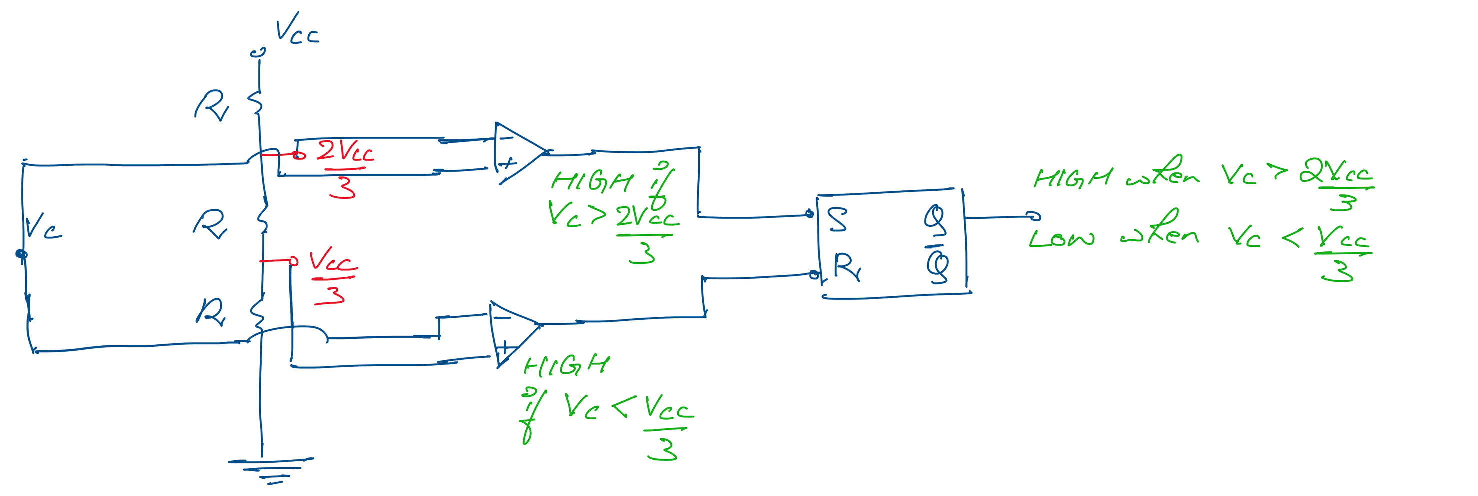
555-Timer Circuit

Monday, 11 March 2024 8:31 PM

→ It can be used as an oscillator circuit. We can generated a square wave using this circuit.
→ It is made of 2 comparators & a potential divider

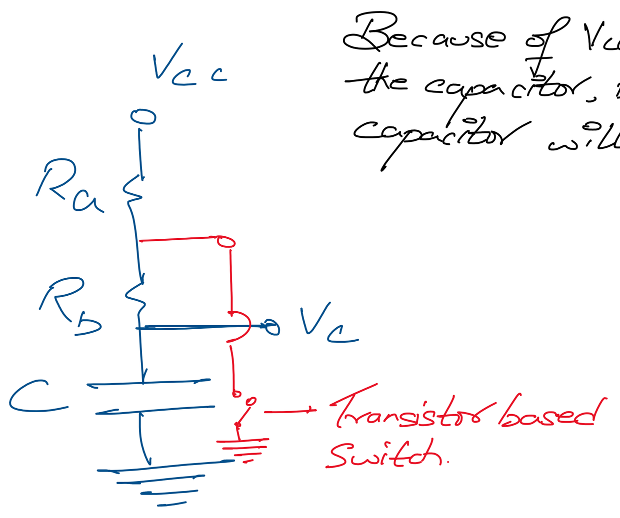


S	R1	O/p
0	0	No Change
0	1	0
1	0	1
1	1	—

→ The task of the 2 comparators is to compare another voltage V_c against the two levels: $\frac{V_{cc}}{3}$ & $\frac{2V_{cc}}{3}$. That's why we have 2 comparators.

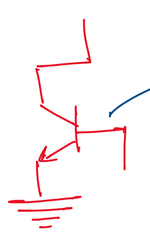
→ What I essentially want is an oscillating voltage. So the voltage will change with time.

Because of V_{cc}, the current will flow & charge the capacitor, because of which voltage on the capacitor will change.



