Analog Circuit Explanation:
Input general Charateristics:
- Normal Voltage Input: 0-5V
- Maximum Overvoltage: 29.4V

R1, R4 Voltage Divider is used to reduce the input range from 0-5V to 0-3.24V. Microcontrolled ADCs can withstand at maximum 3.3V so the Voltage divider must be chosen with a safety factor

R1, C2 create an RC Filter. It is necessary to filter all High Frequency noise that can be injected in the line by the harness. RC cutoff frequency must be chosen accordingly to the sensor connected in the Analog port. In the schematics all Filter Caps are identical value, but the board can be easily modified when harness design will be 100% defined

D3 is used to protect the circuit against ESD strikes

D2, D6 are used to protect against OverVoltage situations.
This circuit is implemented to minimize signal distortion in all 0-5V normal range, while maintaining a perpetual 29.4V Overvoltage board protection.
Maintaining a perperpetual Overvoltage protection means that in case of overvoltage, the voltage in input at the ICs in the board must never exceed the Maximum Absolute Rating described in the datasheet. In the sensorboard case, STM32F4 ADCs can withstand at maximum VRef + 0.3V, so 3.6V.
Using this circuit topologiy, D2 must have a foward voltage of at maximum 0.3V (Shottky diode must be selected to have a Forward Voltage so low). Forward Voltage depends on the forward currente that flows in the Diode, so R1 must dimensioned to ensure that the current flowing in the diode never exceed the maximum that is defined.
To minimize distortion, the voltage drop caused by the leackage current of the Overvoltage protection circuit must be reduced as much as possibile. Voltage drop can be reduced by minimizing two parameters:
- Series Resistor R1: R1 can be lowered, but Power ratings must be considered. if 29.4V is applied in Input, R1, R4 must survive the overvoltage, so if the resistance is reduced, R1 and R4 Power Ratings must be higher.
- Leackage Current of the Overvoltage Protection circuit: Shottky diodes must be selected with the lowest Reverse Voltage Leackage Current as low as possibile. Leackage current temperatuire dependency must be considered, so a maximung operating T must be selected in design phase.
- 0V in Input: leakage current in D2. about 3V3 across D2
- 5V in Input: no leakage current in D2. R1, R4 reduce 5V in input to 3V3, so no voltage across D2

D6 diode is used to protect the circuit against reverse voltage in input, following the same principles described for D2.
D6 will stabilize the circuit in the 0-5V range, because some of the leackage current generated by the D2 will flow directly in D6, reducing the current in R1. This principle works bestat 2,5V in input, because both D2 and D2 will be polarized with the same voltage, their Leackage current will be the same, and R1 will not see any leackage current.

This circuit topology guarantee a good linearity of distortion in the 0-5V input range. Working in the reverse Voltage zone of a Shottky diode ensure that the leackage current is very well defined and will at maximum reach a linearity zone where Leackage current will increase linearly following the Reverse Voltage.
In this situation, it is easy to identify a Worst Case scenario, which is not so easibly recognizable with other circuit Topology (see Zener protection circuit)

Feedback:
1. Implement testing points to test the General Analog circuit properly. Oscilloscope must be connected to various stages of the circuit, to evaluate the circuit behaviour.
Not every circuit must have testing points, only one is sufficient, because all the schematics are the same

2. (THIS POINT WAS NOT EVALUED DURING THIS DESIGN) Maximum output current of the sensors must be considered. 7.69kOhm to GND can be a little to low, and sensors can produce a distortion!

3. All Output PINs that generate a voltage, must be protected against Overcurrent (Fuses, PTC can be studied). The general rule is that "all harness lines, must be protected at the source". If this rule is not followed, an harness error, or a pheriperal malfuction can cause a fire hazard!

4. TVS diodes must be correctly dimensioned. In this design TVS are selected following previous desidgn, but nothing more is known

Maximum operating temperature: 50°C
Diodes Charateristics:
- Forward Voltage: 0.3V @10mA @25°C. If Temperature rises Voltage Drops if Current is constant!
- Leackage Current in Reverse Voltage: 5 uA @50°C @3.3V
Buffer Charateristics:
- Bias Current = 125 nA @25°C (if temperature rise, Bias current decrease)
R1, R4 ratio is defined by the input/output ratio (Maximum 3.3V in normal Condition):
3.3V / 5V > R4 / (R4 + R1) ----> R1 > 0.5 * R4

Maximum Current in Overvoltage Condition (10 mA) defines the mininimum R1 possible:
R1 > (29.4 V - 3.3V) / 10 mA -----> R1 > 2.61 kOhm
10 mA selected because over that the voltage drop in D2 will be over 0.3V. Maximum Voltage in Circuit Output is defined by Maximum Absolute Rating of Buffer, so Vcc + 0.3 V (3.6 V)

