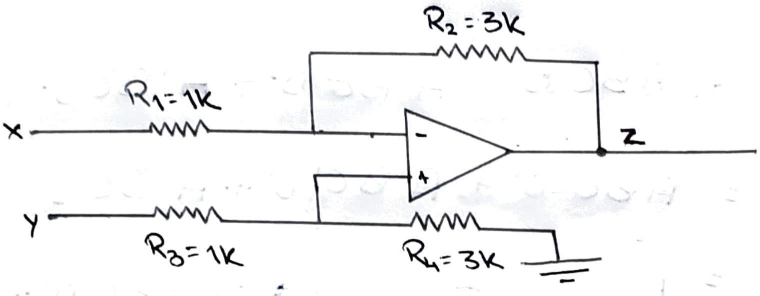
Q.1. Find the output voltage at node Z.




Soln: When $y = 0$,

for inverting amplifier circuit,

$$Z_1 = -\frac{R_2}{R_1} \cdot X$$

$$\therefore Z_1 = -3X$$

When $X = 0$,

$$Y_o = \frac{Y R_4}{R_4 + R_3} = \frac{3Y}{4}$$

And, for non-inverting amplifier circuit

$$Z_2 = \left(1 + \frac{R_2}{R_3}\right) Y_o$$

$$= 4 \cdot \frac{3Y}{4}$$

$$\therefore Z_2 = 3Y$$

Hence,

$$Z = Z_1 + Z_2$$

$$\text{or, } Z = -3X + 3Y$$

$$\therefore Z = 3Y - 3X$$

Q.2. Implement the following boolean expression using a 4:1 multiplexer?

$$F = ABC'D' + A'BC'D' + A'BCD' + ABC'D$$

Soln:

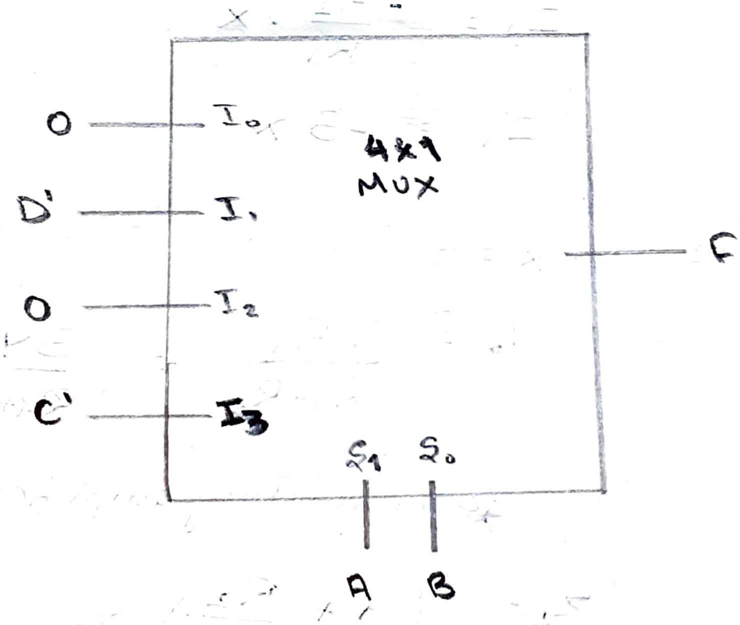
$$F = ABC'D' + A'BC'D' + A'BCD' + ABC'D$$

$$= A(BC'D' + BC'D) + A'(BC'D' + BCD')$$

$$= AB(C'(D'+D)) + A'BD'(C'+C)$$

$$= ABC' + A'BD'$$

So, in multiplexer:

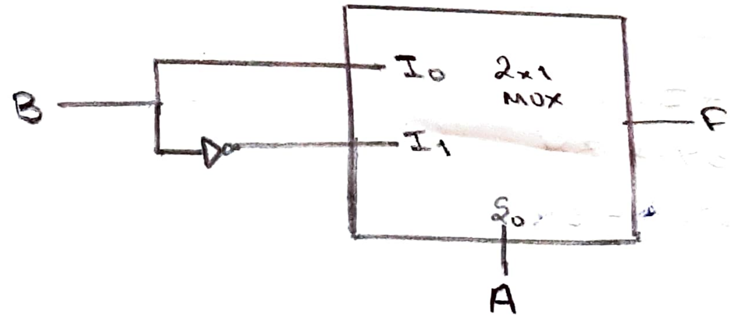



Q.3. Implement XOR gate function with 2:1 MUX.

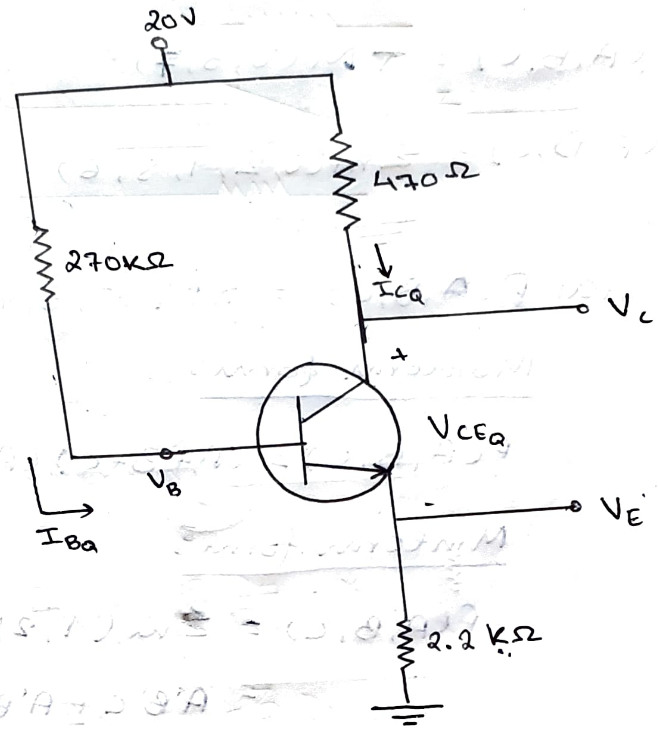
Soln:

$$F = A'B + AB' = A \oplus B$$

So, in multiplexer,



Q.4. For the emitter-bias configuration given below, determine $I_{BQ}$, $I_{CQ}$, $V_{CEQ}$, $V_C$, $V_B$ and $V_E$.




$\beta = 125$

Soln:- from KVL,

$$20 = 270\, I_{BQ} + V_{BE} + 2.2\, I_{EQ}$$

or, $$20 = 270\, I_{BQ} + 0.7 + 2.2\,(1+\beta) I_{BQ}$$

or, $$20 - 0.7 = I_{BQ}\,(270 + (1+125)\,2.2)$$

$$\therefore I_{BQ} = 0.035\ mA.$$

So,

$$I_{EQ} = (1+\beta) I_{CQ} = 126 \times 0.035 = 4.41\ mA$$

$$I_{CQ} = \beta I_{BQ} = 125 \times 0.035 = 4.37\ mA$$

Again from KVL,

$$20 = I_{CQ} \times \frac{470}{1000} + V_{CEQ} + I_{EQ} \times 2.2$$

$$\therefore V_{CEQ} = 8.238\ V$$

So,

$$V_{BE} = V_B - I_{EQ} R_E$$

or, $$V_B = 0.7 + 4.41 \times 2.2$$

$$\therefore V_B = 10.402\ V$$

Q.5. Express the following Boolean Algebraic functions in maxterms and minterms.

