North South University

Department of Electrical & Computer Engineering

LAB REPORT

Course Code : EEE111L

Course Title: Analog Electronics-1

Course Instructor: DMM

Experiment Number: 06

Experiment Name:

The input-output characteristics of CE (common emitter) configuration of BJT

Date of Experiment: 23rd of September, 2023

Date of Submission: 30th of September, 2023

Section: 11

Group Number: 05

Submitted By

Score

	Student Name	ID
1.	Afrin Akter	2112246642
2.	Joy Kumar Ghosh	2211424642
3.	Sazid Hasan	2211513642
4.	Sabrina Haque Tithi	2031265642
5.	Mahmudul Hasan	2011551043

Name of the Experiment: The input-output characteristics of CE (common emitter) configuration of BJT.

Objectives: Study of the input-output characteristics of CE (common emitter) configuration of BJT

Equipment & Components:

Serial	Component Details	Specification	Quantity
1	Transistor	BC 548	1 Piece
2	Resistor	$100 k\Omega$, $1 k\Omega$	1 piece each
3	Trainer Board		1 unit
4	DC Power Supply		1 unit
5	Digital Multimeter		1 unit
6	Chords & Wire		as required.

Theory: A resistor has three doped regions, namely Emitter, Base and Collector. In common emitter configuration, base is the input terminal, collector is the output terminal, and emitter is the common terminal for both input and output. That means the base terminal and common emitter are known as input terminals where as collector terminal and common emitter terminal are known as output terminals. The emitter terminal is grounded and it is regarded as the CE configuration. CE is the most widely used transistor.

The emitter is heavily doped so that it can eject free majority carrier to the base. The base being the most lightly doped, it passes the most of the emitter injected electron into the collector. When V_{BB} is greater than barrier potential, emitter electrons will also enter base region. So, the free electrons can follow either into the base or into the collector. There are three different current in a transistor namely emitor current (I_E), collector current (I_C) and the base current (I_B).

The Formula, $I_E = I_C + I_B$

$$\text{current gain} = \frac{I_C}{I_B}$$

→ The characteristics is measured by two characteristics after

a. Input characteristics

b. Output characteristics

→ ~~Out~~ Input characteristics Curve: It describes the relationship between the input current and input voltage or base-emitter voltage for the constant output voltage (V_{CE})

The input voltage V_{BE} is increased from Zero to different voltage.

→ Output characteristics : It describes the relationship between output current (I_c) and output voltage (V_{CE}).

- The input current is kept constant at 0 µA and the output voltage V_{CE} is cincreased from zero volts to different voltage levels.
- It has three regions namely Saturation, Action and cut off region
- The input current is increased from 0 µA to 20 µA by adjusting the output voltage. The input current is kept constant at 20 µA
- When the collector diode of the transistor before / reverse biased, the graph ~~becomes~~ becomes horizontal. This region is called active region.
- The base current being zero there is some collector current. This region of the transistor curve is known as the cut off region. The small current is called the collector cut off current.
- Different values of ~~IB~~ I_B creates individual curve.

