

2.02: Using 4NEC2 for HF Antenna Design

- High Frequency antenna design using free, open source numerical electromagnetic code software (4NEC2).
- Is multi-band with narrow bandwidth.
- Receives HAM bands (10-40 meter). Focus on the 20m (14.15MHz center) band.
- Will receive using Software Defined Radio (SDR) on a laptop and confirmed with a Vector Network Analyzer.

Roberto Colon

Jorge Blanco

Dennis Liao

Drew Schmidt

4NEC2/HF Antenna Design

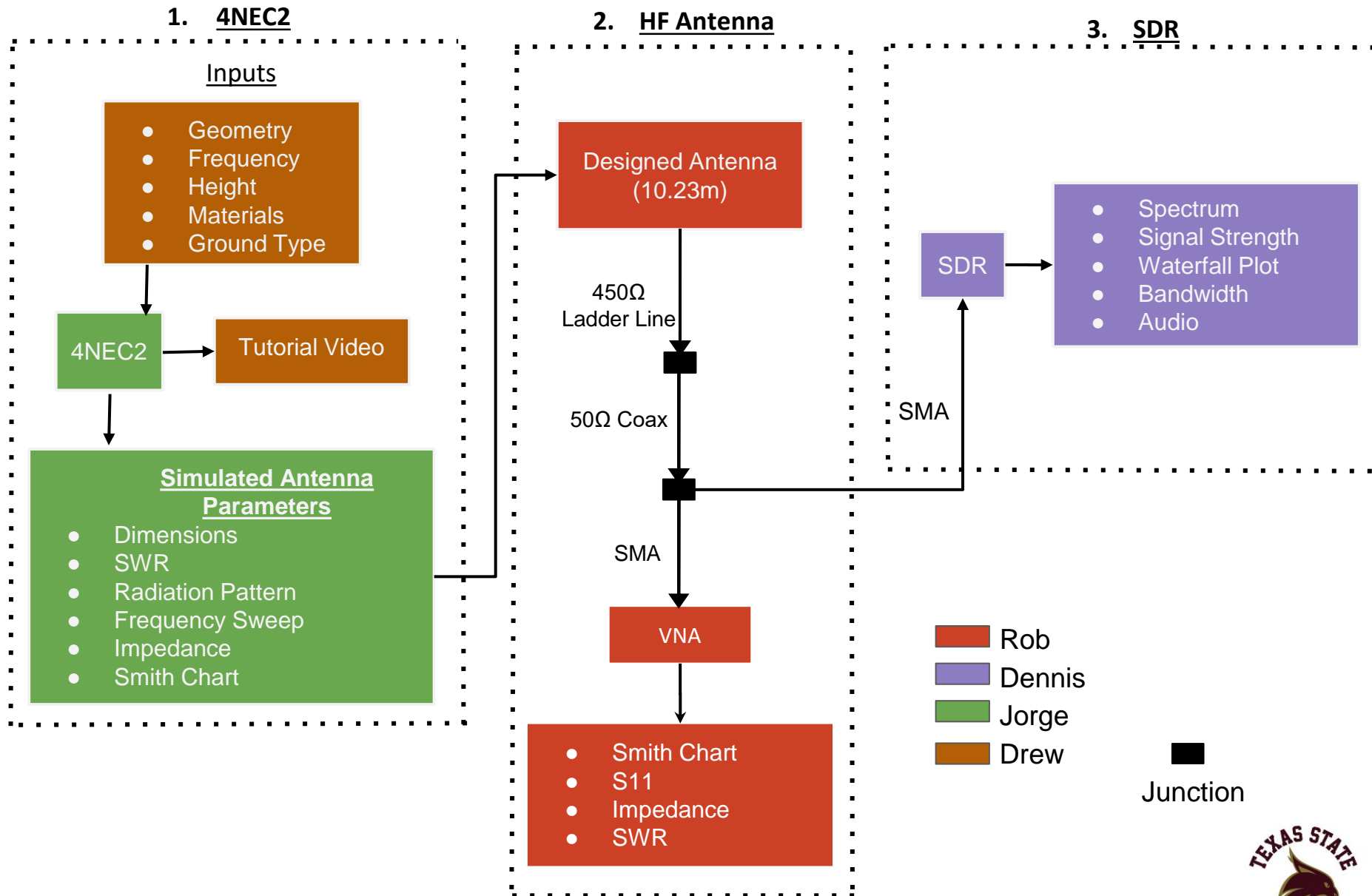


Terminology

<u>Term</u>	<u>Description</u>
4NEC2	Numerical Electromagnetic Code Software
HF	High Frequency Band (3-30MHz)
HAM	Slang term for Amateur Radio Operator
SDR	Software Defined Radio
SDR Sharp	Computer Software for running SDR
SMA Cable	Subminiature Version A Coaxial Cable
SWR	Standing Wave Ratio

