Multivibrators

A MULTIVIBRATOR is an electronic circuit that generates square, rectangular, pulse waveforms, also called nonlinear oscillators or function generators.

Multivibrator is basically a two amplifier circuits arranged with regenerative feedback.

There are three types of Multivibrator:

Astable Multivibrator: Circuit is not stable in either state—it continuously oscillates from one state to the other. (Application in Oscillators)

Monostable Multivibrator: One of the state is stable but the other is not. (Application in Timer)

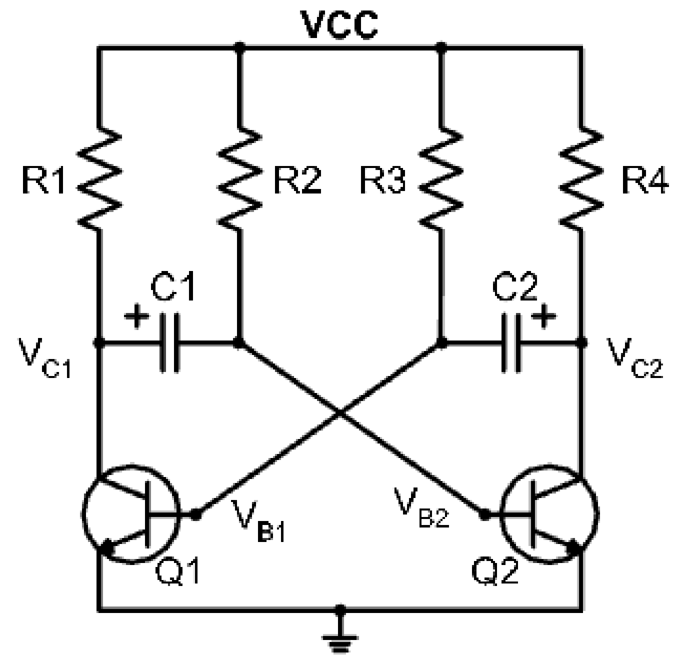
Bistable Multivibrator: Circuit is stable in both the state and will remain in either state indefinitely. The circuit can be flipped from one state to the other by an external event or trigger. (Application in Flip flop)

Reference material: Chapter 18 – Transistor Oscillators and Multivibrators, Electronic Devices and Circuits by Allen Mottershed

Astable Multivibrators

➢ The astable circuit has no stable state. With no external signal applied, the transistors alternately switch from cutoff to saturation at a frequency determined by the RC time constants of the coupling circuits.

➢ Astable multivibrator circuit consist of two cross coupled RC amplifiers.



Consists of two amplifying devices cross-coupled by resistors and capacitors. Typically, R2 = R3, R1 = R4, C1 = C2 and R2 >> R1.

□□ The circuit has two states

✓ State 1: V_{C1} LOW, V_{C2} HIGH, Q1 ON (saturation) and Q2 OFF.

✓ State 2: V_{C1} HIGH, V_{C2} LOW, Q1 OFF and Q2 ON (saturation).

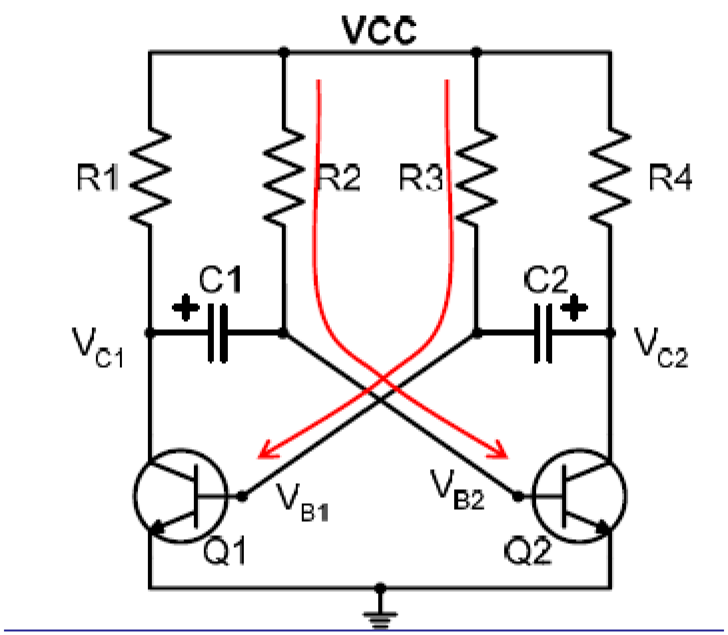
□□ It continuously oscillates from one state to the other.

