

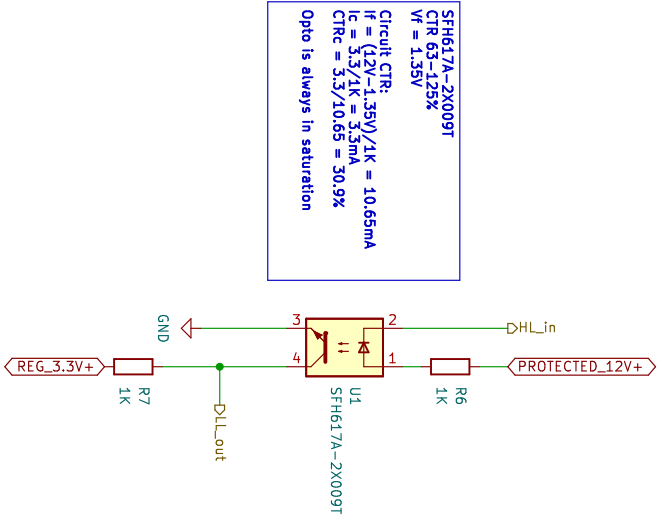
# MAX 2A CONTINUOUS OUTPUT

All resistors low tolerance  
All capacitors low ESR

<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/YXDash>

Sheet:  
File: 12V\_to\_5V\_AP63200WU-7.kicad\_sch  
**Title: 12V to 5V conversion**  
Size: A4 Date: 2023-05-14  
KiCad E.D.A. kicad (7.0.0)

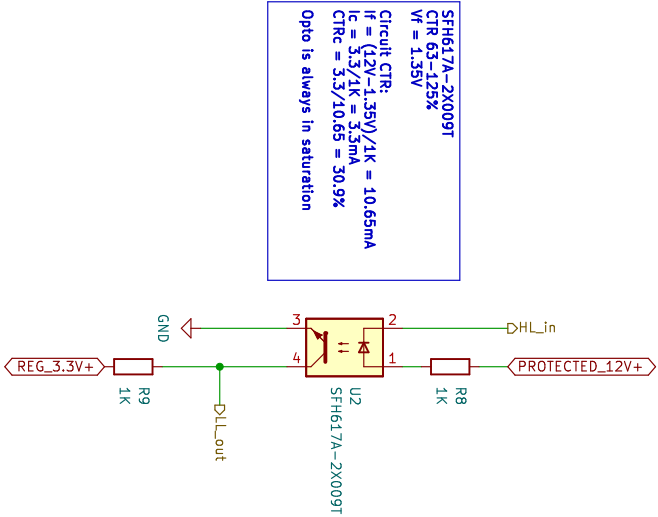
Rev: 1.2.2  
Id: 2/33



SFH617A-2X009T  
CTR 63.125%  
 $V_f = 1.35V$   
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1k = 10.65mA$   
 $I_c = 3.3V / 1k = 3.3mA$   
CTRc =  $3.3 / 10.65 = 30.9\%$   
Opto is always in saturation

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

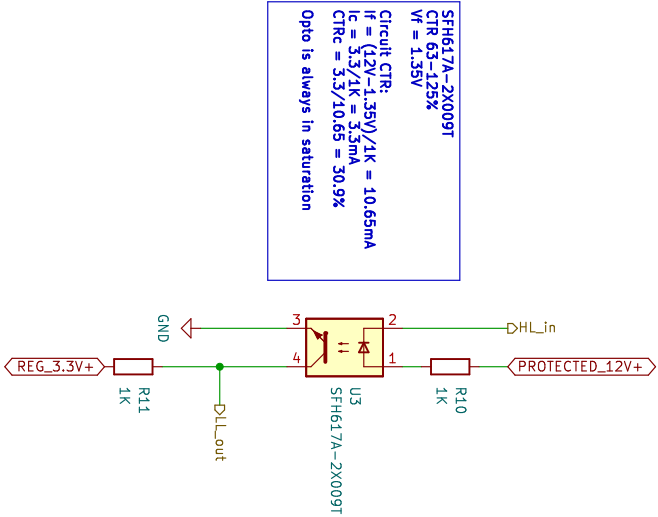
Sheet:	
File: Opto_Accto.kicad_sch	
<b>Title: Active Low Optocoupler circuit</b>	
Size: A4	Date: 2023-05-14
KiCad E.D.A. kicad (7.0.0)	Rev: 1.2.2 Id: 3/33



SFH617A-2X009T  
CTR 63.125%  
 $V_f = 1.35V$   
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1k = 10.65mA$   
 $I_c = 3.3 / 1k = 3.3mA$   
CTRc =  $3.3 / 10.65 = 30.9\%$   
Opto is always in saturation

<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

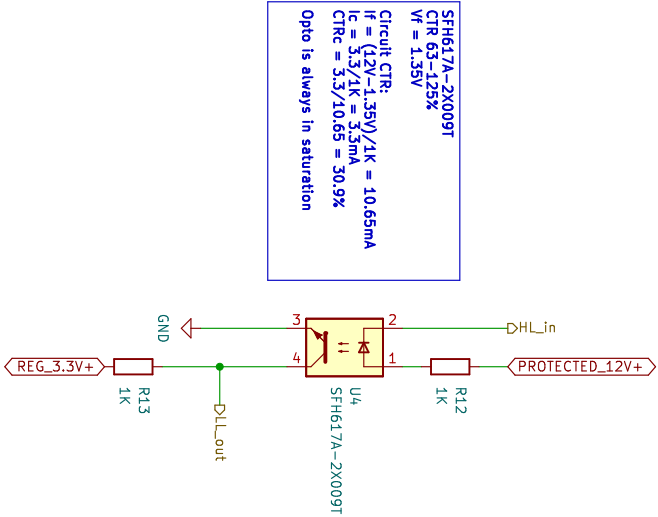
Sheet:	
File: Opto_Acctl0.kicad_sch	
<b>Title: Active Low Optocoupler circuit</b>	
Size: A4	Date: 2023-05-14
KiCad E.D.A. kicad (7.0.0)	Rev: 1.2.2 Id: 4/33



