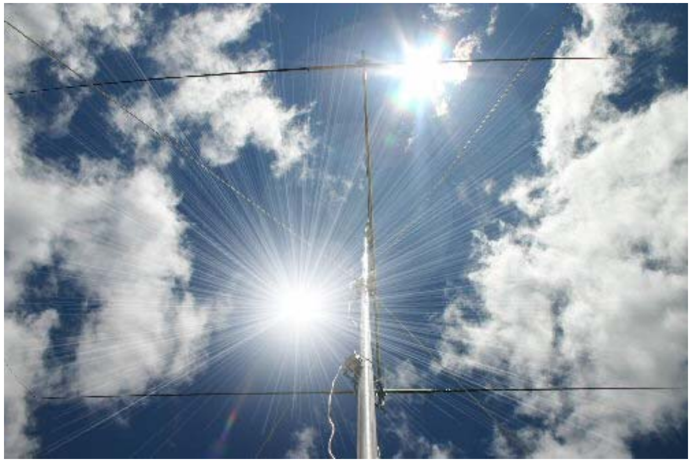
Genesis – the Birth of Antennas

"Why and How Antenna Ideas are Conceived, Computer Simulated, Constructed, and Born Into the Wild for Field Day"

Presenter
Gene Hinkle, K5PA, Austin, Texas
k5pa@arrl.net

No need to take notes. This entire presentation available at www.k5pa.com

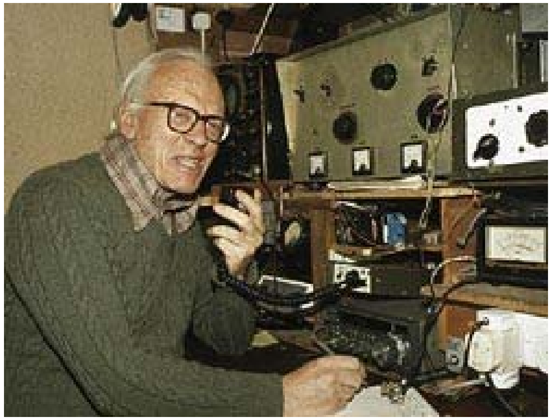


Dedications

- Dr. John D. Kraus
  - » W8JK
  - » Silent Key, July 18, 2004

Kraus

- Les Moxon
  - » G6XN
  - » Silent Key, March 11, 2004



Moxon

Genesis – Birth of Antennas

Why do it?

What do you need?

Genesis – Birth of Antennas

Great Outdoor Activities

Lots of FUN

Genesis – Birth of Antennas

Genesis – Birth of Antennas

Topics

Methods

- Conceptual Ideas
- Computer Modeling
- Construction
- Field Day Usage

Examples

- Wide Band Dipole
- Moxon Beam
- Flipbeam Array (FBA)
- Phased Dipole Array
- Reel Antenna

Idea Evolution Creating Antenna Solutions

- Wide Band Dipole
- Moxon Beam
- Flipbeam Array (FBA)

- Phased Dipole Array
- Reel Antenna

Wide Band Dipole

- Desirable Features

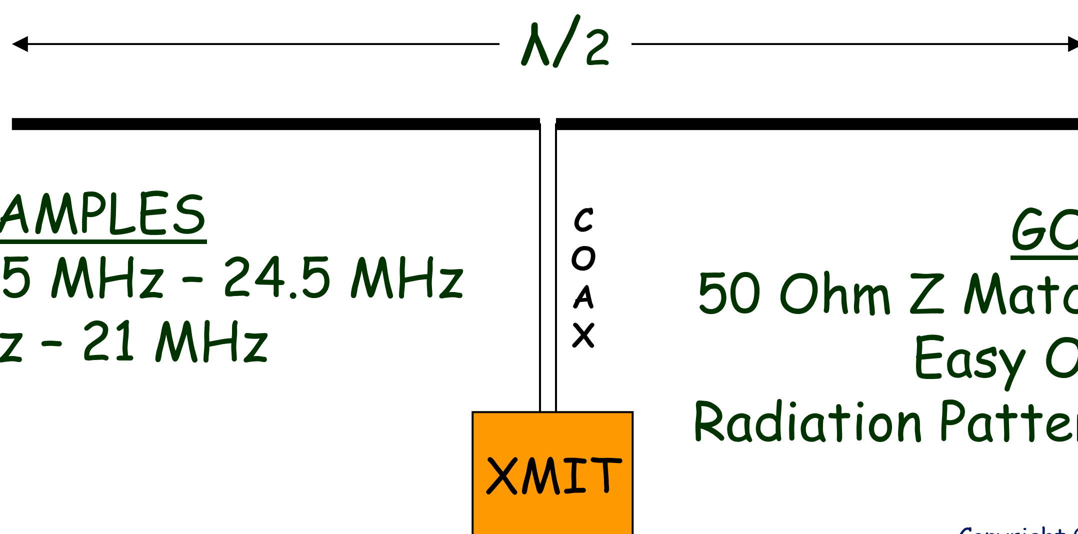
Multiple HF Bands	Easy to Match to Feedline
Fast Band Change	High Efficiency
Simple Design	

Wide Band Dipole

- Conceptual Idea

Basic Dipole is Half Wavelength Long

Great for Fundamental and Odd Harmonics



EXAMPLES
3.5 MHz – 10.5 MHz – 24.5 MHz
7 MHz – 21 MHz

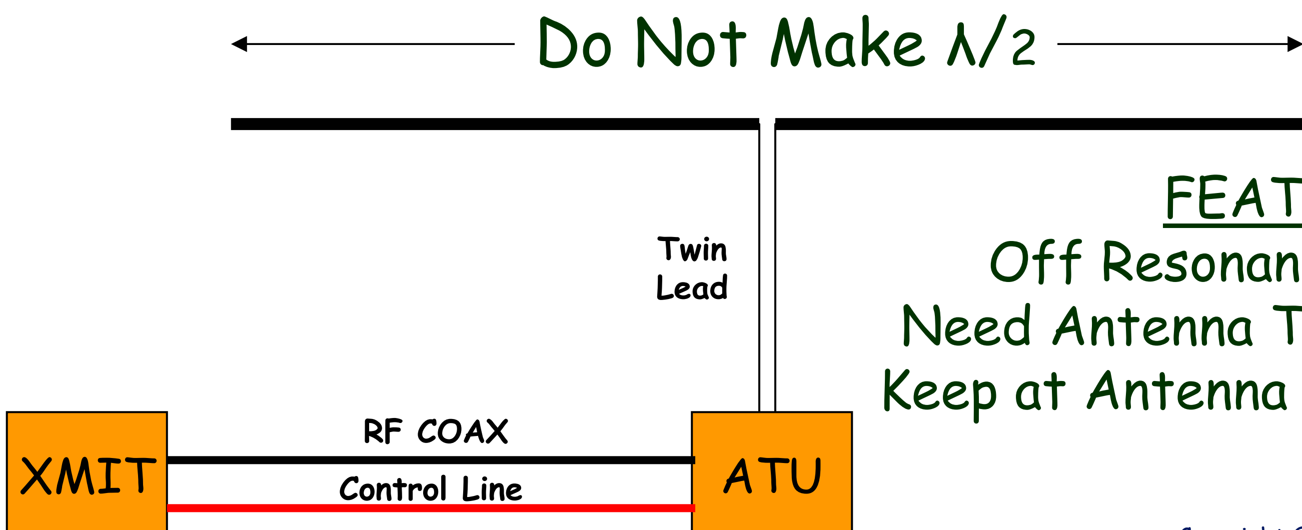
GOALS
50 Ohm Z Match to Transmitter
Easy Operation
Radiation Pattern Not Important

Wide Band Dipole

- Conceptual Idea

Problems

Wide Band Operations are Difficult to Achieve
Coax Losses at High VSWR

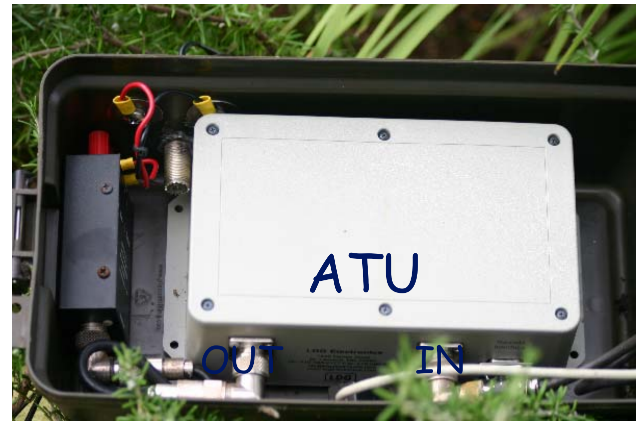


<u>FEATURES</u>
Off Resonance Operation
Need Antenna Tuner Unit (ATU)
Keep at Antenna to Reduce Losses

Wide Band Dipole

- Construction

4:1
BALUN



Tackle Box ATU

Balanced or Unbalance
Output Connections

Wide Band Dipole

- Construction

Wide Band Dipole

- Field Day Usage

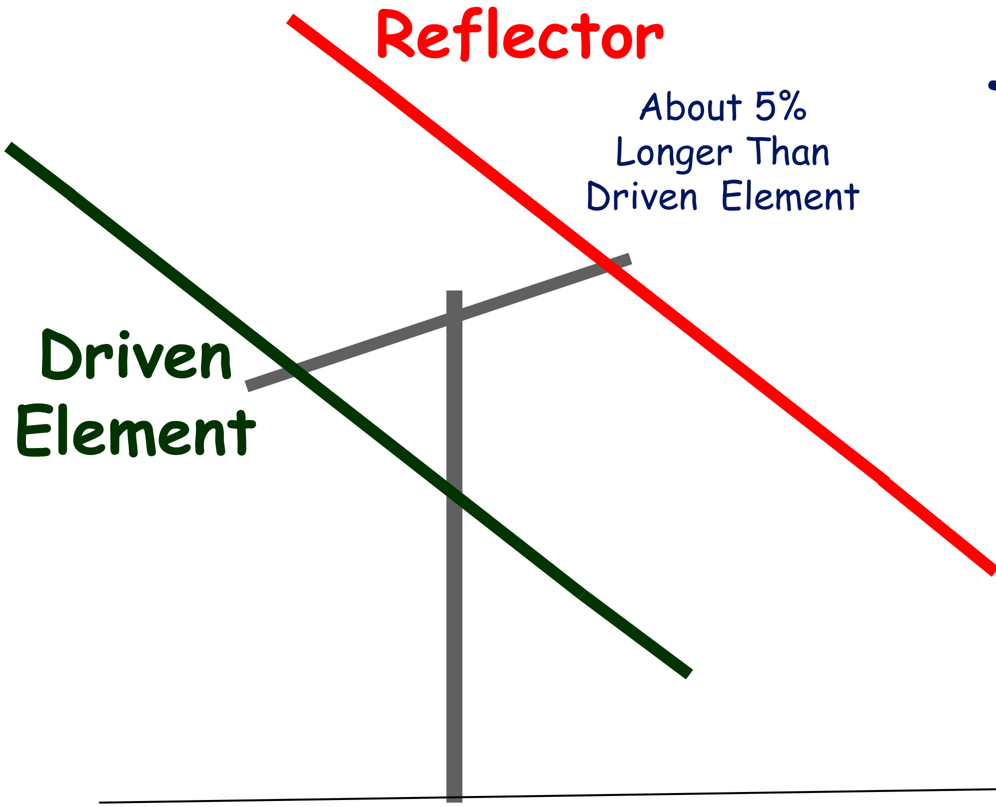
Moxon Beam

- Desirable Features

Gain Over Dipole	Easy to Match to Feedline
Good Front-to-Back Ratio	High Efficiency
Simple Design	Inexpensive
Small Size	Can Be Rotated

Moxon Beam

- Conceptual Idea

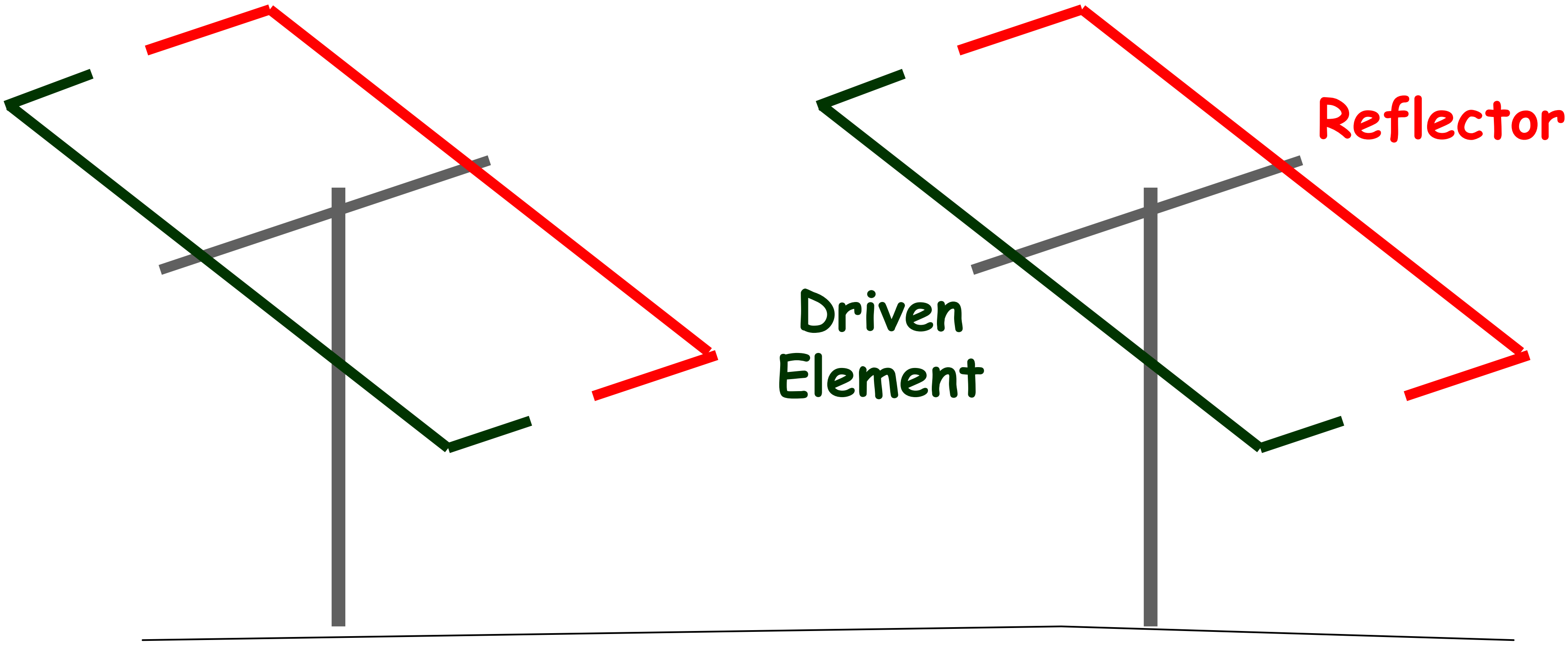


Basic 2-element
Beam

Take a 2-element
Yagi Beam
And Create New
Antenna

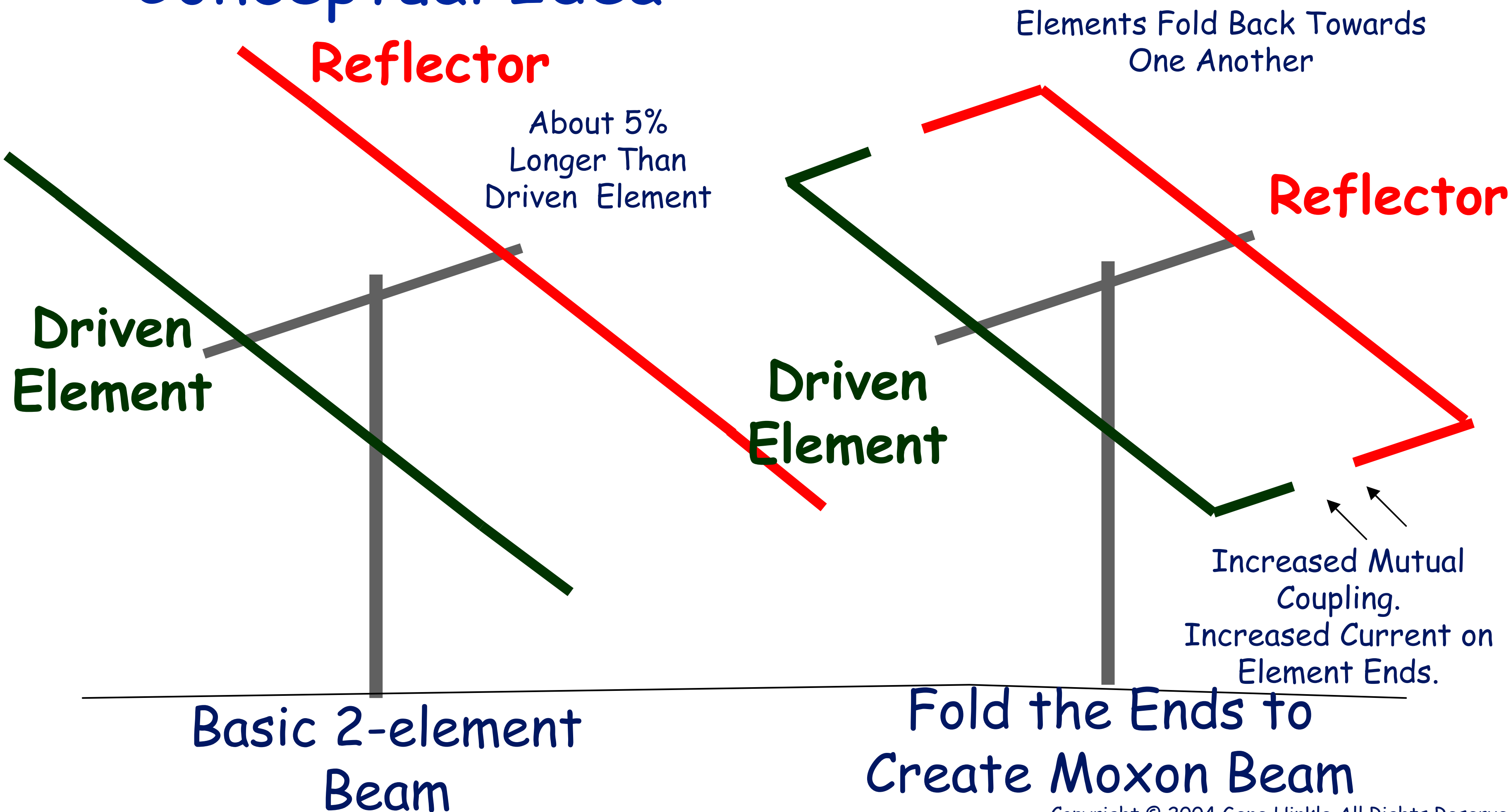
Moxon Beam

- Conceptual Idea



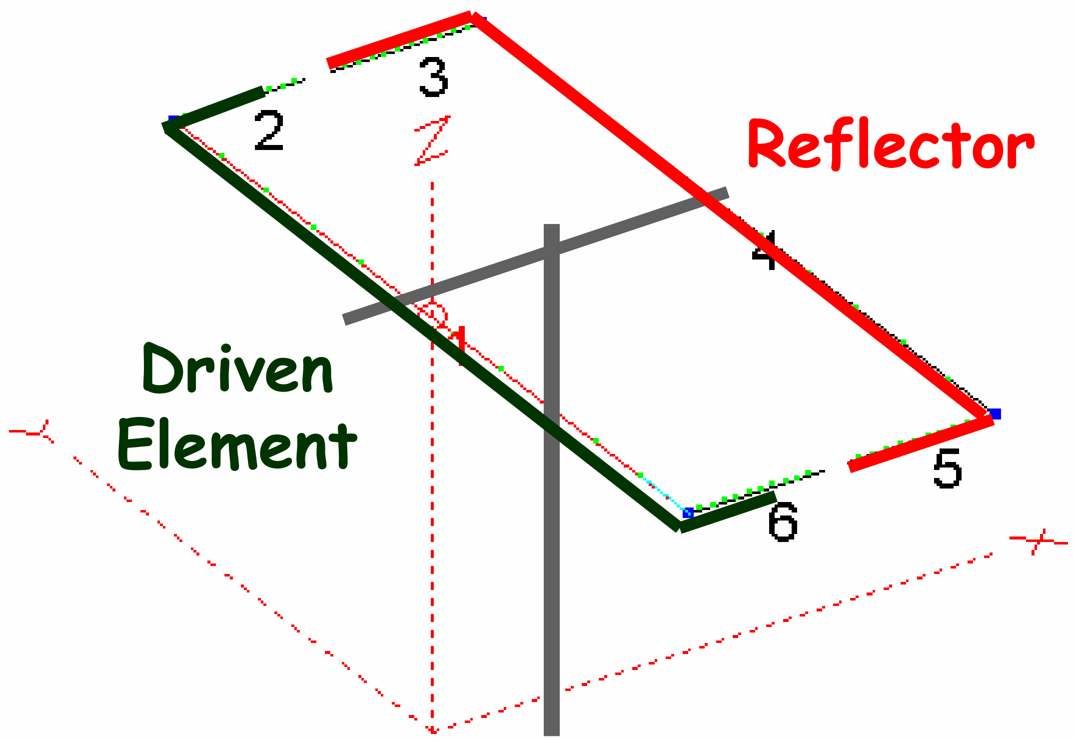
Moxon Beam

- Conceptual Idea



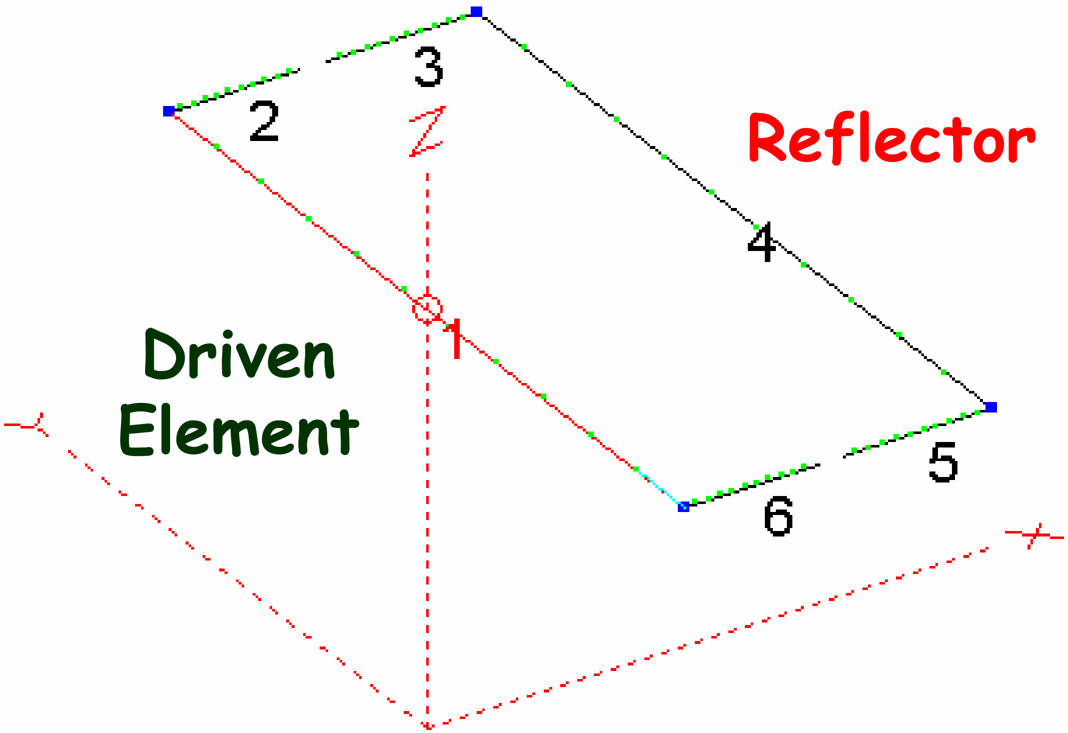
Moxon Beam

- Conceptual Idea



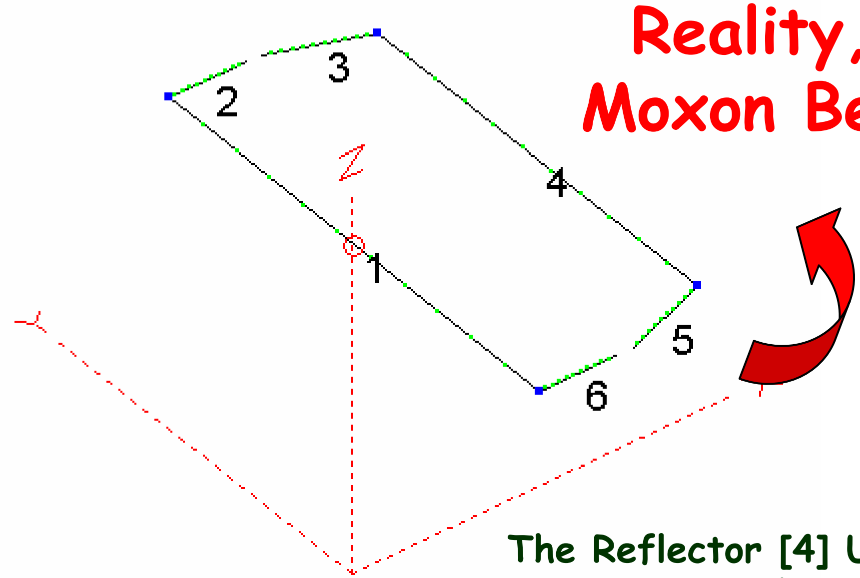
Moxon Beam

- Modeling the Moxon



Moxon Beam

- Modeling



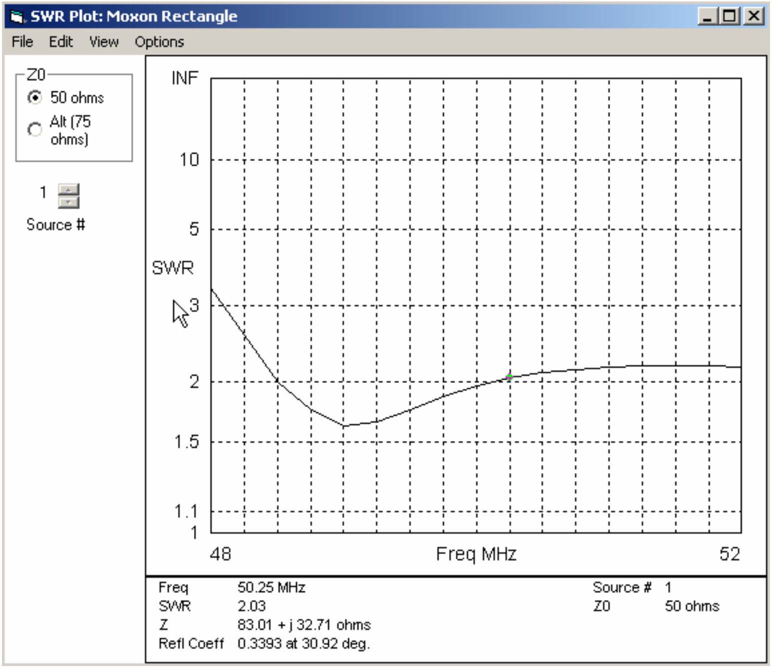
Reality, Stressed Moxon Bends Inward

The Reflector [4] Uses Insulated Wire – Dielectric Loading Shortens Effective Length

