BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI (RAJASTHAN)

I Sem./II Sem./Summer Term 200 - 200

Sec. No.

TEST/~~QUIZ~~ Mid Semester

Instructor's Name

ID No

Name

Course No. EEE F111

Course Title Electrical Sciences

Date 10/10/2017

Day Tuesday

No. of Supplementary copies attached : —

Question No.	Marks obtained	Student's request for rechecking with remarks	Examiner's remarks
1.	20		
2.	20		
3.	25		
4.	15+25		
5.			
6.			
7.			
8.			
Total	105 (in figures)	(in words)	

INSTRUCTIONS TO CANDIDATES

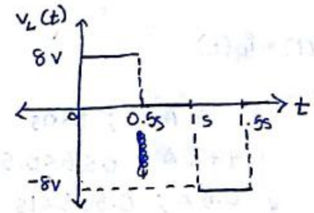
Examiner's Signature

(1) Write clearly and legibly. (2) Enter all the required details on the cover of every answer book. (3) The question number given in the answersheet by the student while answering the question should be the same as in the question paper. (4) Start answering every question from a new page. (5) Write on both sides of the sheet in the answer book. Rough work if any, should be done at the bottom of the page. Finally cross it out and draw a horizontal line to separate it from the rest of the material on the page. (6) Any answer crossed out by the student will not be examined by the examiner. (7) A supplementary answer book should not be asked for until the first answer book is filled up. (8) No sheet should be torn from the answer book. (9) Use of any unfair means will make the candidate liable to disciplinary action. (10) No paper should be brought in the examination hall for scribbling on. (11) A student should not leave the examination hall without handing over the answer book to invigilator on duty.

1. $i_L(t) = \begin{cases} 0\ A\ ; & t < 0s \\ t\ A\ ; & 0 \le t < 0.5s \\ 0.5\ A & 0.5 \le t < 1s \\ (1.5 - t) A\ ; & 1 \le t \le 1.5s \\ 0\ A\ ; & t \geq 1.5\ s \end{cases}$

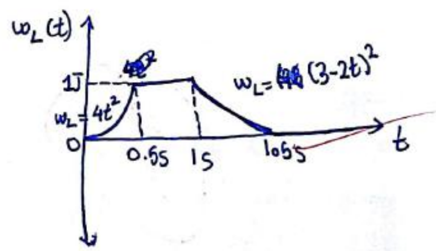
(a) $v(t) = \dfrac{L\, di_L(t)}{dt}$ $[L = 8\ H]$

$= \begin{cases} 0\ v\ ; & t < 0s \\ 8v\ ; & 0 \le t < 0.5s \\ 0v\ ; & 0.5 \le t < 1s \\ -8v\ ; & 1 \le t \le 1.5s \\ 0v\ ; & t \geq 1.5s \end{cases}$

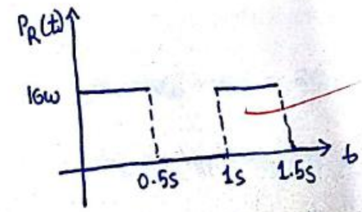


(b) $w_L(t) = \frac{1}{2} L[i_L(t)]^2$

$= \begin{cases} 0\ J\ ; & t < 0s \\ 4t^2\ J\ ; & 0 \le t < 0.5s \\ 1\ J\ ; & 0.5 \le t < 1s \\ 4(1.5 - t)^2\ J\ ; & 1 \le t < 1.5s \\ 0\ J\ ; & t \geq 1.5s \end{cases}$

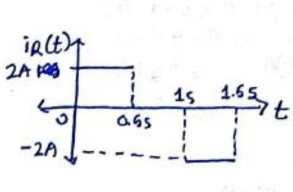


(c) $P_R(t) = \dfrac{[v(t)]^2}{R}$ $= \begin{cases} 0\ W\ ; & t < 0s \\ 16\ W\ ; & 0 \le t < 0.5s \\ 0\ W\ ; & 0.5 \le t < 1s \\ 16\ W\ ; & 1 \le t < 1.5s \\ 0W\ ; & t \geq 1.5s \end{cases}$



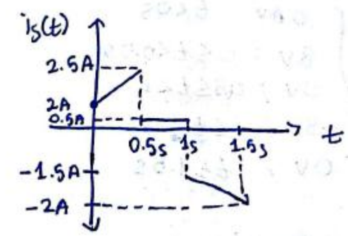
(d) $i_R(t) = \frac{v_R(t)}{R}$

$$= \begin{cases} 0\,A & ; t<0s \\ 2A & ; 0\le t<0.5s \\ 0\,A & ; 0.5\le t<1s \\ -2A & ; 1\le t<1.5s \\ 0\,A & ; t\geq 1.5s \end{cases}$$



