Course Name:	**Elements of Electrical and Electronics Engineering Laboratory**	**Semester:**	**I**
Date of Performance:	**19/11/2024**	**Batch No:**	**C5-3**
Student Name:	**Rajat Kumar**	**Roll No:**	**16014224054**
Faculty Sign & Date:		**Grade/Marks:**	**/20**

Experiment No: 8
Title: BJT Common Emitter Characteristics

Aim and Objective of the Experiment:

- To understand the structure and working of Bipolar Junction Transistor
- To plot the Common Emitter characteristics of a BJT

COs to be achieved:

CO5: Understand Bipolar Junction transistor and its applications.

Requirements:

PC with internet facility

Link for virtual lab:
https://be-iitkgp.vlabs.ac.in/exp/common-emitter-characteristics/

Theory:

Structure of Bipolar Junction Transistor

A bipolar junction transistor, BJT, is a single piece of silicon with two back-to-back P-N junctions. BJTs can be made either as PNP or as NPN. They have three regions and three terminals, emitter, base, and collector represented by E, B, and C respectively.

Emitter (E): It is the region to the left end which supply free charge carriers i.e., electrons in n-p-n or holes in p-n-p transistors. These majority carriers are injected to the middle region i.e. electrons in the p region of n-p-n or holes in the n region of p-n-p transistor. Emitter is a heavily doped region to supply a large number of majority carriers into the base.

Base (B): It is the middle region where either two p-type layers or two n-type layers are sandwiched. The majority carriers from the emitter region are injected into this region. This region is thin and very lightly doped.

Collector (C): It is the region to right end where charge carriers are collected. The area of this region is largest compared to emitter and base region. The doping level of this region is intermediate between heavily doped emitter region and lightly doped base region.

Input Characteristics

It is the plot of the base current, I_B, versus the base-emitter voltage, VBE, for various values of the collector-emitter voltage, V_{CE} for constant V_{CE}

Output Characteristics

It 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

Circuit Diagram/ Block Diagram:

BJT Common Emitter - Input Characteristics

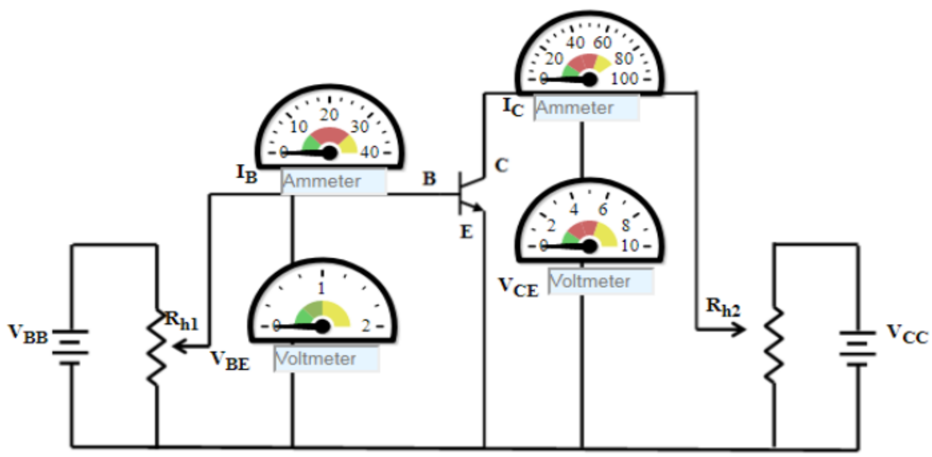


Figure:1

BJT Common Emitter - Output Characteristics

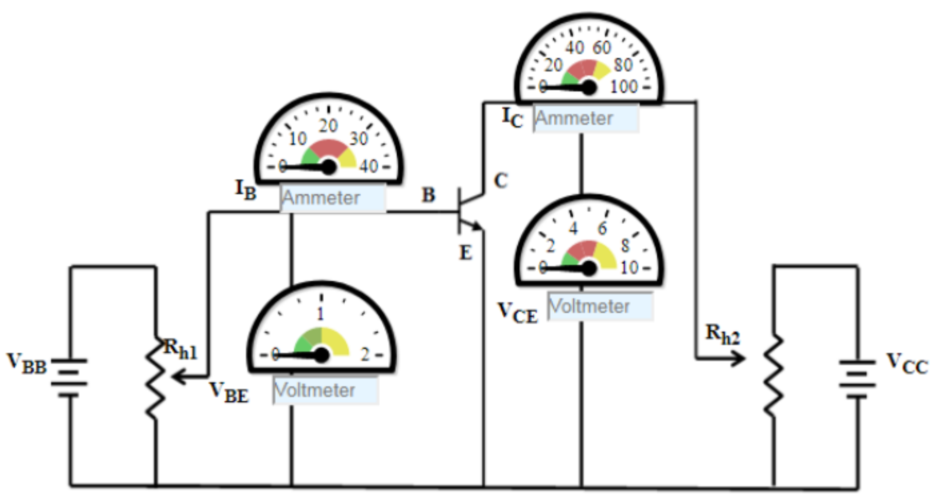


Figure: 2

Stepwise-Procedure:

BJT Common Emitter - Input Characteristics

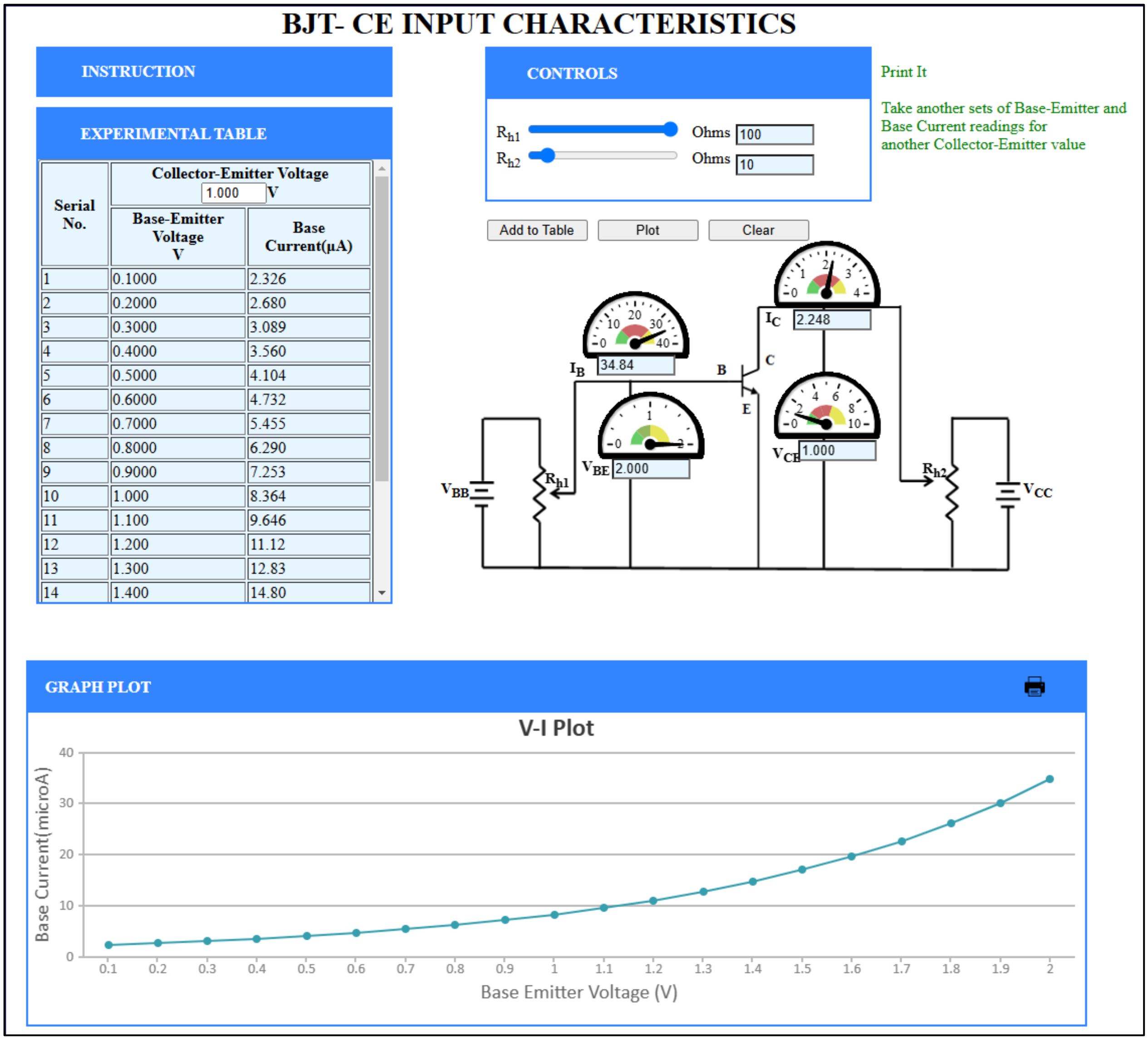
1. Initially set rheostat Rh1 = 1 Ω and rheostat Rh2 = 1 Ω
2. Set the Collector-Emitter Voltage(VCE) to 1 V by adjusting the rheostat Rh2
3. Base Emitter Voltage (VBE) is varied by adjusting the rheostat Rh1.
4. Note the reading of Base current (IB)in micro-Ampere.
5. Click on 'Plot' to plot the I-V characteristics of Common-Emitter configuration. A graph is drawn with VBE along X-axis and IB along Y-axis.
6. Click on 'Clear' button to take another sets of readings
7. Now set the Collector-Emitter Voltage (VCE) to 2V, 3V, 4V.

