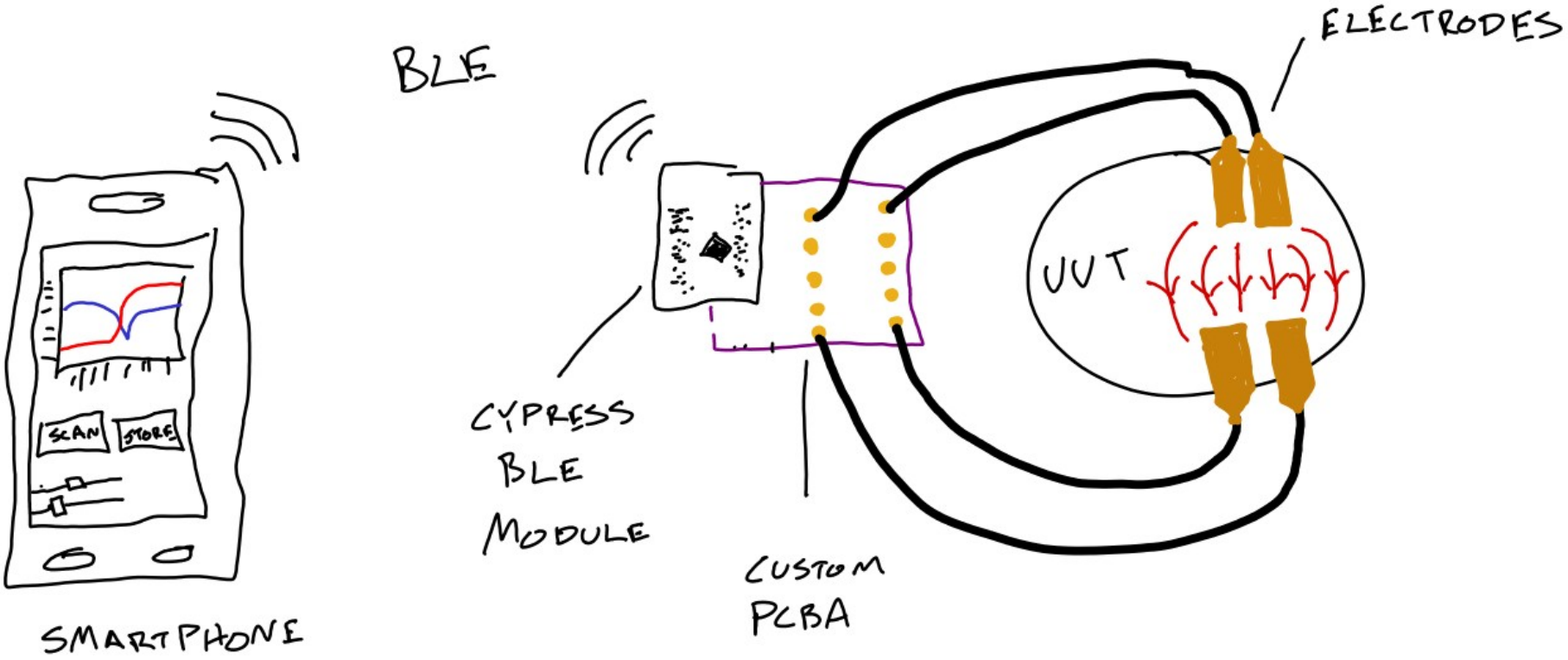
# Portable Impedance Tomography System

## Mid-Term Status

Ashton Johnson

CPE621 Advanced Embedded Systems
Electrical and Computer Engineering
The University of Alabama in Huntsville

# Scenario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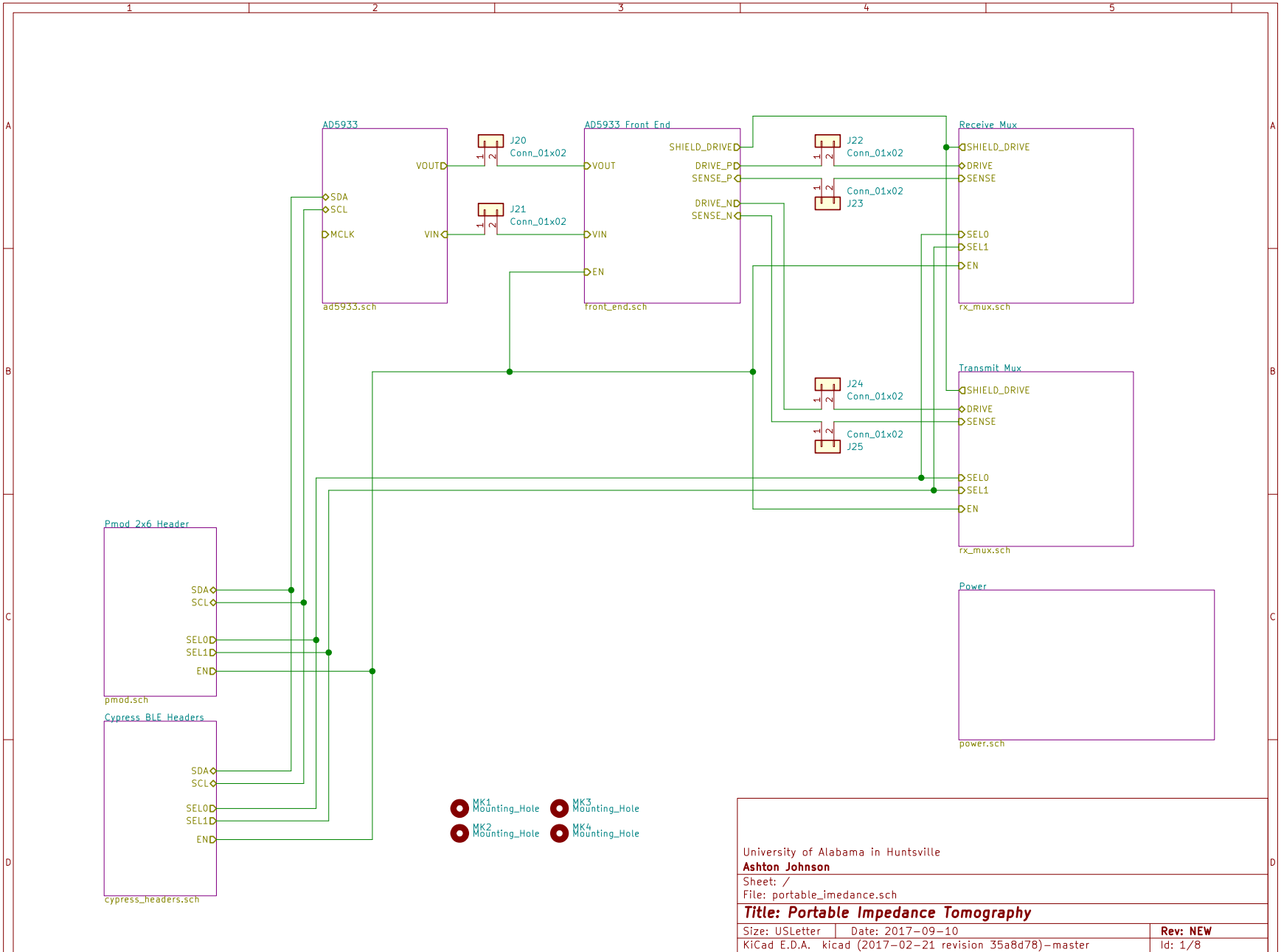
ELECTRODES
SCAN
STORE
UUT
CYPRESS
BLE
MODULE
CUSTOM
PCBA
SMARTPHONE


