SNS COLLEGE OF TECHNOLOGY
Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++'(III Cycle) Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECB101 – CIRCUIT ANALYSIS AND DEVICES

I YEAR/ II SEMESTER

UNIT 4 – TRANSISTORS AND THEIR APPLICATIONS

TOPIC - Bipolar Junction Transistor

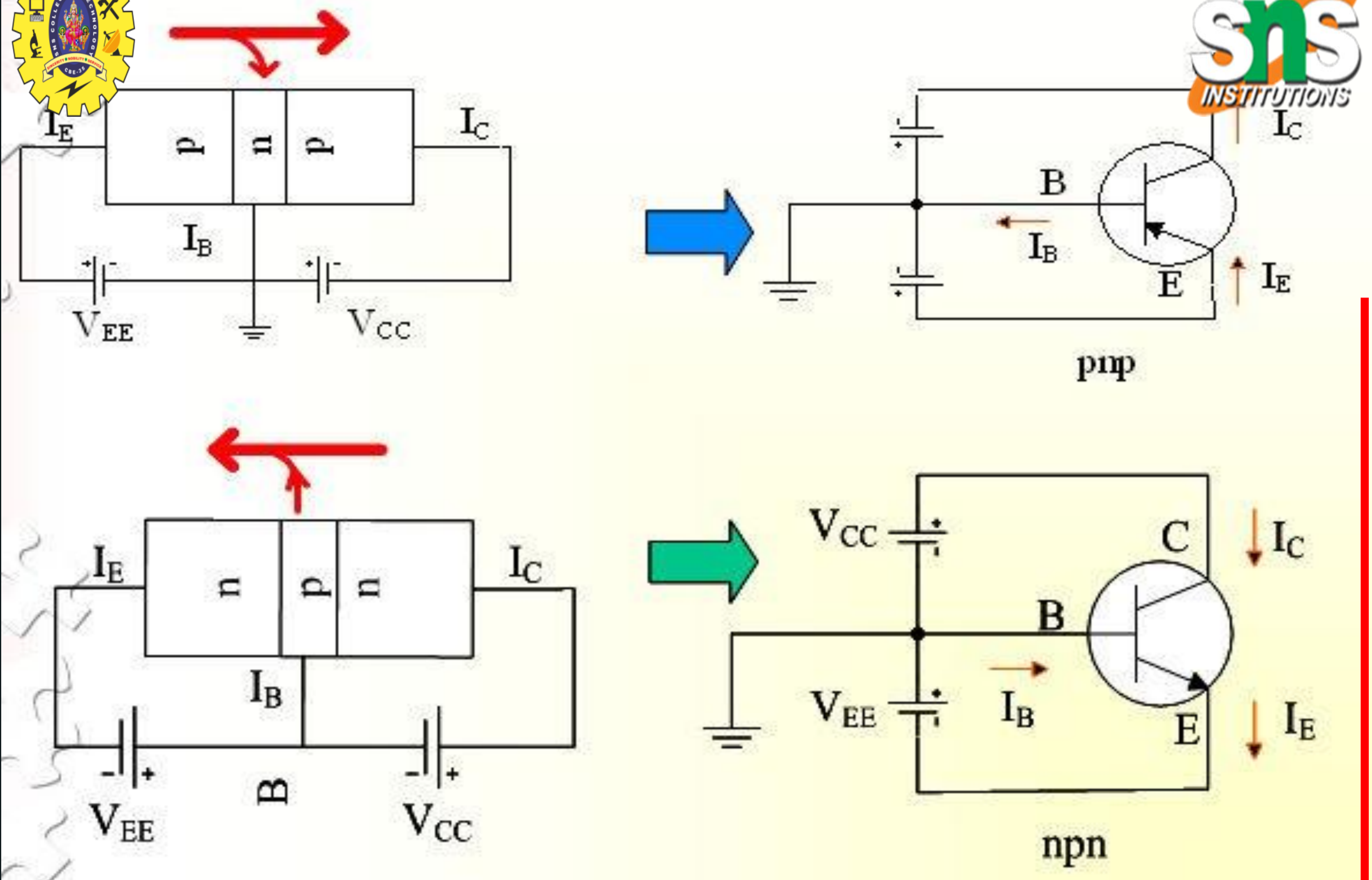
Common-Base Configuration

- Common-base terminology is derived from the fact that the :

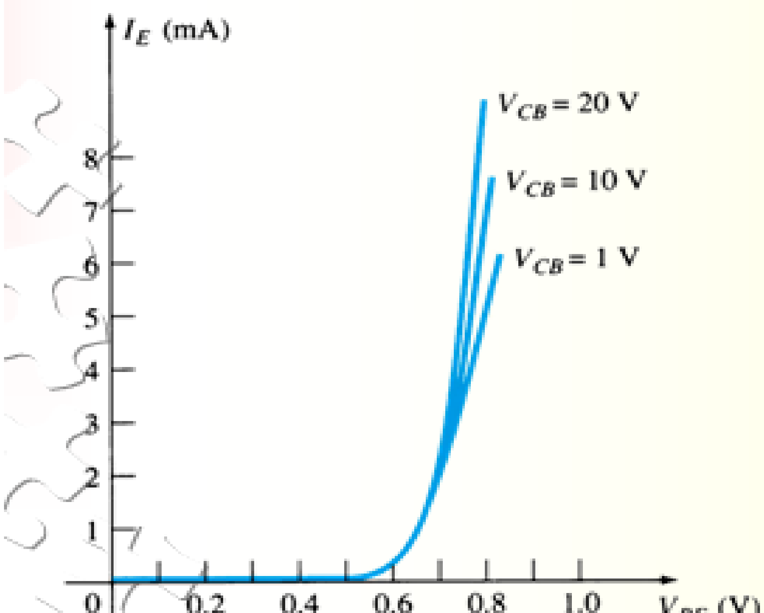
  - base is common to both input and output of the configuration.

