9.16 Repeat Problem 9.15 for $R_1 = 180\ \Omega$, $R_2 = 2.7\ K\Omega$.

9.17 Design the Schmitt trigger circuit of Figure 9.22 for $V_{ut} = 3$ volts and $V_{lt} = -3$ volts. The saturation voltages are ± 14V.

9.18 Draw the circuit diagram of a practical op-amp Schmitt trigger. Design the circuit for $V_{ut} = 6$ volts and $V_{lt} = 3$ volts. Assuming supply voltages of ±15 V, the saturation voltages were found to be ±14 V. Plot the output for a sinusoidal input voltage of $v_i = 10 \sin 314\ t$.

9.19 Assume that the Schmitt-trigger shown in Figure P9.19, uses op-amp of saturation voltages ± 10V.

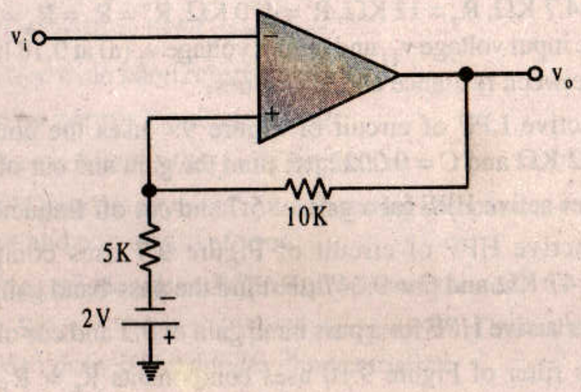

Fig. P 9.19

(i) To what value should R_2 be changed if it is desired to have a hysteresis of 5 volts.

(ii) What are the values of V_{ut} and V_{lt}.

9.20 Design a Schmitt trigger for $V_{ut} = 4$ volts and $V_{lt} = -4$ volts. Plot the output waveform for an input voltage of $v_{in} = 8 \sin 628\ t$.

✦●✦●✦

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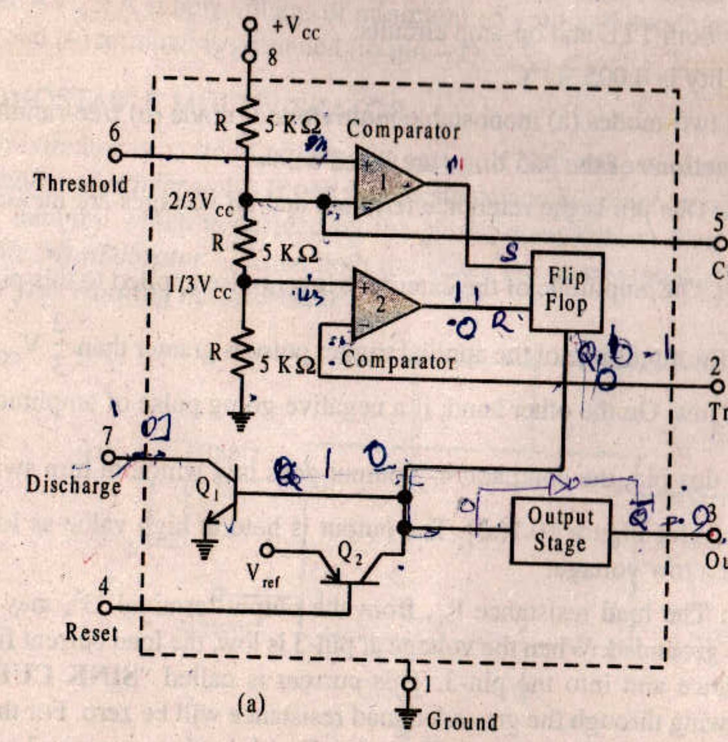
CHAPTER TEN

555 - Timer

10.1 INTRODUCTION

555 timer is one of the most versatile linear IC's having useful and wonderful applications such as monostable and astable multivibrators, electric eyes, voltage regulators, burglar and toxic gas alarms, infrared transmitters, temperature measurement and control, analog frequency meter and tachometer, waveform generators, digital logic probes, dc-to-dc converters etc.



Reset . Q = 0.
∴ $\bar{Q}$ = 1

S	R	Q
0	1	0
1	0	1

Switch
Q_1 = 0 7 = 1
charges
Q_1 = 1 7 = 0
discharge

Fig. 10.1 : (a) Functional diagram of 555 timer

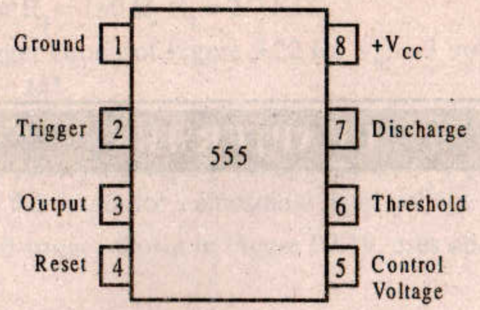


Fig. 10.1 (b) Pin diagram of 555 timer

Figure 10.1(a) shows the functional block diagram of a 555 timer consisting of two comparators, two transistors, 3 equal resistors of 5 KΩ each, a flip-flop and an output stage. Figure 10.1(b) shows 8-pin DIP package diagram of 555 timer. It is designed to operate in the temperature range of 0°C to 70°C for commercial package type.

The important features of 555 timer are as follows :

1. It operates on +5 to +18 volts power supply voltage
2. It has adjustable duty cycle
3. Timing is from a few μ-secs to several hours.
4. It has a high current output: It can source or sink 200 m-Amps.
5. It is compatible with both TTL and op-amp circuits.
6. Its temperature stability is 0.005 %/°C.
7. It can be operated in two-modes (a) monostable multivibrator mode (b) free-running mode.

The various **PIN functions** of the 555 timer are listed below :

PIN-1: GROUND : This pin is the reference terminal and all voltages are measured with respect to this pin.