AD5933
VOUT
SDA
SCL
MCLK
VIN
ad5933.sch
J20
Conn_01x02
J21
Conn_01x02
AD5933 Front End
VOUT
VIN
EN
SHIELD_DRIVE
DRIVE_P
SENSE_P
DRIVE_N
SENSE_N
front_end.sch
J22
Conn_01x02
Conn_01x02
J23
Receive Mux
SHIELD_DRIVE
DRIVE
SENSE
SEL0
SEL1
EN
rx_mux.sch
J24
Conn_01x02
Conn_01x02
J25
Transmit Mux
SHIELD_DRIVE
DRIVE
SENSE
SEL0
SEL1
EN
rx_mux.sch
Pmod 2x6 Header
SDA
SCL
SEL0
SEL1
EN
pmod.sch
Cypress BLE Headers
SDA
SCL
SEL0
SEL1
EN
cypress_headers.sch
Power
power.sch
MK1
Mounting_Hole
MK2
Mounting_Hole
MK3
Mounting_Hole
MK4
Mounting_Hole
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Sheet: /
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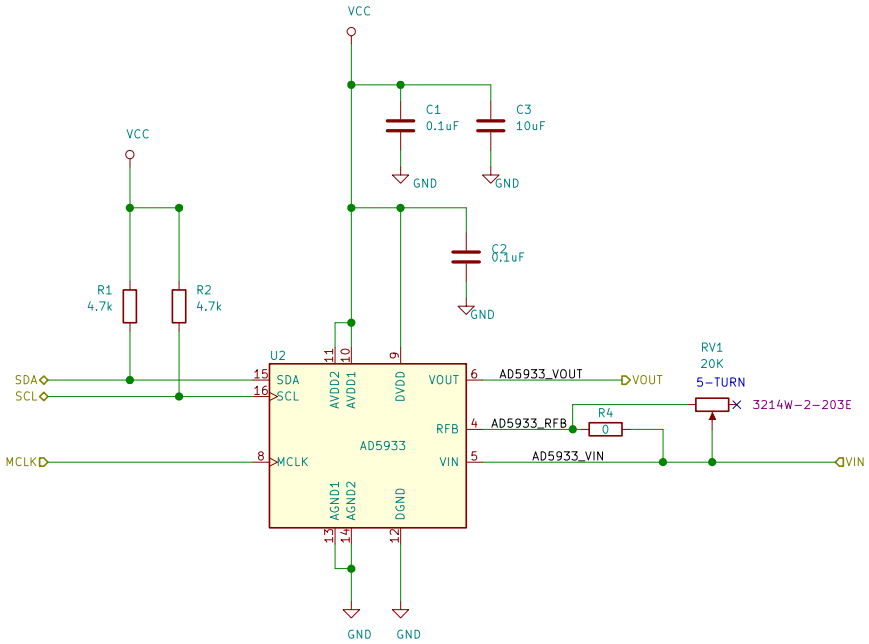
Title: Portable Impedance Tomography
Size: USLetter
Date: 2017-09-10
Rev: NEW
KiCad E.D.A. kicad (2017-02-21 revision 35a8d78)-master
Id: 1/8

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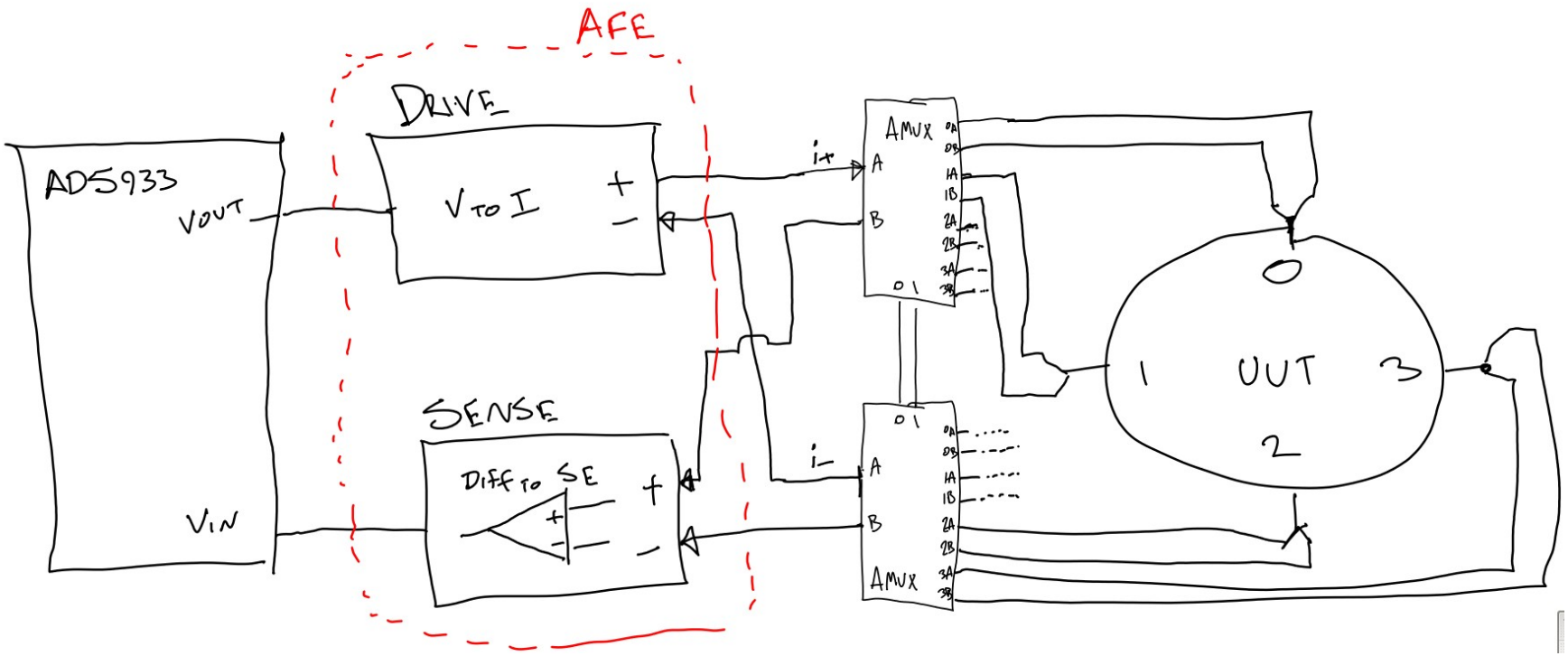
Sheet: /AD5933/

File: ad5933.sch

***Title: Portable Impedance Tomography***

| | | |
|---|---|---|
| Size: A4 | Date: 2017-09-10 | **Rev: NEW** |
| KiCad E.D.A. kicad (2017-02-21 revision 35a8d78)-master | | Id: 2/8 |

# Analog Section



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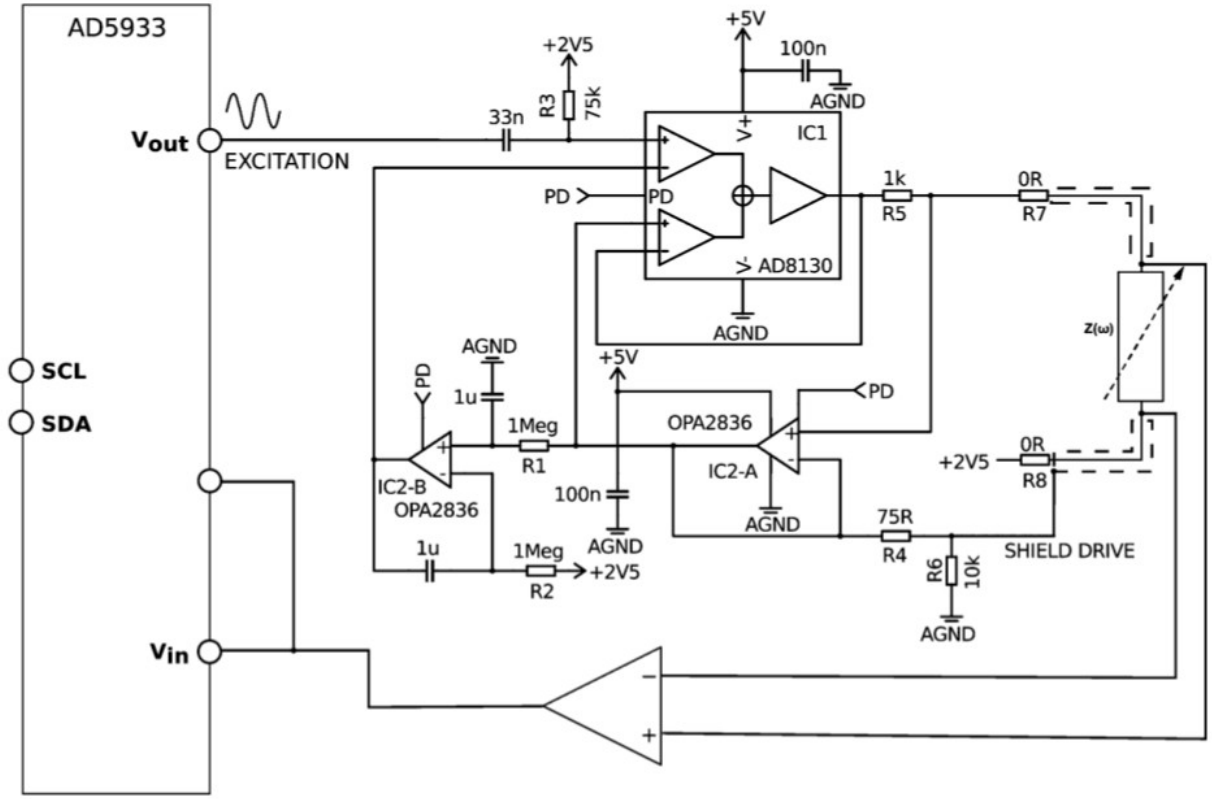
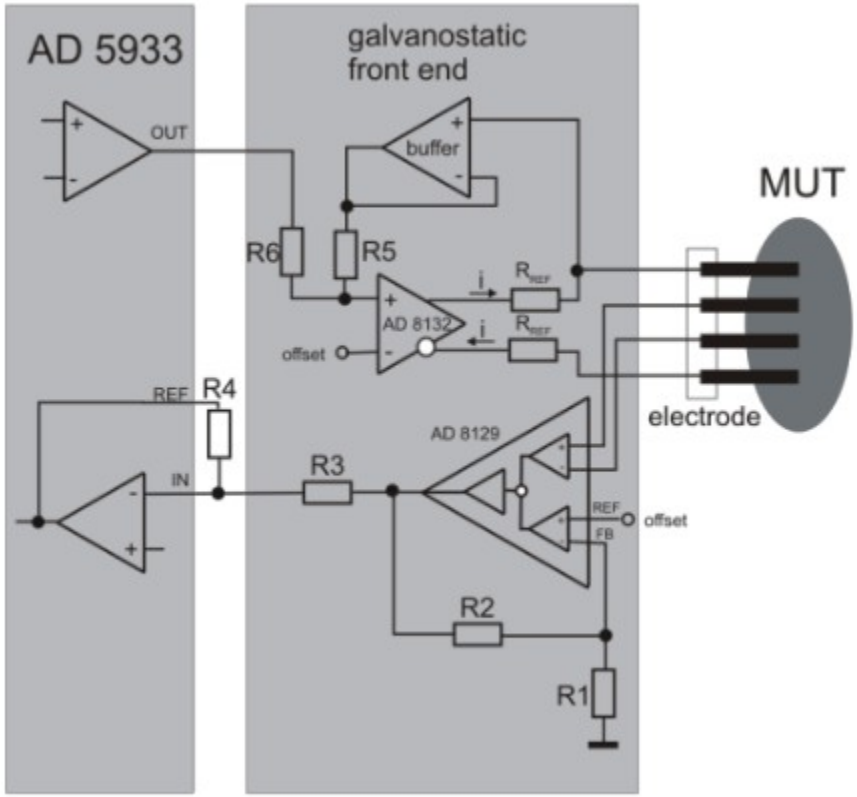


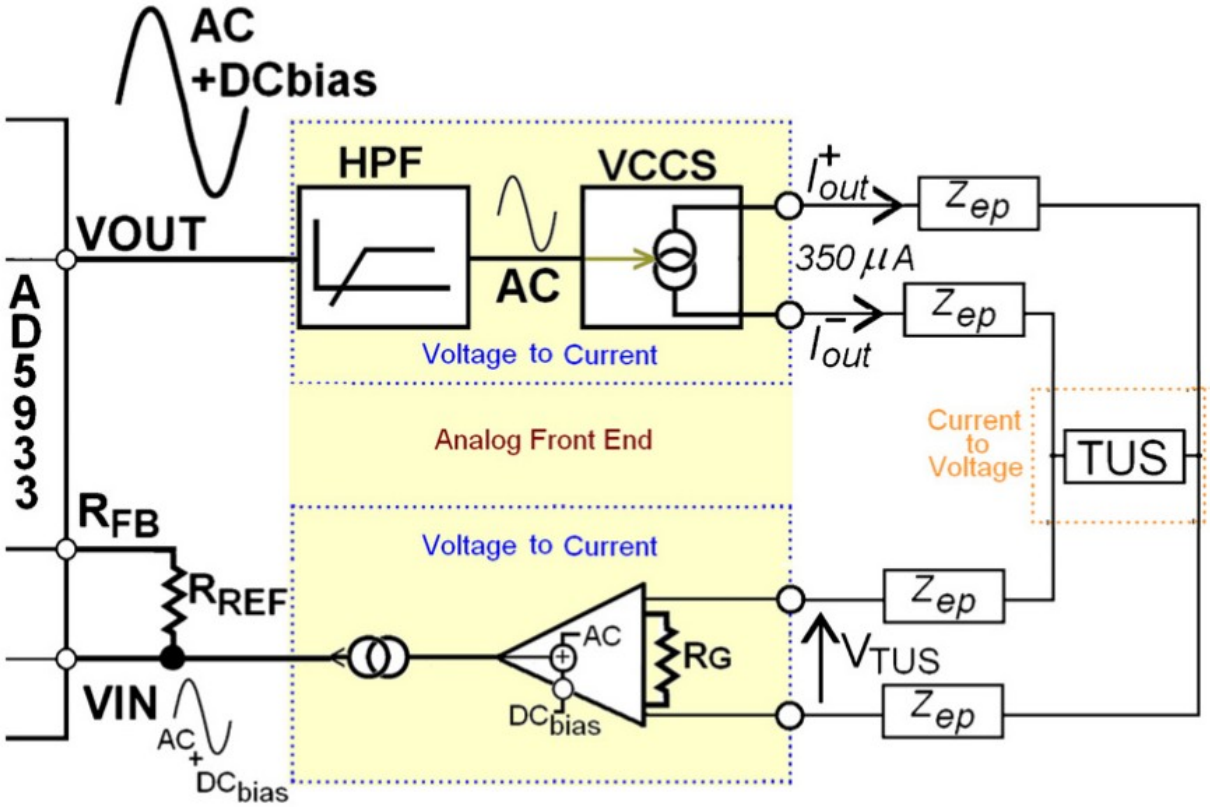

R. Harder, A. Diedrich, J. S. Whitfield, M. S. Buchowski, J. B. Pietsch, and F. J. Baudenbacher, “Smart Multi-Frequency Bioelectrical Impedance Spectrometer for BIA and BIVA Applications,” IEEE Transactions on Biomedical Circuits and Systems, vol. 10, no. 4, pp. 912–919, Aug. 2016.

# Analog Front End

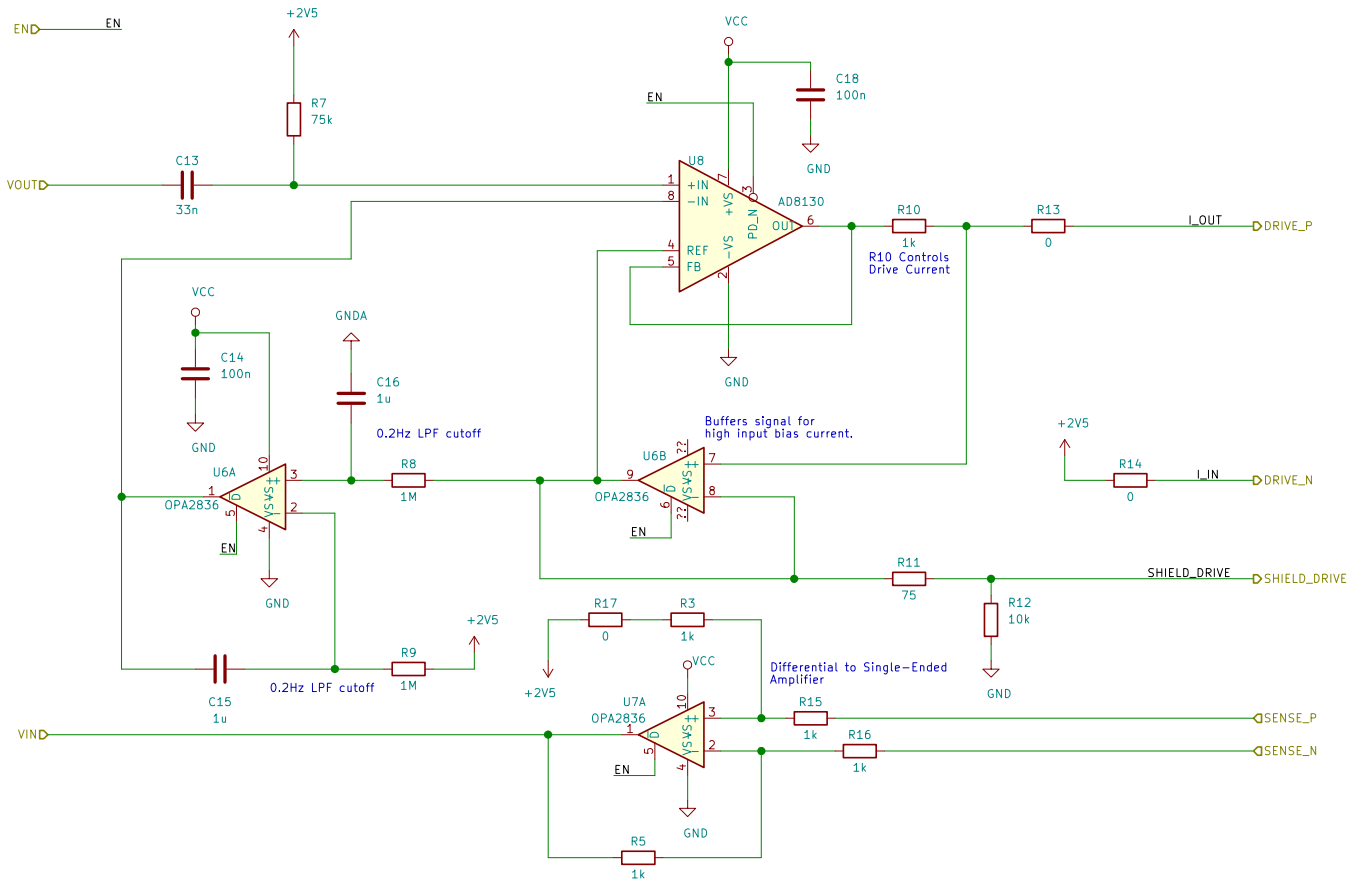



U. Pliquett and A. Barthel, “Interfacing the AD5933 for bio-impedance measurements with front ends providing galvanostatic or potentiostatic excitation,” J. Phys.: Conf. Ser., vol. 407, no. 1, p. 012019, 2012.

# Analog Front End




F. Seoane, J. Ferreira, J. J. Sanchéz, and R. Bragós, “An analog front-end enables electrical impedance spectroscopy system on-chip for biomedical applications,” Physiol. Meas., vol. 29, no. 6, p. S267, 2008.




Design Published in:

R. Harder, A. Diedrich, J. S. Whitfield, M. S. Buchowski, J. B. Pietsch, and F. J. Baudenbacher, "Smart Multi−Frequency Bioelectrical Impedance Spectrometer for BIA and BIVA Applications," IEEE Transactions on Biomedical Circuits and Systems, vol. 10, no. 4, pp. 912-919, Aug. 2016.

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Sheet: /AD5933 Front End/

File: front_end.sch

***Title: Portable Impedance Tomography***

| Size: A4 | Date: 2017−09−10 | **Rev: NEW** |
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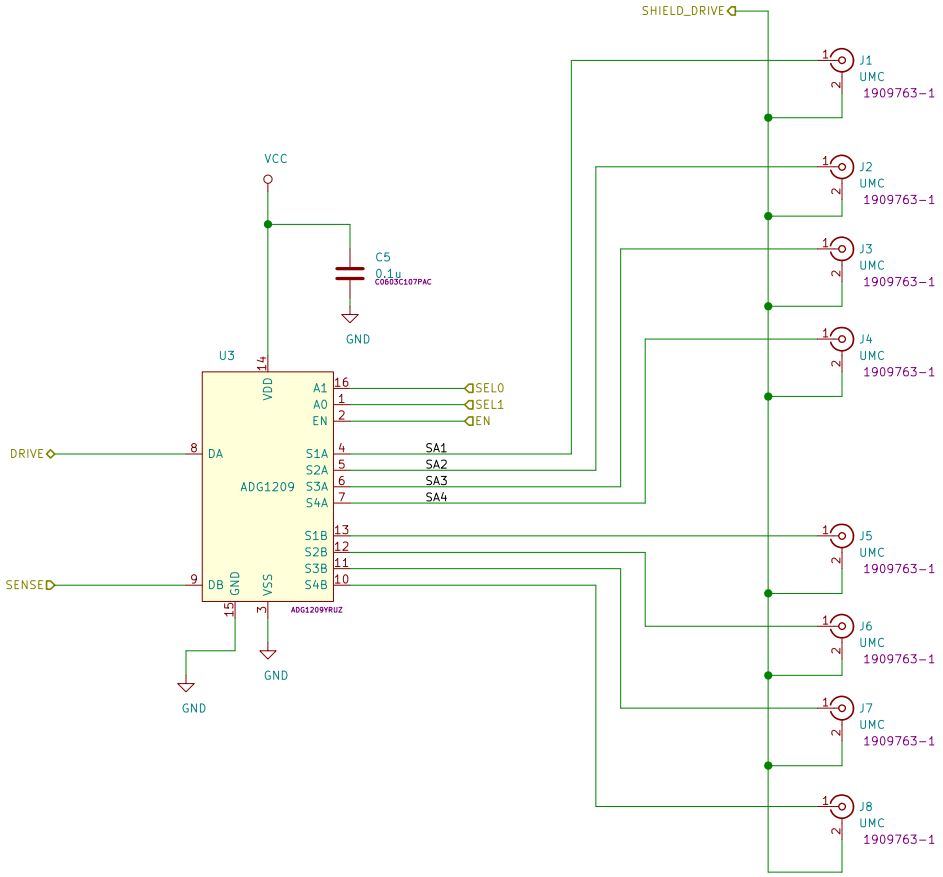


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Sheet: /Receive Mux/

File: rx_mux.sch

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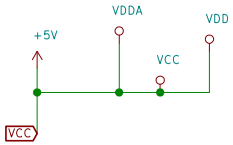
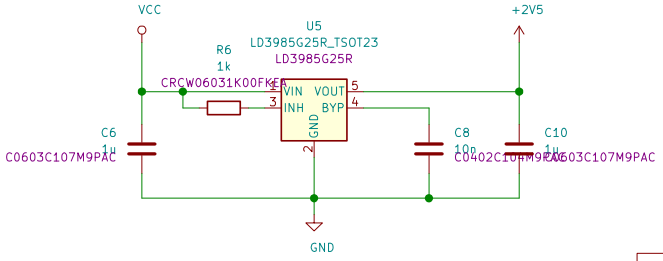
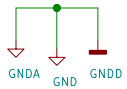



## +2.5V REGULATOR

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Sheet: /Power/
File: power.sch

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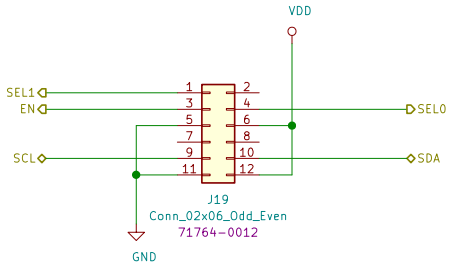


This interface is cabable of being mated to any 2x6 PMOD host, but is specifically compatible for the Digilent Zybo MIO PMOD JF connection.

Digilent PMOD Spec
https://reference.digilentinc.com/_media/reference/pmod/digilent-pmod-interface-specification.pdf

Zybo MIO PMOD JF Pinout (Table 16.1) :
https://reference.digilentinc.com/reference/programmable-logic/zybo-z7/reference-manual

Zynq MIO Signal Routing (Table 2-4):
https://www.xilinx.com/support/documentation/user_guides/ug585-Zynq-7000-TRM.pdf

| | | |
|---|---|---|
| Sheet: /Pmod 2x6 Header/<br>File: pmod.sch | | |
| ***Title:*** | | |
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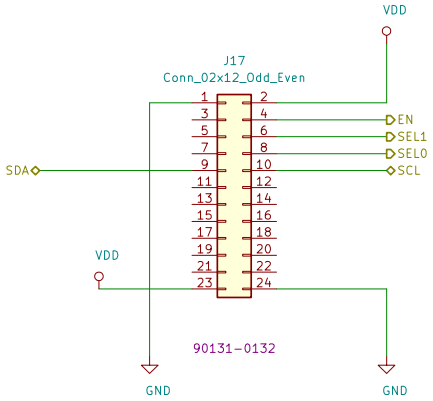



Cypress BLE Module Kit:
http://www.cypress.com/file/140711/download

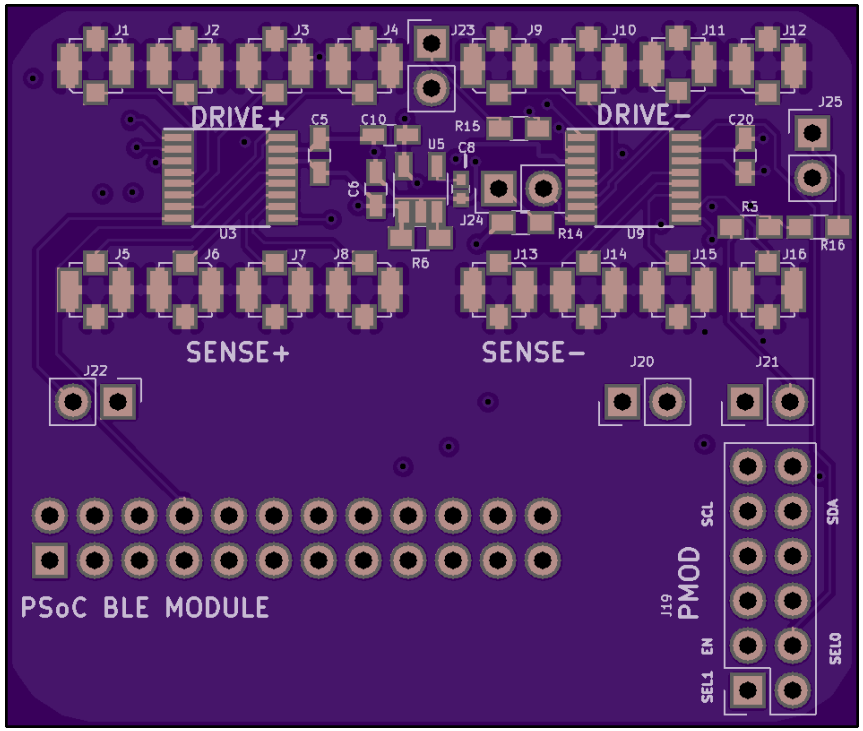
See Table 4 for pinout of CY8C4247LQI-BL483
http://www.cypress.com/file/137466/download

| | | |
|---|---|---|
| Sheet: /Cypress BLE Headers/<br>File: cypress_headers.sch | | |
| **Title:** | | |
| Size: A | Date: | **Rev:** |
| KiCad E.D.A. kicad (2017-02-21 revision 35a8d78)-master | | Id: 7/8 |

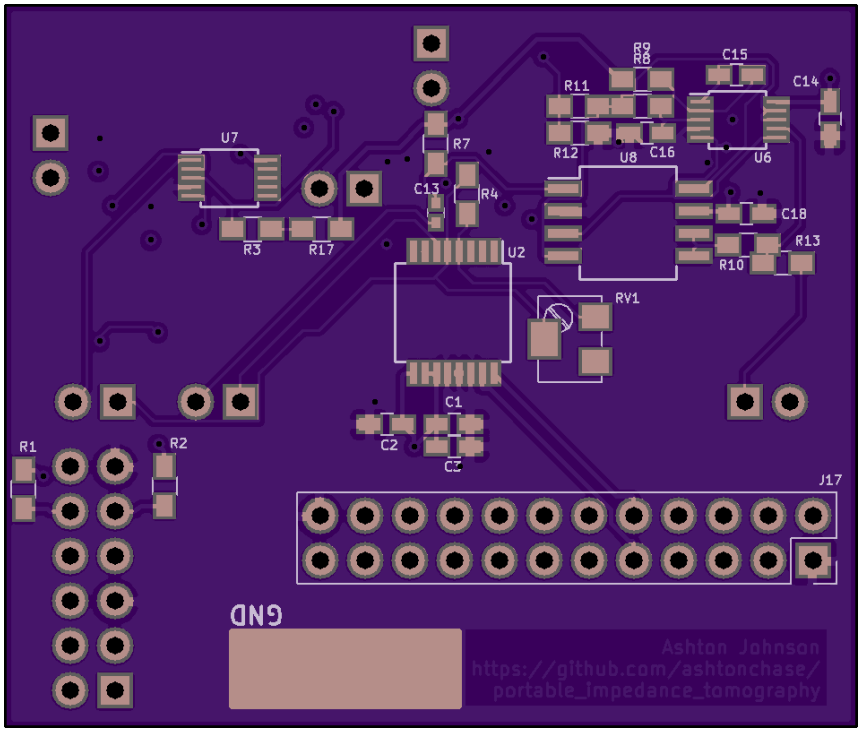
# PCBA OSH Park Order

$30.80 for 3

Top View

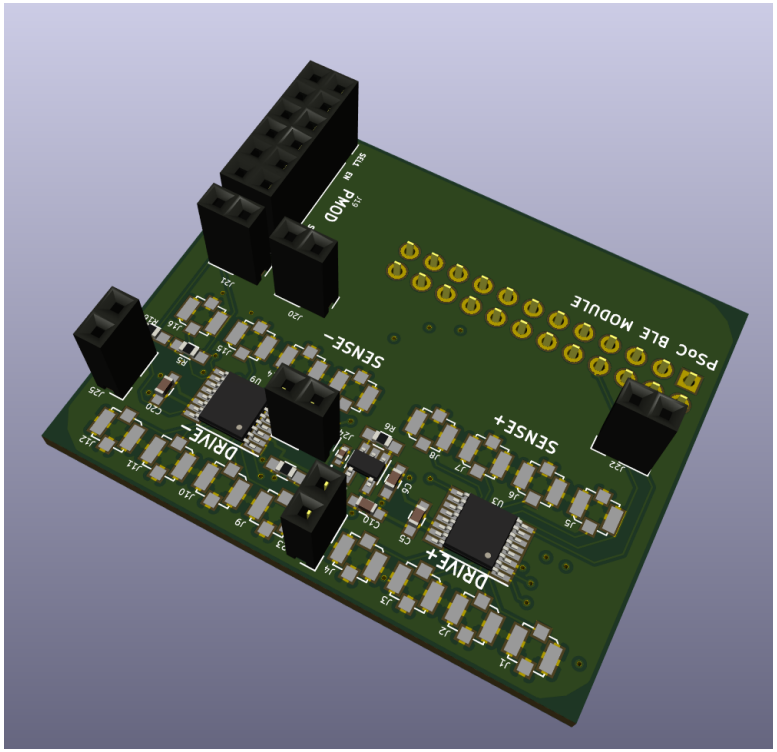



Bottom View

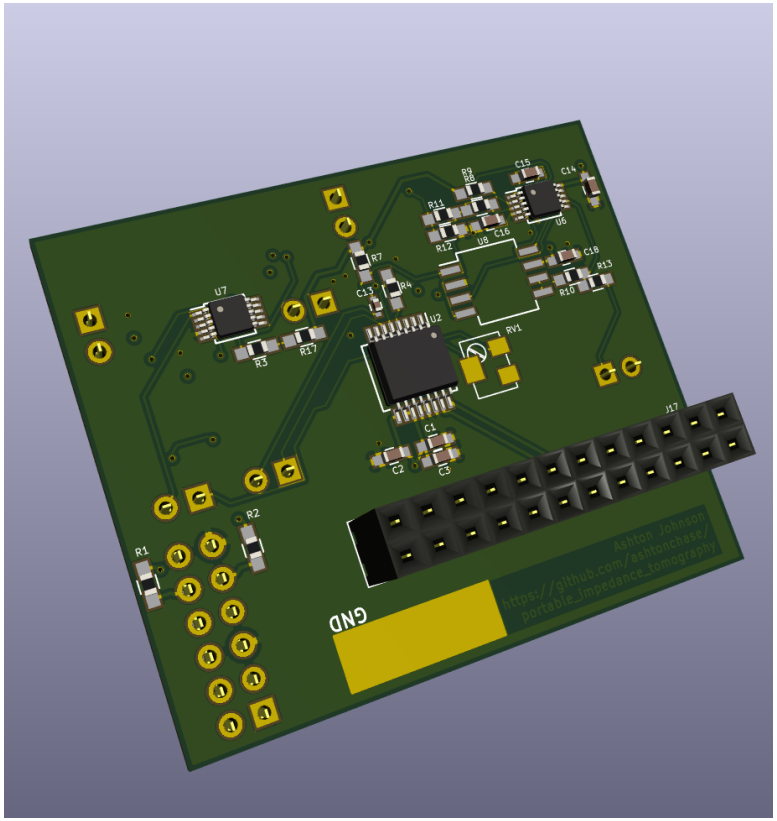


# PCBA 3D View

Top View




Bottom View



# Milestones

## Hardware

☑Platform Selection (19 SEP)

Cypress PsoC BLE Module

Digilent Zybo (Xilinx Zynq-7000 SoC)

☑Schematic Design & Layout Complete (26 SEP)

DRC Checks Competed

DFM Checks Completed

☐PCB Ordered (None Specified)(18 OCT)

☐PCB Assembly Complete (10 OCT) (13 NOV)

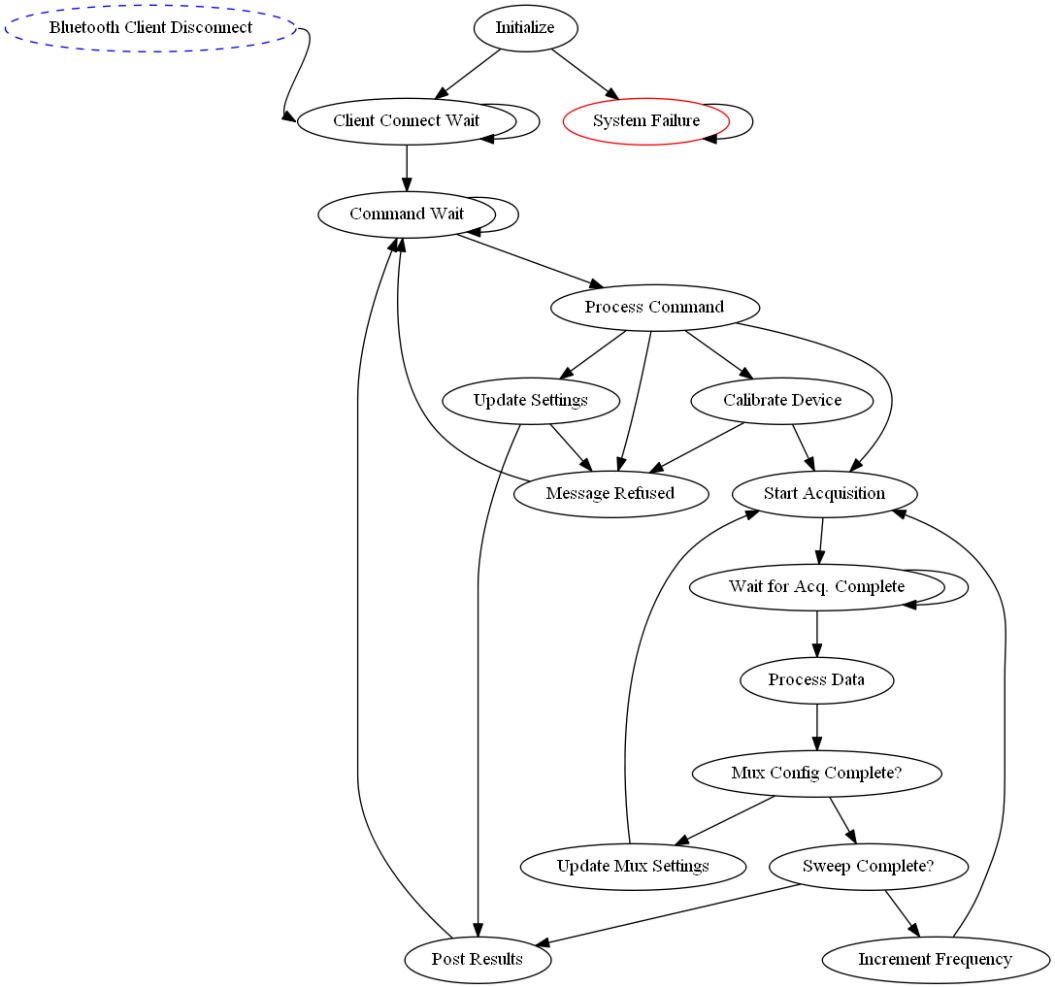
☐PCB Checkout Complete (24 OCT)(20 NOV)

# Milestones

## Software

- ☑ Driver Development
  - ☑ AD5933
  - ☑ Analog Mux
- ☐ Application State Machine (30 OCT)
- ☐ Device Targeted Code
  - ☐ BLE I/F (6 NOV)
  - ☐ UART Debug I/F (6 NOV)
- ☐ Android Application Code (20 NOV)

# Device System States



# Software Development

AD5933 Driver (ad5933/ad5933.h)

uint8_t ad5933_Init (ad5933_deviceConfig *config)
uint8_t ad5933_PerformFrequencySweep (ad5933_deviceConfig *config, uint32_t startFreq, uint32_t incrementFreq, uint16_t numOfIncrements, uint16_t *realArray, uint16_t *imagArray)

uint8_t ad5933_ConvertFreq (ad5933_deviceConfig *config, uint32_t desiredFreq, uint8_t *freqMsb, uint8_t *freqMid, uint8_t *freqLsb)

uint8_t ad5933_SetStartFreq (ad5933_deviceConfig *config, uint32_t desiredFreq)
uint8_t ad5933_SetIncrFreq (ad5933_deviceConfig *config, uint32_t desiredFreq)
uint8_t ad5933_SetIncrCount (ad5933_deviceConfig *config, uint16_t incrNum)
uint8_t ad5933_SetSettleTime (ad5933_deviceConfig *config, uint16_t cycles, uint8_t factor)
uint8_t ad5933_GetStatus (ad5933_deviceConfig *config, uint8_t *result)
uint8_t ad9533_WaitForValidTemp (ad5933_deviceConfig *config)
uint8_t ad9533_WaitForValidImpedance (ad5933_deviceConfig *config)
uint8_t ad9533_WaitForSweepComplete (ad5933_deviceConfig *config)
uint8_t ad5933_ReadRealResult (ad5933_deviceConfig *config, int16_t *real)
uint8_t ad5933_ReadImagResult (ad5933_deviceConfig *config, int16_t *imag)
uint8_t ad5933_InitWithStartFreq (ad5933_deviceConfig *config)
uint8_t ad5933_StartSweep (ad5933_deviceConfig *config)
uint8_t ad5933_IncrementFreq (ad5933_deviceConfig *config)
uint8_t ad5933_RepeatFreq (ad5933_deviceConfig *config)
uint8_t ad5933_MeasureTemp (ad5933_deviceConfig *config)
uint8_t ad5933_PowerDown (ad5933_deviceConfig *config)
uint8_t ad5933_Standby (ad5933_deviceConfig *config)
uint8_t ad5933_Stop (ad5933_deviceConfig *config)
uint8_t ad5933_SetPGAx1 (ad5933_deviceConfig *config)
uint8_t ad5933_SetPGAx5 (ad5933_deviceConfig *config)
uint8_t ad5933_SetVoutRange (ad5933_deviceConfig *config, uint8_t range)

# Software Development

## Analog Mux Driver (amux/hal/gpio_hal.h)

```
uint32_t    Amux_Init(const Gpio_deviceConfig *config, uint8_t selection)
uint32_t    Amux_SetTx(const Gpio_deviceConfig *config, uint8_t selection)
uint32_t    Amux_SetRx(const Gpio_deviceConfig *config, uint8_t selection)
```

## HAL Required Functions

## (amux/hal/gpio_hal.h)

```
uint32_t    Gpio_Init(const Gpio_deviceConfig *config);
uint32_t    Gpio_Write(const Gpio_ConfigType *config, uint8_t value, uint8_t mask)
```

## (ad5933/hal/iic_hal.h)

```
void        Iic_Init (const Iic_ConfigType *config)
uint8_t     Iic_RxByte (const Iic_ConfigType *config, const uint8_t addr, const uint8_t reg, uint8_t *rxValue)
uint8_t     Iic_TxByte (const Iic_ConfigType *config, const uint8_t addr, const uint8_t reg, const uint8_t txValue)
uint32_t    Gpio_Write(const Gpio_ConfigType *config, uint8_t value, uint8_t mask)
```

- Hal functions must implemented for each target