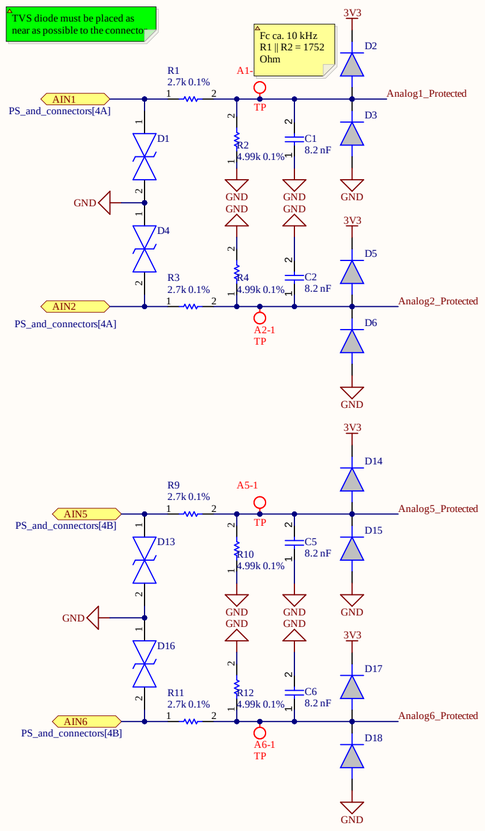
R1 and R4 are selected: R1 = 2.7 kOhm, R4 = 4.99 kOhm

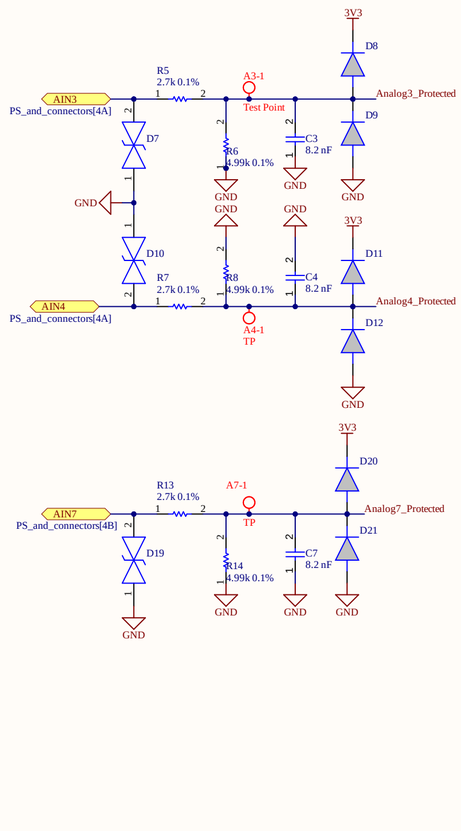
Calculation of Signal DIstortion in Various Cases:
- 0V input: 3.3 V across D2.
Voltage Distortion (Diode) = 5 uA * 2.7 kOhm = 13.5 mV
- 5V Input: similar to 0V, D6 has 3.3V across the Diode, so leackage current similar to 0V Input
- Beetween 0V and 5V: the presence of both D2 and D6 will decrease the leackage current seen by R1, with 0 A seen if 2,5V in input!

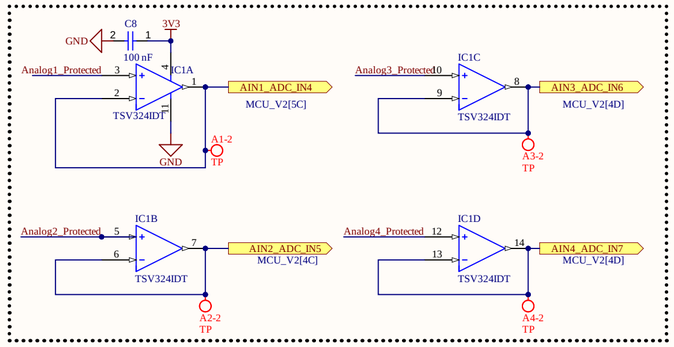
Voltage Distortion is also caused by Buffer polarization current over R1:
Voltage Distortion (Buffer) = 2.7 kOhm * 125 nA = 0.3 mV --> Negligible!!

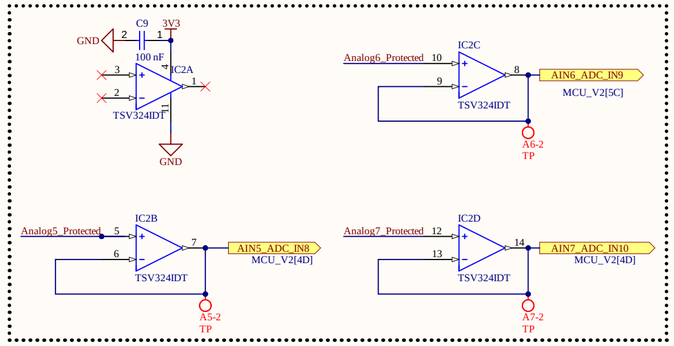
- Strain Gauges not needed anymore -> -4 Anal Inputs

