Multi-band HF Antennas Part 2 – VA3TPV

Every now and again during research for background material for RSARS e-Library articles, a new source of really well written articles is discovered. The Mississauga Amateur Radio Club Ontario Canada produces a well written newsletter with interesting material from its club members, Ed Spingola's (VA3TPV) three articles describing Multi-band HF Antennas appear in the February, March, April 2010 editions of "*The Communicator*".

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"It is the exchange of ideas and information that makes Ham Radio what it is "
Ed Spingola

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The Communicator Newsletter of the Mississauga Amateur Radio Club

Multiband HF Antennas, Part 2
By Ed Spingola, VA3TPV

In the first part of this series on Multi-band HF Antennas, we had a look at the physical construction of the G5RV and its cousins the W5ANB and the ZS6BKW multi-band HF dipoles. In this Part 2, we will look at the VSWR curves for the G5RV and ZS6BKW and suggest procedures for optimizing these antennas.

The SWR plots in this article were produced by the EZNEC1 Antenna Software program by Roy Lewallen, W7EL.

Figure 1 shows the VSWR curve for the G5RV over the frequency range from 3.5 MHz to 30 MHz.

Although these SWR values and frequencies may not seem optimal for the amateur HF bands, the antenna modelling study with EZNEC has indicated some interesting results. The G5RV has acceptable SWR values on only two bands indicating that an antenna tuner is required for successful operation with the G5RV. This was previously stated by Louis Varney, G5RV Figure 2 shows the SWR plot for the ZS6BKW which has acceptable SWR values on five out of eight HF bands. This antenna can be used with out a tuner providing that the band segments where the SWR is 2:1 or less is where you want to operate.

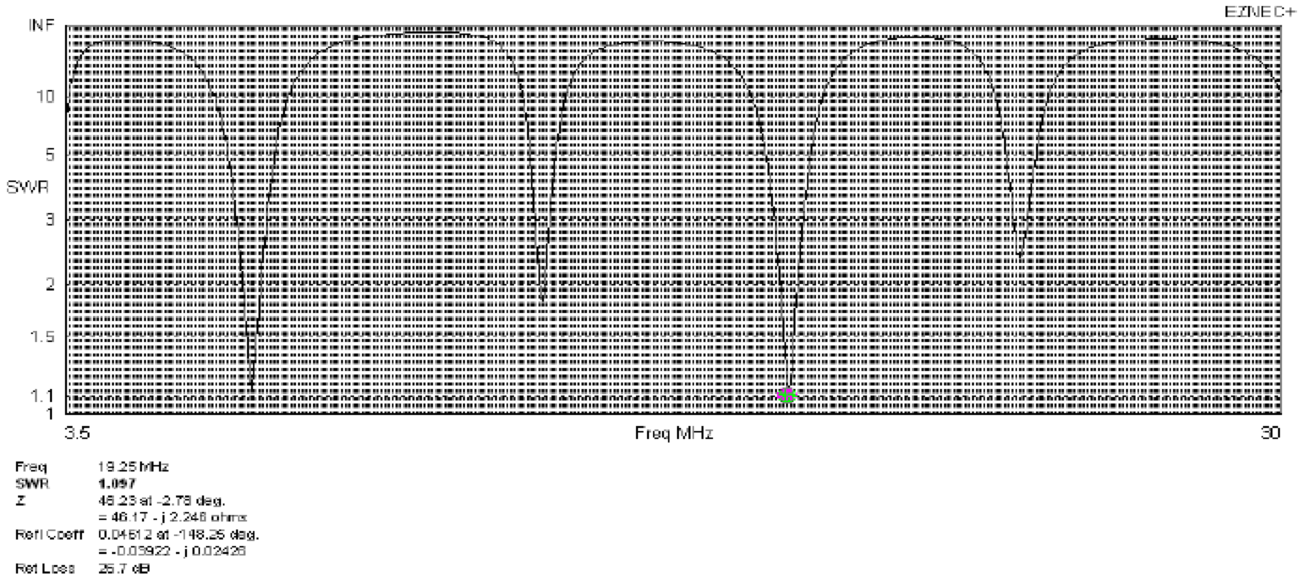

Figure 1: G5RV SWR Plot - SWR minimums are located at 7.1 MHz, 14.15 MHz, 18.2 MHz, and 24.9 MHz.

