Electronics II

Lecture 25
555 Timer IC (Mono Stable Operation)
Voltage Controlled Oscillator and Phase Locked Loop

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Previous Lecture

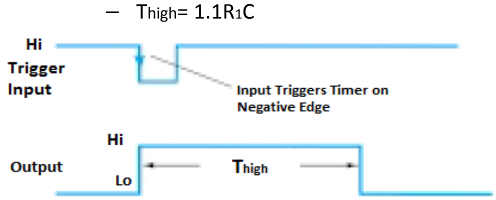
- 555 Timer IC
  - Basic Structure.
  - Internal Components and Circuitry.
  - Modes of Operation.
  - Astable Multivibrator.

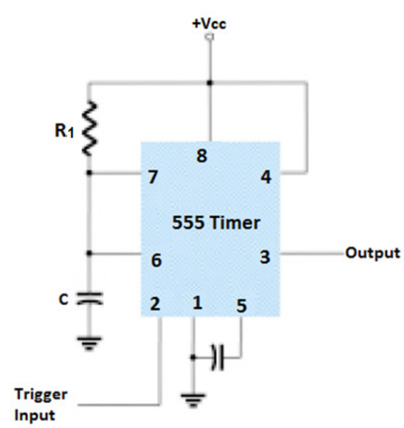
Session Overview

Topic	555 Timer IC(Mono-stable Mode) Voltage Controlled Oscillator Phase Locked Loop.
Concepts	555 Mono-stable Mode, Voltage Controlled Oscillator, Phase Detector, Phase Locked Loop.
Recommended Reading	Section 17-8 of [1].
Keywords	555 Timer, Mono Stable, VCO, Phase Detector, PLL.

555 Timer IC- Mono- Stable Operation

- 555 Timer IC can be used as a mono-stable multi-vibrator which implies that it has only one stable state.
- When the trigger input goes negative, it causes the output at pin 3 to go high for the time period given as
  - $T_{high} = 1.1 R_1 C$

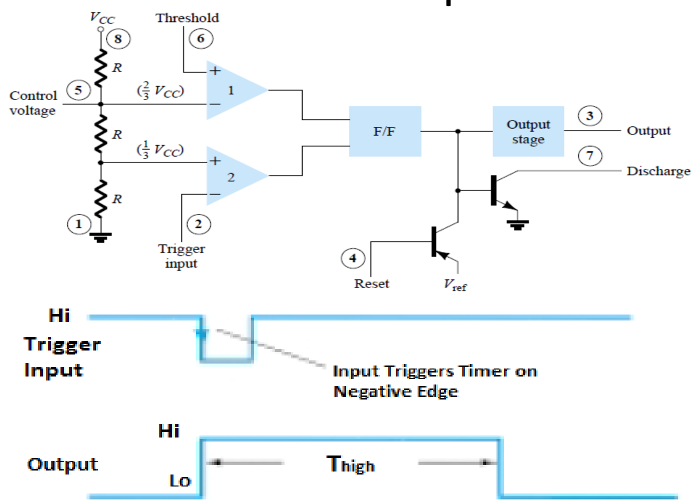




Robert L. Boylestad, *Electronic Devices and Circuit Theory,* 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

555 Timer IC- Mono- Stable Operation

- Negative trigger causes the comparator 2 to trigger the flip flop and output at pin 3 going high.
- During this time capacitor charges through R_A.
- After reaching the voltage level $(2/3)V_{CC}$, comparator 01 triggers the flip flop causing the output to go low.