<u>HAM Radio Bands (F/Wavelength)</u>
3.5 MHz / 80 meter
7.0 MHz / 40 meter
10.1 MHz / 30 meter
14.0 MHz / 20 meter
21 MHz / 15 meter
28 MHz / 10 meter

DETAILED BLOCK DIAGRAM



4NEC2 Subsystem

Drew Schmidt

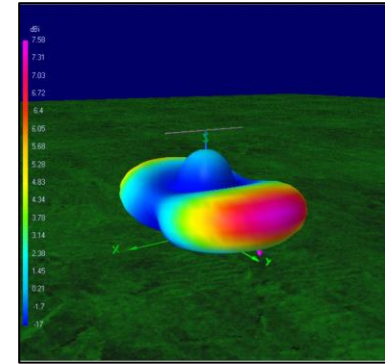
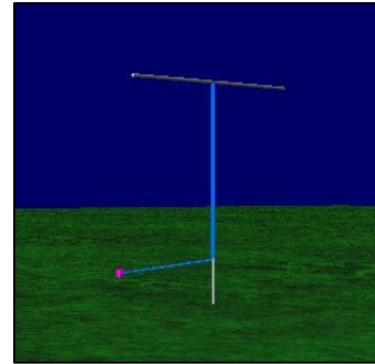
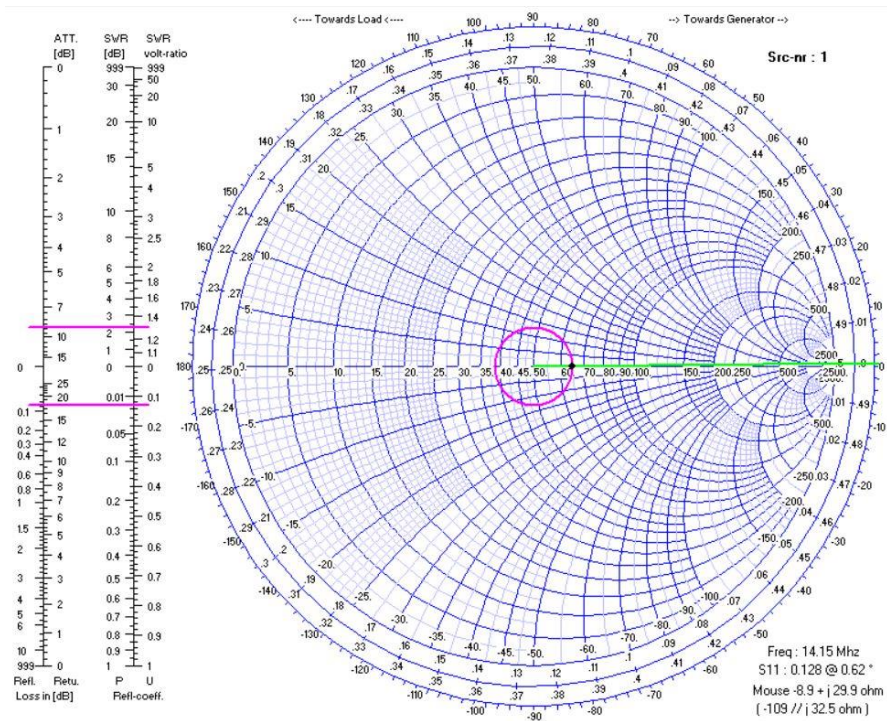
- Used 4NEC2 software to verify antenna input parameters
- Narrowed our antenna down to five main designs using the optimization function in 4NEC2 (results double checked with MATLAB)