    - base is usually the terminal closest to or at ground potential.

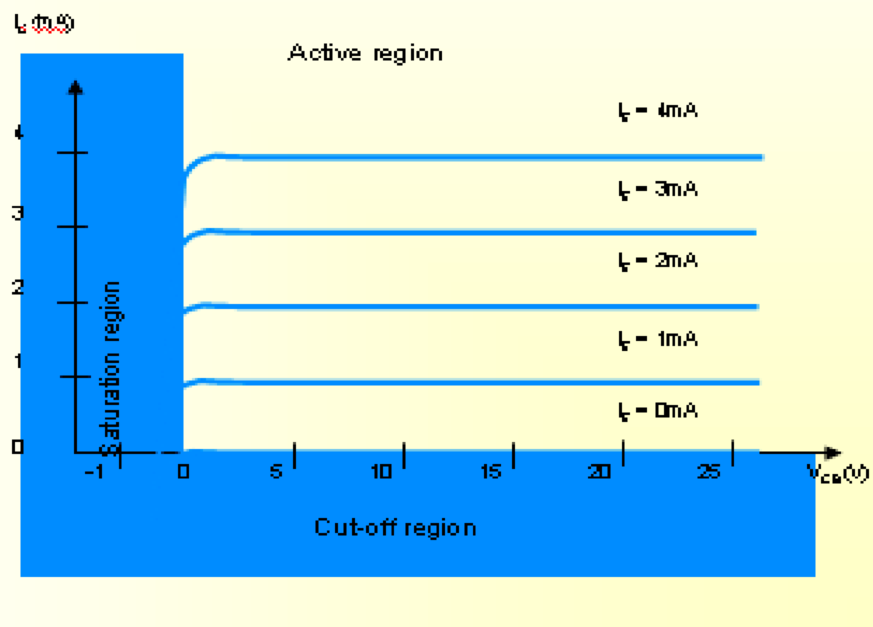
- All current directions will refer to conventional (hole) flow and the arrows in all electronic symbols have a direction defined by this convention.
- Note that the applied biasing (voltage sources) are such as to establish current in the direction indicated for each branch.


I_E
p
n
p
I_C
I_B
V_{EE}
V_{CC}
B
I_C
I_B
E
I_E
pnp
I_E
n
p
n
I_C
I_B
V_{EE}
B
V_{CC}
V_{CC}
C
I_C
B
V_{EE}
I_B
E
I_E
npn

- To describe the behavior of common-base amplifiers requires two set of characteristics:
  - Input or driving point characteristics.
  - Output or collector characteristics
- The output characteristics has 3 basic regions:
  - Active region –defined by the biasing arrangements
  - Cutoff region – region where the collector current is 0A
  - Saturation region- region of the characteristics to the left of $V_{CB} = 0V$



Input characteristics for a common silicon transistor



Output of collector characteristics for common-base transistor amplifier

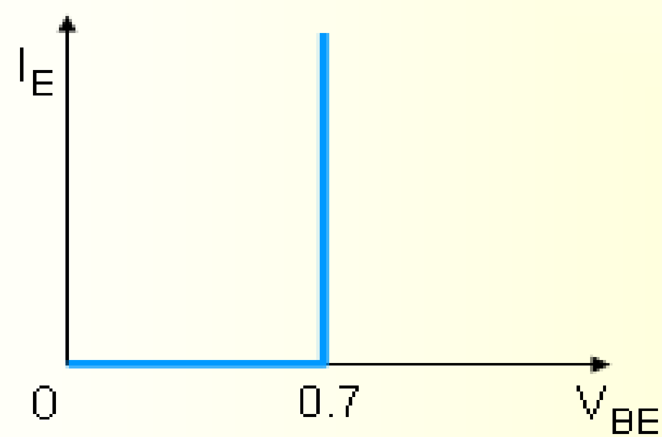
Active region	Saturation region	Cut-off region
• I_E increased, I_C increased • BE junction forward bias and CB junction reverse bias • Refer to the graf, $I_C \approx I_E$ • I_C not depends on V_{CB} • Suitable region for the transistor working as amplifier	• BE and CB junction is forward bias • Small changes in V_{CB} will cause big different to I_C • The allocation for this region is to the left of V_{CB} = 0 V.	• Region below the line of I_E=0 A • BE and CB is reverse bias • no current flow at collector, only leakage current

- The curves (output characteristics) clearly indicate that a first approximation to the relationship between IE and IC in the active region is given by

$$I_C \approx IE$$

- Once a transistor is in the 'on' state, the base-emitter voltage will be assumed to be

$$V_{BE} = 0.7V$$



- In the dc mode the level of I_C and I_E due to the majority carriers are related by a quantity called alpha

