

عنوان البحث

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**Abstract**

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals controls the current through another pair of terminals.

**Introduction**

The Bipolar Junction Transistor usually (BJT) is a semiconductor device which can be used for switching or amplification. If we join two diodes, this will give us two PN-junctions sharing a common P or N terminal. The fusion of these two diodes produces a three-layer, two junction, three-terminal device forming the basis of a Bipolar Junction Transistor. The three terminals are labelled as the Emitter (E), the Base (B) and the Collector (C) respectively. Transistors are made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage. The transistor’s ability to change between these two states enables it to have two basic functions: “switching” (digital) or “amplification” (analog). Thus, BJTs can operate within three different regions:

* **Active Region**: the transistor operates as an amplifier,
* **Saturation**: the transistor is operating as On-switch
* **Cut-off**: the transistor is operating as Off-switch,

Figure1 A typical bipolar transistor

There are three possible ways to connect the BJT within an electronic circuit with one terminal being common to both the input and output.

* **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.

**Research Project Contents**

**The Common Base (CB) Configuration:**

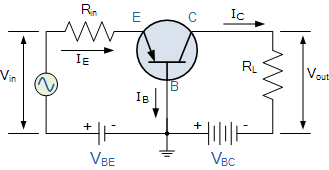


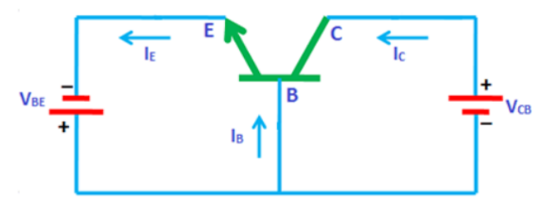
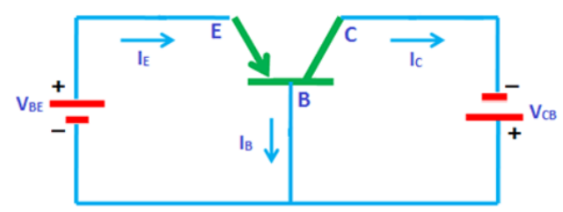
Figure Common Base Transistor Circuit

In the Common Base or grounded base configuration, the **base** **connection** is common to both the input signal and the output signal. The input signal is applied between the transistors base and the emitter terminals, while the corresponding output signal is taken from between the base and the collector terminals as shown. The base terminal is grounded or can be connected to some fixed reference voltage point.

The input current flowing into the emitter is quite large as its the sum of both the base current and collector current respectively.

**The Common Base Transistor Circuit**

This type of amplifier configuration is a non-inverting voltage amplifier circuit, in that the signal voltages and are “in-phase”. This type of transistor arrangement is not very common due to its unusually high voltage gain characteristics. Its input characteristics represent that of a forward biased diode while the output characteristics represent that of an illuminated photodiode.



1. (b)

Figure common base configuration (a) NPN (b) PNP

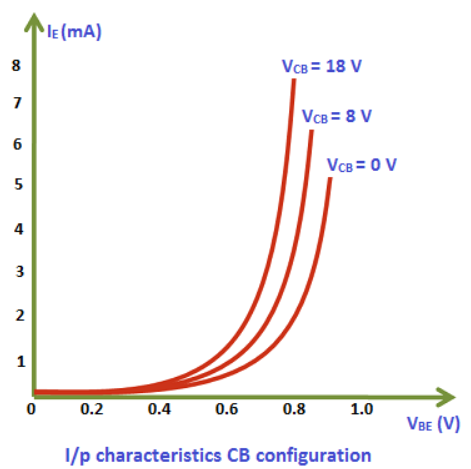
**The input characteristics** describe the relationship between input current () and the input voltage (). To determine the input characteristics, the output voltage (collector-base voltage) is kept constant at zero volts and the input voltage is increased from zero volts to different voltage levels. For each voltage level of the input voltage (), the input current () is recorded. A curve is then drawn between input current and input voltage at constant output voltage (0 volts). Next, the output voltage () is increased from zero volts to a certain voltage level (8 volts) and kept constant at 8 volts. While increasing the output voltage (), the input voltage () is kept constant at zero volts. After we kept the output voltage () constant at 8 volts, the input voltage is increased from zero volts to different voltage levels. For each voltage level of the input voltage (), the input current () is recorded. A curve is then drawn between input current and input voltage at constant output voltage (8 volts).