SFH617A-2X009T  
CTR 63.125%  
 $V_f = 1.35V$   
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1k = 10.65mA$   
 $I_c = 3.3V / 1k = 3.3mA$   
CTRc =  $3.3 / 10.65 = 30.9\%$   
Opto is always in saturation

<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

Sheet:	
File: Opto-Actlo.kicad_sch	
<b>Title: Active Low Optocoupler circuit</b>	
Size: A4	Date: 2023-05-14
KiCad E.D.A. kicad (7.0.0)	Rev: 1.2.2 Id: 5/33

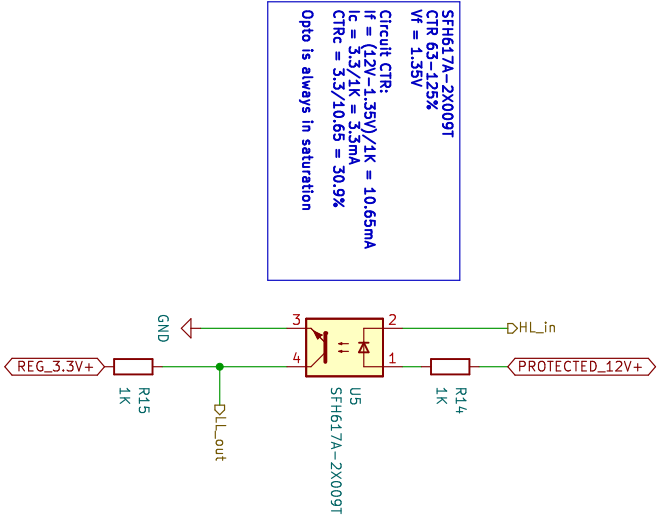


<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: Opto-Actlo.kicad\_sch

Title: Active Low Optocoupler circuit

Size: A4	Date: 2023-05-14	Rev: 1.2.2
KiCad E.D.A. kicad (7.0.0)		Id: 6/33



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

Sheet:  
File: Opto\_Accto.kicad\_sch

**Title: Active Low Optocoupler circuit**

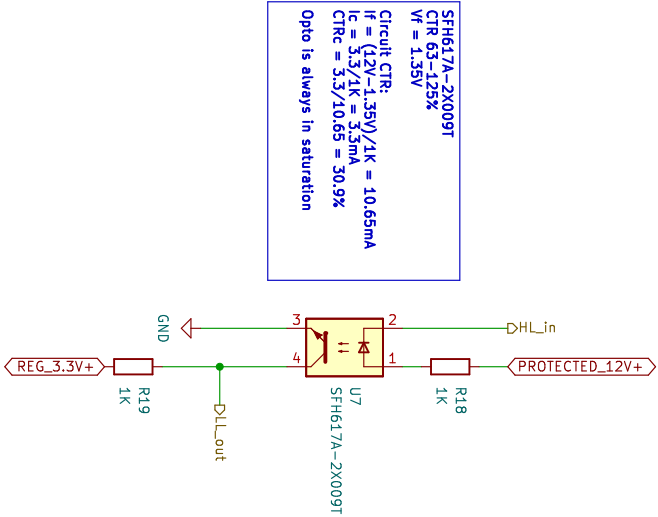
Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: 1.2.2

Id: 7/33





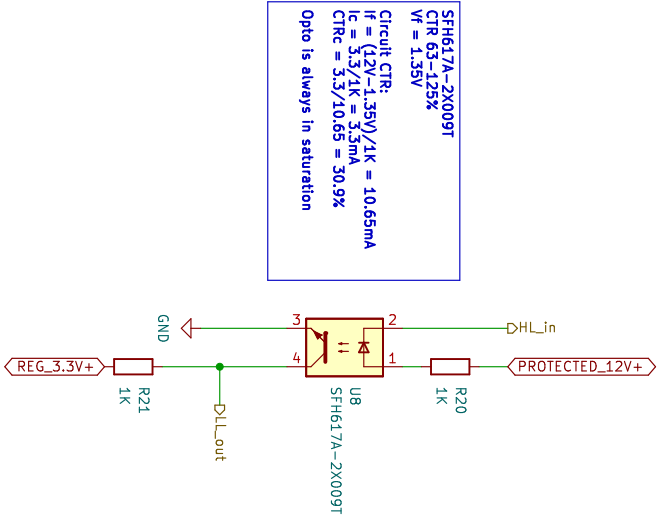


<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: Opto\_Accto.kicad\_sch

Title: Active Low Optocoupler circuit

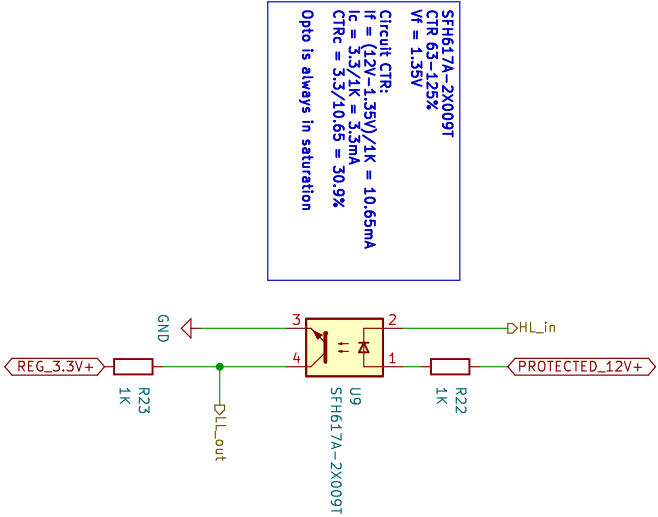
Size: A4	Date: 2023-05-14	Rev: 1.2.2
KiCad E.D.A. kicad (7.0.0)		Id: 9/33



