

INPUT PROTECTION

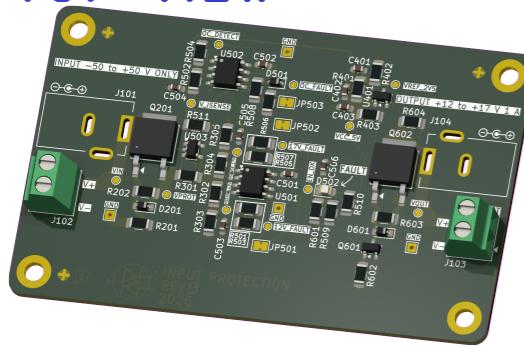
Variant: RELEASED

2026-02-11

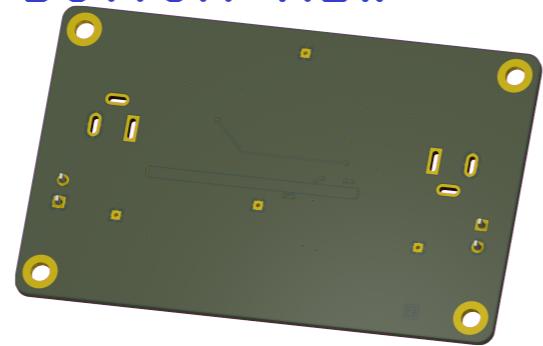
Rev + (Unreleased)

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TOP VIEW



BOTTOM VIEW



NOTES

Comment

Not fitted components are marked as

DRAFT – Very early stage of schematic, ignore details.

PRELIMINARY – Close to final schematic.

CHECKED – There shouldn't be any mistakes. Contact the engineer if found.

RELEASED – A board with this schematic has been sent to production.

DESIGN CONSIDERATIONS

DESIGN NOTE:
Example text for informational design notes.

DESIGN NOTE:
Example text for debug notes.

DESIGN NOTE:
Example text for cautionary design notes.

DESIGN NOTE:
Example text for critical design notes.

LAYOUT NOTE:
Example text for critical layout guidelines.

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DRN
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SHEET PATH

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FILENAME

Input-Protection.kicad_sch

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GIT HASH

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3eaf265

DRAWING No

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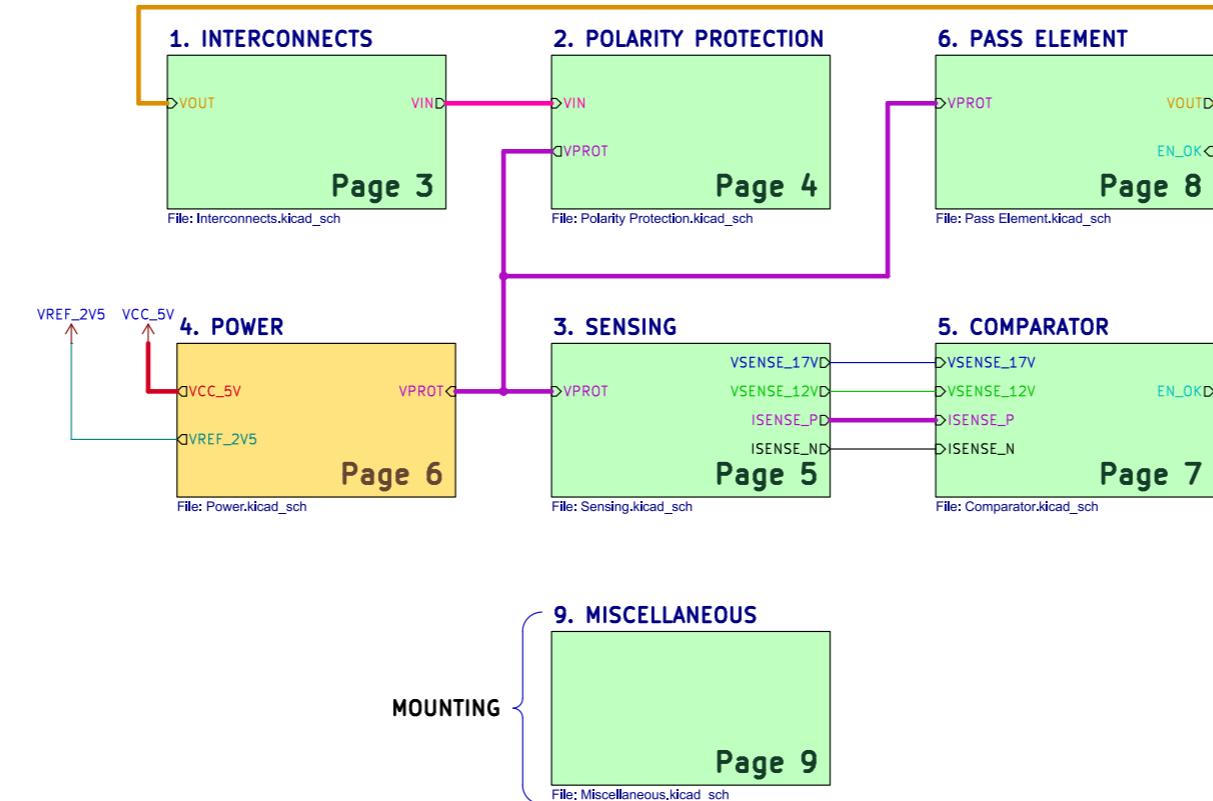
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[2] ARCHITECTURE



