Design a 40 Ω microstrip TL using a 1 oz. copper clad ($\sigma = 5.8 \times 10^7$ S/m) PTFE/woven fiberglass substrate ($\varepsilon_r = 2.33$, $\tan\delta = 0.0011$) that is 3.25 mm thick for use at 8 GHz. Draw a full-labeled sketch of your design. Compute: a) the effective relative permittivity, b) phase velocity, c) phase constant, d) dielectric attenuation constant (Np/m & dB/m), e) conductor attenuation constant (Np/m & dB/m), and f) overall attenuation constant (Np/m & dB/m).

→ Determine W/d using (3.197) and related equations

$$A = \frac{Z_0}{60}\sqrt{\frac{\epsilon_r+1}{2}} + \frac{\epsilon_r-1}{\epsilon_r+1}\left(0.23+\frac{0.11}{\epsilon_r}\right) = \frac{40}{60}\sqrt{\frac{2.33+1}{2}} + \frac{2.33-1}{2.33+1}\left(0.23+\frac{0.11}{2.33}\right)$$

$$= 0.97095$$

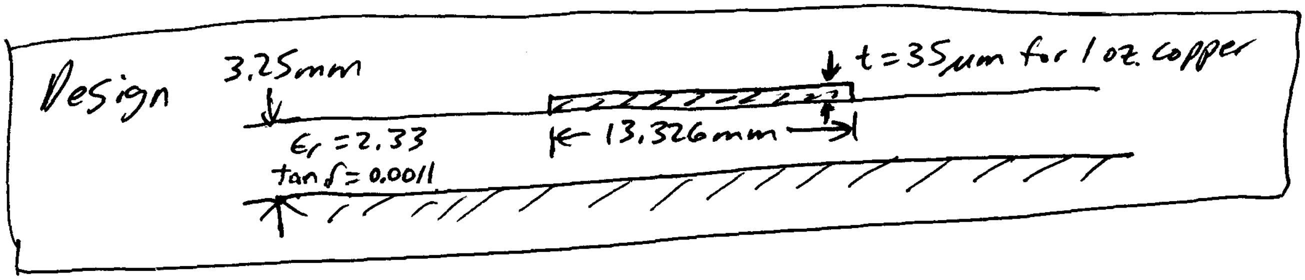
$$B = \frac{377\pi}{2Z_0\sqrt{\epsilon_r}} = \frac{377\pi}{2(40)\sqrt{2.33}} = 9.69892$$

$$\text{Try } W/d = \frac{8e^A}{e^{2A}-2} = \frac{8e^{0.971}}{e^{2(0.971)}-2} = 4.2485 > 2 \text{ NO!}$$

$$\text{Use } \frac{W}{d} = \frac{2}{\pi}\left[B-1-\ln(2B-1) + \frac{\epsilon_r-1}{2\epsilon_r}\left(\ln(B-1)+0.39-\frac{0.61}{\epsilon_r}\right)\right]$$

$$= \frac{2}{\pi}\left[9.699-1-\ln\left(2(9.699)-1\right) + \frac{2.33-1}{2(2.33)}\left(\ln(8.699)+0.39-\frac{0.61}{2.33}\right)\right]$$

$$= 4.10026 \rightarrow W = 4.10026(3.25\text{mm}) \Rightarrow \underline{W = 13.326\text{mm}}$$



a) Per (3.195),

$$\epsilon_{re} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\frac{1}{\sqrt{1+12d/W}}$$

$$= \frac{2.33+1}{2} + \frac{2.33-1}{2}\frac{1}{\sqrt{1+12(3.25/13.326)}}$$

$$\underline{\epsilon_{re} = 2.00059}$$

b) Per (3.193), $v_p = c/\sqrt{\epsilon_{re}} = \frac{2.9979\times10^8}{\sqrt{2.0006}} \Rightarrow \underline{\underline{v_p = 2.1195\times10^8 \text{ m/s}}}$

c) Per (3.194), $\beta = \omega/v_p = \frac{2\pi(8\times10^9)}{2.1195\times10^8} \Rightarrow \underline{\underline{\beta = 237.153 \frac{\text{rad}}{\text{m}}}}$

d) Use (3.198) for α_d $\quad k_0 = \omega/c = \frac{2\pi(8\times10^9)}{2.9979\times10^8} = 167.6676 \frac{\text{rad}}{\text{m}}$

$$\alpha_d = \frac{k_0\epsilon_r(\epsilon_{re}-1)\tan\delta}{2\sqrt{\epsilon_{re}}(\epsilon_r-1)} = \frac{167.67(2.33)(2.0006-1)0.0011}{2\sqrt{2.0006}(2.33-1)}$$

$$\underline{\underline{\alpha_d = 0.1143 \text{ Np/m} = 0.9927 \text{ dB/m}}}$$

e) Use (3.199) for α_c

$$(1.125)\quad R_s = \sqrt{\frac{\omega\mu}{2\sigma}} = \sqrt{\frac{2\pi\,8\times10^9(4\pi\times10^{-7})}{2(5.8\times10^7)}} = 0.02334\,\Omega$$

$$\alpha_c = \frac{R_s}{Z_0 W} = \frac{0.02334}{40(0.013326)} =$$

$$\underline{\underline{\alpha_c = 0.04378 \text{ Np/m} = 0.38025 \text{ dB/m}}}$$

f) $\alpha = \alpha_c + \alpha_d = 0.04378 + 0.1143$

$$\underline{\underline{\alpha = 0.1581 \text{ Np/m} = 1.373 \text{ dB/m}}}$$