Project Report
on

STUDY OF NPN TRANSISTOR CHARACTERISTICS

Presented by

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Presented to
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ERNAKULAM
2022

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THE FEAR OF THE LORD IS THE BEGINNING OF WISDOM
ST. TERESA'S COLLEGE (AUTONOMOUS) ESTD 1925

B.Sc PHYSICS
PROJECT REPORT

Name : LAVANYA GIRISH

Register Number : AB19PHY009

Year Of Work : 2021-2022

This is to certify that this Project work entitled **'STUDY OF NPN TRANSISTOR CHARACTERISTICS'** is an authentic work done by LAVANYA GIRISH.

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Date:08/05/2021

EXAMINERS:

ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM

CERTIFICATE

This is to certify that the project entitled **'STUDY OF NPN TRANSISTOR CHARACTERISTICS'** is an authentic work done by LAVANYA GIRISH, St. Teresa's College, Ernakulam, under my supervision at Department of Physics, St. Teresa's college partial requirements for the award of Degree of Bachelor Of science in Physics during the academic year 2021-22.The work presented in this dissertation has not been submitted for any other degree in this or any other university.

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PLACE: Ernakulam

DATE: 06/05/2022

DECLARATION

I, **LAVANYA GIRISH**, final year B.sc Physics student, Department of Physics, St. Teresa's College, Ernakulam do hereby declare that the project work entitled **'STUDY OF NPN TRANSISITOR CHARACTERISTICS'** has been originally carried out under the guidance and supervision of Dr.Sreeja V G, Assistant Professor, Department of Physics, St.Teresa's College (Autonomous), Ernakulam in partial fulfilment for the award of the degree of Bachelor of Physics.I further declare that this project is not partially or wholly submitted for any other purpose and the data is included in the project is collected from various sources and true to the best of my knowledge.

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DATE: 06/05/2022

Lavanya Girish

ABSTRACT

The transistor is without a doubt one of the most important contributions to the world of electrical components. Many firms have begun large-scale programmes to create transistor circuits, and practical applications will undoubtedly become more common in the near future.

This project **"Study of NPN Transistor Characteristics "** discusses the input and output characteristics of a NPN transistor in all the three configuration- CE, CB and CC.

ACKNOWLEDGEMENT

I thank Almighty for His abundant blessing throughout this journey and to make this project a successful one. I owe a deep sense of gratitude to our project guide Dr.Sreeja V G for her immense support and valuable ideas that helped us to make this project. I would like to express my sincere gratitude to the head of the department Dr. Priya Parvathy Ameena Jose for her esteemed guidance and encouragement. I would also like to thank and express my heartfelt acknowledgement to our teachers, lab assistants and all the non-teaching staff who have always been there to help us throughout. A heartfelt thanks to my group members for being the pillar of support. Last, thanking everyone who has helped and encouraged us to make this project a reality.

CONTENT

CHAPTER - 1

AN INTRODUCTION TO TRANSISTORS

INTRODUCTION

A transistor is a type of semiconductor device that can be used to conduct as well as insulate electric current or voltage. It can act as both a switch and amplifier by providing a small signal voltage. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. They are the key components in most modern devices.

Transistors can be classified into :

- ❖ Bipolar junction transistors (BJTs)
- ❖ Field-Effect Transistors (FETs)
- ❖ Insulated Gate Bipolar Transistors (IGBTs)

Bipolar junction transistors are of two types :

- ❖ npn Transistor
- ❖ pnp Transistor

Field effect transistors are of two types :

- ❖ JFET
- ❖ MOSFET

1.1 BIPOLAR JUNCTION TRANSISTORS

A bipolar junction transistor or BJT is a three terminal semiconductor device consisting of two p-n junction diodes that can amplify signals. It uses both electrons and holes as charge carriers.
A typical transistor has three terminals that help to make connections to external circuits and carry the current. The three terminals are:

1. Emitter
2. Base
3. Collector

Emitter :

The emitter section supplies the charge. Hence it is heavily doped so that it can inject a large number of charge carriers into the base. The size of the emitter is always greater than the base but less than the collector. It is the negative lead of the transistor.

Base :

The base is the middle layer. The size of the base is very small. It is less than the emitter and collector. The size is kept small so that the charge that is coming from the emitter and entering the base do not recombine in the base region and is transferred to the collector region.
The base is lightly doped and it is used to activate the transistor.

Collector :

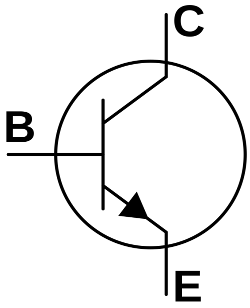
The function of the collector is to collect the charge carriers. It is moderately doped and the size is slightly large when compared to the emitter and base. It is because all the charges coming from the emitter recombine at

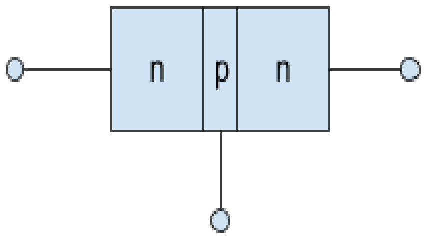
base and heat is released in this process. Hence the collector terminal must be large so that it can dissipate the heat and the device is not burnt.
Bipolar junction transistors can be classified into two types:

- ☐ NPN Transistor
- ☐ PNP Transistor

1.1.1 NPN Transistor

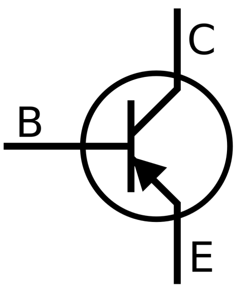
When a P type semiconductor layer is sandwiched between two N-type semiconductor layers the transistor is said to be a NPN transistor.

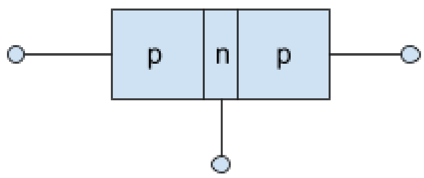




1.1.2 PNP Transistor

When an N-type semiconductor layer is sandwiched between two P-type semiconductor layers the transistor is said to be a PNP transistor





1.2 WORKING OF A TRANSISTOR

The transistor mainly works in three regions:

1. **Active Region** :-

   When the emitter junction is forward biased and the collector junction is reverse bias the transistor is said to be in active mode. This region is used for amplification purpose. In the active region collector current is β times the base current i.e,

   $$I_c = \beta\ I_B$$

   Where,

   I_c = Collector current

   β = current amplification factor

   I_B = base current

2. **Saturation region** :-

   When both the emitter and collector junctions are forward biased the transistor will work in the saturation region. In this region the transistor is used for switching operation. The transistor act as an ON switch. In the saturation region

   $$I_c = I_E$$

   Where,

   I_c = Collector current

   I_E = Emitter current

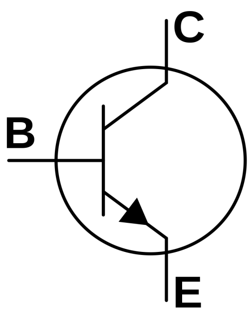
3. **Cut-off region** :-

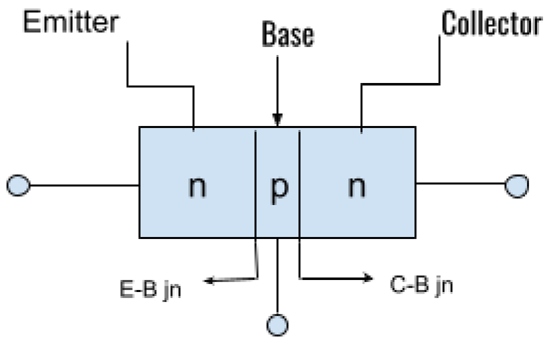
   The transistor works in the Cut-off region when both the emitter and collector are reverse biased. Therefore,

   $$I_E = I_c = I_B$$

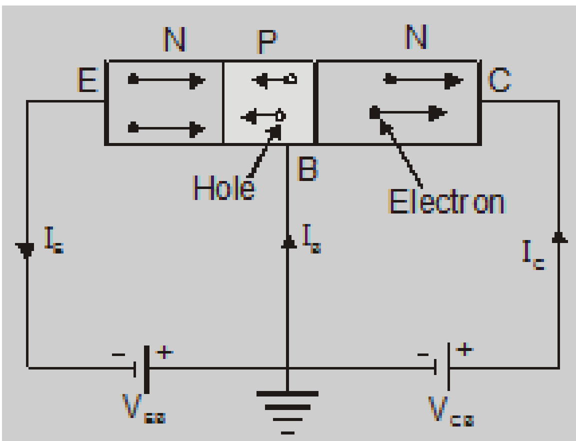
4. **Reverse Active** :-
   In this the emitter base junction is reverse biased and collector base junction is forward biased.

NPN Transistor

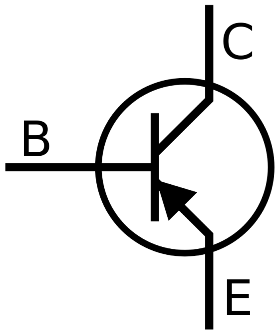


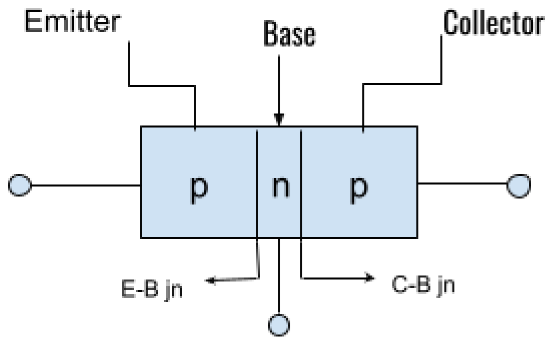


Since the Emitter-Base junction in an npn transistor is forward biased, a lot of electrons from the emitter enters the base region. Base is lightly doped with p-type impurities (Holes). Due to this there is very less electron-hole recombination i.e, very less electrons combine to constitute the base current (I_B). The remaining electrons cross over the collector region to constitute the collector current (I_c).