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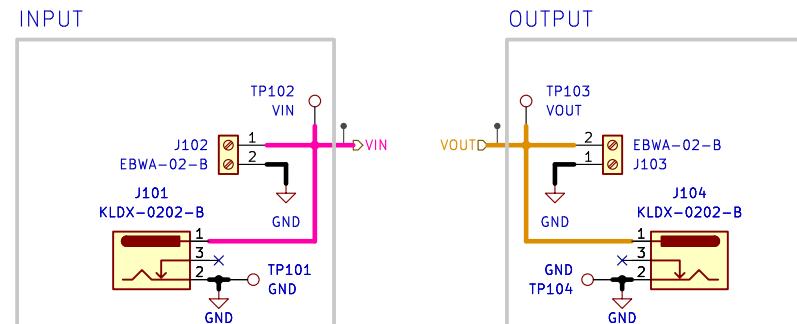
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/ARCHITECTURE/	3eaf265	ARCHITECTURE			
FILENAME	VARIANT	RELEASED	REVISION + (Unreleased)	SHEET	2 OF 10
Project Architecture.kicad_sch					A3

[3] 1. INTERCONNECTS



LAYOUT NOTE:
Large traces for VIN and VOUT, with 1oz copper a track width of >0.8mm is required to handle 2A of current with a FoS=2.

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1. INTERCONNECTS

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FILENAME Interconnects.kicad_sch

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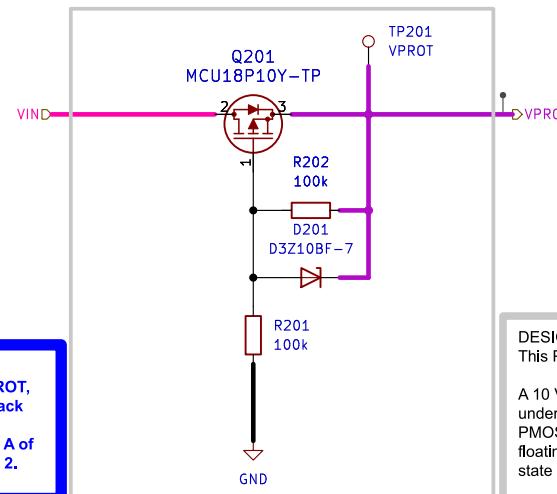
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[4] 2. POLARITY PROTECTION



LAYOUT NOTE:
Large traces for VPROT, with 1oz copper a track width of >0.8 mm is required to handle 2 A of current with a FoS = 2.

DESIGN NOTE:
This PMOS is acting as an ideal diode [1].