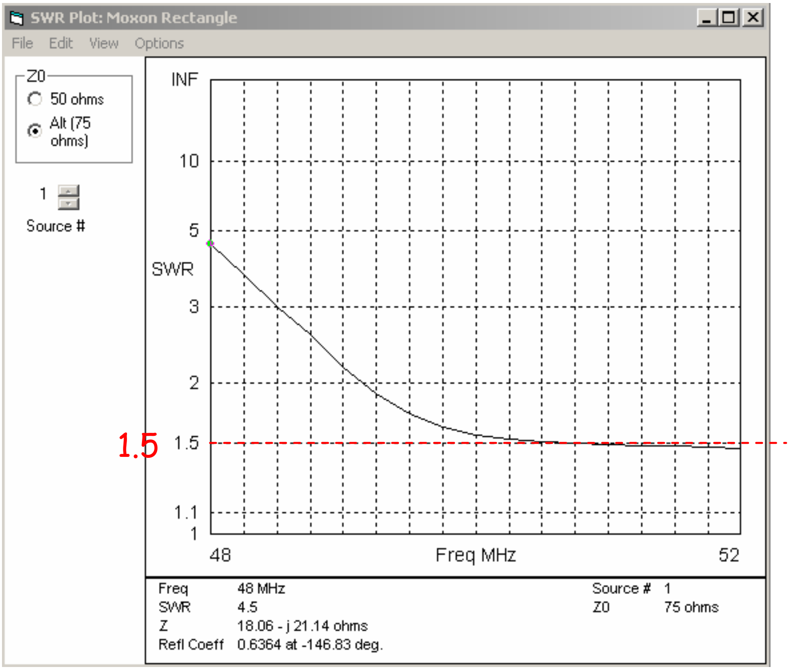
Wires												
No.	End 1				End 2				Diameter	Segs	Insulation	
	X (in)	Y (in)	Z (in)	Conn	X (in)	Y (in)	Z (in)	Conn	(in)		Diel C	Thk (in)
1	0.5	-42.5	118	W6E2	0.5	42.5	118	W2E1	1	11	1	0
2	0.5	42.5	118	W1E2	14.125	42.5	118		0.25	11	1	0
3	16.625	42.5	118		32.75	36.625	118	W4E1	0.25	11	1	0
4	32.75	36.625	118	W3E2	32.75	-36.625	118	W5E1	#14	11	3.5	0.05
5	32.75	-36.625	118	W4E2	16.625	-42.5	118		0.25	11	1	0
6	14.125	-42.5	118		0.5	-42.5	118	W1E1	0.25	11	1	0
*												

Moxon Beam

- Modeling



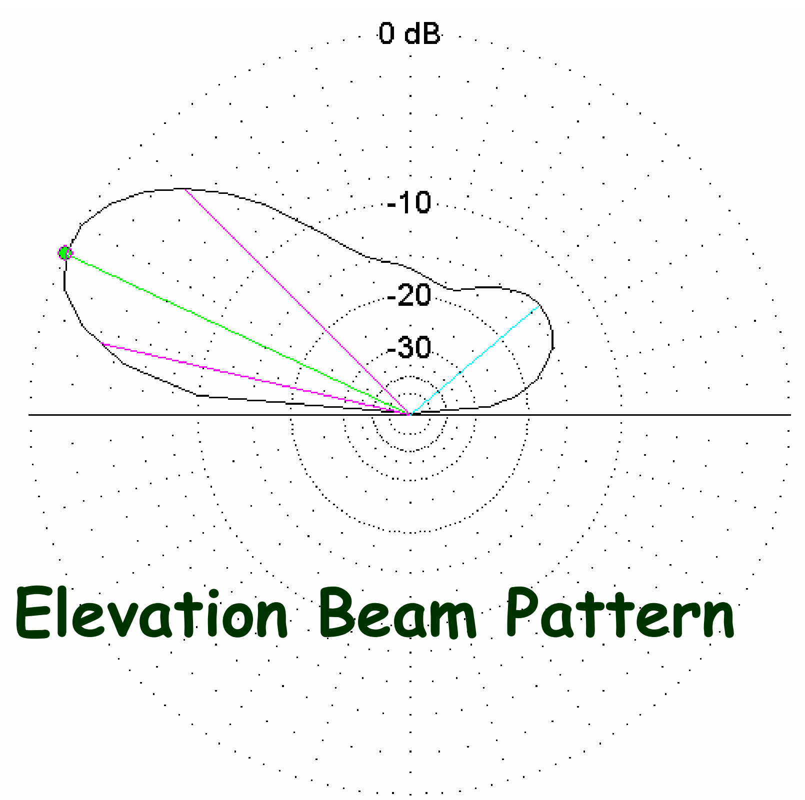
VSWR with 50 Ohm Source Impedance



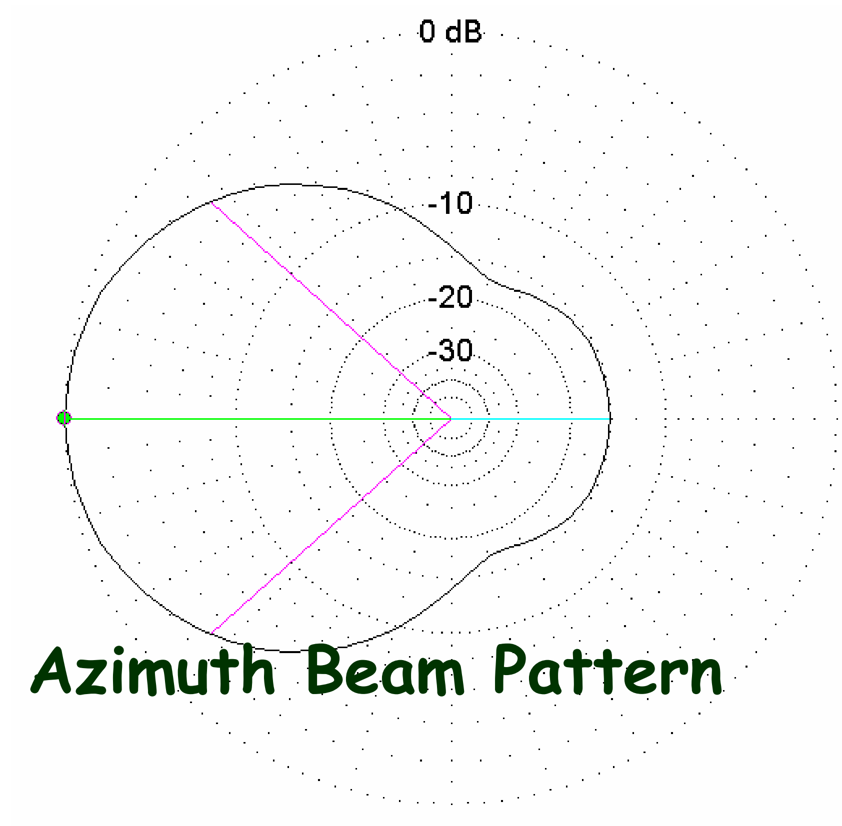
VSWR with 75 Ohm Source Impedance

Moxon Beam

- Modeling



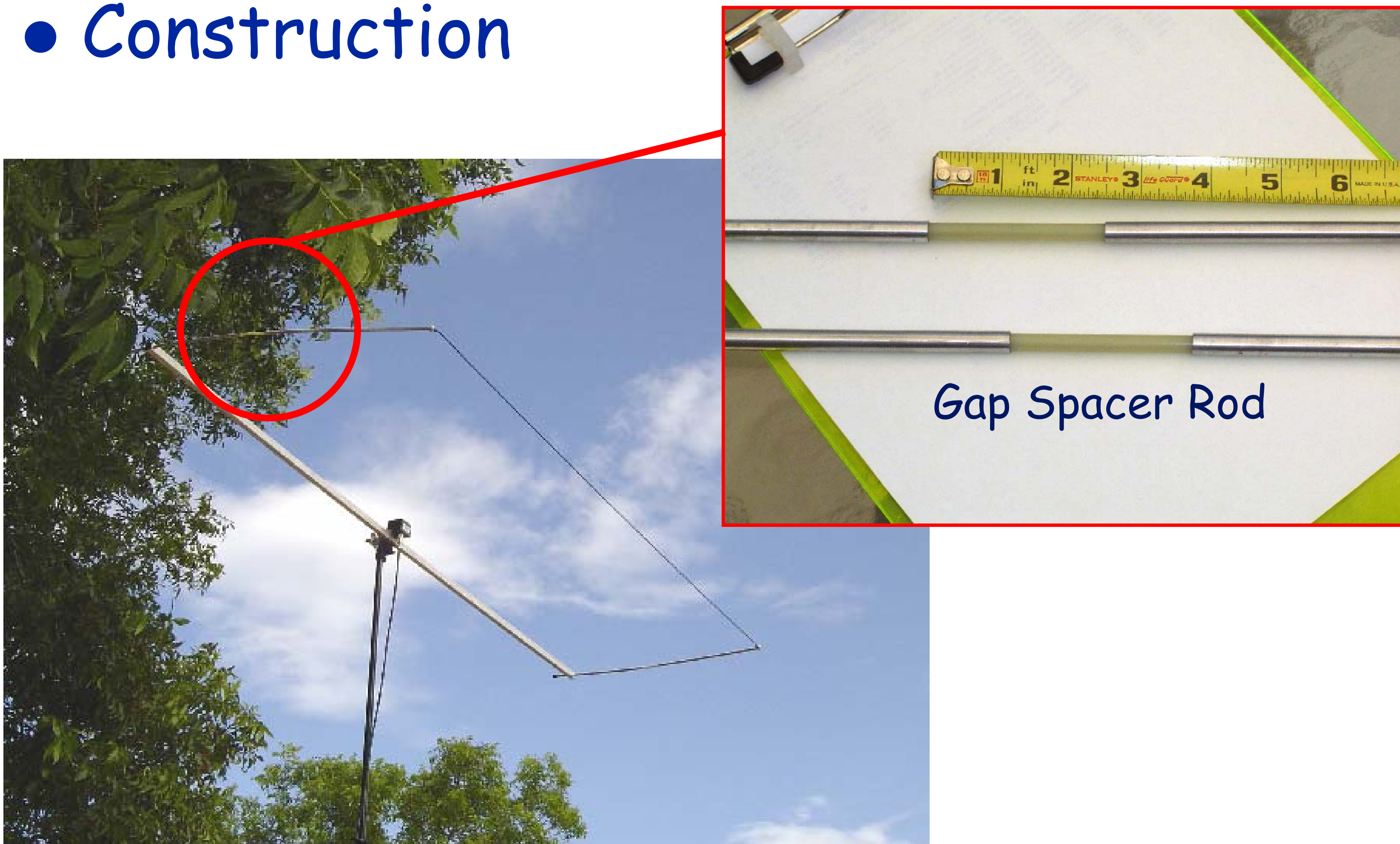
Elevation Beam Pattern



Azimuth Beam Pattern

Moxon Beam

- Construction



Moxon Beam

- Construction

Moxon Beam

- Construction

Moxon Beam

- Field Day Usage

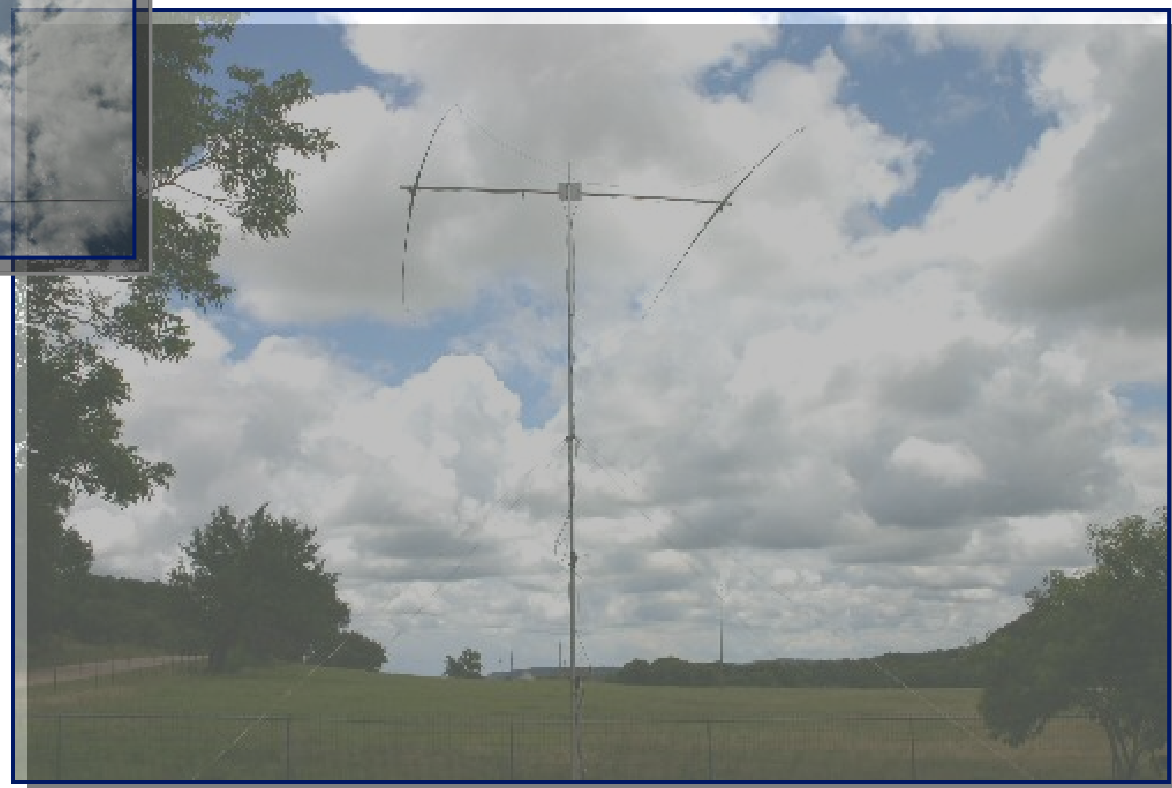
Flipbeam Array (FBA)

- Desirable Features

Gain Over Dipole	Easy to Match to Feedline
Good Front-to-Back Ratio	High Efficiency
Simple Design	Inexpensive
Small Size	Instant Rotation

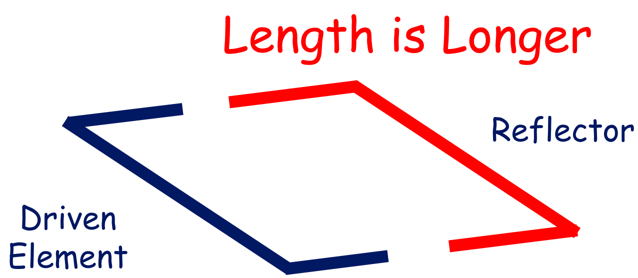
Flipbeam Array (FBA)

- Conceptual Idea

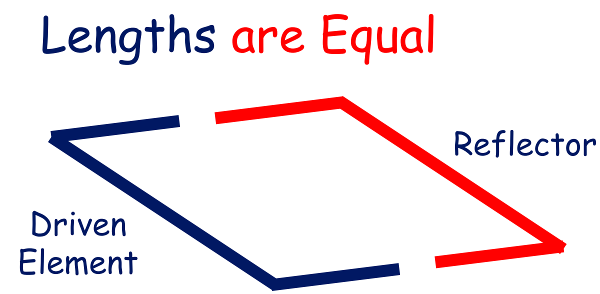


Flipbeam Array (FBA)

- Conceptual Idea



Moxon is Asymmetrical

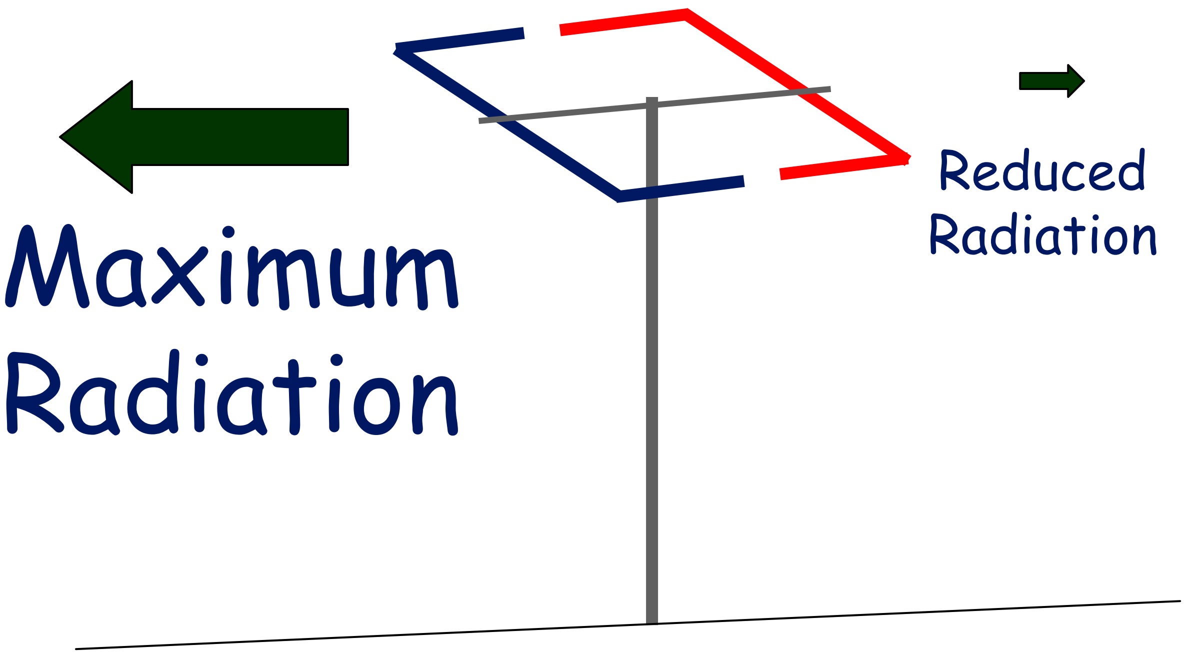


FBA is Symmetrical

So, Electrically, Lengthen
The Reflector
But... HOW?

