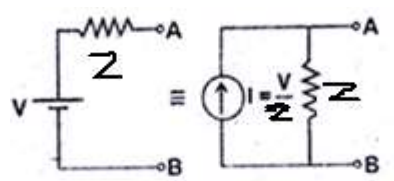
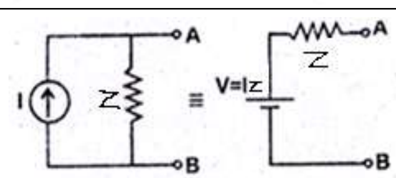
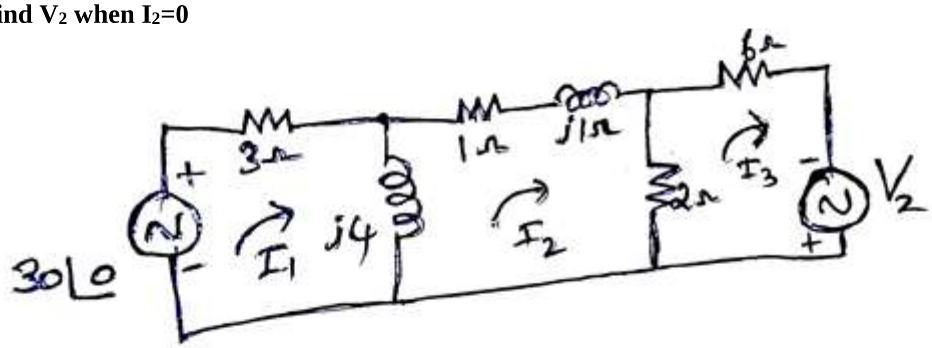
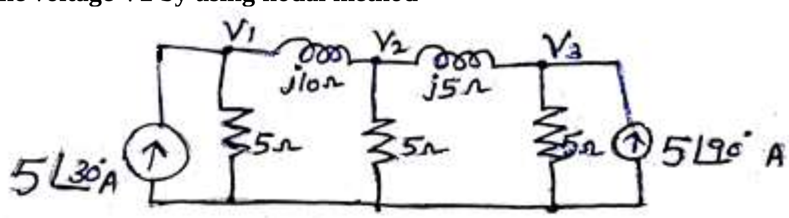
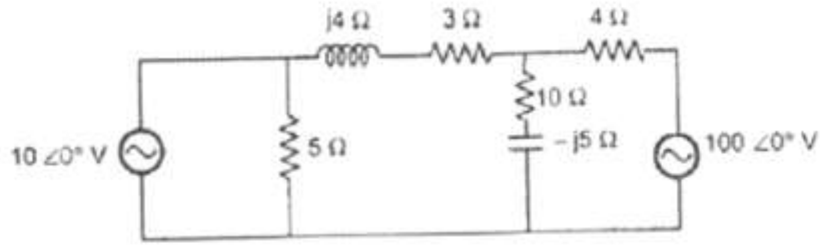
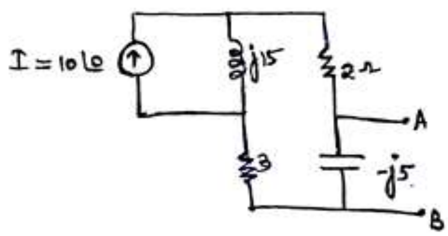
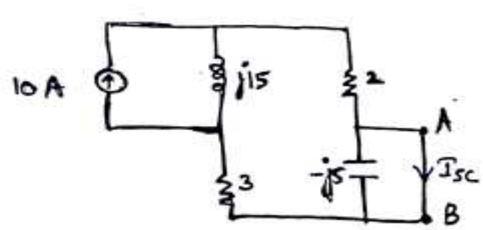
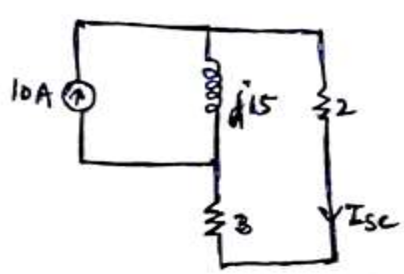
UNIT II – AC CIRCUITS

