ZS6BKW vs G5RV

Antenna Patterns/SWR at 40 ft
Center height, 27 ft end height
~148 Degree Included Angle

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For the AARA Ham Radio Club

Note: All graphs computed using MMANA GAL
http://mmhamsoft.amateur-radio.ca/mmana/index.htm

ZS6BKW / G5RV What is it?

In the mid-1980s, Brian Austin (ZS6BKW) ran computer analysis to develop an antenna System that, for the maximum number of HF bands possible, would permit a low Standing Wave Ratio (SWR) without antenna tuner to interface with a 50-Ohm coaxial cable as the main feed line. He identified a range of lengths which, when combined with a matching ladder line length, would provide this characteristic.

According to an acknowledged expert in computer antenna design and modeling, L. B. Cebik:

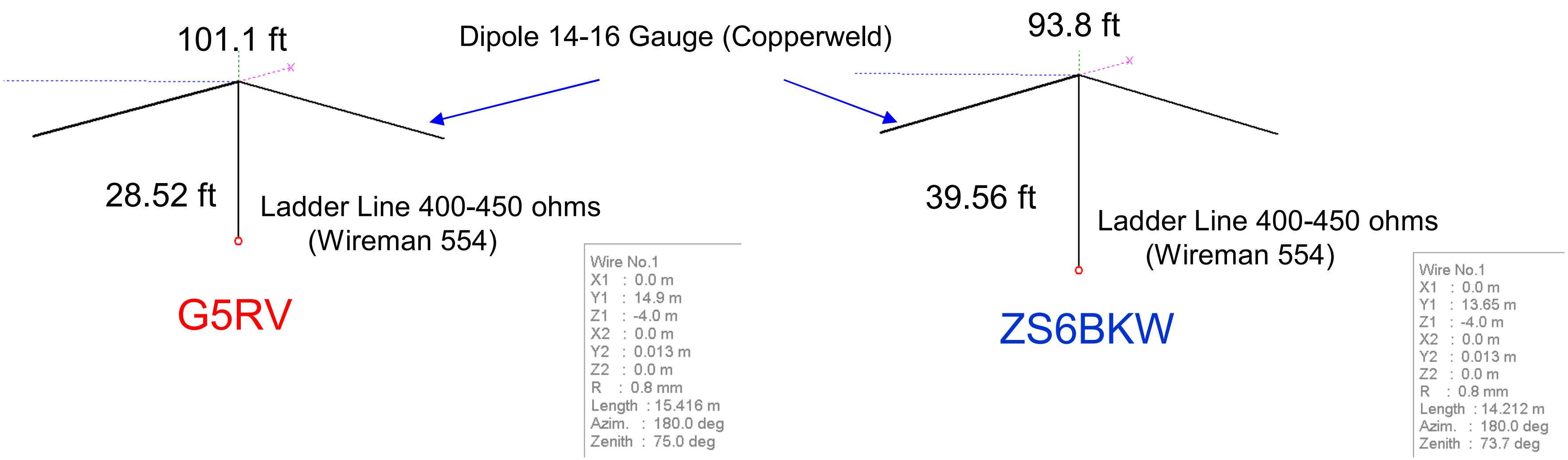
"Of all the G5RV antenna system cousins, the ZS6BKW antenna system has come closest to achieving the goal that is part of the G5RV mythology: a multi-band HF antenna consisting of a single wire and simple matching system to cover as many of the amateur HF bands as possible."

Both are "good" antennas and will work well in defined situations. This presentation is not designed to "bash" the G5RV, but to possibly convince you or a new ham to enjoy the benefits of lower SWR, lower loss, and greater signal strength by using the ZS6BKW version of a ladder line fed dipole.

ZS6BKW / G5RV Why I like it

1. Has low swr in several ham bands at the matching point at the end of the ladder line resulting in lower losses in the coax cable. (I have a 200 ft run from the antenna to the radio making this crucial.)
2. Can be operated without an outboard tuner on at least 5 bands.
3. Has both simplicity and low cost. (Good emergency antenna)
4. Will work with one central support and two lower supports (Inverted Vee) OR two end supports (Flat Top) on a typical city lot.
5. It retains the high-strength in the antenna wire, allowing the antenna to help support the central mounting pole. (No heavy coax or inline traps in the antenna line like the “W5GI” or “W3DZZ”.)
6. Antenna patterns are “reasonable” for local or DX work.
7. Can be operated on non-optimum bands with an external tuner.
8. Multiband means better utilization of available space, fewer antennas and coax runs, and means you can put the extra money in high quality low loss cables or increasing the height to 30-50 ft.
9. One can also erect a 80/40 or 160/80 wire from the same support, at about 90 degrees to the ZS6BKW to keep it stable and free standing in moderate winds. I use a 148 ft W5DXP dual band (80/40M).

Modeled Antenna Geometry

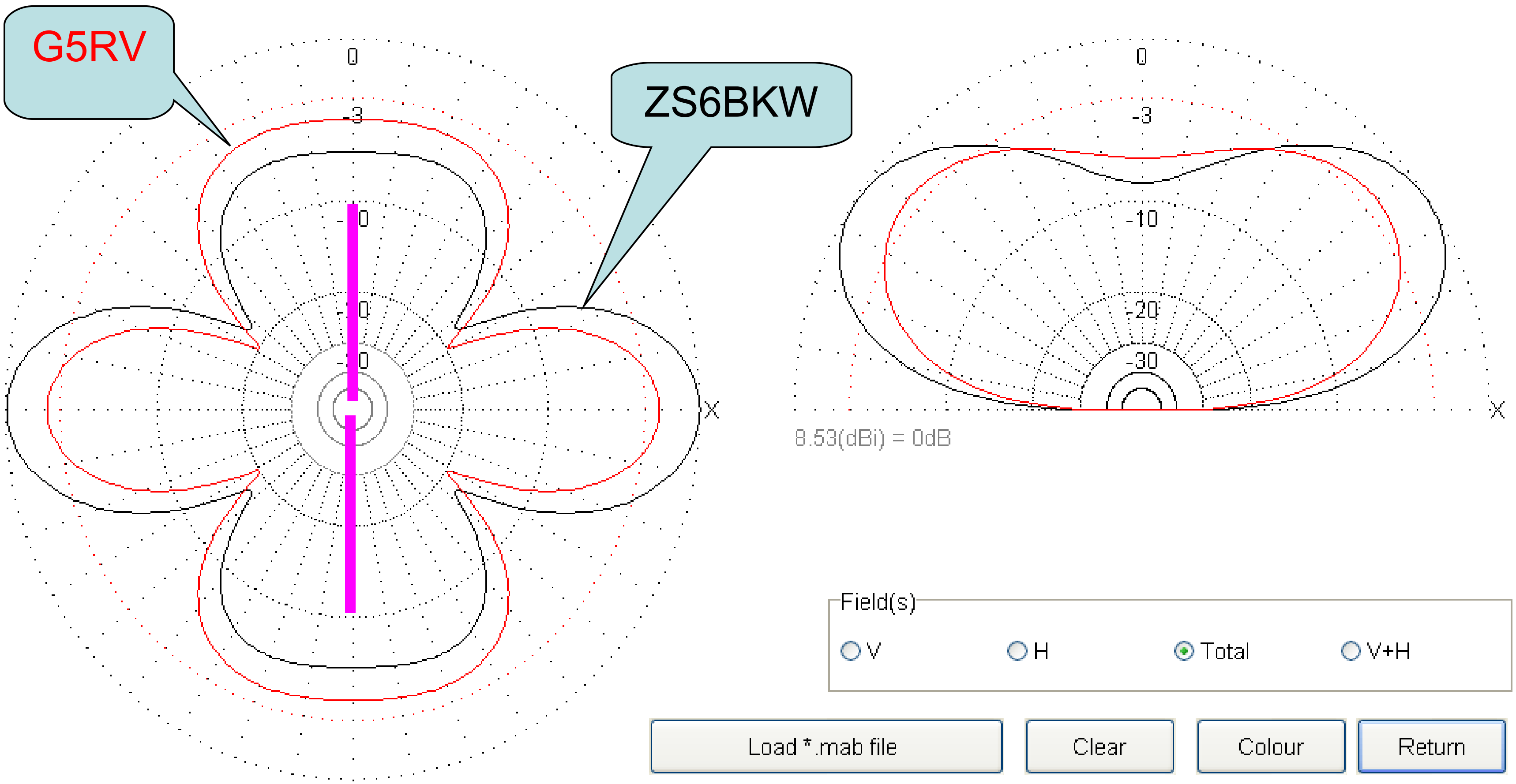


Dipole length is 101.1 ft, ladder line 37.52 ft
(28.52 ft when vf=.9)

Dipole length is 93.8 ft, ladder line 43.95 ft
(39.56 ft when vf=0.9)

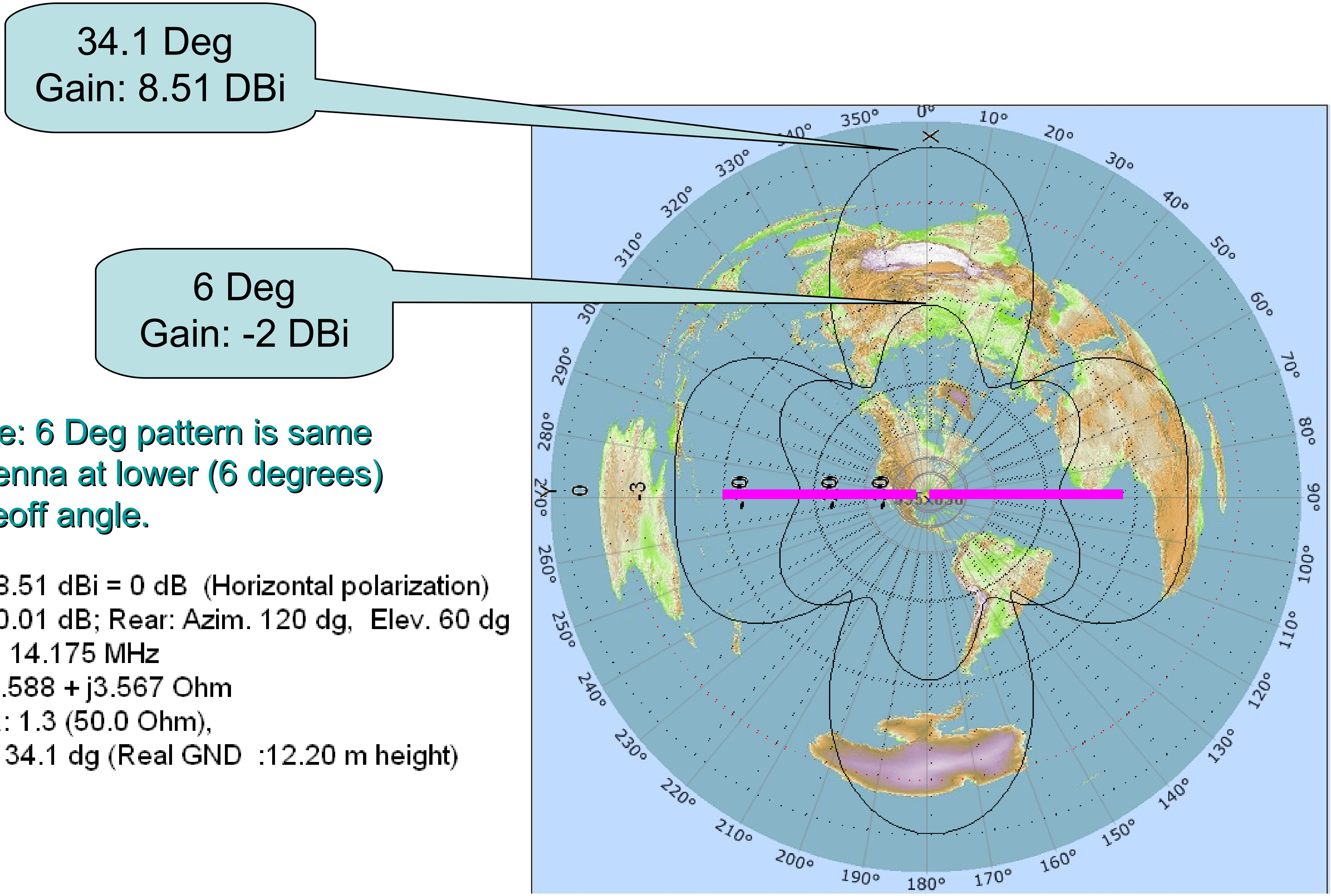
G5RV → 7.3 ft shorter wire
11 ft longer ladder → ZS6BKW

ZS6BKW / G5RV Pattern (20M)



No.	F (MHz)	R	jX	SWR	Gh	Ga	F/B	Elev.	GND	Height	Pol.	File	name
1	14.15	61.906	-3.538	1.25	---	8.53	0.01	34.1	Real	12.2	H	this	ZS6BKW
2	14.15	117.541	-11.108	2.38	---	6.4	0.0	40.1	Real	12.2	H	E:\MyCrypt\Ha	GR5V VEE

Radiation Pattern ZS6BKW 20M



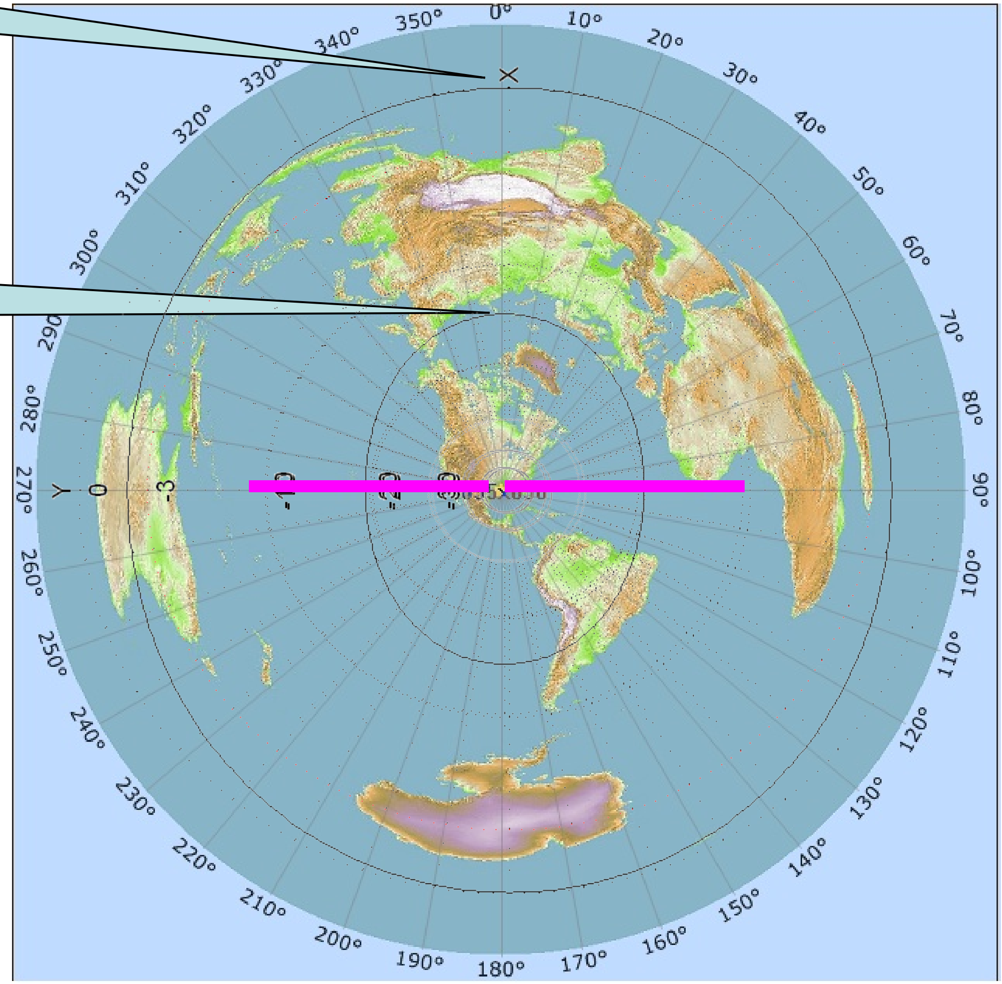
Note: 6 Deg pattern is same antenna at lower (6 degrees) takeoff angle.

Ga : 8.51 dBi = 0 dB (Horizontal polarization)
F/B: 0.01 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 14.175 MHz
Z: 62.588 + j3.567 Ohm
SWR: 1.3 (50.0 Ohm),
Elev: 34.1 dg (Real GND :12.20 m height)

Radiation Pattern ZS6BKW 40M

63 Deg
Gain: 6.3 DBi

6 Deg
Gain: -8 DBi



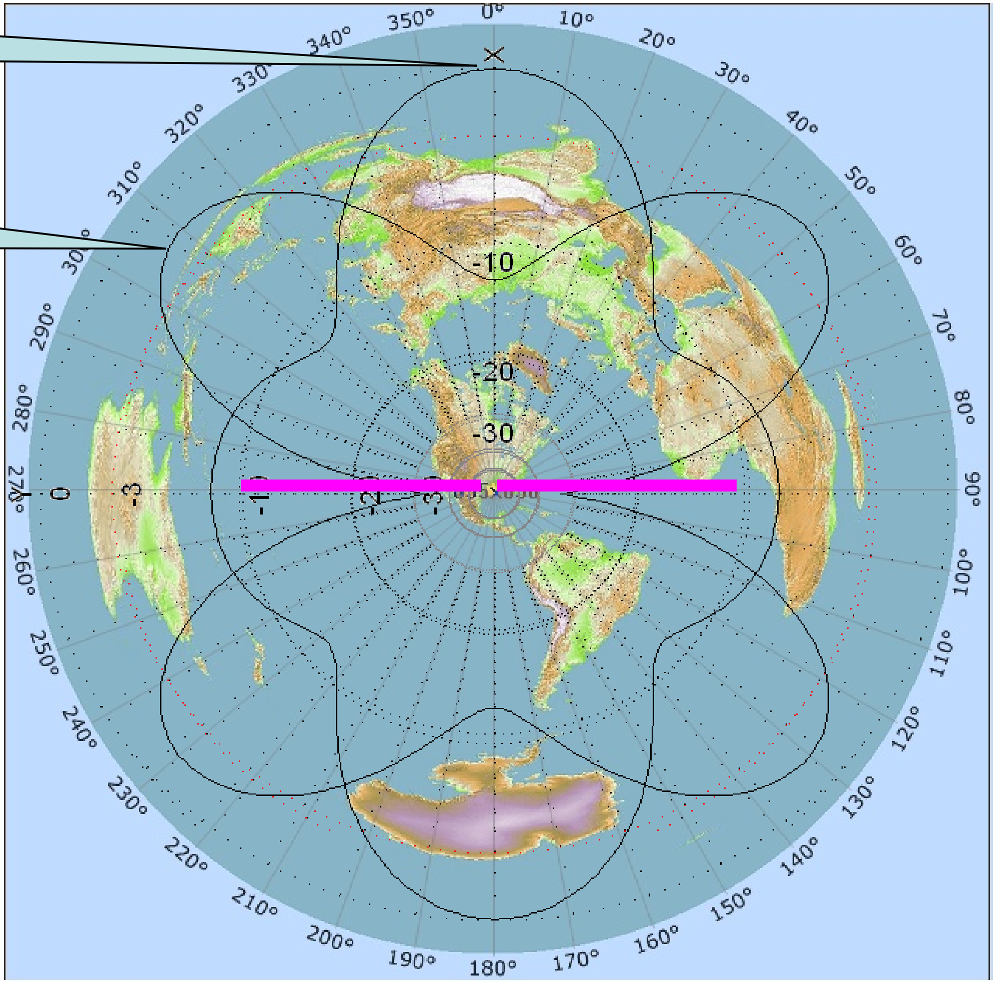
Note: 6 Deg pattern is same antenna at lower (6 degrees) takeoff angle.

Ga : 6.26 dBi = 0 dB (Horizontal polarization)
F/B: -0.00 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 7.150 MHz
Z: 72.682 - j28.268 Ohm
SWR: 1.8 (50.0 Ohm),
Elev: 63.0 dg (Real GND :12.20 m height)

Radiation Pattern ZS6BKW 17M

50 Deg
Gain: 2.5 DBi

6 Deg
Gain: 1.1 DBi



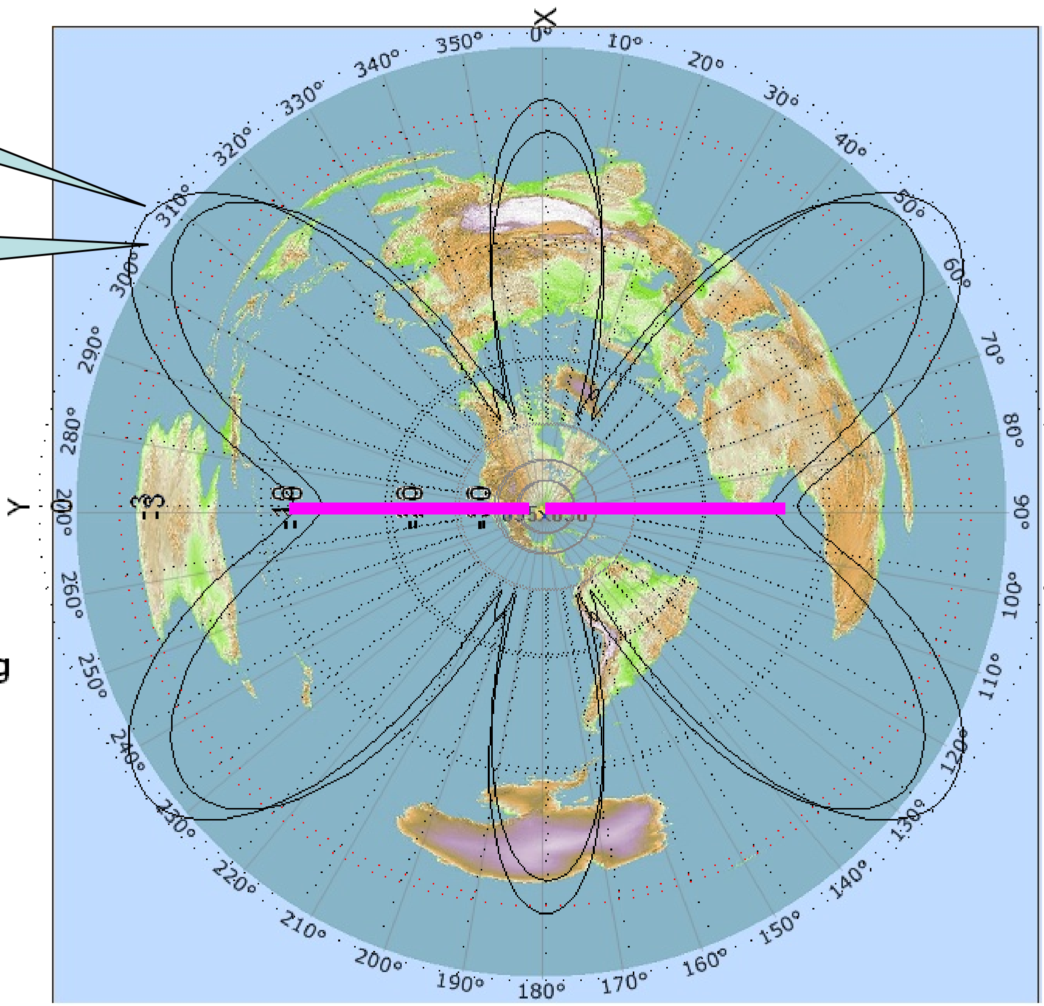
Note: 6 Deg pattern is same antenna at lower (6 degrees) takeoff angle.

Ga : 2.55 dBi = 0 dB (Horizontal polarization)
F/B: -0.03 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 18.120 MHz
Z: 84.435 - j5.839 Ohm
SWR: 1.7 (50.0 Ohm),
Elev: 50.0 dg (Real GND :12.20 m height)

Radiation Pattern ZS6BKW 10M

14 Deg
Gain: 9.4 DBi

6 Deg
Gain: 6.8 DBi



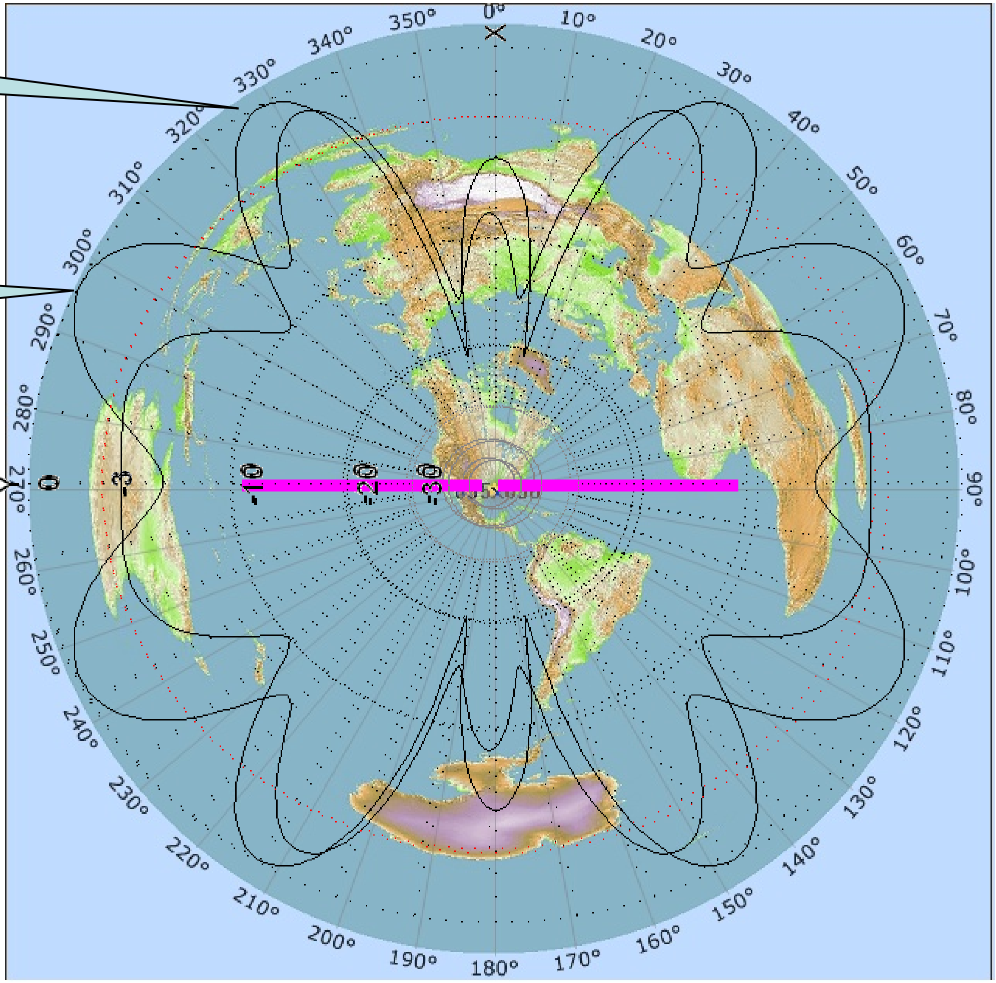
Note: 6 Deg pattern is same antenna at lower (6 degrees) takeoff angle.