$$\alpha = \frac{I_C}{I_E}$$

$$I_C = \alpha I_E + I_{CBO}$$

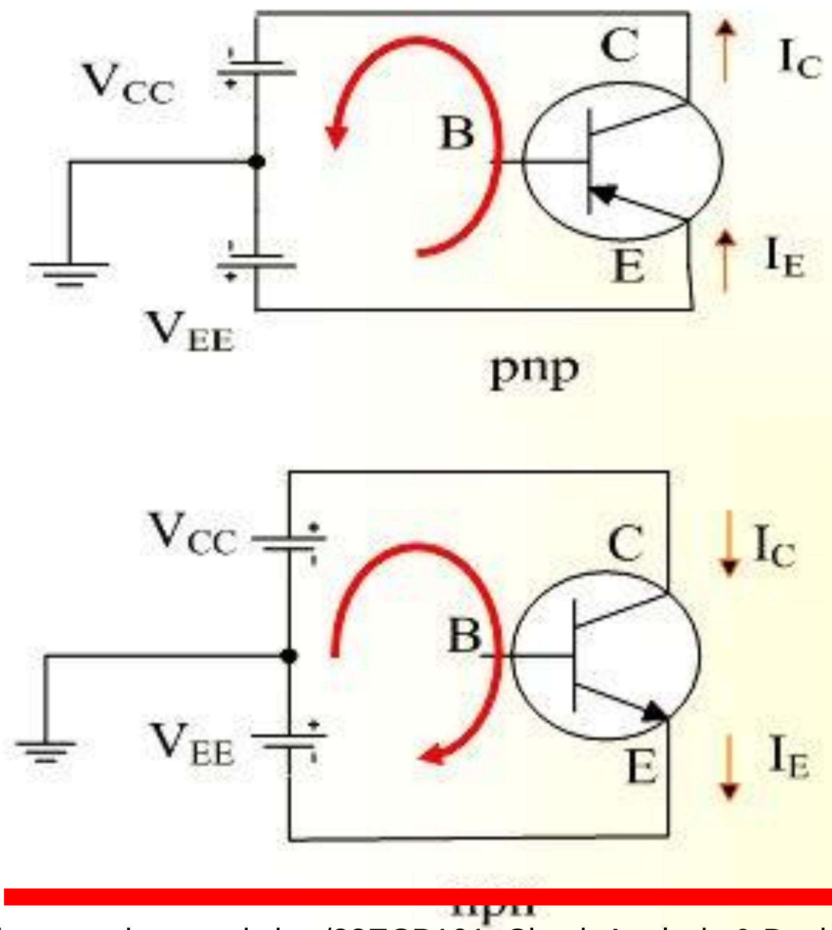
- It can then be summarize to $I_C = \alpha I_E$ (ignore I_{CBO} due to small value)
- For ac situations where the point of operation moves on the characteristics curve, an ac alpha defined by

$$\alpha = \frac{\Delta I_C}{\Delta I_E}$$

- Alpha a common base current gain factor that shows the efficiency by calculating the current percent from current flow from emitter to collector. The value of α is typical from 0.9 ~ 0.998.

Biasing

- Proper biasing CB configuration in active region by approximation I_C □ I_E (I_B □ 0 uA)



Common-Emitter Configuration

- It is called common-emitter configuration since :
  - emitter is common or reference to both input and output terminals.
  - emitter is usually the terminal closest to or at ground potential.
- Almost amplifier design is using connection of CE due to the high gain for current and voltage.
- Two set of characteristics are necessary to describe the behavior for CE ;input (base terminal) and output (collector terminal) parameters.

