JIGNASA STUDENT STUDY PROJECT

Title: TRANSISTORS & TYPES

SUBMITTED TO THE COMMISSIONER OF COLLEGIATE EDUCATION, HYDERABAD.

Under the

JIGNASA-2021-22

Government Degree College
Peddapalli

Submitted by

1. ERRAM PRAVALIKA - BSC MPCS III YEAR - 19077006468004
2. MUTHYALA SOUJANYA -BSC MPCS III YEAR-19077006468010
3. PORANDLA LAXMAN- BSC MPC II YEAR – 20077006441004
4. NIKADI SRIKANTH- BSC MPCS I YEAR – 210770064681013
5. PESARI MADHUKAR- BSC MPCS I YEAR – 210770064681014

Name of the Supervisor
P.NITHIN

DEPARTMENT OF PHYSICS

GDC PEDDAPALLI -TELANGANA

CONTENTS

DECLARATION

We do hereby declare that the work presented in this study project entitled **"TRANSISTORS & TYPES"** is an original one and has been carried out by us in the Department of PHYSICS G D C Peddapalli, Dist: Peddapalli and has not been submitted either in part or in full for the award of any Degree or Diploma of any University earlier.

Date: 18-December-2021

Place:Peddapalli

1. ERRAM PRAVALIKA - BSC MPCS III YEAR – 19077006468004
2. MUTHYALA SOUJANYA -BSC MPCS III YEAR-19077006468010
3. PORANDLA LAXMAN- BSC MPC II YEAR – 20077006441004
4. NIKADI SRIKANTH- BSC MPCS I YEAR – 210770064681013
5. PESARI MADHUKAR- BSC MPCS I YEAR – 210770064681014

DEPARTMENT OF PHYSICS

GOVERNMENT DEGREE COLLEGE, PEDDAPALLI

DIST:PEDDAPALLI

CERTIFICATE

This is to certify that the JIGNASA-Students' Study Project entitled **"TRANSISTORS & TYPES" is** an original one and has been carried out by **ERRAM PRAVALIKA - BSC MPCS III YEAR, MUTHYALA SOUJANYA -BSC MPCS III YEAR, PORANDLA LAXMAN - BSC MPC II YEAR,NIKADI SRIKANTH- BSC MPCS I YEAR and PESARI MADHUKAR- BSC MPCS I YEAR** in the Department of PHYSICS, GOVERNMENT DEGREE COLLEGE, PEDDAPALLI Dist.:PEDDAPALLI, Telangana and completed under my supervision. It is a bonafide work done by them and has not been submitted elsewhere for the award of any Degree or Diploma or Competition. This study project is of the standard expected and I strongly recommend that it may be sent for evaluation.

Date:18-December-2021

Place: Peddapalli

P.NITHIN

Dept. of Physics

Study Project Supervisor

ACKNOWLEDGEMENT

We feel it great honor and proud privilege to extend our heartfelt gratitude to **Sri Navin Mittal IAS** garu, the Commissioner of Collegiate Education, Hyderabad, Telangana, for introducing such a wonderful, research oriented and skill development programme of JIGNASA to Degree College Students across the State of Telangana. Indeed, this programme develops the academic qualities, inquisitiveness, creative talent and the bent of research in the students. Thank you very much Sir for giving us an opportunity to undertake study projects under the **JIGNASA-Student Study Projects.**We owe a great debt of gratitude to **Sri P.Nithin**, beloved Principal of this College and the supervisor for his constant motivation, encouragement for undertaking this study project and constructive suggestions for completion of this project. We thank all those who have directly and indirectly encouraged and supported us to carry out this study project.

From

1. ERRAM PRAVALIKA - BSC MPCS III YEAR – 19077006468004
2. MUTHYALA SOUJANYA -BSC MPCS III YEAR-19077006468010
3. PORANDLA LAXMAN- BSC MPC II YEAR – 20077006441004
4. NIKADI SRIKANTH- BSC MPCS I YEAR – 210770064681013
5. PESARI MADHUKAR- BSC MPCS I YEAR – 210770064681014

ABSTRACT:

This project highlights the different types of transistors and their applications. A detailed study is carried out about the transistors and their types. There are two types of transistors in the broader sense, namely BJT and FET. This type of transistor is further subdivided. There are more than 15 types of transistors available on the market. The project concludes by mentioning the two important applications of the transistors.

I.INTRODUCTION:

In this project, we will learn what is a Transistor**?** What are the different types of Transistor?

What is a Transistor

A transistor is a type of electronic device which is formed by p-type and n-type semiconductors. When a semiconductor is positioned in the middle of two semiconductors of the same type then this arrangement is called the transistor.

