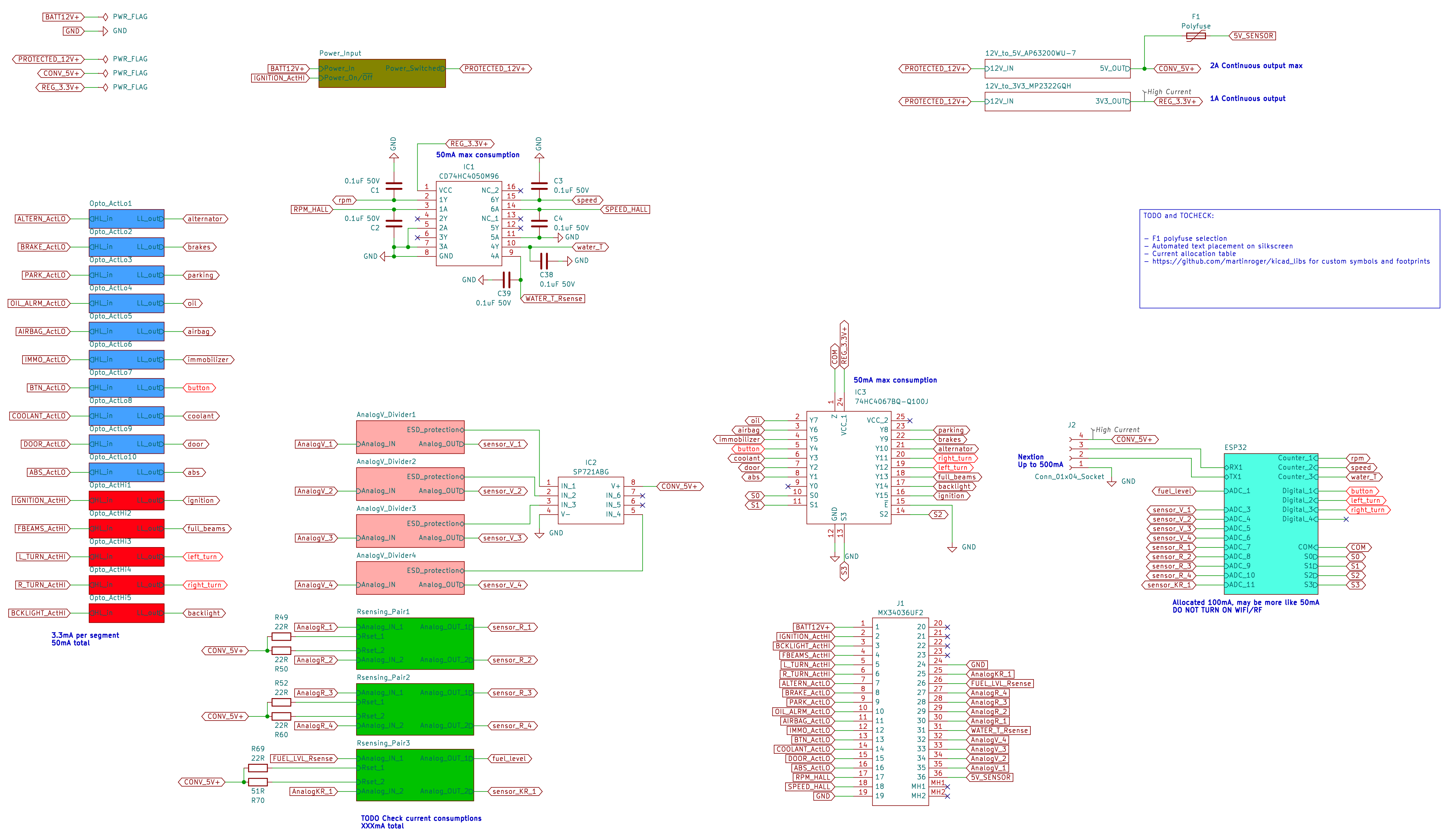


TODO and TOCHECK:

- F1 polyfuse selection
- Automated text placement on silkscreen
- Current allocation table
- https://github.com/martinroger/kicad_libs for custom symbols and footprints

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: VXDash.kicad_sch

Title: Main architecture

Size: A3 | Date: 2023-06-18 | Rev: 1.2.3
KiCad E.D.A. kicad (7.0.0) | Id: 1/27

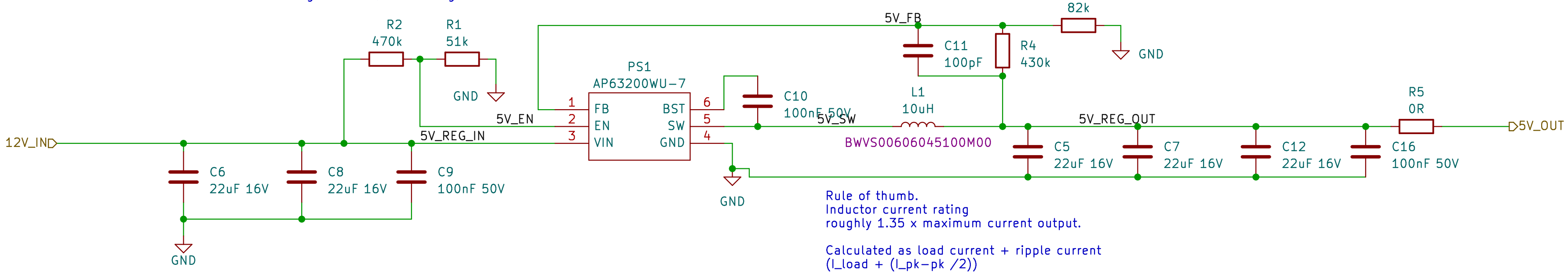
R2 = (0.932 x (Von − Voff)) / 4.1uA.