Figure I/P characteristics CB configuration

This is repeated for higher fixed values of the output voltage (). When output voltage () is at zero volts and emitter-base junction JE is forward biased by the input voltage (), the emitter-base junction acts like a normal p-n junction diode. So, the input characteristics are same as the forward characteristics of a normal pn junction diode. The cut in voltage of a silicon transistor is 0.7 volts and germanium transistor is 0.3 volts. In our case, it is a silicon transistor. So, from the above graph, we can see that after 0.7 volts, a small increase in input voltage () will rapidly increase the input current (). When the output voltage () is increased from zero volts to a certain voltage level (8 volts), the emitter current flow will be increased which in turn reduces the depletion region width at emitter-base junction. As a result, the cut in voltage will be reduced. Therefore, the curves shifted towards the left side for higher values of output voltage .

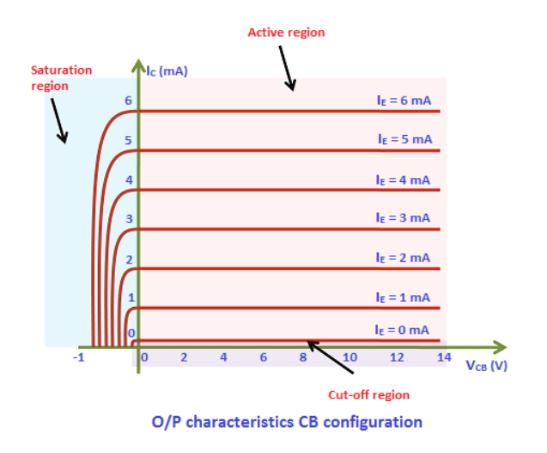
**The output characteristics** describe the relationship between output current () and the output voltage (). To determine the output characteristics, the input current or emitter current is kept constant at zero mA and the output voltage is increased from zero volts to different voltage levels. For each voltage level of the output voltage , the output current () is recorded. A curve is then drawn between output current and output voltage at constant input current (0 mA).

Figure O/P characteristics CB configuration

When the emitter current or input current is equal to 0 mA, the transistor operates in the cut-off region. Next, the input current () is increased from 0 mA to 1 mA by adjusting the input voltage and the input current is kept constant at 1 mA. While increasing the input current , the output voltage is kept constant.

After we kept the input current () constant at 1 mA, the output voltage () is increased from zero volts to different voltage levels. For each voltage level of the output voltage (), the output current () is recorded. A curve is then drawn between output current and output voltage at constant input current (1 mA). This region is known as the active region of a transistor. This is repeated for higher fixed values of input current . From the above characteristics, we can see that for a constant input current , when the output voltage is increased, the output current remains constant. At saturation region, both emitter-base junction and collector-base junction are forward biased. From the above graph, we can see that a sudden increase in the collector current when the output voltage makes the collector-base junction forward biased.

**BJT Transistor Modeling:** a model is an equivalent circuit that represents the AC characteristics of the transistor.Transistor small signal amplifiers can be considered linear for most application. A model is the best approximate of the actual behavior of a semiconductor device underspecific operating conditions, including circuit elements

**Transistor Models**

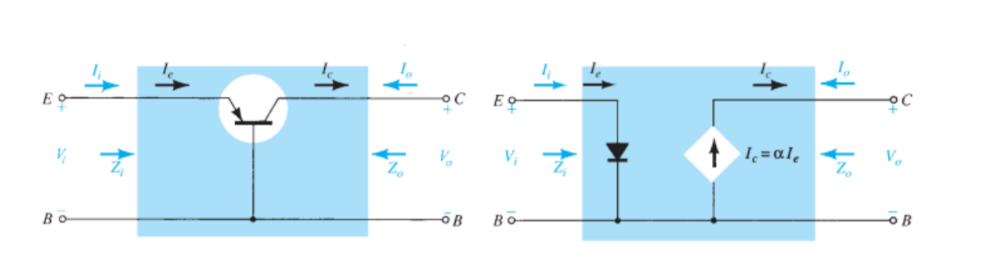
- model: any region of operation, fails to account for output impedance, less accuracy

Hybrid model: limited to a particular operating conditions, more accuracy

**The Transistor Model**

BJTs are basically current-controlled devices; therefore, the models use a diode and a current source to duplicate the behavior of the transistor. One disadvantage to this model is its sensitivity to the DC level. This model is designed for specific circuit conditions.

