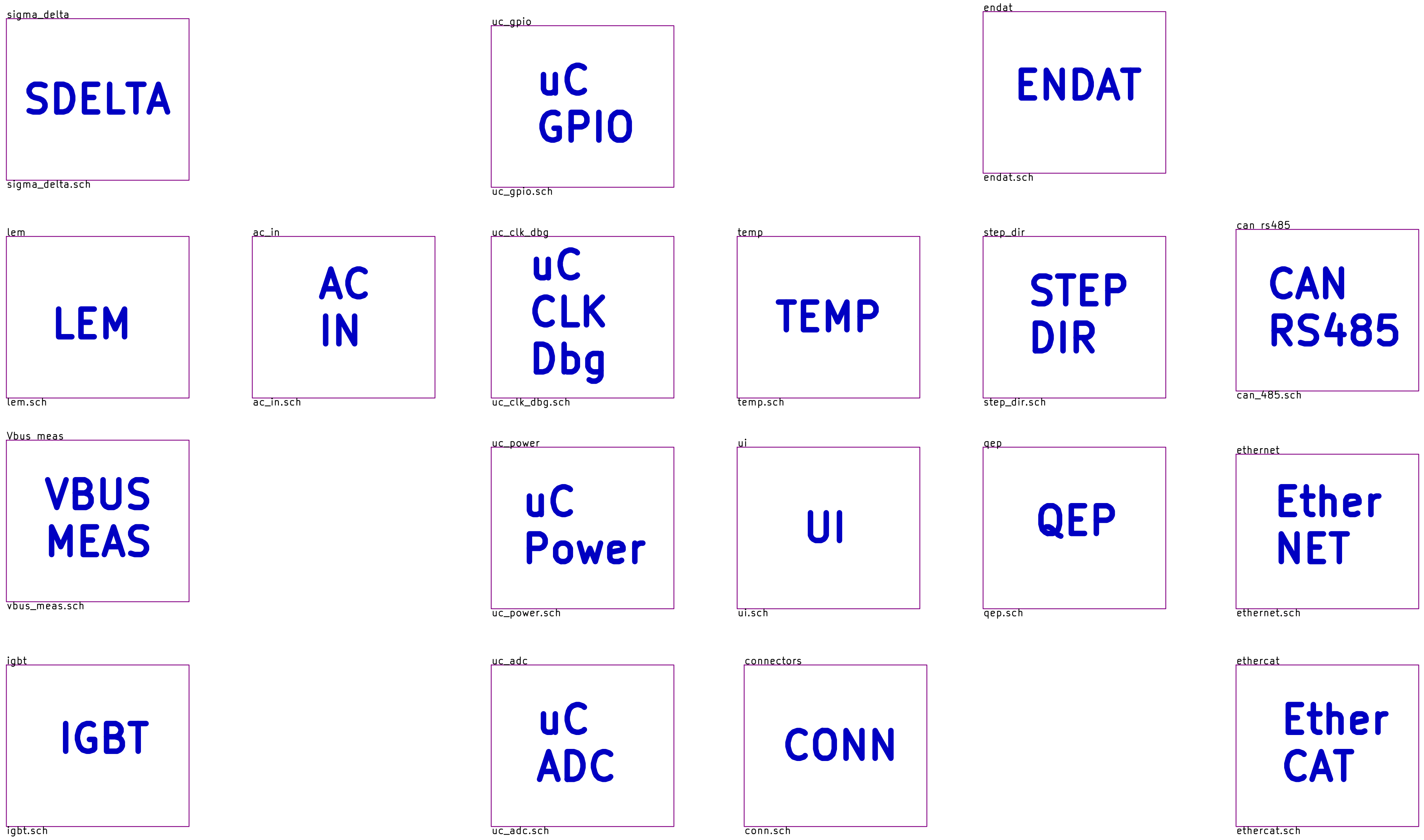
SERVO DRIVER BLOCKS

The project is divided in blocks. Each block join a group os signals and circuits depending on his function. The project is intended to have reinforced insulation using double simple isolation. For that reason, the uC circuitery is on a cold supply and the output logic is at hot supply. BUT take in account that HOT is not 220, is just a name indicating the first isolation stage



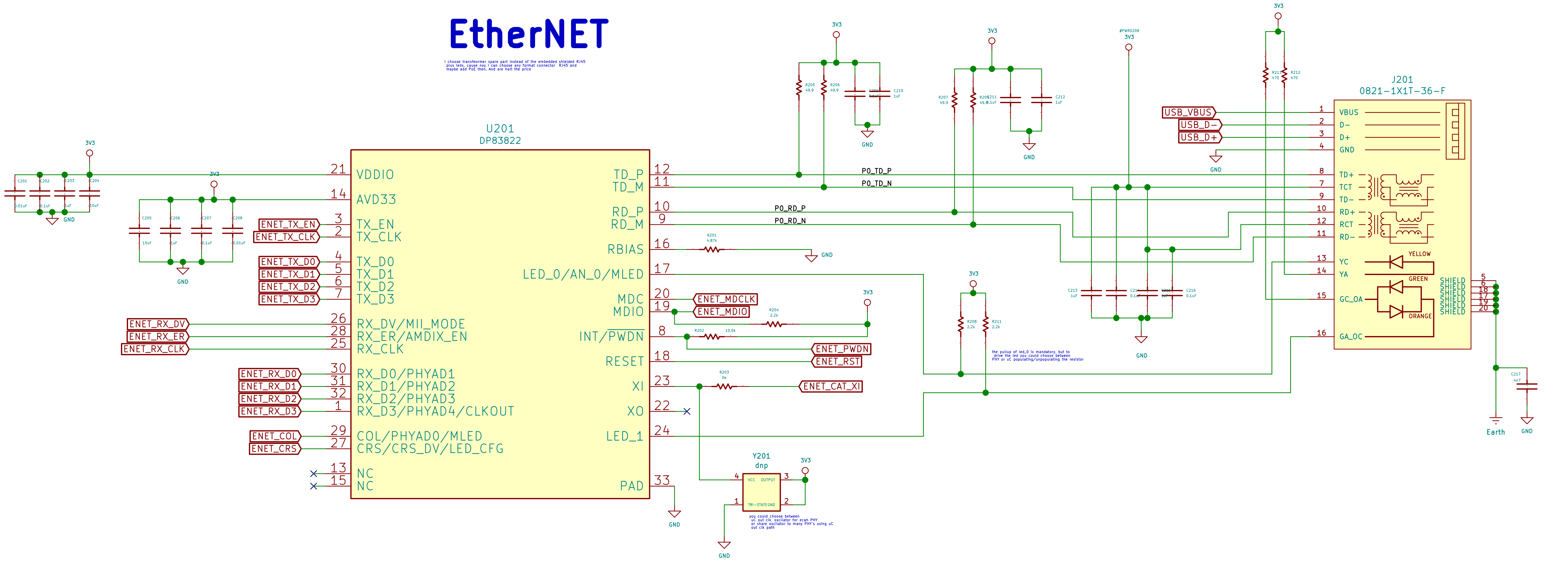
Pablo Slavkin
dci
Sheet: /
File: servo.sch

