

Routing-HINTS:  
- SPI Lines need special care  
- equalize length  
- avoid long forks  
- terminate data & clk if possible

U\_Host-Interface  
Host-Interface.SchDoc

U\_PowerSupplies  
PowerSupplies.SchDoc

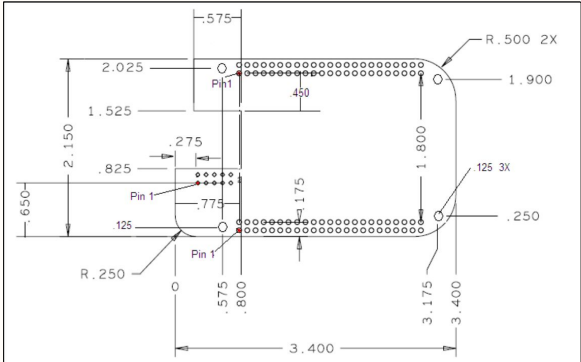
U\_Recorder  
Recorder.SchDoc

U\_VEmulator  
Emulator.SchDoc

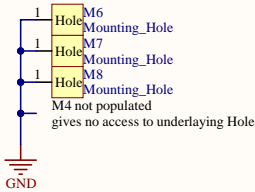
Designator  
LevelTranslators.SchDoc

U\_Targets  
Targets.SchDoc

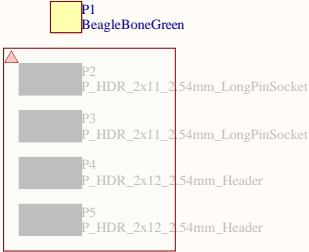
U\_Misc  
Misc.SchDoc



Misc



BOM-Additions



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 (v2.2)

- 2 Variations, recorder / emulator are self-contained and optional
- with Rec & Emu -> 276 parts, 42 unique
- with Emu -> 253 parts, 46 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)

External-BOM

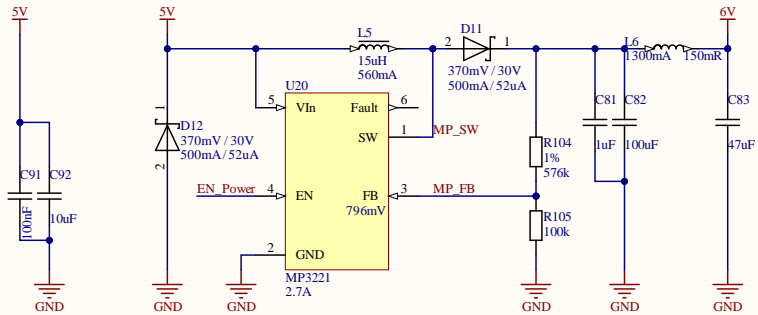
USB-Stick 256 GB  
Ethernet Cables  
POE-Adapter  
uSD-Card (for flashing)

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 € (Default in BOM)  
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 €

Title Shepherd - Overview NES Lab / TU Dresden		
Size A4	Number	Revision
Date: 6.28.2021	Sheet of shepherd_v2.PrjPcb	
File: C:\Users\...\overview.SchDoc	Drawn By: Ingmar	

## BoostConverter

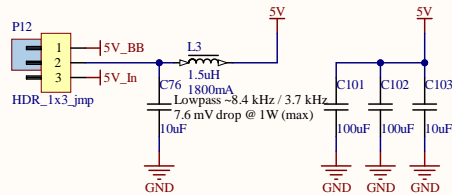


**Output-Voltage:**  
 $V_{out} = 0.796 / 100e3 * (100e3 + 576e3)$   
 $V_{out} = 5.381 \text{ V}$ , 1% range is [5.290; 5.474] V

**Output-Ripple-Calculation:**  
 $I_{L\_out} = 0.15$   
 $V_{fw} = 0.37$   
 $V_{in} = 5.0$   
 $f_{sw} = 1.2e6$   
 $C_{out} = 157e-6$   
 $dV_{out} = I_{L\_out} * (V_{out} + V_{fw} - V_{in}) / (f_{sw} * (V_{out} + V_{fw}) * C_{out})$   
 $dV_{out} <= 27 - 104 \text{ uV (min/max load)}$

**Inductor-Calculation**  
 $L = V_{in} * (V_{out} + V_{fw} - V_{in}) / (f_{sw} * (V_{out} + V_{fw}) * 0.3 * I_{L\_out})$   
 $L = 12 \text{ uH}$

