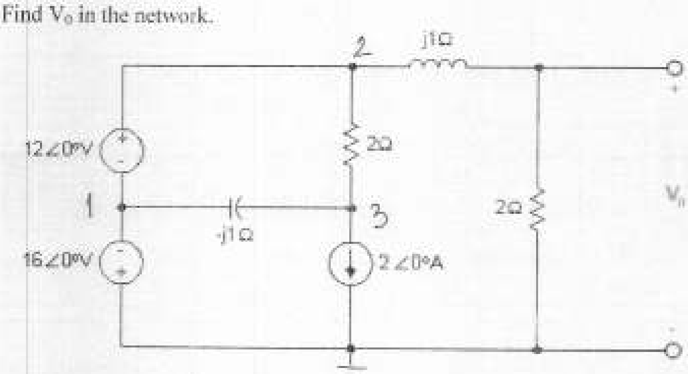
Find V_0 in the network.



Let's use nodal analysis :

$V_1 = -16\angle 0° = -16 \text{ V}$

$V_2 = 12\angle 0° - 16\angle 0° = -4 \text{ V}$

$$2\angle 0° + \frac{V_3 - V_1}{-j1} + \frac{V_3 - V_2}{2} = 0$$

$$2 + j(V_3 + 16) + \frac{1}{2}(V_3 + 4) = 0$$

$$4 + j2V_3 + j32 + V_3 + 4 = 0$$

$$V_3(1 + j2) + (8 + j32) = 0$$

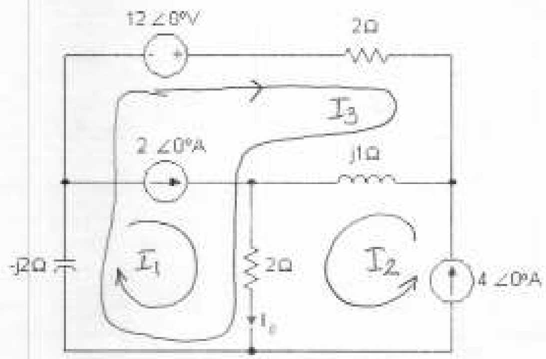
$$V_3 = -\frac{8 + j32}{1 + j2}$$

$V_2 = -4 \qquad V_0 = \frac{2}{2+j1} V_2$

$$V_0 = -\frac{8}{2+j1}\,\frac{2-j1}{2-j1} = -8\,\frac{2-j1}{5}$$

$$V_0 = -\frac{8}{5}(2 - j1)$$

Find I_0 in the network using loop analysis.



$I_1 = 2\angle 0^\circ = 2$

$I_2 = 4\angle 0^\circ = 4$

$-12 + 2(I_3) + j1(I_3 + I_2) + 2(I_1 + I_3 + I_2) - j2(I_1 + I_3) = 0$

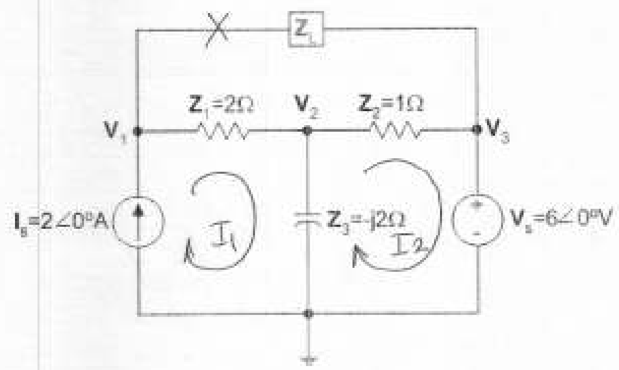
$-12 + (2 + j1 + 2 - j2)I_3 + (j1 + 2)I_2 + (2 - j2)I_1 = 0$

$-12 + (4 - j1)I_3 + (j1 + 2)4 + (2 - j2)2 = 0$

$-\cancel{12} + \cancel{j4} + \cancel{8} + \cancel{4} - \cancel{j4} + (4 - j1)I_3 = 0 \qquad I_3 = 0$

$I_0 = I_1 + I_2 + I_3 = 2 + 4 + 0 = 6\ A$

Determine the impedance Z_L for maximum power transfer and the maximum power transferred. Use thevenin's theorem when solving this problem.



The best way to solve this problem is to use Thévenin's theorem.

$I_1 = 2\angle 0° = 2$

$-j2(I_2 - I_1) + I_2 + 6\angle 0° = 0$

$-j2 I_2 + j2 \times 2 + I_2 + 6 = 0$

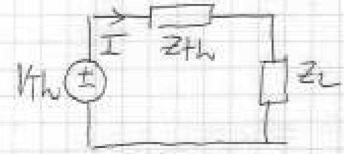
$(1-j2) I_2 + (6+j4) = 0 \Rightarrow I_2 = -\dfrac{6+j4}{1-j2}$

$V_{Th} = 2I_1 + 1\, I_2 = 4 - \dfrac{6+j4}{1-j2} = \dfrac{4(1-j2)-6-j4}{1-j2}$

$V_{Th} = \dfrac{4-j8-6-j4}{1-j2} = \dfrac{-2-j12}{1-j2} = -\dfrac{2(1+j6)}{1-j2}$

