Experiment - 2

BJT Common Emitter Characteristics

Aim - To verify and find input and output characteristics of BJT Common emitter

Apparatus - BJT (BiPolar Junction Transistor), Resistor, connecting wires Ammeter (0-10mA, 0-100uA), DC power supply (0-30V), etc

(Site Link) - vlab.iitkgp.ernet.in/be/exp11/index.html#

Theory - A BJT is a single piece of Si with 2 back to back PN junction BJT's can be made either as PNP or NPN They have 3 regions and 3 terminals emitter, base and collector - E, B and C. When transistor is conducting normally, An easy way to remember is NPN stands for "Not Pointing IN"

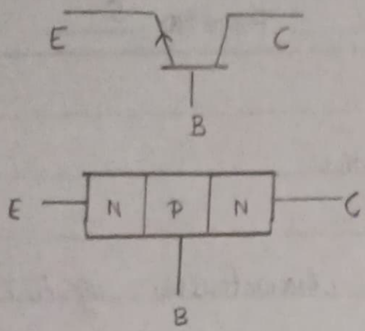
Regions -

- Cutoff region - Base emitter junc^n is reverse biased, no current
- Saturation region - Base emitter is forward biased and collection biased junc^n is forward biased.
- Active region - Base emitter junc^n is forward biased, collector base junction is reverse biased.

Breakdown region - I_c and V_{ce} exceed specifications and can cause damage to the transistor

Cutoff region - Both junctions are reverse biased $V_{BE} < 0$ (Base) and $V_{CB} > 0$ (with reverse biasing, all currents are zero

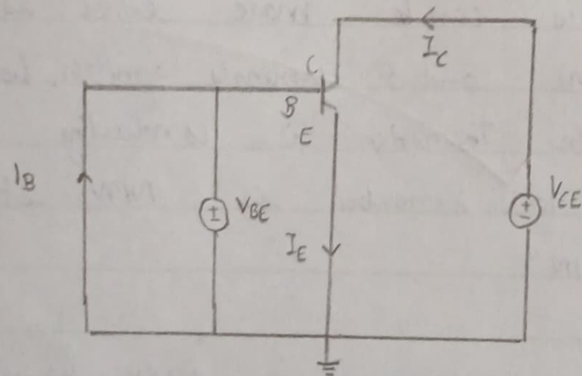
Structure of BJT



FOUR OPERATING CONDITIONS

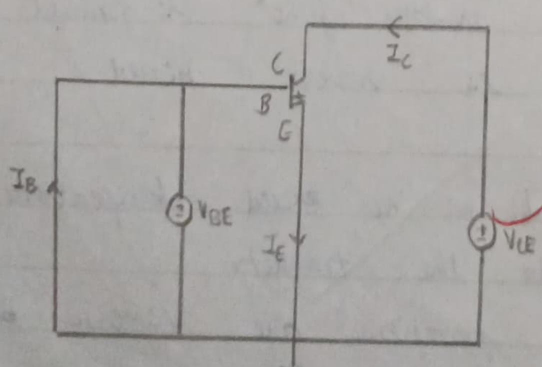
BC Junction \ BE Junction	Reverse	Forward
Reverse	Cut-off	Forward Active
Forward	Reverse Active	Saturation

→ INPUT CHARACTERISTICS CKT



$I_B = \phi(V_{BE}, V_{CE})$ for constant V_{CE}

→ OUTPUT CHARACTERISTICS CKT



$I_C = \phi(V_{CE}, I_B)$ for constant I_B

Forward Active region-

Base is fwd biased ($V_{BC} < 0$) and Collector is reverse biased ($V_{CB} < 0$). fwd bias will cause injection of both holes and e^- across the junction.

$$I_C = \alpha_F I_E + I_{CO}$$, α is forward current transfer ratio

I_{CO} → Collector reverse saturation current

Saturation region

Both junctions fwd biased, Base is $V_{BE} > 0$ and Collector-Base is $V_{CB} < 0$. Max current flow through transistor, only small voltage drop.

Reverse active region

Base-emitter is reverse biased ($V_{BE} < 0$) and collector base is fwd biased ($V_{CB} < 0$). Current gain is smaller.

