Using 75 Ohm CATV Coaxial Cable

Most transceivers and antennas designed for ham use are based on 50 ohm impedance. The easiest way to connect your rig to your antennas is to use 50 ohm coax such as RG-8, RG213, RG-58, or my favorite, LMR-400. LMR-400 has lower losses than the others listed.

Losses waste power from your transmitter and limit the ability to copy weak signals. Losses increase as the length of the coax increase and as frequency increases. The solution of course is to use low loss coax. Unfortunately low loss coax is more expensive than the garden variety types.

Cable TV companies have the same problem. They have to run very long runs of coaxial cable. TV frequencies are in the VHF and UHF range, compounding the problem. The industry uses cable with low loss dielectric and a solid aluminum cover. Because they use thousands of miles of this cable every year the production costs are low. What is even better, cable companies don't like to mess with short lengths. It is cheaper to throw the roll ends out than splice them together. Cable companies consider 100' or more as short lengths. They will often give away or sell these lengths for very low prices.

So, there has to be a catch, right? Actually there are two. The first one is cable impedance. The CATV industry uses a 75 ohm system. Can we use 75 ohm coax with our 50 ham systems? Of course we can! We just have to convert 75 ohms to 50 ohms – or maybe not.

Before getting into impedance considerations of the CATV cable, there is the other catch. The standard PL-259 connectors we use with our rigs and antennas do not fit on the 75 ohm hard line cable. Connectors can be purchased that will work, but they tend to be very expensive and difficult to find. A number of ways to make connectors have been devised. I adapt PL-259 connectors with brass tubing. Instructions are given on another page.

Don't worry about it

The easiest way is to just not worry about the mismatch and just hook up with the 75 ohm line. I do this with one run that connects to a pair of triband Yagis. You will not get a perfect SWR with this method, but perfect SWR is not necessary. There are only two reasons you need low SWR.

1. Your rig can't match to the impedance presented. This is more of a problem with solid state rigs than tube rigs or amplifiers that are have variable output tuning networks.

2. Losses increase with higher SWR, but using low loss coax to begin with reduces this problem.

Many hams don't understand basic transmission like theory. Read the appropriate sections in the ARRL Antenna Book. The 1973 QST series Another Look at Reflections by Walter Maxwell, W2DU, is also well worth reading. Members can down load PDF's of Maxwell's articles for free from the ARRL web site.

Use half wave length coax

Transmission lines have a wonderful property in that they act as impedance transformers. Suppose you have a 100 ohm resistor and an assortment of 50 ohm coax lengths. You put your resistor on one end of each coax and the SWR bridge on the other end. What will the SWR be for each length of coax? It will always be 2:1 for every coax, again assuming your coax has no losses. Now suppose you get out your antenna analyzer and repeat the experiment. You will get 100 ohms right? Wrong!

Depending on the length of the coax you will get a complex impedance with resistive and reactive components. The reactance will be either inductive or capacitive depending on the length. There are two special case. When the coax length is a multiple of a half wave length, you will see 100 ohms resistive and no reactive component. If the coax is an odd multiple of a quarter wave, you will see 25 ohms resistive and no reactive component.

Two assumptions are made for the experiments above. First the same frequency is used for all tests. Changing frequency will change the wavelength. Second, by wave length we mean electrical wavelength. A quarter wave of coax will be physically shorter than a quarter wavelength in free space. See the side bar Velocity Factor.

The special case where the feed line is a multiple of a half wavelength can be used to advantage when the antenna and feed line are of different impedances. The impedance of the far end will be reflected on the near end. Thus our 50 ohm antenna at the other end of the 75 ohm will appear as 50 ohms to the transmitter. This will only happen on one frequency, but will be close enough to cover most of a ham band.

To start out, lay out your coax to the proposed length but make it longer than it needs to be to reach your destination. For the worst case you want to make it about an electrical half wave longer at the frequency of operation. Put a connector on the end at the shack. Strip off about ¾" of the outer conductor and insulation. Attach a small 50 ohm resistor between the center connector and outer shield. I found small rubber bands will hold a good temporary connection and are easy to put on and take off. They also don't require a soldering iron at the tower.

