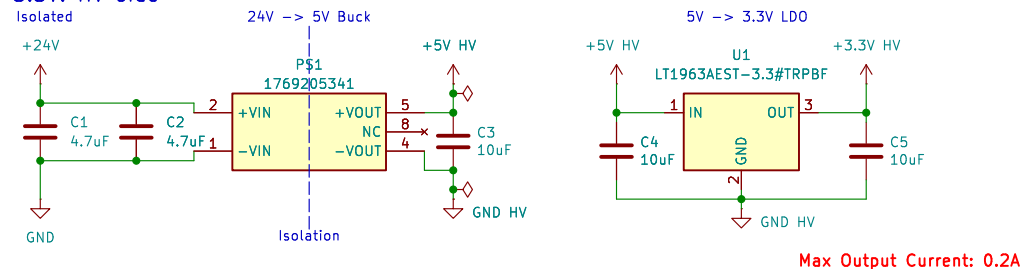


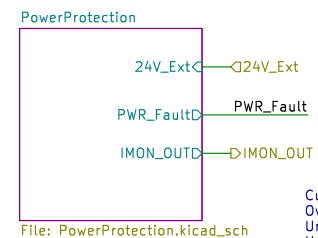
Power

3.3V: HV side



Power Protection

Taken from PSOM



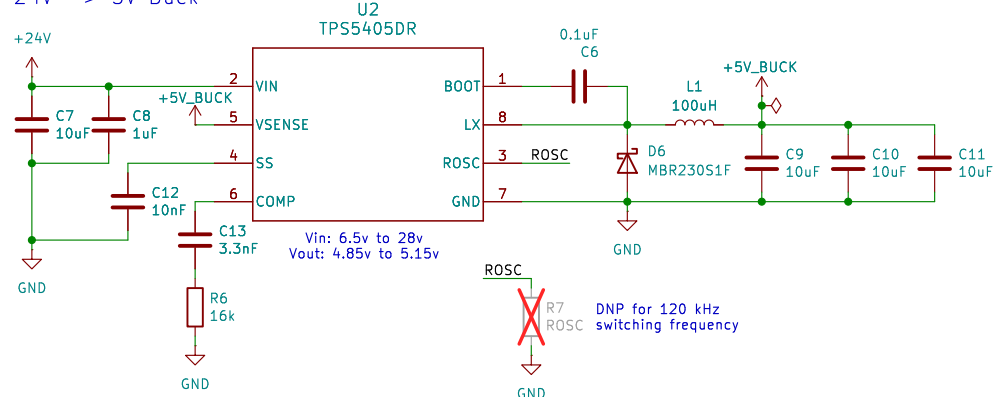
Current Limit: 1.2A
Overvoltage: ~27v
Undervoltage: ~20v
Use 1% resistors
for closest values

