Al-Mustaqbal University
College of Engineering and Technologies
Medical Instrumentation Technique Engineering Department
Class: 2nd
Subject: Electronic Circuits
Lecturer: Dr. Rami Qays Malik
Lecture: 8- Bipolar Junction Transistor 2

Bipolar Junction Transistor(BJT)

3.5 COMMON-EMITTER CONFIGURATION

The most frequently encountered transistor configuration appears in Fig. 3.12 for the *pnp* and *npn* transistors. It is called the *common-emitter configuration* because the emitter is common to both the input and output terminals (in this case common to both the base and collector terminals). Two sets of characteristics are again necessary to describe fully the behavior of the common-emitter configuration: one for the *input* or *base–emitter* circuit and one for the *output* or *collector–emitter* circuit. Both are shown in Fig. 3.13.

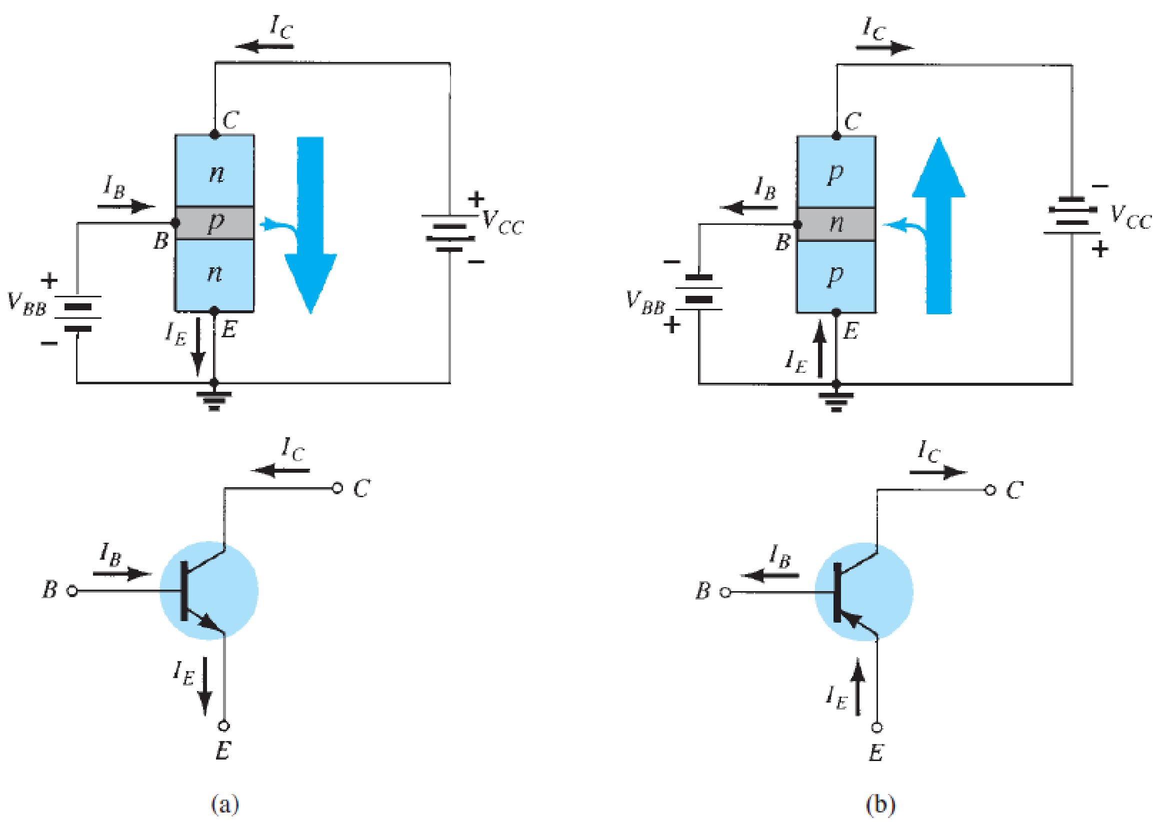

FIG. 3.12
Notation and symbols used with the common-emitter configuration: (a) npn transistor; (b) pnp transistor.

Email: rami.qays@uomus.edu.iq

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CHARACTERISTICS COMMON-EMITTER CONFIGURATION

For the common-emitter configuration the output characteristics are a plot of the output current (IC) versus (output voltage (VCE) for a range of values of input current (IB). The input characteristics are a plot of the input current (IB) versus the input voltage (VBE) for a range of values of output voltage (VCE).