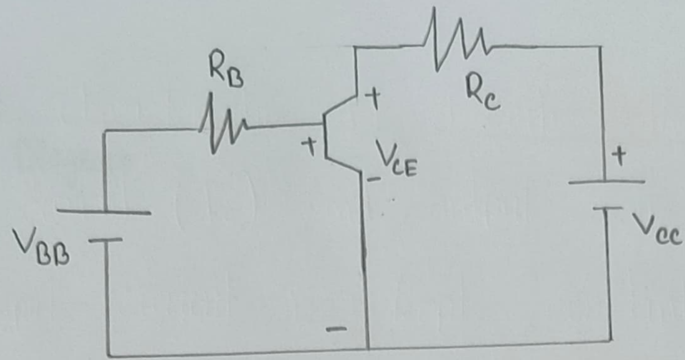


Figure: Biasing of a NPN transistor

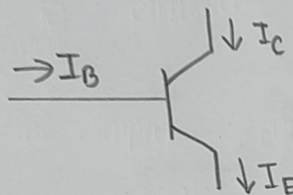


Figure: Different current in transistor

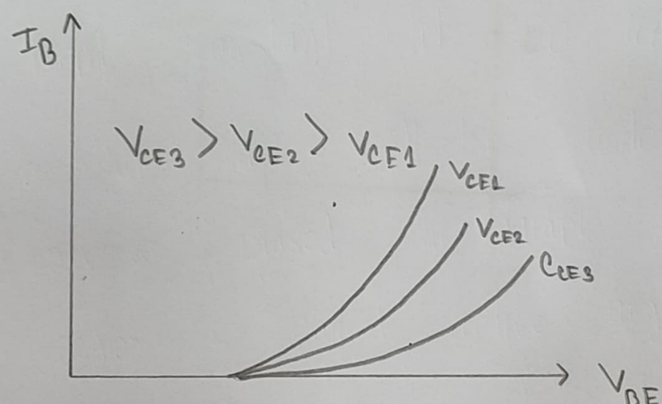


Figure: Input Characteristics

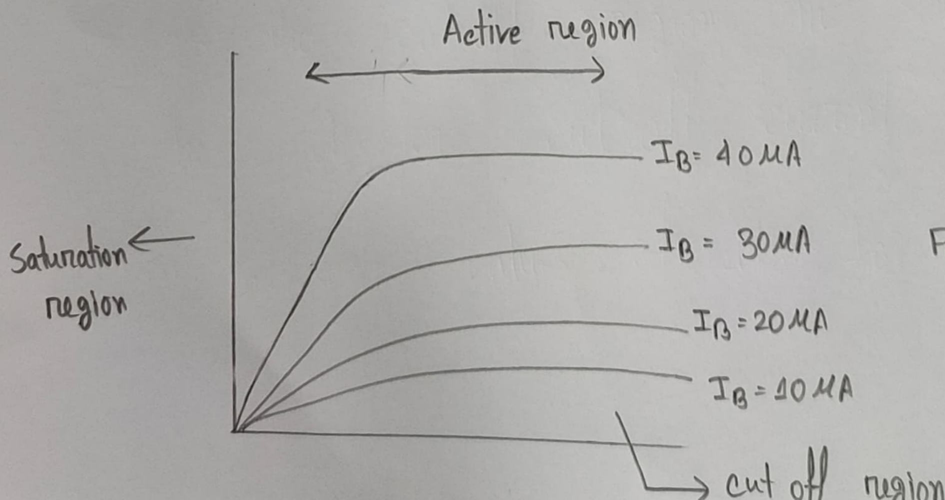
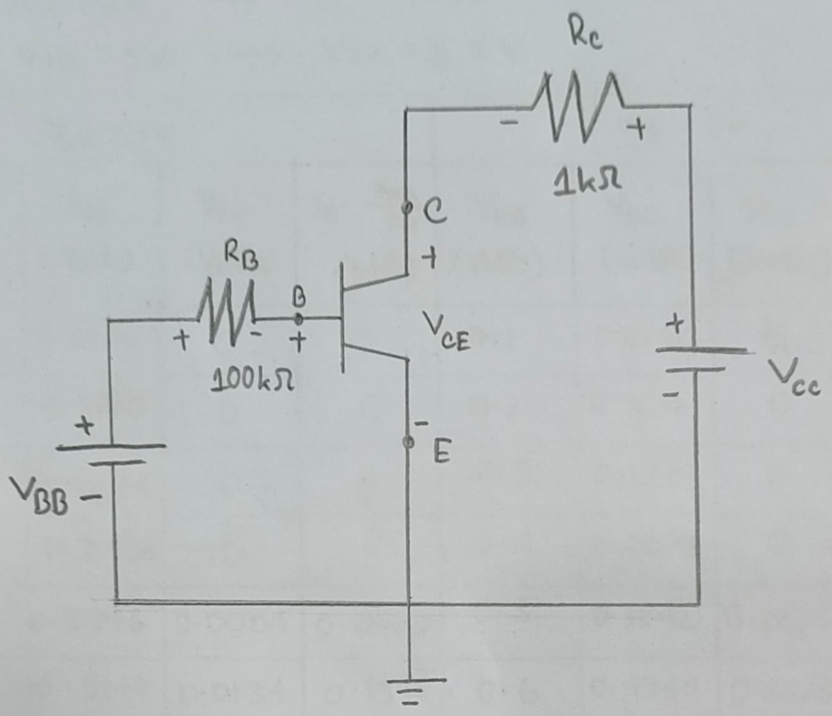


Figure: Output Characteristics

Circuit Diagram



Data Table

$R_B = 100.2\,K\Omega$
$R_C = 1.03\,K\Omega$

Table -1

When, $V_{CE} = 2V \longrightarrow V_{CC} = 1.9V$
When, $V_{CE} = 5V \longrightarrow V_{CC} = 5.0V$

$V_{CE} = 2V$				$V_{CE} = 5V$			
V_{BB} (Volts)	V_{BE} (Volts)	V_{RB} (Volts)	$I_B = \frac{V_{RB}}{R_B}$ (μA)	V_{BB} (Volts)	V_{BE} (Volts)	V_{RB} (Volts)	$I_B = \frac{I_{RB}}{R_B}$ (μA)
0.1	0.0106	0	0	0.1	0.0235	0	0
0.2	0.1770	0	0	0.2	0.9610	0	0
0.3	0.1894	0	0	0.3	0.2377	0	0
0.4	0.3496	0	0	0.4	0.2893	0	0
0.5	0.3996	0.0004	0.0040	0.5	0.3842	0.0185	0.1846
0.6	0.5140	0.0134	0.1340	0.6	0.4940	0.0600	0.5988
0.7	0.5770	0.0862	0.8618	0.7	0.5600	0.1243	1.2405
0.8	0.5920	0.1331	1.3307	0.8	0.5870	0.2430	2.4251
0.9	0.6130	0.2560	2.5595	0.9	0.6110	0.2852	2.8630
1.0	0.6160	0.2924	2.9234	1.0	0.6330	0.5490	5.4790
1.2	0.6310	0.9370	9.3681	1.2	0.6663	0.6780	6.7665
1.4	0.6410	0.9980	9.9780	1.4	0.6840	0.8820	8.8024
1.6	0.6430	1.1090	11.0878	1.6	0.6950	1.0590	10.5790
1.8	0.6460	1.3470	13.4673	1.8	0.6980	1.2960	12.9341
2.0	0.6480	1.5350	15.3469	2.0	0.6930	2.2440	22.3952
3.0	0.6510	2.3290	23.2853	3.0	0.6980	3.3150	22.3952
4.0	0.6560	3.2950	32.9434	4.0	~~0.7110~~ 0.6930	4.3700	33.0838
5.0	0.6560	4.3500	43.4913	5.0	0.7110	4.3700	43.6127

