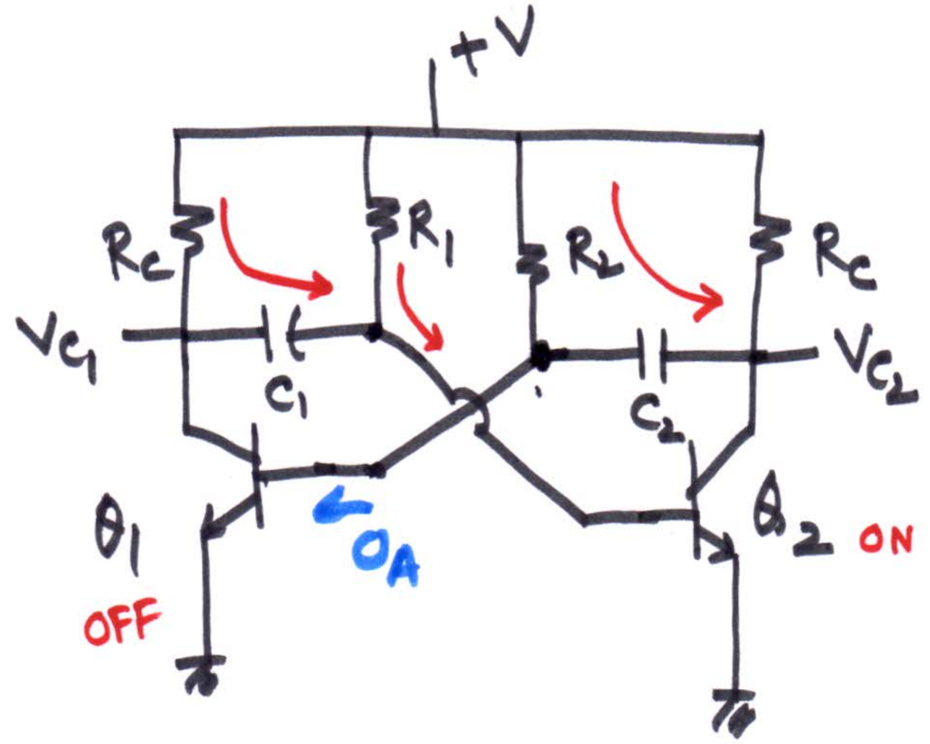
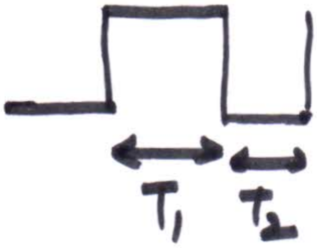
Astable Multivibrator





Consider $Q_2 \rightarrow$ 'Sat'

$Q_1 \rightarrow$ 'Cut-Off'

$$\left\{ \begin{array}{l} R_1 \gg R_C \\ R_2 \gg R_C \end{array} \right.$$

$$T_2 = 0.69\, R_2 C_2$$

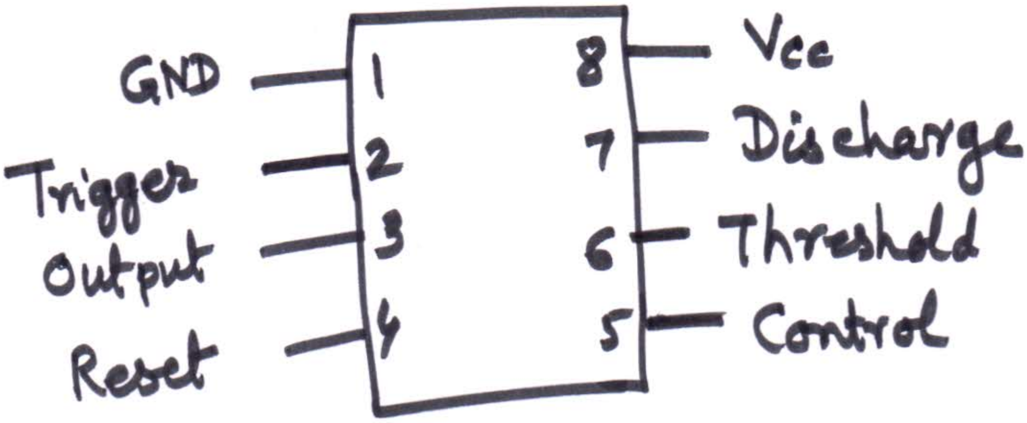
After T_3

$Q_2 \rightarrow$ 'Cut-off'

