Rochester Amateur Radio Association, Inc.

G5RV … on “Steroids”

Presented by Jim Stefano – W2COP

May 6, 2020

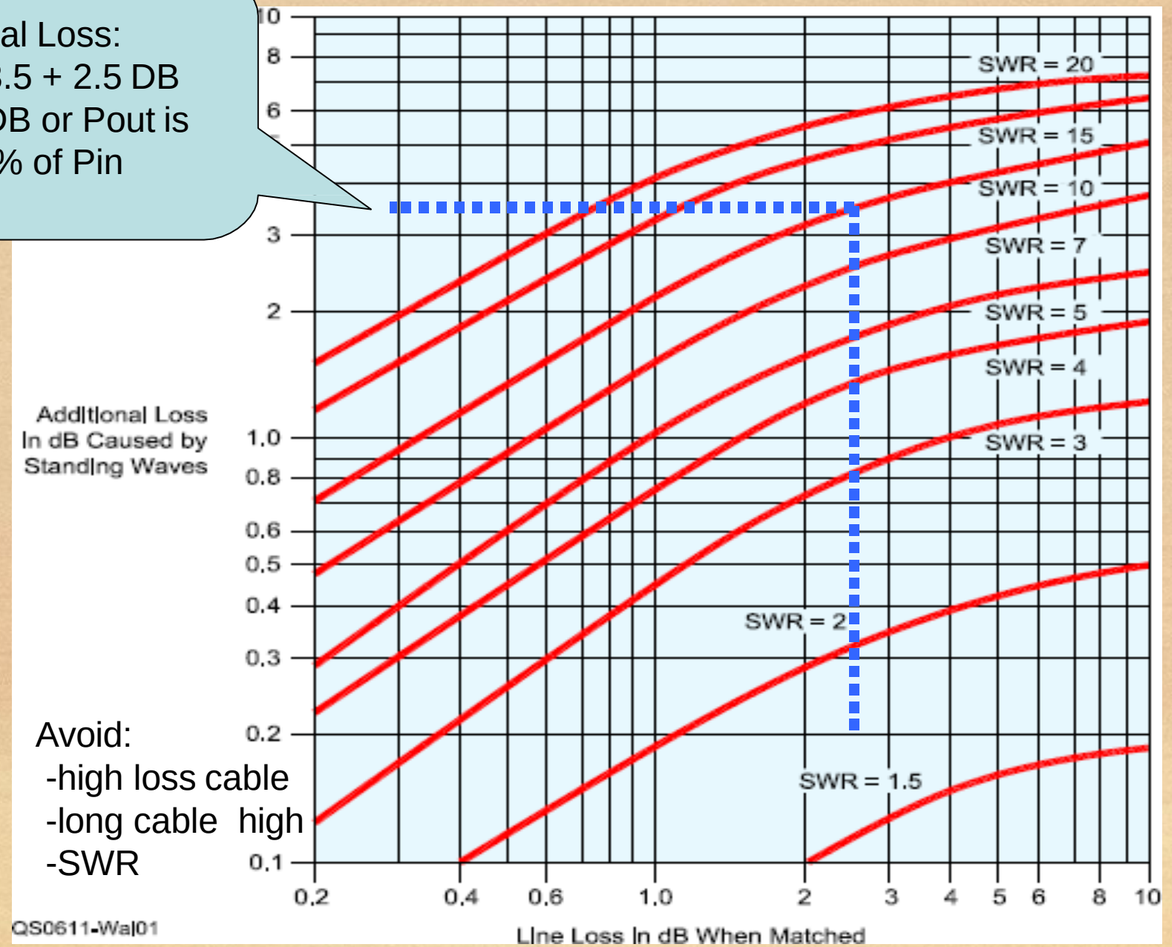
Disclosure:

The following presentation is meant as a primer to pique your interest into further investigating better all-band wire antennas. While no single wire antenna is perfectly resonant on every band, they can be customized to suit your favorite band(s). Analysis of these antenna designs are supported with pages of documentation that you can deep dive on your own. I've included a couple of easy designs that offer the most flexibility with some proven results. This is a compilation of my own materials and those I found on the world-wide-web that led me to this project and where we are today.

Resonance

Signal Loss Due to Poor SWR at the Antenna

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

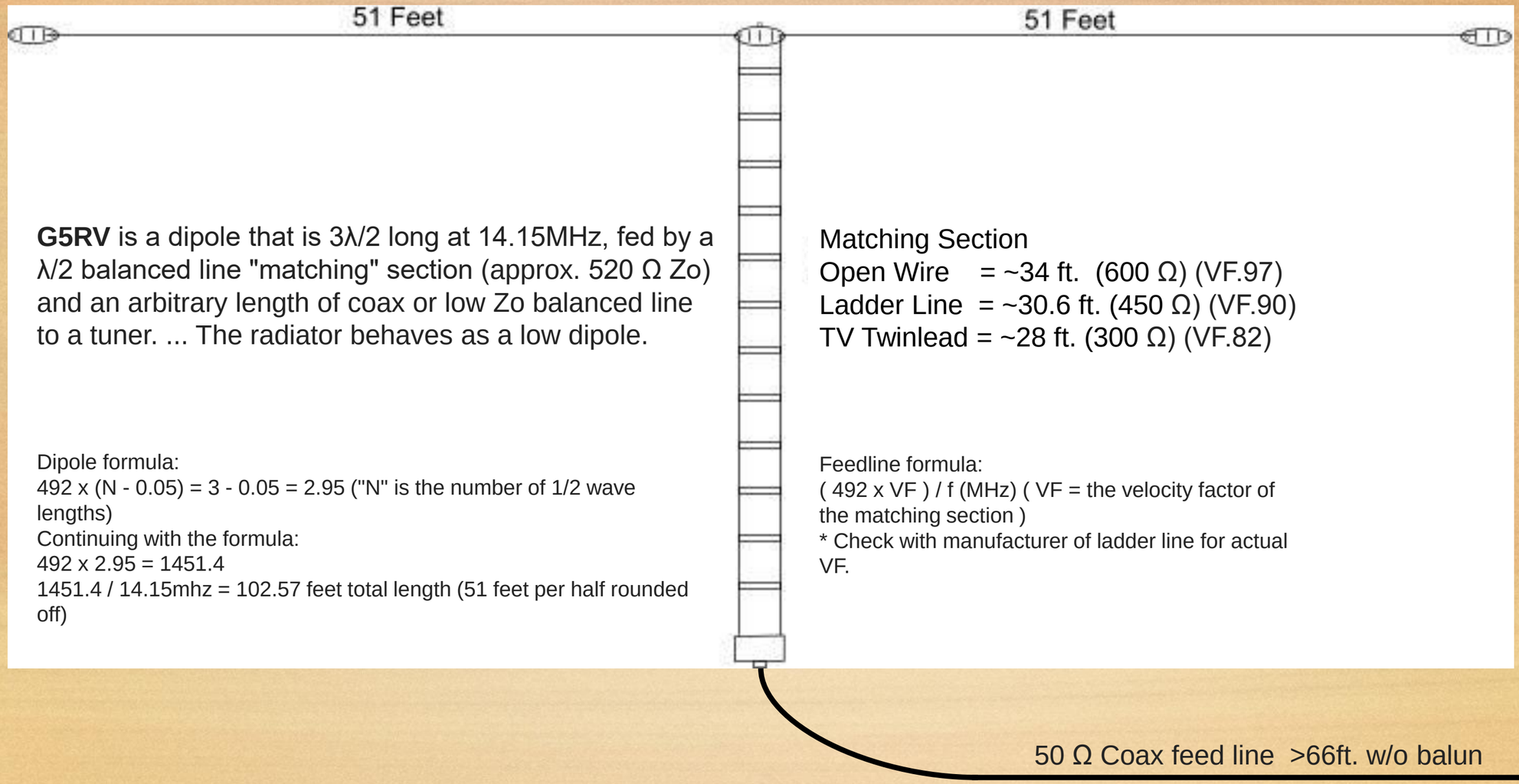


Avoid:
-high loss cable
-long cable high
-SWR

G5RV Antenna

Easily one of the most popular “all-band” antennas in use today. Louis Varney - G5RV ("SK" on June 28, 2000, age 89) invented this antenna in 1946. The antenna can be erected as horizontal dipole, as a sloper, or an inverted-V antenna (>120deg. angle). It is a non-resonant antenna that requires a transmatch to operate on most HF amateur radio bands (3.5–30 MHz, 1.8 Mhz. by shorting the feed). It can typically take up to 1500W. Cost built, around $70.

G5RV Antenna Design



G5RV is a dipole that is 3λ/2 long at 14.15MHz, fed by a λ/2 balanced line "matching" section (approx. 520 Ω Zo) and an arbitrary length of coax or low Zo balanced line to a tuner. ... The radiator behaves as a low dipole.

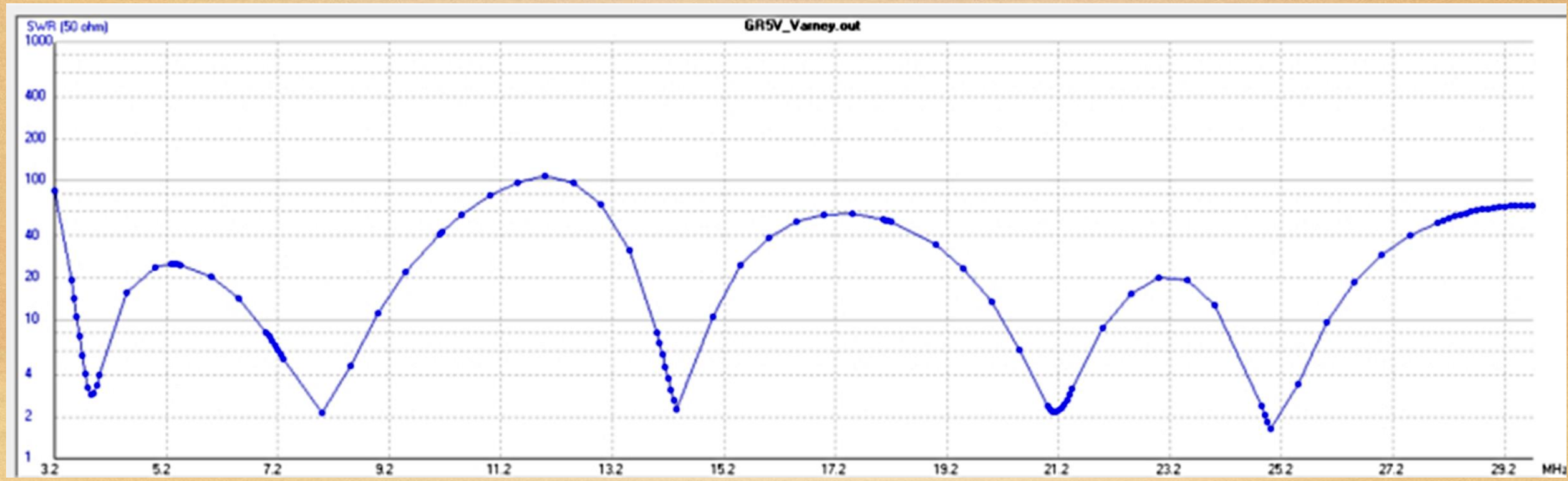
Dipole formula:
492 x (N - 0.05) = 3 - 0.05 = 2.95 ("N" is the number of 1/2 wave lengths)
Continuing with the formula:
492 x 2.95 = 1451.4
1451.4 / 14.15mhz = 102.57 feet total length (51 feet per half rounded off)

Matching Section
Open Wire = ~34 ft. (600 Ω) (VF.97)
Ladder Line = ~30.6 ft. (450 Ω) (VF.90)
TV Twinlead = ~28 ft. (300 Ω) (VF.82)

Feedline formula:
(492 x VF) / f (MHz) (VF = the velocity factor of the matching section)
* Check with manufacturer of ladder line for actual VF.

G5RV Antenna
SWR

Not very resonant in most of the ham bands.



HOLY GRAIL

HOW DO WE GET TO AN ALL-BAND ANTENNA THAT IS NATIVELY RESONANT ON MOST BANDS TO REDUCE LOSSES?

ZS6BKW

vs.

G5RV

Study Compiled By: Larry James LeBlanc – KE5KJD, SK (2019)

Larry was an electrical engineer with two Masters Degrees in Engineering and Computer Science.

Note: All graphs computed using MMANA GAL https://hamsoft.ca/pages/mmana-gal.php

ZS6BKW vs. G5RV

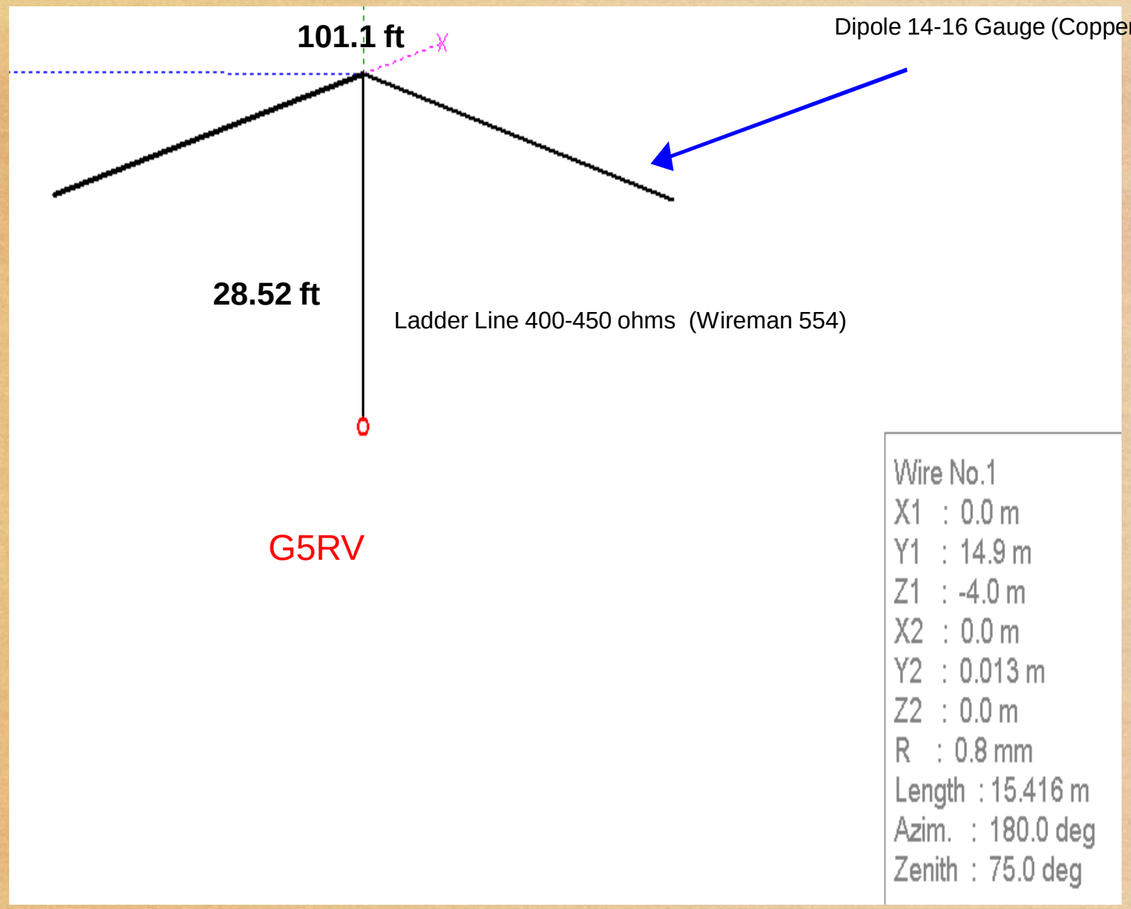
In the mid-1980s, Brian Austin (ZS6BKW) ran computer analysis to develop an antenna System that, for the maximum number of HF bands possible, would permit a low Standing Wave Ratio (SWR) without antenna tuner to interface with a 50-Ohm coaxial cable as the main feed line. He identified a range of lengths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