Table-2

when $V_{RB} = 2V \longrightarrow V_{BB} = 2.6V$

when $V_{RB} = 5V \longrightarrow V_{BB} = 5.6V$

$I_B = 20\mu A$				$I_B = 50\mu A$			
V_{CC} (volts)	V_{CE} (Volts)	V_{RC} (volts)	$I_C = \frac{V_{RC}}{R_C}$ (mA)	V_{CC} (Volts)	V_{CE} (Volts)	V_{RC} (Volts)	$I_C = \frac{V_{RC}}{R_C}$ (mA)
0.1	0.0037	0.0172	0.0167	0.1	0.0070	0.0409	0.0397
0.2	0.0994	0.0752	0.0730	0.2	0.0103	0.1103	0.1070
0.3	0.0340	0.1945	0.1688	0.3	0.0174	0.1619	0.1571
0.4	0.0438	0.3160	0.3067	0.4	0.0238	0.2679	0.2600
0.5	0.0510	0.3480	0.3370	0.5	0.0285	0.3964	0.3848
0.6	0.1012	0.4440	0.4310	0.6	0.0321	0.4680	0.4543
0.7	0.1223	0.5700	0.5530	0.7	0.0357	0.6160	0.5980
0.8	0.0649	0.6280	0.6097	0.8	0.0385	0.6510	0.6320
0.9	~~0.0691~~ 0.0658	0.7560	0.7339	0.9	0.0417	0.7970	0.7737
1.0	~~0.0756~~ 0.0691	0.8270	0.8029	1.0	0.0446	0.9210	0.8941
1.2	~~0.0825~~ 0.0756	1.0800	1.0485	1.2	0.0495	1.0970	1.0650
1.5	~~0.0975~~ 0.0825	1.3190	1.2805	1.5	0.0564	1.3780	1.3378
2.0	~~0.1094~~ 0.0975	1.7920	1.7398	2.0	0.0654	1.8770	1.8223
2.5	~~0.1193~~ 0.1094	~~2.805~~ 2.3320	2.1640	2.5	0.0729	2.3250	2.2570
3.0	~~0.1891~~ 0.1193	2.8050	2.7233	3.0	0.0790	2.8750	2.7864
5.0	~~4.4800~~ 0.1891	4.7900	4.6504	5.0	0.1034	4.7800	4.6407
10.0	~~9.3100~~ 4.4800	5.4000	5.2427	10.0	0.1761	9.6500	9.3689
15.0	~~14~~ 9.3100	5.6300	5.4660	15.0	4.8300	10.2300	9.9320
20.0	14.0900	5.8600	5.6893	20.0	9.8200	11.1800	10.8543
				23.0	10.7500	11.9000	10.1592
				26.0	12.9870	12.3600	10.3252
				30.0	13.7580	16.6500	10.6720

Answer to the ques no : 3

When $I_B = 50\ \mu A$

$I_C = 10\ mA$

$$\therefore \beta = \frac{I_C}{I_B} = \frac{10}{50} = 0.2$$

When $I_B = 20\ \mu A$

$I_C = 5.68\ mA$

$$\therefore \beta = \frac{I_C}{I_B} = \frac{5.68}{20} = 0.284$$

Answer to the ques no:4

From graph of I_c Vs V_{CE}

$$V_{cc} = V_{CE} = 15\,V$$

At saturation region

$$I_c\,(sat) = \frac{V_{cc}}{R_c}$$

$$= \frac{15}{1\,k\Omega}$$

$$= 15\,mA$$

$$\therefore V_{CE} = 0\,V$$

At cut of region

$$V_{CE}\,(\text{cut off}) = V_{cc} = 15\,V$$

$$I_c = 0\,mA$$

From graph we draw the load line and obtain Q point at (14.09, 5.68)

(5, 10)

Discussion:

In this experiment, we have observed the input-output characteristics of common emitter configuration of BJT. We start by buiding the circuit given on the manual, where we use two resistors of resistance $R_B = 100\ k\Omega$ and $R_C = 1\ k\Omega$. Initially, we set V_{BB} to 0V and then vary V_{cc} until V_{CE} becomes 2V. We kept checking V_{CE} using a DMM to check if it was close to 2V. After doing this, we vary V_{BB} from 0.1 V to 5V and record V_{BE} and V_{RB} where V_{BE} is the voltage accross the base and emitter and V_{RB} is the voltage accross the resistor R_B. We repeat the same steps for $V_{CE} = 5V$ where we set V_{BB} to 0V and then make V_{CE} 5V and then take the readings of V_{BE} and V_{RB}. For both V_{CE}, we calculate I_B by dividing V_{RB}/R_B. In this way, we obtain all the data for the input characteristics of BJT.

For the output characteristics of BJT, we use the same circuit as before. However, we now set the V_{cc} to 0V and in order to achieve $I_B = 20\,\mu A$, we vary V_{BB} until V_{RB} becomes 2V. After doing this, we vary V_{cc} from 01 V to 20V and record the corresponding V_{CE} and V_{Re} and calculate I_c by dividing V_{RC}/R_c where, V_{CE} is the voltage accross collector and emitter and V_{Rc} is the resistance across the resistor R_c. We follow the same steps for $I_B = 50\,\mu A$

During the measurement of table-2 when $I_B = 20\,\mu A$, we had faced some problems. DMM was not giving stable output. Then we rechecked the circuit, and found that, for continuous measurement, some pins of the breadboard got damaged. Then we re-construct the circuit and started to measure again. This time we didn't face any problems. DMM was working fine. Hence, we complete our experiment successfully.