~~Application- In digital~~ circuits and analog switching circuits.

$$I_E = -\alpha_R * I_C + I_{EO}$$

α_R → reverse current transfer ratio

I_{EO} → Emitter reverse saturation current

BJT - Common Emitter Circuit

↳ described as Ebers-Moll Model -

$$I_F = I_{ES} \times \left(\exp \frac{V_{BE}}{V_T} - 1\right)$$

$$I_R = I_{CS} \times \left(\exp \frac{V_{CB}}{V_T} - 1\right)$$

I_{ES} → base - emitter Saturation currents

I_{CS} → base - collector saturation currents

CLASSTIME

(A)

S.No	Base emitter Voltage (V)	Base current (μA)	Rh₁(Ω)
1	0.2	2.824	10
2	0.3	3.232	15
3	0.4	3.704	20
4	0.5	4.248	25
5	0.6	4.875	30
6	0.7	5.599	35
7	0.8	6.434	40
8	0.9	7.397	45
9	1	8.508	50
10	1.1	9.789	55
11	1.2	11.27	60
12	1.3	12.97	65
13	1.4	14.99	70
14	1.5	17.21	75
15	1.6	14.83	80

(a) $V_{CE} = 1V$
$Rh_2 = 10\Omega$

(const)
[$Rh_2 = 100\Omega$
CE voltage = 10V]

INPUT CHARACTERISTICS

(B)

S.No	Base emitter Voltage (V)	Base current (μA)	Rh₁ Ω
1	0.02000	2.077	10
2	0.08000	2.261	15
3	0.1400	2.462	20
4	0.2000	2.680	25
5	0.2600	2.918	30
6	0.3200	3.178	35
7	0.3800	3.461	40
8	0.4400	3.769	45
9	0.5000	4.104	50
10	0.5600	4.470	55

(b) $V_{CE} = 2V$
$Rh_2 = 20\Omega$

Experiment :

Date ______

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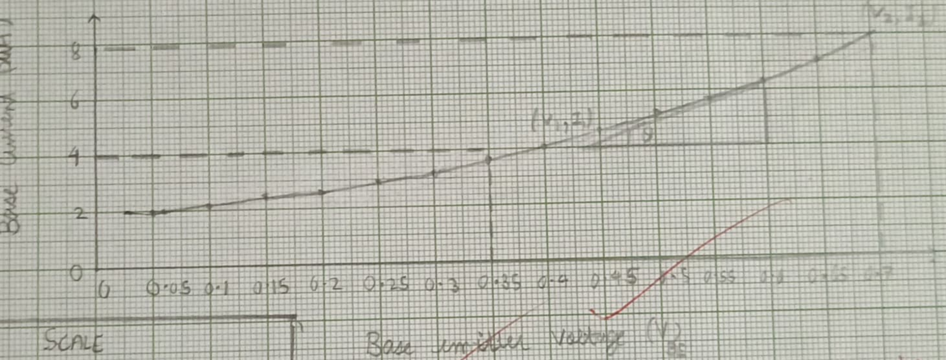
Precautions

1. Ensure proper connection and biasing.
2. Check polarity and avoid overheating
3. Calibrate instruments and avoid static discharge

Result-

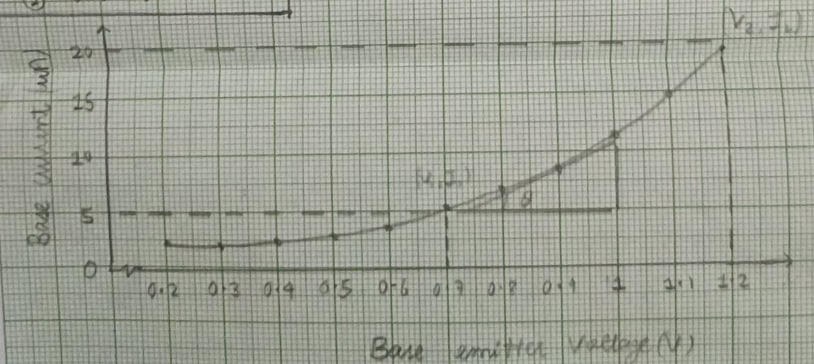
The characteristic behaviour of BJT in various regions such as active, saturation etc is shown. It may be helpful to design circuits involving BJT like- amplifiers and switches.