If we have Von − Voff as ~2V hysteresis
R2 = (0.932 x 2) / 0.0000041 = ~454k.
Closest value = 470k gives around 2.06V

R1 = (1.1 x R2) / (Voff − 1.1V +5.5uA x R2)
If we have Voff ~9V
R1 = (1.1 x 470k) / (9 − 1.1 = 0.0000055 x 470k) = 49.308k.
Closest value = 51k gives ~8.65V

Von rising = ~10.7V, Voff falling = ~8.65V

Feedback divider
R4 = R3 x ((5 / 0.8) −1)



Rule of thumb.
Inductor current rating
roughly 1.35 x maximum current output.

Calculated as load current + ripple current
(I_load + (I_pk−pk /2))

MAX 2A CONTINUOUS OUTPUT

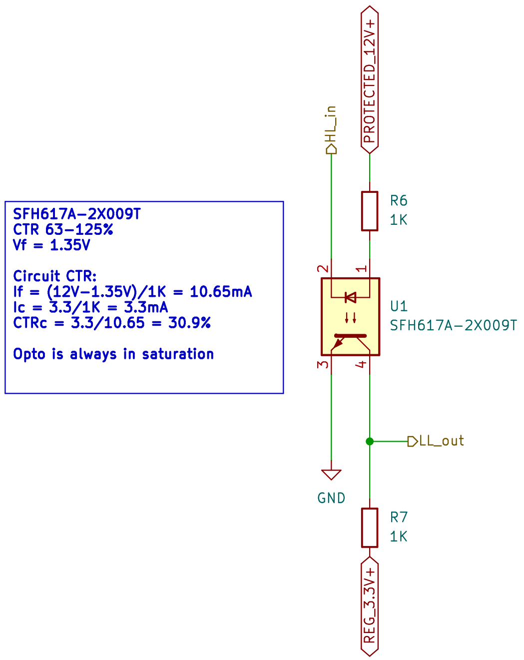
All resistors low tolerance
All capacitors low ESR

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: 12V_to_5V_AP63200WU−7.kicad_sch

Title: 12V to 5V conversion

Size: A4	Date: 2023−06−18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 2/27

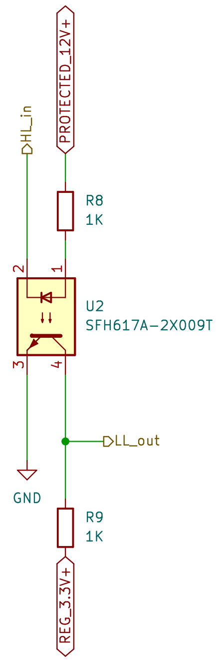


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 3/27



SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
If = (12V-1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

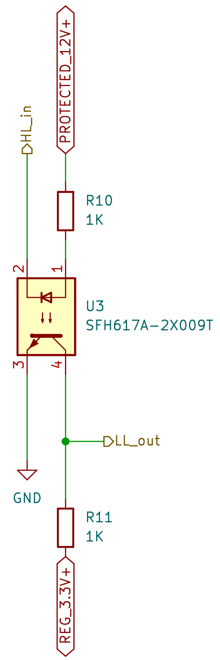
Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 4/27

SFH617A–2X009T
CTR 63–125%
Vf = 1.35V

Circuit CTR:
If = (12V–1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation

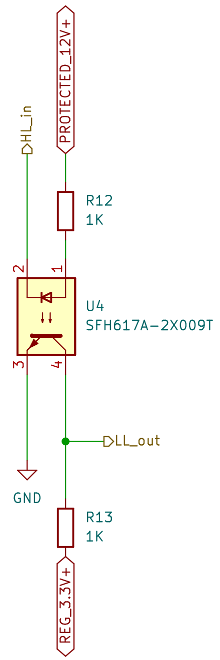


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 5/27



SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
If = (12V-1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

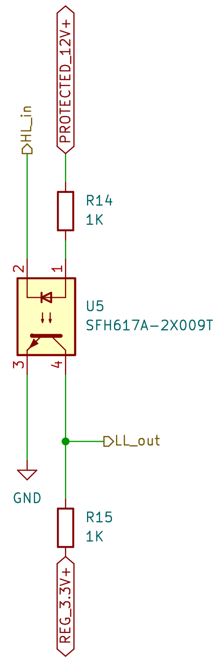
Opto is always in saturation

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 6/27



SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
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Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

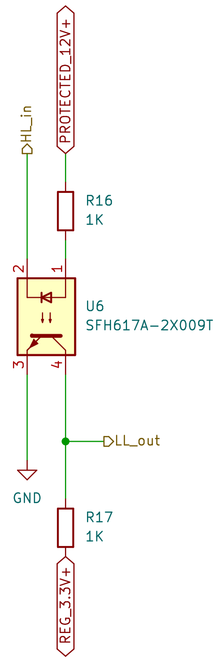
Opto is always in saturation

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 7/27



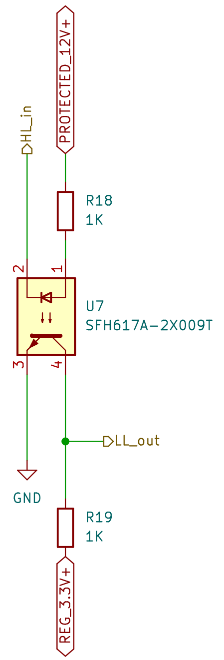
SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
If = (12V-1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:		
File: Opto_ActLo.kicad_sch		
Title: Active Low Optocoupler circuit		
Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 8/27



SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
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Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

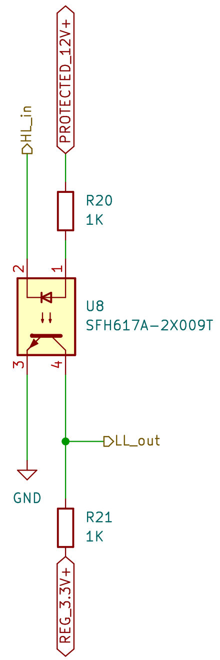
Title: Active Low Optocoupler circuit

Size: A4 | Date: 2023-06-18 | **Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0) | Id: 9/27

SFH617A–2X009T
CTR 63–125%
Vf = 1.35V

Circuit CTR:
If = (12V–1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation

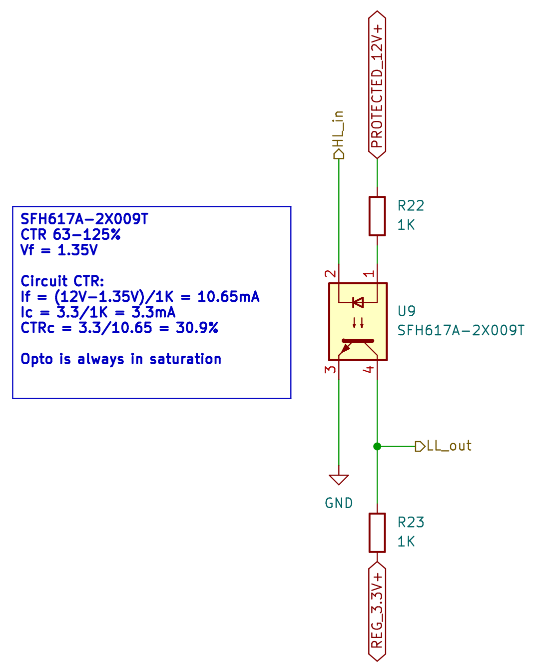


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

Title: Active Low Optocoupler circuit

Size: A4	Date: 2023–06–18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 10/27

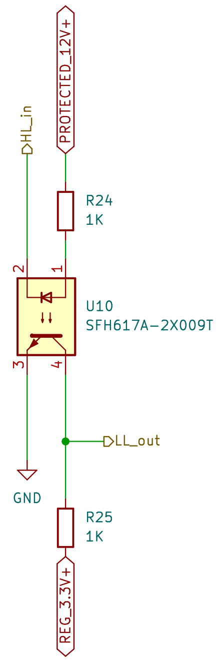


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 11/27



SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
If = (12V-1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation

https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActLo.kicad_sch

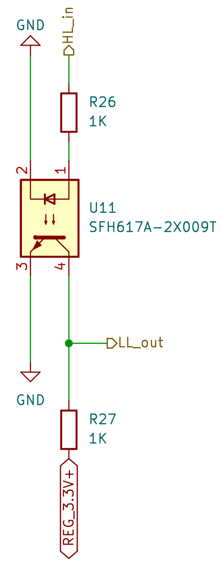
Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 12/27

SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
If = (12V-1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation



https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActHi.kicad_sch

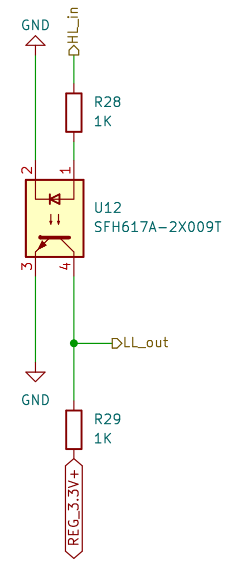
Title: Active Hi Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 13/27

SFH617A−2X009T
CTR 63−125%
Vf = 1.35V

Circuit CTR:
If = (12V−1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation



https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActHi.kicad_sch

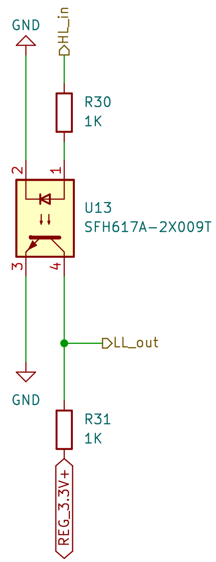
Title: Active Hi Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 14/27

SFH617A−2X009T
CTR 63−125%
Vf = 1.35V

Circuit CTR:
If = (12V−1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation



https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActHi.kicad_sch

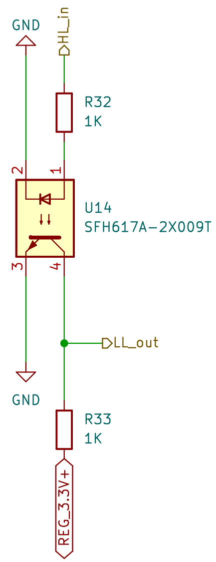
Title: Active Hi Optocoupler circuit

Size: A4	Date: 2023−06−18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 15/27

