1)

$$e_m = \frac{R_2}{R_2 - R_1}$$

R_1 [mΩ]	R_2 [mΩ]
2,01	0,53
2,04	0,54
2,03	0,52
2,02	0,51
2,04	0,53

Q 0,5 % + 2

(1)

$\overline{R_1} = 2{,}028\ m\Omega$

$\overline{R_2} = 0{,}526\ m\Omega$

$S(R_1) = 0{,}015\ m\Omega$

$S(R_2) = 0{,}0114\ m\Omega$

$$\bar{e}_m = \frac{\overline{R_2}}{\overline{R_2} - \overline{R_1}}$$

$\bar{e}_m = -0{,}350199$

$\mu_c(\overline{R_1}) = ?$

$\mu_c(\overline{R_2}) = ?$

$$\mu^2(e_m) = \left[\frac{d\,e_m}{dR_1}\,\mu_c(R_1)\right]^2 + \left[\frac{d\,e_m}{dR_2}\,\mu_c(R_2)\right]^2$$

$$\mu_c(x) = \sqrt{\mu_A^2(x) + \mu_B^2(x)}$$

$$\left[\frac{d\,e_m}{dR_1} = \frac{0(R_2 - R_1) - R_2(-1)}{(R_2 - R_1)^2} = \frac{R_2 - R_1 + R_2}{(R_2 - R_1)^2} = \frac{R_2}{(R_2 - R_1)^2}\right]$$

$$\left[\frac{d\,e_m}{dR_2} = \frac{(R_2 - R_1) - R_2(1)}{(R_2 - R_1)^2} = \frac{R_2 - R_1 - R_2}{(R_2 - R_1)^2} = \frac{-R_1}{(R_2 - R_1)^2}\right]$$

$$\mu_A(R_1) = \frac{S(R_1)}{\sqrt{n}} = \frac{0{,}015\ m\Omega}{\sqrt{5}} = 6{,}708\ m\Omega$$

$$\mu_A(R_2) = \frac{S(R_2)}{\sqrt{n}} = \frac{0{,}0114\ m\Omega}{\sqrt{5}} = 5{,}098\ m\Omega$$

$$\mu_B(R_1) = \frac{\Delta R_1}{\sqrt{3}}$$

$$\Delta R_1 = \left(\frac{\varepsilon_r\ \%}{100} + \frac{n}{c_i}\right) R_{1\,ind}$$

$$\Delta R_1 = \left(\frac{0{,}5}{100} + \frac{2}{2{,}028}\right) 2{,}028\ m\Omega$$

$$\Delta R_1 = 0{,}01212\ m\Omega$$

$$\mu_B(R_2) = \frac{\Delta R_2}{\sqrt{3}} \qquad \Delta R_2 = \left(\frac{0,5}{100} + \frac{2}{0,526} \right) 0,526\,m\Omega$$

$$\Delta R_2 = 0,00463\,m\Omega$$

$\mu_B(R_1) = 6,99749\,10^{-6}\,\Omega$ $\qquad \mu_A(R_1) = 6,708\,m\Omega$

$\mu_B(R_2) = 2,67313\,10^{-6}\,\Omega$ $\qquad \mu_A(R_2) = 5,098\,m\Omega$

$$\mu_C(R_1) = \sqrt{\mu_A^2(R_1) + \mu_B^2(R_1)}$$

$\mu_C(R_1) = 6,70800\,10^{-3}\,\Omega$ $\qquad \mu_B(R_1) = 0,006997\,10^{-3}\,\Omega$

$\mu_C(R_2) = 5,09800\,10^{-3}\,\Omega$ $\qquad \mu_B(R_2) = 0,002673\,10^{-3}\,\Omega$

$$\frac{dem}{dR_1} = 0,23315\,10^{3}\,\Omega$$

$$\frac{dem}{dR_2} = -0,09893\,10^{3}\,\Omega$$

$$\mu^2(em) = \left[\frac{dem}{dR_1} \mu_C(R_1) \right]^2 + \left[\frac{dem}{dR_2} \mu_C(R_2) \right]^2$$

$$\mu(em) = 4,84 = 0,004842$$

$$U(em) = \overset{K}{2}\, \mu(em) = 0,009684$$

$$em = (-0,3501 \pm 0,0097)$$

2)

$\Delta v = V_1 - V_2$

V_1 [mV]	V_2 [mV]	
2,404	0,54	V_1
2,502	0,58	1% + 2c
2,603	0,51	
2,104	0,50	V_2
2,204	0,56	0,5% + 4c

$\overline{V_1} = 2,3634\ mV$

$\overline{V_2} = 0,538\ mV$

(2)

$S(V_1) = 0,20673\ mV$

$S(V_2) = 0,03334\ mV$

$\mu_A(V_1) = \frac{S(V_1)}{\sqrt{n}} = 0,09245\ mV$

$\mu_A(V_2) = \frac{S(V_2)}{\sqrt{n}} = 0,014910\ mV$

$\mu_B(V_1) = \left(\frac{cr}{100} + \frac{n}{ci}\right) \cdot \frac{V_{1ind}}{\sqrt{3}} = \left(\frac{1}{100} + \frac{2}{23634}\right) \cdot \frac{2,3634mV}{\sqrt{3}}$

