Experiment 7

DC Analysis of Bipolar Junction Transistor (BJT)

OBJECTIVE:

- To determine transistor type (NPN, PNP). Terminals, and material using a digital multimeter (DMM).
- To study and verify the functionality of a Transistor to plot Volt-Ampere Characteristics of a Transistor

Introduction

A Bipolar Junction Transistor, or BJT is a three terminal device having two PN-junctions connected together in series. Each terminal is given a name to identify it and these are known as the Emitter (E), Base (B) and Collector (C). There are two basic types of bipolar transistor construction, NPN and PNP, which basically describes the physical arrangement of the P- type and N-type semiconductor materials from which they are made.

The basic transistor consists of two diodes back to back. If the two p doped regions are next to each other then what results is a npn transistor.

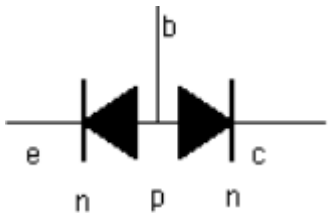


Figure 8.1: NPN Transistor

Two laboratory diodes wired back-to-back will NOT make a transistor. In a real transistor, the region of the two p regions is very narrow or thin so that the carriers can diffuse across the region freely. The symbol for the npn transistor is shown below.

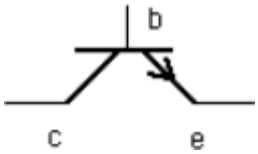


Figure 8.2: NPN Transistor Symbol

Tip for remembering: The arrow on the npn transistor is **Not Pointed in**.

When the two n regions are next to each other (as below) then one has a pnp transistor.

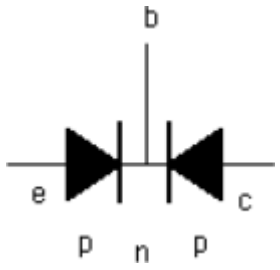


Figure 8.3: PNP Transistor

It should be clear that one of the diodes in a transistor is in the forward direction emitter-collector while one of the diodes is in the reverse direction. The symbol for the pnp transistor is given below.

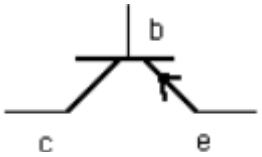


Figure 8.4: PNP Transistor Symbol

So the direction of the arrow is reverse from the npn transistor.

Transistors like the 2N2222 or PN2907 come in a variety of cases and either metal or plastic.

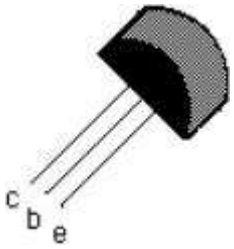


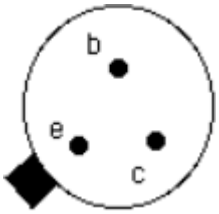
Figure 8.5: transistor package

One style is of plastic case or package is indicated below:

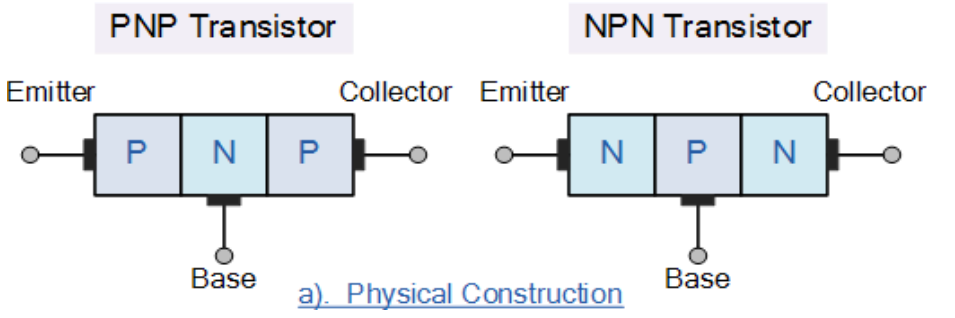
Or the bottom view is as follows:

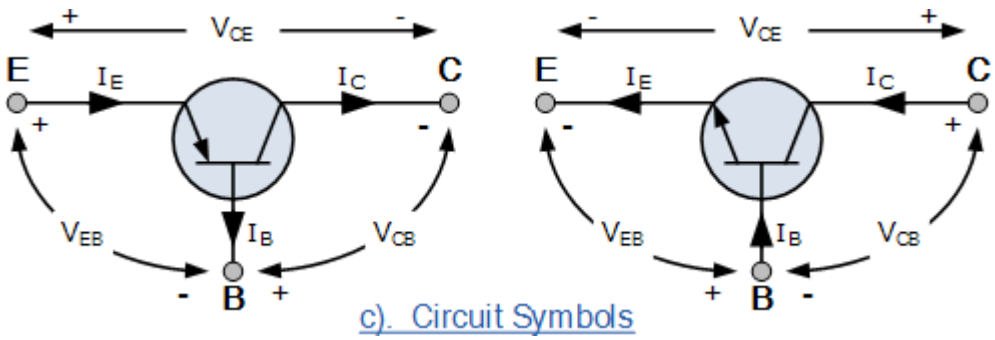


Finally, the view from the bottom of a transistor in a metal package is like as shown below:



Bipolar Transistors are "CURRENT" Amplifying or current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing current applied to their base terminal. The principle of operation of the two transistor types NPN and PNP, is exactly the same, the only difference being in the biasing (base current) and the polarity of the power supply for each type.





The symbols for both the NPN and PNP bipolar transistor are shown above along with the direction of conventional current flow. The direction of the arrow in the symbol shows current flow between the base and emitter terminal, pointing from the positive P-type region to the negative N-type region, exactly the same as for the standard diode symbol. For normal operation, the emitter-base junction is forward-biased and the collector-base junction is reverse-biased.

Transistor Configurations

There are three possible configurations possible when a transistor is connected in a circuit: (a) Common base, (b) Common emitter (c) Common collector. We will be focusing on the first two configurations in this experiment. The behavior of a transistor can be represented by DC current-voltage (V-I) curves, called the static characteristic curves of the device. The three important characteristics of a transistor are: (i) Input characteristics, (ii) Output characteristics and (iii) Transfer Characteristics. These characteristics give information about various transistor parameters, e.g. Input and output dynamic resistance, current amplification factors, etc.

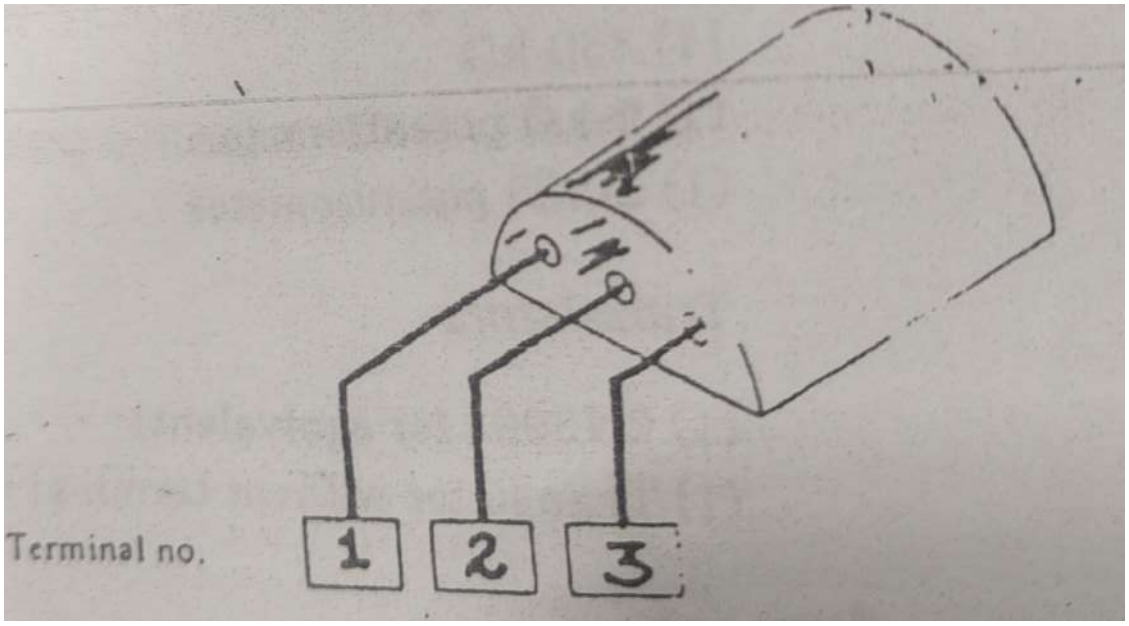
Common Emitter Configuration: When a transistor is used in common emitter configuration the input is fed between its base and emitter terminal and output is taken between the collector and emitter terminal as shown in fig.3.1 shows the circuit for determining the input and output characteristics of NPN transistor in common emitter configuration.