- Update components
Total Sensor Inputs:
- 1 Steering (Anal 5)
- 2 Throttle (Anal 6,9)
- 1 Brake Press (Anal 7)
- 1 Brake Extension (Anal 8)









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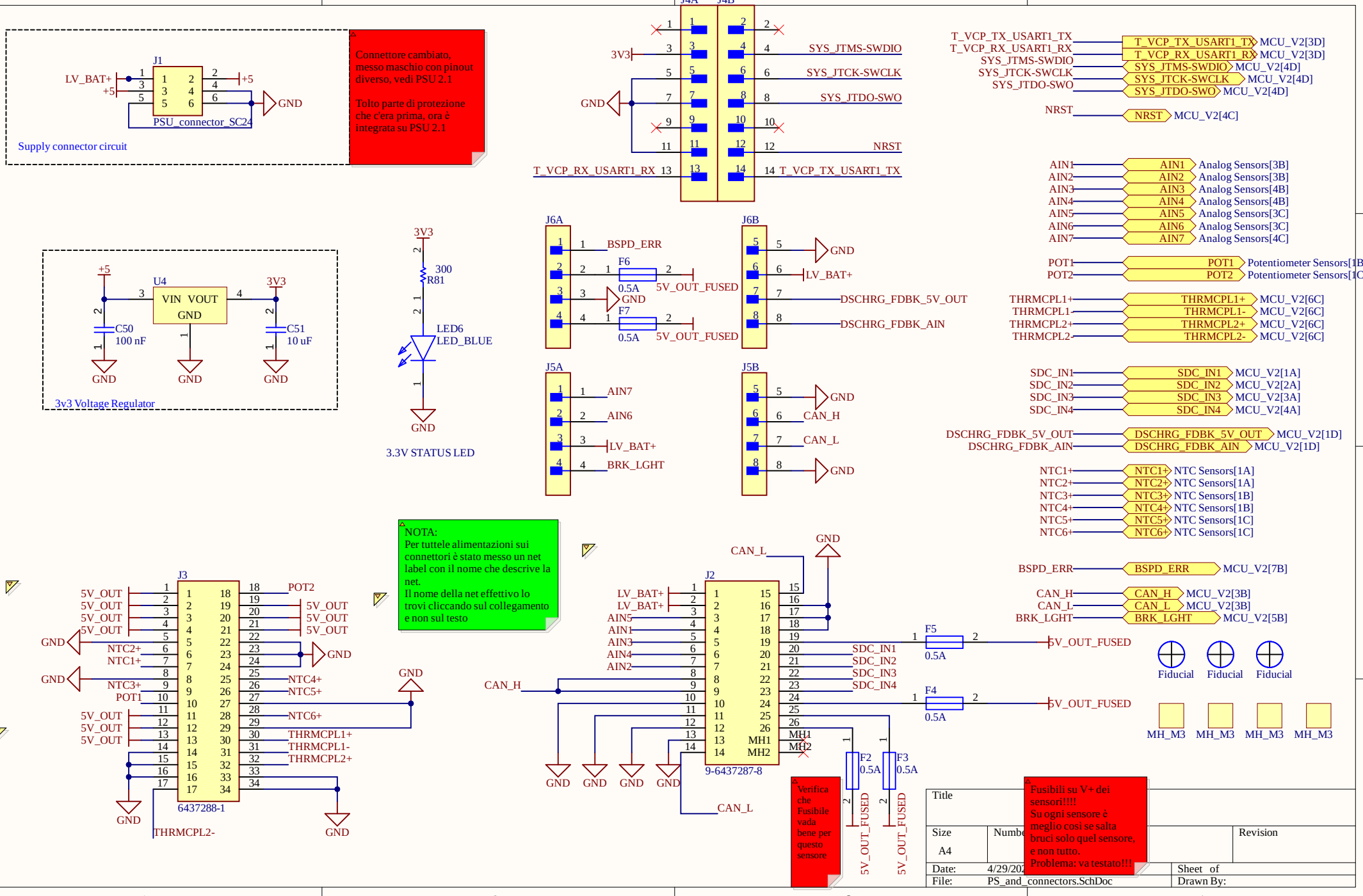
J1
LV_BAT+
+5
GND
PSU_connector_SC24
Supply connector circuit
Connettore cambiato, messo maschio con pinout diverso, vedi PSU 2.1
Tolto parte di protezione che c'era prima, ora è integrata su PSU 2.1
J4A
J4B
3V3
GND
SYS_JTMS-SWDIO
SYS_JTCK-SWCLK
SYS_JTDO-SWO
NRST
T_VCP_RX_USART1_RX
T_VCP_TX_USART1_TX
T_VCP_TX_USART1_TX
T_VCP_RX_USART1_RX
SYS_JTMS-SWDIO
SYS_JTCK-SWCLK
SYS_JTDO-SWO
NRST
MCU_V2[3D]
MCU_V2[4D]
MCU_V2[4C]
U4
VIN VOUT
GND
C50
100 nF
C51
10 uF
3v3 Voltage Regulator
R81
300
LED6
LED_BLUE
3.3V STATUS LED
J6A
J6B
BSPD_ERR
F6
F7
0.5A
5V_OUT_FUSED
DSCHRG_FDBK_5V_OUT
DSCHRG_FDBK_AIN
J5A
J5B
AIN7
AIN6
LV_BAT+
BRK_LGHT
CAN_H
CAN_L
AIN1
AIN2
AIN3
AIN4
AIN5
AIN6
AIN7
Analog Sensors[3B]
Analog Sensors[4B]
Analog Sensors[3C]
Analog Sensors[4C]
POT1
POT2
Potentiometer Sensors[1B]
Potentiometer Sensors[1C]
THRMCPL1+
THRMCPL1-
THRMCPL2+
THRMCPL2-
MCU_V2[6C]
SDC_IN1
SDC_IN2
