SEQUENTIAL CIRCUITS

Combinational logic → Logic gates are building blocks

Sequential logic → Flip-Flop is the building block.

Multivibrator

Bistable (Flip-Flop)	Monostable	Astable (oscillator) square wave.

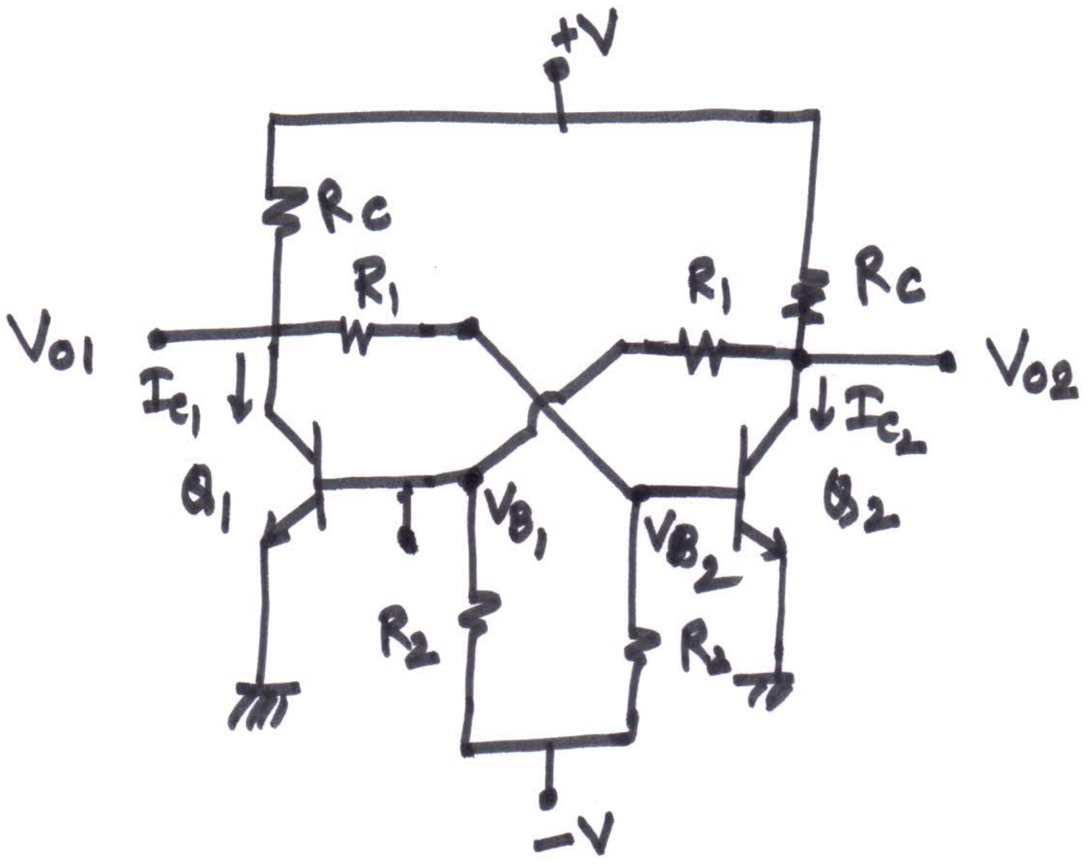
states → '0' and '1'
(LOW) (HIGH)

Bistable : Both the states are stable

Monostable : Only one state is stable

Astable : Both the states are not stable

Bistable Multivibrator



One transistor will be in 'saturation' region & other will be in 'cut-OFF' region.

$$V_{o1} = V_{CE_1} \quad \& \quad V_{o2} = V_{CE_2}$$

Suppose $I_{C_2} > I_{C_1}$

$$I_{C_2}\uparrow \rightarrow V_{CE_2}\downarrow \rightarrow V_{B_1}\downarrow \rightarrow I_{C_1}\downarrow$$

$$V_{B_2}\uparrow \leftarrow V_{CE_1}\uparrow$$

$Q_2 \rightarrow$ 'Sat' & $Q_1 \rightarrow$ 'Cut-off' when, $Q_2 \rightarrow$ 'Sat' & $Q_1 \rightarrow$ 'Cut-off'

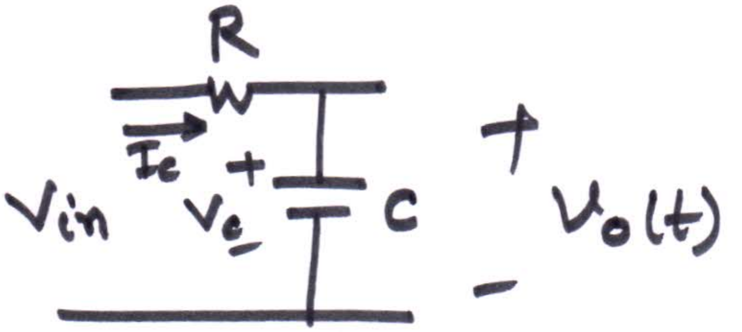
then

$$V_{o_2} \rightarrow \text{Low ('0')}$$

$$V_{o_1} \rightarrow \text{High ('1')}$$

By triggering we can change the states.

