MICROWAVE SHIELDING FOR PERFECT TRANSMISSION

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References: Griffiths, David J. (2007), Introduction to Electrodynamics, 3rd Edition; Pearson Education - Problem 9.35.

Here's a simple example of the transmission coefficient for waves passing from medium 1 through medium 2 into medium 3. Suppose we want to protect a microwave antenna from the weather by enclosing it in a plastic shield, where the dielectric constant of the plastic is 2.5. If the antenna radiates at 10 GHz, what is the best (that is, smallest) thickness of plastic?

The transmission coefficient is given by

$$T^{-1}=\frac{1}{4n_1n_3}\left[\left(n_1+n_3\right)^2+\sin^2\left(\frac{n_2\omega d}{c}\right)\frac{\left(n_1^2-n_2^2\right)\left(n_3^2-n_2^2\right)}{n_2^2}\right] \tag{1}$$

where n_j is the index of refraction of medium j, given by

$$n=\sqrt{\frac{\mu\epsilon}{\mu_0\epsilon_0}} \tag{2}$$

If $\mu=\mu_0$ then

$$n_2=\sqrt{\frac{\epsilon_2}{\epsilon_0}}=\sqrt{\epsilon_{r_2}}=\sqrt{2.5} \tag{3}$$

where ϵ_{r_2} is the dielectric constant of the plastic.

We can see that if the sine is zero and $n_1=n_3$ (which we're assuming here, since both mediums 1 and 3 are air with $n=1$), then $T=1$ and we get perfect transmission. The smallest thickness d is such that

$$\frac{n_2\omega d}{c} = \pi \tag{4}$$

$$\frac{2\pi\nu d\sqrt{2.5}}{c} = \pi \tag{5}$$

$$d = \frac{c}{2\sqrt{2.5}\nu} \tag{6}$$

$$= 9.49\times10^{-3}\text{ m} \tag{7}$$

A plastic shield of about 9.5 mm thickness would allow perfect transmission at that frequency.