Given for lossy dielectric, the electric and magnetic fields are :

$$\bar{E} = E_0 e^{-\alpha z} \cos(\omega t - \beta z)\hat{a}_x$$

$$\bar{H} = \frac{E_0}{|\eta|} e^{-\alpha z} \cos(\omega t - \beta z - \theta_\eta)\hat{a}_y$$

The Instantaneous expression of Poynting vector becomes:

$$\mathscr{P}(z,t) = \frac{E^2{}_0}{|\eta|} e^{-2\alpha z} \cos(\omega t - \beta z)\cos(\omega t - \beta z - \theta_\eta)\hat{a}_z$$

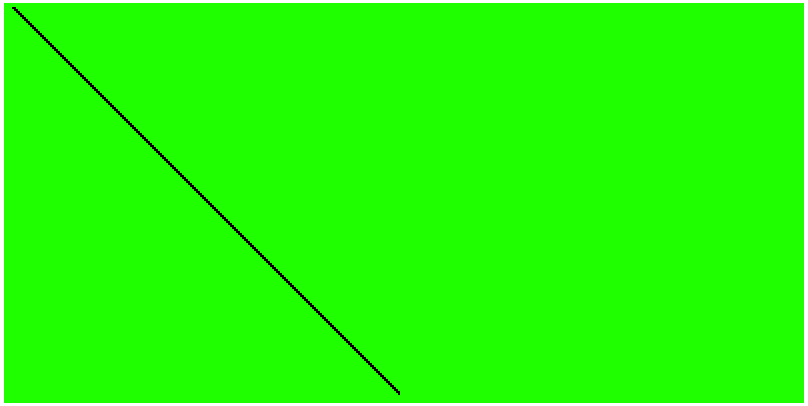
Average power :

$$\mathscr{P}_{av} = \frac{1}{2}\frac{E_0^2}{|\eta|} e^{-2\alpha z} \cos\theta_\eta$$

Plane Waves at Interfaces

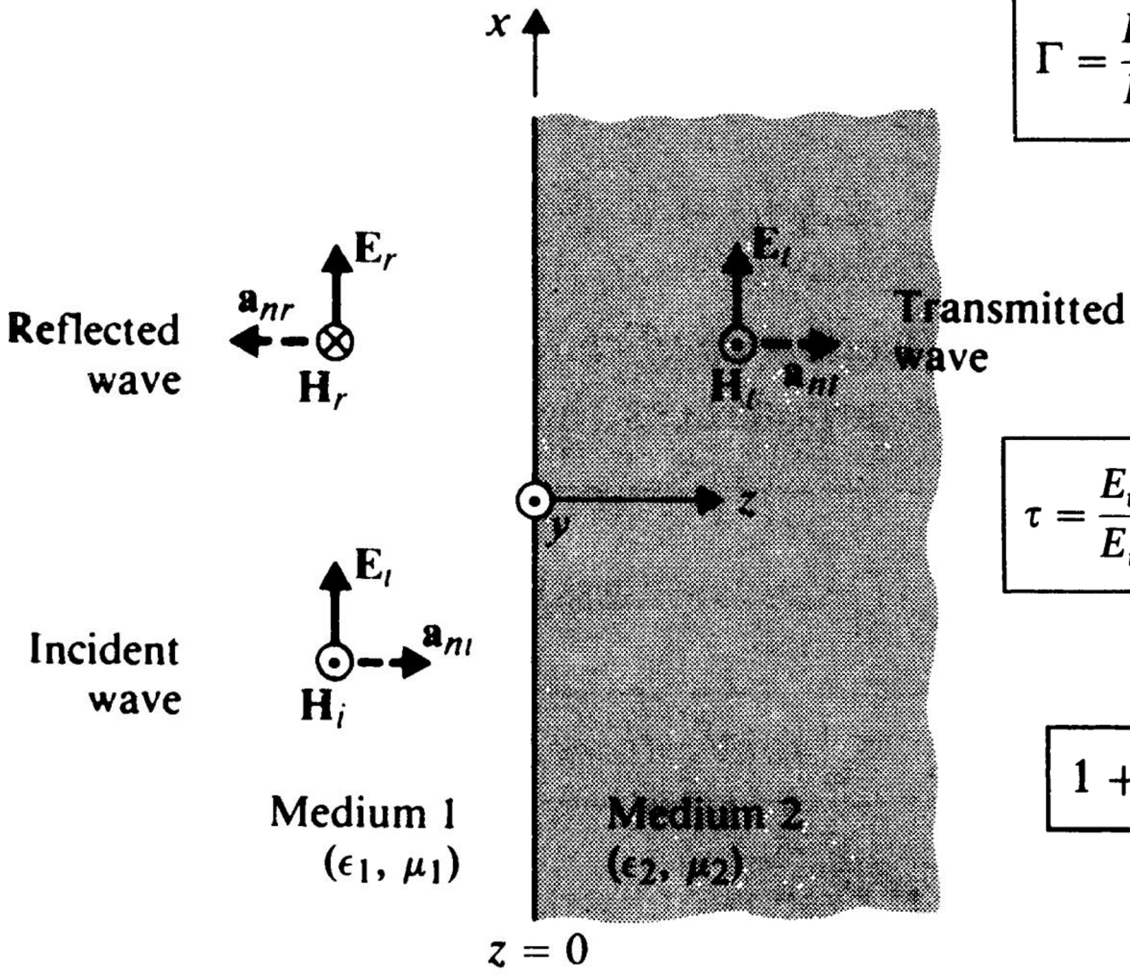
Important concept:

When an EM wave traveling in one medium impinges on another medium with a different intrinsic impedance, it experiences a reflection.



Ref: Hogan, R. J., and J. K. P. Shonk. Proc. ECMWF Seminar, 1-4 Sept 2008:

Normal Incidence -Plane Wave incident on boundary between two media

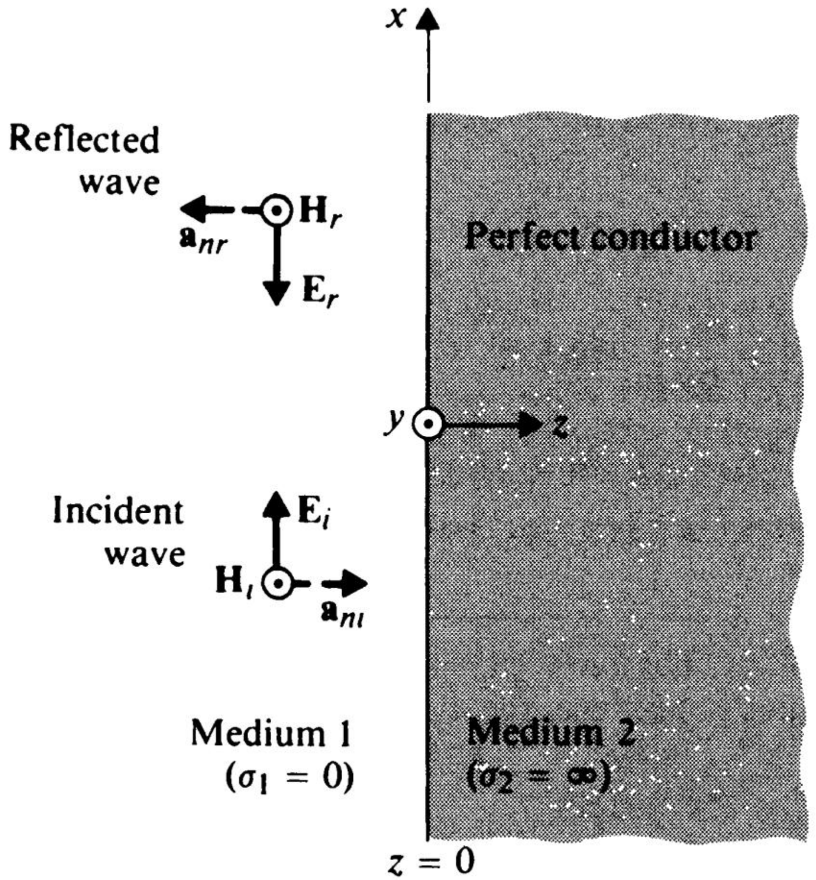


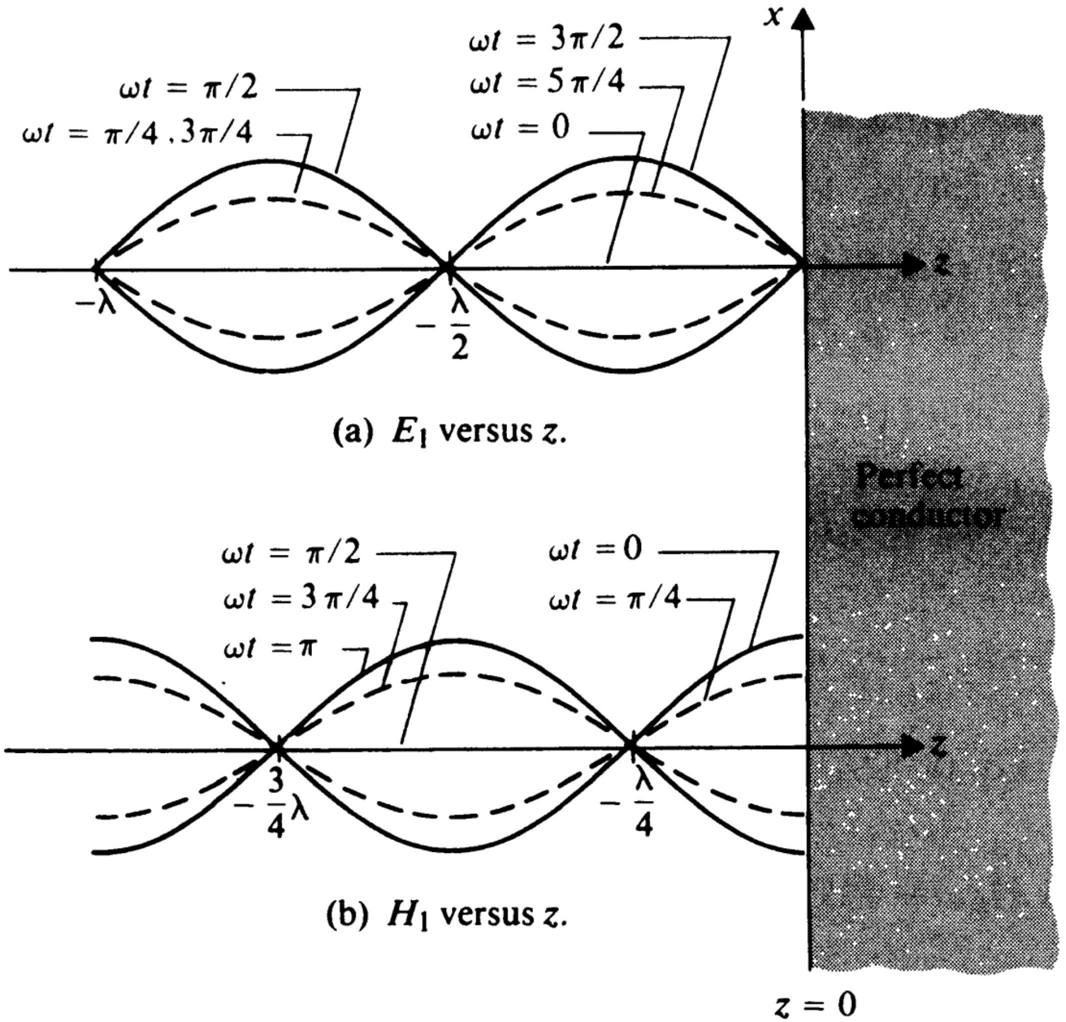
$$\Gamma = \frac{E_{r0}}{E_{i0}} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} \qquad \text{(Dimensionless)}$$

$$\tau = \frac{E_{t0}}{E_{i0}} = \frac{2\eta_2}{\eta_2 + \eta_1} \qquad \text{(Dimensionless).}$$

