The Computer Model Design, Construction and Field Results – of the **WRTC 2014 TriBand Antenna**

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Overview

- World Radiosport Team Championship (**WRTC**) 2014
- **WRTC** Antenna Requirements
- Design Planning
- Electrical Optimization
- Physical Optimization
- Building and Testing the first prototypes
- Interesting Use Examples

World Radiosport Team Championship (**WRTC**) 2014

- An international contest held every 4 years within the **IARU** HF Championship
  - "As equal-as-possible" locations, antennas
  - With all else equal, who are the best operators?
- Two-operator teams
  - Team Leaders selected on the basis of performance in contests in "Qualifying Period"
  - Team Leader selects Team Member
- To be held in New England in July 2014

WRTC Antenna Requirements

WRTC Antenna Requirements (Cont.)

- 65 identical directive antennas that can operate on 10/15/20 Meters
- Ease of assembly / disassembly / reassembly
- Assembled Antenna Weight: 25 - 30 pounds or less as the target (excluding feedline)
- Boom length: 12 -18 feet
- VSWR: Less than 2:1 across the 20, 15, and 10-meter bands (28.0 - 28.5 segment of 10M is sufficient)
- Feed System: Single 50-ohm coax cable
- Material: Stainless-steel hardware, aluminum tubing
- 80 MPH windload handling capability
- Simultaneous operation on all three bands
- Price to performance value

WRTC 2014 World Radiosport Team Championship

Design Planning

- Stan Stockton (K5GO), Kevin Stockton (N5DX) and Scott McClements (WU2X) start planning November 1, 2011
- "Clean sheet of paper" designed exactly to the WRTC requirements
- Sought to deliver a new and exciting antenna design that would be fitting for this unprecedented international contesting event
- Goals for the antenna design:
  - Lightweight
  - Mechanically robust
  - True monopod performance
  - SWR < 1.6:1 across all the bands
  - Greater performance on 10 meters
  - **Most importantly** - Provide WRTC contestants with the very highest level of performance possible for the size

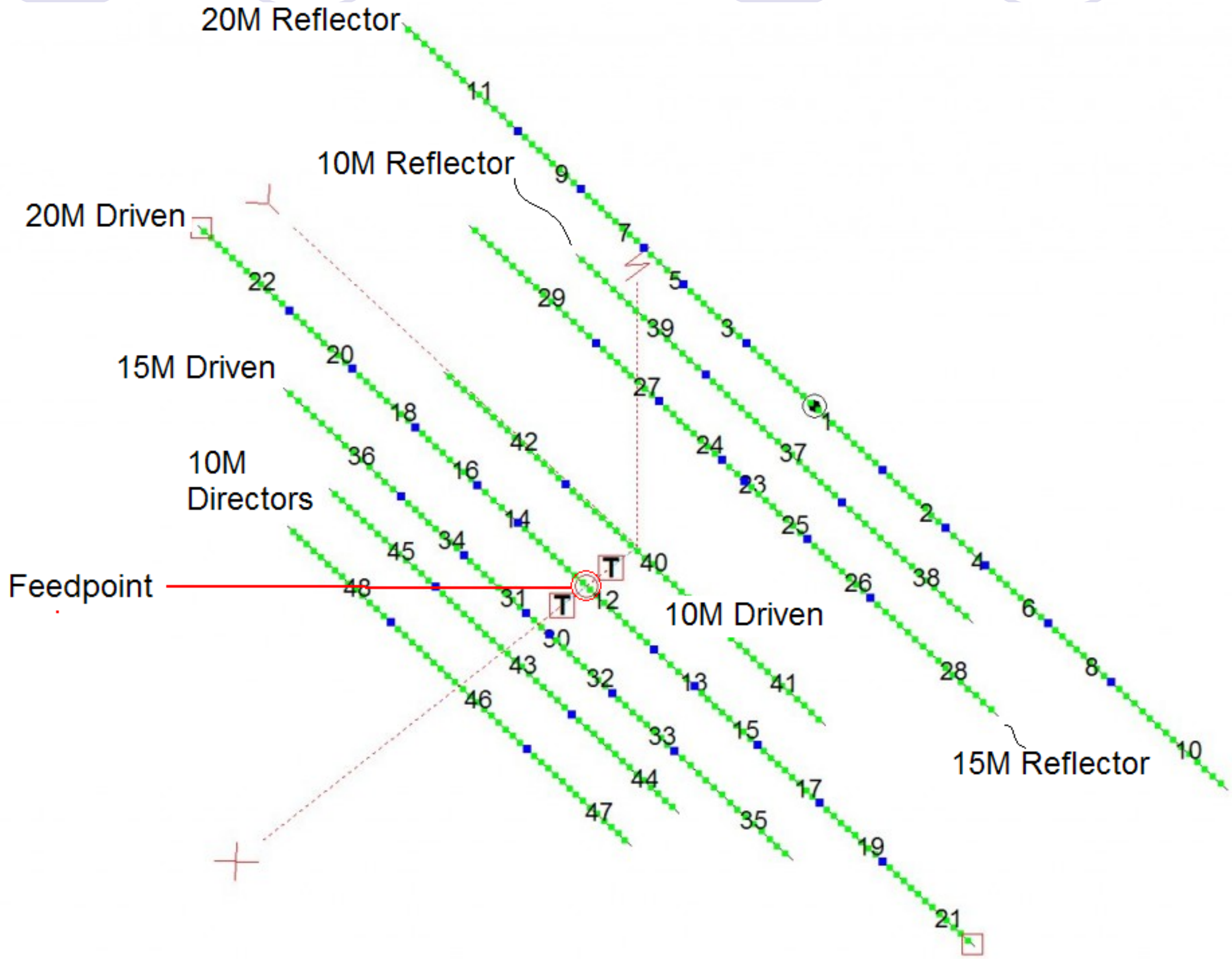
Design Planning (Continued)

- Settled on:
  - 2 elements on 20 meters
  - 2 elements on 15 meters
  - 4 elements on 10 meters
  - Direct 50 Ohm feed, require no matching networks or tuning
- Time was tight – there was only 30 days to design, test and submit a proposal to the WRTC committee
  - Electrical and Mechanical design commenced in parallel
    - K5GO / N5DX = Mechanical design
    - WU2X = Electrical design

Electrical Optimization

- **Numerical Electromagnetics Code** (NEC) v4.1 used for antenna simulation
- Custom front end software used to drive NEC automatically
- Software automatically adjusts antenna model and runs NEC 4.1
- Four Intel i7 quad core machines running in a cluster, operating simultaneously
- Brute force search, every combination tried in ¼" increments
- All results above a certain figure of merit were saved to disk
- Took five days to run – and two days to hand evaluate some of the higher figure of merit models to select the version to build

Electrical Optimization (Continued)



Physical Optimization

- **YagiStress by K7NV**
  - Boom Construction - Light weight boom with minimal sag
  - Element Construction
    1. Center sections for 20, 15, and 10 are 1”, ¾” and ½” respectively
    2. Element tips – long and .040 wall thickness.
- Single socket head cap screw for each element joint
- WRTC – Special provisions
  1. Pre-assembly of element plates and element sections up to 6 feet
  2. Color coding for ease of final assembly
  3. Pop Rivets were not allowed for final assembly of antenna.