A 10 V zener from gate to source limits $V_{GS} \leq 10$ V under all VIN and transient conditions to protect the PMOS. A 100k gate to source resistor stops the gate floating. A 100k gate pulldown resistor sets default state to OFF when no voltage at VIN is present.

[1] <https://www.ti.com/lit/an/slvae57b/slvae57b.pdf?ts=1770319054914>

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/ARCHITECTURE/ 2. POLARITY PROTECTION/

FILENAME Polarity Protection.kicad_sch

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3ea12265 POLARITY PROTECTION

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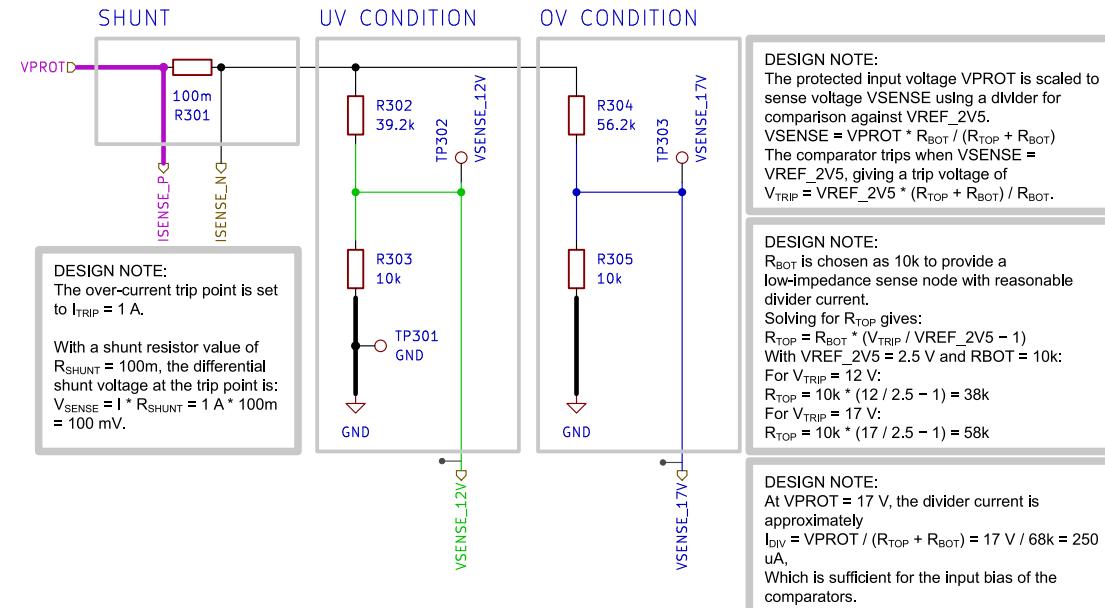
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[5] 3. SENSING



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/ARCHITECTURE/3. SENSING/

FILENAME Sensing.kicad_sch

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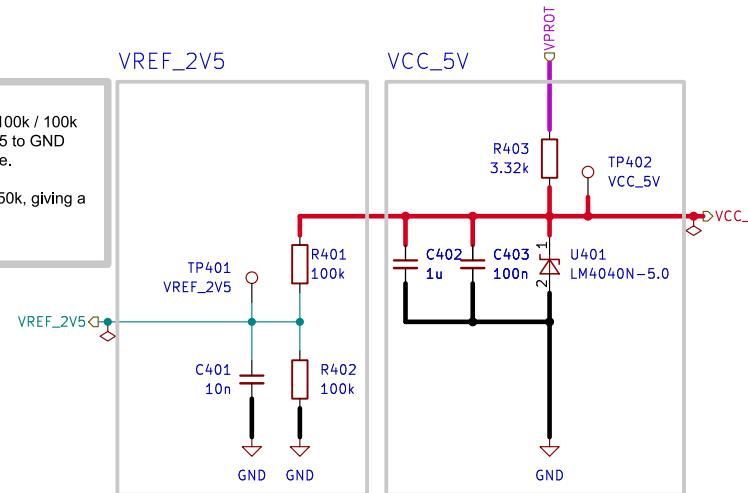
3. SENSING

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[6] 4. POWER

DESIGN NOTE:
VREF_2V5 is generated from VCC_5V using a 100k / 100k resistive divider. A 10n capacitor from VREF_2V5 to GND provides low-pass filtering to reduce supply noise.

