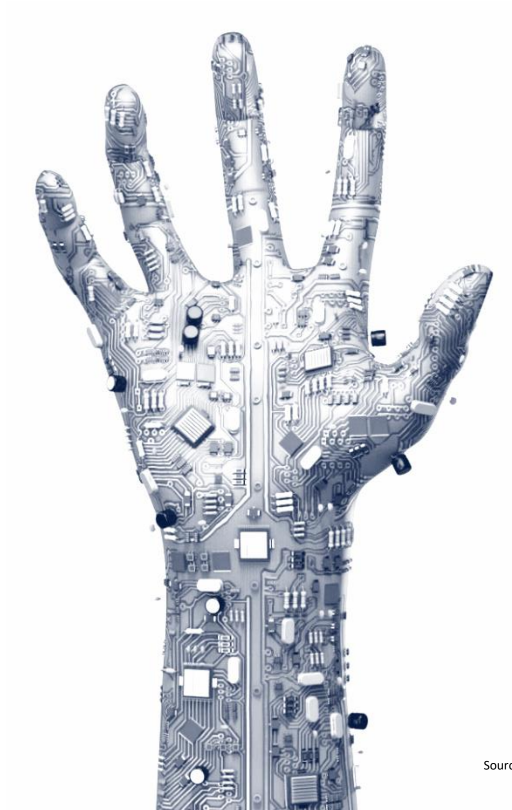


Source: Mark Berry Aberdeen Strategy Research

PCB DESIGN AND FABRICATION SYLLABUS

DAY 3

WORKING OF ASTABLE MULVIBRATOR USING BJT

PREFACE

As you are already familiarized with proteus and soldering now it is the best time to dive into the PCB fabrication section. For PCB fabrication, we will be designing a very simple led blinking circuit, which works on the principle of Astable Multivibrator. First, we will look at bjt transistor thoroughly, look at what Astable Multivibrator really means and then we will be seeing its operation. After the clear insight on a stable multivibrator, we will be designing our own LED blinking circuit using proteus. This same circuit will be used for PCB fabrication latter on in this workshop. After the end of this section, we will be able to modify your circuit as per your wish.

- *Electrical Club 2079, IOE PULCHOWK CAMPUS*

Astable Multivibrator

OBJECTIVES

1. To know about BJT
2. To understand transistor as a switch
3. To know about astable multivibrator
4. To understand the theory of astable multivibrator using BJT
5. Create Astable Vibrator circuit in proteus

BJT

A bipolar junction transistor (BJT) is a three-terminal device in which operation depends on the interaction of both majority and minority carriers and hence the name bipolar. The Bipolar Transistor basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labelled as the Emitter (E), the Base (B) and the Collector (C) respectively. There are two basic types of bipolar transistor construction, PNP and NPN.

Emitter is heavily doped, base is lightly doped, the thinnest region and collector is moderately doped with the largest region.