BJT Common Emitter - Output Characteristics

1. Initially set rheostat Rh1 = 1 Ω and rheostat Rh2 = 1 Ω
2. Set the Base current (IB) 15 uA by adjusting the rheostat Rh1
3. Vary the Collector-Emitter Voltage (VCE)is varied by adjusting the rheostat Rh2.
4. Note the reading of Collector current(IC).
5. Click on 'Plot' to plot the I-V characteristics of Common-Emitter configuration. A graph is drawn with VCE along X-axis and IC along Y-axis.
6. Click on 'Clear' button to take another sets of readings
7. Now set the Base Current (IB) to 20 uA.

V-Lab ScreenShots –

BJT- CE INPUT CHARACTERISTICS - READING 1



Serial No.	Collector-Emitter Voltage 1.000 V	
	Base-Emitter Voltage V	Base Current(μA)
1	0.1000	2.326
2	0.2000	2.680
3	0.3000	3.089
4	0.4000	3.560
5	0.5000	4.104
6	0.6000	4.732
7	0.7000	5.455
8	0.8000	6.290
9	0.9000	7.253
10	1.000	8.364
11	1.100	9.646
12	1.200	11.12
13	1.300	12.83
14	1.400	14.80

BJT- CE INPUT CHARACTERISTICS - READING 2

BJT- CE INPUT CHARACTERISTICS

INSTRUCTION

EXPERIMENTAL TABLE

3	0.3000	3.098
4	0.4000	3.570
5	0.5000	4.114
6	0.6000	4.741
7	0.7000	5.465
8	0.8000	6.300
9	0.9000	7.263
10	1.000	8.374
11	1.100	9.655
12	1.200	11.13
13	1.300	12.84
14	1.400	14.81
15	1.500	17.08
16	1.600	19.69
17	1.700	22.71
18	1.800	26.20
19	1.900	30.22
20	2.000	34.85

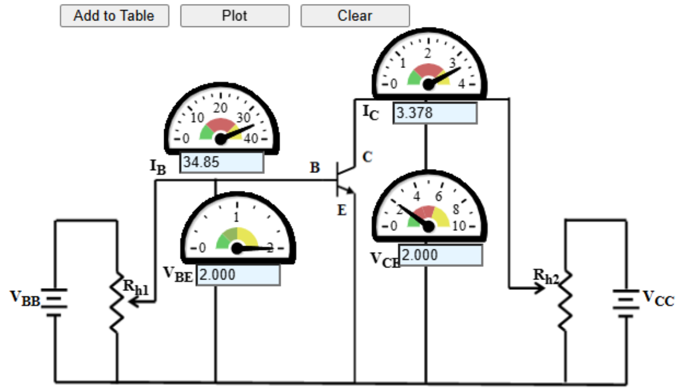
CONTROLS

R_{h1} Ohms 100
R_{h2} Ohms 20

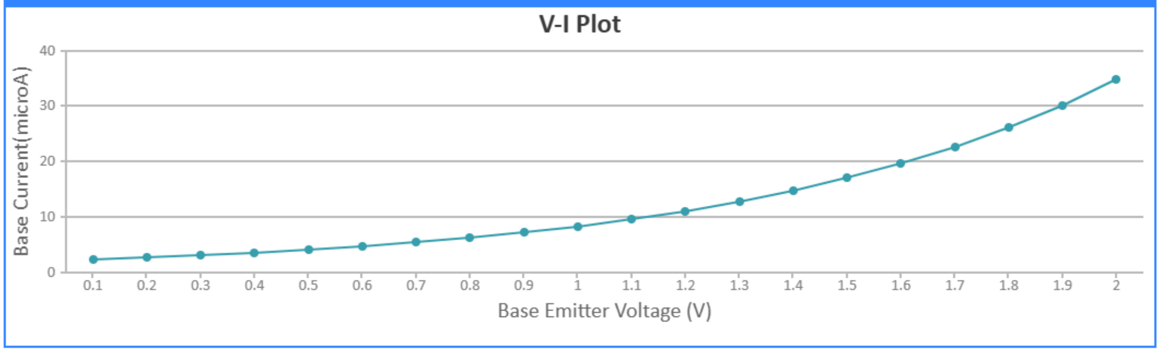
Print It

Take another sets of Base-Emitter and Base Current readings for another Collector-Emitter value

