX} (Fig. No. 2)**  **Fig. No. 2**	**4M**

Ans:

Replace the voltage sources V_1 and V_2 by short circuit to obtain the circuit shown below :



$\therefore R_{TH} = R_1 \parallel^{el} R_2$

$\therefore R_{TH} = \frac{R_1 \times R_2}{R_1 + R_2}$

But the condition for maximum power transfer to the load is -

$R_L = R_{TH}$

$\therefore$ The value of $R_L = R_{TH}$ so that maximum power will transfer from source to it.

The equation for P_{max} -:

$$P_{L(max)} = \left(\frac{V_{TH}}{R_{TH} + R_{TH}}\right)^2 \cdot R_{TH}$$

Substitute $R_L = R_{TH}$

$\therefore$ Therefore the power transfer to the load is given by the equation

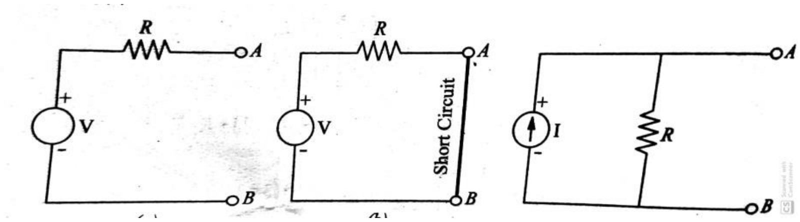
$$P_L = \frac{V_{TH}^2}{4 R_{TH}}$$

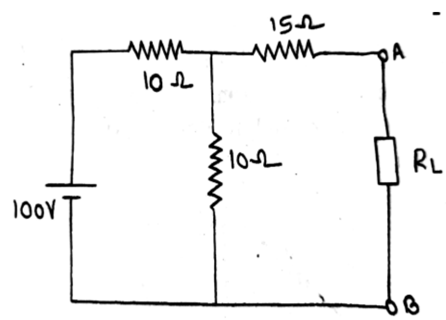
Marking scheme: 3M-for R_L; 1M for power formula

Q. No.	Sub Q. N.	Answers	Marking Scheme
3		**Attempt any THREE of the following :**	**12- Total Marks**
	a)	**List the power factor improves technique and explain any one with advantage and disadvantage**	**4M**
	Ans:	**Power factor improvement techniques are** **i) Synchronous Motors (or capacitors)** **ii) Static Capacitors**	**2Marks for Listing Techniques**

		iii) Phase Advancers i) Synchronous Motors (or capacitors) : These machines draw leading kVAR when they are over-excited and, especially, when they are running idle. They are employed for correcting the power factor in bulk and have the special advantage that the amount of correction can be varied by changing their excitation. ii) Static Capacitors : They are installed to improve the power factor of a group of a.c. motors and are practically loss-free (i.e. they draw a current leading in phase by 90°). Since their capacitance is not variable, they tend to over-compensate on light loads, unless arrangements for automatic switching of the capacitor bank are made. iii) Phase Advancers : They are fitted with individual machines. However, it may be noted that the economical degree of correction to be applied in each case, depends upon the tariff arrangement between the consumers and the supply authorities.	2Marks for any one techniqu e
	b)	Compare series resonance to parallel resonance on the basis of: (i) Resonant frequency (ii) Impedance (iii) Current and (iv) Magnification.	4M
	Ans:	(see table below)	1 marks for each point

S.No.	Parameter	Series Circuit	Parallel Circuit
1	Resonant frequency	$f_r = \frac{1}{2\pi\sqrt{LC}}$	$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$
2	Impedance	Minimum, Z = R	Maximum, Z = L/CR
3	Current	Maximum, I = V/R	Minimum, I = V/(L/CR)

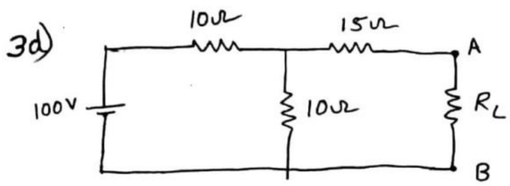
		<table><tr><td>4</td><td>Magnification</td><td>Voltage magnification takes place</td><td>Current magnification takes place</td></tr></table>	
	c)	**Write the procedure to convert voltage source into equivalent current source. Give its application. Draw neat diagrams of both the sources.**	4M
	Ans:	A voltage source with a series resistance can be converted into (or replaced by) and equivalent current source with a parallel resistance. The steps for converting practical voltage source into practical current source. i)Find the value of current supplied by the source when a 'short' is put across terminals A and B. Therefore, Current I=V/R ii)The value of resistance which is connected in parallel with the equivalent current source have the same value of series resistance(R_s=R_{sh}). ii)This equivalent current source is then connected in parallel with the shunt(parallel) resistance. 	2 marks for Procedure 1 mark for diagram

		Application : For the simplification and analysis of complex networks the transformation of voltage source to an equivalent current source or vice versa is often necessary.	**1 mark for Application**
	d)	**Find Norton's equivalent circuit of the Fig. shown (Fig. No. 3)**  **Fig. No. 3**	**4M**
	Ans:		

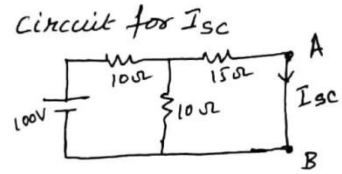
SUMMER– 19 EXAMINATION

Subject Name: Electric circuits and network **Model Answer** **Subject Code: 22330**

3d)



Circuit for I_{sc}



Step1: To obtain the value of I_{sc}:

The Total resistance R_T is given by

$$R_T = 10 + [10 \| 15]$$

$$= 10 + \left[\frac{10 \times 15}{10+15}\right]$$

$$= 10 + 6 = 16\,\Omega$$

The Source current I is given by

$$I = \frac{V}{R_T} = \frac{100}{16} = 6.25\text{ A}$$

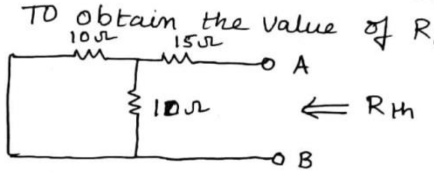
The short circuit current I_{sc} is the current flowing through the 15Ω resistor

$$\therefore I_{sc} = I \times \frac{10}{10+15} = 6.25 \times \frac{10}{25}$$

$$I_{sc} = 2.5\text{ A}$$

2marks for obtaining Short circuit current

Step 2: To obtain the value of R_{th}

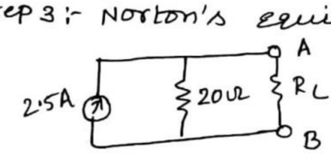


$$\therefore R_{th} = 15 + [10 \| 10]$$

$$= 15 + 5 = 20\,\Omega$$

1mark for R_{th}

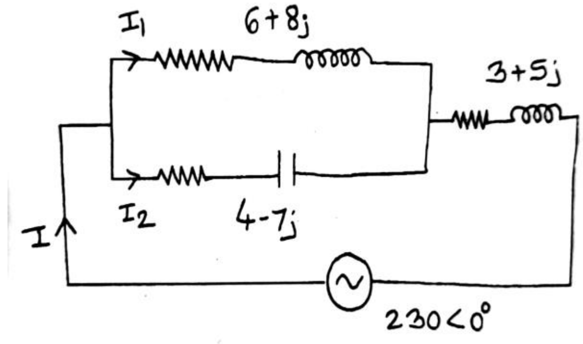
Step 3:- Norton's equivalent circuit



1mark for equivalent circuit

Q. No.	Sub Q. N.	Answers	Marking Scheme
4		**Attempt any THREE of the following :**	**12- Total Marks**
	(a)	**In a series circuit containing pure resistance pure inductance, the current and voltage are expressed as:** **I(t) = 5 sin (314t + 2 Π/3) and v(t) = 20 sin (314t + 5 Π/6)** **Find:** **(i) Impedance of circuit** **(ii) Resistance of circuit** **(iii) Inductance in circuit** **(iv) Average power drawn by circuit.**	**4M**
	Ans:	**I(t) = 5 sin (314t + 2 Π/3) and v(t) = 20 sin (314t + 5 Π/6)** **Converting the above standard sinusoidal forms into polar forms** **Rms values of current and voltage are** **I = 5/√2 = 3.54 A ; V = 20/√2 = 14.14 V** **Converting the above standard sinusoidal forms into polar forms** $\vec{I}$**= (3.54⌊120°) A** $\vec{V}$ **= (14.14⌊150°) V** **By Ohm's law,** **Circuit Impedance,** $\vec{Z}=\vec{V}/\vec{I}$ **= (14.14⌊150°)/(3.54⌊120°)** **= (4⌊30°) Ω**	**1 mark for Impedance**

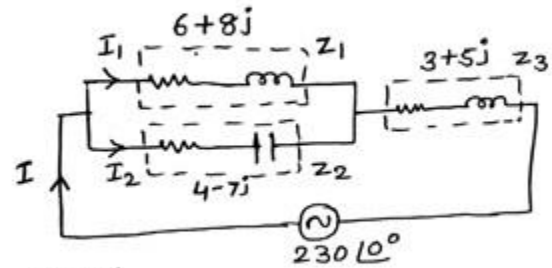
		$=(3.46+j2)\ \Omega$ From polar form of Impedance i) Impedance of circuit = Z = 4 Ω From Rectangular form of impedance ii) Resistance of circuit R = Z Cosϕ = 4 Cos(30) = 3.46 Ω iii) Inductance of circuit L we know that $X_L = 2\ \Omega$ (from rectangular form of impedance) $X_L = 2\pi fL$ $L = X_L/2\pi f = 2/(2\pi\times50) = 6.37\times10^{-3}$ H From polar form of Impedance , ϕ=30° So, pf=cosϕ =cos30° =0.866 lagging iv) Average power, P=VI Cosϕ = 14.14 x 3.54 x cos30° =43.35 W	1 mark for Resistance 1 mark for Inductance 1 mark for Average power
	(b)	Find I, I_1, I_2 power factor of the circuit in Fig. No. 4	4M

		 **Fig. No. 4**	
	Ans:		

SUMMER– 19 EXAMINATION

Subject Name: Electric circuits and network **Model Answer** **Subject Code: 22330**

4b)



Sol Given:
$Z_1 = 6+8j$, $Z_2 = 4-7j$, $Z_3 = 3+5j$, $V = 230\angle 0^\circ$

Total Impedance

$$Z = (Z_1 \| Z_2) + Z_3 = \frac{Z_1 Z_2}{Z_1+Z_2} + Z_3$$

But $Z_1+Z_2 = 6+8j + 4-7j$
$= 10+j$
$= 10\angle 5.71^\circ$

Polar form of $Z_1 = (10\angle 53.13)$
" " $Z_2 = (8.06\angle -60.25)$

$$\therefore \frac{Z_1 Z_2}{Z_1+Z_2} = \frac{(10\angle 53.13)\times(8.06\angle -60.25)}{10\angle 5.71}$$

$$= \frac{80.6\angle -7.12}{10\angle 5.71} = 8.06\angle -12.83^\circ$$
$$= 7.85 - 1.78j$$

$\therefore Z = 7.85 - 1.78j + 3+5j$
$= 10.85 + 3.22j$
$= 11.31\angle 16.52^\circ$

- Total current $I = \frac{V}{Z} = \frac{230\angle 0}{11.31\angle 16.52}$

$\therefore I = 20.33\angle -16.52^\circ$ A

- $I_1 = I \times \frac{Z_2}{Z_1+Z_2} = (20.33\angle -16.52)\ \frac{8.06\angle -60.25}{10\angle 5.71}$