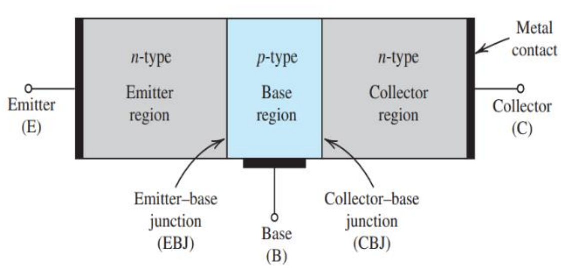


FIG : Simplified form of NPN Transistor

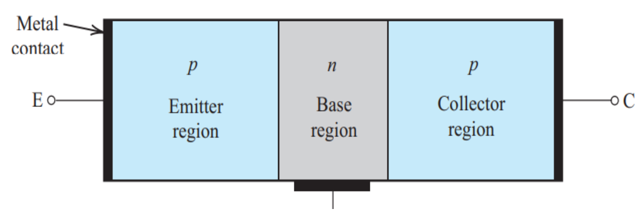


Fig: Simplified form of PNP transistor

BJT CONFIGURATIONS

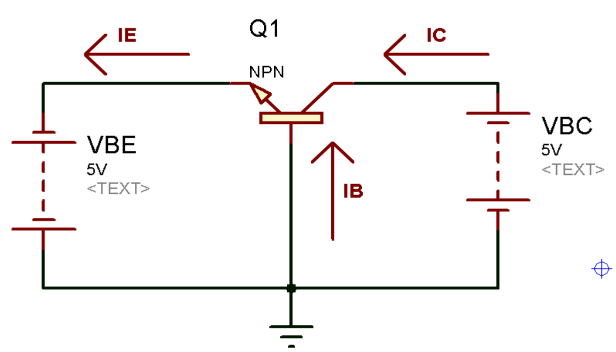
As the Bipolar Transistor is a three-terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor vary with each circuit arrangement.

The three configurations are:

- Common base configuration
- Common emitter configuration
- Common collector configuration

Common Base Configuration

In this circuit arrangement, input is applied between emitter and base and output is taken from collector and base. Here, base of the transistor is common to both input and output circuits and hence the name common base connection.

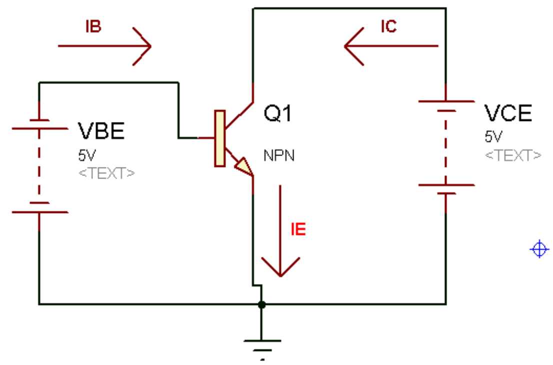


Current amplification factor (α) is the ratio of output current to input current. In a common base connection, the input current is the emitter current IE and output current is the collector current IC. The ratio of change in collector current to the change in emitter current at constant collector base voltage VCB is known

Current Amplification Factor, α = Ic / IE , only DC is considered.

Common Emitter Configuration

In this circuit arrangement, input is applied between base and emitter and output is taken from the collector and emitter. Here, emitter of the transistor is common to both input and output circuits and hence the name common emitter connection.



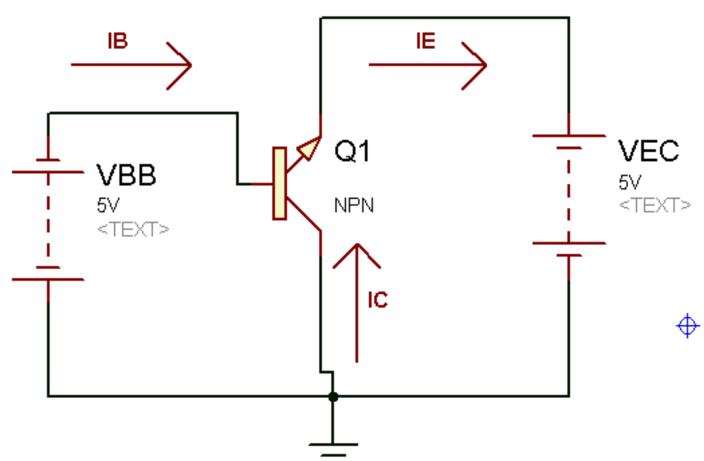
Current amplification factor () is the ratio of output current to input current. In a common emitter connection, the input current is the base current IB and output current is the collector current IC. The ratio of change in collector current to the change in base current at constant collector emitter voltage VCE is known as base current amplification factor

Base current amplification factor, β = Ic / IB, here only DC is considered. In almost any transistor, less than 5% of emitter current flows as the base current. Therefore, the value of β is generally greater than 20. Usually, its value ranges from 20 to 500. This type of connection is frequently used as it gives appreciable current gain as well as voltage gain

Due to this CE configuration is used in amplification circuit.

Common Collector Configuration

In this circuit arrangement, input is applied between base and collector while output is taken between the emitter and collector. Here, collector of the transistor is common to both input and output circuits and hence the name common collector connection.



Current Amplification Factor is always less than 1 so it is not used for amplification purpose.

