Operational Amplifier as mono stable multi vibrator

Aim :- To construct a monostable multivibrator using operational amplifier 741 and to determine the duration of the output pulse generated and to compare it with that of theoretical value.

Apparatus :- Operational amplifier (IC 741), C.R.O., two power supplies to the operational amplifier, four non inductive fixed resistors (R_1, R_2, R_4 and R_5), one non-inductive variable resistor(R_3), two capacitors(C_1 andC_2), three diodes (D_1, D_2 and D_3) and connecting terminals.

Formula :- Duration of the output pulse generated or time duration of quasi-stable state

$$T = 2.303 \text{ x } R_3C_1 \log_{10} \left(\frac{R_1+R_2}{R_1} \right) \quad \text{Sec}$$

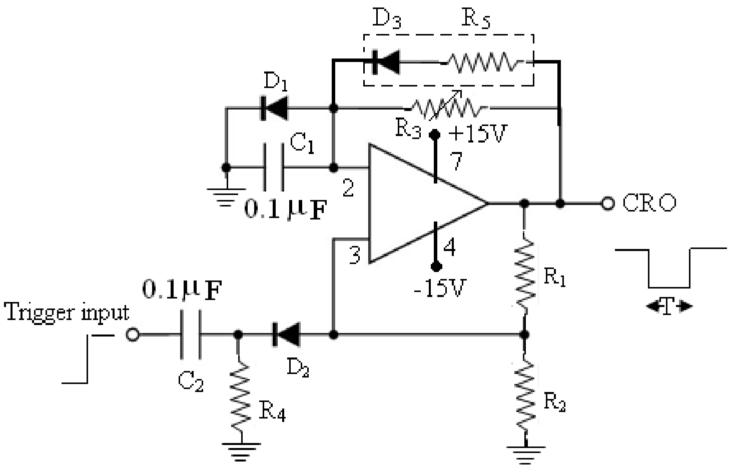
Where R_1 and R_2 = Fixed non-inductive resistances (Ω)

R_3 = Variable non-inductive resistance (Ω)

C_1 = Capacitance (μF)

and if $R_1 = R_2$

Then $T = 0.693\, R_3\, C_1$



Figure

Description :- The above figure is the circuit of the monostable multi vibrator. A capacitor C_1 is connected to the inverting terminal (2) of the operational amplifier from the ground and a diode D_1 is connected in parallel to C_1 such that n of diode D_1 is grounded. Similarly a series combination of a capacitor C_2 another diode D_2 is connected to the non-inverting terminal (3) of the operational amplifier as shown in the figure. The junction of C_2 and D_2 is grounded through a resistor R_4. The in put external triggering pulse is given to the capacitor C_2. The output terminal (6) of the amplifier is fed back to inverting and non-inverting terminals of operational amplifier through resistors R_3 and R_1 respectively. Here R_1 is fixed resistor and R_3 is variable resistor. For the fast recovery of the multivibrator, from the quasi-stable state, a series combination of a diode D_3 and a resistor R_5 is connected parallel to the resistor R_3. The non- inverting terminal (3) is also grounded through another resistor R_1 so as the combination of R_2 and R_1 acts as a potential divider for the feed back. The terminals (7) and (4) of the op. amp. are connected to +15 V and -15 V of the D.C. power supplies separately. To observe the out put wave form, the out put terminal (6) is connected to CRO Y- Plates phase terminal and the other terminal of CRO is grounded. Also observe that $(R_5 < R_3)$ and $(R_4 > R_1)$.

Theory :- Multivibrators are a group of regenerative circuits that are used extensively in timing applications. They are wave shaping circuits which give symmetric or asymmetric square out put. They have two states either stable or quasi-stable depending on the type of the multivibrator.

There are three types of multivibrator. 1) A**stable** (free-running) **2) Monostable** (one shot) and 3) B**istable** (flip-flop).

All the three circuits operate by using positive feedback to drive the op-amp into saturation, therefore it is not the case that the two inputs of the op-amp can be assumed to be at the same potential.

Astable Multivibrator: It is a free running oscillator having two quasi-stable states. Thus there is oscillations between these two states and no external signals are required to produce the change in state. In this the two states are stable only for a limited time and the circuit switches between them with the output alternating between positive and negative saturation values.

Monostable Multivibrator: A **monostable multivibrator** (MMV) has one stable state and one quasi-stable state. The circuit remains in its stable state till an external triggering pulse causes a transition to the quasi-stable state. The circuit comes back to its stable state after a time period T. Thus it generates a single output pulse in response to an input pulse and is referred to as a one-shot or single shot. An external trigger signal generated due to charging and discharging of the capacitor produces the transition to the original stable state. So, mono stable multi vibrator is one which generates a single pulse of specified duration in response to each external trigger signal.

