MECE 347 Final 2017-2018 fall

Q1

if $5 > V_{in}$ V_x open circuit
if $5 < V_{in}$ $V_x = -9$ Volt

} For IC399₁ (upper IC)

if $V_{in} > -5$ V_x open circuit
if $V_{in} < -5$ $V_x = -9$ Volt

} For IC399₂ (lower IC) → (2)

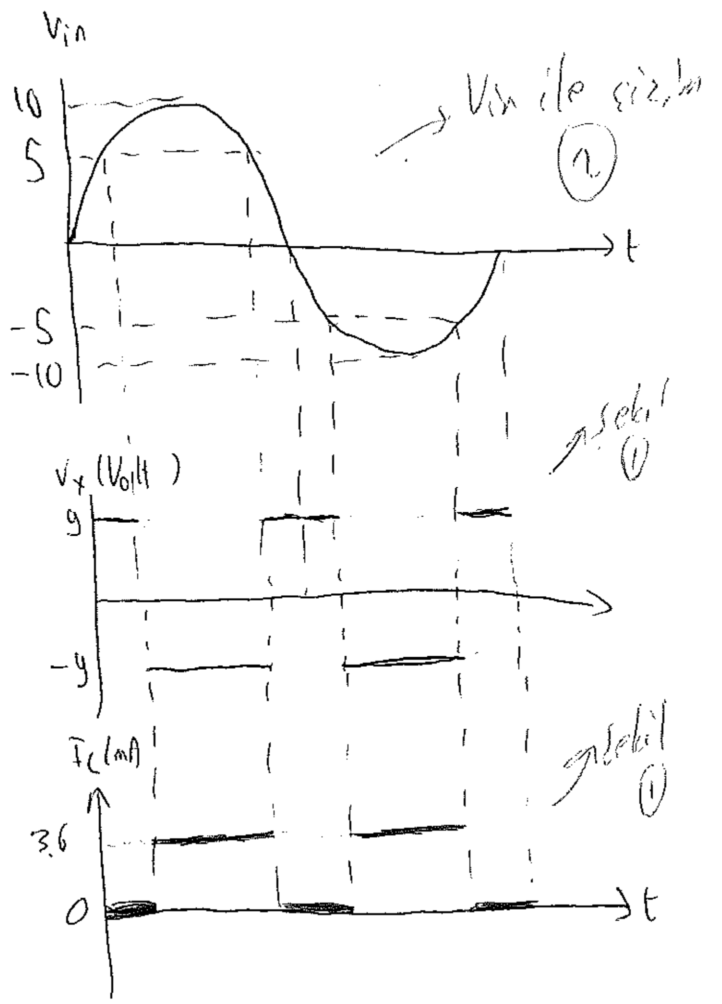
when $-5 < V_{in} < 5$ V_x open from both IC
if V_x is open for Bot IC 399 then $V_x = 9$ Volt

if $5 < V_{in}$ $V_x = -9$ $I_c = \frac{9-(-9)}{5000\,\Omega} = \frac{18}{5000\,\Omega} = 3.6\,mA$

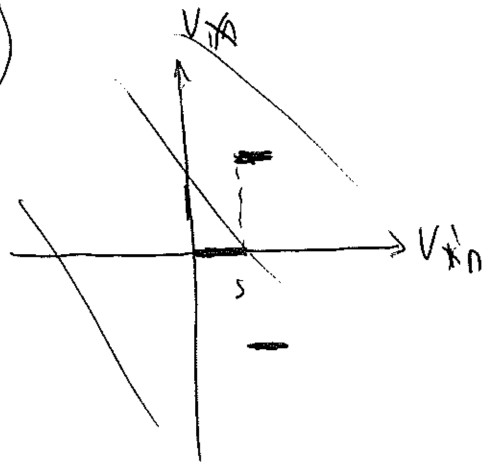
if $-5 < V_{in} < 5$ $V_x = 9$ $I_c = 0$

if $V_{in} < -5$ $V_x = -9$ $I_c = \frac{9-(-9)}{5000\,\Omega} = 3.6\,mA$

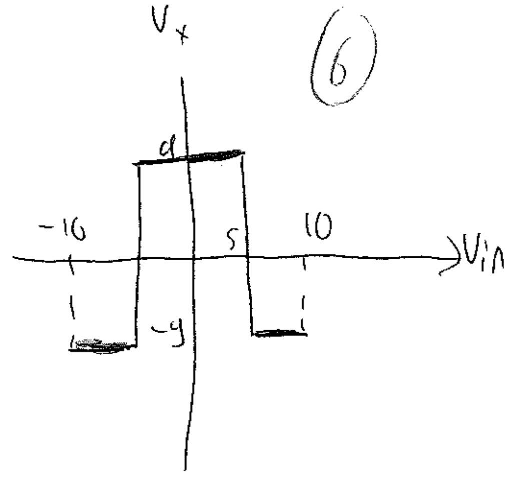
(a)



