

Chapter Five

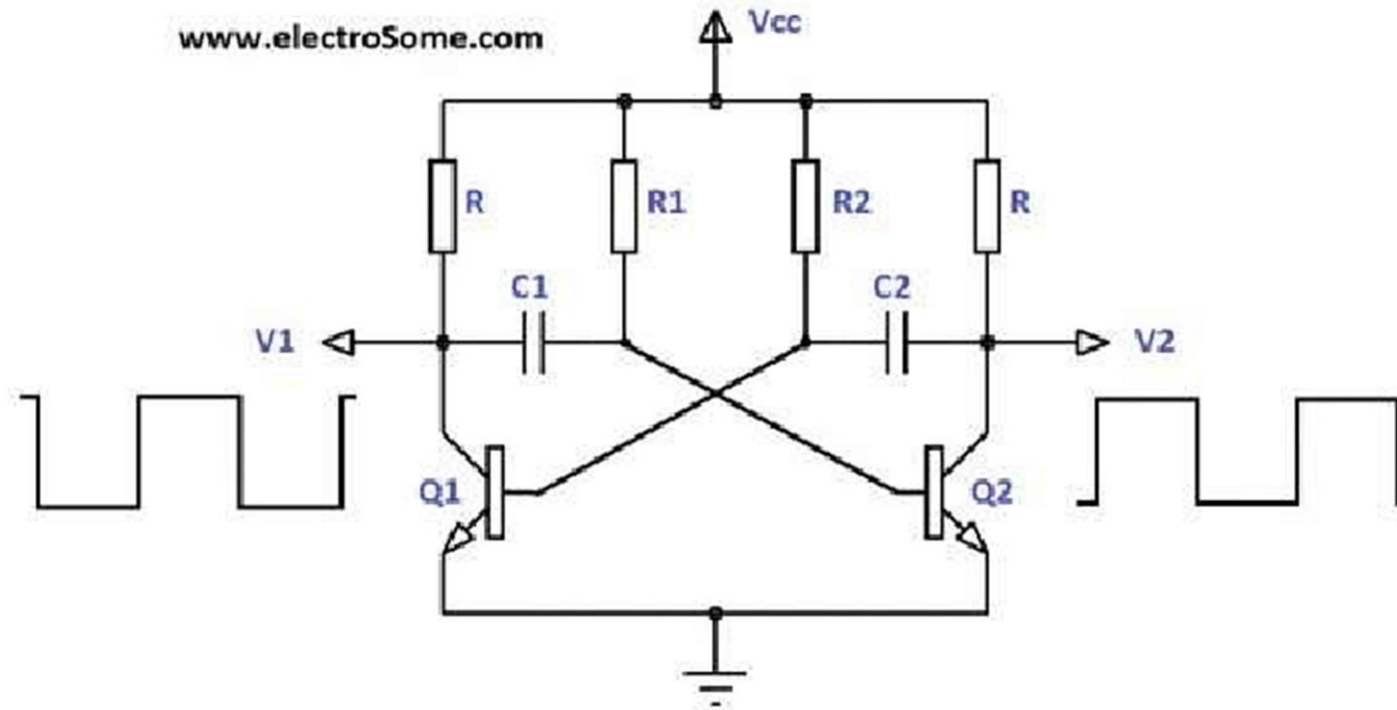
MULTIVIBRATOR

MULTIVIBRATOR

- A MULTIVIBRATOR is an electronic circuit that switches rapidly by means of positive feedback between two or more states.
- Its basically a two amplifier circuit.
- A multivibrator generates square, pulse, triangular waveforms.
- Also called as nonlinear oscillators or function generators.
- **Classification:**
 - Astable Multivibrator
 - Monostable multivibrator
 - Bistable multivibrators