SDC_IN3
SDC_IN4
MCU_V2[1A]
MCU_V2[2A]
MCU_V2[3A]
MCU_V2[4A]
DSCHRG_FDBK_5V_OUT
DSCHRG_FDBK_AIN
MCU_V2[1D]
NTC1+
NTC2+
NTC3+
NTC4+
NTC5+
NTC6+
NTC Sensors[1A]
NTC Sensors[1B]
NTC Sensors[1C]
BSPD_ERR
CAN_H
CAN_L
BRK_LGHT
MCU_V2[7B]
MCU_V2[3B]
MCU_V2[5B]
NOTA:
Per tuttele alimentazioni sui connettori è stato messo un net label con il nome che descrive la net.
Il nome della net effettivo lo trovi cliccando sul collegamento e non sul testo
J3
6437288-1
5V_OUT
GND
NTC2+
NTC1+
NTC3+
POT1
NTC4+
NTC5+
NTC6+
THRMCPL1+
THRMCPL1-
THRMCPL2+
THRMCPL2-
J2
9-6437287-8
LV_BAT+
AIN5
AIN1
AIN3
AIN4
AIN2
SDC_IN1
SDC_IN2
SDC_IN3
SDC_IN4
MH1
MH2
F5
F4
F2
F3
0.5A
5V_OUT_FUSED
Fiducial
MH_M3
Verifica che Fusibile vada bene per questo sensore
Fusibili su V+ dei sensori!!!!
Su ogni sensore è meglio così se salta bruci solo quel sensore, e non tutto.
Problema: va testato!!!
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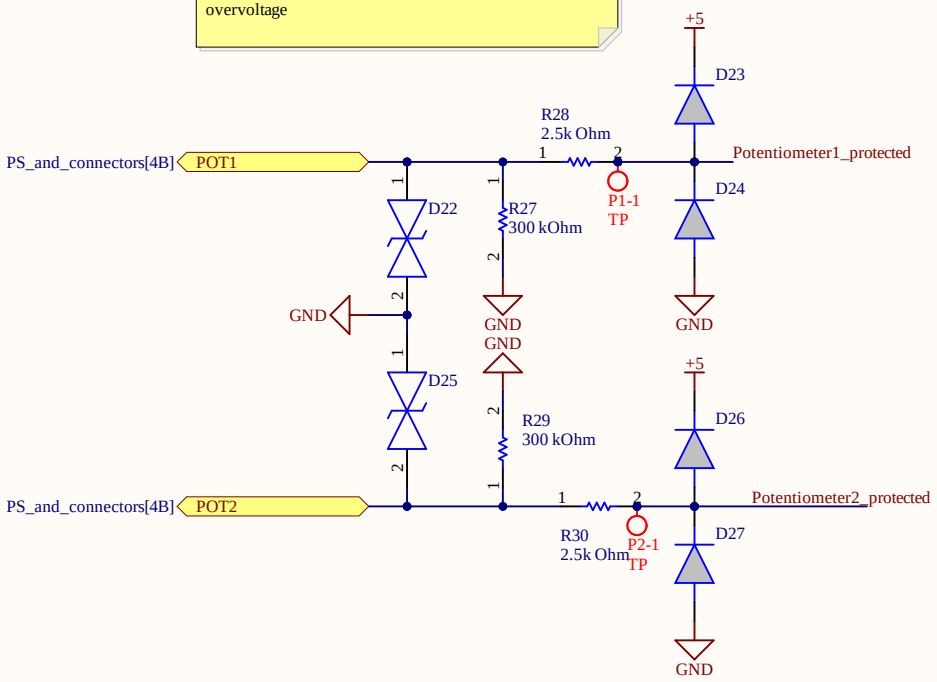
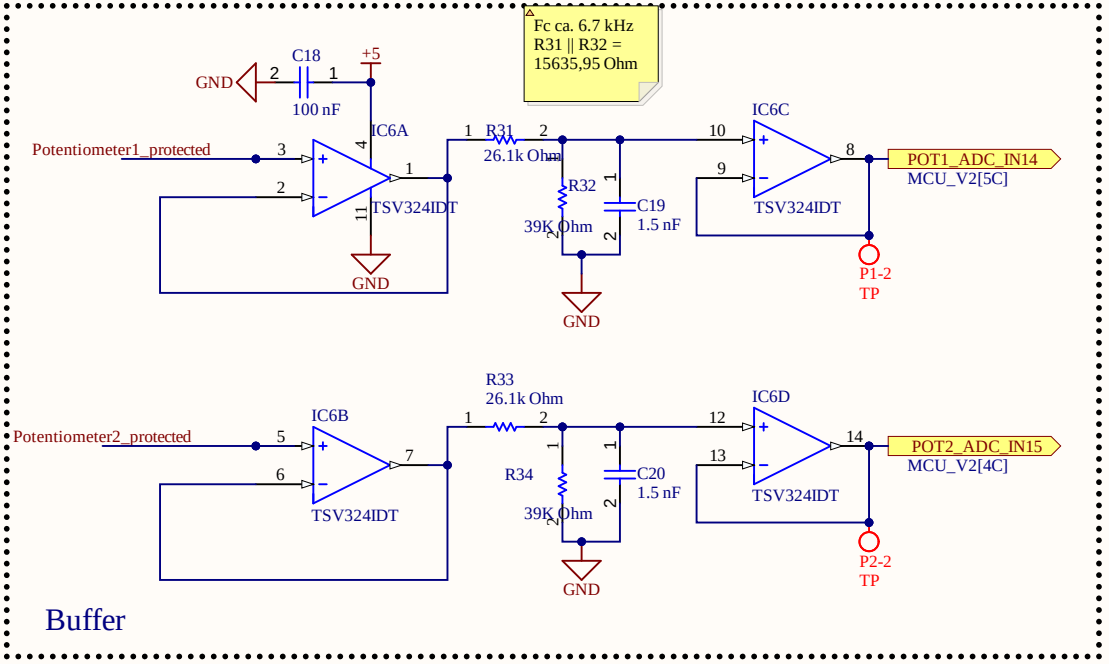
Resistenze shunt sono pull down
Abbiamo alzato il valore rispetto a prima, per evitare che facciano parallelo con potenziometro

