

**PCB Manufacturing Constraints**

- Size 54.1 x 75.2 mm, 4 Layer
- 0.25 mm Track Width
- 0.15 mm Copper Clearance
- 0.38 mm Edge Clearance
- 0.35 mm Toolsize / non plated Hole
- 0.25 mm Plated Hole (End-)Size
- 0.125 mm Annular Ring
- 2.54 mm milling radius
- Solder Paste Pads are optimized for a 90 - 110 um Stencil

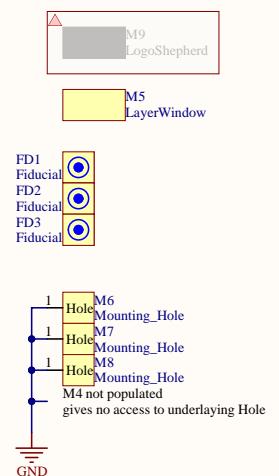
**Assembly (v2r1)**

- 2 Variations, recorder / emulator are self-contained and optional
  - with Rec & Emu -> 276 parts, 42 unique
  - with Emu -> 219 parts, 39 unique
- Mech-15 contains Pick and Place Info
  - cross (+) marks origin of part,
  - chamfered edge and circle mark pad 1 of ICs
  - "C" marks cathode of diodes
- Mech-2 contains Top Part Designators
  - smallest part 0402
  - smallest pitch 0.5 mm, QFN
  - only top layer populated

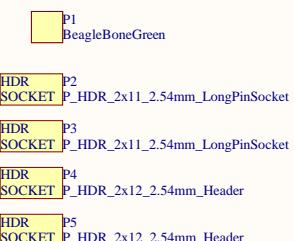
**Manual Assembly**

- Mech-13 contains info about non-reflow parts ( 8 items)
- Mech-13 contains info about non-reflow parts ( 8 items)

## Misc



## BOM-Additions



**External-BOM**

- USB-Stick 256 GB
- Ethernet Cables
- POE-Adapter
- uSD-Card (for flashing)

**Calibration Resistors**

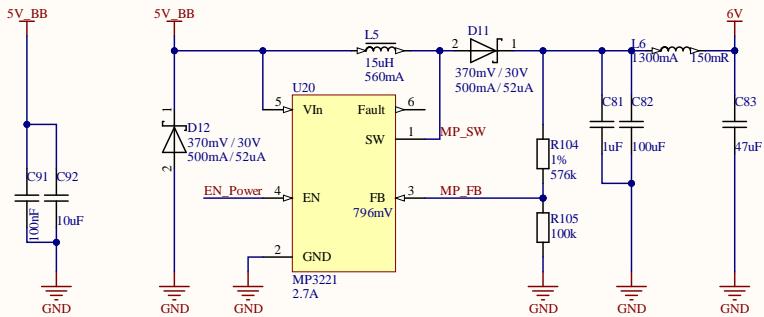
|                 |                      |
|-----------------|----------------------|
| 1k-0603-0.05%   | 667-ERA-3ARW102V     |
| 100R-0603-0.05% | 754-RG1608N-101-W-T1 |

**Pinheader Connection BBone Variants**

- 2x23 Header -> 77313-802-46LF 1.3 €
- 2x23 LongPinSocket
  - Samtec SSQ-123-23-G-D or 03-G-D 6 €
  - Major League SSHQ-123-D-10-G-LF 3 €
- 2x11 LongPinSocket & 2x12 Header
  - Samtec SSQ-111-03-G-D 3 €
  - Amphenol 10129381-924003BLF 0.4 €

> third variant is the default one

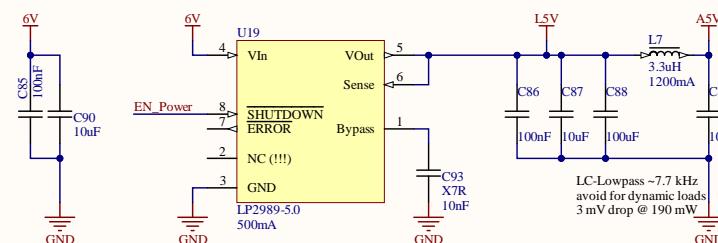
| Title                                       |                              |                             |
|---|------------------------------|-----------------------------|
| Shepherd - Overview<br>NES Lab / TU Dresden |                              |                             |
| Size  | Number                       | Revision                    |
| A4  |                              |                             |
| Date:                                       | 3.23.2021                    | Sheet of shepherd_v2.PriPcb |
| File:                                       | C:\Users\...\overview.SchDoc | Drawn By: Ingmar            |

**BoostConverter**

**A**  
Output-Voltage:  
Vout:  $0.796/100e3 * (100e3 + 576e3)$ ;  
Vout 5.381 V, 1% range is [5.290; 5.474] V

Output-Ripple-Calculation:  
I\_out: 0.15;  
V\_fw: 0.37;  
V\_in: 5.0;  
f\_sw: 1.2e6;  
C\_out: 1.57e-6;  
 $dV_{out} = I_{out} * (V_{out} + V_{fw} - V_{in}) / (f_{sw} * (V_{out} + V_{fw}) * C_{out})$ ;  
 $dV_{out} \leq 27 - 104 \text{ uV}$  (min/max load)

