Evolution of a Shack

Analysis of a Long Wire Antenna

DAVE VE3OOI

DEC 2020 – JAN 2021

HOW THIS STARTED…

1. Goal was to use a Long Wire Antenna
- ICOM AH-4 Remote Antenna Tuner.
- 203 Feet of wire attached to side of my house.
- Unsure about radials

2. Decide to **<u>Test</u>** Configuration for Ground Plane based on YouTube Video – Total amount of copper.
- Attach antenna to top of my wooden fence about 6 feet in height
- Use about 100 Sq Ft of Chicken Wire as Ground Plane

3. Generated concerns about RF Safety

PRESENTATION SCOPE

This is my journey:
- Learn about my long wire antenna
- Concerns about RF Safety. What is safe?
- Understand how to identify/measure RF Energy

What this is not:
- Long Wire Antenna Tutorial –> How I tested the antenna.
- A NEC Tutorial –> Sample uses of NEC
- An Antenna Physics tutorial –> Some concepts (AF, Aperture)

CONCLUSION

Enclosed Measurements
& SC 6

Long Wire:

- ❖ NEC near field simulation
  - Understand Near Field analysis in 4Nec2
  - Measurement probe is comparable to 4Nec2
  - Attenuation from walls and E_y and E_x much lower that E_z

- ❖ NEC far field simulation
  - Efficiency questionable based on ground screen model (5 Parallel wires, no intersections). Can't model 2" x 4" screen.
  - Antenna works in practice. Decent contacts made. Published.
  - NEC says not very efficient. Low at lower frequencies
  - NEC efficiency does increase if I add 1 long radial
  - Need to experiment with different length antenna

ICOM AH-4 Manual

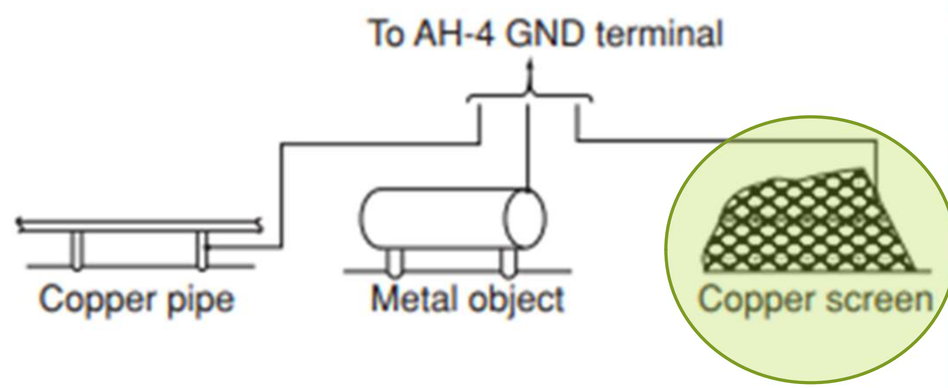
Fig. 3 GROUND CONNECTIONS

The transceiver and antenna tuner must have an adequate ground connection. Otherwise, the overall effency of the transceiver and antenna tuner installation will be reduced. Interference, RF feed back and electrical shocks from other equipment could also occur.

For best results, use the heaviest gauge wire or strap available and make the connection as short as possible. (see right)

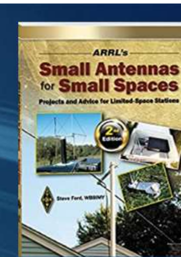
- A long wire connected to the GND terminal as a counterpoise is also acceptable.

• Ground example



ARRL

This is not unique.



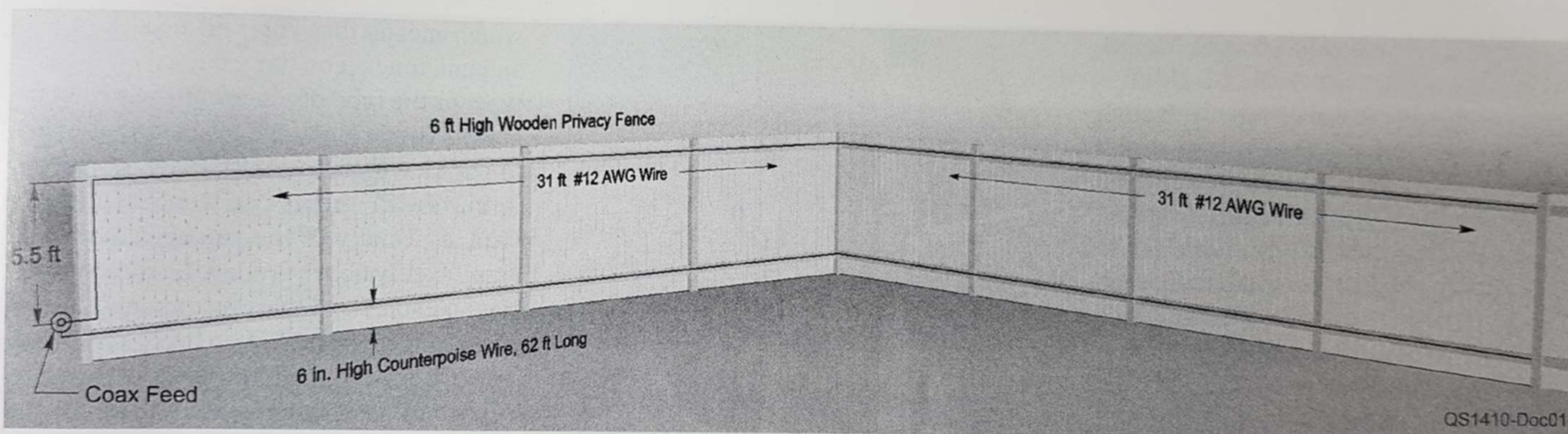


Figure 3.35 — The 80 meter version of the pseudo-DDRR antenna. In this installation, the top radiator wire is a total of 67 ½ feet in length, which is about ¼ wavelength at 3.5 MHz. The bottom wire functions as a counterpoise and runs directly beneath the radiator along its entire length.

ARRL

This is not unique.

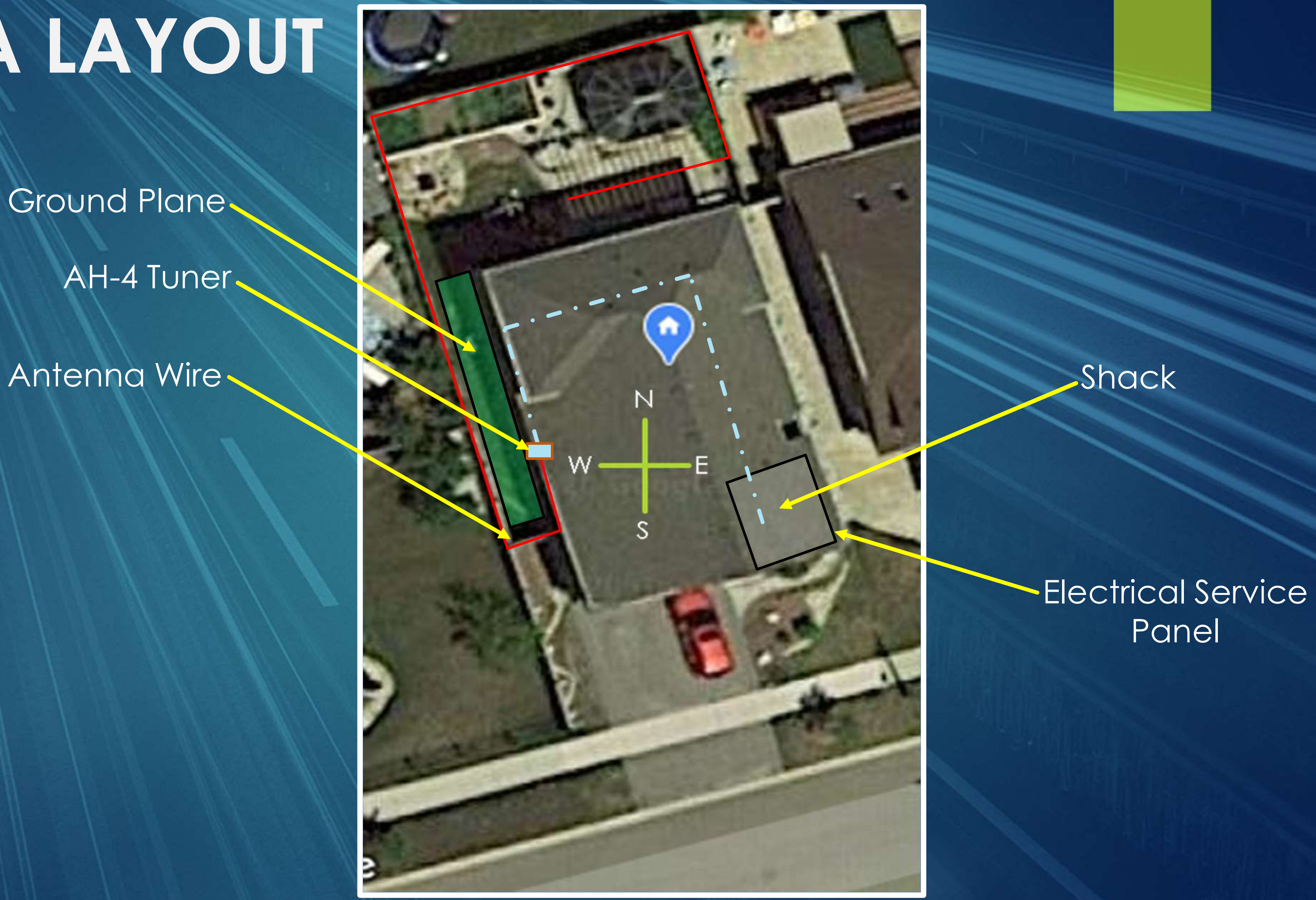
and place the staples every foot or so to hold the wires in place. Over the coming months, the grass will gradually grow over the radials and bury them for you!

Radial wires can be bare or insulated. Insulated wires will have greater longevity by virtue of reduced corrosion and dissolution from soil chemicals. Hardware cloth and chicken wire are also quite effective, although the galvanizing must be of high-quality to prevent rapid rusting. Steer clear of aluminum wire as this will corrode to powder in most soils.

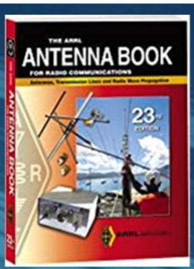
Also resist the urge to rely on ground rods. This is the ground system of absolute last resort and it is a poor one at that. A single ground rod, or group of them bonded together, is seldom as effective as a collection of random-length radial wires.

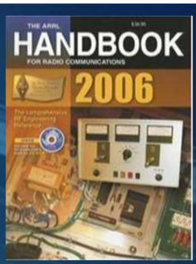
The old saw about radials having to be ¼ wavelength at the lowest operating frequency has also proven to be false. The lengths of the radial wires appear to be less important than the *total number* of wires. Bottom line: put down as many radials as your time and patience allow and make them as long as your space allows. Don't go overboard since you'll reach the point of diminishing returns fairly quickly. If you can only place four 30-foot radial wires, do it. If you can place 20 wires, but they are all only 10 feet in length, that's fine, too. Yes, more radials on the ground will improve your antenna performance, but for casual operating (as opposed to competitive DXing or contesting) the benefits of a large radial network are questionable.

ANTENNA LAYOUT



PREDICTION WITH NEC





The electromagnetic fields around antennas can be very accurately calculated using readily available computer software. Computer antenna modeling programs such as *MININEC* and other codes derived from *NEC* (the Numerical Electromagnetics Code) are very suitable for estimating magnetic and electric fields around amateur antenna systems. You

The mathematics behind the MoM algorithm are pretty formidable, but the basic principle is simple. An antenna is broken down into a number of straight-line wire segments, and the field resulting from the RF current in each segment is evaluated by itself and also with respect to other mutually coupled segments. Finally, the field from each contributing segment is vector-summed to yield the total field, which can be computed for any elevation or azimuth angle desired. The effects of flat-earth ground reflections, including the effect of ground conductivity and dielectric constant, may be evaluated as well.

To calculate the net result, NEC breaks the antenna's elements into a number of sampled points, called *segments*. It uses simple calculations based on the diameter of the conductor and the wavelength of the signal to determine the induced voltage and currents at each of these segments. Depending on the arrangement of the wires, the induced currents in some segments will reinforce or resist the currents in others. NEC sums all of these to determine the net current in each of the conductors.[10]

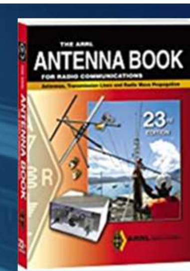
When alternating current flows in a conductor it radiates an electromagnetic wave (radio wave). In multi-element antennas, the fields due to currents in one element induce currents in the other elements. Antennas are self-interacting in this respect; the waves reradiated by the elements superimpose on the original radio signal being studied. NEC calculates the field resulting from these contributions, adds it to the original radio signal, and then runs the entire calculation again with this modified field. Because the reradiated signal is normally small compared to the original signal, it only produces a small change, or perturbation, in the resulting element currents. The program then repeats the calculation again with the new element currents, getting new radiation fields. This process is repeated until resulting values converge.[11]

https://en.wikipedia.org/wiki/Numerical_Electromagnetics_Code

NEC ANTENNA MODELING

- Using 4Nec2.
  - Free with large segment support
  - Includes many “cool” features including optimization, loads and matching network
- Based on a Text file with NEC “cards”. Each card is a command. Anyone remember FORTRAN READ?
- Use cards to define
  - antenna wires and segments
  - earth ground (free space, ideal, soil characteristics, etc.)
  - feed point
  - matching Network
- Autosegmentation

NEAR VS FAR FIELDS



This sort of mutual coupling can occur in the region very close to the antenna under test. This region is called the *reactive near-field* region. The term "reactive" refers to the fact that the mutual impedance between the transmitting and receiving antennas can be either capacitive or inductive in nature. The reactive near field is sometimes called the "induction field," meaning that the magnetic field usually is predominant over the electric field in this region. The antenna acts as though it were a rather large, lumped-constant inductor or capacitor, storing energy in the reactive near field rather than propagating it into space.

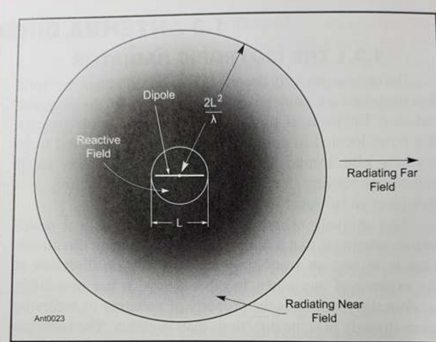
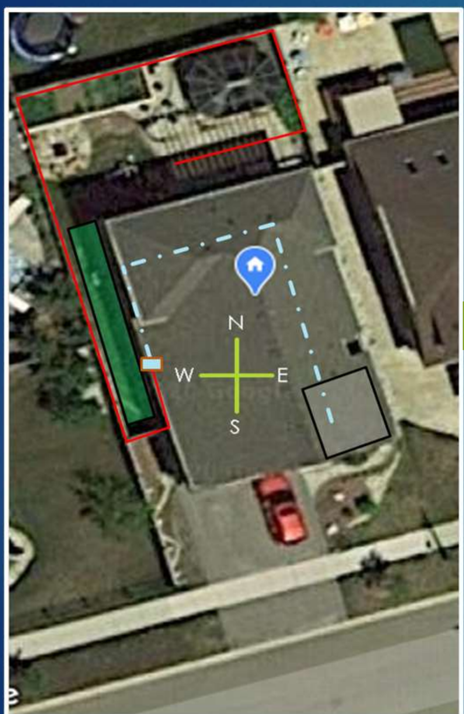


Figure 1.9 — The fields around a radiating antenna. Very close to the antenna, the reactive field dominates. Within this area mutual impedances are observed between the antenna and any other antennas or conductors. Outside the reactive near field, the radiating near field dominates up to the distance shown where L is the length of the largest dimension of the antenna. Beyond the near/far field boundary lies the radiating far field, where power density varies as the inverse square of radial distance.

