



A T M E
College of Engineering



Course Code:1BEE302

Course: Analog Electronic Circuits

Presented by,

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ATME College of Engineering, Mysuru

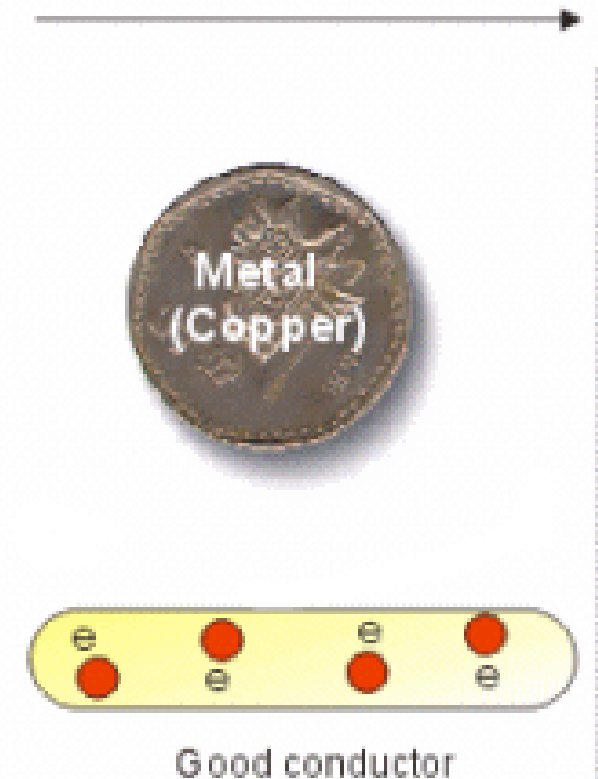


Course Details

Faculty Name : Shilpashri V N		Academic Year: 2026-27					
Department: Electrical & Electronics Engineering							
Course Code	Course Title	Core/Elective	Prerequisite	Contact Hours			Total Hrs. Sessions
				L	T	P	
1BEE302	Analog Electronic Circuits	IPCC	Basic Electrical Engineering	4		2	42 hours Theory + 11 Lab slots

Conductor????

Conductors are materials or objects that **allow electric current (flow of charges) to pass through them easily.**

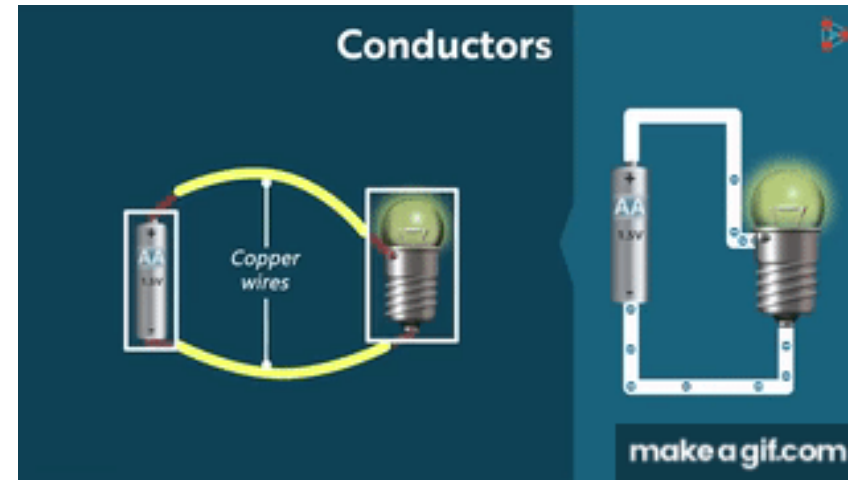
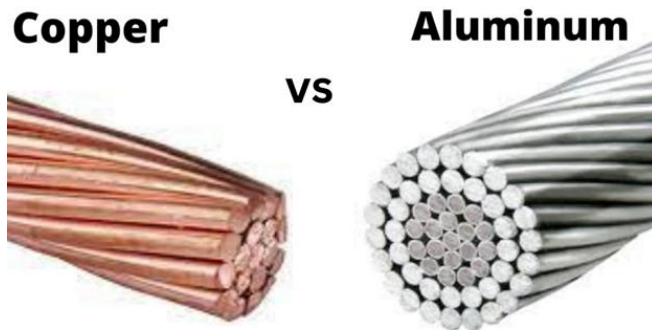


Conductors

It is an object or a type of material that allows flow of charge (electrical current) in one or more directions.

Examples:

Copper wire, Aluminium Wire



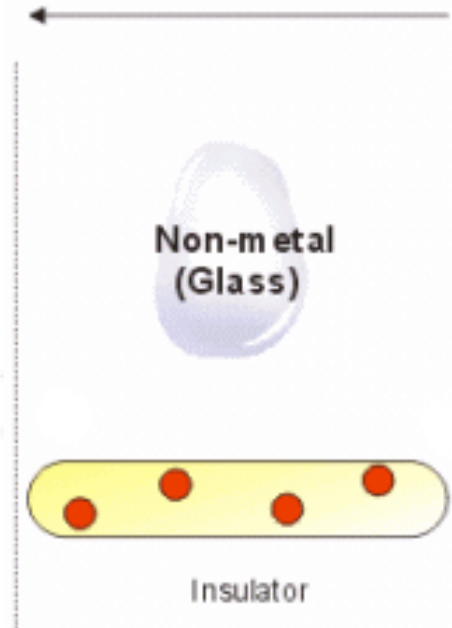
Fun Fact about Conductors:

Did you know that a **single copper wire**, as thin as your hair, can carry millions of electrons every second?

That's why materials like **copper and aluminium** are used in power lines — they let electricity flow freely, almost like a super-fast highway for charges!

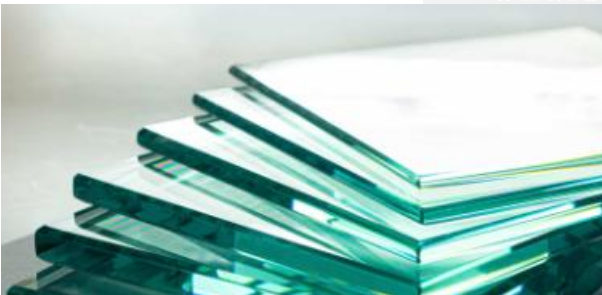
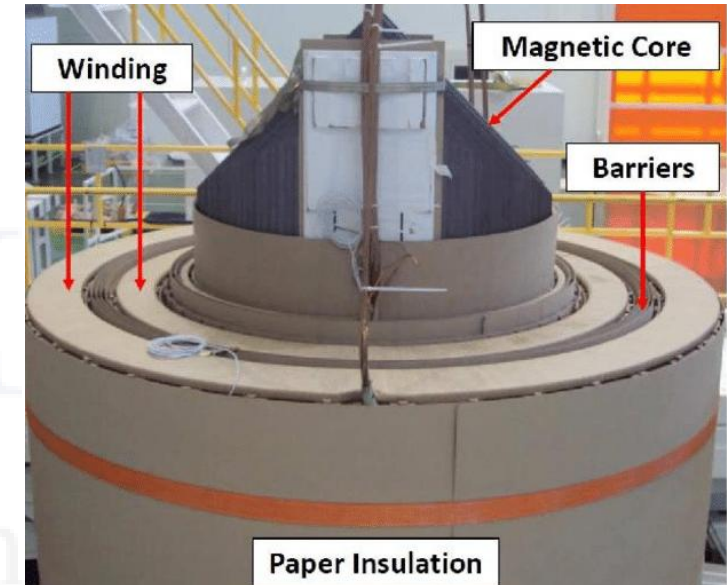
Insulator??

Insulators are materials that **do not allow electric current to pass through them easily.**



Insulators:

It is a material in which the electron does not flow freely. Insulators does not conduct. Examples: **Glass, Porcelain, Paper, Rubber etc.**

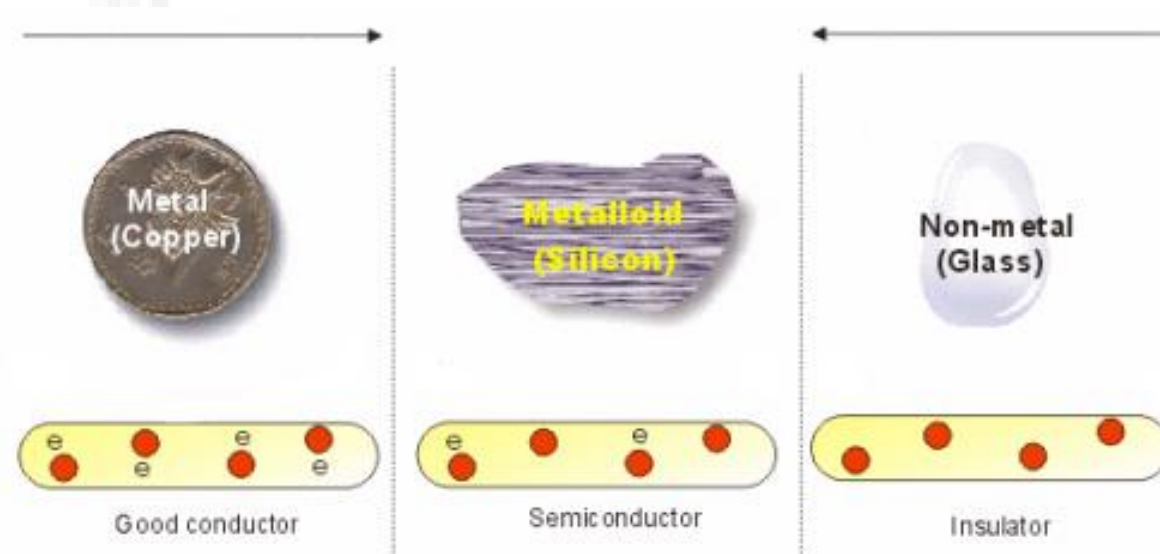


- They have very high resistance to the flow of charges.
- Their electrons are tightly bound to atoms, so they cannot move freely.
- They are mainly used for protection and safety



Semiconductor??

Semiconductor is a material whose ability to conduct electricity is **between that of a conductor and an insulator.**

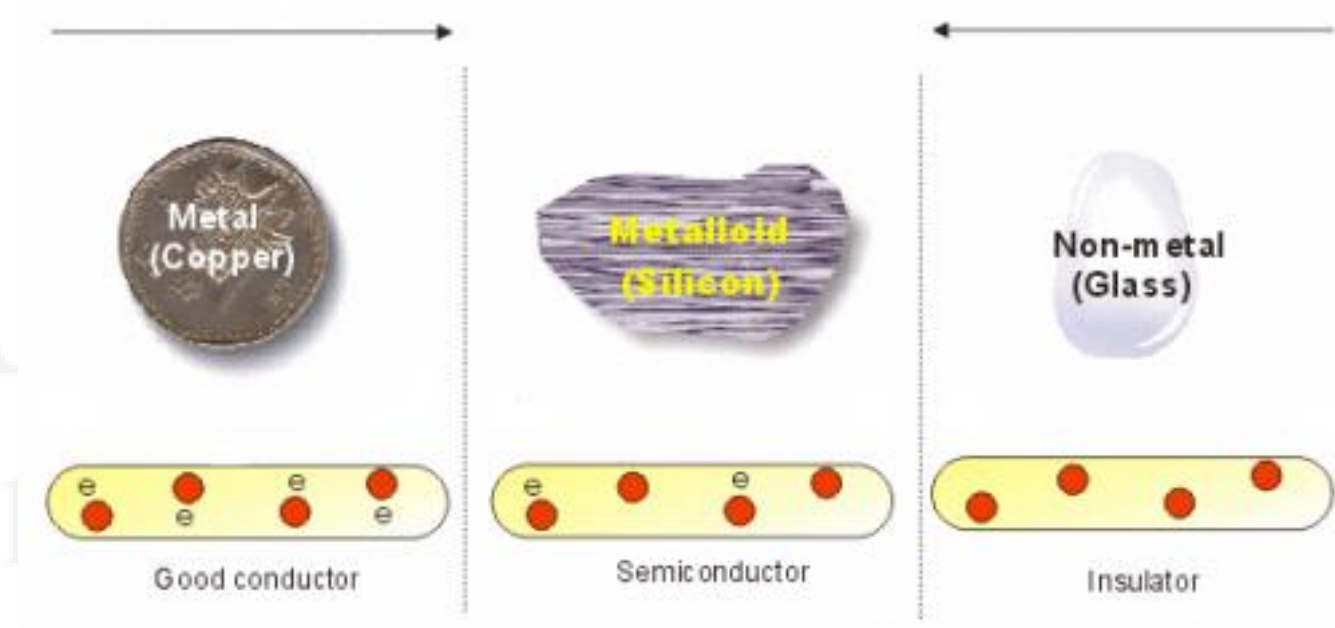


- At **low temperature** → behaves like an **insulator**.
- When **heated** or **doped** with impurities → behaves like a **conductor**.
- Conductivity can be **controlled** with **temperature, light, electric field, or impurities.**

Semiconductors:

A semiconductor material has an electrical conductivity value falling between that of a conductor and an insulator.

Examples: Silicon, Germanium, Gallium Arsenide



Semiconductor Devices

Diode

**Bipolar Junction
Transistor (BJT)**

**Field Effect
Transistor (FET)**

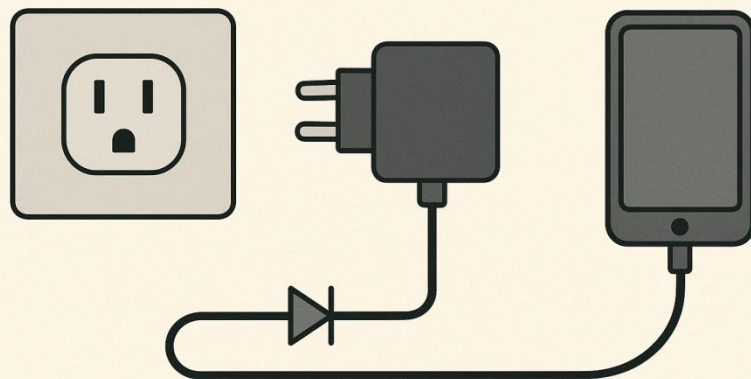
**Metal Oxide
Semiconductor Field
Effect Transistor
(MOSFET)**

Thyristors

**Insulated Gate Bipolar
Junction Transistor
(IGBT)**

"Ever wondered why
your charger doesn't
send **Electricity** *back* into
the **socket**?"

Ever wondered why your charger doesn't
send electricity back into the socket?
That's the diode quietly working.



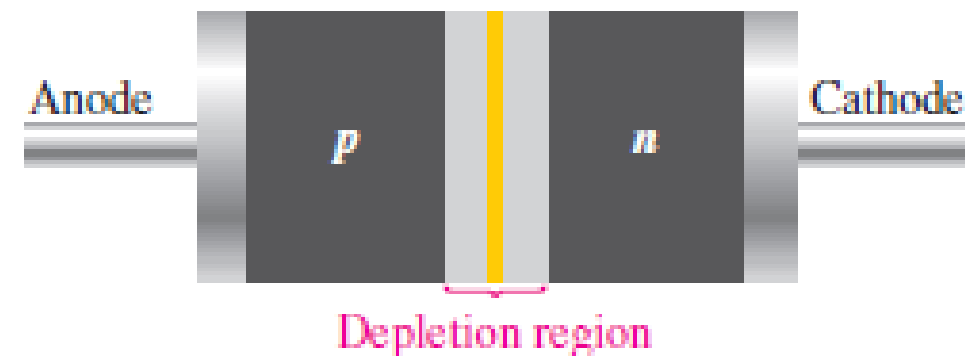
That's the diode quietly
working."

Diode

A **diode** is an electronic component that **allows current to flow in only one direction** and blocks it in the opposite direction.

Key Points:

- **Made of semiconductor material** (usually Silicon, sometimes Germanium).
- **Has two terminals:**
 - **Anode (+)**
 - **Cathode (–)**



(a) Basic structure

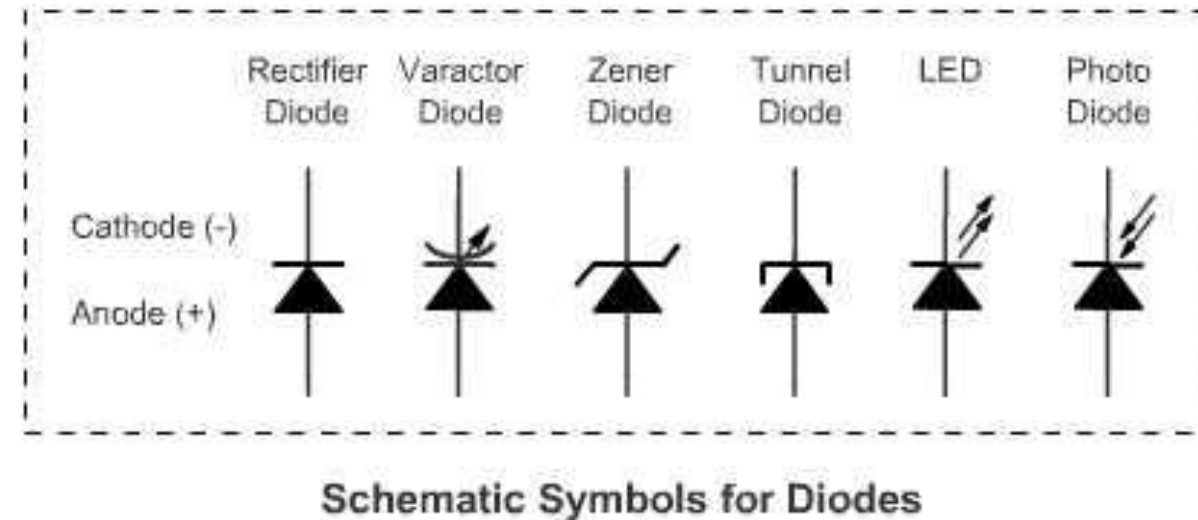


(b) Symbol

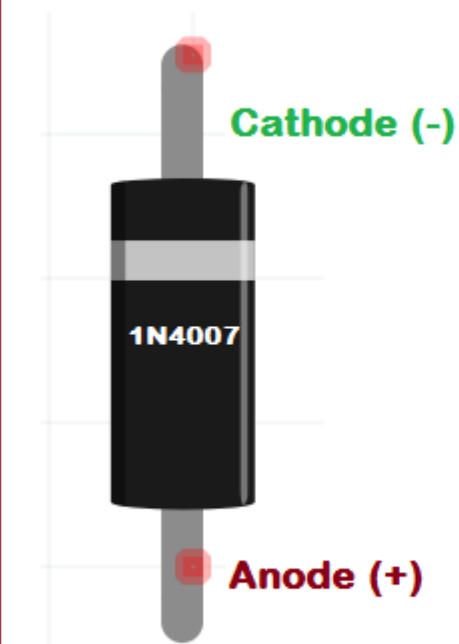
Diode

Types of Diodes:

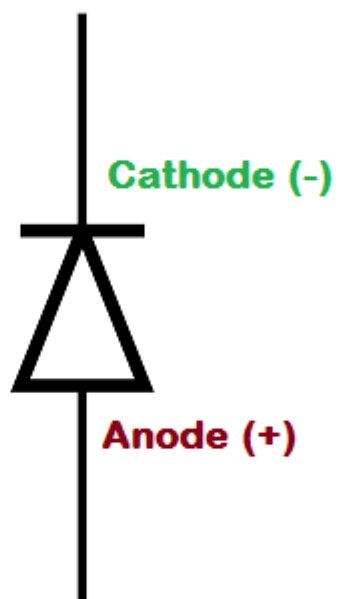
- **Standard PN diode** → **Rectification.**
- **Zener diode** → Voltage regulation.
- **Schottky diode** → Fast switching, low forward drop.
- **Photodiode** → Converts light into current.
- **LED** → Emits light when forward biased.



