MLT - Analog Sensor Board

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Hardware User Manual V.01

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The MLT Analog Sensor Board is based on the Cypress PSoC 5LP. It features several analog output sensors on board as well as an I2C HTP-sensor. Further it has an isolated SPI interface for remote sensors, DAC's or ADC's. A display header for a 2x15 character display is available as well as digital and analog headers.

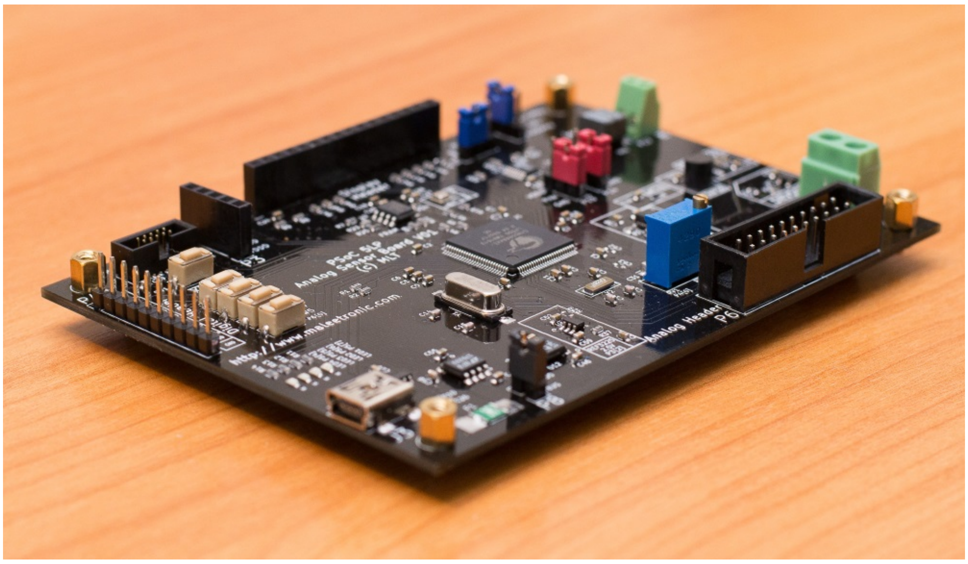

Figure 1: *View of the Board*

License

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The License is attatched at the end of this document as well as a Guide to the CERN OHL v.1.2.

Please feel free to give your highly appreciated feedback, comments and suggestions. Or ask any questions about the board. We'll be glad to answer or help you.

System Overview

The MLT-Analog Sensor Board is an board based on the PSoC 5lp. It features several analog output sensors on board, connected to the PSoC 5LP. Additional it has and Humidity-Temperature-Pressure Sensor, BME280 which is connected via I2C interface to the PSoC. Further it has 1Mbit SPI FRAM chip on board as well as an isolated SPI interface to connect remote digital sensors, ADC's or DAC's. It has an Display header to connect a 2x16 character Display to the board. All unused signals are feed to the analog or digital header respectively.

Below is the system architecture of the board:

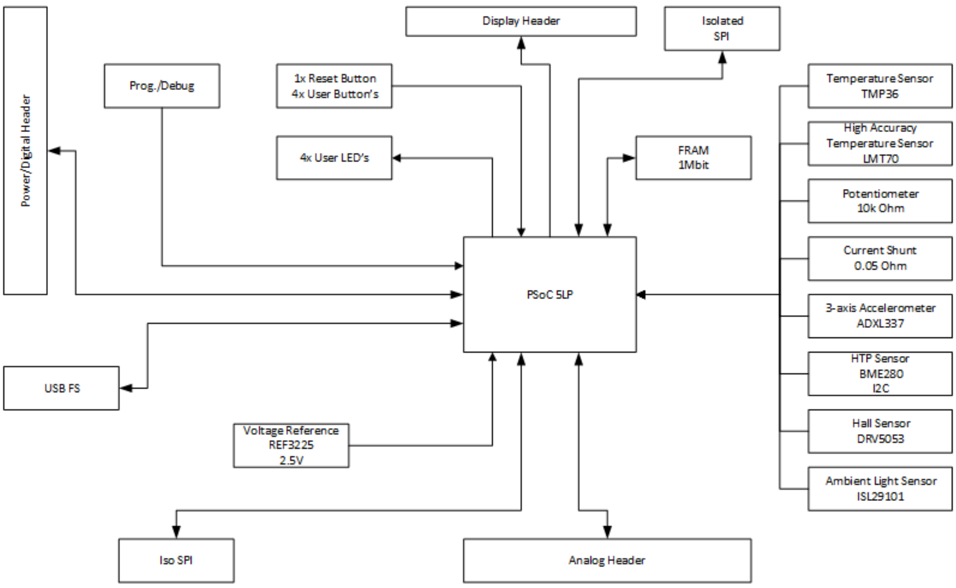


Figure 2: *system diagram*

On-board features and functionality

PSoC 5LP in 100 TQFP footprint

LMT70A high accuracy temperature sensor

TMP36 standard temperature sensor in TO92

ISL29101 Ambient Light Sensor

ADXL337 3-axis accelerometer

DRV5053 hall sensor

WSL25125L000FEA 50 mOhm current shunt resistor

4290 Series 10kOhm 25 turns trimmer

REF3225 2.5V Voltage Reference

BME280 Humidity Temperature Pressure sensor I2C

LTC6820 1500V isolated SPI interface

USB USB (FS) interface to PC

Power Powerd by USB or external source

Header Digital header

Header Analog Header

Header Display Header for 2x16 Char Display

FM25VN10-G SPI FRAM 1Mbit

LED 4x user LED

Push Button 4x user push button, 1x Reset

Header Programming header for Kitprog and Miniprog3

Clock 24 MHz and 32.768 kHz crystals

Description of Components and Features

PSoC 5LP

The PSoC 5LP is a true programmable embedded system-on-chip, integrating configurable analog and digital peripherals, memory, and a micro controller on a single chip. It contains a 32-bit ARM Cortex-M3 core plus DMA controller and digital filter processor, at up to 80 MHz.

Device used in this board: PSoC 5LP CY8C5888AXI-LP096 100-TQFP

Figure 3: *Cypress PSoC 5LP*

Analog Devices TMP36

Analog Output: P4[3]

Package: TO-92

Supply: VDDA 3.3V

The TMP36 is an standard analog output temperature Sensor from Analog Devices. Typical Accuracy is +-2 degree.

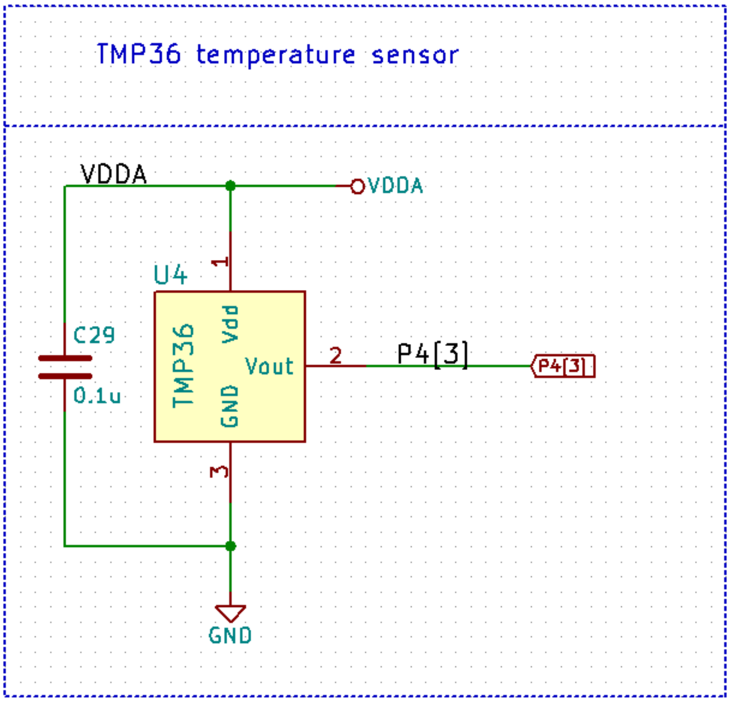


Figure 4: *Schematic TMP36*

Texas Instruments LMT70A

Supply: VDDA 3.3V

Analog Output: P4[4]

Package: DSBGA-WLCSP(4)0.88 mm x 0.88 mm

The LMT70 is an ultra-small, high-precision, low power CMOS analog temperature sensor with an output enable pin. Applications for the LMT70 include virtually any type of temperature sensing where cost effective, high precision and low-power are required, such as Internet of Things (IoT) sensor nodes, medical thermometers, high-precision instrumentation and battery powered devices. The LMT70 is also a great replacement for RTD and precision NTC/PTC thermistors. Its output enable pin is tied to VDDA. The LMT70 also has a linear and low impedance output allowing seamless interface to an off-the-shelf MCU/ADC. Dissipating less than 36W, the LMT70 has ultra-low self-heating supporting its high-precision over a wide temperature range. The LMT70A provides unparalleled temperature matching performance of 0.1C (max) for two adjacent LMT70A's picked from the same tape and reel. Therefore, the LMT70A is an ideal solution for energy metering applications requiring heat transfer calculations.

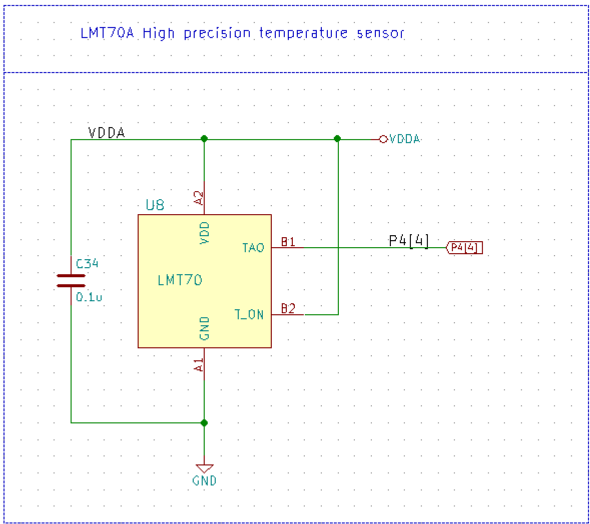


Figure 5: *Schematic LMT70A*

Potentiometer 10k, 25 turns

Analog Output: P4[0]

Package: TH, Top Adjustment

Power: 0.5 W

Resistance: 10kΩ ±10%

The Potentiometer has 25 turns and an 10uF in parallel to the wiper pin. R19 is an 0Ω jumper, which can be removed if the potentiometer is not needed.

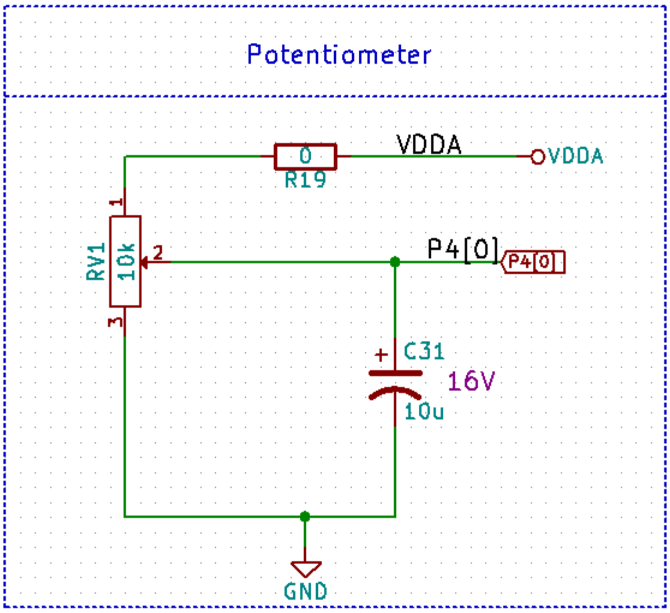


Figure 6: *Schematic Potentiometer RV1*

Vishay Precision Shunt Resistor R15

Analog Input: P3[4] and P3[5]

Package: 2512

Power: 1 W

Resistance: 5mΩ ±1%

Model: WSL25125L000FEA

The Shunt can be used to measure currents by connecting this resistor in series with the current path to be measured. The connector P7 is on the board edge as screw terminal. P3[4] and P3[5] are the OPAMP1 inputs of the PSoC 5LP.

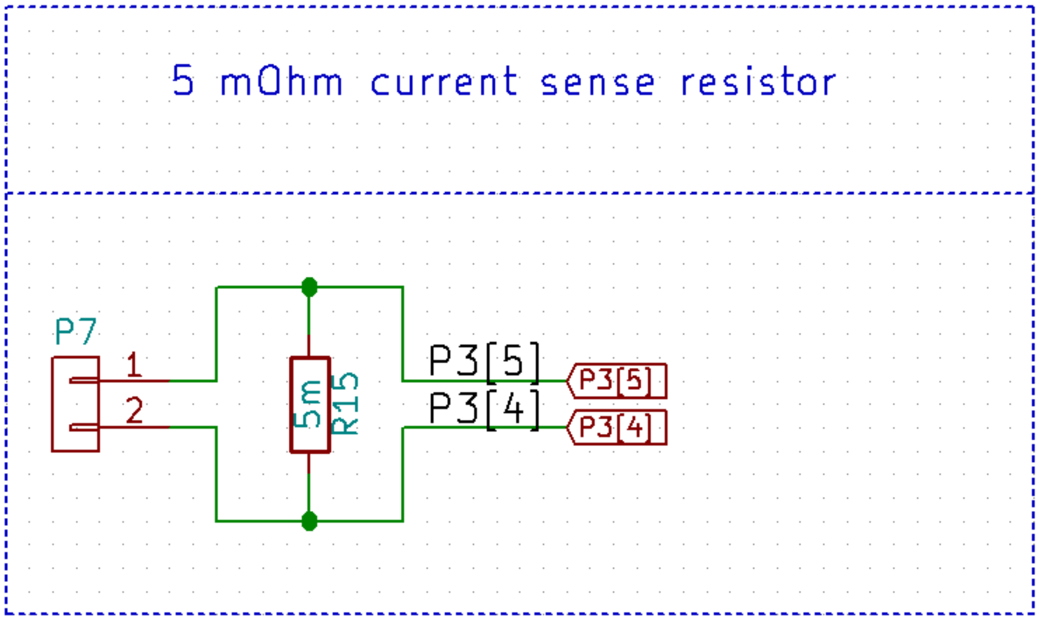


Figure 7: *Schematic Current Shunt*

3-axis Accelerometer ADXL337

The ADXL337 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt- sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

The bandwidth of the accelerometer is set with 0.1uF initially to 50Hz. If higher or lower bandwidth is required, the capacitors must be changed. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for X and Y axes and a range of 0.5 Hz to 550 Hz for the Z axis.

See in the data sheet the section ”Application Information” of the ADXL337 for more details.

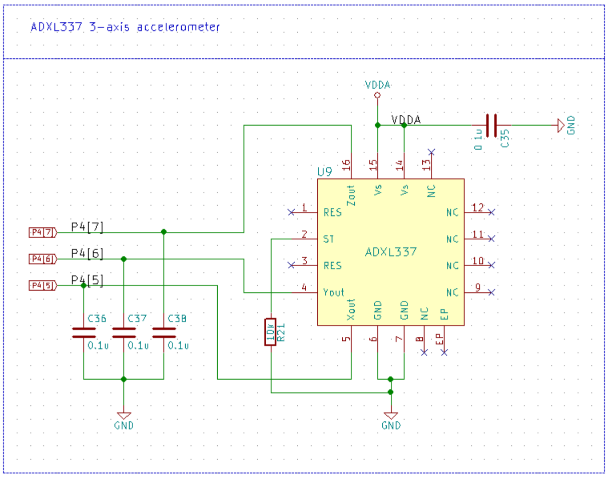


Figure 8: *Schematic ADXL337*

Direction	Port Pin	Capacitor
X	P4[5]	C36
Y	P4[6]	C37
Z	P4[7]	C38

Table 1: *ADXL337 Configuration*

Intersil Ambient Light Photo detect IC ISL29101

Analog Output: P4[2]

Package: 6-ODFN 2 mm x 2.1 mm

The ISL29101 is a low power ambient Light-to-Voltage optical sensor combining a photo diode array, a current amplifier and a micro power operational amplifier on a single monolithic IC. Similar to the human eye, the photo diode array has a peak response at 550nm and spans from 400nm to 600nm, rejecting UV light and IR light. The output voltage is proportional to the visible light intensity from 0.5 lux up to 10,000 lux. However, the input luminance range can go up to 30,000 lux with some compromise in linearity. A dark current compensation circuit aids the photo diode array to minimize temperature dependent leakage currents in the absence of light, improving the light sensity at low lux levels.

The output voltage is linear proportional to the light intensity. R16 is set to 10k, so that the voltage is proportional to 0-10000 lux range.

$Vout = \frac{1.6uA}{100lux*E*R}$

Please see the data sheet of the ISL29101 for more application information.

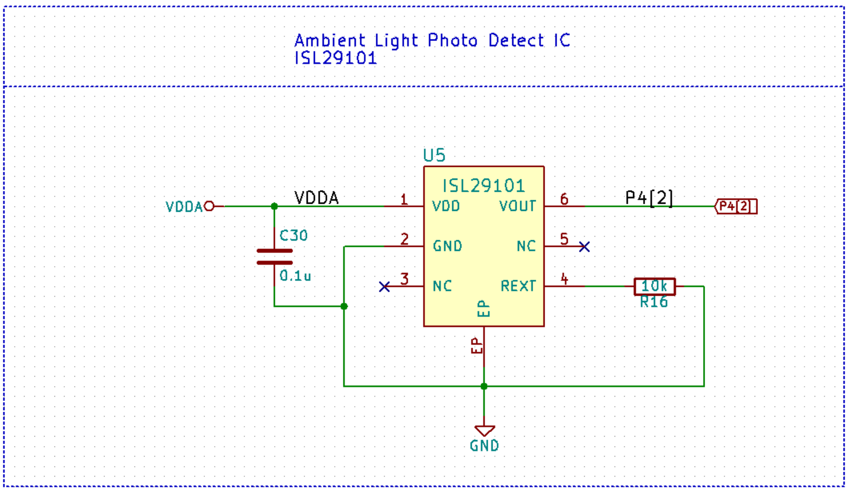


Figure 9: *Schematic ISL29101*

Texas Instruments Hall Sensor DRV5053

Analog Output: P4[1]

Package: SOT-23 2.92 mm x 1.3 mm

Sensitivity: -90mV/mT

Part: DRV5053VAQDBZR

The DRV5053 device is a chopper-stabilized Hall IC that offers a magnetic sensing solution with superior sensitivity stability over temperature and integrated protection features. The 0.2 to 1.8 V analog output responds linearly to the applied magnetic flux density, and distinguishes the polarity of magnetic field direction. B = 0mT, OUT = 1V.

The hall sensor mounted on the board has an sensitivity of -90mV/mT (VA version). Mounting an different hall sensor from the same family is easy possible.

R20 is loaded with a 0Ω resistor. C33 is not loaded. If an output filter is required, please load the appropriate R-C combination.

Please read the data sheet of the hall sensor for more details.

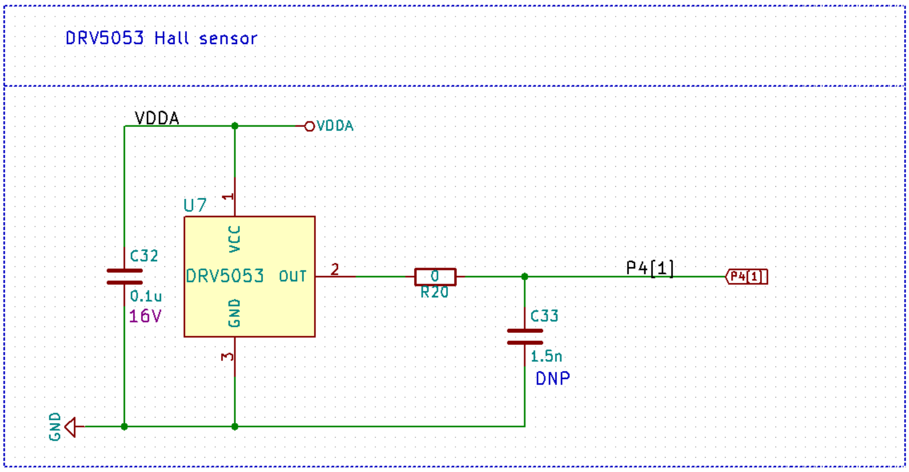


Figure 10: *Schematic DRV5053*

Bosch Sensor Tec Digital Humidity, Pressure and Temperature Sensor BME280

I2C: P12[4] and P12[5], SCL and SDA respectively

Package: metal-lid LGA 2.5 mm x 2.5 mm

Part: BME280

The BME280 is as combined digital humidity, pressure and temperature sensor based on proven sensing principles. The sensor is connected via I2C interface to the PSoC 5LP.

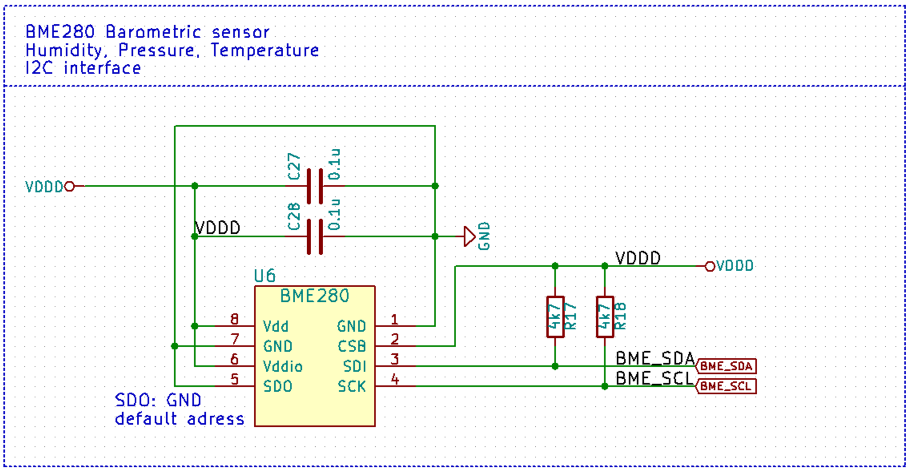


Figure 11: *Schematic BME280*

LED and Push Button

The board has 5 tactile switches and 4 LED's. The following table describes the function.

The LED's are low power LED's Lite-On LTST-C193KSKT-5A, with an 1k resistor in series.

Direction	PSoC pin	Function
SW1	XRES	Reset
SW2	P6[4]	user switch
SW3	P6[5]	user switch
SW4	P6[1]	user switch
SW5	P6[0]	user switch
LED1	P5[7]	user LED green
LED2	P5[6]	user LED red
LED3	P5[5]	user LED blue
LED4	P5[4]	user LED blue

Table 2: *LED's and Push Button's*

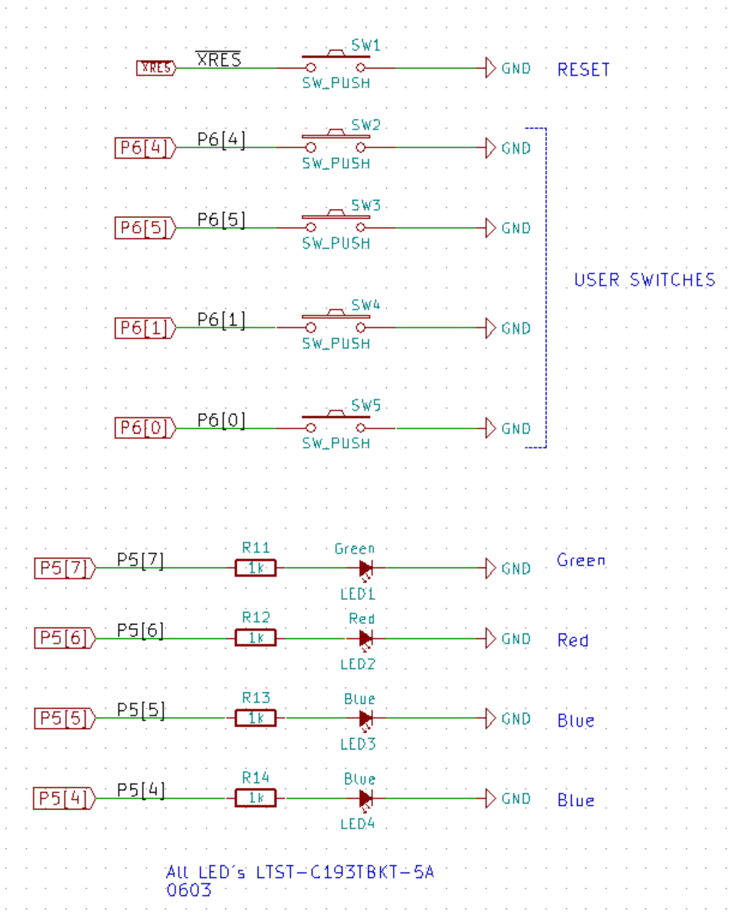


Figure 12: *Schematic LED's and Push Buttons*

LCD 2x16 Char LCD Module

Model: LCM-SO1602DTR/A-3 (shipped with the board)

Voltage: 3.3V

P5 is the display header. The 2x16 char LCD can be attached to the board directly. The LCD can be used directly with the charLCD component in PSoC Creator and is connected to the Port P2[6:0].

P5 pin	Name	Function/Port
1	GND	
2	VCC	3.3V
3	VO	
4	RS	P2[5]
5	R/nW	P2[6]
6	EN	P2[4]
7	NC	
8	NC	
9	NC	
10	NC	
11	D4	P2[0]
12	D5	P2[1]
13	D6	P2[2]
14	D7	P2[3]
15	A	
16	K	

Table 3: *ADXL337 Configuration*

Cypress SPI FRAM FM25VN10-G

Capacity: 1 MBit

Voltage: 3.3V

Interface: SPI, 40MHz

The board has also an SPI FRAM chip on-board, where data can be saved into.

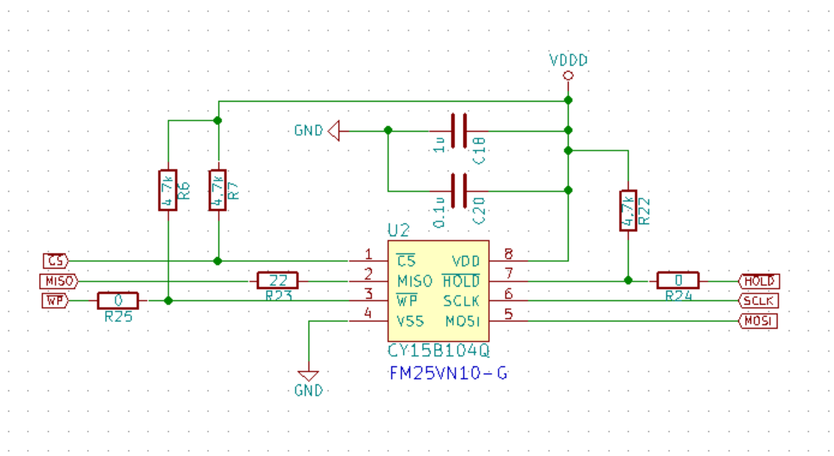


Figure 13: *Schematic Voltage Reference*

Programming

The board is shipped with the demo design, which also can be downloaded from www.maleetronic.com This demo demonstrate the functionality of the board. The demo firmware was created with PSoC Creator 3.3 SP2. The Application software was written in CS.

The board can be programmed in two ways.

Miniprog 3

On P1, the board can be programmed with the Miniprog3. The Target Voltage is 3.3V. If no external power is supplied to the board, a bridge jumper wire has to be connected from VDDD to VDDA.

Kitprog

With the Kitprog, the board can be programmed on P3.

The Kitprog is also available as break away module on the PSoC 5lp prototyping Kit, available for 10 USD from Cypress.

Voltage Reference REF3225

Power domain: VDDA 3.3V

Voltage Output: 2.5V

Package:

The on-board voltage reference is connected to the PSoC pin P3[2]. The reference can be easily replaced with another voltage reference within the family or with the same footprint and pin out.

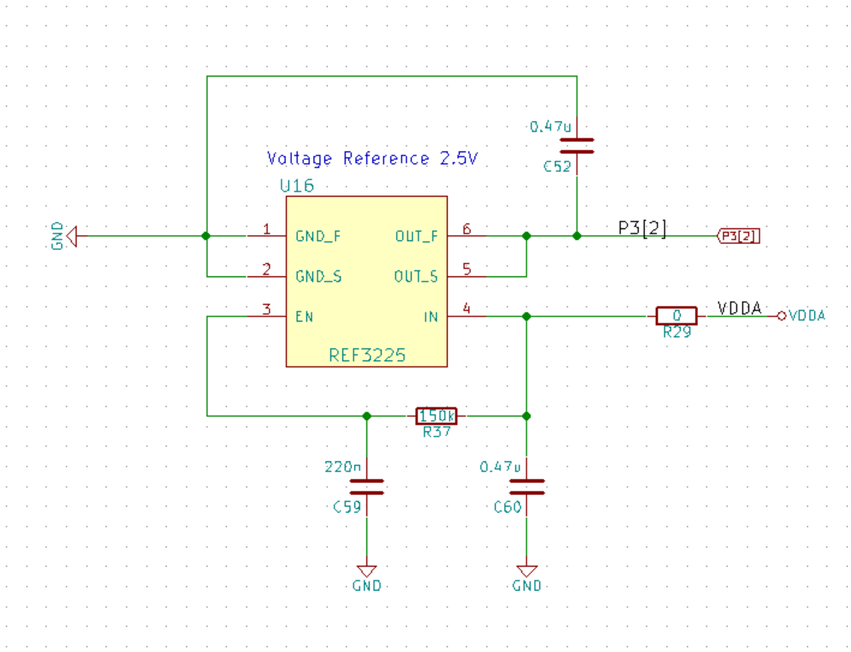


Figure 14: *Schematic Voltage Reference*

Isolated SPI Master interface

The board has an iso SPI interface based on the LTC6820. This can be used to communicate bidirectional with remote sensors, ADC's DAC's and so on, basically everything with an SPI interface. Only a twisted pair wire connection is necessary to communicate in noisy environments of up to 100m. The isoSPI interface supports data rates of 1Mbit/s at 100m and 0.5 Mbit/s at 50m single twisted pair connection.

It is necessary to have an LTC6820 on the remote side as well, like the MLT isoSPI board, which also available from me.

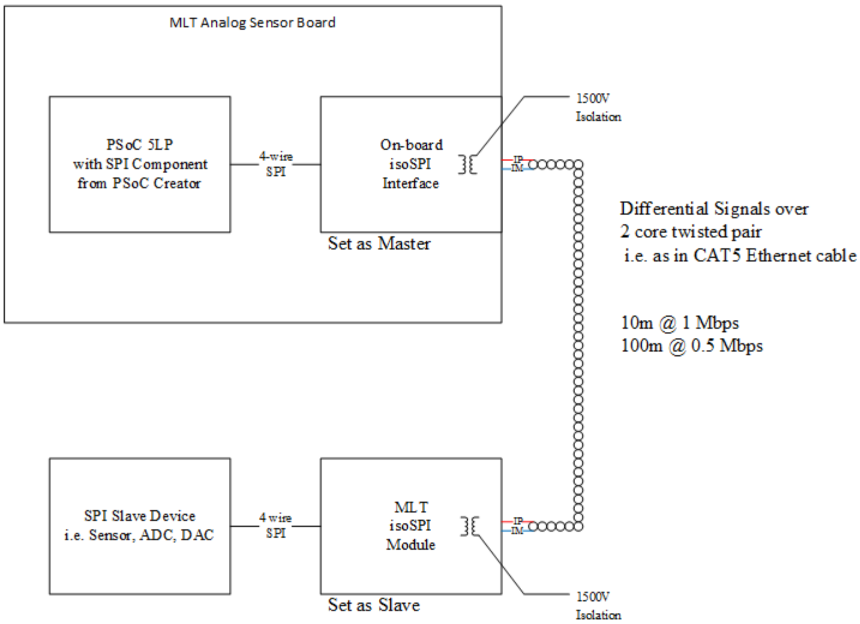


Figure 15: *Application of the iso SPI interface*

Pin connection

The LTC 6820 is connected via the following connections with the PSoC 5LP:

PSoC pin	Signal Name	LTC6820 pin
P15[5]	MOSI-iso	2
P15[4]	MISO-iso	3
P6[3]	SCK-iso	4
P6[2]	CS-iso	5

Table 4: *SPI Signals LTC6820*

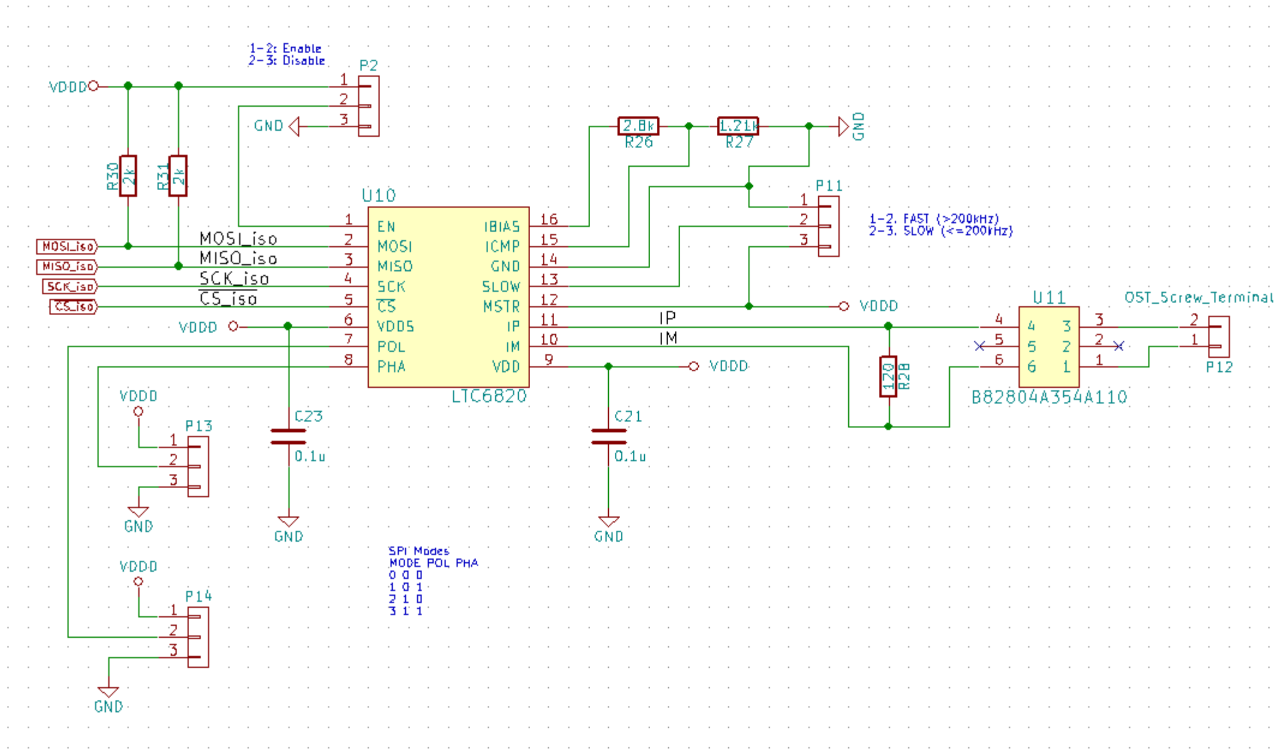


Figure 16: *Schematic isolated SPI interface*

Jumper Settings isoSPI

With Jumper P13(PHA)and P14(POL), you can adjust the Phase and Polarity of the desired SPI mode.

Position	Level
1-2	1
2-3	0

Table 5: *Jumper P13, PHA*

Position	Level
1-2	1
2-3	0

Table 6: *Jumper P14, POL*

With Jumper P11 you can adjust the speed of the SPI communication.

Position	Level	clock speed
1-2	0	200 - 1000 kHz
2-3	1	<=200 kHz

Table 7: *Jumper P11, Clock Speed*

With Jumper P2 you can enable or disable the isoSPI interface. Standard is disabled(2-3).

Position	Function
1-2	Enable
2-3	Disable

Table 8: *Jumper P2, Enable isoSPI*

USB

The USB port can be used to communicate with the PSoC directly by using the USB component in PSoC Creator. The board can be powered from the USB bus voltage by closing Jumper P8.

20 pin Analog Header

The analog header has all unused analog pins connected, as well as analog power and analog ground.

P6 pin	Signal
1	P3[0]
2	P3[1]
3	P3[3]
4	P3[6]
5	P3[7]
6	P12[0]
7	P12[1]
8	P12[2]
9	P12[3]
10	GND
11	GND
12	P0[0]
13	P0[1]
14	P0[3]
15	P0[5]
16	P0[6]
17	GND
18	P0[7]
19	GND
20	VDDA

Table 9: *Pin description Analog Header*

10 pin Digital Header

The digital header has all unused digital pins connected, as well as digital power and digital ground. VIN-LDO is the input of the two LDO's and can be used to power the board. In this case jumper J8 should be removed. VBUS2 is the bus voltage from host, VBUS is the bus voltage from the host after fuse F1.

P6 pin	Signal
1	P2[7]
2	P1[6]
3	P1[7]
4	P12[6]
5	P12[7]
6	P1[5]
7	VIN-LDO
8	VBUS
9	VDDD
10	GND

Table 10: *Pin description Digital Header*

Power Supply

The board is designed to be powered from the USB connector. Jumper P8 is installed by default.

There are two low noise LDO's, LTC1763 3.3V for powering analog and digital domain separately.

However, by removing jumper P8, the board can be powered via the VIN-LDO pin on the digital header P4(7). The input range here should be about 3.5V to 18V, consider reading the data sheet of the LTC1763 for allowable input range of the LDO's.

P8 can also be used to measure the boards power consumption.

Figure 11 shows the boards power supply structure.

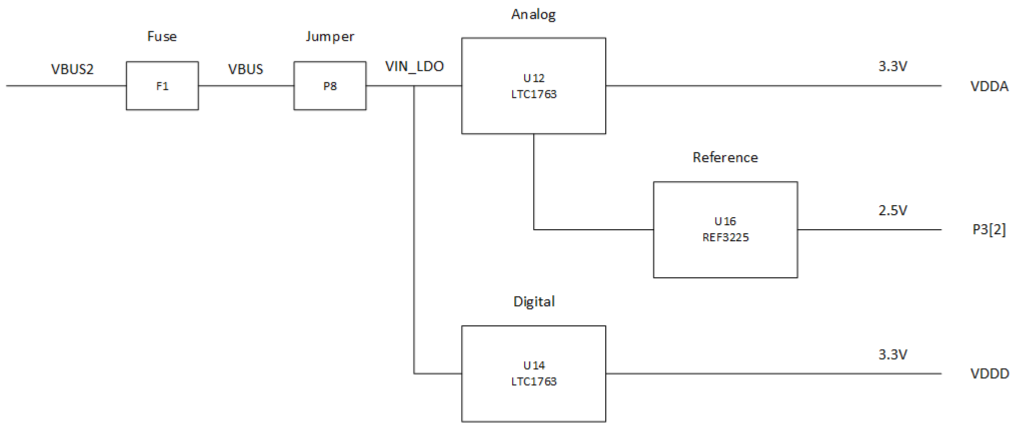


Figure 17: *Power Supply Structure*

Clock

The board has two crystals.

A 24 MHz crystal Y1 which is connected to P15[0] and P15[1] respectively.

A 32.768 kHz crystal Y2 which is connected to P15[3] and P15[2] respectively.

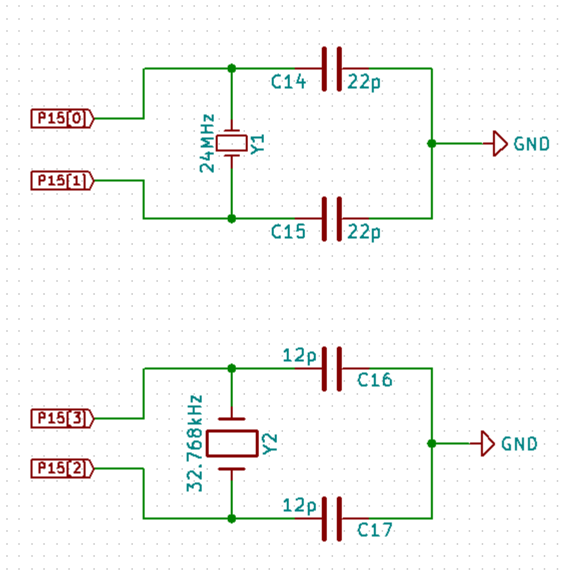


Figure 18: *Crystals Y1 and Y2*

Complete Pin Table PSoC 5LP

IC Pin	Port Pin	Power Domain	Description	Use for
1	P2[5]	D	Display	LCD_RS
2	P2[6]	D	Display	LCD R/$\overline{W}$
3	P2[7]	D	Digital Header	P4_1
4	P12[4]	D	BME280	SCL
5	P12[5]	D	BME280	SDA
6	P6[4]	D	SW3	
7	P6[5]	D	SW2	
8	P6[6]	D	FRAM	Hold
9	P6[7]	D	FRAM	SCLK
10	VSSB		Power	GND
11	IND		Power	GND
12	VBOOST		Power	GND
12	VBAT		Power	GND
14	VSSD		Power	GND
15	XRES		XRES	XRES
16	P5[0]	D	FRAM	MOSI
17	P5[1]	D	FRAM	CS
18	P5[2]	D	FRAM	WP
19	P5[3]	D	FRAM	MISO
20	P1[0]	D	Prog.	SWDIO
21	P1[1]	D	Prog.	SWDCLK
22	P1[2]	D	NU	
23	P1[3]	D	Prog.	SWO
24	P1[4]	D	Prog.	TDI
25	P1[5]	D	Digital Header	P4_6
26	VDDIO1		Power	VDDD
27	P1[6]	D	Digital Header	P4_2
28	P1[7]	D	Digital Header	P4_3
29	P12[6]	D	Digital Header	P4_4
30	P12[7]	D	Digital Header	P4_5
31	P5[4]	D	LED 4	blue
32	P5[5]	D	LED 3	blue
33	P5[6]	D	LED 2	red
34	P5[7]	D	LED 1	green

Table 11: *Pin Assignment Table Part 1*

IC Pin	Port Pin	Power Domain	Description	Use for
35	P15[6]	D	USB	D+
36	P15[7]	D	USB	D-
37	VDDD	D	Power	VDDD
38	VSSD	D	Power	GND
39	VCCD	D	Power	VCCD
40	NC			
41	NC			
42	P15[0]	A	24MHz Crystal	
43	P15[1]	A	24 MHz Crystal	
44	P3[0]	A	Analog Header	P6_1
45	P3[1]	A	Analog Header	P6_2
46	P3[2]	A	On-board Ref	2.5V
47	P3[3]	A	Analog Header	P6_3
48	P3[4]	A	Shunt	0.05Ω
49	P3[5]	A	Shunt	0.05Ω
50	VDDA	A	Power	
51	P3[6]	A	Analog Header	P6_4
52	P3[7]	A	Analog Header	P6_5
53	P12[0]	A	Analog Header	P6_6
54	P12[1]	A	Analog Header	P6_7
55	P15[2]	A	Crystal	32.768kHz
56	P15[3]	A	Crystal	32.768kHz
57	NC			
58	NC			
59	NC			
60	NC			
61	NC			
62	NC			
63	VCCA		Power	VCCA
64	GND		Power	VDDA
65	VDDA		Power	VDDA
66	GND		Power	GND

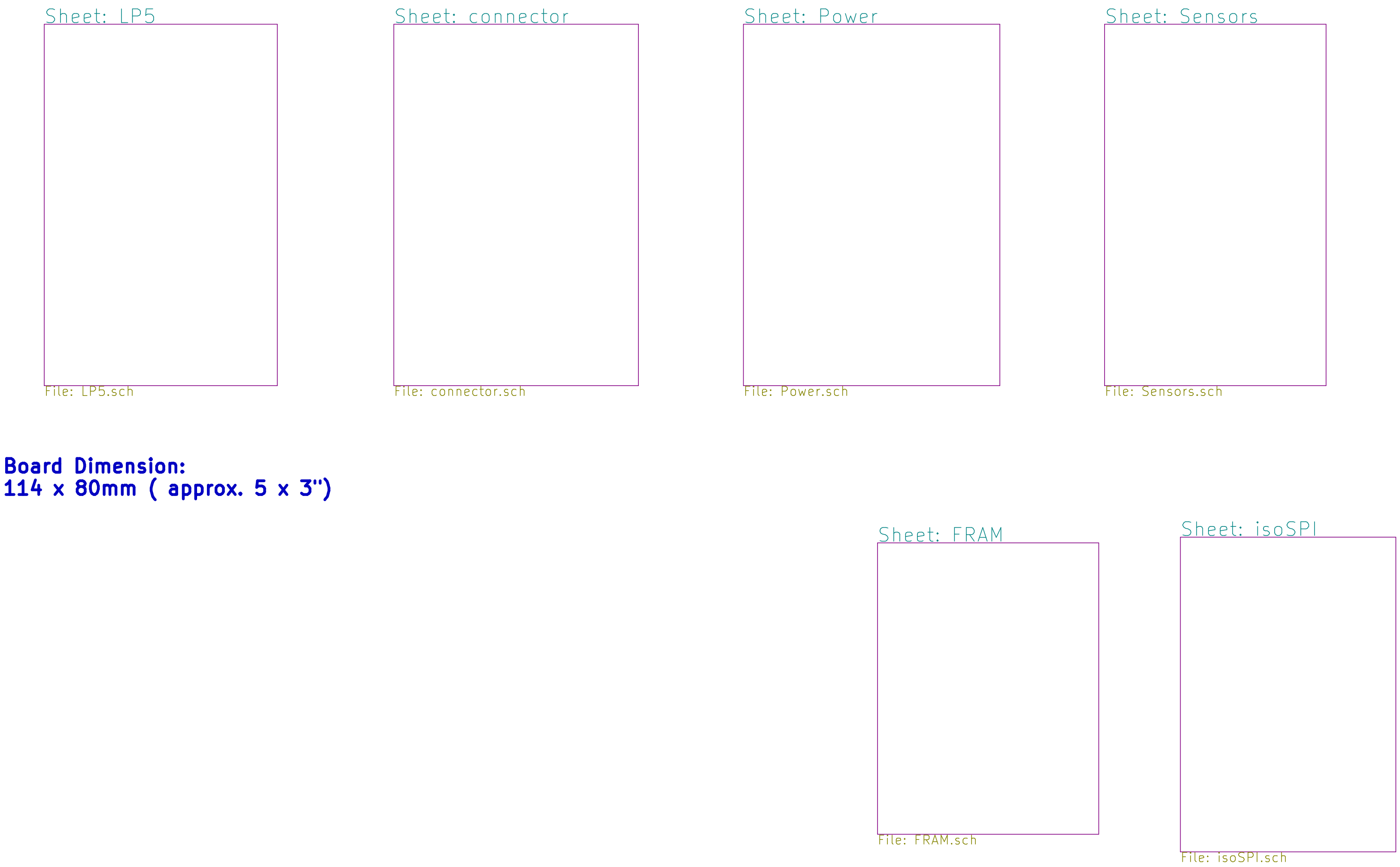
Table 12: *Pin Assignment Table Part 2*

IC Pin	Port Pin	Power Domain	Description	Use for
67	P12[2]	A	Analog Header	P6_8
68	P12[3]	A	Analog Header	P6_9
69	P4[0]	A	Pot	
70	P4[1]	A	Hall Sensor	DRV5053
71	P0[0]	A	Analog Header	P6_12
72	P0[1]	A	Analog Header	P6_13
73	P0[2]	A	SAR cap	
74	P0[3]	A	Analog Header	P6_14
75	VDDA	A		
76	P0[4]	A	SAR cap	
77	P0[5]	A	Analog Header	P6_15
78	P0[6]	A	Analog Header	P6_16
79	P0[7]	A	Analog Header	P6_18
80	P4[2]	A	Light Sensor	ISL29101
81	P4[3]	A	Temp Sensor	TMP36
82	P4[4]	A	Temp Sensor	LMT70A
83	P4[5]	A	Accel.	X
84	P4[6]	A	Accel.	Y
85	P4[7]	A	Accel.	Z
86	VCCD		Power	VCCD
87	GND		Power	GND
88	VDDD		Power	VDDD
89	P6[0]	D	SW5	
90	P6[1]	D	SW4	
91	P6[2]	D	isoSPI	$\overline{CS\_iso}$
92	P6[3]	D	isoSPI	SCK_iso
93	P15[4]	D	isoSPI	MISO_iso
94	P15[5]	D	isoSPI	MOSI_iso
95	P2[0]	D	Display	D4
96	P2[1]	D	Display	D5
97	P2[2]	D	Display	D6
98	P2[3]	D	Display	D7
99	P2[4]	D	Display	LCD_EN
100	VDDD	D	Power	VDDD

Table 13: *Pin Assignment Table Part 3*

Attachments

1. Analog Sensor Board Schematics
2. CERN OHL v1.2
3. CERN OHL v1.2 Howto Guide



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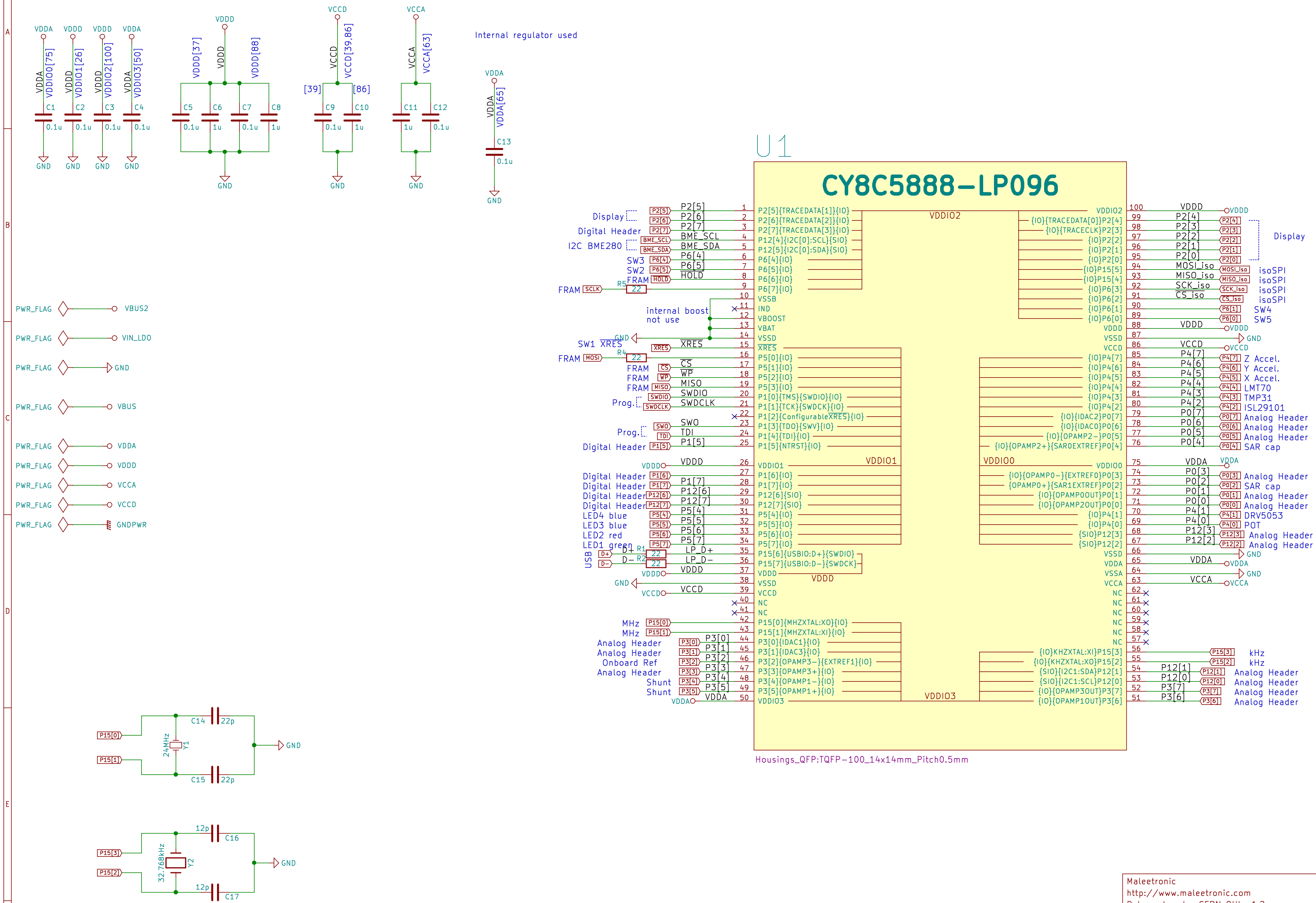

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Sheet: /LP5/
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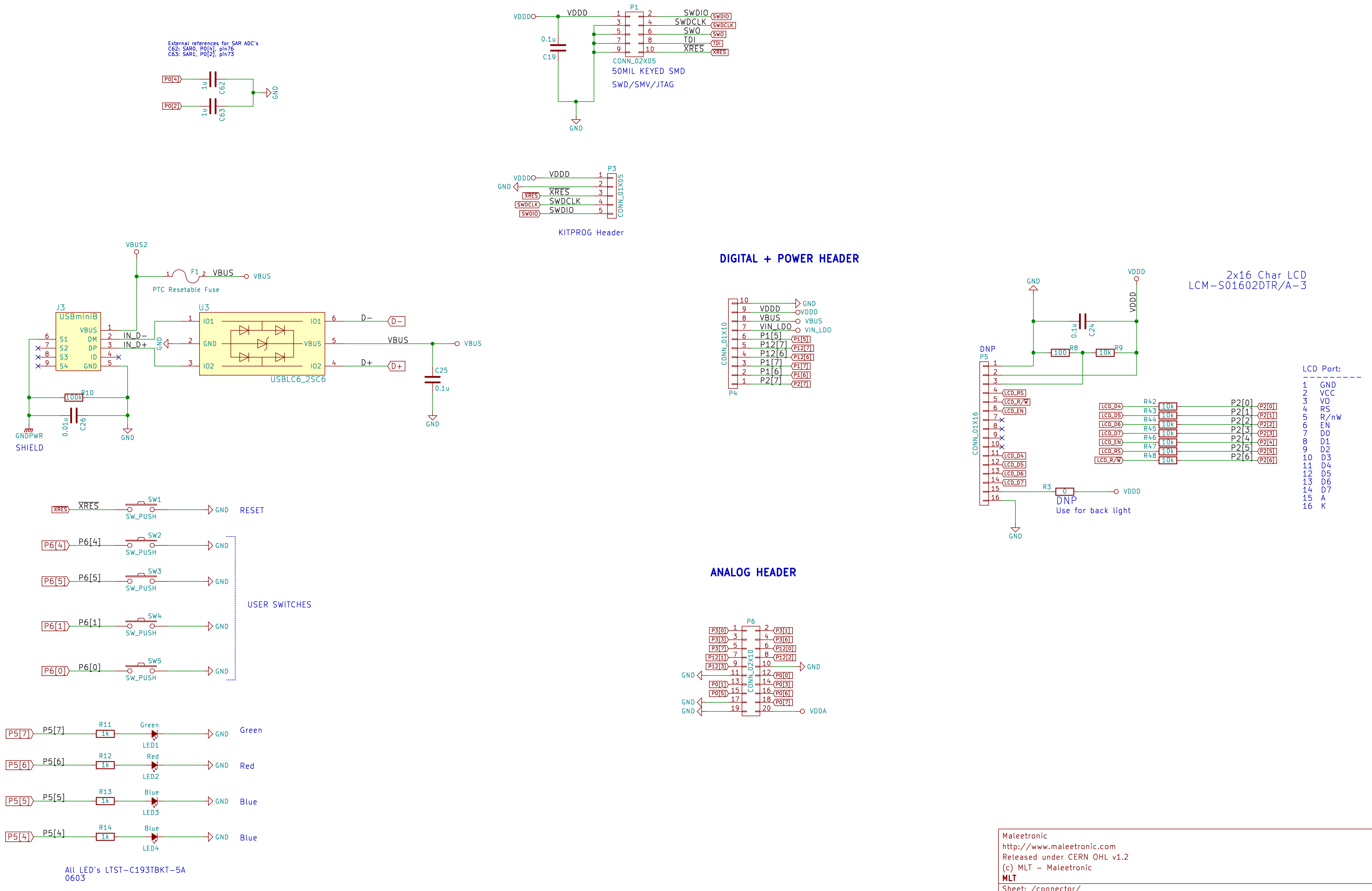
Title: Target PSoC 5LP LP096 TQFP

Size: A3	Date: 2016-09-06	Rev: 1
KiCad E.D.A. kicad 4.0.2-stable		Id: 2/7



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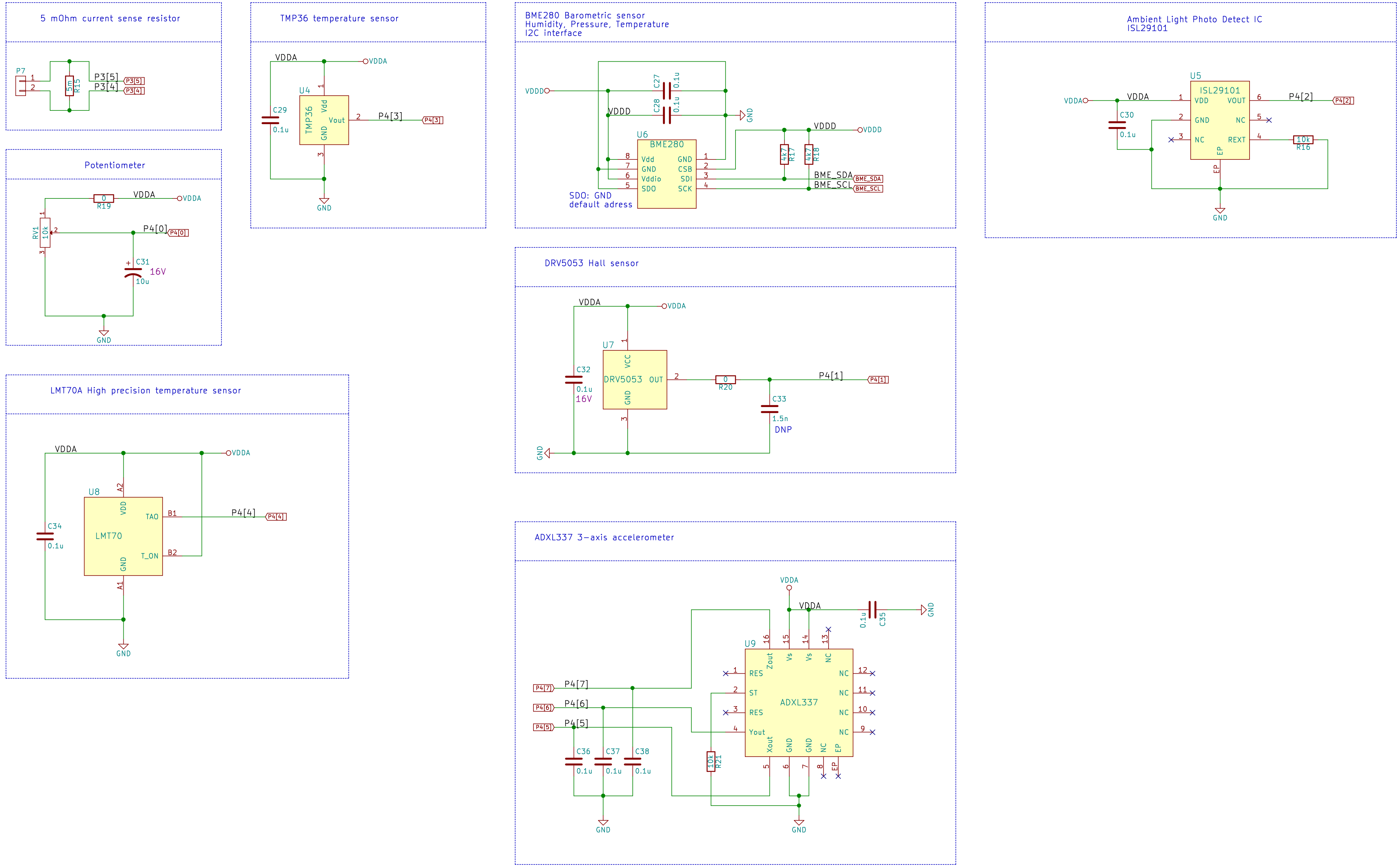
Sheet: /connector/
File: connector.sch

Title: Connector and Interfaces

Size: A3 | Date: 2016−09−06 | **Rev: 1**
KiCad E.D.A. kicad 4.0.2−stable | Id: 3/7



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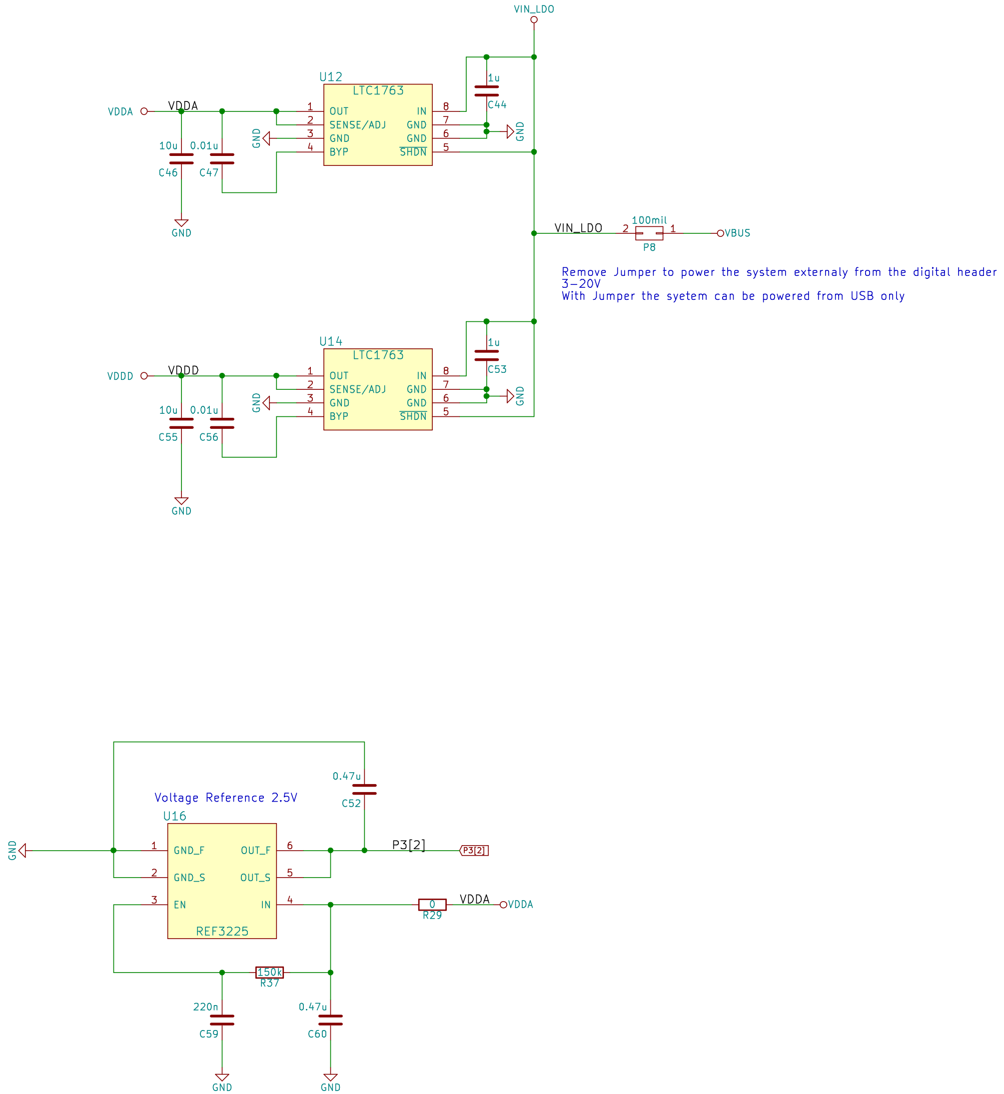
Sheet: /Sensors/
File: Sensors.sch

Title: Onboard Sensors

Size: A3 Date: 2016-09-06 **Rev: 1**
KiCad E.D.A. kicad 4.0.2-stable Id: 4/7



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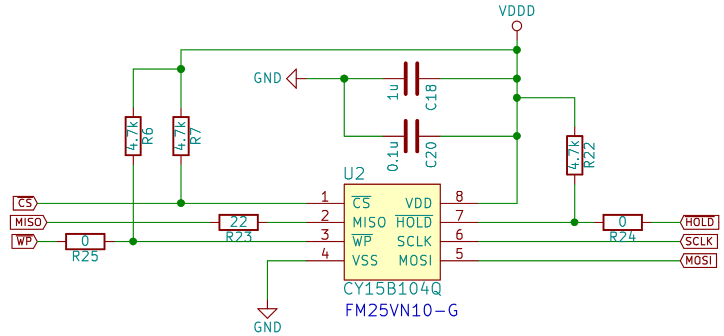
Sheet: /Power/
File: Power.sch

Title: Power Supply Network

Size: A3	Date: 2016-09-06	Rev: 1
KiCad E.D.A. kicad 4.0.2-stable		Id: 5/7



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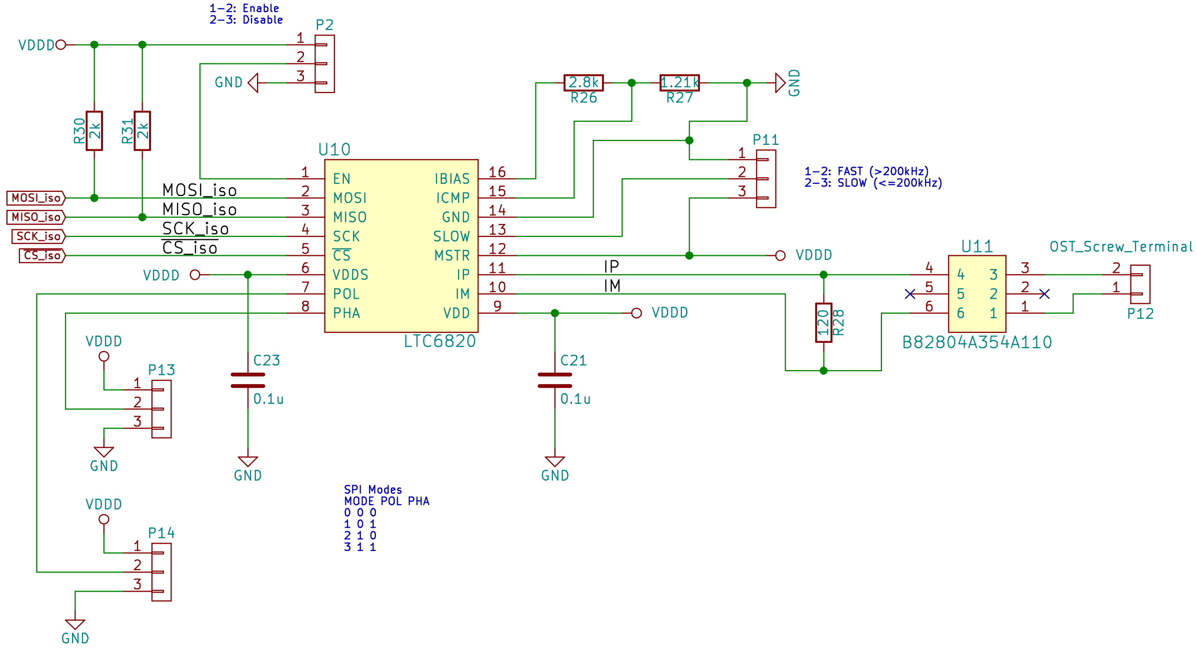
Sheet: /FRAM/ File: FRAM.sch		
Title: FRAM		
Size: A4	Date: 2016-09-06	**Rev: 1**
KiCad E.D.A. kicad 4.0.2-stable		Id: 6/7



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Sheet: /isoSPI/
File: isoSPI.sch

Title: iso SPI

Size: A4	Date: 2016-09-06	**Rev: 1**
KiCad E.D.A. kicad 4.0.2-stable		Id: 7/7

CERN Open Hardware Licence v1.2

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The following documents must be distributed together with the hardware design documentation:

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- This Guide
- Text files (plain ASCII file), where information can be added to but not removed from, listing:
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