The effective source resistance of the divider is 50k, giving a cutoff frequency of:
 $f_c = 1 / (2\pi \cdot 50k \cdot 10n) = 318 \text{ Hz}$



DESIGN NOTE:
Per TI [2], choose the series resistor R_s such that $I_{RMIN} < I_R < I_{RMAX}$ across the full input range, while supplying the worst-case load current from VCC_5V.

Assume:
 $V_{IN,MIN} = 12 \text{ V}$, $V_{IN,MAX} = 50 \text{ V}$, $V_{OUT} = 5 \text{ V}$
 $I_{RMAX} = 15 \text{ mA}$, $I_{RMIN} = 75 \mu\text{A}$
Worst-case VCC_5V load current with EN_OK high is estimated as:
 $I_{LOAD,MAX} = I_{DIV,2V5} + I_{Q,LM393} + I_{Q,INA169} + I_{B,NPN}$
where:
 $I_{DIV,2V5} = 5 \text{ V} / (100k + 100k) = 25 \mu\text{A}$
 $I_{Q,LM393} = 2 * 600 \mu\text{A} = 1.2 \text{ mA}$ (two LM393 packages)
 $I_{Q,INA169} = 125 \mu\text{A}$
 $I_{B,NPN} = (5 \text{ V} - 0.7 \text{ V}) / 10k = 430 \mu\text{A}$
Note:
The fault LED current is drawn only when EN_OK is low and is therefore not included in the EN_OK-high load budget.
Thus:
 $I_{LOAD,MAX} = 25 \mu\text{A} + 1.2 \text{ mA} + 125 \mu\text{A} + 430 \mu\text{A} = 1.78 \text{ mA}$
This gives:
 $R_s,MAX = (V_{IN,MIN} - V_{OUT}) / (I_{LOAD,MAX} + I_{RMIN}) = 7 \text{ V} / (1.78 \text{ mA} + 0.075 \text{ mA}) = 3.8k$
 $R_s,MIN = (V_{IN,MAX} - V_{OUT}) / I_{RMAX} = 45 \text{ V} / 15 \text{ mA} = 3k$
 R_s (R403) is selected as 3.32k to ensure regulation at $V_{IN,MIN}$ while limiting shunt current at $V_{IN,MAX}$.

