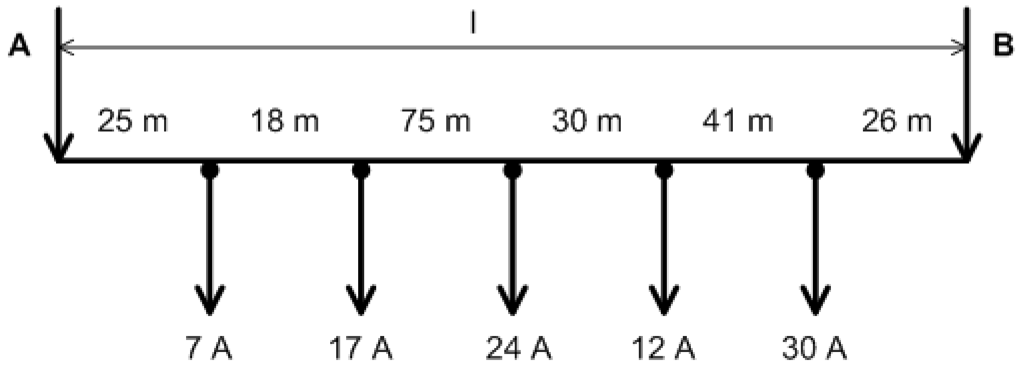
Simple DC line

Ex. 1: DC double-wire line with nominal voltage 220 V is supplied from both sides as shown. The feeders have the same voltages ($U_A = U_B = 231$ V). Aluminium conductors have the same nominal cross-section 16 mm^2. Calculate the maximal voltage drop. Calculate the voltage drop if one feeder has a failure.



Total line length:

$$l = 25 + 18 + 75 + 30 + 41 + 26 = 215 \text{ m}$$

The sum of consumption currents:

$$I = \sum_{1}^{5} I_K = 7 + 17 + 24 + 12 + 30 = 90 \text{ A}$$

Current from feeder A (current moment to the feeder B):

$$I_A = \frac{\sum_{1}^{5} I_K \cdot l_{KB}}{l} =$$

$$= \frac{30 \cdot 26 + 12 \cdot (41 + 26) + 24 \cdot (30 + 41 + 26) + 17 \cdot (75 + 30 + 41 + 26) + 7 \cdot (18 + 75 + 30 + 41 + 26)}{215} = 38 \text{ A}$$

Current from feeder B (current moment to the feeder A):

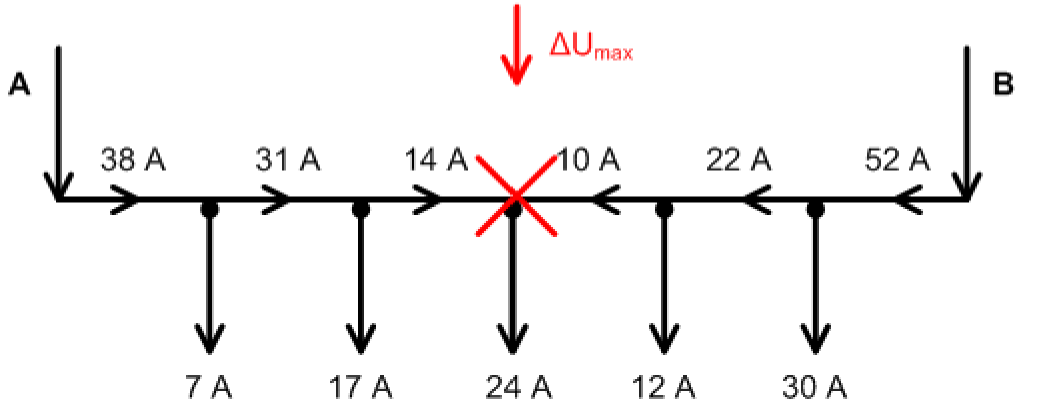
$$I_B = \frac{\sum_{1}^{5} I_K \cdot l_{KA}}{l} =$$

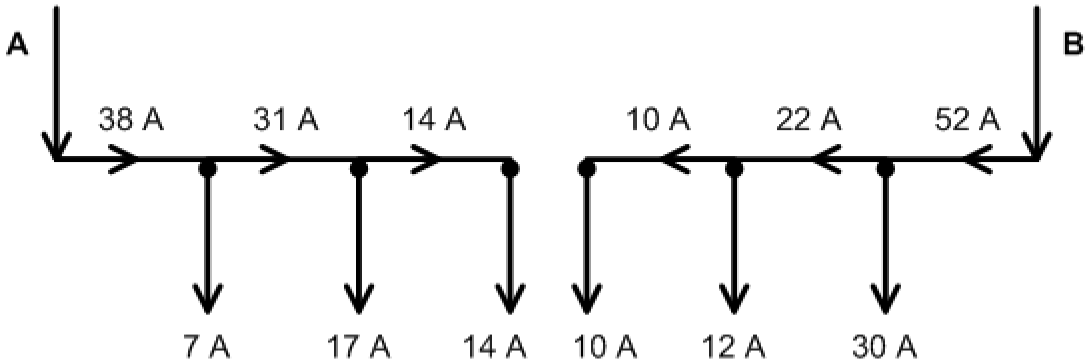
$$= \frac{7 \cdot 25 + 17 \cdot (18 + 25) + 24 \cdot (75 + 18 + 25) + 12 \cdot (30 + 75 + 18 + 25) + 30 \cdot (41 + 30 + 75 + 18 + 25)}{215} = 52 \text{ A}$$

