Exam & Key Solutions

جامعة بيرزيت

BIRZEIT UNIVERSITY
Electrical Engineering Department
Circuits Analysis– ENEE234
Final Exam (summer 2013-2014)

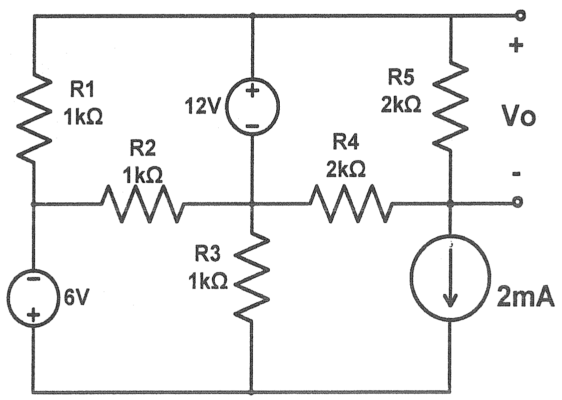
Student Name: **ID:**

Notes and Instructions:

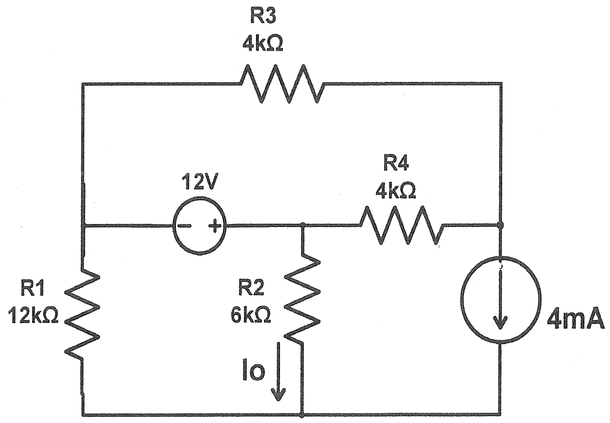
1. **Read each question carefully before starting your solution.**
3. **Write neatly and clearly and leave only one answer for each question.**
4. **Cell Phones are not allowed.**
5. **Percentage (%) of total mark is given for each question. Budget your time accordingly**

Q1. (25 points)

A. Use superposition to find Vo

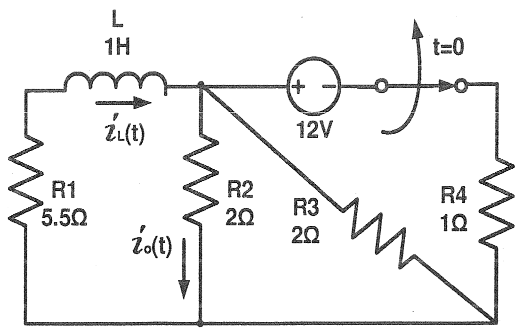


B. Find Io using Norton's equivalent circuit



Q2. (10 points)

Find expression for iL(t) and io(t)



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Q3. (15 points)
Find the maximum average power that can be transferred to the load ZL

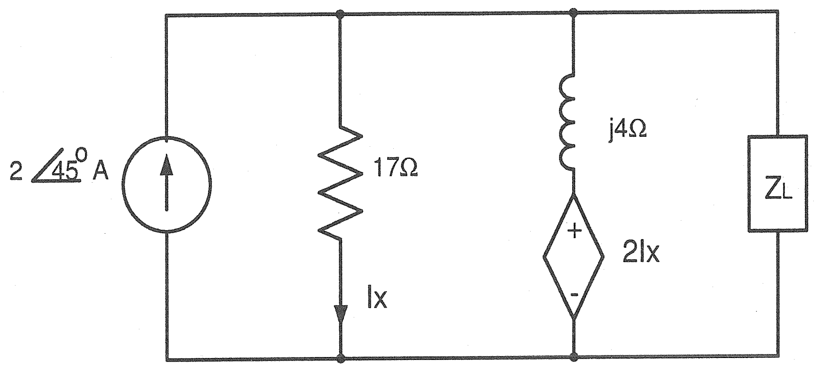


Figure Q3

Q4. (15 points)
An Industrial client is charged a penalty if the plant power factor drops below 0.9. The equivalent plant loads are shown in Figure Q4