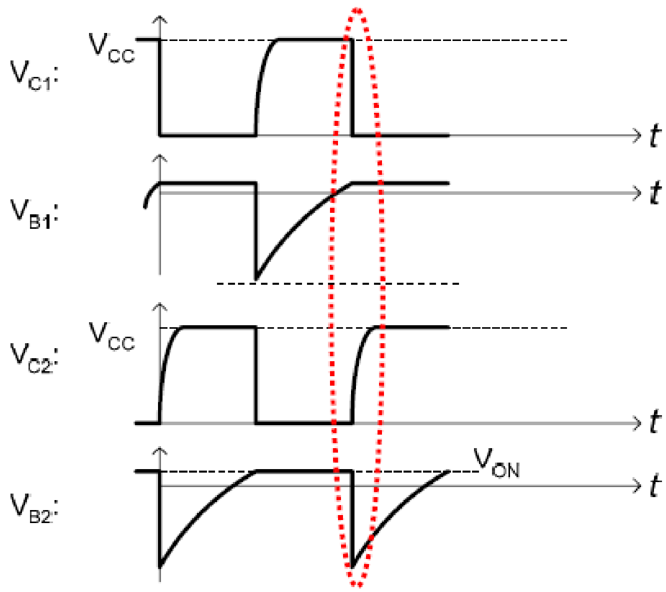
Astable Multivibrators

➢ When the circuit is first powered up, neither transistor is ON.

➢ Both V_{B1} and V_{B2} rise via base resistor R_3 and R_2 respectively. Any one of the transistor will conduct faster than other due to some circuit imbalance. We can not say which transistor will turn on first so for analysis purpose we assume Q1 conducts first and Q2 off (C_1 is fully charged).

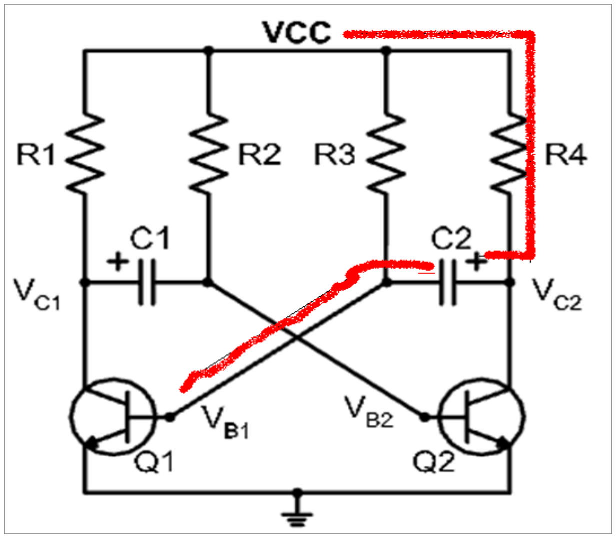
➢ Since Q1 conducts and Q2 off hence Vc1 = 0V and Vc2 = V_{CC}. - state1



