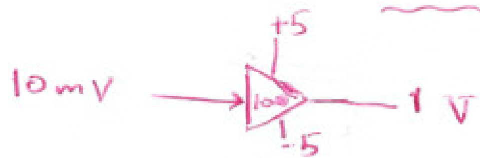
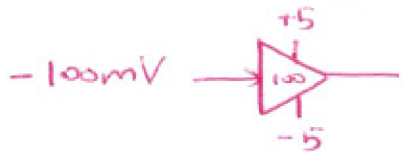
KEY Major Exam I EE205 031

Q1) a)

1. Supports voltage level control.
2. Reduces the amount of power loss in the lines.

b)





-5 V (because the amplifier saturates)

c) Overdamped.

d) Good, because the torque developed at the shaft of a three-phase motor is constant, which in turns means less vibration.

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Q 2)

a) $I_{AB} = \frac{V_{AB}\angle 0}{Z_{AB}} = \frac{13800\angle 0^\circ}{480 + j135} = \frac{13800\angle 0^\circ}{498.62\angle 15.71^\circ}$

$= 27.68\angle -15.71^\circ$ (-ve seq).

$I_{BC} = 27.68\angle 104.29^\circ$, $I_{CA} = 27.68\angle -135.71^\circ$

b) $\cos\theta = \cos\theta_{Y,I} = 0.963$ lagging.

c) $P_T = \sqrt{3}\, V_L I_L \cos\theta_p = 3 V_p I_p \cos\theta_p = 3(13.8k)(27.68)(0.963)$
$= 1.10355$ MW

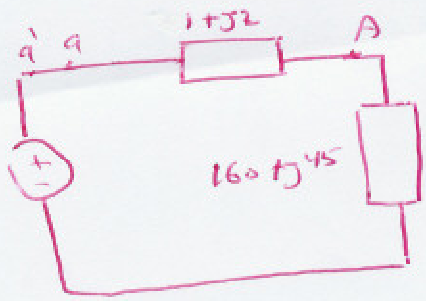
$Q_T = \sqrt{3}\, V_L I_L \cos\theta_p = 3 V_L I_L \sin\theta_p = 3(13.8k)(27.68)(0.27)$
$= 309.407$ kVAR

d)

$I_{aA} = I_{AB} * \sqrt{3}\angle +30^\circ = 47.94\angle 14.29^\circ$

$I_{bB} = 47.94\angle 134.29^\circ$, $I_{cC} = 47.94\angle -105.71$

e) We have to convert to Y $Z_Y = \frac{Z_\Delta}{3} = 160 + j45 = 166.21\angle -15.71$



$V_{an} = I_{aA}(Z_{line} + Z_{load})$
$= 47.94\angle 14.29\,(161 + j47)$

$|V_{an}| = 8040.5$ V

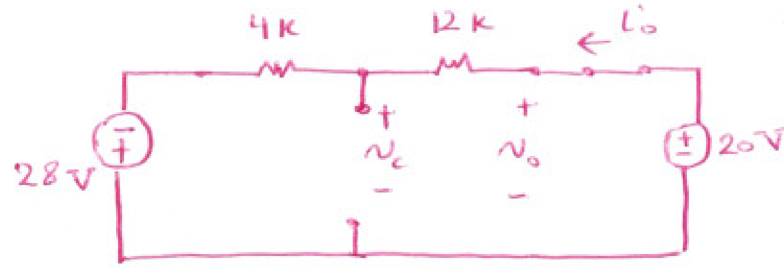
$|V_{ab}| = 13.926$ kV

f) $\text{losses} = 3|I|^2 R_{line} = 3(47.94)^2(1) = 6.894 \text{ kW}$

$$\eta = \frac{1.10355 \times 10^6}{1.10355 \times 10^6 + 6.894k} = 99.37\%$$

Q3)