$Z_{th} = 2 + \dfrac{1(-j2)}{1-j2} = \dfrac{2-j4-j2}{1-j2} = \dfrac{2-j6}{1-j2}$

$$Z_L = Z_{th}^* = \frac{2+j6}{1+j2}$$



$$I = \frac{V_{th}}{Z_{th} + Z_L}$$

$$V_L = \frac{Z_L}{Z_L + Z_{Th}} V_{Th}$$

$$P = VI^* = \frac{Z_L V_{Th}}{(Z_L + Z_{Th})} \cdot \frac{V_{Th}^*}{(Z_L + Z_{Th})^*} = \frac{Z_L |V_{Th}|^2}{|Z_L + Z_{Th}|^2}$$

$$Z_L + Z_{Th} = \frac{2+j6}{1+j2} + \frac{2-j6}{1-j2} = \frac{(2+j6)(1-j2) + (2-j6)(1+j2)}{1+4}$$

$$= \frac{2 + \cancel{j6} - \cancel{j4} + 12 + 2 - \cancel{j6} + \cancel{j4} + 12}{5} = \frac{28}{5}$$

$$|V_{Th}|^2 = \frac{4(1+36)}{1+4} = \frac{4 \times 37}{5}$$

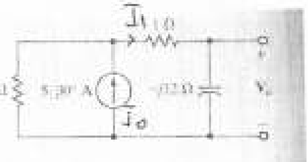
$$Z_L = \frac{2+j6}{1+j2} \frac{1-j2}{1-j2} = \frac{2+j6-j4+12}{1+4} = \frac{14+j2}{5}$$

$$P = \frac{14+j2}{\cancel{5}} \frac{148}{\cancel{5}} \left(\frac{\cancel{5}}{28}\right)^2 = \frac{148}{(28)^2}(14+j2)$$

Power absorbed is the real power only, Namely.

$$P_R = \frac{1}{2} \frac{148 \times \cancel{14}}{\underset{2}{\cancel{28}} \times 28} = \frac{1}{2} \frac{74}{28} = \frac{37}{28} \text{ W}$$

Find the frequency-domain voltage V_0, as shown in the figure below.



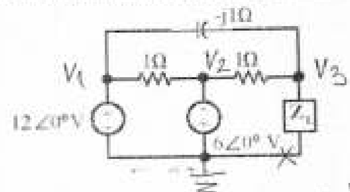
$$I_1 = \frac{15}{15+1-j12}\, 5\angle 30^\circ = \frac{15}{16-j12}\, 5\angle 30^\circ = \frac{15}{4}\,\frac{5\angle 30^\circ}{4-j3}$$

$$V_0 = -j12\, I_1 = -j\cancel{12}^{\,3}\,\frac{15}{\cancel{4}}\,\frac{5\angle 30^\circ}{4-j3} = -j\,\frac{225}{4-j3}\angle 30^\circ$$

$$V_0 = \frac{225\angle 30^\circ - 90^\circ}{\sqrt{16+9}\,\angle -\tan^{-1}\left(\frac{3}{4}\right)} = \frac{225}{5}\angle -60 + \tan^{-1}\left(\frac{3}{4}\right)$$

$$V_0 = 45\angle \tan^{-1}\left(\frac{3}{4}\right) - 60^\circ$$

Given the circuit in Fig. 9.2, determine the impedance Z_L for maximum average power transfer and the value of the maximum average power transferred to this load.



Again, we have to use thevenin's theorem.

$V_1 = 12\angle 0° = 12V$

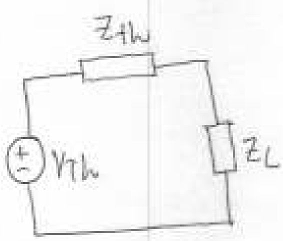
$V_2 = -6\angle 0° = -6V$

$$\frac{V_3 - V_1}{-j1} + \frac{V_3 - V_2}{1} = 0 \qquad \frac{V_3 - 12}{-j1} + (V_3 + 6) = 0$$

$$V_3 - 12 = j(V_3 + 6)$$

$$V_3(1-j) = 12 + j6 \qquad V_3 = \frac{12 + j6}{1 - j1} = V_{Th}$$

$$Z_{Th} = 1 \| (j1) = \frac{1 \cdot (-j1)}{1 - j1} = -j\frac{1}{1-j1}$$



$$Z_L = Z_{th}^* = j\frac{1}{1+j1}$$

$$I = \frac{V_{Th}}{Z_L + Z_{Th}} = \frac{\frac{12+j6}{1-j1}}{\frac{j}{1+j1} - \frac{j}{1-j1}} =$$

$$= \frac{(12+j6)(1+j)}{j(1-j1) - j} = \frac{(12+j6)(1+j)}{j + 1 - j}$$

$$|I_0|^2 = \frac{|V|^2 (1 + 144\omega^2 C^2)}{(24 - 12\omega^2 LC)^2 + (\omega L + 288\omega C)^2}$$