SFH617A-2X009T  
CTR 63.125%  
 $V_f = 1.35V$   
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1k = 10.65mA$   
 $I_c = 3.3V / 1k = 3.3mA$   
CTRc =  $3.3 / 10.65 = 30.9\%$   
Opto is always in saturation

<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

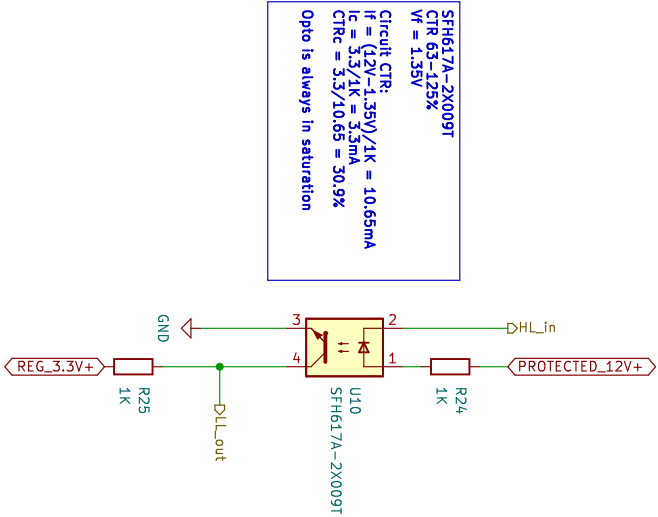
Sheet:	
File: Opto_Actlo.kicad_sch	
<b>Title: Active Low Optocoupler circuit</b>	
Size: A4	Date: 2023-05-14
KiCad E.D.A. kicad (7.0.0)	Rev: 1.2.2 Id: 10/33



SFH617A-2X009T  
CTR 63.125%  
 $V_f = 1.35V$   
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1k = 10.65mA$   
 $I_c = 3.3V / 1k = 3.3mA$   
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_Accto.kicad_sch	
<b>Title: Active Low Optocoupler circuit</b>	
Size: A4	Date: 2023-05-14
KiCad E.D.A. kicad (7.0.0)	Rev: 1.2.2 Id: 11/33



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

Sheet:

File: Opto\_Accto.kicad\_sch

**Title: Active Low Optocoupler circuit**

Size: A4

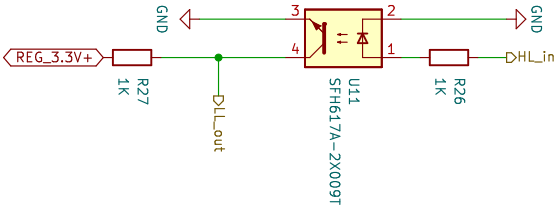
Date: 2023-05-14

KiCad E.D.A. kicad (7.0.0)

Rev: 1.2.2

Id: 12/33

SFH617A-2X009T  
CTR 63-125%  
 $V_f = 1.35V$   
  
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1K = 10.65mA$   
 $I_C = 3.3 / 1K = 3.3mA$   
 $CTR_C = 3.3 / 10.65 = 30.9\%$   
  
Opto is always in saturation



<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

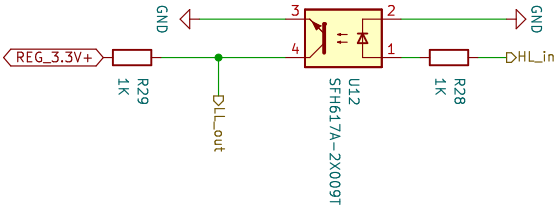
Sheet:  
File: Opto\_ActHi.kicad\_sch

**Title: Active Hi Optocoupler circuit**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: 1.2.2  
Id: 13/33

SFH617A-2X009T  
CTR 63-125%  
 $V_f = 1.35V$   
  
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1K = 10.65mA$   
 $I_C = 3.3 / 1K = 3.3mA$   
 $CTR_c = 3.3 / 10.65 = 30.9\%$   
  
Opto is always in saturation



<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

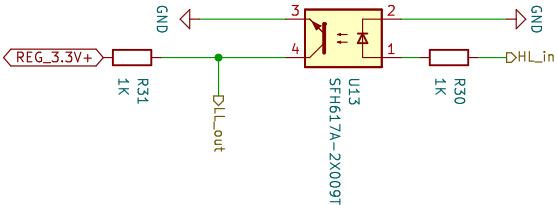
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File: Opto\_ActHi.kicad\_sch

**Title: Active Hi Optocoupler circuit**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: 1.2.2  
Id: 14/33

SFH617A-2X009T  
CTR 63-125%  
 $V_f = 1.35V$   
  
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1K = 10.65mA$   
 $I_C = 3.3 / 1K = 3.3mA$   
 $CTR_C = 3.3 / 10.65 = 30.9\%$   
  
Opto is always in saturation



<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

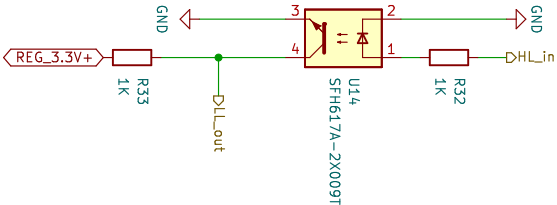
Sheet:  
File: Opto\_ActHi.kicad\_sch

**Title: Active Hi Optocoupler circuit**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: 1.2.2  
Id: 15/33

SFH617A-2X009T  
CTR 63-125%  
 $V_f = 1.35V$   
  
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1K = 10.65mA$   
 $I_C = 3.3 / 1K = 3.3mA$   
 $CTR_C = 3.3 / 10.65 = 30.9\%$   
  
