Question 1: Answer all the questions. **(10 Marks)**

For the above circuit shown in **Figure 1**, determine I_o using Superposition and the power dissipated in 15Ω resistance.

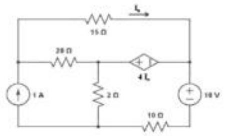
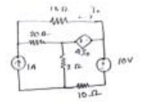


Figure 1.



let,

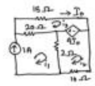
$$I_o = I_{o1} + I_{o2}$$

where,

$I_{o1} \rightarrow 1\,A$

$I_{o2} \rightarrow 10\,V$

for I_{o1},



for mesh-1,

$$i_1 = 1A$$

for mesh-2,

$$2(i_2 - i_1) + 4I_o + 10 i_2 = 0$$

$$\Rightarrow -2i_1 + 12 i_2 + 4 i_3 = 0 \;;[\because i_3 = I_o]$$

$$\Rightarrow -2 \times 1 + 12 i_2 + 4 i_3 = 0$$

$$\Rightarrow 12 i_2 + 4 i_3 = 2 \quad \ldots (1)$$

for mesh-3,

$$15 i_3 - 4I_o + 20(i_3 - i_1) = 0$$

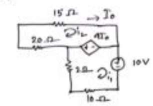
$$\Rightarrow 15 i_3 - 4 i_3 + 20 i_3 - 20 i_1 = 0$$

$$\Rightarrow 31 i_3 - 20 \times 1 = 0$$

$$\Rightarrow i_3 = \frac{20}{31} = 0.6452\,A$$

$$\therefore I_{o1} = i_3 = 0.6452\,A$$

for I_{o2},



for mesh-1,

$$10 i_1 + 2 i_1 + 4I_o + 10 = 0$$

$$\Rightarrow 12 i_1 + 4 i_2 = -10 \;;[\because I_o = i_2] \quad \ldots (1)$$

for mesh-2,

$$15 i_2 - 4I_o + 20 i_2 = 0$$

$$\Rightarrow 35 i_2 - 4 i_2 = 0$$

$$\Rightarrow 31 i_2 = 0$$

$$\therefore i_2 = 0$$

$$\therefore I_{o2} = i_2 = 0\,A$$

$$\therefore I_o = I_{o1} + I_{o2} = 0.6452 + 0 = 0.6452\,A$$

power dissipated; $P = I_o^2 R$

$= (0.6452)^2 \times 15$

$= \boxed{\quad}$ Ans: calculation my own.

Question 2: Answer all the questions. **(10 Marks)**

For the circuit shown in **Figure 2**, determine the following questions: [5+ +2]

i) For the circuit shown below, find the thevenin equivalent circuit at the **A-B** terminal.

ii) For any resistance connected right to **A-B** terminal, what will be the maximum power delivered to the resistance?

iii) If 10Ω resistance is connected between **A-B**, then would maximum power be achieved? If not then what should you do?

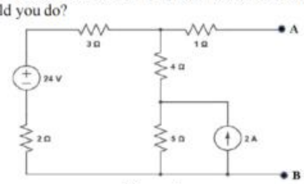
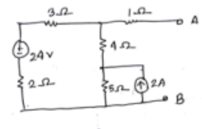
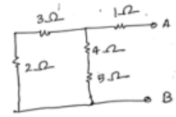


Figure 2.

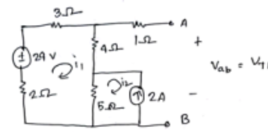


For R_{TH},



$$R_{TH} = 1 + \left((3+2) \parallel (4+5)\right)$$
$$= 4.214\ \Omega$$

For V_{TH},



From mesh-2,

$$i_2 = -2A$$

For mesh-1,

$$3i_1 + 4i_1 + 5(i_1 - i_2) + 2i_1 - 24 = 0$$
$$\Rightarrow 14i_1 - 5i_2 - 24 = 0$$
$$\Rightarrow 14i_1 = 24 + 5 \times (-2)$$
$$\therefore i_1 = 1A$$

$$V_{TH} = 4i_1 + 5(i_1 - i_2)$$
$$= 4 \times 1 + 5(1 - (-2))$$
$$= 19V$$

ii) Max power

$$P_{max} = \frac{V_{TH}^2}{4R_{TH}} = \frac{19^2}{4 \times 4.214}$$
$$= 21.417\ W$$

iii) P_{max} will not occur if $R_L = 10\ \Omega$.