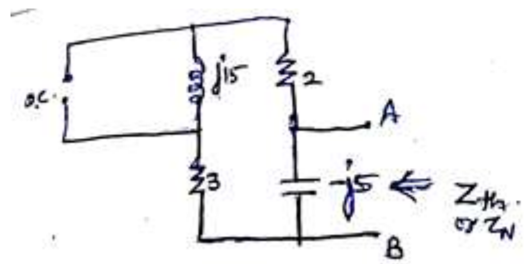
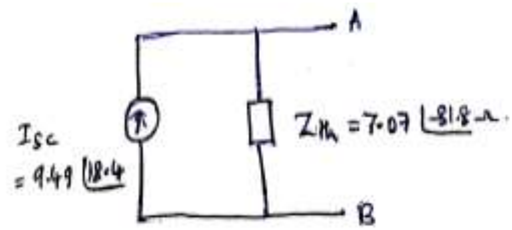
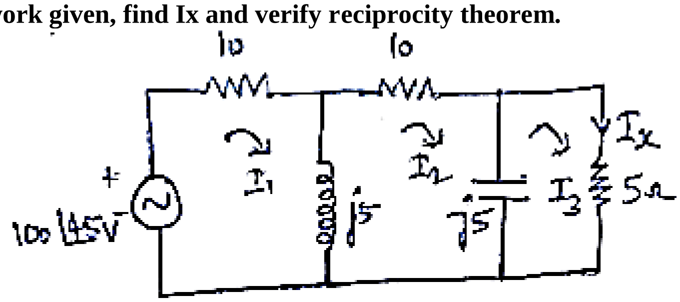
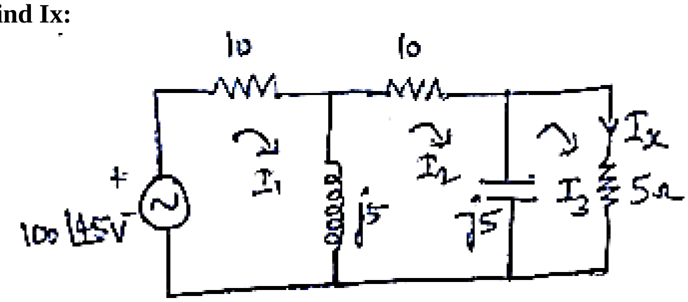
PART – A (2 Mark Questions With Key)

S.No	Questions	Mark	COs	BTL
1	**What are impedance and admittance?**		1	K1
	The ratio of the phasor voltage V to the phasor current I is called impedance, $Z = \frac{V}{I}$	1		
	The inverse of impedance is called admittance, $Y = \frac{1}{Z}$	1		
2	**What are reactance and susceptance?**			
	When impedance is written in cartesian form, the real part is the resistance R and the imaginary part is the reactance.	1	1	K1
	When admittance is written in cartesian form, the real part is admittance Y, and imaginary part is susceptance, B.	1		
3	**A series RC circuit with R =20 ohms and C = 127 microfarad has 160 V, 50 Hz supply connected to it. Find the circuit impedance and admittance**			
	$X_C = 1/2\pi fC$ = 25 ohms Z= SQRT of ($R^2 + X_C^2$) = 32 ohms Y= 1/Z = 0.031 Siemens or mho	1 1	5	K2
4	**A 100 ohm resistor and a 20 mH inductor are connected in series across a 230 V, 50 Hz supply. Find the circuit impedance and admittance**			
	$X_L = 2\pi fL$ = 6.283 ohms Z= SQRT of ($R^2 + X_L^2$) = 100.197 ohms Y= 1/Z = 9.98 X 10^{-3} Siemens or mho	2	5	K2
5	**Convert a 100 <0 V, 50Ω into equivalent current source.**			
	$I = V/Z = 100\angle 0/50 = 2\angle 0A$  Source conversion (From voltage source to current source)	2	5	K2
6	**Convert a 10 <90A, 0.5Ω into equivalent voltage source.** $V = I \times Z = 10\angle 90 \times 0.5 = 5\angle 90V$  Source conversion (from current source to voltage source)	2	5	K2
7	**What is the expression of load current w.r.to Thevenin's circuit and Norton's circuit?**			
	In Thevenin's equivalent circuit, the load current is expressed as, $I_L = \frac{V_{OC}}{Z_{th} + Z_L}$	1 1	5	K2