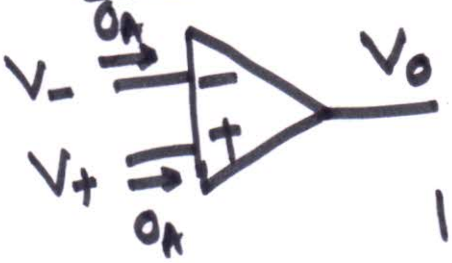
$Q_1 \rightarrow$ 'Sat'

$$T_1 = 0.69\, R_1 C_1$$

IC 555 Timer

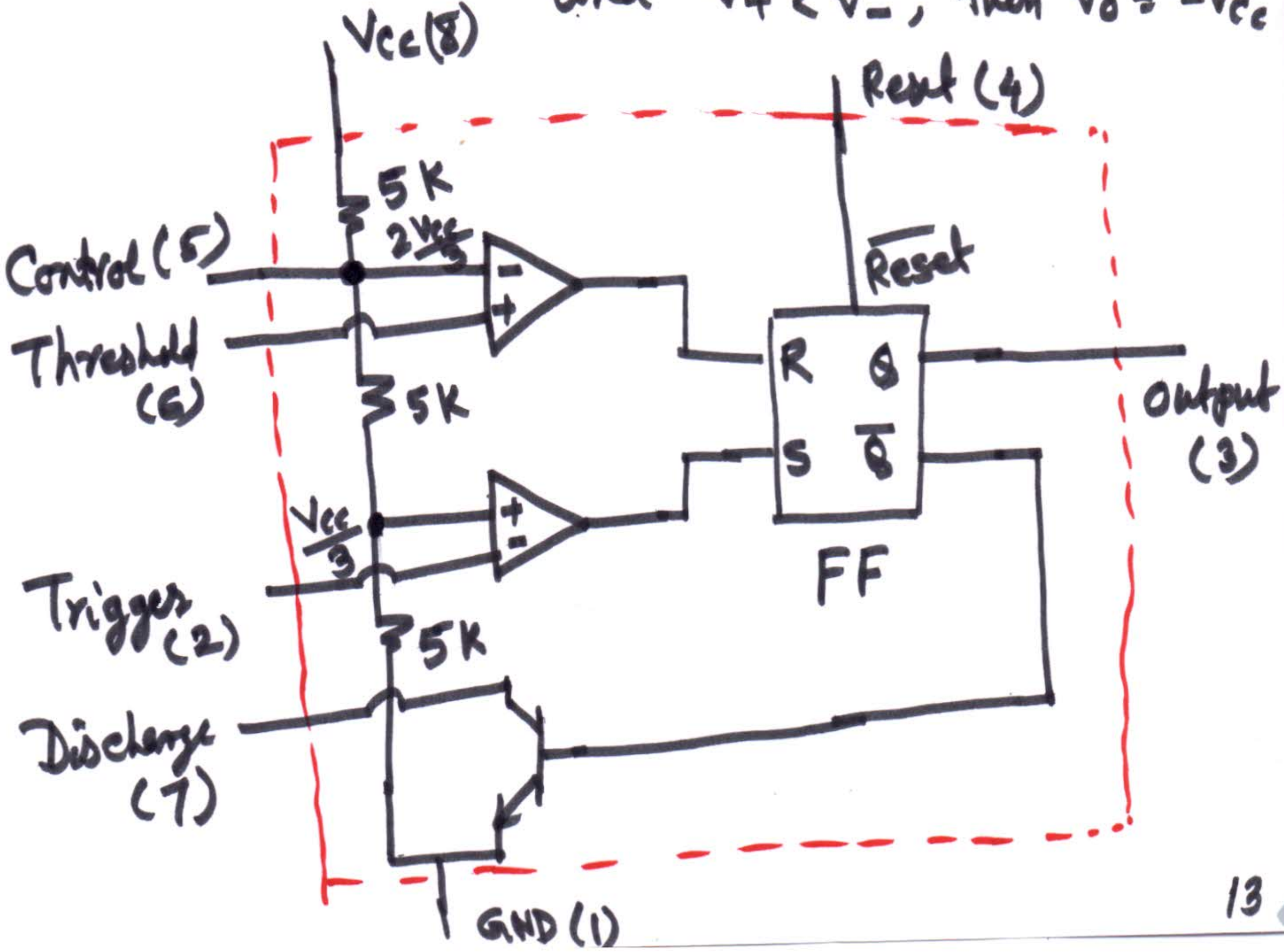


