Electronics II

Lecture 24
555 Timer IC

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Previous Lecture

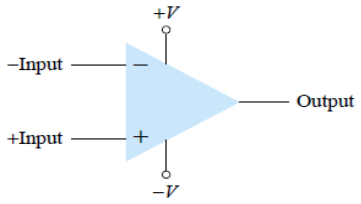
- Types of Oscillator Circuits
  - Wien Bridge Oscillator.
  - Colpitts Oscillator.
  - Hartley Oscillator.
  - Crystal Oscillator.

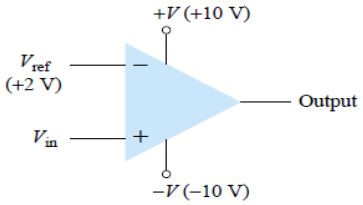
Session Overview

Topic	Voltage Comparator, 555 Timer IC
Concepts	Voltage Comparator. Basic Structure of 555 Timer IC, Astable Operation, Mono Stable Operation.
Recommended Reading	Section 16-6 of [1] Sections 12-1 & 12-2 of [3] Sections 16-1, 16-2 & 16-4 of [2]
Keywords	Voltage Comparator, 555 Timer, Astable, Mono Stable.

Voltage Comparator Basics

- A voltage comparator is a circuit that accepts the linear voltages as inputs and provides a digital output.
- It compares the input voltage levels and its output indicates which of the two inputs is greater.
- The figure shows a comparator configuration when the reference input is given to the inverting input and the non inverting input is connected to Vi.



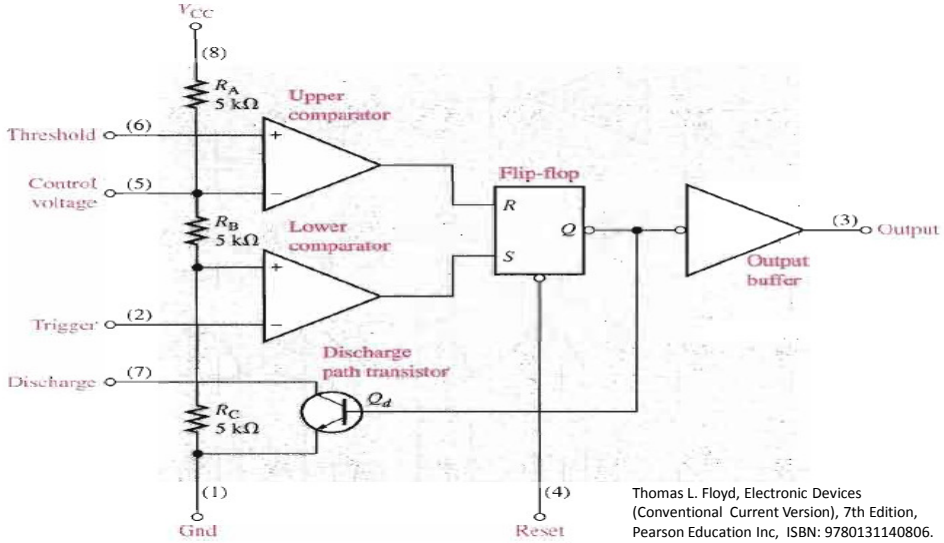


Robert L. Boylestad, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

555 Timer IC- Basic Structure

- 555 timer IC is a analog-digital integrated circuit.
- It consists of
  - linear comparators.
  - A digital flip flop.
  - A resistive voltage divider network.
  - A discharge transistor.
- Linear comparators are devices which provide two level output depending upon the analog input voltage.
- Flip flop is a device which can have two output levels; low and high.
- The resistor voltage divider network is used to set the reference voltages for the comparators.
- The discharge transistor is used to provide a path to the external timing capacitor to discharge.

555 Timer IC- Basic Structure



Thomas L. Floyd, Electronic Devices (Conventional Current Version), 7th Edition, Pearson Education Inc, ISBN: 9780131140806.

