Aim : Study of characteristics of an n-p-n bipolar junction transistor (BJT).

Electronic Parts Required :

(i) Power supply, 2 Nos : 0 ~ 15 V
(ii) R_B , R_C = 1.0 KΩ , 2 Nos
(iii) R_B , = 220 Ω , 1 Nos
(iv) 1.0 kΩ Potentio-meter, 1.0 W
(v) NPN Transistor = 1 No , CL 100 / SL 100 [CK 100 / SK 100 = PNP (equivalent) transistors]
(vi) Breadboard = 1 No
(vii) Two DT-830D multi-meters for current measurements. One 8007 multimeter with probe for Voltage measurements.
(viii) single stand wires = 6 Nos

Theory :

A transistor is an electronic device which has huge applications – in amplifiers, oscillators, gates etc. In this lab we will study one kind of transistor – the **Bipolar Junction Transistor** (BJT). This device can be thought of schematically as a sandwitch – in which two *n* type semiconductors are separated by a *p* type semiconductor (this is the *npn* transistor – there is another kind – the *pnp*). Of the two *n* type regions, one is small and very heavily doped – called the **emitter**, while the other, called the **collector**, is large and comparatively lightly doped. The *p* type region, called the **base**, is very narrow and very lightly doped.

Thus, there are two *pn* junctions in a transistor – the base-emitter and the collector-base. When the transistor is used as an amplifier it is necessary to forward bias the base-emitter and reverse the collector-base junction. In this case, the base-emitter forward bias causes a large flow of electrons from the emitter to the base (there is also flow of holes from the base to the emitter – but that is much smaller, the base being lightly doped). Once these electrons enter the emitter, the base-collector reverse bias sweeps them almost entirely into the collector. Only a small fraction recombines in the base – giving rise to a small base current I_B. Thus the collector current IC is almost equal to or slightly lower than I_E.

Now we define a parameter α by

$$I_C = \alpha\, I_E$$

Where α is a number very close to, but smaller than, 1. Since $I_E = I_C + I_B$

We can easily see that $I_C = \beta\, I_B$, where $\boldsymbol{\beta} = \frac{\alpha}{1-\alpha}$ is usually quite large – in the order of 100 -200.

Characteristics of Common Emitter Connection :

Since two terminals each are needed for a transistor's input and output, while it has only three – one terminal must be common between the input and the output. This leads to the classification of transistor circuits as common emitter (CE), common base (CB) or common collector (CC). We will study the common emitter configuration where the input is applied between the base and the emitter and the output is taken between the collector and the emitter.

The important characteristics of CE arrangement are the *input* and *output* characteristics. In the CE configuration the input current and voltage are I_B and V_{BE}, while the output current and voltage are I_C and V_{CE}.

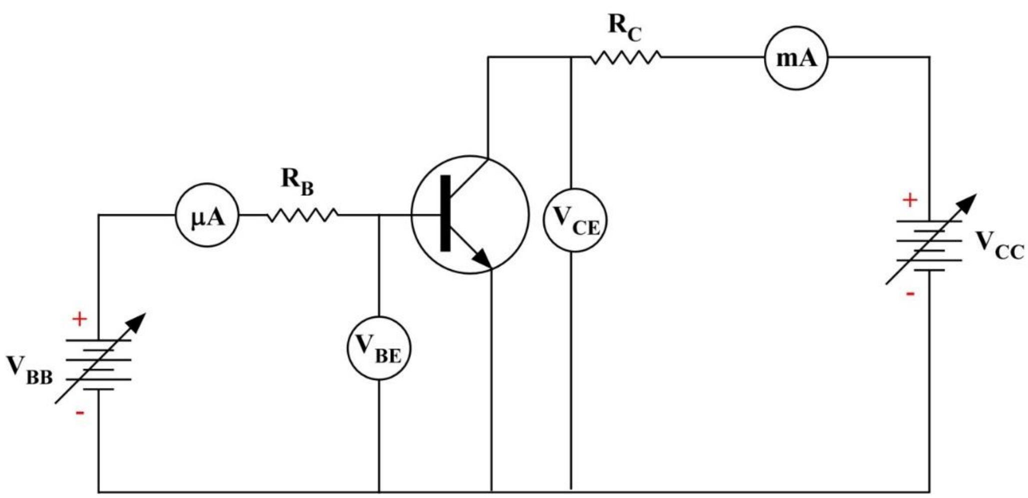
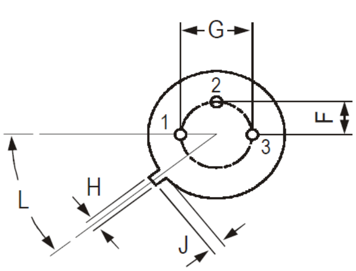
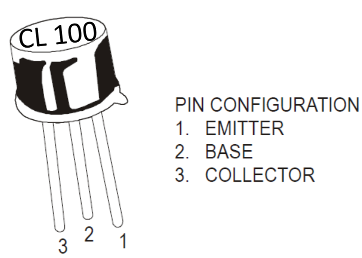
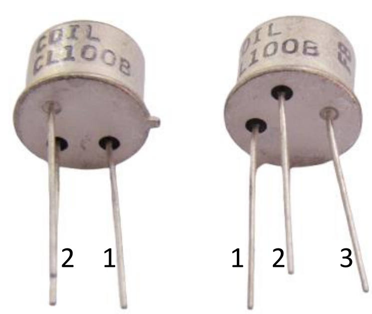