Opto is always in saturation



<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

Sheet:  
File: Opto\_ActHi.kicad\_sch

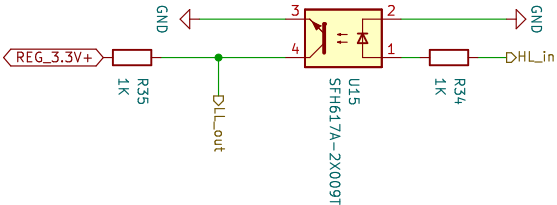
**Title: Active Hi Optocoupler circuit**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: 1.2.2  
Id: 16/33



SFH617A-2X009T  
CTR 63-125%  
 $V_f = 1.35V$   
  
Circuit CTR:  
 $I_f = (12V - 1.35V) / 1K = 10.65mA$   
 $I_C = 3.3 / 1K = 3.3mA$   
 $CTR_C = 3.3 / 10.65 = 30.9\%$   
  
Opto is always in saturation



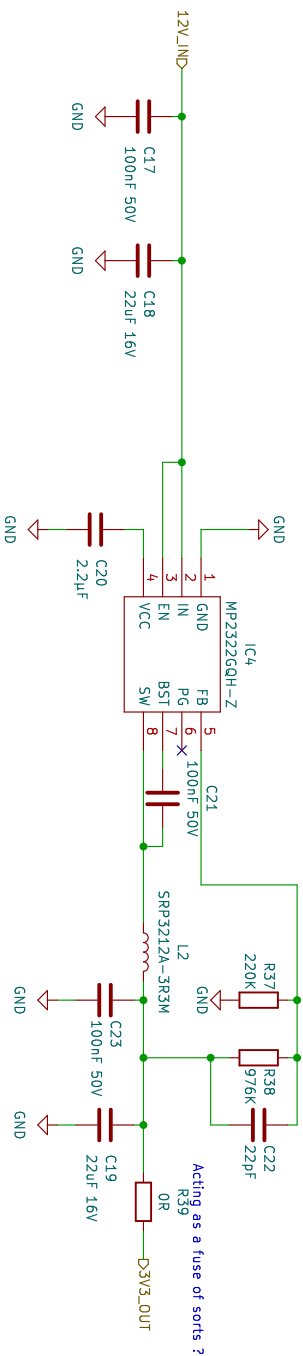
<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXxDash>

Sheet:  
File: Opto\_ActHi.kicad\_sch

**Title: Active Hi Optocoupler circuit**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: 1.2.2  
Id: 17/33



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

Sheet:

File: 12V\_to\_3V3\_MP2322GQH.kicad\_sch

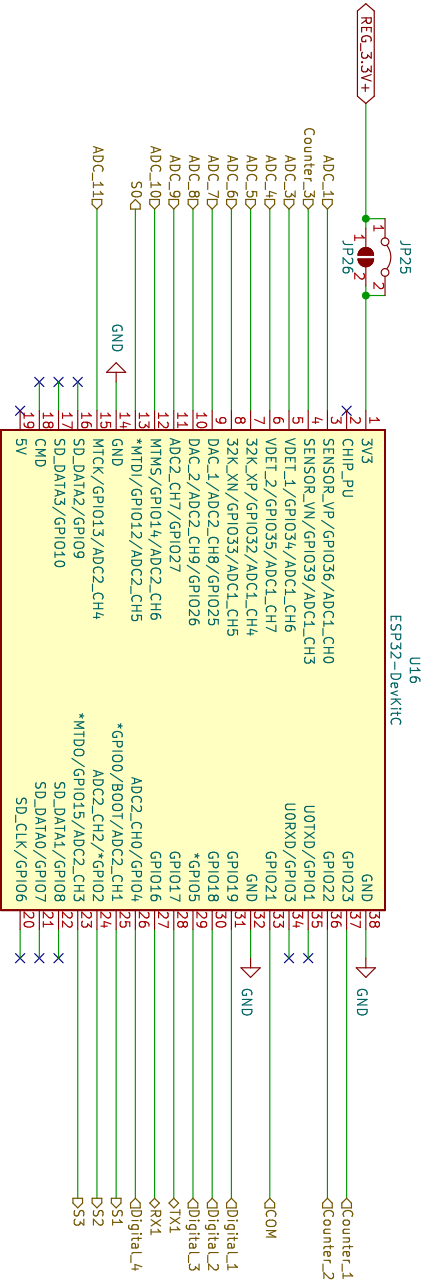
Title: 5 to 3V3 stage

Size: A4 Date: 2023-05-14

KiCad E.D.A. kicad (7.0.0)

Rev: 1.2.2

Id: 18/33



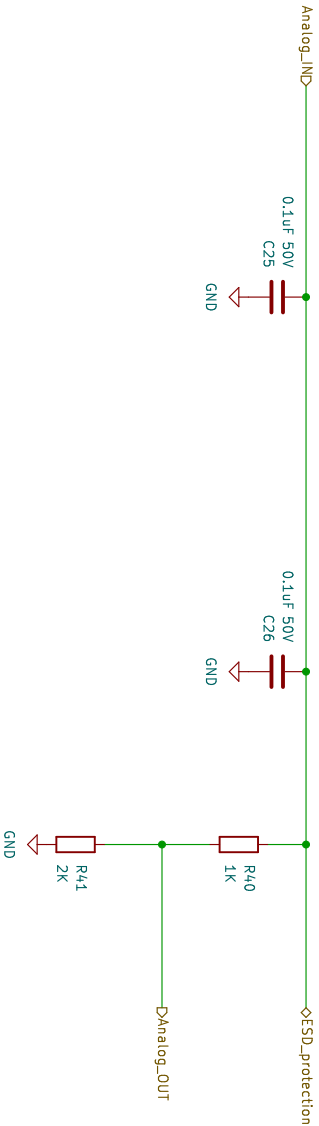
<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: ESP32.kicad\_sch

