DEPARTMENT OF ELECTRNICS & COMMUNICATION ENGINEERING, KITSW

COURSE: **U14EI 205 - BASIC ELECTRONICS ENGINEERING**	**ECE-I, Semester-II, 2015-16**

ASSIGNMENT-5 HINTS &SOLUTIONS

1. **Draw the symbols of NPN and PNP transistors and mention different transistor currents and voltages indicating the polarity**

   (refer to class notes….) Those who missed regular classes are advised to take notes without fail from their friends who attended. Detailed running notes were given in class.

2. **Explain the operation of NPN transistor**

   [*You are expected to cover: (i) Physical structure of the transistor indicating terminals, junctions, physical widths and doping levels, (ii) modes of operation based on biasing conditions of J_{EB} and J_{CB} (iii) operation of transistor in the active mode (iv) What happens when J_{EB} is forward biased (v) What happens when J_{CB} is reverse biased (vi) current components I_E, I_B and I_C (vii) expression for I_C (viii) Why the name transistor is given (ix) circuit symbol of NPN transistor mentioning currents and voltages*]

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3. **Explain *Early effect* or *base width modulation***

   Early effect: Reduction of the width of the base in BJT due to the widening of the base-collector junction depletion region, when collector- base voltage is increased, is known as **Early effect** (*named after James M. Early*) or **base-width modulation**

   (For more information, please refer to class notes….) Those who missed regular classes are advised to take notes without fail from their friends who attended. Detailed running notes were given in class.

4. **Define α , β and γ of a transistor and derive the relation between them.**

   (refer to class notes….)

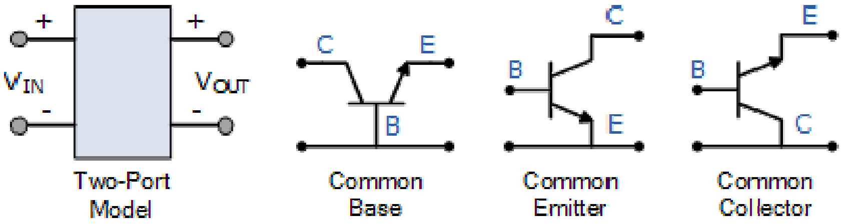
5. **Explain the input and output characteristics of a transistor in CE configuration with reference to early effect.**

   (refer to class notes….) Those who missed regular classes are advised to take notes without fail from their friends who attended. Detailed running notes were given in class.

6. **Explain the input and output characteristics of a transistor in CB configuration with reference to early effect.**

   (refer to class notes….) Those who missed regular classes are advised to take notes without fail from their friends who attended. Detailed running notes were given in class.

7. Compare CB, CE, CC transistor configurations.



S.No.	Characteristics	Common Base	Common Emitter	Common Collector
1.	Input Dynamic Resistance	Very Low (less than $100\,\Omega$)	Low ($< 1K\Omega$)	Very High ($\approx 750K\Omega$)
2.	Output dynamic resistance	Very High ($\approx 1M\Omega$)	High ($< 45K\Omega$)	Low ($\approx 100\ \Omega$)
3.	Current Gain	α Less than $1 (\approx 1)$	$\beta = \frac{\alpha}{1-\alpha}$ High(100)	$\gamma = 1 + \beta$ High (greater than 100)
4.	Voltage Gain	High (About 150)	Very High (About 500)	Very low Less than $1 (\approx 1)$
5.	Power Gain	Medium	Highest	Medium
6.	Leakage Current	I_{CBO}, Very Small (few μA)	I_{CEO}, Very Large (few hundred μA)	I_{ECO}, Very Large (few hundred μA)
7.	Phase relation between i/p and o/p	In Phase (0^o)	Out of Phase (180^o)	In Phase (0^o)
8.	Applications	For High Freq. apps	For Audio Freq. Apps	For impedance Matching Apps.

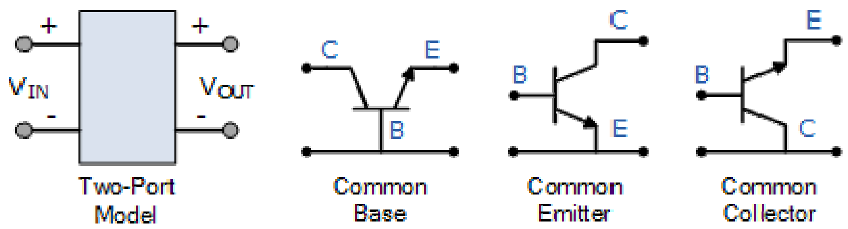
In essence,

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

- **CE configuration is best suited for most of the transistor amplifier applications**

Additional Question:

Why CE configuration is widely used in amplifier circuits ?



