University of Technology
Department of Laser & Optoelectronics Engineering
Final Examination 2011-2012

Subject: Electrical A.C Circuits
Division: Laser & optoelectronics Eng.
Examiner: Dr. Salah Aldeen Adnan

Class: 2nd year
Time: 3 hours
Date: 28/ 5 /2012

Answer only five questions

Q.1:For the series parallel circuit of Fig.(1), the parallel elements is at resonance .
   a. Calculate I, V_R, V_L, and V_C in Phasor form.
   b. Calculate the total power factor.
   c. Calculate the average power delivered to the circuit.
   d. Draw the Phasor diagram.
   e. Obtain the Phasor sum of V_R, V_L, and V_C, and show that it equals the input voltage E.
   f. Find V_R and V_C using the voltage divider rule.

Q.2:Redesign a parallel resonance cct. to have the response curve of fig. (2) , using 2mH,100Ω inductor .

Q.3:Calculate the magnetic flux (Φ) for the magnetic circuit of figure (3) where the flux density of cast iron is 0.39T .

Q.4:Find the voltage V_{AB} of Fig.(4) by nodal theorem .

Q.5:Sketch the output voltage V_0 versus frequency for the R-L filter of Fig.(5) , and Determine the voltage V_0 at F = 100kHz and 1MHz ,where R =10Ω and L = 1mH .

Q.6:Find the equivalent circuit for each current locus diagram shown in Fig.(6).