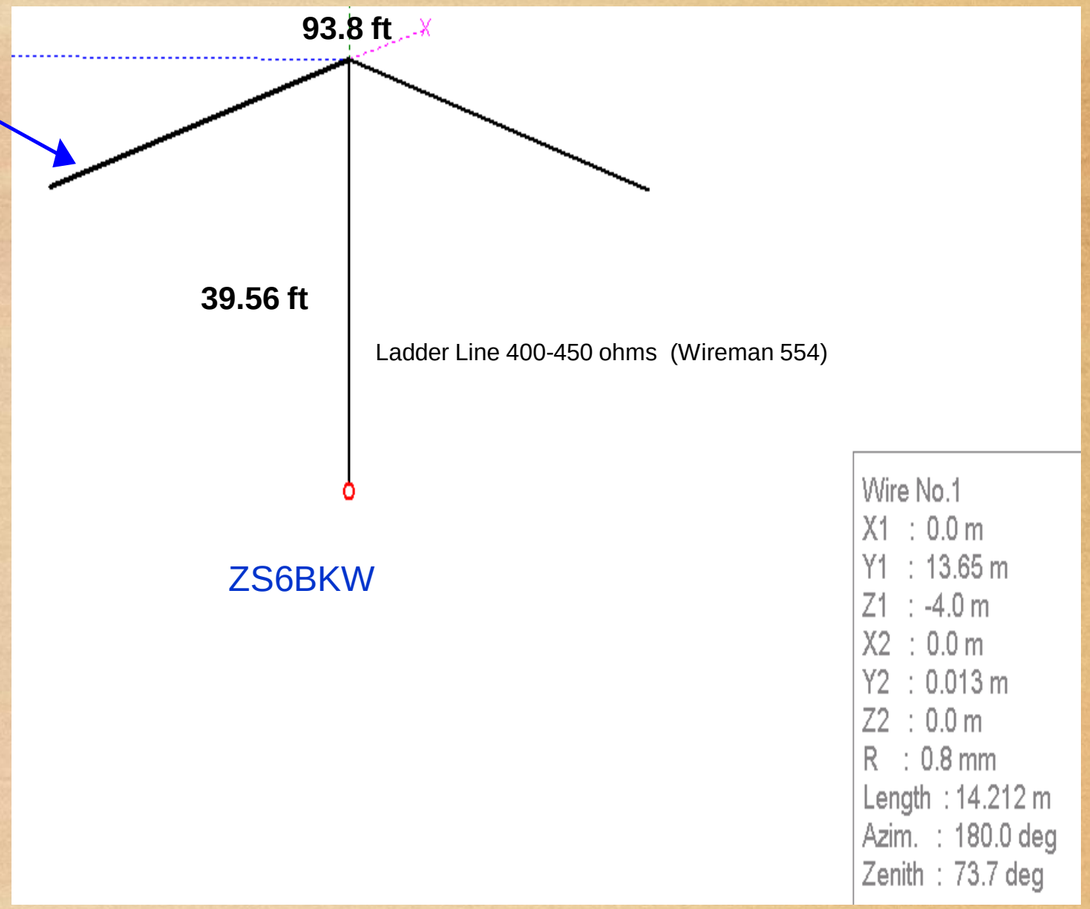
"Of all the G5RV antenna system cousins, the ZS6BKW antenna system has come closest to achieving the goal that is part of the G5RV mythology: a multi-band HF antenna consisting of a single wire and simple matching system to cover as many of the amateur HF bands as possible."

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.

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=.9)

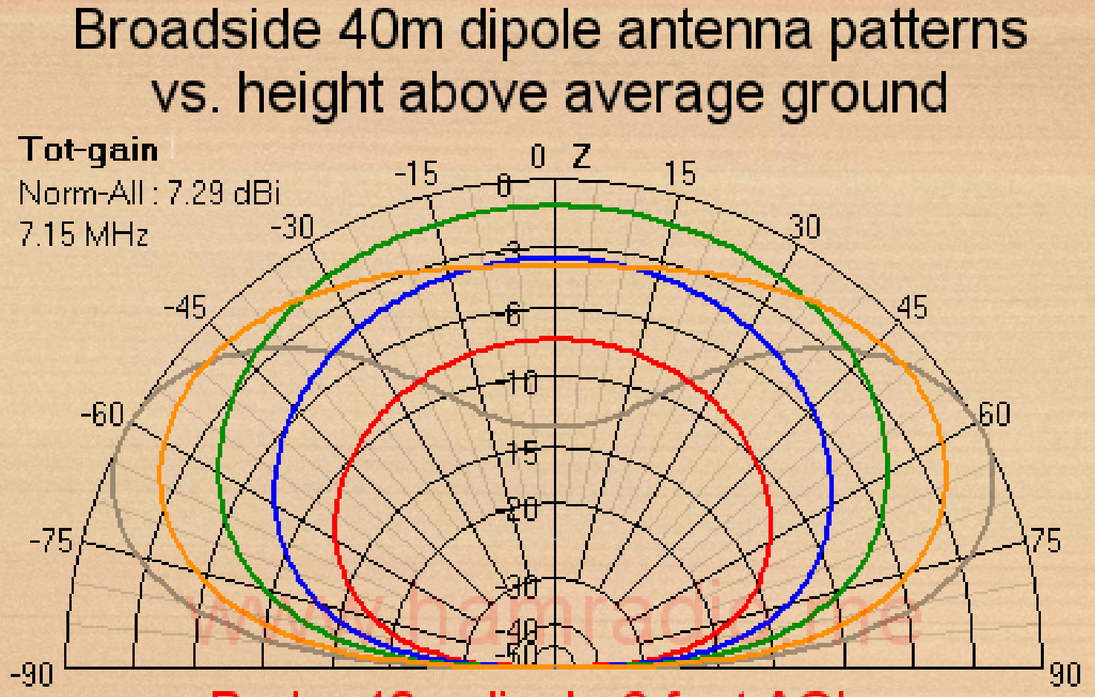
G5RV → 7.3 ft shorter wire
11 ft longer ladder → ZS6BKW

ZS6BKW vs. G5RV

Advantages

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. (… a 200 ft run from the antenna to the radio makes 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.
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.

Antenna Pattern above ground



Red = 40m dipole 6 feet AGL
Blue = 40m dipole 12 feet AGL
Green = 40m dipole 24 feet AGL
Orange = 40m dipole 48 feet AGL
Gray = 40m dipole 65 feet AGL

ZS6BKW vs. G5RV

CHARTS

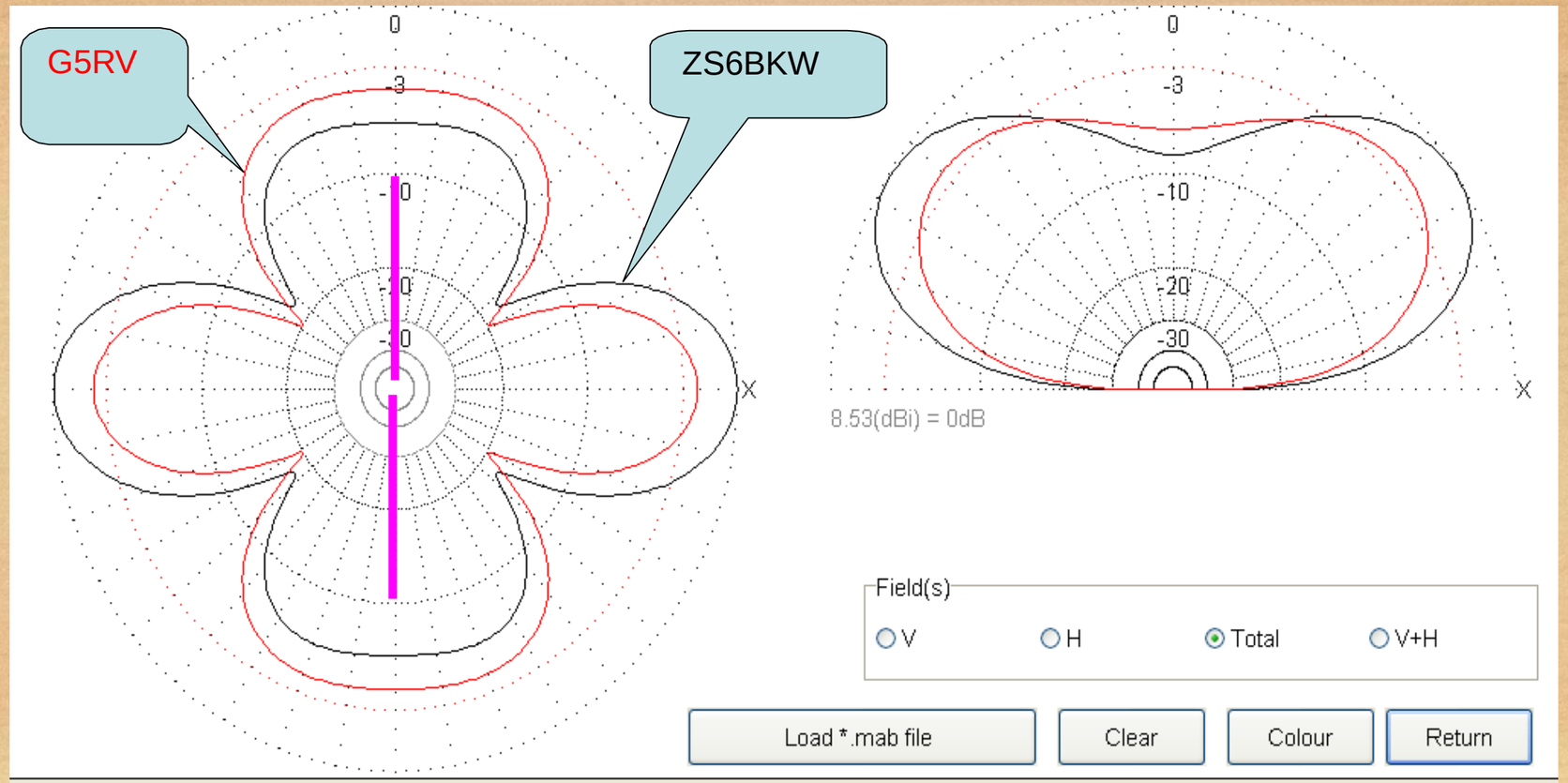
Antenna Patterns / SWR at 40 ft. Center height,

27 ft. end height

~148 Degree Included Angle

(Inverted – V)

ZS6BKW / G5RV
Pattern (20M Native)



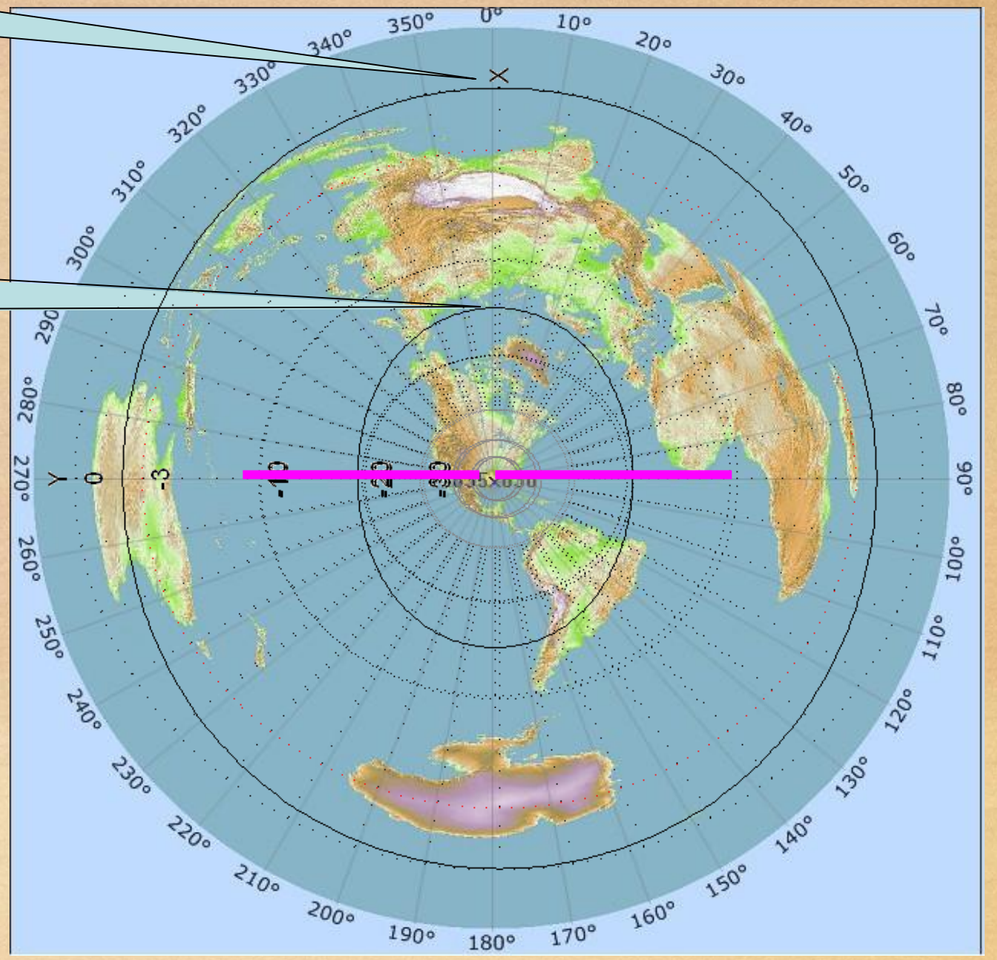
No.	F (MHz)	R	jX	SWR	Gh	Ga	F/B	Elev.	GND	Height	Pol.	File	name
1	14.15	61.906	-3.538	1.25	---	8.53	0.01	34.1	Real	12.2	H	this	ZS6BKW
2	14.15	117.541	-11.108	2.38	---	6.4	0.0	40.1	Real	12.2	H	E:\MyCrypt\Ha	GR5V VEE

Radiation Pattern
ZS6BKW 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.

