NF4RC / ARES HAM RADIO GROUP

ALACHUA COUNTY EOC OCF ANTENNA TEST PLAN & REPORT

John Trites (NO5X), Gordon Gibby (KX4Z)

February 12th, 2020

OVERVIEW

1. Project Background and Description

Alachua County's Sherriff Dept. installed an Off-Center Fed (OCF) Antenna for the 160m, 80m, 40m, 20m, 15m, and 10m Amateur Radio Bands over a year ago. The original installation was described as an Inverted-V topology comprised of a 75ft section and 180ft section of #14AWG THHN insulated wires connected to a 4:1 homebrew dual core Guanella current balun at an approximate elevation of 50ft.

The 75ft short section end was estimated to be installed at an approximate elevation of 8ft and the 180ft section end was estimated to be installed at an approximate elevation of 10ft. The actual lengths are approximate as well. Original SWR and Impedance (Z) measurements were performed using an MFJ-259B and manually plotting points on graph paper.

In 2020, the NF4RC group modified the original OCF Inverted-V antenna by shortening the 75ft section to approximately 65ft. The goal was to improve SWR and Z measurements over the above listed bands. An immediate goal is to add segment(s) to support the 40m and 20m ham bands currently not supported without an Antenna Tuner. A future goal is to add another segment in a fan dipole configuration (TBD) to add the 60m band (5.3 to 5.405 MHz), and ultimately to widen its performance down to 5MHz.

2. Project Scope and Purpose

The purpose of this Test Plan is to describe the setup, calibration, and SWR and Complex Impedance (|Z| and Phase) perform measurements on the recently modified 65/180ft Inverted-V OCF Antenna. All SWR, Z and TDR measurements shall be performed at the RG-8X 100ft feedline weatherproof disconnect point using a RigExpert AA-54 Antenna Analyzer connected to a laptop running their AntScope Antenna Analysis program.

And, we plan to use this test data as input to model, simulate and propose design changes to the recently modified installed design to:

- *Improve performance on the priority amateur radio bands listed above.*
- *Modify the design to add the 40m and 20m Amateur Bands.*
- *A tertiary goal is to modify the design to add the 60m Amateur Band with additional frequency coverage down to 5MHz.*

The AA-54 shall be calibrated using hand fabricated Open, Short, and Load (OSL) Calibration Standards. OSL Calibration measurement scans were performed at the 1.5ft RG 8X coaxial cable extension plane. The Calibration Measurements were saved as (3) saved Measurement (.antdata) files and also to (3) OSL Calibration Touchstone(*s1p) files for future measurements. These hand fabricated OSL Cal standards were found to be accurate out to 30MHz with a minimum Return Loss better than 30dB. All Antenna measurement scans shall be saved to files appropriately named for the test conditions executed.*

Time Domain Reflectometry (TDR) measurements shall be performed in two directions starting approximately from the 100ft RG-8X coaxial feedline weatherproof disconnect point at fence line:

- *100-foot section of RG-8X feedline between the weatherproof disconnect point and the modified OCF Antenna to verify its length adjusted for velocity factor and test if and where there are any Impedance discontinuities (shorts, opens, low-Z, or high-Z). This turned out to be 107 feet of RG-8X coaxial transmission line with propagation velocity, Vp = 0.82.*
- *300 plus foot section of unknown feedline between that same weatherproof disconnect point back to the EOC Radio Room's patch panel (i.e. radio connection) to verify its length and check for Impedance discontinuities. This turned out to be 507 feet of coaxial transmission line with propagation velocity, Vp = 0.85*

3. High-Level Requirements

The test plan must include the following:

- *Open, Short and Load (OSL) Calibrations shall be made from 0 – 30 MHz, covering all HF Amateur Radio Bands, at the 1.5ft RG-8X short cable impedance plane.*
- *All SWR, Z, and TDR measurements shall be made from 1 – 30 MHz at the 100ft antenna feedline weatherproof disconnect point.*
- *All TDR measurements shall be made from 1 – 30 MHz at the 100ft antenna feedline weatherproof disconnect point back to the EOC Radio Room.*

4. Deliverables

The test plan and results shall be entered into Appendix A and delivered to the Alachua County Deputy Sherriff Colonel David Huckstep and NF4RC/ARES Amateur Radio Society.

A 4NEC2 model of this antenna design shall be simulated and compared against the test results from this test report provided in Appendix B.

One or more simulated options that add significant 40m and 20m Amateur Band performance provided in Appendices C and D.

The RigExpert AA-54 Setup, Configuration and Calibration values shall be provided in Appendix E.

Upon permission from the Alachua County Sherriff's office, we shall train NF4RC/ARES members on how to properly test, measure and modify OCF Inverted-V Antenna's. Otherwise, the training will use some other antenna topology and location.

5. Affected Parties

- *Alachua County Sherriff's Office, Emergency Communications Center (EOC)*
- *North Florida Emergency Communications Amateur Radio Society, NF4ARC*

6. Affected Business Processes or Systems

Colonel David Huckstep of the Alachua County Sheriff's Office agreed to provide oversight over execution of this test plan.

7. Specific Exclusions from Scope

The scope of work for this test plan is to measure and test the performance of the recently modified OCF Inverted-V Antenna that was installed at the Alachua County EOC site As-Built. The SOW also shall determine the approximate location a short or open exists in the coaxial feed line from the Radio Room.

The SOW does not include making any significant changes to the installed Antenna, its RG-8X coaxial feedline section(s), topology, section heights, wire gauge, wire type, baluns, grounding, or any other configurations, materials, or setup on the day of baseline testing.

8. Implementation Plan

The first step in the process is to make accurate SWR, Z and TDR measurements of the current Inverted-V OCF Antenna. Then create a reasonably accurate Antenna Model using NEC2 Antenna Modeling and Simulation programs that closely matches the test measurements of the installed antenna.

Then, modify the existing OCF Antenna to add the 40m and 20m Amateur Radio Bands in the near term which are currently not supported on the installed antenna.

A future goal is to add the 60meter Amateur Band extended from 5.0 MHz to 5.405 MHz (or as wide a bandwidth that can be supported with two additional antenna elements.

9. High-Level Timeline/Schedule

The plan is complete this testing in one afternoon on Feb. 5th, 2020 and file a subsequent Test Report within 2 weeks of test completion.

10. Test Results

We setup at the Alachua County EOC 100 FT antenna coaxial feedline to take SWR, Z and TDR measurements around 12:30pm.

The AA-54 Time Domain Reflectometer (TDR) measurement showed an open at approximately 358 feet from the 100 foot antenna feedline disconnect point (at the fence line) looking back towards the Radio Room. We later ran the same TDR measurement in the Radio Room and found the same open at approximately 133 feet towards the same fence line disconnect point. This shows an estimated total length between the Radio Room and the disconnect fence line point of 491 feet. Thus the total coaxial feedline from the Radio Room is 598 feet. We will retake the measurement after the open fault is cleared from the Radio Room to the Antenna feed point at approximately 34.5 ft height.

Appendix A shows the GNV-EOC INV-OCF Antenna Test Results which compares Gordon's MFJ-259B original measurements to the last SWR and |Z| measurements made by the RigExpert AA-54 Antenna Analyzer. Gordon's MFJ-259B original measurements were taken when the short segment was estimated at 75 FT and the long segment was estimated at 180FT. The AA-54 measurements were taken after Gordon took an estimated 10 FT off the short segment only. Also, on this day of testing, Gordon moved the sagging 180FT section to the opposite side of a tree about 1/3 the way from the feed point and tightened up the connecting rope to remove most of the sag that was at a 3 FT low point from the ground.

Appendix B shows the Simulated Adjusted GNV-EOC INV-OCF Antenna Results based on the estimated lengths, heights and distances we could obtain on the job-walk. The 4NEC2 simulation matches closely with the adjusted modified antenna measurements by the RigExpert AA-54 Antenna Analyzer. The pattern closely matches the original MFJ-259B measured pattern but the resonant points are shifted due to an estimated 10 FT of short segment length removed by Gordon after he made those measurements.

Appendix C and D show very good performance of two different Simulated Models adding a Single Stub on the long side for the 40m and 20m Amateur Bands. Each model requires the existing short segment to be shortened and raised to the same 34.5 height as the source feed-point. And both models require a new Single Stub of different lengths to be added above the existing long segment with its end raised to 34.5 FT height. Finally, the existing 189 FT long wire end shall be raised slightly to 10 FT height.

APPROVAL AND AUTHORITY TO PROCEED

We approve the project as described above, and authorize the team to proceed.

Name	**Title**	**Date**
Colonel David Huckstep	*Alachua County* *Deputy Sherriff*	*Feb. 5th, 2020*

Approved By	*Date*	*Approved By*	*Date*

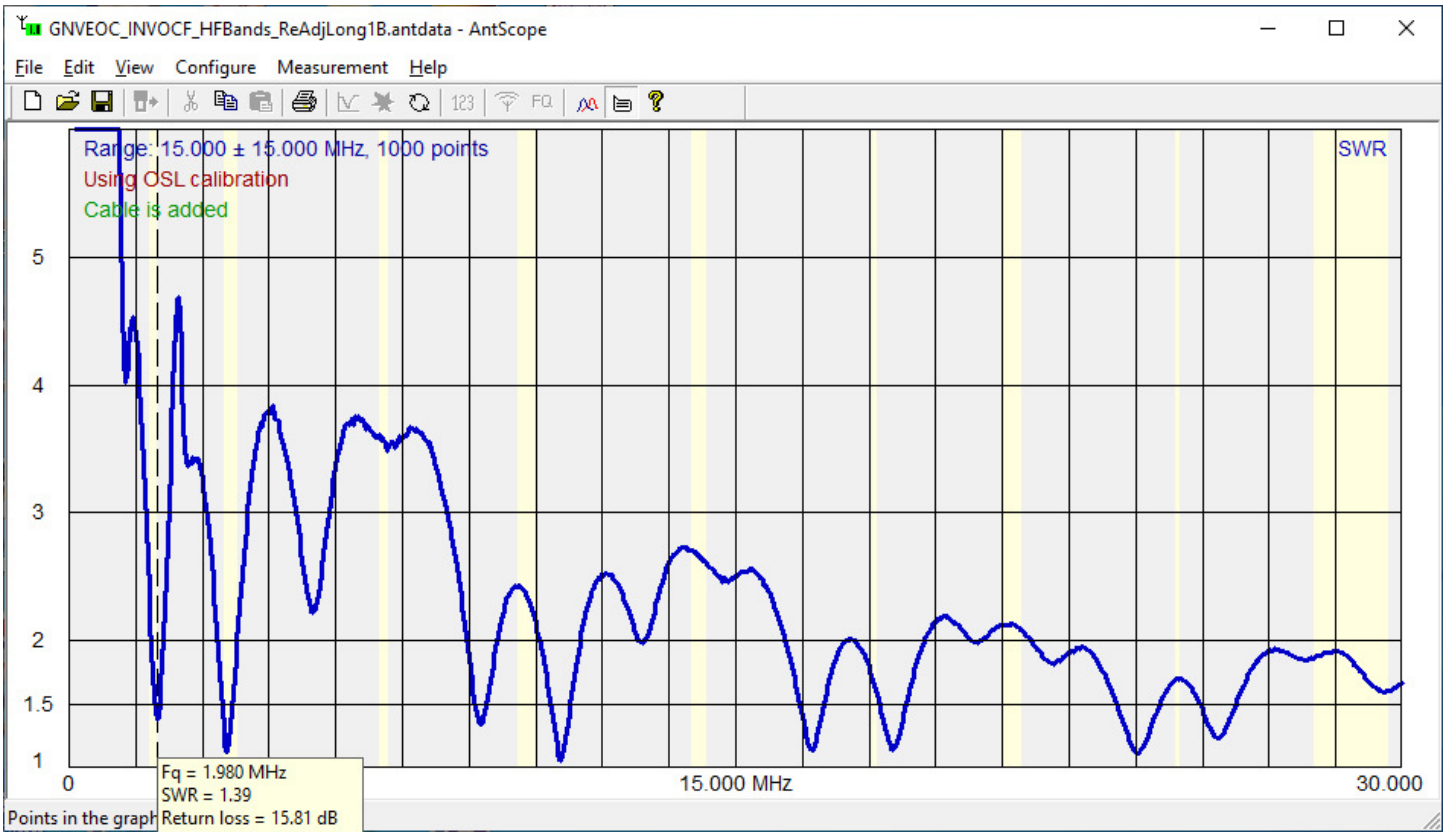
Appendix A – GNV-EOC INV-OCF Antenna Test Results

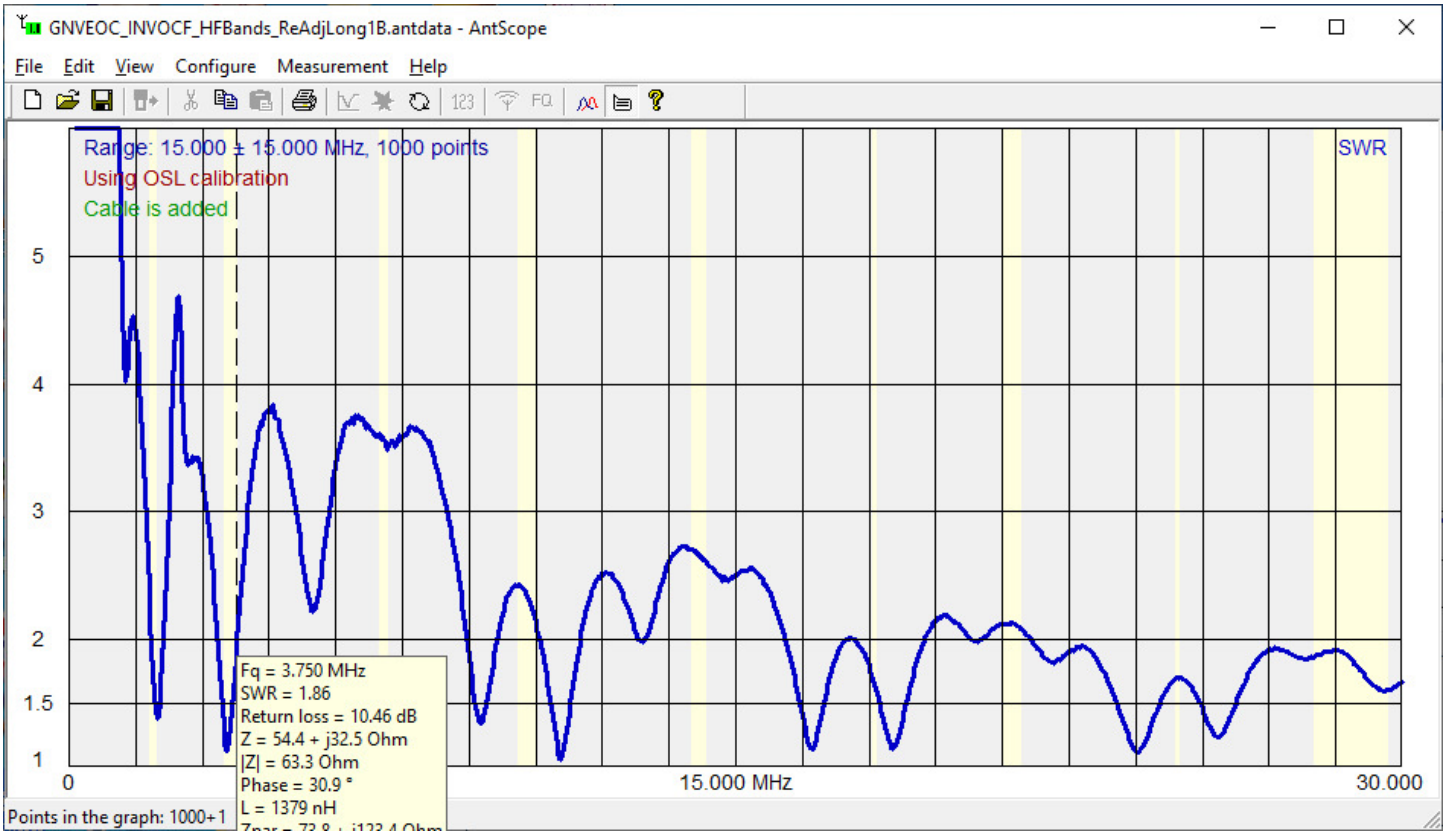
1. SWR and Impedance Measurements – Guanella 4:1 (200:50ohm Impedance)