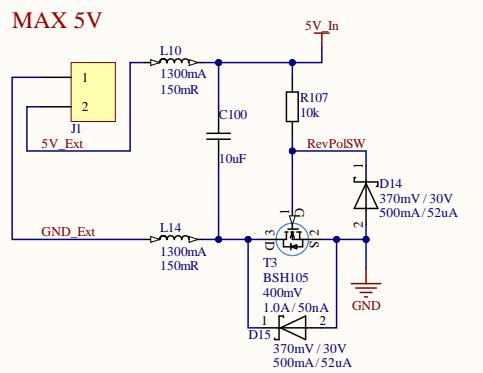
Inductor-Calculation  
L:  $V_{in} * (V_{out} + V_{fw} - V_{in}) / (f_{sw} * (V_{out} + V_{fw}) * 0.3 * I_{out})$ ;  
L: 12 uH

**LowNoise LDOs**

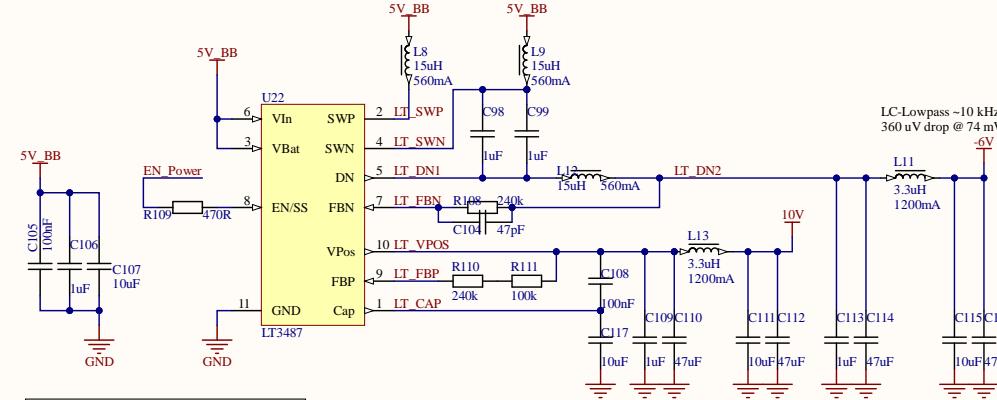
**A**  
Consumption:  
- Disabled < 2 mA  
- Enabled 68 mA @ 5 V  
- BB 390 mA during boot, 170 to 240 mA later

Shepherd ON 340 mW  
4mW @ 3V 190mW @ 5V  
36mW @ 6V 74mW @ 16V  
Shepherd MAX 1006mW (both targets drain 50mA)  
4mW @ 3V 743mW @ 5V  
36mW @ 6V 74mW @ 16V

Main Voltages:  
A5V -> 5.000 V Should be Spot On  
6V -> 5.38 V [5.29; 5.47] V with 1% Res  
10V -> 9.73 V [9.56; 9.90] V with 1% Res  
-6V -> -6 V, [5.94; 6.06] V with 1% Res