For the check-up:

$$I = I_A + I_B \quad \Rightarrow \quad 90 \quad \text{A} \quad = (38 + 52) \quad \text{A} \quad \Rightarrow \quad \text{souhlasí}$$

Current distribution is in the figure. The place with the biggest voltage drop is marked with a cross. In this point the line can be split-up into two one-feeder lines.





The solution of one-feeder line supplied from feeder A.

$$\Delta U = \frac{2 \cdot \rho}{S} \cdot \sum_{1}^{3} I_K \cdot l_K = \frac{2 \cdot 0{,}03}{16} \cdot [7 \cdot 25 + 17 \cdot (25 + 18) + 14 \cdot (25 + 18 + 75)] = 9{,}5 \text{ V}$$

$$\varepsilon = \frac{\Delta U}{U_n} = \frac{9{,}5}{220} = 4{,}4\ \%$$

The same solution for one-feeder line supplied from feeder B.

Failure of feeder B:

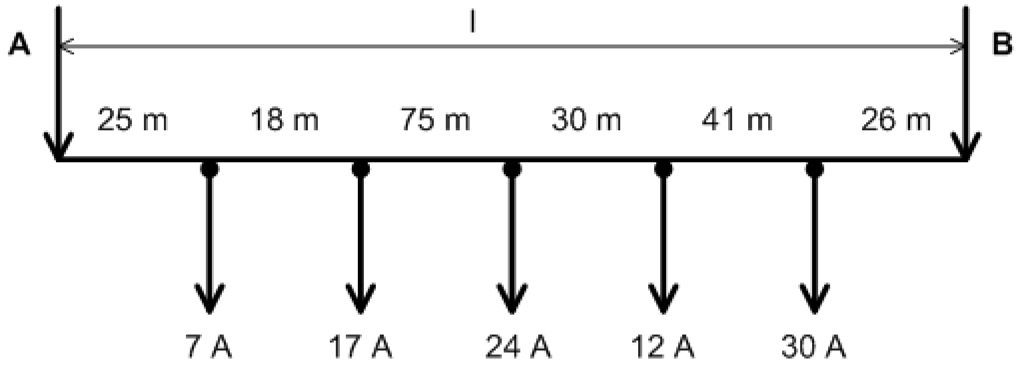
$$\varepsilon_{maxA} = \frac{2 \cdot \rho}{S \cdot U_n} \cdot \sum_{k=1}^{5} I_K \cdot l_K = 19{,}1\ \%$$

Failure of feeder A:

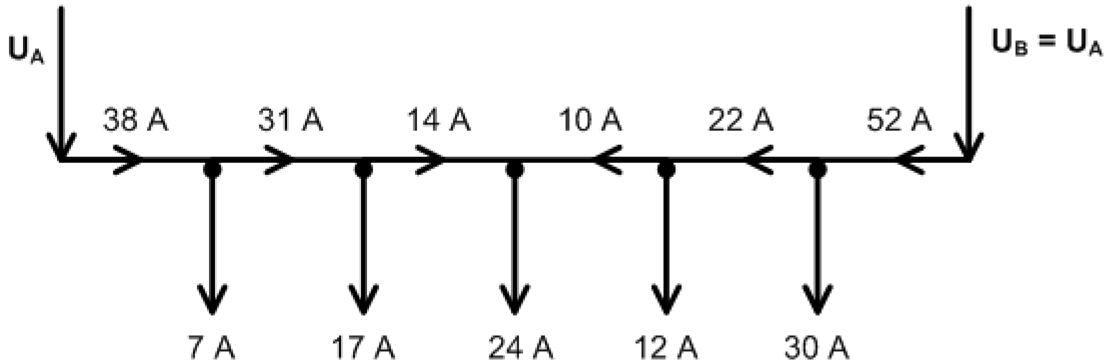
$$\varepsilon_{maxB} = \frac{2 \cdot \rho}{S \cdot U_n} \cdot \sum_{k=1}^{5} I_K \cdot (l - l_K) = 13{,}9\ \%$$

(For both solutions of emergency state voltage drops are too high.)

