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# CHARACTERIZATION OF AN NPN BIPOLAR JUNCTION TRANSISTOR (BJT)

## Measurement practice II.

## FOR VEHICLE ENGINEER STUDENTS



Version: 1.2

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# 1. Introduction

This measurement exercise examines the characterization of an NPN-type Bipolar Junction Transistor (BJT). The type of BJT is 2N2218.

## 1.1 Objectives

## 1.2 Required instruments and components

- power supply (see Fig. 1.);
- resistor table (see Fig. 2.);
- semiconductor table (see Fig. 3.);
- digital multimeters;
- measuring cables (to the power supply and multimeter).


***Fig.1.*** Power supply (TP-2303)

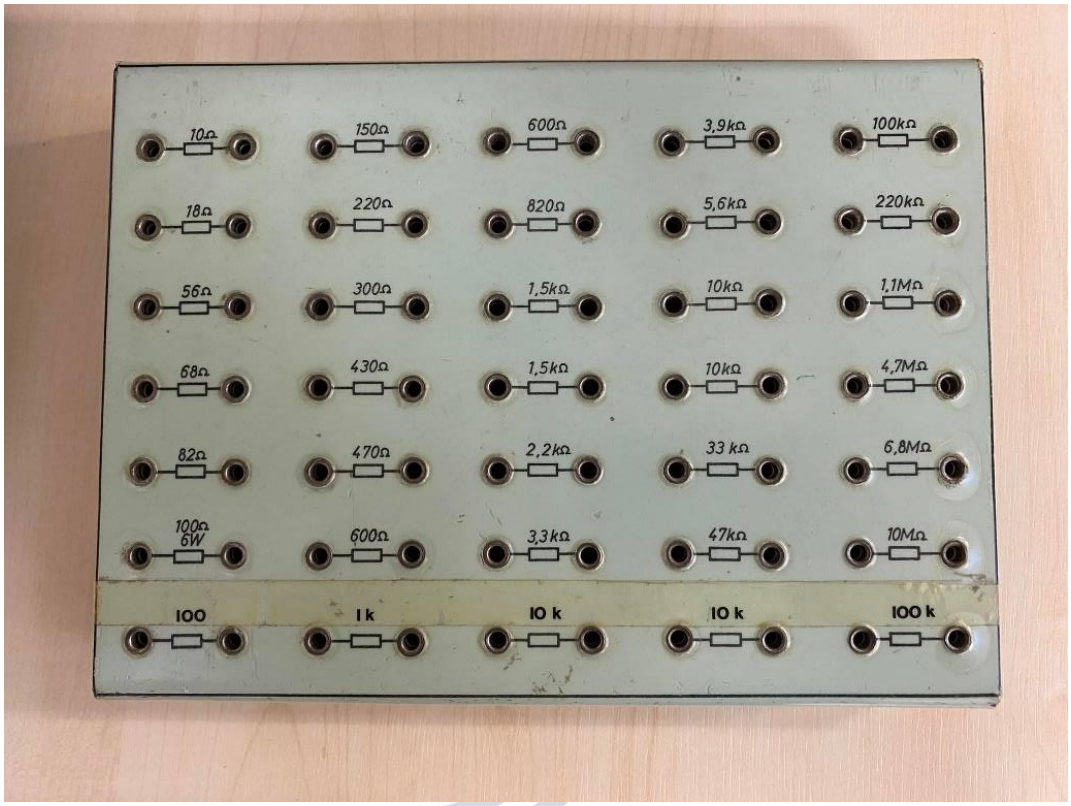


***Fig.2.*** Resistor table

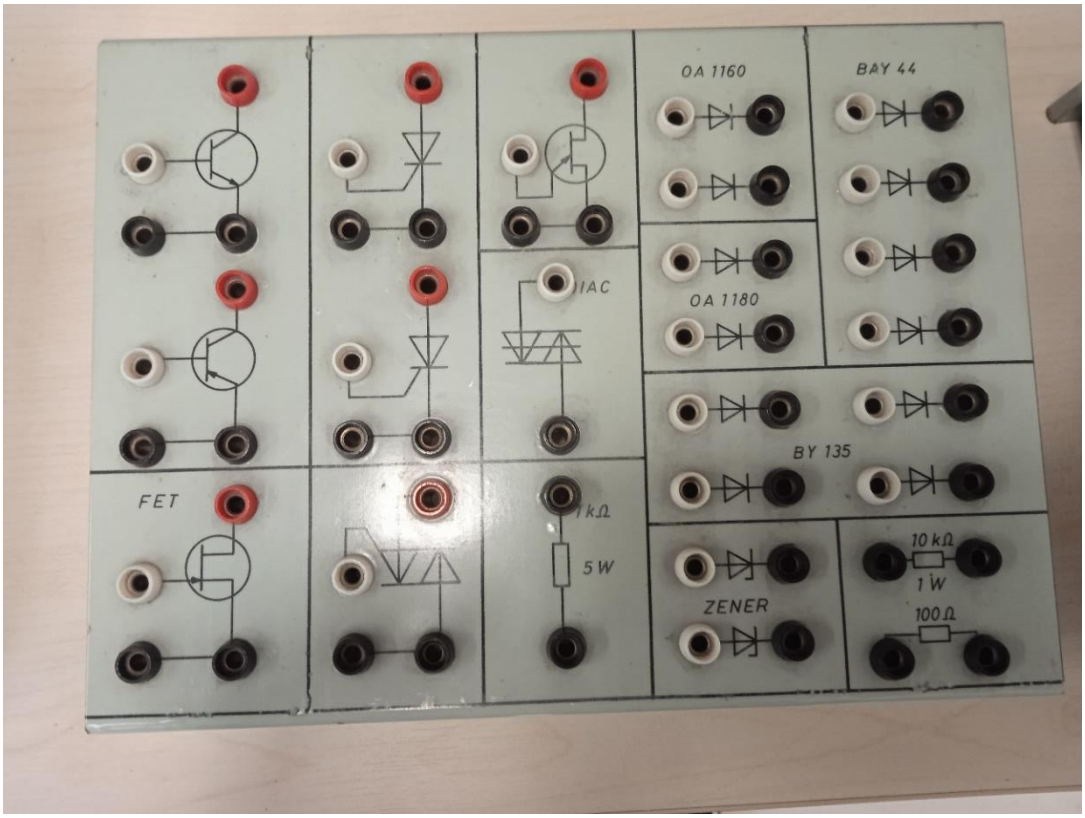


***Fig.3.*** Semiconductor table

## 3. Measurement exercises, wiring diagrams

The circuit diagram of measurement is shown in Fig. 4. The visual connection of the power supply and the measuring instrument is shown in Fig. 5. and 6. As shown in Fig. 6, the left output of the power supply provides the collector (output) voltage and the right output provides the base voltage.