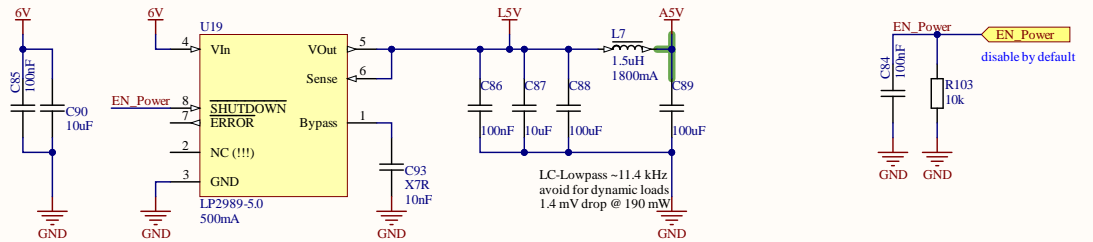
## PowerSelection



Jumper 1:2 - Shepherd is powered by BBone  
 Jumper 2:3 - Shepherd is powered by Screw-Connector (Ext)

There are Holes for soldering a 1 mF 6V3 Cap! (647-UVR0J102MPD1TD)

## LowNoise LDOs



**Consumption:**  
 - Disabled < 2 mA  
 - Enabled 67 mA @ 5.1 V (Emu & Rec)  
 - BB 390 mA during boot, 170 to 240 mA later

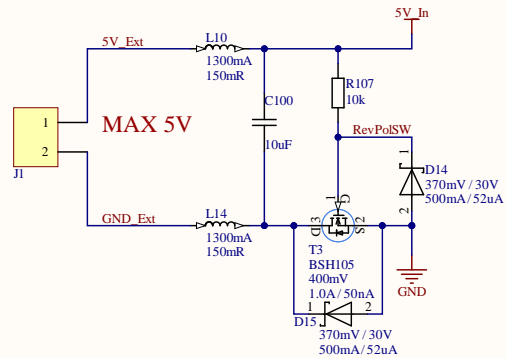
**Shepherd ON 272 mW (Emu only)**  
 18mW @ 3V 144mW @ 5V  
 36mW @ 6V 37mW @ 16V

**Shepherd ON 401 mW (Emu & Rec)**  
 18mW @ 3V 198mW @ 5V  
 36mW @ 6V 101mW @ 16V

**Shepherd MAX 1121 mW (both targets drain 50mA)**  
 20mW @ 3V 795mW @ 5V  
 36mW @ 6V 101mW @ 16V

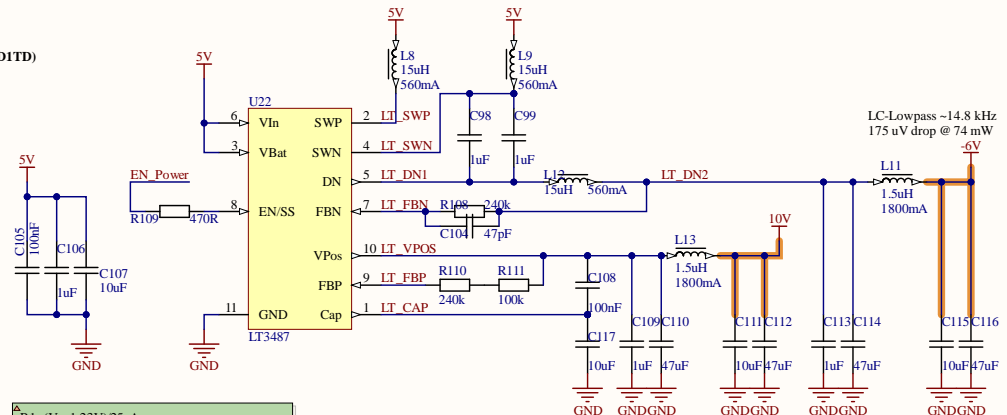
**Main Voltages:**  
 A5V/L5V -> 5.000 V Should be Spot On  
 L3V3 -> 3.300 V Should be Spot On  
 6V -> 5.38 V [5.29; 5.47] V with 1% Res  
 10V -> 9.73 V [9.56; 9.90] V with 1% Res  
 -6V -> -6 V [5.94; 6.06] V with 1% Res