(e) $i_S(t) = i_L(t) + i_R(t)$

$$= \begin{cases} 0\,A & ; t<0s \\ t+2\,A & ; 0\le t<0.5s \\ 0.5\,A & ; 0.5\le t<1s \\ -(t+0.5)A & ; 1\le t<1.5s \\ 0\,A & ; t\geq 1.5s \end{cases}$$



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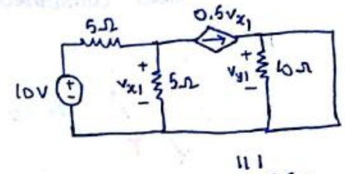
2. Considering contribution of 10V source

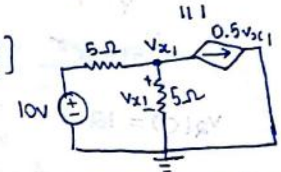
$\boxed{v_{y1} = 0\ V}$

[in parallel with short circuit]



KCL at node v_{x1}

$[0.5v_{x1} = \frac{v_{x1}}{2}]$



$$\frac{v_{x1}-10}{5} + \frac{v_{x1}}{5} + \frac{v_{x1}}{2} = 0$$

~~Power consumed by R~~

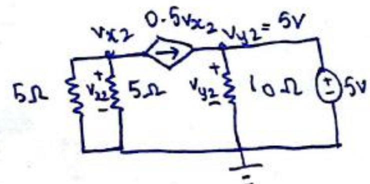
~~$R_L = v_{x1} \times$~~

$$\frac{2v_{x1}}{5} + \frac{v_{x1}}{2} = 2$$

$$\frac{9v_{x1}}{10} = 2$$

$$\boxed{v_{x1} = \frac{20}{9}\ V}$$

Considering contribution of 5V source



KCL at node v_{x2}

$$\frac{v_{x2}}{5} + \frac{v_{x2}}{5} + 0.5v_{x2} = 0$$

$\boxed{v_{x2} = 0\ V}$

~~KCL at node vy2~~

$\boxed{v_{y2} = 5V}$

$v_x = v_{x1} + v_{x2} = \frac{20}{9}\ V$

$v_y = v_{y1} + v_{y2} = 5\ V$

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Power consumed $= (v_x - v_y) \times 0.05 v_x$

$= \left(\frac{20}{9} - 5\right) \times \frac{10}{9}$

$= \frac{-250}{81}$ W

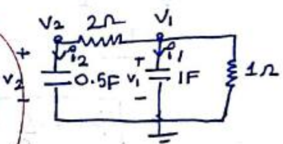
3.

~~$v_1(0) = 12$ V~~ $v_2(0) = 12$ V

For $t \geq 0$

KCL at v_1

$\frac{v_1}{1} + i_1 + i_2 = 0$ —①



$i_2 = \frac{v_1 - v_2}{2} = \frac{1}{2}\frac{dv_2}{dt}$ —② $\left[i = C\frac{dv}{dt}\right]$

$v_1 = v_2 + \frac{dv_2}{dt}$ —③

$i_1 = \frac{dv_1}{dt}$ —④

In ①,

$v_1 + \frac{dv_1}{dt} + \frac{v_1 - v_2}{2} = 0 \Rightarrow \frac{3v_1}{2} + \frac{dv_1}{dt} = \frac{v_2}{2}$

$\frac{3}{2}\left[v_2 + \frac{dv_2}{dt}\right] + \frac{d}{dt}\left[v_2 + \frac{dv_2}{dt}\right] = \frac{v_2}{2}$

~~$2v_1 + \frac{dv_1}{dt} = v_2$~~

~~$2\left[v_2 + \frac{dv_2}{dt}\right] + \frac{d}{dt}\left[v_2 + \frac{dv_2}{dt}\right] = v_2$~~ [from ③]

$\frac{d^2 v_2}{dt^2} + \frac{5}{2}\frac{dv_2}{dt} + v_2 = 0$

$$\frac{d^2v_2}{dt^2} + \frac{3dv_2}{dt} +$$

3

$$2\alpha = \frac{5}{2} \qquad \omega_n^2 = 1$$

$$\alpha = \frac{5}{4} \qquad \omega_n = 1 \text{ rad/s}$$

$\alpha > \omega_n \Rightarrow$ Overdamped response

3

$$S_1 = -\alpha - \sqrt{\alpha^2-\omega_n^2} = -\frac{5}{4} - \sqrt{\frac{25}{16}-1}$$

$$= -\frac{5}{4} - \frac{3}{4} = -2$$

$$S_2 = -\alpha + \sqrt{\alpha^2-\omega_n^2} = -\frac{5}{4} + \sqrt{\frac{25}{16}-1}$$

