Length of NVIS Dipole Reflector Wires in the Field

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Q: What is the length of an NVIS dipole reflector wire laying on or near the surface of the earth ground?
A: It depends on location and the antenna near field ground dielectric and conductive qualities.

Background

The length of a single "resonant halfwave" ground reflector wire forming a pseudo-parasitic reflector, very near or laying on earth ground cannot really be easily calculated or predicted for different locations. Indeed, in most cases, the actual "parasitic reflector yagi effect" may be minimal or it may not even exist for any particular installation if the wire is very close to the surface of earth ground. So, this simple question "What is the length of an NVIS Dipole Wire Reflector?" involves a rather complex answer. But, in practice, a simple field procedure for empirically determining length of the wire can yield good results. First, let's talk about the background of this problem, then a practical solution to it.

The 5% Longer Wire Myth

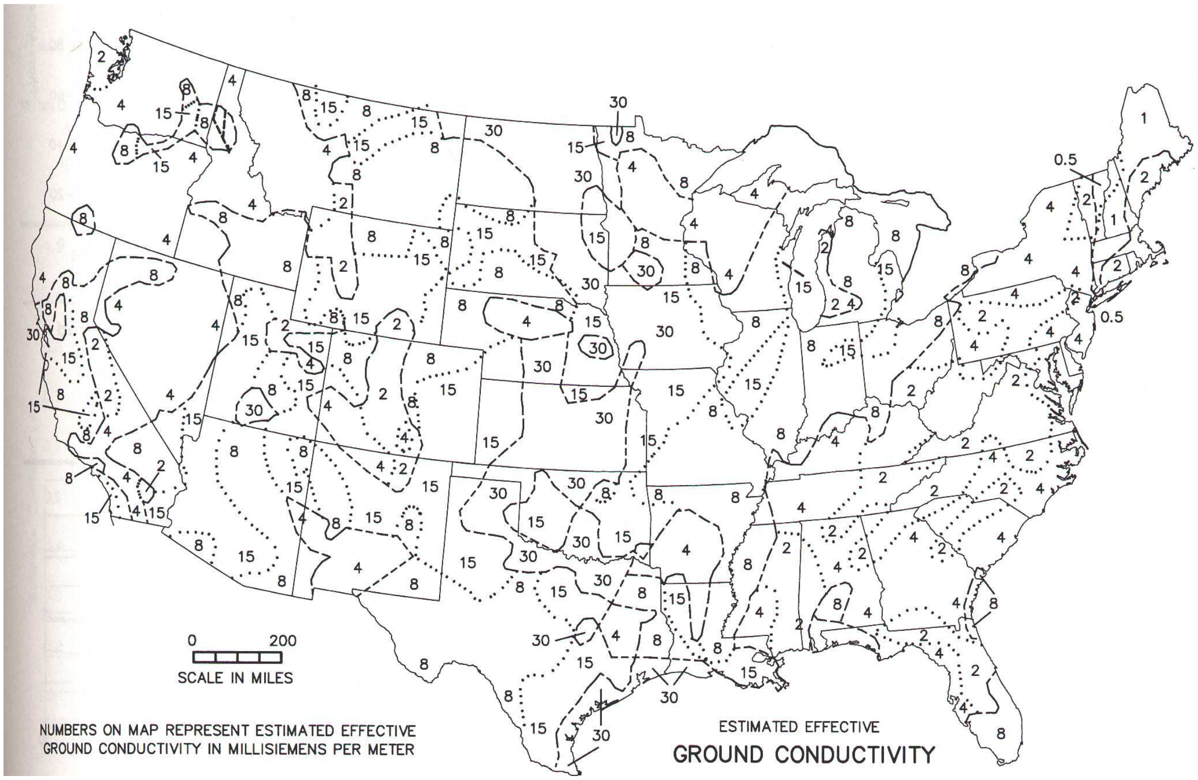
The "5% longer" rule-of-thumb formula is not accurate for "average earth ground" and does not apply at all for "good earth ground". It only applies to yagi parasitic reflector elements in an elevated yagi beam antenna. For most "average earth ground" locations, the resonant wire length of a wire on the earth ground surface (or very near it) may actually be *shorter* than a formula dipole in free space. The yagi formulas and the "NEC" modeling generally does not apply very well to wires close to ground, due to the "GIGO effect"... that is, unless very accurate measurements with ground measuring test equipment at the frequency of interest are included in the calculations. Garbage In = Garbage Out. Computers don't output good models if bad field data is entered.

Earth Ground Effects

Most hams don't think they have RF earth ground measuring test equipment to input this data into the computer models or calculations. But, fortunately, there are some practical methods that the average ham can use, with a little ingenuity and normal ham equipment, to determine the real optimum length in the field. The earth ground often acts as a resistive impedance factor to wires placed on or near the surface, almost as if a resistor has been added to the wire. This is due to"near field" effects, the same near field around the wire that makes parasitic yagi type reflectors function well. In a yagi, the Q of each element should be as high as possible to achieve optimum parasitic effects with the elements in the near field of each other. But, the resistive and dielectric effects of average earth ground tends to lower Q of the wire. Also, the surface area of the earth ground is so large compared to the wire itself, that the ground often dominates the near field interactions, rather than the small wire on its surface.

