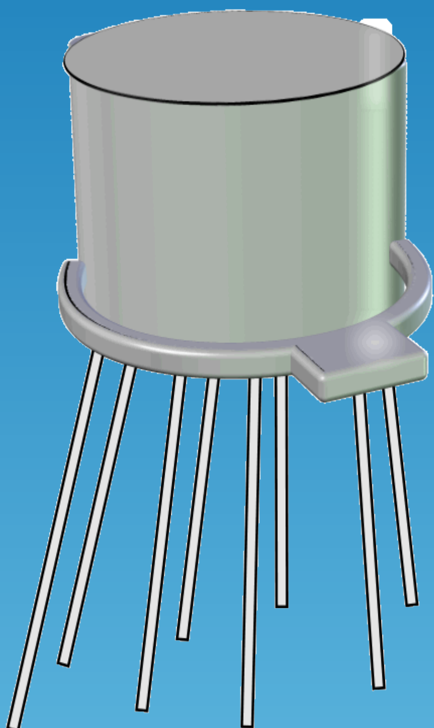
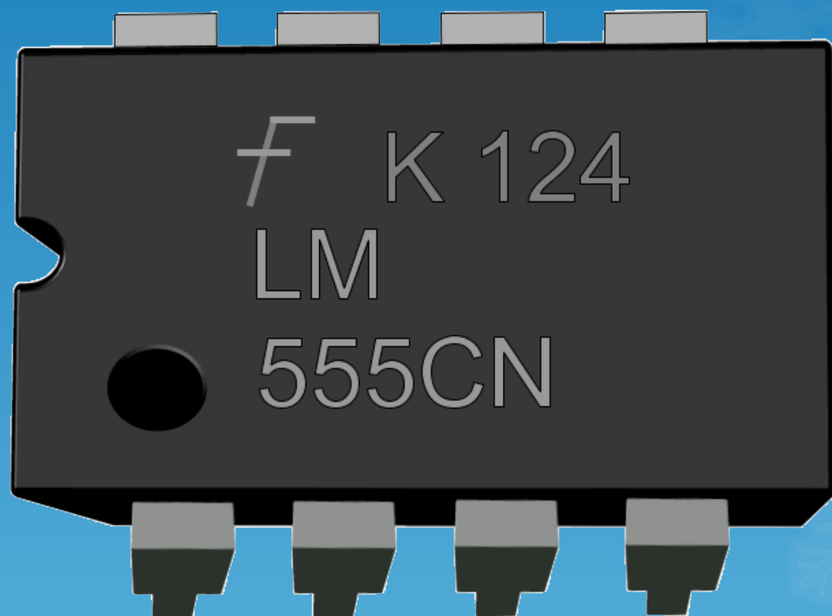
555 Timer Basics