SFH617A-2X009T
CTR 63-125%
Vf = 1.35V

Circuit CTR:
If = (12V-1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation



https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActHi.kicad_sch

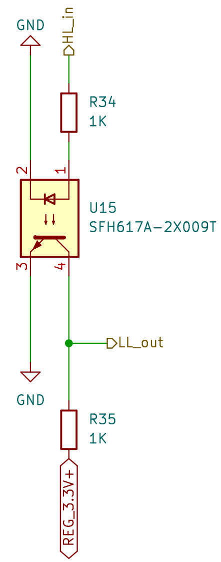
Title: Active Hi Optocoupler circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 16/27

SFH617A–2X009T
CTR 63–125%
Vf = 1.35V

Circuit CTR:
If = (12V–1.35V)/1K = 10.65mA
Ic = 3.3/1K = 3.3mA
CTRc = 3.3/10.65 = 30.9%

Opto is always in saturation

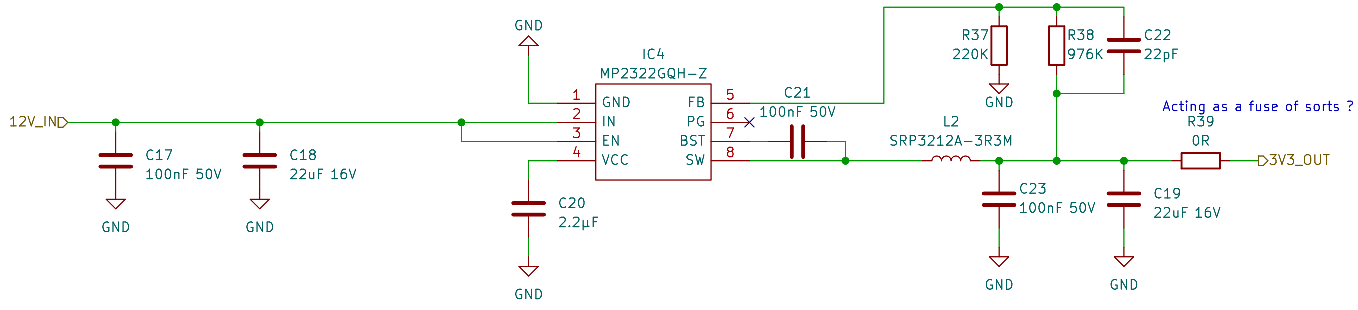


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Opto_ActHi.kicad_sch

Title: Active Hi Optocoupler circuit

Size: A4	Date: 2023–06–18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 17/27

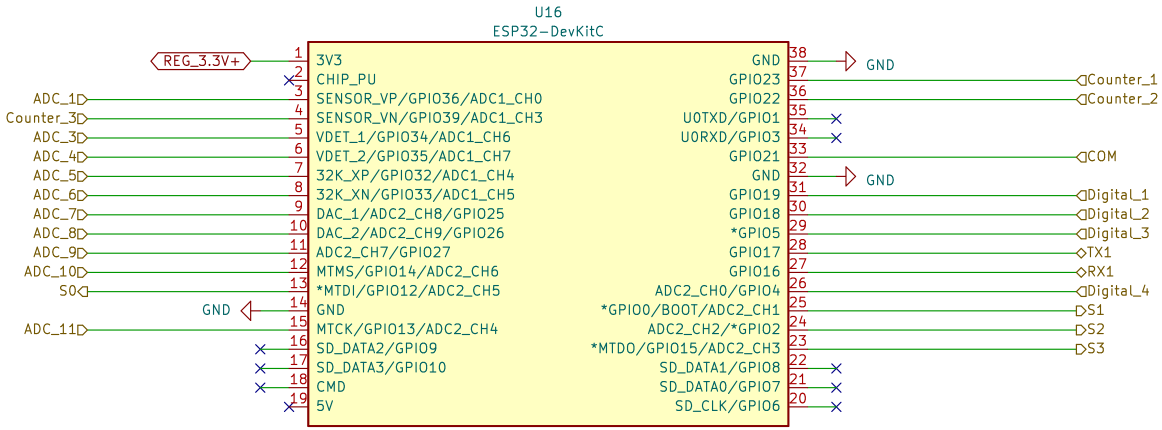


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: 12V_to_3V3_MP2322GQH.kicad_sch