Astable Multivibrator

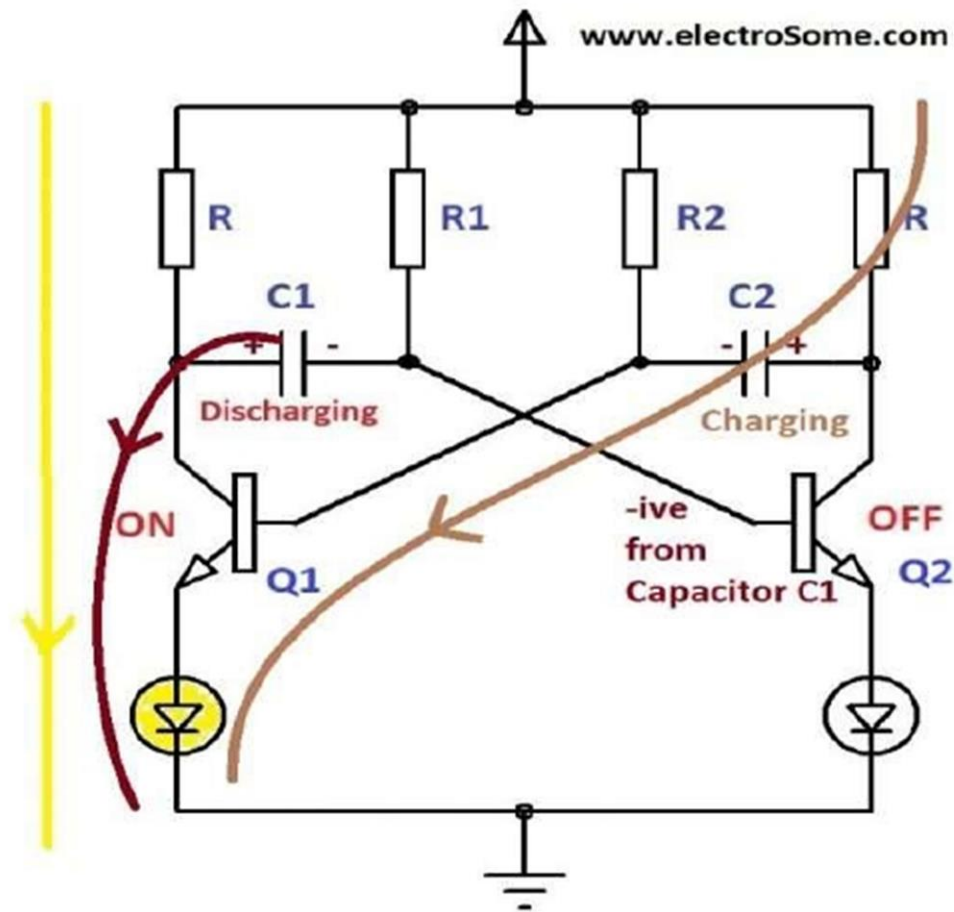
- An Astable Multivibrator or a Free Running Multivibrator is the multivibrator which has no stable states.
- Its output oscillates continuously between its two unstable states without the aid of external triggering.
- The time period of each states are determined by Resistor Capacitor (RC) time constant.



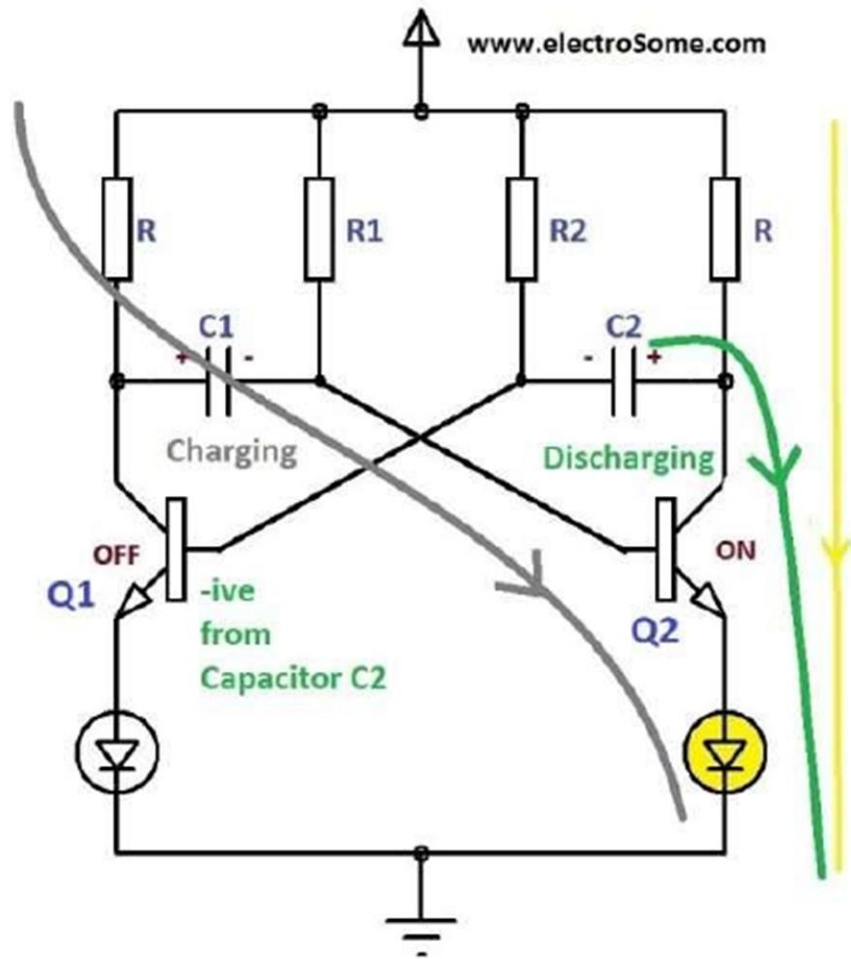
- In the above diagram we can find two transistors which is wired as a switch.

- **Working**

- When the circuit is switched on one transistor will driven to saturation (ON) and other will driven to cutoff (OFF). Consider Q1 is ON and Q2 is OFF.
- During this time Capacitor C2 is charging to V_{cc} through resistor R.
- Q2 is OFF due to the -ive voltage from the discharging capacitor C1 which is charged during the previous cycle. So the OFF time of Q2 is determined by $R1C1$ time constant.



