Is There an Ideal Impedance For Coaxial Cable?

By Steve Lampen, 11/05/2003

In the history of wire and cable, Bell Laboratories tested thousands of cables of different impedances in 1929. They wanted to know;

1. **Is there an ideal impedance for attenuation?**
2. **Is there an ideal impedance for power handling?**
3. **Is there an ideal impedance for high voltage?**

To their surprise, as you can see in Fig. 1, the results for each requirement were quite different.

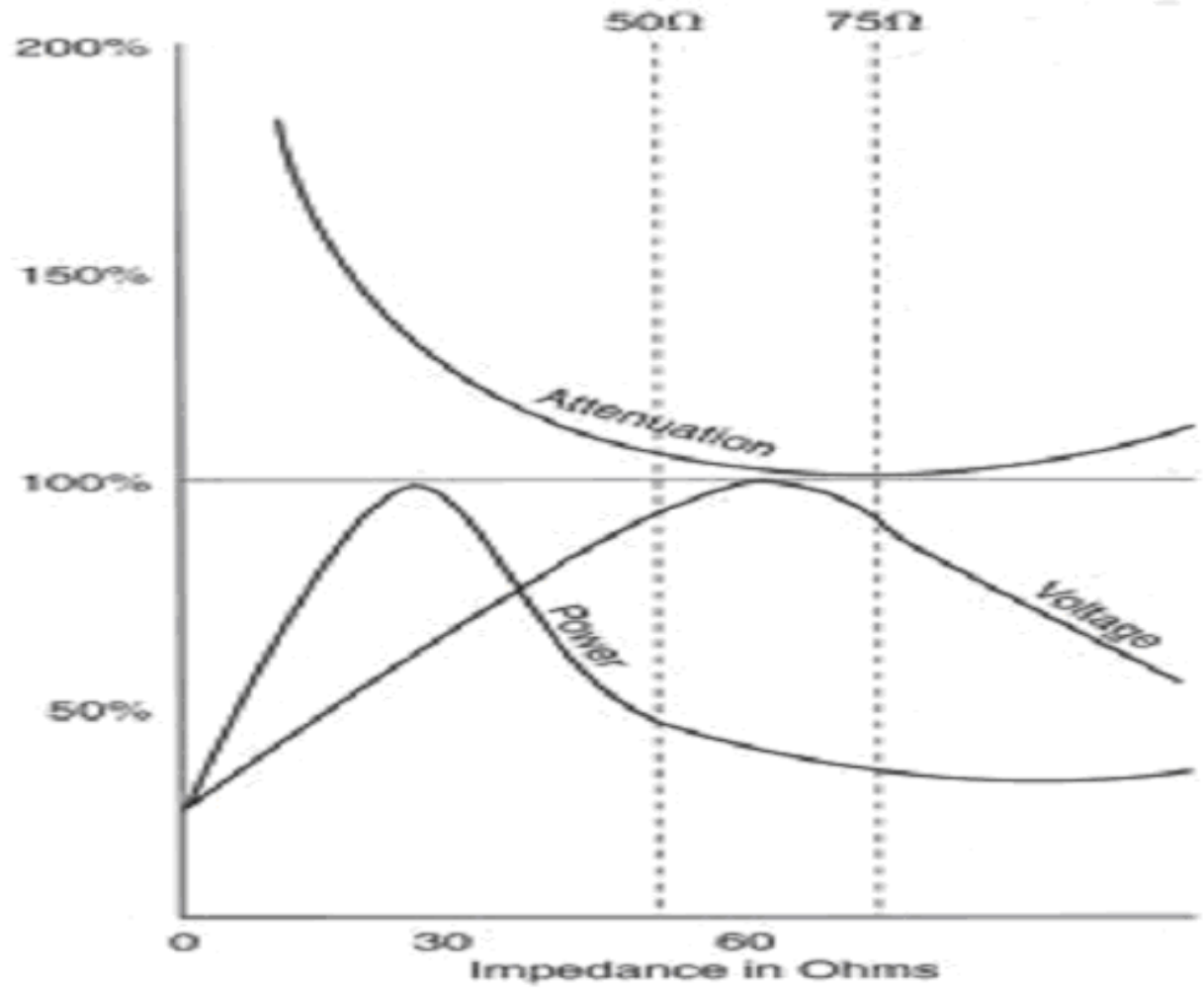

Fig. 1: Coax Impedance and Loss

You will note, for instance, that attenuation gets lowest around 77 ohms and rises on either side of that value. Because this value dictates the relationship of the dimensions of the cable, this calls out the ratio of sizes. That is, if you choose a center conductor, and the material (dielectric) around it (their original dielectric was air), then the distance to the outer conductor (shield) and the overall diameter of the cable are pre-

determined.

Likewise, if you want to build a cable of a specific impedance, you already know the diameter and you have chosen the dielectric inside, the size of the center conductor is pre-determined.

But that's not all they found.

You will note that, while 77 ohms was the best number for attenuation, this is an odd ratio. If you change it slightly to 75 ohms (with a very small increase in attenuation), you can use standard-gage wires. Thus 75-ohm coax was born.

This is why all those coaxes intended to carry signals, not power and not high voltage, are 75 ohms. Cables like baseband video cable, CATV / broadband cable, are all 75 ohms. But for coaxial cables meant to carry high power, an impedance of 30 ohms was required.

Research by Lloyd Espenschied and Herman Affel at Bell Labs in 1929 showed that;

1. **75 ohms was the ideal impedance for low loss coaxial cable.**
2. **30 ohms was the ideal impedance for high power coaxial cable.**
3. **60 ohms was the ideal impedance for high voltage coaxial cable.**

Here is the dilemma for broadcasters. You want a cable that can handle high power and high voltage. This is where 50 ohm coax comes from. It is a compromise between power and voltage.

In fact, the first transmission-line coaxial cables were made by taking small copper pipe and putting it inside large copper pipe. If you do this with standard sizes of copper pipe, you will get impedances like 51.5 ohms or 52 ohms. That was close enough for government work. All you had to do was tune your transmitter and antennas to match. In fact, RCA standard transmission line was 51.5 ohm coax for almost four decades.

Speaking of transmitters: Our solid-state IC transmitters of today no longer require a compromise for high voltage. What you really need is 30-ohm cable, good for high power but not high voltage. Of course, your transmitter would have to be tuned to 30 ohms, and your antenna had better be 30 ohms. But you could probably increase efficiency. Too bad 30-ohm cable is so hard to make.