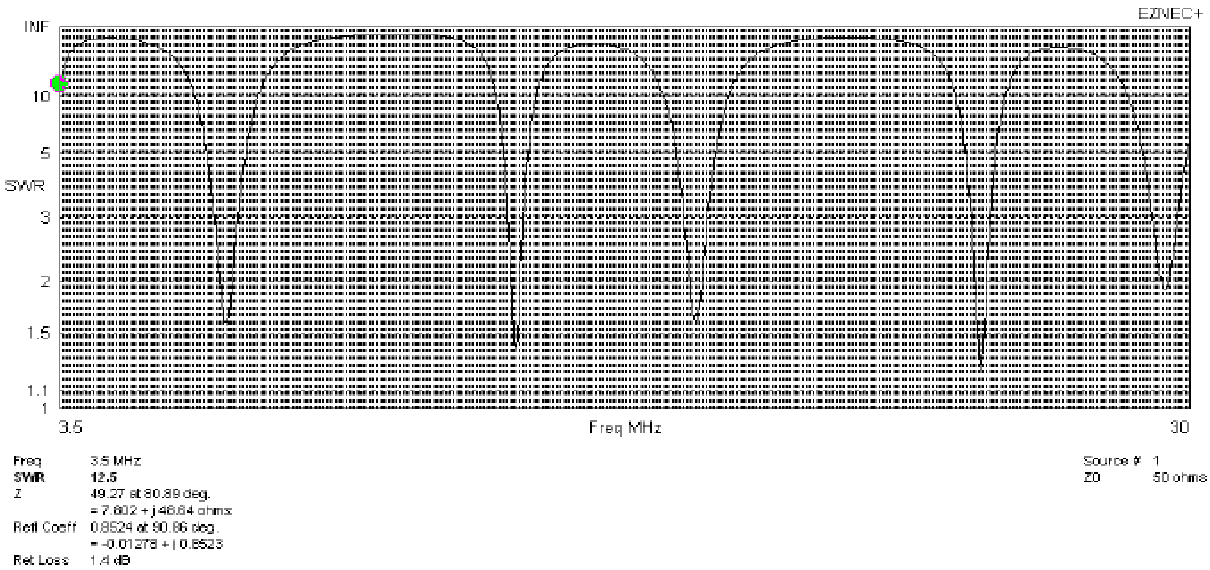

Figure 2: ZS6BKW SWR Plot - SWR minimums are located at 7.0 MHz, 14.1 MHz, 17.9 MHz, 24.7 MHz, and 28.6 MHz.

An antenna tuner would make this antenna truly universal. The EZNEC analysis indicated that the frequencies of minimum SWR values are affected by, the antenna height, the dipole length, and the ladder line length. This indicates that some in situ tuning of the antenna dimensions is required to obtain an optimum antenna configuration this optimization will be the topic of the next section.

Optimizing the G5RV Dipole and Feed Line

Whether your G5RV is a flat top dipole or an inverted-V, both configurations will benefit from optimization. The G5RV dipole is electrically three half waves in length at 14.15MHz. The physical length of the dipole will depend on its height above ground, the nature of the ground, inverted-v angle, proximity of nearby structures, trees etc. Similarly, the actual physical length of the section of parallel wire transmission line that is electrically one half-wave in length at 14.15MHz will depend on the Velocity Factor of the line. The Velocity Factor is dependent upon the line construction and may vary from around 0.65 to 1.00 for true open wire line.

Step 1 -Tuning the G5RV Transmission Line

The G5RV transmission line must be an electrical half-wavelength long when measured at 14.15 MHz. This is important since it affects the tuning of the dipole.

In tuning the transmission line to « wavelength at 14.15 MHz, we will use the fact that the impedance as measured at the input of a half-wavelength transmission line will be the same as the impedance at the output of the line when the test frequency is the frequency where the transmission line =is an electrical « wavelength long.

- Cut the length of transmission line required or use the recommended length, but leave the line an extra foot longer.
- Connect a 50 ohm resistive dummy load to the far end of the transmission line.
- Suspend the transmission line away from ground and any near by objects.
- Connect an MFJ-259B or similar antenna analyzer to the near end of the transmission line through a current choke.
- Slowly sweep the MFJ-259 frequency to determine at which frequency the impedance measures 50 ohms. If the measured frequency is lower than 14.15 MHz the transmission line is too long. If the measured frequency is higher than 14.15 MHz the transmission line is too short. Adjust the length of the transmission line accordingly until an impedance of 50 ohms is measured at 14.15 MHz.

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Step 2 - Tuning the G5RV Dipole

- The G5RV dipole must be electrically three half waves in length at 14.15MHz.
- Cut the length of dipole required but add a few extra feet.
- Attach the parallel transmission line.
- Raise the antenna to its final operating height. Remember that the resonant frequency of dipole antennas is dependent upon their height above ground.
- The feed line should droop vertically from the antenna.
- Connect the MFJ-259B or similar antenna analyzer to the near end of the transmission line through a current choke.
- In this step we are tuning for a minimum SWR in the 20m band. Slowly sweep the MFJ-259 frequency to determine at which frequency the SWR is a minimum. If the measured frequency is lower than 14.15 MHz the antenna is too long. If the measured frequency is higher than 14.15 MHz the antenna is too short. Adjust the length of the antenna accordingly until the minimum SWR is measured at 14.15 MHz.
- Antenna and feed line tuning are complete.

