Antenna Matching Techniques

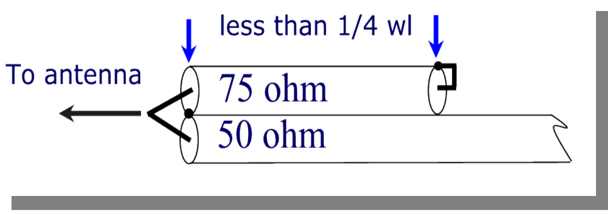
As with antenna types, there are numerous matching techniques employed in amateur radio antennae. Many of these techniques depend on the frequency of use and the antenna type. We will take a quick look at several popular types here. For a more in-depth examination of matching networks, consult the ARRL Antenna Book.

The Matchbox

Perhaps the most popular of matching networks is the matchbox, or tuner as it has come to be known. Previously, we discussed that the tuner is not an antenna matching device but a coax to rig matching device. If this concept is still not clear you should review the discussion we presented earlier until your concept of the matchbox is solidly based on the principles presented here.

Impedance Matching for Dipoles

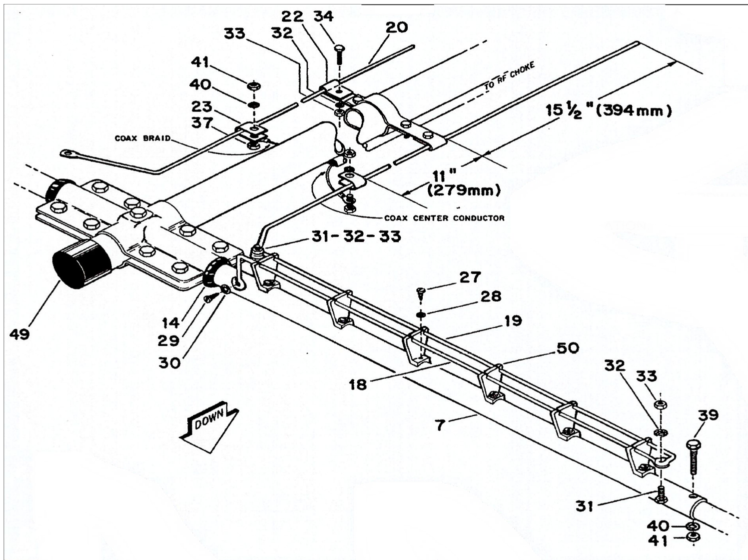
One of the simplest of matches for dipoles is the series lumped component match. This is a complicated way of saying we can put a coil or capacitor in series or parallel with the antenna to bring the impedance presented the feedline, closer to the characteristic impedance of the coax (thus lowering the SWR at the antenna). This form of matching is more often seen in VHF than HF type antennas, but historically is well represented in VHF dipole configurations.



Lumped impedance matching design is of three basic types: series matching, parallel matching (or a combination of the two), and transmission line matching. Transmission line matching is not to be confused with your coax, it is called this because the method uses the same impedance forming components and methods that are used to construct transmission lines.

An example of the lumped impedance transmission line matching is shown in the illustration. If we recall the study of resonate circuits we will be able to apply that knowledge to surmise that antenna matching with very low impedances (like mobile verticals) may need series matching. And in fact almost all marine and CB fiberglass whip antennas do contain some form of series matching to bring the very low (typically 3-10 ohms) impedance up to the nominal coax impedance of 50 or 75 ohms. Dipoles very often are much higher in impedance than coax or twin lead impedances. This situation may use parallel matching to lower impedances presented to the feedline. In the illustration, a short (less than ¼ wavelength) coax stub is used to compensate for antenna impedances that are capacitive or inductive in value. The shorted stub as shown is inductive in value, while an open stub of similar length would be capacitive. It is even possible, (and likely in most fiberglass verticals) that the antenna element has a short length of higher impedance cable in series with the radiating element. A classic example of this type of matching is the ¼ wavelength matching stub. The stub match is a length of transmission line that is one-quarter wavelength at the center operating frequency. Millions of antennas like this have been sold for the Citizen's Band, Marine band, and 2 meter ham band under very famous brand names. Many times (not always, but quite often) transmission line stub matching is an indication of non-resonate wide-SWR bandwidth antenna design parameters for a single narrow band of frequencies (like the 155.5 – 157.0 MHz marine VHF band or 144-148 MHz 2 meter amateur band).