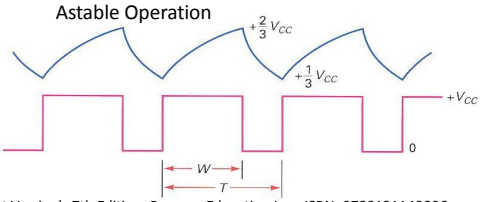
555 Timer IC- Function of Internal Components

- All the resistors in the voltage divider resistive network have equal value.
- Equal resistor values result in the reference levels of (2/3)Vcc for the upper comparator and (1/3)Vcc for the lower comparator.
- The out put of the comparator controls the flip flop. When the trigger voltage level goes below (1/3)Vcc, the flip flop is set with a high output.
- The threshold input is connected to the external RC network; when the external capacitor voltage exceeds (2/3)Vcc, the upper comparator resets the flip flop resulting in the low output.
- When the device output is low, the discharge transistor turns on providing a discharge path for the external timing capacitor.
- With this basic functionality, the timer IC can be configured to work as an oscillator or time delay element etc with the help of external components

555 Timer IC- Modes of Operation

- There are three basic modes of operation of 555 timer IC
  - Astable.
  - Mono-stable.
  - Bi-stable.
- *Astable* mode of operation refers to an operation in which the circuit is not stable in either state. The output continues to switch from one state to another.
- *Mono-stable* mode of operation is when there is one stable state and one unstable state. A trigger pulse causes the circuit to enter the unstable state.
- After entering the unstable state, the circuit remains in that state for a fixed interval of time and then return to the stable state.
- In bi-stable mode of operation the devices have two stable states. Device can enter into any of these two state when triggered by an external pulse.

Astable Operation



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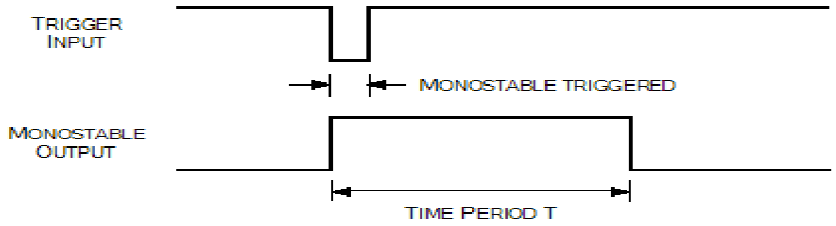
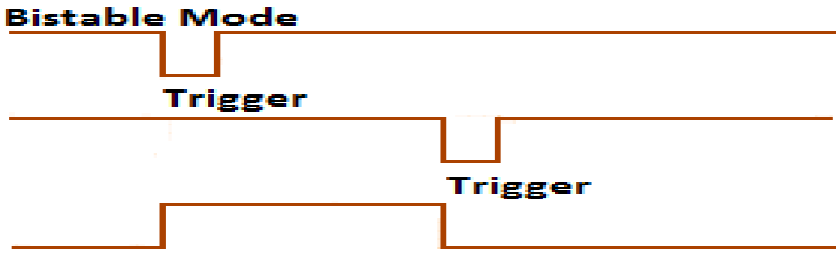
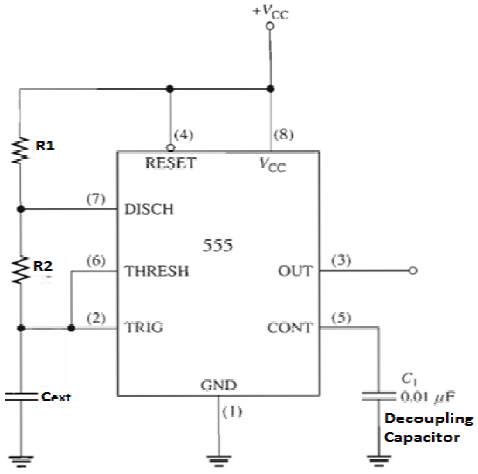
555 Timer IC- Modes of Operation





555 Timer IC- Astable Operation

- Also known as *'astable multi-vibrator'.*
- Threshold input (THRESH) is connected to the trigger(TRIG) input.
- External components R_1, R_2 and C_{ext} form the timing circuit that determines the frequency of oscillations.
- The capacitor connected to control (CONT) input is only for decoupling and has no effect on circuit operation.



