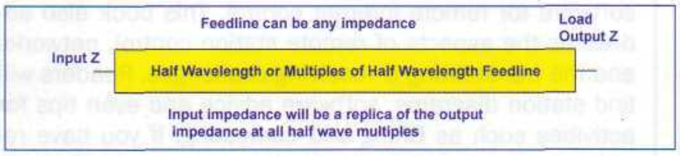
Facts about Feed Lines

Seven useful things you might not know

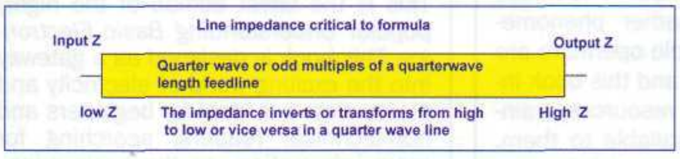
SIMPLE FACTS. In my time as an amateur, as well as my professional life, I've found there are a few fairly simple facts about feed lines that, when understood, shed a lot of light on what goes on in pieces of electric string. Here are seven simple facts – may they bring enlightenment.

FACT 1. Given any feed line, one half wavelength long, the voltage and current will be exactly the same phase at the load end of the line and at the source of the line. The same holds true at multiples of each half wavelength. Because of this, the impedance at the line's input end will be the same impedance as the load end.

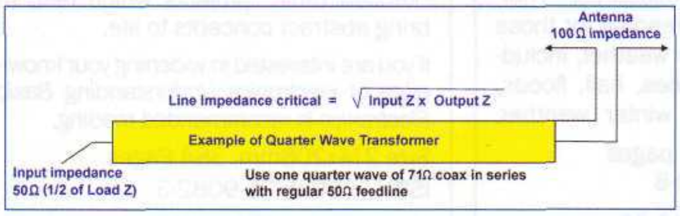


FACT 2. The input impedance of any feed line, no matter what its own impedance, will show the load impedance at all half wave multiples (Z load = Z input). A half wavelength of feed line will transfer the load impedance from one end to the other end of the line. Utilising this property is a great way to measure the actual impedance of an antenna at its operating height. Connect a half wave piece of coax or other transmission line (multiples of half waves if needed) and measure the input end. This is the actual impedance of your antenna.

FACT 3. In a quarter wave transmission line, or odd multiples of a quarter wave line, the voltage and current are out of phase at the end of the quarter wavelength. At the load end, if the voltage is maximum and current is minimum, the voltage is minimum and the current maximum at the input source. This relationship produces high impedance at one end and low impedance at the other. In so many words, we have a way of transforming the impedance from one end to the other of a piece of transmission line. It is a method to match impedances such as a 25Ω beam to a 50Ω coax.



FACT 4. To utilise this concept to match two unequal impedances, multiply the two impedances on each end and take the square root. This becomes the necessary impedance of the quarter wave transformer. You will have to obtain (cut) a quarter wave piece of transmission line made to this impedance. If it's an odd number (not 50 or 75Ω) it can be creatively obtained by paralleling lines or other means.



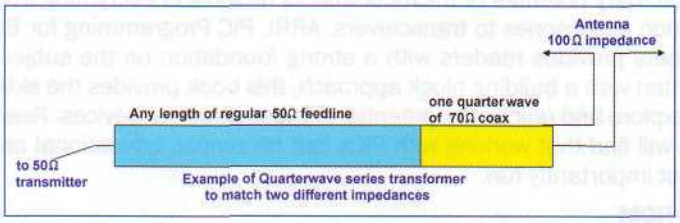
FACT 5. If we needed to match a 100Ω antenna to a 50Ω coax, a quarter wave piece of 70Ω coax in series with the regular line would do the job. Just insert the quarter wave piece before the antenna and you have a good match. (Note: a quarter wave transformer only works at one frequency. It is not a broadband device.) For frequencies above 14MHz the bandwidth is wide enough to operate over most of the ham band.

The formula to calculate the necessary impedance of the line is

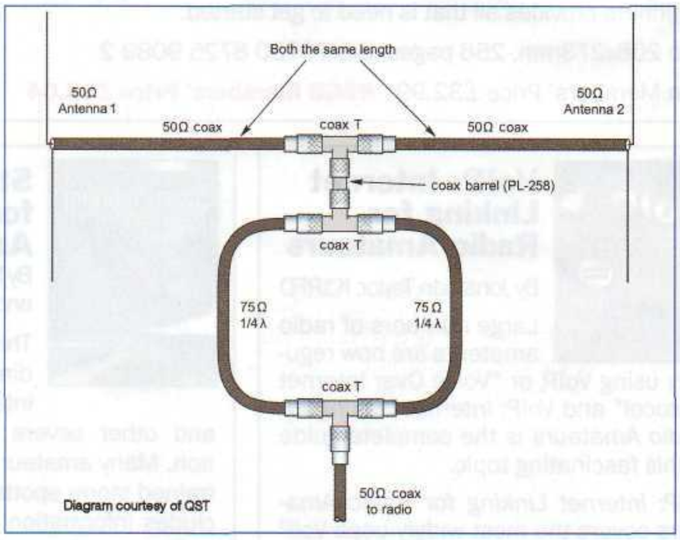
$$Z_{cable} = \sqrt{\text{Input Z} \times \text{Output Z}}$$

$$= \sqrt{50 \times 100}$$

$$= 70.7 \text{ (so use 75Ω cable)}$$



FACT 6. Parallel coaxes can be utilised to match a number of situations with a little creativity when the formula comes out to non-standard transmission line. This diagram shows how to make up a 35Ω quarter wave matching section, required to match the 25Ω of two paralleled 50Ω antennas to a 50Ω feedline.



FACT 7. Radio waves slow down in wire so that change in speed will make the length shorter. This slowing down is known as the velocity factor and is different for various types of cable. 50Ω coax generally has a velocity factor of 66%, so you multiply the physical wavelength by 0.66 to get the correct length. A typical 300Ω flat (ladder) line has a velocity factor of about 93%, RG-8 (non-foam) is 66% but foam-dielectric RG-8 is 82%. (This month's ATV includes a table that lists velocity factors for several other cable types).

Wavelength (metres) = 300 / frequency (MHz)
Half wavelength = 150 / frequency
Quarter wavelength = 75 / frequency

To make a quarter or half wave piece of transmission line, use the formulas to get the physical length and then multiply by the velocity factor for that type of line. Add about 10% as an error margin. Measure out this length and then, using a network analyser, dip meter or other indicator, cut small bits off until you reach the exact quarter or half wave length. (This month's Homebrew explains more about how to do this).