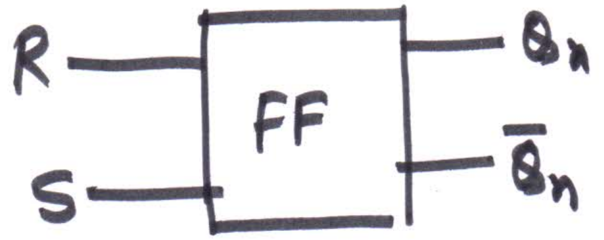
Comparator



If $V_+ > V_-$, then $V_0 = +V_{cc}$

and $V_+ < V_-$, then $V_0 = -V_{cc}$

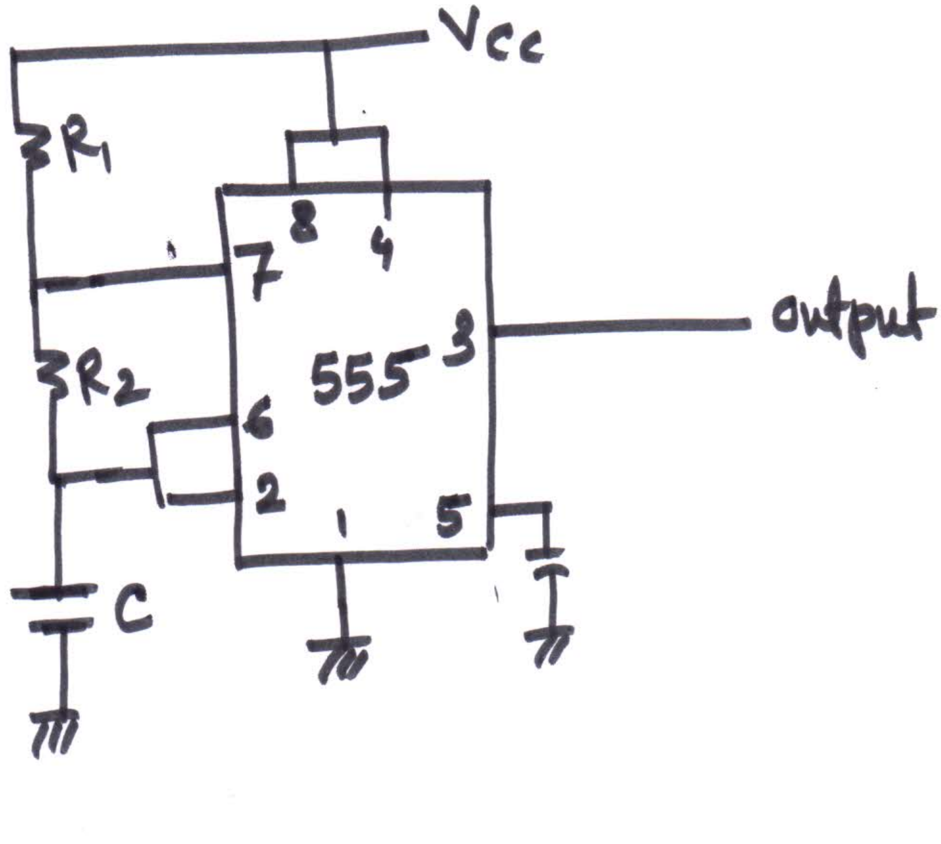