PIN-2: TRIGGER : The amplitude of the external trigger pulse applied to this pin decides the output of the timer. If the amplitude of the applied trigger pulse is greater than $\frac{2}{3}$ V_{CC}, then the output voltage at pin-3 is low. On the other hand, if a negative-going pulse of amplitude greater than $\frac{1}{3}$ V_{CC} is applied at this pin, the comparator-2 output goes low which in turn switches the output of the timer high [refer Figure 10.1(a)]. The output is held at high value as long as the trigger terminal is held at a low voltage.

PIN-3: OUTPUT : The load resistance R_L, from the output terminal '3', may either be connected V_{CC} or may be grounded. When the voltage at pin-3 is low, the load current flows from V_{CC} through load resistance and into the pin-3. This current is called "**SINK CURRENT**". However, the current flowing through the grounded load resistance will be zero. For this reason, the load between pin-3 and V_{CC} is called ***"normally on load"*** and that between pin-3 and ground as ***"normally off load"***.

But when output is high, no current flows through the load connected between pin-3 and V_{CC} and current flows out of pin-3 through load resistance if it is connected between pin-3 and ground. This current is called **"SOURCE CURRENT"**. The maximum value of sink or source current for the 555 timer is 200 m Amps.

PIN-4: RESET : When a negative going pulse is applied at pin-4, then 555 timer can be reset or disabled. This pin is connected to V_{CC} to avoid false triggering when the timer is not in use.

PIN-5: CONTROL VOLTAGE : The threshold voltage or the trigger voltage can be changed by applying an external voltage to this pin. When the wiper arm of potentiometer is connected to pin-5 and varied, then the pulse width and the duty cycle of the output waveform can be varied. When not in use, a grounded 0.01 μF capacitor is connected to this pin to avoid any noise problems.

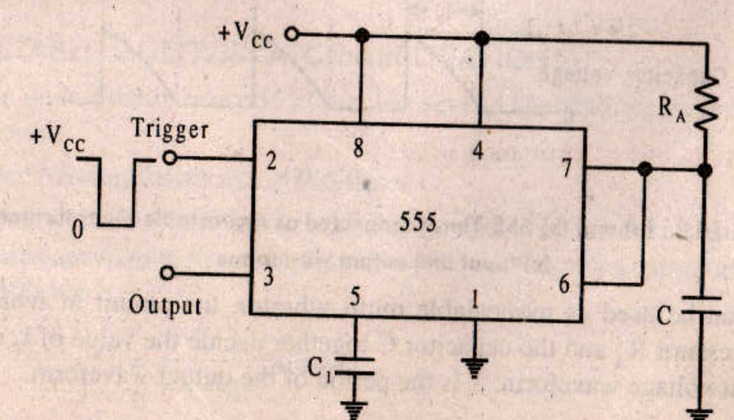
PIN-6: THRESHOLD : This pin is the non-inverting terminal of comparator-1. When the voltage at this pin exceeds $\frac{2}{3}$ V_{CC}, the output of comparator-1 goes high. The flip-flop then resets switching the output of the timer to become low.

PIN-7: DISCHARGE : This pin is the collector terminal of transistor Q_1. When the flip-flop output is high (set), Q_1 is driven into saturation, and pin-7 will be grounded. On the other hand when flip-flop output is low (reset), Q_1 is OFF and becomes open circuit. Normally, this pin is used for charging and discharging of capacitor connected to it.

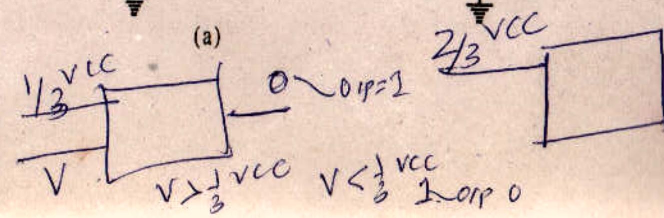
PIN-8: +V_{CC} : A supply voltage of minimum +5 volts and maximum of +18 volts is applied to this pin and (–) terminal is grounded (to pin – 1).

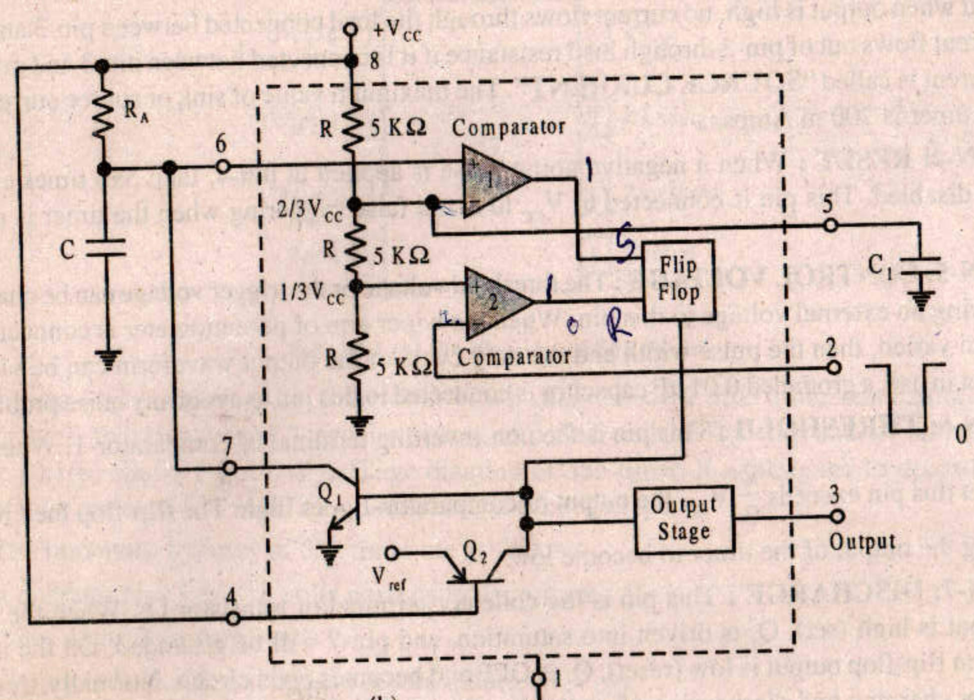
10.2 MONOSTABLE MULTIVIBRATOR

A multivibrator is a circuit having two states. If both the states are stable states, then it is called ***"Bistable Multivibrator"***. If one state is stable and the other quasi-stable (i.e., stable only for a short duration which is decided by the circuit components) then such a circuit is called ***"Monostable Multivibrator"***. When both the states are quasi-stable, then the circuit is called ***"Astable or free running multivibrator"***.