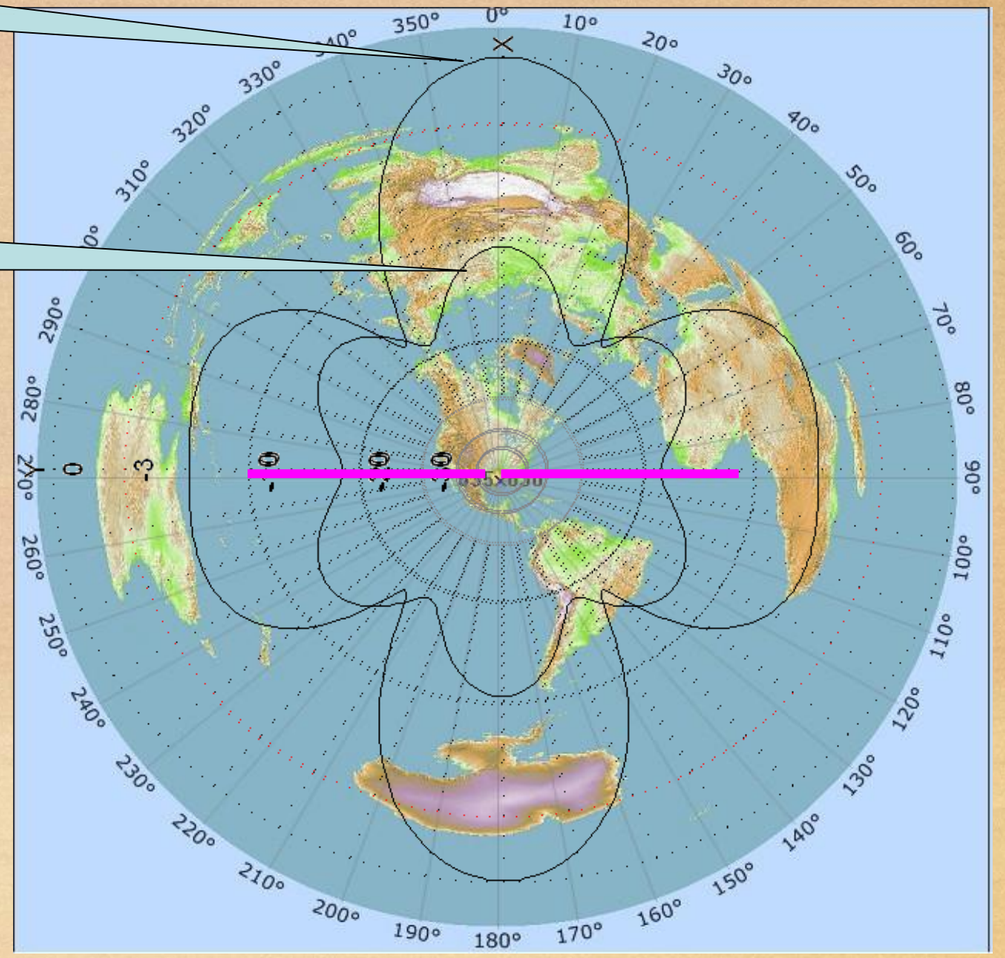


Ga : 6.26 dBi = 0 dB (Horizontal polarization)
F/B: -0.00 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 7.150 MHz
Z: 72.682 - j28.268 Ohm
SWR: 1.8 (50.0 Ohm),
Elev: 63.0 dg (Real GND :12.20 m height)

Radiation Pattern
ZS6BKW 20M

34.1 Deg Gain:
8.51 DBi

6 Deg
Gain: -2 DBi



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

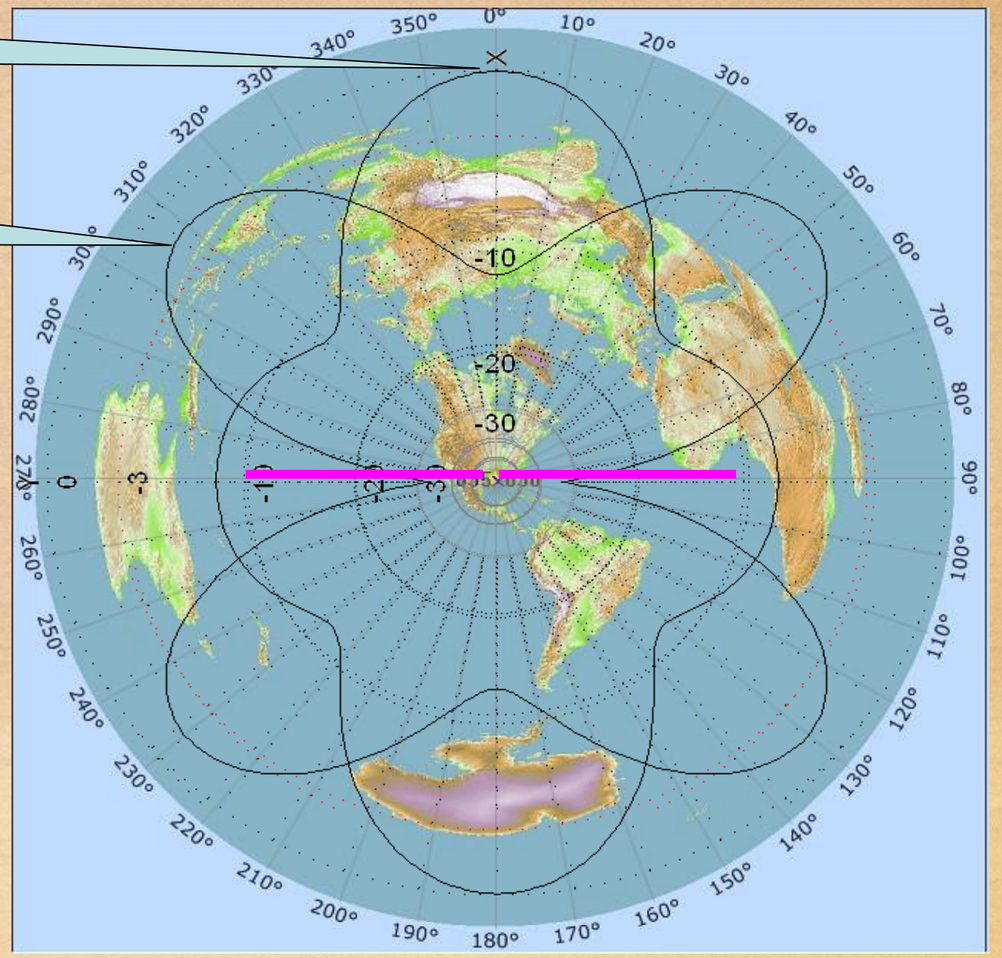
Ga : 8.51 dBi = 0 dB (Horizontal polarization)
F/B: 0.01 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 14.175 MHz
Z: 62.588 + j3.567 Ohm
SWR: 1.3 (50.0 Ohm),
Elev: 34.1 dg (Real GND :12.20 m height)

Radiation Pattern
ZS6BKW 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.



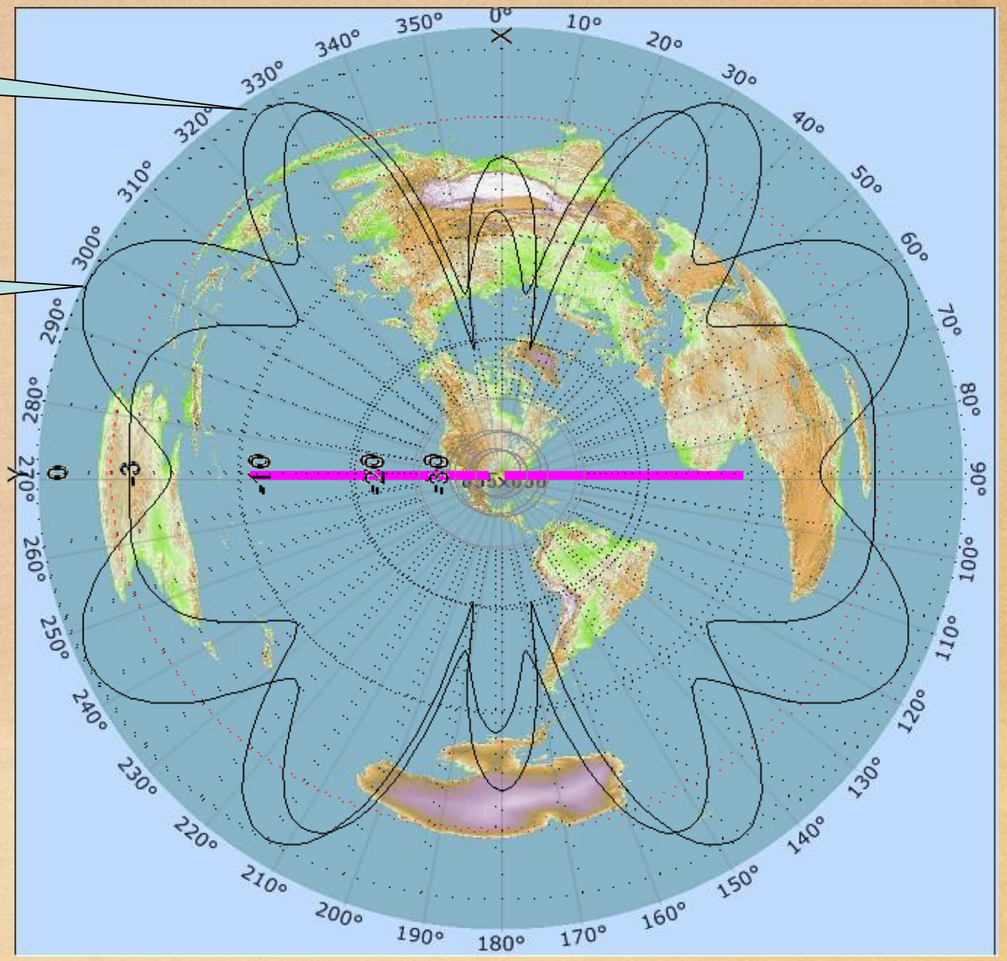
Ga : 2.55 dBi = 0 dB (Horizontal polarization)
F/B: -0.03 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 18.120 MHz
Z: 84.435 - j5.839 Ohm
SWR: 1.7 (50.0 Ohm),
Elev: 50.0 dg (Real GND :12.20 m height)

Radiation Pattern
ZS6BKW 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.



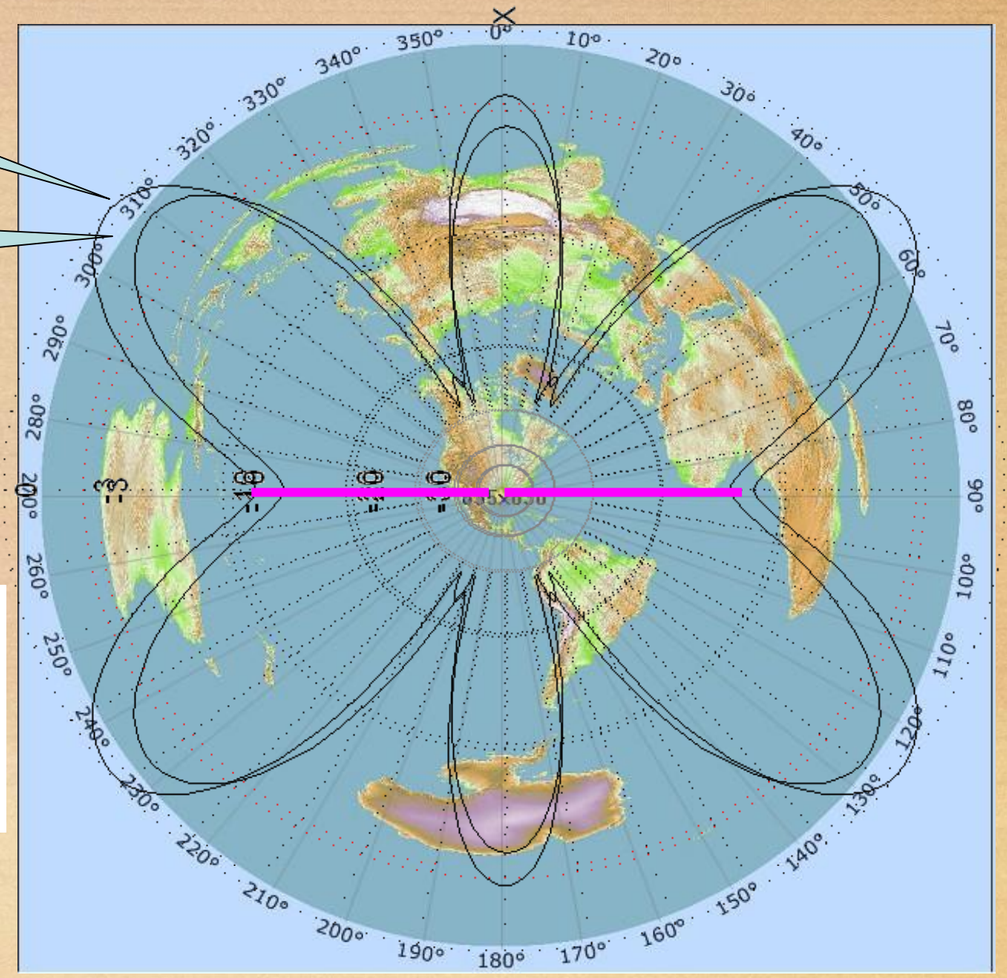
Ga : 7.43 dBi = 0 dB (Horizontal polarization)
F/B: -5.06 dB; Rear: Azim. 120 dg, Elev. 60 dg
Freq: 24.900 MHz
Z: 72.623 + j25.168 Ohm
SWR: 1.7 (50.0 Ohm),
Elev: 25.4 dg (Real GND :12.20 m height)

Radiation Pattern
ZS6BKW 10M

14 Deg
Gain: 9.4 DBi

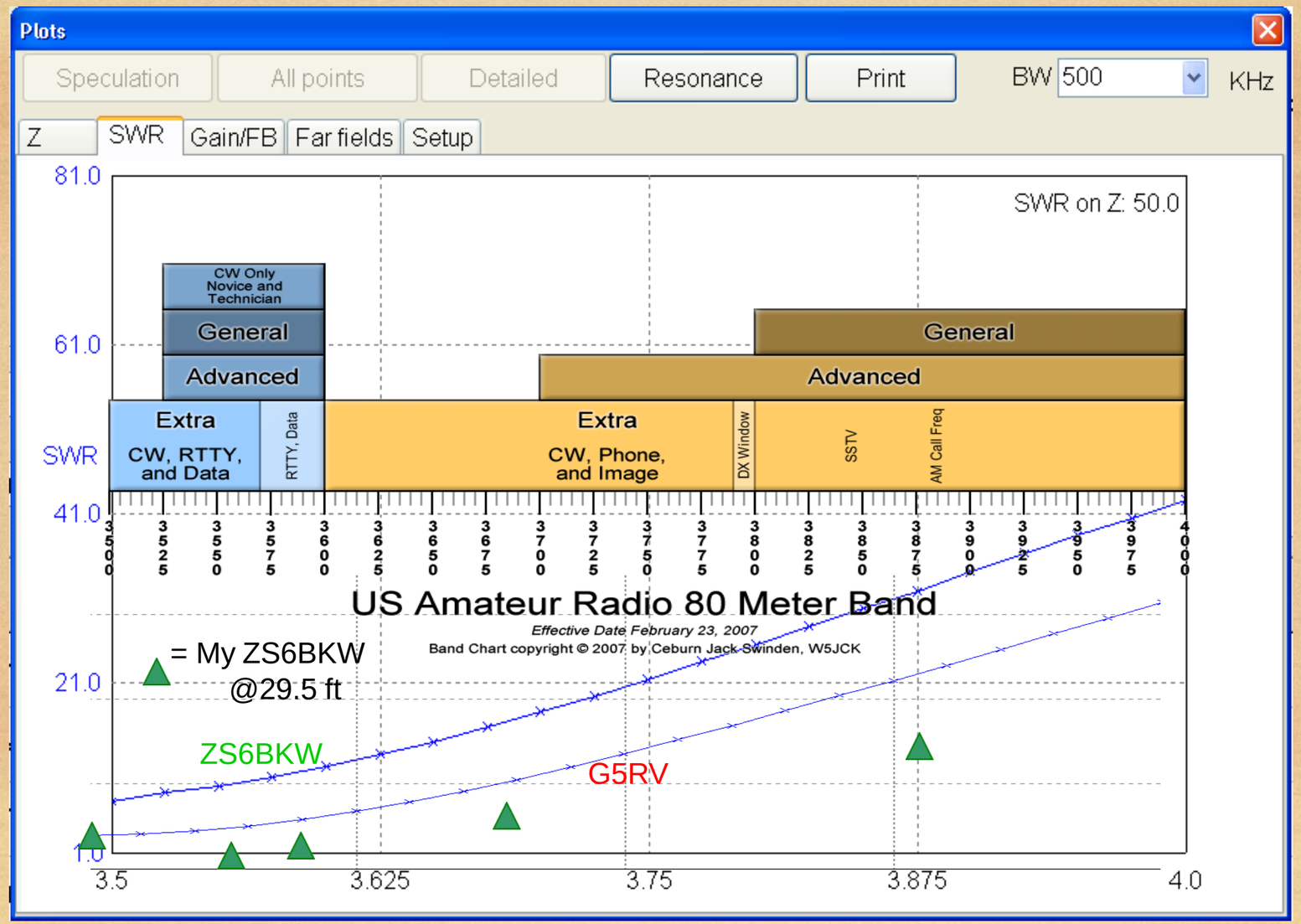
6 Deg
Gain: 6.8 DBi

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)

