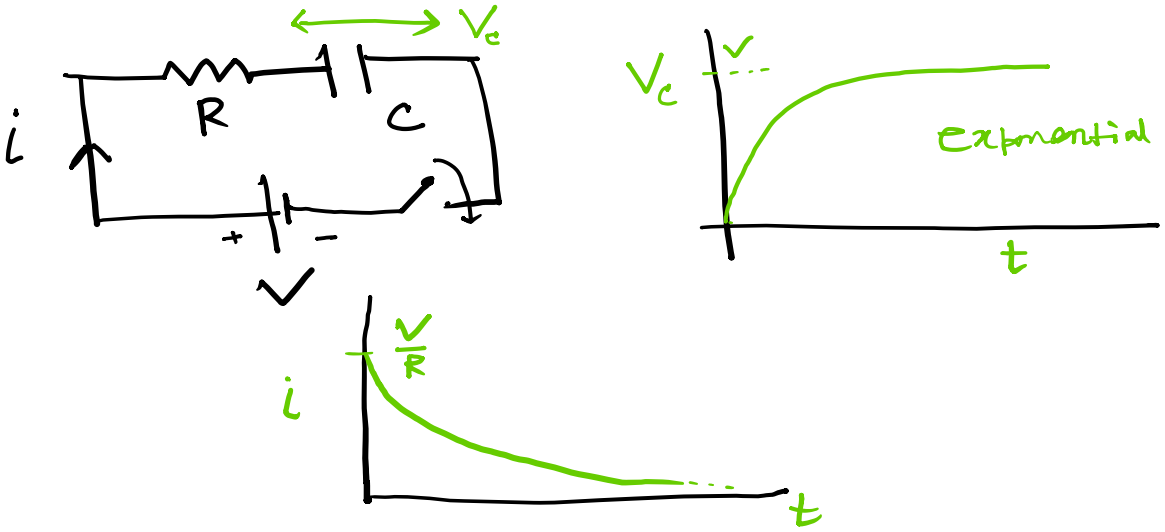
PCB Design workshop : Guide to astable Flip-Flop Circuit

- PCB Designing is all about placing the components, routing the traces in an optimised manner on a circuit board. To do so, it is important to know and understand the circuit in hand, which will be implemented in PCB. For example, we need to know the maximum current level between two specific components, so that we can design the trace connecting them properly.
- For this Workshop purpose, we have chosen astable flip-flop/ Astable multivibrator to be implemented in PCB. Here is a simple explanation of the circuit and as well as the pre-requisite concepts.

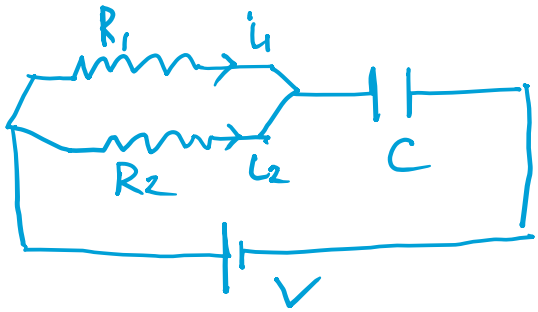
Pre-requisite Concepts

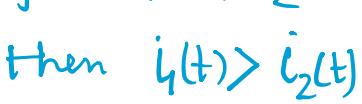
- **R-C circuit**
  For a simple R-C charging circuit as shown below , the voltage across C-capacitor



  increases exponentially to reach a stable value and current decreases exponentially to reach zero.

  In case there are multiple resistor, lower resistance path will allow more current than