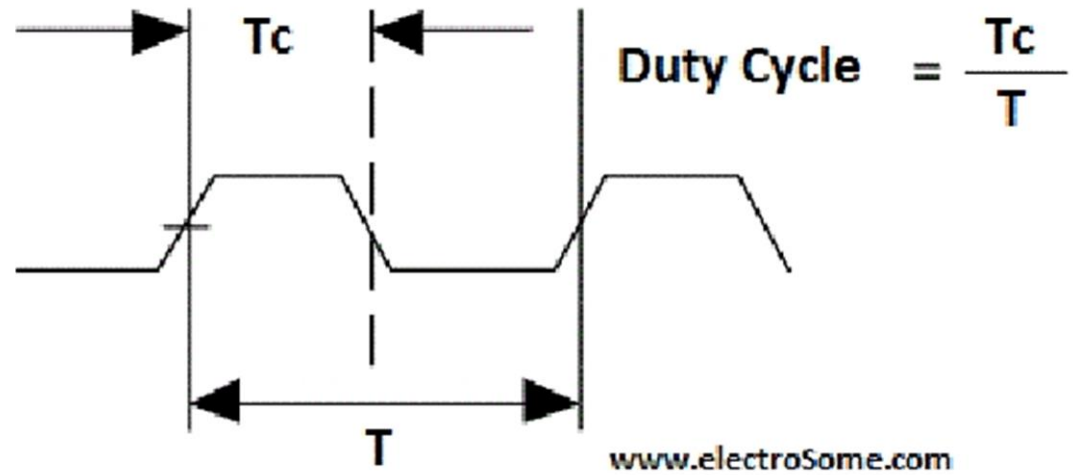
- After a time period determined by $R1C1$ time constant the capacitor $C1$ discharges completely and starts charging in reverse direction through $R1$.
- When the Capacitor $C1$ charges to a voltage sufficient provide base emitter voltage of $0.7V$ to the transistor $Q2$, it turns ON and capacitor $C2$ starts discharging.



- The negative voltage from the capacitor C2 turns off the transistor Q1 and the capacitor C1 starts charging from Vcc through resistor R and base emitter of transistor Q2. Thus the transistor Q2 remains in ON state.
- As in the previous state, when the capacitor C2 discharges completely it starts charging towards opposite direction through R2.

- When the voltage across the capacitor C2 is sufficient to turn ON transistor Q1, Q1 will turn ON and capacitor C1 starts discharging.
- This process continuous and produces rectangular waves at the collector of each transistors.
- Note : Charging time is very less compared to discharging time.
- Design
- R – Collector Resistor
- The resistance R should be designed to limit the collector current I_c with in a safe limit.
- $R = V/I_c$, where V is the voltage across the resistor R.
- In normal cases, $V = (V_{cc} - V_{ce}) = (V_{ce} - 0.3)$ but when an emitter load like LED is connected,
- $V = (V_{cc} - V_{ce} - V_{led})$, where V_{led} is the voltage drop across LED.
- Usually the maximum collector current I_c will be much higher than than the current required for emitter load such as LED. In these cases I_c should be chosen in such a way that it should not exceed the max current limit of emitter load.