1N4007 Pinout



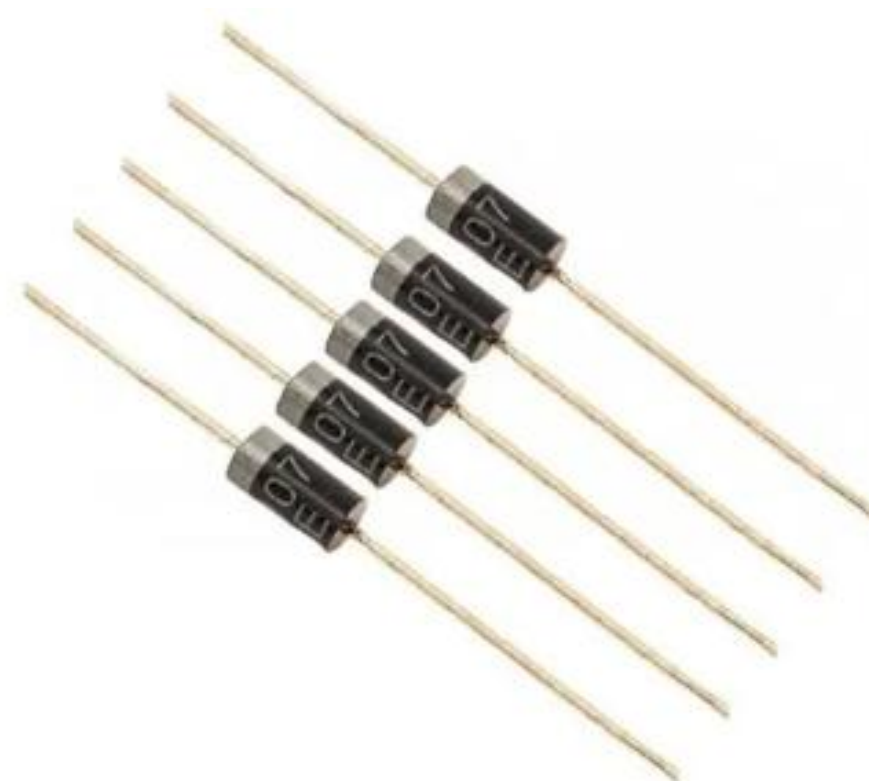
1N4007 Animation



Symbolic
Representation



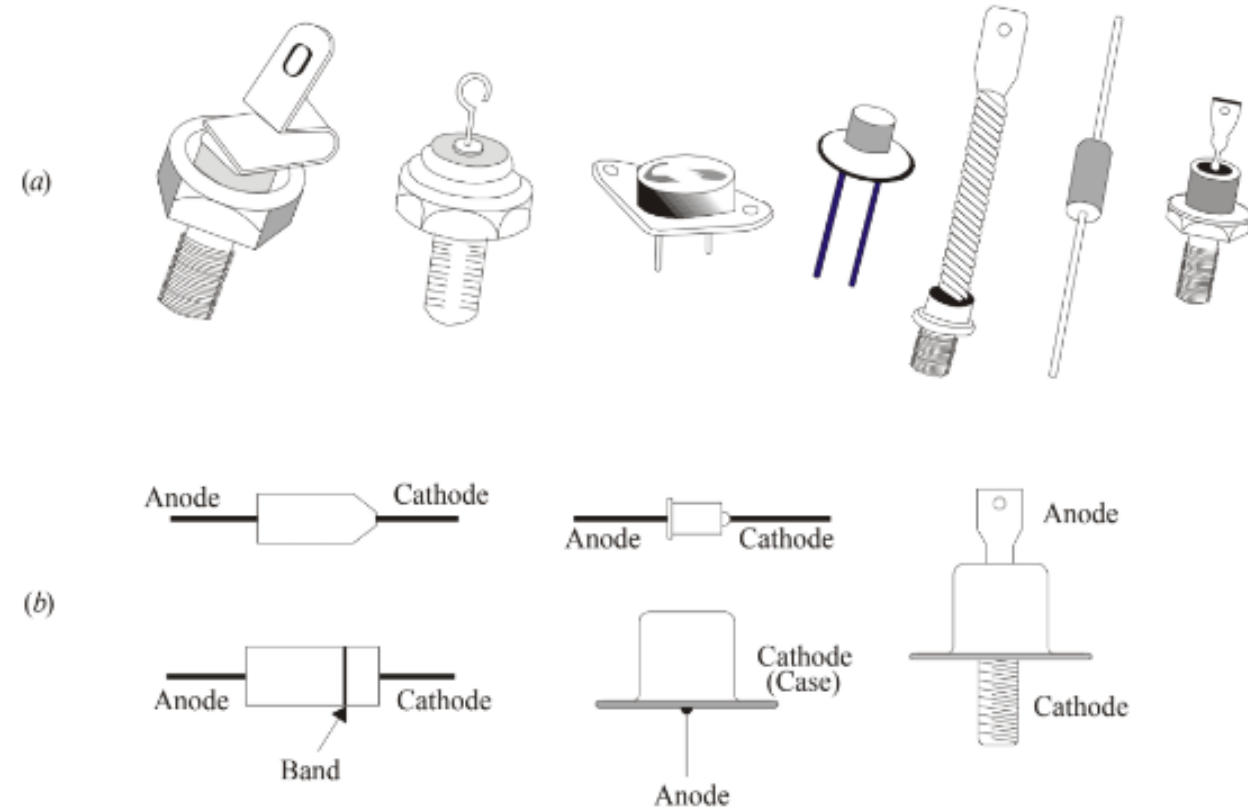
1N4007



Diode

Applications

- **Rectifier** → Converts AC (alternating current) into DC (direct current).
- **Protection** → Prevents reverse current that could damage circuits.
- **Signal demodulation** → Used in radios and communication systems.
- **LED (Light Emitting Diode)** → Special diode that emits light when current flows.
- **Zener Diode** → Provides voltage regulation.



Diode

PN Junction

A **PN junction** is the boundary or interface between a **P-type semiconductor** and an **N-type semiconductor**.

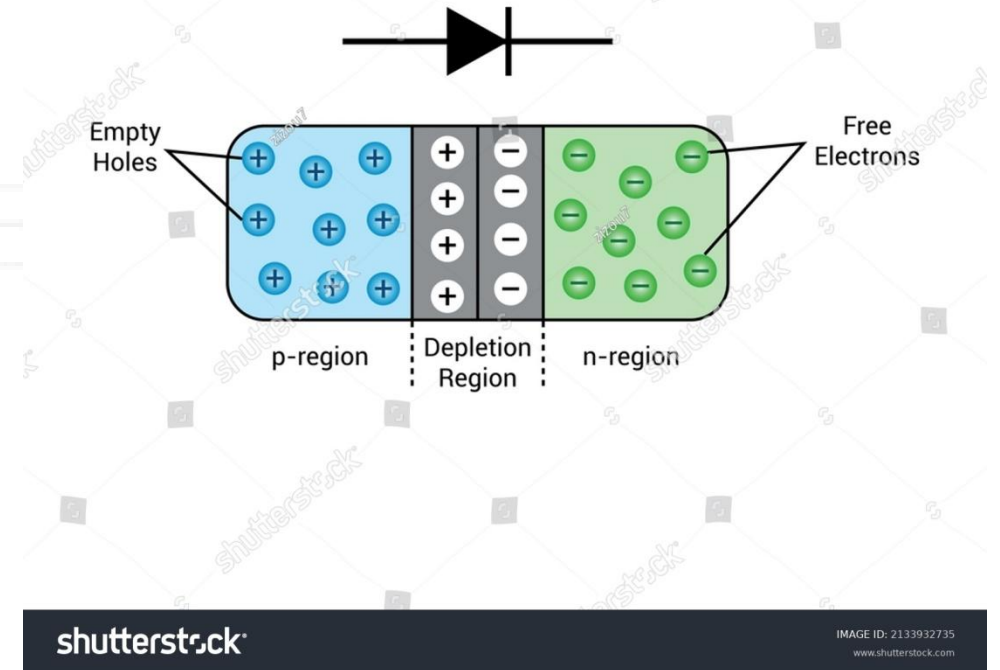
1. Formation

• **P-type semiconductor** → Doped with trivalent atoms (e.g., Boron) → creates **holes** (positive charge carriers).

• **N-type semiconductor** → Doped with pentavalent atoms (e.g., Phosphorus) → creates **electrons** (negative charge carriers).

• When these two regions are joined → a **PN junction** is formed.

P-N Junction



Diode

Key Regions

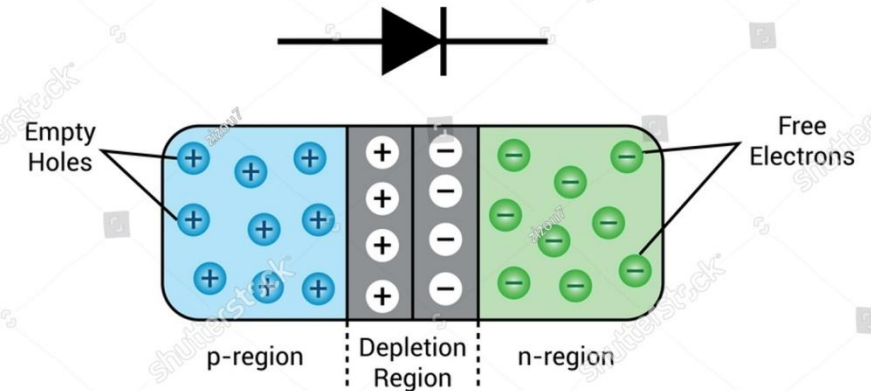
• Depletion Region:

- At the junction, electrons from the N-side combine with holes from the P-side.
- This creates a **region with no free charge carriers** (immobile ions only).
- Acts as an **insulating barrier**.

• Built-in Potential (Barrier Potential):

- An electric field is created across the depletion region.
- Typically ~ 0.3 V for Germanium, ~ 0.7 V for Silicon.

P-N Junction

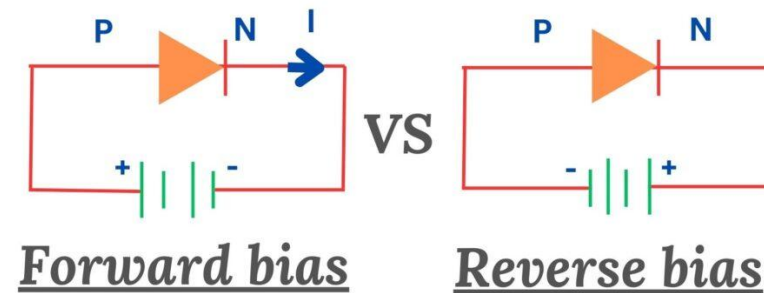


Diode

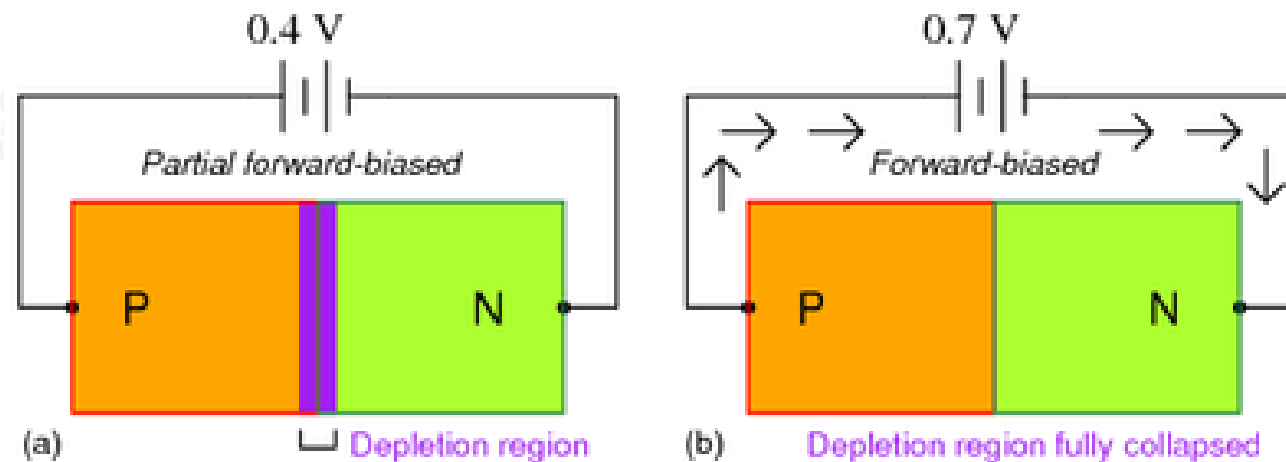
Operation:

•**Forward Bias:** When Anode is connected to +ve and Cathode to -ve → depletion region narrows → current flows.

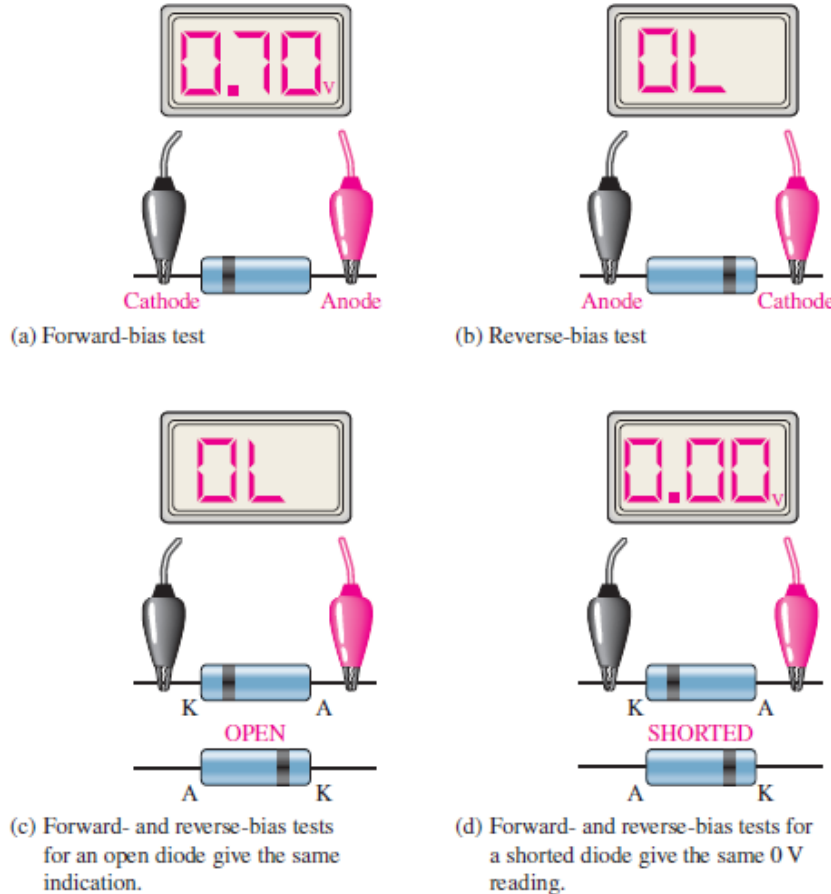
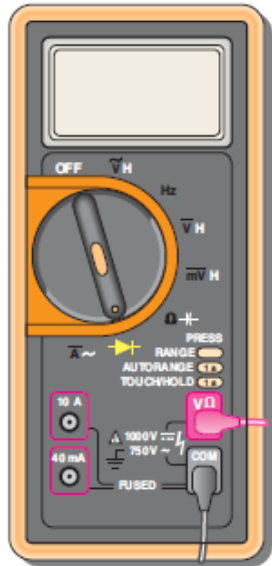
•**Reverse Bias:** When Anode is -ve and Cathode is +ve → depletion region widens → current is blocked (except a very small leakage).



[Circuit design Neat Snicket-Kieran - Tinkercad](#)



