PH3244
Experiment - 2
BJT characteristics & applications

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(Dated: 13 February 2026)

Synopsis

In this experiment we try to see the characteristics of BJT-npn transistor.

CONTENTS

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I. THEORY AND PROCEDURE

A. Theory

BJT is a 3 layer semiconductor device consisting of 2 n and 1 p type layers (npn BJT with, 2 junctions n-p, p-n) or 2 p and 1 n type (pnp BJT with 2 junctions p-n, n-p) layers. Here we try to see the characteristics of the transistor in forward bias, the procedure is explained in the next section.

B. Procedure

To get the Collector-Base-Emmitor of the transistor, we connect the middle pin of transistor and measure the resistance to the other two ends. If it is an NPN transistor then the pin with significantly less resistance compared to other will be emmitor.

1. Input Characteristics

To test the input characteristics of the transistor:

1. Connect the components as shown in FIG - 1.
2. Measure a inital value of V_{CE}.
3. Take measurements of I_{B} and V_{BE}
4. Plot I_{B} and V_{BE} to get characteristics.

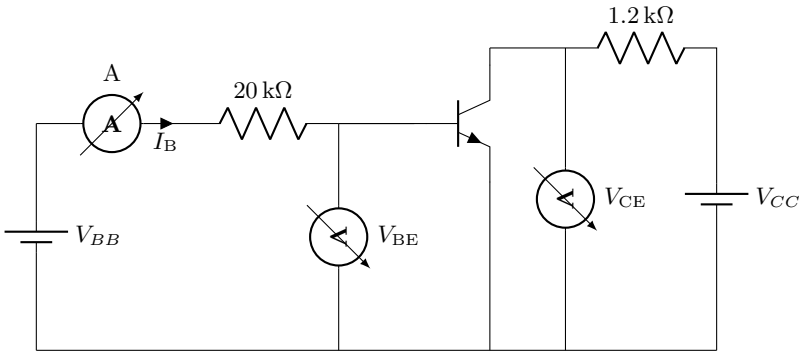

FIG. 1: Input Characterists

2. Output Characteristics

To test the output characteristics of the transistor:

1. Connect the components as shown in FIG - 2.
2. Fix a value of I_{B}.
3. Take measurements of I_{C} and V_{CE}
4. Plot I_{C} and V_{CE} to get characteristics.

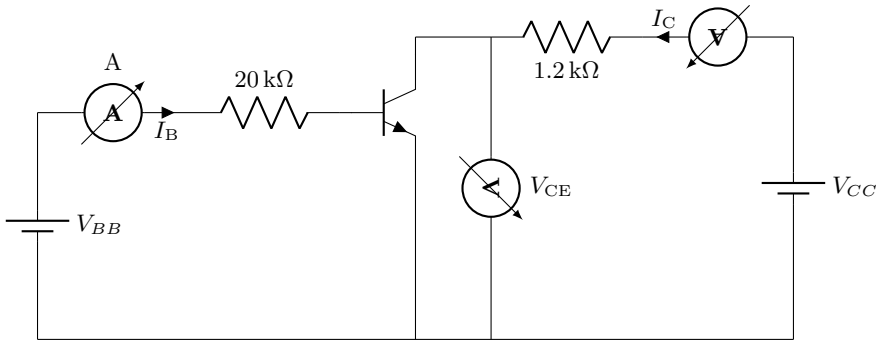

FIG. 2: Output Characterists

3. Phase Shift Ossiclator and Amplifier

Phase shift ossilator is constructed as shown in FIG - 3 where the C and R values are determined using [1].