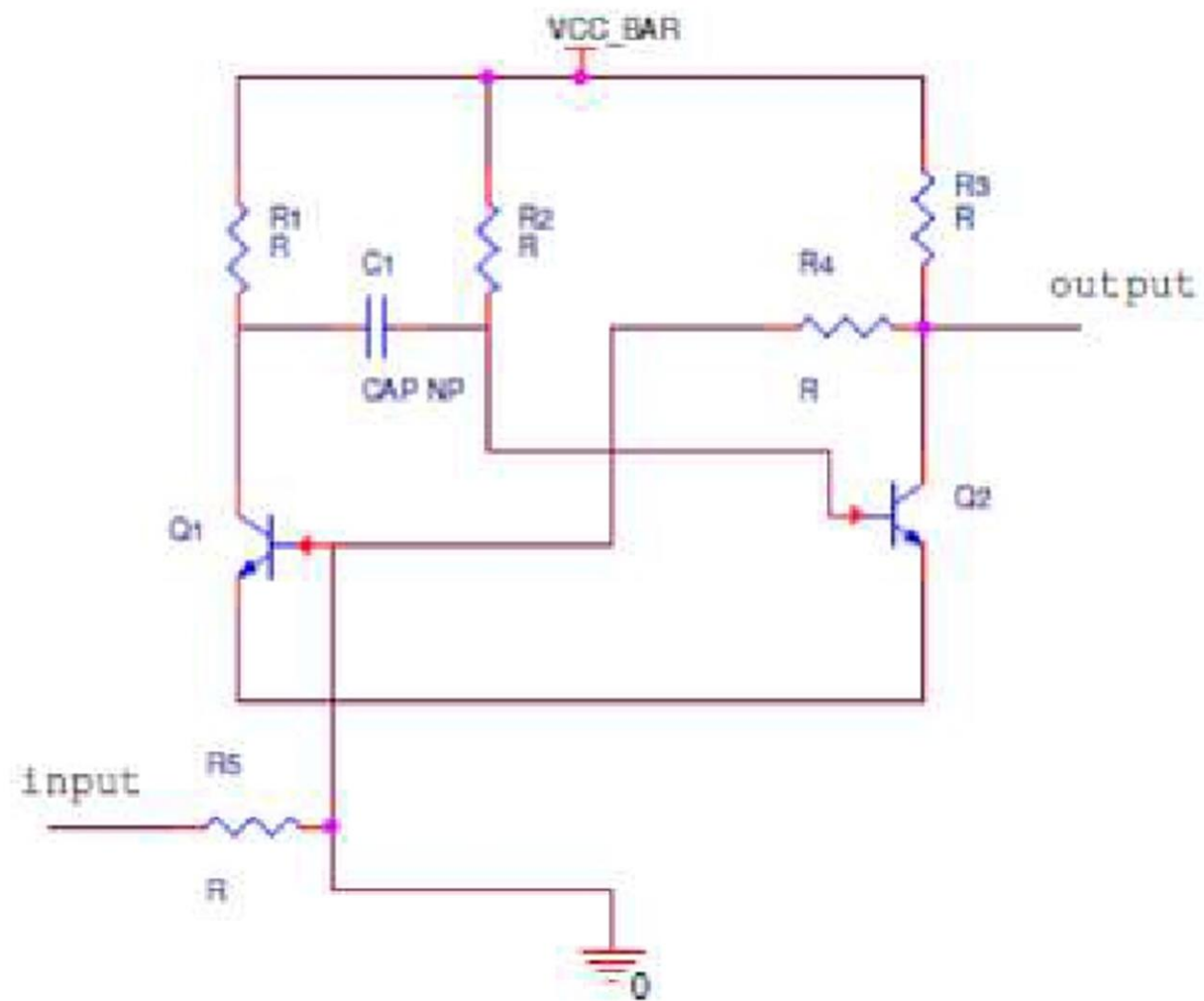
- So, $R = (V_{cc} - V_{ce} - V_{load}) / I_c$
- **R1 & R2 – Base Resistors**
- R1 & R2 should be chosen such that it should give the required collector current during saturation state.
- Min. Base Current, $I_{b_{min}} = I_c / \beta$, where β is the hFE of the transistor
- Safe Base Current, $I_b = 10 \times I_{b_{min}} = 3 \times I_c / \beta$
- **$R1, R2 = (V_{cc} - V_{be}) / I_b$**
- T1 & T2 – Time Period
- T2 = OFF Period of transistor Q1 = ON Period of Transistor Q2 = **$0.693R2C2$**
- T1 = OFF Period of transistor Q2 = ON Period of Transistor Q1 = **$0.693R1C1$**
- From these equations we can find the value of C1 and C2.



- It is the ratio of time T_c during which the output is high to total time period T of the cycle.
- Thus here, **Duty Cycle = $T_{\text{off}} / (T_{\text{off}} + T_{\text{on}})$** when the output is taken from the collector of the transistor T.

Monostable Multivibrator

- Monostable is also called one shot multivibrator.
- Monostable multivibrator has one stable state and one quasi stable state (astable state).
- In the multivibrator the output of first stage is given to the second stage and the second stage output is again feed back to the first stage by this the cutoff state will become saturate and saturate state will become to cutoff.
- Because of the transition of states the multivibrator can be used as oscillators, timers and flip-flops.
- When an external trigger applied to the circuit, the multivibrator will jump to quasi stable state from stable state.
- After the period of time it will automatically set back to the stable state, for returning to the stable state multivibrator does not require any external trigger.
- The time period to returning to stable state circuit is always depends on the passive elements in the circuit (resistor and capacitor values)



Monostable Multivibrator Circuit Diagram

- **Circuit Operation:**

- When there is no external trigger to the circuit the one transistor will be in saturation state and other will be in cutoff state. Q1 is in cutoff mode and put at negative potential until the external trigger to operate, Q2 is in saturation mode.
- Once the external trigger is given to the input Q1 will get turn on and when the Q1 reaches the saturation the capacitor which is connected to the collector of Q1 and base of Q2 will make transistor Q2 to turn off. This is state of turn off Q2 transistor is called astable stable or quasi state.
- When capacitor charges to VCC the Q2 will turn on again and automatically Q1 is turn off. So the time period for charging of capacitor through the resistor is directly proportional to the quasi or astable state of multivibrator when a external trigger occurred ($t=0.69RC$).

- **Uses of Monostable Multivibrator:**

- The monostable multivibrators are used as timers, delay circuits, gated circuits etc.