Amateur Band	Frequency Range	AA-54 SWR @ 100FT	AA-54 Impedance Z = R + jX @ 100FT	MFJ-259B SWR @ 100F
160m – 10m 100 FT RG-8X Feedline	0.00 – 30.00 MHz	File: GNVEOC_INVOCF_HFBands_ReAdjLong1B.antdata		
160 meters	1.80 – 2.00 MHz	1.39 @ 1.980 MHz		1.6 @ 1.89 MHz
75 & 80 meters	3.50 – 4.00 MHz	1.86 @ 3.750 MHz		1.75 @ 3.54 MHz
60 meters	5.30 – 5.405 MHz	2.73 @ 5.480 MHz		4.0 @ 5.35 MHz
40 meters	7.00 – 7.30 MHz	3.54 @ 7.140 MHz		6.3 @ 7.140 MHz
30 meters	10.10 – 10.15 MHz	2.41 @ 10.200 MHz		3.4 @ 10.60 MHz
20 meters	14.00 – 14.350 MHz	2.68 @ 14.130 MHz		2.7 @ 14.150 MHz
15 meters	21.00 – 21.450 MHz	2.12 @ 21.150 MHz		2.0 @ 21.150 MHz
10 meters	28.00 – 29.70 MHz	1.87 @ 28.050 MHz		Not recorded

2. Time Domain Reflectometry (TDR) Measurements

Coaxial Feedline Section	Cable Parameters	Frequency Range	Cable Loss (dB/100ft)	TDR (F7)
100ft Disconnect Point to OCF Antenna RG-8X	Units = US FEET Velocity Factor = 0.82 Cable Length = 107 ft Do not add/sub cable X Subtract Cable _____ Add Cable _____	0 – 30 MHz		Distance = 111.4 ft Time = 133.2 ns Impulse Response = 0.482 Step Response = 0.289 |Z| = 90.6
100ft Disconnect Point to EOC Radio Room _____	Units = US FEET Velocity Factor = 0.85 Cable Length = 491ft Do not add/sub cable X Subtract Cable _____ Add Cable _____	0 – 30 MHz		Distance = 358.3 ft Time = 460.8 ns Impulse Response = 0.359 Step Response = 0.237 |Z| = 81.0


GNVEOC_INVOCF_HFBands_ReAdjLong1B.antdata - AntScope
File Edit View Configure Measurement Help
Range: 15.000 ± 15.000 MHz, 1000 points
Using OSL calibration
Cable is added
SWR
5
4
3
2
1.5
1
0
15.000 MHz
30.000
Fq = 1.980 MHz
SWR = 1.39
Return loss = 15.81 dB
Points in the graph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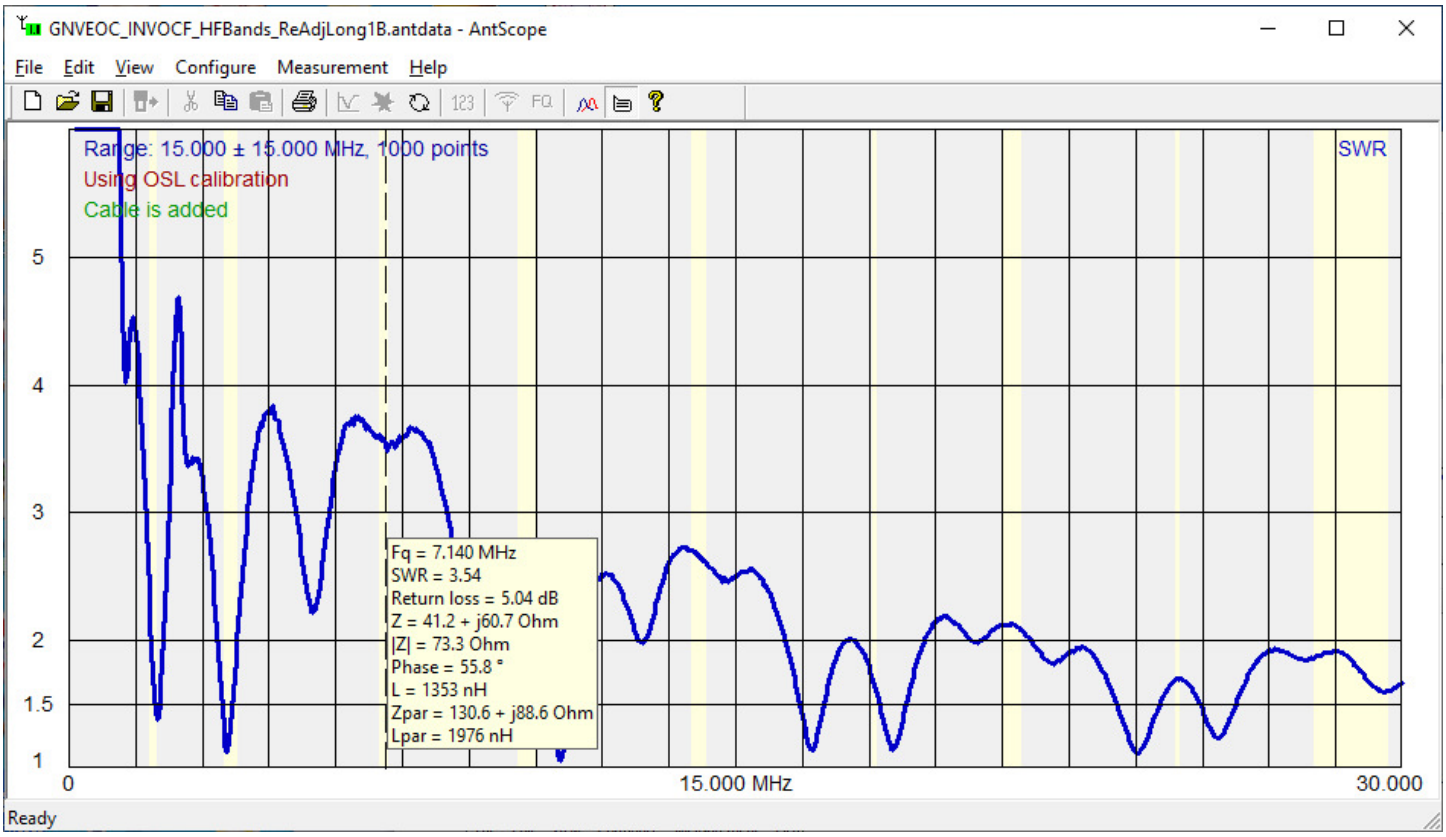
File Edit View Configure Measurement Help
Range: 15.000 ± 15.000 MHz, 1000 points
Using OSL calibration
Cable is added
SWR
5
4
3
2
1.5
1
0
15.000 MHz
30.000
Fq = 3.750 MHz
SWR = 1.86
Return loss = 10.46 dB
Z = 54.4 + j32.5 Ohm
|Z| = 63.3 Ohm
Phase = 30.9 °
L = 1379 nH
Points in the graph: 1000+1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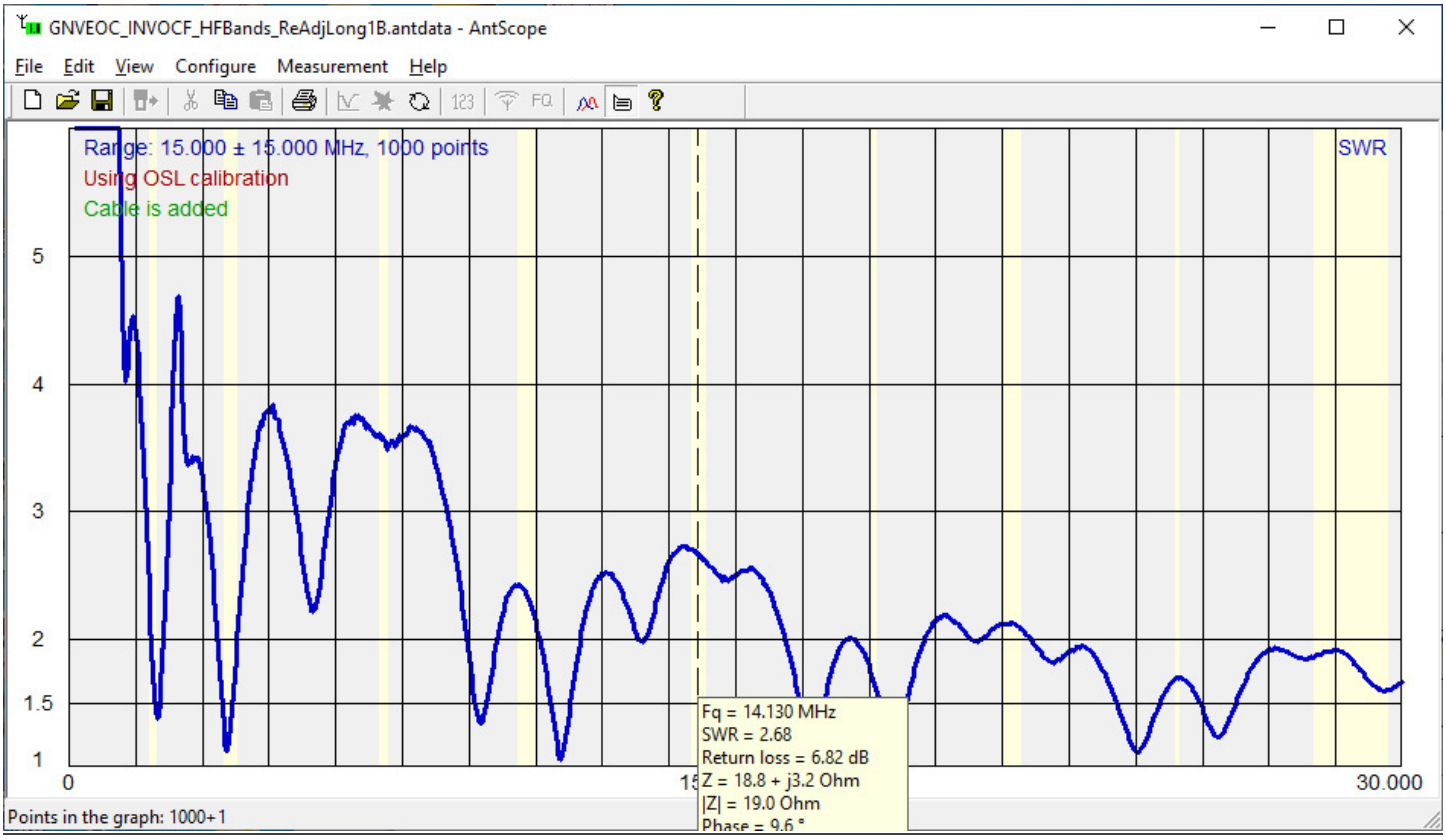
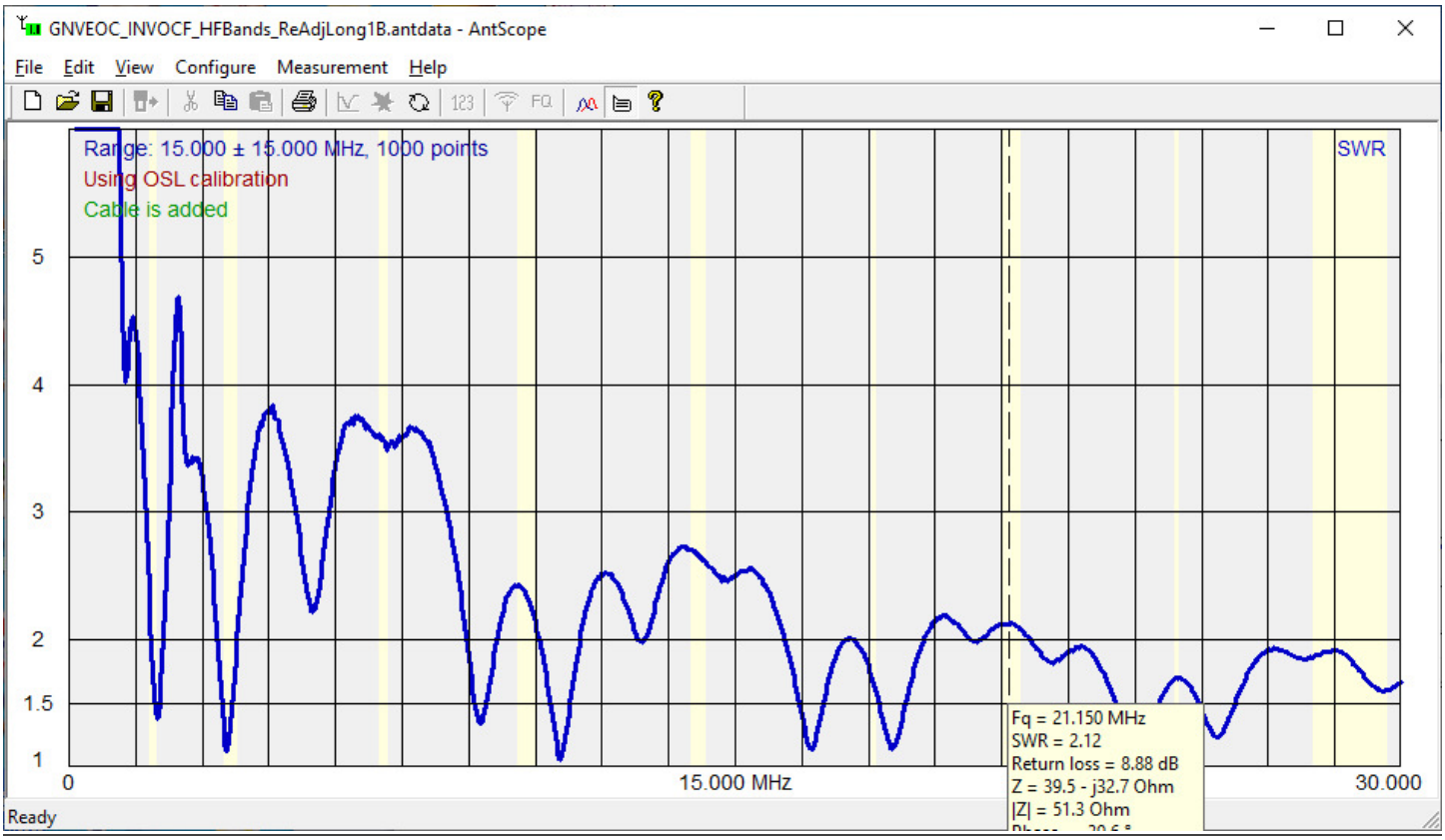
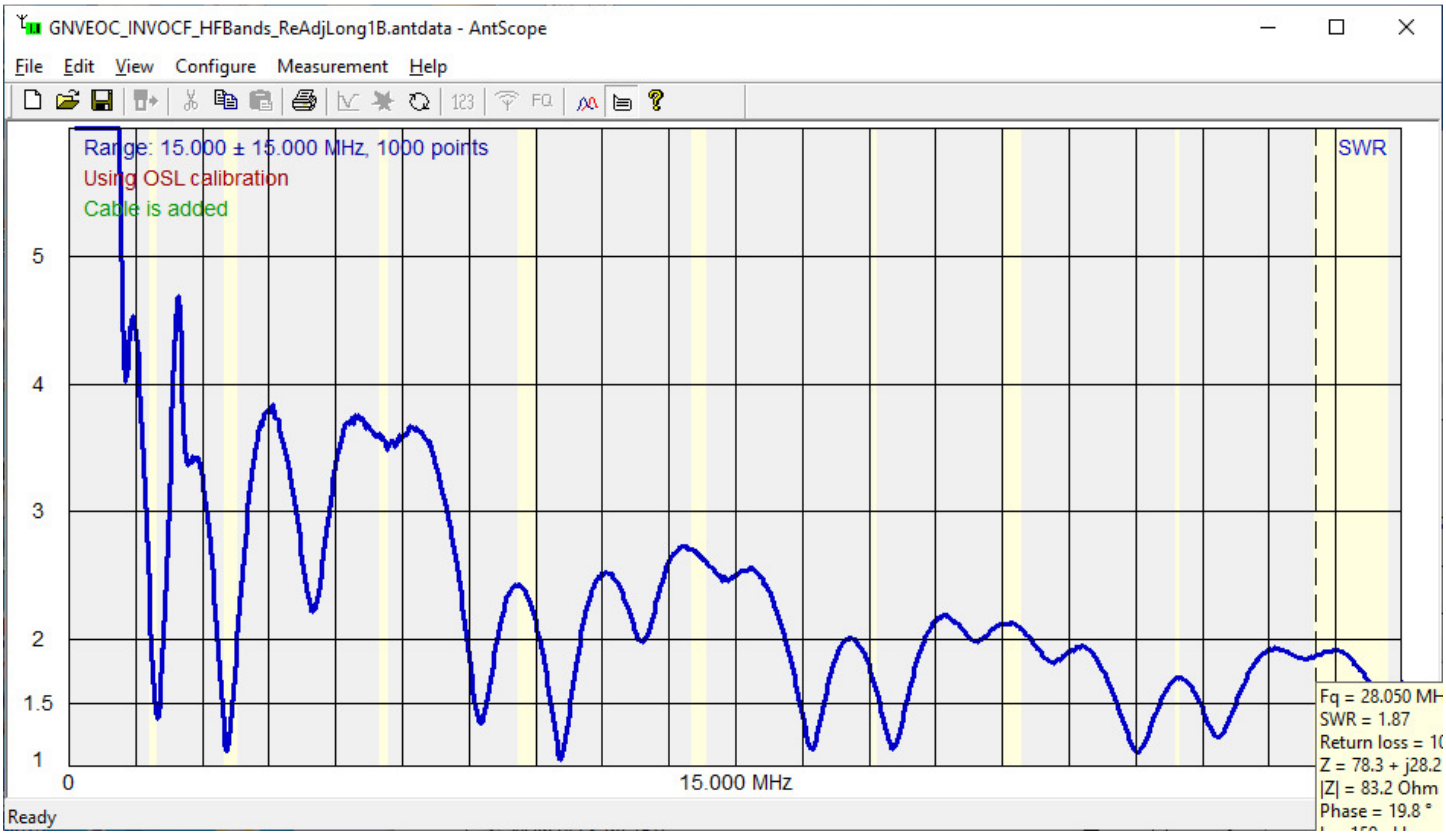
File Edit View Configure Measurement Help
Range: 15.000 ± 15.000 MHz, 1000 points
Using OSL calibration
Cable is added
SWR
5
4
3
2
1.5
1
Fq = 7.140 MHz
SWR = 3.54
Return loss = 5.04 dB
Z = 41.2 + j60.7 Ohm
|Z| = 73.3 Ohm
Phase = 55.8 °
L = 1353 nH
Zpar = 130.6 + j88.6 Ohm
Lpar = 1976 nH
0
15.000 MHz
30.000
Ready


