Analog Electronics

DIPLOMA WALLAH

EE/EEE

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1. Diode – V-I Characteristics, Types, Ratings & Applications; Zener Diode & Voltage Regulation

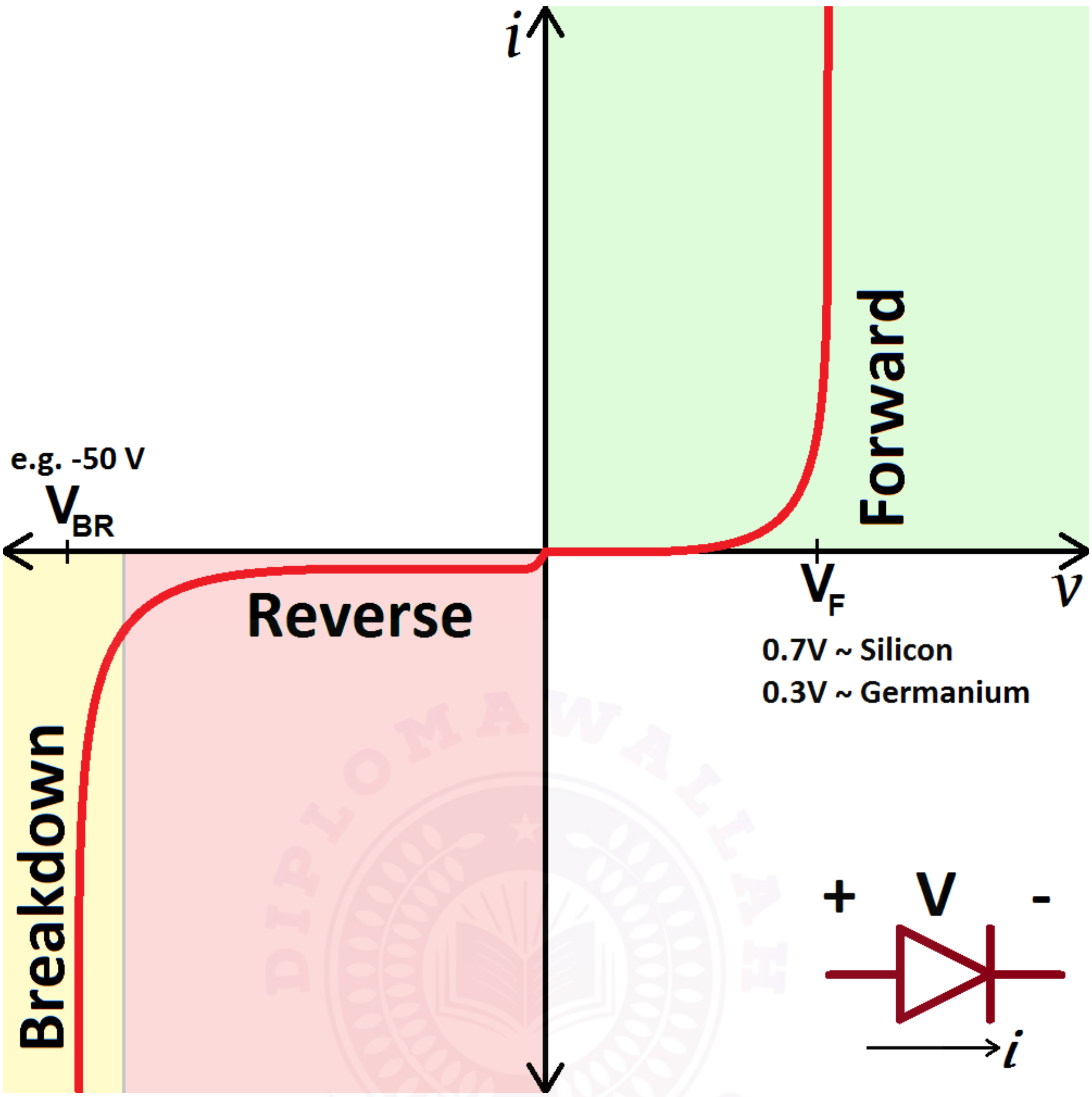
1.1 Diode and its V-I Characteristics

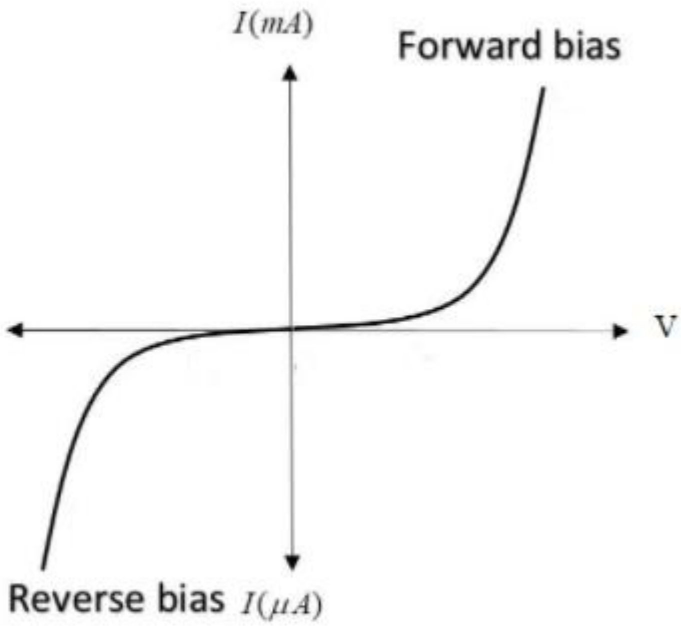
Definition & Basic Operation

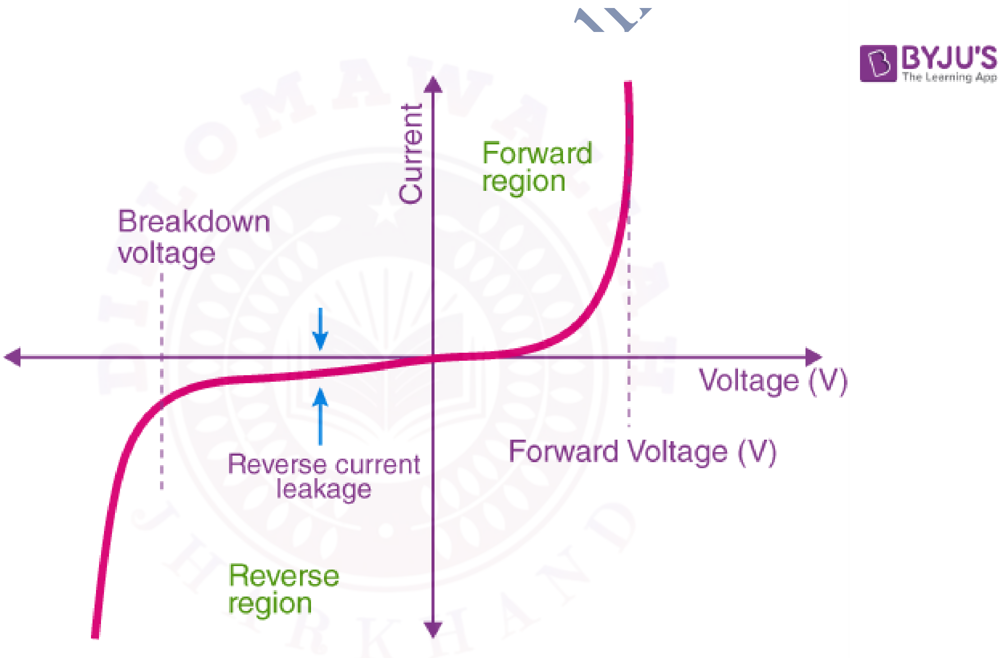
A diode is a two-terminal semiconductor device (one p-side, one n-side) that allows current to flow primarily in one direction (from anode to cathode when forward-biased) and blocks in the opposite direction (when reverse-biased). (GeeksforGeeks)
In simplest terms: anode = p-type, cathode = n-type. When forward-biased (p connected to positive, n to negative), the barrier is reduced and current flows. When reverse-biased, the barrier increases, the depletion region widens and very little current flows. (Virtual Labs)