Ga : 9.36 dBi = 0 dB (Horizontal polarization)
F/B: -2.61 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 29.000 MHz
Z: 75.369 + j15.961 Ohm
SWR: 1.6 (50.0 Ohm),
Elev: 14.0 dg (Real GND :12.20 m height)

Radiation Pattern ZS6BKW 12M

25.4 Deg
Gain: 7.4 DBi

6 Deg
Gain: 2.9 DBi

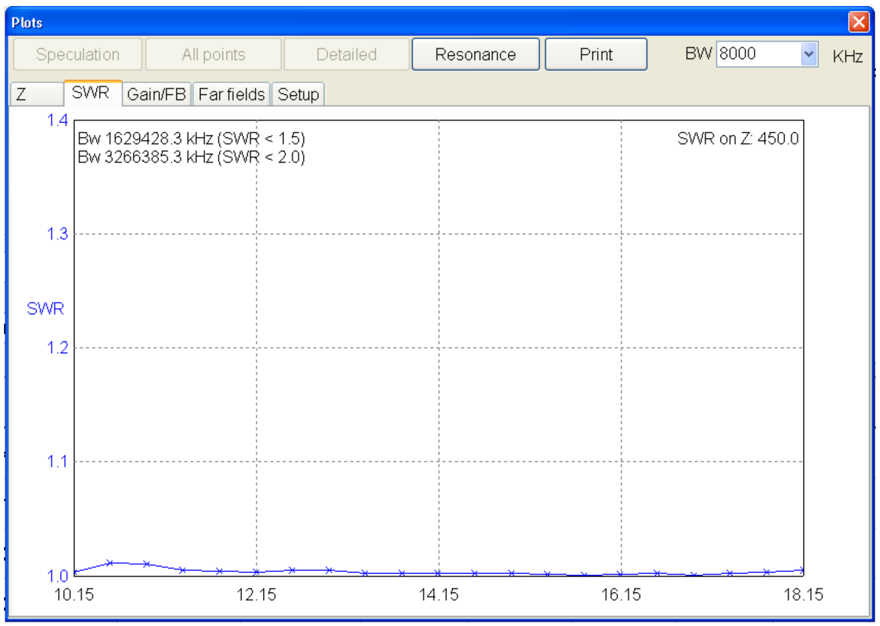


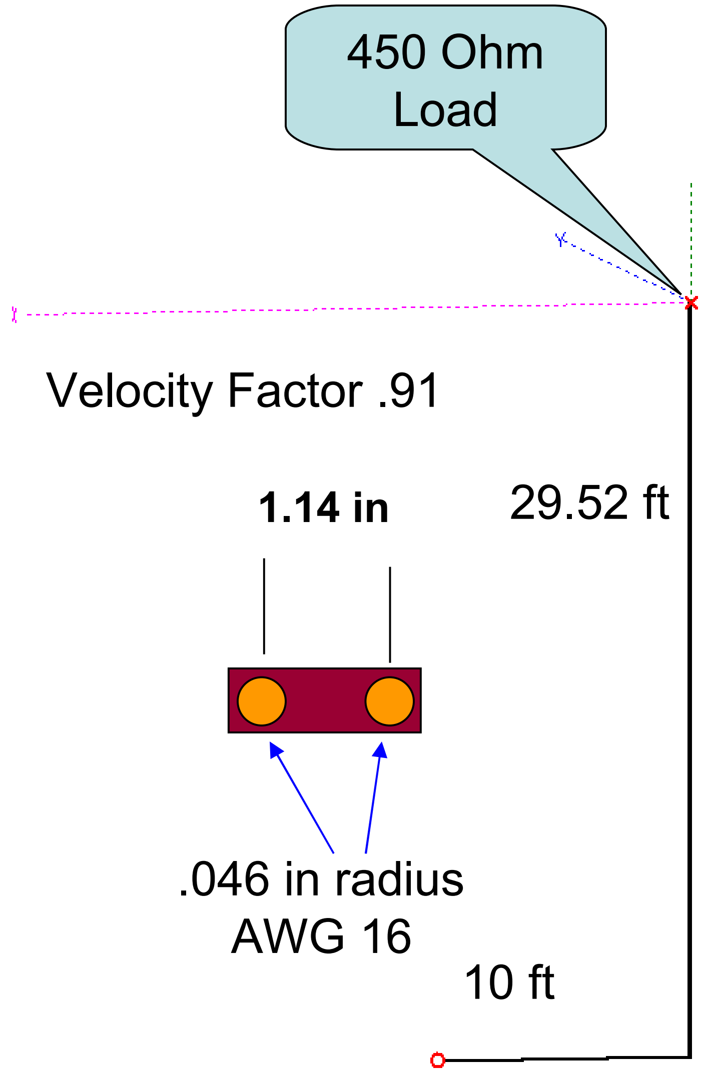
Note: 6 Deg pattern is same antenna at lower (6 degrees) takeoff angle.

Ga : 7.43 dBi = 0 dB (Horizontal polarization)
F/B: -5.06 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 24.900 MHz
Z: 72.623 + j25.168 Ohm
SWR: 1.7 (50.0 Ohm),
Elev: 25.4 dg (Real GND :12.20 m height)

450 Ohm Ladder Feedline

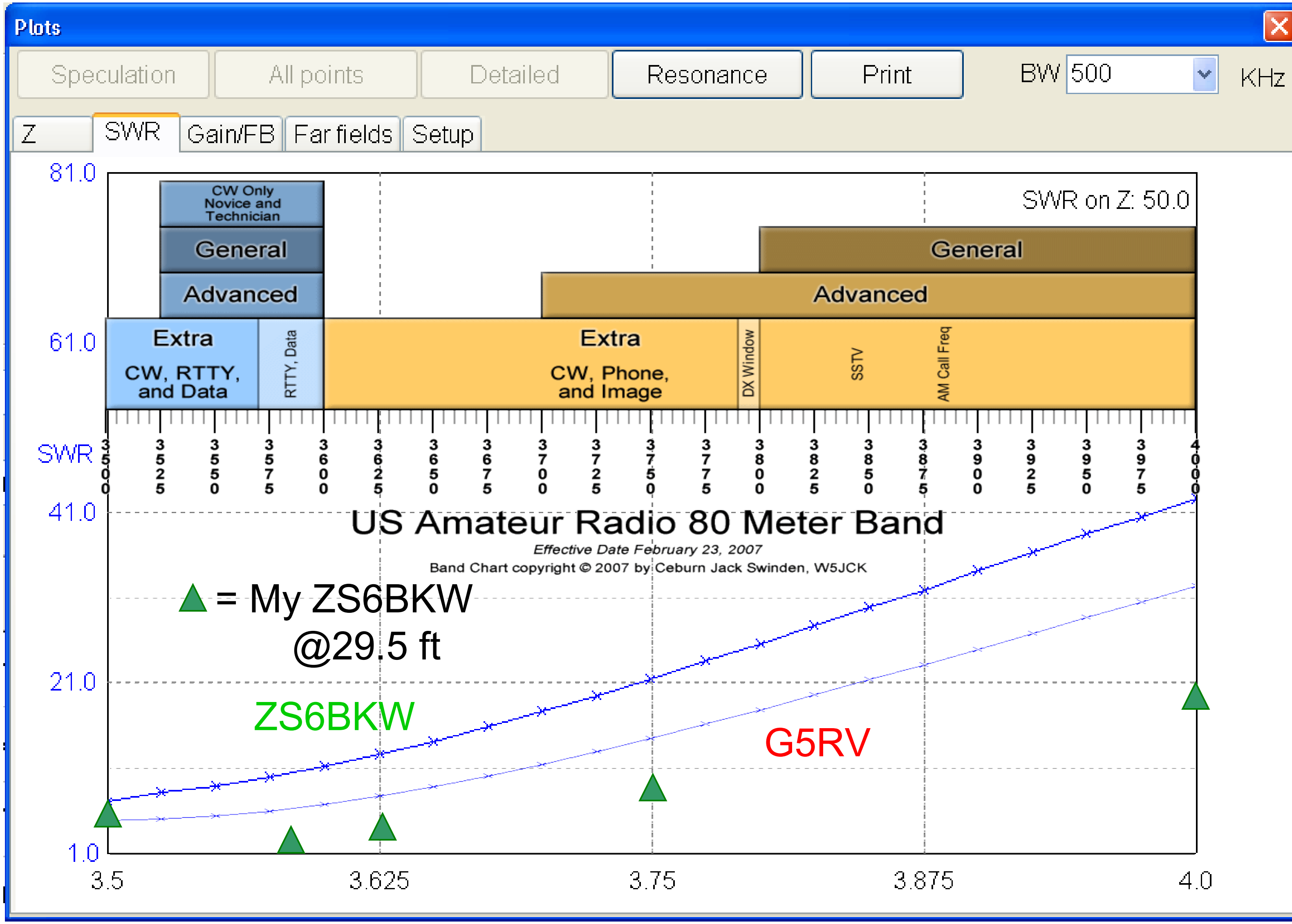
SWR Feedline 450 Ohms



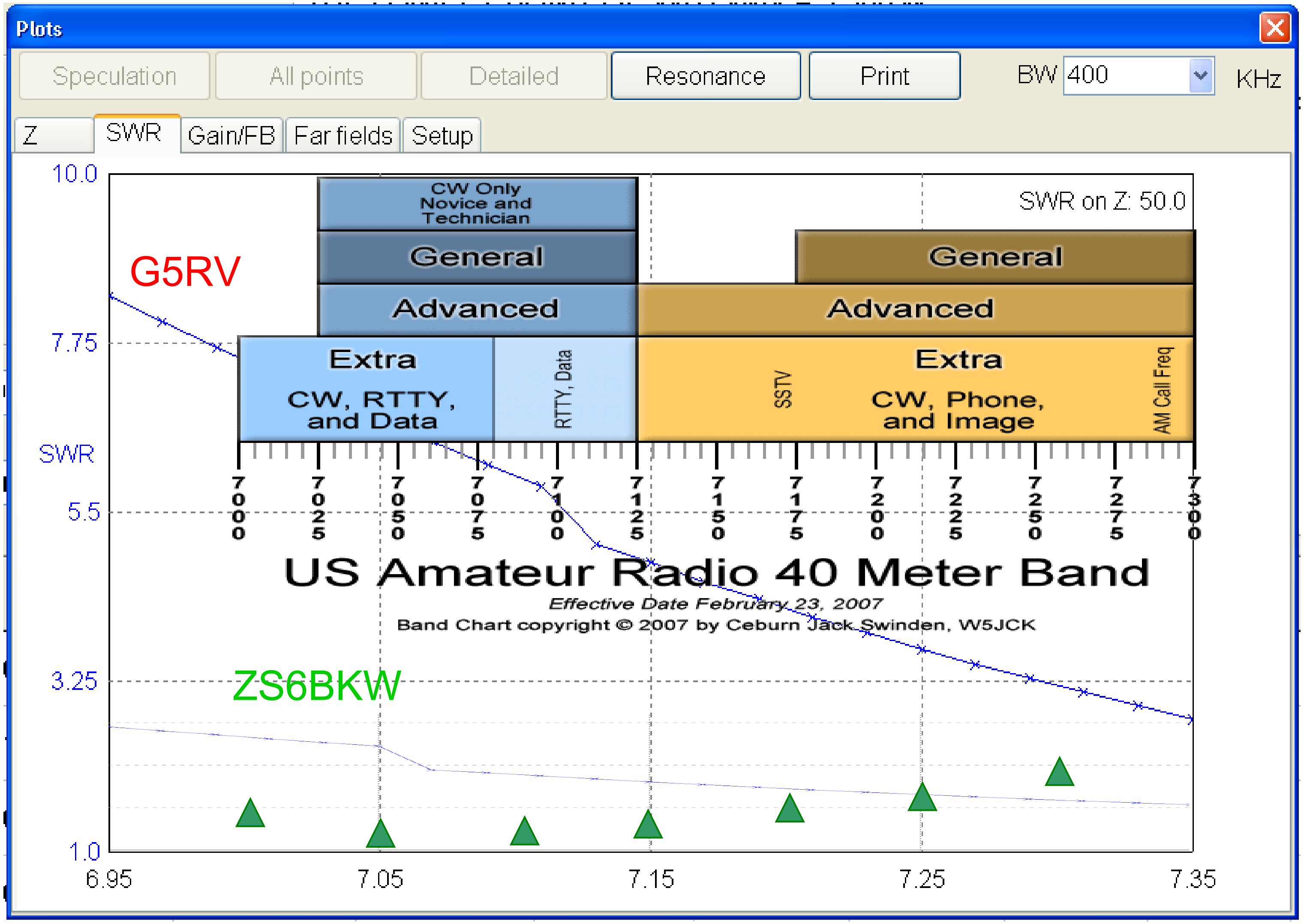


Note: Avoid close proximity between the ladder line and any metal object (at least 3-6 inches) and do not lay the excess ladder line on the ground!)

80 Meter SWR Curves

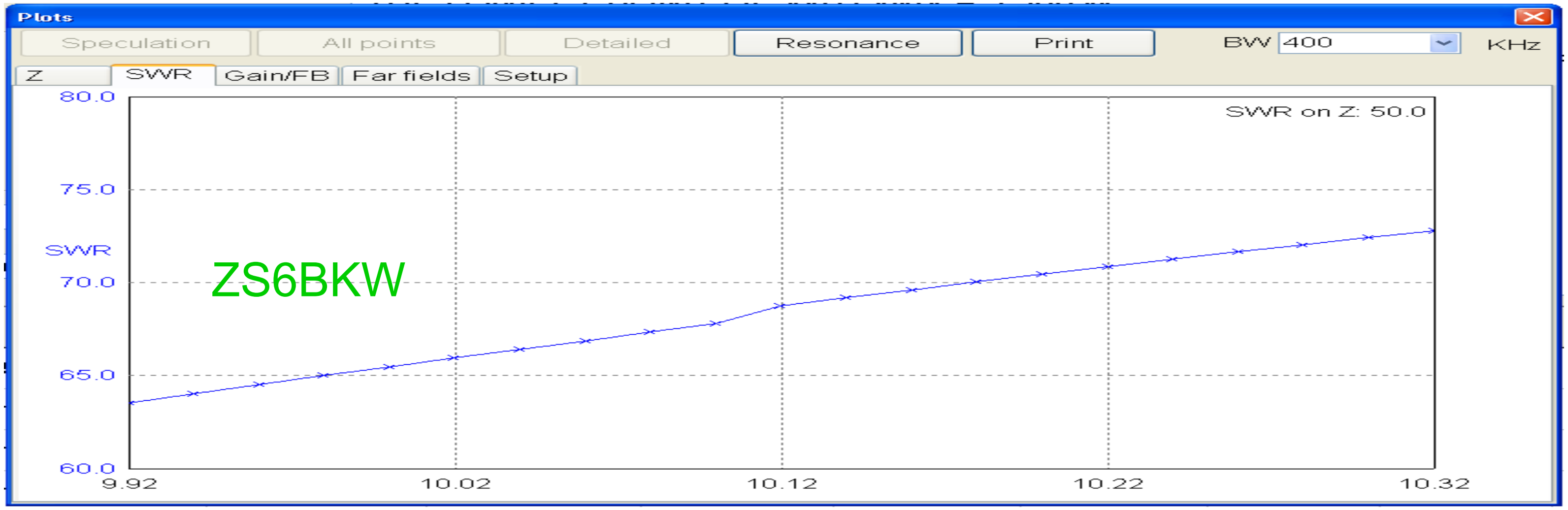


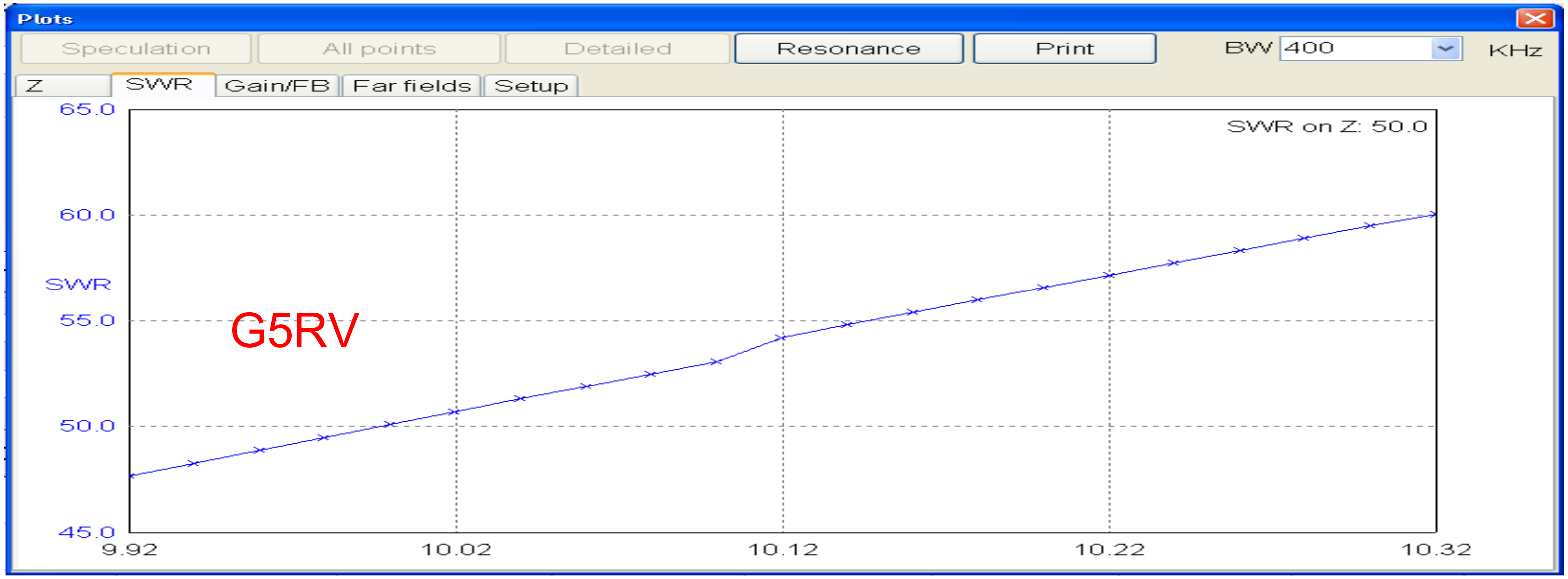
40 Meter SWR Curves



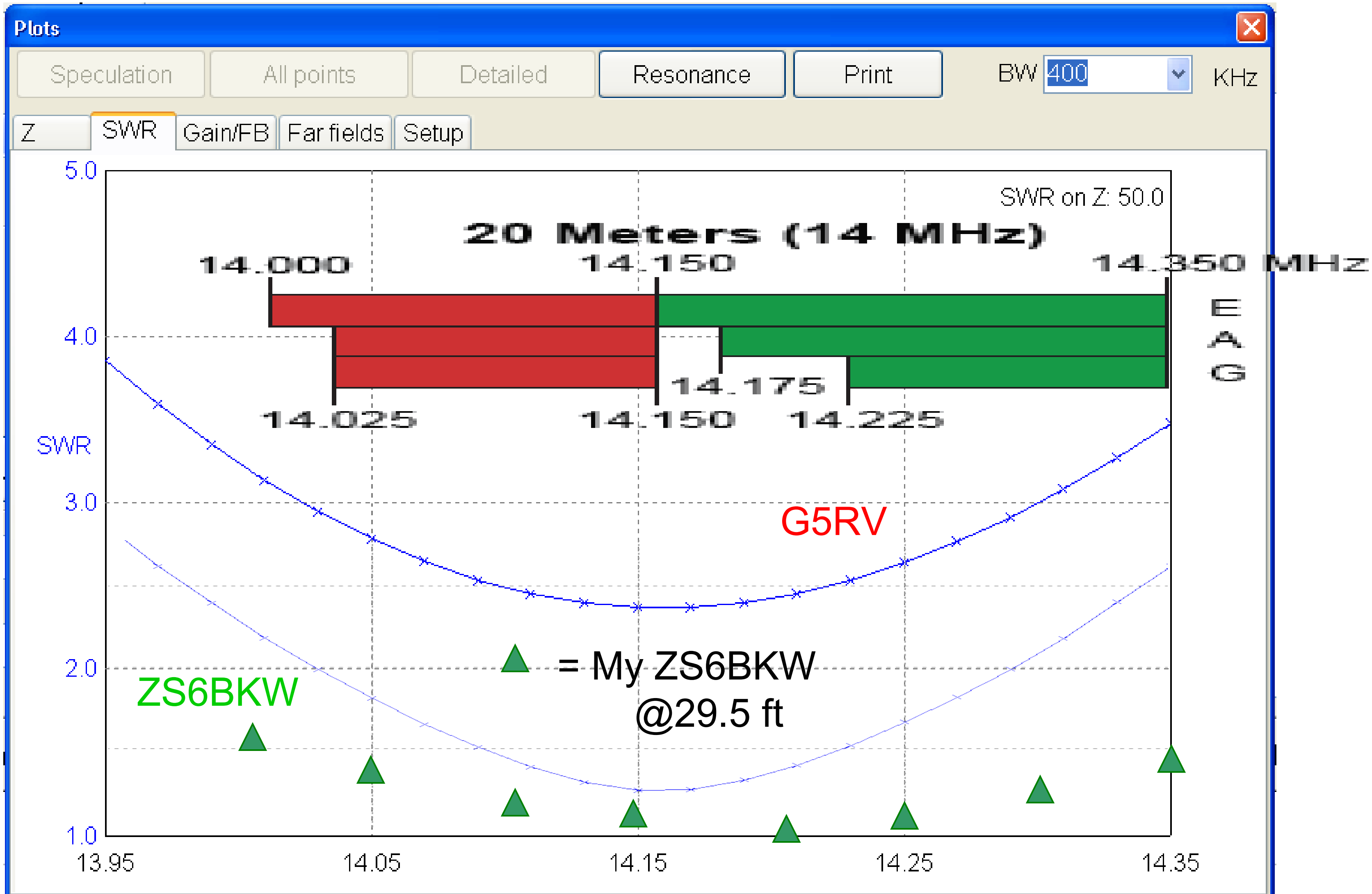
30 Meter SWR Curves

(Neither antenna is useful on this band)