Flipbeam Array (FBA)

- Modeling

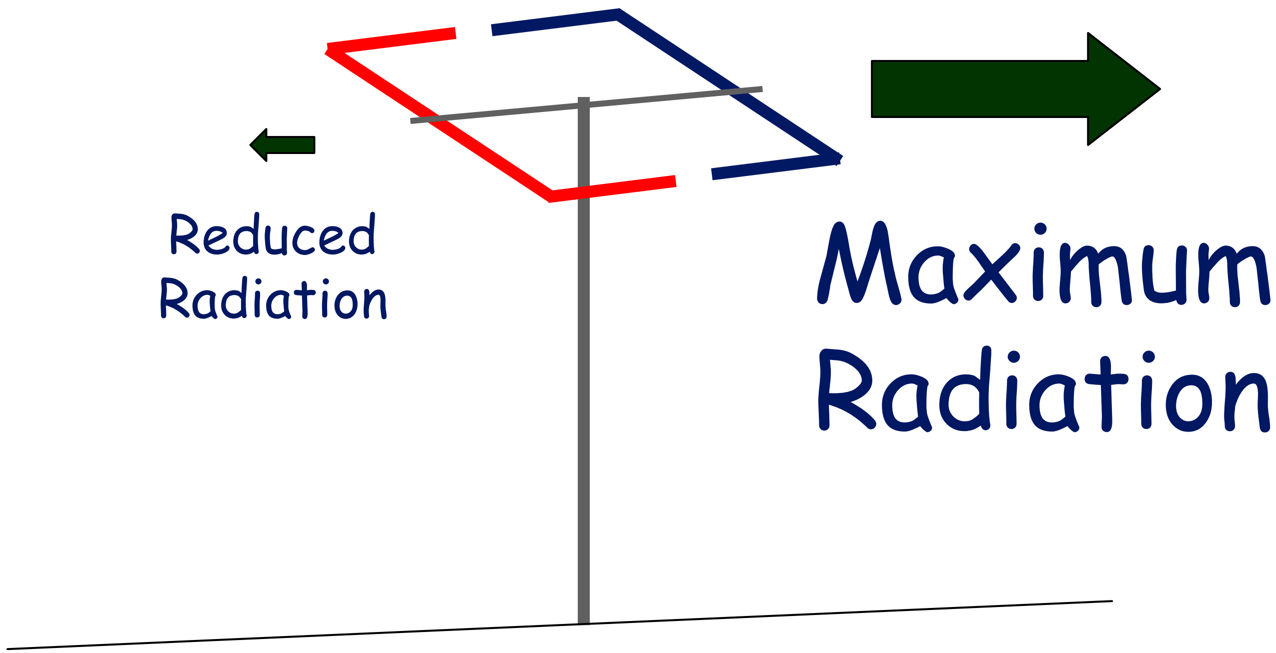


Two Feed Lines

One for Power, The **Other** For Loading

Flipbeam Array (FBA)

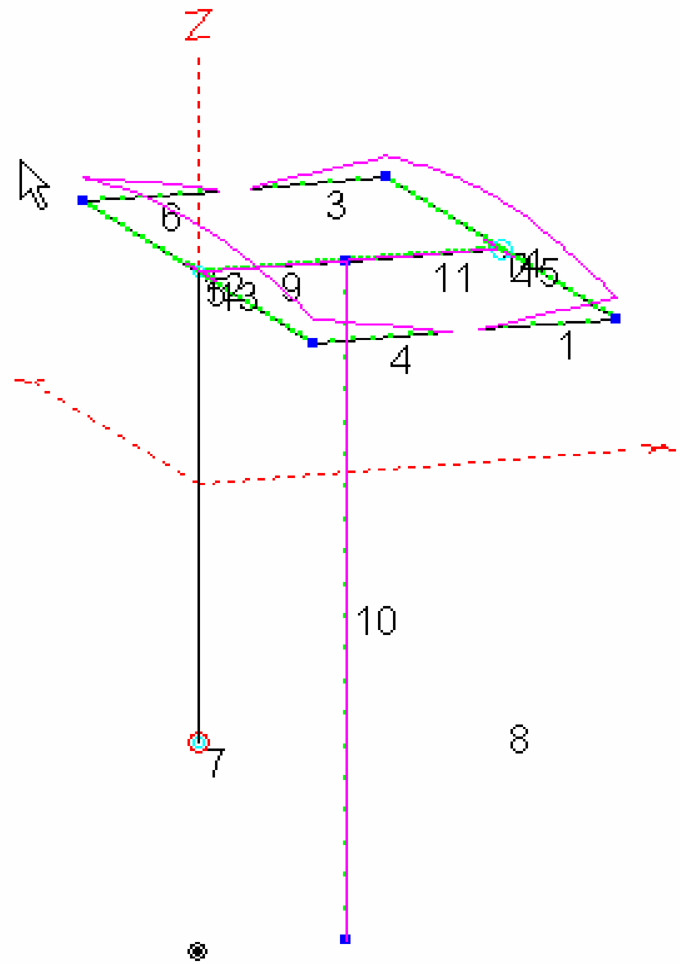
- Modeling



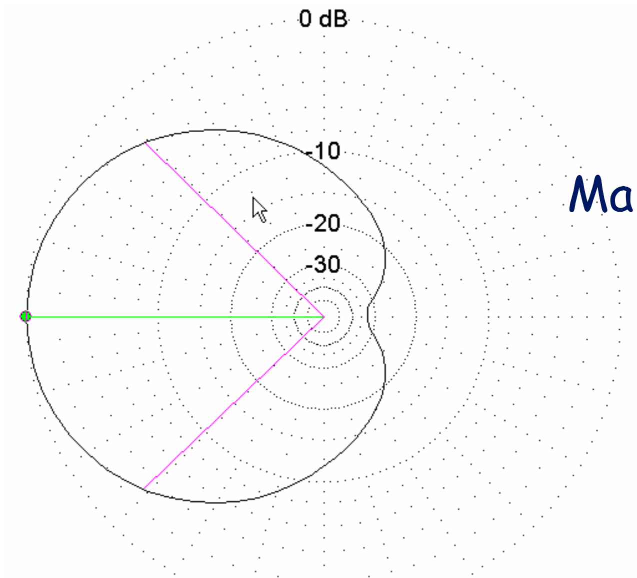
Then Flip

Flipbeam Array (FBA)

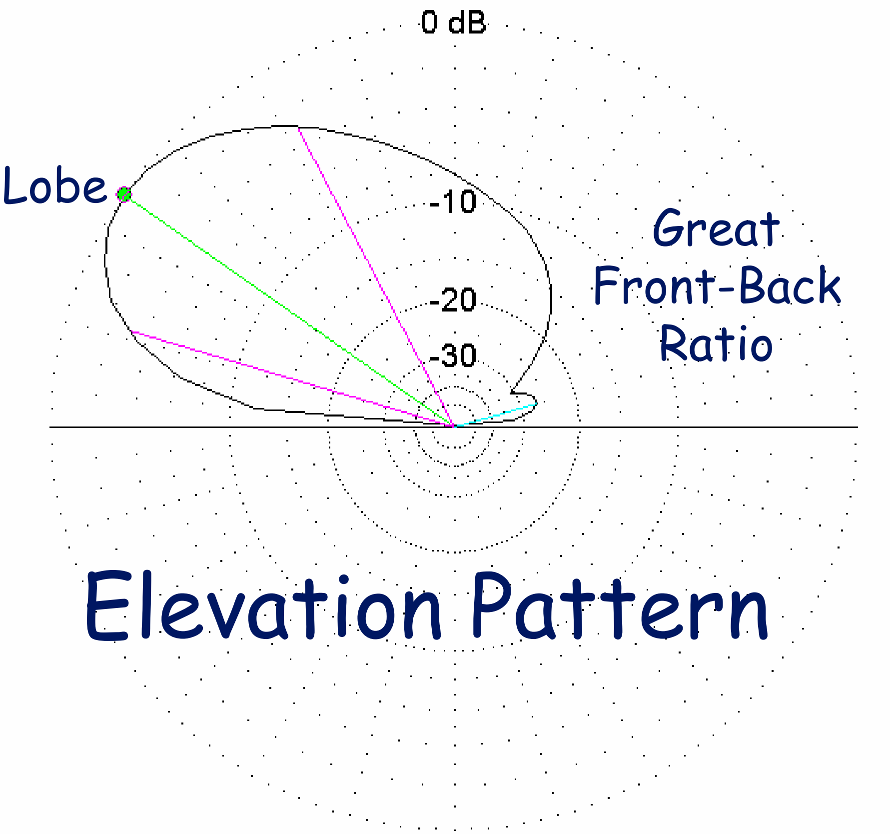
- Modeling



AZ-EL Patterns

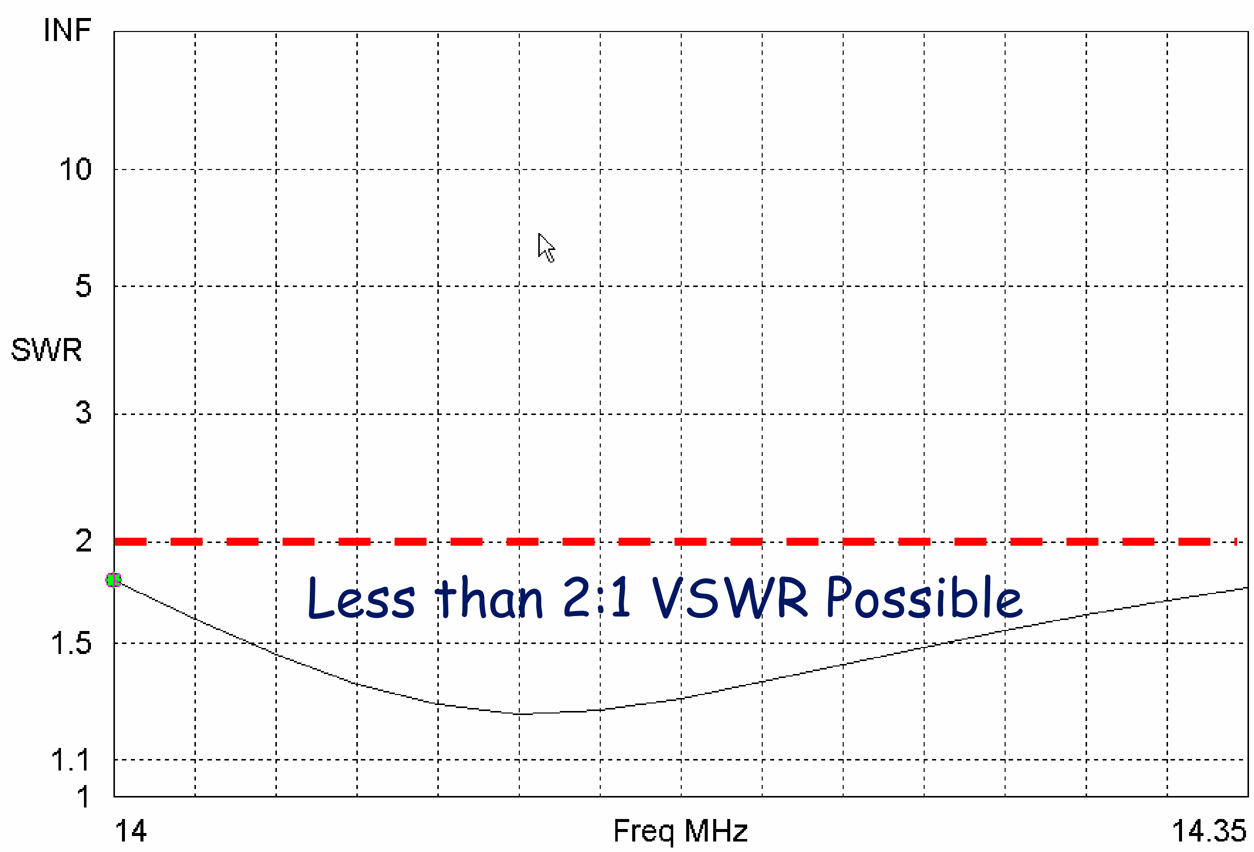


Azimuth Pattern



Elevation Pattern

VSWR Bandwidth Curves



EZNEC+ ver. 4.0

Flip Beam Ant (FBA) 14200 MHZ 7/2/2004 4:31:22 PM

--------------- ANTENNA DESCRIPTION ---------------

Frequency = 14.25 MHz
Wire Loss: Copper -- Resistivity = 1.74E-08 ohm-m, Rel. Perm. = 1

--------------- WIRES ---------------

No.	End 1 Conn.	End 1 Coord. (in) X	Y	Z	End 2 Conn.	End 2 Coord. (in) X	Y	Z	Dia (in)	Segs	Insulation Diel C	Thk(in)
1		72.507,	-141.11,	298	W2E1	132.676,	-141.11,	298	#18	5	1	0
2	W1E2	132.676,	-141.11,	298	W3E1	132.676,	141.11,	298	#12	35	1	0
3	W2E2	132.676,	141.11,	298		72.507,	141.11,	298	#18	5	1	0
4		60.1671,	-141.11,	298	W5E1	0,	-141.11,	298	#18	7	1	0
5	W4E2	0,	-141.11,	298	W6E1	0,	141.11,	298	#18	35	1	0
6	W5E2	0,	141.11,	298		60.1671,	141.11,	298	#12	7	1	0
7		0,	1.0285,	92		0,	-1.0285,	92	#12	1	1	0
8		132.676,	1.0285,	92		132.676,	-1.0285,	92	#12	1	1	0
9		1,	0,	298	W10E2	65,	0,	298	1.625	21	1	0
10	GND	65,	0,	0	W11E1	65,	0,	298	2	21	1	0
11	W9E2	65,	0,	298		131.676,	0,	298	1.625	21	1	0
12		1,	18,	298		1,	1.25,	298	0.5	11	1	0
13		1,	-18,	298		1,	-1.25,	298	0.5	11	1	0
14		131.676,	18,	298		131.676,	1.25,	298	0.5	11	1	0
15		131.676,	-18,	298		131.676,	-1.25,	298	0.5	11	1	0

Total Segments: 203

-------------- SOURCES --------------

No.	Specified Pos. Wire #	Specified Pos. % From E1	Actual Pos. % From E1	Actual Pos. Seg	Amplitude (V/A)	Phase (deg.)	Type
1	7	50.00	50.00	1	1	0	V

No loads specified

-------- TRANSMISSION LINES ---------

No.	End 1 Specified Pos Wire #	End 1 Specified Pos % From E1	End 1 Act % From E1	End 2 Specified Pos Wire #	End 2 Specified Pos % From E1	End 2 Act % From E1	Length (in)	Z0 (ohms)	VF	Rev/Norm
1	2	50.00	50.00	Open ckt			240	75	0.78	N
2	5	50.00	50.00	7	50.00	50.00	240	75	0.78	N

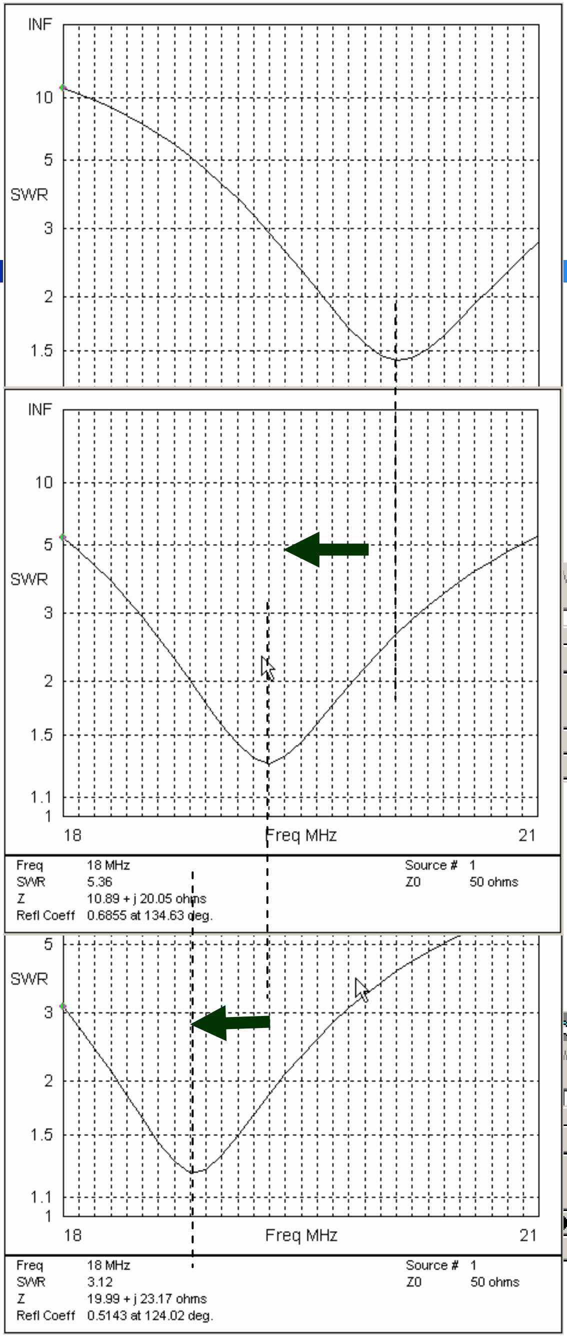
Ground type is Real, MININEC-Type

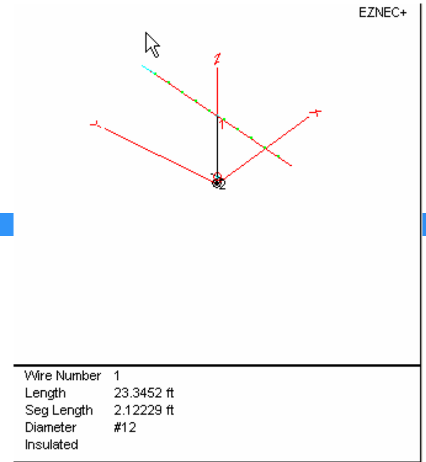
--------------- MEDIA ---------------

No.	Cond. (S/m)	Diel. Const.	Height (in)	R Coord. (in)
1	0.005	13	0	0

Flipbeam Array (FBA)

- Construction





Dielectric Constant = 3.5
Epoxy Material Fiber Glass

Thickness Wall Varied

50 Mil Thickness

Wire Create Edit Other

☐ Coord Entry Mode ☐ Preserve Connections ☑ Show Wire Insulation

Wires

No.	End 1				End 2				Diameter	Segs	Insulation	
	X (ft)	Y (ft)	Z (ft)	Conn	X (ft)	Y (ft)	Z (ft)	Conn	(in)		Diel C	Thk (in)
1	0	11.5	12		0	-11.5	8		#12	11	3.5	0.05
2	0	1	1		0	-1	1		#12	1	1	0

100 Mil Thickness

Wires

Wire Create Edit Other

☐ Coord Entry Mode ☐ Preserve Connections ☑ Show Wire Insulation

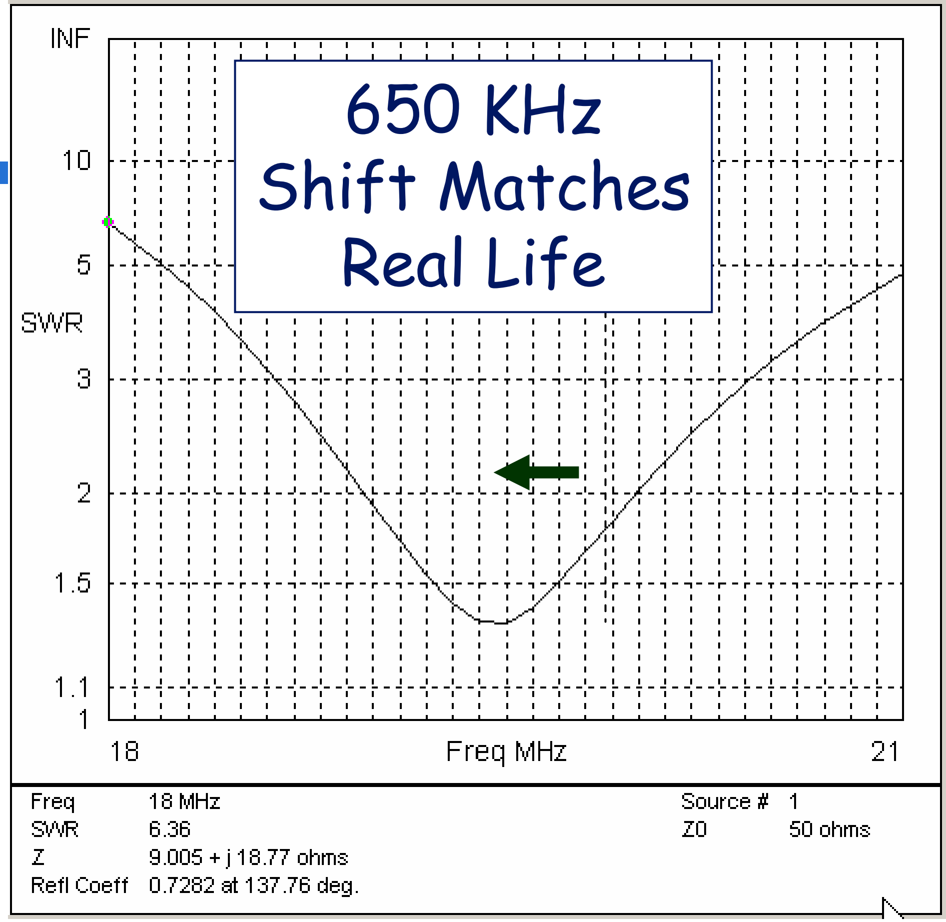
Wires

No.	End 1				End 2				Diameter	Segs	Insulation	
	X (ft)	Y (ft)	Z (ft)	Conn	X (ft)	Y (ft)	Z (ft)	Conn	(in)		Diel C	Thk (in)
1	0	11.5	12		0	-11.5	8		#12	11	3.5	0.1
2	0	1	1		0	-1	1		#12	1	1	0

Modeled Resonance Shift With Thickness

F (MHz)	SWR	R (Ohms)	X (Ohms)	Diel C	Thick (MIL)
18.8	1.24	41	3.5	3.5	100
19.3	1.3	38.8	3.15	3.5	50
19.4	1.32	38.6	4.36	3.5	40
19.5	1.33	37.7	2.18	3.5	37
20.1	1.43	36.3	6.5	1	0

Modeled Vs. Real Life



Wires

Wire Create Edit Other

☐ Coord Entry Mode ☐ Preserve Connections ☑ Show Wire Insulation

37 Mil Thickness

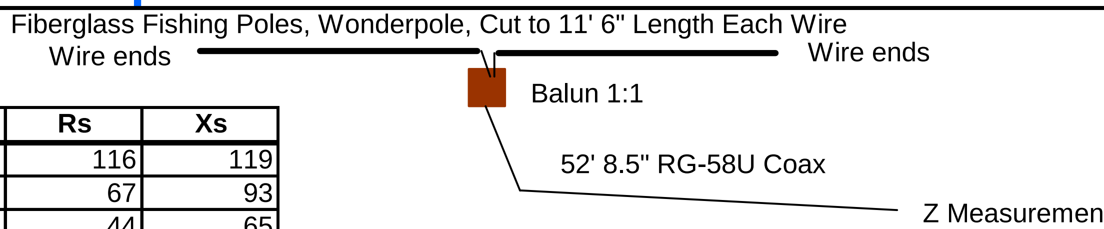
No.	End 1				End 2				Diameter	Segs	Insulation	
	X (ft)	Y (ft)	Z (ft)	Conn	X (ft)	Y (ft)	Z (ft)	Conn	(in)		Diel C	Thk (in)
1	0	11.5	12		0	-11.5	8		#12	11	3.5	0.037
2	0	1	1		0	-1	1		#12	1	1	0

Flipbeam Array (FBA)

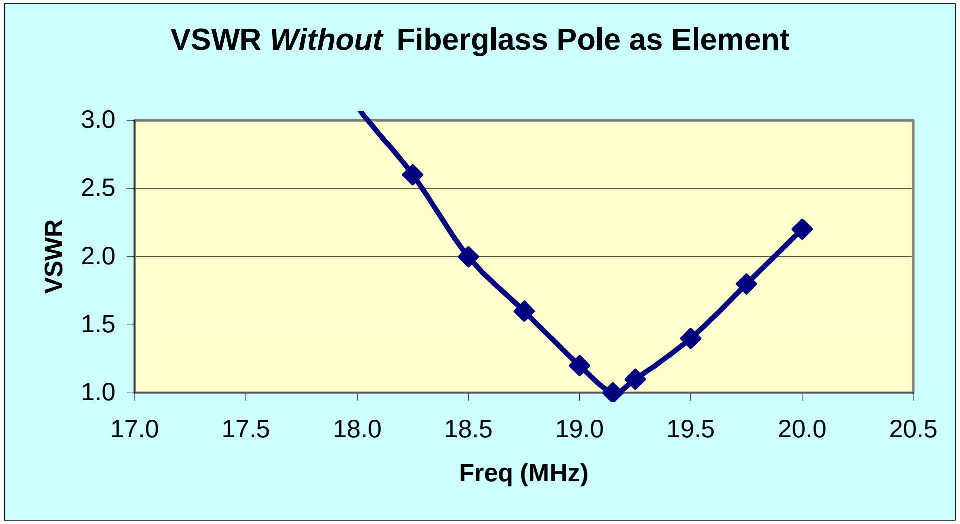
- Test Measurements
  - » Effect of Fiber Glass Loading on Resonance
  - » Test Dipole
  - » BALUN for Balanced Feed Line

Flipbeam Array (FBA)

- Construction Techniques
  - » Detuning Due to Fiber Glass Materials
  - » Basic Dipole Element - Baseline

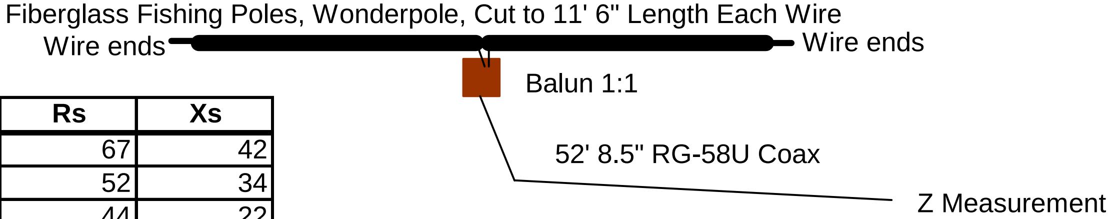


Fo	VSWR	Rs	Xs
17.500	4.3	116	119
17.750	3.7	67	93
18.000	3.1	44	65
18.250	2.6	37	46
18.500	2.0	35	29
18.750	1.6	37	17
19.000	1.2	44	8
19.150	1.0	50	4
19.250	1.1	55	4
19.500	1.4	69	12
19.750	1.8	69	33
20.000	2.2	50	47

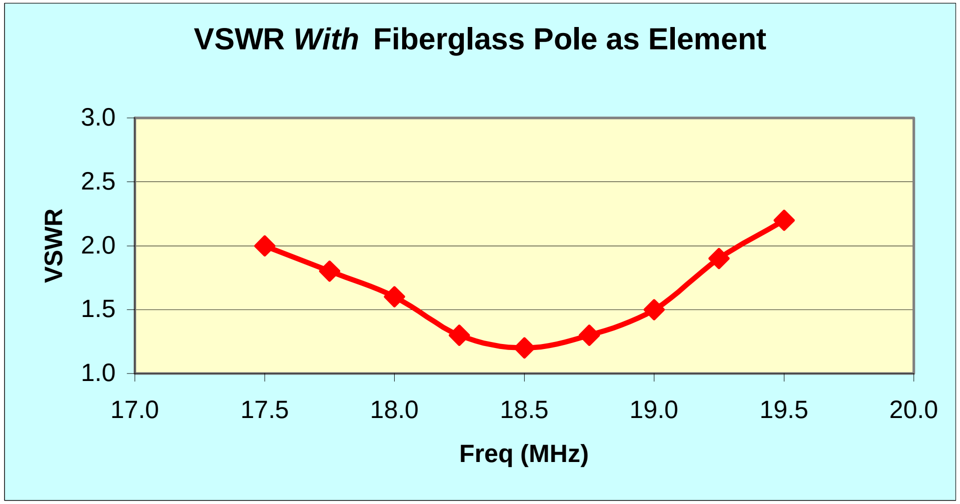


Flipbeam Array (FBA)