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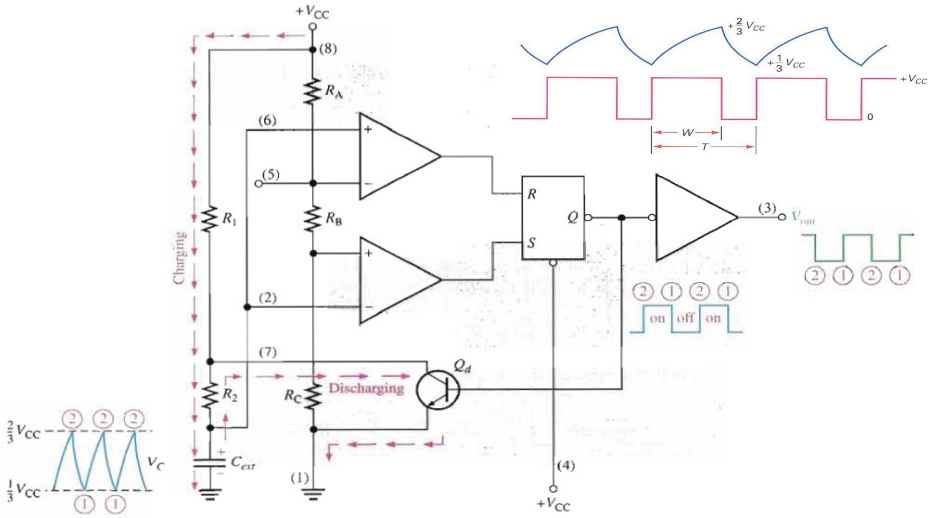
555 Timer IC- Astable Operation



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555 Timer IC- Astable Operation

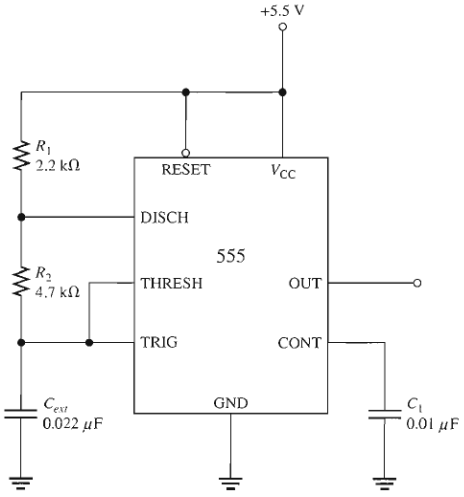
- Summary of Astable Operation
- Initially Cext is uncharged making the trigger voltage at pin 2 equal to 0V.
- This causes the output of lower comparator to be high and the output of upper comparator to be low.
- This results in high output(Q) of flip flop and low (Q') at base of the discharge transistor.
- Cext starts charging through R1 and R2. When it reaches (1/3)Vcc, the lower comparator switched to its low output state and when capacitor charges to (2/3)Vcc the upper comparator switches to high output state.
- This resets the flip flop causing the transistor to switch on and let the capacitor discharge.
- At a point when capacitor discharges to (1/3)Vcc, the lower comparator switches high and at (2/3)Vcc the upper comparator switches to low turning off the transistor. The cycle continues.

555 Timer IC- Astable Operation

- Frequency of Oscillation
  $f_r = 1.44/(R_1+2R_2)C_{ext}$.
- Time duration when the output is high (time required by Cext to charge from (1/3)Vcc to (2/3)Vcc)
  $t_H = 0.694(R_1+R_2)C_{ext}$
- Time duration when the output is low(time required by Cext to discharge from (2/3)Vcc to (1/3)Vcc)
  $t_L = 0.694R_2C_{ext}$
- Total time period
  $T = t_H + t_L = 0.694(R_1+2R_2)C_{ext}$.
- Percent duty cycle
  Duty Cycle(D)= (t_H/T)x 100%
  $D = (t_H/(t_H+t_L))$ x 100%
  $D = [(R_1+R_2)/(R_1+2R_2)]$x100%
- Question: How can we make the duty cycle less than 50 percent? What will be the new formula for duty cycle less than 50 percent.

555 Timer IC- Astable Operation

- *Example 16-6 (Floyd):* Determine the Oscillation frequency and duty cycle of the given astable multi-vibrator.



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References

[1] Thomas L. Floyd, Electronic Devices (Conventional Current Version), 7th Edition, Pearson Education Inc, ISBN: 9780131140806.

[2] Robert L. Boylestad, *Electronic Devices and Circuit Theory,* 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

[3] Theodore F. Bogart, Jeffery S. Beasley, Guilermo Rico, Electronics Devices and Circuits, 6th Edition, Pearson Education Inc, ISBN: 978-81-775-8887-3