GNVEOC_INVOCF_HFBands_ReAdjLong1B.antdata - AntScope
File Edit View Configure Measurement Help
Range: 15.000 ± 15.000 MHz, 1000 points
Using OSL calibration
Cable is added
SWR
5
4
3
2
1.5
1
Fq = 14.130 MHz
SWR = 2.68
Return loss = 6.82 dB
Z = 18.8 + j3.2 Ohm
|Z| = 19.0 Ohm
Phase = 9.6 °
0
30.000
Points in the graph: 1000+1


GNVEOC_INVOCF_HFBands_ReAdjLong1B.antdata - AntScope
File Edit View Configure Measurement Help
Range: 15.000 ± 15.000 MHz, 1000 points
Using OSL calibration
Cable is added
SWR
5
4
3
2
1.5
1
0
15.000 MHz
30.000
Fq = 21.150 MHz
SWR = 2.12
Return loss = 8.88 dB
Z = 39.5 - j32.7 Ohm
|Z| = 51.3 Ohm
Ready

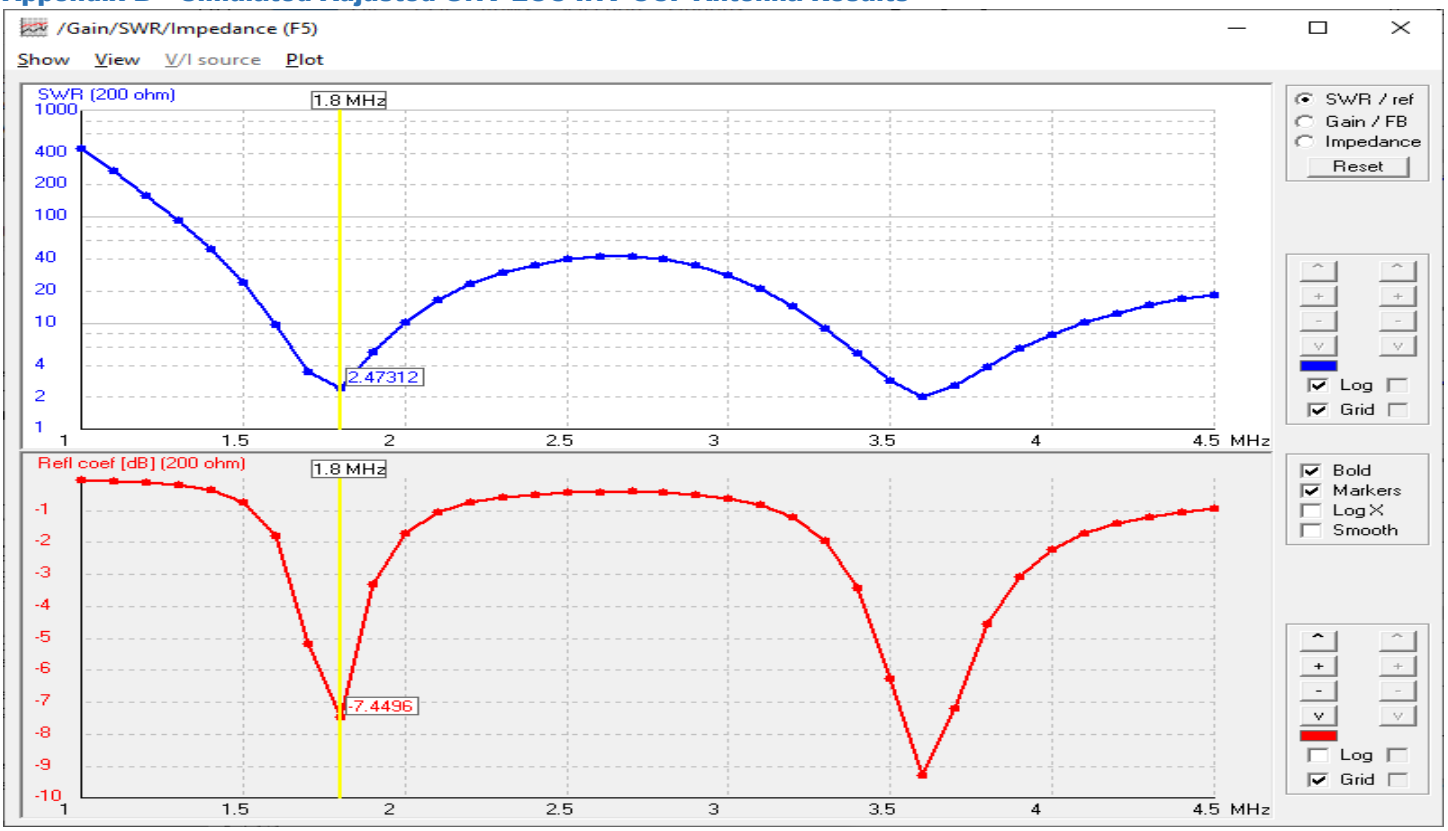

GNVEOC_INVOCF_HFBands_ReAdjLong1B.antdata - AntScope
File Edit View Configure Measurement Help
Range: 15.000 ± 15.000 MHz, 1000 points
Using OSL calibration
Cable is added
SWR
5
4
3
2
1.5
1
0
15.000 MHz
Fq = 28.050 MH
SWR = 1.87
Return loss = 1
Z = 78.3 + j28.2
|Z| = 83.2 Ohm
Phase = 19.8 °
Ready

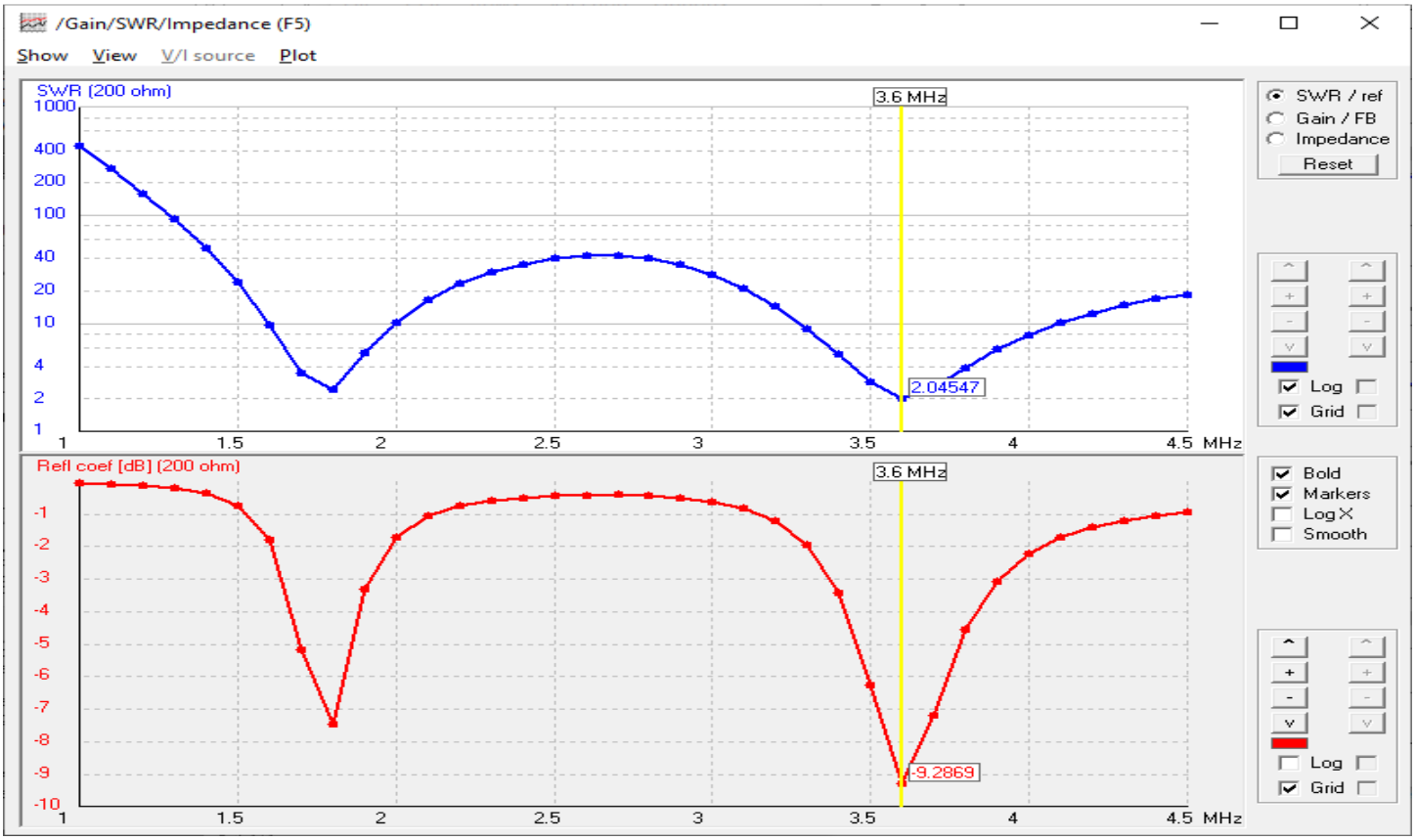
Appendix B – Simulated Adjusted GNV-EOC INV-OCF Antenna Results

3. SWR and Impedance Measurements (Simulated 200:50ohm Impedance)

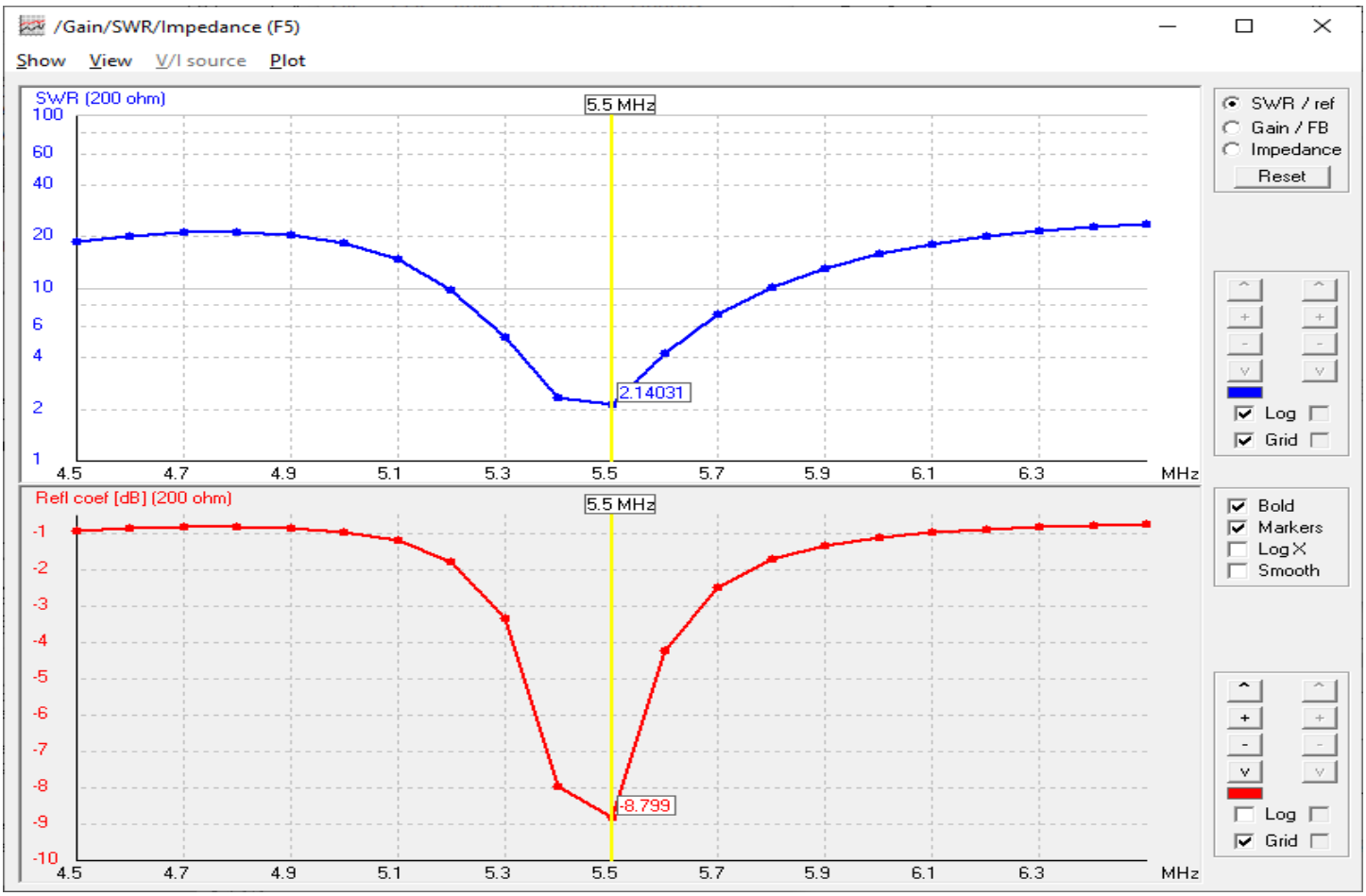
Amateur Band	Frequency Range	4NEC2 Simulated SWR @ 4:1 Source |Z|	4NEC2 Simulated Z = R + jX @ 4:1 Source |Z|	MFJ-259B SWR @ 100FT
160m – 10m 100 FT RG-8X Feedline	0.00 – 30.00 MHz	File: GNVEOC_OCF_JobWalk_2-5-20_Est1.nec		
160 meters	1.80 – 2.00 MHz	2.47 @ 1.80 MHz 5.31 @ 1.90 MHz	98.87 + j84.1 137.38 + j303.79	1.6 @ 1.89 MHz
75 & 80 meters	3.50 – 4.00 MHz	2.05 @ 3.60 MHz 2.54 @ 3.70 MHz	97.82 + j4.09 108.43 + 109.27	1.75 @ 3.54 MHz
60 meters	5.30 – 5.405 MHz	2.35 @ 5.40 MHz 2.13 @ 5.50 MHz	385 – j159.34 364 + j129.6	4.0 @ 5.35 MHz
40 meters	7.00 – 7.30 MHz	> 6 over band		6.3 @ 7.140 MHz
30 meters	10.10 – 10.15 MHz	1.18 @ 9.20 MHz 1.37 @ 11.0 MHz	152.5 – j27.8 175.4 + 17.8	3.4 @ 10.60 MHz
20 meters	14.00 – 14.350 MHz	2.98 @ 14.70 MHz		2.7 @ 14.150 MHz
17 meters	18.068 – 18.168 MHz	Not Useable		
15 meters	21.00 – 21.450 MHz	1.57 @ 22.10 MHz	306.8 – j36.3	2.0 @ 21.150 MHz
12 meters	24.890 – 24.990 MHz	Not Useable		
10 meters	28.00 – 29.70 MHz	1.15 @ 29.50 MHz	216.9 + j24.7	Not recorded

