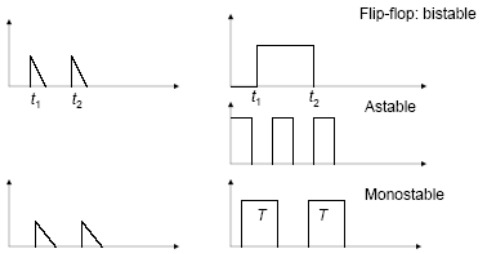
Dept. of Computer Science and Engineering
University of Rajshahi
www.ru.ac.bd

Dr. Shamim Ahmad

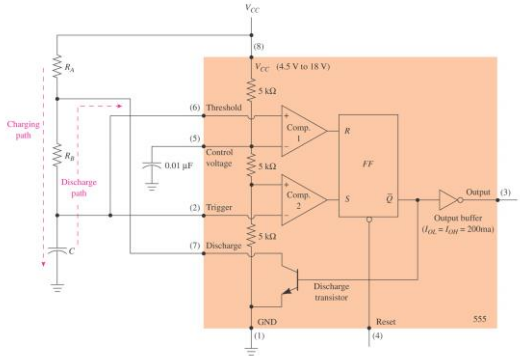
Multivibrator Waveforms



Notes on 555 Timer/Oscillator

- Widely used as a monostable or astable multivibrator.
- Can operate between 4.5 and 16 V.
- Output voltage is approximately 2 V < VCC.
- Output can typically sink or source 200 mA.
- Max. output frequency is about 10 kHz.
- fo varies somewhat with VCC.
- Threshold input (pin 6) and trigger input (pin 2) are normally tied together to external timing RC.

Simplified block diagram of a 555 timer with the external timer components to form an **Astable Multivibrator**.



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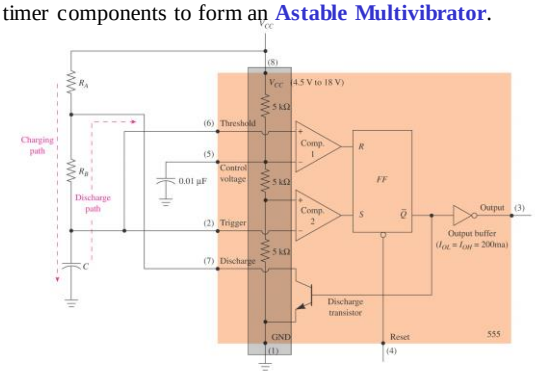

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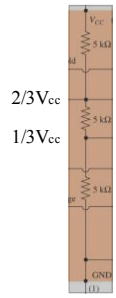

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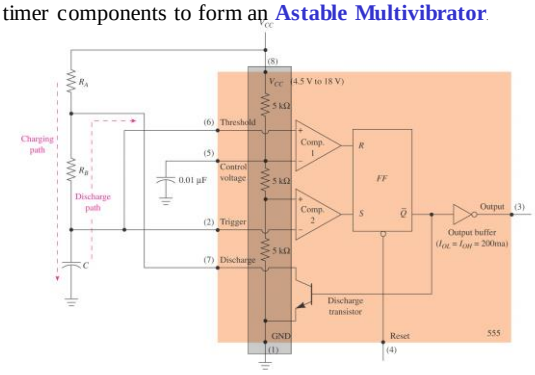

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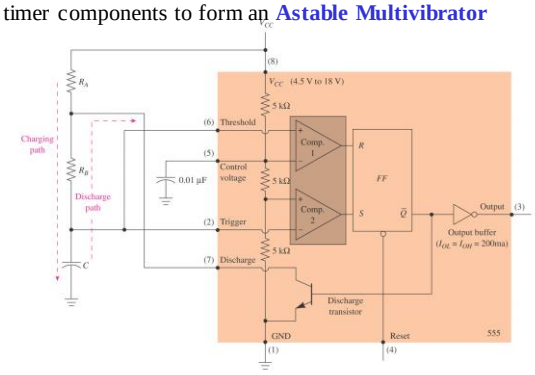

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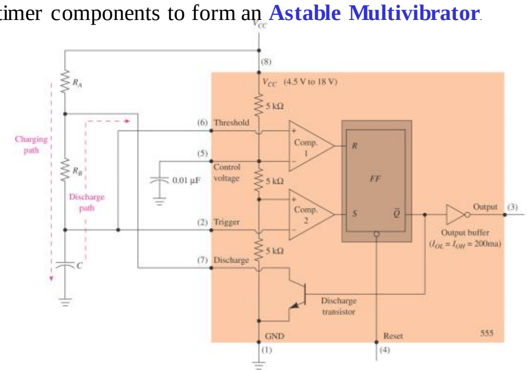

