KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
ELECTRICAL ENGINEERING DEPARTMENT

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| COURSE | EE#205 |
| SECTION | 1,2,3,4 |
| EXAM | MAJOR I |
| PLACE | |
| DATE | March 25,2008 |
| TIME | 8:30 P.M. |
| INSTRUCTOR | |

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STUDENT NAME -------------------------------

STUDENT I.D. -------------------------------

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| PROBLEM 1 | |
| PROBLEM 2 | |
| PROBLEM 3 | |
| TOTAL | |

Q-1

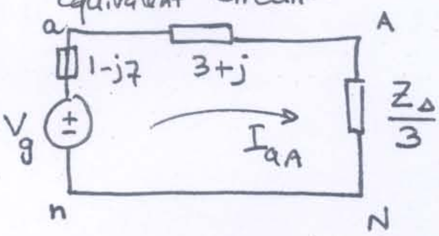
For a positive sequence 3 phase balanced $Y-\Delta$ network, the open circuit terminals voltage of the generator of phase a-n is given by $V_g = 360\angle 0^o$ volts. The phase BC at the load has a voltage $V_{BC} = 300\angle -105^o$. Given that: $Z_g = 1\text{-}j7$ and $Z_{line} = 3+j1$, find:

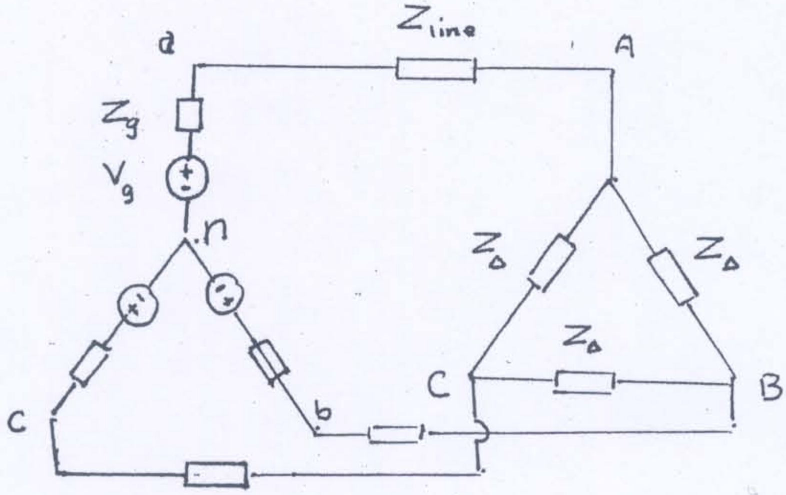
1- The line current $I_{aA}$.
2- The load impedance per phase $Z_\Delta$.
3- The total complex power delivered to the three loads.

$$V_{BC} = V_{AB}\angle -120 = 300\angle -105^\circ$$

$$\therefore V_{AB} = 300\angle 15^\circ \quad (1.5)$$

Equivalent Circuit




$$V_{AB} = \sqrt{3}\, V_{AN}\angle 30^\circ$$

$$\Rightarrow V_{AN} = \frac{V_{AB}}{\sqrt{3}\angle 30^\circ} = \frac{300}{\sqrt{3}}\angle -15^\circ$$

$$= 173.2\angle -15^\circ \quad (1.5)$$

From KVL

$$I_{aA} = \frac{V_g - V_{AN}}{4-j6} = 27.43\angle 69.4^\circ \quad (2)\ (3)$$

$$\frac{Z_\Delta}{3} = \frac{V_{AN}}{I_{aA}} = \frac{173.2\angle -15}{27.43\angle 69.4}$$

$$= 6.313\angle -84.4^\circ$$

$$\therefore Z_\Delta = 18.939\angle -84.4^\circ$$

$$= 1.848 - j\,18.85\ \Omega$$

$$= R_\Delta - jX_\Delta \quad (3)$$

or $$Z_\Delta = \frac{V_{AB}}{I_{AB}} = \frac{300\angle 15^\circ}{15.836\angle 99.4^\circ}$$

