

ELECTROTECHNICS

INTRODUCTION, DC CIRCUITS

Doc. Ing. Stanislav Kocman, Ph.D.

4. 2. 2022, Ostrava

Study texts

- <http://fei1.vsb.cz/kat420/> (only in Czech)
- lectures presentations
- short texts to the lectures
 - recommended on-line literature
- seminars
 - examples
- instructions for lab measurements

Credit (exam) condition

86 ÷ 100 points

1

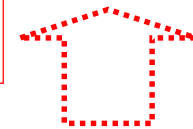
66 ÷ 85 points

2

51 ÷ 65 points

3

SUM



Final test

0 ÷ 35 points

+

**MAX
65 p.**

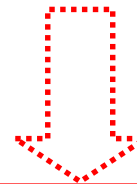
**20 points
Homework (examples)**

**25 points
Reports from lab
measurements**

**20 points
Test (examples)**

**MIN
40 p.**

SUM



**< 51 points
failed**

DC CIRCUITS

Example 1

Assignment

A bell is connected to a battery by long-distance two-wire line. Calculate a necessary value of the supply voltage of the battery if these parameters are done:

nominal voltage of the bell: $V_Z = 6 \text{ V}$

nominal current of the bell: $I_Z = 0,6 \text{ A}$

line length: $l = 70 \text{ m}$

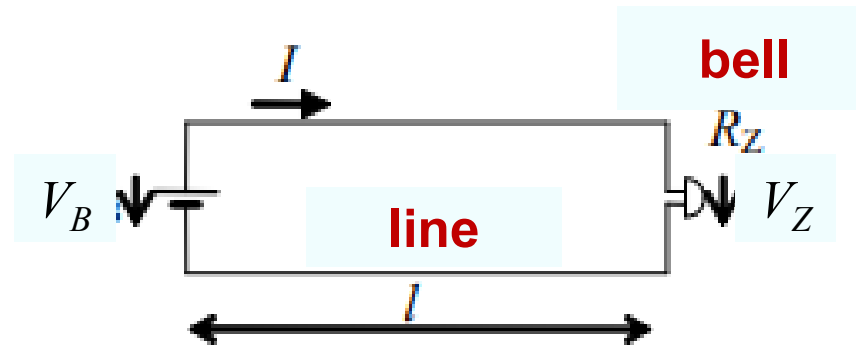
wire cross-section: $S = 0,5 \text{ mm}^2$

resistivity of copper $\rho_{\text{Cu}} = 0,0175 \cdot 10^{-6} \text{ } \Omega \cdot \text{m}$

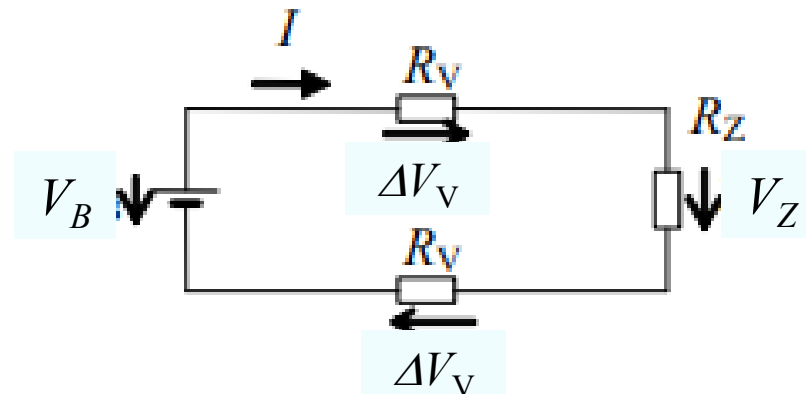
DC CIRCUITS

Example 1

Wiring diagram, substitution diagram



wiring diagram



substitution diagram

DC CIRCUITS

Example 1

Solution

To calculate the voltage of the supply battery we use

2. Kirchhoff's law: $V_B = \Delta V_V + \Delta V_V + V_Z$

Voltage drop on wires: $\Delta V_V = R_V \cdot I_Z$

Wire resistance: $R_V = \rho_{\text{Cu}} \cdot \frac{l}{S} = 0,0175 \cdot 10^{-6} \cdot \frac{70}{0,5 \cdot 10^{-6}} = 2,45 \Omega$