- A transistor can also be defined as a simultaneous connection of two diodes**.**
- A transistor is a device that controls the passage of current or voltage and serves as a button or gate for electronic signals.
- It has three terminals namely emitter, base and collector.
- It is capable of signal amplification as well as signal rectification.
- Transistors have had a significant impact on the electronic industry's revolution.

Transistor terminals:

Emitter – This segment is on the left side of the transistor. It is moderately sized and heavily doped.

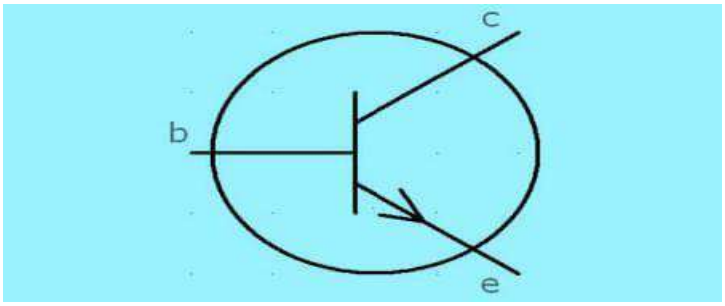
Base – This segment is at the centre of the transistor. It is thin and lightly doped.

Collector – This segment is on the right side of the transistor. It is larger than the emitter and is moderately doped.

A transistor is a semiconductor device that is used to switch or amplify electronic signals in an electric circuit**.** There are mainly 2 types of transistors – field-effect transistors (FETs) and bipolar transistors or bipolar junction transistors, BJTs**.** There can be further many types of transistors based on their characteristics, advantages, and disadvantages.

- A field-effect transistor is a type of unipolar device with no PN junction in its current-carrying path. They can be classified as – N-channel and P-channel transistors.
- A bipolar transistor is a type of transistor using both holes and electrons as charge carriers. They can be classified as NPN and PNP transistors.
- There is another type of transistor – Insulated-gate bipolar transistors that have a voltage-driven MOSFET and a high-current transistor.

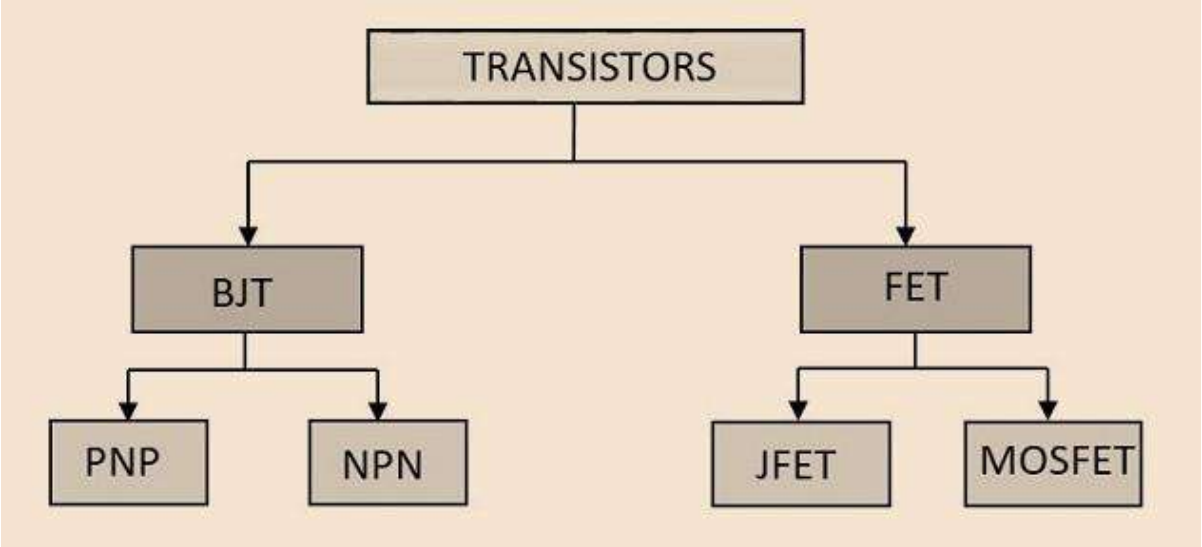
Symbol of a Transistor



Working Principle of Transistor

A transistor is based on the operating principle that it allows to control the flow of current via one path by varying the intensity of the smallest amount of current traveling through a second path.