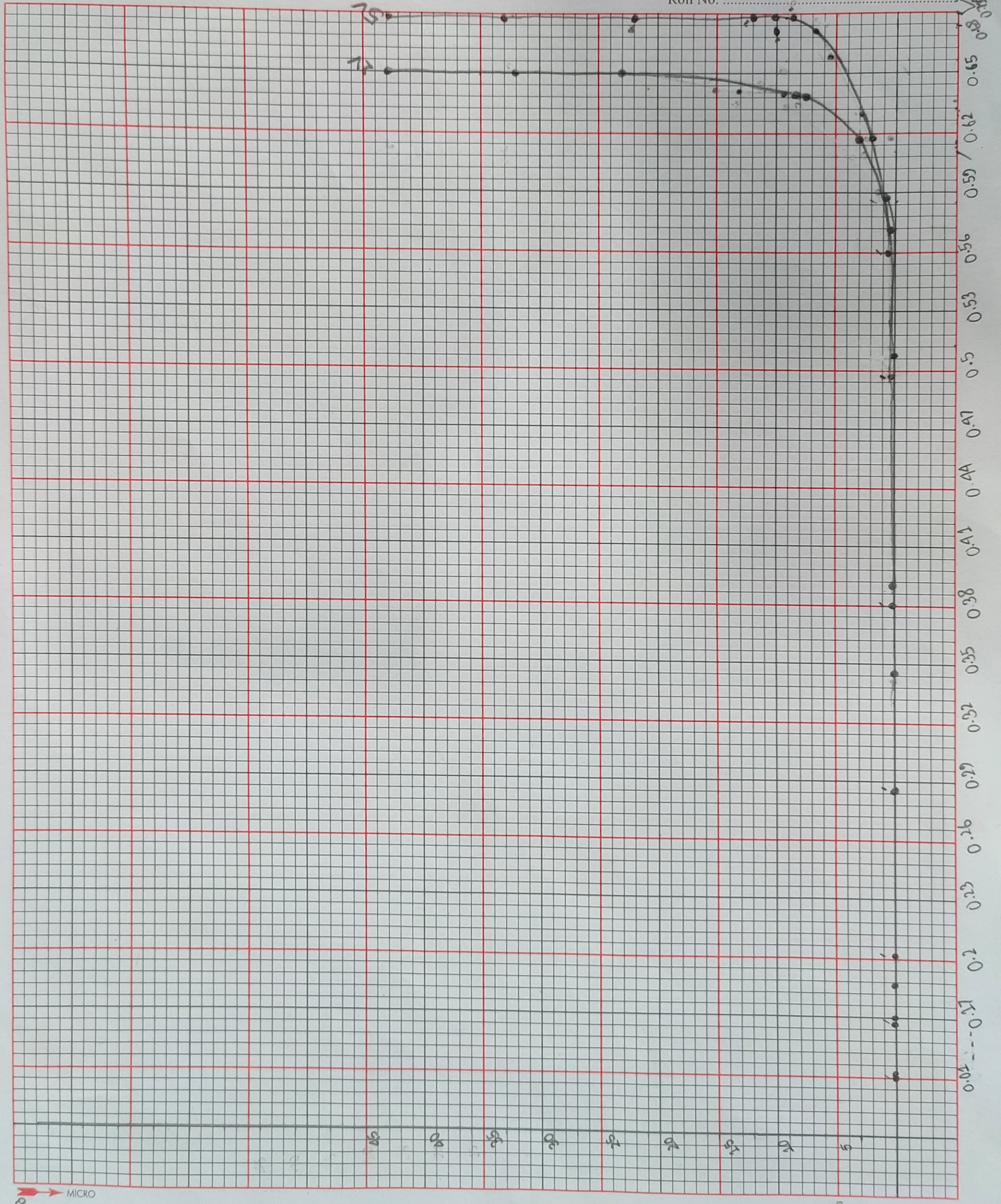
Table of Contribution

No.	Name	ID	Contribution
01	Afrin Akter	2112246642	Took the measurement of table-1 when the $V_{CE}=2V$, Report writing, Graph plotting, Simulation.
02	Sazid Hasan	2211513642	Took the measurement of table-1 when $V_{CE}=5V$, Built the circuit
03	Joy Kumar Ghosh	2211424642	Took the measurement of table-2 when $I_B = 20\ \mu A$, monitoring all the process, Operating the dc power supply, I_B Calculation.
04	Sabrina Haque Tithi	2031265642	Took the measurement of table-2 when $I_B = 50\ \mu A$, monitoring process, I_C calculation
05	Mahmudul Hasan	2011551043	—

Attachment:

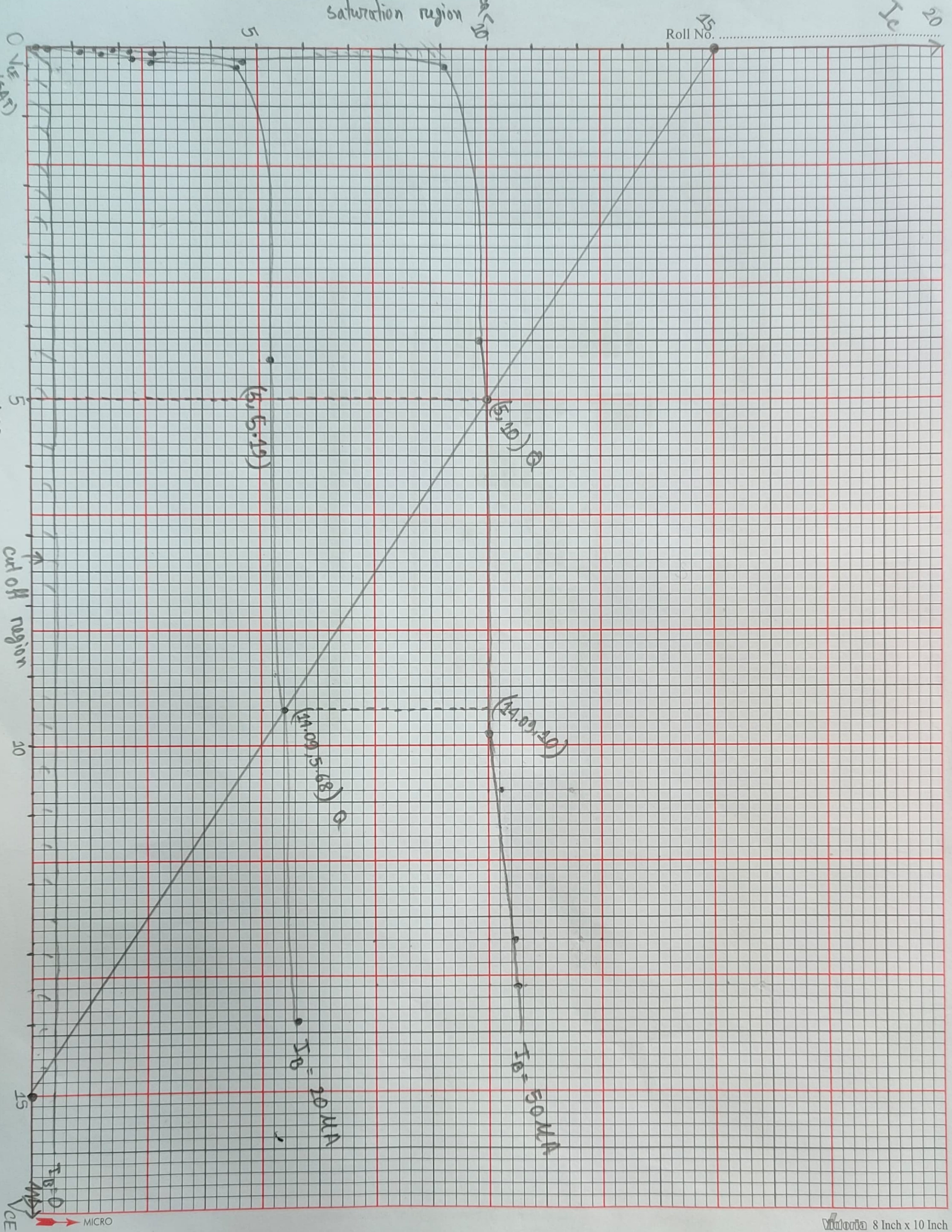
1. Simulation
2. Graph
3. Data Sheet.