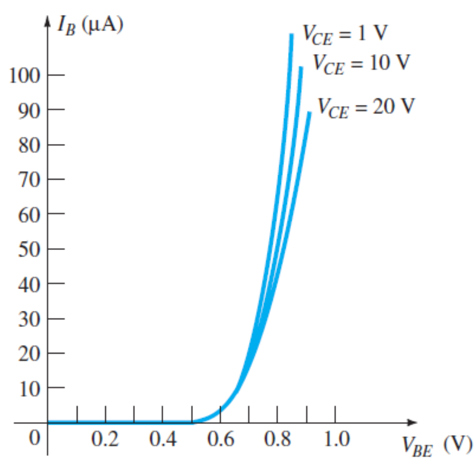
Input characteristics: it is the curve between IB and VBE at constant VCE the magnitude of IB is in microamperes, compared to milliamperes of IC

.**IB** increases less rapidly with VBE

There for the input resistance of CE circuit is higher than that of CB

Circuit ri= VBE/IB

,the input current IE in CB circuit is higher than that of CB circuit IB



Output characteristics; it is the curve between IC and VCE for a range of values of input current (IB).

The output resistance is high ro= VCE/ IC Its value is of the order 500 K

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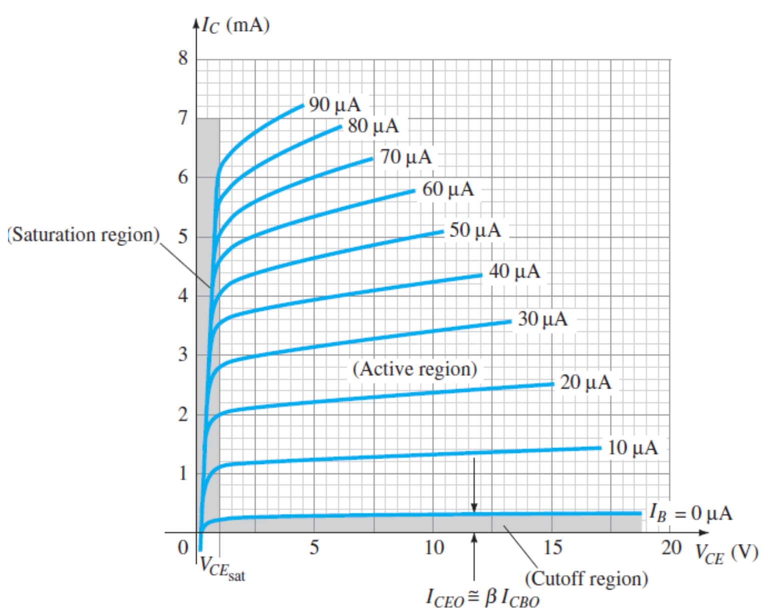
In the active region of a common-emitter amplifier the collector-base junction is reverse-biased, while the base-emitter junction is forward-biased.

The active region of the common emitter configuration can be employed for voltage, current, or power amplification

The active region; for the common-emitter configuration is that portion of the upper-right quadrant that has the greatest linearity, that is, that region in which the curves for IB are nearly straight and equally spaced . In Fig. 3.14a this region exists to the right of the vertical dashed line at VCEsat and above the curve for IB equal to zero. The region to the left of VCE sat is called the saturation region In the active region of a common-emitter amplifier the collector-base junction is reversebiased, while the base-emitter junction is forward-biased.



The collector current Ic varies with VcE for VcE between 0 and 1V only after this Ic becomes almost constant and independent of VcE

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The cutoff region for the common-emitter configuration is not as well defined as for the common-base configuration. Note on the collector characteristics of Fig. 3.14 that IC is not equal to zero when IB is zero. For the common-base configuration, when the input current IE was equal to zero, the collector current was equal only to the reverse saturation current ICO , so that the curve IE=0. and the voltage axis were, for all practical purposes, one Recall for the common-base configuration that the input set of characteristics was approximated by a straight-line equivalent that resulted in VBE =0.7 V for any level of IE greater than 0 mA..