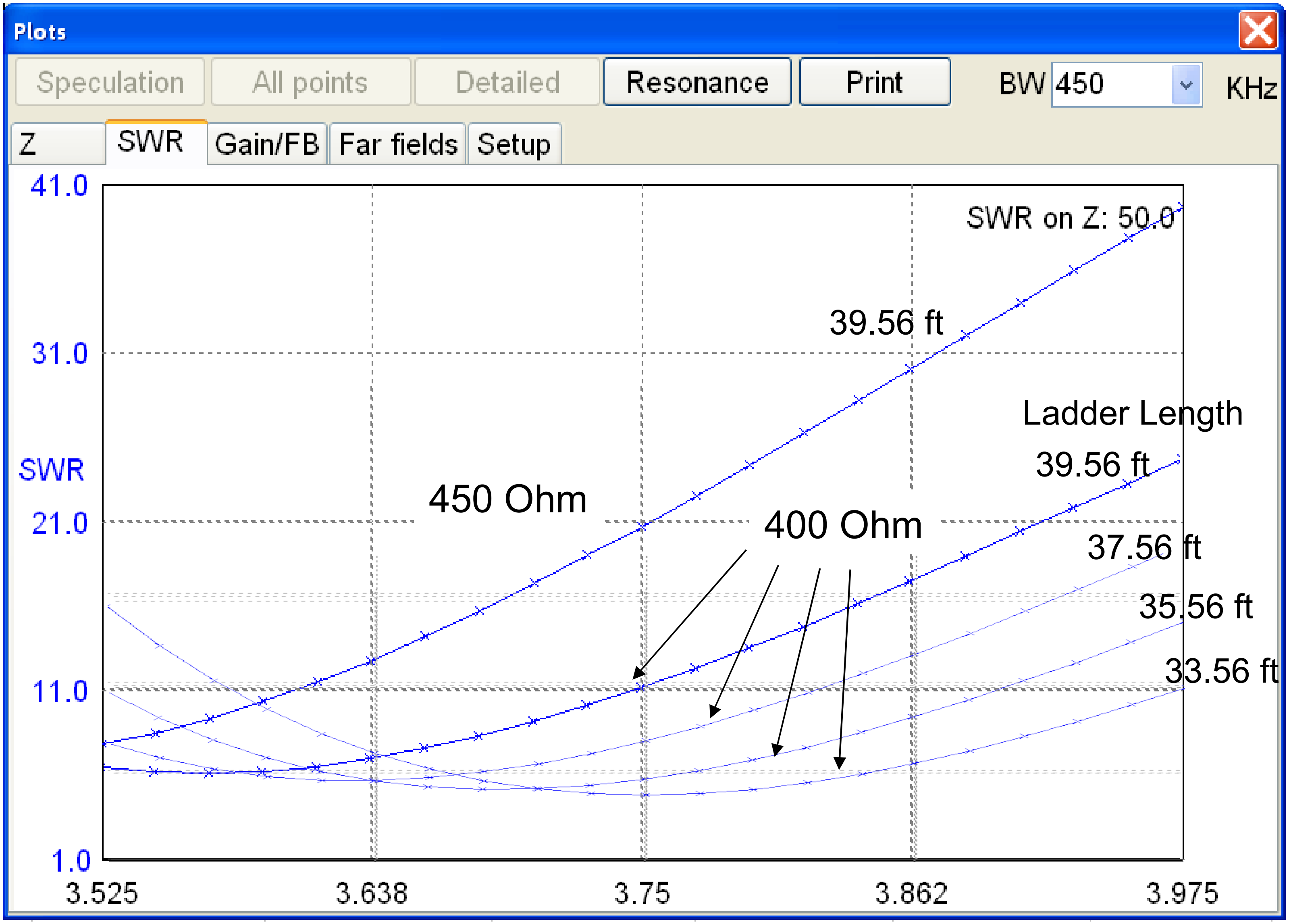


20 Meter SWR Curves

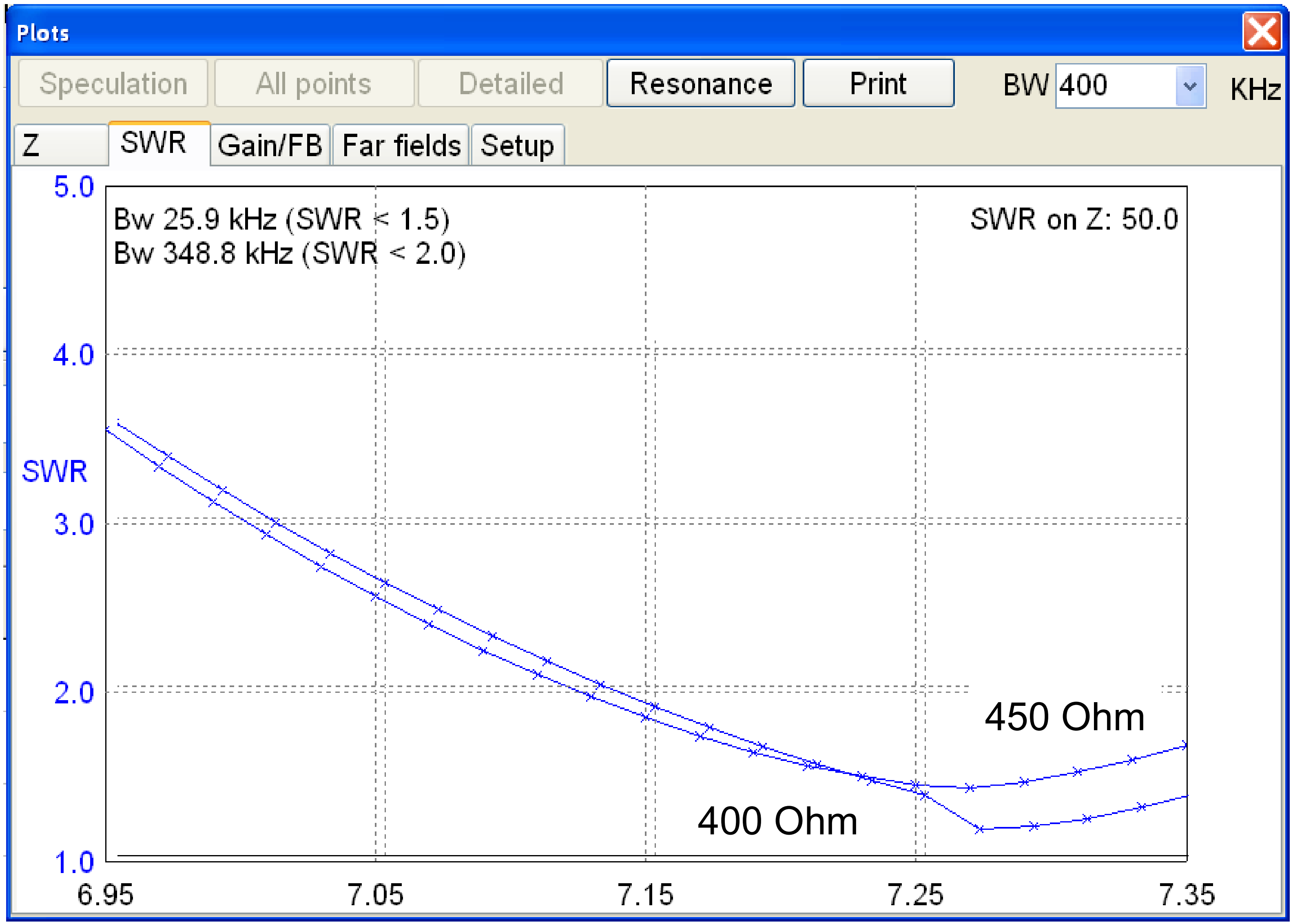


20 Meter SWR Curves – 400 Ohm Feed

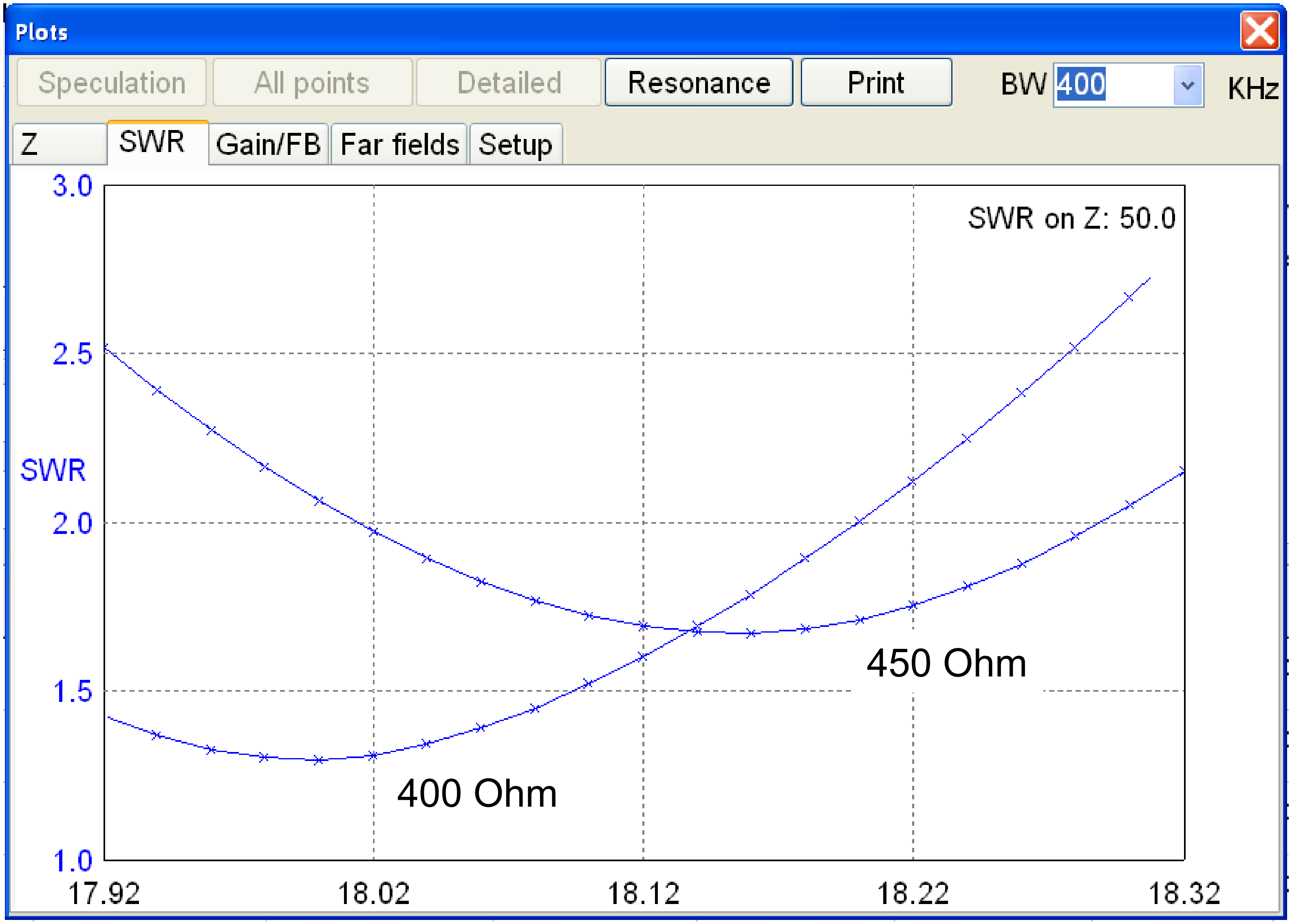
80 Meter SWR Curves – 400 Ohm Feed



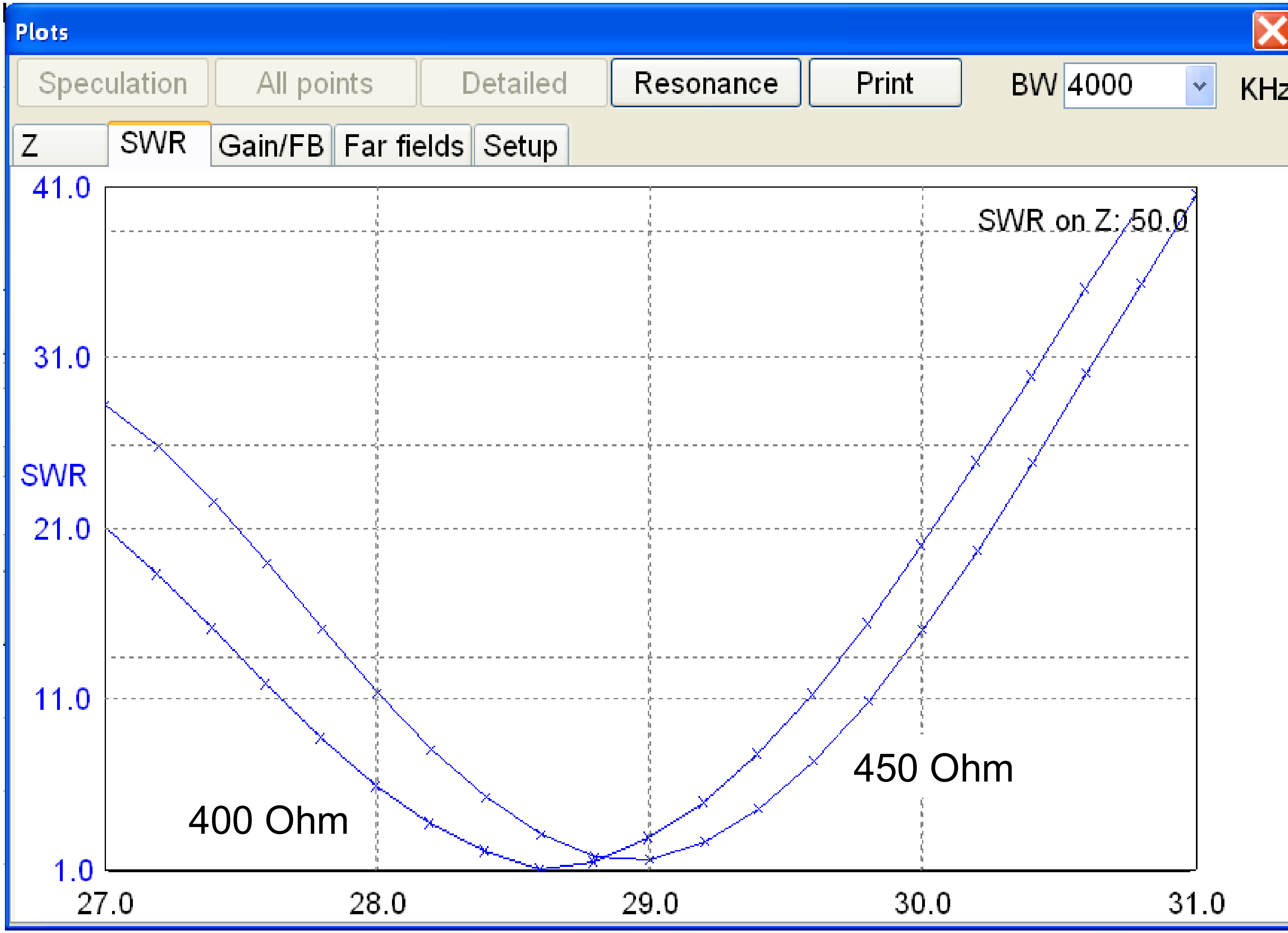
40 Meter SWR Curves – 400 Ohm Feed



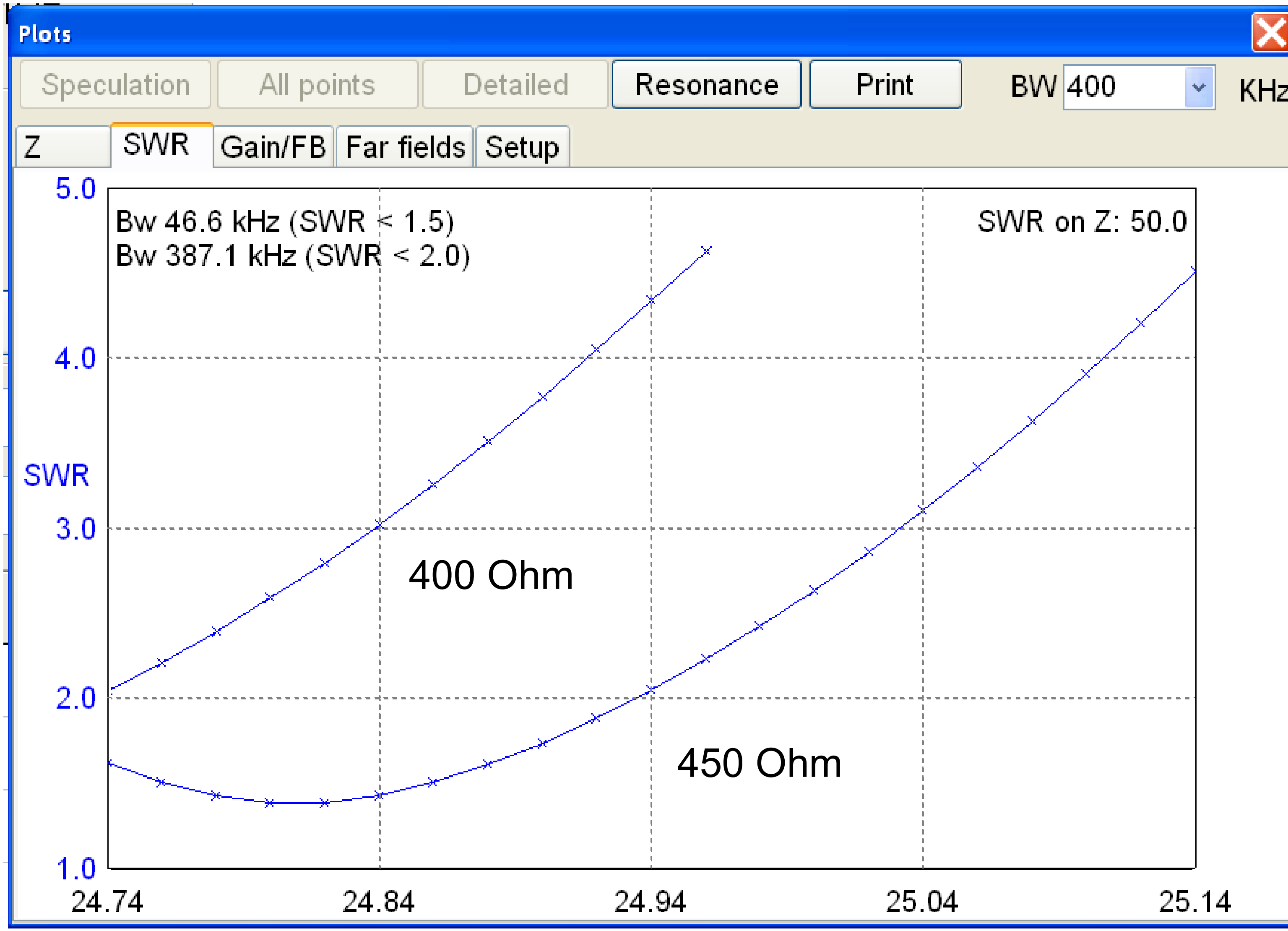
17 Meter SWR Curves – 400 Ohm Feed



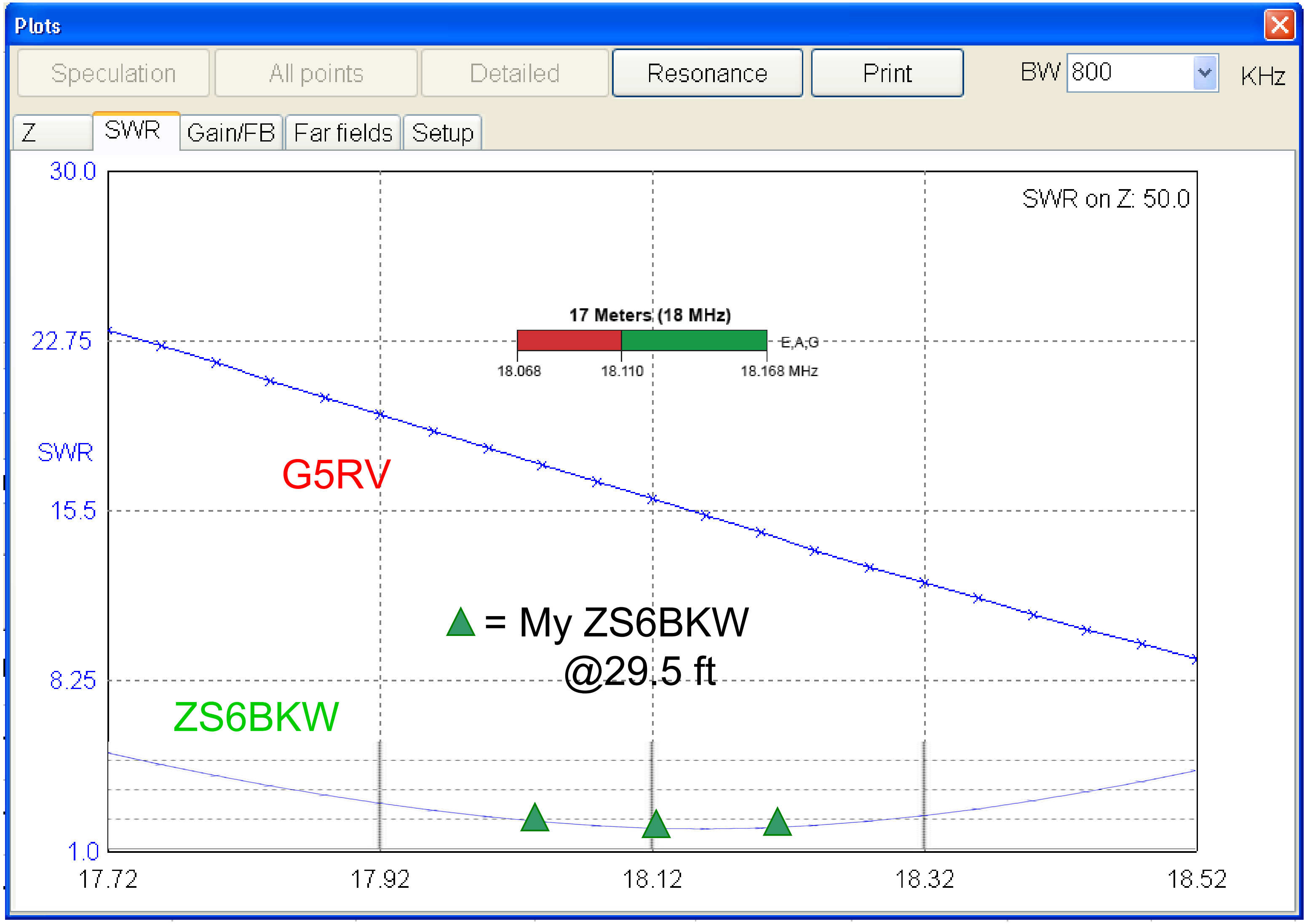
10 Meter SWR Curves – 400 Ohm Feed



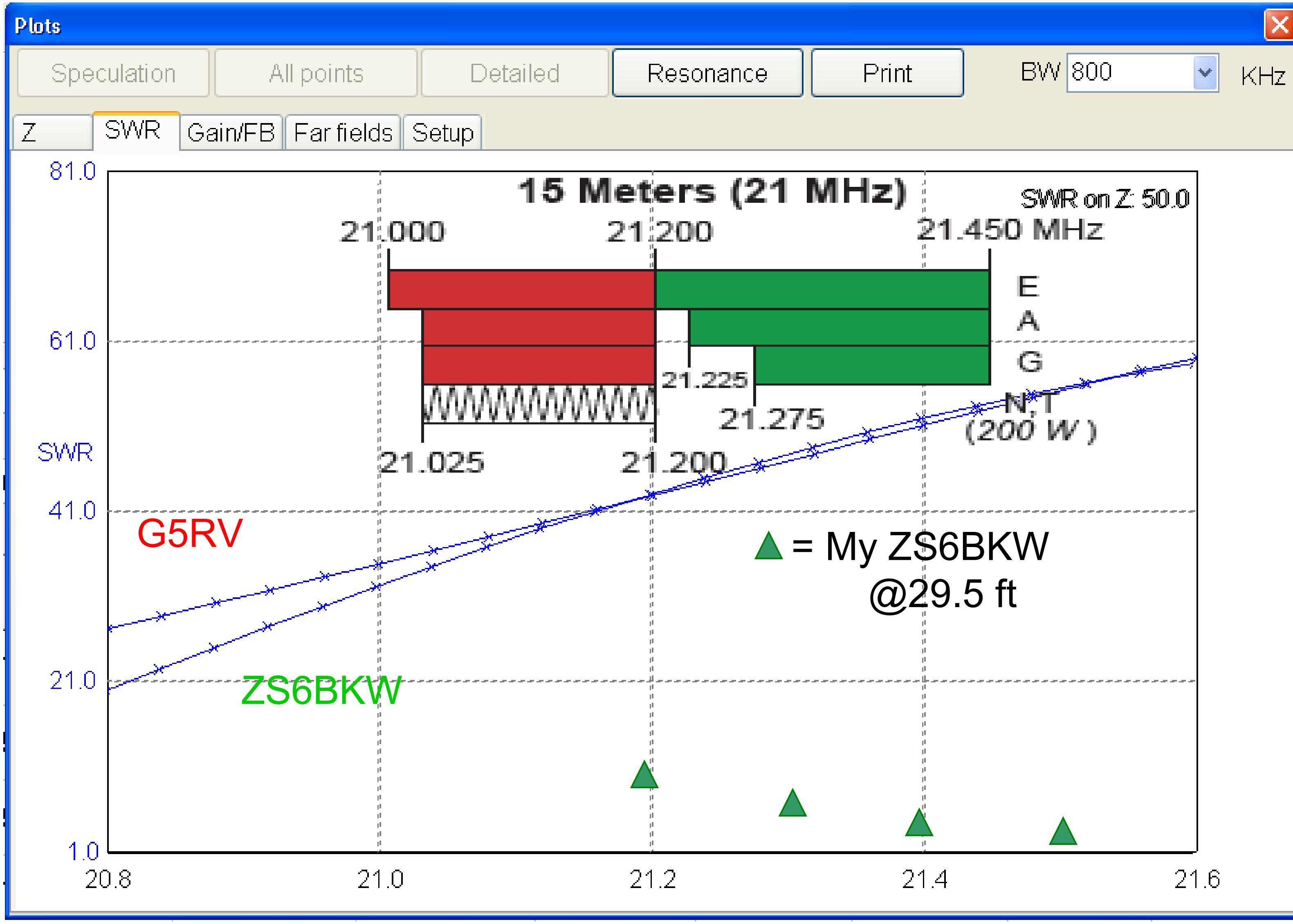
12 Meter SWR Curves – 400 Ohm Feed



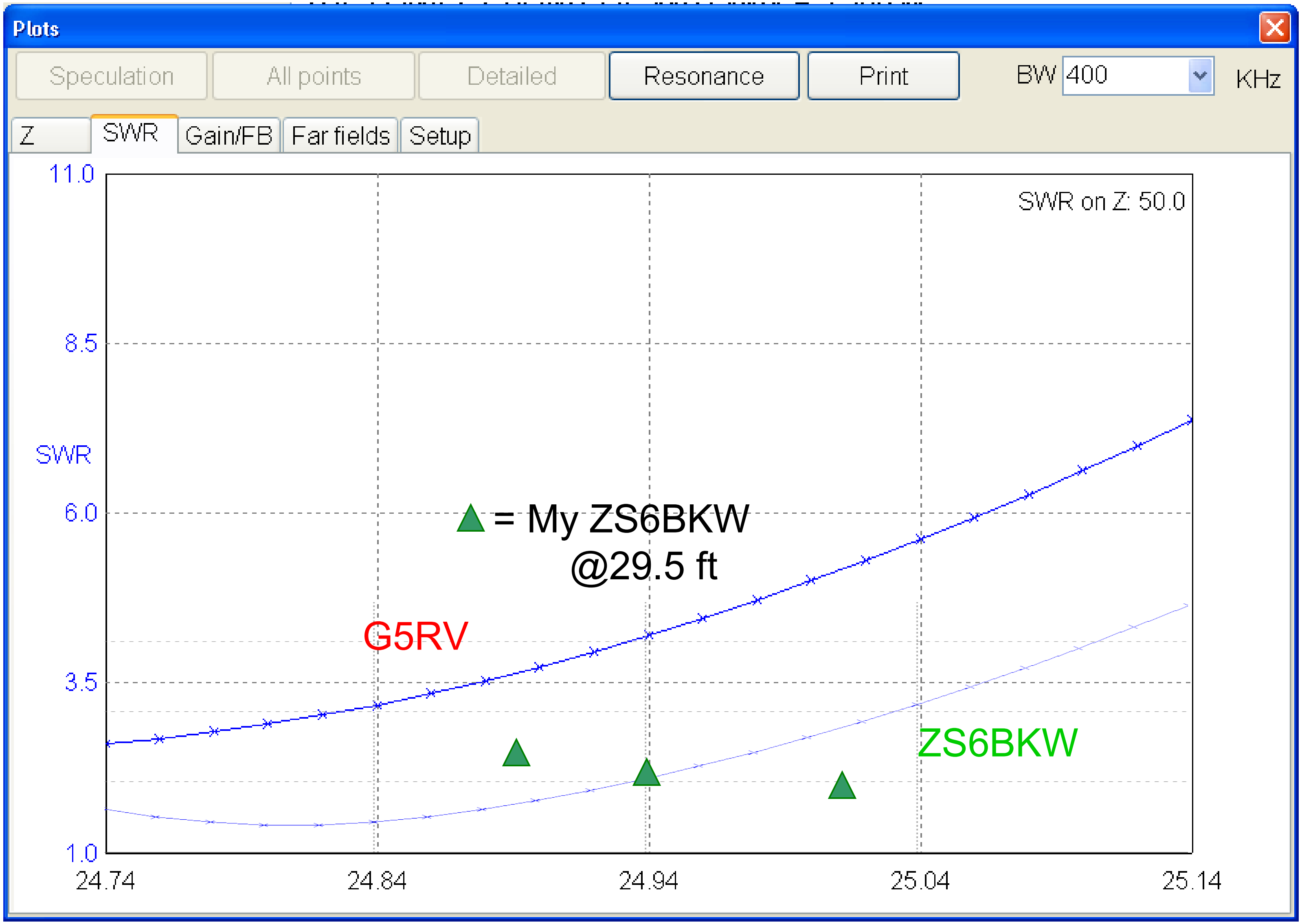
17 Meter SWR Curves



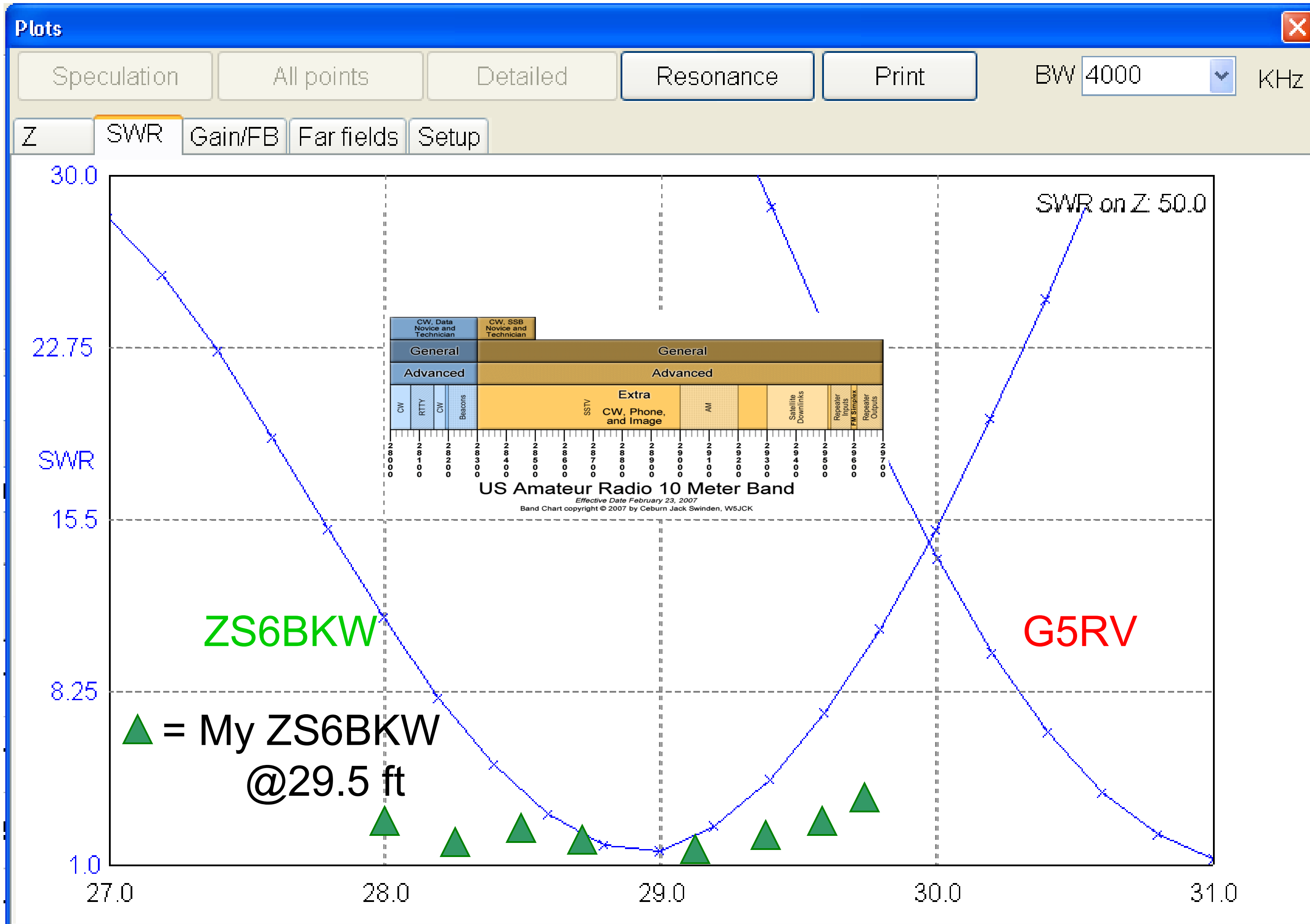
15 Meter SWR Curves



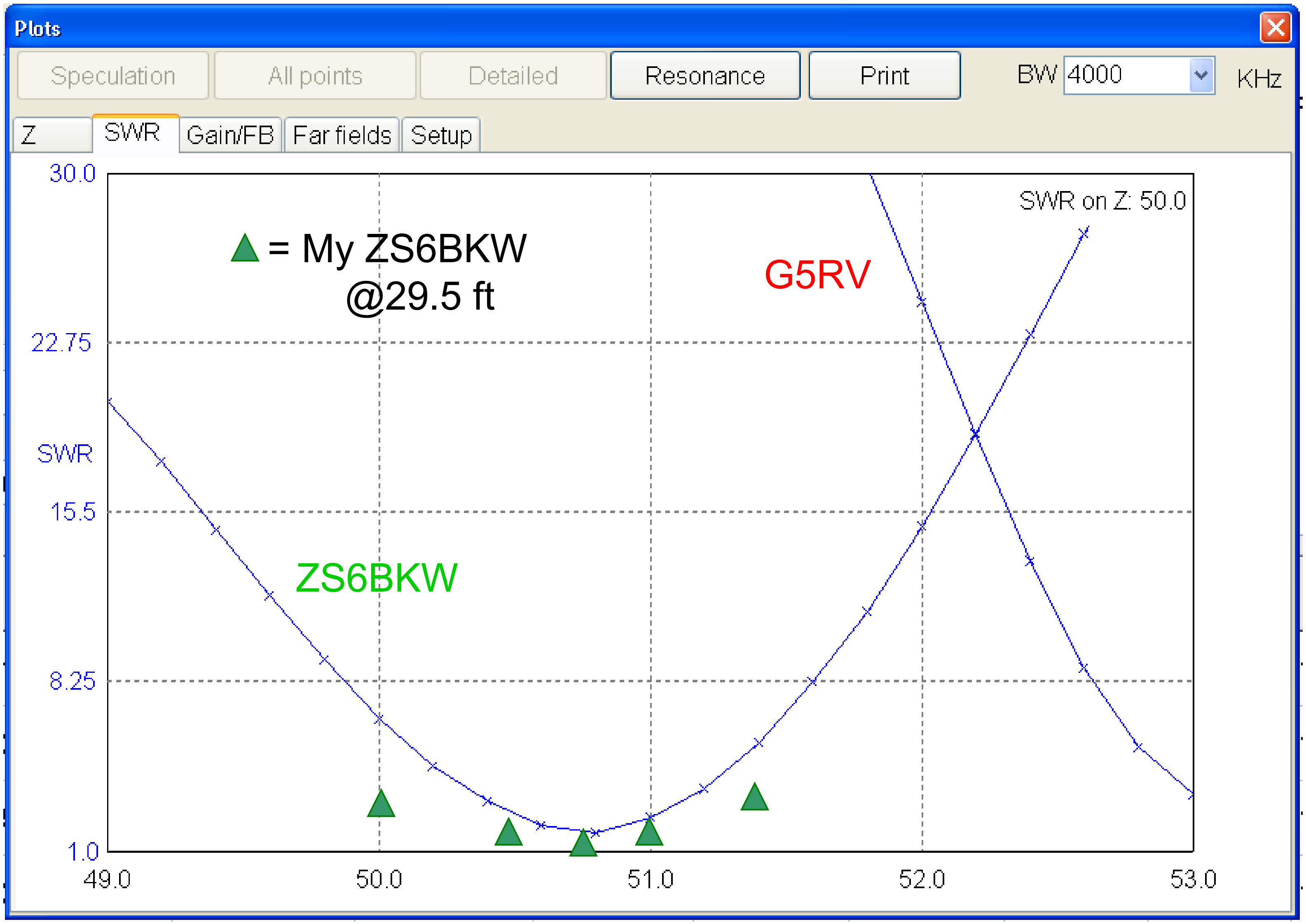
12 Meter SWR Curves



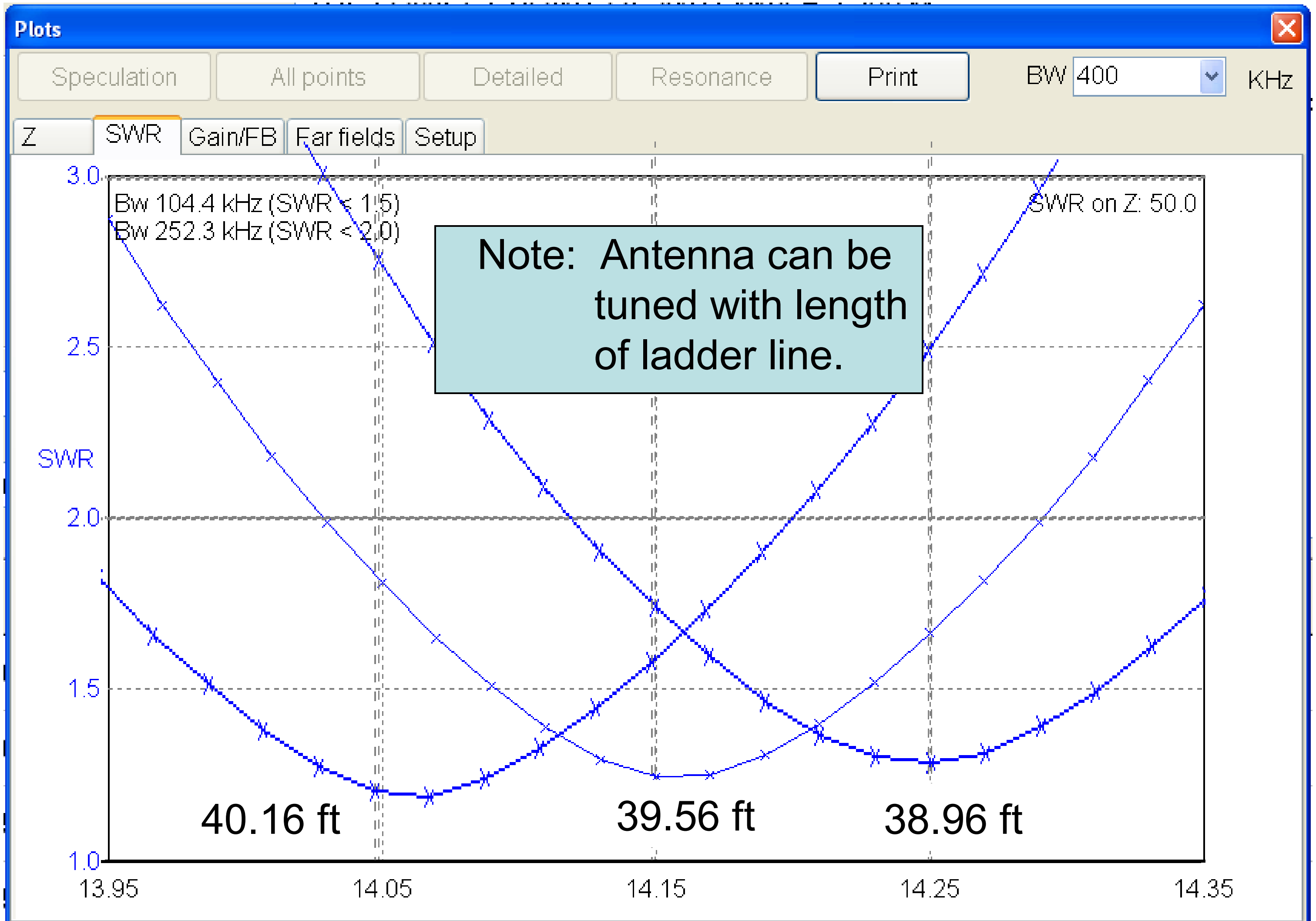
10 Meter SWR Curves



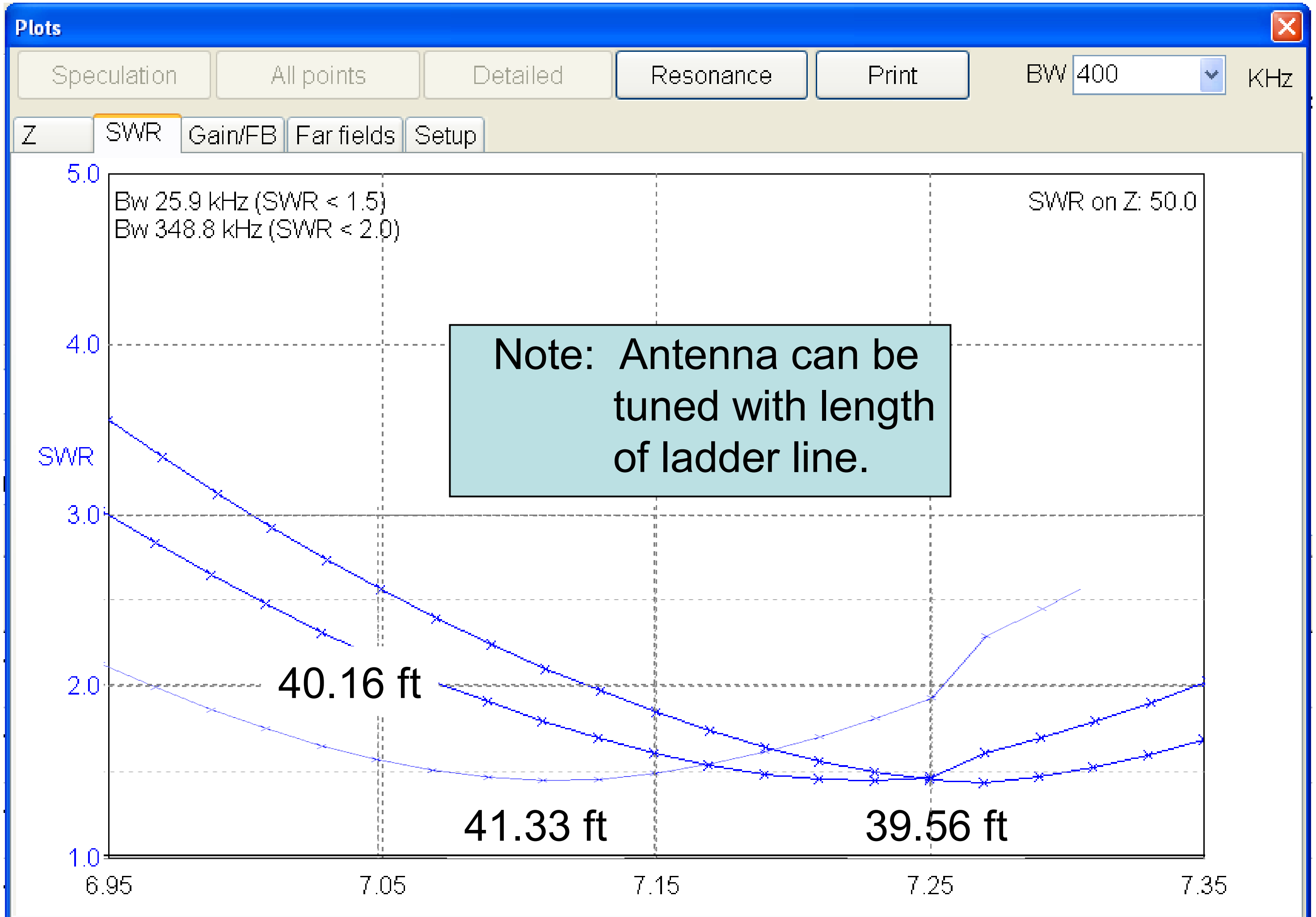
6 Meter SWR Curves



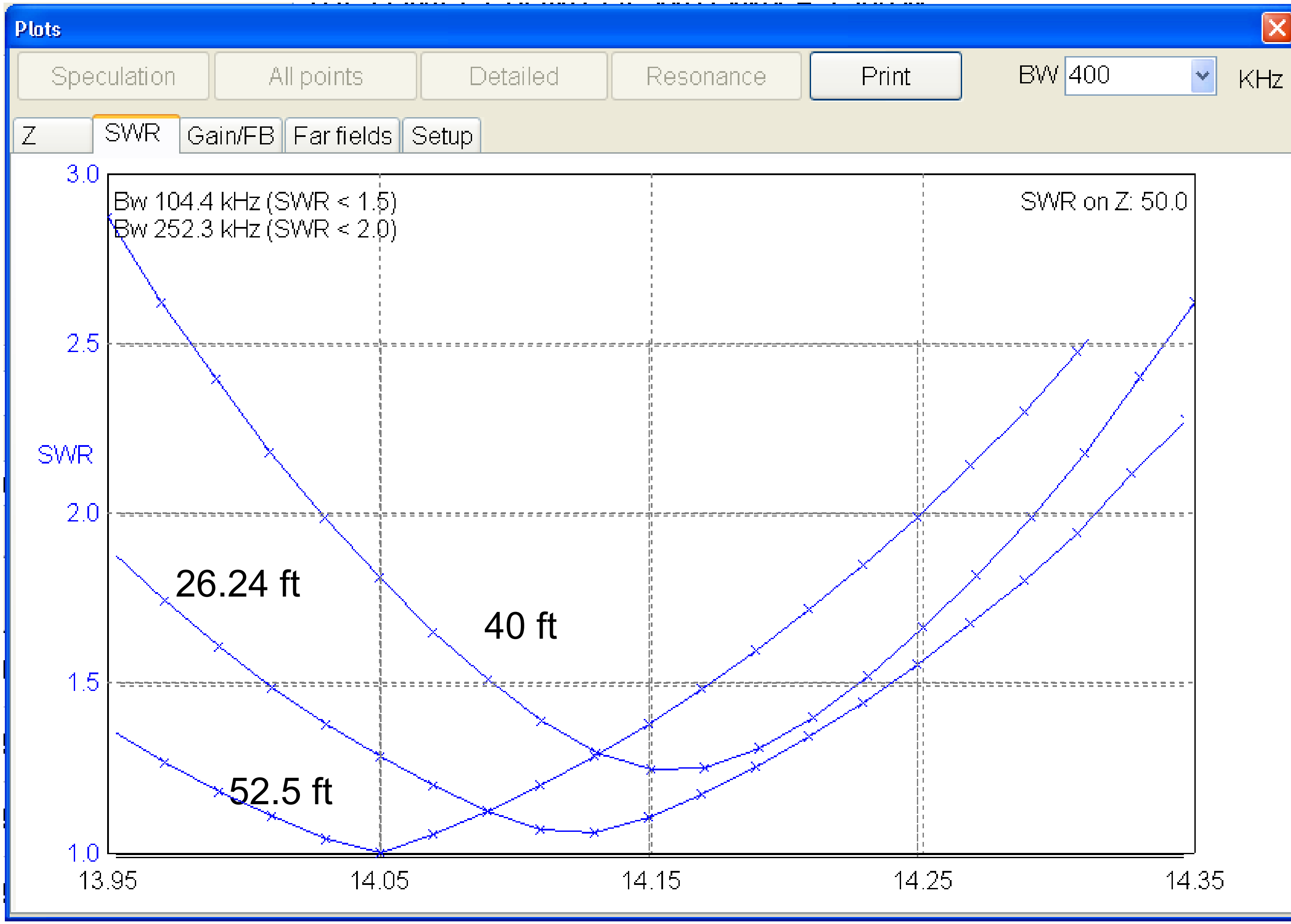
20 M SWR vs Ladder Line Length



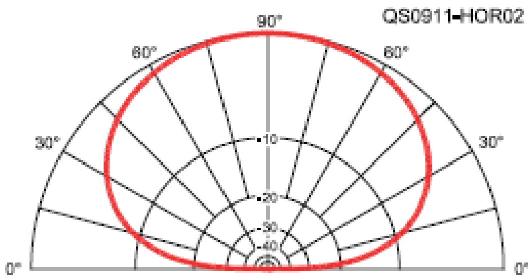
40 M SWR vs Ladder Line Length



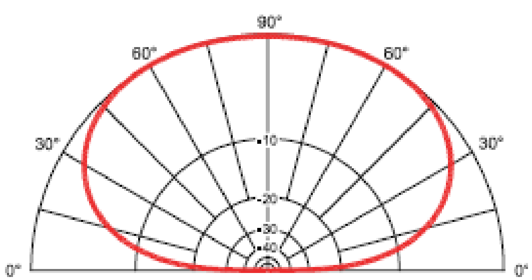
Antenna Height Tunes (Detunes)



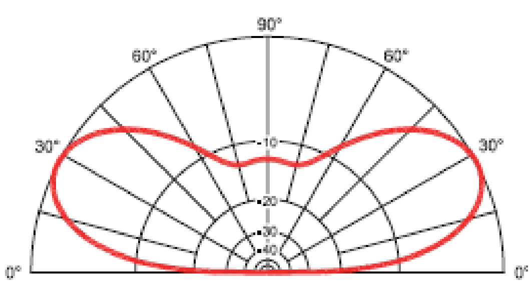
Antenna Height Changes Pattern



(A)



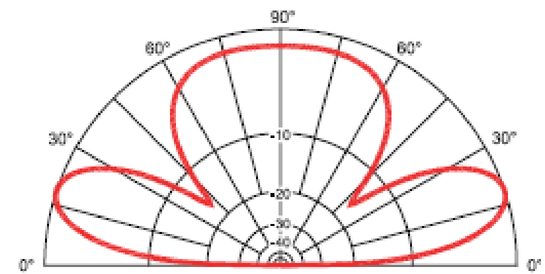
(B)



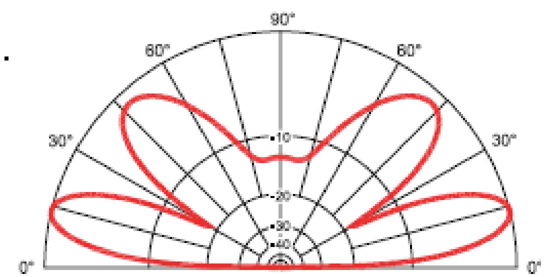
(C)

Antenna height changes the resulting antenna pattern, starting with mainly high angle radiation at 1/8 wavelength then progressing through a lowering of the high angle radiation as one approaches ½ wavelength. Then it grows more high angle radiation and then breaks into “lobes” at distinct take off angles. Note that ½ wavelength on 20 M is about 33 ft (C). This would give the antenna good DX on that band since the energy would not all be “used up” radiating straight up.

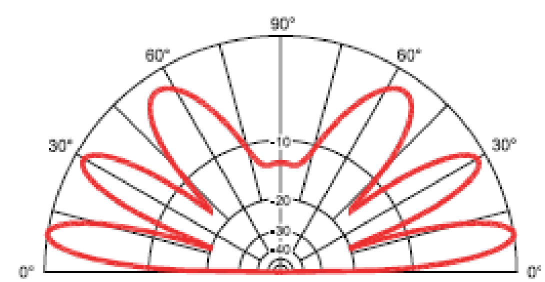
A. 1/8 Wavelength
B. ¼ Wavelength
C. ½ Wavelength
D. ¾ Wavelength
E. 1 Wavelength
F. 3/2 Wavelength



(D)



(E)



(F)

100 ft Coax Loss Due to Frequency

Cable Type	Frequency In Megahertz									
RG/UCABLE	1	10	50	100	200	400	900	1000	3000	5000
6A,212	0.26	0.83	1.9	2.7	4.1	5.9	6.5	9.8	23	32
8MINI,8X	1.1	2.5	3.8	5.4	7.9	8.8	13	26		
LMR-240	0.24	0.76	1.7	2.4	3.4	4.9	7.5	7.9	14.2	18.7
8,8A,10A,213	0.15	0.55	1.3	1.9	2.7	4.1	7.5	8	16	27
9913,9086,9096	0.9	1.4	1.8	2.6	4.2	4.5	13			
4XL8IIA,FLEXI4XL	0.9	1.4	1.8	2.6	4.2	4.5	13			
LMR-400	0.9	1.2	2.5	4.1	4.3					
LMR-500	0.7	1	2	3.2	3.4					