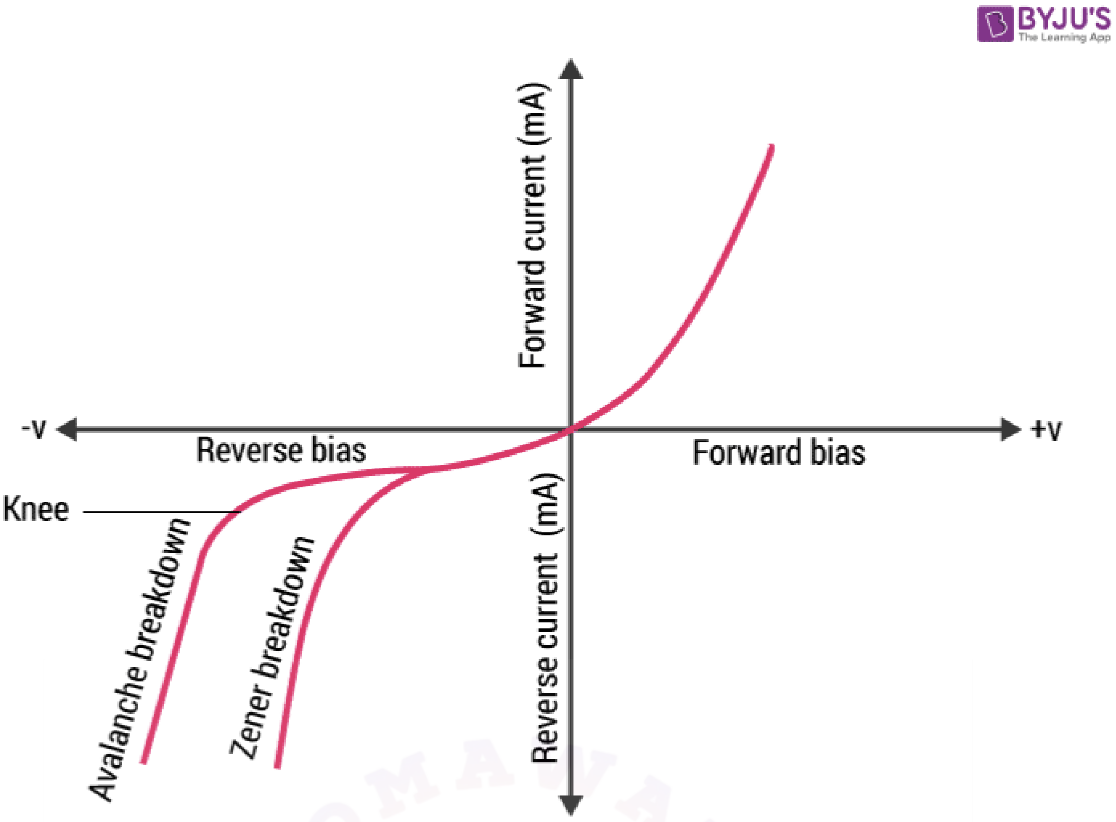
V-I (Volt-Ampere) Characteristic Curve

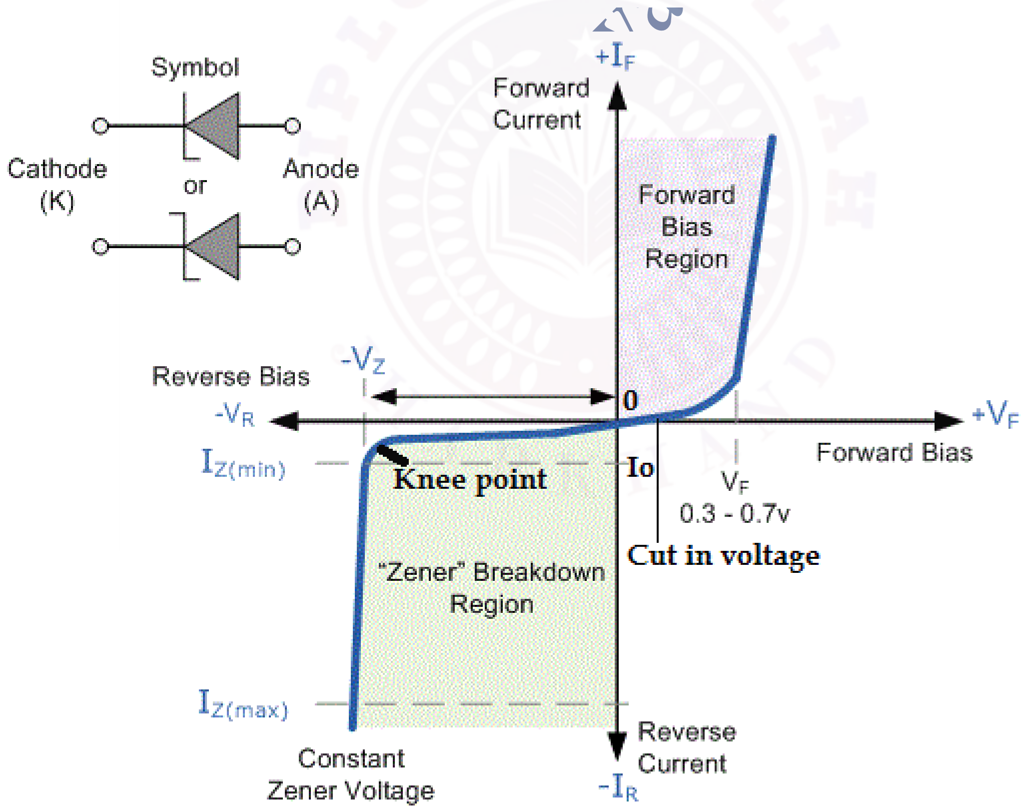
The V-I characteristic shows the relationship between voltage across the diode and the current through it. (Virtual Labs)


i
Forward
e.g. -50 V
V_BR
Reverse
V_F
v
0.7V ~ Silicon
0.3V ~ Germanium
Breakdown
+ V -
i


I(mA)
Forward bias
V
Reverse bias I(μA)


BYJU'S
The Learning App
Current
Forward region
Breakdown voltage
Voltage (V)
Forward Voltage (V)
Reverse current leakage
Reverse region





Key regions of the V-I curve:

- **Zero bias**: No external voltage applied; small equilibrium current carriers only. (Testbook)

- **Forward bias region**: As voltage is increased positive on p-side, once the forward threshold (approx. 0.7 V for Si, ~0.3 V for Ge) is reached, current increases rapidly. The diode acts like a closed switch after that threshold. (Virtual Labs)
- **Reverse bias region**: Diode blocks current; only leakage (micro- or nano-amps) flows. Up to a breakdown voltage (V_{BR}), current remains small. Then at breakdown the current increases steeply (unless limited) and the diode may be destroyed if not a special type. (Inst Tools)

Important observations:

- The curve is **non-linear**. Unlike a resistor, you cannot apply Ohm's law simply. (SparkFun Learn)
- The knee point or threshold (forward) and breakdown (reverse) are characteristic.
- Temperature affects the curves: e.g., forward drop decreases slightly with increasing temperature, reverse leakage increases. (Inst Tools)

Ratings & Important Parameters

When selecting diodes, you must pay attention to:

- Maximum forward current ((I_F(\text{max})))
- Maximum reverse voltage or peak reverse voltage ((V_R(\text{max})))
- Reverse leakage current ((I_{R(\text{leak})}))
- Forward voltage drop ((V_F)) at a given current
- Recovery time (especially in switching diodes)
- Power dissipation (heat)
  Manufacturers specify these so you choose the correct diode for your circuit.

Types of Diodes & Applications

Some common diode types and their uses:

- PN Junction (rectifier) diode: converts AC to DC. (ELECTRICAL TECHNOLOGY)

- Small-signal diode: low current, fast switching. (ELECTRICAL TECHNOLOGY)
- Schottky diode: metal-semiconductor junction, very low forward drop, fast switching. (ELECTRICAL TECHNOLOGY)
- Light Emitting Diode (LED): emits light when forward biased. (ELECTRICAL TECHNOLOGY)
- Photodiode: generates current when exposed to light (reverse biased) — used in sensors. (ELECTRICAL TECHNOLOGY)
- Zener diode (we'll discuss next).
- Tunnel diode, Varicap (voltage-dependent cap) diode, etc.

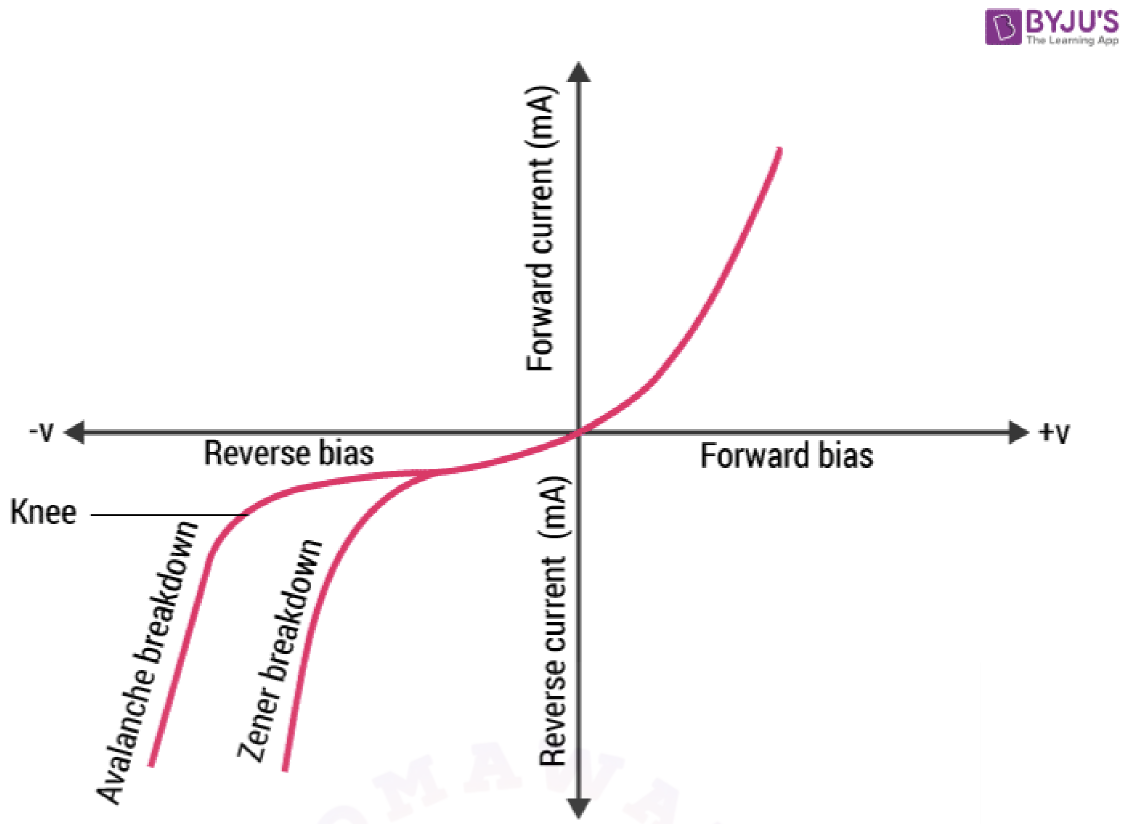
Typical applications: rectification, voltage regulation, switching circuits, signal demodulation, protection circuits (ESD), logic circuits, sensors. (GeeksforGeeks)

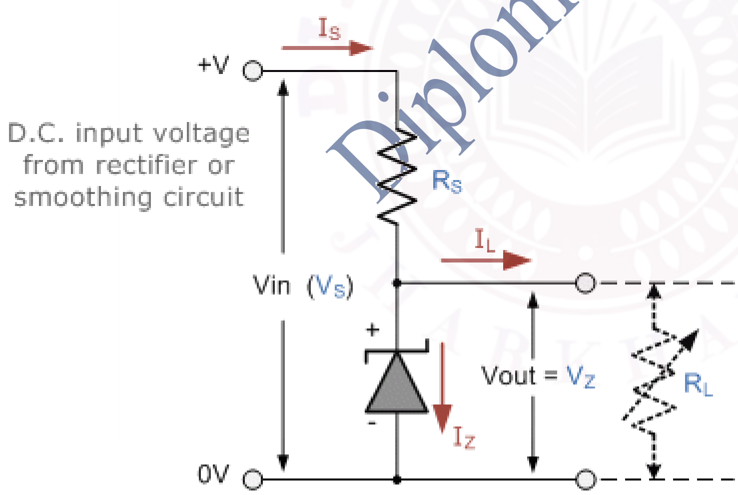
1.2 Zener Diode – Reverse Bias Characteristics, Voltage Regulation, Shunt Voltage Regulator & Applications