Beta (β)

DC Mode In the dc mode the levels of I_C and I_B are related by a quantity called *beta* and defined by the following equation:

$$\beta_{dc} = \frac{I_C}{I_B} \tag{3.10}$$

A relationship can be developed between β and α using the basic relationships introduced thus far. Using $\beta = I_C/I_B$, we have $I_B = I_C/\beta$, and from $\alpha = I_C/I_E$ we have $I_E = I_C/\alpha$. Substituting into

$$I_E = I_C + I_B$$

we have

$$\frac{I_C}{\alpha} = I_C + \frac{I_C}{\beta}$$

and dividing both sides of the equation by I_C results in

$$\frac{1}{\alpha} = 1 + \frac{1}{\beta}$$

or

$$\beta = \alpha\beta + \alpha = (\beta + 1)\alpha$$

so that

$$\alpha = \frac{\beta}{\beta + 1} \tag{3.12}$$

or

$$\beta = \frac{\alpha}{1 - \alpha} \tag{3.13}$$

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COMMON-COLLECTOR CONFIGURATION

The third and final transistor configuration is the common-collector configuration, shown in Fig. 3.20 with the proper current directions and voltage notation. The common-collector configuration is used primarily for impedance-matching purposes since it has a high input impedance and low output impedance, opposite to that of the common-base and common-emitter configurations.

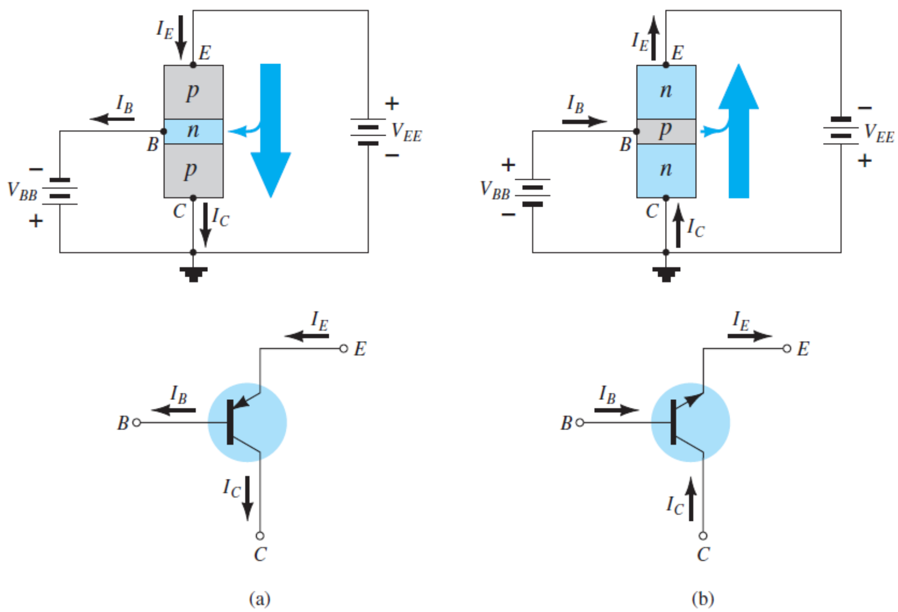

FIG. 3.20
Notation and symbols used with the common-collector configuration: (a) pnp transistor; (b) npn transistor.

A common-collector circuit configuration is provided in Fig. 3.21 with the load resistor connected from emitter to ground. Note that the collector is tied to ground even though the transistor is connected in a manner similar to the common-emitter configuration.

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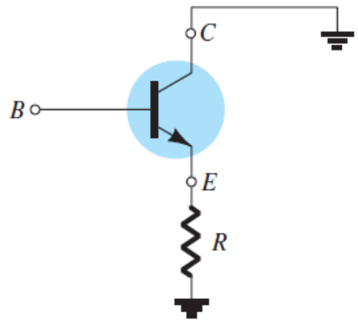

FIG. 3.21
Common-collector configuration used for impedance-matching purposes.

For all practical purposes, the output characteristics of the common-collector configuration are the same as for the common-emitter configuration. For the common-collector configuration the output characteristics are a plot of IE versus VEC for a range of values of IB. The input current, therefore, is the same for both the common-emitter and common collector characteristics. The horizontal voltage axis for the common collector configuration is obtained by simply changing the sign of the collector-to-emitter voltage of the common-emitter characteristics. Finally, there is an almost unnoticeable change in the vertical scale of IC of the common-emitter characteristics if IC is replaced by IE for the common collector characteristics For the input circuit of the common-collector configuration the common-emitter base characteristics are sufficient for obtaining the required information

LIMITS OF OPERATION

For each transistor there is a region of operation on the characteristics which will ensure that the maximum ratings are not being exceeded and the output signal

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exhibits minimum distortion . Such a region has been defined for the transistor characteristics of Fig. 3.22.