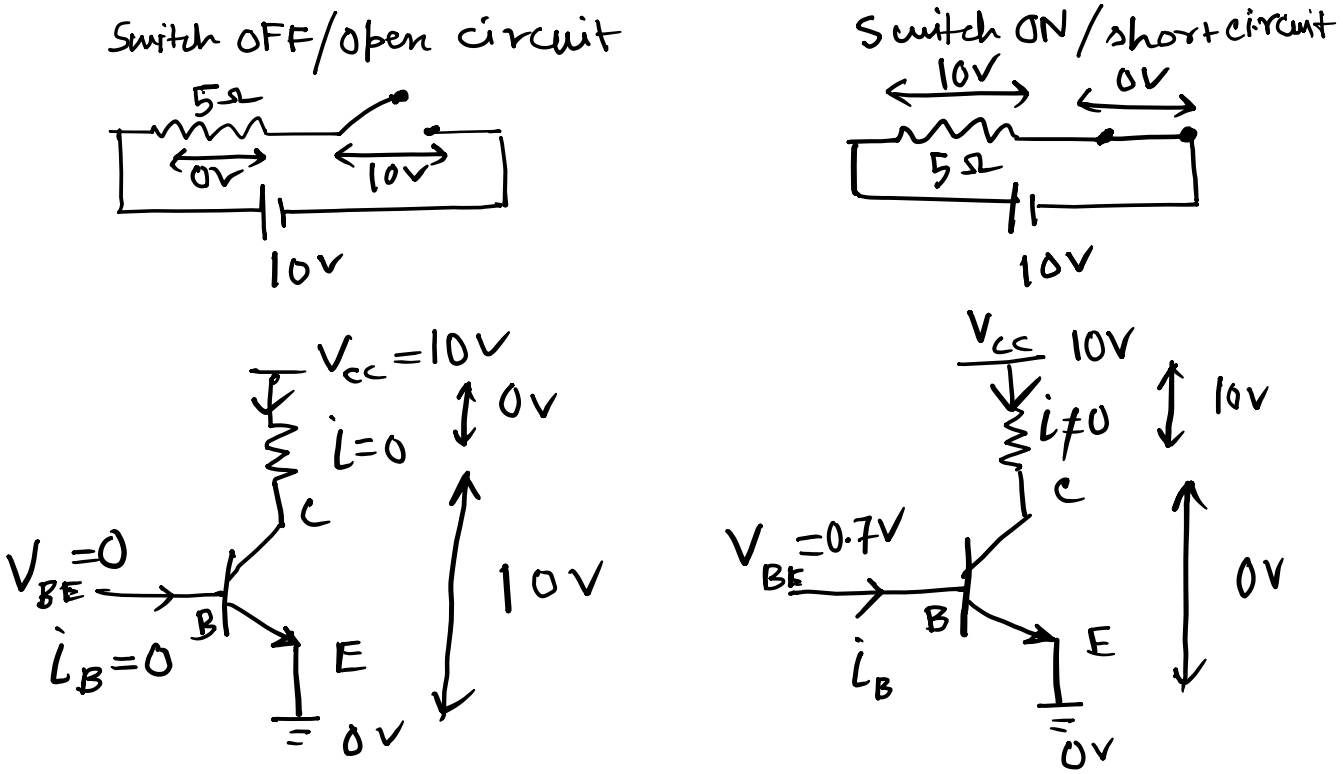




  higher resistance path.

let say R1=10 Ω and R2=100Ω, then i1 will be 10 times i2.

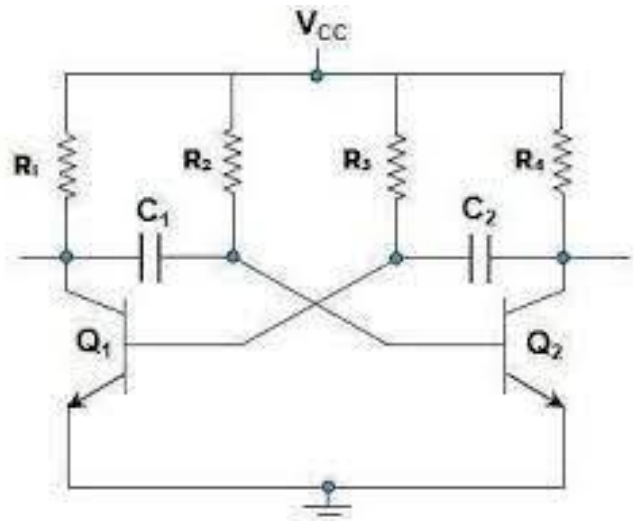
- **Bipolar Junction Transistor as a switch**
  BJT is essentially a current controlled current source device. We can use it as a switch by controlling the base current. When base current I_b is zero the BJT work as open circuit and when base current is bot zero, it act as a short circuit. Note how voltage



across transistor (V_{CE}) changes in open circuit and Short circuit condition.