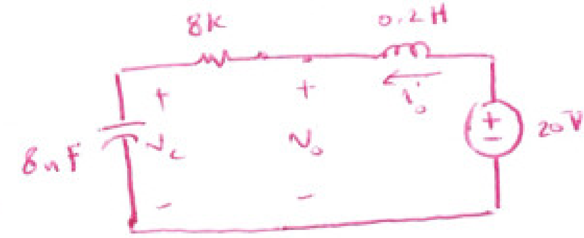
a) $v_o(0^-) = 20\,V$



$i_o(0) = \frac{+48}{16k} = 3\,mA$

$v_c(0) = 20 - 3\ (12) = -16\,V$

b) $24k \parallel 12k = 8k$



$\frac{dv_c(0^+)}{dt} = \frac{i_o(0^+)}{C} = \frac{3m}{8n} = 375000\ V/s$

By KVL

$L\frac{di_o}{dt} + 8k\,i_o + v_c - 20 = 0$

$\Rightarrow \frac{di_o}{dt}(0^+) = \frac{1}{0.2}\left(20 - v_c(0) - 8k\,i_o\right) = 5\ (20 + 16 - 24) = 60\ A/s$

$v_o(0^+) = v_c(0^+) + 8k\,i_o(0^+) = -16 + 24 = 8\,V$

c) $\alpha = \frac{R}{2L} = \frac{8000}{2\times 0.2} = 20\,000$ $\qquad \alpha^2 = 400\times 10^6$

$\omega_o^2 = \frac{1}{LC} = \frac{10^9}{1.6} = 625\times 10^6$ $\qquad \alpha^2 < \omega_o^2$ underdamped.

$s_{1,2} = -20\,000 \pm j\,15\,000$ rad/s

d) $v_c(t) = V_F + B_1' e^{-20\,000t}\cos 15\,000t + B_2' e^{-20\,000t}\sin 15\,000t$

$V_f = v_c(\infty) = 20\,V$

$-16 = 20 + B_1' \Rightarrow B_1' = -36\,V$

$-20000\,B_1' + 15\,000\,B_2' = 375\,000$

$-20(-36) + 15\,B_2' = 375 \Rightarrow B_2' = -23\,V$

e) $i_s = c\dfrac{dv}{dt}$ by taking the derivative and * by c.

f) $v_o = v_c + (8K)\,i_o$

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Q4) a) By KVL (dependent source, C, L_1)

$$6 i_x + v_c - \frac{1}{4}\frac{di_1}{dt} = 0$$

$$\frac{di_1}{dt} = 24 i_x + 4 v_c \quad \text{—— (1)}$$

By KVL (dependent source, 2Ω, L_2)

$$\frac{1}{2}\frac{di_2}{dt} - 6 i_x - 2 i_x = 0$$

$$\frac{di_2}{dt} = 16 i_x \quad \text{—— (2)}$$

By KCL

$$\frac{1}{8}\frac{dv_c}{dt} + i_1 = i_x + i_2$$

$$\Rightarrow \frac{dv_c}{dt} = -8 i_1 + 8 i_2 + 8 i_x \quad \text{—— (3)}$$

By KVL

$$-v_s + 2 i_x + 6 i_x + v_c = 0$$

$$\Rightarrow 8 i_x = -v_c + v_s \Rightarrow i_x = \frac{1}{8}(v_s - v_c) \quad \text{—— (4)}$$

Substitut i_x in (1), (2) & (3)

$$\frac{di_1}{dt} = 3v_s - 3v_c + 4v_c = 3v_s + v_c$$

$$\frac{di_2}{dt} = 2v_s - 2v_c$$

$$\frac{dv_c}{dt} = -8 i_1 + 8 i_2 + v_s - v_c$$

$$\frac{d}{dt}\begin{bmatrix} i_1 \\ i_2 \\ v_c \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & -2 \\ -8 & 8 & -1 \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \\ v_c \end{bmatrix} + \begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix} v_s$$

b) $x_1([k+1]\Delta t) \approx x_1(k\Delta t) + [a_{11}x_1(k\Delta t) + a_{12}x_2(k\Delta t) + a_{13}x_3(k\Delta t)$
$+ b_1 w(k\Delta t)]\Delta t$

$\Delta t = 0.001\ s$ $\quad k=1$

$i_1(0.001) \approx i_1(0) + [v_c(0) + 3\ v_s(0)]\Delta t$

$= 0.9 + [10 + 90]\ 0.001$

$= 0.9 + 0.1 = 1\ A$