Bistable Multivibrator: It maintains a given out put voltage level unless an external trigger signal is applied. Application of an external trigger signal causes a change of state, and this out put level is maintained indefinitely until a second trigger is applied. Thus it requires two external triggers before it returns to its initial state. So, it has two stable states.

Monostable multivibrator circuit illustrated in figure is obtained by modifying the astable multivibrator circuit by connecting a diode D_1 across capacitor C_1 so as to clamp V_c at V_d during positive excursion. The main component of this circuit is the 741, a general-purpose operational amplifier. This is a timing circuit that changes state once triggered, but returns to its original state after a certain time delay. It got its name from the fact that only one of its output states is stable.

Under steady-state condition, this circuit will remain in its stable state with the output $V_{out} = +V_{out}$ and the capacitor C_1, is clamped at the voltage V_D (on-voltage of diode, D_1, i.e. $V_D = 0.7$ V). The voltage V_D must be less than (βV_{out}) for $V_{in} < 0$. The circuit can be switched to the other state by applying a negative pulse with amplitude greater than ($\beta V_{out} - V_D$) to the non-inverting (+) input terminal.

When a trigger pulse with amplitude greater than ($\beta V_{out} - V_D$) is applied, V_{in} goes positive causing a transition in the state of the circuit to $-V_{out}$. The capacitor C_1 now charges exponentially with a time constant $\tau = R_3C_1$ toward $-V_{out}$ (diode D_l being reverse-biased). When capacitor voltage V_c becomes more negative than ($-\beta V_{out}$), V_{in} becomes negative and, therefore, output swings back to $+V_{out}$ (steady- state output). The capacitor now charges towards $+V_{out}$ till V_c attain V_D and capacitor C_1 becomes clamped at V_D.

The width of the trigger pulse T_p is much smaller than the duration of the output pulse T generated i.e. $T_P << T$. For reliable operation the circuit should not be triggered again before T.

During the quasi-stable state, the capacitor voltage is given as

$$V_c = -V_{out} + (V_{out} + V_D)\, e^{-t/\tau}$$

At instant $t = T$ and $V_c = -\beta V_{out}$

Where $\beta = \left(\frac{R_2}{R_1+R_2}\right)$ **= Feed back factor**

So $-\beta V_{out} = -V_{out} + (V_{out} + V_D)\, e^{-T/\tau}$

Where Time constant $\tau = R_3C_1$

or $V_{out}(1-\beta) = V_{out}\left(1 + \frac{V_D}{V_{out}}\right) e^{-T/\tau}$

In general $V_D << V_{out}$

So $(1-\beta) = e^{-T/\tau}$

$$\frac{T}{\tau} = \log_e \frac{1}{(1-\beta)}$$

$$T = R_3C_1 \log_e \frac{1}{(1-\beta)} \quad \because \tau = R_3C_1$$

$$T = R_3C_1 \log_e\left(\frac{R_1+R_2}{R_1}\right)$$

and if $R_1 = R_2$

Then $\beta = \frac{1}{2}$

Or $T = R_3C_1 \log_e 2 = R_3C_1 \times 2.303 \times \log_{10} 2$

$$T = 0.693\, R_3\, C_1$$

Procedure :- Connect the circuit as shown in the figure. Take the $R_1 = R_2 = 1K\Omega$, $C_1 = C_2 = 0.1\mu F$ and $R_3 = 10K\Omega$ (variable resistance) or any convenient values. Apply the DC power supplies to the terminals (7) and (4) of the operational amplifier. Keep the R_3 value at a convenient value. Set the voltage sensitivity band switch of the Y- plate and time base band switch of C.R.O. to the convenient positions such that at least two or more complete square wave forms are observed on the screen of CRO. The length of –ve value or $-V_{out}$ is the duration of the quasi-stable state. Now measure the horizontal length (l) of the quasi-stable state. Also note the time base value (m) of the X-plates of the CRO in the table. From this calculate the time duration of the quasi- stable state. This is the experimental value. Similarly the theoretical value can also be calculated by substituting the values of R_3, R_1, R_2 and C_1 in the above given equation.

Now the experiment is repeated for different values of R_3 by increasing its value in equal steps (Multiples of 100 Ω).

Precautions :- 1. Check the continuity of the connecting terminals before connecting them.
2. Keep the band switches of the C.R.O. such that steady wave form is observed on the screen.
3. Observe the out put square wave on the screen of CRO and measure the horizontal length accurately.

Results :- It is found that the observed duration and calculated duration are equal.

Table

R_1 = Ω R_2 = Ω

S.No.	C_1 (μF)	R_3 (Ω)	Theoritical time duration	Experimental time duration		
			$T = R_3C_1 \log_e \left(\frac{R_1+R_2}{R_1}\right)$ (Sec)	Horizontal length (l) (Div)	Time base (m) Sec/div	Time T = (l x m) (Sec)

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