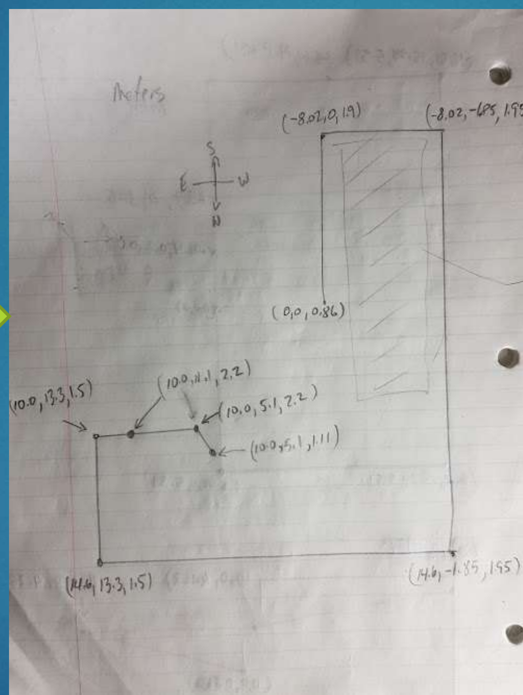
Using 4Nec2 definition

- Near Field < 2 Wave Lengths
- Far Field > 2 Wave Lengths

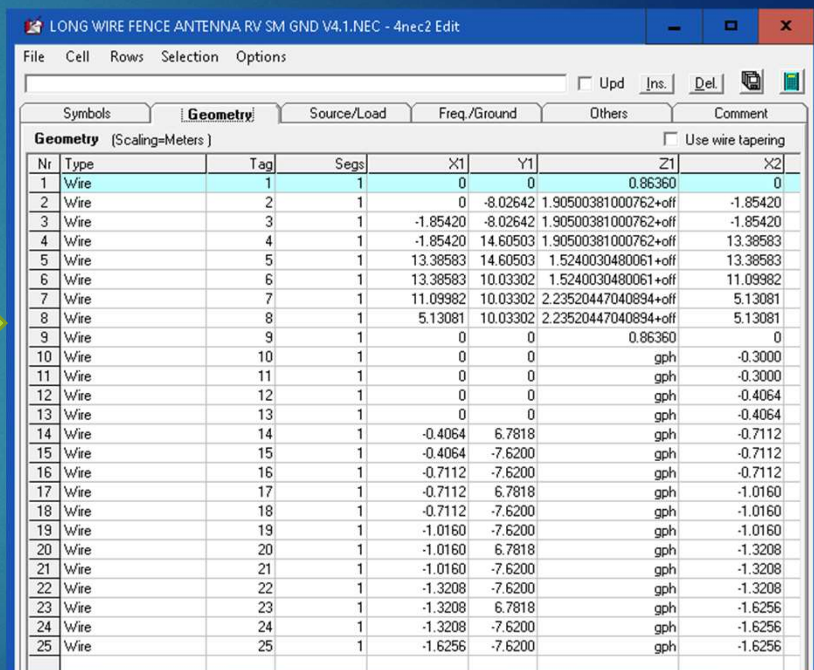
BUILDING THE MODEL



Measurements



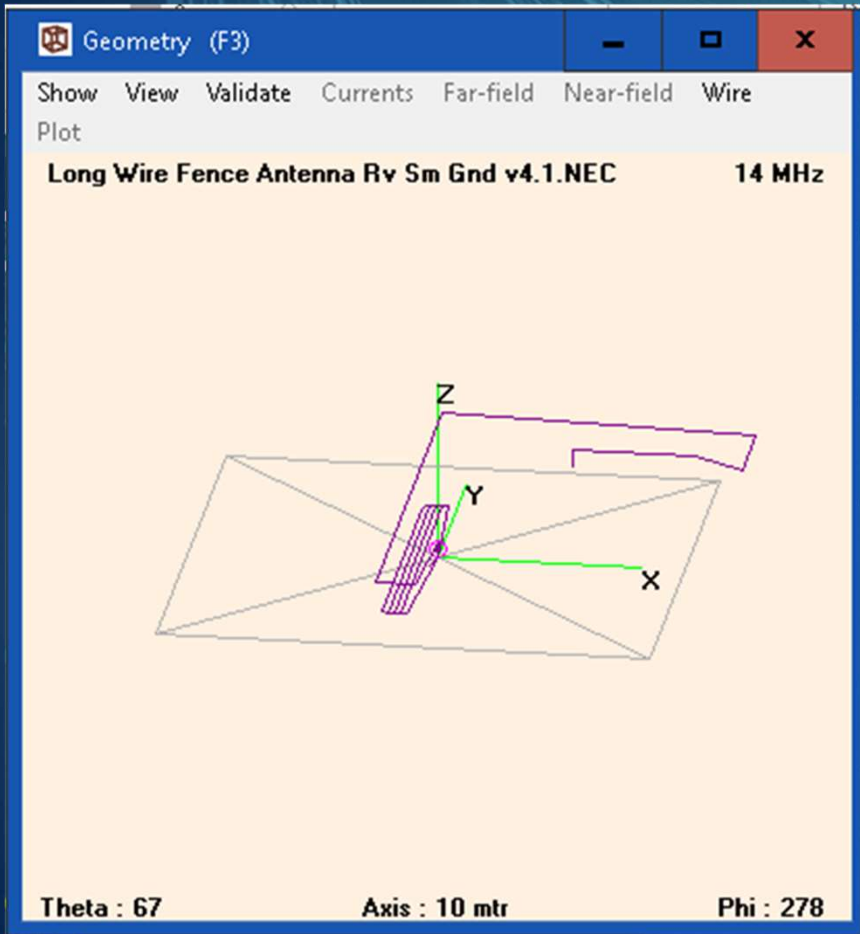
Draw it with Coordinates

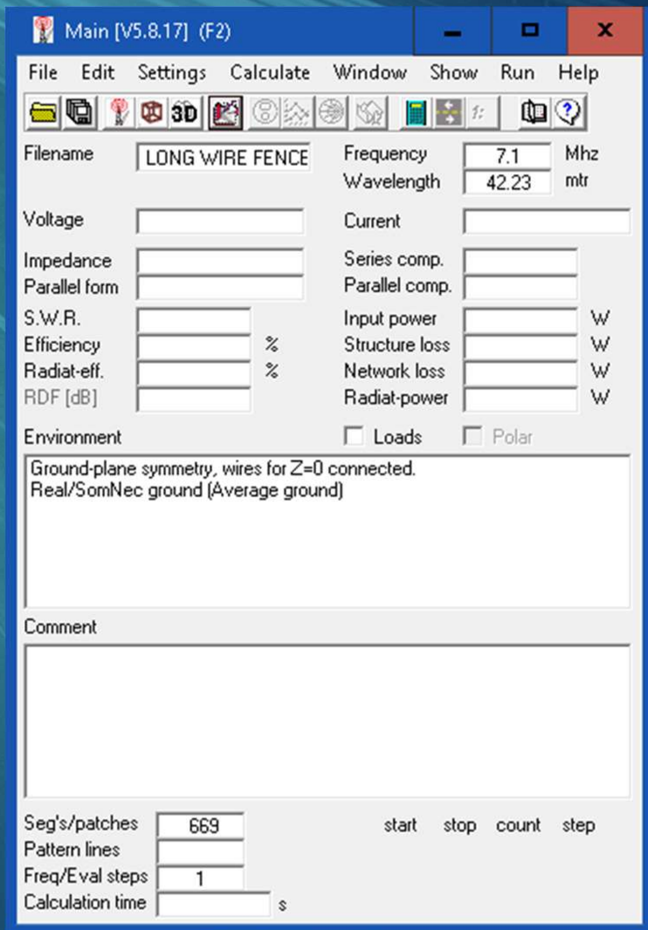


Nr	Type	Tag	Segs	X1	Y1	Z1	X2
1	Wire	1	1	0	0	0.86360	0
2	Wire	2	1	0	-8.02642	1.90500381000762+off	-1.85420
3	Wire	3	1	-1.85420	-8.02642	1.90500381000762+off	-1.85420
4	Wire	4	1	-1.85420	14.60503	1.90500381000762+off	13.38583
5	Wire	5	1	13.38583	14.60503	1.5240030480061+off	13.38583
6	Wire	6	1	13.38583	10.03302	1.5240030480061+off	11.09982
7	Wire	7	1	11.09982	10.03302	2.23520447040894+off	5.13081
8	Wire	8	1	5.13081	10.03302	2.23520447040894+off	5.13081
9	Wire	9	1	0	0	0.86360	0
10	Wire	10	1	0	0	gph	-0.3000
11	Wire	11	1	0	0	gph	-0.3000
12	Wire	12	1	0	0	gph	-0.4064
13	Wire	13	1	0	0	gph	-0.4064
14	Wire	14	1	-0.4064	6.7818	gph	-0.7112
15	Wire	15	1	-0.4064	-7.6200	gph	-0.7112
16	Wire	16	1	-0.7112	-7.6200	gph	-0.7112
17	Wire	17	1	-0.7112	6.7818	gph	-1.0160
18	Wire	18	1	-0.7112	-7.6200	gph	-1.0160
19	Wire	19	1	-1.0160	-7.6200	gph	-1.0160
20	Wire	20	1	-1.0160	6.7818	gph	-1.3208
21	Wire	21	1	-1.0160	-7.6200	gph	-1.3208
22	Wire	22	1	-1.3208	-7.6200	gph	-1.3208
23	Wire	23	1	-1.3208	6.7818	gph	-1.6256
24	Wire	24	1	-1.3208	-7.6200	gph	-1.6256
25	Wire	25	1	-1.6256	-7.6200	gph	-1.6256

Enter in 4Nec2

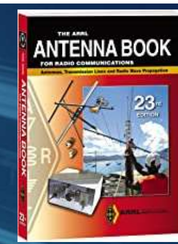
READYFOR 4NEC2 SIMULATION

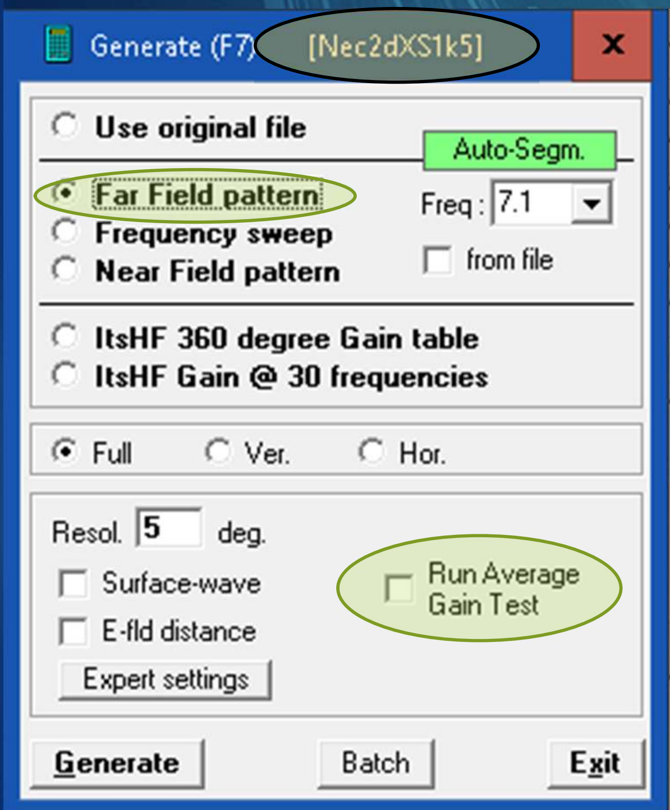




PERFORMANCE (FAR FIELD)

4NEC2 Far Field Calculation



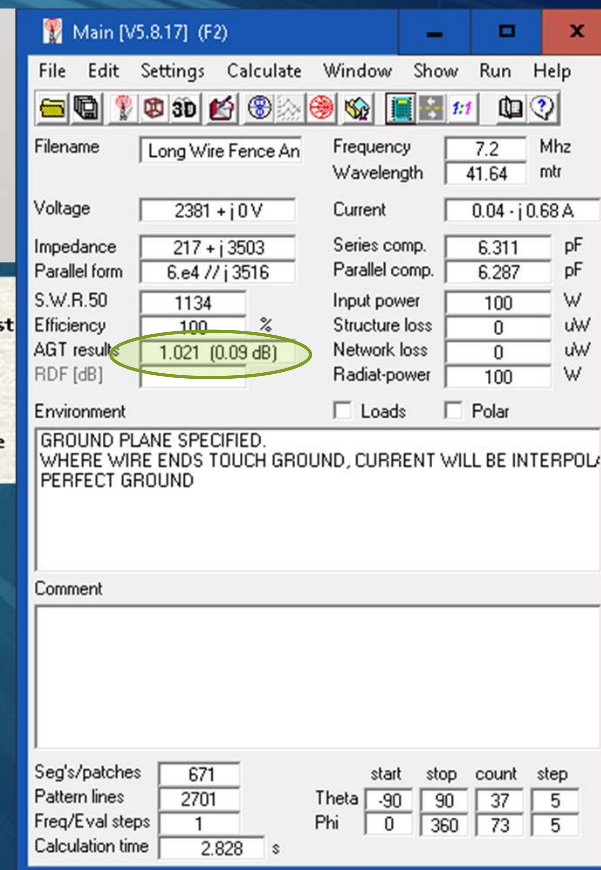


Average Gain Test

Regardless of the engine in use, it's always a good idea to use the Average Gain Test to evaluate and increase the confidence in a model. When a model is inappropriate due to guideline violations or using an engine incorrectly, the Average Gain Test can highlight the problem.

G_{AVE} Value Range	Significance
0.95 - 1.05	Model is considered to have passed the test and is likely to be highly accurate.
0.90 - 0.95 and 1.05 - 1.10	Model is quite usable for most purposes.
0.80 - 0.90 and 1.10 - 1.20	Model may be useful, but adequacy can be improved.
<0.80 and >1.20	Model is subject to question and should be refined.

Can all energy fed into antenna be accounted for



RBN RESULTS

de	dx	freq	cq/dx	snr	speed	time
NC7J	VE3OOI	24924.9	CW CQ	6 dB	20 wpm	1740z 12 Dec

de	dx	freq	cq/dx	snr	speed	time
WA7LNW	VE3OOI	21070.8	CW CQ	2 dB	20 wpm	1738z 12 Dec
NC7J	VE3OOI	21070.9	CW CQ	6 dB	21 wpm	1737z 12 Dec

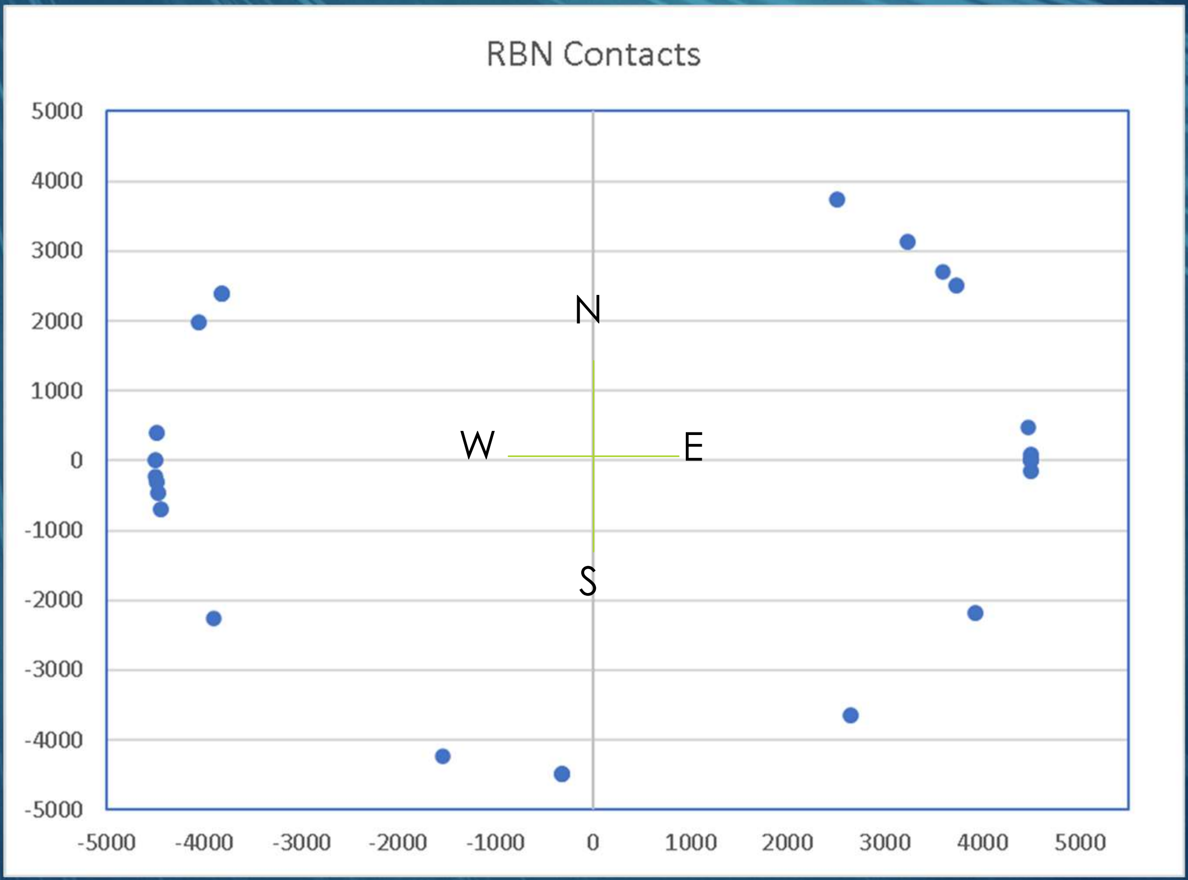
de	dx	freq	cq/dx	snr	speed	time
K9TM-4	VE3OOI	14020.0	CW CQ	4 dB	20 wpm	1730z 12 Dec
F8DGY	VE3OOI	14019.9	CW CQ	7 dB	19 wpm	1730z 12 Dec
VE6WZ	VE3OOI	14020.0	CW CQ	5 dB	20 wpm	1730z 12 Dec

OL7M	VE3OOI	10120.0	CW CQ	3 dB	20 wpm	1724z 12 Dec
F6IIT	VE3OOI	10119.9	CW CQ	6 dB	20 wpm	1723z 12 Dec
VE6WZ	VE3OOI	10120.0	CW CQ	3 dB	21 wpm	1723z 12 Dec
VE7CC	VE3OOI	10120.0	CW CQ	4 dB	20 wpm	1723z 12 Dec
WE9V	VE3OOI	10120.0	CW CQ	5 dB	20 wpm	1723z 12 Dec
W3OA-2	VE3OOI	10120.0	CW CQ	15 dB	20 wpm	1723z 12 Dec
TF4X	VE3OOI	10119.9	CW CQ	8 dB	20 wpm	1723z 12 Dec
W9XG	VE3OOI	10120.0	CW CQ	1 dB	20 wpm	1723z 12 Dec

