Ministry of Higher Education & Scientific Research
University of Technology
Laser & Optoelectronic Eng. Department
Branch: Laser and Optoelectronic Engineering
Class: 2nd Year:
Subject: ***Electrical A.C Circuit***

f inal examination
Time: 3 hours
Date: 25/5/2016
Examiner: Lecturer Inmar Natiq
Code LOPE: 2203
Academic Year 2015-2016

Attempt five questions only

Q1) a: Find the rms values and ω and $\boldsymbol{\theta}$ of the following sinusoidal waveforms:

1. $\mathbf{v} = 140\sin(377t + 60°)$ **2.** $i = 6 \times 10^{-3}\sin(2\pi\, 1000t)$

b: Determine the frequency at which a 1 μF capacitor and a 10 mH inductor will have the same reactance.

10 marks

Q2) For the network in Fig. (1):

a. Find the total impedance $\mathbf{Z}_T$ and the total admittance $\mathbf{Y}_T$.
b. Find the current $\mathbf{I}s$.
c. Calculate $\mathbf{I}_2$ using the current divider rule.
d. Calculate $\mathbf{V}_C$.
e. Calculate the average power delivered to the network

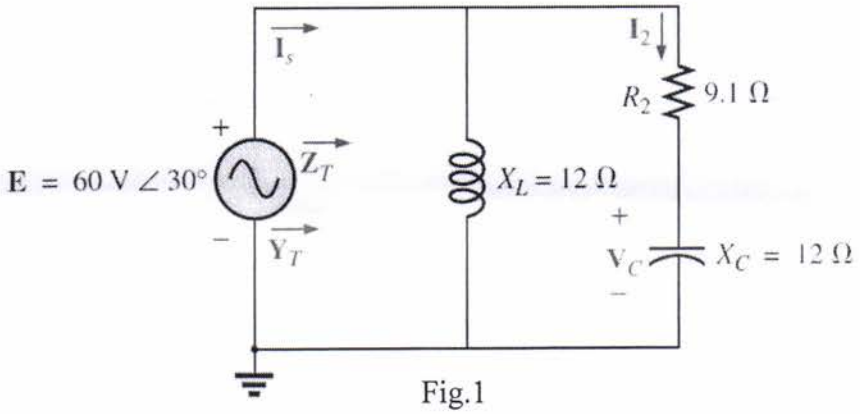


Fig.1

10 marks

Q3) Using the Δ-Y or Y-Δ conversion, determine the current (**I**) for the network in Fig. (2).

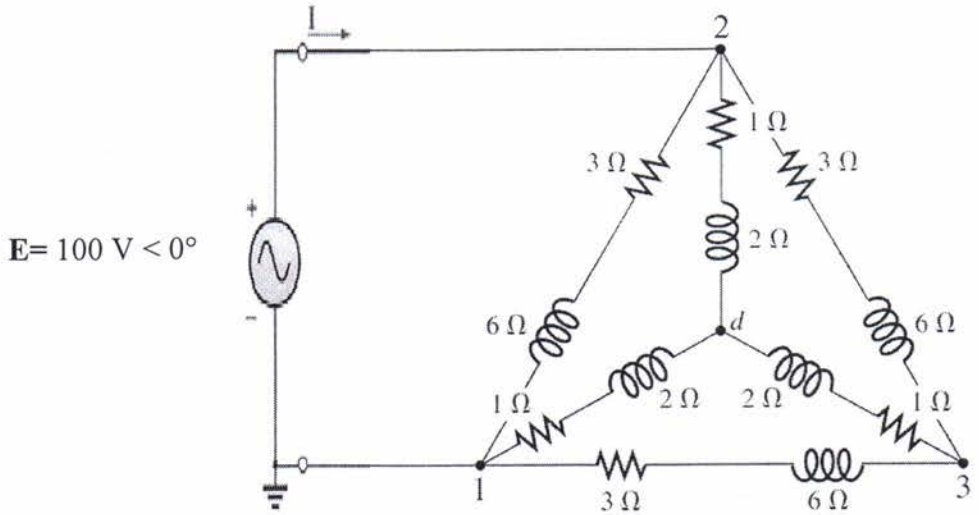


Fig.2

10 marks

Q4) Find the Thévenin equivalent circuit for the network external to branch *a-á* in Fig.(3)