RC Circuit



$$V_o(t) = V_c(t)$$

$$V_c(0-) = V_i$$

$$V_{in} = R.I_c(t) + V_c(t)$$

$$= RC\frac{dV_c}{dt} + V_c(t)$$

Solve for $V_c(t)$.

$$V_c(t) = C.F + P.I$$

C.F

$$RC\frac{dV_c(t)}{dt} + V_c(t) = 0$$

$$\Rightarrow \frac{dV_c(t)}{dt} = -\frac{1}{RC}V_c(t)$$

$$\Rightarrow \int\frac{dV_c(t)}{V_c(t)} = -\int\frac{1}{RC}\cdot dt$$

$$\Rightarrow \ln(V_c(t)) = -\frac{1}{RC}\cdot t + \ln(K)$$

$$\Rightarrow \ln(v_c(t)) - \ln(k) = -t/RC$$

$$\Rightarrow \ln\left(\frac{v_c(t)}{k}\right) = -t/RC$$

$$\Rightarrow v_c(t) = K.e^{-t/RC}$$

<u>P.I (Steady state)</u>

If Vin is a D.C Signal.

$$V_{in} = 0 + V_c(\infty)$$

$$\Rightarrow V_c(\alpha) = V_{in} = V_f$$

Therefore

$$v_c(t) = V_c(\alpha) + K e^{-t/RC}$$

$$= V_f + K e^{-t/RC}$$

At $t=0$, $V_c(0+) = V_i = V_c(0-)$

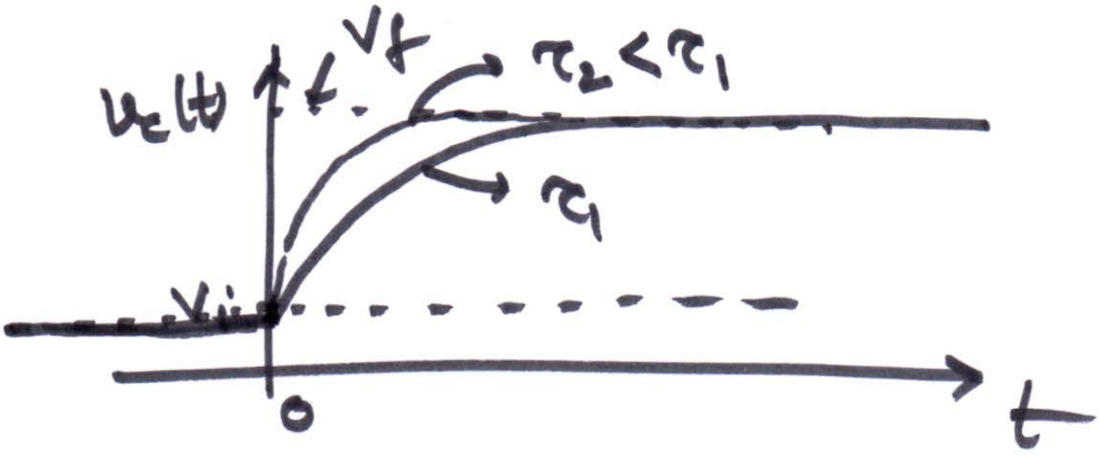
$$\Rightarrow V_i = V_f + K.\underset{(=1)}{e^0}$$