Roll No. ....



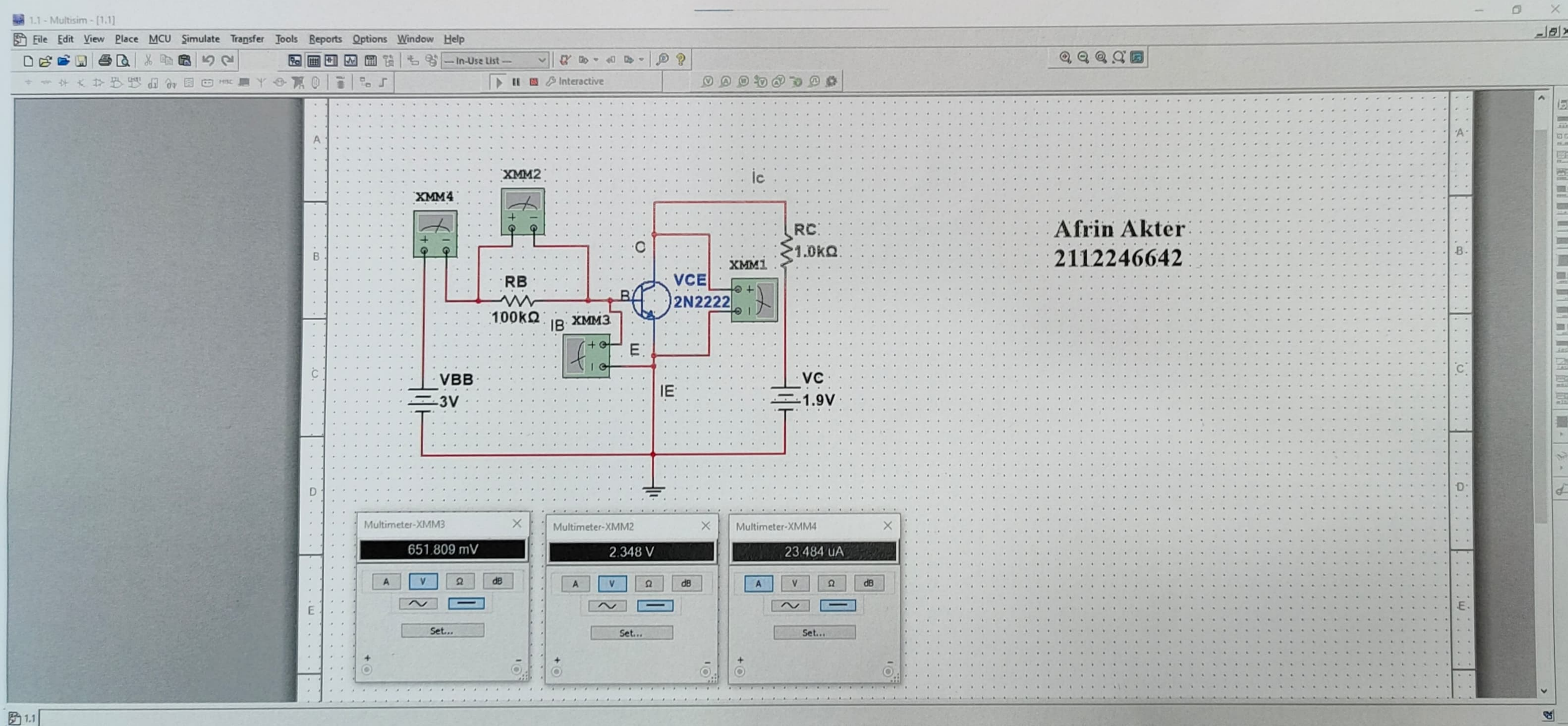
Violia 8 Inch x 10 Inch

Roll No. ....

