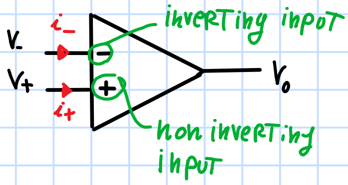
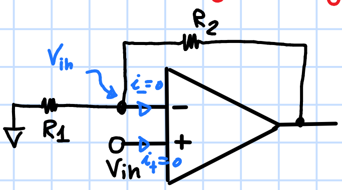
Op Amp

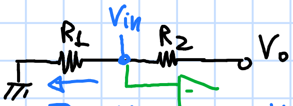


- $V_o = \overset{10^4 \sim 10^5}{A_{OL}} \cdot (V_+ - V_-)$
- $i_+ \approx 0,\ i_- \approx 0$
- If There is negative Feedback: $V_+ = V_-$

• Non inverting Configuration

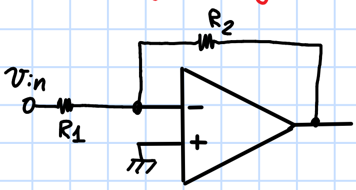


$V_o = V_{in} \cdot \left(1 + \frac{R_2}{R_1}\right)$



$I_{R_1} = V_{in}/R_1 \Rightarrow V_o = (R_2 + R_1)\, I_{R_1} = (R_2 + R_1)\frac{V_{in}}{R_1} = V_{in}\left(1 + R_2/R_1\right)$

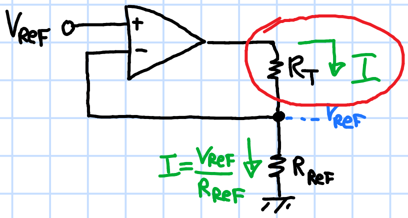
• Inverting Configuration



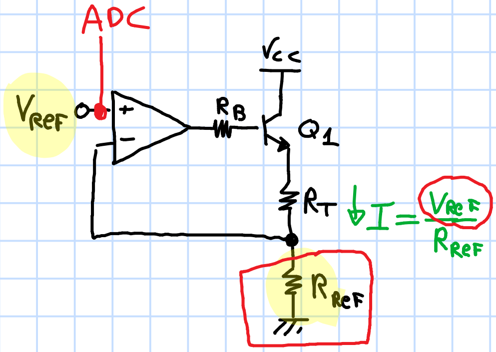
$V_o = -V_{in}\frac{R_2}{R_1}$

- Website:

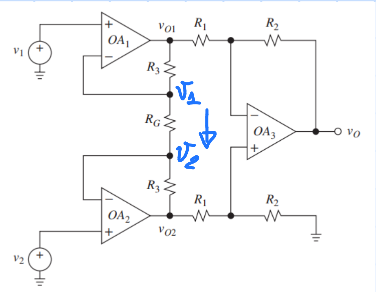
→ Current generator



$\Rightarrow$



Instrument Amplifier (INA)



LM 358 ≈ 0,4 €
AD623 ≈ 5 € / chip

- $v_o = G \cdot (v_2 - v_1)$

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

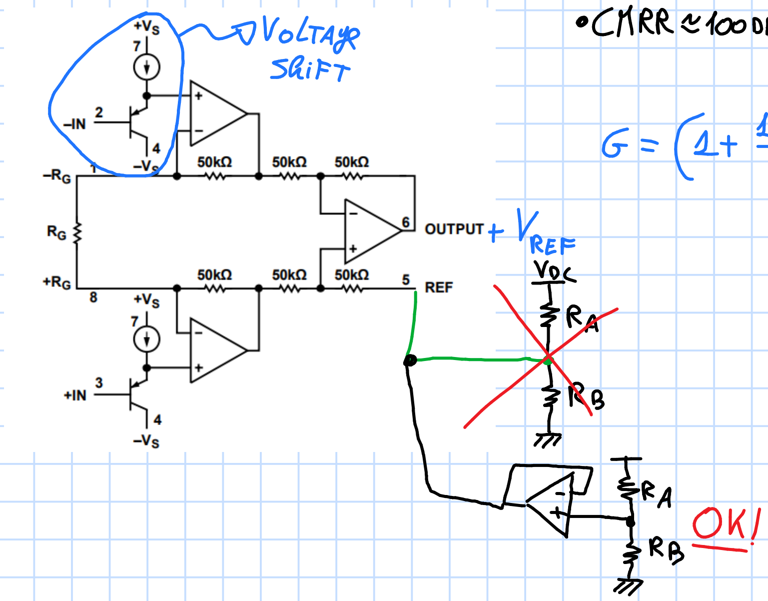
- Differential voltage: $V_D = V_2 - V_1$
- Common Mode voltage: $V_{CM} = \frac{V_2 + V_1}{2}$

