Mt Carmel High School Amateur Radio Club Ocean Buoy Project

Task description: Mt Carmel High School, in San Diego, CA has an amateur radio club which consists of a group of science students. These students, with the aid of the physics teacher and a group of licensed radio amateur volunteer mentors are designing an ocean buoy. This buoy will contain batteries and a transmitter that sends signals on the 20 meter (14.1 MHz) amateur radio band. Signals on this frequency band propagate 1000s of miles due to refraction from the ionosphere. The transmissions from the buoy will take advantage of an existing network of 1000s of radio amateurs around the world that monitor signals from other amateurs to map out radio propagation in real time and upload reception reports to a web page. The buoy will send GPS location, battery voltage and temperature. The battery life is expected to be six months.

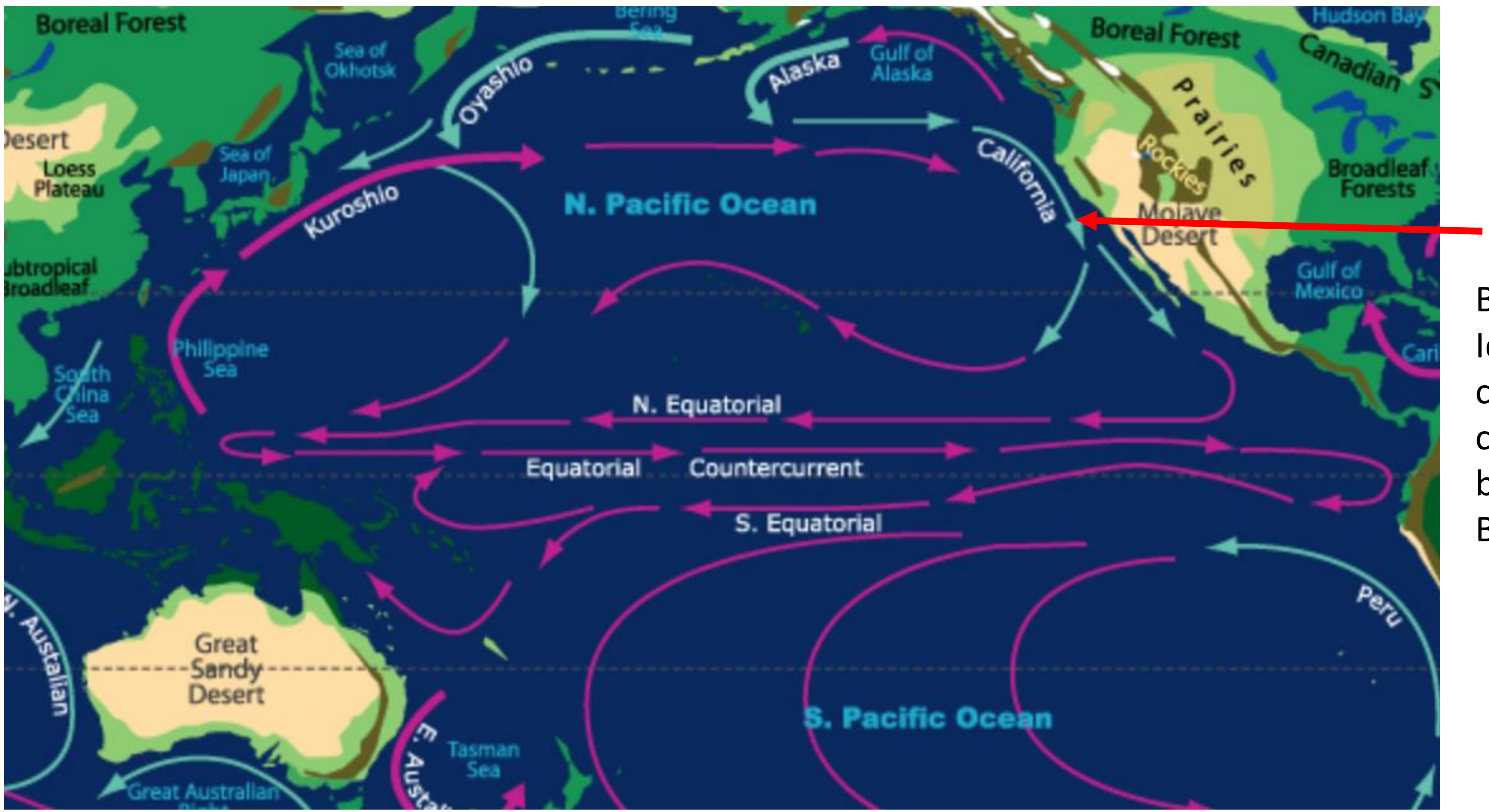
Deployment: Our plan is to have the buoy dropped of from a boat so that it starts its journey heading south in the California Current. From there we hope it continues, heading west when it reaches the northern equatorial current.

Help needed from the Boating Community: Two things; a ride, and advice on drop off location. We have little experience with ocean currents. However, from the little asking around we did, concern has been expressed that if the buoy is not released out far enough there is a good chance it might end up back on the west coast of CA or Baja.

Plan: There will be two buoys. The first will be a "prototype" built by the mentors to test the design. Expected completion late February 2020. The second will be built by the students. Completion expected late May 2020.

Photo of buoy prototype. 4 inch size plastic pipe. Weight 37 lbs. Length = 15 feet total (5 feet pipe below water surface, 1 foot above water surface, 9 foot long whip antenna).

Ocean Currents



Buoy drop off point:
Ideally far enough offshore to be carried south by the California current, and unlikely to end up back on the beach in the USA or Baja California.

Contact information: Randy Standke (619) 890-2697. Email r55stan@gmail.com

Details and Notes Compiled during Development

Adapting a balloon payload for use in a buoy.

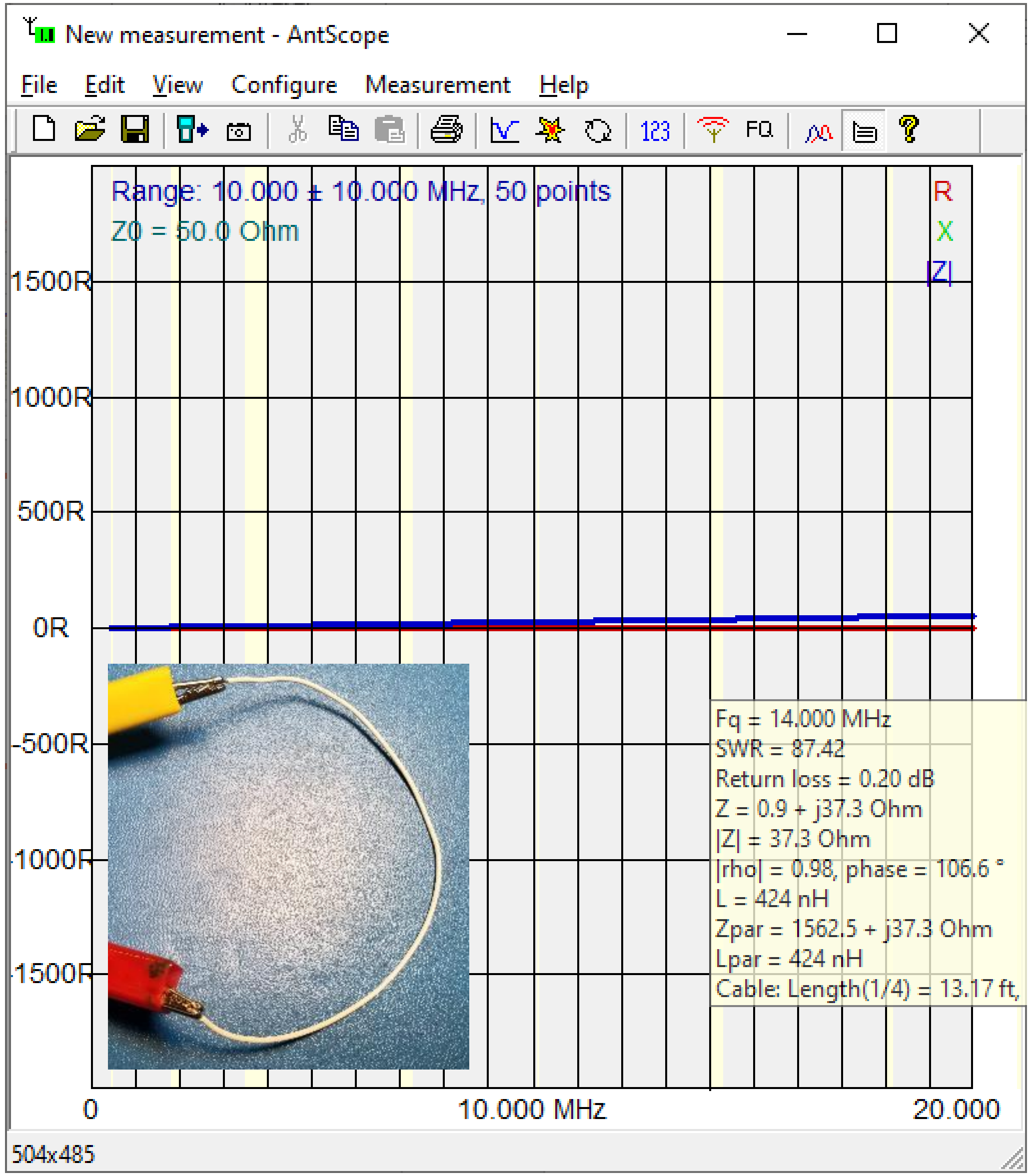
Please note that this is still a running notebook. Not (even close) to a final report.

12/13/2019
Antenna Mounting Hardware:
Threaded hole to connect antenna wire
Welded 3/8-16 to 24 adaptor (before painting)
Demonstration of mounting antenna

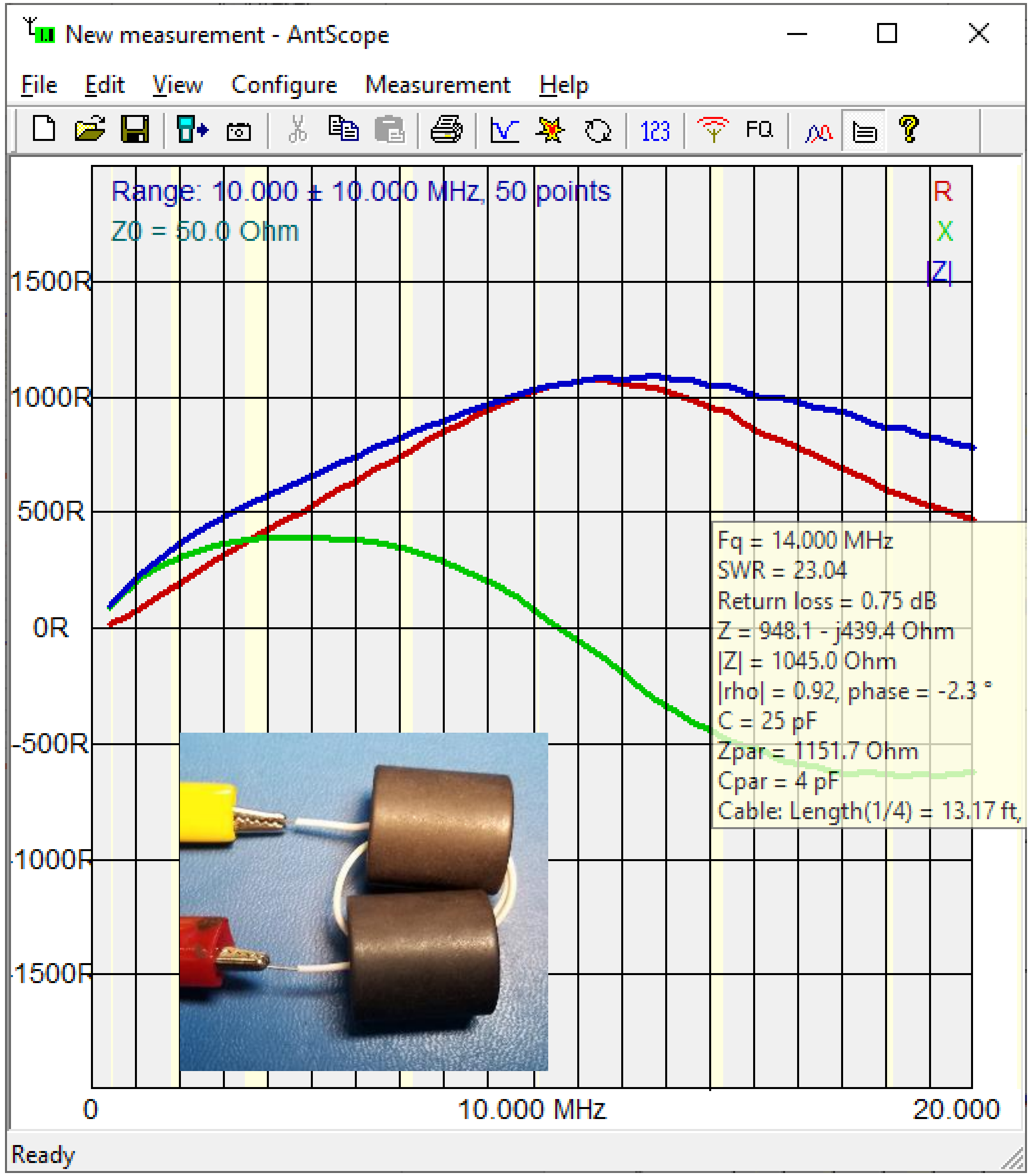
2/14/2020 Final version of antenna mounting hardware

Combining test plug with PVC cap provides both mechanical strength and waterproof seal.
Silicon calk will be applied between the boot and cap and all hardware will be covered with adhesive heat shrink tubing. The threads will also have high strength Loctite applied.

12/18/2019 To tune the antenna length, a temporary coax cable has to be attached. To prevent this cable from altering the antenna impedance, ferrite beads are attached. Two Turns through two Fair-Rite 2631102002 Cores adds about 1000 Ohms .



Wire Alone



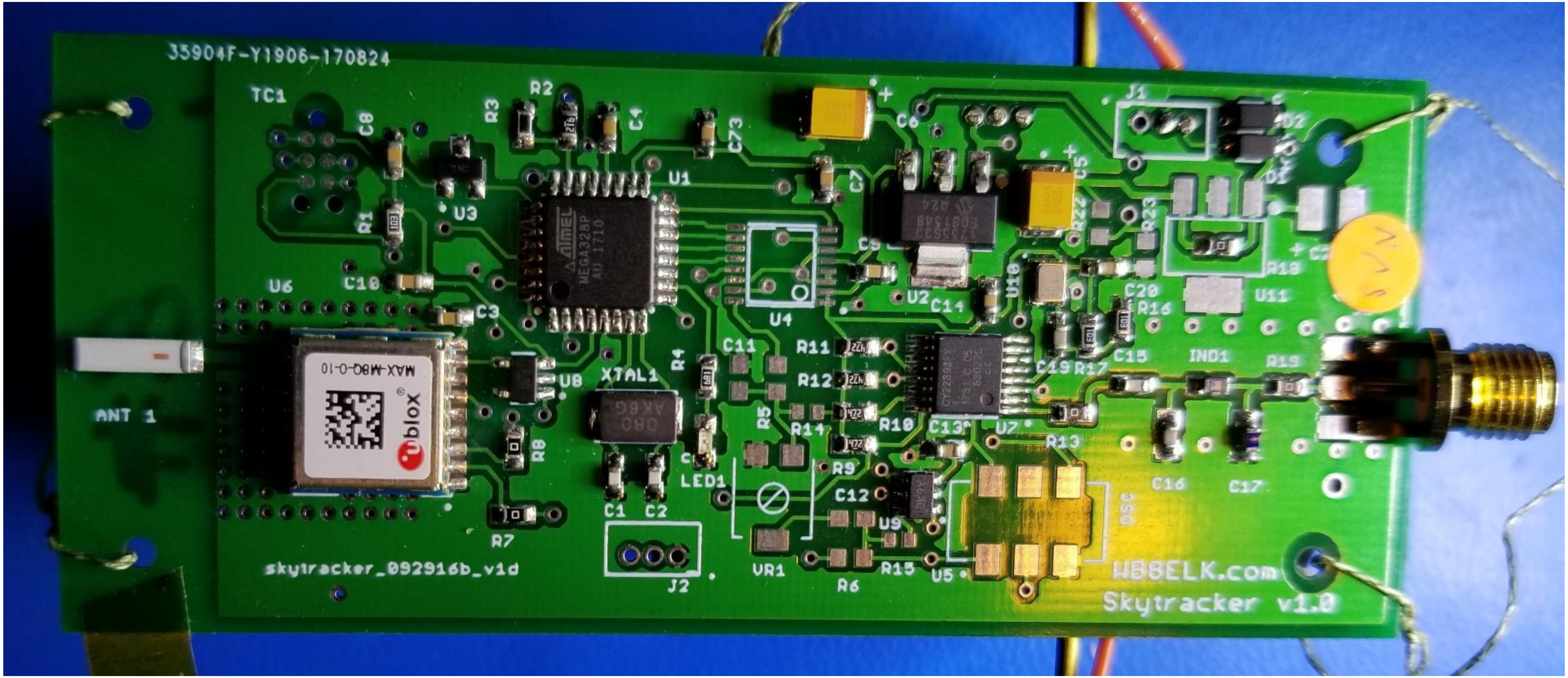
2 turns through 2 ferrites adds 948 Ohms (effect on coax is similar)

Loctite is useful for liquid tight sealing of threads and preventing loosening. A thought is to use it on the antennas. However, is there a risk it will prevent a good electrical contact?

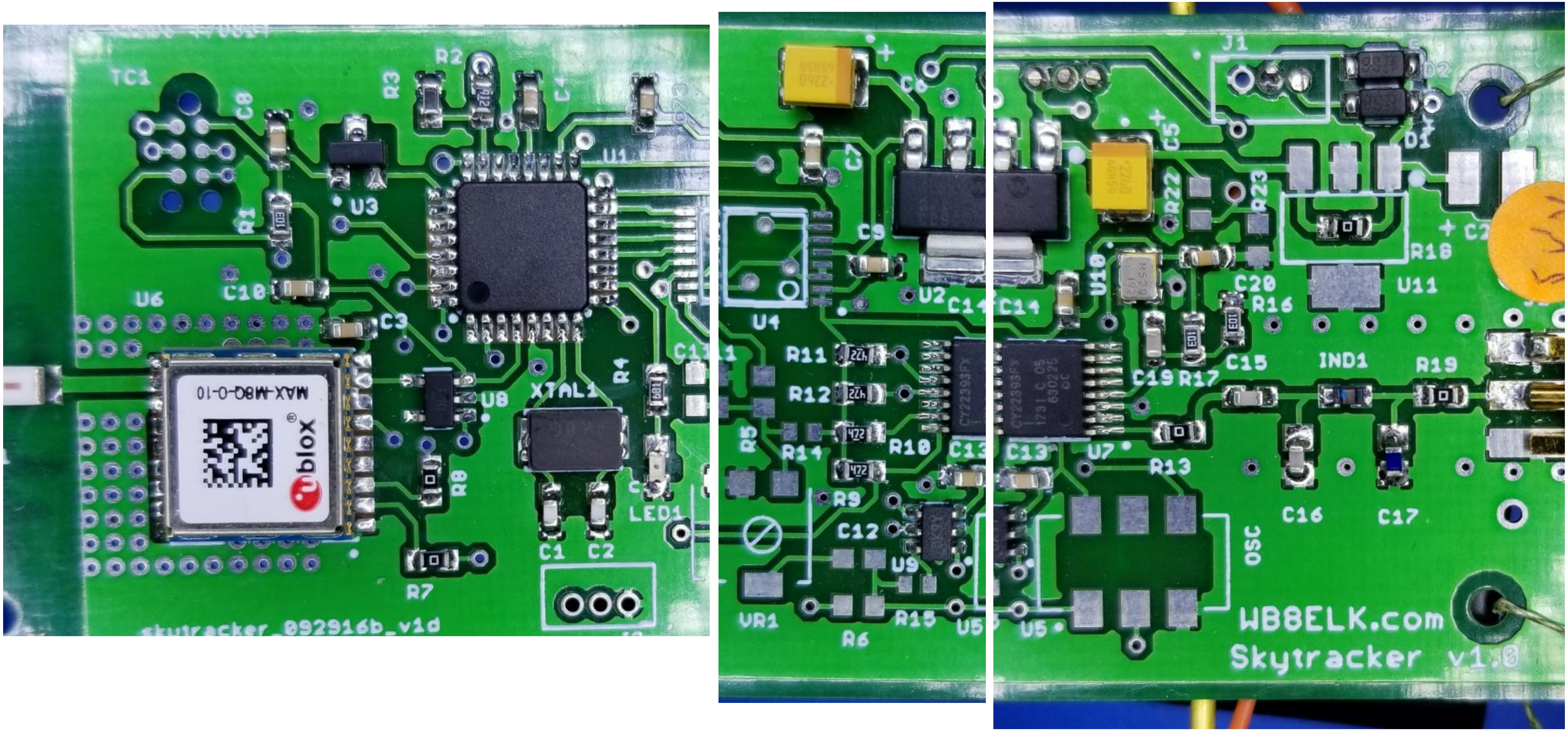
Loctite (red) conductivity test, free nut vs jammed nuts
Found both were zero Ohms to the bolt (size was ¼-20)

The thought is that the free floating nut may be riding on a layer of Loctite that isolates it from the bolt. However, the two nuts that are tightened against each other (and also forcefully against the bolt threads) will press through the Loctite for a good metal to metal contact (and the Loctite will still fill in the voids between the metal parts for a waterproof seal). It turns out that the free floating nut still made contact in this case.

“Balloon Payload” Circuit side – single photo



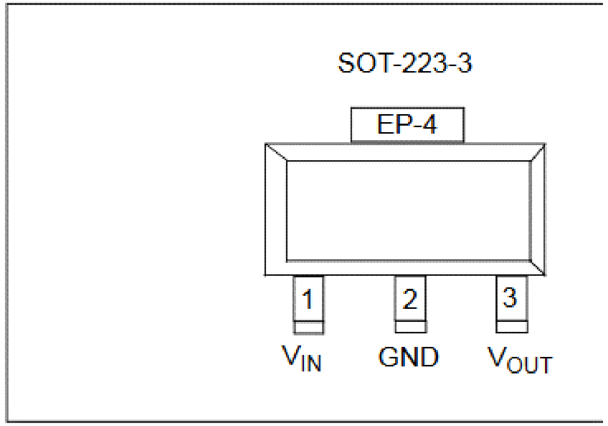
Circuit side – multi photos

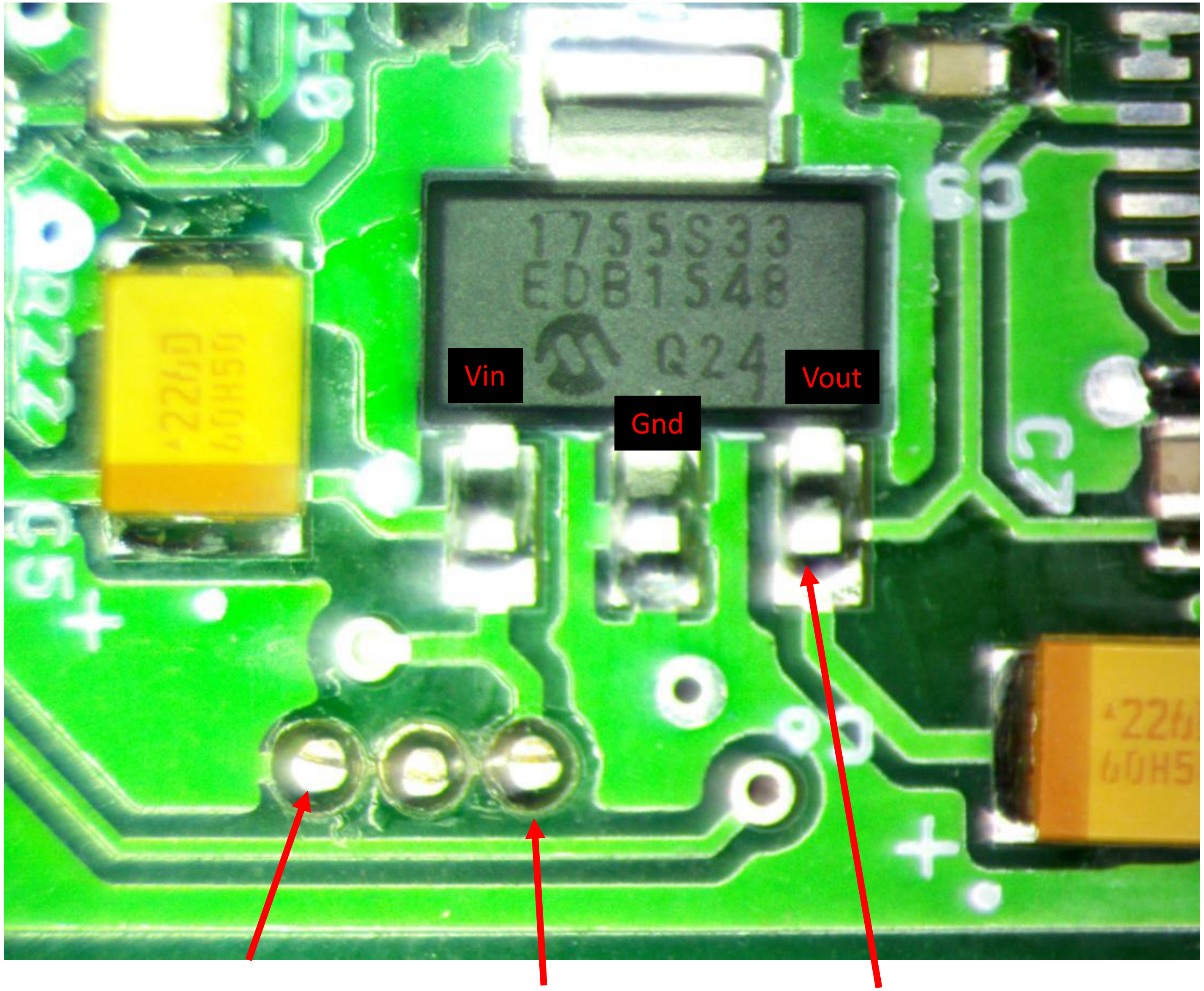


1755S33 (300 mA, 16V, High-Performance LDO) 3.3 Volt version. Has only 300 mV (typical) of input-to-output voltage differential @ 300 mA.

So, nothing should change until the battery drops to 3.6 Volts

Package Types – MCP1755S

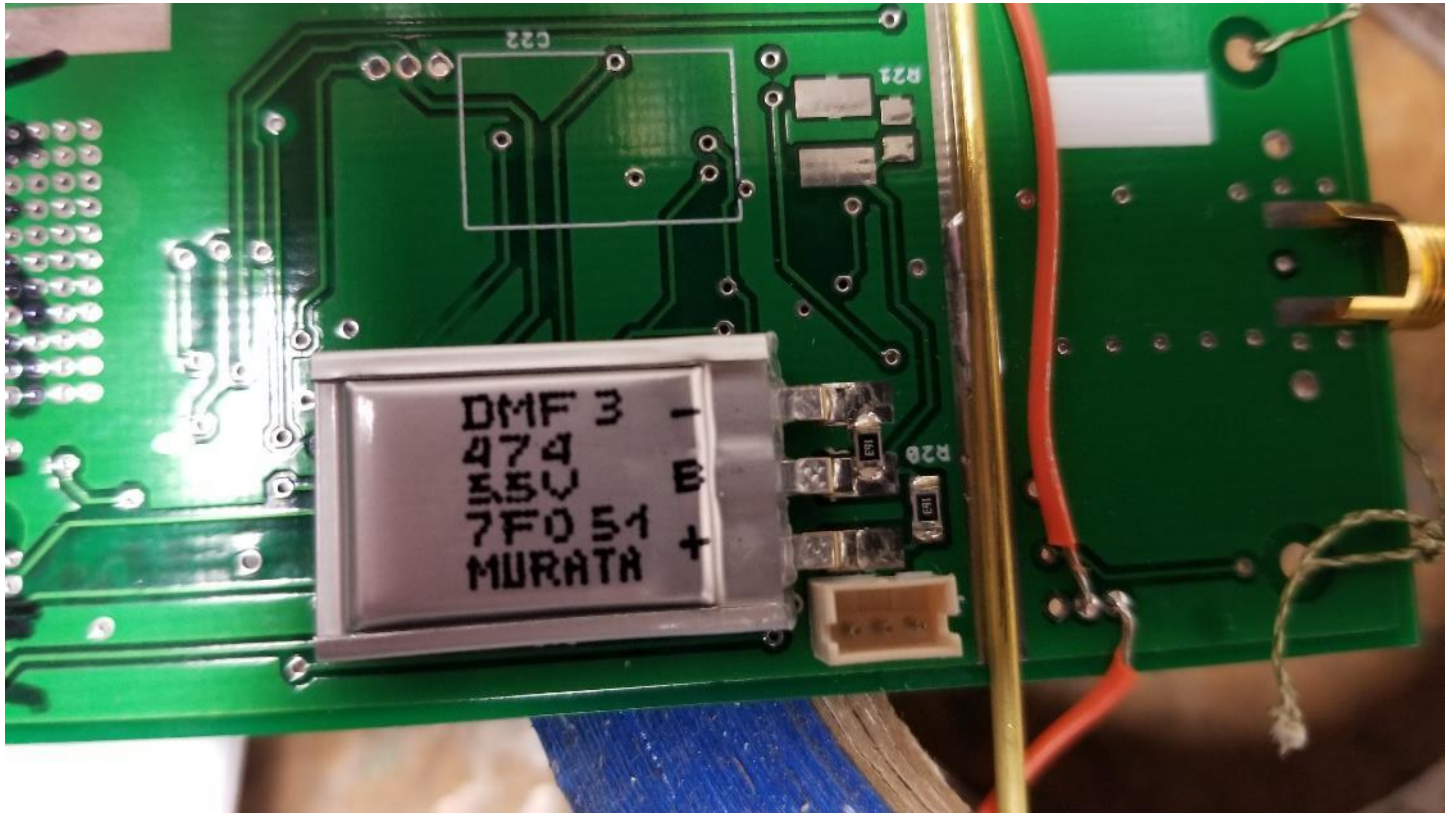




Supercap negative* Supercap positive* 3.3 V regulated

*The external battery connector connects directly to these points

Supercap, 5.5V, 470 mF (needed to hold over power with solar cells, not needed for battery power)



During peak current drain of 35mA a loss of solar (or battery) power would cause the voltage to drop by 0.5 Volt in 0.5 * 470mF / 35mA = 6.7 Seconds

WSPR (Weak Signal Propagation Reporter) Payload and Telemetry

- WSPR transmission duration is 112 seconds long and starts on the even minute
- A WSPR transmission contains only
    - Callsign (e.g. W6SUN, Mount Carmel High School Amateur Radio Club)
    - Grid Square (~70 miles resolution)
    - Power level (claimed by transmitting station)
- WSPR is left running unattended for hours, or days by 1000s of amateur stations around the world
    - Reception reports are uploaded to http://wsprnet.org for anyone to download
    - The payload sends a transmission every 10 minutes
- The buoy payload sends a 2nd transmission with a “dummy callsign” in the 2 minute interval immediately following the normal callsign transmission (e.g. QY7OKX)
    - This means the payload is transmitting four out of every 10 minutes
- By alternating the claimed power level values of both transmissions and the 2nd, 4th, 5th and 6th value of the dummy call sign the payload encodes:
    - Sub Grid Square location (~3 mile resolution)
    - Altitude (60 meter resolution)
    - GPS quality status (no fix, 4-8 sats, >8 sats)
    - Battery Voltage (0.1 Volt resolution)
    - Temperature (5°C resolution)

What the unit sends

The other parameters are determined by the receiver or web site

From ALL_WSPR.TXT

yymmdd	hhmm		dB		Freq	Call	Grid							
Date	UTC	?	dB	DT	FREQ	CALL	GRID	dBm	Drift	?	?			
191219	1942	6	21	1.05	14.0970794	W6SUN	DM12	0	0	1	0	1	764	0
191219	1944	7	25	1.05	14.0970792	QY7OKX	DM12	7	0	1	0	1	807	0
191219	2132	9	27	1.18	14.0970802	W6SUN	DM12	0	0	1	0	1	810	0
191219	2134	9	27	0.96	14.0970802	QY7HKX	DM12	3	0	1	0	1	810	0
191219	2212	9	25	1.39	14.0970802	W6SUN	DM12	0	0	1	0	1	810	0
191219	2214	8	23	1.22	14.0970802	QY7GKX	DM12	7	0	1	0	1	805	0

From WSJT-X display

UTC	dB	DT	Freq	Drift	Call	Grid	dBm	mi
1942	21	1.0	14.097079	0	W6SUN	DM12	0	33
1944	25	1.0	14.097079	0	QY7OKX	DM12	7	33
2132	27	1.2	14.097080	0	W6SUN	DM12	0	33
2134	27	1.0	14.097080	0	QY7HKX	DM12	3	33
2212	25	1.4	14.097080	0	W6SUN	DM12	0	33
2214	23	1.2	14.097080	0	QY7GKX	DM12	7	33

From wsprnet.org (which seems to convert power to Watts)

Timestamp	Call	MHz	SNR	Drift	Grid	Pwr	Reporter	Rgrid	km	az
2019-12-19 21:32	W6SUN	14.097080	+27	0	DM12	0.001	KQ6RS	DM12kx	56	352
2019-12-19 21:34	QY7HKX	14.097080	+27	0	DM12	0.002	KQ6RS	DM12kx	56	352
2019-12-19 22:12	W6SUN	14.097080	+25	0	DM12	0.001	KQ6RS	DM12kx	56	352
2019-12-19 22:14	QY7GKX	14.097080	+23	0	DM12	0.005	KQ6RS	DM12kx	56	352

Pwr	dBm
0.001	0
0.002	3
0.005	7

Encoding: Call (W6SUN) power gives course altitude in 1000 meter steps. Special call (e.g. QY7GKX) power level gives fine altitude in 60 meter steps. Q & 7 are "channel number" and don't change. Y gives both temperature in 5 degree C steps and GPS status as 0 (no fix) 1 (4-8 sats) 2 (>8 sats), KX are the sub grid square position (~3x5 mile resolution).

Average Current consumption vs Voltage supplied to external battery connector

From WSJT-X display

```
UTC     dB    DT     Freq        Drift   Call          Grid      dBm     mi  (Decoded information)
2019-12-20 Power (Avg): 4.80V, 28.6mA (> 1 hour averaging time)  (RF output is 12.7 dBm)
0102    35    1.2    14.097078    0    W6SUN         DM12      0       33  (0 meters course altitude)
0104    37    1.0    14.097078    0    QZ7PKX        DM12      7       33  (120 meters altitude, GPS 2, 25 °C Batt 4.7 V)
0234    36    1.3    14.097079    0    QZ7PKX        DM12      7       33  (same)
2019-12-20 Power (Avg): 4.00V, 28.2mA (> 1 hour averaging time)Still has 3.29 V at the regulator output
0254    36    1.2    14.097079    0    QZ7HKX        DM12      7       33  (120 meters altitude, GPS 2, 25 °C Batt 3.9 V)
0344    37    1.0    14.097079    0    QZ7HKX        DM12      7       33  (same)
2019-12-20 Power (Avg): 3.60V, 28.1mA (= 1 hour averaging time)Still has 3.29 V at the regulator output
0354    36    1.0    14.097079    0    QZ7DKX        DM12      7       33  (120 meters altitude, GPS 2, 25 °C Batt 3.5 V)
0444    34    1.3    14.097079    0    QZ7DKX        DM12      7       33  (same)
2019-12-20 Power (Avg): 3.38V, 27.4mA (40 minutes averaging time)Still has 3.29 V at the regulator output
0454    34    1.3    14.097079    0    QZ7BKX        DM12      7       33  (120 meters altitude, GPS 2, 25 °C Batt 3.3 V)
0524    34    1.0    14.097079    0    QZ7BKX        DM12      7       33  (same)
2019-12-20 Power (Avg): 3.28V, 27.9mA (30 minutes averaging time)Now 3.23 V at the regulator output (RF out 12.5 dBm)
0534    30    1.0    14.097077    0    QZ7AKX        DM12      7       33  (120 meters altitude, GPS 2, 25 °C Batt 3.2 V)
0604    14    1.0    14.097077    0    QZ7AKX        DM12      7       33  (same)
2019-12-20 Power (Avg): 3.14V, 26.8mA (20 minutes averaging time)Now 3.06 V at the regulator output (RF out 12.0 dBm)
0624    13    1.0    14.097068    0    QY7AKX        DM12      7       33  (120 meters altitude, GPS 1, 25 °C Batt 3.2 V)
2019-12-20 Power (Avg): 3.01V, 27.1mA (30 minutes averaging time)Now 2.95 V at the regulator output (RF out 11.7 dBm)
0654    12    -0.2   14.097061    0    QY7AKX        DM12      7       33(120 meters altitude, GPS 1, 25 °C Batt 3.2 V)
2019-12-20 Power (Avg): 2.81V, 27.0mA (10 minutes averaging time)Now 2.75 V at the regulator output (RF out 10.9 dBm)
0704    12    0.9    14.097052    0    QY7AKX        DM12      7       33(120 meters altitude, GPS 1, 25 °C Batt 3.2 V)

At 2.6 V power it dies.  Regulator output is 2.2 Volts.  Regulator seems to abruptly drop off below 2.8 V battery, which
is well below the specified minimum voltage for this regulator.
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Current average 27.6 mA from 4.8V down to 2.8V.
Current range (mA) 15 (minutes 6-8) to 35 (during minutes 8-2).
29 mA during Tx minutes 2-6.
GPS status as 0 (no fix) 1 (4-8 sats) 2 (>8 sats).

Note that Ublox MAX-M8Q GPS receiver specifications show a typical current of 19 mA. So, maybe idle is 15mA (mins 6-8). GPS adds 19mA (mins 8-2). Tx adds 14mA (mins 2-6).

Behavior:
Timing intervals (minutes, repeats every 10 minutes):
2-4 transmits normal call (light solid) (current ~29mA)
4-6 transmits special call (light solid) (current ~29mA)
6-8 no light (current ~15mA)
8-2 light blinks (getting GPS fix?) (current 35mA)

WSPR signals always sent as two messages. The first is a normal call sign (W6SUN), followed by a "special call sign" (e.g. QY7GKX) which has additional parameters encoded.

```
Call        Grid    dBm
W6SUN       DM12    0
QZ7PKX      DM12    7
```

The call sign message (W6SUN) provides Grid Square normally, but instead of using its actual (12 dBm) Tx power level, it uses the Tx power field to encode course altitude in 1000 meter steps (0dBm = 0 meters, 3dBm = 1000 meters, 7 dBm = 2000 meters, 10 dBm = 3000 meters, 13 dBm = 4000 meters, and so on)

The special call (e.g. QY7GKX) encodes fine altitude (using the dBm value like call sign message, but in 60 meter steps from 0 to 960*), sub grid square position, temperature, battery voltage and GPS status. Temperature is in 5 °C steps. GPS status is No Fix, 4-8 sats, > 8 sats.
The special call has 6 characters.
Characters 1 & 3 provide a "channel number" and don't change (e.g. Q & 7)
Character 2 (e.g. Y) encodes temperature (5 °C increments) and GPS status (see table)
Character 4 (e.g. P) encodes the battery voltage (see table). Stays at A for < 3.2 volts. Unit dies ~2.7 Volts.
Characters 5 & 6 are the sub grid position (e.g. KX) (step size about 3 mi latitude and 5 mi longitude)

*(0dBm = 0 meters, 3dBm = 60 meters, 7 dBm = 120 meters, 10 dBm = 180 meters, 13 dBm = 240 meters, and so on)

For fixed location testing, only Characters 2 and 4 will change.

"Secret Decoder Tables" for special call

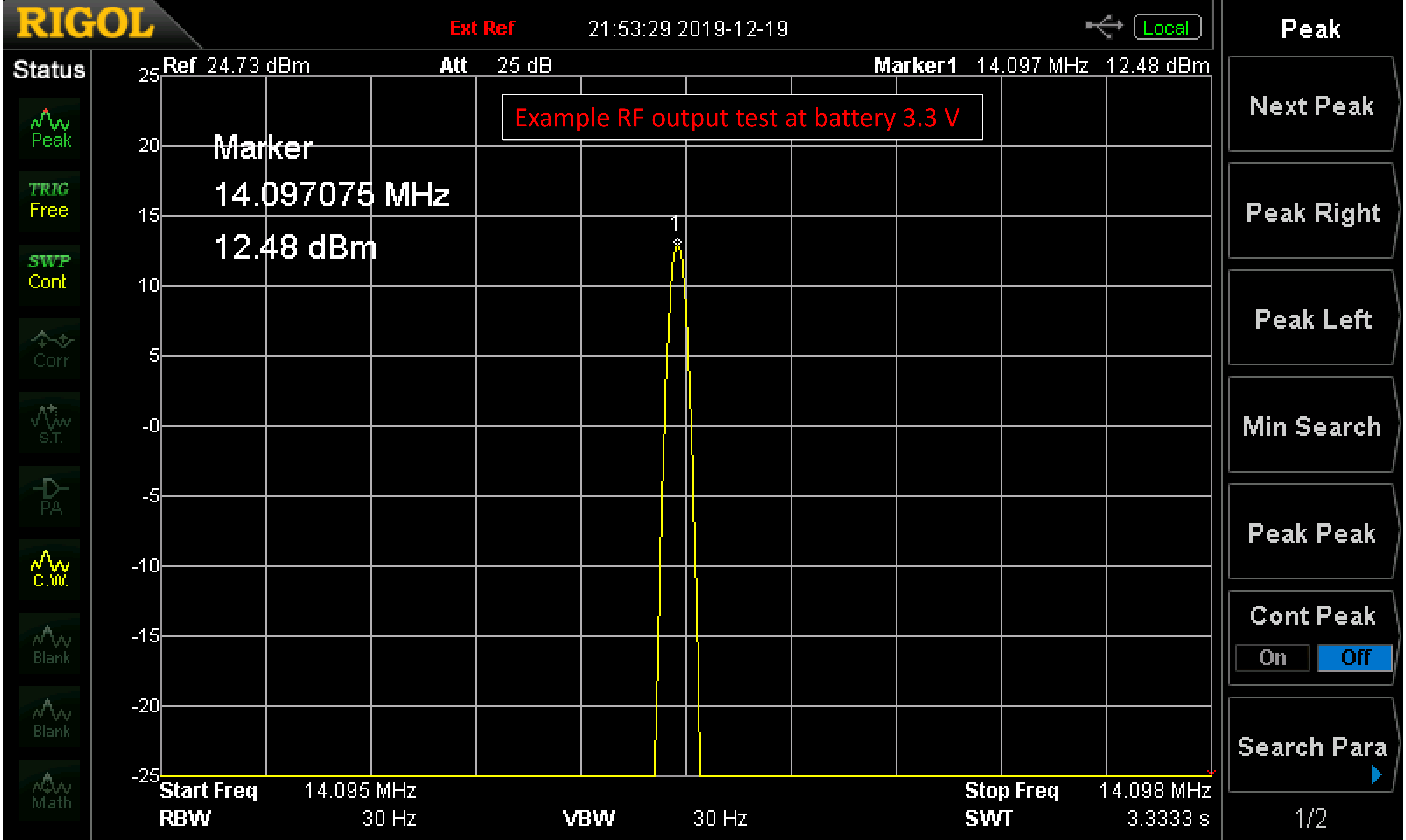
2nd character

Call 2		
Temp/Sats	Sat Status	Temp
F	0	-5
G	1	-5
H	2	-5
I	0	0
J	1	0
K	2	0
L	0	5
M	1	5
N	2	5
O	0	10
P	1	10
Q	2	10
R	0	15
S	1	15
T	2	15
U	0	20
V	1	20
W	2	20
X	0	25
Y	1	25
Z	2	25

GPS Sat Status:
0 = no fix
1 = 4-8 sats
2 = >8 sats

4th character

Voltage	Call 4
3.2	A
3.3	B
3.4	C
3.5	D
3.6	E
3.7	F
3.8	G
3.9	H
4	I
4.1	J
4.2	K
4.3	L
4.4	M
4.5	N
4.6	O
4.7	P
4.8	Q
4.9	R
5	S
5.1	T
5.2	U
5.3	V
5.4	W
5.5	Y
5.6	X
5.7	Z

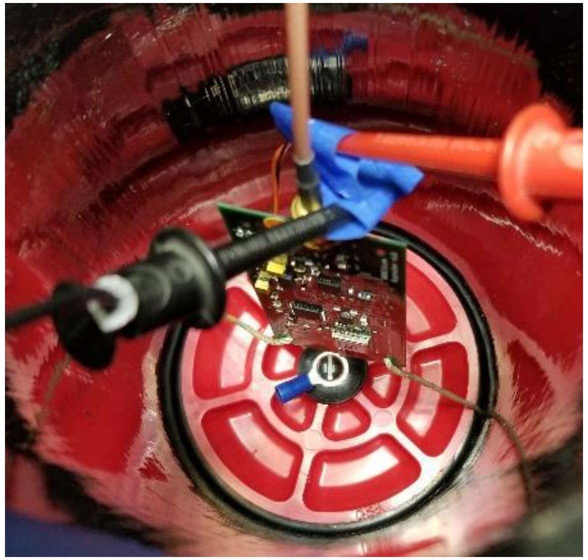


RIGOL
Ext Ref
21:53:29 2019-12-19
Local
Peak
Status
Peak
TRIG Free
SWP Cont
Corr
S.T.
PA
C.W.
Blank
Blank
Math
Ref 24.73 dBm
Att 25 dB
Marker1 14.097 MHz 12.48 dBm
Example RF output test at battery 3.3 V
Marker
14.097075 MHz
12.48 dBm
25
20
15
10
5
-0
-5
-10
-15
-20
-25
1
Start Freq 14.095 MHz
Stop Freq 14.098 MHz
RBW 30 Hz
VBW 30 Hz
SWT 3.3333 s
Next Peak
Peak Right
Peak Left
Min Search
Peak Peak
Cont Peak
On
Off
Search Para
1/2

12/20/2019 – GPS performance inside the top of the tube. Will the cover over the top with the 14 MHz antenna hardware and pipes on the side cause poor GPS performance?

GPS antenna at top of board

The top of the board is suspended 3 inches below the top of the pipe. All the final hardware around and above the circuit board are in place.



View from underneath

Includes outer ABS cap

GPS Performance Inside the Buoy, Outdoors – Is very Good (>8 sats most of the time)

<u>From WSJT-X display</u>

UTC	dB	DT	Freq	Drift	Call	Grid	dBm	mi	(Decoded information)
2019-12-20									
2312	31	0.1	14.097079	0	W6SUN	DM12	0	33	(0 dBm = 0 meters course altitude)
2314	31	-0.1	14.097078	0	QY7HKX	DM12	7	33	(7 dBm = 120 meters fine altitude, H = Batt 3.9 V)
2324	24	-0.1	14.097078	0	QY7HKX	DM12	7	33	(Y = GPS status 1 & 25 °C)
2334	26	0.9	14.097079	0	QY7HKX	DM12	7	33	
2344	37	1.0	14.097079	0	QY7HKX	DM12	7	33	
2354	38	1.0	14.097079	0	QZ7HKX	DM12	7	33	(Z = GPS status 2 & 25 °C)
2019-12-21									
0004	37	1.0	14.097079	0	QV7HKX	DM12	7	33	(V = GPS status 1 & 20 °C)
0014	37	1.3	14.097079	0	QV7HKX	DM12	7	33	
0024	38	1.3	14.097079	0	QV7HKX	DM12	7	33	
0034	37	1.3	14.097079	0	QV7HKX	DM12	7	33	
0044	38	1.0	14.097080	0	QW7HKX	DM12	7	33	(W = GPS status 2 & 20 °C)
0054	38	1.0	14.097080	0	QV7HKX	DM12	7	33	(V = GPS status 1 & 20 °C)
0104	38	1.0	14.097080	0	QT7HKX	DM12	7	33	(T = GPS status 2 & 15 °C)
0114	37	1.0	14.097080	0	QT7HKX	DM12	7	33	
0124	38	1.0	14.097080	0	QT7HKX	DM12	7	33	
0134	38	1.0	14.097080	0	QT7HKX	DM12	7	33	
0144	38	1.3	14.097080	0	QT7HKX	DM12	7	33	
0154	38	1.3	14.097080	0	QT7HKX	DM12	7	33	
0204	38	1.3	14.097080	0	QT7HKX	DM12	7	33	
0214	38	1.0	14.097081	0	QT7HKX	DM12	7	33	
End of test									

GPS Sat status: 0 = no fix, 1 = 4-8 sats, 2 = >8 sats

GPS status 1 or 2 is similar to what it was with the external amplified outdoor antenna

Question – How well will a +12dBm WSPR signal into a MFJ-1620T antenna be heard?

Testing on my truck with the mag mount in street, in front of my house (with blockage from houses) will probably be worse than out in the open ocean with no blockage. Comparing with +11dBm (measured, used an IC-7300 power setting at minimum & 10 dB attenuator) into a hex beam.

From WSJT-X display

```
UTC     dB    DT     Freq       Drift  Call          Grid      dBm    mi  (Decoded information)
2019-12-21
Start of test 0242 (not not every transmission is listed below)
0242    38    1.2    14.097081     0   W6SUN         DM12       0     33
0244    37    1.0    14.097081     0   QW7SKX        DM12       7     33 (S = GPS status 1 & 15 °C, 5.0 Volts)
0412    32    1.3    14.097080     0   W6SUN         DM12       0     33
0414    32    1.0    14.097080     0   QT7SKX        DM12       7     33 (T = GPS status 2 & 15 °C
0524    33    1.0    14.097080     0   QT7SKX        DM12       7     33
0604    24    1.2    14.097080     0   QQ7SKX        DM12       7     33 (Q = GPS status 2 & 10 °C)
0614    34    1.0    14.097080     0   QP7SKX        DM12       7     33 (P = GPS status 1 & 10 °C)
1554   -19    0.8    14.097201     0   QQ7SKX        DM12       7     33
2044    27    1.0    14.097079     0   QZ7SKX        DM12       7     33 (Z = GPS status 2 & 25 °C)
Stopped recording them here
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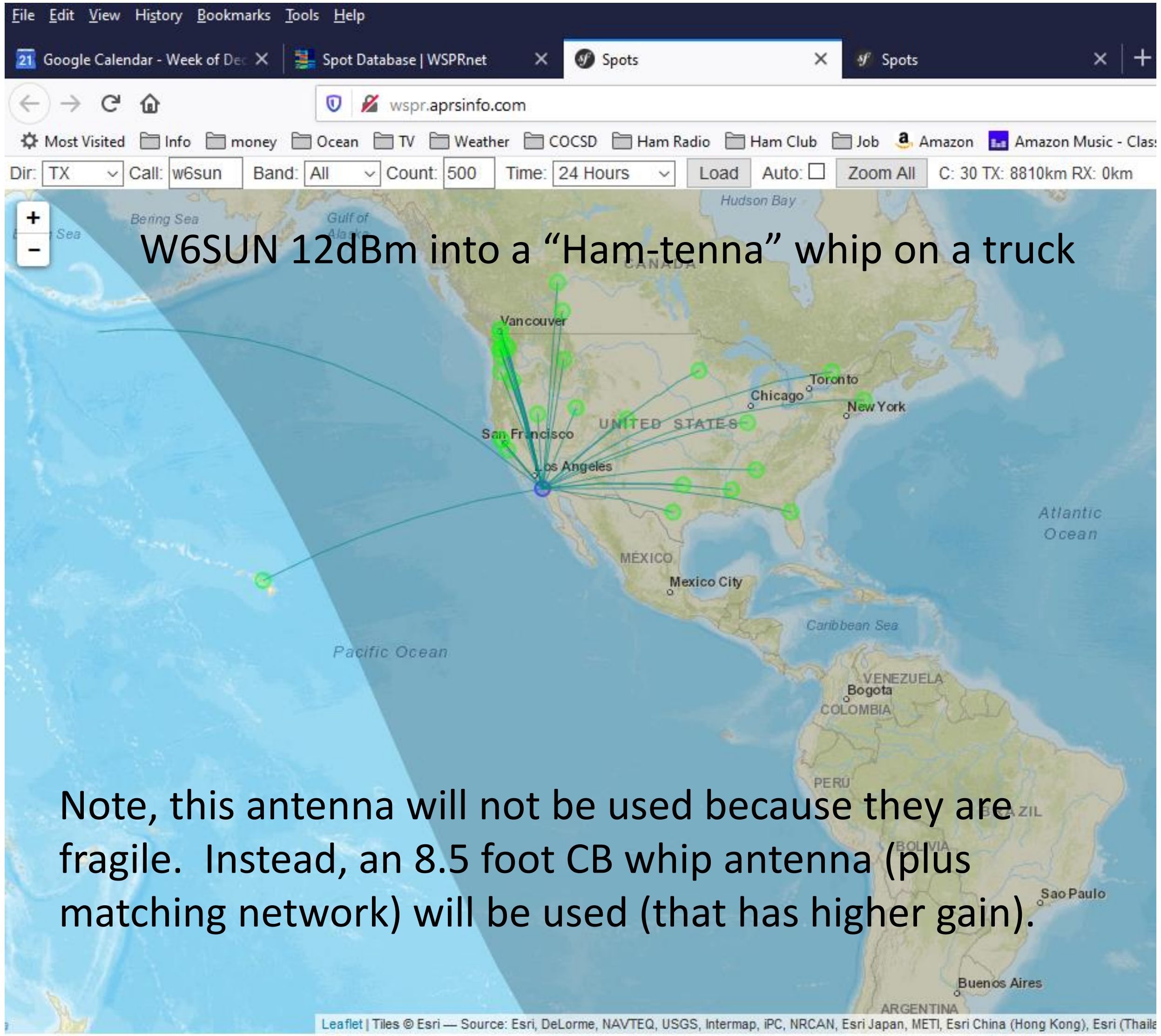
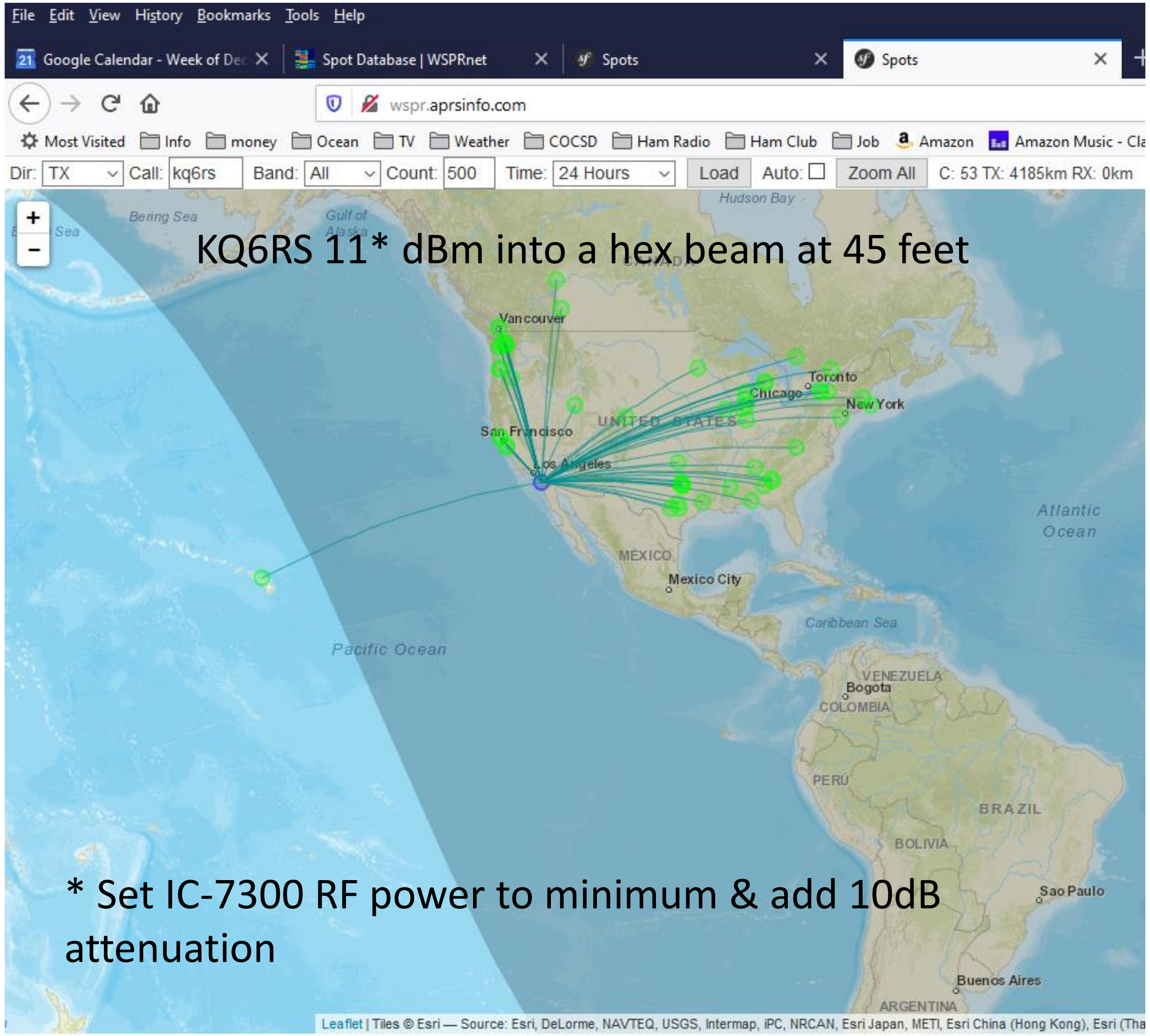
```
From wsprnet.org (which converts power to Watts)
Timestamp        Call   MHz       SNR Drift Grid Pwr Reporter Rgrid km az
2019-12-21 04:04 QT7SKX 14.097079 -28 0    DM12 0.005 KPH    CM88mc 824 321
2019-12-21 04:12 W6SUN  14.097079 -23 0    DM12 0.001 KPH    CM88mc 824 321
Only these examples.  See maps on next page for coverage performance.
```

Pwr	dBm
0.001	0
0.002	3
0.005	7

Coverage results from about UTC 2019-12-21 0300 to 2019-12-22 0300 (local 7 pm to 7pm)
Equal power truck mounted portable vertical does very well in comparison to a hex beam at 45 feet.



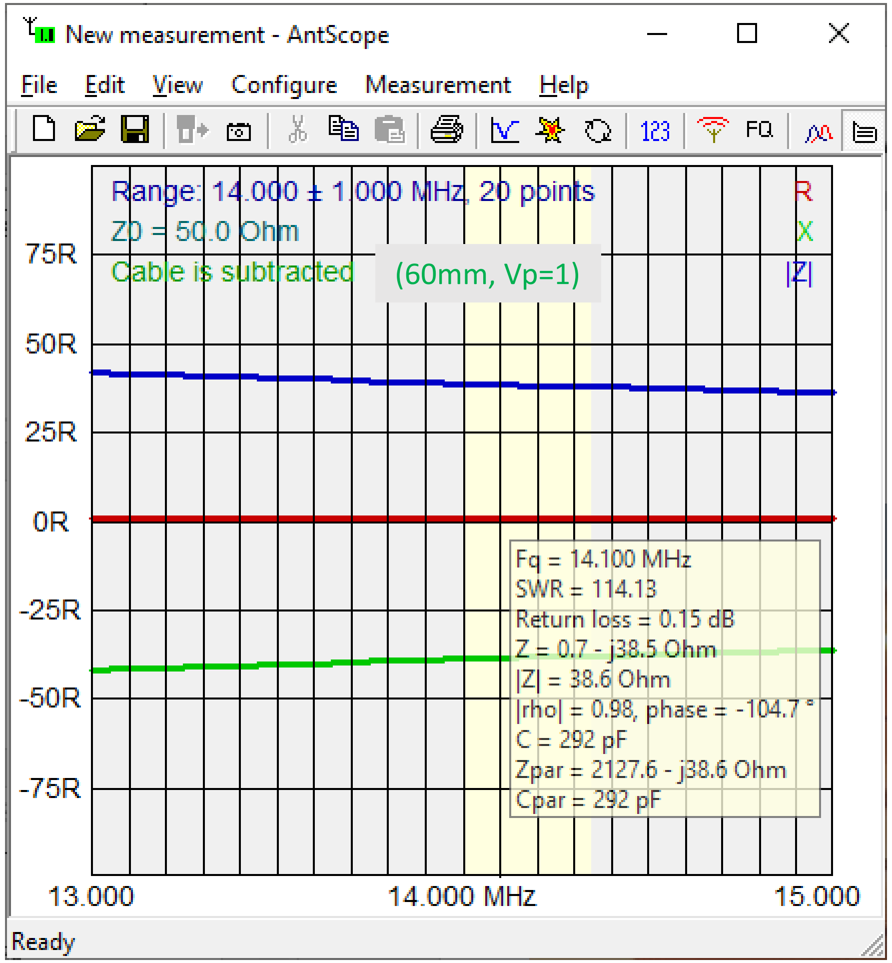


12/21/2019. What about using the thinner wall PVC (Type SDR 35), making the "float" out of PVC pipes instead of a foam ring and putting the ground inside the pipe to capacitively couple it to the water?

This is the capacitor test using some 3 inch size pipe sample. It is similar to the 4 inch size except for diameter and wall thickness. The 4 inch size is OD 4.2" and 0.125 thick.

Parallel plate capacitor on 3" size pipe

Used to determine 60mm (Vp = 1) cable needs to be subtracted



C = Єo*Єr*(A/h). Єo = 8.85 pF/m, Єr=3.23, A = 0.0255 m^2, h = 0.0025 m
C = 292 pF. Xc at 14.1 MHz = 39Ω

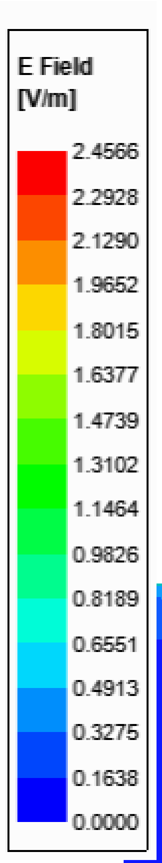
What is the reactance (Xc) of 2 ft (0.61m) of 4.2 in OD (0.107m), 0.125" thick (0.0032m) PVC covered on the inside with copper tape?
A=π*0.105*0.61=0.20 m^2, h=0.0032m
C=8.85*3.23*0.20/0.0032 = 1787 pF
Xl = 6 Ω This is very low and will work great.
Note: even though skin depth of seawater is only 2.4 inches, EM modeling (with HFSS) shows that the full depth contributes to capacitive coupling.

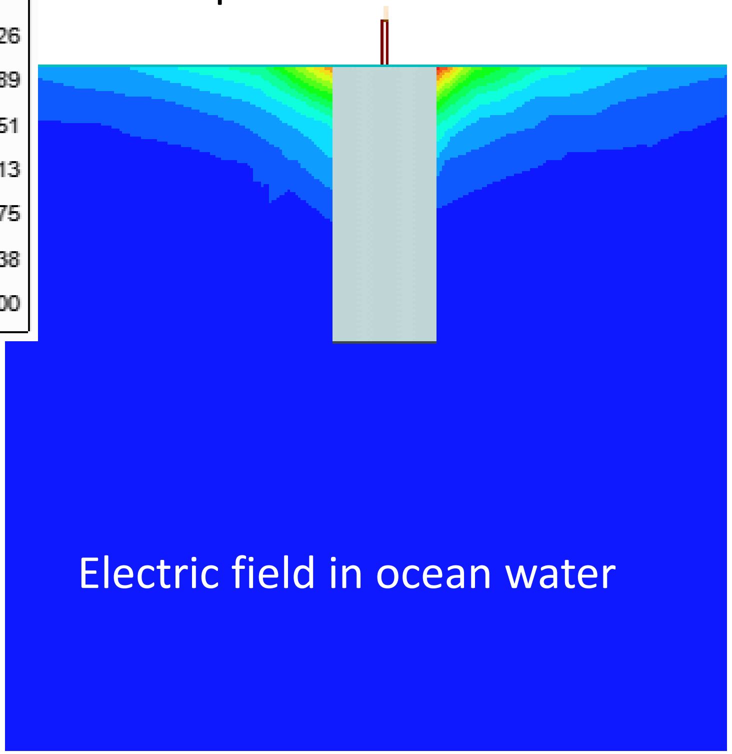
HFSS Simulations of Capacitive Coupling through PVC Pipe to Sea Water

Metal Pipe Direct Water Contact

4.5 diameter metal pipe
12 inch long ground

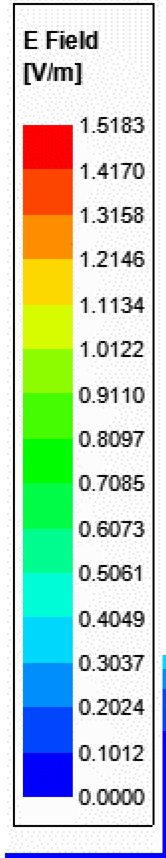
Skin depth is 2.5 inches. Note how the electric field in water dies out in about 2 skin depths.

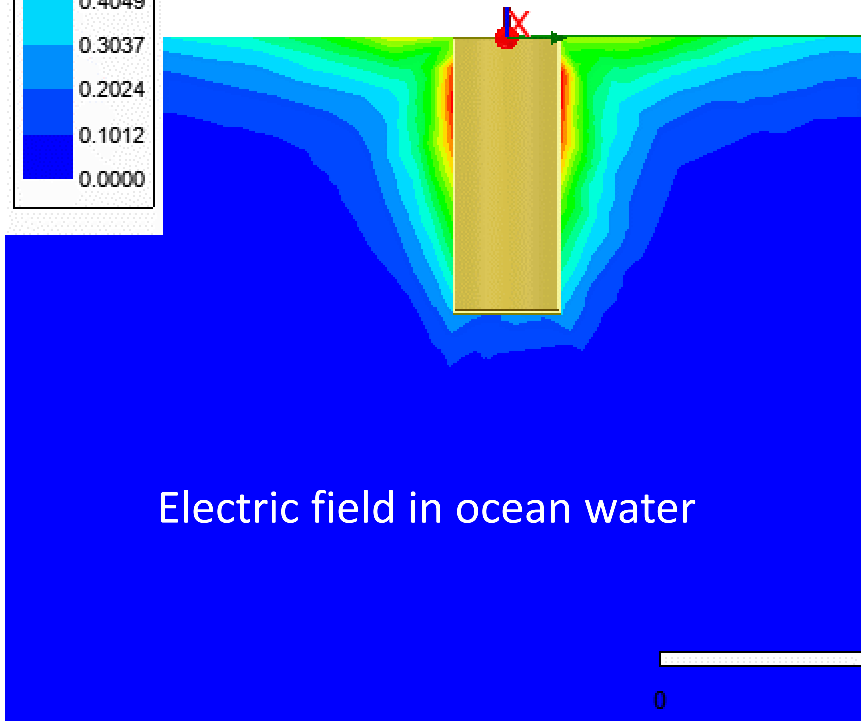




Capacitive Coupling to Water

4.5 diameter, 12 inch long ground inside 0.125 inch thick PVC. Even though skin depth is only 2.5 inches, the capacitance in the first few inches of the "PVC capacitor" is low enough that the voltage difference between the ground and ocean continues deeper to "use more of the length of the capacitor."



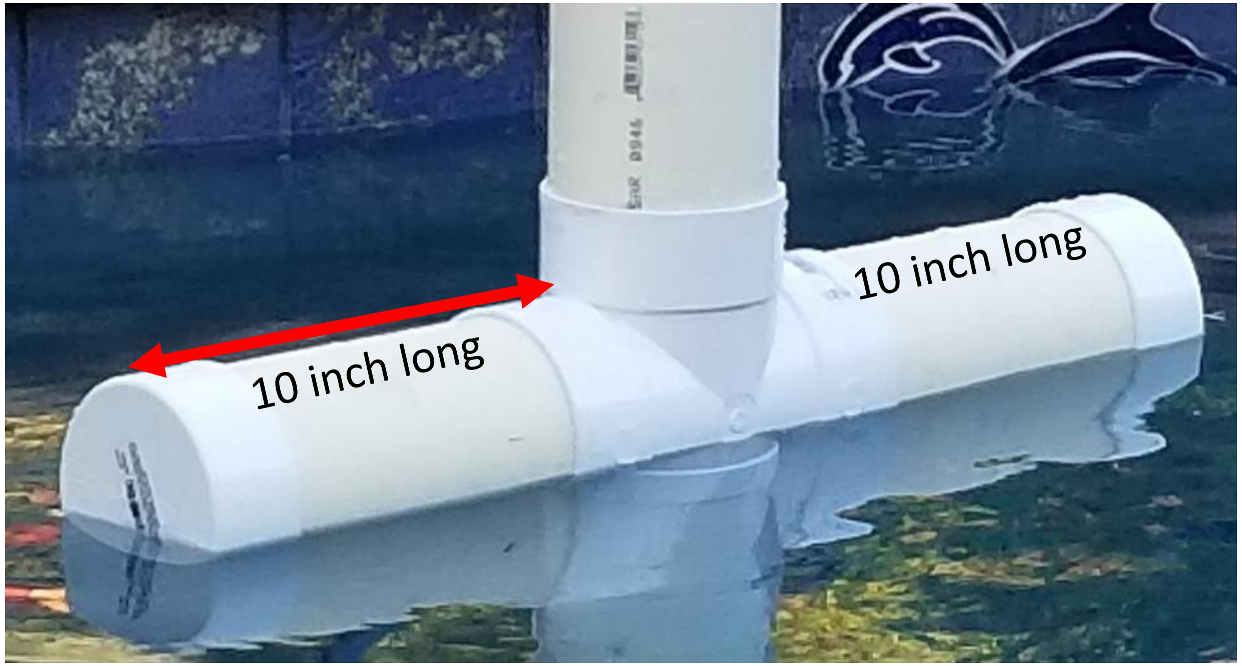


Fortunately, using the ocean to a deeper depth makes for a good connection to it. The only difference between direct contact and through the PVC pipe is about 3 Ohms of capacitive reactance.

12/31/2019 Buoy made from 4 inch size Type SDR 35 PVC with horizontal pipe sections to provide 10 lb buoyancy. This requires 2 x 10 inch long sections of 4.2 inch diameter pipe.

9.6 lb empty pipes
36.2 lb total with weights

26.4 lb added weight



~1/3 of anti-bobbing side pipes submerged with 36 lb total weight (in fresh water).
Since sea water density is 1025 kg/m^3 (2.5% more) the total weight to sit at the same level in the ocean is 37 lb.

How to solder wires to batteries (Note: use this as a backup method. It is safer for the batteries to spot weld solder tabs):
A large (high thermal mass) soldering iron is required to heat the battery terminal almost instantly above the melting temperature of solder. Compressed air is desirable to quickly cool the battery terminal. The goal is to have the battery terminals go from room temperature to molten solder to room temperature in about five seconds. This prevents the heat from transferring into the battery. The typical soldering iron used for electronics work does not have enough heat to raise the large terminals of the battery immediately to the melting temperature of solder. A slow job will result in much higher internal battery temperatures due to the long time period the terminal remains at an elevated temperature.

Step 1. Clean the battery ends with an abrasive such as Scotch-Brite.

Step 2. Touch the end of the battery with a large soldering iron and solder to instantly place a molten blob of solder on the end. Immediately cool the solder with low pressure compressed air. You may have to start several inches away to not blow the solder off while it is still molten.

Step 3. Before this step, have a wire prepared with a good size drop of solder melted to the end. Place the wire on the battery and then place the large soldering iron on the wire just long enough to melt into the surface of the solder on the battery. Immediately cool with compressed air.

1/1 to 1/26, 2020 Battery life test run. Three D Cells in series (measured 16,100 mAh with payload load).
Before connection 4.860V (1.62/cell)
Just after connection at 9:30 pm (UTC 1/2/2020 05:30) 4.800V
Average current is 27.6 mA
Life was 16,100/27.6 = 583 hours (24 days). Our plan is 7 cells in parallel for 7x this run time would be 168 days but will be slightly more with less current/cell and will meet our 180 day goal.

Notes:

- Actual battery voltage was found to be 0.15 V above decode value.
- At 3.3 V and below broadcast value is the 3.2 V minimum
- Unit dies at 2.75 V

Log From WSJT-X receiving payload signal

UTC	dB	DT	Freq	Drift	Call	Grid	dBm	mi	(Decoded information)
200102									
0602	8	1.2	14.097079	0	W6SUN	DM12	0	33	(0 dBm: 0 x 1000 meters)(test start, 0 hours)
0604	9	1.0	14.097079	0	QY7PKX	DM12	7	33	(0 dBm: 120 meters)
0614	7	1.0	14.097079	0	QY7PKX	DM12	7	33	(Y: GPS1, 25°C, P: 4.7 Volts)
0644	5	1.0	14.097079	0	QZ7PKX	DM12	7	33	(Z: GPS2, 25°C, P: 4.7 Volts)
0724	5	1.0	14.097079	0	QY7OKX	DM12	7	33	(Y: GPS1, 25°C, O: 4.6 Volts) (just changed, 2 hours)
1134	4	1.0	14.097079	0	QV7NKX	DM12	7	33	(V: GPS1, 20°C, N: 4.5 Volts) (just changed, 6 hours)
1804	4	1.0	14.097079	0	QW7MKX	DM12	7	33	(W: GPS2, 20°C, M: 4.4 Volts) (just changed, 13 hours)
200103_0000 (18.5 hours)									
0444	-6	1.0	14.097079	0	QZ7LKX	DM12	7	33	(Z: GPS2, 25°C, L: 4.3 Volts) (just changed, 23 hours)
2024	-6	1.0	14.097079	0	QZ7KKX	DM12	7	33	(Z: GPS2, 25°C, K: 4.2 Volts) (just changed, 39 hours)
200104_0000 (43 hours)									

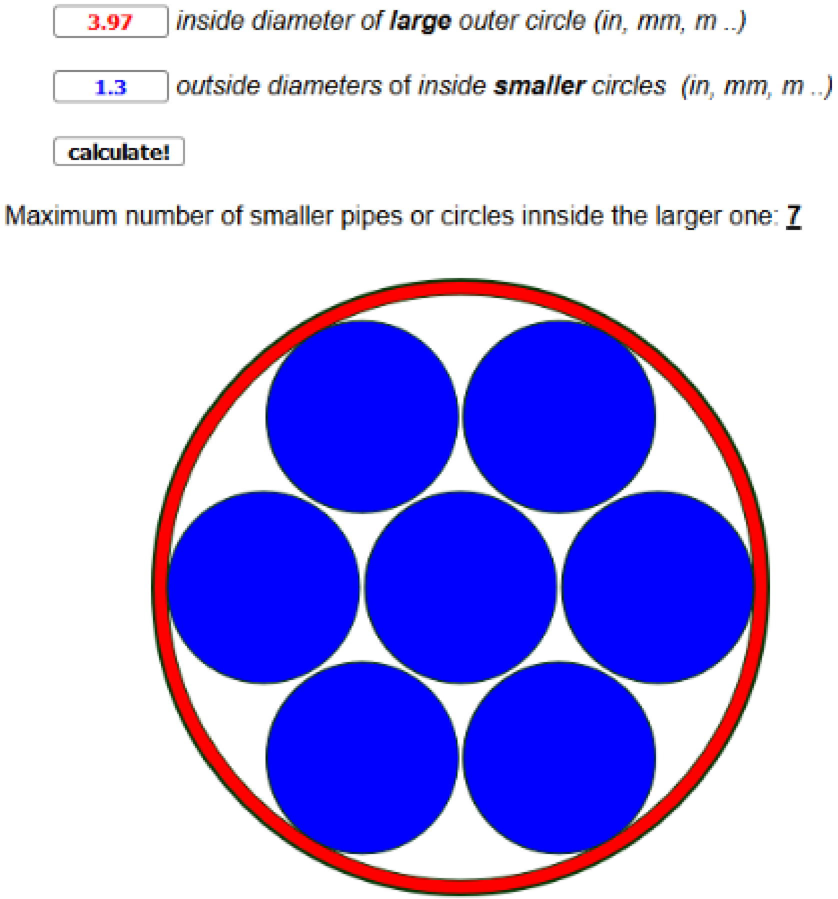
Continued next page

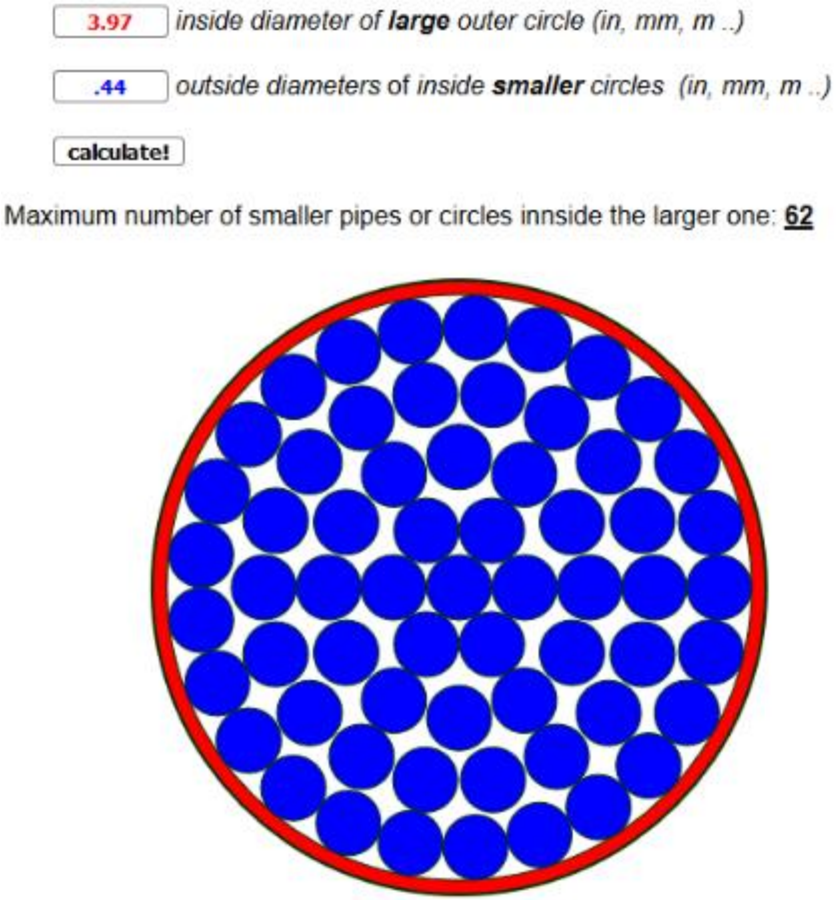
GPS Sat status: 0 = no fix, 1 = 4-8 sats, 2 = >8 sats

Log continued from WSJT-X

```
UTC     dB    DT     Freq       Drift  Call            Grid       dBm     mi (Decoded information)
200104_0000 (43 hours, still ”K”)
200105_0000 (67 hours, still ”K”)
0824    -0    1.0    14.097079    0    QY7JKX          DM12       7      33 (Y: GPS1, 25°C, J: 4.1 Volts) (just changed, 75 hours)
200106_0000 (91 hours, still ”J”)
0144    15    1.2    14.097079    0    QY7JKX          DM12       7      33 (Measured Battery 4.207, 0.1 higher than ”J”)
1724    13   -0.7    14.097079    0    QW7JKX          DM12       7      33 (Measured Battery 4.170)
200107_0000 (115 hours, still ”J”)
0434     0    1.0    14.097079    0    QZ7JKX          DM12       7      33 (Measured Battery 4.163)
1024    -0    1.0    14.097079    0    QZ7IKX          DM12       7      33 (Z: GPS2, 25°C, I: 4.0 Volts) (just changed, 125 hours)
200109_0000 (163 hours, still ”I”)
1154    -0    1.0    14.097079    0    QY7HKX          DM12       7      33 (Y: GPS1, 25°C, H: 3.9 Volts) (just changed, 175 hours)
200111_0000 (211 hours, still ”H”)
1904     2    1.0    14.097080    0    QV7GKX          DM12       7      33 (V: GPS1, 20°C, G: 3.8 Volts) (just changed, 230 hours)
200115_0000 (307 hours, It has been alternating between ”G” and ”F” for several hours)
0204     2    0.9    14.097080    0    QZ7FKX          DM12       7      33 (Z: GPS2, 25°C, F: 3.7 Volts) (just changed, 309 hours)
200117_0000 (355 hours, still ”F”)
1644     3    1.0    14.097080    0    QW7EKX          DM12       7      33 (W: GPS2, 20°C, E: 3.6 Volts) (just changed, 372 hours)
200119_0000 (403 hours, still ”E”)
1344    -6    1.0    14.097080    0    QV7DKX          DM12       7      33 (V: GPS1, 20°C, D: 3.5 Volts) (just changed, 417 hours)
200121_0000 (451 hours, still ”D”)
0414     7    1.0    14.097080    0    QY7CKX          DM12       7      33 (Y: GPS1, 25°C, C: 3.4 Volts) (just changed, 455 hours)
200122_0000 (475 hours, still ”C”)
0414     4    0.6    14.097080    0    QY7BKX          DM12       7      33 (Y: GPS1, 25°C, B: 3.3 Volts) (just changed, 479 hours)
1700 individual cells, measured from – side to + side during GPS on state: 1.128 1.112 1.126 (lowest -1.4% of highest)
200123_0000 (499 hours, still ”B”)
0004     2    1.0    14.097080    0    QZ7AKX          DM12       7      33 (A: 3.2 Volts, voltmeter reads 3.36) (499 hours)
200124_1515 (538 hours, voltmeter reads 3.134)
1834     4    1.0    14.097070    0    QZ7BKX          DM12       7      33 (an occasional ”B” shows up now and then, measured = 3.107V)
200124_1932 (RF Power = 12.4 dBm)
200126_0424   -7    1.0    14.097056    0    QY7BKX (still getting an occasional ”B”)
200126_1414   -9    1.0    14.097052    0    QZ7AKX (the last transmission, battery at 2.75V)
```

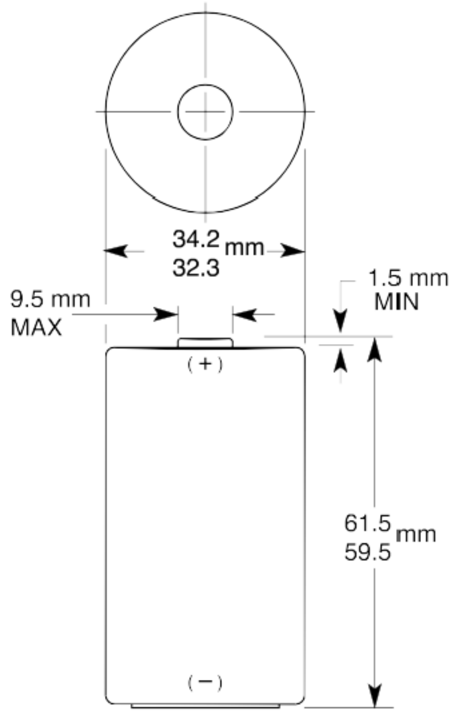
Dimensions:
3/8 rebar (max dimension) 0.44
Pipe ID 3.97 (OD 4.22)
D Cell Battery 1.30



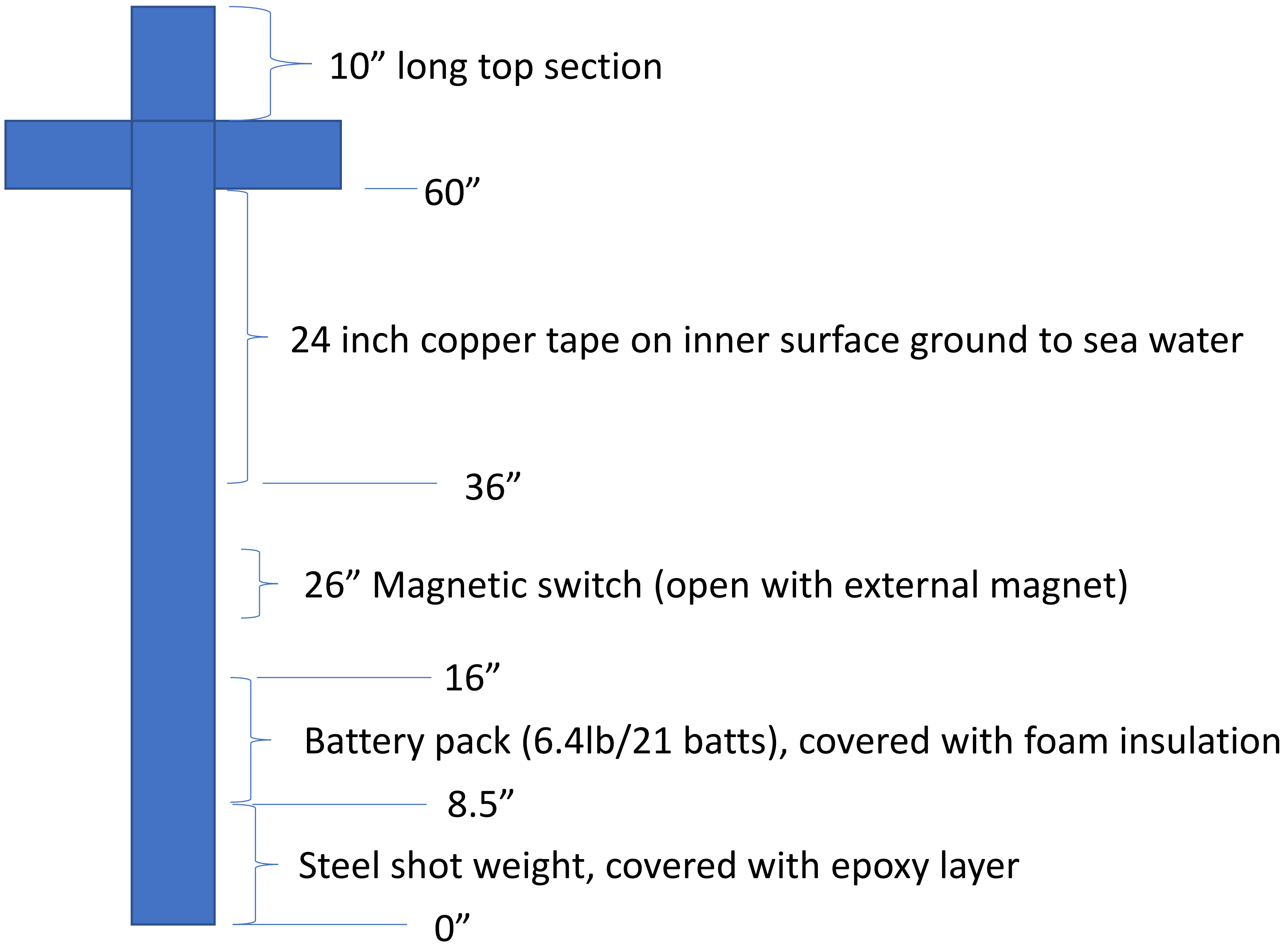


7 parallel batteries will fit into 4 inch SDR35 pipe. 62 pieces of 3/8 rebar will fit. Weighting with rebar? 6 lb of battery + 20 lb of weights are needed. 3/8 rebar weighs 0.38 lb/ft (costs $1.00/lb). 20/0.38 = 53 feet. So, cut rebar in 1 ft lengths and place 53 of them in the bottom foot of the pipe.

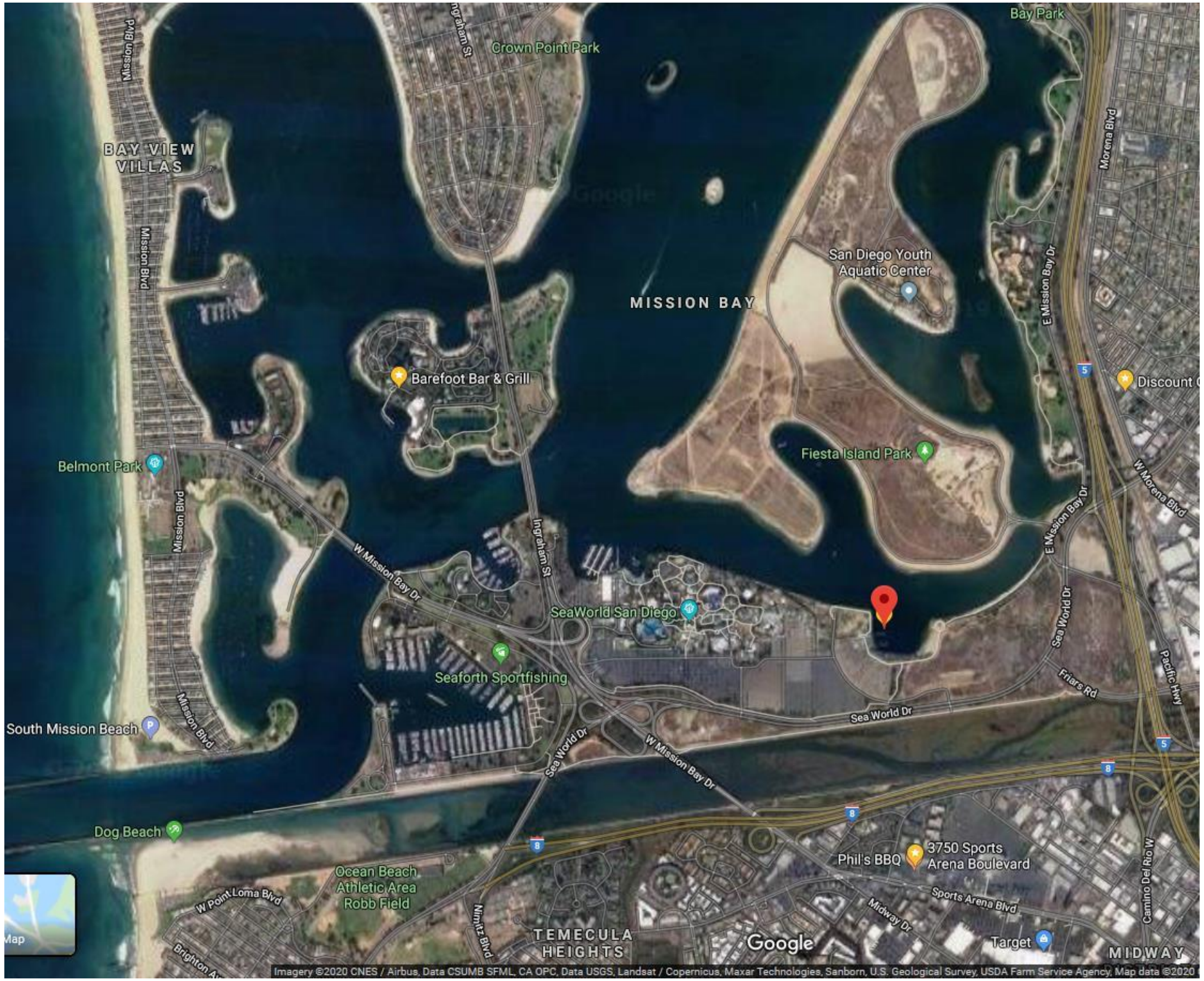
Vertical dimensions for weights, battery, grounding



Dimensions shown are IEC standards



Convenient Ocean Water Antenna Tuning Facility was the South Shores Boat Launching Area



End of pier: 32.764586, -117.217254

22mi (24 minutes) from PQ

Assembly order (this page needs to be revised):

- Cut 2 ft ground pipe section (add 2” for future cutting out coupler) and line with copper tape
- Prepare coax cable with long extension to both center and ground conductors
    - Male SMA for attachment to transmitter board & temporary tuning cable
    - Allows for attachment to antenna bolt, series inductor, shunt inductor
- Solder copper tape joints at both ends and securely attach coax cable ground at top
- For the top section there is the issue of requiring a hole for the tuning cable and no hole for the final version. What worked was to use separate 10 inch long pieces of pipe. One for antenna tuning with the cable, and the second for the final version. This was probably easier than finding a reliable way to seal the hole.
- Cut 3 ft battery/weight section (add 2” for future cutting out coupler) and attach cap
- Cut and cap 10 inch side arms
- Test fit all 4 sections to cross
- Glue side and copper taped sections to cross. Tape upper (temporary antenna tuning) section to cross. Seal it with electrical tape (this joint is above the water line).
- Glue weight section on with coupling
- Determine total weight in pool & add 2.5% for ocean
- Measure and tune antenna in ocean (Randy will help you with this part)
- Cut out coupling (ground section is now 24” long)
- Cut battery/weight section in half
- Install batteries and magnetic switches (two in parallel for redundancy) above battery section
    - Plenty of battery wiring to run to top
    - Tape on magnet to turn off battery power
- Glue battery section to ground section
- Assemble top section and glue to cross
- Weigh everything and determine weight to add to weight section (37 lb was the total weight of the prototype buoy)
- Glue on weight section
- Remove magnet to verify transmitter operation. Drywall spackle magnet on if OK.

Missing steps: covering antenna with heat shrink tubing, use of Loctite on antenna threads.

Copper tape application to the inside of the PVC pipe
Tape it to a wooden dowel, extend the PVC pipe over the dowel and then press the tape against the inside of the PVC pipe.

Copper tape tends to curl up and stick to itself once the backing is removed. Using the dowel worked out very well.

After it is installed: Smooth it out, solder the seams at both ends and attach a secure connection (that won't easily get pulled off) at the top end. Electrically it is not necessary to solder the seams in the middle or bottom end since just below the top of the ground the current in the copper tape runs vertically. The only location important for connection to all copper strips is at the top. At the bottom soldering the strips will help prevent them from getting pealed from the PVC, but this is likely to not be necessary.

Finished copper tape lined PVC pipe

Antenna tuning notes – using the CB antenna plus a matching network.
Electrically, the MFJ antenna would have been fine. Mechanically we thought the risk it will break in rough waters is high. Step 1 is to model in EZNEC. Step 2 is to measure in the ocean.
EZNEC Z coordinates (inch) will be 120 – measuring tape values.

Antenna top at zero. This will be Z = 120 in the model.

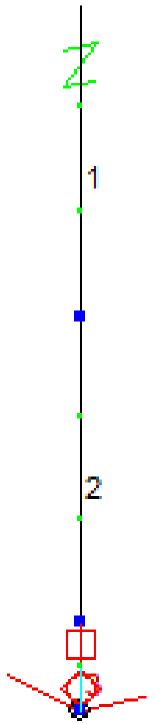
Upper half of antenna avg dia ~ 0.166 inch
Z = 67” to 120” in model (Wire 1)

Lower half of antenna avg dia ~ 0.200 inch
Z = 15 to 67 in model (Wire 2)

Antenna “rod” starts 15 in above ground. Assume series inductor just below the antenna bolt and shunt inductor just above the ground (inserted in Wire 3).

Ground at 120 in. This will be zero in the EZNEC model (Wire 3 End 1).

Model = MCHS Buoy antenna.EZ



Wires

Wire Create Edit Other

☐ Coord Entry Mode ☑ Preserve Connections ☑ Show Wire Insulation

Wires

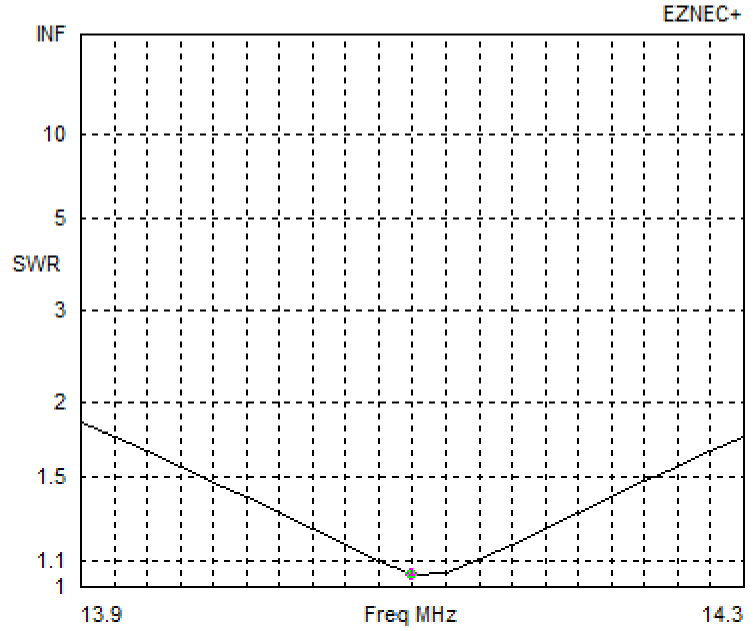
No.	End 1				End 2				Diameter	Segs
	X (in)	Y (in)	Z (in)	Conn	X (in)	Y (in)	Z (in)	Conn	(in)	
1	0	0	67	W2E2	0	0	120		0.166	3
2	0	0	15	W3E2	0	0	67	W1E1	0.2	3
3	0	0	0	Ground	0	0	15	W2E1	0.05	2

Sources

Source Edit

Sources

No.	Specified Pos.		Actual Pos.		Amplitude	Phase	Type
	Wire #	% From E1	% From E1	Seg	(V, A)	(deg.)	
1	3	0	25	1	1	0	I



Freq	14.1 MHz	Source #	1
SWR	**1.045**	Z0	50 ohms
Z	50.89 at 2.33 deg.		
	= 50.85 + j 2.066 ohms		
Refl Coeff	0.02214 at 66.51 deg.		
	= 0.008826 + j 0.02031		
Ret Loss	33.1 dB		

Average gain -3.1dB due to inductor losses

Loads (RLC)

Inductor Qs ~ 25

Load Edit Other

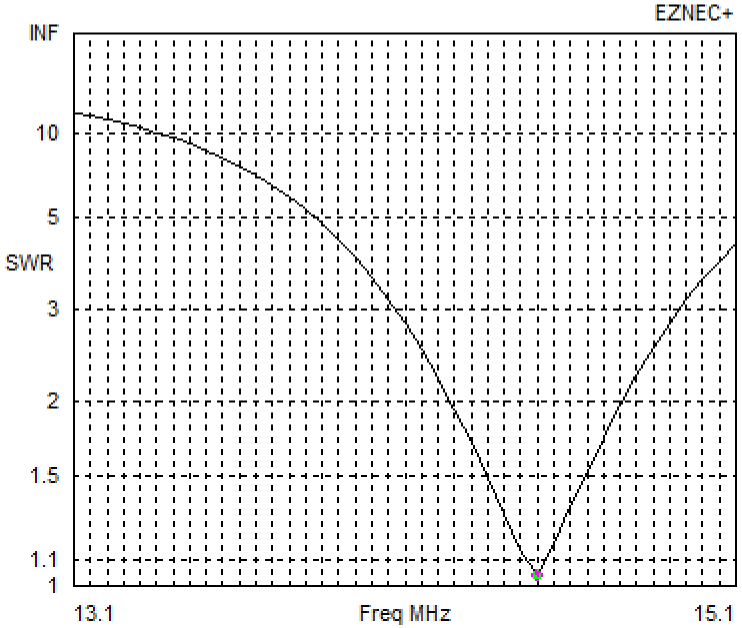
Loads

No.	Specified Pos.		Actual Pos.		R	L	C	R Freq	Config	Ext Conn
	Wire #	% From E1	% From E1	Seg	(ohms)	(uH)	(pF)	(MHz)		
1	3	100	75	2	10	3.13	Short	0	Ser	Ser
2	3	0	25	1	2	0.47	Short	0	Ser	Par

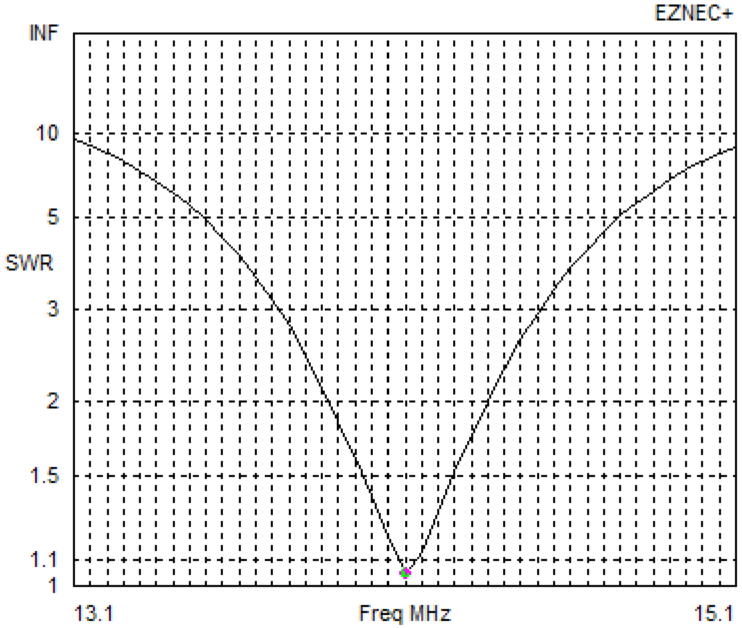
Series inductor (15 turns, insulated 20 ga wire on ½" PVC pipe)

Shunt inductor (4 turns, insulated 20 ga wire on ½" PVC pipe)

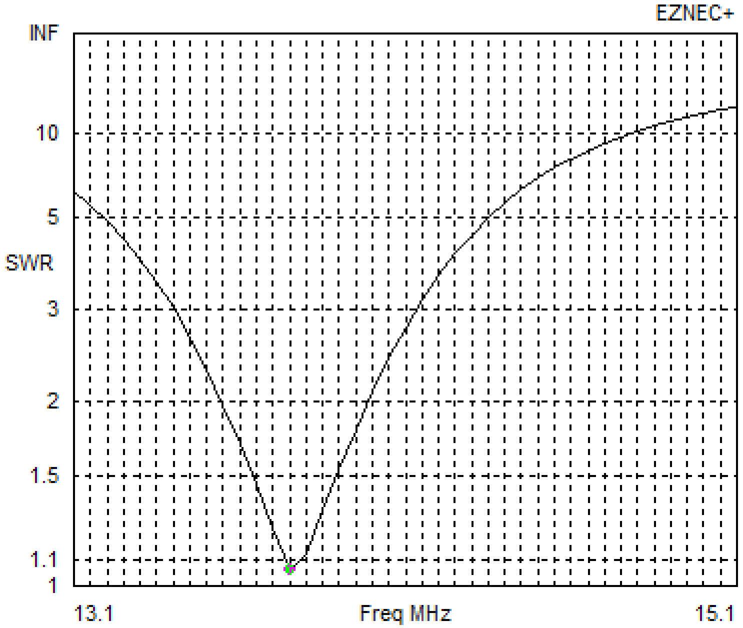
Tuning sensitivity – Series Inductor (changes frequency, but not SWR depth)
Tuning plan: 1. Tune series to center freq. 2. Tune shunt for low SWR. 3. Final tune series to center on 14.1 MHz.



Freq 14.5 MHz
SWR **1.036**
Z 49 at 1.68 deg.
= 48.97 + j 1.44 ohms
Refl Coeff 0.01786 at 124.63 deg.
= -0.01015 + j 0.01469
Ret Loss 35.0 dB
Source # 1
Z0 50 ohms



Freq 14.1 MHz
SWR **1.045**
Z 50.89 at 2.33 deg.
= 50.85 + j 2.066 ohms
Refl Coeff 0.02214 at 66.51 deg.
= 0.008825 + j 0.02031
Ret Loss 33.1 dB
Source # 1
Z0 50 ohms



Freq 13.75 MHz
SWR **1.063**
Z 51.82 at 2.85 deg.
= 51.76 + j 2.572 ohms
Refl Coeff 0.03063 at 54.16 deg.
= 0.01793 + j 0.02483
Ret Loss 30.3 dB
Source # 1
Z0 50 ohms

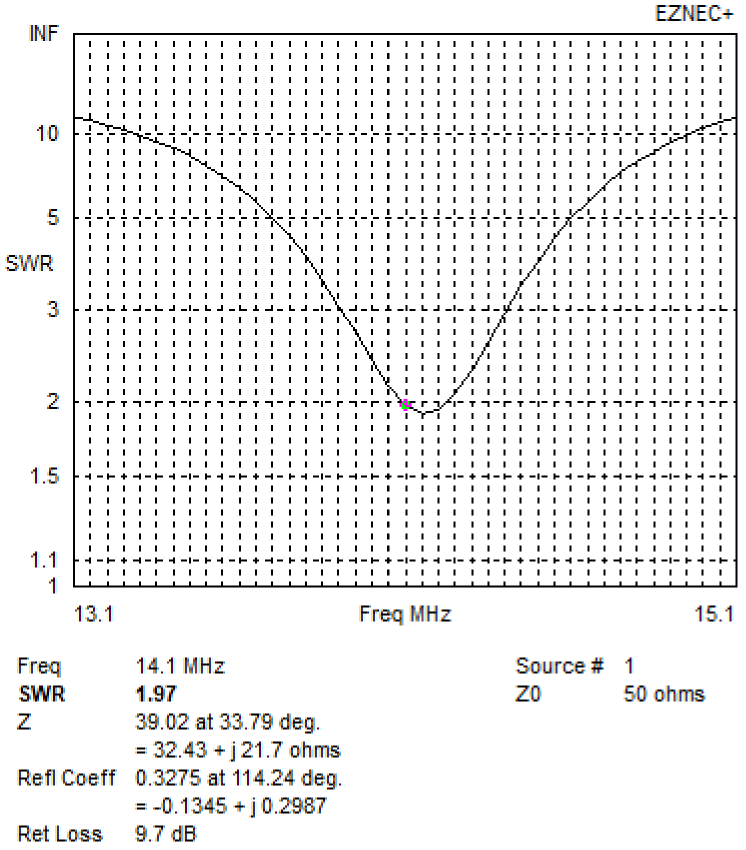
Series 14 turns (2.86 µH)
Shunt 4 turns (0.47 µH)

Series 15 turns (3.13 µH)
Shunt 4 turns (0.47 µH)

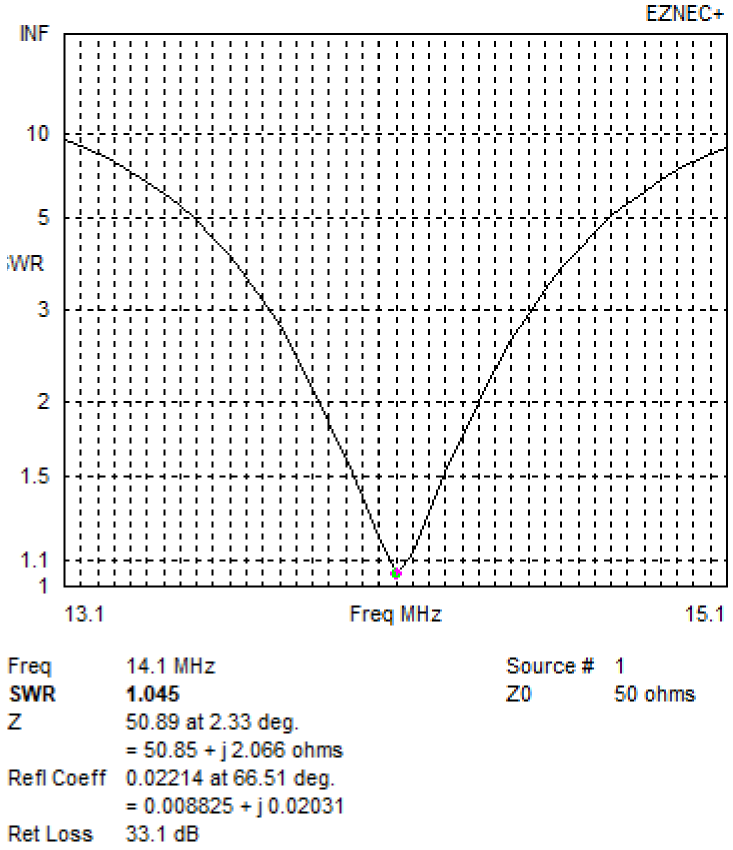
Series 16 turns (3.39 µH)
Shunt 4 turns (0.47 µH)

About 0.4 MHz per turn for the series inductor.

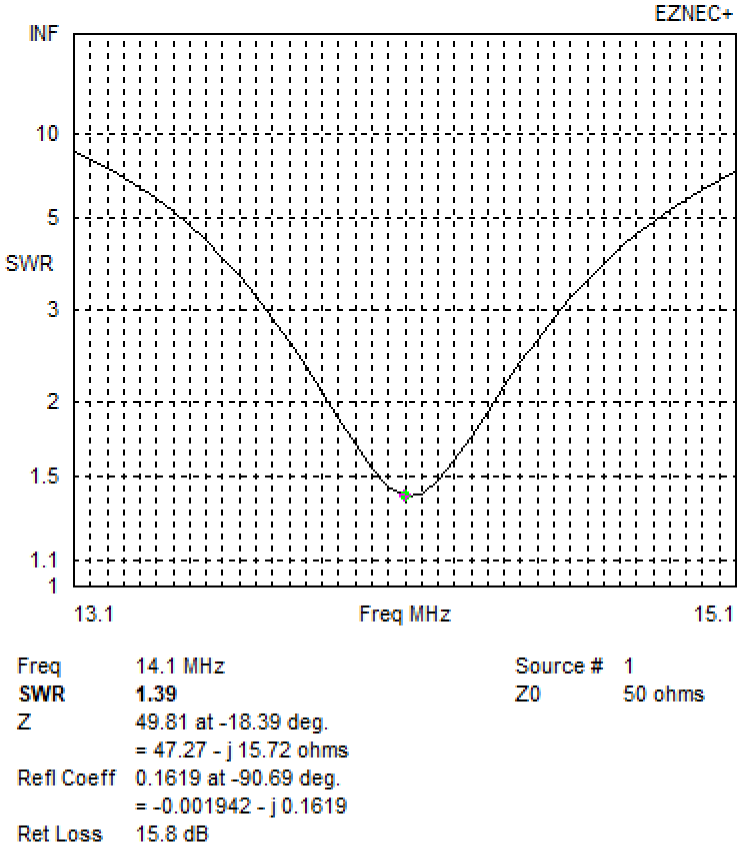
Tuning sensitivity – Shunt Inductor (changes depth of SWR, but little change to center frequency)



Series 15 turns (3.13 µH)
Shunt 3 turns (0.30 µH)



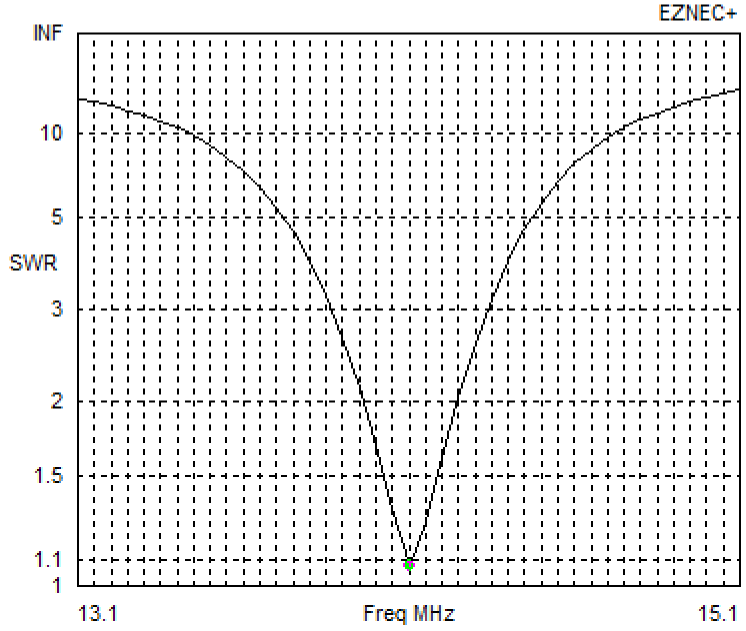
Series 15 turns (3.13 µH)
Shunt 4 turns (0.47 µH)



Series 15 turns (3.13 µH)
Shunt 5 turns (0.67 µH)

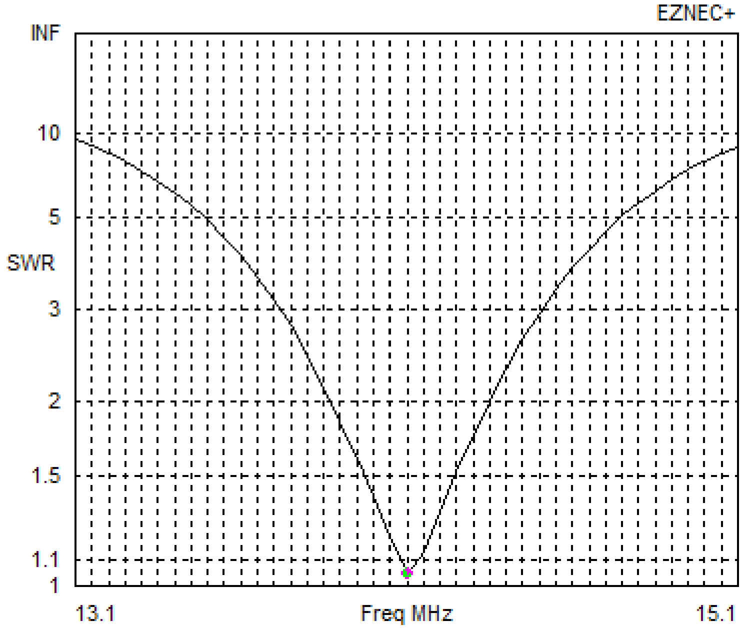
1/17/2020 Antenna pre-ocean tuning in the back yard. EZNEC+ simulations show similar impedances between a perfect ground and two radials elevated 9 feet. The inductors were tuned for get the match within ~2:1. Small changes for ocean tuning are expected.

Setup (the two radials are hard to see)



Freq	14.1 MHz	Source #	1
SWR	**1.076**	Z0	50 ohms
Z	52.22 at -3.35 deg.		
	= 52.13 - j 3.054 ohms		
Refl Coeff	0.03646 at -53.35 deg.		
	= 0.02176 - j 0.02925		
Ret Loss	28.8 dB		

MCHS Buoy antenna - radials.EZ
9 feet above ground
With two 20’ 1’’ radials (#18 wire)
(Same 3.13, 0.47 µH inductors)

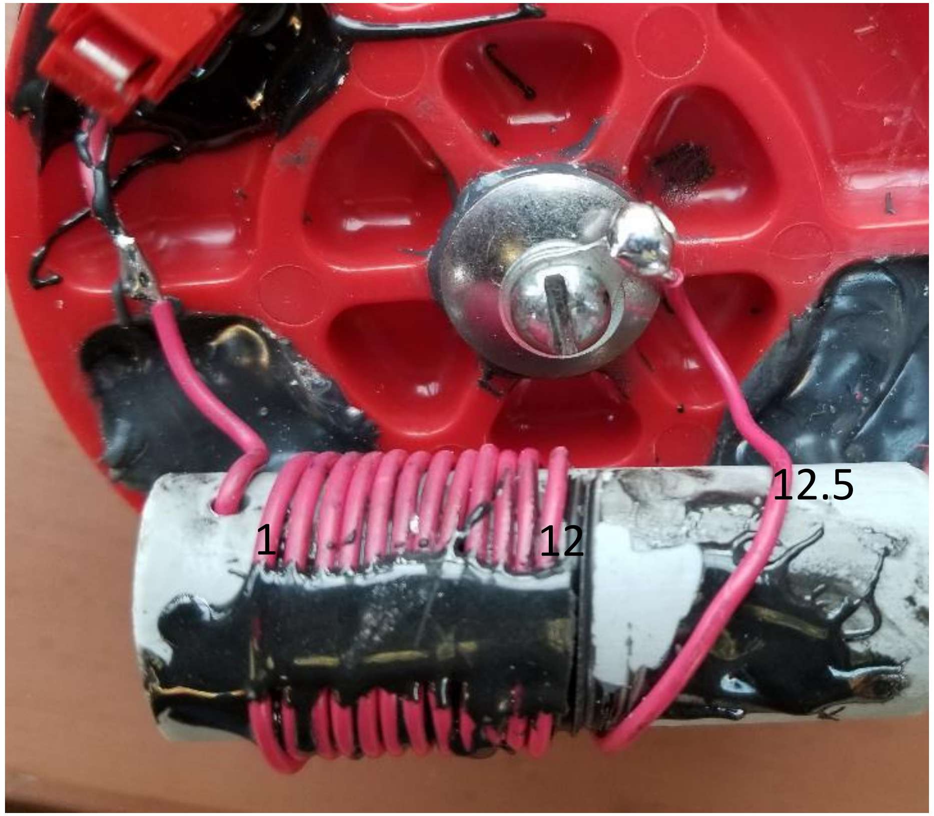


Freq	14.1 MHz	Source #	1
SWR	**1.045**	Z0	50 ohms
Z	50.89 at 2.33 deg.		
	= 50.85 + j 2.066 ohms		
Refl Coeff	0.02214 at 66.51 deg.		
	= 0.008825 + j 0.02031		
Ret Loss	33.1 dB		

MCHS Buoy antenna.EZ
On perfect ground
With Series 3.13 µH
Shunt 0.47 µH

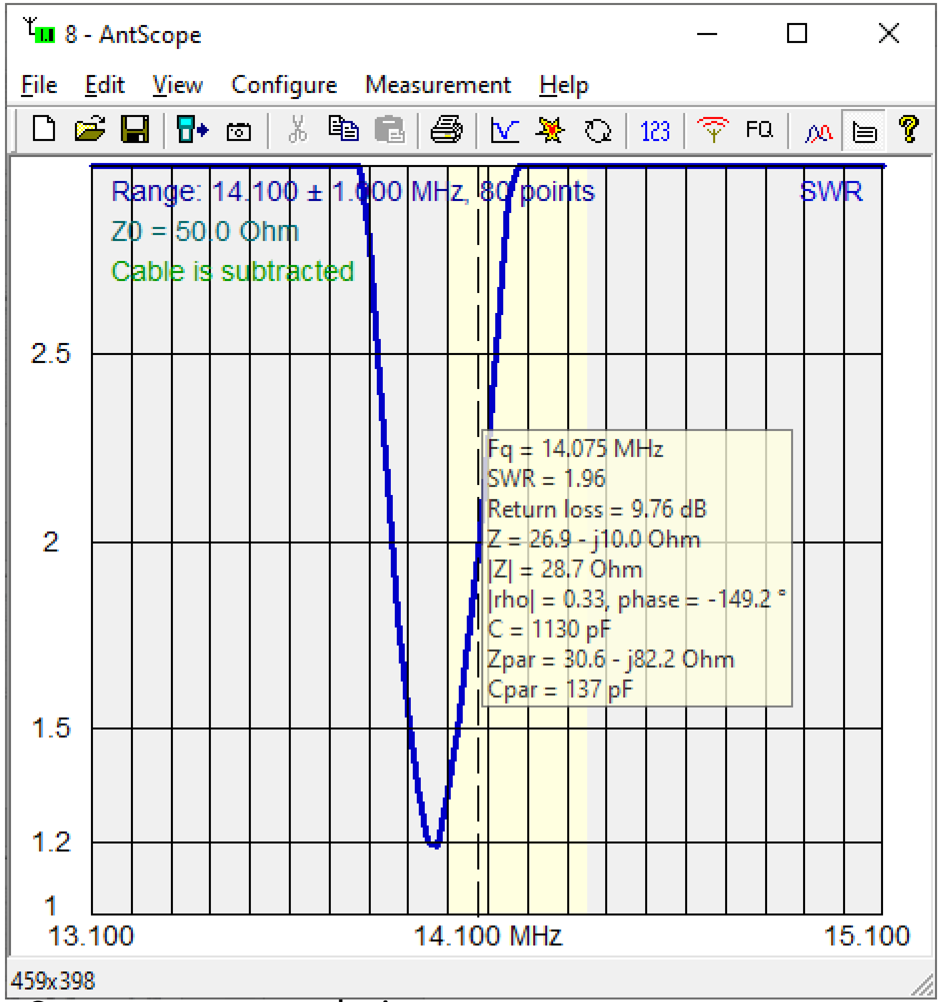
Inductors used for pre-ocean back yard tune

Shunt inductor
2 turns, 2" diameter
Measured ~0.39 µH

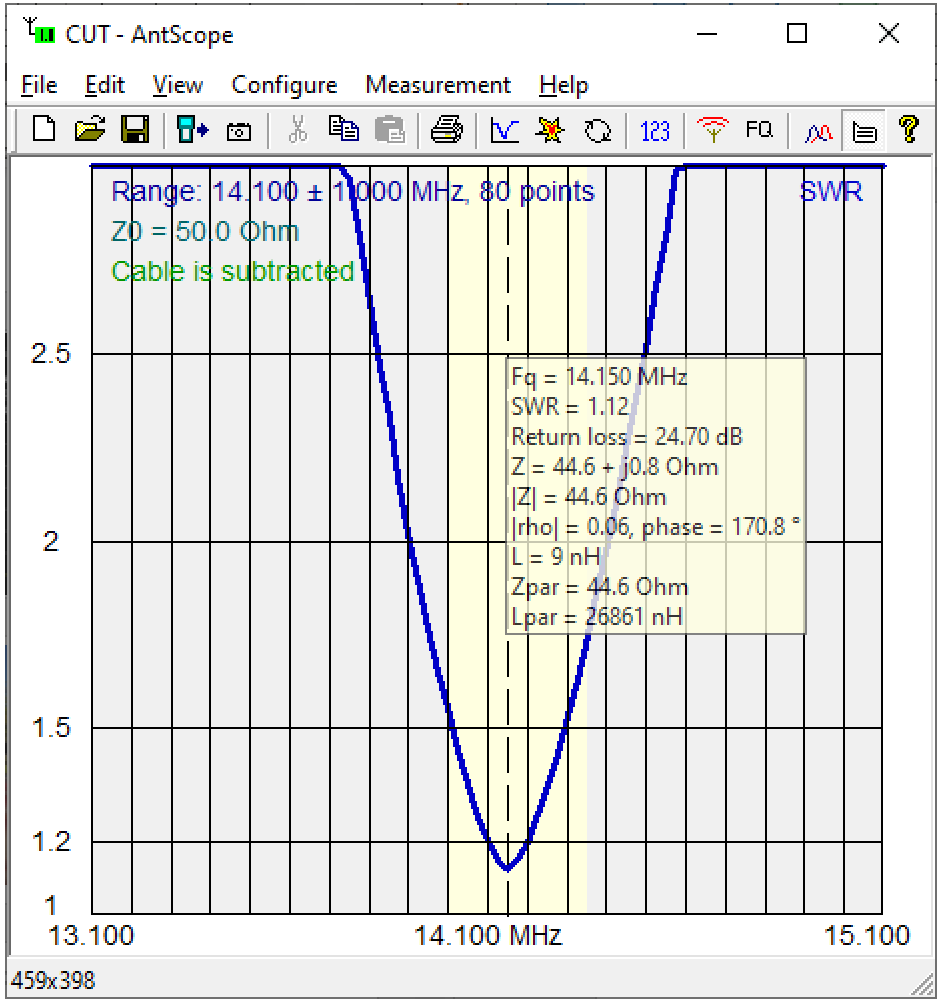


Series inductor ~12.5 turns
Measured effective inductance at 14.1 MHz = 3.3 µH
Low frequency inductance = 2.53 µH
SRF = 27 MHz

Antenna comparison. The first choice for the antenna was the MFJ-1620T because tuning would be easy. However low mechanical strength was a concern. The (27 MHz) CB antenna is mechanically tough, but a complicated antenna tuning process is required. It does appear that the efficiency of the tuned CB antenna is better. Lower losses show up as less bandwidth for antennas of the same length.

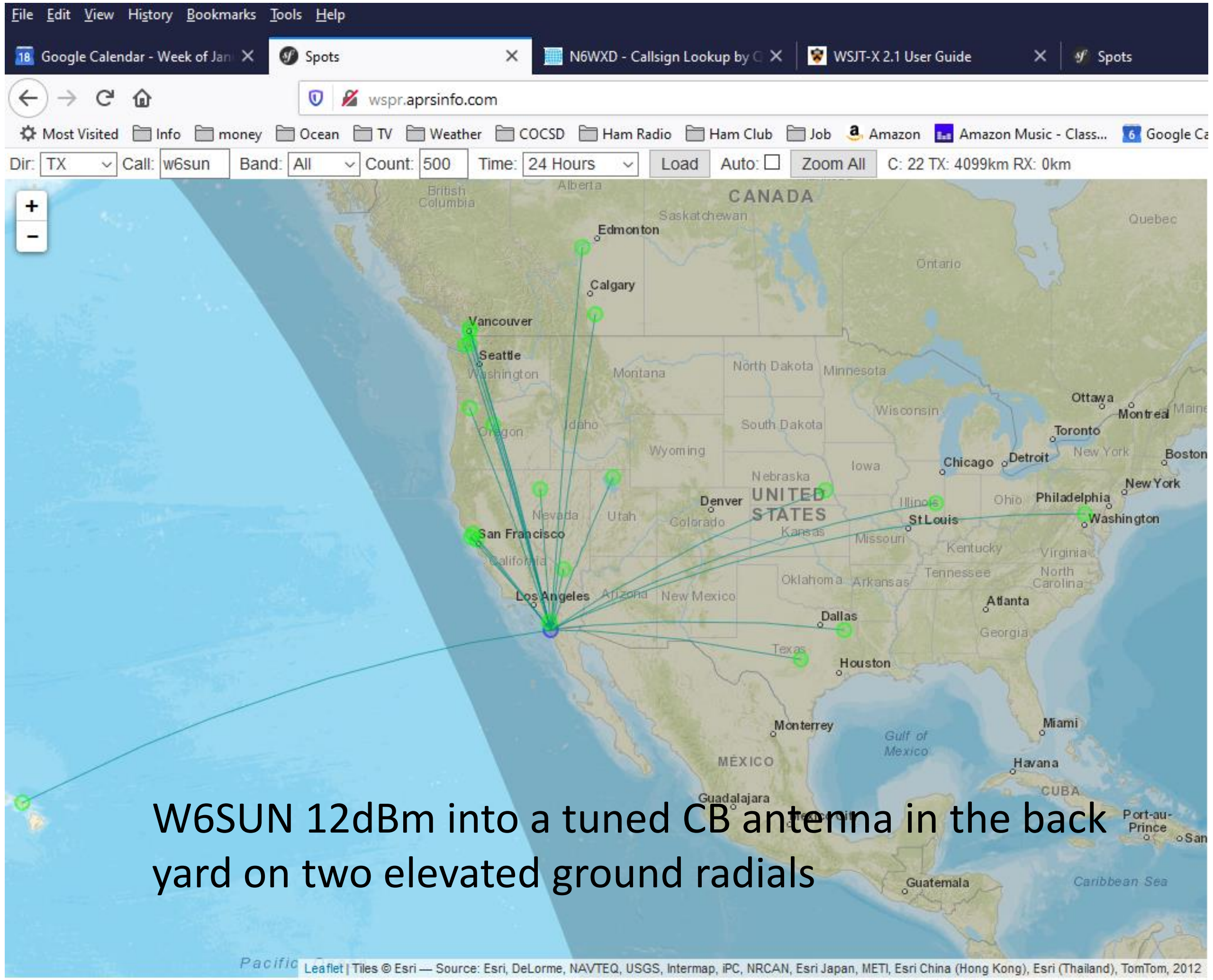


Current antenna choice:
Tuned CB antenna on elevated radials
The 3:1 bandwidth is 400 kHz

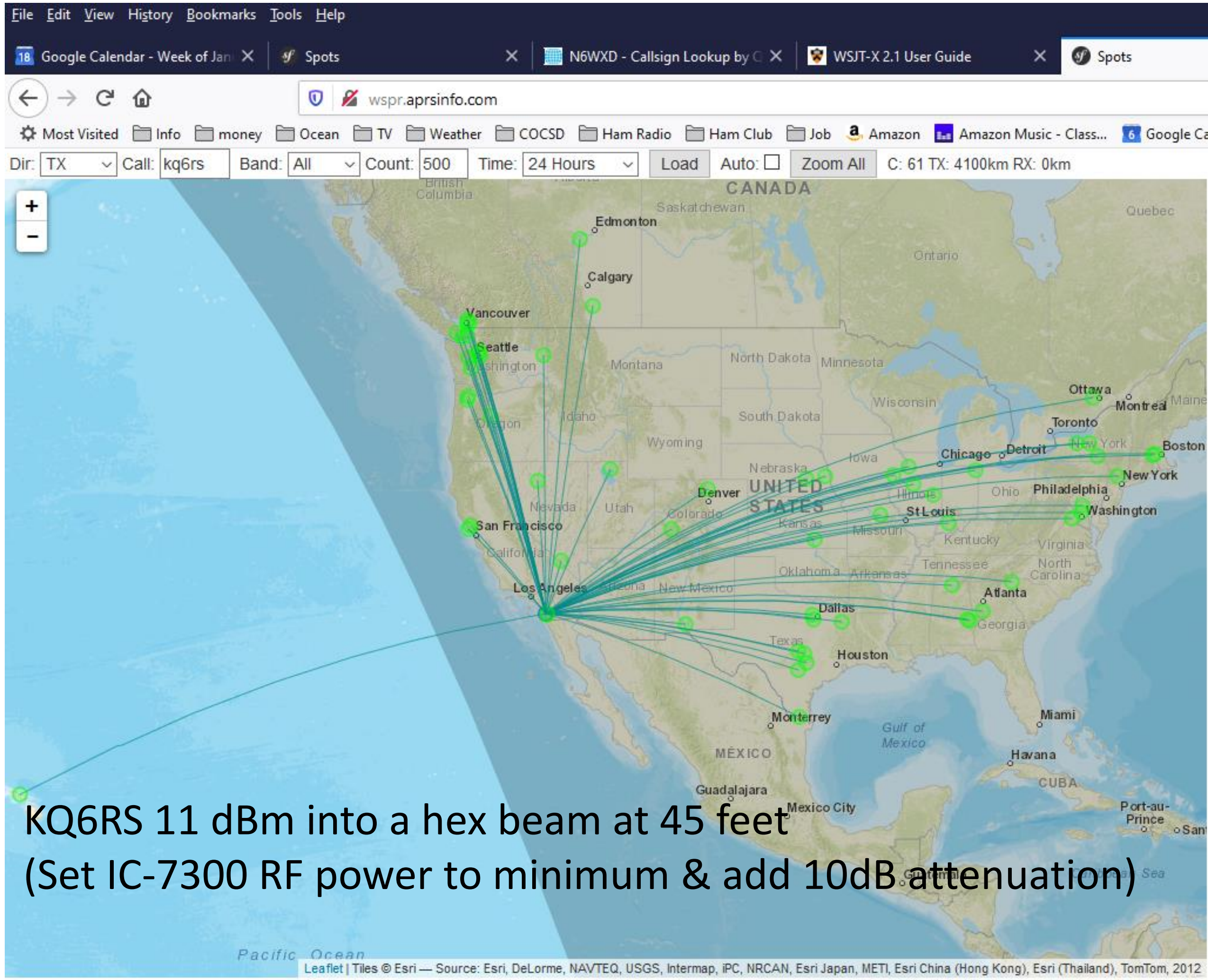


Previous antenna candidate:
MFJ-1620T Antenna on truck magnetic mount.
The 3:1 bandwidth is 800 kHz.

1/17/2020 Over the air testing (24 hours). In backyard with approximately tuned inductors (SWR 2:1) using two 9' elevated radials in place of the ocean



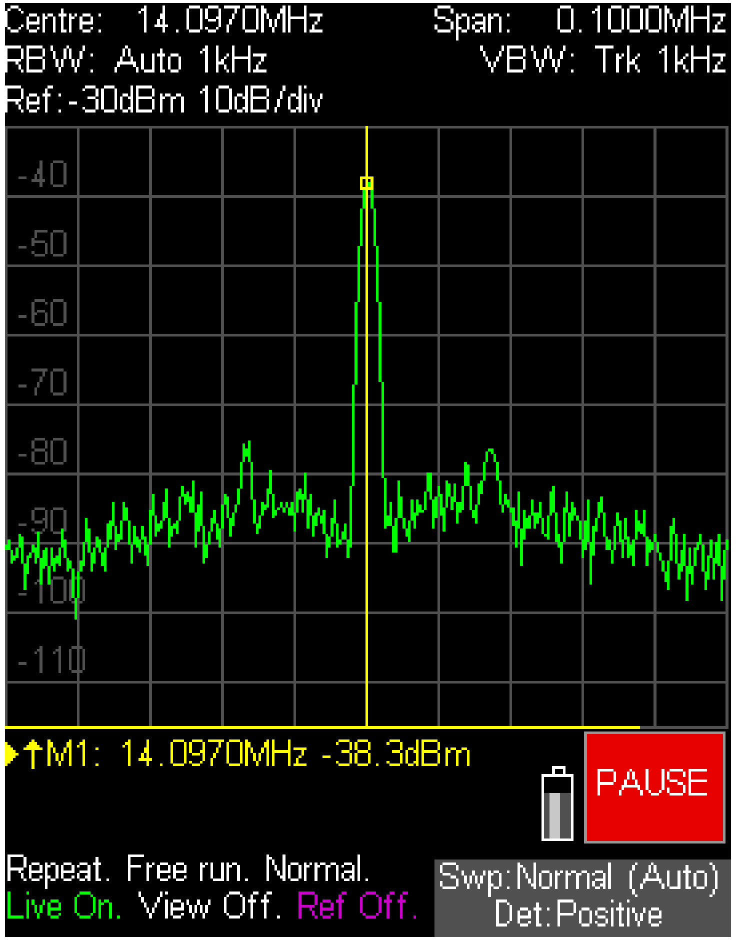
W6SUN 12dBm into a tuned CB antenna in the back yard on two elevated ground radials



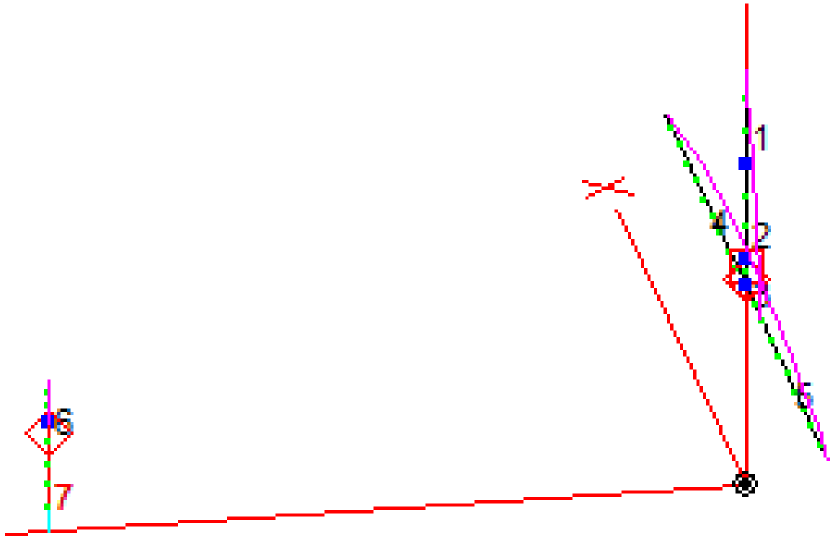
KQ6RS 11 dBm into a hex beam at 45 feet
(Set IC-7300 RF power to minimum & add 10dB attenuation)

Radiated power sanity check on elevated radials ground. Use after buoy is completed, but before given to launch boat

Tx power +12dBm

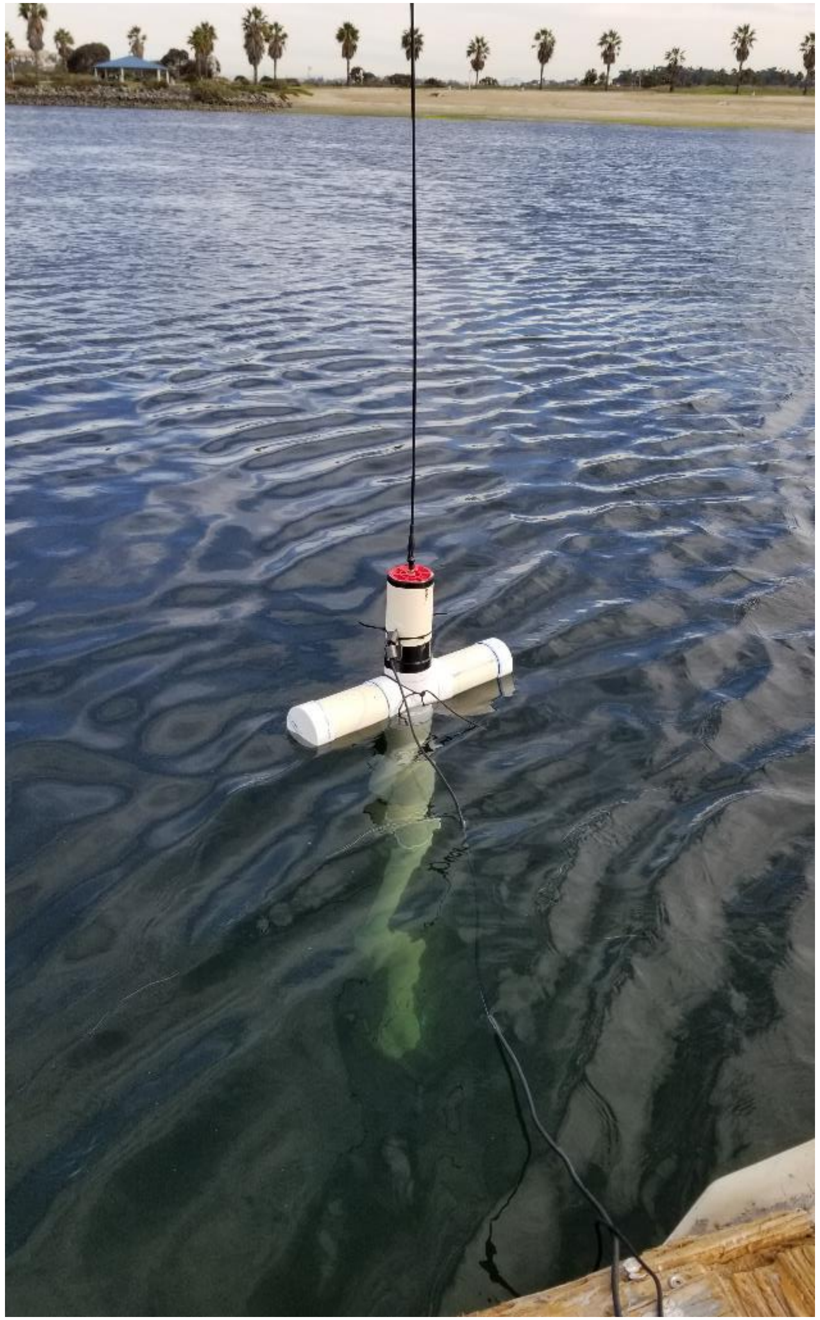


Rx power -38dBm ~30 feet away on portable analyzer with a 24” whip antenna (path loss -50dB)



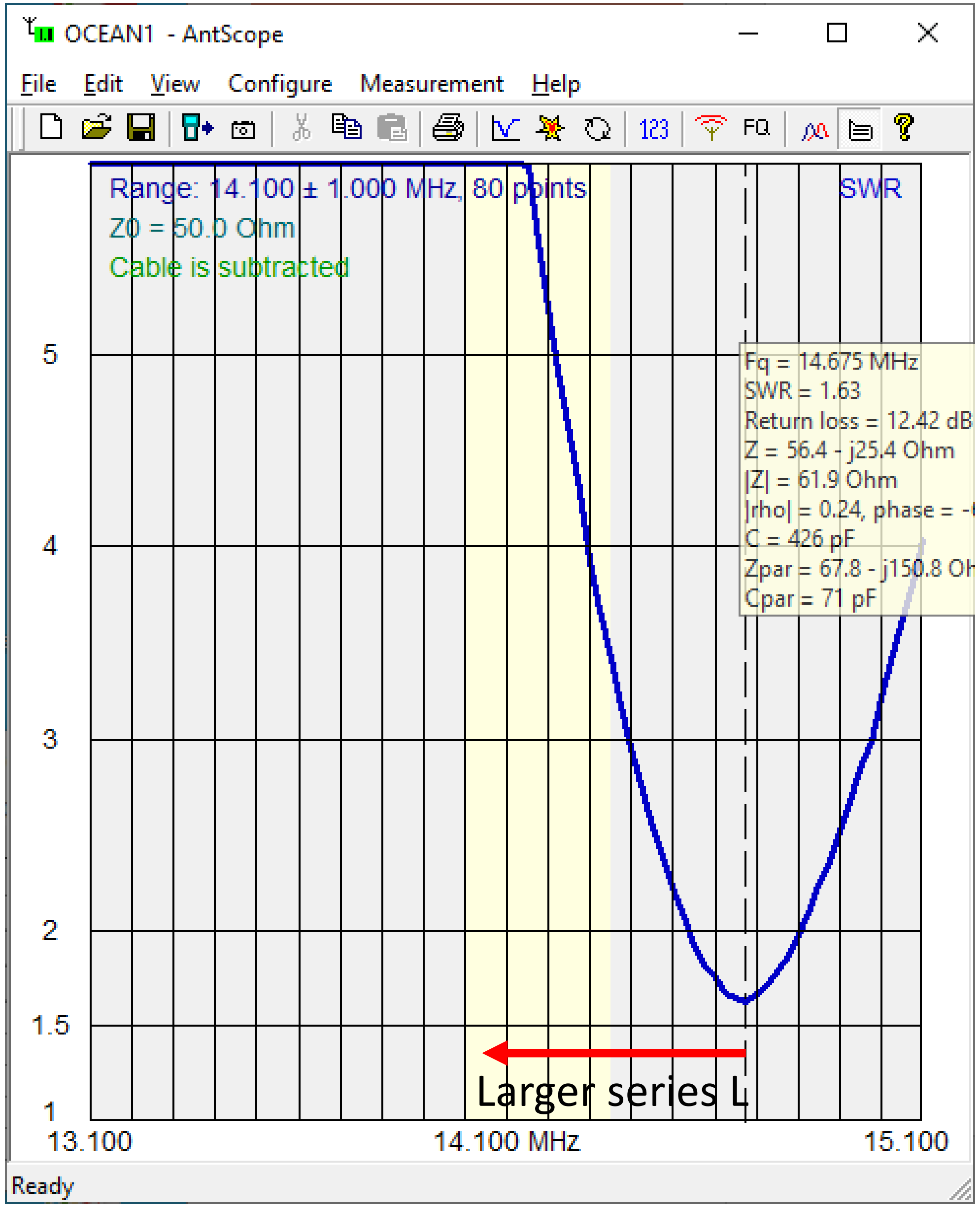
MCHS Buoy antenna, land signal strength.EZ
Shows -49dB

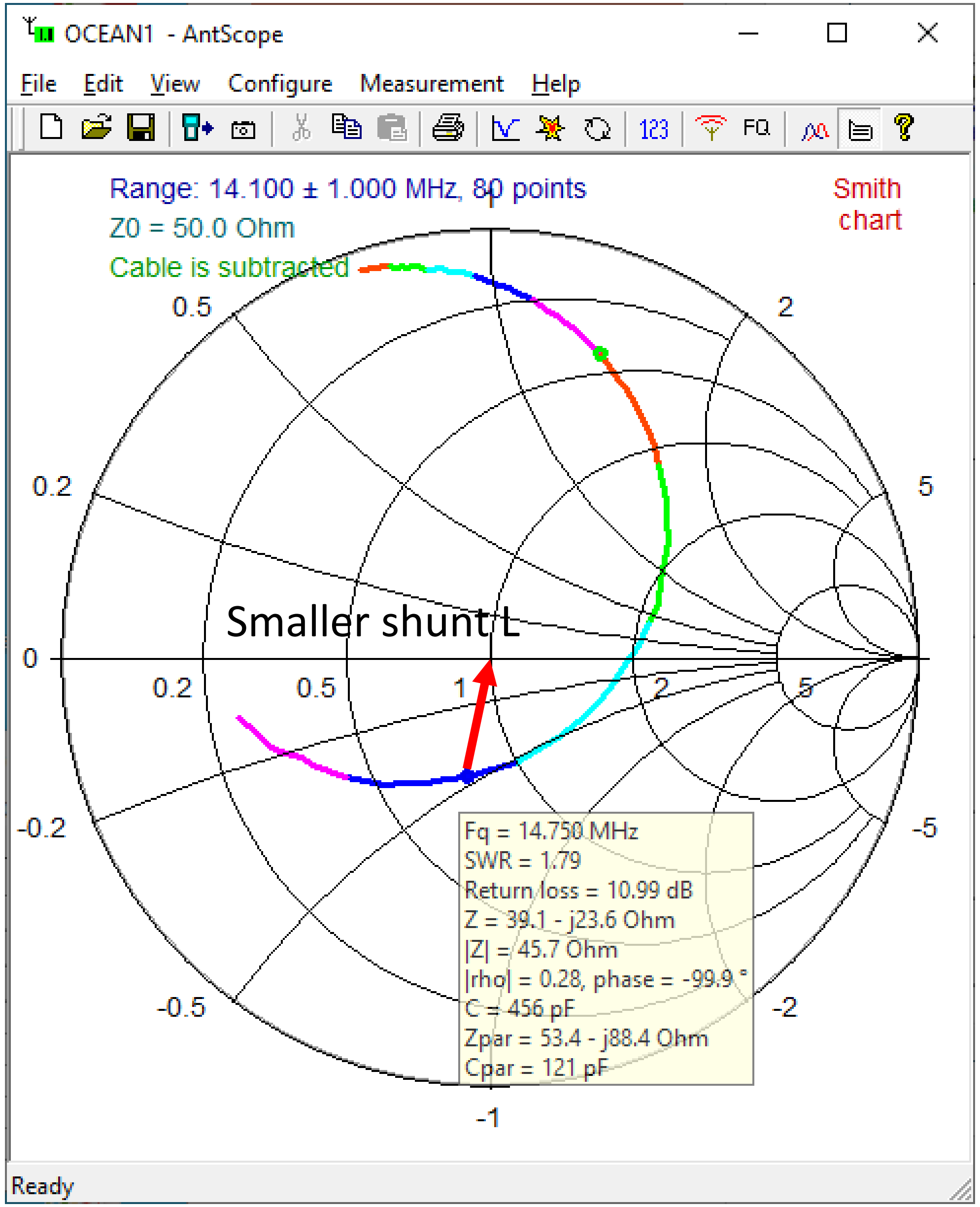
1/19/2020 First antenna match measurement in the ocean – just to check out the process. Did not bring tools to retune.



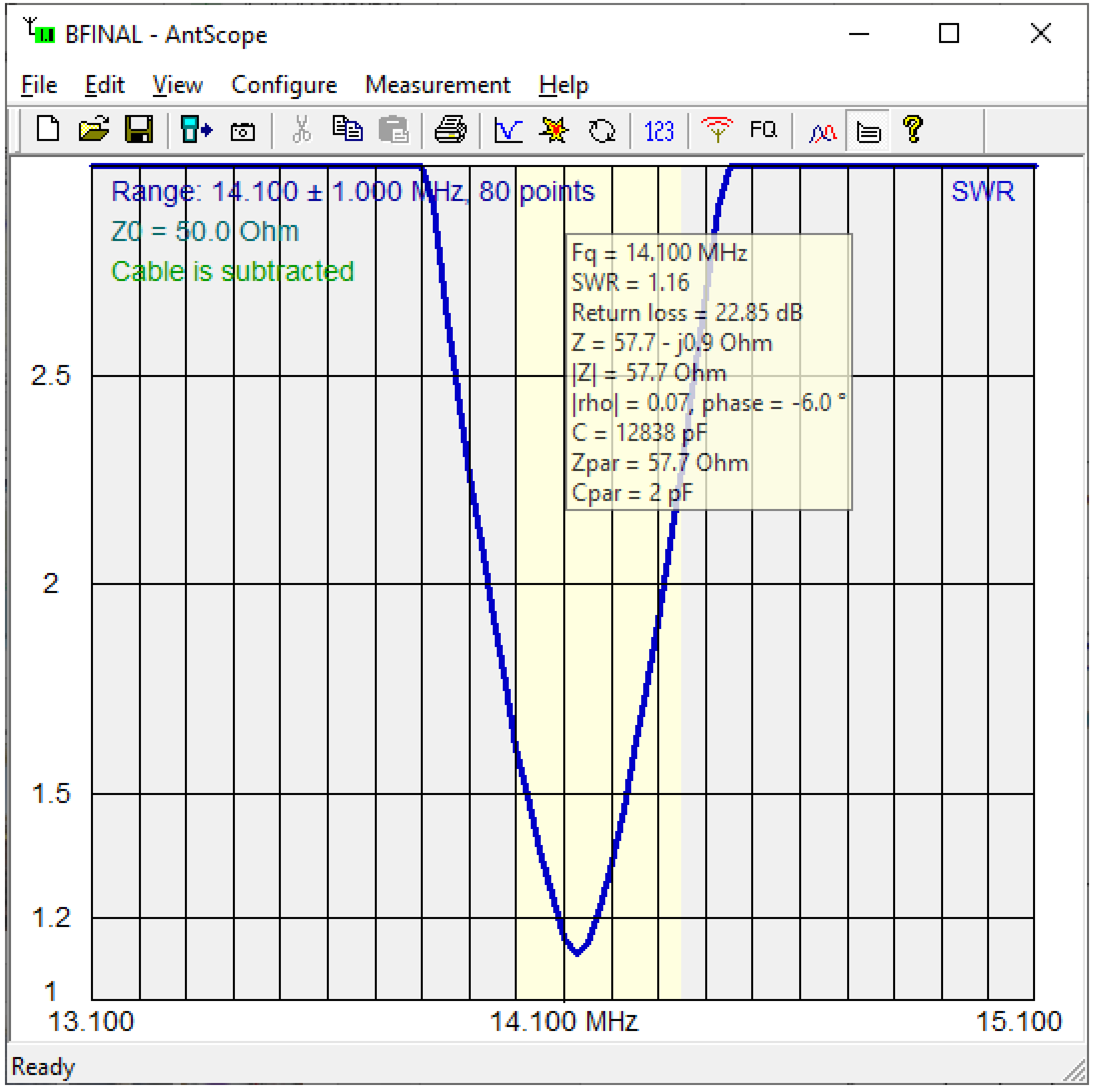
Check out the ferrite chokes on the coax (sealed with RTV). The temporary top section is only held in place with electrical tape (since it is above the water level). The top section will be replaced with a new piece of pipe, rather than try to patch the hole. The other sections of pipe were glued using purple primer and “Christy’s Red Hot Blue Glue” (recommended by a plumber buddy). At 37lb total weight about 1/3 of the horizontal pipes are submerged.

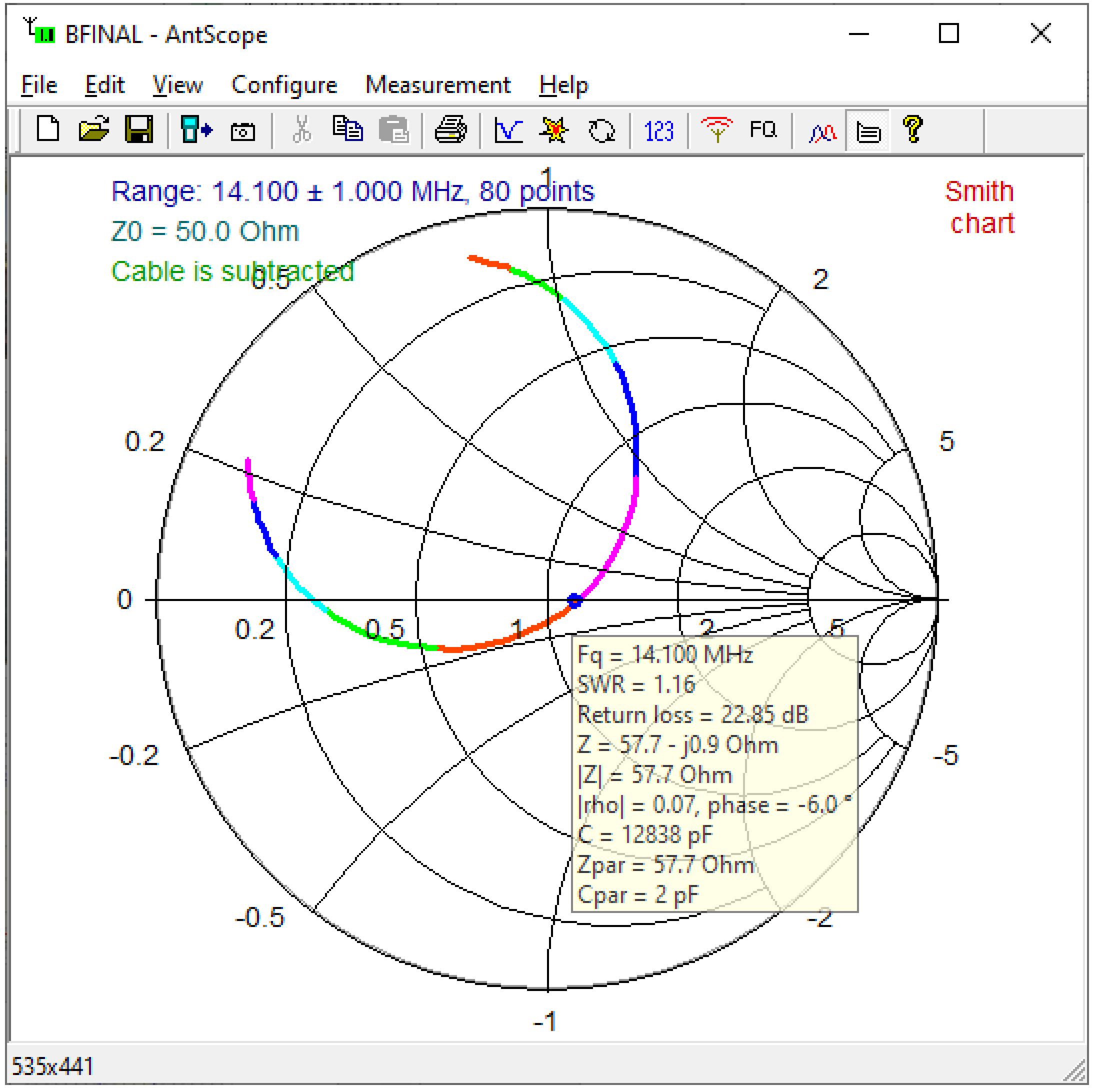
1/19/2020 Ocean measurement #1 Needs larger series L to lower the frequency and smaller shunt L to raise the resistive value of the impedance. Estimated tuning rate is 0.022 MHz/j1Ω.





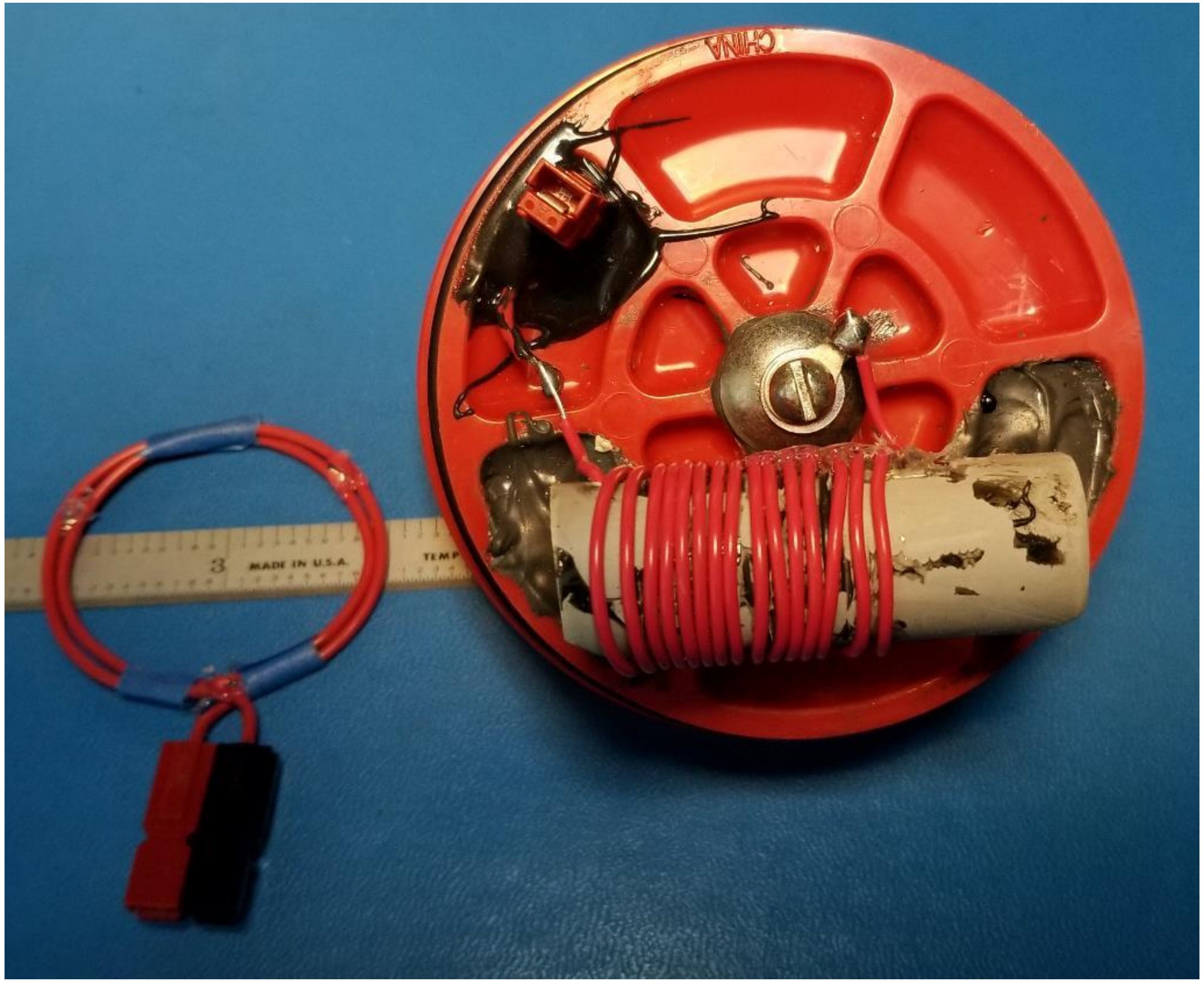
1/28/2020 Final buoy antenna tuning





The 3:1 bandwidth is 650 kHz

1/28/2020 Final antenna tuning inductors

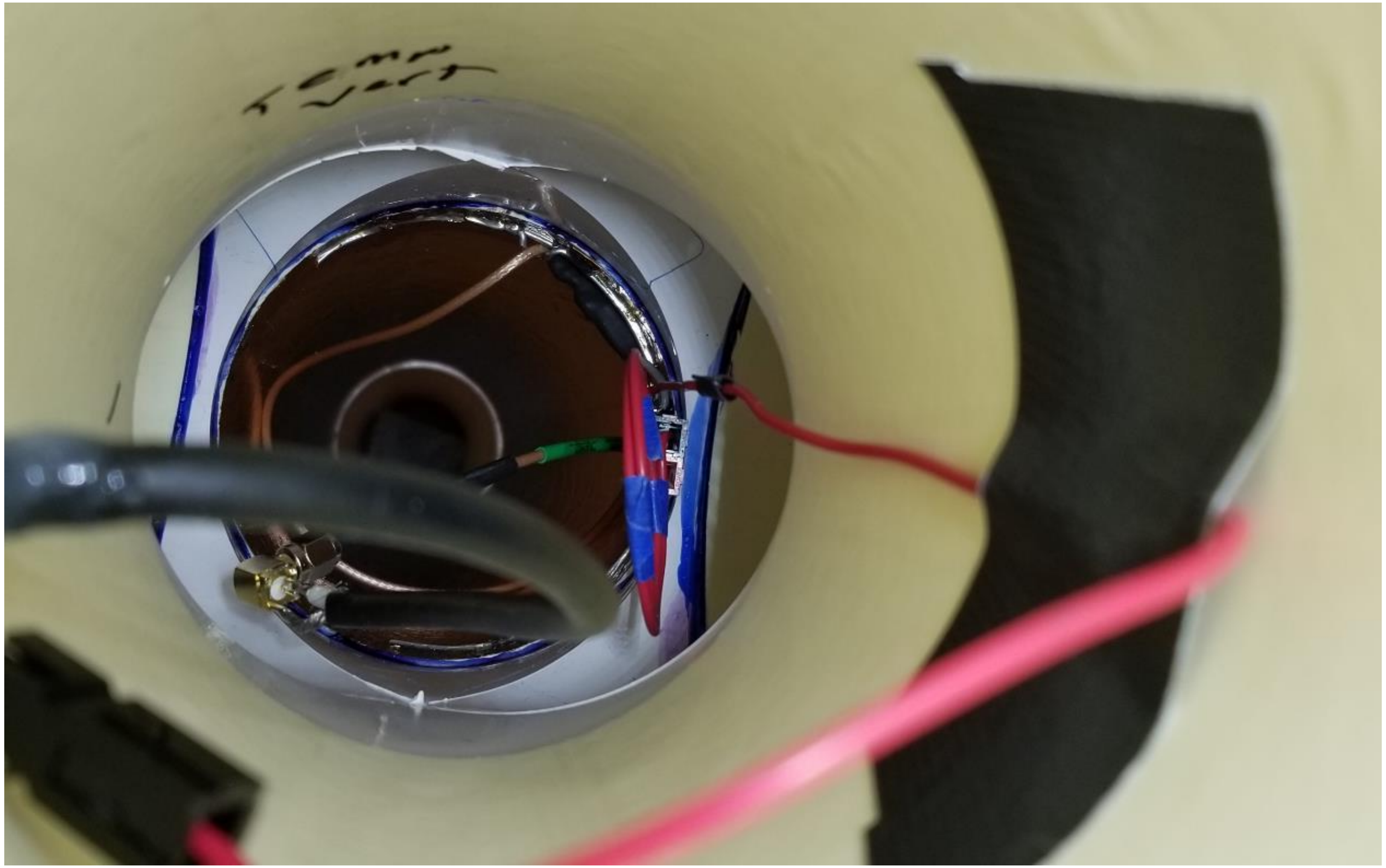


Shunt is 2 turns at 2 inch diameter measures 0.41 µH.
Series is 15 turns and measures 4.11 µH.

Total weight as tested 37.8 lb

Interior views of upper section. The antenna wire extends straight up from the matching network area. Some extra length is added so a connection can be made to the top plug. As the plug is lowered into the pipe, rotate it about 90 degrees so the wire lies about where the line drawn on the outside of the pipe is. This makes for a more consistent wire position than letting it form a loop.

Note the line shows about where the wire is when the cap is assembled.



A piece of tape holds the wire in position. Use more tape for the final assembly.

Buoy Leak Testing by adapting a pressure gauge to a test plug. Check for no pressure loss in 12 hours.

Drill and epoxy in a ¼ inch plastic tube to the bottom piece of the test plug. Drill a clearance hole to the top piece (which is not part of the seal to the pipe).

3 psi is a good test pressure. Safety note – at this pressure there is 38 pounds of force on the test plug. It is held in with friction and more pressure may force it out.

Test pipes, not actual buoy

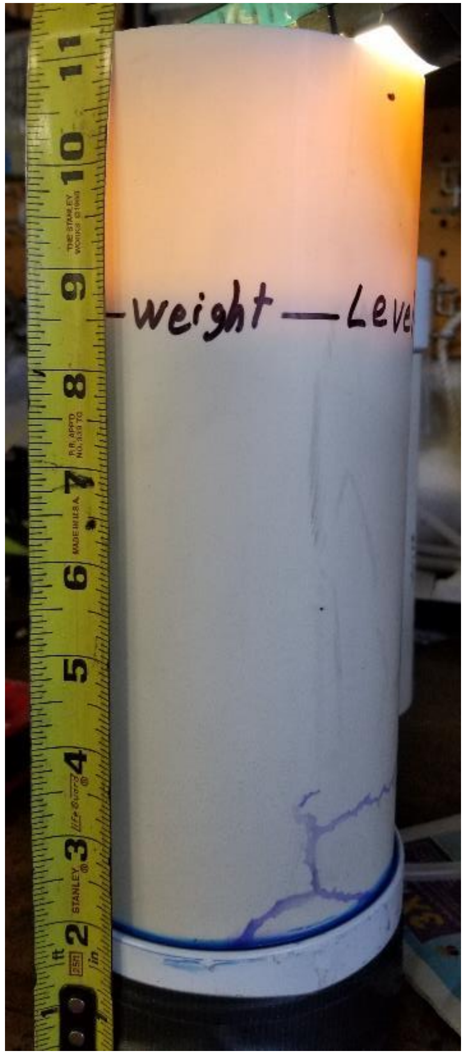
Safety – use ropes as a backup to holding the test plug in & mount the buoy so the plug is not facing anyone in case it “shoots out.”

1/31/2020 Added 18 lbs. of weight. Steel shot with 3 oz of epoxy poured over the top to hold it in place

Part	Weight
Antenna rod	1.000
Top cap (with matching coil)	0.848
Top pipe	0.882
Cross and ground assembly	5.414
Bottom pipe (total)	3.362
2 couplings	0.760
All batteries (21)	6.444
Wiring	0.080
Circuit and mounting	0.178
Total weight (minus weights)	19.0
Final total weight goal	37.0
Steel shot (& support epoxy) to add	18.0

Weight calculations

Look down on epoxy on steel shot



Steel shot height

The bottom 11 inches of the buoy is a separate piece. The weight fills up to the 8.6 inch level. The batteries will be installed in the section above this one.

1/31/2020 Mount for the payload circuit board.
A piece of acrylic is epoxied to the inside wall of the top section. To minimize detuning the GPS antenna by the dielectric loading of the PVC pipe and the acrylic support board, the width of the support board was chosen to provide some spacing away from the inside of the PVC pipe, but still leave enough room to reach into the pipe. In addition, a notch was cut into the acrylic under the GPS antenna. The circuit board will be attached to it by both adding two dabs of RTV, and bending over the red wires.

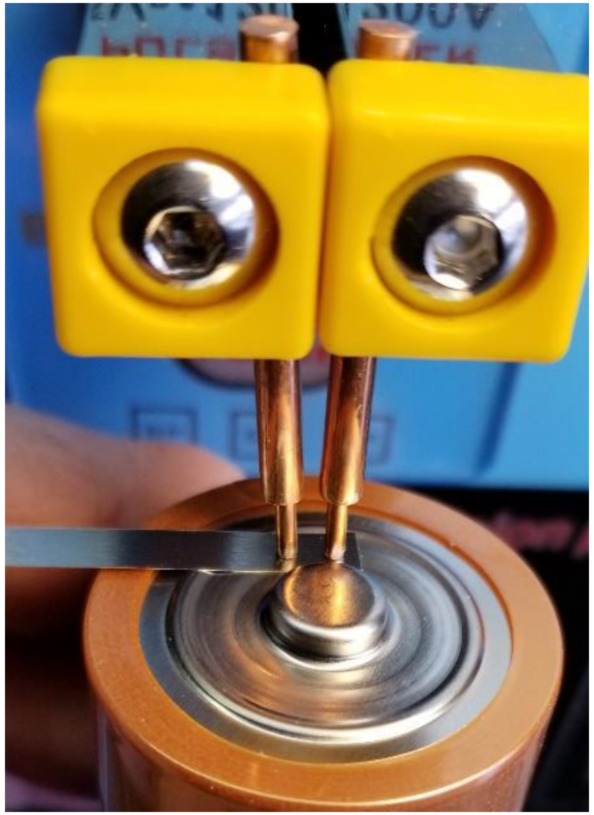
2/1/2020. Battery wiring. Is 18 gauge wiring a good choice in terms of battery voltage? The distance between the batteries and circuit board is 5 feet. That means 10 feet of wire length. The circuit draws 0.028 Amps. 18 gauge copper wire has a resistance of 0.0064 Ω/foot. The resistance of 10 feet of it is 0.064 Ω. $V = IR = 0.028 \times 0.064 = 0.0018$ Volts. I would say 0.05 Volts would have been an acceptable voltage drop. This is a tiny fraction of that. So, 18 gauge wire is both convenient to use and overkill in terms of low voltage drop.

Recommend only using Duracell batteries when making direct connections (not using a holder) (even though both have the same capacity)

Found: 1. Soldering the negative (bottom) side of Energizers creates an open circuit. 2. Pulling spot welded tabs from the bottom side open circuits Energizers. These were not problems with the Duracells.

Battery Spot Welding of Solder Terminals using a Sunkko model 737G+ (Settings: Pulse 1P, Current 00, Super Pulse all off, contact pressure three turns CCW of full CW)

These provide a “no heat” method of attaching connections to a battery. This is the method used to make electrical attachments in all commercial battery packs

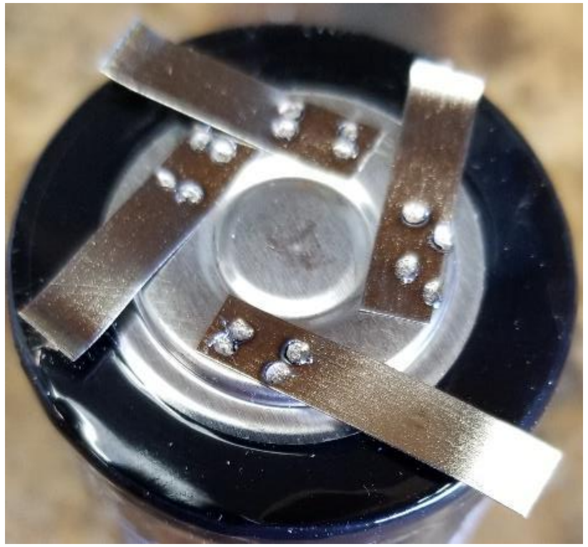


Press battery to raise contact arms most of the way up, against the spring resistance.

The contact strip is spot welded under where the probes were. These welds look good. Too little power and the tabs can come off. To much can melt holes in the battery ends.

After wiring up one side of a battery pack. The battery supply is 21 Duracell D-cells configured as 7P3S.

Spot welding “torture testing”
Goals: how well are the tabs attached & does this hurt the battery?



4 tabs on each end and 2 applications (4 spots) of welding.

Solder tab tear off tests. These test how unlikely it is for the tabs to come off, and if pulling on the tabs can damage the batteries.

Results: The welder was set to the minimum power. Even at that there is no way the tabs will come off in handling. They had to be ripped off using pliers. This caused no problems for Duracell batteries, but killed Energizer batteries. Two out of two Energizer batteries resulted in an open circuit from this test. One was found to work only when the negative end was being pressed against the battery with a screwdriver. So, don’t use Energizer batteries for this application. I am sure Energizers are fine used in a battery holder. Somehow the bottom contact does not tolerate heat or pulling.

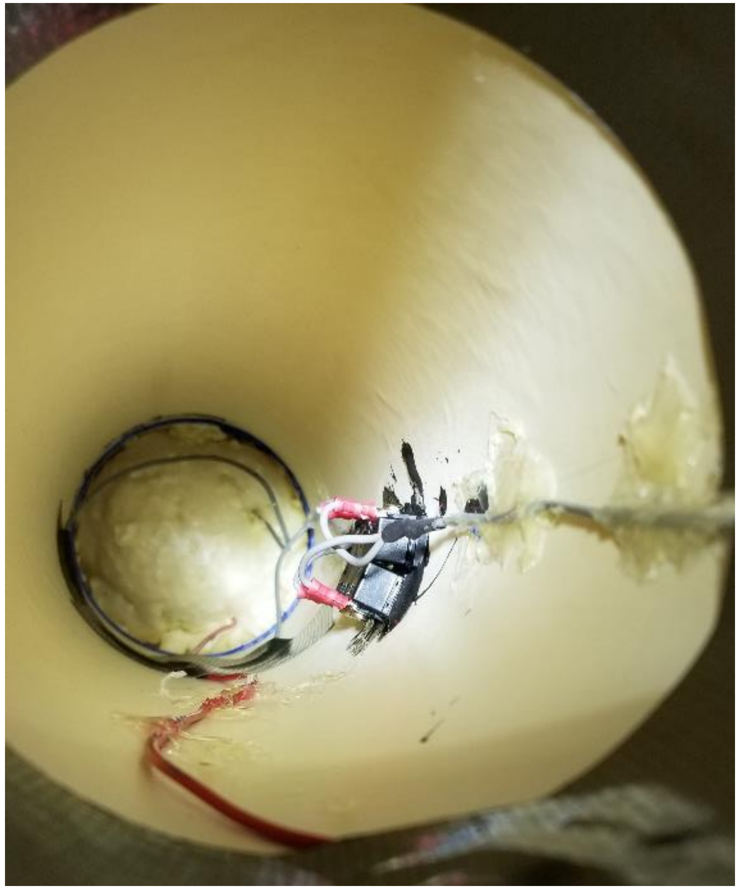
More on the battery pack

You don’t want to heat the battery when soldering to the tab. I experimented with putting insulation under the tab, but found this extra step was not necessary. Just bend the tab up enough to not touch the battery when you solder a wire to it. Do use an abrasive to clean the tab and flux for a better solder job.

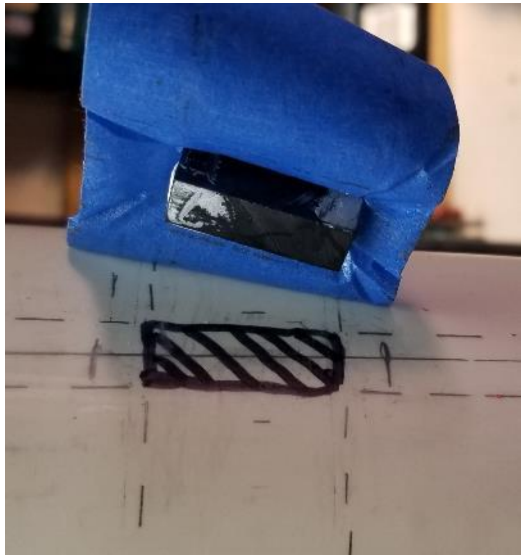
Final battery close to 6.444 lb estimate.

Batteries “foamed in” above weight section with the cheapest insulating foam Home Depot sells.

2/11/2020 Magnetic Switch to Save Batteries Until Deployed. The goal is to delay starting our 180 day battery life until the buoy is close to launch or just at the time of launch.



Two magnetic switches in parallel for redundancy. The switches both close in the absence of a magnet.



The location of best magnet position to hold both switches open is marked. Power is on when the magnet is gone. Use tape for home testing. Use drywall spackle for final mounting.

Fail safe magnet release - stick the magnet on with a water-soluble material (e.g. dry wall spackle). The scenario this addresses is a boat can take the buoy from us, but won’t be launching it for a few weeks - and they forget to remove the magnet before tossing it in the ocean.

3/5/2020 Board arrived today
Calls KQ6RS & 0Y7JKX (the 0 and 7 are the ID number)

Idle 0-2 (~15 mA)
GPS 2-6 (~34 mA)
Transmits on 6-8, 8-0 (~30 mA)

Long average from 5:30 pm PST to 8:30 pm is 28 mA, the <u>same current requirement as the W6SUN board</u>.

"Secret Decoder Tables" for special call
<u>Note: The Voltage scale has changed.</u>

2nd character

Call 2		
Temp/Sats	Sat Status	Temp
F	0	-5
G	1	-5
H	2	-5
I	0	0
J	1	0
K	2	0
L	0	5
M	1	5
N	2	5
O	0	10
P	1	10
Q	2	10
R	0	15
S	1	15
T	2	15
U	0	20
V	1	20
W	2	20
X	0	25
Y	1	25
Z	2	25

GPS Sat Status:
0 = no fix
1 = 4-8 sats
2 = >8 sats

4th character

Battery	Call 4
3.3	A
3.4	B
3.5	C
3.6	D
3.7	E
3.8	F
3.9	G
4.0	H
4.1	I
4.2	J
4.3	K
4.4	L
4.5	M
4.6	N
4.7	O
4.8	P
4.9	Q
5.0	R
5.1	S
5.2	T
5.3	U
5.4	V
5.5	W
5.6	Y
5.7	X
5.8	Z

New KQ6RS Board

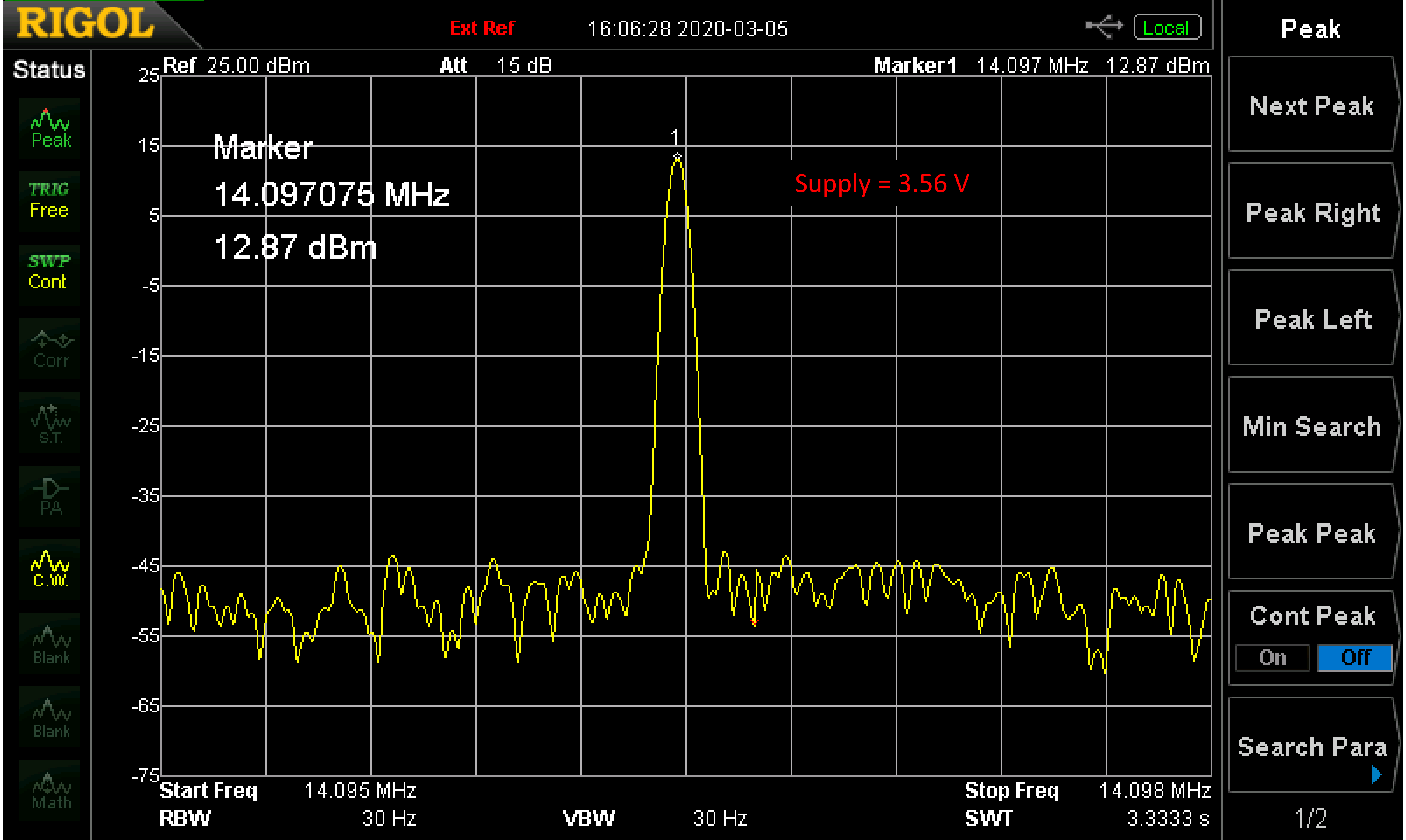
<u>From WSJT-X display</u>

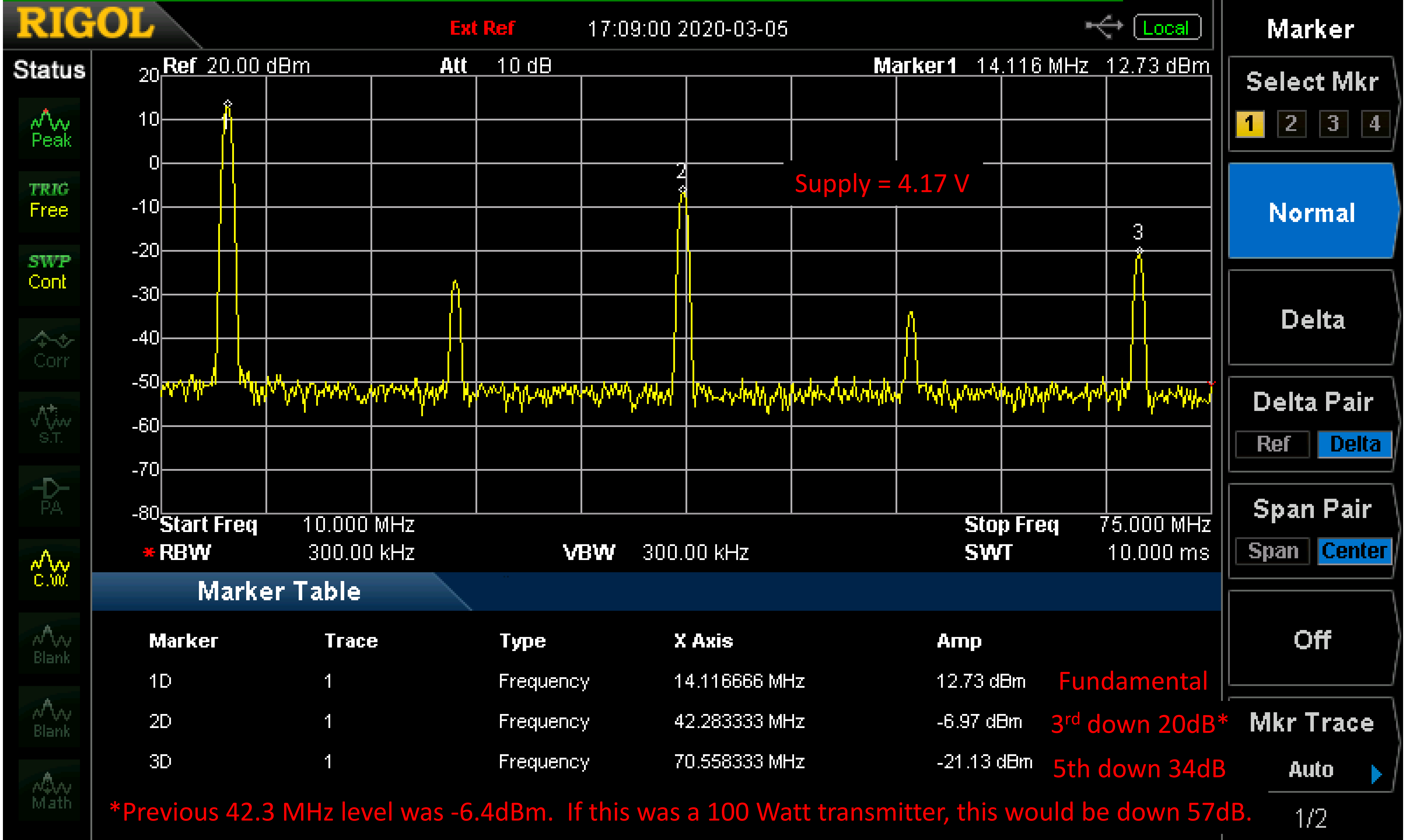
UTC	dB	DT	Freq	Drift	Call	Grid	dBm	mi	(Decoded information)
2020-03-05 Power 3.56V, (RF output is 12.9 dBm)									
2346	27	1.3	14.097077	0	KQ6RS	DM12	0	33	(0 meters course altitude)
2348	31	1.0	14.097077	0	0Y7DKX	DM12	7	33	(120 meters altitude, GPS 1, 25 °C Batt 3.6 V)
2020-03-06 Power 3.56V (RF output is 12.9 dBm)									
0006	15	1.3	14.097077	0	KQ6RS	DM12	0	33	
0008	23	1.0	14.097077	0	0Y7DKX	DM12	7	33	
2020-03-06 Power 2.91V, (RF output is 11.5 dBm)									
0036	14	1.3	14.097056	0	KQ6RS	DM12	0	33	
0038	14	1.1	14.097056	0	0Y7BKX	DM12	7	33	
2020-03-06 Power 2.83V* It did not seem to get a GPS fix and did not transmit									
2020-03-06 Power 2.90V, (RF output is 11.5 dBm)									
0056	12	1.3	14.097056	0	KQ6RS	DM12	0	33	
0058	26	1.0	14.097056	0	0Y7BKX	DM12	7	33	
0106	6	1.3	14.097077	0	KQ6RS	DM12	0	33	
0108	6	1.0	14.097077	0	0Y7JKX	DM12	7	33	(measured voltage 4.17 V, Y = GPS 1, 25 C; J = 4.2V)
0546	-3	1.4	14.097058	0	KQ6RS	DM12	0	33	
0548	-3	1.2	14.097058	0	0W7BKX	DM12	7	33	(measured 2.88 V, W = GPS 2, 20 C; B** = 3.4V)
0556	-4	1.4	14.097053	0	KQ6RS	DM12	0	33	
0558	-4	1.2	14.097053	0	0Z7BKX	DM12	7	33	(measured 2.77 V*, Z = GPS 2, 25 C; B** = 3.4V)
0606	-3	1.4	14.097080	0	KQ6RS	DM12	0	33	
0608	-3	1.2	14.097080	0	0Q7XKX	DM12	7	33	(measured 5.56 V, Q = GPS 2, 10 C; X = 5.7V)
0616	-2	1.4	14.097080	0	KQ6RS	DM12	0	33	
0618	-3	1.2	14.097080	0	0Q7XKX	DM12	7	33	(measured 5.56 V, Q = GPS 2, 10 C; X = 5.7V)

Freq counter 10 sec (average of several measurements) 14,097,077 Hz

*Between 2.75 and 2.80V is where the other board quits.

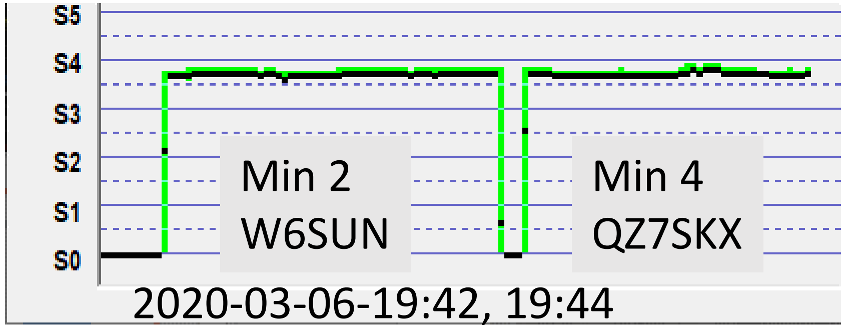
**Does not report voltage below "B" even when well below 3.3V.

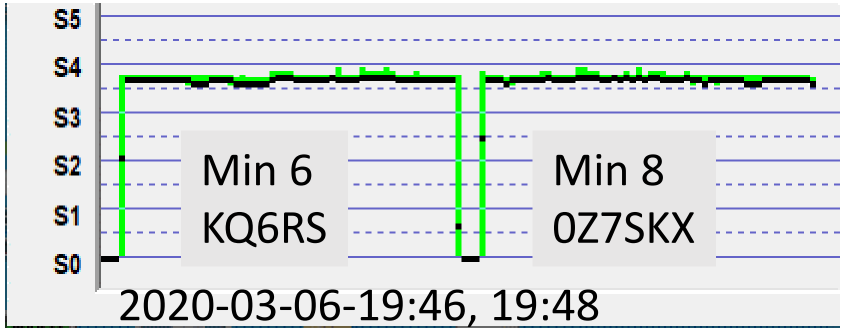

RIGOL
Ext Ref
16:06:28 2020-03-05
Local
Peak
Status
Ref 25.00 dBm
Att 15 dB
Marker1 14.097 MHz 12.87 dBm
Marker
14.097075 MHz
12.87 dBm
Supply = 3.56 V
Peak
TRIG Free
SWP Cont
Corr
S.T.
PA
C.W.
Blank
Blank
Math
25
15
5
-5
-15
-25
-35
-45
-55
-65
-75
Next Peak
Peak Right
Peak Left
Min Search
Peak Peak
Cont Peak
On
Off
Search Para
1/2
Start Freq 14.095 MHz
Stop Freq 14.098 MHz
RBW 30 Hz
VBW 30 Hz
SWT 3.3333 s

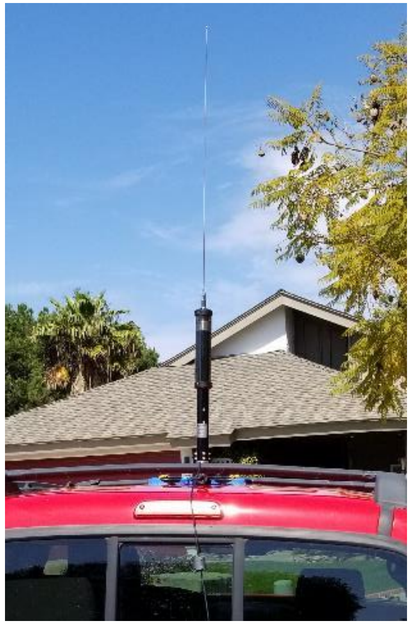

RIGOL
Ext Ref
17:09:00 2020-03-05
Local
Status
Peak
TRIG Free
SWP Cont
Corr
S.T.
PA
C.W.
Blank
Blank
Math
Ref 20.00 dBm
Att 10 dB
Marker1 14.116 MHz 12.73 dBm
Supply = 4.17 V
Start Freq 10.000 MHz
Stop Freq 75.000 MHz
* RBW 300.00 kHz
VBW 300.00 kHz
SWT 10.000 ms
Marker Table
Marker Trace Type X Axis Amp
1D 1 Frequency 14.116666 MHz 12.73 dBm Fundamental
2D 1 Frequency 42.283333 MHz -6.97 dBm 3rd down 20dB*
3D 1 Frequency 70.558333 MHz -21.13 dBm 5th down 34dB
*Previous 42.3 MHz level was -6.4dBm. If this was a 100 Watt transmitter, this would be down 57dB.
Marker
Select Mkr
1 2 3 4
Normal
Delta
Delta Pair
Ref Delta
Span Pair
Span Center
Off
Mkr Trace
Auto
1/2

3/6/20 W6SUN & KQ6RS side by side board testing with mobile antenna
Tx sequence (min): 0 No Tx, 2 W6SUN (normal), 4 W6SUN (Qx7), 6 KQ6RS (normal), 8 KQ6RS (0x7), repeat

S-meter levels into my Icom IC-7300 (with antennas off) is the same





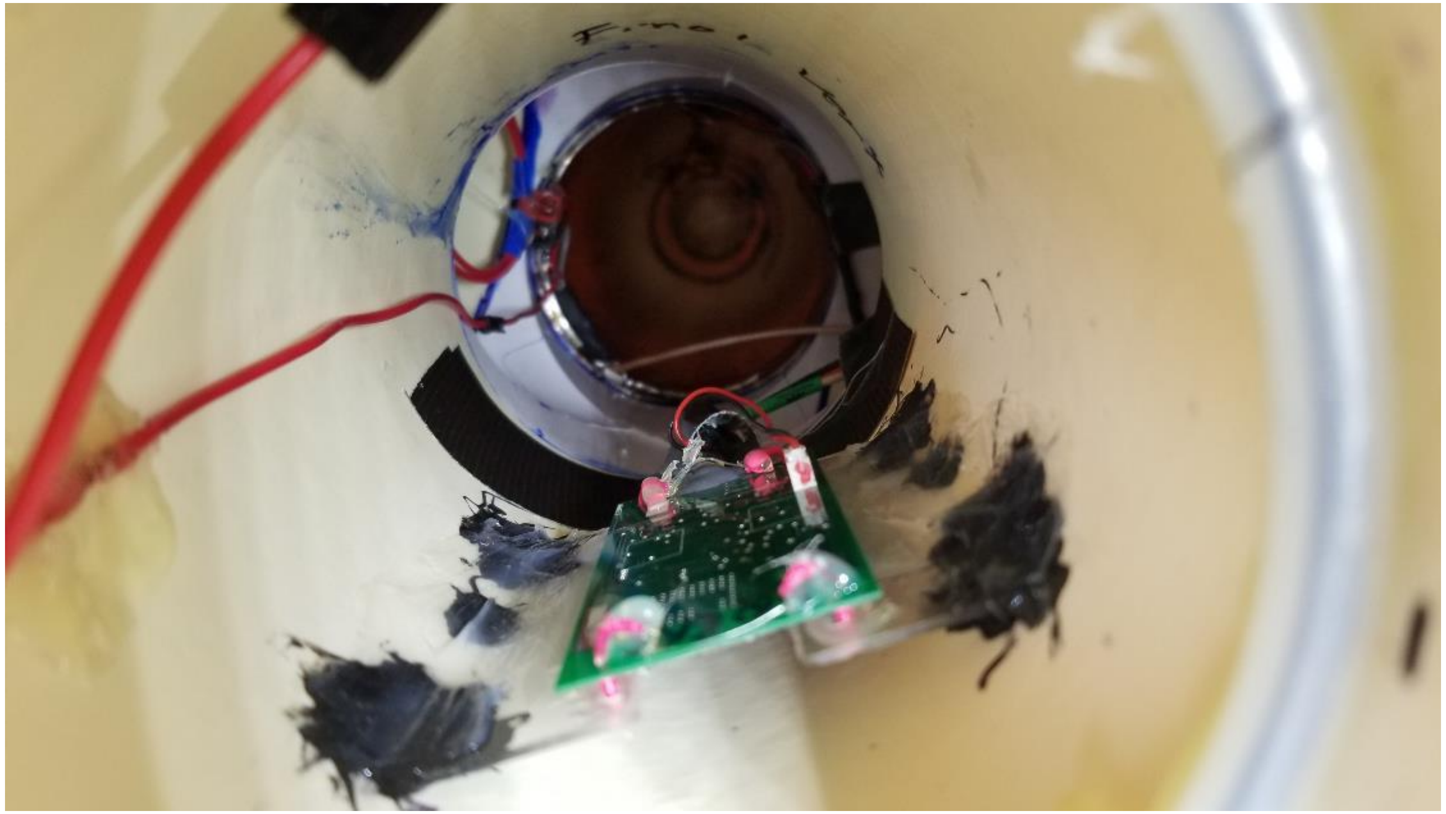


32 inch whip on screwdriver

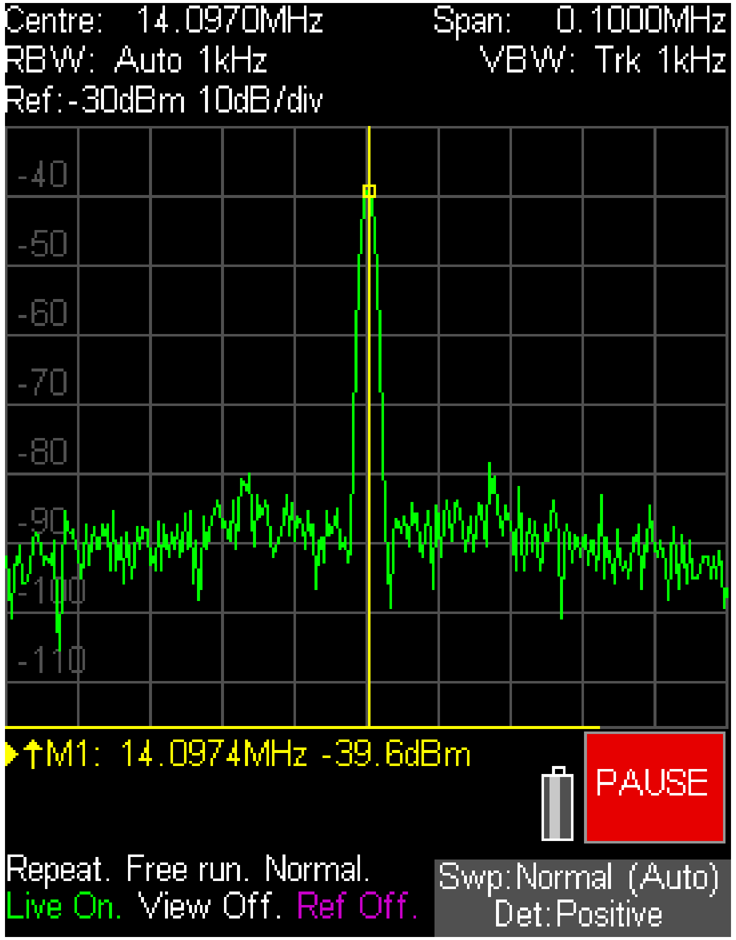
Setup using Splitter

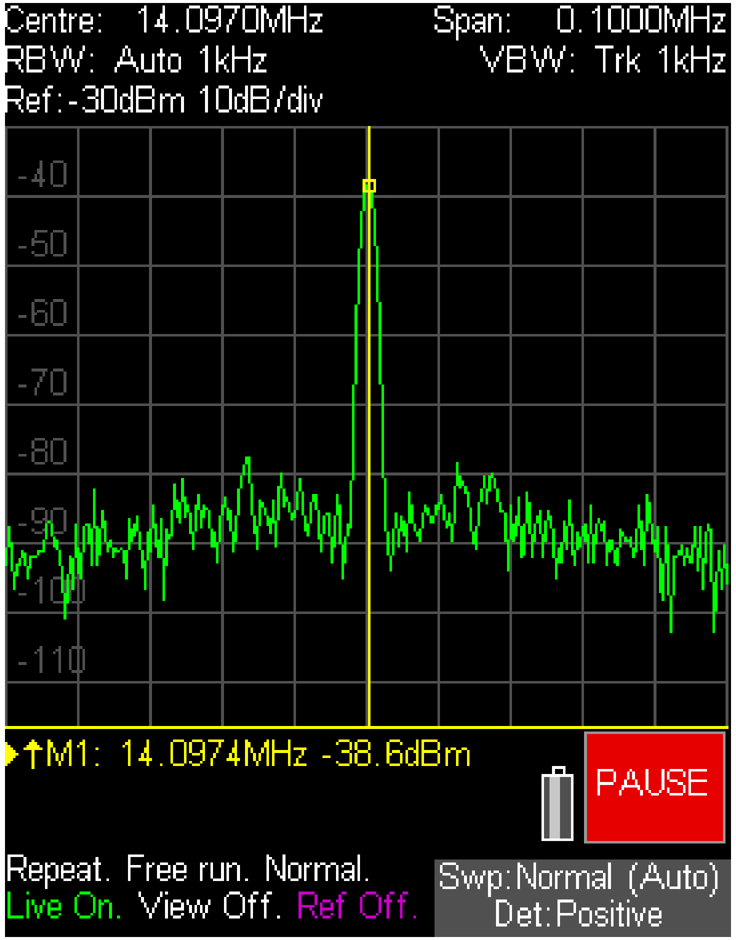
Supply Voltage

3/6/2020 Final assembly of buoy, interior views of upper section



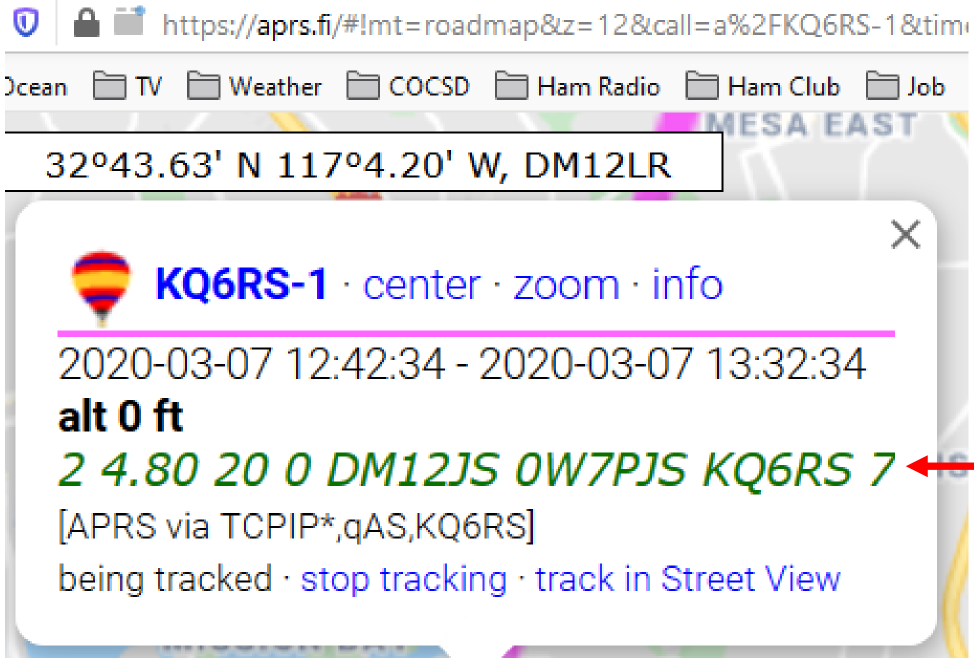
3/6/2020 Completed buoy in pool (with freshwater ground). Measured about 30 feet away with 24" antenna Comparison with 1/17/2020 test with elevated grounds got -38.3dBm. This is almost the same, even with a poor ground. Everything seems to be working.





3/7/2020 Running Bill’s (WB8ELK) wspr2aprs_040718fb.exe program

Note about the Sequence number when starting the program: Enter the last number reported* (because it increments the next transmission by 1). This can be found by looking at aprs.fi. Better yet, it can be found in “wspr_python_rx.txt” by searching from the bottom up looking for KQ6RS (e.g. KQ6RS-1>APRS,TCPIP*:/213230h3246.24N/11712.50WO000/000/A=000000 2 4.80 20 0 DM12JS 0W7PJS KQ6RS 7)

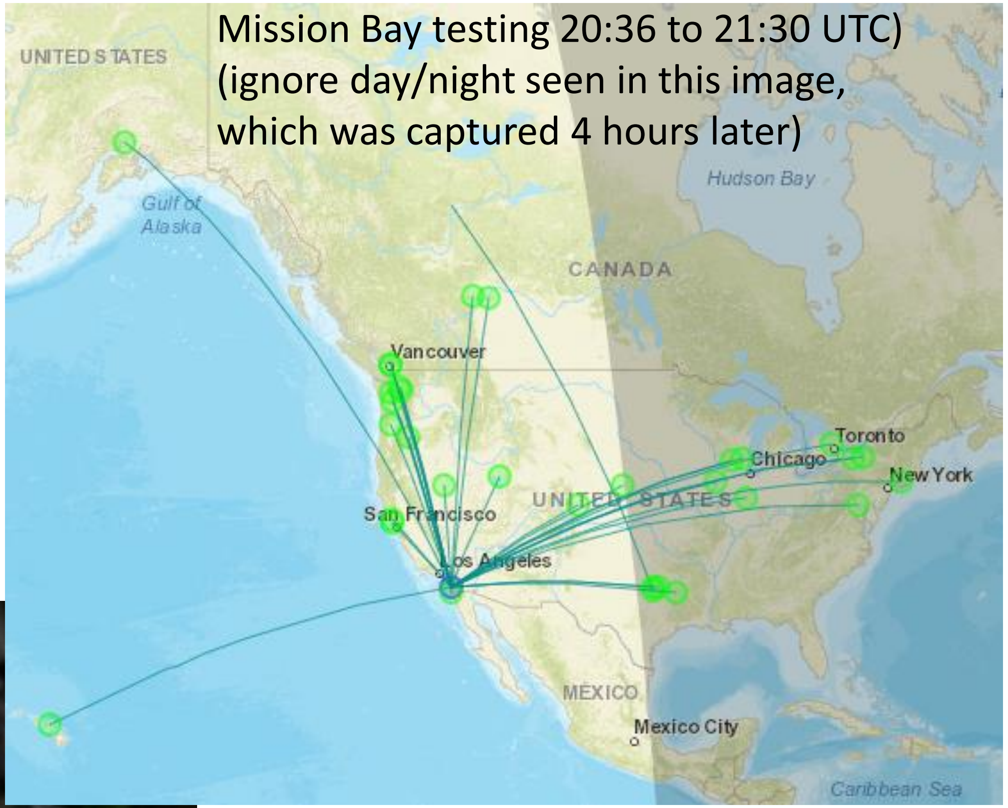


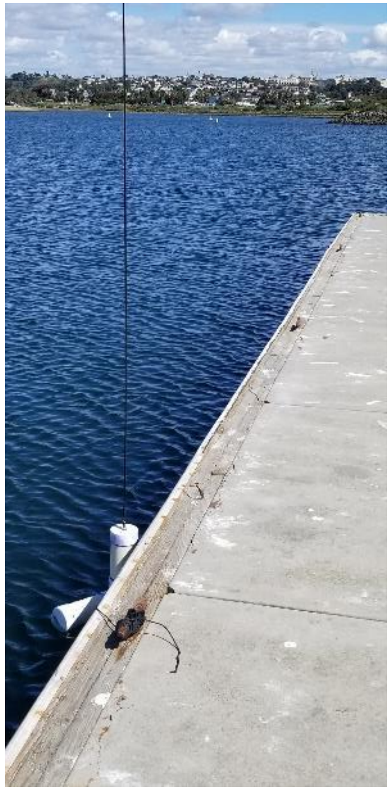
GPS status 2 (>8 Sats, 1 = 4-8, 0 = no fix)
4.80 Volts
20°C
0 meters altitude (60 m increments)
Grid to sub-square level
0x7xxx call sign with telemetry
Call sign
Sequence number*

0W7PJS decoded: W = GPS status 2 (“really good” >8 sats) & 20°C, P = 4.8 Volts, JS is the grid sub square (the last part of “DM12js”)

3/7/2020 Completed Buoy Pier Testing
Ran 20:36 to 21:30 UTC (six WSPR transmissions)
Reception was “amazingly good.”

Average 15 reports per transmission, many in the 2000-4000 km range.
By comparison, I also ran the identical W6SUN board at the same time into a 32” mobile whip + screwdriver antenna on my truck and it typically received 5 reports per WSPR transmission. The ocean makes a great counterpoise!
GPS was great too (>8 sats reported for all six transmissions)





Only needs Loctite and taping antenna before hand-off to boat.
Identification by scuffing pipe, Sharpie pen, several coats of clear enamel (go lite with the first coat or the ink will run).

To be attached with water soluble adhesive