OPERATION MODES OF TRANSISTORS

Active Mode

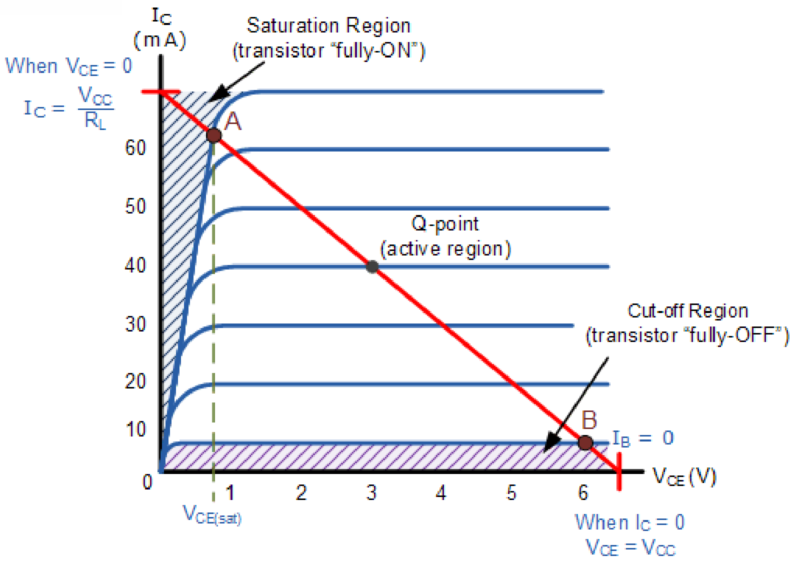
In this mode the junction is differently biased and it is used mostly for amplification purposes. Here emitter-base junction or emitter diode is forward biased whereas collector-base junction or collector diode is reversed biased. In this mode current flow is directly proportional to the base current, thus the amount of base current can control or limit the current flowing between emitter and collector. So, it can act as amplifier.

Cutoff Mode

In this mode, both the emitter-base junction or emitter diode and collector-base junction or collector diode are reversed biased. In this mode, current flow from collector to emitter is not permitter when base-emitter voltage is low. In this mode, device is switched off as there is not current flow.

Saturation Mode

In this mode, both the emitter-base junction or emitter diode and collector-base junction or collector diode are forward biased. As a result current flows freely from collector to emitter when base-emitter voltage is high and thus the device behaves as switched on.



Transistor as a switch

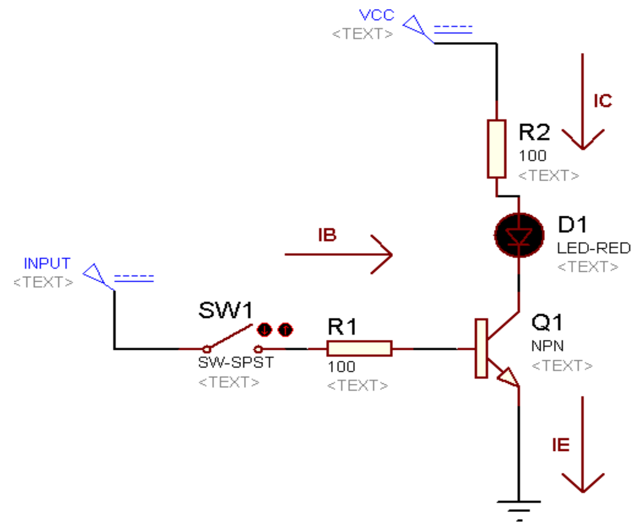
For this purpose, we will use common emitter configuration. While working as a switch it either works in complete cutoff region or in complete saturation region. In the cut-off region, the collector current and base current both are zero which results in a large depletion layer and no current is flowing through the device. Therefore, the transistor is switched "Fully-off"

Now in saturation region, both junctions are forward biased so that the maximum amount of base current is applied resulting in maximum collector current resulting in the minimum voltage across collector-emitter junction drop which results in the depletion region being as small as possible and maximum current flowing through the transistor

