Tutorial 2

[redacted]

Q Calculate the average power delivered by current $4 - j2$ A

$$Z = \frac{1.5 \angle -19^\circ}{2+j} \; k\Omega$$

Solⁿ

$$Z = \frac{1.5 \angle -19^\circ}{2+j}$$ → convert to polar form

$$Z = \frac{1.5 \angle -19^\circ}{2.24 \angle 26.57^\circ} = 0.66 \angle -45.57^\circ \, k\Omega$$

$$V = Z \cdot I$$

$$= 669.66 \angle -45.57^\circ \cdot (4 - j2)$$

$$= (669.66 \angle -45.57^\circ) \cdot (4.47 \angle -26.57)$$

$$V = 2993.3 \angle -72.14^\circ \; V$$

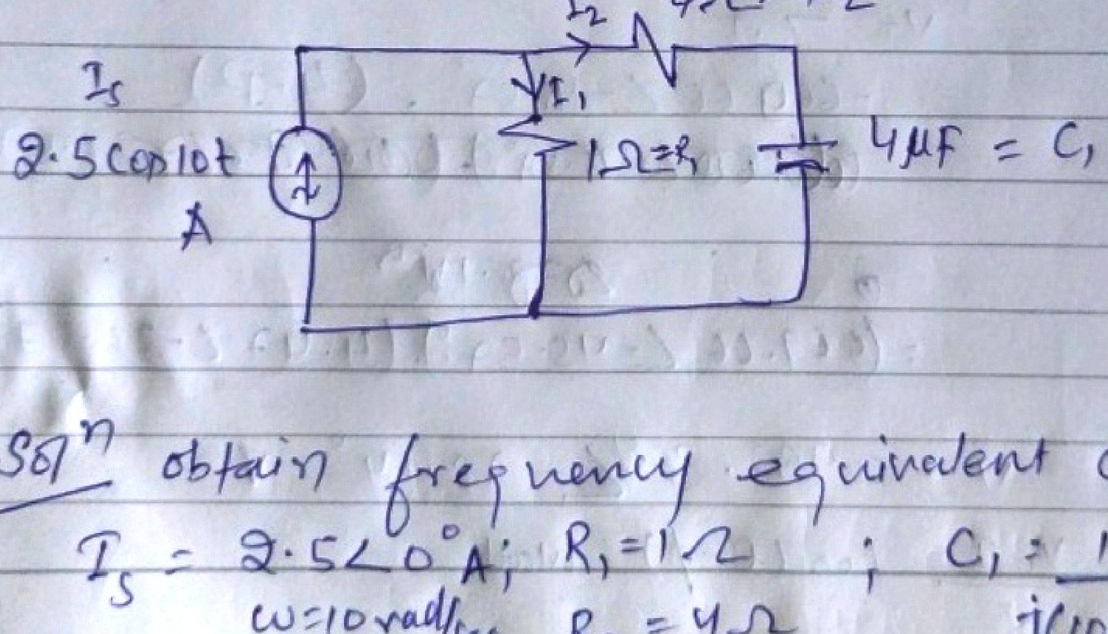
$$\langle P_{avg} \rangle = \frac{V_0 I_0}{2} \cos(\theta - \phi) \text{ Watts}$$

$$= \frac{2993.3 \times 4.47}{2} \cos(-72.14 - (-26.57))$$

$$= 6690 \cos(-45.57^\circ)$$

$$= 4.68\ kW$$

Q Assuming no transients are present, calculate the power absorbed by each element at $t = 0, 10,$ and $20\ ms$



Sol^n obtain frequency equivalent circuit

$I_s = 2.5\angle 0^\circ A$; $R_1 = 1\Omega$; $C_1 = \frac{1}{j(10)(4\times10^{-6})} = -j25\ k\Omega$

