

# BJT BIAS CIRCUITS AND DC MEASUREMENTS

*Part II: Laboratory assignment*

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POLITECNICO DI TORINO

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## Team

Team no. **B13**

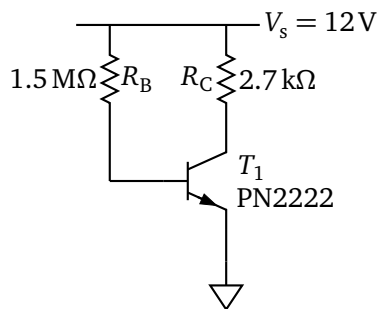
Student	Last name	First name	Signature
1	Sakacı	Ali Fuat	.....
2	Unver	Muzaffer Murathan	.....
3			.....
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5			.....

# 1 Assignment

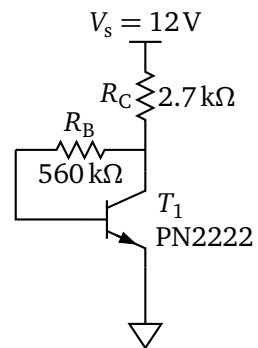
For *each* circuit of figure 1 on the following page:

- 1 Assemble the circuit on the breadboard and use the bench power supply to generate the  $V_s = 12\text{V}$  supply voltage. The BJT should be a PN2222 (PN2222 data sheet) (**before connecting the device, check the pinout from the data sheet!**).
- 2 Measure with the *handheld* digital multimeter  $I_B$ ,  $I_C$ ,  $V_{BE}$  and  $V_{CE}$ .
- 3 Evaluate the uncertainties of the above measurements.
- 4 Estimate the instrument loading error for  $I_C$  and  $V_{CE}$ .
- 5 Measure with the *bench* digital multimeter  $I_B$ ,  $I_C$ ,  $V_{BE}$  and  $V_{CE}$ .
- 6 Evaluate the uncertainties of the above measurements.
- 7 Estimate the instrument loading error for  $I_C$  and  $V_{CE}$ .
- 8 Report the above measurements in tables 1, 2, 3 and 4, respectively for each circuit.
- 9 Remeasure  $I_C$ , and now touch also the BJT case with a finger, heating it up (keep the finger for around a minute). How much does  $I_C$  change when you touch the case?
- 10 Compare the results obtained in the above and comment whether the measurements with the handled and bench multimeters are compatible with each other or not, explain possible discrepancies, and compared the results obtained in the lab with those obtained in the analysis of part 1. Report the comments in the form of page 7. Discuss also the observed change in  $I_C$  with respect to the sensitivities obtained in the analysis of part 1.

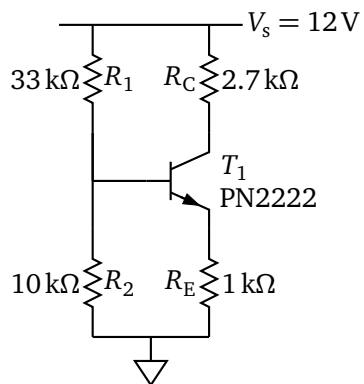
Upload the filled PDF form, one upload for each team, by April 15, 2024.



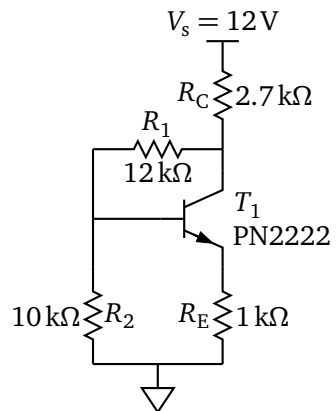
(a)



(b)



(c)



(d)

Figure 1: DC bias circuits

Table 1: Results for the circuit of figure 1(a).

Quantity	Handheld multimeter			Bench multimeter		
	Value	Uncert.	Loading error	Value	Uncert.	Loading error
$I_B/\mu A$	8 $\mu A$	%22		7.7 $\mu A$		
$I_C/mA$	1.072 mA	%1		1.067 mA		
$V_{CE}/V$	9.20 V	%3		9.168 V		
$V_{BE}/V$	0.625 V	%0.06		0.622 V		

Table 2: Results for the circuit of figure 1(b).

Quantity	Handheld multimeter			Bench multimeter		
	Value	Uncert.	Loading error	Value	Uncert.	Loading error
$I_B/\mu A$	12 $\mu A$	%23		12.58 $\mu A$		
$I_C/mA$	1.746 mA	%1.2		1.73 mA		
$V_{CE}/V$	7.66 V	%5.2		7.38 V		
$V_{BE}/V$	0.63 V	%0.06		0.634 V		

Table 3: Results for the circuit of figure 1(c).