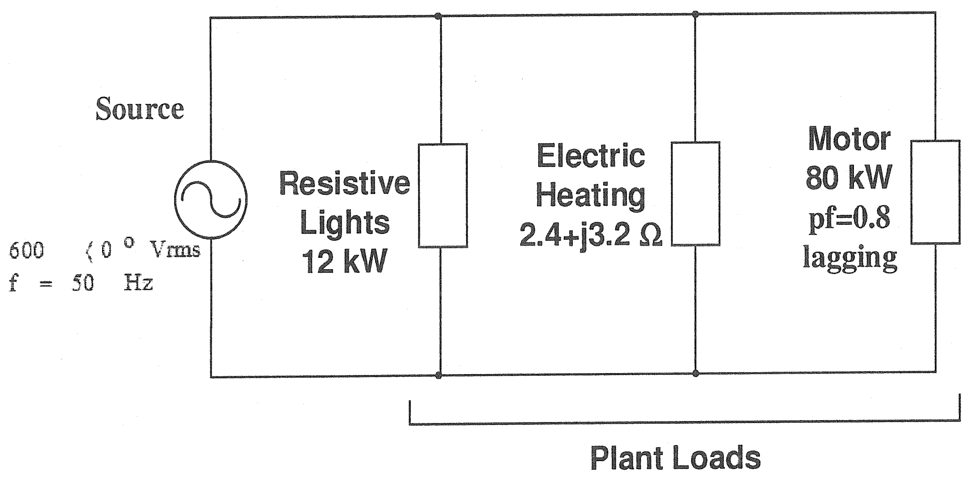


Figure Q4

a) Determine total average power (P_T), total reactive power (Q_T) and total apparent power of the source.
b) Determine the value of the required capacitor to be added in parallel with the plant load to raise the plant power factor to 0.9 lagging.
c) Find the source current and apparent power for the source with the added capacitor.
d) If the plant load was expanded by adding a resistive load of 102kW in parallel to the other loads, is it still necessary to add a capacitor in order to have $pf \geq 0.9$ lagging?

Q5. (20 points)

a) Use Laplace Transform to find the expression for Vo(s) for t > 0 in the circuit given in Fig Q5a. Note that at t=0 : SW1 closes and SW2 opens.

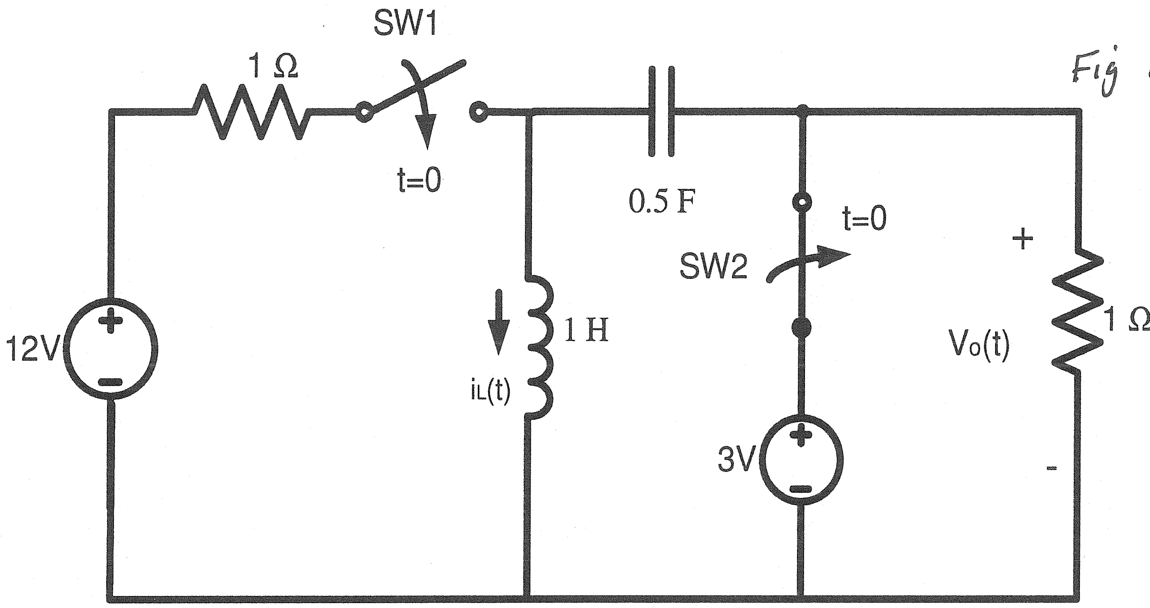


Fig Q5.a

b) Assuming that the expression for Vo(s) is :

$$Vo(s) = \frac{12(S+3)}{S\left(S^2+4S+5\right)}$$

Find Vo(t)

c) A transfer function H(s) relating the input voltage Vin(s) to the output voltage Vout(s) is given by the following expression

$$H(s) = \frac{Vout(s)}{Vin(s)} = \frac{10^3}{S^2+2S+10^3}$$

Find the steady state value of Vout(t) knowing that Vin(t)=10 cos(50t+15°) V

Q6. (10 points)

Find the h-parameters for the two-port network represented in Fig. Q6

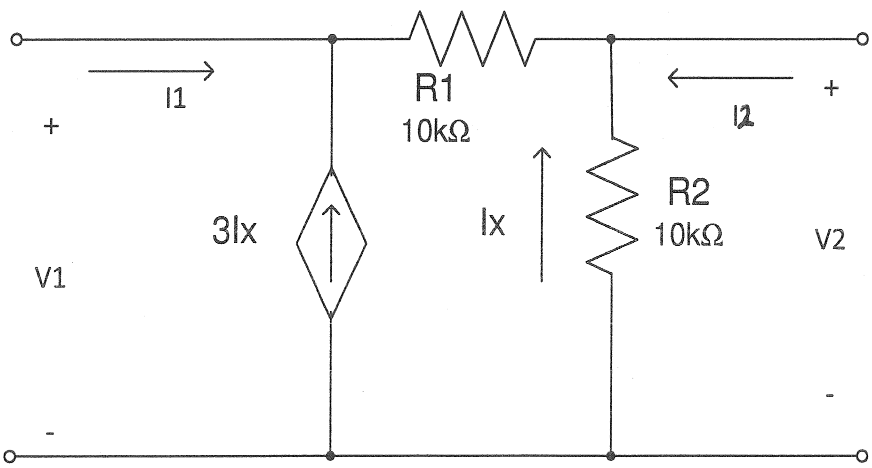


Fig. Q6

Q7. (10%)