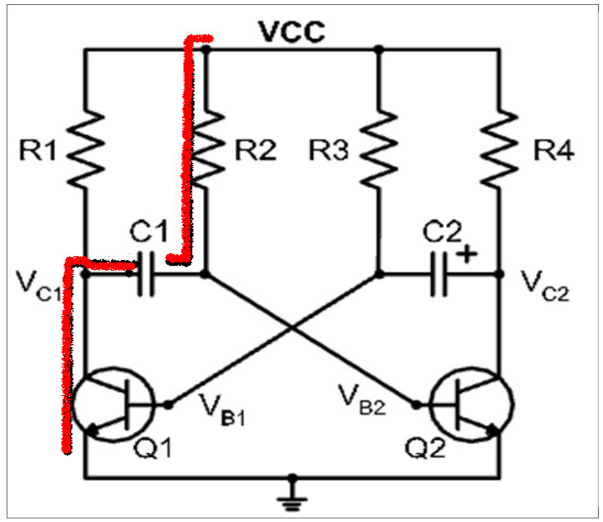


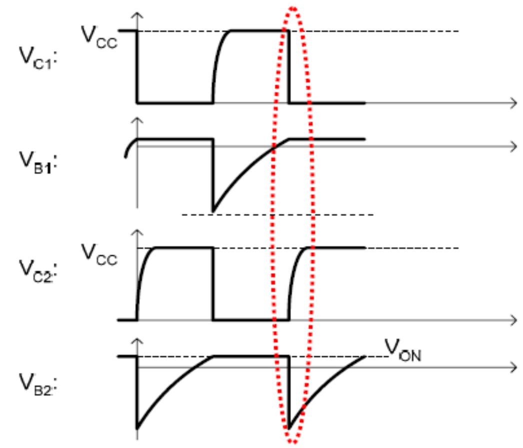
Astable Multivibrators

Charging $C_2(T_2 = R_4C_2)$



Discharging $C_1(T1 = R_2C_1)$





- Since Q1 conducts and Q2 off hence Vc1 = 0V and Vc2 = V_{CC}. Due to higher voltage at V_{c2}, capacitor C_2 will be charged via R_4 (low resistance path because $R_4 < R_2$). C_1 (which was charged earlier, and can not hold the charge for indefinite period) starts discharging via R_2 (high resistance path because $R_2 > R_1$). Time taken to discharge $C_1(T_1 = R_2C_1)$ > time taken to charge C_2 $(T_2 = R_4C_2)$

- When C_2 is fully charged then left plate of C_2 will be at $-V_{cc}$ which switch off the Q1. When C_1 is fully discharged then left plate of C_1 will be at $+V_{cc}$ which switch on the Q2. – State 2

When V_{B2} reaches V_{on}, the circuit enters in state 1 again, and the process repeats.

Switching time & Frequency for Astable Multivibrators

- Time period of wave depends only upon the discharge of capacitors C_1 and C_2.
- Consider V_{B2} during discharge of C_2: $V_{B2} = V_{CC} - i_{C1} R_2$
- Since the capacitor C_1 charged up to V_{CC}, the initial discharge current will be

$$i_{C1} = \frac{V_{CC} + V_{CC}}{R_2}$$

Current decays exponentially with a time constant of $R_2 C_1$

$$V_{B2} = V_{CC} - 2V_{CC}(e^{-t/R_2C_1})$$

Transistor will switch when V_{B2} = 0V (actually 0.7V for Si which is small compare to V_{CC})

$$\boxed{0 = V_{CC} - 2V_{CC}(e^{-t/R_2C_1})} \qquad \boxed{2e^{-t/R_2C_1} = 1} \qquad \boxed{t = T_2 = R_2 C_1 \ln(2)}$$

where T2 is the off time for transistor Q_2

Switching time & Frequency for Astable Multivibrators

- Similarly off time for transistor Q_1 can be obtained.

$$\boxed{t = T_1 = R_3 C_2 \ln(2)}$$

- Total time period T:

$$\boxed{T = T_1 + T_2 = [R_3 C_2 + R_2 C_1]\ln(2) = 0.694(R_3 C_2 + R_2 C_1)}$$

- If R2 = R3 = R, C1 = C2 = C then $\boxed{T = 1.4RC}$

- Frequency of oscillation is given by

$$\boxed{f = \frac{1}{T} = \frac{0.7}{RC}}$$

Monostable Multivibrators

➢ One of the state is stable but the other is not. For that capacitive path between V_{C2} and V_{B1} removed.