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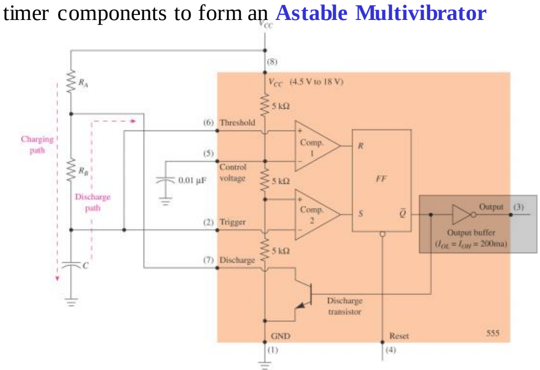

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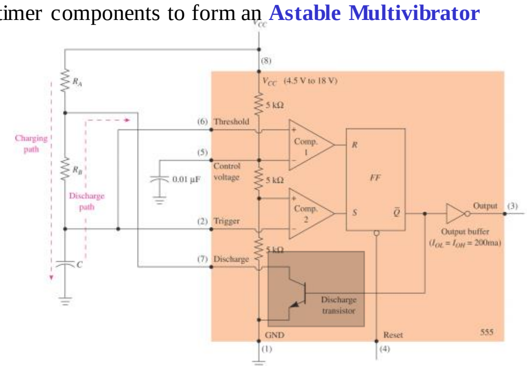

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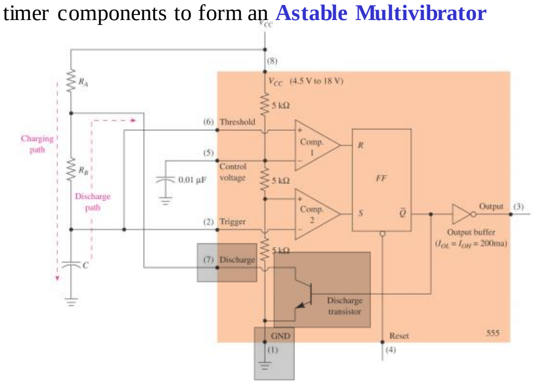

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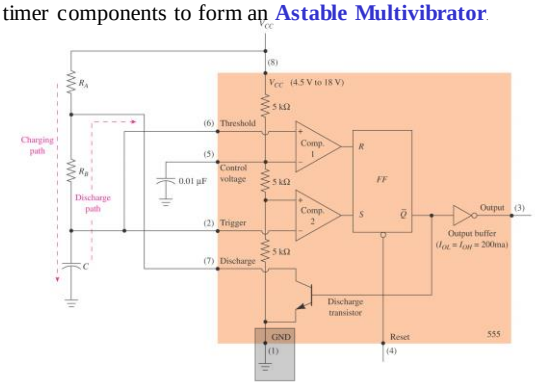

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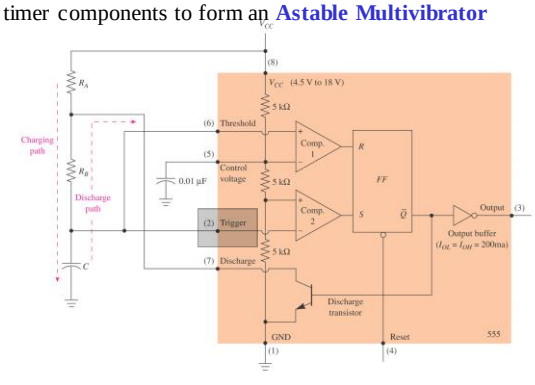

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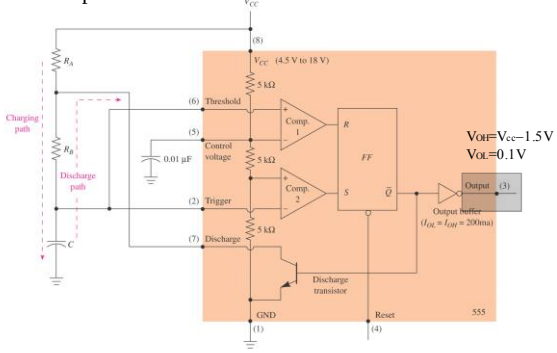