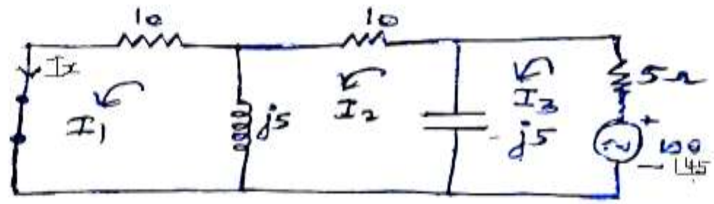
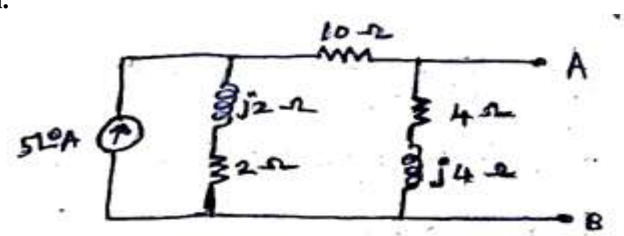
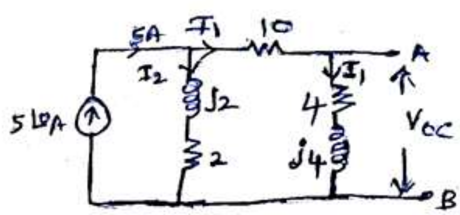
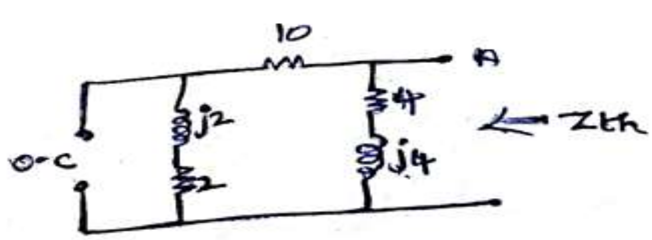
	(ii) In Norton's equivalent circuit, the load current is expressed as, $I_L = \frac{I_{SC} \times Z_{th}}{Z_{th} + Z_L}$			
8	**Give the condition for maximum power transfer in DC and AC circuits.**			
	condition for maximum power transfer in DC circuit, $P_{max} = V^2_{th}/4R_L$ condition for maximum power transfer in AC circuit, $P_{max} = V^2_{th}/4Z_L$, where $Z_L=Z_{th}^*$	1 1	5	K2
9	**Give the limitations of the superposition theorem**			
	superposition theorem doesn't useful for power calculations also not suitable for single source. It is not applicable to non-linear elements, unilateral devices and coupled circuits	1 1	1	K1
10	**State Thevenin's theorem for AC circuits**			
	Thevenin's theorem states that "Any two terminal linear network having a number of voltage, current sources and impedances can be replaced by a simple equivalent circuit consisting of a single voltage source in series with a impedance, where the value of the voltage source is equal to the open circuit voltage across the two terminals of the network and impedance measured between the terminals with all the energy sources are replaced by their internal impedances.	2	1	K1
11	**State Norton's theorem for AC circuits**			
	Norton's theorem states that "Any two terminal linear network having a number of voltage, current sources and impedances can be replaced by a simple equivalent circuit consisting of a single current source in parallel with a impedance, where the value of the current is the short circuit current between two terminals of the network and the impedance is the equivalent impedance measured between the terminals of the network with all the energy sources replaced by their internal impedance.	2	1	K1
12	**State maximum power transfer theorem for AC circuits**			
	The theorem states "Maximum power will be transferred from a voltage source to a load, when the load impedance is equal to the impedance of the source (or complex conjugate of that if vary both load resistance and reactance).	2	1	K1
13	**Give the limitations of the reciprocity theorem**			
	Reciprocity theorem only applicable for single source. It is not applicable to non-linear elements, unilateral devices and coupled circuits.	1 1	1	K1
14	**When do we go for super mesh analysis?**			
	Suppose any of the branches in the network has a current source, then it is difficult to apply mesh analysis, as we should assume an unknown voltage across the current source, write mesh equations and then relate the source current to the assigned mesh currents, which is a difficult approach. So we go for super mesh analysis.	2	1	K1
15	**When do we go for super node?**			
	Suppose any of the branches in the network has a voltage source, and then it is slightly difficult to apply nodal analysis. To overcome this difficulty, we go for super node analysis.	2	1	K1