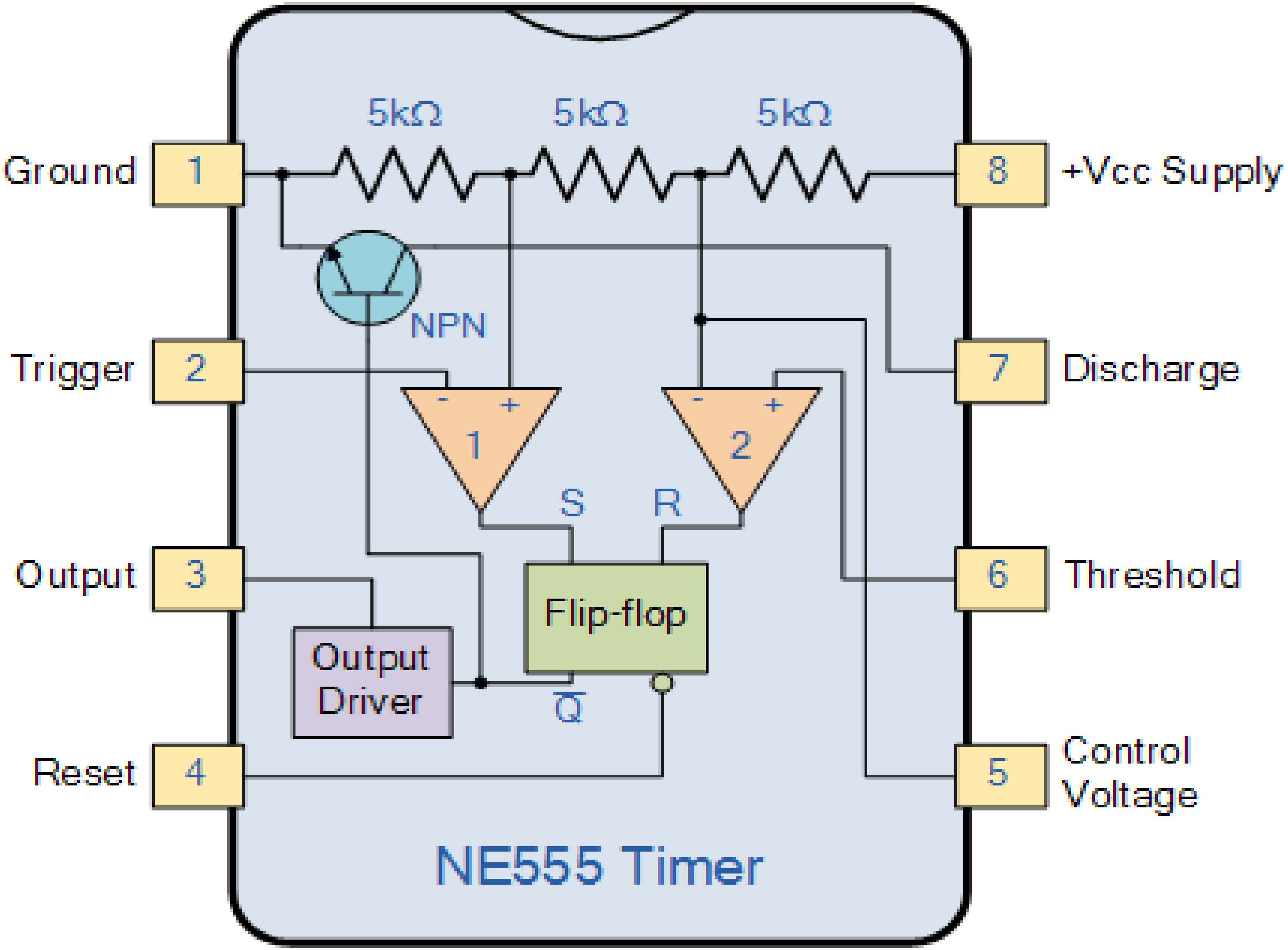
TO-5 Package



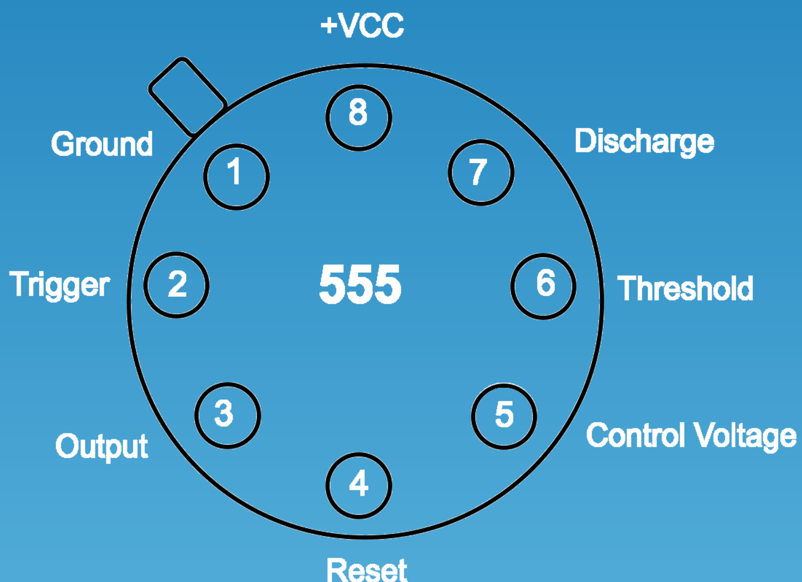
Eight-pin IC, LM555CN

What is a 555 Timer?

- The 555 timer is an 8-pin IC that is capable of producing accurate time delays and/or oscillators.
- In the time delay mode, the delay is controlled by one external resistor and capacitor.
- In the oscillator mode, the frequency of oscillation and duty cycle are both controlled with two external resistors and one capacitor.


