Jimma University
College of Natural Sciences
Department of Physics

Lecture Notes : ***Electronics I (Phys 2062)***

Chapter Three: Bipolar junction transistor (BJT)

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Outline of the Chapter

- PNP and NPN transistors
- The surprising action of a transistor
- The working of a transistor
- Transistor amplifying action
- Transistor configurations
- Biasing the BJT for discrete circuit design
- Biasing single stage BJT amplifier (Common emitter, base and collector configuration)
- Transistor Operation
- Transistor Parameter
- Analysis of transistor circuits at DC

Chapter Three: Bipolar junction transistor (BJT)

❑ *Chapter Objective*

➢ ***After studying this chapter you should be able to:***

- ✓ Understand construction and working of Bipolar Junction Transistor.
- ✓ Explainn the difference between operation of NPN and PNP transistor.
- ✓ Develop knowledge of various types of transistor configuration.
- ✓ Explain the difference between CB, CE and CC configuration.
- ✓ Get the knowledge about transistor parameters.

Introduction: Transistors

- Transistor are electronic devices that can amplify voltages, current and power by the application of a small signal voltage on one lead.
- It is a three lead semiconductor device that acts as:
  - ✓ an electrically controlled switch, or
  - ✓ a current amplifier.

- Transistor is analogous to a faucet.
  - ✓ Turning faucet's control knob alters the flow rate of water coming out from the faucet.
  - ✓ A small voltage/current applied at transistor's control lead controls a larger current flow through its other two leads.
- Transistors have two basic functions "switching" (digital electronics) and "amplification" (analog electronics)
- They are made by adding one additional semiconductor layer in the pn junction diode

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Introduction: Semiconductors

Introduction: Transistors types

Transistor Types: BJT, JFET, and MOSFET

- **B**ipolar **J**unction **T**ransistor **(BJT)**
  - ✓ NPN and PNP
- **J**unction **F**ield **E**ffect **T**ransistor **(JFET)**
  - ✓ N-channel and P-channel
- **M**etal **O**xide **S**emiconductor **FET (MOSFET)**
  - ✓ Depletion type (n- and p-channel) and enhancement type (n- and p-channel) BJT JFET

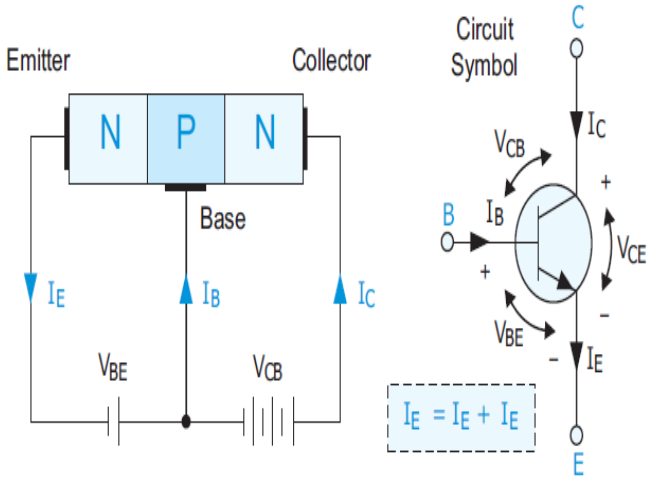
BJT

JFET

MOSFET

Bipolar Junction Transistors

- A Semiconductor device consisting of two pn junctions formed by sandwiching either p type or n type semiconductor between a pair of opposite types is known as a transistor
- Thus it is also well known by the name bipolar junction transistor because its operation depends upon both the majority and minority carriers.