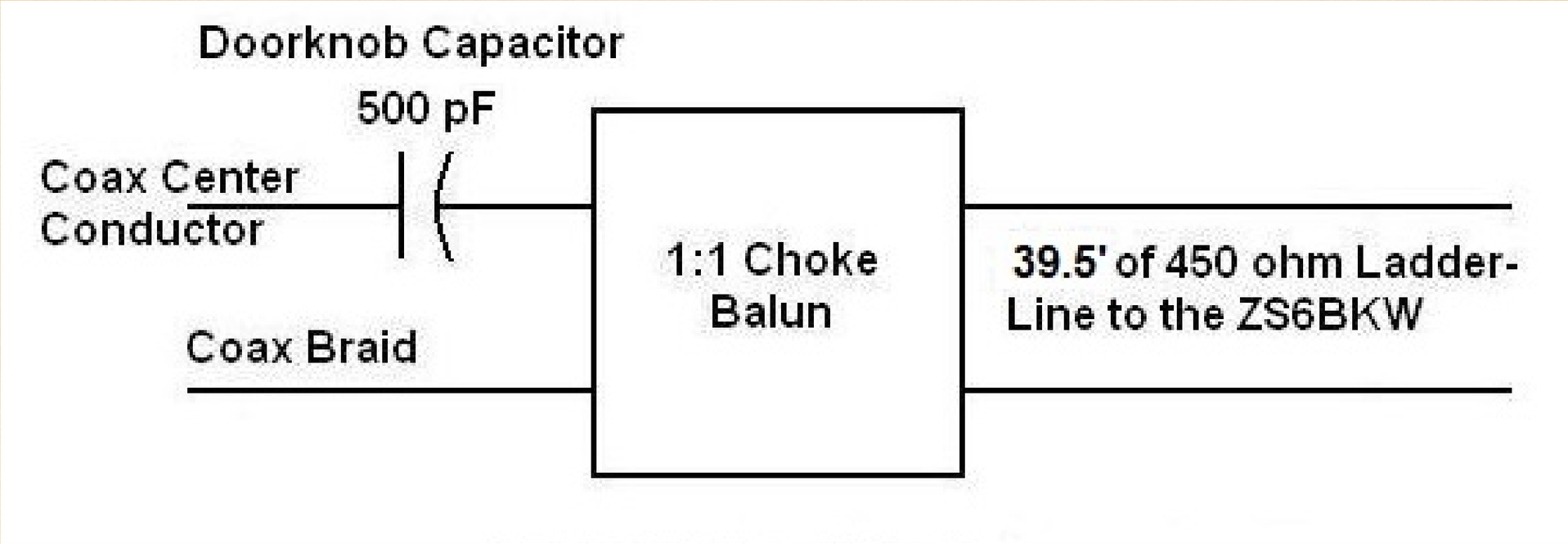
80 Meter SWR Curves



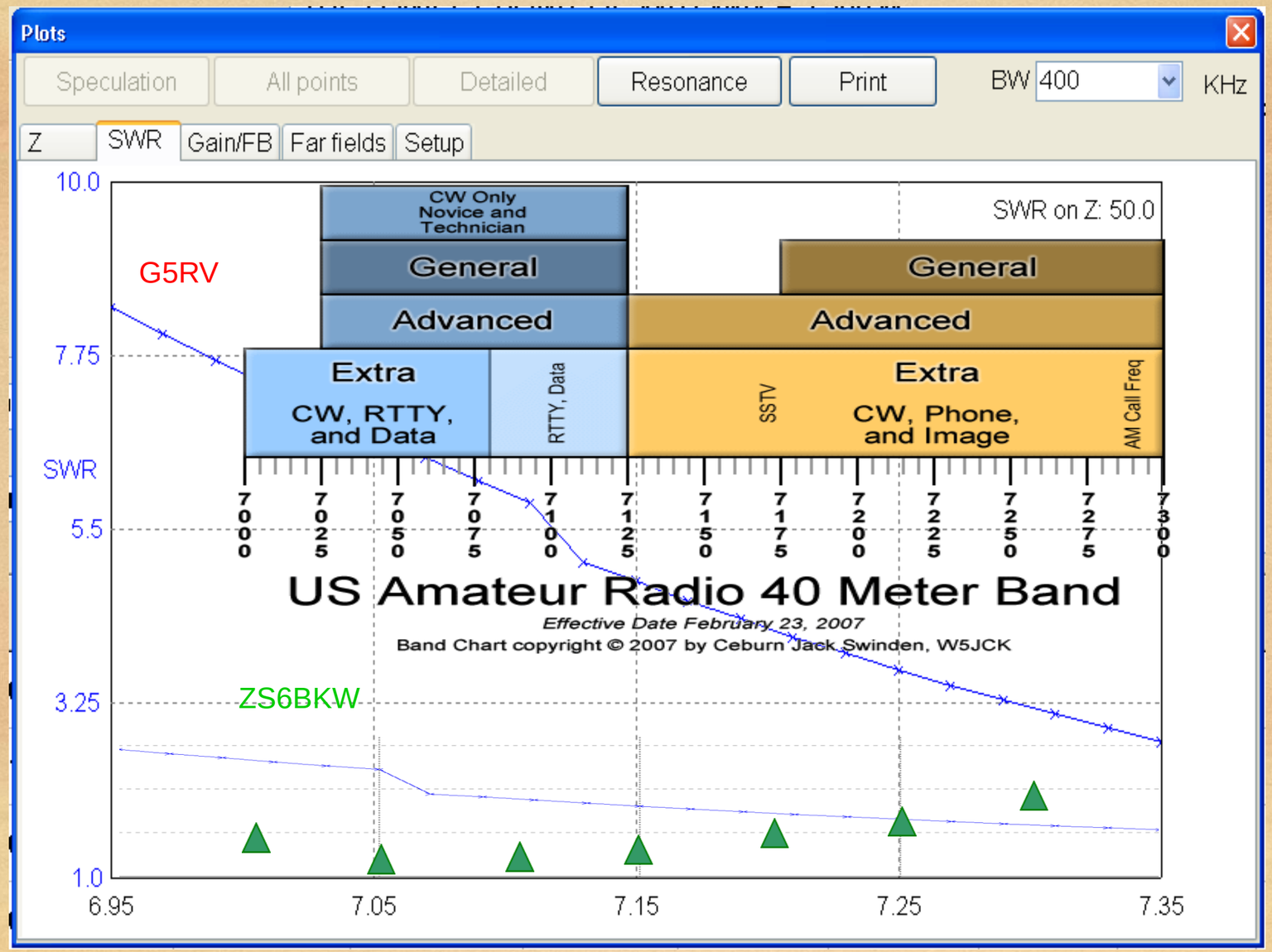
http://www.w5dxp.com/ZS6BKW80/ZS6BKW80.HTM

80 Meter Mod

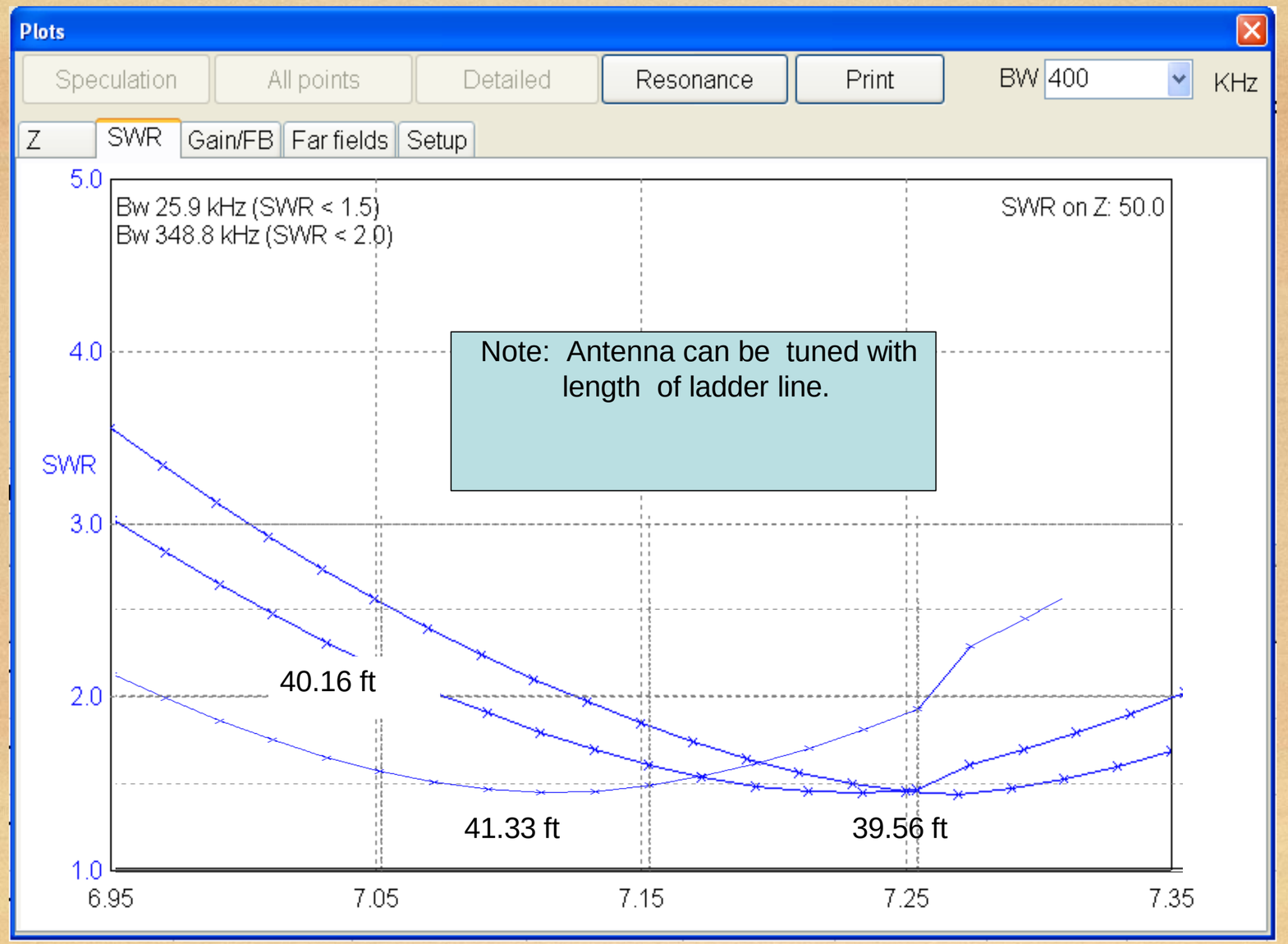
Assuming a choice of 500pf which would result in an SWR of 2:1 on 3.85 MHz, here is how to install the capacitor on the coax side of the 1:1 choke-balun.