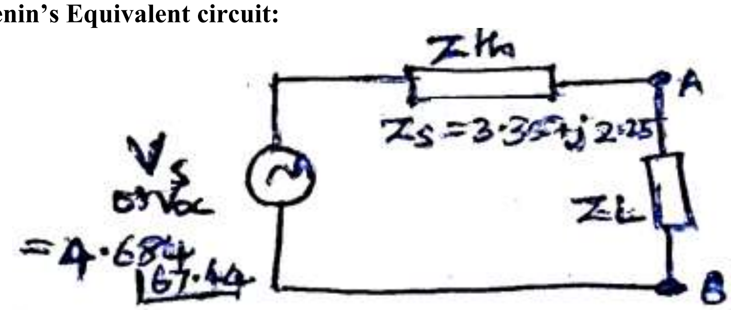
PART – B (12 Mark Questions with Key)				
S.No	**Questions**	**Mark**	**COs**	**BTL**
1	**Find V_2 when I_2=0** 	12	5	K3
	Using mesh analysis (method of inspection) $\begin{pmatrix} 3+j4 & -j4 & 0 \\ -j4 & 3+j5 & -2 \\ 0 & -2 & 8 \end{pmatrix}\begin{pmatrix} I1 \\ I2 \\ I3 \end{pmatrix} = \begin{pmatrix} 30\angle 0 \\ 0 \\ V2 \end{pmatrix}$ $I_2 = \Delta I_2/\Delta = 0$ So, $\Delta I_2 = 0$ $\begin{vmatrix} 3+j4 & 30\angle 0 & 0 \\ -j4 & 0 & -2 \\ 0 & V2 & 8 \end{vmatrix} = 0$ Answer: **V_2 = 96 < -143.13 V**	4 2 4 2		
2	**Obtain the voltage V2 by using nodal method** 	12	5	K3
	Using nodal analysis (method of inspection) $\begin{pmatrix} \frac{1}{5}+\frac{1}{j10} & \frac{-1}{j10} & 0 \\ \frac{-1}{j10} & \frac{1}{j10}+\frac{1}{5}+\frac{1}{j5} & \frac{-1}{j5} \\ 0 & \frac{-1}{j5} & \frac{1}{j5}+\frac{1}{5} \end{pmatrix}\begin{pmatrix} V1 \\ V2 \\ V3 \end{pmatrix} = \begin{pmatrix} 5\angle 30 \\ 0 \\ 5\angle 90 \end{pmatrix}$ Δ = - 6.311- j0.025 = 6.311< -180 ΔV_2 = 0.173-j0.242 = 0.298 < -54.44 **V2 = $\Delta V_2/\Delta$ = 0.0472< 125.56 V**	4 4 4		

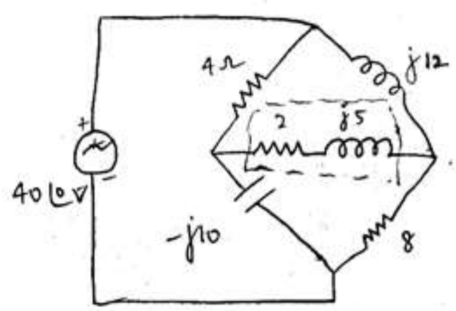
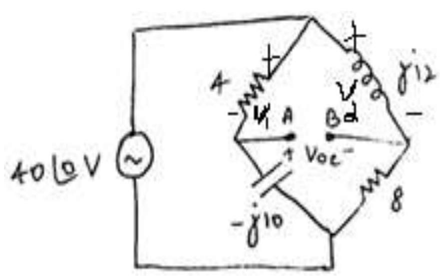
3	**Find current through 3+j4 ohm using superposition theorem**  	12	5	K3
	Case(i) 10<0 source alone active: Case(ii) 100<0 source alone active: Case(iii) both 10<0 source and 100<0 source active: Δ= -260+j120= 286.36<155.22 ΔI_2= -4300+j2250= 4853.1<152.4 A **Answer**: current through 3+j4 ohm **= 16.93-j0.83= 16.95<-2.82 A**	4 4 4		
4	**Obtain Norton's equivalent circuit across the terminals A&B for the network given.**  	12	5	K3
	(a) To find IN or Isc   **Isc= 9.49<18.4 A**	4		