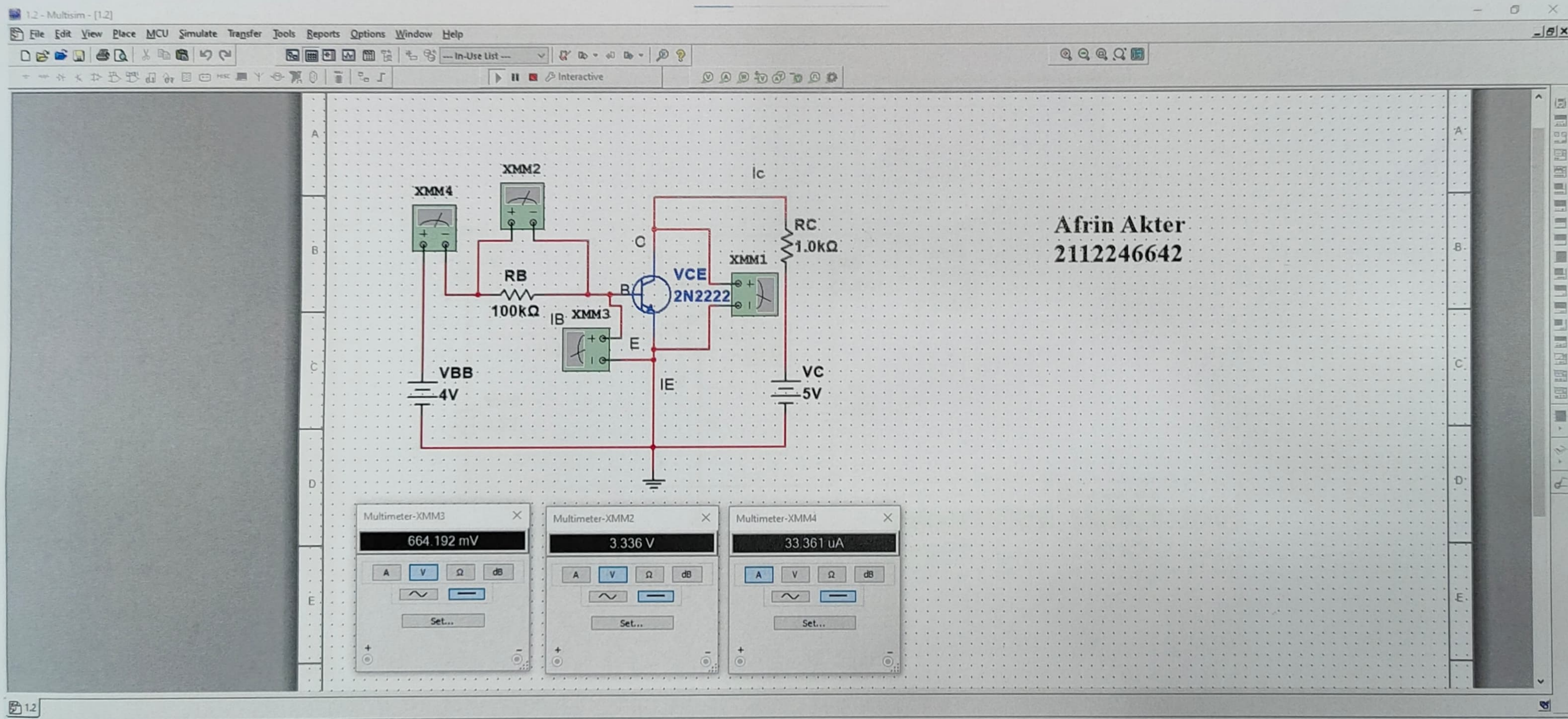


MICRO

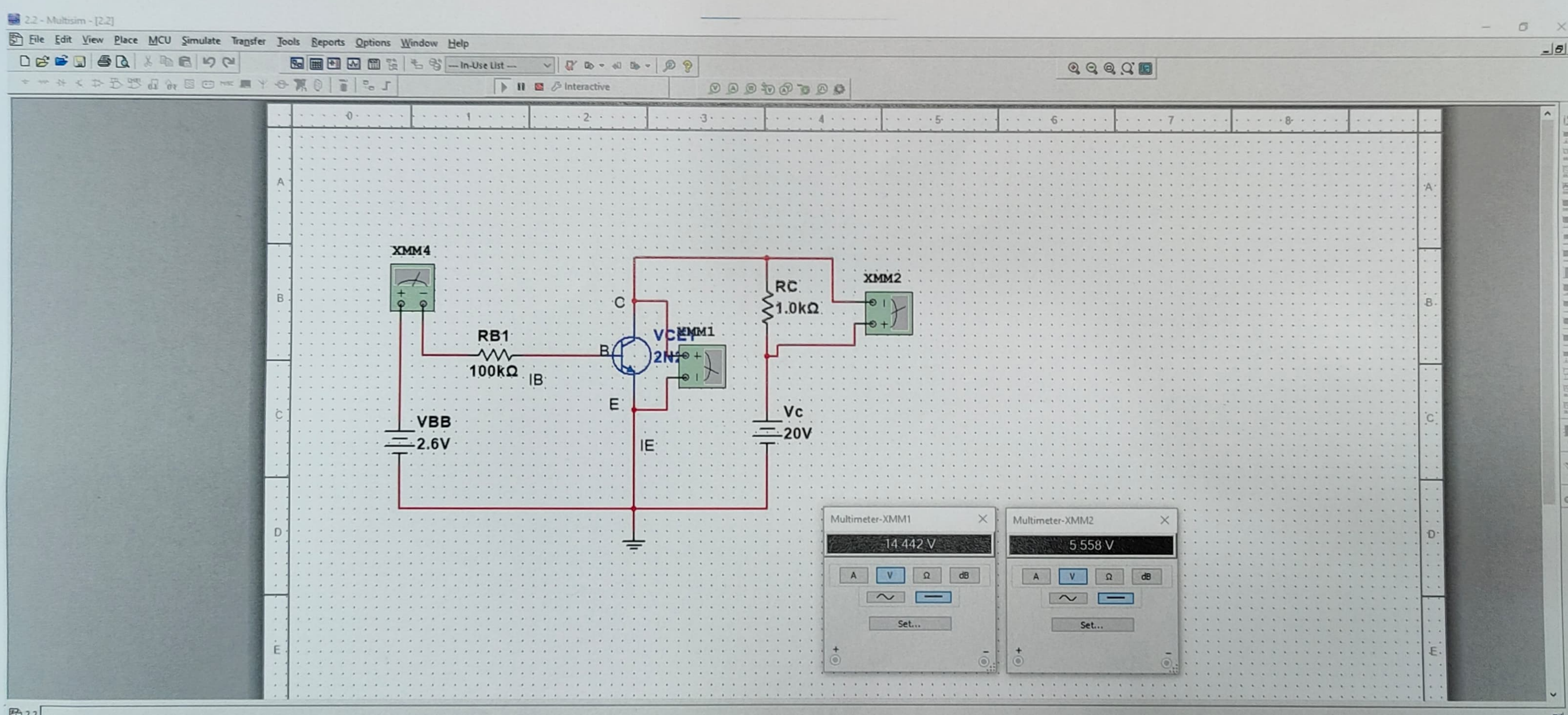
Victoria 8 Inch x 10 Inch

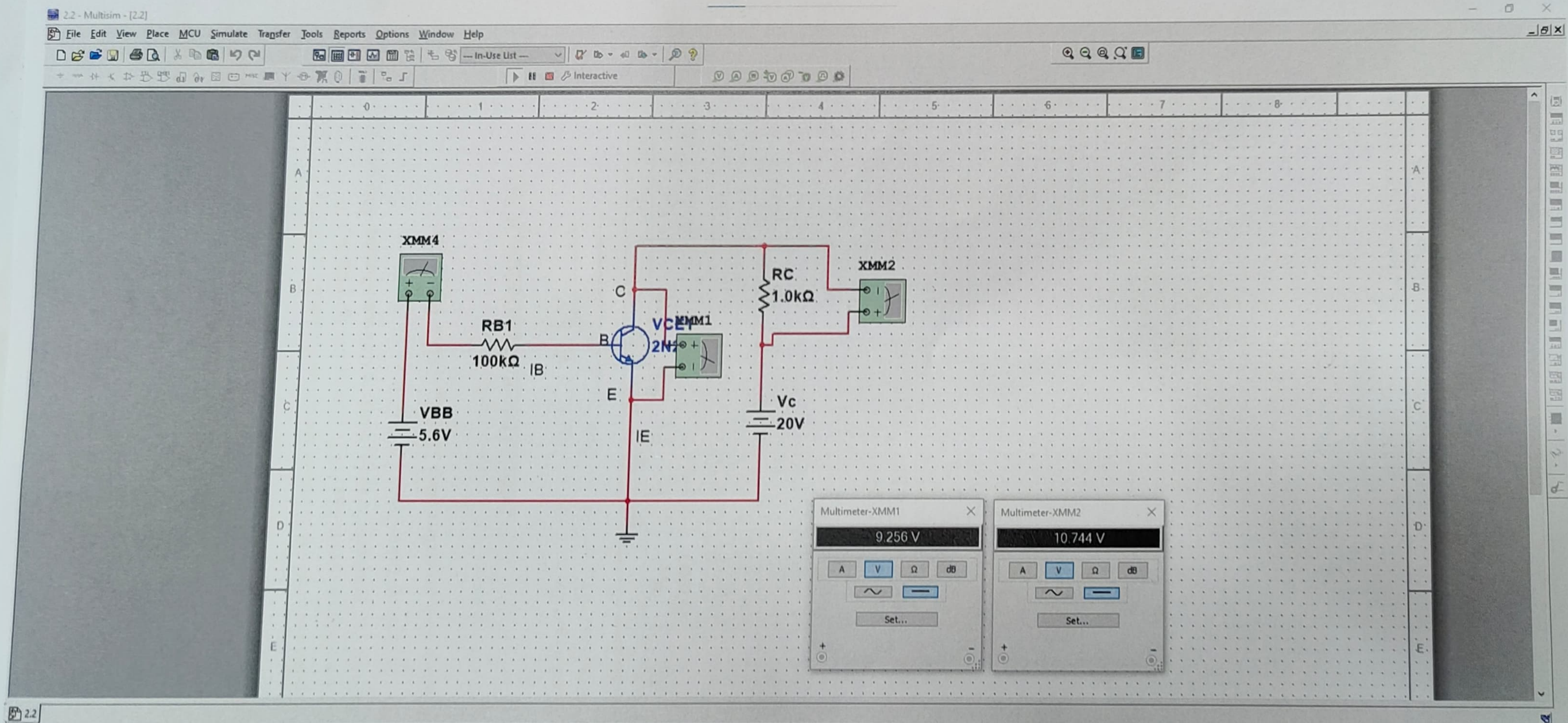


1.1 - Multisim - [1.1]
File Edit View Place MCU Simulate Transfer Tools Reports Options Window Help
--- In-Use List ---
Interactive
XMM4
XMM2
Ic
RC
1.0kΩ
C
RB
100kΩ
B
VCE
2N2222
XMM1
IB
XMM3
E
VBB
3V
IE
VC
1.9V
Afrin Akter
2112246642
Multimeter-XMM3
651.809 mV
Multimeter-XMM2
2.348 V
Multimeter-XMM4
23.484 uA
Set...



1.2 - Multisim - [1.2]
File Edit View Place MCU Simulate Transfer Tools Reports Options Window Help
--- In-Use List ---
Interactive
XMM4
XMM2
Ic
RC
1.0kΩ
C
RB
100kΩ
B
VCE
2N2222
XMM1
IB
XMM3
E
VBB
4V
IE
VC
5V
Afrin Akter
2112246642
Multimeter-XMM3
664.192 mV
Multimeter-XMM2
3.336 V
Multimeter-XMM4
33.361 uA
Set...


2.2 - Multisim - [2.2]
File Edit View Place MCU Simulate Transfer Tools Reports Options Window Help