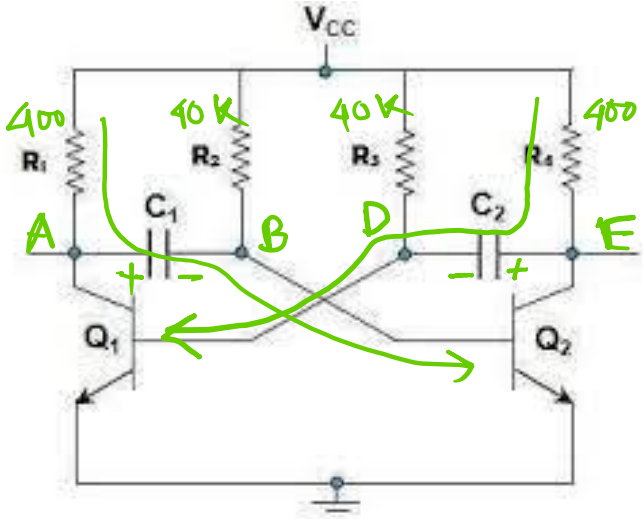
Astable Multivibrator

A multivibrator circuit has 2 states--- High and low. Astable means none of the states are stable and continuously changing, although the input is only steady DC. The frequency of change is determined by the passive components (R and C). The circuit is as below----



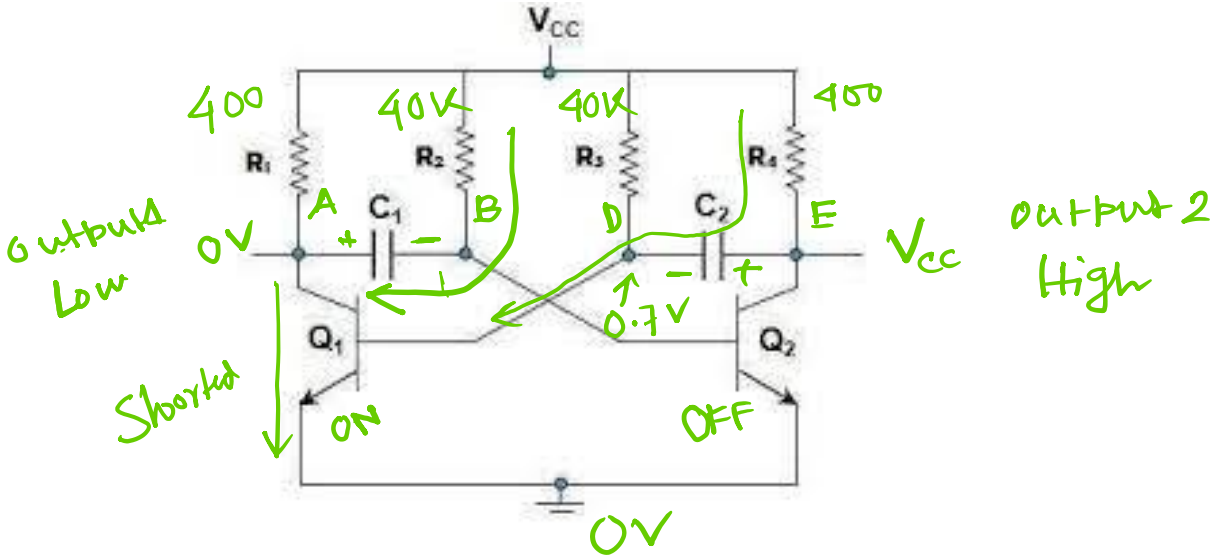
So How it works?