CASE 1

WHEN SWITCH IS OPEN

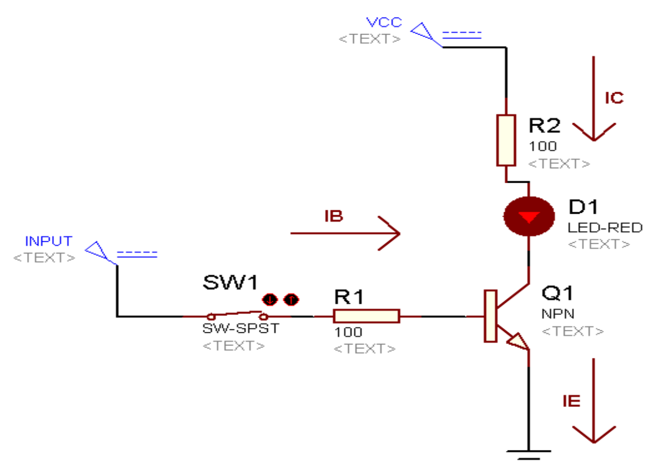
When the base is open circuit, base emitter junction won't be forward biased and there won't be emitter current. As there is no emitter current there will be no collector current due to reverse biasing of the collector-base junction. So, the transistor is in cutoff region and the LED is off



CASE 2

WHEN SWITCH IS CLOSED

Now when the base is closed.Emitter-base junction is forward biased and emitter current flows into the base which then divides into base current and collector current.Now the lED turns on. Here the transistor is in saturation region.

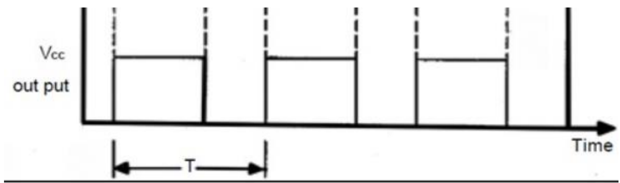


SN	Switch	LED	Transistor Mode
1	on	on	Saturation region
2	off	off	Cutoff region

Hence, transistor can be used in cutoff as well as in saturation region to make it work as a switch

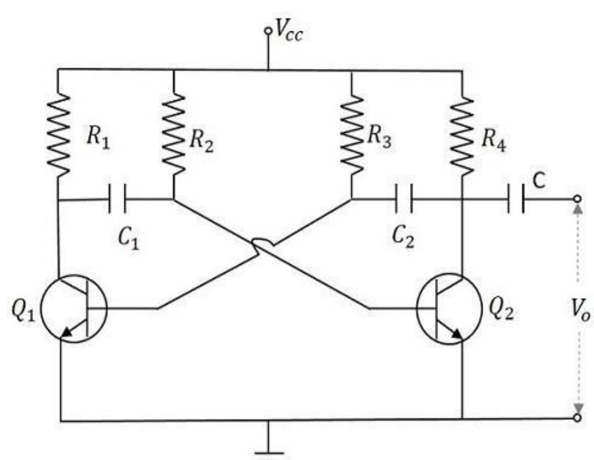
What is Astable Multivibrator?

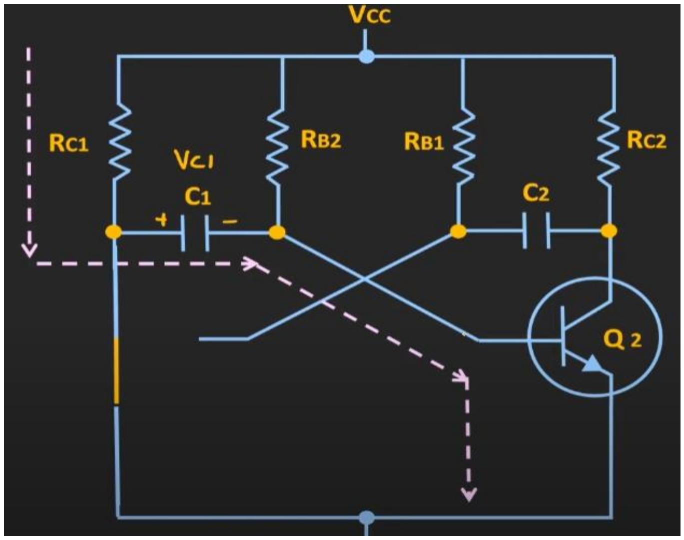
Astable multivibrator, also called flip-flop circuit is a circuit which has no stable state. Its output oscillates continuously between its two unstable states without external triggering. Once the Multivibrator is ON, it just changes its states on its own after a certain time period which is determined by the RC time constants. A dc power supply or V_{cc} is given to the circuit for its operation.