Add to Table | Plot | Clear



GRAPH PLOT



BJT- CE INPUT CHARACTERISTICS - READING 3

BJT- CE INPUT CHARACTERISTICS

INSTRUCTION

EXPERIMENTAL TABLE

3	0.3000	3.099
4	0.4000	3.571
5	0.5000	4.115
6	0.6000	4.742
7	0.7000	5.466
8	0.8000	6.300
9	0.9000	7.264
10	1.000	8.375
11	1.100	9.656
12	1.200	11.13
13	1.300	12.84
14	1.400	14.81
15	1.500	17.08
16	1.600	19.69
17	1.700	22.71
18	1.800	26.20
19	1.900	30.22
20	2.000	34.85

CONTROLS

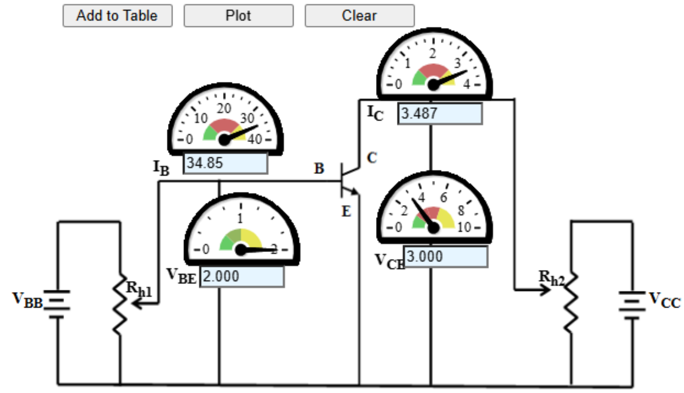
R_{h1} Ohms 100

R_{h2} Ohms 30

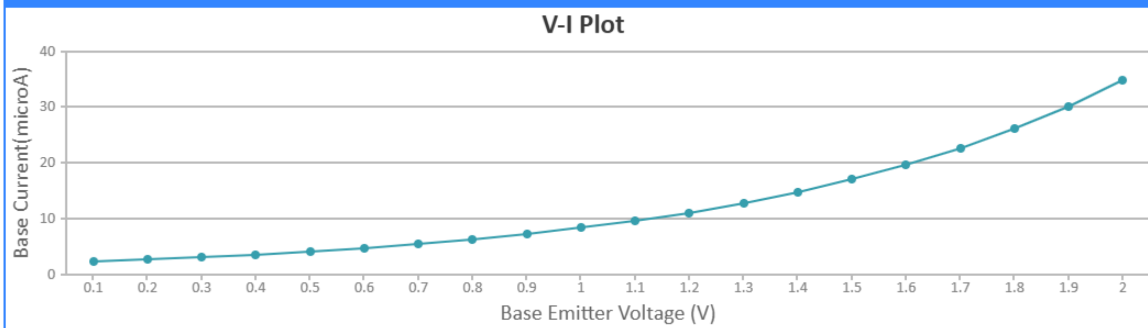
Print It

Take another sets of Base-Emitter and Base Current readings for another Collector-Emitter value

Add to Table | Plot | Clear



GRAPH PLOT



BJT- CE OUTPUT CHARACTERISTICS - READING 1

BJT- CE OUTPUT CHARACTERISTICS

INSTRUCTION

EXPERIMENTAL TABLE

Serial No.	Base-Current 15.35 µA	
	Collector-Emitter Voltage V	Collector Current mA
1	0.1000	5.994
2	0.2000	11.87
3	0.3000	17.52
4	0.4000	22.85
5	0.5000	27.79
6	1.000	45.81
7	2.000	57.98
8	4.000	60.10
9	6.000	60.14
10	8.000	60.14
11	10.00	60.14