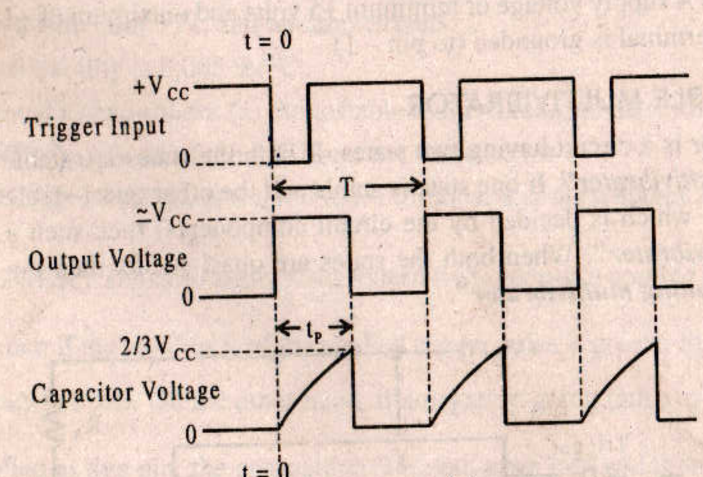


(a)





(b)



(c)

Fig. 10.2 : (a) and (b) 555 Timer connected as monostable Multivibrator
(c) Input and output waveforms

555 Timer can be used as monostable multi-vibrator, the circuit of which is shown in Figure 10.2. The resistor R_A and the capacitor C together decide the value of t_p called the ***pulse width*** of the output voltage waveform. T is the period of the output waveform.

Operation

Stable State : When the circuit is in stable state, the output voltage is low, the transistor Q_1 is in saturation and the capacitor C is shorted to the ground and no voltage exists across the capacitor.

Quasi-stable state : At t = 0, the negative going trigger pulse is applied at pin-2 which is connected to inverting terminal of comparator-2. When the voltage at this terminal goes below $\frac{1}{3}V_{CC}$, the comparator-2 output becomes high which resets the flip-flop. The transistor Q_1 comes out of saturation due to resetting of Flip-flop. This releases the short circuit across capacitor C. At this moment, the output at pin-3 becomes high ($\approx V_{CC}$). The capacitor C now starts charging up towards V_{CC} through the resistance R_A with a time constant R_AC. However, when the capacitor voltage exceeds $\frac{2}{3}V_{CC}$, comparator-1 switches from low state to high state and the flip-flop sets. This high output from flip-flop turns – ON the transistor Q_1 and the capacitor C rapidly discharges to the ground through Q_1. The high output from flip-flop drives the output to low state. The circuit now reverts back to stable state and output remains low until another trigger pulse is applied. This cycle repeats.

Figure 10.2 (c) shows the waveforms of trigger pulses, output voltage and the capacitor voltage.

The pulse width of the trigger pulses must be smaller than the expected pulse width of output waveform and the amplitude of the trigger pulses must be greater than $\frac{1}{3}V_{CC}$.

The time duration for which the output remains high is given by

$$t_P = 1.1\,R_AC \text{ seconds} \qquad \text{..... (10.1)}$$

Once triggered, the circuit's output will remain at high state until the set time t_p elapses. The output will not change state even if the input trigger pulse is applied again during this time interval t_p.

10.3 MONOSTABLE MULTIVIBRATOR APPLICATIONS

Monostable multivibrator using 555 timer has several applications. Some of them are listed and discussed below:

(a) Capacitance Measurement using 555 timer

The unknown Capacitor C to be measured is connected to the circuit and the output pulse width t_p is measured accurately. Knowing the value of R_A the unknown capacitance C is calculated from equation (10.1) as

$$C = \frac{t_P}{1.1\,R_A} \text{ farads}$$

(b) Frequency Divider

By adjusting the length of the timing cycle (pulse width) t_p with respect to the time period T of the trigger input signal applied to pin-2, it is possible to use the monostable multivibrator of Figure 10.2 (a) as a frequency divider. This frequency divider application is possible due to the fact that the monostable multivibrator cannot be triggered during the timing cycle t_p.

