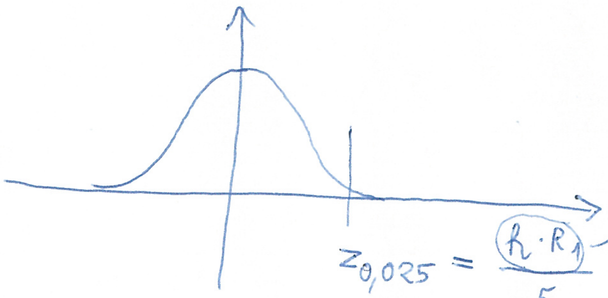
3.21. $R_1 = 2{,}2\,k\Omega \qquad R_2 = 10\,k\Omega \qquad R_3 = 22\,k\Omega$

$h = 1\% \qquad p = 95\%$

$h_e = ? \qquad p_e = 90\%$



$$z_{0,025} = \frac{h \cdot R_1}{\sigma_1}$$

$h \cdot R_1$ → hiba

σ_1 → viszonyítási alap

$$\sigma_1 = \frac{h \cdot R_1}{z_{0,025}} = \frac{0{,}01 \cdot 2{,}2\,k\Omega}{1{,}96} = 11{,}22\,\Omega$$

$$\sigma_2 = \frac{h\,R_2}{z_{0,025}} = 51{,}02\,\Omega$$

$$\sigma_3 = \frac{h\,R_3}{z_{0,025}} = 112{,}2\,\Omega$$

Re = R1 + R2 + R3

$$\sigma_e = \sqrt{\sum_{k=1}^{3} \left(c_k^2 \cdot \sigma_k^2\right)} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2} = 123{,}76\,\Omega$$

$$c_k = 1$$

$$h_e = \frac{z_{0,05} \cdot \sigma_e}{R_e} = \frac{1{,}65 \cdot 123{,}76\,\Omega}{34{,}2 \cdot 10^3\,\Omega} = \underline{\underline{0{,}597\%}}$$

3.19. $u(U) = \sigma_u \qquad u(I) = \sigma_I \qquad U = 1V \quad \sigma_u = 0{,}01V$

$I = 1mA \quad \sigma_i = 10\,\mu A$

$$R = \frac{U}{I} \qquad C_U = \frac{1}{I} \qquad C_I = -\frac{U}{I^2}$$

$$R = 1\,k\Omega \qquad u(R) = \sqrt{c_u^2 \cdot u^2(U) + c_I^2 \cdot u^2(I)} = 0{,}0141\,k\Omega$$

3\. 16.

$x = 2000\,m \pm 0{,}5\%$
$t = 2000\,s \pm 0{,}1\%$ → normális, $p = 90\%$

$k = 2$

$$u_x = \frac{h_x \cdot x}{z_{0{,}05}} = \frac{0{,}5 \cdot 10^{-2} \cdot 2000}{1{,}65}\,m = 6{,}06\,m$$

$$u_t = \frac{h_t \cdot t}{z_{0{,}05}} = \frac{0{,}1 \cdot 10^{-2} \cdot 2000}{1{,}65}\,s = 1{,}21\,s$$

$$v = \frac{x}{t} \qquad c_x = \frac{\partial v}{\partial x} = \frac{1}{t} \qquad c_t = \frac{\partial v}{\partial t} = -\frac{x}{t^2}$$

$$u = \sqrt{c_x^2 \cdot u_x^2 + c_t^2 u_t^2} = 3{,}09 \cdot 10^{-3}\,\frac{m}{s} = 0{,}00309\,\frac{m}{s}$$

$$v = 1{,}0000\,(\overset{k=2}{62})\,\frac{m}{s}$$

2\.9*

$R_1 = 1\,k\Omega \qquad h_1 = 0{,}01\%$
$R_2 = 10\,k\Omega \qquad h_2 = 0{,}1\%$
$R_3 = 100\,k\Omega \qquad h_3 = 1\%$
$R_4 = 1\,M\Omega \qquad h_4 = 10\%$

$p = 99\%$

$$u_1 = \frac{h_1 \cdot R_1}{\underset{2{,}58}{z_{0{,}005}}} = 0{,}04\,\Omega$$

~~$u_2 = u_3 = u_4 = 0{,}04\,\Omega$~~

$u_2 = \cancel{0{,}4\,\Omega}\ 4\,\Omega$

$u_3 = \cancel{40\,\Omega}\ 400\,\Omega \qquad u_4 = \cancel{40\,\Omega}\ 40k\Omega$

$p_e = 90\%$

$$c_i = \frac{1}{R_i^2 \cdot \left(\sum_{i=1}^{4} \frac{1}{R_i}\right)^2}$$

$$u = \sqrt{\sum c_i^2 \cdot u_i^2} = \sqrt{4 \cdot \left(\frac{u_1}{R_1^2 \cdot \left(\sum_{i=1}^{4} \frac{1}{R_i}\right)^2}\right)^2} = \sqrt{\cancel{4} \cdot \frac{0{,}04 \cdot 900{,}9^2}{10^6 \cdot 900{,}09^2}} =$$

$$= \cancel{0{,}36\,\Omega}\ 0{,}065\,\Omega$$

~~$k = 4$~~ → $\cancel{0{,}36}\ 0{,}065 \cdot 1{,}64 = \cancel{0{,}59\,\Omega}\ 0{,}11\,\Omega$

3.34. $R = 100,123 \pm 0,046\,\Omega$

$T_0 = 20\,°C$

$T = 26\,°C \quad \alpha = 2 \cdot 10^{-5}\,\frac{1}{°C}$

$U_i = [138,75\,mV \quad 138,78\,mV \quad 138,72\,mV \quad 138,69\,mV \quad 138,74\,mV]$

a/ $\hat{U} = \frac{1}{N} \cdot \sum_{i=1}^{N} U_i = 138,736\,mV$

$s = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (U_i - \hat{U})^2} = 33,615\,\mu V$

$u(U)_A = \frac{s}{\sqrt{N}} = 15,033\,\mu V$

b/ $h_m = \hat{U}\left[h_{o.v} + h_{o.r.} \frac{\overbrace{U_{max}}^{200\,mV}}{\hat{U}}\right] = 37,747\,\mu V \qquad h_{o.v} = 0,02\,\% \quad h_{o.r} = 0,005\,\%$

$u(U)_B = \frac{h_m}{\sqrt{3}} = 21,793\,\mu V$

egyenletes eloszlást feltételezve

$u(U) = \sqrt{u(U)_A^2 + u(U)_B^2} = 26,475\,\mu V$

c/ $\hat{R} = R_0\{1+\alpha[T - T_0]\} = 100,135\,\Omega$

Pontosabban: dR * (1+alpha*(T- T0)), de ez a "hiba hibája"

$u_R = u(R)_B = \frac{\Delta R}{\sqrt{3}} = \frac{0,046\,\Omega}{\sqrt{3}} = 0,0266\,\Omega$

egyenletes eloszlás

d/ $\hat{I} = \frac{\hat{U}}{\hat{R}} = 1{,}38549 \text{ mA}$

$$u_I = \sqrt{c_U^2 \cdot u^2(U) + c_R^2\, u^2(R)} = 4{,}53 \cdot 10^{-7}\,\text{A} = 0{,}453\,\mu\text{A}$$

$$c_U = \frac{1}{R} \qquad c_R = -\frac{U}{R^2}$$

2*0.453 uA = 0.906 uA ~ 0.91 uA

$k=2$

$$I = 1{,}38549(9\cancel{0}1)\text{ mA}$$

e/ 95%

~~4. 10.~~