Transmission Line Notes

Purpose

The textbook presents electromagnetic waves before transmission lines and thus assumes that the reader is already familiar with some concepts that occur in both. Nevertheless, transmission lines can be understood without previously studying electromagnetic waves and the logical development of this is contained in Chapter 7. It is intermixed, however, with explanations based on Chapter 6. The purpose of these notes is to lead you through the explanation that doesn't require Chapter 6.

Distributed capacitance and inductance - p. 430 -433, 436 ->

The model of transmission lines that is not based on concepts from Chapter 6 is a circuit model. It is described in the text starting on the last paragraph of p. 430 through the middle of p. 433. This model is continued in Section 7.2 which starts on the bottom of p. 436. The key equations in the derivation are (9a), (9b), (24a), and (24b).

Any transmission line has an inductance and capacitance per unit length associated with it. For example, the capacitance and inductance of coaxial cables are calculated in examples 3.20 and 4.16. Since the two are distributed over the entire length of the cable, a proper circuit model includes a chain of LC sections as shown in Fig. 7.6. From this model, you can derive equations (9), and then (24).

Solution to wave equation

Equations (24) are wave equations. Any equation of the form,

$\partial^2 f/\partial t^2 = (1/u^2)\, \partial^2 f/\partial z^2$

is a wave equation and they occur in many fields of engineering and science. Solutions to the equations are any functions f(s) where $s = t \pm z/u$. These are functions that move with velocity u in either the -z or +z direction. In Chapter 6, this type of equation for **E** and **H** is used to solve for electromagnetic waves. The solutions in Chapter 6 were sinusoidal functions such as $\mathbf{E} = E_0 \cos(\omega t - \beta z)\, \mathbf{a}_x$ with $u = \omega/\beta = (\mu\varepsilon)^{-0.5}$. In the case of transmission lines, we will be using other functions in addition to the sinusoidal functions (featured in Section 7.3). Therefore, the book discusses the general solution to the equations on pp. 437-439.

Field Model

The other parts of Section 7.1 (pp. 426- 430 and Section 7.1.1) are based on the electromagnetic waves studied in Chapter 6. You should read those sections, but don't worry if some items aren't completely explained. For the cases we examine, , you can get the correct time dependent fields if you take the static fields (calculated as in Chaps. 3 and 4) and simply multiply those fields by an f(s). One of the in-class problems takes this approach for a coaxial cable, with $f(s) = \cos(\omega s) = \cos(\omega t - \beta z)$, and $\beta = \omega/u$.