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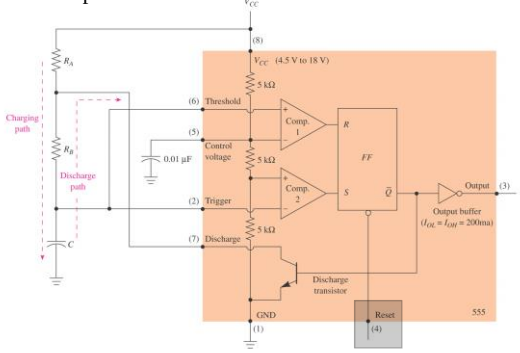

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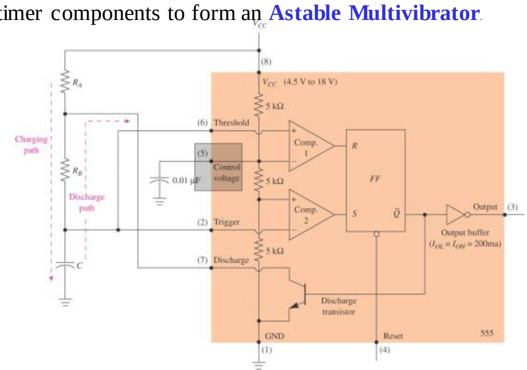

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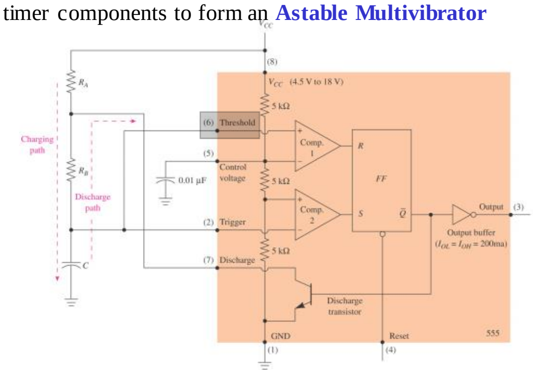

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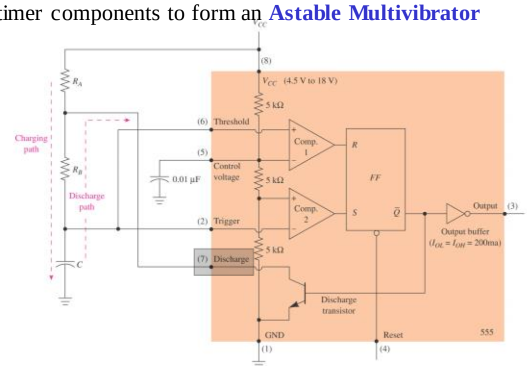

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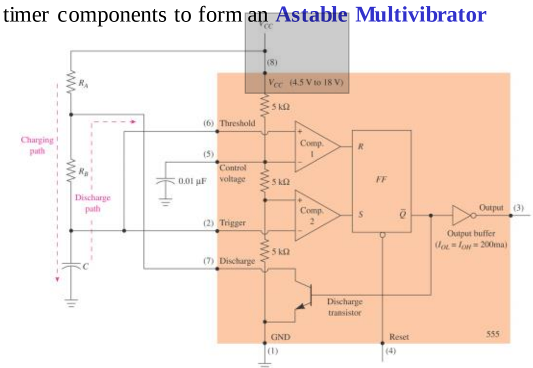

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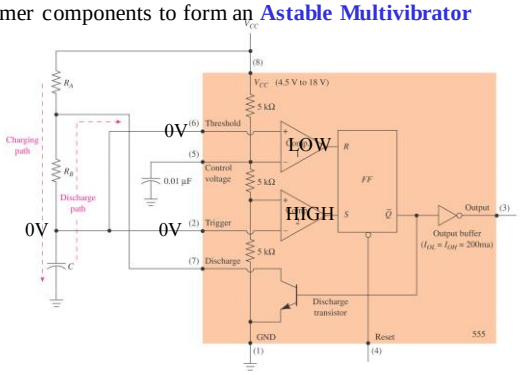

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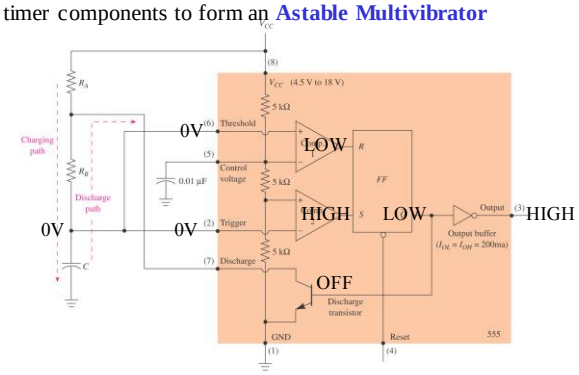

