Question 1

THE INTERNATINONAL UNIVERSITY (IU) – VIETNAM NATIONAL UNIVERSITY – HCMC

Final Examination

Date: Jan. 16, 2017

Duration: 120 minutes

SUBJECT: Principles of EE2	
Dean of School of Electrical Engineering Signature: Full name: Tran Van Su	Lecturer Signature: Full name: Tran Van Su

INTRODUCTIONS:

1. This in an open book examination
2. Answer all questions

Review for Final exam

- lecture 5 & 6 : - Laplace transform in circuit analysis (CR & LR only)
- lecture 7 & 8 : - Intro to frequency selective circuit (LPF, HPF, high order op-amp filter only)
  - Full active filter circuit.
- lecture 9 : Fourier series (trigonometric form, rms, power)
- lecture 10 : Two port circuits
- lecture 11 : Balanced three-phase circuits

Question 1 (10 Marks)

Find f(t) for each of the following function:

a. $F(s)=\dfrac{10s^2+28s+36}{(s+2)(s^2+2s+10)}$ (5 Marks)

b. $F(s)=\dfrac{5s^2+9s+4}{s^2(s+4)}$ (5 Marks)

Question 2 (10 Marks)

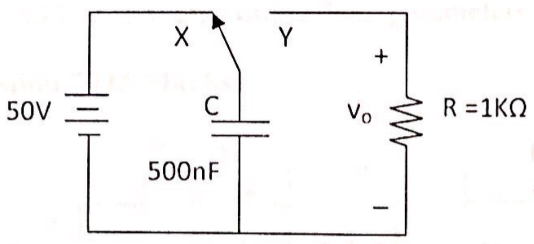


Fig. 1

The switch in the circuit in Fig. 1 has been in position X for a long time. At t = 0, the switch moves instantaneously to position Y

a. Construct an S-domain circuit for t >0. (3 Marks)
b. Find $V_o(s)$. (4 Marks)
c. Find $v_o(t)$. (4 Marks)

Question 3 (15 Marks)

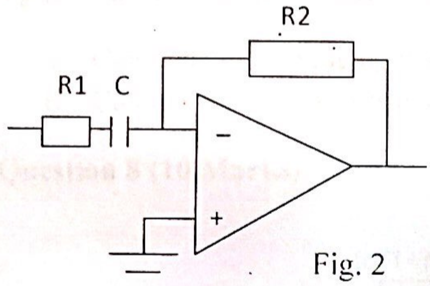


Fig. 2

Design an op-amp based HPF with a cutoff frequency of 4 Khz and a passband gain of 8 using a 250nF capacitor

a. Label the component values in Fig. 2. (10 Marks)
b. If the value of the feedback resistor is changed but the value of the resistor in the forward path is unchanged. What characteristic of the filter is changed. (5 Marks)

Quesstion 4 (15 Marks)

a) Using 2kΩ resistors and ideal op-amp, design a circuit that will implement the low pass Butterworth filter specified as follows: n = 2, f_c = 1000 Hz, gain in the passband of 1. (10 Marks)
b) Construct the circuit diagram and label all component values. (5 Marks)

Question 5 (15 Marks)

For the periodic function in Fig. 3, specify

a. ω_o (4 Marks)
b. a_v (3 Marks)
c. a_k and b_k (5 Marks). (Hint: odd function ~~and half symmetry~~)
~~d. v(t) as a Fourier series (2 Marks)~~

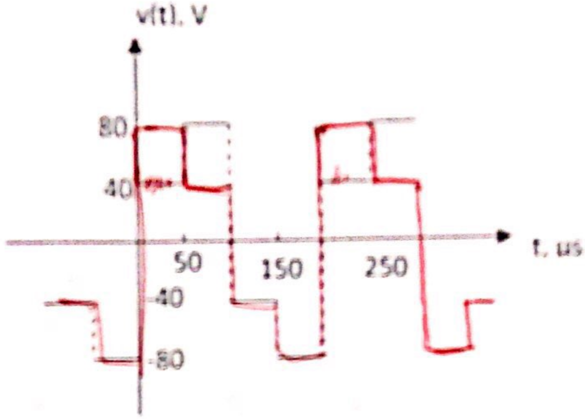
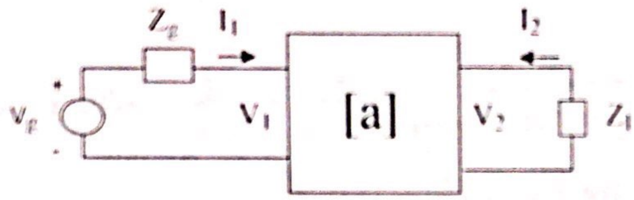


Fig. 3

Question 6 (10 Marks)

The following measurements were made on a resistive two-port network that is symmetric and reciprocal with port 2 open, $V_1 = 90V$, $I_1 = 3A$. With a short circuit across port 2, $V_1 = 80V$ and $I_2 = -1A$. Determine the z-parameters of two-port network.