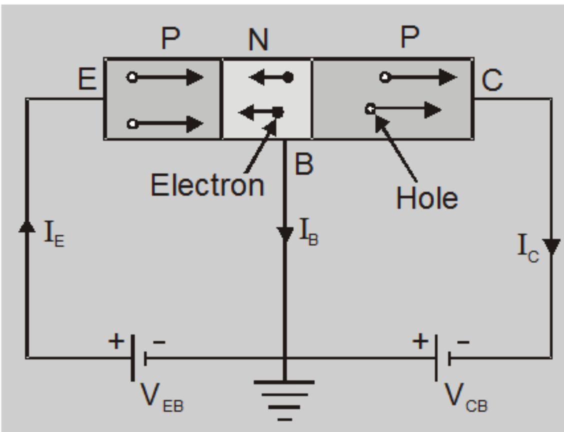


PNP Transistor





In a pnp transistor the emitter base junction is forward biased and collector base junction is reverse biased. Due to this a large number of holes flow from the emitter to the base and the electrons from base to the emitter region. The base is lightly doped with n-type impurities and hence number of electrons in base is very small. Due to this electron-hole recombination is less and a very few holes combine with the electrons to create the base current (I_B). The remaining holes cross over the collector region to create the collector current (I_c).



1.3 ADVANTAGES OF USING TRANSISTORS

Transistors have been proven as a very important invention in science. It has many uses and advantages:

- It is small in size and is very cost-efficient.
- It needs very low voltage to function.
- It has a long life and requires no power to operate.
- A single integrated circuit can be developed using the transistor.
- Current switches fast in the terminals.

1.4 LIMITATIONS OF TRANSISTORS

Even though transistors are extremely efficient, there are some limitations to its uses:

- Transistors get damaged very easily due to changes in electrical and temperature conditions.
- They lack higher electron mobility.
- They can get affected by radiation.

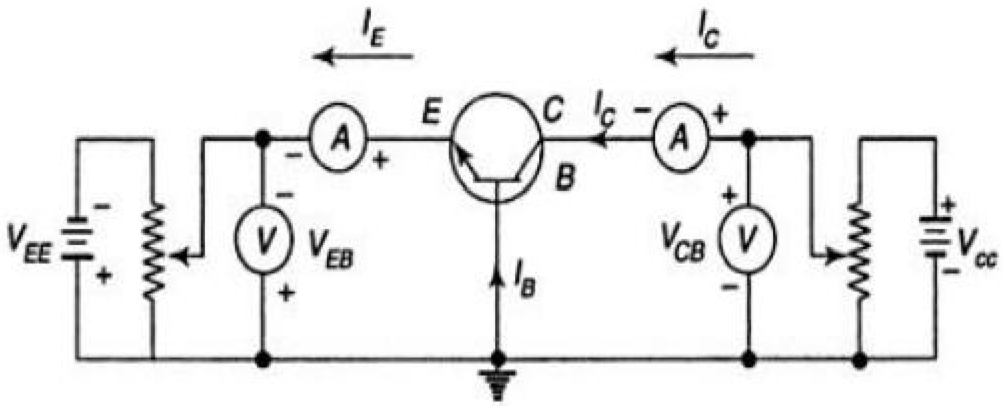
1.5 TRANSISTOR CONFIGURATIONS

Three types of configurations in a transistor are :

- Common Base configuration (CB)
- Common Emitter configuration (CE)
- Common Collector configuration (CC)

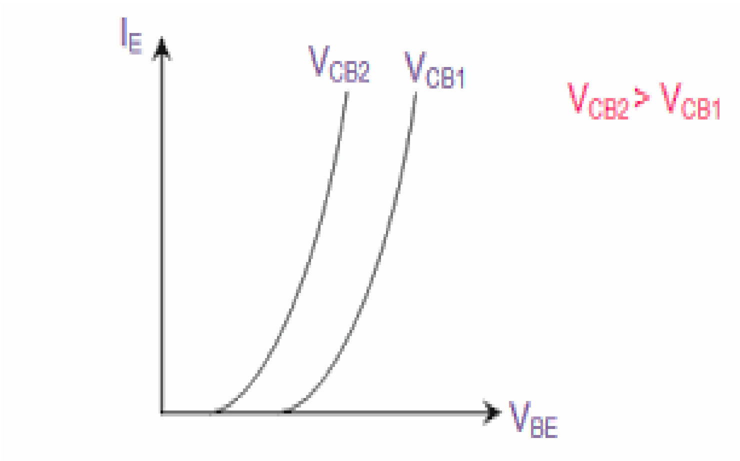
1.5.1 COMMON BASE CONFIGURATION

In the Common base configuration (CB) the Base is grounded and used as a common terminal for both input and output. It is also known as grounded base configuration. Here, the emitter is the input terminal and the collector is the output terminal.



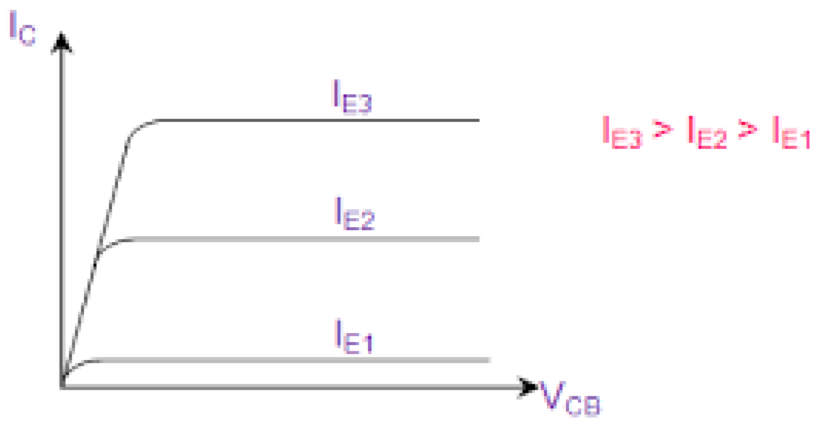
Input Characteristics

It is defined as the characteristic curve drawn between the input voltage to input current keeping output voltage constant. To determine the input voltage the collector base voltage (V_{CB}) is kept constant at zero and the emitter current I_E is increased from zero by increasing V_{EB}. This is repeated for higher fixed values of V_{CB}



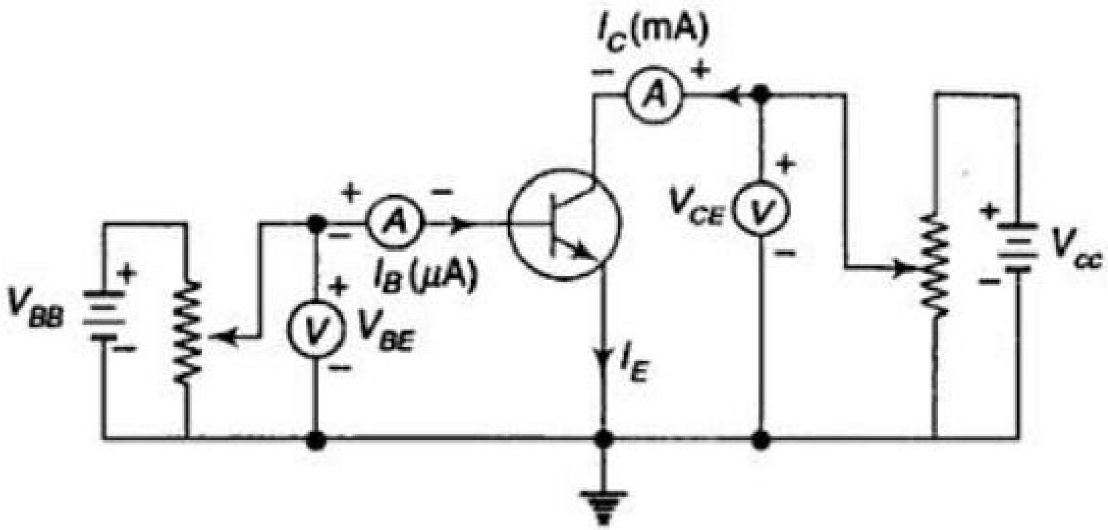
Output characteristics

It is defined as the characteristic curve drawn between output current and output voltage keeping input current constant. To determine the output characteristics the emitter current is kept constant at a particular value and the collector current (IC) is increased from zero to higher values by increasing VCB. This is repeated for higher fixed values of IE. It is seen that for a constant value of I_E , I_C is independent of V_{CB} and the curves are parallel to X-axis of V_{CB}



1.5.2 COMMON EMITTER CONFIGURATION

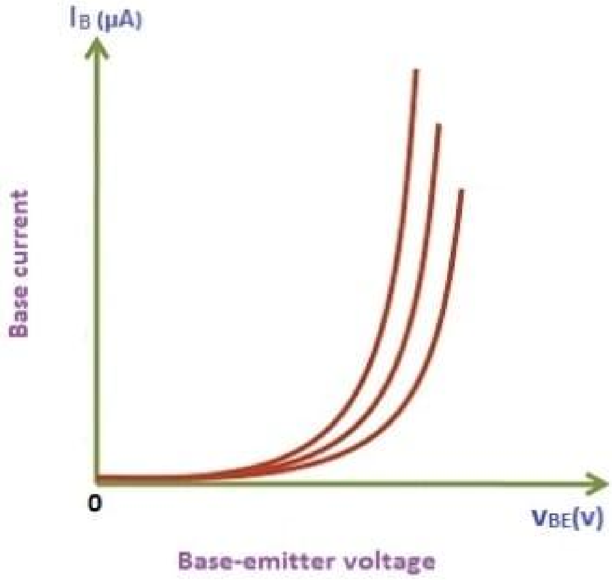
In common Emitter configuration (CE) the emitter is grounded and is a common terminal for both the input and output. It is also known as grounded emitter configuration. Here base is used as the input terminal and collector as the output terminal.



Input Characteristics

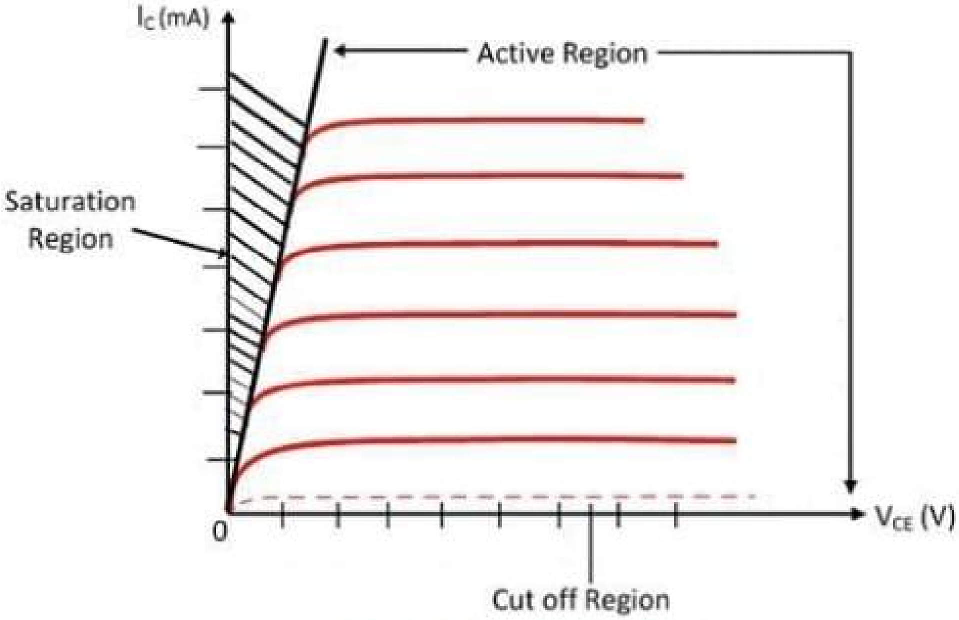
It is defined as the curve drawn between the input voltage and the input current at constant output voltage.