$= (20.33\angle -16.52)(0.806\angle -65.96)$

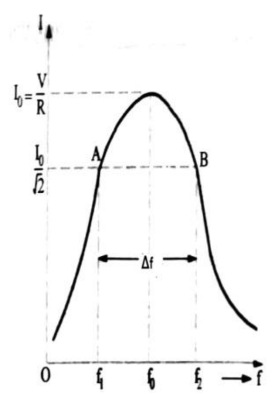
$I_1 = 16.38\angle -82.48^\circ$ A

1mark for I

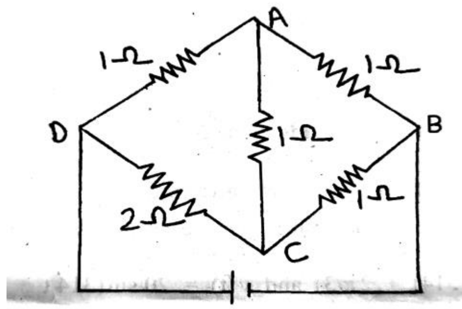
1mark for I_1

1mark for I_2

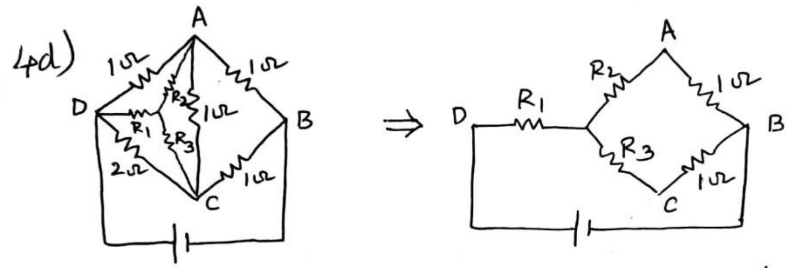
1mark for Power factor

		• $I_2 = I \times \frac{Z_1}{Z_1+Z_2} = (20.33\angle -16.52)\frac{(10\angle 53.13)}{(10\angle 5.71)}$ $= (20.33\angle -16.52)(1\angle 47.42)$ $\therefore I_2 = 20.33\angle 30.9^\circ$ A • power factor $= \cos\phi = \cos(-16.52)$ $= 0.958$ lagging	
	(c)	**Explain the term bandwidth of a series resonant circuit. Derive its equation.**	**4M**
	Ans:	**Band width (BW) of a series resonance circuit is defined as the range of frequency over which circuit current is equal to or greater than $\frac{I_r}{\sqrt{2}}$ or 70.7 % of maximum current where I_0 or I_r = current at resonance.** **The resonance curve for a series RLC circuit is shown below:**  **From the graph it is clear that for all frequencies lying between f_1 and f_2 the circuit current is equal to or greater than 70.7 % of maximum current i.e.**	**Explanation 2 Marks**

		$I_r = V/R$ Thus Band width of the circuit, BW = $\Delta f = (f_2 - f_1)$ Hz Or BW = $\Delta\omega = (\omega_2 - \omega_1)$ rad/sec Derivation of equation for bandwidth - The relationship between bandwidth , Q factor and resonant frequency is given by $(f_2 - f_1) = f_r/Q_r$ Where $f_2 - f_1$= bandwidth, f_r =resonant frequency and Q_r = Q factor at resonance But $f_r = \frac{1}{2\pi\sqrt{LC}}$ And $Q_r = \frac{1}{R}\sqrt{\frac{L}{C}}$ Substituting these values in the equation for bandwidth, $\Delta f = f_r / Q_r = \frac{\frac{1}{2\pi\sqrt{LC}}}{\frac{1}{R}\sqrt{\frac{L}{C}}} = \frac{R\sqrt{C}}{2\pi\sqrt{CL^2}} = \frac{R}{2\pi L}$ Hz Therefore bandwidth $\Delta f = f_2 - f_1 = \frac{R}{2\pi L}$ Hz OR $\Delta\omega = 2\pi\,\Delta f = \frac{R}{L}$ rad/sec	2marks for Derivation

	(d)	**A bridge network ABCD has arms AB, BC, CD and DA of resistances 1, 1,2 and 1 ohm respectively . If the detector AC has a resistance of 1 ohm, determine by star/delta transformation, the network resistance as viewed from the battery terminals.**  **Fig. No. 5**	**4M**
	Ans:		**2 marks for Converting delta to star** **2 marks for Network resistance**

4d)

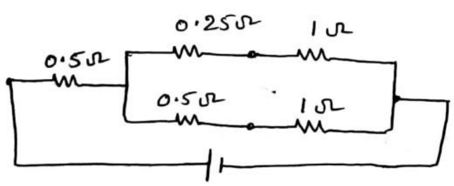


Step 1: Converting the delta formed by ACD into Equivalent star network.
(ie) Δ ACD ⇒ Y ACD

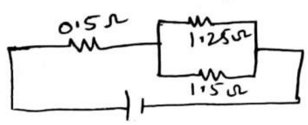
$$\therefore R_1 = \frac{1\times 2}{1+2+1} = \frac{2}{4} = 0.5\Omega$$

$$R_2 = \frac{1\times 1}{1+2+1} = \frac{1}{4} = 0.25\Omega$$

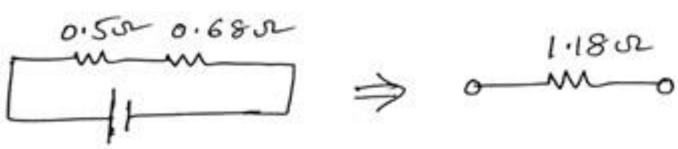
$$R_3 = \frac{1\times 2}{1+2+1} = \frac{2}{4} = 0.5\Omega$$



The above circuit is converted as



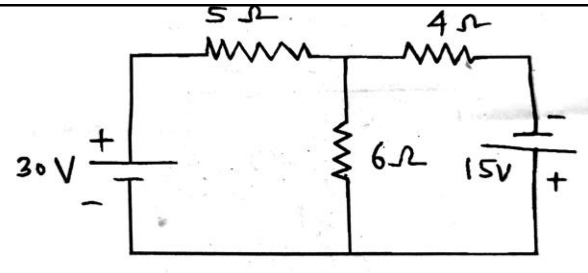
Here 1.25Ω & 1.5Ω are in parallel
$[1.25 \parallel 1.5] = 0.68$



$\therefore$ network resistance = 1.18Ω

Note: The problem can be done by converting delta ABC into equivalent star also.