Proper Biasing common-emitter configuration in active region

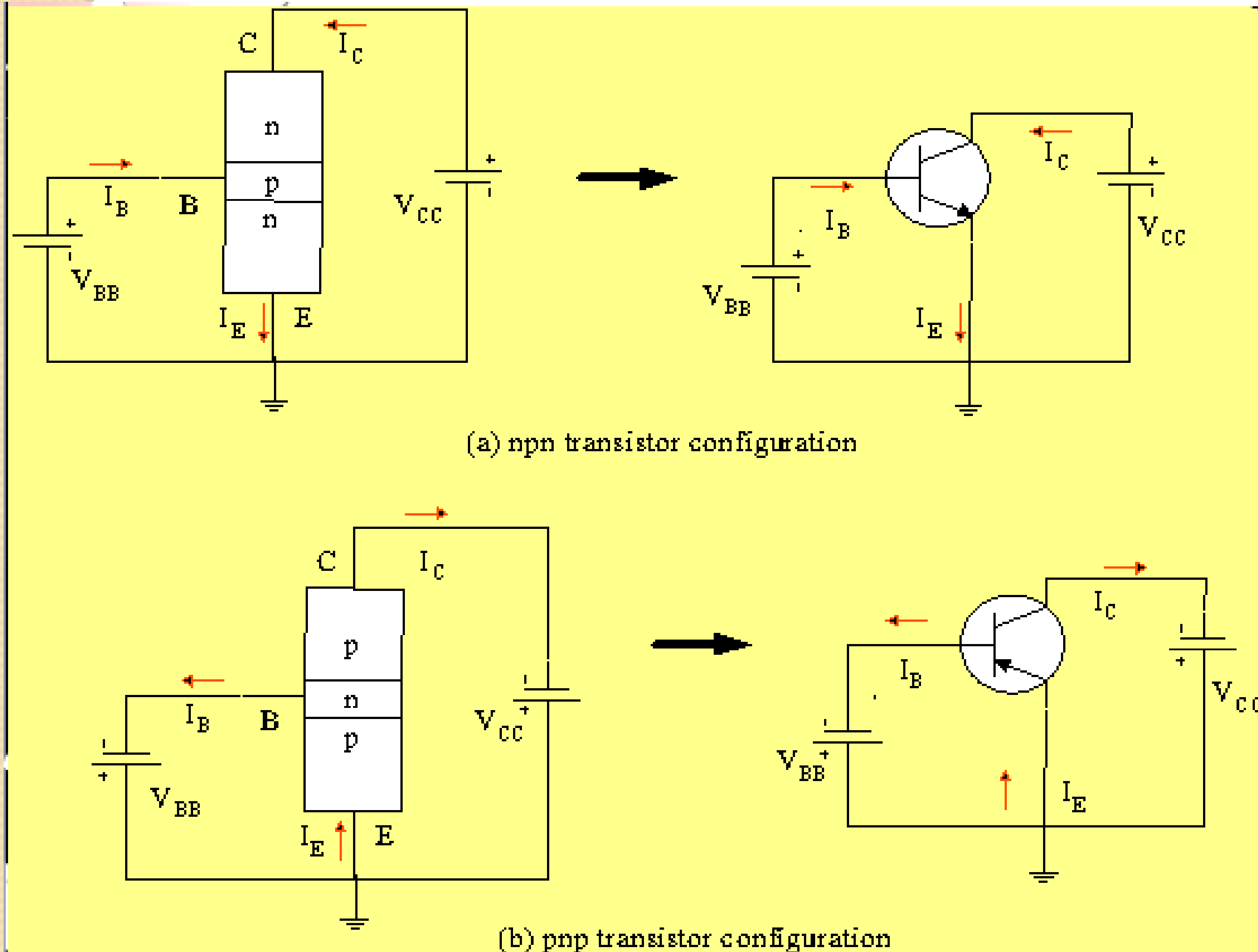
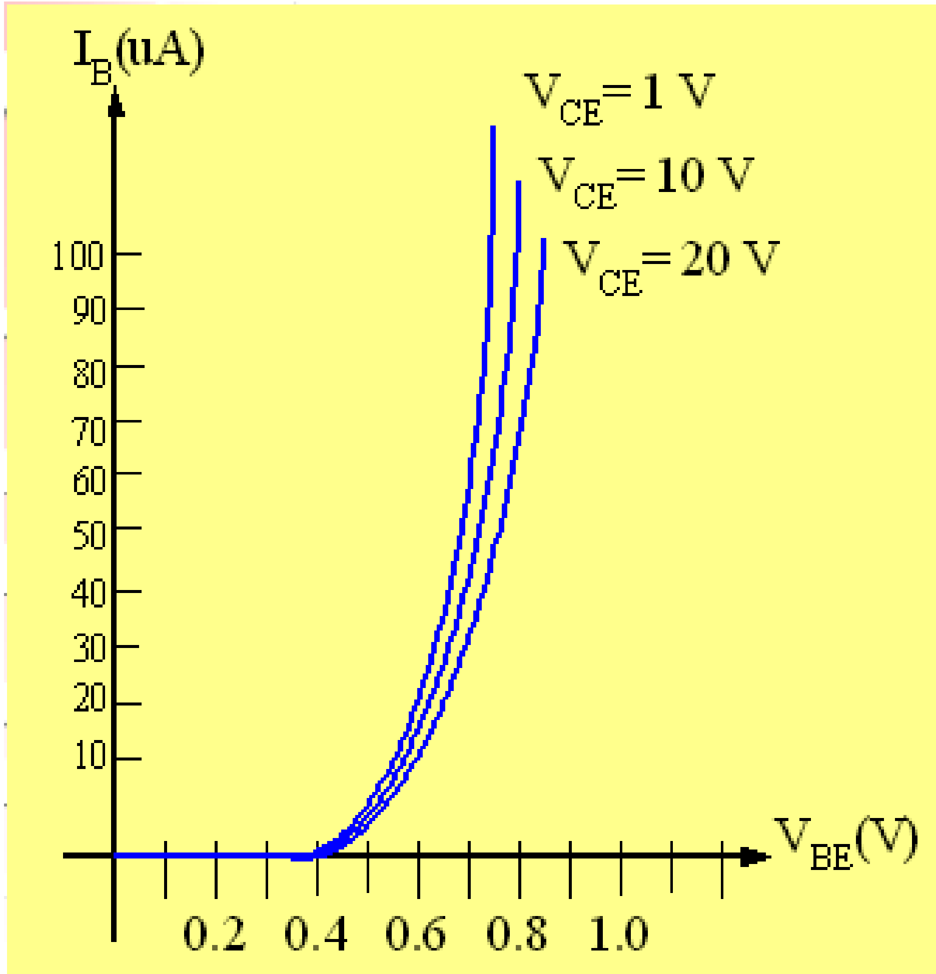