To determine the input characteristics the collector base voltage is kept constant V_{CB} at zero and base current I_B is increased from zero by increasing $V_{BE.}$ This is repeated for higher values of $V_{CE.}$



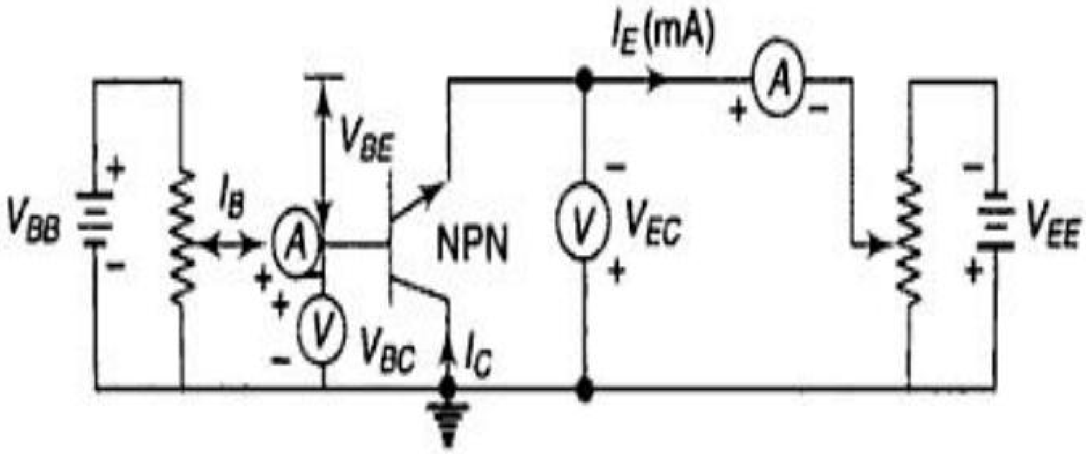
Output Characteristics

It is defined as the characteristic curve drawn between the output voltage to the output current at constant input current. To determine output characteristics, the base current I_B is kept constant at zero and collector current I_c is increased from zero by increasing V_{CE}.This is repeated for higher fixed values of I_B.



1.5.3 COMMON COLLECTOR CONFIGURATION

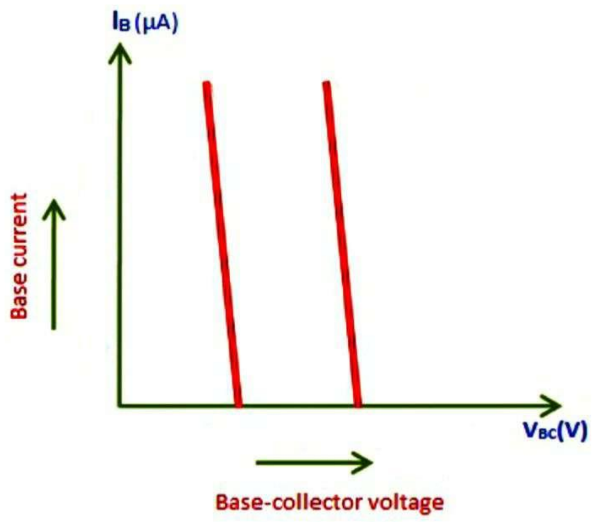
In a common collector configuration the collector is grounded and is used as the common terminal for both the input and the output terminal. It is also known as grounded collector configuration . Here the base is the input terminal and the emitter is the output terminal.



Input Characteristics

It is defined as the characteristic curve drawn between input voltage to input current whereas output voltage is constant.

To determine input characteristics, the emitter base voltage V_{EB} is kept constant at zero and base current I_B is increased from zero by increasing V_{BC}.This is repeated for higher fixed values of $V_{CE.}$

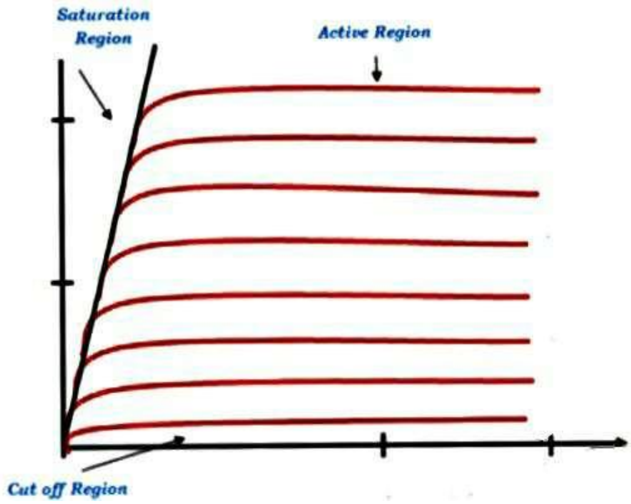


Output characteristics

It is defined as the characteristic curve drawn between output voltage to output current whereas input current is constant.

To determine output characteristics, the base current I_B is kept constant at zero and emitter current I_E is increased from zero by increasing V_{EC}. This is repeated for higher fixed values of I_B.

From the characteristic it is seen that for a constant value of I_B, I_E is independent of V_{EB} and the curves are parallel to the axis of V_{EC}.


Saturation Region
Active Region
Cut off Region

CONCLUSION

Thus, a transistor is an electronic device made of three layers of semiconductor material that can act as an insulator and a conductor.It is an essential part of many technological advances and devices.This chapter helps to give an idea about the basic theory of transistors. It contains a quick view on the construction, working, types of transistors(npn and pnp transistors) and advantages and limitations. It also covers the three configurations of transistors - Common Emitter Configuration(CE), Common Base Configuration(CB) and Common Collector Configuration(CC) and their respective input and output characteristics.

CHAPTER 2

BASIC REQUIREMENTS

(Details of Components and Devices)

INTRODUCTION

The experiment works with a npn transistor in all the three configuration i.e. CE, CB and CC configuration, to find the input and output characteristics. The basic devices used are transistor, voltmeter, ammeter, rheostat, battery eliminator, bread board and connection wires. This chapter contains the details regarding the components and devices used for the experiments.

2.1. COMPONENTS AND DEVICES

(i) **Transistor BC 107**

The BC107 is a small single NPN Transistor available in TO-18 metal can package. These transistors are age old and have been used in low noise and low signal designs. Today a lot of new transistors have come as replacement for BC107, but still the transistor can be found in the market for its legacy.

The **BC107** is a low signal NPN which is known for its low noise operations making it famously used in signal processing circuits and television receivers.

The transistor is still available in the market due to its legacy but you will find better modern transistors as replacement for BC107.

Applications:

- Driver Modules like Relay Driver, LED driver etc..
- Amplifier modules like Audio amplifiers, signal Amplifier etc..
- Darlington pair

(ii) **Voltmeter:**

It is an instrument that measures voltages of either direct or alternating electric current on a scale usually graduated in volts, millivolts (0.001 volt), or kilovolts (1,000 volts). Many voltmeters are digital, giving readings as numerical displays.

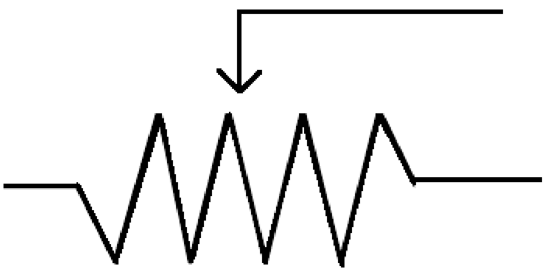
Analog voltmeters move a pointer across a scale in proportion to the voltage measured and can be built from a galvanometer and series resistor. Metres using amplifiers can measure tiny voltages of microvolts or less. Digital voltmeters give a numerical display of voltage by use of an analog-to-digital converter.

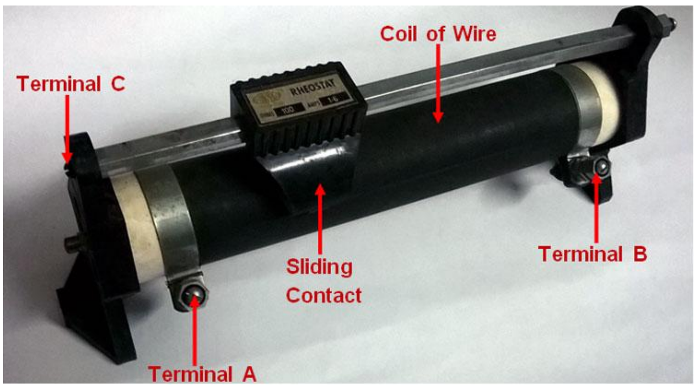
(iii) **Ammeter**

It is an instrument for measuring either direct or alternating electric current, in amperes. An ammeter can measure a wide range of current values because at high values only a small portion of the current is directed through the meter mechanism; a shunt in parallel with the meter carries the major portion.

(iii) **Rheostat**

A rheostat is defined as variable resistor which is used for controlling the flow of electric current either by increasing or decreasing the resistance. The term rheostat was coined by the English scientist Sir Charles Wheatstone and is derived from the Greek word “rheos” and “statis” which means current controlling device.





For any given rheostat, we can change its resistance. We know that resistance is dependent on three factors:

- Length
- Areas of cross-section
- Type

In order to change the resistance of the rheostat, the effective length needs to be changed with the help of sliding contact. The effective length is defined as the length between the fixed terminal and the position of the sliding terminal. As the effective length changes, the resistance of the rheostat changes.

(iv) **Battery Eliminator**:

A battery eliminator is a device powered by an electrical source other than a battery, which then converts the source to a suitable DC voltage that may be used by a second device designed to be powered by batteries. A battery eliminator eliminates the need to replace batteries but may remove the advantage of portability. A battery eliminator is also effective in replacing obsolete battery designs.