- Construction Techniques
  - » Fiber Glass Lowers Resonant Frequency
  - » Must Account for This in Final

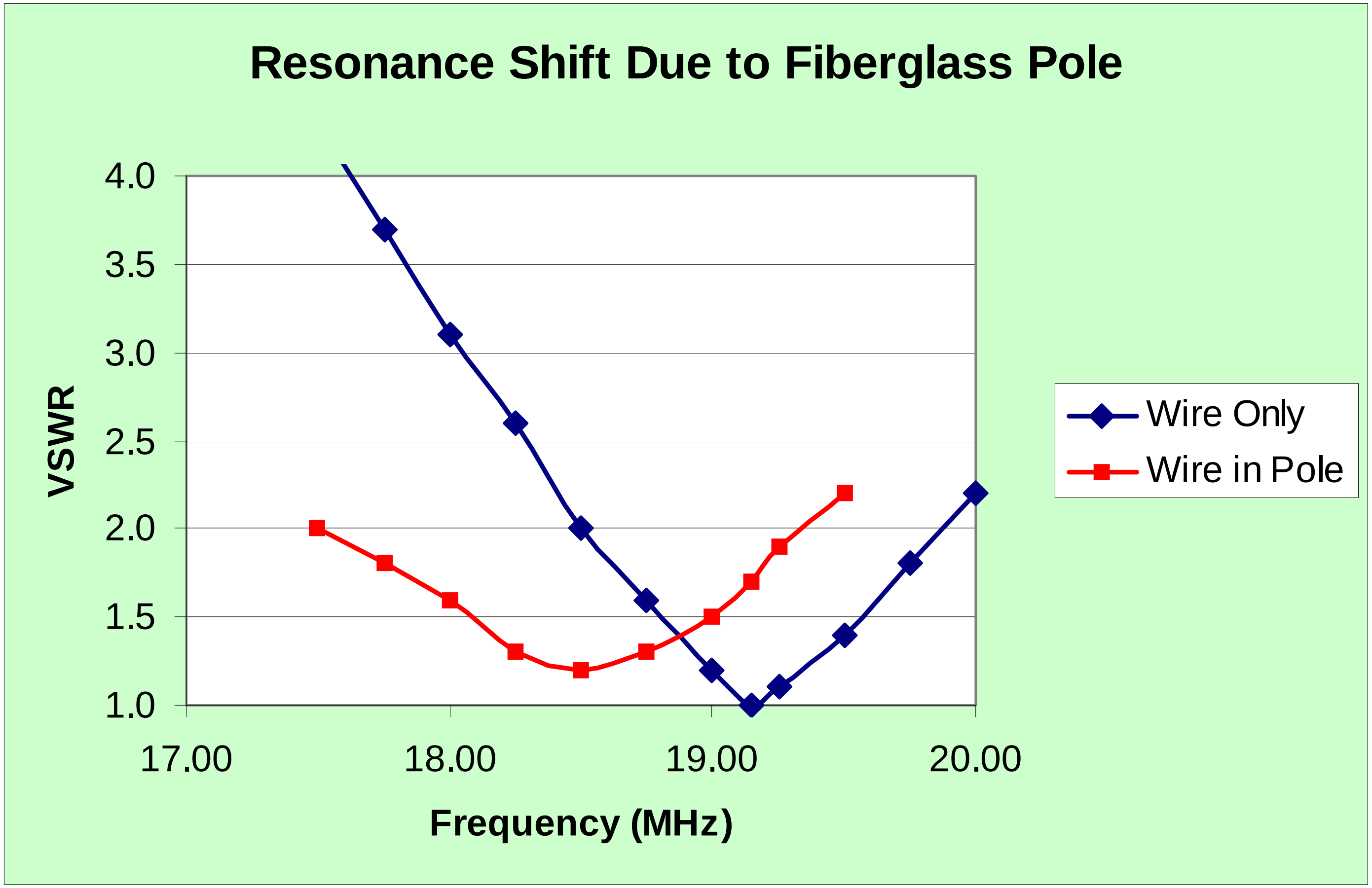


Fo	VSWR	Rs	Xs
17.500	2.0	67	42
17.750	1.8	52	34
18.000	1.6	44	22
18.250	1.3	41	11
18.500	1.2	43	7
18.750	1.3	52	14
19.000	1.5	67	20
19.250	1.9	88	23
19.500	2.2	95	44



Flipbeam Array (FBA)

- Construction Techniques
  - » Overall Shift is -650KHz, So Make Antenna Shorter!



Flipbeam Array (FBA)

- Construction Details

Driven Element

Wonderpole™ by Shakespeare

Flipbeam Array (FBA)

- Construction

Driven Element
Cross Arm Assembly

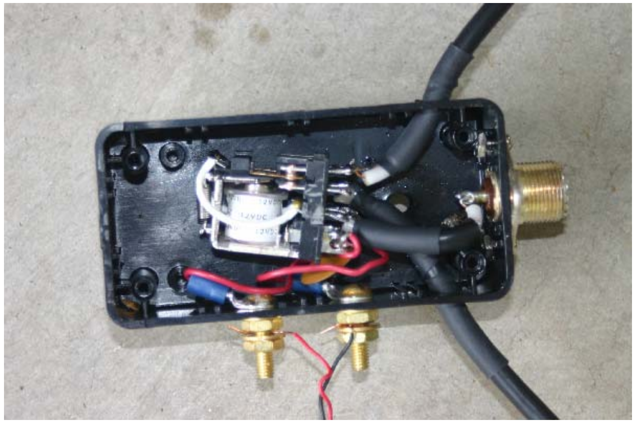
Element to Boom Assembly Bracket
Home Depot Home Product

Mast to Boom Assembly Bracket
DX Engineering Product

Flipbeam Array (FBA)

- Construction

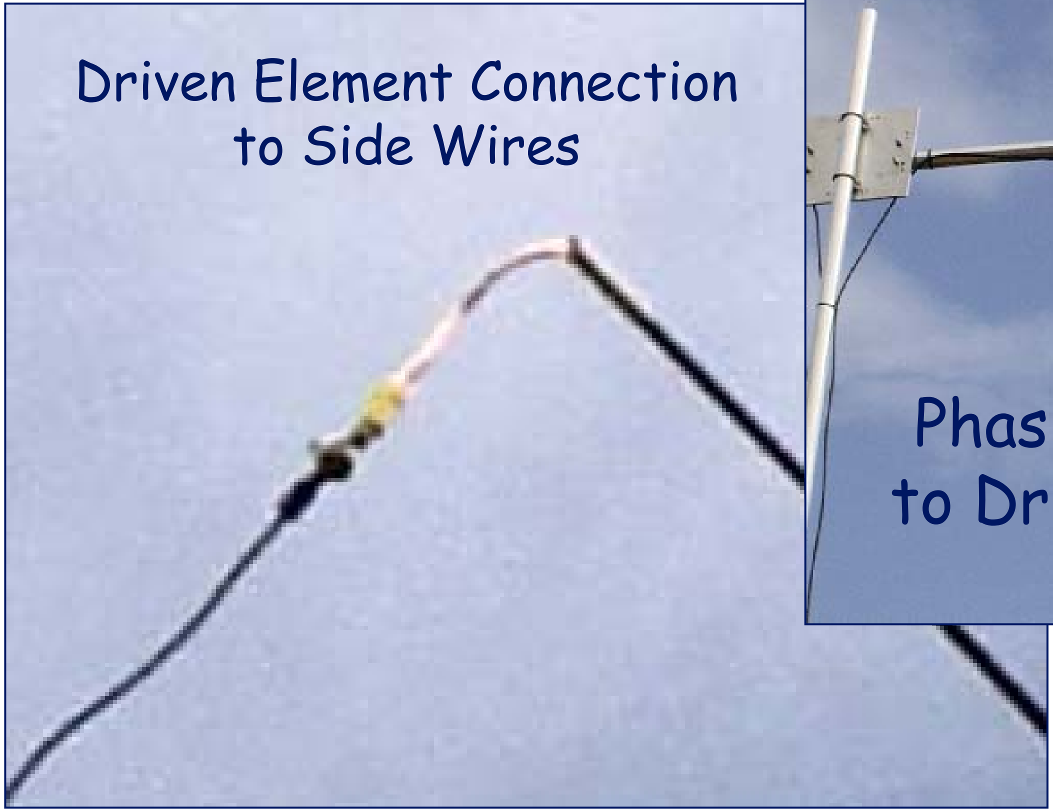
Phasing Harness with
Relay Box/Control Line



DPDT Relay with
N.O. Contacts

Flipbeam Array (FBA)

- Construction



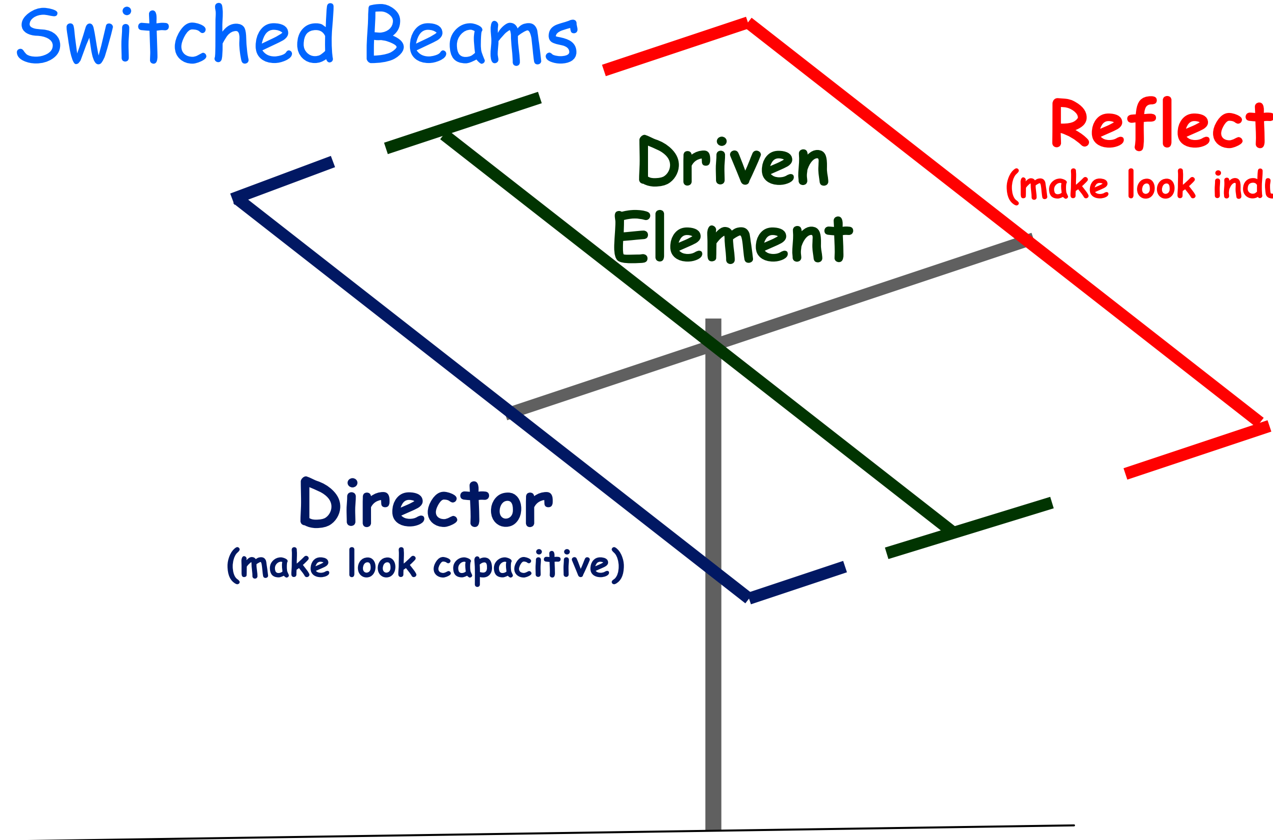
Flipbeam Array (FBA)

- Field Day Usage

Inspection of
RF Relay

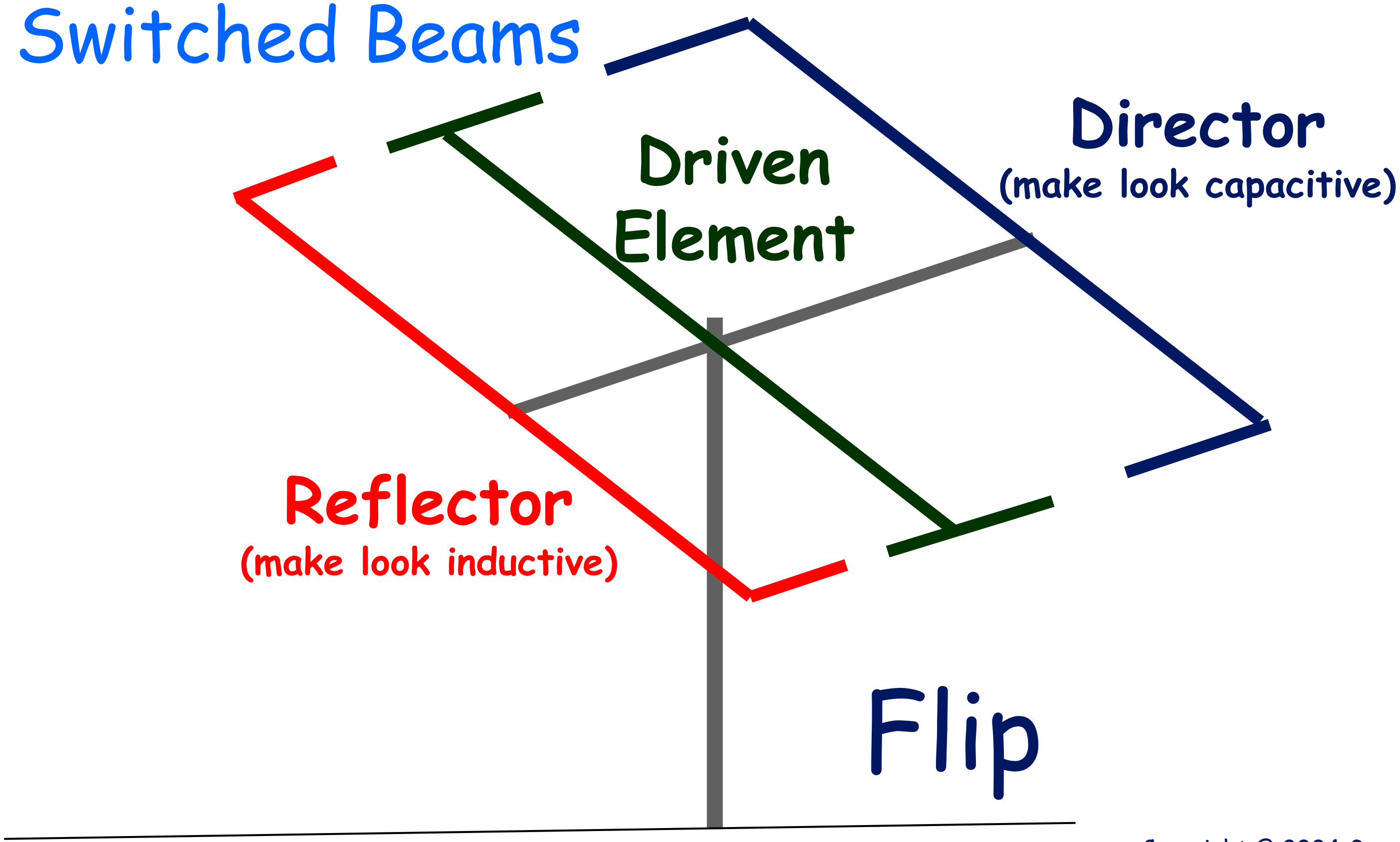
Flipbeam Array (FBA)

- Evolutions
  - » Greater Gain & F/B
  - » Switched Beams



Flipbeam Array (FBA)

- Evolutions
  - » Greater Gain & F/B
  - » Switched Beams



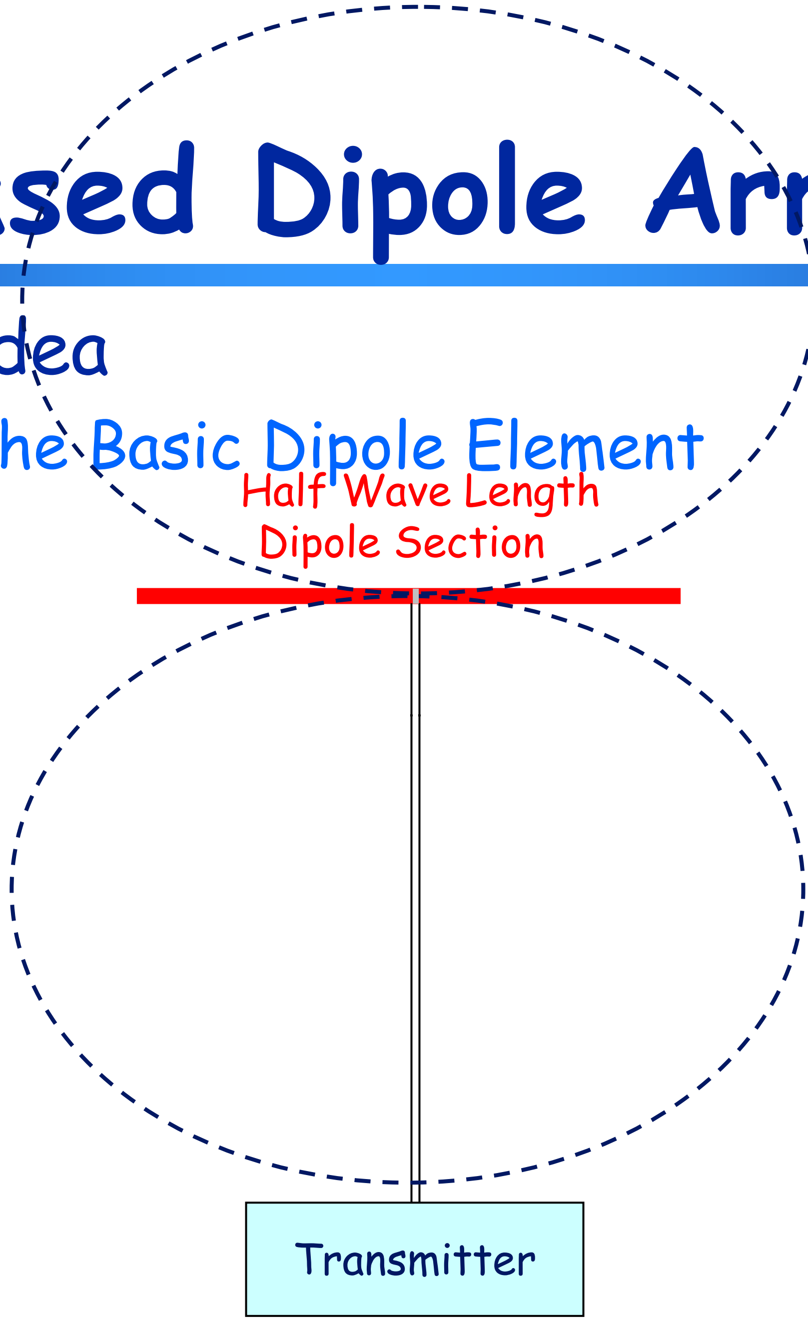
Phased Dipole Array

- Desirable Features

Gain Over Dipole	Easy to Match to Feedline
High Efficiency	Simple Design
Inexpensive	