Antenna Length	Ladder Line Length	Impedance	SWR @ 14.15MHz
18.844m	5m	52.2+j0.4 Ω	1.05
15.55m (G5RV Jr)	4.77m	50.1-j133 Ω	8.86
10.23m	9.737m	64.7+j0.18 Ω	1.29

4NEC2 Subsystem Results

Drew Schmidt

-Smith Chart tells us input impedance, SWR, and reflection coefficient



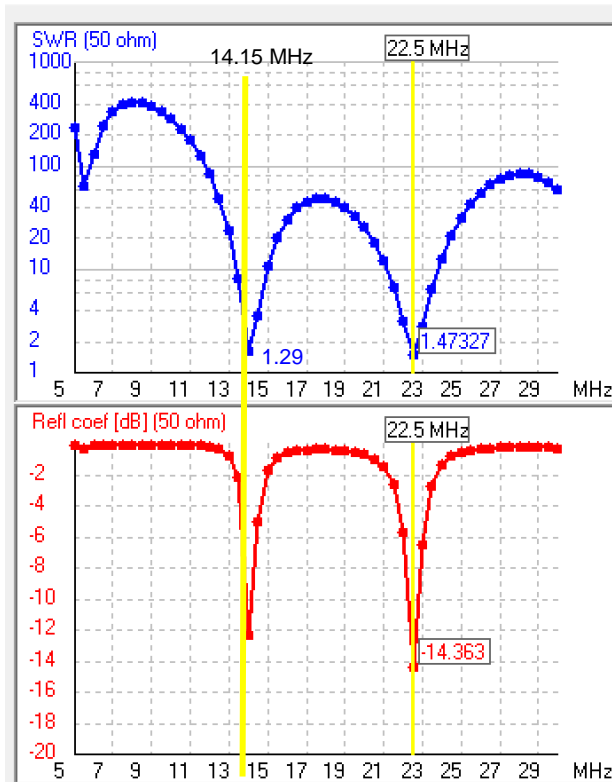
Antenna Length	10.23m
Ladder Line length	9.737m
Impedance	64.7+j0.18Ω
SWR	1.29

4NEC2 Subsystem Results

Jorge Blanco

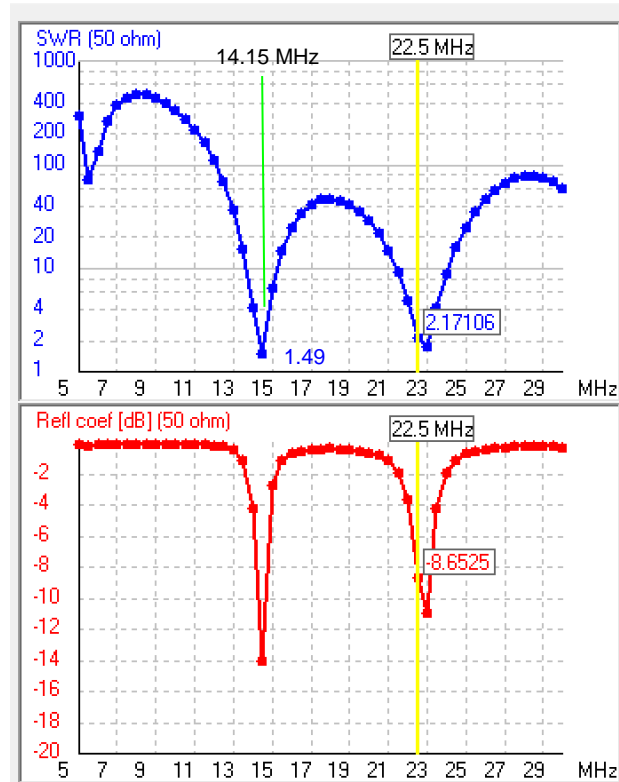
-Frequency sweep across the 10m-40m bands