**Common-Base Configuration**



1. (b)

Figure Common Base transistor model

We know that from diode equation re is defined as follows

Applying KVL to input and out circuit of figure 6 (b), we will get

**input impedance:**

**Output impedance:**

**Voltage gain:**

**Current gain:**

**H – Parameter model:**

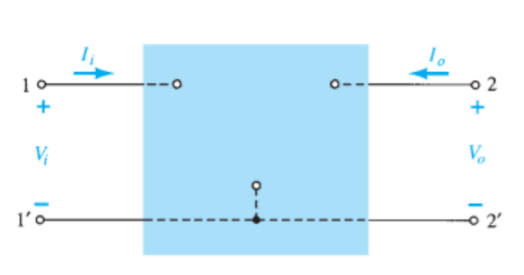
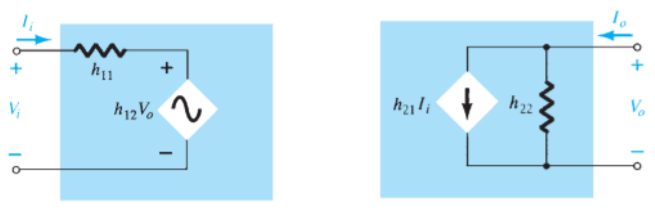
The equivalent circuit of a transistor can be dram using simple approximation by

retaining its essential features. These equivalent circuits will aid in analyzing transistor circuits easily and rapidly.

**Two port devices & Network Parameters:**

A transistor can be treated as a two-part network. The terminal behavior of any two

part network can be specified by the terminal voltages & at parts 1 & 2 respectively and current and , entering parts 1 & 2, respectively, as shown in fig. 7.



(b) (c)

(a)

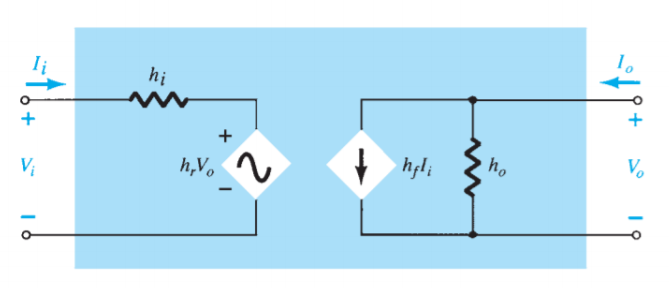


Figure Two port Network

(a) Two-port system (b) hybrid input equivalent circuit

(c) hybrid output equivalent circuit (d) Complete hybrid equivalent circuit.

(d)

**Hybrid parameters (or) h – parameters:**

If the input current and output Voltage are takes as independent variables, the input voltage and output current can be written as

The four hybrid parameters and are defined as follows.

with Input Impedance with output part short circuited.

with Output admittance with input part open circuited.

with reverse voltage transfer ratio with input part open circuited.

with Forward current gain with output part short circuited.

The dimensions of h – parameters are as follows:

- Ω

– mhos

– dimension less.

as the dimensions are not alike, (i.e.) they are hybrid in nature, and these parameters are called as hybrid parameters.

input; output;

forward transfer Reverse transfer.