2.2 PROCEDURE

Connections are made as shown in the circuit diagrams. The rheostat Rh1 is used to vary base voltage (input voltage) V_{BE} and it is read from voltmeter V1. The base current (input current) I_B is measured using a microammeter (μA). The collector voltage (output voltage) VCE is varied using the rheostat Rh2 and readings are noted from voltmeter V2. The collector current (output current) I_c is measured by the milliammeter (mA).

CONCLUSION

The chapter briefs the details, uses and types of various components and devices used in the experiment to find out the input and output characteristics of the transistor. The experiment is, thus, done with the npn transistor - Transistor BC 107, ammeter - to measure the current, voltmeter - to measure the voltage drop, rheostat - used as a variable resistance, battery eliminator - for supply of voltage, bread board and connecting wires.

CHAPTER-3

CHARACTERISTICS OF COMMON EMITTER CONFIGURATION

INTRODUCTION

In this chapter we try to find the input and output characteristics of common emitter configuration experimentally and compare it with the theoretical values.

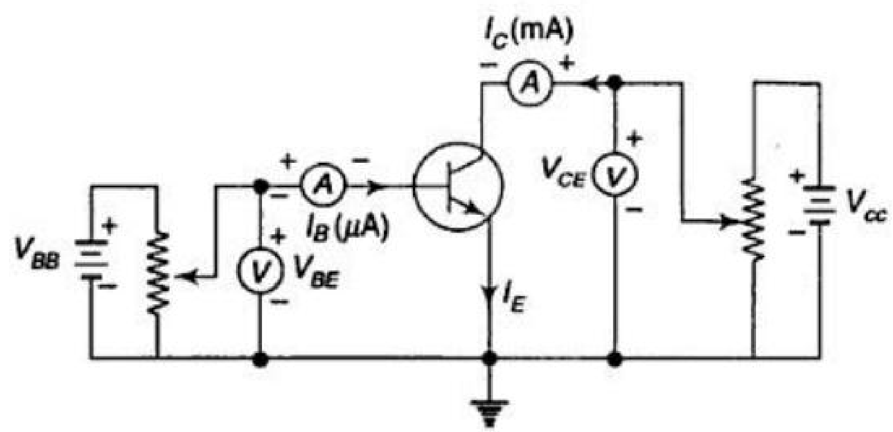
Aim

To study the input and output characteristics of a transistor in common emitter (CE) configuration.

Apparatus

Transistor BC107, Breadboard, Rheostat, Analogue Ammeter, Analogue voltmeter

Circuit diagram



3.1 Procedure

a) To find input characteristics:

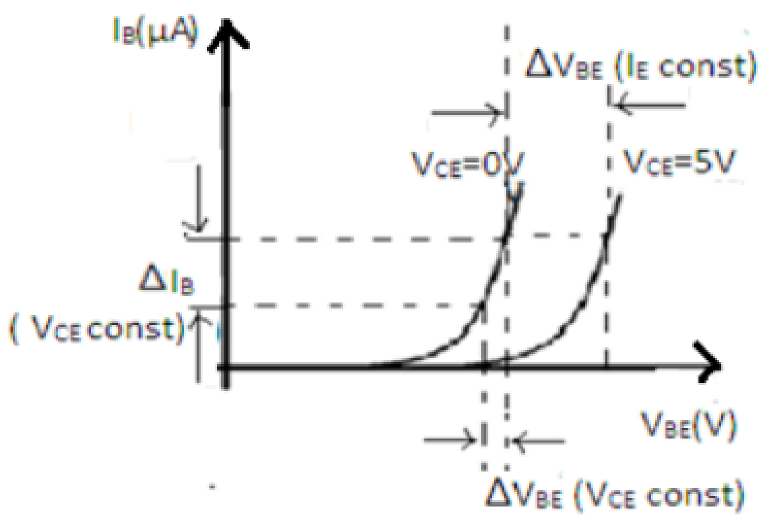
Connect the circuit diagram as shown in the circuit diagram.Keep output voltage V_{CE}=0V by varying Vcc.Varying V_{BB} gradually, note down the base current I_B and base emitter voltage V_{BE}.Step size is not fixed because of linear curve.Initially vary V_{BB} in steps of 0.1 V.Once the current starts increasing vary V_{BB} in steps of 1V up to 12 V.Repeat the above procedure.

b) To find output characteristics:

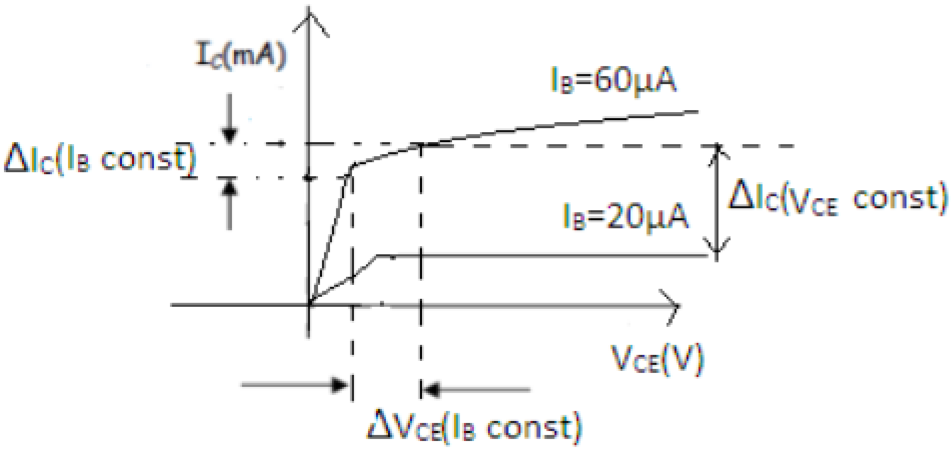
Connect the circuit diagram as shown in the figure. Keep base current (I_B) constant by varying the rheostat. Varying the rheostat gradually note down collector current (I_C) and collector emitter voltage (V_{CE}) Repeat the above experiment.

Plot the graph of input characteristics by taking V_{BE} on X axis and IB on Y axis at a constant V_{CE} as a constant parameter. Plot the graph of output characteristics by taking V_{CE} on X axis and taking Ic on Y axis taking I_B as a constant parameter.