Construction of Astable Multivibrator using BJT

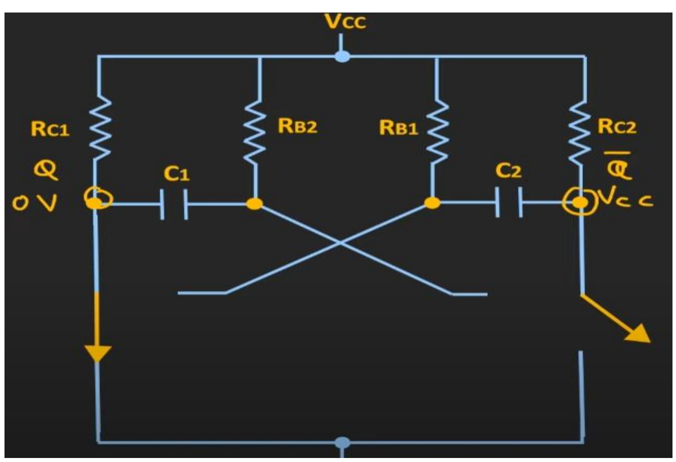
Two transistors named Q1 and Q2 are connected in feedback to one another. The collector of transistor Q1 is connected to the base of transistor Q2 through the capacitor C1 and vice versa. The emitters of both the transistors are connected to the ground. The collector load resistors R1 and R4 and the biasing resistors R2 and R3 are of equal values. The capacitors C1 and C2 are of equal values.



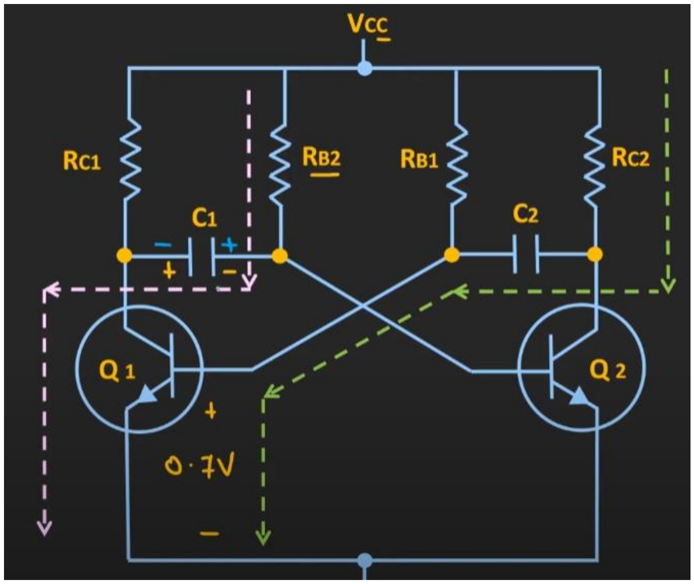


When Vcc is applied, collector current start flowing in Q1 and Q2. In addition, the coupling capacitors C1 and C2 also start charging up. As the characteristics of no two transistors (β, VBE) are exactly alike, therefore, one transistor, say Q1, will conduct more rapidly than the other (dotted line represents the current flow). And also let that the voltage across the capacitor is Vc1(which was charged when Q2 was on). As Q1 is on and Q2 is in off state, Q1 acts as short circuit and Q2 acts as an open circuit.