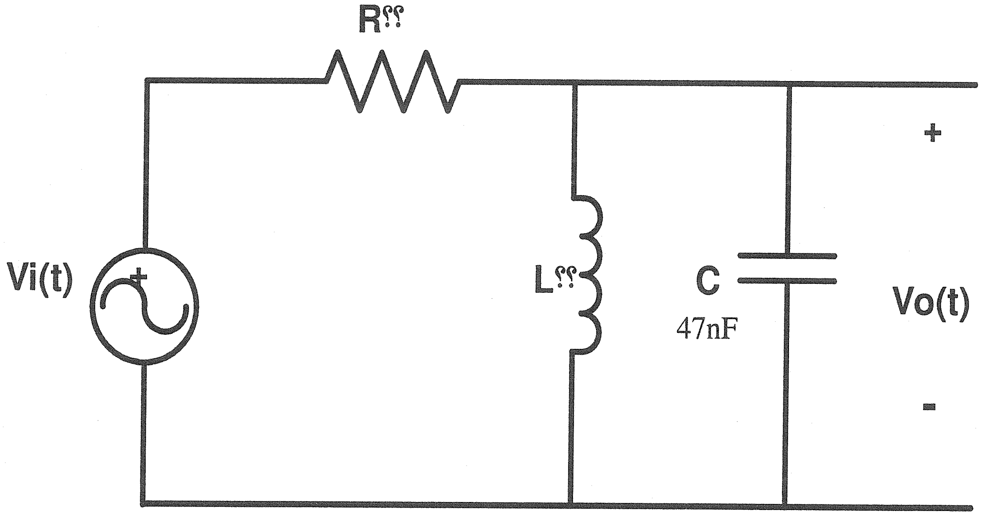
a) Show the type of filter which the RLC circuit in Fig.(Q7) is ? (use qualitative analysis)

b) Using a 47 nF capacitor , complete the design of the [redacted] filter, so that its Quality factor Q = 10 and its center frequency ω_0 =314 Krad/s.

c) Calculate the bandwidth of the filter (β) .

d) Calculate the upper and lower cutoff frequencies (ω_{c1} and ω_{c2})

e) Assume that the band pass filter of Fig.(Q5) is loaded with a 1KΩ resistor , calculate the new bandwidth



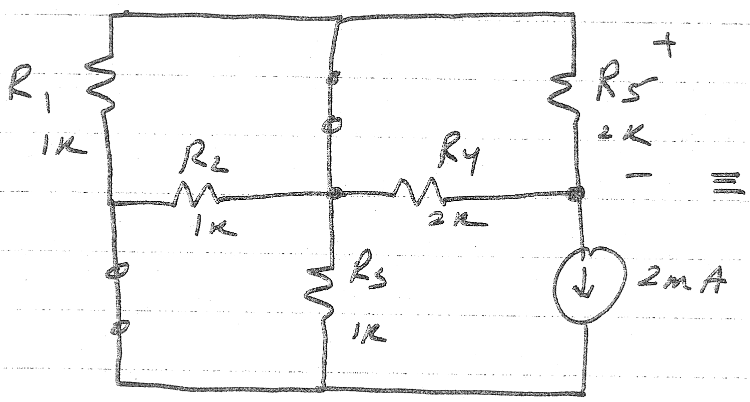
GOOD LUCK

Nasser Ismail

Solutions ENEE234
Final Exam
Summer 2014

Q1. A. [12 points]

[4 points]



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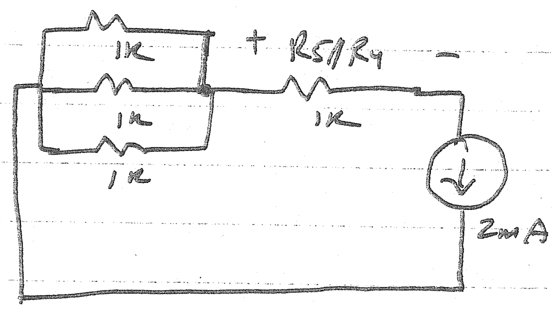
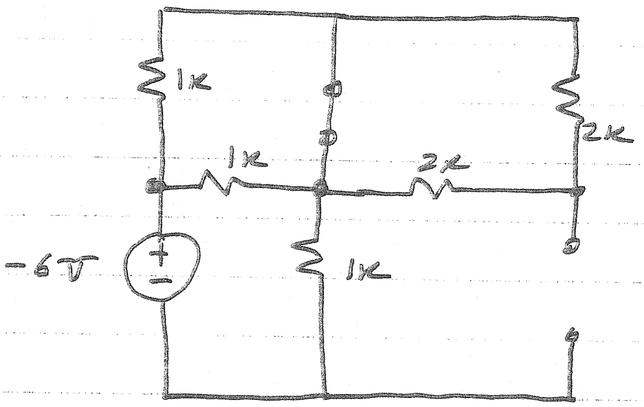