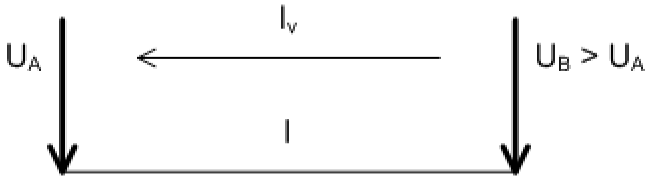
Ex. 2: DC double-wire line with nominal voltage 220 V is supplied from both sides as shown. The feeders has different voltages $U_A = 231$ V, $U_B = 240$ V. Aluminium conductors have the same nominal cross-section 16 mm^2. Find the place with the biggest voltage drop and calculate the biggest percentage voltage drop.



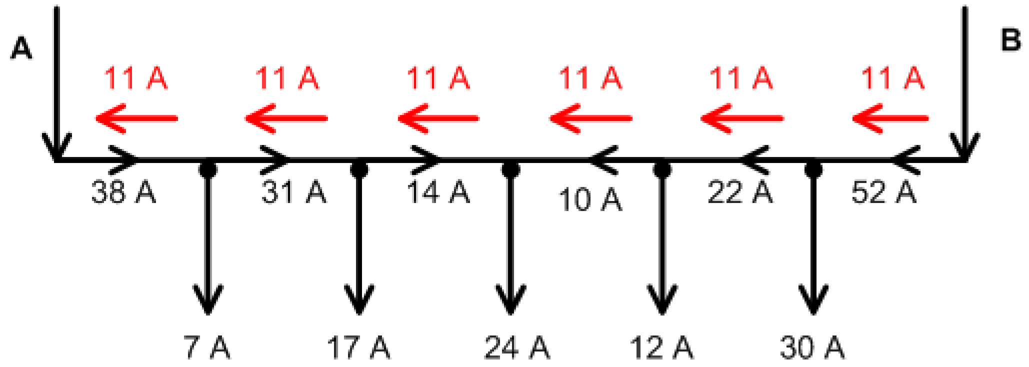
First it is assumed that the voltages of both feeders are equal. Hence we calculate the load currents of feeder A and feeder B. Then we make a current distribution along the line. (Values are the same as in example 1).



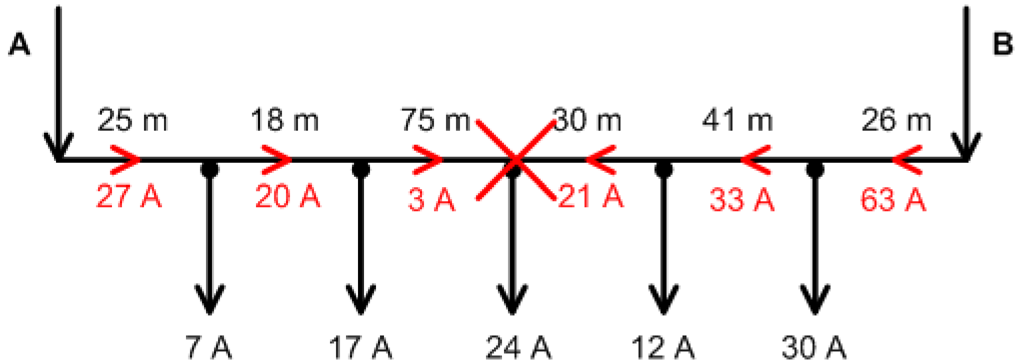
Balancing current caused by different voltages of feeders:



$$I_v = \frac{U_B - U_A}{\frac{2 \cdot \rho}{S} \cdot l} = \frac{240 - 231}{\frac{2 \cdot 0{,}03}{16} \cdot 215} \doteq 11\ \text{A}$$



Current distribution is shown. The point of the biggest voltage drop is marked with a cross.



Voltage drop from feeder A to the point with the biggest voltage drop:

$$\Delta U_{\max A} = \frac{2 \cdot \rho}{S} \cdot \sum_{k=1}^{3} I_K \cdot l_K = \frac{2 \cdot 0{,}03}{16} \cdot [7 \cdot 25 + 17 \cdot (25 + 18) + 3 \cdot (25 + 18 + 75)] = 4{,}6\ \mathrm{V}$$

$$\varepsilon_{\max A} = \frac{\Delta U_{\max A}}{U_n} = 2{,}1\ \%$$

Voltage drop from feeder B to the point with the biggest voltage drop:

$$\Delta U_{\max B} = \frac{2 \cdot \rho}{S} \cdot \sum_{k=3}^{5} I_K \cdot (l - l_K) = \frac{2 \cdot 0{,}03}{16} \cdot [30 \cdot 26 + 12 \cdot (26 + 41) + 21 \cdot (26 + 41 + 30)] = 13{,}6\ \mathrm{V}$$

$$\varepsilon_{\max B} = \frac{\Delta U_{\max B}}{U_n} = 6{,}2\ \%$$