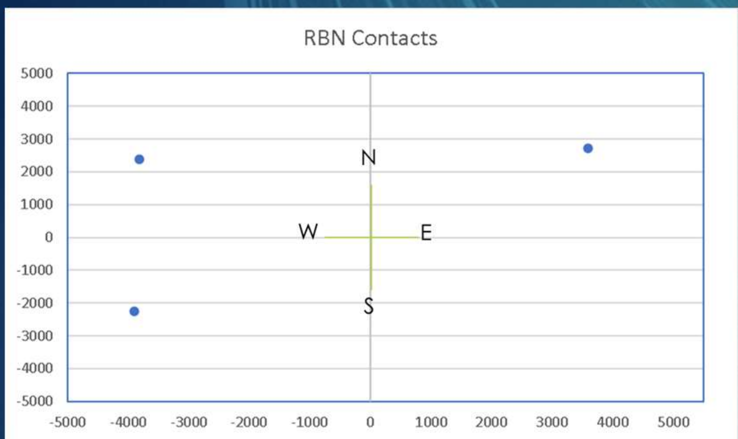
K9LC	VE3OOI	7031.0	CW CQ	13 dB	20 wpm	1726z 12 Dec
KM3T-2	VE3OOI	7031.0	CW CQ	18 dB	20 wpm	1725z 12 Dec
KM3T	VE3OOI	7031.0	CW CQ	17 dB	20 wpm	1725z 12 Dec
K9IMM	VE3OOI	7031.0	CW CQ	8 dB	21 wpm	1725z 12 Dec
W3OA	VE3OOI	7031.0	CW CQ	11 dB	20 wpm	1725z 12 Dec
W1NT-2	VE3OOI	7031.0	CW CQ	6 dB	20 wpm	1725z 12 Dec
WS3W	VE3OOI	7031.0	CW CQ	19 dB	21 wpm	1725z 12 Dec
KD2OGR	VE3OOI	7031.0	CW CQ	7 dB	20 wpm	1725z 12 Dec
WC2L	VE3OOI	7031.0	CW CQ	6 dB	20 wpm	1725z 12 Dec

W8WTS	VE3OOI	3530.0	CW CQ	4 dB	20 wpm	1728z 12 Dec
W2AXR	VE3OOI	3530.0	CW CQ	14 dB	20 wpm	1727z 12 Dec

DIRECTIONALITY



20m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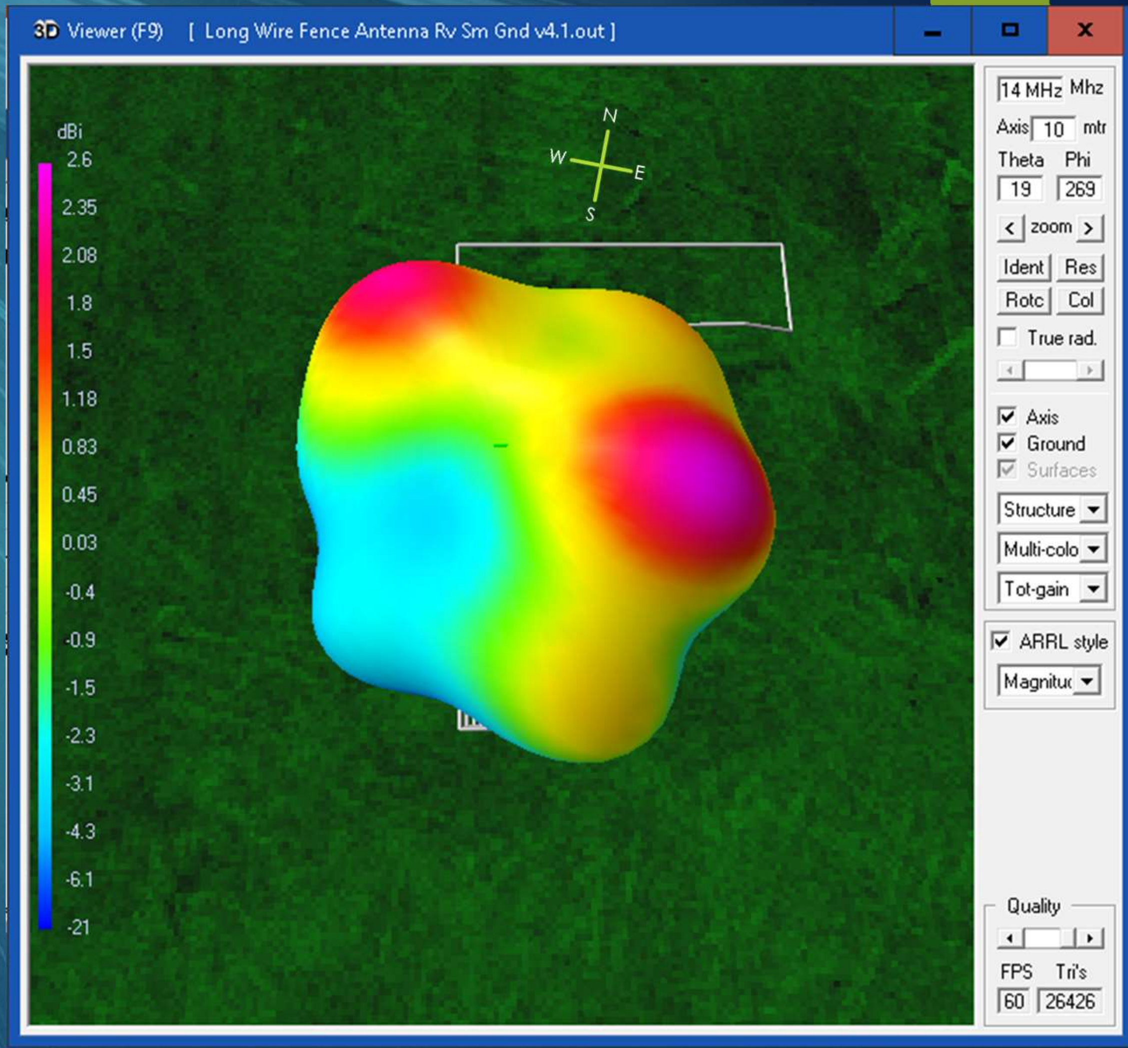
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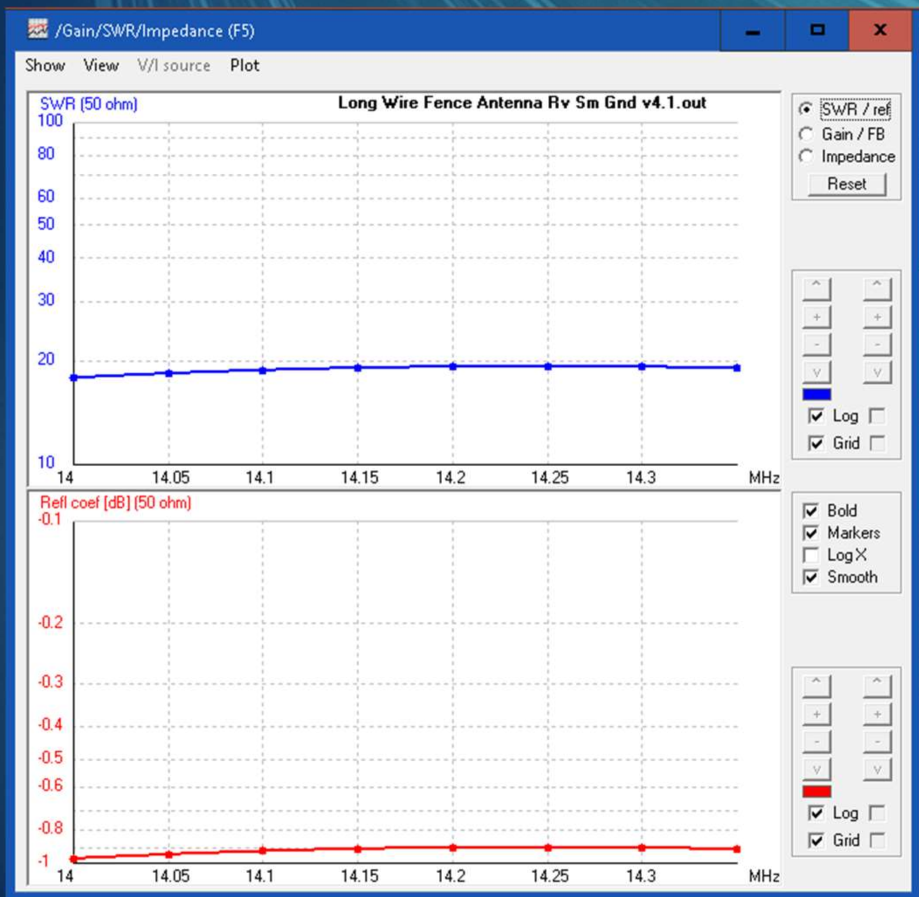
20m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Show View V/I source Plot
SWR (50 ohm)
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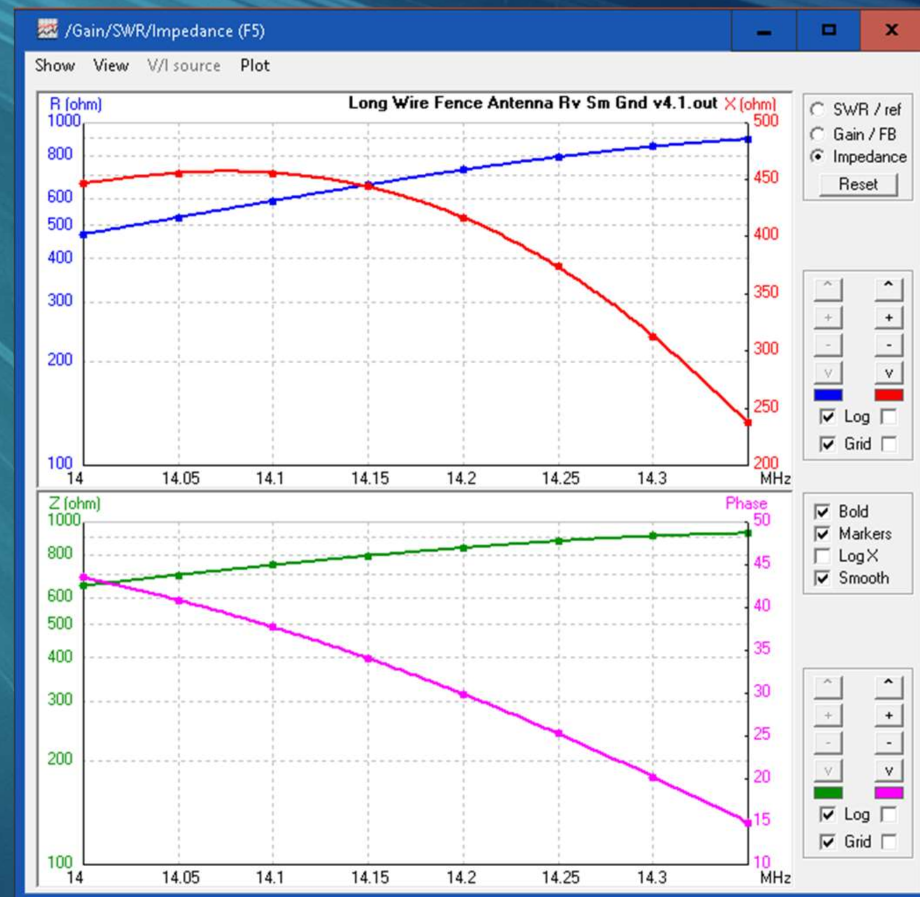
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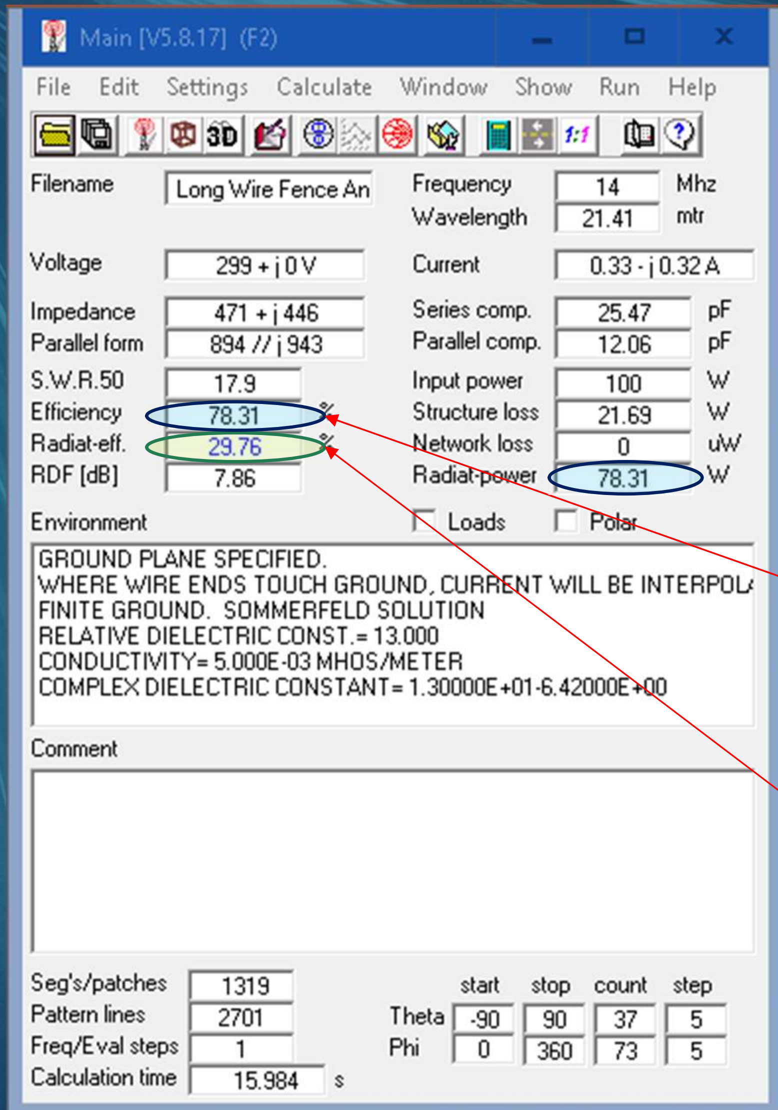
20m

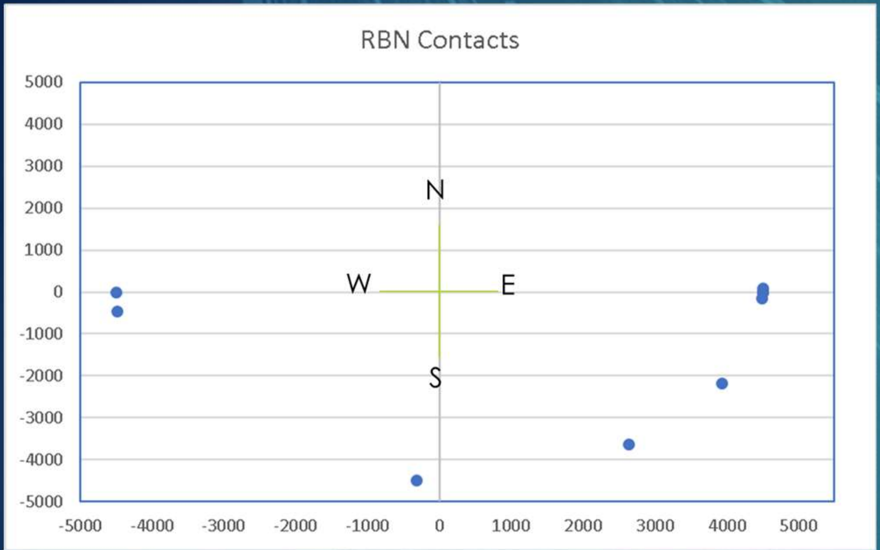
Dipole Efficiency: 74%



This is amount of energy AVAILABLE to be radiated by the antenna considering structure loss (e.g., antenna heating)

This is actual amount of energy "actually" radiated because of losses from ground and other near field structures