LMR-600	0.6	0.8	1.4	2.5	2.7					
8214	0.6	1.2	1.7	2.7	4.2	7.8	14.2	22		
9095	1	1.8	2.6	3.8	6	7.5				
9,9A,9B,214	0.21	0.66	1.5	2.3	3.3	5	7.8	8.8	18	27
11,11A,12,12A,13,13A,216	0.19	0.66	1.6	2.3	3.3	4.8	7.8	16.5	26.5	
14,14A,217	0.12	0.41	1	1.4	2	3.1	5.5	12.4	19	
17,17A,18,18A,218,219	0.06	0.24	0.62	0.95	1.5	2.4	4.4	9.5	15.3	
55B,223	0.3	1.2	3.2	4.8	7	10	14.3	16.5	30.5	46
58	0.33	1.2	3.1	4.6	6.9	10.5	14.5	17.5	37.5	60
58A,58C	0.44	1.4	3.3	4.9	7.4	12	20	24	54	83
59,59B	0.33	1.1	2.4	3.4	4.9	7	11	12	26.5	42
62,62A,71A,71B	0.25	0.85	1.9	2.7	3.8	5.3	8.3	8.7	18.5	30
62B	0.31	0.9	2	2.9	4.2	6.2	11	24	38	
141,141A,400,142,142A	0.3	0.9	2.1	3.3	4.7	6.9	13	26	40	
174	2.3	3.9	6.6	8.9	12	17.5	28.2	30	64	99
178B,196A	2.6	5.6	10.5	14	19	28	46	85	100	
188A,316	3.1	6	9.6	11.4	14.2	16.7	31	60	82	
179B	3	5.3	8.5	10	12.5	16	24	44	64	
393,235	0.6	1.4	2.1	3.1	4.5	7.5	14	21		
402	1.2	2.7	3.9	5.5	8	13	26	26		
405	22									
LDF4-50A	0.06	0.21	0.47	0.68	0.98	1.4	2.2	2.3	4.3	5.9
LDF5-50A	0.03	0.11	0.25	0.36	0.53	0.78	1.2	1.4	2.5	3.5

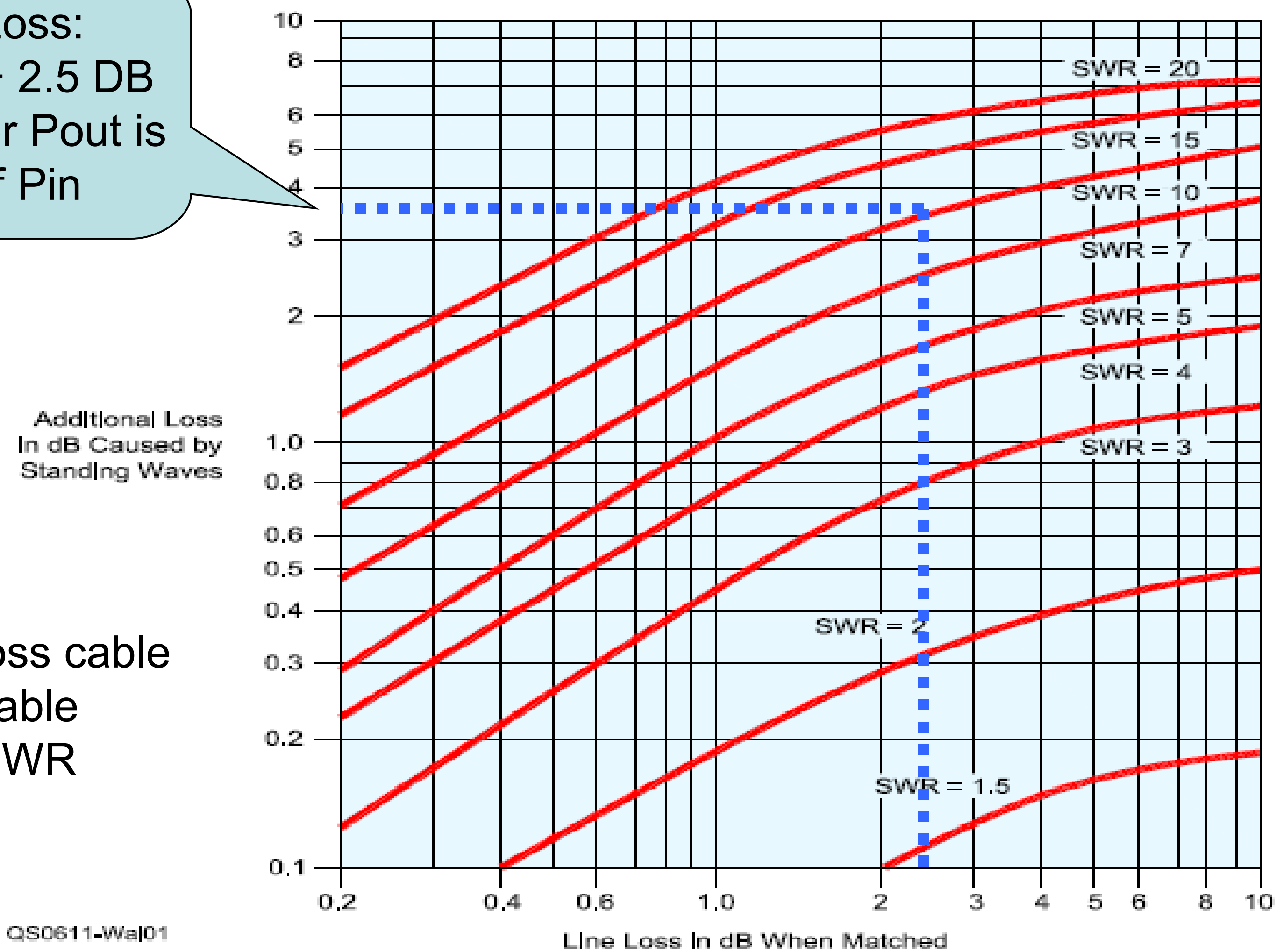
Additional Coax Loss Due to SWR

table 3. Additional loss caused by standing waves. Find the line loss when perfectly matched in the vertical column; read across for the actual SWR. Find the figures that are closest to yours if yours are not exactly represented. Conditions above and to the left of the heavy line indicate an SWR loss of less than 1 dB.

line loss matched (dB)	actual SWR (at antenna) 1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0	0	0	0	0	0	0	0	0	0	0	0	.0
0.2	0	0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.7
0.4	0	0	0.1	0.2	0.2	0.4	0.5	0.7	0.8	1.0	1.1	1.3
0.6	0	0	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7
0.8	0	0	0.2	0.3	0.4	0.7	0.9	1.2	1.5	1.7	1.9	2.1
1.0	0	0	0.2	0.3	0.5	0.8	1.2	1.4	1.7	1.9	2.2	2.5
1.2	0	0	0.2	0.4	0.6	1.0	1.3	1.7	1.9	2.2	2.5	2.8
1.4	0	0	0.3	0.4	0.6	1.1	1.5	1.8	2.1	2.4	2.7	3.0
1.7	0	0	0.3	0.5	0.7	1.3	1.7	2.0	2.3	2.6	3.0	3.3
2.0	0	0.1	0.3	0.5	0.8	1.3	1.8	2.1	2.5	2.8	3.2	3.6
2.5	0	0.1	0.3	0.6	0.9	1.5	1.9	2.3	2.8	3.1	3.5	3.7
3.0	0	0.1	0.4	0.6	1.0	1.5	2.0	2.5	2.9	3.2	3.7	4.0
3.5	0	0.1	0.4	0.7	1.1	1.6	2.1	2.6	3.1	3.4	3.8	4.1
4.0	0	0.1	0.4	0.7	1.1	1.7	2.2	2.7	3.2	3.5	3.9	4.2
4.5	0	0.1	0.4	0.7	1.1	1.7	2.3	2.8	3.2	3.6	4.0	4.3
5.0	0	0.1	0.4	0.8	1.2	1.8	2.3	2.9	3.3	3.7	4.1	4.4
5.5	0	0.1	0.5	0.8	1.2	1.8	2.4	2.9	3.3	3.8	4.2	4.5