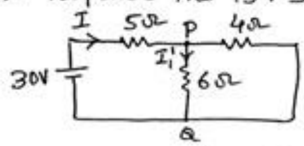
	(e)	**Find current through 6Ω resistor using superposition theorem. Fig. No. 6**	**4M**

		 **Fig. No. 6**	
	Ans:		**1mark for R_T**

SUMMER– 19 EXAMINATION

Subject Name: Electric circuits and network **Model Answer** **Subject Code: 22330**

4e) Replace the 15V source by a short circuit, keeping 30V

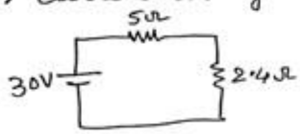


Resistor 6Ω & 4Ω are parallel

$\therefore 6 \| 4 = 2.4\Omega$

1mark for I'_1

→ current through 6Ω Resistor due to 30V source ie I_1'



Resistor 5Ω & 2.4Ω are in series

Total Resistance :

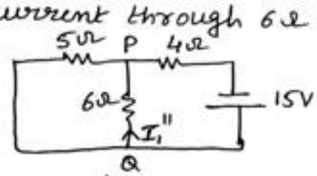
$R_T = 5 + 2.4 = 7.4\Omega$

$R_T = 7.4\Omega$

$\therefore$ Total current $I = \frac{30}{7.4} = 4.05A$

$\therefore I_1' = I \times \frac{4}{4+6} = 4.05 \times \frac{4}{10} = 1.62A$

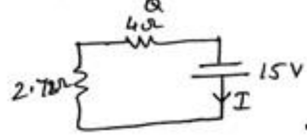
→ current through 6Ω Resistor due to 15V source ie I_1''



Resistor 5Ω & 6Ω are in parallel

$\therefore 5 \| 6 = \frac{30}{11} = 2.72\Omega$

1mark for I''_1



Resistor 2.72Ω & 4Ω are in series

$\therefore$ Total Resistance is

$R_T = 2.72 + 4 = 6.72\Omega$

$\therefore$ Total current $I = \frac{V}{R_T} = \frac{15}{6.72} = 2.23A$

1mark for $I_{6\Omega}$

$\therefore I_1'' = I \times \frac{5}{5+6} = 2.23 \times \frac{5}{11}$

$I_1'' = -1.01A$ (As current is flowing from Q to P we will consider it to be negative)

$\therefore$ Total current in 6Ω Resistor is (from P to Q)

$I_1' + I_1''$

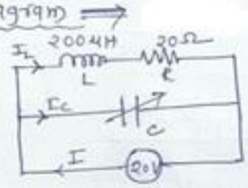
$= 1.62 - 1.01$

$I_{6\Omega} = 0.61A$

Q. No.	Sub Q. N.	Answers	Marking Scheme
5.		**Attempt any TWO of the following:**	**12- Total Marks**
	a)	**A coil of resistance 20 Ω and 200 μH is in parallel with a variable capacitor. The voltage of the supply is 20 V at a frequency of 10^6 Hz . Calculate :** **(i) The value of C to give resonance.** **(ii) The Q of the coil.** **(iii) The current in each branch of the circuit at resonance.**	**6M**

	Ans:	Pg. No. (1)

Q.5 a) Diagram ⟹



Dia 1 M

i) The value of 'C' to give resonance

* If value of 'R' is considered very small in comparison with inductor 'L' then

$$\therefore f_r = \frac{1}{2\pi\sqrt{LC}} \longrightarrow \tfrac{1}{2}\text{ M}$$

$$\therefore (10^6) = \frac{1}{2\pi\sqrt{200\times10^{-6}\times C}}$$

squaring to both sides.

$$(10^6)^2 = \frac{1}{4\pi^2\times200\times10^{-6}\times C}$$

$$\therefore C = \frac{1}{(10^6)^2\times4\pi^2\times200\times10^{-6}}$$

$$C = 1.2665\times10^{-10}\,F \quad \text{or} \quad = 126.65\,pF \Longrightarrow \tfrac{1}{2}\text{ M}$$

OR

* If value of 'R' is considered very high in comparison with inductor 'L' then

$$\therefore f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} \Longrightarrow \tfrac{1}{2}\text{ M}$$

Squaring to both sides

$$\therefore f_r^2 = \frac{1}{4\pi^2}\left[\frac{1}{LC} - \frac{R^2}{L^2}\right]$$

$$\therefore f_r^2 * 4\pi^2 = \frac{1}{LC} - \frac{R^2}{L^2}$$

$$f_r^2 * 4\pi^2 + \frac{R^2}{L^2} = \frac{1}{LC}$$

$$(10^6)^2 * 4\pi^2 + \frac{(20)^2}{(200\times10^{-6})^2} = \frac{1}{LC}$$

$$3.948\times10^{15} = \frac{1}{LC}$$

$$3.948\times10^{15}\times200\times10^{-6} = \frac{1}{C}$$

$$\boxed{C = 126.65\ pF} \longrightarrow \tfrac{1}{2}M$$

ii) The Q-of the coil

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} \longrightarrow 1M$$

$$= \frac{1}{20}\sqrt{\frac{200\times10^{-6}}{126.65\times10^{-12}}}$$

$$\boxed{Q = 62.832}$$

OR

$$Q = \frac{X_L}{R} = \frac{2\pi fL}{R} = \frac{2\pi\times10^{6}\times200\times10^{-6}}{20}$$

$$\boxed{Q = 62.832} \longrightarrow 1M$$

iii) The current in each branch of the ckt at resonance

Since this is a parallel circuit. We presume the applied voltage will be across each reactive element.

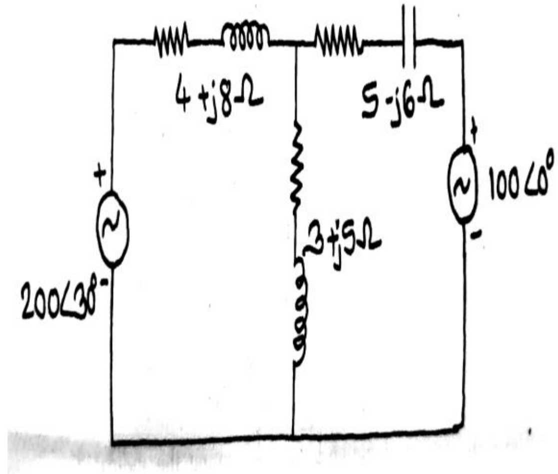
i) $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi\times10^{6}\times126.65\times10^{-12}} = 1.256\ k\Omega$

ii) $X_L = 2\pi fL = 2\pi\times10^{6}\times200\times10^{-6} = 1.256\ k\Omega$ → 1M

$$I_C = \frac{V}{X_C} = \frac{20}{1.256\times10^{3}} = 15.92\ mA \longrightarrow 1M$$