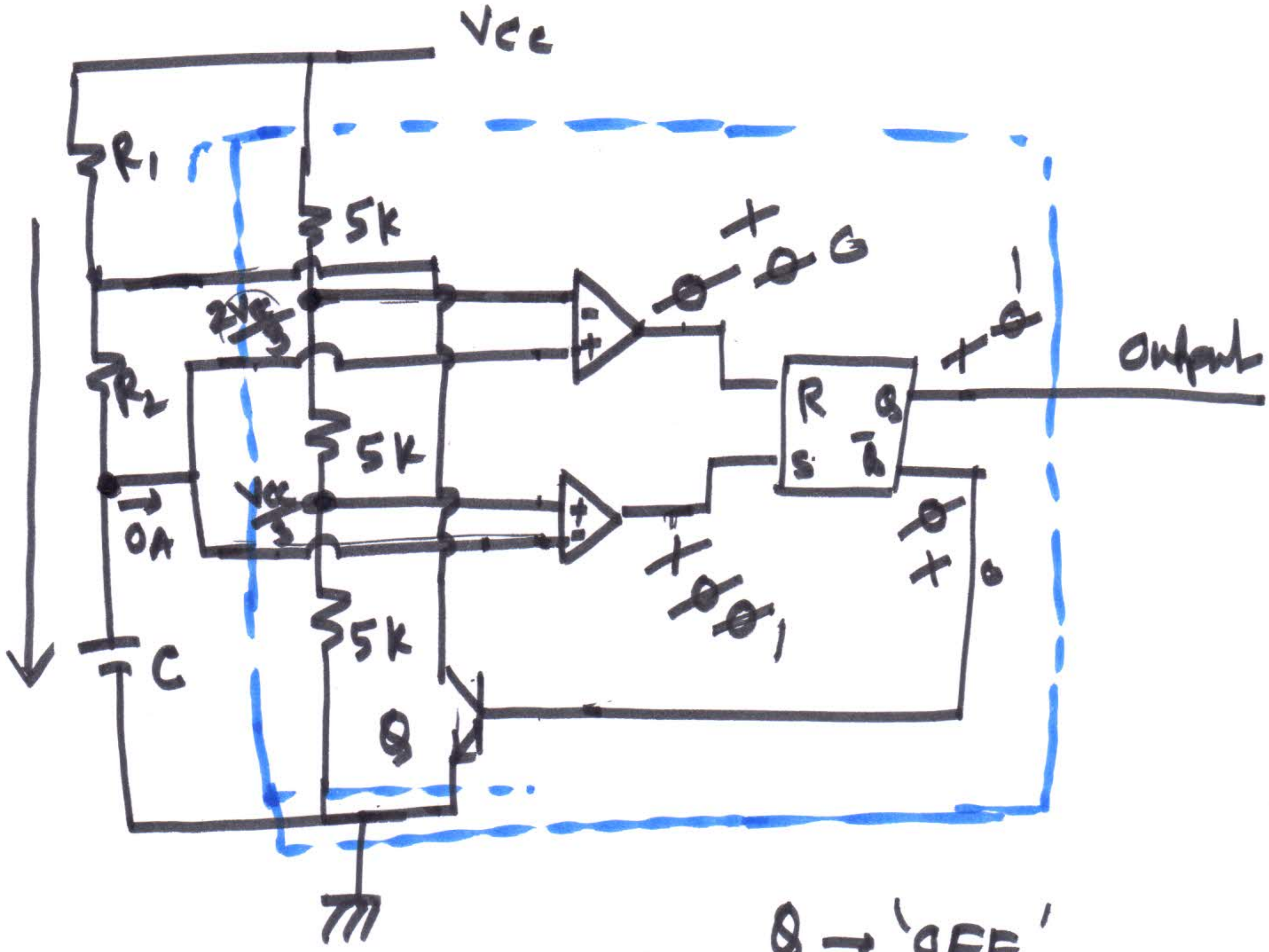


R	S	Q_{n+1}
0	0	Q_n
0	1	1
1	0	0
1	1	Invalid

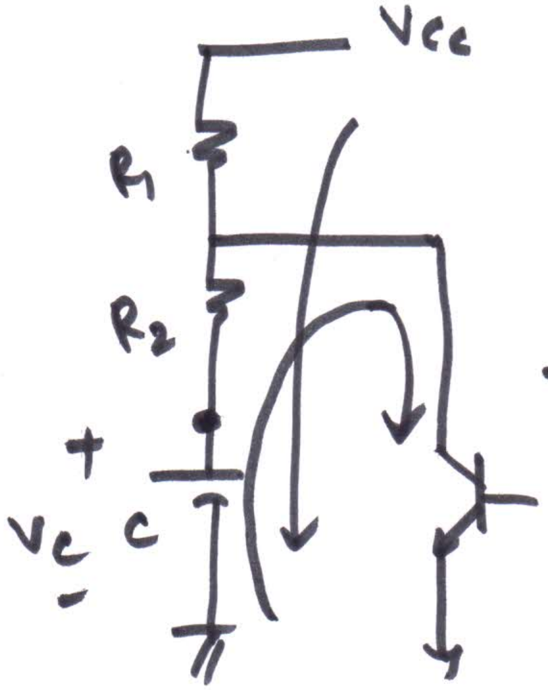
R → Reset (0)
S → Set (1)