5kΩ
5kΩ
5kΩ
Ground
1
8
+Vcc Supply
NPN
Trigger
2
7
Discharge
1
2
S
R
Output
3
6
Threshold
Flip-flop
Output Driver
Q̅
Reset
4
5
Control Voltage
NE555 Timer

555 IC, 8 Pin Pinout Diagrams



Top View of Metal Can Package

8 Pin DIP (Dual Inline Package)

555 Schematic

(c) Tony van Roon

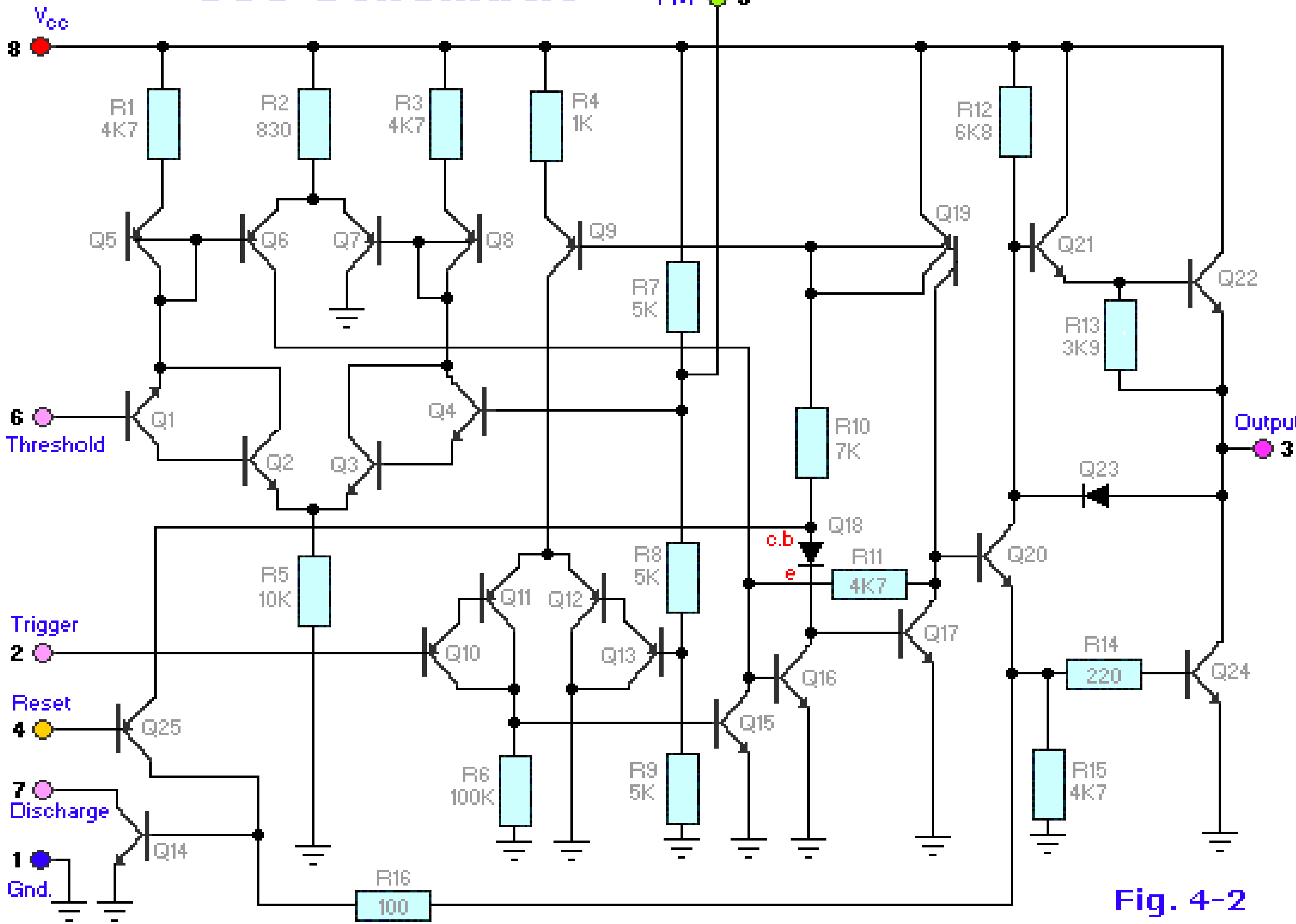


Fig. 4-2

Pin 1: Grounded Terminal: All the voltages are measured with respect to this terminal.