**External Power Inp with OVP**

internal MOSFET-Diode needs support

**Boost & Inverter**

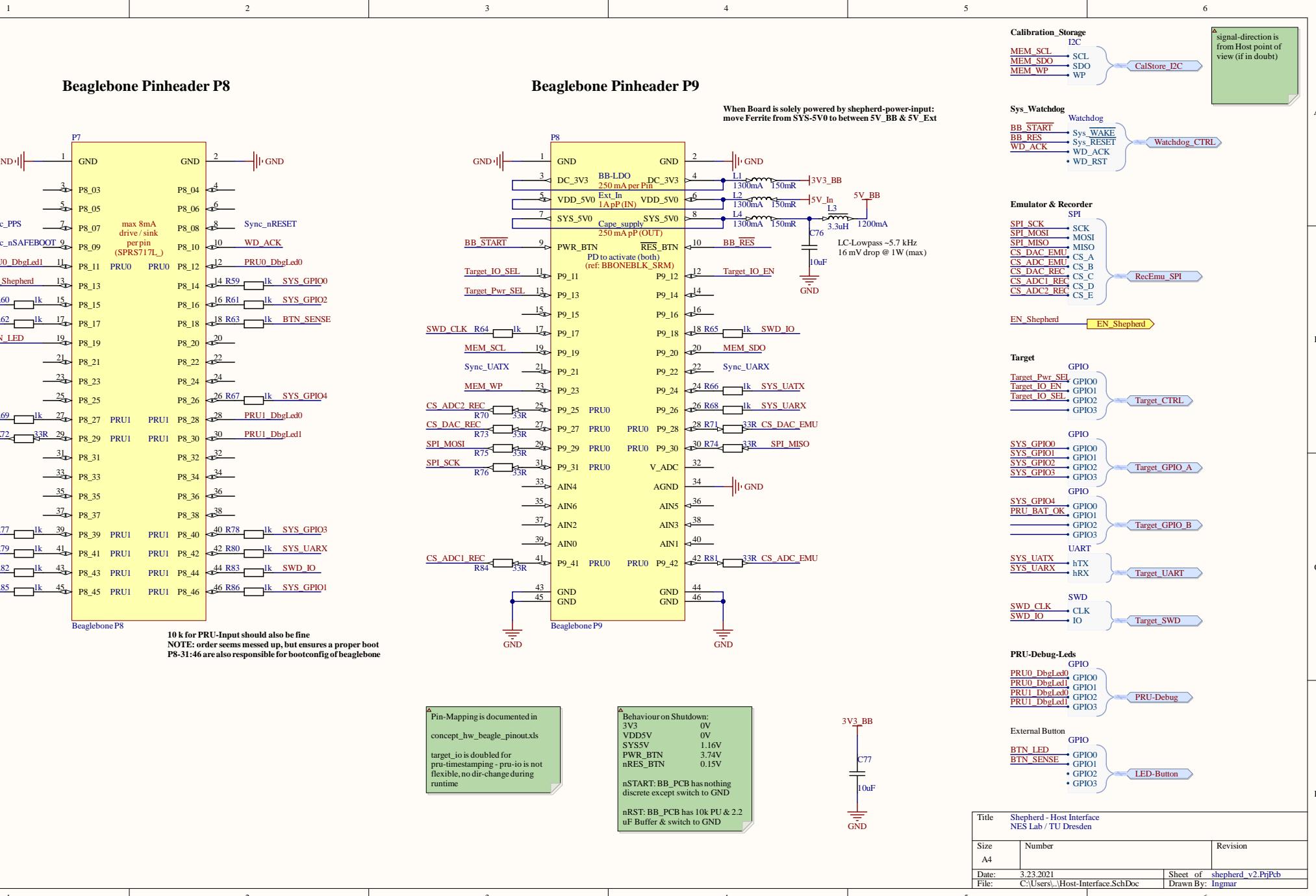
R1=(Vp-1.23V)/25uA  
R1=350.8 kOhm (10V)  
340kOhm -> 9.73V @ 1%

R2=-Vn/25uA  
R2=240 kOhm (-6V)

Regulator drives at least 50mA on both Outputs

Title Shepherd - Power Supplies  
NES Lab / TU Dresden

| Size  | Number                            | Revision                    |
|-------|-----------------------------------|-----------------------------|
| Date: | 3.23.2021                         | Sheet of shepherd_v2.PnjPcb |
| File: | C:\Users\...\PowerSupplies.SchDoc | Drawn By: Ingmar            |



# Signal-Propagation-Delay  
DAC8562 7-10 us Settling, 0.75 V/us Slew rate  
OPA188 2 us Settling (0.01%), 50 V/us Slew rate  
INA190 0.8 us Settling (0.001%), 35 V/us Slew rate  
ADS8691 665 ns conversion, 335 ns acquisition

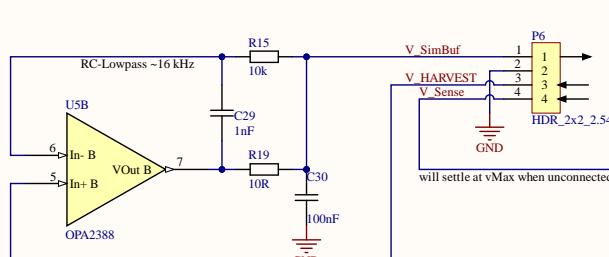
# Noise-Estimate  
ADS8691:  
- unipolar mode 0 .. 5.12V @ 18bit, LSB = 19.53 uV  
- integral nonlin < 2 LSB  
- 90 dB SNR  
AD8421:  
- Imp. Noise 3.2 nV/sqrtHz  
- Input Voltage Noise 60 nV / sqrtHz  
OPA188 / OPA2388:  
- Noise 7nV/sqrtHz, 100fA/sqrtHz  
- no 1/f-Noise: 140 nVpp  
DAC8562:  
- noise density 90 nV / sqrtHz  
- output noise 2.6 uVpp  
- crosstalk 5 / 15uV (Ext / Int Reference)  
- 16 bit, LSB = 76 uV

InAmpNoise Peak Voltage with 16kHz BW and variable Input-Resistor  
>> see maxima-sheet "OpAmpNoiseCalculation.wxm"

OpRes AD8421 AD8429  
0.1 kOhm 2.9 uV 1.76 uV  
1 kOhm 5.05 uV 4.72 uV  
10 kOhm 14.0 uV 21.1 uV  
100 kOhm 48 uV 167 uV