Title: servo drive

Size: A3	Date: 2020-01-09	Rev: 1.0
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 1/19

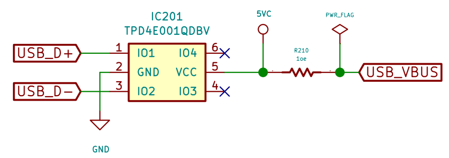
EtherNET

I choose transfeormer spare part instead of the embedded shielded RJ45 plus leds, cause noy I can choose any format connector RJ45 and maybe add PoE then. And are halt the price



USB HOST

it's just an USB protection



Pablo Slavkin
dci
Sheet: /ethernet/
File: ethernet.sch

Title: ethernet

Size: A3 | Date: 2020-01-09 | **Rev: 1.0**

KiCad E.D.A. kicad 5.0.2+dfsg1-1 | Id: 2/19

uC ADC PINS

Every interface to the ADC has the responsability to filter it's output before enter ADC pin. For that reason these page just connect to the uC without noise in the middle

using the DAC out to manage audio or other multipurpose signals

LCD_AUDIO
DACB_DBG
NTCA1_P
NTCA1_N
NTCB1_P
NTCB1_N
LEM_B_U
LEM_B_V
LEM_B_ALL
LEM_B_W
VBUS_B_P
VBUS_B_N
NTCA2_P
NTCA2_N
NTCB2_P
NTCB2_N
LEM_A_U
LEM_A_V
LEM_A_ALL
LEM_A_W
VBUS_A_P
VBUS_A_N

low all host to be connected on positive pin of comparator CMPHOST because the internal DAC reference work on the negative side only.

TPD4E001QDBV IC301 5VC
TPD4E001QDBV IC302 5VC
TPD4E001QDBV IC303 5VC
TPD4E001QDBV IC306 5VC
TPD4E001QDBV IC304 5VC
TPD4E001QDBV IC305 5VC
IO4 VCC IO3 IO1 GND IO2 1 2 3 GND

U301A
TMS320F28388DZWTS

U1 ADCINA0/DACOUTA
T1 ADCINA1/DACOUTB
U2 ADCINA2/CMPIN1P
T2 ADCINA3/CMPIN1N
U3 ADCINA4/CMPIN2P
T3 ADCINA5/CMPIN2N
T4 ADCIN14/CMPIN4P
U4 ADCIN15/CMPIN4N
V2 ADCINB0
W2 ADCINB1
V3 ADCINB2/CMPIN3P
W3 ADCINB3/CMPIN3N
V4 ADCINB4
W4 ADCINB5
R3 ADCINC2/CMPIN6P
P3 ADCINC3/CMPIN6N
R4 ADCINC4/CMPIN5P
P4 ADCINC5/CMPIN5N
T5 ADCIND0/CMPIN7P
U5 ADCIND1/CMPIN7N
T6 ADCIND2/CMPIN8P
U6 ADCIND3/CMPIN8N
T7 ADCIND4
U7 ADCIND5

V1 VREFHIA
R2 VREFLOA
W5 VREFHIB
V6 VREFLOB
R1 VREFHIC
P2 VREFLOC
V5 VREFHID
W6 VREFLOD

adc_refh
C301 22uF
C302 1uF
R301 1k
3V3A
It's just for lower the reference of the ADC
R302 1k(dnp)
C303 2.2uF
C304 0.1uF
GND

Pablo Slavkin
dci

Sheet: /uc_adc/		
File: uc_adc.sch		
Title: ADC		
Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 3/19

EtherCAT

I choose transformer spare part instead of the embedded stiched RJ45 plus 1ms, cause say I can choose any format connector RJ45 and maybe add PoE then. And we halt the price

The eeprom is mandatory in order to ESC read save some internal configuration.

Leds are optional, but the PHY's has som pins used as a bootstrap, so you have to respect that

EtherCAT P0

U402
DP83822

VDDIO
AVD33
TX_EN
TX_CLK
TX_D0
TX_D1
TX_D2
TX_D3
RX_DV/MII_MODE
RX_ER/AMDIX_EN
RX_CLK
RX_D0/PHYAD1
RX_D1/PHYAD2
RX_D2/PHYAD3
RX_D3/PHYAD4/CLKOUT
COL/PHYAD0/MLED
CRS/CRS_DV/LED_CFG
NC
NC
TD_P
TD_M
RD_P
RD_M
RBIAS
LED_0/AN_0/MLED
MDC
MDIO
INT/PWDN
RESET
XI
XO
LED_1
PAD

ECAT0_TX_EN
ECAT0_TX_CLK
ECAT0_TX_D0
ECAT0_TX_D1
ECAT0_TX_D2
ECAT0_TX_D3
ECAT0_RX_DV
ECAT0_RX_ER
ECAT0_RX_CLK
ECAT0_RX_D0
ECAT0_RX_D1
ECAT0_RX_D2
ECAT0_RX_D3
P0_TD_P
P0_TD_N
P0_RD_P
P0_RD_N
ECAT_MDCLK
ECAT_MDIO
ECAT_RST
ENET_CAT_XI
ECAT0_RJ_LED0
ECAT0_RJ_LED1

Address select. Be shure you select two distinct

Y401
dnp

you could choose between 'no out clk' outputs for arch PHY or share oscillator to many PHY's using uC out clk path

The pullup of led_0 is mandatory, but to shut the led you could choose between PHY or uC populating/unpopulating the resistor

ICE be optional!

EtherCAT P1

U403
DP83822

ECAT1_TX_EN
ECAT1_TX_CLK
ECAT1_TX_D0
ECAT1_TX_D1
ECAT1_TX_D2
ECAT1_TX_D3
ECAT1_RX_DV
ECAT1_RX_ER
ECAT1_RX_CLK
ECAT1_RX_D0
ECAT1_RX_D1
ECAT1_RX_D2
ECAT1_RX_D3
P1_TD_P
P1_TD_N
P1_RD_P
P1_RD_N
ECAT_MDCLK
ECAT_MDIO
ECAT_RST
ENET_CAT_XI
ECAT1_RJ_LED1
ECAT1_RJ_LED0

Address select. Be shure you select two distinct

Y402
dnp

you could choose between 'no out clk' outputs for arch PHY or share oscillator to many PHY's using uC out clk path

The pullup of led_0 is mandatory, but to shut the led you could choose between PHY or uC populating/unpopulating the resistor

ICE be optional!

ECAT_MDIO

2k2 pullup as indicated by phy IC's

U404
rj45x2

Led+
Led−
TD+
TCT
TD−
Gnd
RD+
RD−

Earth

EtherCAT EEPROM

These IC is a 'must'. Especified on the ethercat slave

U401
CAT24C16WI

NC
NC
NC
VSS
VCC
WP
SCL
SDA

ECAT_EEPROM_SCL
ECAT_EEPROM_SDA

Run and Error LEDs

It's a good idea to have them on these PCB steps but could be throught away on next release.

