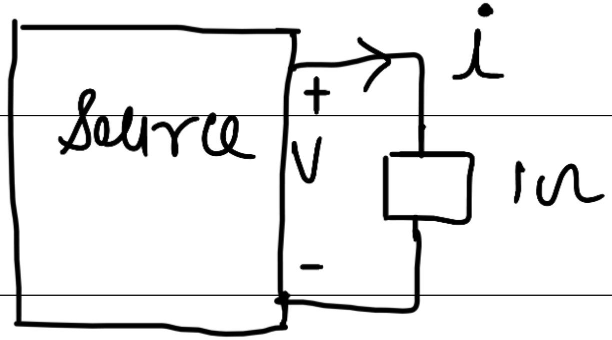
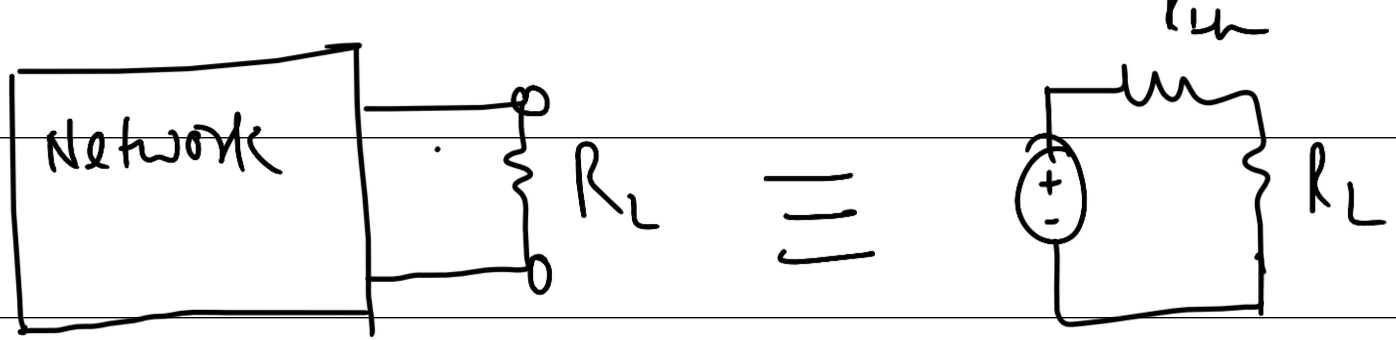
Q-1 As shown in the figure, a $1\,\Omega$ resistor is connected to a source that has a load line $v + i = 100$, the current through the resistance is?



Sol^n: Any two terminal bilateral linear DC Circuits can be replaced by an equivalent circuit consisting of a voltage source and a series resistor.



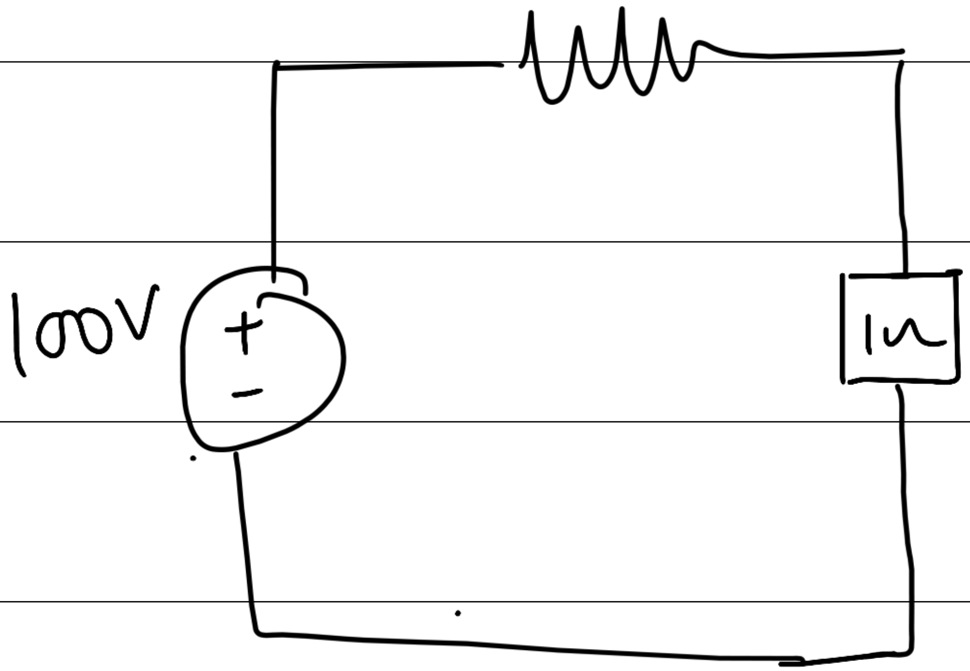
Given : Load line equation $= V + i = 100$

