konstantin.rykov@tut.fi

SMG-8306 Transmission lines and waveguides

Small Exam I, February 3rd 2012. Answer to three of the four questions.
Each question gives in maximum 4 points
Jari Kangas

1. (a) It can be shown that the propagation of signals can be analyzed using the 2nd order wave equation

$$\frac{\partial^2 V(z)}{\partial z^2} = LC\frac{\partial^2 V(z)}{\partial t^2}. \tag{1}$$

   i. Consider a reasonable starting point and derive the wave equation.

   ii. Assume a lossless line, find a solution to the equation.

   (b) Consider how to approximate the derivatives in eqn. (1) and present a numerical scheme in view of the FDTD-codes (similarly as was done with the *leap–frog scheme*).

   (4 p.)

2. (a) Express the Poynting theorem and give interpretation of it and its terms.

   (b) Correct or incorrect? *To get points, support your answer by an argument or an example.*

   i. Surface current is an idealization that helps in analyzing cases that include very good conductors at high frequencies.

   ii. Consider a transmission line (whose characteristic impedance is Z_0) of length l connected to a load (characterized as Z_L). The impedance seen at the generator end is

$$Z_i = Z_0\frac{Z_L + Z_0\tanh\gamma l}{Z_0 - Z_L\tanh\gamma l}.$$

   (4 p.)

3. (a) Prepare a concise description about the core assumptions inherent in analysis of transmission lines.

   (b) Outline a procedure to find out the parameters of a lossless transmission line.

   (4 p.)

4. (a) Define in a few words:

   i. phase velocity

   ii. quasi–TEM wave

   (b) Lets consider a plane wave that is travelling along z–axis and whose electric field is $\mathbf{E}(\mathbf{x}, t) = E_0\cos(\omega t - kz)\mathbf{j}$. Let it travel in medium whose relative permittivity is 4 and relative permeability 1. Let frequency be 3.0GHz and $E_0 = 30\text{V/m}$.

   i. Find the amplitude and direction of magnetic field.

   ii. Find the phase velocity and wavelength.

   iii. Find the phase shift (in degrees) between positions $z_1 = 0.5\text{m}$ and $z_2 = 1.7\text{m}$.

   (4 p.)