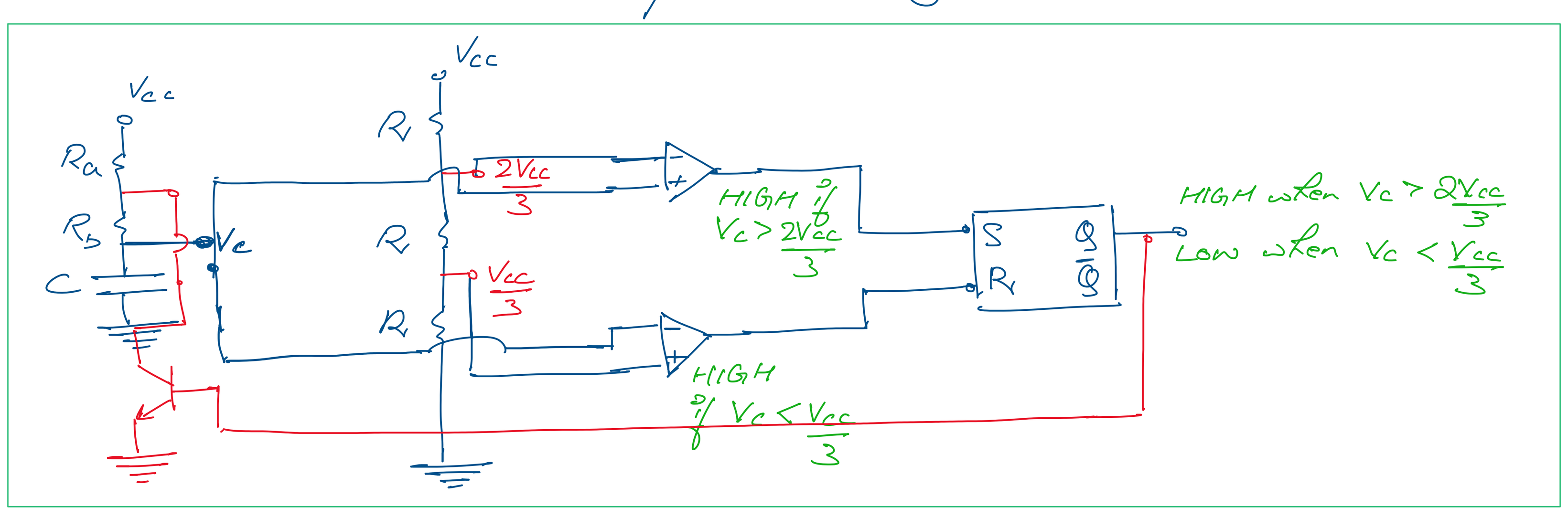
Switch is open ⇒ It will charge the capacitor
⇒ Potential will increase

Switch is closed ⇒ It will discharge the capacitor
⇒ Potential will decrease.



High Voltage at the base. Transistor will act like a short circuit
⇒ Switch is ON
⇒ Capacitor Discharges.

Low Voltage at Input
⇒ Transistor will act like an open circuit
⇒ Capacitor will charge