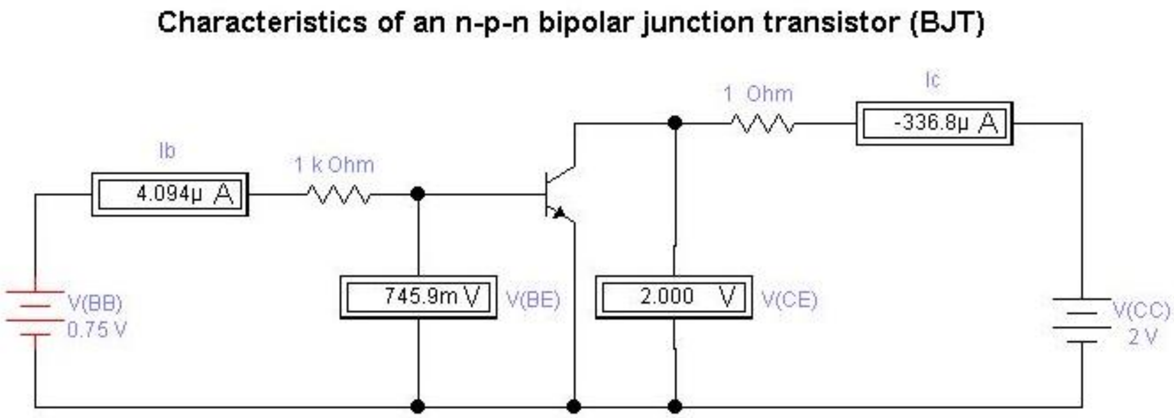
Figure: Circuit for transistor characteristics





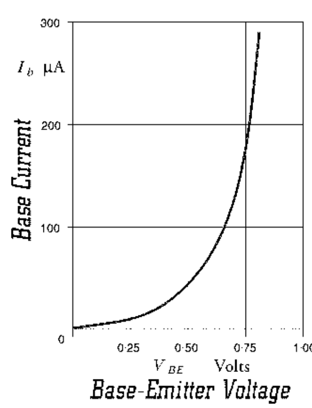


i) CE input characteristics :



R_B = 1K Ohm, R_C = 1 Ohm , V_CE = 2 V						
Sl. No	V_BB (V)	V_BE (V)	I_b (micro)	V_CC (V)	V_CE (V)	I_c (micro)
1	0	0	0	2	2	2
2	0.1	0.999	0.1	2	2	2
3	0.2	0.1998	0.2	2	2	2
4	0.3	0.2997	0.3	2	2	2
5	0.4	0.3996	0.4	2	2	2.001
6	0.5	0.4995	0.5	2	2	2.024
7	0.6	0.5994	0.611	2	2	3.16
8	0.7	0.6988	1.24	2	2	56.09
9	0.8	0.7844	15.61	2.001	2	1.484 mA
10	0.9	0.8258	74.23	2.007	2	7.343 mA
11	1	0.845	155	2.015	2	15.42 mA
12	1.1	0.8567	243.3	2.024	2	24.25 mA
13	1.2	0.865	335	2.033	2	33.42 mA

It is the curve between base current I_B and base-emitter voltage V_{BE} at constant collector-emitter voltage V_{CE}. In the above circuit diagram, set the voltage V_{CE} at 2 Volts. Change the input voltage and measure the variation of I_B with V_{BE}. Note that you have to readjust the battery V_{CC} to keep V_{CE} fixed at 2 Volts. Repeat the same for V_{CE} fixed at 3 and 4 Volts.