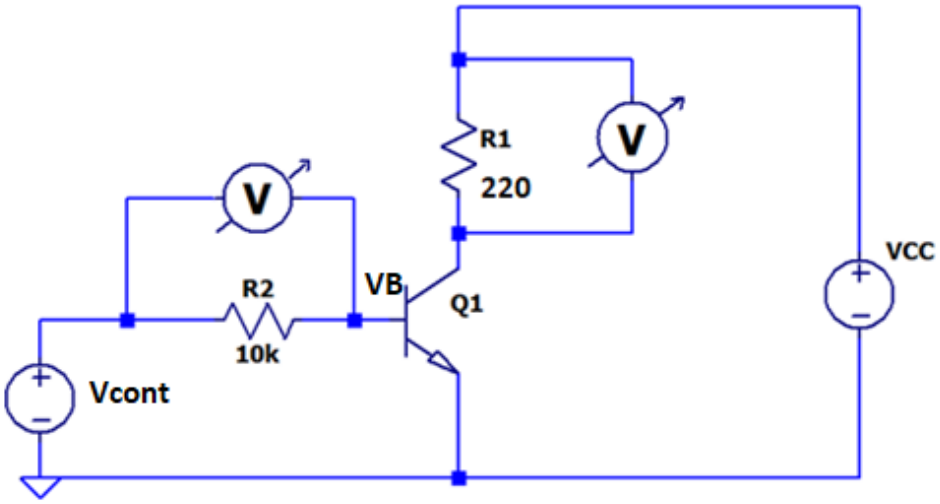


***Fig.4.*** Circuit diagram

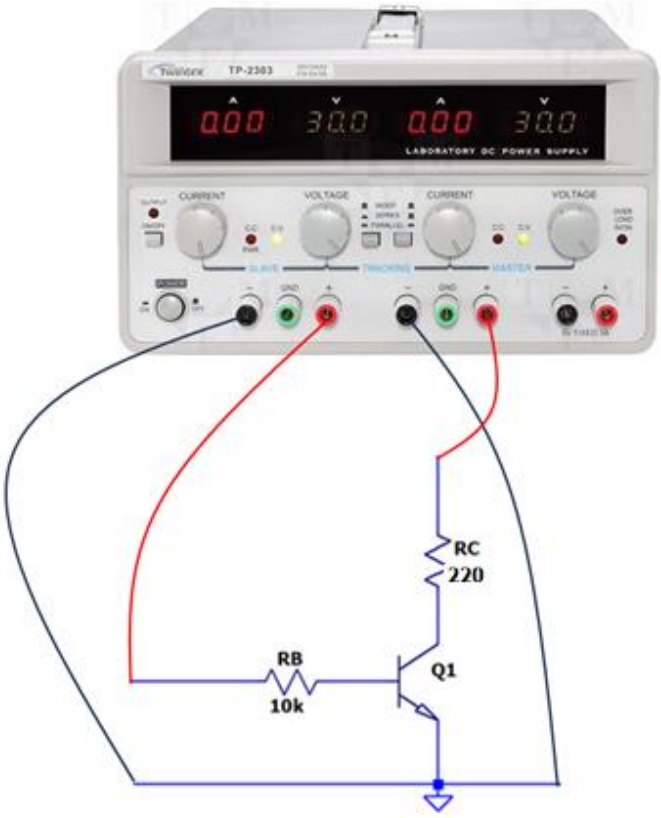


***Fig.5.*** Connecting power supply

During the measurement exercise, the voltage of the base resistance (RB) and the collector resistance (RC) are measured by a digital multimeter (see Fig. 6.)