$V_o' = 2mA \times 1K\Omega = 2V$

[4 points]



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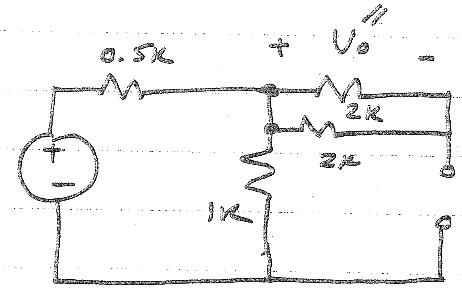
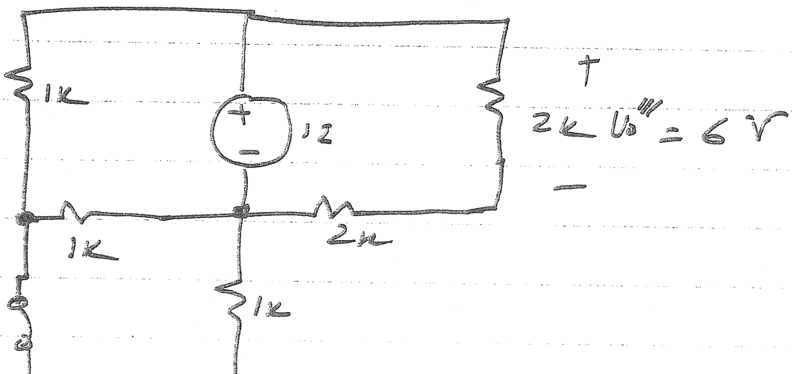


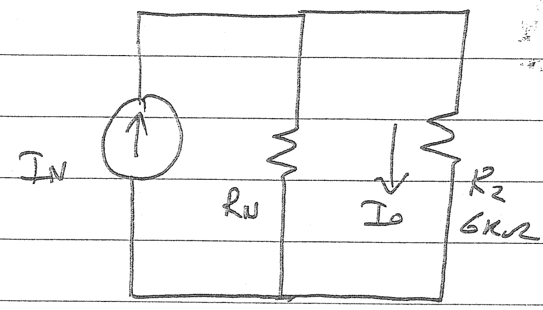
$V_o'' = 0V$

[4 points]



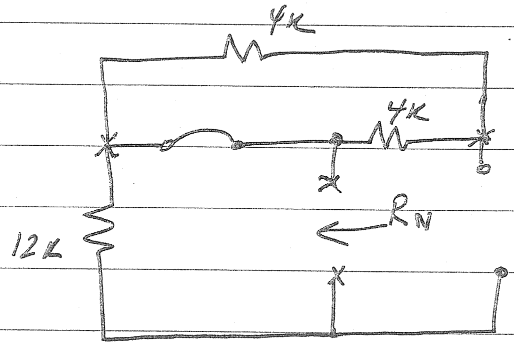
$V_o = 0 + 6 + 2 = 8V$

Q1: B [13 points]



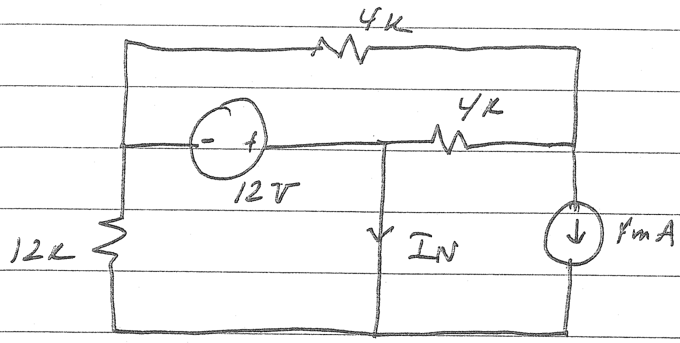
[5 points]

$$I_o = I_N \cdot \frac{R_N}{R_N + R_2} = -3mA \times \frac{12}{6+12} = -2\ mA$$

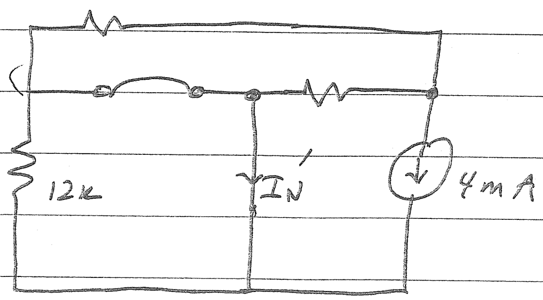


$R_N = 12k\Omega$

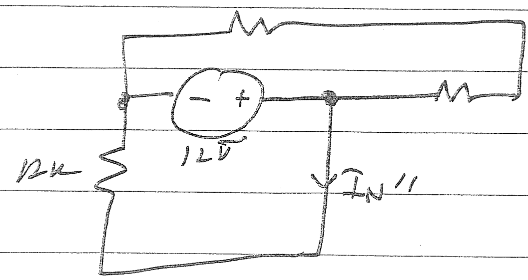
[3 points]