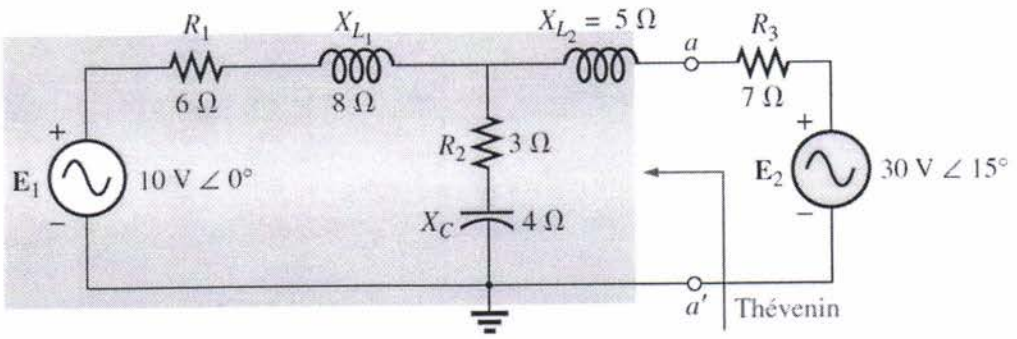


Fig.3

10 marks

Q5) Given R =20 kΩ and C= 1200 pF

a. Sketch the normalized plot if the filter is used as a high-pass filter.

b. Sketch the phase plot for high-pass filter.

c. Determine the magnitude and phase of **Av** =**Vo** /**Vi** at (f=1/2 fc) for the high-pass filter.

10 marks

Q6) **choose(a)or (b)**

a) The bandwidth of a series resonant circuit is 400 Hz.

1) If the resonant frequency is 4000 Hz, what is the value of *Qs*?

2)If R = 10 Ω, what is the value of *XL* at resonance?

3)Find the inductance L and capacitance C of the circuit.

b) For the network in Fig. (4) with *fp* provided:

1. Determine *Ql* .
2. Determine *Rp*
3. Calculate Z_{Tp}
4. Find C at resonance.
5. Find *Qp* .

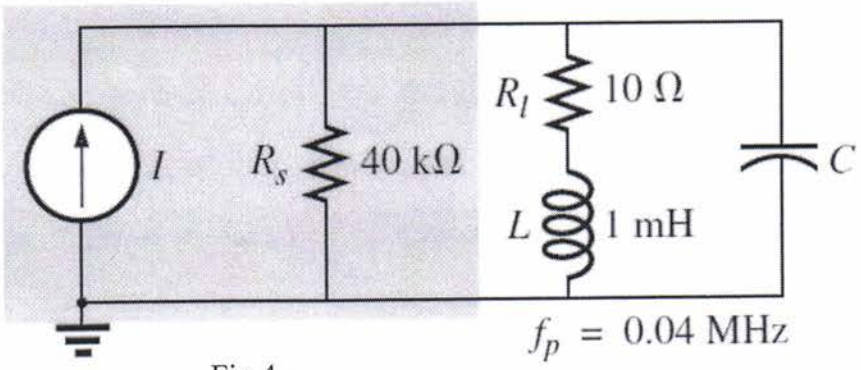


Fig.4

10 marks

Solutions of A.C 2016

Q1)a) $V_{rms} = 0.7071(140\text{ V}) = \mathbf{98.99\text{ V}}$, $\omega = 377$, $\theta = 60^\circ$

$I_{rms} = 0.7071(6\text{ mA}) = \mathbf{4.24\text{ mA}}$, $\omega = 2\pi \times 1000 = 2000\pi$, $\theta = 0^\circ$

b)

$$X_C = X_L$$

$$\frac{1}{2\pi fC} = 2\pi fL$$

$$f^2 = \frac{1}{4\pi^2 LC}$$

$$\text{and } f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(10\times10^{-3}\text{ H})(1\times10^{-6}\text{ F})}} = \mathbf{1.59\text{ kHz}}$$

Q2)

a. $\mathbf{Z}_T = 12\ \Omega\ \angle 90^\circ \parallel (9.1\ \Omega - j12\ \Omega) = 12\ \Omega\ \angle 90^\circ \parallel 15.06\ \Omega\ \angle -52.826^\circ$

$$= \frac{180.72\ \Omega \angle 37.17^\circ}{9.10 \angle 0^\circ}$$

$$= \mathbf{19.86\ \Omega\ \angle 37.17^\circ}$$

$$\mathbf{Y}_T = \frac{1}{\mathbf{Z}_T} = \frac{1}{19.86\ \Omega\ \angle 37.17^\circ} = \mathbf{50.35\text{ mS}\ \angle -37.17^\circ}$$

b. $$\mathbf{I}_s = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{60\text{ V}\ \angle 30^\circ}{19.86\ \Omega\ \angle 37.17^\circ} = \mathbf{3.02\text{ A}\ \angle -7.17^\circ}$$

