

# Nalanda Open University

## B.SC Part-3

Course : Physics(Hons)

Paper : 8

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Topic- Multivibrator (Electronics)

# Multivibrator

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:

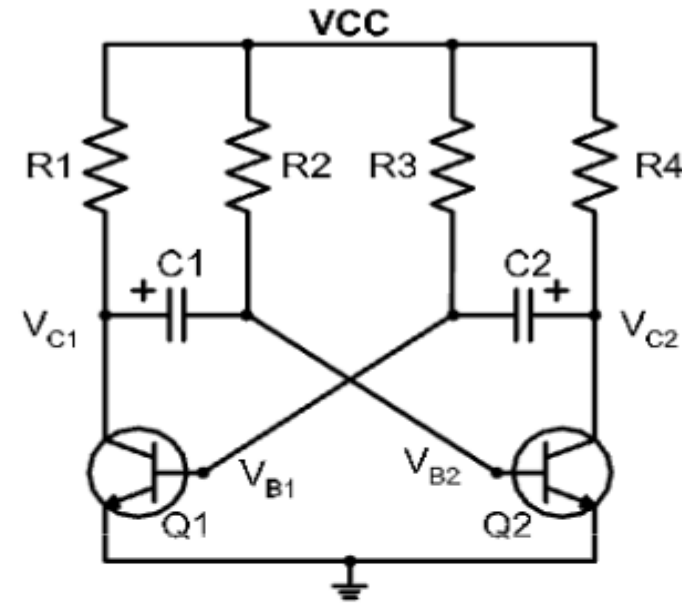
**Astable Multivibrator:** Circuit is not stable in either state—it continuously oscillates from one state to the other. (Application in Oscillators)

**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)

## Astable Multivibrator

- 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.



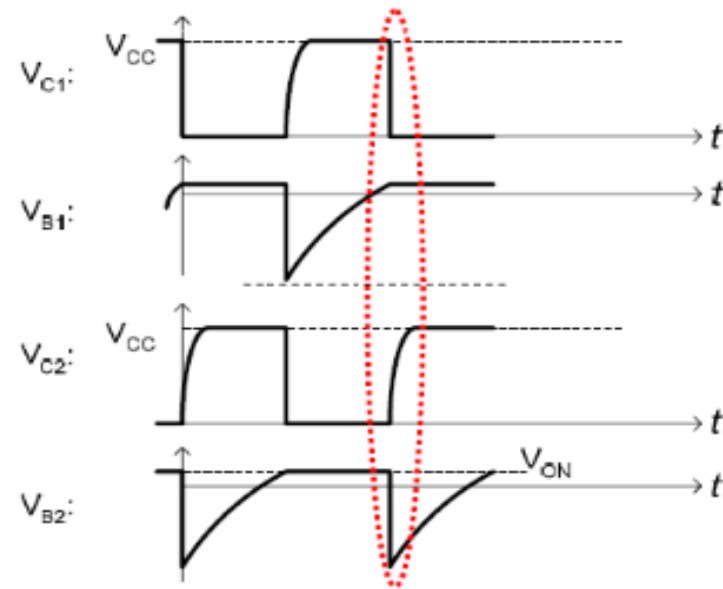
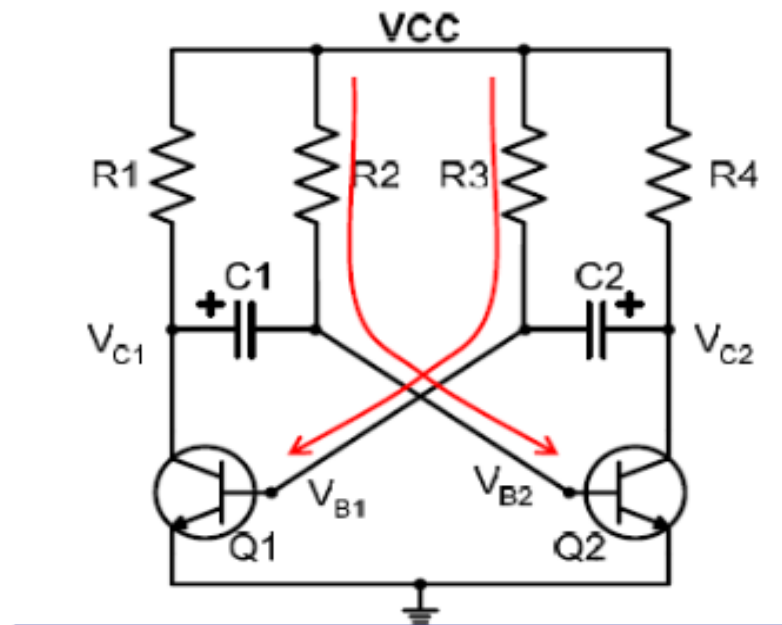
Consists of two amplifying devices cross-coupled by resistors and capacitors. Typically,  $R2 = R3$ ,  $R1 = R4$ ,  $C1 = C2$  and  $R2 \gg R1$ .