$$I_1^2 = \frac{|V|^2}{(24 - 12\omega^2 LC)^2 + (\omega L + 288\omega C)^2}$$

1. when $V = 60$

$$P_1 = \left(\cancel{24} \cdot \frac{60^2}{24^{\cancel{2}}} + \frac{\cancel{1}}{2}\, 12 \cdot \frac{60^2}{24^{2}}\right)$$

$$P_1 = \frac{60^2}{24}\left(1 + \frac{1}{2}\right)$$

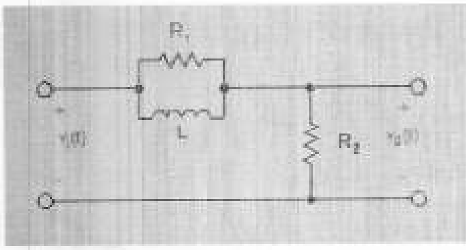
2. when $V = 36\angle 45^\circ$

$$P_2 = \frac{24 \cdot 36^2 (1 + 144\omega_0^2 C^2)}{(24 - 12\omega_0^2 LC)^2 + (\omega_0 L + 288\omega_0 C)^2}\,\frac{1}{2} +$$

$$+ \frac{1}{2}\, 12\, \frac{36^2}{(24 - 12\omega_0^2 LC)^2 + (\omega_0 L + 288\omega_0 C)^2}$$

3. when $V = 24\angle 60^\circ$ and $\omega = 2\omega_0$ we get similar to the above expression under 2 except that the voltage is 24 and the frepuency is $2\omega_0$.

Determine the type of the filter network shown in the figure below, by determining the voltage transfer function.



$$\frac{V_o(s)}{V_i(s)} = \frac{R_2}{R_2 + \frac{sL \cdot R_1}{R_1 + sL}} = \frac{(R_1 + sL)R_2}{R_1 R_2 + sL(R_1 + R_2)}$$

$$H_o(s) = \frac{R_2(R_1 + sL)}{R_1 R_2 + sL(R_1 + R_2)}$$

$$|H_o(j\omega)|^2 = \frac{|R_2(R_1 + j\omega L)|^2}{(R_1 R_2)^2 + \omega^2 L^2 (R_1 + R_2)^2} = \frac{R_2^2(R_1^2 + (\omega L)^2)}{(R_1 R_2)^2 + (\omega L)^2 (R_1 + R_2)^2}$$

1. $\omega \to 0$ $\quad |H_o(0)|^2 = \frac{R_1^2 R_2^2}{(R_1 R_2)^2} = 1$

2. $\omega \to \infty$ $\quad |H_o(\infty)|^2 = \frac{R_2^2 \cancel{L^2}}{\cancel{L^2}(R_1 + R_2)^2} = \frac{R_2^2}{(R_1 + R_2)^2} < 1$

when $R_2 \to 0$ $\quad |H_o(\infty)|^2 = 0$ [redacted] pass filter

when $R_2 \to \infty$ $\quad |H_o(\infty)|^2 = 1$ all pass filter

Find the average power absorbed by the network if:
$v(t) = 60 + 36\cos(377t + 45°) + 24\cos(754t + 60°)$.

$$v(t) = 60 + 36\angle 45° + 24\angle 60°$$

$$I_0 = \frac{V}{24 + j\omega L + \dfrac{12 \cdot \frac{1}{j\omega C}}{12 + \frac{1}{j\omega C}}} = \frac{V(1 + j12\omega C)}{(24 + j\omega L)(1 + j12\omega C) + 12}$$

$$I_0 = \frac{V(1 + j12\omega C)}{24 + j\omega L + j12 \times 24\,\omega C - 12\omega^2 LC}$$

$$\begin{array}{r} 48 \\ 24 \\ \hline 288 \end{array}$$

$$I_0 = \frac{V(1 + j12\omega C)}{24 - 12\omega^2 LC + j(\omega L + 288\omega C)}$$

$$I_1 = I_0 \frac{\frac{1}{j\omega C}}{12 + \frac{1}{j\omega C}} = \frac{I_0}{1 + j12\omega C}$$

$$I_1 = \frac{1}{\cancel{1 + j12\omega C}} \cdot \frac{V(\cancel{1 + j12\omega C})}{(24 - 12\omega^2 LC) + j(\omega L + 288\omega C)}$$

$$I_1 = \frac{V}{(24 - 12\omega^2 LC) + j(\omega L + 288\omega C)}$$

$$I = 12 + j6 + j12 - 6 = 6 + j18$$

$$P_L = Z_L I I^* = Z_L |I|^2 = \frac{j}{1+j}(36 + 18^2)$$

$$P_L = \frac{j(1-j)}{1+1}(36+18^2)\frac{1}{2} = \frac{j+1}{2}(36+18^2)$$

$$P_{Dissipated} = \frac{1}{2}\frac{1}{2}(36+18^2) = \frac{1}{2}(18 + 9 \times 18) = 18\left(\frac{10}{2}\right) = \frac{180}{2} W$$

$$P_{Dissipated} = 90 W$$