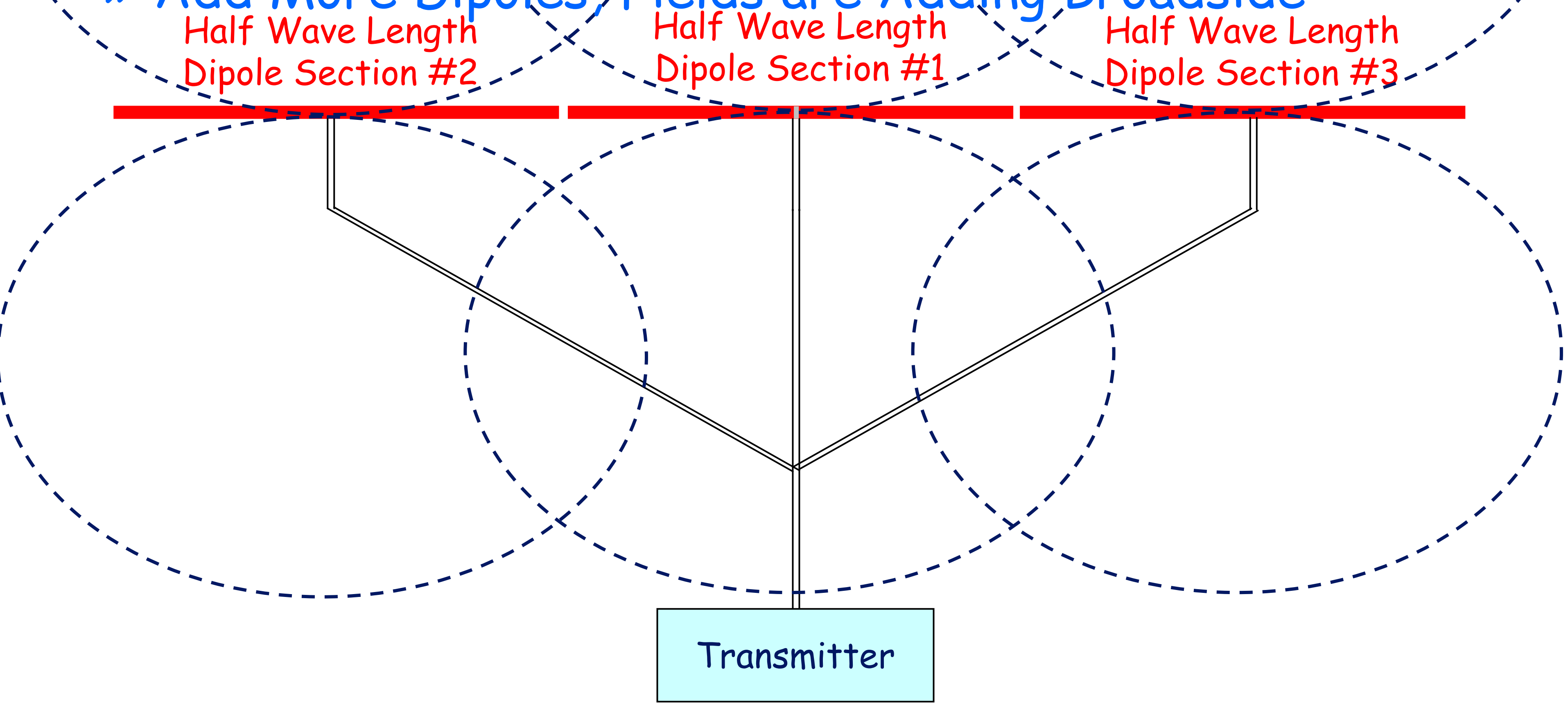
Phased Dipole Array

- Conceptual Idea
  - » Start with the Basic Dipole Element



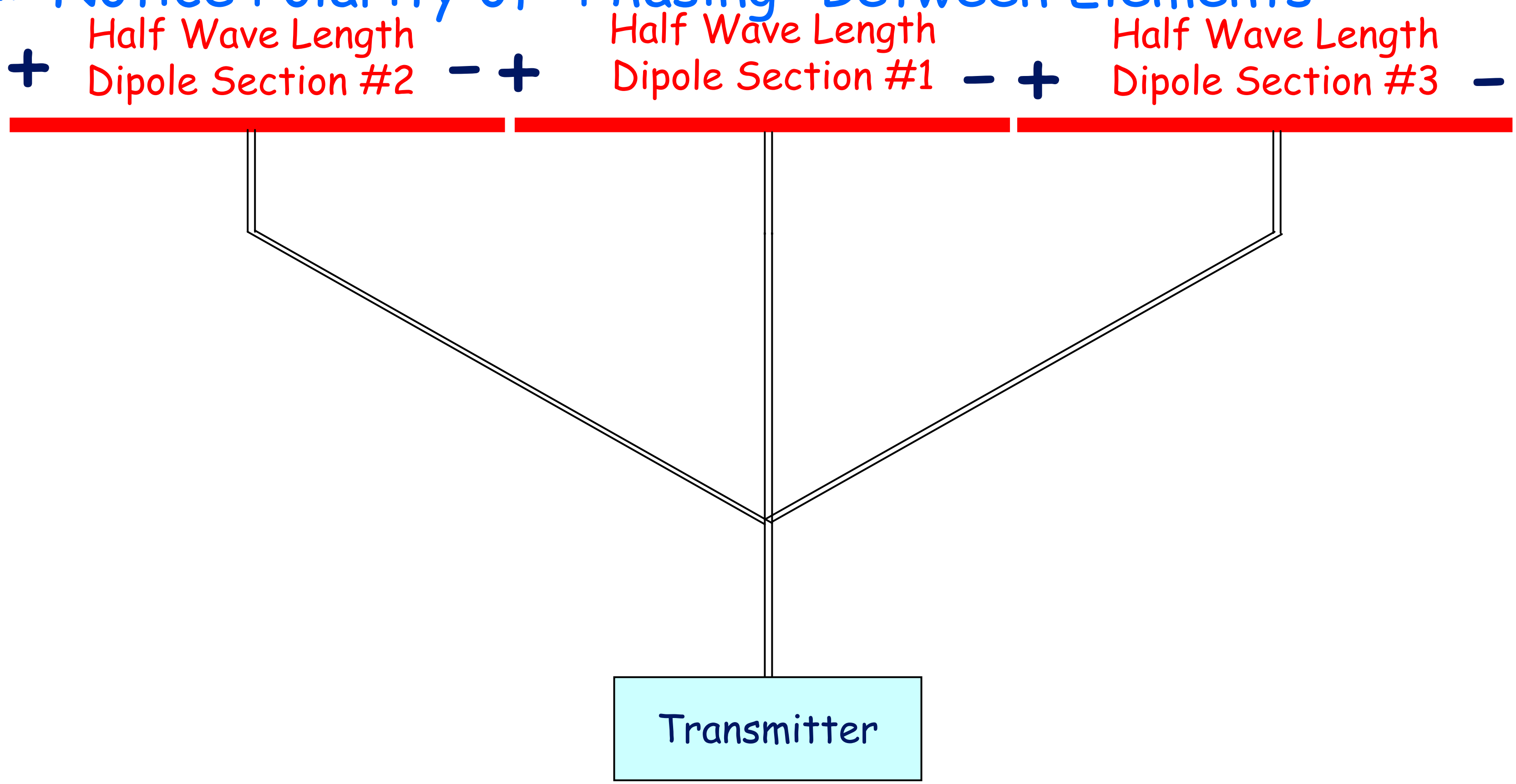
Phased Dipole Array

- Conceptual Idea
  - » Add More Dipoles, Fields are Adding Broadside



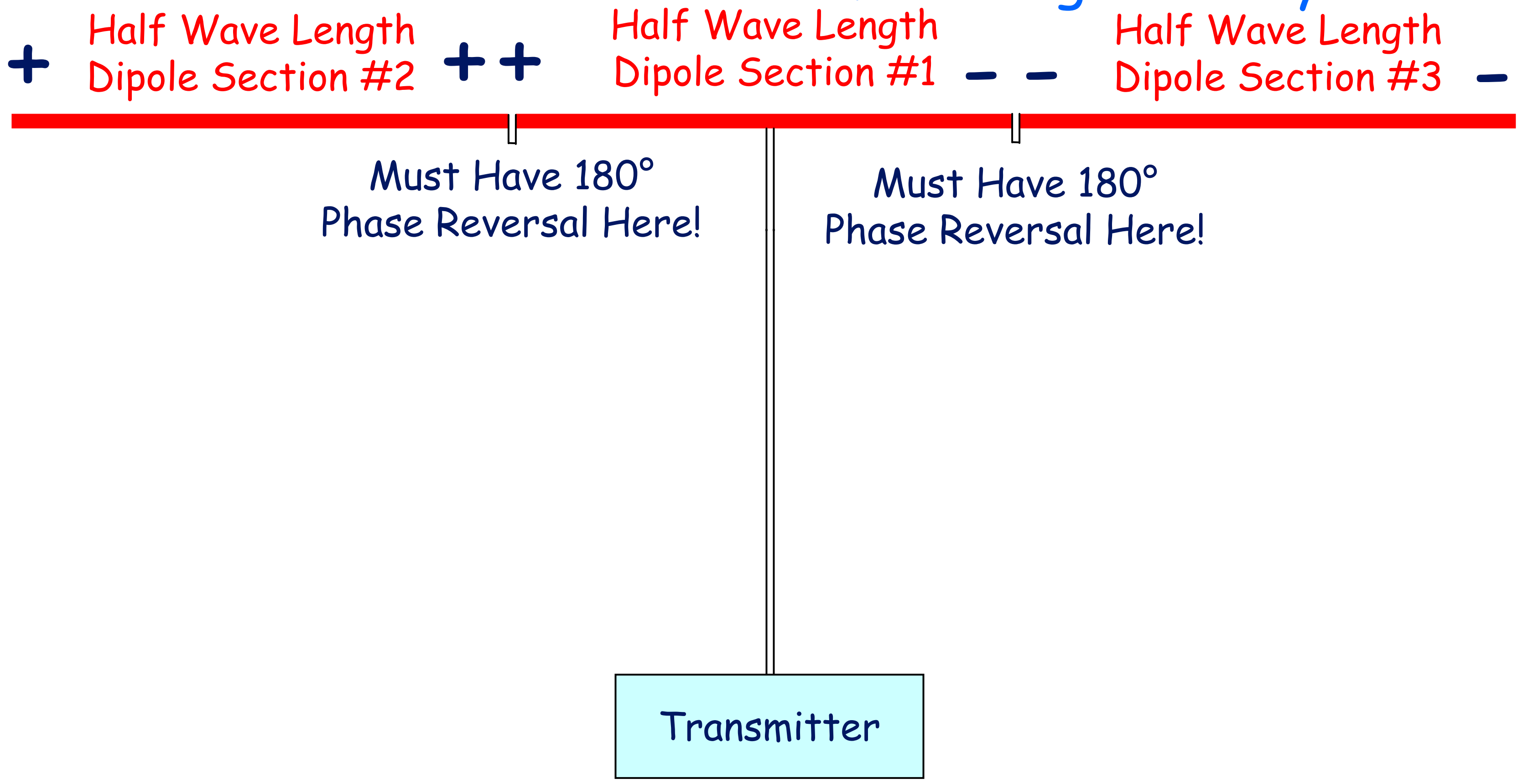
Phased Dipole Array

- Conceptual Idea
  - » Notice Polarity of "Phasing" Between Elements



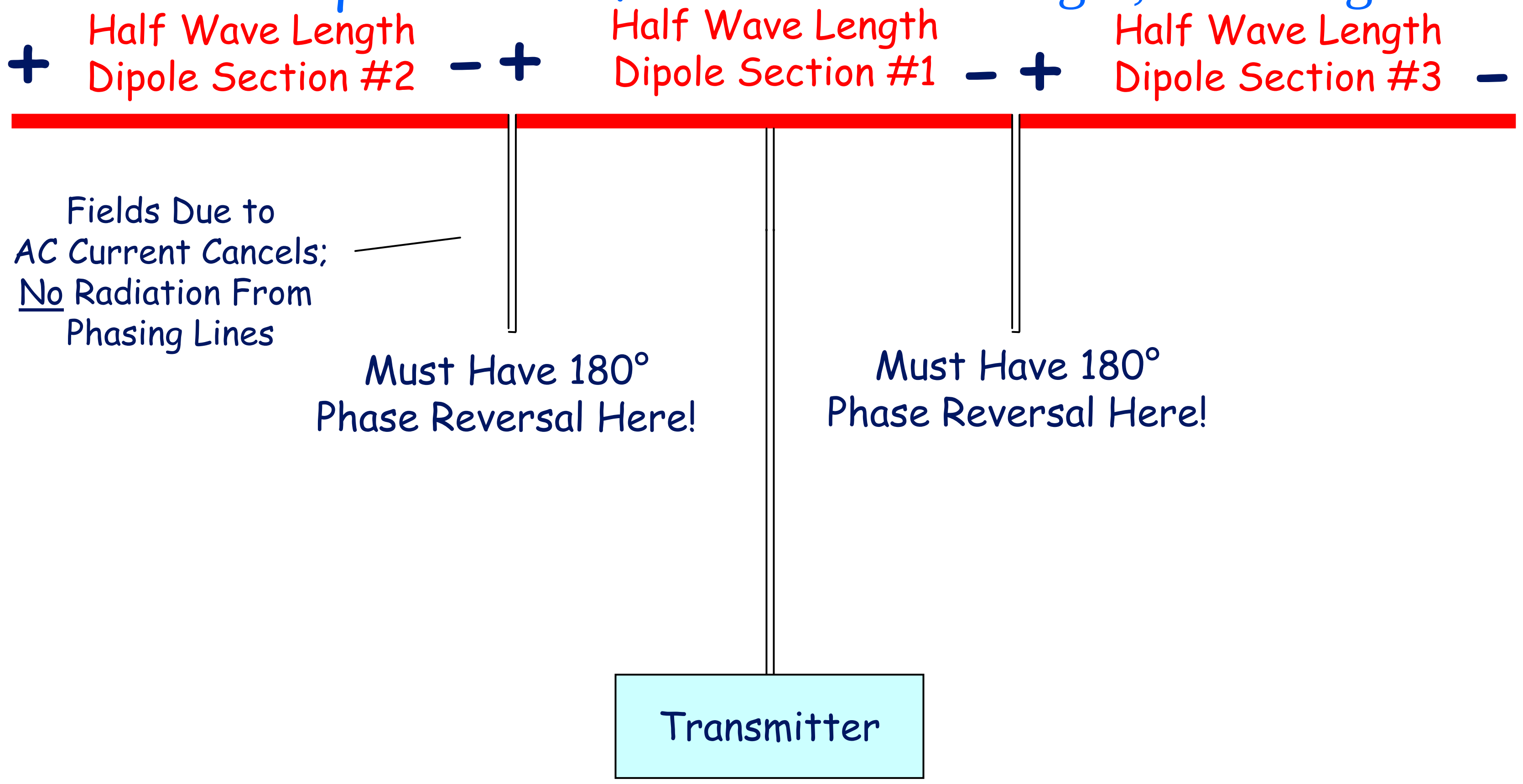
Phased Dipole Array

- Conceptual Idea
  - » Can't Just Connect Wire Ends; Phasing Destroyed



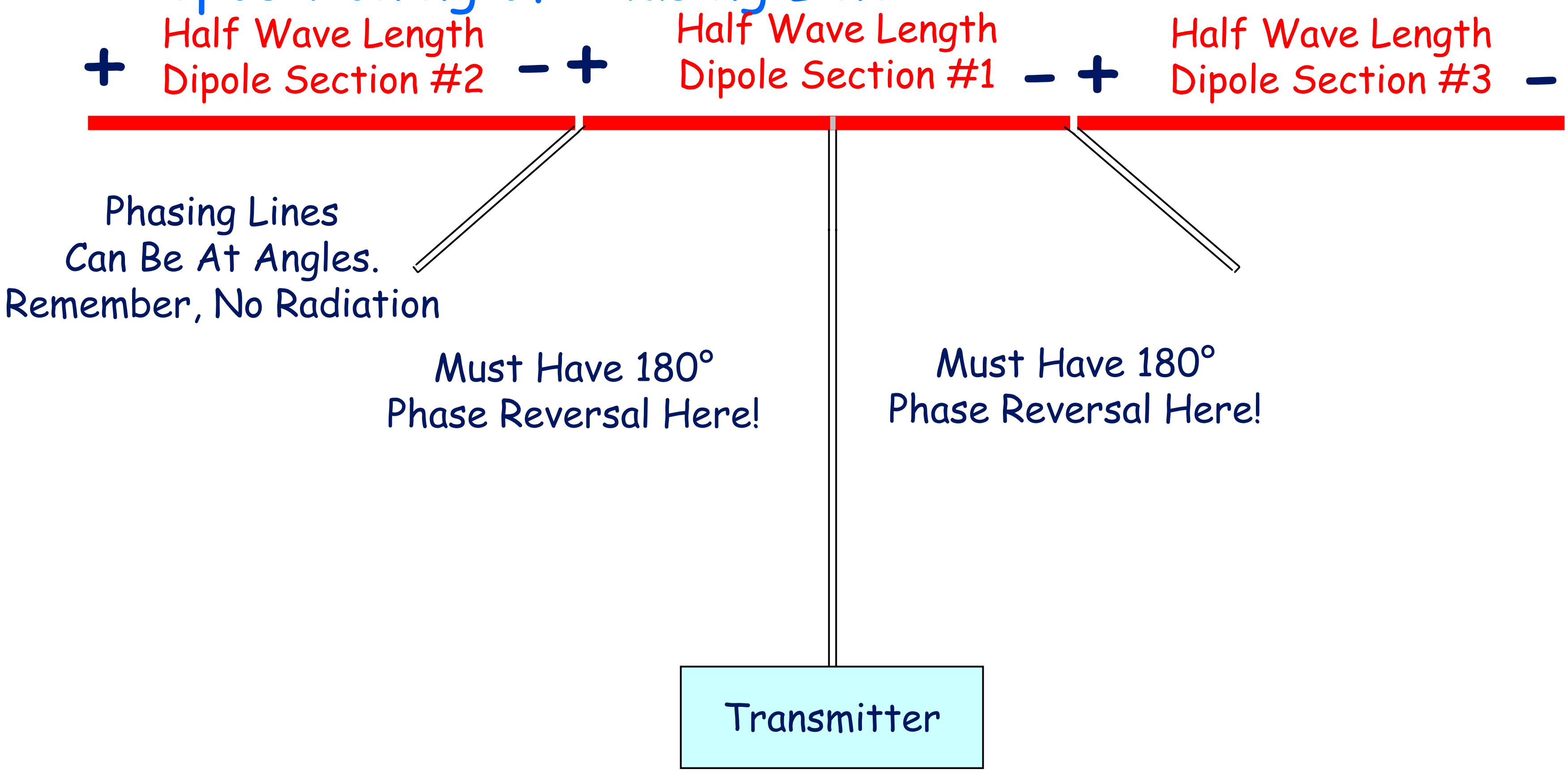
Phased Dipole Array

- Conceptual Idea
  - Can Add Equivalent of 180° of Wire length; “Phasing Harness”