$$1 + \Gamma = \tau \qquad \text{(Dimensionless).}$$

Normal incidence at plane conducting boundary

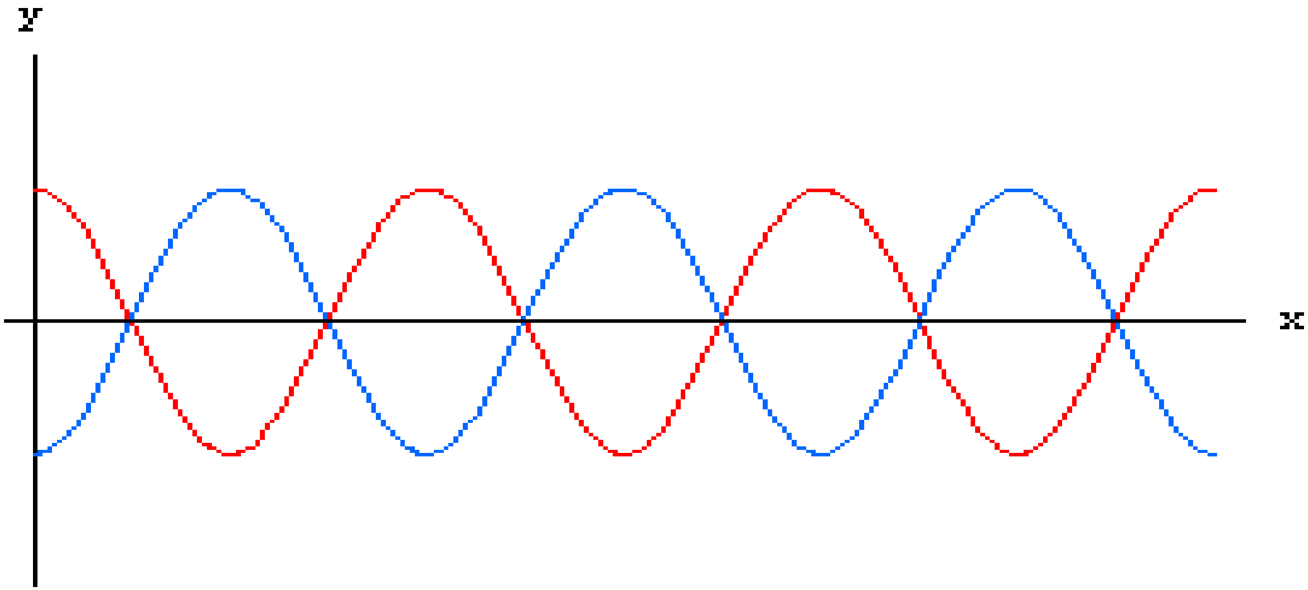




(a) E_1 versus z.

(b) H_1 versus z.

- It will result in a **pure standing wave.**
- It consists of a superposition of two waves traveling in opposite directions.
- The maxima and minima stand at the same location as time advances.



The ratio of the maximum value to the minimum value of the electric field intensity of a standing wave is called the **standing-wave ratio (SWR),** S

$$S = \frac{|E|_{\max}}{|E|_{\min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