3.3V: LV side

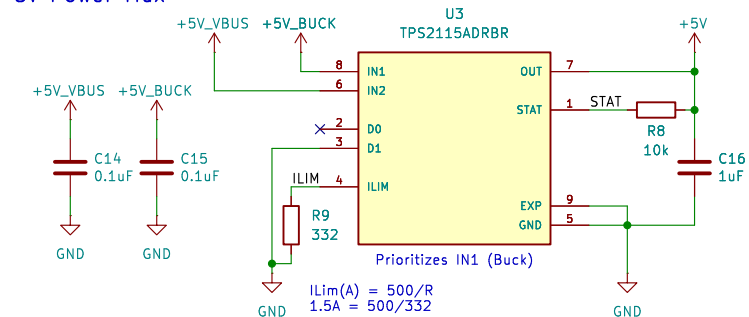
MCU, CAN

Taken from PSOM

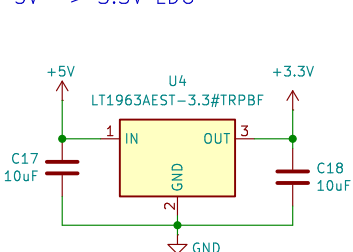
24V -> 5V Buck



5v Power Mux



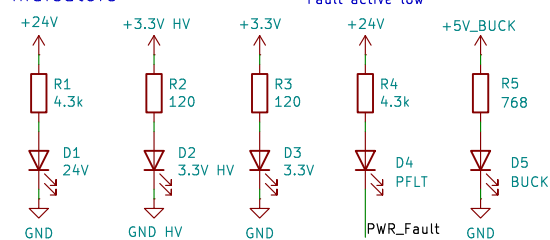
5V -> 3.3V LDO



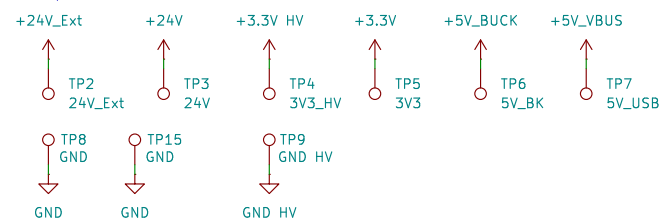
Max Output Current: 1.5A

Indicators

Fault active low



Testpoints



Sheet: /Power/
File: Power.kicad_sch

Title:

Size: A4

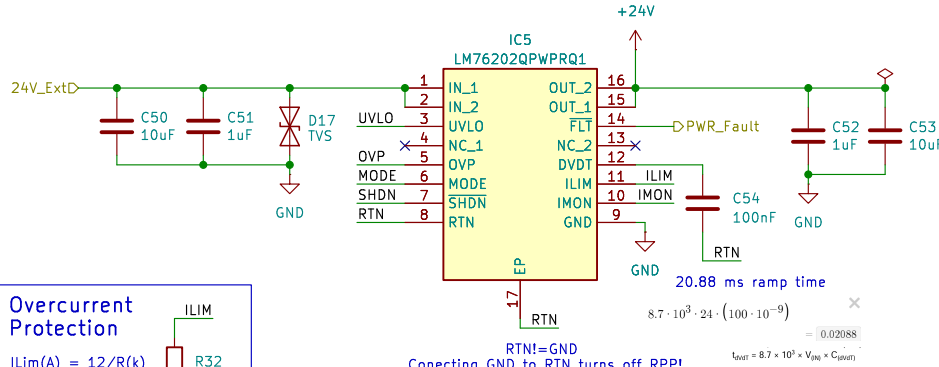
Date:

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Rev:

Id: 2/7

Taken from PSOM



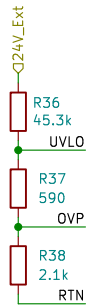
Overcurrent Protection

$$I_{Lim}(A) = 12/R(k)$$

$$1.2A = 12/10k\Omega$$



Under/Overvoltage Protection



| | Setpoint | Ideal | Actual |
|------|----------|-------|--------|
| UVLO | 20v | 1.1v | 1.12v |
| OVP | 27v | 1.1v | 1.18v |

OVP set to 27v for buck max voltage of 28v

$$\left(\frac{2.1 + 0.59}{2.1 + 0.59 + 45.3} \right) 20$$

$$= 1.1210668894$$

$$\left(\frac{2.1}{2.1 + 0.59 + 45.3} \right) 27$$

$$= 1.18149614503$$

Functional Mode Selection

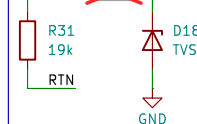
Set to circuit breaker (latchoff)

Use 0 ohm resistor for auto-retry (540ms)



Current Monitoring

IMON ~~R30~~ DNP until validated



Typical gain: 78.28 uA/A
Vout @ 1.3A = 2.407v
R(imon) = 23.7 mΩ

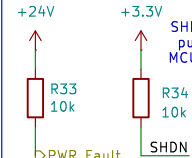
$$R_{(IMONmax)} = \frac{\min[(V_{in} - 1.5), 4 V]}{1.8 \times I_{(LIM)} \times GAIN(IMON)}$$

$$\text{For } I_{(LIM)} > 50 \text{ mA, } V_{(IMON)} = [I_{(OUT)} + GAIN(IMON)] \times R_{(IMON)}$$

$$\text{For } I_{(LIM)} < 50 \text{ mA (typical), IMON output current is close to } I_{(LIM,OUT)}$$

$$\text{With } R_{(IMON)} = (R_{(IMON_OUT)} + R_{(IMON)})$$

Pullups



SHDN has weak internal pullup – pulled up to MCU voltage after initial power on

Sheet: /Power/PowerProtection/
File: PowerProtection.kicad_sch

Title:

Size: A5
KiCad E.D.A. 9.0.5

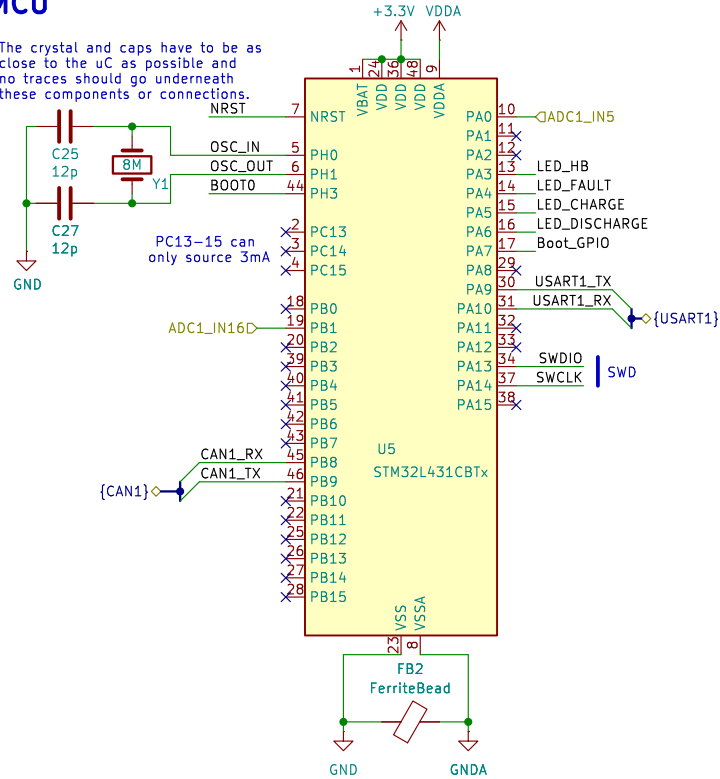
Date:

Rev:

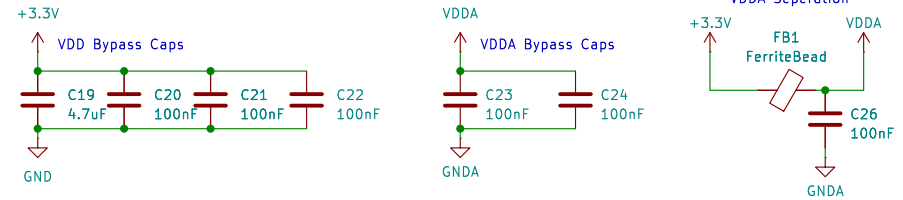
Id: 7/7

MCU

The crystal and caps have to be as close to the uC as possible and no traces should go underneath these components or connections.

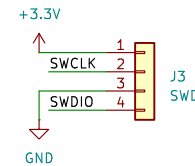


Bypass, Separation

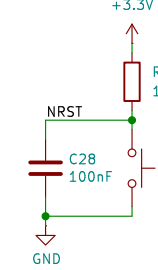


SWD Connector

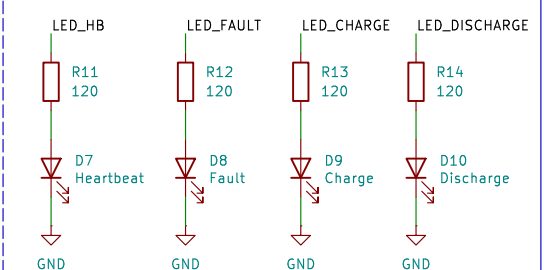
Moles Nanofit 1053091104
Mates with 0022013047