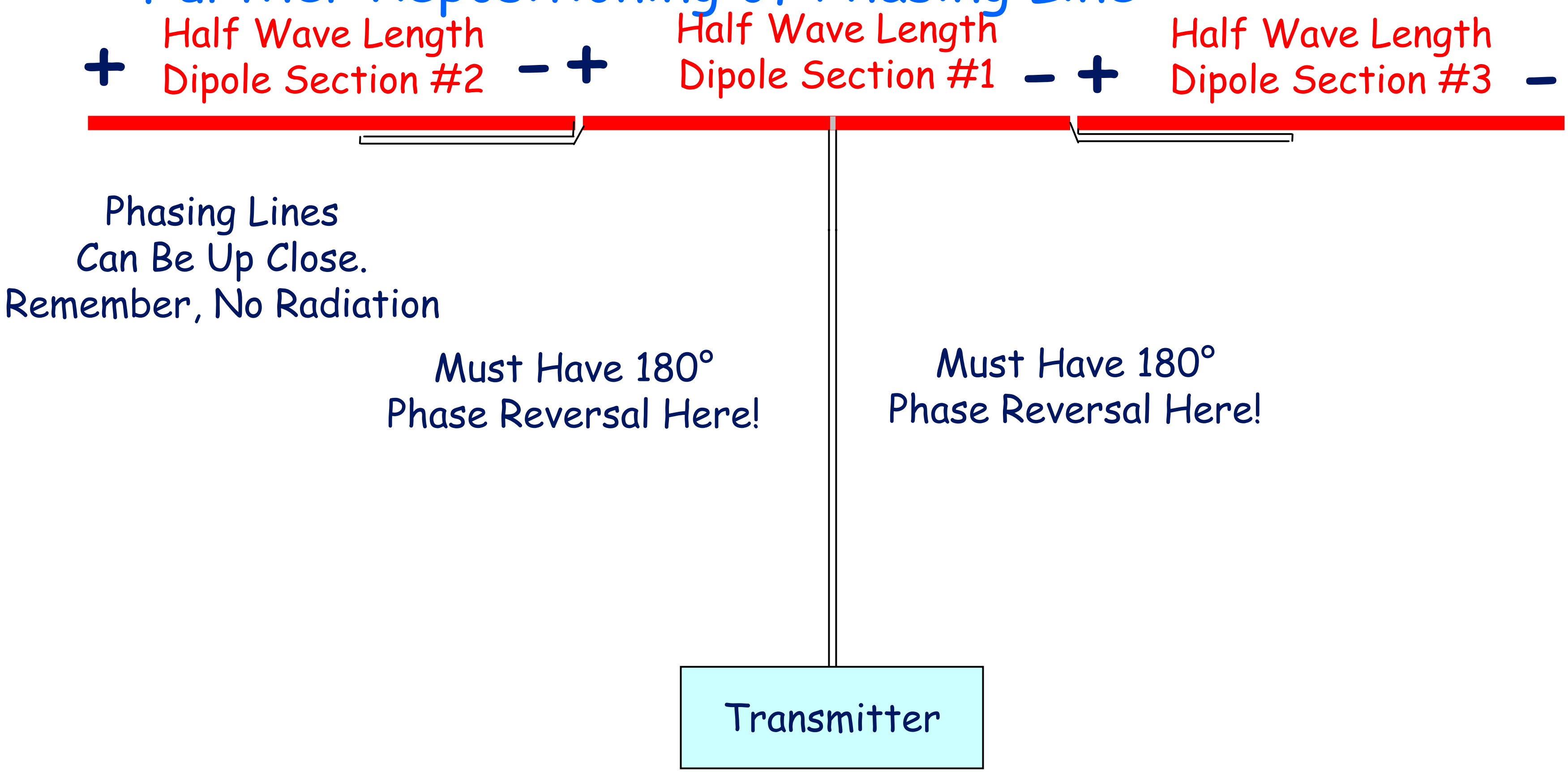
Phased Dipole Array

- Conceptual Idea
  - » Repositioning of Phasing Line



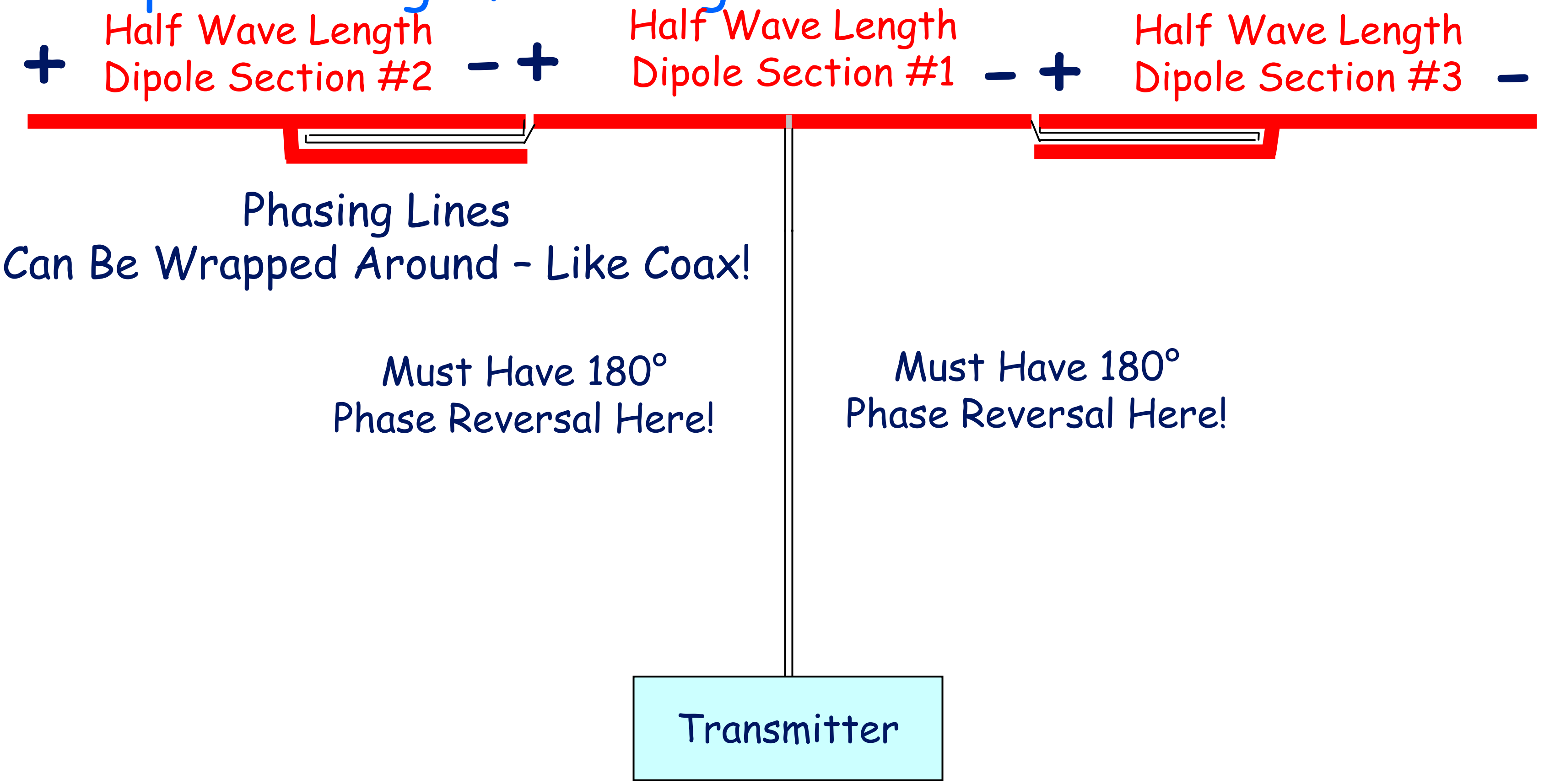
Phased Dipole Array

- Conceptual Idea
  - » Further Repositioning of Phasing Line



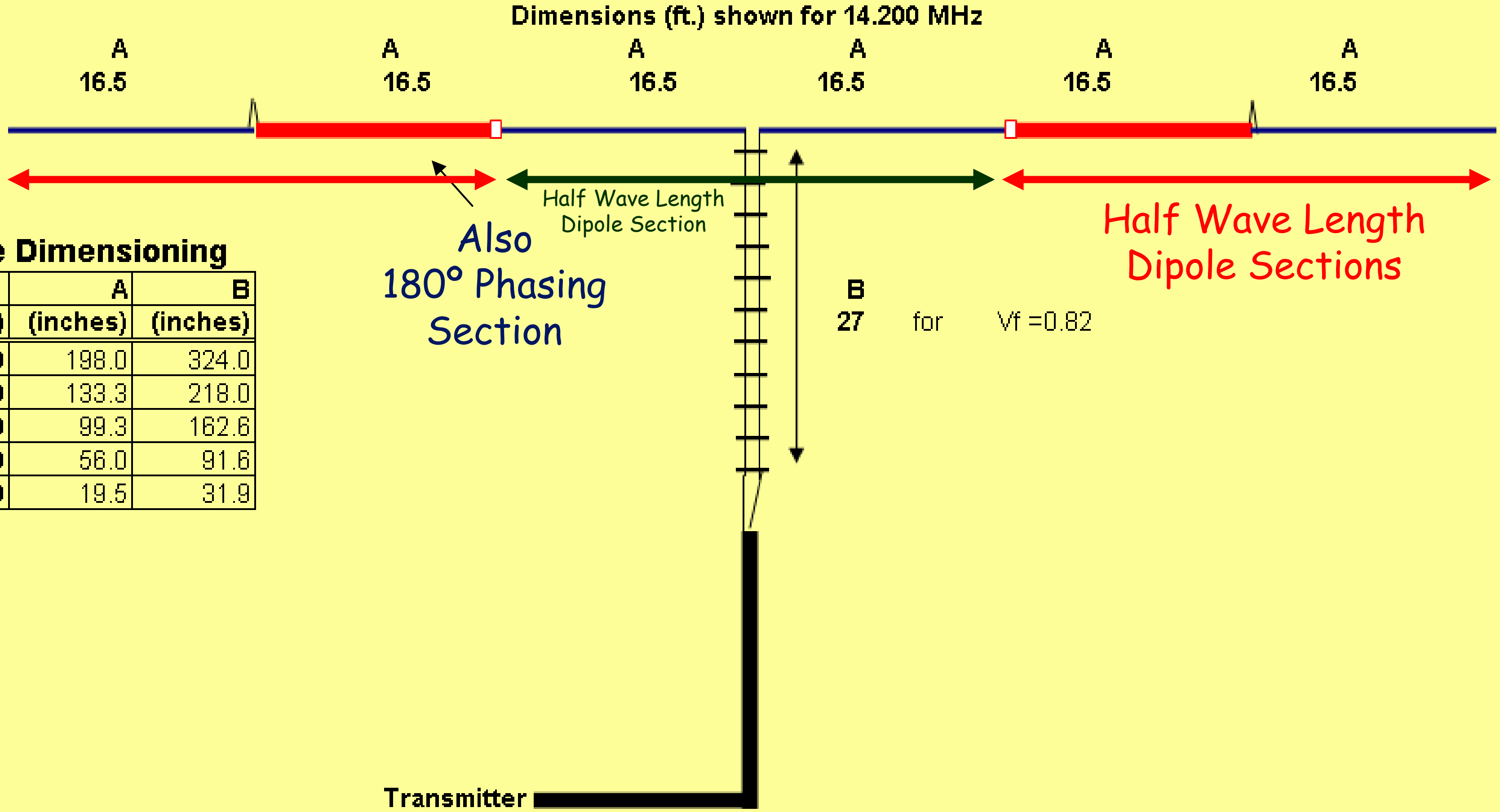
Phased Dipole Array

- Conceptual Idea
  - » Repositioning of Phasing Line



Phased Dipole Array

- Conceptual Idea

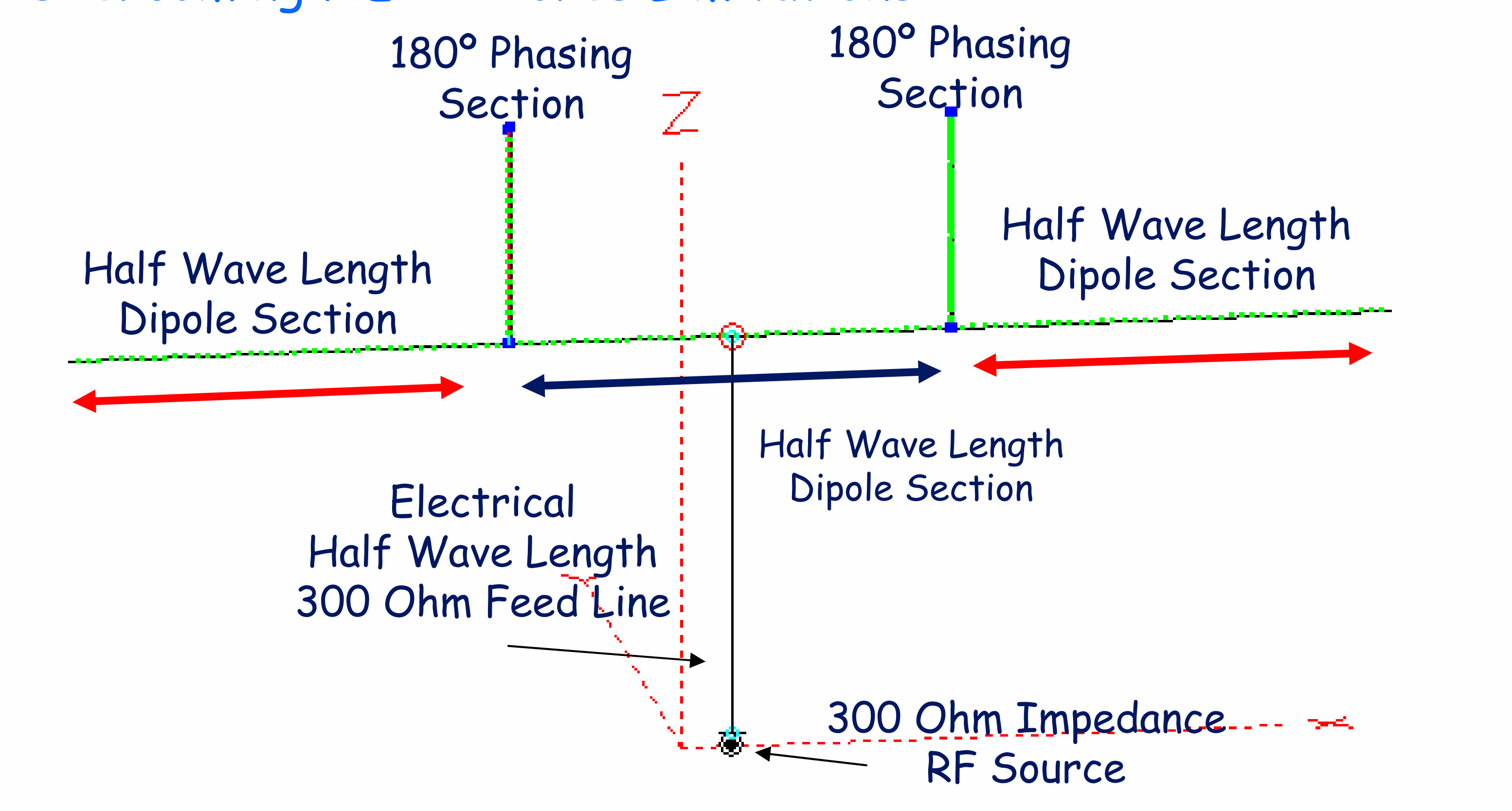


Scalable Dimensioning

Freq. (MHz)	A (inches)	B (inches)
14.200	198.0	324.0
21.100	133.3	218.0
28.300	99.3	162.6
50.200	56.0	91.6
144.200	19.5	31.9

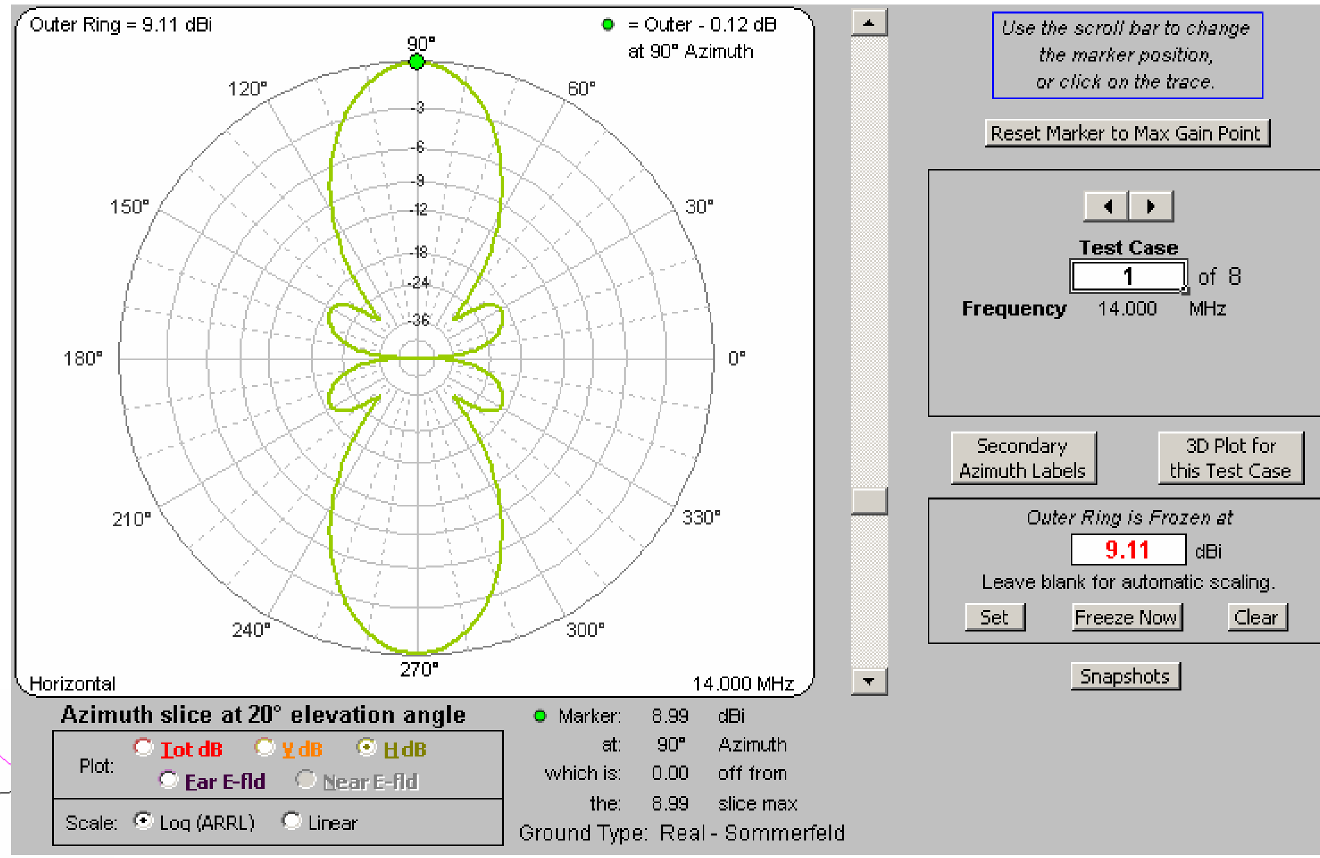
Phased Dipole Array

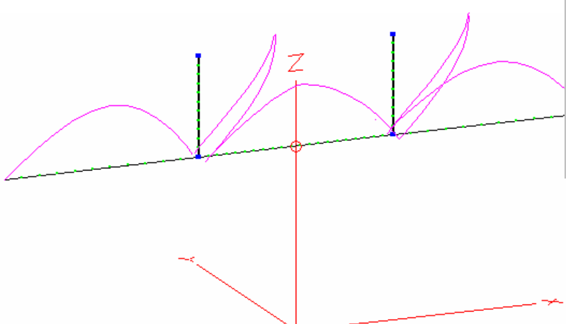
- Conceptual Idea
  - » Conversion to Modeling
  - » Overcoming NEC-2 Cores Limitations



Phased Dipole Array

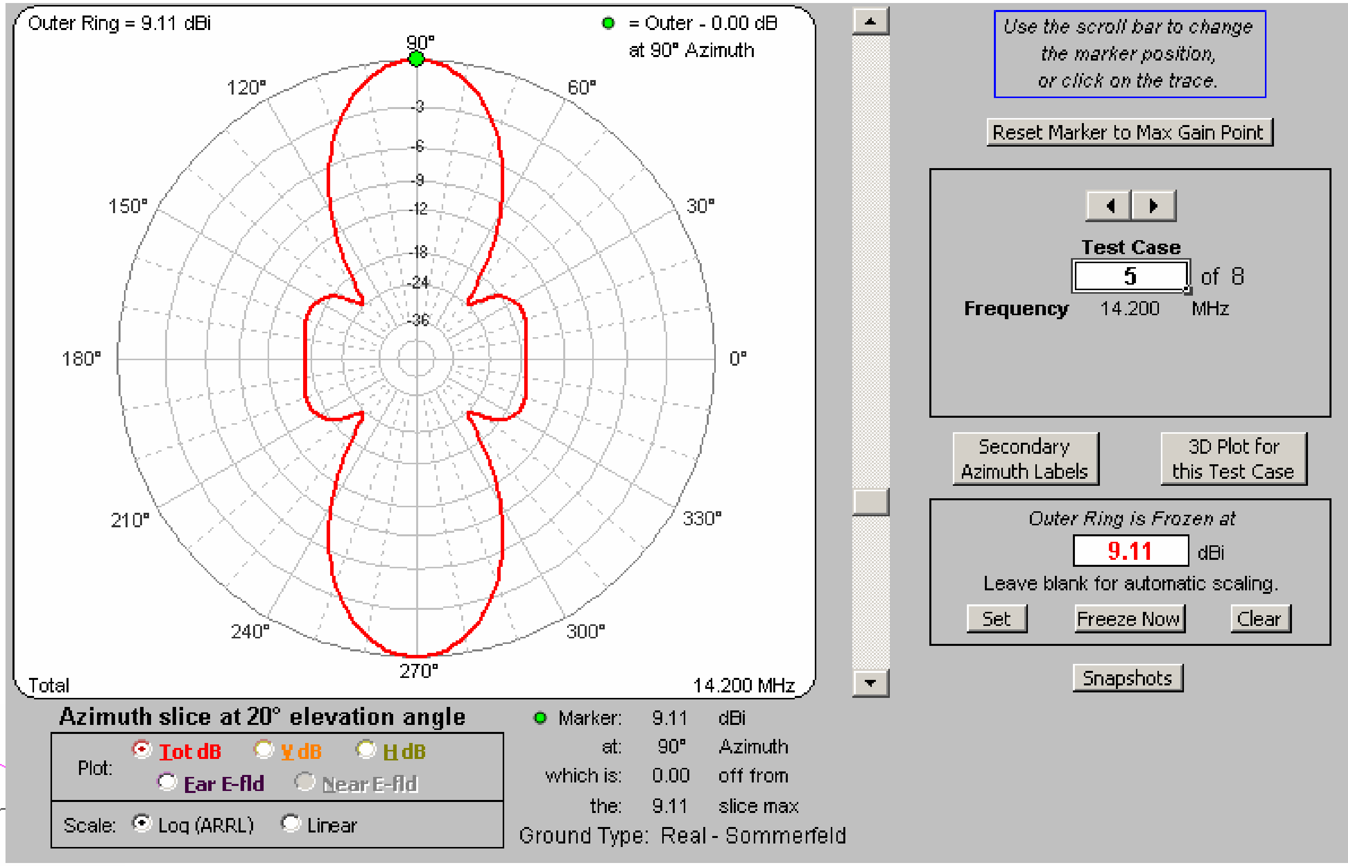
- Modeling
  - » Horizontal Component

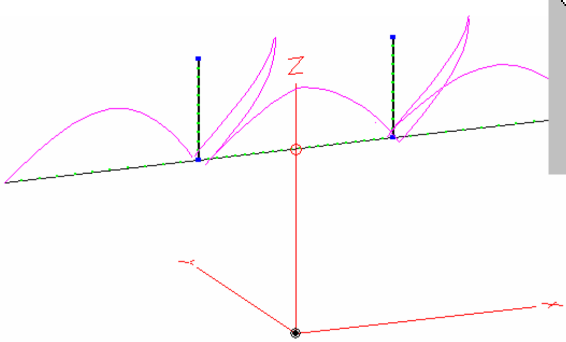




Phased Dipole Array

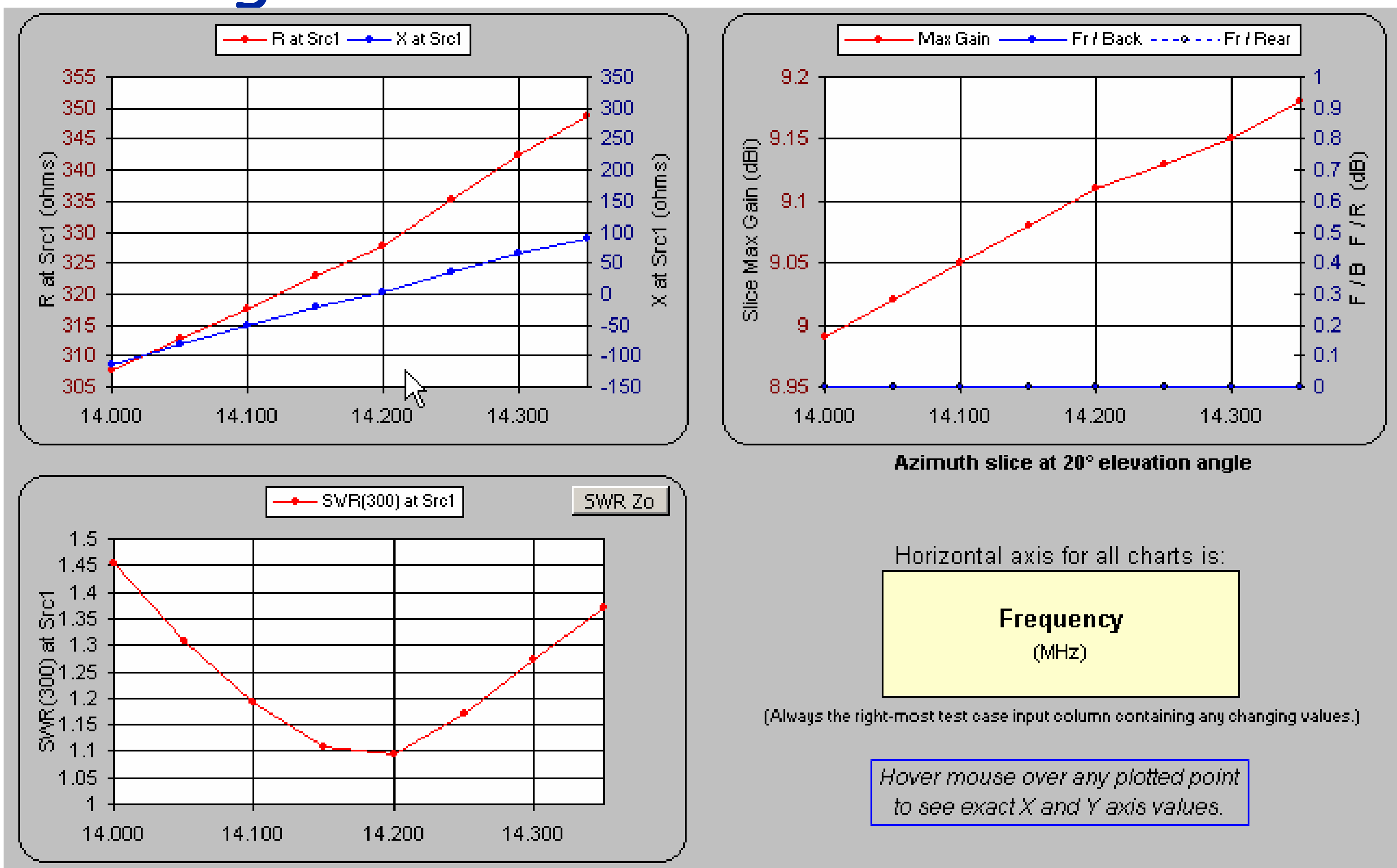
- Modeling
  - » Vert+Horz Component
  - » Skywave Validity





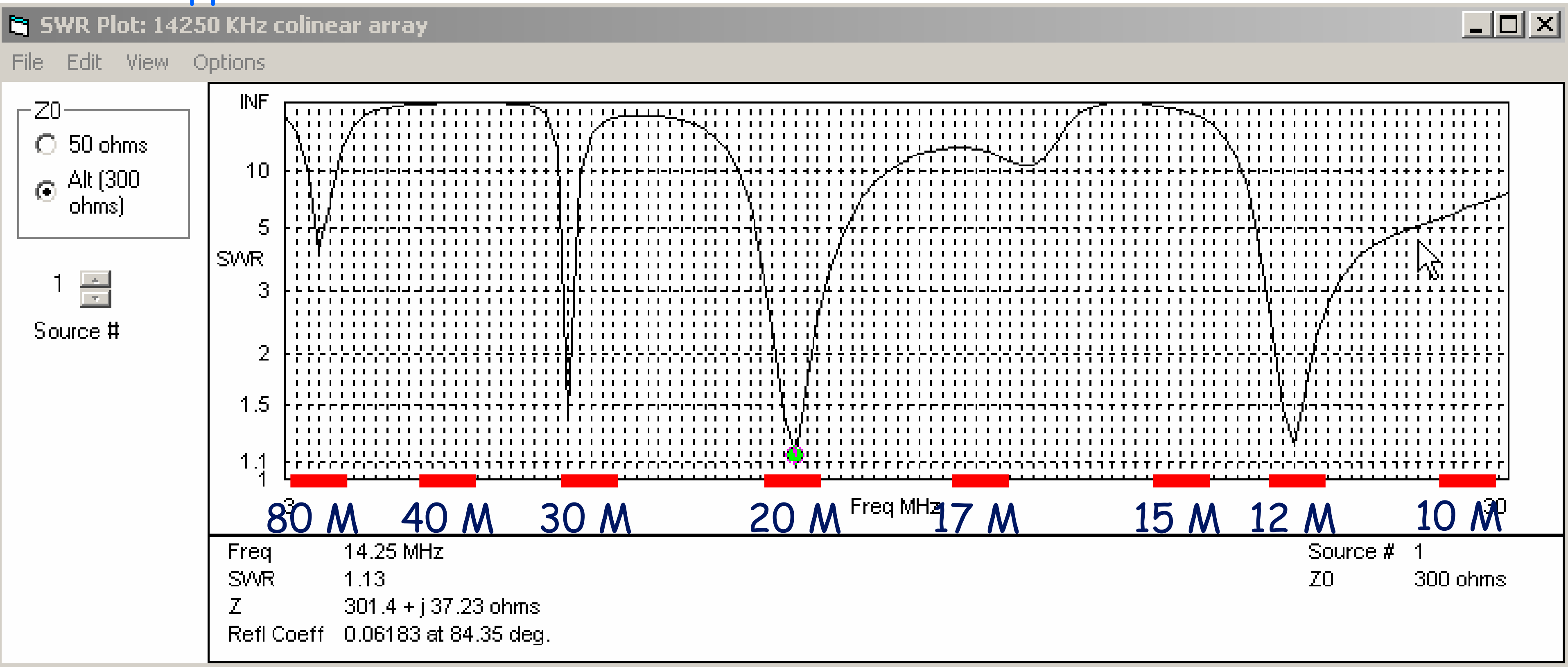
Phased Dipole Array

- Modeling



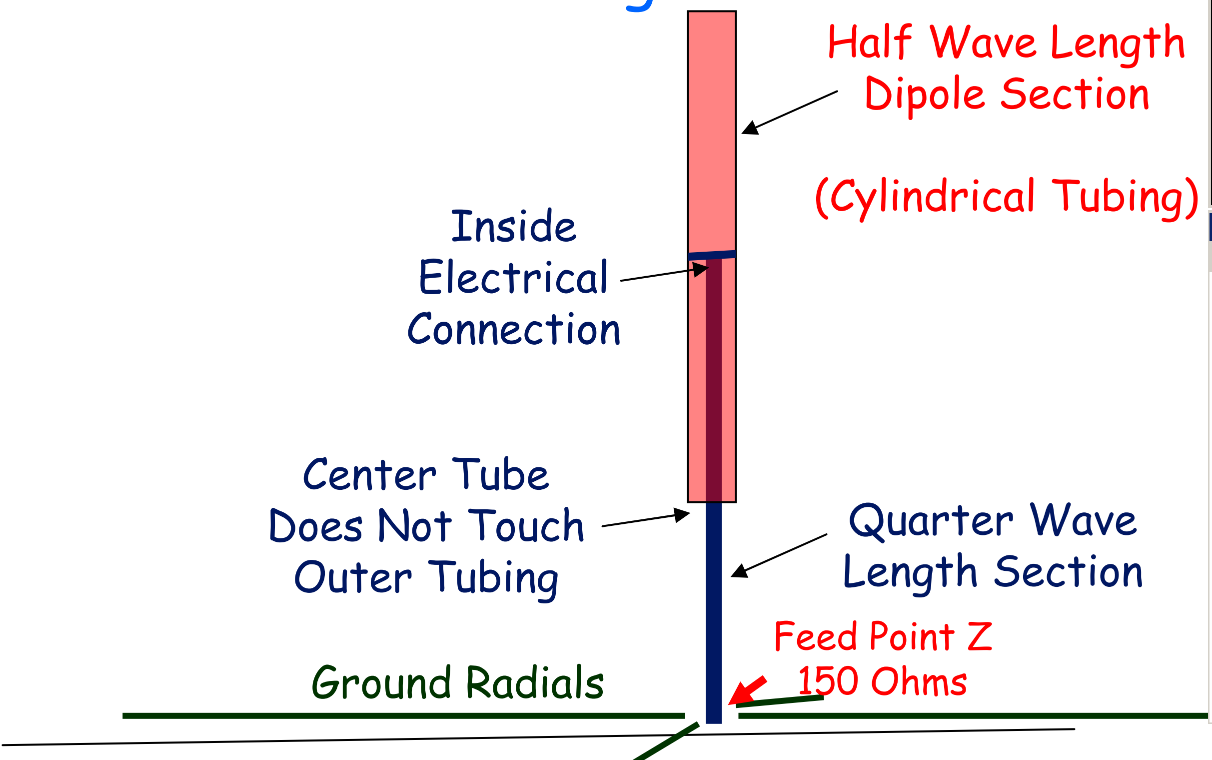
Phased Dipole Array

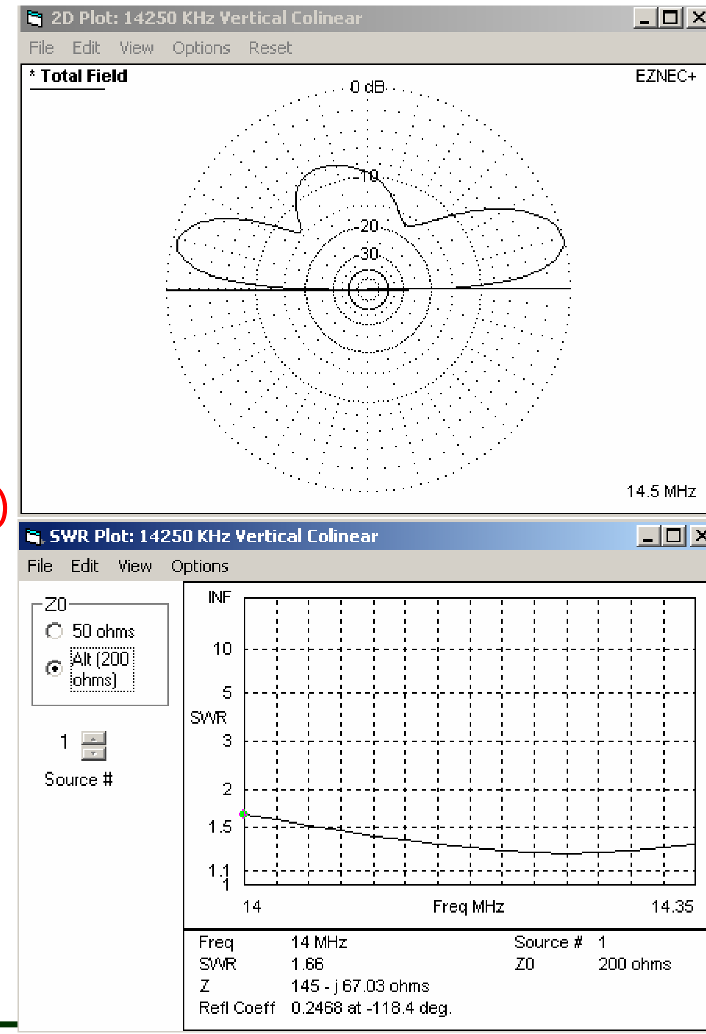
- Modeling
  - » Just Like Our Old Friend the ***Wide Band Dipole*** – Use a Tuner
  - » Phasing Line Has Little Effect Off Frequency
  - » Approximate Locations of **Ham Bands** Shown



