3. 555 Circuit (time and oscillation)

1972 by Signetics Corporation

Inside the circuit, there is a RS flip-flop.

Review: RS Flip-flop

<table>
<thead>
<tr>
<th>R (reset)</th>
<th>S (set)</th>
<th>Q</th>
<th>Q̅</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>never used</td>
<td>never used</td>
</tr>
</tbody>
</table>

Logic:
- Keep original states
- External Reset = 1 ⇒ Q = 0, Q̅ = 1
- Typically, we don't use it.

Example:

\[ \begin{array}{c}
R(t) \\
S(t) \\
Q(t)
\end{array} \]
$$V_{TH} = \frac{2}{3} V_{CC}, \quad V_{TL} = \frac{1}{3} V_{CC}$$
Monostable Multivibrator (1)
Monostable

Multivibrator (II)

$V_{TH} = \frac{2}{3} V_{CC}$

$V_{TL} = \frac{1}{3} V_{CC}$
Stable State: \( V_c(R) = 0 \quad R = 0, S = 0 \)

\( V_c = 0 \), transistor turns on \((\bar{Q} = 1)\)

Trigger: \( V_{\text{trigger}} < V_{\text{TL}} \), \( S \rightarrow 1 \) \((R \text{ sunk} 0)\)

\[ \Rightarrow Q = 1, \bar{Q} = 0 \text{ (turn off transistor)} \]

\( V_{\text{trigger}} > V_{\text{TL}} \) \( S \rightarrow 0 \) \((Q, \bar{Q} \text{ keep})\)

\[ \Rightarrow C \text{ starts to charge, } V_c(t) \uparrow \]

But maximally, \( V_c \) can only reach \( V_{\text{TH}} \)!

Once \( V_c \rightarrow V_{\text{TH}} \) \( \Rightarrow R \rightarrow 1 \) \((S \text{ sunk} 0)\)

\[ \Rightarrow Q = 0, \bar{Q} = 1 \text{ (turn on transistor)} \]

\( C \) starts to discharge

\( C \) will discharge at almost 0 time!

\((\text{recovery time} \approx 0)\)
\[ V_c(t) = V_{\text{final}} + (V_{\text{initial}} - V_{\text{final}}) e^{-\frac{t}{\tau}} \]

\[ V_{\text{th}} = V_{cc} + (0 - V_{cc}) e^{-\frac{t}{\tau}} \quad \tau = R_A C \]

\[ \Rightarrow \quad T = \tau \ln \frac{V_{cc}}{V_{cc} - V_{\text{th}}} \]

\[ V_{\text{th}} = \frac{2}{3} V_{cc} \]

\[ = \tau \ln 3 \approx 1.1 R_A C \]