Show View V/I source Plot



Original Design: 10.23m

Show View V/I source Plot



Tuned Design: 9.83m

4NEC2 Subsystem Results

Jorge Blanco

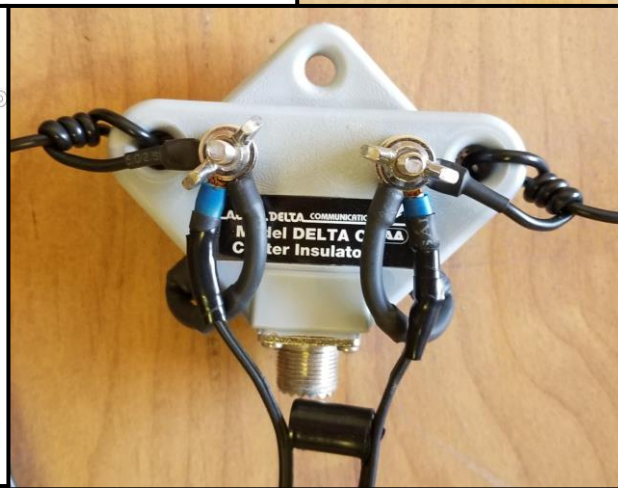
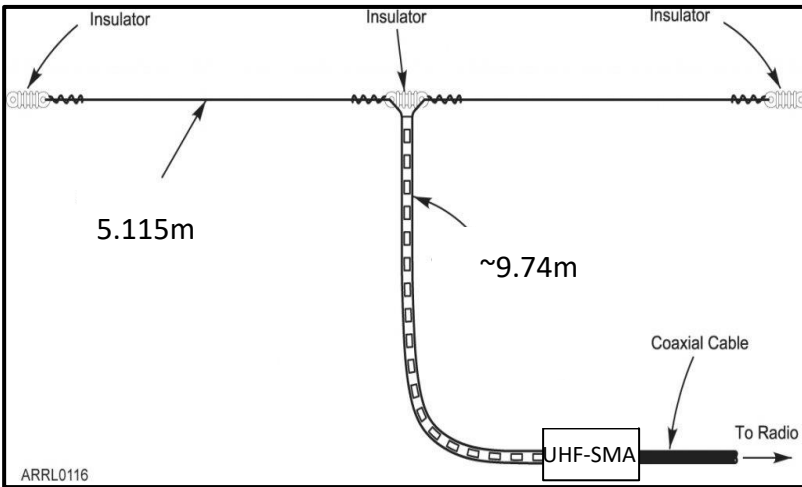
Comparison of simulated and final physical designs

Antenna Length	SWR (20m Band)	SWR (15m Band)	Impedance
10.23m (4NEC2)	1.29	6.75	$64.7 + j0.18\Omega$
10.23m	2.0	N/A	$30.4 - j18.6\Omega$
9.83m (4NEC2)	1.49	4.83	$65.64 + j17.08\Omega$
9.83m	1.3	1.02	$42.4 - j8.9\Omega$

HF Antenna Subsystem

Roberto Colon

- Input is the output of 4NEC2 (design parameters)
- Receives electromagnetic waves and transfers them to the SDR via the custom impedance matching network.
- Consists of wire, insulators, feedpoint, and connectors.
- Quality depends on lengths of dipoles and ladder line. These lengths are designed around a specific set of frequencies.