Title: 5 to 3V3 stage

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 18/27

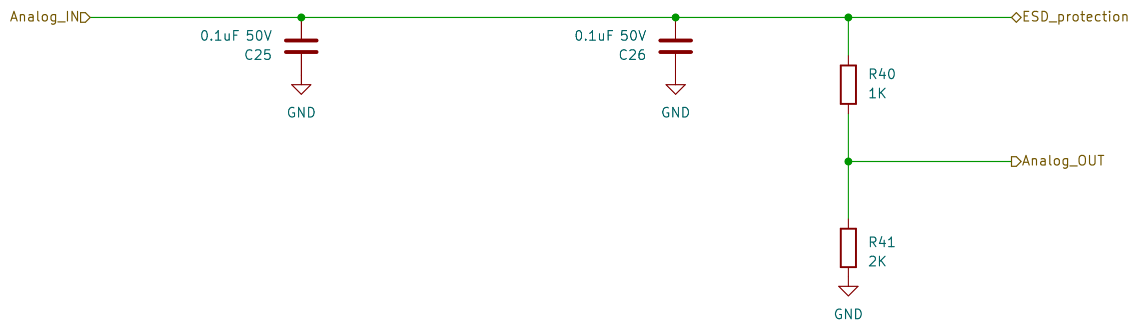


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: ESP32.kicad_sch

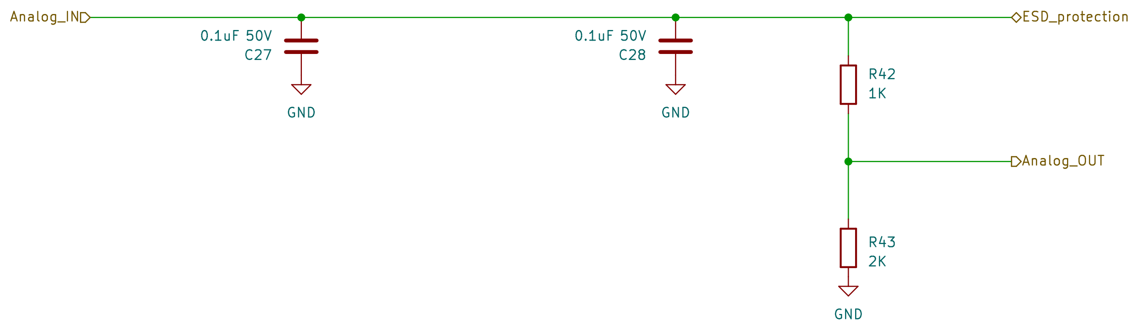
Title: ESP32 container

Size: A4 | Date: 2023−06−18 | **Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0) | Id: 19/27



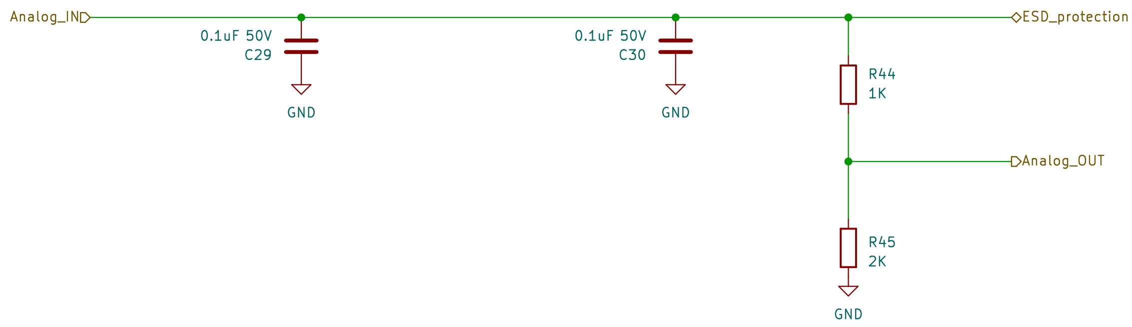
https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:		
File: AnalogV_Divider.kicad_sch		
Title: 0–5V voltage sensing circuit		
Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 20/27



https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:	
File: AnalogV_Divider.kicad_sch	
Title: 0–5V voltage sensing circuit	
Size: A4 Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)	Id: 21/27

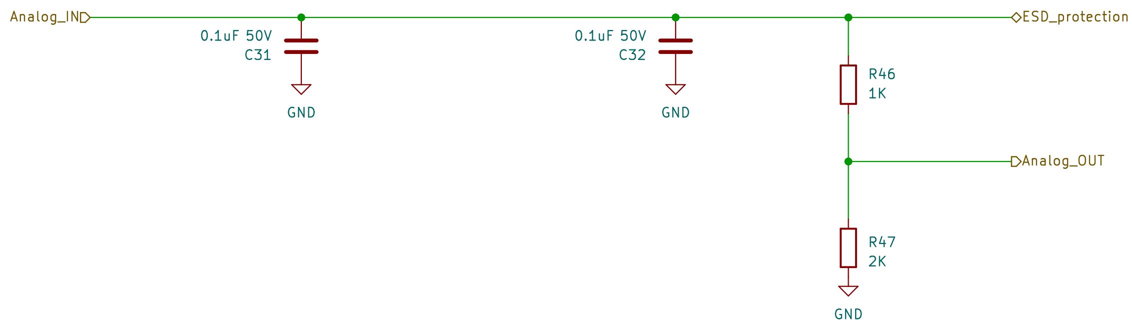


https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: AnalogV_Divider.kicad_sch

Title: 0–5V voltage sensing circuit

Size: A4 | Date: 2023-06-18 | **Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0) | Id: 22/27



https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: AnalogV_Divider.kicad_sch

