Aim ↬ To study the input and output characteristics of a Bipolar Junction Transistor connected in a Common Collector configuration.

Equipment Required ↬

Bipolar Junction Transistor, Resistance, Power supply, Ammeter, Voltmeter, Breadboard and connecting wires.

Theory ↬

A Bipolar Junction Transistor (BJT) is a three-terminal semiconductor device used for amplification and switching, comprising three regions: the emitter, the base, and the collector. BJTs come in two types, NPN and PNP, with the primary difference being the polarity of the voltages and the direction of the currents. In a common collector (CC) configuration, also known as an emitter follower, the collector terminal is common to both the input and the output circuits. The input signal is applied between the base and the collector, and the output is taken from the emitter and the collector.

The input characteristics of a BJT in CC configuration describe the relationship between the base current (I_B) and the base-collector voltage (V_{BC}) for various levels of emitter-collector voltage (V_{EC}). These characteristics are observed by varying V_{BC} and measuring I_B while keeping V_{EC} constant. In the forward active region, the base-collector junction is forward-biased, resulting in a significant change in I_B for a small change in V_{BC}.

The output characteristics describe the relationship between the emitter current (I_E) and the emitter-collector voltage (V_{EC}) for different levels of base current (I_B). These are obtained by varying V_{EC} and measuring I_E while keeping I_B constant. In the active region, the base-collector junction is forward-biased and the emitter-base junction is reverse-biased, leading to I_E being largely independent of V_{EC} and primarily determined by I_B. The saturation region occurs when V_{EC} is low, and both junctions are forward-biased, causing I_E to increase significantly. The cutoff region is when the base-collector junction is not forward-biased, resulting in minimal current flow.

The common collector configuration is characterized by high input impedance, low output impedance, and a voltage gain of approximately 1. However, it provides significant current gain, which is the ratio of the emitter current to the base current. This configuration is useful for impedance matching and buffering applications due to its high input impedance and low output impedance.

The current gain (α), which is the ratio of the emitter current to the base current ($\alpha = \frac{I_E}{I_B}$), is typically greater than 1, making this configuration suitable for applications where buffering and impedance matching are required. The voltage gain in a common collector configuration is close to unity, as the output voltage follows the input voltage with a slight drop due to the base-emitter junction voltage.

The common collector configuration is widely used in applications requiring buffering and impedance matching due to its high input impedance and low output impedance. The primary objectives of studying the input and output characteristics of a BJT in this configuration are to plot the input characteristic curves (I_B vs. V_{BC} for different values of V_{EC}) and the output characteristic curves (I_E vs. V_{EC} for different values of I_B). Understanding these characteristics is crucial for designing and analyzing buffer circuits and impedance-matching applications using BJTs in the common collector configuration.