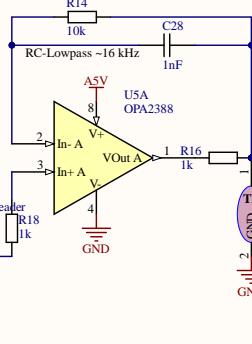
# Signal Ranges  
DAC8562 > 0 .. AVDD (max) >  
default Gain=1 for VRefExt or 2 for VRefInt (modd  
V\_out = (Din / 2^16) \* VRef \* Gain

### Emulate V\_Sim of Converter

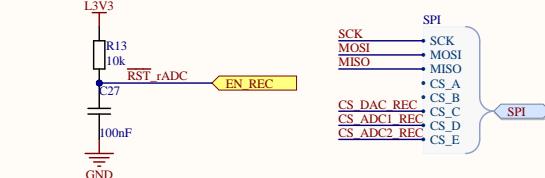


### Harvest-Port

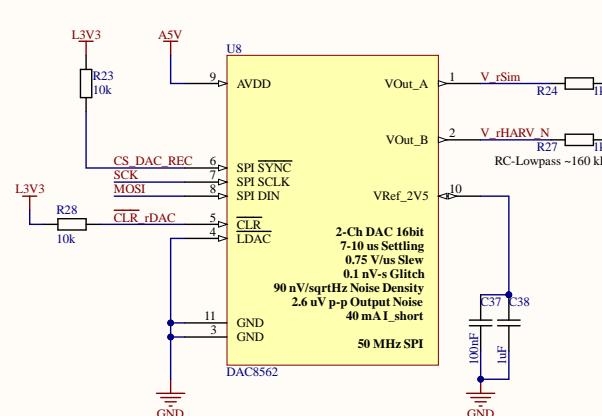
### Voltage Buffer



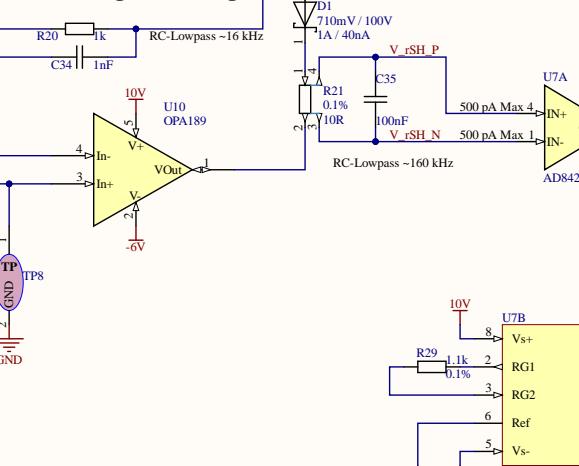
### precision ADCs



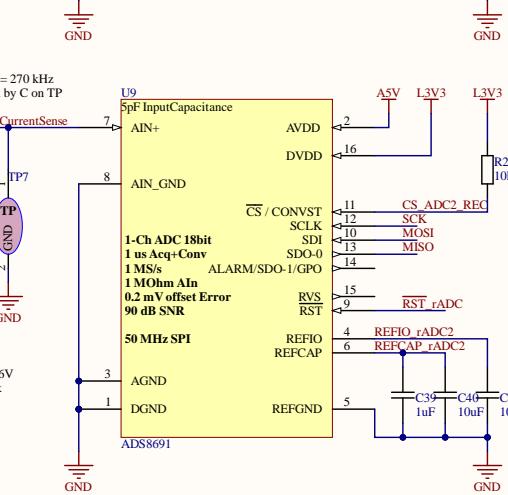
### precision DAC



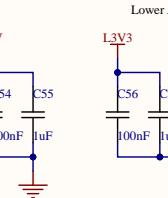
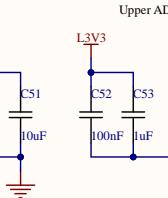
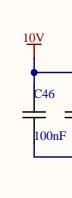
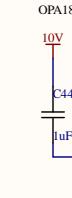
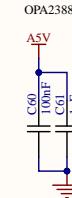
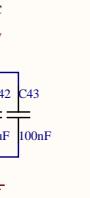
### Harvest Voltage-Matching