40m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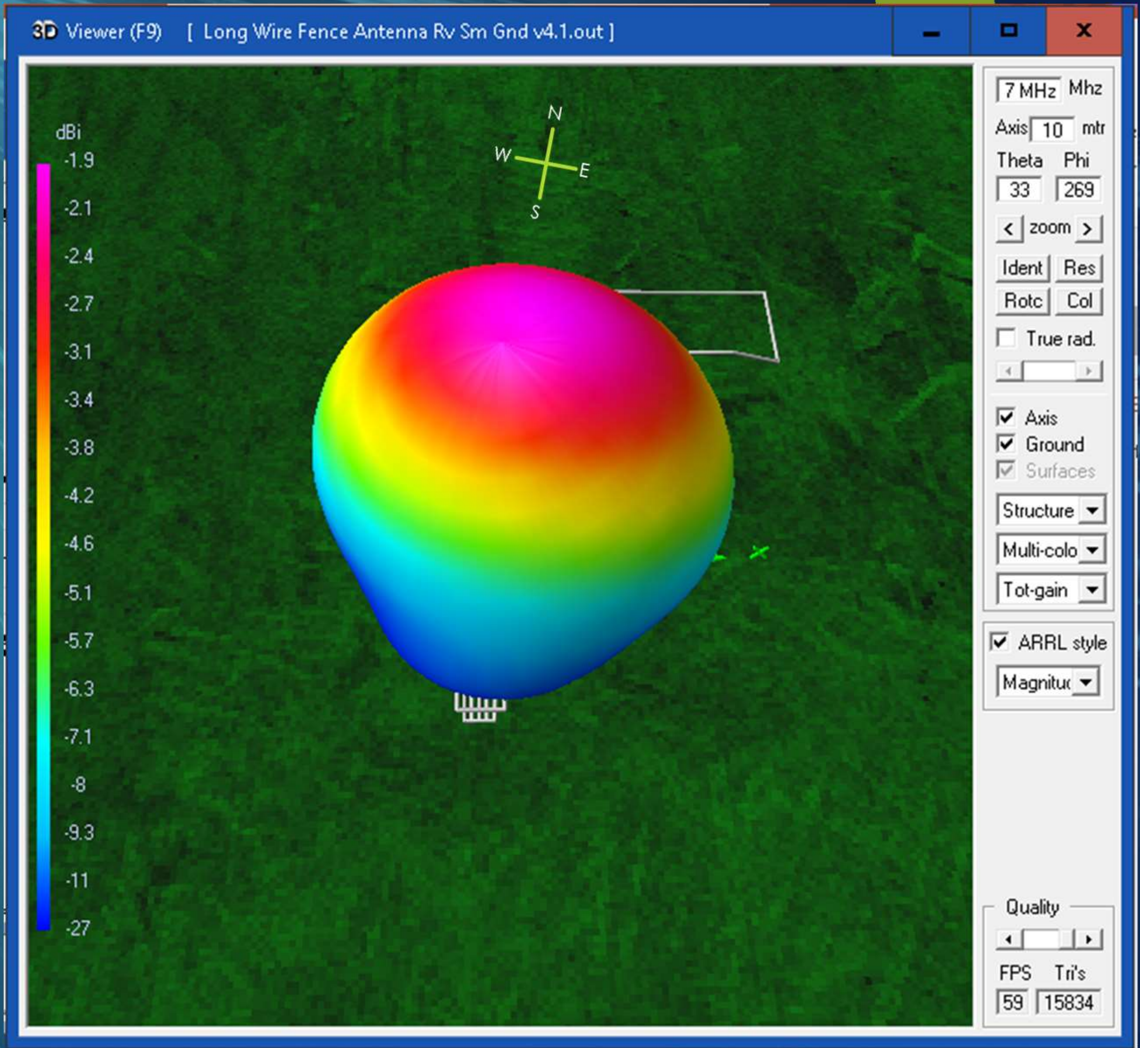
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Tot-gain
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Quality
FPS Tri's
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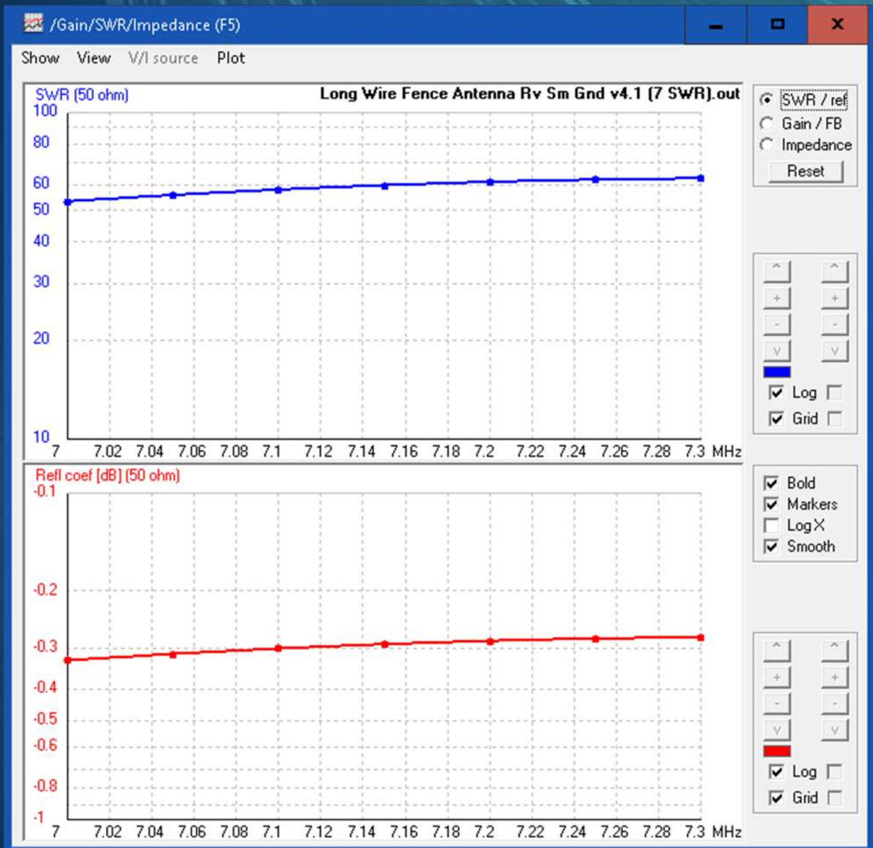
40m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Show View V/I source Plot
SWR (50 ohm)
Long Wire Fence Antenna Rv Sm Gnd v4.1 (7 SWR).out
SWR / ref
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Refl coef [dB] (50 ohm)
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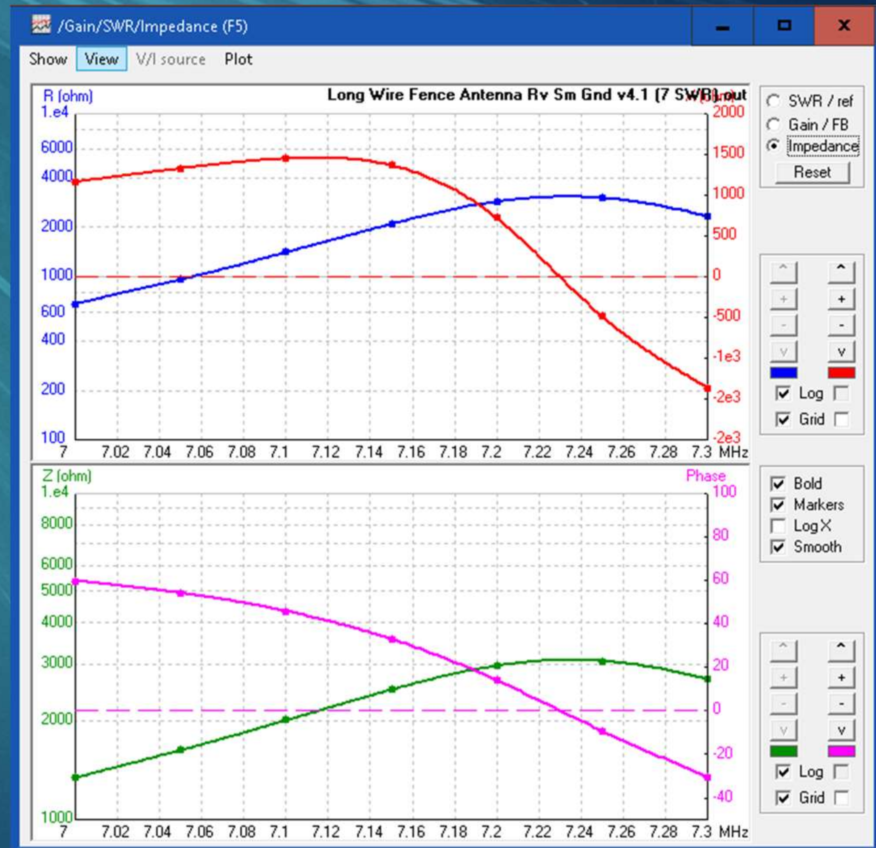
/Gain/SWR/Impedance (F5)
Show View V/I source Plot
R (ohm)
Long Wire Fence Antenna Rv Sm Gnd v4.1 (7 SWR).out
SWR / ref
Gain / FB
Impedance
Reset
Log
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Z (ohm)
Phase
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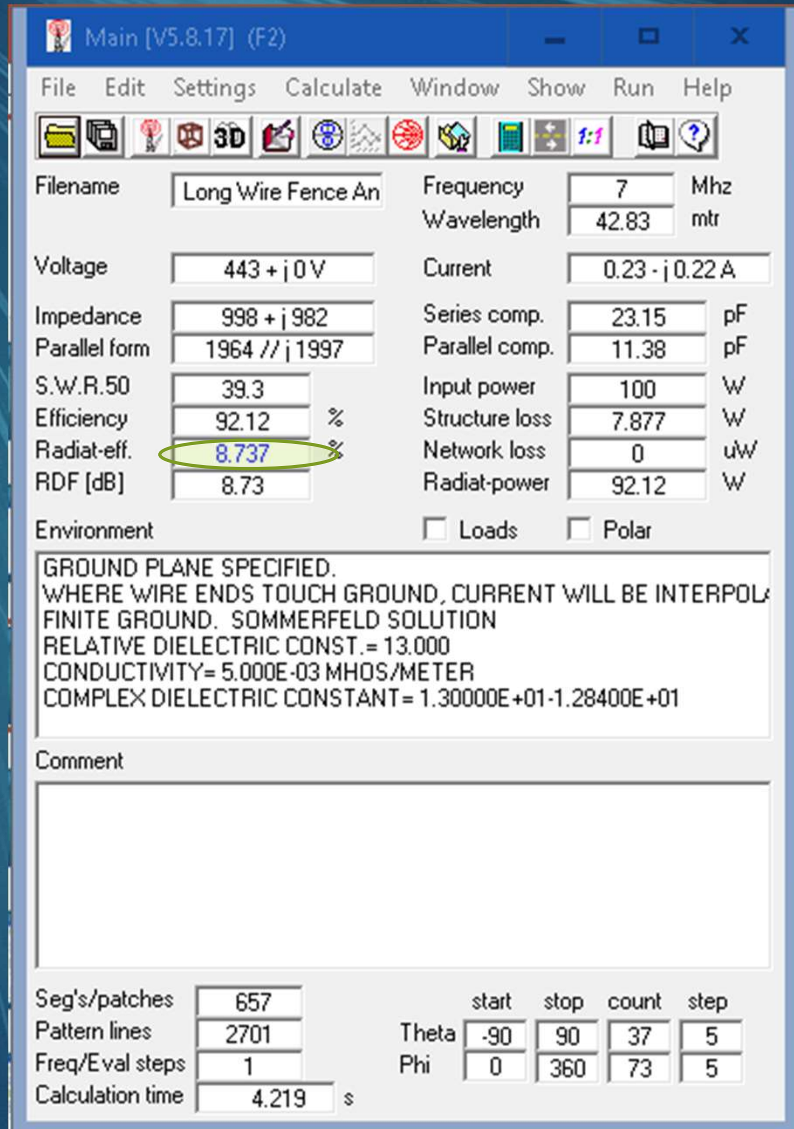
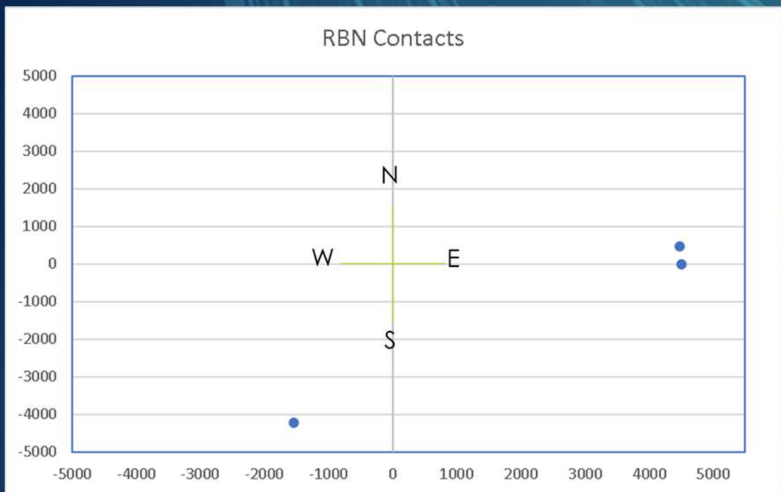
Log X
Smooth
MHz

40m

Dipole Efficiency: 77%



80m



RBN Contacts
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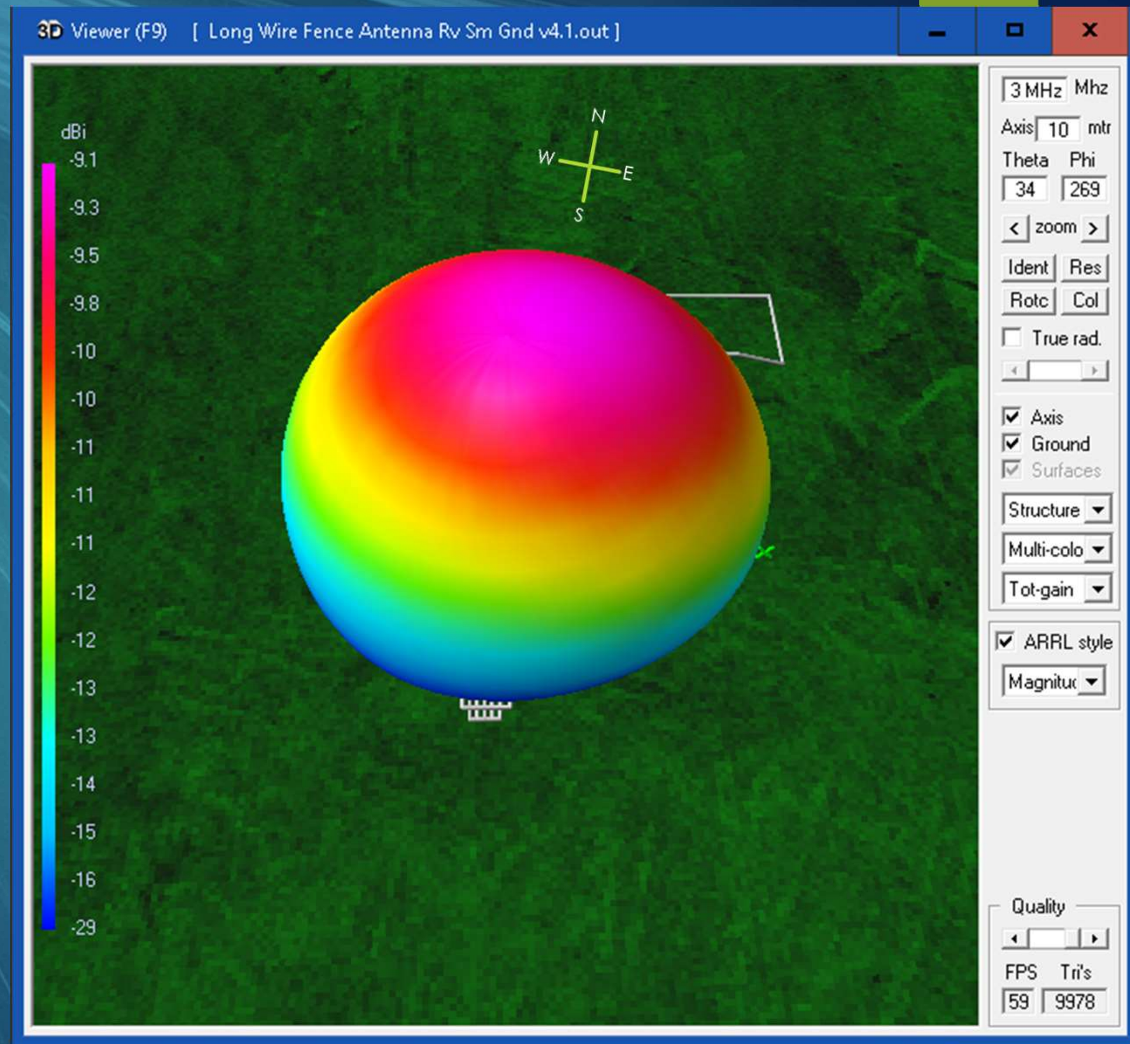