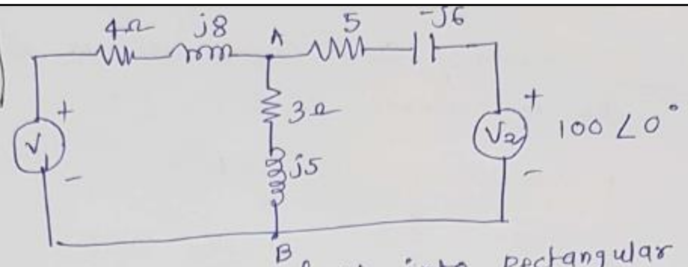
$$I_L = \frac{V}{X_L} = \frac{20}{1.256\times10^{3}} = 15.92\ mA \longrightarrow 1M$$

	b)	**Find current through impedance 3 + j5 using superposition theorem in the circuit as shown in Fig. No. 7.**	**6M**

		 **Fig. No. 7**	

	Ans:	(see below)	

Q.5 b)

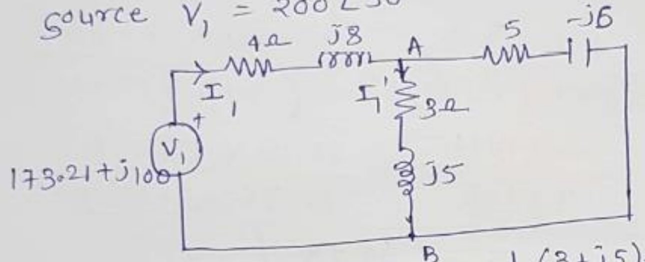


Step 1 :- convert V_1 & V_2 into Rectangular form

$V_1 = 200\angle 30° = 173.21 + j100$

$V_2 = 100\angle 0° = 100 + j0$

find the current thr Branch 'AB' as I_1' due to source $V_1 = 200\angle 30°$



⟹ 2 Mark

The impedances $(5-j6)\Omega$ and $(3+j5)\Omega$ are in parallel and this combination is in series with $(4+j8)\Omega$

$$R_{Th} = \frac{(5-j6)*(3+j5)}{(5-j6)+(3+j5)} = \frac{15+j25-j18+30}{(8-j1)}$$

$$= \frac{45+j7}{8-j1} = \frac{45.54\angle 8.842}{8.062\angle -7.13}$$

$$R_{Th} = 5.65\angle 15.97$$

$$I_1 = \frac{200\angle 30°}{5.65\angle 15.97}$$

$$\therefore I_1 = 35.398\angle -14.03°$$

$$I_1' = \frac{(5-j6)}{(5-j5)+(3+j5)} * I_1 = \frac{5-j6}{(8-j1)} * 35.398\angle -14.03°$$

$$= \frac{7.810\angle -50.19}{8.062\angle -7.13} * 35.398\angle -14.03$$

$$I_1' = 34.28\angle -57.09°$$

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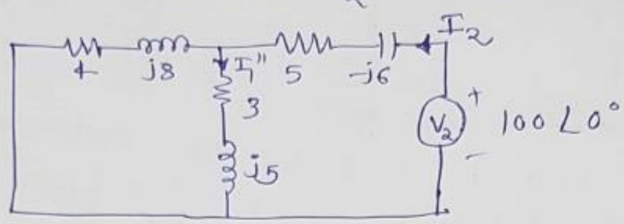
Step 2 :- Similarly find current thr AB Branch due to source $V_2 = 100\angle 0^\circ$

Step 3



The impedances $(4+j8)\Omega$ & $(3+j5)\Omega$ are in parallel & this combination is in series with $(5-j6)\Omega$

$$R_{Th} = \frac{(4+j8)(3+j5)}{(4+j8)+(3+j5)} = \frac{12+j20+j24-40}{(7+j13)}$$

$$= \frac{-28+j44}{7+j13} = \frac{52.15\angle 122.47}{14.765\angle 61.69}$$

$$\therefore R_{Th} = 3.532\angle 60.78^\circ$$

$$I_2 = \frac{100\angle 0^\circ}{3.532\angle 60.78}$$ ⟹ (2 Marks)