(a) $F(A,B,C) = \pi M(0,3,7)$

(b) $F(A,B,C) = \Sigma m(0,2,4,5,6)$

Soln:- (a) $F(A,B,C) = \pi M(0,3,7)$

Maxterm form:

$F(A,B,C) = (A+B+C)(A+B'+C')(A'+B'+C')$

Minterm form:

$F(A,B,C) = \Sigma m(1,2,4,5,6)$

$= A'B'C + A'BC' + AB'C' + AB'C + ABC'$

(b) $F(A,B,C) = \Sigma m(0,2,4,5,6)$

Minterm form

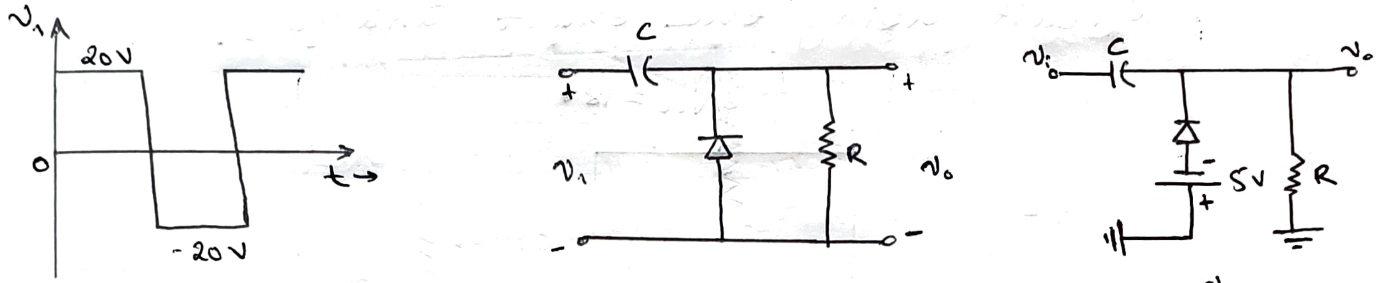
$F(A,B,C) = A'B'C' + A'BC' + AB'C' + AB'C + ABC'$

Maxterm form

$F(A,B,C) = \pi M(1,3,7)$

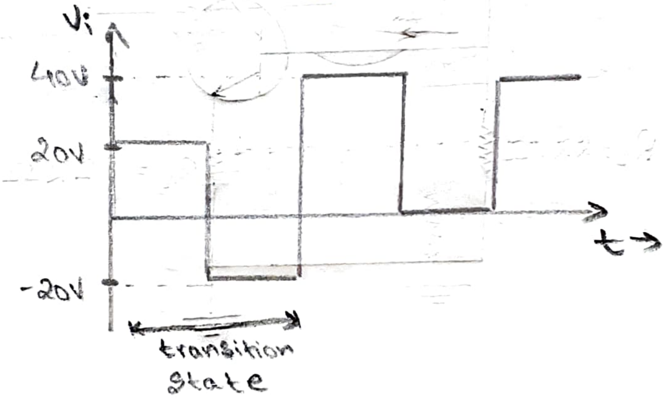
$= (A+B+C')(A+B'+C')(A'+B'+C')$

Q.6. Determine output voltage and sketch $V_o$ for the network shown in fig. (a) and (b) below:



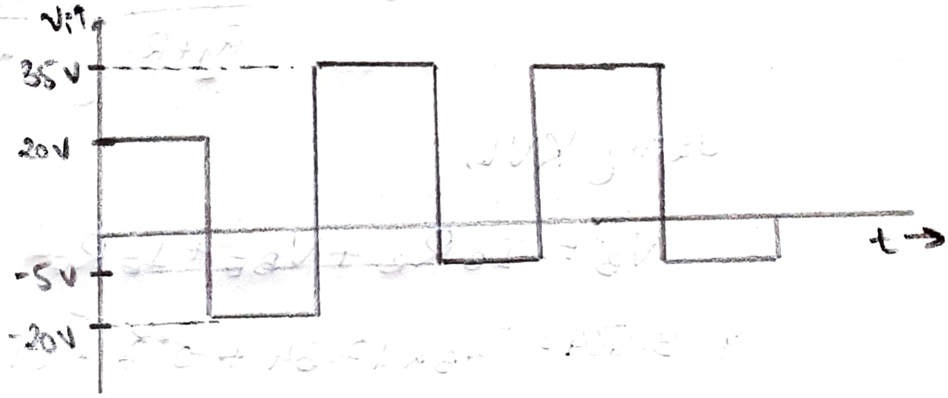

(a) (b)