Bistable Multivibrator

- The bistable multivibrator has two absolutely stable states. It will remain in whichever state it happens to be until a trigger pulse causes it to switch to the other state.
- For instance, suppose at any particular instant, transistor Q1 is conducting and transistor Q2 is at cut-off.
- If left to itself, the bistable multivibrator will stay in this position for ever.
- However, if an external pulse is applied to the circuit in such a way that Q1 is cut-off and Q2 is turned on, the circuit will stay in the new position. Another trigger pulse is then required to switch the circuit back to its original state.
- In other words a multivibrator which has both the state stable is called a bistable multivibrator. It is also called flip-flop, trigger circuit or binary.
- The output pulse is obtained when, and why a driving (triggering) pulse is applied to the input. A full cycle of output is produced for every two triggering pulses of correct polarity and amplitude.
- Here the output of a transistor Q2 is coupled put of a transistor Q1 through a resistor R2.
- Similarly, the output of a transistor Q1 is coupled to the base of transistor Q2 through a resistor R1.

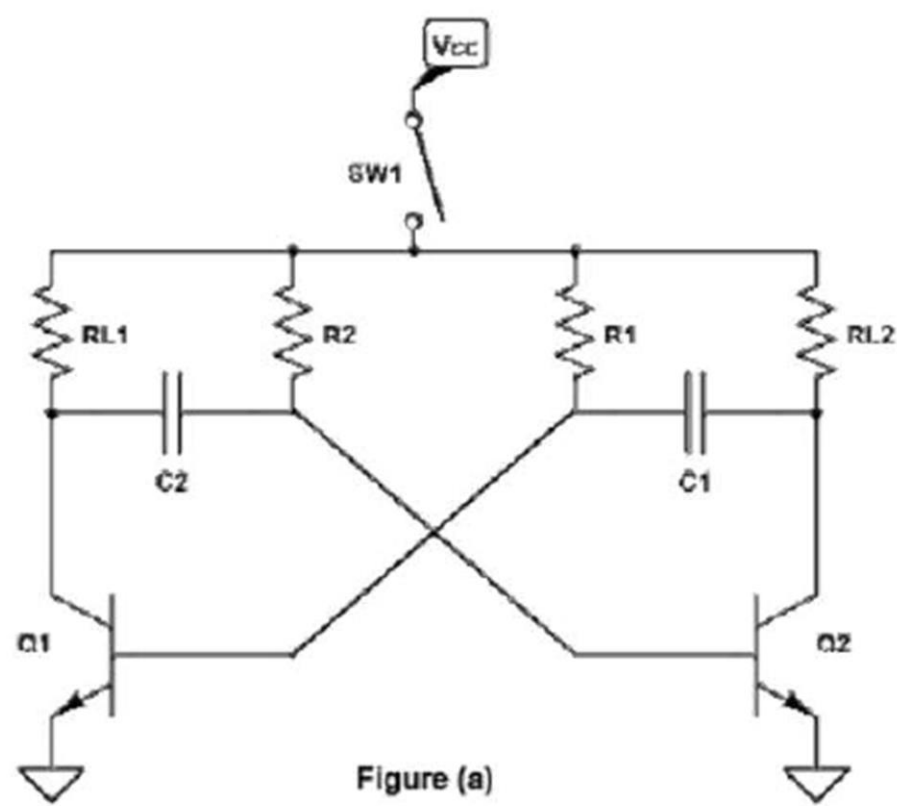


Figure (a)
Bistable Astable Multivibrator

- The capacitors C2 and C1 are known as speed up capacitors.
- Their function is to increase the speed of the circuit in making abrupt transition from one stable state to another stable state.
- The base resistors (R3 and R4) of both the transistors are connected to a common source ($-V_{BB}$).
- The output of a bistable multivibrator is available at the collector terminal of the both the transistor Q1 and Q2.
- However, the two outputs are the complements of each other.

- Let us suppose, if Q1 is conducting, then the fact that point A is at nearly 0V makes the base of Q2 negative (by the potential divider R2 - R4) and holds Q2 off.
- Similarly with Q2 OFF, the potential divider from VCC to -VBB (R1, R3) is designed to keep base of Q1 at about 0.7V ensuring that Q1 conducts. It is seen that Q1 holds Q2 OFF and Q2 holds Q1 ON.
- Suppose, now a positive pulse is applied momentarily to R. It will cause Q2 to conduct. As collector of Q2 falls to zero, it cuts Q1 OFF and consequently, the BMV switches over to its other state.
- Similarly, a positive trigger pulse applied to S will switch the BMV back to its original state.
- **Uses:**
 - 1. In timing circuits as frequency divider
 - 2. In counting circuits
 - 3. In computer memory circuits

Bistable Multivibrator Triggering

- To change the stable state of the binary it is necessary to apply an appropriate pulse in the circuit, which will try to bring both the transistors to active region and the resulting regenerative feedback will result on the change of state.
- Triggering may be of two following types:

I. Asymmetrical triggering

II. Symmetrical triggering

(I) Asymmetrical triggering

- In asymmetrical triggering, there are two trigger inputs for the transistors Q1 and Q2.
- Each trigger input is derived from a separate triggering source.
- To induce transition among the stable states, let us say that initially the trigger is applied to the bistable.
- For the next transition, now the identical trigger must appear at the transistor Q2.
- Thus it can be said that the asymmetrical triggering the trigger pulses derived from two separate source and connected to the two transistors Q1 and Q2 individually, sequentially change the state of the bistable.