3D Viewer (F9) [Long Wire Fence Antenna Rv Sm Gnd v4.1.out]
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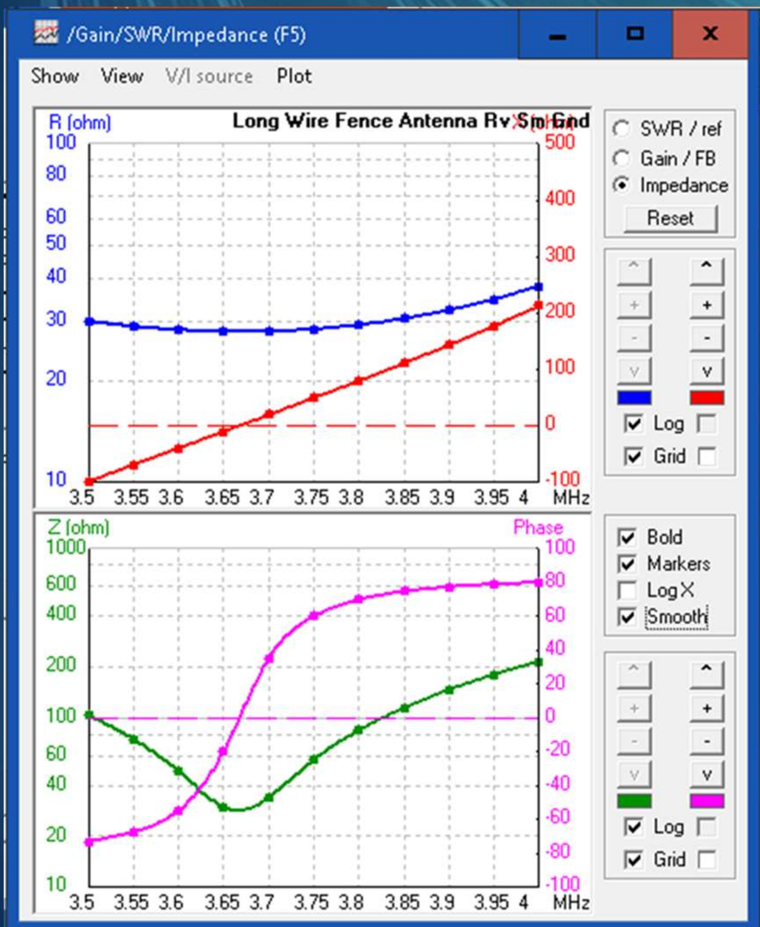
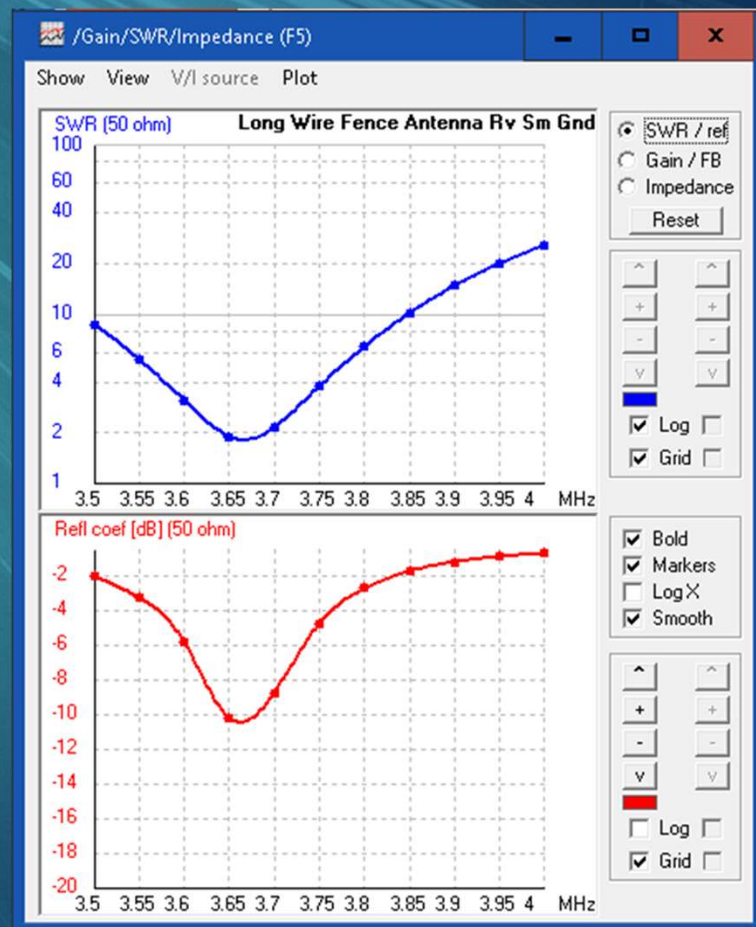
Surfaces
Structure
Multi-colo
Tot-gain
ARRL style
Magnitu
Quality
FPS Tri's
59 9978

80m

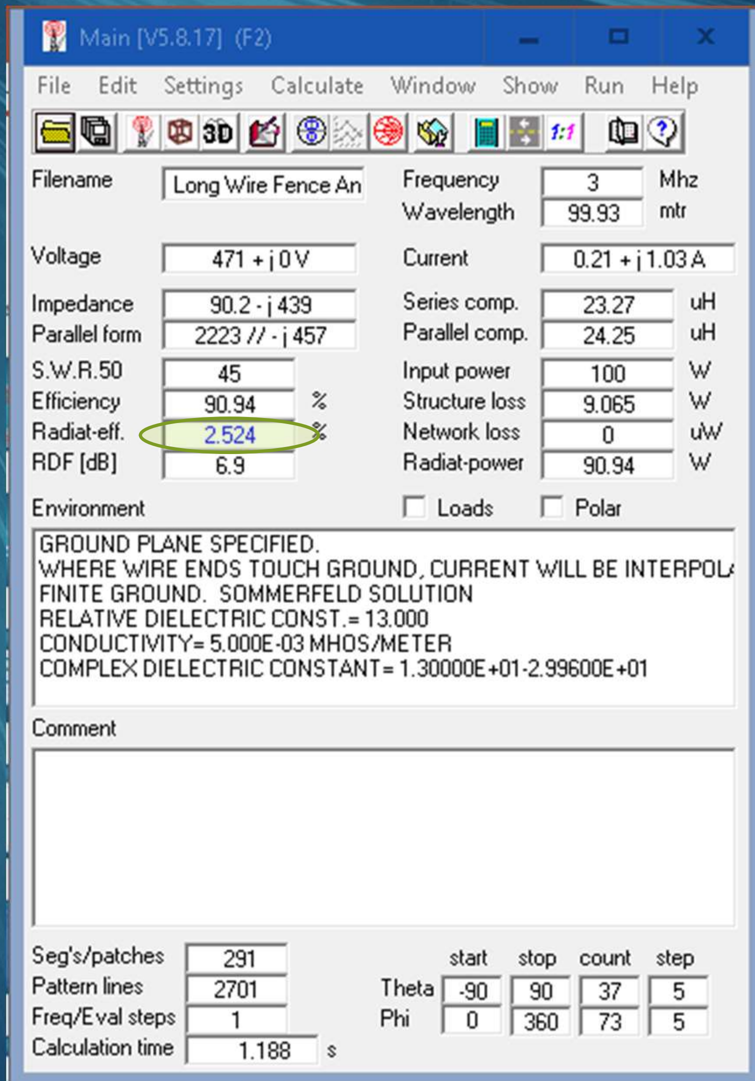




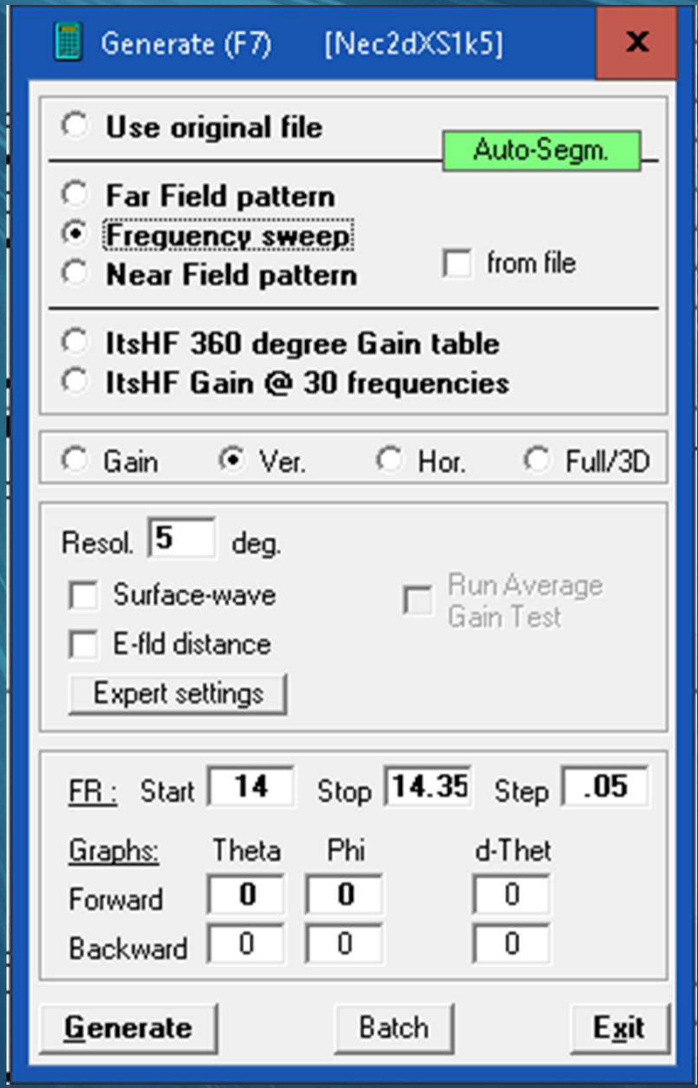
Adjust length?

80m

Dipole Efficiency: 80%

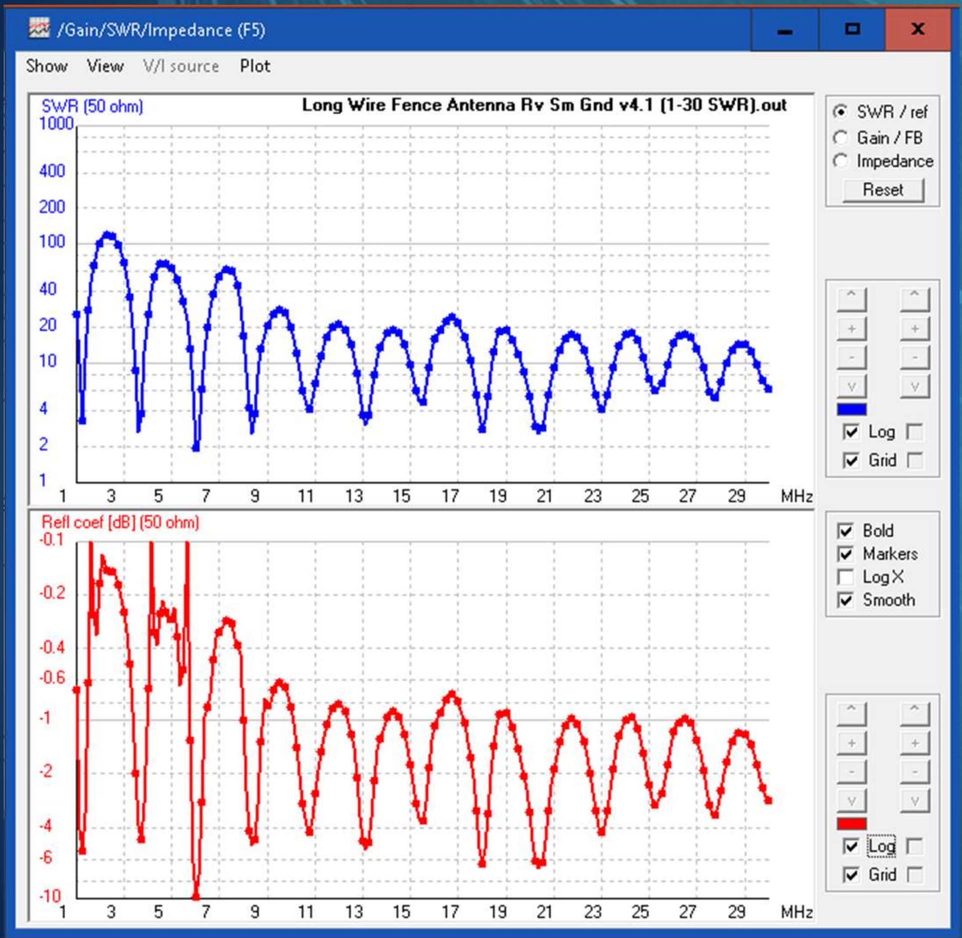


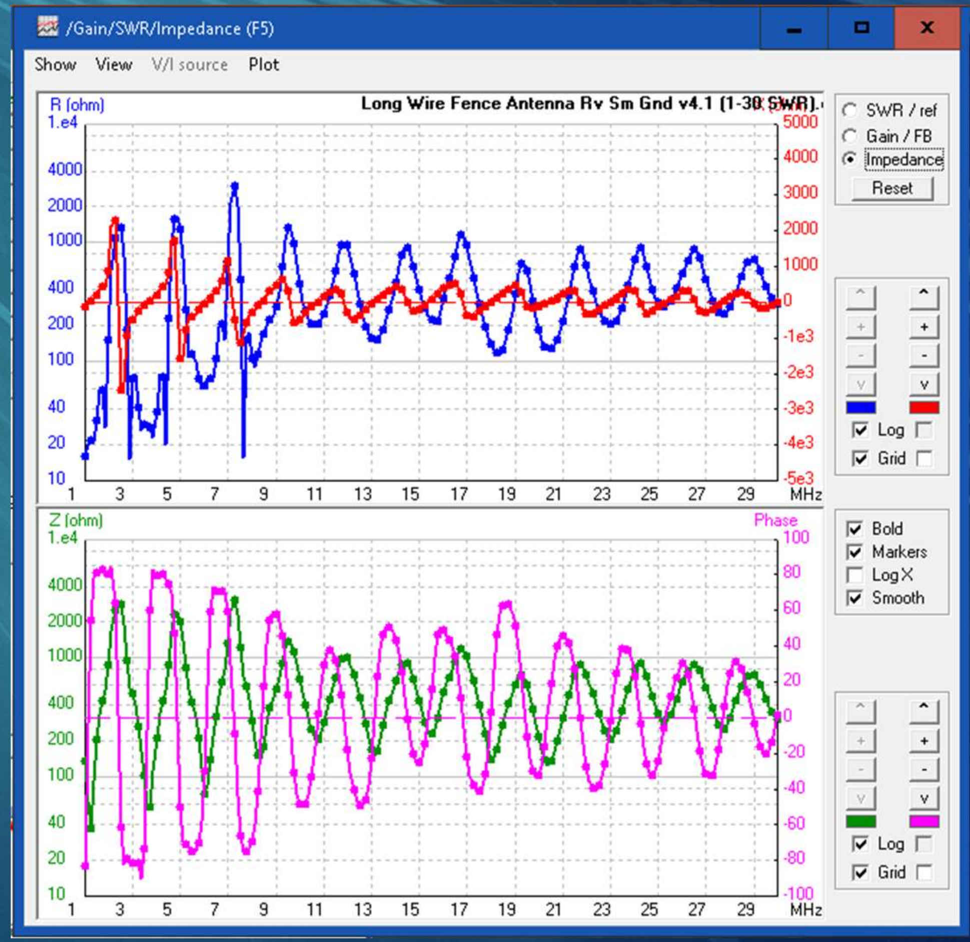
SWR Sweep



Generate (F7) [Nec2dXS1k5]
Use original file
Auto-Segm.
Far Field pattern
Frequency sweep
Near Field pattern
from file
ItsHF 360 degree Gain table
ItsHF Gain @ 30 frequencies
Gain
Ver.
Hor.
Full/3D
Resol. 5 deg.
Surface-wave
E-fld distance
Run Average Gain Test
Expert settings
FR : Start 14 Stop 14.35 Step .05
Graphs: Theta Phi d-Thet
Forward 0 0 0
Backward 0 0 0
Generate
Batch
Exit

Wide SWR Sweep

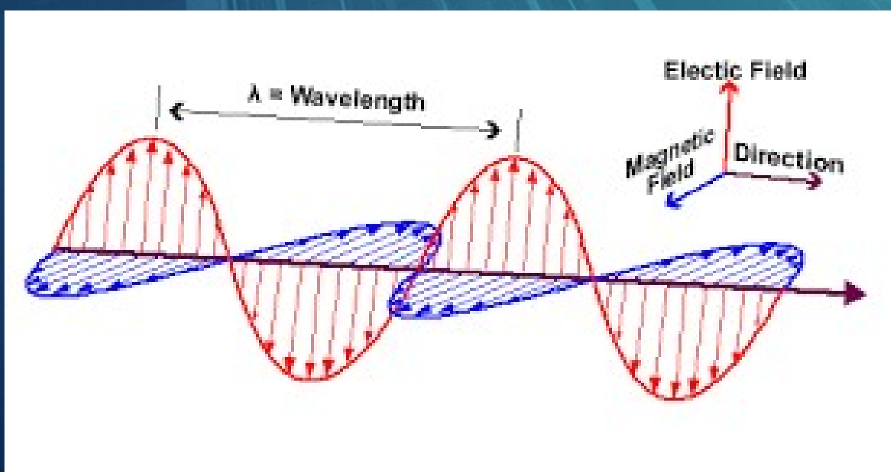




SAFETY (NEAR FIELD)

RF FIELD UNITS

- Electric and magnetic fields are orthogonal (Maxwell's Eqn.)
- Electric field (E) measured in V/m
  - E.g., 1V/m is a potential difference of 1 V existing between two points that are 1 m apart
- Magnetic field H measured in A/m or flux density B measured in Nm/A or T (Tesla)
  - E.g., 1A/m is 1 Amp of current through 1 m (think of current in a toroid with 1 m circumference)



$$\vec{\nabla} \times \vec{B} = \mu_0 (\vec{J} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t})$$

A circulating magnetic field is produced by an electric current and by an electric field that changes with time.

EMF MEASUREMENT

and contact currents. In the far-field zone of an electromagnetic source, electric field strength, magnetic field strength and power density are interrelated by simple mathematical expressions, where any one of these parameters defines the remaining two. In the near-field zone, both the unperturbed electric- and magnetic-field strengths shall be measured, since there is no simple relationship between these two quantities. Instrumentation for the measurement of magnetic fields at certain frequencies may not be commercially available. In this case, the electric field strength shall be measured and used for assessing compliance with the reference levels in this code.

Health Canada Safety Code 6

RF IMPACT

There are 2 scientifically-established adverse health effects from exposures to radiofrequency EMF:

- At frequencies **below** 10 megahertz (MHz), peripheral nerve stimulation (a tingling sensation) can occur. The exposure limits in Safety Code 6 for frequencies below 10 MHz are set below the level (threshold) at which this effect could happen.
- At frequencies **above** 100 kilohertz (kHz), tissue heating can occur. The exposure limits in Safety Code 6 for frequencies above 100 kHz are set below the level (threshold) at which this could happen.

No adverse health effects have been scientifically established at levels below the limits in Safety Code 6.