$$= 18.939\angle -84.4^\circ$$

$$S = 3\, V_{AB}\, I_{AB}^*$$

$$I_{AB} = \frac{I_{aA}}{\sqrt{3}}\angle 30^\circ$$

$$= 15.836\angle 69.4^\circ + 30^\circ \quad (4)$$

$$= 15.836\angle 99.4^\circ$$

$$\therefore S = 3\left(300\angle 15\right)\left(15.836\angle 99.4^\circ\right)^*$$

$$= 14253\angle -84.4^\circ$$

$$= 1390.8 - j\,14184.9\ \text{VA}$$

Also

$$S = 3\left[|I_{AB}|^2 R_\Delta - j\,|I_{AB}|^2 X_\Delta\right]$$

$$= 3 * (15.836)^2 * 1.848$$

$$-j\,3 * (15.836)^2\, 18.85$$

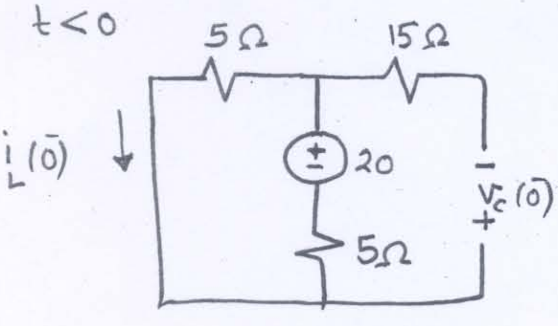
$$= 1390.8 - j\,14184.9\ \text{VA}$$

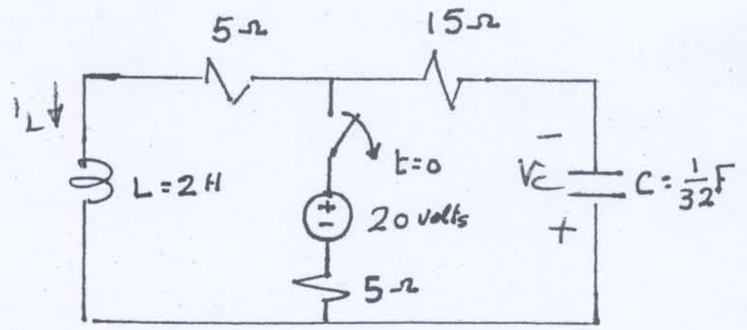
Q-2

The switch S is closed for a long time and then opened at t=0.

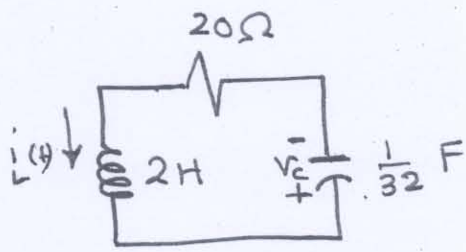
1- Find $V_C(0)$ and $I_L(0)$.
2- Obtain an expression for the inductor current $I_L(t)$ for any time $t > 0$.

$t<0$




$i_L(0^-) = \frac{20}{10} = 2\text{ A}$ (1.5) , $V_c(0^-) = 10 - 20 = -10\text{ V}$ (1.5)




Series RLC circuit

$$L\frac{di_L}{dt} + V_c + Ri_L = 0$$

$$L\frac{di_L}{dt} + \frac{1}{C}\int i_L(\tau)d\tau + Ri_L = 0$$

$$\therefore \frac{d^2 i_L}{dt^2} + \frac{R}{L}\frac{di_L}{dt} + \frac{1}{LC}i_L(t) = 0 \Rightarrow 2\alpha = \frac{R}{L} = 10$$

$$\omega_o^2 = \frac{1}{LC} = 16$$

$\alpha = 5$ , $\omega_o = 4 \Rightarrow \alpha > \omega_o \Rightarrow$ overdamped