INPUT CHARACTERISTICS (V-I PLOT)



SCALE
Y-axis
Base current (µA)
① 1cm = 2 µA
X-axis
Base emitter Voltage (V_{BE})
② 1cm = 0.05 V

Y axis 1cm =



Slope = $\frac{V_2 - V_1}{I_2 - I_1}$ ⇒ $\frac{1}{0.0333}$

SCALE
Y-axis
Base current
① 1cm = 5 µA
X-Axis
Base emitter Voltage (V)
② 1cm = 0.1 cm

S.No	Output Emitter Voltage (V)	Collector Current (mA)	Rh_2 (Ω)
1	1	1750	10
2	1.5	2080	15
3	2	2215	20
4	2.5	2267	25
5	3	2286	30
6	3.5	2293	35
7	4	2296	40
8	4.5	2297	45
9	5	2297	50
10	5.5	2297	55
11	6	2298	60
12	7	2298	65
13	7.5	2298	70
14	8	2298	80

(A) $I_b = 15.35$

$Rh_1 = 15$

OUTPUT CHARACTERISTICS

(const)

$Rh_1 = 100\Omega$

Base-current 174.14mA

(B)

S.No	Collector emmitter Voltage (V)	Collector Current (mA)
1	0.1000	7.427
2	0.4000	35.08
3	0.7000	55.80
4	1.000	70.31
5	1.300	79.86
6	1.600	85.09
7	1.900	88.28
8	2.200	91.08
9	2.500	91.09
10	2.800	91.64

(B) $I_b = 20.43$

$Rh_1 = 25$

($I_b \rightarrow$ Base current)

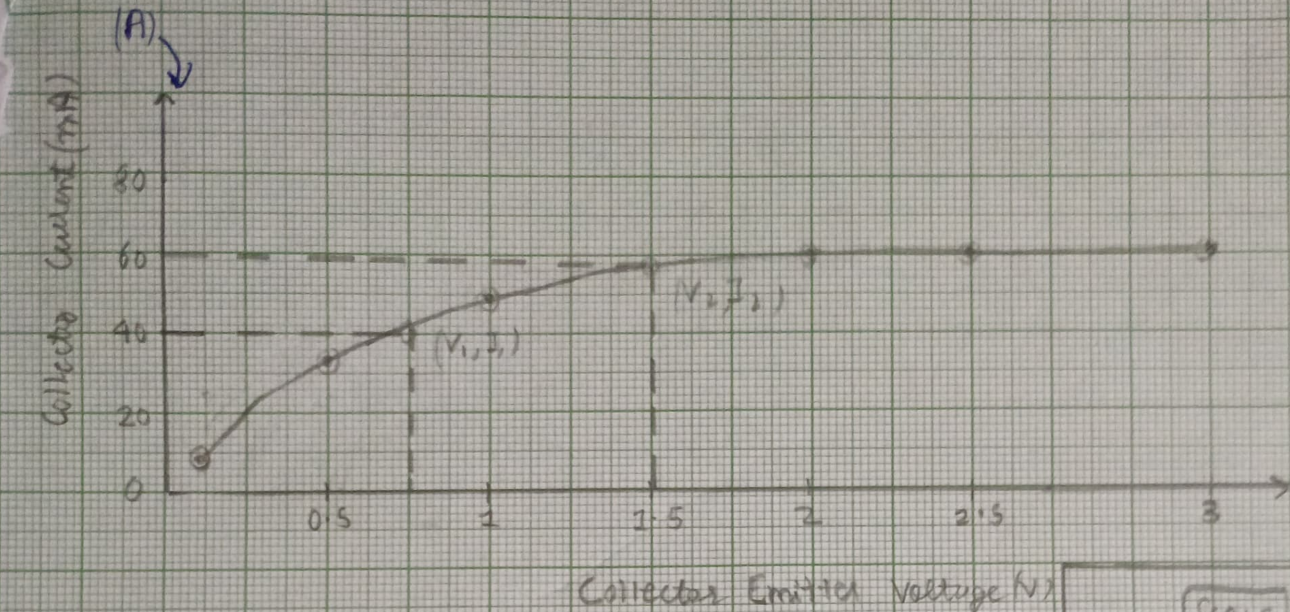
(C)