Reset Button



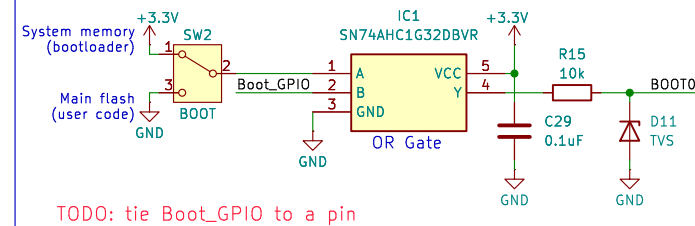
LED Indicators



USART bootloader pins (same as PSOM)

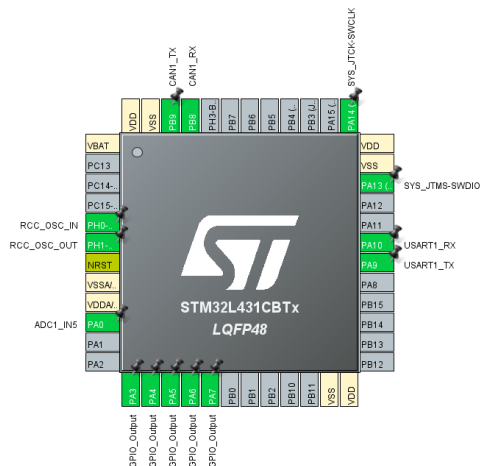
| | | |
|---------------|--------|---|
| USART1_RX pin | Input | PA10 pin: USART1 in reception mode. Used in input no pull mode. |
| USART1_TX pin | Output | PA9 pin: USART1 in transmission mode. Used in input no pull mode. |

Boot Selector



TODO: tie Boot_GPIO to a pin

Pin Functions



Sheet: /MCU/
File: MCU.kicad_sch

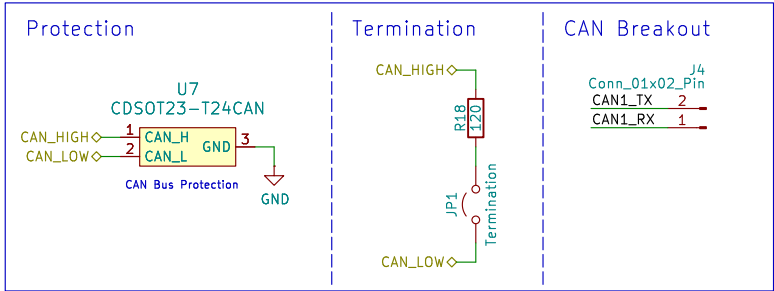
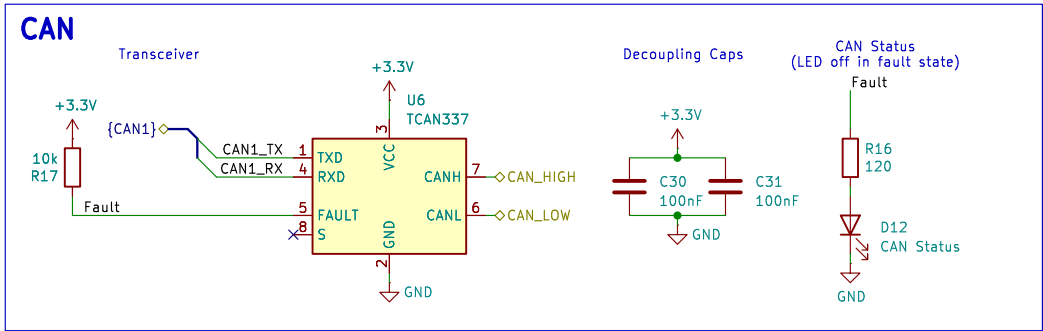
Title:

Size: A4
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Date:

Rev:

Id: 3/7



Sheet: /CAN/
File: CAN.kicad_sch

Title:

Size: A5
KiCad E.D.A. 9.0.5

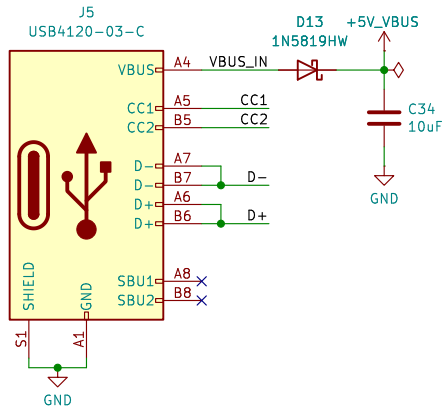
Date:

Rev:

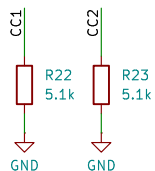
Id: 4/7

USB-C

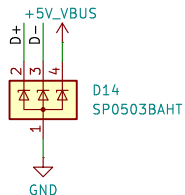
Vertical USB C Port



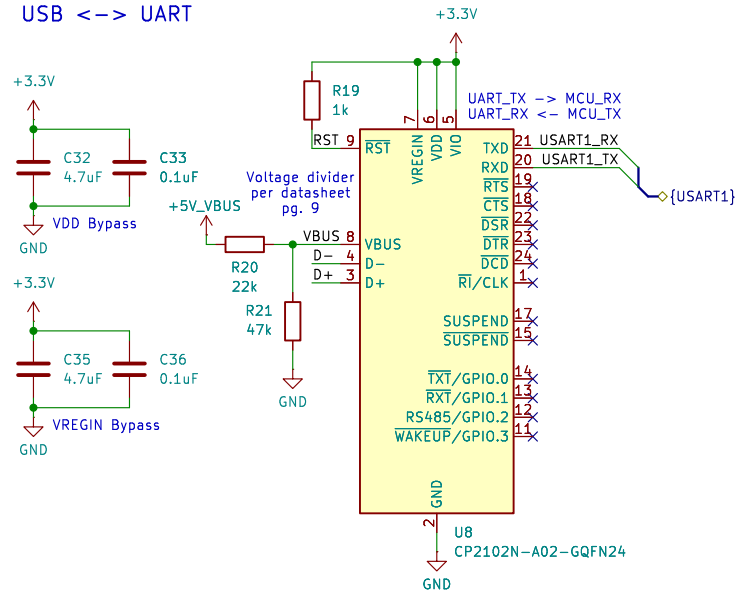
CCx Pulldown



USB Protection



USB <-> UART



Sheet: /USB/
File: USB.kicad_sch

Title:

Size: A5
KiCad E.D.A. 9.0.5

Date:

Rev:

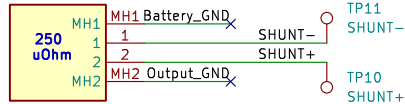
Id: 5/7

Current Sensing

Shunt -> current sense -> isolation -> filter

250uOhm Shunt Resistor

R39
WSBS58518L2500JTP3



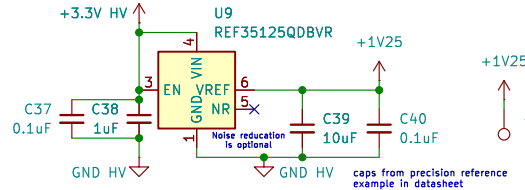
Expected current range: -32A to +70A
=> Voltage range: -8 to 17.5 mV

Low-Side Shunt:

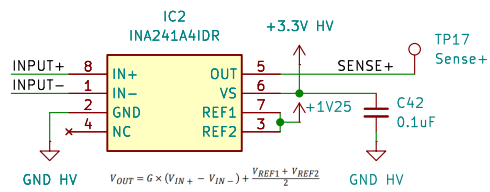
* Discharge: Output_GND -> Battery_GND
* Charge: Battery_GND -> Output_GND

Footprint is M4 version; edit it to have M3 holes

Voltage Reference (1.25V)



Bidirectional current sense amp



Gain: 100 V/V (INA241 A4 version)

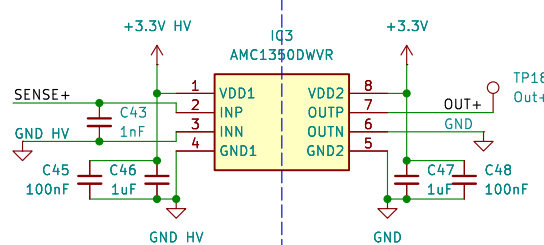
Reference voltage (bias for discharge): 1.25V