1)



$I_N' = -4\ mA$



$$I_N'' = \frac{12V}{12k} = 1\ mA$$

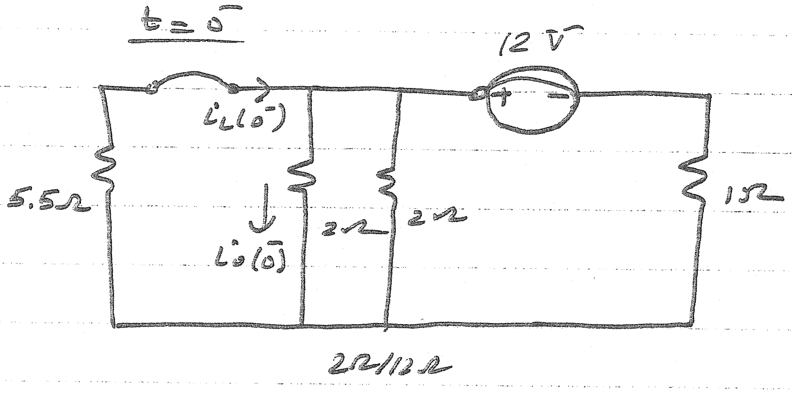
[5 points]

$I_N = -4mA + 1mA = -3mA$

Q2. [10 points]

initial conditions

t = 0⁻



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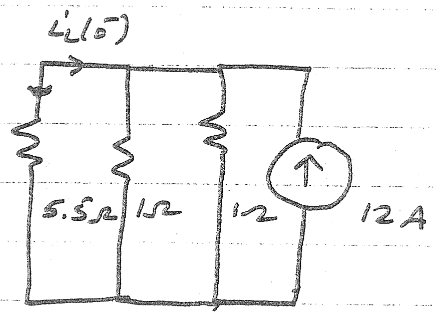
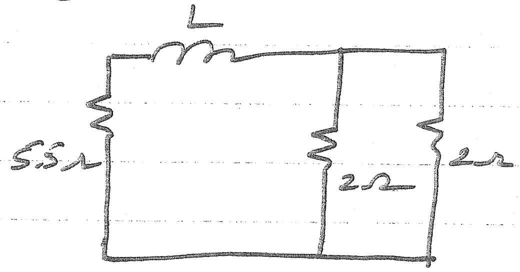


$$i_L(0^-) = -\frac{0.5}{0.5+5.5} \times 12 = -1\,A$$ [2 points]

t = 0⁺



$$R_{eq} = (2 // 2) + 5.5 = 6.5\,\Omega$$

$$\tau = \frac{L}{R_{eq}} = \frac{1}{6.5} = 153.8\ ms$$

[2 points]

t = ∞

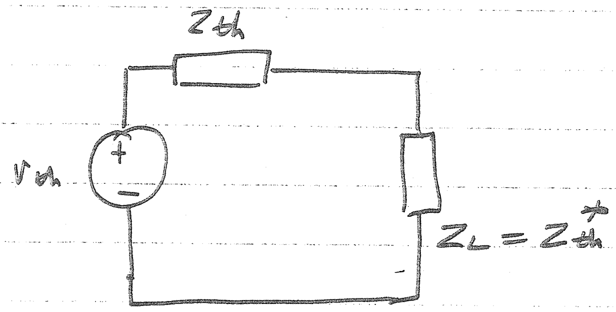
$i(\infty) = 0$ [2 points]

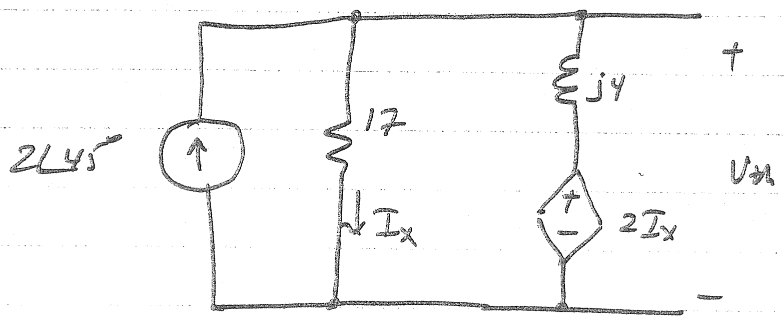
$$i_L(t) = i_L(\infty) + (i_L(0^+) - i(\infty))\, e^{-t/\tau} \quad A$$

$$i_L(t) = -1\, e^{-6.5\,t} \quad A$$ [2 points]

$$i_o(t) = \frac{i_L(t)}{2} = -0.5\, e^{-6.5\,t} \quad A$$ [2 points]