## External Power Inp with OVP



internal MOSFET-Diode needs support

## Boost & Inverter

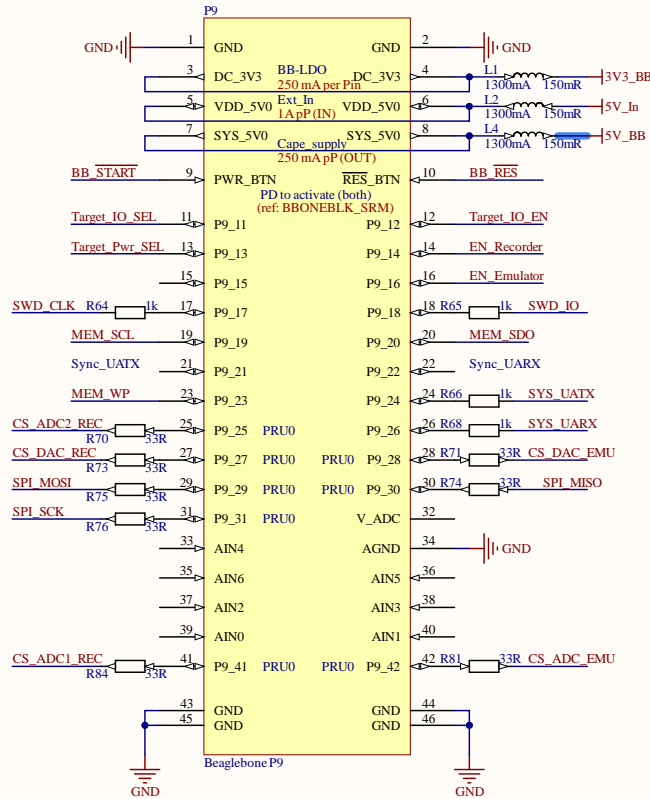


**R1**=(Vp-1.23V)/25uA  
 $R1 = 350.8 \text{ kOhm (10V)}$   
 $340 \text{ kOhm} \rightarrow 9.73 \text{ V @ 1\%}$

**R2**=-Vn/25uA  
 $R2 = 240 \text{ kOhm (-6V)}$

Regulator drives at least 50mA on both Outputs

Title Shepherd - Power Supplies NES Lab / TU Dresden		
Size A4	Number	Revision
Date: 6.28.2021	Sheet of shepherd_v2.PjPcb	
File: C:\Users\...PowerSupplies.SchDoc	Drawn By: Ingmar	

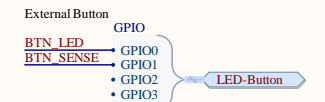
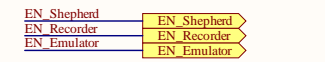
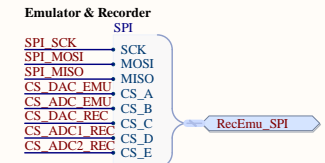
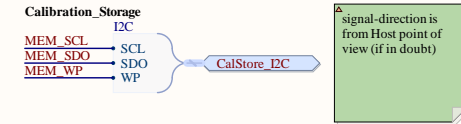


Pin-Mapping is documented in  
concept\_hw\_beagle\_pinout.xls  
target\_io is doubled for  
pru-timestamping - pru-io is not  
flexible, no dir-change during  
runtime

Behaviour on Shutdown:	
3V3	0V
VDD5V	0V
SY55V	1.16V
PWR_BTN	3.74V
nRES_BTN	0.15V

nSTART: BB\_PCB has nothing discrete except switch to GND

nRST: BB\_PCB has 10k PU & 2.2 uF Buffer & switch to GND



Title <b>Shepherd - Host Interface</b> NES Lab / TU Dresden		
Size A4	Number	Revision
Date: 6.28.2021	Sheet of	<b>shepherd_v2.PriPb</b>
File: C:\Users\...Host-Interface.SchDoc	Drawn By:	<b>Ingmar</b>

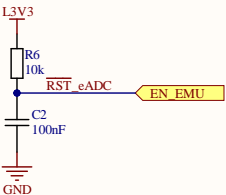
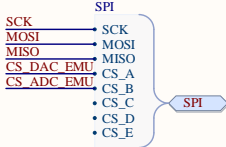


precision DAC

Voltage-Buffer

Current Shunt

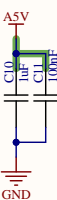
Gain & precision ADC



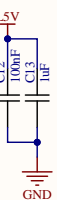
for Performance-Analysis see Recorder-Schematic  
# Signal-Propagation-Delay  
# Noise-Estimate  
# Signal Ranges

InAmp-Gain is 48:1  
paired with 2 Ohm Shunt  
max Current = 50 mA, equals 5 V Signal

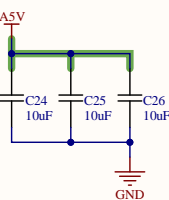
DAC



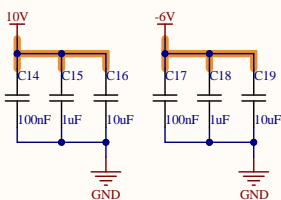
OPA2388



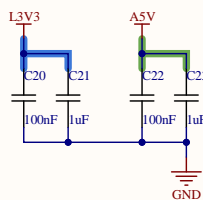
General



AD8421



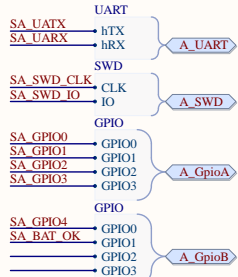
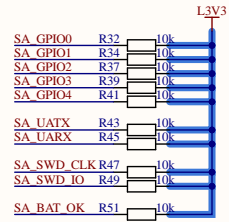
ADC