Voltage drop on 1 wire: $\Delta V_V = R_V \cdot I_Z = 2,45 \cdot 0,6 = 1,47 \text{ V}$

Required battery voltage:

$$V_B = \Delta V_V + \Delta V_V + V_Z = 1,47 + 1,47 + 6 = 8,94 \text{ V}$$

Chosen battery voltage: **9 V**

Conclusion: not to neglect voltage drops

DC CIRCUITS

Example 2

Assignment

Electrodynamic measuring system of an analog measuring instrument has parameters as follows:

allowed (maximum) voltage $V_m = 0,3 \text{ V}$

allowed (maximum) current $I_m = 1 \text{ mA}$

Measuring system will be used for voltage measurement (voltmeter), and for current measurement (ammeter).

Calculate:

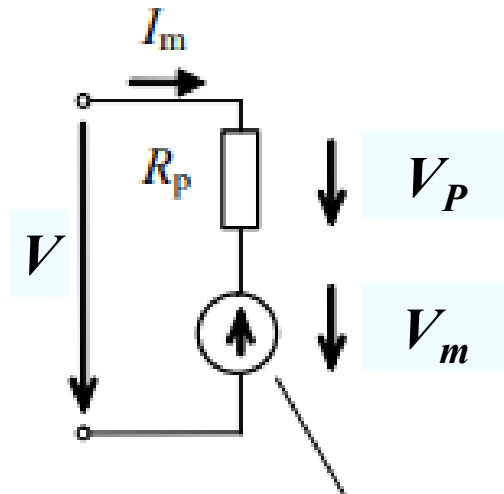
- 1. Parameters R_p a P_p (resistance and power) of series resistor for voltage measurement with range of 10 V**
- 2. Parameters R_b a P_b of parallel resistor (shunt) for current measurement with range of 10 A**

DC CIRCUITS

Example 2

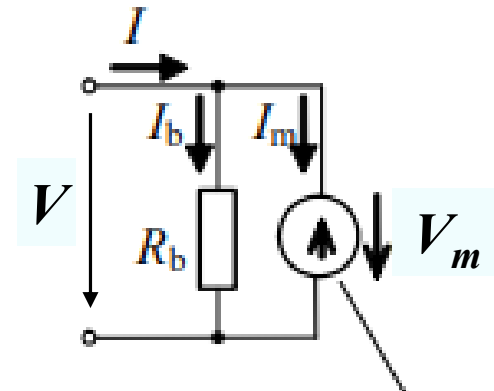
Wiring diagram

Voltage meas. (voltmeter)



measuring system

Current meas. (ammeter)



measuring system



DC CIRCUITS

Example 2

Solution for voltage measurement

To calculate the parameters of series resistor we must know its voltage and current.

Voltage: 2. Kirchhoff's law:

$$V_p = V - V_m = 10 - 0,3 = 9,7 \text{ V}$$

Resist.: $R_p = \frac{V_p}{I_m} = \frac{9,7}{1 \cdot 10^{-3}} = 9700 \text{ } \Omega$

Power: $P_p = V_p \cdot I_m = 9,7 \cdot 1 \cdot 10^{-3} = 9,7 \text{ mW}$

DC CIRCUITS

Example 2

Solution for current measurement

To calculate the parameters of parallel resistor we must know its voltage and current.

Current: 1. Kirchhoff's law:

$$I_b = I - I_m = 10 - 0,001 = 9,999 \text{ A}$$

Resist.: $R_b = \frac{V_m}{I_b} = \frac{0,3}{9,999} = 0,03 \text{ } \Omega$

Power: $P_b = V_m \cdot I_b = 0,3 \cdot 9,999 = 3 \text{ W}$

DC CIRCUITS

Example 3

Assignment

Calculate current I_2 flowing across resistor R_2 in the circuit shown in the scheme. Entered parameters:

Source voltage $V = 10\text{ V}$

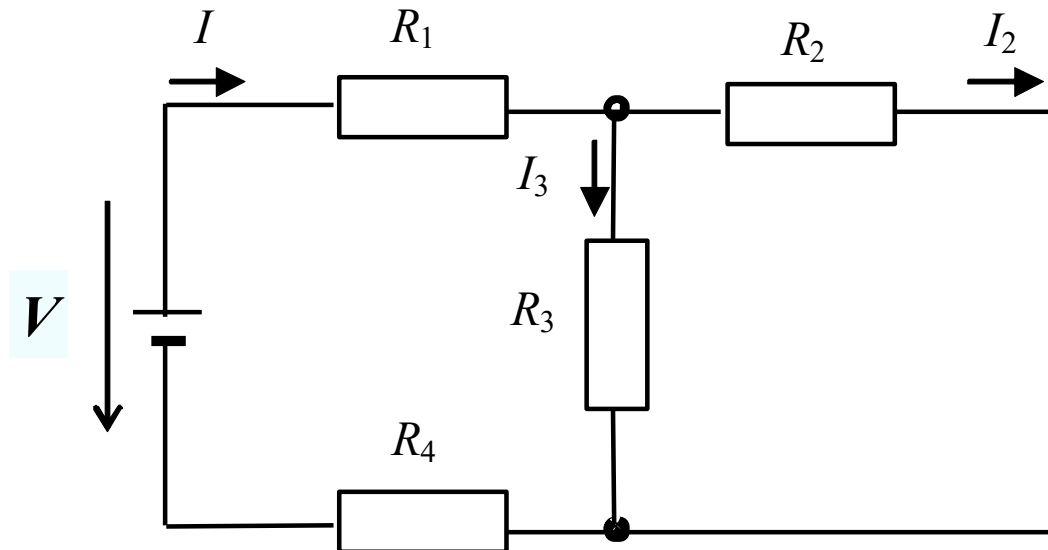
Resistor resistances: $R_1 = 1000\ \Omega$, $R_2 = 2000\ \Omega$, $R_3 = 2000\ \Omega$, $R_4 = 1000\ \Omega$

For the calculation the method **step-by-step simplification** will be used.

DC CIRCUITS

Example 3

Wiring diagram



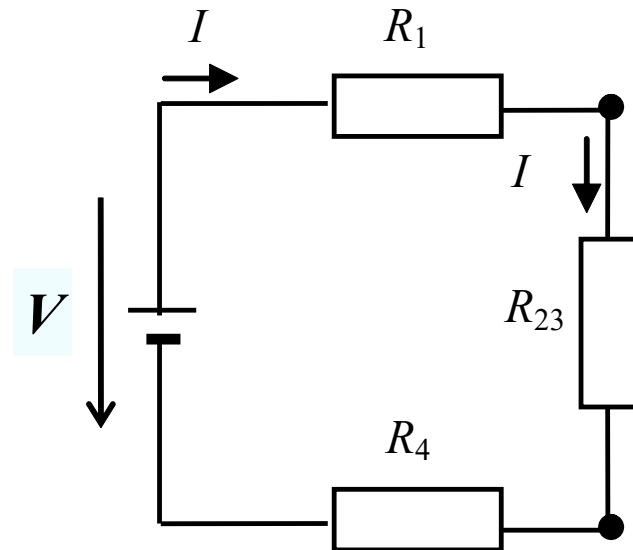
DC CIRCUITS

Example 3

Solution

Using the method step-by-step simplification the total resistance will be determined

$$\frac{1}{R_{23}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2000} + \frac{1}{2000} \rightarrow R_{23} = 1000\Omega$$