* (70A * 250 uOhm * 100)V + Vref = 3 V

* (-32A * 250 uOhm * 100)V + Vref = 0.45 V

Maximum current range: -46 to +78A (0.1 to 3.2V output)

Isolation



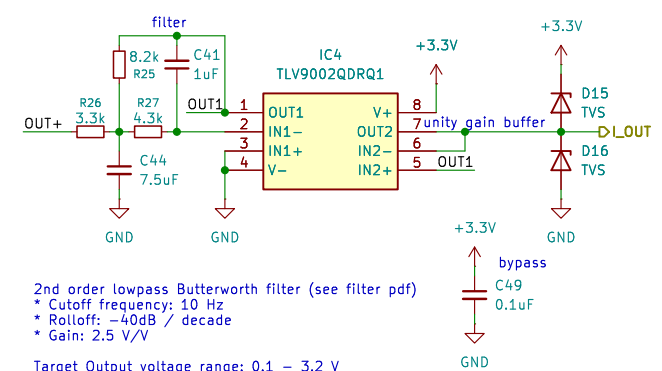
Fixed Gain: 0.4 V/V

Target Voltage Ranges:

* Input: 0.1 - 3.2 V

* Output: 0.04 - 1.28 V

Low-Pass Filter



2nd order lowpass Butterworth filter (see filter pdf)

* Cutoff frequency: 10 Hz

* Rolloff: -40dB / decade

* Gain: 2.5 V/V

Target Output voltage range: 0.1 - 3.2 V

Table 8-1. R_{SENSE} Selection and Power Dissipation ⁽¹⁾

| PARAMETER | EQUATION | RESULTS AT V _S = 5V | | | | |
|--------------------|--|--|----------------|----------------|----------------|----------------|
| | | A1, B1 DEVICES | A2, B2 DEVICES | A3, B3 DEVICES | A4, B4 DEVICES | A5, B5 DEVICES |
| G | Gain | 10V/V | 20V/V | 50V/V | 100V/V | 200V/V |
| V _{SENSE} | Ideal differential input voltage | V _{SENSE} = V _{OUT} / G | 500mV | 250mV | 100mV | 50mV |
| R _{SENSE} | Current sense resistor value | R _{SENSE} = V _{SENSE} / I _{MAX} | 50mΩ | 25mΩ | 15mΩ | 5mΩ |
| P _{SENSE} | Current-sense resistor power dissipation | R _{SENSE} * I _{MAX} ² | 5W | 2.5W | 1W | 0.5W |

Gain: 100 V/V

R_{sense} = 250 uOhm

P_{sense} = R_{sense} * (70A)² = 1.225 W

Picked shunt first, then adjusted gain to meet ADC range

If additional gain is needed, tweak filter circuit

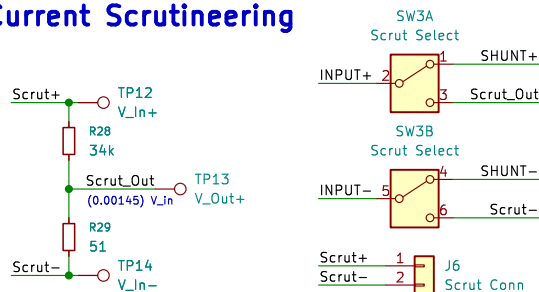
ADC to Current Conversion

Current = ((ADC * (3.3 / 4096) - Vref) / (Shunt * gain))

Vref = 1.25

Shunt * gain = 250u * 100 V/V = 0.025

Current Scrutineering



Scrutineering:

- Pass in voltage from scrutineering board
- Use switch to select between shunt / scrutineering inputs

Expected Voltage Input: +- 12V

Scrutineering Output: +- 18 mV

Sheet: /Current Sense/

File: Current_Sense.kicad_sch

Title:

Size: A4

Date:

KiCad E.D.A. 9.0.5

Rev:

Id: 6/7