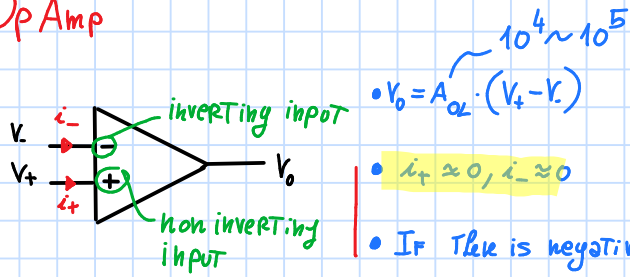
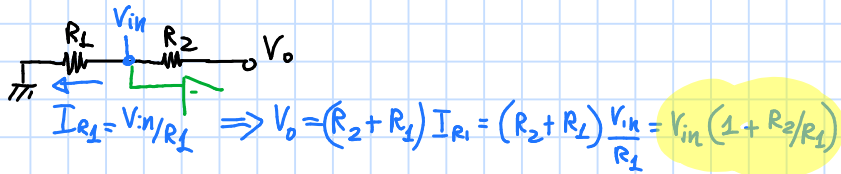
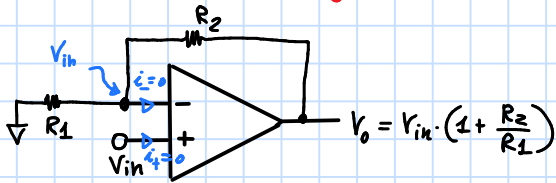


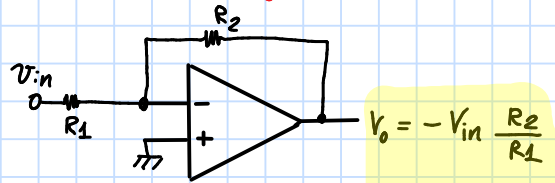
Op Amp



• Non inverting Configuration

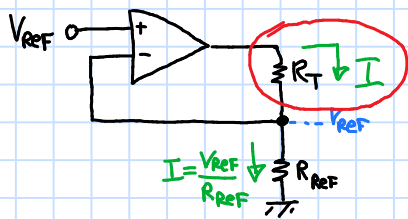


• Inverting Configuration

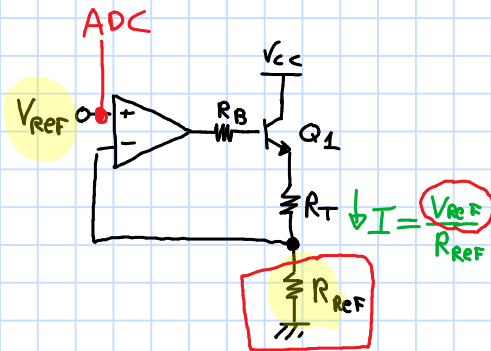


• Website:

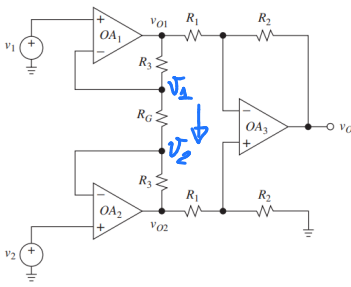
→ CURRENT GENERATOR



\Rightarrow



Instrument Amplifier (INA)



- $V_0 = G \cdot (V_2 - V_1)$

$$G = \left(1 + \frac{2R_3}{R_G}\right) \frac{R_2}{R_1}$$

LM358 $\approx 0,4\text{€}$

AD623 $\approx 5\text{€}/\text{chip}$

- Differential voltage: $V_D = V_2 - V_1$

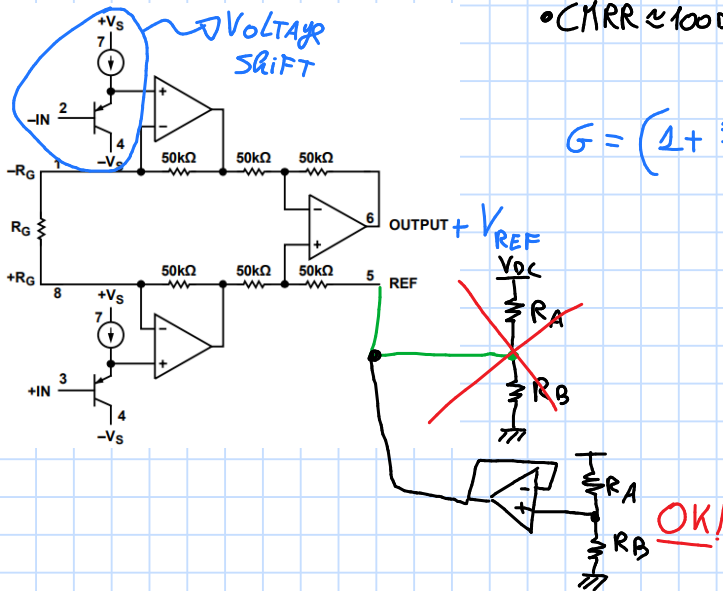
- Common Mode voltage: $V_{CM} = \frac{V_2 + V_1}{2}$