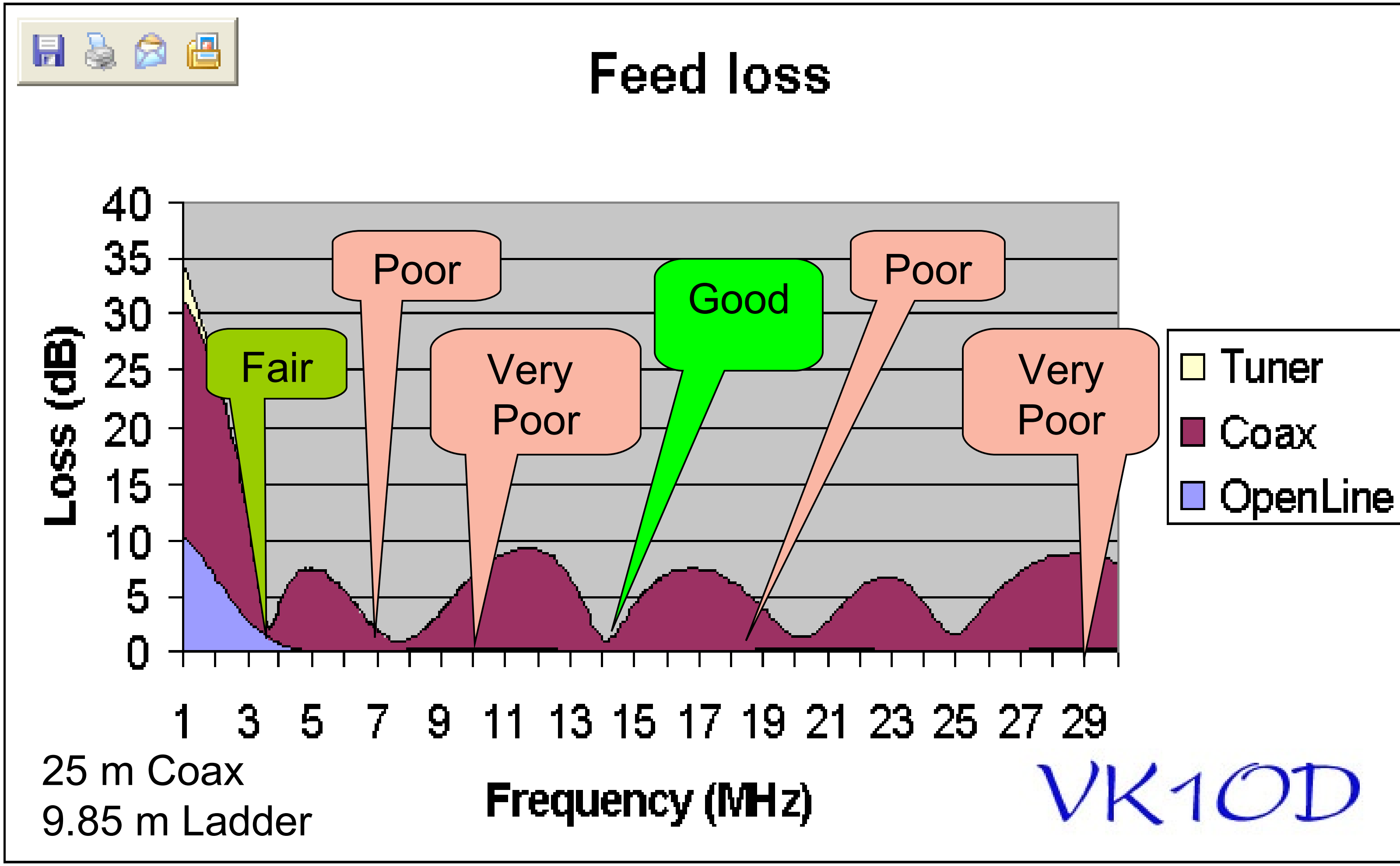
Coax Loss Due to SWR at Antenna

Total Loss:
= 3.5 + 2.5 DB
6 DB or Pout is
25% of Pin



Avoid:
- high loss cable
- long cable
- high SWR

All Losses RG213 To G5RV



SWR Summary and Conclusions

The table below summarizes the content of the previous slides. It shows the areas where the ZS6BKW has a SWR advantage over the G5RV. So, “Shorten that G5RV antenna by 7.3 feet and extend the ladder line by 11 feet!”

Compare Mid Band SWR - ZS6BKW vs G5RV		MID BAND		LOW BAND EDGE			HIGH BAND EDGE		
BASE	Fmid	ZS6BKW	G5RV	Flow	ZS6BKW	G5RV	Fhigh	ZS6BKW	G5RV
80 M	3.75	9.5	7	3.5	5.75	4.23	4	21.5	17.31
40 M	7.15	2.37	4.93	7	3.56	3.53	7.3	1.64	3.53
30M	10.12	83	67	10.1	82.3	65.29	10.15	84.5	68.58
20 M	14.15	1.93	1.7	14	4.22	3.42	14.35	1.9	2.97
17M	18.12	1.28	14.66	18.68	1.3	5.55	18.168	1.42	13.75
15M	21.2	75	25	21	71.4	29.62	21.45	77.84	41.46
12M	24.94	1.83	4.9	24.89	2.16	4.28	24.99	1.61	5.51
10M	28.5	4.7	44.2	28	11.82	50.21	29.7	7.06	19.55
6M	50.5	2.82	54.16	50.1	6.53	54.43	54	42.6	15.38

The only band where the G5RV has good SWR is on 20M.
The G5RV has a better match on 80M due to its longer length.
The ZS6BKW has a large portion of the 10m band where it can be used without a tuner.
Note that the G5RV has a somewhat better (but unaccepatable SWR) on 80M
Note that the ZS6BKW can be operated on a portion of the 6M band but the G5RV cannot.
Note that the ZS6BKW can operate on the whole of the 17M band but the G5RV cannot
The ZS6BKW will fit in a smaller lot than the G5RV
The G5RV has a shorter run of ladder line down the main support (34 ft) than the ZS6BKW (39.5 ft)
Both are good antennas when a tuner is used - The ZS6BKW will have significantly lower coax loss
Costs are virtually identical and less than $60 (Excluding mounting structure and coax cable to radio)
Both have very low loss on ladder line down to the coax feed, with the ZSBKW slightly longer
The ZS6BKW has lower coax losses because it is a closer match to 50 ohms on most bands

Summary and Conclusions (Cont'd)

This antenna is being actively used at the QTH of KE5KJD, where comparisons have been made with three other antenna systems. About 20 stations were logged on each band and signal strengths (S-units) measured using an antenna switch to measure and verify S-unit measurements.

Switched Antennas	Cost	Averaged S-Units By Band		
Antenna	**Total**	**80 Meters**	**40 Meters**	**20 Meters**
Butternut 80/40 Vertical Dipole	~$350	10	9.5	5.6
Hustler 6BTV Trap Vertical	~$300	6.9	9.9	9.8
ZS6BKW Dipole (94 ft)	~$70	10	9.2	8.5
80/40 Dipole W5DXP (148 ft)	~$80	11	8.2	5.7

As can be seen above, The ZS6BKW performs quite well on all three bands. The other antennas perform as expected, with some advantages of each based on their intended use. Not shown above is that the 6BTV Vertical antenna nearly always has the advantage on a DX contact due to its excellent ground radial system and low angle of radiation. No tuner was used to obtain above results. Frequency within the band was random.

ZS6BKW ManaGal Model Data

```
ZS6BKW VEE
*
14.15
***Wires***
7
0.0,    13.75,   -4.0,   0.0,   0.0145,   0.0,    8.000e-04, -1
0.0,    -13.75,  -4.0,   0.0,   -0.0145,  0.0,    8.000e-04, -1
0.0,    0.0145,  -10.0,  0.0,   0.0145,   0.0,    7.000e-04, -1
0.0,    -0.0145, -10.0,  0.0,   -0.0145,  0.0,    7.000e-04, -1
3.4,    -0.0145, -10.0,  3.4,   0.0145,   -10.0,  7.000e-04, -1
0.0,    -0.0145, -10.0,  3.4,   -0.0145,  -10.0,  7.000e-04, -1
0.0,    0.0145,  -10.0,  3.4,   0.0145,   -10.0,  7.000e-04, -1
***Source***
1,      1
w5c,    0.0,     1.0
***Load***
0,      1
***Segmentation***
800,    80,      2.0,    1
***G/H/M/R/AzEl/X***
2,      12.2,    1,      50.0,  120,      60,     0.0
###Comment###
Mod by Larry, KE5KJD 11/4/2009 1:47:47 AM
E:\ZS6BKW.maa
```

G5RV ManaGal Model Data

```
GR5V VEE
*
14.15
***Wires***
7
0.0,    14.9,     -4.0,   0.0,    0.0145,   0.0,    8.000e-04, -1
0.0,    -14.9,    -4.0,   0.0,    -0.0145,  0.0,    8.000e-04, -1
0.0,    0.0145,   -10.0,  0.0,    0.0145,   0.0,    7.000e-04, -1
0.0,    -0.0145,  -10.0,  0.0,    -0.0145,  0.0,    7.000e-04, -1
1.44,   -0.0145,  -10.0,  1.44,   0.0145,   -10.0,  7.000e-04, -1
0.0,    -0.0145,  -10.0,  1.44,   -0.0145,  -10.0,  7.000e-04, -1
0.0,    0.0145,   -10.0,  1.44,   0.0145,   -10.0,  7.000e-04, -1
***Source***
1,      1
w5c,    0.0,      1.0
***Load***
0,      1
***Segmentation***
800,    80,       2.0,    1
***G/H/M/R/AzEl/X***
2,      12.2,     1,      50.0,   120,      60,     0.0
###Comment###
Mod by Larry, KE5KJD 11/4/2009 1:48:51 AM
E:\G5RV.maa
```

Sources and References

1. Mmana Gal
2. L. B. Cebik (W4NL)
   http://www.nonstopsystems.com/radio/G5RV-1.pdf
4. Brian Austin (ZS6BKW)
5. Louis Varney (G5RV)
6. Owen Duffy (VK1OD)
7. ARRL Antenna Handbook

If interested, perform a Google search on the above for more information than you may have time to read.

Making Your Own Antenna

Antenna Wire Sources

Purchase wire
Old telephone wire
Unwind old transformer
Unwind TV Yoke wire
Clothesline Wire
Fence wire

Antenna Insulators

Purchase insulators
Short PVC pipe pieces
Strips of Deldrin or Kelvar
(Kitchen cutting board, etc)
Unwind TV Yoke wire
Clothesline Wire

Ladder Line

Purchase line
Make from parallel wires

Center Pole

Tv Pole
Hang from tree
Wood pole
Lumber
Fiberglas pole

Two End Poles

Two poles
Two trees
Tree and other structure
Barn to house
Lumber poles
Fiberglas poles

Coax To Radio

Purchase coax
Surplus 50 ohm cable
Surplus Tv 75 ohm
Not practical to build

Making Your Own Antenna - Hints

Antenna Wire
Use Quality copper coated steel for strength
Solder all connections if possible
Coat all exposed connections with UV resistant glue and waterproof tape
Provide stress relief at wire connections
Tension wire to prevent sag and loss of height

Center Insulator
Provide stress and bend/flex relief at connection to antenna
Support ladder line directly, not depending on joints to antenna
Put a 2-10 W ~20K Ohm resistor across antenna terminals.

Ladder Line
Use quality line with stranded wire for better flex characteristics
Do not use flat TV 300 ohm line, use windowed version if possible
Twist line about one half turn every two feet (less net wind area)
Run twine through line "windows" and attach ladder wire to it for stress relief
Keep line off ground and away from metal poles or surfaces by six inches
Provide multiple connectors along last 5 feet for "tuning"

Coax Feed
Use quality connectors and waterproof all connection to avoid "wicking"

Antenna Article ZS6BKW

This short article will describe a simple dipole SYSTEM which will work very well for both the new and experienced ham. It tends to have low SWR on many amateur bands and low losses over most of these bands.

In the mid-1980s, Brian Austin (ZS6BKW) ran computer analysis to develop an antenna System that, for the maximum number of HF bands possible, would permit a low Standing Wave Ratio (SWR) without an antenna tuner to interface with a 50-Ohm coaxial cable as the main feed line. He identified a range of lengths which, when combined with a matching ladder line length, would provide this characteristic. (See Figure 1).

According to an acknowledged expert in computer antenna design and modeling, L. B. Cebik:

"Of all the G5RV antenna system cousins, the ZS6BKW antenna system has come closest to achieving the goal that is part of the G5RV mythology: a multi-band HF antenna consisting of a single wire and simple matching system to cover as many of the amateur HF bands as possible."

Antenna Article ZS6BKW (2)

So, what is this “magic” antenna? It consists of a simple dipole, either in a flat top or inverted V form, fed with a measured length of ladder line (300, 400, or 450 ohms) connected to a length of coax back to the ham shack and transceiver. In most cases, it does not require a tuner to match the antenna system to the transceiver. It can handle full legal power.

In the full article posted on the AARA intranet, there is a full analysis of this antenna in a practical environment which shows graphically how the antenna will match under different conditions and the resulting antenna patterns you can expect on the different bands. It also gives construction details so you can make your own. All analysis used the free “MANA-Gal” program.

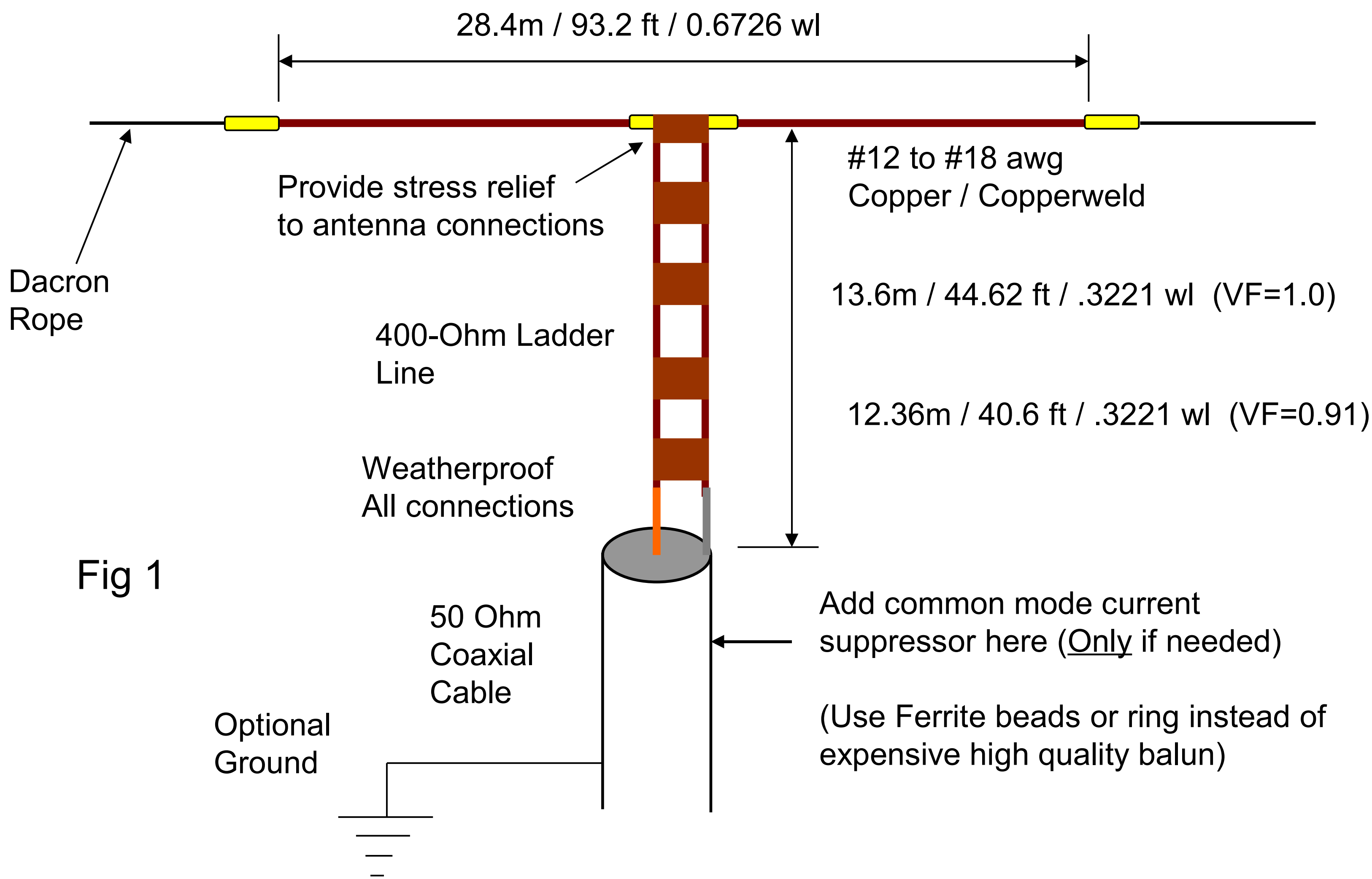
This antenna is being actively used by KE5KJD, where comparisons have been made with three other antenna systems. A 6 band vertical, a 2 Band (80/40) vertical, and a 148 ft long dipole. About 20 stations were logged on each band and signal strengths (S-units) measured using an antenna switch to measure and verify S-unit measurements. Here is the summary of those results.

Antenna Article ZS6BKW (3)

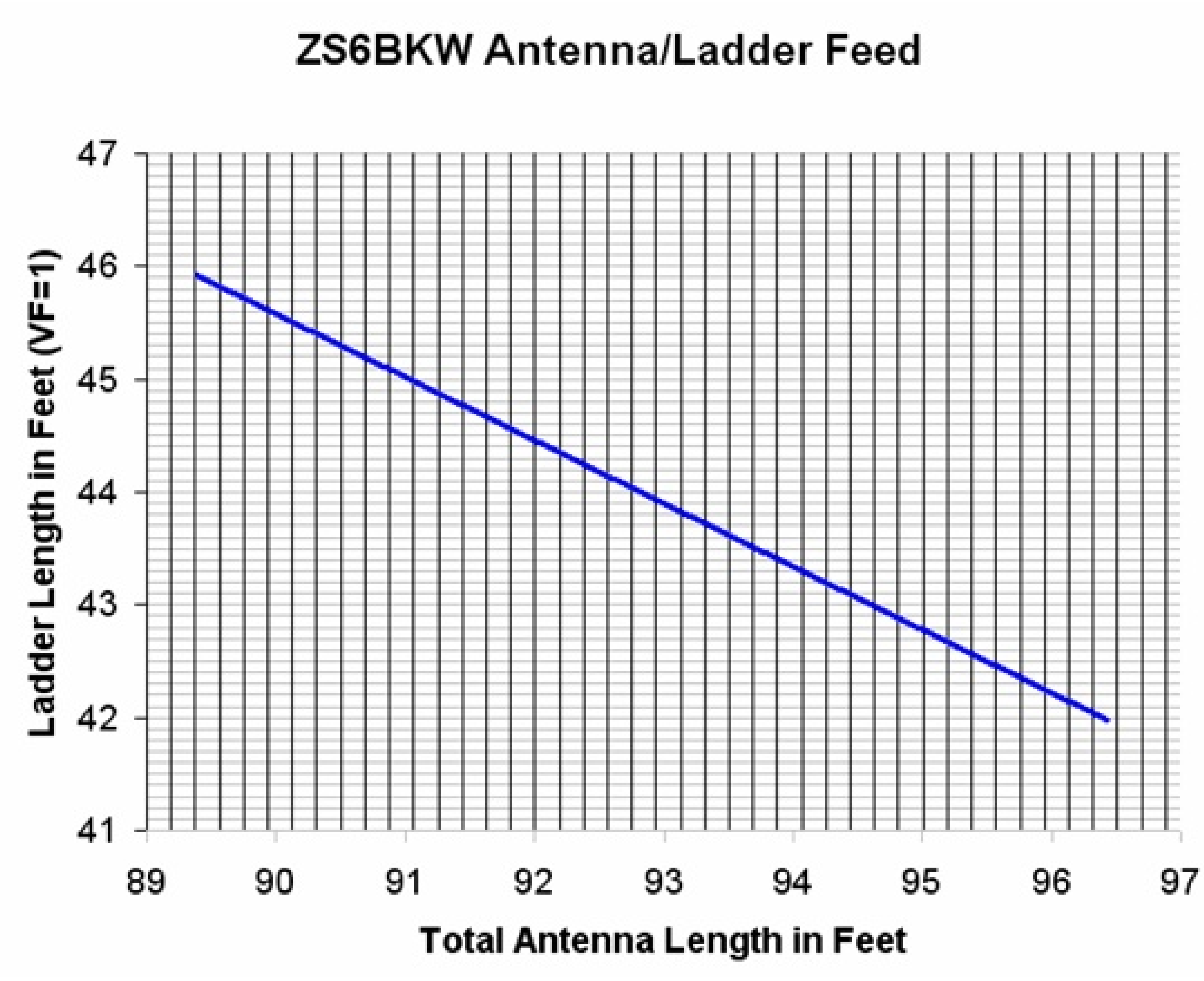
Switched Antennas	Cost	Averaged S-Units By Band		
Antenna	**Total**	**80 Meters**	**40 Meters**	**20 Meters**
Butternut 80/40 Vertical Dipole	~$350	10	9.5	5.6
Hustler 6BTV Trap Vertical	~$300	6.9	9.9	9.8
ZS6BKW Dipole (94 ft)	~$70	10	9.2	8.5
80/40 Dipole W5DXP (148 ft)	~$80	11	8.2	5.7

As can be seen above, The ZS6BKW performs quite well on all three bands. The other antennas perform as expected, with some advantages of each based on their intended use. Not shown above is that the 6BTV vertical antenna nearly always has the advantage on a DX contact due to its excellent ground radial system (>100 radials) and low angle of radiation. Also not shown is the verticals had slightly higher noise levels, making copy of weak signals difficult. No tuner was used to obtain above results. Frequency used within each band was chosen at random.

The ZS6BKW Multi-Band Antenna System



Antenna Article ZS6BKW (4)



ZS6BKW / G5RV Why I like it

1. Has low swr in several ham bands at the matching point at the end of the ladder line resulting in lower losses in the coax cable. (I have a 200 ft run from the antenna to the radio making this crucial.)
2. Can be operated without an outboard tuner on at least 5 bands.
3. Has both simplicity and low cost. (Good emergency antenna)
4. Will work with one central support and two lower supports (Inverted Vee) OR two end supports (Flat Top) on a typical city lot.
5. It retains the high-strength in the antenna wire, allowing the antenna to help support the central mounting pole. (No heavy coax or inline traps in the antenna line like the “W5GI” or “W3DZZ”.)
6. Antenna patterns are “reasonable” for local or DX work.
7. Can be operated on non-optimum bands with an external tuner.
8. Multiband means better utilization of available space, fewer antennas and coax runs, and means you can put the extra money in high quality low loss cables, increasing the height to 30-50 ft, improving loss on all bands, especially the higher frequency bands.
9. One can also erect a 80/40 or 160/80 wire from the same support, at about 90 degrees to the ZS6BKW to keep it stable and free standing in moderate winds. This gives better performance on the low bands.

The End

So, what are you waiting for? Go out and build one!

Or

Take down your G5RV and fold over each end by 3.65 feet and tack on a 11 ft length of ladder line, put it back up and load up on more bands!!!

ZS6BKW vs G5RV

Antenna Patterns/SWR at 40 ft
Center height, 27 ft end height
~148 Degree Included Angle

Compiled By: Larry James LeBlanc 2010
For the AARA Ham Radio Club

Note: All graphs computed using MMANA GAL
http://mmhamsoft.amateur-radio.ca/mmana/index.htm

1

This presentation compares two dipoles configurations with the primary focus being adjustment of Standing Wave Ratio (SWR) to match a modern solid state transceiver with an internal autotuner. The results are studied using antenna design software adapted from the MiniNec version called MMana Gal.

The ZS6BKW antenna configuration is a very good choice for a beginning ham radio operator who wants to get on the air quickly and effectively on the HF bands and who may not have a tuner or autotuner. It also will put more RF energy in the air and dissipate less in the coax, especially if the coax is not of the highest quality or when operating in the 10 meter band.

The antennas were chosen for their low cost and availability. Each can be built by the average amateur for a total cost of less than 50 dollars (US). In addition, each antenna can be modified and transformed into the other antenna configuration with minimal effort. (Add or subtract wire or matching ladder line length)

ZS6BKW / G5RV What is it?

In the mid-1980s, Brian Austin (ZS6BKW) ran computer analysis to develop an antenna System that, for the maximum number of HF bands possible, would permit a low Standing Wave Ratio (SWR) without antenna tuner to interface with a 50-Ohm coaxial cable as the main feed line. He identified a range of lengths which, when combined with a matching ladder line length, would provide this characteristic.

According to an acknowledged expert in computer antenna design and modeling, L. B. Cebik:

"Of all the G5RV antenna system cousins, the ZS6BKW antenna system has come closest to achieving the goal that is part of the G5RV mythology: a multi-band HF antenna consisting of a single wire and simple matching system to cover as many of the amateur HF bands as possible."

Both are "good" antennas and will work well in defined situations. This presentation is not designed to "bash" the G5RV, but to possibly convince you or a new ham to enjoy the benefits of lower SWR, lower loss, and greater signal strength by using the ZS6BKW version of a ladder line fed dipole.

2

Both antennas are simple dipoles fed with a selected length of standard ladder line. Both 450 and 300 ohm lines are commonly used. The ZS6BKW was introduced using 400 ohm line, and 300 ohm line, which provides a marginally better match for some antenna lengths and length of matching section than a length of 450 ohm line.

The antenna portion uses 14 gauge copper coated steel wire for strength. Insulators should be capable of handling the high voltage at the center and ends of the antenna. The rope holding the antenna to the supports should resist UV rays and be strong enough to withstand the wind gusts expected. I use a tar coated twine designed for fishing nets for this purpose (750 pound test). I favor the copper coated antenna wire because of its favorable strength and good RF conductivity. Pure copper most likely has slightly lower resistance, but does not have the tensile strength of steel. The copper coating over the steel improves the conductivity over steel alone. However, the antenna can be constructed of steel, copper, or aluminum wire as well.