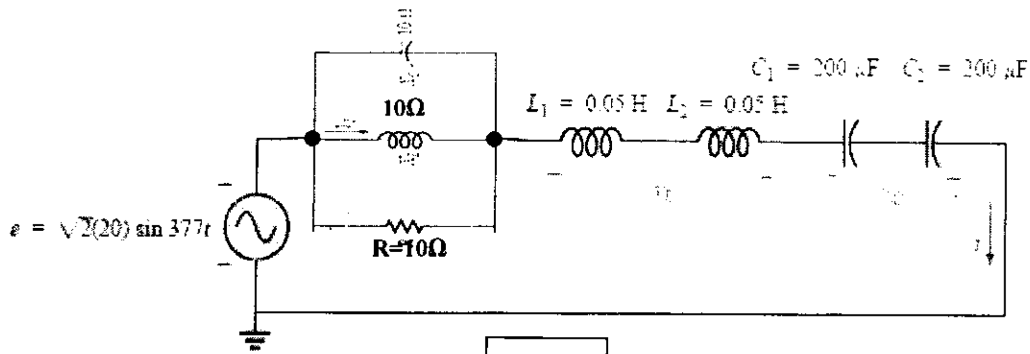


Fig.1

أقلب الصفحة

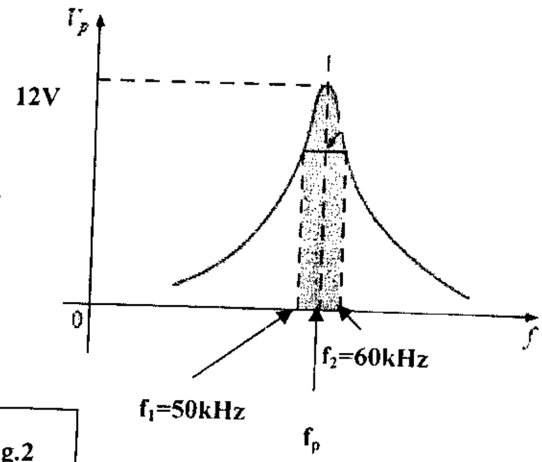


Fig.2

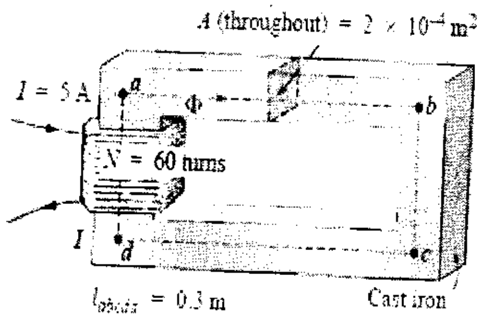


Fig.3

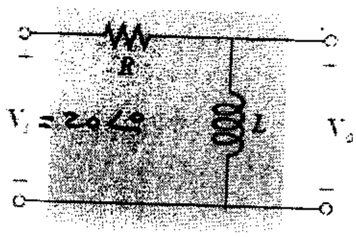


Fig.5

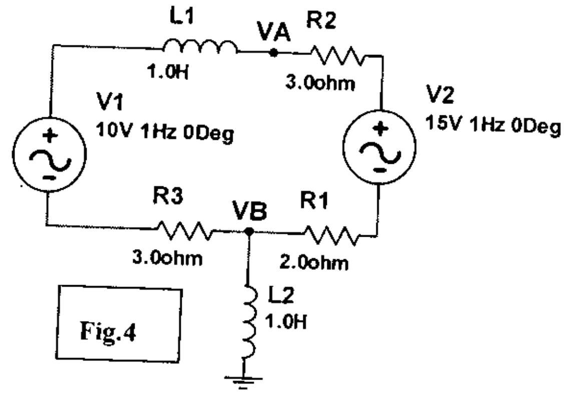


Fig.4

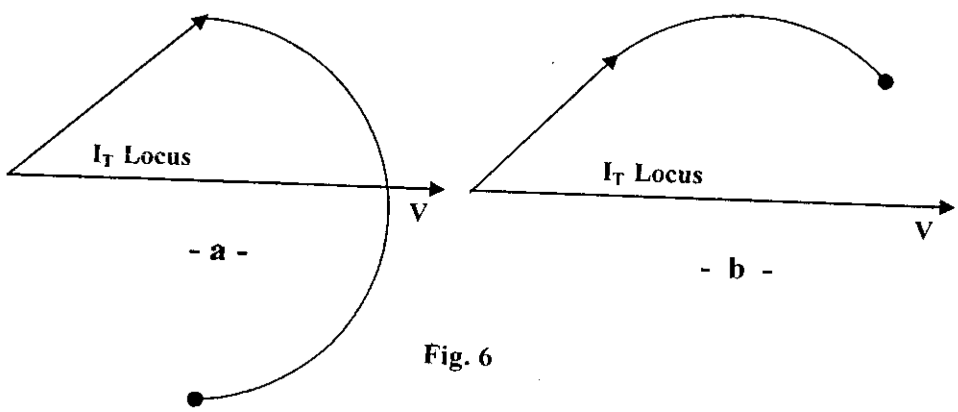


Fig. 6

Ac cct. (V-1)

Q.1

for (Laser + optoelectronics)

(a)

$R_T = 6\ \Omega + 4\ \Omega = 10\ \Omega$

$L_T = 0.05\ \text{H} + 0.05\ \text{H} = 0.1\ \text{H}$

$C_T = \dfrac{200\ \mu\text{F}}{2} = 100\ \mu\text{F}$

$$X_L = \omega L = (377\ \text{rad/s})(0.1\ \text{H}) = 37.70\ \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{(377\ \text{rad/s})(100 \times 10^{-6}\ \text{F})} = \frac{10^6\ \Omega}{37{,}700} = 26.53\ \Omega$$

Redrawing the circuit using phasor notation results in Fig. 15.43.

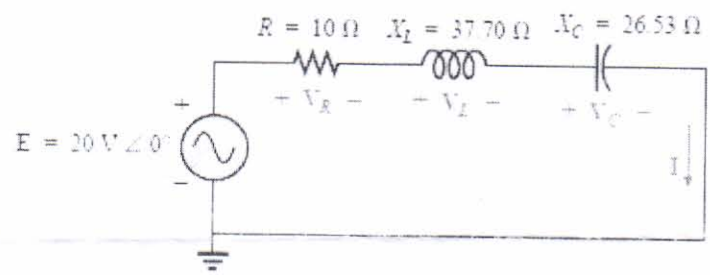


FIG. 15.43
Applying phasor notation to the circuit of Fig. 15.42.