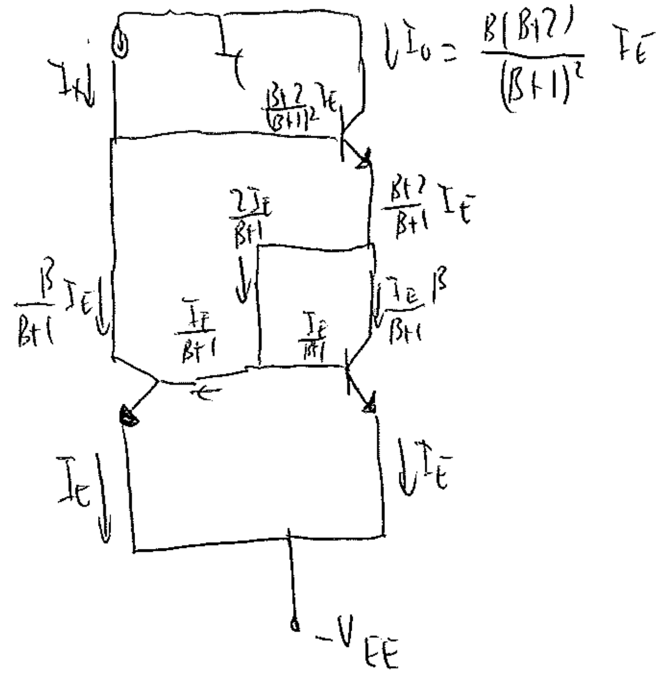
(b)



(b)



Q2



gidiş 8

$$I_o = \frac{\beta(\beta+2)}{(\beta+1)^2}$$

$$I_x = \left[\frac{\beta+2}{(\beta+1)^2} + \frac{\beta}{\beta+1}\right] I_E$$

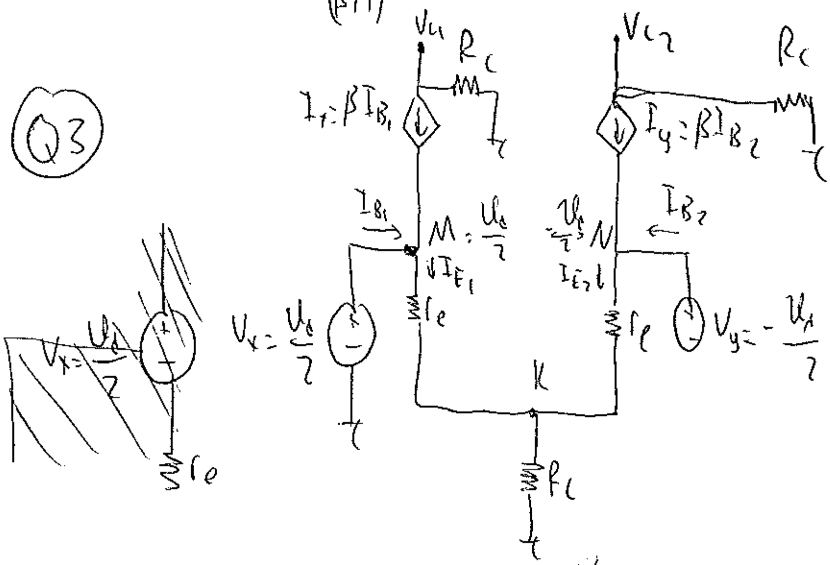
$$I_x = \frac{\beta+2+\beta(\beta+1)}{(\beta+1)^2} I_E$$

$$I_x = \frac{\beta^2+2\beta+2}{(\beta+1)^2} I_E$$

soruş 1

$$\frac{I_o}{I_x} = \frac{\frac{\beta(\beta+2)}{(\beta+1)^2}}{\frac{\beta^2+2\beta+2}{(\beta+1)^2}} = \frac{\beta^2+2\beta}{\beta^2+2\beta+2} = \frac{1}{1+\frac{2}{\beta^2+2\beta}} = \frac{1}{1+\frac{2}{\beta(\beta+2)}}$$