ZS6BKW / G5RV Why I like it

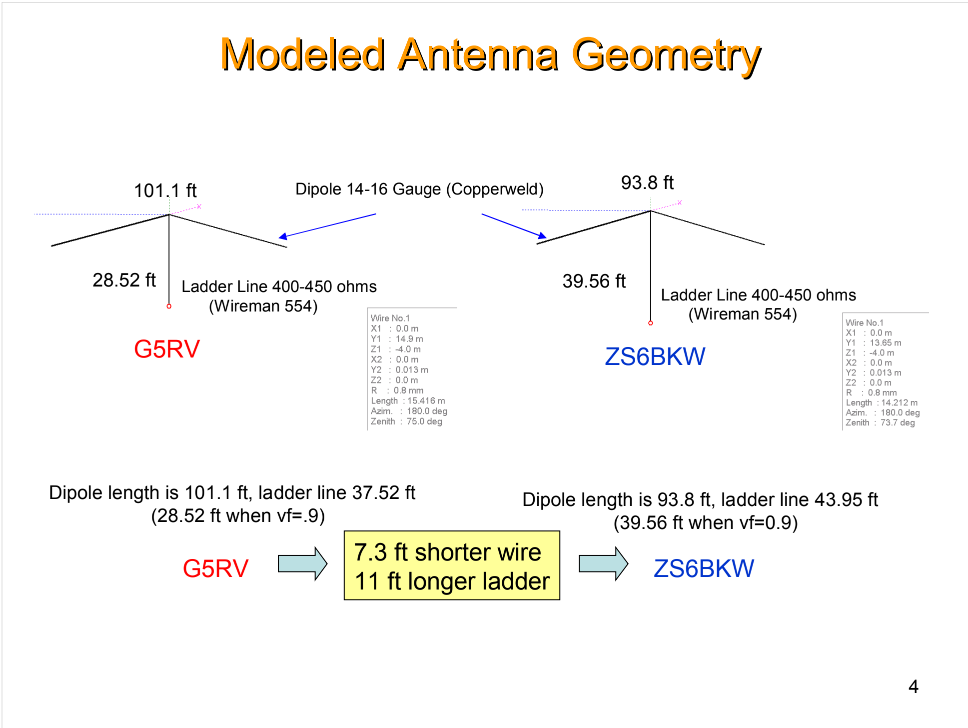
1. Has low swr in several ham bands at the matching point at the end of the ladder line resulting in lower losses in the coax cable. (I have a 200 ft run from the antenna to the radio making this crucial.)
2. Can be operated without an outboard tuner on at least 5 bands.
3. Has both simplicity and low cost. (Good emergency antenna)
4. Will work with one central support and two lower supports (Inverted Vee) OR two end supports (Flat Top) on a typical city lot.
5. It retains the high-strength in the antenna wire, allowing the antenna to help support the central mounting pole. (No heavy coax or inline traps in the antenna line like the “W5GI” or “W3DZZ”.)
6. Antenna patterns are “reasonable” for local or DX work.
7. Can be operated on non-optimum bands with an external tuner.
8. Multiband means better utilization of available space, fewer antennas and coax runs, and means you can put the extra money in high quality low loss cables or increasing the height to 30-50 ft.
9. One can also erect a 80/40 or 160/80 wire from the same support, at about 90 degrees to the ZS6BKW to keep it stable and free standing in moderate winds. I use a 148 ft W5DXP dual band (80/40M).

3

I have a fairly large yard (161 ft wide and 245 ft deep) and a 2 story home with a metal roof. In order to reach the antenna, I have to run my cable down about 29 feet from the second story radio location, then about 100 feet to the antenna support and then up about 30 ft up to the antenna. This means that I can have a significant amount of loss, especially on bands with high SWR..

I needed to have some distance from the house because I have a large metal roof, both on the house and the garage, as well as aluminum foil on the insulating boards on the sides of the house. Radio waves do not penetrate large metal structures, hence the choice of antenna location.

I do have a fairly clear path to the North and Northeast from all my antennas.



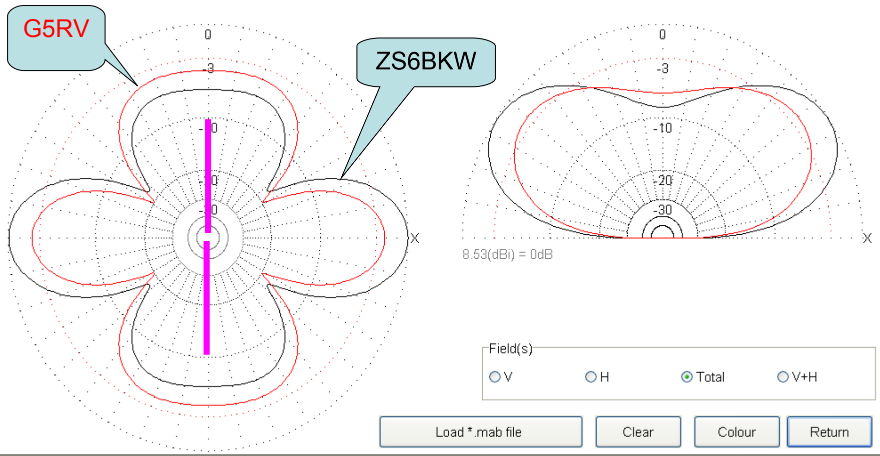
The design of both antennas consist of a dipole configuration fed with a length of ladder line. I use copper coated steel for the dipole portion because I use the antenna wire as a partial support for the insulated pole supporting the antenna.

The modeling was done with the same apex height (40 ft) and end heights (26.9 ft) for both antennas. The ladder line definition was the same for both antennas except for the length of the line. I chose 450 ohms for the modeling because it is commonly available, reasonably priced, and can handle full amateur legal power.

My current height for my ZS6BKW is about 29.5 ft. This is different than that used in this model. I plan to replace the center support in the near future with a 40 ft push up pole. That is why I chose 40 ft as the modeling height.

One advantage of the G5RV has over the ZS6BKW is that at practical (low) antenna heights for most hams, the G5RV 28.5 ft ladder line will not reach the ground. The 39.56 ft ladder line of the ZS6BKW must be hung or folded such that it does not lay on the ground or come in close proximity any metal objects, including the supporting pole if it is metal. If folded, the line should not have sharp bends, should be kept at least 4-6 inches away from metal or other ladder lines or coax runs.

ZS6BKW / G5RV Pattern (20M)

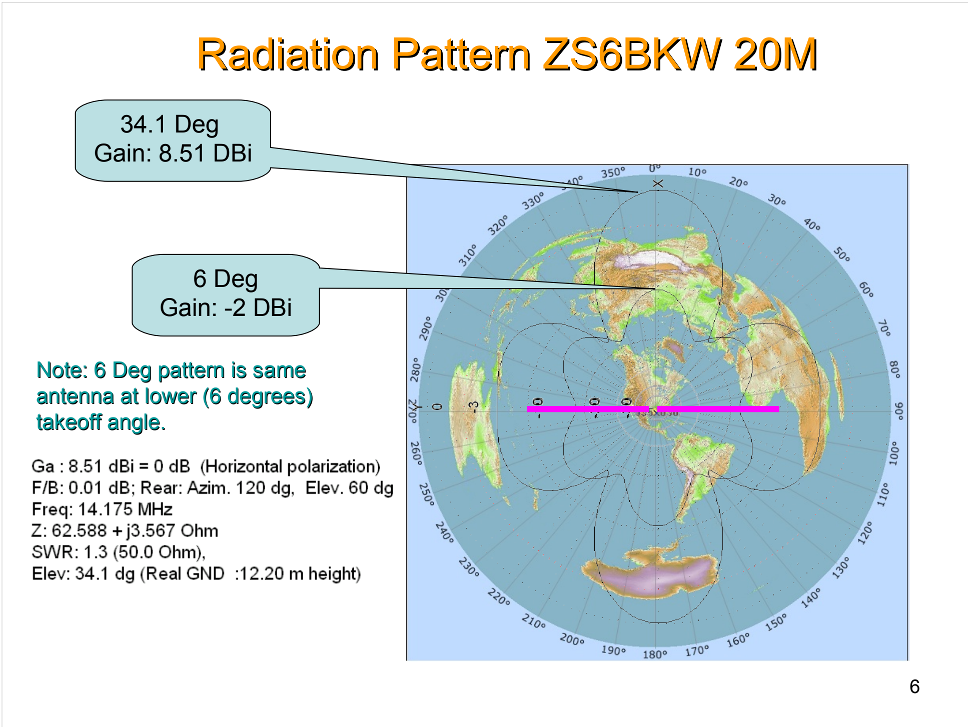


No.	F (MHz)	R	jX	SWR	Gh	Ga	F/B	Elev.	GND	Height	Pol.	File	name
1	14.15	61.906	-3.538	1.25	---	8.53	0.01	34.1	Real	12.2	H	this	ZS6BKW '
2	14.15	117.541	-11.108	2.38	---	6.4	0.0	40.1	Real	12.2	H	E:\MyCrypt\Ha	GR5V VEE

The antenna patterns are very similar because the radiating antenna lengths are fairly close. This is true for each band analyzed. The ZS6BKW being shorter exhibits less pattern variation because it is closer to a standard dipole on most bands.

Note that the antenna pattern is mainly a function of the antenna length, and the ladder matching section does not contribute much to the radiation pattern.

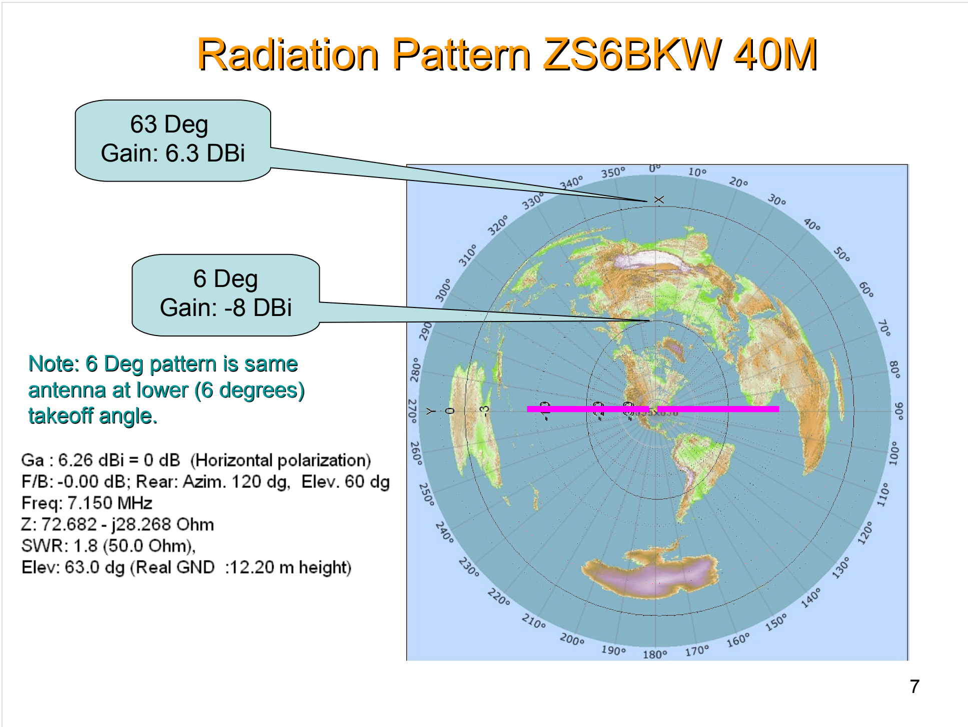
The ZS6BKW has more gain broadside to the antenna, while the G5RV has better gain in its side lobes.



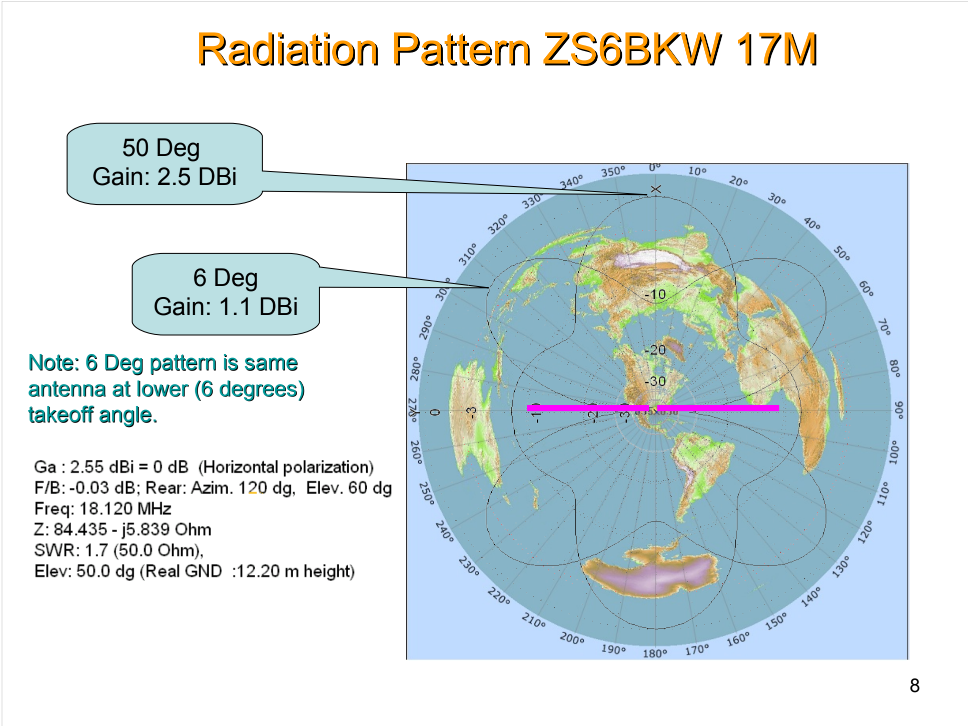
These plots are overlaid on a great circle view of the world to be able to visualize the preferred directional coverage of the antenna. I arbitrarily chose to orient the antenna broadside North to South for visualization. In my own installation, I have the antenna broadside and a little to the West of due north because of my choice of supports.

Given a choice, I would have preferred to orient the maximum lobe which is broadside to the antenna at 20 meters in a NNE direction to favor the European areas. I may make that adjustment when I re-arrange the antennas.

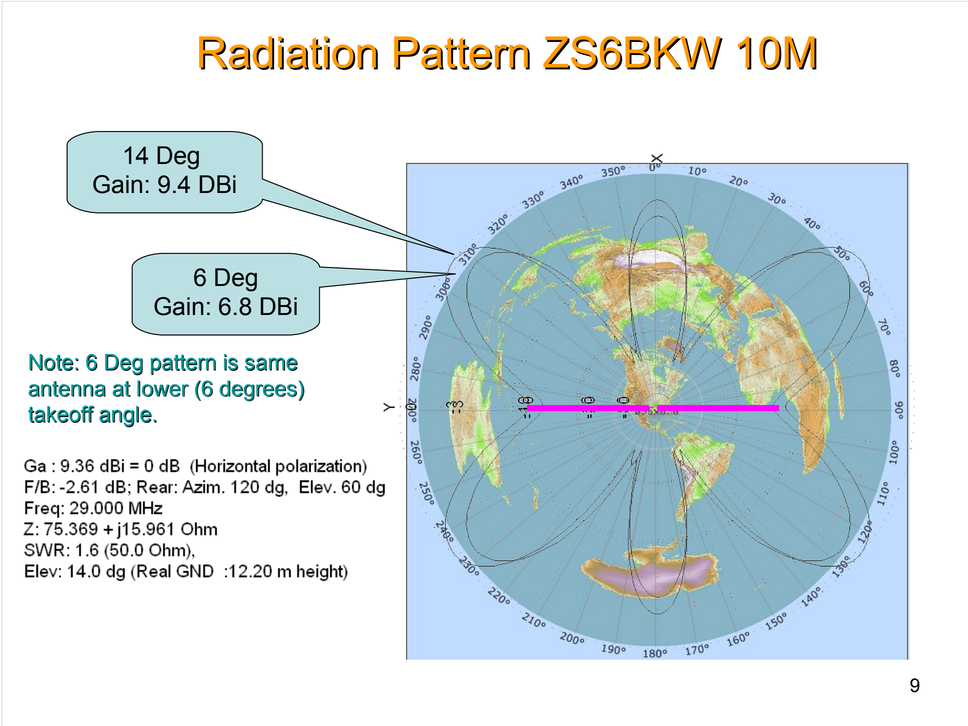
Note that two patterns are given, one at the maximum gain angle provided by the modeling program, and one at 6 degrees elevation, which is some indicator of how well it will perform on the band for DX work.



Forty meters has a slight directive pattern broadside to the antenna. It has some gain over a 40 M dipole at the same height.



The antenna pattern changes with the elevation angle, so orienting the antenna may entail a tradeoff between stateside and DX coverage. Note the large pattern change at 6 degrees vs that at 50 degrees.



The antenna pattern on 10 meters has considerable gain with multiple lobes. It also has good low angle radiation, even at the modest height of 12.2 meters.

The direction and amplitude of maximum gain is very similar at both the lower and higher elevation angles on this band.

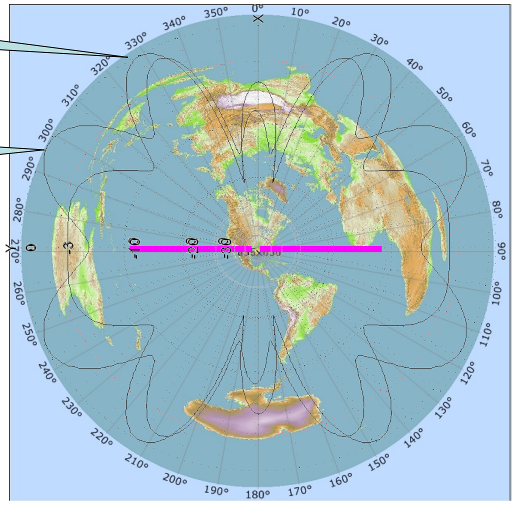
The region of low SWR covers only a small portion of the band, making it necessary to use a tuner for full band coverage. The SWR at other portions of the 10M band can be very high, making the loss in the coax rise to very high levels.

Radiation Pattern ZS6BKW 12M

25.4 Deg
Gain: 7.4 DBi

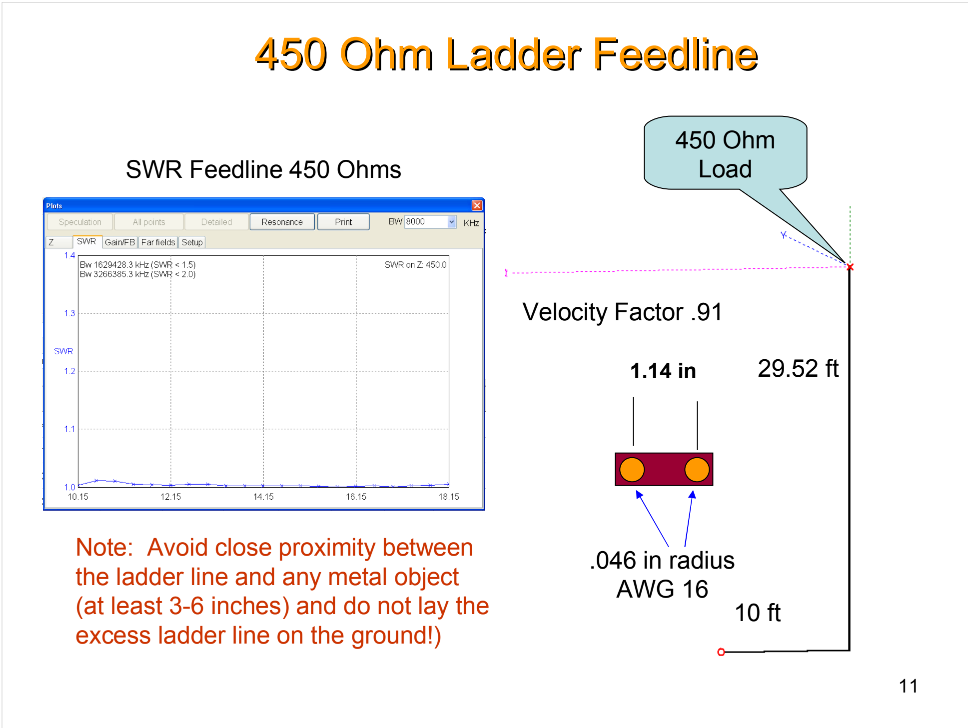
6 Deg
Gain: 2.9 DBi

Note: 6 Deg pattern is same antenna at lower (6 degrees) takeoff angle.



Ga : 7.43 dBi = 0 dB (Horizontal polarization)
F/B: -5.06 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 24.900 MHz
Z: 72.623 + j25.168 Ohm
SWR: 1.7 (50.0 Ohm),
Elev: 25.4 dg (Real GND :12.20 m height)

10

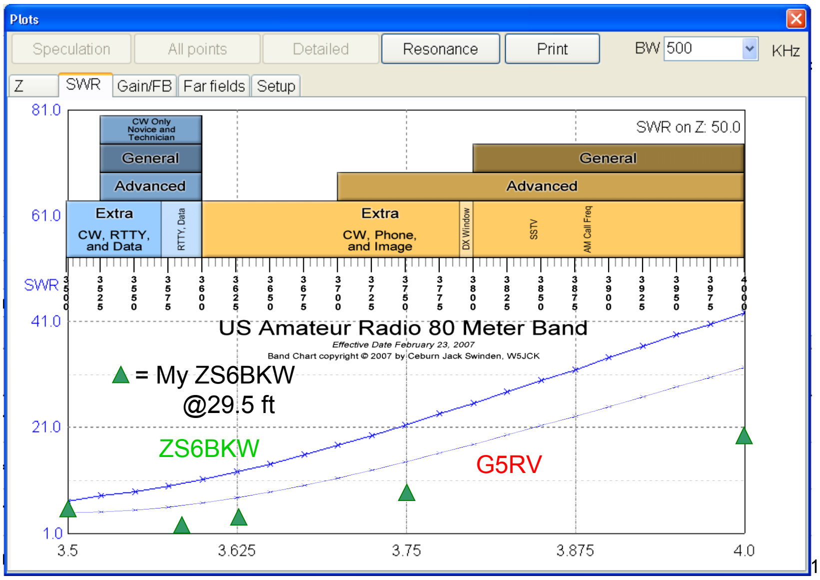


The slide shows the parameters used to model the feed line for both the G5RV and the ZS6BKW antennas. A resistive load was applied at the apex of the antenna instead of connecting the antenna wires. The SWR graph indicates that the model is realistic, at least when the load is matched to the line.

The ladder line at these frequencies has very low loss, even with high values of SWR. The maximum added loss of the ZS6BKW ladder line is less than 0.7 DB at 29 mhz (40 ft with SWR of 14 at band edges). The loss for the G5RV with its shorter ladder line may be slightly smaller or larger, depending on the frequency, but very low nevertheless.

A similar analysis was done for both 400 ohm and 300 ohm feed lines. The results are not shown here.

80 Meter SWR Curves



12

This indicates that the G5RV is marginally better than the ZS6BKW on the 80 meter band. However, both exhibit unsatisfactory SWR and would require a tuner to match it to your transmitter.

Four options are available to improve the performance on this band:

1. Use an antenna tuner to match either antenna to the transmitter.

2. Insert traps or loading coils on the ends of the antenna and add wire to resonate the antenna within the 80 M band.

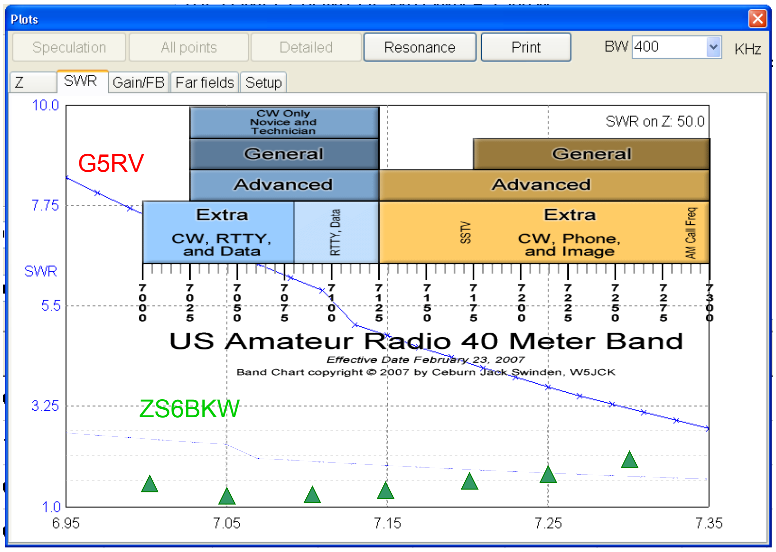
3. Lengthen the ladder line to move the resonant frequency within the band.

4. Use a separate antenna for 80 M and potentially 160 or 40 on the same center support but at 90 degrees to the primary antenna. This has an advantage of providing better support for both antennas and can replace the need for guy wires, letting the antenna wire act as guying for the center pole.

I use a 80/40 meter antenna about 148 feet long modeled on the W5DXP design in this role. This antenna uses a ladder line to have resonant points in both the 80 and 40 meter bands which can be set to your favorite portion of each band.

It does perform noticeably better on 80 meters and equal to the ZS6BKW on 40 meters. I use this antenna to join a couple of nets on 80 meters.

40 Meter SWR Curves



13

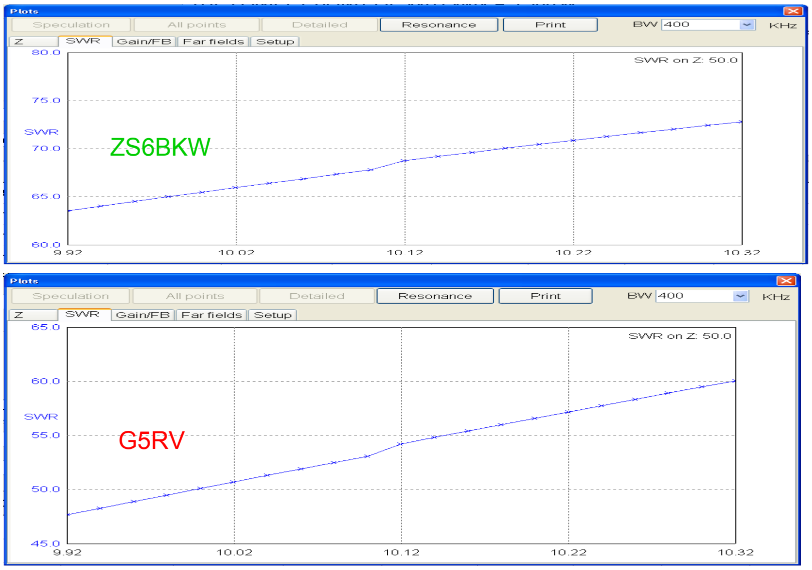
The 40 meter band is a natural for the ZS6BKW antenna. Its length is longer than a half wave and thus has some gain over a dipole in the broadside direction.

It can be driven by most transceivers across the entire band without the use of a tuner or autotuner.

The G5RV also performs fairly well, especially on the high end of the phone band. However, on the lower portion of this band the SWR of the G5RV may not be low enough to match many transmitters.

30 Meter SWR Curves

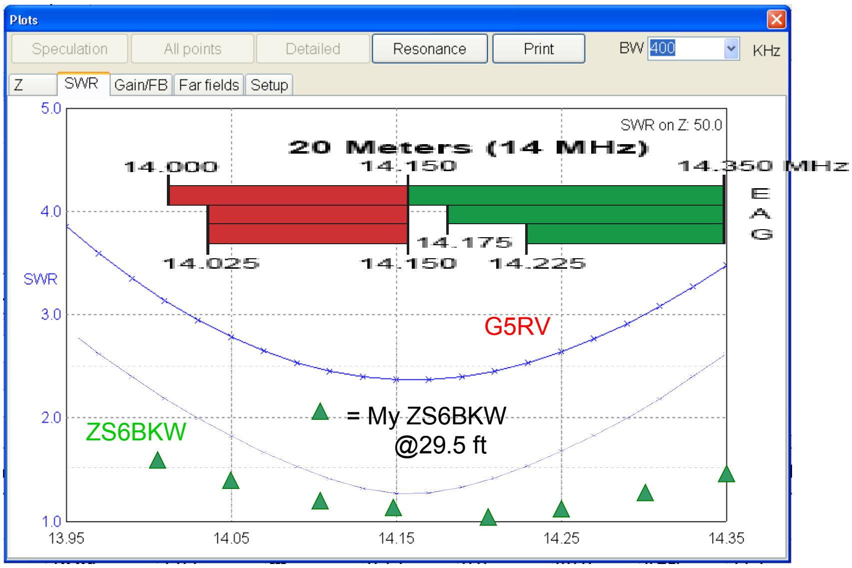
(Neither antenna is useful on this band)



14

Neither antenna will provide satisfactory results on this band. The high SWR and the accompanying losses will make it difficult to make contacts on this band.

20 Meter SWR Curves



15

This is the band that the G5RV was specifically designed to cover with both low SWR and a usable pattern. The ZS6BKW will have slightly lower losses and will match the transmitter over a larger portion of the band. However, both antennas should perform well on this band. The orientation of the antenna can make a significant difference in what areas are covered by the antenna pattern.