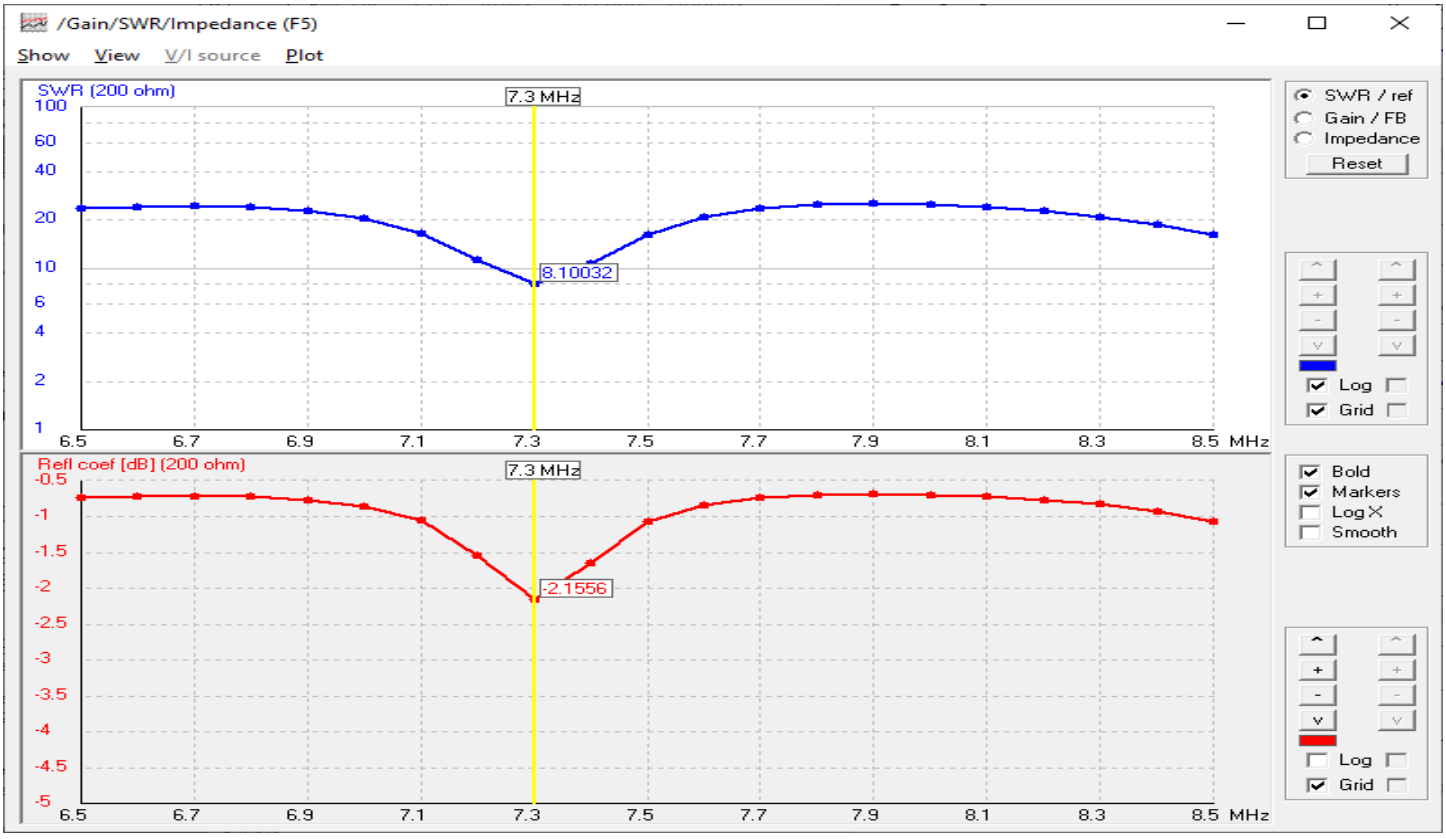
Appendix B – Simulated Adjusted GNV-EOC INV-OCF Antenna Results



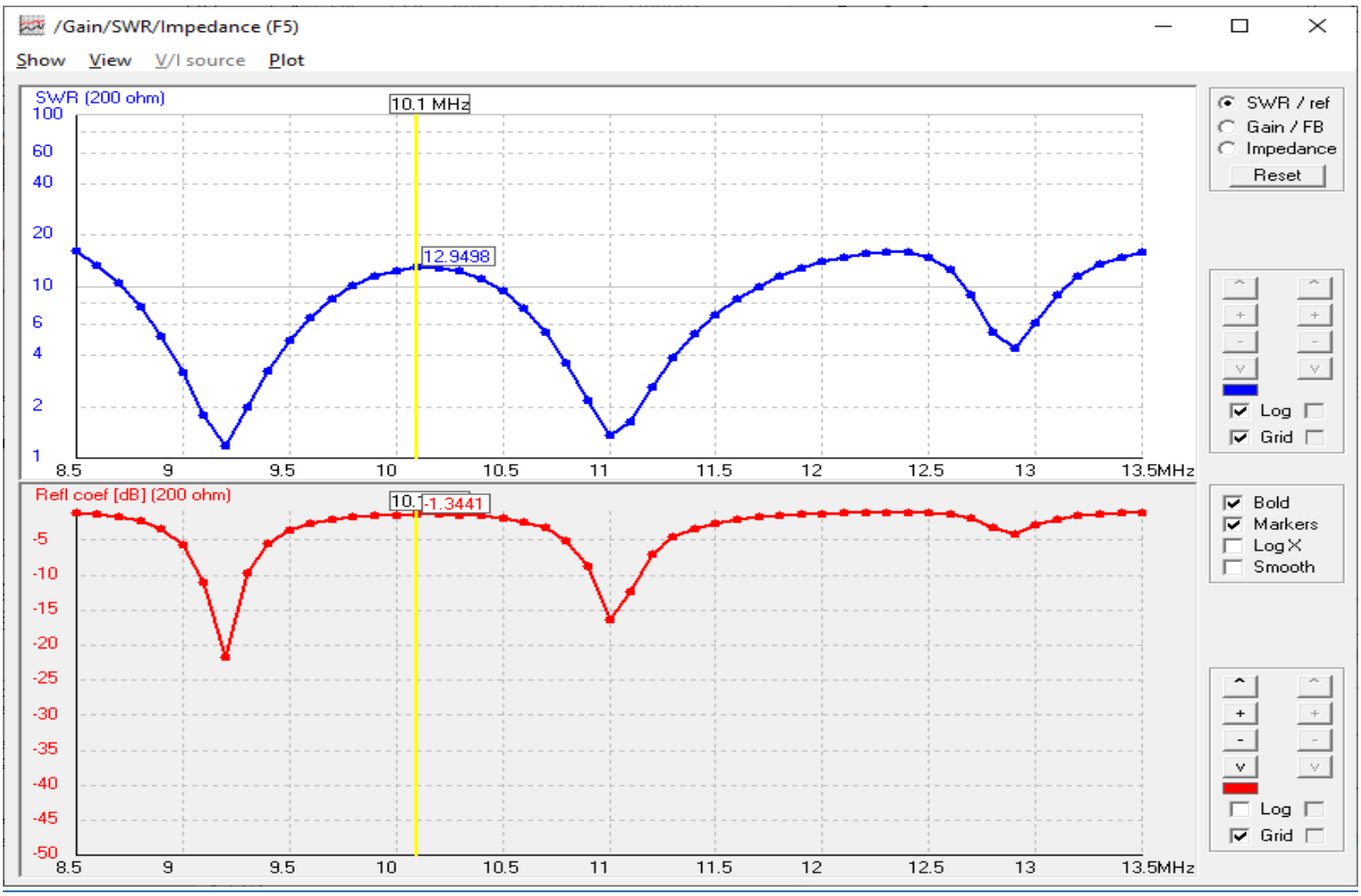


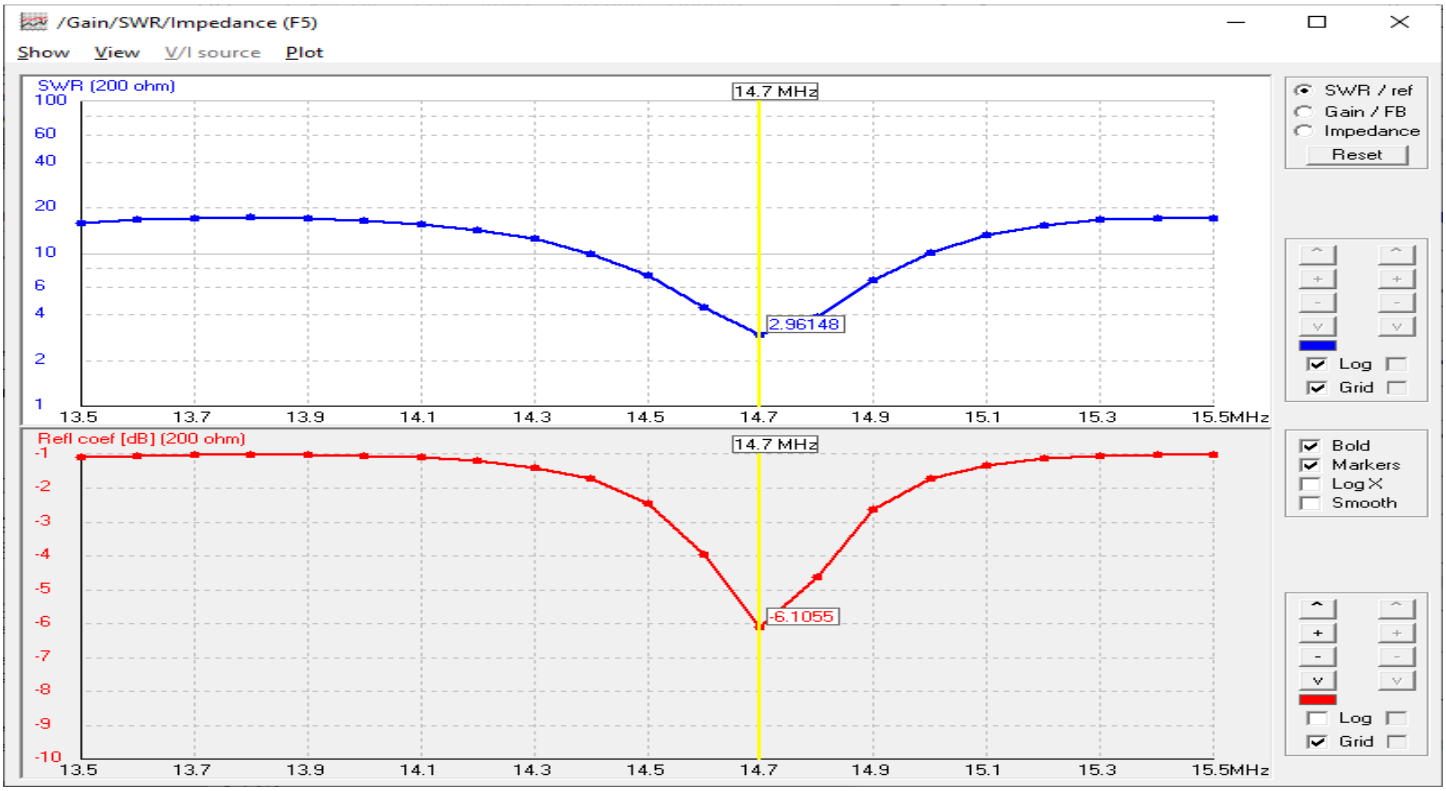
Appendix B – Simulated Adjusted GNV-EOC INV-OCF Antenna Results