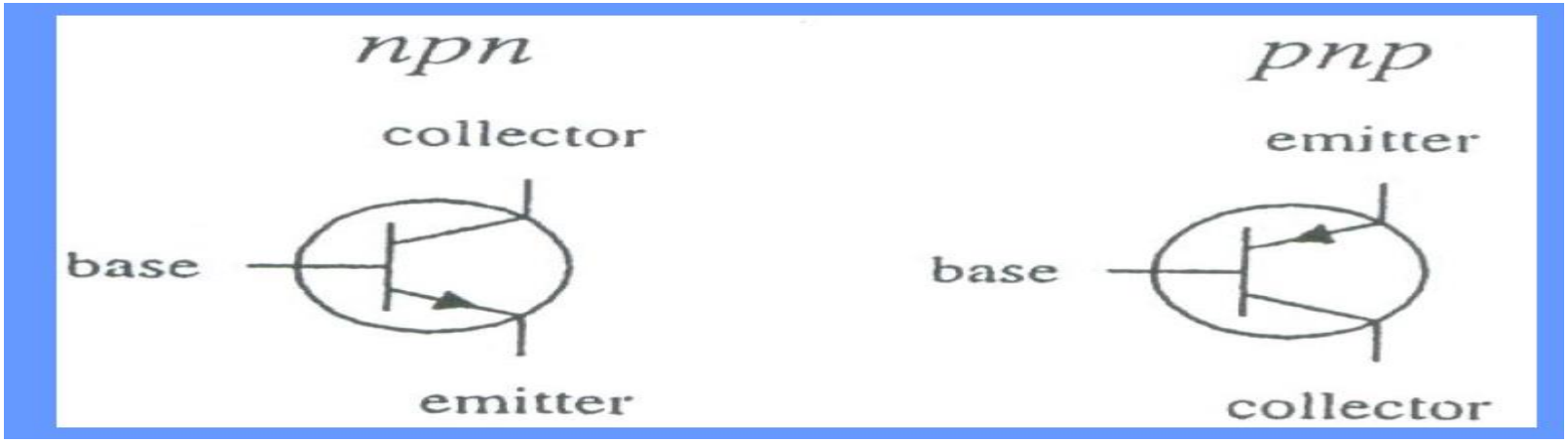
- Accordingly, there are two types of transistors namely;
  - ✓ NPN Transistor
  - ✓ PNP Transistor
- **NPN Transistor:** A transistor in which two blocks of n-type semiconductor are separated by a thin layer of p-type semiconductor is known as NPN Transistor.
- **PNP Transistor:** A transistor in which two blocks of p-type semiconductors are separated by a thin layer of n- type semiconductor is known as PNP Transistor

- Every transistor has three terminals called emitter, base and collector.

Bipolar Junction Transistors: How it works

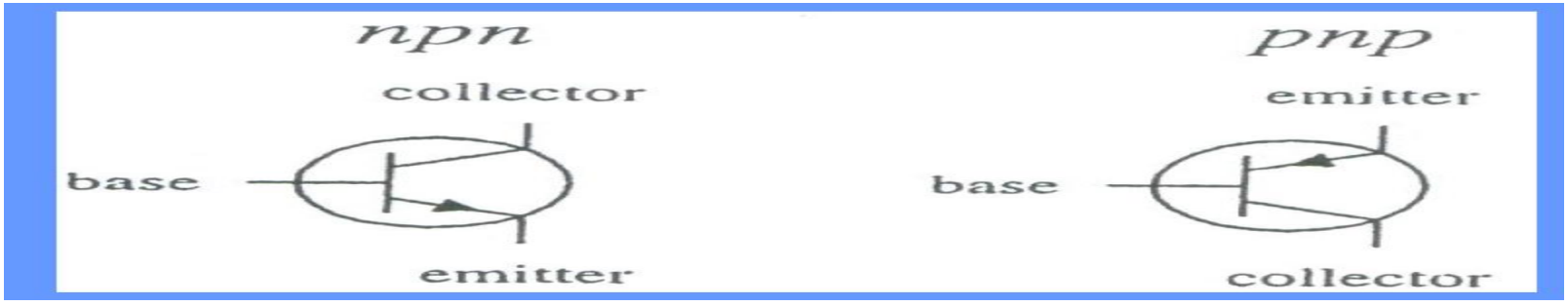
- When no voltage is applied at transistor's base, electrons in the emitter are prevented from passing to the collector side because of the pn junction.

- If a negative voltage is applied to the base, things get even worse as the pn junction between the base and emitter becomes reverse biased resulting in the formation of a depletion region that prevents current flow.



Bipolar Junction Transistors: How it works

- If a positive voltage (>0.6V) is applied to the base of an npn transistor, the pn junction between the base and emitter becomes forward-biased. During forward bias, escaping electrons are drawn to the positive base.
- Some electrons exit through the base, but because the p-type base is so thin, the onslaught of electrons that leave the emitter get close enough to the collector side that they begin jumping into the collector.
- Increasing the base voltage increases the emitter-to collector electron flow.
- Recall, positive current flow is in the direction opposite to the electron flow ⍰current flows from collector to emitter.



Bipolar Junction Transistors: Basic terms

(i) Emitter

- The Section on one side of the transistor that supplies a large number of majority carriers (electrons if emitter is n- type and holes if the emitter is of p-type) is called emitter.
- The emitter is always forward biased with respect to base so that it can supply a large number of majority carriers to its junction with the base.
- Since emitter is to supply or inject a large amount of majority carriers into the base, it is heavily doped but moderate in size.

(ii) Base

- The middle section which forms two pn junctions between emitter and collector is called base.
- The base form two circuits, one input circuit with emitter and other output circuit with collector. The base emitter junction is forward biased, providing low resistance to the emitter circuit.
- The base collector junction is reversed biased, offering high resistance path to the collector circuit. The base is lightly doped and very thin so that it can pass on most of the majority carriers supplied by emitter to the collector.

(iii) Collector

- The section on the other side of the transistor that collects the major portion of the majority carriers supplied by the emitter is called collector. The collector base junction is always reverse biased.
- Its main function is to remove majority carriers (or charges) from its junction with base.
- The collector is moderately doped but larger in size so that it can collect most of the majority carriers supplied by the emitter.

Bipolar Junction Transistors: Biasing

- The process by which required condition such as proper flow of zero signal collector current and the maintenance of proper collector emitter voltage during the passage of signal are obtained is known as transistor biasing.

- The basic procedure of transistor biasing is to keep the emitter junction forward biased and the collector junction properly reverse biased during the application of signal so that faithful amplification can be achieved.

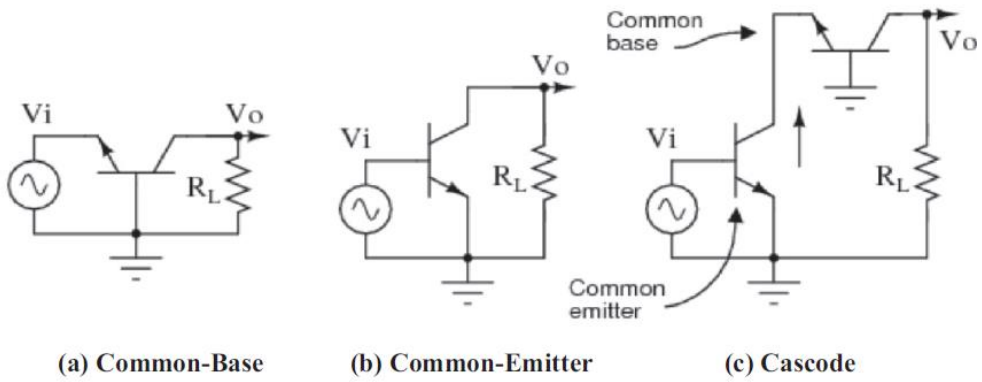
- The biasing can be achieved either by using bias batteries V_{bb} and V_{cc} or by applying associating circuitry with the transistor. Generally, the latter method is employed since it is more efficient.

- The circuitry which provides the necessary conditions of transistor biasing is known as biasing circuit

CB, CE and CC Configuration

- A transistor has three leads, namely emitter, base and collector. However, to handle input and output four terminals are needed (two for input and two for output).
- Therefore to connect transistor in the circuit, one lead or terminal is made common. The input is fed between common and one of the remaining terminals whereas, output is connected between the common and other terminal of the transistor.
- Accordingly a transistor can be connected in the circuit in the following three ways figure below
  - ✓ Common Base Connection (CB Configuration)
  - ✓ Common Emitter Connections (CE Configuration)
  - ✓ Common Collector Connection(CC Configuration)

- It is important to note that transistor may be connected in any one of the above said three ways, the emitter base junction is always forward biased and collector base junction is always reverse biased to operate the transistor in active region.



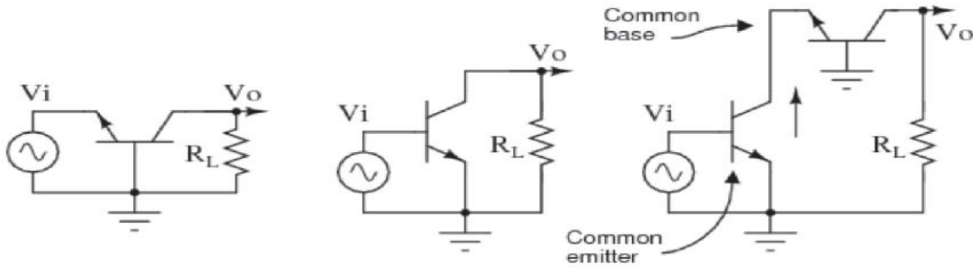
(a) Common-Base (b) Common-Emitter (c) Cascode

Common Base Connection (or CB Configuration)

- The common base circuit arrangement for npn transistor and pnp transistor is shown in fig. (a) and (b) respectively.
- In this case, the input is connected between emitter and base while output is taken across collector and base.
- Thus the base of the transistor is common to both input and output circuit and hence the name common base connection or common base configuration.

Current Amplification Factor (Alpha)

- The ratio of output to input current is known as current amplification factor in a common base connection the output current is collector current Ic whereas the input current is emitter current Ie.
- Thus the ratio of change in collector current to the change in emitter current at constant collector base voltage Vcb is known as current amplification factor of transistor in common base configuration. It is generally represented by Greek letter (alpha).



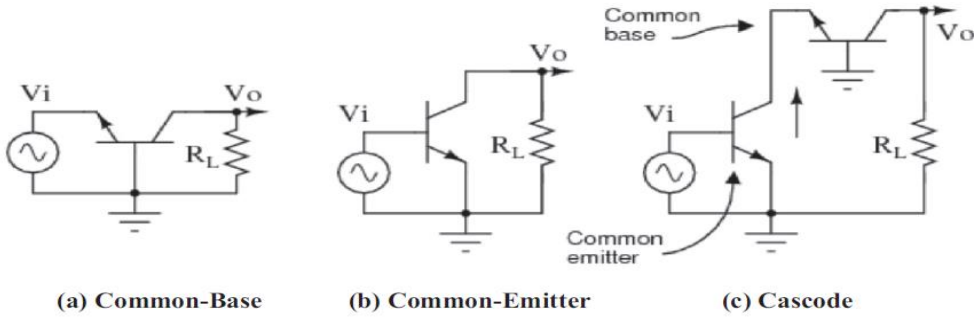
(a) Common-Base (b) Common-Emitter (c) Cascode

Common Emitter Connection (or CE Configuration)

- The common emitter circuit arrangement for npn transistor and pnp transistor is shown in fig. (a) and (b) respectively.
- In this case, the input is connected between emitter and base while output is taken across collector and emitter.
- Thus the emitter of the transistor is common to both input and output circuit and hence the name common emitter connection or common emitter configuration.

Base Current Amplification Factor (Beta)

- The ratio of output to input current is known as base current amplification factor. In a common emitter connection the output current is collector current Ic whereas the input current is base current Ib.
- Thus the ratio of change in collector current to the change in base current is known as base current amplification factor of transistor in common emitter configuration.it is generally represented by Greek letter (beta).



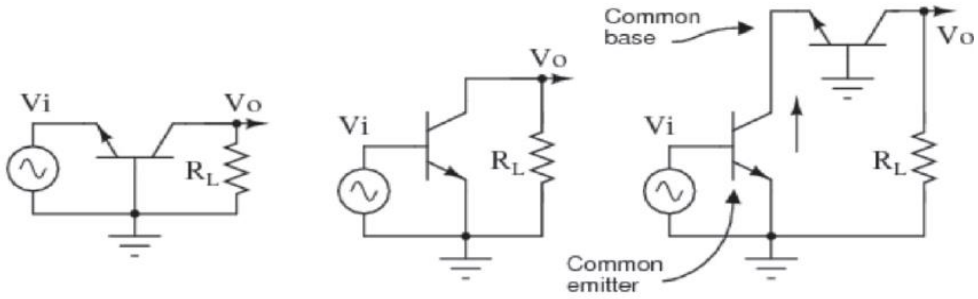
(a) Common-Base (b) Common-Emitter (c) Cascode

Common Collector Connection (or CC Configuration)

- The common collector circuit arrangement for npn transistor and pnp transistor is shown in fig. (a) and (b) respectively.
- In this case, the input is connected between base and collector while output is taken across emitter and collector.
- Thus the collector of the transistor is common to both input and output circuit and hence the name common collector connection or common collector config.

Current Amplification Factor (Gama)

- The ratio of output to input current is known as current amplification factor. In a common collector connection the output current is emitter current Ie whereas the input current is base current Ib.
- Thus the ratio of change in emitter current to the change in base current is known as current amplification factor of transistor in common collector configuration. It is generally represented by Greek letter (Gama).



(a) Common-Base (b) Common-Emitter (c) Cascode

Thank you