c. (CDR) $$\mathbf{I}_2 = \frac{(12\ \Omega \angle 90^\circ)(3.02\text{ A} \angle -7.17^\circ)}{j12\ \Omega + 9.1\ \Omega - j12\ \Omega} = \frac{36.24\text{ A} \angle 82.83^\circ}{9.1 \angle 0^\circ}$$

$$= \mathbf{3.98\text{ A}\ \angle 82.83^\circ}$$

d. (VDR) $$\mathbf{V}_C = \frac{(12\ \Omega \angle -90^\circ)(60\text{ V} \angle 30^\circ)}{9.1\ \Omega - j12\ \Omega} = \frac{720\text{ V} \angle -60^\circ}{15.06 \angle -52.826^\circ}$$

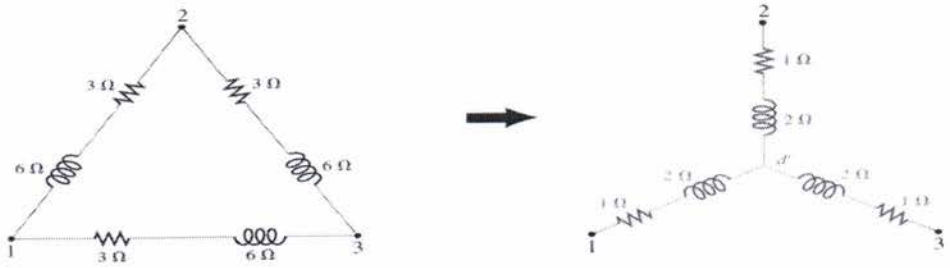
$$= \mathbf{47.81\text{ V}\ \angle -7.17^\circ}$$

e. $$P = EI\cos\theta = (60\text{ V})(3.02\text{ A})\cos(30^\circ - 7.17^\circ)$$

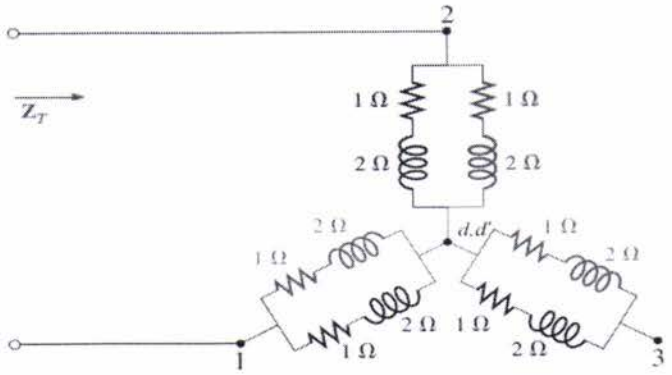
$$= 181.20(0.922) = \mathbf{167.07\text{ W}}$$

Q3)

$$\mathbf{Z}_Y = \frac{\mathbf{Z}_\Delta}{3} = \frac{3\ \Omega + j\,6\ \Omega}{3} = 1\ \Omega + j\,2\ \Omega$$

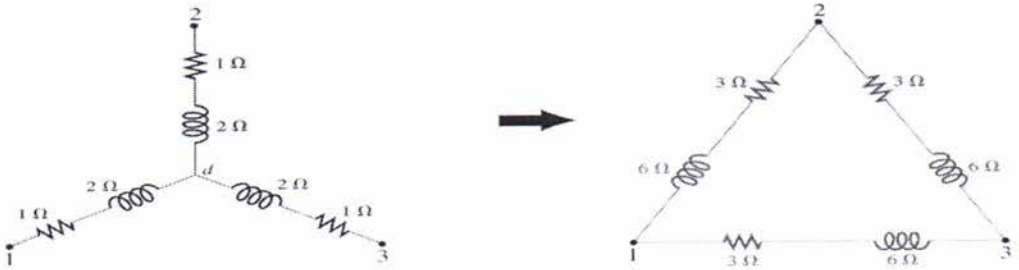


$$\mathbf{Z}_T = 2\left(\frac{1\,\Omega + j\,2\,\Omega}{2}\right) = \mathbf{1\,\Omega + j\,2\,\Omega}$$