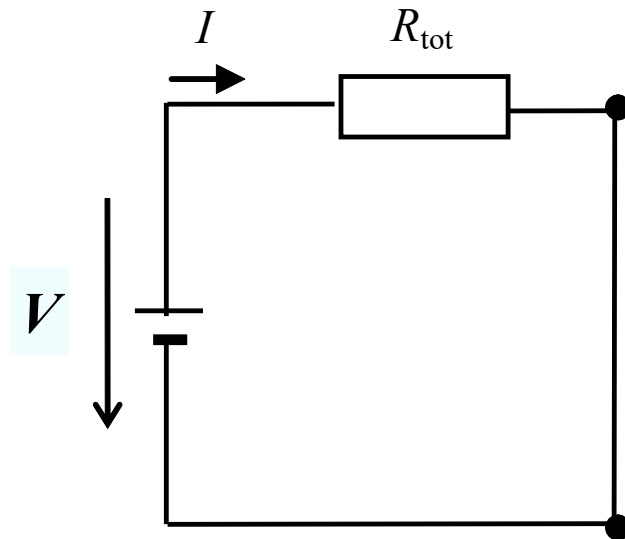


DC CIRCUITS

Example 3

Solution

$$R_{\text{tot}} = R_1 + R_{23} + R_4 = 1000 + 1000 + 1000 = 3000 \, \Omega$$



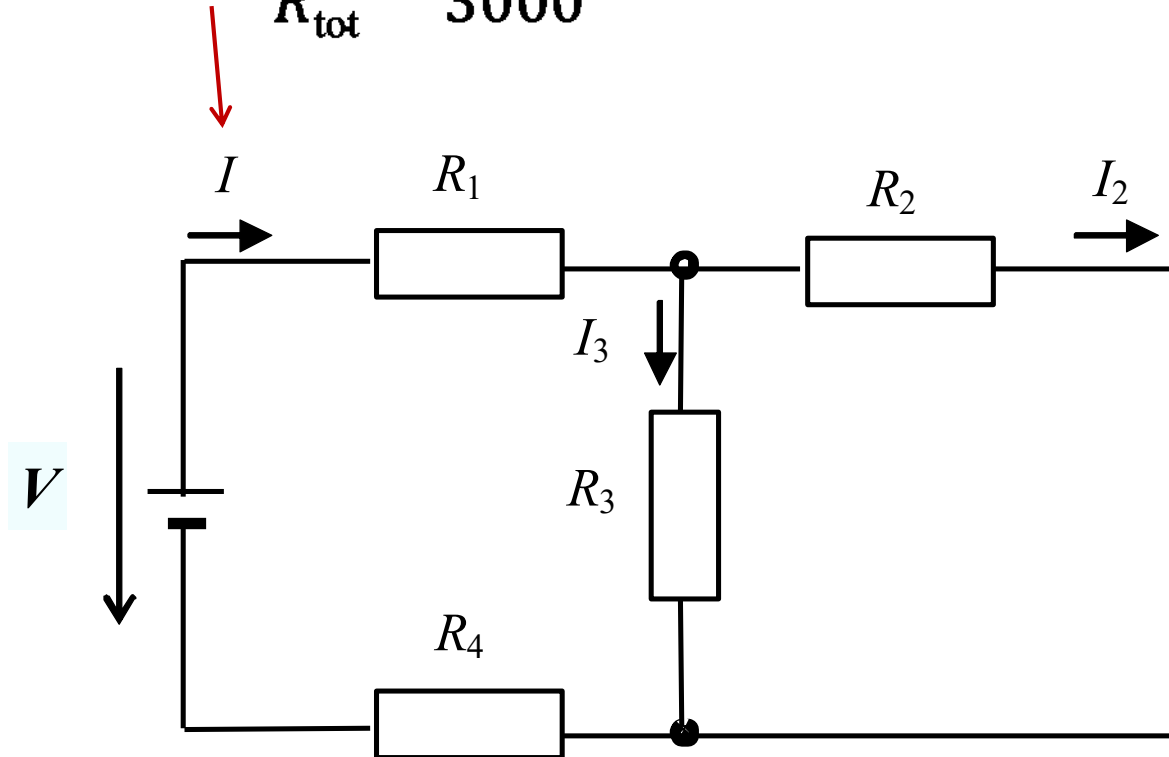
DC CIRCUITS

Example 3

Solution

The total current calculation

$$I = \frac{V}{R_{\text{tot}}} = \frac{10}{3000} = 0,0033 \text{ A} = 3,3 \text{ mA}$$



