University of Calgary

HASP Preliminary Payload Specification and Integration Plan

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Payload Title: APOGEE (Atmospheric Phenomenon Observer Gamma/VLF Emissions Experiment)

Payload Class: Small

Payload ID: 04

Institution: University of Calgary

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Submit Date: April 24, 2015

***Disclaimer*:** All information in this document is to be confirmed in the final revision of the PSIP due June 26, 2015

I. Mechanical Specifications:

A. Payload total weight (not including payload plate): 1533 grams

Mechanical Components Masses

Component	**Manufacturer**	**Mass (g)**
Chassis Walls x 5 (0.25 in., 6061 aluminum alloy)	University of Calgary	950
Threaded Rods x 4 (0.250-20 http://www.bgmfg.com/rod_weight.htm)	B&G Manufacturing Company	95
Mounting plate/ceiling nuts (1/4"-20 Zinc Finish Grade 5 Finished Hex Nut, https://www.fastenal.com/products/details/0147964)	Fastenal	32

PCB Spacers (1/2"OD x 1"L x #14 Hole Nylon Round Spacer, https://www.fastenal.com/products/details/0145822)	Fastenal	41
GoPro HERO3 White Camera	GoPro Inc.	75
Antenna Plumb Bob	University of Calgary	10
	Subtotal	**1203**

Electrical Components Masses

Component	**Manufacturer**	**Mass (g)**
VLF Receiver PCB (main control board + ADCs)	University of Calgary	100
VLF Pre-amp	University of Calgary	20
Geiger Tubes x10 (LND 714 http://www.lndinc.com/products/318/)	LND Inc.	8
Geiger Counter PCB + Potting Compound	University of Calgary	100
VLF Antenna (50 cm of 22 AWG wire) (http://www.rfcafe.com/references/electrical/wire-cu.htm)	University of Calgary	2
Power Regulation Board	University of Calgary	100
	Total	**330**

B. Mechanical drawing: See appendix 1

C. Hazardous components: High voltage however all high voltage components and connectors will be covered with a potting compound.

D. Other relevant mechanical information:

Our VLF Antenna will consist of several wires and the pre-amplifier hung from the bottom of our payload in a 'Y' shape (See Appendix of Mechanical Drawings). A plumb bob is attached to the lower dipole wire to ensure the wire remains vertical. The total length of the antenna is short enough to preclude the possibility of any part of the antenna array from contacting the main HASP platform.

II. Power Specifications:

A. Measured current draw at 30 VDC: 30VDC @ 231 mA (estimated) (see appendix 2 for power diagram)

VLF receiver (main control board, ADCs, Pre-amp) (estimated from ABOVE boards)	12V @ 0.35A ± 0.05A = 4.2W ± 0.6W
GoPro Hero 3 White Camera (720p 60 fps)[1]	3.7V @ 0.467A = 1.728W (can also be powered with 5V through USB)
Geiger counter board	5V @ 0.2A = 1W
Total	6.92W ± 0.6W

B. See appendix 2 for power diagram. EDAC 516 Connector:

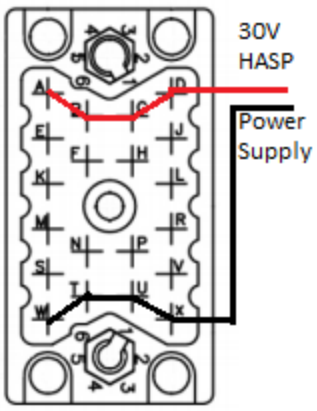


Figure 1: EDAC connector

C. Other relevant power information: N/A

[1] "GoPro Hero3 White|Technical Specs" 12 Dec. 2014. <http://shop.gopro.com/cameras/hero3-white/CHDHE-302.html>

III. **Downlink Telemetry Specifications:**

A. Serial data downlink format: Stream Packetized (circle one)

B. Approximate serial downlink rate (in bits per second): 912 bits/second

C. Serial data record: 114 bytes every second (including record length and information contained in each record byte.) (See Table 1 below for format)

Time Stamp (HHMMSS)	6 bytes/s
Amplitude & phase of transmitter 1 (24.0 kHz Cutler, Maine)[2]	8 bytes/s
Amplitude & phase of transmitter 2 (24.8 kHz Jim Creek, Washington)[2]	8 bytes/s
Amplitude & phase of transmitter 3 (25.2 kHz La Moure, North Dakota)[2]	8 bytes/s
Amplitude & phase of transmitter 4 (37.5 kHz Grindavik, Iceland)[2]	8 bytes/s
Number of sferics this second (12 bit number represented in hexadecimal)	3 bytes/s
500 V HV (divided down to 2.5 V) monitor (2x 8 bit ADC output in Hexadecimal) = 16 bits	2 bytes/s
Temperature (8 bit ADC output represented in hexadecimal)	2 bytes/s
5 V monitor (8 bit ADC output represented in hexadecimal)	2 bytes/s
12 V monitor (8 bit ADC output represented in hexadecimal)	2 bytes/s
Count rate of Geiger counter #1	4 bytes/s
Count rate of Geiger counter #2	4 bytes/s
Count rate of Geiger counter #3	4 bytes/s
Count rate of Geiger counter #4	4 bytes/s
Count rate of Geiger counter #5	4 bytes/s
Count rate of Geiger counter #6	4 bytes/s
Count rate of Geiger counter #7	4 bytes/s

[2] These will be transmitted as 64 bit complex numbers (32 bit real, 32 bit imaginary) encoded in hexadecimal <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=4610935&sortType%3Dasc_p_Sequence%26filter%3DAND%28p_Publication_Number%3A4610933%29>

Count rate of Geiger counter #8	4 bytes/s
Count rate of Geiger counter #9	4 bytes/s
Count rate of Geiger counter #10	4 bytes/s
Comma delimiting	25 bytes/s
Total	114 bytes/s

Table 1: Data Format

D. Number of analog channels being used: None

E. If analog channels are being used, what are they being used for? N/A

F. Number of discrete lines being used: None

G. If discrete lines are being used what are they being used for? N/A

H. Are there any on-board transmitters? If so, list the frequencies being used and the transmitted power. There will be no on-board transmitters.

I. Other relevant downlink telemetry information. N/A

IV. Uplink Commanding Specifications:

A. Command uplink capability required: No

B. If so, will commands be uplinked in regular intervals: N/A

C. How many commands do you expect to uplink during the flight: N/A

D. Provide a table of all of the commands that you will be uplinking to your payload: N/A

E. Are there any on-board receivers? If so, list the frequencies being used. Yes, Our VLF receiver will be receiving in the frequency range of about 200 Hz to 100 kHz

F. Other relevant uplink commanding information. N/A

V. Integration and Logistics

A. Date and Time of your arrival for integration: The student team will arrive to Palistine, TX on Aug 2, 2015. The team will be available to integrate at any time assigned by HASP from Aug 3 to Aug 7.

B. Approximate amount of time required for integration: 4 hours (1 hours setting up and mounting the detector on the mounting plate, 1 hour for communication and power testing, 2 hours for trouble shooting)

C. Name of the integration team leader: Alex Sheldon

D. Email address of the integration team leader: alexshel44@gmail.com

E. List **ALL** integration participants (first and last names) who will be present for integration with their email addresses:

Name	Email address
Alex Sheldon	alexshel44@gmail.com
Student 2	student 2 email

F. Define a successful integration of your payload:
- Mechanical system:
  - ❏ Successful mechanical fit to the platform
- Electrical system
  - ❏ Successful turn on
  - ❏ Current lies within expectations
- Communication system
  - ❏ Successful communication with HASP Platform
  - ❏ Verify housekeeping data including voltages, temperature and Geiger counts

G. List all expected integration steps:
- ❏ Mechanically mount the payload to the platform
- ❏ Connect antenna/pre-amp array
- ❏ Connect power cable
- ❏ Turn on
- ❏ Measure current draw
- ❏ Connect communication cable
- ❏ Verify that the communication with the platform is working
- ❏ Verify housekeeping data

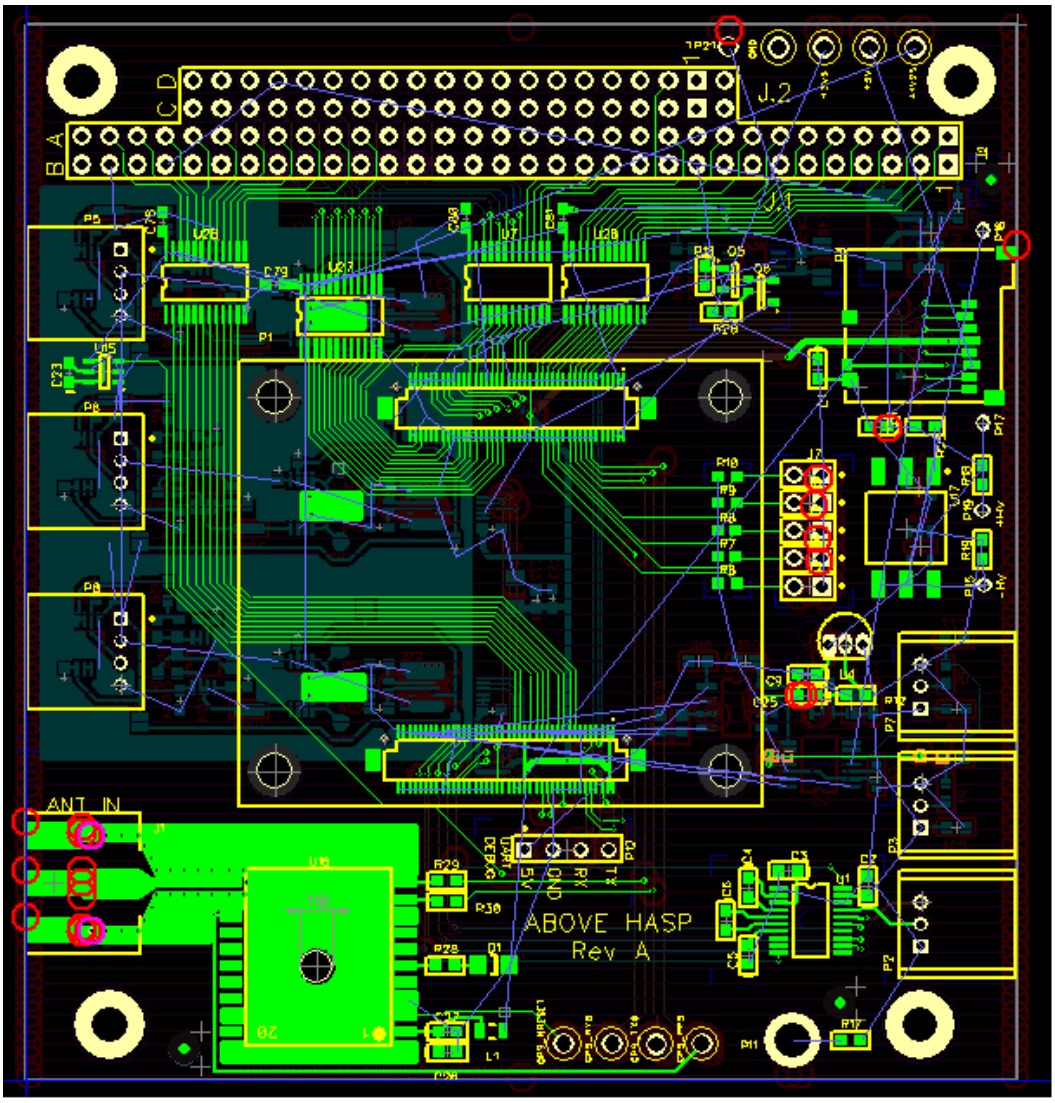
H. List all checks that will determine a successful integration: All items in point F.

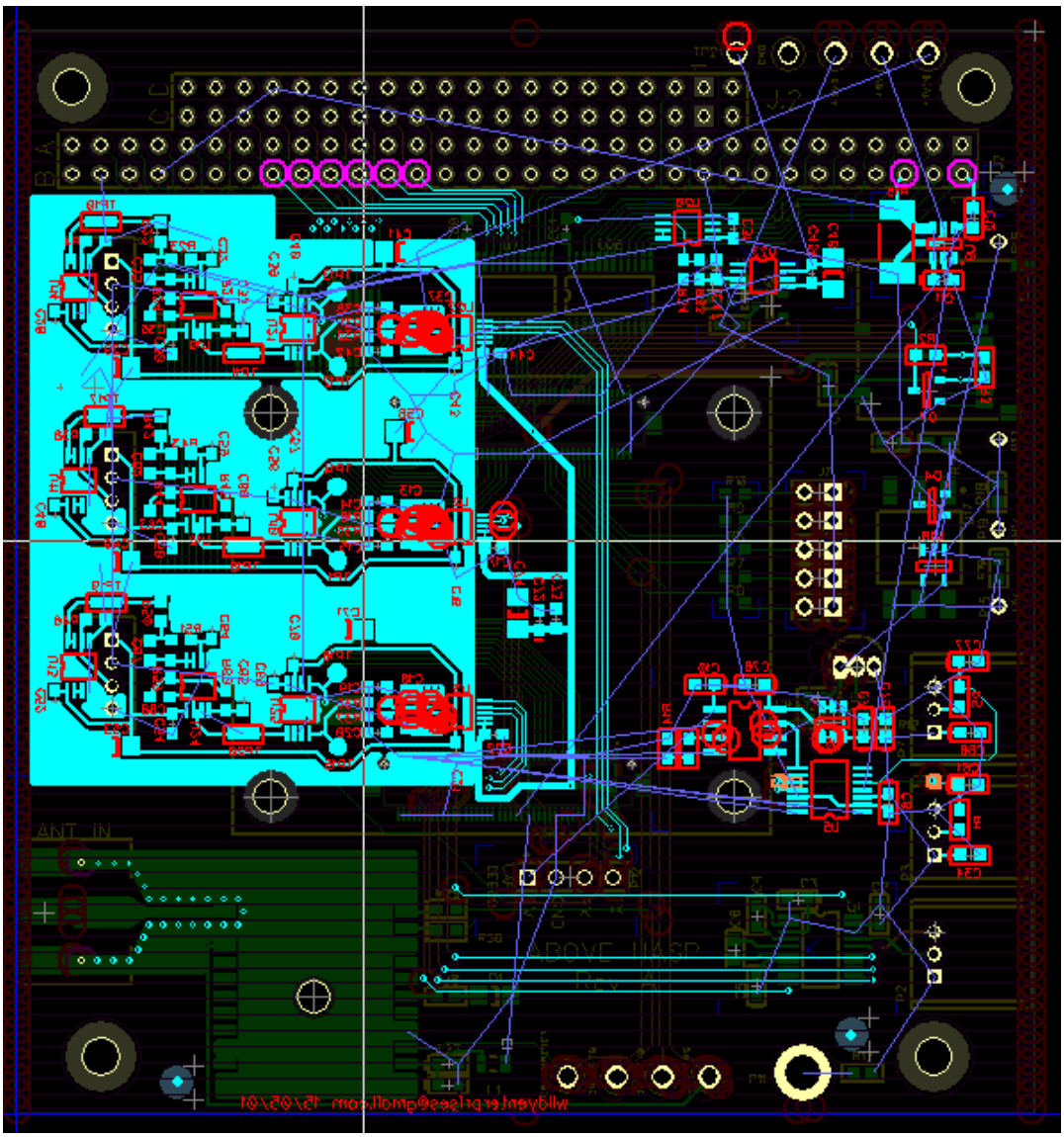
I. Additional LSU personnel support needed for a successful integration other than directly related to the HASP integration:
- ❏ Any other team arriving to Dallas with space on their rental car to give a ride to students to CSBF? (Any daily carpooling also from hotel to CSBF?)
- ❏ Introduction to the facility
- ❏ Familiarization with the gondola and the interface
- ❏ Answering Q&A if any arise
- ❏ Any tools/supplies available at CSBF if needed (or should we bring our own tools?)

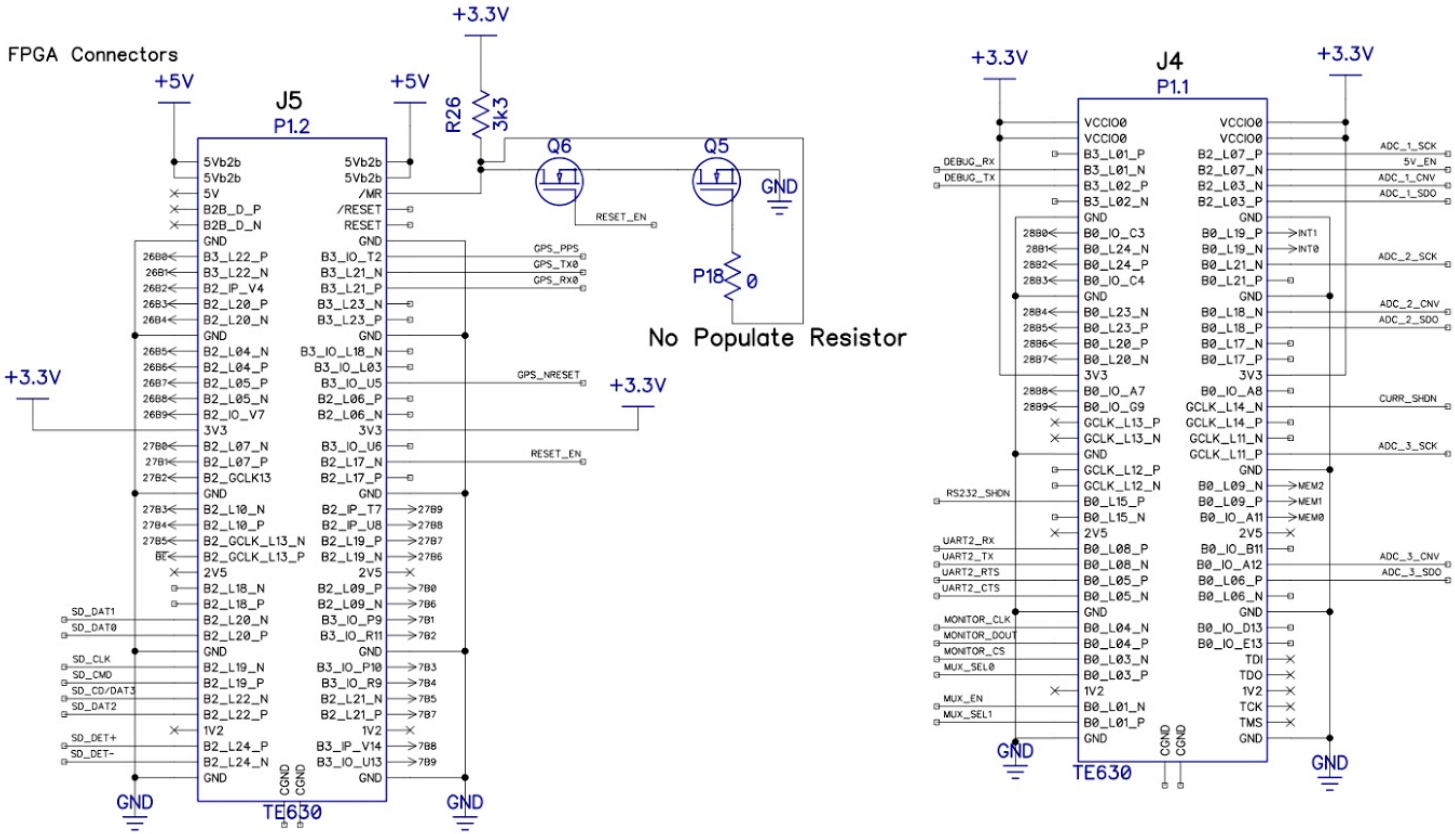
J. List any LSU supplied equipment that may be needed for a successful integration: None

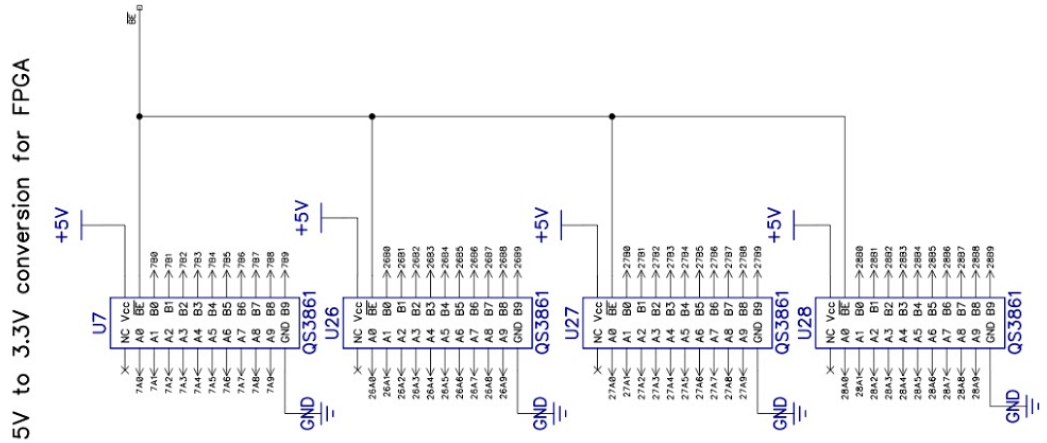
Appendix 1 - Mechanical and Circuit Layouts

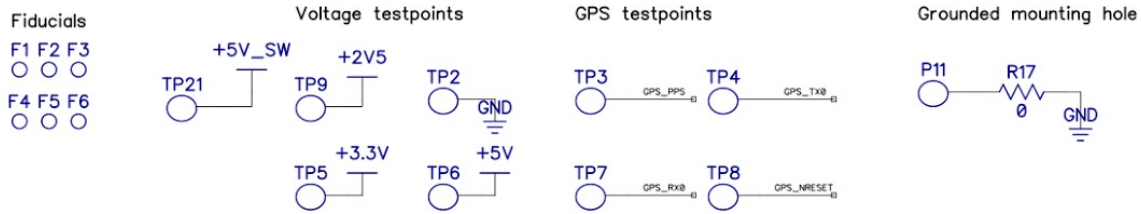
VLF Main Board

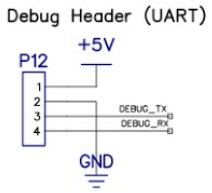


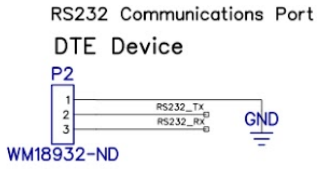


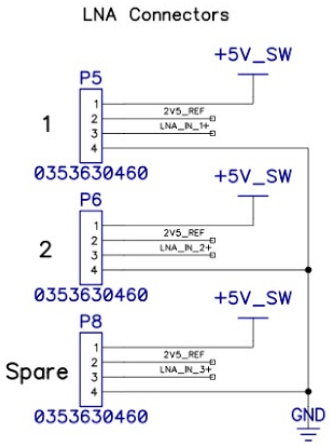

FPGA Connectors
J5
P1.2
TE630
J4
P1.1
TE630
+3.3V
+5V
R26
3k3
Q6
Q5
P18
0
No Populate Resistor
GPS_PPS
GPS_TX0
GPS_RX0
GPS_NRESET
RESET_EN
SD_DAT1
SD_DAT0
SD_CLK
SD_CMD
SD_CD/DAT3
SD_DAT2
SD_DET+
SD_DET-
DEBUG_RX
DEBUG_TX
RS232_SHDN
UART2_RX
UART2_TX
UART2_RTS
UART2_CTS
MONITOR_CLK
MONITOR_DOUT
MONITOR_CS
MUX_SEL0
MUX_EN
MUX_SEL1
ADC_1_SCK
5V_EN
ADC_1_CNV
ADC_1_SDO
ADC_2_SCK
ADC_2_CNV
ADC_2_SDO
CURR_SHDN
ADC_3_SCK
ADC_3_CNV
ADC_3_SDO
GND

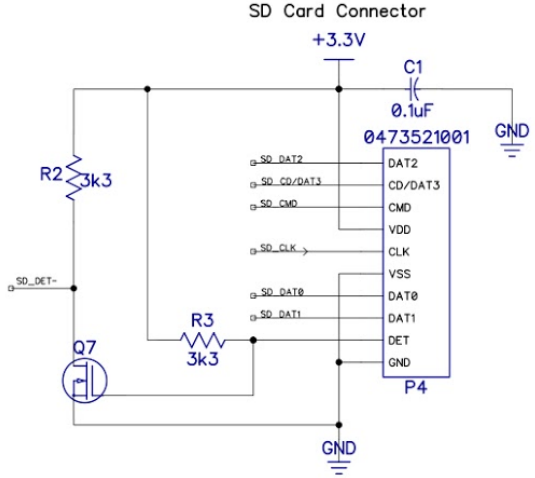

5V to 3.3V conversion for FPGA
U7
U26
U27
U28
QS3861
+5V
GND

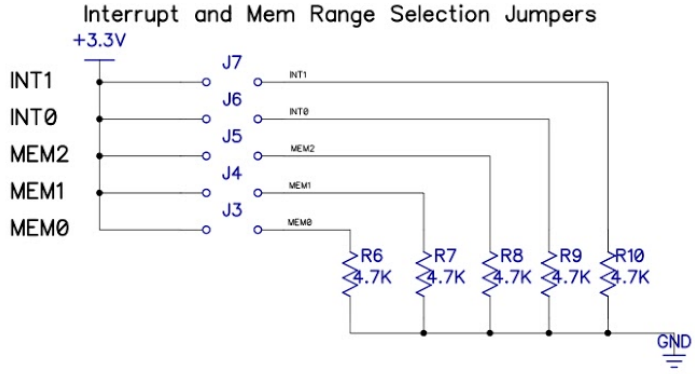

Fiducials
F1 F2 F3
F4 F5 F6
Voltage testpoints
TP21
+5V_SW
TP9
+2V5
TP2
GND
TP5
+3.3V
TP6
+5V
GPS testpoints
TP3
GPS_PPS
TP4
GPS_TX0
TP7
GPS_RX0
TP8
GPS_NRESET
Grounded mounting hole
P11
R17
0
GND

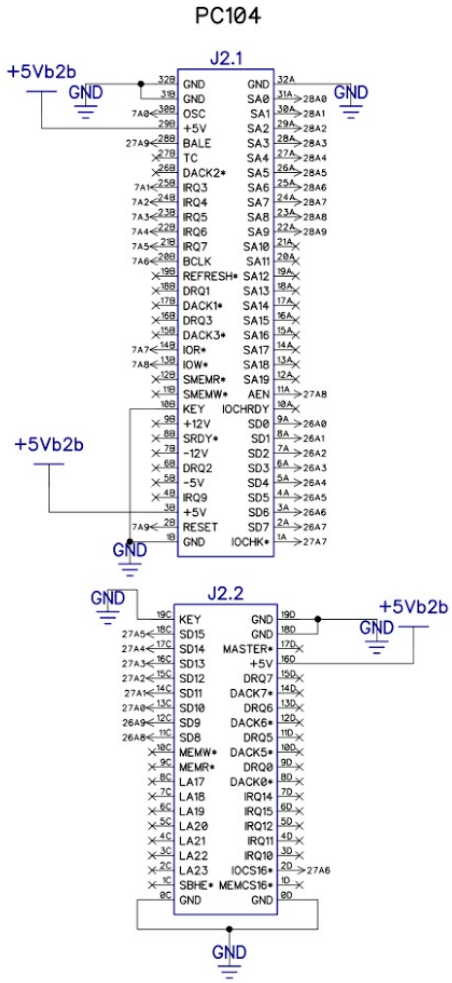

Debug Header (UART)
P12
+5V
DEBUG_TX
DEBUG_RX
GND


RS232 Communications Port
DTE Device
P2
RS232_TX
RS232_RX
GND
WM18932-ND

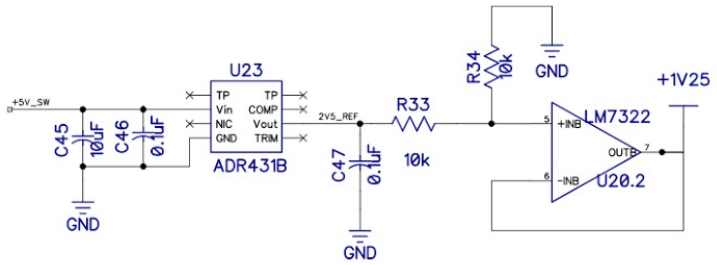

LNA Connectors
P5
+5V_SW
2V5_REF
LNA_IN_1+
1
0353630460
P6
+5V_SW
2V5_REF
LNA_IN_2+
2
0353630460
P8
+5V_SW
2V5_REF
LNA_IN_3+
Spare
0353630460
GND


SD Card Connector
+3.3V
C1
0.1uF
0473521001
GND
R2
3k3
SD_DAT2
SD_CD/DAT3
SD_CMD
SD_CLK
SD_DET-
SD_DAT0
SD_DAT1
DAT2
CD/DAT3
CMD
VDD
CLK
VSS
DAT0
DAT1
DET
GND
P4
R3
3k3
Q7
GND


Interrupt and Mem Range Selection Jumpers
+3.3V
INT1
INT0
MEM2
MEM1
MEM0
J7
J6
J5
J4
J3
R6
4.7K
R7
4.7K
R8
4.7K
R9
4.7K
R10
4.7K
GND

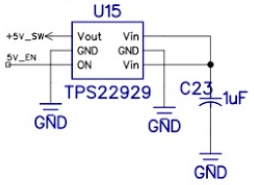

PC104
J2.1
+5Vb2b
GND
GND
GND
+5Vb2b
GND
J2.2
+5Vb2b
GND
GND

2.5V Voltage Reference for Signal ADC's

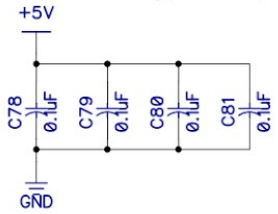


Load Switch For ADC and LNA

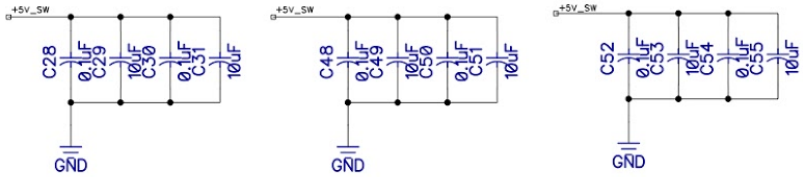
+5V_SW Source



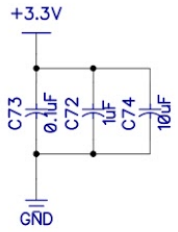
QS3861 Bypass Capacitors

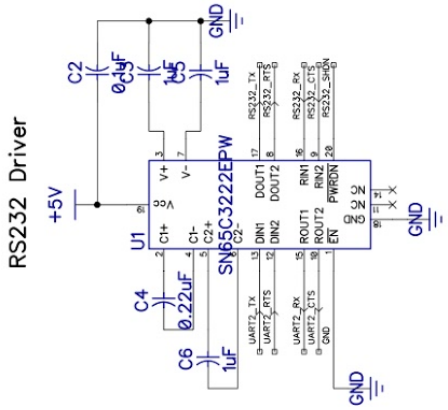


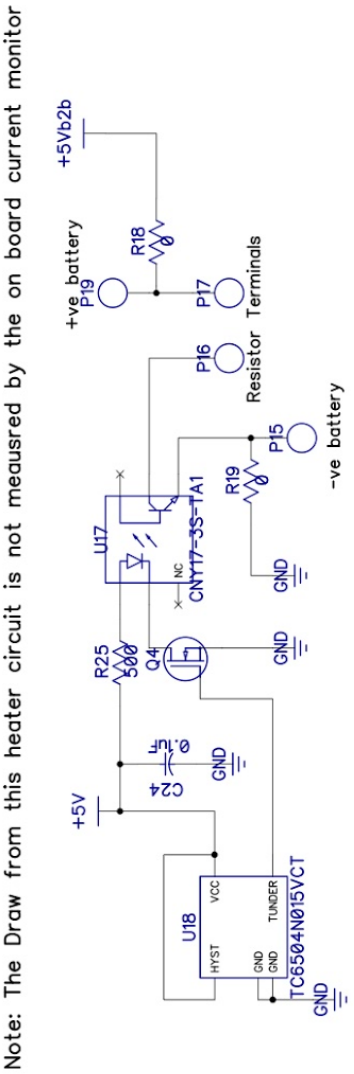
Receiver Level Shifter Bypass Capacitors



FPGA 3.3V Source Bypass



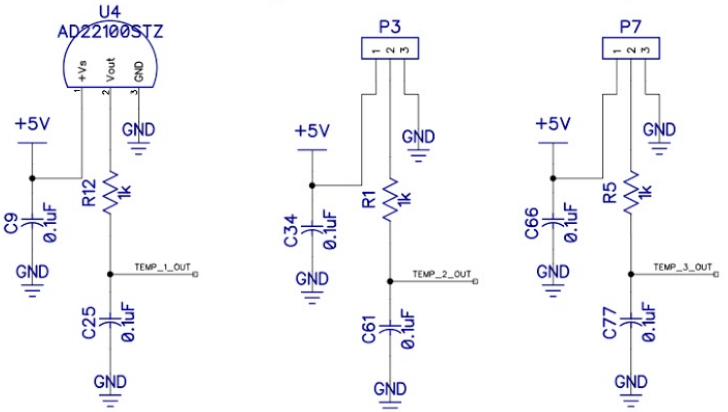

RS232 Driver
+5V
C2
0.1uF
C3
1uF
C5
1uF
GND
U1
SN65C3222EPW
C4
0.22uF
C6
1uF
GND
GND


Note: The Draw from this heater circuit is not meausred by the on board current monitor
+5Vb2b
+ve battery
P19
R18
0
P17
Resistor Terminals
P16
P15
-ve battery
R19
0
U17
CNY17-3S-TA1
NC
GND
R25
500
Q4
GND
+5V
C24
0.1uF
GND
U18
HYST
VCC
GND
GND
TUNDER
TC6504N015VCT
GND

With 4.096 Voltage Reference this ckt would be good to approx 177 degC

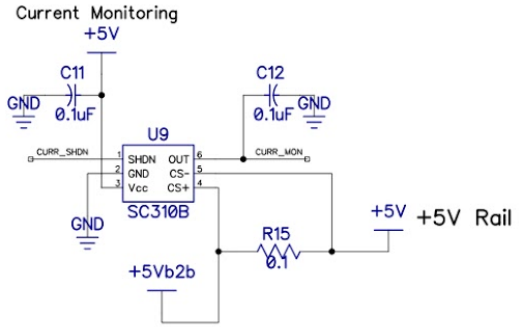
Temperature Monitoring

Fly-off headers for external temp channels



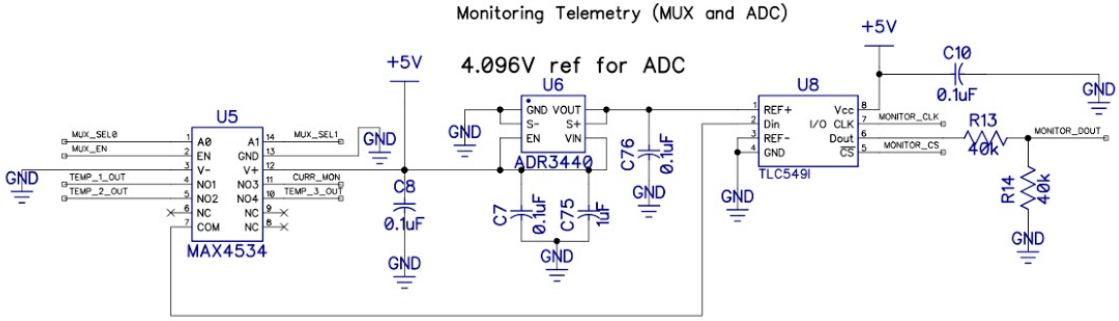
0.75A draw would produce approx 3.75V output

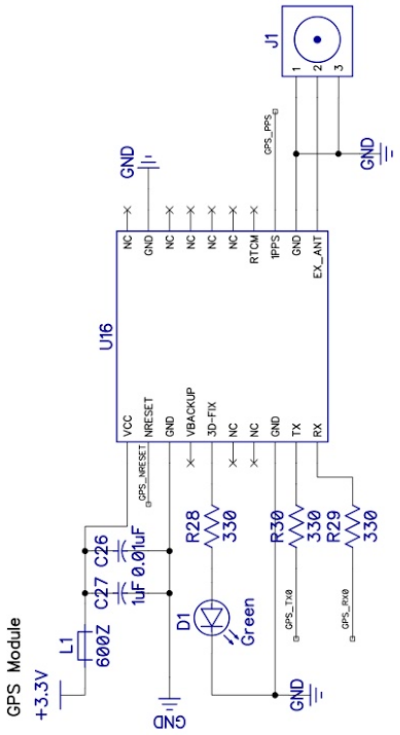
Current Monitoring



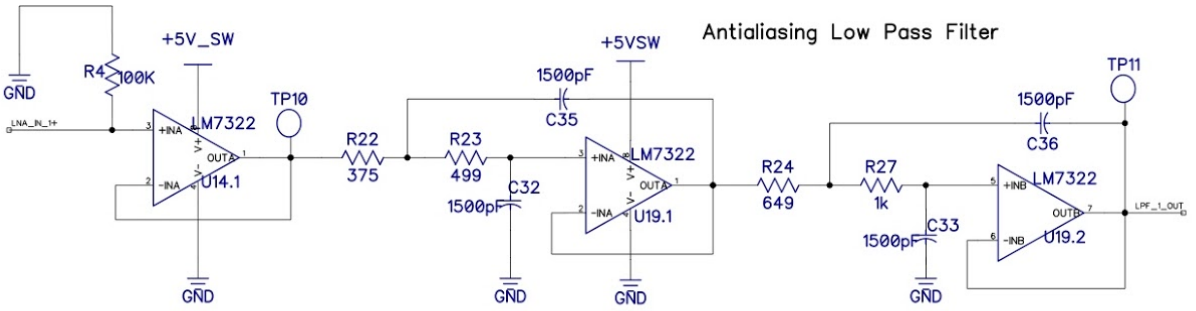
Monitoring Telemetry (MUX and ADC)

4.096V ref for ADC

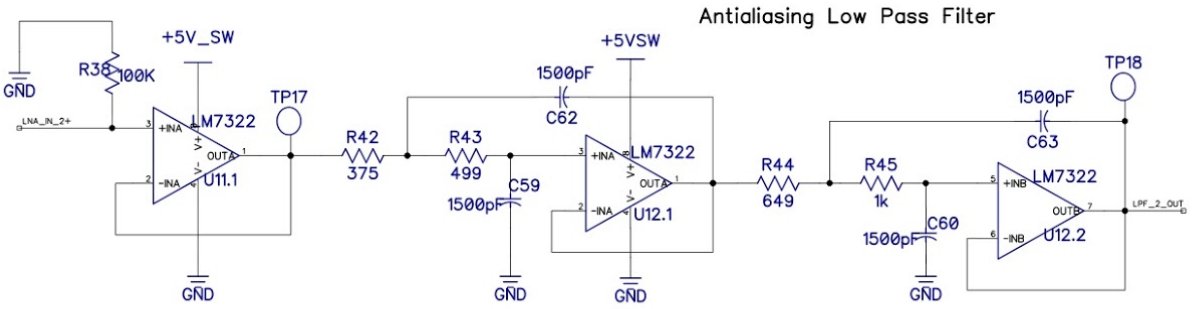



GPS Module
+3.3V
L1
600Z
C27
C26
1uF
0.01uF
GND
D1
Green
R28
330
R30
330
R29
330
U16
VCC
NRESET
GND
VBACKUP
3D-FIX
NC
NC
GND
TX
RX
NC
GND
NC
NC
NC
NC
RTCM
1PPS
GND
EX_ANT
GPS_NRESET
GPS_TX0
GPS_RX0
GPS_PPS
J1
1
2
3
GND
GND

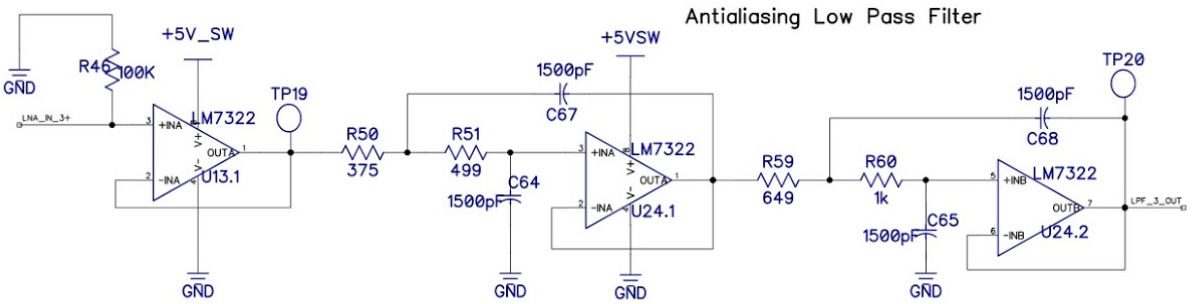
#1 Receiver and Level Shifter

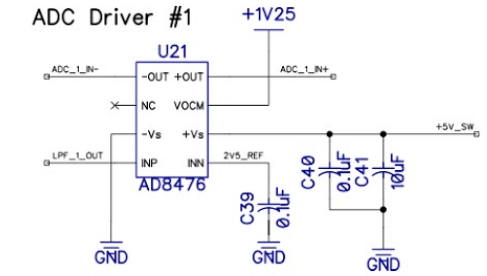


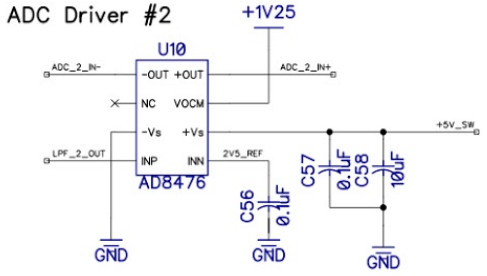
#2 Receiver and Level Shifter

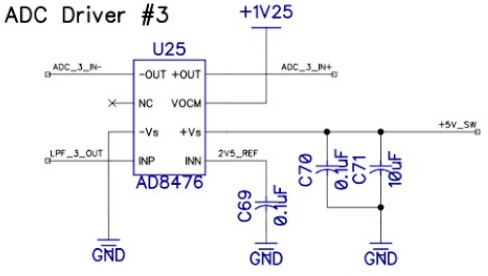


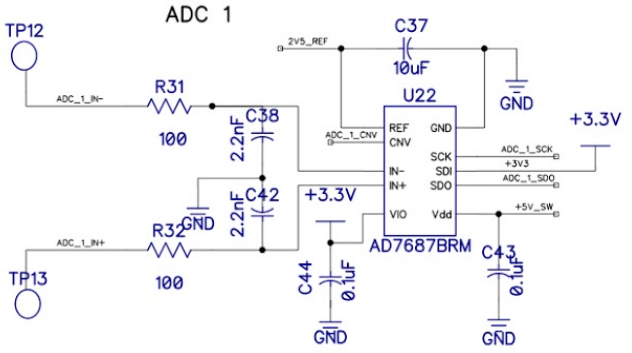
Spare Receiver and Level Shifter

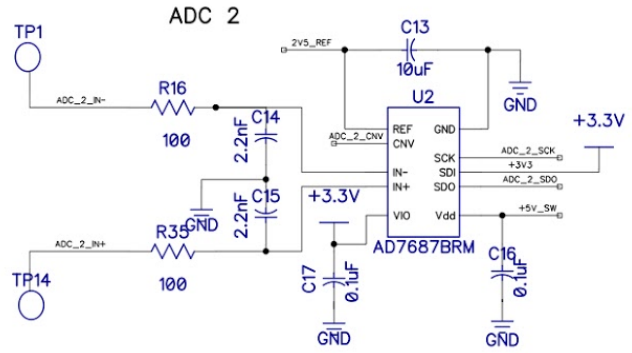


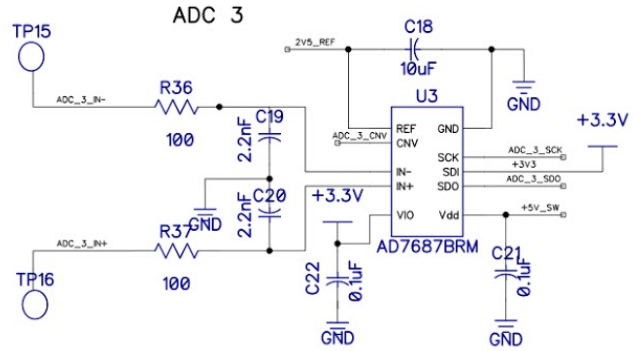

ADC Driver #1
+1V25
U21
ADC_1_IN-
-OUT +OUT
ADC_1_IN+
NC VOCM
-Vs +Vs
+5V_SW
LPF_1_OUT
INP INN
2V5_REF
AD8476
C40
0.1uF
C41
10uF
C39
0.1uF
GND
GND
GND


ADC Driver #2
+1V25
U10
ADC_2_IN-
-OUT +OUT
ADC_2_IN+
NC VOCM
-Vs +Vs
+5V_SW
LPF_2_OUT
INP INN
2V5_REF
AD8476
C57
0.1uF
C58
10uF
C56
0.1uF
GND
GND
GND

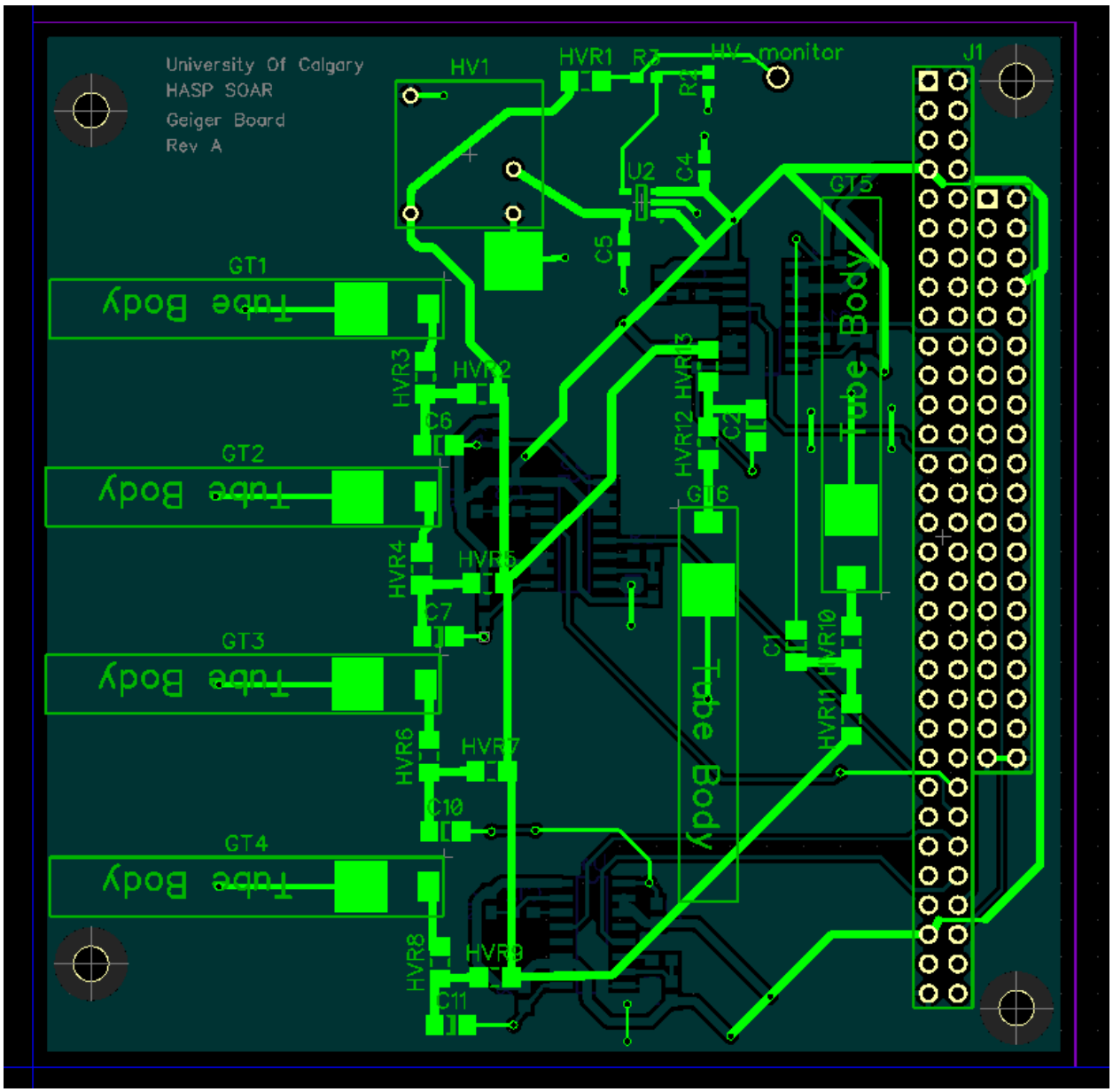

ADC Driver #3
+1V25
U25
ADC_3_IN-
-OUT +OUT
ADC_3_IN+
NC VOCM
-Vs +Vs
+5V_SW
LPF_3_OUT
INP INN
2V5_REF
AD8476
C70
0.1uF
C71
10uF
C69
0.1uF
GND
GND
GND

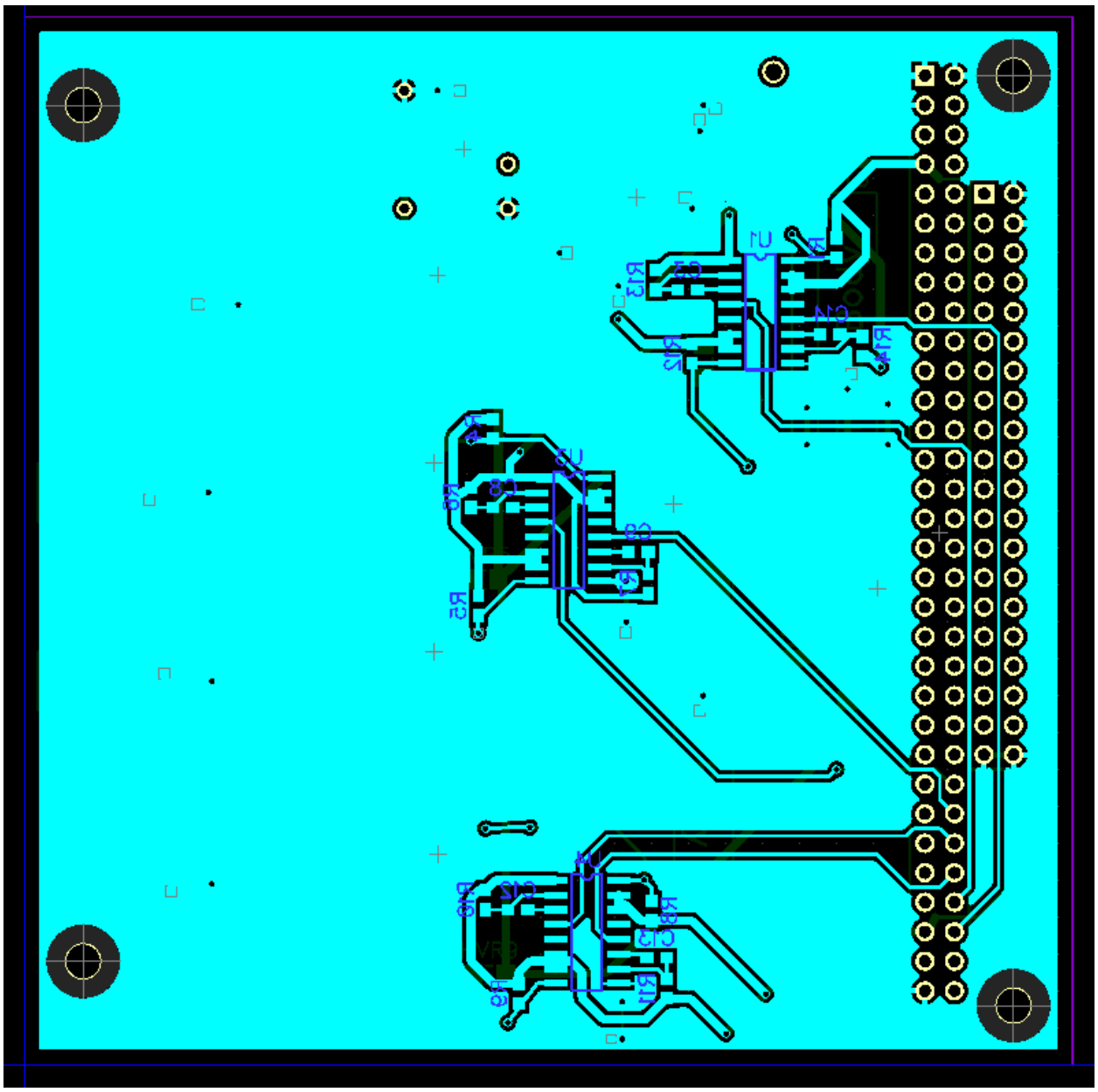

ADC 1
TP12
2V5_REF
C37
10uF
GND
ADC_1_IN-
R31
100
C38
2.2nF
U22
REF GND
ADC_1_CNV
CNV
SCK
ADC_1_SCK
+3.3V
+3V3
IN-
SDI
ADC_1_SDO
IN+
SDO
+3.3V
C42
2.2nF
VIO Vdd
+5V_SW
ADC_1_IN+
R32
100
GND
AD7687BRM
TP13
C44
0.1uF
C43
0.1uF
GND
GND


ADC 2
TP1
2V5_REF
C13
10uF
GND
ADC_2_IN-
R16
100
C14
2.2nF
U2
REF GND
ADC_2_CNV
CNV
SCK
ADC_2_SCK
+3.3V
+3V3
IN-
SDI
ADC_2_SDO
IN+
SDO
+3.3V
C15
2.2nF
VIO Vdd
+5V_SW
ADC_2_IN+
R35
100
GND
AD7687BRM
TP14
C17
0.1uF
C16
0.1uF
GND
GND

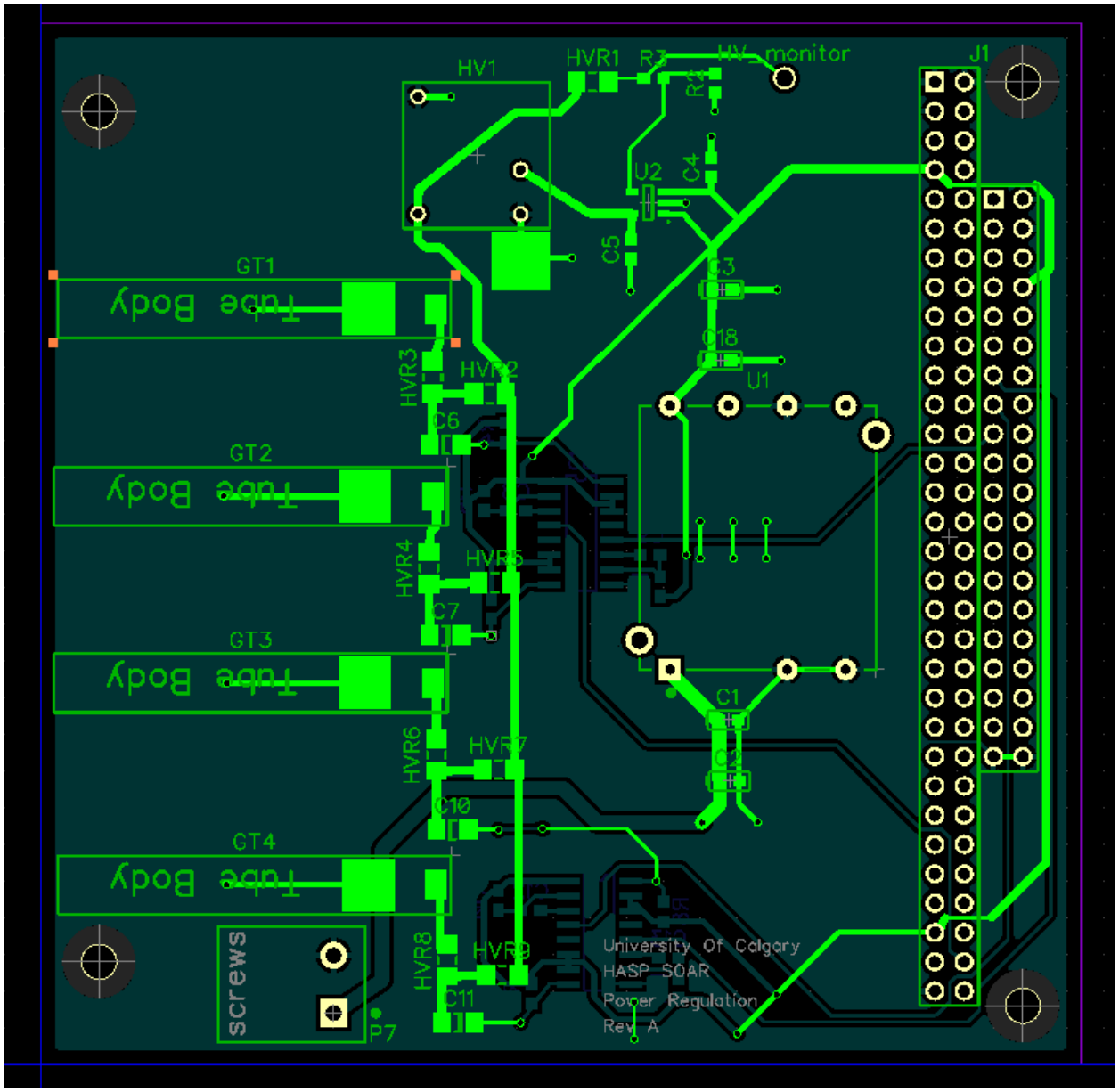

ADC 3
TP15
2V5_REF
C18
10uF
GND
ADC_3_IN-
R36
100
C19
2.2nF
U3
REF GND
ADC_3_CNV
CNV
SCK
ADC_3_SCK
+3.3V
+3V3
IN-
SDI
ADC_3_SDO
IN+
SDO
+3.3V
C20
2.2nF
VIO Vdd
+5V_SW
ADC_3_IN+
R37
100
GND
AD7687BRM
TP16
C22
0.1uF
C21
0.1uF
GND
GND

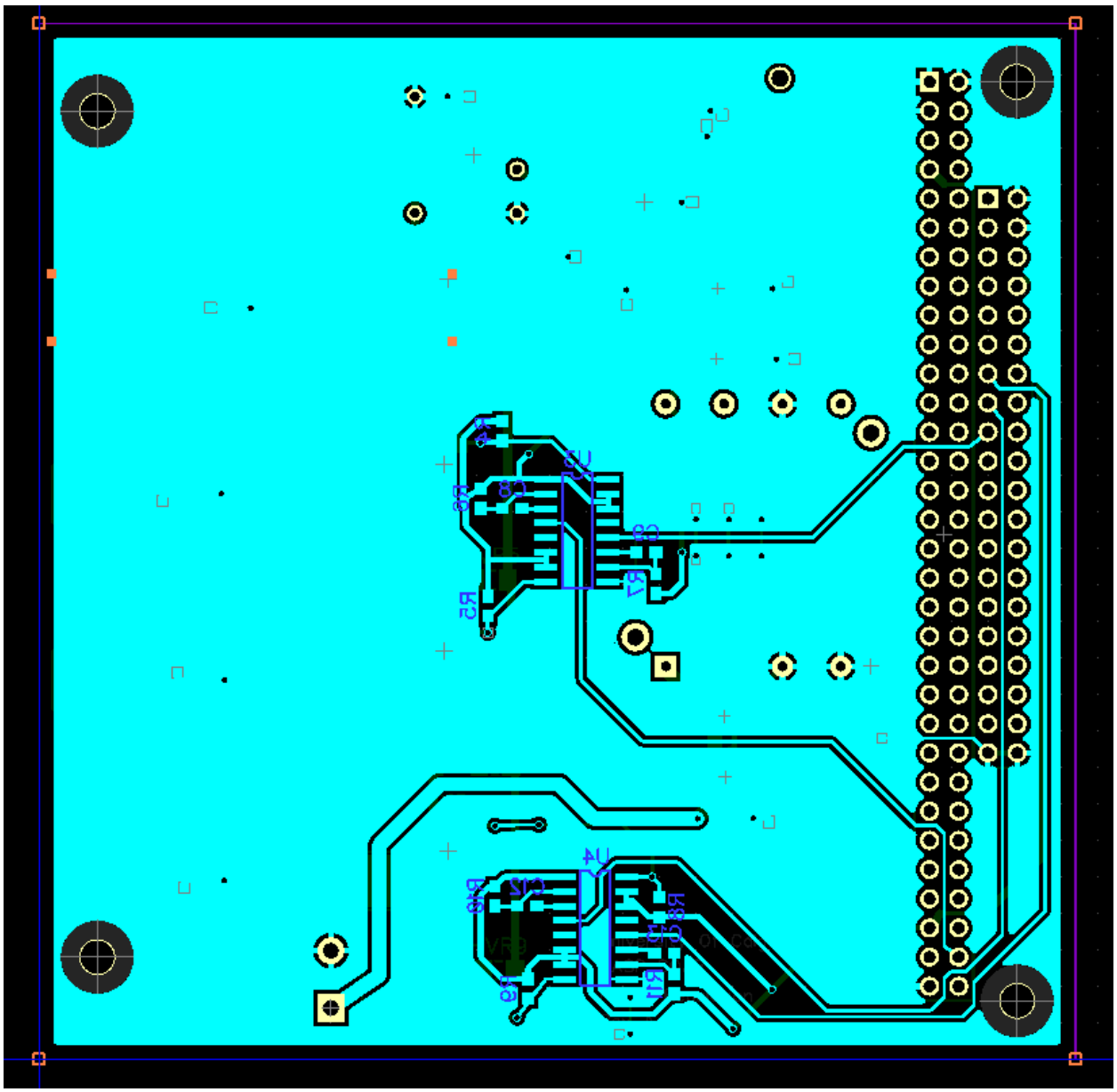
Geiger Counter Board



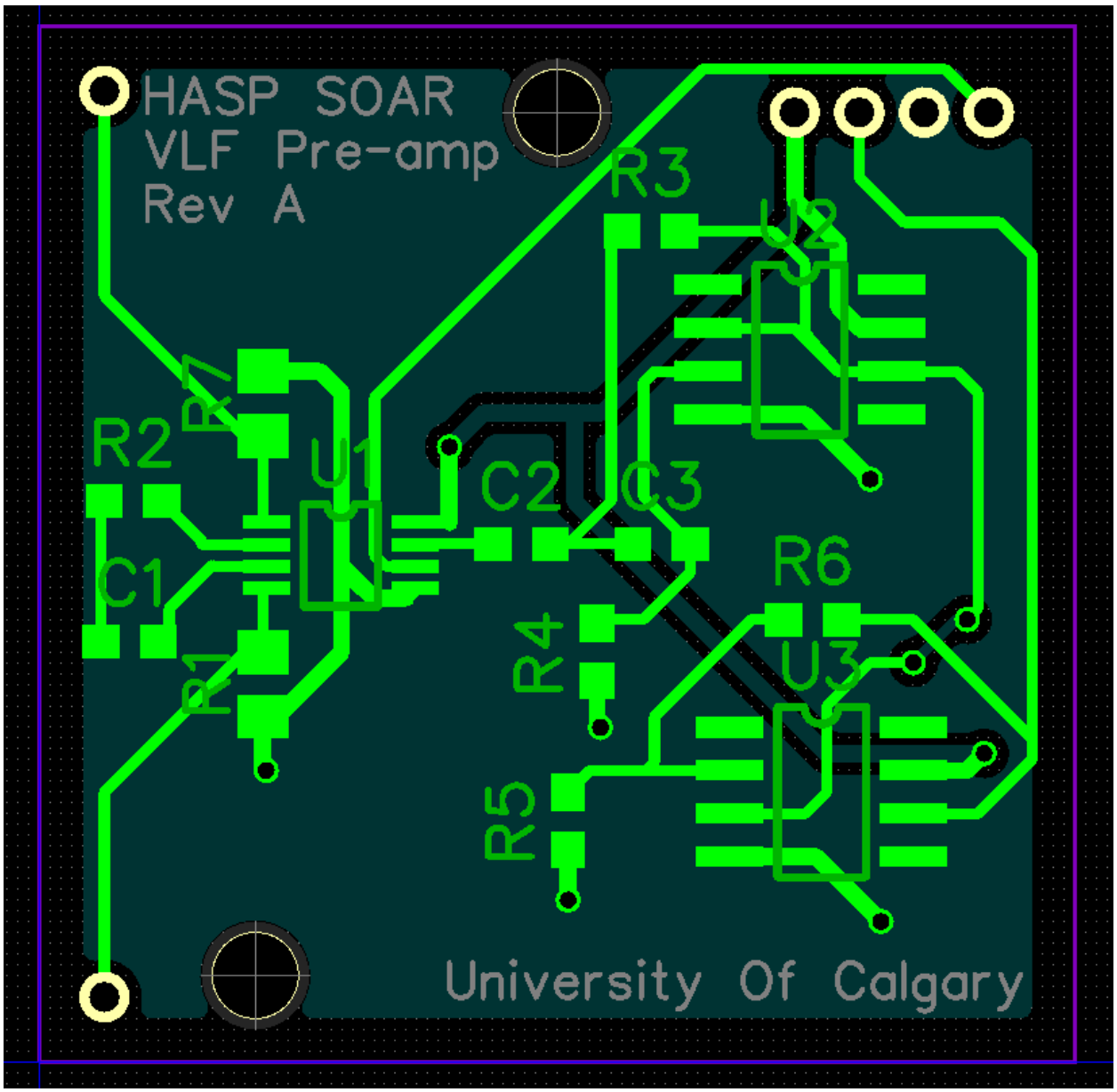


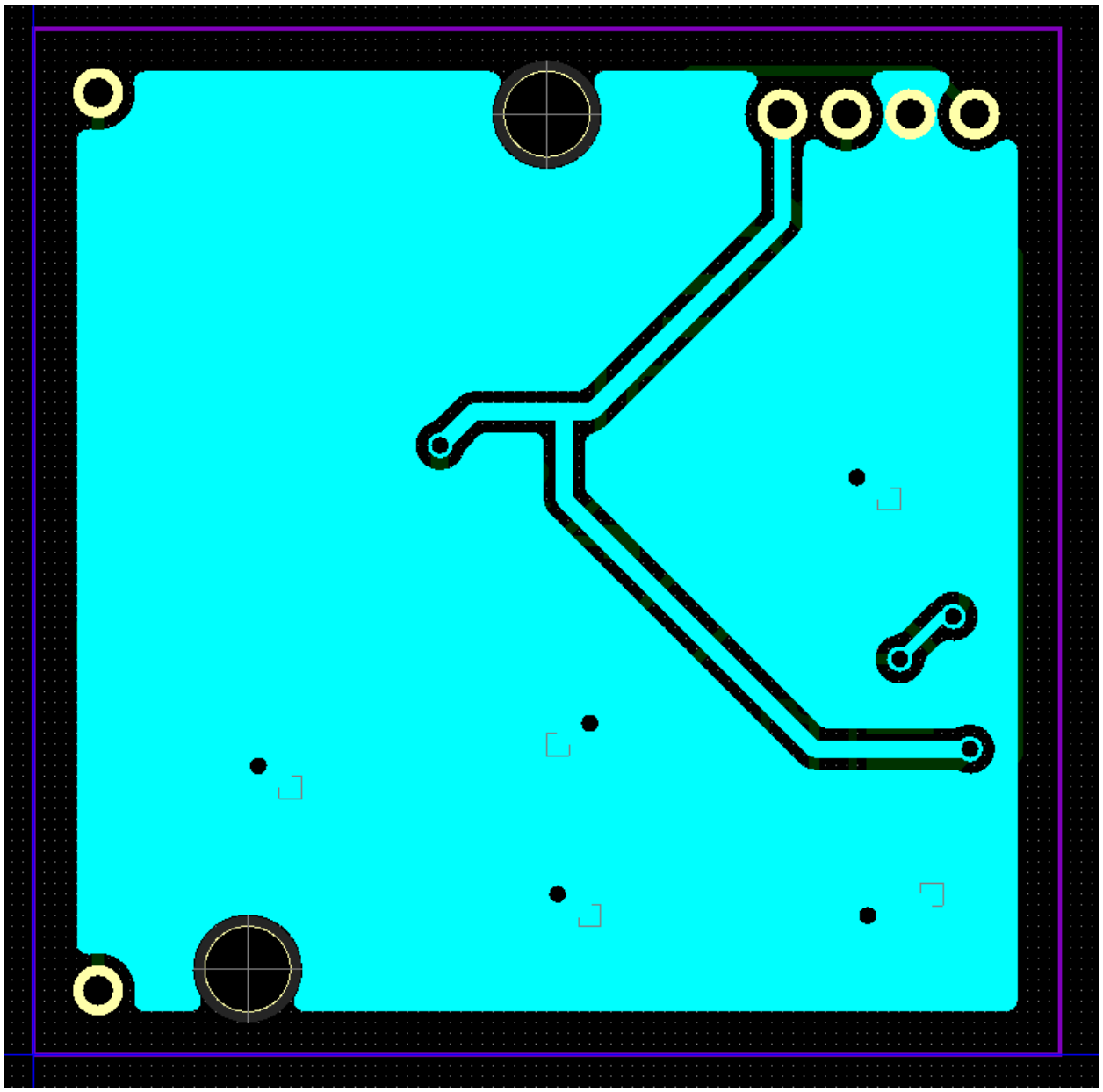
Power Regulation/Second Geiger Board



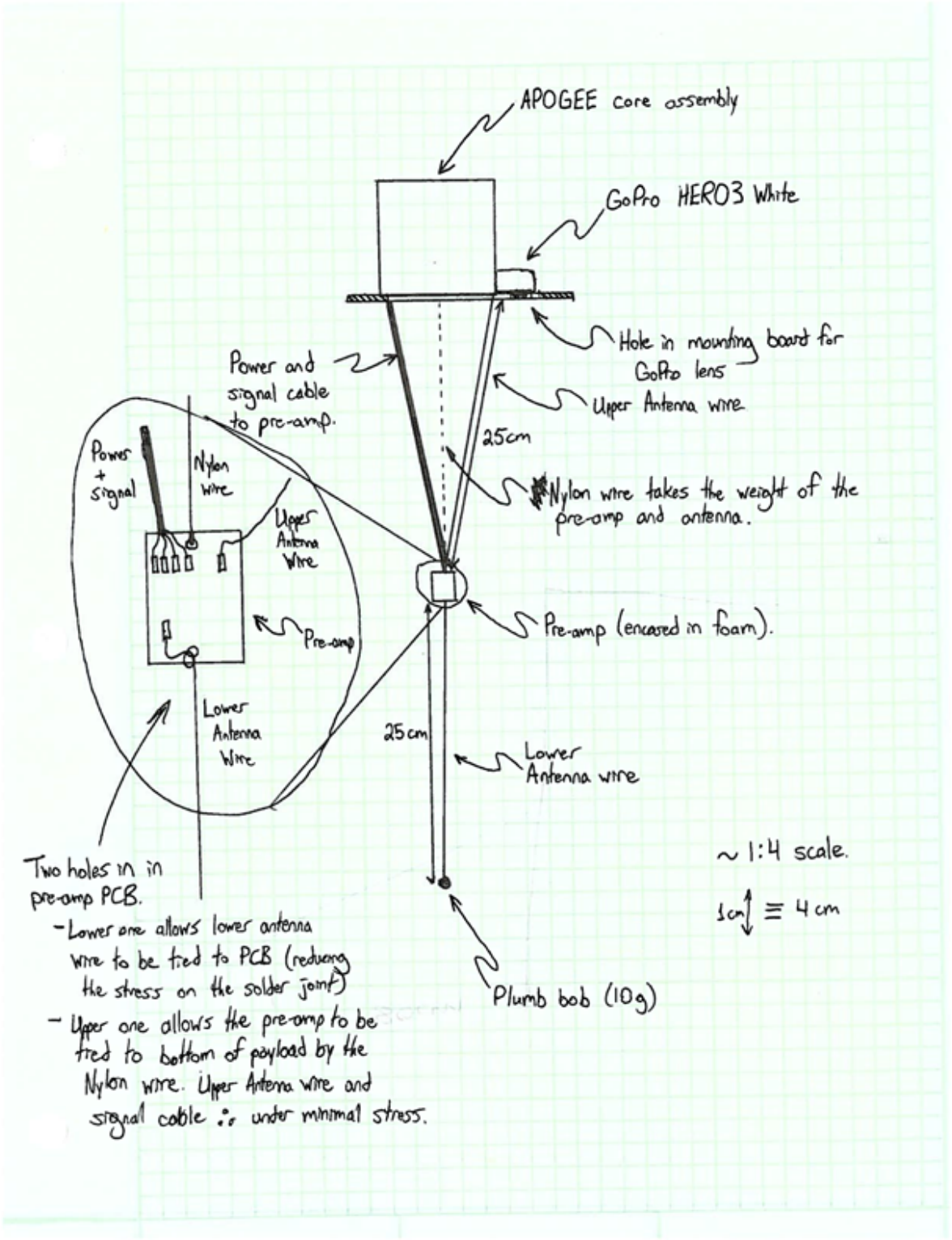


VLF Pre-amplifier

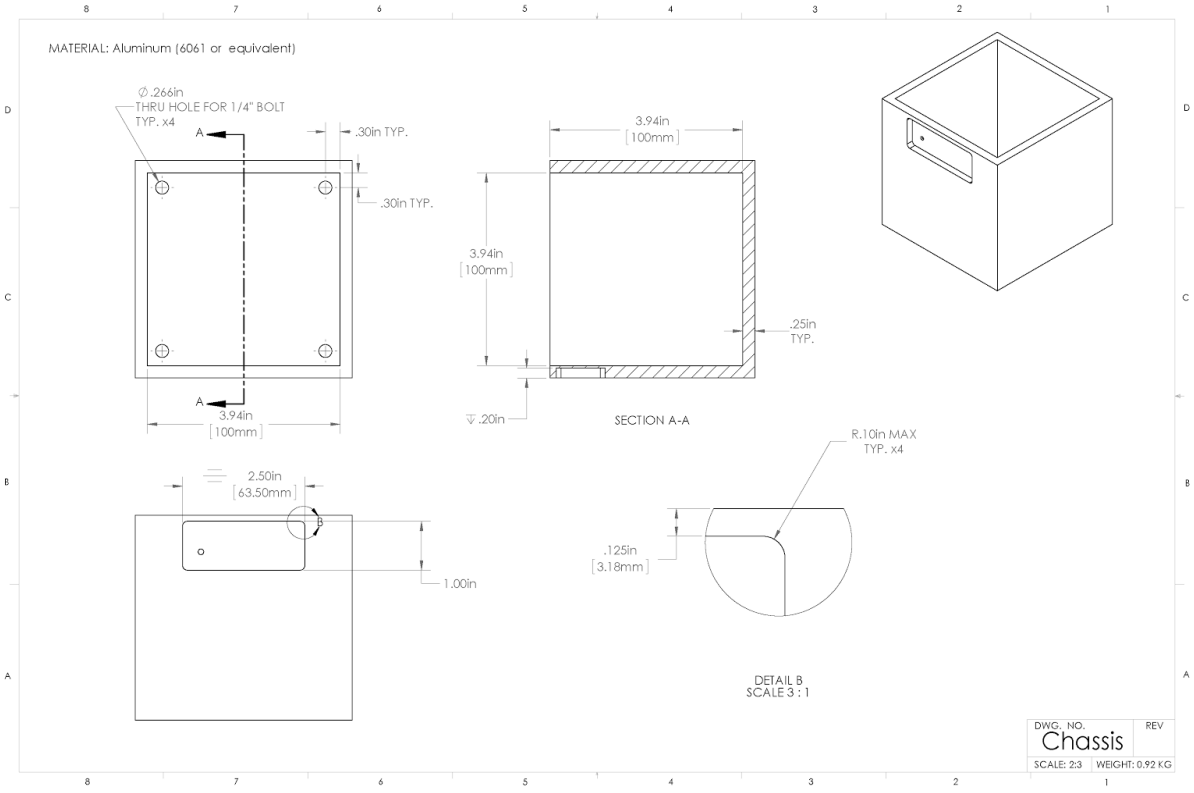




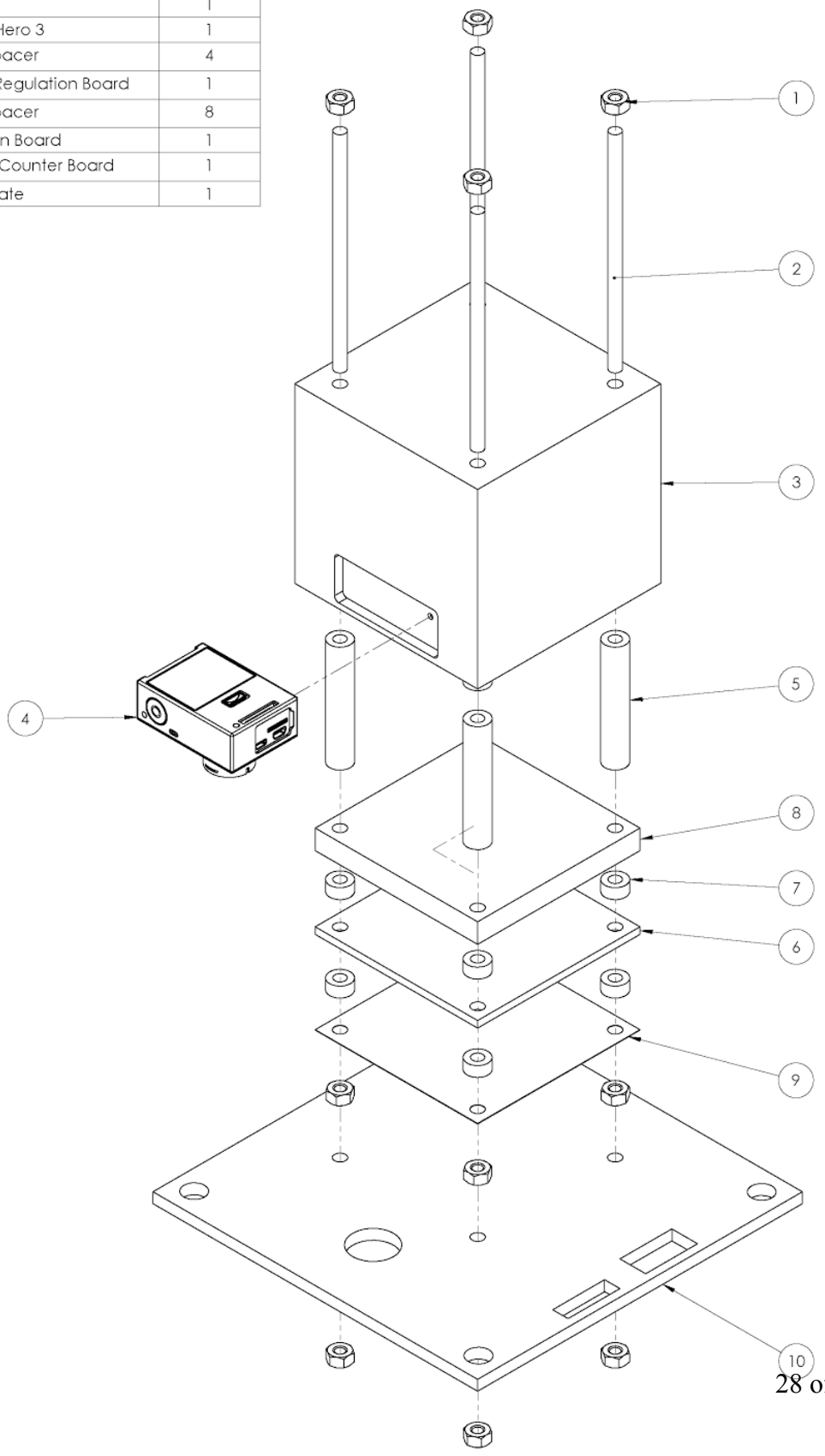
Antenna/Pre-amplfier Array



Mechanical Drawings



ITEM NO.	PART NUMBER	QTY.
1	UNC 1/4-20 Nut	12
2	UNC 1/4-20 Threaded Rod	4
3	Chassis	1
4	GoPro Hero 3	1
5	Long Spacer	4
6	Power Regulation Board	1
7	Short Spacer	8
8	VLF Main Board	1
9	Geiger Counter Board	1
10	HASP Plate	1



Appendix 2 - Power Diagram