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Physical Optimization (Continued)

YS.EXE

Designer: K5GO | AREA & WEIGHT | CYCLE 24 TX38 WRTC TRIBANDER

No.	ELEMENTS	Location (In)	Proj AREA (SqIn)	WEIGHT (Lb)	Sag (In)	Speed (Mph)
1	20m Reflector	2.500	282.750	4.96	21.889	80
2	10m Reflector	22.180	87.750	1.16	5.075	82
3	15m Reflector	41.872	133.875	2.03	9.194	82
4	10m Driven Element	89.704	84.563	1.13	4.243	87
5	20m Driven Element	113.027	273.844	4.86	17.540	83
6	15m Driven Element	136.360	129.938	1.98	7.792	85
7	10m Director 1	152.840	78.375	1.06	2.943	94
8	10m Director 2	174.500	77.250	1.05	2.746	96
			1148.344	18.23		

Units Area Print ESC

Physical Optimization (Continued)

YS.EXE

Designer: K5GO   Element No. 1 --> 20m Reflector   File: TX-38

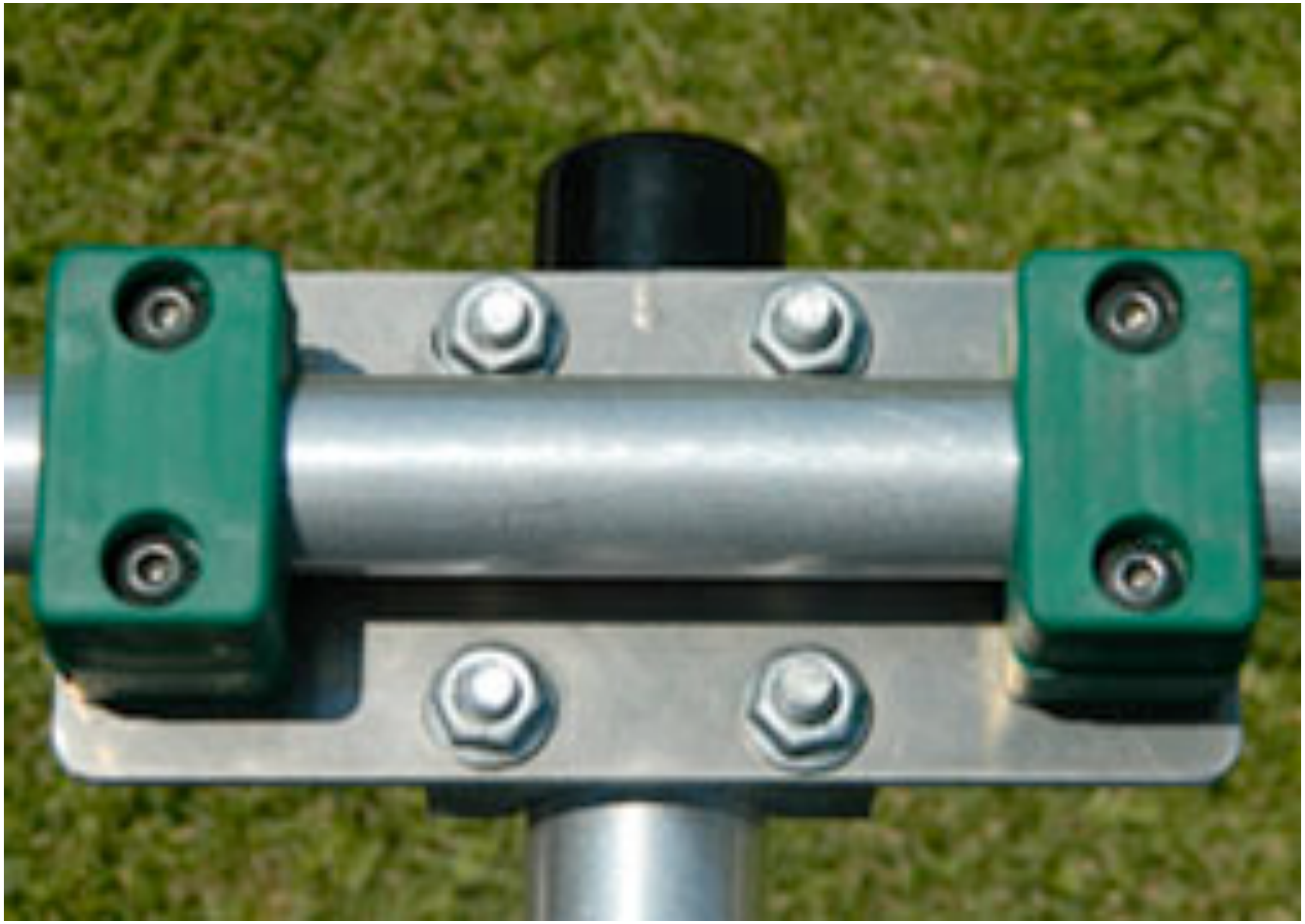
Location (In)	Eff Area (SqIn)	Weight (Lb)	Sag (In)	Safe @ 80 Mph
2.500	188.500	4.96	21.889	

Section No	Diameter In	Wall In	Length Exposed	Length In Total	Stress Max = 35.00 Ksi
Tip--> 1	0.375	0.040	63.000	66.000	27.73
2	0.500	0.058	33.000	36.000	26.73
3	0.625	0.058	33.000	36.000	30.72
4	0.750	0.058	21.000	24.000	28.84
5	0.875	0.058	33.000	36.000	33.05
6	1.000	0.058	27.000	27.000	34.70
7 Dblr	1.000	0.116	9.000	9.000	23.02

Half Length = 219.000 In
Res Frequency = 13.565 Mhz

View Edit Add/Rem Move Wind/F1 Next El Name Units Tubing Print ESC

Physical Optimization (Continued)



Physical Optimization (Continued)

Physical Optimization (Continued)

8450 holes to drill – WHAT?!