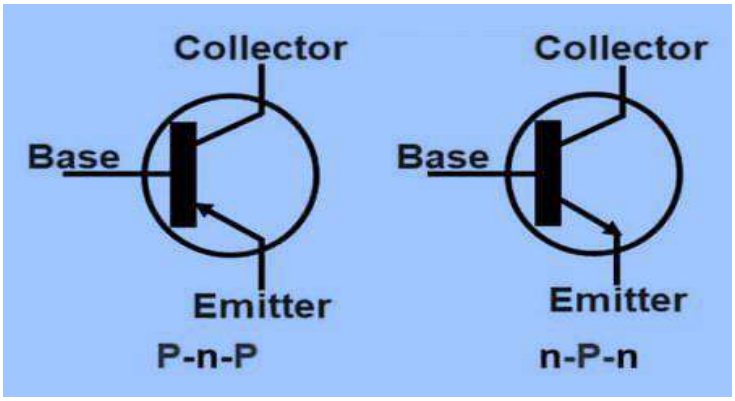
II. Types of Transistors



1. Bipolar Junction Transistor (BJT)

Bipolar Junction Transistors are those types of transistors that are made up of three regions: the base, collector, and emitter. Different from FET transistors, bipolar junction transistors are current-controlled devices.

- A little current flowing from the emitter to the collector region of the transistor causes a considerably bigger current to flow from the base to the emitter.
- NPN and PNP are the two main types of bipolar junction transistors.

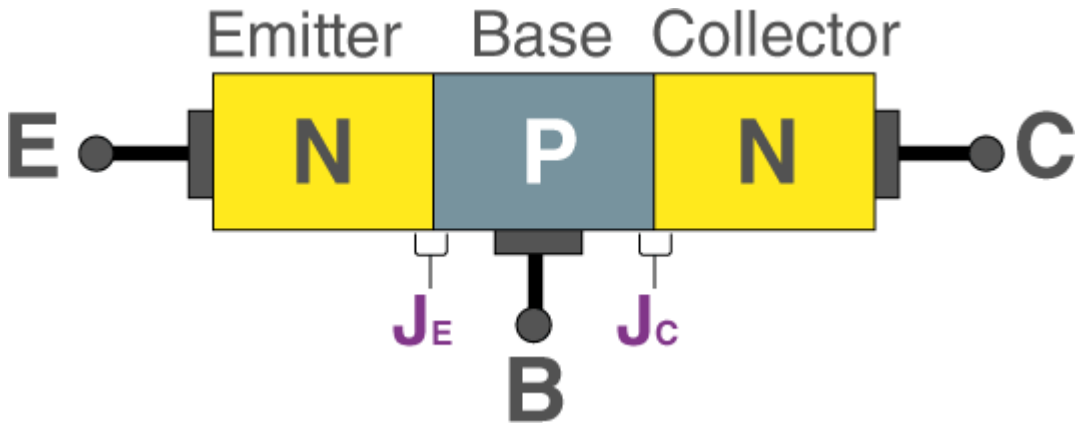


Bipolar Junction Transistor

NPN Transistor

In these types of transistors, there are two p-type semiconductor materials. A thin n-type semiconductor layer separates these materials. The majority of charge carriers in these transistors are holes, whereas the minority are electrons**.**

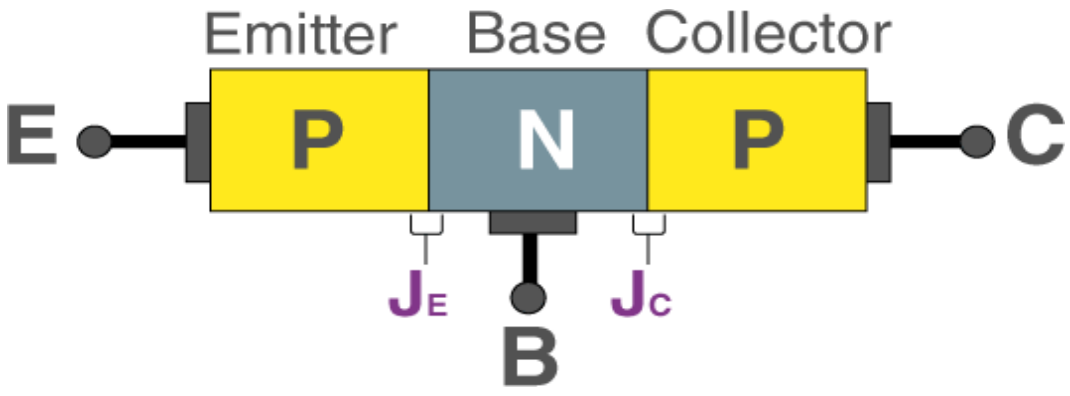
- The current flows from the emitter terminal to the collector terminal in this transistor.
- When the base terminal is pulled to LOW in comparison to the emitter terminal, the transistor will switch on.



PNP Transistor

PNP Transistor consists of two n-type semiconductor layers separated by a thin p-type semiconductor layer. The majority of charge carriers in an NPN transistor are electrons, whereas the minority are holes.