--- In-Use List ---
Interactive
XMM4
RB1
100kΩ
IB
C
B
E
IE
VCE
XMM1
RC
1.0kΩ
XMM2
VBB
2.6V
Vc
20V
Multimeter-XMM1
14.442 V
A V Ω dB
Set...
Multimeter-XMM2
5.558 V
A V Ω dB
Set...
2.2



2.2 - Multisim - [2.2]
File Edit View Place MCU Simulate Transfer Tools Reports Options Window Help
XMM4
RB1
100kΩ
IB
B
C
E
IE
VCE
XMM1
RC
1.0kΩ
XMM2
VBB
5.6V
Vc
20V
Multimeter-XMM1
9.256 V
Multimeter-XMM2
10.744 V
Set...

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Output Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. By varying $\mathbf{V_{BB}}$, make $\mathbf{V_{RB}} = 2V$. This makes $\mathbf{I_B} = 20\mu A$.
3. Varying $\mathbf{V_{CC}}$ gradually in steps, measure Collector-Emitter Voltage, $\mathbf{V_{CE}}$ and $\mathbf{V_{RC}}$. Calculate $\mathbf{I_C} = \frac{V_{RC}}{R_C}$. Fill up Table-2.
4. Repeat above procedure (step 3) for $\mathbf{I_B} = 50\mu A$ [$V_{RB} = 5V$]