To obtain open-circuit voltage (V_{th}) put $i=0$ in load line equation

$\Rightarrow V_{th} = 100V$

To obtain short-circuit current (i_{sc}) put $V=0$ in load line equation $i_{sc} = 100A$

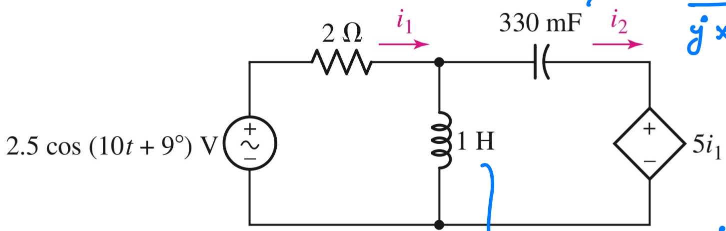
So, $R_{th} = \dfrac{V_{th}}{i_{sc}} = \dfrac{100}{100} = 1\Omega$



current $(i) = \frac{100}{2} = 50A$. **Ans**

$V_3 = 1.5\angle 17°$ V.

52. Employ phasor analysis techniques to obtain expressions for the two mesh currents i_1 and i_2 as shown in Fig. 10.61.



$$\frac{1000}{j \times 10 \times 330} = -\frac{10j}{33} = -0.30j\,\Omega$$

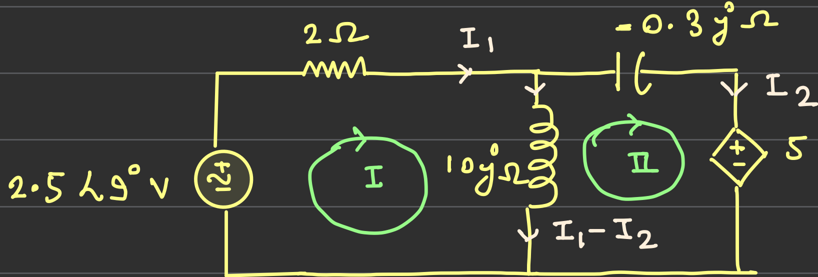
$j\omega L = j10\,\Omega$

■ **FIGURE 10.61**

Sol^n :

converting into phasor domain

$\omega = 10$ rad/s



mesh analysis :

(I) $\quad -2.5\angle 9° + 2I_1 + (I_1 - I_2)(10j) = 0$

$\Rightarrow \quad -2.46 - 0.391j + (2+10j)I_1 - 10jI_2 = 0$

$\Rightarrow \quad (2+10j)I_1 - 10jI_2 = 2.46 + 0.391j \quad -(1)$

(II) $\quad 5I_1 - 10j(I_1 - I_2) - 0.3jI_2 = 0$

$\Rightarrow \quad (5-10j)I_1 + 9.7jI_2 = 0 \quad -(2)$

Solving the equations by cramer's rule

$$\Delta = \begin{vmatrix} 2+10j & -10j \\ 5-10j & 9.7j \end{vmatrix} = (2+10j)(9.7j) + 10j(5-10j)$$

$$= -97 + 19.4j + 50j + 100$$

$$\Delta = 3 + 69.4j$$

$$\Delta_1 = \begin{vmatrix} 2.46+0.39j & -10j \\ 0 & 9.7j \end{vmatrix}$$

$$\Delta_1 = -3.78 + 23.86j$$

$$\Delta_2 = \begin{vmatrix} 2+10j & 2.46+0.39j \\ 5-10j & 0 \end{vmatrix}$$

$$= -(16.2 - 22.65j)$$

$$\Delta_2 = -16.2 + 22.65j$$

$$I_1 = \frac{\Delta_1}{\Delta} = \frac{-3.78 + 23.86j}{3 + 69.4j}$$

$$= (0.34 + 0.069j)\ A$$

$$I_1 = 0.35 \angle 11.48^\circ\ A$$

In time domain:

$$i_1(t) = 0.35 \cos(10t + 11.48^\circ)\ A$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-16.2 + 22.65j}{3 + 69.4j}$$