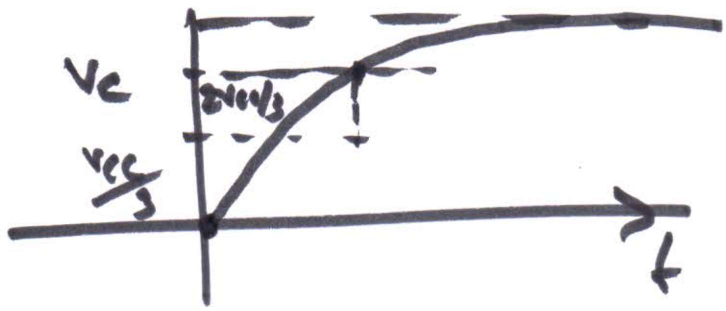
Astable Multivibrator using 555 timer



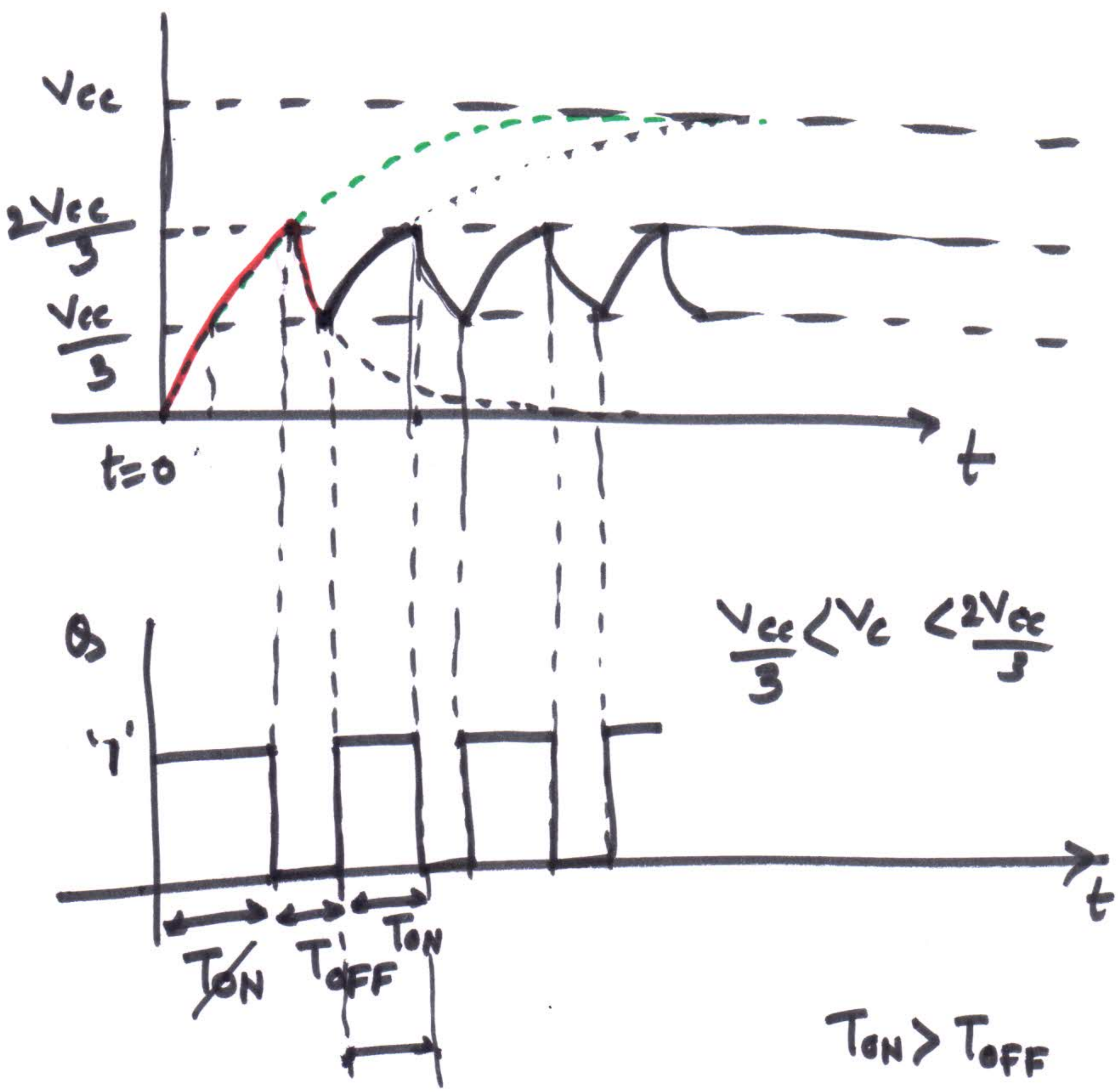


Q → 'OFF'





$\tau = (R_1 + R_2)C$



$\frac{V_{cc}}{3} < V_c < \frac{2V_{cc}}{3}$

$T_{ON} > T_{OFF}$

$$v_c(t) = V_f + (V_i - V_f)\, e^{-t/\tau}$$

For T_{ON}

$$V_i = \frac{V_{cc}}{3} \quad \text{and} \quad V_f = V_{cc}$$

at $t = T_{ON}$, $v_c(t) = \frac{2V_{cc}}{3}$

$$\text{So,}\quad \frac{2V_{cc}}{3} = V_{cc} + \left(\frac{V_{cc}}{3} - V_{cc}\right) e^{-\frac{T_{ON}}{(R_1+R_2)C}}$$

$$\Rightarrow \frac{2V_{cc}}{3} - V_{cc} = -\frac{2V_{cc}}{3} \cdot e^{-T_{ON}/(R_1+R_2)C}$$

$$\Rightarrow \cancel{-}\frac{\cancel{V_{cc}}}{\cancel{3}} = \cancel{-}\frac{2\cancel{V_{cc}}}{\cancel{3}} \cdot e^{-\frac{T_{ON}}{(R_1+R_2)C}}$$

