Tech Note - Theory - 08 Transmission Lines and Zc

In most Ham installations, the antenna and transmitter are widely separated physically. It would be much simpler if we could connect the transmitter directly to the antenna. This is hardly likely and virtually impossible. In practice, a transmission line is universally used. Not just any piece of wire will do for this. Unfortunately this transmission line has to be carefully crafted to function properly. Strange things begin to happen when we subject a length of wire to RFE.

Lets go back to basic physics (R.A.C. Study Guide - Basic Qualifications: Page 8-2 Para. 8-2) When current flows through a wire, the wire is surrounded by a magnetic field. If the current should vary the magnetic field moves. And should the moving magnetic field cross another wire, a current will be induced into that second wire.

If we apply this principle to two wires paired together, because this is what a transmission line really is, a basis is established and we will be able to see the how and why of the problems we will face. Have a look at Fig 1a, current flowing through wire A, induces a current into wire B which tries to flow in the same direction as the current in A. However wire B is the return path for the circuit, and has its normal current flowing in the opposite direction to that in wire A. This current produces a magnetic field which induces a current in wire A. The induced currents in the two wires oppose the current we are trying to deliver to the antenna and impeding the delivery of power.

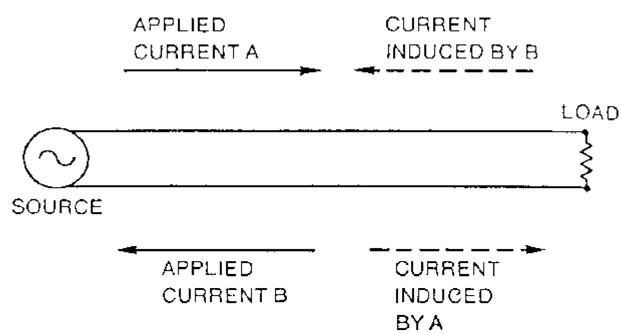

Fig 8.1a

Additionally, a transmission line is made up of two conductors separated by an insulator. Back to basics again (page 4-9 para. 4.6) This is the definition of a capacitor. Unless it is a perfect capacitor, some miniscule amount of current will flow between the two conductors even when the line is open circuited.

From this we can see the line acts as if it had a definite amount of impedance. This impedance, which is determined by the inductive and capacitive qualities of the line is a constant, regardless of the length of the line, (distributed constants). These features affecting characteristic impedance (Zc) hold not only for parallel conductor line, but for coaxial cable as well.

Close space conductors have a low impedance and widely space conductors have a high impedance. Exact values of impedance can be calculated by using the appropriate formula. In parallel conductor lines it becomes, $Zc=276 \log b/a$ where b is the centre to centre distance between the conductors and a is the diameter of the conductors, the dimensions may be expressed in inches or metric as long as the same units are used throughout. Coaxial cable Zc may be arrived at using the formula, $ZC=138 \log b/a$, where b is the inside diameter (or bore) of the outer conductor and "a" is the outside diameter of the inner conductor.

There are only two kinds of transmission line regardless of the physical appearance , these are balanced and unbalanced line, balanced to ground that is! A transmission line is a closed oscillatory circuit, (a continuation of the closed oscillatory circuit of the transmitter). Of course this means that, that end fed piece of wire is all radiator, right from the coax connector on the back of the rig or antenna tuner to the far insulator of the antenna . It is all an open oscillatory circuit because it is spread over a wide area deliberately so radiation would take place. I hope this has taken some of the mystery out of characteristic impedance.