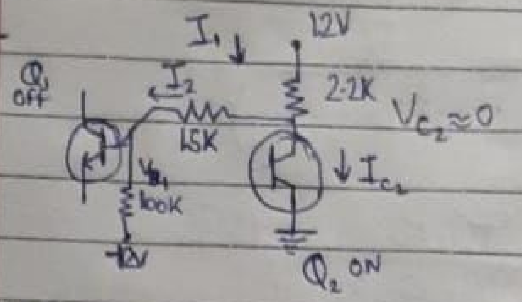
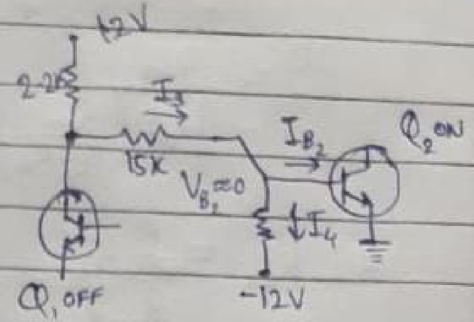
Tutorial - 4

1)-





1st Stable State $\quad V_{B_2} = 0 \;,\; V_{C_2} = 0$

$Q_2 \rightarrow$ Sat. $\;,\; Q_1 \rightarrow$ OFF

Neglecting I_{CB_0}, $\quad V_{B_1} = -12\left[\frac{15}{15+100}\right] = \underline{-1.56\,V}$

$$I_{C_2} = I_1 - I_2 \;,\; I_1 = \frac{12}{2.2} = 5.45\,mA \text{ and}$$

$$I_2 = \frac{12}{15+100} = 0.1\,mA$$

$$\Rightarrow I_{C_2} = \underline{5.35\,mA}$$

$$(I_{B_2})_{min} = \frac{I_{C_2}}{h_{FE}} = \frac{5.35}{20}$$

$$I_3 = \frac{12}{2.2+15} = 0.7\,mA$$

$$I_4 = \frac{12}{100} = 0.12\,mA$$

$$I_{B_2} = I_3 - I_4 = \underline{0.58\,mA}$$

As $I_{B_2} >> (I_{B_2})_{min} \Rightarrow Q_2$ is in Sat.

2nd Stable State, $\quad Q_2 \rightarrow$ OFF $,\; Q_1 \rightarrow$ ON

$$V_{B_1} = -12\left[\frac{15}{15+100}\right] + 0.15\left[\frac{100}{15+100}\right] = \underline{-1.43\,V}$$

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$I_{C_2} = I_1 - I_2$, $I_1 = \frac{12-0.15}{2.2} = \underline{5.39mA}$ and

$I_2 = \frac{0.15+12}{15+100} = \underline{0.11mA}$

$\Rightarrow I_{C_2} = \underline{5.28mA}$

$(I_{B_2})_{min} = \frac{5.28}{20} = \underline{0.26\ mA}$

$I_3 = \frac{12-0.7}{2.2+15} = 0.66mA$

$I_4 = \frac{0.7+12}{100} = 0.13mA$

$\Rightarrow I_{B_2} = I_3 - I_4 = \underline{0.53mA}$

$V_{C_1} = 12 - (0.66)(2.2) = \underline{10.5V}$

2) - i) - $R_1 = R_2 = 10k\Omega$ $C_1 = C_2 = 0.01\mu F$

Sym Astable MV

$T = 1.38RC$

$= 1.38 \times 10 \times 10^3 \times 10^{-2} \times 10^{-6}$

$= 0.138ms$

$\Rightarrow f = \underline{7.284kHz}$

ii). $R_1 = R_2 = 47k\Omega$ $C_1 = C_2 = 0.01\mu F$

$T = 1.38RC$

$\Rightarrow T = \underline{0.648ms}$

$\Rightarrow f = 1.543kHz$

3) $R_1 = 20k\Omega$, $R_2 = 30k\Omega$, $C_1 = C_2 = 0.01\mu F$

Unsym Astable MV

$\Rightarrow T_2 = 0.69R_2C = 0.2ms$

and $T_1 = 0.69R_1C = 0.138ms$

$$T = T_1 + T_2 = \underline{0.338ms}$$

$$\text{Duty cycle} = \frac{T_1}{T} \times 100\%$$

$$= \frac{0.138}{0.338} \times 100 = \underline{59.17\%}$$

and $f = \underline{2.95kHz}$

4)- $R_1 = 100k\Omega = R_2$, $C_1 = 0.02\mu F$, $C_2 = 0.01\mu F$

$$T_2 = 0.69RC_1 = 1.38ms, \quad T_1 = 0.69RC_2 = 0.69ms$$

$$T = T_1 + T_2 = \underline{2.09ms}$$

$$\text{Duty cycle} = \frac{T_1}{T} \times 100\% = \frac{0.69}{2.09} \times 100 \approx \underline{33\%}$$

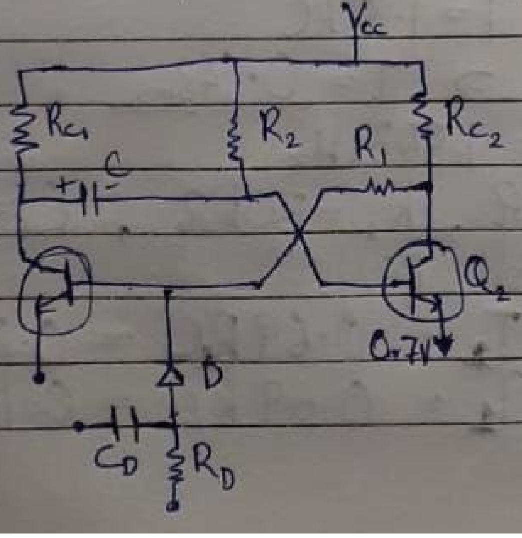
and $f = \underline{483Hz}$

5)- Stable state, $V_c(t) = V_c(\infty) - (V_c(0) - V_c(\infty))e^{-t/RC}$

$$\Rightarrow V_c(0) = -(V_{CC} - V_{BE})$$

$$= \underline{V_{BE} - V_{CC}}$$

Unstable state, $V_c(\infty) = V_{CC}$



$t = T$ when C reaches $0.7V$

$$\Rightarrow V_c[T] = V_{BE}$$

$$V_{BE} = V_{cc} - [V_{BE} - V_{cc} - V_{cc}]e^{-T/RC}$$

$$\Rightarrow e^{-T/RC} = \frac{-V_{cc} + V_{BE}}{V_{BE} - 2V_{cc}} = \frac{1}{2}$$

$$\Rightarrow V_{cc} >> V_{BE}, \quad T = -R_2 C \times \ln(1/2)$$

$$\Rightarrow \boxed{T = 0.693 R_2 C}$$