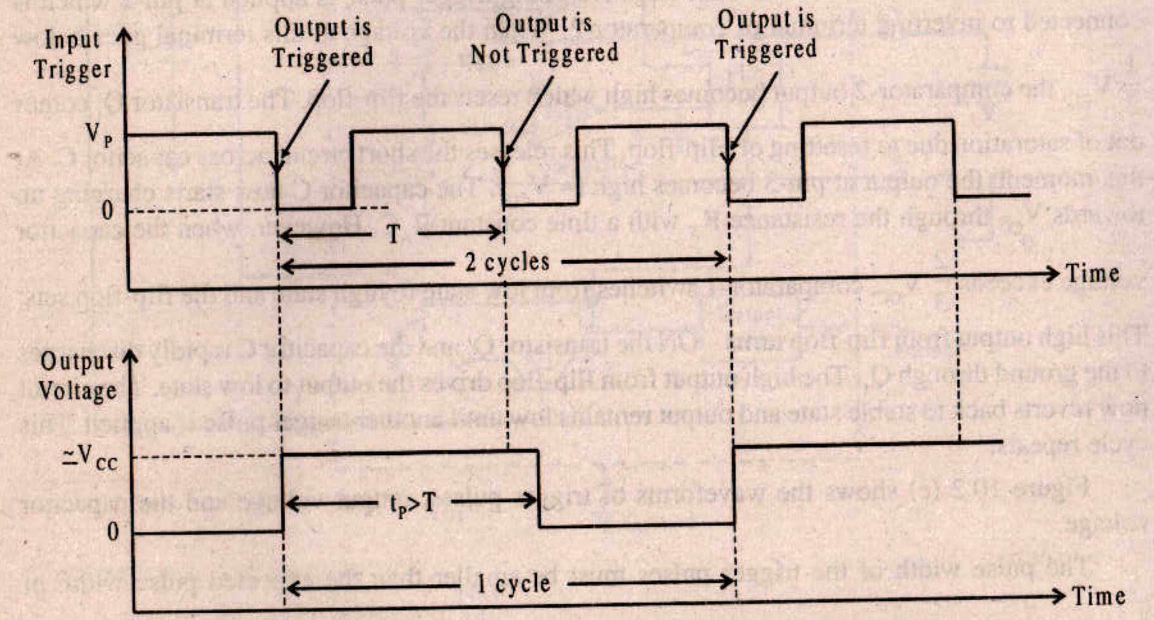


Fig. 10.3 : Input trigger and output voltage waveform of monostable multivibrator used as divide-by-2 network

To use the monostable multivibrator as a divide-by-2 circuit, the timing interval t_p must be made slightly larger than the time period T of the trigger input signal as shown in Figure 10.3. If t_p is made slightly greater than 2T, then monostable multivibrator can be used as divide-by-3 circuit and so on.

(c) Pulse Stretcher

As seen from the waveforms of Figure 10.2 (c), the pulse width t_p is of longer duration than the negative pulse width of the trigger input. Thus the output of monostable multivibrator can be thought of as a stretched version of the narrow input trigger pulse and hence the application as a "***Pulse Stretcher***". For driving LED display clearly, a pulse of longer duration becomes a necessity.

10.4 ASTABLE MULTIVIBRATOR

Astable Multivibrator also called free-running multivibrator is a square wave generator capable of generating both symmetrical and unsymmetrical square waveforms. In this multivibrator, external trigger pulse is not necessary to change the state of the output. The circuit changes its state by itself and hence called ***"free-running"***. The duty cycle of the output waveform is decided by two resistors and a capacitor.

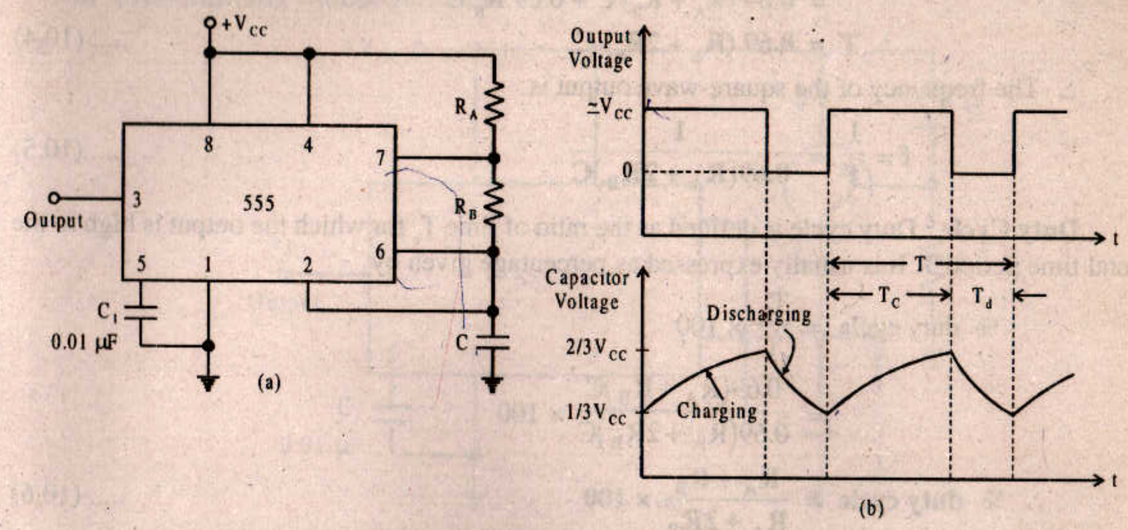


Fig. 10.4 : (a) 555 Timer as an astable multivibrator
(b) Output voltage and Capacitor voltage waveforms

Figure 10.4 (a) shows the circuit of Astable multivibrator using 555 timer. Initially, when the output is high ($\approx V_{CC}$), the transistor Q_1 is OFF and the capacitor C starts changing through R_A and R_B. As soon as the voltage across capacitor becomes $\frac{2}{3}V_{CC}$, the comparator-1 output becomes high and the flip-flop sets which forces output to go low and drives Q_1 into saturation. Now, the capacitor starts discharging through resistor R_B and transistor Q_1. When the voltage across capacitor goes just below $\frac{1}{3}V_{CC}$, comparator-2 output becomes high forcing the flip-flop to reset. This drives the output stage and output becomes high. But the transistor Q_1 turns off. The same cycle repeats itself. The output voltage and the capacitor voltage waveforms are shown in Figure 10.4 (b).

From the waveforms, the time duration for which the output is high is given by

$$T_c = 0.69\,(R_A + R_B)\,C \qquad \text{..... (10.2)}$$

During this interval T_c, the capacitor C is charging from $\frac{1}{3}V_{CC}$ to $\frac{2}{3}V_{CC}$ through resistors R_A and R_B.