Q3. 15 points





$$I_x = \frac{V_{th}}{17}$$

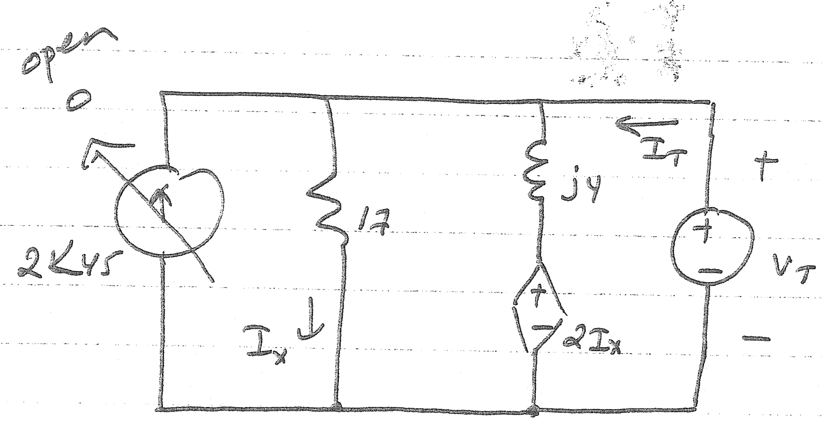
$$2\angle 45^\circ = V_{th}\left(\frac{1}{17} + \frac{1}{j4}\right) - 2I_x\left(\frac{1}{j4}\right)$$

$$2\angle 45^\circ = V_{th}\left(\frac{1}{17} + \frac{1}{j4}\right) - \frac{2V_{th}}{17}\left(\frac{1}{j4}\right)$$

$$2\angle 45^\circ = V_{th}\left(\frac{j4 + 17 - 2}{j68}\right) \Longrightarrow \therefore V_{th} = \frac{2\angle 45 \times j68}{15 + j4}$$

$$V_{th} = \frac{136\angle 135}{15 + j4} = \frac{136\angle 135^\circ}{15.52\angle 14.93} = 8.76\angle 120.06^\circ \ V$$

5 points



$$\not{2\angle 45}^{\,0} + I_T = V_T\left(\frac{1}{17}+\frac{1}{j4}\right) - \frac{2V_T}{17}\left(\frac{1}{j4}\right)$$

$$I_T = V_T\left(\frac{j4+17-2}{j68}\right)$$

$$Z_{th} = \frac{V_T}{I_T} = \frac{j68}{15+j4} = \frac{68\angle 90}{15.52\angle 14.93} = 4.38\angle 75.06^\circ$$

[5 points]

$$Z_L = Z_{th}^* = 4.38\angle -75.06 = 1.13 - j\,4.23$$

[2.5 points]

$$P_L = \frac{1}{8}\frac{U_{th}^2}{R_L} = \frac{1}{8}(8.76)^2 \cdot \frac{1}{1.13} = 8.475 \text{ W}$$

[2.5 points]

Q4 [15 points]

load 1

$P_1 = 12\,KW$

$pf_1 = 1 \Rightarrow \theta_1 = 0$

$Q_1 = 0$

$S_1 = 12 \quad KVA$

[2 points]

load 2

$S_2 = V_2 I_2^*$

$$I_2 = \frac{V_2}{Z_2} = \frac{600\angle 0^\circ}{2.4+j3.2} = \frac{600\angle 0^\circ}{4\angle 53.16^\circ}$$

$= 150\angle -53.16^\circ \ A$

$S_2 = (600\angle 0^\circ)(150\angle 53.16^\circ)$

$= 90\angle 53.16 \quad KVA$

$= 54 + j72 \quad KVA$

[2 points]

load 3

$P_3 = 80\,KW$

$pf_3 = 0.8 \rightarrow \theta_3 = 36.9^\circ$

$Q_3 = P_3 \tan\theta_3 = 80 \times 0.75 = 60 \ KVAR$

$S_3 = 80 + j60 \quad KVAR$

[2 points]

$S_T = P_T + jQ_T$

$= (12+54+80) + j(0+72+60)$

$= 144 + j132 \quad KVA$

$= 195.35\angle 42.53 \quad KVA$

b) [3 points]

$pf_T = \cos 42.53 = 0.737$

$pf_{new} = 0.9 \rightarrow \theta_{new} = 25.85^\circ$

$Q_{new} = P_{old} \tan\theta_{new} = 144 \tan 25.85 = 69.742 \quad KVAR$

$Q_{cap} = Q_{new} - Q_{old} = -62.257 \quad KVAR$

$$Q_c = \frac{-V^2}{\frac{1}{\omega C}} \implies Q_c = -\omega C V^2$$

$$C = \frac{Q_c}{\omega V^2} = \frac{62257}{2\pi \cdot 50 \times 600^2} = 550.8 \ \mu F$$

