UNIT V

Timer Circuits

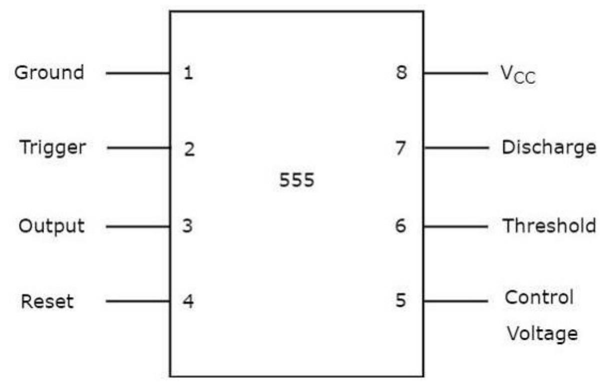
MULTIVIBRATOR (IC 555):

A multivibrator is a circuit used to generate square waves and pulses. Using IC 555 Timer, two types of multivibrators can be implemented:

- Astable Multivibrator
- Monostble Multivibrator

Pin Diagram

The 555 Timer IC is an 8 pin mini Dual-Inline Package (DIP). The pin diagram of a 555 Timer IC

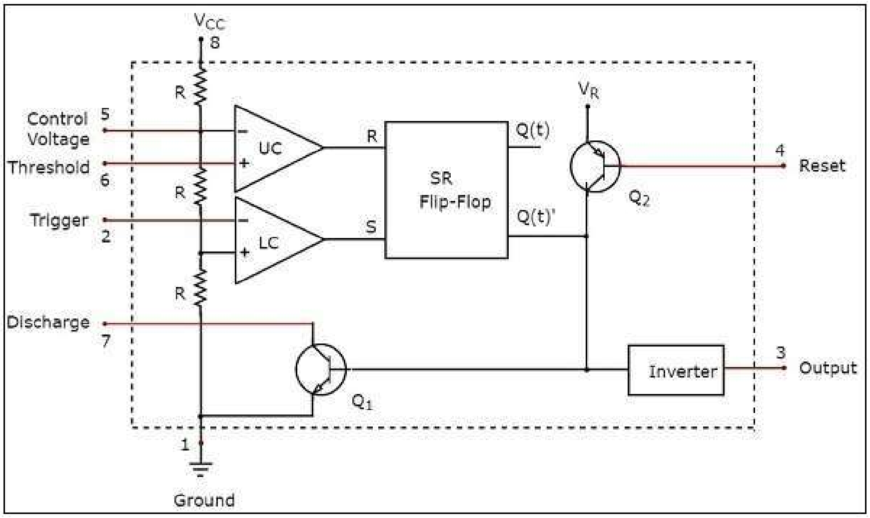


- This is the IC 555 timer pin diagram, which has 8 pins used for various functions like triggering, resetting, output, and controlling timing operations.
- It is widely used in timer, delay, oscillator, and pulse generation circuits.

FUNCTIONAL DIAGRAM OF 555 TIMER IC:

The internal functional block diagram of the 555 Timer IC, which consists of comparators, flip-flop, transistor, and voltage divider.

1. Voltage Divider Circuit:
   - Formed by three equal resistors (R) connected between Vcc (Pin 8) and Ground (Pin 1).
   - Divides Vcc into 2/3 Vcc and 1/3 Vcc, which are reference voltages for the comparators.
2. Comparators:
   - Upper Comparator (UC):
     - Non-inverting input connected to Threshold (Pin 6).
     - Inverting input connected to 2/3 Vcc.
     - Compares threshold voltage with 2/3 Vcc and sets the flip-flop accordingly.
   - Lower Comparator (LC):
     - Inverting input connected to Trigger (Pin 2).
     - Non-inverting input connected to 1/3 Vcc.
     - Compares trigger voltage with 1/3 Vcc to reset the flip-flop.