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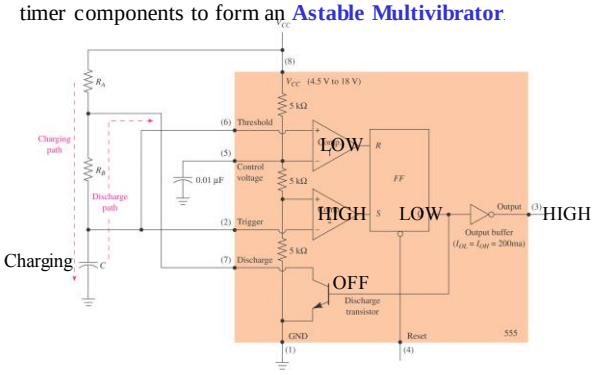

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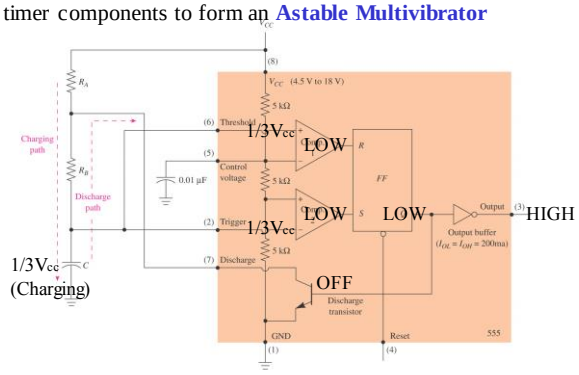

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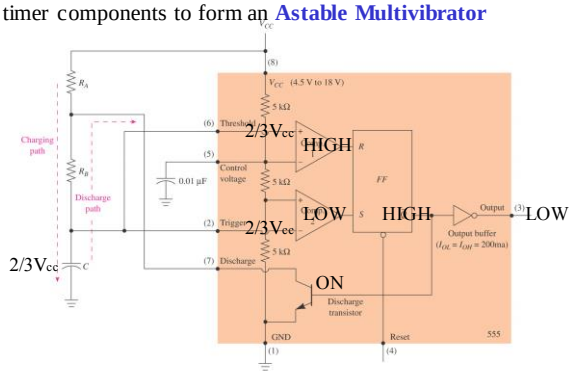

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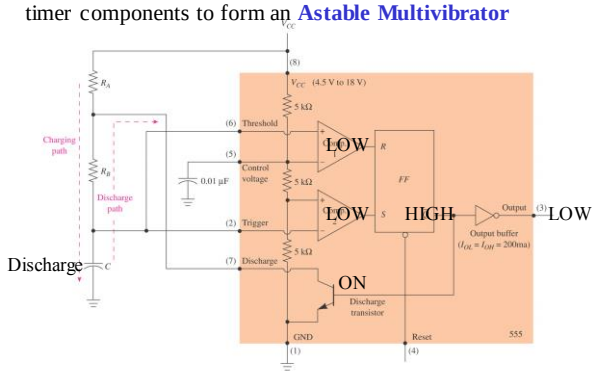

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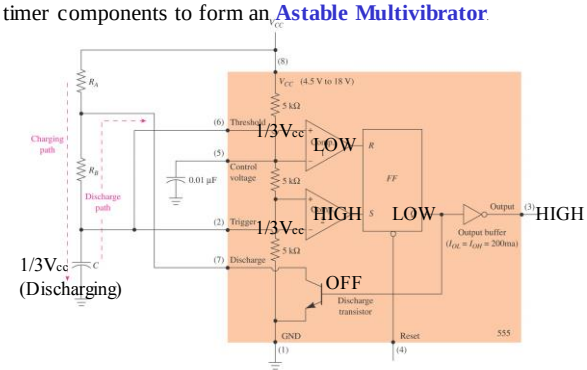

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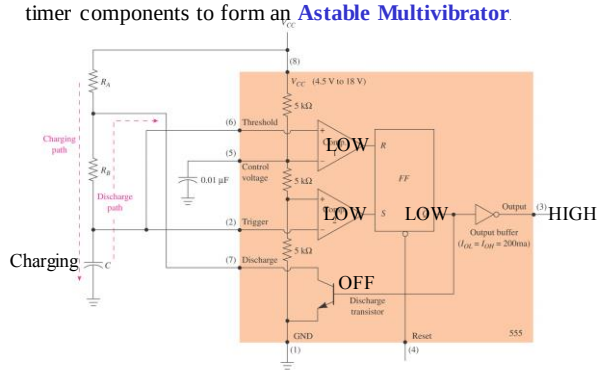