Calls for a six foot wing span and SO2DP

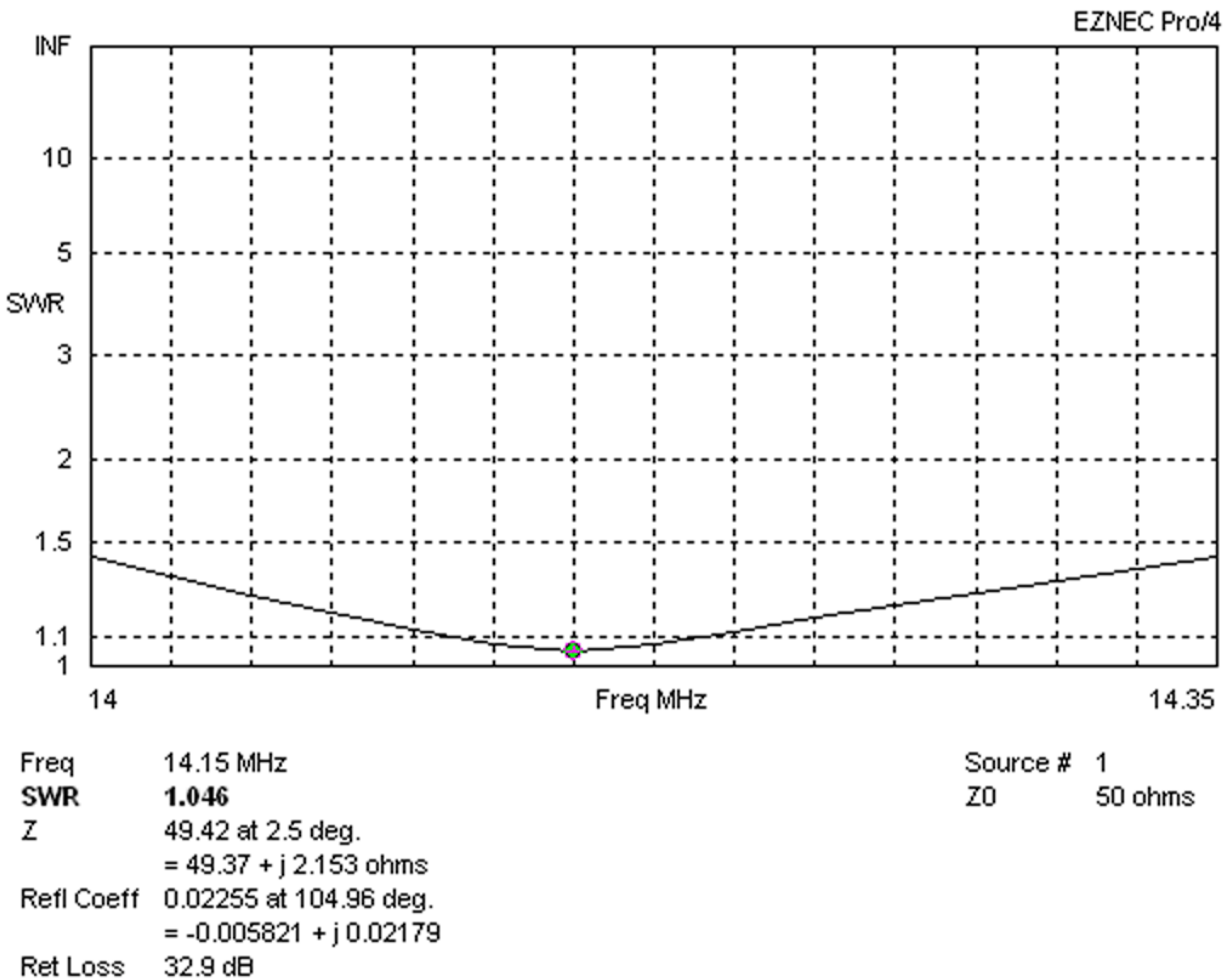
K1DG 8450 M K5GO 67 AR

Building and Testing the first prototypes

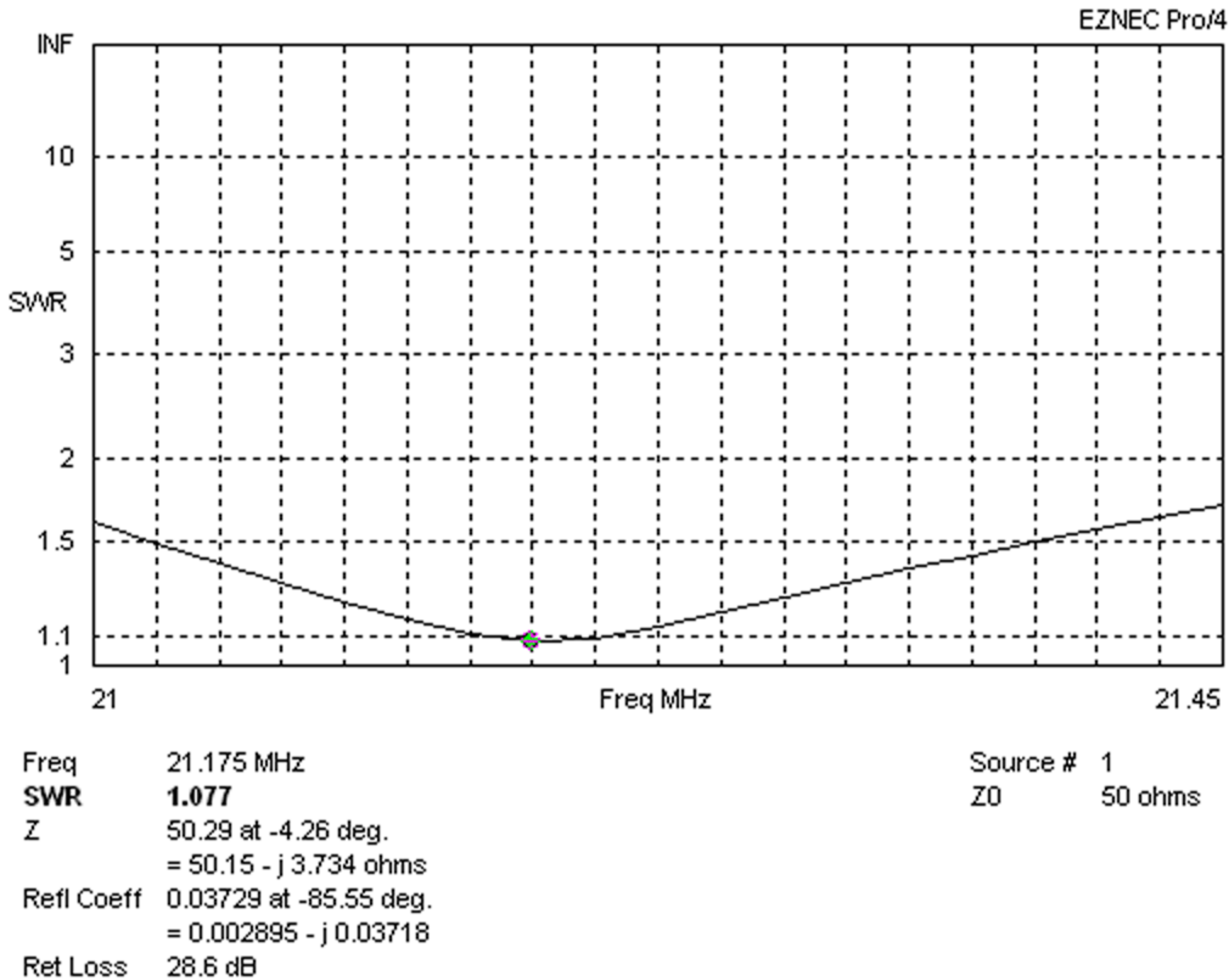
- In the second week of November 2011, two physical prototypes were built and tested independently
- Discovered a NEC anomaly related to transmission lines
- SWR curve and resonance frequency on 15M and 10M are a dead match with NEC 4.1
- Higher resonance frequency on 20M required lengthening the reflector and driven element 1.5” per side, to bring both resonance and F/R curve into the band
- Both models demonstrated the same SWR curves and performance
- PowerSDR/IF Stage used to plot azimuth pattern (0.1dB resolution)