For the circuit of Fig. 15.43,

$$\begin{aligned}\mathbf{Z}_T &= R\angle 0^\circ + X_L\angle 90^\circ + X_C\angle -90^\circ\\ &= 10\ \Omega + j\,37.70\ \Omega - j\,26.53\ \Omega\\ &= 10\ \Omega + j\,11.17\ \Omega = \mathbf{15\ \Omega\angle 48.16^\circ}\end{aligned}$$

The current **I** is

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{20\ \text{V}\angle 0^\circ}{15\ \Omega\angle 48.16^\circ} = \mathbf{1.33\ A\angle -48.16^\circ}$$

The voltage across the resistor, inductor, and capacitor can be found using Ohm's law:

$$\begin{aligned}\mathbf{V}_R = \mathbf{IZ}_R &= (I\angle\theta)(R\angle 0^\circ) = (1.33\ \text{A}\angle -48.16^\circ)(10\ \Omega\angle 0^\circ)\\ &= \mathbf{13.30\ V\angle -48.16^\circ}\end{aligned}$$

$$\begin{aligned}\mathbf{V}_L = \mathbf{IZ}_L &= (I\angle\theta)(X_L\angle 90^\circ) = (1.33\ \text{A}\angle -48.16^\circ)(37.70\ \Omega\angle 90^\circ)\\ &= \mathbf{50.14\ V\angle 41.84^\circ}\end{aligned}$$

$$\begin{aligned}\mathbf{V}_C = \mathbf{IZ}_C &= (I\angle\theta)(X_C\angle -90^\circ) = (1.33\ \text{A}\angle -48.16^\circ)(26.53\ \Omega\angle -90^\circ)\\ &= \mathbf{35.28\ V\angle -138.16^\circ}\end{aligned}$$

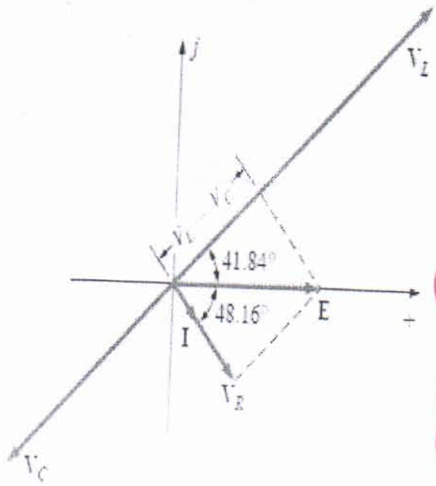


FIG. 15.44
Phasor diagram for the circuit of Fig. 15.42.

b. The total power factor, determined by the angle between the applied voltage E and the resulting current I, is 48.16°:

$$F_p = \cos\theta = \cos 48.16° = \mathbf{0.667\ lagging}$$

or

$$F_p = \cos\theta = \frac{R}{Z_T} = \frac{10\ \Omega}{15\ \Omega} = \mathbf{0.667\ lagging}$$

c. The total power in watts delivered to the circuit is

$$P_T = EI\cos\theta = (20\text{ V})(1.33\text{ A})(0.667) = \mathbf{17.74\ W}$$

d. The phasor diagram appears in Fig. 15.44.

e. The phasor sum of $\mathbf{V}_R$, $\mathbf{V}_L$, and $\mathbf{V}_C$ is

$$\mathbf{E} = \mathbf{V}_R + \mathbf{V}_L + \mathbf{V}_C$$
$$= 13.30\text{ V}\angle -48.16° + 50.14\text{ V}\angle 41.84° + 35.28\text{ V}\angle -138.16°$$
$$\mathbf{E} = 13.30\text{ V}\angle -48.16° + 14.86\text{ V}\angle 41.84°$$

Therefore,

$$E = \sqrt{(13.30\text{ V})^2 + (14.86\text{ V})^2} = \mathbf{20\ V}$$

and $\theta_E = 0°$ (from phasor diagram)

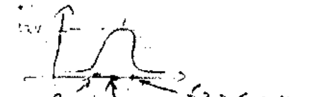
and $\mathbf{E} = 20\angle 0°$

f.
$$\mathbf{V}_R = \frac{\mathbf{Z}_R\mathbf{E}}{\mathbf{Z}_T} = \frac{(10\ \Omega\angle 0°)(20\text{ V}\angle 0°)}{15\ \Omega\angle 48.16°} = \frac{200\text{ V}\angle 0°}{15\angle 48.16°}$$
$$= \mathbf{13.3\ V\angle -48.16°}$$