The circuit has two states

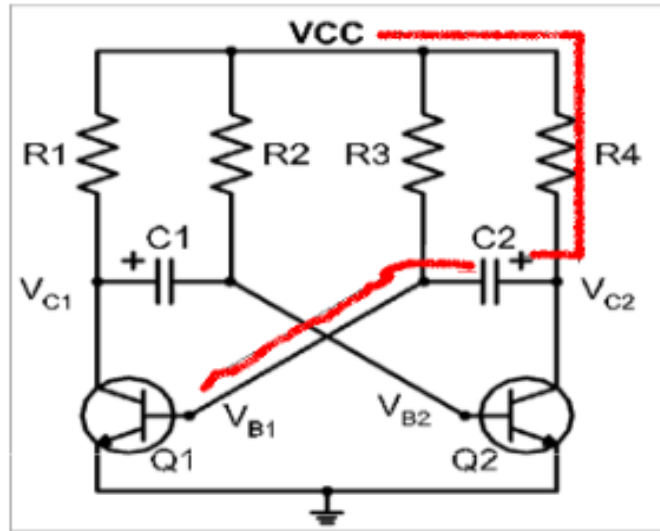
- ✓ State 1:  $V_{C1}$  LOW,  $V_{C2}$  HIGH, Q1 ON (saturation) and Q2 OFF.
- ✓ State 2:  $V_{C1}$  HIGH,  $V_{C2}$  LOW, Q1 OFF and Q2 ON (saturation).

It continuously oscillates from one state to the other.

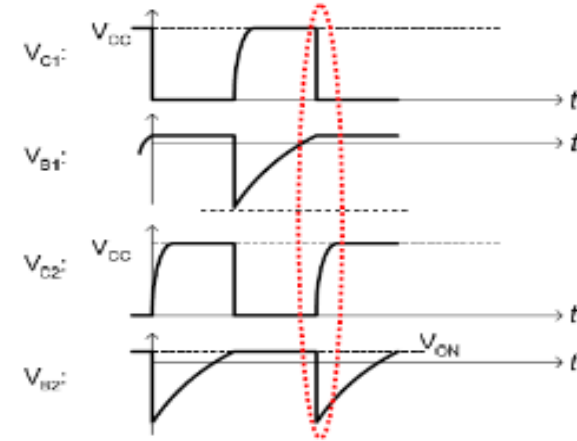
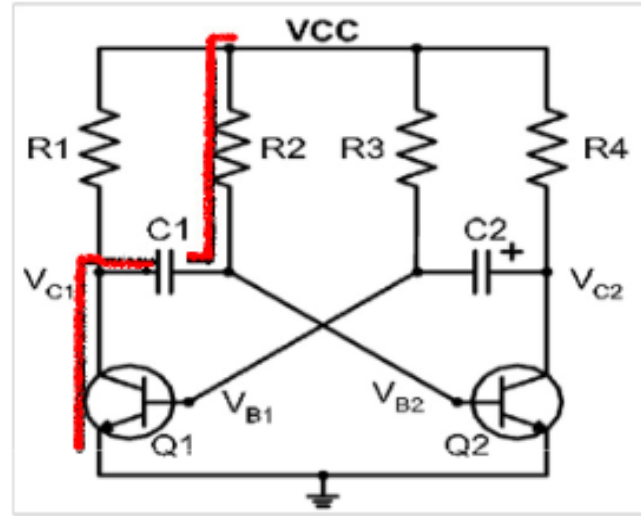
- When the circuit is first powered up, neither transistor is ON.
- Both  $V_{B1}$  and  $V_{B2}$  rise via base resistor  $R_3$  and  $R_2$  respectively. Any one of the transistor will conduct faster than other due to some circuit imbalance. We can not say which transistor will turn on first so for analysis purpose we assume Q1 conducts first and Q2 off ( $C_1$  is fully charged).
- Since Q1 conducts and Q2 off hence  $V_{C1} = 0V$  and  $V_{C2} = V_{CC}$ . - state1



Charging  $C_2$  ( $T_2 = R_4 C_2$ )



Discharging  $C_1$  ( $T_1 = R_2 C_1$ )



➤ Since Q1 conducts and Q2 off hence  $V_{c1} = 0V$  and  $V_{c2} = V_{CC}$ . 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  $C_1$  ( $T_1 = R_2 C_1$ )  $>$  time taken to charge  $C_2$  ( $T_2 = R_4 C_2$ )