[2] <https://www.ti.com/lit/ds/symlink/lm4040-n.pdf?ts=1752678691365>

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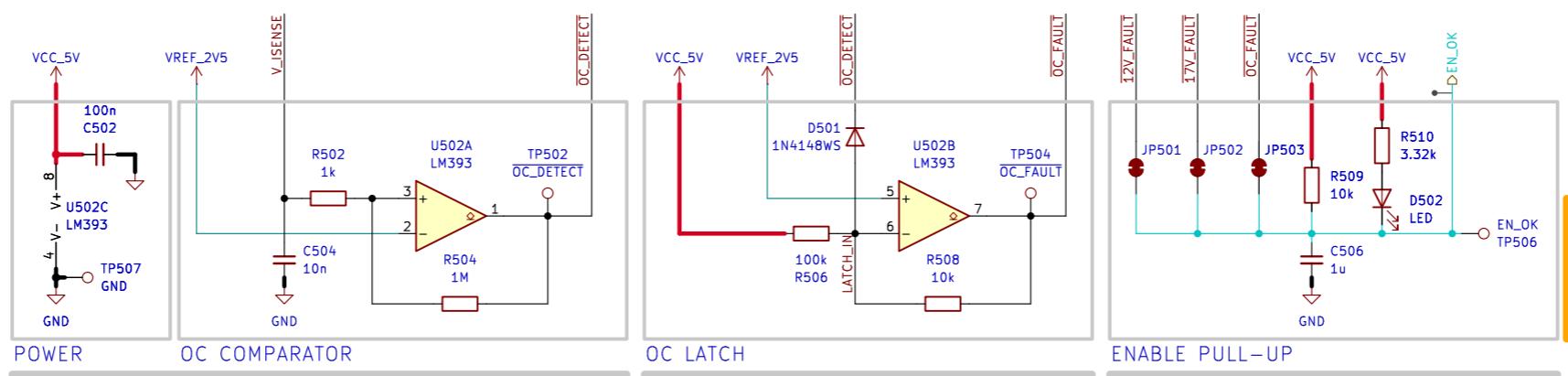
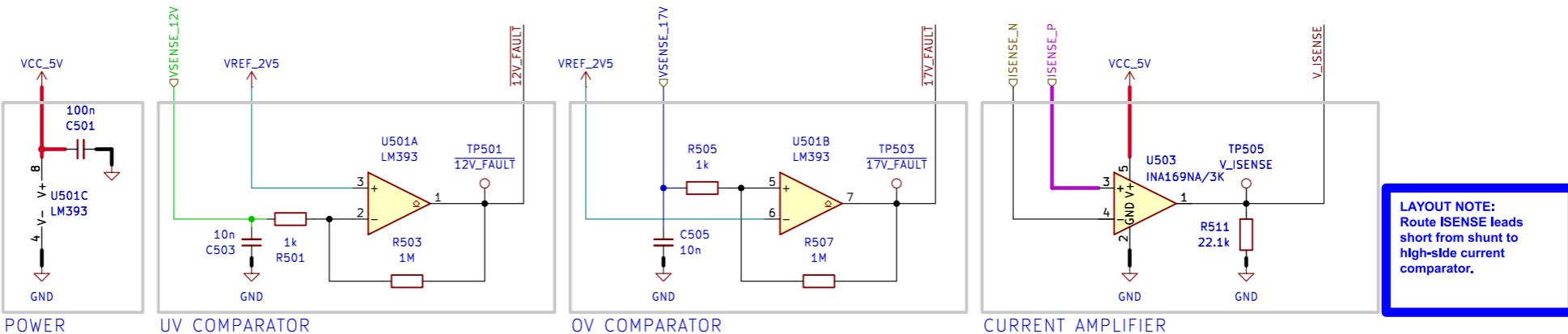
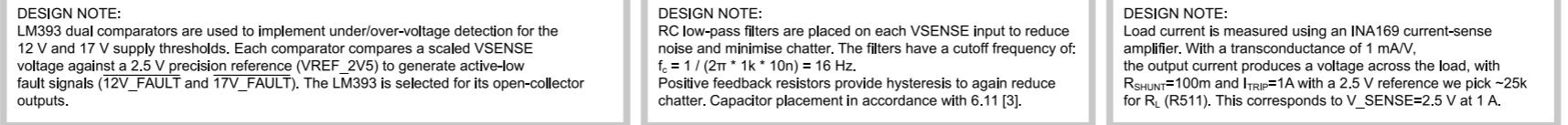


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/ARCHITECTURE/4. POWER/	3eaf265			
FILENAME	VARIANT	RELEASED	REVISION + (Unreleased)	SHEET
Power.kicad_sch				6 OF 10

[7] 5. COMPARATOR

[3] <https://www.ti.com/lit/an/sn0aa35f/sn0aa35f.pdf?ts=1770697404856>



DESIGN NOTE:
A second LM393 comparator monitors the V_ISENSE signal from the current-sense amplifier and compares it against the 2.5 V reference to detect over-current conditions. When the sensed current exceeds the programmed threshold, the comparator output asserts an active-low over-current fault signal (OC_FAULT).

DESIGN NOTE:
The spare LM393 comparator is configured as a latch. This prevents "hiccupps". OC_DETECT is reverse bias diode-coupled into the latch input. Once an over-current condition occurs, the latch forces OC_FAULT low and maintains the fault state until power is removed.

DESIGN NOTE:
All active-low fault signals (12V_FAULT, 17V_FAULT, and OC_FAULT) are combined using wired-AND logic enabled by the open-collector comparator outputs. A single pull-up resistor biases EN_OK high during normal operation. Assertion of any fault pulls EN_OK low, disabling the pass MOSFET.