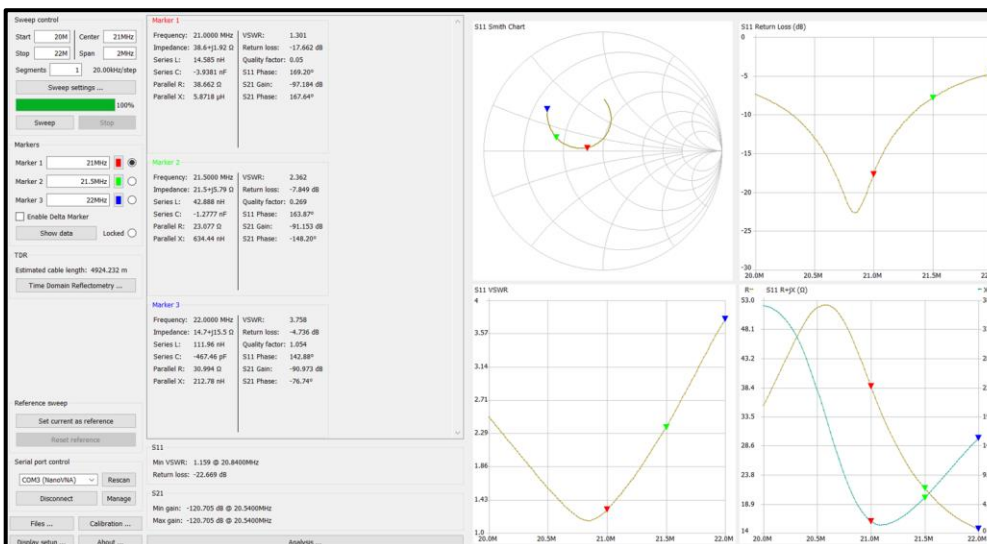
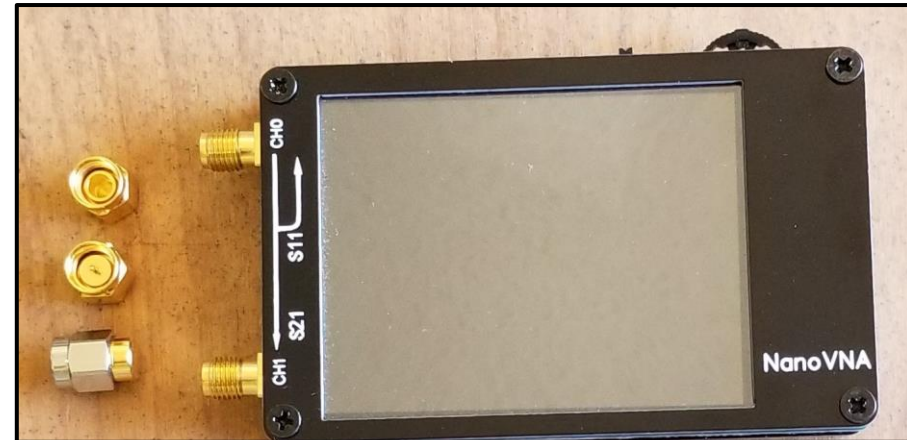


HF Antenna Subsystem

Roberto Colon

-Stretch goal was to purchase and characterize using an affordable VNA (Nano VNA)

-Allows measurement of SWR, Impedance, Reflection Coefficient and outputs Smith Charts as well as other plots when combined with *Nano VNA Saver* software.