CONTROLS

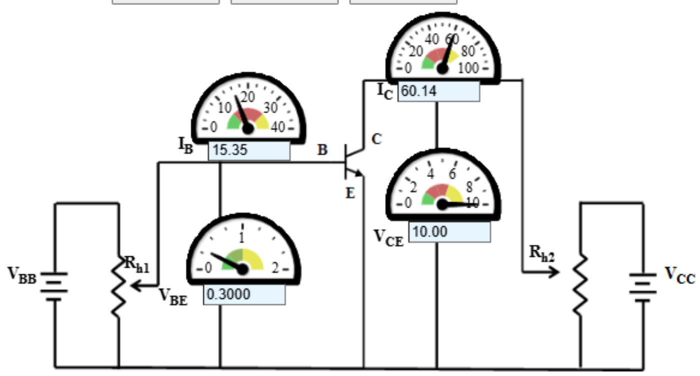
R_{h1} Ohms 15

R_{h2} Ohms 100

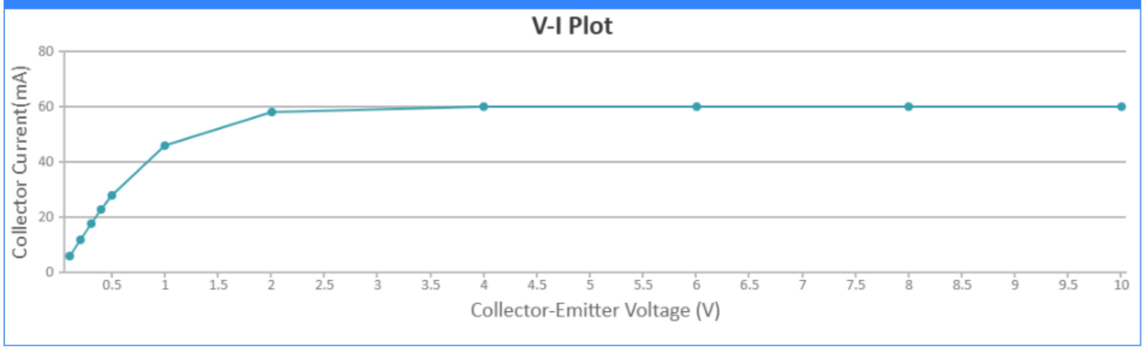
Print It

Take another sets of Collector-Emitter and Collector Current readings for another Base Current

Add to Table | Plot | Clear



GRAPH PLOT



BJT- CE OUTPUT CHARACTERISTICS - READING 2

BJT- CE OUTPUT CHARACTERISTICS

INSTRUCTION

EXPERIMENTAL TABLE

Serial No.	Base-Current 20.43 µA	
	Collector-Emitter Voltage V	Collector Current mA
1	0.1000	9.202
2	0.2000	18.22
3	0.3000	26.90
4	0.4000	35.08
5	0.5000	42.66
6	1.000	70.31
7	2.000	89.00
8	4.000	92.26
9	6.000	92.32
10	8.000	92.32
11	10.00	92.32