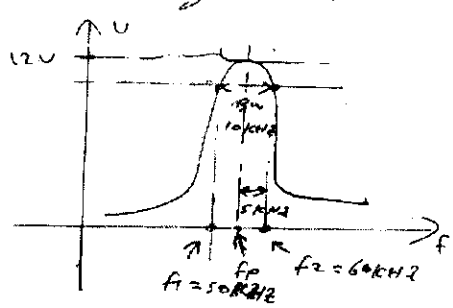
$$\mathbf{V}_C = \frac{\mathbf{Z}_C\mathbf{E}}{\mathbf{Z}_T} = \frac{(26.5\ \Omega\angle -90°)(20\text{ V}\angle 0°)}{15\ \Omega\angle 48.16°} = \frac{530.6\text{ V}\angle -90°}{15\angle 48.16°}$$
$$= \mathbf{35.37\ V\angle -138.16°}$$

Q.2

① AC. cct



Q.1: Redesign a parallel resonance cct. to have the response curve of fig. ( ), using 2mH, 100 Ω inductor ?



$f_1 = 50kHz$, $f_2 = 60kHz$.

$BW = 60k - 50k = 10kHz$

$\frac{BW}{2} = 5kHz$

① $f_p = 60k - 5k = 55kHz$

② $Q_p = \frac{f_p}{BW} = \frac{55kHz}{10k} = 5.5$

③ $X_L = 2\pi f_p . L = 2\pi \times 55 \times 10^3 \times 2 \times 10^{-3} = 691 \Omega$

④ $Q_1 = \frac{X_L}{R_1} = \frac{691}{100} = 6.91 < 10$

* Q_1 must be ≥ 10, because max. current or Impedance at resonant frequency (f_p) and because $f_p = f_m = f_s$

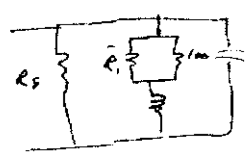
take $\boxed{Q_1 = 10}$

$\therefore Q_1 = \frac{X_L}{R_1}$ $\therefore R_1 = \frac{X_L}{Q_1} = \frac{691}{10} = 69.1 \Omega$

$\therefore$ we must add another Resistance ($\bar{R}_1$) in parallel with (R_1) to reduce R_1 to (69.1Ω).

$69.1 = \frac{100 \times \bar{R}_1}{100 + \bar{R}_1} \rightarrow 6910 + 69.1 \bar{R}_1 = 100 \bar{R}_1$

$6910 = 30.9 \bar{R}_1$ $\therefore$ $\bar{R}_1 = 223.6 \Omega$



(5) $Q_1 = 10$

$\therefore X_{Lp} = X_L = X_C = 691$

$f_s = f_p = f_m = 55\,KHz$

$R_p = Q_1^2 \cdot R_1$

$= (10)^2 \cdot \times 69.1 = 6910\Omega$

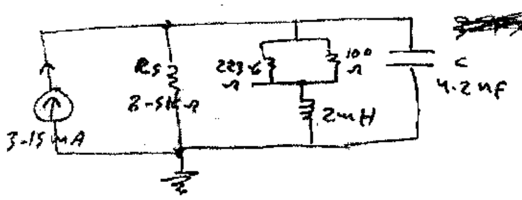
(6) $Q_p = \frac{R}{X_{Lp}} = \frac{R}{X_C} = \frac{R_s // R_p}{X_C}$

$$Q_p = \frac{\frac{R_s \cdot R_p}{R_s + R_p}}{X_C}$$

$$5.5 = \frac{\frac{6910 R_s}{R_s + 6910}}{691}$$

$$3.8 \times 10^3 = \frac{6910 R_s}{R_s + 6910}$$

$$3.8 \times 10^3 R_s + 26.3 \times 10^6 = 6910 R_s$$



$$26.3 \times 10^6 = 3110 R_s$$

$$R_s = \frac{26.3 \times 10^6}{3110} =$$

(7) $R_s = 8.5\,K\Omega$

$X_C = \frac{1}{2\pi f_p c} = X_L = 691\,\Omega$

(8) $c = \frac{1}{2\pi \times 55 \times 10^3 \times 691} = 4.2\,nF$ or $c = \frac{L}{R_1 \cdot R_p} = 4.2\,nF$

(9) $I = V_p / Z_{TP} \rightarrow Z_{TP} = R_s // R_p = \frac{R_s \times R_p}{R_s + R_p}$