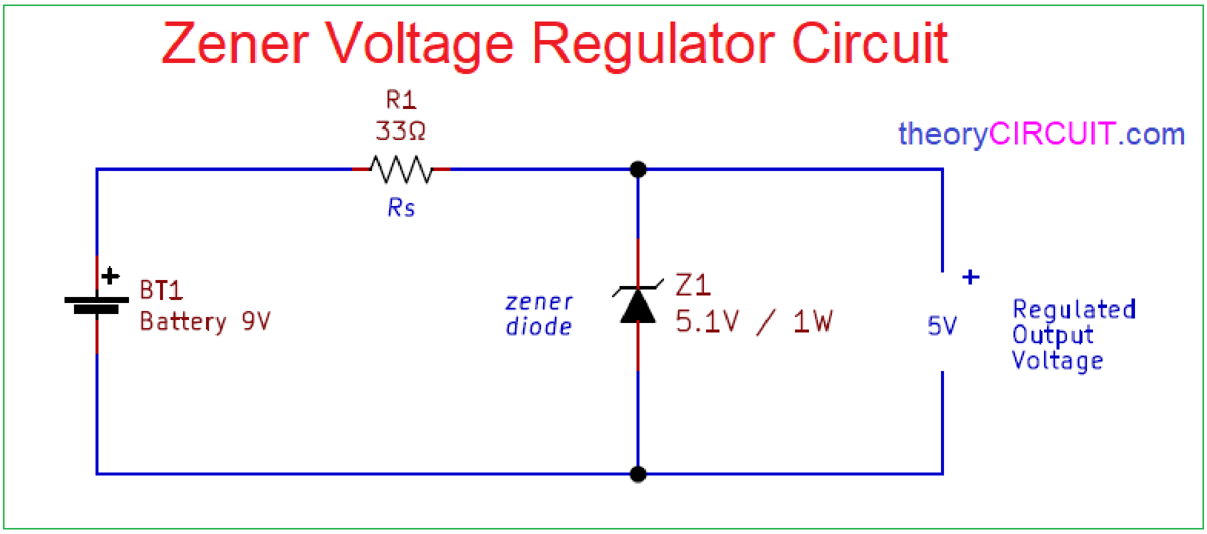
Definition & Operation

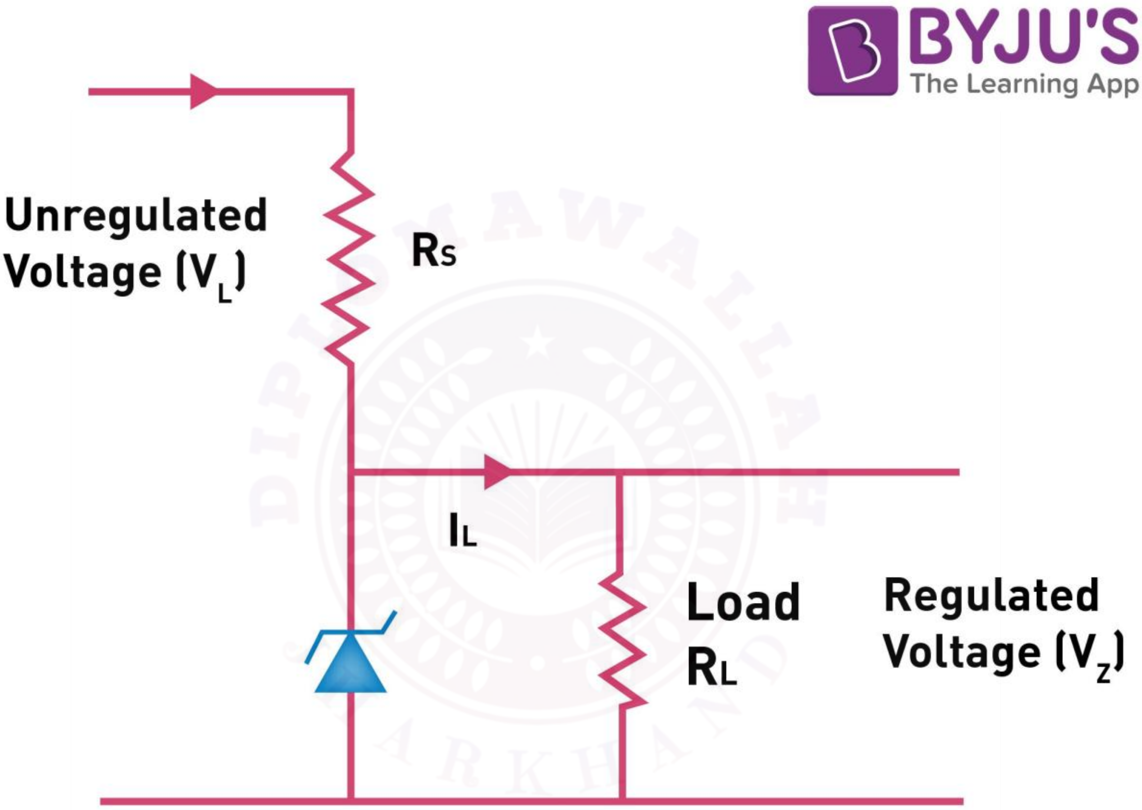
A Zener diode is a specially fabricated p-n junction diode designed to operate in the reverse breakdown region at a precise voltage. It is heavily doped to achieve a thin depletion region and a sharp breakdown characteristic. (Physics and Radio Electronics)
In forward bias it behaves like a normal diode (approx. 0.7 V drop for Si). In reverse bias when the reverse voltage reaches the Zener breakdown voltage (Vz), the diode conducts in reverse and maintains a nearly constant voltage (with the current varying) provided current is within specified limits. (Physics and Radio Electronics)

V-I Characteristic in Reverse Bias


BYJU'S
The Learning App
Forward current (mA)
-v
+v
Reverse bias
Forward bias
Knee
Avalanche breakdown
Zener breakdown
Reverse current (mA)


Is
+V
D.C. input voltage
from rectifier or
smoothing circuit
Rs
IL
Vin (Vs)
+
-
Iz
Vout = Vz
RL
0V





The curve in reverse shows: small leakage current until breakdown knee; then as voltage approaches Vz, the voltage stays almost constant while current rises (if limited) — this is the key for regulation.

Voltage Regulation & Shunt Regulator

A Zener diode configured as a shunt regulator works as follows: You connect a resistor (R) from supply (V_{in}) to Zener diode in reverse bias, load connected in parallel with Zener. The resistor drops the excess voltage, the Zener holds the output node at nearly constant Vz. As load current varies, the diode current adjusts to maintain voltage. This provides a simple voltage regulation.
Important: the resistor must be chosen to maintain Zener current above minimum required and below maximum when load current changes; without proper design the regulated voltage may deviate or diode may overheat.

Applications of Zener Diode & Shunt Regulation

- Provision of fixed reference voltage (e.g., 5.6 V, 12 V) for circuits.
- Protection of circuits against over-voltage (Zener acts as clamp).
- Simple low-cost voltage regulators in low current applications.
- Waveform clippers and clampers.
- In measurement circuits, transistor bias circuits, etc.

Advantages & Limitations

Advantages: Simple, inexpensive, stable reference, useful for moderate current, robust.
Limitations: Not efficient for high current/high power regulation (because excess energy is dissipated in resistor & Zener), regulation poor compared to active regulators, wasteful at no-load (Zener current still flows).

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2. Bipolar Junction Transistor (BJT) – Structure, Types, Symbols, Construction, Operation, Configurations, Currents & α/β Relationships

2.1 Structure, Types & Symbols

Structure & Construction

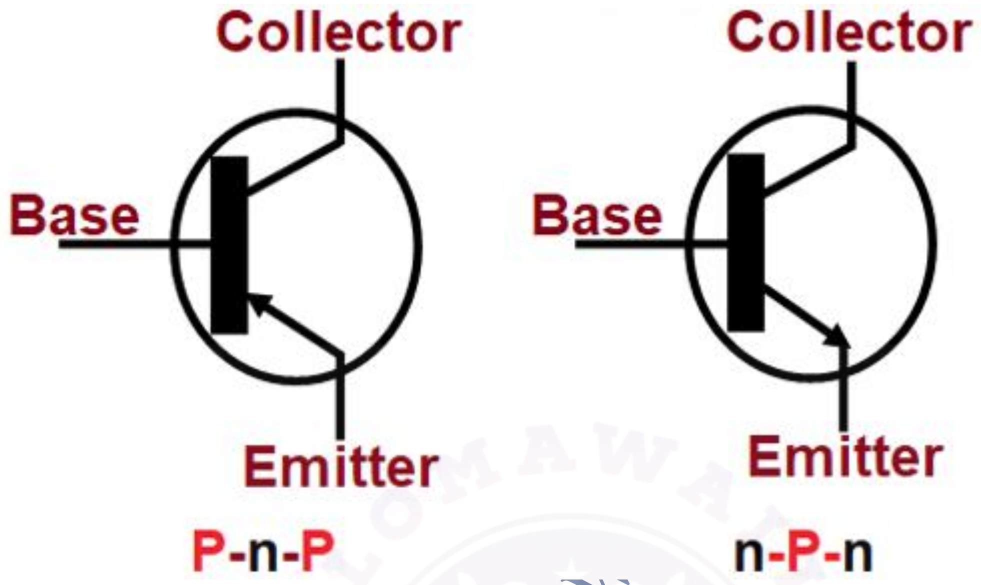
A BJT is a three-layer semiconductor device: either NPN or PNP. It consists of an emitter region (heavily doped), a base region (thin, lightly doped), and a collector region (moderately doped, larger area) to collect carriers. (Engineering LibreTexts)

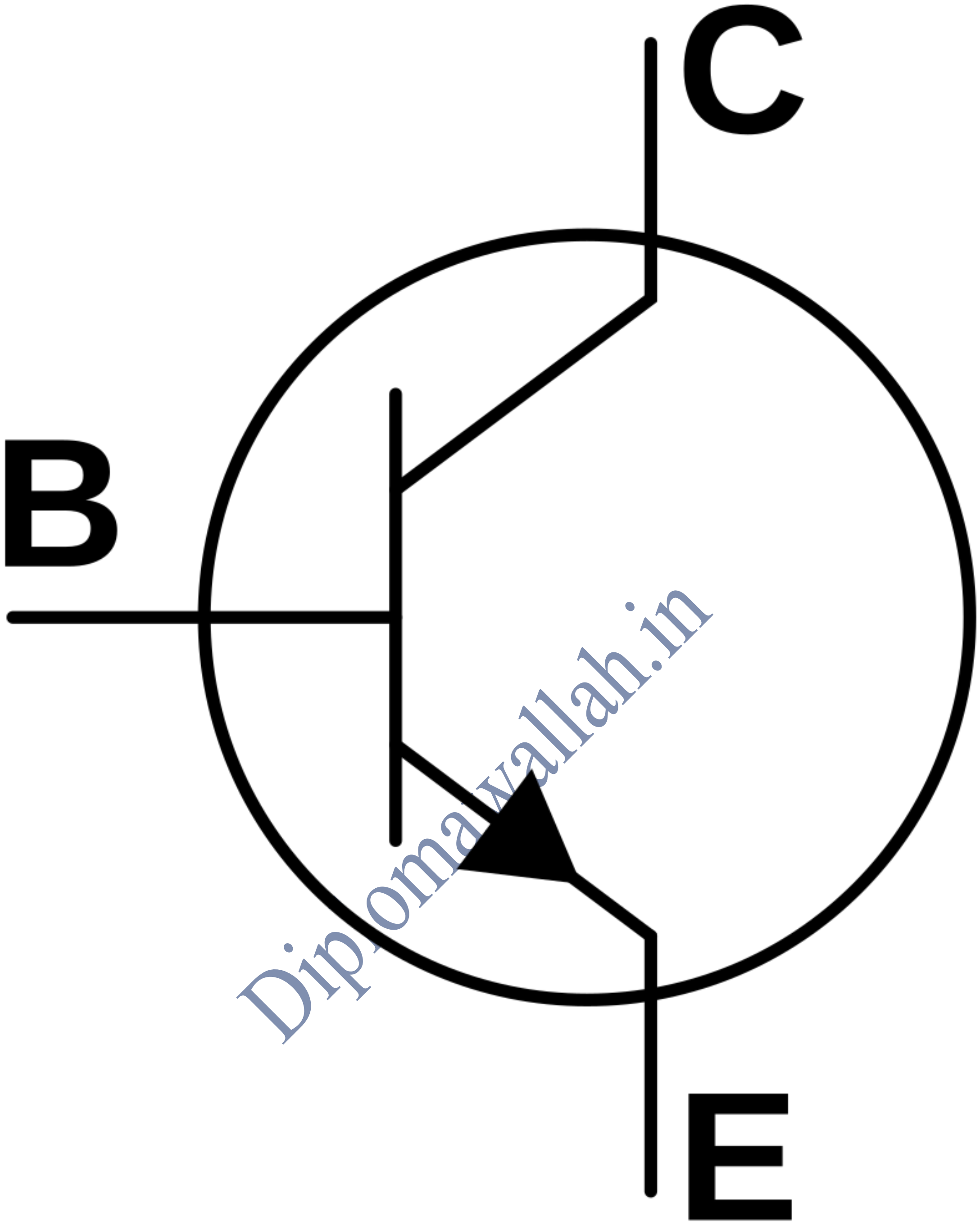
- For **NPN**: emitter is n-type, base p-type, collector n-type.

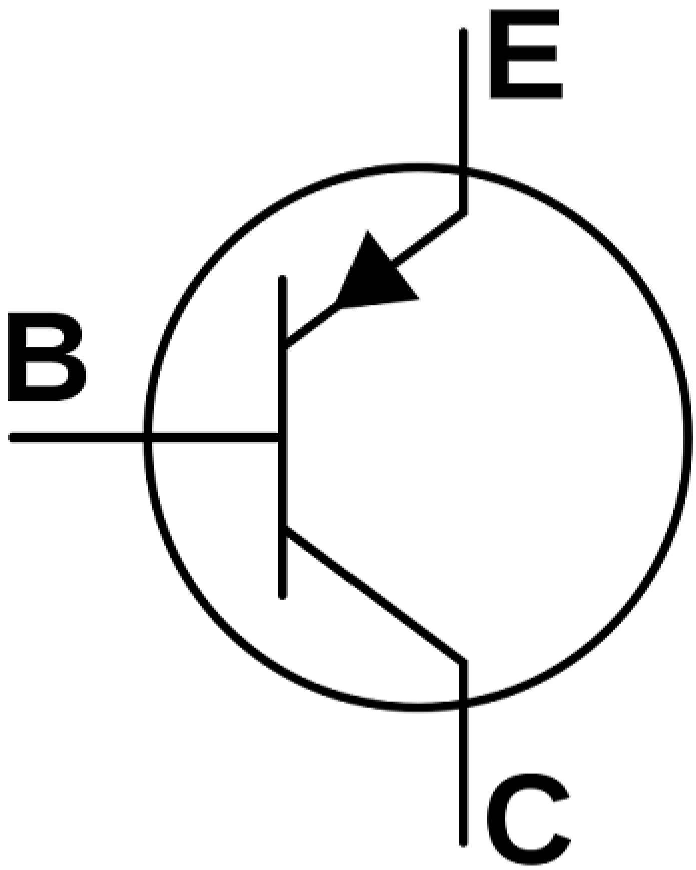
- For **PNP**: emitter p-type, base n-type, collector p-type.