- The current flow within the base terminal of the transistor is formed by electrons flowing from the emitter terminal to the collector terminal.
- In a transistor, a low current supply at the base terminal can result in a large amount of current flowing from the emitter to the collector.
- NPN transistors are currently the most widely used BJTs because electron mobility is greater than hole mobility in them.



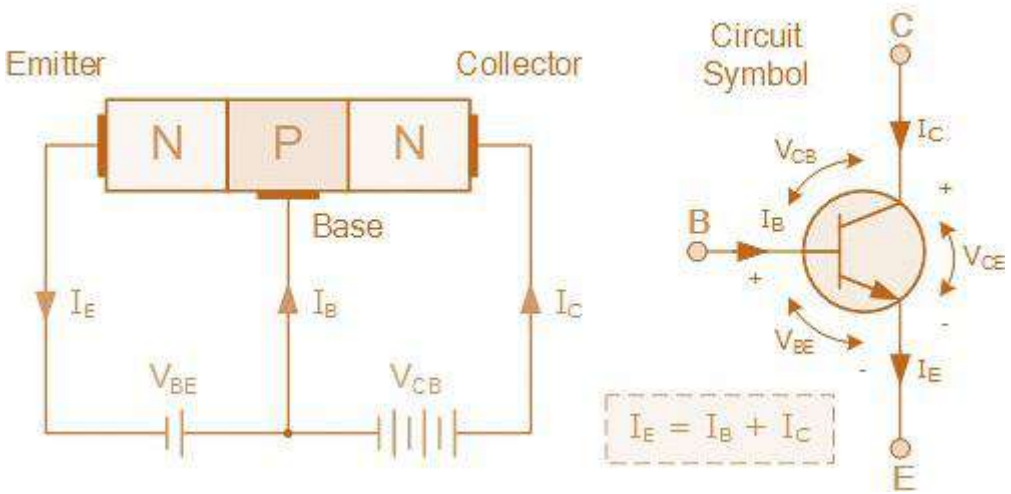
Difference Between NPN and PNP Transistors

NPN Transistor

In these types of transistors, there are two p-type semiconductor materials. A thin n-type semiconductor layer separates these materials. The majority of charge carriers in these transistors are holes, whereas the minority are electrons.

- NPN transistor is a type of Bipolar Junction Transistor.
- In this, electrons are major current carriers, and minor ones are holes.
- Their arrangement is in such a way that N-type doped semiconductors are separated by the layer of P-type doped semiconductors which is a thin layer material embedded between them.
- Emitter Current = Collector Current + Base Current

NPN Transistor -Circuit Diagram



Working:

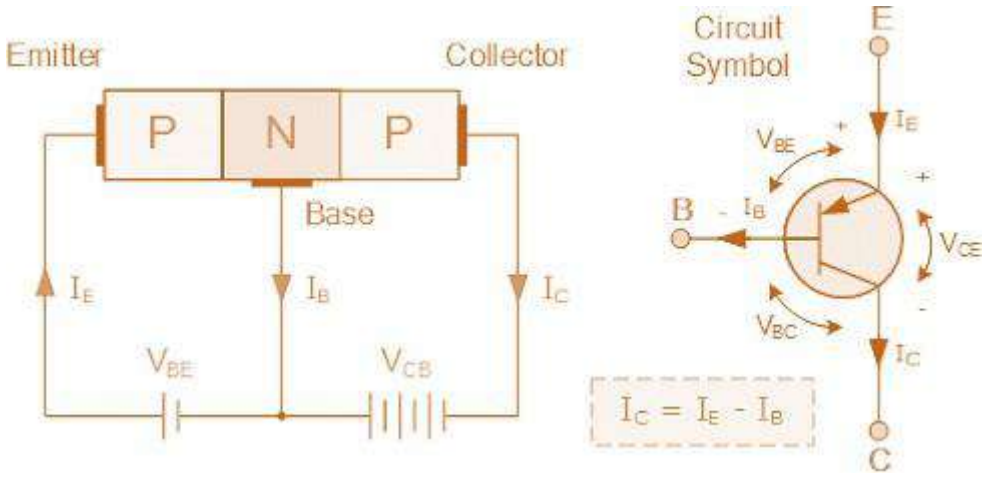
- The electrons are majority charge carriers in P-type semiconductors and are beaten back by the positive terminal of the battery V_{EE} in emitter current I_E.
- Electron density is less, only 5% of holes enter the base with the electrons which show up to base current I_B. Base current is 5% of I_B.
- The remaining 95% runs over to the collector base. Collector current I_C which is 95% of I_E.
- When the hole combines with the electrons in the base, it is reimbursed by the flow of electrons from a negative terminal of the battery to the base through the wire.
- Current in this transistor is because of holes. In the external circuit, current is due to flow of electrons.
- From the circuit diagram, we find, $I_E = I_B + I_C$.