Testing a Diode

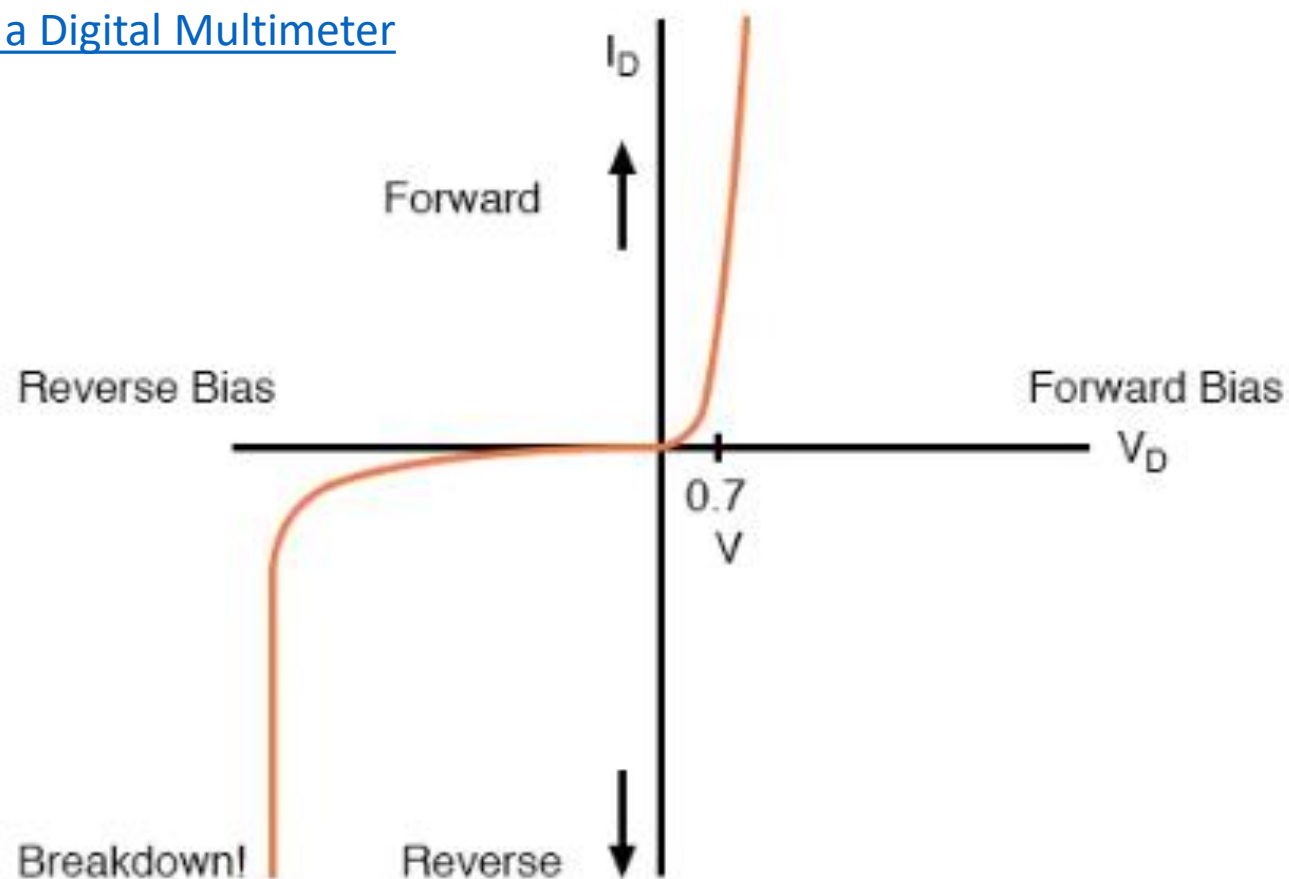


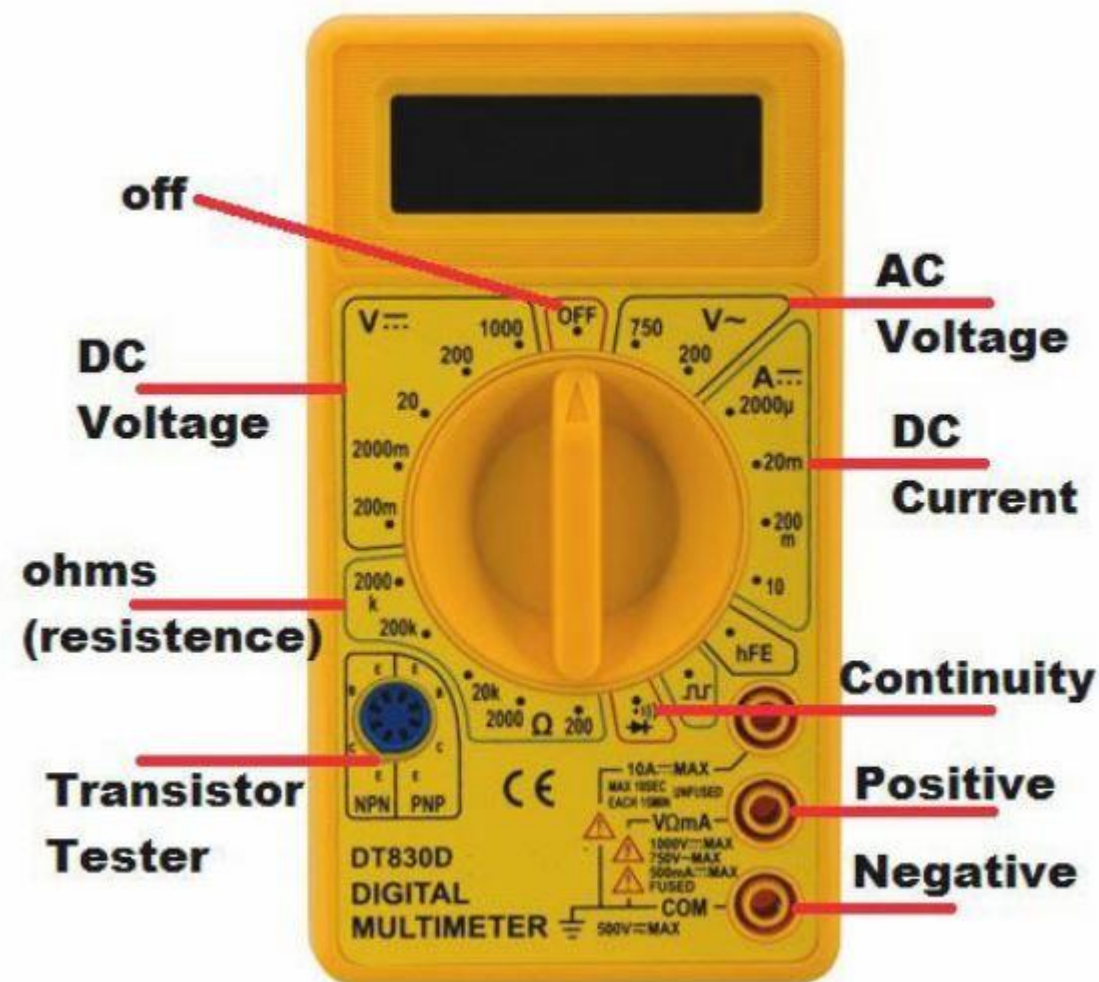
- The red (positive) lead of the meter is connected to the anode and the black (negative) lead is connected to the cathode to forward bias the diode.
- If the diode is good, you will get a reading of between approximately 0.5 V and 0.9 V, with 0.7 V being typical for forward bias.

▲ FIGURE 2-76

Testing a diode out-of-circuit with a DMM.

How to test Diodes Using a Digital Multimeter





- **Clippers/Clampers:** "How do radios, TVs, or even your phone *shape* signals so music sounds clear? → Clippers & Clampers.“
- **Transistors:** "What makes your Alexa, smartphone, or even Google servers run? Billions of tiny *transistors* switching ON/OFF at lightning speed.“

Course Code:1BEE303

Course: Analog Electronic Circuits

Objectives

1. To provide the knowledge for the analysis of transistor biasing and thermal stability circuits.
2. To develop skills to design the electronic circuits like amplifiers, power amplifiers and oscillators.
3. To understand the importance of FET and MOSFET and FET/MOSFET amplifiers

Course Code:1BEE303

Course: Analog Electronic Circuits

At the end of the course the student will be able to:

CO1: Explain the operating principles, characteristics, and applications of semiconductor diodes, rectifiers and BJTs in various biasing conditions and circuit configurations.[L2]

CO2: Apply the principles of BJT biasing and small-signal amplifier circuits using different bias configurations and transistor models, considering temperature effects, bias stability and frequency response.[L3]

Course Outcomes **CO3: Analyze** BJT amplifier circuits to determine voltage and current gains, frequency response and the effects of source and load resistances using various amplifier configurations and transistor connections.[L4]

CO4: Analyze the frequency response feedback amplifiers, oscillators and power amplifier circuits to evaluate their performance under different operating conditions.[L4]

CO5: Explain the construction, operating principles, characteristics, and biasing of JFETs and MOSFETs and **Analyze** DC and AC performance of FET amplifier circuits in common-source configuration.[L4]

Course Code:1BEE302
Course: Analog Electronic Circuits
CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	-	PSO1	PSO2
CO1	3	3	2	-	2	2	-	3	2	-	2	-	3	-
CO2	3	3	2	-	2	2	-	3	2	-	2	-	3	-
CO3	3	3	2	-	2	2	-	3	2	-	2	-	3	-
CO4	3	3	2	-	2	2	-	3	2	-	2	-	3	-
CO5	3	3	2	-	2	2	-	3	2	-	2		3	-



Course Code:1BEE302
Course: Analog Electronic Circuits
CO-PO Mapping

TEXT BOOKS:

- 1. Electronic Devices and Circuit Theory, Robert L Boylestad Louis Nashelsky, Pearson, 11th Edition, 2015**
2. Electronic Devices and Circuits, Millman and Halkias, Mc Graw Hill, 4th Edition, 2015
3. Electronic Devices and Circuits, David A Bell, Oxford University Press, 5th Edition, 2008

Course Code:1BEE302

Course: Analog Electronic Circuits

CO-PO Mapping

Need for Analog Electronic Circuits:

Analog electronics are essential for:

- Signal Processing:** Interfacing real-world Analog signals (sound, temperature, etc.) with digital systems.
- Power Management:** Voltage regulation, amplification, and filtering.
- Consumer Electronics:** Audio systems, sensors, and communication devices.
- Industrial & Automotive Applications:** Control systems, instrumentation, and sensor interfaces.



Course Code:1BEE302

Course: Analog Electronic Circuits

Job Prospects in India:

Roles:

- Analog Design Engineer
- Embedded Systems Engineer (Analog-focused)
- PCB Design Engineer
- Test & Validation Engineer

Sectors:

- Semiconductor(e.g.,Texas Instruments, Qualcomm)
- Consumer electronics
- Automotive (EVs, sensors)
- Aerospace & Defense

Module-1:

Semiconductor Diode: Introduction, semiconductor materials, working principle and forward and reverse bias conditions, resistance levels, diode equivalent circuit, transition and diffusion capacitance, reverse recovery time. Half-wave and full-wave rectifiers, necessity of clippers and clampers, different types of clippers and clampers. Zener diode, power Supply and series and parallel Voltage Regulators. Light emitting diodes (LEDs)

Bipolar Junction Transistors: Introduction, NPN and PNP transistors, construction, operation. Characteristics of common base (CB), common emitter (CE) and common collector configuration, cutoff region, active region, and saturation region. Relation between collector current, base current and emitter current.

Module-2:

BJT Biasing: Introduction to biasing, operating point, bias configurations; fixed-bias, emitter bias, voltage divider bias, DC bias with voltage feedback, design of bias circuits, effect of temperature on bias; thermal runaway, bias stabilization, stability, stability factors of bias circuits.

BJT AC Analysis: Amplification in AC domain, Transistor modelling for small signal analysis; resistance (r_e) model of CB, CE, and CC configurations, hybrid equivalent model CB, CE, and CC configurations, hybrid π model. Low frequency analysis, high frequency analysis

Module-3:

BJT AC Analysis: Determination voltage and current gains, effect of R_L and R_S . General frequency considerations, low frequency response, miller's capacitance, high frequency response. Amplifier operation, common emitter amplifier - DC and AC analysis (base and voltage divider bias only), multistage amplifier, Cascade and cascode connections, amplifier frequency response: decibel scale, Darlington circuits, analysis and design.

Module-4:

Feedback Amplifiers: Feedback concept, different types, practical feedback circuits, analysis and design of feedback circuits. Feedback amplifier; phase and frequency considerations, oscillators operation, phase-shift, Wien-bridge, tuned and crystal oscillators.

Power Amplifiers: Classification, analysis and design of Class A – Directly Coupled and Transformer Coupled, Class B- Complementary Symmetry and Push Pull, Class C and Class AB.

Module-5:

Field Effect Transistors: Introduction to FET, Construction, difference between FET, JFET and metal oxide Semiconductor Field Effect Transistor (MOSFET), N-Channel and P-Channel MOSFET in the Enhancement Mode and Depletion Mode, Characteristics, Transfer Characteristics, Fixed Bias, Self Bias and Voltage Divider Bias, DC and AC Analysis.

Clipper Circuits or Limiters

The clipper circuits are used to **remove the certain portions of the waveform** above or below the certain levels, or **Between the two reference voltages** as per the requirement.

- There are varieties of networks that have the ability to clip-off a portion of the input signal without distorting the remaining part of the input signal, called **clipper**.
 - Clipping circuits are also referred to as voltage (or current) limiters, amplitude selectors or slicers.
 - Depending on the orientation of the diode and the polarity of the reference voltage, the input signal will clip.
- A clipping circuit requires a minimum of one diode (either in series or parallel) and one resistor.

Classification of Clippers

```
graph TD; A[Classification of Clippers] --> B[Series Clippers]; A --> C[Shunt Clippers]; A --> D[Double Ended Clippers]; B --> B1[1. Series Negative Clippers]; B --> B2[2. Series Positive Clippers]; C --> C1[1. Shunt Negative Clippers]; C --> C2[2. Shunt Positive Clippers];
```

Series Clippers

1. Series Negative Clippers
2. Series Positive Clippers

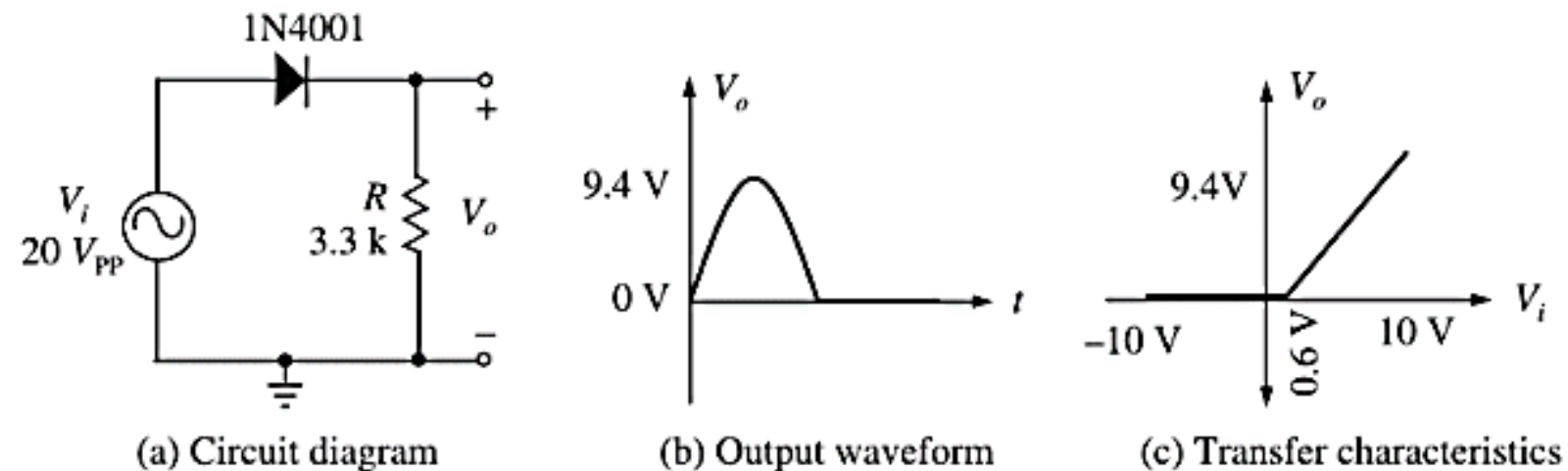
Shunt Clippers

1. Shunt Negative Clippers
2. Shunt Positive Clippers

Double Ended Clippers

In series clippers the diode is connected in series with the load.

Series Negative Clipper Circuit (Unbiased)



The diode conducts (ON) for

$$v_I \geq V_K$$

Where,

v_I = Input voltage

V_K = Voltage drop across diode

The diode is in OFF condition for

$$v_I \leq +V_K$$

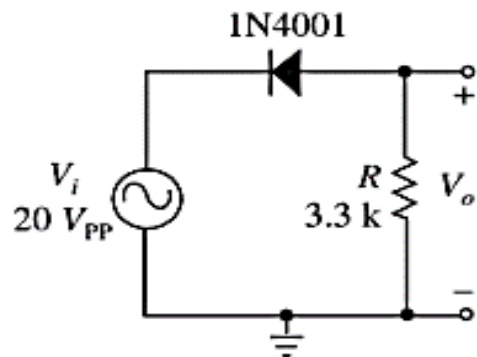
Series Negative Clipper (Unbiased)

Step-1: Diode Orientation: Anode is connected to the input, cathode to the resistor $\rightarrow$ load.

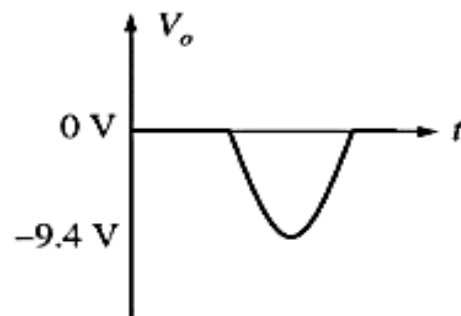
Step-2: Clipping Action: Diode conducts during **positive half-cycle**, passes it; during **negative half-cycle**, it blocks $\rightarrow$ clips the negative part.

Step-3: Result: Output waveform clips **below $\sim 0.6\text{ V}$** (diode's cut-in voltage).

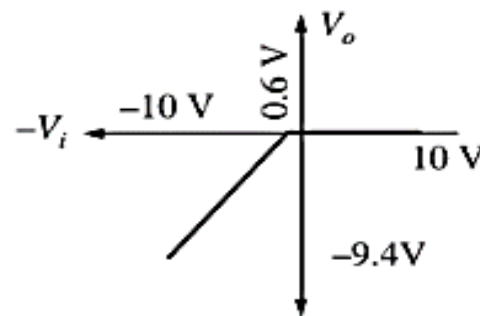
Series Positive Clipper Circuit (Unbiased)



(a) Circuit diagram



(b) Output waveform



(c) Transfer characteristics

$V_{in(p-p)}$	$V_{o+(p)}$	$V_{o-(p)}$
8V		
12V		
20V		

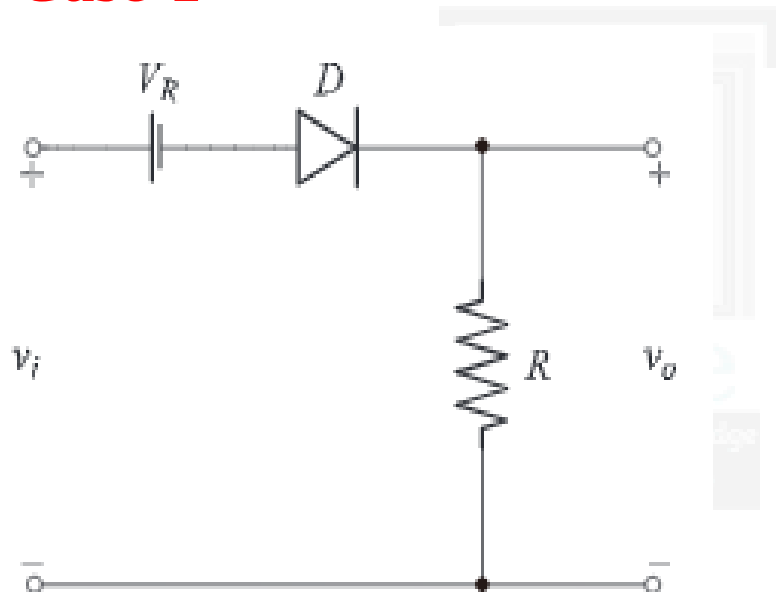
Series Positive Clipper (Unbiased)

- 1.Diode Orientation:** Cathode connected to input, anode to resistor → load (reversed).
- 2.Clipping Action:** Diode conducts during **negative half-cycle**, passes it; blocks **positive half-cycle** → clips the positive part.
- 3.Result:** Output waveform clips **above ~0.6V**.

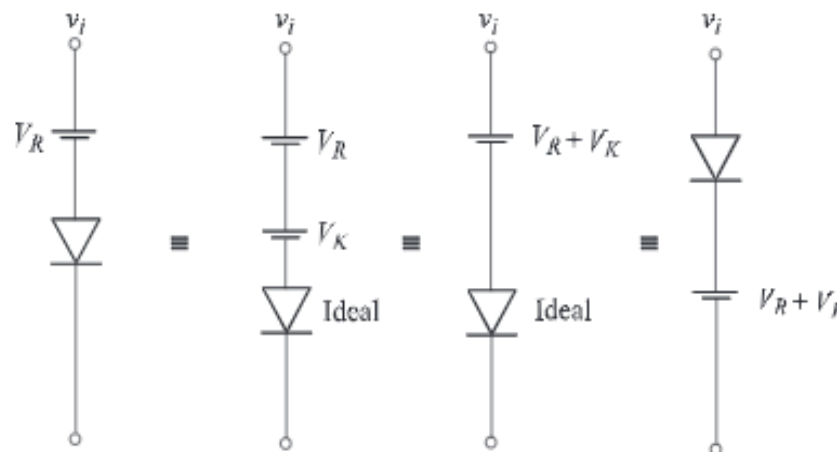
Series Negative Clippers (**Biased**)

In series clippers the diode is connected in series with the load.