**Notations used in transistor circuits:**

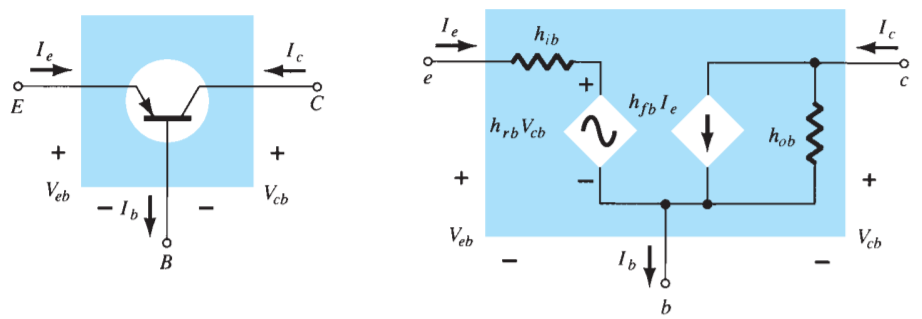
Short circuit input impedance

Open circuit output admittance

Open circuit reverse voltage transfer ratio

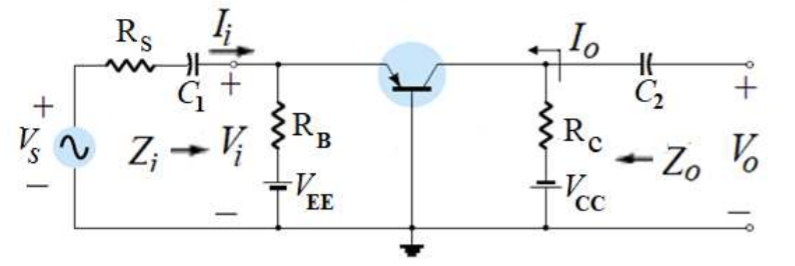
Short circuit forward current Gain.

For the **common-base configuration** of Fig. 8 with and . The networks of Figs. 8 are applicable for pnp or npn transistors.

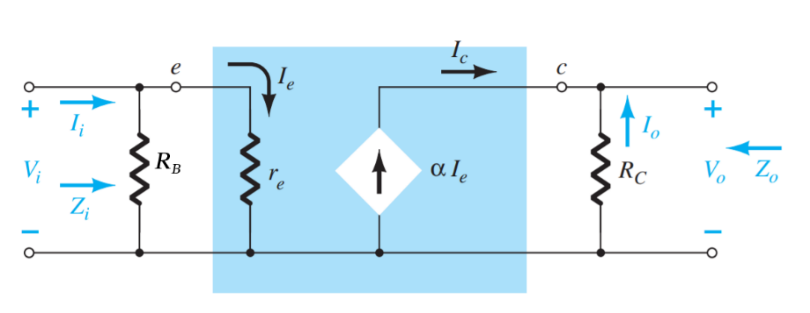
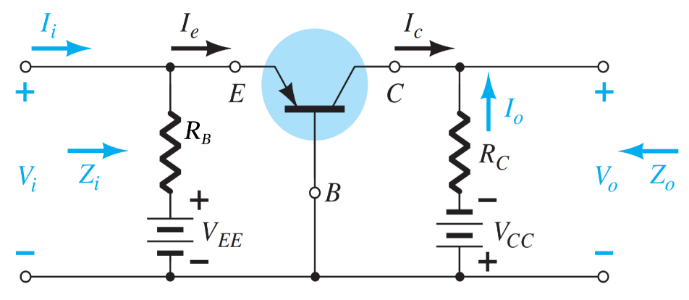


(a) (b)

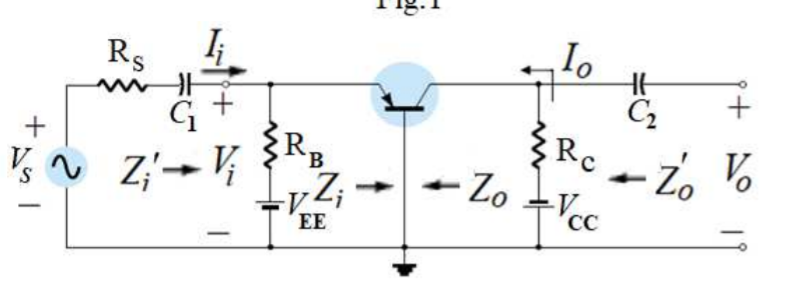
Figure Common-base configuration: (a) graphical symbol; (b) hybrid equivalent circuit

Define and derive the ac circuit parameters for the network shown in Fig 9, replacing the transistor with its model.

Figure

**solution**

Define and derive the ac circuit parameters for the network shown in Fig.2, replacing the transistor with its **hybrid model**.