PNP Transistor

PNP Transistor consists of two n-type semiconductor layers separated by a thin p-type semiconductor layer. The majority of charge carriers in an NPN transistor are electrons, whereas the minority are holes.

- The current flow within the base terminal of the transistor is formed by electrons flowing from the emitter terminal to the collector terminal.
- In a transistor, a low current supply at the base terminal can result in a large amount of current flowing from the emitter to the collector.
- NPN transistors are currently the most widely used BJTs because electron mobility is greater than hole mobility in them.
- PNP transistor is also a type of Bipolar Junction Transistor.
- In these, holes are the major source that carries current, and electrons are minor.
- Their arrangement is in a way that P-type doped semiconductor is separated by N-type doped semiconductor material which is a thin layer.
- Emitter Current = Collector Current + Base Current

PNP Transistor-Circuit Diagram



Working:

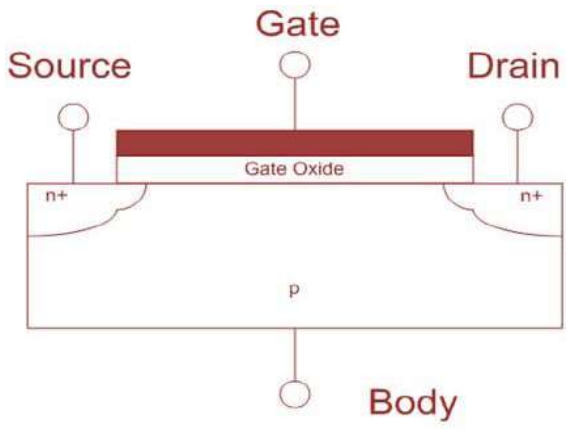
- Electrons are the majority charge carriers in N-type semiconductors and are beaten back by the negative terminal of the battery V_{EE} in emitter current I_E.
- Electron density is less, only 5% of electrons enter the base with the holes which show up to base current IB. Base current is 5% of I_B.
- The remaining 95% runs over to the collector base. Collector current I_C which is 95% of I_E.
- When the emitter combines with the hole in the base, it is reimbursed by the flow of holes from a positive terminal of the battery to the base through the wire.
- The flow of electrons is responsible for the current N-P-N transistor and external circuit.
- From the circuit diagram, we find, $I_E = I_B + I_C$.

2. Field-Effect Transistors (FETs)

A field-effect transistor shortly termed as FET is a voltage-controlled device, unlike BJT which is a current controlled device. The FET is a **unipolar device**, which means that it is made using either p-type or n-type material as the main substrate. One of the many of its advantages is that it has very high input impedance, which is in the order of Mega Ohms. It has many other advantages such as low heat dissipation and low power consumption.

Field-Effect Transistors are those types of transistors that are made up of three regions: the gate, source, and drain. FETs are voltage-controlled bipolar transistors that are different from bipolar transistors. A voltage applied to the transistor's gate controls the current flow from the source to the drain.

- Field-Effect transistors have extremely high input impedances, ranging from a few mega ohms (M) to very high values.
- Due to their high input impedance, these types of transistors only receive a little amount of current. (The current is inversely impacted by the value of the circuit's resistance, according to Ohm’s Law.)
- The current is very low if the impedance is high.
- As a result, FETs draw extremely little current from the power source of a circuit.
- FETs can be further classified as JFETs and MOSFETs.



Field-Effect Transistors (FETs)

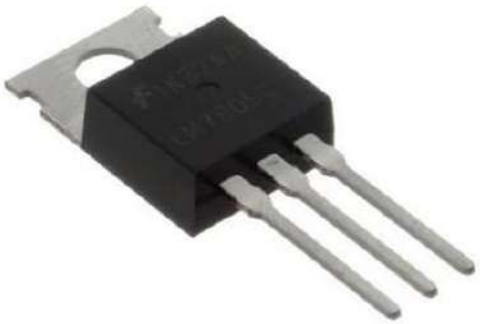
i) Junction Field-Effect Transistor (JFET)

These are the type of FET transistors, which are used in resistors, amplifiers, **switches**, and other applications. This gadget is voltage-controlled and does not require any biasing of current. The current flow between the source and drain of the JFET transistor is controlled by the voltage supplied between the gate and source terminals.