$$\Rightarrow e^{\frac{T_{ON}}{(R_1+R_2)C}} = 2$$

$$\Rightarrow T_{ON} = (R_1+R_2)C \ln 2$$

$$= 0.69(R_1+R_2)C$$

<u>For T_{OFF}</u>

$$V_i = \frac{2V_{cc}}{3} \text{ and } V_f = 0$$

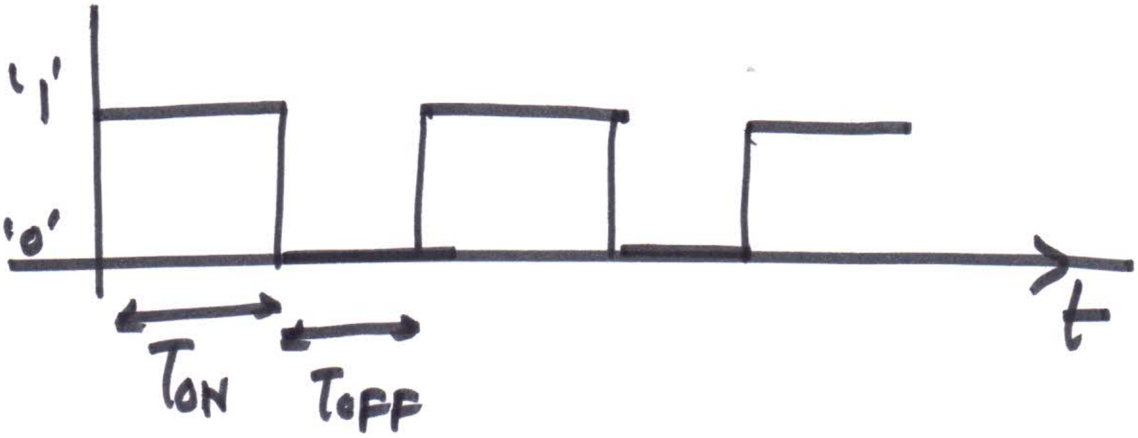
at $t = T_{OFF}$, $V_c(t) = \frac{V_{cc}}{3}$

$$\Rightarrow V_c(t) = V_f + (V_i - V_f)e^{-t/\tau}$$

$$\Rightarrow \frac{V_{cc}}{3} = 0 + \left(\frac{2V_{cc}}{3} - 0\right) e^{-\frac{T_{OFF}}{R_2C}}$$

$$\Rightarrow 1 = 2e^{-\frac{T_{OFF}}{R_2C}}$$

$$\Rightarrow T_{OFF} = R_2C \ln 2 = 0.69 R_2C$$



$$T_{ON} = 0.69\,(R_1 + R_2)\,C$$

$$T_{OFF} = 0.69\,R_2 C$$

Total Time period $T = T_{ON} + T_{OFF}$

$$= 0.69\,(R_1 + 2R_2)\,C$$

<u>Frequency</u>

$$f = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)\,C}$$

Duty cycle (D):

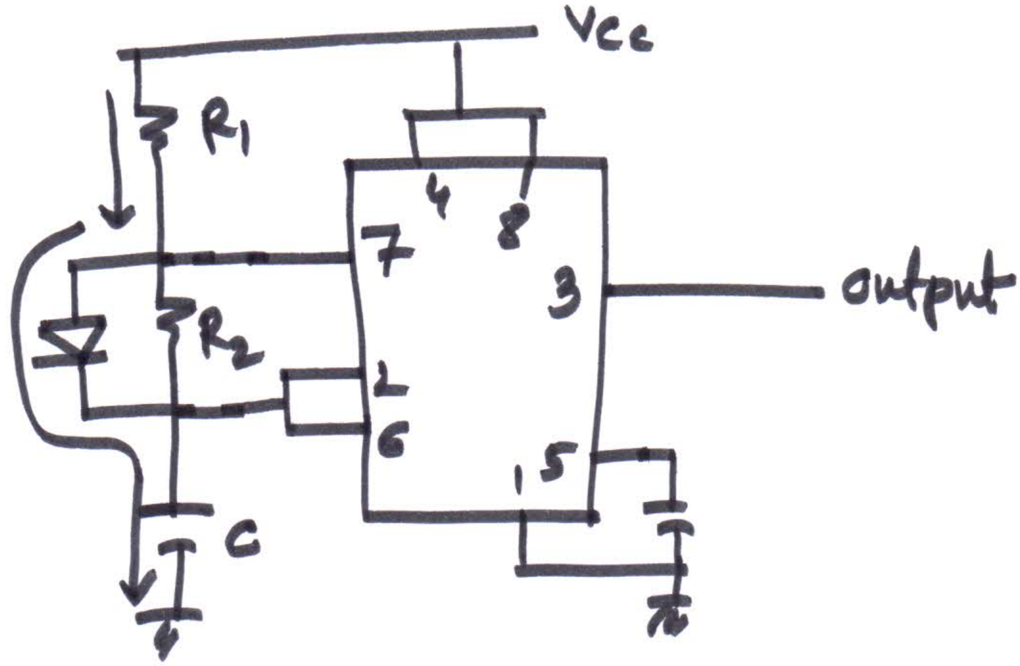
$$D = \frac{T_{ON}}{T} \times 100\,\%$$

$$= \frac{R_1 + R_2}{R_1 + 2R_2} \times 100\,\%$$

$$> 50\%$$

$$\left(\frac{R_1 + R_2}{R_1 + 2R_2} - \frac{1}{2}\right) > 0$$

To produce square wave with $D < 50\%$.



