OVERVIEW

The purpose of cable television coaxial cable is to transport information as efficiently as practical. Attenuation, then, becomes a key design feature. Since the center conductor is the cause of about 2/3 of the total cable attenuation, it might appear that attenuation might be reduced by increasing the center conductor size in an attempt to decrease the AC resistance. An optimum center conductor size exists where the attenuation is minimized for a given size and type cable and increasing the center conductor size does not necessarily improve attenuation. This technical note provides the theory to determine the optimum center conductor size.

THEORY

The calculation of attenuation of coaxial cable can be simplified if some constraints are placed on its characteristics and uses. If the cable conductors are smooth, solid, cylindrical, and homogeneous materials and are operated at a frequency where the skin depth is sufficiently developed (but below cut-off) and no significant discontinues exist along the line, the attenuation can be approximated with great accuracy as:

$$\alpha = \frac{3296}{Z_0}\left(\frac{\sqrt{\rho_d}}{d} + \frac{\sqrt{\rho_D}}{D}\right)\sqrt{F} + \frac{0.884\pi d f F}{Vg}$$

Where:

- α = attenuation of the cable (dB/100 feet)
- Z_0 = characteristic impedance (ohms)
  = 60 Vg ln (D/d)
- ρ_d = resistivity of the center conductor (ohm-m)
- ρ_D = resistivity of the outer conductor (ohm-m)
- d = outside diameter of the inner conductor (inches)
- D = inside diameter of the outer conductor (inches)
- F = frequency (MHz)
- df = dissipation factor of the dielectric (dimensionless)
- Vg = relative velocity of propagation (dimensionless)

If we wish to minimize the attenuation of the cable, this equation tells us which variables should be addressed. Clearly, by increasing Vg and D the attenuation will decrease. Practical limits prohibit increasing Vg to its optimum value approaching 1.0 because increases in Vg generally result in mechanical performance tradeoffs. The physical size and weight of the finished cable limit D.

What remains to be determined, after Vg and D are selected, is the size of the center conductor. From the equation, an increase in d will decrease α; but d also affects Z_0. An increase in d causes Z_0 to decrease thus increasing α. It can be shown that an optimum value for d can be selected that will minimize the attenuation for any given D. The relationship for an aluminum sheath outer conductor and copper (or copper clad aluminum) center conductor is:

$$d = 0.2636D$$

and the optimum impedance is:

$$Z_0 = Vg\ 79.99$$

To illustrate this phenomenon, the attenuation of a 0.875 inch cable was calculated at 400 MHz using Eq. 1 and a range of center conductor sizes from 0.119 inch to 0.310 inch (See Figure 1). Although these relationships provide a minimum attenuation, there is very little attenuation change (i.e., 0.005 dB/100 feet) for center conductor diameters between 0.184 inch and 0.238 inch.

Although a change in the center conductor has only marginal effect on attenuation in this region, it has a large effect on impedance (i.e., 63.8 to 77.4 ohms), obviously beyond the acceptable range for cable television cable.

Figure 1.