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To Investigate the Performance of the Propagation Model of the Indoor Wireless Communication Model

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Abstract: ***Due to the rattle development in the field of technology, there are significant increases in the wireless communication devices. So there are over six billion mobile phones users in the world, and this number goes on increase day by day. The wireless communication can be possible with electromagnetic waves and radio waves. When a radio wave travels from transmitter to receiver, there are different obstacles in the path of that radio wave, than the radio wave undergoes different propagation mechanism. So there is need to investigate the propagation mechanism of the rays. In this paper, we have investigated the Fresnel's propagation model at different frequency levels i.e. in the range of 2000MHz to 5000MHz. we have investigate the performance of propagation mechanism for the different mediums i.e. (a).Very dry ground, (b).wet ground and (c).Brick wall. We have also investigated the Pseudo Brewster angle of the propagation mechanism.***

Keywords: Microcell, Parallel Propagation Coefficient, Perpendicular Propagation Coefficient, Pseudo Brewster AnglePicocells, etc

1. Introduction

There is massive increase in no. of users of the wireless communication. So that, there has need to investigate the performance of the reflection coefficient of radio wave. Fresnel coefficients of reflection and transmission can be calculated the reflected and transmitted fields. These coefficients are different for the parallel and perpendicular polarization. There has need to find the Pseudo Brewster Angle.The paper is organized as follows: section 1: Introduction, section 2: The propagation mechanism, section 3: Types of rays of propagation mechanism, section 4: Fresnel's propagation model, section 5: Implementation and section 6: Conclusions.

2. The Propagation Mechanism

These mechanisms are classified as (a) Direct rays or Line-Of-Sight propagation, (b). Reflected and transmitted rays, (c).Diffraction and (d).Scattering.

a) Direct rays or Line-Of-Sight: The ray travels directly from the transmitter to receiver, it is called direct ray and it is related to line-of-sight. Line-Of-Sight is also a type of propagation that can transmit and receive data only where transmitter and receiver stations are in view of each other without any sort of an obstacle.
b) Reflected and transmitted rays: The ray is called reflected ray, if a ray is reflected one or more times before reaching to the transmitter. The direction propagation of a reflected ray can be determined by the law of reflection or refraction. The magnitude of the reflected field is transmitted by Fresnel's equation for different polarizations.
c) Diffraction:Diffracted rays are more complicated as compared to thedirect, reflected, and transmitted rays. The diffracted is rays spawn or a continuum cone of rays.
d) Scattering:- scattering isanother propagation mechanism in which the ray is scattered from rough surfaces such as the ocean surface and building facades.

3. Types of Rays of Propagation Mechanism

The radio wave interaction follows Snell's laws of reflection and refraction (Figure 1).The law of reflection states that the angle of the reflected field(θ_r), is equal to the angle of the incident field(θ_i), where these angles are referred to the normal of surface. Snell's law is also known as law of refraction and Snell- Descartes Law. Snell's Law states that the ratio of Sin of angle of incidence to the Sin of angle of reflection is equal to the ratio of phase velocities in the two mediums and also equal to ratio of reflective indexes of two medium[1]. The ray is reflected towards the normal or away from the normal when ray is incident on the boundary of two mediums. These two mediums are isotropic mediums and they also have different refractive indexes. Angle of incidence is denoted by θ_i and angle of reflection is denoted by θ_r. The refractive index of one medium is η_1 and the refractive index of second medium is η_2.

$$\frac{\sin\theta_i}{\sin\theta_t} = \sqrt{\frac{\epsilon_2\mu_2}{\epsilon_1\mu_1}} = \frac{n_2}{n_1} \quad (1)$$

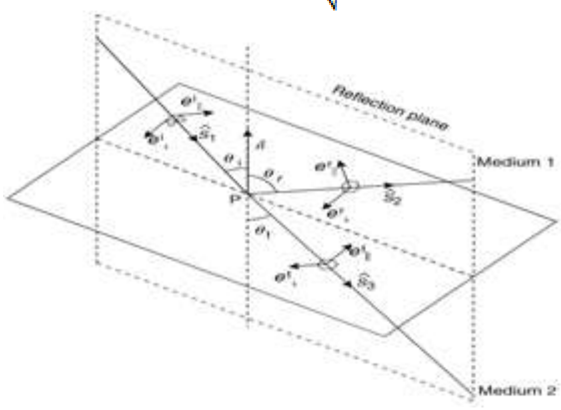

Figure 1: Polarizations in transmissions and reflections

The permittivity of two mediums are denoted by$\varepsilon_1$and ε_2, and permeability of two mediums are denoted by$\mu_1$and μ_2. The refractive index of a medium is the ratio of the free-space velocity (c), to the phase velocity of the wave in that medium (υ), that is

$$n = \frac{c}{v} = \sqrt{\frac{\varepsilon\mu}{\varepsilon_\circ\mu_\circ}} = \sqrt{\varepsilon_r\mu_r} \quad (2)$$

The phase constants for both mediums are β_1 and β_2 are related to the refraction indexes through the angular frequency, v, i.e.

$$\beta = \omega\sqrt{\mu\varepsilon} = \omega\sqrt{\mu_\circ\varepsilon_\circ}\sqrt{\mu_r\varepsilon_r} = \omega\frac{n}{c} \quad (3)$$

The incident ray, the normal vector to the interface at the refraction point and the refracted ray are on the same plane.