$$\Rightarrow K = (V_i - V_f)$$

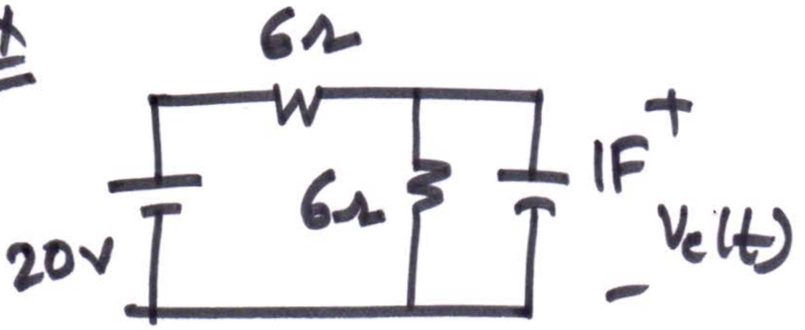
So,

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

$RC = \tau =$ time constant

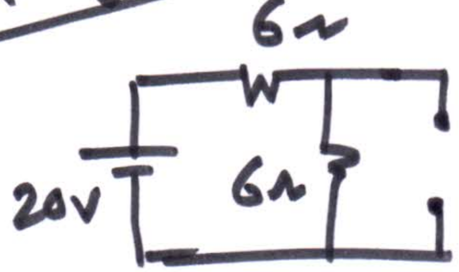


ex



$V_i = 0$

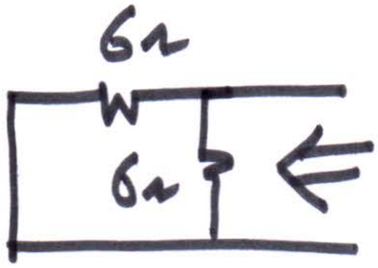
At steady state



$$V_f = \frac{6}{6+6} \times 20$$

$$= 10V$$

Req

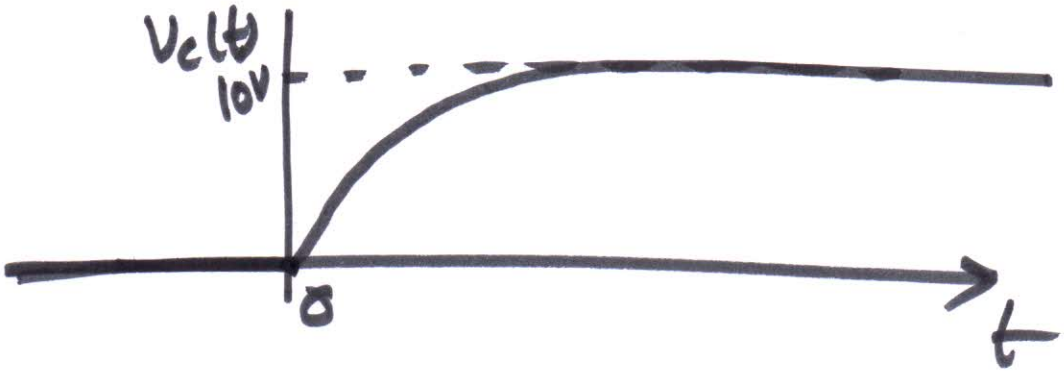


$$R_{eq} = \frac{6 \times 6}{6+6} = 3\Omega$$

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

$$= 10 + (0 - 10)\, e^{-t/(3.1)}$$