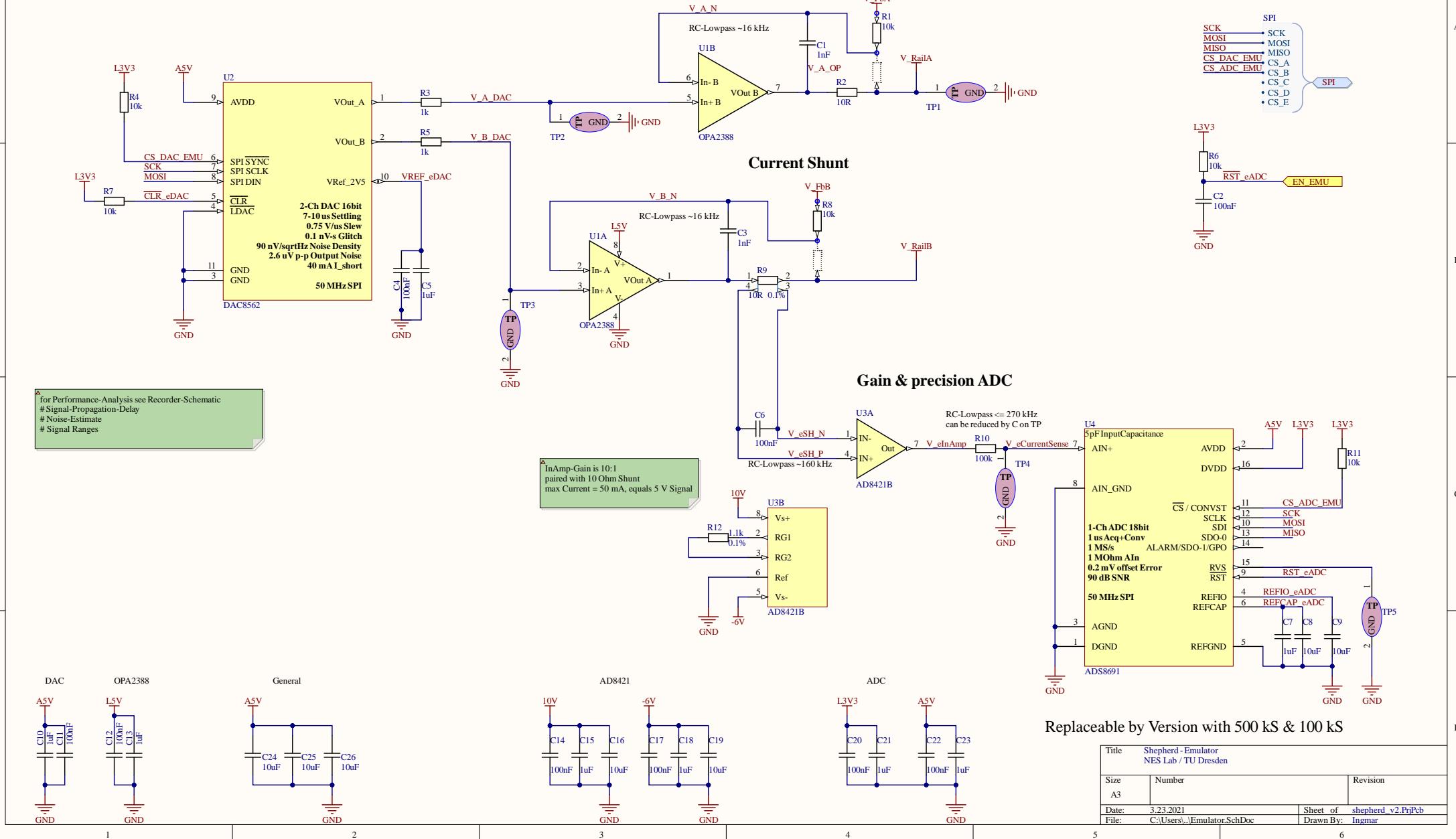
### Current Sensing

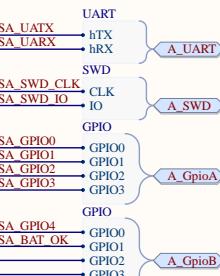
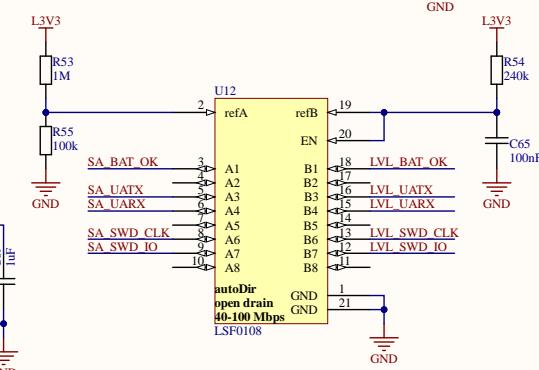
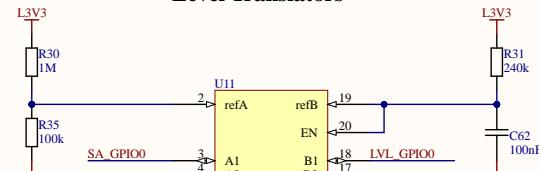
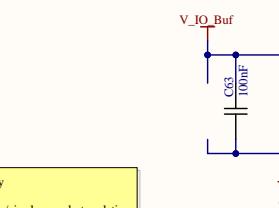