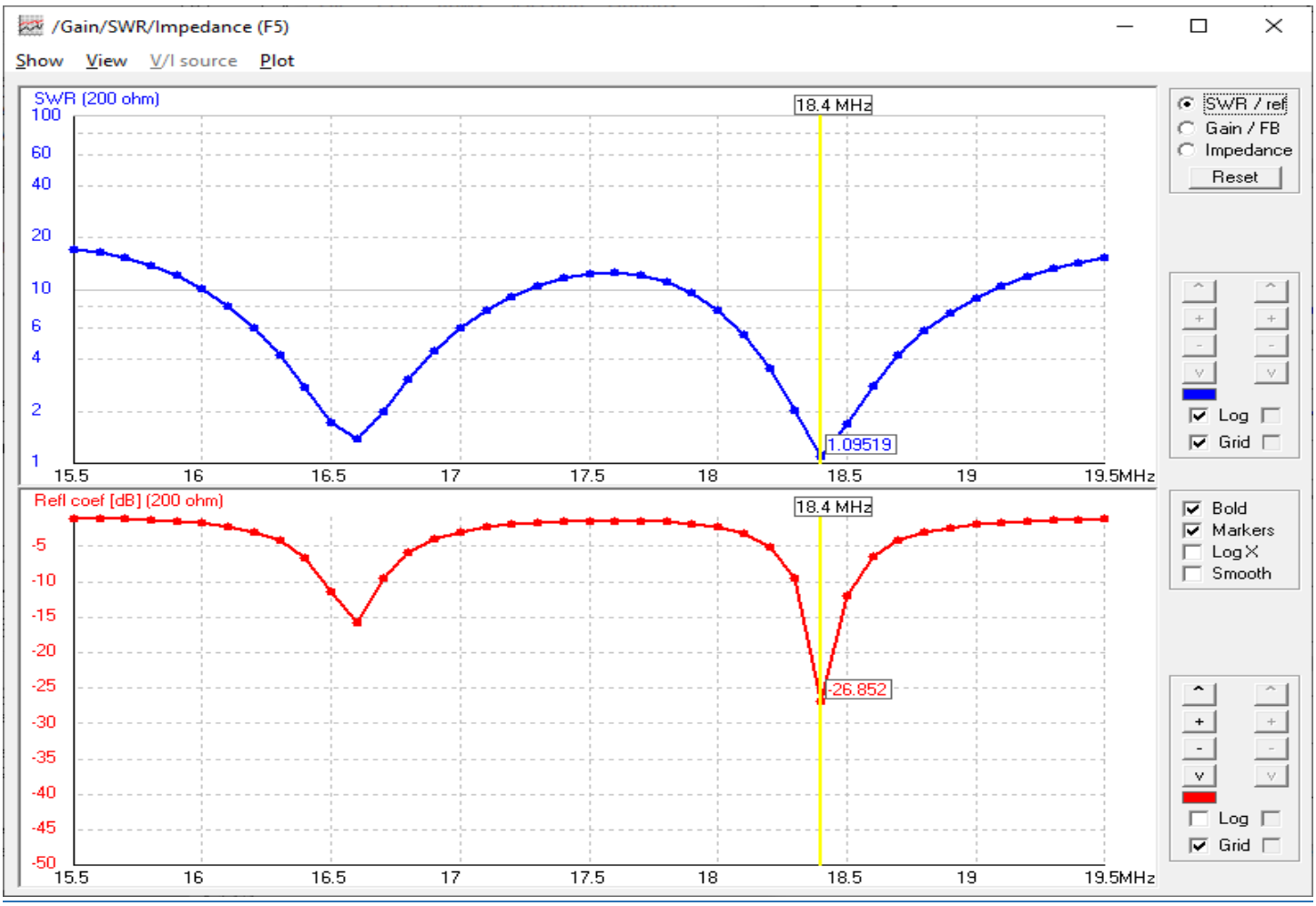


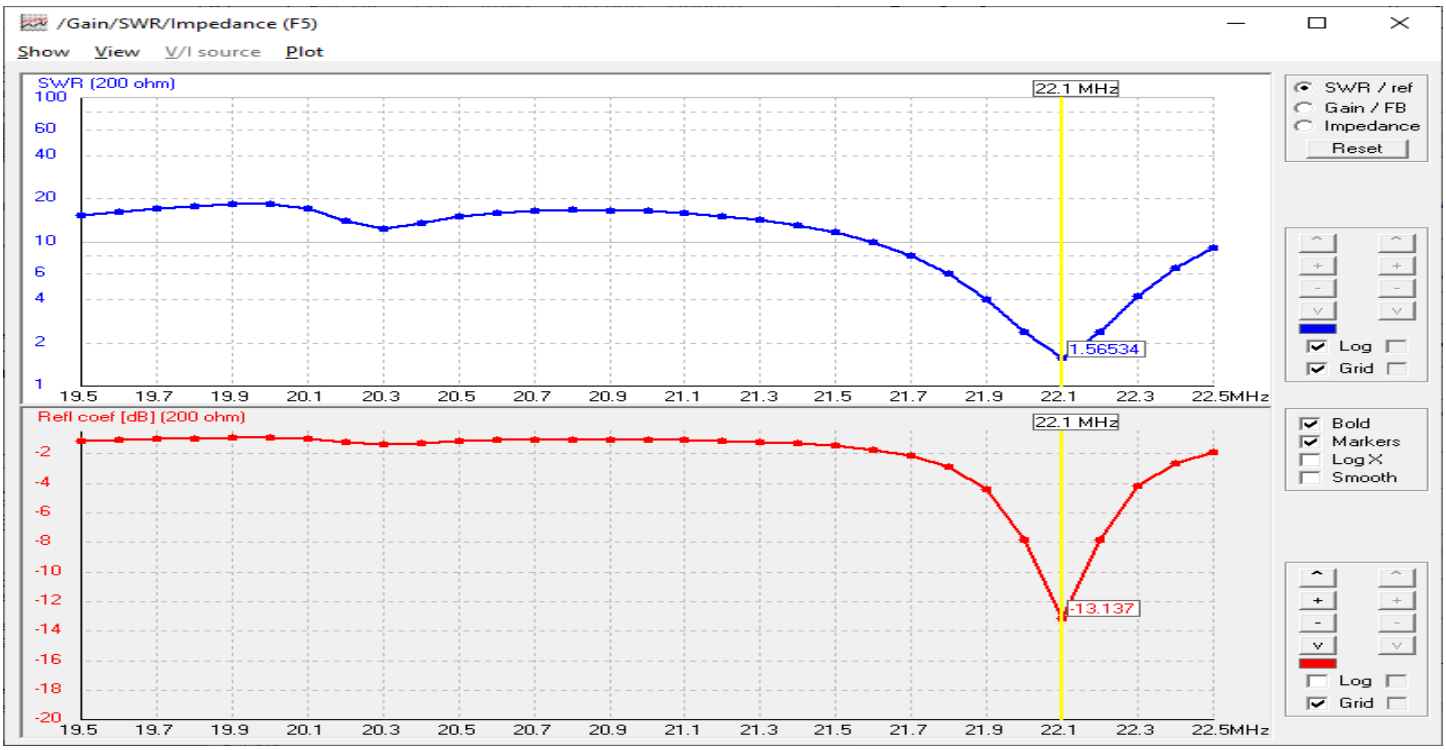
Appendix B – Simulated Adjusted GNV-EOC INV-OCF Antenna Results



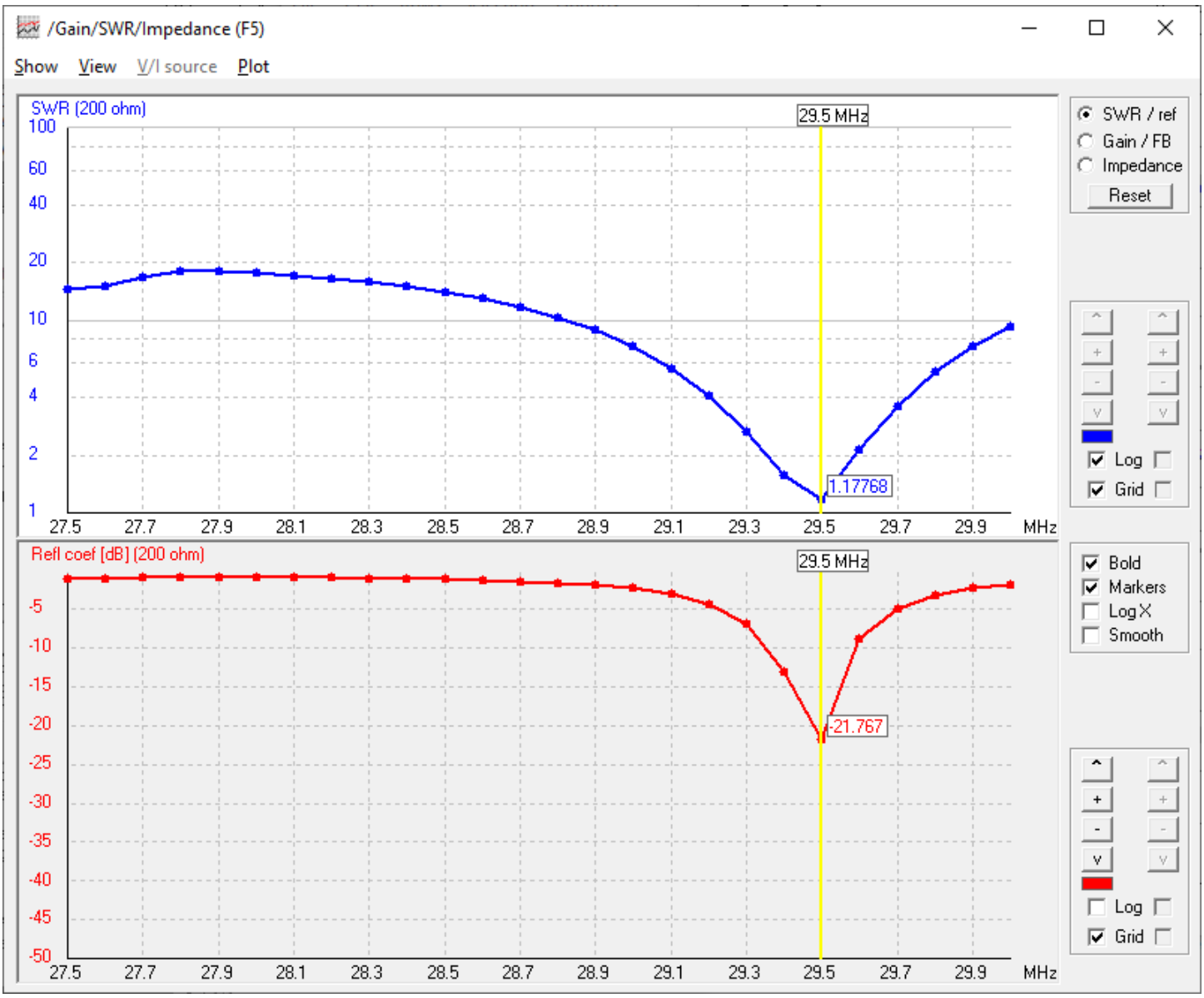


Appendix B – Simulated Adjusted GNV-EOC INV-OCF Antenna Results





Appendix B – Simulated Adjusted GNV-EOC INV-OCF Antenna Results



Appendix C – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_1

4. SWR and Impedance Measurements (Simulated 200:50ohm Impedance)

Required Modifications:

Shortened 69.64 FT short element to 46.0 FT ending at 34.5 FT height

Lengthened 189.2 FT long element to 196.74 FT ending at 10 FT height

Added new 40m/20m 26.0 FT Single Stub above long element, ending at 34.5 FT height.

4:1 Balun - not part of model (substitute 200 ohm flat impedance) estimated measured height of 34.5 FT

RG8-X Coaxial Transmission Line: approximately 107 FT according to TDR measurement

VSWR / 2.5:1 Bandwidth (BW)

160m 1.33 @ 1.90 MHz / 100 kHz BW

80m 1.89 @ 3.90 MHz / 200 kHz BW

40m 1.95 @ 7.10 MHz / 225 kHz BW

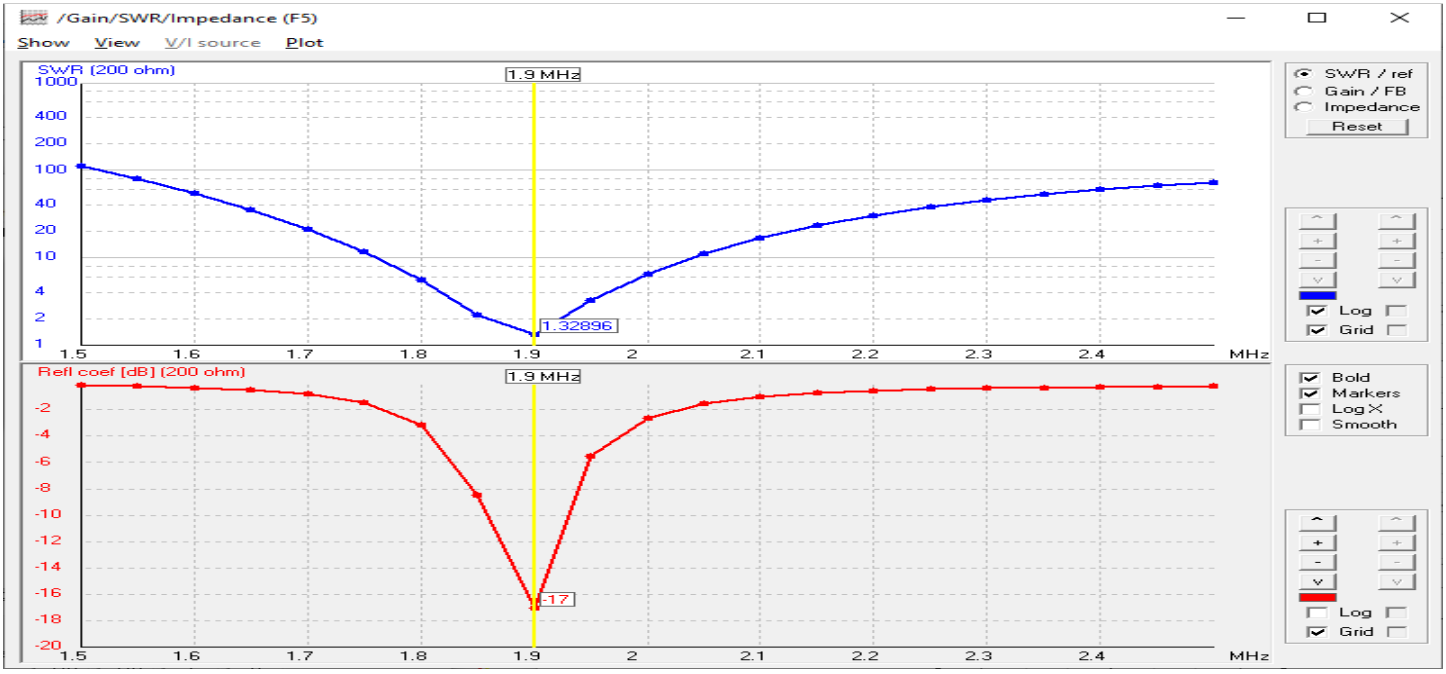
20m 1.73 @ 14.00 MHz, 2.38 @ 14.150MHz / 175 kHz BW

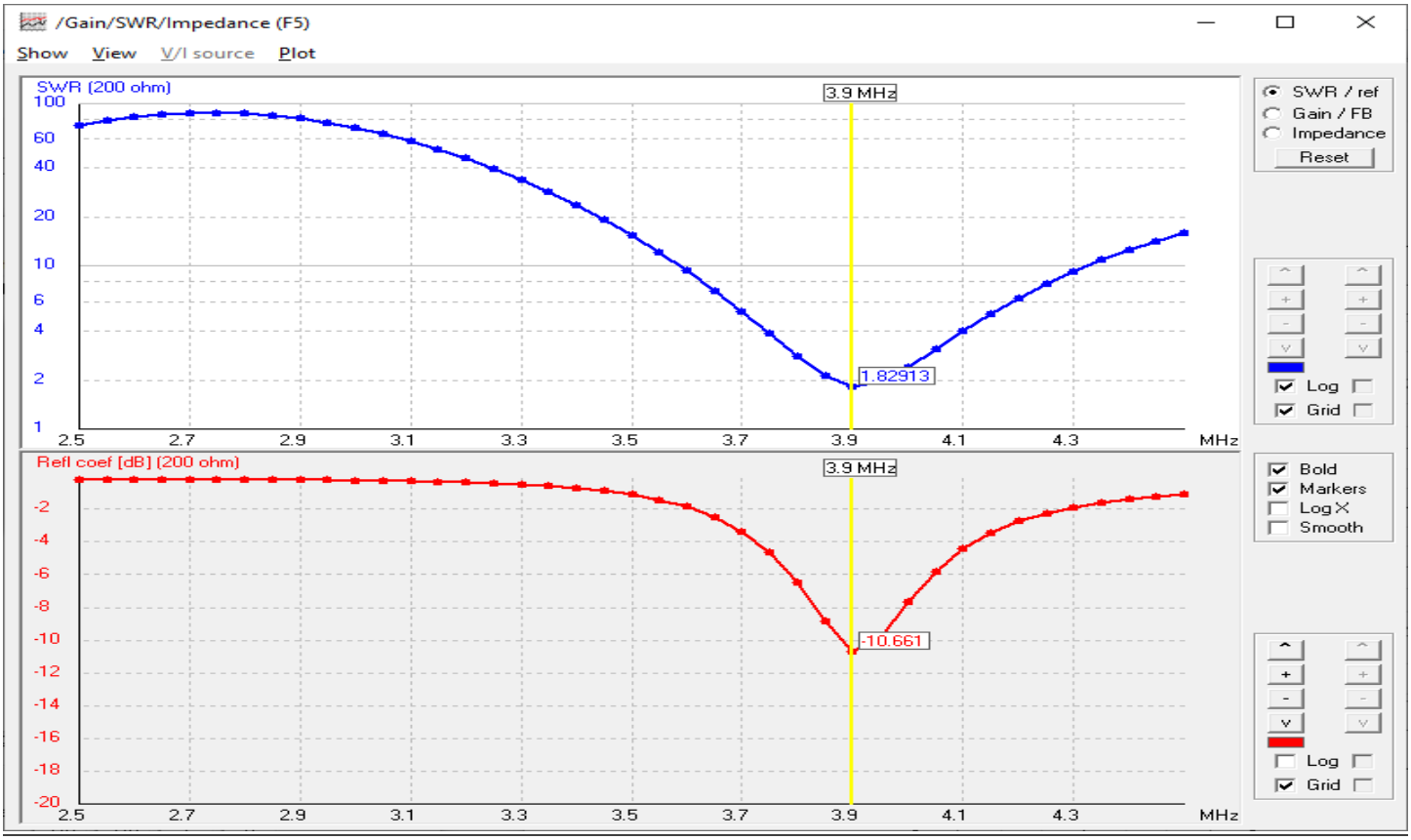
15m > 7.85 @ 21.85 MHz / not useable without TUNER