$$V_D = \frac{G}{A_D} \cdot V_D + \frac{A_{CM}}{A_D} \cdot V_{CM}$$

- $CMRR_{dB} = 20 \cdot \log_{10} \left(\frac{A_D}{A_{CM}} \right)$

\uparrow
= 100 dB
AD623

• AD623

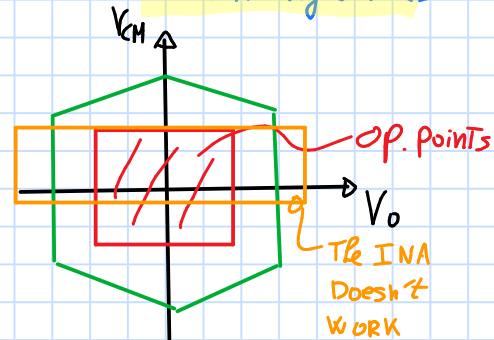


- $CMRR \approx 100\text{ dB}$

$$G = \left(1 + \frac{100k\Omega}{R_G}\right)$$

- Operating Limit

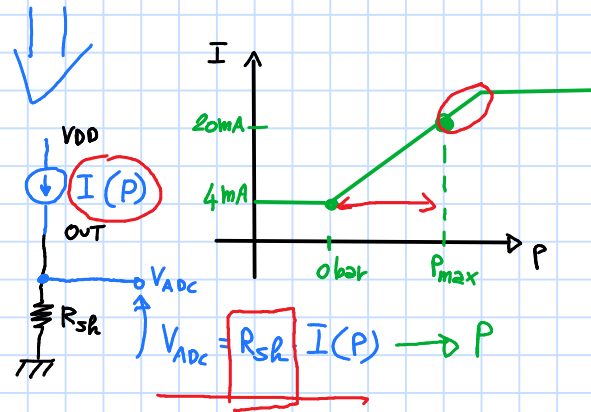
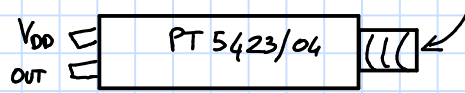
→ Tool: Diamond Plot
From Analog Devices



• Pressure Sensor

- PT5402 (100 bar)
- PT5423 (60 bar)

From iFm



$$I(P) = 20 \text{ mA} \Rightarrow V_{adc} = 3,3 \text{ V} \Rightarrow R_{sh} = \frac{V_{adc}}{I(P)} = 165 \Omega$$

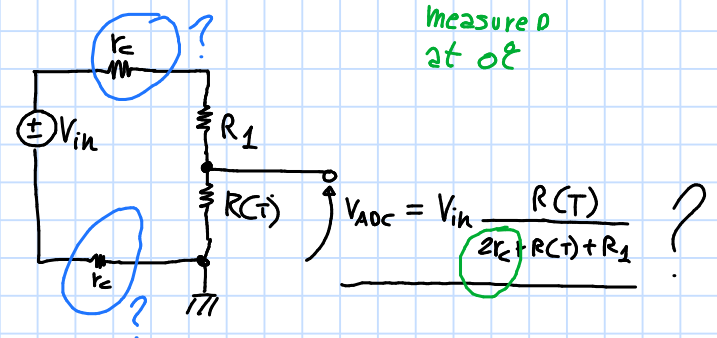
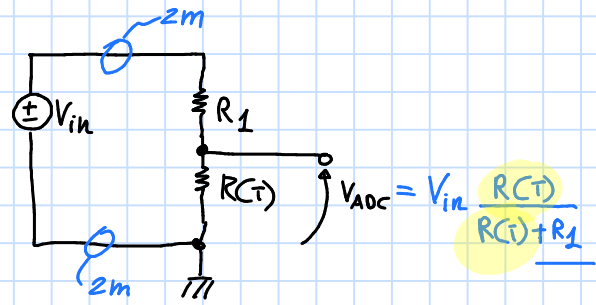
$$P_R = R_{sh} \cdot I(P)^2 = \underline{0,066 \text{ W}}$$

