EE 363M Spring 2000
Homework Set 6
Wed. April 5
Due: Wed. April 12

1. (10 points) Using the formulas from Wheeler calculate the following for a microstrip on a microwave pc board with the characteristics:
$\varepsilon_r = 2.2$ loss tangent: $\tan\theta = 9\text{x}10^{-4}$ h = 25 mils w = 74 mils t = 1.4 mils (1 oz. copper)

a) Z_o for the line.

b) The effective dielectric constant, phase velocity (in fractions of c, the speed of light), and the guide wavelength at 10GHz.

c) Check the results of (a) and (b) against the simple empirical results for a wide (i.e. h < 0.8w) line:

$$\varepsilon_{reff} = 0.475\cdot\varepsilon_r + 0.67 \qquad Z_o = \frac{87}{\sqrt{\varepsilon_r + 1.41}}\ln\left[\frac{5.98h}{0.8w + t}\right]$$

d) Check results against those in Pozar, pp. 185-186:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\cdot\frac{1}{\sqrt{1 + 12\,h/w}}\,,\quad Z_O = \begin{cases} \dfrac{60}{\sqrt{\varepsilon_{reff}}}\ln\left(\dfrac{8h}{w} + \dfrac{w}{4h}\right) & \text{for } w/h \le 1 \\ \dfrac{120\pi}{\sqrt{\varepsilon_{reff}}\left[w/h + 1.393 + 0.667\ln(w/h + 1.444)\right]} & \text{for } w/h > 1 \end{cases}$$

e) Find the dielectric loss factor α_d and conductor (assume the metal is copper) loss factor α_c (the units below are dB/distance, found by multiplying the field loss factors by 8.68) at 10 GHz.

$$\alpha_d \approx 8.68\cdot\frac{\beta_O\,\varepsilon_r\,(\varepsilon_{reff} - 1)}{2\sqrt{\varepsilon_{reff}}\,(\varepsilon_r - 1)}\cdot\tan\theta \ \text{ dB/distance},\quad \alpha_c = 8.68\cdot\frac{R}{2\,Z_O} \ \text{ dB/distance, where}$$

$$R \approx \frac{1}{\sigma\cdot\delta\cdot(\text{perimeter})} = \sqrt{\frac{\omega\cdot\mu_o}{2\cdot\sigma}}\cdot\frac{1}{(2w + 2t)}$$

2. (10 points) You are now given a different microwave pc board and asked to design a 50? line; again use the formulas from Wheeler. The new board characteristics are:
$\varepsilon_r = 10.2$ loss tangent: $\tan\theta = 2\text{x}10^{-3}$ h = 25 mils t = 1.4 mils

a) Find the linewidth w.

b) What is the effective dielectric constant, phase velocity (in fractions of c), and the guide wavelength at 10GHz?

c) Using the equations above, what is the dielectric loss factor α_d and conductor (for copper) loss factor α_c (in dB/cm) at 10 GHz?

d) Check the results of (a) and (b) against the empirical formulas given in Pozar pp. 185-186:

$$\frac{w}{h} = \begin{cases} \dfrac{8e^A}{e^{2A} - 2} & \textit{for } w/h < 2 \\ \dfrac{2}{p}\left[B - 1 - \ln(2B - 1) + \dfrac{e_r - 1}{2\,e_r}\left\{\ln(B - 1) + 0.39 - \dfrac{0.61}{e_r}\right\}\right] & \textit{for } w/h > 2 \end{cases}$$

$$A = \frac{Z_O}{60}\sqrt{\frac{e_r + 1}{2}} + \frac{e_r - 1}{e_r + 1}\left(0.23 + \frac{0.11}{e_r}\right),\quad B = \frac{377\,p}{2\,Z_O\sqrt{e_r}}$$