Soln:- for (a), Output signal waveform:



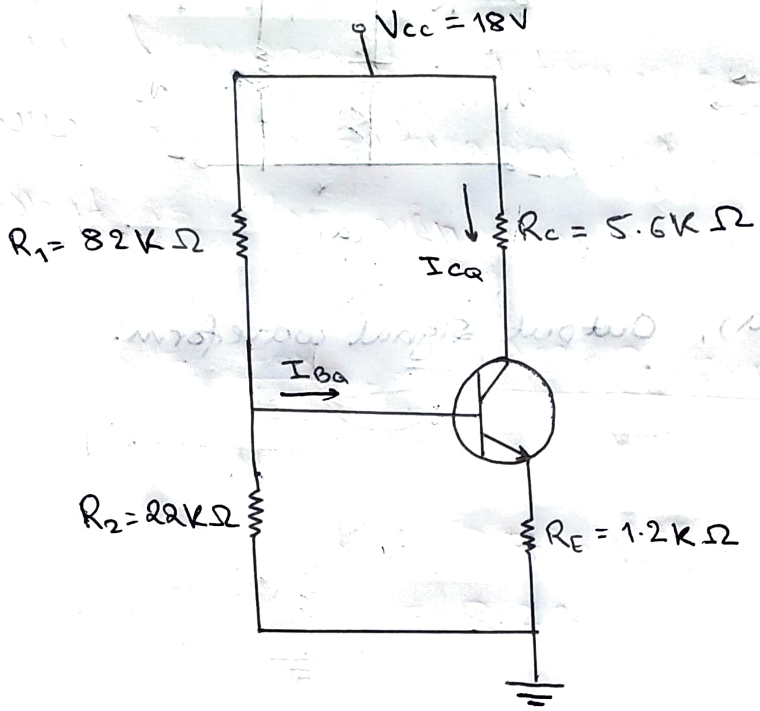

So, output voltage, $V_o = 40V$

for (b), Output signal waveform:




So, output voltage, $V_o = 35V$

Q.7. Determine the levels of $I_{CQ}$ and $V_{CEQ}$ for the voltage-divider configuration for the given circuit using the exact analysis.




$\beta = 50$

Soln:-

$$V_B = \frac{V_{CC} \times R_2}{R_1 + R_2} = \frac{18 \times 22}{22+82} = 3.807\,V$$

$$R_B = R_1 \parallel R_2 = \frac{R_1 R_2}{R_1 + R_2} = \frac{22 \times 82}{22+82} = 17.34k$$