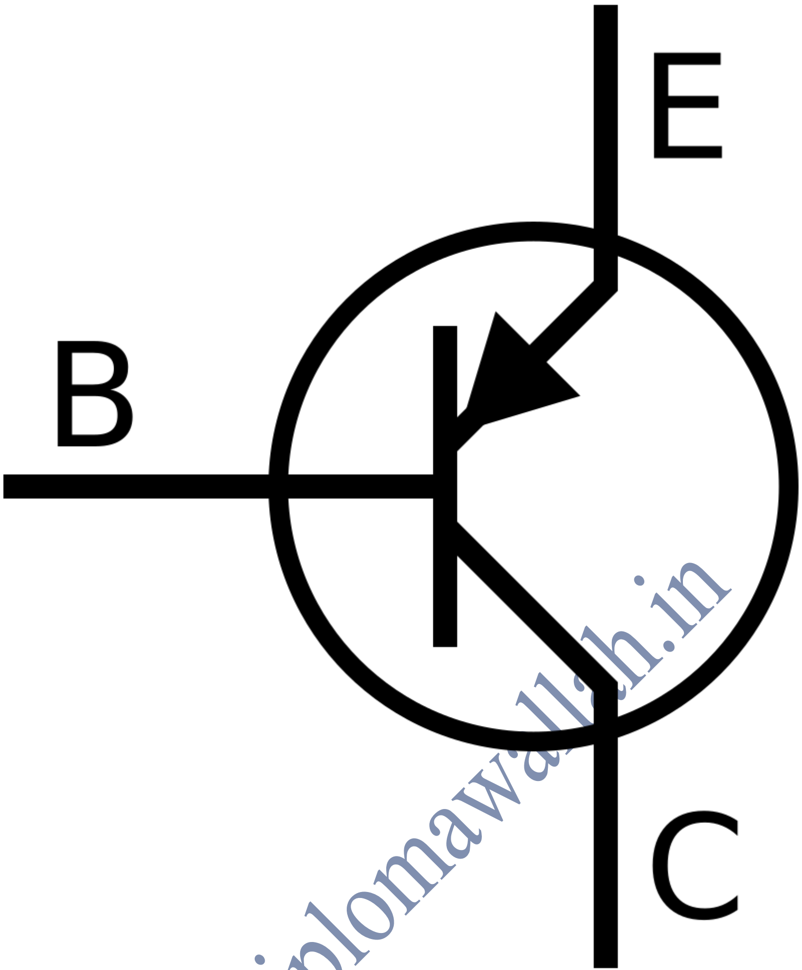
The emitter-base junction is forward-biased (for normal active operation) and the collector-base junction is reverse-biased. Most carriers are injected from emitter into base then swept into collector. (Wikipedia)

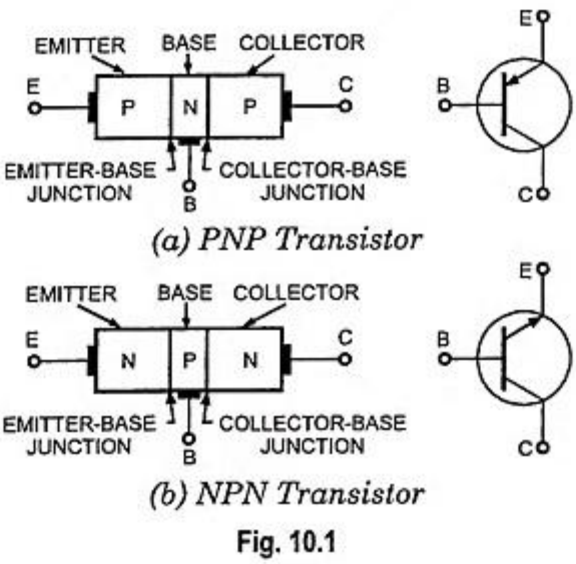
Symbols




C
B
E


E
B
C

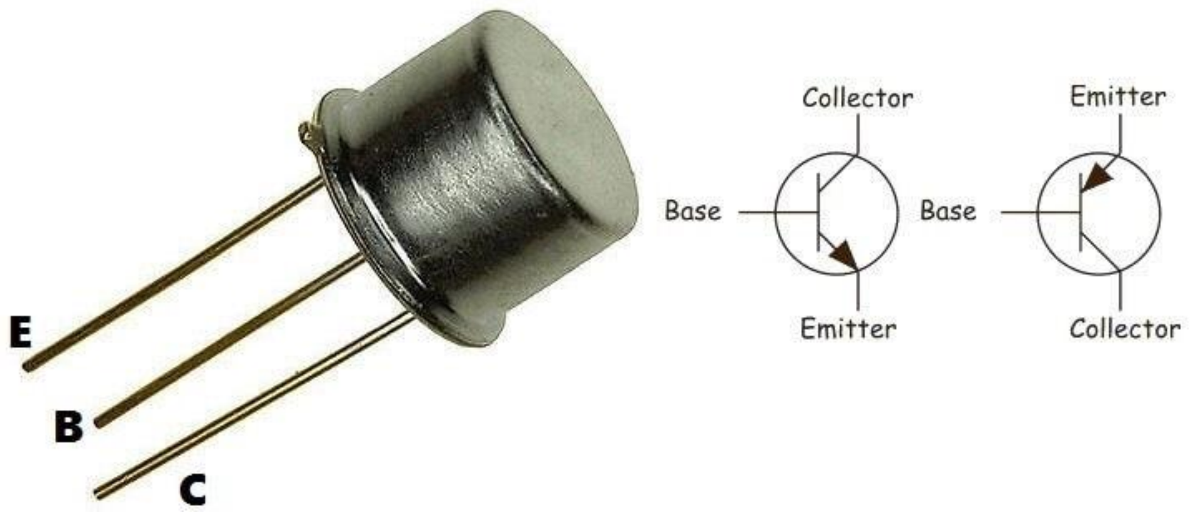




(a) PNP Transistor

(b) NPN Transistor

Fig. 10.1



Symbols show three terminals: E (emitter), B (base), C (collector); the arrow indicates the emitter current direction (for NPN arrow points out of emitter, for PNP into emitter).

2.2 Operation (NPN / PNP)

NPN Operation (common)

When the base-emitter junction is forward biased (for example +ve on base relative to emitter in NPN) and base-collector junction is reverse biased, electrons from the emitter are injected into the base. The base is thin and lightly doped, so most electrons diffuse across to the collector, only a small fraction recombines in the base. Hence collector current is largely controlled by emitter injection and base biasing. (Engineering LibreTexts)

PNP Operation

Same principle but with reversed polarities: emitter emits holes into base, base is n-type, collector collects the holes, arrow direction and biasing reversed accordingly.

2.3 BJT Configurations

There are three basic circuit configurations for a BJT:

- Common Emitter (CE) – emitter is common to input & output circuits; high gain, phase inversion.
- Common Base (CB) – base is common; lower input impedance, high output impedance, no phase inversion.

- Common Collector (CC) or Emitter Follower – collector common; high input impedance, low output impedance, unity gain (≈1).
  In exam/analogy, CE is most used.

2.4 Transistor Currents, α, β and the relationship

Transistor Currents

Define:

- I_E = emitter current
- I_B = base current
- I_C = collector current

From Kirchhoff's current law:

$$I_E = I_C + I_B$$

(Basic Electronics Tutorials)

Definitions of α and β

- **α (alpha)**: Common-base current gain = $\alpha = \dfrac{I_C}{I_E}$. It is less than unity (since some emitter current recombines in base). (Wikipedia)
- **β (beta)**: Common-emitter current gain = $\beta = \dfrac{I_C}{I_B}$. It is typically much greater than 1 (e.g., 20 to 200). (Basic Electronics Tutorials)

Relationship between α and β

The two are related by the formulas:

$$\alpha = \dfrac{\beta}{\beta + 1}, \quad \beta = \dfrac{\alpha}{1 - \alpha}$$

(Electrical Engineering Stack Exchange)
Also because $I_E = I_C + I_B$ and $I_C = \alpha I_E$ we can derive the relationships. (Basic Electronics Tutorials)

Important to mention: in design or exam you may get values of β or α and you must convert or use these relations to compute currents.

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3. CE Input/Output Characteristics – Cut-off, Saturation, Active Regions; Transistor Biasing – Definition, Importance,

Types; Voltage Divider Bias; Transistor as Switch in CE Mode; Stabilisation, Thermal Runaway, Heat-Sink

3.1 CE (Common Emitter) Input & Output Characteristics

Regions of Operation

In CE configuration the transistor can operate in three major regions:

- **Cut-off region**: Base current ($I_B \approx 0$), so collector current ($I_C \approx 0$). Transistor is essentially "OFF".
- **Active region**: Base-emitter junction forward biased, base-collector junction reverse biased. Collector current ~ $\beta \times$ base current. Useful for amplification.
- **Saturation region**: Both junctions forward biased; transistor is "fully ON", collector-emitter voltage is very small (~0.1-0.3 V). Used for switching.

Input & Output Characteristics

- **Input characteristic**: Plot of base current (I_B) versus base-emitter voltage (V_{BE}) (keeping collector-emitter voltage constant).
- **Output characteristic**: Plot of collector current (I_C) versus collector-emitter voltage (V_{CE}) for various base currents. In output curves, regions of operation (cut-off, active, saturation) are visible (collector current rises with (V_{CE}) in active region until saturation etc.).

3.2 Transistor Biasing – Definition & Importance

Definition: Setting a fixed DC operating point (Q-point) of the transistor by applying DC voltages/currents so that the transistor remains in the required region (usually active for amplifier) during signal variations.

Importance:

- Ensures that signal swings (AC component) do not push transistor out of its region (for example into saturation or cut-off) unless intended.
- Provides stability against variations (temperature, β variation, power supply fluctuation) so the amplifier works reliably.

- Improper biasing can lead to distortion, instability, thermal runaway or device damage.

3.3 Types of Transistor Biasing

Common types include:

- Fixed bias (base resistor from supply).
- Emitter-bias (resistor in emitter to provide feedback).
- Collector-feedback bias.
- Voltage-divider bias (also called potential divider bias) – widely used due to better stability. (Basic Electronics Tutorials)

3.4 Voltage Divider Bias – Explanation

In this method, two resistors form a divider from the supply (V_{CC}) forming a stable base bias voltage (V_B). The base is connected to the junction of the divider, emitter has an emitter resistor for negative feedback, collector has load resistor.
This arrangement is preferred because the base bias point is largely independent of β variations and transistor parameter changes; it improves Q-point stability. (Engineering LibreTexts)

Design steps (briefly):

1. Choose desired collector current (I_C) and (V_{CE}) (Q-point).
2. Choose emitter resistor (R_E) so that emitter voltage (V_E) is comfortable (e.g., ~10–20% of (V_{CC})).
3. Choose base voltage ($V_B \approx V_E + V_{BE}$).
4. Choose divider resistors (R_1, R_2) such that base current perturbations have minimal effect (e.g., divider current much larger than base current).
5. Check actual values and adjust.

