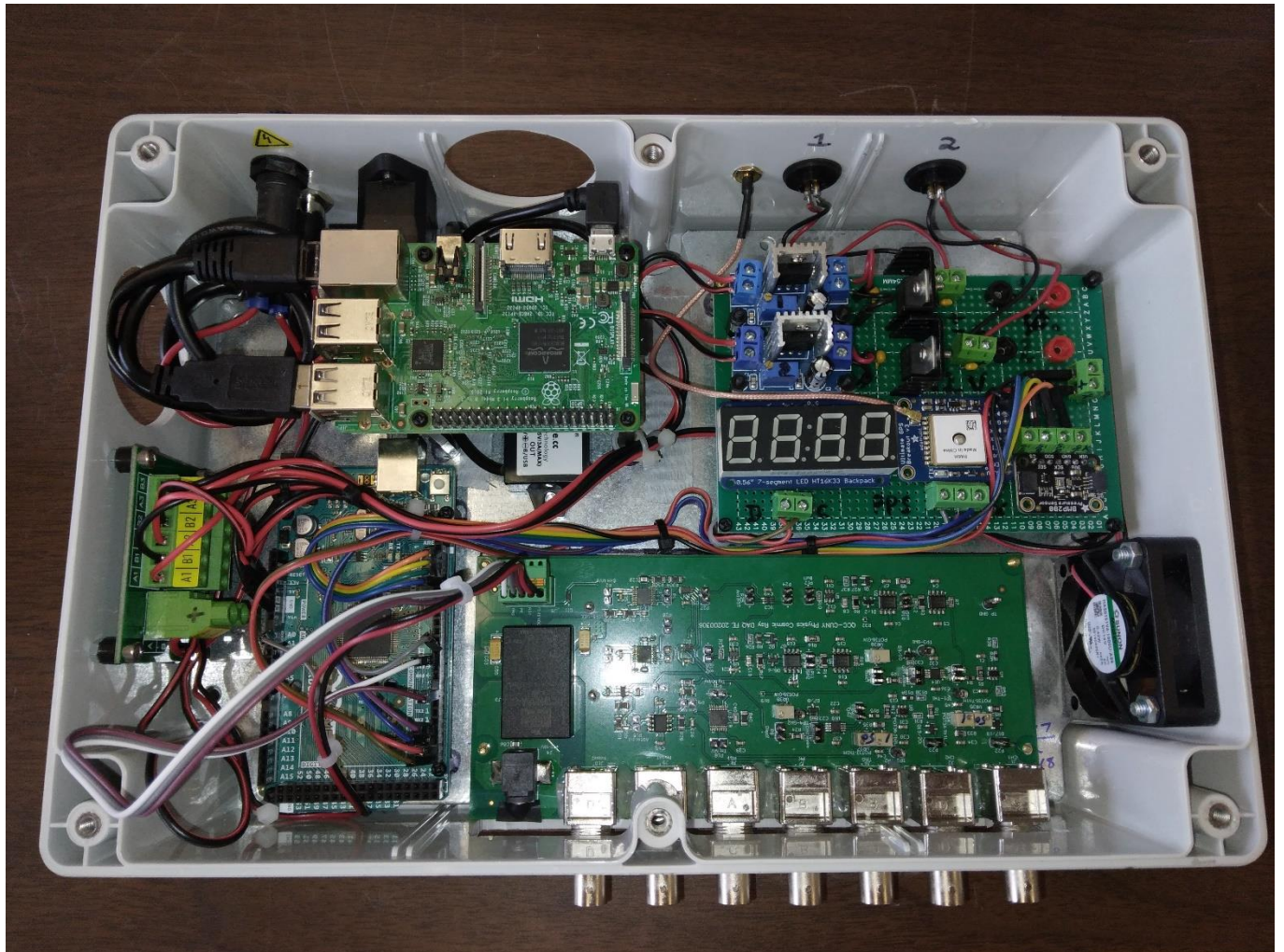


## Cosmic ray muon detector DAQ electronics box assembly instructions

QCC-CUNY Physics dept. (Armendariz) – Draft 10-21-2024

The DAQ front-end PCB includes amplifiers, discriminators, event counters, and signal amplitude detector circuitry to make two channel coincidence measurements from 2 PMTs. The perforated electronics bread-board contains a GPS receiver, two LM317 variable voltage regulators, two voltage regulators, capacitors, ambient temperature and pressure sensors, LCD counter, voltage test points, and terminal blocks; the DAQ box also contains an Arduino Mega, Raspberry Pi, fan, terminal block, fuse, 20V to 5V DC-DC buck-converter, and various connectors.



You will need drill bits: 1/8", 9/64" (3.5 mm is okay), 3/16" (5 mm is ok), 1/4", 3/8", 1/2" (13 mm is okay)

Circular hole cutting tools: 3/4", 1 3/4"

Drill, drill press, 2 clamps, screw drivers, wire cutters, wire strippers, solder iron, solder, wire, ruler

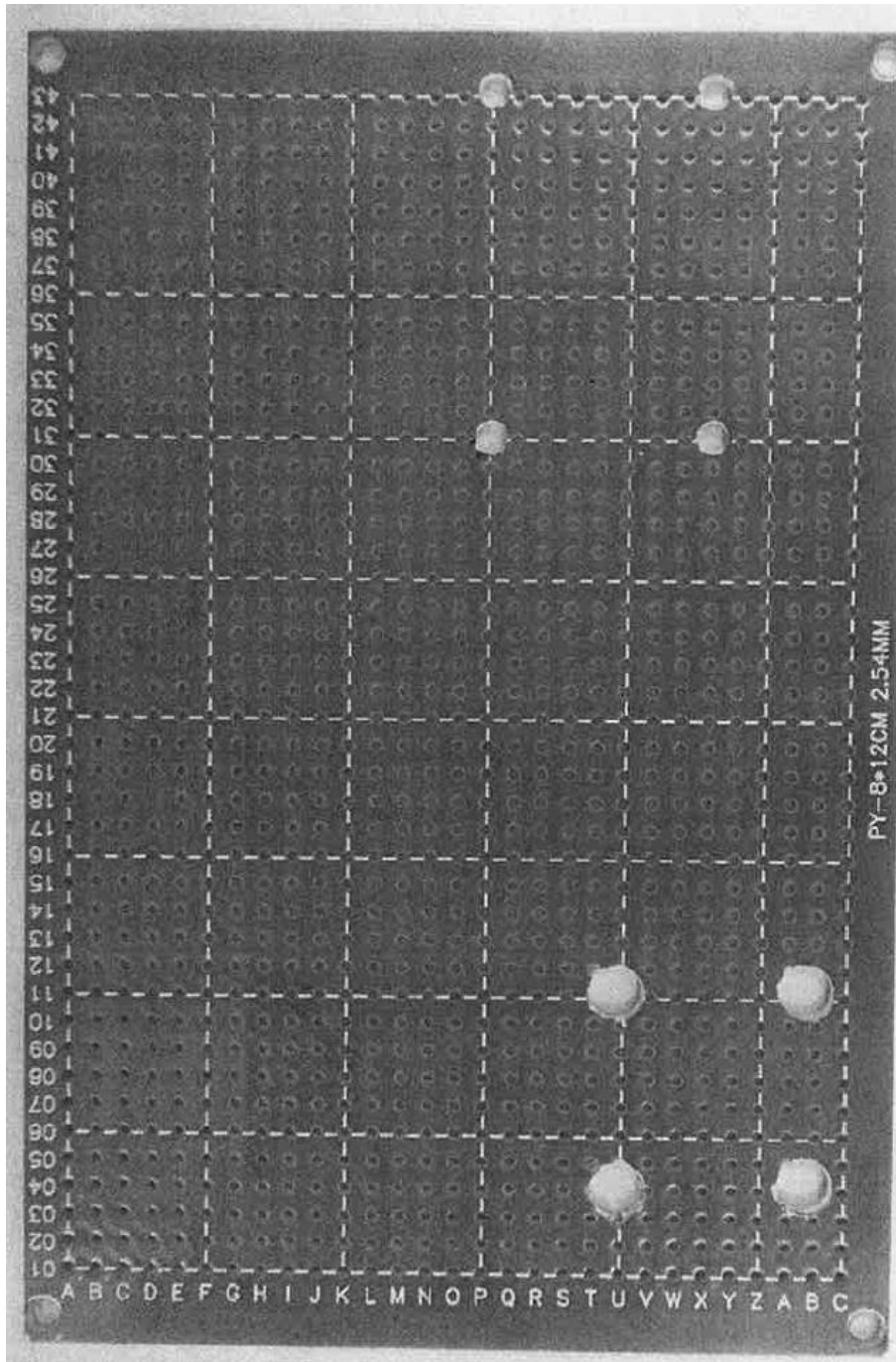
Nut drivers: 5mm, 5.5mm. Small Phillips screw driver, pliers

## Perfboard for electrical components

Drill 4 holes in the electronics perfboard with a 3/16" drill bit at holes 11B2, 4B2, 11U, and 4U

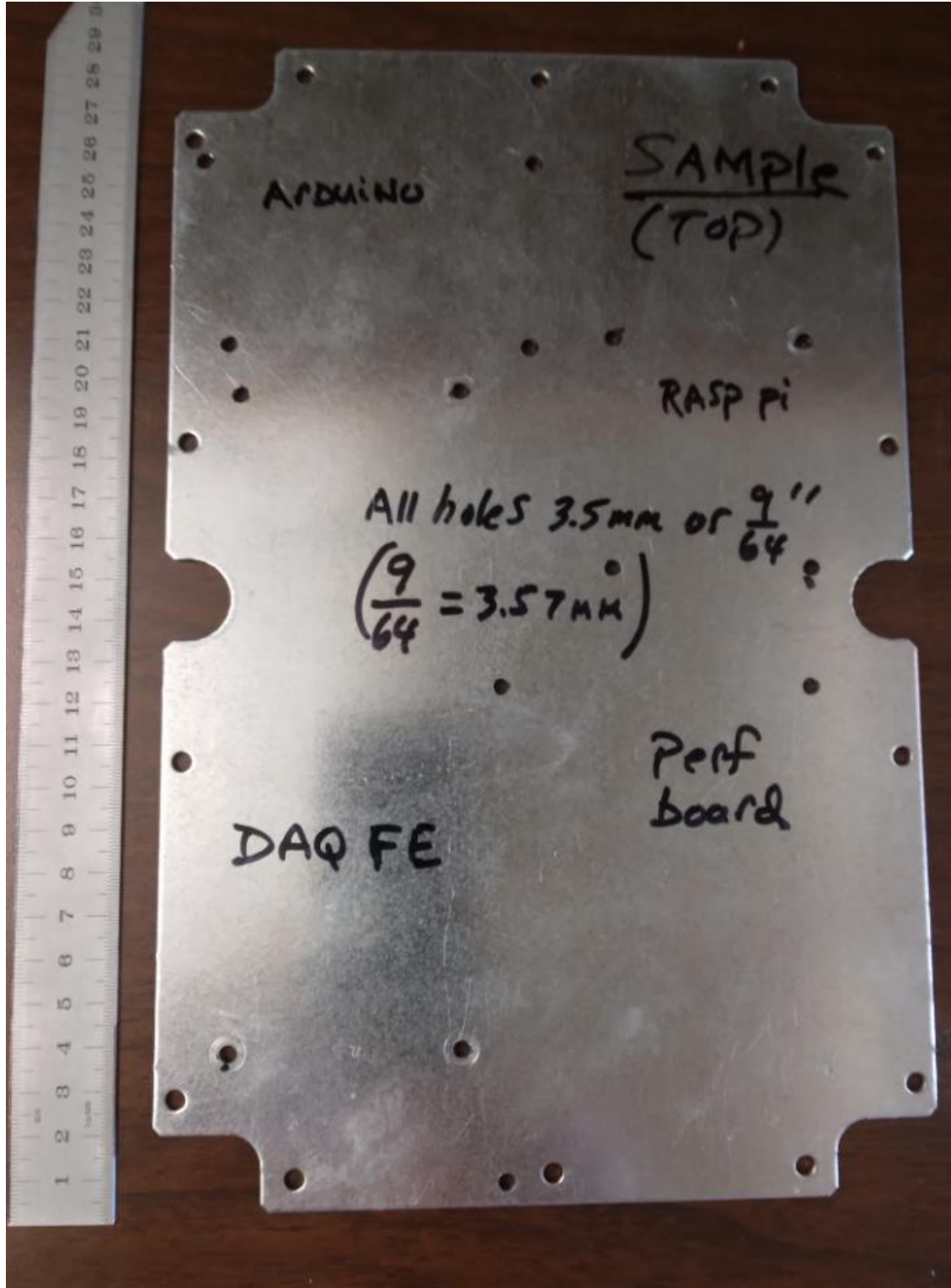
Drill 4 holes in the perfboard with a 1/8" drill bit at holes 43X, 31X, 43P, and 31P

See the example perfboard in the lab.



## Metal mounting plate

Drill holes in the mounting plate with a 9/64" drill bit (or 3.5 mm is okay); use the example template to overlay on the plate you will drill into. After drilling the holes have sharp burrs, use the tool to clean them



You can use the adjustable clamp to hold the metal plate when bolting the electronic boards to it



## Tools and hardware needed

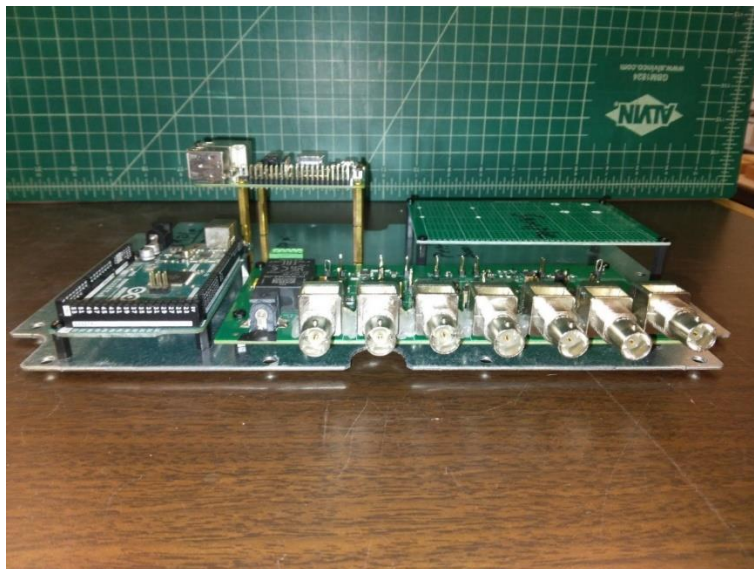
to mount standoffs: nut drivers: 5mm, 5.5mm. Small Phillips screw driver, pliers

M2.5 Standoffs needed: 12 1cm, and 12 2cm (use 8 of them to make 4 4cm standoffs)

M2.5 hardware needed: 16 washers, 20 nuts, 20 bolts (bolts heads no larger than 4.7 mm)

Mount the Raspberry Pi with 4cm standoffs, the perfboard with 2cm standoffs, the Arduino Mega and DAQ FE board with 1 cm standoffs as shown in the picture; mount the LM317s with 1cm standoffs.

When screwing standoffs onto the metal mounting plate, insert the male ends of the standoffs through the holes from the top side of the plate; the nuts screw onto the standoffs underneath the plate.



## Drilling out the enclosure

Use the various drawings and pictures below to mark on the enclosure the points where you will drill the holes, and cutouts. See the pictures for how they will look when finished.

You will need:

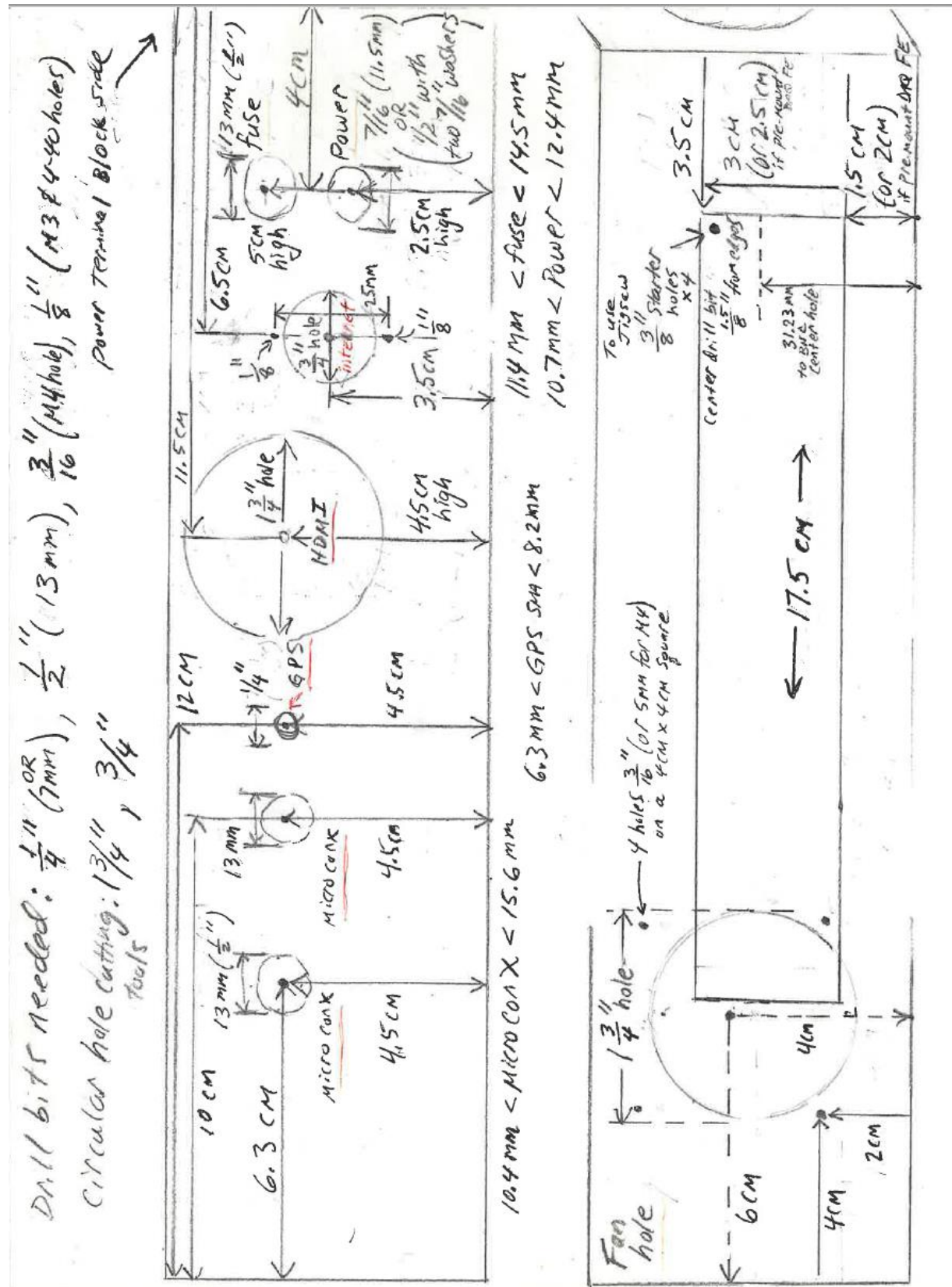
Drill press to drill all the holes

drill bits:  $1/8''$ ,  $3/16''$ ,  $1/4''$ ,  $3/8''$ ,  $1/2''$

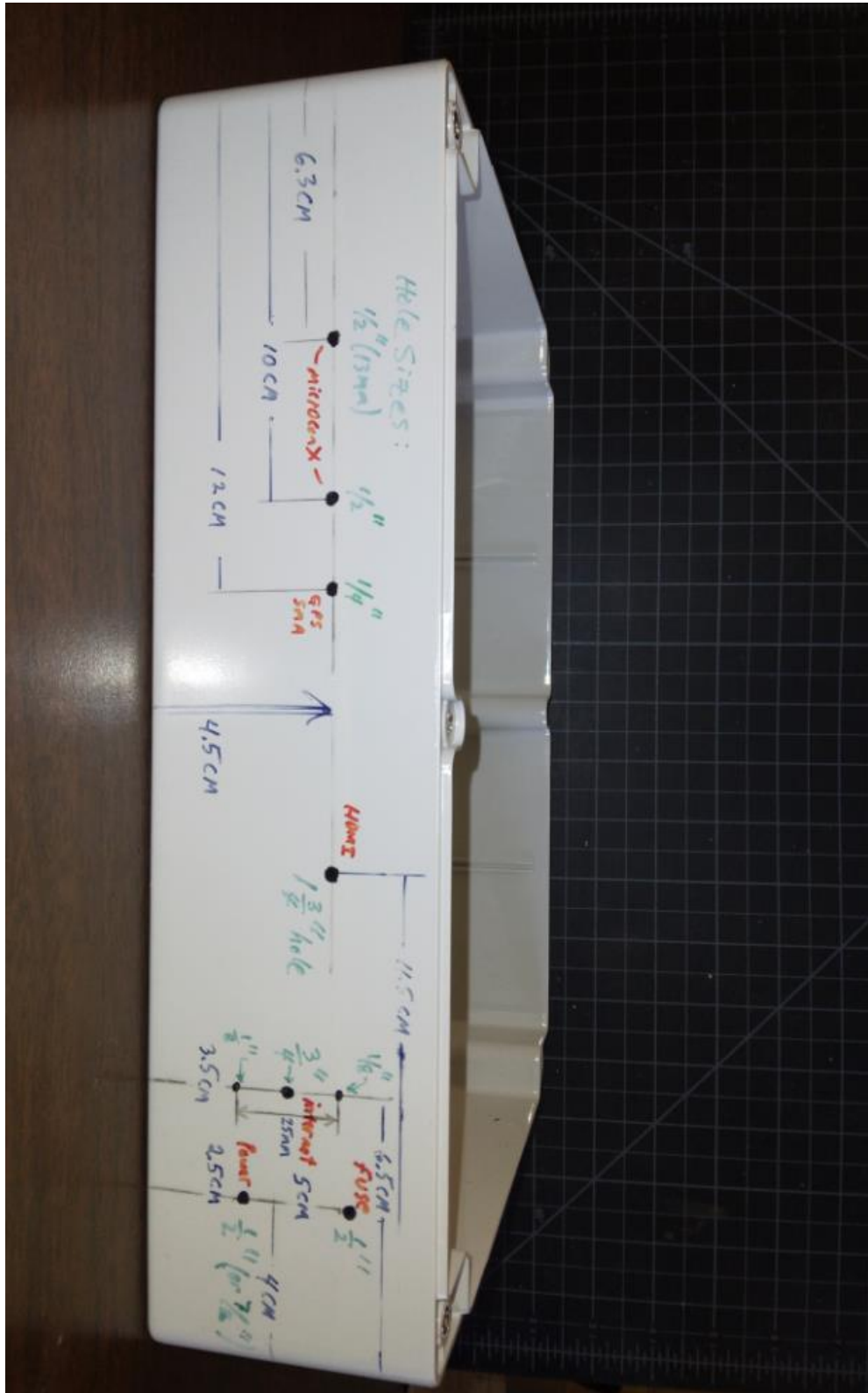
circular hole cutting tools:  $3/4''$ ,  $1\ 3/4''$

Before using the circular cutting tool drill a smaller starter hole; be careful the box doesn't spin under the torque of the drill bit or circular cutting tool

This drawing has the holes and cutouts for 3 of the 4 sides of the enclosure:



Rear side of the enclosure where all the connectors will go

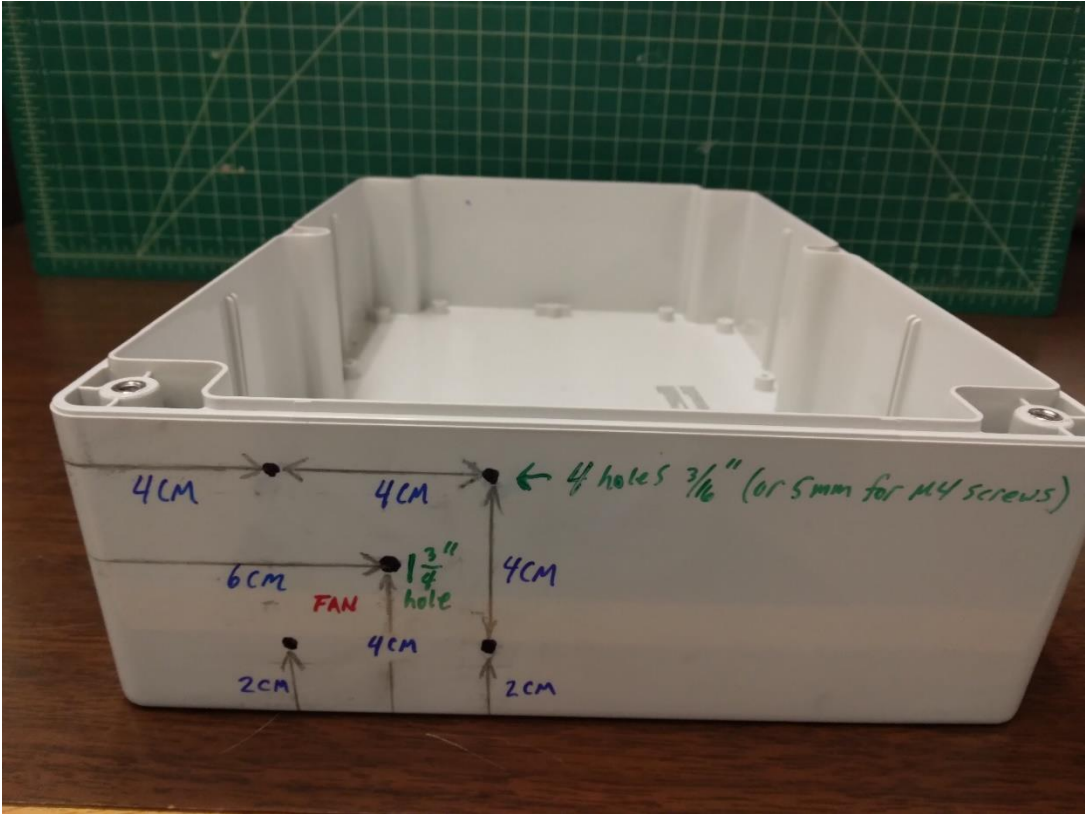




Rear side of the enclosure with all the connectors mounted



Fan side of the enclosure

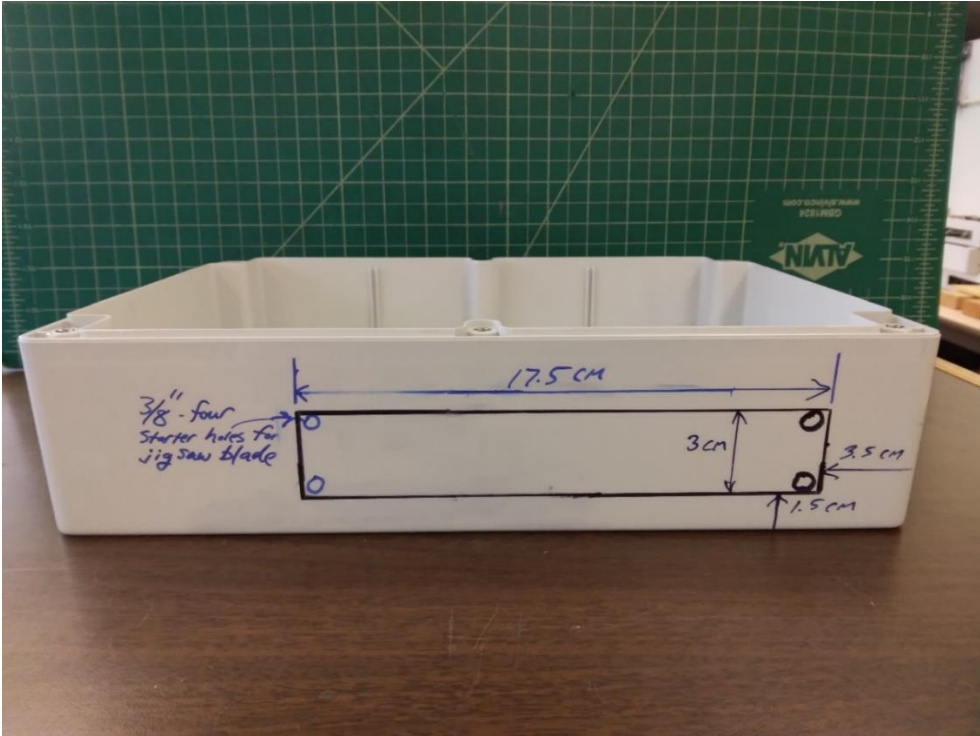


Fan side of the enclosure after cutout and holes drilled

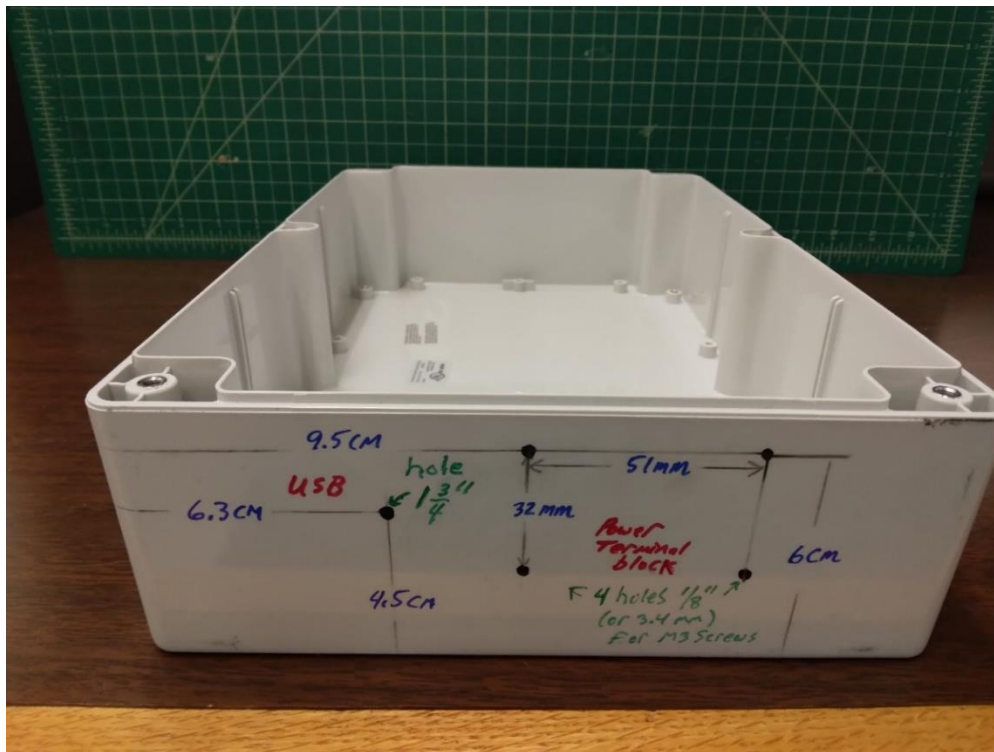
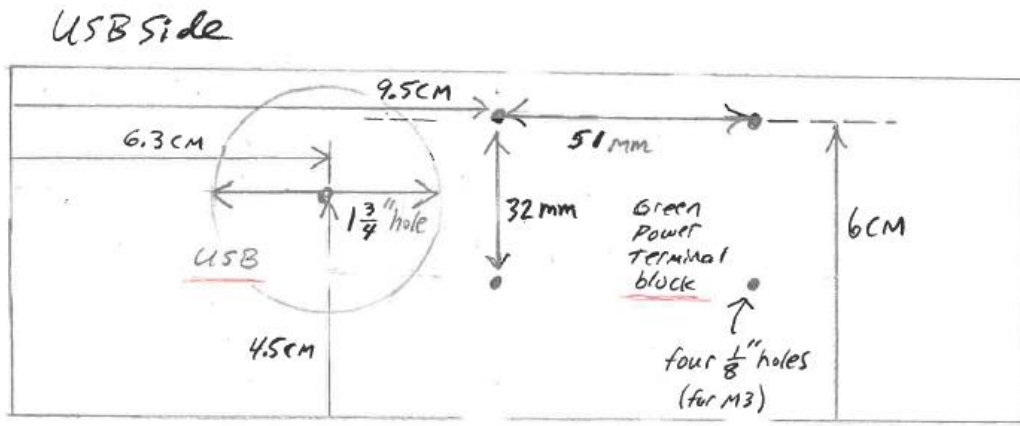


**Front side of the enclosure where the slot gets cutout for the DAQ front-end circuit board.**

Put the lid on the box and secure it in the vice when drilling and cutting out the slot. Use a 3/8" drill bit to make 4 starter holes to fit the jigsaw blade into when cutting out the rectangular slot.

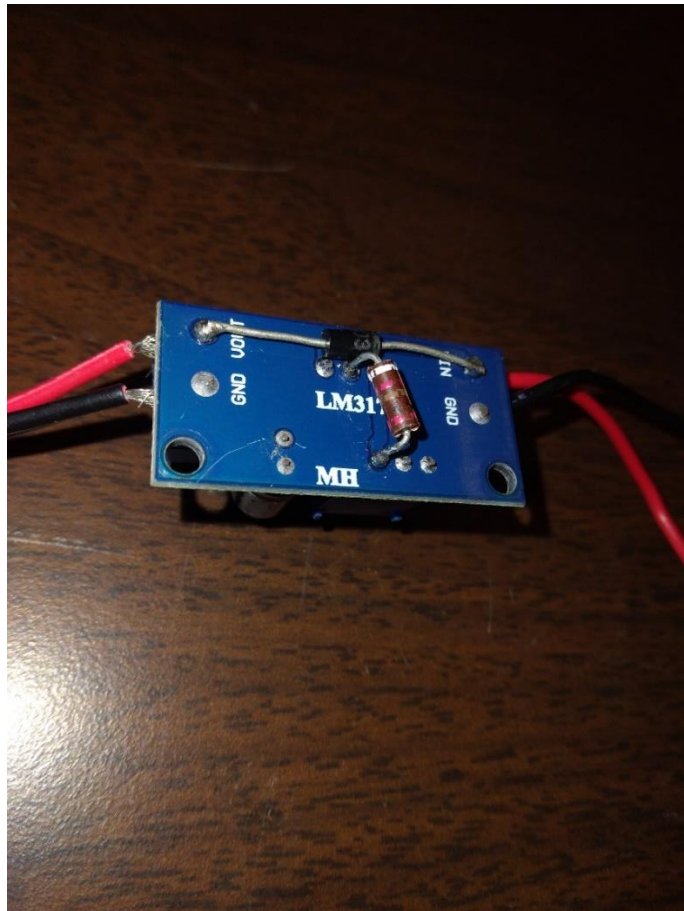
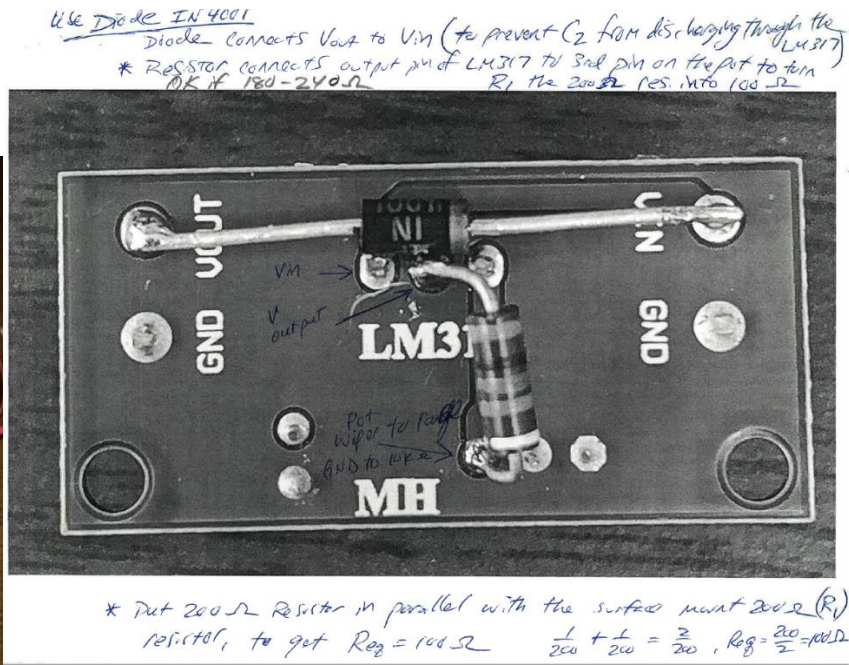


USB side of the enclosure which also has 4 holes for the power terminal block



## LM317 variable voltage regulators

On two LM317 variable voltage regulators solder a 200 Ohm resistor and Diode IN4004 underneath



## Wires and jumper wires needed

Need: 22 AWG single core wire, black 1.35m, red 1.75m. Cut the wires as described below.

Need: Fourteen 12" male-to-male jumper wires (including one black and one red). Strip and tin the ends of some of them as specified below.

TLE \_\_\_\_\_ DAQ wiring Project No. \_\_\_\_\_  
Book No. \_\_\_\_\_  
Page No. \_\_\_\_\_

22 gauge wires needed:

Black & Red (1)

- ① 15 cm for Fan - 1 blk 1 red
- ② 15 cm for DC converter - 1 blk 1 red
- ③ 10 cm for LM317 signals - 2 blk 2 red
- ④ 12" DAQ FE POWER - 1 blk 1 red
- ⑤ 30 cm (2 red, 2 black) for LM317 Power
- ⑥ Red 30 cm (1) - fuse to terminal block
- ⑦ Red 10 cm (1) fuse to quick disconnect

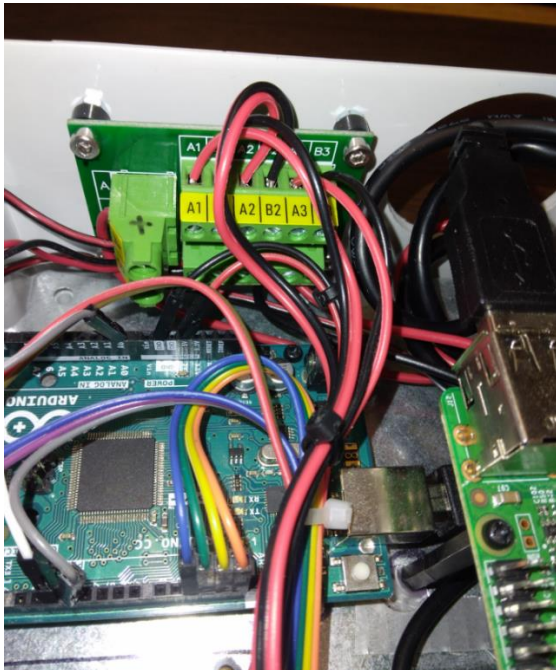
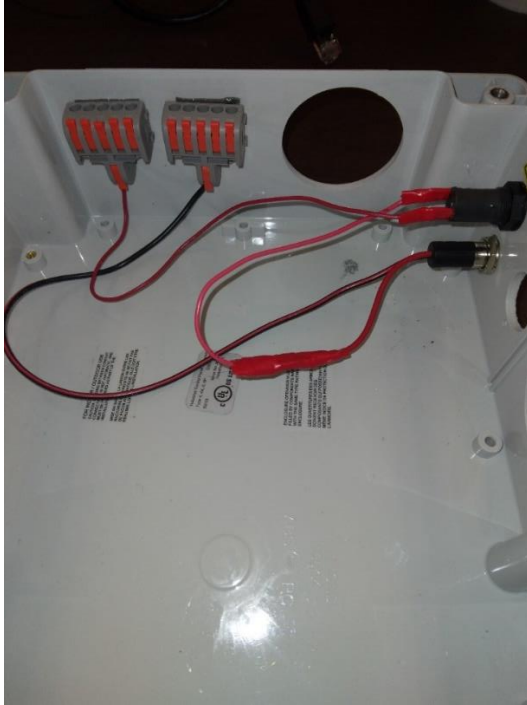
12" Jumper wires (male to male)

Arduino

- Black (1), Red (1) for 5V & GND to perf board
- 4 conductor strand from pressure/temp sensor ~~to perf board~~  
Pin 13 to SCK, Pin 12 to SDO, Pin 11 to SDI, Pin 10 to CS
- 3 conductor strand from GPS - Strip and tin ends of one side  
Pin 3 to PPS, Pin 18 (Tx1) to RX, Pin 19 (Rx1) to TX
- 3 conductor strand from DAQ FE  
Strip and tin ends of one side  
Pin A to PK, Pin 14 (Tx3) to RST, Pin 2 to TRG
- 2 conductor strand from LED Backpack counter  
Strip and tin ends of one side  
Pin 20 (SDA) to 'D'  
Pin 21 (SCL) to 'C'

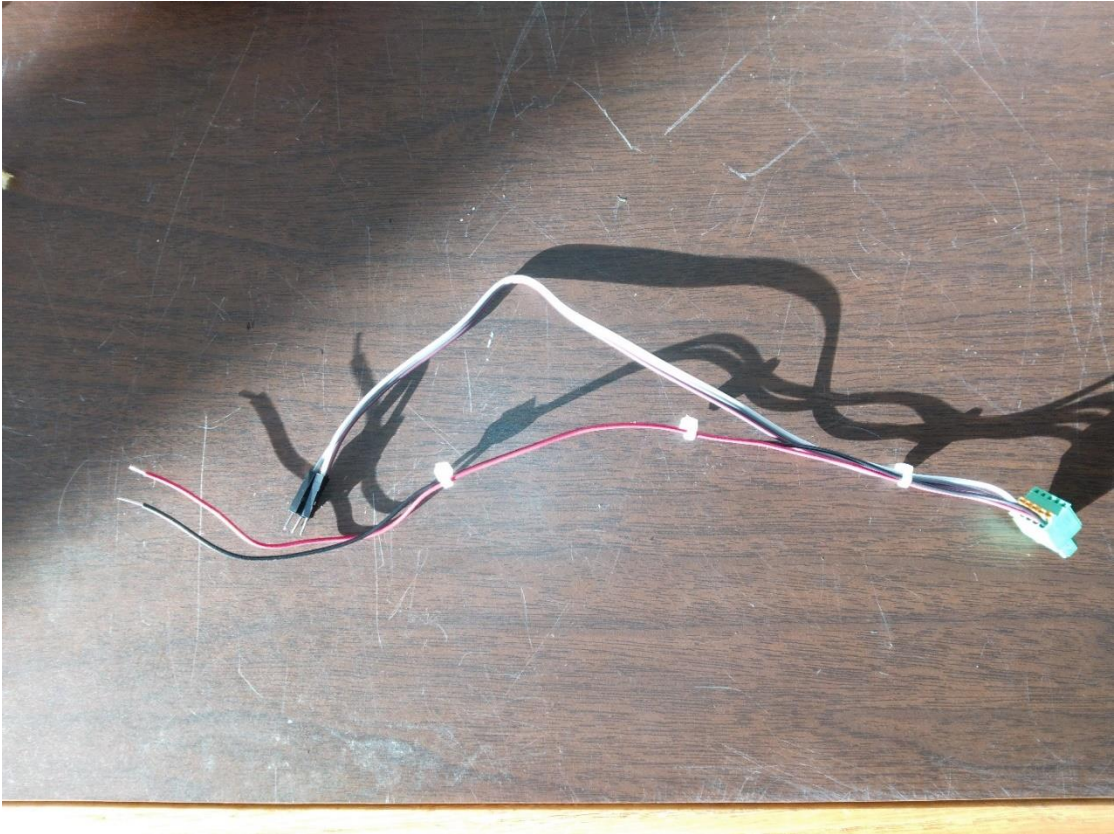
## Terminal block for 15V power into the box from the power supply

Wire the power input connector to the fuse using a quick disconnect connector on the positive red wire. The power connector requires a washer with an ID of  $7/16''$ , and an OD between:  $1/2'' < OD \leq 7/8''$ . The two gray terminal blocks with orange tabs are an older design; now we are using the green terminal block shown in the bottom picture.

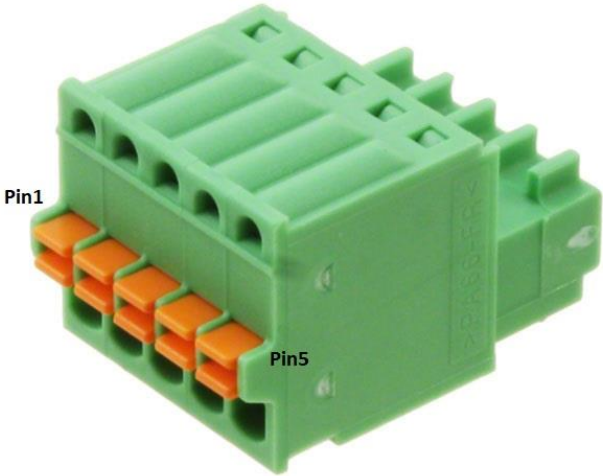


### Connector for the DAQ Front-End electronics board

Assemble the wires to this Phoenix Contact connector that plugs into the DAQ front-end PCB. There are 5 wires, two bring +15V and GND, and three bring signals to and from Arduino board



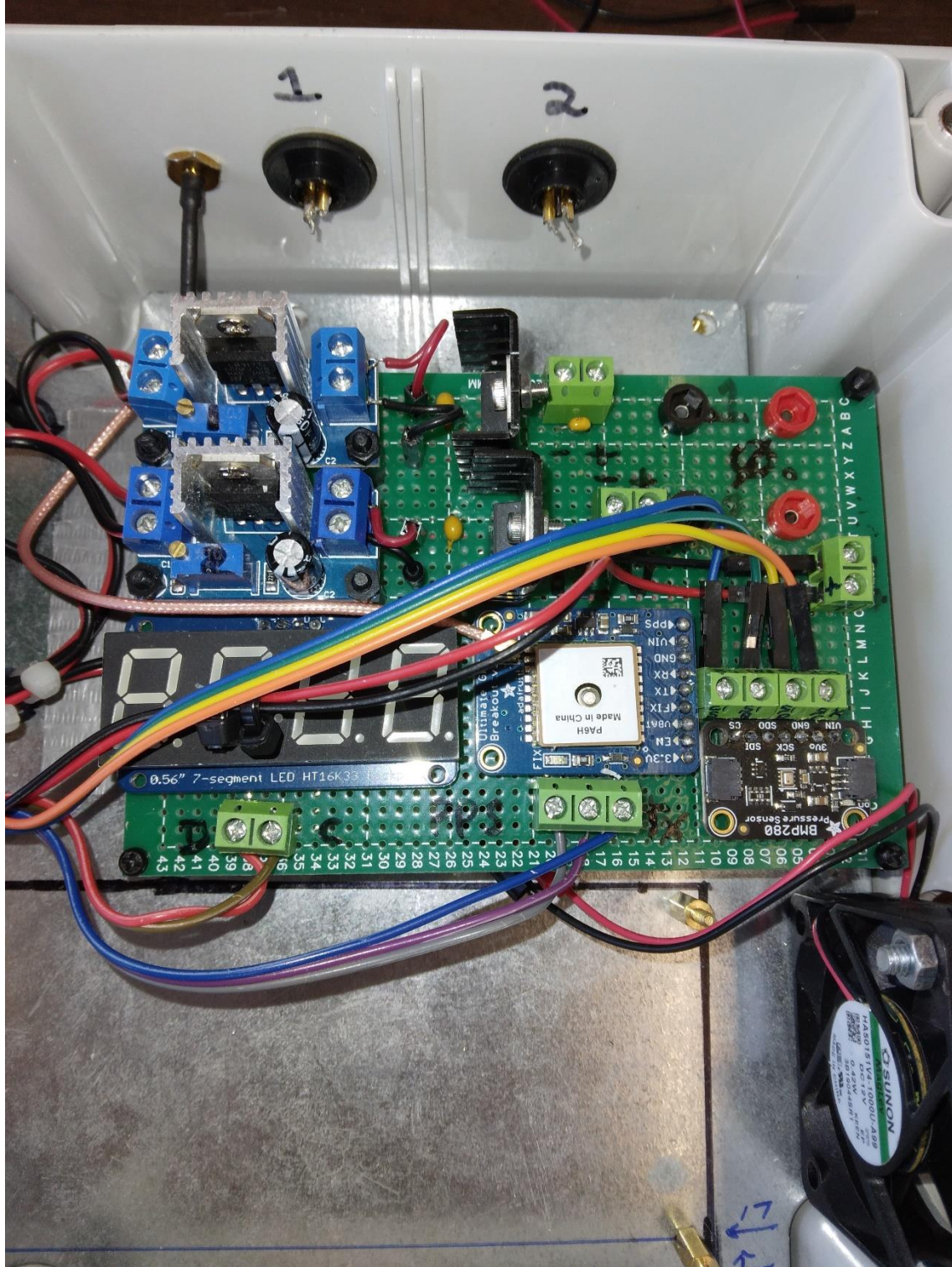
- |  |                 |
|--|-----------------|
| <b>Connector:</b>                      | <b>Arduino:</b> |
| pin1                                   | pin2 (trigger)  |
| pin2                                   | pin A0 (peak)   |
| pin3                                   | pin14 (TX3)     |
| pin4- to main terminal block A4 (+15V) |                 |
| pin5- to main terminal block B4 (GND)  |                 |





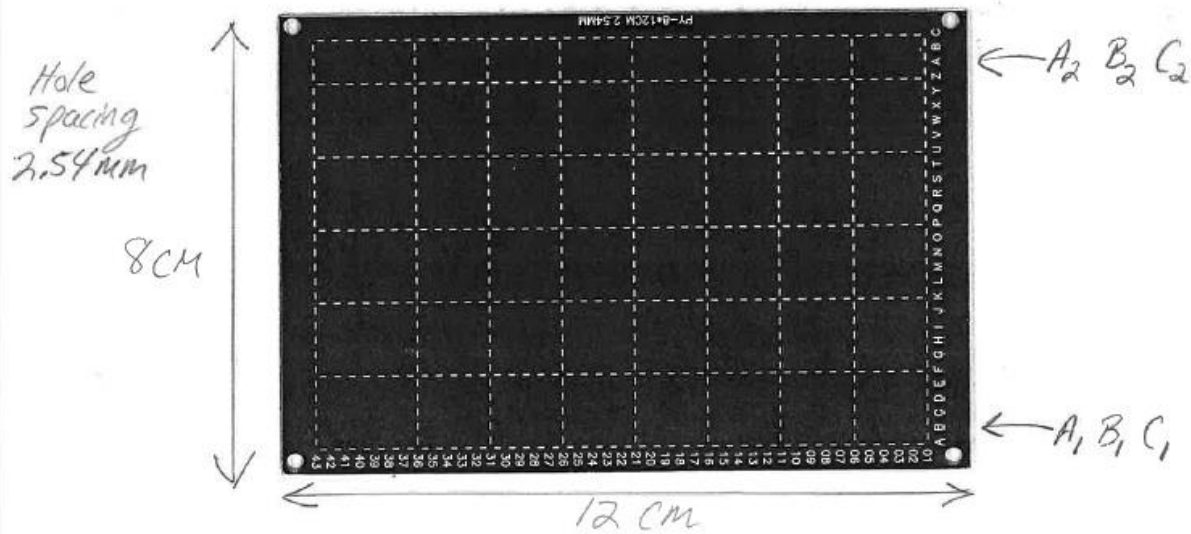
## The Perfboard when fully assembled

Assemble the electronics components on the perfboard and solder all the connections. there are several drawings and tables below that describe how this is done. This is what it will look like when finished:



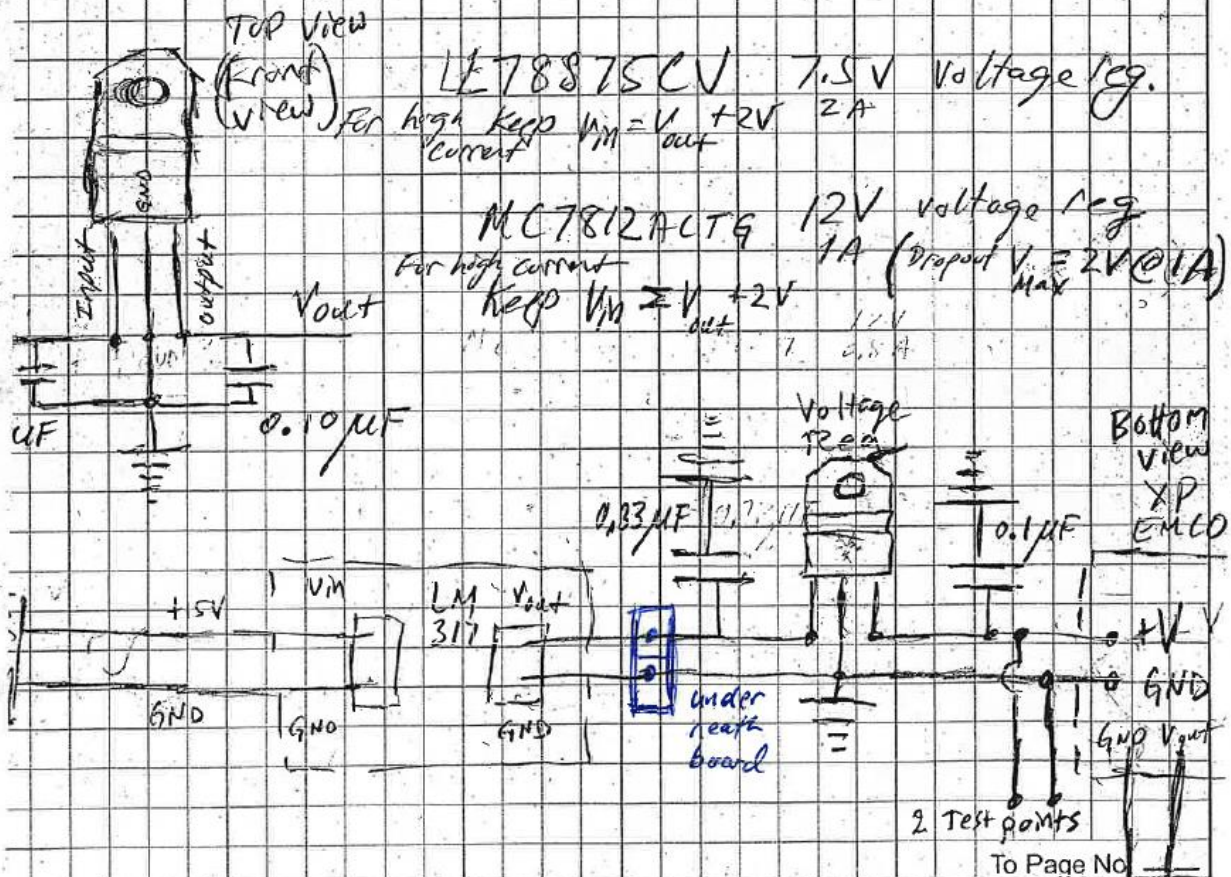
## Placing of electrical components on the perfboard

- 1 Drill four  $\frac{3}{16}$ " holes for test points at  $11B_2$   $4B_2$   $11U$   $4U$   
Black Red Black Red
- 2 Drill four  $\frac{1}{8}$ " holes for LM3175:  
 $43X$   $31X$   $43P$   $31P$
- 3 Solder four 4cm wires to board: Red:  $28B_2$  &  $28T$  Black  $28Y$  &  $28Q$
- 4 Capacitors  $\#334$   $.33\mu F$   $26C_2$   $26A_2$   $\#104$   $0.1\mu F$   $19A_2$   $17A_2$
- 5 Capacitors  $.33\mu F$   $26U$   $26S$   $.1\mu F$   $16S$   $14S$
- 6 Voltage Regulator  $23B_2$   $23A_2$   $23Z$   
input pins GND output pins
- 7 Voltage Regulator  $23T$   $23S$   $23R$   
input pin output pin
- 8 Terminal blocks for Voltage Regulators  $17C_2$   $19C_2$
- 9 Terminal block for voltage Regulator  $14U$   $16U$
- 10 LCD counter  $34N$   $35N$   $36N$   $37N$  Terminal block  $36B_1$   $38B_1$
- 11 GPS  $12F$  to  $12N$  Terminal block  $16C_1$   $18C_1$   $20C_1$
- 12 Temp-pressure sensor  $3G$  to  $9G$  Terminal block  $4J$   $6J$   $8J$   $10J$
- 13 Terminal block for 5V power  $2P$   $2R$



# Voltage Regulator connections to capacitors and terminal blocks

LM317 only needs to apply  $\leq 9.08V$   
 but could apply up to  $13.75V$  if use  $15V$  p.  
 $P_{max}$  output =  $3W$ , so too low.  
 $I_{max}$  output =  $1.5A$ , okay

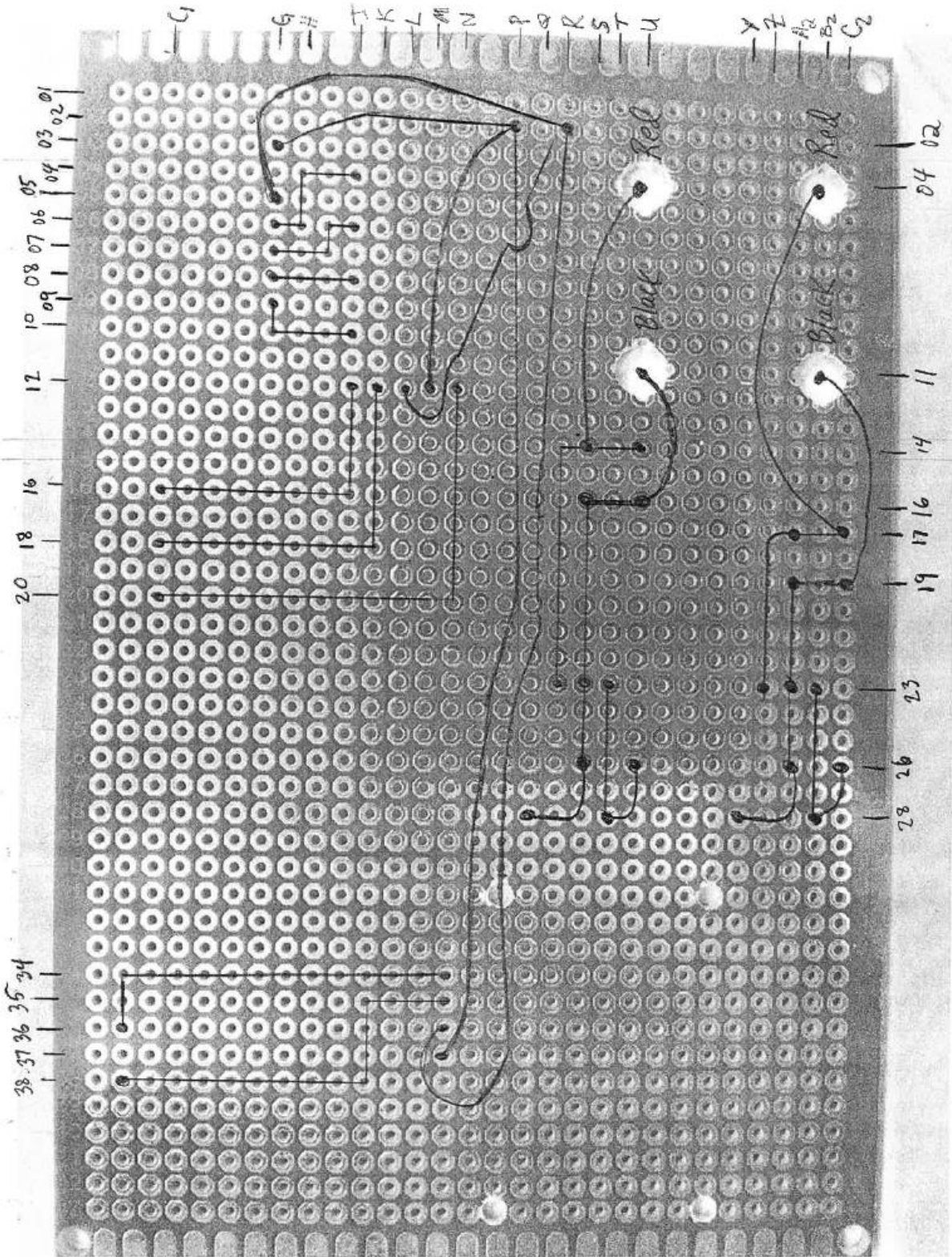


& Understood by me, Date Invented by: Date  
 Recorded by:

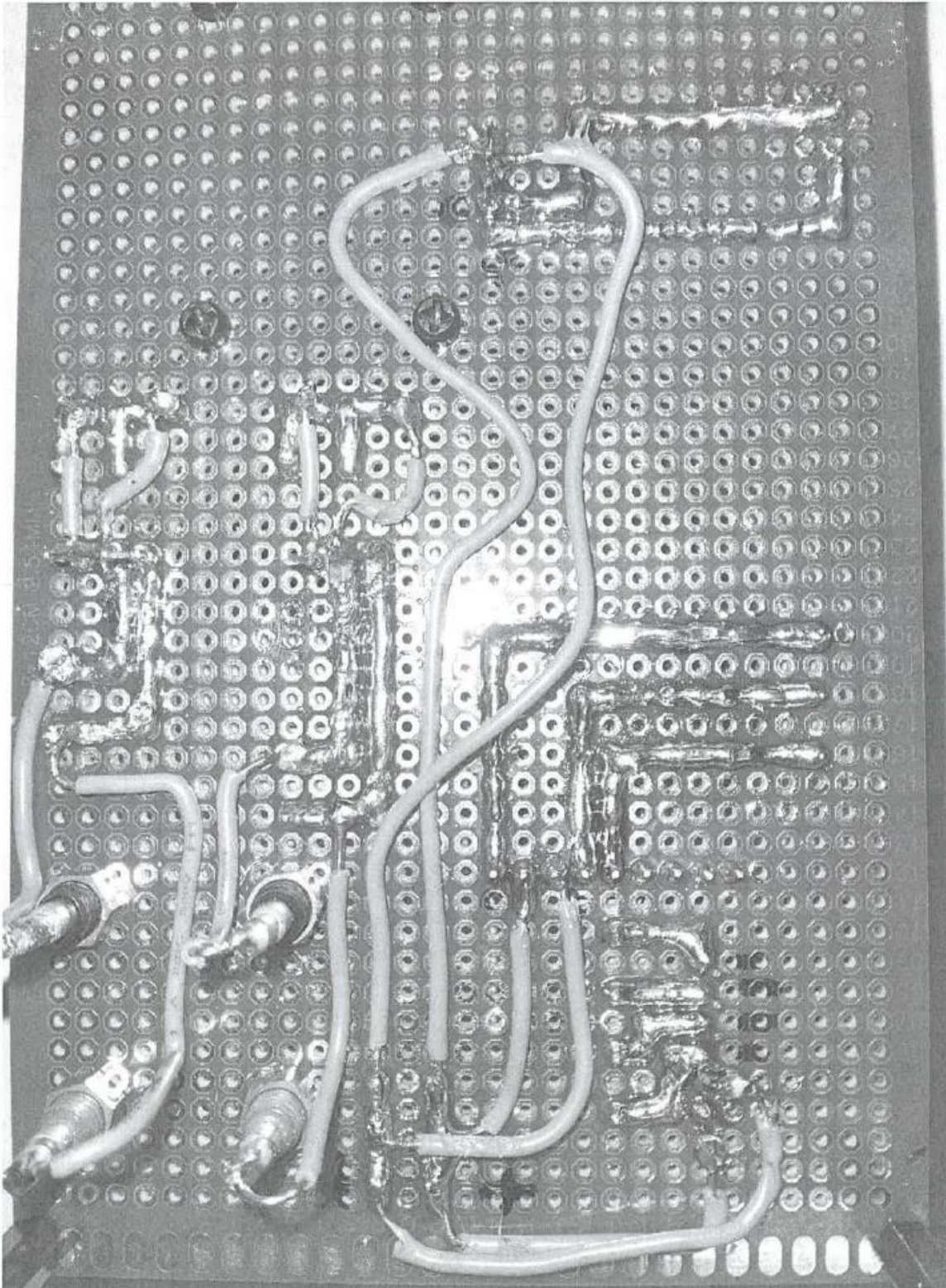
PMT



This shows the soldering connections to make on the underside of the perfboard



This shows you an example of the soldering connections on the underside of the perfboard



These are the solder connections on the underside of the perfboard. The sizes of the standoffs needed for the LM317s, and other boards, are below.

### DAQ perfboard solder connections

38B<sub>1</sub> - 35N

36B<sub>1</sub> - 34N

36N - 02R

37N - 02P

20C<sub>1</sub> - 12N

18C<sub>1</sub> - 12K

16C<sub>1</sub> - 12J

12L - 02R

12M - 02P

9G - 10J

8G - 8J

7G - 6J

6G - 4J

5G - 2R

3G - 2P

28Q - 26S - 23S - 16S - 16U - 11U

23R - 14S - 14U - 4U

28T - 23T - 26U

28Y - 26A<sub>2</sub> - 23A<sub>2</sub> - 19A<sub>2</sub> - 19C<sub>2</sub> - 11B<sub>2</sub>

23Z - 17A<sub>2</sub> - 17C<sub>2</sub> - 4B<sub>2</sub>

28B<sub>2</sub> - 23B<sub>2</sub> - 26C<sub>2</sub>

### Standoff sizes

Raspberry Pi 4cm

DAQ Perfboard 2cm

Arduino 1cm

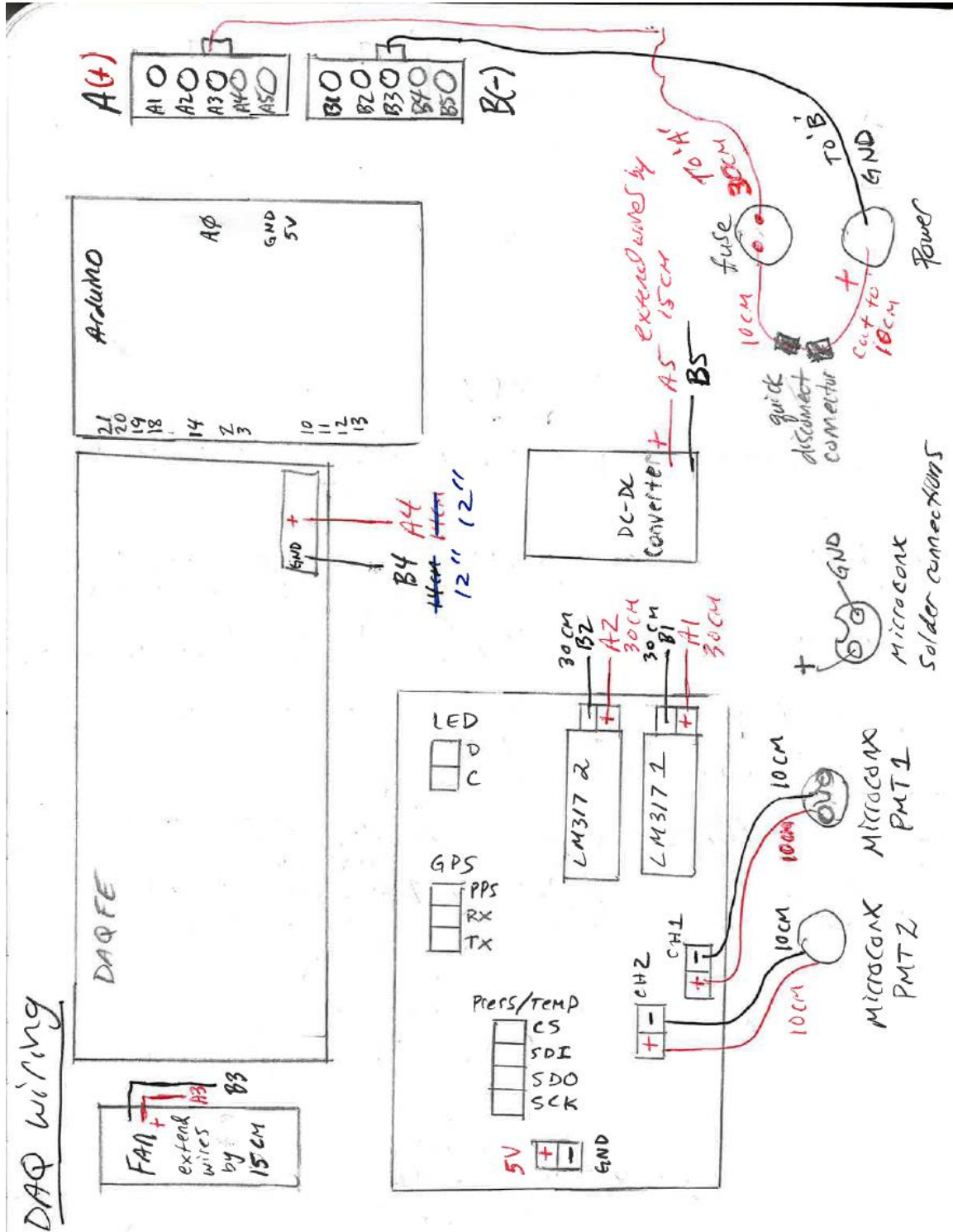
LM317s 1cm

DAQ FE 1cm





The wires will be used to make various connection in the DAQ enclosure; see the drawing:



## **Wire connections from Arduino board to electronic boards mounted on perfboard**

### **BMP280 sensor**

pin sck to Arduino pin 13

pin sdo to Arduino pin 12

pin sdi to Arduino pin 11

pin cs to Arduino pin 10

BMP280 +5V and GND are connected to Arduino +5V and GND through perfboard

### **GPS Receiver**

Pin pps to Arduino pin 3

Pin RX to Arduino pin 18 (TX1)

Pin TX to Arduino pin 19 (RX1)

GPS +5V and GND are connected to Arduino +5V and GND through perfboard

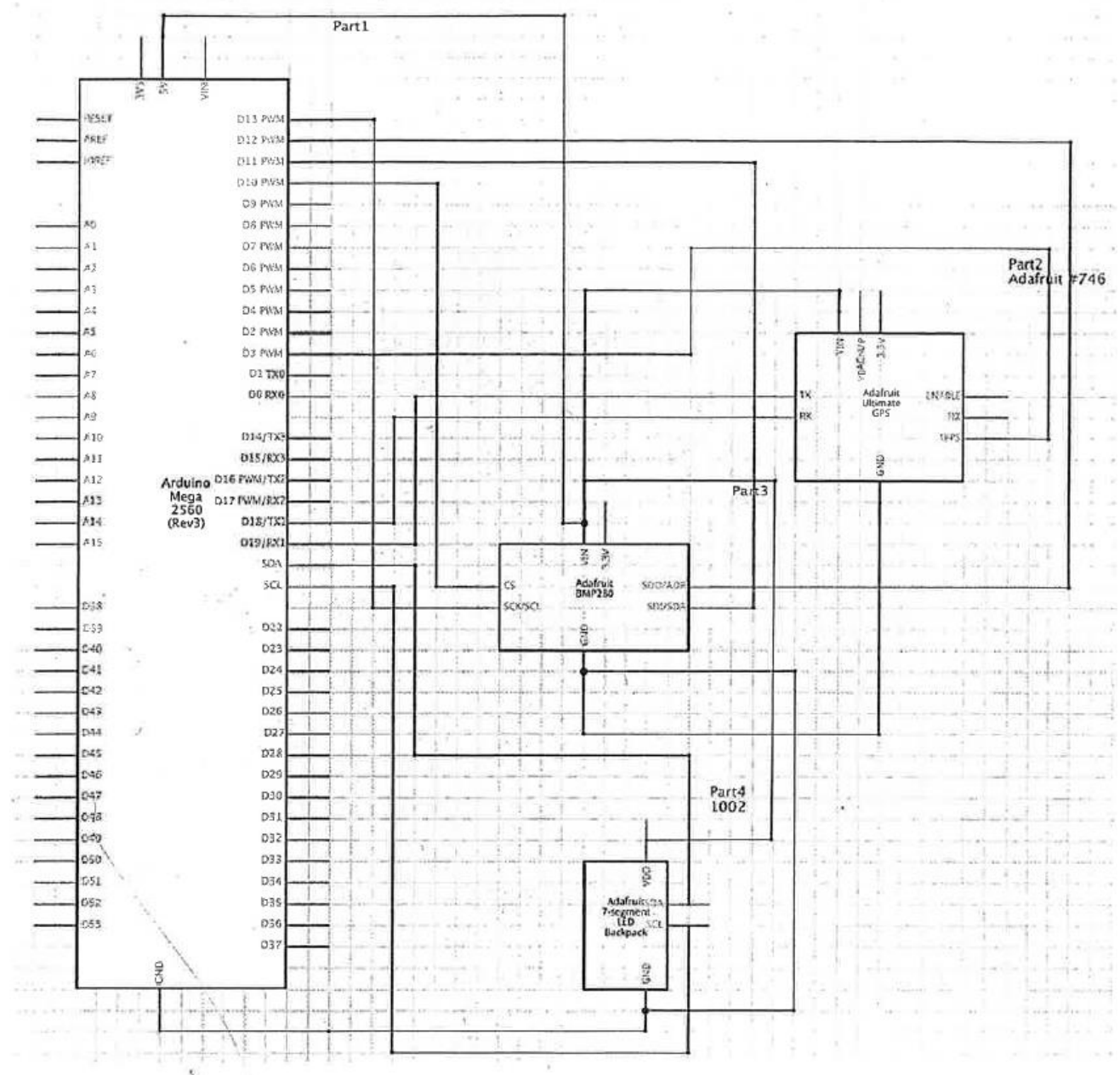
### **LED counter, 7-segment display**

Pin D to Arduino pin 20 (SDA)

Pin C to Arduino pin 21 (SCL)

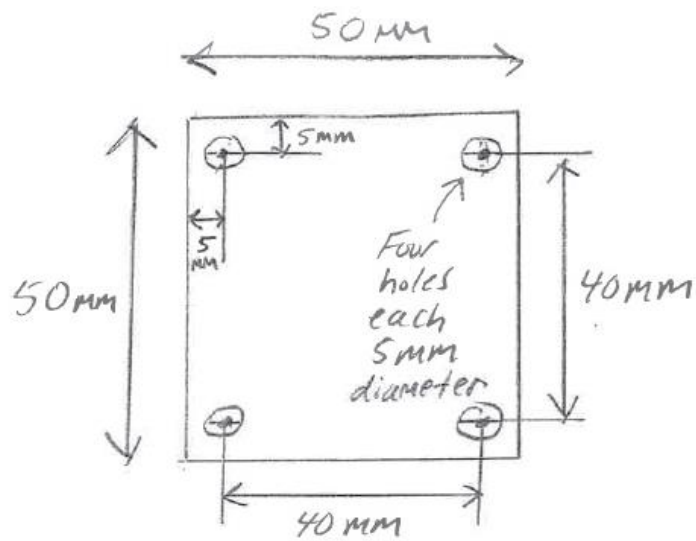
LED +5V and GND are connected to Arduino +5V and GND through perfboard

**Wiring between Arduino and electronic boards (the +5V and GND connections are made through the perfboard)**



### 3D-printed fan cover

DAQ FAN COVER - 3D PRINT FOR SIRON FAN

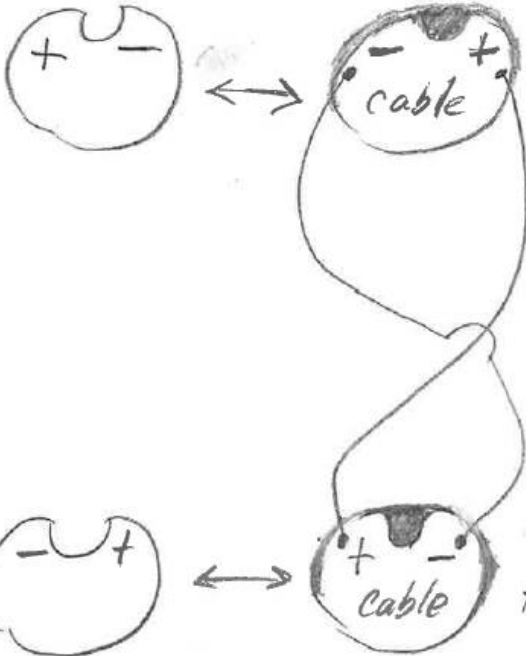


Two MicroConX connectors for low voltage power wires extending from DAQ box (LM317 output) to DC-DC converter (PMT input power)

## MicroConX and MiniConX connections

MicroConX  
female connector  
on DAQ box

MicroConX  
Male connector  
on cable that  
connects to DAQ box



MicroConX  
female connector  
on EMCO 630 box

and  
MiniConX female  
connector on  
Rifle case

MicroConX  
male connector  
that connects  
to EMCO 630 box

and  
MiniConX  
male connector  
that connects  
to Rifle case  
EMCO 620



122	Female socket terminal block wire connector to connect to DAQ FE PCB terminal block	TERM BLOCK PLUG 5POS STR 2.5MM	"Female socket"	Phoenix Contact	1881354	Digikey 277-1433-ND		\$7.87	1	<a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a>	
123	Mounting Bases, to tie/wrap down wires	0.78" square	Black	HUSASU		Amazon B09PDDNKCZ		\$9.99 (qty 100)		<a href="https://www.amazon.com/Hs-M">https://www.amazon.com/Hs-M</a>	
124	Jumper wires, Male/Male - pack of 20 x 12"					Mouser 485-1955		\$3.95 qty 20	14 wires	<a href="https://www.mouser.com/Product">https://www.mouser.com/Product</a> <a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a>	
125	Wire 22 AWG black, single core (cut into piec need 1.35m total					Adafruit				<a href="https://www.amazon.com/ELECT">https://www.amazon.com/ELECT</a>	
126	Wire 22 AWG Red, single core (cut into piece need 1.75m total									<a href="https://www.amazon.com/ELECT">https://www.amazon.com/ELECT</a>	
127	2 Conductor 1m, Black, Red	22 AWG		Tensility Internat	30-00417	Digikey T1307-1-ND		\$2.02	2	<a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a>	
128											
129	<b>Hardware for boards:</b>										
130	Standoff, hex 1cm alum, male-female, M2.5-4.5mm, 25 pack			for Arduino, LM317, DaqFE		Amazon B01MOP0IOF		\$12.83	12	<a href="https://www.amazon.com/UNIC">https://www.amazon.com/UNIC</a>	
131	Standoff, hex 2cm alum, male-female, M2.5-4.5mm, 25 pack			for perfBoard (2cm), Pi (4cm)		Amazon B01LXF8JH		\$13.09	12	<a href="https://www.amazon.com/UNIC">https://www.amazon.com/UNIC</a>	
132	Bolt M2.5, 6mm, for 2cm standoff			Small Parts Class 4.8 Steel Machine Screw, Zinc Plat		Amazon B000NHVQ7S		\$6.13 (qty 100)	19	<a href="https://www.amazon.com/dp/BK">https://www.amazon.com/dp/BK</a>	
133	Washer, flat, M2.5 stainless, 100 pack, for standoffs					Amazon B0844SPW74		\$6.93	16	<a href="https://www.amazon.com/M2-5">https://www.amazon.com/M2-5</a>	
134	Nuts, M2.5 (thread pitch 0.45mm) hex, stainless, 200 pack, for standoffs					Amazon B086474KGM		\$7.99	20	<a href="https://www.amazon.com/HELIF">https://www.amazon.com/HELIF</a>	
135	Nuts (for Pi), M2.5 (thread pitch 0.45mm) hex, nylon, 50 pack; Amazon = Blk, Digikey = white					Digikey RPC7085-ND Amazon B09Q563KCC		3.53 8.51	4	<a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a> <a href="https://www.amazon.com/M2-5">https://www.amazon.com/M2-5</a>	
136	Optional: Screw for standoffs, M2.5 (thread pitch .45mm), nylon, slotted, 100 pack					Amazon B00137P0A4		\$6.65		<a href="https://www.amazon.com/Mach">https://www.amazon.com/Mach</a>	
137	OPTIONAL in bulk: NOT GOOD QUALITY										
137	Standoffs kit 450PCS M2.5 Nylon, Hex		male-female, female-female	Yontafeng	HTM25P4508	Amazon B085LTQXX8		\$13.99		<a href="https://www.amazon.com/dp/BK">https://www.amazon.com/dp/BK</a>	
138											
139	USB2.0 A Male to Right Angle USB B Male Cabli 12", black			Inovat		Amazon B01HB91CRM		\$7.99	1	<a href="https://www.amazon.com/dp/BK">https://www.amazon.com/dp/BK</a>	
140	Ethernet cable, jack to plug panel mount, 1 ft	JACK-PLUG 0.98"	unshielded CAT5	Adafruit	909	Digi-key 1528-1572-ND	total L = 0.98 ft (303 mm	\$4.95	1	<a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a>	
141	Test point, panel mount, red 20 AWG	BAN2 F DLP INSUL	Tip Jack	Radiall USA, Inc.	R921921000	Digi-key 2201-R92192100 Red, Tip Jack L = 0.744"		\$1.81	2	<a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a>	
142	Test point, panel mount, black 20 AWG	BAN2 F DLP INSUL	Tip Jack	Radiall USA, Inc.	R921920000	Newark 55X2163	Black, Tip Jack, L = 0.74	\$1.81	2	<a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a> <a href="https://www.newark.com/radiall">https://www.newark.com/radiall</a>	
143	Terminal Block Connector 60pcs 2 & 3 Pin	need 8 two-termin	14-22 AWG, gree	Tiiseasm	CATN-T03G	Amazon B088LS14I		\$8.98 (60 pieces)	1 three	<a href="https://www.amazon.com/Tiise">https://www.amazon.com/Tiise</a> <a href="https://www.digikey.com/en/prc">https://www.digikey.com/en/prc</a>	

144	Fan for enclosure	FAN AXIAL 50X15MM VAP0 12VDC0	Sunan	HA50151V4-1000U	Digi-Key 259-1816-ND	M4 x 25 mm		\$3.87	1	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
145	Screws (needs nuts) for Sunan Fan	M4 x 25mm (or use 8-32 x 1")								<a href="https://www.amazon.com/">https://www.amazon.com/</a>
146	DC Buck Converter 12V to 5V 3A 15W Micro US 2 PCS DC Converter For Rasp Pi		yuSheng/Esrakee	ES-M4PVMFT	Amazon B098QZQ8FT	M4 x 25 mm		\$7.99 (qty 50) (2 is ok)	2	<a href="https://www.amazon.com/">https://www.amazon.com/</a>
147	Double Sided Tape, 3M, Waterproof, High Tem 0.5" x 15.6'		Aideepen (Amazon)	RS-5952-Z	Amazon B09TFLZMC2	46x14x27mm (1.81x0.5		\$11.99 for 2	2	<a href="https://www.amazon.com/">https://www.amazon.com/</a>
148	Arduino Mega 2560		Rusenweelite	A000067	Amazon B08JTSVZM1	0.5" x 15.6'		\$8.99 roll	1	<a href="https://www.amazon.com/">https://www.amazon.com/</a>
149	Raspberry Pi 3 B+		Arduino	A000067	Mouser-358-RPI3-MODSP-BULK			\$48.40	1	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
150	SD Card, 10 pack, micro SD HC		Pi 3 B+		Amazon B0876H87X			35.00 Digikey	1	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
151	Digital counter							\$34.98	1	<a href="https://www.amazon.com/">https://www.amazon.com/</a>
152	Barometric Press., Temp, Alt sensor								1	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
153	6" Cable for GPS antenna-to-receiver		Adafruit	2651	Digikey 1528-1473-ND			\$9.95	1	<a href="https://www.amazon.com/">https://www.amazon.com/</a>
154	GPS receiver breakout board		Adafruit	851	Digikey 1528-2053-ND			\$3.95	1	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
155			Adafruit	746	Digikey 1528-1153-ND			\$29.95	1	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
156	GPS external Antenna 28dB gain		Active antenna 3	960	Digikey			\$14.95	1	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
157									1	<a href="https://www.adafruit.com/">https://www.adafruit.com/</a>
158	can purchase in bulk:								1	
158	Perboard 8x12 cm, copper clad, prototype	includes 5.7x9cm,						\$11.99 (qty 10)	1	<a href="https://www.amazon.com/">https://www.amazon.com/</a>
159	2 position connector receptacle (female)	5.8x12cm	YUNGU	ALL	Amazon B07FVDW5C			\$6.88	2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
160	2 position connector plug (male)	micro conx cable c	micro - panel mo	17282-25G-300	Digi-Key: 17282-25G-300			\$7.45	2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
161		micro conx cable c	micro - cable enc	16282-2PG-311	Digi-Key: SC1202-ND				2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
162	<b>DAQ - LM317:</b>									
163	LM317 voltage regulator with pot	LM317 adjustable	Hiletgo	B07VDPZ2L				11.29 (for 10)	2	<a href="https://www.amazon.com/">https://www.amazon.com/</a>
164	200 Ohm (180-240 Ohm is ok) resistor for LM317		ProtoSupplies	PWR-1				1.95	2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
165	Diode 1N4001 for LM317								2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
166	12V Linear Voltage Regulator IC Positive Fixed 1 Output 1A TO-220								2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
167	7.5V Linear Voltage Regulator IC - 2 Amp								2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
168	HEATSIK TO-220 2.5W LOW PROFILE							\$1.07	2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
169	Bolt M3 6mm, (or 4-40 0.0025") for heatsink							\$0.28	2	<a href="https://www.digikey.com/">https://www.digikey.com/</a>
170	Nut M3 (or 4-40), for heatsink to regulator								2	
171	Capacitor 0.33 microF (for Volt Reg input)								2	
172	Capacitor 0.1 microF (for Volt Reg output)								2	