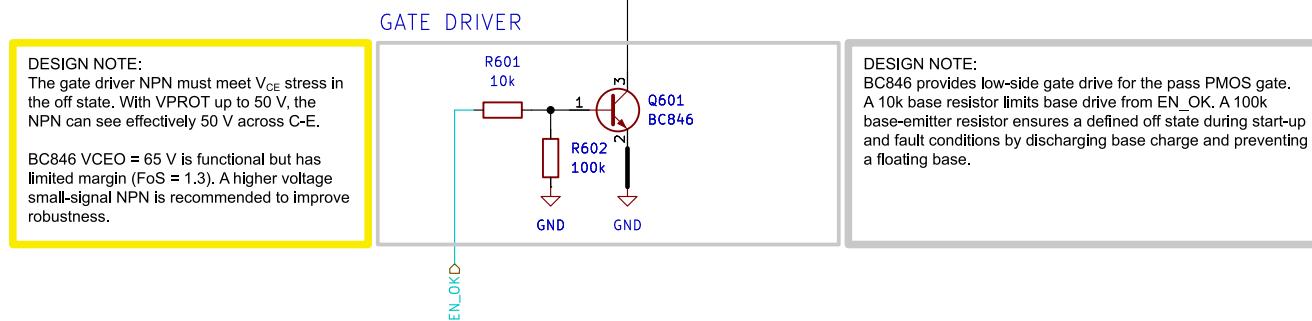
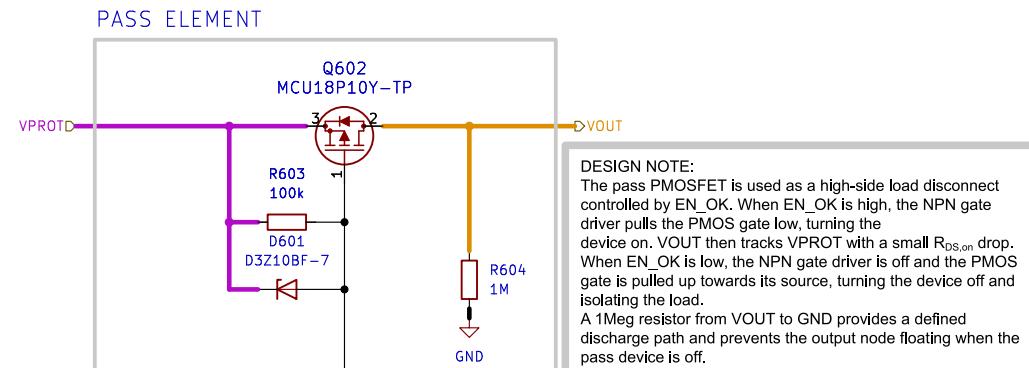
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FILENAME	Comparator.kicad_sch
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[8] 6. PASS ELEMENT



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/ARCHITECTURE/6. PASS ELEMENT/

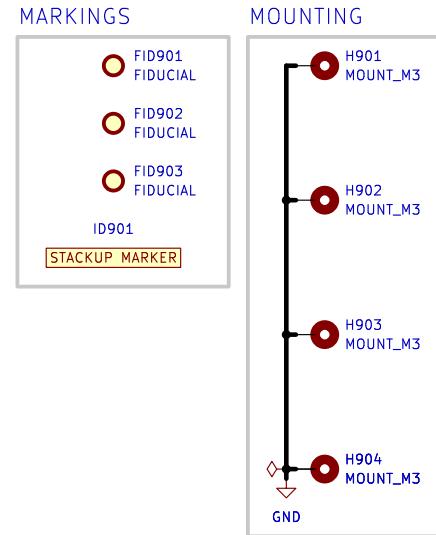
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GIT HASH 3eaf265	DRAWING No 6. PASS ELEMENT			
FILENAME Pass Element.kicad_sch	VARIANT	RELEASED	REVISION + (Unreleased)	SHEET 8 OF 10

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[9] 9. MISCELLANEOUS



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9. MISCELLANEOUS

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FILENAME Miscellaneous.kicad_sch

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[10] REVISION HISTORY

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