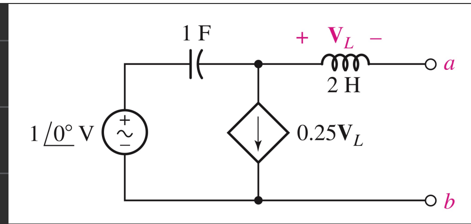
$$= (0.31 + 0.24j)\ A$$

$$I_2 = 0.4 \angle 38.04^\circ\ A$$

In time domain:

$$i_2(t) = 0.4 \cos(10t + 38.04^\circ)\ A$$

70. Use $\omega = 1$ rad/s, and find the Norton equivalent of the network shown in Fig. 10.74. Construct the Norton equivalent as a current source $\mathbf{I}_N$ in parallel with a resistance R_N and either an inductance L_N or a capacitance C_N.

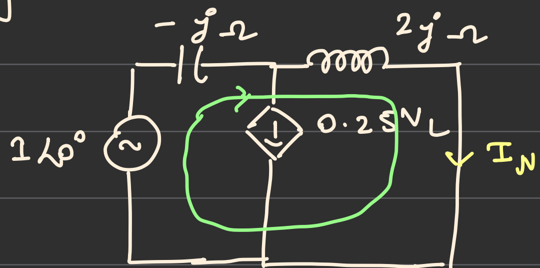


Solⁿ :

$\omega = 1$ rad/s

$V_{oc} = 1\angle 0°$ V

finding short circuit current



KVL :

$$1\angle 0° = -j\,(0.25 I_N (j2) + I_N) + 2j\, I_N$$

$$1\angle 0° = (0.5 + j)\, I_N$$

$$I_N = 0.4 - j0.8 = 0.89\angle -63.13° \text{ A}$$

$$Z_N = \frac{V_{oc}}{I_N} = 0.5 + j = \frac{1}{\frac{1}{R} + \frac{1}{jX}}$$

$\Rightarrow$ $R = 2.5\,\Omega$, $X = 1.25$

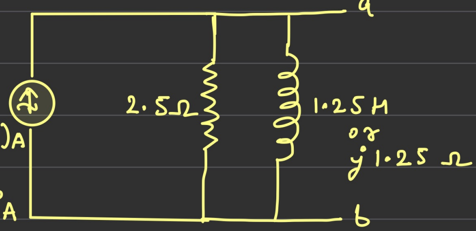
$L = 1.25$ H

$\underline{\underline{70}}$

$i_N = 0.89\cos(t - 63.43^\circ)\,A$

or

$I_N = 0.89\angle -63.43^\circ\,A$



value, redesign the circuit to achieve a corner frequency of 2 kHz.

80. Design a purely passive network (containing only resistors, capacitors, and inductors) which has an impedance of $(22 - j7)/5\angle 8^\circ\ \Omega$ at a frequency of $f = 100$ MHz.

$\underline{\underline{\text{Soln}}}$: one of the possible combinations

$$Z = \frac{22 - j7}{5\angle 8^\circ} = 4.618\angle -25.65^\circ$$
$$= (4.1629 - j2)\ \Omega$$

· Z is constructed using a series combination of single resistor, capacitor and an inductor

$R = 4.16\ \Omega$, $-j2 = j\omega L - \dfrac{j}{\omega C}$, setting $L = 200$ mH

$\Rightarrow$ $C = 0.12$ pF

$f = 100\,MHz = 100 \times 10^6\,Hz$

$= 10^8\,Hz$

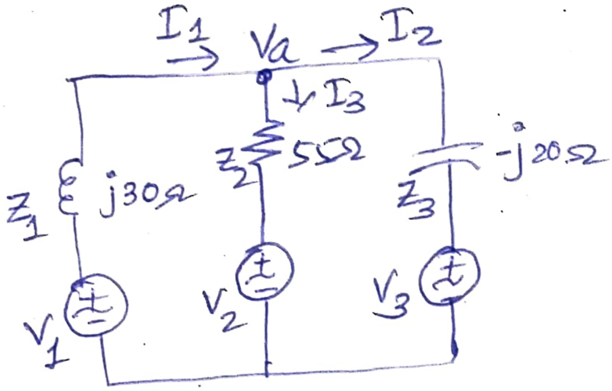
$\omega = 2\pi f = 2\pi \times 10^8\,Hz$