R28 limita corrente nei diodi a 10mA in caso di overvoltage



Fc ca. 6.7 kHz
R31 || R32 = 15635,95 Ohm



Segnale passa nel buffer -> partitore (dopo buffer per non degradare risoluzione) -> buffer -> MCU

Funzionamento Circuito:

Estensimetro è potenziometro alimentato a 5V, che crea partitore di tensione con Signal output e GND, quindi varia la tensione che da sul piedino di OUT, questa tensione è quella che entra in questo circuito
->noi abbiamo un segnale in tensione sull'ingresso.

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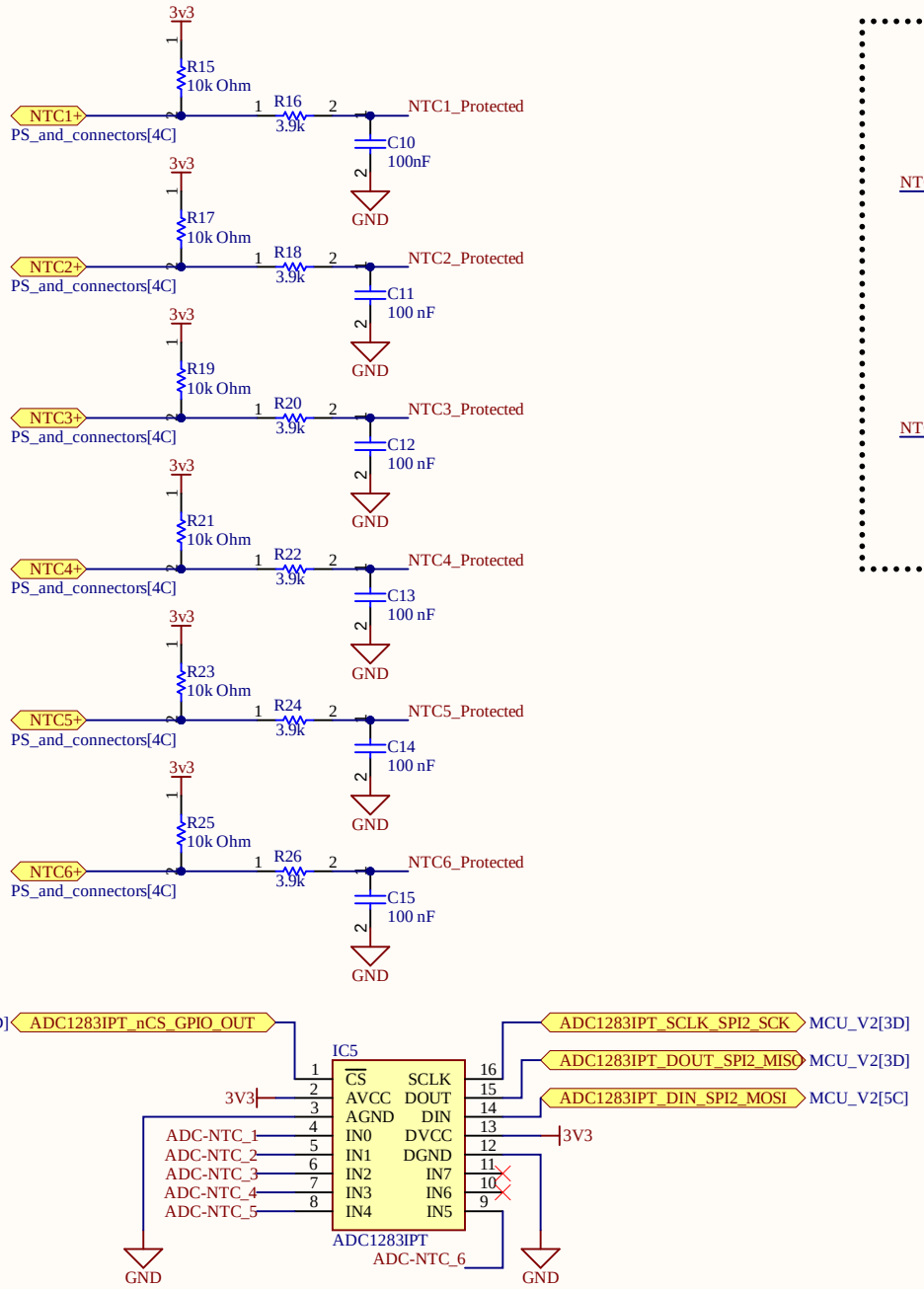