Similarly, the time duration for which the output is low is given by

$$T_d = 0.69\,R_B C \qquad \text{..... (10.3)}$$

During this interval T_d, the capacitor is discharging from $\frac{2}{3}V_{CC}$ to $\frac{1}{3}V_{CC}$ through the resistor R_B only.

$\therefore$ The total period of the output voltage waveform is

$$T = T_c + T_d$$

$$= 0.69\,(R_A + R_B)\,C + 0.69\,R_B\,C$$

$$\therefore\; \mathbf{T = 0.69\,(R_A + 2R_B)\,C} \qquad \text{..... (10.4)}$$

$\therefore$ The frequency of the square-wave output is

$$f = \frac{1}{T} = \frac{1}{0.69(R_A + 2R_B)C} \qquad \text{..... (10.5)}$$

Duty Cycle : Duty cycle is defined as the ratio of time T_c for which the output is high to the total time period T. It is usually expressed as percentage given by

$$\%\text{ duty cycle} = \frac{T_C}{T} \times 100$$

$$= \frac{0.69(R_A + R_B)C}{0.69(R_A + 2R_B)C} \times 100$$

$$\therefore\; \%\textbf{ duty cycle} = \frac{\mathbf{R_A + R_B}}{\mathbf{R_A + 2R_B}} \times \mathbf{100} \qquad \text{..... (10.6)}$$

10.5 ASTABLE MULTIVIBRATOR APPLICATIONS

(a) Symmetrical Square Wave Oscillator

A symmetrical square wave has a duty cycle of 50%. According to equation (10.6), a duty cycle of 50% means that the resistance $R_A = 0$. With $R_A = 0$, terminal 7 is directly connected V_{CC}, which, then drives heavy current through the transistor Q_1 damaging it and also damaging the timer. Hence R_A cannot be made zero. Instead, a diode D may be connected across R_B as shown in Figure 10.5. The capacitor C charges through R_A and forward resistance of diode D (usually small → a few tens of ohms) to $\frac{2}{3}V_{CC}$ and discharges through R_B and transistor Q_1, till its value becomes $\frac{1}{3}V_{CC}$ and the cycle repeats itself. Resistor R_A is normally chosen as a combination of a fixed resistor and a potentiometer.