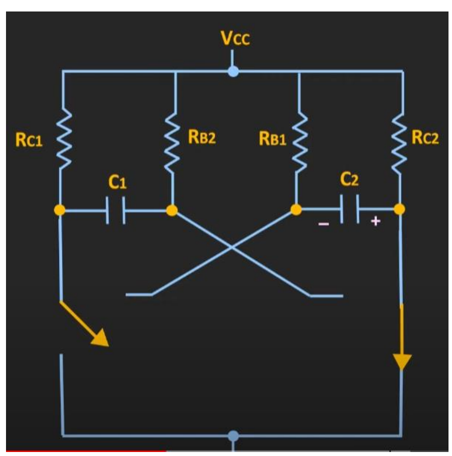
From the theory of voltage across short and open circuit we can conclude that voltage on the left side of C1 is 0V and that of C2 is Vcc. So, the base of Q2 receives minus(-) of Vc1, which reverse biases Q2.



Now the charging current has the direction as shown in the figure below(blue indication represents the sign configuration of this state).



C1 charges through RB2 and C2 charges through RC2. After some duration, the voltage across C1 reaches 0.7V in the direction shown by the blue indication. As C1 is connected to the base of Q2, +0.7V appears across the base of Q2 so Q2 starts conducting. As before voltage Q' approaches to zero and the base of Q1 receives minus(-) of Vc2, which reverse biases it.



In this way, the two transistors change its state periodically

When Q1 is on it charges through the path of RC1. So, its charging time depends upon RC1. Similarly, when Q2 is on it charges through RC2. So, its charging time depends upon RC2.

The ON time of transistor Q1 or the OFF time of transistor Q2 is given by

$$t1 = 0.69R_{C1}C1$$

Similarly, the OFF time of transistor Q1 or ON time of transistor Q2 is given by

$$t2 = 0.69R_{C2}C2$$

Hence, total time period of square wave

$$t = t1 + t2 = 0.69(R_{C1}C1 + R_{C2}C2)$$

As $R_{C1} = R_{C2} = R$ and C1 = C2 = C, the frequency of square wave will be

$$f = \frac{1}{\mathrm{t}} = \frac{0.7}{\mathrm{RC}}$$

Hence, total time period of square wave

t = t1 + t2 = 0.69(R1C1 + R2C2)