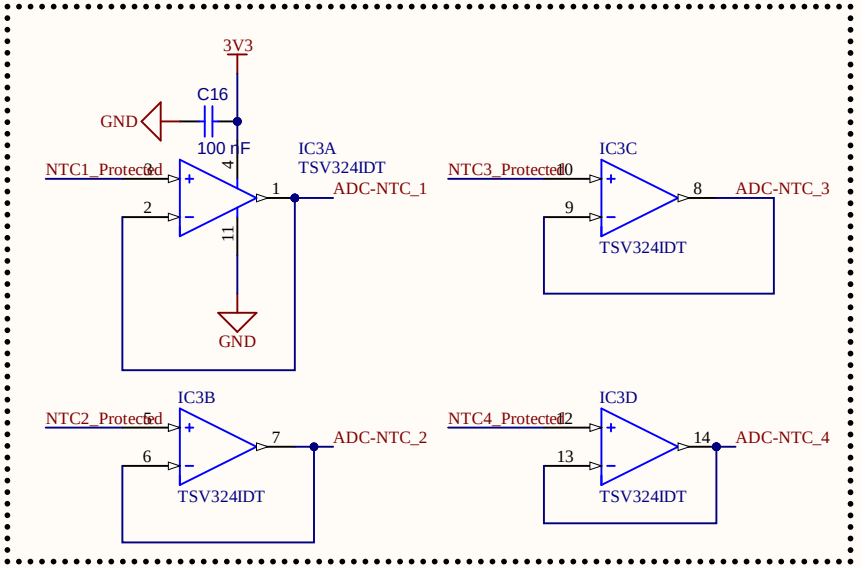

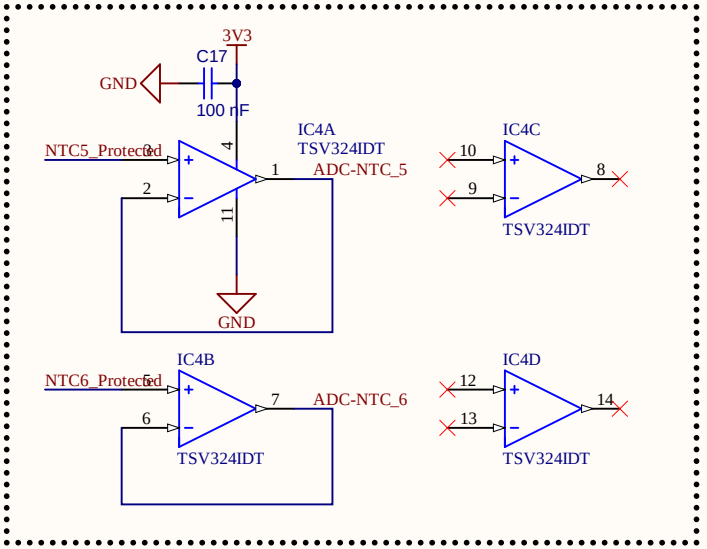

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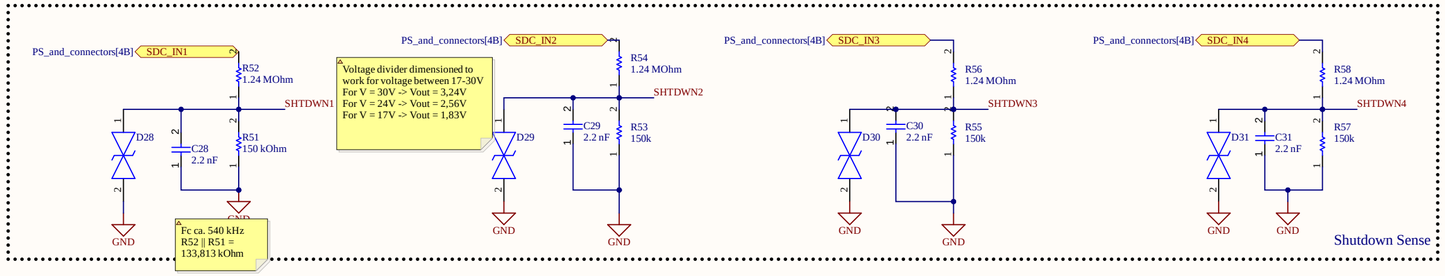