Health Canada Safety Code 6

SC 6 RF LIMITS

UNC Limits	Max	V/m	W/m^2	mW/m^2	Period
ARRL		117		4	30
SC 6	83	33	NA		6
ICNIRP	83	171	NA		6
CON Limits	**Max**	**V/m**	**W/m^2**	**mW/m^2**	**Period**
ARRL		263		18	6
SC 6	170	72	NA		6
ICNIRP	170	385	NA		6

This is for 7 MHz

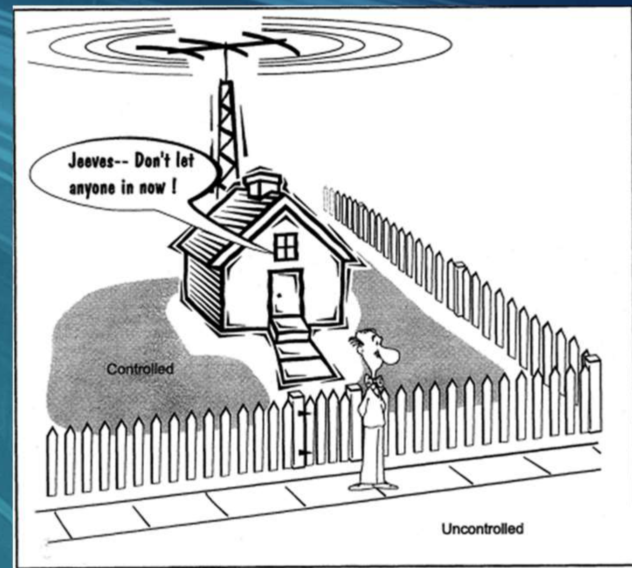


Fig 4.3—If you cannot control access to the area, the average for *uncontrolled* areas apply.

SC 6, 14 MHz – No Max, 6 Min Avg:
V/m: 27/61, W/m²: 2/10

Time Average	Max	V/m	Avg Time (m)	Max Tx Time (m)	Duty Cycle
CON	170	72	6	2.54	42%
UNC	83	33	6	2.39	40%

DUTY CYCLE

Table 5.4

Operating Duty Factor of Modes Commonly Used by Amateurs

Mode	*Duty Cycle*	*Notes*
Conversational SSB	20%	1
Conversational SSB	40%	2
SSB AFSK	100%	
SSB SSTV	100%	
Voice AM, 50% modulation	50%	3
Voice AM, 100% modulation	25%	
Voice AM, no modulation	100%	
Voice FM	100%	
Digital FM	100%	
ATV, video portion, image	60%	
ATV, video portion, black screen	80%	
Conversational CW	40%	
Carrier	100%	4

Note 1: Includes voice characteristics and syllabic duty factor. No speech processing.
Note 2: Includes voice characteristics and syllabic duty factor. Heavy speech processor employed.
Note 3: Full-carrier, double-sideband modulation, referenced to PEP. Typical for voice speech. Can range from 25% to 100%, depending on modulation.
Note 4: A full carrier is commonly used for tune-up purposes

SC 6 NOTES

1. * At no point in time shall the RMS values for electric- and magnetic-fields exceed the reference levels with an instantaneous reference period in Tables 3 and 4. In the case of RF fields with amplitude modulation, the RMS value during the maximum of the modulation envelope shall be compared to the reference level.
2. ** For exposures shorter than the reference period, field strengths may exceed the reference levels, provided that the time average of the squared value of the electric or magnetic field strength over any time period equal to the reference period shall not exceed E_{RL}^2 or H_{RL}^2, respectively. For exposures longer than the reference period, including indefinite exposures, the time average of the squared value of the electric or magnetic field strength over any time period equal to the reference period shall not exceed E_{RL}^2 or H_{RL}^2, respectively.

Health Canada Safety Code 6

3. S_{inc}, E_{inc}, and H_{inc} are to be averaged over 6 min, and where spatial averaging is specified in Notes 6–7, over the relevant projected body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see eqn 8 in Appendix A for details).

ICNIRP

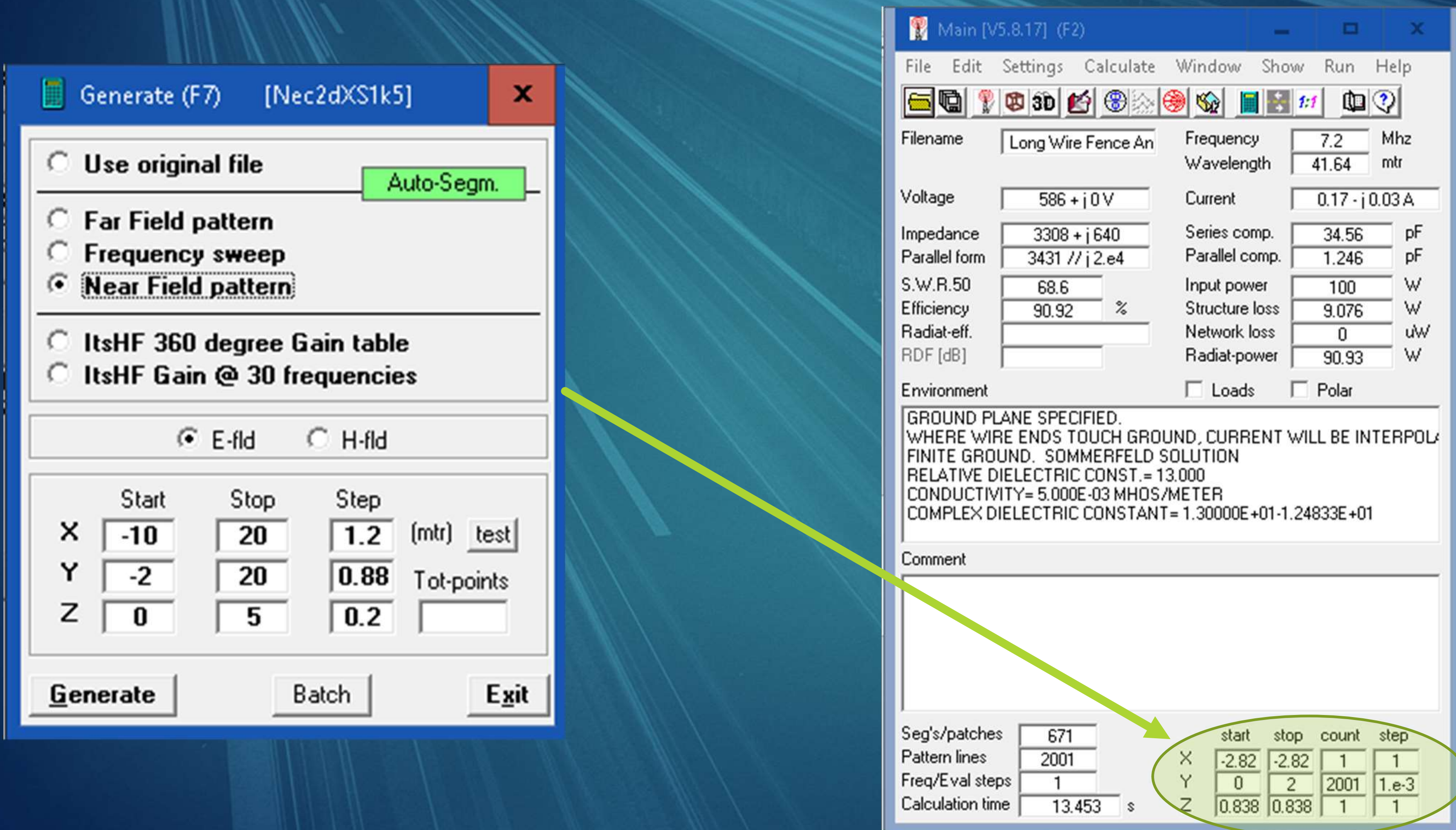
E.g. Limit: 72*72 = 5,184
Time Avg (18%): 170*170*1.1/6 = 5,298

Need more investigation.

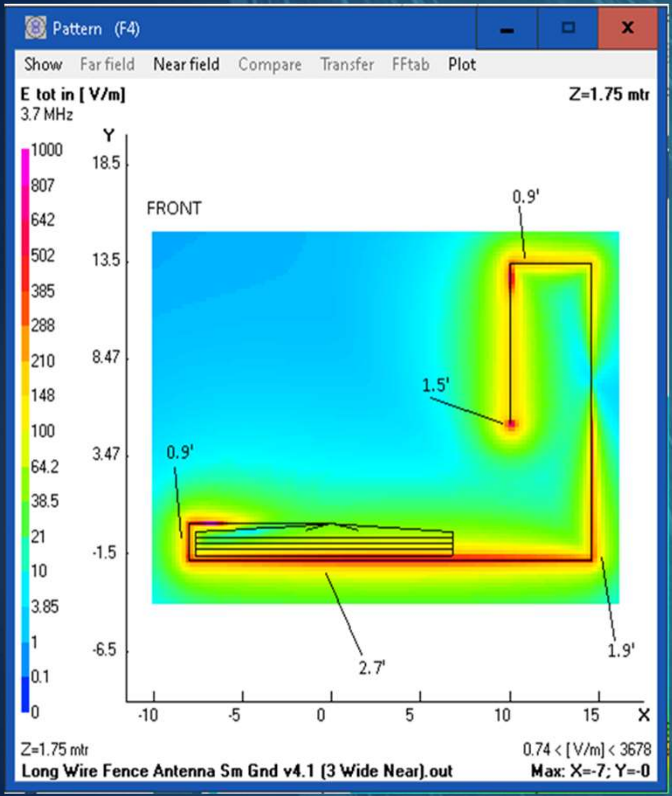
Assume my original interpretation is correct

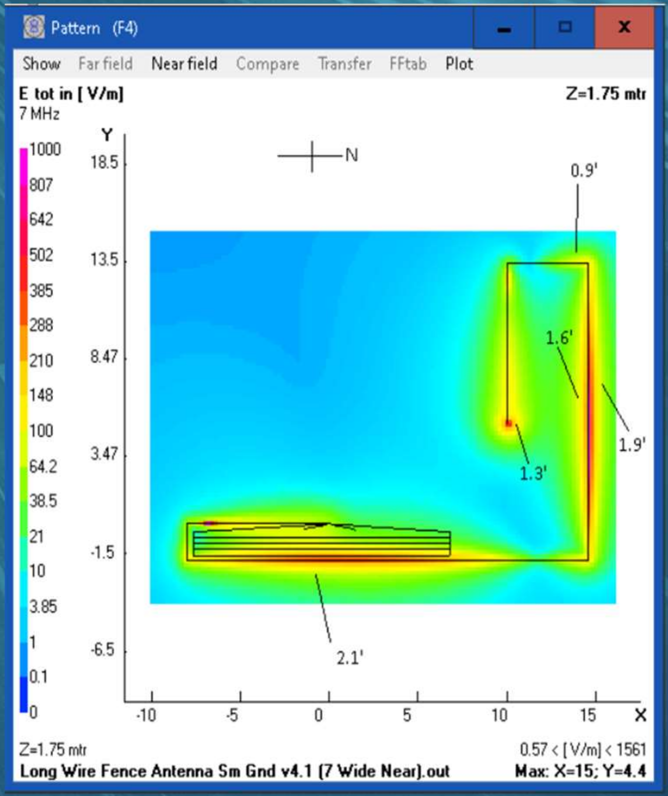
NEAR FIELD PREDICTION

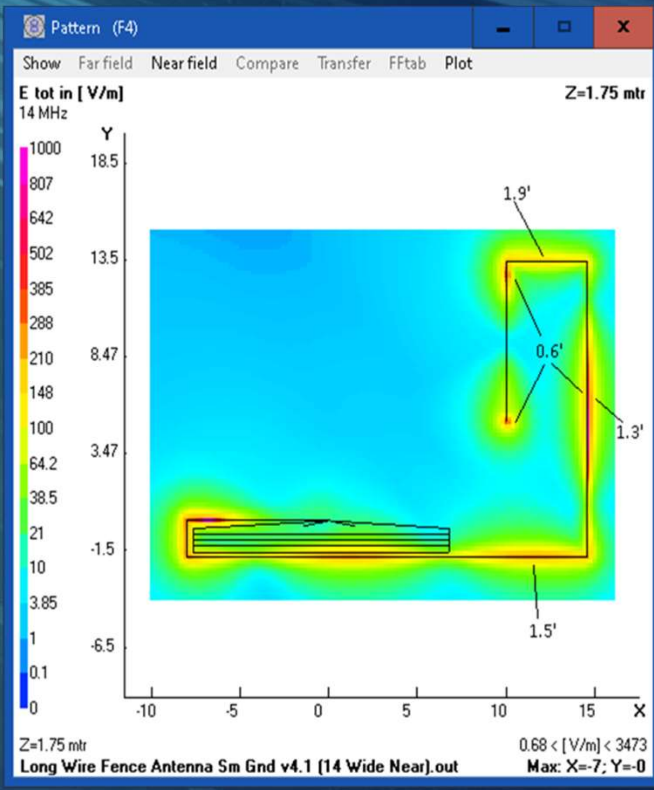
4NEC2 NEAR FIELD CALCULATION



SAFE DISTANCES

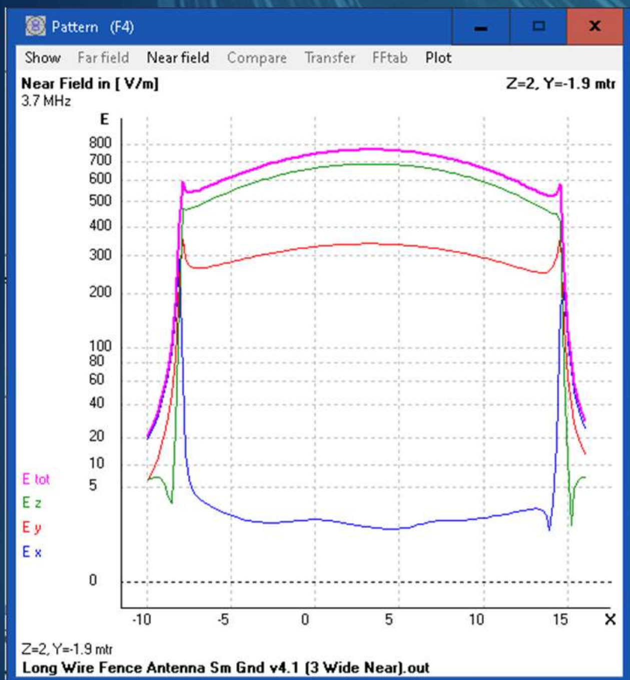


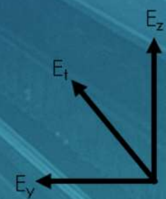


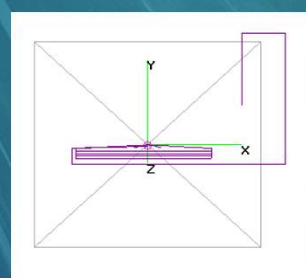


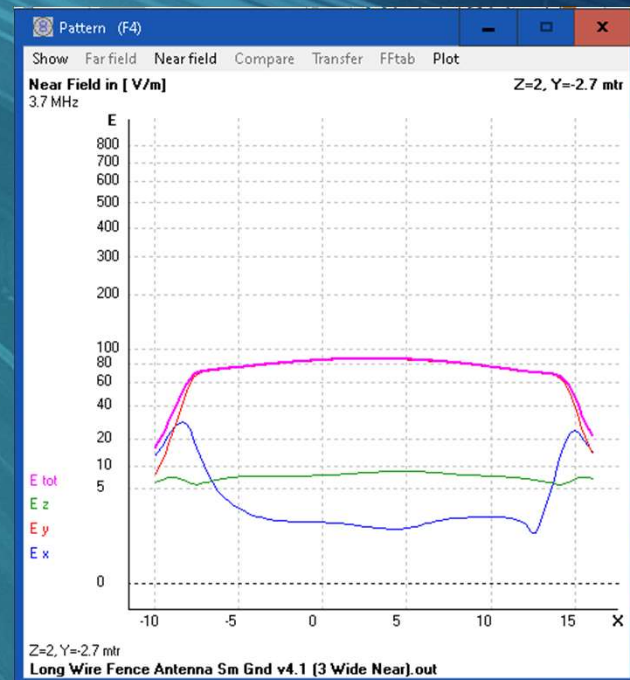
7 MHz Unc: 83, Con: 170

SAFE DISTANCES









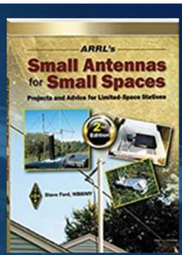
7MHz Unc: 83, Con: 170

Along NS Fence at Antenna

- Z contribution is largest (800 V/m).
- Y contribution is less than ½ (300 V/m)

- At 0.6 m(1.9’) drops to “max” UNC safe limit in Y direction. At 2.1 m (6.8’) drops to 100% safe limit Y direction (Chart missing)

"ARRL" CALCULATOR (FCC LIMITS)



Amateur Radio RF Safety Calculator

Calculation Results

Average Power at the Antenna	100 watts
Antenna Gain in dBi	0 dBi
Distance to the Area of Interest	2.5 feet 0.762 metres
Frequency of Operation	7 MHz
Are Ground Reflections Calculated?	Yes
Estimated RF Power Density	3.5085 mW/cm²

	Controlled Environment	Uncontrolled Environment
Maximum Permissible Exposure (MPE)	18.3723 mW/cm²	3.6785 mW/cm²
Distance to Compliance From Centre of Antenna	1.1426 feet 0.3483 metres	2.4932 feet 0.7599 metres
Does the Area of Interest Appear to be in Compliance?	yes	yes

Interpretation of Results

1. The power value entered into these calculations should be the average power seen at the antenna and not Peak Envelope Power (PEP). You should also consider feedline loss in calculating your average power at the antenna.
2. If you wish to estimate the power density at a point below the main lobe of a directional antenna, and if the antenna's vertical pattern is known, recalculate using the antenna's gain in the relevant direction.
3. Please also consult FCC OET Bulletin 65 Supplement B, the Amateur Radio supplement to FCC OET Bulletin 65. It contains a thorough discussion of the RF Safety regulations as they apply to amateur stations and contains numerous charts, tables, worksheets and other data to help determine station compliance.