Or

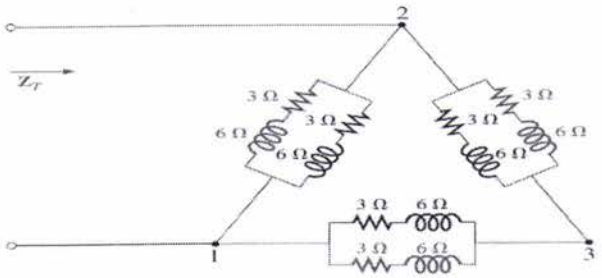
$$\mathbf{Z}_\Delta = 3\mathbf{Z}_Y = 3(1\,\Omega + j\,2\,\Omega) = 3\,\Omega + j\,6\,\Omega$$



$$\mathbf{Z}' = \frac{3\,\Omega + j\,6\,\Omega}{2} = 1.5\,\Omega + j\,3\,\Omega$$

$$\mathbf{Z}_T = \frac{\mathbf{Z}'(2\mathbf{Z}')}{\mathbf{Z}' + 2\mathbf{Z}'} = \frac{2(\mathbf{Z}')^2}{3\mathbf{Z}'} = \frac{2\mathbf{Z}'}{3}$$

$$= \frac{2(1.5\,\Omega + j\,3\,\Omega)}{3} = \mathbf{1\,\Omega + j\,2\,\Omega}$$



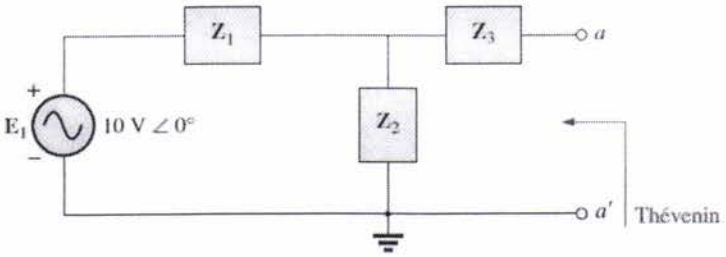
Z_T=1+j2 Z_T=2.236< 63.43

I= E/Z

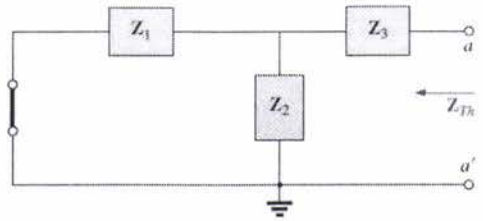
$$I = \frac{100<0}{2.236<63.43} = 44.722 < -63.43 \text{ A}$$

Q4)

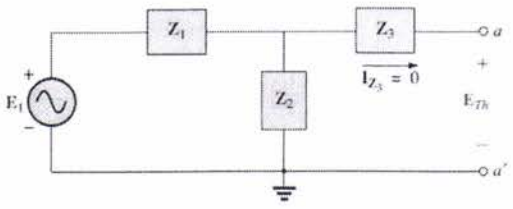
$$\mathbf{Z}_1 = R_1 + jX_{L_1} = 6\,\Omega + j8\,\Omega$$
$$\mathbf{Z}_2 = R_2 - jX_C = 3\,\Omega - j4\,\Omega$$
$$\mathbf{Z}_3 = +jX_{L_2} = j5\,\Omega$$

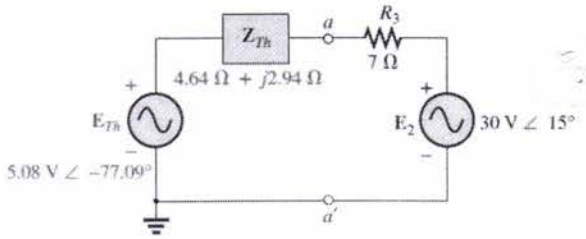


$$\mathbf{Z}_{Th} = \mathbf{Z}_3 + \frac{\mathbf{Z}_1\mathbf{Z}_2}{\mathbf{Z}_1 + \mathbf{Z}_2} = j5\,\Omega + \frac{(10\,\Omega\angle 53.13^\circ)(5\,\Omega\angle -53.13^\circ)}{(6\,\Omega + j8\,\Omega) + (3\,\Omega - j4\,\Omega)}$$
$$= j5 + \frac{50\angle 0^\circ}{9 + j4} = j5 + \frac{50\angle 0^\circ}{9.85\angle 23.96^\circ}$$
$$= j5 + 5.08\angle -23.96^\circ = j5 + 4.64 - j2.06$$
$$\mathbf{Z}_{Th} = \mathbf{4.64\,\Omega + j\,2.94\,\Omega = 5.49\,\Omega\angle 32.36^\circ}$$



$$\mathbf{E}_{Th} = \frac{\mathbf{Z}_2\mathbf{E}}{\mathbf{Z}_2 + \mathbf{Z}_1} \quad \text{(voltage divider rule)}$$
$$= \frac{(5\,\Omega\angle -53.13^\circ)(10\text{ V}\angle 0^\circ)}{9.85\,\Omega\angle 23.96^\circ}$$
$$\mathbf{E}_{Th} = \frac{50\text{ V}\angle -53.13^\circ}{9.85\angle 23.96^\circ} = \mathbf{5.08\text{ V}\angle -77.09^\circ}$$