ECAT_LED_RUN
ECAT_LED_ERR

D401
D402

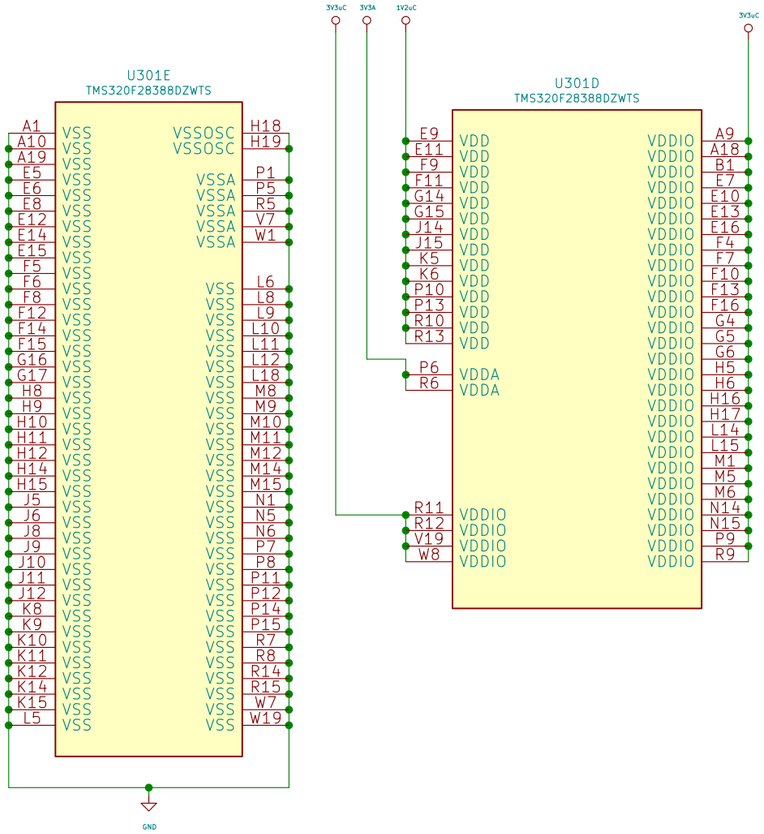
Pablo Slavkin
dci

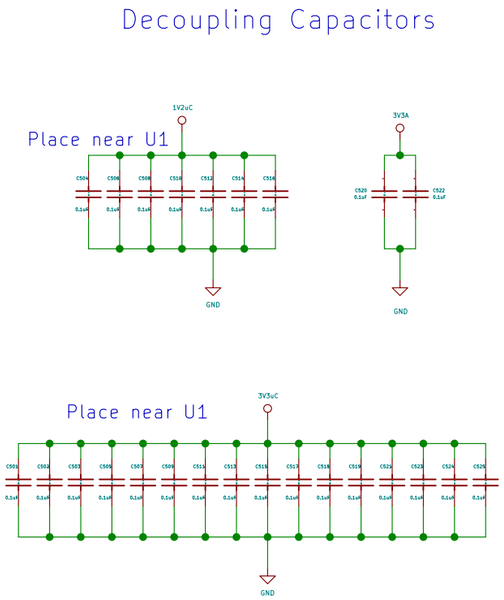
Sheet: /ethercat/
File: ethercat.sch

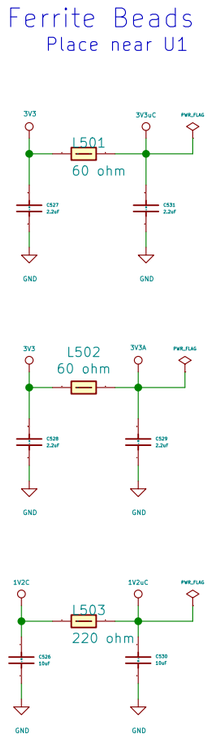
Title: ethercat

Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 4/19

DECOUPLING FILTERS

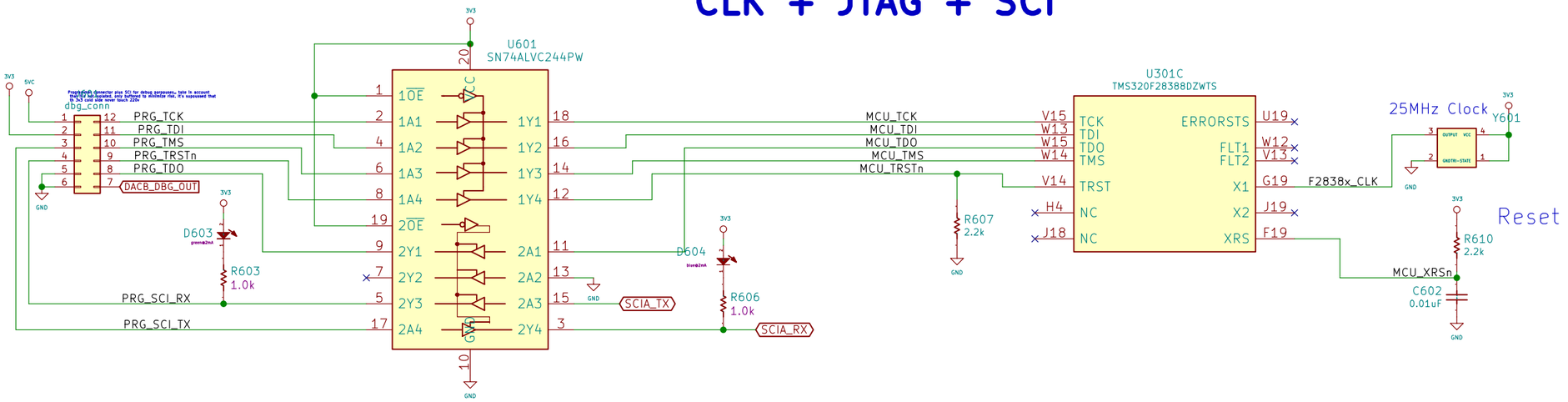




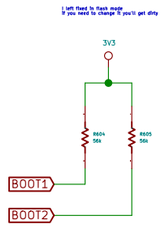


Pablo Slavkin		
dci		
Sheet: /uc_power/		
File: uc_power.sch		
Title: uC Power		
Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 5/19

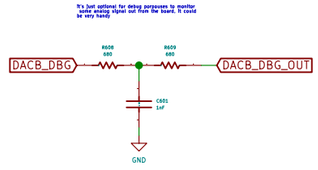
CLK + JTAG + SCI



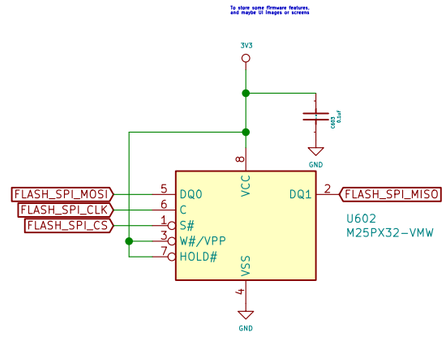
BOOTSRAP R's



ADC/DAC DBG OUT



SPI FLASH



Pablo Slavkin
dci

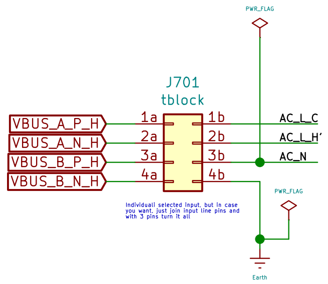
Sheet: /uc_clk_dbg/		
File: uc_clk_dbg.sch		
Title: clk		
Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 6/19