Tutorial-2

1. Given, $V_1 = 10\angle{-80^\circ}$ V

$V_2 = 4\angle{-0^\circ}$ V

$V_3 = 2\angle{-23^\circ}$ V



$Z_1 = j30\,\Omega = 30\angle{90^\circ}\,\Omega$

$Z_2 = 55\,\Omega = 55\angle{0^\circ}\,\Omega$

$Z_3 = -j20\,\Omega = 20\angle{-90^\circ}\,\Omega$

Apply KCL at node 'Va':

$$I_1 = I_2 + I_3 \quad \text{—(1)}$$

$$\Rightarrow \frac{V_1 - V_a}{Z_1} = \frac{V_a - V_3}{Z_3} + \frac{V_a - V_2}{Z_2}$$

$$\Rightarrow \frac{10\angle{-80^\circ} - V_a}{30\angle{90^\circ}} = \frac{V_a - 2\angle{-23^\circ}}{20\angle{-90^\circ}} + \frac{V_a - 4\angle{-0^\circ}}{55\angle{0^\circ}}$$

$$\Rightarrow \frac{10\angle{-80^\circ}}{30\angle{90^\circ}} - \frac{V_a}{30\angle{90^\circ}} = \frac{V_a}{20\angle{-90^\circ}} - \frac{2\angle{-23^\circ}}{\angle{-90^\circ}} + \frac{V_a}{55\angle{0^\circ}} - \frac{4\angle{-0^\circ}}{55\angle{0^\circ}}$$

$$\Rightarrow V_a\left[\frac{1}{30\angle{90^\circ}} + \frac{1}{20\angle{-90^\circ}} + \frac{1}{55\angle{0^\circ}}\right] = \frac{10\angle{-80^\circ}}{30\angle{90^\circ}} + \frac{2\angle{-23^\circ}}{20\angle{-90^\circ}} + \frac{4\angle{0^\circ}}{55\angle{0^\circ}}$$

$$\Rightarrow V_a(0.018 + j0.0167) = -0.216 + j0.0342$$

$$\Rightarrow V_a = \frac{-0.216 + j0.0342}{0.018 + j0.0167}$$

$$\Rightarrow \boxed{V_a = -5.502 + j7.004 = 8.91\angle{128.15^\circ}} \quad \text{—(2)}$$

$$I_1 = \frac{V_1 - V_a}{Z_1} = \frac{10\angle -80^\circ - 8.91\angle 128.15^\circ}{30\angle 90^\circ}$$

$$\Rightarrow \boxed{I_1 = 0.61\angle -156.45^\circ \text{ A} = -0.56 - j0.24 \text{ A}} \quad \text{--- (3)}$$

$$I_2 = \frac{V_a - V_3}{Z_3} = \frac{8.91\angle 128.15^\circ - 2\angle -23^\circ}{20\angle -90^\circ}$$

$$\Rightarrow \boxed{I_2 = 0.54\angle -136.4^\circ \text{ A} = -0.39 - j0.37 \text{ A}} \quad \text{--- (4)}$$