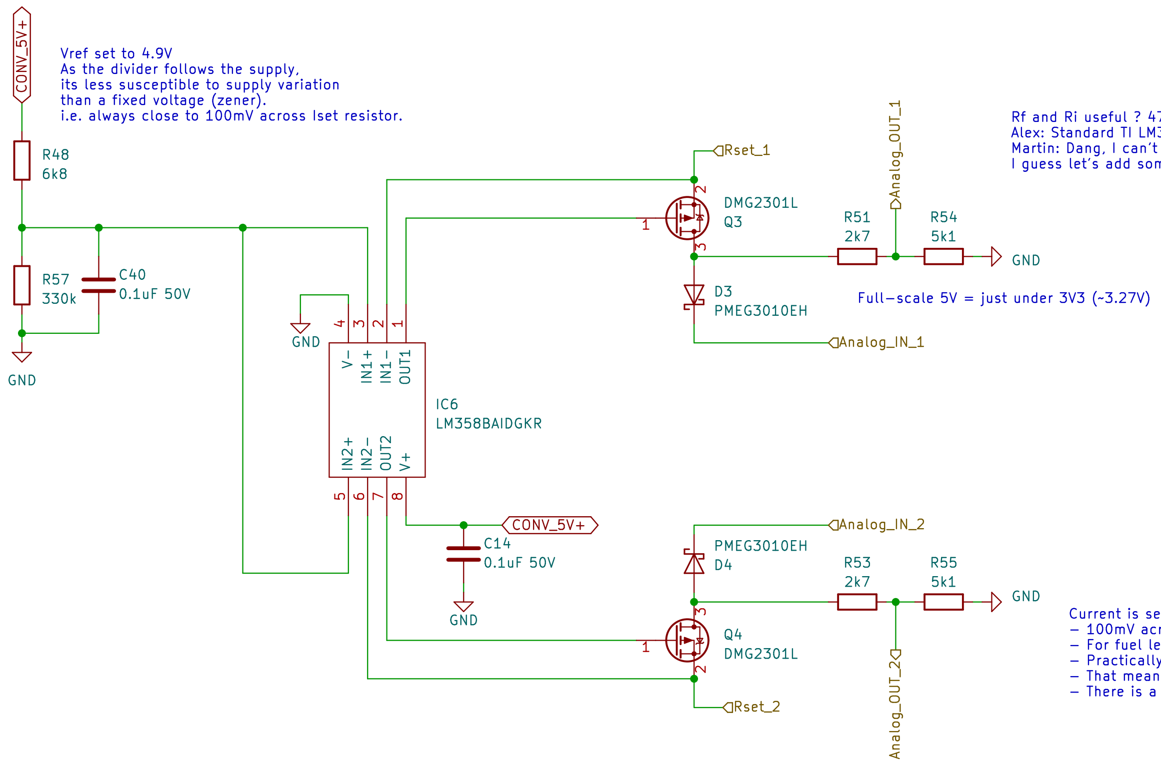
Title: 0–5V voltage sensing circuit

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 23/27

Ideas/issues :
- How to account for variations in the Vf of PMEG3010EH
    Alex: At ~4.5mA, Vf varies by ~120mV from -40 to 80degC. This equates to ~24ohm error over a large temp
    Martin : gotcha
- 5V may not be true 5V -> Zener regulator there too ? evaluate possible swings
    Alex: Used a Vref that follows any variation of 5V. More worried about keeping a set V across the current set resistor.
- Design is a bit limited to be usable on >750Ohm sensors like ECU sensors
    Alex: Could be used for sensors up to 900ohm. We could look to add configurable range switchig future versions.
    Martin : Currently I am reserving one I/O for higher impedance sensors. I guess increasing the Iset resistor is also a method, for example to 51R?
- Something better than PMEG3010EH to use ?
    Alex: At ~4.5mA, Vf is only ~200mV which is pretty good!
- No issue with Vset being so close to the Vcc for the LM358? I got a bit confused by the datasheet.

Vref set to 4.9V
As the divider follows the supply,
its less susceptible to supply variation
than a fixed voltage (zener).
i.e. always close to 100mV across Iset resistor.

Rf and Ri useful ? 47K, but apparently LM358B/BA integrates Rf and Ri
Alex: Standard TI LM358B or BA doesn't include resistors from what I can find.
Martin: Dang, I can't find where I read that Rf and Ri at 1k were integrated to simplify application.
I guess let's add some then ?



Current is set as follows :
- 100mV across 22R = ~4.54mA. MOSFET used to avoid influence from additional base current.
- For fuel level and common sensors (0-250Ohm), that gives a sensor voltage of anywhere between 0 and 1.135V
- Practically the maximum voltage that can be is 4.9V-0.550V = 4.35V (the schottky typical Vf, although usually lower)
- That means that in this current setup the maximum limit for sensor resistance readout is approximately 950Ohm
- There is a 5 -> 3.3V divider for the ESP32 ADC using a resistor divider. This accounts for when no sensor is attached.

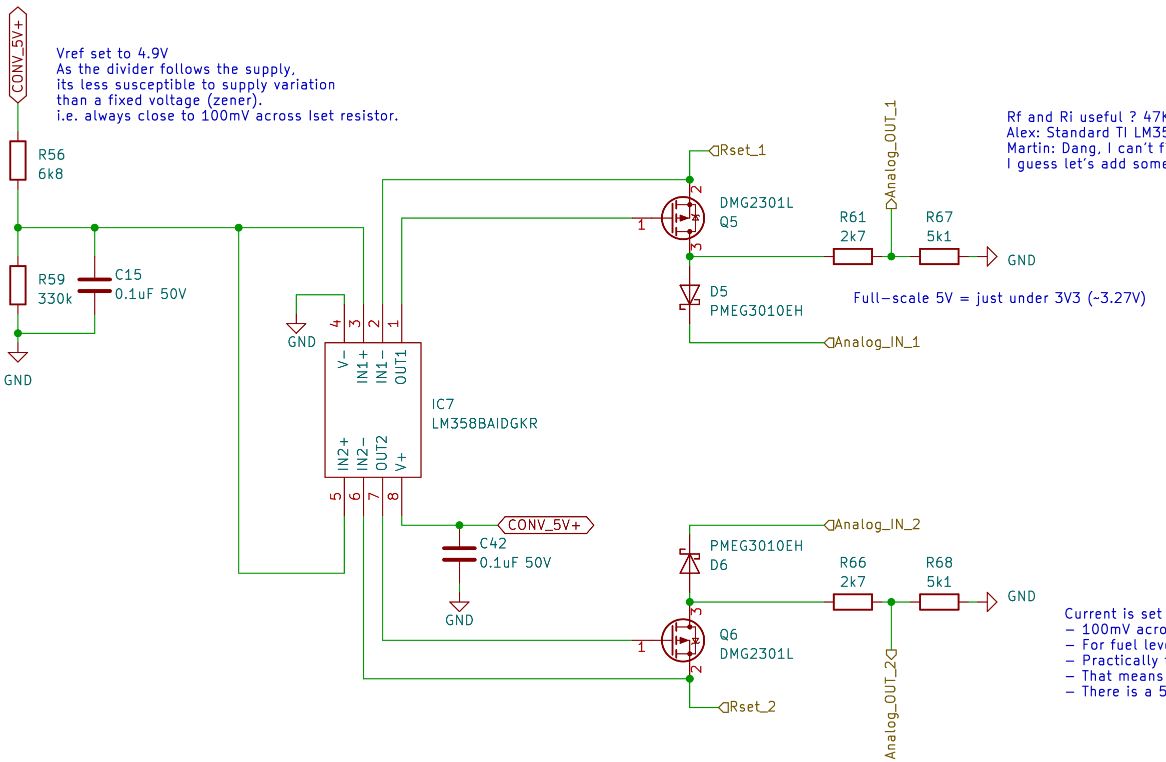
https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Rsensing_Pair.kicad_sch