Optimizing the ZS6BKW Dipole and Feed Line

The ZS6BKW antenna is a little more difficult to tune than the G5RV. This is because the dipole length for the ZS6BKW is 1.35 wavelengths long and the transmission line length is 0.62 wavelengths long on 20 meters.

Step 1 ? Tuning the ZS6BKW Transmission Line

- Cut a length of transmission line 43 feet 6 inches in length.
- Connect a 50 ohm resistive dummy load to the far end of the transmission line.
- Suspend the transmission line away from ground and any near by objects.
- Connect an MFJ-259B or similar antenna analyzer to the near end of the transmission line through a current choke.
- Slowly sweep the MFJ-259 frequency to determine at which frequency the impedance measures 50 ohms.

Note:

Wavelength = Velocity/Frequency

where Velocity = 3 x 108 m/s, wavelength is in meters, and frequency is in Hertz.

Therefore a 43 feet 6 inches (13.3m) length would equate to a half-wavelength frequency of 11.27 MHz.

- The Velocity Factor of the transmission line is the ratio of 11.27 MHz to the measured frequency.
- Re-cut the transmission line according to 43 feet 6 inches (13.3m) x Velocity Factor.

Step 2 - Tuning the ZS6BKW Dipole

- The ZS6BKW dipole must be electrically 1.35 waves in length at 14.15MHz.
- Cut the length (93 feet 6 inches) of dipole required but add a few extra feet.
- Attach the parallel transmission line.
- Raise the antenna to its final operating height. Remember that the resonant frequency of dipole antennas is dependent upon their height above ground.
- The feed line should droop vertically from the antenna.
- Connect the MFJ-259B or similar antenna analyzer to the near end of the transmission line through a current choke.
- In this step we are tuning for a minimum SWR in the 20m band. Slowly sweep the MFJ-259 frequency to determine at which frequency the SWR is a minimum.
- If the measured frequency is lower than 14.20 MHz the antenna is too long. If the measured frequency is higher than 14.20 MHz the antenna is too short.
- If the measured frequency is other than 14.20 MHz adjust the length of the antenna accordingly until the minimum SWR is measured at 14.20 MHz.
- Antenna and feed line tuning are complete.

Using the above procedures you can optimize your antenna installation. The benefits are a better SWR, wider bandwidths, less stress on your antenna tuner if you use one, and no tuner on five bands if you employ the ZS6BKW.

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Other Multi-band HF Antennas

There are three other types of horizontal multi-band HF wire antennas fed with coaxial transmission line which are true performers requiring no tuner. All of these antennas may be erected in either the horizontal flat top or inverted-V configuration.

The first antenna is an arrangement of dipoles connected in parallel on the same feed line. This antenna type is termed the fan dipole[2] or parallel dipole. An example of which is the classic Alpha Delta DXCC antenna. This antenna is a resonant antenna on the bands 80m through 10m and presents an antenna impedance of 50 to 75 ohms depending upon the antenna height. The fan dipole since it is resonant on each band gives the widest bandwidth on the bands of operation. If fine pruning of the antenna elements are required to obtain the desired operating frequencies, start the pruning with the lowest frequency of operation first. Then proceed to the next lowest frequency and so forth until the 10m wire is pruned.

A second antenna[3] structure, pioneered by C. L. Buchanan, W3DZZ, in 1954, uses a single trap to obtain multi-band operation.. By a careful selection of the inductance and capacitance values in the trap, the antenna may be made to operate on multiple bands with only a single trap.

This technique was later extended by Al Buxton, W8NX, with the use of coaxial traps[4,5]

A third system used for multi-band operation uses multiple traps along a single wire to obtain multiple bands. These traps act like switches to connect or disconnect subsequent sections of the antenna wire with changes in frequency. The drawback of this type of construction is the added weight and wind loading to the antenna structure due to multiple raps. The use of traps also results in reduced bandwidth on each band of operation. Information on these later three types of antennas may be found in most editions of The ARRL Handbook 6 and The ARRL Antenna Book 7

Notes:

1) EZNEC Antenna Software, Roy Lewallen, W7EL http://www.eznec.com/index.shtml

2) Fan Dipole http://www.hamuniverse.com/multidipole.html
3) C. L. Buchanan, W3DZZ, The Multimatch Antenna System, QST, March 1955.

4) Al Buxton, W8NX, Two New Multiband Trap Dipoles, QST, August 1994.

5) Al Buxton, W8NX, An Improved Multiband Trap Dipole Antenna, QST, July 1996

6) The ARRL Handbook, 2010 Edition, Chapter 21

7) The ARRL Antenna Book, 21st Edition