### DAC

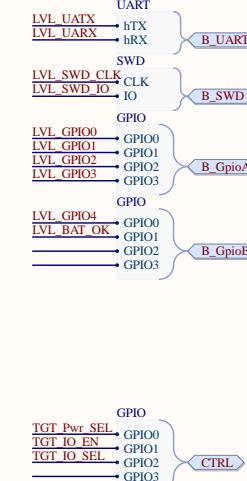
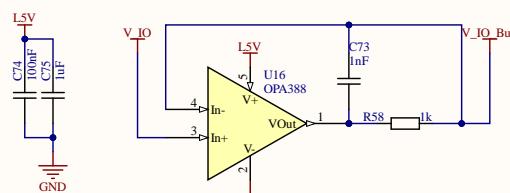
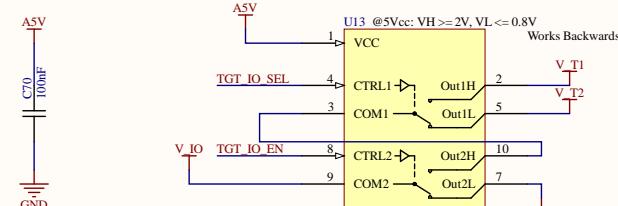
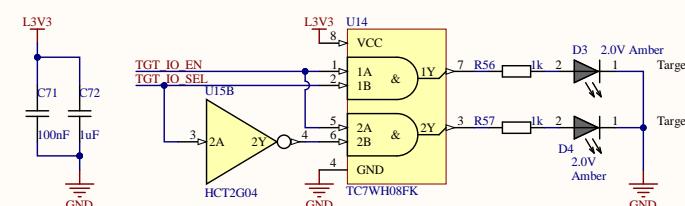


| Title Shepherd - Recorder         |                             | Revision      |
|-----------------------------------|-----------------------------|---------------|
| Size                              | Number                      |               |
| A3                                |                             |               |
| Date: 3.23.2021                   | Sheet of shepherd.v2.PriPcb |               |
| File: C:\Users...\Recorder.SchDoc |                             | Drawn By: Kai |

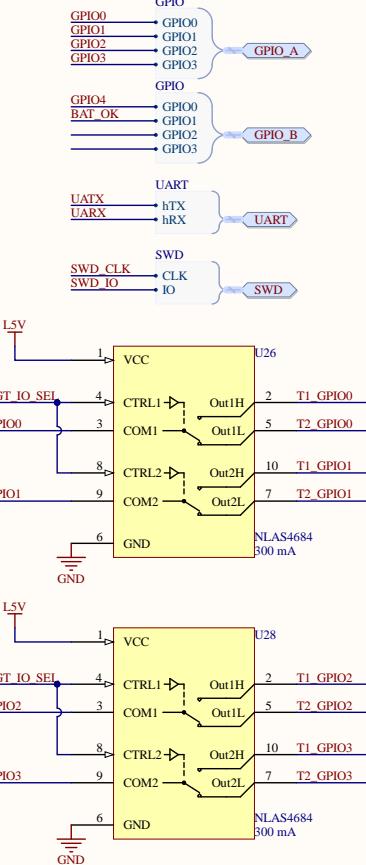


**SideA - Pull Ups****Level Translators****SideB - Pull Ups**

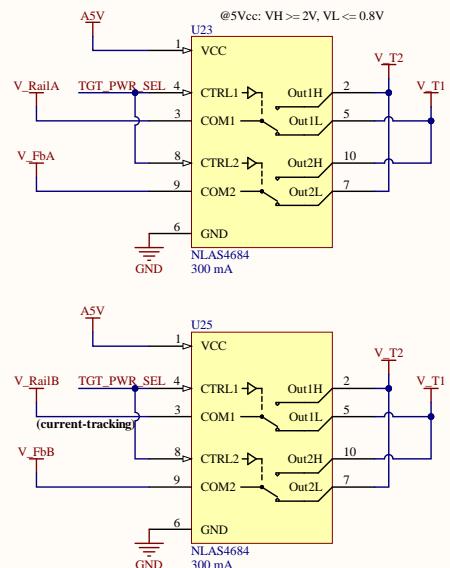
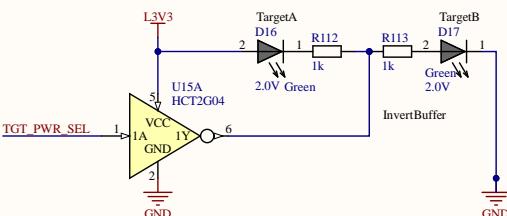
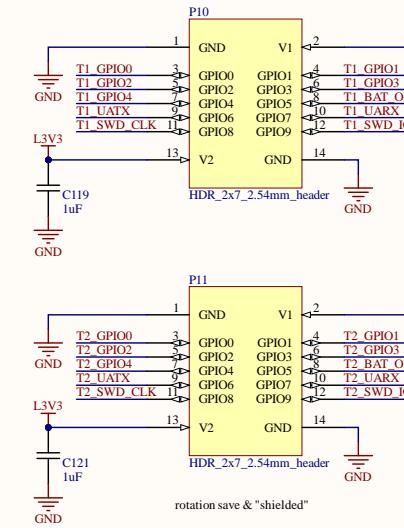
**Single Voltage Supply**  
As proposed here:  
<https://training.ti.com/single-supply-translator-lsf-family>  
Current Config sets VRefA to 0.9V.  
That's also the threshold voltage for both sides  
(An/Bn) where the FET inbetween stops  
conducting and the PUs start working.