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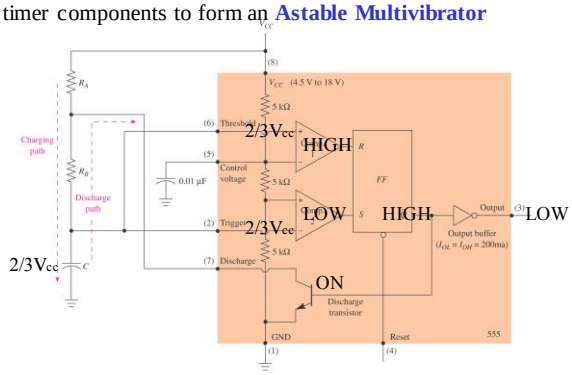

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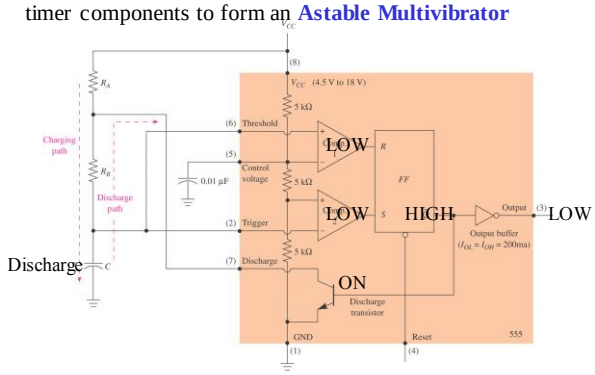

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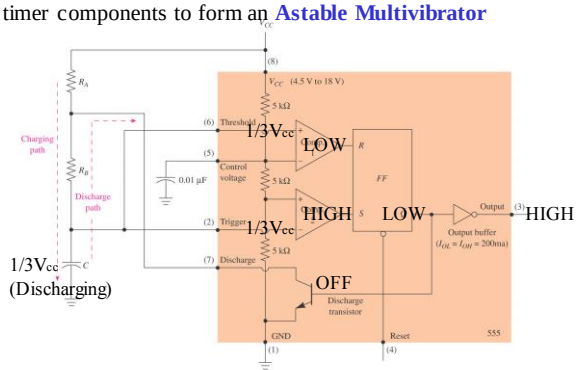

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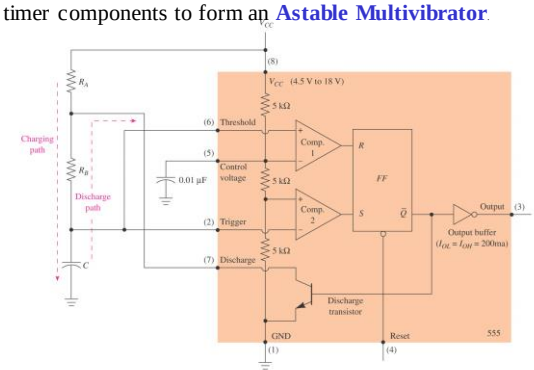
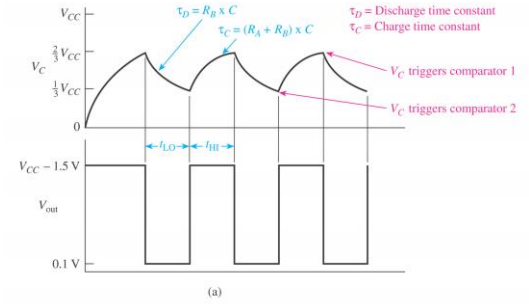
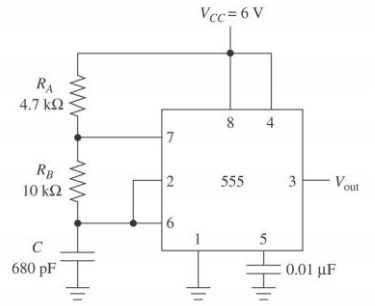


The 555 astable multivibrator: (a) theoretical V_C and V_{out} versus time waveforms and (b) actual breadboarded circuit, power supply, and oscilloscope displaying the measured V_C and V_{out} waveforms.