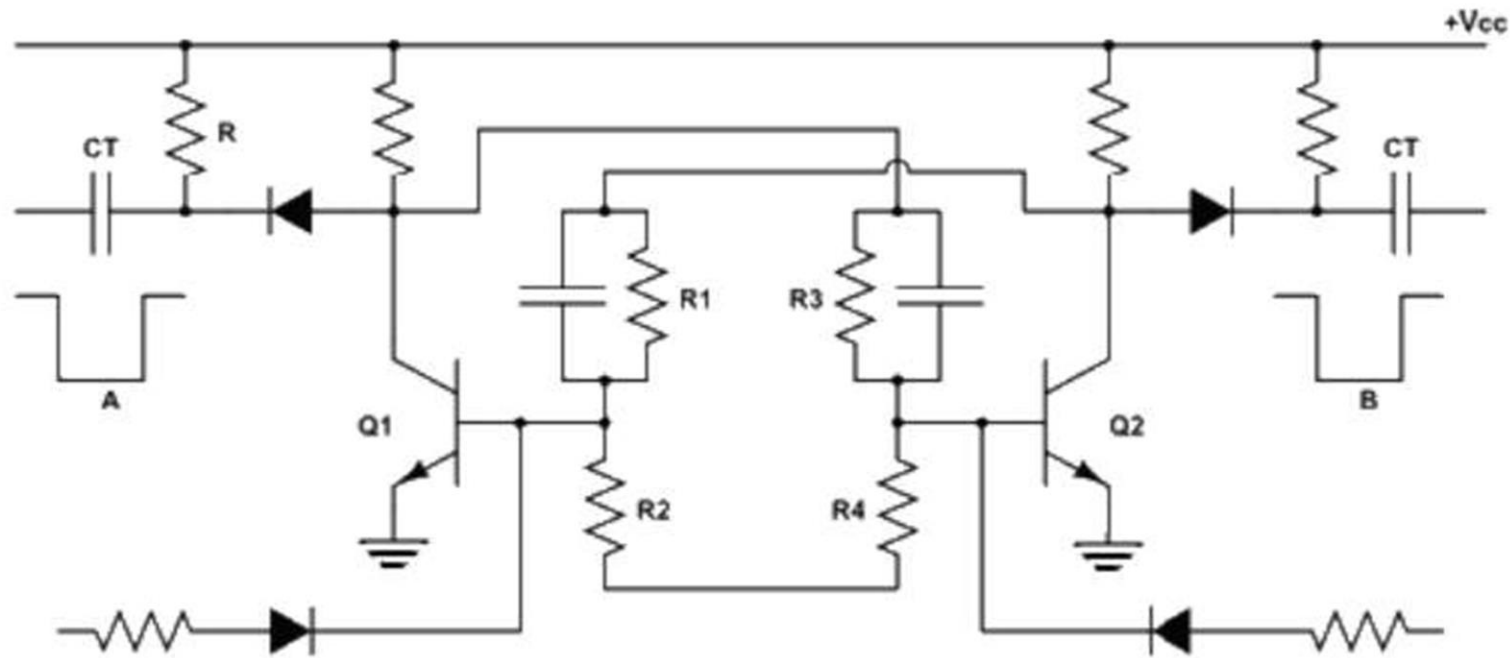


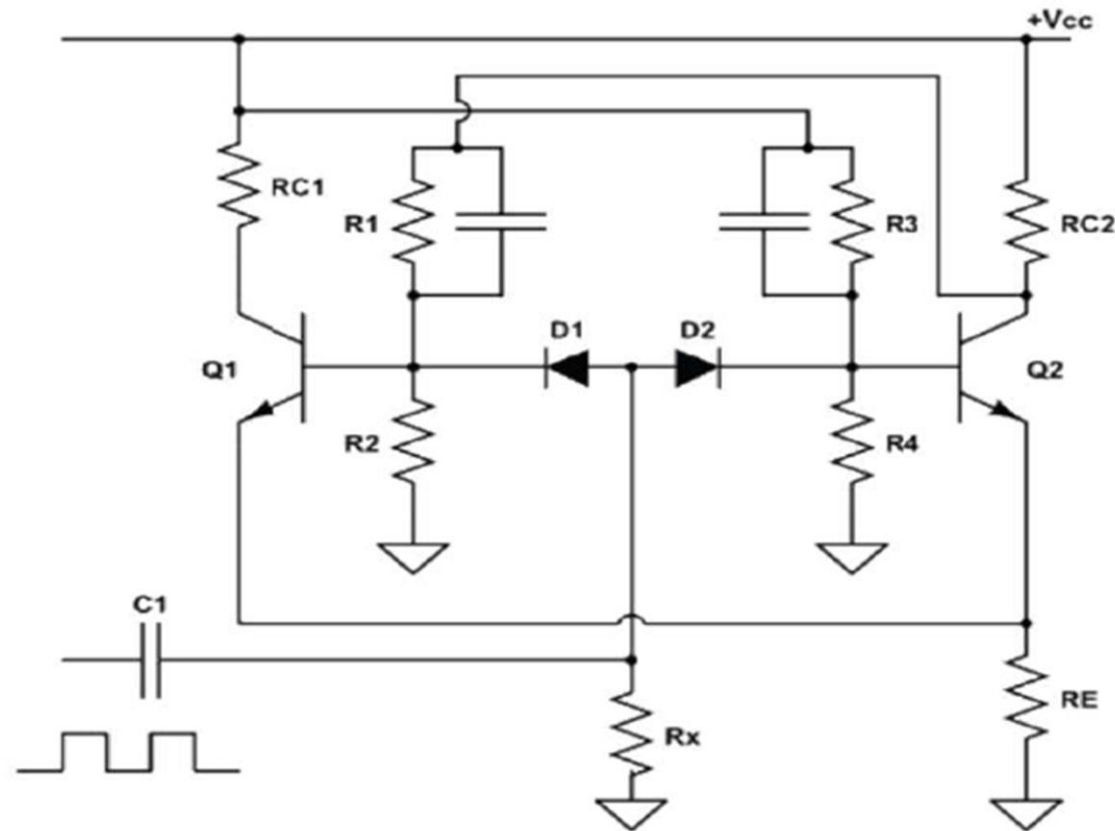
Figure: (b) Asymmetrical triggered bistable multivibrator