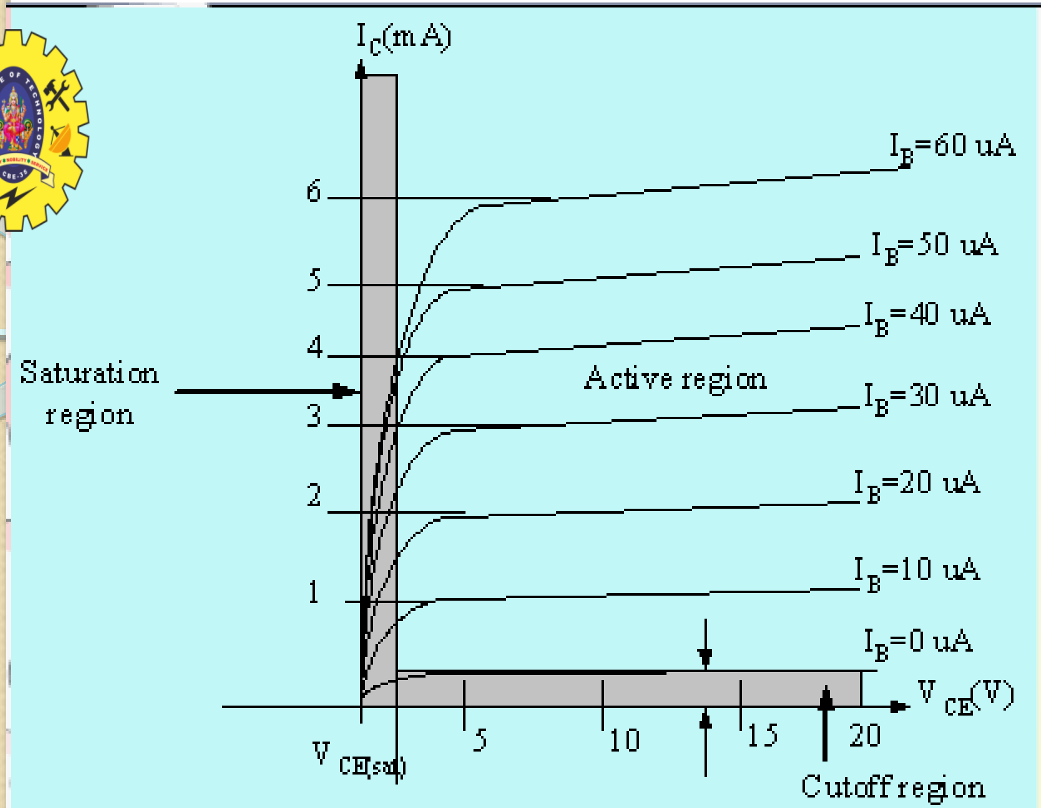
Fig 4.7 : Common-emitter configuration

$$I_E = I_C + I_B$$



Input characteristics for a common-emitter NPN transistor

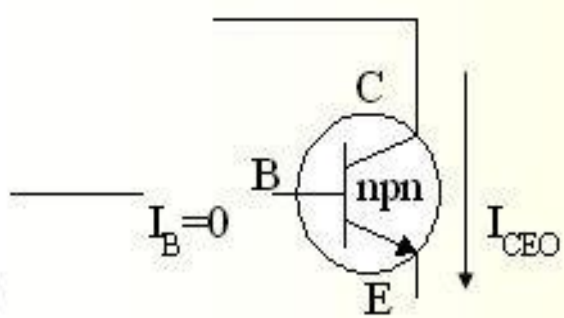
- I_B is microamperes compared to miliamperes of I_C.
- I_B will flow when $V_{BE} > 0.7V$ for silicon and 0.3V for germanium
- Before this value I_B is very small and no I_B.
- Base-emitter junction is forward bias
- Increasing V_{CE} will reduce I_B for different values.

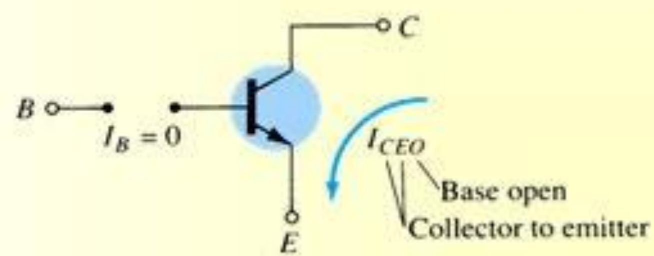


Output characteristics for a common-emitter npn transistor

- For small V_{CE} ($V_{CE} < V_{CESAT}$, I_C increase linearly with increasing of V_{CE}
- $V_{CE} > V_{CESAT}$ I_C not totally depends on V_{CE} □ constant I_C
- I_B(uA) is very small compare to I_C (mA). Small increase in I_B cause big increase in I_C
- I_B=0 A □ I_{CEO} occur.
- Noticing the value when I_C=0A. There is still some value of current flows.

Active region	Saturation region	Cut-off region
• B-E junction is forward bias • C-B junction is reverse bias • can be employed for voltage, current and power amplification	• B-E and C-B junction is forward bias, thus the values of I_B and I_C is too big. • The value of V_{CE} is so small. • Suitable region when the transistor as a logic switch. • NOT and avoid this region when the transistor as an amplifier.	• region below I is to be avoided if an undistorted o/p signal is required • B-E junction and C-B junction is reverse bias • I_B=0, I_C not zero, during this condition $I_C=I_{CEO}$ where is this current flow when B-E is reverse bias.

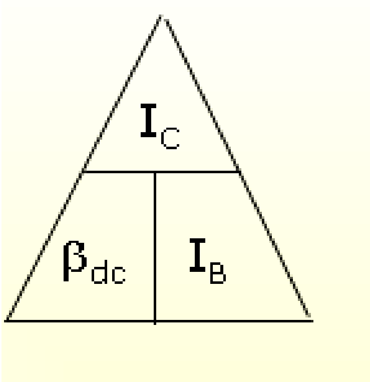




Beta (β) or amplification factor

- The ratio of dc collector current (IC) to the dc base current (IB) is dc beta (βdc) which is dc current gain where IC and IB are determined at a particular operating point, Q-point (quiescent point).

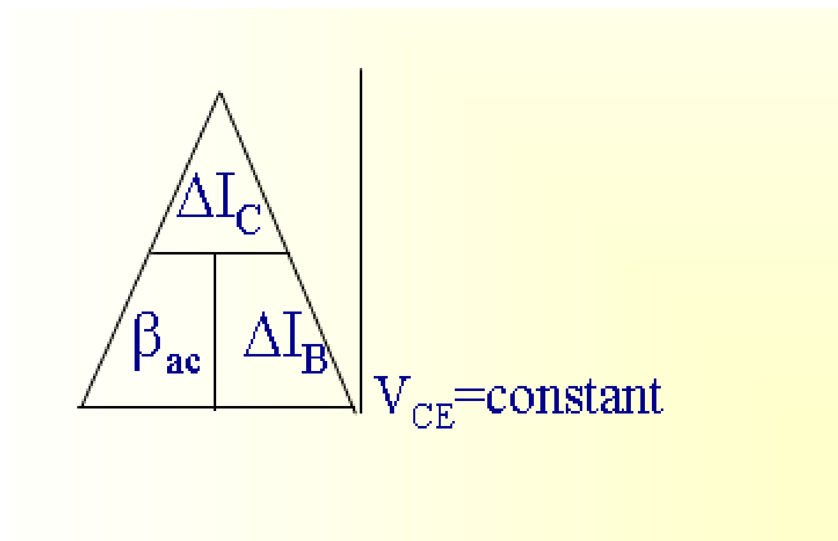
- It's define by the following equation:



30 < βdc < 300 □ 2N3904

- On data sheet, $\beta_{dc} = h_{FE}$ with h is derived from ac hybrid equivalent cct. FE are derived from forward-current amplification and common-emitter configuration respectively.