Case-1



Circuit Diagram



Voltage on Diode Terminals

The diode conducts (ON) for

$$v_i \geq V_R + V_K$$

Where,

v_i = Input voltage

V_R = Reference voltage

V_K = Voltage drop across diode

Series Negative Clippers (Biased)

The diode conducts (ON) for

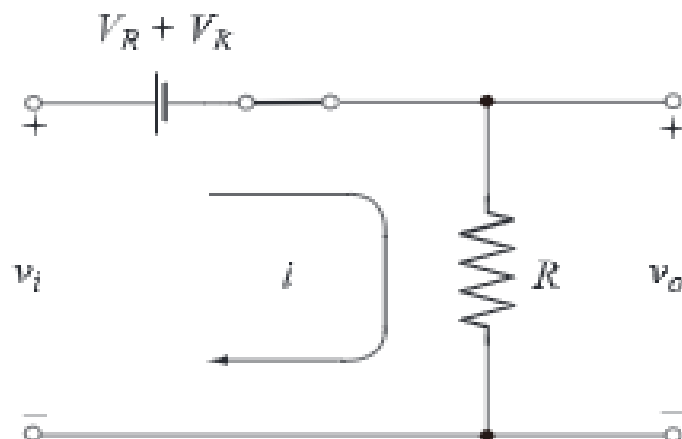
$$v_i \geq V_R + V_K$$

Where,

v_i = Input voltage

V_R = Reference voltage

V_K = Voltage drop across diode



Diode ON Condition

Apply KVL to the circuit, we get;

$$v_i - [V_R + V_K] - v_o = 0$$

$$v_o = v_i - [V_R + V_K] \text{ for } v_i \geq V_R + V_K$$

$$\text{when } v_i = v_m, v_o = v_m - [V_R + V_K]$$

Since $V_R + V_K$ is constant

$$\Delta v_o = \Delta v_i$$

$$\text{Hence slope } \frac{\Delta v_o}{\Delta v_i} = 1$$

1. Diode Operation with Bias:

Step-1: The diode turns **ON** only when the input voltage $v_I \geq V_R + V_K$

Step-2: V_R is the reference (bias) voltage and $V_K \approx 0.6V$ is the diode's cut-in voltage.

Step-3: This **shifts the clipping level downward**, so negative parts of the input **below** $-(V_R + V_K)$ are **clipped**.

Output Behaviour (Using KVL):

Applying Kirchhoff's Law:

$$v_o = v_i - (V_R + V_K)$$

As $V_R + V_K$ is constant, **slope** of output vs input is 1, i.e.,

$$\Delta v_o / \Delta v_i = 1$$

The waveform is **linearly passed above threshold**, and **clipped below** it.

Series Negative Clippers (Biased)

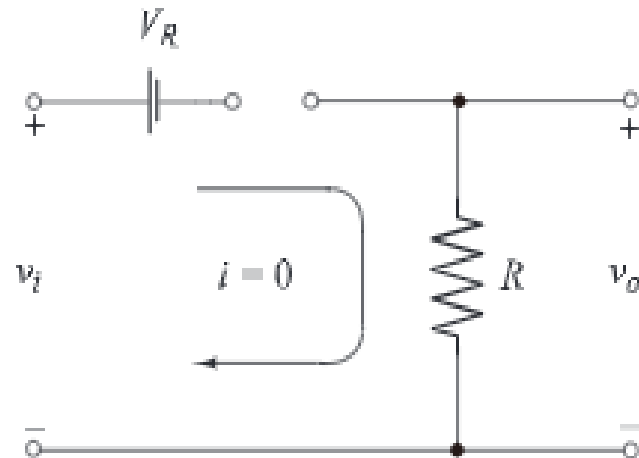
The diode is in OFF condition for

$$v_i \leq V_R + V_K$$

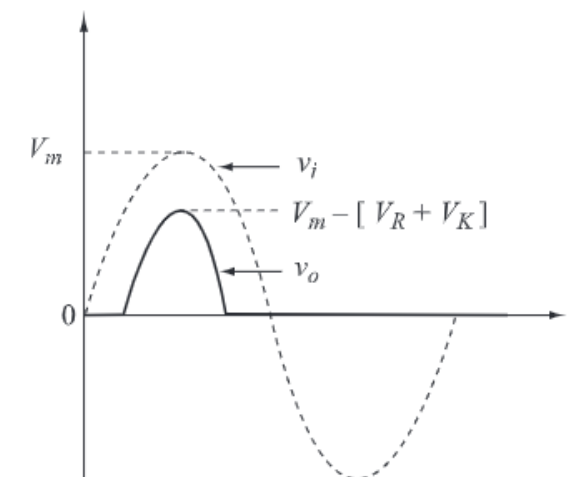
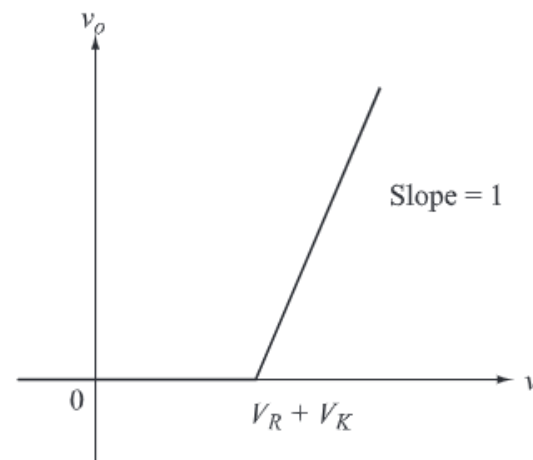
Apply KVL to the circuit, we get;

$$v_o = iR = 0$$

Hence slope $\frac{\Delta v_o}{\Delta v_i} = 0$

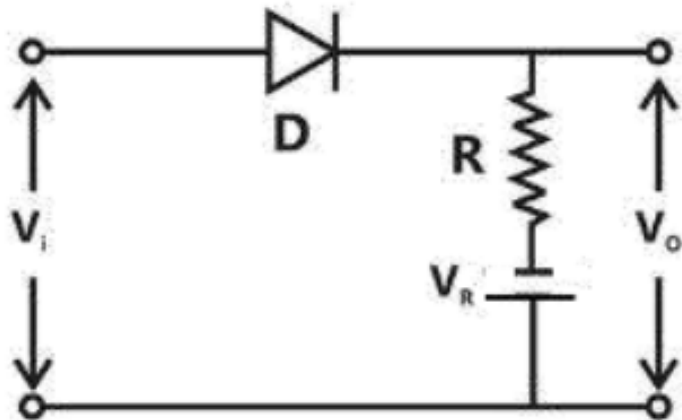


Diode OFF Condition



Transfer Characteristics and Output voltage Waveform

Series Negative Clippers (Biased)

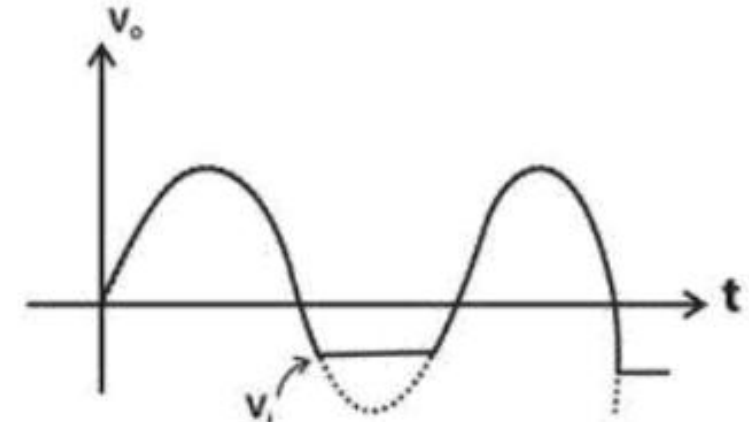
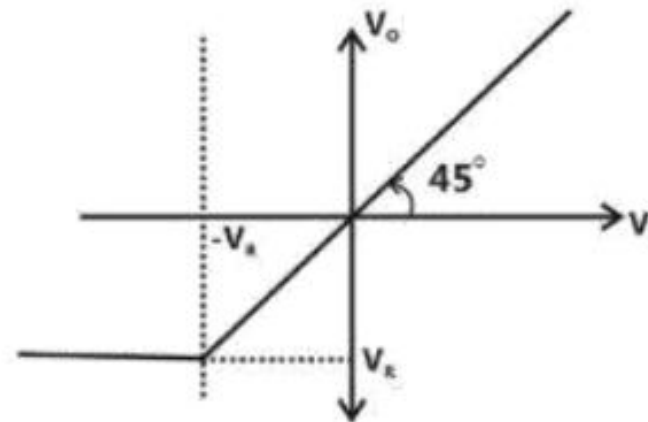


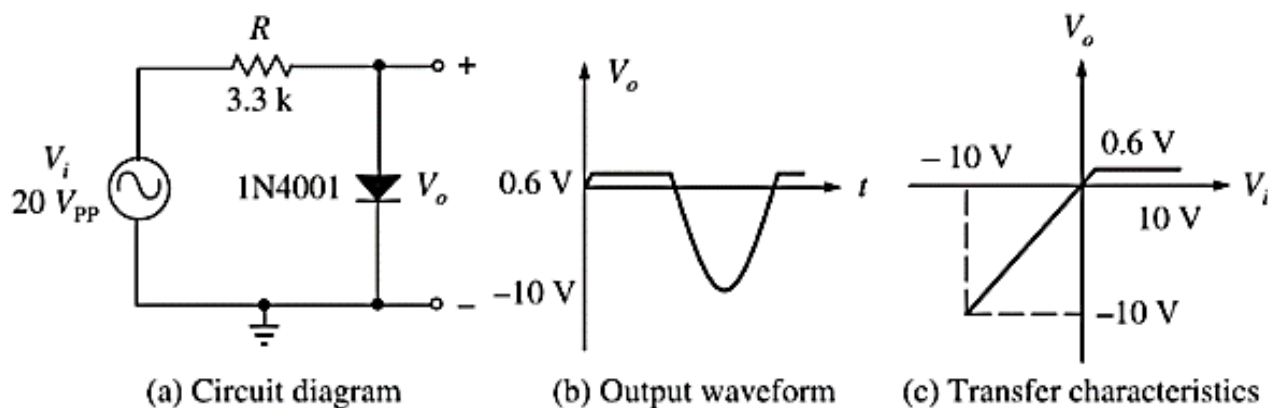
On to the leading edge
www.atme.in

$$V_i = V_m \sin \omega t : \text{ When } V_i < -V_R \Rightarrow V_o = -V_R$$

$$V_m > -V_R$$

$$\text{When } V_i > -V_R \Rightarrow V_o = V_i$$





Circuit Operation;

for $v_i \geq +V_K$ **Diode is ON** $v_o = V_K$

for $v_i \leq V_K$ **Diode is OFF** $v_o = v_i$

Step 1: Circuit Setup

- Diode connected **in parallel** with the load resistor.
- **Cathode** of diode to input signal, **anode** to ground.
- No external bias voltage applied.

Step 2: Diode Operation

- During **positive half-cycle** (input $> 0.6\text{ V}$), diode **turns ON** and shorts output to ground $\rightarrow$ output clipped near 0 V .
- During **negative half-cycle**, diode is **OFF**, output follows input.

Step 3: Output Behavior

- Positive part of waveform is **clipped at $\sim 0.6\text{ V}$** (close to 0 V output).
- Negative part of waveform appears **unchanged** at output.

$V_{in(p-p)}$	$V_{o+(p)}$	$V_{o-(p)}$
8V		
12V		
20V		

Shunt Negative Clipper Circuit (Unbiased)

Step 1: Circuit Setup

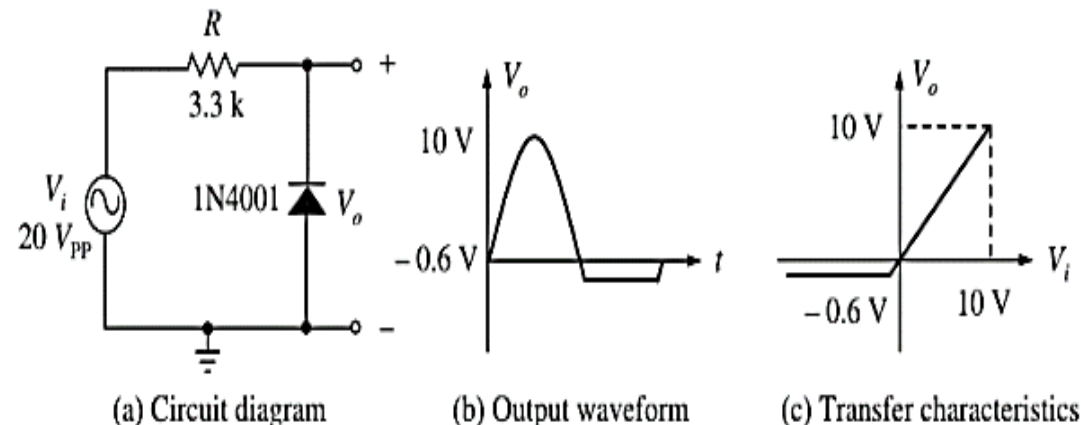
- Diode is connected in **shunt (parallel)** with the load resistor.
- **Cathode** of the diode is connected to the **input signal**, and **anode** is grounded.
- No external DC bias is applied.

Step 2: Diode Operation

- During **positive half-cycle**, input voltage exceeds $\sim 0.6\text{ V}$ $\rightarrow$ diode turns **ON** and **shorts** the signal to ground $\rightarrow$ output = 0 V .
- During **negative half-cycle**, diode is **OFF**, so the input passes through to the output.

Step 3: Output Behavior

- The output waveform has its **positive part clipped** at $\sim 0.6\text{ V}$.
- **Negative half** appears at output **unaltered**.



Circuit Operation;

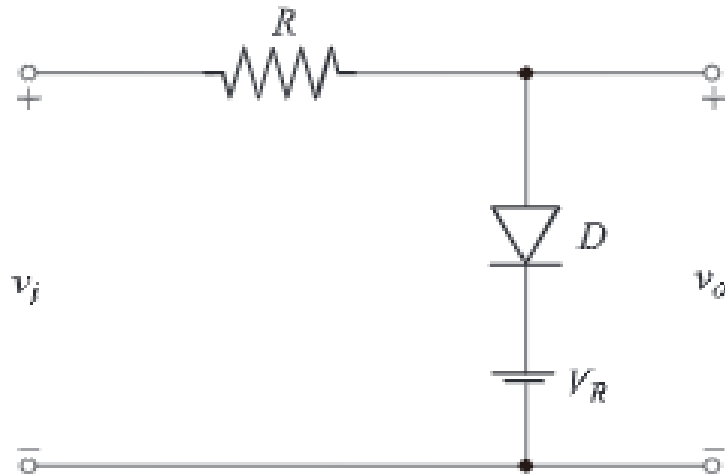
for $v_i \leq -V_K$ **Diode is ON** $v_o = -V_K$

for $v_i \geq -V_K$ **Diode is OFF** $v_o = v_i$

Shunt Positive Clippers (Biased)

CASE 1

- The level to which an AC voltage is limited can be adjusted by adding a bias voltage, V_{BIAS} (V_{ref}), in series with the diode, as shown in Figure.

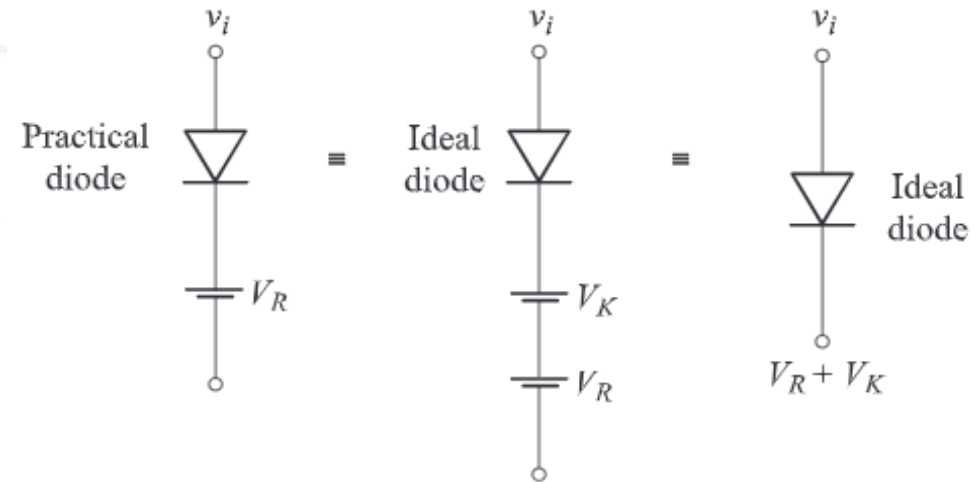


Circuit Diagram

v_i = Input voltage

V_R = Reference voltage/ Bias Voltage

V_K = Voltage drop across diode



Voltage on Diode Terminals

Shunt Positive Clippers (Biased)

The diode conducts (ON) for

$$v_I \geq V_R + V_K$$

Where,

v_I = Input voltage

V_R = Reference voltage

V_K = Voltage drop across diode

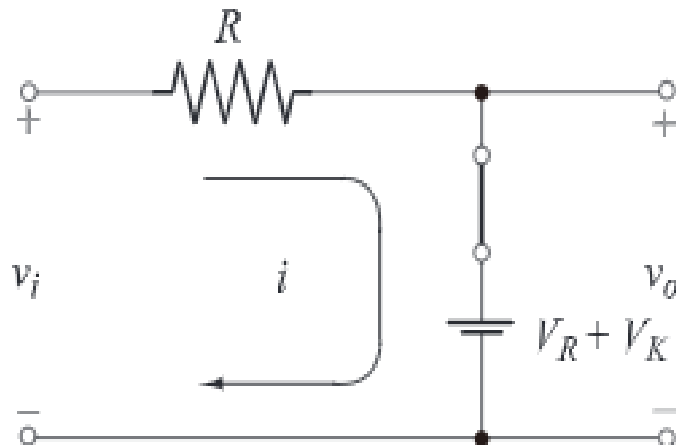
Apply KVL to the circuit, we get;

$$v_O = V_R + V_K \text{ for } v_I \geq V_R + V_K$$

Since $V_R + V_K$ is constant

$$\Delta v_o = 0$$

$$\text{Hence slope } \frac{\Delta v_o}{\Delta v_i} = 0$$

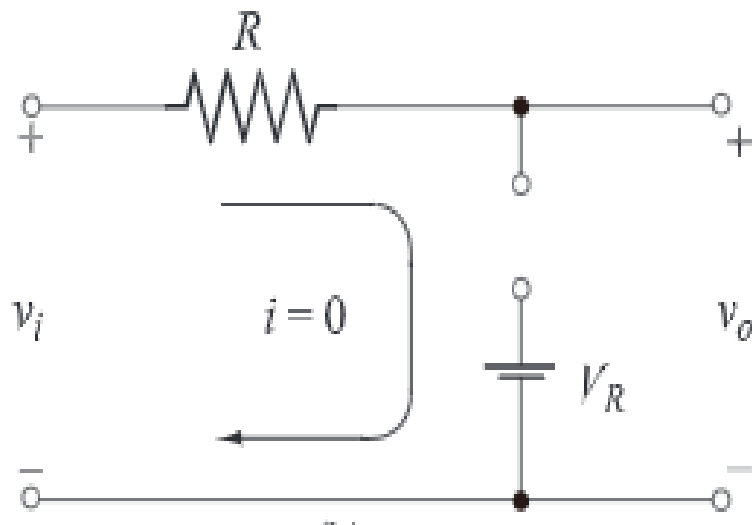


Diode ON Condition

Shunt Positive Clippers (Biased)

