

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-emitter 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  $\mu\text{F}$   
Resistors: 100  $\Omega$ , 300  $\Omega$ , 470  $\Omega$ , 1 k $\Omega$  (x2) 33 k $\Omega$ , 100 k $\Omega$  (x2)

## 3 Schematics

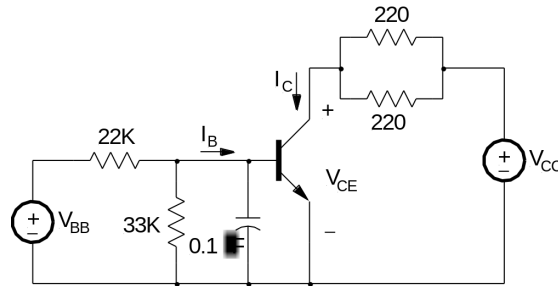


Figure 1: Common-emitter transistor circuit

## 4 Procedure

1. Construct the circuit of Figure 1. Use the +6 V power supply for  $V_{BB}$  and the +25 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  $\mu\text{A}$ .
3. Adjust  $V_{CC}$  from 0.5 – 1.5 V in 0.25 V steps, then from 2 – 20 V in 2 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  $50\text{ }\mu\text{A}$ ,  $80\text{ }\mu\text{A}$ , and  $100\text{ }\mu\text{A}$ . Repeat steps 3 and 4 at each  $I_B$  value.

## 5 Results

$V_{CC}$ (V)	$I_C$ (mA)	$V_{CE}$ (V)	$\beta$
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:  $I_B = 20\text{ }\mu\text{A}$

## 6 Conclusion

## 7 Equations

$$\beta = \frac{I_C}{I_B} \tag{1}$$

$$h_{oe} \approx \frac{1}{r_o} = \frac{\Delta I_C}{\Delta V_{CE}} \tag{2}$$

$V_{CC}$ (V)	$I_C$ (mA)	$V_{CE}$ (V)	$\beta$
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)	$\beta$
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:  $I_B = 80 \mu\text{A}$

$V_{CC}$ (V)	$I_C$ (mA)	$V_{CE}$ (V)	$\beta$
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:  $I_B = 100 \mu\text{A}$

$I_B$ ( $\mu\text{A}$ )	$\beta_{avg}$
20	12.55
50	105.85
80	132.00
100	137.99

Table 5: Average values of  $\beta$  per  $I_B$

$I_B$ ( $\mu\text{A}$ )	$I_C$ (mA)	$\beta$
20	0.25	12.26
50	5.20	104.00
80	11.10	138.75
100	14.67	146.68

Table 6:  $V_{CE} = 5 \text{ V}$

$I_B$ ( $\mu\text{A}$ )	$I_C$ (mA)	$\beta$
20	0.26	12.97
50	5.64	112.84
80	12.47	155.88
100	18.00	180.00

Table 7:  $V_{CE} = 10 \text{ V}$

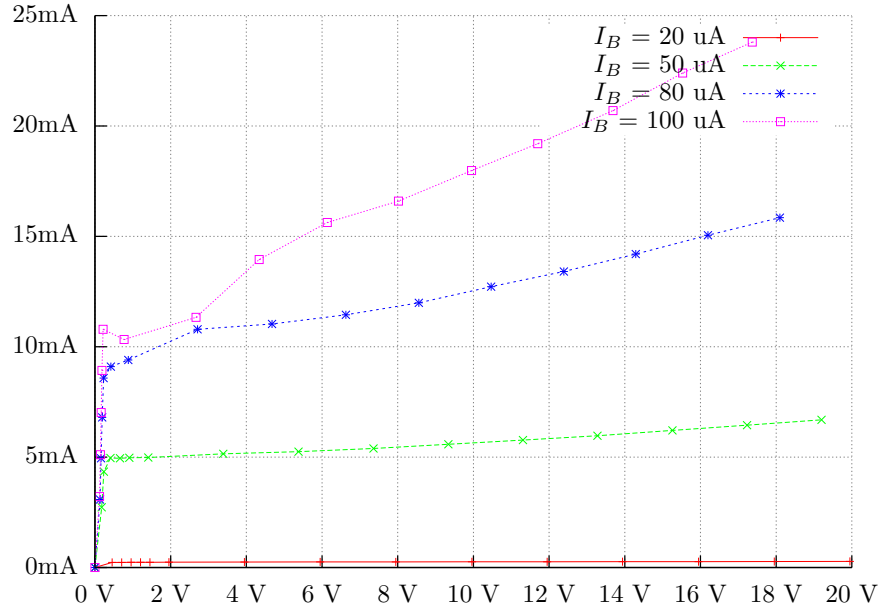


Figure 2:  $V_{CE}$  vs.  $I_C$

$I_B$ ( $\mu\text{A}$ )	$I_C$ (mA)	$\beta$
20	0.27	13.32
50	6.18	123.61
80	14.50	181.25
100	22.93	229.30

Table 8:  $V_{CE} = 15 \text{ V}$

$V_{CE}$ (V)	$\beta_{avg}$
5	100.42
10	115.42
15	136.87

Table 9: Average values of  $\beta$  per  $V_{CE}$

$I_B$ ( $\mu\text{A}$ )	$h_{oe}$	$r_o$ ( $\text{k}\Omega$ )
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 10:  $h_{oe}$  vs.  $r_o$