3.5 Transistor as a Switch in CE Mode

In CE mode, when used as a switch:

- **OFF state**: Transistor is in cut-off; ($I_B \approx 0$), ($I_C \approx 0$); load receives no current (or minimal leakage).
- **ON state**: Transistor is saturated; both junctions forward biased; ($V_{CE(sat)}$) is small (~0.1-0.3 V); collector current flows

strongly (limited by load/resistors).
This is common in digital switching, driver circuits, relay drives etc.

3.6 Stabilisation, Thermal Runaway & Heat-Sink

Stabilisation

Refers to design considerations so that the Q-point remains stable against variations: transistor β variation, temperature changes, power supply fluctuations, device ageing.

Thermal Runaway

Transistors generate heat when current flows. Increased temperature causes increased leakage current, reducing (V_{BE}), increasing base current (for fixed bias), increasing collector current, leading to more heat — a positive feedback loop. Ultimately device may destroy itself. Good biasing, emitter resistor, heat-sink and thermal feedback help avoid this.

Heat-Sink

A heat-sink is a device that increases surface area and thermal conduction to ambient, lowering the transistor's junction temperature for a given power dissipation. This assists in preventing thermal runaway and improving reliability.

Summary Table

Topic	Key Points
Diode V-I characteristics	Non-linear curve; forward threshold; reverse leakage; breakdown region.
Types of diode	Rectifier, small-signal, Schottky, LED, photodiode, Zener, etc.
Zener diode & regulation	Reverse breakdown at fixed voltage; used as reference or shunt regulator.
BJT structure/types	NPN & PNP; emitter, base, collector; doping levels.
BJT operation	Emitter injects carriers, base thin & lightly doped, collector collects.

Currents & gains	(I_E = I_C + I_B); (\alpha = I_C/I_E); (\beta = I_C/I_B); (\alpha = \beta/(\beta+1)).
CE characteristics & regions	Cut-off, active, saturation; input/output characteristic curves.
Biasing & voltage divider	Provide stable Q-point; voltage divider preferred for stability; design steps.
Switching & thermal issues	Transistor used as switch (cut-off/ saturation); must avoid thermal runaway; use heat-sink.

1. BJT Configurations; Transistor Currents; α, β and their Relationship

1.1 BJT Configurations

The three basic configurations

A Bipolar Junction Transistor (BJT) has three terminals: Emitter (E), Base (B), Collector (C). There are three standard ways to connect it in a circuit, distinguished by **which terminal is common** (i.e., used by both input and output). (EC Studio Systems)

- **Common Base (CB)**: The base is the common terminal (grounded or fixed). Input is between emitter and base; output between collector and base. (Basic Electronics Tutorials)
- **Common Emitter (CE)**: The emitter is the common terminal. Input between base & emitter; output between collector & emitter. This is the most widely used for amplification. (Basic Electronics Tutorials)
- **Common Collector (CC)** or "emitter-follower": The collector is the common terminal. Input between base & collector; output from emitter & collector. Often used for impedance matching/buffer. (Basic Electronics Tutorials)

Key characteristics comparison

Configuration	Input impedance	Output impedance	Voltage gain	Current gain	Phase shift

CB	Low	Very high	High	Less than or ≈ 1	~0° (Basic Electronics Tutorials)
CE	Medium	High	Medium to high	High	~180° (Basic Electronics Tutorials)
CC (Emitter follower)	High	Low	≈1 (unity)	High	~0° (Basic Electronics Tutorials)

Why pick one over another?

- If you need **high voltage gain**, CB can be useful (especially at high frequency) though current gain is small. (Wikipedia)
- If you need **both voltage and current gain**, CE is often the design choice.
- If you need **buffering/impedance transformation** (i.e., high input, low output), CC (emitter-follower) is used.

1.2 Transistor Currents and Definitions of α & β

Currents in a BJT

By Kirchhoff's law at the transistor node:
[
I_E = I_C + I_B
]
Where:

- (I_E) = emitter current
- (I_C) = collector current
- (I_B) = base current

Definitions

- **α (alpha)**: The current-gain in the **common-base** configuration; defined as
  $$\alpha = \frac{I_C}{I_E}$$
  Since (I_C) is slightly less than (I_E) (because (I_B) is small but non-zero), α is less than 1 (typical values ~0.95 to 0.99 for small signal transistors). (Basic Electronics Tutorials)

- **β (beta)**: The current-gain in the **common-emitter** configuration; defined as
  $$\beta = \frac{I_C}{I_B}$$
  Because base current is small and collector current much larger, β is typically much greater than 1 (values like 20 to 300 are common for small-signal BJTs).

1.3 Relationship between α and β

From ($I_E = I_C + I_B$), substitute ($I_C = \alpha I_E$). Because ($I_B = I_E - I_C$), you can derive the relationship between α and β:
$$\beta = \frac{\alpha}{1 - \alpha}, \quad \alpha = \frac{\beta}{\beta + 1}$$
So for example if β = 99 → α = 99 / (99 + 1) = 0.99. And if α = 0.98 → β = 0.98 / (1 - 0.98) = 49.
These relationships are important when you're given one gain and need to compute the other, or if you're analysing a circuit and need to find one of the values.

1.4 Why the relationships & what they mean

- Because the emitter current is sum of base + collector, the fraction of emitter current that becomes collector current is α.
- In practical circuits, base current is often small compared to collector current, so β provides a measure of how much a small base current controls a much larger collector current.

- These gains directly affect how a transistor may be used: for example, if you need a large current gain, you use a transistor with large β (CE configuration).
- However β is not a fixed constant—it varies with device, temperature, collector current, etc. That's one reason why biasing (discussed later) is important: to make transistor operation stable despite such variation.

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2. CE Input/Output Characteristics; Transistor Biasing; Voltage Divider Bias; Transistor as Switch; Stabilisation & Thermal Runaway

2.1 CE Input & Output Characteristics

Regions of operation

In the CE configuration a transistor has three main operating regions:

- **Cut-off region**: Base-emitter junction not sufficiently forward biased; base current ~0; collector current ~0. The transistor behaves like an open switch between collector and emitter.
- **Active region**: Base-emitter is forward biased; base-collector is reverse biased; the transistor behaves like an amplifier: collector current ≈ β × base current. The collector-emitter voltage is above some minimum threshold and allows control of collector current by base current.
- **Saturation region**: Both junctions (base-emitter and base-collector) are forward biased; the transistor is fully ON; collector-emitter voltage is at minimal saturation voltage (~0.1-0.3 V). The transistor behaves like a closed switch between collector and emitter.

Input characteristic

Graph of base current (I_B) vs base-emitter voltage (V_{BE}) with collector-emitter voltage (V_{CE}) held constant. It shows how much base current flows for a given base-emitter voltage.

Output characteristic

Graph of collector current (I_C) vs collector-emitter voltage (V_{CE}) for different values of base current (I_B). On this graph you can locate the cut-off (lowest curves where ($I_B \approx 0$)), active region (slanted curves where (I_C) roughly proportional to (I_B)), and saturation (when (V_{CE}) is small and (I_C) no longer rises significantly).

2.2 Transistor Biasing – Definition & Importance

Definition

Biasing means applying DC voltages/currents to the transistor's terminals so that it operates at a desired point (called the Q-point or quiescent point) in the appropriate region (most commonly the active region for amplifiers).

Importance

- Without correct biasing, circuits may not behave predictably: e.g., a transistor may drift into saturation or cut-off in the presence of input signal swings → distortion.
- Transistor parameters like β vary widely between devices and with temperature, so biasing must be designed so that such variation does not ruin circuit behavior.
- Proper biasing ensures that the amplifier or switch will operate reliably under variations in supply voltage, transistor parameters, temperature, etc.

Common types of biasing methods

- Fixed bias (base resistor method)
- Collector-feedback bias
- Emitter-feedback bias
- **Voltage-divider bias** (most widely used for stability) (TutorialsPoint)

2.3 Voltage Divider Bias – Explanation

This is a biasing scheme where two resistors (R_1) and (R_2) form a voltage divider across the supply (V_{CC}). The midpoint of the divider is connected to the base of the transistor. The emitter usually has a resistor (R_E), and the collector has (R_C). The idea is to establish a fairly fixed base voltage (V_B), which gives a predictable emitter voltage ($V_E \approx V_B - V_{BE}$). That in turn gives emitter current ($I_E \approx V_E / R_E$) (neglecting small base current in the first approximation).

Why this method is good

- It makes the base voltage less dependent on β (since base current does not significantly affect the divider if the divider current is large compared to base current). (Atlantic Canada Pressbooks)
- With emitter resistor (R_E), negative feedback is introduced: if emitter current tends to increase, (V_E) increases, reducing base-emitter voltage, which reduces current → stable operation.
- The Q-point becomes more stable against transistor parameter variations and temperature changes.

Basic design steps (exam-type)

1. Choose (V_{CE}) (collector-emitter voltage) and (I_C) (collector current) desired for Q-point (for example, mid-supply point to allow maximum swing).
2. Choose (R_C) from ($V_{CC} - V_{CE} - V_E$) divided by (I_C).
3. Choose emitter resistor (R_E) so that (V_E) is some fraction (e.g., ~10-20%) of (V_{CC}) to provide effective feedback.
4. Set base voltage ($V_B = V_E + V_{BE}$) (with ($V_{BE} \approx 0.7$ V) for Si transistor).
5. Choose divider resistors (R_1) and (R_2) such that (V_B) is attained and the current through the divider is, say, 10× base current, to keep base current loading small.
6. Verify actual base current, collector current (using ($I_C = \beta I_B$) approx), and adjust resistor values if needed.
7. Check for thermal stability, power dissipation, sufficient margins.

2.4 Transistor as a Switch in CE Mode

When you use a BJT in CE configuration as a switch:

- **OFF state (cut-off region)**: Base current is zero (or very small), so collector current is nearly zero; transistor acts as open circuit between collector and emitter.
- Such switching is common in digital circuits, relay drivers, switching loads where transistor acts like a controlled switch rather than linear amplifier.

Design considerations: ensure base drive is sufficient (i.e., base current is enough to saturate transistor for given collector current, usually one uses forced β (called $\beta(_{forced})$) lower than usual to ensure saturation). Provide a resistor between base and control signal to limit base current. Provide heat dissipation if power is high.

2.5 Stabilisation, Thermal Run-away & Heat-Sink

Stabilisation

Operating point shifts can occur due to: changes in transistor β, temperature variations, changes in supply voltage, changes in transistor parameters with age. To stabilise: include emitter resistor (introduce feedback), use voltage divider bias, keep transistor away from extreme current densities, use good thermal management.

Thermal Run-away

Because transistor current generates heat, which increases junction temperature, which can increase leakage current and reduce (V_{BE}), which in turn increases collector/emitter current — a positive feedback loop. Without counter-measures, transistor may self-destruct. Important measures: use emitter resistor, bias for safe current/power, ensure transistor does not dissipate too close to thermal limits, provide proper thermal path to ambient.

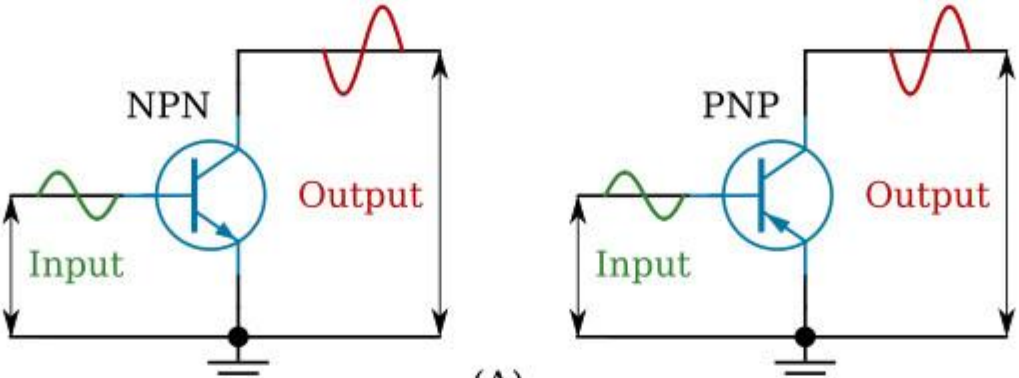
Heat-Sink

When transistor dissipates significant power ($P = V_{CE} \times I_C$), it must be mounted on a device (heat-sink) that transfers the heat to ambient air, reducing junction temperature rise. Lower junction temperature improves reliability, decreases leakage, reduces risk of thermal runaway. Use thermal resistance ratings, ensure mounting and airflow are appropriate.

