Low-Cost Transmission Lines

What you don't know can cost you.

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At first glance, this title seems to contain a conflict of terms. Transmission lines are the more significant part of the cost in most simple antenna systems. We all like the convenience of using coax, even if it is not the most economical solution. After all, what else is there? Open-wire line and twin lead require an antenna tuner. That at least gives us a choice, but the expense is still there, either in the cost of coax or the purchase of an antenna tuner. Bargain-style coax is not a good solution. It is usually either of very questionable quality and has poor shielding, or it's embrittled with age.

For medium and high power use, RG8 or equivalent is the most logical choice in coax. It's heavy enough to handle the power. It's also heavy enough to require some pretty stout wire and supports if used in a flat-topped dipole installation with no center support. Then, if you want to add a balun at the antenna feed point, you compound the weight problem.

Twin lead is the most obvious solution. It can be matched to a short length of coax through a 4:1 balun for easy routing to the shack. That helps the situation somewhat, but what if our antenna does not match 300 ohms and we don't want to use a balun at the elevated feed point? We could always construct the dipole from twin lead, giving us our impedance match and broadband performance at the same time. That solution also has its drawbacks. Twin lead does not weather as well as simple wire and coax. The cheaper, receiving type of twin lead may not handle the full legal power limit.

The variations and permutations of this decision-making process seem endless because there are so many variables involved. What we really need here is some magic do-everything transmission line that can provide more options to deal with these variables. Chief among these options would be a line made from inexpensive materials that can be used without worry regarding impedance match to the antenna. Such a device does exist; it can be made from inexpensive materials, or from almost any type of wire or cable. You could even use that 1,000-foot roll of lamp cord that was such an irresistible bargain two years ago.

An electrical half-wave section of transmission line has the unique property of mirroring impedance from one end to the other. For all practical purposes, the electrical properties seen at one end are the same as at the other end. The reaction of most people when they are first introduced to this well-known fact is "So what?" The conventional use of transmission lines takes advantage of the fact that such a line has a characteristic surge impedance for *any* physical length. All that is needed is termination in that characteristic impedance at both ends. However, the mirroring ability of a half-wave transmission line becomes infinitely more useful when we realize that it has nothing to do with the surge impedance of the line. This means that we can use virtually any two conductor lines available to physically bring the electrical equivalent of the antenna feed point down to ground level where we can more effectively deal with our matching problem.

The Procedure

The key here is to ensure that the nondescript line is equal to a multiple of *electrical* half waves in length. The downside is that this trick will only work on exact multiples of a fundamental frequency. A line cut for 3.5 MHz will also work on 7.0 MHz, 14.0 MHz, and 28.0 MHz. A line cut for 3.9 MHz will work best on 7.8 MHz, 15.6 MHz, and 31.2 MHz. As you can see, multiband operation using this concept is somewhat limited unless we use an antenna tuner. The other problem is determining what physical length of cable corresponds to an electrical half wave at your chosen frequency.

The electrical half-wave length of any transmission line will *always* be physically shorter than the length calculated from the formula: half-wavelength in feet = 468/frequency, in MHz. The ratio between its shorter physical length and the length from the formula is known as the velocity factor of the line. Velocity factors for various popular transmission lines can be found in *The ARRL Handbook*. You won't find lamp cord listed there.

You can calculate the velocity factor of any line with nothing more than your station equipment using the following procedure (use a frequency in the 10 meter band to avoid wasting any more of your valuable lamp cord than necessary): From the formula above, calculate the half wavelength in feet for the frequency you are using. Cut a section of lamp cord to this length. Connect the output of your transmitter to a dummy load using a short length of coax in series with your SWR meter. Tune up on frequency using as little power as possible. Note and record the SWR into the dummy load—it should be very close to 1 to 1. If it isn't, check your hookup and verify that your dummy load is indeed 50 to 75 ohms. Now replace the short length of coax with your lamp cord transmission line (Figure 1). Do not readjust your transmitter except for drive to the final, if needed. Apply power and take an SWR reading—it will probably be higher than 1 to 1. Trim a few inches off the lamp cord section and try again. Continue this until you get the lowest possible SWR—it should be close to what you experienced with the dummy load connected through the coax. Measure the final length of the lamp cord and divide it by its original length. The result will be less than one and will represent the velocity factor of your line cord. Now you can use that value to calculate the physical length of lamp cord required to give an electrical half wavelength on any frequency.

Qualifications

You might be tempted to do this test at 2 meters if you have the equipment. That would waste even less cable, but it may also give you bogus information that will not scale down to HF frequencies. The formula we used is only good for frequencies up to 30 MHz.

Of course, you are not restricted to using lamp cord. Almost any line having two conductors will work, as long as its physical makeup is uniform throughout its length. For instance, using alternate sections of twin lead and lamp cord where each section is less than an electrical half wavelength might not be a good idea. The surge impedance of the line is not a factor, but I don't think that allows it to be a variable through its electrical half wavelength. You could even use a twisted pair, as long as the pitch of the twist is uniform throughout its length. We also need to exercise a little common sense here. You can't bury a section of lamp cord in the ground like you would coax. A twisted pair made from #24 enameled wire might work for a receiving application, but I wouldn't use it for transmitting.

Another example application of this principle is my recent experience with a dual dipole phased array for 40 meters. This is an active array; each leg of each dipole receives power. Some sort of balanced feed was required, but I wanted to use shielded cable to reduce noise pickup on the vertical sections of the transmission lines. I ended up using four electrical half-wave sections of surplus RG62 coax, two sections per dipole. The center conductors of the coax were connected to the dipole legs. The shield of the coax was tied together at both ends of the transmission line and grounded at the phasing network located in a box below the array.