40 Meter SWR Curves

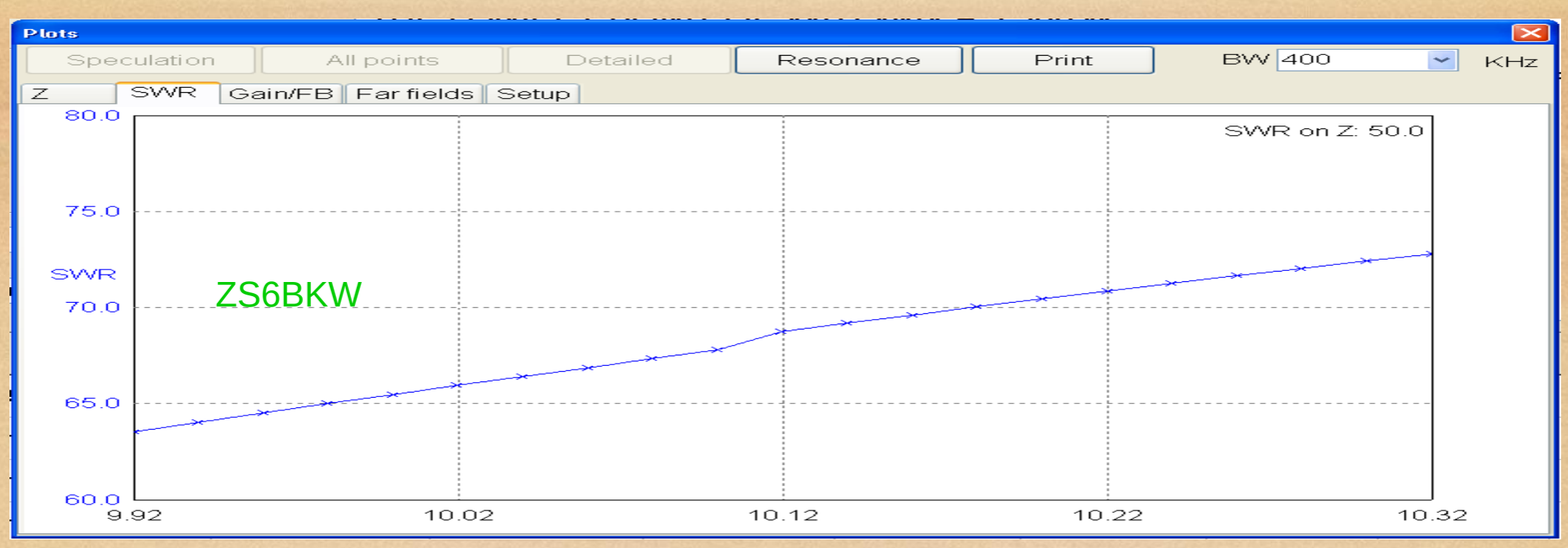


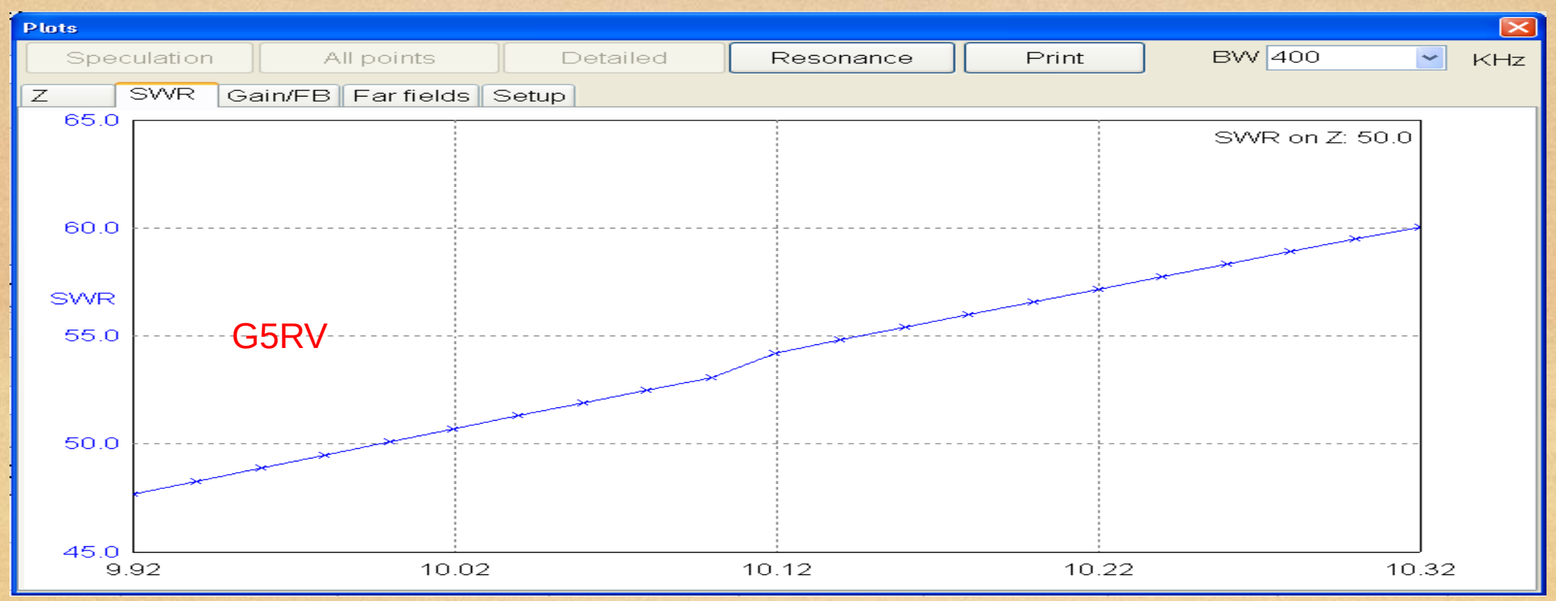
40 M SWR vs. Ladder Line Length



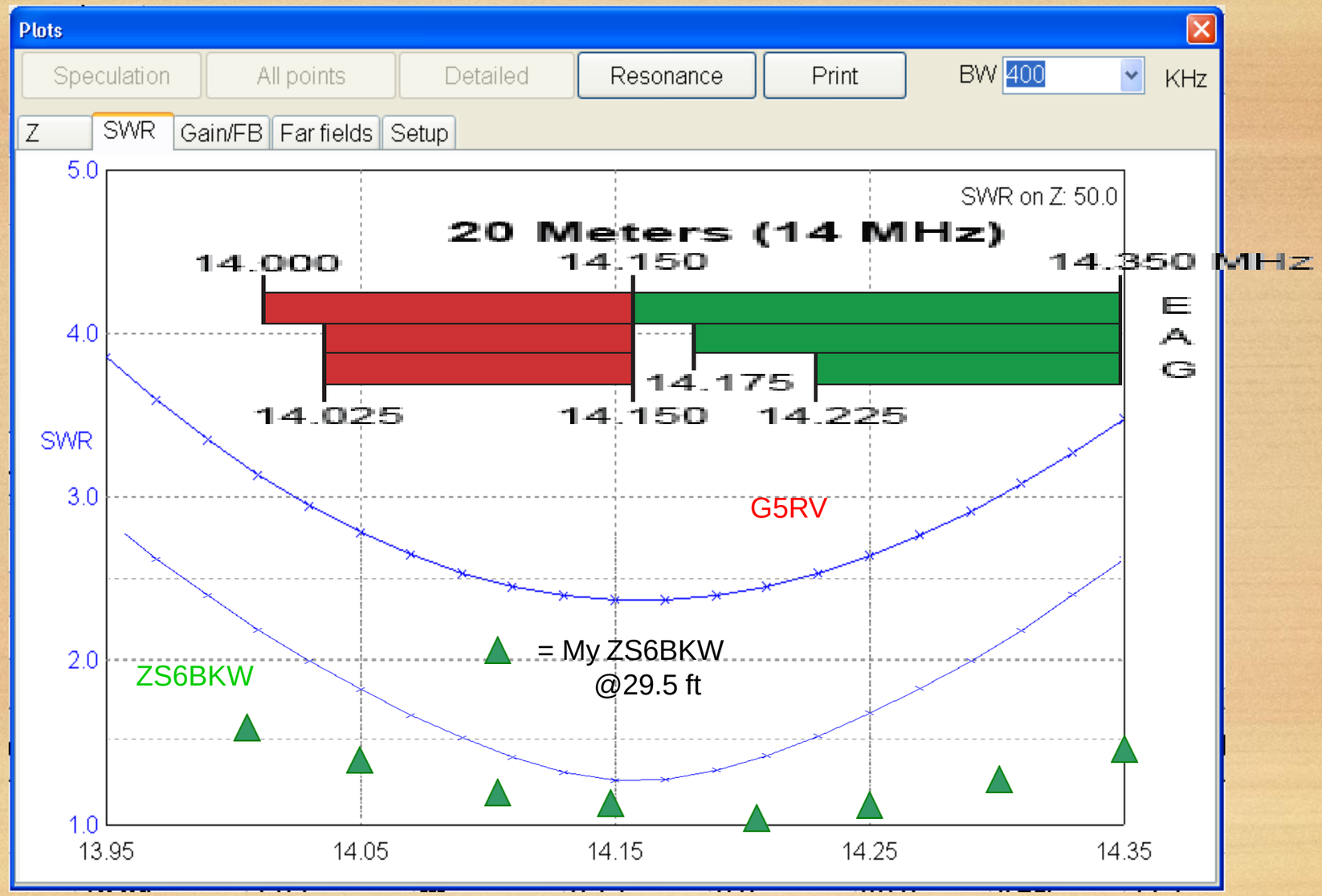
30 Meter SWR Curves

(Neither antenna is useful on this band)

