

# BIPOLAR JUNCTION TRANSISTOR

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**Abstract-** The transistor is the main building block “element” of electronics. It is a semiconductor device and it comes in two general types: the Bipolar Junction Transistor (BJT) and the Field Effect Transistor (FET). Here we will describe the system characteristics of the BJT configuration . The BJT is a three terminal device and it comes in two different types. The npn BJT and the pnp BJT. The BJT symbols and their corresponding block diagrams. The BJT is fabricated with three separately doped regions. The npn device has one p region between two n regions and the pnp device has one n region between two p regions. The BJT has two junctions (boundaries between the n and the p regions). These junctions are similar to the junctions we saw in the diodes and thus they may be forward biased or reverse biased.

## I. HISTORY:-

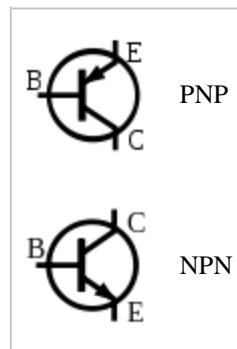
The bipolar point-contact transistor was invented in December 1947 at the Bell Telephone Laboratories by John Bardeen and Walter Brattain under the direction of William Shockley. The junction version known as the bipolar junction transistor, invented by Shockley in 1948, enjoyed three decades as the device of choice in the design of discrete and integrated circuits. Nowadays, the use of the BJT has declined in favor of CMOS technology in the design of digital integrated circuits. The incidental low performance BJTs inherent in CMOS ICs, however, are often utilized as bandgap voltage reference, silicon bandgap temperature sensor and to handle electrostatic discharge.

## II. INTRODUCTION

A bipolar junction transistor is a type of transistor that relies on the contact of two types of semiconductor for its operation. BJTs can be used as amplifiers, switches, or in oscillators. BJTs can be found either as individual discrete components, or in large numbers as parts of integrated circuits. *Bipolar* transistors are so named because their operation involves both electrons and holes. . The regions of a BJT are called *emitter*, *collector*, and *base*. A discrete transistor has three leads for connection to these

regions. By design, most of the BJT collector current is due to the flow of charges injected from a high-concentration emitter into the base where there are minority carriers that diffuse toward the collector, and so BJTs are classified as minority-carrier devices.

BJTs come in two types, or polarities, known as PNP and NPN based on the doping types of the three main terminal regions. An NPN transistor comprises two semiconductor junctions that share a thin p-doped anode region, and a PNP transistor comprises two semiconductor junctions that share a thin n-doped cathode region.



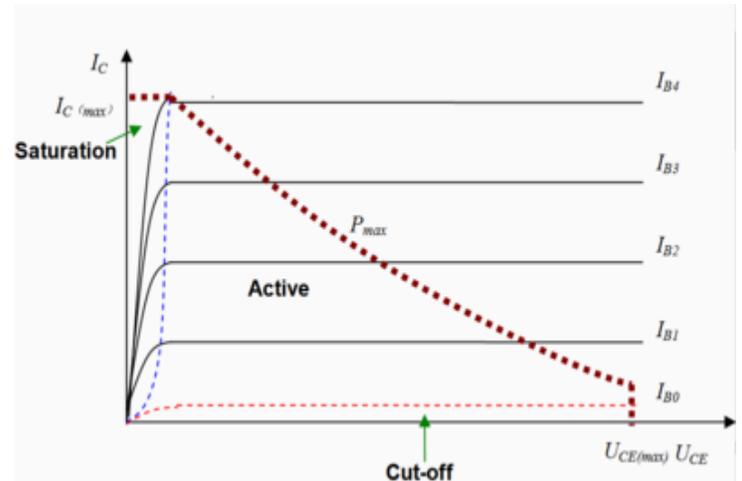
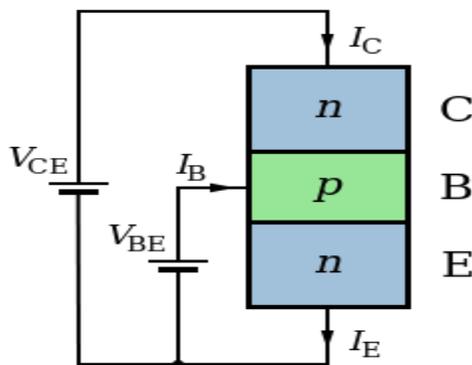
Schematic symbols PNP- and NPN-type for BJTs. To minimize the percentage of carriers that recombine before reaching the collector–base junction, the transistor's base region must be thin enough that carriers can diffuse across it in much less time than the semiconductor's minority carrier lifetime. In particular, the thickness of the base must be much less than the diffusion length of the electrons. The collector–base junction is reverse-biased, and so little electron injection occurs from the collector to the base, but electrons that diffuse through the base towards the collector are swept into the collector by the electric field in the depletion region of the collector–base junction. The bipolar junction transistor, unlike other transistors, is usually not a symmetrical device. This means that interchanging the collector and the emitter makes the

transistor leave the forward active mode and start to operate in reverse mode. Because the transistor's internal structure is usually optimized for forward-mode operation, interchanging the collector and the emitter makes the values of  $\alpha$  and  $\beta$  in reverse operation much smaller than those in forward operation; often the  $\alpha$  of the reverse mode is lower than 0.5. Early transistors were made from germanium but most modern BJTs are made from silicon. A significant minority are also now made from gallium arsenide, especially for very high speed applications