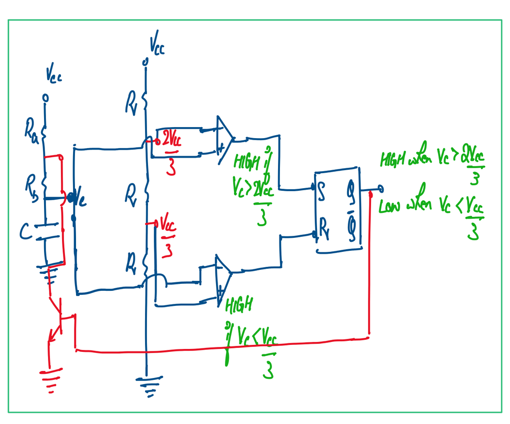


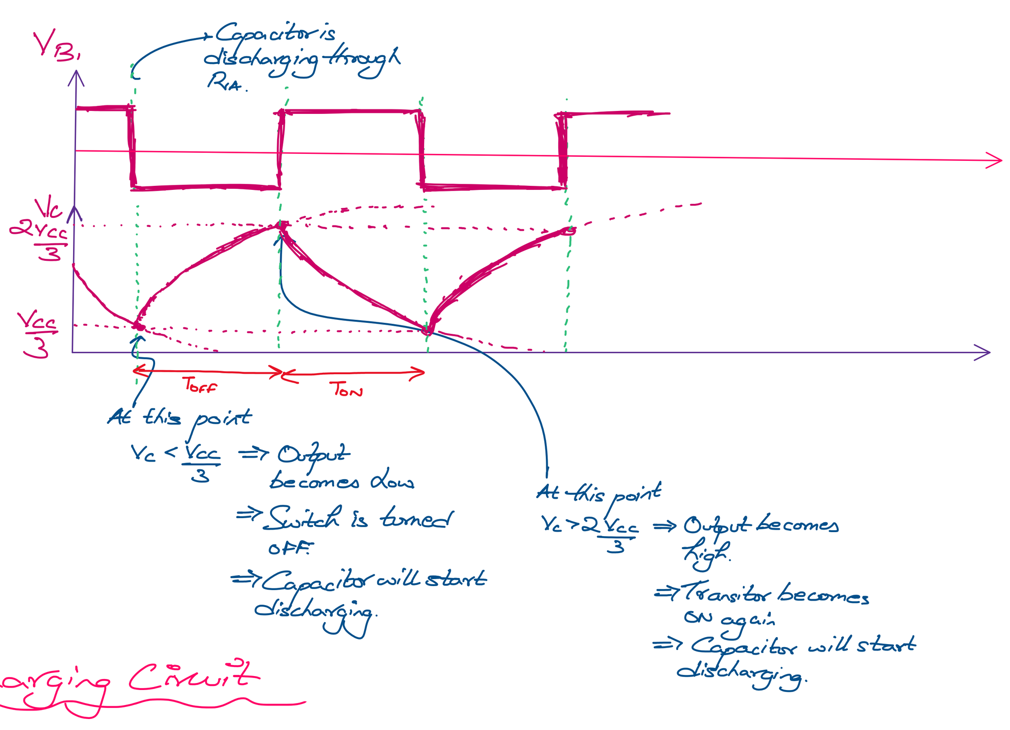
Working

① Suppose the transistor is an open circuit.
② Capacitor will charge. After some time $V_c > \frac{2V_{cc}}{3}$.
③ Output becomes high.
④ Transistor shorts.
⑤ Capacitor starts discharging. After some time $V_c < \frac{V_{cc}}{3}$
⑥ Output becomes low.
⑦ Transistor again becomes open. In this way, it oscillates between charging & discharging.

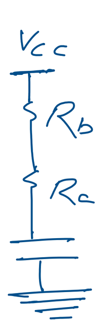
Note:- Duty Cycle = $\frac{T_H}{T_H+T_L}$

Q) What is the frequency of the circuit.

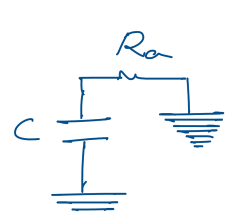




Charging Circuit



Discharging Circuit



Toff

→ V_c starts from $\frac{V_{cc}}{3}$ & trying to go to V_{cc}.

→ Gap = Target − Initial
$= \frac{2V_{cc}}{3}$

→ $\boxed{V_c(t) = \text{Target} - (\text{Target} - \text{Initial})\, e^{-t/\tau}}$ — Derived from writing the differential Equation.

⇒ $V_c(t) = V_{cc} - \frac{2V_{cc}}{3} e^{-t/\tau}$; $\tau = (R_A + R_B)C$ — Charging time Constant.

⇒ $\frac{2V_{cc}}{3} = V_{cc} - \frac{2V_{cc}}{3} e^{-t/\tau}$

⇒ $e^{-t/\tau} = 1/2$

⇒ $\frac{t}{\tau} = \ln 2$

⇒ $t = \tau \ln 2$

⇒ $\boxed{T_{off} = (R_A + R_B)C \cdot \ln 2}$

Ton

→ V_c starts from $\frac{2V_{cc}}{3}$ & target voltage = 0V

→ $V_c(t) = \text{Target} - (\text{Target} - \text{Initial})\, e^{-t/\tau}$

→ $V_c(t) = \frac{2V_{cc}}{3} e^{-t/\tau}$; $\tau = R_A \cdot C$ — Discharging time Constant

→ $\frac{V_{cc}}{3} = \frac{2V_{cc}}{3} e^{-t/\tau}$

⇒ $e^{-t/\tau} = 1/2$

⇒ $t_{on} = \ln 2 \cdot \tau$

⇒ $\boxed{T_{on} = R_A C \ln 2}$

Total Time Period = $T_{on} + T_{off}$
$= (R_a C)\ln 2 + (R_a + R_b) C \ln 2$