Transmission Lines and Antennas, 2012-3
Exercises on physical transmission lines and waveguides (2)

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1 Comparison of Rectangular/Circular Waveguides and Coaxial line

Consider air-filled rectangular and circular waveguides and a coaxial line filled with teflon. Compute their dimensions such that they have the same upper frequency limit (cutoff frequency for the first higher-order mode) of 10GHz and compare them in terms of:

- Attenuation in dB/m at 7GHz and 9GHz considering both conduction and dielectric loss where applicable.
- Power handling considering dielectric breakdown (you need to evaluate numerically the integral required for the circular waveguide case).

2 Tx Line model of waveguides

Consider a rectangular waveguide operating in its fundamental mode alone. In this condition we have that fields for a wave propagating along z are:

$$\mathbf{H}(x,y,z) = H_0\left[\hat{x}\frac{j\beta a}{\pi}\sin\left(\frac{\pi x}{a}\right)+\hat{z}\cos\left(\frac{\pi x}{a}\right)\right]e^{-j\beta z} \quad (1)$$

$$\mathbf{E}(x,y,z) = -\hat{y}H_0 Z_{TE_{10}}\frac{j\beta a}{\pi}\sin\left(\frac{\pi x}{a}\right)e^{-j\beta z} \quad (2)$$

$$Z_{TE_{10}} = \frac{\omega\mu}{\beta} \quad (3)$$

A transmission line model can be given in terms of equivalent voltage/current which refer only to the transverse components of the fields as follows:

$$I(z) = I_0 e^{-j\beta z} \quad (4)$$

$$V(z) = Z_c I_0 e^{-j\beta z} \quad (5)$$

$$Z_c = Z_{TE_{10}} \quad (6)$$

1. Find the value of I_0 such that the circuit and field expressions give the same power flow: $\frac{1}{2}\Re\left(VI^*\right) = \frac{1}{2}\iint\Re\left(\mathbf{E}\times\mathbf{H}^*\right)ds$
2. Use the above model to compute the reflection coefficient of a waveguide WR430 with length 50cm that has its final 10cm filled with a material with $\epsilon_r = 2 - j0.1, \mu_r = 1$ and terminates in short circuit as shown in the diagram.