Q3



$$M = \frac{U_d}{2} \quad N = -\frac{U_d}{2}$$

(4)

$$\frac{M-K}{r_e} + \frac{N-K}{r_e} = \frac{K}{R_L}$$

$$\frac{\frac{U_d}{2}-K}{r_e} + \frac{-\frac{U_d}{2}-K}{r_e} = \frac{K}{R_L}$$

$$\frac{U_d}{2r_e} - \frac{U_d}{2r_e} = K\left[\frac{1}{R_L}+\frac{1}{r_e}+\frac{1}{r_e}\right]$$

$$0 \longrightarrow K = 0 \ (1)$$

$$I_{E_1} = \frac{\frac{U_d}{2}-K}{r_e} = \frac{U_d}{2r_e} \ (1) \qquad I_{B_1} = \frac{U_d}{2r_e(\beta+1)} \ (1) \qquad I_{C_1} = \frac{\beta U_d}{2r_e(\beta+1)} \ (1)$$

$$U_{c_1} = -R_c[I_{c_1}] = -R_c\left(\frac{\beta U_d}{(\beta+1)2r_e}\right) \ (1)$$

$$I_{E_2} = \frac{-\frac{U_d}{2}-K}{r_e} = -\frac{U_d}{2r_e} \ (1) \qquad I_{B_2} = -\frac{U_d}{2r_e(\beta+1)} \ (1)$$

$$I_{C_2} = -\frac{\beta U_d}{2r_e(\beta+1)} \ (1) \qquad U_{c_2} = -R_c I_{c_2} = -R_c\left(-\frac{\beta U_d}{2r_e(\beta+1)}\right) = \frac{U_d \beta R_c}{2r_e(\beta+1)} \ (1)$$

$$v_{c_1} - v_{c_2} = -\frac{R_c \beta v_d}{2r_e(\beta+1)} - \left(\frac{R_c \beta v_d}{2r_e(\beta+1)}\right)$$

$$v_{c_1} - v_{c_2} = -\frac{R_c \beta v_d}{r_e(\beta+1)}$$ (0.5)

$$\frac{v_{c_1} - v_{c_2}}{v_d} = \text{Gain}_{-diff} = -\frac{R_c \beta}{r_e(\beta+1)}$$ (0.5)

(Q4) $V_{in} = V_i + V_f$ (3 puan) $V_i A = V_o$ $\quad V_o \beta = V_f$

$$V_{in} = \frac{V_o}{A} + V_o \beta \qquad V_{in} = V_o\left[\frac{1}{A} + \beta\right] \qquad V_{in} = V_o\left[\frac{1+\beta A}{A}\right]$$

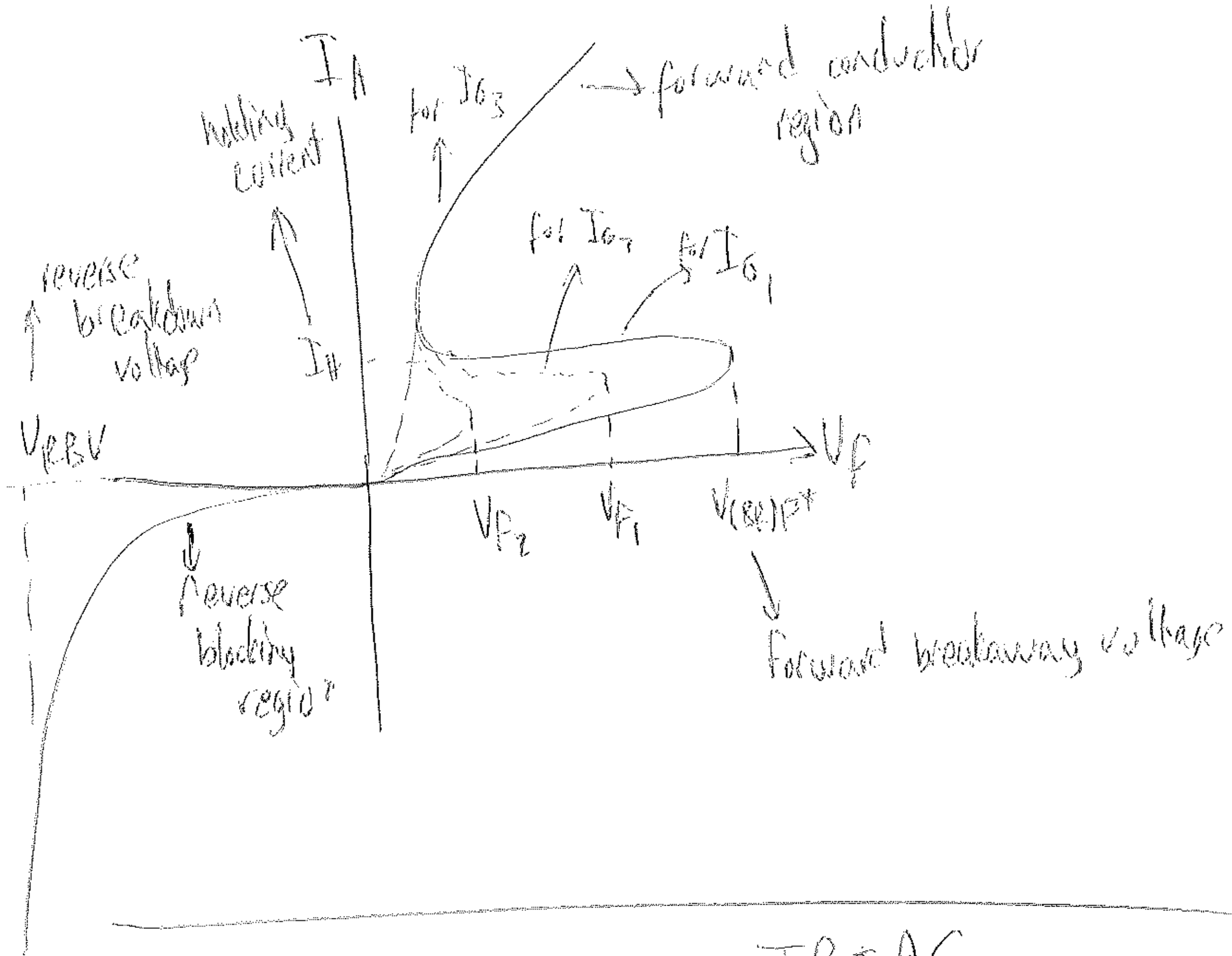
$$\frac{V_o}{V_{in}} = \frac{A}{1+\beta A}$$