Building and Testing the first prototypes

Building and Testing the first prototypes (Continued)



Building and Testing the first prototypes (Continued)



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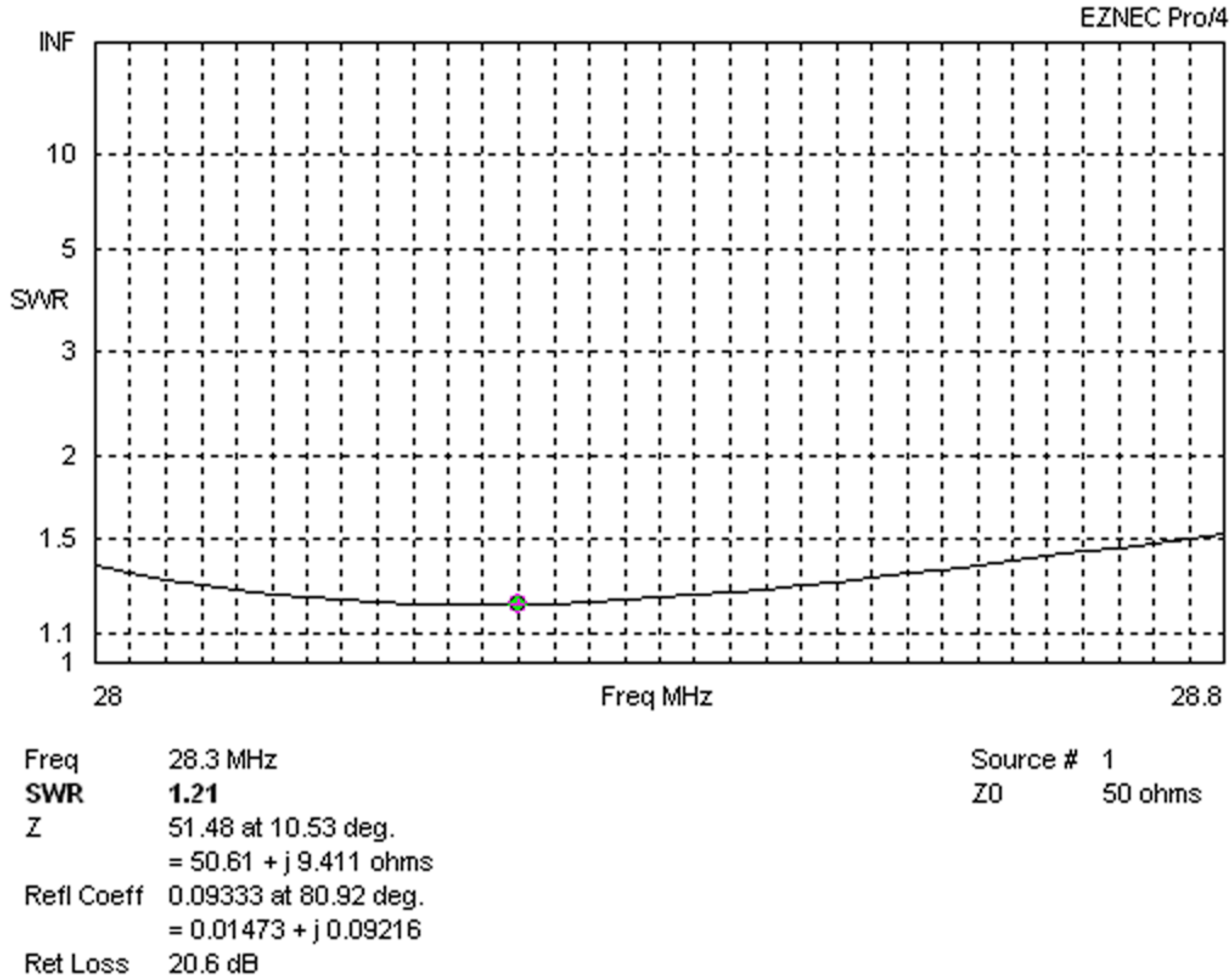
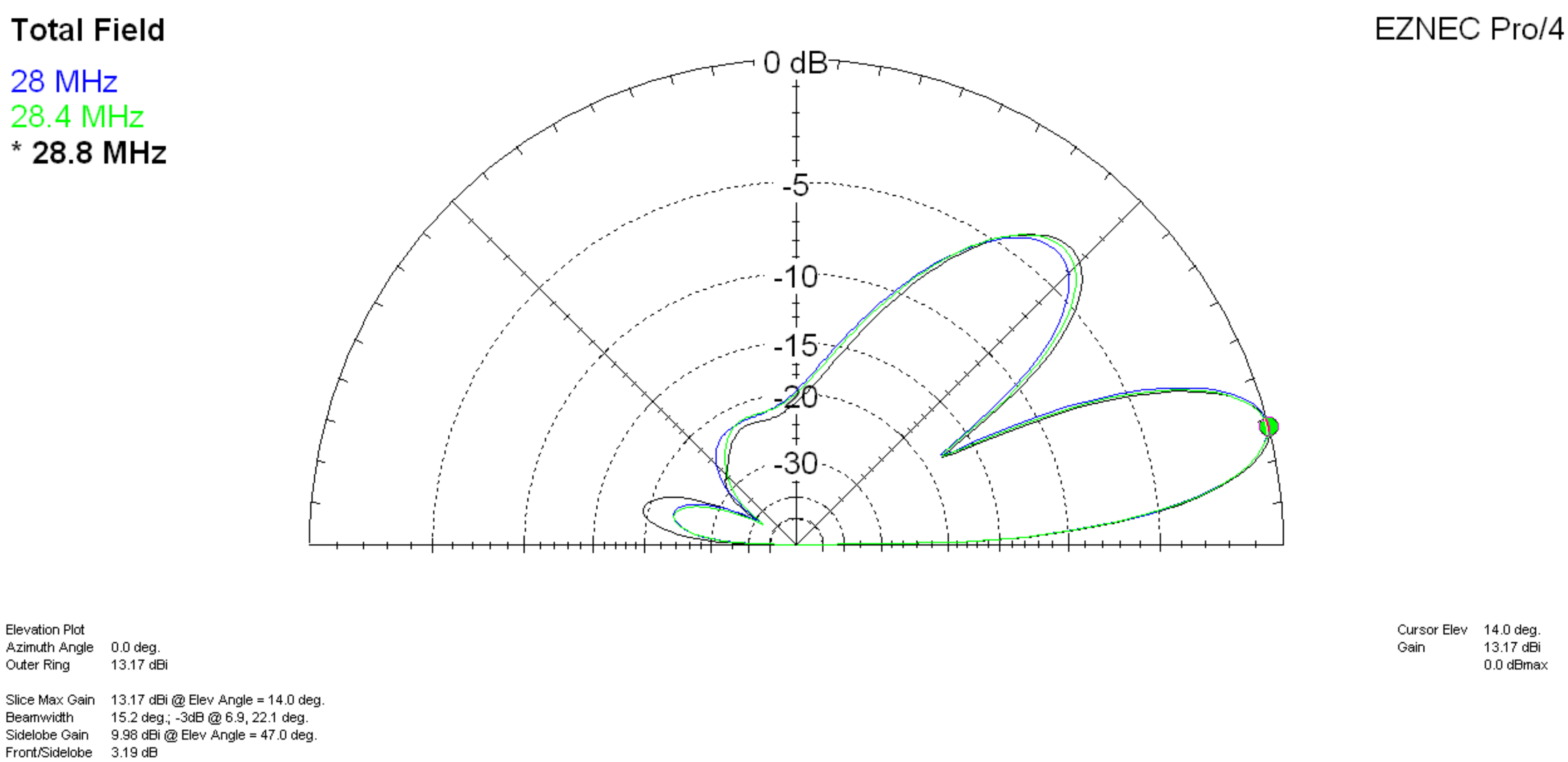
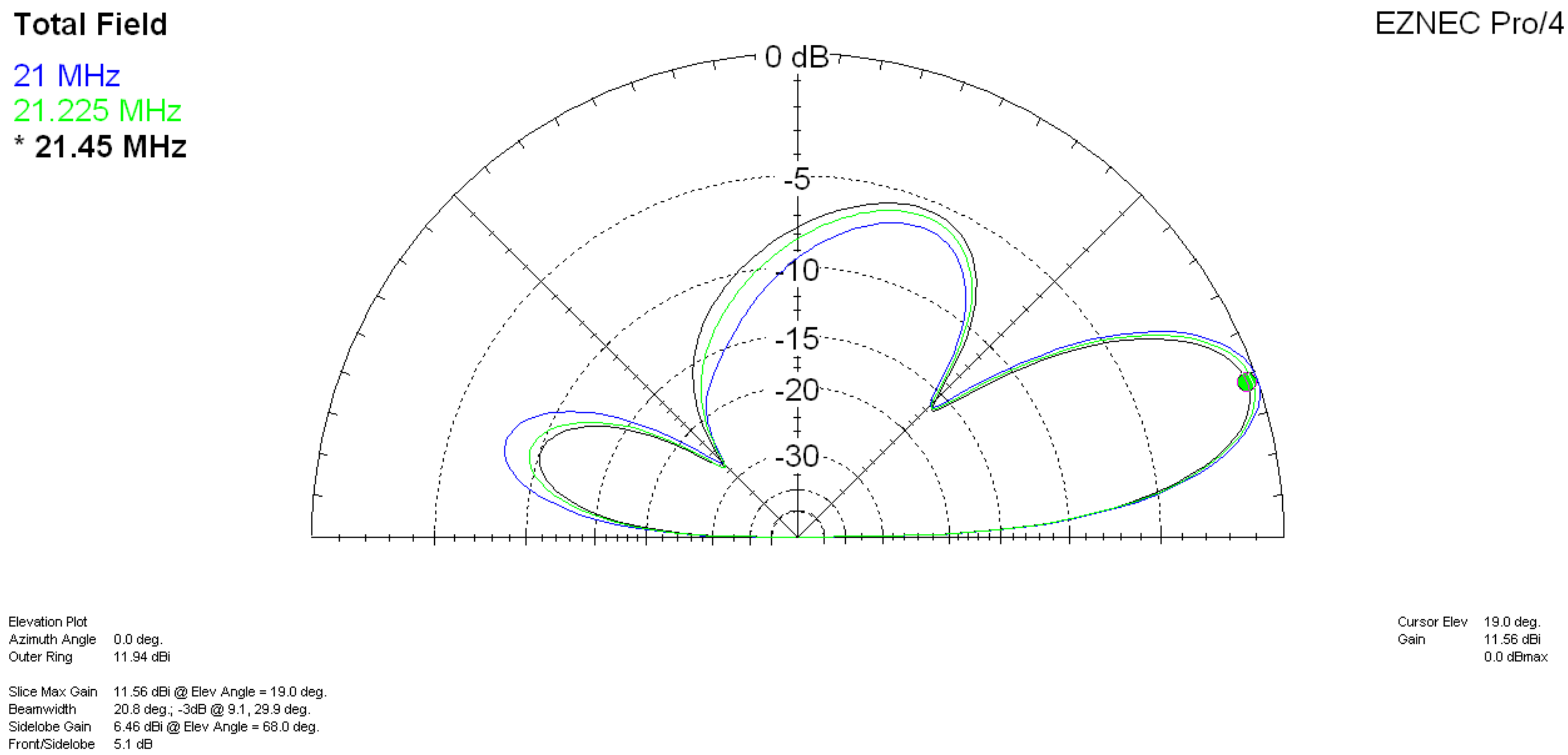