c) $$I_s^* = \frac{S_{new}}{V_s} = \frac{144 + j69.742}{600\angle 0°} \ KVA$$

$$= 240 + j116.24 \ A$$

$$I_s = 240 - j116.24 \ A$$

3 points

$$S_s = 144 + j69.742 \ KVA = 185.06 \angle 38.4° \ KVA$$

d) $$S_T = (144 + 102) + j132 = 279.18 \angle 28.23° \ A$$

$$pf_T = \cos(28.23°) = 0.881 < 0.9$$

still a cap is needed

3 points

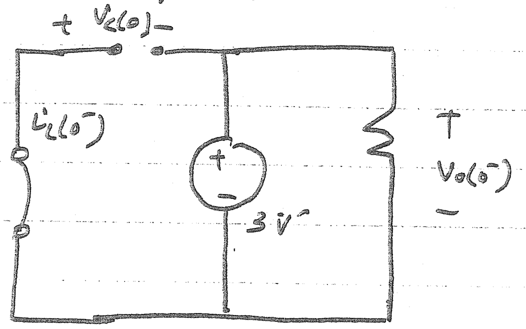
20 points

Q5. a)

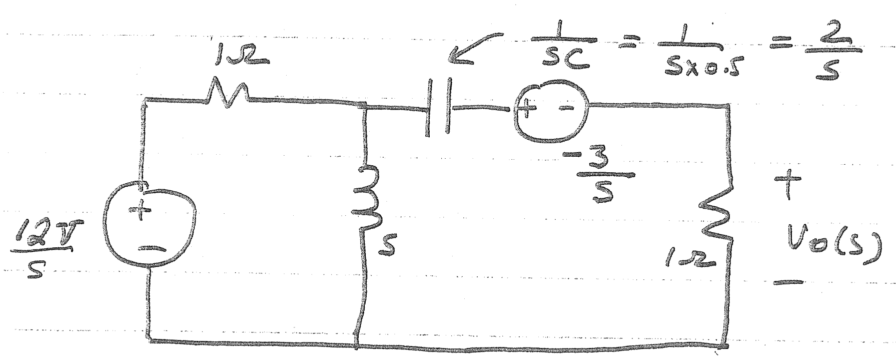
$t = 0^-$ (sw1 open, sw2 closed)

$i_L(0^-) = 0$

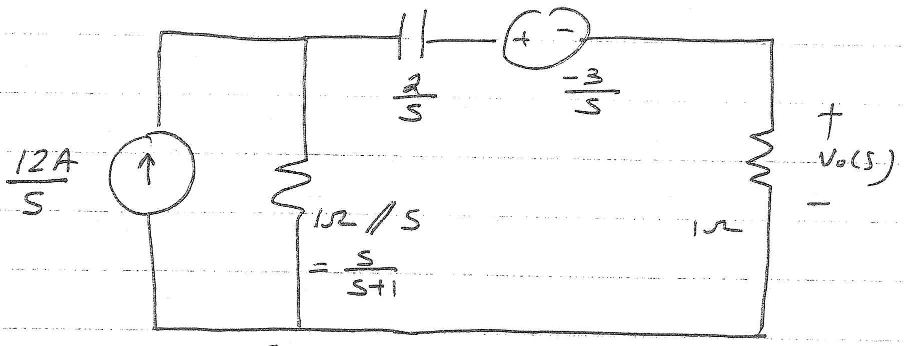
$V_c(0^-) = -3\,V$

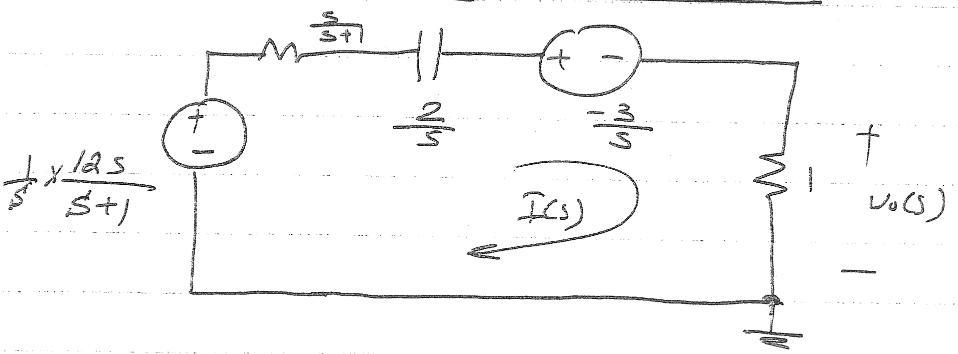


$t = 0^+$



5 points





5 points

$$V_o(s) = I(s) = \left(\frac{12}{s+1} + \frac{3}{s}\right) \Big/ 1 + \frac{2}{s} + \frac{s}{s+1}$$

