Analysis of a Failure

You learn more from a failure than a success !

K0NA

80 Meter Receive Only Antennas

- Hearing the DX stations on 80 meters is my biggest problem
  - Directivity in receiving is the next key to sucess
- Investigated directional antennas
  - Beverage on ground
  - Flag
  - K9AY
  - Shared apex loop antenna
    - A couple of phased loop antennas with good reviews
- I have always been fascinated with ferrite core antennas
  - Combine a couple of ferrite loop antennas with a phasing line?
  - Mount them on the boom of a yagi to make a rotatable array?

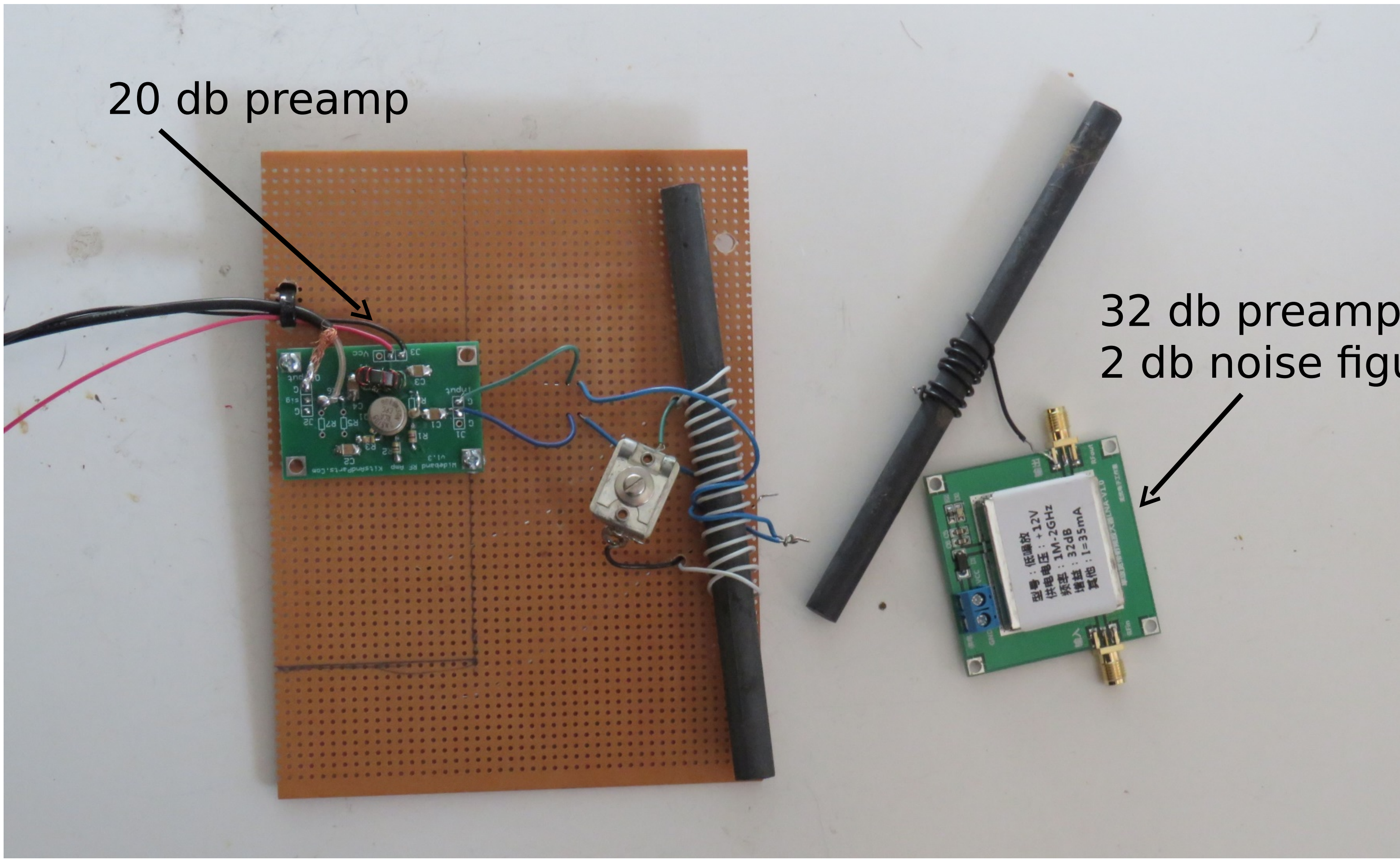
Ferrite Loop Antennas

- The classic loop stick used in most portable AM radios
- Used in some portable short wave receivers
- Used as an active antenna by some manufacturers for short wave
- They have a very deep null off the ends to eliminate interference
  - Used for fox hunting
- A rod with a permeability of 36 increases the area of the loop by 36 times
  - A ½ inch core now looks like it is 3” in diameter

The Dream

- 18 foot spacing between phased loops looked good on paper
- Mount the loops on a boom for a yagi
  - A rotatable directional 80 meter receive only antenna!
  - At minimum, rotate the antenna to null out interference with a single element
- The plan was for a preamplifier at each loop, a phasing line, and then into a combiner
- Step one, get a single ferrite loop tested
  - Initial results looked good on strong signals
  - Weak signals were not there

Trials



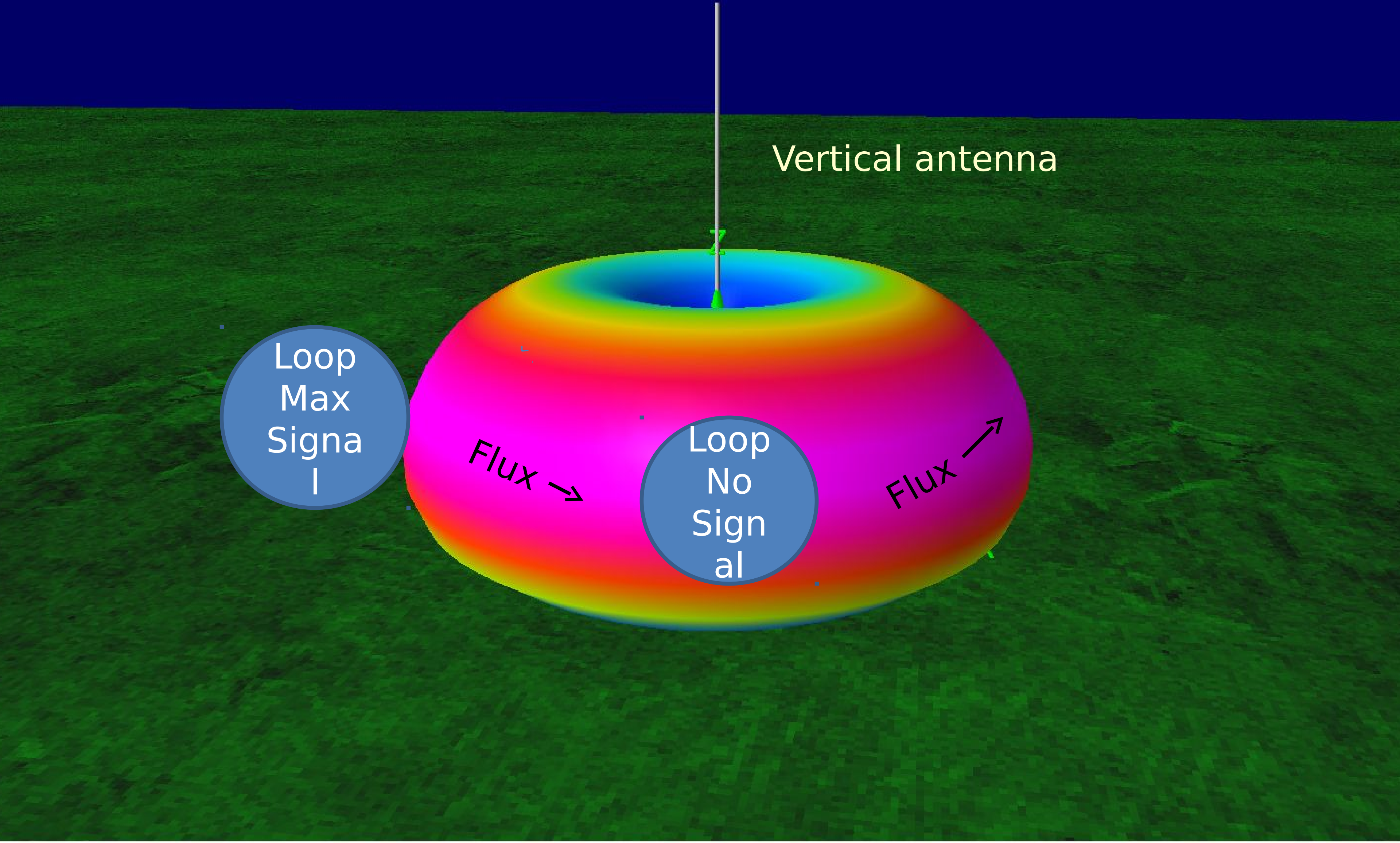
Ferrite Loop Antennas

- There is very little information available on their design
- Initial test showed great promise indoors
- Outdoors, weak signals were buried in the noise
- A preamplifier might solve the problem and stabilize the impedance on the feed line

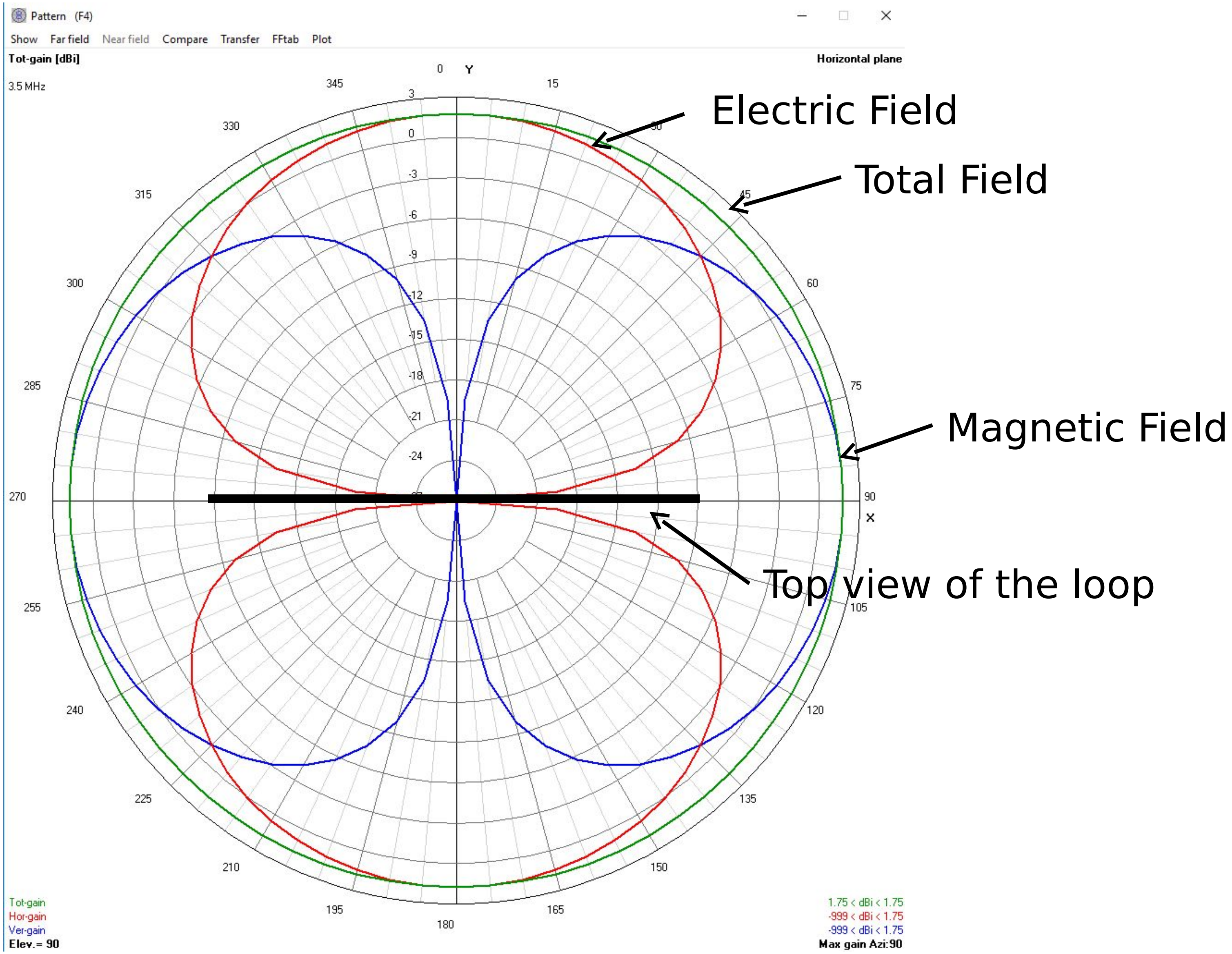
The Question was Why the Poor Sensitivity

- The new ARRL Antenna Handbook (23rd edition) had ferrite loop antenna design information
- There was an equation for output of the antenna but it was in terms of Volts/Meter
  - What is volts/meter?
  - How does it relate to a S meter reading?
  - Let the quest for understanding begin

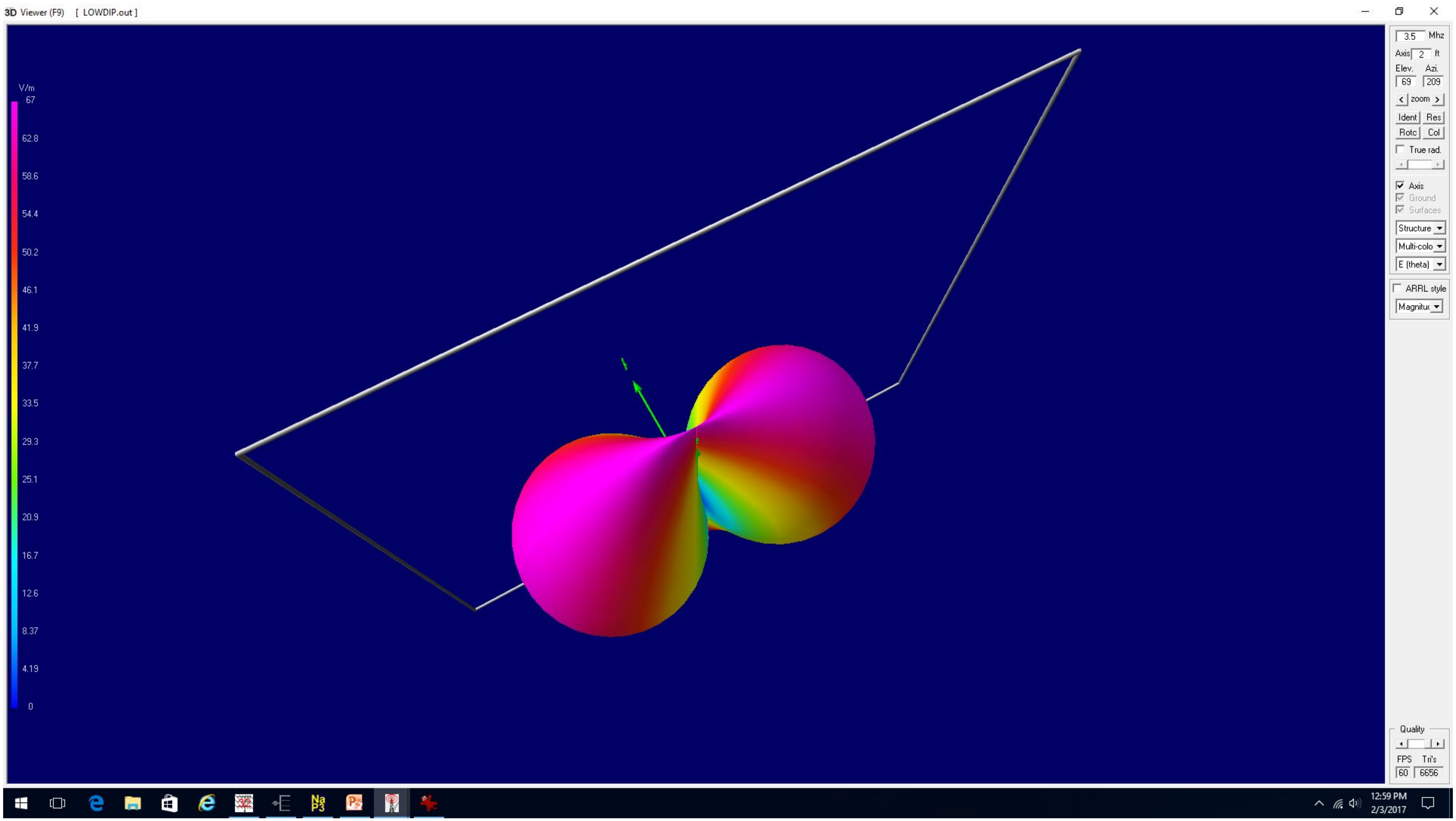
Loop Reponse with a Vertica



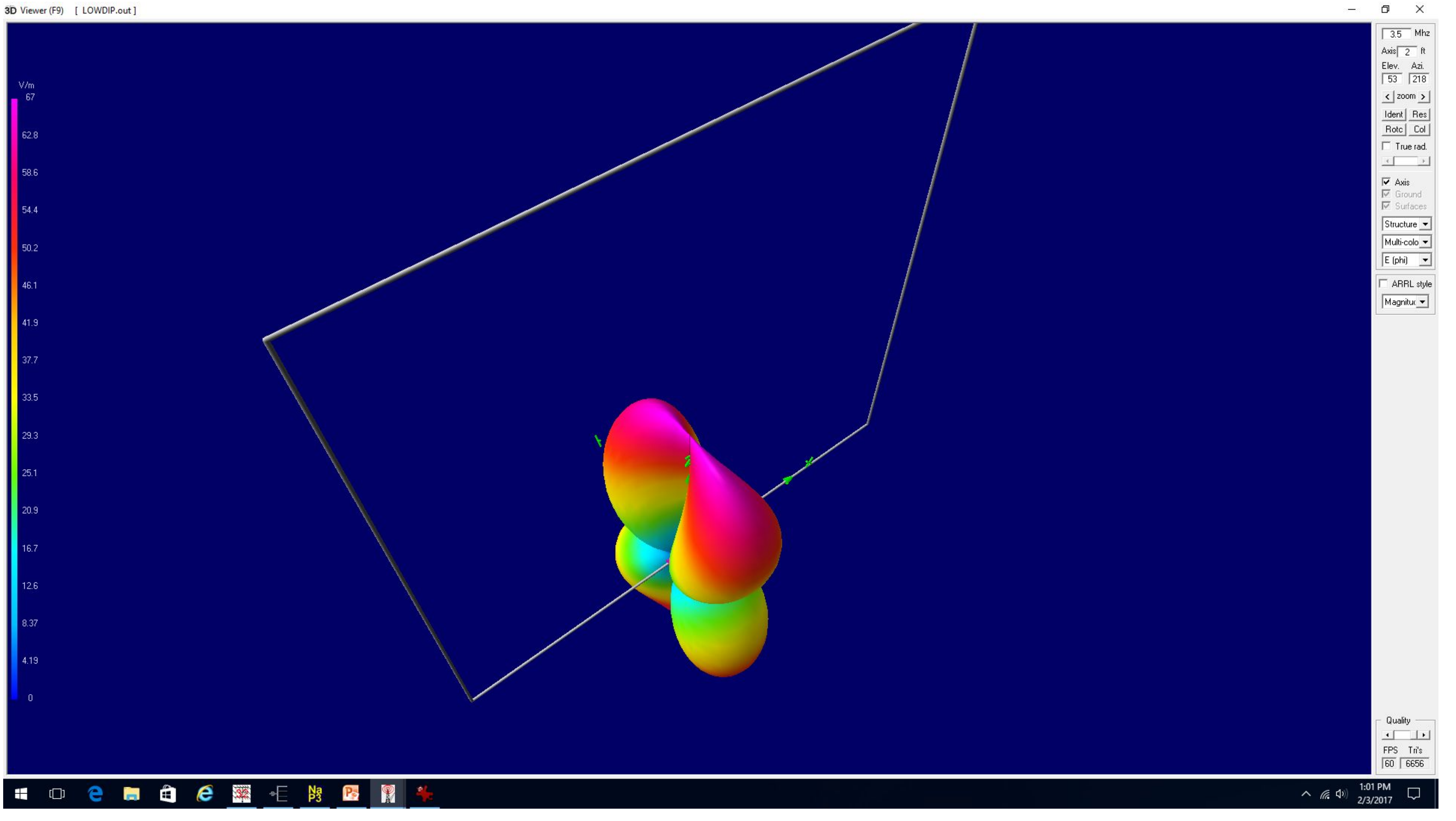
Pattern of Square Loop



3D View of the Magnetic Field



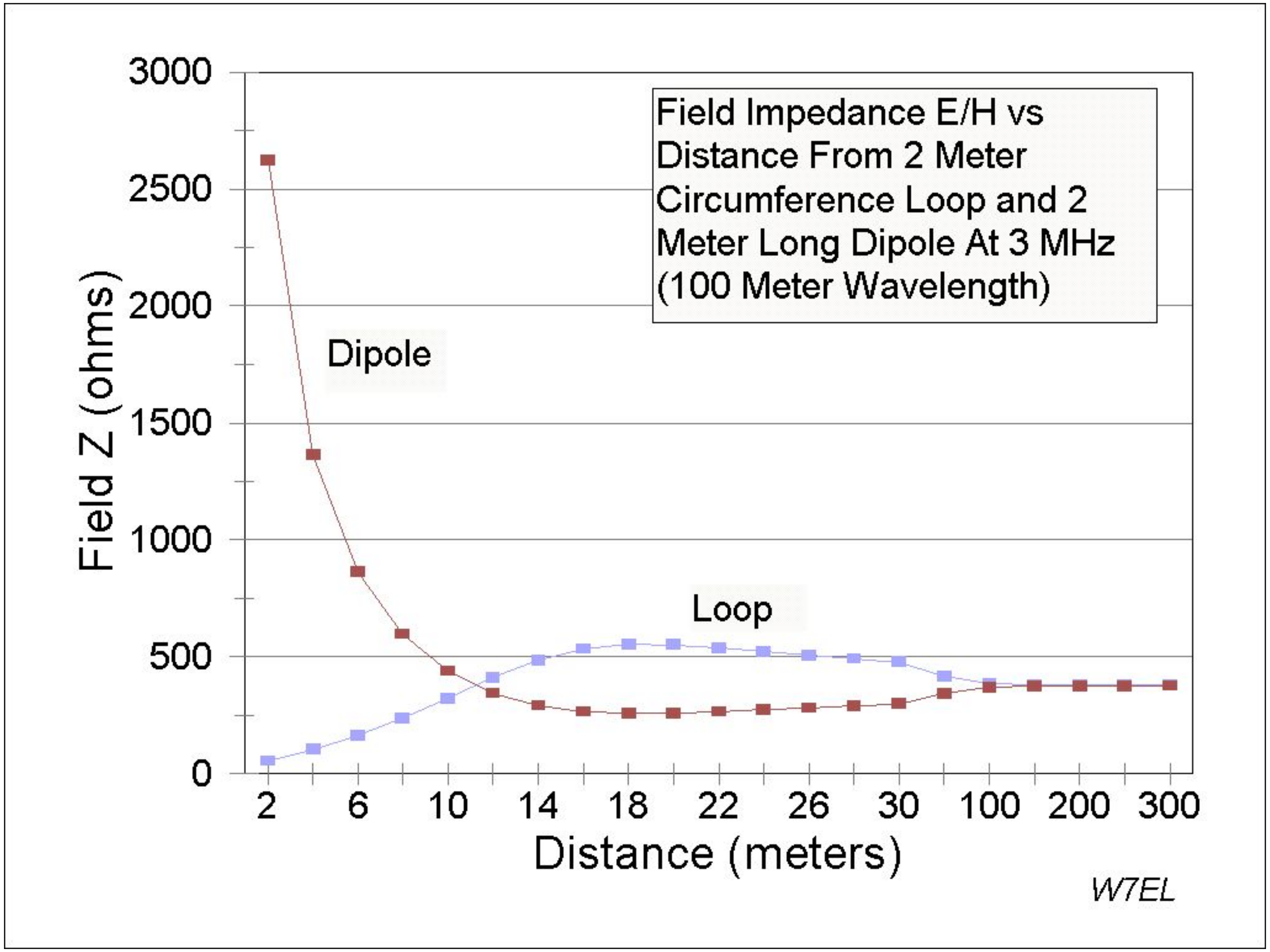
3D View of the Electric Field



Mixed Results with Magnetic Loop Antennas

- Some people have had great luck eliminating noise with a magnetic loop antenna
  - I have seen at a ham fest a magnetic loop and active antenna compared in the exposition hall
  - An AM station was buried in static from the lighting system on the active antenna
  - The AM station was Q5 with the magnetic loop!
- Most people have not had good luck with magnetic loop antennas to eliminate noise
  - Why?

Near Field Response W8JI.COM



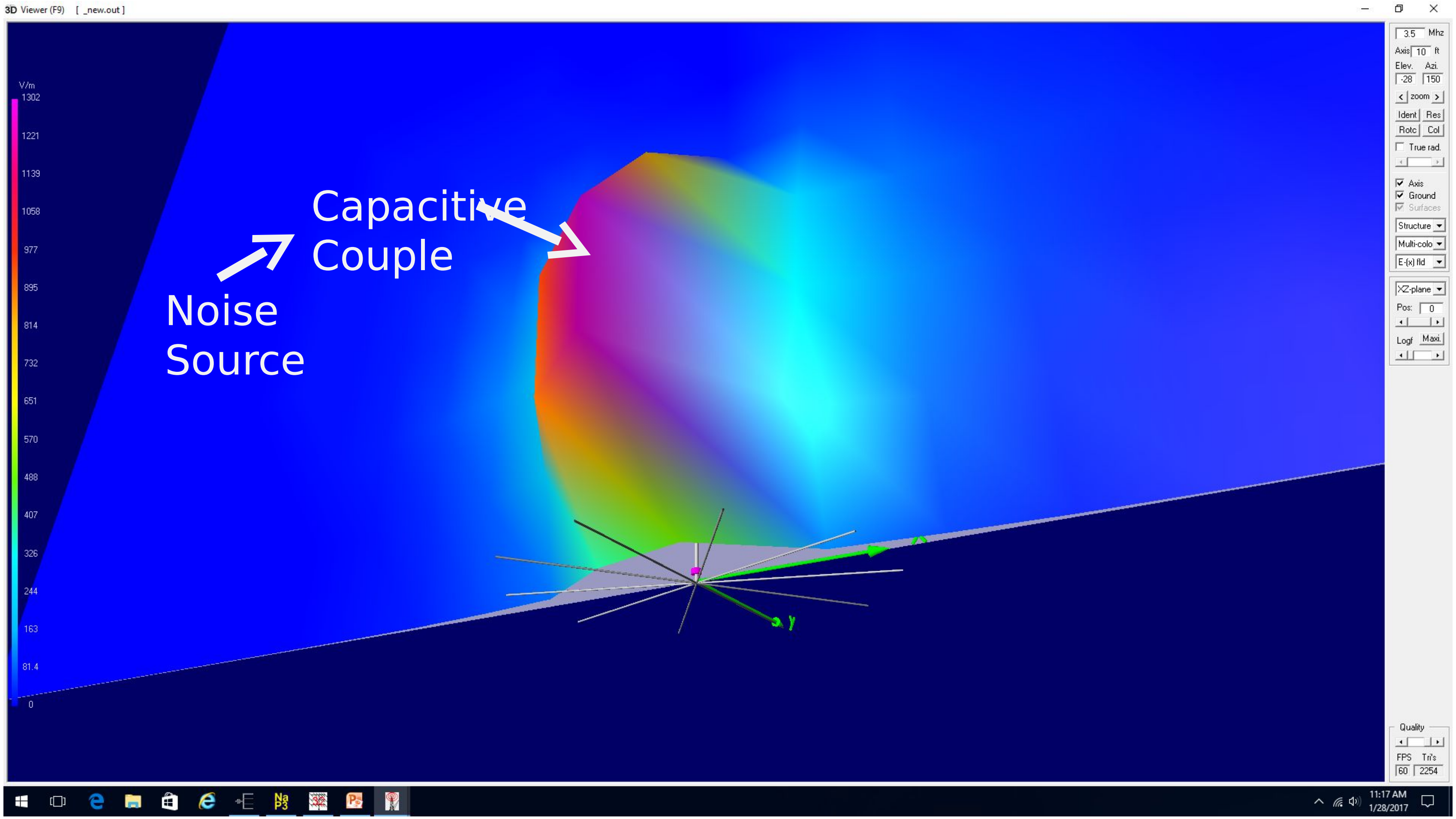
Per W8JI.COM

- If the noise source is coupled to the antenna within a distance of about 1/2 wl or so, you might find a difference in noise coupling between the short dipole and small loop systems. At larger distances, only directivity and polarization would make a difference.
- ***So much for the myth that a receiving antenna can sort good signals from bad signals (noise) by virtue of being "magnetic"! We not only don't have the field response we might have imagined, we also almost certainly have no idea if close-by unwanted noise or signal sources are radiated from electric or magnetic field dominant sources. Successful noise reduction by virtue of by antenna "style" would mostly be a matter of hitting a lucky combination through experimentation.***

Editorial Comments

- If a magnetic loop eliminates noise it is in the near field
  - For a wave to propagate very far both a magnetic and electric field must be present
  - Find it and fix it!
- If you can null out the noise it is point source
  - Follow the null to find it and try to get it fixed !

Near E Field Response of a Vertical



The S Meter Reading

- Hearing a S2 signal is the minimum sensitivity acceptable
- S2 has a power of -115 dbm
  - S2 = 0.4 microvolts on a 50 ohm load
  - S2 = 0.0032 micro micro watts
- Next question is “How does the energy get from the surrounding space into the antenna?”

Capture Area

- Capture area is the equivalent area energy is extracted out of space
- Capture area has NOTHING to do with physical size
- The capture area for a infinitely small isotropic radiator is A=(wave length)^2/(4 pi) or .13*(wavelength)^2

Capture Area

- A 80 meter unity gain antenna has a capture area of .13*80*80 or 832 sq meters
  - A 40 meter antenna is 208 sq meters
- If an antenna’s size is reduced by half
  - peak current will approximately double
  - voltage at the ends double
  - Impedance will be about ¼
  - This is to generate or receive an equivalent field as with a full size antenna

Watts per Square Meter

- This is the power density in space independent of frequency and antenna
  - The FCC uses millawatts/cm^2 for RF exposure
  - Part of the form we fill out for our license
- For our S2 signal:
  - Power = 3.2E-15 watts/832 M^2 or 3.84E-18 watts per sq meter

Volts/Meter

- Volts per meter is a measure of electric field intensity independent of frequency
- Knowing the impedance of free space the voltage, current, and power can be calculated for a square meter
  - Z = 377 ohms per meter
  - E = Sqrt(power/meter^2/377)
  - I = Sqrt(pwr/meter^2*377)
- The volts per meter of our S2 signal on 80 meters
  - E = Sqrt(3.84E-18/377) = 1.01E-10 volts per meter

Thermal Noise

- Unless we use cryogenic techniques the minimum detectable signal is limited by thermal noise and band width
- Room temperature noise is -174 dbm with a 1hz band width
- At 500Hz the noise is 500X greater
  - Noise floor = -174 + 10Log(500) = -147dbm

Signal to Noise Ratio

- Per the ARRL Antenna Handbook:
  - SNR= 66.3*N*A*u*E*sqrt(Q*f/L)/sqrt(bw)
- Running the calculations with estimates of the loop:
  - SNR=2.09E-5
  - Converting to db = 10 log(2.09E-5) =-46 db !

Conclusions

- Even working on improving the variables there is no way to make up 46 db
  - Preamplifiers would have made the noise problem worse
  - There would have been even more noise introduce from the phasing system
- The learning experience was very insightful as to how antennas work
  - Again you learn more though failure than success
  - Don’t be afraid to try things

Conclusions

- I will not be trying to eliminate noise with a magnetic loop
  - The ferrite loop antennas will be used to locate noise sources
- With my new found knowledge of RF near fields and experience modeling them I want to check how close I am to the FCC limits