MONOSTABLE MULTIVIBRATOR

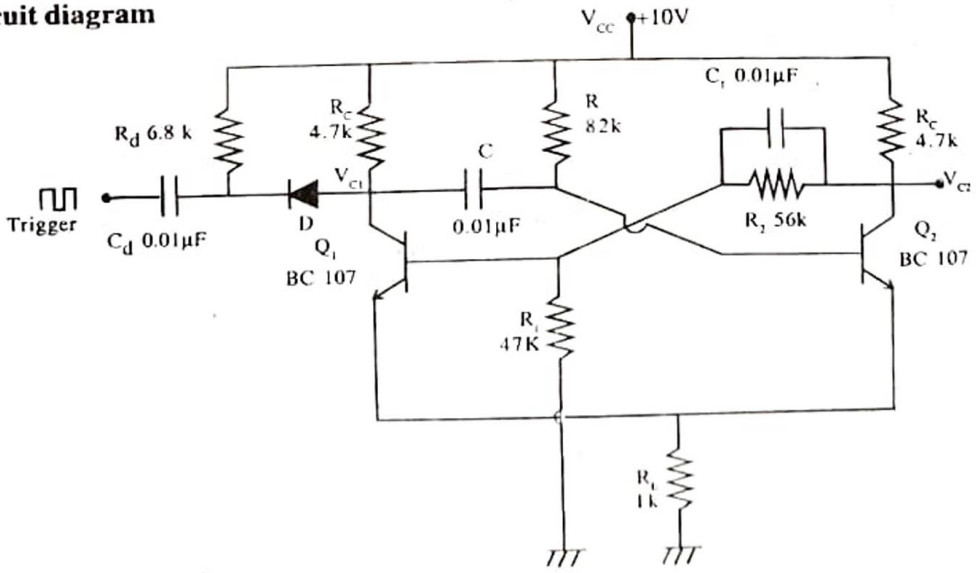
Aim: To set up and study a monostable multivibrator using transistors.

Components and equipments required Transistors, resistors, capacitors, signal generator, dc power source, bread board and CRO.

Theory This multivibrator has only one stable state as its name suggests. It has one quasi-stable state also. An external trigger forces this circuit to go to quasi-stable state from its stable state and remain in that state for an amount of time determined by the discharging time of the capacitor. R and C are the timing elements and C_1 is the speed up capacitor.

Figure shows a monostable multivibrator using single bias supply. As soon as the power supply is switched ON, transistor Q_1 goes to cut off state and Q_2 goes to saturation state due to regenerative action. The stable state voltages are $V_{C1} = V_{CC}$, $V_{C2} = V_{CE}$ (sat), $V_{B1} = -V_f$, and $V_{B2} = V_{BE}$(sat). The moment a negative trigger is applied at the collector of the transistor Q_1, transistor Q_2 goes to cut off state. Hence V_{C2} jumps to V_{CC}. This sudden change is coupled to the base of the transistor Q_1 and hence it goes to ON state. The collector voltage of the transistor Q_1 suddenly drops by an amount $I_{C1}R_{C1}$, where I_{C1} is the current through the resistance R_{C1}. Since capacitor acts as a short circuit for a sudden change, the base voltage of Q_2 suddenly drops by an equal amount. Now the polarity of the charge of the capacitor is such a way that the negative is at its right side. Now capacitor charges from this negative potential to $+V_{CC}$ through R and Q_1. Capacitor discharges through the ON transistor. Once it becomes zero it further charges towards V_{CC}. But, when the positive potential at the right side of the capacitor reaches the cut in voltage, Q_2 turns ON. Thus the circuit comes back to the stable state. It will continue till the next trigger comes at the base of Q_2. The time duration of the quasi-stable state is given by the expression $T = 0.69\ RC$.

Circuit diagram



Design **Output requirements** Amplitude = 10 V, pulse width = 1ms.

Selection of transistor and diode Choose transistors BC 107 and diode 1N4001.

DC bias conditions $V_{CC} = 10$ V, $V_{RE} = 2$ V

Design of R_E $R_E = V_{RE}/I_E = 1$ k Since $I_E = I_C$

Design of R_1 and R_2 Consider the astable state (Q_1 is OFF and Q_2 is ON)

Assume $V_{BE} = -1$ V to assure that the transistor is in cut off state. Then $V_{B1} = 2 - (-1) = 1$ V.