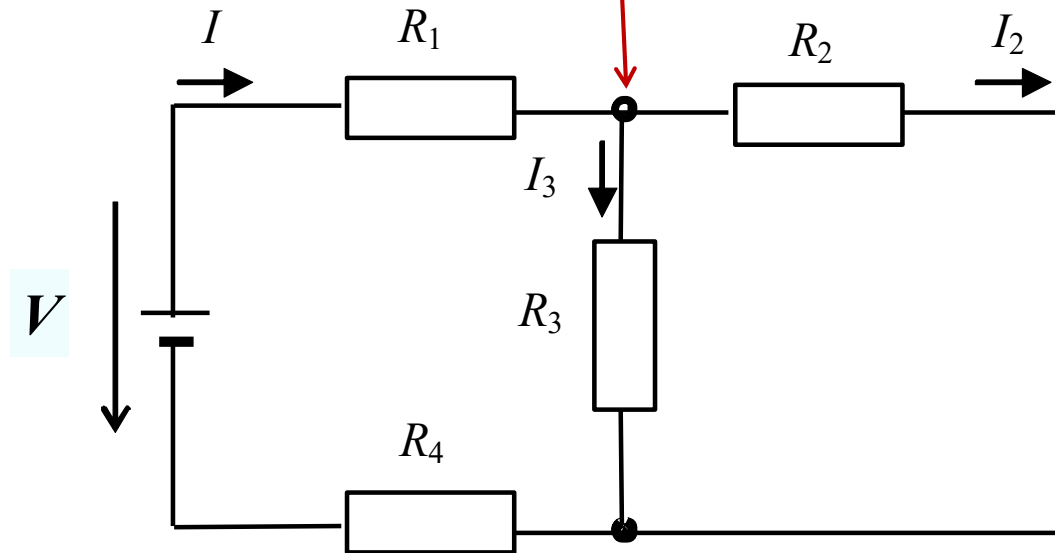
DC CIRCUITS

Example 3

Solution

The current I_2 calculation procedure

1. Kirchhoff's law: $I = I_2 + I_3$



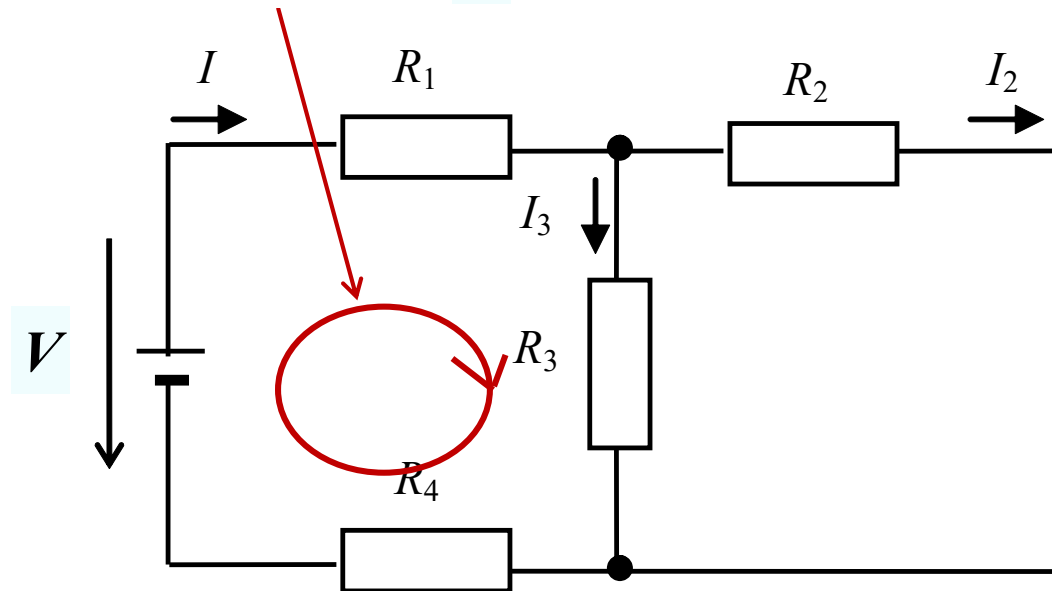
Note: the current I_3 is not known

DC CIRCUITS

Example 3

Solution

2. Kirchhoff's law: $V = IR_1 + I_3R_3 + IR_4$



$$V_3 = I_3R_3 = V - IR_1 - IR_4 = 10 - 0,0033 * 1000 - 0,0033 * 1000 = 3,33 V$$

$$I_3 = \frac{V_3}{R_3} = \frac{3,33}{2000} = 0,00165 A \rightarrow I_2 = I - I_3 = 0,00165 A$$