$$T_{ON} = 0.69\, R_1 C$$

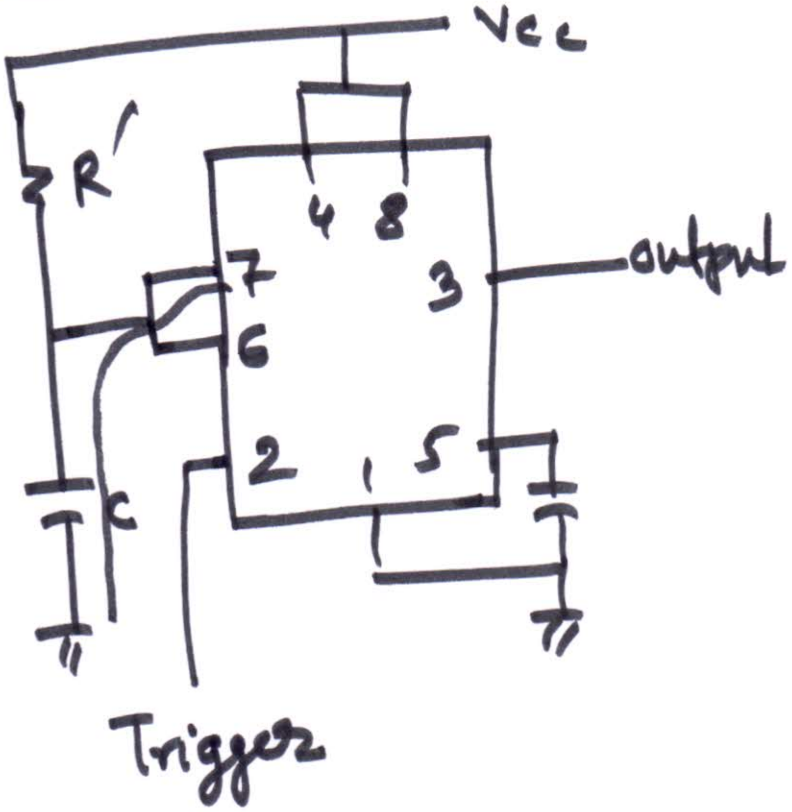
$$T_{OFF} = 0.69\, R_2 C$$

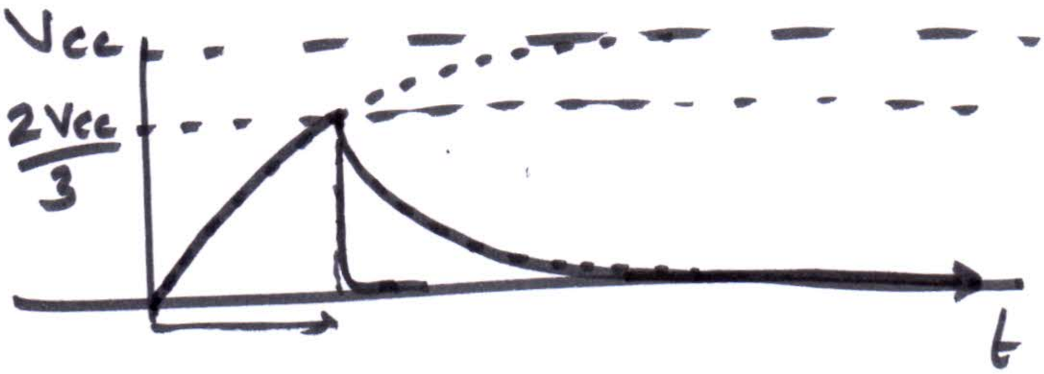
$$D = \frac{T_{ON}}{T_{ON} + T_{OFF}} \times 100\%$$