S.No	Collector emitter Voltage (V)	Collector Current (mA)
1	0.1000	12.96
2	0.4000	49.42
3	0.7000	78.62
4	1.000	99.07
5	1.300	112.1
6	1.600	119.9
7	1.900	124.4
8	2.200	126.9
9	2.500	128.3
10	2.800	129.1
11	3.100	129.6
12	3.400	129.8

(C) $I_b = 25.67$ $Rh_1 = 33$

CHARACTERISTICS (V-I PLOT)

(A)



Slope = $\frac{60-40}{1.5-0.75}$ = 26.66

SCALE

Y-axis

Collector Current

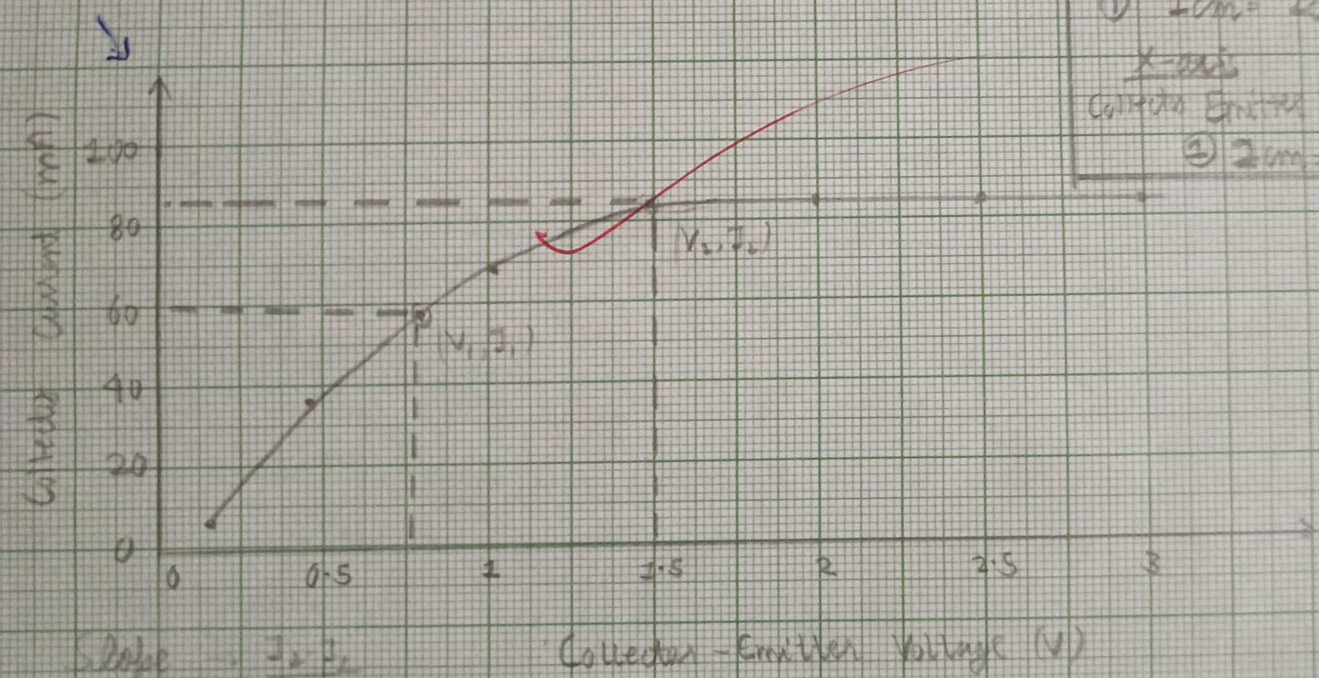
① 1 cm = 20 mA

X-axis

Collector Emitter Voltage

① 2 cm = 0.5 V

(B)



Slope = $\frac{I_2 - I_1}{V_2 - V_1}$

$\rightarrow \frac{86-60}{1.5-0.75}$

$= \frac{20}{0.75}$

$\rightarrow$ 26.666

SCALE

Y-axis

Collector Current

1 cm = 20 mA

① X-axis

Collector Emitter Voltage

③ 2 cm = 0.5 V