Title: **ESP32 container**

Size: A4 Date: 2023-05-14

KiCad E.D.A. kicad (7.0.0) Rev: 1.2.2 Id: 19/33

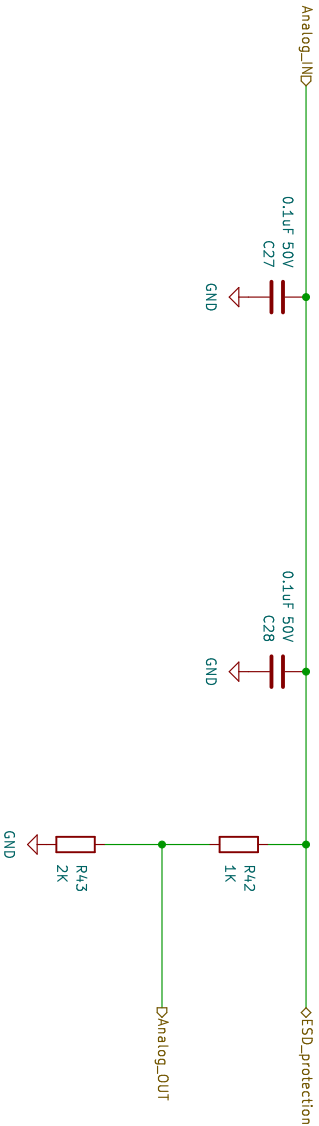


<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: AnalogV\_Divider.kicad\_sch

**Title: 0-5V voltage sensing circuit**

Size: A4	Date: 2023-05-14	Rev: 1.2.2
KiCad E.D.A. kicad (7.0.0)		Id: 20/33

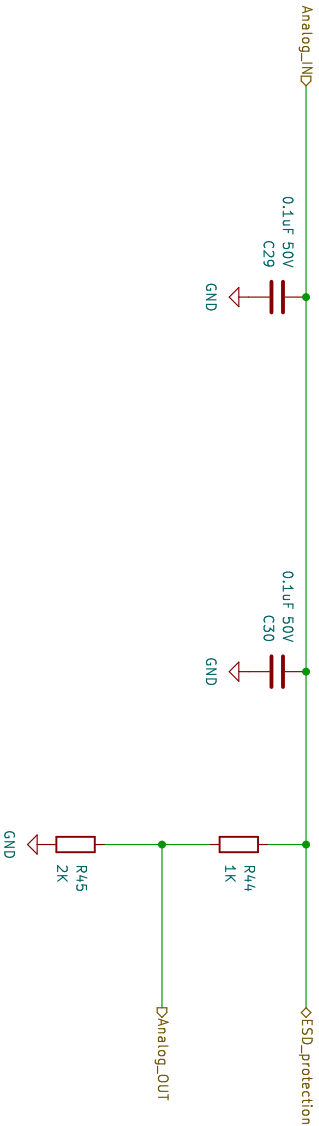


<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: AnalogV\_Divider.kicad\_sch

**Title: 0-5V voltage sensing circuit**

Size: A4	Date: 2023-05-14	Rev: 1.2.2
KiCad E.D.A. kicad (7.0.0)		Id: 21/33

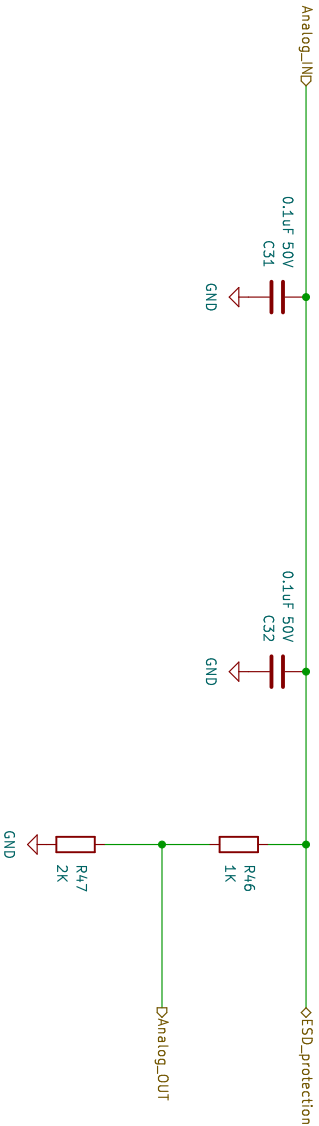


<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: AnalogV\_Divider.kicad\_sch

**Title: 0-5V voltage sensing circuit**

Size: A4	Date: 2023-05-14	Rev: 1.2.2
KiCad E.D.A. kicad (7.0.0)		Id: 22/33



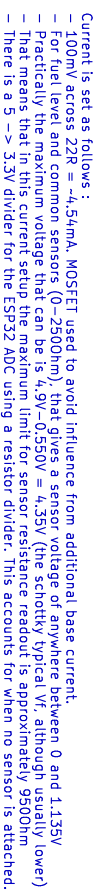
<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: AnalogV\_Divider.kicad\_sch

**Title: 0-5V voltage sensing circuit**

Size: A4	Date: 2023-05-14	Rev: 1.2.2
KiCad E.D.A. kicad (7.0.0)		Id: 23/33

- Rf and Ri useful ? 47k, but apparently LM358B/BA integrates Rf and Ri Alex: Standard TL 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 ?