Main Power

In case the control board have to be supply directly with socket voltage (220v) populate these. It's not a good idea cause I'll like to keep hight voltage outside these controller board, but it's a requeriment, so I let it as an option. But you have the low voltage input 15vc and 15vh connectors also

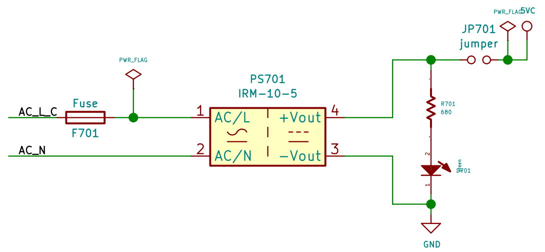
I've choosen to add 2 power supply for Cold and Hot sides because it's cheaper than have only one double sized power supply and add a DC/DC isolated controller, and it has the advantage to choose which one to use and if there is some isue in the HOT side, the Cold side keeps working without affect. I've choosen 15W size beouse has similar price as 10.2W and is pin-to-pin compatible with 20W, so you could change if you need more power

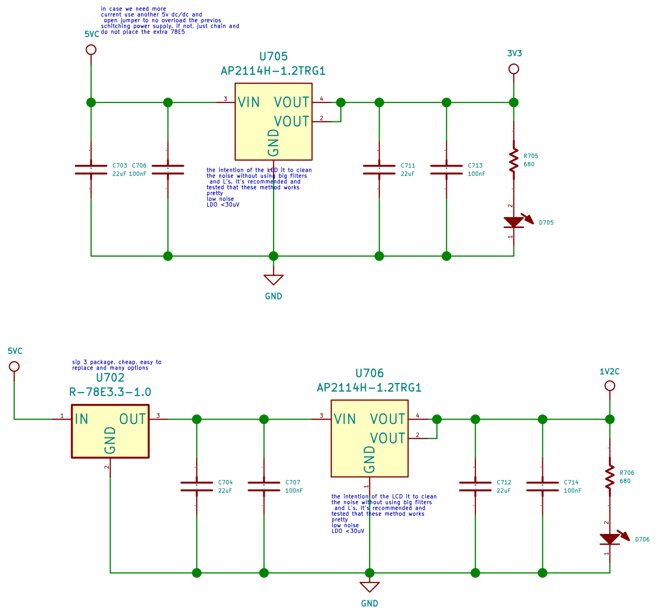
I wrote 15v on the DC voltage side, but it's better to use 12v. But the range coulg be from 8 to 18 more or less



COLD SUPPLY

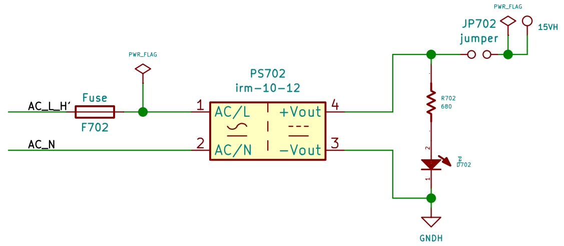
It is inteded to use only, I mean ONLY inside the control board, none of these coopers wires has to leave the board. I isolate every single pin from these supply to go outside, take these in account

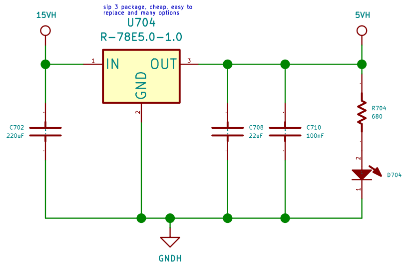




HOT SUPPLY

Take in account that hot doesn't mean that it is refered to high voltage AC socket input path like 220v/380v. It is intended to isolate the uC /logic/user interfase side from accidentally high voltage contact on the hot side and prevent injuries as to make the reinforced isolation possible with one single isolateion added





Pablo Slavkin
dci
Sheet: /ac_in/
File: ac_in.sch
Title: AC input
Size: A3 | Date: 2020-01-09 | Rev: 1.0
KiCad E.D.A. kicad 5.0.2+dfsg1-1 | Id: 7/19

PWM OUT -> ISOLATOR -> BUFFER -> FILTER

these pins has isolation and a buffer. They could be directly connected to a IGBT module for test porpouses or to a power board and another isolation stage for production porpouses to have a reinforced isolation. In next stages of the development of the board, the buffers could be eliminated, but not the isolation Scmith trigger stage

I left other multiporpouse IN/OUT using the free pins on isolators

U801
SI8660BD

U802
SI8662BD

U813
SI8660BD

U814
SI8662BD

Choose a package pin-to-pin compatible whit TI ISO7760. But blades cost had the price as TI

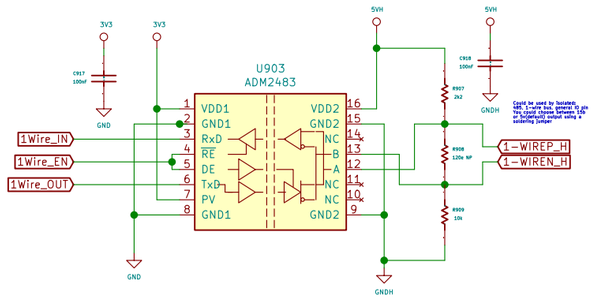
Free to other users. If you choose another version of these IC that has some pins reverted to input, you could use these as an isolated general input also. Just remember to bridge the output buffer or reverse it also

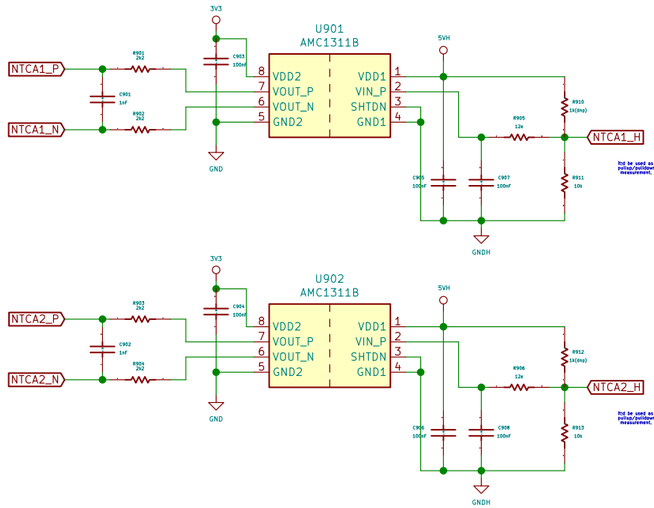
Pablo Slavkin	
dci	
Sheet: /igbt/	
File: igbt.sch	
Title: Igbt interface	
Size: A3	Date: 2020-01-09
KiCad E.D.A. kicad 5.0.2+dfsg1-1	Id: 8/19
	Rev: 1.0