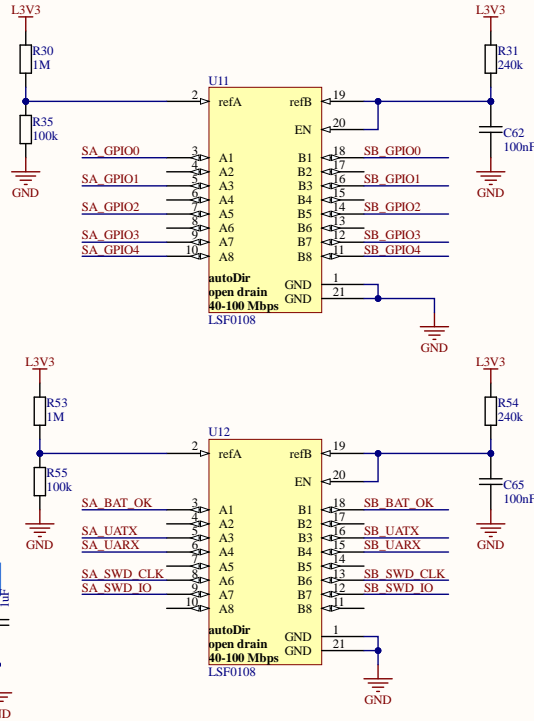
Replaceable by Version with 500 kS & 100 kS

Title		Shepherd - Emulator NES Lab / TU Dresden	
Size	A3	Number	Revision
Date:	6.28.2021	Sheet of	shepherd_v2.PrjPcb
File:	C:\Users\...Emulator.SchDoc	Drawn By:	Ingmar

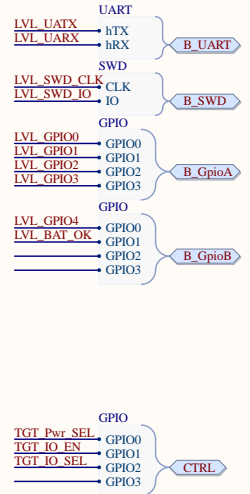
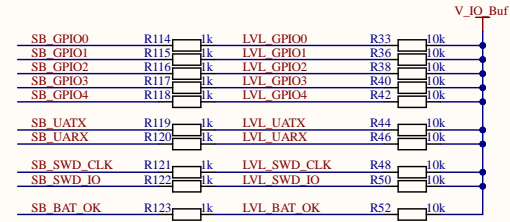
## SideA - Pull Ups



## Level Translators

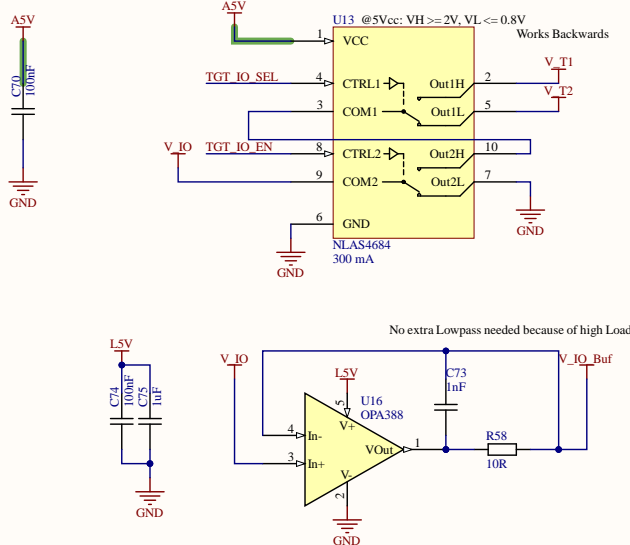


## SideB - Pull Ups

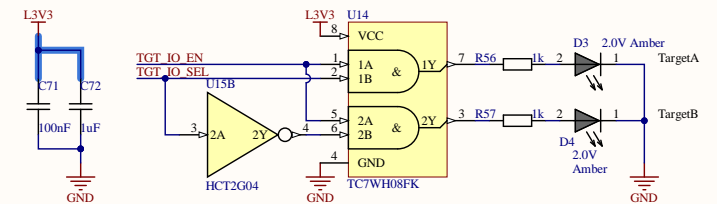


Single Voltage Supply  
As proposed here:  
<https://training.ti.com/single-supply-translator-lsf-family>  
Current Config sets VRefA to 966 mV.  
That's also the threshold voltage for both sides (An/Bn) where the FET inbetween stops conducting and the PUS start working.