Some of the limits of operation are self-explanatory, such as maximum collector current (normally referred to on the specification sheet as continuous collector current) and maximum collector-to-emitter voltage (often abbreviated as VCEO or V(BR)CEO on the specification sheet). For the transistor of Fig. 3.22, ICmax was specified as 50 mA and VCEO as 20 V. The vertical line on the characteristics defined as VCEsat specifies

At $I_{C_{max}}$ At any point on the characteristics the product of V_{CE} and I_C must be equal to 300 mW. If we choose I_C to be the maximum value of 50 mA and substitute into the relationship above, we obtain

$$V_{CE}I_C = 300\text{ mW}$$
$$V_{CE}(50\text{ mA}) = 300\text{ mW}$$
$$V_{CE} = \frac{300\text{ mW}}{50\text{ mA}} = \mathbf{6\ V}$$

At $V_{CE_{max}}$ As a result we find that if $I_C = 50$ mA, then $V_{CE} = 6$ V on the power dissipation curve as indicated in Fig. 3.22. If we now choose V_{CE} to be its maximum value of 20 V, the level of I_C is the following:

$$(20\text{ V})I_C = 300\text{ mW}$$
$$I_C = \frac{300\text{ mW}}{20\text{ V}} = \mathbf{15\ mA}$$

defining a second point on the power curve.

At $I_C = \frac{1}{2}I_{C_{max}}$ If we now choose a level of I_C in the midrange such as 25 mA and solve for the resulting level of V_{CE}, we obtain

$$V_{CE}(25\text{ mA}) = 300\text{ mW}$$

and

$$V_{CE} = \frac{300\text{ mW}}{25\text{ mA}} = \mathbf{12\ V}$$

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Important Conclusions and Concepts

1. Semiconductor devices have the following advantages over vacuum tubes: They are (1) of **smaller size**, (2) more **lightweight**, (3) more **rugged**, and (4) more **efficient**. In addition, they have (1) **no warm-up period**, (2) **no heater requirement**, and (3) **lower operating voltages**.
2. Transistors are **three-terminal devices** of three semiconductor layers having a base or center layer a great deal **thinner** than the other two layers. The outer two layers are both of either *n*- or *p*-type materials, with the sandwiched layer the opposite type.
3. One *p–n* junction of a transistor is **forward-biased**, whereas the other is **reverse-biased**.
4. The dc emitter current is always the **largest current** of a transistor, whereas the base current is always the **smallest**. The emitter current is always the **sum** of the other two.
5. The collector current is made up of **two components**: the **majority component** and the **minority current** (also called the ***leakage*** **current**).
6. The arrow in the transistor symbol defines the direction of **conventional current flow for the emitter current** and thereby defines the direction for the other currents of the device.
7. A three-terminal device needs **two sets of characteristics** to completely define its characteristics.
8. In the active region of a transistor, the base–emitter junction is **forward-biased**, whereas the collector–base junction is **reverse-biased**.
9. In the cutoff region the base–emitter and collector–base junctions of a transistor are **both reverse-biased**.
10. In the saturation region the base–emitter and collector–base junctions are **forward-biased**.
11. On an average basis, as a first approximation, the base-to-emitter voltage of an operating transistor can be assumed to be **0.7 V**.
12. The quantity alpha (α) relates the collector and emitter currents and is always close to **one**.

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13. The impedance between terminals of a forward-biased junction is always relatively **small**, whereas the impedance between terminals of a reverse-biased junction is usually **quite large**.
14. The arrow in the symbol of an *npn* transistor points out of the device (**n**ot **p**ointing i**n**), whereas the arrow points in to the center of the symbol for a *pnp* transistor (**p**ointing i**n**).
15. For linear amplification purposes, cutoff for the common-emitter configuration will be defined by $I_C = I_{CEO}$.
16. The quantity beta (β) provides an important relationship between the base and collector currents, and is usually between **50 and 400**.
17. The dc beta is defined by a simple **ratio of dc currents at an operating point**, whereas the ac beta is **sensitive to the characteristics** in the region of interest. For most applications, however, the two are considered equivalent as a first approximation.
18. To ensure that a transistor is operating within its maximum power level rating, simply find the **product of the collector-to-emitter voltage and the collector current**, and compare it to the rated value.