3.19 A copper stripline transmission line is to be designed for a 100 Ω characteristic impedance. The ground plane separation is 1.02 mm and the dielectric constant is 2.20, with $\tan\delta = 0.001$. At 5 GHz, find the guide wavelength on the line and the total attenuation.

- Assume the land is 1 oz. copper. Draw a fully-labeled sketch of the design.

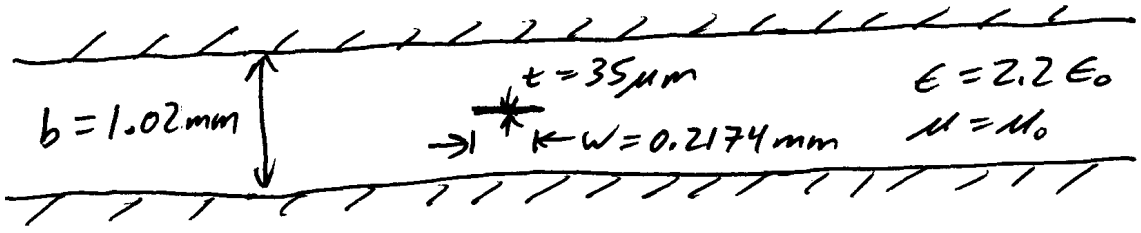
The parameter $\sqrt{\epsilon_r}\, Z_0 = \sqrt{2.2}\,100 = 148.3\,\Omega$ is needed for (3.180a & b) and (3.181).

(3.180b) $x = \frac{30\pi}{\sqrt{\epsilon_r}\, Z_0} - 0.441 = \frac{30\pi}{148.3} - 0.441 = 0.194418$

Use bottom equation of (3.180a)

$$\frac{W}{b} = 0.85 - \sqrt{0.6 - x} = 0.213147$$

$$W = 0.213147\,(1.02\text{ mm}) = \underline{0.21741\text{ mm}}$$



Per (3.176), $v_p = c/\sqrt{\epsilon_r} = \frac{2.9979\times10^8}{\sqrt{2.2}} = 2.0212\times10^8\text{ m/s}$

$$\lambda_g = v_p/f = \frac{2.0212\times10^8}{5\times10^9}$$

$$\underline{\lambda_g = 0.040424\text{ m} = 4.0424\text{ cm}}$$

Find dielectric attenuation constant using (3.30)

$$\alpha_d = \frac{k \tan\delta}{2} = \frac{2\pi(5\times10^9)\sqrt{4\pi\times10^{-7}(2.2)8.854\times10^{-12}}\,0.001}{2}$$

$$\alpha_d = 0.07772 \text{ Np/m}$$

Find conduction attenuation constant from bottom equation $\sqrt{\varepsilon_r}$ to >120 Ω of (3.181)

$$\alpha_c = \frac{0.16 R_s}{Z_0 b} B$$

where (1.125) $R_s = \sqrt{\frac{\omega\mu}{2\sigma}} = \sqrt{\frac{2\pi(5\times10^9)4\pi\times10^{-7}}{2(5.813\times10^7)}}$

$$= 0.018427\ \Omega$$

→ Copper is non-magnetic (μ_0) and $\sigma_{Cu} = 5.813\times10^7$ S/m from Appendix F of text

From text, $B = 1 + \frac{b}{0.5W+0.7t}\left[0.5 + \frac{0.414t}{W} + \frac{1}{2\pi}\ln\left(\frac{4\pi W}{t}\right)\right]$

$$B = 1 + \frac{1.02\times10^{-3}}{0.5(2.1741\times10^{-4})+0.7(35\times10^{-6})}\left[0.5 + \frac{0.414(35\times10^{-6})}{2.1741\times10^{-4}} + \frac{1}{2\pi}\ln\left(\frac{4\pi\,2.174\times10^{-4}}{35\times10^{-6}}\right)\right]$$

$$= 1 + 7.6574[0.5 + 0.06665 + 0.69351] = 10.64951$$

$$\alpha_c = \frac{0.16(0.018427)}{100(1.02\times10^{-3})}\,10.64951 \Rightarrow \alpha_c = 0.30783 \text{ Np/m}$$

$$\alpha = \alpha_c + \alpha_d = 0.30783 + 0.07772 \Rightarrow \boxed{\alpha = 0.38555 \text{ Np/m}}$$

$$\boxed{\alpha = 3.349 \text{ dB/m}}$$