Graph



Input Characteristics

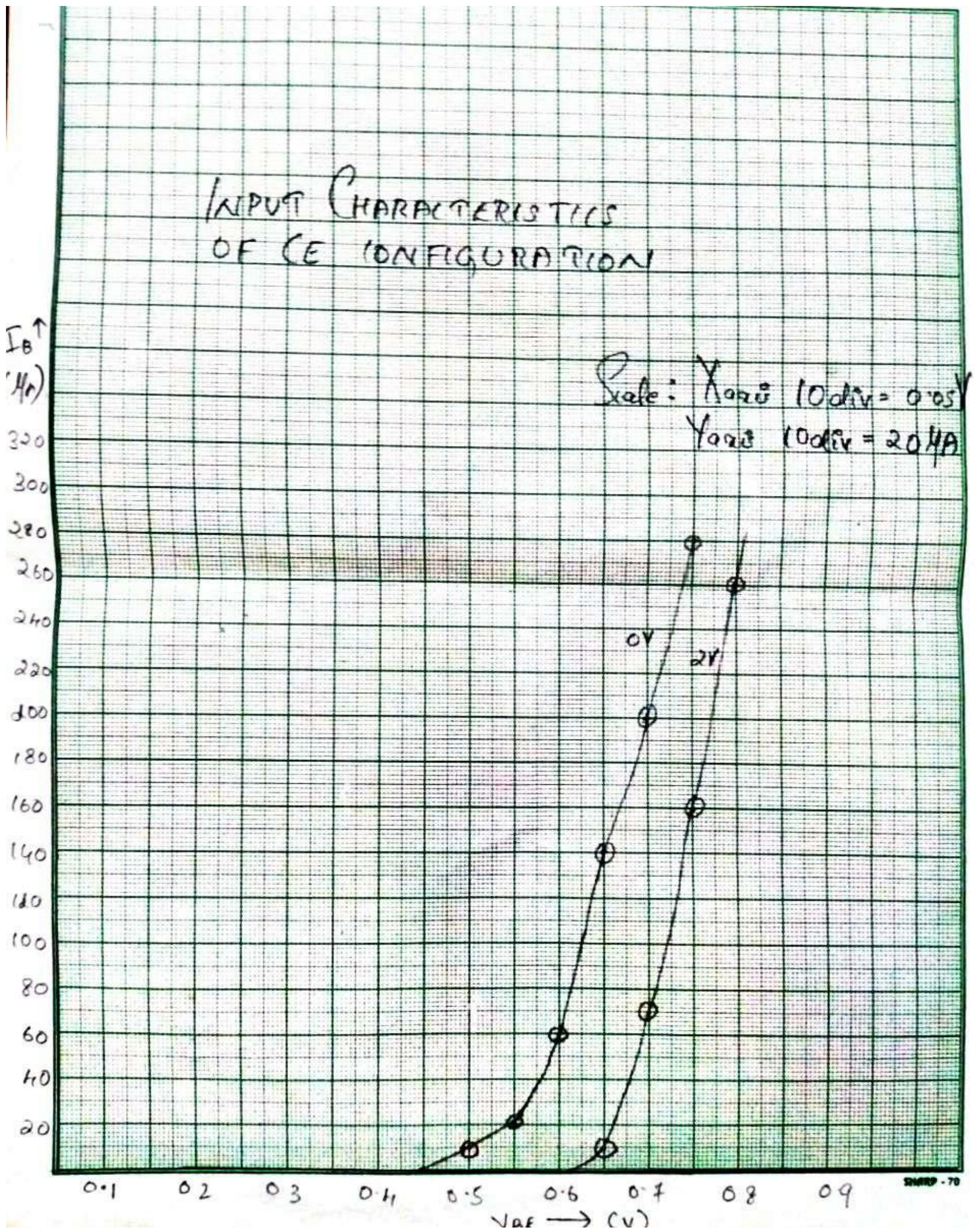


Output Characteristics

3.2 Observations

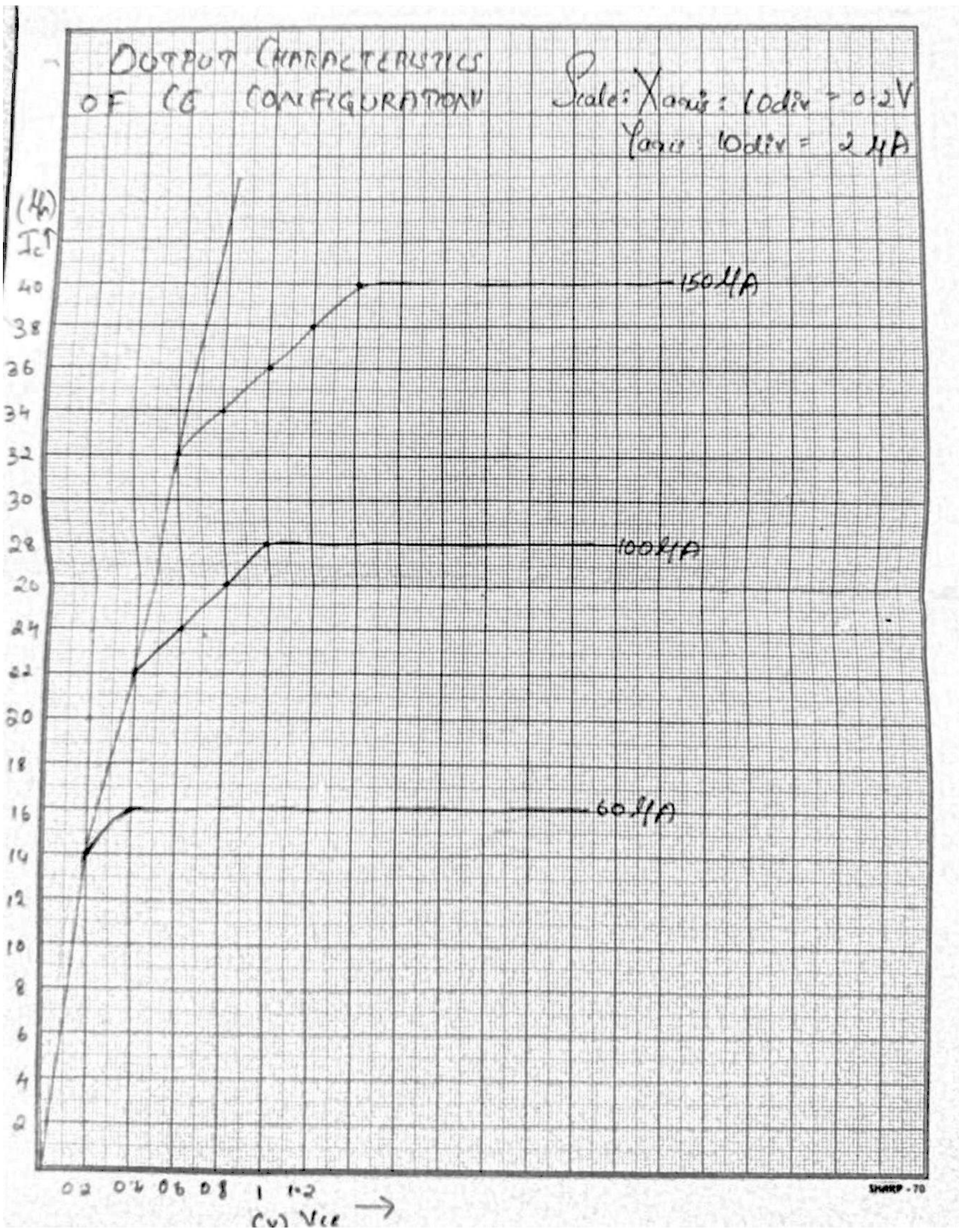
INPUT CHARACTERISTICS

V_{CE}= 0V		V_{CE}= 2V	
V_{BE}(V)	IB=(µA)	V_{BE}=(V)	I_B=(µA)
0.5	10	0.65	10
0.55	20	0.7	70
0.6	60	0.75	160
0.65	140	0.8	260
0.7	200	0.85	370
0.75	280	0.9	460


INPUT CHARACTERISTICS
OF CE CONFIGURATION
Scale: X axis 10 div = 0.05 V
Y axis 10 div = 20 μA
IB (μA)
VBE → (V)
0V
2V
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

OUTPUT CHARACTERISTICS

I_B=0 µA		I_B=100 µA		I_B=150 µA	
V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)
0	0	0	0	0	0
0.2	14	0.2	20	0.2	24
0.4	16	0.4	22	0.4	28
0.6	16	0.6	24	0.6	32
0.8	16	0.8	26	0.8	34
1	16	1	28	1	36
1.2	16	1.2	28	1.2	38
1.4	16	1.4	28	1.4	40
1.6	16	1.6	28	1.6	40
1.8	16	1.8	28	1.8	40



Calculations from the Graph

To obtain input resistance find $\triangle V_{BE}$ and $\triangle I_B$

For a constant V_{CE} on one of the input characteristics;

Input impedance = $\triangle V_{BE} / \triangle I_B$ = (0.6 - 0.5) ⁄ (60-10)

= 0.1⁄50 = 0.002 Ω

Reverse voltage gain = $\triangle V_{EB} / \triangle V_{CE}$ = (0.6-0.5)⁄(0.4-0.2)

= 0.1 / 0.2 = 0.5

To obtain output resistance find $\triangle I_c$ / $\triangle V_{CB}$ at a constant I_B.

Forward current gain = $\triangle I_C$ / $\triangle I_B$ = (16 - 14) / (20- 10)

= 2 / 10 = 0.2

3.3 Results

a.The input resistance = 0.002 Ω

b.The reverse voltage gain = 0.5

c.The forward current gain = 0.2

CONCLUSIONS

In this Chapter we studied the input and output characteristics of an NPN transistor in CE configuration. We have also included the observations and graphs of the same.

CHAPTER-4

CHARACTERISTICS OF COMMON BASE CONFIGURATION

INTRODUCTION

In this chapter we try to find out the input and output characteristics of Common base (CB) configuration experimentally and compare it to theoretical values.

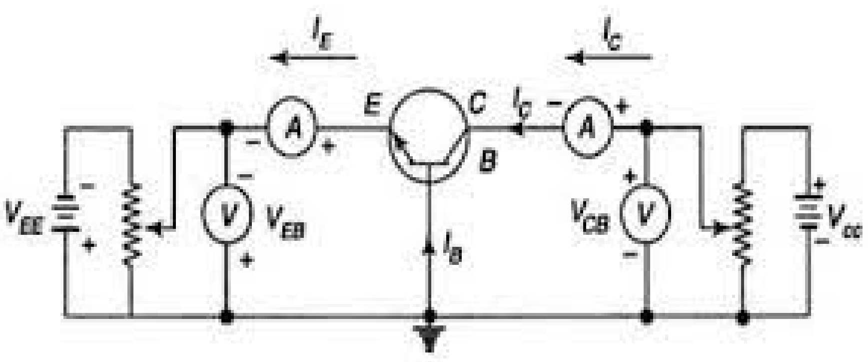
Aim

To study the input and output Characteristics of a transistor in a CB configuration.

Apparatus

Transistor BC 107,Rheostat,Analogue Ammeter,Analogue Voltmeter,Connecting wires.

Circuit Diagram



4.1 Procedure

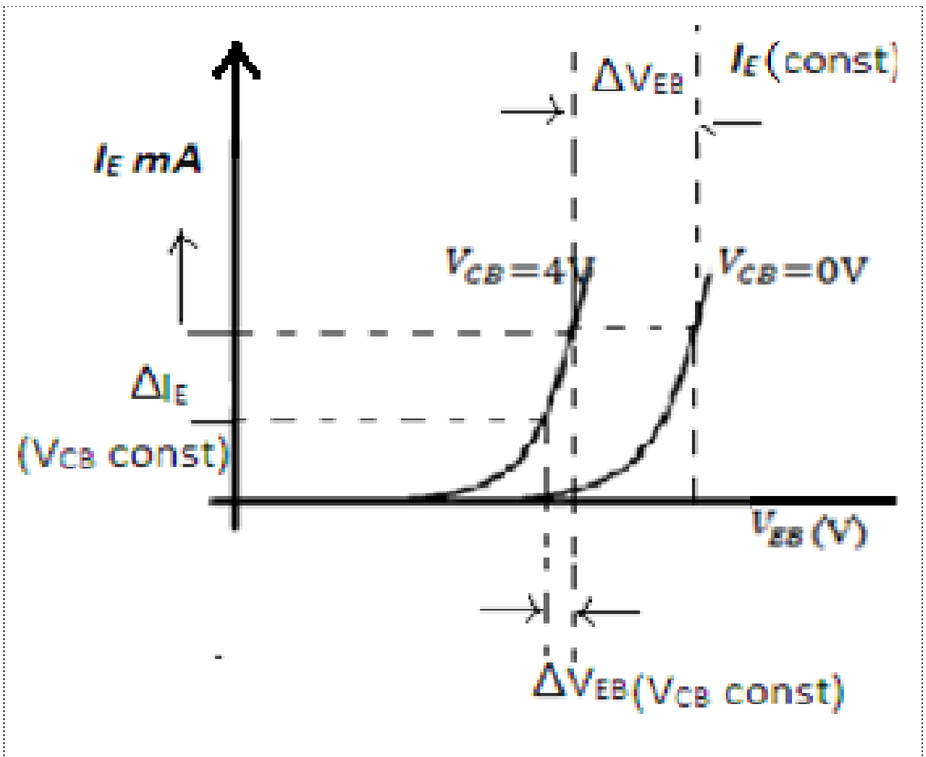
a) To find Input Characteristics:

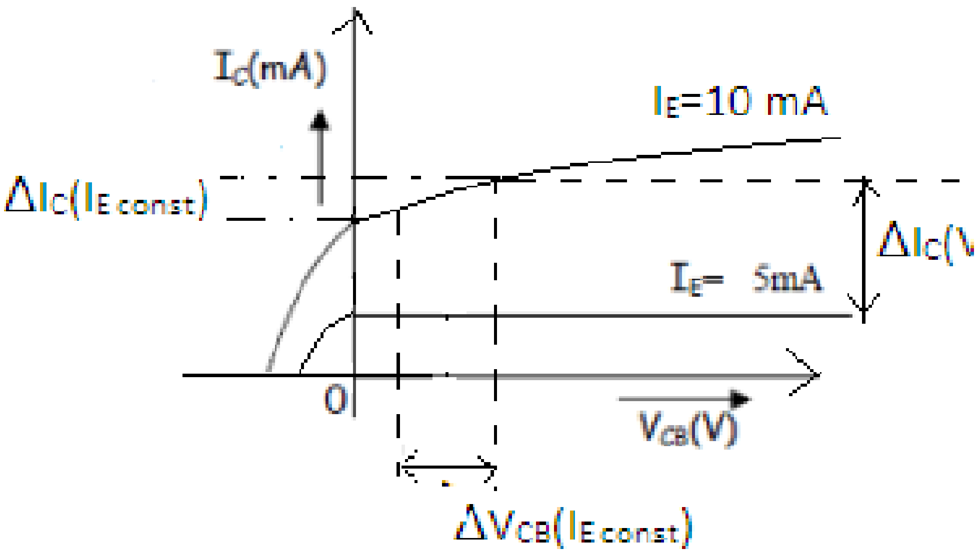
Connect the circuit as shown in the circuit diagram. Keep output voltage V_{CB} constant by varying rheostat. Varying rheostat gradually, note down emitter current (I_E) and emitter-base voltage (V_{EB}). Step size is not fixed because of the nonlinear curve. Repeat above procedure for different constant value V_{CB}

b) To find Output Characteristics:

Connect the circuit as shown in the circuit diagram. Keep emitter current (I_E) by varying resistance in rheostat and note down collector current I_C and collector-base voltage (V_{CB}). Repeat the procedure for different constant values of I_E Plot the input characteristics for different values of V_{CB} by taking V_{EB} on X-axis and $I_E$on Y-axis taking V_{CB} as constant parameter. Plot the output characteristics by taking V_{CB} on X-axis and I_C on Y-axis taking I_E as a constant parameter.