$$= \frac{12s + 3(s+1)}{s(s+1)} \times \frac{s(s+1)}{s(s+1) + 2(s+1) + s^2}$$

$$V_o(s) = \frac{12s + 3s + 1}{2s^2 + 3s + 2} = \frac{15s + 1}{2s^2 + 3s + 2}$$

b) $V_o(s) = \dfrac{12(s+3)}{s(s^2+4s+5)}$; $s^2 + 4s + 5 = (s+2-j1)(s+2+j1)$

$$V_o(s) = \frac{12(s+3)}{s(s+2-j1)(s+2+j1)}$$

$$V_o(s) = \frac{K_0}{s} + \frac{K_1}{(s+2-j1)} + \frac{K_1^*}{(s+2+j1)}$$

3 points

$K_0 = 36/5$

$K_1 = (s+2-j1)\,V_o(s)\big|_{s=-2+j1} = 3.79 \angle 161.57^\circ$

$K_1^* =$

$V_o(t) = K_0 + 2|K_1|\,e^{-2t}\cos(t + 161.57^\circ)$ V

2 points

c) $V_o(t) = V_m\,|H(j\omega_0)|\cos(\omega_0 t + \angle H(j\omega_0) + \theta)$

$$H(j\omega_0) = \frac{10^3}{(j50)^2 + 2\times j50 + 10^3} = \frac{10^3}{-2500 + j100 + 1000}$$

$$= \frac{1000}{-1500 + j100} = 0.665 \angle 3.816^\circ$$

5 points

$V_o(t) = 6.65\cos(50t + 18.816^\circ)$ V

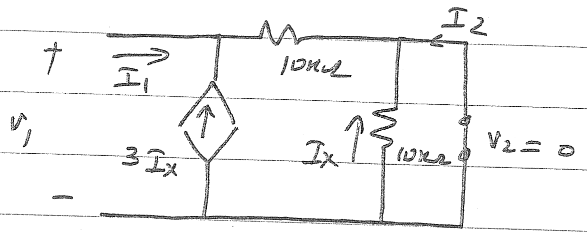
Q6. [10 points]

Summary

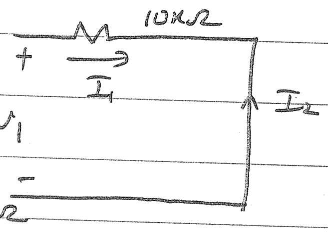
$h_{11} = \frac{V_1}{I_1}\Big|_{V_2=0} = 10\,k\Omega$ $\qquad h_{12} = \frac{V_1}{V_2}\Big|_{I_1=0} = 2$

$h_{21} = \frac{I_1}{I_1}\Big|_{V_2=0} = -1$ $\qquad h_{22} = \frac{I_2}{V_2}\Big|_{I_1=0} = 0.4\,mS$

test 1 $\quad V_2 = 0$



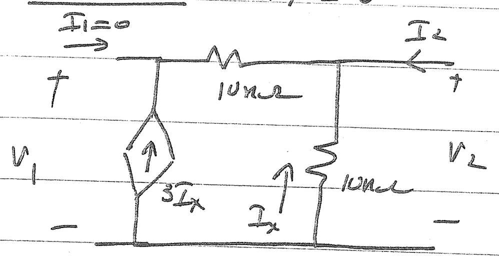
$I_x = 0\ ,\ 3I_x = 0$



$V_1 = I_1 \cdot 10\,k\Omega \Rightarrow \frac{V_1}{I_1} = h_{11} = 10\,k\Omega$

$I_2 = -I_1 \Rightarrow \frac{I_2}{I_1} = -1 = h_{21}$

test 2 $\quad I_1 = 0$



$I_x = \frac{-V_2}{10\,k\Omega}$

$I_2 + I_x = -3I_x$

$\Rightarrow I_2 = -4I_x$

$= \frac{-4(-V_2)}{10\,k\Omega}$

$\therefore \quad h_{22} = \frac{I_2}{V_2} = \frac{4}{10\,k\Omega} = 0.4\,mS$

$V_2 = \frac{10\,k\Omega}{20\,k\Omega} \cdot V_1 \Rightarrow h_{12} = \frac{V_1}{V_2} = 2$

10 points

Q7. a) $\omega = 0$ $V_o = 0$

(L short, C-open)

2 points

$\omega = \infty$ $V_o = 0$

(L open, C-short)

$\therefore$ This is Band-pass filter

b) $\omega_o = \frac{1}{\sqrt{LC}}$

2 points

$\therefore L = \frac{1}{\omega_o^2 C} = \frac{1}{(314 \cdot 10^3)^2 \, 47 \cdot 10^{-9}} = 215.8 \text{ mH}$

c) $\beta = \frac{1}{RC} = \frac{\omega_o}{Q} = \frac{314 \text{ krad/sec}}{10} = 31.4 \text{ krad/sec}$

2 points

$\therefore R = \frac{1}{\beta . C} = \frac{1}{31.4 \cdot 10^3 \times 47 \cdot 10^{-9}} = 677.6 \ \Omega$

d) $\omega_{c1,2} = -\beta/2 \mp \sqrt{(\beta/2)^2 + \omega_o^2}$

$\omega_{c1} = 298,692$ krad/sec

2 points

$\omega_{c2} = 314, 392$ krad/sec

e) with $R_L = 1k\Omega$

2 points

$R_{eq} = 1k\Omega \,//\, 677.6 \cong 404 \ \Omega$

$\beta_{new} = \frac{1}{R_{eq} \cdot C} = 52676$ rad/sec

↓

higher than befor