10m > 7.56 @ 28.00-29.70 MHz / not useable without TUNER

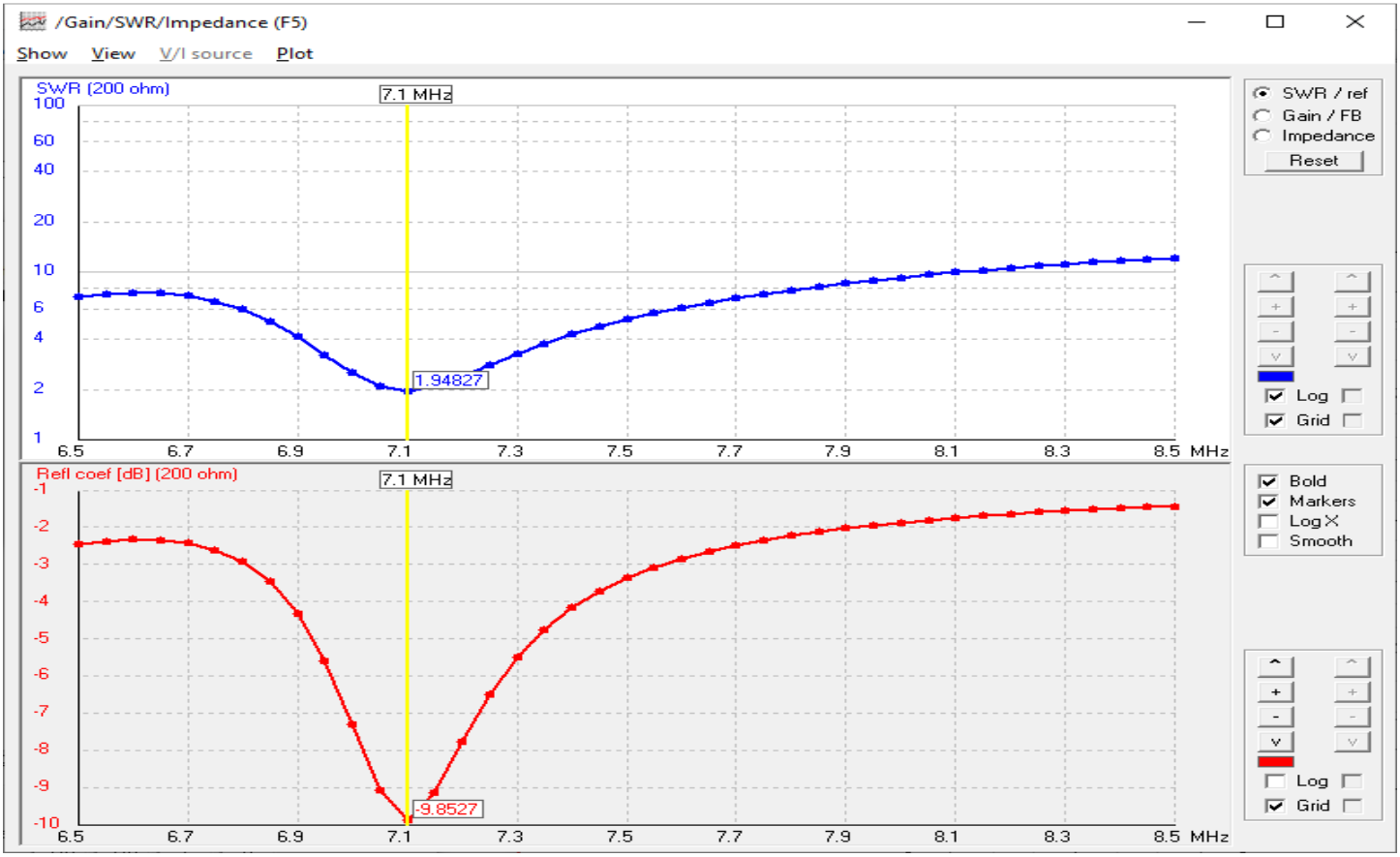
Amateur Band	*Frequency Range*	*4NEC2 Simulated SWR @ 4:1 Source |Z|*	*4NEC2 Simulated Z = R + jX @ 4:1 Source |Z|*	*MFJ-259B SWR @ 100FT*
160m – 10m 100 FT RG-8X Feedline	*0.00 – 30.00 MHz*	***File: GNVEOC_160-6m_OCF_4020mSingleStub_1.nec***		
160 meters	*1.80 – 2.00 MHz*	*1.33 @ 1.90 MHz*	*189.3 + j54.5*	*1.6 @ 1.89 MHz*
75 & 80 meters	*3.50 – 4.00 MHz*	*1.89 @ 3.90 MHz*	*111.7 + j24.7*	*1.75 @ 3.54 MHz*
60 meters	*5.30 – 5.405 MHz*	*Not Useable*		*4.0 @ 5.35 MHz*
40 meters	*7.00 – 7.30 MHz*	*1.95 @ 7.1 MHz*	*102.9 – j9.73*	*6.3 @ 7.140 MHz*
30 meters	*10.10 – 10.15 MHz*	*Not Useable*		*3.4 @ 10.60 MHz*
20 meters	*14.00 – 14.350 MHz*	*2.38 @ 14.150 MHz*	*198 + j178*	*2.7 @ 14.150 MHz*
17 meters	*18.068 – 18.168 MHz*	*Not Useable*		
15 meters	*21.00 – 21.450 MHz*	*7.85 @ 22.45 MHz*	*Not Useable*	*2.0 @ 21.150 MHz*
12 meters	*24.890 – 24.990 MHz*	*Not Useable*		
10 meters	*28.00 – 29.70 MHz*	*Not Useable*		*Not recorded*

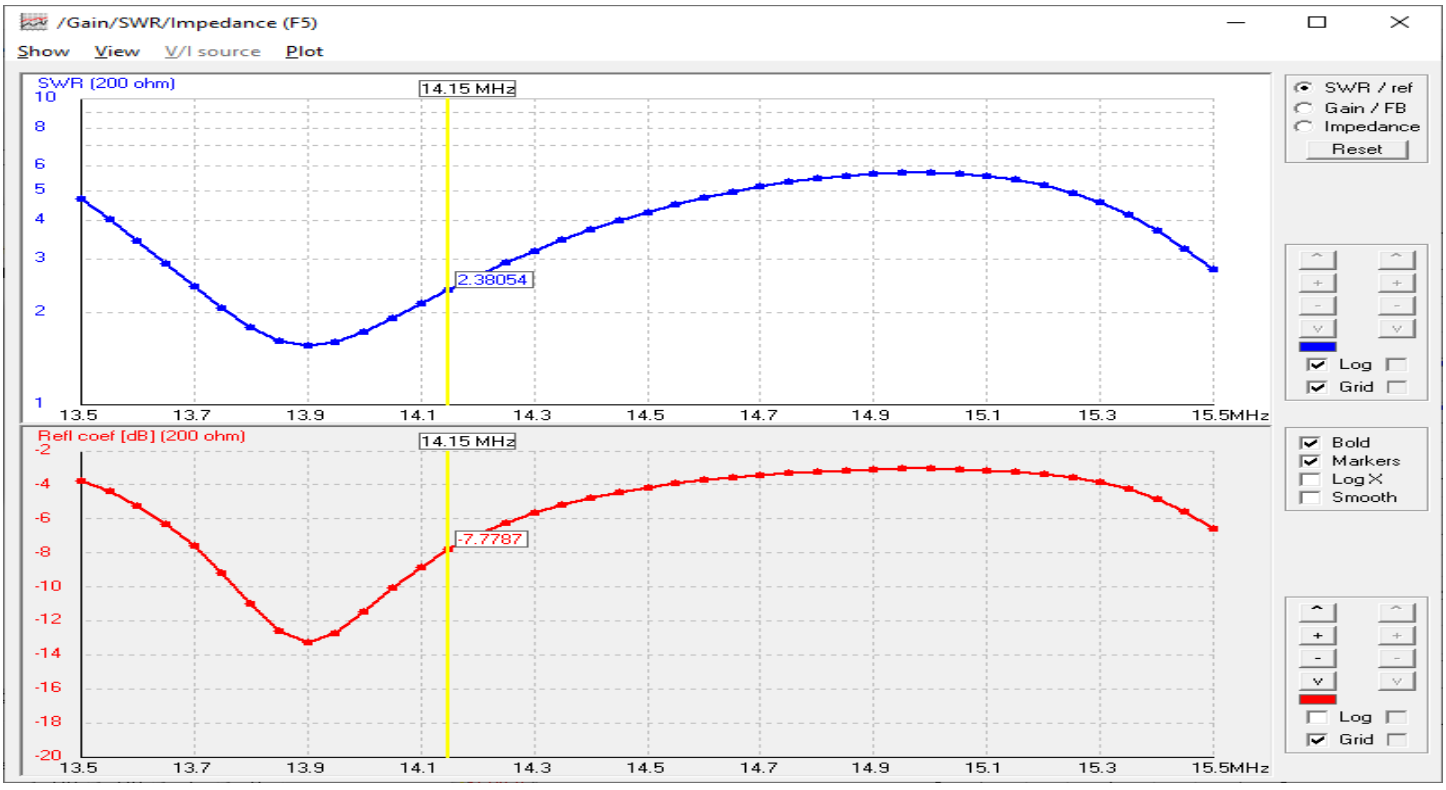
Appendix C – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_1



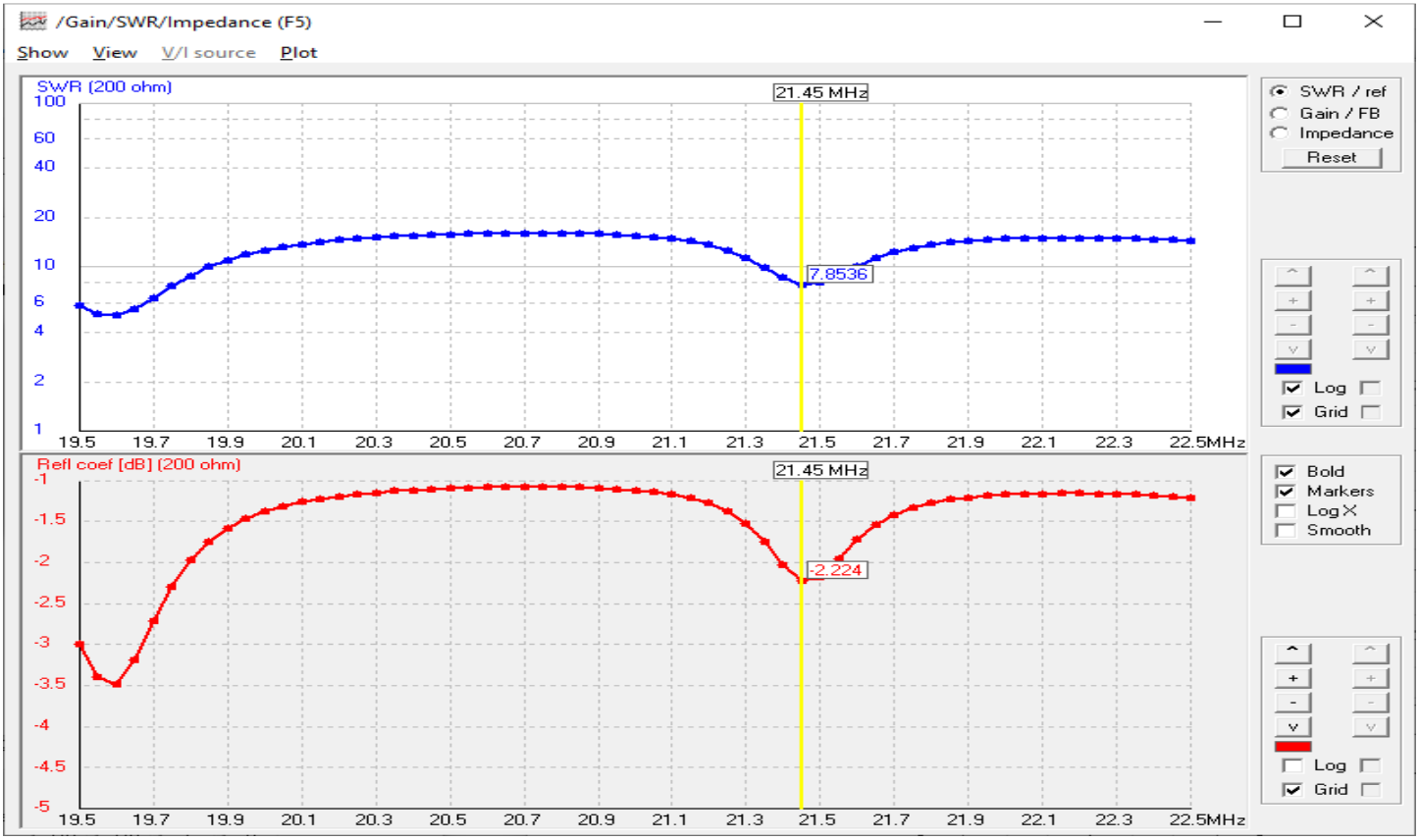


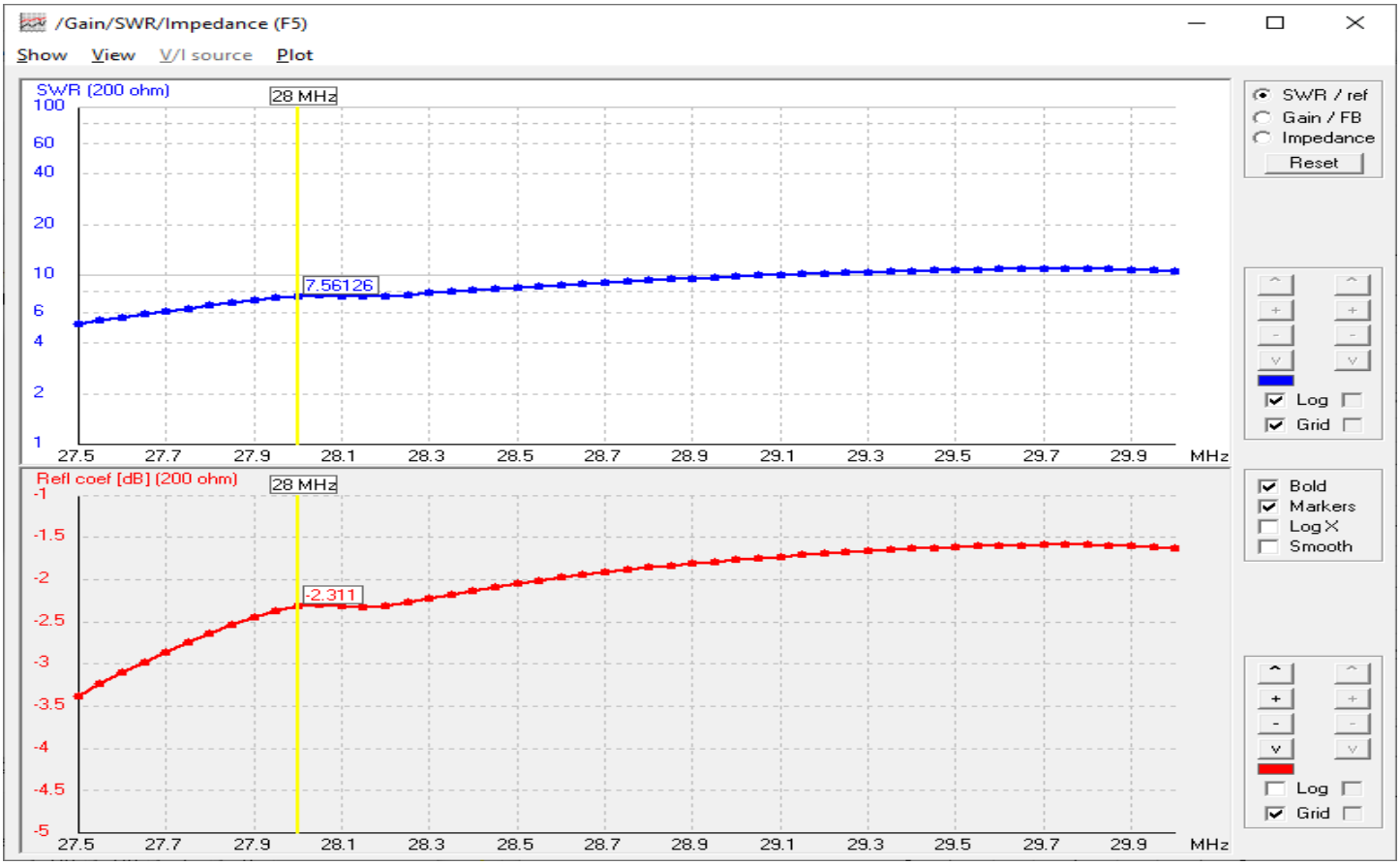
Appendix C – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_1





Appendix C – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_1





Appendix D – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_2

5. SWR and Impedance Measurements (Simulated 200:50ohm Impedance)

Required Modifications:

Shortened 69.64 FT short element to 46.0 FT ending at 34.5 FT height

Lengthened 189.2 FT long element to 196.74 FT ending at 10 FT height

Added new 40m/20m 23.5 FT Single Stub above long element, ending at 34.5 FT height.