- Pin 2. – **Trigger**, The negative input to comparator No 1. A negative pulse on this pin "sets" the internal Flip-flop when the voltage drops below 1/3Vcc causing the output to switch from a "LOW" to a "HIGH" state.
- Pin 3. – **Output**, The output pin can drive any TTL circuit and is capable of sourcing or sinking up to 200mA of current at an output voltage equal to approximately Vcc – 1.5V so small speakers, LEDs or motors can be connected directly to the output.
- Pin 4. – **Reset**, This pin is used to "reset" the internal Flip-flop controlling the state of the output, pin 3. This is an active-low input and is generally connected to a logic "1" level when not used to prevent any unwanted resetting of the output.
- Pin 5. – **Control Voltage**, This pin controls the timing of the 555 by overriding the 2/3Vcc level of the voltage divider network. By applying a voltage to this pin the width of the output signal can be varied independently of the RC timing network. When not used it is connected to ground via a 10nF capacitor to eliminate any noise.

- Pin 6. – **Threshold**, The positive input to comparator No 2. This pin is used to reset the Flip-flop when the voltage applied to it exceeds 2/3Vcc causing the output to switch from "HIGH" to "LOW" state. This pin connects directly to the RC timing circuit.
- Pin 7. – **Discharge**, The discharge pin is connected directly to the Collector of an internal NPN transistor which is used to "discharge" the timing capacitor to ground when the output at pin 3 switches "LOW".
- Pin 8. – **Supply +Vcc**, This is the power supply pin and for general purpose TTL 555 timers is between 4.5V and 15V.

The **555 Timers** name comes from the fact that there are three 5kΩ resistors connected together internally producing a voltage divider network between the supply voltage at pin 8 and ground at pin 1. The voltage across this series resistive network holds the negative inverting input of comparator two at 2/3Vcc and the positive non-inverting input to comparator one at 1/3Vcc.

The two comparators produce an output voltage dependent upon the voltage difference at their inputs which is determined by the charging and discharging action of the externally connected RC network. The outputs from both comparators are connected to the two inputs of the flip-flop which in turn produces either a "HIGH" or "LOW" level output at $\overline{Q}$ based on the states of its inputs. The output from the flip-flop is used to control a high current output switching stage to drive the connected load producing either a "HIGH" or "LOW" voltage level at the output pin.

The most common use of the 555 timer oscillator is as a simple astable oscillator by connecting two resistors and a capacitor across its terminals to generate a fixed pulse train with a time period determined by the time constant of the RC network. But the 555 timer oscillator chip can also be connected in a variety of different ways to produce Monostable or Bistable multivibrators as well as the more common Astable Multivibrator.

by applying a DC control voltage to pin 5. This permits manual or electronic remote control of the timed interval.

The control terminal is seldom used when the timer is operated in the monstable mode and should be grounded through a 0.01 μF capacitor to prevent the timed interval from being affected by pickup of a stray AC or RF signal.

When the timer is operated as an oscillator in the astable mode, the generated signal can be frequency modulated or pulse-width modulated by applying a variable DC control voltage to pin 5.

Monostable Operation

In this mode of operations the timer acts as a one shot. Details of the external connections and the wave-forms are shown in Fig. 6. The external timing capacitor C_T is held initially discharged by the transistor (T1 in Fig. 2) inside the timer. Upon application of a negative pulse to pin 2, the flip-flop is set which releases the short circuit across the external capacitor and drives the output high. The voltage across the capacitor, now, rises exponentially with the time constant $R_T C_T$. When the voltage across the capacitor equals $\frac{2}{3}$ V_{CC}, the threshold comparator resets the flip-flop which, in turn, discharges the capacitor rapidly and drives the output to its low state. The circuit rests in this state till the arrival of next pulse.