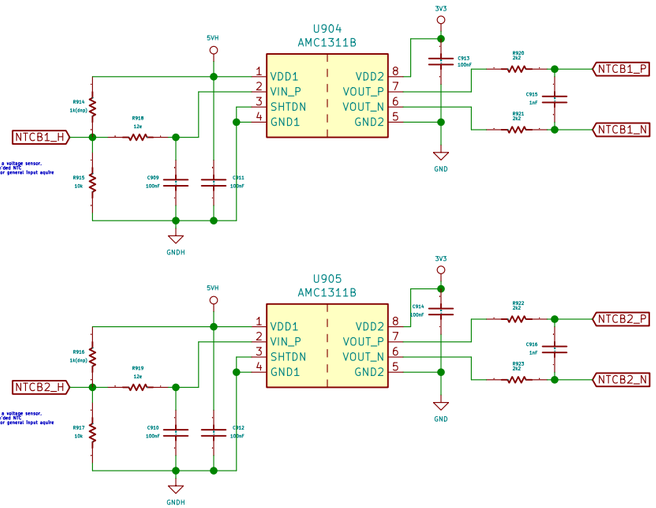
2 isolated NTC interfase +
1 isolated 1-wire/485

I left 2 isolated analog input to measure until 2 NTC for each motor. If each motor has one inside the motor and other for IGBT disipator.

If you need more precision or more sensors, I left also an isolated 1-wire/RS485 interface that could manage a lot of 18B20 on a bus network.



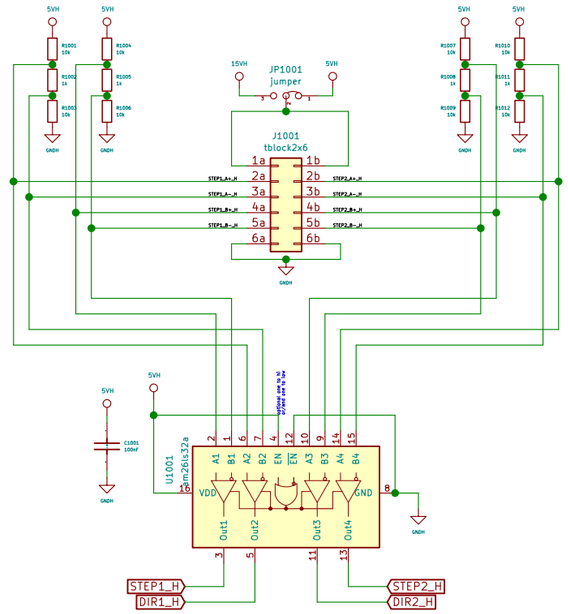




Pablo Slavkin **dci**		
Sheet: /temp/ File: temp.sch		
Title: gpio		
Size: B	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 9/19

Differential STEP-DIR input HOT

The isolation part is shared with QEP



Pablo Slavkin
dci

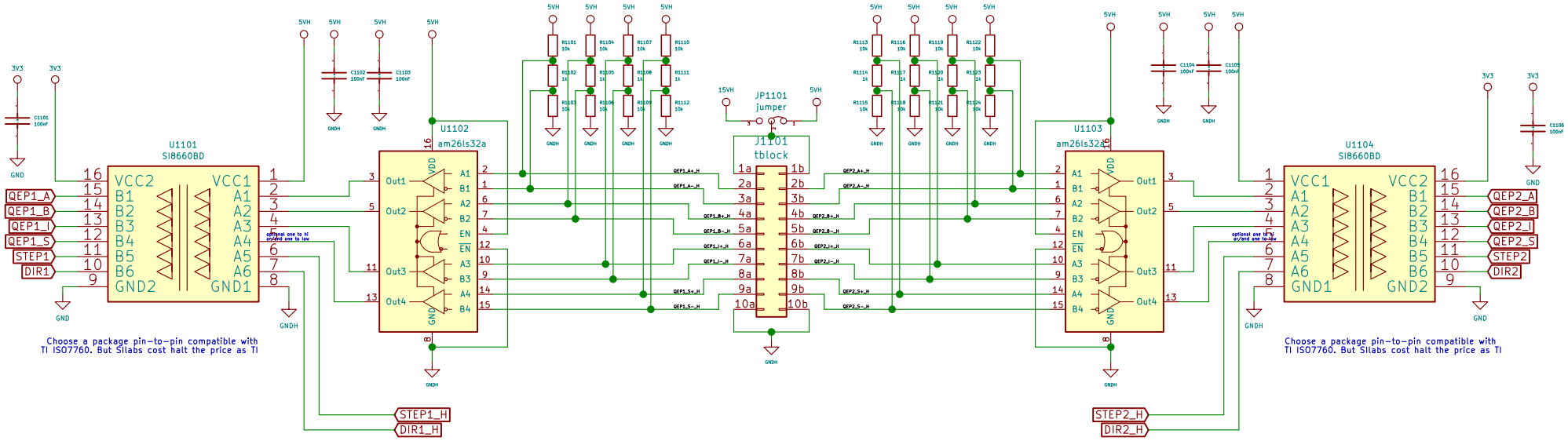
Sheet: /step_dir/
File: step_dir.sch

Title: ENDAT/BISS Interface

Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 10/19

2x Isolated Idifferential ncremental encoder interfase 5v input A-B-I-S

! left the input for two isolated incremental encoders.
! left the 4 signals input plus two auxiliary output for eny porpous plus the ability to choose between 5 or 15vdt



Pablo Slavkin	
dci	
Sheet: /qep/	
File: qep.sch	
Title: QEP encoder Interfase	
Size: A4	Date: 2020-01-09
KiCad E.D.A. kicad 5.0.2+dfsg1-1	Id: 11/19

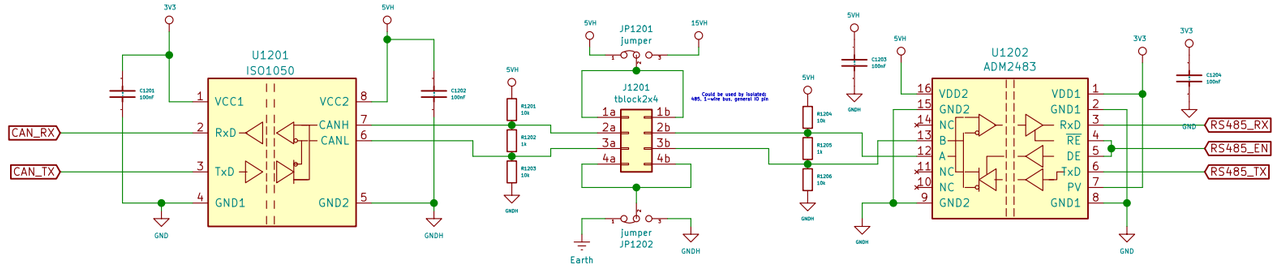
Rev: 1.0

Isolated CAN interfase

A simple CAN driver, it also could be used as a RS485 driver in his speed, the minimum for CAN is 40kbps, so in RS485 at 9600 could be fine

Isolated RS485

With these interface you could manage isolated RS485 or isolated CPIO or isolated 1-Wire, using 5V or 15V as a supply