Nano Saver Software

VNA LCD Screen Readout

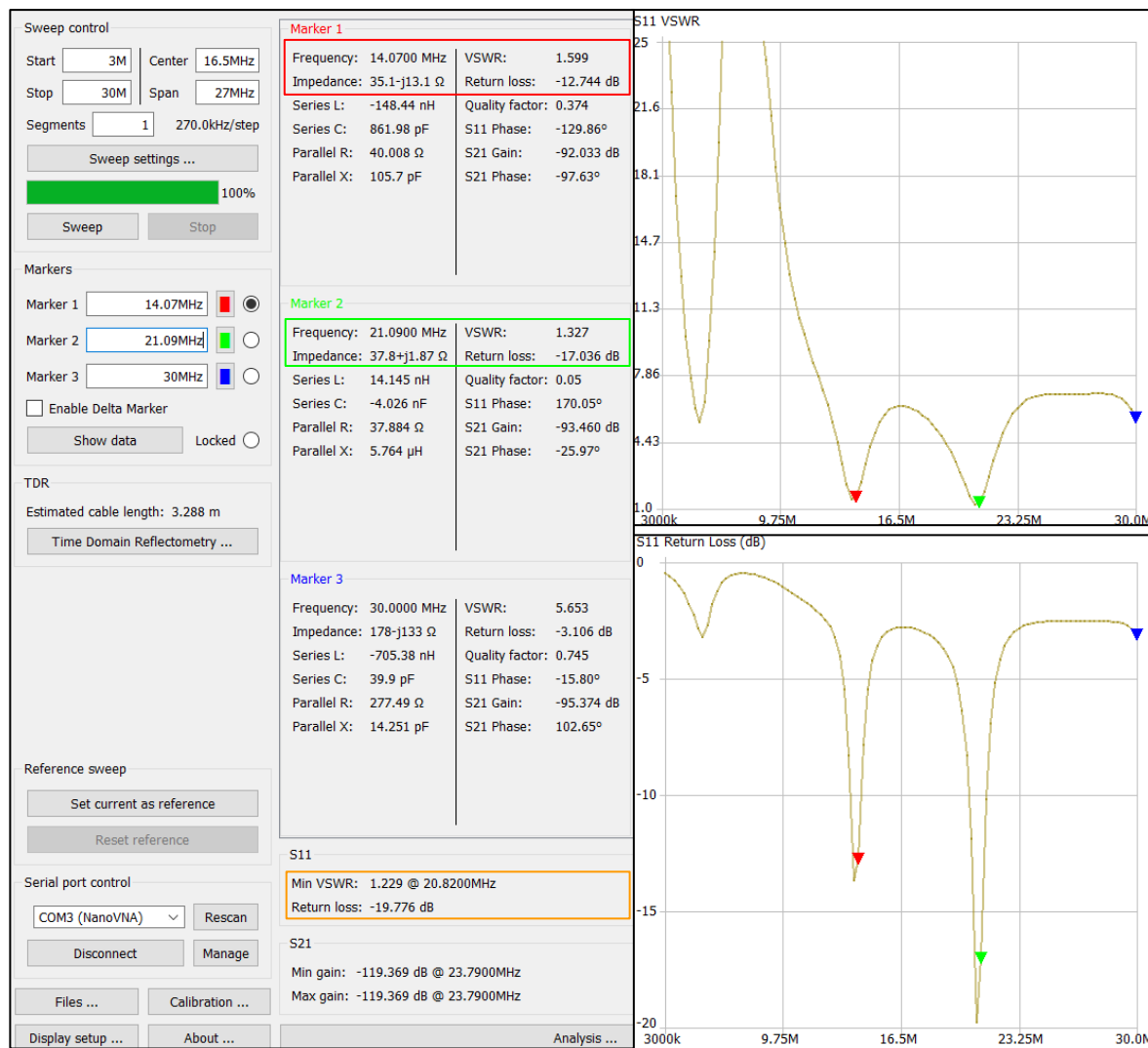
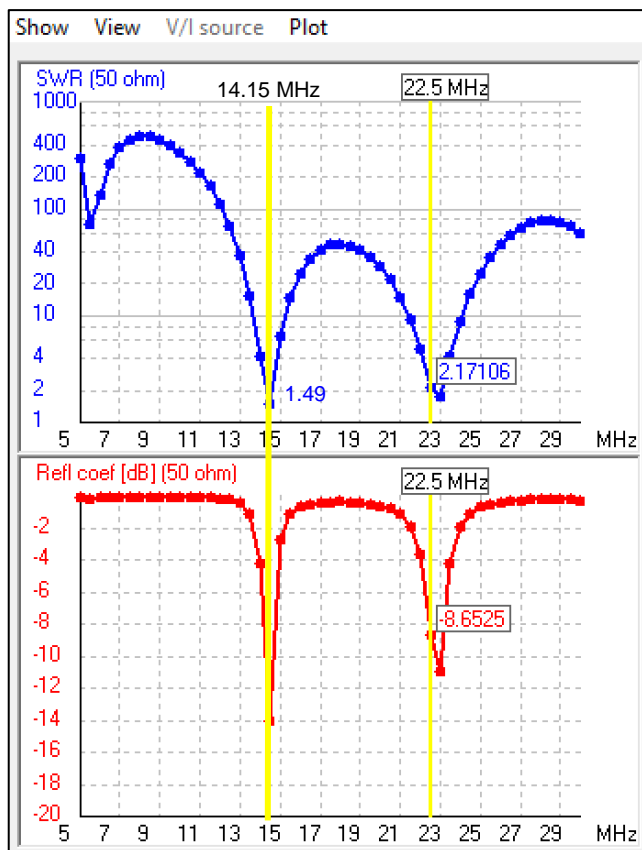