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

- $CMRR_{DB} = 20 \cdot \log_{10}\left(\frac{A_D}{A_{CM}}\right) = 100\text{ DB}$

AD623

• AD623

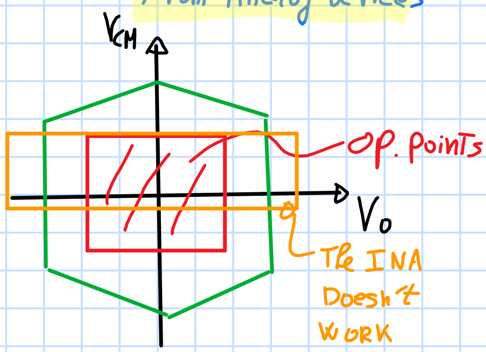


- CMRR ≈ 100 DB

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

- Operating Limit

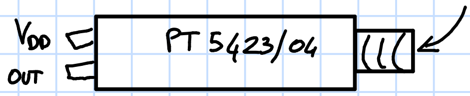
→ Tool: Diamond Plot
From Analog Devices

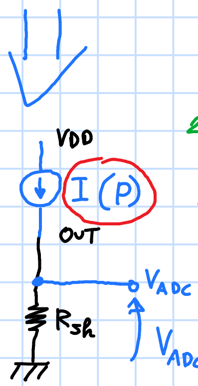


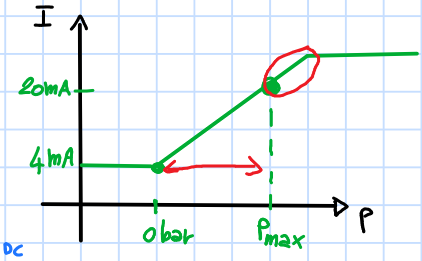
• Pressure Sensor

- PT5402 (100 bar)
- PT 5423 (60 bar)

From iFm







$V_{ADC} = \boxed{R_{sh}}\, I(P) \longrightarrow P$

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

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

Temperature Sensor

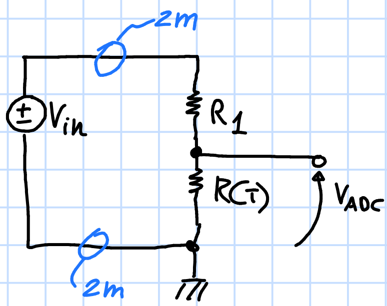
- TM4411 (~100€) + Precise, + reliability → 4 wires sensor; → $T_{MAX} \simeq 150°C$; → 100 bar max
- NBPTCO-176 (~2€) → 2 wires; → $T_{max} \simeq 600°C$

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

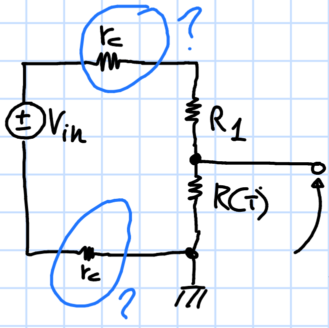
R_0: Resistance measured at 0°C

α: 3850 ppm

T: [°C]



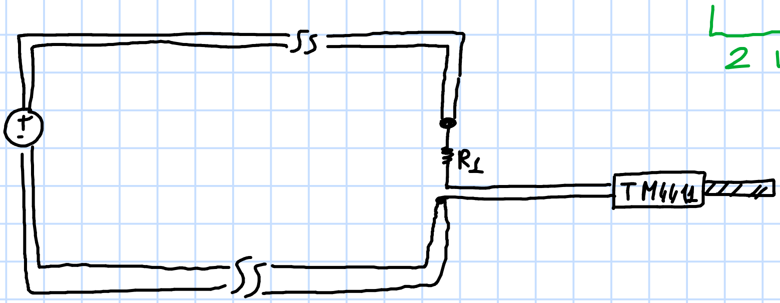
$V_{ADC} = V_{in} \frac{R(T)}{R(T)+R_1}$



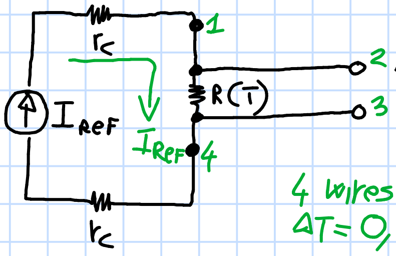
$V_{ADC} = V_{in} \frac{R(T)}{2r_c + R(T) + R_1}$?