$$= \frac{R_1}{R_1 + R_2} \times 100\%$$

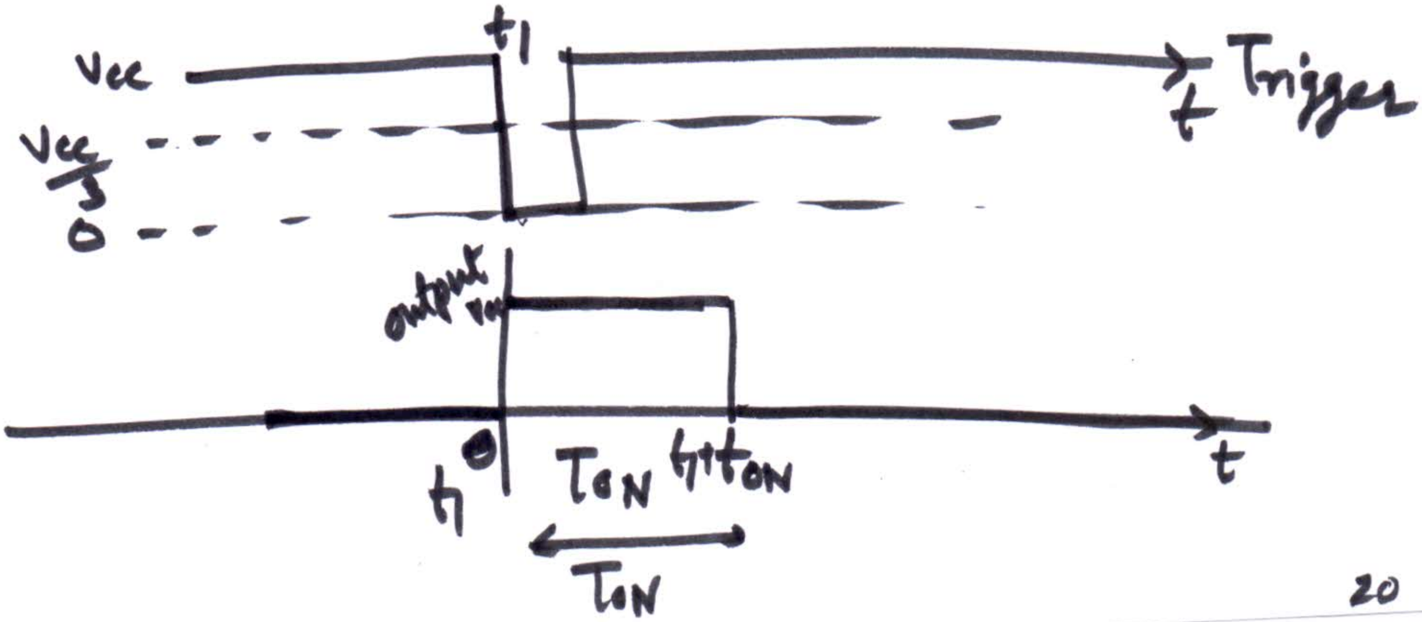
$$\underline{0 < D < 100\%}$$

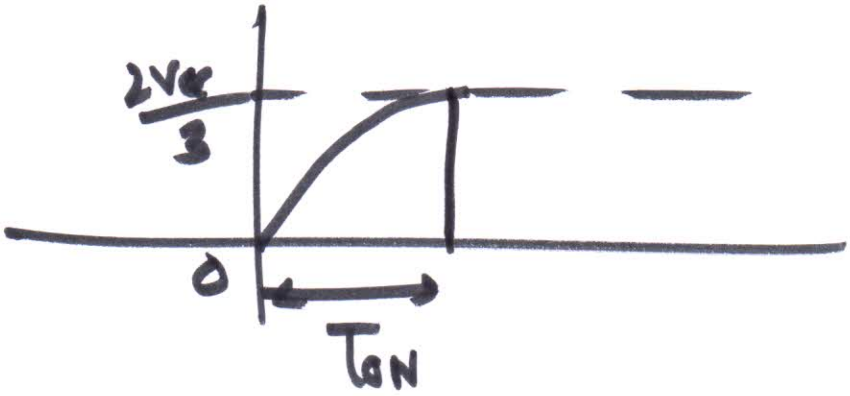
Monostable Multivibrator Using 555





'0' → Stable state





$$V_i = 0 \;,\quad V_f = V_{cc}$$

<u>$t = T_{ON}$</u>

$$V_c(t) = \frac{2V_{cc}}{3}\,.$$

$$V_c(t) = V_f + (V_i - V_f)\,e^{-t/\tau}$$

$$\Rightarrow \frac{2V_{cc}}{3} = V_{cc} + (0 - V_{cc})\,e^{-T_{ON}/RC}$$

$$\underline{\underline{T_{ON} = 1.1\,RC}}\,.$$

$$\frac{2V_{cc}}{3} - V_{cc} = -\frac{V_{cc}}{3}\,e^{-\frac{T_{ON}}{RC}}$$

$$\Rightarrow -\frac{V_{cc}}{3} = -V_{cc}\,e^{-\frac{T_{ON}}{RC}}$$

$$\Rightarrow e^{\frac{T_{ON}}{RC}} = 3 \Rightarrow T_{ON} = \ln 3\; RC$$

$$= 1.1RC$$