The diode is in OFF condition for

$$v_i \leq V_R + V_K$$



Diode OFF Condition

Apply KVL to the circuit, we get;

$$v_i - iR - v_o = 0$$

Neglecting the drop iR

$$v_o = v_i \text{ for } v_i \leq V_R + V_K$$

$$\Delta v_o = \Delta v_i$$

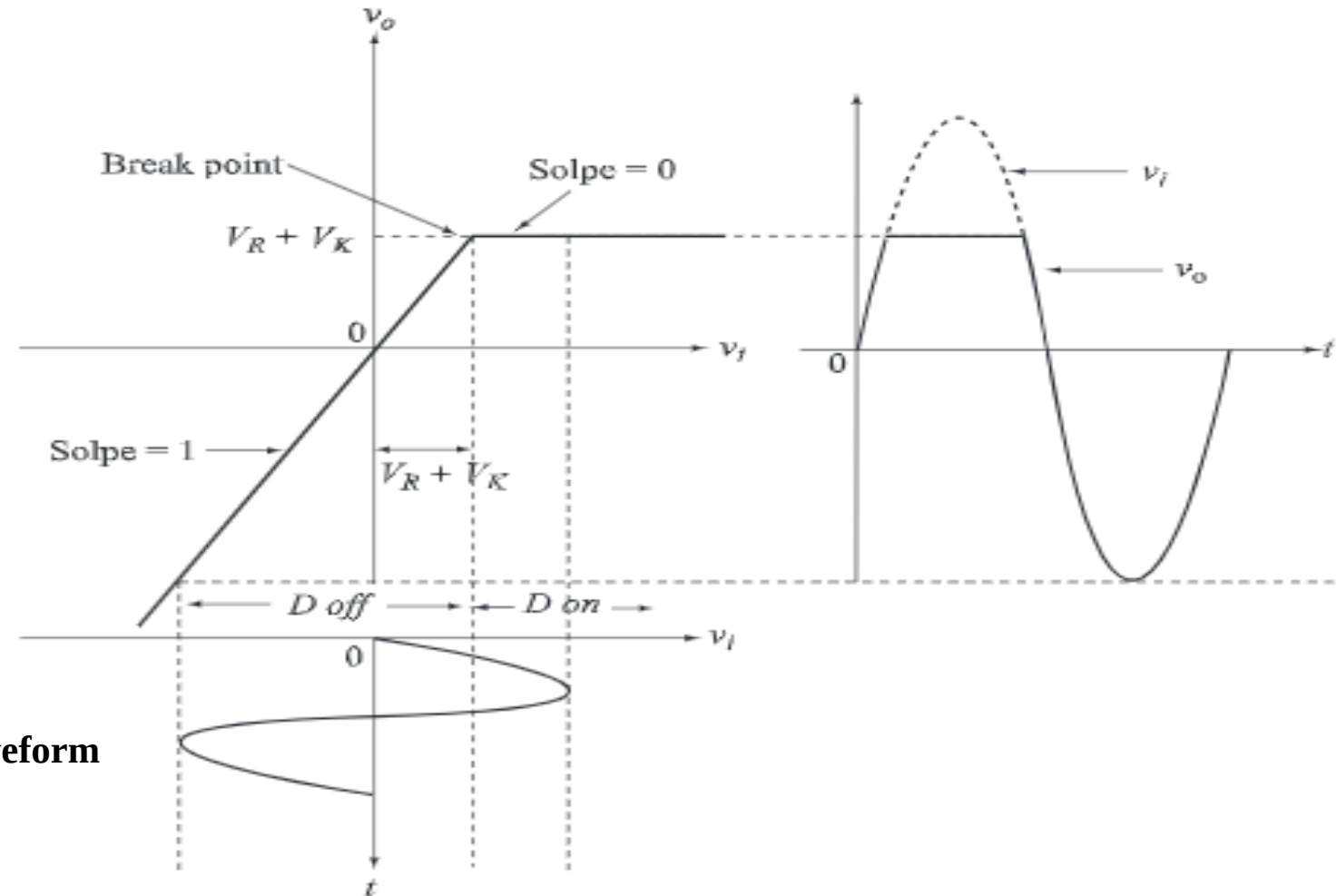
$$\text{Hence slope } \frac{\Delta v_o}{\Delta v_i} = 1$$

Shunt Positive Clippers (Biased)

Circuit Operation;

$$v_O = V_R + V_K \text{ for } v_I \geq V_R + V_K$$

$$v_O = v_i \text{ for } v_i \leq V_R + V_K$$

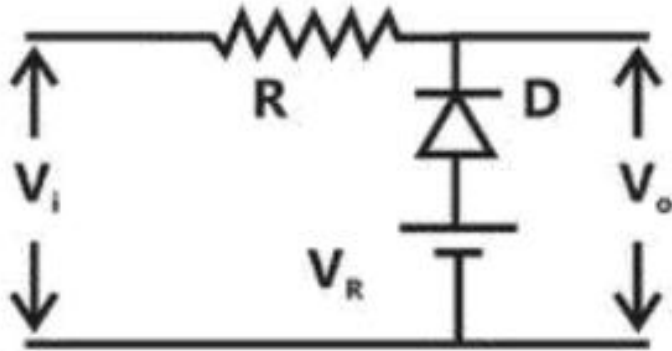


Transfer Characteristics and Output voltage Waveform

Shunt Positive Clippers (Biased)

- CASE 2** ■ By turning the diode around of Case-1, the positive limiter can be modified to limit the output voltage to the portion of the input voltage waveform above ($V_{BIAS} - 0.7V$), as shown by the output waveform in

Figure

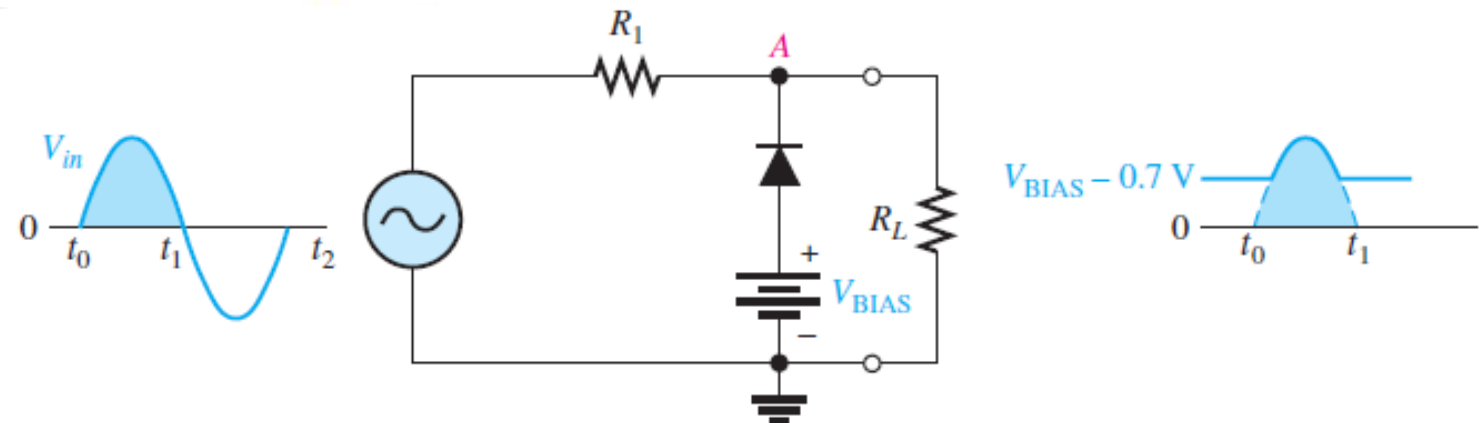


When $V_i < V_R$, D is ON

$$V_o = V_R$$

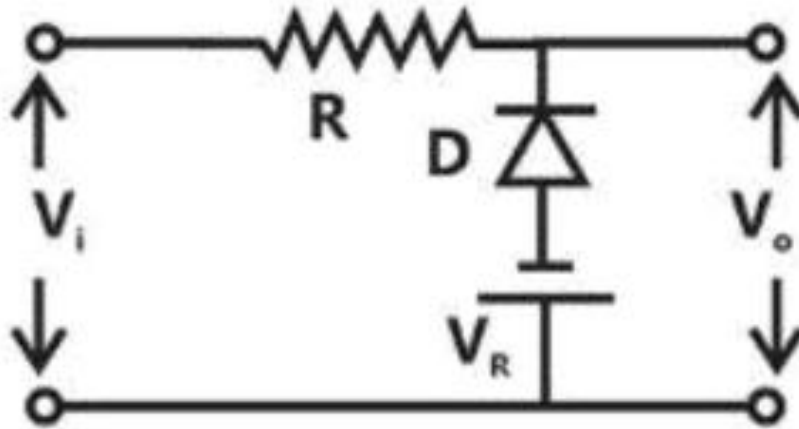
When $V_i > V_R$, D is OFF

$$V_o = V_i$$



Shunt Negative Clippers (Biased)

CASE 3



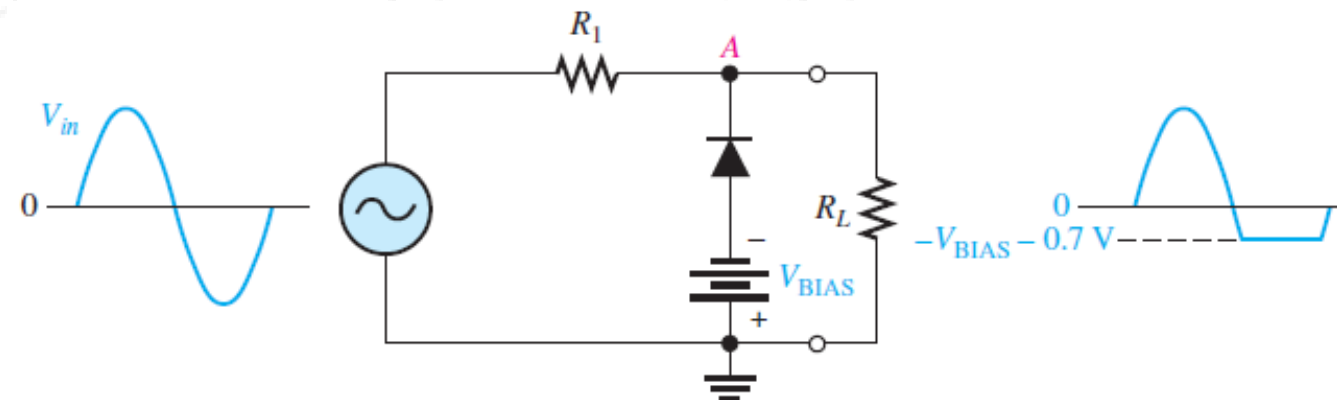
When $V_i < -V_R$, D is ON

$$V_o = -V_R$$

When $V_i > -V_R$, D is OFF

$$V_o = V_i$$

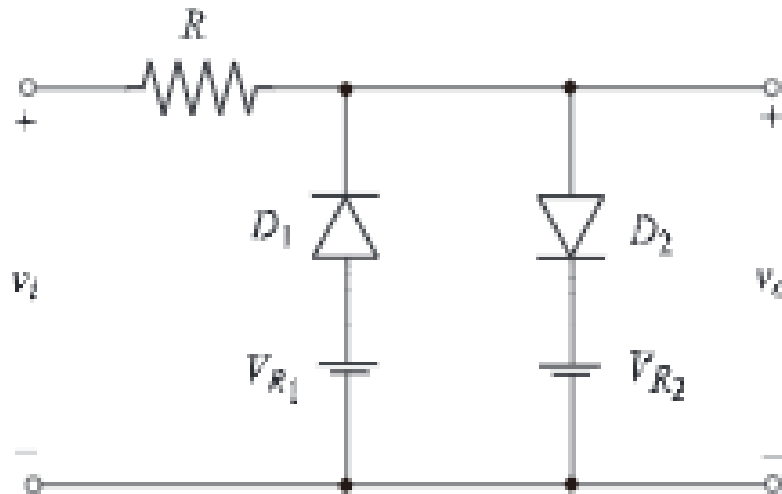
- To limit a voltage to a specified negative level, the diode and bias voltage must be connected as in Figure.
- In this case, the voltage at point A must go below $(-V_{BIAS} - 0.7 \text{ V})$ to forward-bias the diode and initiate limiting action as shown
- Once the diode begins to conduct, the voltage at point A is limited to $(-V_{BIAS} - 0.7 \text{ V})$ so that all input voltage below this level is clipped off



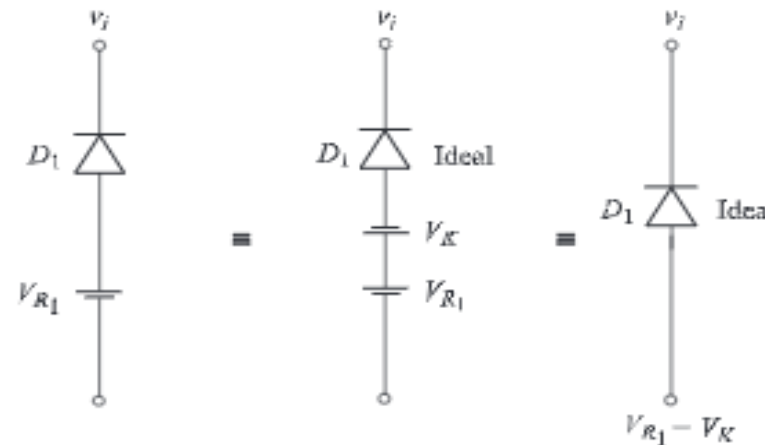
Double Ended Clippers

Two shunt clippers can be combined to obtain clipping at two independent levels.

CASE 1



Circuit Diagram



Voltage on Diode (D_1) Terminals

Note:

V_{R1} and V_{R2} are positive
 V_{R1} forward biases D_1
 V_{R2} reverse biases D_2
 $V_{R2} > V_{R1}$

Double Ended Clippers

The diode D_1 conducts (ON) for

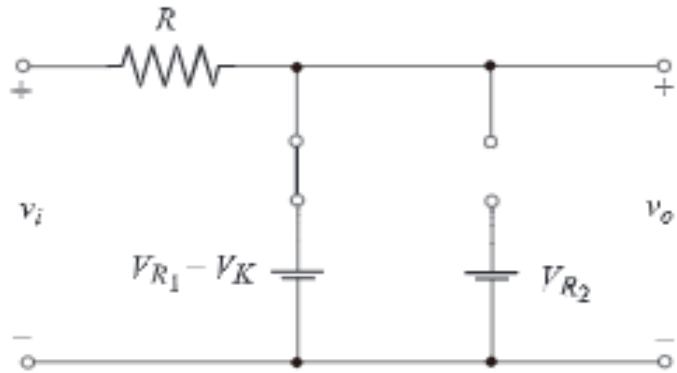
$$v_I \leq V_{R1} - V_K$$

Where,

v_I = Input voltage

V_{R1} = Reference voltage

V_K = Voltage drop across diode



Diode D_1 ON Condition

Apply KVL to the circuit, we get;

$$v_o = V_{R1} - V_K \text{ for } v_I \leq V_{R1} - V_K$$

$$\text{Hence slope } \frac{\Delta v_o}{\Delta v_i} = 0$$

Clamper Circuits

A Clamper adds a dc level to an ac voltage.

Clamper circuits can also be referred to as D.C Restorers, Baseline Stabilizers, DC Reinserters, Level Shifter

Classification of Clampers

1. Positive Clampers
2. Negative Clampers

Assumptions

1. The time constant $\tau = RC$ is designed to **very large** by selecting large values of **R** and **C**.

Clamper Circuits

Clamping circuits will clamp an input signal to a different DC level or they are used to add dc level (positive or negative) to the input AC signal, it moves the entire signal up or down to place the peaks at the desired reference level.

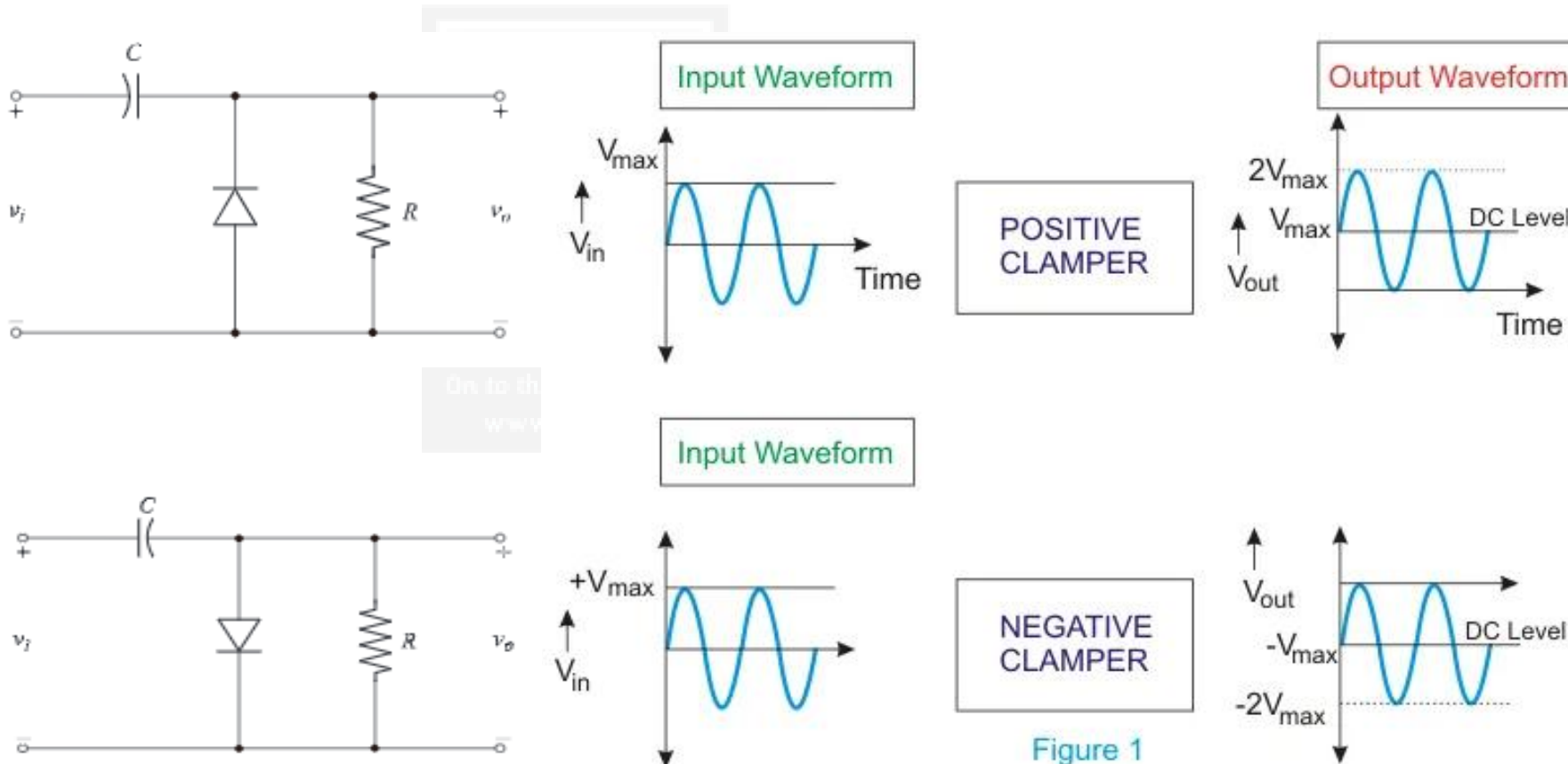


Figure 1

The positive clamper circuit adds the **positive dc level to the input signal**

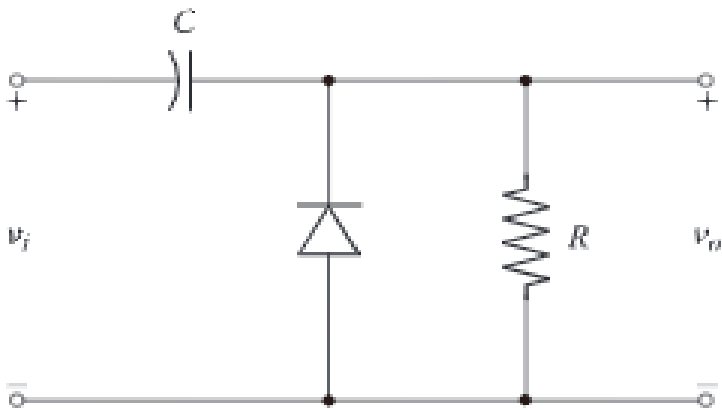
when it shifts the signal to the upward or positive sides, both the negative peak and the zero levels will meet, which is **called the positive clamper circuit**

A simple negative clamper circuit is used to add a **negative level to the ac output**.