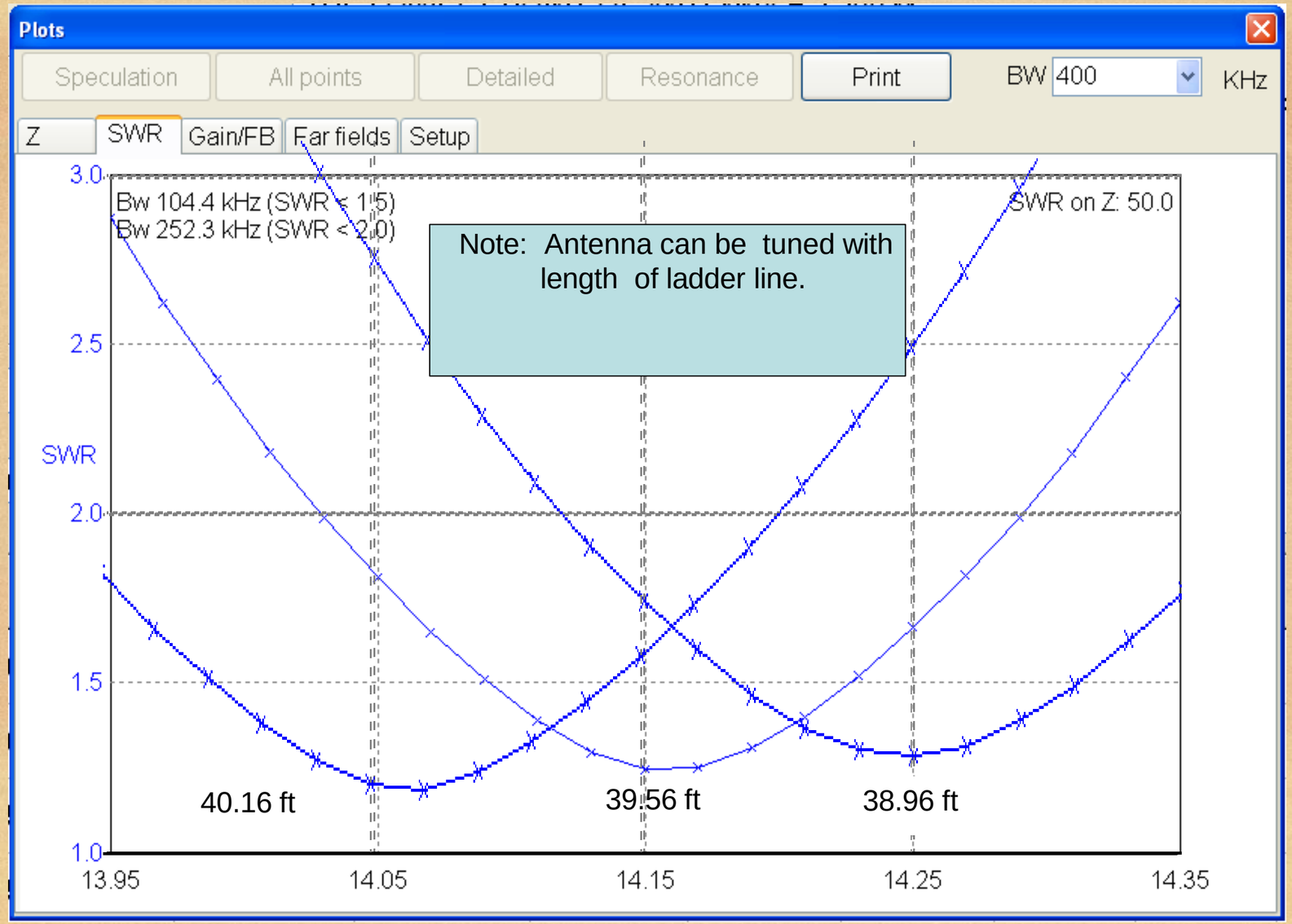




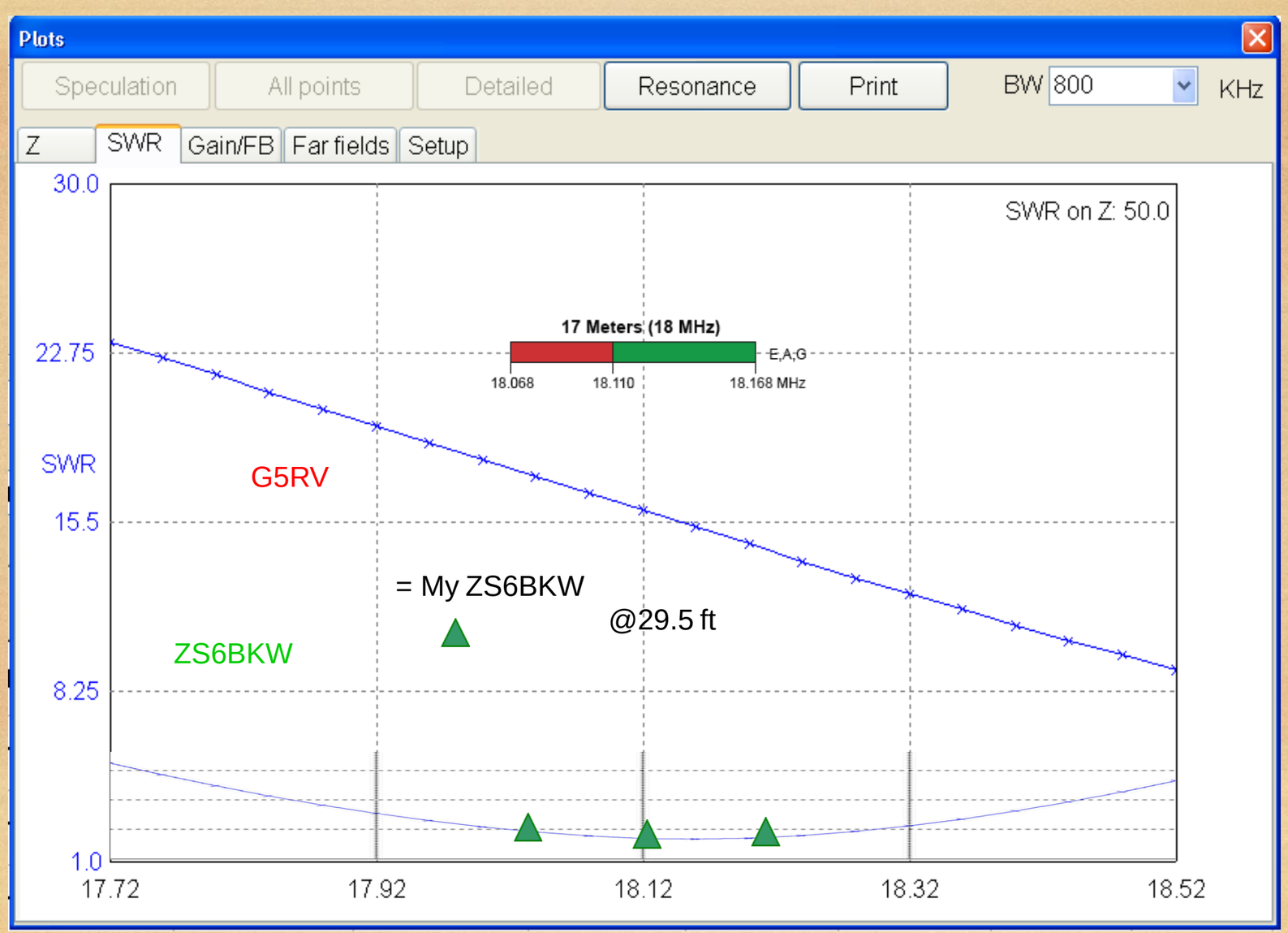
20 Meter SWR Curves



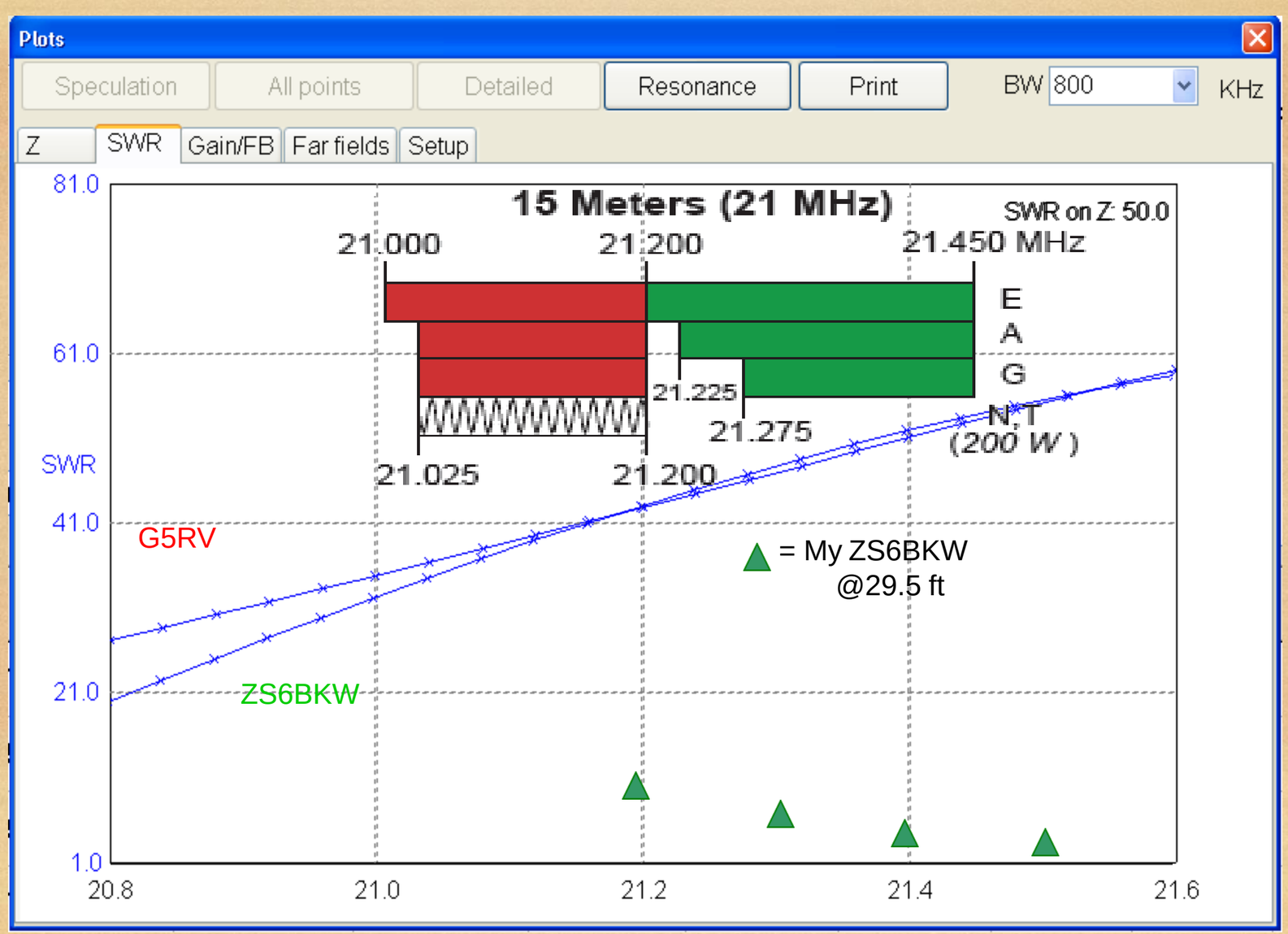
20 M SWR vs. Ladder Line Length



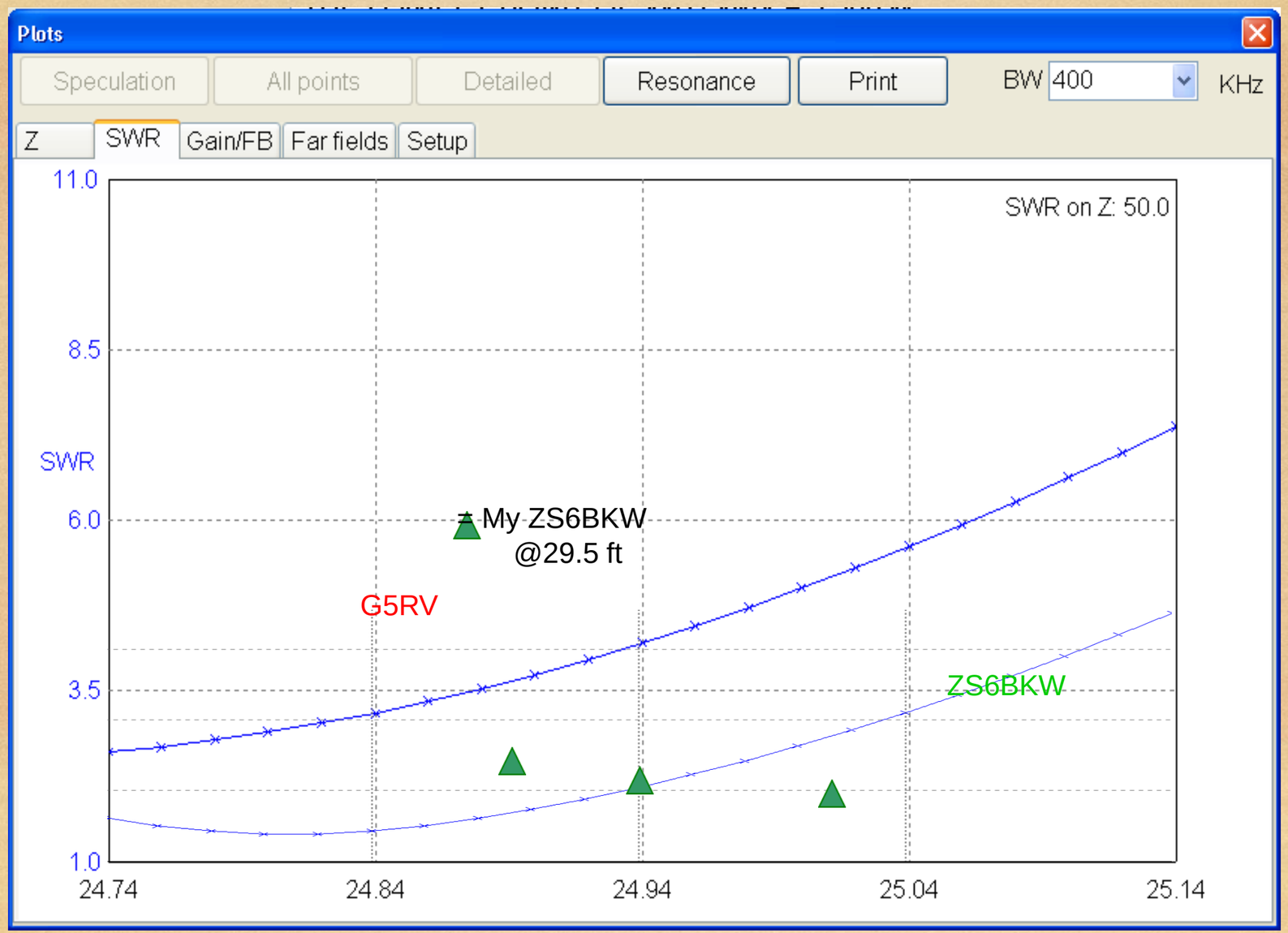
17 Meter SWR Curves



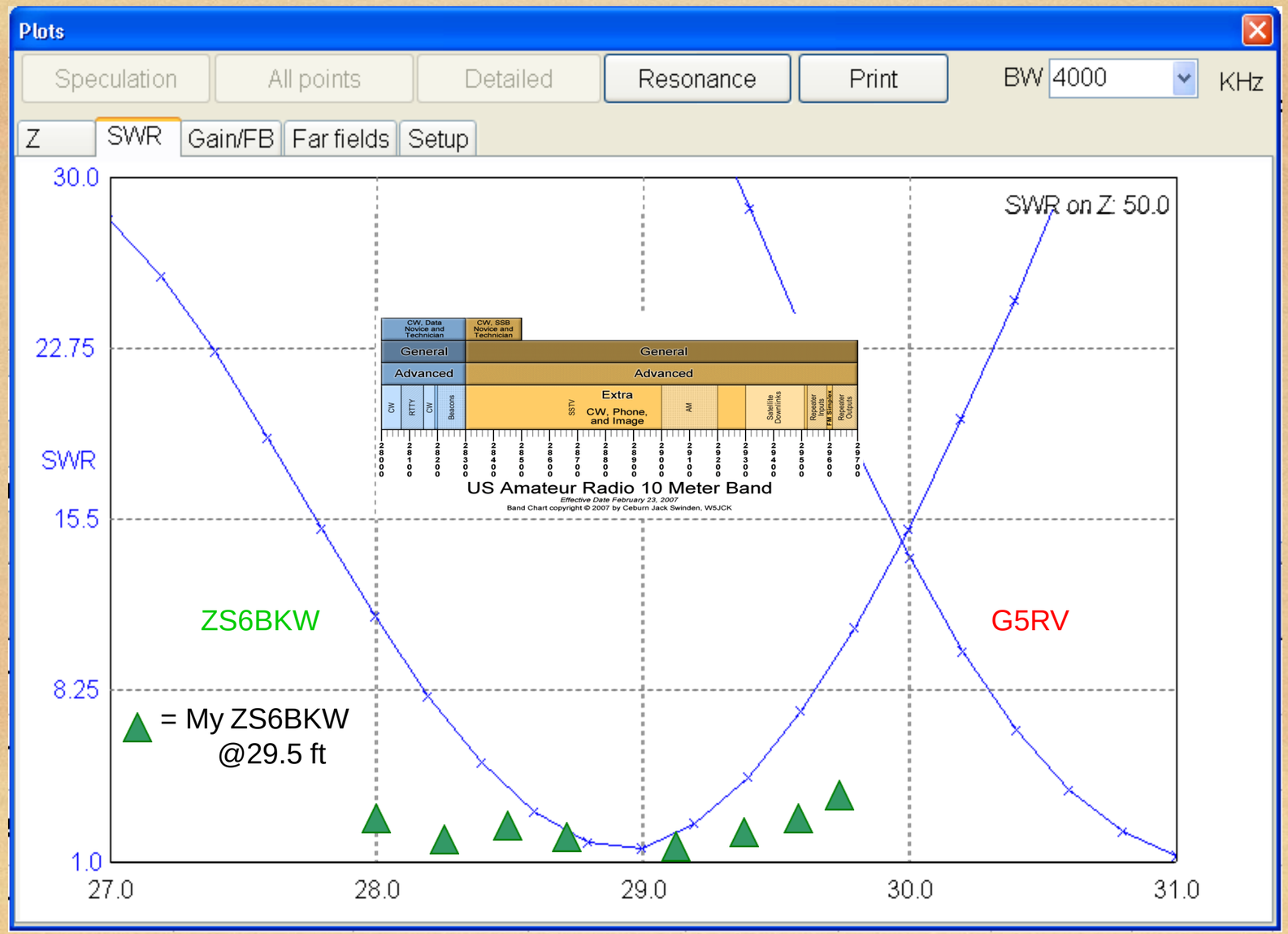
15 Meter SWR Curves



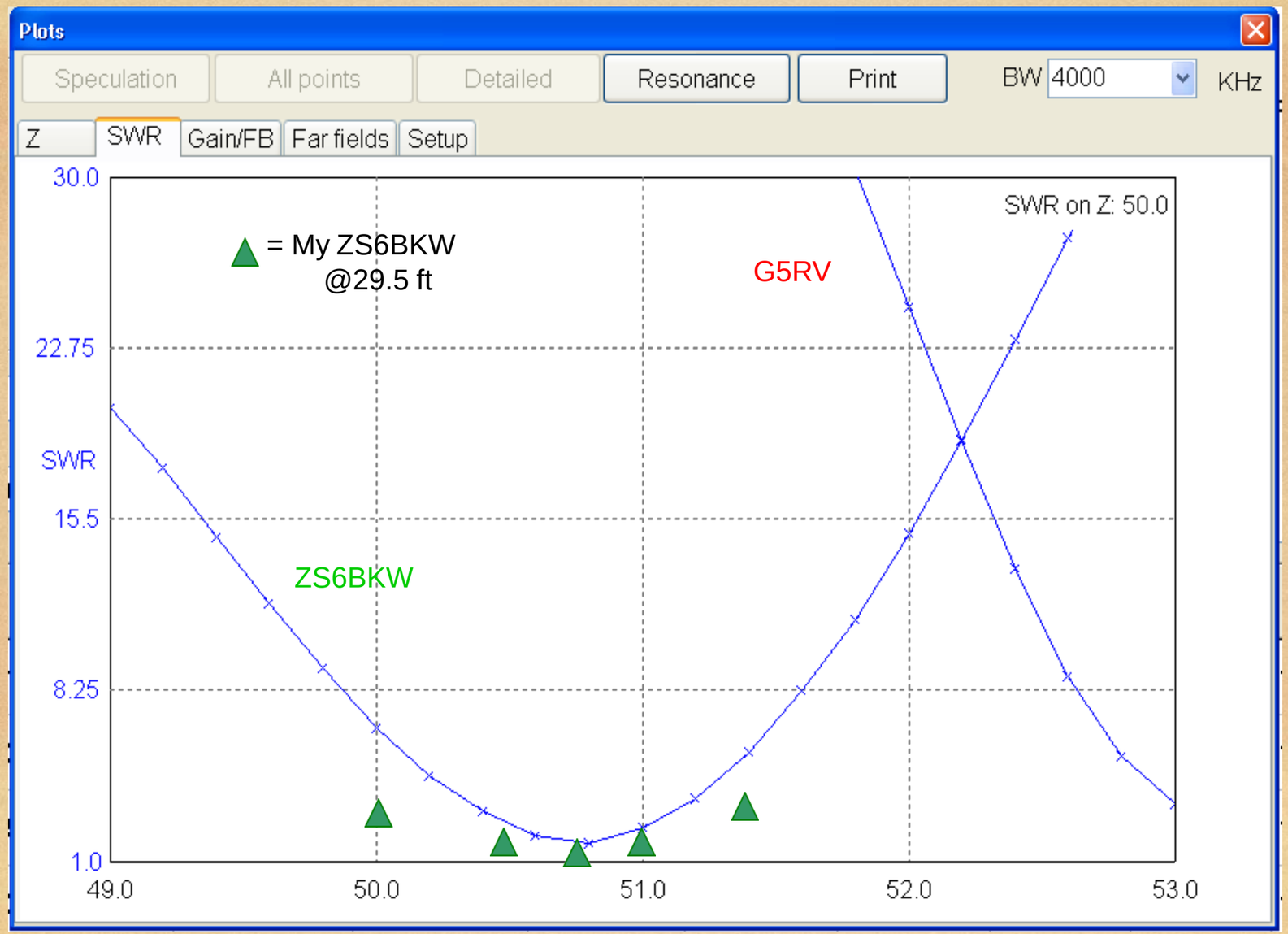
12 Meter SWR Curves



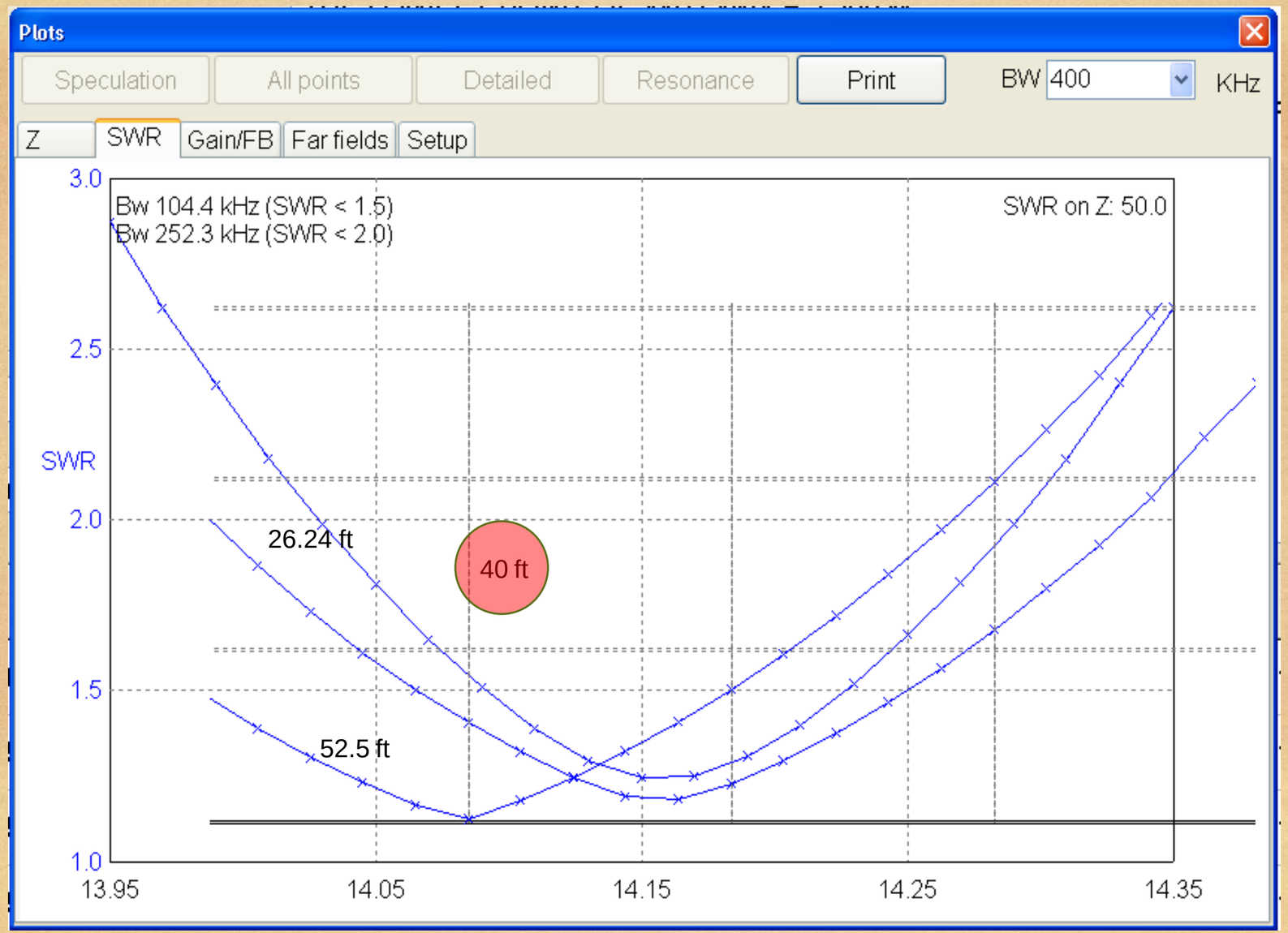
10 Meter SWR Curves



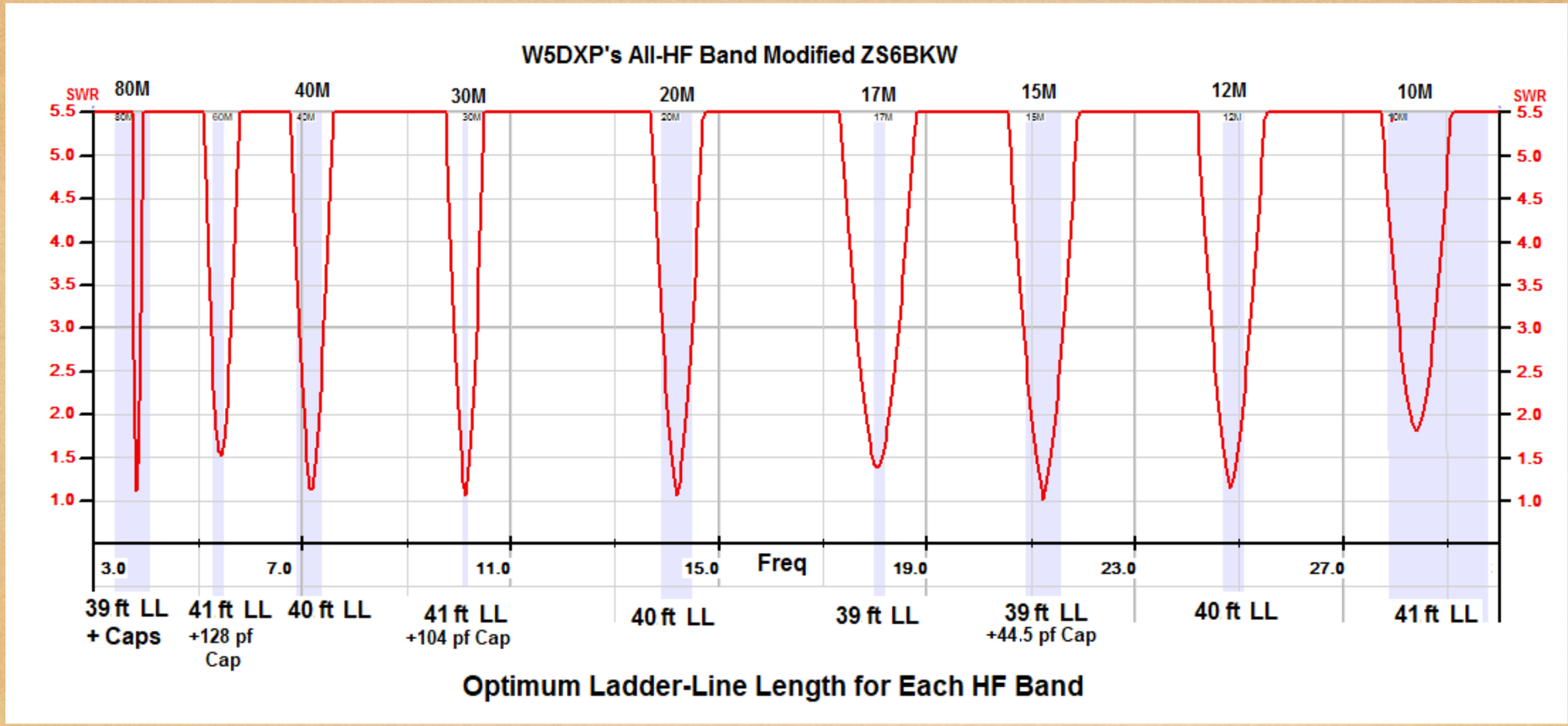
6 Meter SWR Curves



Antenna Height Tunes (Detunes)



Single band mods



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

ZS6BKW

Testimonials and photos

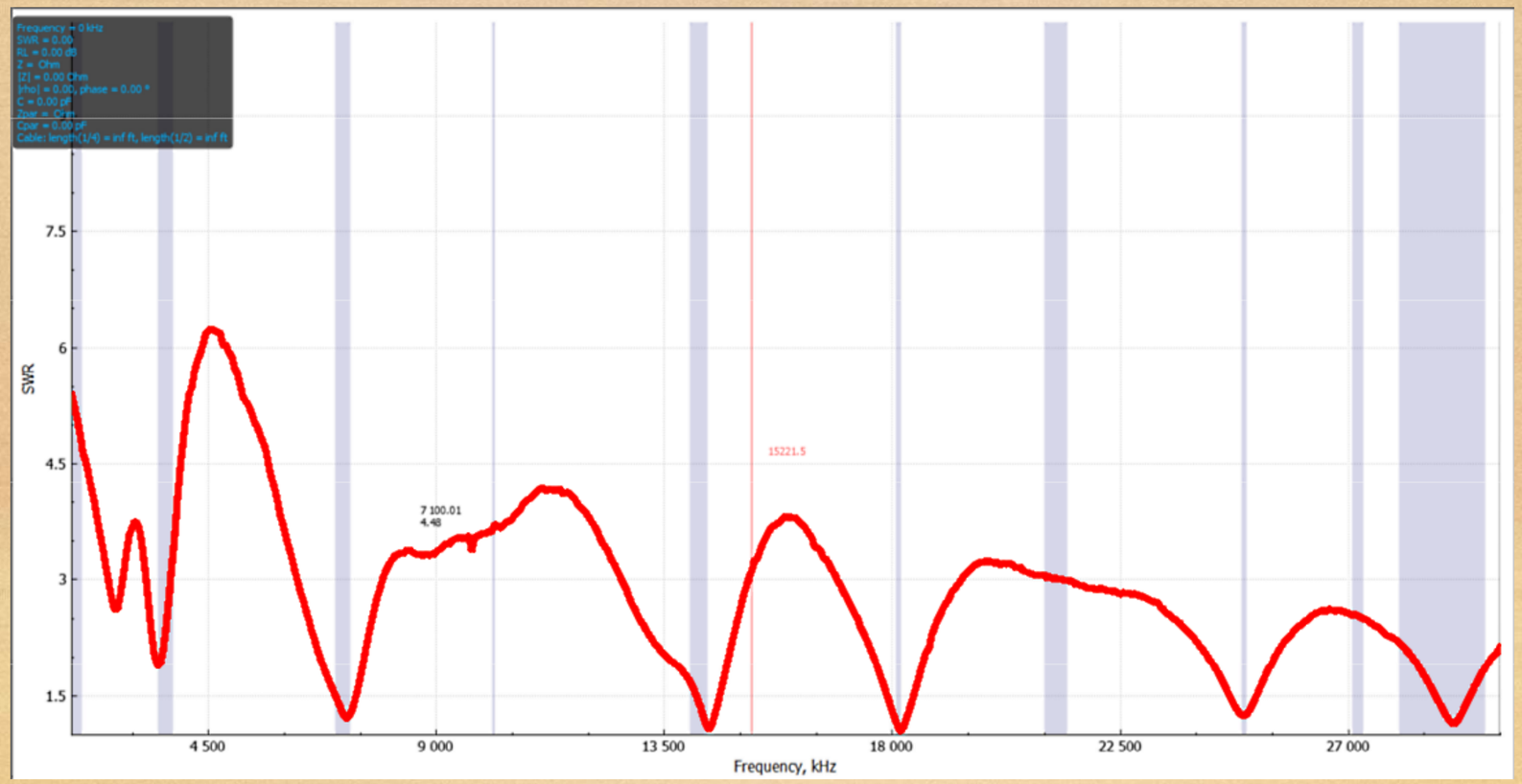
From:

- **Phil Visali-K2ELV**
- **Stephen Denny-K2SET**

ZS6BKW

Phil Visali - K2ELV

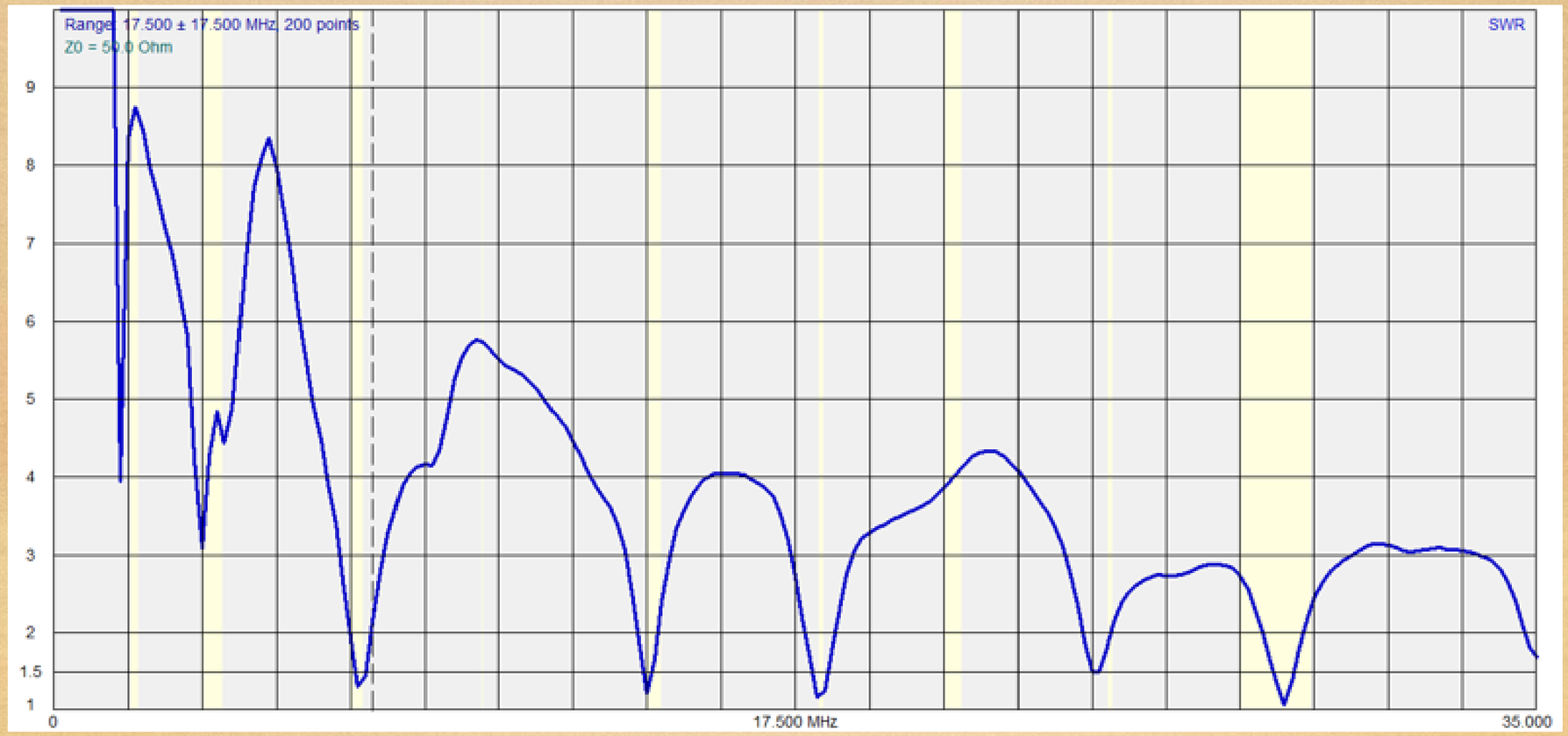
June of 2017, Phil was newly licensed and had purchased a G5RV to put up as his first HF antenna. I told Phil about the ZS6BKW that I had been reading about and showed him the differences. He said, "lets do it". We