ECE 391: Transmission Lines

Spring Term 2020

Homework Assignment #1

due Monday, Apr. 13 on Canvas

1. A SiGe digital chip has a rise and fall time of about 40ps. On a PCB with a Teflon dielectric ($\epsilon_r = 2.2$), up to what lengths (in mm) can transmission line effects be ignored? (Assume an effective dielectric constant equal to the dielectric constant.) How does your result change if you use an FR4 PCB with $\epsilon_r = 4.5$?

   Useful Information: Propagation velocity of a signal on a channel with a relative dielectric (Vp) is given as $v_p = \frac{c}{\sqrt{\epsilon_r}}$. Transmission line effects (transit time effect) can be ignored if the signal delay through the transmission line is less than one sixth of the rise or fall time of the signal.

2. Find the component body dimensions of:

   (i) 1/4W axial leaded resistor
   (ii) 0402 SMD resistor

   Assume that these elements will be used in an RF circuit with sinusoidal excitation. Also, assume the velocity of propagation across the elements is equal to $0.6c$, where $c = 3e8$ m/s. For each component, compute the upper frequency below which it can safely be considered to be a lumped element. Use the lambda versus component body size criterion.

   Useful Information: Transit time effect can be safely ignored if the length of the transmission line is less than 1% of the signal wavelength.

3. A sinusoidal wave $f(z,t) = A\sin(\omega t + \beta z - \pi/6)$ with phase constant $\beta = 0.4\pi$ rad/m travels with phase velocity $v_p = 15$cm/ns. Determine (a) the direction of wave propagation, (b) the frequency of the wave, and (c) the wavelength of the wave.

4. (a) A loss-less transmission line has the following distributed parameters: $L = 1.3\mu$H/m and $C = 14.5$pF/m. Determine the characteristic impedance.