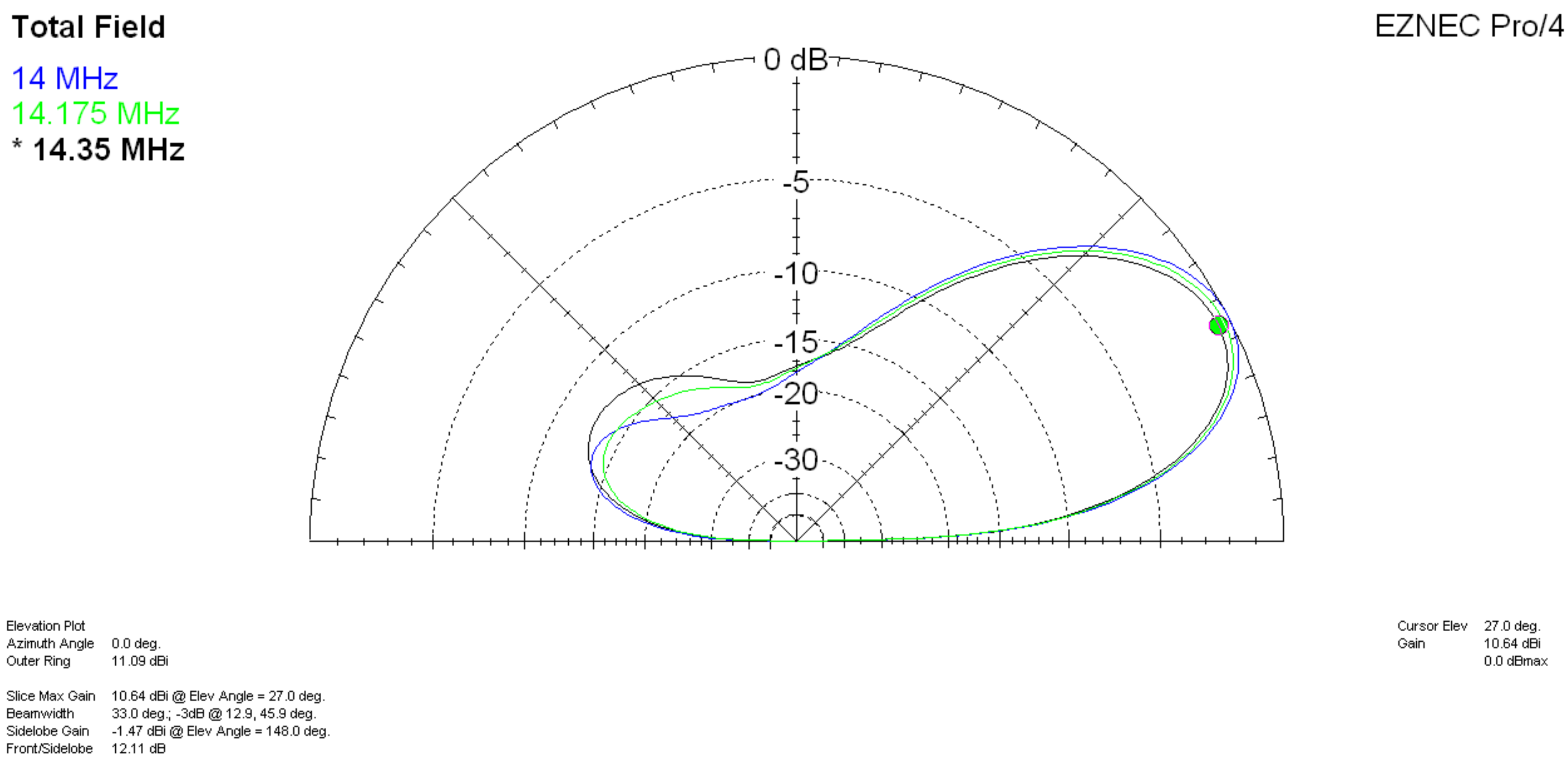
Building and Testing the first prototypes (Continued)



Building and Testing the first prototypes (Continued)



Building and Testing the first prototypes (Continued)



Interesting Use Example # 1
Triplexing

- Using a triplexer device allows 3 different transceivers to operate a single antenna on the 3 different bands simultaneously
- **Field Day** operations can have three stations operating into one antenna at once
- **WRTC** 2 person teams will be able to operate simultaneously on different bands during the contest