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

Sheet:  
File: Rsensing\_Pair.kicad\_sch

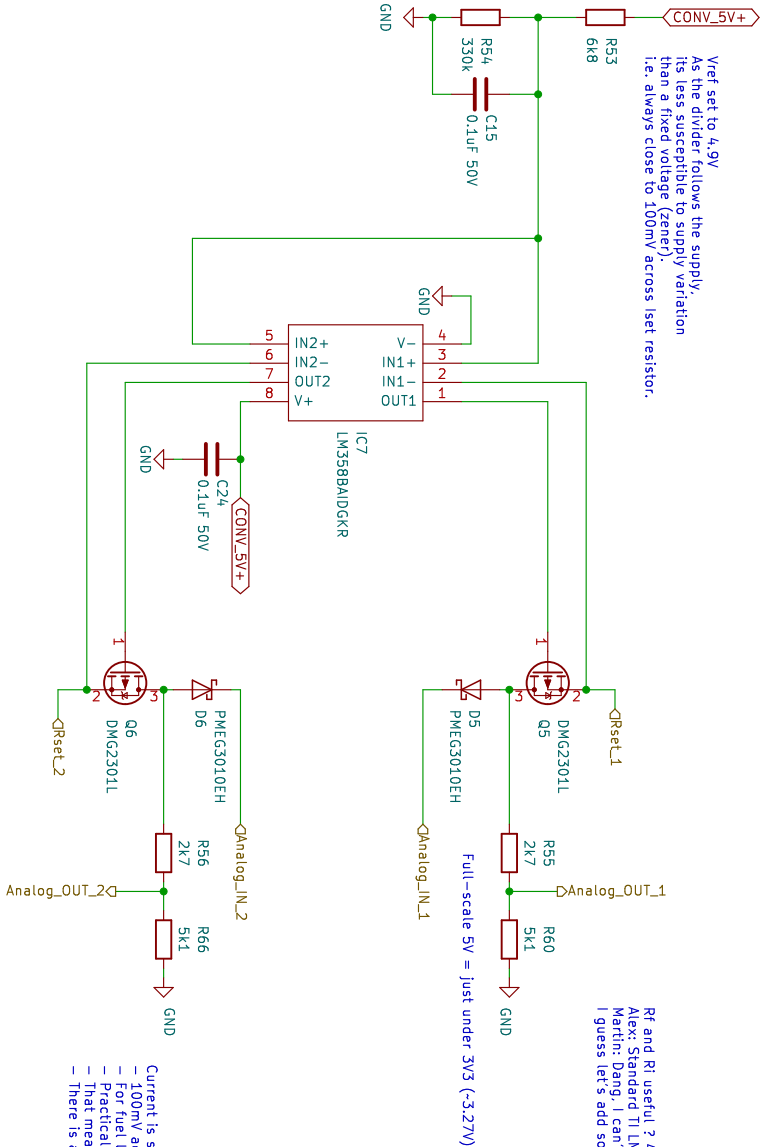
**Title: Dual Op-Amp Constant current source resistive sensor**

Size: A4	Date: 2023-05-14
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KiCad E.D.A. kicad (7.0.0)	Id: 24/33
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- Ideas/issues :
- How to account for variations in the  $V_f$  of PMEG3010EH
  - Alex: At  $-4.5\text{mA}$ ,  $V_f$  varies by  $-120\text{mV}$  from  $-40$  to  $80^\circ\text{C}$ . This equates to  $-240\text{m}$  error over a large temp
  - $5\text{V}$  may not be true  $5\text{V}$   $\rightarrow$  Zener regulator there too ? evaluate possible swings
  - Alex: Used a  $V_{ref}$  that follows any variation of  $5\text{V}$ . More worried about keeping a set  $V$  across the current set resistor.
  - Design is a bit limited to be usable on  $>7500\Omega$  sensors like ECU sensors
  - Alex: Could be used for sensors up to  $9000\Omega$ . We could look to add configurable range switching future versions.
  - Martin : Currently I am reserving one I/O for higher impedance sensors. I guess increasing the  $I_{set}$  resistor is also a method, for example to  $51\text{R}$ ?
  - Something better than PMEG3010EH to use ?
  - Alex: At  $-4.5\text{mA}$ ,  $V_f$  is only  $-200\text{mV}$  which is pretty good!
  - No issue with  $V_{set}$  being so close to the  $V_{cc}$  for the LM358? I got a bit confused by the datasheet.



$R_f$  and  $R_i$  useful  $2.47\text{k}$ , but apparently LM358B/BA integrates  $R_f$  and  $R_i$ .  
Alex: Sending LM358B or BA doesn't include resistors from what I can find.  
Martin: Design, can't find where I read that  $R_f$  and  $R_i$  at  $1\text{k}$  were integrated to simplify application.  
I guess let's add some then ?

- Current is set as follows :
- $100\text{mV}$  across  $22\text{R} = -4.5\text{mA}$ , MOSFET used to avoid influence from additional base current.
  - For fuel level and common sensors ( $0-2500\Omega$ ), that gives a sensor voltage of anywhere between  $0$  and  $1.135\text{V}$
  - Practically the maximum voltage that can be is  $4.9\text{V}-0.550\text{V} = 4.35\text{V}$  (the schottky typical  $V_f$ , although usually lower)
  - That means that in this current setup the maximum limit for sensor resistance readout is approximately  $9500\Omega$
  - There is a  $5 \rightarrow 3.3\text{V}$  divider for the ESP32 ADC using a resistor divider. This accounts for when no sensor is attached.

