

**Problem 7.36** A team of scientists is designing a radar as a probe for measuring the depth of the ice layer over the antarctic land mass. In order to measure a detectable echo due to the reflection by the ice-rock boundary, the thickness of the ice sheet should not exceed three skin depths. If  $\epsilon'_r = 3$  and  $\epsilon''_r = 10^{-2}$  for ice and if the maximum anticipated ice thickness in the area under exploration is 1.2 km, what frequency range is useable with the radar?

**Solution:**

$$3\delta_s = 1.2 \text{ km} = 1200 \text{ m}$$

$$\delta_s = 400 \text{ m.}$$

Hence,

$$\alpha = \frac{1}{\delta_s} = \frac{1}{400} = 2.5 \times 10^{-3} \text{ (Np/m).}$$

Since  $\epsilon''/\epsilon' \ll 1$ , we can use (7.75a) for  $\alpha$ :

$$\alpha = \frac{\omega\epsilon''}{2} \sqrt{\frac{\mu}{\epsilon'}} = \frac{2\pi f\epsilon''_r\epsilon_0}{2\sqrt{\epsilon'_r}\sqrt{\epsilon_0}} \sqrt{\mu_0} = \frac{\pi f\epsilon''_r}{c\sqrt{\epsilon'_r}} = \frac{\pi f \times 10^{-2}}{3 \times 10^8 \sqrt{3}} = 6f \times 10^{-11} \text{ Np/m.}$$

For  $\alpha = 2.5 \times 10^{-3} = 6f \times 10^{-11}$ ,

$$f = 41.6 \text{ MHz.}$$

Since  $\alpha$  increases with increasing frequency, the useable frequency range is

$$f \leq 41.6 \text{ MHz.}$$