The transmission line type matching is much harder to recognize and describe.



Hy-Gain 204BA 40 meter Beam matching network

The next illustration is of a classic single-band dipole beam antenna incorporating transmission line matching into a production model. This antenna was very popular many years ago because of the small size for 40 meter operation. Notice that this type of matching is larger than traditional Beta or "T" matching techniques. This is because it takes advantage of the nature of transmission line characteristics common to the linear match methodology. This type of match is inherently broad-banded, but is mechanically more complex comparative to other matching types.

As you can see from the illustration, the loading wires run along the lengthwise axis of the driven elements and return to form a stub match in the middle along the boom. This is a very mathematically and theoretically complex model to approximate on computer driven design programs. Most modeling is done by reducing the net effects to lumped impedances or R+jX equivalence.

It does, however, illustrate how variations on mechanical means can accomplish a broad range of challenging matching conditions. This beam accomplishes 4.9 db of gain with 15 db f:b in only a sixteen foot boom on 40 meters. The 3:1 SWR bandwidth is 150 kHz. Quite good for a very compact 40 meter beam.

The same kind of loading/matching can be seen in the linear loaded dipole seen in QST July 2002 issue. The author, Lew Gordon K4VX, has used the same loading/matching principals to make a shortened wide-band dipole for 40 meters. The stated 2:1 SWR bandwidth is 300 kHz from the design center frequency. The article provides SWR graphics to show the performance of this unique antenna. Although the physical appearance is different, the principals are the same between the two antennas of vastly differing construction methods.

The Real Scoop On SWR

In this treatise we have looked at SWR and discovered many things that are true, and dispelled a few myths perpetuated in ham radio circles. So what does all this come down to?

If there is anything you need to carry away from a thorough reading of the material, it is that:

1) There are a number of factors, simple and complex that affect SWR.
2) Not all antennas are 50 ohms. They come in all manner of impedances.
3) SWR alone is not a sole consideration for antenna effectiveness. We must also consider radiation efficiency and radiated pattern in the entire system.
4) Low SWR does not mean your antenna is radiating properly. Nor does a modest SWR mean your antenna will not “work” or that you cannot use some antenna types at your installation.
5) An antenna that “Works” may mean something different to you than to another ham. Generally we give this term the meaning that it is relatively easy to tune to a workable SWR in our band segment and we get good signal reports from the important distant stations contacted. Very Low SWR should not be the only meaning given to how an antenna “works”. You may notice that some antennas that exhibit very low SWR are not necessarily the best performers in your application.
6) You CAN operate your rig on an antenna system that exhibits a significant SWR – WITHOUT DAMAGE due to SWR. Notwithstanding that some rigs and power amps have a SWR lockout set at about 3:1, with a good tuner you can operate with high SWR under some circumstances without equipment damage and with surprising results.
7) Your tuner does not “tune” your antenna. It provides an additive phase-linear match to the transmission line by redirecting the reflected power measured (due to impedance mismatch at the antenna). At the same time a nominal impedance is presented to your transmitter so it will operate efficiently enough so as not to damage components due to the increased heat generated from working harder than it should to generate operable RF power.
8) Antennas are complex and are affected by everything around them, especially the ground and resonating conductors near them. This can be a good thing (as in Yagi antennas) or a bad thing (as in ground-loop resonating).
9) Don't trust advertising hype from manufacturers. Look at stated specs with an educated eye. No one can operate beyond the laws of physics and wave dynamics. If you are skeptical, consult an Elmer before spending your hard earned cash on unrealistic promises. Use the knowledge you have gained from these pages and make better, more informed choices.

You are highly encouraged to use the information sources provided at the end. There is much more to antenna theory and practice than could be covered here. These sources provide a wealth of information that you can use every day.