2 wires measurement $\Delta T = T_{meas} - T_{real}$

$\approx 2°C$



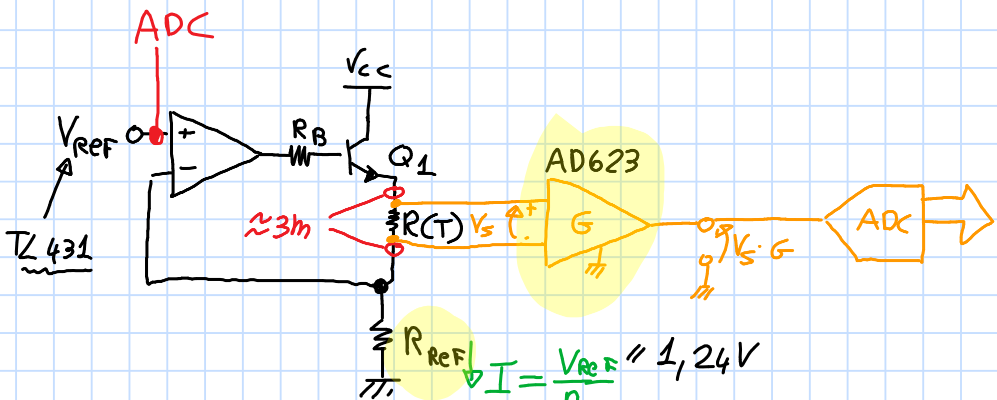
→ 4 wire measurement



$V_{ADC} = I_{Ref} \cdot R(T)$

4 wires measurment

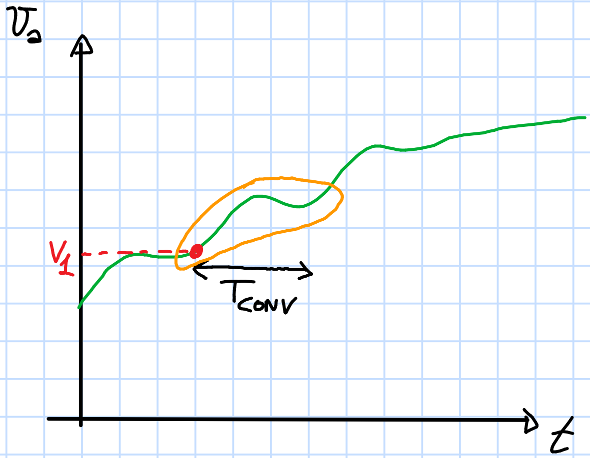
$\Delta T = 0{,}15°C$



$I = \frac{V_{Ref}}{R_{Ref}}$ // 1,24V

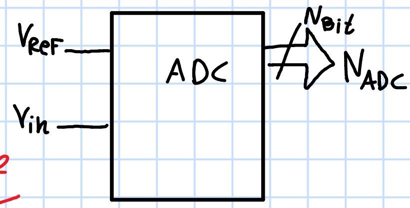
$R_{Ref} = 1k\Omega$

Note on ADC

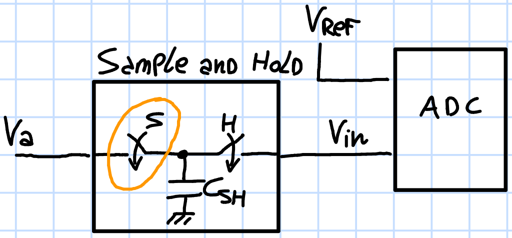


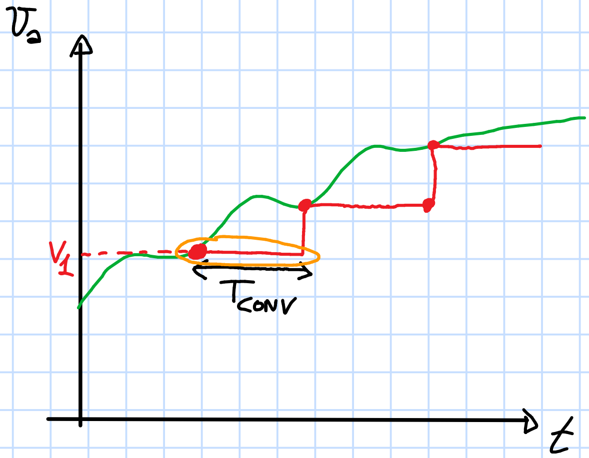
ADC $\Rightarrow$

$$N_{ADC}(V_{in}) = V_{in} \cdot \frac{2^{12}}{V_{REF}}$$

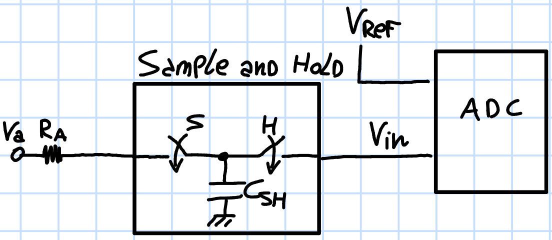


- Sample and Hold

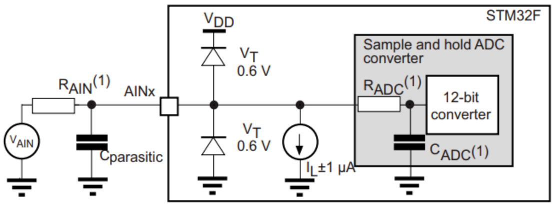




- On STM32 It's possible to select The Time interval in which S is closed



$\tau = R_A \cdot C_{SH}$



$f_{clk} = 25\,MHz$

$T_{conv} = 15$ ADC clock cycles
$T_{samp} = 28$ " "

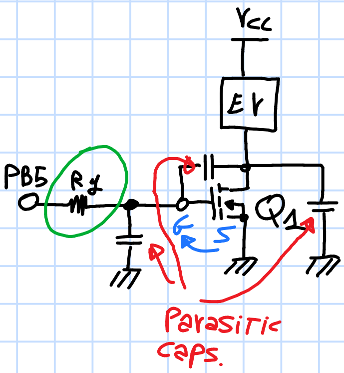
$C_{ADC} \approx 7pF$ $R_{ADC} = 6\,K\Omega$

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.