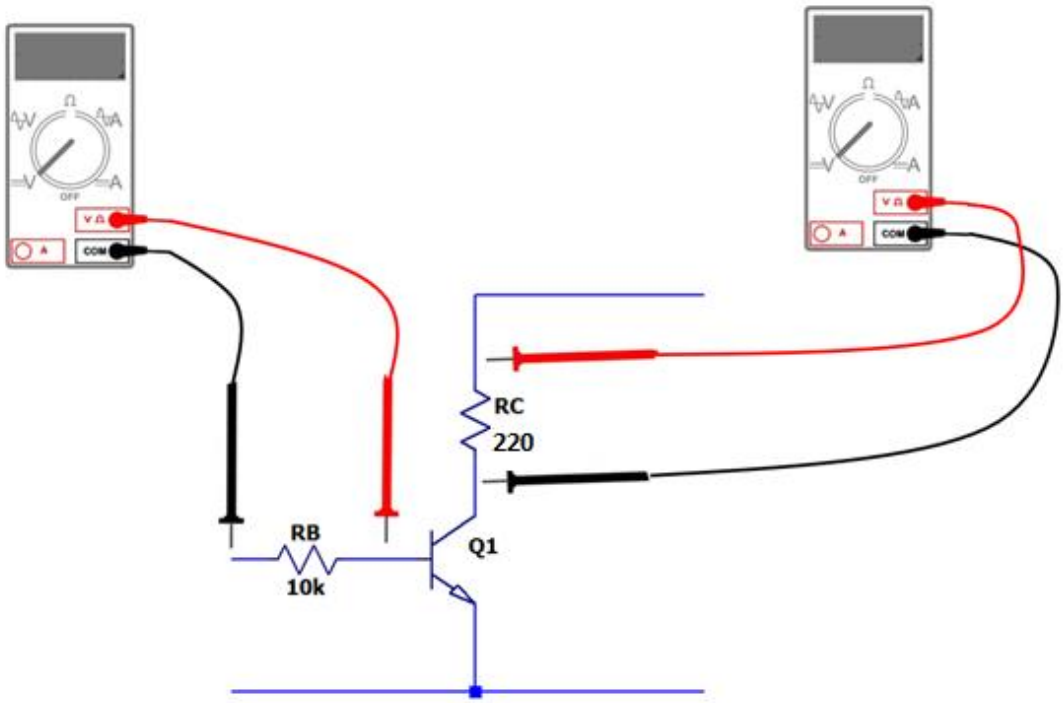


***Fig.6.*** Connecting power supply

The steps of measurement:

1. Build the circuit depicted in Fig. 5. using the NPN type BJT (Fig. 5. help!);
2. Adjust the left side of the power supply until it equals 2,5V (it is the control voltage ($V_{CONT}$)). Adjust the current limit to 0.5A!
3. Adjust the CH2 (right side) of the power supply until it equals 0V (it is the supply voltage ($V_{CC}$)). Adjust the current limit to 0.5A!
4. Use a digital multimeter to measure the voltage at resistor $R_B$. From this, you can later calculate the base current (IB) and base–emitter ($V_{BE}$) voltage. Record $V_{RB}$ before the Table 1.
5. Use a digital multimeter to measure the voltage at resistor $R_C$. From this, you can later calculate the collector (IC) current and collector–emitter ($V_{CE}$) voltage.
6. Record $V_{RC}$ in Table 1.
7. Repeat steps 5. – 6. above, with higher supply voltage. Use the values given in Table 1!

## 5. Measurement results

Table 1. shows the measurement results and calculated values. Of the values in Table 1, Vcc is a set value, $V_{RC}$ is a measured value, and the others are calculated values ( at the same time, the values of the following three quantities are constant during the measurement and are not included in Table 1.) After the calculations, determine if the diode of the base emitter or the base-collector is closed or open.

The base voltage ($V_B$) to be adjusted: 2V

The measured voltage at resistor $R_B$:……..

The calculated base–emitter voltage ($V_{BE}$): …….

The calculated base current ($I_B$): …….

***Table 1.*** Results of the measurement

| **Vcc [V]** | **$V_{RC}$ [V]** | **$V_{CE}$ [V]** | **$I_C$ [mA]** | **Current gain (β)** | **Base–emitter diode** | **Base–collector diode** |
|---|---|---|---|---|---|---|
| 0 | | | | | closed | closed |
| 0.5 | | | | | | |
| 1 | | | | | | |
| 1.5 | | | | | | |
| 2 | | | | | | |
| 2,5 | | | | | | |
| 3 | | | | | | |
| 3,5 | | | | | | |
| 4 | | | | | | |
| 4,5 | | | | | | |
| 5 | | | | | | |
| 5,5 | | | | | | |

## 5.1 Necessary equations

$$V_B = V_{RB} + V_{BE} \quad (1)$$

$$I_B = \frac{V_{RB}}{R_B} \quad (2)$$

$$V_{CE} = V_{CC} - V_{RC} \quad (3)$$

$$I_C = \frac{V_{RC}}{R_C} \quad (4)$$

$$\beta = \frac{I_C}{I_B} \quad (5)$$

The semiconductor is active region, if:

$$V_B > V_E \quad (6)$$

$$V_C > V_B \quad (7)$$

The semiconductor is cut-off region, if:

$$V_E > V_B \quad (8)$$

$$V_C > V_B \quad (9)$$

The semiconductor is in saturation region if:

$$V_E < V_B \quad (10)$$

$$V_C < V_B \quad (11)$$

Plot the output characteristics of the BJT ($I_C$ - $V_{CE}$)!

# 6. Conclusions