## IO-Voltage: Buffer and Switch



## LED-Feedback for IO-State

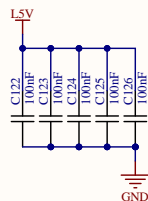
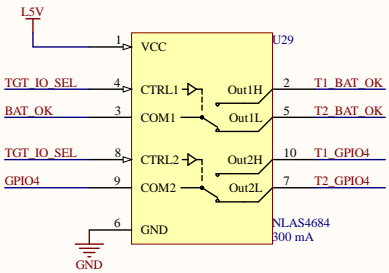
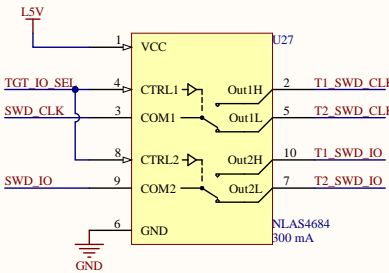
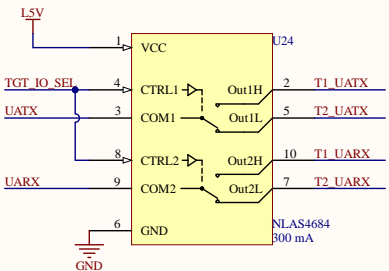
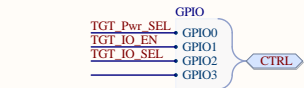
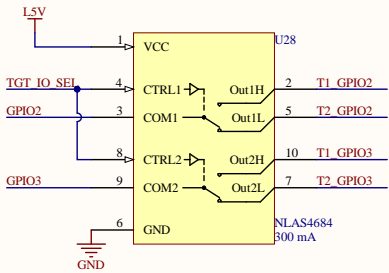
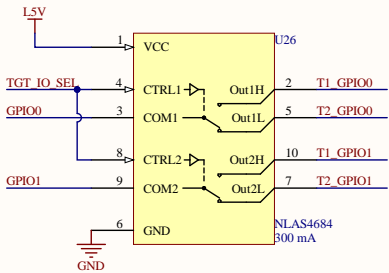
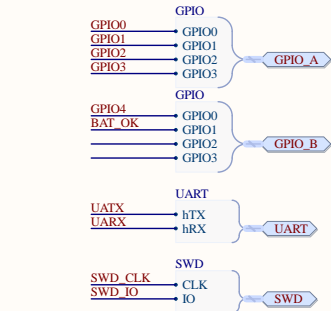


Title			Shepherd - Level Translators
Size			NES Lab / TU Dresden
A3	Number	Revision	
Date:	6.28.2021	Sheet of	shepherd_v2.PriPcb
File:	C:\Users\...LevelTranslators.SchDoc	Drawn By:	Ingmar

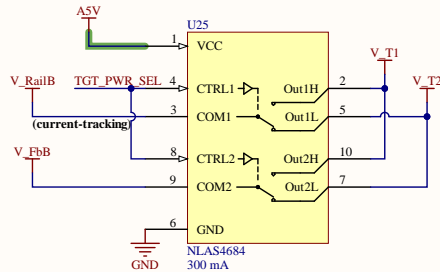
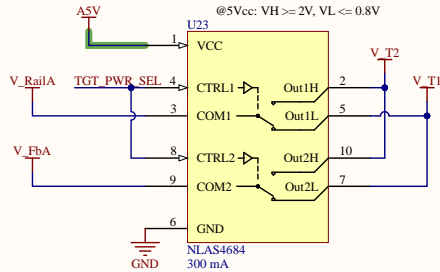
## Signal Switches

SEL	Tar1	Tar2
0	VA	VB
1	VB	VA

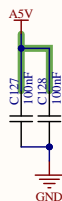
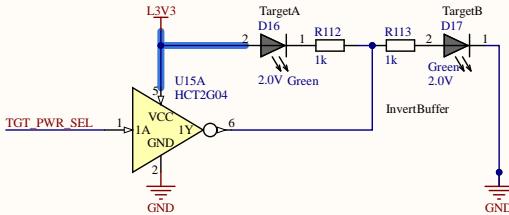
only VB has current-tracking  
-> so SEL=1 enables tracking of Target 1



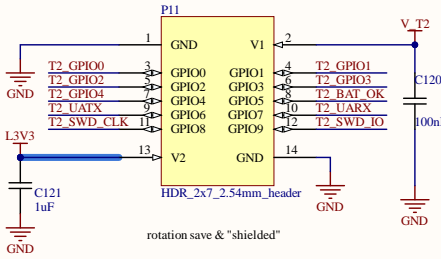
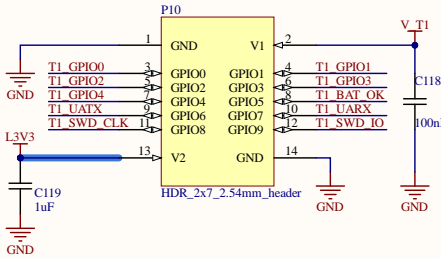
## Power Switches



## LED-Feedback for PWR-State



## Target Ports



Programming-Hints:

- Equalize DACs before switching
- unused GPIOs 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:

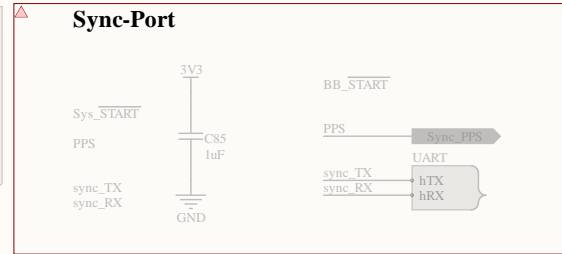
SWD	-> nRF52, STM32L4
SBW	-> MSP430, MSP432, CC430
SBW-TDIO, -TCK (nRST/NMI)	

Title: Shepherd - Target Interface NES Lab / TU Dresden		
Size: A3	Number:	Revision:
Date: 6.28.2021	Sheet of: shepherd_v2.PriPcb	
File: C:\Users\...\Targets.SchDoc	Drawn By: Ingmar	

**SYNC-PORT (GPS, RF-Broadcast, Ext-Trigger, Sys\_WakeUp)**

GPS or external rf-trigger could also wake system by dedicated alarm-pulse

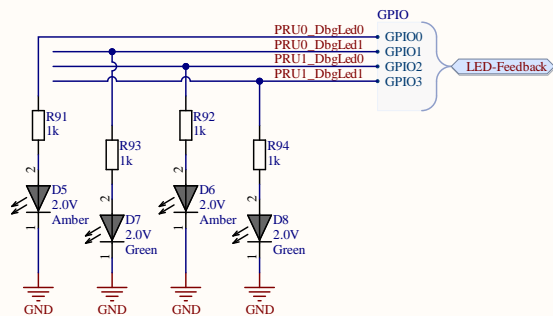
-> BB-Cape-System stays - so it moves to separate PCB



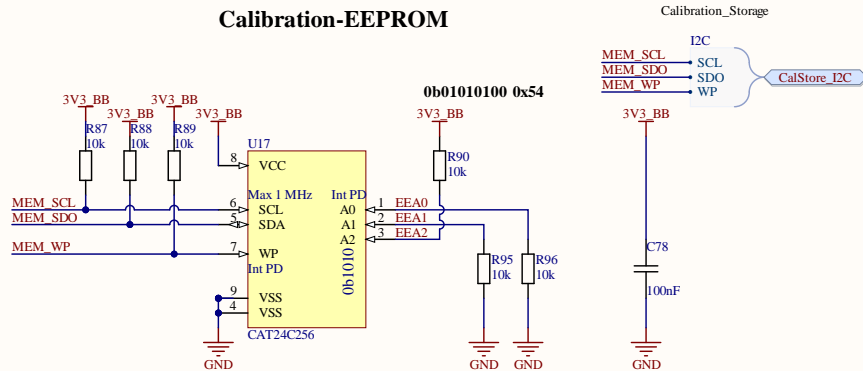
**TODO:**  
Separate into smaller Individual Schem

Possible Changes:  
- LED Button could be designed with just 3 Leads, or even 2  
- One LED per PRU is enough

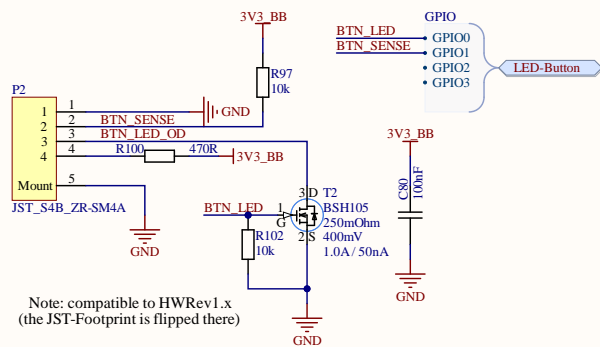
## PRU-LED-Feedback



## Calibration-EEPROM



## Local Control Button

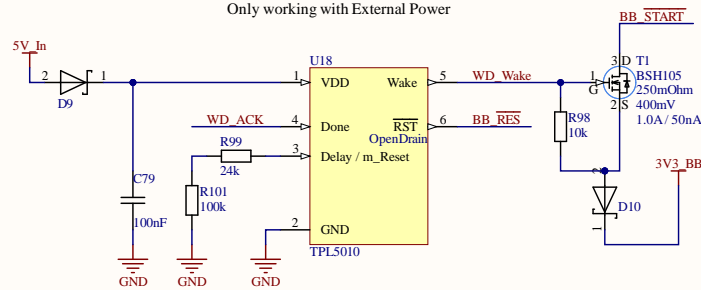


Note: compatible to HWRev1.x  
(the JST-Footprint is flipped there)

schematic changed to avoid internal voltages on cable

## Watchdog

Only working with External Power



to change 60 to 20 min: add a second 100k over first one

**BB-Behaviour on Shutdown:**

3V3	0V
VDD5V	0V
SY5V	1.16V

nSTART: BB\_PCB has nothing discrete except pull-switch to GND, normally 5V Signal  
-> use 3V3 as Pull-down to only get affected by wake-signal when BB is powered off -> seems fine

nRST: BB\_PCB has 10k PU & 2.2 uF Buffer & pull-switch to GND

**Watchdog - Advantages:**

- nodes are in remote rooms, often without access
- fallback if we can't control POE-Power of ports (most likely)
- with a WD the BB can shut down and be woken up periodically
- BB does not mind a wake-up-signal when already running
- routine: BB asks server for tasks, waits or goes to sleep again