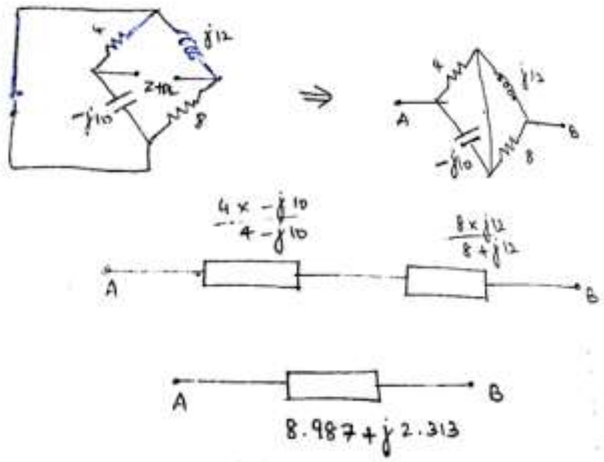
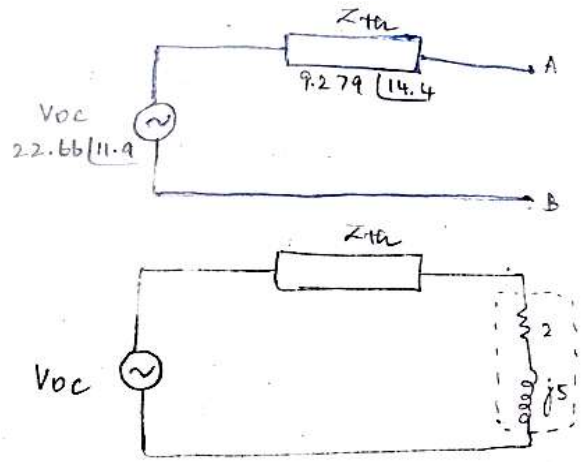
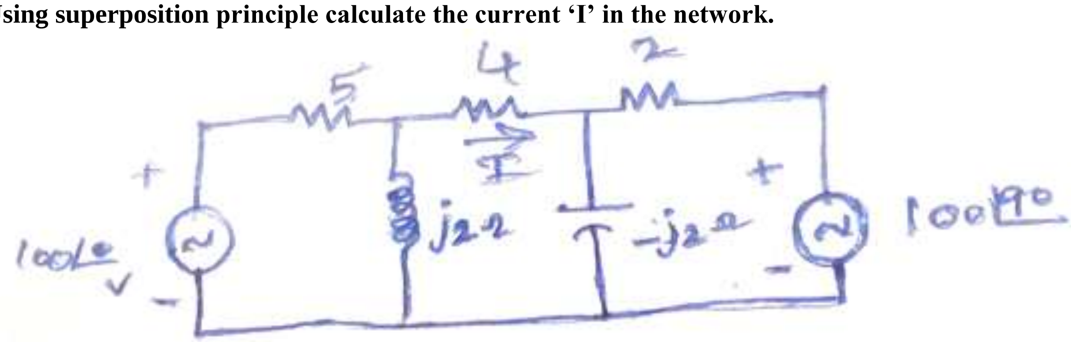
<table>
<tr><td></td><td>(b) To find Z_{th}:
$Z_{th} = (2+3+j15) \parallel (-j5) =$ 7.07 <-81.8 Ω

</td><td>4</td><td></td><td></td></tr>
<tr><td></td><td>(c) Norton's equivalent circuit:

</td><td>4</td><td></td><td></td></tr>
<tr><td>5</td><td>For the network given, find Ix and verify reciprocity theorem.