shortened the antenna and lengthened the ladder line. The antenna went up just over 40 feet in a slight inverted-V and the results were astounding. Below is the SWR sweep of his antenna. Phil will talk about what radio and power he is using, how the antenna is tuned (if needed), the stations he has worked and how much cable he is feeding it with that also allow him to tune on 160M!



ZS6BKW

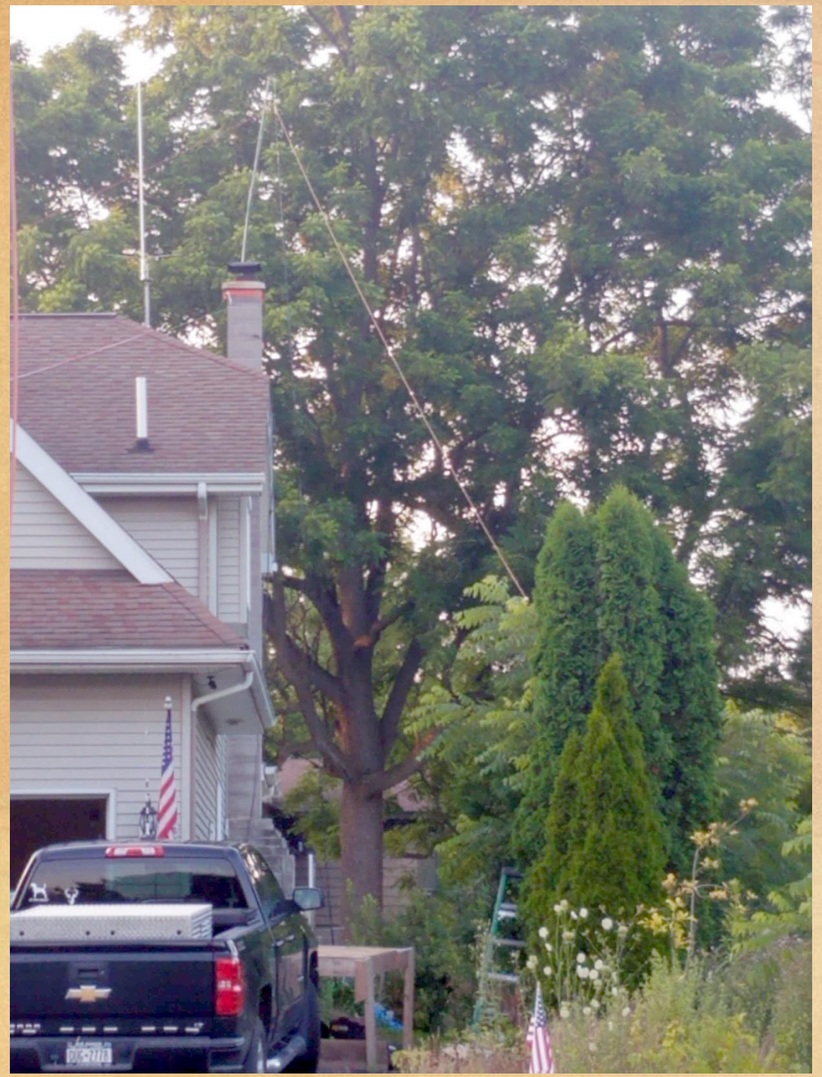
Steven Denny - K2SET

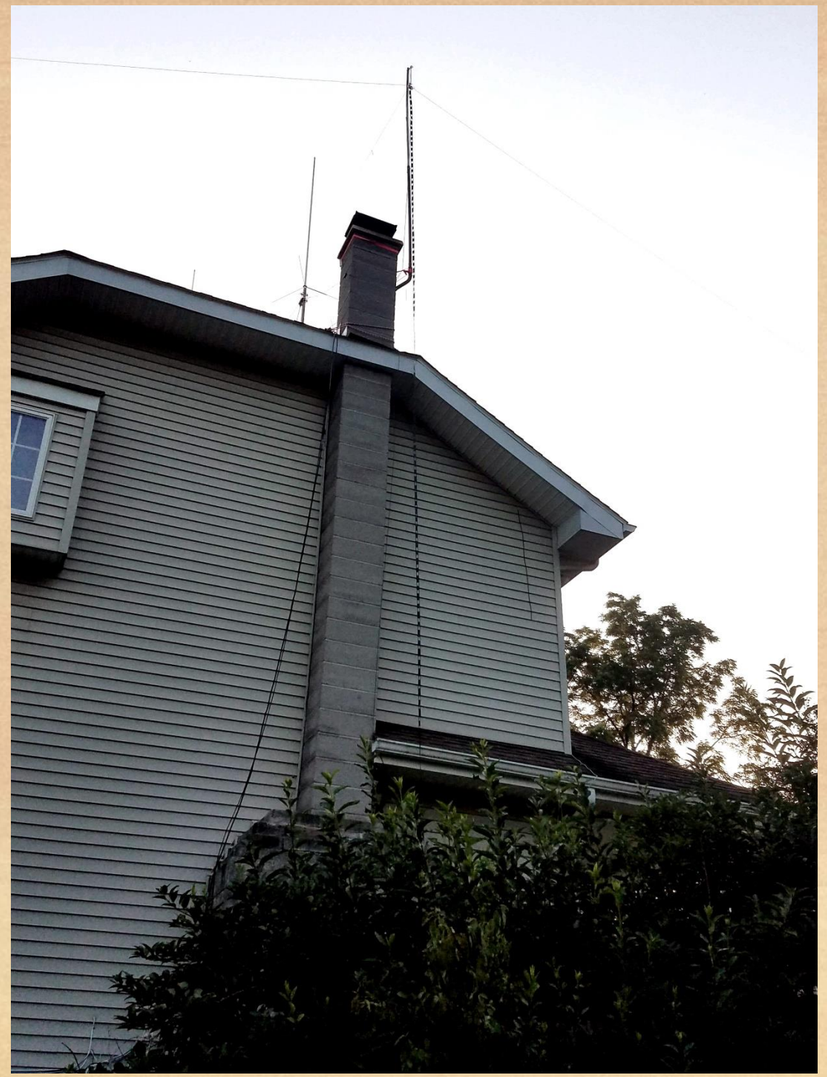
Summer of 2019, Steve was newly licensed and had also purchased a G5RV. I told him about the ZS6BKW and the results that Phil had. Phil actually ended up helping Steve modify his G5 and to a ZS6 and helped him put it up. The antenna went up just under 40 feet in an inverted-V and again, the results have been excellent. Below is the SWR sweep of his antenna. Steve will talk about his setup and power, how the antenna is tuned, the stations he has worked, how much cable he is feeding it with and what mods he has planned.