Temperature Sensor

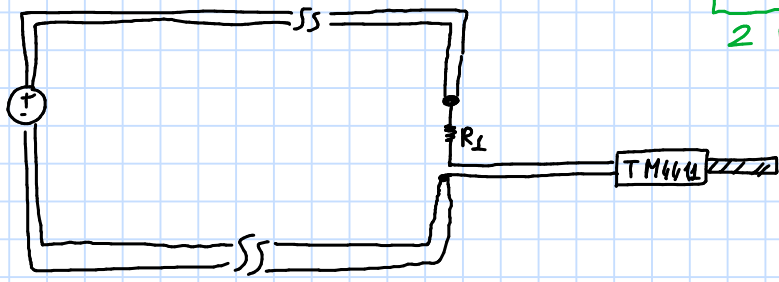
- TM4411 (~100€) + Precise, + reliability
 - NBPTCO-176 (~2€) → 2 wires
- 4 wires sensor
 $T_{MAX} \approx 150^\circ C$
 100 bar max

$$R(T) = R_0 [1 + \alpha T]$$

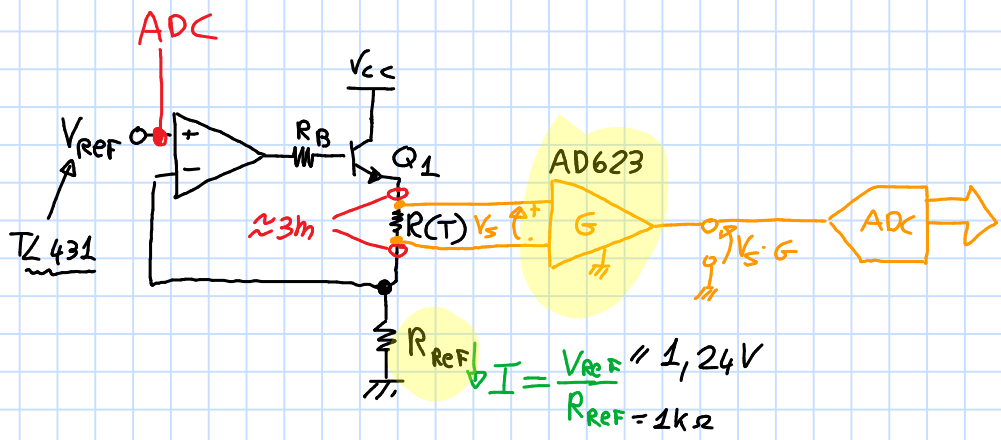
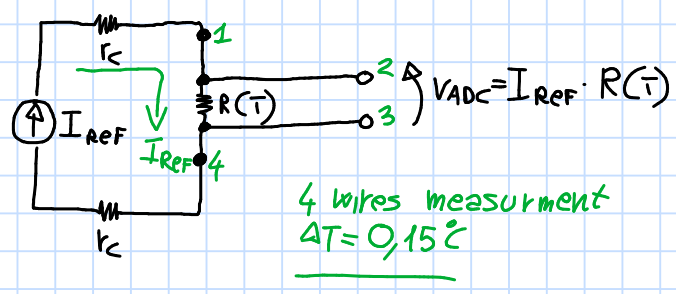
Resistance measure 0 at 0°
 3850 ppm

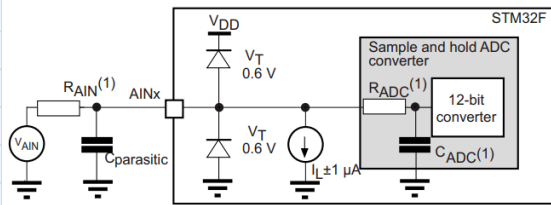


2 wires measurement $\Delta T = T_{meas} - T_{real} \approx 2^\circ C$



→ 4 wire measurement





$$f_{clk} = 25 \text{ MHz}$$

$$T_{conv} = 15 \text{ ADC clock cycles}$$

$$T_{smp} = 28 \text{ "}$$

$$C_{ADC} \approx 7 \text{ pF} \quad R_{ADC} = 6 \text{ K}\Omega$$

Equation 1: R_{AIN} max formula

$$R_{AIN} = \frac{(k - 0.5)}{f_{ADC} \times C_{ADC} \times \ln(2^{N+2})} - R_{ADC}$$

The formula above (Equation 1) is used to determine the maximum external impedance allowed for an error below 1/4 of LSB. $N = 12$ (from 12-bit resolution) and k is the number of sampling periods defined in the ADC_SMPR1 register.