Perform another computation

Amateur Radio RF Exposure Calculator

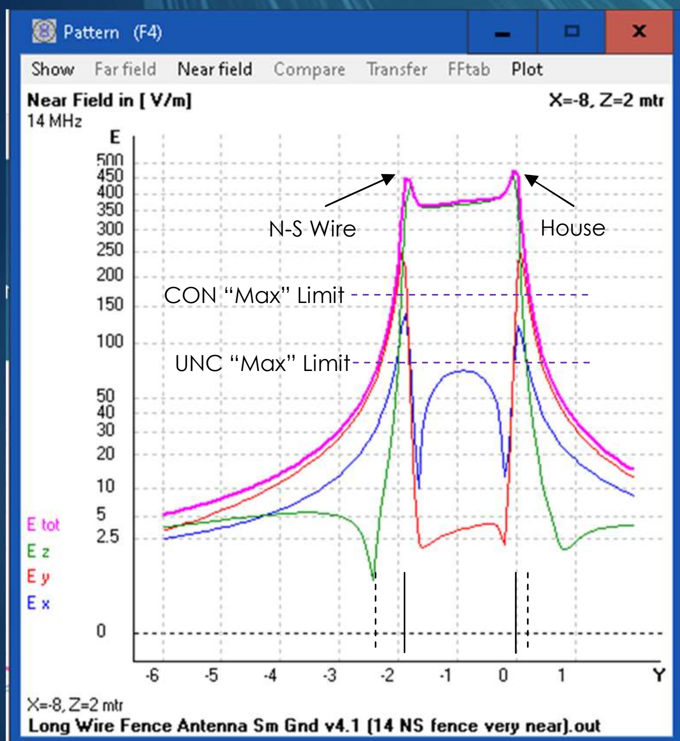
v1.4 (2020-04-01) by Paul Evans, VP9KF, Hintlink Technology.
New page UK page Help page.<-- to see CHANGES, go here

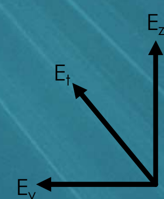
At 7 MHz

- 4Nec2: 2.1' UNC / 1.3' CONT
- ARRL: 2.5' UNC / 1.1' CONT

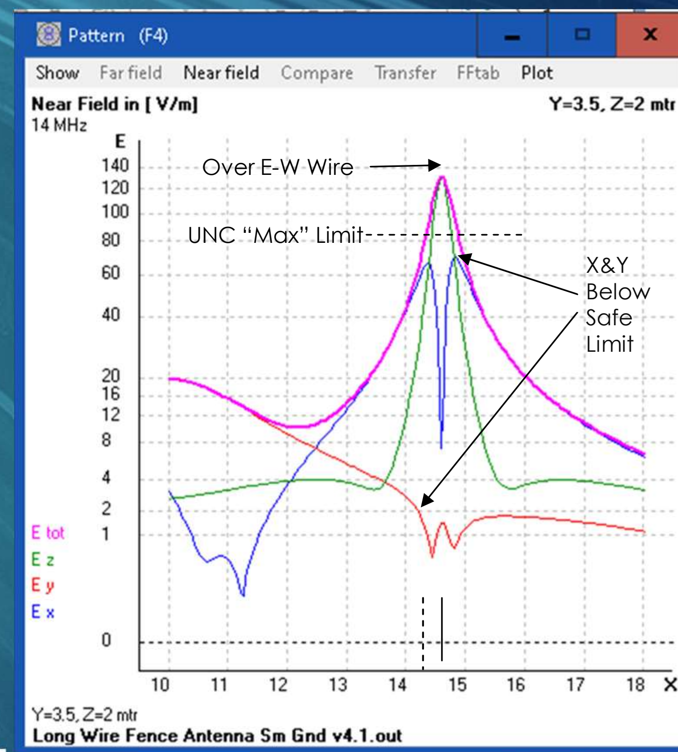
FLUKE?

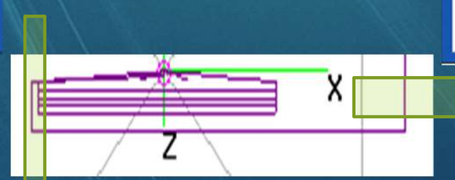
DROP OFF



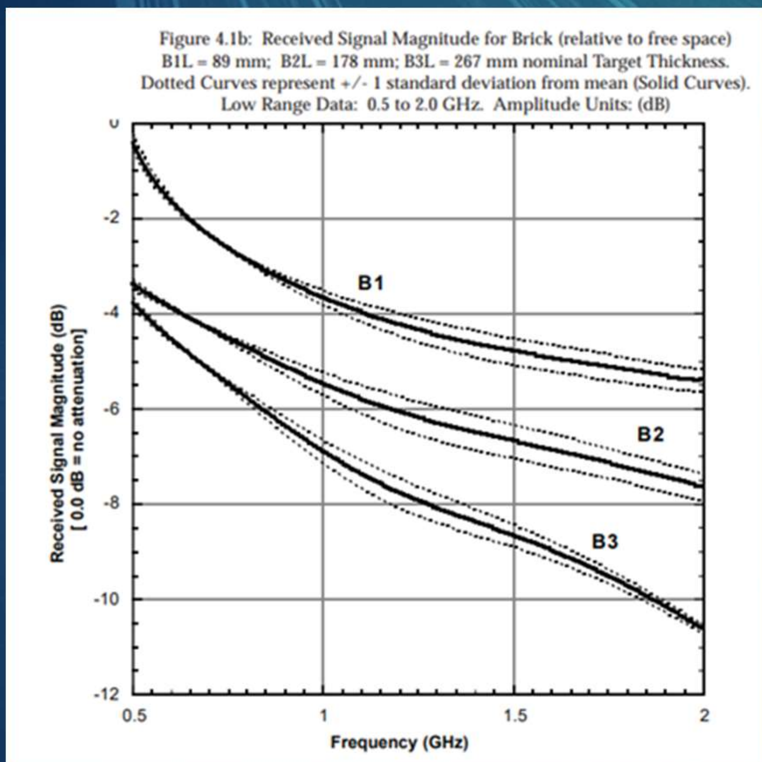


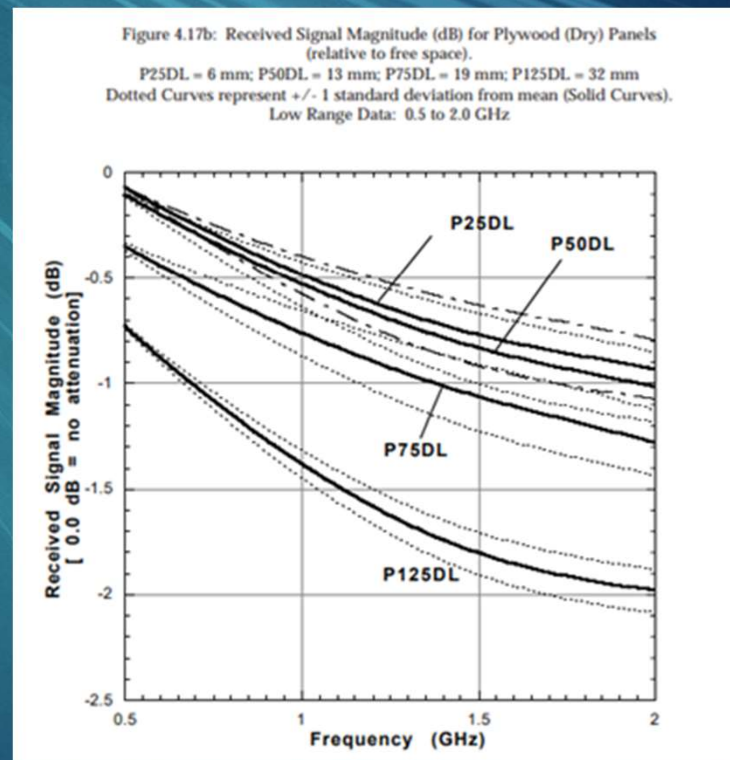
7 MHz Unc: 83, Con: 170





BUILDING ATTENUATION

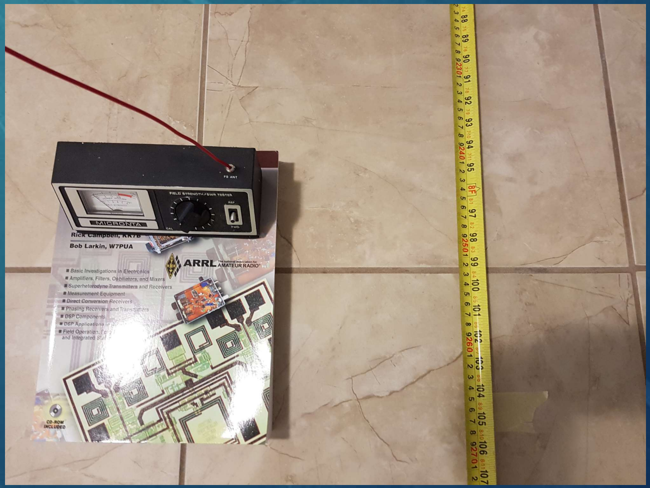




NEAR FIELD MEASUREMENT

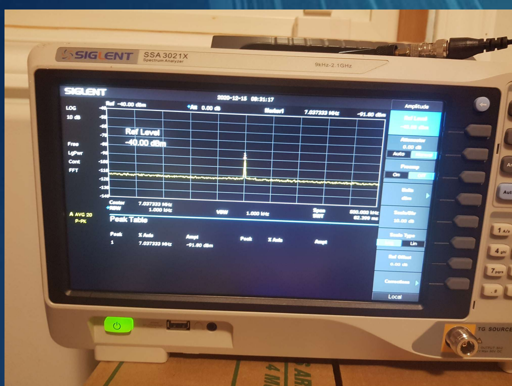
FS METER

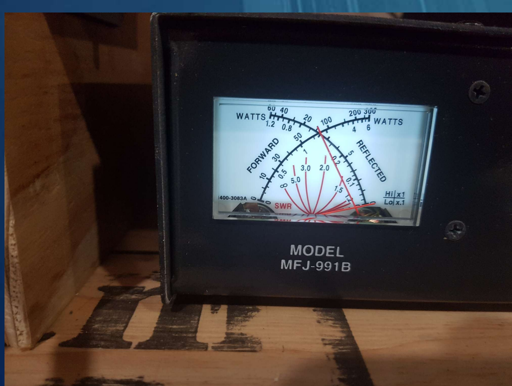
- Used Tandy Field Strength Meter. 40 M & 100 W
- At Antenna, set max to “5”
- At about ~8 Feet, FS drops from “5” to “0” for 100 Watts
- Entire backyard is about “3” to “4”
- What does ‘”3” mean?



SPECTRUM ANALYZER

- Used small 2m rubber duck, 40M, 30 dB Atten, 6 to 8 MHz, 1 KHz BW, 10 Avg



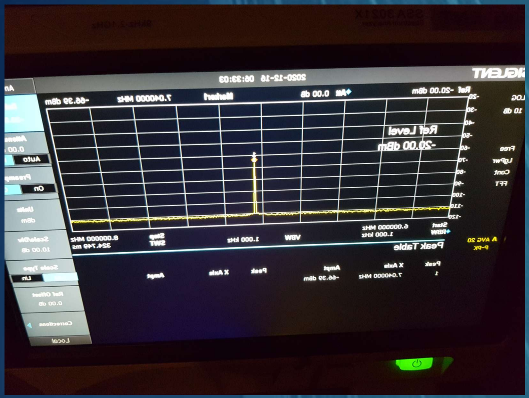


Distance	Power	Reading
0	100 W	-61 dBm
0	50 W	-64 dBm; (3 dB)
0	5 W	-72 dBm; (11 dB)
6 Ft	100 W	-75 dBm (14 dB)
6 Ft	50 W	-78 dBm (17 dB, 14 dB)
6 Ft	5 W	-86 dBm (25 dB, 14 dB)

- Ratios are consistent - i.e. relative measurement are ok
- Does not account for antenna losses. 2m used to measure 40m!

POWER MEASUREMENT

- Use small rubber duck, 40M, 30 dB Atten, 6 to 8 MHz, 1 KHz BW



Location	Power	Reading	Density
Yard	100 W	-66 dBm	800 uW
Yard	50 W	-69 dBm	570 uW
Yard	5 W	-77 dBm	227 uW
Patio	50 W	-59 dBm	2 mW
House	50 W	-63 dBm	1 mW

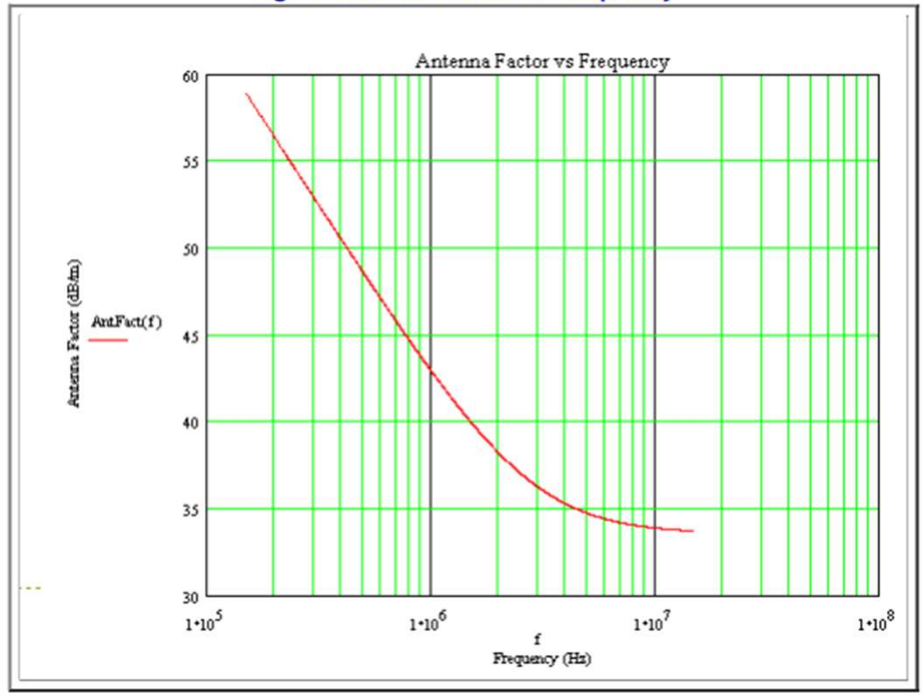
Power Levels are obviously incorrect

Does not account for antenna losses. 2m uses to measure 40m!

ANTENNA FACTOR

- Antenna Factor (or correction factor) is defined as the ratio of the incident Electromagnetic Field to the output voltage from the antenna and the output connector.
- For a frequency, this is the voltage at the receiver for a given field received in the antenna.
- Frequency dependent. i.e. antenna is resonant for a frequency
- Lower value is for more efficient antenna

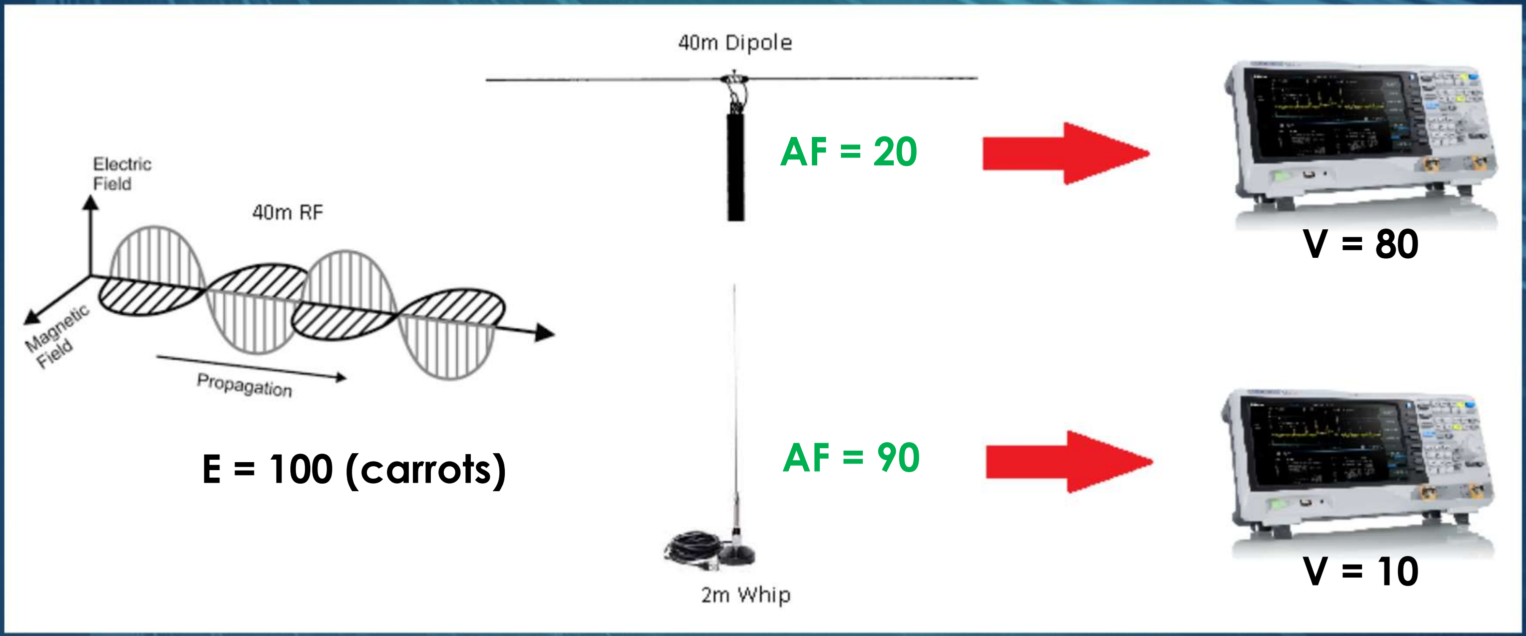
Fig 7: Antenna Factor vs Frequency



The field strength, E, is the sum of the adjusted spectrum analyzer reading and the antenna factor:

$$E = \underbrace{27\ \text{dB}\mu\text{V}}_{\substack{\text{Analyzer}\\ \text{Reading}}} + \underbrace{12.3\ \text{dB/meter}}_{\substack{\text{Antenna}\\ \text{Factor}}} = 39.3\ \text{dB}\mu\text{V/meter}.$$