Quantity	Handheld multimeter			Bench multimeter		
	Value	Uncert.	Loading error	Value	Uncert.	Loading error
$I_B/\mu A$	270 $\mu A$	%1,3		250 $\mu A$		
$I_C/mA$	2,03 mA	%0,875		2,05		
$V_{CE}/V$	4,66	%1,2		4,628		
$V_{BE}/V$	0,643	%0,66		0,66 V		

Table 4: Results for the circuit of figure 1(d).

Quantity	Handheld multimeter			Bench multimeter		
	Value	Uncert.	Loading error	Value	Uncert.	Loading error
$I_B/\mu A$	269 $\mu A$	%26,72		268 $\mu A$		
$I_C/mA$	2,27 mA	%21,34		2,27 mA		
$V_{CE}/V$	4,04 V	%0,2		4,019 V		
$V_{BE}/V$	0,64 V	%0,6		0,63 V		

# Uncertainties

Circuit A

Handheld

$$\delta V_{CE} = \frac{0,1}{100} \times 9,20V + (3 \times 0,001V) = 0,03 = \%3$$

$$V_{CE} =$$

$$\delta V_{BE} = \frac{0,025}{100} \times 0,625V + (5 \times 0,0001V) = 0,0006 = \%0,06$$

$$V_{BE} =$$

$$\delta I_B = \frac{0,25}{100} \times 8\mu A + (20 \times 0,01\mu A) = 0,22 = \%22$$

$$I_B =$$

$$\delta I_C = \frac{0,15}{100} \times 1,072mA + (10 \times 0,001mA) = 0,011 = \%1$$

$$I_C =$$



## Circuit B *handheld*

$$\delta V_{CE} = \frac{0,03}{100} \times 7,44V + (3 \times 0,001) = 0,0052$$
$$= \% 0,52$$

$$\underline{V_{CE}} =$$

$$\delta V_{BE} = \frac{0,025}{100} \times 0,63 + (5 \times 0,0001) = 0,00063$$
$$= \% 0,06$$

$$\underline{V_{BE}} =$$

$$\delta I_B = \frac{0,25}{100} \times 12\mu A + (20 \times 0,001) = 0,23$$
$$I_B = \% 23$$

$$\delta I_C = \frac{0,15}{100} \times 1,746 + (10 \times 0,001) = 0,012$$
$$I_C = \% 1,2$$

## Circuit C) Handheld

Handheld

$$\delta V_{CE} = \frac{0,025}{100} \times 4,622 \text{ V} + 10 \times 0,0001 = 0,012$$
$$= \% \underline{1,2}$$

$$V_{CE} = (4,622 \mp 0,012) \text{ V}$$

$$\delta V_{BE} = \frac{0,025}{100} \times 0,643 \text{ V} + 5 \times (0,1 \times 10^{-3}) = 0,00066$$
$$= \% 0,66$$

$$V_{BE} =$$

$$\delta I_B = \frac{0,25}{100} \times 270 \mu\text{A} + (20 \times 0,01 \mu\text{A}) = 0,875 \mu\text{A}$$
$$I_B = 0,00000875 \text{ A}$$
$$= \% 0,00087$$

$$\delta I_C = \frac{0,15}{100} \times 2,03 \text{ mA} + (10 \times 0,001 \text{ mA}) = 0,013$$
$$I_C = \% 1,3$$

## Circuit D Handheld

$$\delta V_{CE} = \left( \frac{0,025}{100} \times 4,04 \text{ V} \right) + (10 \times 0,0001) = 0,0020 \\ = \% 0,2$$

$$V_{CE} =$$

$$\delta V_{BE} = \left( \frac{0,025}{100} \times 0,64 \text{ V} \right) + (5 \times 0,0001) = 0,00066 \\ = \% 0,6$$

$$V_{BE} =$$

$$\delta I_B = \left( \frac{0,25}{100} \times 269 \text{ } \mu\text{A} \right) + (20 \times 0,01) = 0,2672 \text{ } \mu\text{A} \\ I_B = \% 26,72$$

$$\delta I_C = \left( \frac{0,15}{100} \times 2,27 \text{ mA} \right) + (10 \times 0,001) = 0,0134 \\ I_C = \% 1,34$$

Comments on the results:

The measurements and uncertainties of voltages that we found are accurate and logical to calculations we did on paper, however we can not tell the same for measurements on current uncertainties, the reason is that the values given for on data sheet are large and uncertainties becomes also ridiculous compared to real life.