When it shifts the signal to the downside or negative side, both the positive peak and the zero levels will meet, which we refer to as the **negative clamper circuit**⁵⁴

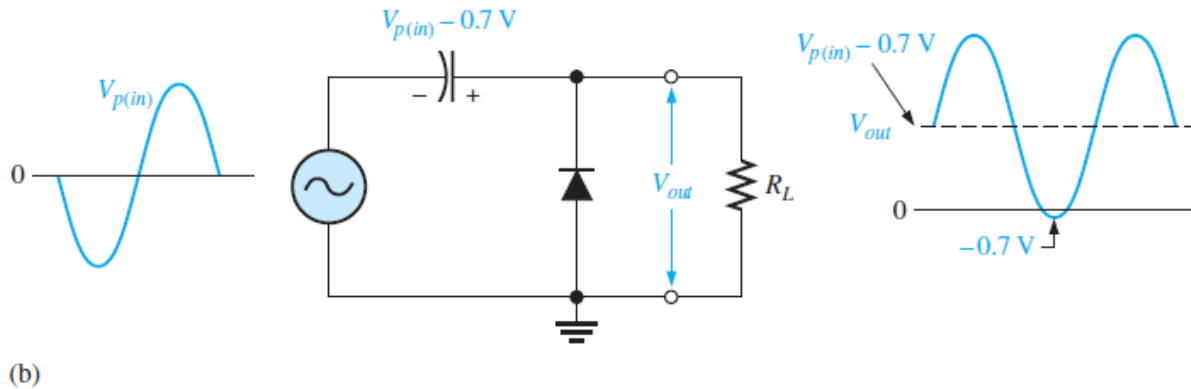
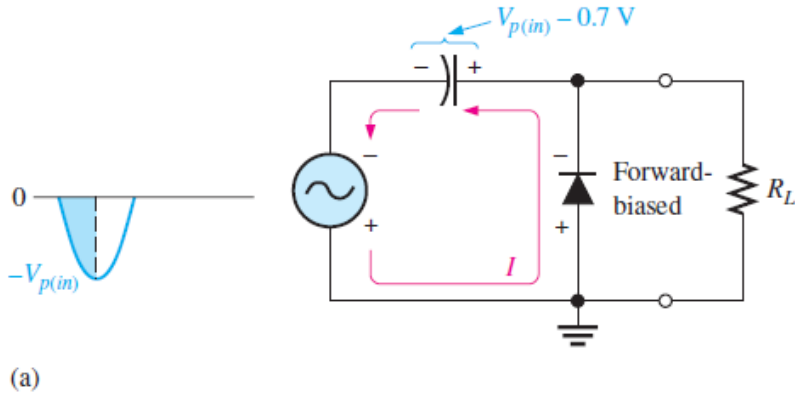
Positive Clamper Circuits

The positive clamper circuit adds the **positive dc level to the input AC signal**.

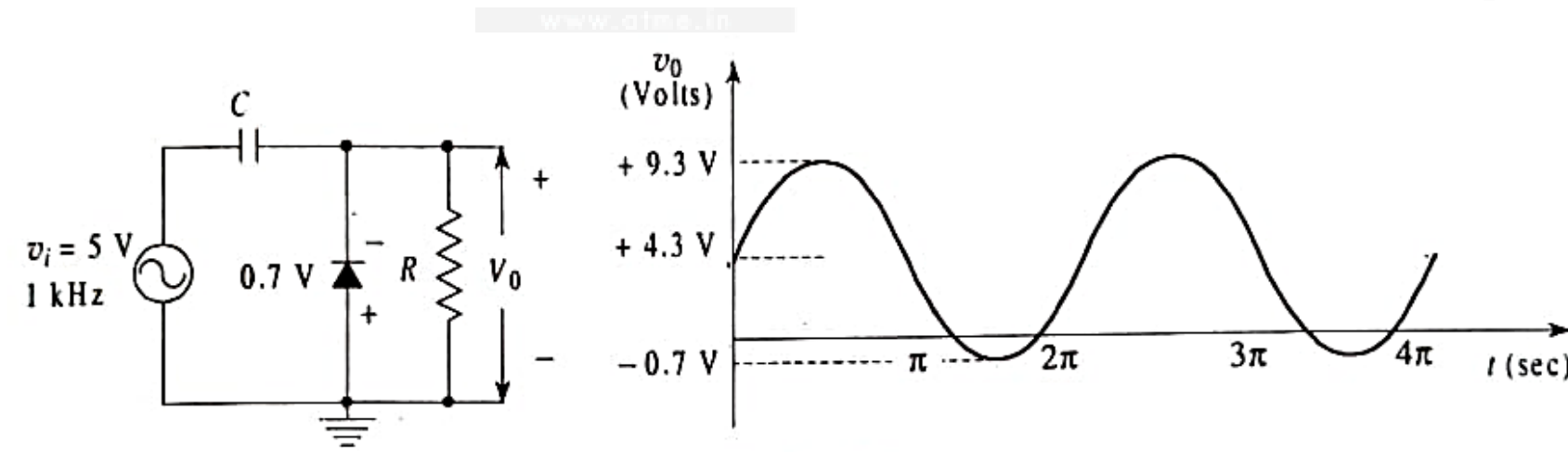


Circuit Diagram

- The diode conducts during **negative half cycle**.
 - The capacitor gets charged to a voltage level of **V_M** (Peak of the input)
 - The charging time constant is **$\tau = RC$** .
-
- The diode is in OFF condition during positive **half cycle**.
 - The capacitor gets discharged into R.

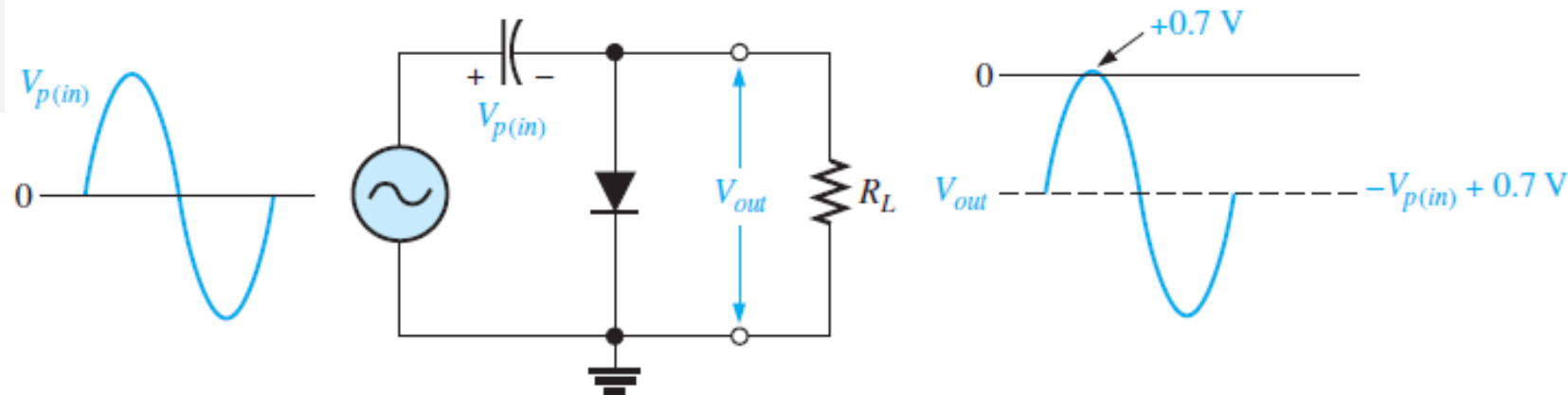


- The operation of this circuit can be seen by considering the first negative half-cycle of the input voltage. When the input voltage initially goes negative, the diode is forward biased, allowing the capacitor to charge to near the peak of the input ($V_{p(in)} - 0.7 \text{ V}$), as shown in Figure(a).
- Just after the negative peak, the diode is reverse-biased. This is because the cathode is held near $V_{p(in)} - 0.7 \text{ V}$ by the charge on the capacitor. The capacitor can only discharge through the high resistance of R_L .

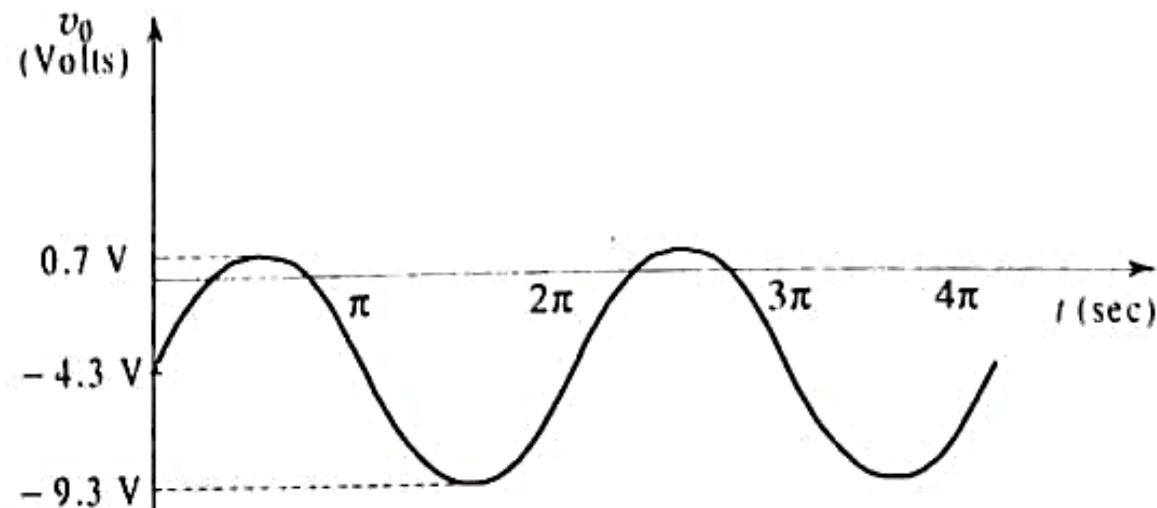
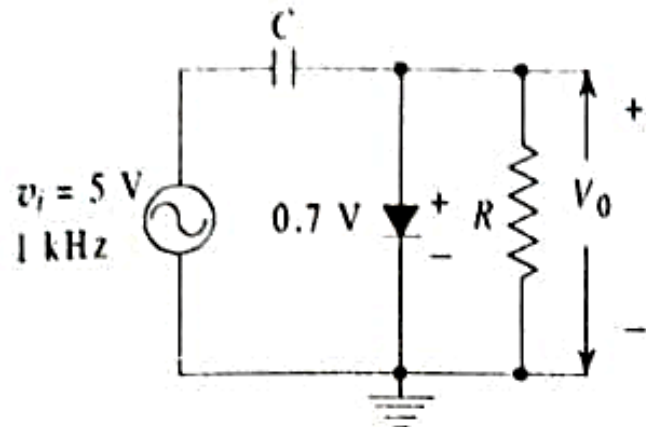


- So, from the peak of one negative half-cycle to the next, the capacitor discharges very little. The amount that is discharged, of course, depends on the value of R_L .

- If the capacitor discharges during the period of the input wave, clamping action is affected. If the RC time constant is 100 times the period, the clamping action is excellent.
- An RC time constant of ten times the period will have a small amount of distortion at the ground level due to the charging current.
- The net effect of the clamping action is that the capacitor retains a charge approximately equal to the peak value of the input less the diode drop. The capacitor voltage acts essentially as a battery in series with the input voltage. The dc voltage of the capacitor adds to the input voltage by superposition, as in Figure(b).
- If the diode is turned around, a negative dc voltage is added to the input voltage to produce the output voltage as shown in Figure



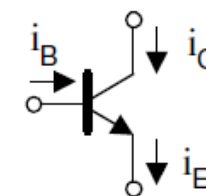
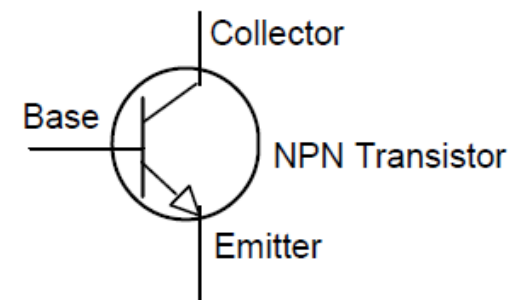
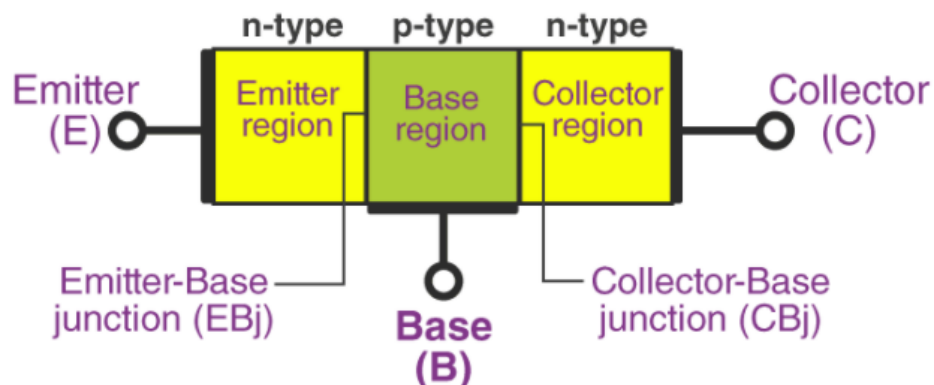
Negative clamper



- The magnitude of R and C must be chosen such that the time constant, $\tau = RC$, is large enough to ensure that the voltage across the capacitor does not discharge significantly during the interval when the diode is non-conducting.
- During the positive half-cycle, diode is forward biased and shorts out the effect of the resistor, R. This results in small RC time constant so that the capacitor will charge to peak value (diode drop is considered) very quickly. During this interval, the output voltage is almost short-circuited voltage, $V_o = + 0.7 \text{ V}$ (diode drop alone).
- During the negative half-cycle, diode will be reverse biased. Therefore the effective output voltage is the voltage drop across the resistance, R.
- Voltage drop across R = drop across capacitor + input voltage = $-(V - \text{Diode drop}) - V = -4.3 - 5 = 9.3 \text{ V}$

Transistor

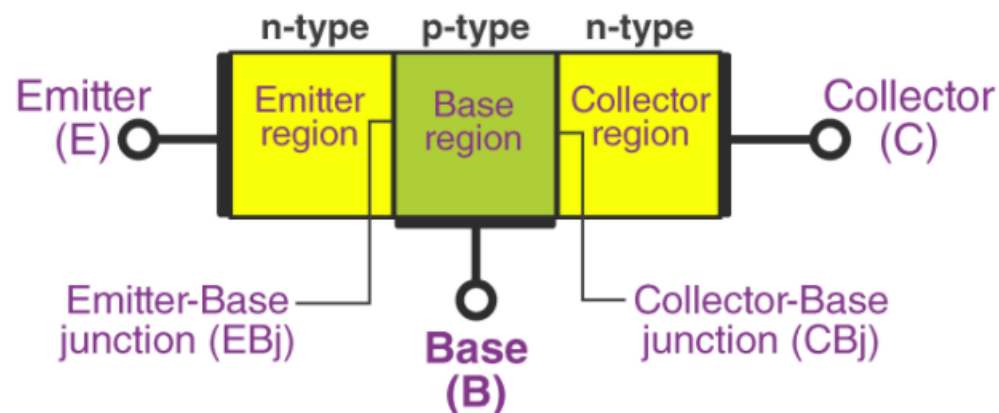
- Transistors can be broadly classified as unipolar and bipolar based on the charge carriers taking part in the conduction.
- In a unipolar transistor the conduction is due to majority charge carriers alone while in a bipolar transistor the conduction is due to both majority and minority charge carriers.



- A BJT or a Bipolar Junction Transistor is a three terminal two junction semiconductor device and the conduction here is due to both the charge carriers. Hence it is a bipolar device and it amplifies the electrical Signal as they are transferred from the input the output.
- A BJT has Two PN Junctions, one junction is forward biased and the other is reverse biased. The forward biased junction has a low resistance path whereas a reverse biased junction has a High Resistance path. The weak signal is introduced into Low Resistance circuit and output is taken from the High Resistance circuit. Therefore, a transistor transfers a signal from a low resistance to high resistance

BJT STRUCTURE

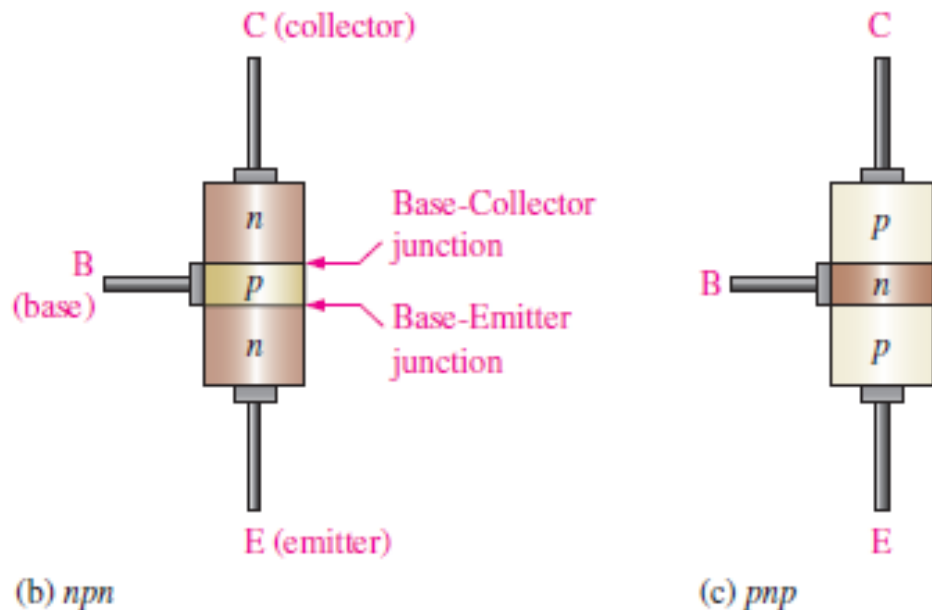
- BJT is classified into two types based on the structure (NPN & PNP).
- A NPN transistor consists of two n-layers in between which a p-layer is sandwiched. Similarly, the pnp transistor consists of two p-layers in between which a n-layer is sandwiched.
- The transistor consists of three terminals-the Emitter, Base, and Collector.
- The emitter layer is the source of charge carriers and it is heavily doped with a moderate cross-sectional area.
- The collector collects the charge carriers emitted by the emitter region and hence has a moderate doping and a large cross-sectional area.
- The base region is in between these and it acts as a path for the movement of charge carriers.
- In order to reduce the recombination of electrons and holes in the base region, this region is lightly doped and is of narrow cross-sectional area.