The 555 Astable connections



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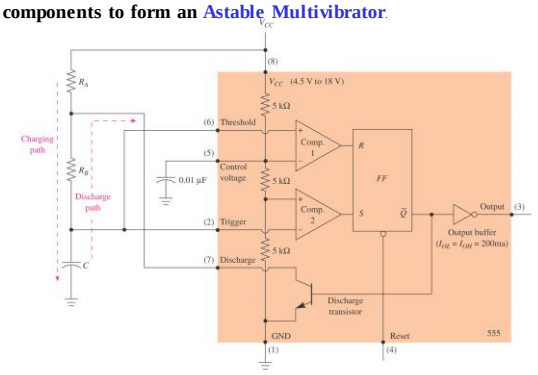
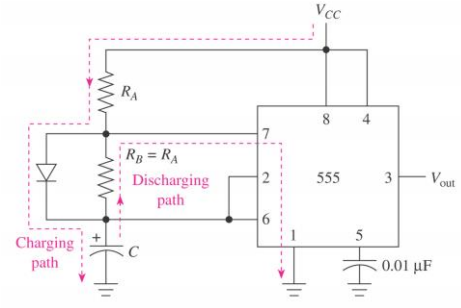
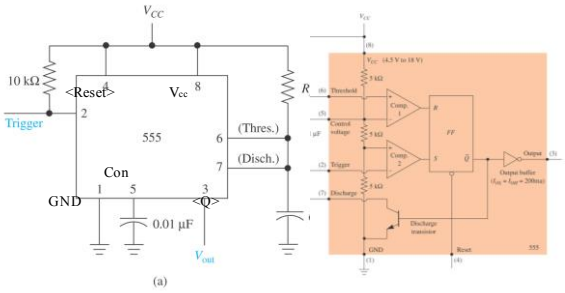
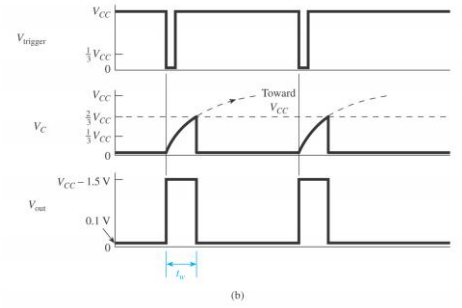


The 555 astable multivibrator set up for a 50% duty cycle.

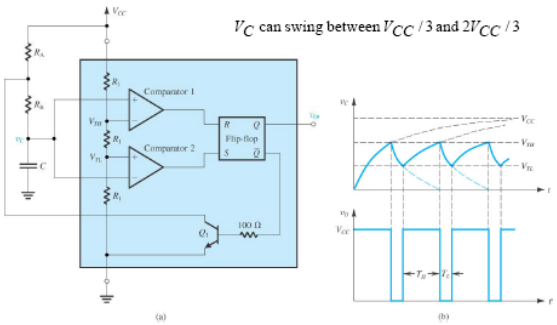




The 555 connections for one-shot operation:
(a) circuit-diagram and (b) waveforms.



Astable Multivibrator



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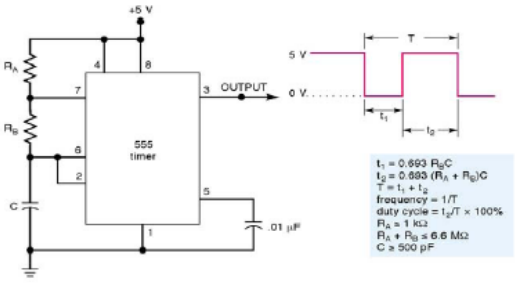
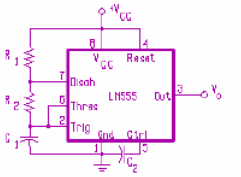


555 as a Simple Oscillator



$t_{ch} = 0.693(R_1 + R_2)C_1$

$t_{disch} = 0.693\ R_2C_1$

$T = 0.693(R_1 + 2R_2)C_1$

Duty cycle is:

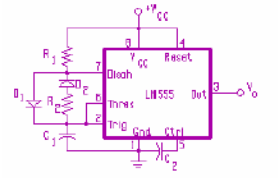
$$D = \frac{t_{ch}}{T} = \frac{R_1 + R_2}{R_1 + 2R_2}$$

Given f_o and D,

$$R_1 = \frac{2D-1}{0.693 f_o C_1}\ ;\ R_2 = \frac{1-D}{0.693 f_o C_1}$$

Note that D must always be > 0.5. To get 50% duty cycle, $R_1 = 0$, which would short out V_{CC}.