Graph



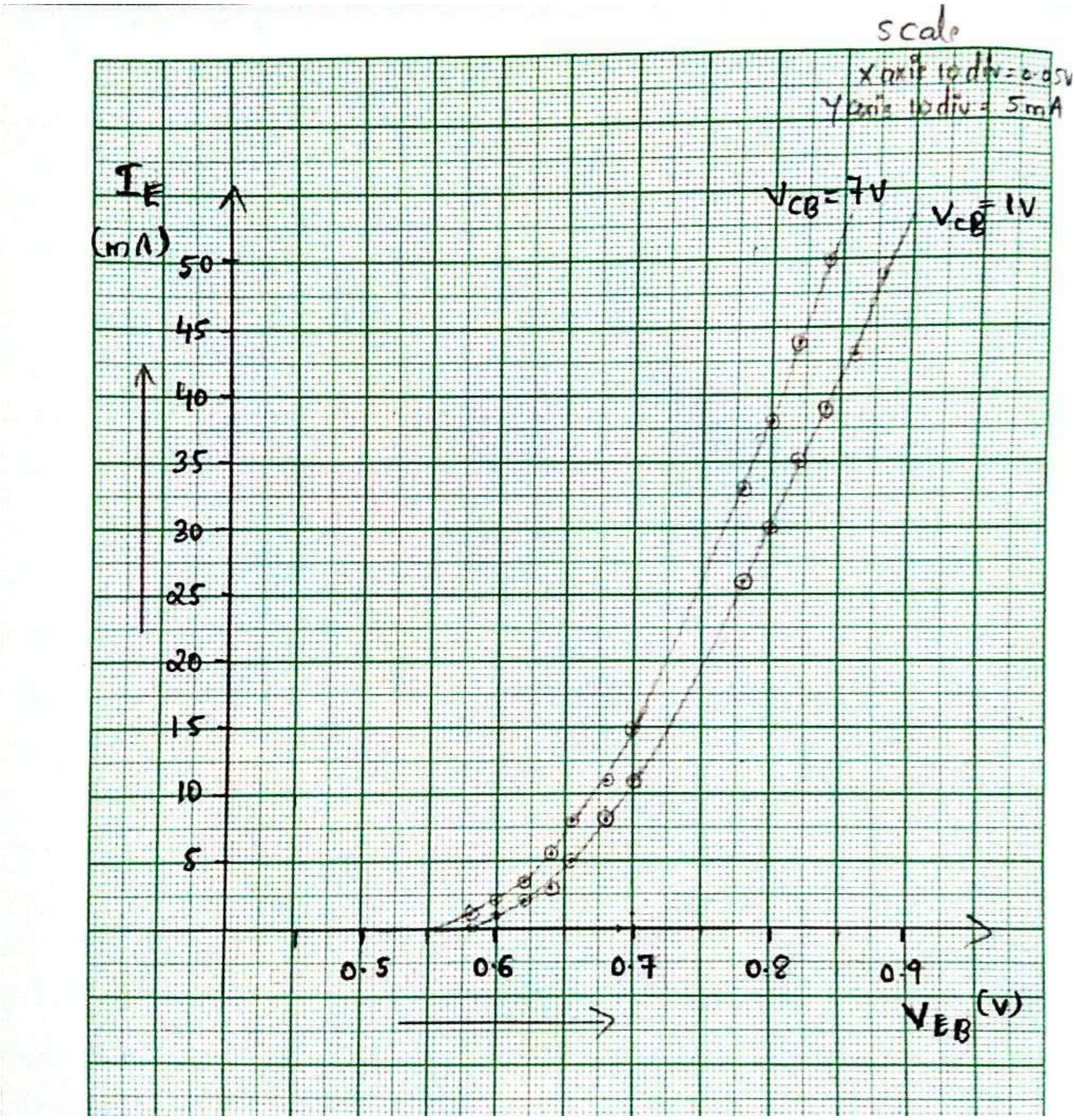


4.2 Observations

INPUT CHARACTERISTICS

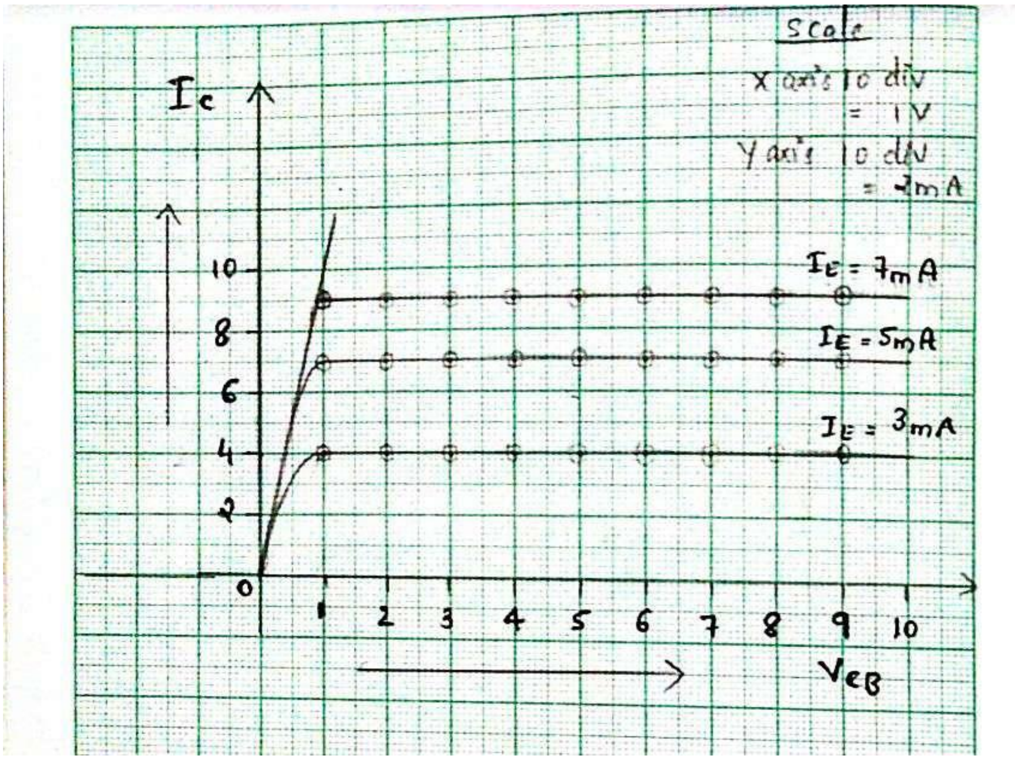
V_{CB} = 1 V		V_{CB} = 7 V	
V_{EB} (V)	I_E (mA)	V_{EB} (V)	I_E (mA)
0.58	0	0.58	1
0.6	1	0.6	2
0.62	2	0.62	3.5
0.64	3	0.64	5.5
0.66	5	0.66	8
0.68	8	0.68	11
0.7	11	0.7	15
0.72	14	0.72	18
0.74	18	0.74	23
0.76	22	0.76	28

0.78	26	0.78	33
0.8	30	.8	38
0.82	35	.82	44
0.84	39	.84	50
0.86	43	.86	Out of range
0.88	49		
0.9	Out of range		



OUTPUT CHARACTERISTICS

I_E = 3 mA		IE = 5 mA		IE = 7 mA	
V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)
0	4	0	7	0	9
1	4	1	7	1	9
2	4	2	7	2	9
3	4	3	7	3	9
4	4	4	7	4	9
5	4	5	7	5	9
6	4	6	7	6	9
7	4	7	7	7	9
8	4	8	7	8	9
9	4	9	7	9	9



Calculations from the Graph

1) Input characteristics:

Input Impedance = $\Delta V_{EB}/\Delta I_E$= (0.88-0.84) / (50-49)

= 0.25 / 1 = 0.25 Ω

Reverse voltage gain = $\Delta V_{EB} / \Delta V_{CB}$ = (0.64 - 0.62) / (3 - 2)

= 0.02 / 1 = 0.02

2) Output Characteristics:

Forward Current gain= $\Delta I_C/\Delta I_E$= (9-7)/(7-5)= 2/2 = 1

4.3 Results

a. The Input resistance = 0.25 Ω

b. The Reverse Voltage gain =0.02

c. The Forward Current gain =1

CONCLUSIONS

In this Chapter we studied the input and output characteristics of an NPN transistor in CB configuration. We have also included the observations and graphs of the same.

CHAPTER-5

CHARACTERISTICS OF COMMON COLLECTOR CONFIGURATION

INTRODUCTION

In this chapter we will be discussing about the input and output characteristics of Common Collector Configuration

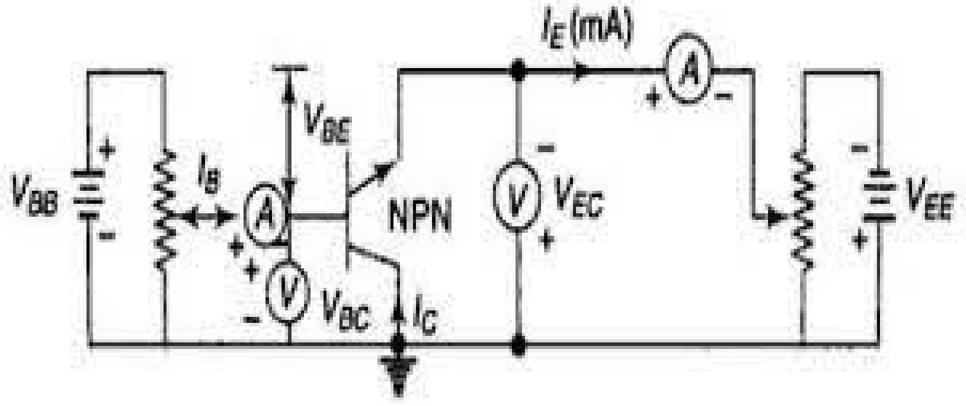
Aim

To study the input and output characteristics of a transistor in a common collector configuration(CC).