HF Antenna Subsystem Results

Roberto Colon

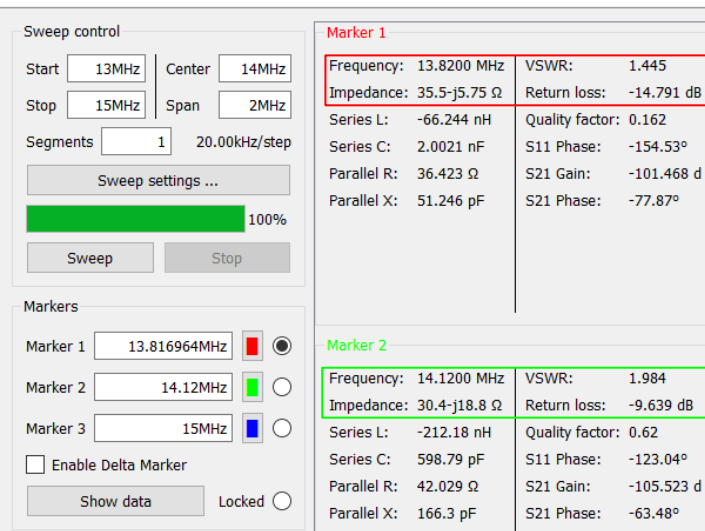
4NEC2

Nano VNA

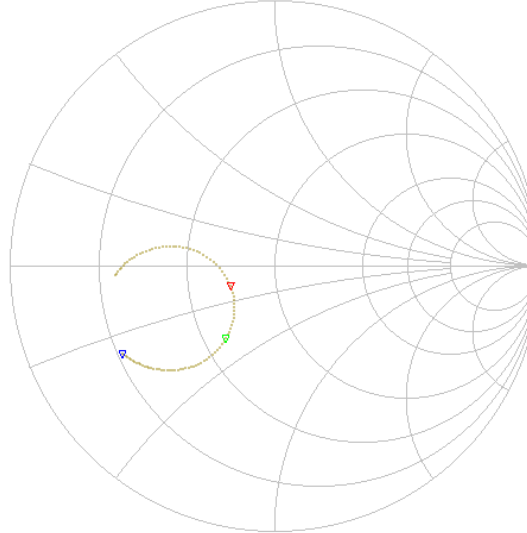


HF Antenna Subsystem Results

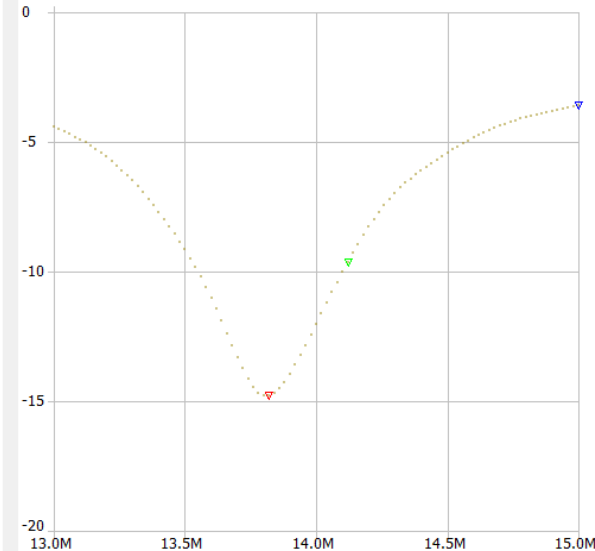
Roberto Colon



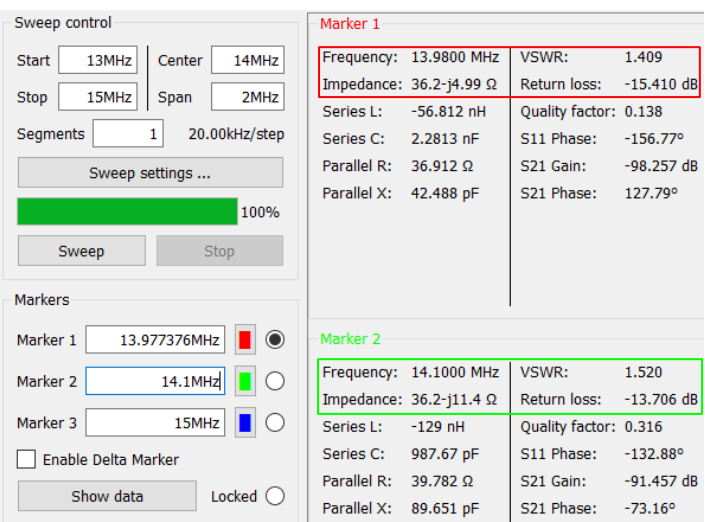
S11 Smith Chart



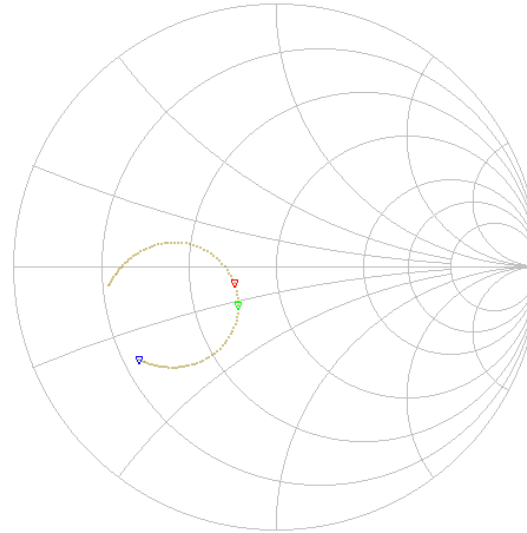
S11 Return Loss (dB)



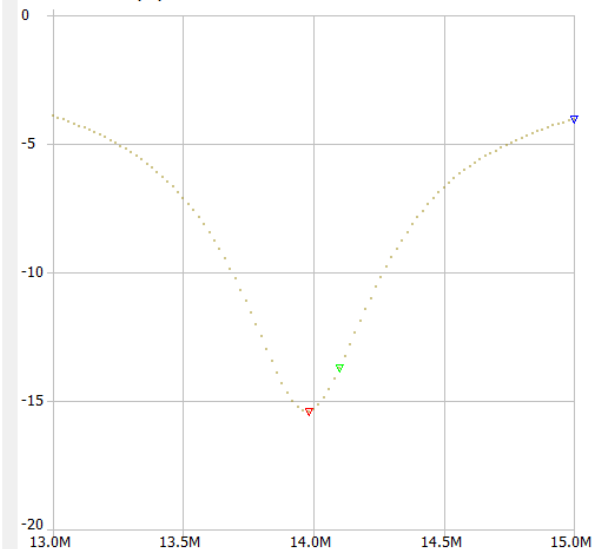
Before Tuning



S11 Smith Chart



S11 Return Loss (dB)



After Tuning

HF Antenna Subsystem Results

Roberto Colon

Requirement	Requirement Parameter	Measured Data	Result
SWR	Less than 2	SWR(14.15MHz) = 1.3 SWR(21MHz) = 1.03	Pass
Impedance	Match 50 Ohm Imped.	42.4-j8.9Ω	Acceptable
Reflection Coefficient	Greater than 10 dB	14.15MHz: 18 dB 21MHz: 38.18 dB	Pass
Wire Length	5-25 meters	9.83 meters	Pass
Height	15-50 feet above ground	23 feet (fiberglass mast)	Pass