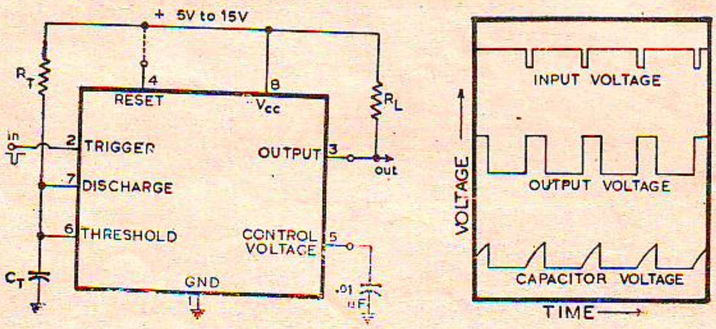
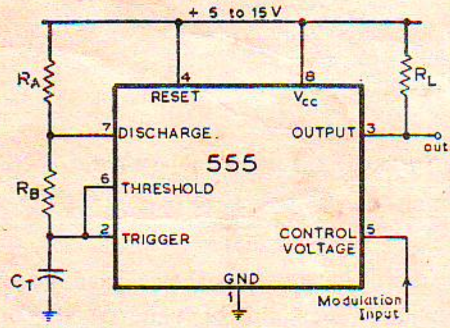


Fig. 6. Monostable Hookup For 555

The circuit triggers on a negative going input signal when the level reaches $\frac{1}{3}$ V_{CC}. Once triggered the circuit will remain in this state until the set time is elapsed, even if it is triggered again during this interval. The time that the output is in the high state is given by $t=1.1\ R_T C_T$. Applying a negative pulse simultaneously to the reset terminal (pin 4) and the trigger terminal (pin 2) during the timing cycle discharges the external capacitor C_T and causes the cycle to start over again. The timing cycle will now commence on the positive edge of the reset pulse. During the time the reset pulse is applied, the output is driven to its low state. When the reset function is not in use, it is recommended that it be connected to V_{CC} to avoid any possibility of false triggering.

Astable Operation

If the circuit is connected as shown in Fig. 7, it will trigger itself and free run as a multi-vibrator. The external capacitor charges through R_A and R_B and discharges through R_B only. Thus the duty cycle may be set precisely by the ratio of these two resistors.



$$t_1 = 0.693\,(R_A + R_B).C_T$$

$$t_2 = 0.693\,(R_B).C_T$$

$$T = 0.693\,(R_A + 2R_B).C_T$$

$$f = \frac{1}{T} = \frac{1.44}{(R_A+2R_B)C_T}$$

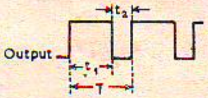


Fig. 7. Astable Operation Of 555 Timer.

In this mode of operation, the capacitor charges and discharges between $\frac{1}{3}$ V_{CC} and $\frac{2}{3}$ V_{CC}. As in the triggered mode, the charge and discharge times and hence the frequency is independent of the supply voltage.

The charge time (output high) is given by:

$$t_1 = 0.693\,(R_A + R_B)\,C_T$$

The discharge time (output low) is given by :

$$t_2 = 0.693\,(R_B)\,C_T$$

Thus the total period T is given by :

$$T = t_1 + t_2 = 0.693\,(R_A + 2\,R_B)\,C_T$$

and the frequency of oscillation is then :

$$f = \frac{1}{T} = \frac{1.44}{(R_A + 2\,R_B)} C_T$$

This may be easily found by figure 8 graph.

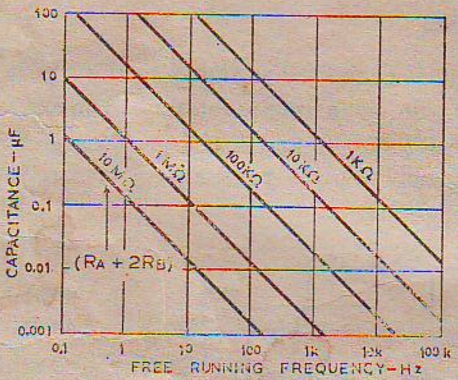


Fig. 8. Free Running Frequency Of Astable Multivibrator.

The duty cycle is given by $D = \frac{R_B}{(R_A + 2\,R_B)}$

From the above equation, it will be seen that the frequency and the duty cycle are inter-dependent and change of value of R_A or R_B affects both. It is possible to have a completely independent control of the charge and discharge times by using two external diodes as shown in Fig. 9. The timing capacitor C1 charges through D1 and R1 and discharges through D2 and R2. A modified arrangement shown separately at left in Fig. 9 provides a control over duty cycle without changing the output pulse frequency. The diode voltage drops, however, make the time more sensitive to supply votage variations.