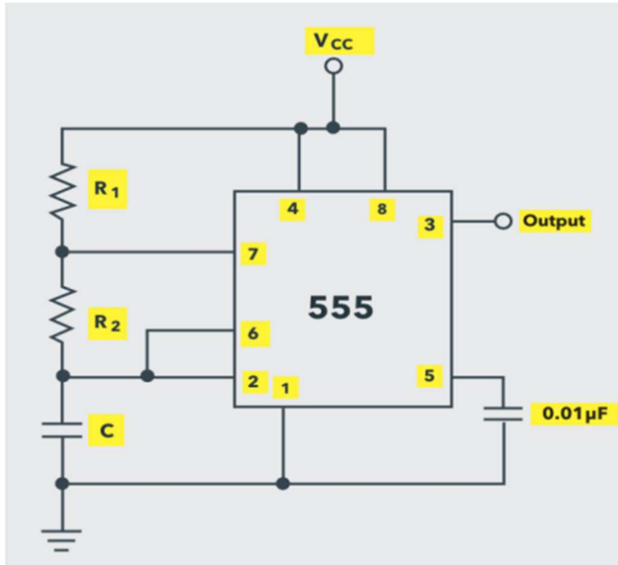


3. SR Flip-Flop:
   - Receives outputs from both comparators and controls the output state.
   - Provides two complementary outputs Q and $\overline{Q}$ (Q-bar).
4. Discharge Transistor (Q1):
   - Connected to Discharge Pin (Pin 7).
   - Used to discharge the timing capacitor to ground when necessary.
   - Controlled by flip-flop output.
5. Output Stage:
   - Output taken from Pin 3 via an inverter to ensure proper logic levels.
6. Control Voltage (Pin 5):
   - Provides access to the 2/3 Vcc point.
   - Can be used to change reference voltage dynamically for modulation purposes.
7. Reset Pin (Pin 4):
   - Used to reset the flip-flop directly.
   - Active low; when connected to ground, it disables the output regardless of other inputs.

Working Summary:
- The internal circuit allows IC 555 to operate in Astable, Monostable, and Bistable modes.
- By charging and discharging an external capacitor via the discharge transistor, it produces timing pulses and oscillations.

ASTABLE MULTIVIBRATOR:

It is an Astable Multivibrator configuration using the IC 555 Timer, which generates a continuous square wave without any external triggering. It is called "astable" because it has no stable state — it keeps switching between HIGH and LOW states automatically.



1. Circuit Components:

- IC 555 Timer: Main component for generating timing signals.
- Resistors R1 and R2: Used to charge and discharge the capacitor, controlling the time period and frequency.
- Capacitor C: Determines the timing interval along with R1 and R2.
- Bypass Capacitor (0.01 µF) at Pin 5 (Control Voltage): Used to avoid noise and voltage fluctuations.

2. Pin Configuration and Connections:

- Pin 1 (Ground): Connected to negative terminal (0V).
- Pin 8 (Vcc): Connected to positive supply voltage (typically 5V to 15V).
- Pin 3 (Output): Provides the square wave output.
- Pin 4 (Reset): Connected to Vcc to disable the reset function (active LOW).
- Pin 5 (Control Voltage): Connected to a 0.01 µF capacitor to filter noise.
- Pin 2 (Trigger) & Pin 6 (Threshold): Shorted together and connected to the junction of R2 and C.
- Pin 7 (Discharge): Connected between R1 and R2, used to discharge capacitor C.

3. Working Principle:

- Charging Phase:
  Capacitor C charges through R1 and R2.
  As C charges, voltage across C increases.
- Threshold Detection:
  When the voltage across C reaches 2/3 Vcc, the internal Upper Comparator (UC) resets the flip-flop, and output goes LOW.
- Discharging Phase:
  The Discharge transistor (inside IC) turns ON and discharges the capacitor C through R2 to ground.
- Trigger Detection:
  When voltage drops to 1/3 Vcc, the Lower Comparator (LC) sets the flip-flop, and output goes HIGH.
  The cycle repeats continuously, generating a square wave output.

4. Time Period and Frequency Calculation:
High Time (T_1):

$$T_1 = 0.693 \times (R1 + R2) \times C$$

Low Time (T_2):

$$T_2 = 0.693 \times R2 \times C$$

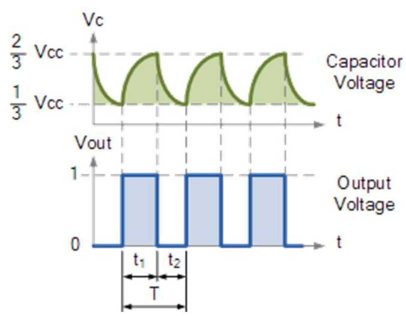
Total Time Period (T):

$$T = T_1 + T_2 = 0.693 \times (R1 + 2R2) \times C$$

Frequency (f):

$$f = \frac{1.44}{(R1 + 2R2) \times C}$$

5. Waveform Explanation:



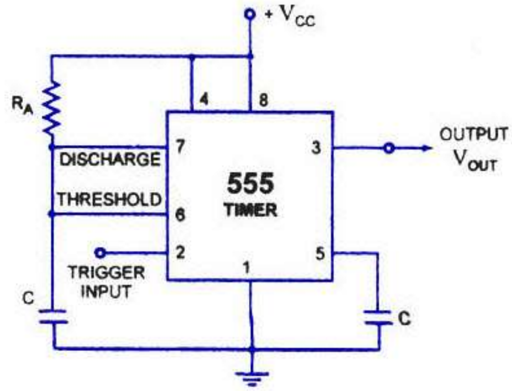
- This graph shows the capacitor voltage and output waveform of an astable multivibrator using IC 555, where the capacitor charges and discharges between 1/3 Vcc and 2/3 Vcc, generating a continuous square wave at the output.
- The output is high when the capacitor charges and low when it discharges, forming a periodic waveform.