Procedure:

Part 1. Determination of the transistor's type, Terminal and Materials

The following procedure will determine the type of a transistor, the terminals of a transistor, and the material from which it is made. The procedure will utilize the diode testing found on many modern multimeters. If no such scale is available the resistance scales of the meter may be used.

a) Label the transistor terminals of the fig shown below. Use the transistor without terminal identification for this part of the experiment



Terminal ☐ ☐ ☐ identity

b) Set the selector switch of the multimeter to the diode scale and connect the positive lead of the meter to terminal 1 and negative lead to terminal 2; record your reading in table 8.1

Table 8.1

Meter leads Connected to BJT			Diode Check Reading
Sr. no.	**Positive**	**Negative**	
1	**1**	**2**	
2	**1**	**3**	
3	**2**	**1**	
4	**2**	**3**	
5	**3**	**1**	
6	**3**	**2**	

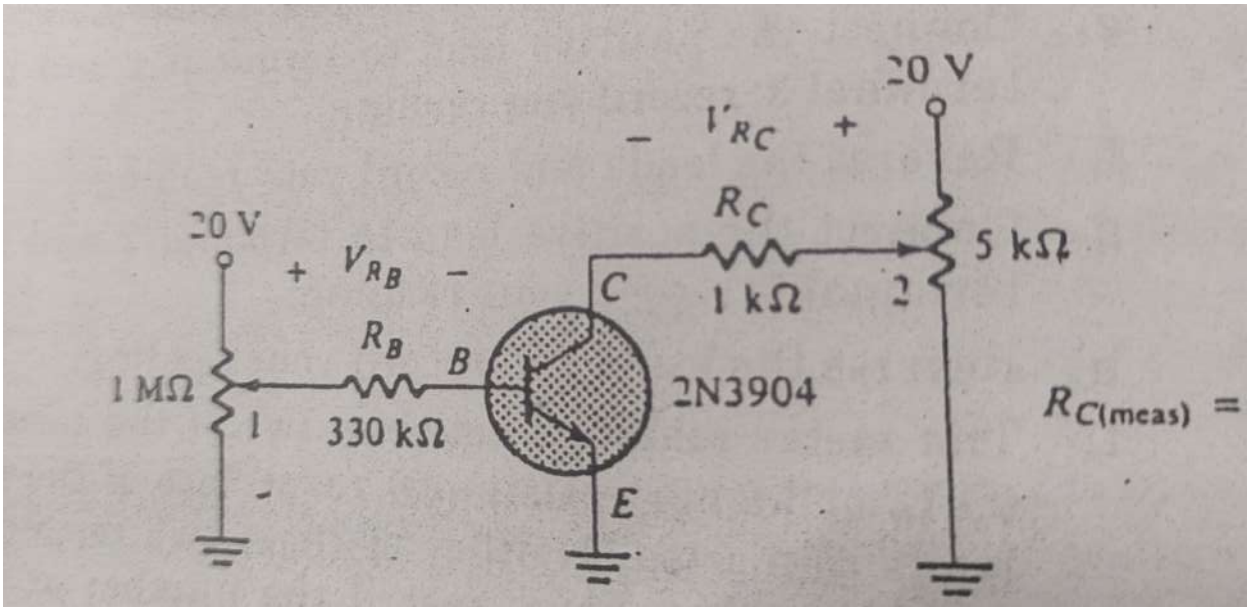
c) Based on the reading noted in table 8.1, record the number of the bas terminal in table 8.2

Table 8.2

Base Terminal	
Transistor Type	
Collector Terminal	
Emitter Terminal	
Transistor Material	

Part 2. The Collector Characteristics

a) Construct the network as shown below



b) Set the voltage V_{RB} to 3.3Vby varying the 1MΩ potentiometer, this adjustment will set $I_B = V_{RB}/R_B$ to 10uA as indicated in Table 8.3

c) Then set the VCE to 2V by varying the 5KΩ potentiometer as required by the first line of table 8.3. Record the values of voltages and current mentioned in table 8.3

d) Using the data of Table 8.3, plot the collector characteristics of the transistor on the

graph shown after table. That plot is I_C versus V_{CE} for the various values of I_B. Choose an appropriate scale.