(Q5) $V_f + V_{in} = V_i$ $\quad V_{in} = V_i - V_f$ $\quad V_i A = V_o$ $\quad V_o \beta = V_f$

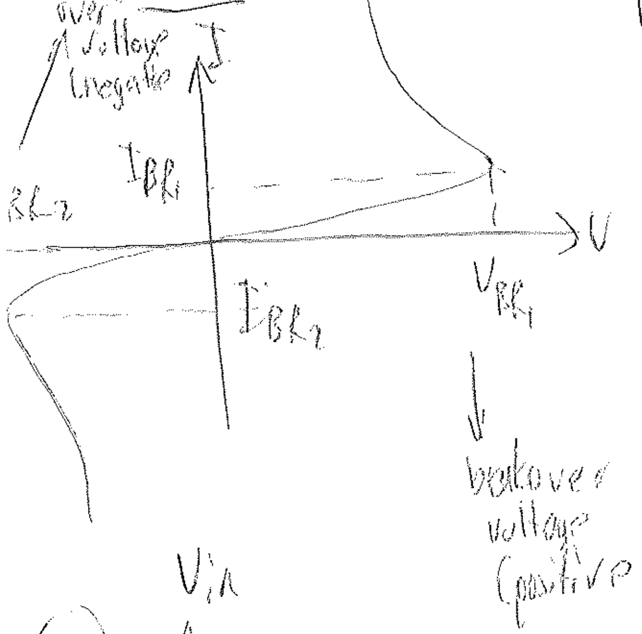
$$V_{in} = \frac{V_o}{A} - \beta V_o \qquad V_{in} = V_o\left[\frac{1}{A} - \beta\right] = V_o\left[\frac{1-A\beta}{A}\right]$$