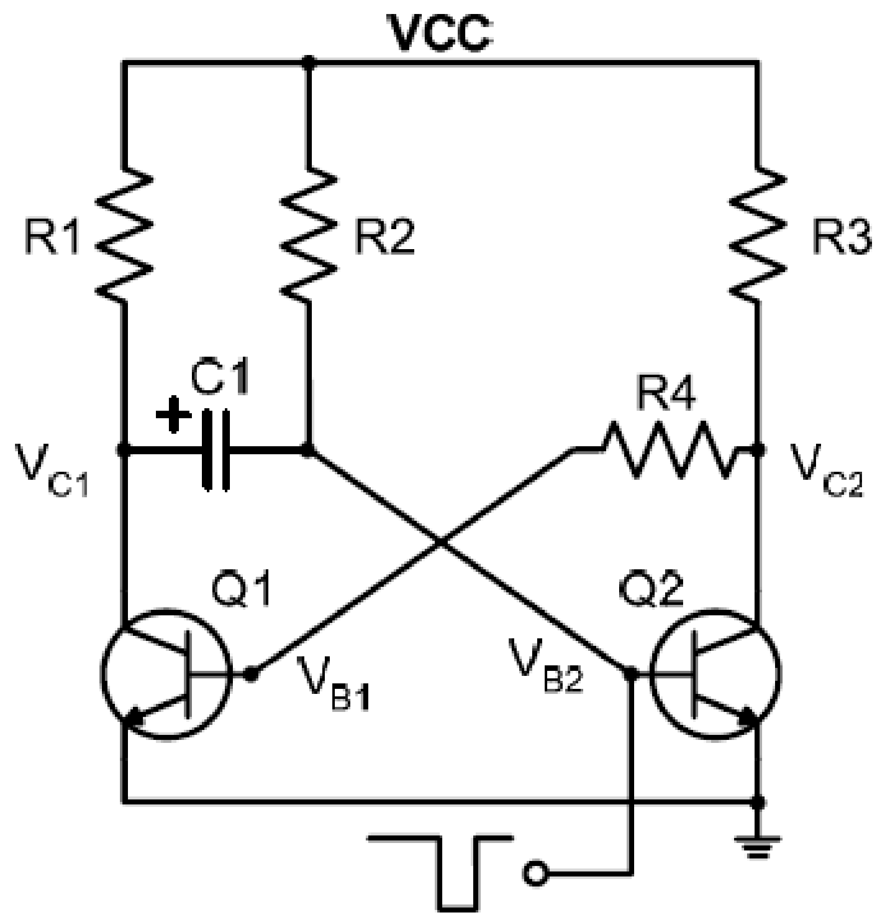
➢ In stable state any one transistor conducts and other is off.

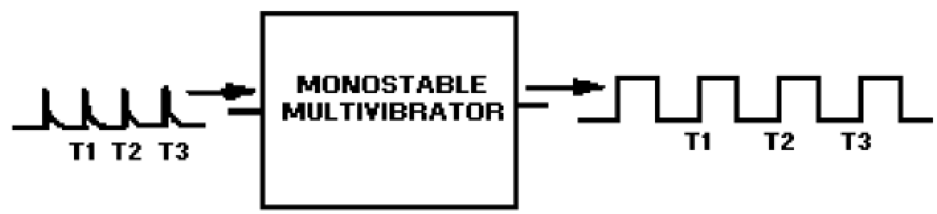
➢ Application of external trigger change the state.

➢ When the external signal goes high
✓ V_{B2} charges up to V_{CC} through R_2
✓ After a certain time T, $V_{B2}=V_{ON}$, Q2 turns on
✓ V_{C2} pulled to 0V, Q1 turns off.

➢ Enters state 1 and remains there

➢ When V_{B2} is momentarily pulled to ground by an external signal
✓ V_{C2} rises to V_{CC}
✓ Q1 turns on
✓ V_{C1} pulled to 0V



