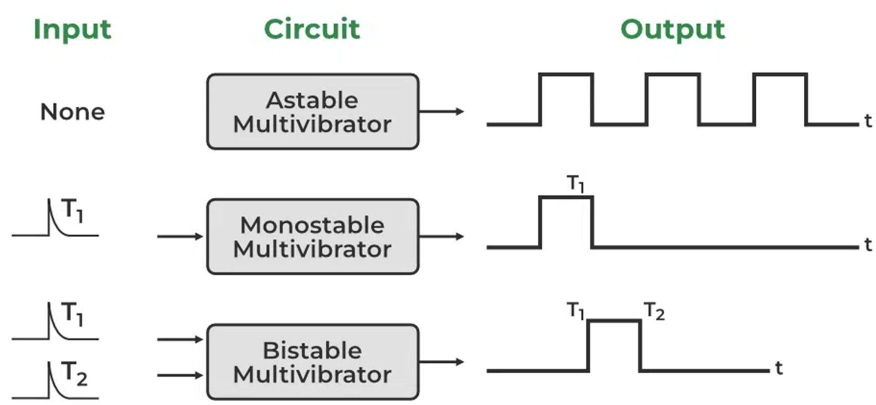
UNIT V

Introduction to Multivibrators

A **multivibrator** is an electronic circuit used to implement two or more distinct voltage levels or states. It operates by toggling between these states, making it one of the basic types of waveform generators. Multivibrators are widely used in digital electronics, pulse generation, and clock circuit applications. They are key building blocks in creating oscillations, timing signals, and square waveforms, and can be made from transistors, operational amplifiers, or other electronic components.

Classification of Multivibrators

Multivibrators are generally classified into three types based on their operation modes:



1. **Astable Multivibrator**:
   - **Nature**: No stable state.
   - **Operation**: Continuously oscillates between two states (high and low voltage).
   - **Purpose**: Functions as a **free-running oscillator**, generating square waves without external triggering.
   - **Applications**: Used in clock pulse generation, timers, and in pulse-width modulation (PWM) circuits.
2. **Monostable Multivibrator**:
   - **Nature**: One stable state and one quasi-stable state.
   - **Operation**: When triggered by an external pulse, it shifts from its stable state to the quasi-stable state for a specific duration before returning to the stable state.
   - **Purpose**: Used as a **one-shot pulse generator**.
   - **Applications**: Used in timing circuits, delay circuits, and pulse stretching.

3. **Bistable Multivibrator**:
    - **Nature**: Two stable states.
    - **Operation**: The circuit toggles between these two states when triggered by external inputs.
    - **Purpose**: Functions as a **flip-flop**, maintaining one of the two states until an external trigger causes a switch.
    - **Applications**: Used in memory storage elements, digital counters, and toggle switches.

Summary of the Three Types:

- **Astable Multivibrator**: No stable state (oscillates continuously).
- **Monostable Multivibrator**: One stable state (produces a single output pulse upon triggering).
- **Bistable Multivibrator**: Two stable states (requires an input trigger to switch between them).

These circuits are fundamental components in digital logic design and signal processing, with diverse applications in timing, waveform generation, and electronic control systems.

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Astable Multivibrator

An **Astable Multivibrator** is an electronic circuit with no stable state. It continuously oscillates between two unstable states (high and low voltage), making it a free-running oscillator. The circuit automatically switches between these states without requiring any external trigger, hence producing a periodic output in the form of a square or rectangular waveform.

Astable Multivibrator using Transistors

An **astable multivibrator** built using transistors is a simple, two-transistor oscillator circuit that switches back and forth between two states, continuously generating a square wave output. This type of astable multivibrator operates without a stable state, meaning it never settles in one state and instead oscillates between two voltage levels.

Circuit Configuration

In an astable multivibrator using transistors, two **NPN transistors** are connected in a symmetrical configuration, with each transistor working alternately in saturation (on) and cutoff (off) states. The circuit also includes:

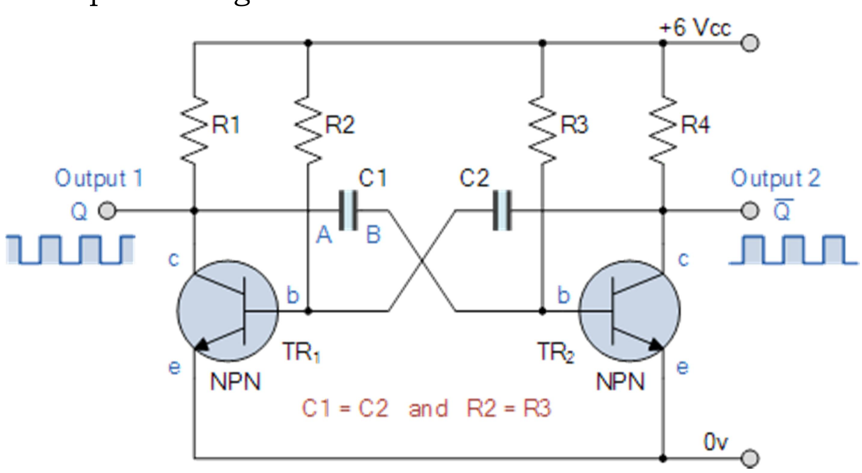
1. **Two capacitors**: These capacitors control the charging and discharging process that determines the time for switching between the two transistors.
2. **Two resistors**: These limit the base current to the transistors and help control the timing and frequency of oscillation.
3. **Transistors**: Used to switch the states of the multivibrator alternately.
4. **Power Supply**: Provides the necessary DC voltage to power the circuit.

Working Principle of Transistor-Based Astable Multivibrator

1. **Initial Condition**:
   - Initially, one of the transistors (let's say Q1) turns on, and the other transistor (Q2) is off.
   - The capacitor connected to the base of Q2 begins to charge through the resistor connected to Q1's collector.
2. **Switching Action**:
   - Once the capacitor charging to the base of Q2 reaches a threshold voltage, Q2 switches on, and Q1 switches off.
   - This causes the second capacitor connected to Q1's base to begin charging, and the process repeats in reverse.
3. **Oscillation**:
   - The circuit oscillates continuously because the capacitors alternately charge and discharge, causing each transistor to turn on and off in an alternating fashion.
   - The output at the collector of each transistor is a square wave, and these two outputs are 180° out of phase.

Circuit Diagram

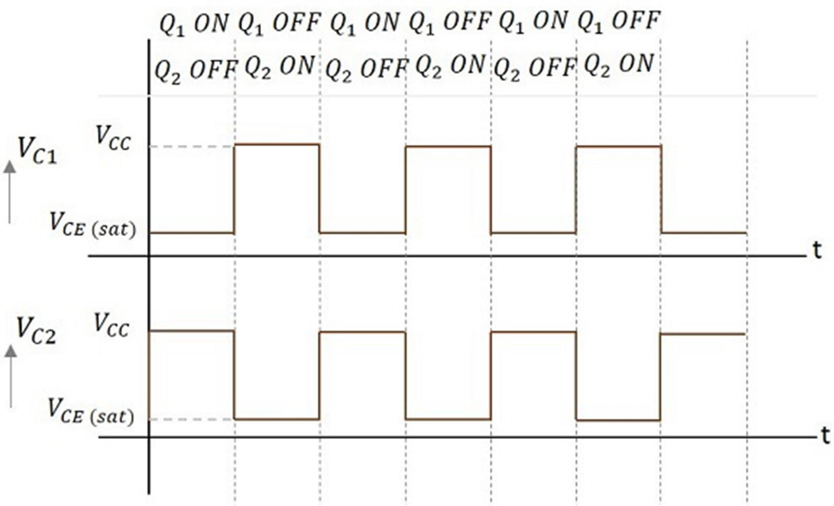
Below is a simplified diagram of a transistor-based astable multivibrator:



- **R2, R3**: Base resistors limiting the current to the transistors.
- **C1, C2**: Capacitors controlling the timing of switching.
- **Q1, Q2**: NPN transistors switching on and off alternately.

Waveforms

The output waveforms at the collectors of Q_1 and Q_2 are shown in the following figures.