$\omega = 10\ rad/sec$ $R_2 = 4\Omega$

$$I_1 = \frac{R_2 + \frac{1}{j\omega C_1}}{R_1 + R_2 + \frac{1}{jC\omega}} \cdot I_S$$

$$= \frac{4 + \frac{1}{j \times 10 \times 4 \times 10^{-6}}}{1 + 4 + \frac{1}{j \times 10 \times 4 \times 10^{-6}}} \cdot 2.5\angle 0^\circ$$

$$= \frac{25.02 \angle -90^\circ}{25.02 \angle -89.98^\circ} \cdot (2.5\angle 0^\circ)$$

$$I_1 \approx 2.5\angle 0^\circ \text{ A}$$

$$I_{4\Omega} \simeq 0 \text{ A}$$

$$P_{R_1}(t) = i_1^2(t) \cdot R_1 \; W = (2.5\cos 10(t))^2 \cdot 1$$

$$= 6.25\cos^2 10(t)$$

$$= 6.25\left(\frac{1 + \cos 20(t)}{2}\right)$$

$$= 3.125(1 + \cos 20(t))$$

at $t = 0 \Rightarrow 6.25$ W

at $t \Rightarrow 10 \Rightarrow 3.125\left(1 + \cos\left(20 \times 10 \times 10^{-3} \times \frac{180^\circ}{\pi}\right)\right) = 6.19$ W

$t = 20ms = 6W$

$P_{R_2}(t) \simeq 0$ for all t

$P_{C_1}(t) \simeq 0$ for all t

Across Current Source :-

at $t = 0$

$P_s(t) \Rightarrow -\underbrace{(2.5 \angle 0^\circ)}_{i_s(t)} \times \underbrace{2.5 \angle 0^\circ}_{V_s(t) = i_1(t) \cdot R_1}$

$\Rightarrow -6.25 W$

Negative sign : Because the source delivers the power and thus :-

Power consumed = − power delivered.

at $t = 10msec$

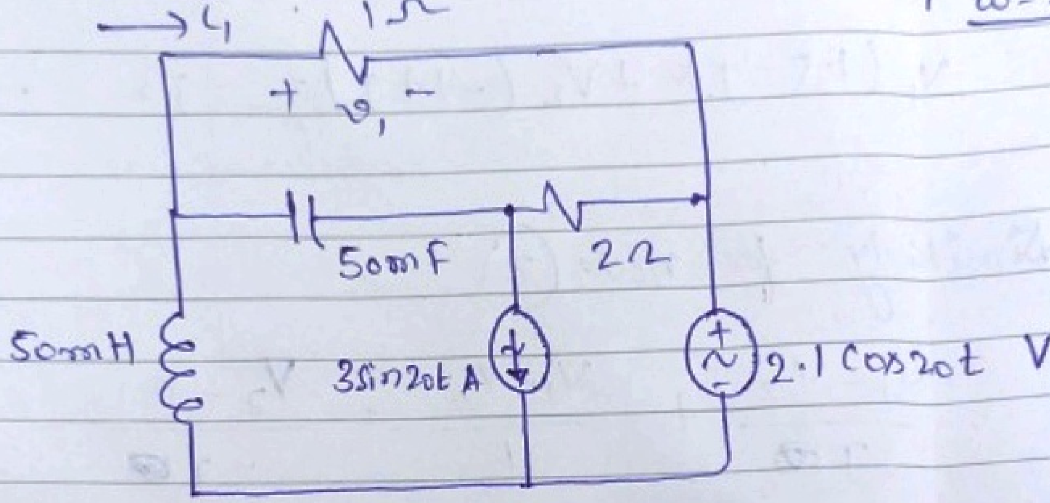
$P_s(10ms) = -6.19W$

at $t = 20ms$

$P_s(20ms) = -6W$

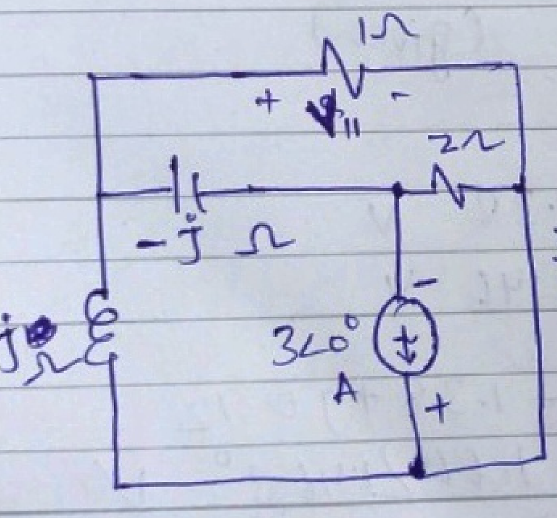
Q Determine the individual contribution of each source to the voltage $v_1(t)$