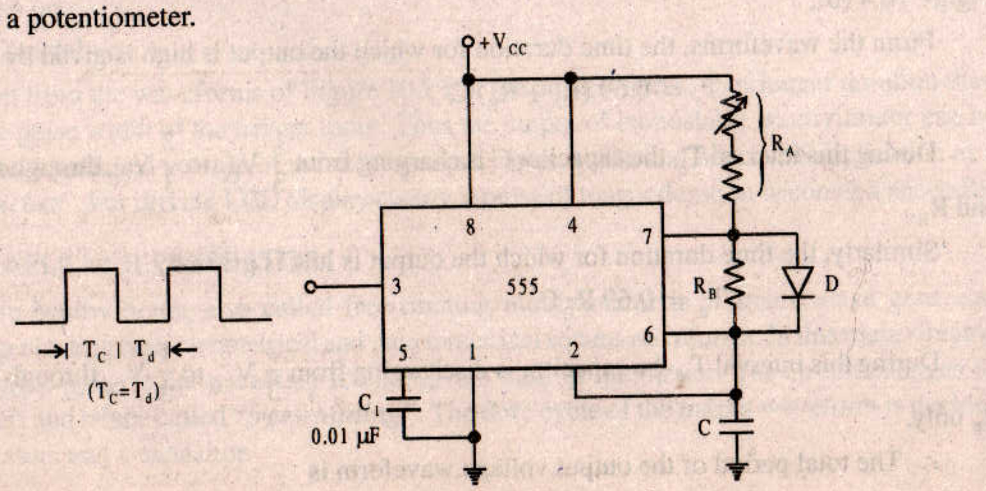


Fig. 10.5 : Circuit to obtain 50% duty cycle

(b) Free-Running Ramp Generator

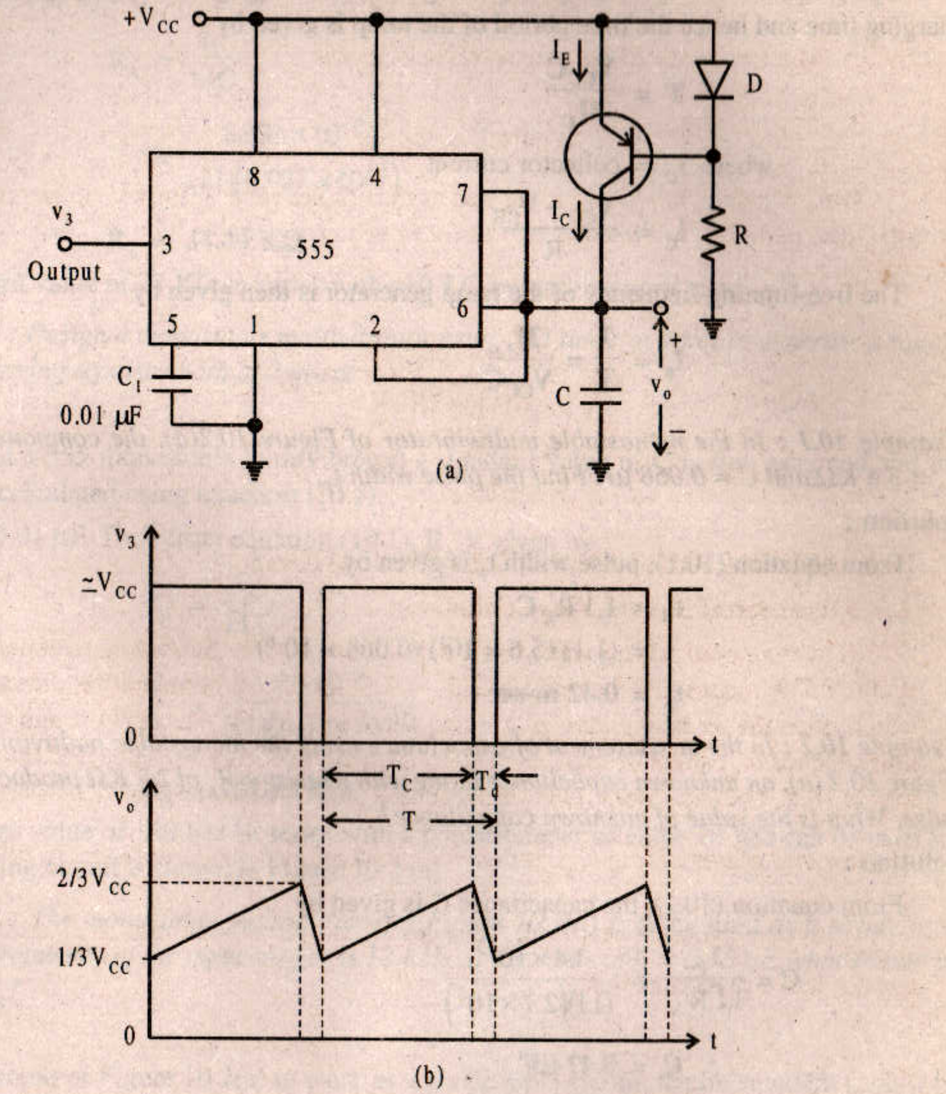


Fig. 10.6 : (a) Free running ramp generator (b) Output and capacitor voltage waveform

When the resistors R_A and R_B are replaced by a diode-transistor circuit, the astable multivibrator can be used as a free-running ramp generator as shown in Figure 10.6. The collector current starts charging the capacitor C towards V_{CC} at a constant rate [The transistor works as a constant current source]. When the voltage across C reaches $\frac{2}{3}V_{CC}$, comparator-1 output drives Q_1 to saturation and C, then, rapidly discharges through Q_1. When the discharging capacitor voltage goes just below $\frac{1}{3}V_{CC}$, the comparator-2 output forces Q_1 to become off and capacitor C starts re-charging again. This cycle keeps repeating. The discharging time is negligible compared to charging time and hence the time period of the ramp is given by

$$T = \frac{V_{CC}C}{3I_C} \quad ..... (10.7)$$

where I_C = collector current

$$I_C = \frac{V_{CC} - V_{BE}}{R} \quad ..... (10.8)$$

The free-running frequency of the ramp generator is then given by

$$f_0 = \frac{1}{T} = \frac{3I_C}{V_{CC}C} \quad ..... (10.9)$$

Example 10.1 : *In the monostable multivibrator of Figure 10.2(a), the component values are R_A = 5.6 KΩ and C = 0.068 μF. Find the pulse width t_p.*

Solution :

From equation (10.1), pulse width t_p is given by

$$t_p = 1.1\, R_A\, C$$

$$= (1.1)(5.6 \times 10^3)(0.068 \times 10^{-6})$$

$$\mathbf{t_p = 0.42\ m\text{-}sec}$$

Example 10.2 : *In the measurement of capacitance using the monostable multivibrator circuit of Figure 10.2 (a), an unknown capacitance along with a resistor R_A of 2.7 KΩ produces a 1.4 m-sec pulse. What is the value of unknown capacitance?*

Solution :

From equation (10.1), the capacitance C is given by

$$C = \frac{t_P}{1.1\, R_A} = \frac{1.4 \times 10^{-3}}{(1.1)(2.7 \times 10^3)}$$

$$\therefore\ \mathbf{C = 0.47\ \mu F}$$

Example 10.3 : *The circuit of Figure 10.2(a) is to be used as a divide-by-2 circuit. The frequency of the input trigger signal is 1.5 KHz. If the value of C = 0.022 μF, what must be the value of the resistor R_A?*

Solution :

For the circuit of Figure 10.2(a) to work as a divide-by-2 circuit, the pulse width t_p must be slightly greater than the period T.

$$\text{Let} \quad t_p = 1.25\,T = \frac{1.25}{f}$$

$$= \frac{1.25}{1.5 \times 10^3}$$

$$\therefore\ t_p = 8.333 \times 10^{-4}\ \text{secs}$$

From equation (10.1)

$$R_A = \frac{t_P}{1.1C}$$

$$= \frac{8.333 \times 10^{-4}}{(1.1)(0.022 \times 10^{-6})}$$

$$\therefore\ \mathbf{R_A = 34.44\ K\Omega}$$

A standard value of 27 KΩ in series with a10 KΩ potentiometer is used as R_A.

Example 10.4 : *Design a monostable multivibrator using 555 timer in order to generate a square wave output having a pulse width of 2 m-sec.*

Solution :

To design a 555 monostable multivibrator, a standard value of C is first assumed and the resistor R_A is calculated using equation (10.1).

Let C = 0.01 μF. Then from equation (10.1), R_A is given by

$$R_A = \frac{t_P}{1.1\,C}$$

$$= \frac{2 \times 10^{-3}}{(1.1)(0.01 \times 10^{-6})}$$

$$\mathbf{R_A = 181.82\ K\Omega}$$

A standard value of 180 KΩ in series with a potentiometer of value 10 KΩ can be used for R_A. The resulting circuit is shown in Figure 10.2 (a).

Example 10.5 : *The monostable multivibrator of Figure 10.2(a) is to be used as a divide-by-3 network. The frequency of the input trigger is 12 KHz. If the value of C = 0.05 μF, what should be the value of R_A?*

Solution :

For the circuit of Figure 10.2(a) to work as a divide-by-3 circuit, the pulse width t_p must be slightly greater than 2T.

$$\text{Let } t_p = 2.2T$$

$$= \frac{2.2}{f}$$

$$= \frac{2.2}{12 \times 10^3}$$

$$= 1.833 \times 10^{-4}\ \text{secs.}$$

From equation (10.1),

$$R_A = \frac{t_P}{1.1C}$$

$$= \frac{1.833 \times 10^{-4}}{(1.1)(0.05 \times 10^{-6})}$$

$$\mathbf{R_A = 3.33\ K\Omega}$$

Example 10.6 : *For the astable multivibrator of Figure 10.4 (a), $R_A = 4.7\ K\Omega$, $R_B = 1\ K\Omega$ and $C = 1\ \mu F$. Determine*

(i) The positive pulse width T_C

(ii) The negative pulse width T_d

(iii) Free-running frequency f

(iv) Duty cycle.