Title: Dual Op-Amp Constant current source resistive sensor

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 24/27

Ideas/issues :
- How to account for variations in the Vf of PMEG3010EH
  - Alex: At ~4.5mA, Vf varies by ~120mV from -40 to 80degC. This equates to ~24ohm error over a large temp
  - Martin : gotcha
- 5V may not be true 5V -> Zener regulator there too ? evaluate possible swings
  - Alex: Used a Vref that follows any variation of 5V. More worried about keeping a set V across the current set resistor.
- Design is a bit limited to be usable on >750Ohm sensors like ECU sensors
  - Alex: Could be used for sensors up to 900ohm. We could look to add configurable range switchig future versions.
  - Martin : Currently I am reserving one I/O for higher impedance sensors. I guess increasing the Iset resistor is also a method, for example to 51R?
- Something better than PMEG3010EH to use ?
  - Alex: At ~4.5mA, Vf is only ~200mV which is pretty good!
- No issue with Vset being so close to the Vcc for the LM358? I got a bit confused by the datasheet.



Rf and Ri useful ? 47K, but apparently LM358B/BA integrates Rf and Ri
Alex: Standard TI LM358B or BA doesn't include resistors from what I can find.
Martin: Dang, I can't find where I read that Rf and Ri at 1k were integrated to simplify application.
I guess let's add some then ?

Current is set as follows :
- 100mV across 22R = ~4.54mA. MOSFET used to avoid influence from additional base current.
- For fuel level and common sensors (0-250Ohm), that gives a sensor voltage of anywhere between 0 and 1.135V
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- That means that in this current setup the maximum limit for sensor resistance readout is approximately 950Ohm
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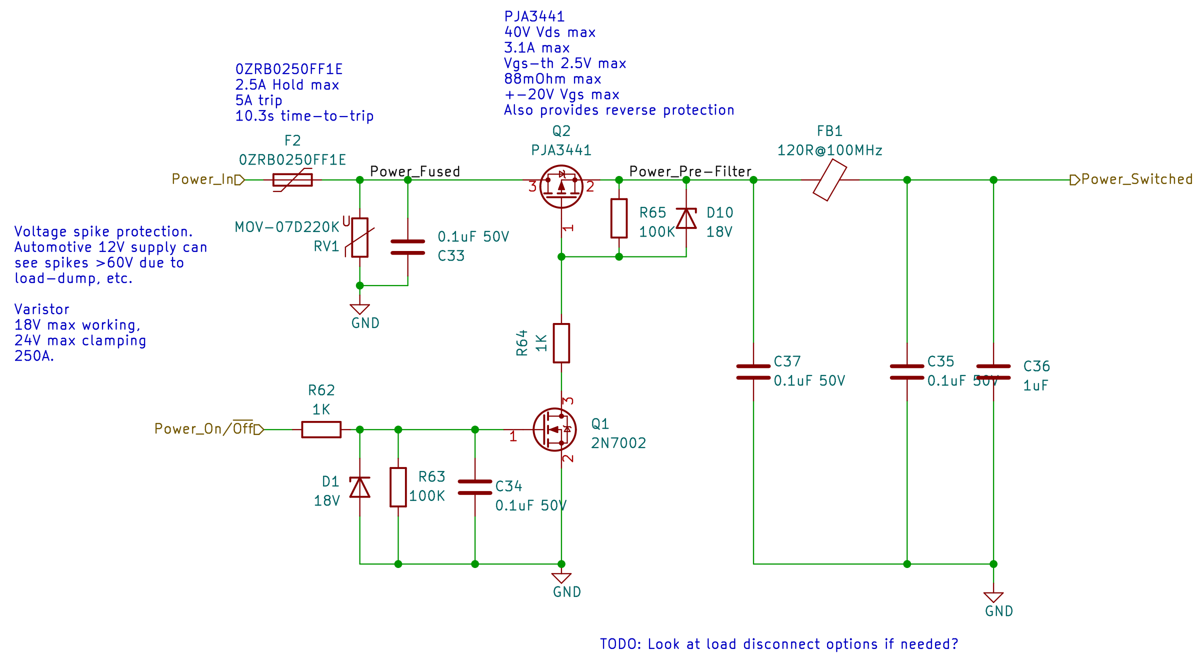
https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Rsensing_Pair.kicad_sch