Pablo Slavkin
dci

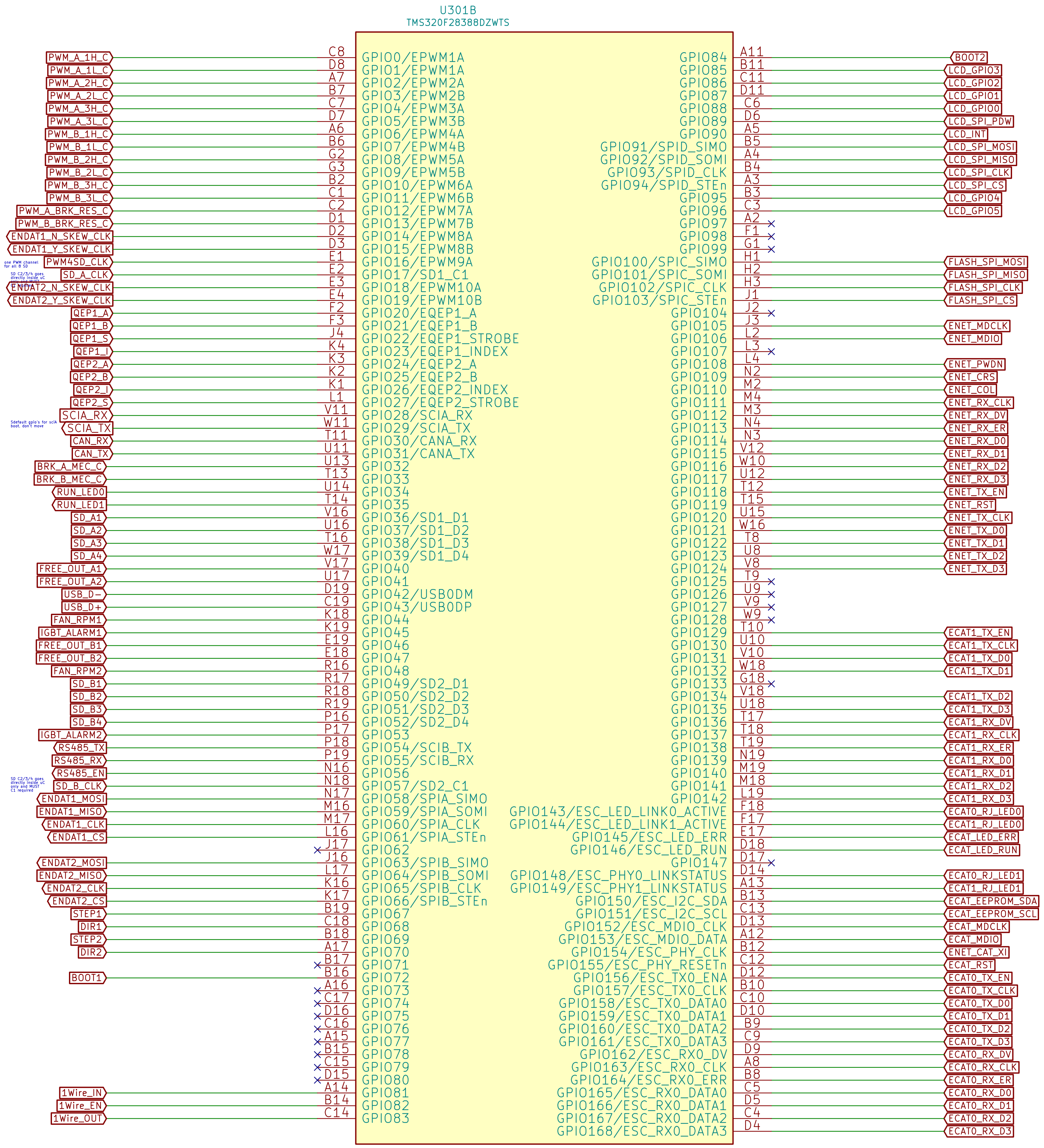
Sheet: /can rs485/
File: can_485.sch

Title:

Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 12/19

uC GPIO's pins

I've spend hours to choose the GPIO's for each interfase trying to not crash one to the other, just pay attemtion if you wanna move some pieces...
I've used global labels connector to go from one page to another instead the off-page connector because it's more proune to errors.. I know that is not too orthodox.. but it's better and fastly for now

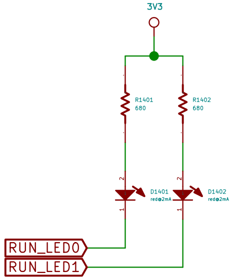


Pablo Slavkin
dci
Sheet: /uc_gpio/
File: uc_gpio.sch

Title: gpio

Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 13/19

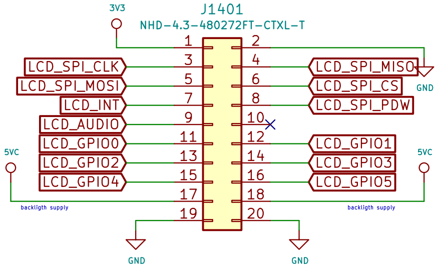
Multipropouse LEDs



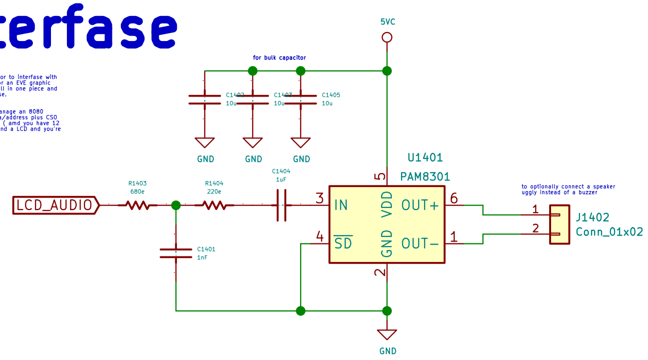
LCD UI interfase

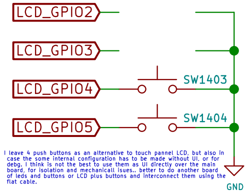
I leve a multi LCD/Touch/button 20 pins IDC connector to interfase with some UI. It could be simple leds., a character LCD or an EVE graphic LCD as I recomment 'cause for same price you've all in one piece and it's already done, clean, usefull and intuitive interfase.

I've added 2 more GPIO's 4 and 5 apart of LCD to manage an 8080 motorola LCD interfase as well. Using 4 bits for data/address plus CS0 /CS1 plus R/W plus E = 7 pins plus 4 buttons = 11 (amd you have 12 available) Just made another board with 4 buttons and a LCD and you're done



interfase directly using f20 wires flat cable
for NHD-4.3-480272FT-CTXL-T newheaven LCD
or hand wiring
EA eDIP128B-6LWTP
or using any paralel 8080 3v3 interface bitbanging
the SPI and GPIO pins





I leave 4 push buttons as an alternative to touch pannel LCD, but also in case the some internal configuration has to be made without UI, or for debg. I think is not the best to use them as UI directly over the main board, for isolation and mechanicall isues.. better to do another board of leds and buttons or LCD plus buttons and interconnect them using the flat cable.