Frequency of Oscillations

The ON time of transistor Q_1 or the OFF time of transistor Q_2 is given by

$$t_1 = 0.69R_1C_1$$

Similarly, the OFF time of transistor Q_1 or ON time of transistor Q_2 is given by

$$t_2 = 0.69R_2C_2$$

Hence, total time period of square wave

$$t = t_1 + t_2 = 0.69(R_1C_1 + R_2C_2)$$

As $R_1 = R_2 = R$ and $C_1 = C_2 = C$, the frequency of square wave will be

$$f=1/t = 1/1.38RC$$

Applications of Astable Multivibrator using Transistors

1. **LED Flasher/Light Blinkers**: The continuous square wave output can drive LEDs alternately, making them flash on and off in sequence. This is useful in decorative lighting, emergency blinkers, and warning indicators.
2. **Clock Pulse Generator**: The astable multivibrator can be used to generate clock pulses needed in digital circuits, such as in flip-flops, counters, and microprocessors.
3. **Tone Generation**: It can generate audio tones when used with speakers or piezoelectric buzzers. The frequency of oscillation can be adjusted to produce various tones used in alarms, buzzers, and sirens.
4. **Oscillator in Electronic Testing**: As an oscillator, it can be used in signal generation for testing other circuits, such as amplifiers or frequency response testing.
5. **Pulse Width Modulation (PWM) Circuits**: By adjusting the resistances and capacitances, the duty cycle of the output waveform

can be modified, which is essential in PWM circuits used for controlling the speed of DC motors or for dimming LED brightness.

Advantages of Transistor-Based Astable Multivibrator

- **Simplicity**: The circuit is easy to build using only basic components like transistors, resistors, and capacitors.
- **Low Cost**: It uses inexpensive components, making it cost-effective.
- **Wide Range of Applications**: It can be used in various fields from simple timing circuits to more complex modulation and signal generation tasks.

Limitations

- **Limited Frequency Range**: The frequency of oscillation is determined by passive components (resistors and capacitors), which may limit precision for high-frequency applications.
- **Temperature Sensitivity**: Changes in temperature can affect the values of the components, thus slightly affecting the timing characteristics.

Summary

A **transistor-based astable multivibrator** is a basic circuit that generates a continuous square wave, operating as a free-running oscillator. It has broad applications in clock pulse generation, signal processing, PWM, and flashing lights, making it an essential building block in many electronic systems.

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Monostable Multivibrator

A **Monostable Multivibrator** is an electronic circuit that has **one stable state** and **one quasi-stable state**. It is often referred to as a **one-shot multivibrator** because it produces a single output pulse when triggered by an external input. After the pulse, it returns to its stable state until triggered again.

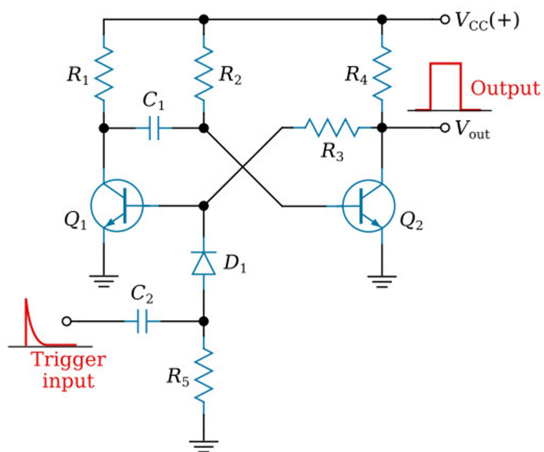
Working Principle of Monostable Multivibrator

In a monostable multivibrator:

- The circuit remains in its **stable state** until an external trigger pulse is applied.
- When triggered, the circuit switches to its **quasi-stable state** for a predefined period determined by external components (typically resistors and capacitors).
- After the predefined time, the circuit automatically returns to its stable state.

The time duration for which the circuit remains in the quasi-stable state is called the **pulse width** or **time period**, and it is determined by the values of the timing components (resistors and capacitors).

Circuit Configuration

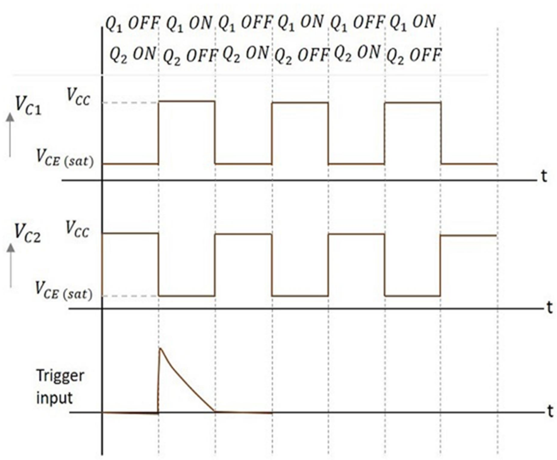


A basic monostable multivibrator using transistors consists of:

1. **Two NPN transistors**: These transistors are used to switch the circuit between its stable and quasi-stable states.
2. **Resistor (R)**: Controls the time duration the circuit stays in the quasi-stable state.
3. **Capacitor (C)**: Determines the timing of the pulse output.
4. **Trigger Input**: External signal used to initiate the quasi-stable state.
5. **Power Supply (Vcc)**: Provides DC power to the circuit.

Working Principle

1. **Stable State**:
   - Initially, one of the transistors (Q1) is in the **off** state (cutoff), while the other transistor (Q2) is in the **on** state (saturation).
   - In this state, the circuit is not generating any output pulse, and it remains idle until it receives a trigger pulse.



2. **Trigger Input**:
   - When an external trigger pulse is applied to the base of Q1, it momentarily turns on Q1.
   - This causes Q2 to turn off, and the circuit enters the **quasi-stable state**.
   - A capacitor (C) connected between the collector of Q2 and the base of Q1 starts charging through a resistor (R).
3. **Quasi-Stable State**:
   - In the quasi-stable state, the circuit stays on for a specific time, which is determined by the charging time of the capacitor C.
   - Once the capacitor is fully charged, Q1 turns off, and Q2 turns back on, returning the circuit to its original stable state.

4. **Return to Stable State**:
   - After the time determined by the RC network, the circuit automatically returns to the stable state, and the output pulse ends.

The time duration T for which the circuit stays in the quasi-stable state (the pulse width) is given by the formula:

$$T=0.69R_1C_1$$

Where:

- R is the resistance in ohms.
- C is the capacitance in farads.
- T is the time period in seconds.

Applications of Monostable Multivibrator using Transistors

Monostable multivibrators are used in various applications where generating a precise pulse of fixed duration is necessary. Below are some common applications:

1. **Pulse Generators**: Monostable multivibrators are often used to generate pulses of a specific width in timing and synchronization circuits. These pulses can be used to control other digital circuits.
2. **Timers**: In electronic timing circuits, monostable multivibrators are used to generate precise time delays. For example, in relay circuits or automated systems, they can be used to trigger actions after a set delay.
3. **Switch Debouncing**: Mechanical switches often produce bouncing effects (rapid, unintended on-off cycles) when pressed. A monostable multivibrator can clean up the bouncing signal, ensuring a stable and clean output pulse for further processing.
4. **Frequency Divider**: By producing a single pulse for every input trigger, a monostable multivibrator can be used as a frequency divider, reducing the input frequency for applications like digital clocks or counters.
5. **Missing Pulse Detection**: In pulse trains, a monostable multivibrator can be used to detect if a pulse is missing. If the next pulse doesn't arrive within the expected time, the circuit can trigger an alarm or corrective action.

Advantages of Monostable Multivibrators using Transistors

- **Simple Design**: The circuit is easy to design using basic electronic components like transistors, resistors, and capacitors.
- **Precise Pulse Width**: The time duration of the output pulse is predictable and can be easily adjusted by changing the resistor or capacitor values.
- **Low Cost**: The components required for the circuit are inexpensive and widely available.

- **Wide Application**: It is useful in many practical applications that require controlled timing, pulse generation, or signal conditioning.

Limitations

- **Trigger Dependent**: The circuit relies on an external trigger pulse to operate and cannot generate pulses on its own without an input.
- **Temperature Sensitivity**: The timing components, especially capacitors, may be affected by temperature changes, resulting in small variations in pulse width.
- **Limited Frequency Response**: The circuit is suitable for low- to moderate-frequency applications, and at very high frequencies, performance may degrade.

Summary

A **monostable multivibrator using transistors** is a simple and effective circuit for generating a single pulse of fixed duration in response to an external trigger. It finds widespread use in pulse generation, timers, switch debouncing, frequency division, and data synchronization. Its simplicity and versatility make it valuable for many practical electronic applications, particularly in timing, control, and signal processing circuits.

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Bistable Multivibrator:

A **Bistable Multivibrator**, also known as a **flip-flop**, is an electronic circuit with **two stable states**. Unlike astable and monostable multivibrators, a bistable multivibrator stays in either of its two stable states until an external input triggers it to switch states. The circuit remains in one state indefinitely until an external input is applied to toggle the state.

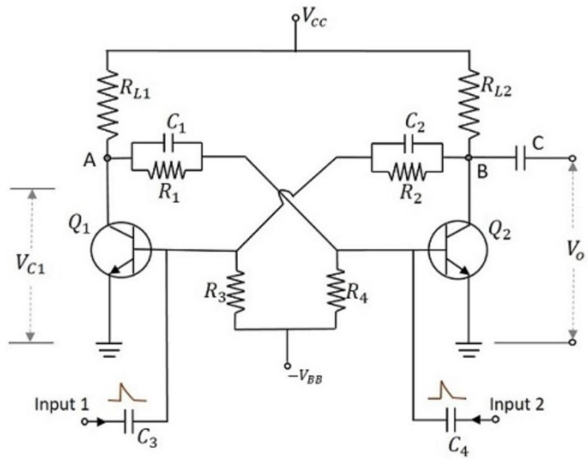
Characteristics of Bistable Multivibrator

- **Two Stable States**: The output can be in either of two stable states (high or low, represented as logic 1 or 0) until an input changes the state.
- **Memory**: It retains the state (either 1 or 0) even after the input signal is removed, making it a basic memory element in digital circuits.
- **Trigger**: The state changes only when triggered by an external input, usually in the form of a clock or control signal.

Circuit Design of Bistable Multivibrator (Using Transistors)

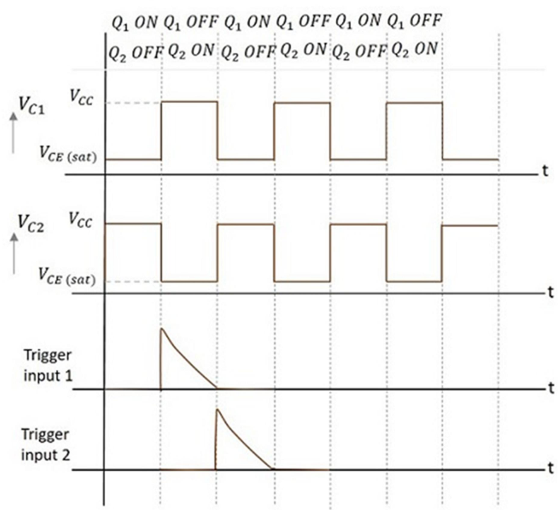
A bistable multivibrator can be designed using two **NPN transistors** in a cross-coupled configuration, where the output of one transistor is connected to the input of the other, forming positive feedback. The circuit requires:

1. **Two Transistors (Q1 and Q2)**: They act as the switches that toggle the output between high and low.
2. **Resistors (R1, R2, etc.)**: Used to limit the base and collector current of the transistors.
3. **Capacitors (optional)**: In some designs, capacitors are used to ensure that state transitions are sharp.
4. **Trigger Input**: An external input is applied to toggle the state.



Operation of Transistor-Based Bistable Multivibrator

1. **Stable State**: In one stable state, one transistor (Q1) is **on** (conducting), and the other transistor (Q2) is **off** (non-conducting). This state remains indefinitely unless an external trigger is applied.
2. **Trigger Pulse**: When a trigger pulse is applied, the conducting transistor turns off, and the non-conducting transistor turns on, switching the state of the circuit.
3. **New Stable State**: After the transition, the circuit enters a new stable state where Q2 is now conducting, and Q1 is off. The circuit remains in this state until another trigger pulse causes it to switch back.



Applications of Bistable Multivibrator:

1. **Memory Storage**: Stores a single bit of data (0 or 1) and is used in digital memory circuits like flip-flops and latches.
2. **Switch Debouncing**: Eliminates noise or bouncing effects from mechanical switches, ensuring a clean, stable output signal.
3. **Digital Counters**: Used in counters and frequency dividers to toggle between two states, useful in clock dividers and counting circuits.
4. **Data Latching**: Holds and stores data in digital systems like microprocessors for processing and communication.

5. **Toggle Switches**: Acts as an electronic toggle switch to turn devices on/off by switching between two stable states.
6. **Pulse Detection**: Detects and stores the presence of a pulse in communication systems and signal processing.
7. **Control Systems**: Utilized in control systems where two stable outputs (ON/OFF) is needed for various operations.

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Schmitt Trigger

A **Schmitt Trigger** is a comparator circuit with **hysteresis**, used to convert an analog input signal into a clean digital output signal. It helps in eliminating noise from an input signal and is often used to clean up noisy signals, producing a stable and noise-free output. When implemented with transistors, the Schmitt trigger uses positive feedback to create two distinct threshold voltage levels, which define when the output switches states (high or low).

Key Features of Schmitt Trigger:

- **Hysteresis**: The circuit has two threshold voltages—upper threshold (VUT) and lower threshold (VLT). The output changes from one state to another when the input crosses these thresholds, which adds noise immunity.
- **Stable Output**: It produces a clean, stable digital output from a noisy or slowly varying input signal.
- **Positive Feedback**: Essential to ensure the difference between the two thresholds (hysteresis).

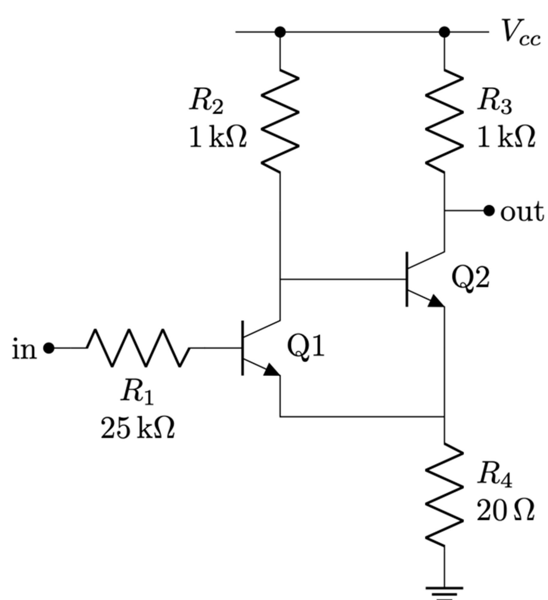
Working Principle of Schmitt Trigger

- When the input signal exceeds the upper threshold (VUT), the output switches from **low** to **high**.
- When the input signal falls below the lower threshold (VLT), the output switches from **high** to **low**.
- If the input stays between these two thresholds, the output remains unchanged.

Schmitt Trigger Circuit Using Transistors

A simple Schmitt Trigger can be constructed using two **NPN transistors** in a configuration similar to a bistable multivibrator but with slight modifications to achieve the required hysteresis behavior.

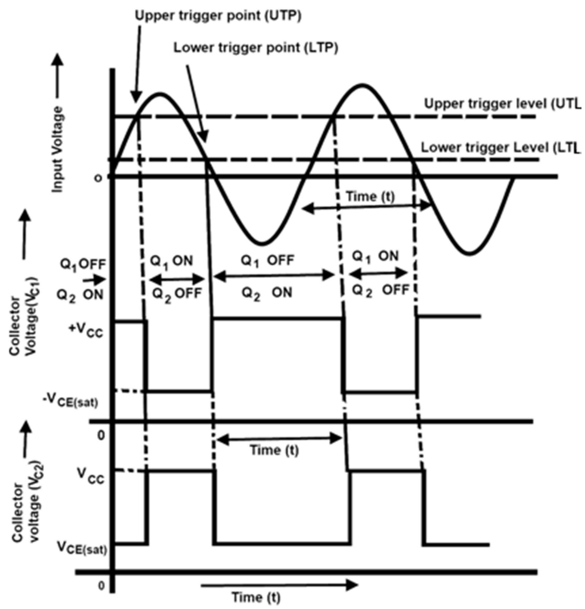
Basic Circuit Design:



1. **Transistor Q1**: Connected to the input signal and serves as the comparator.
2. **Transistor Q2**: Acts as the feedback element, ensuring the hysteresis effect by controlling the switching thresholds.
3. **Resistors R1, R2, R3, R4**: Define the current flow and voltage levels to achieve hysteresis.

Operation of Schmitt Trigger (Transistor Version)

1. **Low Input Voltage**: When the input voltage is low, transistor Q1 is **off**, and Q2 is **on**, pulling the output low.
2. **Increasing Input Voltage**: As the input voltage rises, it reaches a point where Q1 starts conducting. This causes Q2 to turn off due to the feedback loop, switching the output to a **high** state.
3. **High Input Voltage**: With a high input, the output remains high as Q1 remains conducting and Q2 is off.
4. **Decreasing Input Voltage**: As the input voltage falls and reaches the lower threshold (VLT), Q1 turns off, and Q2 turns on again, pulling the output low.



Hysteresis in the Schmitt Trigger

The key feature of the Schmitt Trigger is its hysteresis, or the difference between the upper and lower threshold voltages (VUT and VLT). This ensures that small fluctuations in the input signal near the threshold do not cause rapid switching of the output, which is useful for noisy signals or slowly varying inputs.

Applications of Schmitt Trigger Using Transistors

1. **Noise Reduction**: Schmitt triggers are used to clean noisy or fluctuating input signals, ensuring stable digital output signals in circuits like pulse generators or signal conditioners.
2. **Waveform Shaping**: Used in converting sinusoidal, triangular, or noisy analog signals into clean square waves, which are easier to process in digital circuits.
3. **Debouncing Switches**: In mechanical switches, Schmitt triggers can eliminate the bounce effect, generating a single, clean transition for each switch press.

4. **Level Detection**: Schmitt triggers are useful in level detection circuits, where they detect when an input signal crosses a certain threshold.
5. **Comparator Circuits**: It acts as a comparator with hysteresis, providing a more stable output compared to a traditional comparator, which might have issues with noisy or slowly varying inputs.

Advantages of Transistor-Based Schmitt Trigger

- **Simple Design**: Can be implemented using basic components like transistors, resistors, and capacitors.
- **Noise Immunity**: Hysteresis helps in rejecting small, unwanted noise or signal variations around the threshold.
- **Fast Switching**: Provides fast and sharp transitions between high and low states, useful for signal processing.

Limitations

- **Fixed Thresholds**: In the basic design, the upper and lower thresholds are fixed by the resistors and are not easily adjustable without changing component values.
- **Limited Input Range**: The circuit may not work well for very high-frequency or very low voltage signals without optimization.

Summary

A **Schmitt Trigger using transistors** is an effective circuit for cleaning noisy signals and ensuring stable digital output by introducing hysteresis. It is widely used in applications such as noise reduction, waveform shaping, and switch debouncing, where the goal is to provide sharp transitions between two distinct states despite fluctuations in the input signal.

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Clipping and Clamping Circuits

Clipping and **clamping** circuits are non-linear electronic circuits that modify the shape of an input signal. These circuits are often used to limit or shift the voltage levels in analog signals, making them essential in signal conditioning, protection circuits, and waveform shaping.

1. Clipping Circuits (Limiters)

A **clipping circuit** removes or “clips” portions of an input signal that exceed a predefined voltage level, effectively limiting the amplitude of the output signal. It is used to prevent signal amplitudes from going beyond a certain threshold, which is helpful in applications like **waveform shaping** and **over-voltage protection**.

Types of Clipping Circuits

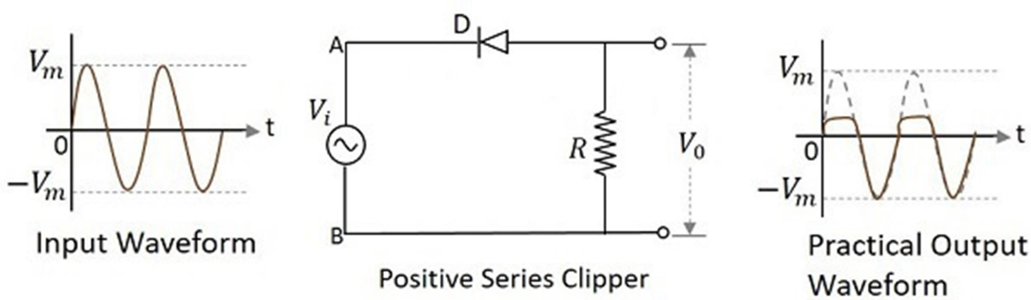
1. **Positive Clipper**:
   - Clips the **positive half** of the input signal above a specified voltage level.
   - It uses a diode oriented to conduct during the positive cycle and a reference voltage to set the clipping level.
2. **Negative Clipper**:
   - Clips the **negative half** of the input signal below a specified voltage level.
   - A diode is used in reverse bias for the negative cycle, preventing the signal from going beyond the set threshold.
3. **Biased Clipper**:
   - A clipping circuit where the clipping level is not zero but can be adjusted to any voltage using a reference (bias) voltage.
4. **Combination Clipper**:
   - Combines both positive and negative clipping circuits to limit both the positive and negative peaks of the input signal, often used to shape a sine wave into a square or triangular waveform.

Basic Clipper Circuit Design:

- **Components**: Diode, resistor, and sometimes a reference (bias) voltage.
- **Operation**: When the input signal exceeds the reference voltage in either polarity, the diode becomes forward biased and conducts, clipping the output to the reference voltage level.

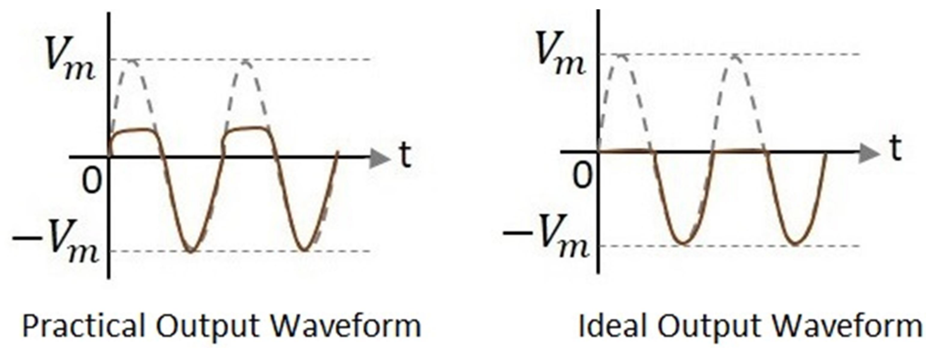
Positive Series Clipper

A Clipper circuit in which the diode is connected in series to the input signal and that attenuates the positive portions of the waveform, is termed as **Positive Series Clipper**. The following figure represents the circuit diagram for positive series clipper.



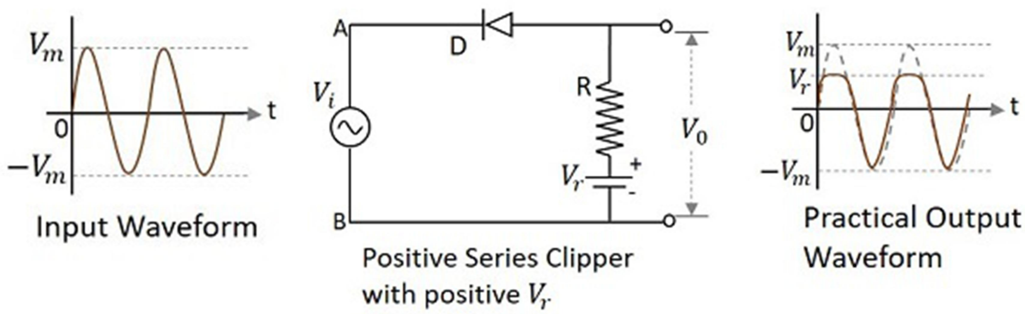
Positive Cycle of the Input – When the input voltage is applied, the positive cycle of the input makes the point A in the circuit positive with respect to the point B. This makes the diode reverse biased and hence it behaves like an open switch. Thus the voltage across the load resistor becomes zero as no current flows through it and hence V_0 will be zero.

Negative Cycle of the Input – The negative cycle of the input makes the point A in the circuit negative with respect to the point B. This makes the diode forward biased and hence it conducts like a closed switch. Thus the voltage across the load resistor will be equal to the applied input voltage as it completely appears at the output V_0.



Positive Series Clipper with positive Vr

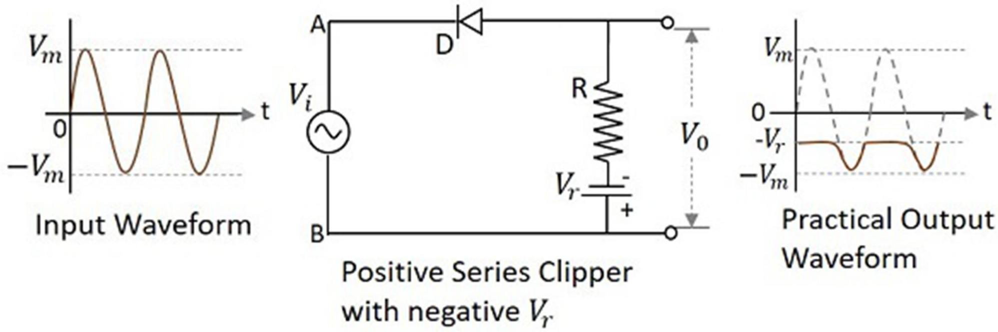
A Clipper circuit in which the diode is connected in series to the input signal and biased with positive reference voltage Vr and that attenuates the positive portions of the waveform, is termed as **Positive Series Clipper with positive** Vr. The following figure represents the circuit diagram for positive series clipper when the reference voltage applied is positive.



During the positive cycle of the input the diode gets reverse biased and the reference voltage appears at the output. During its negative cycle, the diode gets forward biased and conducts like a closed switch. Hence the output waveform appears as shown in the above figure.

Positive Series Clipper with negative Vr

A Clipper circuit in which the diode is connected in series to the input signal and biased with negative reference voltage Vr and that attenuates the positive portions of the waveform, is termed as **Positive Series Clipper with negative** Vr. The following figure represents the circuit diagram for positive series clipper, when the reference voltage applied is negative.



During the positive cycle of the input the diode gets reverse biased and the reference voltage appears at the output. As the reference voltage is negative, the same voltage with constant amplitude is shown. During its negative cycle, the diode gets forward biased and conducts like a closed switch. Hence the input signal that is greater than the reference voltage, appears at the output.

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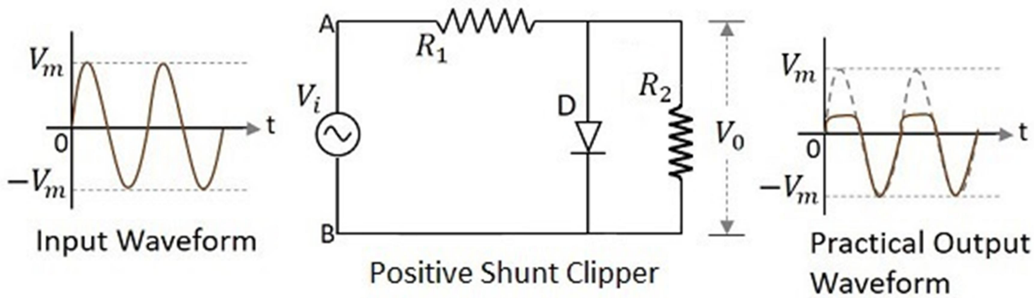
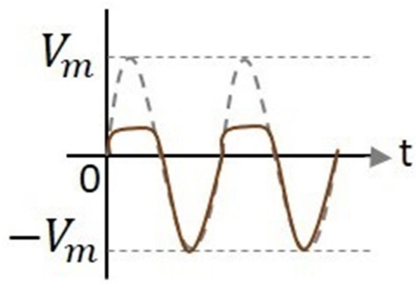
Positive Shunt Clipper

A Clipper circuit in which the diode is connected in shunt to the input signal and that attenuates the positive portions of the waveform, is termed as **Positive Shunt Clipper**. The following figure represents the circuit diagram for positive shunt clipper.

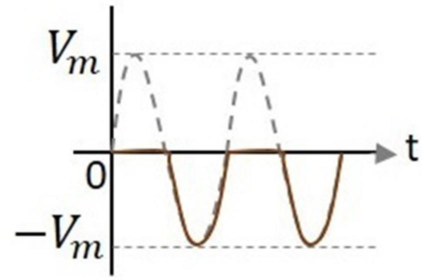


Positive Cycle of the Input – When the input voltage is applied, the positive cycle of the input makes the point A in the circuit positive with respect to the point B. This makes the diode forward biased and hence it conducts like a closed switch. Thus the voltage across the load resistor becomes zero as no current flows through it and hence V_0 will be zero.

Negative Cycle of the Input – The negative cycle of the input makes the point A in the circuit negative with respect to the point B. This makes the diode reverse biased and hence it behaves like an open switch. Thus the voltage across the load resistor will be equal to the applied input voltage as it completely appears at the output V_0.



Practical Output Waveform

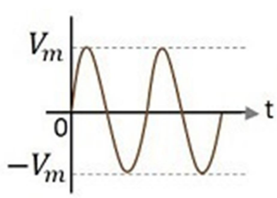


Ideal Output Waveform

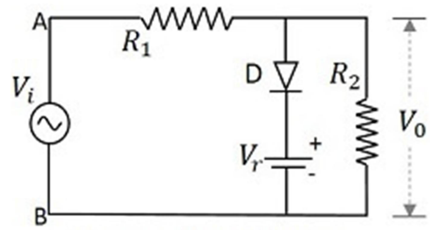
Unlike the ideal output, a bit portion of the positive cycle is present in the practical output due to the diode conduction voltage which is 0.7v. Hence there will be a difference in the practical and ideal output waveforms.

Positive Shunt Clipper with positive Vr

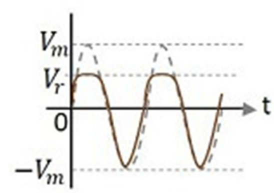
A Clipper circuit in which the diode is connected in shunt to the input signal and biased with positive reference voltage Vr and that attenuates the positive portions of the waveform, is termed as **Positive Shunt Clipper with positive** Vr. The following figure represents the circuit diagram for positive shunt clipper when the reference voltage applied is positive.



Input Waveform



Positive Shunt Clipper with positive V_r.

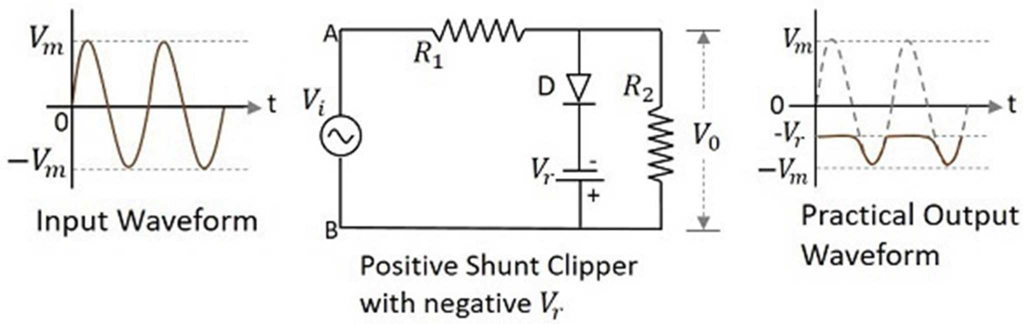


Practical Output Waveform

During the positive cycle of the input the diode gets forward biased and nothing but the reference voltage appears at the output. During its negative cycle, the diode gets reverse biased and behaves as an open switch.

Positive Shunt Clipper with negative Vr

A Clipper circuit in which the diode is connected in shunt to the input signal and biased with negative reference voltage Vr and that attenuates the positive portions of the waveform, is termed as **Positive Shunt Clipper with negative** Vr.



During the positive cycle of the input, the diode gets forward biased and the reference voltage appears at the output. As the reference voltage is negative, the same voltage with constant amplitude is shown. During its negative cycle, the diode gets reverse biased and behaves as an open switch. Hence the input signal that is greater than the reference voltage, appears at the output.

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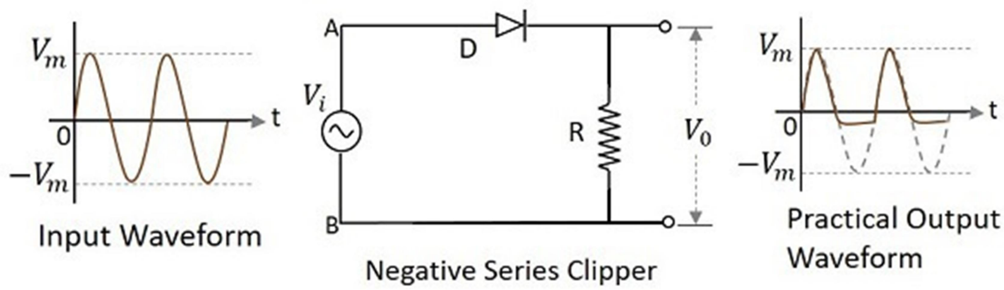
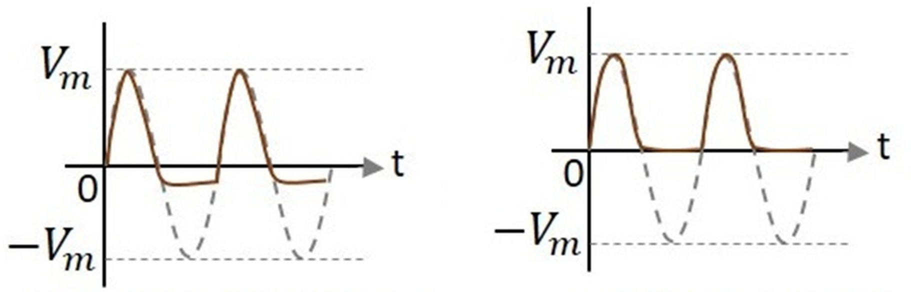
Negative Series Clipper

A Clipper circuit in which the diode is connected in series to the input signal and that attenuates the negative portions of the waveform, is termed as **Negative Series Clipper**. The following figure represents the circuit diagram for negative series clipper.



Positive Cycle of the Input − When the input voltage is applied, the positive cycle of the input makes the point A in the circuit positive with respect to the point B. This makes the diode forward biased and hence it acts like a closed switch. Thus the input voltage completely appears across the load resistor to produce the output V0.

Negative Cycle of the Input − The negative cycle of the input makes the point A in the circuit negative with respect to the point B. This makes the diode reverse biased and hence it acts like an open switch. Thus the voltage across the load resistor will be zero making V0 zero.

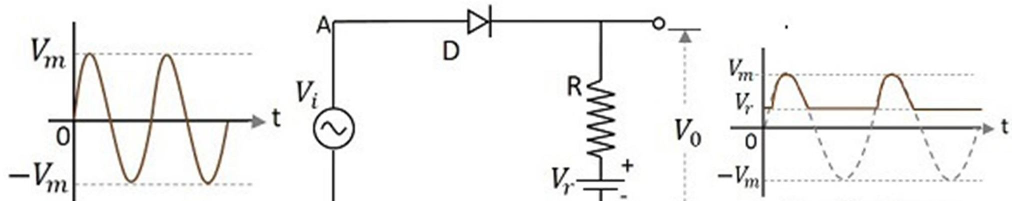


Practical Output waveform　　Ideal Output Waveform

Unlike the ideal output, a bit portion of the negative cycle is present in the practical output due to the diode conduction voltage which is 0.7v. Hence there will be a difference in the practical and ideal output waveforms.

Negative Series Clipper with positive Vr

A Clipper circuit in which the diode is connected in series to the input signal and biased with positive reference voltage Vr and that attenuates the negative portions of the waveform, is termed as **Negative Series Clipper with positive** Vr. The following figure represents the circuit diagram for negative series clipper when the reference voltage applied is positive.



Input Waveform

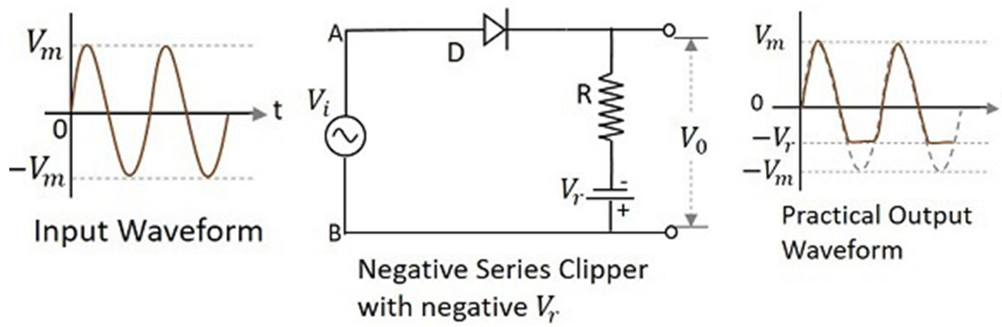
Negative Series Clipper with positive V_r

Practical Output Waveform

During the positive cycle of the input, the diode starts conducting only when the anode voltage value exceeds the cathode voltage value of the diode. As the cathode voltage equals the reference voltage applied, the output will be as shown.

Negative Series Clipper with negative Vr

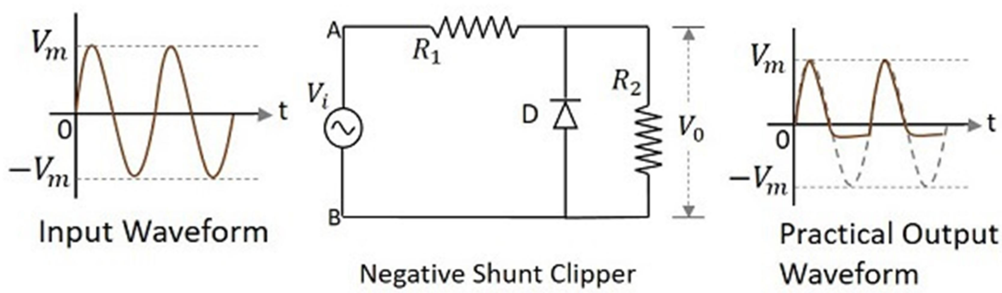
A Clipper circuit in which the diode is connected in series to the input signal and biased with negative reference voltage Vr and that attenuates the negative portions of the waveform, is termed as Negative Series Clipper with negative Vr. The following figure represents the circuit diagram for negative series clipper, when the reference voltage applied is negative.



During the positive cycle of the input the diode gets forward biased and the input signal appears at the output. During its negative cycle, the diode gets reverse biased and hence will not conduct. But the negative reference voltage being applied, appears at the output. Hence the negative cycle of the output waveform gets clipped after this reference level.

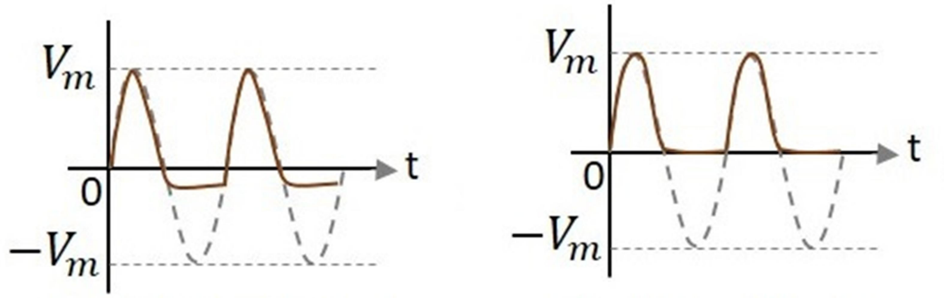
Negative Shunt Clipper

A Clipper circuit in which the diode is connected in shunt to the input signal and that attenuates the negative portions of the waveform, is termed as Negative Shunt Clipper. The following figure represents the circuit diagram for **negative shunt clipper**.



Positive Cycle of the Input – When the input voltage is applied, the positive cycle of the input makes the point A in the circuit positive with respect to the point B. This makes the diode reverse biased and hence it behaves like an open switch. Thus the voltage across the load resistor equals the applied input voltage as it completely appears at the output V0

Negative Cycle of the Input – The negative cycle of the input makes the point A in the circuit negative with respect to the point B. This makes the diode forward biased and hence it conducts like a closed switch. Thus the voltage across the load resistor becomes zero as no current flows through it.

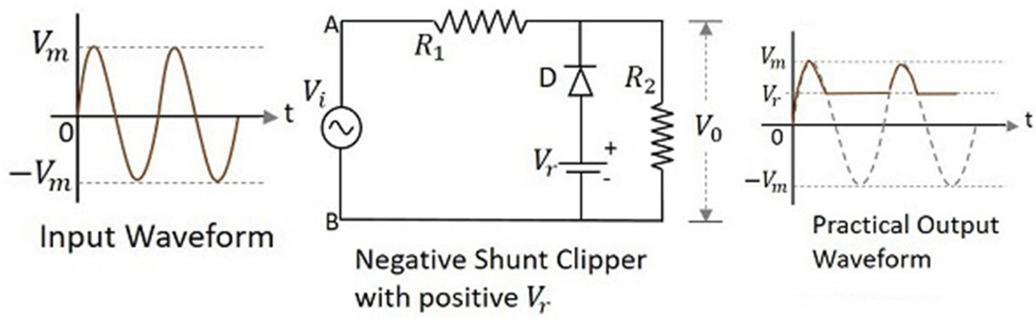


Practical Output Waveform   Ideal Output Waveform

Unlike the ideal output, a bit portion of the negative cycle is present in the practical output due to the diode conduction voltage which is 0.7v. Hence there will be a difference in the practical and ideal output waveforms.

Negative Shunt Clipper with positive Vr

A Clipper circuit in which the diode is connected in shunt to the input signal and biased with positive reference voltage Vr and that attenuates the negative portions of the waveform, is termed as Negative Shunt Clipper with positive Vr.

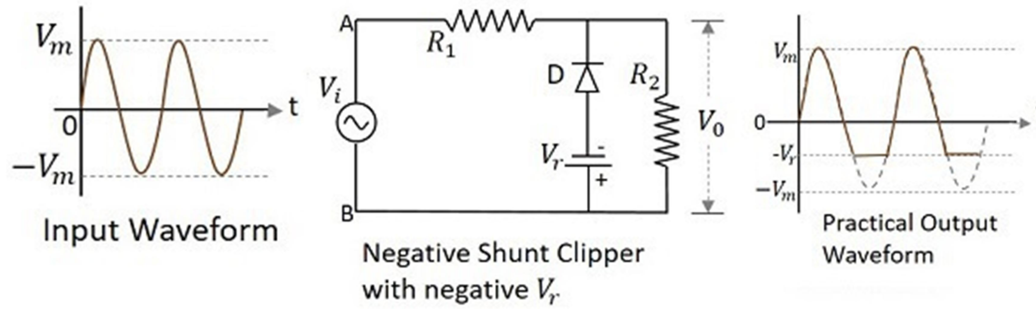


During the positive cycle of the input the diode gets reverse biased and behaves as an open switch. So whole of the input voltage, which is greater than the reference voltage applied, appears at the output. The signal below reference voltage level gets clipped off.

During the negative half cycle, as the diode gets forward biased and the loop gets completed, no output is present.

Negative Shunt Clipper with negative Vr

A Clipper circuit in which the diode is connected in shunt to the input signal and biased with negative reference voltage Vr and that attenuates the negative portions of the waveform, is termed as Negative Shunt Clipper with negative Vr.

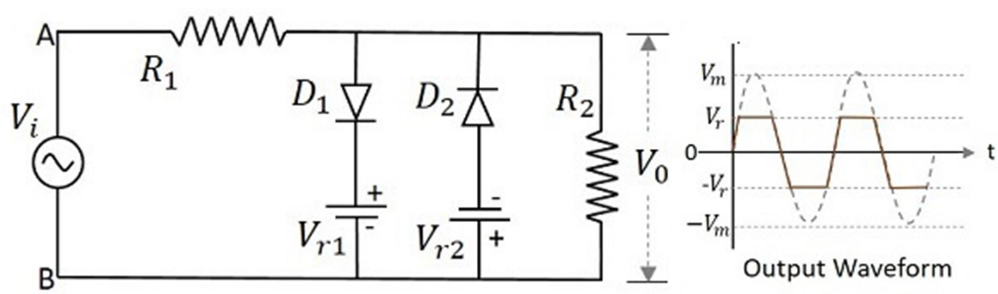


During the positive cycle of the input the diode gets reverse biased and behaves as an open switch. So whole of the input voltage, appears at the output VoVo. During the negative half cycle, the diode gets forward biased. The negative voltage up to the reference voltage, gets at the output and the remaining signal gets clipped off.

Two-way Clipper

This is a positive and negative clipper with a reference voltage Vr. The input voltage is clipped two-way both positive and negative portions of the input waveform with two reference voltages. For this, two diodes D1 and D2 along with two reference voltages Vr1 and Vr2 are connected in the circuit.

This circuit is also called as a **Combinational Clipper** circuit. The figure below shows the circuit arrangement for a two-way or a combinational clipper circuit along with its output waveform.



During the positive half of the input signal, the diode D1 conducts making the reference voltage Vr1 appear at the output. During the negative half of the input signal, the diode D2 conducts making the reference voltage Vr1 appear at the output. Hence both the diodes conduct alternatively to clip the output during both the cycles. The output is taken across the load resistor.

Comparison of Clipping and Clamping Circuits

Feature	Clipping Circuit	Clamping Circuit
Purpose	Limits signal amplitude	Shifts signal voltage (DC level)
Signal Modification	Removes part of the signal	Shifts signal without distortion
Types	Positive, Negative, Biased	Positive, Negative, Biased
Main Components	Diodes, Resistors	Diodes, Capacitors, Resistors
Applications	Signal Limiting, Protection	DC Restoration, Level Shifting

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Clamper

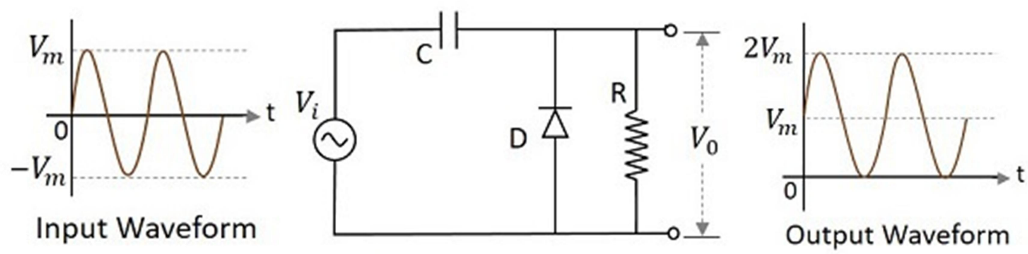
A Clamper Circuit is a circuit that adds a DC level to an AC signal. Actually, the positive and negative peaks of the signals can be placed at desired levels using the clamping circuits. As the DC level gets shifted, a clamper circuit is called as a **Level Shifter**.

Clamper Circuit

A Clamper circuit can be defined as the circuit that consists of a diode, a resistor and a capacitor that shifts the waveform to a desired DC level without changing the actual appearance of the applied signal.

Positive Clamper Circuit

A Clamping circuit restores the DC level. When a negative peak of the signal is raised above to the zero level, then the signal is said to be **positively clamped**.



Positive Clamper circuit

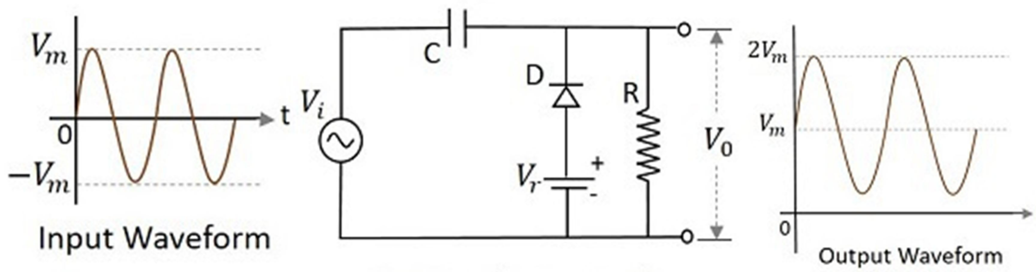
Initially when the input is given, the capacitor is not yet charged and the diode is reverse biased. The output is not considered at this point of time. During the negative half cycle, at the peak value, the capacitor gets charged with negative on one plate and positive on the other. The capacitor is now charged to its peak value V_m. The diode is forward biased and conducts heavily.

During the next positive half cycle, the capacitor is charged to positive V_m while the diode gets reverse biased and gets open circuited. The output of the circuit at this moment will be

$$V_0=V_i+V_m$$

Positive Clamper with Positive V_r

A Positive clamper circuit if biased with some positive reference voltage, that voltage will be added to the output to raise the clamped level.

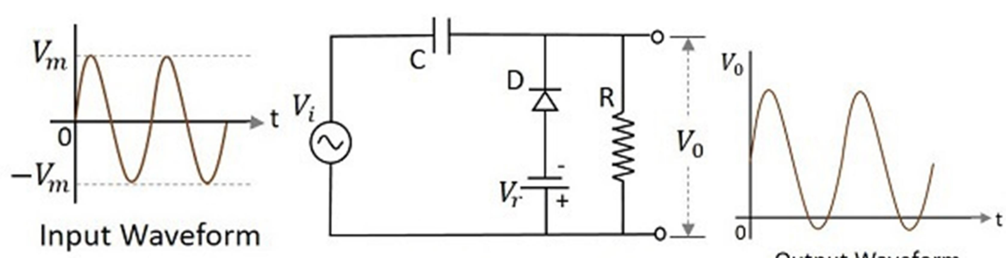


Positive Clamper with positive reference V_r.

During the positive half cycle, the reference voltage is applied through the diode at the output and as the input voltage increases, the cathode voltage of the diode increase with respect to the anode voltage and hence it stops conducting. During the negative half cycle, the diode gets forward biased and starts conducting. The voltage across the capacitor and the reference voltage together maintain the output voltage level.

Positive Clamper with Negative Vr

A Positive clamper circuit if biased with some negative reference voltage, that voltage will be added to the output to raise the clamped level.

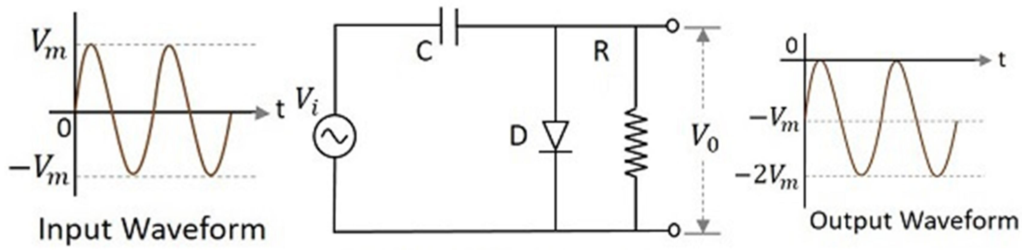


Positive Clamper with negative reference V_r.

During the positive half cycle, the voltage across the capacitor and the reference voltage together maintain the output voltage level. During the negative half-cycle, the diode conducts when the cathode voltage gets less than the anode voltage. These changes make the output voltage as shown in the above figure.

Negative Clamper

A Negative Clamper circuit is one that consists of a diode, a resistor and a capacitor and that shifts the output signal to the negative portion of the input signal.



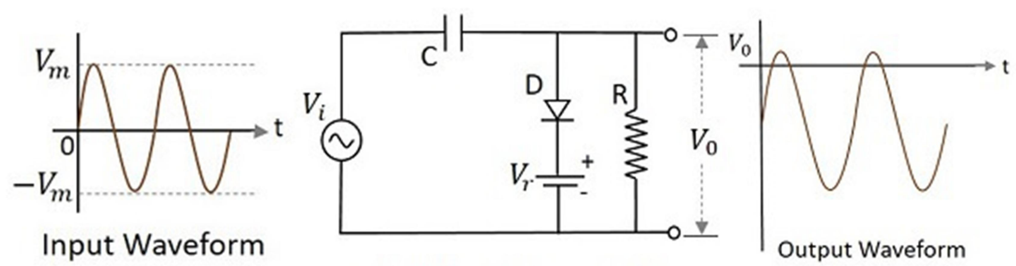
Negative Clamper circuit

During the positive half cycle, the capacitor gets charged to its peak value vmvm. The diode is forward biased and conducts. During the negative half cycle, the diode gets reverse biased and gets open circuited. The output of the circuit at this moment will be

$$V_0=V_i+V_m$$

Negative clamper with positive V_r

A Negative clamper circuit if biased with some positive reference voltage, that voltage will be added to the output to raise the clamped level.

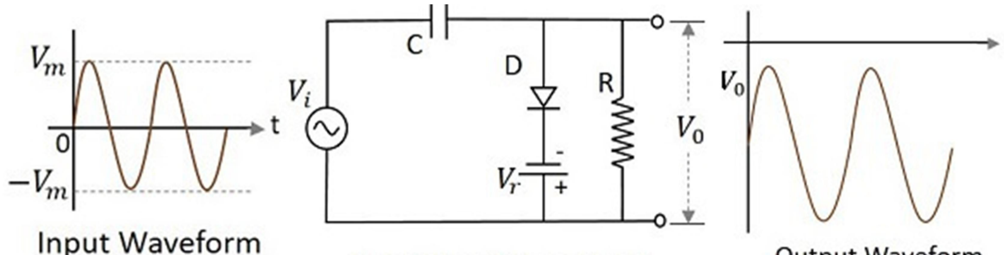


Negative Clamper with positive reference V_r

Though the output voltage is negatively clamped, a portion of the output waveform is raised to the positive level, as the applied reference voltage is positive. During the positive half-cycle, the diode conducts, but the output equals the positive reference voltage applied. During the negative half cycle, the diode acts as open circuited and the voltage across the capacitor forms the output.

Negative Clamper with Negative V_r

A Negative clamper circuit if biased with some negative reference voltage, that voltage will be added to the output to raise the clamped level. Using this, the circuit of the negative clamper with negative reference voltage is constructed as below.



Negative Clamper with negative reference V_r

The cathode of the diode is connected with a negative reference voltage, which is less than that of zero and the anode voltage. Hence the diode starts conducting during positive half cycle, before the zero voltage level. During the negative half cycle, the voltage across the capacitor appears at the output. Thus the waveform is clamped towards the negative portion.

Applications of Clippers

- Used for the generation and shaping of waveforms
- Used for the protection of circuits from spikes
- Used for amplitude restorers
- Used as voltage limiters
- Used in television circuits
- Used in FM transmitters

Applications of Clampers

- Used as direct current restorers
- Used to remove distortions
- Used as voltage multipliers
- Used for the protection of amplifiers
- Used as test equipment
- Used as base-line stabilizer