$$= -\frac{5}{4} + \frac{3}{4} = -\frac{1}{2}$$

$$v_2(t) = A_1 e^{S_1 t} + A_2 e^{S_2 t}$$

$$= A_1 e^{-2t} + A_2 e^{-t/2} \text{ V}$$

$v_2(0) = 12\text{ V} \Rightarrow A_1 + A_2 = 12$ —①

$$v_1(t) = v_2 + \frac{dv_2}{dt} = A_1 e^{-2t} + A_2 e^{-t/2} - 2A_1 e^{-2t} - \frac{A_2}{2} e^{-t/2}$$

$$= -A_1 e^{-2t} + \frac{A_2}{2} e^{-t/2}$$

$v_1(0) = 12\text{ V} \Rightarrow -A_1 + \frac{A_2}{2} = 12$ —②

3

$$A_1 = -4 \qquad A_2 = 16$$

$$v_2(t) = -4e^{-2t} + 16e^{-t/2} \text{ V} \qquad v_1(t) = 4e^{-2t} + 8e^{-t/2} \text{ V}$$

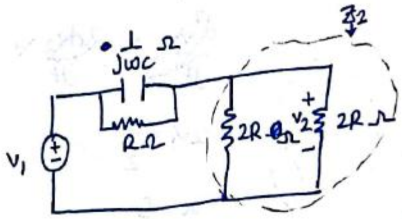
$$v_1(t) = \begin{cases} 12 \text{ V}; & t < 0\text{s} \\ 4e^{-2t} + 8e^{-t/2} \text{ V}; & t \geq 0\text{s} \end{cases}$$

$$v_2(t) = \begin{cases} 12 \text{ V}; & t < 0\text{s} \\ -4e^{-2t} + 16e^{-t/2} \text{ V}; & t \geq 0\text{s} \end{cases}$$

4. (A)

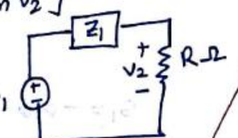
$Z_1 = Z_C \,||\, Z_R$

$= \dfrac{R\left(\frac{1}{j\omega C}\right)}{R + \frac{1}{j\omega C}} = \dfrac{R}{1 + j\omega CR}\ \Omega$



$Z_2 = 2R \,||\, 2R = \dfrac{2R \times 2R}{4R} = R\ \Omega$ [voltage across it will remain V_2] |||

By voltage division



$V_2 = \dfrac{R}{R + Z_1} \times V_1$

$V_2 = \dfrac{R}{R + \frac{R}{1 + j\omega CR}} \times V_1 = \dfrac{R}{\frac{R + j\omega CR^2 + R}{1 + j\omega CR}} V_1$

$= \dfrac{\cancel{R}(1 + j\omega CR)}{\cancel{R}[2 + j\omega CR]} V_1$

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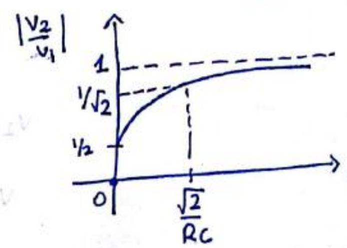
$\dfrac{V_2}{V_1} = \dfrac{1 + j\omega CR}{2 + j\omega CR}$

$H(j\omega) = \left|\dfrac{V_2}{V_1}\right| = \sqrt{\dfrac{1 + \omega^2 C^2 R^2}{4 + \omega^2 C^2 R^2}}$



$H(0) = \dfrac{1}{2} \qquad H(\infty) = 1$

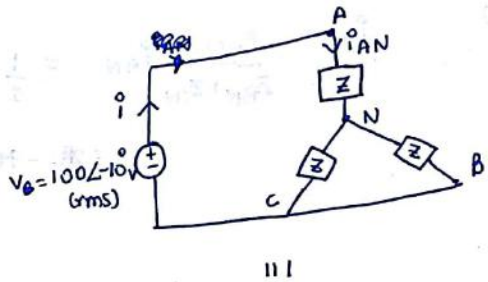
$H(j\omega_c) = \dfrac{1}{\sqrt{2}} \times H(\infty) = \dfrac{1}{\sqrt{2}} = \sqrt{\dfrac{1 + \omega_c^2 R^2 C^2}{4 + \omega_c^2 C^2 R^2}}$

$4 + \omega_c^2 C^2 R^2 = 2 + 2\omega_c^2 R^2 C^2$

$2 = \omega_c^2 R^2 C^2 \Rightarrow \boxed{\omega_c = \dfrac{\sqrt{2}}{RC}}$ rad/s

By current division,

(B) $i_{BN} = \dfrac{Z_{CN}}{Z_{CN}+Z_{BN}} \, i_{AN} = \dfrac{Z}{Z+Z} \, i_{AN}$