</td><td>12</td><td rowspan="2">5</td><td rowspan="2">K3</td></tr>
<tr><td></td><td>Case(i) To find Ix:


Using mesh analysis (method of inspection)
$$\begin{pmatrix} 10+j5 & -j5 & 0 \\ -j5 & 10+j5-j5 & j5 \\ 0 & j5 & 5-j5 \end{pmatrix}\begin{pmatrix} I1 \\ I2 \\ I3 \end{pmatrix} = \begin{pmatrix} 100\angle 45 \\ 0 \\ 0 \end{pmatrix}$$
Ix=$I_3 = \Delta I_3/\Delta =$ 2.169 <57.53 A</td><td>5</td></tr>
</table>

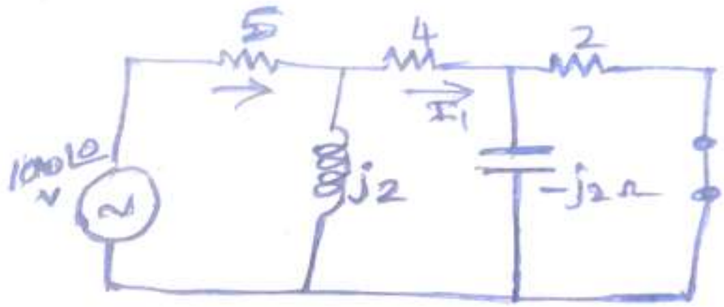
	Case(ii) **To find Ix:**  Using mesh analysis (method of inspection) $\begin{pmatrix} 10+j5 & -j5 & 0 \\ -j5 & 10+j5-j5 & j5 \\ 0 & j5 & 5-j5 \end{pmatrix} \begin{pmatrix} I1 \\ I2 \\ I3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 100\angle 45 \end{pmatrix}$ **Ix**=I_1= $\Delta I_1/\Delta$ = **2.169 <57.53 A** Ix is same in both cases. Hence, the reciprocity theorem is verified.	5 2		
6	**Determine the load impedance that can be connected across terminals A& B for maximum power transfer to load impedance. Also calculate the maximum power transfer to load.** 	12	5	K3
	(i)To find V_{oc}:  Voc= $I_1 \times (4+j4)$ Usin CDP, $I_1 = 5 \times \frac{2+j2}{10+4+j4+2+j2} = 0.8275\angle 24.44A$ Voc= 4.684<69.44 V = 1.645+j4.386 V	4		
	(ii)To find Z_{th}:  $\mathbf{Z_{th}}$ **=** (2+j2+10) $\parallel$ (4+j4) = **4.03<33.9 Ω = 3.35+j2.25 Ω**	4		

	(iii)Thevenin's Equivalent circuit: 	2		
	For max. power transfer, Z_L=Zs* Zs= **Z_{th} = 4.03<33.9 Ω = 3.35+j2.25 Ω** Z_L=Zs* = (**3.35+j2.25 Ω)* = 3.35-j2.25 Ω** **$P_L = I_L^2 \times R_L$** **$I_L = \frac{Voc}{Zs + Z_L}$ = 0.699<69.49 A** **$P_L = I_L^2 \times R_L$ = (0.699)2 × 3.35 =1.6373 W**	2		

PART – C (20 Mark Questions with Key)				
S.No	**Questions**	**Mark**	**COs**	**BTL**
1	**Use Thevenin's theorem to find current through 2+j5 Ω impedance.** 	20	5	K3
	(i)To find V_{oc}:  V_{AB}=Voc=? Voc+V_1-V_2=0 so, Voc=V_2-V_1 Usin VDP, $V_1 = 40\angle 0 \times \frac{4}{4 - j10} = 5.52 + \text{j}13.79V$ $V_2 = 40\angle 0 \times \frac{j12}{j12 + 8} = 27.69 + j18.46V$ **Voc=** V_2-V_1 = **22.1751+j4.668 V = 22.66<11.9 V**	6		