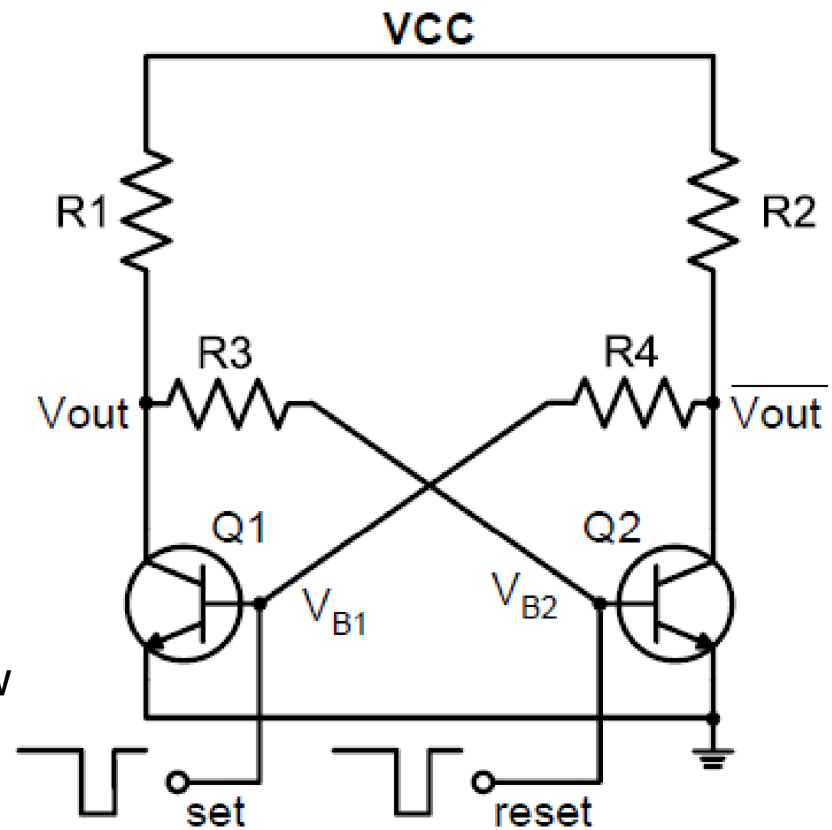


Bistable Multivibrators

- ➢ Both capacitors removed
- ✓ Stable for either state 1 or 2
- ✓ Can be forced to either state by Set or Reset signals

- ➢ If Set is low,
- ✓ Q1 turns off
- ✓ V_{C1} (Vout) and V_{B2} rises towards V_{CC}
- ✓ Q2 turns on
- ✓ V_{C2} pulled to 0V
- ✓ V_{B1} is latched to 0V
- ✓ Circuit remains in state 2 until Reset is low

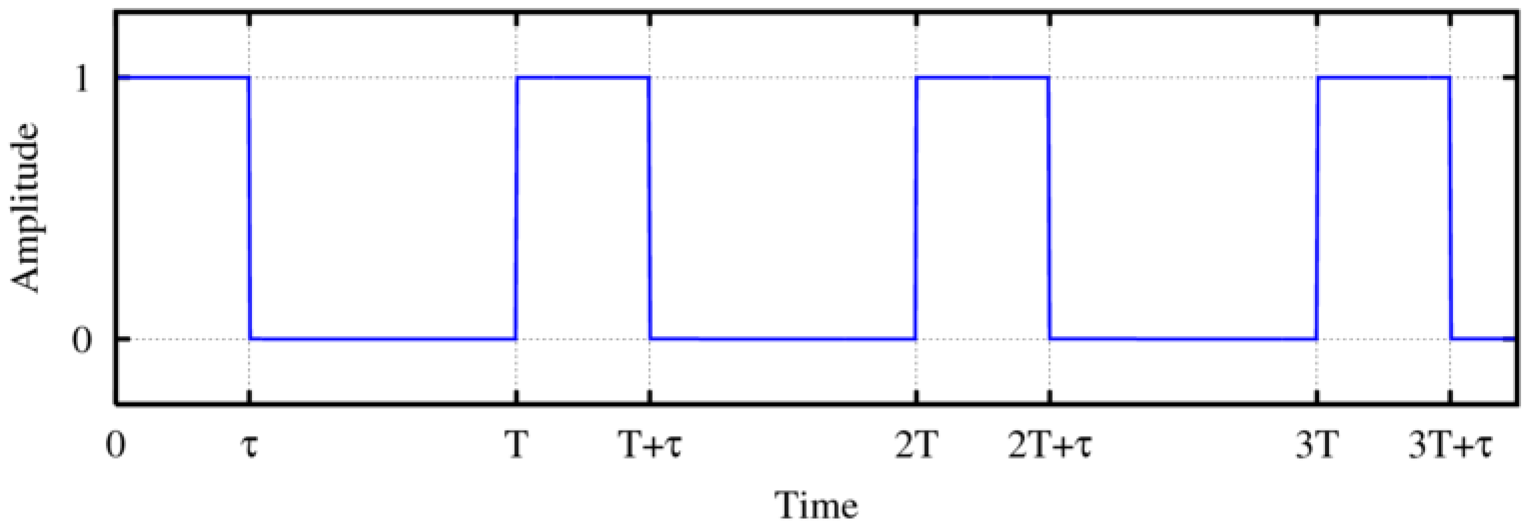
- ➢ If Reset is low
- ✓ Similar operation
- ✓ Circuit remains in state 1 until Set is low



- ➢ Behave as an RS flip-flop (memory element)

Some Important terms

Duty Cycle duty cycle is defined as the ratio of pulse duration to pulse period.



The pulse duration is τ; this is how long the pulse remains high (amplitude=1 in the figure).The pulse period is T ; this is the duration of one complete cycle, and is just the inverse of the frequency in Hz (*f = 1/T).*

$$D = \tau / T$$