6. **Applications:**

- Clock pulses for digital circuits.
- Flashing LED circuits.
- Pulse generation for timing purposes.
- Tone generators and alarms.

MONOSTABLE MULTIVIBRATOR:

The given circuit represents a Monostable Multivibrator using the 555 Timer IC, which is used to generate a single pulse of fixed duration in response to an external trigger input. It has one stable state (LOW output) and one quasi-stable state (HIGH output for a defined time).



1. Circuit Components:

- IC 555 Timer: Main device to generate pulse.
- Resistor (RA): Determines timing along with capacitor.
- Capacitor (C): Controls the pulse width or time duration.
- Trigger input: External signal to initiate the output pulse.
- Vcc (Pin 8): Power supply (typically 5V to 15V).
- Ground (Pin 1): Connected to 0V.
- Output (Pin 3): Provides the output pulse.

2. Pin Configuration and Connections:

- Pin 1 (Ground): Connected to 0V (negative terminal).
- Pin 8 (Vcc): Connected to the positive supply voltage.
- Pin 3 (Output): Pulse output.
- Pin 4 (Reset): Connected to Vcc to disable reset function.
- Pin 5 (Control Voltage): Connected to a bypass capacitor to ground (0.01 µF) to avoid noise (optional but recommended).
- Pin 2 (Trigger Input): Used to start the timing cycle when pulled below 1/3 Vcc.
- Pin 6 (Threshold): Connected to capacitor for monitoring voltage during charge.
- Pin 7 (Discharge): Connected between RA and the capacitor to discharge it when required.

3. Working Principle:

- Initial State (Stable State):
  Output (Pin 3) is LOW. Capacitor is discharged via Discharge transistor (Pin 7).
- Triggering:
  When a negative pulse (below 1/3 Vcc) is applied at Trigger (Pin 2), output (Pin 3) goes HIGH, and Discharge transistor turns OFF.
- Timing Cycle (Quasi-Stable State):
  Capacitor C begins to charge through resistor RA. Output remains HIGH for a fixed time.
- Return to Stable State:
  Once capacitor voltage reaches 2/3 Vcc, output (Pin 3) goes LOW, and capacitor discharges via Pin 7, ready for next trigger.

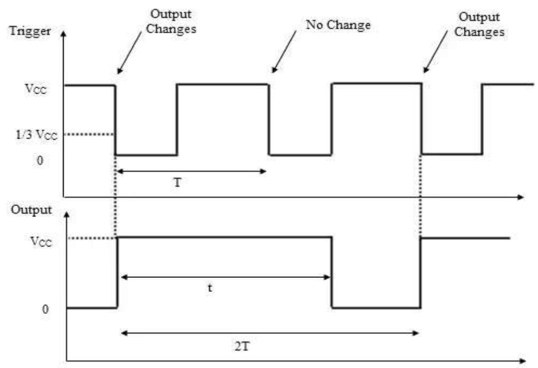
4. Time Duration (Pulse Width) Formula:

$$T = 1.1 \times RA \times C$$

Where,

- T = Output pulse width (seconds)
- RA = Resistance (ohms)
- C = Capacitance (farads)

5. Waveform Explanation



- This waveform represents the Monostable Multivibrator using IC 555, where the output goes HIGH for a fixed time (t) only when a trigger pulse falls below 1/3 Vcc, and remains LOW otherwise.
- Each trigger initiates a single output pulse, making it useful for generating precise time delays.

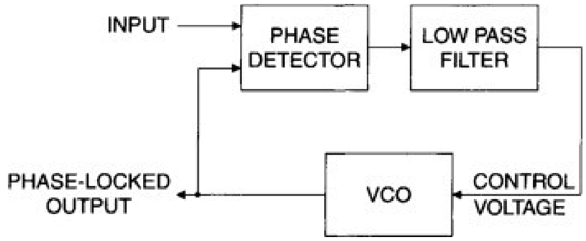
6. Applications:

- Timers and delay circuits.
- Pulse generation.
- Debouncing switches.
- Frequency division.
- Missing pulse detection.