4:1 Balun - not part of model (substitute 200 ohm flat impedance) estimated measured height of 34.5 FT

RG8-X Coaxial Transmission Line: approximately 107 FT according to TDR measurement

VSWR / 2.5:1 Bandwidth (BW)

160m 1.20 @ 1.90 MHz / 100 kHz BW

80m 1.83 @ 3.90 MHz / 175 kHz BW

40m 1.96 @ 7.20 MHz / 225 kHz BW

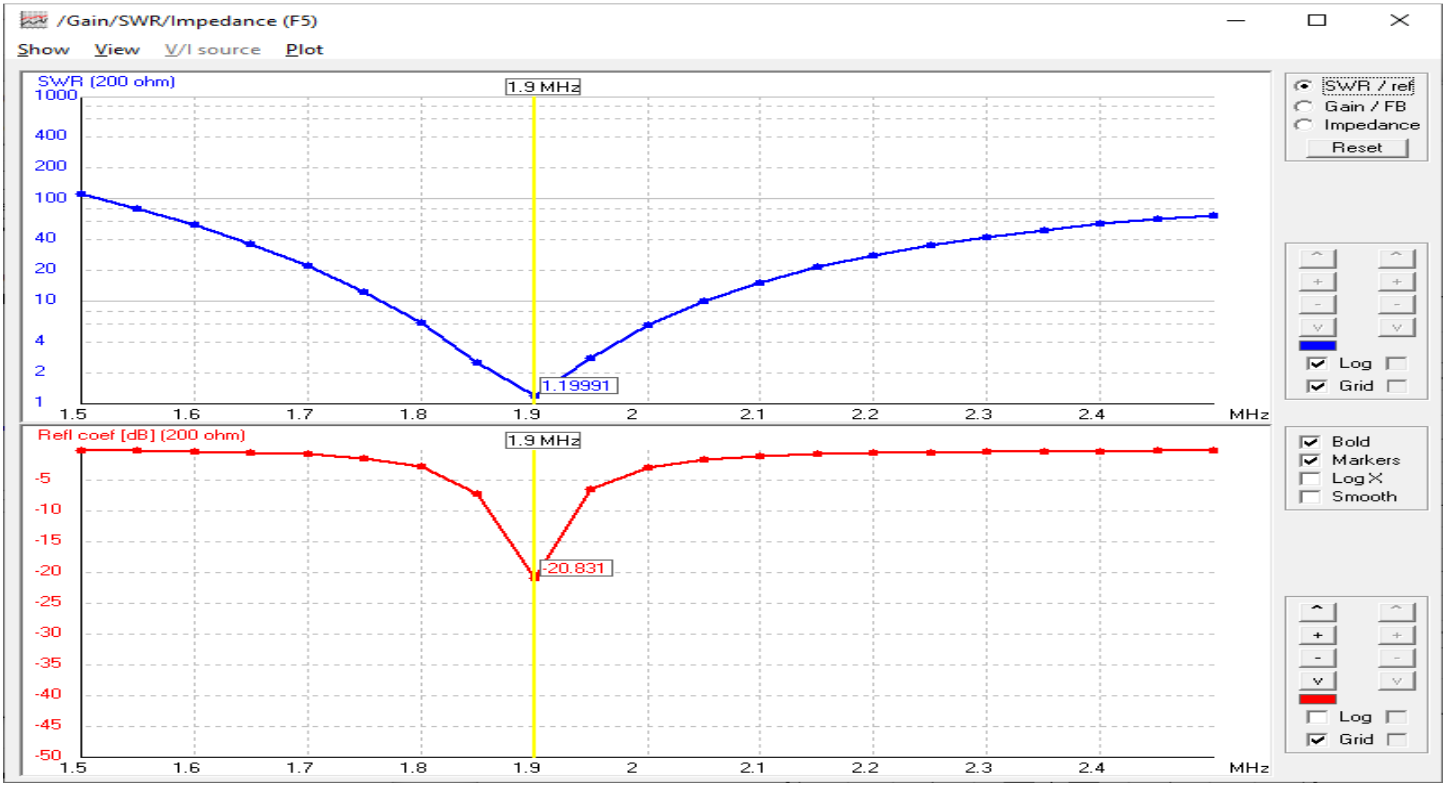
20m 1.95 @ 14.20 MHz / 325 kHz BW

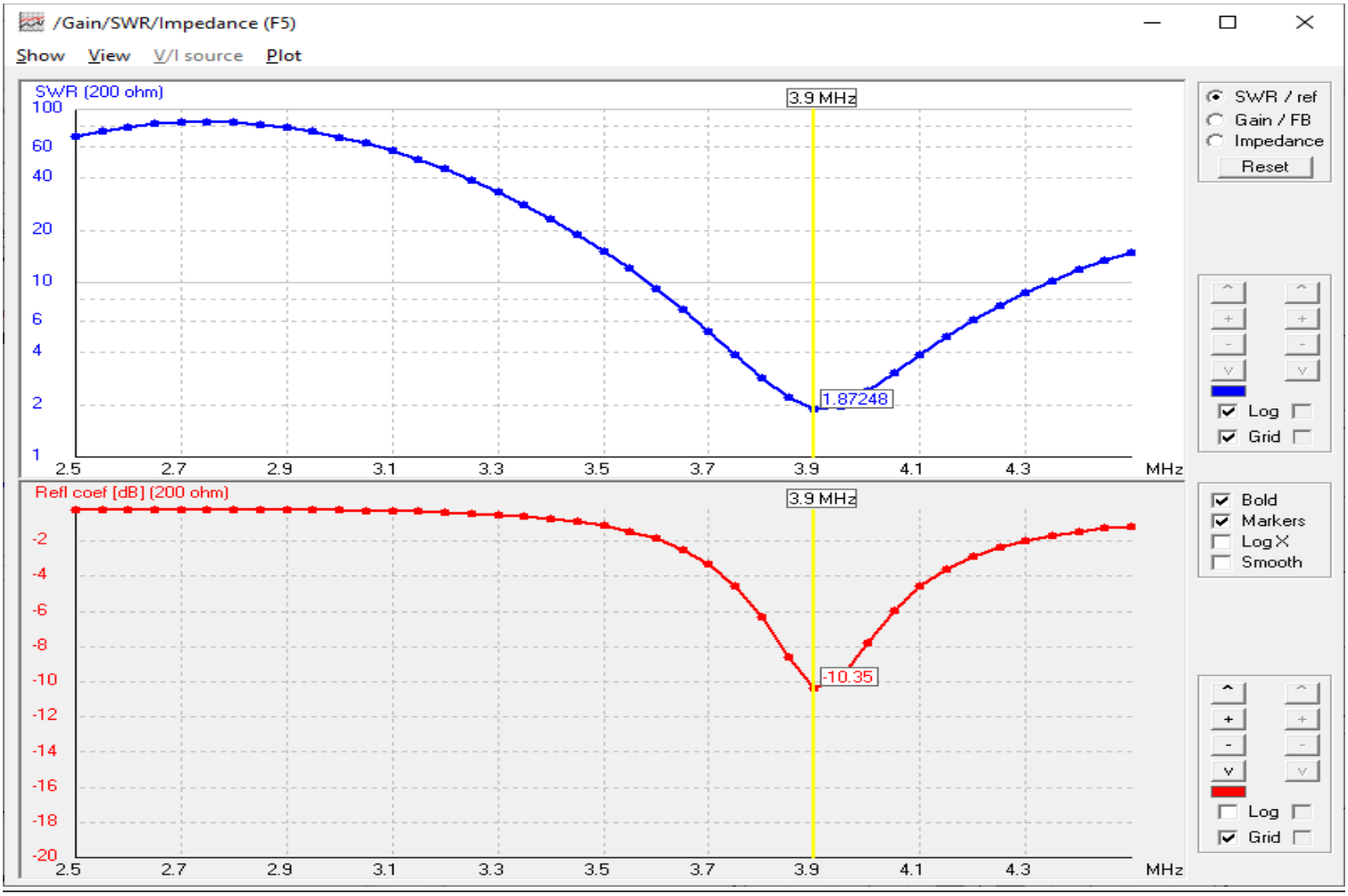
15m 6.31 @ 21.60 MHz – Useable with TUNER

10m 2.08 @ 28.65 MHz / 175 kHz BW

Amateur Band	*Frequency Range*	*4NEC2 Simulated SWR @ 4:1 Source |Z|*	*4NEC2 Simulated Z = R + jX @ 4:1 Source |Z|*	*MFJ-259B SWR @ 100FT*
160m – 10m 100 FT RG-8X Feed	*0.00 – 30.00 MHz*	***File: GNVEOC_160-6m_OCF_4020mSingleStub_2.nec***		
160 meters	*1.80 – 2.00 MHz*	*1.20 @ 1.90 MHz*	*177.3 + j25.7*	*1.6 @ 1.89 MHz*
75 & 80 meters	*3.50 – 4.00 MHz*	*1.83 @ 3.90 MHz*	*108.6 + j21.7*	*1.75 @ 3.54 MHz*
60 meters	*5.30 – 5.405 MHz*	*Not Useable*		*4.0 @ 5.35 MHz*
40 meters	*7.00 – 7.30 MHz*	*1.96 @ 7.20 MHz*	*110.4 – j48.8*	*6.3 @ 7.140 MHz*
30 meters	*10.10 – 10.15 MHz*	*Not Useable*		*3.4 @ 10.60 MHz*
20 meters	*14.00 – 14.350 MHz*	*1.80 @ 14.000 MHz* *1.95 @ 14.250 MHz* *2.59 @ 14.350 MHz*	*199.3 + j196.9*	*2.7 @ 14.150 MHz*
17 meters	*18.068 – 18.168 MHz*	*Not Useable*		
15 meters	*21.00 – 21.450 MHz*	*> 6 over band*	*Useable with TUNER*	*2.0 @ 21.150 MHz*
12 meters	*24.890 – 24.990 MHz*	*Not Useable*		
10 meters	*28.00 – 29.70 MHz*	*2.08 @ 28.65 MHz*		*Not recorded*