**TPL5000 Watchdog behaviour:**

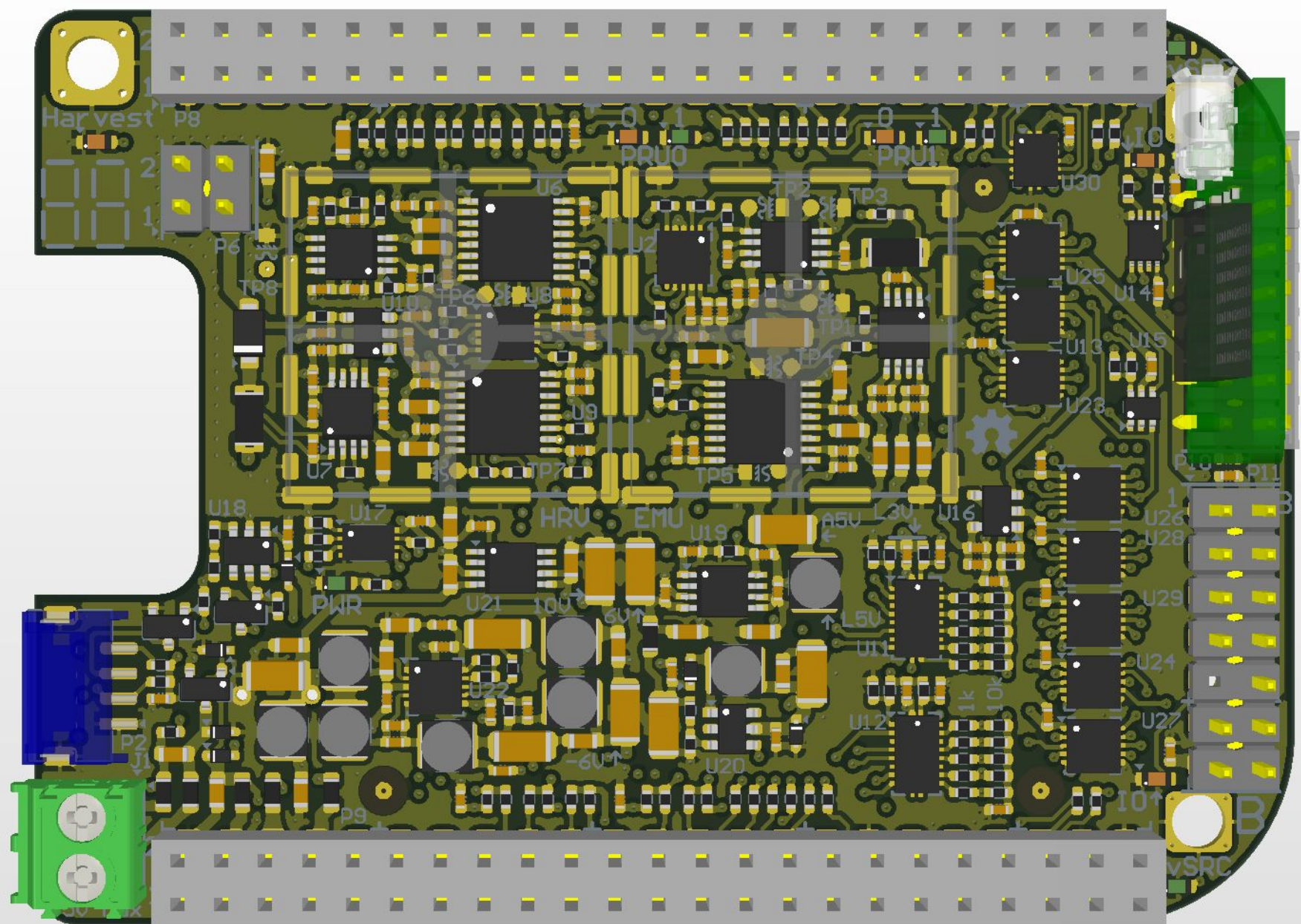
- time-delay is configured via resistor (100ms .. 2h)
- "wake" is triggered for 31 ms on timer-match
- system has to confirm wake by triggering "done"
- if "done" is not triggered before next "wake" a reset occurs