Figure

**Solution**: The common-base hybrid parameters are derived from the common-emitter

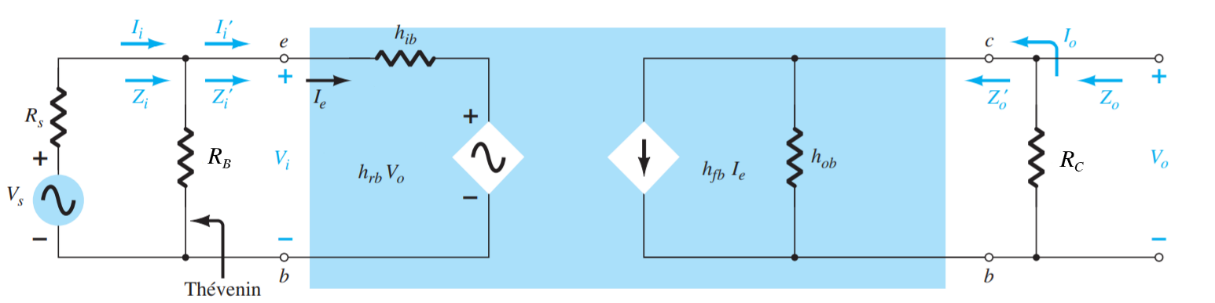
parameters using the approximate equations of Appendix B:

Or

Also,

Substituting the common-base hybrid equivalent circuit into the network of Fig 10

results in the small-signal equivalent network of Fig 11.



Figure

so that the equation above becomes

The familiar form of is obtained if the second factor in the denominator () is sufficiently smaller than one.

Applying Kirchhoff’s current law to the output circuit yields

Rewriting the equation above, we have

Note that the current gain reduces to the familiar result of is sufficiently small compared to 1.

Applying Kirchhoff’s voltage law to the input circuit results in

Solving for the ratio yields

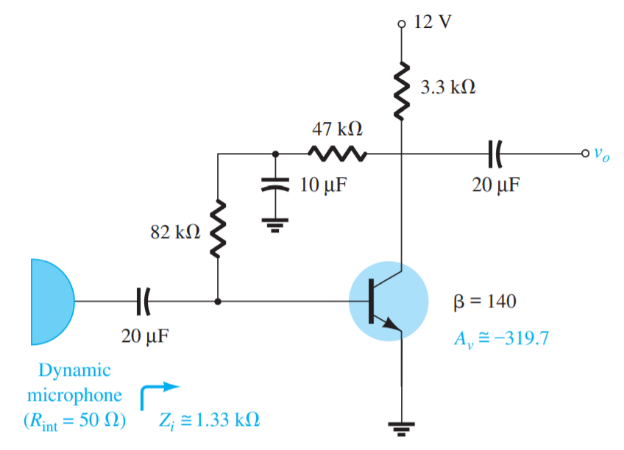
In this case, the familiar form of returns if the factor

is sufficiently small compared

The output impedance of an amplifier is defined to be the ratio of the output voltage to the output current with the signal set to zero. For the input circuit with

In this case, the output impedance is reduced to the familiar form for the transistor when the second factor in the denominator is sufficiently smaller than the fir

**Preamplifier**

 The primary function of a preamplifier is as its name implies: an amplifier used to pick up the signal from its primary source and then operate on it in preparation for its passage

into the amplifier section. Typically, a preamplifier will amplify the signal, control its volume, perhaps change its input impedance characteristics, and if necessary, determine its route through the stages to follow—in total, a stage of any system with a multitude of functions.

Figure Preamplifier for a dynamic microphone.

A preamplifier such as shown in Fig. 12 is often used with dynamic microphones

to bring the signal level up to levels that are suitable for further amplification or power

amplifiers. Typically, dynamic microphones are low-impedance microphones because

their internal resistance is determined primarily by the winding of the voice coil. The basic construction consists of a voice coil attached to a small diaphragm that is free to move within a permanent magnet. When one speaks into the microphone, the diaphragm moves accordingly, and causes the voice coil to move in the same manner within the magnetic field. In accord with Faraday’s law, a voltage will be induced across the coil that will carry the audio signal.

**References**

1. Boylestad, R. L., & Nashelsky, L. (2013). Electronic devices and circuit theory. Upper Saddle River, N.J: Pearson Prentice Hall.
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer January. 2009. Analysis and Design of Analog Integrated Circuits, 5th Edition.
3. Grebene, A. B. (2003). Bipolar and MOS analog integrated circuit design. Hoboken, N.J: Wiley-Interscience.
4. Paolo Antognetti and Giuseppe Massobrio (1993). Semiconductor Device Modeling with Spice. McGraw–Hill Professional.
5. Paul Horowitz and Winfield Hill (1989). The Art of Electronics (2nd ed.). Cambridge University Press. pp. 62–66.