This band would benefit from a higher antenna, which would increase the pattern gain and low angle radiation.

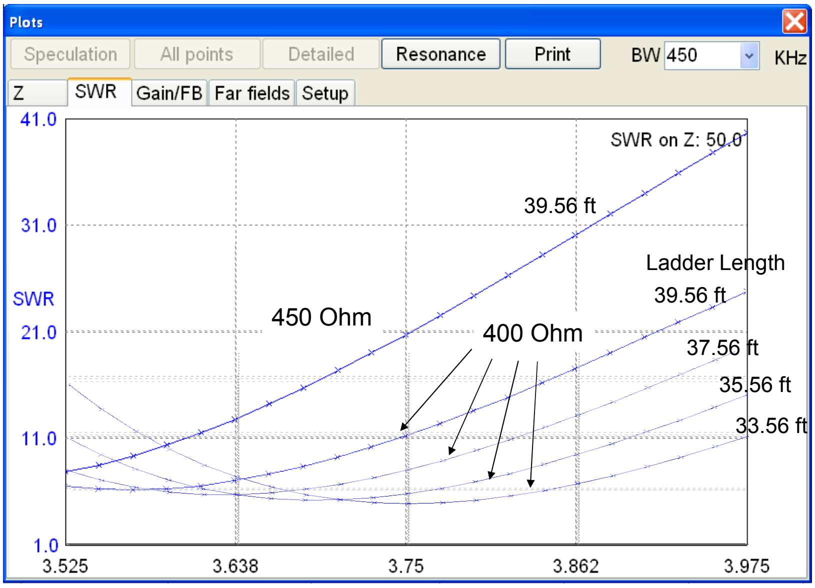
Note that many hams will brag about their LOW SWR, as if that is the best criteria to judge an antenna. However, in most cases SWR that is lower than the modeled SWR comes about from losses introduced into the system by the coax length and cable routing. In my case, with a long run of coax, I enjoy a very low SWR on all portions of this band

20 Meter SWR Curves – 400 Ohm Feed

16

Just to make sure that 450 Ohm cable is not going to disrupt totally the ZS6BKW run with 400 ohm transmission line proposed by Brian Austin, here are both plotted together. They are very similar and that is true for most of the bands studied.

80 Meter SWR Curves – 400 Ohm Feed

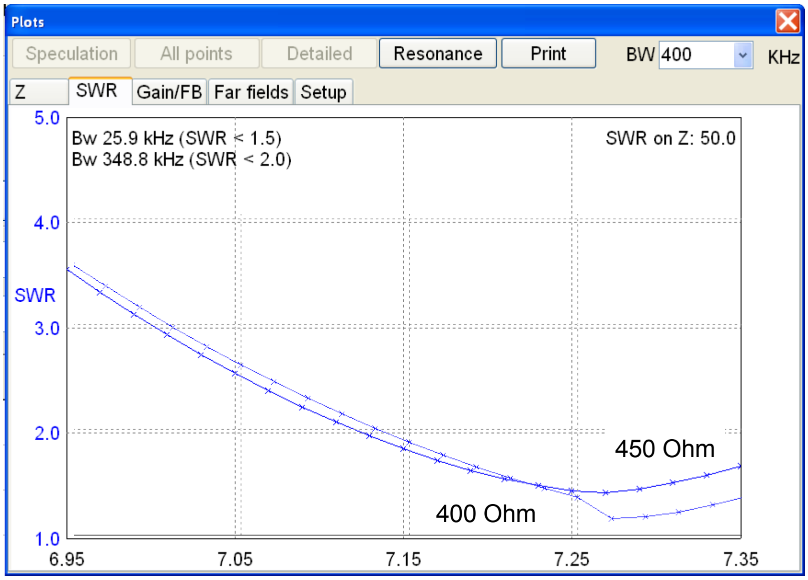


17

This band is improved considerably by using a 400 ohm matching section instead of 450 ohm line. Also shown on this graph is the range of matching that can be achieved by modifying the length of the matching section. This brings up the possibility of using a specially built short antenna with a matching section built specially for this band. This specially modified antenna can be used in conjunction with the standard ZS6BKW to improve performance on the 80 meter band. This is essentially what I have done by using the W5DXP configuration for 80 and 40 meters, which is a better choice for 80M because of the increased antenna wire length.

However, if your setting will not allow for a longer antenna, the ZS6BKW (93.8 ft) or G5RV (101.1 ft) specially tuned for 80 M may offer a suitable alternative.

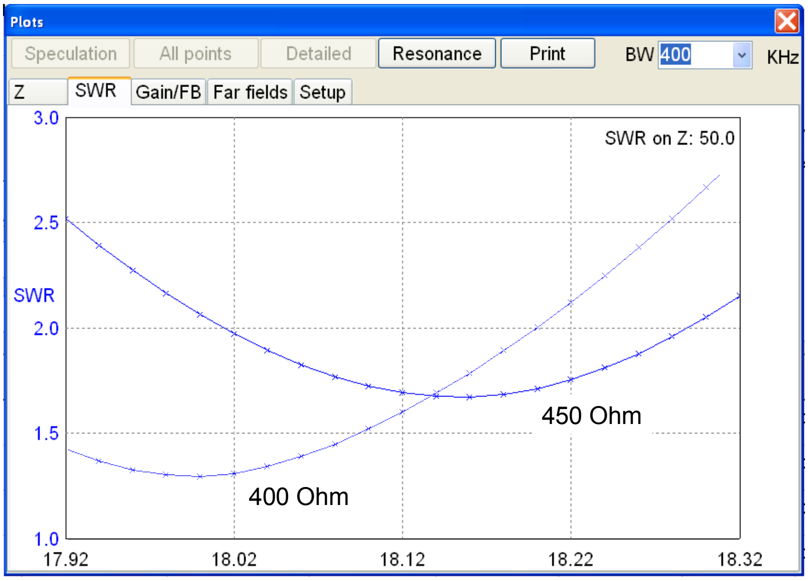
40 Meter SWR Curves – 400 Ohm Feed



18

The 40 meter band is not significantly different with either line feed.

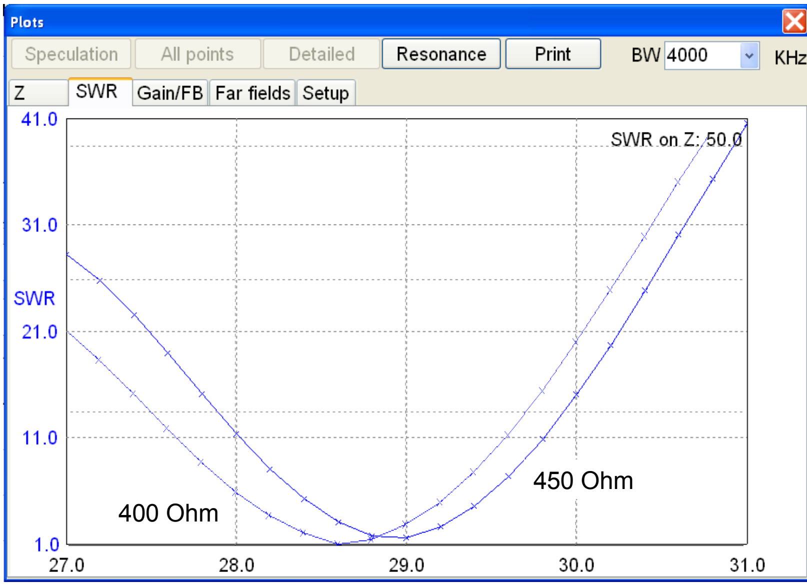
17 Meter SWR Curves – 400 Ohm Feed



19

This band is not helped much by using 400 ohm line, although there is a difference in SWR curves.

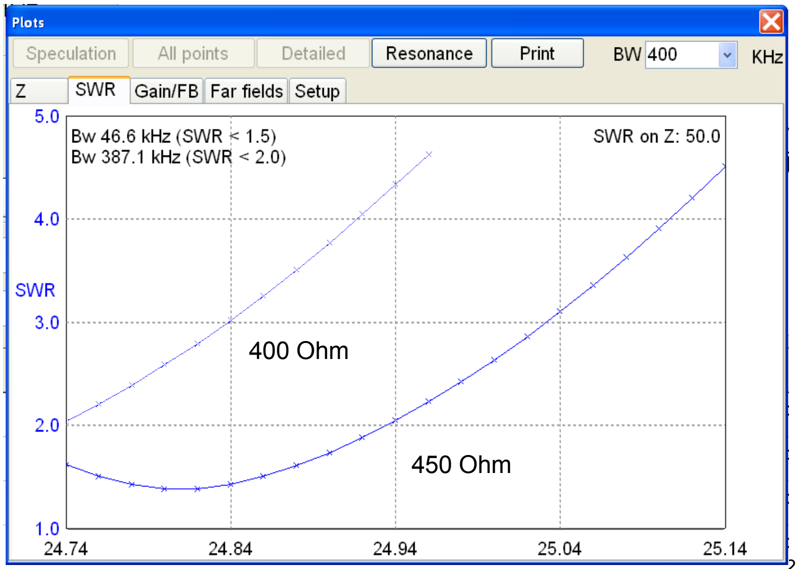
10 Meter SWR Curves – 400 Ohm Feed



20

The frequency of minimum SWR is shifted a little lower, but the useful range of the antenna is still limited.

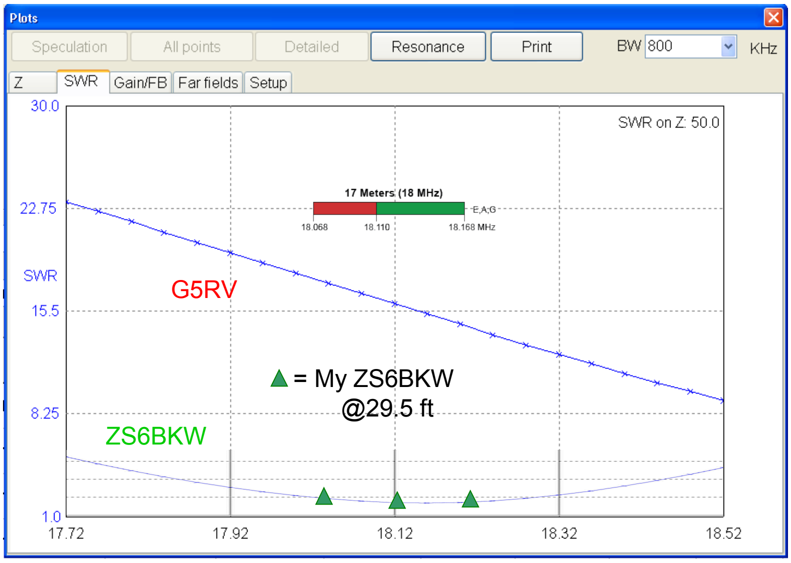
12 Meter SWR Curves – 400 Ohm Feed



21

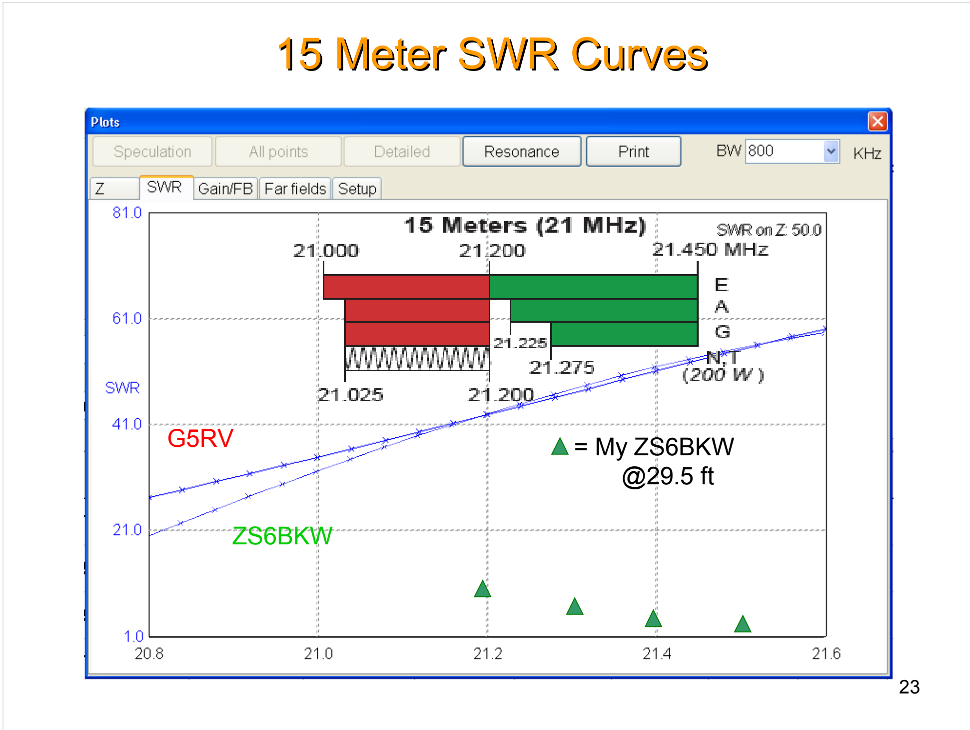
Looks like the 450 ohm feed line provides the better match on this band.

17 Meter SWR Curves



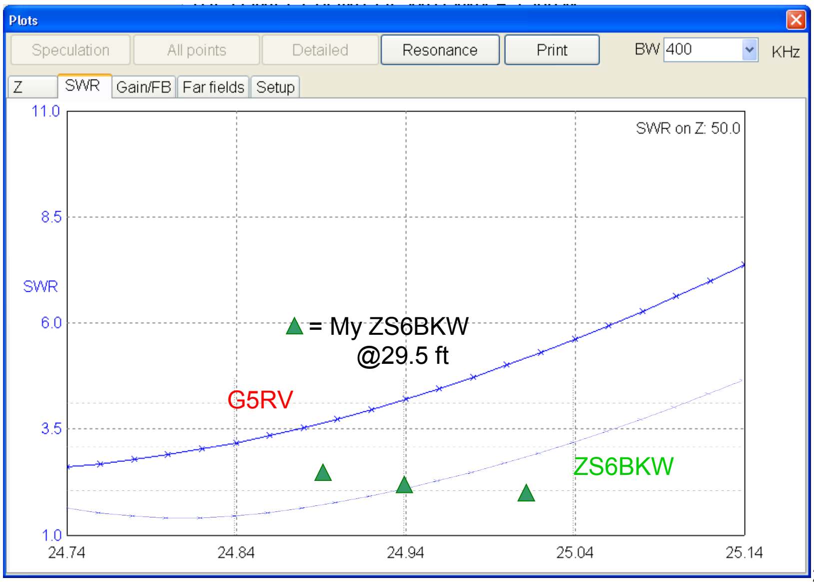
22

The 17 meter band is one of my favorite bands. It looks like it matches fairly well over the majority of the band. The G5RV will not match well, and when matched by a tuner will have significant losses. (> 3 DB loss or half the power.)



Both antennas are poor on this band. I do not understand why I measure fairly good SWR on this band. Most likely my particular length of coax is acting as an impedance transfromer “matching” the antenna to the transmitter. I have not operated on this band and so do not know how well the antenna performs on this band.

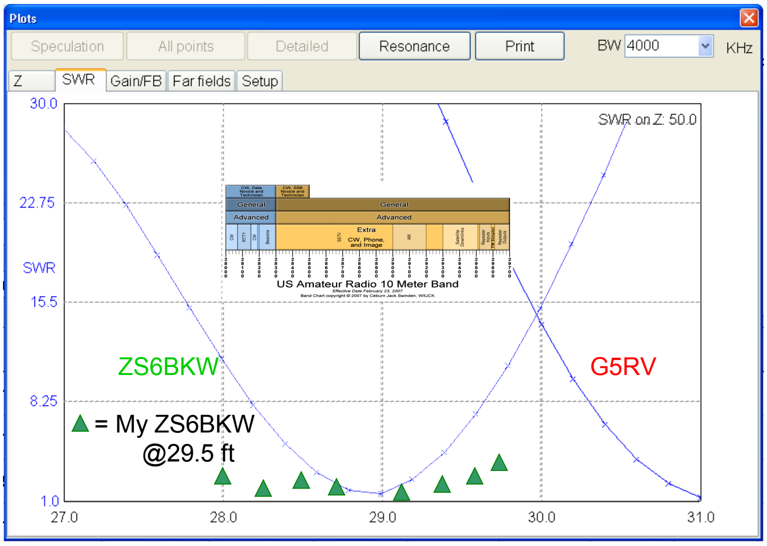
12 Meter SWR Curves



24

The ZS6BKW is somewhat better than the G5RV over most of this band.

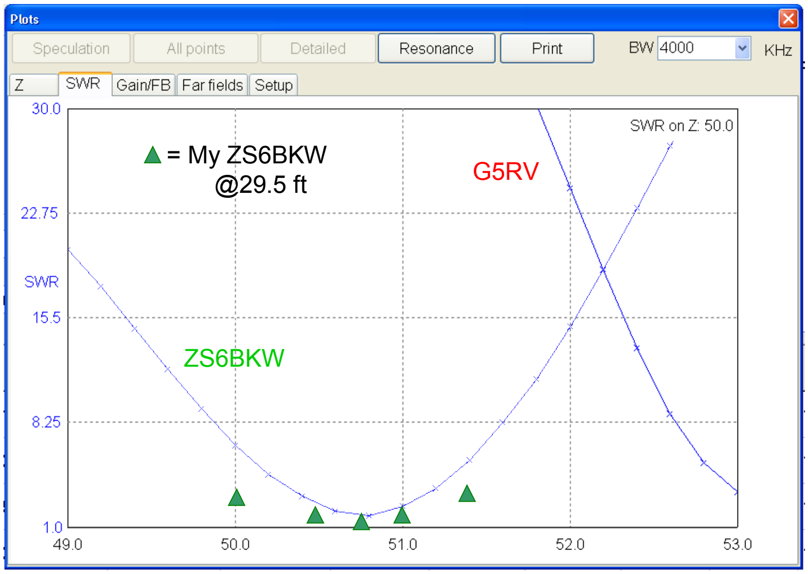
10 Meter SWR Curves



25

The ZS6BKW resonates in the 10 meter band. However, it will not cover the entire band without a tuner. The G5RV resonates outside the band. It will not perform well on 10 meters with high losses due to the SWR. Note that the measured SWR is MUCH better than the modeled antenna SWR. This is because of the losses in the cable run to the antena at this frequency.

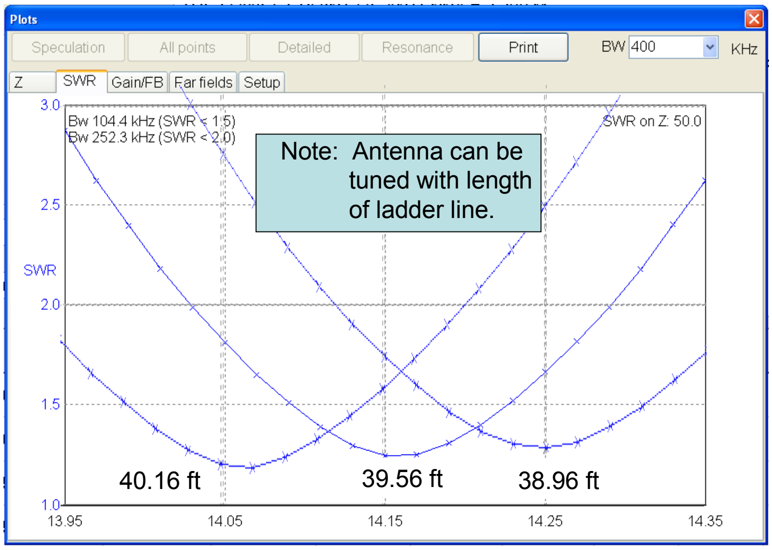
6 Meter SWR Curves



26

Interesting that it also resonates within the 6 meter band. The G5RV would have high losses over the entire band.

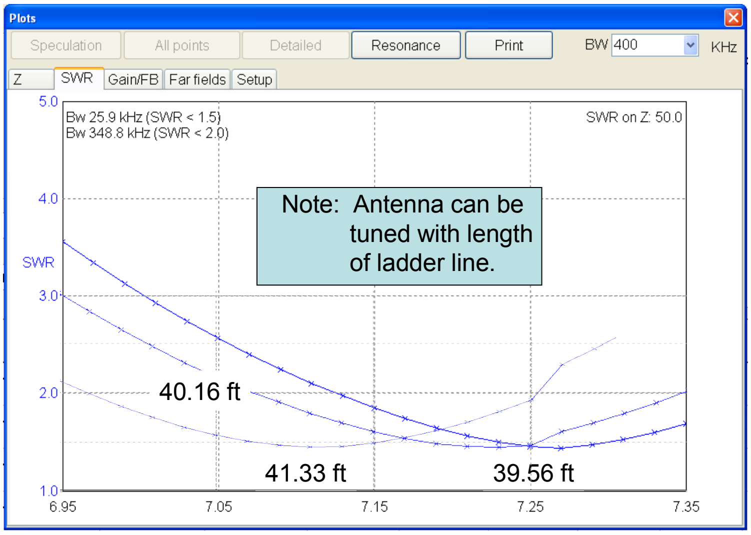
20 M SWR vs Ladder Line Length



27

The ladder line is the “magic” that allows the ZS6BKW to match so many bands. Here we see that we can change the resonant point in the 20 meter band simply by adjusting the ladder line length. However, the characteristics of the other bands will change as well. If you have a favorite portion of a band, more than likely the antenna can be optimized for that portion of the band.

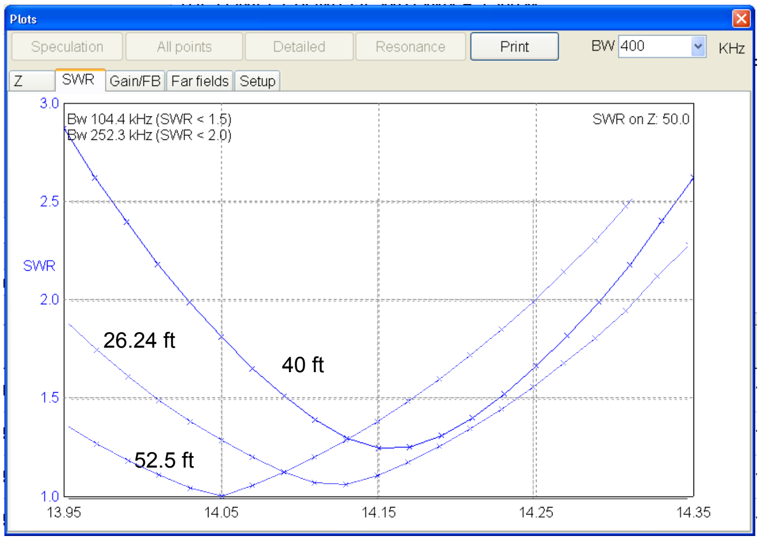
40 M SWR vs Ladder Line Length



28

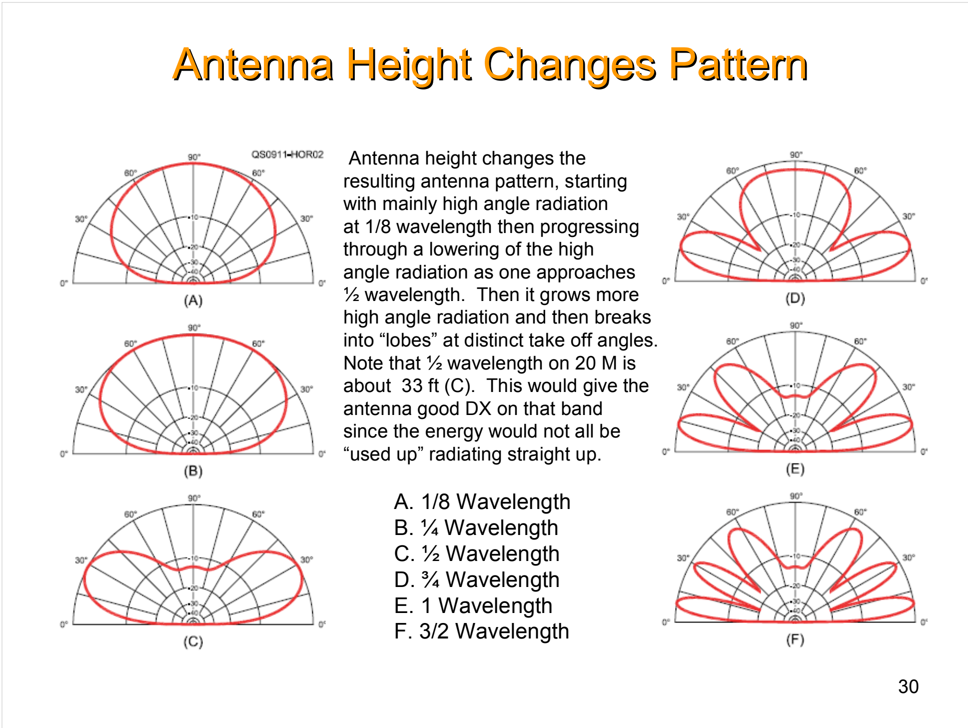
The frequency can also be shifted in the 40 meter band. It can be “tuned” for either the CW portion or the phone portion of the band.

Antenna Height Tunes (Detunes)



29

There is a small dependence of the SWR with height. This is true for all antennas and not unique to the ZS6BKW and G5RV. It is also true for the standard dipole. This can be factored into your modeled design of the antenna for optimum results.



The pattern change on either antenna with height is minimal for practical amateur installations. The effects are more noticeable at the higher frequencies.

For instance, with the antenna up at 40 ft, to get a pattern which would look similar to the example “F” above (3/2 wavelength) you would need to have the antenna at these heights.

PATTERN “F”	
40 M	196.8 ft
20 M	98.4 ft
17 M	83.64 ft
10 M	49.2 ft
6 M	29.52 ft

PATTERN “C”	
40 M	65.6 ft
20 M	32.8 ft
17 M	27.9 ft
10 M	16.4 ft
6 M	9.84 ft

100 ft Coax Loss Due to Frequency

Cable Type	Frequency In Megahertz									
RG/UCABLE	1	10	50	100	200	400	900	1000	3000	5000
6A,212	0.26	0.83	1.9	2.7	4.1	5.9	6.5	9.8	23	32
8MINI,8X	1.1	2.5	3.8	5.4	7.9	8.8	13	26		
LMR-240	0.24	0.76	1.7	2.4	3.4	4.9	7.5	7.9	14.2	18.7
8,8A,10A,213	0.15	0.55	1.3	1.9	2.7	4.1	7.5	8	16	27
9913,9086,9096	0.9	1.4	1.8	2.6	4.2	4.5	13			
4XL8IIA,FLEXI4 XL	0.9	1.4	1.8	2.6	4.2	4.5	13			
LMR-400	0.9	1.2	2.5	4.1	4.3					
LMR-500	0.7	1	2	3.2	3.4					
LMR-600	0.6	0.8	1.4	2.5	2.7					
8214	0.6	1.2	1.7	2.7	4.2	7.8	14.2	22		
9095	1	1.8	2.6	3.8	6	7.5				
9,9A,9B,214	0.21	0.66	1.5	2.3	3.3	5	7.8	8.8	18	27
11,11A,12,12A,13,13A,216	0.19	0.66	1.6	2.3	3.3	4.8	7.8	16.5	26.5	
14,14A,217	0.12	0.41	1	1.4	2	3.1	5.5	12.4	19	
17,17A,18,18A,218,219	0.06	0.24	0.62	0.95	1.5	2.4	4.4	9.5	15.3	
55B,223	0.3	1.2	3.2	4.8	7	10	14.3	16.5	30.5	46
58	0.33	1.2	3.1	4.6	6.9	10.5	14.5	17.5	37.5	60
58A,58C	0.44	1.4	3.3	4.9	7.4	12	20	24	54	83
59,59B	0.33	1.1	2.4	3.4	4.9	7	11	12	26.5	42
62,62A,71A,71B	0.25	0.85	1.9	2.7	3.8	5.3	8.3	8.7	18.5	30
62B	0.31	0.9	2	2.9	4.2	6.2	11	24	38	
141,141A,400,142,142A	0.3	0.9	2.1	3.3	4.7	6.9	13	26	40	
174	2.3	3.9	6.6	8.9	12	17.5	28.2	30	64	99
178B,196A	2.6	5.6	10.5	14	19	28	46	85	100	
188A,316	3.1	6	9.6	11.4	14.2	16.7	31	60	82	
179B	3	5.3	8.5	10	12.5	16	24	44	64	
393,235	0.6	1.4	2.1	3.1	4.5	7.5	14	21		
402	1.2	2.7	3.9	5.5	8	13	26	26		
405	22									
LDF4-50A	0.06	0.21	0.47	0.68	0.98	1.4	2.2	2.3	4.3	5.9
LDF5-50A	0.03	0.11	0.25	0.36	0.53	0.78	1.2	1.4	2.5	3.5

31

These are typical coax losses vs frequency for coax cable terminated in its characteristic impedance. Always use the cable with the lowest losses if you can afford its cost.