- The Junction Field Effect Transistor (JFET) lacks PN-junctions in favour of a narrow section of high resistive semiconductor material producing a Channel of either N-type or P-type silicon with two ohmic electrical connections at either end.
- It is generally referred to as the Drain and Source.
- The N-channel JFET and the P-channel JFET are the two main configurations of a junction field-effect transistor.

ii) Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET)

MOSFET is the most commonly used transistor. As the name implies, it incorporates the metal gate's terminal. The source, drain, gate, and substrate, or body, are the four terminals of this transistor.



MOSFETs

- MOSFETs have various advantages over BJT and JFET including a high input (i/p) impedance and a low output (o/p) impedance.
- MOSFETs are primarily employed in low-power circuits, particularly in chips.
- These transistors come in two varieties: depletion and enhancement.
- These types are further divided into P-channel and N-channel types.

Other Types of Transistors:

Some other major types of transistors are –

- **Avalanche Transistor:** It is a type of Bipolar Junction Transistor that processes the region of collector-current/collector-to-emitter voltage area. It has avalanche-mode operations that change between high currents in less than nanoseconds**.**
- **Diffusion Transistor:** These are a type of BJT that is created via dopant diffusion into a semiconductor substrate. Example: the micro-alloy diffused transistor of Philco.
- **Darlington Transistor:** It's a transistor circuit with two distinct transistors in it. It is more capable of gaining current. Its circuit can also be contained within an integrated circuit.
- **Schottky Transistor:** Schottky Transistors are types of transistors that have been integrated with a **Schottky diode**. By introducing that type of diode, the transistors are prevented from saturating due to the diversion of high input current.
- **Heterojunction Bipolar Transistor:** These transistors are utilized in higher-frequency analog or digital microwaves. It has a faster switching speed and a higher lithographic yield. They have a higher efficiency of emitter injection.
- **Multiple-Emitter Transistor:** The emitters are used with input signals in these transistors. It has the ability to reduce switching time and power consumption.

❖ There are different types of transistors available based on the function like the small-signal, small switching, power, high frequency, phototransistor, UJT. Some kinds of transistors are mainly used for amplification otherwise switching purposes.

Small Signal Types of Transistors

- Small signal transistors are used mainly used to amplify low-level signals but can also function well as switches. These transistors available through an hFE value, that specifies how a transistor amplifies input signals. The range of typical hFE values is from 10 to 500 including the highest collector current (Ic) rating ranges from 80 mA to 600mA.

- These transistors are available in two forms like PNP and NPN. The highest operating frequencies of this transistor have from 1 to 300 MHz. These transistors are used when amplifying small signals like a few volts & simply when a mill ampere of current is used. A power transistor is applicable once a huge voltage, as well as current, is used.

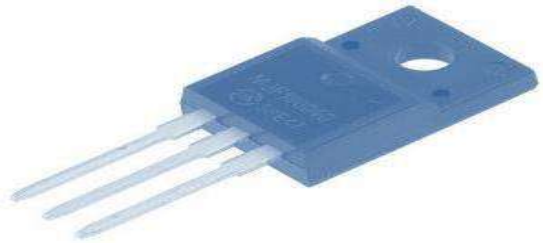
Small Switching Types of Transistors

- Small Switching Transistors are used like switches as well as amplifiers. The typical hFE values for these transistors range from 10 to 200 including least collector current ratings which range from 10 mA to 1000mA. These transistors are available in two forms like PNP and NPN

- These transistors are not capable of the small-signal amplification of transistors, which can include up to 500 amplification. So this will make the transistors more helpful for switching, although they may be used as amplifiers for providing gain. Once you require additional gain, then these transistors would function better like amplifiers.

Power Transistors

- These transistors are applicable where a lot of power is used. The collector terminal of this transistor is allied to the base terminal of metal so that it works like a heat sink to dissolve surplus power. The range of typical power ratings mainly ranges from approximately 10 W to 300 W including frequency ratings which range from 1 MHz – 100 MHz.



Power Transistors

- The values of the highest collector current will range between 1A – 100 A. Power transistors are available in PNP & NPN forms whereas the Darlington transistor comes in either PNP or NPN forms.

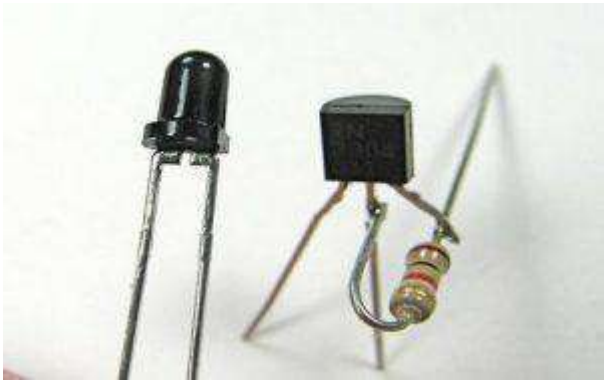
High-Frequency Types of Transistors

- High-Frequency Transistors are used especially for small signals that work at high frequencies and used in high-speed based switching applications. These transistors are applicable in high-frequency signals & should be capable of turning ON/OFF at extremely high speeds.