Question 7 (15 Marks)



A two-port network has a-parameters as follows:

$a_{11} = 4\times10^{-5}$, $a_{12} = 20\ \Omega$

$a_{21} = 10^{-5}S$, $a_{22} = -2\times10^{-2}$

Fig. 4

Vg is sinusoid with amplitude of 100mV and internal impedance of 50Ω. $Z_L = 2k\Omega$.

a. Calculate the average power delivered to the load resistor. (9 Marks)
b. Calculate the load resistance of max average power. (6 Marks)

Question 8 (10 Marks)

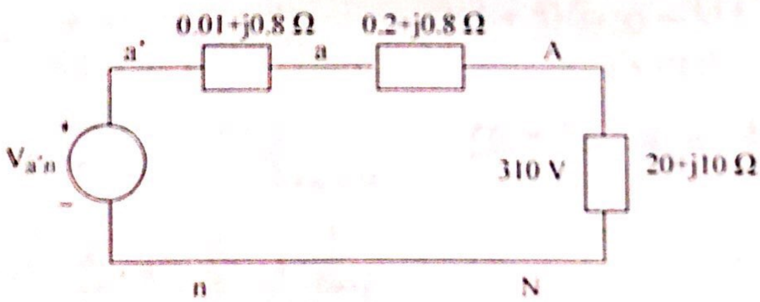


Fig. 5

The phase voltage at the terminals of a balanced three phase Y-connected load is given in Fig. 5. The phase sequence is positive.

a. Calculate line currents I_{aA}, I_{bB}, I_{cC} (5 Marks)
b. Calculate line voltages at the source V_{ab}, V_{bc} abd V_{ca}. (5 Marks)

Jan 16, 2018

Final Exam Solution
principles of EE2.

Answer to question 1

a) $F(s)=\dfrac{10s^2+28s+36}{(s+2)(s^2+2s+10)} \Rightarrow \quad s^2+2s+10=(-1+j3)(-1-j3)$

$$=\frac{K_1}{s+2}+\frac{K_2}{[s-(-1+j3)]}+\frac{K_2^*}{[s-(-1-j3)]}$$

$$K_1=\left.\frac{10s^2+28s+36}{(s^2+2s+10)}\right|_{s=-2}=\frac{40-56+36}{4-4+10}=\frac{20}{10}=2$$

$$K_2=\left.\frac{10s^2+28s+36}{(s+2)(s+1+j3)}\right|_{s=-1+j3}=4$$

$$\Rightarrow F(s)=\frac{2}{s+2}+\frac{4}{s-(-1+j3)}+\frac{4}{s-(-1-j3)}$$

$$\Rightarrow f(t)=\left[2e^{-2t}+8e^{-t}\cos 3t\right]u(t)$$

5

b) $F(s)=\dfrac{5s^2+9s+4}{s^2(s+4)}=\dfrac{K_1}{s^2}+\dfrac{K_2}{s}+\dfrac{K_3}{s+4}.$

$$K_1=\left.\frac{5s^2+9s+4}{(s+4)}\right|_{s=0}=1$$

$$K_2=\frac{d}{ds}\left.\left(\frac{5s^2+9s+4}{s+4}\right)\right|_{s=0}=\left.\frac{(10s+9)(s+4)-(5s^2+9s+4)}{(s+4)^2}\right|_{s=0}=\frac{36-4}{16}=2.$$

$$K_3=\left.\frac{5s^2+9s+4}{s^2}\right|_{s=-4}=\frac{80-36+4}{16}=3$$

$$\Rightarrow F(s)=\frac{1}{s^2}+\frac{2}{s}+\frac{3}{s+4}$$

$$f(t)=\left[t+2+3e^{-4t}\right]u(t)$$

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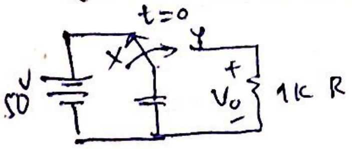
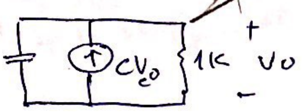
Answer to question 2



* Initial voltage: $V_{co}=50^V$ 3

* $t>0$

a)



b) $\Rightarrow V_o(s)=CV_{co}\times\left(\dfrac{\frac{1}{sC}\cdot 10^3}{\frac{1}{sC}+10^3}\right)$

