Incidence of EM Wave

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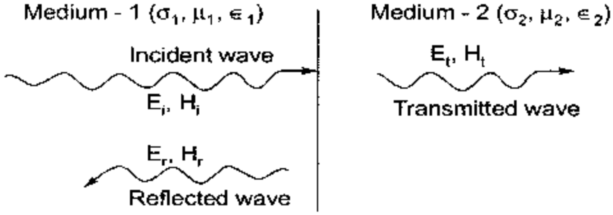
Normal Incidence



Reflection Coefficient

It is the ratio of electric field of reflected wave to the electric field of incident wave

$$\Gamma = \frac{E_r}{E_i} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

Note: ....

- Reflection coefficient is a complex quantity and can be written as

$$\Gamma = |\Gamma| e^{j\theta}$$

where $|\Gamma| = \rho$

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Transmission Coefficient (T)

It is defined as the ratio of transmitted electric field to the incident electric field

$$T = \frac{E_t}{E_i}$$

$$T = 1 + \Gamma$$

$$T = \frac{2\eta_2}{\eta_2 + \eta_1}$$

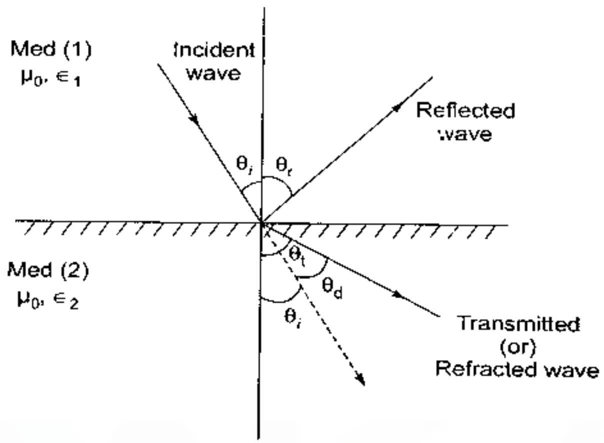
Standing Wave Ratio

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

Note:

- $0 \le |\Gamma| \le 1$.
- $1 \le S \le \infty$.
- Total power reflected $= P_{reflected} = \Gamma^2$.
- Total power transmitted $= P_{transmitted} = (1 - \Gamma^2)$.

Oblique Incidence



$$\boxed{\theta_d = \theta_i - \theta_t}$$

Snell's Law

$$\boxed{\eta_1 \sin\theta_i = \eta_2 \sin\theta_t}$$

where, $\eta_1 = C\sqrt{\mu_1 \epsilon_1} = C\sqrt{\epsilon_1}$; $\eta_2 = C\sqrt{\mu_2 \epsilon_2} = C\sqrt{\epsilon_2}$

are the refractive indices of the media.

Snell's law for EM wave is

$$\boxed{\frac{\sin\theta_t}{\sin\theta_i} = \sqrt{\frac{\epsilon_1}{\epsilon_2}}}$$

Total internal Reflection of EM wave

$$\boxed{\theta_c = \sin^{-1}\sqrt{\frac{\epsilon_2}{\epsilon_1}}}$$

where θ_c = critical angle for total internal reflection

Note:

θ_c is the minimum angle of incidence at which total internal reflection just starts.

Condition for total internal reflections

(a) $n_1 > n_2$

(b) $\theta_i \ge \theta_c$ or $\theta_i \ge \sin^{-1}\sqrt{\frac{\epsilon_2}{\epsilon_1}}$

(c) $T = 0 \quad \Rightarrow \Gamma = (T - 1) = -1$

Brewster's Angle (θ_B)

This is the angle of incidence for which complete transmission of EM wave occurs.

$$\boxed{\tan\theta_B = \sqrt{\frac{\epsilon_2}{\epsilon_1}} = \frac{n_2}{n_1}}$$

Note:

When a circularly or elliptically polarized wave is incident at Brewster's angle then the reflected and transmitted wave is linearly polarized. Therefore this angle is also known as polarization angle.

Polarization

This is the orientation electric vector at a fixed position in space with respect to time.

Linear Polarization

Condition: ($\phi = 0°$ or $180°$)

$$E_x = E_{x_0} \cos\omega t \text{ and } E_y = E_{y_0} \cos(\omega t + \phi)$$

1. **Parallel polarization**

$$E_x = E_{x_0} \cos\omega t \text{ and } E_y = 0$$

2. **Perpendicular polarization**

$$E_x = 0 \text{ and } E_y = E_{y_0} \cos\omega t$$

Circular Polarization

Condition: $(\phi = \pm 90°)$ and $(E_{x_0} = E_{y_0} = E_0)$

$$E_x = E_{x_0} \cos\omega t \text{ and } E_y = E_{y_0} \cos(\omega t + \phi) = \pm E_0 \sin\omega t$$

Note: ....

- If $\phi = +90°$ the rotation is in clockwise direction than the wave is said to be left hand circularly polarized.
- If $\phi = -90°$ the rotation is in anti-clockwise direction than the wave is said to be right hand circularly polarized.

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Elliptical Polarization

Condition: $(\phi = \pm 90°)$ and $(E_{x_0} \neq E_{y_0})$

$$E_x = E_{x_0} \cos\omega t \text{ and } E_y = E_{y_0} \cos(\omega t + \phi) = \pm E_{y_0} \sin\omega t$$

Note: ....

- If $\phi = +90°$ the rotation is in clockwise direction than the wave is said to be left hand elliptically polarized.
- If $\phi = -90°$ the rotation is in anti-clockwise direction than the wave is said to be right hand elliptically polarized.

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