CONTROLS

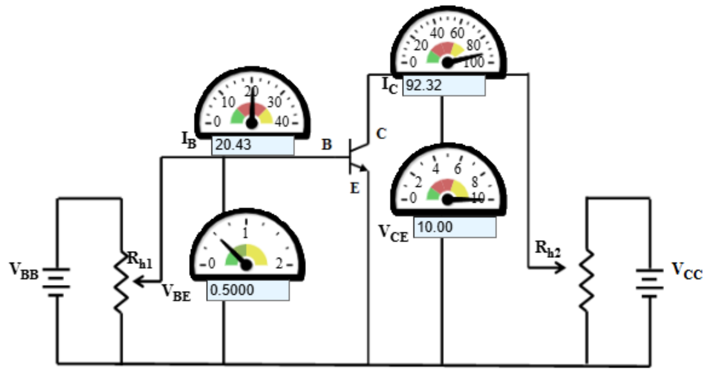
R_{h1} Ohms 25

R_{h2} Ohms 100

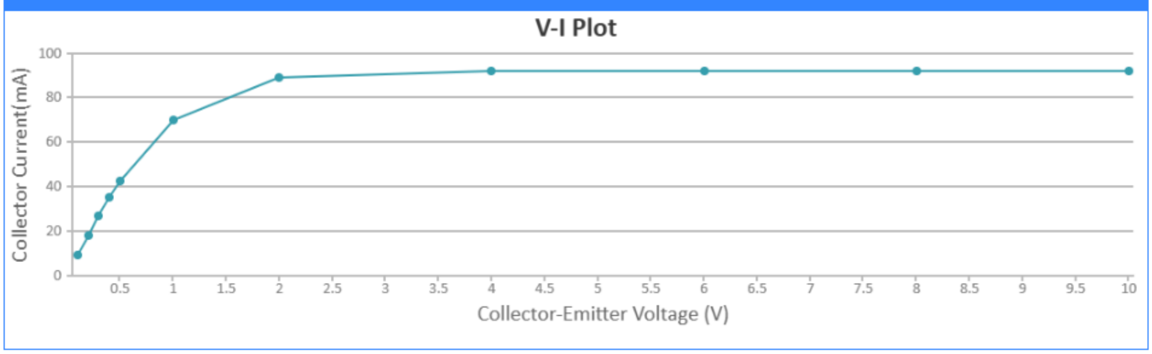
Print It

Take another sets of Collector-Emitter and
Collector Current readings for another Base Current

Add to Table | Plot | Clear



GRAPH PLOT



BJT- CE OUTPUT CHARACTERISTICS - READING 3

BJT- CE OUTPUT CHARACTERISTICS

INSTRUCTION

EXPERIMENTAL TABLE

Base-Current 25.67 µA

Serial No.	Collector-Emitter Voltage V	Collector Current mA
1	0.1000	12.96
2	0.2000	25.67
3	0.3000	37.89
4	0.4000	49.42
5	0.5000	60.11
6	1.000	99.07
7	2.000	125.4
8	4.000	130.0
9	6.000	130.1
10	8.000	130.1
11	10.00	130.1

CONTROLS

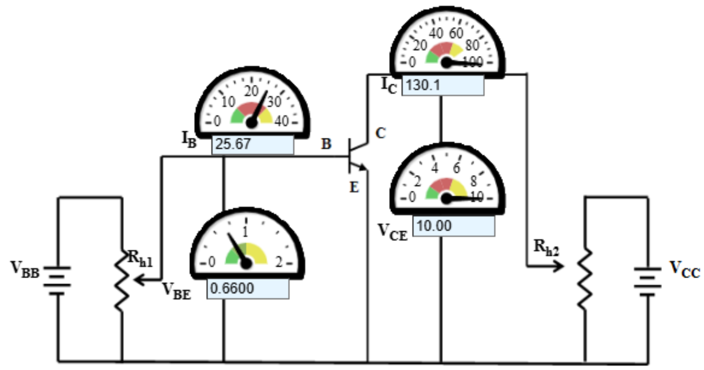
R_{h1} Ohms 33

R_{h2} Ohms 100

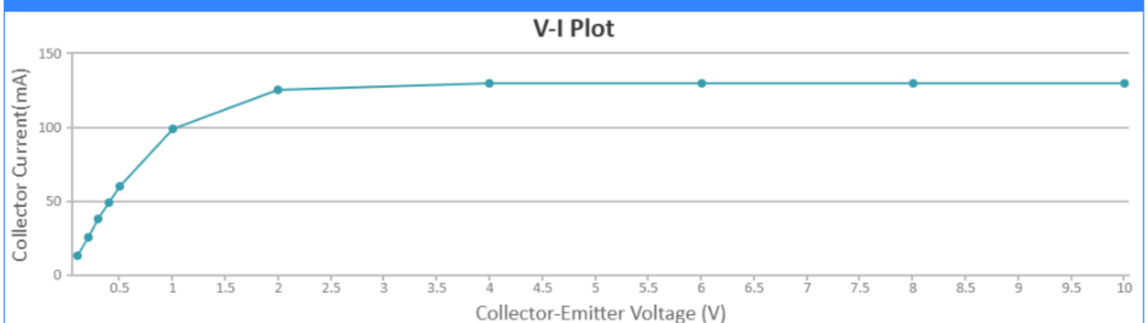
Add to Table | Plot | Clear

Print It

Take another sets of Collector-Emitter and Collector Current readings for another Base Current



GRAPH PLOT



Observation Table:

BJT Common Emitter - Input Characteristics

Collector to Emitter voltage VCE= 1 Volts		Collector to Emitter voltage VCE = 2 Volts		Collector to Emitter voltage V_{CE} = 3 Volts	
V_{BE} (V)	I_B(µA)	V_{BE} (V)	I_B(µA)	V_{BE} (V)	I_B (µA)
0.1	2.326	0.1	2.335	0.1	2.336
0.2	2.680	0.2	2.690	0.2	2.690
0.3	3.089	0.3	3.098	0.3	3.099
0.4	3.560	0.4	3.570	0.4	3.571
0.5	4.104	0.5	4.114	0.5	4.115
0.6	4.732	0.6	4.741	0.6	4.742
0.7	5.455	0.7	5.465	0.7	5.466
0.8	6.290	0.8	6.300	0.8	6.300
0.9	7.253	0.9	7.263	0.9	7.264