A good working graph with standard coax types can also be found in the ARRL Antenna book. Making a choice of good low loss coax cable with help to minimize losses when matched AND help to keep the SWR down when the coax is not matching the antenna/ladder line. This is true both for the ZS6BKW and the G5RV.

Note that running ladder line all the way to the transmitter would result in the lowest loss, but would require a tuner on most bands for matching to the transmitter. This is not a bad choice if you can run the ladder line to avoid proximity to metal objects or avoid losses by having the line too close to the ground.

Additional Coax Loss Due to SWR

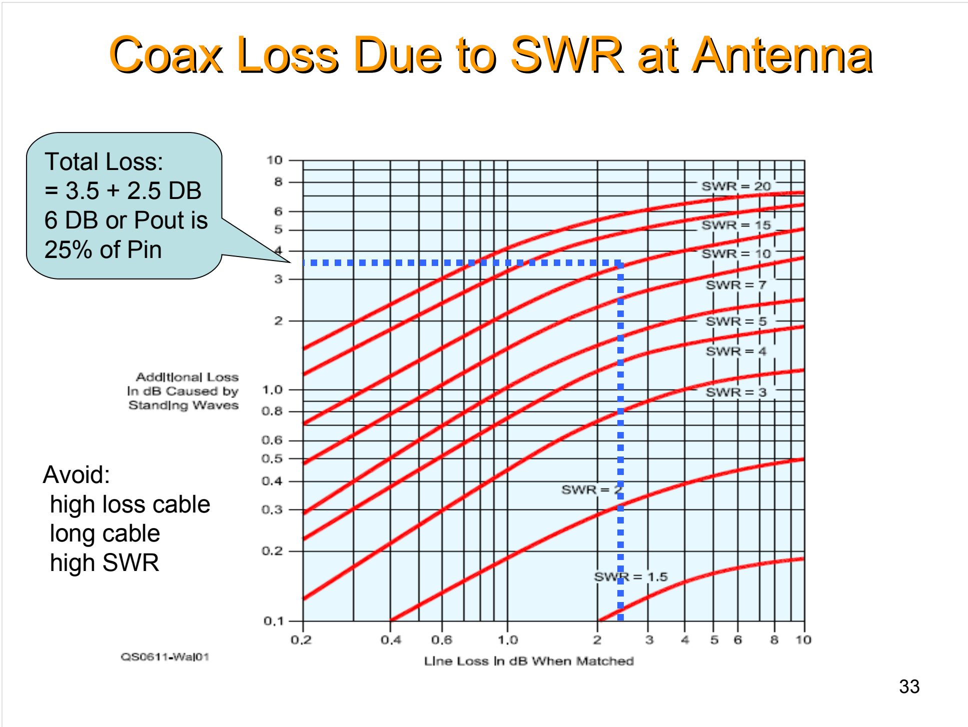
table 3. Additional loss caused by standing waves. Find the line loss when perfectly matched in the vertical column; read across for the actual SWR. Find the figures that are closest to yours if yours are not exactly represented. Conditions above and to the left of the heavy line indicate an SWR loss of less than 1 dB.

line loss matched (dB)	actual SWR (at antenna) 1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0	0	0	0	0	0	0	0	0	0	0	0	.0
0.2	0	0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.7
0.4	0	0	0.1	0.2	0.2	0.4	0.5	0.7	0.8	1.0	1.1	1.3
0.6	0	0	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7
0.8	0	0	0.2	0.3	0.4	0.7	0.9	1.2	1.5	1.7	1.9	2.1
1.0	0	0	0.2	0.3	0.5	0.8	1.2	1.4	1.7	1.9	2.2	2.5
1.2	0	0	0.2	0.4	0.6	1.0	1.3	1.7	1.9	2.2	2.5	2.8
1.4	0	0	0.3	0.4	0.6	1.1	1.5	1.8	2.1	2.4	2.7	3.0
1.7	0	0	0.3	0.5	0.7	1.3	1.7	2.0	2.3	2.6	3.0	3.3
2.0	0	0.1	0.3	0.5	0.8	1.3	1.8	2.1	2.5	2.8	3.2	3.6
2.5	0	0.1	0.3	0.6	0.9	1.5	1.9	2.3	2.8	3.1	3.5	3.7
3.0	0	0.1	0.4	0.6	1.0	1.5	2.0	2.5	2.9	3.2	3.7	4.0
3.5	0	0.1	0.4	0.7	1.1	1.6	2.1	2.6	3.1	3.4	3.8	4.1
4.0	0	0.1	0.4	0.7	1.1	1.7	2.2	2.7	3.2	3.5	3.9	4.2
4.5	0	0.1	0.4	0.7	1.1	1.7	2.3	2.8	3.2	3.6	4.0	4.3
5.0	0	0.1	0.4	0.8	1.2	1.8	2.3	2.9	3.3	3.7	4.1	4.4
5.5	0	0.1	0.5	0.8	1.2	1.8	2.4	2.9	3.3	3.8	4.2	4.5

32

This chart tells the story behind the concern expressed in this presentation. If you have losses in your coax (and you will have loss) and if the SWR at the load end of the coax is high, you will have lost some (or most) of the power you put into the coax at the transmitter end. This is even before it gets a chance to radiate.

The above chart has a line cutting through the data, showing where the matched loss and SWR reading results in a 1 DB loss in signal strength. This difference of 1 DB is thought by most hams to be the level at which the effects would be too small to notice.

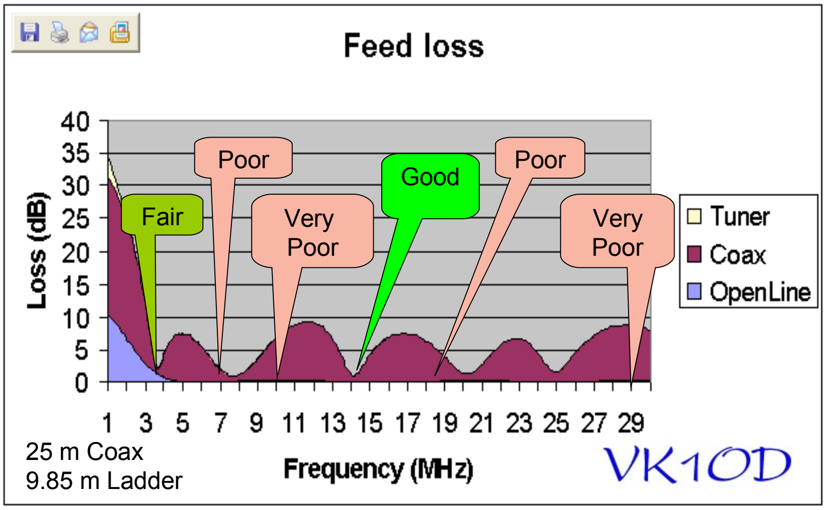


This graph shows that the losses in an ANTENNA SYSTEM is dependent on the cable losses as given by the manufacturer PLUS an additional loss due to the SWR of the load to which the coax is connected.

Sometimes the losses are small, as when the coax cable run is short and high quality coax is used. However, even with high quality coax, the losses can be substantial if the SWR at the antenna end is large.

Note that a loss of 3 DB is equivalent to one half of your transmit power. This is equivalent to making a 200 watt transmitter equal to one with 100 watts.

All Losses RG213 To G5RV



34

The above data is taken from the VK1OD web site. He has performed extensive computer analysis using NEC modeling software and custom computations, computing total system losses for the G5RV antenna with different feed systems. The data is not available for the ZS6BKW, but because the SWR is lower within the same ham bands, the losses will be lower as well.

The above graph shows that there are significant gains to be made when coax losses are minimized and SEVERE penalties when they are not.

Note that the above graph is with about 80 feet of high quality cable. The graph would show higher losses with a longer coax run or with lesser quality coax.

SWR Summary and Conclusions

The table below summarizes the content of the previous slides. It shows the areas where the ZS6BKW has a SWR advantage over the G5RV. So, "Shorten that G5RV antenna by 7.3 feet and extend the ladder line by 11 feet!"

Compare Mid Band SWR - ZS6BKW vs G5RV MID BAND				LOW BAND EDGE			HIGH BAND EDGE		
BASE	Fmid	ZS6BKW	G5RV	Flow	ZS6BKW	G5RV	Fhigh	ZS6BKW	G5RV
80 M	3.75	9.5	7	3.5	5.75	4.23	4	21.5	17.31
40 M	7.15	2.37	4.93	7	3.56	3.53	7.3	1.64	3.53
30M	10.12	83	67	10.1	82.3	65.29	10.15	84.5	68.58
20 M	14.15	1.93	1.7	14	4.22	3.42	14.35	1.9	2.97
17M	18.12	1.28	14.66	18.68	1.3	5.55	18.168	1.42	13.75
15M	21.2	75	25	21	71.4	29.62	21.45	77.84	41.46
12M	24.94	1.83	4.9	24.89	2.16	4.28	24.99	1.61	5.51
10M	28.5	4.7	44.2	28	11.82	50.21	29.7	7.06	19.55
6M	50.5	2.82	54.16	50.1	6.53	54.43	54	42.6	15.38

The only band where the G5RV has good SWR is on 20M.
The G5RV has a better match on 80M due to its longer length.
The ZS6BKW has a large portion of the 10m band where it can be used without a tuner.
Note that the G5RV has a somewhat better (but unaccepatable SWR) on 80M
Note that the ZS6BKW can be operated on a portion of the 6M band but the G5RV cannot.
Note that the ZS6BKW can operate on the whole of the 17M band but the G5RV cannot
The ZS6BKW will fit in a smaller lot than the G5RV
The G5RV has a shorter run of ladder line down the main support (34 ft) than the ZS6BKW (39.5 ft)
Both are good antennas when a tuner is used - The ZS6BKW will have significantly lower coax loss
Costs are virtually identical and less than $60 (Excluding mounting structure and coax cable to radio)
Both have very low loss on ladder line down to the coax feed, with the ZSBKW slightly longer
The ZS6BKW has lower coax losses because it is a closer match to 50 ohms on most bands

35

The data here is displayed to spotlight those bands or portions of bands where the antennas are effective (lower SWR and lower losses).

Even if you have an antenna tuner to match antennas, you may still want to use the ZS6BKW version because it has lower coax cable losses due to the SWR at the antenna end of the coax. The tuner only serves to make the transmitter happy with delivering power into this mismatched coax and does not change the actual losses in the coax due to high SWR at the antenna end.

Also Note: For those of you who still have a tube transmitter or amplifier, you will be glad to know that the matching range of your transmitter or amplifier will in most cases be greater that that assumed in this presentation. If so, it will allow you to operate in more portions of the ham bands using either antenna.

Summary and Conclusions (Cont'd)

This antenna is being actively used at the QTH of KE5KJD, where comparisons have been made with three other antenna systems. About 20 stations were logged on each band and signal strengths (S-units) measured using an antenna switch to measure and verify S-unit measurements.

Switched Antennas	Cost	Averaged S-Units By Band		
Antenna	Total	80 Meters	40 Meters	20 Meters
Butternut 80/40 Vertical Dipole	~$350	10	9.5	5.6
Hustler 6BTV Trap Vertical	~$300	6.9	9.9	9.8
ZS6BKW Dipole (94 ft)	~$70	10	9.2	8.5
80/40 Dipole W5DXP (148 ft)	~$80	11	8.2	5.7

As can be seen above, The ZS6BKW performs quite well on all three bands. The other antennas perform as expected, with some advantages of each based on their intended use. Not shown above is that the 6BTV Vertical antenna nearly always has the advantage on a DX contact due to its excellent ground radial system and low angle of radiation. No tuner was used to obtain above results. Frequency within the band was random.

36

This graph should give you a good sense of the performance of these four antennas. Each of the antennas are "good" antennas and will make ham radion contacts on multiple bands.

The W5DXP dipole is the best performer on the 80 and 75 M bands, with the tall vertical being a close second.

The 6BTV vertical is the best performer on 40 M, only slightly better than the others.

The 6BTV is also the better performer on 20 M with the ZS6BKW a close second.

The ZS6BKW has consistently good performance on each of the above bands and would make an excellent station antenna. It is the easiest to construct and install, and is very portable. It is also the least expensive of all the antennas.

Now for the cost: The commercial vertical antennas listed can be purchased for less than the indicated amount. However, you will need several added components to complete your antenna system. First, you will need a ground mount, like a pipe or wood pole to attach the antenna. Then you will need a substantial amount of copper wire, insulated or not, for the ground system. Especially for multiband use, a large number of radials of different lengths will be required.

The wire antennas may need a center pole if you do not have a good tree.

ZS6BKW ManaGal Model Data

```
ZS6BKW VEE
*
14.15
***Wires***
7
0.0,      13.75,     -4.0,     0.0,     0.0145,     0.0,      8.000e-04, -1
0.0,      -13.75,    -4.0,     0.0,     -0.0145,    0.0,      8.000e-04, -1
0.0,      0.0145,    -10.0,    0.0,     0.0145,     0.0,      7.000e-04, -1
0.0,      -0.0145,   -10.0,    0.0,     -0.0145,    0.0,      7.000e-04, -1
3.4,      -0.0145,   -10.0,    3.4,     0.0145,     -10.0,    7.000e-04, -1
0.0,      -0.0145,   -10.0,    3.4,     -0.0145,    -10.0,    7.000e-04, -1
0.0,      0.0145,    -10.0,    3.4,     0.0145,     -10.0,    7.000e-04, -1
***Source***
1,        1
w5c,      0.0,       1.0
***Load***
0,        1
***Segmentation***
800,      80,        2.0,      1
***G/H/M/R/AzEl/X***
2,        12.2,      1,        50.0,    120,        60,       0.0
###Comment###
Mod by Larry, KE5KJD 11/4/2009 1:47:47 AM
E:\ZS6BKW.maa
```

37

For those who may want to model the antenna in their particular location, the above antenna definition can serve as a starting point. Just change the lengths to match and set up the height and end height of the antenna elements.

G5RV ManaGal Model Data

```
GR5V VEE
*
14.15
***Wires***
7
0.0,     14.9,     -4.0,   0.0,   0.0145,   0.0,    8.000e-04, -1
0.0,     -14.9,    -4.0,   0.0,   -0.0145,  0.0,    8.000e-04, -1
0.0,     0.0145,   -10.0,  0.0,   0.0145,   0.0,    7.000e-04, -1
0.0,     -0.0145,  -10.0,  0.0,   -0.0145,  0.0,    7.000e-04, -1
1.44,    -0.0145,  -10.0,  1.44,  0.0145,   -10.0,  7.000e-04, -1
0.0,     -0.0145,  -10.0,  1.44,  -0.0145,  -10.0,  7.000e-04, -1
0.0,     0.0145,   -10.0,  1.44,  0.0145,   -10.0,  7.000e-04, -1
***Source***
1,       1
w5c,     0.0,      1.0
***Load***
0,       1
***Segmentation***
800,     80,       2.0,    1
***G/H/M/R/AzEl/X***
2,       12.2,     1,      50.0,  120,      60,     0.0
###Comment###
Mod by Larry, KE5KJD 11/4/2009 1:48:51 AM
E:\G5RV.maa
```

38

For those who may want to model the antenna in their particular location, the above antenna definition can serve as a starting point. Just change the lengths to match and set up the height and end height of the antenna elements.

Sources and References

1. Mmana Gal
2. L. B. Cebik (W4NL)
   http://www.nonstopsystems.com/radio/G5RV-1.pdf
4. Brian Austin (ZS6BKW)
5. Louis Varney (G5RV)
6. Owen Duffy (VK1OD)
7. ARRL Antenna Handbook

If interested, perform a Google search on the above for more information than you may have time to read.

Note: From the outset, I have stated that the antenna design presented here is not mine. I only extended the analysis to show that the antenna is effective and can be used in multiple ham bands, and for many is a better choice than the venerable G5RV.

Making Your Own Antenna

Antenna Wire Sources

Purchase wire
Old telephone wire
Unwind old transformer
Unwind TV Yoke wire
Clothesline Wire
Fence wire

Antenna Insulators

Purchase insulators
Short PVC pipe pieces
Strips of Deldrin or Kelvar
(Kitchen cutting board, etc)
Unwind TV Yoke wire
Clothesline Wire

Ladder Line

Purchase line
Make from parallel wires

Center Pole

Tv Pole
Hang from tree
Wood pole
Lumber
Fiberglas pole

Two End Poles

Two poles
Two trees
Tree and other structure
Barn to house
Lumber poles
Fiberglas poles

Coax To Radio

Purchase coax
Surplus 50 ohm cable
Surplus Tv 75 ohm
Not practical to build

The above list is a generic list of materials that can be used to build the antenna. Your sources may be different. In particular, do not skimp on the coax run back to the shack. Any losses in the coax will not radiate from the antenna, and any losses on transmit will also be seen on the received signal strength.

Making Your Own Antenna - Hints

Antenna Wire
Use Quality copper coated steel for strength
Solder all connections if possible
Coat all exposed connections with UV resistant glue and waterproof tape
Provide stress relief at wire connections
Tension wire to prevent sag and loss of height

Center Insulator
Provide stress and bend/flex relief at connection to antenna
Support ladder line directly, not depending on joints to antenna
Put a 2-10 W ~20K Ohm resistor across antenna terminals.

Ladder Line
Use quality line with stranded wire for better flex characteristics
Do not use flat TV 300 ohm line, use windowed version if possible
Twist line about one half turn every two feet (less net wind area)
Run twine through line "windows" and attach ladder wire to it for stress relief
Keep line off ground and away from metal poles or surfaces by six inches
Provide multiple connectors along last 5 feet for "tuning"

Coax Feed
Use quality connectors and waterproof all connection to avoid "wicking"

Study the hints above before starting your antenna construction. The resistor across the middle antenna is optional, but will allow charge to drain from the antenna instead of building up and creating noise in the receiver.

Antenna Article ZS6BKW

This short article will describe a simple dipole SYSTEM which will work very well for both the new and experienced ham. It tends to have low SWR on many amateur bands and low losses over most of these bands.

In the mid-1980s, Brian Austin (ZS6BKW) ran computer analysis to develop an antenna System that, for the maximum number of HF bands possible, would permit a low Standing Wave Ratio (SWR) without an antenna tuner to interface with a 50-Ohm coaxial cable as the main feed line. He identified a range of lengths which, when combined with a matching ladder line length, would provide this characteristic. (See Figure 1).

According to an acknowledged expert in computer antenna design and modeling, L. B. Cebik:

"Of all the G5RV antenna system cousins, the ZS6BKW antenna system has come closest to achieving the goal that is part of the G5RV mythology: a multi-band HF antenna consisting of a single wire and simple matching system to cover as many of the amateur HF bands as possible."

The next set of slides provide the text of a short article on the ZS6BKW antenna without the full presentation. I converted it to MicroSoft publisher for inclusion in our AARA LARC newsletter.

Antenna Article ZS6BKW (2)

So, what is this “magic” antenna? It consists of a simple dipole, either in a flat top or inverted V form, fed with a measured length of ladder line (300, 400, or 450 ohms) connected to a length of coax back to the ham shack and transceiver. In most cases, it does not require a tuner to match the antenna system to the transceiver. It can handle full legal power.

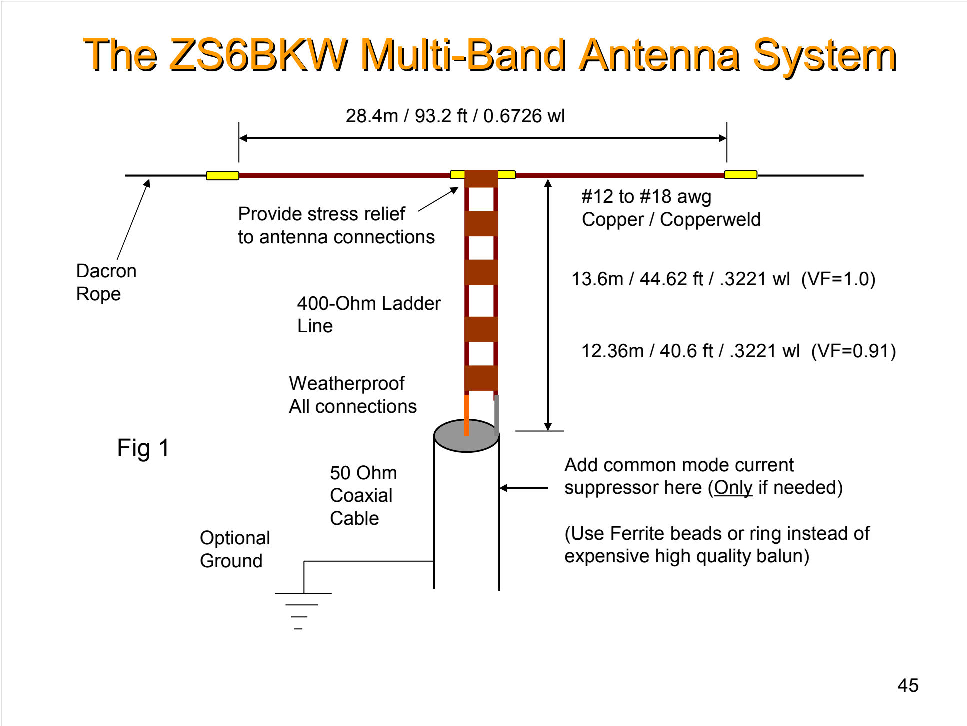
In the full article posted on the AARA intranet, there is a full analysis of this antenna in a practical environment which shows graphically how the antenna will match under different conditions and the resulting antenna patterns you can expect on the different bands. It also gives construction details so you can make your own. All analysis used the free “MANA-Gal” program.

This antenna is being actively used by KE5KJD, where comparisons have been made with three other antenna systems. A 6 band vertical, a 2 Band (80/40) vertical, and a 148 ft long dipole. About 20 stations were logged on each band and signal strengths (S-units) measured using an antenna switch to measure and verify S-unit measurements. Here is the summary of those results.

Antenna Article ZS6BKW (3)

Switched Antennas	Cost	Averaged S-Units By Band		
Antenna	**Total**	**80 Meters**	**40 Meters**	**20 Meters**
Butternut 80/40 Vertical Dipole	~$350	10	9.5	5.6
Hustler 6BTV Trap Vertical	~$300	6.9	9.9	9.8
ZS6BKW Dipole (94 ft)	~$70	10	9.2	8.5
80/40 Dipole W5DXP (148 ft)	~$80	11	8.2	5.7

As can be seen above, The ZS6BKW performs quite well on all three bands. The other antennas perform as expected, with some advantages of each based on their intended use. Not shown above is that the 6BTV vertical antenna nearly always has the advantage on a DX contact due to its excellent ground radial system (>100 radials) and low angle of radiation. Also not shown is the verticals had slightly higher noise levels, making copy of weak signals difficult. No tuner was used to obtain above results. Frequency used within each band was chosen at random.



The above is the flat-top version of the ZS6BKW antenna. Note especially the location for torroid suppressor choke (only if required.) Do not assume that you will need a choke. Another choke is to wind about 10 turns of your coax run on a form of about 6 incles.

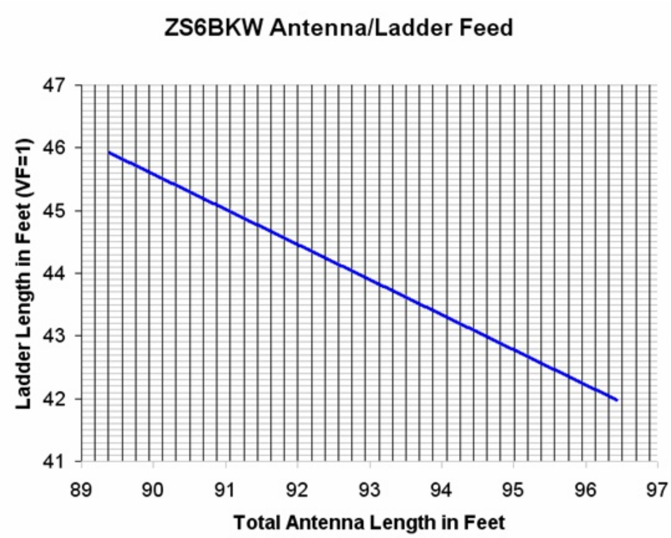
The antenna is a balanced system and should not require either type of choke, which will add to the expense and in some cases increase your losses. The factors which may create imbalance in the antenna system are:

1. Unequal antenna lengths on either side of the middle.
2. Unequal heights of the antenna on either side of the middle
3. Variation in ground conductivity on either side of the antenna.
4. Proximity of metal structures on either side of the antenns.
5. Large difference in the proximity of trees to the antenna.

Try the antenna first without a balun or choke. If you get feedback through your microphone or in your audio system, then look at the various sources for RF and a choke in that case may be part of the solution.

Also note the optional ground, which should be on the shack side of the choke or balun. It is there to provide some lightning protection to the antenna.

Antenna Article ZS6BKW (4)



46

If you want to use different lengths for the ladder line or antenna, the above graph was provided by Brian Austin as part of his computer modeling. I have truncated the graph to a straight line through the center of his area graph for simplicity.

ZS6BKW / G5RV Why I like it

1. Has low swr in several ham bands at the matching point at the end of the ladder line resulting in lower losses in the coax cable. (I have a 200 ft run from the antenna to the radio making this crucial.)
2. Can be operated without an outboard tuner on at least 5 bands.
3. Has both simplicity and low cost. (Good emergency antenna)
4. Will work with one central support and two lower supports (Inverted Vee) OR two end supports (Flat Top) on a typical city lot.
5. It retains the high-strength in the antenna wire, allowing the antenna to help support the central mounting pole. (No heavy coax or inline traps in the antenna line like the "W5GI" or "W3DZZ".)
6. Antenna patterns are "reasonable" for local or DX work.
7. Can be operated on non-optimum bands with an external tuner.
8. Multiband means better utilization of available space, fewer antennas and coax runs, and means you can put the extra money in high quality low loss cables, increasing the height to 30-50 ft, improving loss on all bands, especially the higher frequency bands.
9. One can also erect a 80/40 or 160/80 wire from the same support, at about 90 degrees to the ZS6BKW to keep it stable and free standing in moderate winds. This gives better performance on the low bands.

The End

So, what are you waiting for? Go out and build one!

Or

Take down your G5RV and fold over each end by 3.65 feet and tack on a 11 ft length of ladder line, put it back up and load up on more bands!!!

48

The antenna system presented has incremental improvement over a G5RV with the same basic design. Except for 80 M, there is no reason NOT to use the ZS6BKW over the G5RV design. Although the improvements are minimal if you do use a tuner, they are real. If you do not have a tuner, you will find that the ZS6BKW will allow you to operate on more bands and more of each band than the G5RV.