Apparatus

Transistor BC 107, Rheostat, Analogue ammeter, Analogue voltmeter, Connecting wires

Circuit Diagram

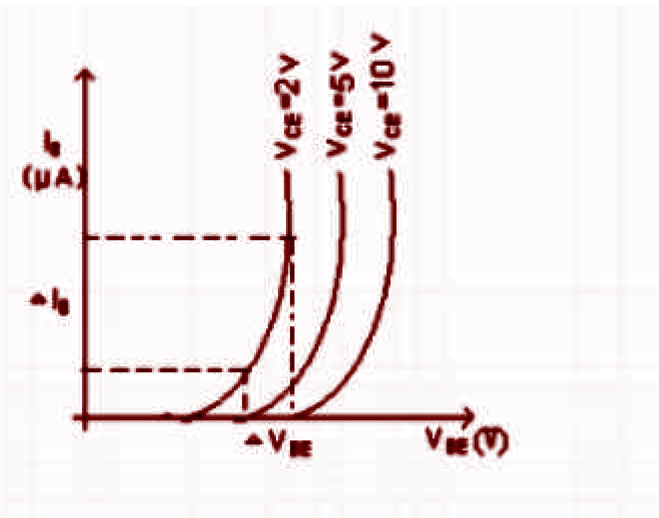


5.1 Procedure

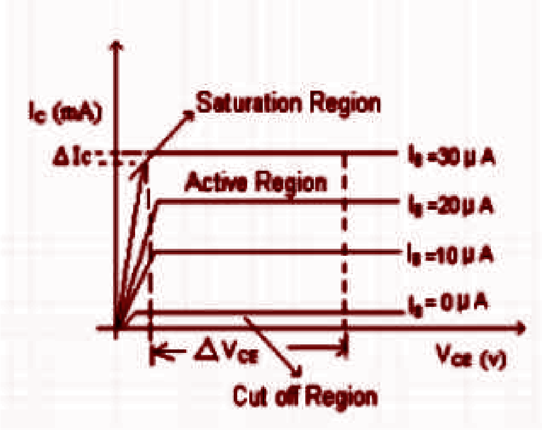
a) Input Characteristics:
   Connect the circuit as shown in the circuit diagram. Keep output voltage V_{CE} as constant rheostat. Varying gradually, note down base current I_B and emitter-base voltage (V_{BE}). Step size is not fixed because of the nonlinear curve. Repeat the experiment for different constant values of $V_{CE.}$

b) Output Characteristics:
   Fix base current, I_B at constant value. Vary the output voltage in steps. Measure the voltage V_{CE} and current I_C for different values. Repeat the experiment for different constant values of I_B. Draw output static characteristics for tabulated values.
   Plot the input characteristics for different values of V_{CE} by taking V_{BE} on X-axis and I_B on Y-axis taking V_{CC} as constant parameter. Plot the output characteristics by taking V_{CE} on X-axis and I_C on Y-axis taking I_B as a constant parameter.

Graph



Input Characteristics

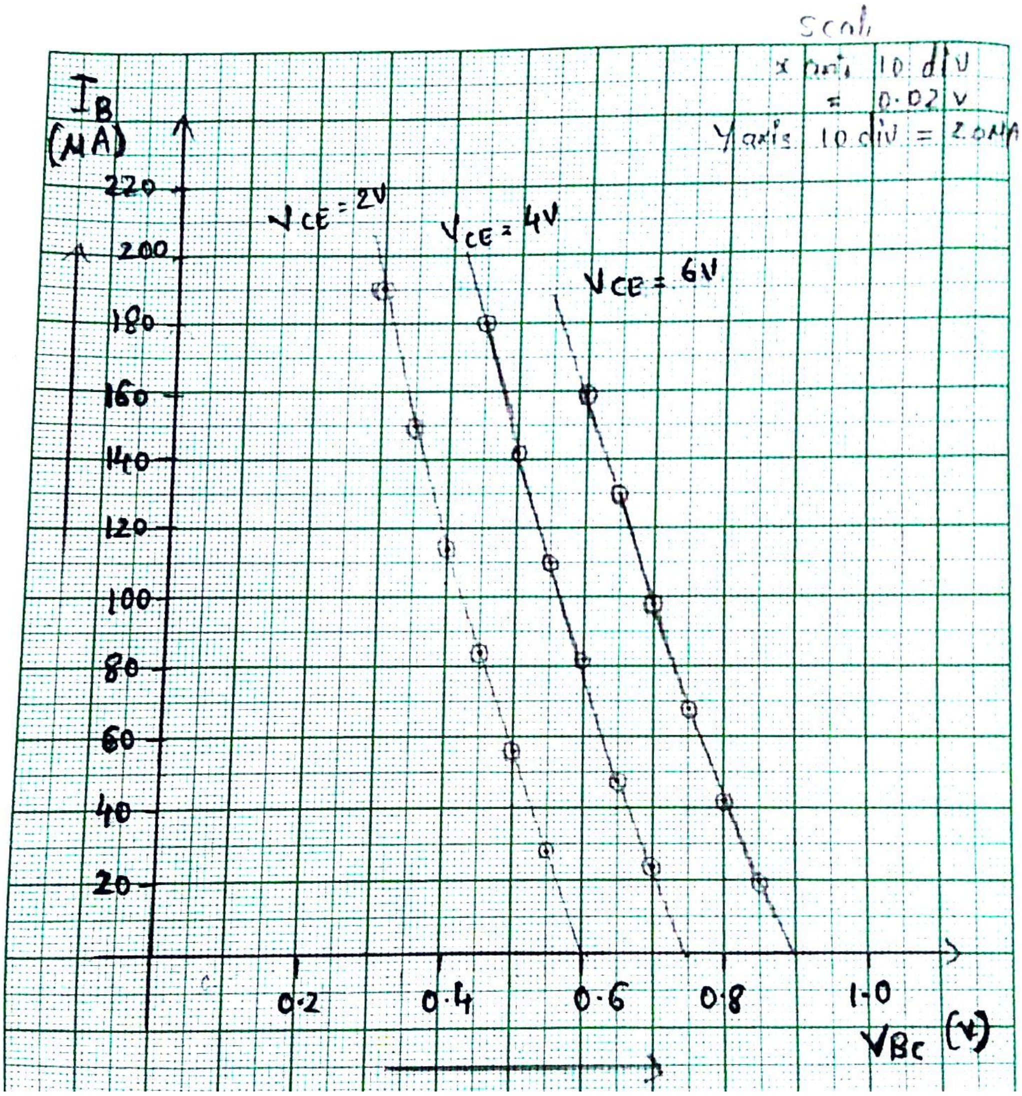


Output Characteristics

5.2 Observations

INPUT CHARACTERISTICS

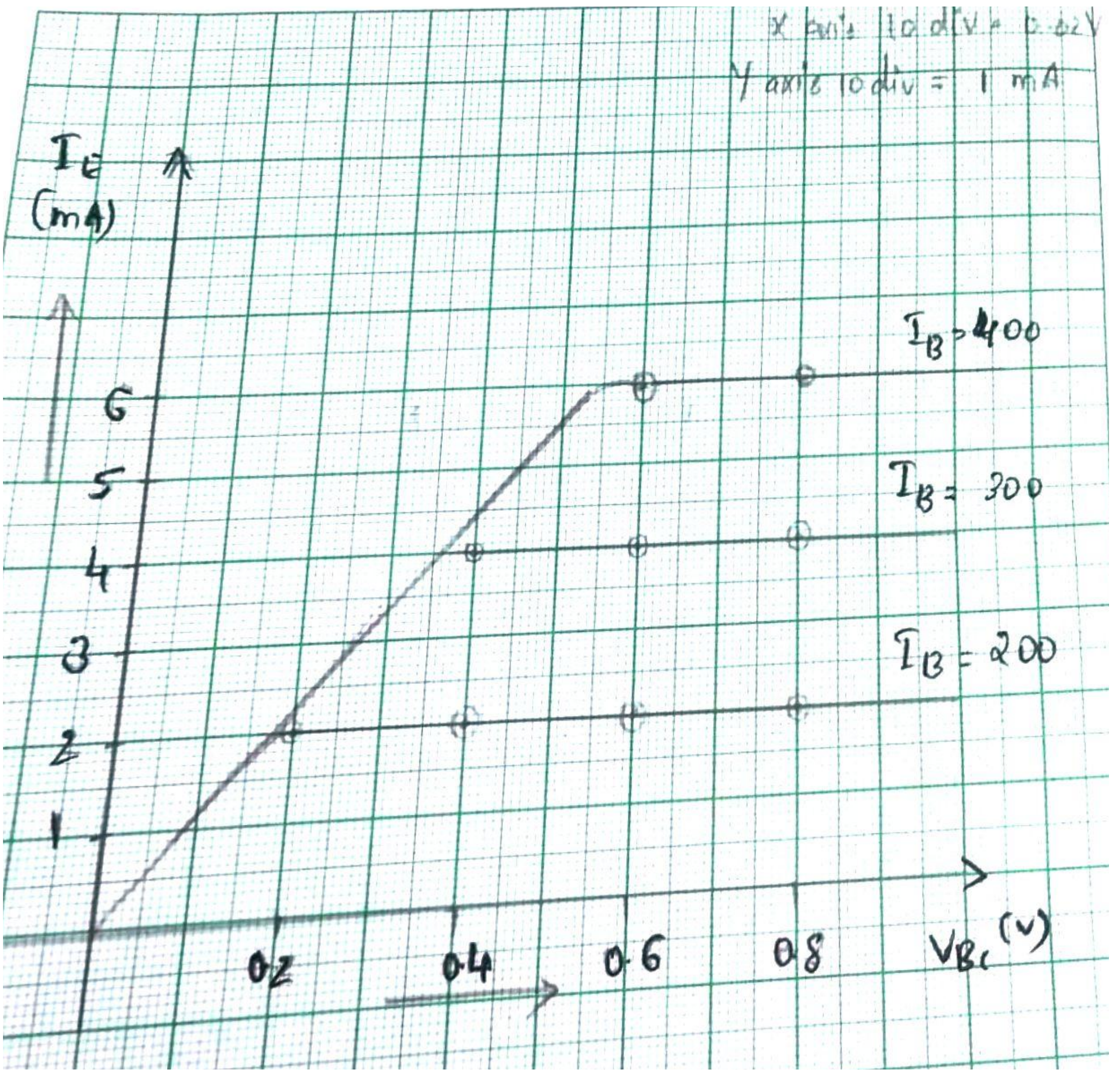
V_{EC} = 2V		V_{EC} = 4V		V_{EC} = 6V	
V_{BC} (V)	I_B (μA)	V_{BC} (V)	I_B (μA)	V_{BC} (V)	I_B (μA)
0.9	0	0.75	0	0.6	0
0.85	20	0.7	24	0.55	28
0.8	42	0.65	48	0.5	56
0.75	68	0.6	82	0.45	84
0.7	98	0.55	110	0.4	114
0.65	130	0.5	142	0.35	150
0.6	160	0.45	180	0.3	190