555 Square-Wave Oscillator



$$D = \frac{R_1}{R_1 + R_2}$$

$$R_1 = \frac{D}{0.693 f_o C_1}\ ;\ R_2 = \frac{1-D}{0.693 f_o C_1}$$

For 50% duty cycle,

$t_{ch} = 0.693\ R_1C_1$; $t_{disch} = 0.693\ R_2C_1$

$$R_1 = R_2 = \frac{1}{1.386 f_o C_1}$$

$$f_o = \frac{1}{0.693(R_1 + R_2)C_1}$$

Design problem: Design the 555 IC as an astable multivibrator for a specific frequency and duty cycle. Assume the frequency 50 kHz and the duty cycle as 75 %. Let C = 1 nF.

$$f = \frac{1}{0.69(R_A + 2R_B)C}$$

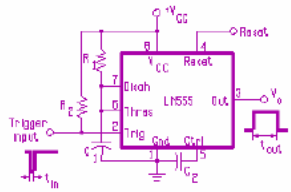
$$R_A + 2R_B = \frac{1}{(0.69)fC} = 28.9\ \text{k}\Omega$$

$$\text{Duty Cycle} = 0.75 = \frac{R_A + R_B}{R_A + 2R_B}$$

$$R_A = 2R_B$$

$$R_A = 14.5\ \text{k}\Omega \text{ and } R_B = 7.23\ \text{k}\Omega$$

555 as a Timer / Monostable Multivibrator

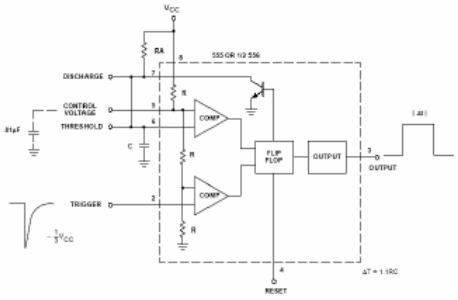


$t = 1.1\ R_1C_1$

Time pulses from a few μs to many minutes are possible The limitation for very long time delays is the leakage in the large-value capacitor for C_1.

R_2 (typically 10 kΩ) is a **pull-up resistor**.
C_2 (typically 0.001 μF) is for bypass.
Timing starts when trigger input is grounded.

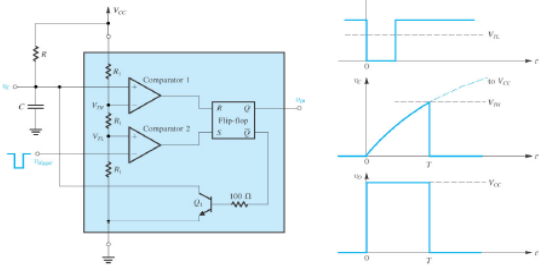
Monostable Multivibrator – One Shot



Implementing a Monostable Multivibrator Using the 555 IC

$v_C = V_{cc}(1-e^{-t/RC}); v_C = V_{TH} = \frac{2}{3}Vcc \text{ at } t = T$

$T = CR\ln 3 = 1.1CR$



Operation of Monostable Multivibrator

It called also one shot,

- Operates by charging a timing capacitor
- With a current set by external resistance.

When the one shot is triggered

- The charging network cycles only once during the t iming interval.
- The total timing interval includes the recovery time needed for the capacitor to charge up to the threshold level.

Operation of Monostable Multivibrator

When *Vcc* high is applied to the trigger input

- The trigger comparator output is low
- The flip flop output is high
- The transistor is on
- The timing capacitor is discharged to ground potential.
- The output of the 555 circuit is low.

When negative voltage is applied to the trigger input

- Output of trigger comparator goes high
- When trigger pulse drops below 1/3 Vcc
- Output of flip flop goes low
- Output of 555 circuit goes high and the transistor turns off

Design problem: Design the 555 IC as a monostable multivibrator **with 100 µs output pulse. Let *C* = 15 nF.**

The pulse width is a function of only the external resistor and capacitance values. A wide range of pulse widths can be obtained by changing these component values.

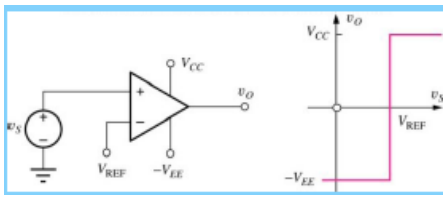
The 555 timer is popular for low frequency applications, but it cannot be used when smaller rise and fall times are required.