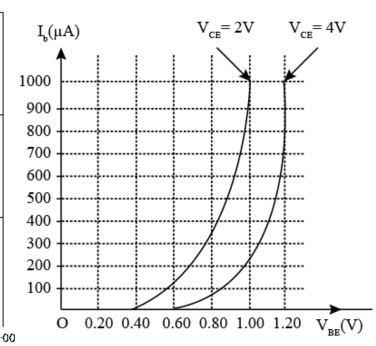


Table – I

Sl. No	V_{CE} = 2 V		V_{CE} = 3 V		V_{CE} = 4 V	
	V_{BE} (V)	I_B (μA / mA)	V_{BE} (V)	I_B (μA / mA)	V_{BE} (Volts)	I_B (μA / mA)
1.						
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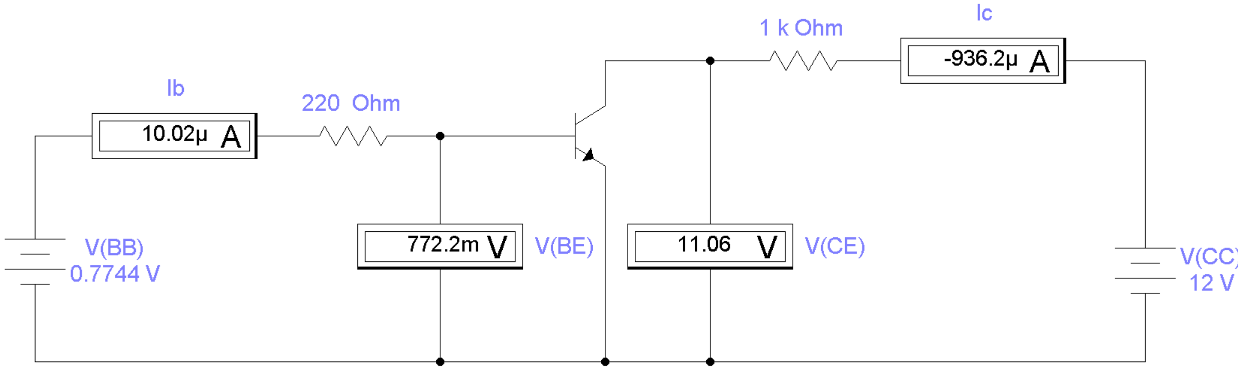
10						

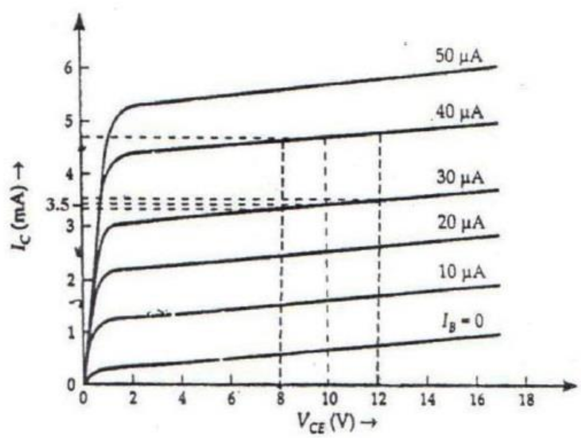
ii) CE output characteristics :

Characteristics of an n-p-n bipolar junction transistor (BJT)



R_B = 220 Ohm, R_C = 1K Ohm , I_b = 10 micro A						
Sl. No	V_BB (V)	V_BE (V)	I_b (micro)	V_CC (V)	V_CE (mV)	I_c (micro)
1	0.6618	0.6596	10.01	0	6.561	6.561
2	0.7058	0.7036	10.04	0.1	52.13	47.87
3	0.7258	0.7236	10.06	0.2	74.51	125.5
4	0.7378	0.7356	10.06	0.3	89.42	210.6
5	0.7462	0.744	10.03	0.4	101.3	298.7
6	0.7526	0.7504	9.98	0.5	112	388
7	0.7578	0.7556	10.02	0.6	121.7	478.3
8	0.7658	0.7636	10.1	0.8	142.3	657.7
9	0.7715	0.7693	10.01	1	174.7	825.3
10	0.7743	0.7721	10.1	1.2	278.1	921.9
11	0.7744	0.7722	10.02	1.5	574.3	925.7
12	0.7744	0.7722	10.02	1.8	874	926
13	0.7744	0.7722	10.02	2.1	1.274 V	926.4
14	0.7744	0.7722	10.02	2.5	1.573 V	926.7
15	0.7744	0.7722	10.02	3	2.073 V	927.2

16	0.7744	0.7722	10.02	5	4.071	929.2
17	0.7744	0.7722	10.02	8	7.068	932.2
18	0.7744	0.7722	10.02	12	11.06	936.2



It is the curve between collector current I_C and collector-emitter voltage V_{CE} at constant base current I_B. Use the above circuit with R_B = 220 Ω and R_C = 1 kΩ. Adjust V_{BB} to fix the current I_B at 10 μA. Vary the voltage V_{CE} by varying V_{CC} from 0 Volts to 10 Volts and note the values of I_C (ignore the –ve sign due to direction). Note that I_C increases rapidly at small values of V_{CE} < 0.7 Volts. Try to take readings at smaller voltage intervals in this region – you can use large intervals (may be bigger steps) once you cross this region and the current stops increasing rapidly. Repeat this for I_B = 20, 30, and 40 μA. In one graph, plot the variation of I_C verses V_{CE} for each successive value of I_B. Calculate the value of β at V_{CE} = 5 volts using the formula $\beta = I_C / I_B$.

Table – II

Sl. No	I_B = 10 μA		I_B = 20 μA		I_B = 30 μA		I_B = 40 μA	
	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)
1.								
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