Module 5 : Plane Waves at Media Interface

Lecture 38 : Wave Polarization at Media Interface

Objectives

In this course you will learn the following

- Wave Polarization at Media Interface.
- Brewster Angle.

Wave Polarization at Media Interface

- **Media interface can be used for changing the state of polarization of an Electromagnetic Wave**
- The electric field for any state of polarization can be resolved into two orthogonal components one parallel to the plane of incidence and other perpendicular to it. Therefore the incident electric field can be written as

$$\mathbf{E_i} = \mathbf{E_{i\parallel}} + \mathbf{E_{i\perp}} e^{j\phi}$$

- The reflected and transmitted fields can be written as

$$\mathbf{E_r} = \mathbf{E_{r\parallel}} + \mathbf{E_{r\perp}} = \Gamma_{\parallel}\mathbf{E_{i\parallel}} + \Gamma_{\perp}\mathbf{E_{i\perp}} e^{j\phi}$$

$$\mathbf{E_t} = \mathbf{E_{t\parallel}} + \mathbf{E_{t\perp}} = \tau_{\parallel}\mathbf{E_{i\parallel}} + \tau_{\perp}\mathbf{E_{i\perp}} e^{j\phi}$$

where the reflection coefficients $\Gamma_{\parallel}$ and $\Gamma_{\perp}$ are real for ordinary reflection and complex for Total Internal Reflection.

Linearly Polarized Incident Wave

- For a linearly polarized wave $\phi = 0$ then

(a) For ordinary reflection since Γ and τ are real the reflected and transmitted fields also remain linearly polarized. However, since in general $\Gamma_{\parallel} \neq \Gamma_{\perp}$ and $\tau_{\parallel} \neq \tau_{\perp}$ the plane of polarization changes.

(b) If the reflection is total internal then $\Gamma_{\parallel}$ and $\Gamma_{\perp}$ are complex and therefore the reflected and transmitted field components are not in phase. Consequently the transmitted and reflected waves are elliptically polarized.

Circularly Polarized Incident Wave

- In this case $\left|\mathbf{E_{i\parallel}}\right| = \left|\mathbf{E_{i\perp}}\right|$ and $\phi = \pm\frac{\pi}{2}$
- In general since $\Gamma_{\parallel} \neq \Gamma_{\perp}$ and $\tau_{\parallel} \neq \tau_{\perp}$ the reflected and transmitted both waves will become elliptically polarized.

Conclusion

- **A linearly polarizeed wave remains linearly polarized at orid reflection. But becomes elliptically polarized at Total Internal Reflection.**
- **An elliptical or circularly polarized wave become elliptically polarized wave become elliptically polarized wave with change in actual ratio and the tilt angle.**

Click here to see an interactive visualization: Applet 5.1

Brewster Angle

- Breswter angle is the angle of incidence for which there is no reflection from the media interface i.e it is the angle of incidence for which the reflection coefficient is zero.

Brewster Angle for Dielectric Interface

- For a dielectric interface the permeablilities of both the media's are same as that of the free space.
- There is no Brewster angle for perpendicular polarization.
- For parallel polarization equating the reflection coefficient to zero we get the Brewster angle as

$$\theta_{B\|} = \tan^{-1}\left(\sqrt{\frac{\epsilon_2}{\epsilon_1}}\right)$$

- Since tangent of an angle can attain any value between zero and infinity for any value of ϵ_1, ϵ_2 the Brewster angle exist. That means for every dielectric interface there exist an angle of incidence at which there is complete transmission of electro magnetic wave across the interface.
- If an arbitrary polarized wave is incident at the Brewster angle the parallel polarization is completely transmitted but the perpendicular polarization is only partially transmitted. The reflected wave then has only perpendicular polarization irrespective of the polarization of the incident wave. In other words, the reflected wave is linearly polarized (perpendicular polarization) irrespective of the state of polarization of the incident wave.
- Even a randomly polarized wave incident at Brewster angle produces a linearly polarized wave after reflection. The Brewster angle therefore is also called he 'POLARIZING ANGLE'

Note:

Although the Brewster angle exist for only parallel polarization at the dielectric interface, in principle there could be Brewster angle's for both polarizations if the permeablilities of two media are not same.

Recap

In this course you have learnt the following

- Wave Polarization at Media Interface.
- Brewster Angle.