➤ 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

$$i_{C1} = \frac{V_{CC} + V_{CC}}{R_2} \quad \text{Current decays exponentially with a time constant of } R_2C_1$$

$$V_{B2} = V_{CC} - 2V_{CC}(e^{-t/R_2C_1}) \quad \text{Transistor will switch when } V_{B2} = 0V \text{ (actually } 0.7V \text{ for Si which is small compare to } V_{CC}\text{)}$$

$$0 = V_{CC} - 2V_{CC}(e^{-t/R_2C_1})$$

$$2e^{-t/R_2C_1} = 1$$

$$t = T_2 = R_2C_1 \ln(2)$$

where  $T_2$  is the off time for transistor  $Q_2$

- Similarly off time for transistor  $Q_1$  can be obtained.

$$t = T_1 = R_3 C_2 \ln(2)$$

- Total time period T:

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

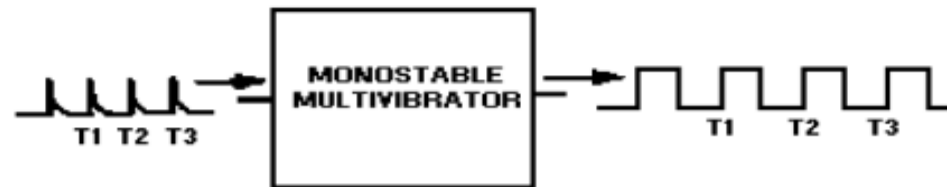
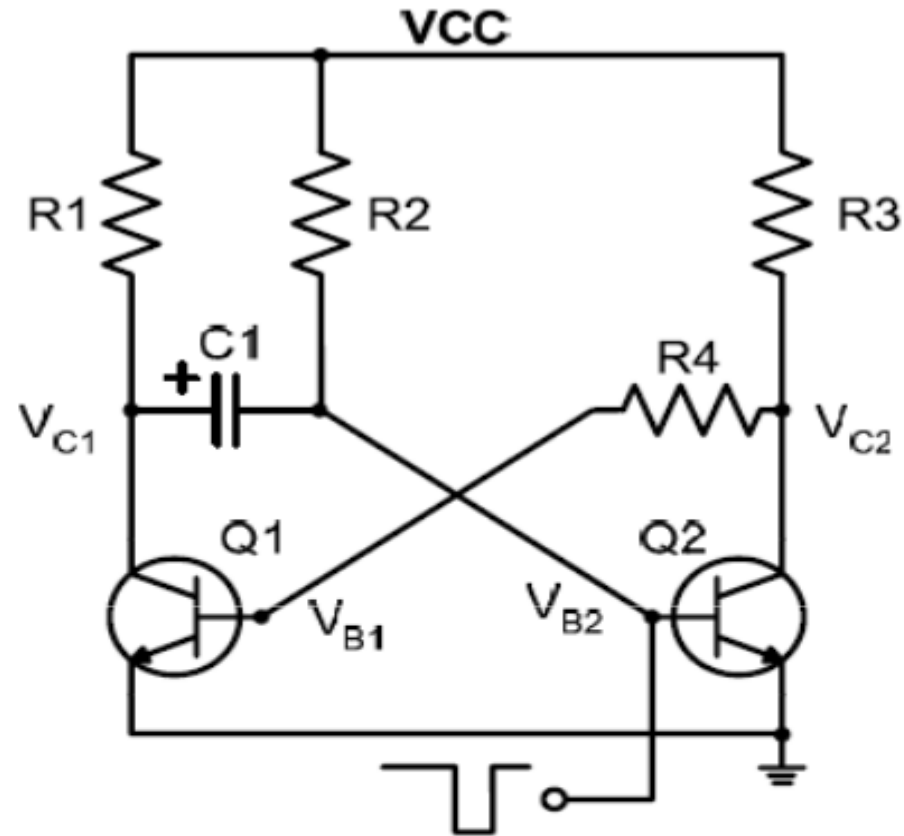
- If  $R_2 = R_3 = R$ ,  $C_1 = C_2 = C$  then  $T = 1.4RC$

- Frequency of oscillation is given by

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

## Monostable multivibrator

- 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  $T$ ,  $V_{B2} = V_{ON}$ ,  $Q_2$  turns on
  - ✓  $V_{C2}$  pulled to  $0V$ ,  $Q_1$  turns off.
- Enters state 1 and remains there
- When  $V_{B2}$  is momentarily pulled to ground by an external signal
  - ✓  $V_{C2}$  rises to  $V_{CC}$
  - ✓  $Q_1$  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
- ✓  $V_{C1}$  ( $V_{out}$ ) 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)