- Lets assume R1=R4=400 Ω , R2=R4= 40000 Ω and C1=C2= 100 uF. When supply is given, both capacitor will draw current to charge up (through resistor R1, R4 and not through R2, R3 as they are of much higher value) and both transistor will try to turn



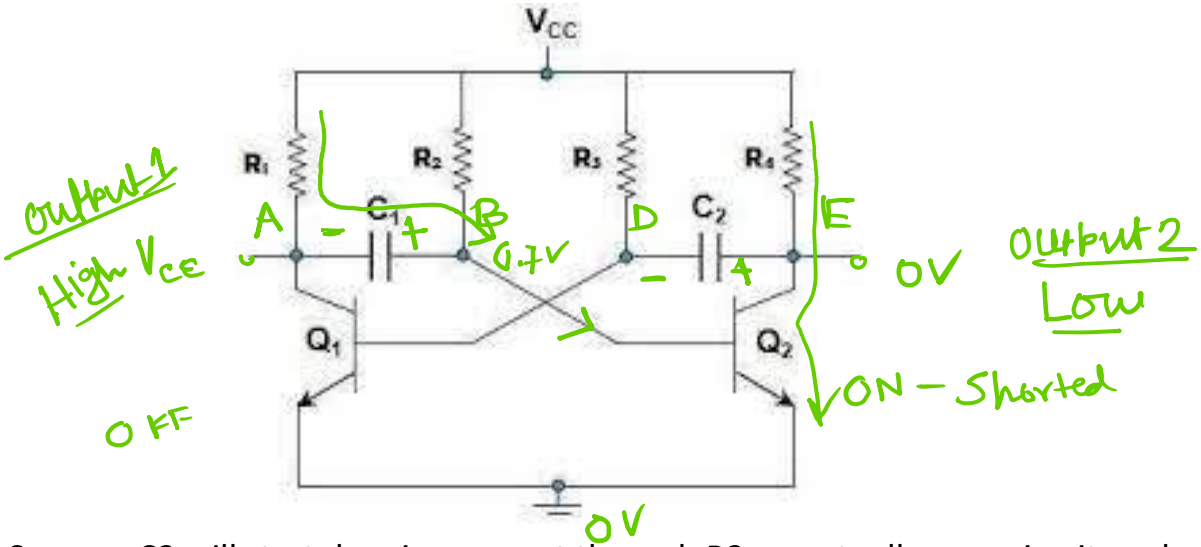
on. But due to inherent mismatch in transistors and circuit, only one will turn on first. Lets assume Q1 turns on first.

- The moment Q1 turns on, it gets shorted with ground and point A becomes grounded that is 0 volt. According to polarity of C1 , then B must be at some negative value. And if B is at some negative value, the base of Q2 is reverse biased, so Q2 remain turned OFF. So voltage at E is V_{CC}. So now output1 is Low and output2 is High



- At this moment B is at some negative voltage and D is at 0.7 V(As base-emitter junction of Q1 is conducting, and we know V_{BE}= threshold value=0.7V). Now that B is at negative voltage and Q1 is shorted, C1 will draw current in reverse direction through R2 and the polarity across C1 will eventually reverse.
- During reverse charging, when point B reaches 0.7 V , it turns on Q2. The moment Q2 turns on , point E becomes grounded and D becomes some negative voltage ,

stopping base current of Q1 and turning it off. So now output 1 is high and output 2 is low.



- So now, C2 will start drawing current through R3, eventually reversing its polarity and when point D reaches 0.7 V from some negative value it will turn on Q1 and turn off Q2. Thus the process will continue.

