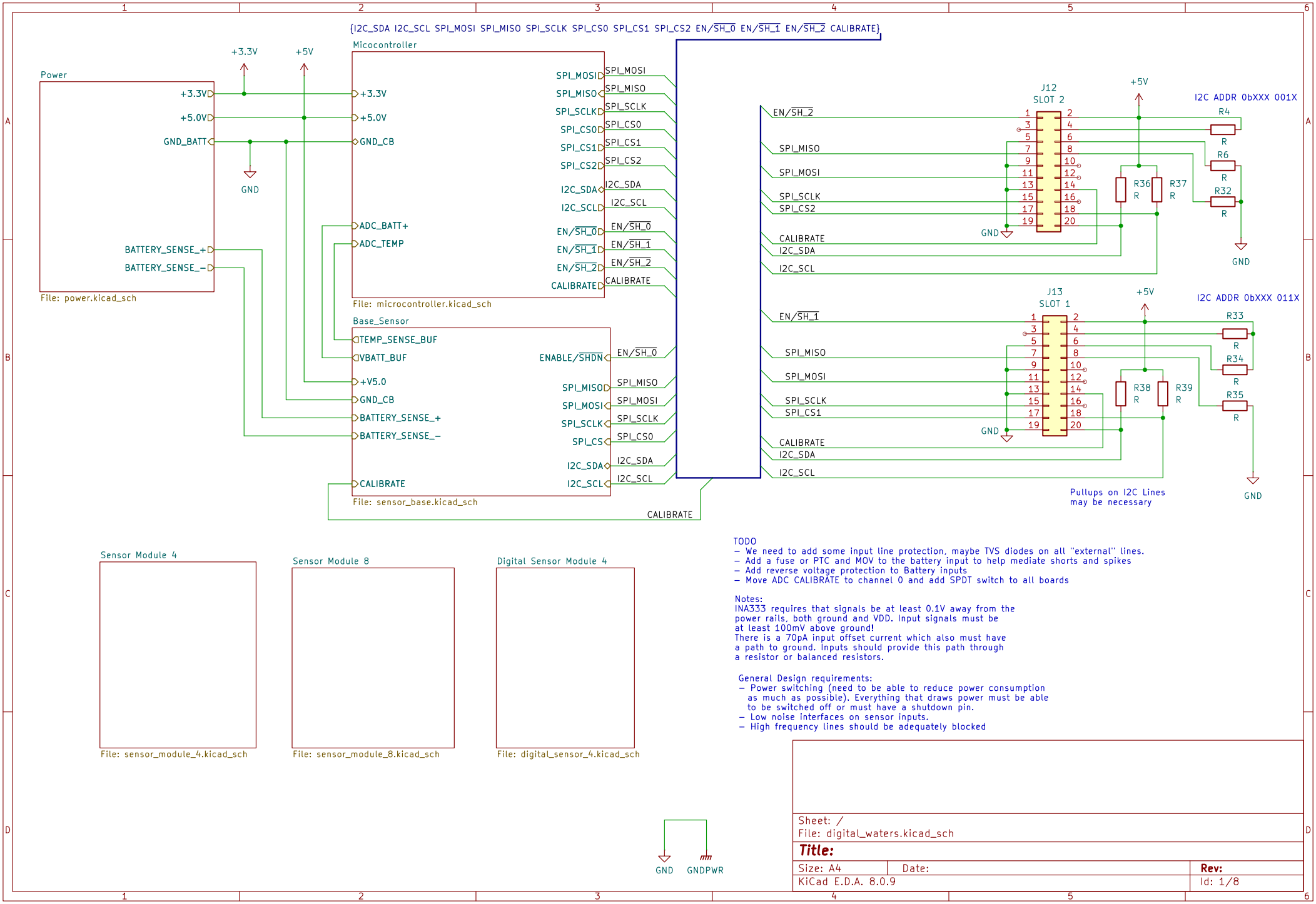

{I2C_SDA I2C_SCL SPI_MOSI SPI_MISO SPI_SCLK SPI_CS0 SPI_CS1 SPI_CS2 EN/SH_0 EN/SH_1 EN/SH_2 CALIBRATE}
Power
+3.3V
+5.0V
GND_BATT
GND
BATTERY_SENSE_+
BATTERY_SENSE_−
File: power.kicad_sch
Micocontroller
+3.3V
+5.0V
GND_CB
ADC_BATT+
ADC_TEMP
SPI_MOSI
SPI_MISO
SPI_SCLK
SPI_CS0
SPI_CS1
SPI_CS2
I2C_SDA
I2C_SCL
EN/SH_0
EN/SH_1
EN/SH_2
CALIBRATE
File: microcontroller.kicad_sch
Base_Sensor
TEMP_SENSE_BUF
VBATT_BUF
+V5.0
GND_CB
BATTERY_SENSE_+
BATTERY_SENSE_−
CALIBRATE
ENABLE/SHDN
SPI_MISO
SPI_MOSI
SPI_SCLK
SPI_CS0
I2C_SDA
I2C_SCL
File: sensor_base.kicad_sch
CALIBRATE
J12
SLOT 2
I2C ADDR 0bXXX 001X
R4
R6
R32
R36
R37
J13
SLOT 1
I2C ADDR 0bXXX 011X
R33
R34
R35
R38
R39
Pullups on I2C Lines
may be necessary
Sensor Module 4
File: sensor_module_4.kicad_sch
Sensor Module 8
File: sensor_module_8.kicad_sch
Digital Sensor Module 4
File: digital_sensor_4.kicad_sch
TODO
– We need to add some input line protection, maybe TVS diodes on all "external" lines.
– Add a fuse or PTC and MOV to the battery input to help mediate shorts and spikes
– Add reverse voltage protection to Battery inputs
– Move ADC CALIBRATE to channel 0 and add SPDT switch to all boards
Notes:
INA333 requires that signals be at least 0.1V away from the
power rails, both ground and VDD. Input signals must be
at least 100mV above ground!
There is a 70pA input offset current which also must have
a path to ground. Inputs should provide this path through
a resistor or balanced resistors.
General Design requirements:
– Power switching (need to be able to reduce power consumption
as much as possible). Everything that draws power must be able
to be switched off or must have a shutdown pin.
– Low noise interfaces on sensor inputs.
– High frequency lines should be adequately blocked
GND
GNDPWR
Sheet: /
File: digital_waters.kicad_sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. 8.0.9
Id: 1/8

The 5V power rail is supplied by a battery bank. We need to have some more power conditioning in order to make sure that we aren't coupling too much noise into the ADC circuits. To this end, we may want to use an LDO to provide a lower voltage rail to the OP-amp circuits, or use a higher voltage battery and use the LDO to provide a "clean" 5.0V rail.

Place-holder for a 3.3V supply. Might not need this since the CPU modules may have built-in 5V-3.3V regulators. Should be SMPS regulator, not linear.

Battery Pack

BT1
Battery

J7
Conn_01x02_Socket

J6

F1
Polyfuse

+5.0V

U15
TVS0500DRV
Det & Drv

GNDPWR

Transient suppression

Battery Decoupling

C10
C

C11
C

U29
LM1084-3.3
VI
VO
GND

C36
C

C37
C

+3.3V

R5
0

R_shunt_batt
0.1 Ohm 0.1% / 1Amp

Kelvin Junction if possible

R31
0

C33
100u

C9
10u

BATTERY_SENSE_+

BATTERY_SENSE_-

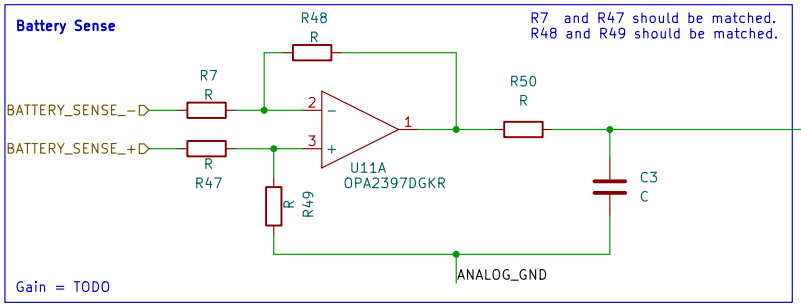
Sense Filter

GND_BATTD

Sheet: /Power/		
File: power.kicad_sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. 8.0.9		Id: 2/8

Battery Sense

R7 and R47 should be matched.
R48 and R49 should be matched.

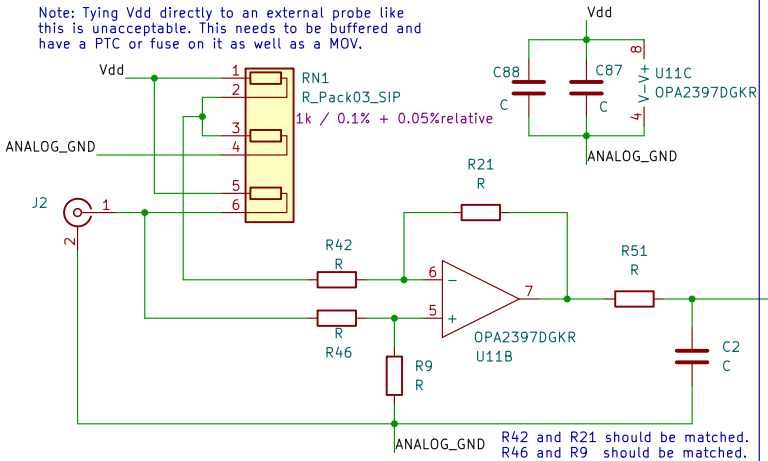


Gain = TODO

Ext Temperature Sense
PT-100 Probe (960-1156Ohm)

Note that this circuit has a 5mA draw when enabled.
It would be better to add a current limiting
resistor to the top (Vdd) node and add some gain.

Note: Tying Vdd directly to an external probe like
this is unacceptable. This needs to be buffered and
have a PTC or fuse on it as well as a MOV.



R42 and R21 should be matched.
R46 and R9 should be matched.

Gain = TODO

For RPi CPU, solder 2 to 3.
For CPU with built-in ADC, solder 1 to 2

VBATT_BUF

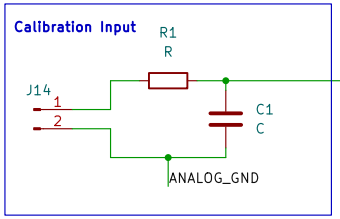
JP1

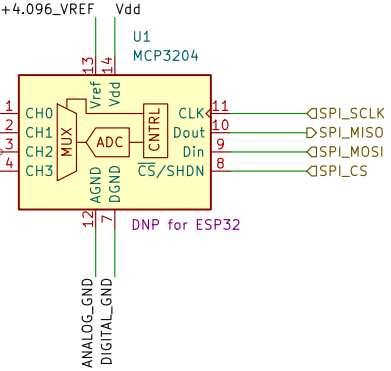
TEMP_SENSE_BUF

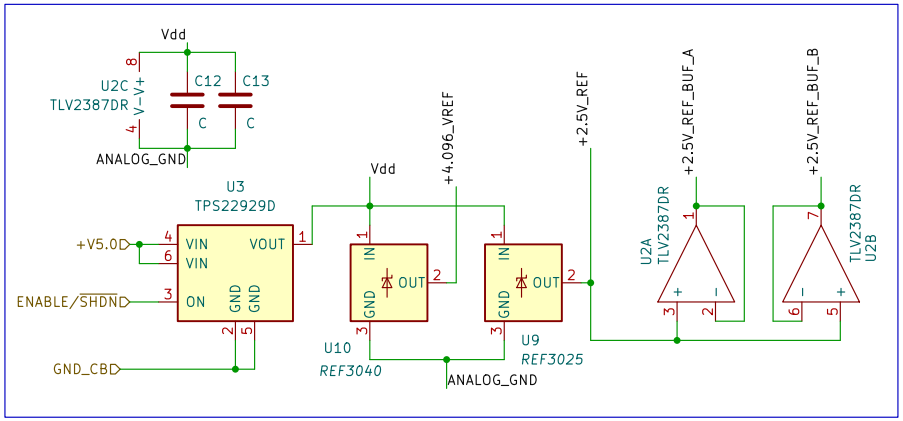
JP2

For RPi CPU, solder 2 to 3.
For CPU with built-in ADC, solder 1 to 2

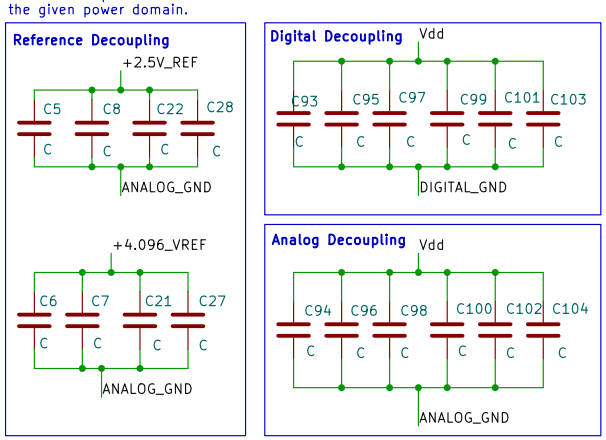
Calibration Input





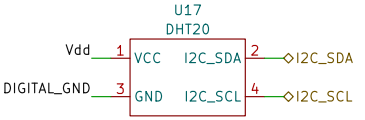


Decoupling Capacitors are connected
as close as possible to each IC of
the given power domain.



Internal Temp / Humidity (DTH 20)

I2C Addr 0x38



Base Sensor Circuit
This sensor board is included in the base unit. It includes built-in
temperature probe, battery Coulomb counting, leak detector, and TBD.

Sheet: /Base_Sensor/
File: sensor_base.kicad_sch

Title:

Size: A4	Date:	**Rev:**
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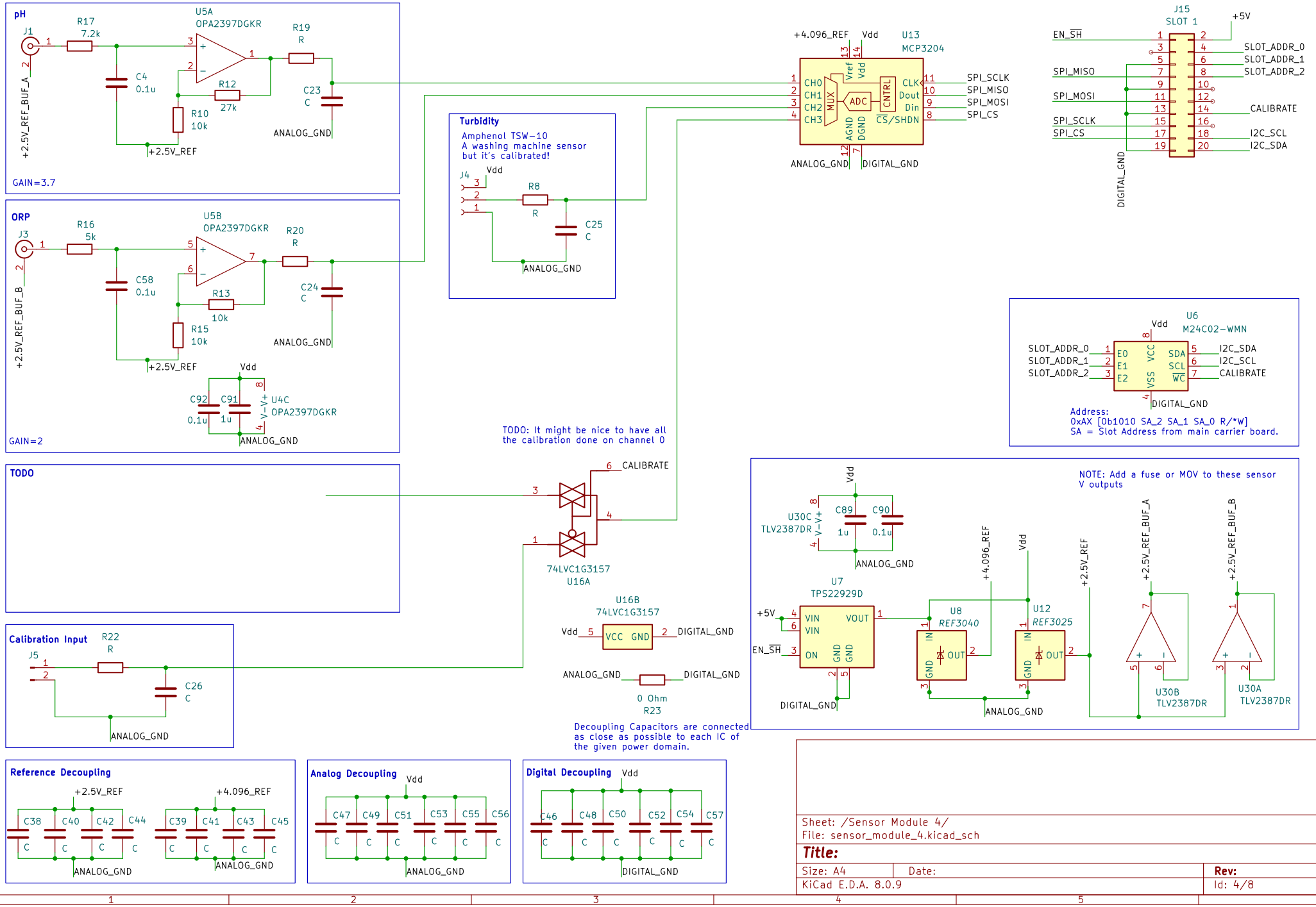
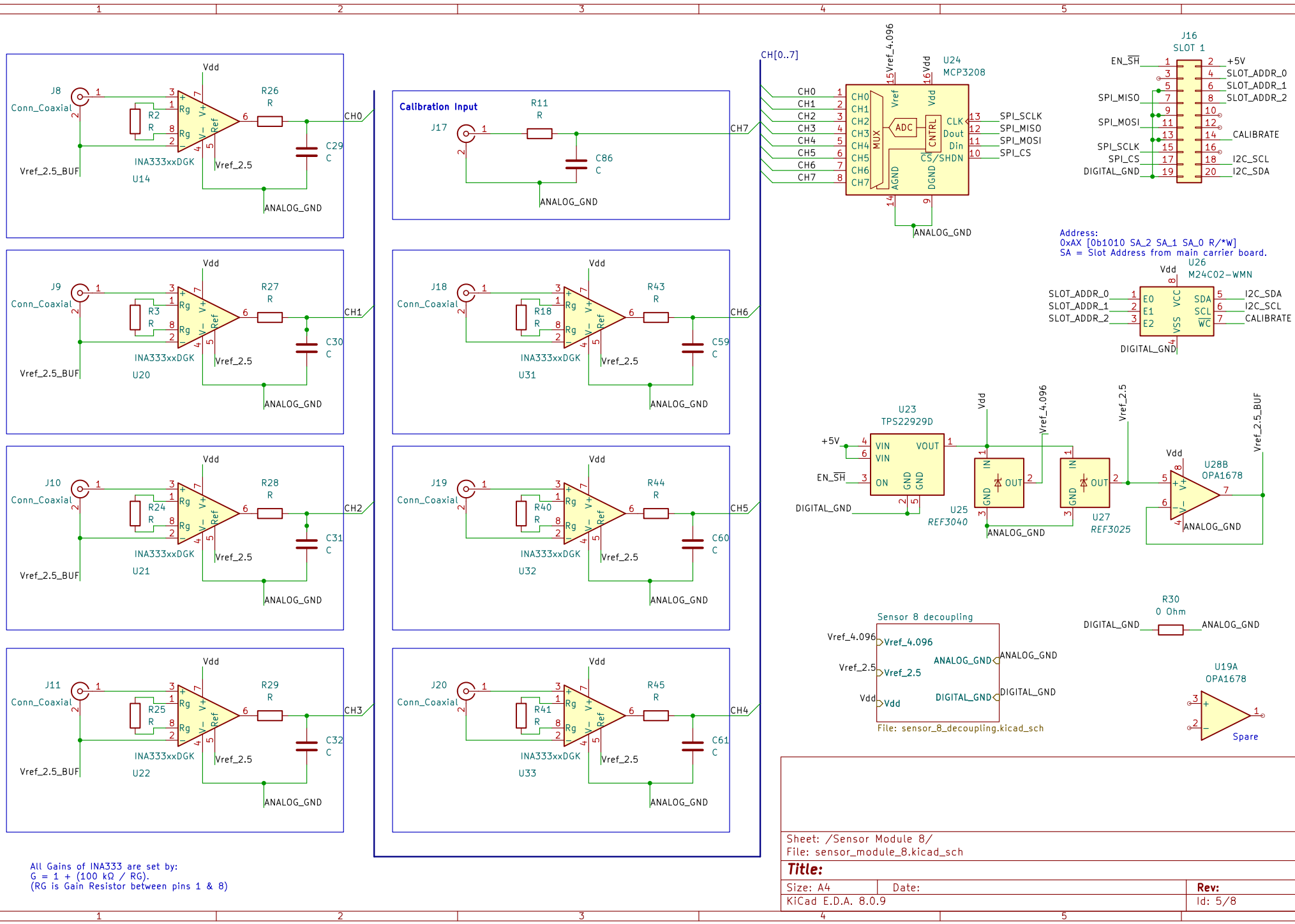

pH
J1
R17
7.2k
U5A
OPA2397DGKR
R19
R
C4
0.1u
R12
27k
C23
C
R10
10k
+2.5V_REF_BUF_A
+2.5V_REF
ANALOG_GND
GAIN=3.7
ORP
J3
R16
5k
U5B
OPA2397DGKR
R20
R
C58
0.1u
R13
10k
C24
C
R15
10k
+2.5V_REF_BUF_B
+2.5V_REF
ANALOG_GND
Vdd
C92
C91
0.1u
1u
U4C
OPA2397DGKR
GAIN=2
Turbidity
Amphenol TSW-10
A washing machine sensor
but it's calibrated!
J4
Vdd
R8
R
C25
C
ANALOG_GND
+4.096_REF
Vdd
U13
MCP3204
CH0
CH1
CH2
CH3
MUX
ADC
CNTRL
Vref
Vdd
AGND
DGND
CLK
Dout
Din
CS/SHDN
SPI_SCLK
SPI_MISO
SPI_MOSI
SPI_CS
ANALOG_GND
DIGITAL_GND
J15
SLOT 1
+5V
EN_SH
SLOT_ADDR_0
SLOT_ADDR_1
SLOT_ADDR_2
SPI_MISO
SPI_MOSI
SPI_SCLK
SPI_CS
CALIBRATE
I2C_SCL
I2C_SDA
DIGITAL_GND
U6
M24C02-WMN
Vdd
E0
E1
E2
VSS
VCC
SDA
SCL
WC
SLOT_ADDR_0
SLOT_ADDR_1
SLOT_ADDR_2
I2C_SDA
I2C_SCL
CALIBRATE
DIGITAL_GND
Address:
0xAX [0b1010 SA_2 SA_1 SA_0 R/*W]
SA = Slot Address from main carrier board.
TODO
TODO: It might be nice to have all
the calibration done on channel 0
CALIBRATE
74LVC1G3157
U16A
U16B
74LVC1G3157
Vdd
VCC
GND
DIGITAL_GND
ANALOG_GND
0 Ohm
R23
Calibration Input
J5
R22
R
C26
C
ANALOG_GND
Decoupling Capacitors are connected
as close as possible to each IC of
the given power domain.
NOTE: Add a fuse or MOV to these sensor
V outputs
U30C
TLV2387DR
V-
V+
C89
C90
1u
0.1u
ANALOG_GND
U7
TPS22929D
+5V
VIN
VOUT
EN_SH
ON
GND
DIGITAL_GND
U8
REF3040
U12
REF3025
+4.096_REF
Vdd
+2.5V_REF
+2.5V_REF_BUF_A
+2.5V_REF_BUF_B
U30B
TLV2387DR
U30A
TLV2387DR
Reference Decoupling
+2.5V_REF
+4.096_REF
C38
C40
C42
C44
C39
C41
C43
C45
C
ANALOG_GND
Analog Decoupling
Vdd
C47
C49
C51
C53
C55
C56
Digital Decoupling
Vdd
C46
C48
C50
C52
C54
C57
DIGITAL_GND
Sheet: /Sensor Module 4/
File: sensor_module_4.kicad_sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. 8.0.9
Id: 4/8


J8
Conn_Coaxial
R2
R
R26
R
C29
C
Vdd
Vref_2.5_BUF
INA333xxDGK
U14
Vref_2.5
ANALOG_GND
CH0
J9
R3
R27
C30
U20
CH1
J10
R24
R28
C31
U21
CH2
J11
R25
R29
C32
U22
CH3
Calibration Input
J17
R11
C86
CH7
J18
R18
R43
C59
U31
CH6
J19
R40
R44
C60
U32
CH5
J20
R41
R45
C61
U33
CH4
CH[0..7]
U24
MCP3208
Vref_4.096
Vdd
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
MUX
ADC
CNTRL
AGND
DGND
Vref
CLK
Dout
Din
CS/SHDN
SPI_SCLK
SPI_MISO
SPI_MOSI
SPI_CS
J16
SLOT 1
EN_SH
+5V
SLOT_ADDR_0
SLOT_ADDR_1
SLOT_ADDR_2
SPI_MISO
SPI_MOSI
CALIBRATE
SPI_SCLK
SPI_CS
I2C_SCL
I2C_SDA
DIGITAL_GND
Address:
0xAX [0b1010 SA_2 SA_1 SA_0 R/*W]
SA = Slot Address from main carrier board.
U26
M24C02-WMN
E0
E1
E2
VCC
VSS
SDA
SCL
WC
U23
TPS22929D
VIN
VOUT
ON
GND
U25
REF3040
U27
REF3025
U28B
OPA1678
Vref_2.5_BUF
Sensor 8 decoupling
File: sensor_8_decoupling.kicad_sch
R30
0 Ohm
U19A
OPA1678
Spare
All Gains of INA333 are set by:
G = 1 + (100 kΩ / RG).
(RG is Gain Resistor between pins 1 & 8)
Sheet: /Sensor Module 8/
File: sensor_module_8.kicad_sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. 8.0.9
Id: 5/8

This is a placeholder for a CPU module.
Could be a Raspberry Pi or ESP32 or another microcontroller module with (TBD) GPIO lines, at least one SPI bus with (3) CS lines, and one I2C Bus.

◁ADC_BATT

◁ADC_TEMP

◇I2C_SDA
▷I2C_SCL

◁SPI_MISO
▷SPI_MOSI
▷SPI_SCLK
▷SPI_CS0
▷SPI_CS1
▷SPI_CS2

◁+5.0V
◁+3.3V
◇GND_CB

▷EN/$\overline{\text{SH\_0}}$
▷EN/$\overline{\text{SH\_1}}$
▷EN/$\overline{\text{SH\_2}}$

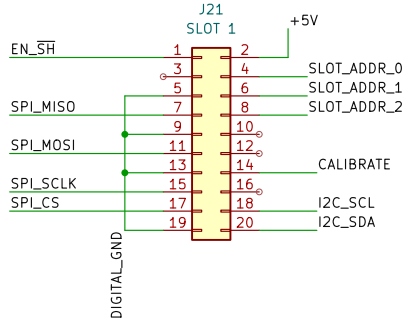
▷CALIBRATE

Sheet: /Micocontroller/
File: microcontroller.kicad_sch

Title:

Size: A4	Date:	**Rev:**
KiCad E.D.A. 8.0.9		Id: 6/8

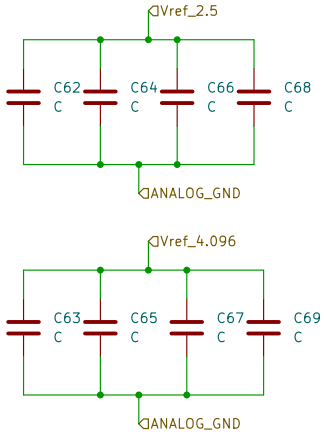
Some sensors will need to come with their own digital breakout boards (DO, CO2, EC, etc.) To support these, this board provides a common interface to the CPU and signal conditioning to those units.



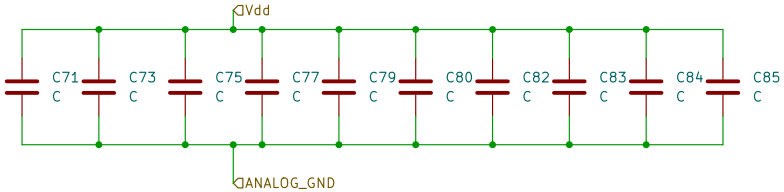
Sheet: /Digital Sensor Module 4/ File: digital_sensor_4.kicad_sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. 8.0.9		Id: 7/8

Decoupling Capacitors are connected as close as possible to each IC of the given power domain.

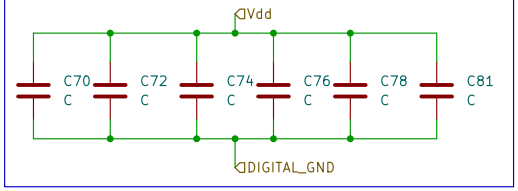
Reference Decoupling



Analog Decoupling



Digital Decoupling



Sheet: /Sensor Module 8/Sensor 8 decoupling/
File: sensor_8_decoupling.kicad_sch

Title:

Size: A4	Date:	**Rev:**
KiCad E.D.A. 8.0.9		Id: 8/8