$$I_2 = 28.32\angle -60.78^\circ$$

$$I_1'' = \frac{(4+j8)}{(7+j13)} * I_2$$

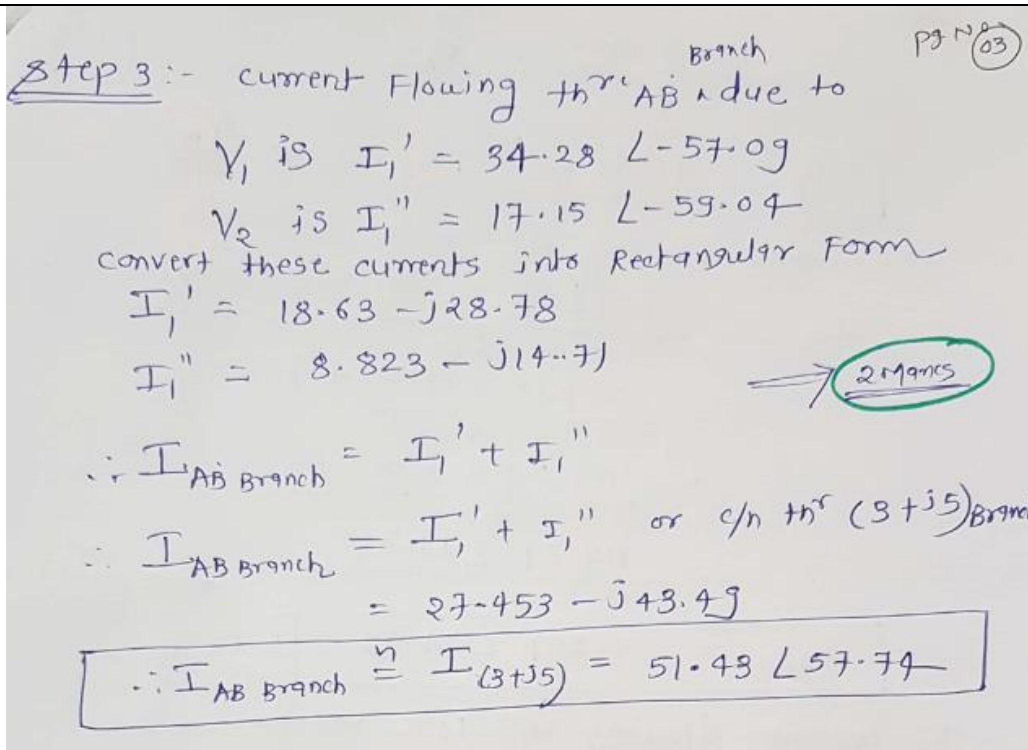
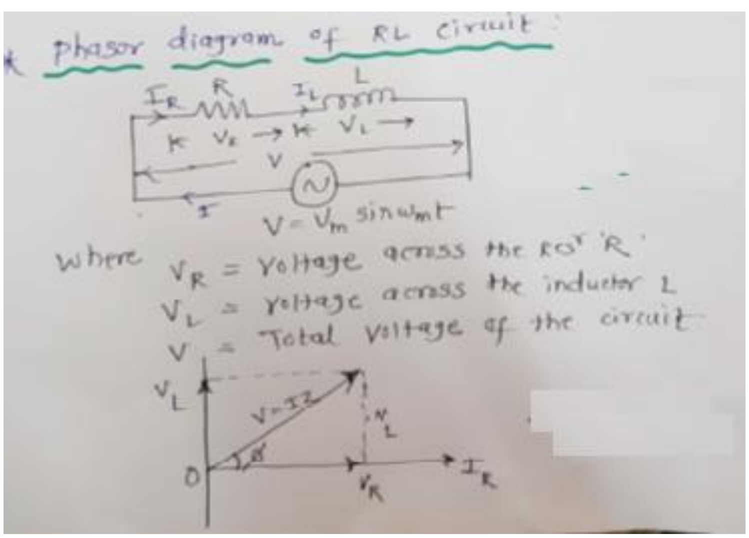
$$= \frac{(4+j8)}{(7+j13)} * 28.32\angle -60.78$$

$$= \frac{8.944\angle 63.43}{14.765\angle 61.69} * 28.32\angle -60.78$$

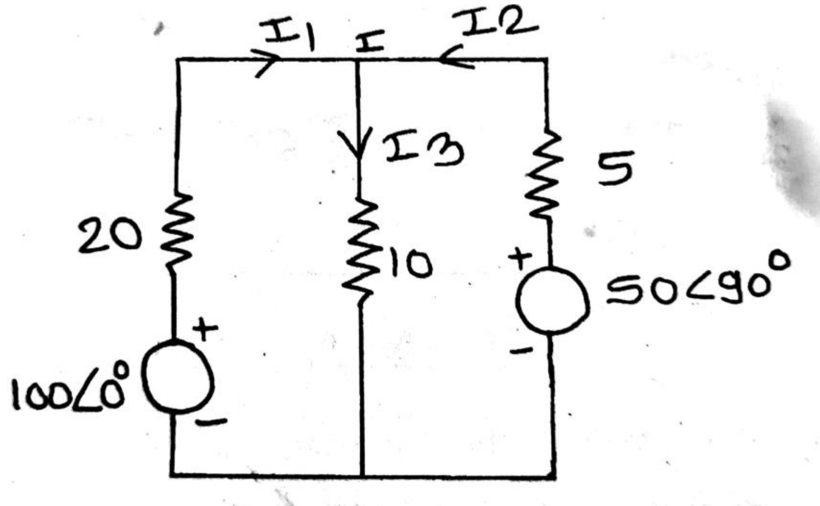
$$= \frac{8.944 * 28.32\angle 63.43+(-60.78^\circ)}{14.765\angle 61.69}$$

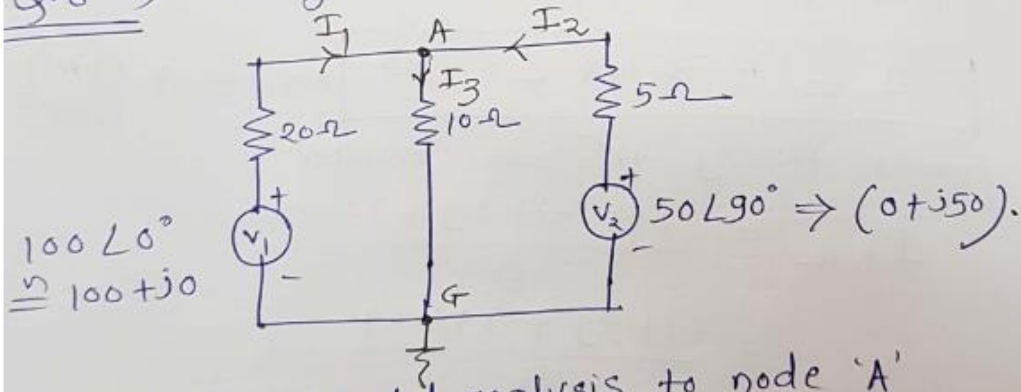
$$I_1'' = \frac{253.29\angle 2.65}{14.765\angle 61.69}$$

$$I_1'' = 17.15\angle -59.04$$

		 Step 3 :- current Flowing thr' AB Branch due to V_1 is $I_1' = 34.28 \angle -57.09$; V_2 is $I_1'' = 17.15 \angle -59.04$; convert these currents into Rectangular Form ; $I_1' = 18.63 - j28.78$; $I_1'' = 8.823 - j14.71$ → 2 Marks ; $\therefore I_{AB\ Branch} = I_1' + I_1''$; $\therefore I_{AB\ Branch} = I_1' + I_1''$ or c/n thr $(3+j5)$ Branch ; $= 27.453 - j43.49$; $\therefore I_{AB\ Branch} \overset{n}{=} I_{(3+j5)} = 51.43 \angle 57.74$	
	c)	**Sketch the phasor diagram for the nominal drawn circuit with justification of each phasor drawn.**	**6M**
	Ans:	**Consider series R-L circuit** 	**Circuit diagram : 1 Mark** **Phasor diagram : 3 Marks**