Here is some simulation result from LTSpice

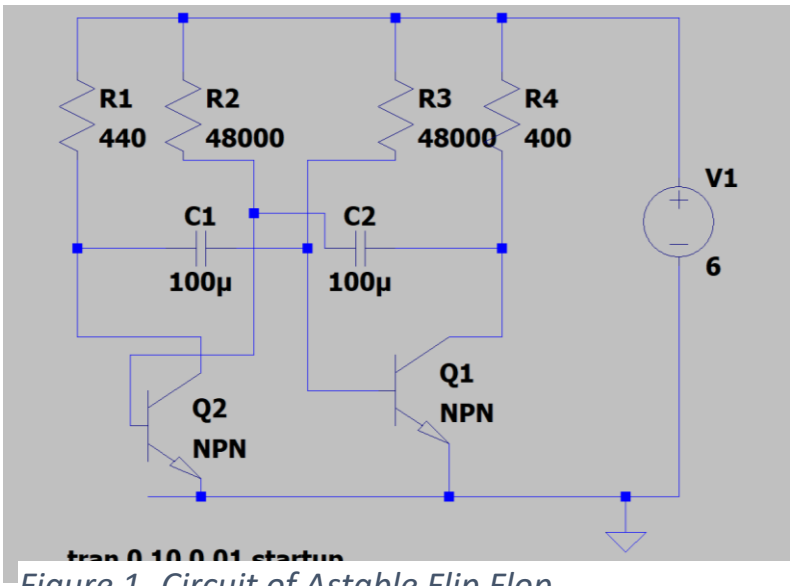


Figure 1 -Circuit of Astable Flip Flop

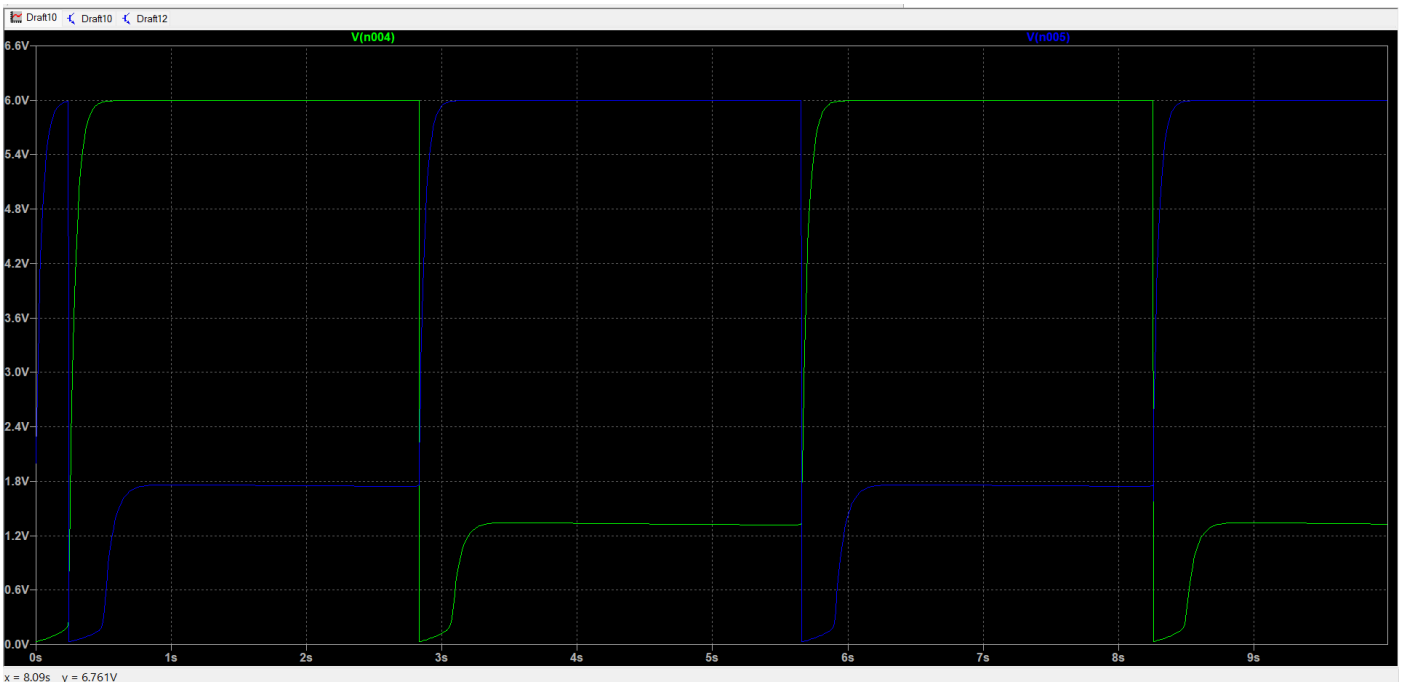


Figure 2 --Simulation result in LTSpice , green waveform is for output1 and blue for output2

References

Here is some web resources for astable flip-flop.

- https://www.tutorialspoint.com/pulse_circuits/pulse_circuits_astable_multivibrator.htm
- https://www.electrical4u.com/astable-multivibrator/
- https://www.youtube.com/watch?v=dQbrI_iQWig
- https://www.youtube.com/watch?v=EZ0YZcC84m4