Title: Dual Op-Amp Constant current source resistive sensor

Size: A4	Date: 2023-06-18	**Rev: 1.2.3**
KiCad E.D.A. kicad (7.0.0)		Id: 25/27



https://cadlab.io/projects/vxdash
https://github.com/martinroger/VXDash

Sheet:
File: Power_Input.kicad_sch

Title: Power switching and protection

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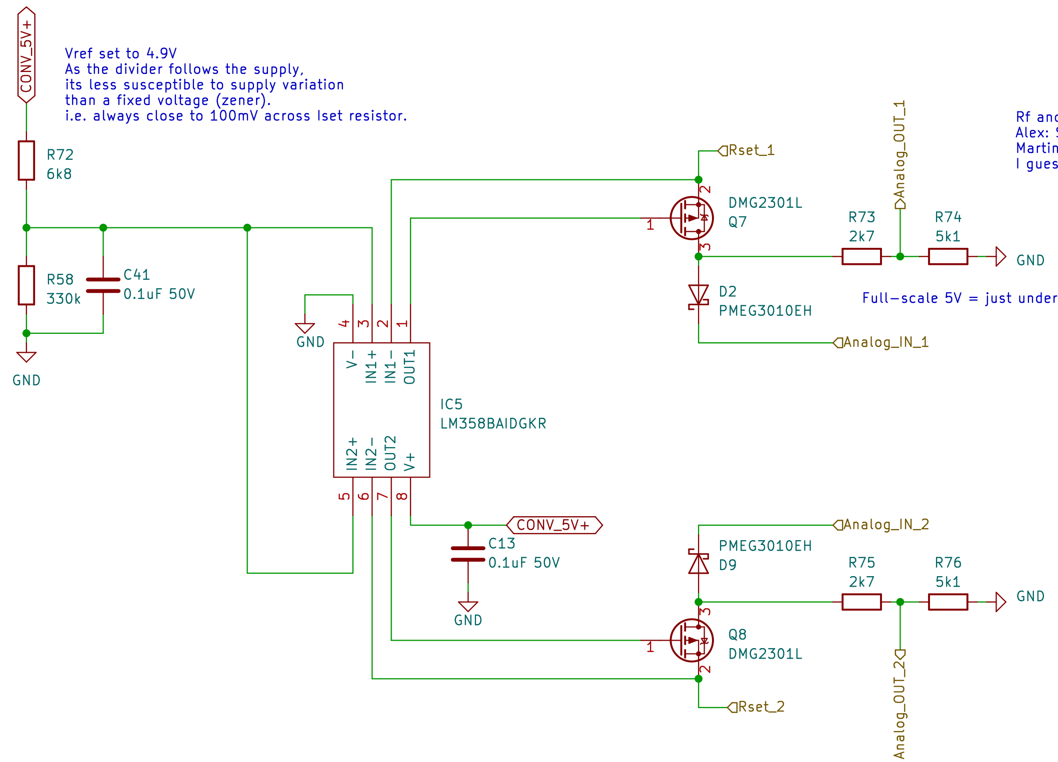
KiCad E.D.A. kicad (7.0.0) | Id: 26/27

Ideas/issues :
- How to account for variations in the Vf of PMEG3010EH
  Alex: At ~4.5mA, Vf varies by ~120mV from -40 to 80degC. This equates to ~24ohm error over a large temp
  Martin : gotcha
- 5V may not be true 5V -> Zener regulator there too ? evaluate possible swings
  Alex: Used a Vref that follows any variation of 5V. More worried about keeping a set V across the current set resistor.
- Design is a bit limited to be usable on >750Ohm sensors like ECU sensors
  Alex: Could be used for sensors up to 900ohm. We could look to add configurable range switchig future versions.
  Martin : Currently I am reserving one I/O for higher impedance sensors. I guess increasing the Iset resistor is also a method, for example to 51R?
- Something better than PMEG3010EH to use ?
  Alex: At ~4.5mA, Vf is only ~200mV which is pretty good!
- No issue with Vset being so close to the Vcc for the LM358? I got a bit confused by the datasheet.

Vref set to 4.9V
As the divider follows the supply,
its less susceptible to supply variation
than a fixed voltage (zener).
i.e. always close to 100mV across Iset resistor.



Rf and Ri useful ? 47K, but apparently LM358B/BA integrates Rf and Ri
Alex: Standard TI LM358B or BA doesn't include resistors from what I can find.
Martin: Dang, I can't find where I read that Rf and Ri at 1k were integrated to simplify application.
I guess let's add some then ?

Full-scale 5V = just under 3V3 (~3.27V)

Current is set as follows :
- 100mV across 22R = ~4.54mA. MOSFET used to avoid influence from additional base current.
- For fuel level and common sensors (0-250Ohm), that gives a sensor voltage of anywhere between 0 and 1.135V
- Practically the maximum voltage that can be is 4.9V-0.550V = 4.35V (the schottky typical Vf, although usually lower)
- That means that in this current setup the maximum limit for sensor resistance readout is approximately 950Ohm
- There is a 5 -> 3.3V divider for the ESP32 ADC using a resistor divider. This accounts for when no sensor is attached.

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Sheet:
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