ZS6BKW

Steven Denny – K2SET



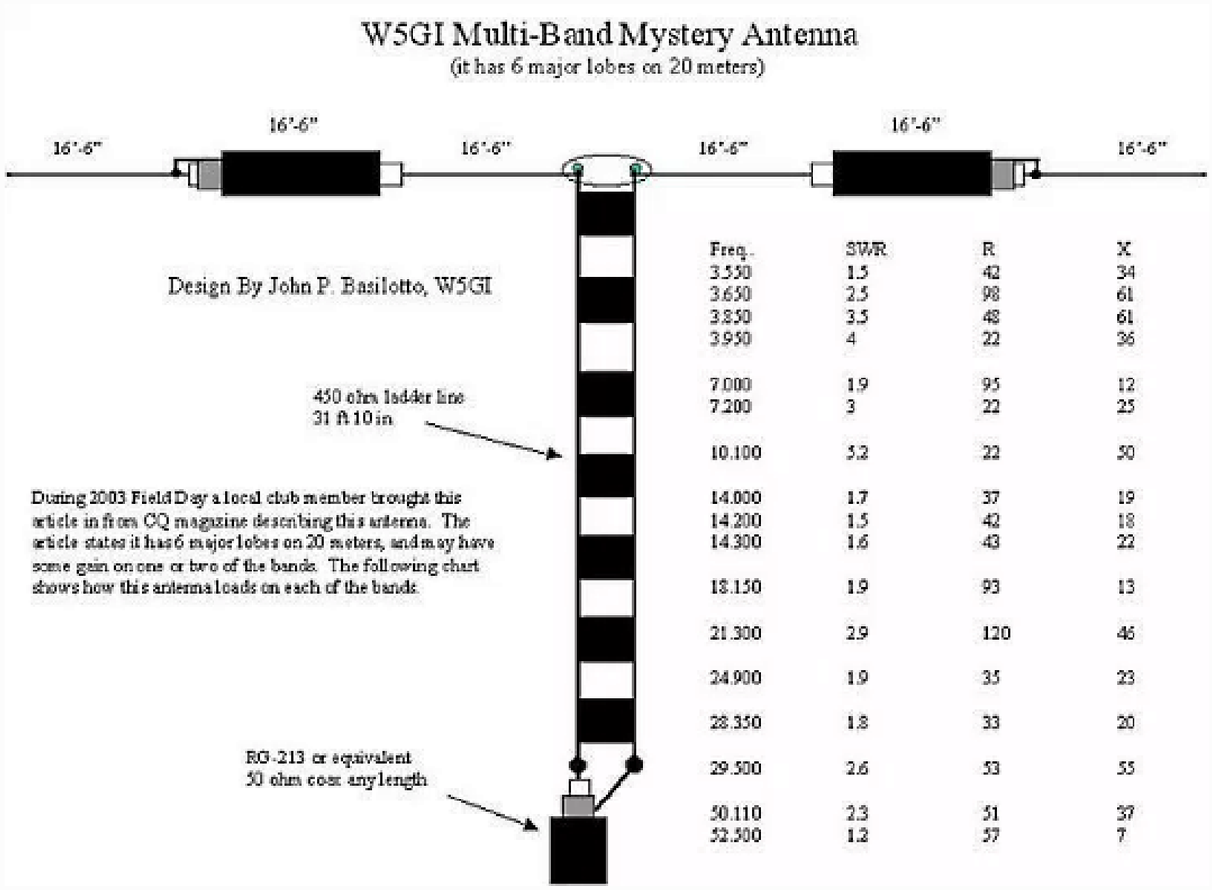


W5GI Mystery Antenna

This is the next project. If made from 300 ohm ladder line, it can make for a great “no-tune” light portable Field Day antenna.

A multi-band wire antenna that performs exceptionally well even though it confounds antenna modeling software

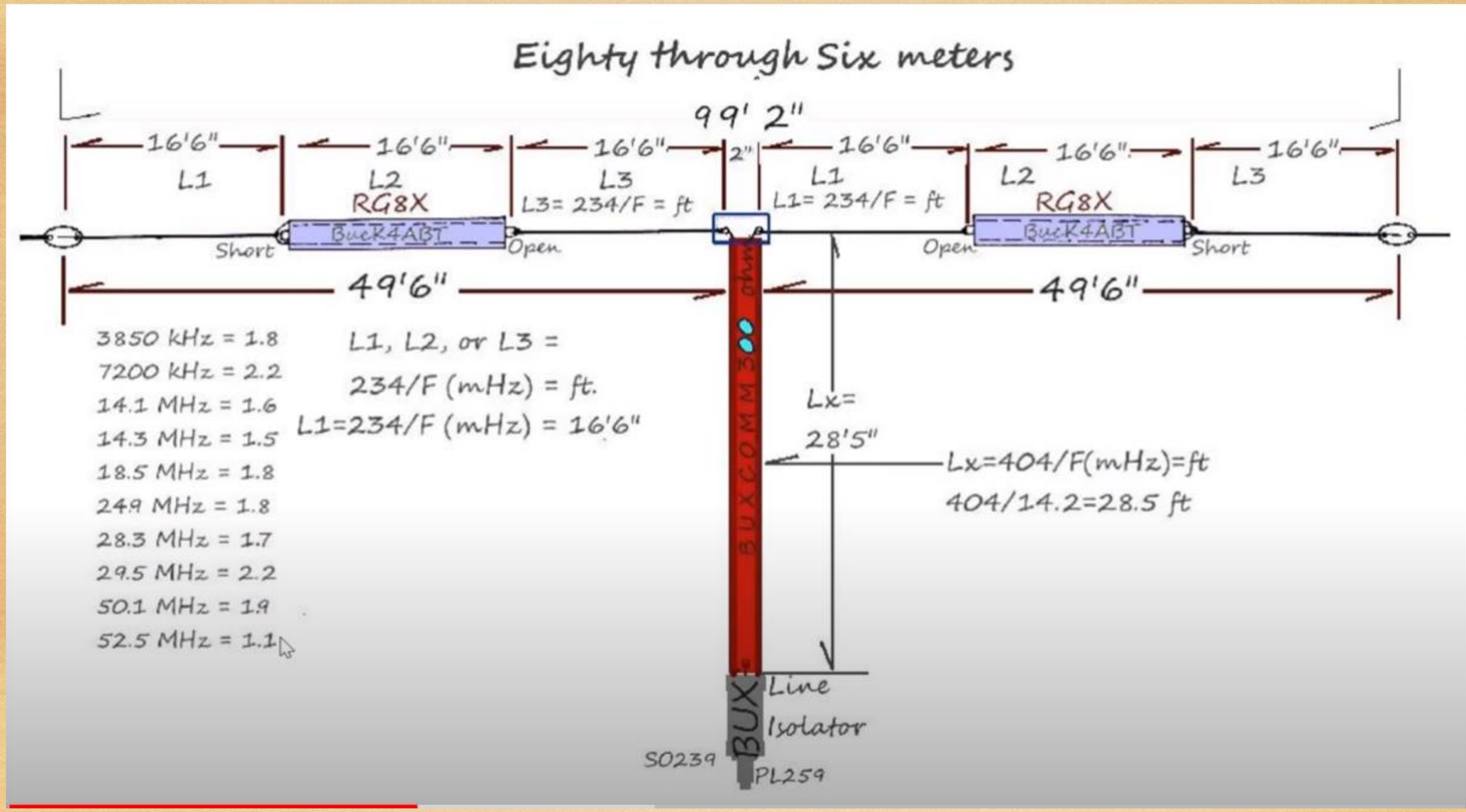
Article by W5GI (SK)



The design of the Mystery antenna was inspired by an article written by James E. Taylor, W2OZH, in which he described a low profile collinear coaxial array. This antenna covers 80 to 6 meters with low feed point impedance and will work with most radios, with or without an antenna tuner. It is approximately 100 feet long, can handle the legal limit, and is easy and inexpensive to build. It’s similar to a G5RV but a much better performer especially on 20 meters.

There have been reviews on Eham that this antenna is also quieter than comparable counterparts.

W5GI Mystery Antenna



W5GI Mystery Antenna

Comments from Radio Reference forum, builder:

Comparison model was a Flat top G5RV full size at 40 feet high. The tests per band are as follows:
160:Not tried it yet...Most reports show that it doesn't work here with the W5GI. Will find out...
75/80: - No huge difference in noise, but Signal Strength was 2 S Units higher on the W5GI.
40: 2 S units stronger then the G5RV. Noticeable difference on receive. CW on 40 was much better with the W5GI.
20: This is where it started to really shine.. The W5GI shows having a 6 lobe Radiation pattern, what I do see a consistent 2-4 S units difference with the use of the W5GI over the G5RV. If I hear them, I can work them. The G5RV did a good job on 20, it's a 3/2 wave there, but the W5 Was stronger in all aspects. Lower noise floor with the W5GI.
17: W5GI doesn't do a great job here..1:6:1 with an R of 76 though it is usable..G5RV doesn't tune here. Receive on this band is outstanding on the W5GI.
15/12/10:W5GI tunes well here with a tuner, the G5RV doesn't tune these bands well at all. Had 5+9 signals reports from anyone I worked.

My conclusion is that W5GI tunes quicker then the G5RV. The noise floor on the W5 is lower by 2-3 S units in some bands and weak stations are heard by 2, sometimes 3 s units better then the G5RV. No, it won't beat my beam by any stretch, but for scraps laying around, and an hour of time, it was well worth it. If you don't have the space to run it flat, you can do an inverted V at 30 feet and get good results.
The W5 also claims to work on 6 Meters and 2 Meters... I have yet to try this.

WIRE ANTENNA CONSTRUCTION TIPS

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

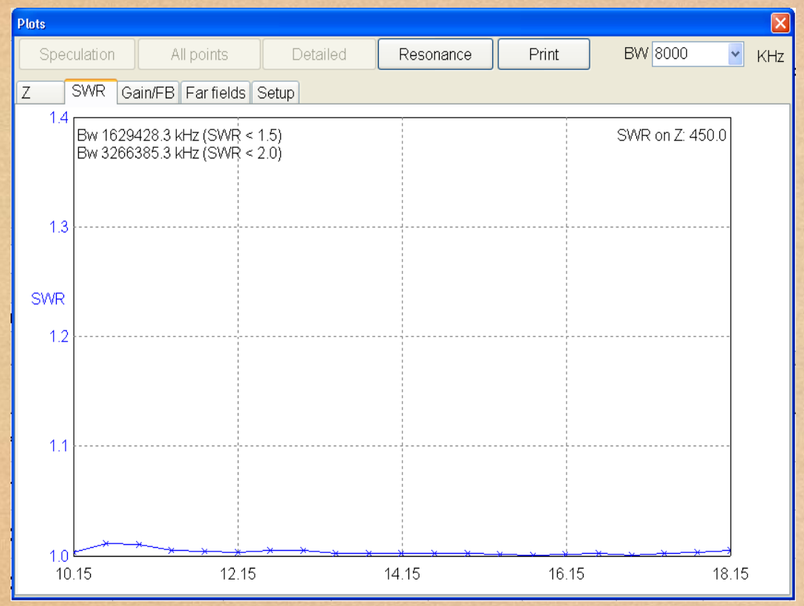
Use quality line with stranded wire for better flex characteristics Do not use flat TV 300 ohm line, use windowed version if possible Twist line about one half turn every two feet (less net wind area)
Run twine through line “windows” and attach ladder wire to it for stress relief Keep line off ground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

Coax Feed

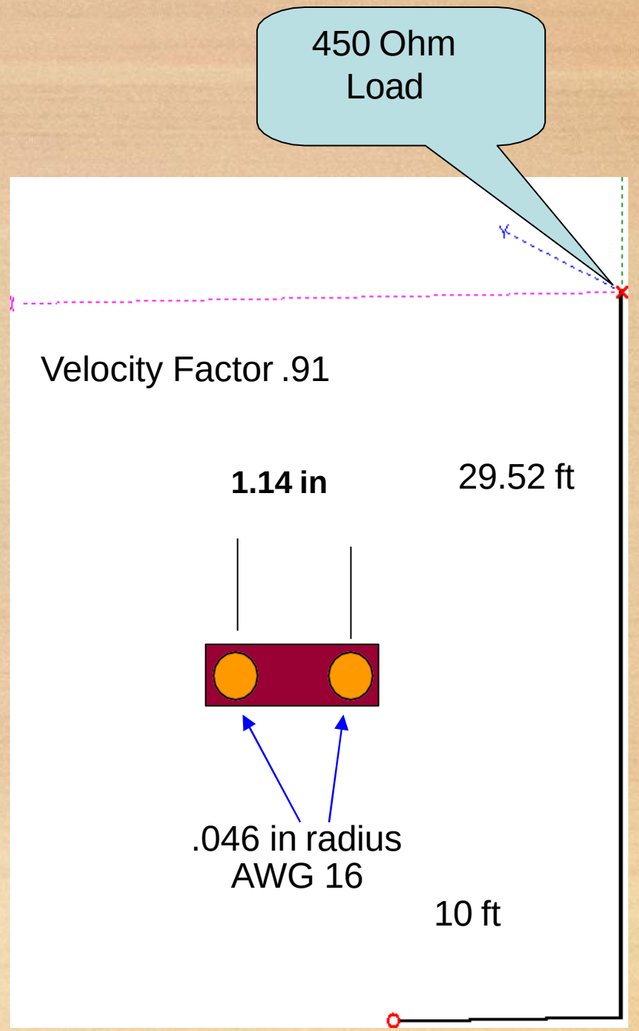
Use quality connectors and waterproof all connection to avoid “wicking”

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!)



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

Referenced web links

https://en.wikipedia.org/wiki/G5RV_antenna
https://www.w5ddl.org/files/Zs6bkw_vs_G5rv_20100221b.pdf
https://www.hamradio.me/antennas/nvis-gain-of-loop-and-dipole-vs-height.html
http://www.w5dxp.com/ZS6BKW80/ZS6BKW80.HTM (recommend experimenting with length first)
http://www.iw5edi.com/technical-articles/w5gi-mystery-antenna
https://www.youtube.com/watch?v=JhANyza5dY4
https://forums.radioreference.com/threads/w5gi-mystery-antenna-installed.207811/
http://www.w5ddl.org/files/ComputerModelingSimple6.pdf
http://www.k4tr.com/ (Purchase pre-made)

G5RV
Alternatives

Testimonials

- **Would like to hear back from YOU!**