4. Fresnel's Propagation Model

In the Fresnel's propagation model, there are 4 types of the coefficients. (a). Parallel reflection coefficient, (b).perpendicular propagation coefficient, (c).parallel transmission coefficient and (d).perpendicular transmission coefficient.

These coefficients are depends on the constitutive parameters of the materials, the polarization of the incident field and the angle of incidence. The coefficients are different for the parallel ($\parallel$) and perpendicular ($\perp$) polarization. The parallel components are along with the reflection plane and the perpendicular components are perpendicular to the reflection plane [1].

For reflections on non-perfectly conducting surfaces, the plane wave Fresnel reflection coefficients are given by

$$R_\perp(\theta) = \frac{\cos\theta - \sqrt{(\varepsilon - \sin^2\theta)}}{\cos\theta + \sqrt{(\varepsilon - \sin^2\theta)}} \quad (4)$$

For reflections on non-perfectly conducting surfaces, Fresnel reflection coefficients are given by

$$R_\parallel(\theta) = \frac{\varepsilon\cos\theta - \sqrt{(\varepsilon - sin^2\theta)}}{\varepsilon\cos\theta + \sqrt{(\varepsilon - sin^2\theta)}} \quad (5)$$

ε = the permittivity of the material,θ = the angle of incidence formed by the incident ray and the normal vector to the surface.

The incident field of the parallel and the perpendicular component is

$$\vec{e} = e_{i\parallel}.\hat{a}_\parallel + e_{i\perp}.\hat{a}_\perp \quad (6)$$

The reflected field of reflection coefficient is

$$\vec{e_r} = e_{r\parallel}.\hat{a}_\parallel + e_{r\perp}.\hat{a}_\perp \quad (7)$$

The transmitted field of the coefficients is

$$T_\perp = \frac{2\cos\theta_i}{\cos\theta_i + \sqrt{\varepsilon - \sin^2\theta_i}} \quad (8)$$

$$T_\parallel = \frac{2\sqrt{\varepsilon}\cos\theta_i}{\varepsilon\cos\theta_i + \sqrt{\varepsilon - sin^2\theta_i}} \quad (9)$$

The parallel coefficients can be identified with the vertical polarization coefficients and the perpendicular polarization coefficients with the horizontal polarization coefficients.

5. Implementation

To investigate the performance of the Fresnel's coefficients of the reflected wave there we have consider three mediums (1). Dry (2) wet ground and (3) brick wall.

5.1 For dry ground area

The Fresnel's coefficients have different features for the very dry ground medium at the frequency range of 2000MHz to 5000MHz.

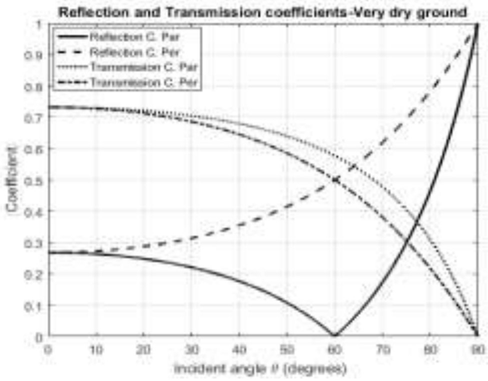

Figure 2: Fresnel's coefficients for very dry ground medium

When the incidence angle is 0° :- (1) At the frequency range of 2GHz to 5GHz, the parallel reflection coefficient and perpendicular reflection coefficient both have same value approximately in between 2 to 3 and The parallel transmission coefficient and perpendicular transmission coefficient both has same value approximately in between 0.7 to 0.8 and (2) At frequency range of 6GHz to 10GHz, the parallel reflection coefficient and perpendicular reflection coefficient both have same value approximately equal to 0.1 and The parallel transmission coefficient and perpendicular transmission coefficient both has same value approximately equal to 0.9. When incidence angle is 90°, Parallel and perpendicular reflection coefficients both has same value it is 1,Parallel and perpendicular transmission coefficients both has same value it is 0 for the frequency range of 2GHz to 10GHz. The parallel reflection coefficient value first decreased to zero for the incident angle 0° to 60° and it increased to 1 for incidence angle60°to 90°. The perpendicular reflection coefficient and perpendicular transmission coefficient both has same value i.e. 0.5, when incidence angle is 60°.The parallel transmission coefficient has coefficient value more than perpendicular transmission coefficients. As the frequency increased from 2GHz to 10GHz, the transmission coefficient value is also increased and the reflection coefficient value decreased. At lower frequency range

5.2 For wet ground area

The Fresnel's coefficients have different features for the wet ground medium at the frequency range of 2000MHz to 5000MHz.

