Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Department

Microwave fundamentals
3rd Year Communications
(2013-2014)

Sheet1

1 Starting from the transmission line model, derive an equation for the attenuation constant and phase constant of transmission line in terms of R, L, C, G.

From lecture 1 , pozar pp.50

2 Use the telegrapher equation, and general solution of wave equation to derive an equation for the characteristic impedance of transmission line.

From lecture 1 , pozar pp.50-51

3 The current on a transmission line is given as i (t) =1.2Cos (1.51×10^{10}t-80.3z) A. Determine (a) the frequency, (b) the wavelength, (c) the phase velocity, and (d) The phasor representation of this current.

$i(t) = 1.2 \cos(1.51\times10^{10} t - 80.3z)$

a) $\omega = 2\pi f = 1.51\times10^{10} \Rightarrow f = 2.4\ GHz$

b) $k = 80.3\ m^{-1} = 2\pi/\lambda \rightarrow \lambda = 0.0782\ m$

c) $v_p = \omega/k = 1.88\times10^{8}\ m/sec \Rightarrow \epsilon_r = \sqrt{c/v_p} = 2.55$

d) $I = 1.2\angle -80.3z$ (rad)

4 A transmission line has the following per unit length parameters: L=0.2µH/m, C=300pF/m, R=5Ω/m and G=0.01S/m. Calculate the propagation constant and the characteristic impedance of this line at 500MHz. Recalculate these quantities in the absence of loss (R=G=0).

$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \sqrt{(5+j628)(0.01+j0.94)} = \sqrt{(628\angle 89.54^\circ)(.94\angle 89.39^\circ)}$

$= 24.3\angle 89.465^\circ = 0.23 + j\,24.3 = \alpha + j\beta$ np/m, rad/m ✓

$Z_0 = \sqrt{\dfrac{R+j\omega L}{G+j\omega C}} = \sqrt{\dfrac{628\angle 89.54^\circ}{.94\angle 89.39^\circ}} = 25.8\angle 0.08^\circ = 25.8 + j0.03\,\Omega$ ✓

5 RD-402U semi-rigid coaxial cable has an inner conductor diameter of 0.91 mm, and a dielectric diameter (equal to the inner diameter of the outer conductor) of 3.02 mm. Both conductors are copper and the dielectric material is Teflon. Compute the R, L, G, and C parameters of this line at 1 GHz, and use these results to find the characteristic impedance and attenuation of the line at 1 GHz.

Given: Teflon relative permittivity=2.08bcopper conductivity σ=5.813X10^7 s/m, surface resistivity Rs= $(\omega\mu/2\sigma)^{.5}$

From Table 2.1:

$$R_s = \sqrt{\frac{\omega\mu}{2\sigma}} = 0.00825\,\Omega$$

$$L = \frac{\mu_0}{2\pi}\ln\frac{b}{a} = 2.40\times10^{-7}\ \text{H/m}$$

$$C = \frac{2\pi\epsilon_0\epsilon_r}{\ln b/a} = 9.64\times10^{-11}\ \text{Fd/m}$$

$$R = \frac{R_s}{2\pi}\left(\frac{1}{a}+\frac{1}{b}\right) = 3.76\ \Omega/\text{m}$$

$$G = \frac{2\pi\omega\epsilon_0\epsilon_r\tan\delta}{\ln b/a} = 2.42\times10^{-4}\ \text{S/m}$$

For small loss, $Z_0 = \sqrt{L/C} = 49.9\,\Omega$ ✓

From (2.85a), $\alpha \simeq \frac{1}{2}\left(\frac{R}{Z_0} + GZ_0\right) = 0.044\ \text{np/m} = 0.38\ \text{dB/m}$ ✓

REPORT

6 The characteristic impedance of a certain lossless transmission line is 72 Ω. If

L = 0.5μH / m, Find C, v_{ph} and β If f = 80MHz.

*h*int

characteristic impedance $z_o = \sqrt{\frac{L}{c}} = 72 = \sqrt{\frac{0.5*10^{-6}}{C}}$

$$V_{ph} = \frac{1}{\sqrt{LC}}$$

$$\beta = \omega\sqrt{LC}$$

Good Luck

Dr. Gehan Sami