$$\frac{V_o}{V_{in}} = \frac{A}{1-A\beta}$$

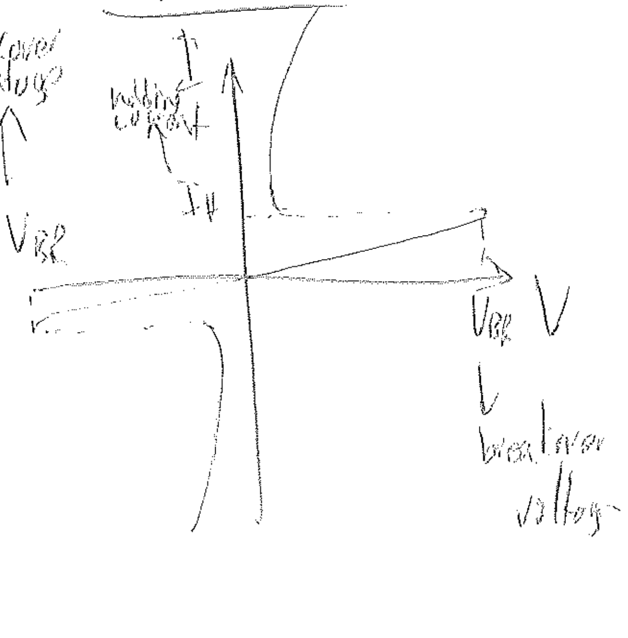
Q6 Silicon Controlled Rectifier



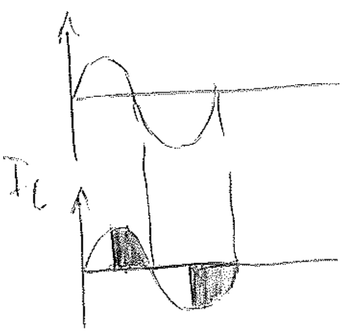
DIAC



TRIAC



Q7



Q8

$$V_i = V_{in} - V_f \qquad V_i = (\beta+1)\, i_b (r_e + R_E) \;(?)$$

(a) $$\frac{v_o}{v_i} = \frac{R_E}{r_e + R_E} = A \quad \text{(1 point)} \qquad K = -V_f$$

$$\frac{v_o - K}{R_1} = \frac{K}{R_2} + I_{in} \quad (3)$$

$$I_{in} = \frac{v_i}{R_B} + I_B \quad (2)$$

$$\frac{v_o - K}{R_1} = \frac{K}{R_2} + \frac{v_i}{R_B} + I_B \rightarrow \frac{v_o}{R_1} = K\left[\frac{1}{R_1} + \frac{1}{R_2}\right] + \frac{v_i}{R_B} + \frac{v_i}{(\beta+1)(r_e+R_E)} \quad (1)$$

$$K = -V_f$$

$$v_i = \frac{r_e + R_E}{R_E} v_o \qquad v_o = \underbrace{\frac{R_E}{r_e + R_E}}_{A} v_i \;\rightarrow\; \frac{v_o}{A} = v_i$$

$$\frac{v_o}{R_1} = -V_f\left[\frac{R_1 + R_2}{R_1 R_2}\right] + v_i\left[\frac{1}{R_B} + \frac{1}{(\beta+1)(r_e+R_E)}\right] \quad (1)$$

$$\frac{v_o}{R_1} = -v_f\left[\frac{R_1 + R_2}{R_1 R_2}\right] + v_o \frac{r_e + R_E}{R_E}\left[\frac{1}{R_B} + \frac{1}{(\beta+1)(r_e+R_E)}\right]$$

$$v_o\left[\frac{1}{R_1} - \frac{r_e + R_E}{R_E}\left[\frac{1}{R_B} + \frac{1}{(\beta+1)(r_e+R_E)}\right]\right] = v_f\left[-\left[\frac{R_1 + R_2}{R_1 R_2}\right]\right]$$

$$v_o \underbrace{\frac{\left[\frac{1}{R_1} - \frac{r_e+R_E}{R_E}\left[\frac{1}{R_B} + \frac{1}{(\beta+1)(r_e+R_E)}\right]\right]}{\left[-\left[\frac{R_1+R_2}{R_1 R_2}\right]\right]}}_{M} = v_f \quad (1)$$

(c) (2)

$$V_i = v_{in} - v_f \Rightarrow V_i = v_{in} - M V_o \Rightarrow \frac{v_o}{A} = v_{in} - M V_o$$

$$v_o\left[\frac{1}{A} + M\right] = v_{in} \qquad \frac{v_o}{v_{in}} = \frac{A}{1 + AM} \quad (5)$$

$$\frac{v_o}{v_{in}} = \frac{\frac{R_E}{r_e + R_E}}{1 + \left[\frac{R_E}{r_e+R_E}\right]\left[\frac{\frac{1}{R_1} - \frac{r_e+R_E}{R_E}\left[\frac{1}{R_B} + \frac{1}{(\beta+1)(r_e+R_E)}\right]}{-\left[\frac{R_1+R_2}{R_1 R_2}\right]}\right]} \quad (3)$$

(Q9) Assume V_{out} is decreased (by decreasing R_L]

If R_L decreases $V_{out} = V_E$ decreases

If V_E decreases V_{BE} increases as V_B is nearly kept constant due to zener diode (nearly at 12 Volt)

If V_{BE} increases more current passes from Q transistor hence I_C → collector current, I_B → base current and $I_E = I_C$ → emitter current increases

As I_E increase V_{out} increases and regulation is provided.