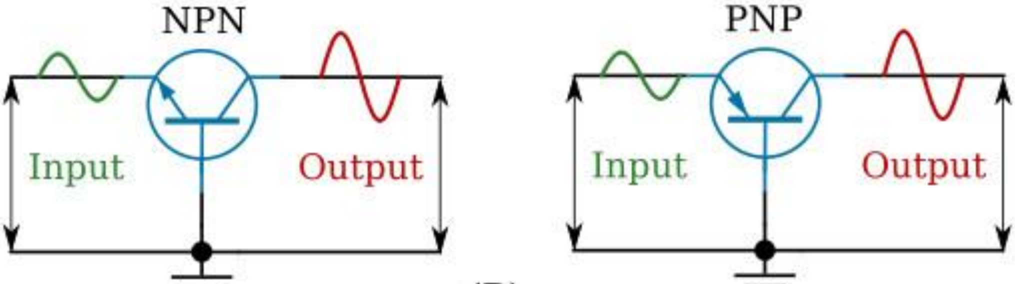
Summary of Some Key Equations & Relationships

- $(I_E = I_C + I_B$

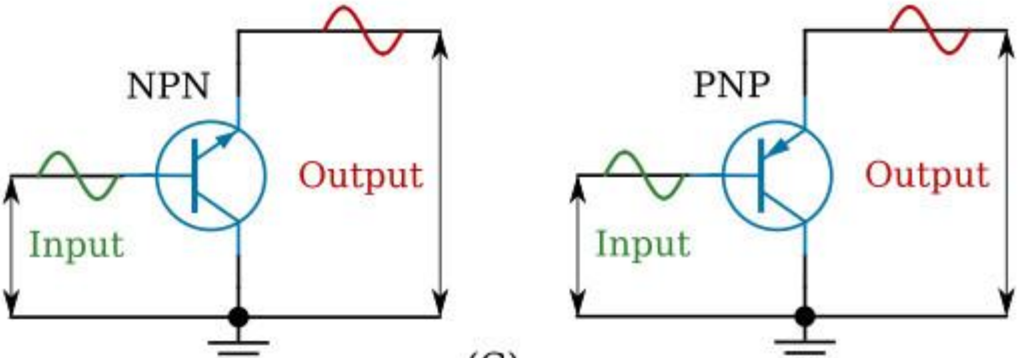
Transistor Configurations (CB / CE / CC)



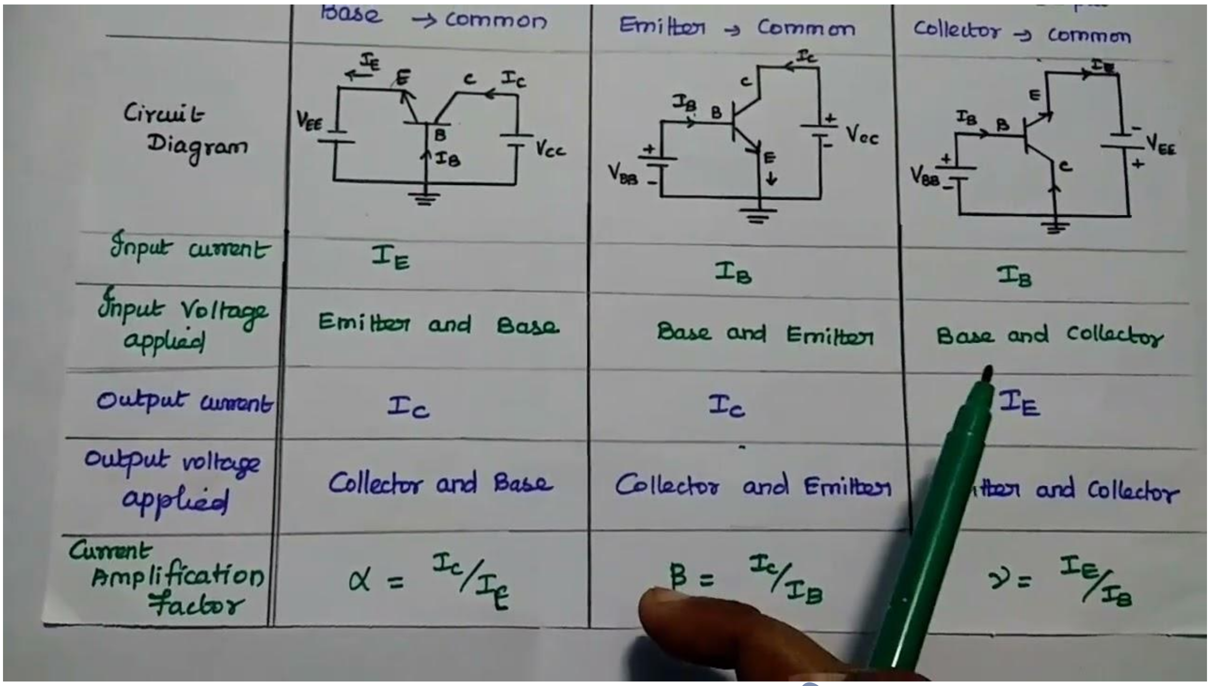
(A)
Common emitter



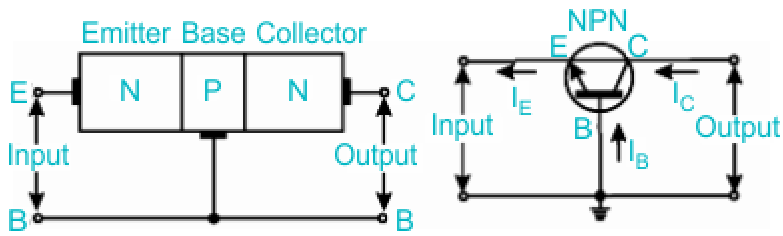
(B)
Common base



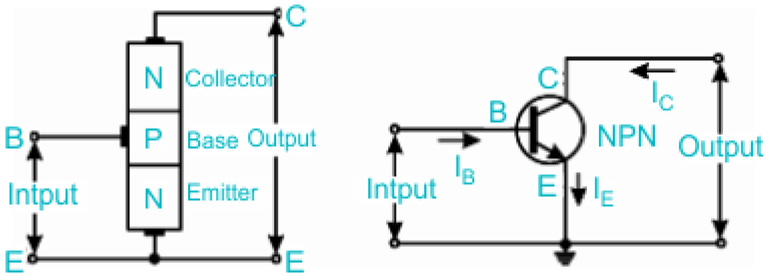
(C)
Common collector



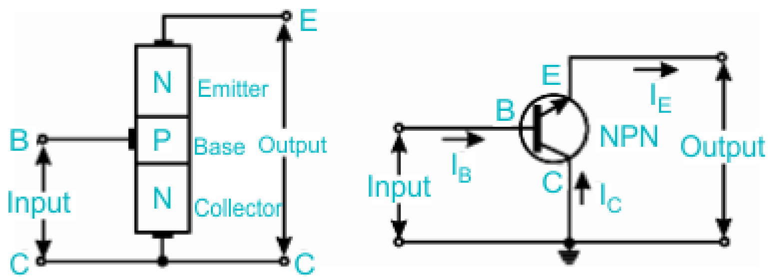
	Base → common	Emitter → Common	Collector → common
Circuit Diagram			
Input current	I_E	I_B	I_B
Input Voltage applied	Emitter and Base	Base and Emitter	Base and Collector
Output current	I_C	I_C	I_E
Output voltage applied	Collector and Base	Collector and Emitter	itter and Collector
Current Amplification Factor	$\alpha = I_C/I_E$	$\beta = I_C/I_B$	$\gamma = I_E/I_B$



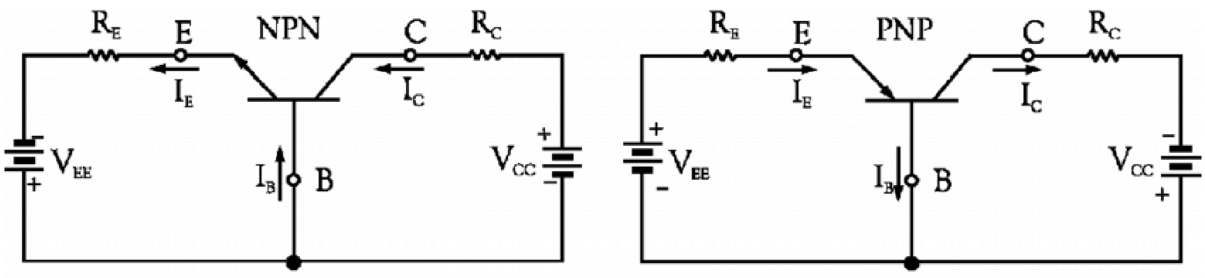
Common Base Configuration



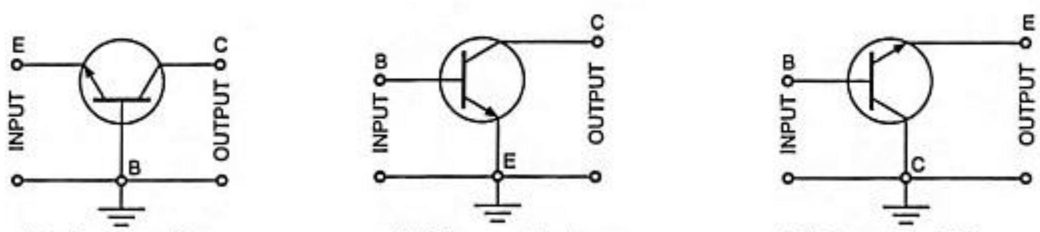
Common Emitter Configuration



Common Collector Configuration

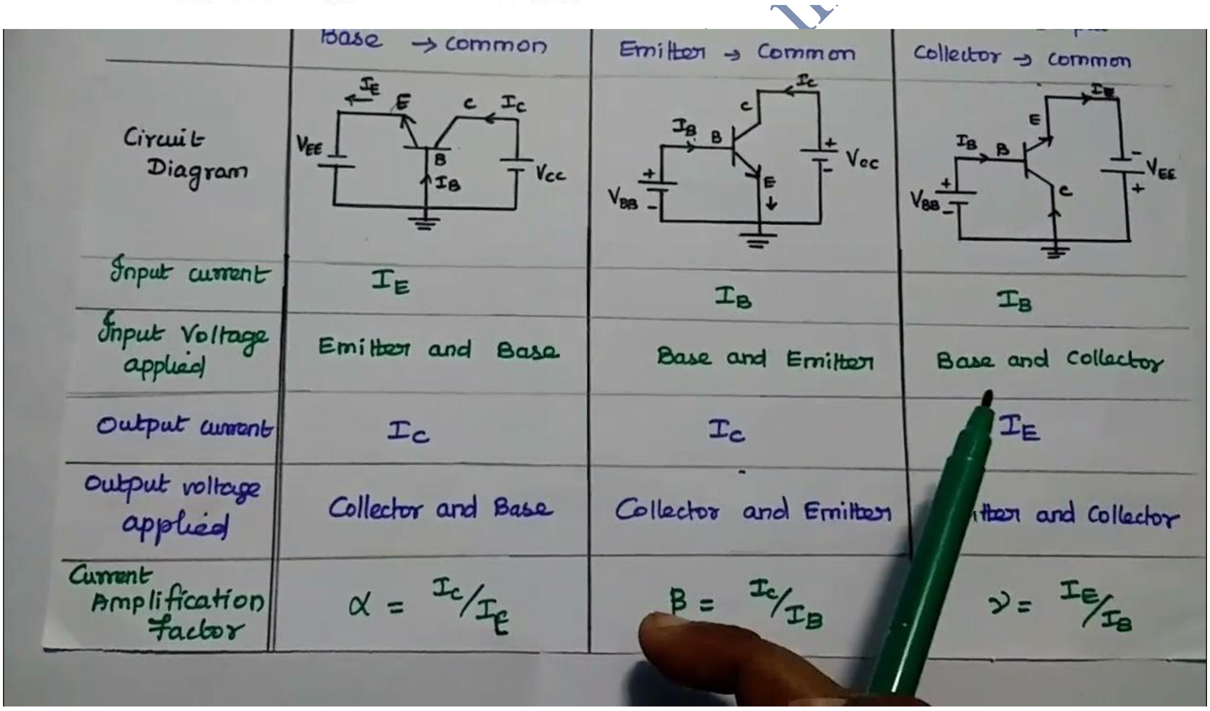


(a) Common-base NPN transistor circuit. (b) Common-base PNP transistor circuit.