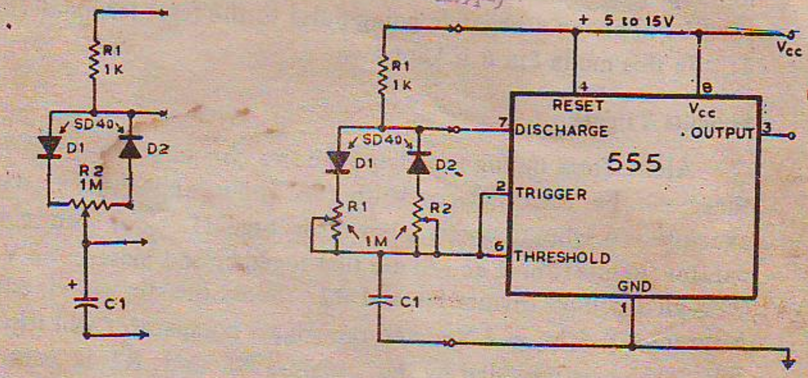


Fig. 9. Independent Control Of Charge And Discharge Timings.

Bistable Operation.

The 555 timer can also function as a bistable flip-flop in such applications as TTL compatible drivers. This flip-flop offers the advantage that it operates from many different supply voltages, uses little power and requires no external components other than bypass capacitors in noisy environments. It also provides a direct relay driving capability.

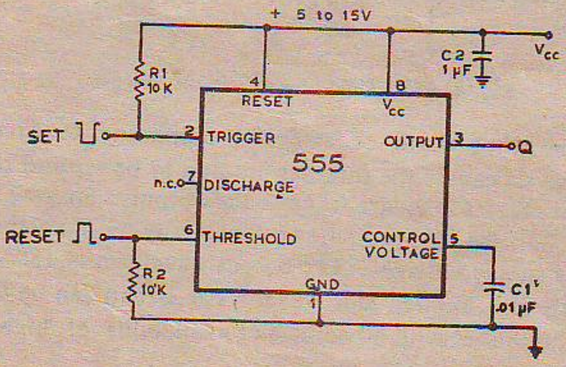


Fig. 10. 555 Timer Operated As A Flip Flop.

As shown in Fig. 10, a negative pulse applied to the trigger input terminal (Pin2) sets the flip flop and the output Q goes high. A positive going pulse applied to threshold terminal will reset the flip-flop and drive the Q output low. The flip-flop can also be reset by applying a negative going pulse to the reset terminal (Pin 4). In this mode Pin 6 is kept low.

Schmitt Trigger

Apart from timing functions, the two comparators of the 555 timer can be used independently for other applications. One example is a schmitt trigger shown in Fig. 11. The two comparator inputs (Pin 2 and 6) are tied together and biased at $\frac{1}{2}$ V_{CC} through a voltage divider R1 and R2. Since the threshold comparator will trip at $\frac{2}{3}$ V_{CC} and the trigger comparator will trip at $\frac{1}{3}$ V_{CC}, the bias provided by the resistors R1 and R2 is centred within the comparators' trip limits.

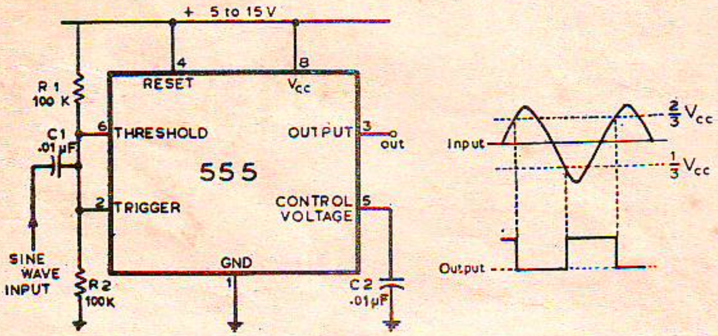


Fig. 11. 555 Timer As A Schmitt Trigger.

A sine wave input of sufficient amplitude to exceed the reference levels causes the internal flip-flop to be set and reset. In this way, it creates a square wave at the output. So long as R1 is equal to R2; the 555 will be automatically biased correctly for almost any supply voltage. The output waveform is 180° out of phase with the applied sine wave. The circuit can be used as a signal shaper/buffer with advantage of availability of high output current.

By modifying the input time constant of the circuit shown in Fig. 11 (e.g., reducing the value of input capacitor to .001 μF) so that the input pulses get differentiated, the arrangement can also