$Z_{TP} = \frac{8.5 \times 10^3 \times 6.91K}{8.5K + 6.91K} = 3.81\,K\Omega$

$I = 12 / 3.81K\Omega = 3.15\,mA$

Q.3

Solution: By Ampère's circuital law,

$$NI = H_{abcda} l_{abcda}$$

or

$$H_{abcda} = \frac{NI}{l_{abcda}} = \frac{(60\ \text{t})(5\ \text{A})}{0.3\ \text{m}}$$

$$= \frac{300\ \text{At}}{0.3\ \text{m}} = 1000\ \text{At/m}$$

and

$$B_{abcda}\ (\text{from Fig. 11.23}) \cong 0.39\ \text{T}$$

Since $B = \Phi/A$, we have

$$\Phi = BA = (0.39\ \text{T})(2 \times 10^{-4}\ \text{m}^2) = \mathbf{0.78 \times 10^{-4}\ Wb}$$

Q.4

Q.4 : BY NODAL

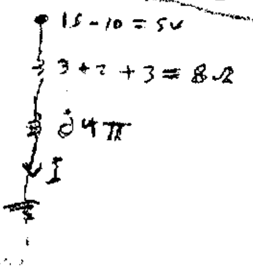
$$\frac{V_A - 10 - V_B}{3 + j2\pi} = \frac{V_B + 15 - V_A}{5} = I \longrightarrow (1)$$

$$\frac{V_B}{j2\pi} = I \longrightarrow (2)$$

$V_A = ?$ $V_B = ?$

$V_{AB} = V_A - V_B$

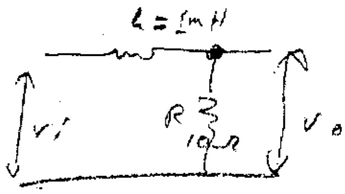
طريقة أخرى على
غير ال
(NODAL)



$$I = \frac{5}{8 + j4\pi}$$

APF

Q.5 :- $f_c = \frac{R}{2\pi L}$



$V_o = ?$ at $f = 100\,kHz$ and $1\,MHz$ $V_i = 20\angle 0$

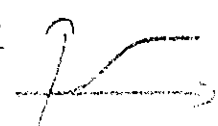
$$V_o = V_i \frac{X_L}{R + jX_L} = \frac{V_i X_L}{\sqrt{R^2 + X_L^2}} = \frac{V_i}{\sqrt{\left(\frac{R}{X_L}\right)^2 + 1}}$$

$X_L = 2\pi f L$ $f_c = \frac{10}{2\pi \times 10^{-3}} = 1.6\,kHz$

1) $f = 100 \times 10^3$. $X_L = 2\pi \times 100 \times 10^3 \times 10^{-3} =$

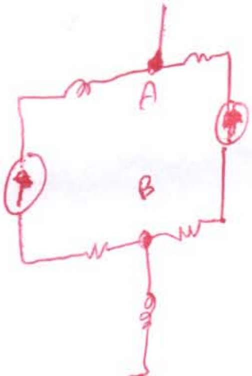
$= 628.3\,\Omega$

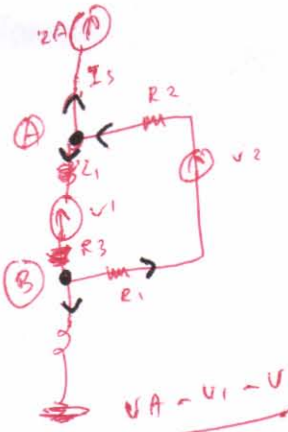
$$V_o = \frac{20}{\sqrt{\left(\frac{10}{628.3}\right)^2 + 1}} = 20\angle 0.91$$



2) $f = 10^6\,Hz$ $X_L = 6283.1$

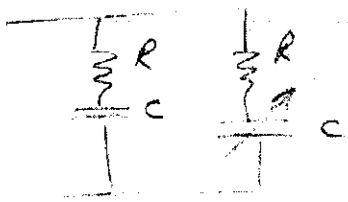
$V_o = 19.9\angle 90 - \tan^{-1}\frac{6283.1}{10}$



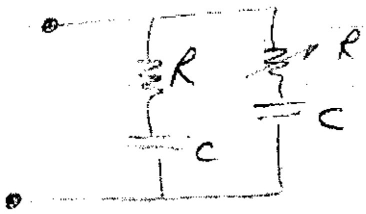


$$\frac{VA - V_1 - VB}{L_1 + R_3} + 55 = \frac{VB + V_2 - VA}{R_1 + R_2}$$

Q.6



(a)



(b)