BJT Common Emitter - Output Characteristics

Base current I_B = 15.35 (µA)		Base current I_B = 20.43 (µA)		Base current I_B = 25.67 (µA)	
V_{CE} (V)	I_C(mA)	V_{CE} (V)	I_C(mA)	V_{CE} (V)	I_C(mA)
0.1	5.994	0.1	9.202	0.1	12.96
0.2	11.87	0.2	18.22	0.2	25.67
0.3	17.52	0.3	26.90	0.3	37.89
0.4	22.85	0.4	35.08	0.4	49.42
0.5	27.79	0.5	42.66	0.5	66.11
1.0	45.81	1.0	70.31	1.0	99.07

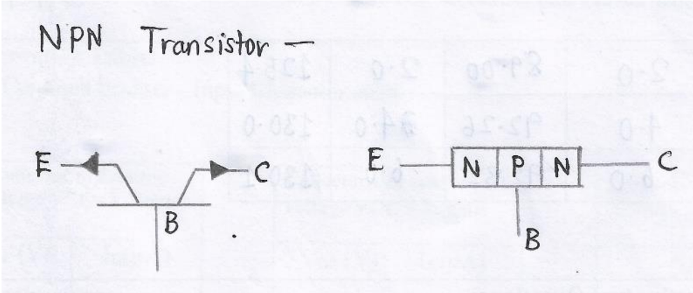
2.0	57.98	2.0	89.00	2.0	125.4
4.0	60.10	4.0	92.26	4.0	130.0
6.0	60.14	6.0	92.32	6.0	130.1

Post Lab Subjective/Objective type Questions:

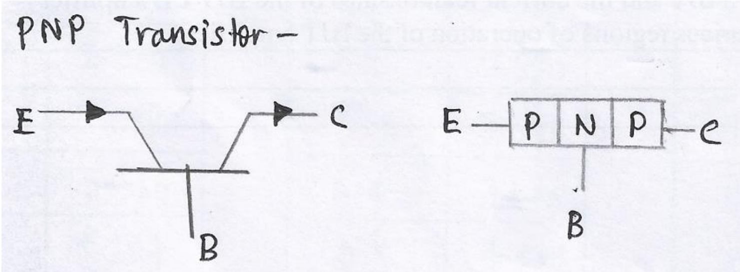
1. **Explain the structute of a BJT and the current relationships of the BJT CE amplifier.**

Ans: A **Bipolar Junction Transistor (BJT)** is a three-terminal semiconductor device used for amplification and switching. It has two main types:

A) NPN BJT: Consists of a thin layer of P-type material (Base) sandwiched between two Ntype materials (Emitter and Collector).



B) PNP BJT: Consists of a thin layer of N-type material (Base) sandwiched between two Ptype materials (Emitter and Collector).



Layers and Terminals:
1. Emitter (E): Heavily doped region that emits charge carriers (electrons in NPN, holes in PNP).
2. Base (B): Thin and lightly doped, allowing charge carriers to pass through to the collector.
3. Collector (C): Moderately doped region that collects charge carriers from the emitter through the base.

Current Relationships in BJT CE Amplifier –

In a Common Emitter (CE) amplifier configuration:

1. **Base Current (IB):** Small current flows into the base terminal.

2. **Collector Current (IC):** Large current flows from the collector terminal to the emitter (NPN) or emitter to collector (PNP).

3. **Emitter Current (IE):** Total current flowing out of the emitter terminal.

The current relationships in a BJT are:

• **IE = IB + IC** : The emitter current is the sum of the base current and the collector current.

• **IC ≈ βIB** : The collector current is approximately β times the base current, where β (current gain) is a constant

2. **Draw and explain the various regions of operation of the BJT amplifier.**

Ans: A **Bipolar Junction Transistor (BJT)** can operate in three main regions, depending on the biasing of the junctions and the applied voltages:

1. Cut-off Region

• Description: In this region, both the Base-Emitter (BE) and Base-Collector (BC) junctions are reverse-biased.

• Condition: VBE < 0.7 V (for silicon BJT), IB = 0,IC ≈ 0.

• Operation: The transistor is OFF, and no current flows through the collector-emitter path.

• Application: Used as a switch in digital circuits (OFF state).

2. Active Region

• Description: The BE junction is forward-biased, and the BC junction is reverse-biased.

