Vertical Antenna Troubleshooting

R9

6,10, 12, 15, 17, 20, 30, 40, 80 Meters

F. L/C Tuning

E. Trap Tuning

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D. Capacity Hat Tuning

C. Stub Length

B. Stub Tuning
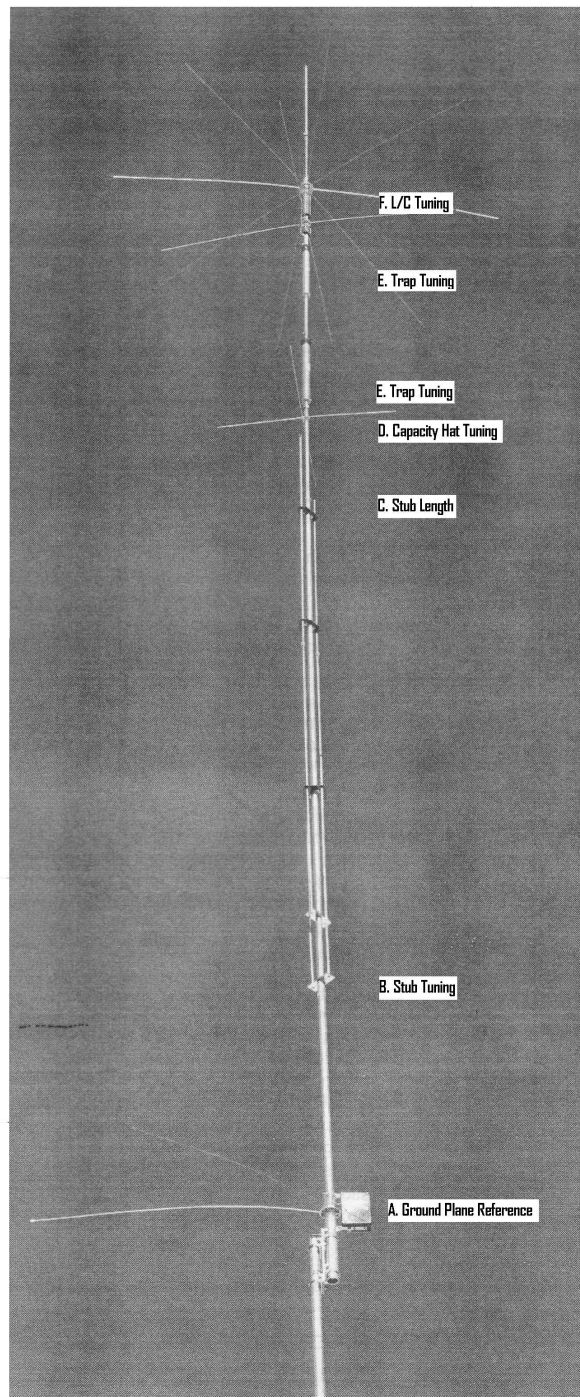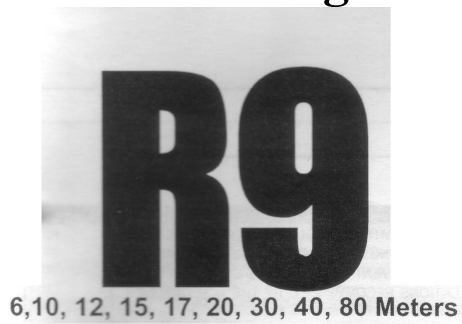
A. Ground Plane Reference

Figure 1
Typical Non-Grounded Vertical Antenna

This document will explore the operation of current flow in a vertical antenna, to help understand how it works. Current flow will be traced up to the radiating point, but not beyond. Beyond the radiating point lies antenna field theory.

A very good procedure to follow when troubleshooting is to find what works and what doesn't work. Measure or plot an swr chart for each band used. Don't measure only one frequency and say it doesn't work. If you don't know how to plot an swr chart, another article on the Knowledgebase is available.

When considering why a problem exists, you will have to trace the power flow throughout the antenna as you would for a conventional electrical circuit. The power flows in from the source, travels to the farthest conduction point it can, and radiates away from the antenna.

Current flow should always be referenced to the source, even for receiving, to simplify the problem. For this article, transmission mode will be assumed. Even though ac is in use, the current flow can be considered as dc, or even a water flow model.

Figure 1 shows an antenna which contains a variety of items used in the majority of vertical antennas. The version shown is made by Cushcraft, but other brands use similar technology. This model is designed to work without an earth ground connection, and uses a ground plane instead of an earth ground. For a grounded antenna, such as a quarter wave antenna, a grounded radial system would be drawn in place of the ground radials. Above the ground reference, they work essentially the same. This model was chosen because it uses several different ways of obtaining resonance.

Current will first come into contact with a choke or impedance balun at the input connector. The balun is either a current type to prevent feed line radiation, or a voltage type to match impedance. On any antenna, a choke type should be used, even with a voltage type balun. The Cushcraft R9 uses both.