		Explanation :- In RL circuit Resistor 'R' & inductor 'L' are connected in series with a voltage supply of 'V' v. Since both R & L are connected in series, so the current in both the elements of the ckt remains same. ie $I_R = I_L = I$ Let V_R & V_L be voltage drop across resistor & inductor. In Resistor the voltage V_R & I_R are in phase. Whereas in inductor, the voltage V_L & current are not in phase. The voltage leads the current by 90°. **Note: If the student has attempted to solve the question considering any one of the following circuits : Series R-C or R-L-C circuit or Parallel R-L or R-C or R-L-C circuit, give appropriate marks.**	**Explanation :2Marks**

Q. No.	Sub Q. N.	Answers	Marking Scheme
6.		**Attempt any TWO of the following :**	**12- Total Marks**
	a)	**Use nodal analysis to calculate the current flowing in each branch of the network shown in Fig. No. 8**  **Fig. No. 8**	**6M**

	Ans:	Q.6 a) Using Nodal Analysis.  Applying Nodal analysis to node 'A' $$\frac{100-V_A}{20} - \frac{V_A}{10} + \frac{j50-V_A}{5} = 0 \quad \Longrightarrow \text{1M}$$ $$\frac{100-V_A-2V_A+j200-4V_A}{20} = 0$$ $$100-7V_A+j200=0$$ $$100+j200=7V_A$$	

$$\frac{100+j200}{7} = V_A$$

$\therefore V_A = 31.94\angle 63.43$ V → (1M)

$\therefore V_A = 14.29 + j28.566$

(a) current flowing thr 20Ω resistor

$$I_{20\Omega} = \frac{(100\angle 0^\circ) - (31.94\angle 63.43)}{20}$$

$$= \frac{100+j0-14.29-j28.57}{20}$$

$$= \frac{100-14.29-j28.57}{20} = \frac{85.72-j28.56}{20}$$

$$= \frac{90.35\angle -18.42^\circ}{20}$$ → (2M)

$\therefore I_{20\Omega} = 4.517\angle -18.42^\circ$ Amp. or $4.285 - j1.427$ Amp.

(b) current flowing thr 10Ω resistor

$$I_{10\Omega} = \frac{V_A}{10} = \frac{31.94\angle 63.43}{10}$$

$\therefore I_{10\Omega} = 3.194\angle 63.43$ Amp. → (1M)

(c) current flowing thr 5Ω resistor

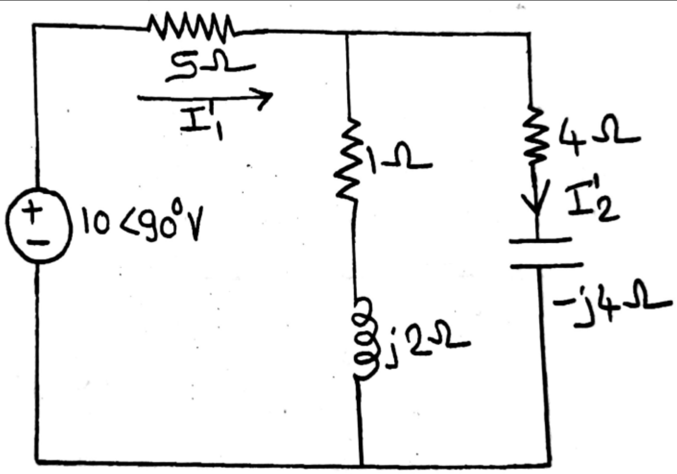
$$I_{5\Omega} = \frac{j50 - 14.29 - j28.57}{5}$$

$$= \frac{-14.29 + j21.43}{5}$$

$$= \frac{25.757\angle 123.69}{5}$$ → (1M)

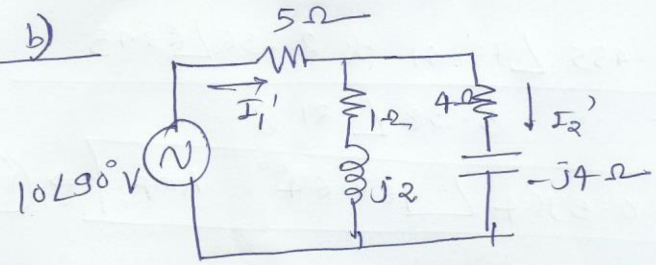
$I_{5\Omega} = 5.151\angle 123.69$ Amp

	b)	**Verify the reciprocity theorem in the circuit given in Fig. No. 9**	**6M**

		 **Fig. No. 9**	
	Ans:		

Pg. No. 9

Q6 b)



Case: 1
Step 1 :- consider the given circuit as it is

$$Z_{eq} = 5 + [(1+j2)] \parallel [(4-j4)]$$

$$= 5 + \frac{[(1+j2)(4-j4)]}{1+j2+4-j4}$$

$$= 5 + \frac{(4-j4+j8+8)}{5-j2}$$

$$= 5 + \frac{12+j4}{5-j2}$$

$$= \frac{25-j10+12+j4}{(5-j2)}$$

$$= \frac{37-j6}{5-j2} = \frac{37.48\angle -9.21}{5.38\angle -21.8}$$

$$\boxed{Z_{eq} = 6.966\angle 12.59\ \Omega} \rightarrow (1M)$$

$$I_1' = \frac{10\angle 90°}{6.966\angle 12.59} = 1.435\angle +77.41 \text{ Amp.} \Rightarrow (1M)$$

using c/n division rule,

$$I_2' = 1.435\angle 77.41 * \frac{(1+j2)}{1+j2+4-j4}$$

$$= \frac{1.435\angle 77.41 * (1+j2)}{5-j2}$$

SUMMER– 19 EXAMINATION

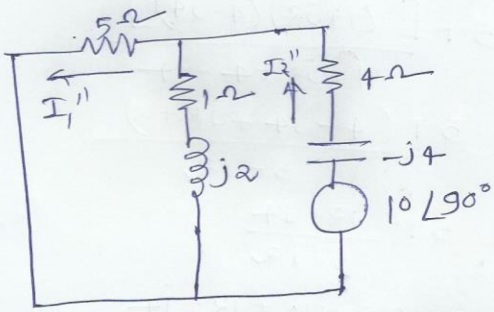
Subject Name: Electric circuits and network **Model Answer** **Subject Code: 22330**

$$= \frac{1.435 \angle 77.41 * 2.236 \angle 63.43}{5.38 \angle -21.8}$$

$$\boxed{I_2' = 0.5964 \angle 162.64^\circ \text{ Amp}} \Rightarrow (1M)$$

case 2: change the position of voltage source

Step 1 :- & calculate currents.