Repeat $\omega = 30$ rad/sec



Sol^n: Let consider current source only and draw equivalent frequency domain

$\omega = 20$ rad/sec



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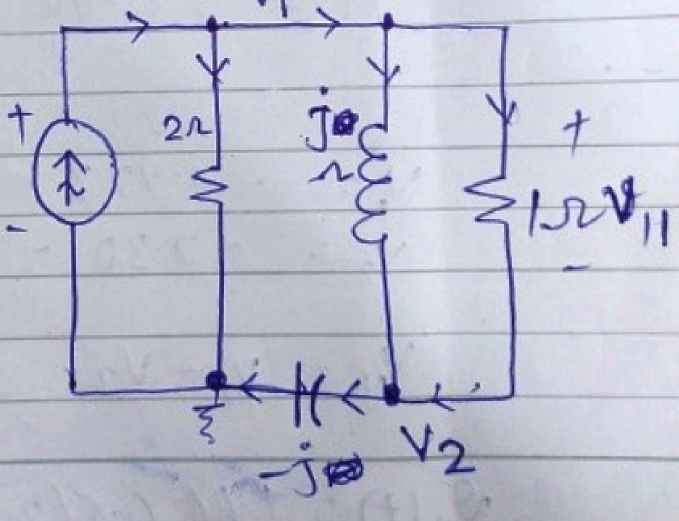


at Node 1

$$I_s = \frac{V_1}{2} + \frac{V_1 - V_2}{j} + \frac{V_1 - V_2}{1}$$

$$V_1(1.5 - j) + V_2(-1 + j) = -j3 \quad — (1)$$

Similarly for node 2

$$\frac{V_1 - V_2}{j} + \frac{V_1 - V_2}{1} = \frac{V_2 - 0}{-j}$$

$$V_1(-j + 1) + V_2(+j - 1 - j) = 0$$

$$V_1(1 - j) - V_2 = 0 \quad — (2)$$

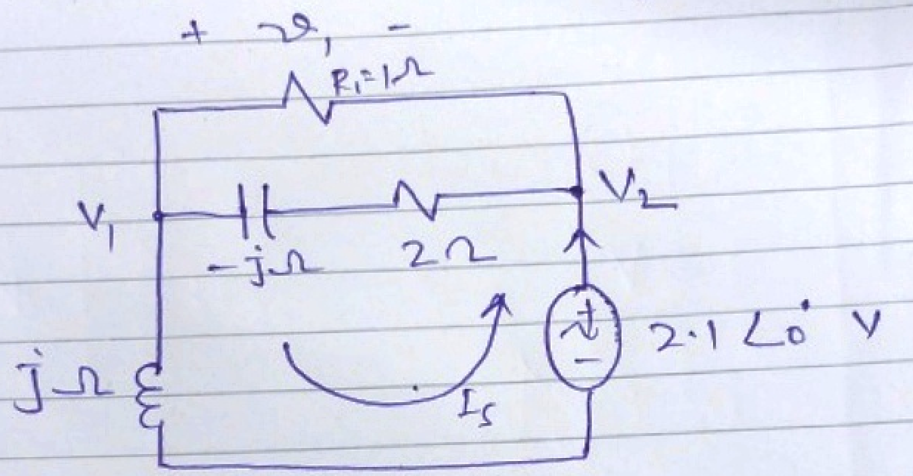
$I_s = 3\angle -90^\circ$ A (given)

$V_1 = -0.923 - j1.38$ V
$V_2 = -2.30 - j0.46$ V

$$V_{11} = V_1 - V_2 = -1.38 + j0.92$$
$$= 1.66\angle 146.3^\circ \text{ V}$$

$$v_{11}(t) = 1.66\cos(20t + 146.3^\circ) \text{ V}$$

Now let us consider voltage Source only :-



$$I_s = \frac{V_s}{Z} = \frac{2.1}{\frac{2-j}{3-j}+j} = 1.13 - j\,1.45 \text{ A}$$

$$= 1.84\angle -52.07 \text{ A}$$

$$V_1 = I_s \cdot j \Rightarrow (1.84\angle -52.07)\cdot(1\angle 90°)$$

$$V_1 = 1.84\angle 37.93 \text{ Volt}$$

$$v_1 = V_1 - V_2$$

$$= 1.84\angle 37.93 - 2.1\angle 0°$$

$$= 1.3\angle 119.8° \text{ V}$$