DUMB IT DOWN…



Think of Antenna Factor as the missing carrots (i.e. correction factor)

For rubber duck, need the Antenna Factor to get field strength

VK1OD (Owen M Duffy)

- Extensive work measuring field strengths using a square loop with a power meter

- Use calculation from first principals as well as NEC

Inputs:

Frequency (MHz)	7.0
Loop type	Square
Loop perimeter (m)	2.4
Wire diameter (mm)	1.0
Wire conductivity (S/m)	5.8e6
Load resistance (Ω)	50
Other loss (dB)	0.0
Received power (dBm)	-40.0

Calculate | Example 1 | Reset

Results:

Antenna factor (dB/m)	34.64
Field strength dBμV/m	101.63
Field strength dBμA/m	10.11

Copper conductance	5.70E+07
Permeability of free space	1.25664E-06
RG58C/U k1	1.30257E-05
RG58C/U k2	2.95286E-10
Balun loss (dB)	0.2
RG58C/U line length (m)	8
Loop side (m)	0.13
Loop wire diameter (m)	0.001
Loop area (m^2)	0.015625
Inductance of loop	4.74746E-07
Frequency step	1.2384
fmax (MHz	72.0
Frequency (MHz)	7.10
Transmission line loss (dB)	0.29
Radiation resistance	2.38747E-06
Loss resistance	1.11607E-01
Loop reactance	21.18
E/Voc (dB/m)	52.68
Loop R	0.11
Loop X	21.18
Receiver R	50.00
Receiver X	0.00
Voc/Vl (dB)	0.73
Antenna Factor (dB/m)	53.90
Isotropic 50 ohms Antenna Factor (dB)	12.75
Gain (dBi)	-65.67

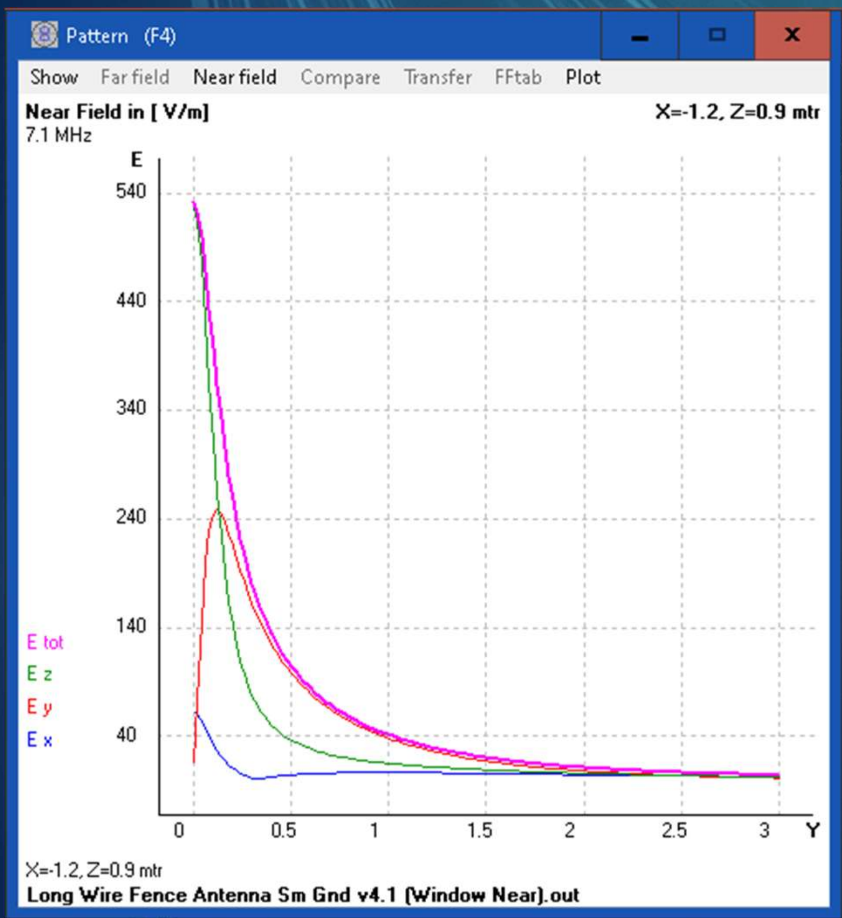
My Version

MY VERSION

- Initial measurements from 1m version and a 2.6m (VK1OD)

Measurement	Location	dBm	AF	E (dBm/m)	E (V/m)	W/m^2	mW/cm^2	Delta (db)
1m PWM	Window	-3.0	56	53	100	26.46	2.646	
1m SA	Window	3.0	56	59	199	105.3	10.535	
2.6m SA	Window	6.3	37	43	33	2.809	0.281	
1m PWM	2 Feet	-14.0	56	42	28	2.102	0.210	11
1m SA	2 Feet	-8.0	56	48	56	8.368	0.837	11
2.6m SA	2 Feet	-1.4	37	36	14	0.486	0.049	8
2.6m SA	3 feet	-2.3	37	35	12	0.388	0.039	6
2.6m SA	4.75 Feet	-2.3	37	35	12	0.394	0.039	12

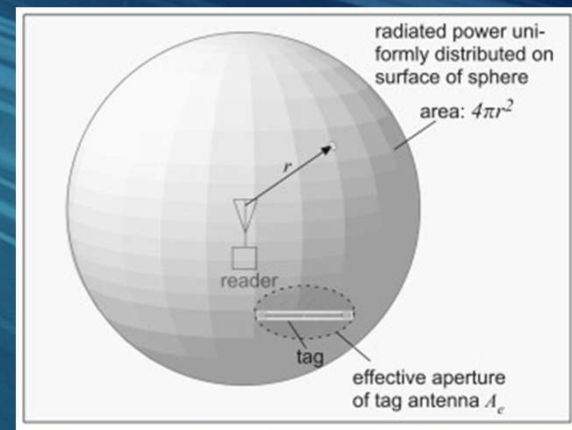
COMPARISON



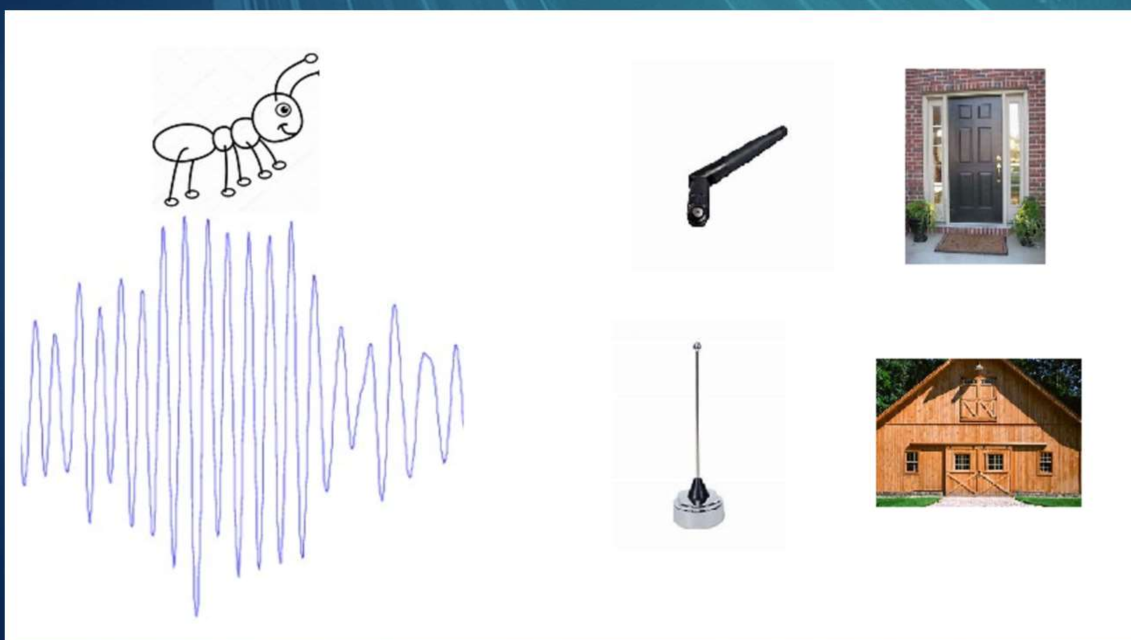
Measurement	Location	E (V/m)	NEC (E_y)
1m PWM	Window	100	190
1m SA	Window	199	190
2.6m SA	Window	33	190
1m PWM	2 Feet	28	45
1m SA	2 Feet	56	45
2.6m SA	2 Feet	14	45
2.6m SA	3 feet	12	35
2.6m SA	4.75 Feet	12	25

Winner Winner Chicken Dinner!!

NOODLING NEEDED



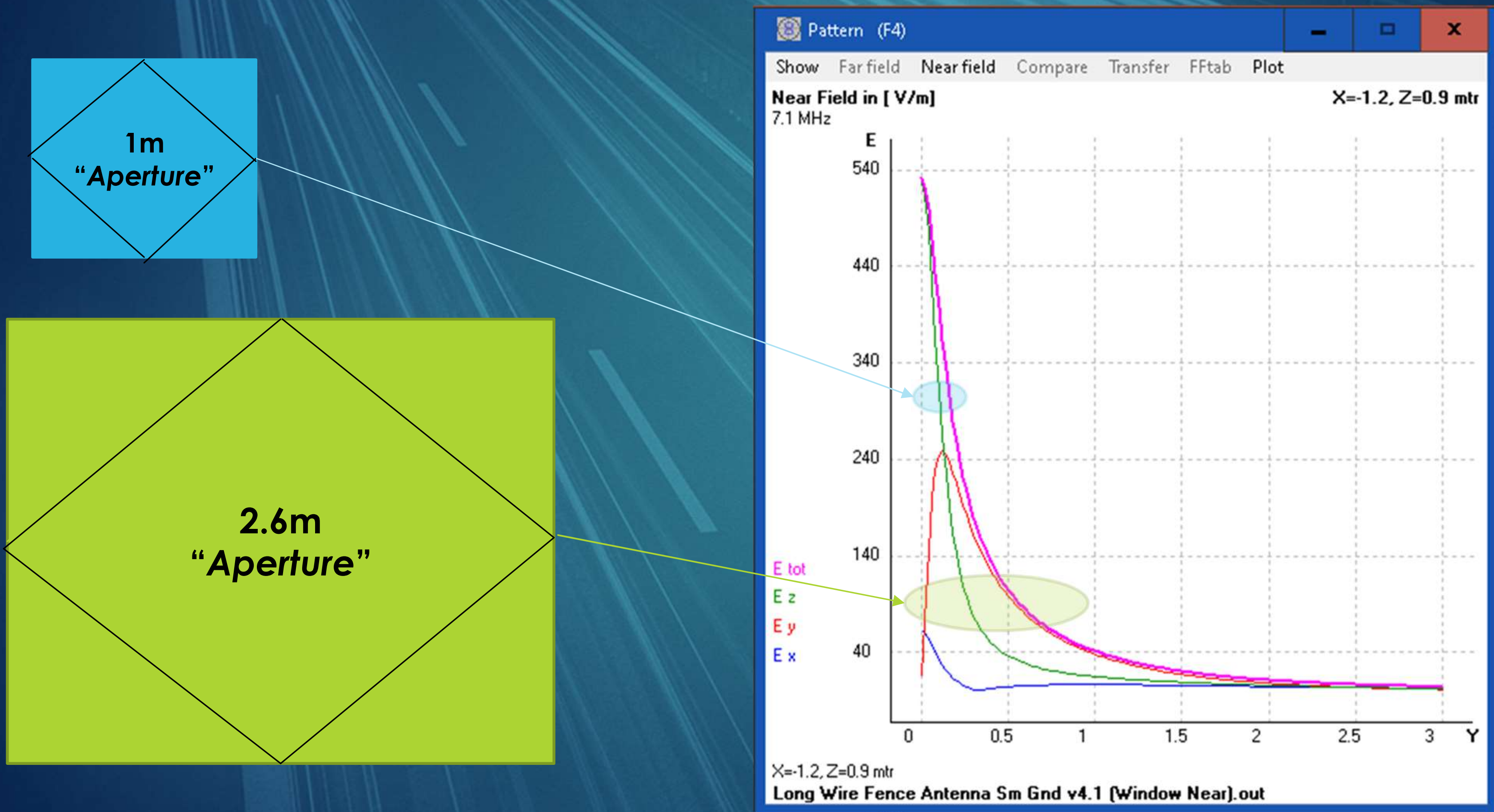
In electromagnetics and antenna theory, **antenna aperture, effective area, or receiving cross section**, is a measure of how **effective an antenna is at receiving the power** of electromagnetic radiation (such as radio waves)



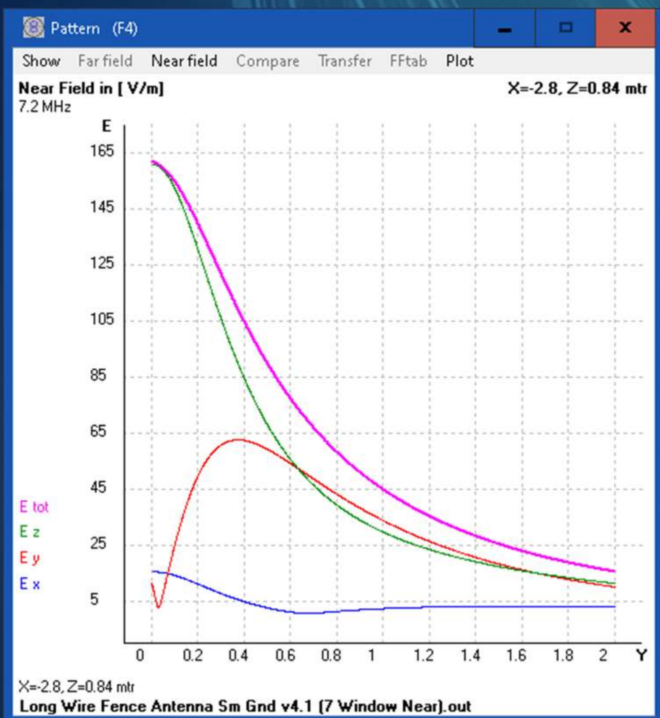
Theoretical or Electrical Prosperity
e.g.

- **Untuned antenna looks like a house door…a much smaller effective area**
- **Tuned antenna looks like a barn door… a much larger effective area**
- **Includes "physical characterizes", losses, and scattering**

NOODLING NEEDED



DETAILED COMPARISON



Measurement	Location	dBm	AF	E (dBm/m)	E (V/m)	NEC (E_T) (V/m)	NEC (E_y) (V/m)	EMF Meter (V/m)
1m SA	Window	2	56	58	178	135	55	957
1m SA	2'	-6	56	50	71	53	40	53
1m SA	3'	-9	56	47	51	40	30	38
1m SA	4.7'	-10	56	46	45	20	15	19

CONCLUSION

Enclosed Measurements & SC 6

Long Wire:

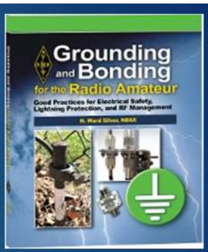
- ❖ NEC near field simulation
  - Understand Near Field analysis in 4Nec2
  - Measurement probe is comparable to 4Nec2
  - Attenuation from walls and E_y and E_x much lower that E_z

- ❖ NEC far field simulation
  - Efficiency questionable based on ground screen model (5 Parallel wires, no intersections). Can't model 2" x 4" screen.
  - Antenna works in practice. Decent contacts made. Published.
  - NEC says not very efficient. Low at lower frequencies
  - NEC efficiency does increase if I add 1 long radial
  - Need to experiment with different length antennas

FIN

Stay Safe

“RF GROUNDING”



The Earth, Ground, and Zero Volts

“The Earth is not a sink into which we can pour RF current or noise and simply have it disappear.” (Jim Brown, K9YC, and others) Across the wide range of frequencies, currents, and voltages encountered by amateurs, there is no way the Earth can be considered as a constant voltage, also known as an *equipotential surface*. Voltage drops from large lightning

RF Ground and Ground Planes

The idea of an “RF ground” is really a myth. No set of wires or even the Earth itself can maintain a constant voltage across a range of frequencies above a few kHz. That term creates unrealistic expectations. What we will use instead is the idea of an “RF ground plane.”

ductor” which are more exact references to what the connection is for. But the layer of soil and rock at the Earth’s surface is not a magic zero-voltage point into which we can pour any amount of electric charge where it safely disappears! The current’s strength and frequency, soil characteristics, wheth-