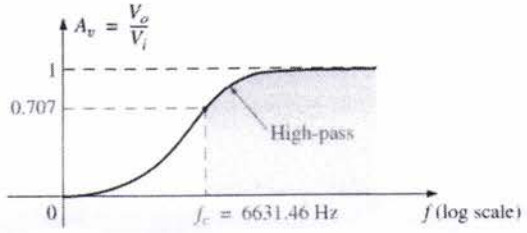




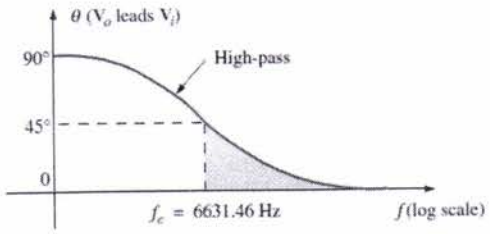
Q5)

a. $$f_c = \frac{1}{2\pi RC} = \frac{1}{(2\pi)(20\text{ k}\Omega)(1200\text{ pF})}$$
$$= \mathbf{6631.46\ Hz}$$

a-



b-



c. $$f = \frac{1}{2}f_c = \frac{1}{2}(6631.46\text{ Hz}) = 3315.73\text{ Hz}$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{(2\pi)(3315.73\text{ Hz})(1200\text{ pF})}$$
$$\cong 40\text{ k}\Omega$$

$$A_v = \frac{V_o}{V_i} = \frac{1}{\sqrt{1 + \left(\frac{X_C}{R}\right)^2}} = \frac{1}{\sqrt{1 + \left(\frac{40\text{ k}\Omega}{20\text{ k}\Omega}\right)^2}} = \frac{1}{\sqrt{1 + (2)^2}}$$

$$= \frac{1}{\sqrt{5}} = 0.4472$$

$$\theta = \tan^{-1}\frac{X_C}{R} = \tan^{-1}\frac{40\text{ k}\Omega}{20\text{ k}\Omega} = \tan^{-1} 2 = 63.43°$$

and $$\mathbf{A_v} = \frac{\mathbf{V_o}}{\mathbf{V_i}} = \mathbf{0.447\ \angle 63.43°}$$

Q6)

a)

1- $$BW = \frac{f_s}{Q_s} \quad \text{or} \quad Q_s = \frac{f_s}{BW} = \frac{4000\ \text{Hz}}{400\ \text{Hz}} = \mathbf{10}$$

2- $$Q_s = \frac{X_L}{R} \quad \text{or} \quad X_L = Q_s R = (10)(10\ \Omega) = \mathbf{100\ \Omega}$$

3- $$X_L = 2\pi f_s L \quad \text{or} \quad L = \frac{X_L}{2\pi f_s} = \frac{100\ \Omega}{2\pi(4000\ \text{Hz})} = \mathbf{3.98\ mH}$$

3- $$X_C = \frac{1}{2\pi f_s C} \quad \text{or} \quad C = \frac{1}{2\pi f_s X_C} = \frac{1}{2\pi(4000\ \text{Hz})(100\ \Omega)}$$
$$= \mathbf{397.89\ nF}$$

b)

1. $$Q_l = \frac{X_L}{R_l} = \frac{2\pi f_p L}{R_l} = \frac{2\pi(0.04\ \text{MHz})(1\ \text{mH})}{10\ \Omega} = \mathbf{25.12}$$

2. $Q_l \geq 10$. Therefore,
$$R_p \cong Q_l^2 R_l = (25.12)^2(10\ \Omega) = \mathbf{6.31\ k\Omega}$$

3 $$Z_{T_p} = R_s \| R_p = 40\ \text{k}\Omega \| 6.31\ \text{k}\Omega = \mathbf{5.45\ k\Omega}$$

4 $Q_l \geq 10$. Therefore,
$$f_p \cong \frac{1}{2\pi\sqrt{LC}}$$
and $$C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4\pi^2 (0.04\ \text{MHz})^2 (1\ \text{mH})} = \mathbf{15.83\ nF}$$

5. $Q_l \geq 10$. Therefore,
$$Q_p = \frac{Z_{T_p}}{X_L} = \frac{R_s \| Q_l^2 R_l}{2\pi f_p L} = \frac{5.45\ \text{k}\Omega}{2\pi(0.04\ \text{MHz})(1\ \text{mH})} = \mathbf{21.68}$$