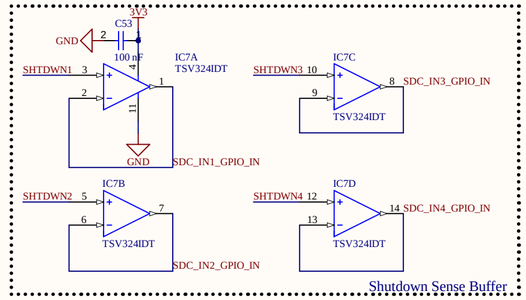

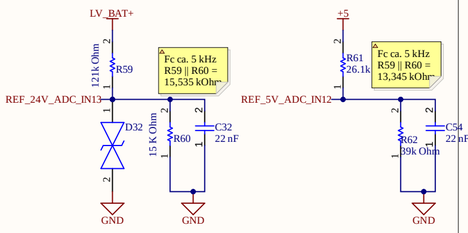

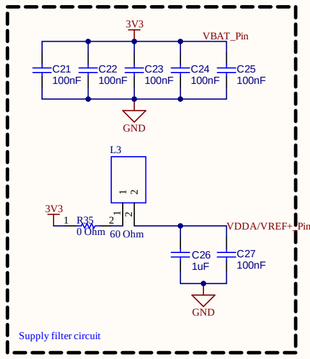

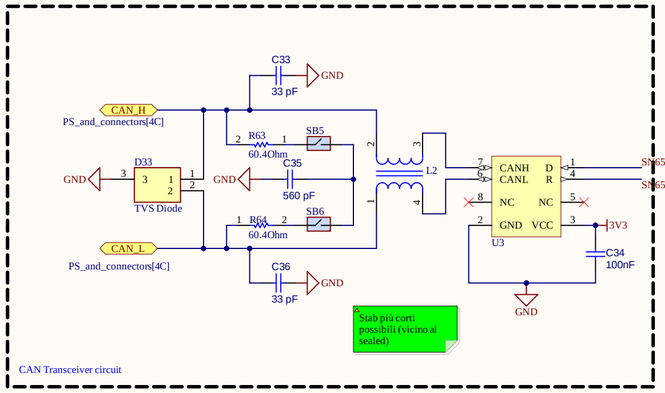

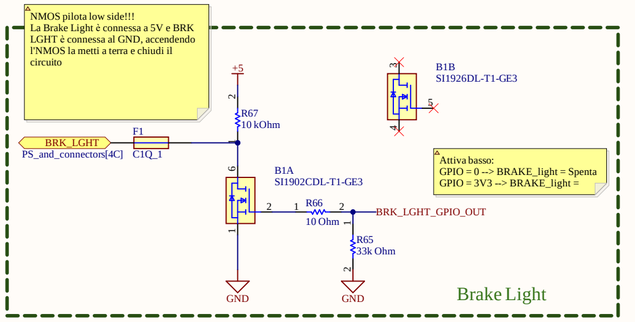

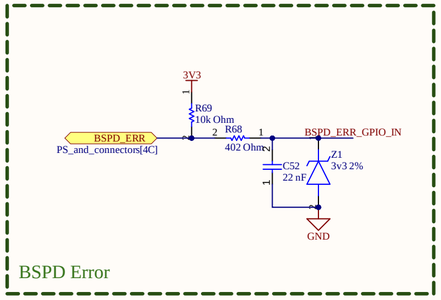

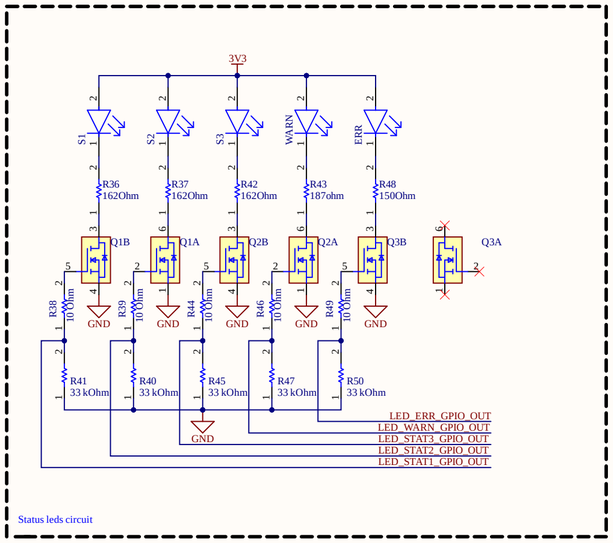

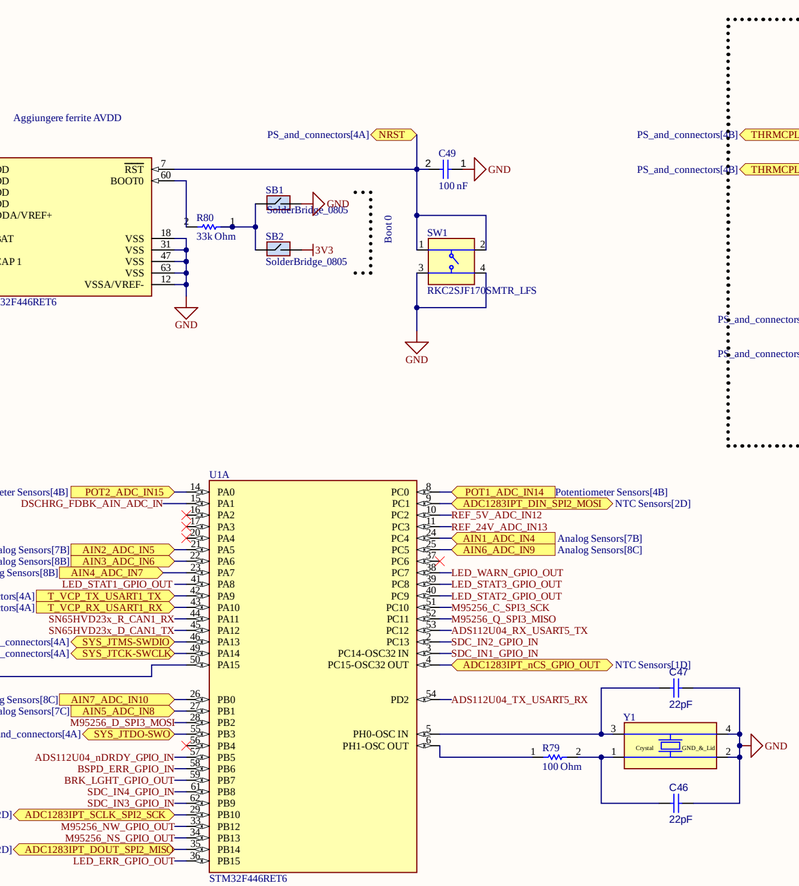

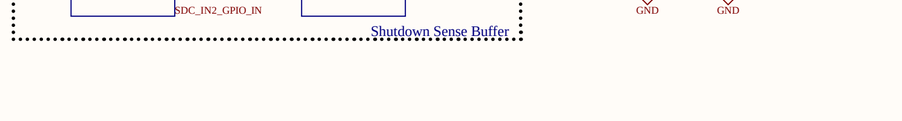

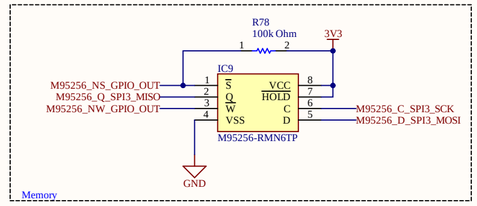

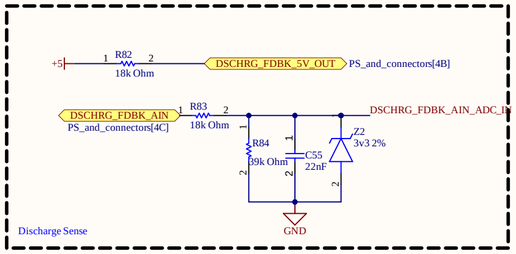

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TERMOCOPPIE
termocoppie di tipo K (con range tra -270° e 1370°) danno un segnale in un range tra -6.5 mV a 55mV.
L'ADC ha un PGA (Programmable Gain Amplifier) interno che può essere usato per amplificare il segnale della termocoppia (pre sfruttare meglio dinamica ADC).

Resistenze di pull-up in ingresso all'ADC devono essere tra 500 kOhm e 1 MOhm, in base alle correnti di ingresso all'ADC.

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