As we know for P_{max},

$$R_L = R_{TH} = 4.214\ \Omega$$

Question 3: Answer all the questions (10 Marks)

For the circuit shown in **Figure 3**, $V_s(t) = 15\cos(100t + 30°)$. Now, determine the following questions: [6+4]

(a) Find equivalent impedance at terminals a – b.

(b) Find $I_1(t)$, $V_c(t)$, $V_d(t)$ and $V_{cd}(t)$.

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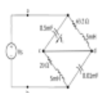


Figure 3.

let,

Z_1 = Impedance of the 0.5mF capacitor

Z_2 = Impedance of the 5mH inductor in series with the 63.2 Ω resistance

Z_3 = Impedance of the 5mH inductor in series with the 20 Ω resistance

Z_4 = Impedance of the 0.01 mF capacitor

Here, $V_s(t) = 15\cos(100t + 30°)$ So, $\omega = 100$

$$Z_1 = \frac{1}{j\omega C} = \frac{1}{j \times 100 \times 0.5 \times 10^{-3}}$$

$$= -20j$$

$$Z_2 = 63.2 + j\omega L = 63.2 + j \times 100 \times 5 \times 10^{-3}$$

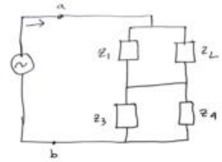
$$= 63.2 + 0.5j$$

$$Z_3 = 20 + j\omega L = 20 + j \times 100 \times 5 \times 10^{-3}$$

$$= 20 + 0.5j$$

$$Z_4 = \frac{1}{j\omega C} = \frac{1}{j \times 100 \times 0.01 \times 10^{-3}} = -1000j$$

So,



(a) $$Z_{ab} = (Z_1 \parallel Z_2) + (Z_3 \parallel Z_4)$$

$$= 25.196 - 21.617j$$

$$= 33.199\angle -40.629°$$

(b) $$I = \frac{V}{Z_{ab}} = \frac{15\angle 30°}{33.199\angle -40.629}$$

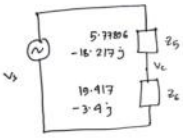
$$= 0.9518\angle 70.629°$$

$$I_1 = \frac{Z_2}{Z_1 + Z_2} \times I$$

$$= 0.4318\angle 88.229°$$

$$\therefore I_1(t) = 0.4318\cos(100t + 88.229°)$$

$V_{cd}(t) = 0$ because $V_c(t) = V_d(t)$



$Z_5 = Z_1 \parallel Z_2$

$Z_6 = Z_3 \parallel Z_4$

$$V_c = \frac{Z_6}{Z_5 + Z_6} \times V_s$$

$$= 15.472\angle 92.466°$$

$$\therefore V_c(t) = V_d(t) = 15.472\cos(100t + 92.466°)$$

Question 4: Answer all the questions. **(10 Marks)**

For the waveform shown in **Figure 4a**, determine the rms value of the current, i_{rms}. Also, [: determine the power absorbed by 5Ω resistance for the circuit shown in **Figure 4b**.

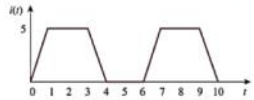


Figure 4a.

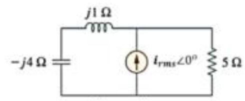


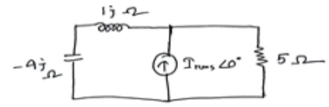
Figure 4b.

$$I_{rms}^2 = \frac{1}{T}\int_0^T i^2(t)dt = \frac{1}{6}\left[\int_0^1 25t^2dt + \int_1^3 25dt + \int_3^4 (-5t+20)^2 dt\right]$$

$$I_{rms}^2 = \frac{1}{6}\left[25\frac{t^3}{3}\Big|_0^1 + 25(3-1) + (25\frac{t^3}{3} - 100t^2 + 400t)\Big|_3^4\right] = 11.1056$$

$$I_{rms} = 3.332 \text{ A}$$

$I_{rms} = 3.332 A$



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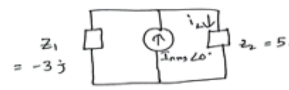

As, 1j inductor and −4j capacitor are in series

So, $Z_1 = 1j - 4j$
$= -3j$

$$i_2 = \frac{Z_1}{Z_1 + Z_2} \times I$$

$$= \frac{-3j}{-3j + 5} \times 3.332\angle 0^{\circ}$$

$$\therefore i_2 = 1.7143\angle -59.036^{\circ}$$

$$P_{5\Omega} = \frac{1}{2} I_m^2 R = \frac{1}{2}\times(1.7143)^2 \times 5$$
$$= 7.347 \text{ watt}$$