Know Your Earth Ground Type

To begin with, it is good to start with some knowledge about the type of "earth ground type" you have at your installation. If this is not already known by you, it will become more evident during this installation and testing, as explained later. Ground conductivity measurements at DC, Low Frequency (LF) may not be effective for predicting the 3MHz to 12MHz range of dielectric or conductive properties of earth ground, in the spectrum often used for NVIS communications. Maps of estimated ground conductivity are available such as the maps in this example:
http://hflink.com/ground/



But, no matter what a map indicates, your antenna site is a unique environment for RF, and reliance upon a map may not provide good data for your particular antenna site.

Poor earth ground: the best case for using NVIS dipole wire reflectors. Poor earth ground, usually dry, sandy, or rocky... is more like an insulator and less like a conductor. Thus, the reflector wire's length is more similar to dipole free space length. The parasitic yagi reflector principle may actually work with wires laid directly on the surface at "very poor earth ground" locations.

Average earth ground: a single reflector wire laying on the ground will have little or no parasitic reflector effect, and will be difficult to get resonance effects, due to the resistive and lossy dielectric nature of the ground. If the wire is elevated about 2 meters (6ft or more) above ground, the reflector wire can be "resonated" and have a more beneficial effect for zenith radiation (straight up). Sometimes, elevating the ends of the reflector wire can enable the Q of the reflector element to increase, even if the center of the wire is still laying on the surface.

Good earth ground: this type of ground is rather "conductive" already, so it does not need a reflector wire at all. The good earth ground is reflective. You are a lucky ham, if you live in an area of "good earth ground", common in salt marsh areas.

NVIS Reflector Wire Length by Antenna Analyzer Method

There are several round-about ways of determining reflector wire length, assuming the above criteria has been met, for "poor earth ground" or "average earth ground". One method will be presented here for a single band or frequency. This is the antenna analyzer method for determining NVIS dipole ground reflector wire length. (Other methods exist for this, as well as other reflector methods, and these may be presented later or in other forums.)

The optimum reflector wire length can be determined by empirical method (i.e. trial & error), if you have an antenna analyzer that measures and displays frequency and reactance. This method uses trimming of a wire for zero reactance at a frequency approximately 5% lower than the desired operating frequency.

1. Choose your site for the NVIS dipole with reflector, but do not put up the NVIS dipole yet.

2. Cut a thickly insulated wire (#12 AWG or the larger gauge the better) to a starting length determined by calculation of the 1/2 wave free space dipole formula at a frequency 7% lower than the desired operating frequency.

3. Place this wire on or near earth ground (according to your above ground type) at the location for the antenna installation.

4. Cut the wire in the exact center, forming a "dipole", and connect the antenna analyzer directly to the center feedpoint of this "dipole". Do not connect the antenna analyzer or the wire to a ground rod system, but instead place the analyzer on a slightly elevated insulated support; avoid capacitive effects from the case of the instrument to earth ground or to the body of the person doing the measurement. The analyzer must be internal battery operated and thus isolated from all other wiring.

5. Sweep the frequency of the antenna analyzer to find the "reflector dipole" lowest resonant frequency (the frequency which has zero reactance).

6. Trim the ends of the "reflector dipole" by trial and error, while sweeping the frequency of the antenna analyzer. The objective is to achieve zero reactance at a frequency 7% lower than the desired operating frequency.

7. The zero reactance range of frequency will probably be more broad than what you would normally see with an elevated dipole, and the impedance will be low. This is due to the resistive effects of proximity to earth ground.

8. If you cannot see a clear point of zero reactance at any frequency within 50% of the desired operating range, it may not be possible to determine the resonant point, because you have "good earth ground" or "better than average earth ground". So, in this case, then try raising the ends of wire up higher (or preferably raise the entire wire) until you can get a clearer resonant point reading. Try to center this broad resonant point at the 7% lower in frequency to your desired operating frequency.

9. When the zero reactance objective has been met by trimming the wire, disconnect the antenna analyzer, and re-connect the center of the wire together where you cut it before.

10. Deploy an elevated dipole with a 1:1 ferrite current choke balun mounted at the feedpoint, and run a 50 ohm coaxial cable to your transmitter. The height of this dipole should be at least 1/8 wavelength to 1/3 wavelength directly above the reflector wire. This "NVIS dipole" should be installed in the same wire direction as the reflector. Dress the feedline so it is perpendicular to the dipole and perpendicular to the reflector wire for a distance of at least 1/3wavelength.

Note: Multiple reflector wires can be installed for different frequencies, or the same frequency, keeping in mind that all the wires should be present and shorted when measuring the other wires for resonance. These wires should be spaced apart, or the wire angles can be slightly skewed or fanned, similar to a fan dipole, to achieve resonance at the different frequencies.

Adjust the length of your elevated NVIS dipole for the lowest SWR at the desired frequencies. Antenna system installation is complete. May the ionosphere reflect kindly upon your signal!

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