Resonance	20m (14.15MHz) band	14.15 MHz w/SWR@1.3	Pass
Multiband Resonance	20m Ham band and as many other bands as possible	20 meter band 15 meter band	Pass

SDR Subsystem

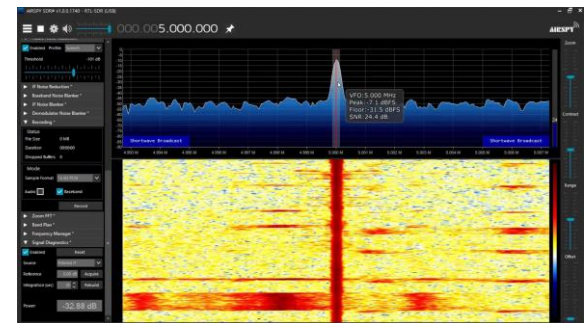
Dennis Liao



- This subsystem uses an RTL USB dongle to digitally process the incoming signal from the antenna allowing a user to listen via a computer or laptop.
- The inputs are SMA cable into the USB dongle and the outputs are spectrum , signal strength , waterfall plot and bandwidth.
- Offers ability to modulate filtering, noise floor, bandwidth, as well as many other options to improve listening capability.



RTL-SDR Dongle with SMA/USB connections on each side



SDR Sharp of at 5MHZ

We Thank you for your time and Interest.

Project Sponsor: Dr. Compeau, TX State University

Project Advisor: Dr. Karl Stephan, TX State University