Solution :

(i) From equation (10.2),

$$T_c = 0.69\,(R_A + R_B)C$$
$$= 0.69\,(4.7K + 1K)\,(1 \times 10^{-6})$$
$$\therefore\ \mathbf{T_c = 3.933\ m\text{-}sec}$$

(ii) From equation (10.3),

$$T_d = 0.69\,R_B\,C$$
$$= (0.69)\,(1K)\,(1 \times 10^{-6})$$
$$\therefore\ \mathbf{T_d = 0.69\ m\text{-}sec}$$

(iii) The free running frequency

$$f = \frac{1}{T} = \frac{1}{T_c + T_d}$$
$$= \frac{1}{(3.933 + 0.69)10^{-3}}$$
$$\therefore\ \mathbf{f = 216.31\ Hz}$$

(iv)

$$\text{Duty cycle} = \frac{T_c}{T} \times 100\%$$
$$= \frac{T_c}{T_c + T_d} \times 100\%$$
$$= \frac{3.933 \times 10^{-3}}{3.933 \times 10^{-3} + 0.69 \times 10^{-3}} \times 100\%$$
$$\therefore\ \textbf{Duty cycle} = \mathbf{85.07\ \%}$$

Example 10.7 : *In the circuit of Figure 10.5, the component values are $R_A = 8.2\ K\Omega$, $R_B = 3.9\ K\Omega$ and $C = 1\ \mu F$. Determine*

(i) The positive pulse width T_C

(ii) The negative pulse width T_d

(iii) Free-running frequency f

(iv) Duty cycle.

Solution :

(i) The capacitor C charges through R_A and the diode D. Assuming D to be ideal, the charging time T_c which is the positive pulse width is given by

$$T_c = 0.69\,R_A\,C \qquad \text{..... (10.10)}$$
$$= (0.69)\,(8.2 \times 10^3)\,(1 \times 10^{-6})$$
$$\mathbf{T_c = 5.658\ m\text{-}secs}$$

(ii) The discharge time T_d is same as equation (10.3) given by

$$T_d = 0.69\,R_B\,C$$
$$= (0.69)\,(3.9 \times 10^3)\,(1 \times 10^{-6})$$
$$\mathbf{T_d = 2.691\ m\text{-}secs}$$

(iii) The free running frequency is given by

$$f = \frac{1}{T} = \frac{1}{T_c + T_d}$$
$$= \frac{1}{(5.658 + 2.691) \times 10^{-3}}$$
$$\therefore\ \mathbf{f = 119.77\ Hz}$$

(iv)

$$\text{Duty cycle} = \frac{T_c}{T} = \frac{T_c}{T_c + T_d}$$
$$\therefore\ \text{Duty cycle} = \frac{0.69 R_A C}{0.69 R_A C + 0.69 R_B C}$$
$$\therefore\ \text{Duty cycle} = \frac{R_A}{R_A + R_B} \times 100\% \qquad \text{..... (10.11)}$$
$$= \frac{8.2K}{8.2K + 3.9K} \times 100\%$$
$$\therefore\ \textbf{Duty cycle} = \mathbf{67.77\%}$$

Note : By using the circuit of Figure 10.4 (a), a duly cycle of more than 50% only can be achieved. But by using the circuit of Figure 10.5 any value of duty cycle can be obtained by properly choosing the values of R_A and R_B.

Example 10.8 : *Design an astable multivibrator using 555 timer to generate a symmetrical square wave of frequency 4 KHz.*

Solution :

Since the square wave is symmetrical, we have duty cycle = 50%

From equation (10.11),

$$\text{Duty cycle} = 50\% = \frac{R_A}{R_A + R_B} \times 100\%$$

$$\therefore R_A + R_B = 2R_A$$

$$\therefore \mathbf{R_A = R_B}$$

$$\text{Given } f = 4\text{ KHz} = \frac{1}{T}$$

$$\therefore T = \frac{1}{4\text{KHz}} = 0.25\text{ m-sec} = T_c + T_d$$

Since the square wave is symmetrical, we have

$$T_c = T_d$$

$$\therefore 2T_c = 0.25\text{ m-sec}$$

$$\therefore T_c = T_d = 0.125\text{ m-sec}$$

From equation (10.10),

$$T_c = 0.69 R_A C$$

$$\therefore R_A C = \frac{T_c}{0.69} = \frac{0.125 \times 10^{-3}}{0.69}$$

Choose C = 0.01 μF, we get

$$R_A = \frac{0.125 \times 10^{-3}}{0.69 \times 0.01 \times 10^{-6}}$$

$$\therefore \mathbf{R_A = 18\ K\Omega = R_B}$$

The circuit is shown in Figure 10.5 with $R_A = R_B = 18\ K\Omega$ and $C = 0.01\ \mu F$.

Example 10.9 : *Design an astable multivibrator using 555 timer to generate an unsymmetrical square wave of frequency 2.5 KHz and duty cycle of 30%.*

Solution :

Since the duty cycle ≤ 50%, the circuit of Figure 10.5 is to be designed.