(a) Common Base Configuration *(b) Common Emitter Configuration* *(c) Common Collector Configuration*

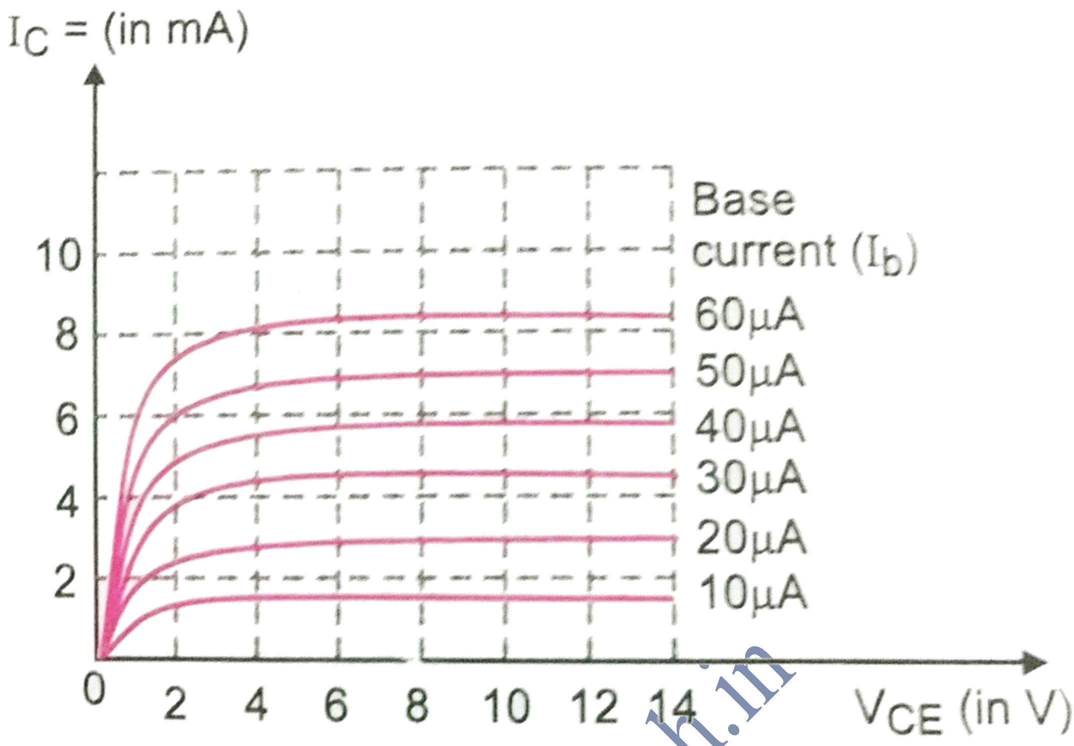
Fig. 10.14 *Different Circuit Configurations For NPN Transistor*



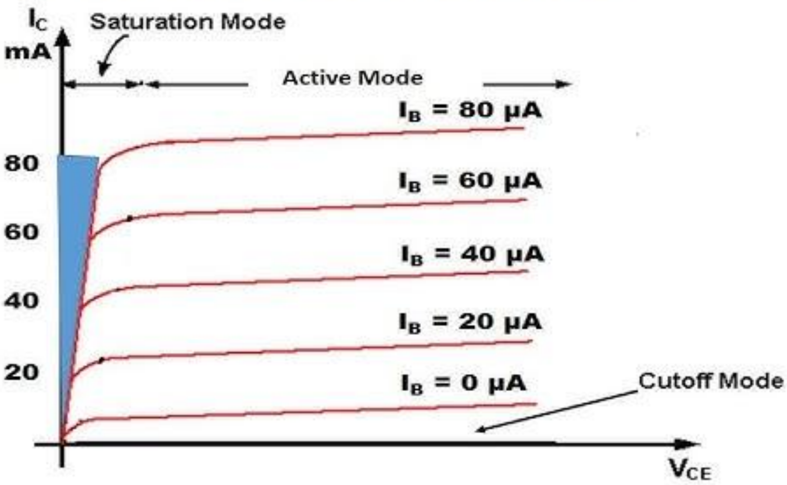
	Base → common	Emitter → Common	Collector → common
Circuit Diagram			
Input current	I_E	I_B	I_B
Input Voltage applied	Emitter and Base	Base and Emitter	Base and Collector
Output current	I_C	I_C	I_E
Output voltage applied	Collector and Base	Collector and Emitter	…itter and Collector
Current Amplification factor	$\alpha = I_C / I_E$	$\beta = I_C / I_B$	$\gamma = I_E / I_B$

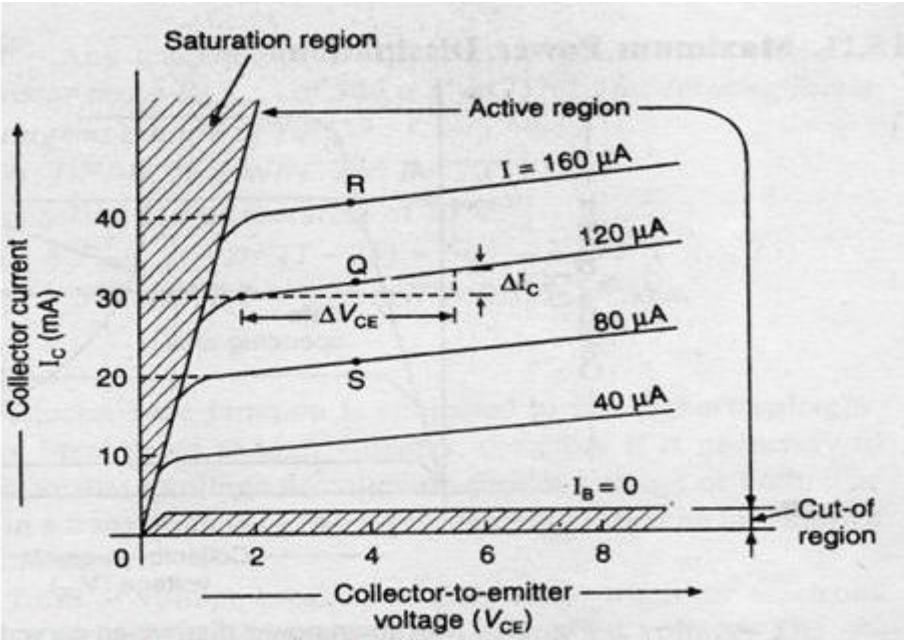
These show the three basic ways Bipolar Junction Transistors (BJTs) can be connected, with one terminal common to both input and output. Use them when describing “common-emitter”, “common-base” and “common-collector” configurations.

CE Output Characteristic Curves (Cut-off / Active / Saturation Regions)



Common emitter Output characteristics





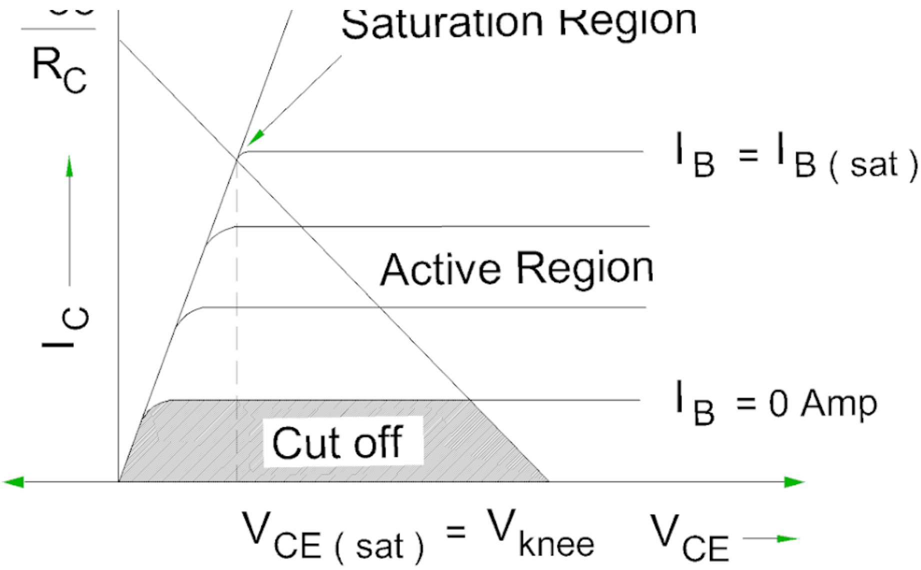
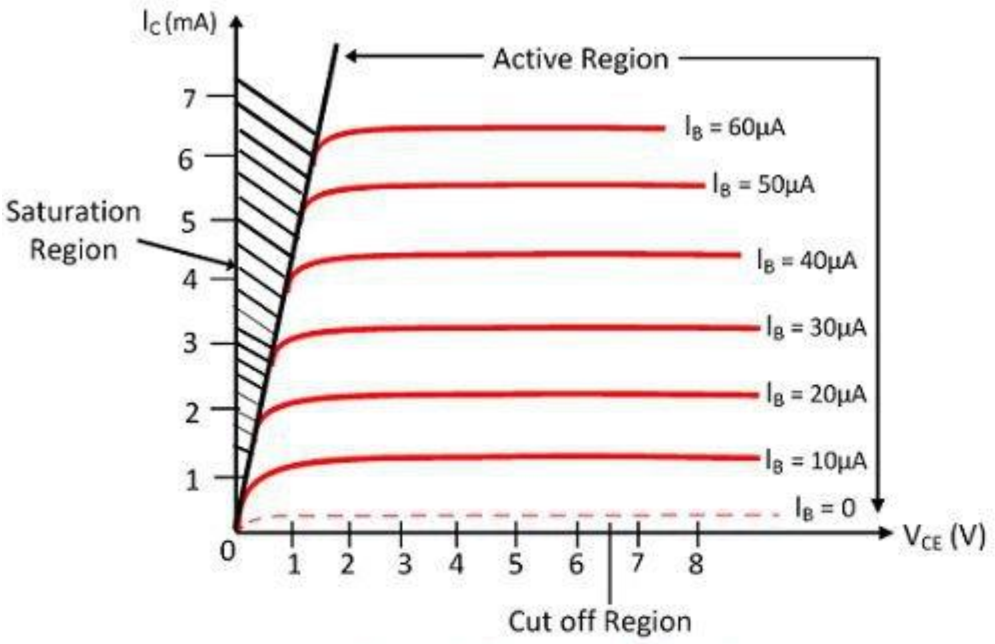