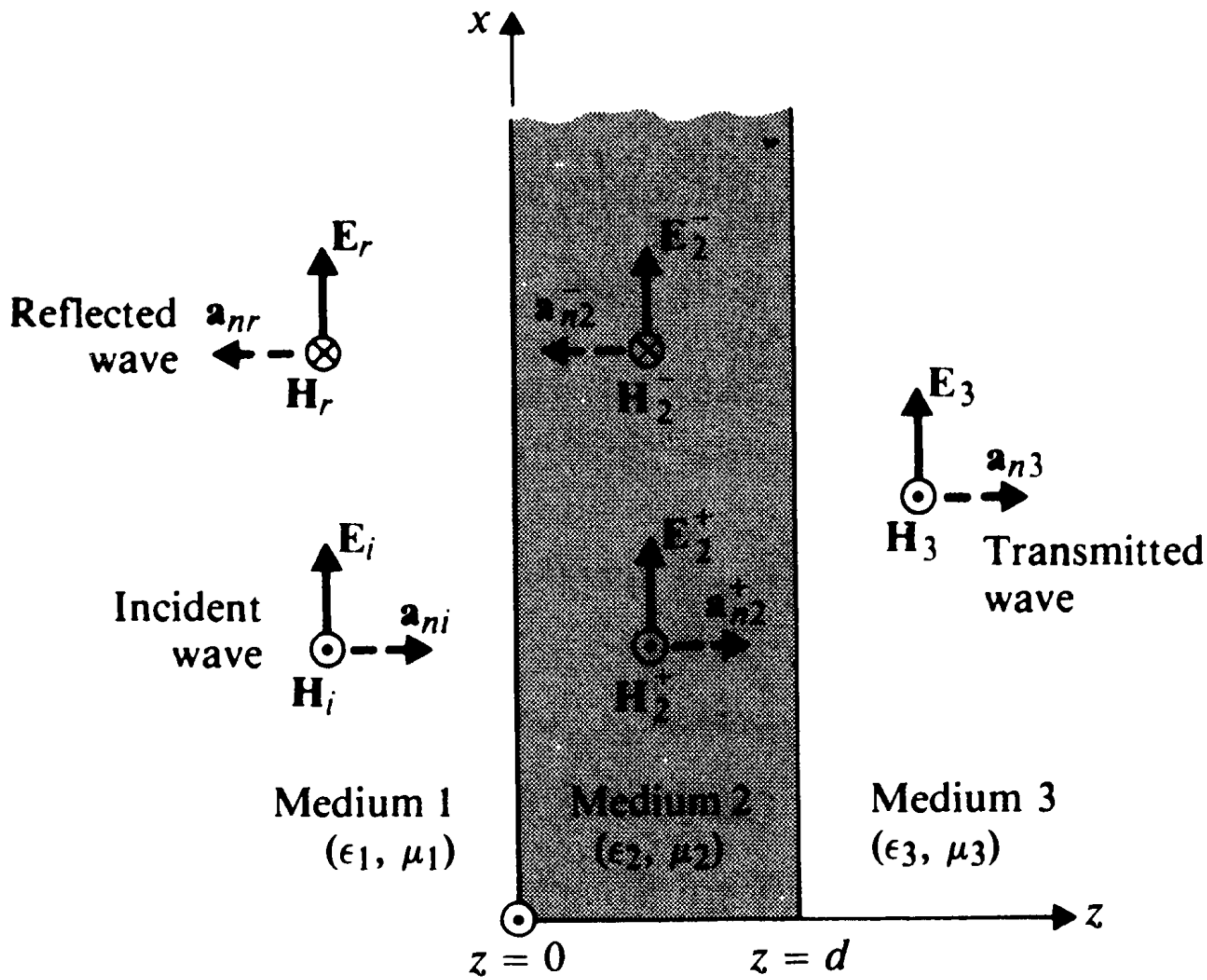
$$|\Gamma| = \frac{S-1}{S+1}$$

Multiple Dielectric Interfaces

- To reduce reflections and to improve the coupling of the wave energy.
- Applications include:
  - Stealth technology (specially coated aircraft to reduce radar reflectivity)
  - Antireflection coating to improve light transmission of a lens
  - RF shielding
  - Radar domes (radomes)