Pablo Slavkin
dci
Sheet: /ui/
File: ui.sch
Title: clk
Size: A4 | Date: 2020-01-09 | **Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1 | Id: 14/19

8 LEM's current measurement
U+V+W+ALL x 2

with 6 screw connector you could choose
3 range of current measurement 1x, 2x or 3x.
IN 1 BRIDGE 1-2-3 and 4-5-6 OUT 4 -------- X
IN 1 BRIDGE 1-2 and 3-5-6 OUT 4 -------- 2X
IN 1 BRIDGE 2-6 and 3-5 OUT 4 -------- 3X

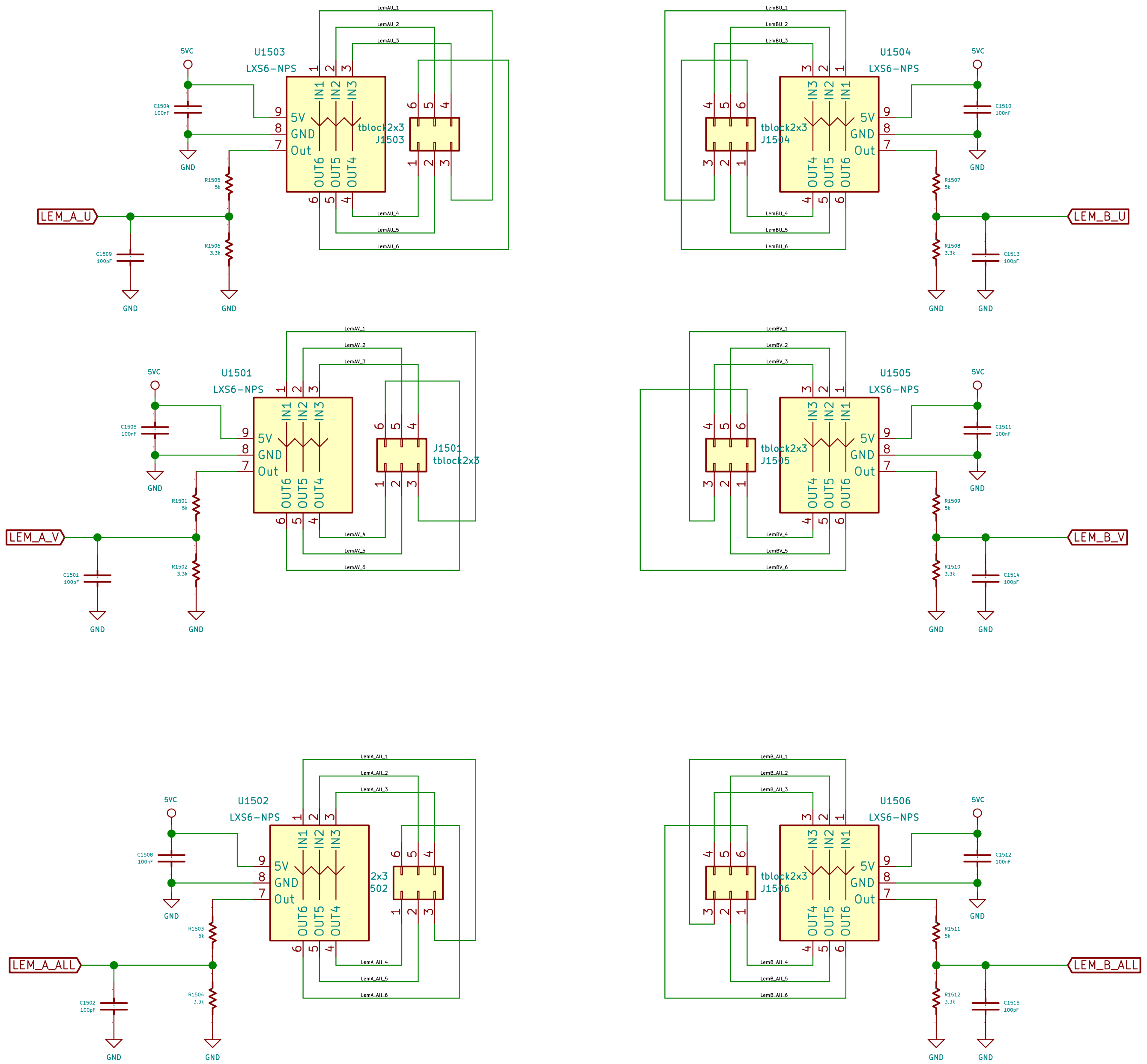
The intention of these lems is to have the capacity on the control board to measure all the current, without the need of the sigma delta chips on power board side. Why?? becouse I've study the two options carrefullty and I've conclude that there are very similar, and more or less buck per byck (a little expensive is SD) but the new generation LEM's I'm includin here has <0.5uSeg response time, and the SD has all the SD filter delay, so LEM is faster. The other advantage is that for same LEM I've choosen you could rearange the connection to multiply the preccision 1x,2x or 3x without touching nothing, and is pretty linear. In the case of SD you have to change the precission shunt. or puts more than one, that is costly and take some board space.
The disadvantage of LEM is that the output is single ended, so it could not travel across boards, for that reason I've put them on control board, but is completely isolated becouse of these phisics effect. and also becouse of that single ended I just use one ADC channel per current. I't not the only option, becous if you insist and wanna use SD, l'eft all the SD channels available as an inputs on SD schematic page.

these LEM's version doesn't need a buffer,
it's one already included inside LEM

LXS6 is LTS and CAS pin to pin compatible, but LXS is a little better.
I don't usa an opamp becous with the external conection I have x,2x and 3x amplifier option without any component

I've decided to make the loop over the LEM on board and if you wanna change it you have to use the soldering iron..becouse the connetor is 2 terminal, not 6

chanlog1: I've decided to return to a 2x3 terminal block output 'cause it match the size of the LEM



LEM_A_W LEM_B_W

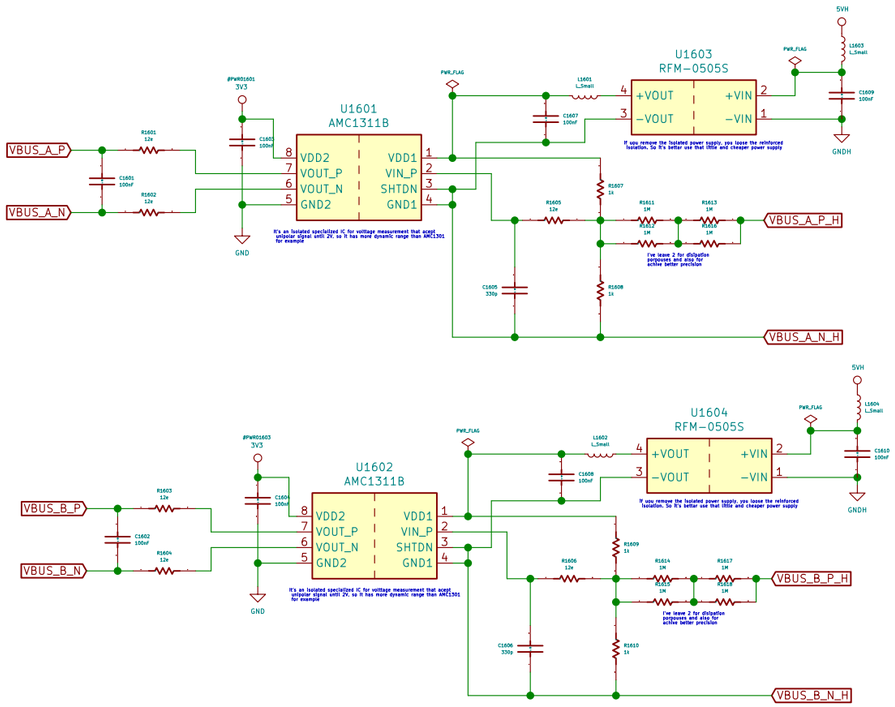
I've decided to eliminate 1 LEM, you could use 3 in line measurement, or 2 in line plus one for all. De reason is size of board and complexity