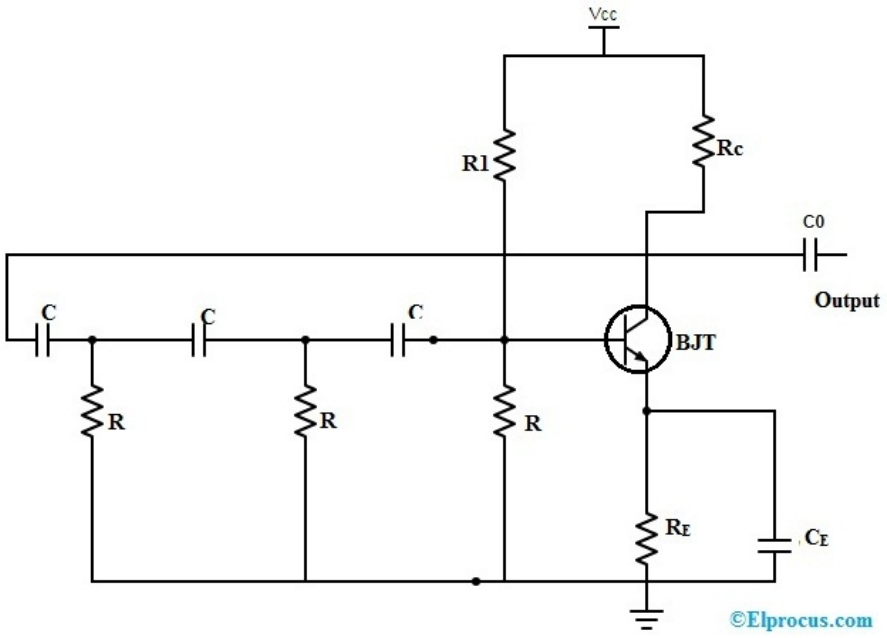

FIG. 3: Phase Shift Oscillator

II. OBSERVATION

A. Input Characteristics

TABLE I: For $V_{\text{CE}} = 1.00$ V

I_B (µA)	V_{BE} (mV)
0	3
0	280
0	441
5	632
10	663
15	672
30	675
50	677
80	679
120	683

I_B (µA)	V_{BE} (mV)
0	3
0	198
0	358
5	583
10	634
15	636
30	639
50	644
80	649
120	656
200	667

TABLE II: For $V_{\text{CE}} = 4.00$ V

TABLE III: For $V_{\text{CE}} = 10.00$ V

I_B (µA)	V_{BE} (mV)
0	3
0	335
0	553
5	636
10	661
15	672
30	696
50	701
80	704
120	706
200	710

Data taken on: 28th Jan 2025

1. least count of Ammeter: 5 μA
2. least count of Voltmeter (V_{CE}): 0.01 V
3. least count of Voltmeter (V_{BE}): 1 mV

B. Output Characteristics

1. least count of Ammeter (I_{C}): 10 μA
2. least count of Ammeter (I_{B}): 5 μA
3. least count of Voltmeter (V_{CE}): 1-10 mV depending on value.

TABLE IV: For $I_{\text{B}} = 80$ μA

V_{CE} (V)	I_C (mA)
0.004	0.00
0.057	2.05
0.106	7.13
0.177	13.84
0.327	17.01
0.529	18.73
0.823	20.32
1.191	20.95
1.958	21.80
3.205	23.09
5.66	25.96
9.68	29.76
16.76	34.46
22.65	38.19

V_{CE} (V)	I_C (mA)
0.005	0.00
0.058	1.24
0.134	7.19
0.208	10.25
0.405	11.04
0.606	12.29
0.844	12.38
1.134	12.44
2.231	12.67
3.262	12.94
4.86	13.54
7.32	14.05

TABLE V: For $I_{\text{B}} = 50$ μA

TABLE VI: For $I_B = 20$ μA

V_{CE} (V)	I_C (mA)
0.004	0.00
0.012	0.02
0.067	0.46
0.118	1.64
0.243	2.88
0.338	2.97
0.540	2.97
0.798	2.97
1.214	2.98
1.922	2.99
2.829	3.01
4.91	3.07
9.11	3.16
32.53	4.59

Data taken on: 28th Jan 2025

C. Comments

During the measurement of output characteristics, when I_{B} is above 20 mA, the values of V_{CE} and I_{C} decrease and increasre over time. Most values are taken immiditely after adjusting V_{CE}.