PHASE LOCKED LOOP:

A Phase-Locked Loop (PLL) is a feedback control system that compares the phase of an input signal with the phase of an output signal and adjusts the output to keep them synchronized. It maintains a constant phase angle between the input and output signals.

Block Diagram:



Block Diagram Explanation:

1. **Phase Detector (PD):**

- Function: Compares the phase of the input signal with the phase of the signal generated by the Voltage-Controlled Oscillator (VCO).
- Output: Generates an error signal (voltage) proportional to the phase difference.
- Purpose: Indicates how much the VCO output needs to adjust to match the input phase.

2. Low Pass Filter (LPF):

- Function: Filters out high-frequency components from the error signal.
- Output: Provides a smooth DC voltage as control voltage for the VCO.
- Purpose: Prevents fast fluctuations and stabilizes the control signal.

3. Voltage Controlled Oscillator (VCO):

- Function: Produces an output frequency that varies with the input control voltage.
- Output: Generates a frequency that gets locked to the input frequency when the loop is stable.
- Purpose: Adjusts frequency to reduce phase error and lock to input.

4. Feedback Loop:

- The output of VCO is fed back to the Phase Detector, closing the loop.
- This allows continuous adjustment until input and output frequencies are synchronized (locked).

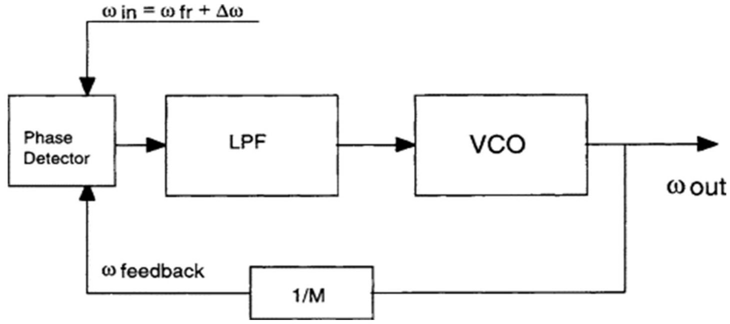
Working of PLL:

- When the system starts, VCO runs at a free-running frequency.
- Phase Detector compares VCO output with input and generates an error signal.
- Low Pass Filter smoothens this error signal.
- VCO adjusts its frequency based on the control voltage until its phase matches input phase.
- Once locked, VCO output follows input frequency and phase, achieving synchronization.

Applications of PLL:

- Frequency Synthesizers for communication systems.
- FM Demodulation in radio receivers.
- Clock Recovery in digital systems.
- Tone Decoding in telecommunication.
- Motor Speed Control systems.

PHASE DETECTORS:



- A Phase Detector (PD) is a critical component of Phase Locked Loop (PLL) circuits.
- It compares the phase of two input signals and produces a voltage (or current) proportional to the phase difference.
- The output of the Phase Detector is called an error signal, used to adjust the frequency of the Voltage Controlled Oscillator (VCO) to maintain synchronization.

Working Principle:

- The Phase Detector takes two input signals:
  - Reference Input (Input Signal) – The signal with which synchronization is needed.
  - Feedback Signal – Usually from the output of the VCO (possibly divided).
- If there is a phase difference between the input and feedback signals, the PD generates an error voltage.
- This error voltage is filtered and applied to the VCO to adjust its frequency, thereby reducing the phase difference to zero (locked condition).

Types of Phase Detectors:

1. Analog Phase Detector (Multiplier Type):
   - Uses analog multipliers.
   - Generates a signal proportional to the sine of the phase difference.
2. Digital Phase Detector (Logic Gates, XOR, Flip-Flop based):
   - Uses logic gates or flip-flops.
   - Provides a pulse-width modulated output proportional to the phase difference.

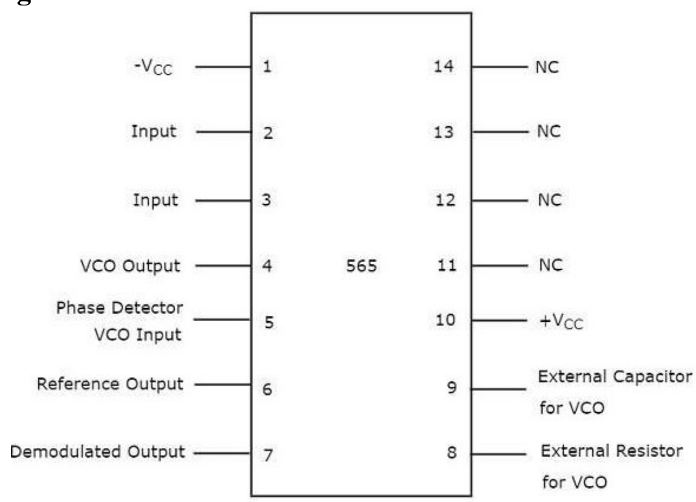
Characteristics of Phase Detector:

- Phase Detection Range: The range of phase difference it can detect.
- Linearity: The relation between output voltage and phase difference.
- Sensitivity (K_pd): Output voltage per unit phase difference.
- Dead Zone: Smallest phase difference that can be detected (should be minimal).

Applications of Phase Detector:

- Frequency Synthesizers (e.g., RF circuits).
- Demodulation of FM signals.
- Clock Recovery Circuits in communication systems.
- Motor speed control systems using PLL.
- Synchronization of oscillators in communication.

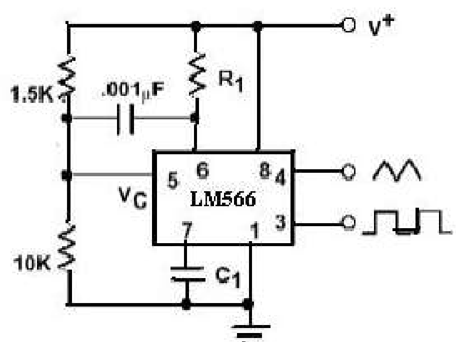
IC 565: Pin Configuration:



- IC 565 is a Phase Locked Loop (PLL) IC with 14 pins used for frequency synthesis and demodulation.
- Pins 4 and 5 are VCO output and phase detector input to control frequency and phase.
- Pin 7 gives the demodulated output, while pins 8 and 9 connect external components for VCO operation.
- Pins 1 and 10 are for power supply (-Vcc and +Vcc), and pins 2, 3 are signal inputs.

VOLTAGE CONTROLLED OSCILLATOR (IC566):

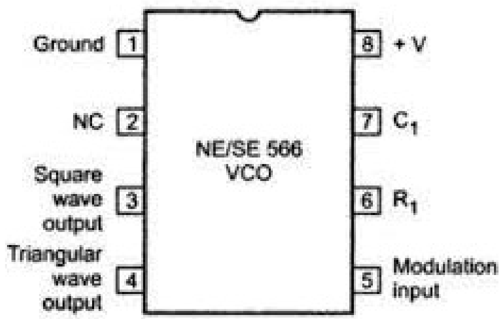
- A Voltage Controlled Oscillator (VCO) is an electronic oscillator whose frequency is controlled by an input control voltage (Vc).
- The circuit shown uses LM566, a popular IC for generating square and triangular waveforms.
- VCOs are widely used in communication systems, signal generators, and modulators.



Circuit Description:

- IC LM566 is used to generate a variable frequency output depending on the applied control voltage (Vc).
- The output is available in two forms:
  - Square wave from pin 3.
  - Triangular wave from pin 4.
- R1 and C1 are external timing components that set the frequency range.
- The control voltage (Vc) applied at pin 5 modulates the frequency of the output waveform.
- Resistors and capacitors at the left side form a network to adjust Vc and set operational biasing.

Pin Configuration (LM566):



- The NE/SE 566 VCO IC provides both square wave (pin 3) and triangular wave (pin 4) outputs with frequency controlled by external resistor (R1), capacitor (C1), and modulation input (pin 5).
- It operates with +V (pin 8) and ground (pin 1), and allows frequency modulation using a control voltage applied at the modulation input.

Working:

- The LM566 works on the principle of charging and discharging a capacitor (C1) linearly using a controlled current.
- The voltage across C1 forms a triangular waveform.
- Internal Schmitt trigger circuitry converts this triangular waveform into a square wave.
- The oscillation frequency (f) is a function of R1, C1, and Vc, and can be approximated by:

$$f = \frac{V_c}{8 \times R_1 \times C_1 \times (V_{cc} - V_c)}$$

- By varying Vc, the frequency can be tuned over a wide range.

Applications:

1. Frequency Modulation (FM) circuits.
2. Function generators for producing different waveforms.
3. Tone generators for audio applications.
4. Used in phase-locked loops (PLLs) as the VCO element.
5. Signal synthesizers in communication systems.

Features of LM566 VCO:

- Simultaneous square and triangular wave outputs.
- Wide frequency range by adjusting Vc.
- Low distortion triangular output.
- Operates over a wide range of supply voltages.