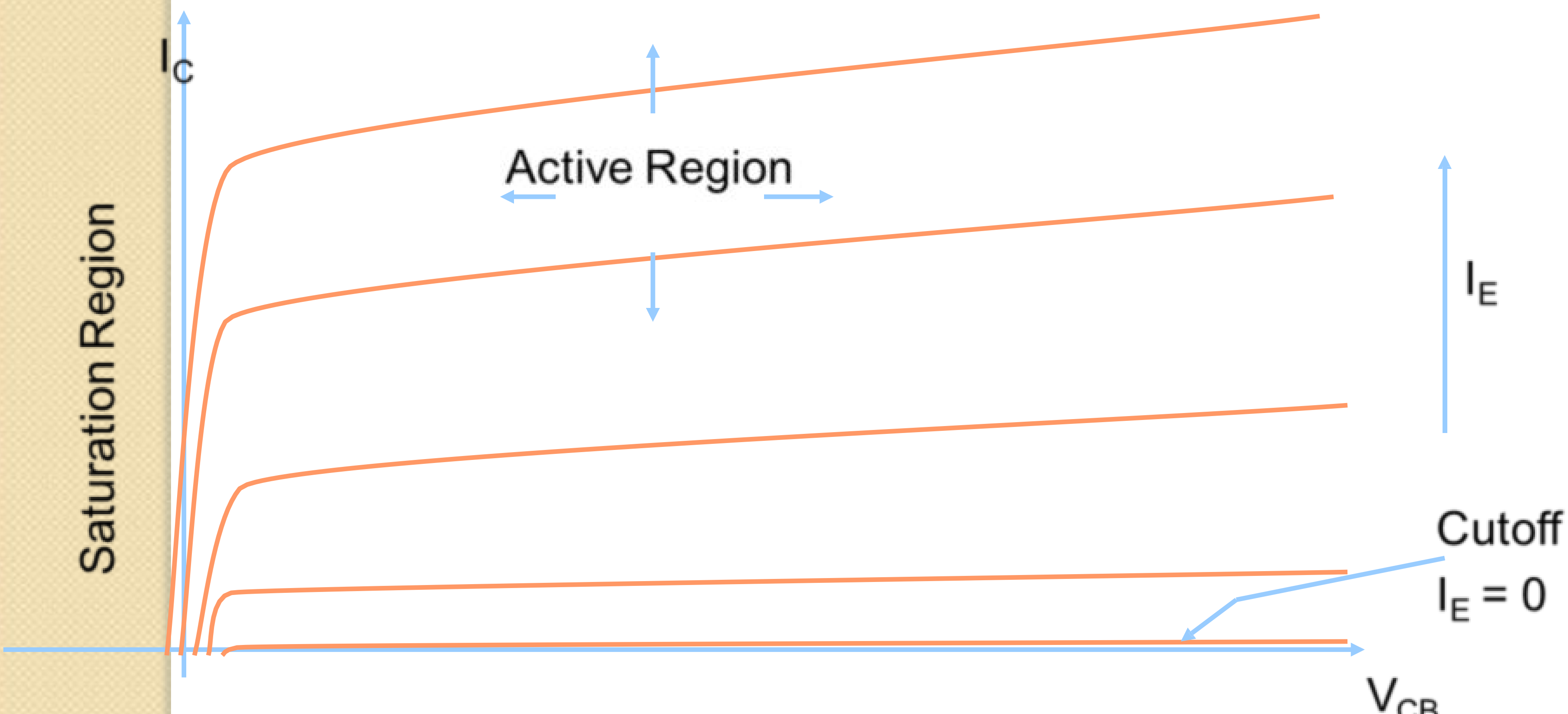
- For ac conditions an ac beta has been defined as the changes of collector current (I_C) compared to the changes of base current (I_B) where I_C and I_B are determined at operating point.
- On data sheet, $\beta_{ac}=h_{fe}$
- It can defined by the following equation:



Common-Base

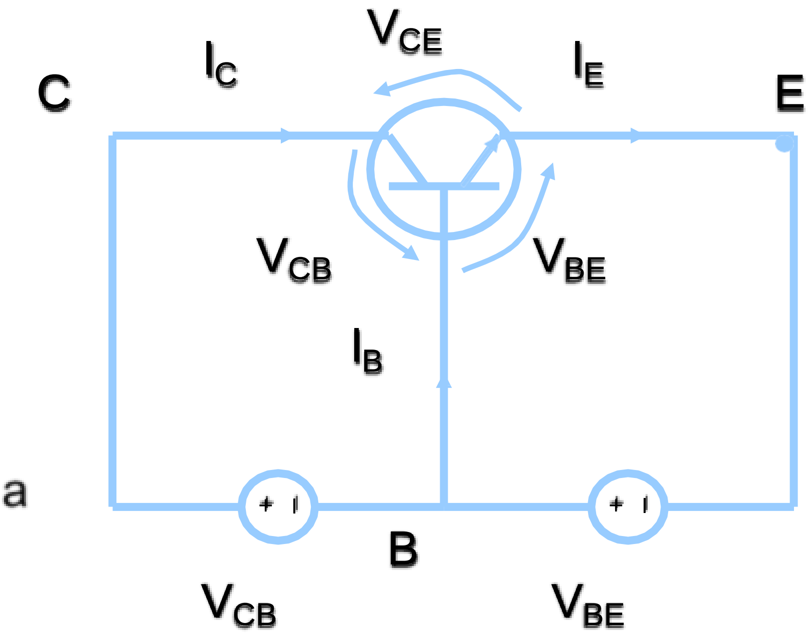
Although the Common-Base configuration is not the most common biasing type, it is often helpful in the understanding of how the BJT works.