$3\angle -70° = \dfrac{i_{AN}}{2}$

$i = i_{AN} = 6\angle -70°$ A (rms)

(a) $\theta = \angle v - \angle i$

$= (-10°) - (-70°)$

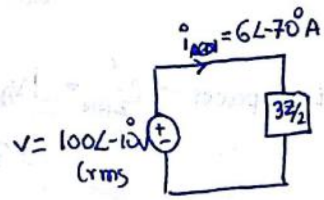
$= 60°$

P.F $= \cos\theta = \cos 60°$

$= 0.5$

(b) $Z_{eq} = Z_{AN} + (Z_{BN} \| Z_{CN})$

$= Z + \dfrac{Z \times Z}{Z+Z} = \dfrac{3Z}{2}$



$\dfrac{3Z}{2} = \dfrac{V}{i_{AN}} = \dfrac{100\angle -10°}{6\angle -70°}$

$\boxed{Z = \dfrac{100}{9} \angle 60° \ \Omega}$

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(c) $\dot{i}_{CN} = \frac{Z_{BN}}{Z_{BN}+Z_{CN}} \dot{i}_{AN} = \frac{1}{2} \dot{i}_{AN}$

$= 3\angle -70^\circ A$ (rms)

$V_{AN} = \dot{i}_{AN} \times Z$

$= \cancel{\frac{200}{3} \angle -180^\circ} \quad 6\angle -70^\circ \times \frac{100}{9} \angle 60^\circ$

$= \frac{200}{3} \angle -10^\circ$ V (rms)

$\cancel{\theta = \angle V_{AN} - \angle i_{AN}} = 60^\circ$

$V_{BN} = \dot{i}_{BN} \times Z$

$= 3\angle -70^\circ \times \frac{100}{9} \angle 60^\circ$

$= \frac{100}{3} \angle -10^\circ$ V (rms)

Active power $\rightarrow P_{Z_{AN}} = |V_{AN}||\dot{i}_{AN}| \cos\theta$ $[\theta = 60^\circ]$

$= \frac{200}{3} \times 6 \times \frac{1}{2}$

$= 200$ W

Active power $\rightarrow P_{Z_{BN}} = |V_{BN}||i_{BN}| \cos\theta$

$= \frac{100}{3} \times 3 \times \frac{1}{2}$

$= 50$ W

Reactive power $\rightarrow P'_{Z_{AN}} = |V_{AN}||i_{AN}| \sin\theta = \frac{200}{3} \times 6 \times \frac{\sqrt{3}}{2}$

$= 346.41$ VAR

Reactive power $\rightarrow P'_{Z_{BN}} = |V_{BN}||\dot{i}_{BN}| \sin\theta$

$= \frac{100}{3} \times 3 \times \frac{\sqrt{3}}{2}$

$= 86.6$ VAR

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As $V_{BN} = V_{CN}$, $i_{BN} = \dot{i}_{CN}$, $Z_{BN} = Z_{CN} = Z$

By symmetry,

$\therefore$ Active power $\rightarrow P_{Z_{CN}} = P_{Z_{BN}} = 50$ W

Reactive power $\rightarrow P'_{Z_{CN}} = P'_{Z_{BN}} = 86.6$ VAR

Active→ $P_{source} = -|v||i|\cos\theta$

$= -100 \times \cancel{6}^{3} \times \frac{1}{\cancel{2}}$

$= -300\ W$

Reactive→ $P'_s = -|v||i|\sin\theta$

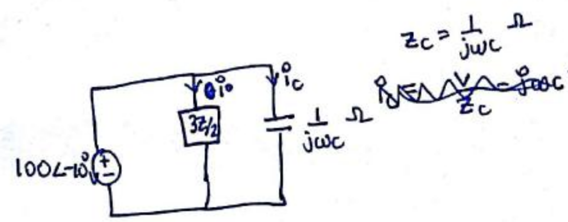
$= -100 \times 6 \times \frac{\sqrt{3}}{2}$

$= -519.62\ VAR$

(d) $i_c = \frac{V}{Z_c} = j\omega C V$

$= j(2\pi \times 50) C \times 100\angle -10^\circ)$

$= 31415.93C \angle 80^\circ\ A$

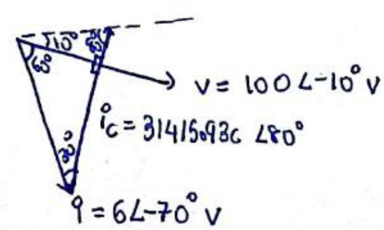


By phasor

$\sin 60^\circ = \frac{|i_c|}{|i|}$

$\frac{\sqrt{3}}{\cancel{2}} = \frac{31415.93C}{\cancel{6}\,3}$

$\boxed{C = 165.4\ \mu F}$



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