$\mu_B(V_1) = 0,013760\ 10^{-3}\ V$

$\mu_B(V_2) = \left(\frac{0,5}{100} + \frac{4}{538}\right) \frac{0,538mV}{\sqrt{3}}$

$\mu_B(V_2) = 0,003862\ 10^{-3}\ V$

$\mu_C(V_1) = \sqrt{\mu_A^2(V_1) + \mu_B^2(V_1)}$

$\mu_C(V_1) = 0,09346\ 10^{-3}\ V$

$\mu_C(V_2) = 0,01540\ 10^{-3}\ V$

$\mu^2(\Delta V) = \left[\mu_C(V_1)\frac{d\Delta V}{V_1}\right]^2 + \left[\mu_C(V_2)\frac{d\Delta V}{dV_2}\right]^2$

$\frac{d\Delta V}{V_1} = 1$

$\frac{d\Delta V}{V_2} = -1$

$\mu(\Delta V) = 0,094720\ 10^{-3}\ V$

$\mu(\Delta V) \cdot 2 = U(\Delta V) = 0,18944\ 10^{-3}\ V$

$\overline{\Delta V} = 1,8254\ mV$

$\Delta V = (1,82 \pm 0,19)\ mV$

9)

$V_{out} = V_{off} + a_s\, g\, \mathrm{Sen}(\theta)$

Ref	θ [°]	V_{off} [V]
$\bar{x}$	30,028	20,03
(s) σ	0,01304	0,01581
N	5	5

θ 0,1 % + 0,5°

V 0,5 % + 2c

$\mu_A(\theta) = \frac{0,01304}{\sqrt{5}} = 0,00583$

Sens a_s = 800mV/g

$g = 9,80665 \frac{m}{s^2}$

$\mu_A(V_{off}) = \frac{0,01581}{\sqrt{5}} = 0,007070$

$\mu_B(\theta) = \left(\frac{\varepsilon_i}{100} + \frac{n}{c_i}\right)\frac{\bar{\theta}}{\sqrt{3}} = \left(\frac{0,1}{100} + \frac{0,5}{30028}\right)\cdot\frac{30,028}{\sqrt{3}}$

$\mu_B(\theta) = 0,017625$

$\mu_B(V_{off}) = \left(\frac{0,5}{100} + \frac{2}{2003}\right)\frac{20,03}{\sqrt{3}}$

$\mu_B(V_{off}) = 0,06936$

$\mu^2(V_{out}) = \left[\mu_c(V_{off})\frac{dV_{out}}{dV_{off}}\right]^2 + \left[\frac{dV_{out}}{d\theta}\mu_c(\theta)\right]^2$

$\left[\frac{dV_{out}}{dV_{off}} = 1\right]$ $\quad \frac{dV_{out}}{d\theta} = a_s\, g \cos\theta$

$\left[\frac{dV_{out}}{d\theta} = 800mV \cdot 9,80665 \frac{m}{s^2} \cos\theta\right]$ (30,028)

$\mu_c(\theta) = \sqrt{\mu_A(\theta)^2 + \mu_B(\theta)^2}$

$\mu_c(\theta) = 0,01785642°$

$\mu_c(V_{off}) = \sqrt{\mu_A(V_{off})^2 + \mu_B(V_{off})^2}$

$\mu_c(V_{off}) = 0,069719\ V$

$$\mu^2(V_{out}) = (0,067919)^2 + 0,165328\,10^{-3}$$

$$\mu(V_{out}) = 0,069125\ V$$

$$U(V_{out}) = k\,\mu(V_{out}) = 0,138250\ V$$

(3)

$$\overline{V_{out}} = 20,43033$$

$$\boxed{V_{out} = (20,43 \pm 0,14)\ V}$$

4)

$$R_1 = \frac{V_1}{I_1}$$

$$R_1 = V_1\, I_1^{-1}$$

$$\overline{R_1} = 0,003734\ m\Omega$$

V_1 [mV]	I_1 [mA]
2,021	0,541
2,023	0,542
2,026	0,544
2,021	0,543
2,021	0,538

V_1
0,5 % + 1 c

I_1 1 % + 3 c

Q. Corr = 0,63

$$\overline{V_1} = 2,0224\ mV$$

$$\overline{I_1} = 0,5416\ mA$$

$$s(\overline{V_1}) = 2,19089\ mV$$

$$s(\overline{I_1}) = 2,30217\ \mu A$$

$$\mu_A(\overline{V_1}) = \frac{s(\overline{V_1})}{\sqrt{5}} = 0,979795\ mV$$

$$\mu_A(\overline{I_1}) = \frac{s(\overline{I_1})}{\sqrt{5}} = 1,029561\ \mu A$$

$$\mu_B(\overline{V_1}) = \left(\frac{Er}{100} + \frac{n}{a}\right)\frac{\overline{V_1}}{\sqrt{3}} = \left(\frac{0,5}{100} + \frac{1}{2\,0224}\right)\frac{2,0224\,mV}{\sqrt{3}}$$