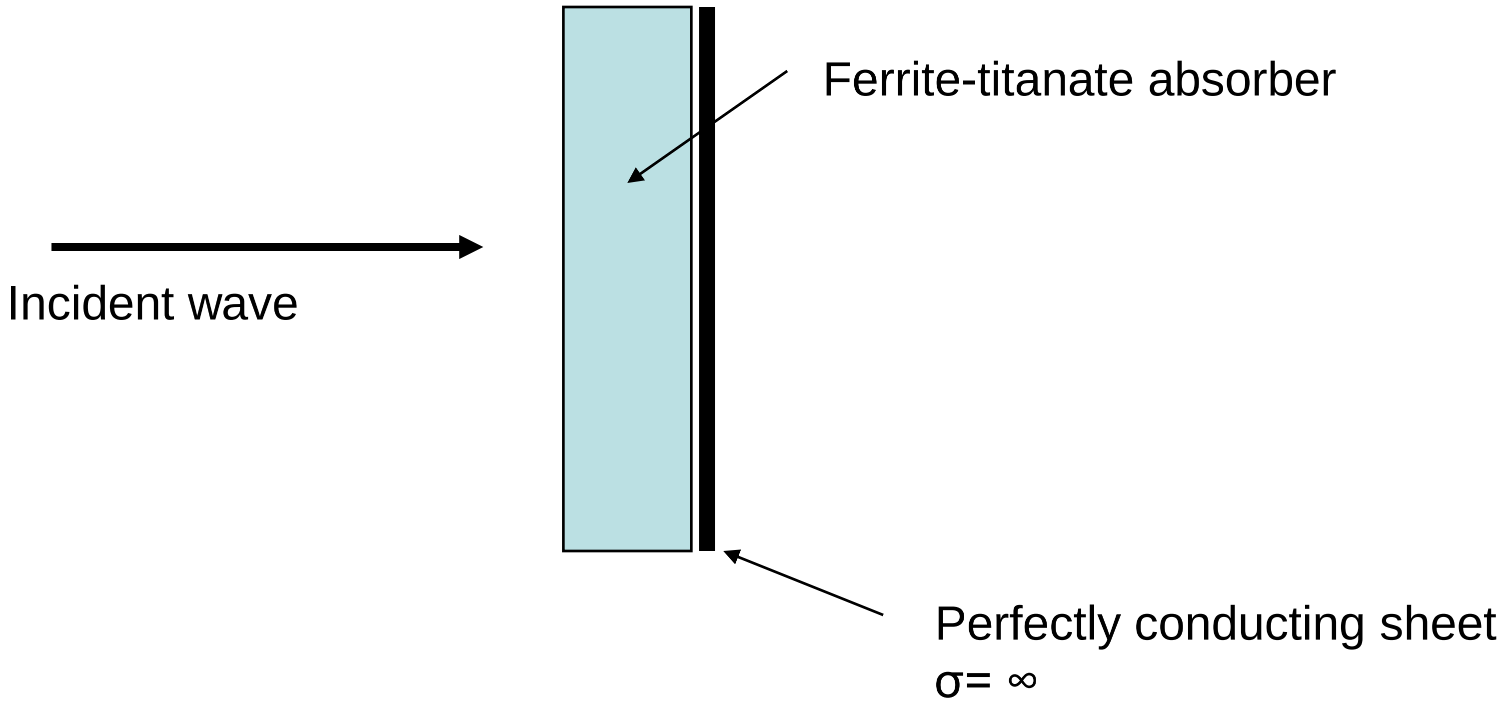
A **radome** (the word is a contraction of radar and dome) is a structural, weatherproof enclosure that protects a microwave (e.g.radar) antenna. The radome is constructed of material that minimally attenuates the electromagnetic signal transmitted or received by the antenna. In other words, **the radome is transparent to radar or radio waves.**

Multiple Dielectric Interfaces



Radar Absorbing Material

- For a wider bandwidth operation a lossy mixture of a **high-μ** (ferrite) material and a **high-ε**(barium titanate) material can be used.



Lossy medium with same impedance as space

- **Example-:** Let a plane 100-MHz (3-m) wave be incident normally on a solid ferrite-titanate slab of thickness d = 10 mm for which $\mu_r = \varepsilon_r = 60(2\text{-}j1)$. The medium is backed by a flat conducting sheet. How much is the reflected wave attenuated with respect to the incident wave? The medium is nonconducting (σ=0)
- **Results:**
  - total attenuation will be 22 dB down from the incident wave.
  - Thus, reflected wave power is less than 1/100 of the incident wave power.
  - Reduced enough for radar detection.

Transmission through a metal foil: RF Shielding

Practice Exercise

- In free space ($z \le 0$), a plane wave with

$$\vec{H}_i = 10\cos\left(10^8 t - \beta z\right)\hat{a}_x \, mA/m$$

is incident normally on a lossless medium ($\varepsilon = 2\varepsilon_o$, $\mu = 8\mu_o$) in region $z>=0$. Determine the reflected wave $\mathbf{H}_r$, $\mathbf{E}_r$ and the transmitted wave $\mathbf{H}_t$, $\mathbf{E}_t$