FIG : CUT OFF, ACTIVE AND SATURATION



Output Characteristic Curve

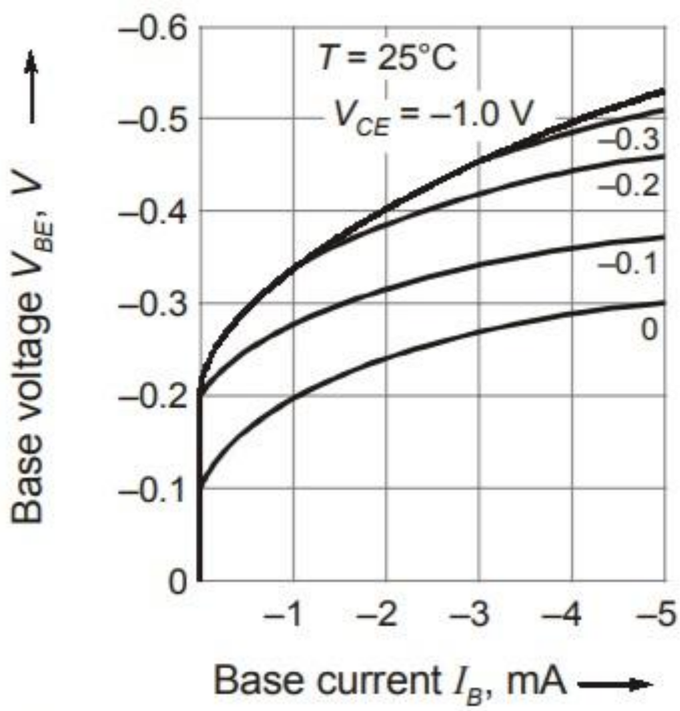
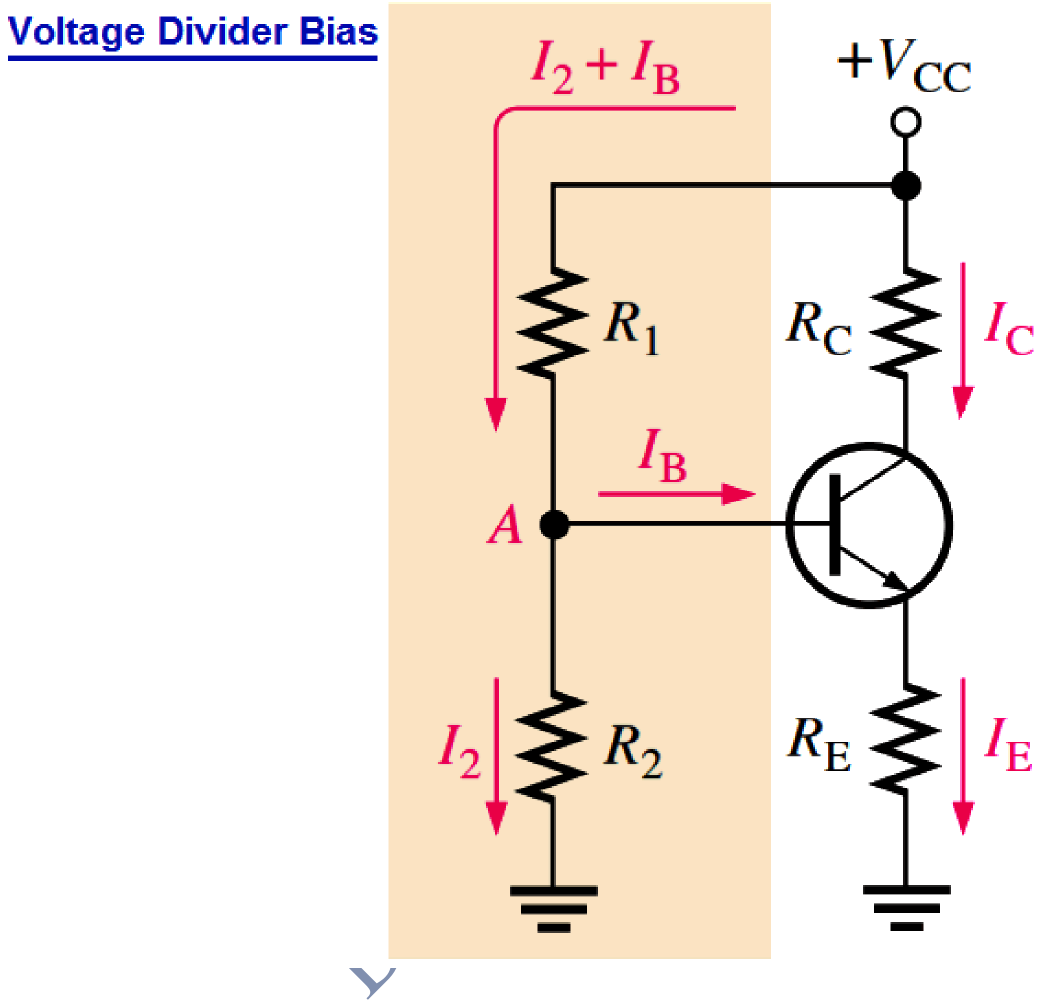
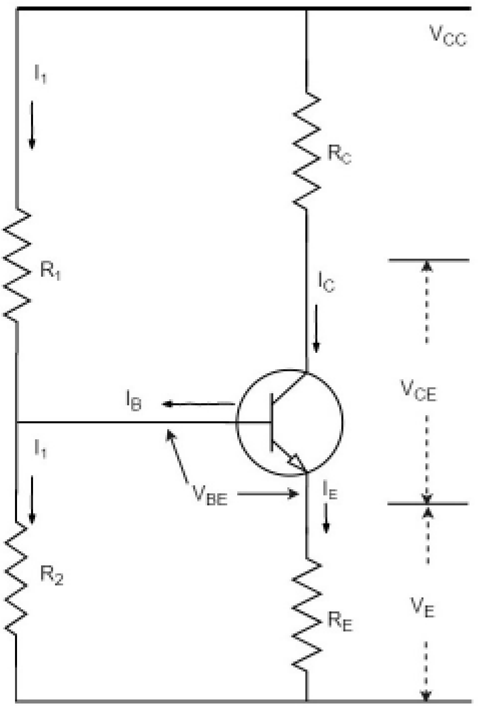


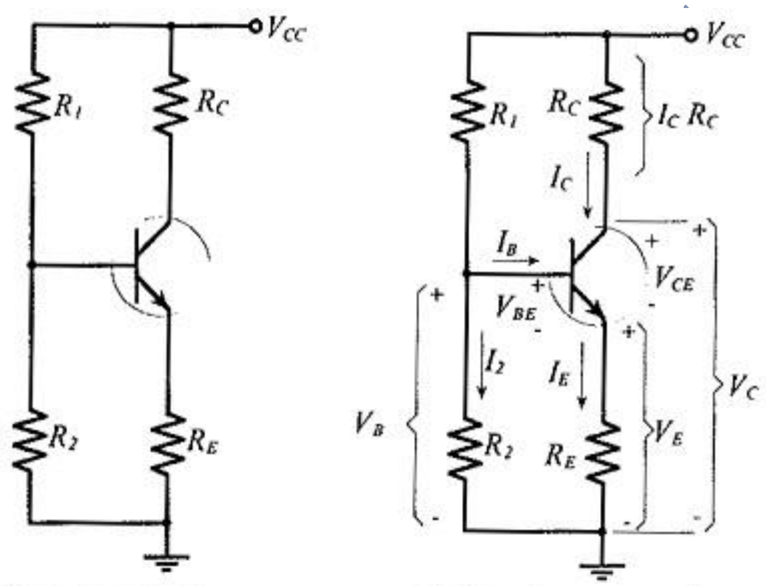
Fig. : *Typical common-emitter input characteristics of the p-n-p germanium junction transistor of figure*

These illustrate the output characteristic of a BJT in the CE mode — curves of collector current (I_C) vs collector-emitter voltage (V_{CE}) for different base currents (I_B). The graphs clearly show the cut-off region (near zero current), active region (flat-ish part), and saturation region (where (V_{CE}) is very low).

Voltage Divider Bias Circuit



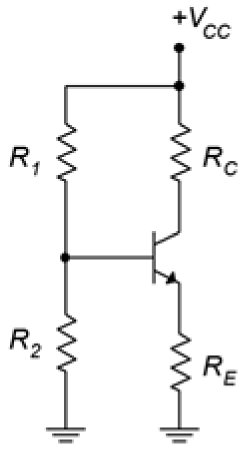


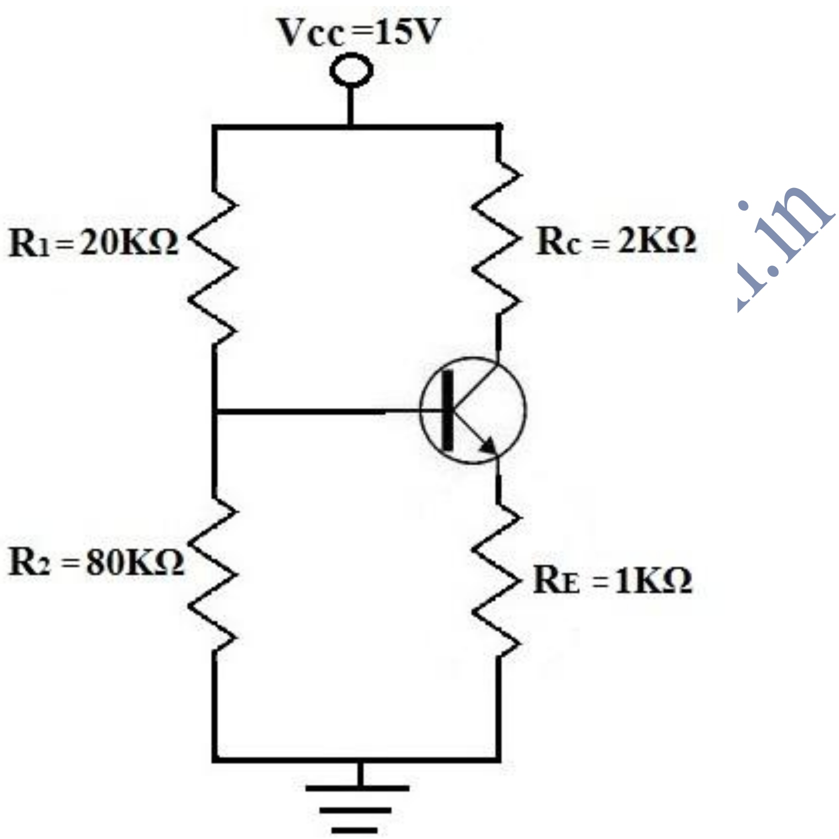


(a) Voltage divider bias circuit

(b) Circuit currents and voltage drops

Figure 5-22
Voltage divider bias circuits. The emitter current remains constant at, $I_E = (V_B - V_{BE})/R_E$.


+V_{CC}
R_1
R_C
R_2
R_E


Vcc =15V
R1 = 20KΩ
Rc = 2KΩ
R2 = 80KΩ
RE = 1KΩ

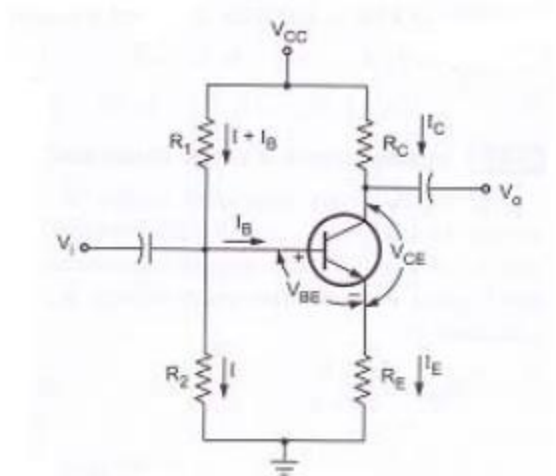


Fig. Voltage divider bias circuit

These figures depict the voltage-divider bias scheme: two resistors forming a divider from (V_{CC}) to establish base voltage, emitter resistor for stabilization, etc. Very helpful when explaining how biasing stabilizes the transistor operating point.

Diploma Wallah

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