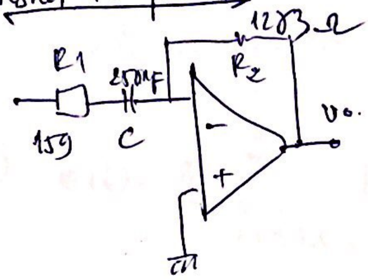
$$=CV_{co}\times\left(\frac{10^3}{1+sC10^3}\right)$$

or $V_o(s)=\dfrac{CV_{co}}{C10^3}\left(\dfrac{10^3}{s+\frac{1}{C10^3}}\right)=\dfrac{50}{s+\frac{1}{5\,10^{-7}\times10^3}}=\dfrac{50}{s+\frac{10^4}{5}}=\dfrac{50}{s+2000}$ 9

c) $v_o(t)=50e^{-2000t}u(t)$ 3

Answer to question 3

a)



$\omega_c = 2\pi f_c = 2\pi \times 4000 = 8000\pi$ rad/s

$\omega_c = \frac{1}{CR_1} = \frac{1}{250\times10^{-9}\, R_1} = 8000\pi$

$\Rightarrow R_1 = \frac{10^9}{250\times 8000\times\pi} = 159\,(\Omega)$

10

~~20 log(R2/R1)~~ $\frac{R_2}{R_1} = 8 \Rightarrow R_2 = 8R_1 = 1273\,\Omega$

b) ω_c doesn't change, gain changes

5

Answer to question 4

a) polynomial $s^2+\sqrt{2}s+1$ for $n=2$ $\rightarrow b=\sqrt{2}$ & $\frac{1}{C_1C_2}=1$, $C_1=\frac{2}{b}=\sqrt{2}$ (F)

$C_2=\frac{1}{C_1}=\frac{1}{\sqrt{2}}$ (F)

$R' = 2000\,\Omega \Rightarrow k_m = 2000$

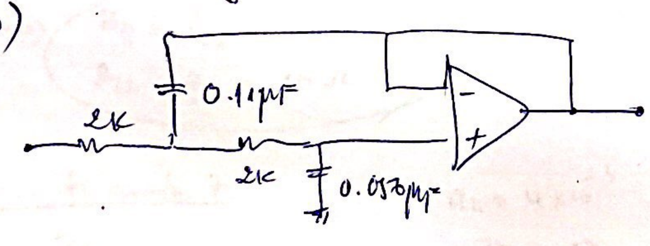
$k_f = \frac{\omega_0'}{\omega_0} = \frac{2\pi\times 1000}{1} = 2000\pi$

$C_1' = \frac{C_1}{k_m k_f} = \frac{\sqrt{2}}{2000\times 2000\pi} = \cancel{11.25\,\mu F}$ $0.11\,\mu F$

$C_2' = \frac{C_2}{k_m k_f} = \frac{1/\sqrt{2}}{2000\times 2000\pi} = 0.056\,\mu F$

10

b)



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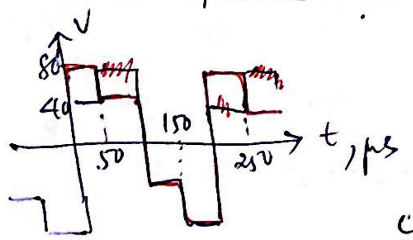
Answer to question 5



a) $T = 200\,\mu s \Rightarrow \omega_0 = \frac{2\pi}{T} = \frac{2\pi}{200\,\mu s} = 31{,}416$ rad/s

b) $a_v = 0$

c) ~~for k odd only~~

$a_k = \frac{4}{T}\int_0^{T/4} 40\cos\frac{2\pi kt}{T}\,dt + \frac{4}{T}\int_{T/4}^{T/2} 80\cos\frac{2\pi kt}{T}\,dt = \frac{160}{T}\frac{T}{2\pi k}\sin\frac{2\pi kt}{T}\Big|_0^{T/4} + \frac{320}{T}\frac{T}{2\pi k}\sin\frac{2\pi kt}{T}\Big|_{T/4}^{T/2}$

$= \frac{80}{\pi k}\sin\frac{\pi k}{2} + \frac{160}{\pi k}\left(\sin\pi k - \sin\frac{\pi k}{2}\right)$

