Three measurement points give coax loss equation

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The design of amplitude equalizers for both analog and digital coaxial-line systems requires a knowledge of the insertion loss (L) of the line in decibels, expressed as a function of the length (l) of the line, frequency (f) of the test signal, and perhaps temperature (T). Once this information is available in equation form, the insertion loss can be determined for any length of a given cable at any frequency and any temperature. A loss equation of the form

$$L = l(a + bf^{1/2} + cf)$$

usually provides a satisfactory fit over a wide range of frequencies.

The constants a, b, and c can be derived from three linear equations that are based on measurements of insertion losses in a length of cable at three different known frequencies. Carrying through this procedure, if the loss equation is rewritten as

$$\alpha = L/l = a + bf^{1/2} + cf$$

and α has measured values α_1, α_{10}, and α_{100} at frequencies of 1, 10, and 100, respectively, then

$$\alpha_1 = a + b + c$$
$$\alpha_{10} = a + 10^{1/2}b + 10c$$
$$\alpha_{100} = a + 10b + 100c$$

Solving for a, b, and c yields

$$b = (-10\alpha_1 + 11\alpha_{10} - \alpha_{100})/[11(10)^{1/2} - 20]$$
$$c = [\alpha_{10} - \alpha_1 - b(10^{1/2} - 1)]/9$$
$$a = \alpha_1 - b - c$$

For example, the loss in 1.85 kilometers of type 174 coaxial cable was measured at 20°C, yielding the values α_1 = 5.281 dB/km, α_{10} = 16.584 dB/km, and α_{100} = 52.61 dB/km. Therefore, cable loss in dB at 20°C is

$$L = l(0.068 + 5.21f^{1/2} + 0.0045f)$$

where l is in kilometers and f is in megahertz.

The effect of different temperatures on the insertion loss can be included in the equation as follows:

$$L_T = l_0(1 + \gamma\Delta T)(a + bf^{1/2} + cf)$$

where l_0 is the length of the cable at the reference temperature T_0, and ΔT is $(T - T_0)$. Using a test signal with a fixed frequency, the value of the constant γ can be determined by measuring the insertion loss of a given cable at temperatures T_1 and T_2. Then

$$\gamma = (L_2 - L_1)/[L_1(\Delta T)_2 - L_2(\Delta T)_1]$$

where L_1 denotes the insertion loss at T_1, $(\Delta T)_1 = (T_1 - T_0)$, and so forth. □