Bistable Astable Multivibrator

- Initially Q1 is OFF and transistor Q2 is ON.
- The first pulse derived from the trigger source A, applied to the terminal turn it OFF by bringing it from saturation region to active transistor Q1 is ON and transistor Q2 is OFF.
- Any further pulse next time then the trigger pulse is applied at the terminal B, the change of stable state will result with transistor Q 2 On and transistor Q1 OFF.

(II) Symmetrical Triggering

- There are various symmetrical triggering methods called symmetrical collector triggering, symmetrical base triggering and symmetrical hybrid triggering.
- Here we would like to explain only symmetrical base triggering (positive pulse) only as given under symmetrical Base Triggering



Bistable Astable Multivibrator

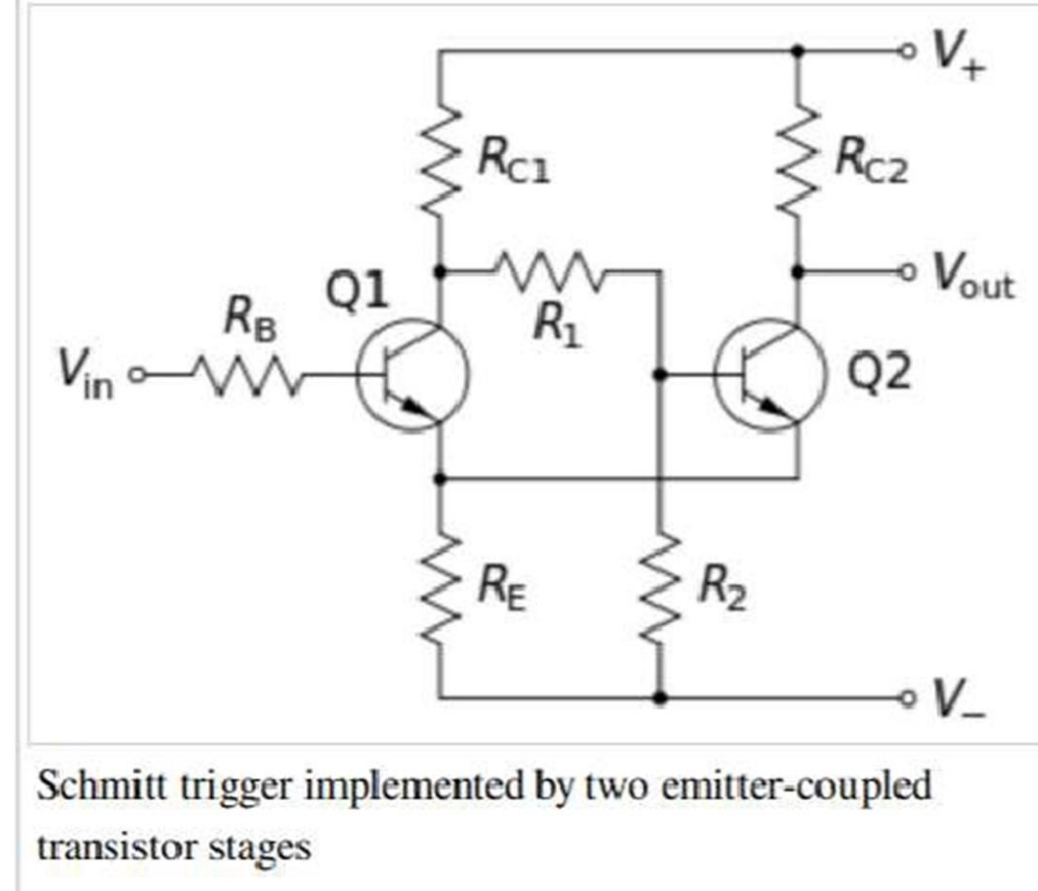
- Diodes D1 and D2 are steering diodes. Here the positive pulses, try to turn ON and OFF transistor.
- Thus when transistor Q1 is OFF and transistor Q2 is ON, the respective base voltages are $V_{B1N, OFF}$ and $V_{B2N, ON}$. It will be seen that $V_{B1N, OFF} > V_{B1N, ON}$. Thus diode D2 is more reverse-biased compared to diode D1.
- When the positive differentiated pulse of amplitude greater than $(V_{B1N, OFF} + V_\gamma)$ appears, the diode D1 gets forward biased, and transistor Q1 enters the active region and with subsequent regenerative feedback Q1 gets ON, and transistor Q2 becomes OFF.
- On the arrival of the next trigger pulse now the diode D2 will be forward biased and ultimately with regenerative feedback it will be in the ON state.