<https://cadlab.io/projects/vxldash>  
<https://github.com/martinroger/VXxDash>

Sheet:  
File: Rsensing\_Pair.Kicad.sch

Title: Dual Op-Amp Constant current source resistive sensor

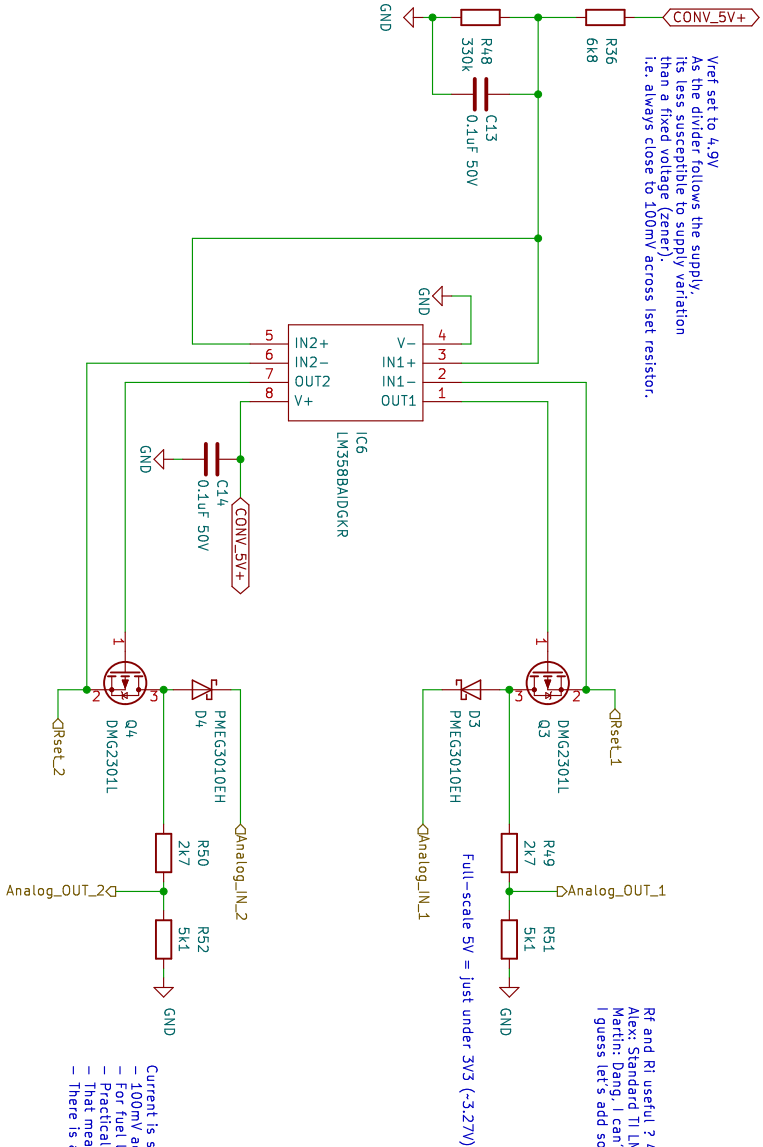
Size: A4 Date: 2023-05-14

KiCad E.D.A. kicad (7.0.0)

Rev: 1.2.2  
Id: 25/33



- Ideas/issues :
- How to account for variations in the  $V_f$  of PMEG3010EH
  - Alex: At  $-4.5\text{mA}$ ,  $V_f$  varies by  $-120\text{mV}$  from  $-40$  to  $80^\circ\text{C}$ . This equates to  $-240\text{m}$  error over a large temp
  - $-5\text{V}$  may not be true  $5\text{V} \rightarrow$  Zener regulator there too ? evaluate possible swings
  - Alex: Used a  $V_{ref}$  that follows any variation of  $5\text{V}$ . More worried about keeping a set  $V$  across the current set resistor.
  - Design is a bit limited to be usable on  $>7500\Omega$  sensors like ECU sensors
  - Alex: Could be used for sensors up to  $9000\Omega$ . We could look to add configurable range switching future versions.
  - Martin : Currently I am reserving one I/O for higher impedance sensors. I guess increasing the  $I_{set}$  resistor is also a method, for example to  $51\text{R}$ ?
  - Something better than PMEG3010EH to use ?
  - Alex: At  $-4.5\text{mA}$ ,  $V_f$  is only  $-200\text{mV}$  which is pretty good!
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Alex: Standard LM358B or BA doesn't include resistors from what I can find.  
Martin: Design, I can't find where I read that  $R_f$  and  $R_i$  at  $1\text{k}$  were integrated to simplify application.  
I guess let's add some then ?

- Current is set as follows :
- $100\text{mV}$  across  $22\text{R} = -4.5\text{mA}$ , MOSFET used to avoid influence from additional base current.
  - For fuel level and common sensors ( $0-2500\Omega$ ), that gives a sensor voltage of anywhere between  $0$  and  $1.135\text{V}$
  - Practically the maximum voltage that can be is  $4.9\text{V}-0.550\text{V} = 4.35\text{V}$  (the schottky typical  $V_f$ , although usually lower)
  - That means that in this current setup the maximum limit for sensor resistance readout is approximately  $9500\Omega$
  - There is a  $5 \rightarrow 3.3\text{V}$  divider for the ESP32 ADC using a resistor divider. This accounts for when no sensor is attached.

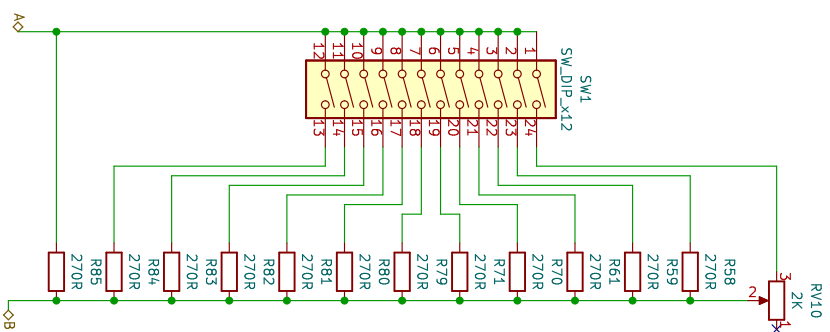
<https://cadlab.io/projects/vxldash>  
<https://github.com/martinroger/VXxDash>

