Design a 75 Ω stripline using a ground plane separation of 1.5 mm with an ABS dielectric ($\varepsilon_r = 2$, $\tan\delta = 0.005$). Assume the ground planes and land are made with 2 oz. copper (ε_0, μ_0, $\sigma = 5.7 \times 10^7$ S/m). Draw a fully-labeled sketch of the design. At 2 GHz, find: a) the phase velocity, b) guided wavelength, 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).

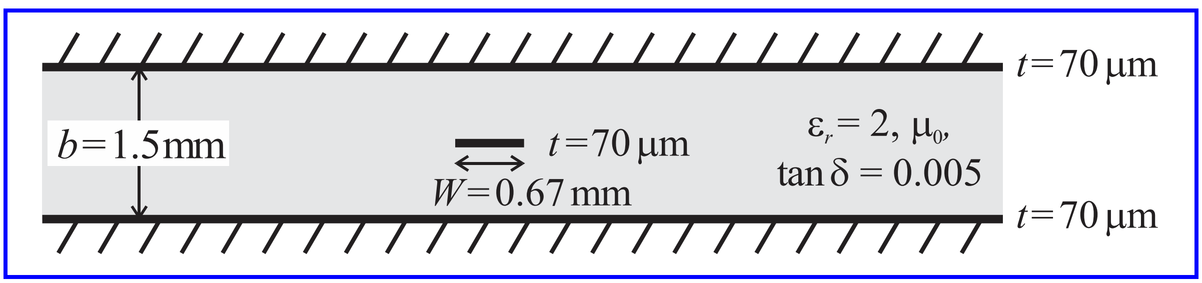
Given dimensions: $b = 1.5$ mm and $t = 70$ μm (2 oz. copper).

Per (3.180a), $\dfrac{W}{b} = \begin{cases} x & \text{for } \sqrt{\varepsilon_r}Z_0 < 120\,\Omega \\ 0.85 - \sqrt{0.6 - x} & \text{for } \sqrt{\varepsilon_r}Z_0 > 120\,\Omega \end{cases}$ where (3.180b) $x = \dfrac{30\pi}{\sqrt{\varepsilon_r}Z_0} - 0.441$.

Here, $\sqrt{\varepsilon_r}Z_0 = \sqrt{2}\,(75) = 106.066\ \Omega < 120\ \Omega$ and $x = \dfrac{30\pi}{\sqrt{2}\,(75)} - 0.441 = 0.447577$.

Using the bottom equation of (3.180a), $\dfrac{W}{b} = x = 0.447577$. Therefore, the land width is

$W = x\,b = (0.447577)1.5$ $\Rightarrow$ **$W = 0.6714$ mm**.



a) Per (3.76), $v_p = \dfrac{c}{\sqrt{\varepsilon_r}} = \dfrac{2.9979\times10^8}{\sqrt{2}}$ $\Rightarrow$ **$v_p = 2.11985 \times 10^8$ m/s**.

b) $\lambda_g = \dfrac{v_p}{f} = \dfrac{2.11985\times10^8}{2\times10^9}$ $\Rightarrow$ **$\lambda_g = 0.10599$ m $= 10.6$ cm**.

c) Per (3.177), $\beta = \dfrac{\omega}{v_p} = \dfrac{2\pi(2\times10^9)}{2.11985\times10^8}$ $\Rightarrow$ **$\beta = 59.27945$ rad/m**.

[Note: For a TEM wave, $k = \beta$.]

d) Per (3.30), $\alpha_d = \dfrac{k\tan\delta}{2} = \dfrac{59.27945(0.005)}{2}$ $\Rightarrow$ **α_d = 0.1482 Np/m = 1.2872 dB/m**.

e) Per (3.181), $\alpha_c = \begin{cases} \dfrac{2.7\times10^{-3} R_s \varepsilon_r Z_0}{30\pi(b-t)} A & \text{for } \sqrt{\varepsilon_r} Z_0 < 120\,\Omega \\ \dfrac{0.16 R_s}{Z_0 b} B & \text{for } \sqrt{\varepsilon_r} Z_0 > 120\,\Omega \end{cases}$

where $A = 1 + \dfrac{2W}{b-t} + \dfrac{1}{\pi}\dfrac{b+t}{b-t}\ln\left(\dfrac{2b-t}{t}\right)$ and

$B = 1 + \dfrac{b}{0.5W + 0.7t}\left[0.5 + \dfrac{0.414t}{W} + \dfrac{1}{2\pi}\ln\left(\dfrac{4\pi W}{t}\right)\right]$. Here, $\sqrt{\varepsilon_r} Z_0 = 106.066\ \Omega$.

Per (1.125), $R_s = \sqrt{\dfrac{\omega\mu}{2\sigma}} = \sqrt{\dfrac{2\pi(2\times10^9)4\pi\times10^{-7}}{(2)5.7\times10^7}}$ $\Rightarrow$ $R_s = 0.011769\,\Omega$

$$A = 1 + \frac{2(0.6714\times10^{-3})}{1.5\times10^{-3} - 70\times10^{-6}} + \frac{1}{\pi}\left(\frac{1.5\times10^{-3} + 70\times10^{-6}}{1.5\times10^{-3} - 70\times10^{-6}}\right)\ln\left(\frac{2(1.5\times10^{-3}) - 70\times10^{-6}}{70\times10^{-6}}\right)$$

$\Rightarrow A = 3.244$.

$\alpha_c = \dfrac{2.7\times10^{-3}(0.01177)2(75)}{30\pi(1.5\times10^{-3} - 70\times10^{-6})}(3.244)$ $\Rightarrow$ **α_c = 0.1147 Np/m = 1.2872 dB/m**.

f) The overall attenuation constant at 2 GHz is

$\alpha_d + \alpha_c = 0.1482 + 0.1147$ $\Rightarrow$ **α = 0.2629 Np/m = 2.2838 dB/m.**