Pablo Slavkin
dci
Sheet: /lem/
File: lem.sch
Title: LEM currente measurement
Size: A3 Date: 2020-01-09 **Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1 Id: 15/19

VBUS -> R divider -> ISO ADC -> uC

It's intended to measure the Vbus, one per motor, but they cold be joined if both motor share same VBus. The Vbus informatio will be used by the control algorith and to drive the break resistor PWM to protect the rise of the Vbus more than a threshold

The Input is expected not to be 220v or 380v. It's supoused to be a isolated low voltage to maintaint the reinforced insulation. In case you can't you could input 220v directly but the isolation would be simple



Pablo Slavkin	
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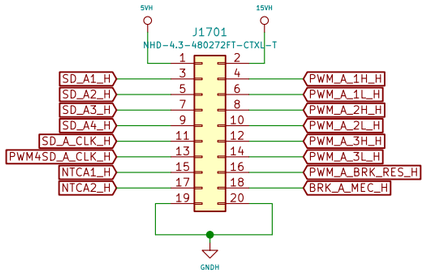
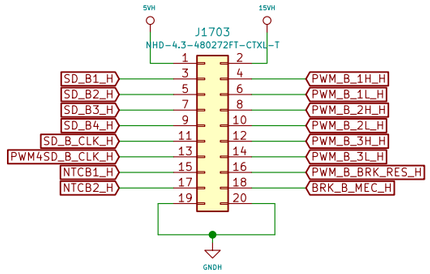
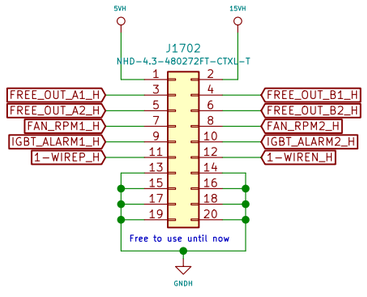
Sheet: /Vbus meas/	
File: vbus_meas.sch	
Title: Shunt isolated	
Size: A3	Date: 2020-01-09
KiCad E.D.A. kicad 5.0.2+dfsg1-1	Id: 16/19
	Rev: 1.0

Common Connections







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dci

Sheet: /connectors/
File: conn.sch

Title: Common connections

Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 17/19

Isolated sigma delta ADC

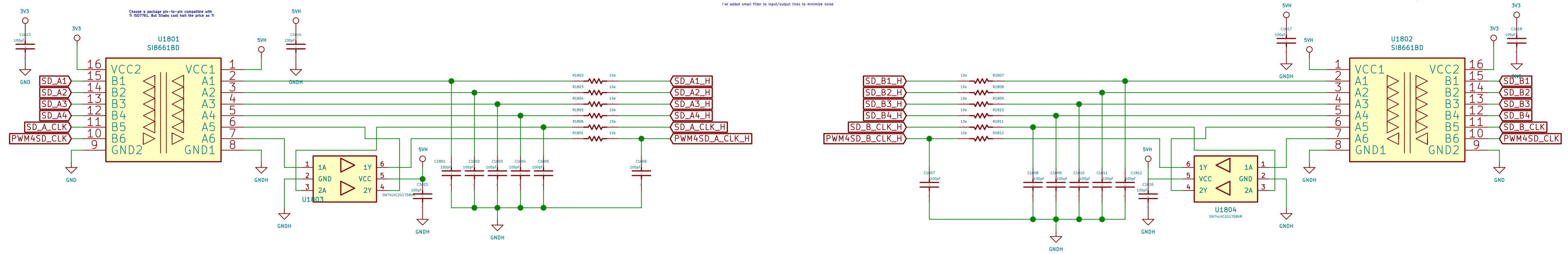
It's intended for power board circuitery to supply all the signals to control board. The control board will use the SD filter to aquire the data. All the power part will be at power board.

PWM clk output to powerboard and then come back again to maintain delays with resect to SD data channels. On power board you have to respect traces length between clk and data

I use 5VH on power side to be less prone to noise error on the way on connection the two boards (and I've decided to not supply 3v3H too)

I've added small filter to input/output lines to minimize noise

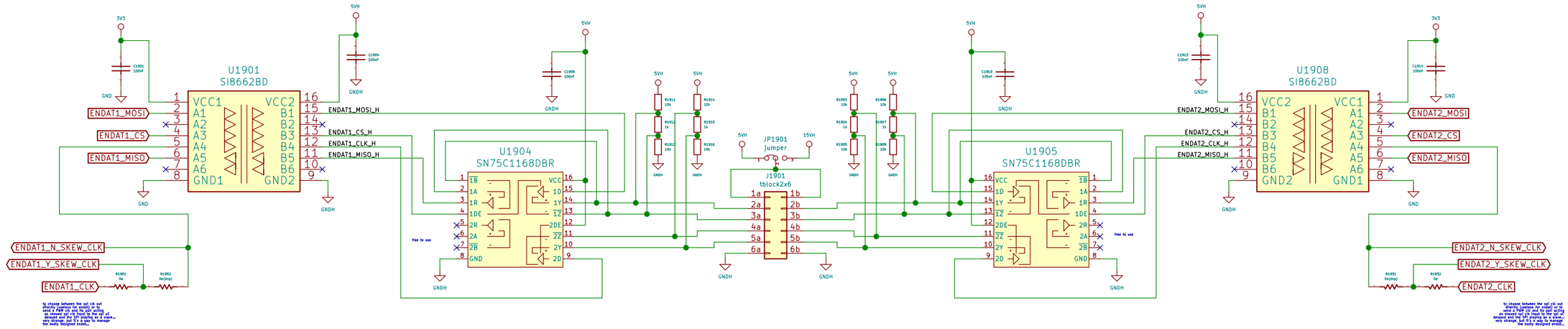
Choose a package pin-to-pin compatible with TI ISO7761. But Silabs cost halt the price as TI



Pablo Slavkin
dci
Sheet: /sigma_delta/
File: sigma_delta.sch
Title: Shunt Sigma Delta isolated

Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 18/19

2X Isolated diferential ENDAT interface



Pablo Slavkin
dci

Sheet: /endat/
File: endat.sch

Title: ENDAT/BISS Interface

Size: A3	Date: 2020-01-09	**Rev: 1.0**
KiCad E.D.A. kicad 5.0.2+dfsg1-1		Id: 19/19