Sheet:  
File: Rsensing\_Pair.kicad\_sch

Title: Dual Op-Amp Constant current source resistive sensor

Size: A4 Date: 2023-05-14

KiCad E.D.A. kicad (7.0.0) Rev: 1.2.2 Id: 27/35



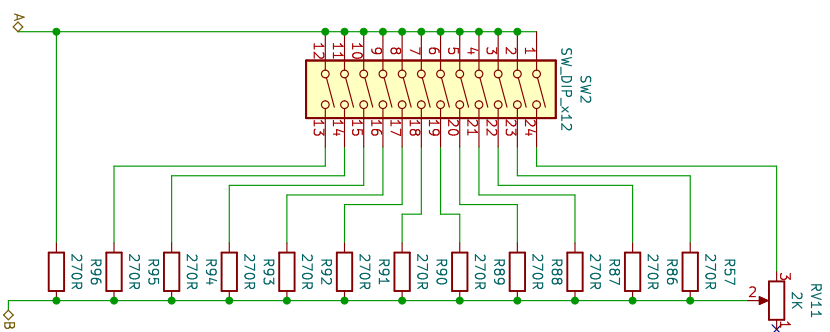
<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: R\_bank.kicad\_sch

Title: 270R divider

Size: A4 Date: 2023-05-14  
KiCad E.D.A. kicad (7.0.0)

Rev: 1.2.2  
Id: 28/33



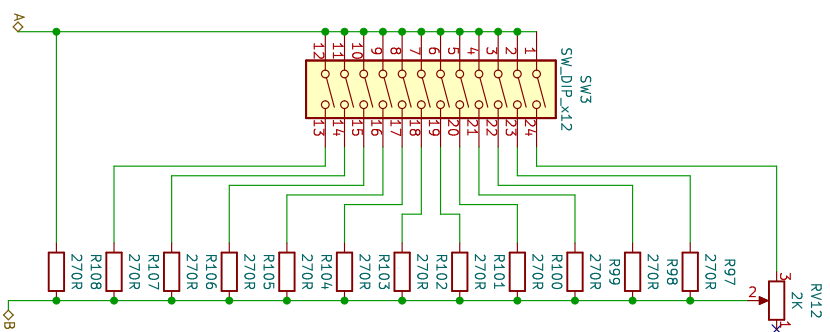
<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: R\_bank.kicad\_sch

Title: **270R divider**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: **1.2.2**  
Id: 29/33



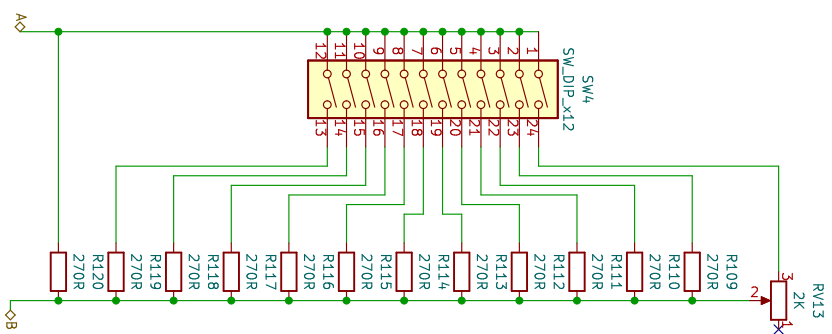
<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: R\_bank.kicad\_sch

Title: **270R divider**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: **1.2.2**  
Id: 30/33



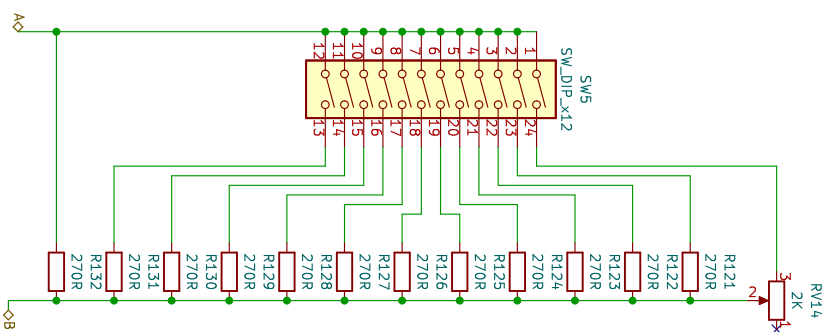
<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

Sheet:  
File: R\_bank.kicad\_sch

Title: **270R divider**

Size: A4 Date: 2023-05-14  
KiCad E.D.A. kicad (7.0.0)

Rev: **1.2.2**  
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<https://cadlab.io/projects/vxdash>  
<https://github.com/martinroger/VXDash>

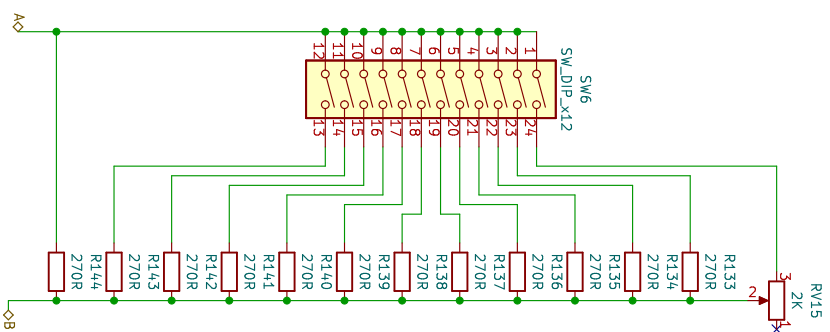
Sheet:  
File: R\_bank.kicad\_sch

Title: **270R divider**

Size: A4 Date: 2023-05-14  
KiCad E.D.A. kicad (7.0.0)

Rev: **1.2.2**  
Id: 32/33





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

Sheet:  
File: R\_bank.kicad\_sch

Title: **270R divider**

Size: A4  
Kicad E.D.A. kicad (7.0.0)

Rev: **1.2.2**  
Id: 33/33