• Condition: VBE ≥ 0.7 V (for silicon BJT), VCE > VBE.

• Operation: The transistor operates as an amplifier. The collector current (IC) is proportional to the base current (IB), i.e., IC = βIB.

• Application: Used in analog amplification.

3. Saturation Region

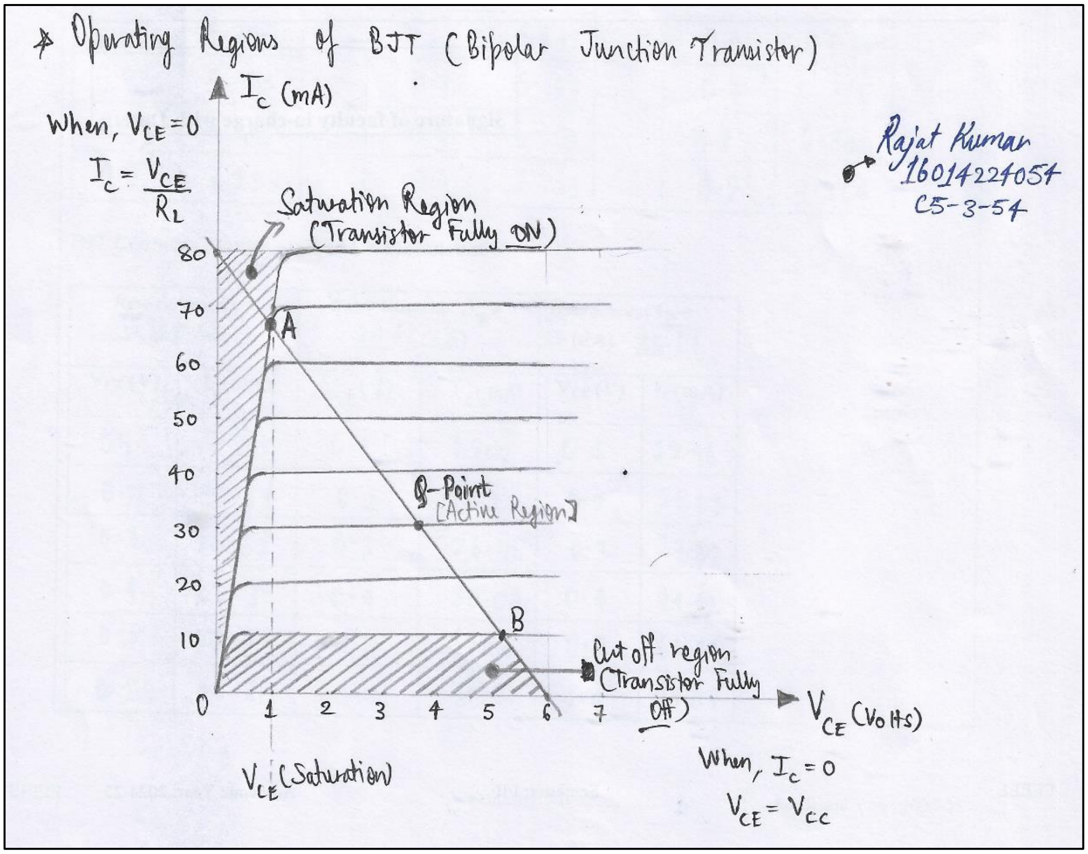
• Description: Both BE and BC junctions are forward-biased.

• Condition: VBE ≥ 0.7 V, VCE ≈ 0.2 V (for silicon BJT).

• Operation: The transistor is fully ON, and maximum current flows through the collectoremitter path.

• Application: Used as a switch in digital circuits (ON state).

Graph for various operating regions of BJT (Bipolar Junction Transistor)



Conclusion:

The experiment on the BJT common emitter (CE) characteristics provided us an in-depth understanding of the structure and working of a Bipolar Junction Transistor (BJT). A BJT is made of two back-to-back P-N junctions, it operates through three key regions: emitter, base, and collector where each serve a unique function in charge carrier movement and amplification.

By plotting the input and output characteristics using the readings keeping VCE and IB constant respectively and taking the respective readings, we observed the relationship between IB, VBE, IC, and VCE, highlighting the transistor's behavior in different regions of operation that is cut-off region, active region, and saturation region.

The CE configuration demonstrated its use as an amplifier, showing how small variations in base current (IB) result in significant changes in collector current (IC), enabling signal amplification. This experiment helped us understand the practical application of BJTs in amplifiers and switches, showing their importance in electronic circuits.

Signature of faculty in-charge with Date: