ECE 6130 – Coaxial Lines

Text Section 3.5

Coaxial Lines

These are probably THE most widely-used transmission lines, used for all measurement connections, most connections to antennas, and most connections between RF "boards". They are popular because of they are naturally shielded by the outer conductor, are inexpensive, efficient, and easy to use and manufacture. Issues and problems include attenuation at high frequencies (as we have seen in lab), and connector "mismatches". Small reflections are almost inevitable at connections, and these can cause errors in high-precision measurements.

TEM Modes (Ez = Hz = 0) This mode is what we studied in more detail in the transmission line section.

Derivation: See text.

General method:

1) Solve Laplace's Equation for potential Φ
   This is equivalent to solving the Helmholtz wave equation for TEM waves (See pp. 107-108)
   (a) Guess the form of the solution Φ
   (b) Specify boundary conditions (BCs). These will generally be that tangential electric fields = 0 on metal boundaries. At dielectric interfaces, normal electric and /or magnetic fields may also be used in boundary conditions.
   (c) Find form of transverse electric and /or magnetic fields as needed to apply BCs from
   $\mathbf{e}(x,y) = -\nabla_t\Phi(x,y)$ and / or $\mathbf{h}(x,y) = (1/\eta)\ \mathbf{z} \times \mathbf{e}(x,y)$
   (d) Apply boundary conditions to solve for constants. Some constants will still be left at end of solution, representing the magnitude of the fields.
2) Find the transverse electric field from $\mathbf{e}(x,y) = -\nabla_t\Phi(x,y)$, applying constants
3) Find the transverse magnetic field from $\mathbf{h}(x,y) = (1/\eta)\ \mathbf{z} \times \mathbf{e}(x,y)$, applying constants. Where $\eta = \text{sqrt}(\mu / \varepsilon) = 377$ for air.
4) These fields can then be used to find RLGC. RLGC can be used to find vp, wavelength, Zo, etc.

Results : See Table 2.1

Coaxial lines are intended to be used exclusively in the TEM mode.
VIEWGRAPH Fig. 3.17 TEM Fields and TE_{10} fields.

TE Modes:

Coaxial lines are NOT to be used in TE or TM modes in practice.
The only reason to study these modes, is to find their cutoff frequencies, so that you know the maximum frequency to which it can be used.

See book for derivation. Pp. 143-144

Most important result: $k_c = 2 / (a+b) = 2\pi/ \lambda_c = 2\pi f_c / c_\varepsilon$ for TE_{10} mode (lowest order mode).
So coaxial line can be used up to frequency f_c.

In practice, 5% safety margin is allowed, so $f_{max} = 0.95 f_c$

CONNECTORS