The 555 timer is designed to operate with a power-supply voltage ranging from 5 V to 18 V.

$$R = \frac{T}{1.1C} = \frac{100\times10^{-6}}{(1.1)(15\times10^{-9})} = 6.06\,\text{k}\Omega$$

Comparator

It is a circuit which compares a signal voltage applied at one input of an op- amp with a known reference voltage at the other input. It is an open loop op - amp with output + Vsat

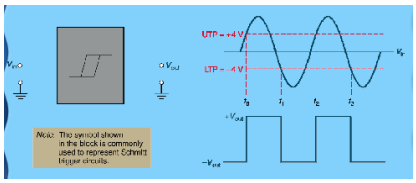


Schmidt Trigger 7414

- **A Schmidt trigger (a comparator with Hysteresis) is a bistable digital (two-state) device**
- **It accepts virtually any analog input and provides a logic 0 or 1 output**
  - **A typical use is to take distorted digital signals (due to RC time constant of transmission line) and provide a used to square-wave output**
  - **Can be used to eliminate noise near reference point that would cause problems in analog comparators**

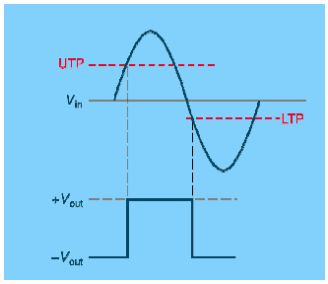
Bistable Multivibrator (Schmitt Trigger)

- **Schmitt trigger – A voltage-level detector.**
- **The output of a Schmitt trigger changes state when**
  - **When a positive-going input passes the upper trigger point (UTP) voltage.**
  - **When a negative-going input passes the lower trigger point (LTP) voltage.**



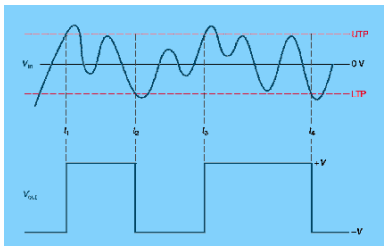
Trigger Point Voltages

Trigger point voltages may be equal or unequal in magnitude, and are opposite in polarity.

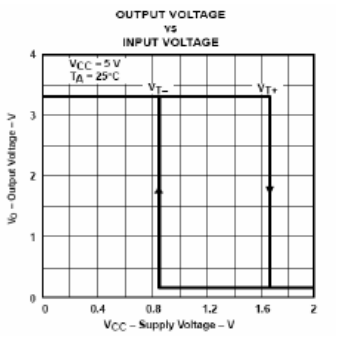


Hysteresis

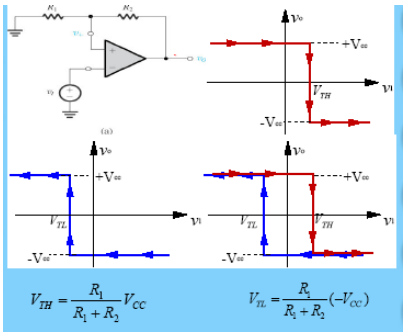
Hysteresis – A term that is often used to describe the range of voltages between the UTP and LTP of a Schmitt trigger.



Hysteresis



Inverting Schmitt Trigger



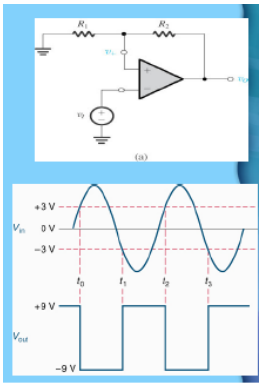
Example

If $V_i = 3 \sin wt$, $V_{CC}=9V$

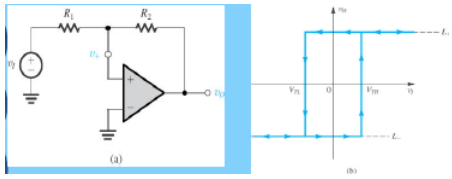
$R_1=1K$

$R_2=2K$

Sketch $V_o(t)$



Noninverting Schmitt Trigger



$$v_+ = v_i \frac{R_2}{R_1 + R_2} + v_o \frac{R_1}{R_1 + R_2}$$

$$V_{TL} = -V_{CC} \frac{R_1}{R_2} \qquad V_{TH} = -(-V_{CC}) \frac{R_1}{R_2}$$