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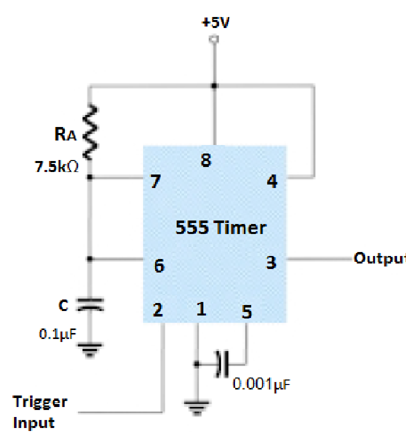
555 Timer IC- Mono-Stable Operation

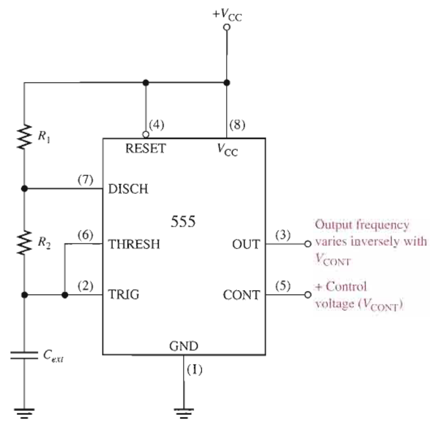
- *Example 18-2 (Boylstead):* Determine the period of output waveform for the given circuit used as monostable multivibrator.



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

Voltage Controlled Oscillator (VCO)

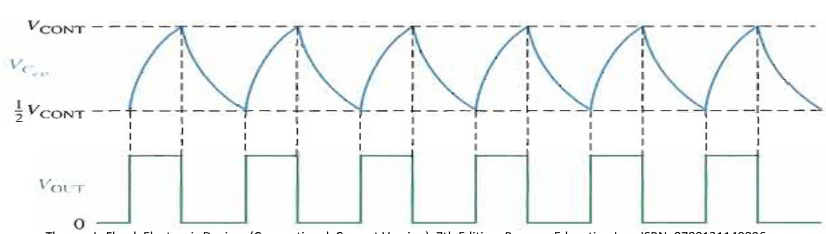
- The basic principle of voltage controlled oscillator is that the oscillation frequency is controlled by an external voltage.
- 555 Timer IC can be used as a voltage controlled oscillator in an astable configuration.
- The only difference is that the control voltage V_{cont} at pin 5 is not grounded as in astable mode. An external voltage is connected to the pin 5. The variation in this voltage controls the oscillation frequency.



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

Voltage Controlled Oscillator (VCO)

- The control voltage at pin 5 changes the threshold/ reference values of (2/3)Vcc and (1/3)Vcc for internal comparators
- With this control voltage the maximum value of capacitor charging is V_{cont} and the minimum value is (1/2)V_{cont}.
- An increase in Vcont increases the charging and discharging time of capacitor while a decrease in Vcont decreases the charging and discharging time of capacitor. This change in charging and discharging affects the oscillation frequency.



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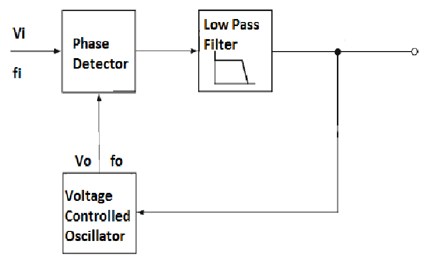
Phase Locked Loop (PLL)

- The phase locked loop is a feedback circuit, consisting of phase detector, voltage controlled oscillator and a low pass filter.
- Some PLL circuit can have an amplifier in the loop while some others can also work without the low pass filter.
- The basic function of the PLL is to lock onto the incoming signal using above mentioned components.
- This implies that the voltage controlled oscillator will have the same frequency as the input signal.



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General Operation of PLL

- The phase detector compares the phase difference between the input signal Vi and the VCO signal Vo.
- If the frequencies of both the inputs to phase detector are different, there will be a phase difference between the two signals.
- Phase detector generates a voltage that is proportional to this phase difference.
- This voltage is fed to the VCO thereby forcing the frequency of the VCO towards the frequency of the incoming signal until both the frequencies are equal.
- Any change in the frequency of the input signal causes the phase detector's output to change. This forces the VCO to change its frequency accordingly.