$$Z_{eq}' = \frac{5+j10}{6+j2} + (4-j4)$$

$$= \frac{11.18 \angle 63.43}{6.32 \angle 18.43} + (4-j4)$$

$$= (1.718 \angle 45) + (4-j4)$$

$$= 1.25 + j1.25 + 4 - j4$$

$$= 5.25 - j2.75$$

$$\boxed{Z_{eq}' = 5.926 \angle -27.64 \; \Omega} \Rightarrow (1M)$$

$$I_2'' = \frac{10\angle 90^\circ}{5.926\angle -27.61}$$

$$\boxed{I_2'' = 1.687\angle 117.64 \text{ Amp}}$$

using current division rule,

$$I_1'' = 1.687\angle 117.64 * \frac{(1+j2)}{6+j2}$$

$$= \frac{1.687\angle 117.64 * (2.236\angle 63.43)}{6.32\angle 18.43}$$

$$\boxed{I_1'' = 0.596\angle 162.64 \text{ Amp}} \Longrightarrow (1M)$$

Proof:- As per Reciprocity thm statement,

Case:-1: Ratio of voltage source to response is

$$\frac{V}{I_2'} = \frac{10\angle 90^\circ}{0.596\angle 162.64} \Longrightarrow (1M)$$

$$= 16.77\angle -76.64$$

Case: 2

$$\frac{V_1}{I_1''} = \frac{10\angle 90^\circ}{0.596\angle 162.64}$$

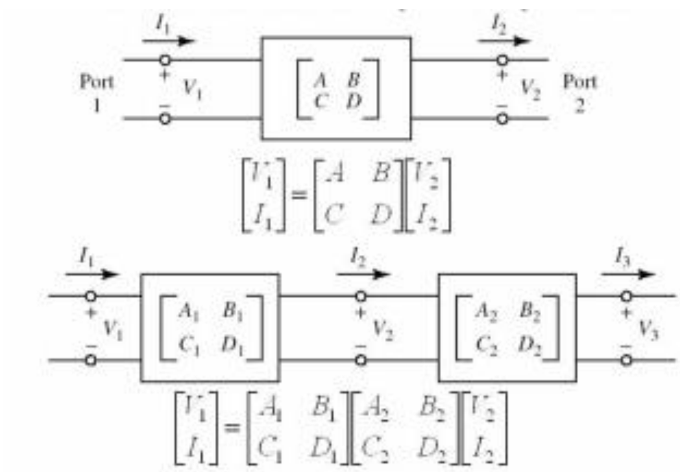
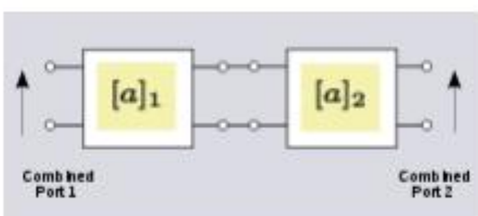
$$= 16.77\angle -76.64$$

As the transfer ratio is same in both cases.
Thus the Reciprocity thm is verified.

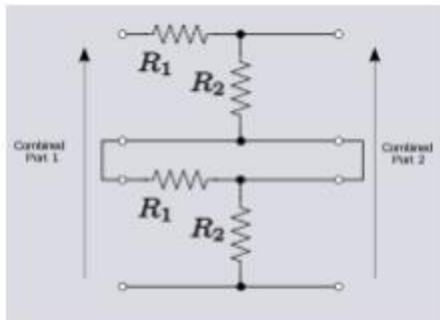
	c)	Draw the two port network and determine the indicated parameters for the following configurations: (i) Cascade configurations (ABCD parameter) (ii) Series configurations (iii) Parallel configurations.	6M

SUMMER– 19 EXAMINATION

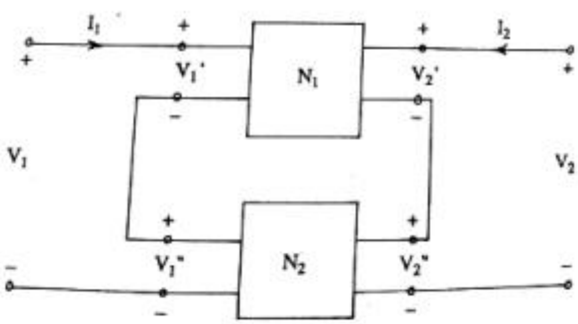
Subject Name: Electric circuits and network **Model Answer** **Subject Code: 22330**

	Ans:	**Cascade configuration ABCD parameter :-**  **OR** 	**1 mark for the diagram and 1 mark for equation for each configuration**

Series configurations:-



OR



Where N1 and N2 are two port Network

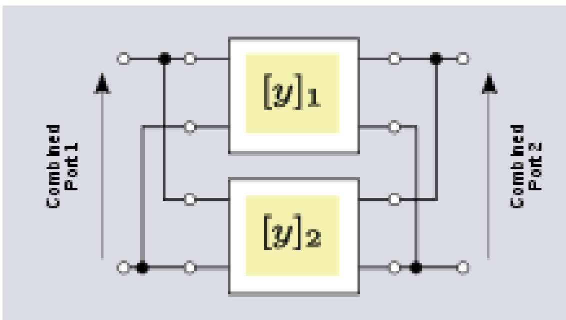
$$[Z] = [Z_1] + [Z_2]$$

The Z parameter equation can be written as below

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

where Z_{11}, Z_{12}, Z_{21} and Z_{22} are sum of corresponding values of individual networks.

Parallel configurations:-



When two-ports are connected in a parallel configuration as shown in figure, The choice of two-port parameter is the *y*-parameters. The *y*-parameters of the combined network are found by matrix addition of the two individual *y*-parameter matrices.

$$[\mathbf{y}] = [\mathbf{y}]_1 + [\mathbf{y}]_2$$

Where Y parameter equation can be written as below

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

where Y_{11}, Y_{12}, Y_{21} and Y_{22} are sum of corresponding values of individual networks.