Table 8.3

V_{RB} (meas)	I_B (calc)	V_{CE} (meas)	V_{RC} (meas)	I_C (calc)	V_{BE} (meas)	I_E (calc)	α (calc)	β (calc)
3.3V	10uA	2						
		4						
		6						
		8						
		10						
		12						
		14						
6.6V	20uA	2						
		4						
		6						
		8						
		10						
		12						
		14						
9.9V	30uA	2						

		4						
		6						
		8						
		10						
		12						
		14						

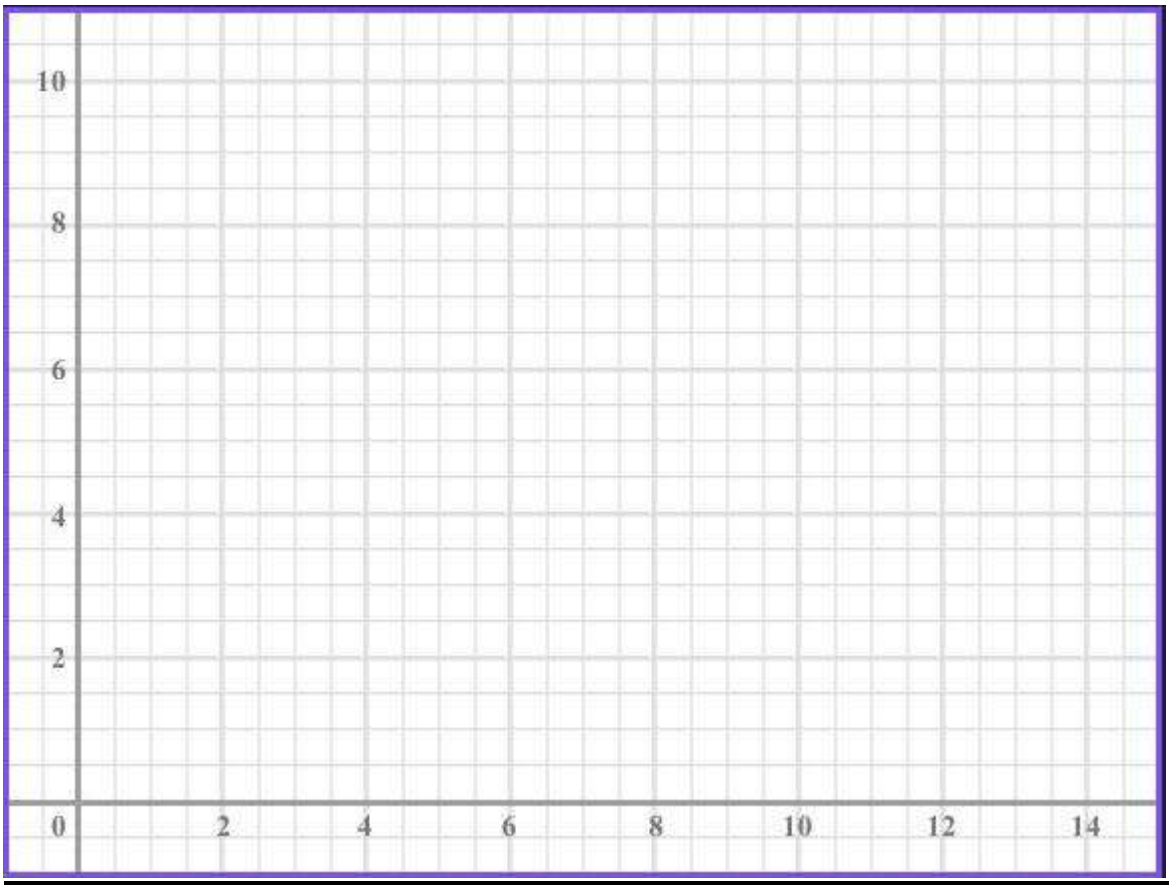


Figure 8.6 characteristics curve from experiment data

Lab Exercise and Summary

Summary should cover Introduction, Procedure, Data Analysis and Evaluation.