Phase Detector

- The phase detector will have two inputs that are

$$v_i = V_i \sin(2\pi f_i t + \theta_i)$$
$$v_o = V_o \sin(2\pi f_o t + \theta_o)$$

- Phase detector multiplies the two signals and produces a sum and difference frequency output

$$V_d = V_i \sin(2\pi f_i t + \theta_i) \times V_o \sin(2\pi f_o t + \theta_o)$$

- When phase locked loop is locked

$$f_i = f_o \qquad 2\pi f_i t = 2\pi f_o t$$

- Detector's output voltage is

$$V_d = \frac{V_i V_o}{2}[\cos(\theta_i - \theta_o) - \cos(4\pi f_i t + \theta_i + \theta_o)]$$

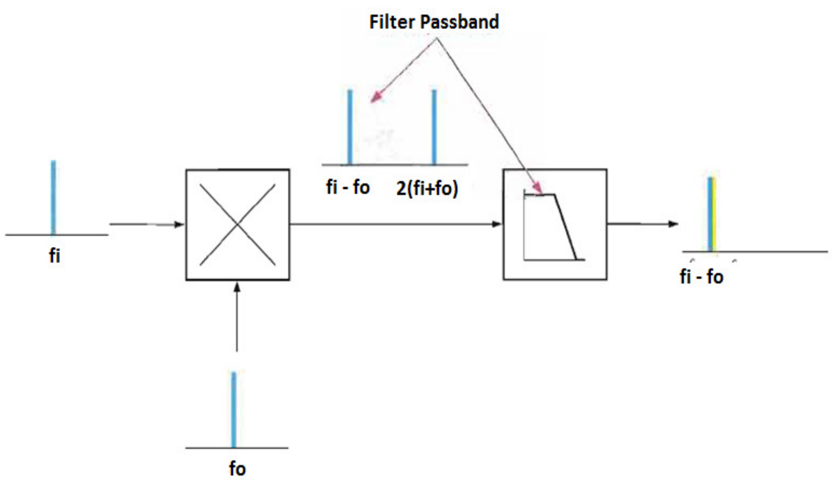
- The second cosine term in the detector output is second harmonic and filtered by the low pass filter. The voltage at the output of the filter reduces to

$$V_c = \frac{V_i V_o}{2}\cos\theta_e$$

- Where θ_e is the phase error and given as

$\theta_e = \theta_i - \theta_o$.

Phase Detector



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Phase Detector

- Example 17-7 (Floyd):

A PLL is locked onto an incoming signal with a frequency of 1 MHz at a phase angle of 50°. The VCO signal is at a phase angle of 20°. The peak amplitude of the incoming signal is 0.5 V and that of the VCO output signal is 0.7 V.

(a) What is the VCO frequency?

(b) What is the value of the control voltage being fed back to the VCO at this point?

Voltage Controlled Oscillator (VCO)

- VCO have can have multiple forms including RC, LC etc. the VCO incorporated in PLL uses varactor diode for variable reactance.
- Capacitance of varactor diode varies inversely with the reverse bias voltage.
- For RC oscillators, the frequency of oscillation is given as

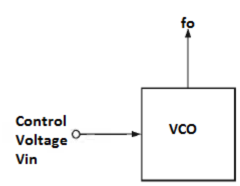
$$f_o = \frac{1}{2\pi RC}$$

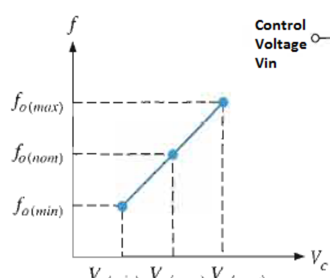
- For LC oscillators

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

- Conversion gain/ transfer function of VCO is defined as frequency deviation per unit change in control voltage

$$K = \frac{\Delta f_o}{\Delta V_c}$$





Voltage Controlled Oscillator (VCO)

- Example 17-8 (Floyd):

  The output frequency of a certain VCO changes from 50 kHz to 65 kHz when the control voltage increases from 0.5 V to 1 V. What is the conversion gain, K?

Basic PLL Operation

Next Lecture

- The next lecture will cover the following topic(s)
  - Power Amplifiers.
  - Different Classes of Power Amplifiers.

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