Appendix D – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_2





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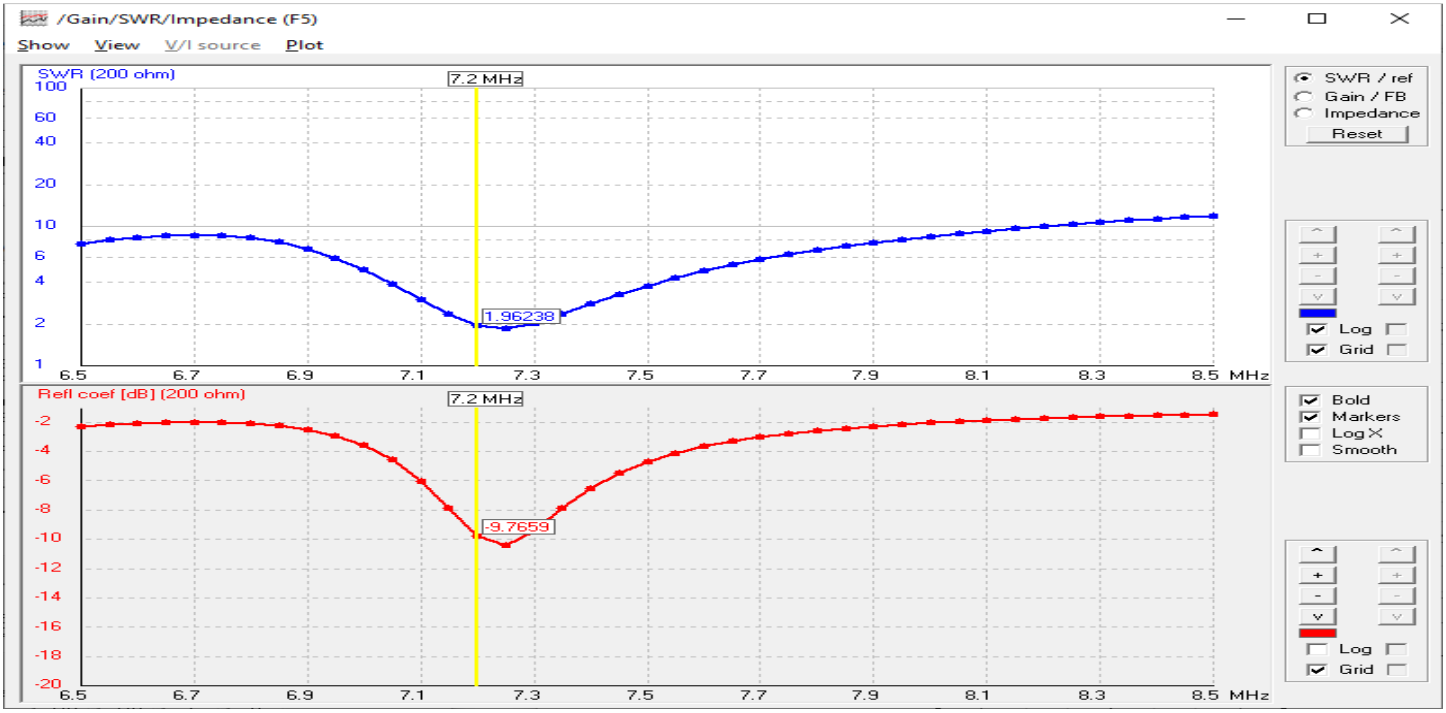
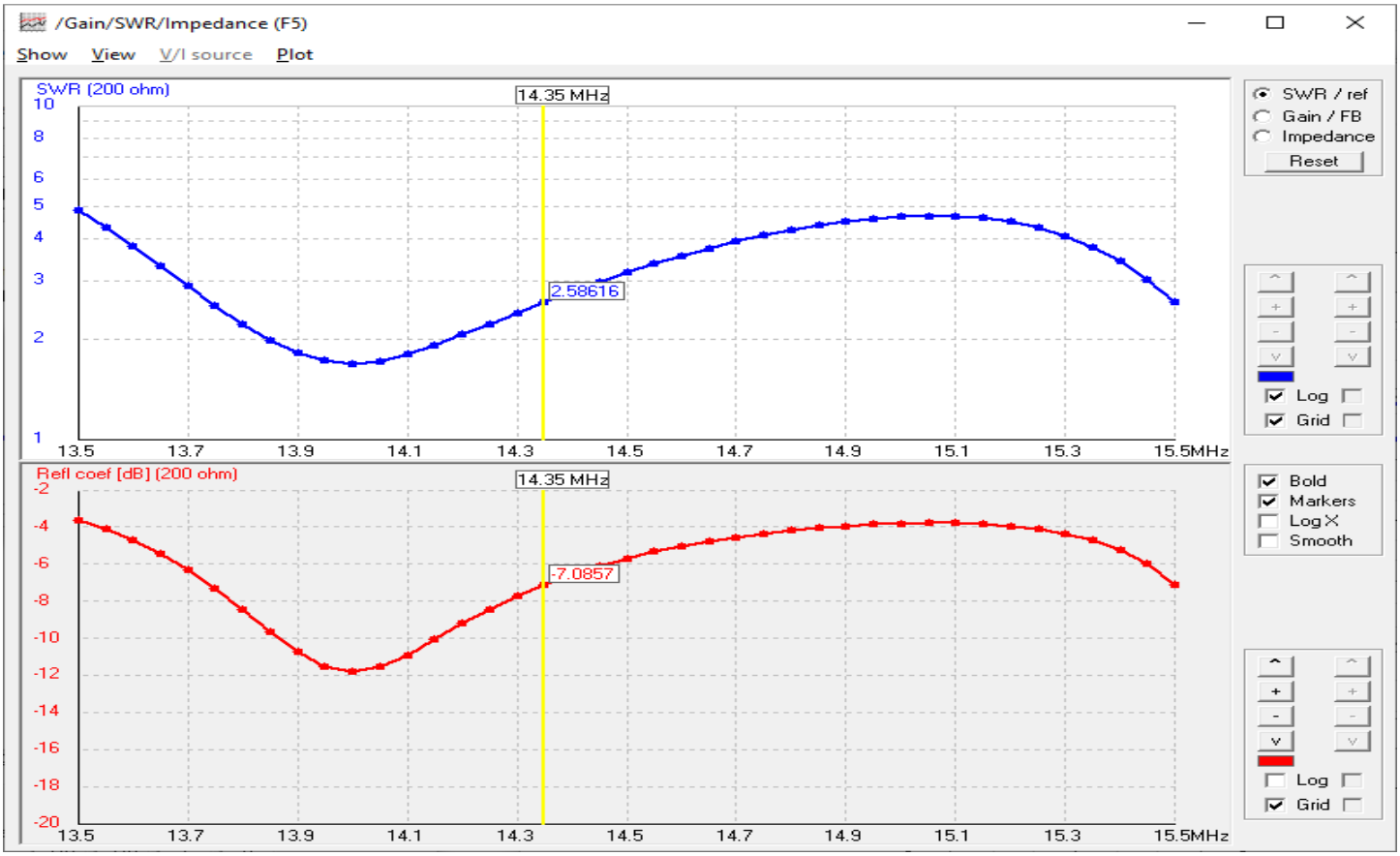
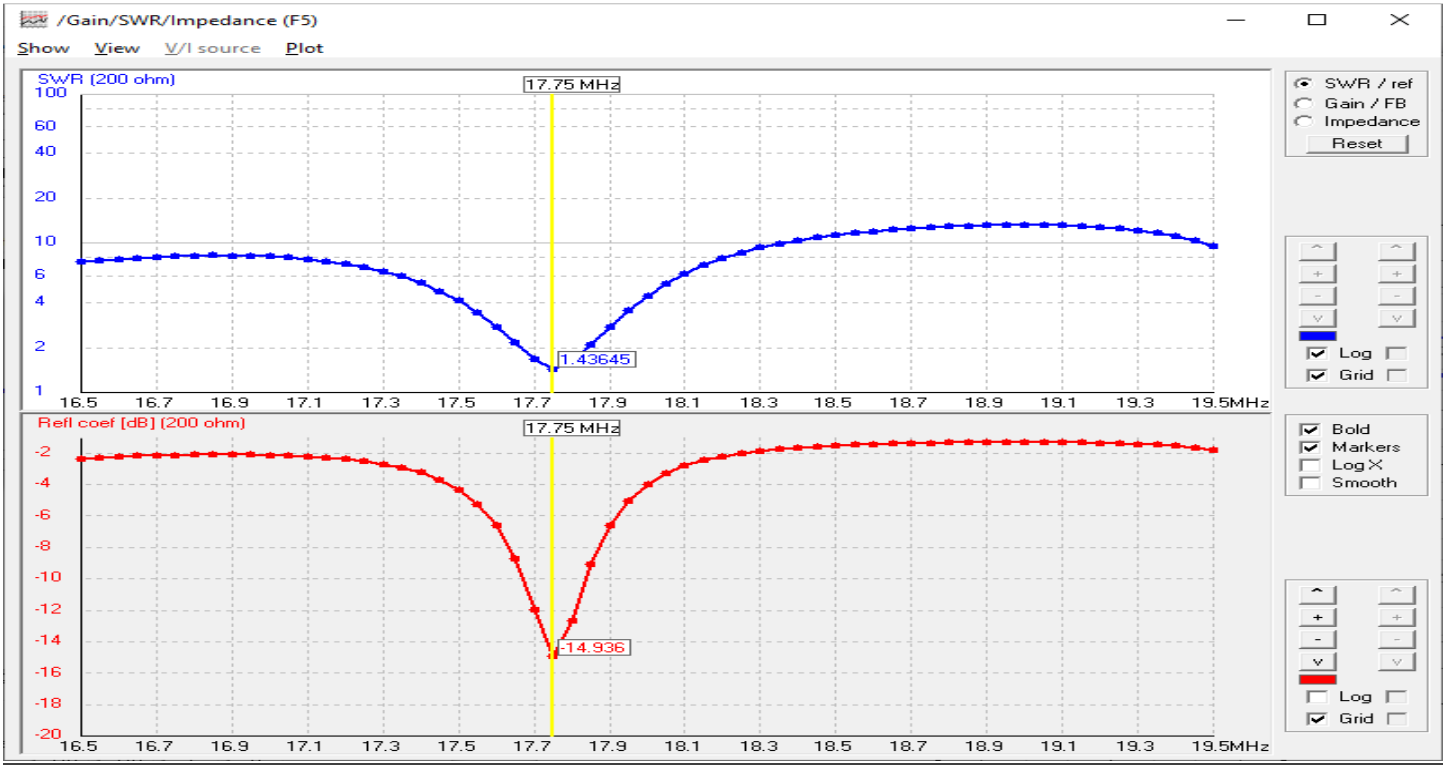
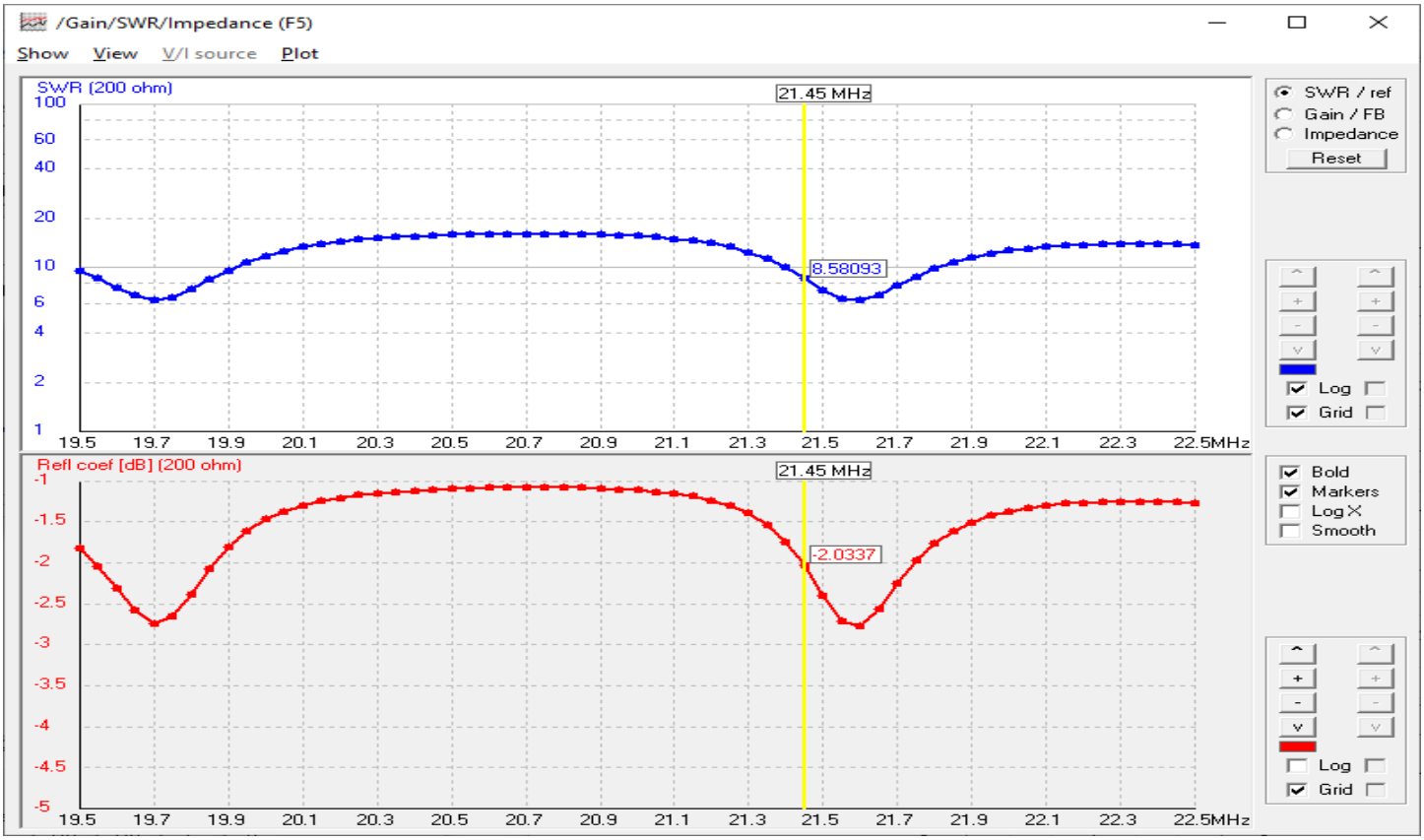


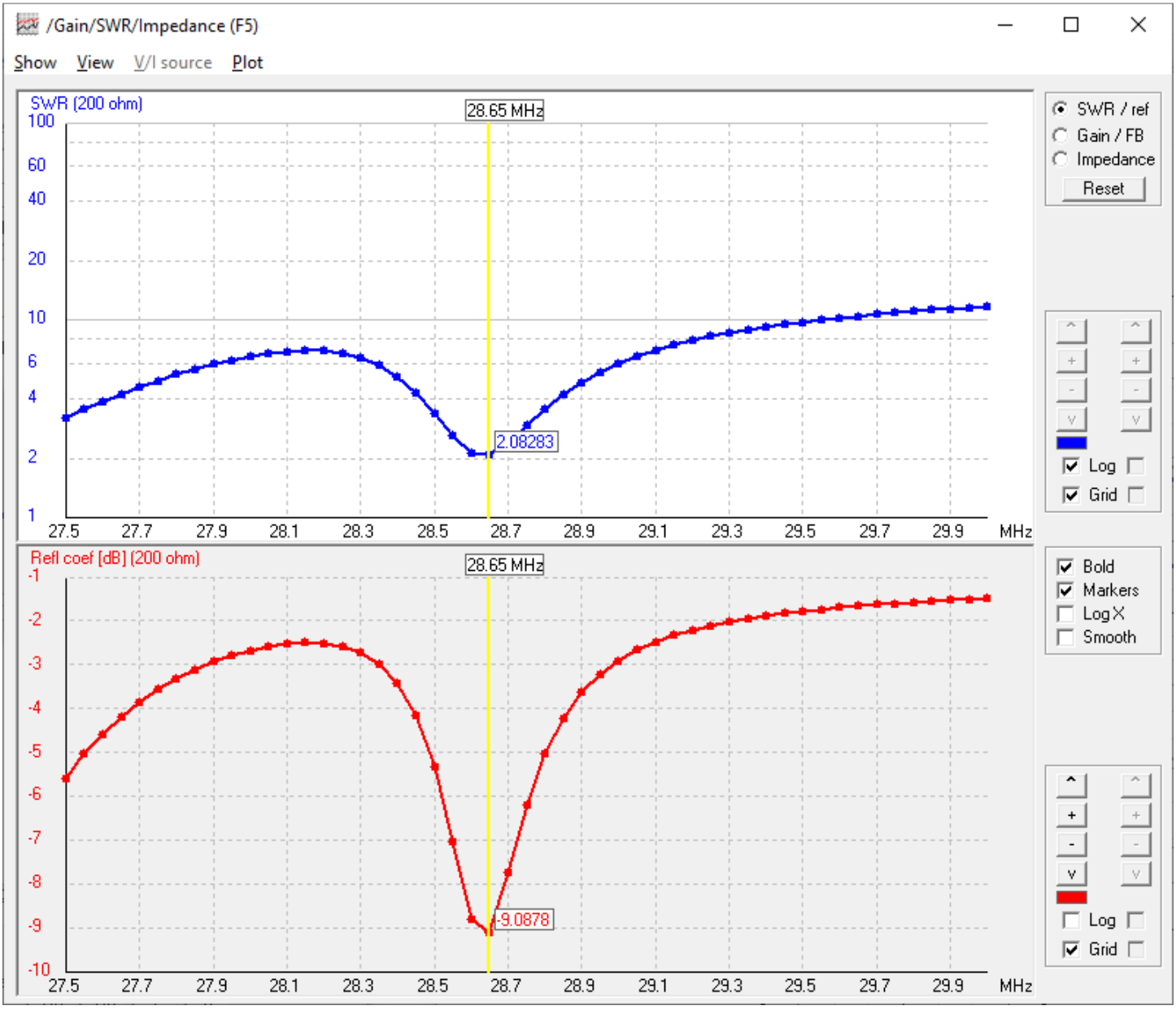


Appendix D – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_2





Appendix D – Simulated GNV-EOC INV-OCF Antenna 40m20m Single Stub_2



Appendix E – RigExpert AA-54 Test Procedures

1. Configuration & Setup:

Menu	Sub-Menu	Value(s)	Sub-Menu	Value(s)	Option(s)
Configure	AA-54 Analyzer		System Impedance	50 ohms	
	Comm Port	COM5	Cable Parameters	Belden 9258 RG-8X	Transmission Line – Add Cable Length = 1.5ft
	Units	US	Parameters of Calibration Standards	Ideal Models	
View	Graph Size	800 x 600	SWR – F2	Z = R + jX F3	
			Return Loss F6	Smith Chart F8	Set SWR Circle Radius = 2
Measurement	Range	Resolution: 1,000 Points	From: 0 kHz	To: 30,000 kHz	Limits

2. Calibration Process:

Menu	Sub-Menu	2nd Sub-Menu	CAL Std. Files	Calibration Std.	Step(s)
Configure	Save Last Measured Data	Select Folder for Calibration Files:		Hand Fabricated SO-239 to SMA (cut-off) Open	Install Open Calibration Std. Start/Stop F8 Remove Open Calibration Std.
	Save Last Measured Data	As "Open" Calibration	Cal_open.s1p	Hand Fabricated SO-239 to SMA (cut-off) Short	Install Short Calibration Std. Start/Stop F8 Remove Short Calibration Std
	Save Last Measured Data	As "Short" Calibration	Cal_short.s1p	MFJ-260C 300 Watt 50 ohm Dummy Load	Install Load Calibration Std. Start/Stop F8 Remove Short Calibration Std
	Save Last Measured Data	As "Load" Calibration	Cal_load.s1p		