Use an antenna analyzer and measure the impedance. Most likely it will not be 50 ohms resistive. Cut down the coax a little bit at a time measure until you get the 50 ohm resistive reading. Put a connector on at that point and use regular 50 coax the rest of the way to the antenna.

The obvious problem is that your coax will be longer than it needs to be. That is not a big deal on 2 meters were a worst case is the coax will be about 3' longer than needed to reach the antenna. On 160 meters it could be about 250' longer than needed to reach the antenna. For that reason I have only used this technique on 10 meters and above. There is another way to use shorter lengths of coax.

Transformers

Transformers with wire windings around a core can also be built. Basically a transformer consists of two magnetically coupled coils. The impedance transformation will depend on the ratio of the number of turns of the two coils. Transformers for 75:50 coax are usually built around toroid cores. These can be home built or purchased commercially.

Another form of transformer can be made by using the impedance transforming effects of transmission lines. Two sections of 1/12 wavelength feed line will transform one impedance

Velocity factor

Radio waves propagate through free space at about 300,000,000 meters per second common known as the speed of light. From that the wavelength can be calculated by the formula

$$\lambda = 300/f$$

Where λ is the wavelength in meters and f = frequency in MHz.

When electricity flows through solids it travels slower than free space. Data sheets for coaxial cable will include a to another. Figure 1 shows how it is done. For short lengths it might be easier to use RG-11 or similar coax instead of hard line for the 75 ohm segment.

Normally you would want to put one of these at each end of the 75 ohm run. Don't forget to include the coax velocity factor when calculating the length of the 1/12 wave sections.

This technique is only good for a single band. The bandwidth is good. I used one on 10 meters and was able to cover 28.000 MHz up to at least 28.8 MHz.

correction value, known as the "velocity factor" for calculating physical wave lengths of the cable. Calculate the length in free space for the wavelength and frequency of operation. Then multiply that length by the velocity factor to find the physical length of coax needed.

Typical velocity factors for coax are between .66 and .90 of the free space length. Like all things electrical, there will be tolerances and you should cut long, measure and trim. If you need several identical lengths of coax from the same reel, you will usually be trimming the first piece and making the rest the same length.

A generic formula for calculating a needed length of coax is

L = (S * W * Vf)/f

Where

L = Length in meters or feet depending on value used for S

S = speed of light in free space, use 300 if you want L in meters, 984 if you want L in feet

W = number of wavelengths desired, 1 = 1 wavelength, .5 for half wavelength, etc.

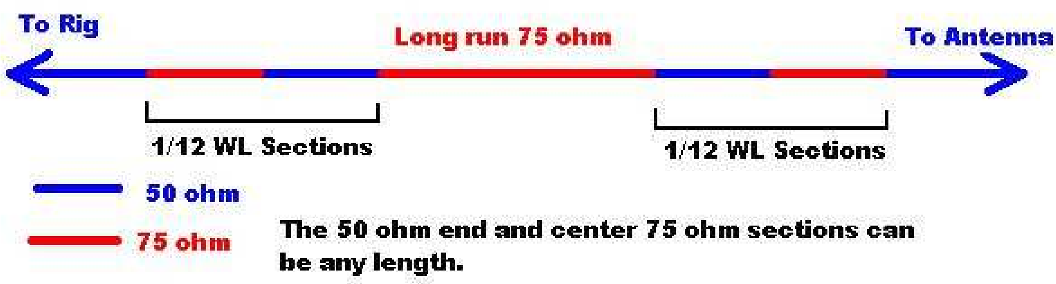

Figure 1. 50:70 Ohm impedance transformation using only coaxial cable

Summary

Running long coaxial runs with low losses can be done economically with 75 ohm cable TV coax if one is willing to deal with the impedance mismatch considerations.