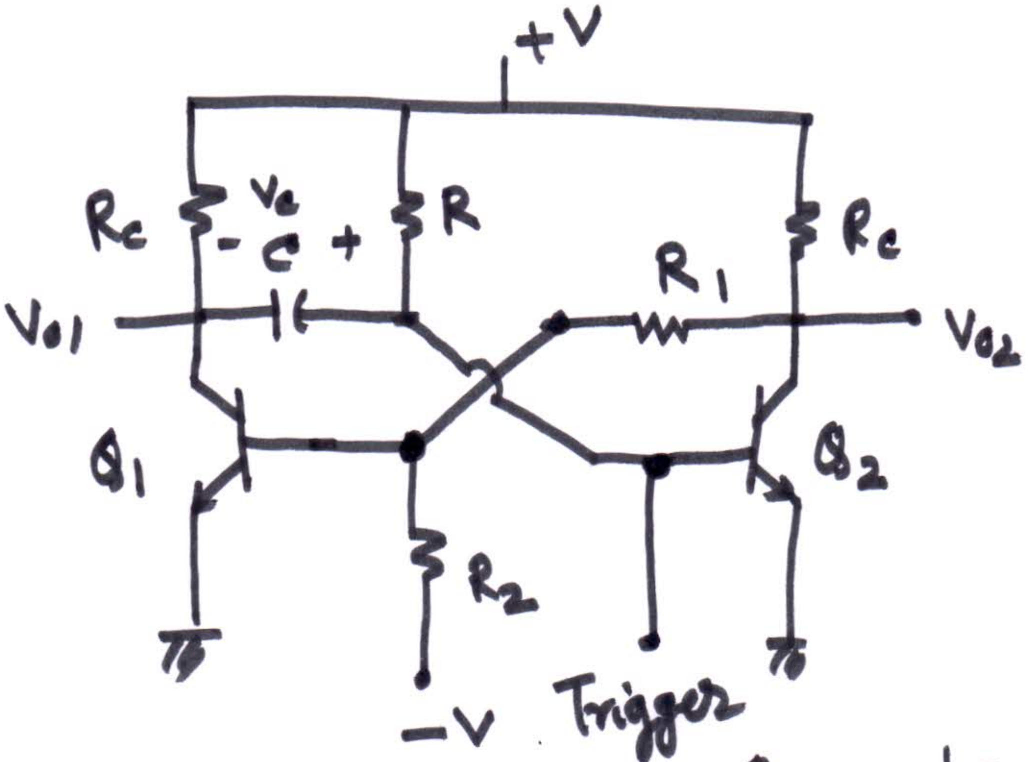
$$= 10\left(1 - e^{-t/3}\right)$$

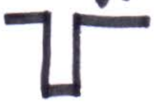


Mono-stable Multivibrator

One state → ~~stale~~ stable

Othe state → Quasi-stable

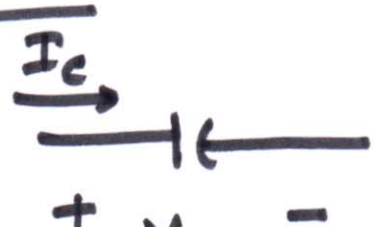




$Q_2 \rightarrow$ 'Sat'

$Q_1 \rightarrow$ 'Cut-off'

Capacitor



$$I_c = \cancel{\frac{dq}{dt}} \frac{dq}{dt}$$

$$= \frac{d}{dt}(C v_c)$$

$$= C \frac{dV_c}{dt}$$

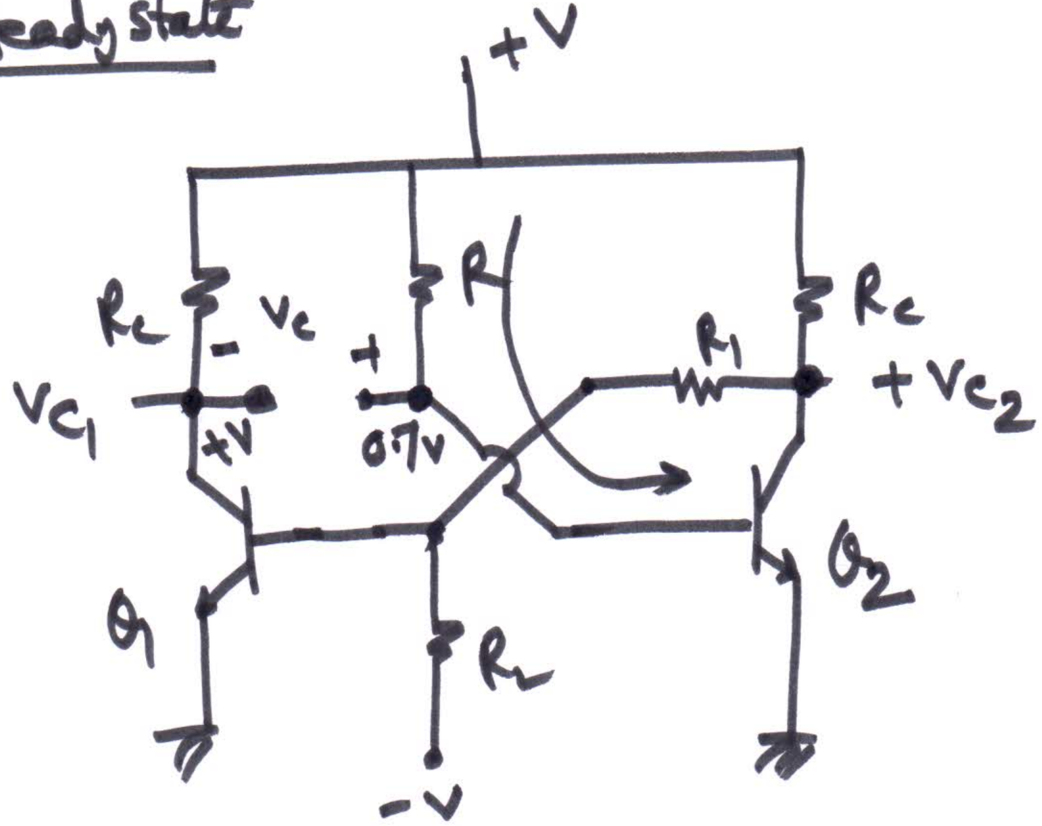
Under steady-state,

$V_c(t) \rightarrow$ constant

$I_c(t) = C\frac{dV_c(t)}{dt} = 0$

(open ckt)

