Charakteristic impedance in coaxial line (book "Electromagnetics" by John D. Kraus)

If a cross-section of the coaxial line is drawn to scale with conducting paint on a sheet of space paper, 69 Ω is measured directly on an ohmmeter connected between the inner and outer conductors.

When this resistance-measurement method is applied to open types of line such as a two-wire line, the sheet of resistance material should extend out to a distance that is large compared with the line cross-section if accurate results are to be obtained.

Although graphical, analog-computer, and digital-computer methods can be applied to two-conductor lines of any shape, some configurations yield to a simple calculation. Thus, for the *coaxial line* of Fig. 12-13 we have from (6-10-8) for L and (4-12-2) for C that its characteristic impedance

$$\boxed{Z_0 = \sqrt{\frac{L}{C}} = \frac{1}{2\pi}\sqrt{\frac{\mu}{\epsilon}}\ln\frac{b}{a}} = 0.367\sqrt{\frac{\mu}{\epsilon}}\log\frac{b}{a} \qquad (\Omega) \tag{21}$$

If there is no ferromagnetic material present, $\mu = \mu_0$ and (21) reduces to

$$\boxed{Z_0 = \frac{138}{\sqrt{\epsilon_r}}\log\frac{b}{a} \qquad (\Omega)} \quad \text{Coaxial line impedance} \tag{22}$$

where ϵ_r = relative permittivity of medium filling line, dimensionless
a = outside radius of inner conductor
b = inside radius of outer conductor, same units as a

For an air-filled line $\epsilon_r = 1$, and (22) becomes

$$Z_0 = 138\log\frac{b}{a} \qquad (\Omega) \tag{23}$$

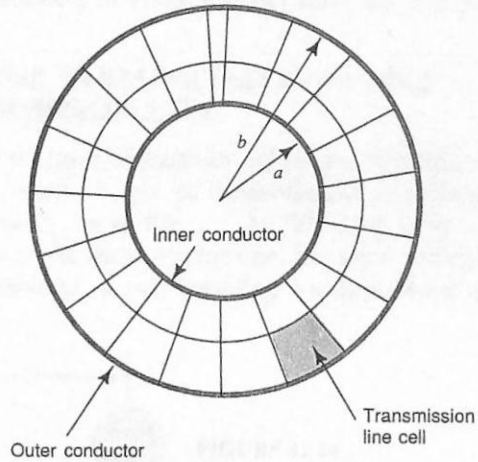

FIGURE 12-13
Coaxial transmission line with 18.3 transmission-line cells in parallel and 2 in series.

Example 12-2 Circular coaxial line. The air-filled coaxial line in Fig. 12-13 has a radius ratio $b/a = 2$. Find its characteristic impedance.

Solution. From (23)

$$Z_0 = 138 \log 2 = 41.4\ \Omega \qquad \text{(exact)}$$

From the graphical field map in Fig. 12-13

$$Z_0 = \frac{N_s}{N_p} 376.7 = \frac{2}{18.3} 376.7 = 41.2\ \Omega \qquad \text{(map)}$$

This value agrees well with the exact value.

In a similar way, the characteristic impedance can be obtained for a *two-wire line*, as in Fig. 12-14. Thus, if $D \gg a$, we have

$$Z_0 = \frac{1}{\pi}\sqrt{\frac{\mu}{\epsilon}} \ln \frac{D}{a} = 0.73 \sqrt{\frac{\mu}{\epsilon}} \log \frac{D}{a} \qquad (\Omega) \tag{24}$$

If there is no ferromagnetic material present, $\mu = \mu_0$ and (24) reduces to

$$\boxed{Z_0 = \frac{276}{\sqrt{\epsilon_r}} \log \frac{D}{a} \qquad (\Omega)} \qquad \text{Two-wire line impedance} \tag{25}$$

where ϵ_r = relative permittivity of medium, dimensionless
D = center-to-center spacing (see Fig. 12-14)
a = radius of conductor (in same units as D)

If the medium is air, $\epsilon_r = 1$, and (25) becomes

$$Z_0 = 276 \log \frac{D}{a} \qquad (\Omega) \tag{26}$$

The impedances of various media and lines are summarized in Table 12-1.

12-6 THE TERMINATED UNIFORM TRANSMISSION LINE

Thus far we have considered only lines of infinite length. Let us now analyze the situation where a line of characteristic impedance Z_0 is terminated in a load impedance Z_L, as in Fig. 12-15*a*. The load is at $x = 0$, and positive distance x is measured to the left along the line. The total voltage and total current are expressed as the resultant of two traveling waves moving in opposite directions as on an

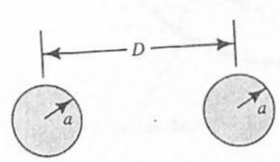

FIGURE 12-14
Two-wire transmission line.