**IO-Voltage: Buffer and Switch****LED-Feedback for IO-State**

|   |                             |                  |
|---|-----------------------------|------------------|
| Title Shepherd - Level Translators        |                             |                  |
| Size A3                                   | Number                      | Revision         |
| Date 3.23.2021                            | Sheet of shepherd_v2.PriPcb |                  |
| File: C:\Users...\LevelTranslators.SchDoc |                             | Drawn By: Ingmar |

**Signal Switches**

SEL Tar1 Tar2  
0 VA VB  
1 VB VA  
only VB has current-tracking  
> so SEL=1 enables tracking of Target 1

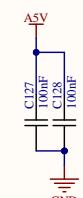
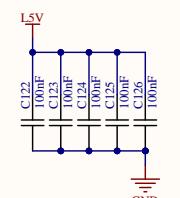
**Power Switches****LED-Feedback for PWR-State****Target Ports**

**Programming-Hints:**  
 - Equalize DACs before switching  
 - unused GPIO should be switched to Input (target and bbone)  
 - level translators can be switched to other target for low leakage

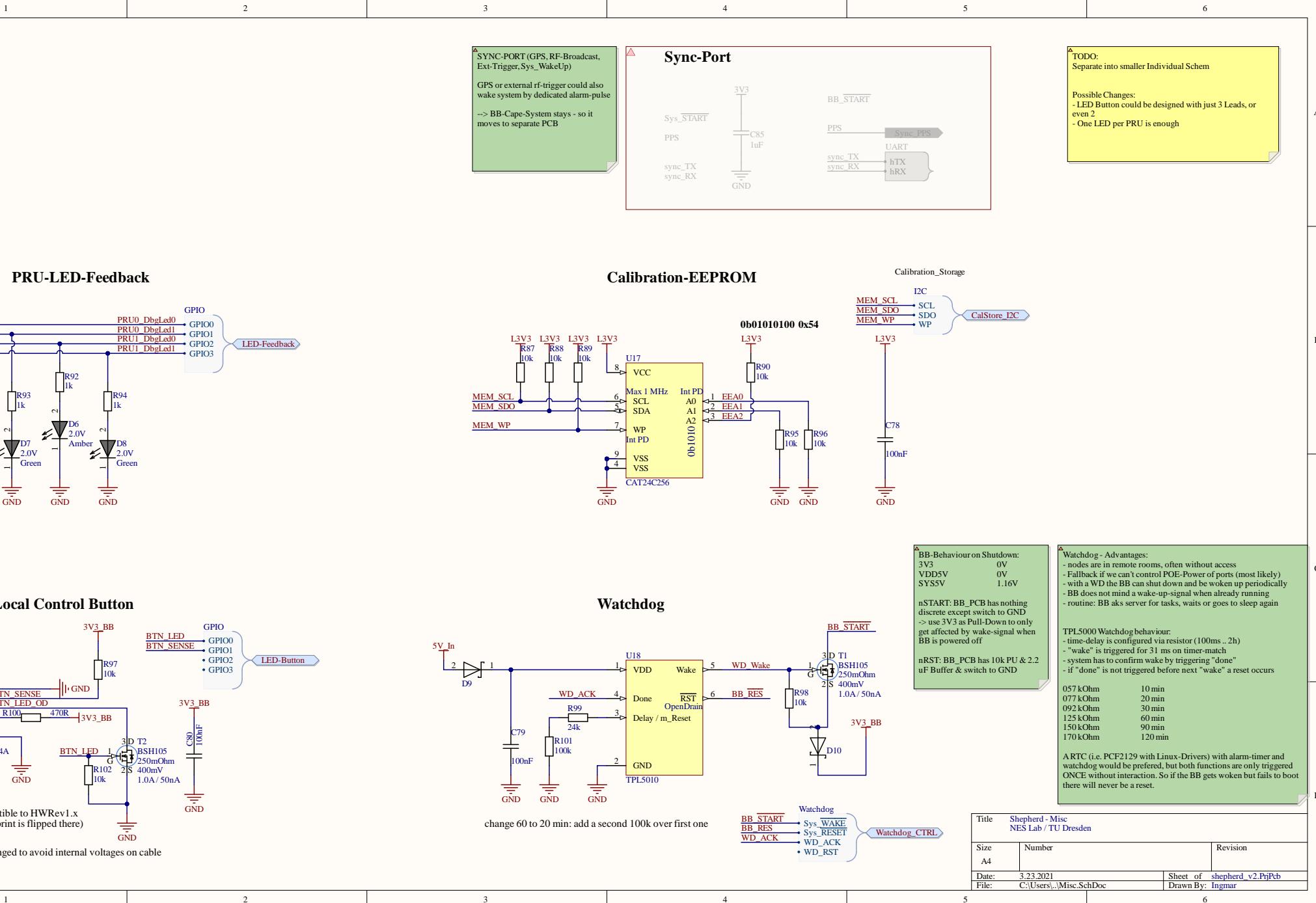
**Leakage Analysis (max per Pin):**  
 NLAS4684 1-2 nA  
 NXS0101 1 uA  
 LSF010x 1-5 uA