Without the choke balun, rf reflections can radiate back toward the transmitter, along the outer coax conductor (skin effect). Two problems can now occur. First, current flow can travel back into the transmitter, and can cause shocks, and create radio frequency interference in various electrical products. Second, the coax becomes part of the antenna and radiates like another driven element. This radiation mixes with the main radiation from the antenna, and can skew the pattern.

After rf leaves the balun, the current approaches the inner point of the main radiator, or driver element, point A. The center conductor usually goes to the driven element, and the ground shield goes to the ground system or ground plane in the case of the R9.

Rf current now flows along the driven element as far as it can go. For maximum efficiency, the antenna is designed to bring the end of current flow into resonance at the operating frequency. A tuner can also bring the antenna system into resonance. Be

aware of the difference in an antenna and an antenna system. A tuner electrically lengthens or shortens the antenna, and feedline as needed.

Once the current is on the radiator element, the current travels until it can go no further. The conduction path ends, whether electrically or physically. In figure 1, the current travels from point A and stops at one of the other points shown, depending on frequency. Higher frequencies have shorter conduction paths, in general.

6 meters has a path which runs from point A to point B. Tuning stubs are used here to stop the rf at the 3/8 wave point. A tuning stub presents high impedance when tuned to resonance. The rf radiation stops at the top of the stub, but is tuned at the bottom of the stub. The length of the stub sets the resonant frequency of the stub itself. The length will determine the final swr presented to the transmitter at the frequency set by the bottom of the stub. It's confusing, but see a more detailed document for a better explanation of rf stubs. Stubs are very useful on higher frequencies, as they are very lightweight and have a low wind profile.

10, 12, and 15 meters have a current path flow which is the same as for 6 meters. The difference is the path length traveled. The individual stubs are tuned for each band. Non resonant stubs do not present high impedance to rf flow. The distance from the ground plane to the stub bottom sets the frequency. If the frequency is lower than the target frequency, shorten the distance from A to B. If higher, then increase the length to lower the frequency.

Point D is a capacity hat which serves to reduce the overall size of the antenna a few feet, and normally needs no adjustments. If you do change it, review all other bands for changes.

The bottom trap shown in figure 1, point E is designated as BT1 by Cushcraft. This trap is dual banded, and resonates both 17 and 20 meters. The bands are linked together, so by changing one the other also changes. The distance from point A to point E sets the frequency for these bands. More distance results in lower frequency. Less distance raises the resonant frequency.

The top trap is designated BT2 by Cushcraft. This is a 30 meter trap. The distance to point A sets the resonant frequency. Again, more distance gives a lower frequency.

Point F uses another method for obtaining resonance through the use of an L/C network. The combined coil and capacity hat function as a high efficiency trap and are tuned to resonance. Changing either one will affect the resonant frequency. Usually, these bands will be at the lowest frequency available. You can add or subtract inductance, but you can only subtract capacitance.

On this model the coil has a movable tap which selects or deselects the turns of the coil. The tap shorts out the unused coils. By shorting out the turns, less inductance is selected,

and this raises the frequency. Adding more turns lowers the frequency.   Reducing the spoke length reduces the capacitance, and raises the frequency.

So, three types of trap are used on this model. When any adjustment on one band changes the current path of another band, the other bands will have to be readjusted. For example, by changing the height of BT1 trap you tune this band. But by changing the height of BT1, you also changed the height of BT2, and also the length of the 40 and 80 meter traps, referenced to point A. So, when tuning, it is advised to work from the bottom up to prevent changes above. The physical and electrical length of the bands physically below the change is not affected, so they do not need to be revised.

Troubleshooting

1. Stubs - If you only have a stub for one band, then it's obvious that the stub is the problem. Only the bottom of the stub is usually connected to the mast. Remove the bracket and polish both the bracket and the mast where it mounts. If threaded into the bracket, clean the threads also. For multiple band stubs, find the stub that affects the bad band, and clean it as above.

2. Traps – Traps are harder to troubleshoot in some cases. Usually, the trap for the band affected is bad. If 20, 30, 40, and 80 are not working, it is probably the 20 meter trap. The current flows through the 20 meter trap first, in order to reach the upper bands. The trap can be either open or shorted, although open is more common. Very likely, the coil in the center of the trap is open. Sometimes 30, 40 and 80 meters will work some, but off frequency, with 20 meters bad. In this case the center coil allows current to pass through the trap, and the trap only acts as an inductor. The likely problem now is the capacitor section which is formed by the outer sleeve of the trap. This trap design is popular with Hy-gain, Cushcraft, and other brands.

3. L/C resonators – On many antennas, the resonators are mounted in parallel, with bypass wires to provide power to the outer coils. Usually only one band is at fault at a time. Identify which coil corresponds to the band in question. Power flows into the feed side of the coil, through the coil, out the far end, and out to the capacity spokes. Check for cold solder joints by reheating all connection points such as solder lugs. Check for loose hardware. If many or all of the bands are bad, check the current flow between the tubing from the source, to a common connection which is common to all of the L/C bands.

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