Since $I_{B1} = 0$, current flowing through R_2 = current flowing through R

$$V_{B1} = \frac{V_{C2} R_1}{R_1 + R_2} = \frac{2.3\ V \times R_1}{R_1 + R_2}$$

From this, $R_2 = 1.3\ R_1$

Consider the astable state (Q_1 is ON and Q_2 OFF):

$V_{C2} = 12$ V since Q_2 is OFF.

$V_{B1} = V_{BEsat} + V_{RE} = 2.8$ V

Also, $I_{R2} = I_{B1} + I_{R1}$

$$\text{i.e.,}\quad \frac{12\ V - 2.8\ V}{R_2} = I_{B1} + \frac{2.8\ V}{R_1}$$

Substituting the value of R_2 we get $9.2\ R_1 = 1.3 \times 10^{-4} \times R_1^2 + 3.64 \times R_1$

or $1.3 \times 10^{-4} \times R_1^2 - 5.56 \times R_1 = 0$

Solving this quadratic expression

$$R_1 = + \frac{-5.56 \pm \sqrt{31}}{2 \times 1.3 \times 10^{-4} \times R_1^2} = 42.8 \text{ k. Use 47 k std.}$$

Then $R_2 = 55.64$ k use 56 k std.

Design of R_{C1} and R_{C2} $R_C = \frac{V_{CC} - V_C}{I_C sat} = 4.35$ k. Use 4.7 k std.

Take $R_{C1} = R_{C2} = R_C$

Design of R R must be able to provide base current enough to keep the transistors in saturation.

I_B min $= I_C/h_{FE} = 2$ mA$/h_{FE} = 20$ µA

Consider an over-driving factor 5, so that transistor will be indeed in saturation.

Then actual base current $I_B = 5\ I_B$ min $= 0.1$mA

$R = (V_{CC} - V_{BE}$ sat$)/\ 0.1$mA $= 73$ k. Use 82 k.

We have $T = 0.69RC$. substituting the value of R we get, $C = 0.01$ µF.

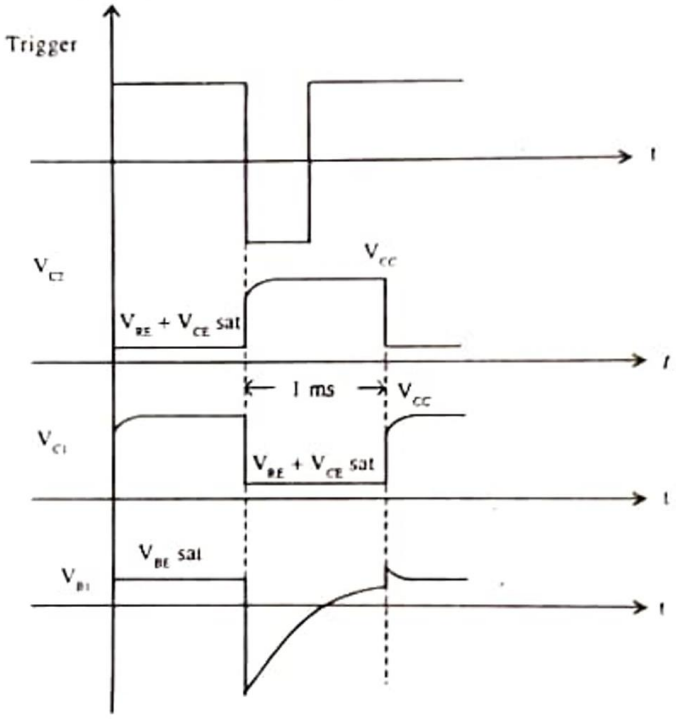
Design of differentiator circuit: The condition is $R_d C_d < 0.0016 T_t$, where T_t = time period of trigger signal. To avoid the loading of the signal generator by the differentiator, take $R_d = 6.8$ k.

Let T_t be 2 ms. Then $C_d = 0.01$ µF.

Procedure

1. Test all components and probes before rigging up the circuit.
2. Switch ON V_{CC} supply and verify Q_1 is in OFF state and Q_2 is in ON state. V_{C1} should be high and V_{C2} should be low.
3. Switch ON trigger supply. Trigger should have sufficient amplitude.
4. Observe the collector and base waveforms of both transistors. Note down all aspects of the waveforms such as the pulse width, amplitudes, overshoots etc.

Waveforms



Reference

Electronics Lab Manual Volume I, K.A. Navas, **Rajath Publishers**