- The applications of high-frequency transistors mainly include HF, UHF, VHF, MATV, and CATV amplifier as well as oscillator applications. The range of maximum frequency rating is about 2000 MHz & the highest collector currents range from 10 mA – 600mA. These are obtainable in both PNP & NPN forms.

Phototransistor

- These transistors are light-sensitive and a common type of this transistor looks like a bipolar transistor where the base lead of this transistor is removed as well as changed through a light-sensitive region. So this is the reason that a phototransistor includes simply two terminals in place of the three terminals. Once the outside region is kept shady, then the device will be turned off.



Phototransistor

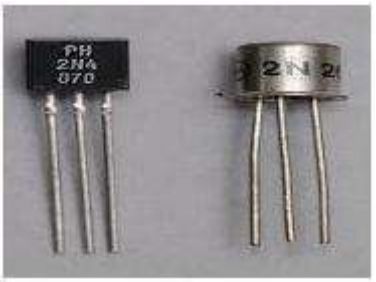
- Basically, there is no flow of current from the regions of the collector to the emitter. But, whenever the region of light-sensitive is exposed toward daylight, then a small amount of base current can be produced to control a much high collector to emitter current.

- Similar to normal transistors, these can be both FETs and BJTs. FETs are light-sensitive transistors, not like photo bipolar transistors, photo FETs utilize light to produce a gate voltage that is mainly used for controlling a drain-source current. These are very responsive to changes within light as well as more delicate as compared with bipolar phototransistors.

Uni-junction Types of Transistors

- Unijunction transistors (UJTs) include three-leads that work completely like electrical switches so they are not utilized like amplifiers. Generally, transistors work like a switch as well as an amplifier. However, a UJT does not give any kind of amplification due to its design. So it is not designed for providing enough voltage otherwise current.

- The leads of these transistors are B1, B2 & an emitter lead. The operation of this transistor is simple. When voltage exists between its emitter or base terminal then there will be a small flow of current from B2 to B1.



Unijunction Transistor

- The control leads in other types of transistors will provide a small additional current whereas, in UJT, it is quite opposite. The primary source of the transistor is its emitter current. The flow of current from B2 to B1 is simply a small amount of the whole

combined current, which means that UJTs are not appropriate for amplification but they are suitable for switching.

Heterojunction Bipolar Transistor (HBT)

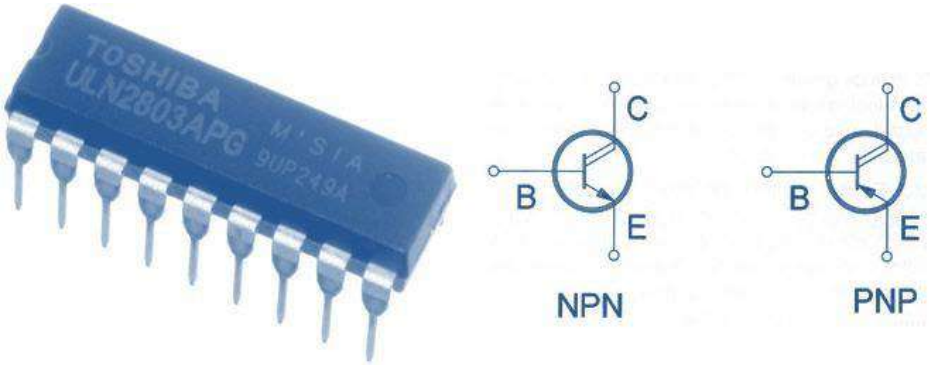
- AlgaAs/GaAs heterojunction bipolar transistors (HBTs) are used for digital and analog microwave applications with frequencies as high as the Ku band. HBTs can supply faster-switching speeds than silicon bipolar transistors mostly because of reduced base resistance and collector-to-substrate capacitance. HBT processing requires less demanding lithography than GaAs FETs, therefore, HBTs can priceless to fabricate and can provide better lithographic yield.

- This technology can also provide higher breakdown voltages and easier broadband impedance matching than GaAs FETs. In assessment with Si bipolar junction transistors (BJTs), HBTs show better presentation in terms of emitter injection efficiency, base resistance, the base-emitter capacitance, and cutoff frequency. They also present good linearity, low phase noise and high power-added efficiency. HBTs are used in both profitable and high-reliability applications, such as power amplifiers in mobile telephones and laser drivers.