At Steady state



$Q_2 \rightarrow$ 'Sat' $\Rightarrow v_{C_2} = 0v$

$Q_1 \rightarrow$ 'cut-off' $\Rightarrow$

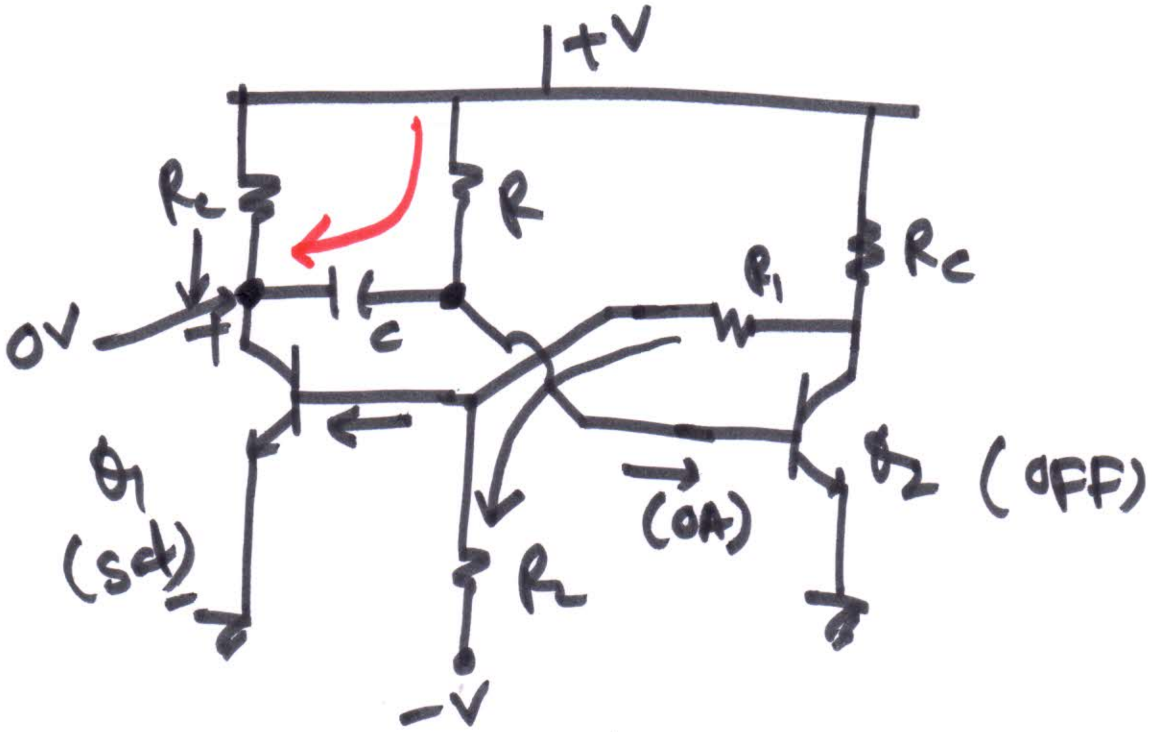
$v_{C_1} \cong +V$

$v_c = 0.7 - V$

when trigger (-ve) is applied

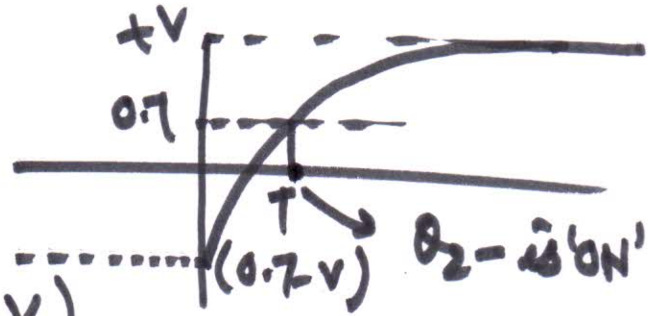
$Q_2 \rightarrow$ 'Cut-off'

$Q_1 \rightarrow$ 'Sat'



$V_f = V$

$V_i = (0.7 - V)$



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

at t=T $\quad v_c(t) = 0.7$

$$\Rightarrow \underline{0.7} = V + (\underline{0.7} - V - V)\, e^{-T/RC}$$

$$\Rightarrow \quad 0 = V + (-2V)\, e^{-T/RC}$$

$$\Rightarrow \quad e^{-T/RC} = \frac{\cancel{V}}{2\cancel{V}} = \frac{1}{2}$$

$$\Rightarrow \quad e^{+T/RC} = 2$$

$$T = RC \ln 2$$

$$= 0.69\, RC$$