Scale
x axis 10 div
= 0.02 V
Y axis 10 div = 20 μA
I_B
(μA)
220
200
180
160
140
120
100
80
60
40
20
$V_{CE} = 2V$
$V_{CE} = 4V$
$V_{CE} = 6V$
0.2
0.4
0.6
0.8
1.0
V_{BC} (V)

OUTPUT CHARACTERISTICS

I_B= 200 µA		I_B= 300 µA		I_B= 400 µA	
V_{BC} (V)	I_E (mA)	V_{BC} (V)	I_E (mA)	V_{BC} (V)	I_E (mA)
0	0	0	0	0	0
0.2	2	0.2	2	0.2	2
0.4	2	0.4	4	0.4	4
0.6	2	0.8	4	0.6	6
0.8	2	2	4	0.8	6



Calculations from the Graph

a.Input resistance= $\Delta V_{BC}/\Delta I_B$= 0.5/20 = 0.025Ω

b.Reverse voltage gain = $\Delta V_{BC} / \Delta V_{EC}$ = 0.15/2 = 0.075

c.Forward current gain = $\Delta I_E / \Delta I_B$ = 2/100 = 0.02

5.3 Results

a. Input Resistance = 0.025Ω
b. Reverse Voltage Gain = 0.07
c. Forward Current Gain = 0.02

CONCLUSIONS

In this Chapter we studied the input and output characteristics of an NPN transistor in CC configuration. We have also included the observations and graphs of the same.

CHAPTER-6

SUMMARY AND FUTURE PROSPECTS

6.1 SUMMARY

In this project we conducted a detailed study of characteristics of the transistor in different configurations i.e, common emitter configuration,common base configuration and common collector configuration.

In Common emitter configuration, the emitter is grounded and it is the common terminal for both the input and output.The base is used as input terminal and collector is used as output at terminal.In common emitter configuration current gain and voltage gain are calculated.

In Common base configuration the base is grounded and it acts as the common terminal.Here emitter is the input terminal and collector is the output terminal.In common base configuration output voltage gain is calculated .

In common collector configuration the collector is grounded and it is the common terminal for both the input and output.Here base is input terminal and emitter is the output terminal.

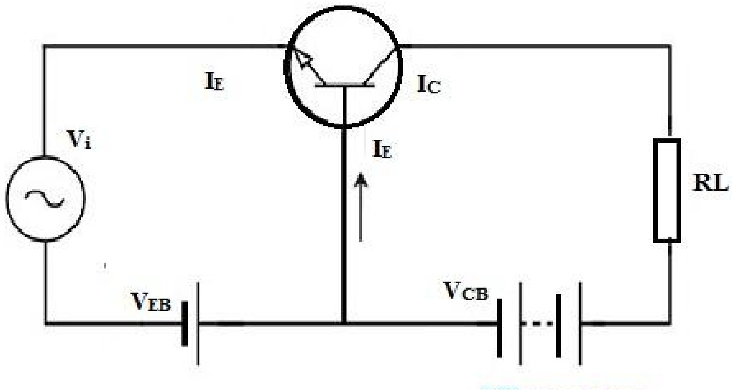
Common Emitter (CE)	Common Base (CB)	Common Collector (CC)
Emitter is grounded.	Base is grounded.	Collector is grounded.
Current gain (β) in CE configuration is given by $\beta = \Delta I_C / \Delta I_B$ We got β = 0.2	Current gain (α) in CB configuration is given by: $\alpha = \Delta I_C / \Delta I_E$ Here α = 1	The current gain is calculated as , $\gamma = \Delta I_E / \Delta I_B$ We got γ = 0.02
Input resistance is obtained 0.002 Ω	Input resistance is obtained as 0.25 Ω	Input resistance is obtained as 0.025Ω
The reverse voltage gain is given by: $\Delta V_{EB} / \Delta V_{CE} = 0.5$	The reverse voltage gain is given by: $\Delta V_{EB} / \Delta V_{CB} = 0.02$	The reverse voltage gain in CC configuration is given by $\Delta V_{BC} / \Delta V_{EC} = 0.07$
It is used as audio frequency	It is used for amplification purposes.	. It is used for impedance matching

6.2 FUTURE PROSPECTS OF PRESENT WORK

- **Transistor as an Amplifier:** An amplifier circuit can be defined as a circuit that amplifies a signal. The amplifier's input is either a voltage or a current, and the output is an amplifier input signal. A transistor amplifier is an amplifier circuit that uses a transistor . Transistor amplifier circuits are used in a variety of applications, including audio, radio, and optical fibre communication.
- **Transistor as an Amplifier Circuit:** A transistor can be used as an amplifier by boosting the strength of a weak signal. One may

gain a sense of how a transistor circuit operates as an amplifier circuit by looking at the transistor amplifier circuit below.

The input signal can be applied between the emitter-base junction and the output across the Rc load in the collector circuit in the circuit below.



Always remember that the input is forward-biased, while the output is connected reverse-biased for proper amplification. Thus , we apply DC voltage (VEE) to the input circuit in addition to the signal, as indicated in the above diagram. Generally, the input circuit often has low resistance; a small change in signal voltage at the input causes a considerable change in the emitter current. Because of the transistor's action, a change in the emitter current will result in a change in the collector circuit. The flow of collector current through a Rc currently generates a huge voltage across it. As a result, the weak signal applied at the input circuit will be amplified at the collector circuit in the output. The transistor acts as an amplifier in this manner.

- **Microphone**: Our voice or sound wave is converted to an electronic signal by the microphone, which is a transducer. The magnitude of the sound wave varies with time according to our voice because it does not have a constant value. Because of the small alternating voltage created by the microphone, the electrical output of the microphone varies in response to sound waves, as the base current Ib varies. This means that a slight change in Ib can induce a huge change in Ic. When the microphone output is fed into the transistor as an input, the variable collector current Ic flows into the loudspeaker, and we know that if the transistor's input changes, the output of the transistor will fluctuate dramatically. As a result, the transistor enhances the microphone's electronic signal. Although the frequency remains constant, the amplitude of the sound wave from the loudspeaker is greater than that of the sound waves fed into the microphone.

❖ **Transistor Used as a Switch**: BJT Transistors can be used to manage DC power to a load by acting as a switching device. The controlling current flows between the emitter and the base, whereas the switched (controlled) current flows between the emitter and the collector.
To brief other practical application of transistors, it includes:

- Transistors are used in oscillators and modulators as amplifiers.
- Transistors are used in Radio-frequency circuits for wireless systems.
- Transistor switches are used in Burglar alarms, industrial control circuits, memories and microprocessors.
- They are used in Sub Wordline Driver (SWD) to produce low frequency currents.
- MOSFETs are used in Chopper circuits.
- JFET, MOSFET can act as a passive element like Resistor.

The first announcement of the transistor's development was made with absolutely no fanfare. Originally, the integrated circuit was supposed to be solely valuable in military applications. Investors in the microprocessor pulled out before it was built, believing it would be a waste of money. The transistor and its descendants have always been discounted, despite the fact that they have shown to be more capable than anyone anticipated. Today's predictions also suggest that the transistor's capabilities are limited. This time, the expectations are that transistors will not be able to shrink any farther than they are now. Then again, in 1961, scientists predicted that no transistor on a chip could ever be smaller than 10 millionths of a metre -- and on a modern Intel Pentium chip they are 100 times smaller than that.

With the benefit of hindsight, such predictions appear absurd, and it's easy to imagine that today's predictions will sound just as absurd thirty years from now. However, recent size limit predictions are based on some very basic physics, such as the size of the atom and the electron. Because transistors operate on electric current, they must constantly be large enough to allow electrons to pass through.

On the other hand, all that's really needed is a single electron at a time. It would be phenomenally small for a transistor to operate with only one electron, but it is theoretically possible. Future transistors could make contemporary circuits appear as large and bulky as vacuum tubes are now. The trouble is that once gadgets get that small, everything moves according to quantum mechanics' principles, which allows electrons to perform some strange things. In such a small device, the electron behaves more like a wave than a single particle. It would smear out in space as a wave, and it may even tunnel through the transistor without actually acting on it.

Despite this, researchers are actively working on new ways to produce such tiny devices, forsaking silicon and all current production methods. Single electron transistors are what they're called, and depending on whether or not they're keeping an electron, they're termed "on" or "off." (At this level, transistors are only employed as binary coding switches, not as amplifiers.) In reality, the quantum weirdness of the ultra-small might be exploited by such a minuscule device. Instead of merely "on" or "off," the electron might be configured to have three positions: "somewhere between on and off." This would pave the way for whole new types of computers. However, there are currently no practical single electron transistors.

Miniaturisation is possible even without new technology. Present transistors are expected to be at least twice as small by 2010 if current manufacturing procedures are improved. Intel's latest processor has nearly a billion transistors, implying that four times as many transistors on a chip are theoretically achievable. Computers with chips like this would be far "smarter" than they are now.

Transistors are the most basic electronic components that can be found in every device. They've grown in size and performance over the last 30 years. Their capacity to behave as a switch or to amplify current or voltage has allowed them to be used in a wide range of applications, including logic gates in computer processors and sound amplifiers. The ability to hold more electronics in one's hand than could be contained in a large building in the days when vacuum tubes were the only active devices available is perhaps transistors' most important contribution. They have made it possible to hold more electronics in one's hand than could be contained in a large building in the days when vacuum tubes were the only active devices available. As a result, complex functionality may now be packed into small packages—computers, cell phones, automotive engine controllers, and a variety of other devices.

A continuous process of research and development is underway to improve transistor performance parameters and to identify new semiconductor materials other than silicon. Transistors are being created to assist rapid technological advances such as wireless charging and energy conversion. Transistors are still being studied extensively around the world, as reducing the size and power consumption of individual transistors on a chip can result in quick profits. Researchers have already produced extremely small transistors made of only a few molecules in the lab, including one that uses only a single electron. They've also shown that transistors constructed of plastic are feasible, and that they could be even cheaper and more shock-resistant than conventional electronics.

Increasing transistor densities on chips (which manufacturers desire) is expected to be achieved in the near future via improving fabrication techniques for classic semiconductor devices.

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