Using KVL,

$$V_B = I_B R_B + V_{BE} + I_E R_E$$

or, $3.804 = I_B \times 17.34 + 0.7 + (1+\beta) I_B \times 1.2$

$\therefore I_{BQ} = 0.0395\,mA$

$I_{CQ} = \beta I_{BQ} = 50 \times 0.0395 = 1.977\,mA$

$I_{EQ} = (1+\beta) I_{BQ} = 51 \times 0.0395 = 2.01\,mA$

Also, from KVL,

$$V_{CC} = I_{CQ} R_C + V_{CE} + I_{EQ} R_E$$

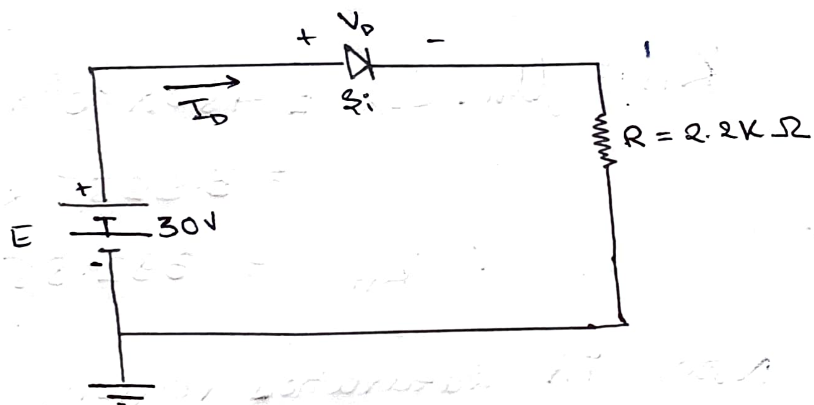
or, $18 = 1.977 \times 5.0 + V_{CE} + 2.07 \times 1.2$

$\therefore V_{CEQ} = 4.5084 \text{ V}$

$\therefore$ The required values of $I_{CQ}$ and $V_{CEQ}$ are 1.977 mA and 4.5 V respectively.

Q.8 (a) Using approximate characteristics for the Si diode, determine $V_D$, $I_D$ and $V_R$ for the circuit of given figure.

(b) Perform the same analysis as part (a) using the ideal model for the diode.




Soln:-

(a) $V_D = 0.7 \text{ V}$ (for Si-diode)

Using KVL,

$$30 = 0.7 + I_D R$$

$\therefore I_D = 13.31 \text{ mA}$

(b) $V_D = 0 \text{ V}$ (for ideal diode)

using KVL,

$$30 = 0 + I_D R.$$

$\therefore I_D = 13.63 \text{ mA}$

$C_{ox}$, $K_n'$ and the overdrive voltage $V_{ov}$ required to operate a transistor having $(W/L) = 20$ in saturation with $I_D = 0.3mA$. What is the minimum value of $V_{DS}$ needed?

Soln.:-

$$C_{ox} = \frac{E_{ox}}{t_{ox}} = \frac{3.95 \times 8.55 \times 10^{-12}}{4 \times 10^{-9}}$$

$$\therefore C_{ox} = 8.73 \times 10^{-3} F/m^2$$
$$= 8.73$$

$$K_n' = \mu_n . C_{ox} = 450 \times 10^{8} \times 8.73 \times 10^{-15}$$
$$= 3.9285 \times 10^{-4}$$
$$\therefore K_n' = 392.85 \ \mu A/V^2$$

Now, in saturation region,

$$I_D = \frac{K_n'}{2} \left(\frac{W}{L}\right) \left(\frac{V_{ov}^2}{\ }\right)$$

$$\text{or, } 300 = \frac{392.85}{2} \times 20 \times (V_{ov})^2$$

$$\therefore V_{ov} = 0.27V$$

$\therefore$ Minimum $V_{DS}$ required,

$$V_{DS\,min} = V_{ov} = 0.27V$$

Q.10. An NMOS transistor is operating at the edge of saturation with an overside voltage $V_{ov}$ and a drain current $I_D$. If $V_{ov}$ is doubled, and we must maintain operation at the edge of saturation, what should $V_{DS}$ be changed to? What value of drain current results?

Soln:-

Initially,

$$I_D = \frac{K_n}{2} V_{ov}^2$$

for saturation region, $(V_{DS} \geq V_{ov})$

$$\therefore V_{DS} = V_{ov}$$

Finally,

$$V_{ovf} = 2V_{ov}$$

At saturation region,

$$V_{DSf} = \frac{K_n}{2} (V_{ovf})^2$$

$$= \frac{K_n}{2} (2V_{ov})^2$$

$$\therefore V_{DSf} = 4I_D$$

So, the current will increase by 4 times.