Phased Dipole Arrays

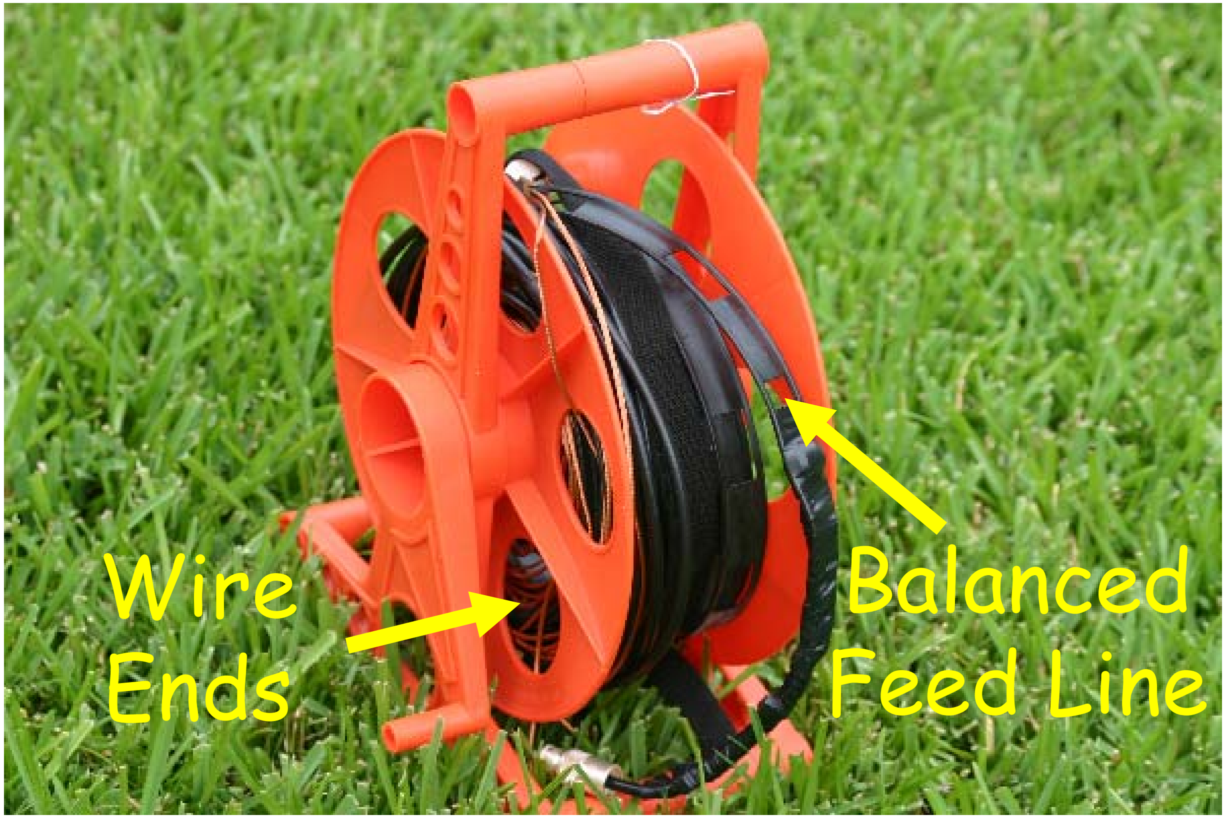
- Evolutions
  - » Vertical Applications
    - – "Sleeve Antenna"
  - » Better Low Angle Performance





Phased Dipole Array

- Construction
  - » Reel Makes Storage a Snap



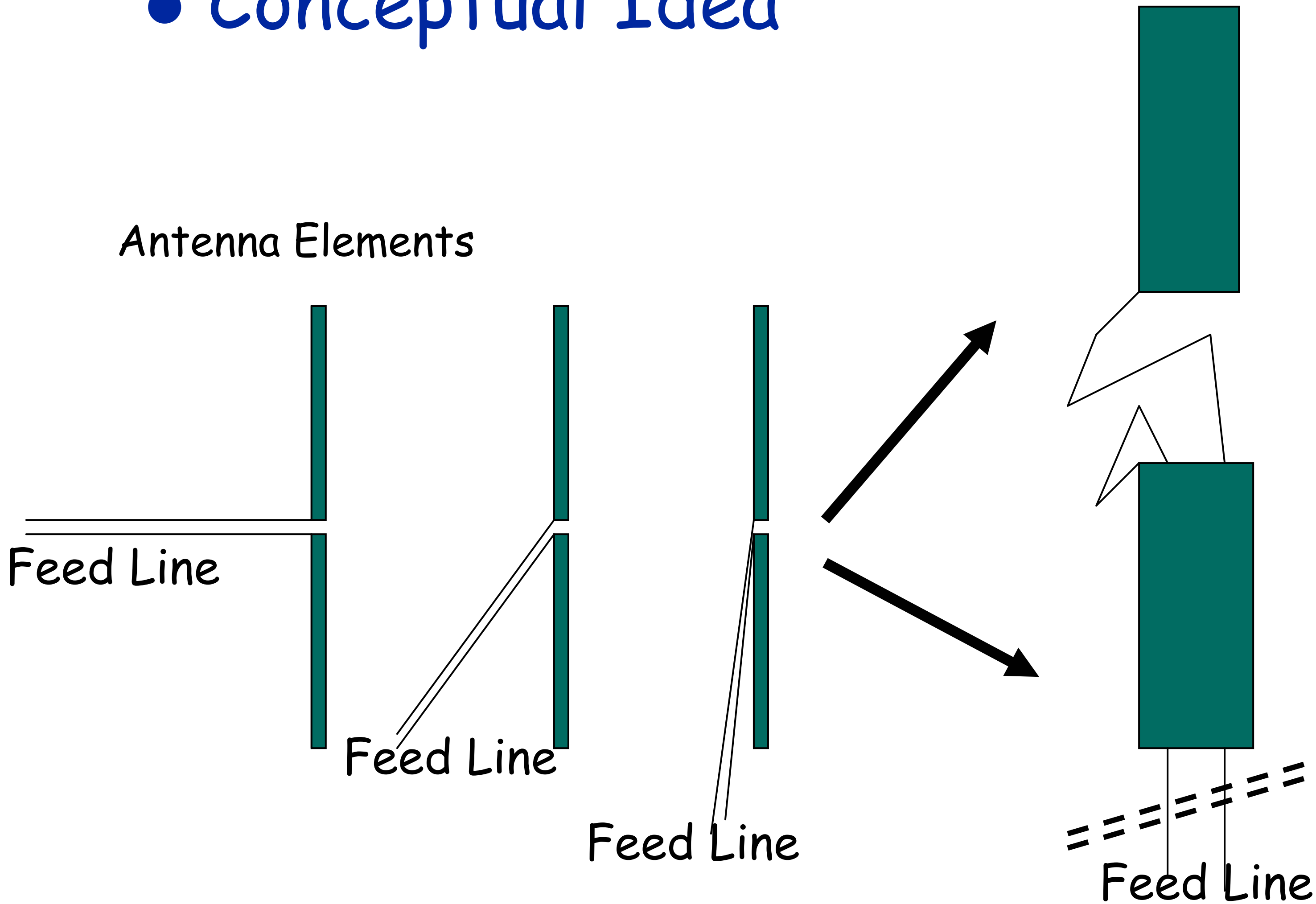
Reel Antennas

- Desirable Features

Easy to Unwind or Wind	Easy to Match to Feedline
High Efficiency	Simple Design
Inexpensive	

Reel Antennas

- Conceptual Idea

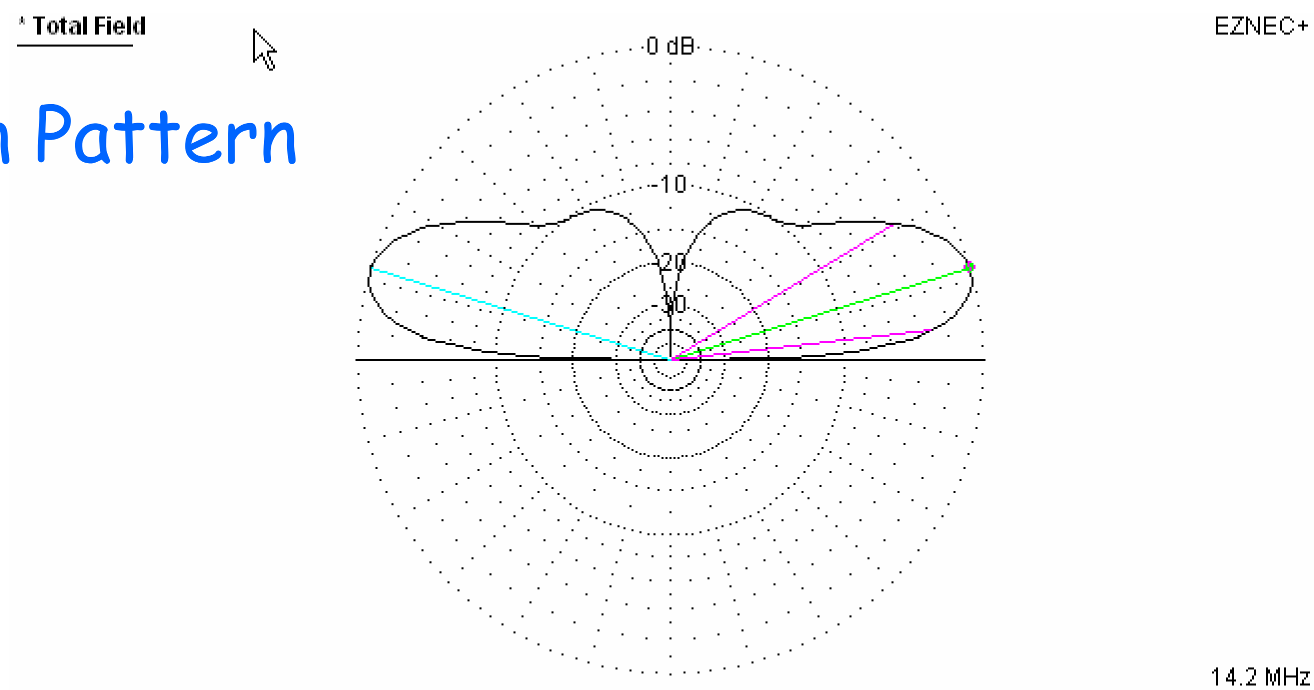


Roll Up Onto
a
Reel for Easy
Storage

Need to Isolate End From Coax Line!

Reel Antennas

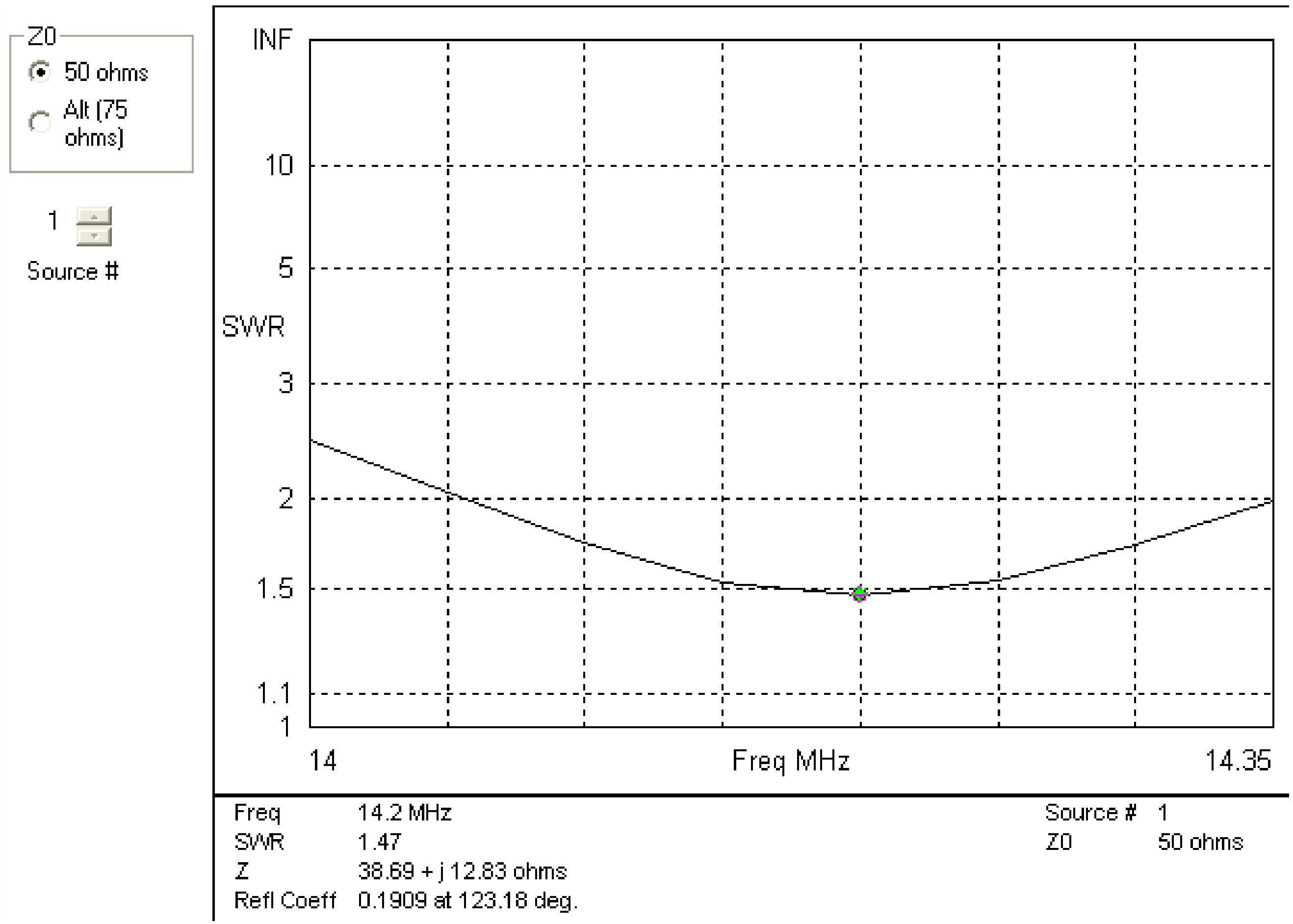
- Modeling
  - » Elevation Pattern



Elevation Plot			Cursor Elev	17.0 deg.
Azimuth Angle	0.0 deg.		Gain	0.61 dBi
Outer Ring	0.61 dBi			0.0 dBmax
Slice Max Gain	0.61 dBi @ Elev Angle = 17.0 deg.			
Beamwidth	24.6 deg.; -3dB @ 6.6, 31.2 deg.			
Sidelobe Gain	0.61 dBi @ Elev Angle = 163.0 deg.			
Front/Sidelobe	0.0 dB			

Reel Antennas

- Modeling
  - » VSWR

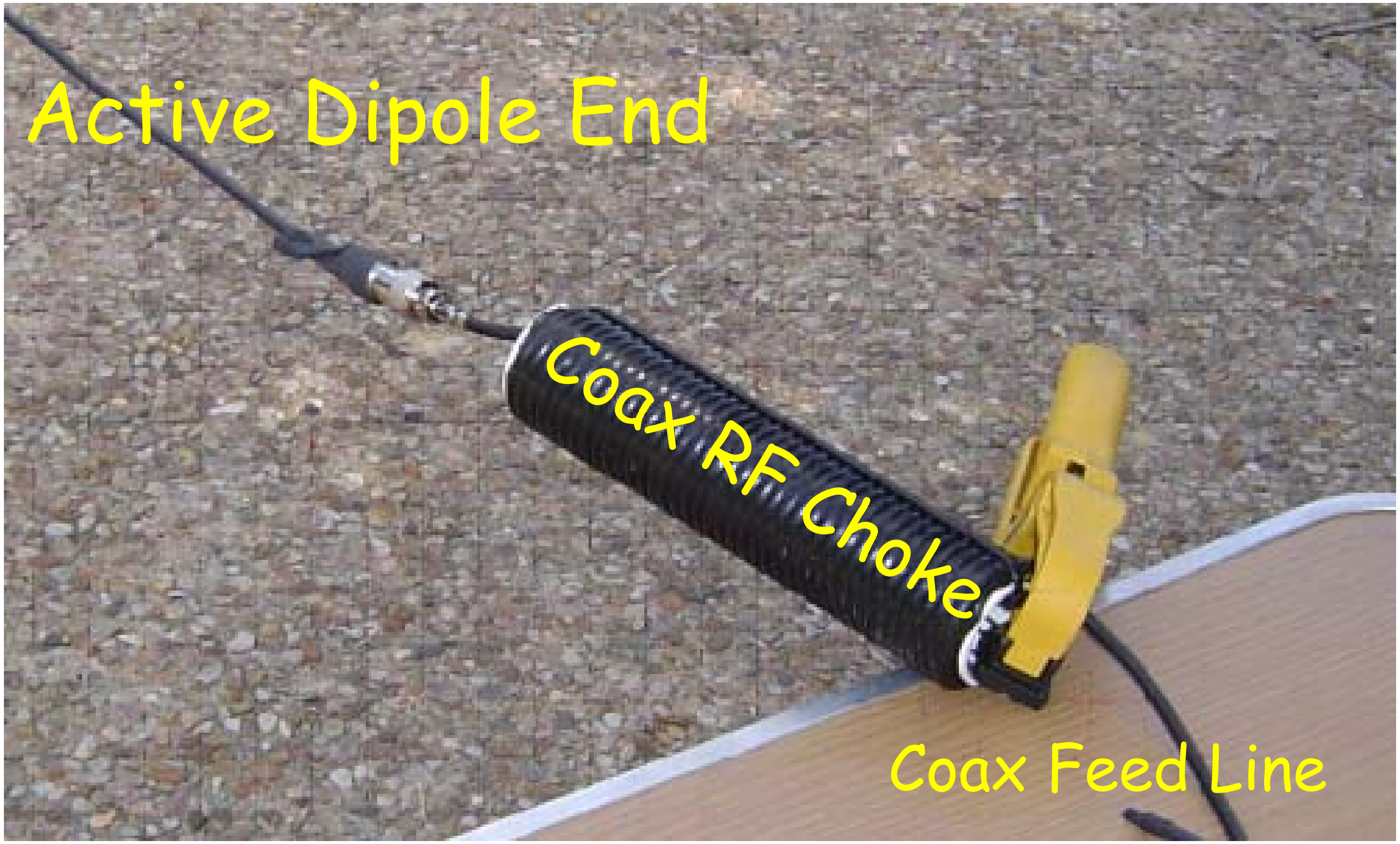


Reel Antennas

- Construction
  - » 3 Methods for Isolation

Reel Antennas

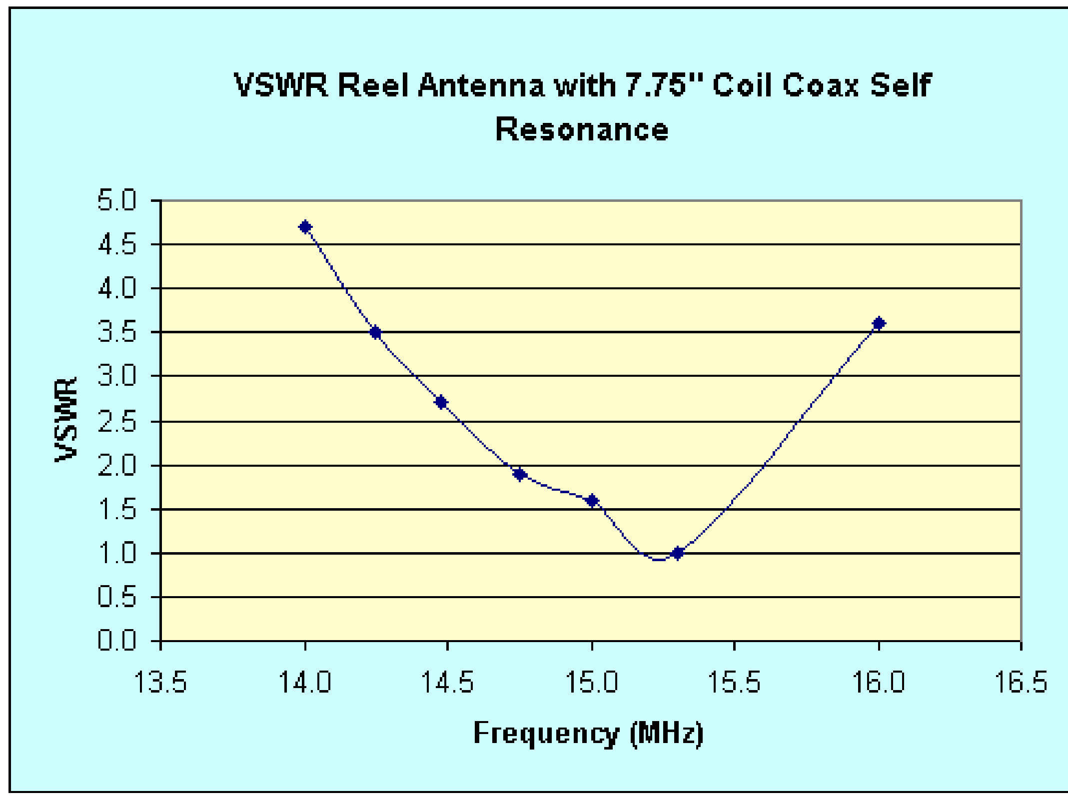
- Construction



Reel Antennas

Reel start length 16 ft. 4 in.   Reel end length 16 ft. 4 in.