Circuit Diagram ↬

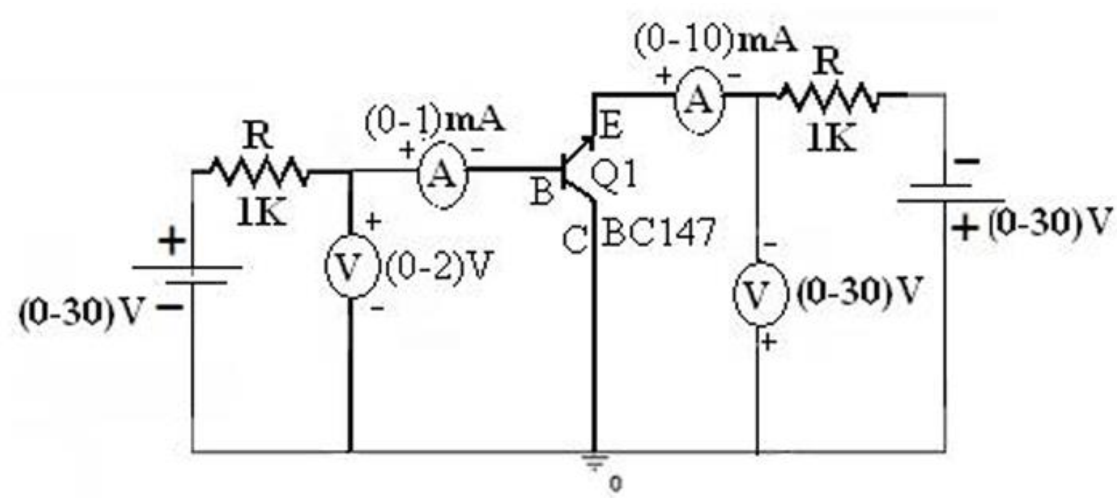

Fig 1. npn transistor in common collector configuration

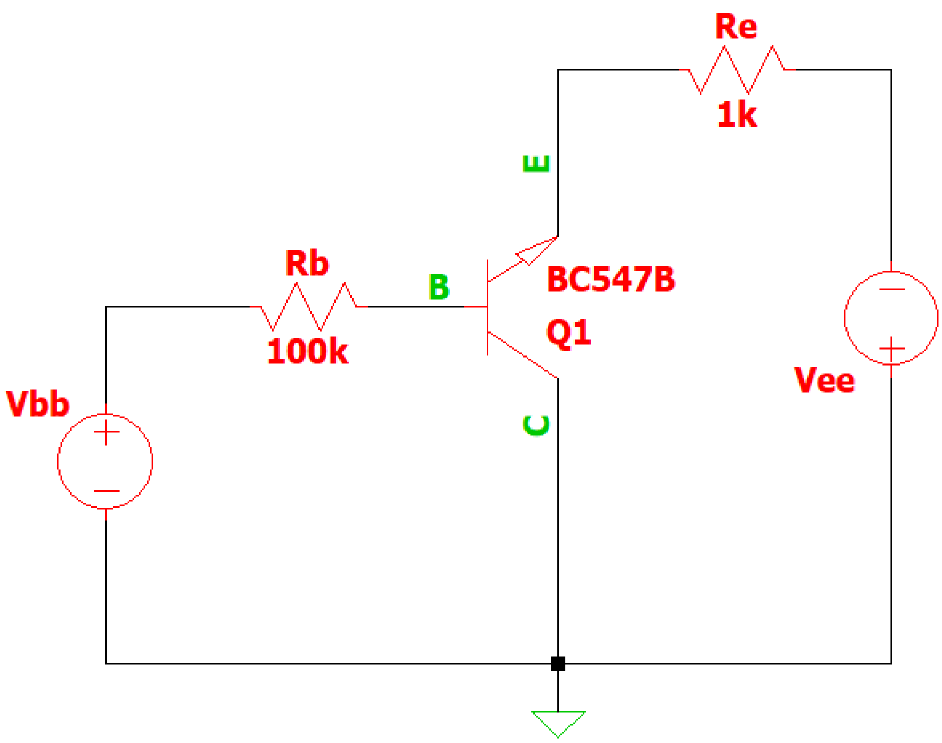

Fig 2. Circuit in LTSpice

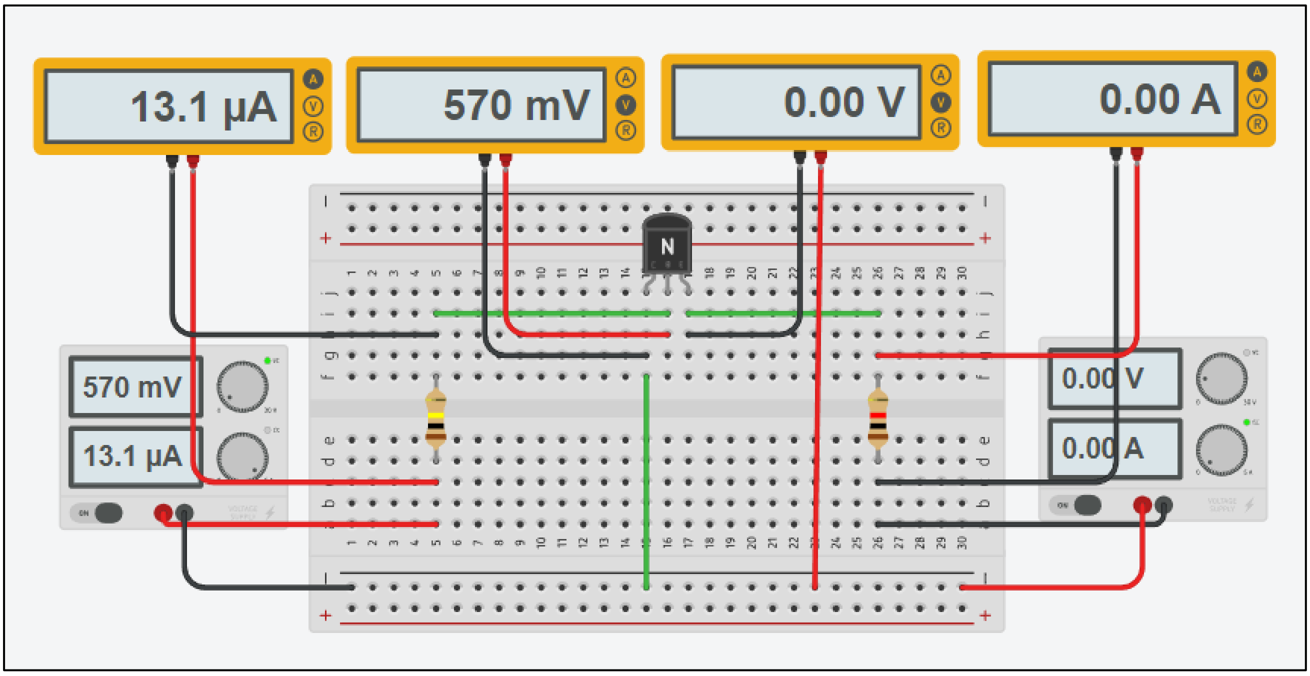

Fig 3. Circuit in TinkerCad

Observation Table ↬

➢ Input Characteristics ↪

S.No.	Vbb(V)	Vee = 0V		Vee = 5V		Vee = 10V	
		Ib(μA)	Vcb(V)	Ib(μA)	Vcb(V)	Ib(μA)	Vcb(V)
1	0.1	0	0.1	11.54	1.05	24.57	2.36
2	0.2	0	0.2	11.81	0.98	24.86	2.29
3	0.3	0	0.3	12.08	0.90	25.16	2.22
4	0.4	0.03	0.4	12.36	0.83	25.45	2.15
5	0.5	0.33	0.47	12.63	0.76	25.74	2.07
6	0.6	1.01	0.50	12.91	0.69	26.03	2.00
7	0.8	2.74	0.53	13.46	0.55	26.62	1.86
8	1.0	4.59	0.54	14.02	0.40	27.22	1.72
9	1.5	9.40	0.56	15.43	0.04	28.71	1.37
10	2.0	14.28	0.57	16.85	-0.32	30.21	1.02

➢ Output Characteristics ↪

S.No.	Vee(V)	Vbb = 0V		Vbb = 1V		Vbb = 2V	
		Ie(mA)	Vce(V)	Ie(mA)	Vce(V)	Ie(mA)	Vce(V)
1	0	0	0	0	0	0	0
2	0.1	0	0.1	0.06	0.04	0.08	0.02
3	0.2	0	0.2	0.14	0.05	0.17	0.03
4	0.5	0	0.50	0.41	0.08	0.45	0.05
5	0.8	0.16	0.65	0.69	0.11	0.73	0.07
6	1	0.29	0.71	0.87	0.12	0.92	0.07
7	2	1.08	1	1.73	0.27	1.89	0.11
8	5	3.20	1.79	3.92	1.08	4.63	0.37
9	8	5.41	2.59	6.12	1.88	6.82	1.18
10	10	6.88	3.12	7.58	2.42	8.28	1.72