057 kOhm	10 min
077 kOhm	20 min
092 kOhm	30 min
125 kOhm	60 min
150 kOhm	90 min
170 kOhm	120 min

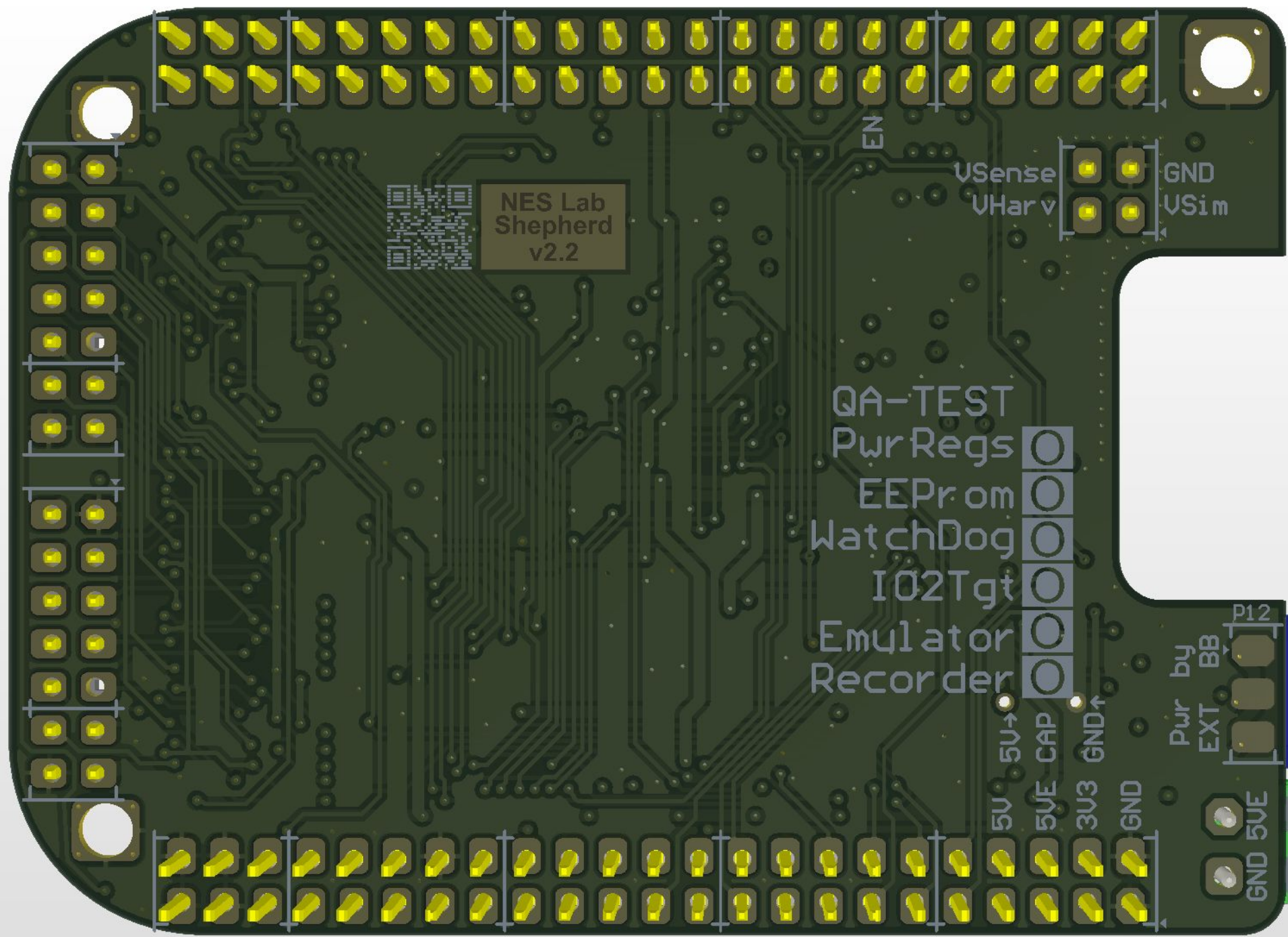
ARTC (i.e. PCF2129 with Linux-Driver) with alarm-timer and watchdog would be preferred, but both functions are only triggered ONCE without interaction. So if the BB gets woken but fails to boot there will never be a reset.

Title Shepherd - Misc NES Lab / TU Dresden		
Size A4	Number	Revision
Date: 6.28.2021	Sheet of shepherd_v2.PjPcb	
File: C:\Users\...\Misc\SchDoc	Drawn By: Ingmar	









NES Lab  
Shepherd  
v2.2

QA-TEST  
Pwr Regs  
EEProm  
WatchDog  
IO2Tgt  
Emulator  
Recorder

VSense  
VHarv

GND  
USim

5V  
5VE  
3V3  
GND

Pwr by  
EXT BB  
P12

GND  
5VE