$$\mu_B(\overline{V_1}) = 0,00589959\ mV$$

$$\mu_B(\overline{I_1}) = \left(\frac{1}{100} + \frac{3}{5416}\right)\frac{0,5416\,mA}{\sqrt{3}}$$

$$\mu_B(\overline{I_1}) = 0,00330013\ mA = 3,30013\ \mu A$$

$$\mu_C(V_1) = \sqrt{\mu_A(V_1)^2 + \mu_B(V_1)^2} = 0{,}9799812\ 10^{-3}\ V$$

$$\mu_C(I_1) = \sqrt{\mu_A(I_1)^2 + \mu_B(I_1)^2} = 3{,}4574004\ 10^{-6}\ A$$

$$\left[\frac{dR}{dV} = \frac{1}{I_1} = \frac{1}{0{,}5416mA}\right] \left[\frac{dR}{dI} = -\frac{V_1}{I_1^2} = \frac{-2{,}0224mV}{(0{,}5416mA)^2}\right]$$

$$\mu^2(R) = \left[\mu_C(V_1)\left(\frac{1}{I_1}\right)\right]^2 + \left[\mu_C(I_1)\left(-\frac{V_1}{I^2}\right)\right]^2$$

$$\mu(R) = 1{,}809\,26 = 0{,}001809263\ m\Omega$$

$$U(R) = 0{,}63\,\mu(R) = 1{,}139835913\ 10^{-6} = 0{,}001139835\ 10^{-3}$$

$$\boxed{R = (0{,}0037 \pm 0{,}0011)\ m\Omega}$$

5)

$$V_o = (H_1 - H_o)\ K_H\ S\ A_V$$

$$A_V = 1 + \frac{50K\Omega}{R6}$$

H_o [m]	H_1 [m]	R_6 [mΩ]
0,145	4,525	10,1
0,123	4,524	11,1
0,145	4,521	11,2
0,145	4,553	12,1
0,143	4,551	11,2

R 0,5 % +2 C

H 0,3 %

$\bar{H_o} = 0{,}1402m$ $S(H_o) = 4{,}654014$

$\bar{H_1} = 4{,}5346m$ $S(H_1) = 0{,}015786$

$\bar{R_6} = 11{,}14m\Omega$ $S(R_6) = 0{,}709224$

$V_o = 77348{,}62766\ V$

$A_V = 4498331{,}341$

Sen S

$K_H = 9{,}810\ \frac{KPa}{m}$

$S = 0{,}4\ \frac{mV}{KPA} \pm 3{,}75\ \%$

$\mu_A(H_o) = 4{,}3174\ mm$

$\mu_A(H_1) = 7{,}0597\ mm$

$\mu_A(R_6) = 0{,}3171\ m\Omega$

$\mu_B(H_o) = 0{,}004324m$

$\mu_B(H_1) = 0{,}010056m$

$\mu_B(R_6) = 0{,}320179m\Omega$

$$\mu_B(H_o) = \left(\frac{ES}{100} + \frac{n}{ci}\right)\frac{\bar{H_o}}{\sqrt{3}} = 0{,}004324m$$

$$\mu_C(H_o) = \sqrt{\mu_A(H_o)^2 + \mu_B(H_o)^2} = 6{,}1103941\ 0^{-3}\ m$$

$$\mu c(H_1) = \sqrt{\mu_A(H_1)^2 + \mu_B(H_1)^2} = 0{,}012702 \text{ m}$$

$$\mu c(R6) = \sqrt{\mu_A(R6)^2 + \mu_B(R6)^2} = 0{,}317100 \text{ m}\Omega$$

$$\mu c^2(V_0) = \left[\frac{dV_0}{dH_0}\mu c(H_0)\right]^2 + \left[\frac{dV_0}{dH_1}\mu c(H_1)\right]^2 + \left[\frac{dV_0}{dR6}\mu c(R6)\right]^2$$

(4)

$$+\left[\frac{dV_0}{dS}\mu(S)\right]^2$$

$$\frac{dV_0}{dH_0} = -K_H S\left(\overbrace{1+\frac{50k\Omega}{R6}}^{A_V}\right) = -17612{,}21218 \text{ V/m}$$

$$\frac{dV_0}{dH_1} = K_H S\left(\overbrace{1+\frac{50k}{R6}}^{A_V}\right) = 17612{,}21219 \text{ V/m}$$

$$\frac{dV_0}{dR6} = \frac{-50k}{R6}(H_1 - H_0) K_H S = -77398{,}61041 \text{ V/}\Omega$$

$$\frac{dV_0}{ds} = (H_1 - H_0) K_H \left(1+\frac{50k}{R6}\right) = 193299324{,}9 \text{ hpa}$$

$$\mu c(V_0) = 724807246 68{,}8$$

$$U(V_0) = 2 \cdot \mu c(V_0) = 1449744938 \rightarrow \text{me dió } \underline{\text{muy grande}}.$$

$$V_0 = (\quad \pm \quad) \text{ V}$$