1. The amplitude of an XM Satellite Radio Wave is described by the function:

\[ z(y,t) = 0.6\cos(24 \times 10^9 \pi t + 160\pi y - \frac{\pi}{3}) e^{0.00003y} \text{ (Volts/m)} \]  \hspace{1cm} (1)

This signal is received by a parabolic antenna and is fed to a rectangular Teflon-filled \((\varepsilon_r = 2.1)\) waveguide with a cross-section of \(2.286\text{cm} \times 1.016\text{cm}\).

(a) Calculate the cutoff frequencies \(f_{c\alpha}\) for all TE/TM modes that are excited by the XM signal and sort them in ascending order. Is the system well-designed? (15\%)

(b) Determine the propagation constant and the transverse-wave impedance for the dominant TE mode at the frequency of the XM signal. How close are these values to the TEM values? (15\%)

(c) The above waveguide is terminated in a hotel Media room with a transceiver that is equivalent to a series combination of a resistor \(R = 60\Omega\) and of an inductor \(L = 0.266nH(= 20/(24\pi))\). Assuming that only the dominant mode can propagate, through the use of the appropriate waveguide filters, what is the reflection Coefficient \(\Gamma\) and the Standing Wave Ratio \(S\) at the load? Is it a good matching? (10\%)

2. The XM wave of Problem (1) propagates at a \(75 - \Omega\) lossless coaxial line which is terminated in 50 rooms. Each room’s transceiver is equivalent to a combination of a series resistor \(R = 3000\Omega\), a shunt capacitor \(C = 20pF\) and a series resistor \(R = 3000\Omega\).

(a) Calculate the ABCD and Y matrices for EACH ROOM’S transceiver, ignoring the length of the feeding line. (10\%)

(b) Is it reciprocal (verify) and/or lossless? (10\%)

(c) Plot the \(\pi\) equivalent circuits. (5\%)

3. A parallel polarized monochromatic laser wave in air is obliquely incident upon a Silicon printboard at an incidence angle of 30\(^\circ\). The wave frequency is 50 GHz (1 GHz = \(10^9\) Hz), and the dielectric constant of Silicon is 10.89 (Silicon is a nonmagnetic lossless material). If the electric field amplitude of the incident wave is 20 mV/m (quality control-phasmatooscopy), determine: (a) the reflection and transmission coefficients; What is the ratio of the transmitted over the incident power? (15\%)

(b) the phasor expressions for Incident and Transmitted Electric field, (20\%)

(c) – BONUS If the Silicon layer gets replaced by a lossy Teflon layer with \(\varepsilon_r = 2.1, \sigma = 0.003\text{S/m}\), how many skin depths will be needed for the attenuation of the power to the 0.01\% of its maximum value in the Teflon region? (10\%)

GOOD LUCK !!!