Interesting Use Example # 2 **Stacking**

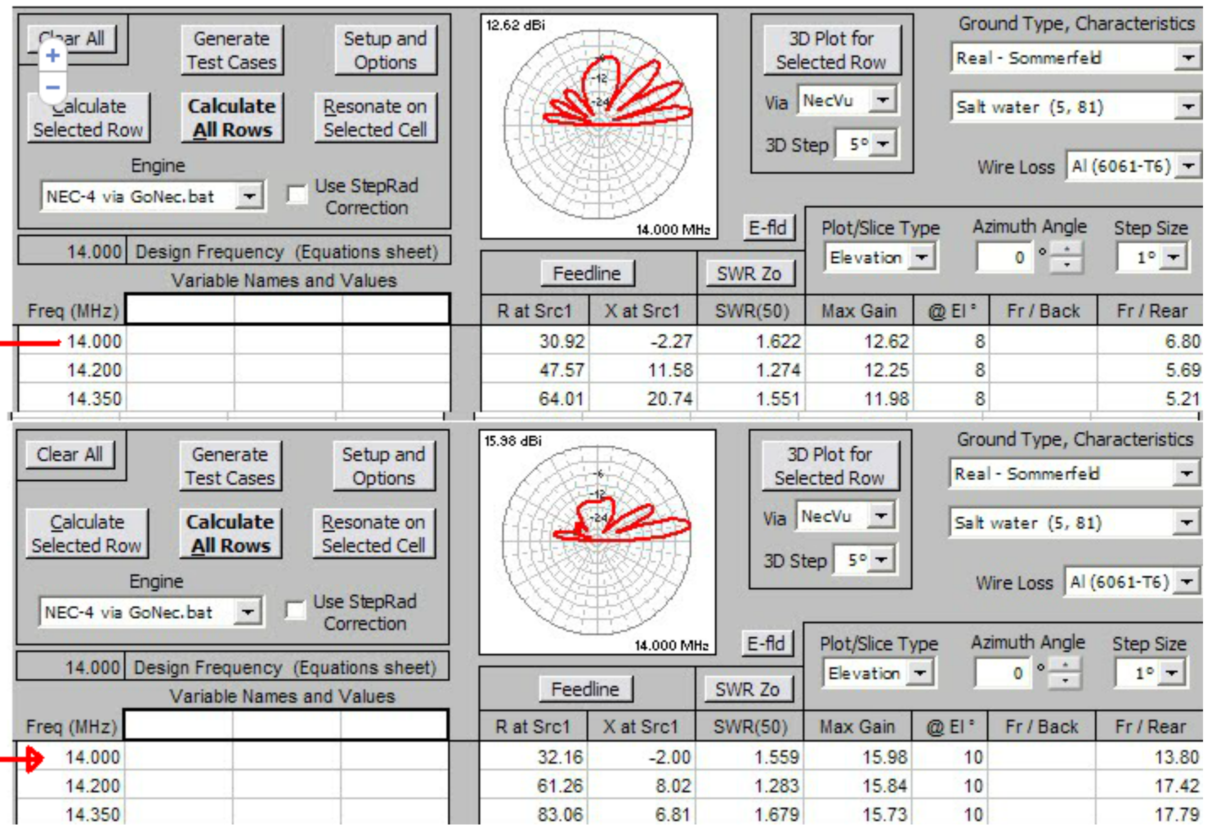
- Reasons to stack antennas
  - More gain
  - Better angle coverage
- WRTC antenna is light on a tower weight and windload wise
- 47” opening at mounting point – wide enough for even side arms
- Optimum stacking distance is 25’
  - Wider is not recommended as 10 Meters will suffer with a major secondary high angle lobe
- Cost effective compared to stacking monobanders on a single tower

Interesting Use Example # 2
Stacking (Continued)

Single ant. @ 121 feet

~+3.36 dB

3 ant. @ 121/96/71 feet

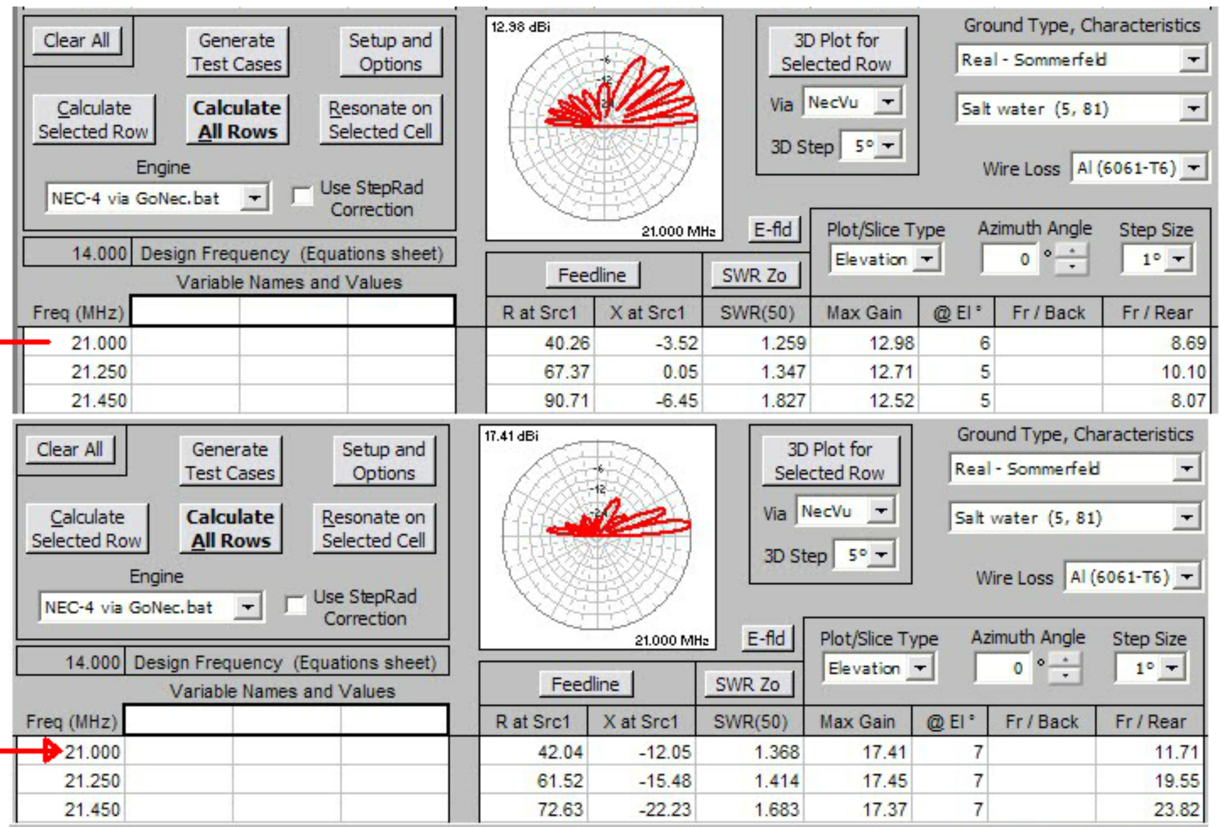


Interesting Use Example # 2
Stacking (Continued)