Ch. Eqn : $s^2 + 10s + 16 = (s+2)(s+8) = 0$

$\therefore s = -2, -8$ (4)

$$i_L(t) = A_1 e^{-2t} + A_2 e^{-8t}$$

$$\frac{di_L}{dt}(t) = -2A_1 e^{-2t} - 8A_2 e^{-8t}$$

$V_L(0^+) + V_R(0^+) + V_c(0^+) = 0$

$V_L(0^+) = -40 + 10 = -30$

$\therefore \frac{di_L}{dt}(0^+) = \frac{-30}{2} = -15$

(2)

Using Initial Conditions

$A_1 + A_2 = 2 \Rightarrow 2A_1 + 2A_2 = 4$

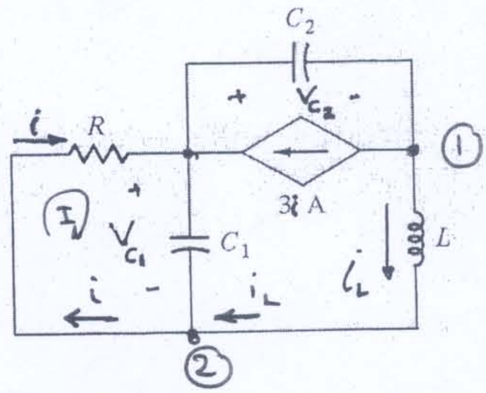
$-2A_1 - 8A_2 = -15$

$\therefore -6A_2 = -11 \Rightarrow A_2 = \frac{11}{6}$ , $A_1 = \frac{1}{6}$

$$\therefore i_L(t) = \frac{1}{6}e^{-2t} + \frac{11}{6}e^{-8t}$$

For the following circuit:

a) Find the **state equations**
b) Write them in a matrix form (**matrix state equation**)




KCL @ node 1

$$C_2 \frac{dv_{c2}}{dt} = 3i + i_L \quad — 1$$

KCL @ node 2

$$i_L + C_1 \frac{dv_{c1}}{dt} = i \quad — 2$$

KVL 2 Loop I

$$Ri + v_{c1} = 0 \quad — 3$$

KVL 2 loop II

$$v_{c2} + L\frac{di_L}{dt} - v_{c1} = 0 \quad — 4 \quad \Rightarrow \quad \boxed{\frac{di_L}{dt} = \frac{1}{L}v_{c1} - \frac{1}{L}v_{c2}}$$

from 3 $\Rightarrow$ $\boxed{i = -\frac{1}{R}v_{c1}}$

from 2 $\Rightarrow$ $\frac{dv_{c1}}{dt} = -\frac{1}{C_1}i_L + \frac{1}{C_1}i = -\frac{1}{C_1}i_L + \frac{1}{C_1}\left(-\frac{1}{R}v_{c1}\right)$

$$\therefore \boxed{\frac{dv_{c1}}{dt} = -\frac{1}{C_1}i_L - \frac{1}{RC_1}v_{c1}}$$

From 1 $\quad \frac{dv_{c2}}{dt} = \frac{1}{C_2}i_L + \frac{3}{C_2}i$

$$\boxed{\frac{dv_{c2}}{dt} = \frac{1}{C_2}i_L + \frac{3}{C_2}\left(-\frac{1}{R}v_{c1}\right) = \frac{1}{C_2}i_L - \frac{3}{RC_2}v_{c1}}$$

$$\frac{d}{dt}\begin{bmatrix} i_L \\ v_{c1} \\ v_{c2} \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{L} & -\frac{1}{L} \\ -\frac{1}{C_1} & -\frac{1}{RC_1} & 0 \\ \frac{1}{C_2} & \frac{-3}{RC_2} & 0 \end{bmatrix} \begin{bmatrix} i_L \\ v_{c1} \\ v_{c2} \end{bmatrix}$$