III. CALCULATIONS AND CHARACTERISTICS

A. Sources of Error

1. Systematic Errors

1. Heating of transistor.
2. Restance of wires, breadboard and other parts.

2. Random Errors

1. Uncertanity of values of resistance.
2. Uncertanity from least count.

B. Error Propogation

To calculate the standard deviation from least count, we use the formula [2]:

$$\sigma = \frac{\text{Least Count}}{\sqrt{12}}$$

from this we see that the variance is insignificant and hence while plotting graph isn't labeled with error bars, also the error due to heating and other errors are not taken into consideration and are assumed insignificant.

C. Input Characteristics

From Table - 1,2,3 we plot them for input characteristics. The error in data points is not taken into consideration due to least count as it is insignificant.

D. Output Characteristics

From Table - 4,5,6 we plot them for output characteristics. Here again the error in data points is not taken into consideration due to least count as it is insignificant. We plot the graph till only 10 V for V_{CE} as the characteristics after that is the same.

IV. RESULT AND CONCLUSION

From the graph of input characteristics we can say that the transistor turns on in the range of 0.6 V - 0.7 V, the graph looks exponential and the greater the V_{CE} the more the V_{BE} is required to turn it on.

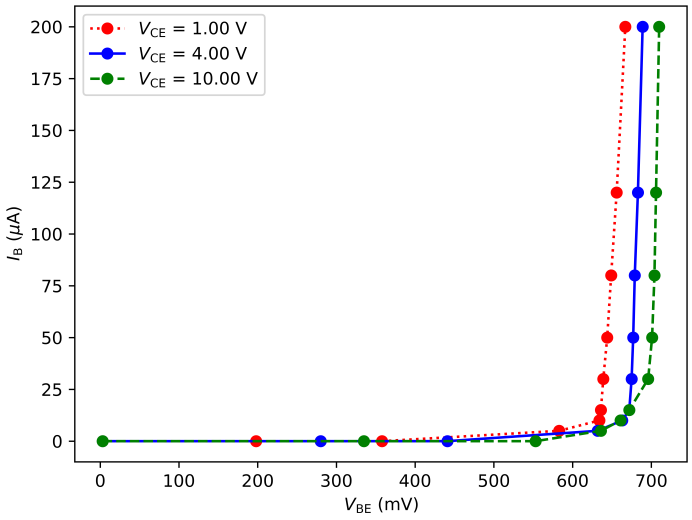

FIG. 4: Input characterists

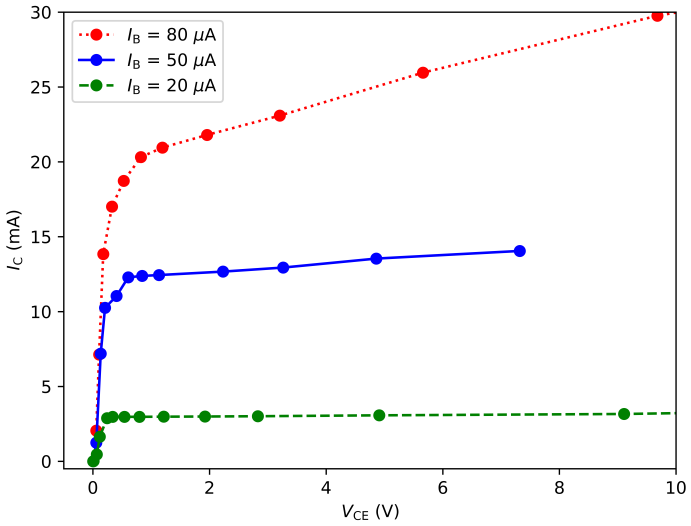

FIG. 5: Output Characterists

From the graph of output characteristics, we can see that after a certain voltage is reached the transistor characteristics beyond that point becomes linear and up unitl that point it increases very rapidly.

REFERENCES

Laughing Cat Meme, Github repository for ph3244, `https://github.com/LAUGHINGCATMEME/PH3244`, ac-

cessed: 2026-02-04.
[2] https://www.ilsi-india.org/International_Workshop_and_Training_Program_on_Good_Food_Laboratory_Practices/Measurement%20Uncertainty%20by%20Dr.%20G%20M%20Tewari,%20NABL%20Assessor.pdf

Appendix A: Comments on Phase Shift Ossilator

The Osiciloscope required to measure the frequency of phase shift ossilator was deemed faulty, hence no measurements/images of it is taken.