Single ant. @ 121 feet

+4.43dB

3 ant. @ 121/96/71 feet

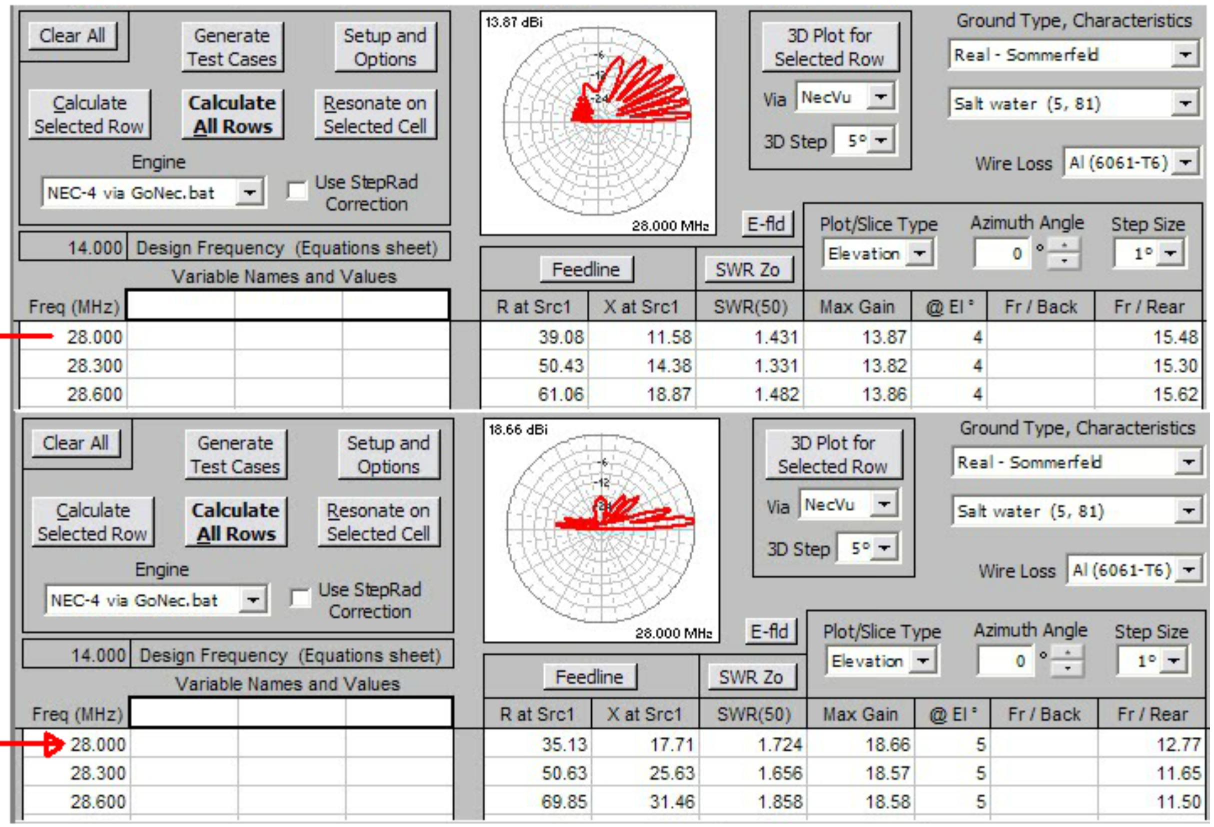


Interesting Use Example # 2
Stacking (Continued)

Single ant. @ 121 feet

+4.79dB

3 ant. @ 121/96/71 feet

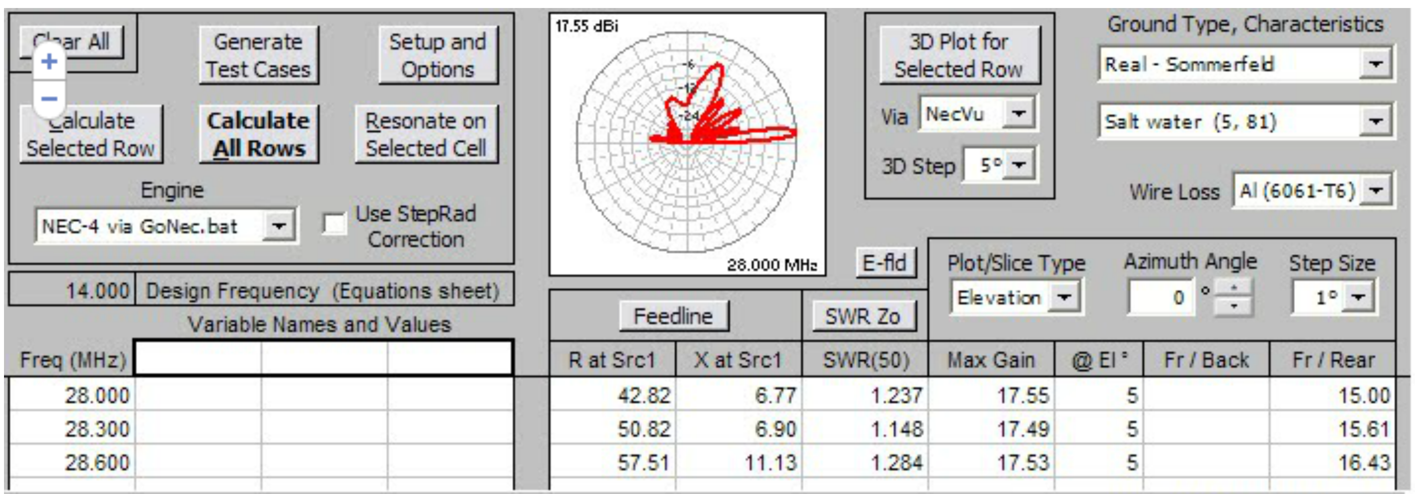


Freq (MHz)	R at Src1	X at Src1	SWR(50)	Max Gain	@ El °	Fr / Back	Fr / Rear
28.000	39.08	11.58	1.431	13.87	4		15.48
28.300	50.43	14.38	1.331	13.82	4		15.30
28.600	61.06	18.87	1.482	13.86	4		15.62

Freq (MHz)	R at Src1	X at Src1	SWR(50)	Max Gain	@ El °	Fr / Back	Fr / Rear
28.000	35.13	17.71	1.724	18.66	5		12.77
28.300	50.63	25.63	1.656	18.57	5		11.65
28.600	69.85	31.46	1.858	18.58	5		11.50

Interesting Use Example # 2
Stacking (Continued)

- Stack spacings wider than 25' hurt 15M and 10M performance



Freq (MHz)				R at Src1	X at Src1	SWR(50)	Max Gain	@ El °	Fr / Back	Fr / Rear
28.000				42.82	6.77	1.237	17.55	5		15.00
28.300				50.82	6.90	1.148	17.49	5		15.61
28.600				57.51	11.13	1.284	17.53	5		16.43

121 / 86 / 50 (35 feet)