Schmitt trigger circuit.

- A Schmitt trigger is a comparator circuit with hysteresis, implemented by applying positive feedback to the noninverting input of a comparator or differential amplifier.
- It is an active circuit which converts an analog input signal to a digital output signal.
- The circuit is named a "trigger" because the output retains its value until the input changes sufficiently to trigger a change.
- Schmitt trigger devices are typically used in signal conditioning applications to remove noise from signals used in digital circuits, particularly mechanical switch bounce.
- They are also used in closed loop negative feedback configurations to implement relaxation oscillators, used in function generators and switching power supplies.

- **Classic emitter-coupled circuit**

- The original Schmitt trigger is based on the dynamic threshold idea that is implemented by a voltage divider with a switchable upper leg (the collector resistors R_{C1} and R_{C2}) and a steady lower leg (R_E).
- Q1 acts as a comparator with a differential input (Q1 base-emitter junction) consisting of an inverting (Q1 base) and a non-inverting (Q1 emitter) inputs.
- The input voltage is applied to the inverting input; the output voltage of the voltage divider is applied to the non-inverting input thus determining its threshold.
- The comparator output drives the second common collector stage Q2 (an emitter follower) through the voltage follower R_1 - R_2 .
- The emitter-coupled transistors Q1 and Q2 actually compose an electronic double throw switch that switches over the upper legs of the voltage divider and changes the threshold in a different (to the input voltage) direction



- **Initial state.**
- For NPN transistors as shown, imagine the input voltage is below the shared emitter voltage (high threshold for concreteness) so that Q1 base-emitter junction is backward-biased and Q1 does not conduct.
- Q2 base voltage is determined by the mentioned divider so that Q2 is conducting and the trigger output is in the low state.

- The two resistors R_{C2} and R_E form another voltage divider that determines the high threshold.
- Neglecting V_{BE} , the high threshold value is approximately

$$V_{HT} = \frac{R_E}{R_E + R_{C2}} V_+$$

- **Crossing up the high threshold:**
- When the input voltage (Q1 base voltage) rises slightly above the voltage across the emitter resistor R_E (the high threshold), Q1 begins conducting.
- Its collector voltage goes down and Q2 begins going cut-off, because the voltage divider now provides lower Q2 base voltage
- The common emitter voltage follows this change and goes down thus making Q1 conduct more.
- The current begins steering from the right leg of the circuit to the left one. Although Q1 is more conducting, it passes less current through R_E (since $R_{C1} > R_{C2}$); the emitter voltage continues dropping and the effective Q1 base-emitter voltage continuously increases.
- This avalanche-like process continues until Q1 becomes completely turned on (saturated) and Q2 turned off.

- The trigger is transitioned to the high state and the output (Q2 collector) voltage is close to V+.
- Now, the two resistors RC1 and RE form a voltage divider that determines the low threshold. Its value is approximately

$$V_{LT} = \frac{R_E}{R_E + R_{C1}} V_+$$

- **Crossing down the low threshold.**
- With the trigger now in the high state, if the input voltage lowers enough (below the low threshold), Q1 begins cutting-off.
- Its collector current reduces; as a result, the shared emitter voltage lowers slightly and Q1 collector voltage rises significantly. R1-R2 voltage divider conveys this change to Q2 base voltage and it begins conducting.
- The voltage across RE rises, further reducing the Q1 base-emitter potential in the same avalanche-like manner, and Q1 ceases to conduct. Q2 becomes completely turned-on (saturated) and the output voltage becomes low again.

- **Applications**

- Schmitt triggers are typically used in open loop configurations for noise immunity and closed loop configurations to implement function generators.

- **Noise immunity**

- One application of a Schmitt trigger is to increase the noise immunity in a circuit with only a single input threshold.
- With only one input threshold, a noisy input signal [nb 4] near that threshold could cause the output to switch rapidly back and forth from noise alone.
- A noisy Schmitt Trigger input signal near one threshold can cause only one switch in output value, after which it would have to move beyond the other threshold in order to cause another switch.

- **Use as an oscillator**

- A Schmitt trigger is a bistable multivibrator, and it can be used to implement another type of multivibrator, the relaxation oscillator.