From equation (10.11)

$$\text{Duty cycle} = \frac{R_A}{R_A + R_B} \times 100\% = 30\%$$

$$\therefore \frac{R_A}{R_A + R_B} = 0.3$$

$$\therefore 0.7 R_A = 0.3 R_B$$

$$\therefore \mathbf{R_A = \frac{3}{7} R_B} \qquad \text{..... (10.12)}$$

$$\text{Given } f = \frac{1}{T} = 2.5\text{ KHz}$$

$$\therefore T = \frac{1}{2.5\text{KHz}} = 0.4\text{ m-sec} = T_c + T_d$$

Duty cycle is also given by

$$\text{Duty cycle} = \frac{T_c}{T} \times 100\% = 30\%$$

$$\therefore T_c = 0.3\,T = 0.3\,(0.4\text{ m-sec})$$

$$\therefore \mathbf{T_c = 0.12\ m\text{-}sec}$$

$$\therefore T_d = 0.4\text{ m-sec} - T_c$$

$$= 0.4\text{ m-sec} - 0.12\text{ m-sec}$$

$$\therefore \mathbf{T_d = 0.28\ m\text{-}sec}$$

Let C = 0.01 μF. Then from equation (10.10), we get

$$T_c = 0.69 R_A C$$

$$\therefore R_A = \frac{T_c}{0.69C}$$

$$= \frac{0.12 \times 10^{-3}}{0.69 \times 0.01 \times 10^{-6}}$$

$$\therefore \mathbf{R_A = 17.39\ K\Omega}$$

From equation (10.12),

$$R_B = \frac{7}{3} R_A$$

$$= \frac{7}{3} \times 17.39\text{ K}$$

$$\therefore \mathbf{R_B = 40.58\ K\Omega}$$

The complete circuit is shown in Figure 10.5.

Example 10.10 : *In the circuit of Figure 10.6 (a), R = 18 KΩ, C = 0.022 μF. Determine the frequency of the ramp generator if V_{CC} = 5 volts, V_{BE} = 0.7 V.*

Solution :

From equation (10.8),

$$\text{Collector Current } I_c = \frac{V_{CC} - V_{BE}}{R}$$

$$= \frac{5-0.7}{18K}$$

$$\therefore \; I_c = 0.239 \text{ m Amps}$$

∴ The frequency of the ramp generator output is given by equation (10.9) as

$$f_0 = \frac{1}{T} = \frac{3I_C}{V_{CC}C}$$

$$= \frac{3 \times 0.239 \times 10^{-3}}{5 \times 0.022 \times 10^{-6}}$$

$$\therefore \; f_0 = 6.515 \text{ KHz}$$

10.6 QUESTIONS

10.1 Draw the functional diagram of a 555 timer and explain the features of each of the Pin functions.

10.2 Explain the differences between the two operating modes of the 555 timer?

10.3 Discuss the important features of the 555 timer.

10.4 With a neat diagram and waveforms, explain monostable multivibrator using 555 timer.

10.5 Repeat Q 10.4 for astable multivibrator.

10.6 Discuss the applications of monostable multivibrator.

10.7 Discuss the applications of a stable multivibrator.

10.8 Explain how 555 timer can be used to generate symmetrical square wave.

10.9 Explain how 555 timer can be used to generate unsymmetrical square wave of given duty cycle.

10.10 Explain how capacitance can be measured using monostable multivibrator of 555 timer.

10.11 With a neat diagram, explain the operation of a free running ramp generator using 555 timer.

10.12 With neat diagram and waveforms, explain how a monostable multivibrator constructed using 555 timer can be used as a divide-by-n circuit where n = 2, 3, 4 .....

10.13 With neat diagram and waveforms, explain how a monostable multivibrator constructed using 555 timer can be used as a pulse stretcher.

10.7 PROBLEMS

10.1 In the monostable multivibrator of Figure 10.2 (a), C = 0.1 μF and the output pulse width is 1 m-sec. Determine the value of R_A.

10.2 In the monostable multivibrator of Figure 10.2 (a), C = 0.01 μF and R_A = 2.7 KΩ. Calculate the duration of the output pulse width t_p.

10.3 The monostable multivibrator of Figure 10.2 (a) is to be used as a divide-by-3 network. The frequency of the input trigger is 15 KHz. If the value of C = 0.1 μF, what should be the value of R_A? Draw the waveforms.

10.4 Repeat problem 10.3 with the frequency of the input trigger as 5 KHz.

10.5 In the measurement of capacitance using the monostable multivibrator circuit of Figure 10.2 (a), an unknown capacitance along with a resistor R_A of 39 KΩ produces a 100 μ-sec pulse. What is the value of unknown capacitance?

10.6 Using the 555 timer, design a monostable multivibrator having an output pulse width of 100 m-secs.

10.7 The circuit of Figure 10.2 (a) is to be used as a divide-by-2 circuit. The frequency of the input trigger signal is 3.2 KHz. If the value of C = 0.047 μF, what must be the value of the resistor R_A?

10.8 For the astable multivibrator of Figure 10.4 (a), R_A = 5.6 KΩ, R_B = 1.8 KΩ, and C = 0.22 μF.

(i) The positive pulse width T_C

(ii) The negative pulse width T_d

(iii) Free-running frequency f

(iv) Duty cycle.

10.9 In the circuit of Figure 10.5, the component values are R_A = 15 KΩ, R_B = 18 KΩ and C = 0.15 μF. Determine (i) T_c (ii) T_d (iii) f (iv) Duty cycle

10.10 Using 555 timer, design an astable multivibrator to generate a symmetrical square wave of frequency 2.8 KHz.

10.11 Using 555 timer, design an astable multivibrator to generate an unsymmetrical square wave of frequency 4.5 KHz with duty cycle = 80%

10.12 Using 555 timer, design an astable multivibrator to generate an unsymmetrical square wave of frequency 8 KHz with duty cycle = 25%

10.13 In the circuit of Figure 10.6 (a), R = 27 KΩ and C = 0.068 μF. Determine the frequency of the ramp generator if V_{CC} = 5 volts and V_{BE} = 0.7 V.

10.14 Design a ramp generator using 555 timer having an output frequency of approximately 5 KHz.

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