$= -\frac{80}{\pi k}\sin\frac{\pi k}{2}$

$a_k = 0$ (odd function)

$$b_K = \frac{4}{T}\int_0^{T/4} 80 \sin\frac{2\pi k t}{T}\,dt + \frac{4}{T}\int_{T/4}^{T/2} 40 \sin\frac{2\pi k t}{T}\,dt = \frac{160}{\pi K}\left[1-\cos\frac{\pi K}{2}\right] + \frac{80}{\pi K}\left[\cos\frac{\pi K}{2} - \cos\frac{\pi}{K}\right]$$

$$= -\frac{80}{\pi K}(0-1) + \frac{160}{\pi K}(-1-0) = \frac{240}{\pi K}$$

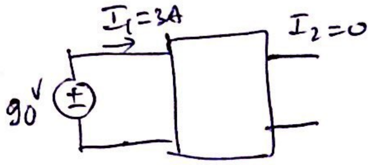
d) $$v(t) = \frac{80}{\pi}\sum_{n=1,3,5..}^{\infty}\left(-\frac{1}{n}\sin\frac{n\pi}{2}\cos n\omega_0 t + \frac{3}{n}\sin n\omega_0 t\right) \text{ (V)}$$

Answer to question 6

$Z_{11} = Z_{22}$

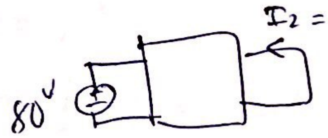
$Z_{12} = Z_{21}$

1st experiment:



$\Rightarrow$ $90 = Z_{11} \times 3 + 0 \Rightarrow Z_{11} = \frac{90}{3} = 30\,\Omega$

2nd experiment:



$$\begin{cases} 80 = 30 I_1 - Z_{12} \\ 0 = Z_{12} I_1 - 30 \end{cases}$$

$$\Leftrightarrow \begin{cases} I_1 = \frac{30}{Z_{12}} \\ 80 = 30\frac{30}{Z_{12}} - Z_{12} \end{cases} \Leftrightarrow 80 Z_{12} = 900 - Z_{12}^2 \Leftrightarrow Z_{12}^2 + 80 Z_{12} - 900 = 0$$

$\Delta = 6400 + 3600 = 10{,}000$

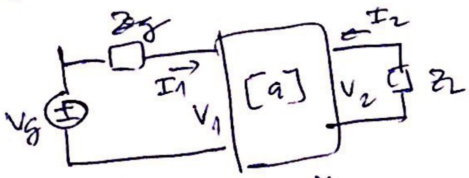
$\Rightarrow Z_{12} = \frac{-80+100}{2} = 10\,\Omega$

$$\Rightarrow \begin{matrix} Z_{11} = Z_{22} = 30\,\Omega \\ Z_{12} = Z_{21} = 10\,\Omega \end{matrix}$$

Answer to question 7:

$a_{11} = 4\times10^{-3}$, $a_{12} = 20$, $a_{21} = 10^{-5}$, $a_{22} = -2\times10^{-2}$.

$Z_g = 50$, $Z_L = 2000$, $V_g = 100\,mV$

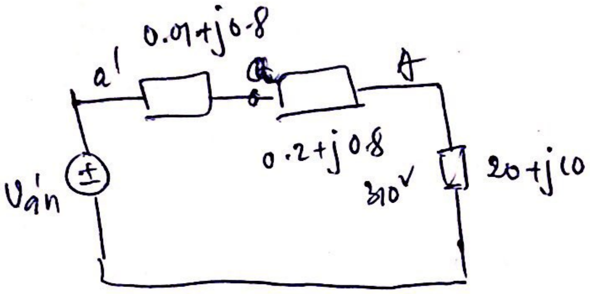


a) $$I_2 = \frac{-V_g}{a_{11}Z_L + a_{12} + a_{21}Z_g Z_L + a_{22}Z_g} = -3.571\text{ mA.}$$

$$P_L = \frac{1}{2}\left(3.571\times10^{-3}\right)^2(2000) = 12{,}8\text{ mW}$$ 9

b) $$Z_{th} = \frac{a_{12} + a_{22}Z_g}{a_{11} + a_{21}Z_g} = 4.2K$$ 6

Answer to question 8



a) $\bar{I}_{aA} = \dfrac{310}{20+j10} = 12.4 - j6.2 = 13.86\angle -26°56$

$I_{\bar{b}B} = 13.86 \angle -26°56 - 120° = -146.56°$

$I_{\bar{c}B} = 13.86 \angle -26°.56 + 120° = 93°44$

b) $\bar{V}_{aN} = \bar{I}_{aA} \times (0.2 + j0.8 + 20 + j10) = 318.56 \angle 1.56°$

$\bar{V}_{bN} = 318.56 \angle 1.56° - 120° = -118°.44$

$\bar{V}_{ab} = \bar{V}_{an} - \bar{V}_{bN} = \underbrace{\sqrt{3} \times 318.56}_{550} \angle +30° + 1.56 = 31.56°$ 5

$\bar{V}_{bc} = 550 \angle 31°.56 - 120 = -88°44$

$\bar{V}_{cA} = 550 \angle 31.56 + 120 = 151.56$.