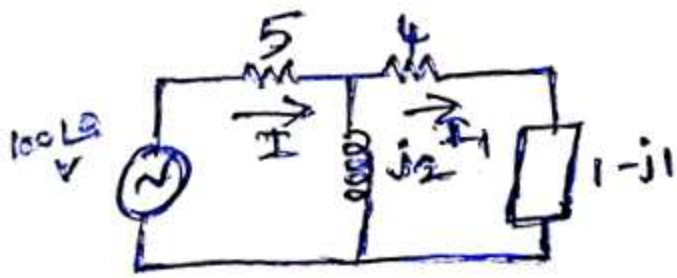
	(ii)To find Z_{th}:  **Z_{th} = 8.987+j2.313 Ω = 9.279<14.4 Ω** **(iii)Thevenin's Equivalent circuit:**  **(iv) To find load current:** $\mathbf{I_L} = V_{oc}/(Z_S + Z_L) = 1.717\angle -21.8A$	6 4 4		
2	**Using superposition principle calculate the current 'I' in the network.** 	20	5	K3

Case(i) 100<0 source alone active: 8



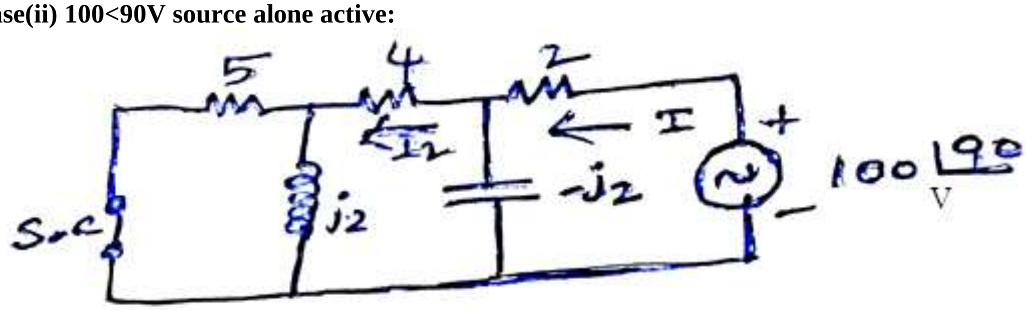
$$Z_T = \left\langle \left\{ \frac{(2\times -j2)}{(2-j2)} + 4 \right\} \| \; j2 \right\rangle + 5 = 5.77 + j1.85$$

$$I_T = V/Z_T = 100\angle 0^\circ / (5.77 + j1.85) \text{ A}$$



Using CDP, $I_1 = I \times \dfrac{j2}{4 + j2 + 1 - j1} = 6.475\angle 61 = 3.14 + j5.66A$

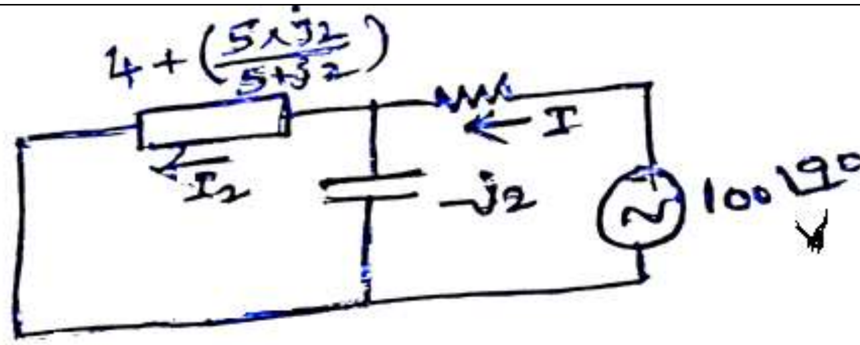
Case(ii) 100<90V source alone active:



8

$$Z_T = \left\langle \left\{ \frac{(5\times j2)}{(5+j2)} + 4 \right\} \| -j2 \right\rangle + 2 = 2.85 - j1.95$$

$$I_T = V/Z_T = 100\angle 90^\circ / (2.85 - j1.95)$$



According to superposition theorem:

I= I_1-I_2 = **(- 6.61-j1.89) A = 6.875∟-164° A** 4