Emitter - Current Curves



Common-Base

Circuit Diagram: NPN Transistor

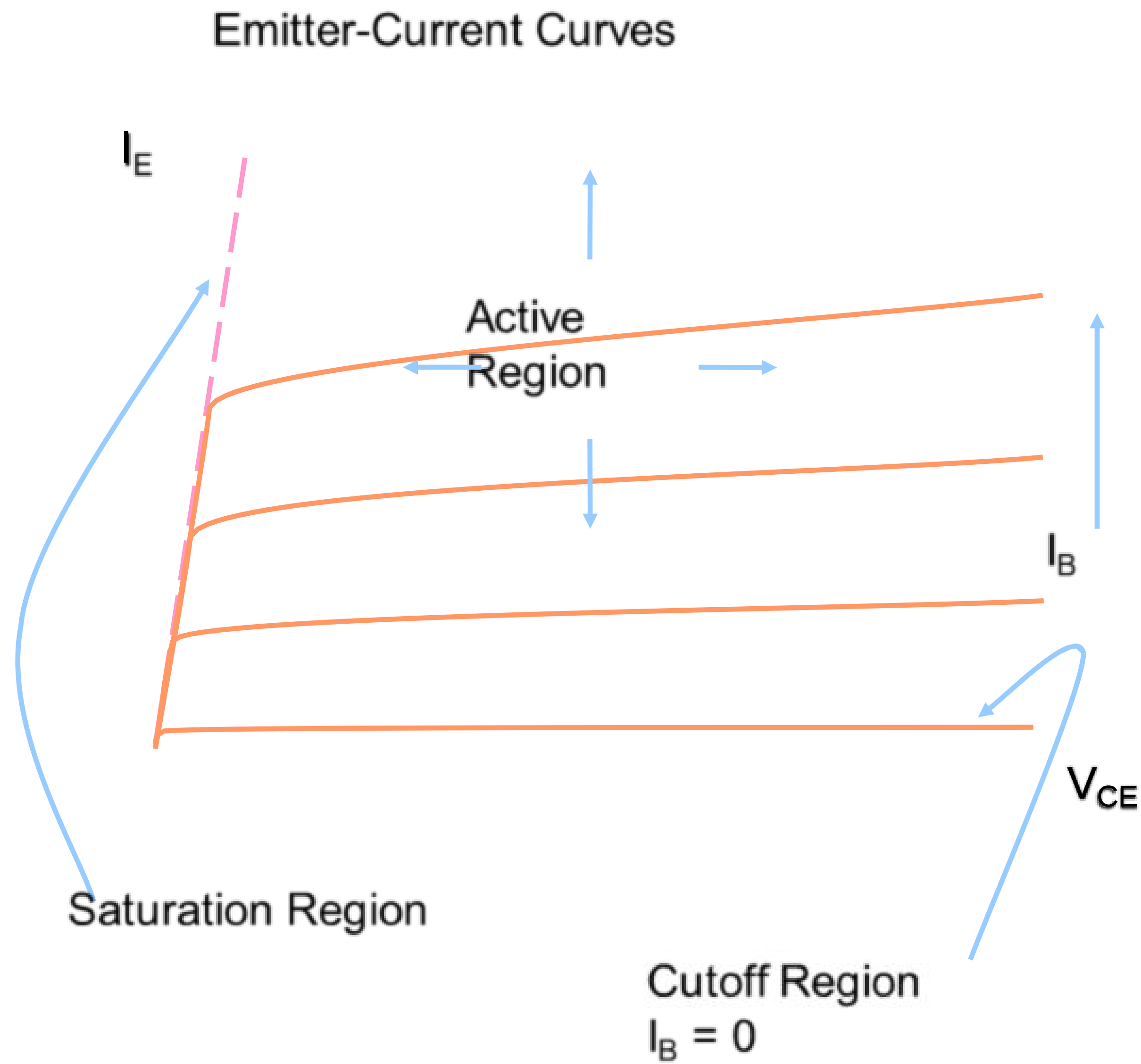


The Table Below lists assumptions that can be made for the attributes of the common-base biased circuit in the different regions of operation. Given for a Silicon NPN transistor.