Student's Signature: _____ **Date:_____**

LABORATORY SKILLS ASSESMENT (Psychomotor)

Total Marks: 100

Criteria (Max Marks)	Level 1 0% ≤ S < 50%	Level 2 50% ≤ S< 70%	Level 3 70% ≤ S< 90%	Level 4 90%≤ S ≤100%	Score (S)
Procedural Awareness (20)	Selects inappropriate skills and/or strategies required by the task	Selects and applies appropriate skills and/or strategies required by the task with some errors	Selects and applies the appropriate strategies and/or skills specific to the task without significant errors	Selects and applies appropriate strategies and/or skills specific to the task without any error	
Practical Implementation (30)	Makes several critical errors in applying procedural knowledge related to DC analysis of Bipolar Junction Transistor	Makes few critical errors in applying procedural knowledge related to DC analysis of Bipolar Junction Transistor	Makes some non-critical errors in applying procedural knowledge related to DC analysis of Bipolar Junction Transistor	Applies the procedural knowledge in perfect ways related to DC analysis of Bipolar Junction Transistor	
Safety (10)	Requires constant reminders to follow safety procedures	Requires some reminders to follow safety procedures	Follows safety procedures with only minimal reminders	Routinely follows safety procedures	
Use of Tool/Equipment (20)	Uses tools, equipment and materials with limited competence	Uses tools, equipment and materials with some competence	Uses tools, equipment and materials with considerable competence	Uses tools, equipment and materials with a high degree of competence	
Participation to Achieve Group Goals (10)	Shows little commitment to group goals and fails to perform assigned roles	Demonstrates commitment to group goals, but has difficulty performing assigned roles	Demonstrates commitment to group goals and carries out assigned roles effectively	Actively helps to identify group goals and works effectively to meet them in all roles assumed	
Interpersonal Skills in Group Work (10)	Rarely interacts positively within a group, even with prompting	Interacts with other group members if prompted	Interacts with all group members spontaneously	Interacts positively with all group members and encourages such interaction in others	
				Marks Obtained	

Instructor's Signature: _____ **Date: _____**

LABORATORY SKILLS ASSESMENT (Affective)

Total Marks: 40

Criteria (Max. Marks)	Level 1 0% ≤ S < 50%	Level 2 50% ≤ S < 70%	Level 3 70% ≤ S < 90%	Level 4 90% ≤ S ≤ 100%	Score (S)
Introduction (5)	Very little background information provided or information is incorrect	Introduction is brief with some minor mistakes	Introduction is nearly complete, missing some minor points	Introduction complete and well-written; provides all necessary background principles for the experiment	
Procedure (5)	Many stages of the procedure are not entered on the lab report.	Many stages of the procedure are entered on the lab report.	The procedure could be more efficiently designed but most stages of the procedure are entered on the lab report.	The procedure is well designed and all stages of the procedure are entered on the lab report.	
Data Record (10)	Data is brief and missing significant pieces of information.	Data provides some significant information and has few critical mistakes.	Data is almost complete but has some minor mistakes.	Data is complete and relevant. Tables with units are provided. Graphs are labeled. All questions are answered correctly.	
Data Analysis (10)	Data is presented in very unclear manner. Error analysis is not included.	Data is presented in ways (charts, tables, graphs) that are not clear enough. Error analysis is included.	Data is presented in ways (charts, tables, graphs) that can be understood and interpreted. Error analysis is included.	Data are presented in ways (charts, tables, graphs) that best facilitate understanding and interpretation. Error analysis is included.	
Report Quality (10)	Report contains many errors.	Report is somewhat organized with some spelling or grammatical errors.	Report is well organized and cohesive but contains some grammatical errors.	Report is well organized and cohesive and contains no grammatical errors. Presentation seems polished.	
				Marks Obtained	

LABORATORY SKILLS ASSESSMENT (Cognitive)

Total Marks: 10

(If any) **Marks Obtained**	

Instructor's Signature: _____ **Date: _____**