Terminal	Nature of doping	Cross-sectional area
Emitter	Heavy	Moderate
Base	Light	Narrow
Collector	Moderate	High

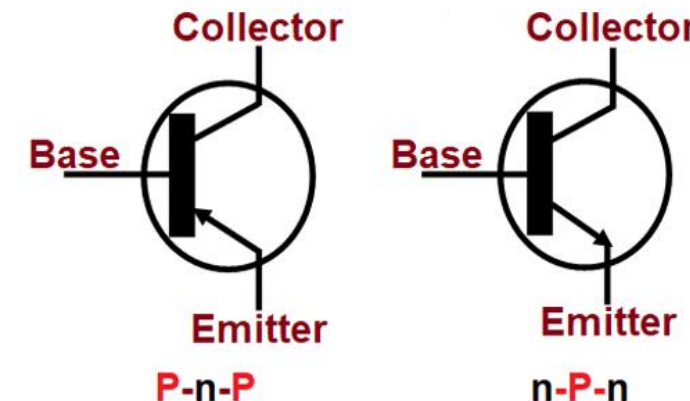
Bipolar Junction Transistor (BJT)

The **BJT** is constructed with three doped semiconductor regions separated by two pn junctions



Junctions of Transistor

- Collector – Base Junction
- Base- Emitter Junction



Symbols.

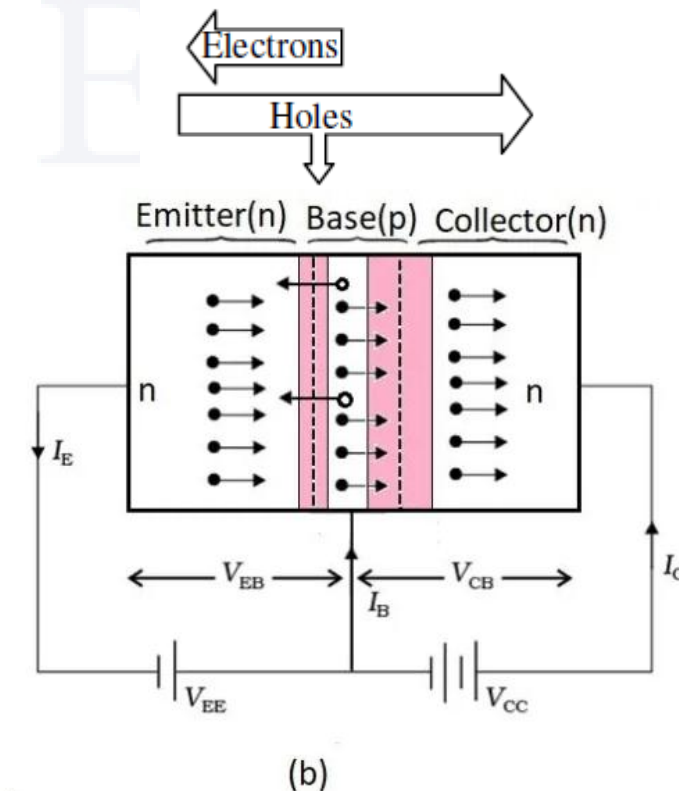
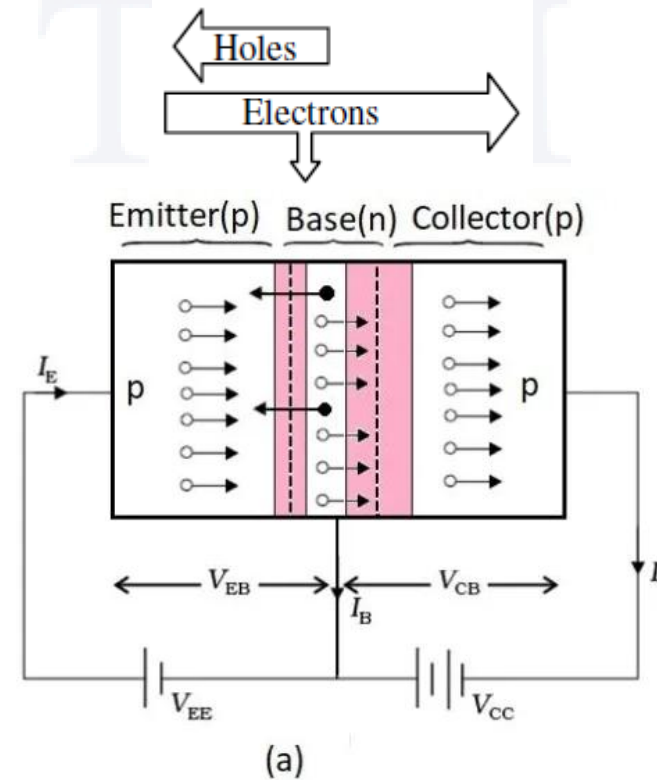
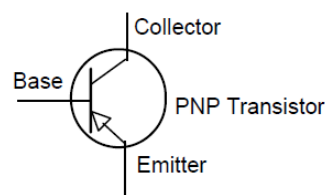
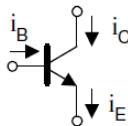
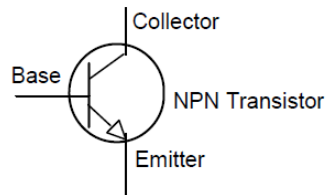
Operating regions of BJT

Operating Regions	Emitter-Base Junction	Collector-Base Junction	Function
Cut-off region	Reverse Biased	Reverse Biased	OFF Switch
Active region	Forward Biased	Reverse Biased	Amplifier
Saturation region	Forward Biased	Forward Biased	ON Switch

The arrow on the emitter inside the transistor symbols points in the direction of conventional current

Bipolar Junction Transistor: BJT is a three terminal component, which is constructed with three doped semiconductor regions separated by two p-n junctions; the three regions are Emitter (E), Base (B) and collector(C). There are two types of BJT, such as a) NPN b) PNP

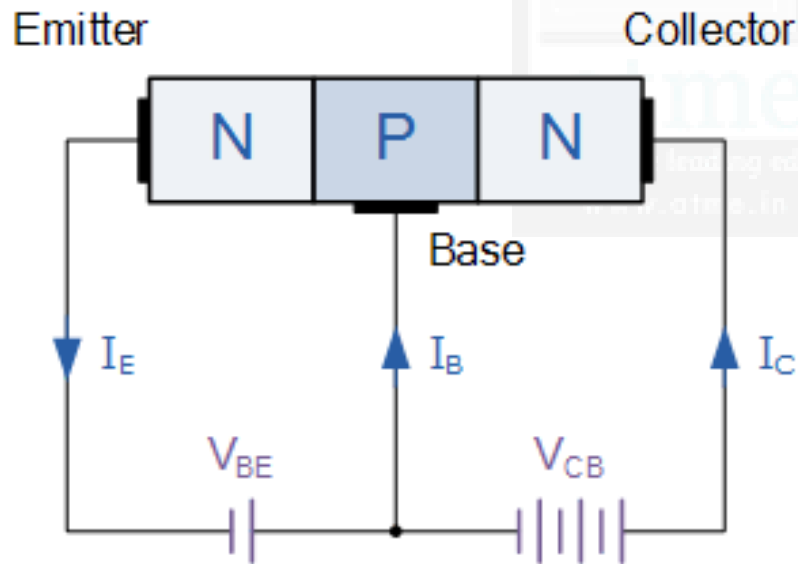
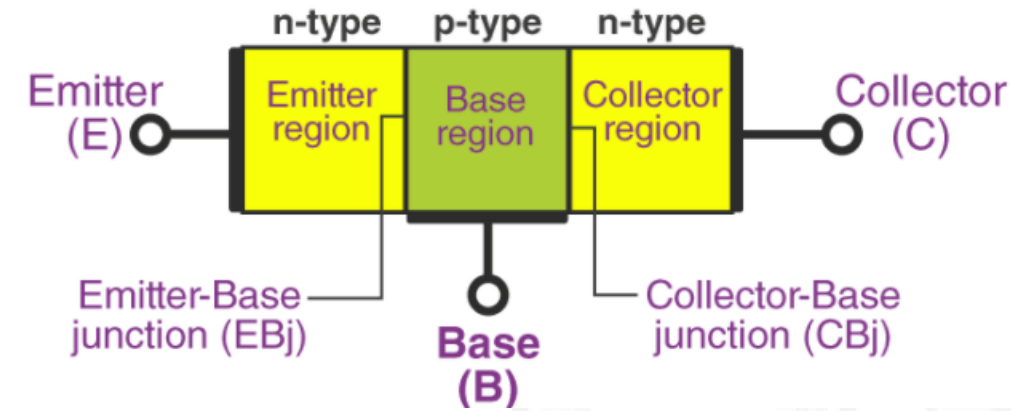
NPN transistor has N-type emitter & collector and a P-type base, while PNP has P-type emitter & collector and a N-type base as shown in figure 1(a) and (b).



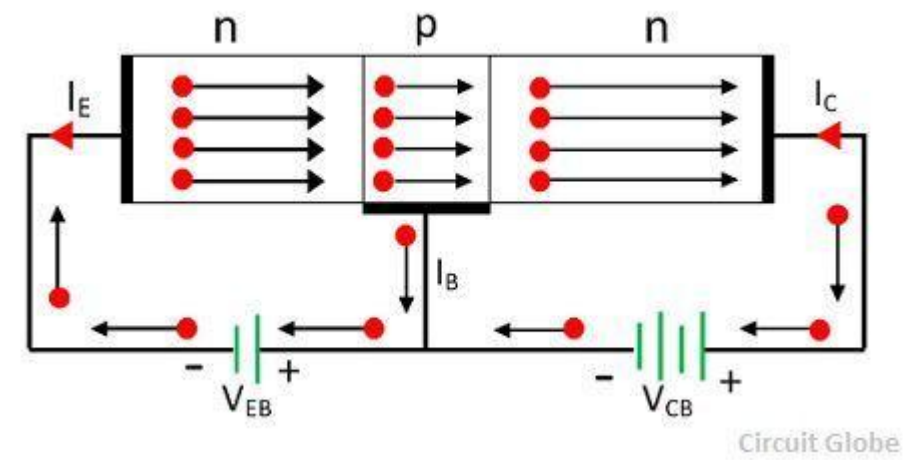
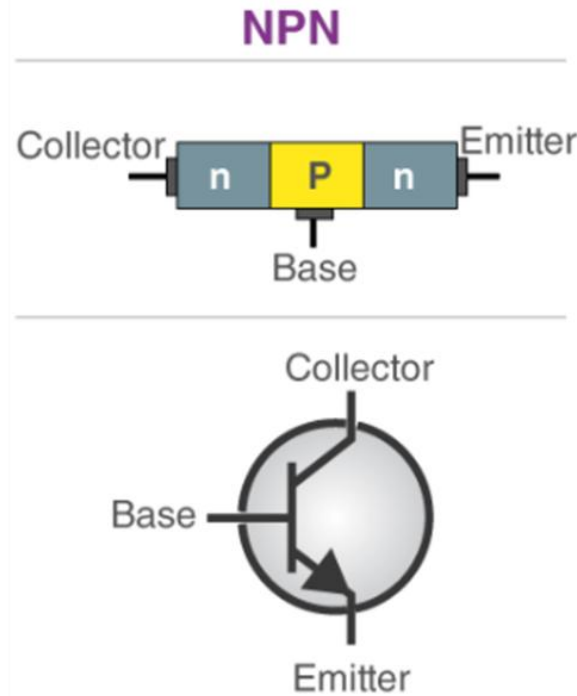
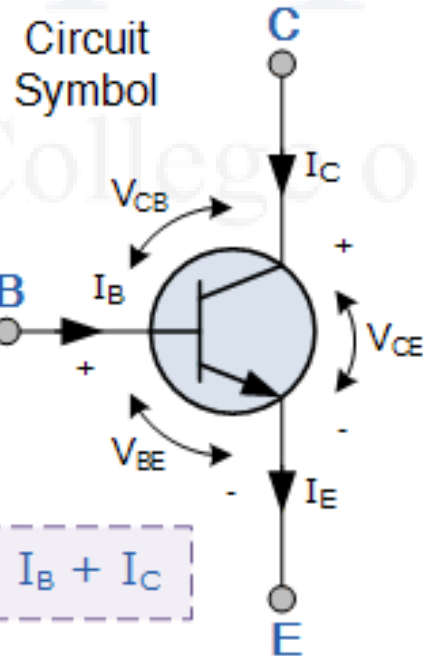


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$$I_E = I_B + I_C$$



For a bipolar transistor to conduct correctly,
Base- Emitter Junction is to Forward Biased
Collector – Base Junction as to Reverse Biased

Bipolar NPN transistor the Collector must always more positive with respect to both the Base and the Emitter terminals

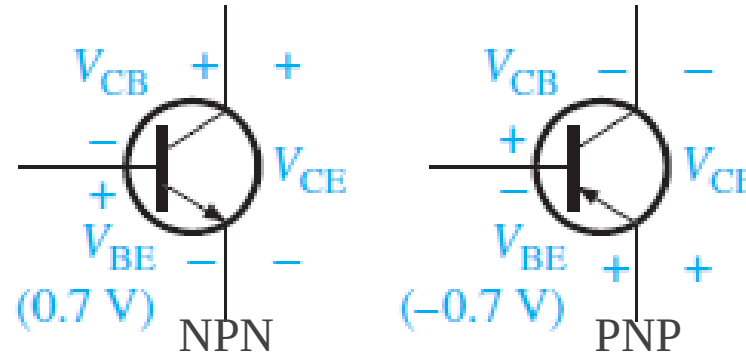
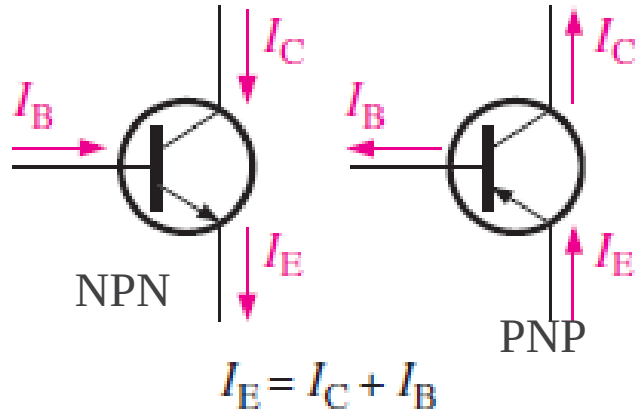
I_B provides the input and I_C provides the output



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CURRENTS AND VOLTAGES

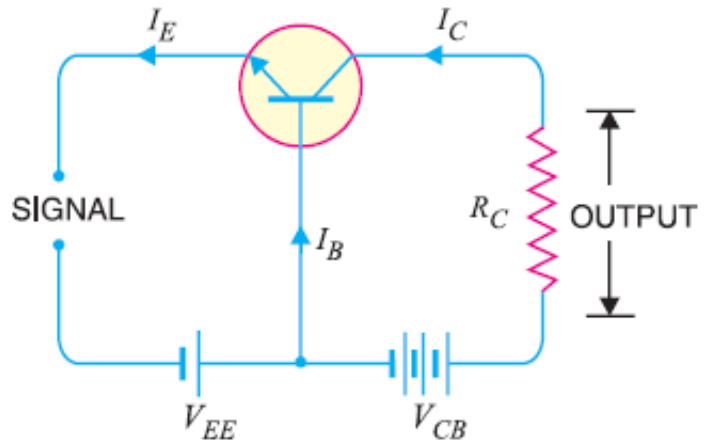


► Transistor has Three basic configurations:

- Common Emitter Configuration – has both Current and Voltage Gain.
- Common Base Configuration – has Voltage Gain but no Current Gain.
- Common Collector Configuration – has Current Gain but no Voltage Gain.

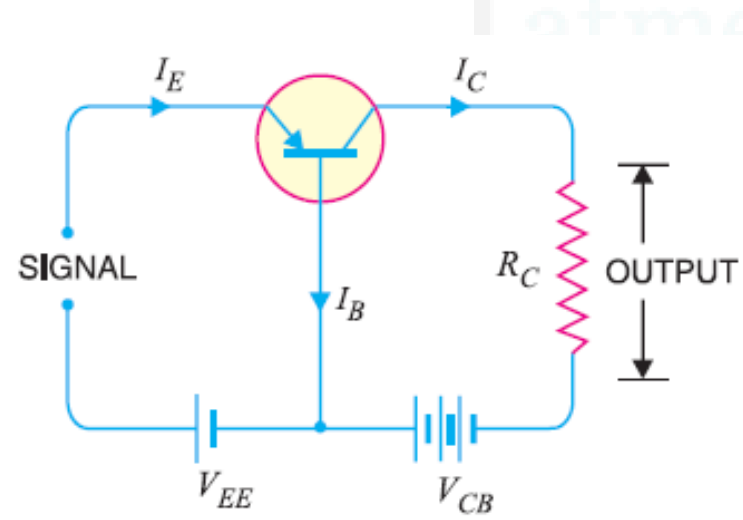
► Bipolar Transistors have the ability to operate within three different regions:

- Active Region – the transistor operates as an amplifier and $I_C = \beta \cdot I_B$
- Saturation – the transistor is "Fully-ON" operating as a switch
- Cut-off – the transistor is "Fully-OFF" operating as a switch

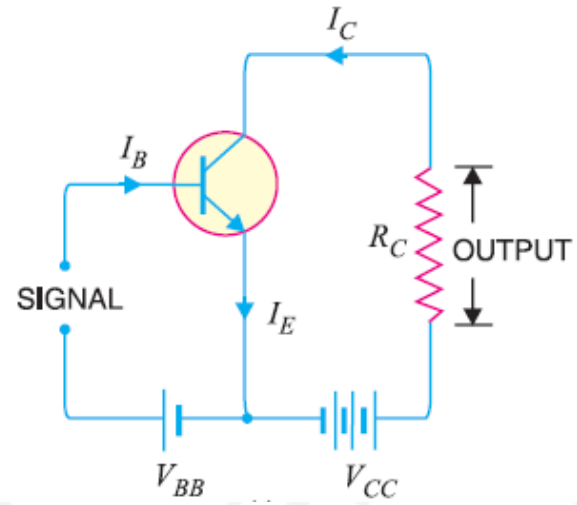


Common Base NPN Transistor Circuit

In a common base configuration, Emitter current I_E is the input current and collector current I_C is the output current.

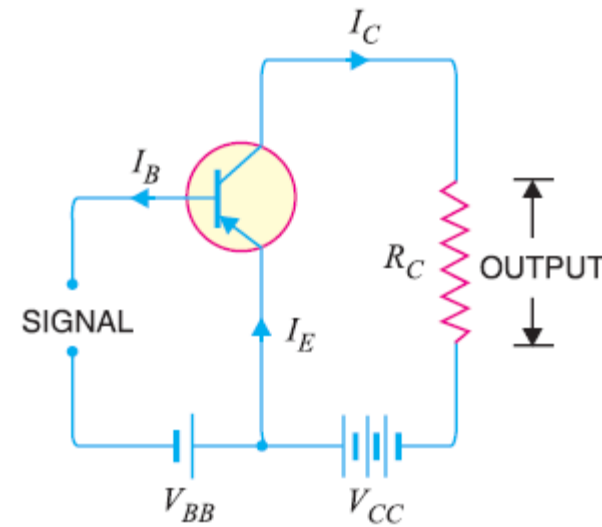


Common Base PNP Transistor Circuit

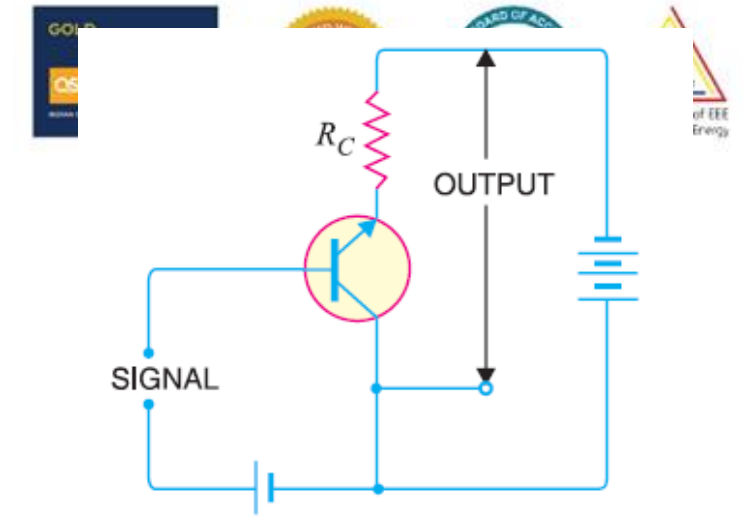


Common Emitter NPN Transistor Circuit

Input is applied between Base and Emitter and output is taken between Collector and Emitter Terminal

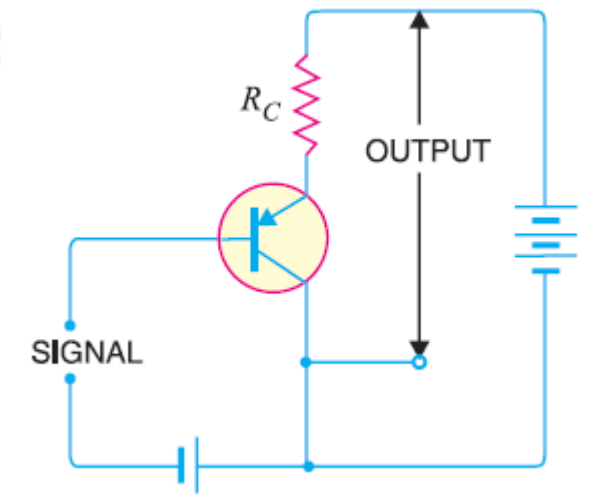


Common Emitter PNP Transistor Circuit



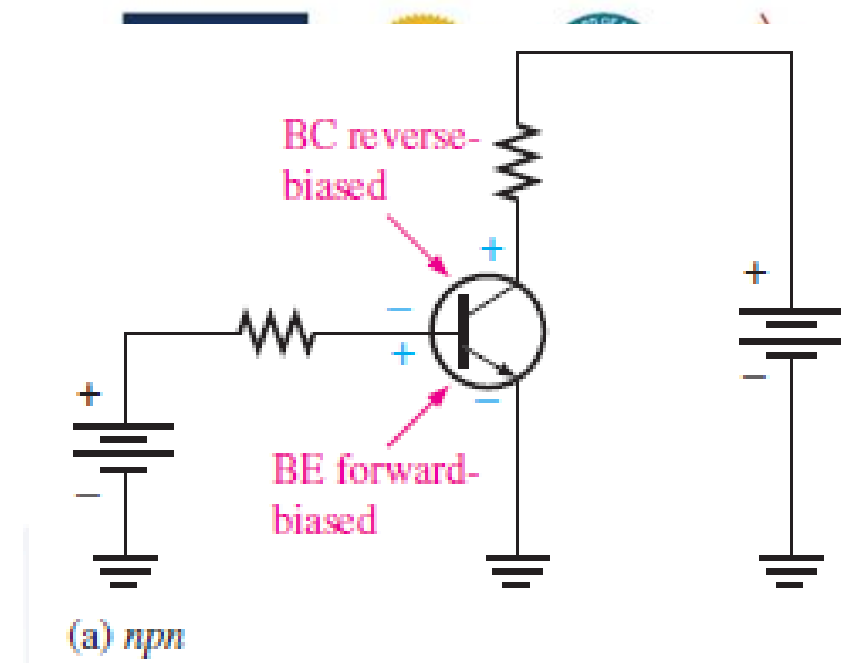
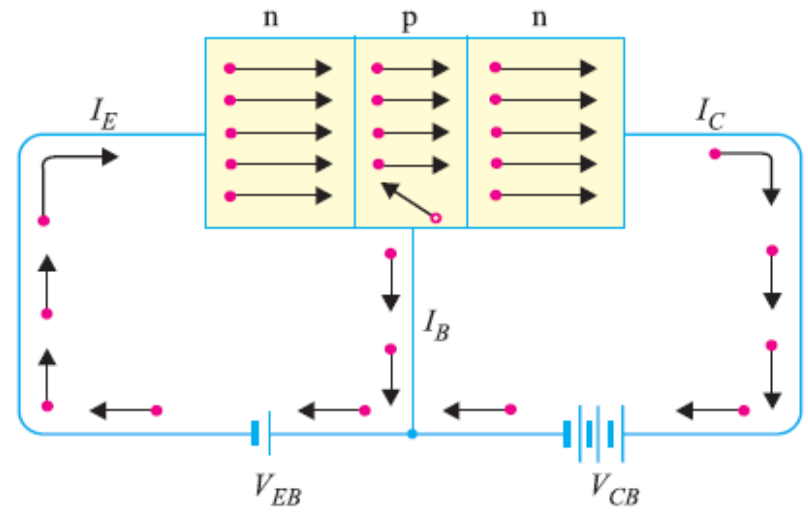
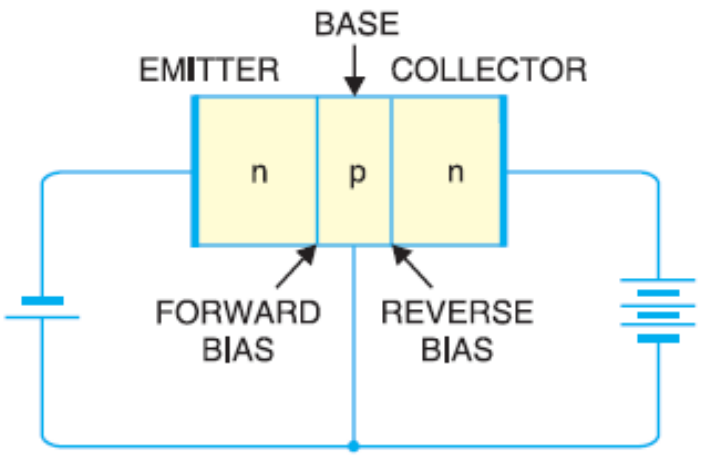
Common Collector NPN Transistor Circuit

Input is applied between the Base and Collector and the output is taken between the Emitter and Collector terminals

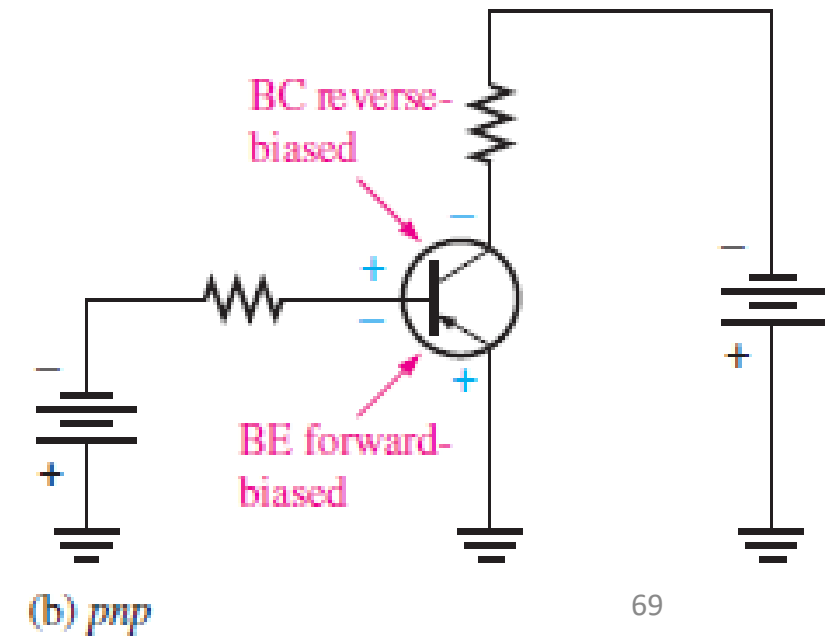
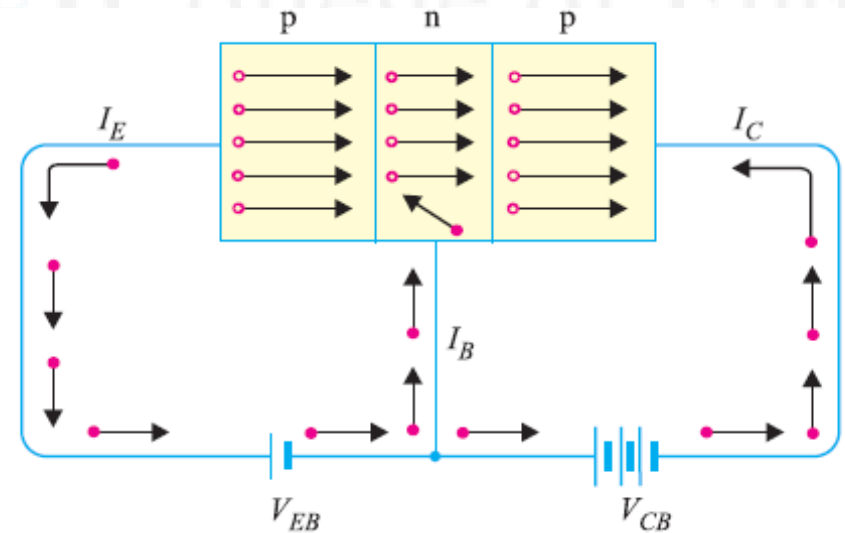
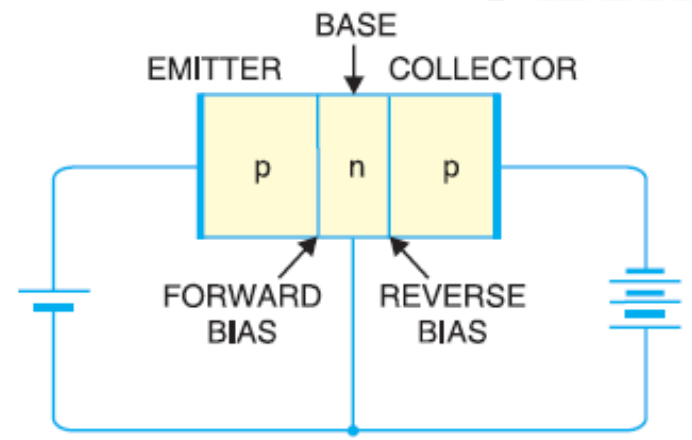


Common Collector PNP circuit

Biasing Arrangement



PNP Transistor Working

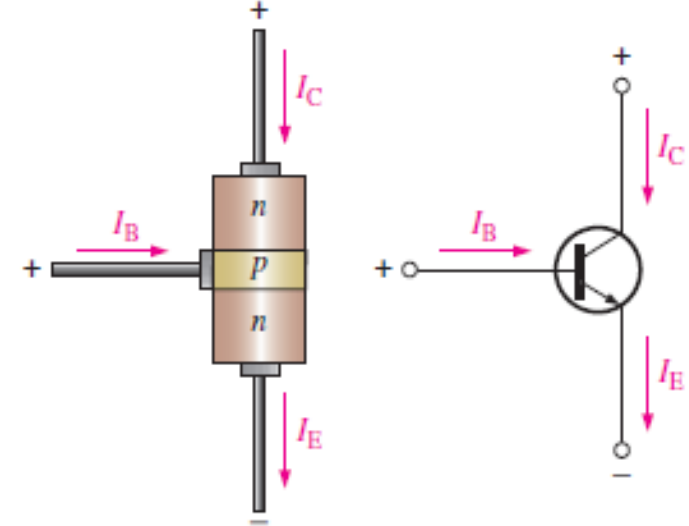


Biasing Arrangement & Transistor Currents

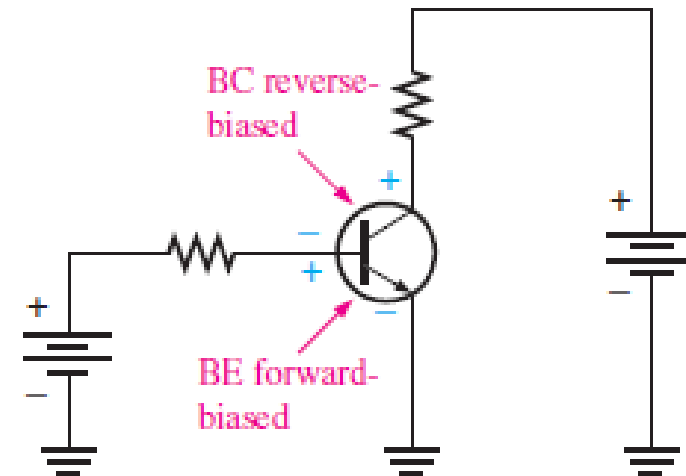
NPN Transistor Working

$$I_E = I_C + I_B$$

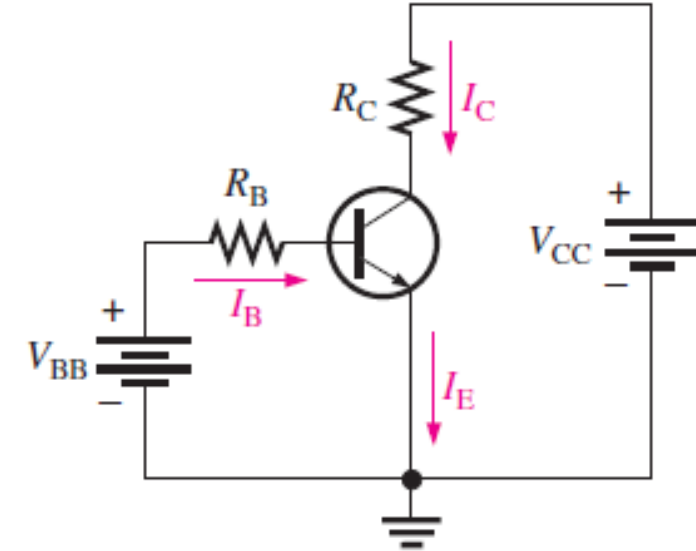
I_B is very small compared to I_E or I_C . The capital-letter subscripts indicate dc values. Lowercase italic subscript Indicate AC quantities I_b , I_c , and I_e



(a) npn

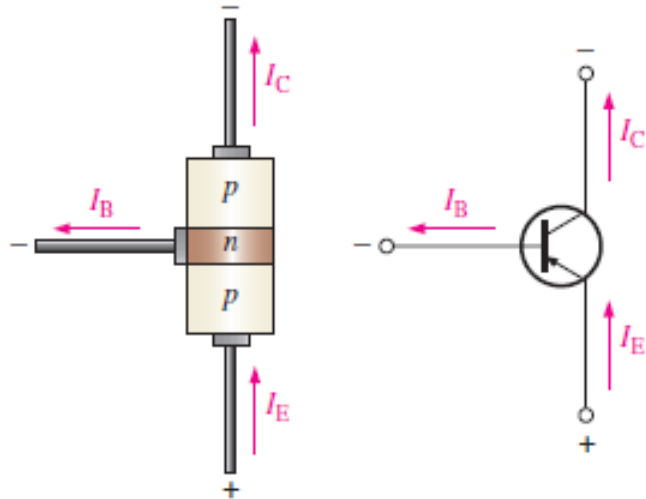


(a) npn

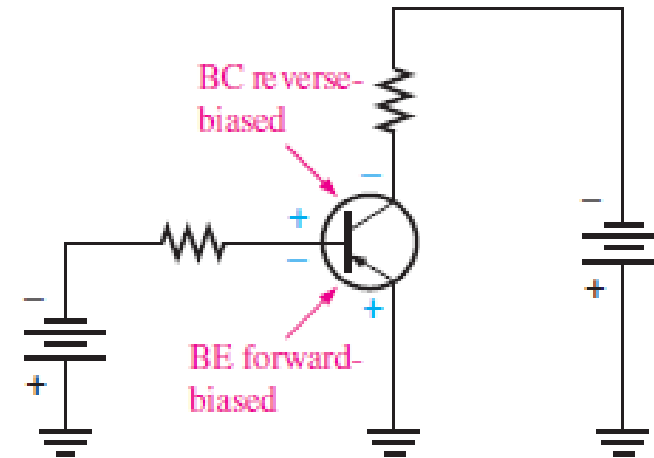


(a) npn

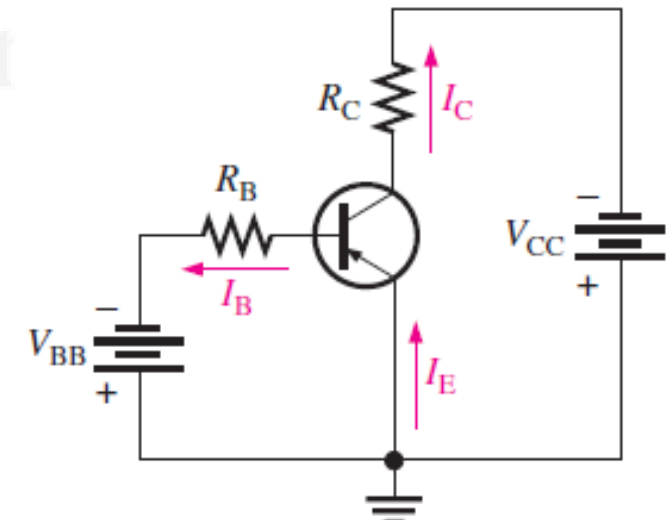
PNP Transistor Working



(b) pnp



(b) pnp



(b) pnp

Voltage Divider Bias Stabilisation

Method – 1

$$S_{I_{C0}} = \frac{1 + \beta}{1 + \beta \left(\frac{R_E}{R_E + R_B} \right)}$$

Method – 2

$$S_{V_{BE}} = \frac{-\beta}{R_B + (1 + \beta)R_E}$$

(where $R_B = R_{TH}$)

Method – 3

$$S_{\beta} = \frac{I_{C1}(R_B + R_E)}{\beta_1(R_B + R_E(1 + \beta_2))}$$

(with $R_B = R_{TH}$)



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Thank You

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