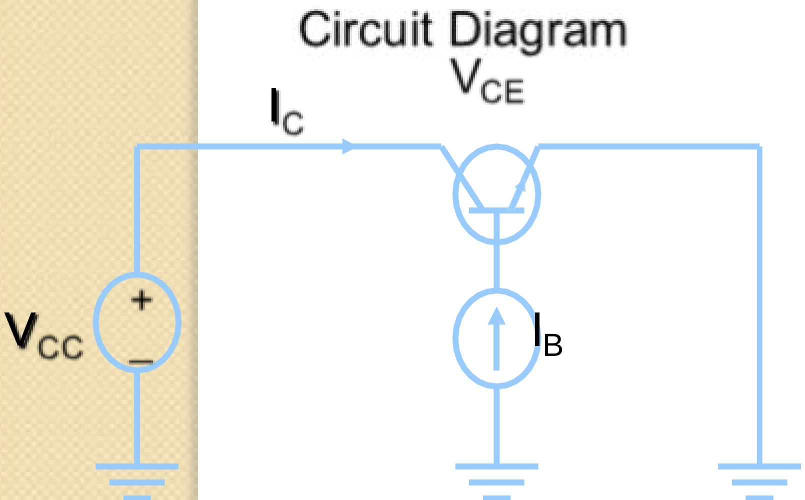
Region of Operation	I_C	V_{CE}	V_{BE}	V_{CB}	C-B Bias	E-B Bias
Active	βI_B	$=V_{BE}+V_{CE}$	~0.7V	0V	Rev.	Fwd.
Saturation	Max	~0V	~0.7V	$-0.7V<V_{CE}<0$	Fwd.	Fwd.
Cutoff	~0	$=V_{BE}+V_{CE}$	0V	0V	Rev.	None /Rev.

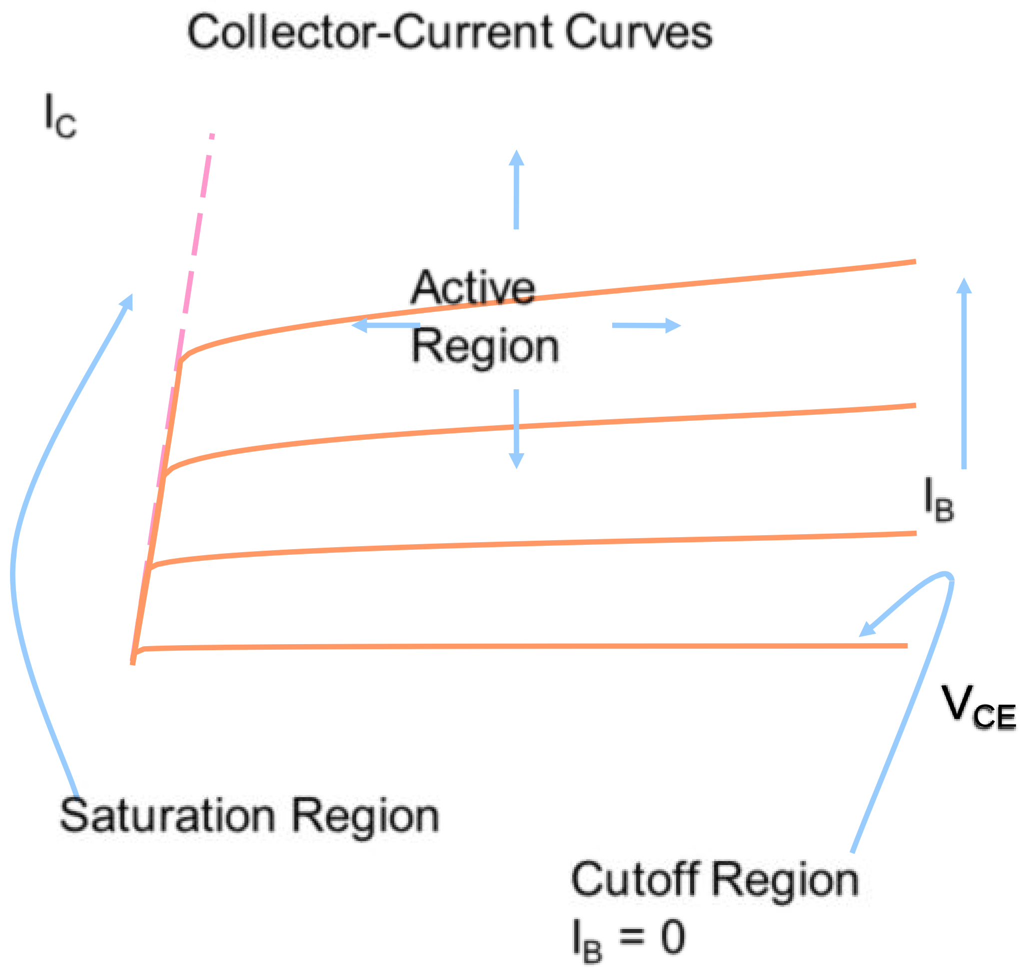
Common-Collector

The Common-Collector biasing circuit is basically equivalent to the common-emitter biased circuit except instead of looking at I_C as a function of V_{CE} and I_B we are looking at I_E. Also, since $\alpha \sim 1$, and $\alpha = I_C/I_E$ that means $I_C \sim I_E$



Common-Emitter





Region of Operation	Description
Active	Small base current controls a large collector current
Saturation	$V_{CE(sat)} \sim 0.2V$, V_{CE} increases with I_C
Cutoff	Achieved by reducing I_B to 0, Ideally, I_C will also equal 0.

Three Types of BJT Biasing

Biasing the transistor refers to applying voltage to get the transistor to achieve certain operating conditions.

Common-Base Biasing (CB) : input $= V_{EB}$ & I_E

output $= V_{CB}$ & I_C

Common-Emitter Biasing (CE): input $= V_{BE}$ & I_B

output $= V_{CE}$ & I_C

Common-Collector Biasing (CC): input $= V_{BC}$ & I_B

output $= V_{EC}$ & I_E

Configurations of Transistors Summary

Transistor Configuration Summary Table			
Transistor Configuration	**Common Base**	**Common Collector (Emitter Follower)**	**Common Emitter**
Voltage Gain	High	Low	Medium
Current Gain	Low	High	Medium
Power Gain	Low	Medium	High
Input / Output Phase Relationship	0°	0°	180°
Input Resistance	Low	High	Medium
Output Resistance	High	Low	Medium


THANK YOU