Darlington Transistor

- A Darlington transistor sometimes called a “Darlington pair” is a transistor circuit that is made from two transistors. Sidney Darlington invented it. It is like a transistor, but it has a much higher ability to gain current. The circuit can be made from two discrete transistors or it can be inside an integrated circuit.

- The hfe parameter with a Darlington transistor is every transistor hfe multiplied mutually. The circuit is helpful in audio amplifiers or in a probe that measures a very small current that goes through the water. It is so sensitive that it can pick up the current in the skin. If you connect it to a piece of metal, you can build a touch-sensitive button.



Darlington Transistor

Schottky Transistor

- A Schottky transistor is a combination of a transistor and a Schottky diode that prevents the transistor from saturating by diverting the extreme input current. It is also called a Schottky-clamped transistor.

Multiple-Emitter Transistor

- A multiple-emitter transistor is a specialized bipolar transistor frequently used as the inputs of transistor logic (TTL) NAND logic gates. Input signals are applied to the emitters. Collector current stops flowing simply, if all emitters are driven by the logical high voltage, thus performing a NAND logical process using a single transistor. Multiple-emitter transistors replace diodes of DTL and agree to a reduction of switching time and power dissipation.

Dual Gate MOSFET

- One form of MOSFET that is particularly popular in several RF applications is the dual-gate MOSFET. The dual-gate MOSFET is used in many RF and other applications where two control gates are required in series. The dual-gate MOSFET is fundamentally a form of MOSFET where two gates are made-up along the length of the channel one after the other.

- In this way, both gates influence the level of current flowing between the source and drain. In effect, the dual-gate MOSFET operation can be considered the same as two MOSFET devices in series. Both gates affect the general MOSFET operation and therefore the output. The dual-gate MOSFET can be used in a lot of applications including RF mixers /multipliers, RF amplifiers, amplifiers with gain control, and the like.

Avalanche Transistor

- An avalanche transistor is a bipolar junction transistor designed for process in the region of its collector-current/collector-to-emitter voltage characteristics beyond the collector-to-emitter breakdown voltage, called the avalanche breakdown region. This region is characterized by the avalanche breakdown, an occurrence similar to Townsend discharge for gases, and negative differential resistance. Operation in the avalanche breakdown region is called avalanche-mode operation: it gives avalanche transistors the capability to switch very high currents with less than a nanosecond rise and fall times (transition times).

- Transistors not particularly designed for the purpose can have reasonably consistent avalanche properties; for example, 82% of samples of the 15V high-speed switch 2N2369, manufactured over a 12-year period, were capable of generating avalanche breakdown pulses with a rising time of 350 ps or less, using a 90V power supply as Jim Williams writes.

Diffusion Transistor

- A diffusion transistor is a bipolar junction transistor (BJT) formed by diffusing dopants into a semiconductor substrate. The diffusion process was implemented later than the alloy junction and grown junction processes for making BJTs. Bell Labs developed the first prototype diffusion transistors in 1954. The original diffusion transistors were diffused-base transistors.

- These transistors still had alloy emitters and sometimes alloy collectors like the earlier alloy-junction transistors. Only the base was diffused into the substrate. Sometimes the substrate produced the collector, but in transistors like Philco's micro-alloy diffused transistors, the substrate was the bulk of the base.

III. Applications of Transistor:

Transistors are basically used in our day to day lives in various forms such as amplifiers and switching apparatus**.** They, as amplifiers, are being used in various oscillators, modulators, detectors and nearly in any circuit in order to perform a function. In a digital circuit**,** transistors have an application as switches. Transistor is a device that regulates the current flow and is usually used in electric circuits. Here, we will learn more about the uses and applications of transistors in the practical world and discuss some important questions.

Transistors are most commonly used as electronic switches in digital circuits or as an amplifier. Below mentioned are both the uses of transistors.

- **Transistors as Switches**

Transistors act as a switch by creating a binary on/off effect of a switch. As a result, voltage is required to flip it instead of an actuator. The application is used to control the flow of power in another portion of the circuit. In simpler terms, small current which is flowing through one part of the transistor allows for a bigger current to flow through the other part of the transistor. The perfect example of a transistor as a switch is a memory chip.

- **Transistors as Amplifier**

Another use of a transistor is as an amplifier. When a transistor works as an amplifier it takes tiny electric currents and produces a large current output on the other end. This kind of transistors is usually found in products like radio, hearing aids or anything from the UV range.

IV. CONCLUSION:

This project has given scope to learn the variety of Transistors available. The knowledge of technical know-how and their applications have enriched the knowledge of students.

This project facilitated the students to know the types and the uses of Transistors.