For a microstrip TL made using a 2 oz. copper clad (ε_0, μ_0, $\sigma = 5.7 \times 10^7$ S/m) ABS substrate ($\varepsilon_r = 2$, $\tan\delta = 0.005$) that is 0.75 mm thick for use at 2 GHz, calculate the threshold frequencies. Is the operating frequency of 2 GHz lower than these threshold frequencies?

****

Design a 75 Ω microstrip TL using a 2 oz. copper clad (ε_0, μ_0, $\sigma = 5.7 \times 10^7$ S/m) ABS substrate ($\varepsilon_r = 2$, $\tan\delta = 0.005$) that is 0.75 mm thick for use at 2 GHz. Draw a full-labeled sketch of your design. <snip>

From earlier problem: $d = 0.75$ mm, $t = 70$ μm (2 oz. copper), and $W = 1.2794$ mm.

****

Per (3.201), the TM_1 surface wave threshold frequency is approximately

$$f_{T1} \simeq \frac{c}{2\pi d}\sqrt{\frac{2}{\varepsilon_r - 1}}\tan^{-1}\varepsilon_r = \frac{2.9979\times10^8}{2\pi(0.75\times10^{-3})}\sqrt{\frac{2}{2-1}}\tan^{-1}2$$

$$\Rightarrow \underline{f_{T1} = 9.961\times10^{10} \text{ Hz} = 99.61 \text{ GHz}}.$$

Per (3.202), the TE_1 surface wave threshold frequency is approximately

$$f_{T2} \simeq \frac{c}{4d\sqrt{\varepsilon_r - 1}} = \frac{2.9979\times10^8}{4(0.75\times10^{-3})\sqrt{2-1}} \quad \Rightarrow \underline{f_{T2} = 9.993\times10^{10} \text{ Hz} = 99.93 \text{ GHz}}.$$

Per (3.203), the transverse resonance threshold frequency is approximately

$$f_{T3} \simeq \frac{c}{\sqrt{\varepsilon_r}\,(2W + d)} = \frac{2.9979\times10^8}{\sqrt{2}\,[2(1.2794\times10^{-3}) + 0.75\times10^{-3}]}$$

$$\Rightarrow \underline{f_{T3} = 6.407\times10^{10} \text{ Hz} = 64.07 \text{ GHz}}.$$

Per (3.204), the parallel plate waveguide mode threshold frequency is approximately

$$f_{T4} \simeq \frac{c}{2d\sqrt{\varepsilon_r}} = \frac{2.9979\times10^8}{2(0.75\times10^{-3})\sqrt{2}} \quad \Rightarrow \underline{f_{T4} = 1.4132\times10^{11} \text{ Hz} = 141.32 \text{ GHz}}.$$

Yes, the 2 GHz operating frequency of the microstrip TL is **far** below the threshold frequencies.