Fo	VSWR	Z
14.000	4.7	40
14.250	3.5	50
14.480	2.7	55
14.750	1.9	58
15.000	1.6	52
15.300	1.0	45
16.000	3.6	55



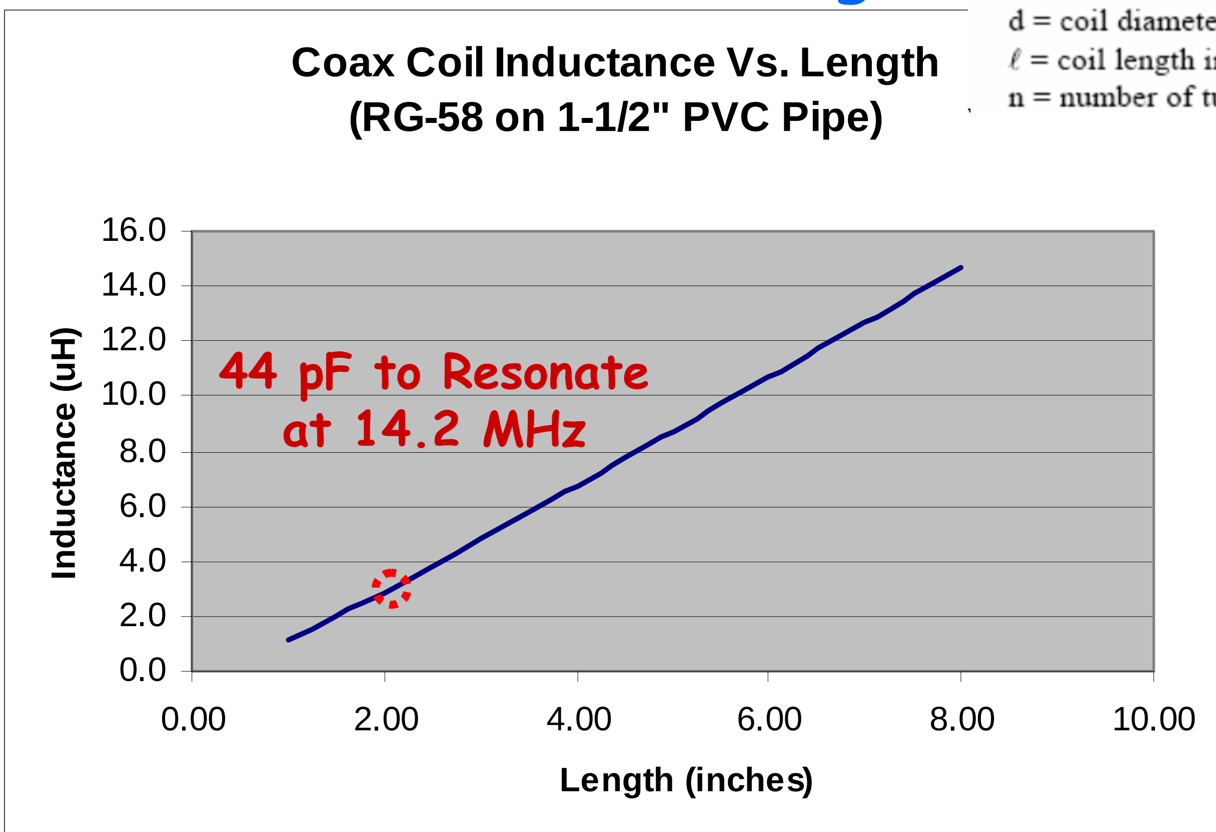
Reel Antennas

- Modeling
  - » Inductance vs. Length

$$L\,(\mu H) = \frac{d^2\,n^2}{18\,d + 40\,\ell}$$

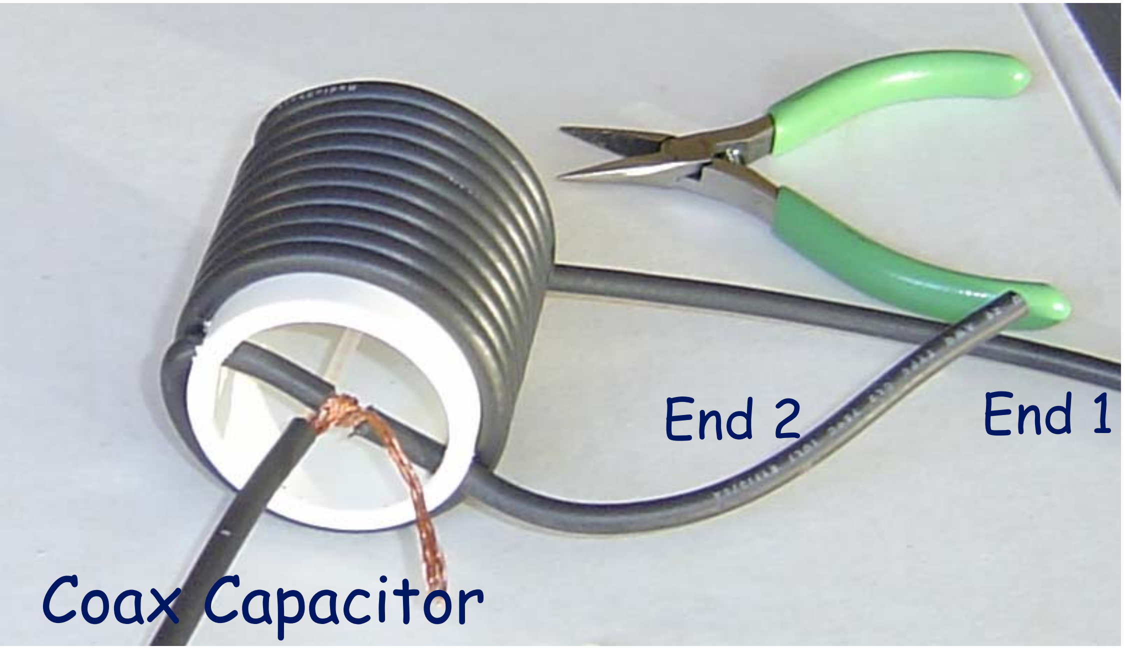
where:

L = inductance in microhenrys,
d = coil diameter in inches (from wire center to wire center),
ℓ = coil length in inches, and
n = number of turns.



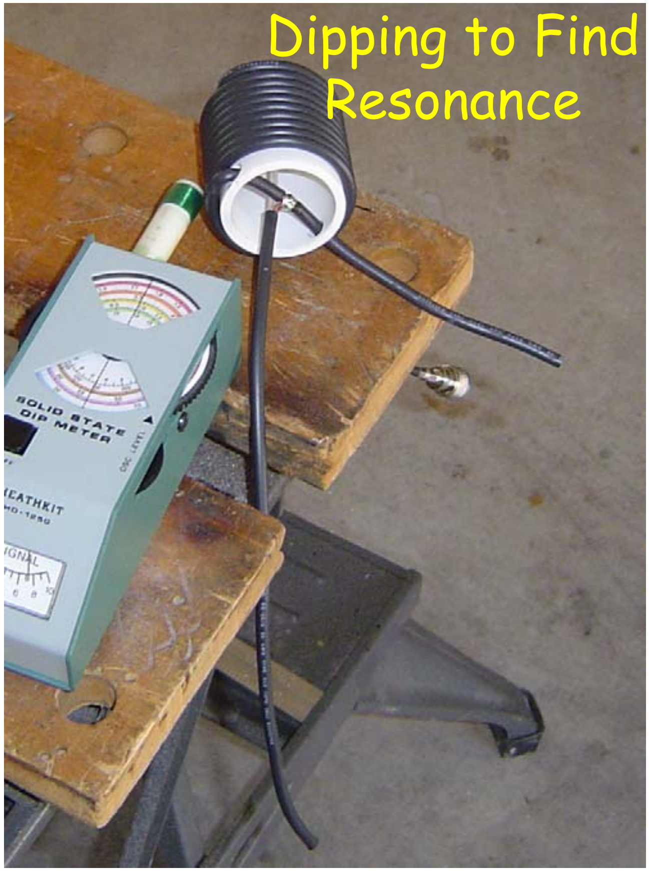
Reel Antennas

- Construction



Reel Antennas

- Construction

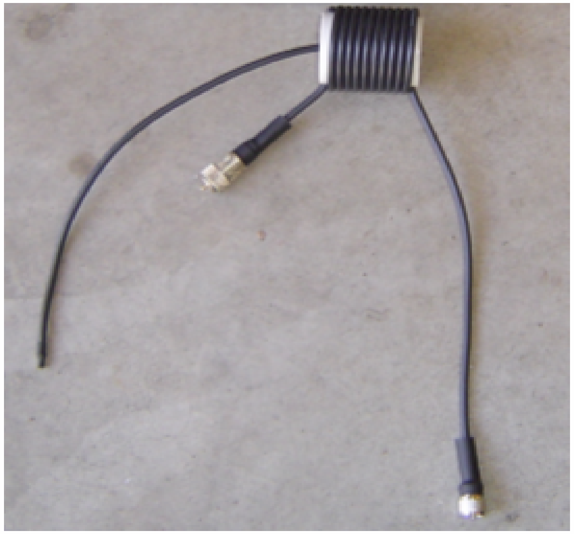


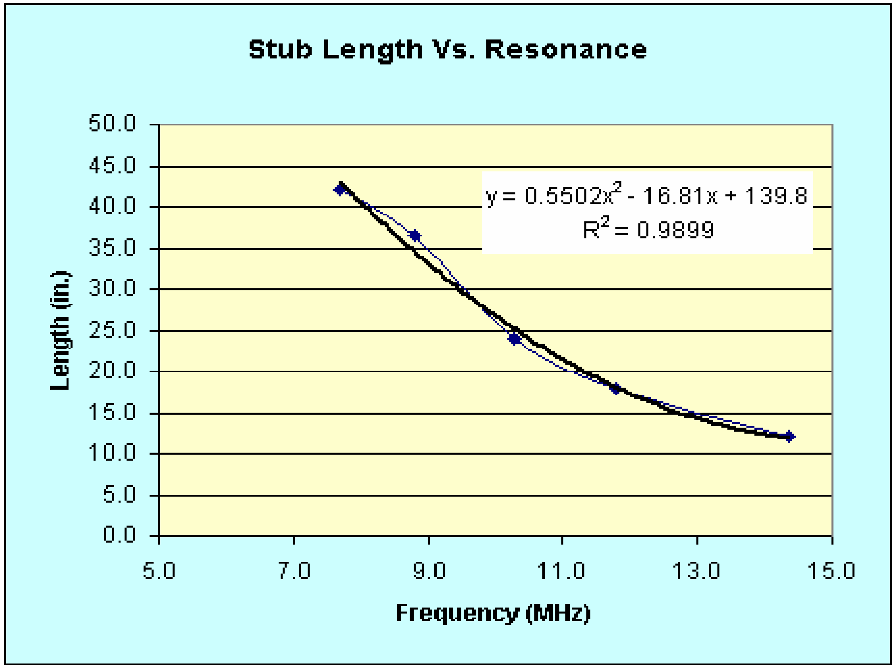
Reel Antennas

Stub Length To Create Resonance

Coil 10 Turns
RG-58U (solid center)
Wound on 1.5 in. O,D, PVC pipe, 2.5 in long.

Resonance Fo	Stub Len. L (in.)	Capacitance (pF)	Cap/Ft.	L (uH)
7.700	42.0	100.8	28.8	4.24
8.800	36.5	87.6	28.8	3.73
10.280	24.0	57.6	28.8	4.16
11.800	18.0	43.2	28.8	4.21
14.350	12.0	28.8	28.8	4.27



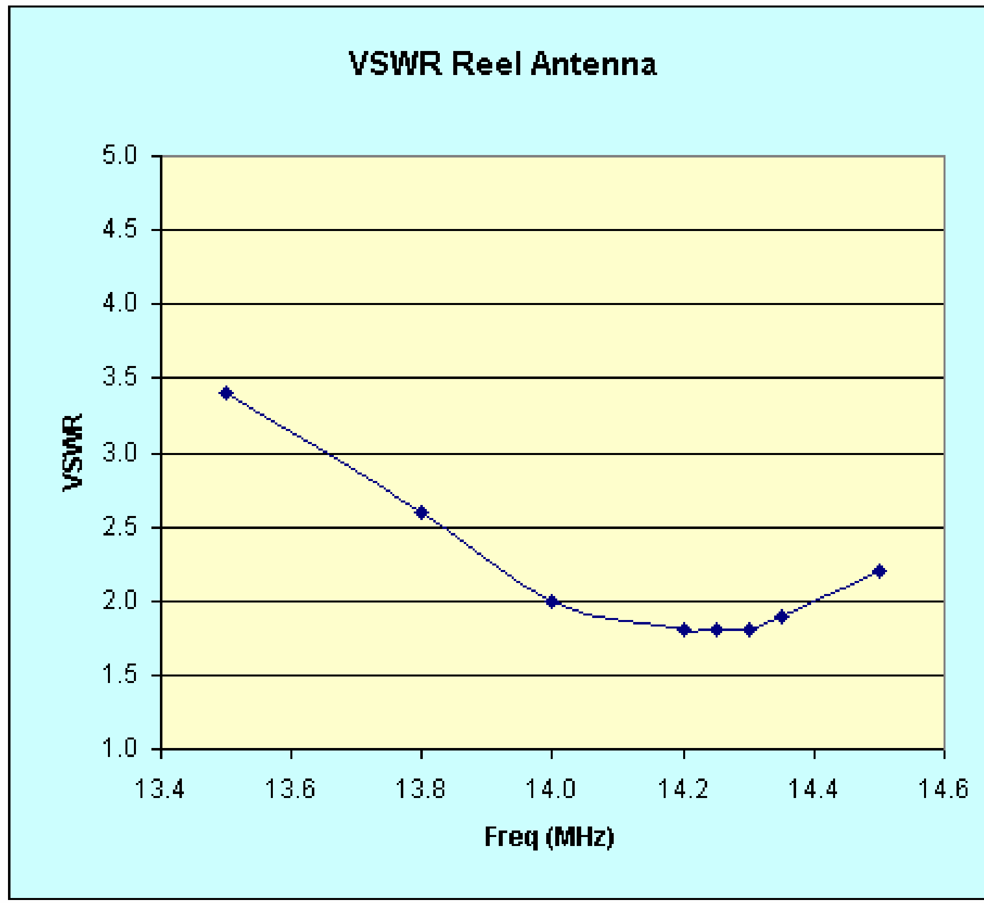


Reel Antennas

Reel start length 16 ft. 4 in. Reel end length 16 ft. 4 in.

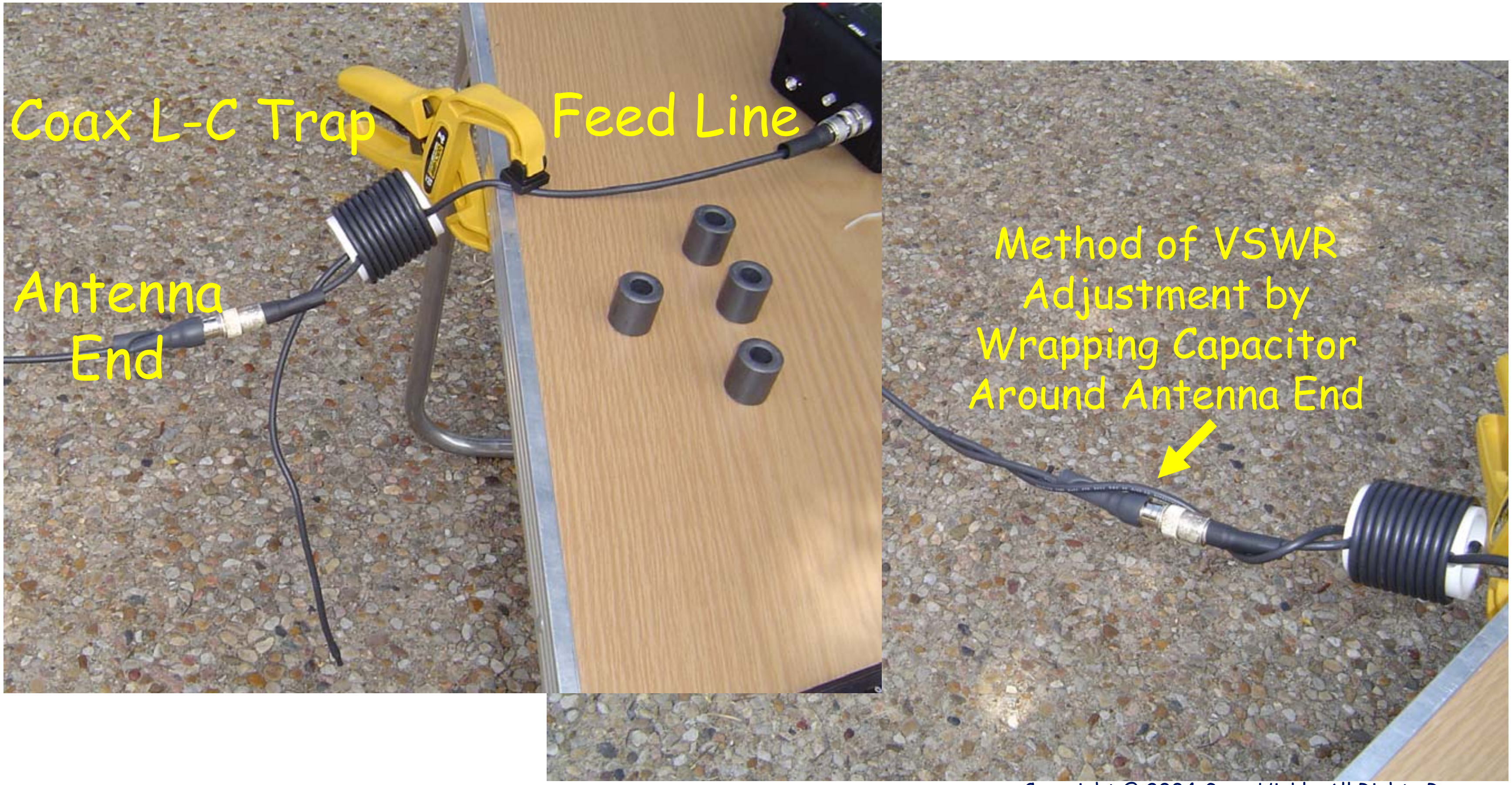
Final Antenna VSWR

Fo	VSWR	Rs	Xs
13.500	3.4	30	45
13.800	2.6	26	27
14.000	2.0	28	16
14.200	1.8	31	13
14.250	1.8	31	14
14.300	1.8	30	14
14.350	1.9	30	14
14.500	2.2	25	14



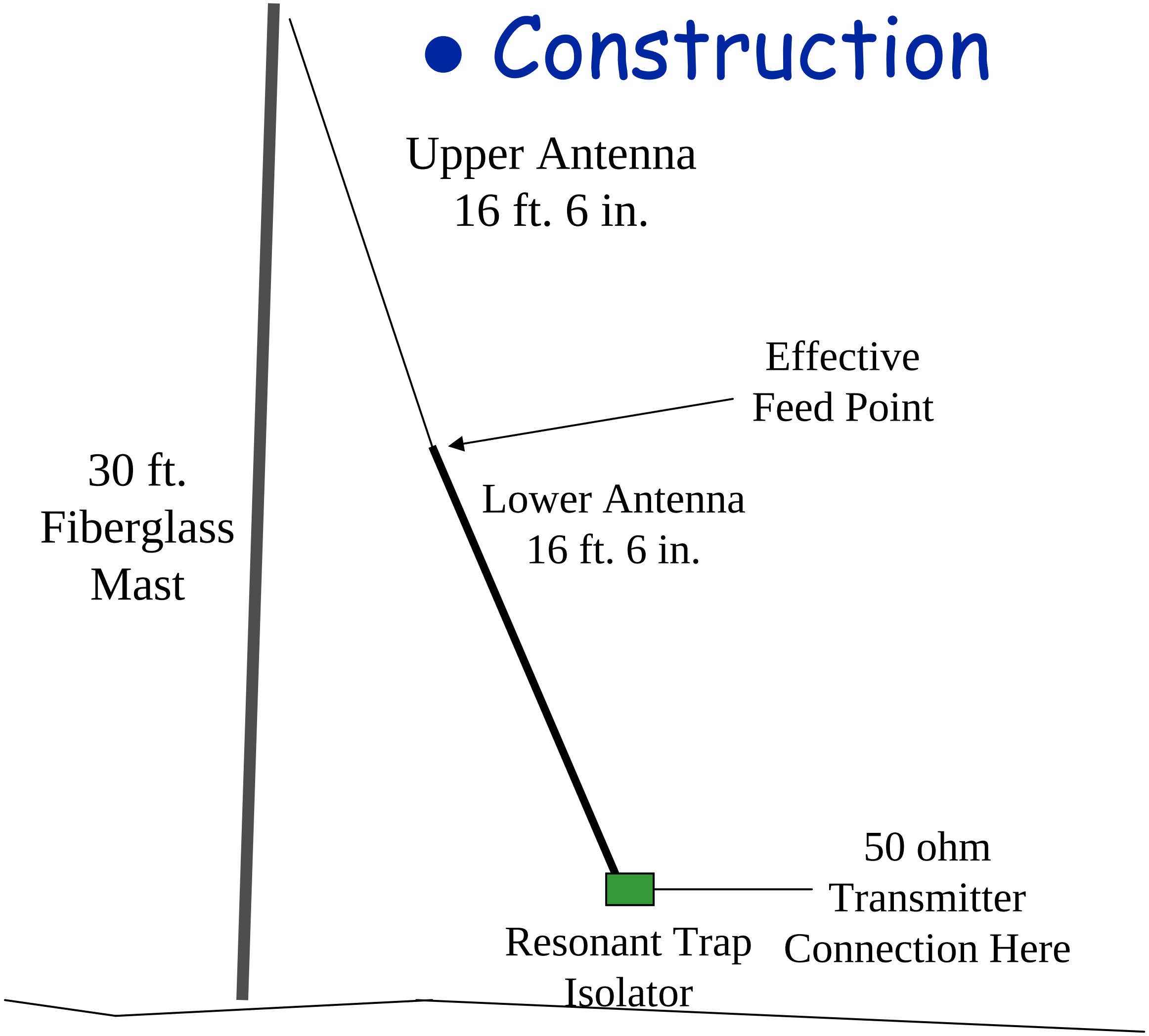
Reel Antennas

- Construction



Reel Antennas

- Construction



Reel Antennas

- Construction
  - » Reel Really Makes It EZ to Stow

Where to go for more into ...

- Reel Antennas
  - » New Dipole Feeder- Tuned Feeder Yet!, A.F. Stahler, AA6AX, 73 Magazine, June 1978
  - » RFD-1 and RFD-2: Resonant Feed-Line Dipoles, James Taylor, W2OZH, QST, August 1991
- Wide Band Dipoles
  - » Five Bands, No Tuner, Bill Wright, G0FAH, QST, June 1995
- Phased Arrays
  - » Antennas for All Applications, John Kraus and Ronald Marhefka, McGraw Hill, 2002..
  - » Collinear Phased Antennas for the HF Bands, Douglas Fouts, KI6QR, QST, March 1989
  - » The W5GI Mystery Antenna, John Basilotto, W5GI, CQ Magazine, July 2003.
  - » An Invisible DX Aerial for 14 MHz, Del Arthur, G0DLN, International Antenna Collection, RSGB, 2003, pp. 103-105.
- Moxon Antennas
  - » HF Antennas for All Locations, Les Moxon, G6XN, 2nd Edition, Printed 2002.
  - » Two-Element 40-Meter Switched Beam, Carrol Allen, AA2NN, The ARRL Antenna Compendium, Vol. 6, 1999, pp. 23-25.

Where to go for more info ...

- Antenna Modeling & Software
  - » ARRL Antenna Modeling Course, L.B. Cebik, edited by Dean Straw, American Radio Relay League, 2002.
  - » EZNEC or EZNEC+, Version 4.0.0, Roy Lewallen, www.eznec.com/
  - » MultiNEC, Version 2.2.1, Dan Maguire, AC6LA, www.qsl.net/ac6la/multinec.html
- Antenna Modeling Software, Shareware
  - » 4NEC2, http://www.qsl.net/wb6tpu/swindex.html
  - » MMANA, by JE3HHT (Mininec derivative), http://www.qsl.net/mmhamsoft/mmana/

Thanks for Being a Great Audience ...

See You in the Field

You can download this presentation at

www.k5pa.com

End Slide

Wide Band Dipole - Show 'n Tell

- Remote ATU
- Ladder Line

Moxon – Show 'n Tell

- 6 M Moxon Beam Pieces

Flipbeam Ant - Show 'n Tell

- Antenna Flip Switch Control
- Flip Switch Ant Relay
- Antenna Switch
- Dipole Element Collapsed
- Phasing Harness

Phased Array - Show 'n Tell

- 20 M Phased Dipoles with Reel

Reel Antenna - Show 'n Tell