### III. TRANSISTOR OPERATION AND CHARACTERISTIC I-V CURVES

The three terminals of the transistors and the two junctions, present us with multiple operating regimes. In order to distinguish these regimes we have to look at the i-v characteristics of the device.

The most important characteristic of the BJT is the plot of the collector current,  $I_C$ , versus the collector-emitter voltage,  $V_{CE}$ , for various values of the base current,  $I_B$  as shown on the circuit the qualitative characteristic curves of a BJT. The plot indicates the four regions of operation: the saturation, the cutoff, the active and the breakdown. Each family of curves is drawn for a different base current and in this plot  $I_{B4} > I_{B3} > I_{B2} > I_{B1}$



### Bipolar transistors have five distinct regions of operation, defined by BJT junction biases

**Forward-active:-** The base-emitter junction is forward biased and the base-collector junction is reverse biased. Most bipolar transistors are designed to afford the greatest common-emitter current gain,  $\beta_F$ , in forward-active mode. If this is the case, the collector-emitter current is approximately proportional to the base current, but many times larger, for small base current variations.

- **Reverse-active :-** By reversing the biasing conditions of the forward-active region, a bipolar transistor goes into reverse-active mode. In this mode, the emitter and collector regions switch roles. Because most BJTs are designed to maximize current gain in forward-active mode, the  $\beta_F$  in inverted mode is several times smaller (2-3 times for the ordinary germanium transistor). This transistor mode is seldom used, usually being considered only for failsafe conditions and some types of bipolar logic. The reverse bias breakdown voltage to the base may be an order of magnitude lower in this region.
- **Saturation:-** With both junctions forward-biased, a BJT is in saturation mode and facilitates high current conduction from the emitter to the collector (or the other direction in the case of NPN, with negatively charged carriers flowing from emitter to collector). This mode corresponds to a logical "on", or a closed switch.
- **Cutoff:-** In cutoff, biasing conditions opposite of saturation (both junctions

reverse biased) are present. There is very little current, which corresponds to a logical "off", or an open switch.

#### IV. AMPLIFIERS:-

The transistor parameters  $\alpha$  and  $\beta$  characterizes the current gain of the BJT. It is this gain that allow BJTs to be used as the building blocks of electronic amplifiers. The three main BJT amplifier topologies are

- Common emitter
- Common base
- Common collector

#### V. TEMPERATURE SENSORS

Because of the known temperature and current dependence of the forward-biased base-emitter junction voltage, the BJT can be used to measure temperature by subtracting two voltages at two different bias currents in a known ratio.

#### VI. LOGARITHMIC CONVERTERS

Because base-emitter voltage varies as the log of the base-emitter and collector-emitter currents, a BJT can also be used to compute logarithms and anti-logarithms. A diode can also perform these nonlinear functions but the transistor provides more circuit flexibility.

#### VII. APPLICATIONS

The BJT remains a device that excels in some applications, such as discrete circuit design, due to the very wide selection of BJT types available, and because of its high transconductance and output resistance compared to MOSFETs. The BJT is also the choice for demanding analog circuits, especially for very-high-frequency applications, such as radio-frequency circuits for wireless systems. Bipolar transistors can be combined with MOSFETs in an integrated circuit by using a BiCMOS process of wafer fabrication to create circuits that take advantage of the application strengths of both types of transistor.

#### VIII. CONCLUSION

A bipolar junction transistor (BJT or bipolar transistor) is a type of transistor that relies on the contact of two types of semiconductor for its

operation. BJTs can be used as amplifiers, switches, or in oscillators. BJTs can be found either as individual discrete components, or in large numbers as parts of integrated circuits. The resulting reduction in minority carrier lifetime causes gradual loss of gain of the transistor. Power BJTs are subject to a failure mode called secondary breakdown, in which excessive current and normal imperfections in the silicon die cause portions of the silicon inside the device to become disproportionately hotter than the others. The doped silicon has a negative temperature coefficient, meaning that it conducts more current at higher temperatures. Thus, the hottest part of the die conducts the most current, causing its conductivity to increase, which then causes it to become progressively hotter again, until the device fails internally. The thermal runaway process associated with secondary breakdown, once triggered, occurs almost instantly and may catastrophically damage the transistor package. If the emitter-base junction is reverse biased into avalanche or Zener mode and current flows for a short period of time, the current gain of the BJT will be permanently degraded.

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