Graphs ↬

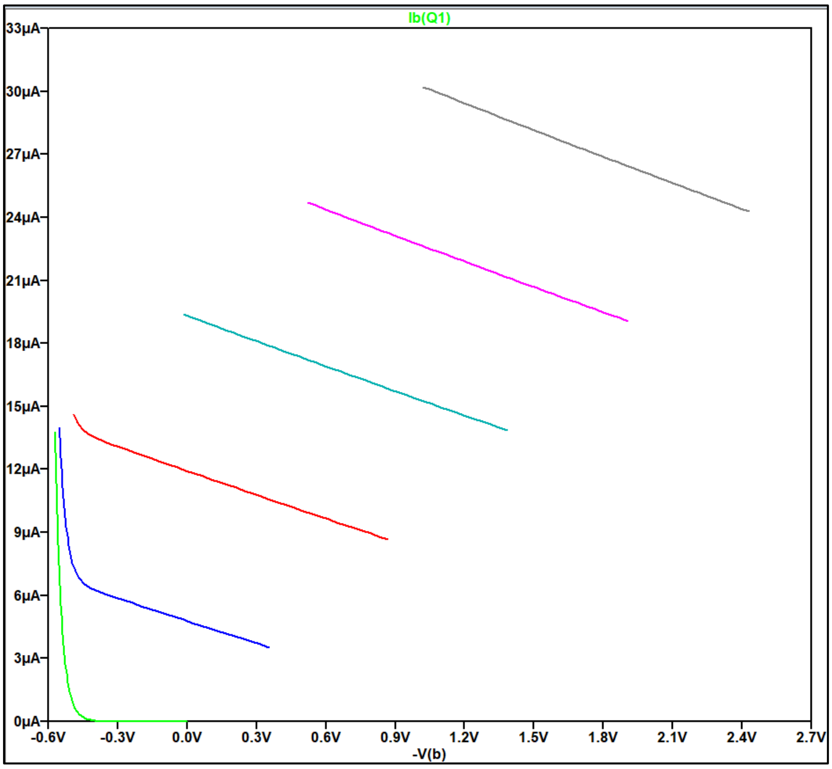

Fig 4. Input Characteristics

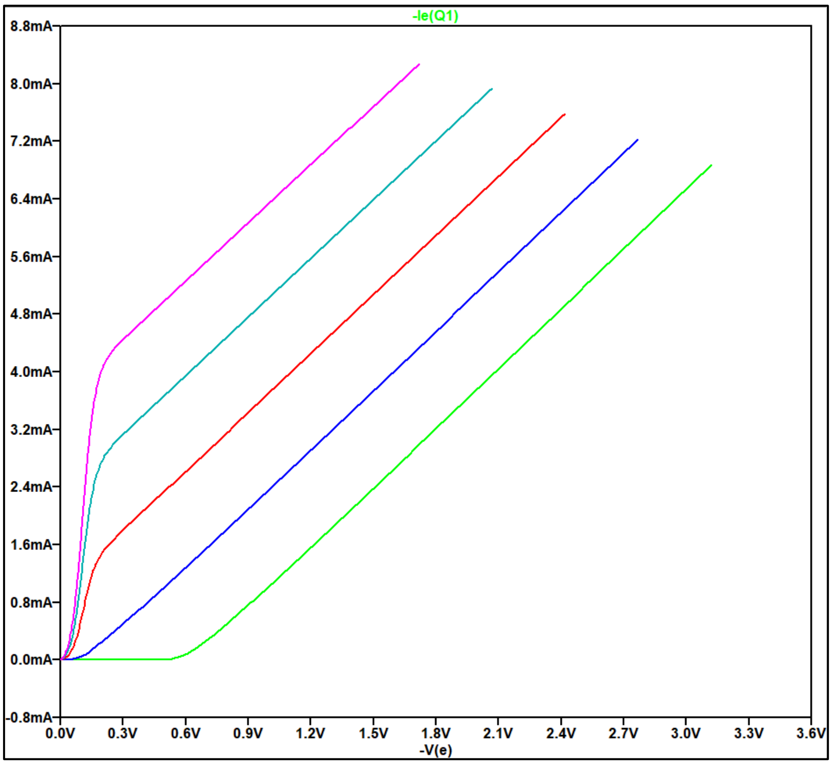

Fig 5. Output Characteristics

Result ↬

The experiment revealed that in a common collector (CC) configuration, the base current (I_B) increased significantly with base-collector voltage (V_{BC}) while keeping the emitter-collector voltage (V_{EC}) constant. The emitter current (I_E) showed a notable increase with V_{EC} at low values and then stabilized at higher V_{EC} levels for a fixed I_B, indicating that I_E is primarily controlled by I_B. These results confirm the expected behaviour of high input impedance, low output impedance, and a voltage gain close to unity, validating the theoretical predictions for the common collector configuration of a BJT.

Conclusion ↬

Successfully performed the experiment and matched the result with the simulation result.

Precautions ↬

- While doing the experiment, do not exceed the ratings of the transistor. This may lead to damage to the transistor.
- Connect the Voltmeter and Ammeter in the correct polarities as shown in the circuit diagram.
- Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.