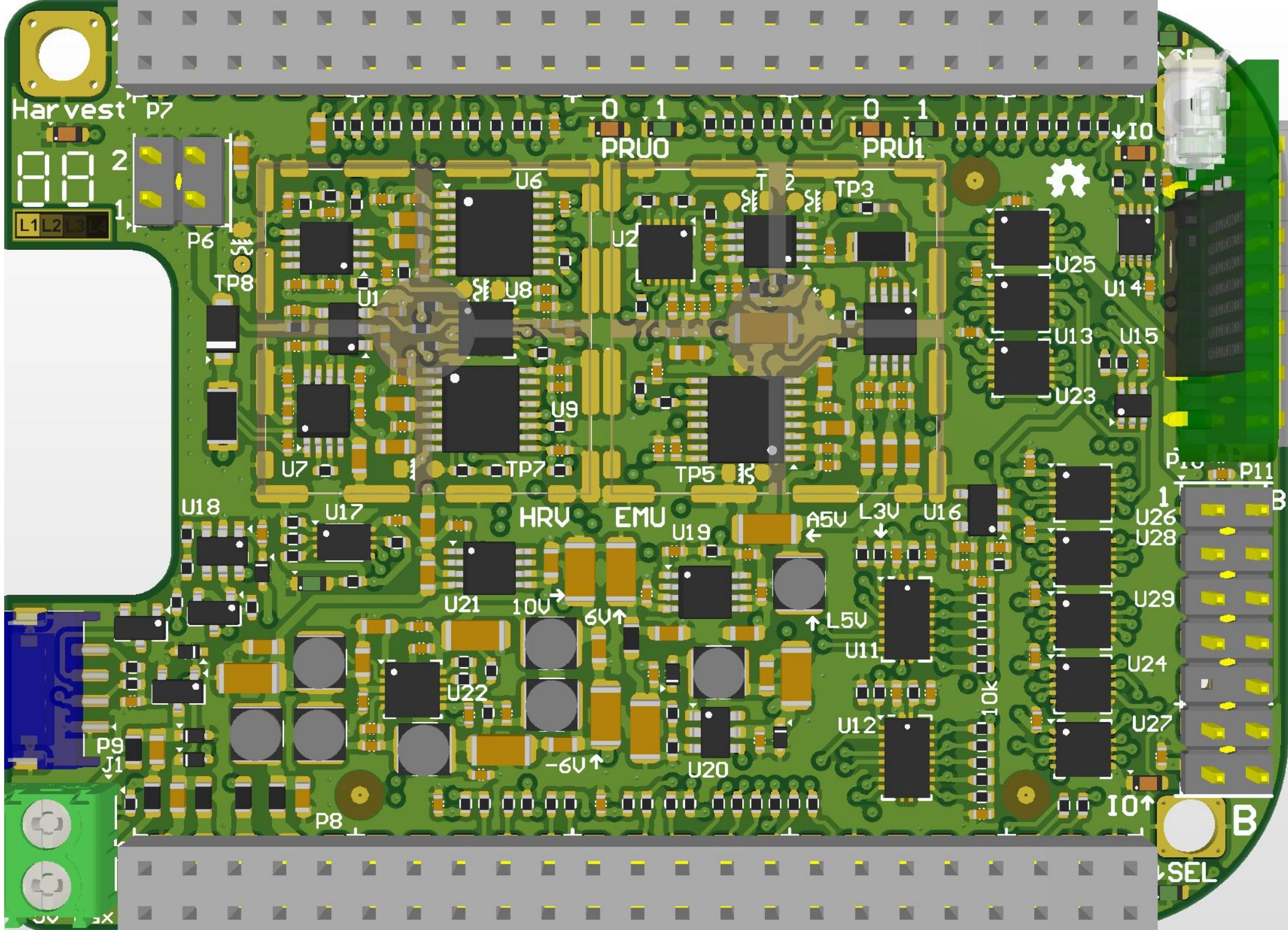
**Max Current:**  
 TargetSwitches 300mA  
 3V3 (unmonitored) 250mA  
 V.Target -> OPA#388 VoltageBuffers source 30-60mA, current measurement up to 50mA

**Programming Target:**  
 SWD -> nRF52, STM32L4  
 SBW -> MSP430, MSP432, CC430  
 SBW-TDIO -> nRST/NMI



| Title Shepherd - Target Interface |                             |                  |
|-----------------------------------|-----------------------------|------------------|
| Size A3                           | Number                      | Revision         |
| Date: 3.23.2021                   | Sheet of shepherd.v2.PriPeb |                  |
| File: C:\Users...\Targets.SchDoc  |                             | Drawn By: Ingmar |





NES Lab  
Shepherd  
v2.1r0

EN

vSense  
vHarv

GND  
VCap

L3L4

QA-TEST  
Pwr Regs

EEProm

WatchDog

LEDs

IO2Tgt

Emulator

Recorder

5V  
5VE  
3V  
GND  
GND  
GND  
5VExt