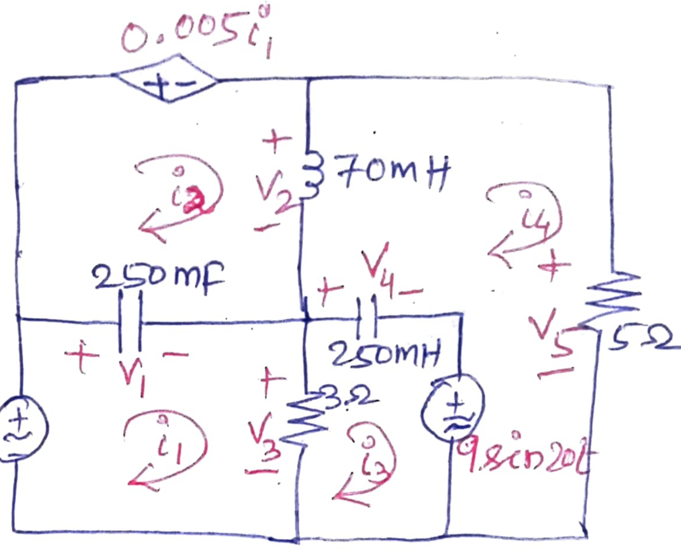
2) Given, $C = 250\,mF \Rightarrow$

$Z_C = -j0.2\,\Omega$

$L = 70\,mH,\ Z_L = j1.4\,\Omega$

$V_{s_1} = 9\cos(20t)\,V = 9\ V$

$V_{s_2} = 9\sin(20t)\,V = -j9\,V$



Mesh-1

Apply KVL, $-9 + V_1 + V_3 = 0$

$$\Rightarrow -9 + Z_C(I_1 - I_2) + Z_R(I_1 - I_3) = 0$$

$$\Rightarrow -9 - j0.2(I_1 - I_2) + 3(I_1 - I_3) = 0$$

$$\Rightarrow \boxed{(3 - j0.2)I_1 + j0.2I_2 - 3I_3 = 9} \quad (1)$$

Mesh-2

Apply KVL, $0.005I_1 + V_2 - V_1 = 0$

$$\Rightarrow 0.005I_1 + (I_2 - I_4)(j1.4) - (I_1 - I_2)(-j0.2) = 0$$

$$\Rightarrow \boxed{(0.005 + j0.2)I_1 + j1.2I_2 - j1.4I_4 = 0} \quad (2)$$

Mesh-3

Apply KVL, $-j9 - V_3 + V_4 = 0$

$$\Rightarrow -j9 - (I_1 - I_3)3 + (I_3 - I_4)(-j0.2) = 0$$

$$\Rightarrow \boxed{-3I_1 + (3 - j0.2)I_3 + j0.2I_4 = j9} \quad (3)$$

Mesh-4

Apply KVL,

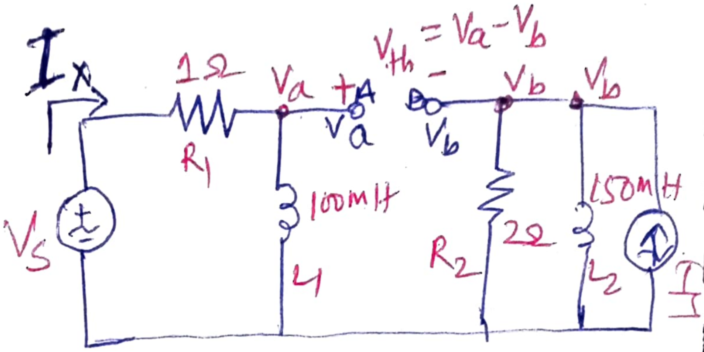
$$V_5 - (-j9) - V_4 - V_2 = 0$$

$$\Rightarrow 5I_4 + j9 - (I_3 - I_4)(-j0.2) - (I_2 - I_4)(j1.4) = 0$$

$$\Rightarrow \boxed{-1.4I_2 + j0.2I_3 + (5 + j1.2)I_4 = -j9} \quad (4)$$

3) Given, $R_1 = 1\Omega$

$\Rightarrow Z_{R1} = 1\Omega$



$L_1 = 100\,mH \Rightarrow Z_{L_1} = j2\Omega$

$R_2 = 2\Omega \Rightarrow Z_{R_2} = 2\Omega$

$L_2 = 150\,mH \Rightarrow Z_{L_2} = j3\Omega$

$V_s = 5\sin(20t + 12^\circ)\,V = 5\cos(20t + 12^\circ - 90^\circ)$

$= 5\cos(20t - 78^\circ)$

$$\boxed{V_s = 5\angle -78^\circ V = (1.04 - j4.89)\,V} \quad \text{(1)}$$

$I_s = 2\sin(20t + 45^\circ) = 2\cos(20t - 45^\circ)$

$$\boxed{I_s = 2\angle -45^\circ A = (1.41 - j1.41)\,A} \quad \text{(2)}$$

→ Apply KCL at node 'A' or voltage divider rule to find out V_a.

* Let us apply voltage divider rule,

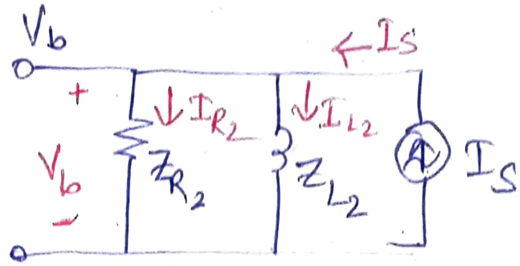
$$V_a = \frac{V_s Z_{L_1}}{Z_{R_1} + Z_{L_1}} = \frac{(1.04 - j4.89)(j2)}{(1 + j2)}\,V$$

$$\Rightarrow V_a = \frac{9.78 + j2.08}{1 + j2}\,V = 2.79 - j3.49\,V$$

$$\Rightarrow \boxed{V_a = 2.79 - j3.49\,V = 4.47\angle -51.2^\circ V} \quad \text{(3)}$$