As R1 = R2 = R and C1 = C2 = C, the frequency of square wave will be

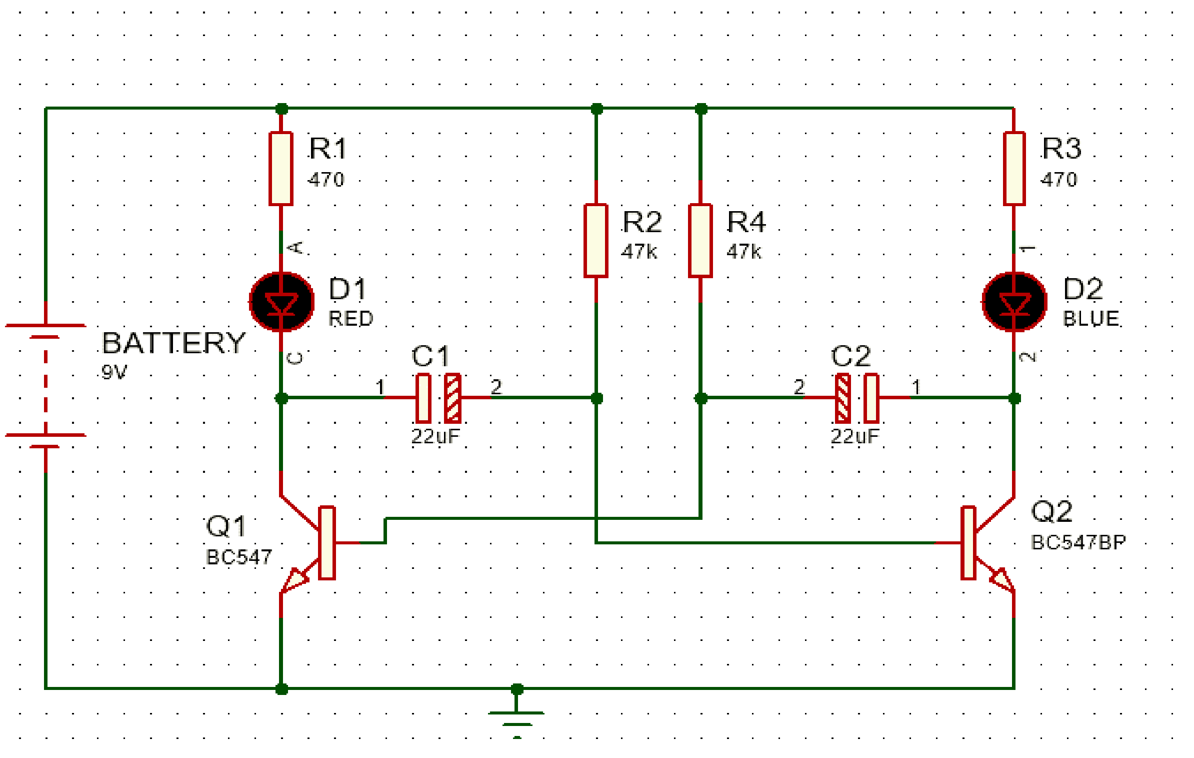
$$f = \frac{1}{t} = \frac{0.7}{RC}$$

Simulation

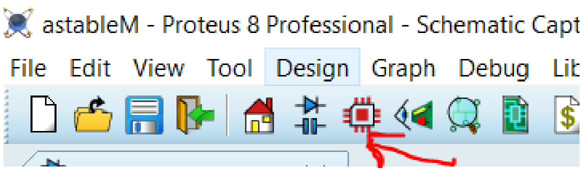
Components required

1. Transistors (BC547) – 2
2. 470-ohm resistors – 2
3. 47k resistors – 2
4. Red LED – 1
5. Blue LED – 1
6. 22uf capacitors – 2
7. Power supply (5 – 9 volts)

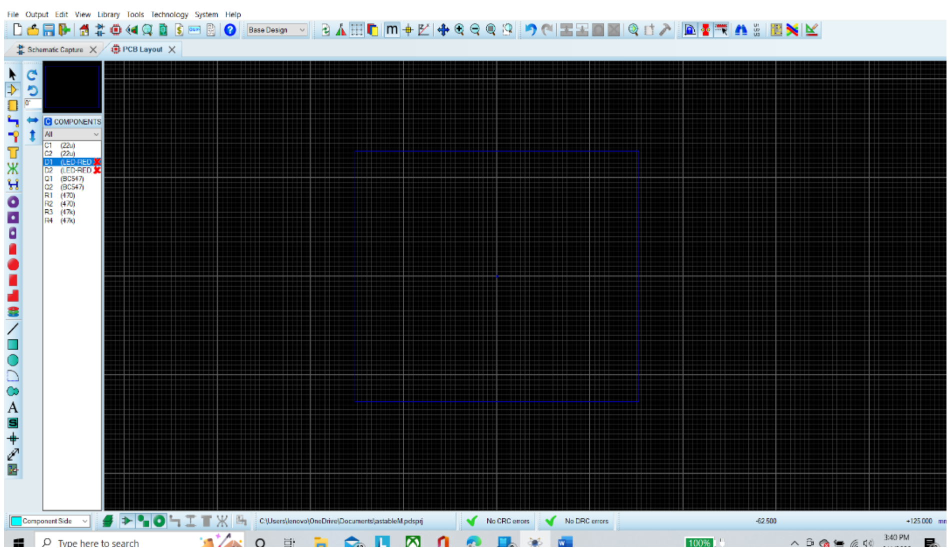
We will be designing the circuit as shown below


R1
470
R2
47k
R4
47k
R3
470
A
D1
RED
1
D2
BLUE
BATTERY
9V
C
C1
1
2
22uF
2
C2
2
1
22uF
Q1
BC547
Q2
BC547BP

After completing the simulation now, we can design our own PCB circuit. For that we need to go to the PCB board option in the proteus.



The PCB editing layout looks like this



We will begin making our own PCB from next week.

Assignment

Try to make your own led blinking circuit using different values of resistors and capacitors thereby changing the frequency of the circuit.

CONGRATS!!!!!!!!

YOU ARE HALF WAY THROUGH THE WORKKSHOP.

YOU ARE PROBABLY TIRED.

GO TAKE A REST YOU DESERVE IT