ELEC-313
Lab 8: Bipolar Junction Transistor Characterization

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1 Objective

The objective is to plot the output characteristic of a common-emmitter transistor circuit, and use it to determine the current gain and output conductance.

2 Equipment

Transistor: 2N7000	Power supply: HP E3631A
Function generator: HP 33120	Multimeter: HP 34401A
Oscilloscope: Agilent 54622D	Capacitors: 0.1 µF

Resistors: $100\,\Omega$, $300\,\Omega$, $470\,\Omega$, $1\,\mathrm{k}\Omega$ (x2) $33\,\mathrm{k}\Omega$, $100\,\mathrm{k}\Omega$ (x2)
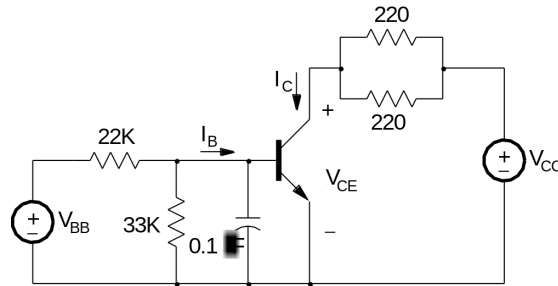
3 Schematics

Figure 1: Common-emitter transistor circuit

4 Procedure

1. Construct the circuit of Figure 1. Use the $+6\,\mathrm{V}$ power supply for V_{BB} and the $+25\,\mathrm{V}$ supply for V_{CC}. Be sure to keep the connection distance between the capacitor and the transistor short. Use the HP multimeter to measure the base current (I_B) on the source side of the capacitor and Fluke multimeters to measure the collector voltage and current (V_{CE} and I_C).

2. Adjust V_{BB} so that base current (I_B) is $20\,\mu\mathrm{A}$.

3. Adjust V_{CC} from $0.5 - 1.5\,\mathrm{V}$ in $0.25\,\mathrm{V}$ steps, then from $2 - 20\,\mathrm{V}$ in $2\,\mathrm{V}$ steps.

4. At each step measure the collector current, I_C, and the collector-to-emitter voltage, V_{CE}. If I_B has drifted, readjust V_{BB} before recording the values of I_C and V_{CE}.

5. Adjust V_{BB} for a base current of $50\,\mu A$, $80\,\mu A$, and $100\,\mu A$. Repeat steps 3 and 4 at each I_B value.

5 Results

V_{CC} (V)	I_C (mA)	V_{CE} (V)	β
0.50	0.232	0.454	11.60
0.75	0.233	0.705	11.65
1.00	0.234	0.954	11.70
1.25	0.237	1.204	11.85
1.50	0.237	1.454	11.85
2	0.242	1.954	12.10
4	0.25	3.95	12.30
6	0.25	5.95	12.60
8	0.26	7.95	12.75
10	0.26	9.96	12.85
12	0.26	11.95	13.10
14	0.27	13.94	13.30
16	0.27	15.95	13.40
18	0.27	17.95	13.50
20	0.27	19.95	13.70

Table 1: $I_B = 20\,\mu A$

6 Conclusion

7 Equations

$$h_{oe} \approx \frac{1}{r_o} = \frac{\Delta I_C}{\Delta V_{CE}} \tag{1}$$

$$\beta = \frac{I_C}{I_E} \tag{2}$$

V_{CC} (V)	I_C (mA)	V_{CE} (V)	β
0.50	2.73	0.178	54.60
0.75	4.34	0.236	86.80
1.00	4.96	0.41	99.20
1.25	4.95	0.662	99.00
1.50	4.97	0.91	99.40
2	4.98	1.41	99.60
4	5.15	3.39	103.00
6	5.25	5.38	105.00
8	5.39	7.36	107.80
10	5.58	9.34	111.60
12	5.77	11.31	115.40
14	5.97	13.28	119.40
16	6.21	15.26	124.20
18	6.45	17.23	129.00
20	6.69	19.20	133.80

Table 2: $I_B = 50\,\mu\text{A}$

V_{CC} (V)	I_C (mA)	V_{CE} (V)	β
0.50	3.08	0.135	38.50
0.75	4.95	0.163	61.88
1.00	6.8	0.191	85.00
1.25	8.58	0.229	107.25
1.50	9.1	0.421	113.75
2	9.4	0.881	117.50
4	10.79	2.71	134.88
6	11.03	4.68	137.88
8	11.45	6.63	143.13
10	11.99	8.56	149.88
12	12.72	10.47	159.00
14	13.41	12.39	167.63
16	14.20	14.29	177.50
18	15.05	16.20	188.13
20	15.85	18.10	198.13

Table 3: $I_B = 80\,\mu\text{A}$

V_{CC}	I_C	V_{CE}	β
(V)	(mA)	(V)	
0.50	3.21	0.12	32.10
0.75	5.11	0.143	51.10
1.00	7.02	0.164	70.20
1.25	8.93	0.186	89.30
1.5	10.79	0.214	107.90
2	10.33	0.77	103.30
4	11.33	2.67	113.30
6	13.95	4.34	139.50
8	15.63	6.14	156.30
10	16.60	8.02	166.00
12	17.98	9.95	179.80
14	19.20	11.70	192.00
16	20.70	13.69	207.00
18	22.40	15.53	224.00
20	23.80	17.37	238.00

Table 4: $I_B = 100\,\mu\text{A}$

Figure 2: V_{CE} vs. I_C

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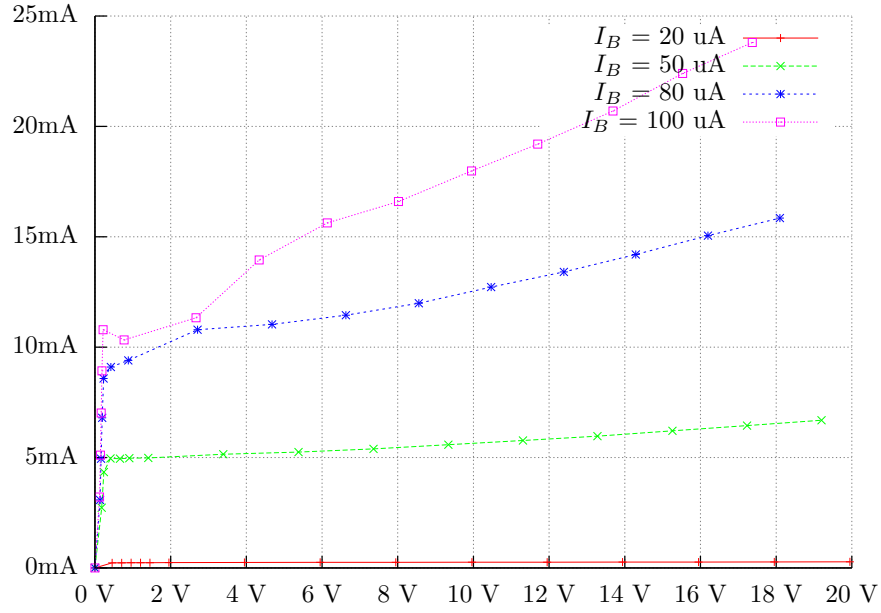
I_B (µA)	β_{avg}
20	12.55
50	105.85
80	132.00
100	137.99

Table 5: Average values of β

I_B (µA)	h_{oe}	r_o (kΩ)
20	7.412E-4	1.349
50	3.669E-4	2.726
80	9.950E-5	10.10
100	1.700E-6	58.82

Table 6: h_{oe} vs. r_o