2.03

Table 2: Output Characteristics of BJT

- When $V_{RB} = 2V$ → V_{BB} = 2.6V
- When $V_{RB} = 5V$ → V_{BB} = 5.6V

	$I_B = 20\mu A$				$I_B = 50\mu A$		
V_{CC}	V_{CE} (Volts)	V_{RC} (Volts)	$I_C = \frac{V_{RC}}{RC}$ (Amp)	V_{CC}	V_{CE} (Volts)	V_{RC} (Volts)	$I_C = \frac{V_{RC}}{RC}$ (Amp)
0.1	0.0037V	0.0172	0.0167 mA	0.1	0.0070	0.0409	0.0397 mA
0.2	0.0924V	0.0752	0.0730 mA	0.2	0.0103	0.9103	0.1070 mA
0.3	0.0340V	0.19451	0.1888 mA	0.3	0.0174	0.1619	0.1571 mA
0.4	0.0438V	0.3160	0.3067 mA	0.4	0.02380	0.2679	0.2600 mA
0.5	0.0510V	0.3480	0.3370 mA	0.5	0.0285	0.3964	0.3848 mA
0.6	0.1012V	0.4440	0.4310 mA	0.6	0.0321	0.4680	0.4543 mA
0.7	0.1223	0.5700	0.5530 mA	0.7	0.0357	0.6160	0.5980 mA
0.8	0.0649	0.6289	0.6097 mA	0.8	0.0385	0.6510	0.6320 mA
0.9	0.0658	0.7560	0.7339 mA	0.9	0.0417	0.7970	0.7737 mA
1.0	0.0691	0.8270	0.8029 mA	1.0	0.0446	0.9210	0.8941 mA
1.2	0.0756	1.0800	1.04850 mA	1.2	0.0495	9.0970	1.0650 mA
1.5	0.0825	1.3190	1.2805 mA	1.5	0.0564	1.3780	1.3378 mA
2.0	0.0975	1.7920	1.7398 mA	2.0	0.0654	1.8770	1.8223 mA
2.5	0.1094	2.3320	2.1640 mA	2.5	0.0729	2.3250	2.2570 mA
3.0	0.1193	2.8050	2.7233 mA	3.0	0.0790	2.8750	2.7864 mA
5.0	0.1891	4.7900	4.6504 mA	5.0	0.1034	4.7800	4.6407 mA
10.0	4.4800	5.4000	5.2427 mA	10.0	0.1761	9.6500	9.3689 mA
15.0	9.3100	5.6300	5.4660 mA	15.0	4.8300	10.2300	9.9320 mA
20.0	14.0900	5.8600	5.6893 mA	20.0	09.8200	11.1800	10.8543 mA
				23.0	10.7500	11.9000	10.1592 mA
				26.0	12.9870	12.3600	10.3252 mA
				30.0	13.5780	16.6500	10.6720 mA

Report:

1. Plot $\mathbf{I_B}$ vs. V_{BE} for different values of $\mathbf{V_{CE}}$.
2. Plot $\mathbf{I_C}$ vs V_{CE} for different values of $\mathbf{I_B}$. Show different regions of operations.
3. Find β for the each $\mathbf{I_B}$ [for active region only]
4. For V_{cc}= 15V, draw the load line and write the coordinates of the Q-point.

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DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Data Collection:

Signature of instructor: Riddiana

23.09.23

Experiment: 6,
Performed by Group# ______

- R_B = 100.2 kΩ
- R_C = 1.03 kΩ

Input Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. By varying V_{CC}, make $\mathbf{V_{CE}} = 2$V.
3. Varying $\mathbf{V_{BB}}$ gradually, measure $\mathbf{V_{RB}}$ and base-emitter voltage $\mathbf{V_{BE}}$.
4. Calculate $\mathbf{I_B} = \frac{V_{RB}}{R_B}$. Complete Table 1.
5. Step size is not fixed because of non-linear curve. Initially vary $\mathbf{V_{BB}}$ in steps of 0.1V.
6. Repeat above procedure (step 3) for $\mathbf{V_{CE}} = 5$V.

Table 1: Input Characteristics of BJT

- When $V_{CE} = 2$V → V_{CC} = 1.9V
- When $V_{CE} = 5$V → V_{CC} = 5.0V

$V_{CE} = 2$ V				$V_{CE} = 5$V			
V_{BB} (Volts)	V_{BE} (Volts)	V_{RB} (Volts)	$I_B = \frac{V_{RB}}{R_B}$ (µA)	V_{BB} (Volts)	V_{BE} (Volts)	V_{RB} (Volts)	$I_B = \frac{V_{RB}}{R_B}$ (µA)
0.1	0.0106V	0V	0µA	0.1	0.0235V	0V	0
0.2	0.177V	0V	0µA	0.2	0.9610V	0V	0
0.3	0.1894V	0V	0µA	0.3	0.2377V	0V	0
0.4	0.3496V	0V	0µA	0.4	0.2893V	0V	0
0.5	0.3996V	0.0004V	0.0040	0.5	0.3842V	0V	0
0.6	0.5140V	0.0134V	0.1340	0.6	0.4940V	0.0185V	0.1846
0.7	0.5770V	0.0862V	0.8618	0.7	0.5600V	0.0600V	0.5988
0.8	0.5920V	0.1331V	1.3307	0.8	0.5870V	0.1243V	1.2405
0.9	0.6130V	0.2560V	2.5595	0.9	0.6110V	0.2430V	2.4251
1.0	0.6160V	0.2924V	2.9234	1.0	0.6330V	0.2852V	2.8630
1.2	0.6310V	0.9370V	9.3681	1.2	0.6663V	0.5490V	5.4790
1.4	0.6410V	0.9980V	9.0878	1.4	0.6840V	0.6780V	6.7665
1.6	0.6430V	1.1090V	9.9780	1.6	0.6950V	0.8820V	8.8024
1.8	0.6460V	1.3470V	13.4673	1.8	0.6980V	1.0540V	10.5190
2.0	0.6480V	1.5350V	15.3469	2.0	0.6930V	1.2960V	12.9341
3.0	0.6510V	2.3290V	23.2853	3.0	0.6980V	2.2440V	22.3952
4.0	0.6560V	3.2950V	32.9434	4.0	0.6930V	3.3150V	33.0838
5.0	0.6560V	4.3500V	43.4913	5.0	0.6910V	4.3700V	43.6127

0.036