S.No.	Characteristics	Common Base	Common Emitter	Common Collector
1.	**Input Dynamic Resistance**	Very Low (less than 100 Ω)	Low (< 1K Ω)	Very High ($\approx$ 750K Ω)
2.	**Output dynamic resistance**	Very High ($\approx$ 1M Ω)	High (< 45K Ω)	Low ($\approx$ 100 Ω)
3.	**Current Gain**	α Less than 1($\approx$ 1)	$\beta = \frac{\alpha}{1-\alpha}$ High(100)	$\gamma = 1+\beta$ High (greater than 100)
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8.	**Applications**	For High Freq. apps	For Audio Freq. Apps	For impedance Matching Apps.

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

- **The main utility of transistor lies in its ability to amplify weak signals.**
- **A good amplifier stage is one which has high input resistance and low output resistance.**
- **A transistor in CB configuration:**
    - **It has very low input resistance (< 100Ω) and a very high output resistance** ($\approx$1MΩ). It is just reverse of what we desire. That is why CB configuration is unpopular as amplifier.
    - However, it is **used as constant current source**, as $I_C = \alpha I_E$. For a given α, once emitter current I_E is fixed, the output collector current I_C will be fixed and maintained at constant level αI_E.
    - **Hence CB configuration is used in applications where constant current is required in circuits**
- **A transistor in CE configuration:**
    - **Comparatively, CE configuration is much better with regards to resistances. Its input resistance is about** 1KΩ and output resistance is about 10KΩ.
    - Furthermore, the current gain, voltage gain and power gain of CE is much more than those of CB.
    - Hence a transistor in CE configuration makes a much better amplifier.
- **A transistor in CC configuration:**
    - **Its input resistance is very high** ($\approx$750KΩ) and output resistance is quite low ($\approx$ 100Ω). However, its essential voltage gain is very low (< 1). Therefore, we use CC configuration where requirement of high input resistance is of prime importance.
    - CC configuration is used in cascading of amplifiers stages as **Buffer Amplifier**.

- **So, CE configuration is best suited for most of the transistor amplifier applications** due to its
    1. *high current, voltage, and power gains*
    2. *moderate input and output resistances, and*
    3. *flexibility*

8. **Calculate I_C and I_E for a transistor that has α_{dc}=0.98 and I_B=100μA. Find the value of β_{dc} of the transistor.**

Solution:

$$\text{Given}: \alpha = 0.98,\ I_B = 100\mu A$$

$$\alpha = \frac{I_C}{I_E} \Rightarrow 0.98 = \frac{I_C}{I_E} \Rightarrow I_C = 0.98 I_E \ ....(1)$$

$$\text{We know } I_E = I_C + I_B \Rightarrow I_E = 0.98 I_E + I_B$$

$$0.02 I_E = I_B \Rightarrow I_E = \frac{I_B}{0.02} \Rightarrow I_E = \frac{100\mu A}{0.02}$$

$$I_E = 5000\mu A = 5mA$$

$$(1) \Rightarrow I_C = 0.98 I_E = 0.98 \text{ x } 5mA$$

$$I_C = 4.9mA$$

$$\text{We know, } \beta = \frac{\alpha}{1-\alpha}$$

$$\beta = \frac{0.98}{1-0.98} = 49$$

9. **The current gain of a transistor in CE mode (β) is 49. Calculate its CB current gain (α). Also find the collector current when the emitter current is 3mA.**

$$\text{Given}: \beta = 49,\ I_E = 3mA$$

CB current gain is α

$$\text{We know, } \beta = \frac{\alpha}{1-\alpha} \Rightarrow \alpha = \frac{\beta}{1+\beta}$$

$$\alpha = \frac{49}{1+49} = 0.98$$

$$\alpha = \frac{I_C}{I_E} \Rightarrow 0.98 = \frac{I_C}{I_E} \Rightarrow I_C = 0.98 I_E$$

$$I_C = 0.98 I_E = 0.98 \text{ x } 3mA$$

$$I_C = 2.94mA$$