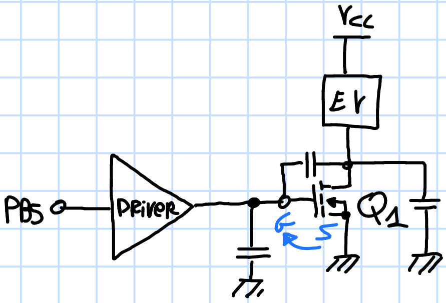
Note on Power Electronic



- Q_1 Turns on if $V_{GS} > V_{TR}$

✓ Rarerly Turn on/off

✓ if you have alot of time to turn on the MOSFET

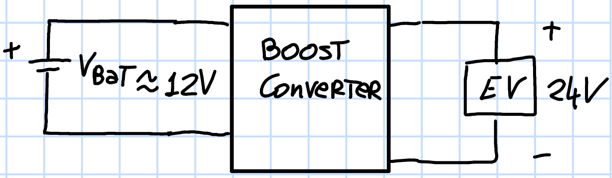


✓ Turn on/off FrequenTy

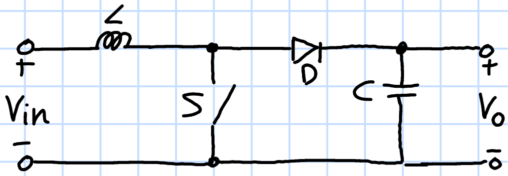
✓ Time Constraints

- IXDI602

- Supply voltage for EV



$\eta \simeq 95\%$

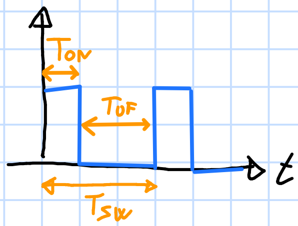


- First design

$V_{in} \in [6-12]V$
$V_o = 24V$
$P \cong 50W$

- Second design

$V_{in} \in [10-15]V$
$V_o = 24V$
$P_o = 120W$



$$\boxed{V_o = \frac{1}{1-D} \cdot V_{in}}$$

$T_{sw} = T_{ON} + T_{OFF}$

$D = \frac{T_{ON}}{T_{sw}}$ (duty cycle)

$T_{EV} = 250ms$

$I_{EV} = 3A \Rightarrow I_{cap} = 1A$

$i_c = C \frac{dV_c}{dt} \Rightarrow V_c = \frac{1}{C} \int i_c \cdot dt = \frac{I_{cap}}{C} \cdot T_{EV}$

ΔV

$\Rightarrow C = \frac{I_{cap} \cdot T_{EV}}{\Delta V} = 250mF$ ($\Delta V = 1V$) → It's Too Big