* Let's find V_b:

→ By using current division rule,



$$I_{R_2} = \frac{I_S Z_{L_2}}{Z_{R_2} + Z_{L_2}}$$

$$\Rightarrow I_{R_2} = \frac{(1.41 - j1.41)j3}{2 + j3}$$

$$\Rightarrow \boxed{I_{R_2} = 1.63 - j0.33 \text{ A}} \quad (4)$$

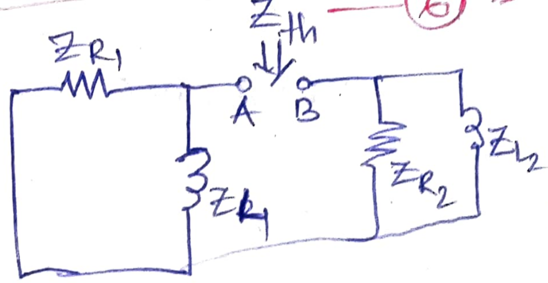
$$\therefore V_b = I_{R_2} R_2 = (1.63 - j0.33) \times 2$$

$$\Rightarrow \boxed{V_b = 3.26 - j0.66 \text{ V}} \quad (5)$$

(b) Using (3) & (5),

$$V_{th} = V_a - V_b = (2.79 - j3.49) - (3.26 - j0.66)$$

$$\Rightarrow \boxed{V_{th} = (-0.47 - j2.83) V = 2.87\angle -99.43^\circ} \quad (6) \text{ Ans}$$

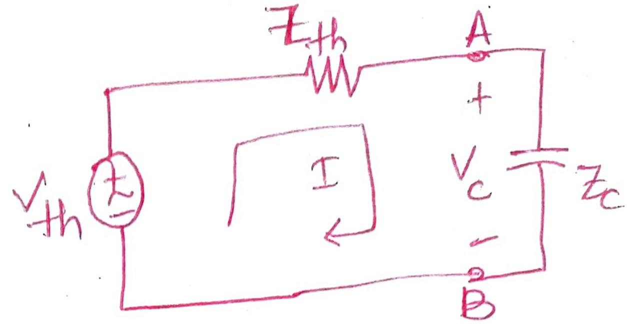


$$Z_{th} = \left(\frac{Z_{R_1} Z_{L_1}}{Z_1 + Z_{L_1}}\right) + \left(\frac{Z_{R_2} Z_{L_2}}{Z_{R_2} + Z_{L_2}}\right)$$

$$\Rightarrow Z_{th} = \left(\frac{1 \times j2}{1 + j2}\right) + \left(\frac{2 \times j3}{2 + j3}\right)$$

$$\Rightarrow \boxed{Z_{th} = (2.19 + j1.32)\,\Omega = 2.56\angle 31.08^\circ} \quad (7)$$

Apply KVL,



$$-V_{th} + IZ_{th} + IZ_c = 0$$

$$\Rightarrow I = \frac{V_{th}}{Z_{th} + Z_c}$$

$C = 15\,mF$

$\therefore Z_c = -j3.33\,\Omega$

$$\Rightarrow I = \frac{(-0.47 - j2.83)}{2.19 + j1.32 + (-j3.33)}$$

$$\Rightarrow I = \frac{-0.47 - j2.83}{2.19 - j2.01}\ A$$

$$\Rightarrow \boxed{I = (0.53 - j0.81)\ A = 0.97\angle -56.8^\circ\ A}$$ —(8)

$$\therefore V_c = IZ_c = (0.53 - j0.81)(-j3.33)$$

$$\Rightarrow \boxed{V_c = (-2.69 - j1.76)\ V = 3.21\angle -146.8^\circ\ V}$$ —(9)

(b)

$$\therefore \boxed{v_c(t) = 3.21 \sin(20t - 146.8^\circ)\ V}$$ —(10)

(c) The current flowing out of the positive reference terminal of the source voltage is

$$I_x = \frac{V_s - V_a}{Z_{R_1}} = \frac{(1.04 - j4.89) - (2.79 - j3.49)}{1}$$

$$\Rightarrow \boxed{I_x = (-1.75 - j1.4)\ A}$$ Ans