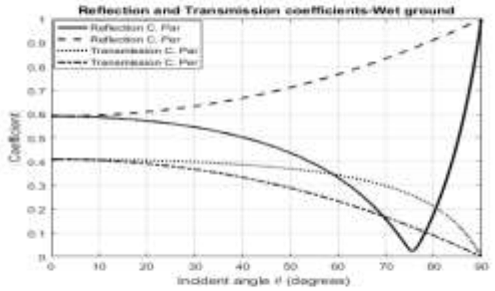

Figure 3: Fresnel coefficients for wet ground

The parallel reflection coefficient and perpendicular reflection coefficient both have same value i.e. approximately 0.59, when incidence angle is 0°. The parallel transmission coefficient and perpendicular transmission coefficient both has same value i.e. 0.4, when incidence angle is0°. The parallel and perpendicular reflection coefficients both have same value i.e. 1, when incidence angle is 90°. The parallel and perpendicular transmission coefficients both have same value = 0, when incidence angle is 90°. The parallel transmission coefficient has coefficient value more than perpendicular transmission coefficients. Parallel reflection coefficient is first decreased from incidence angle0°to 70°, then its value increased to 1 from incidence angle 70° to 90°.The perpendicular reflection coefficient is increased from the incidence angle0° to90°and value increased from 0.5925 to 1.

5.3 For brick wall

The Fresnel's coefficients have different features for the brick wall at the frequency range of 2000MHz to 5000MHz.

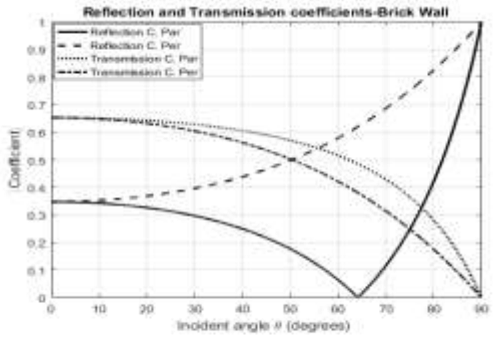

Figure 4: Fresnel coefficients for brick wall

The parallel reflection coefficient and perpendicular reflection coefficient both have same value= 0.3473, when incidence angle is 0°. The parallel transmission coefficient and perpendicular transmission coefficients both have same value i.e. 0.6527, when incidence angle is0°. The parallel and perpendicular reflection coefficients both have same value i.e. 1, when incidence angle is 90°. The parallel and perpendicular transmission coefficients both have same value i.e. 0, when incidence angle is 90°. The parallel transmission coefficient has coefficient value more than perpendicular transmission coefficients.Parallel reflection coefficient is first decreased from incidence angle0°to70°, then its value increased to 1 from incidence angle70° to90°.The perpendicular reflection coefficient is increased from the incidence angle0°to 90° and value increased from 0.59 to 1.The perpendicular reflection coefficient and perpendicular transmission coefficient both has same value i.e. 0.5023, when incidence angle is 50°.

6. Conclusions

For the perfect conductors the reflection coefficients values $R_{\parallel} = +1$ and $R_{\perp} = -1$ and transmission coefficients values are zero.For the dry and wet Ground, the parallel coefficients can be identified with vertical polarization coefficients.For the dry and wet ground, the perpendicular coefficients can be identified with horizontal polarization coefficients.The parallel reflection coefficients becomes zero or near to zero at an angle called pseudo Brewster angle, $\theta_B = tan^{-1}\left(\frac{n_2}{n_1}\right)$ .The parallel coefficients can be identified with horizontal polarization coefficients for the brick wall. The perpendicular coefficients can be identified with vertical polarization coefficients for the brick wall.

Conclusions

For the perfect conductors the reflection coefficients of microcell values $R_{\parallel} = +1$ and $R_{\perp} = -1$ and transmission coefficients values are zero.

For the brick wall, the parallel coefficients of microcell can be identified with horizontal polarization coefficients.

For the brick wall, the perpendicular coefficients of microcell can be identified with vertical polarization coefficients.

The parallel reflection coefficients becomes zero or near to zero at an angle called pseudo Brewster angle, $\theta_B = tan^{-1}\left(\frac{n_2}{n_1}\right)$. The value for the pseudo Brewster angle is near-about 60° for dry ground, 75° for wet ground and 65° for brick wall.

In case of indoor and outdoor-to-indoor propagation of the rays got effected by the attenuation.

In case of wireless communication, the losses are depends upon the conditions of environment and medium in which they are propagate. In this case I have considered the environment conditions of microcell is free space and three mediums, these are dry ground medium, wet ground medium and brick wall.

In these three mediums, I have compared the Fresnel's coefficient values of microcell for these three mediums. Parallel reflection coefficient values of microcell of wet ground less in case of brick wall and more in case of dry ground.

Dry Ground < Wet Ground < Brick Wall

Perpendicular reflection coefficient valueof brick wall is less as compared to wet ground and more as compared to dry ground.

Dry Ground < Brick Wall < Wet Ground

Parallel transmission coefficient value of brick wall is less as compared to dry ground and more as compared to for wet ground.

Wet Ground < Brick Wall < Dry Ground

Perpendicular transmission coefficient value of brick wall is less as compared to dry ground and less as compared to wet ground.

Wet Ground < Brick Wall < Dry Ground

From the investigation, we have concluded that the reflection losses are less in dry ground and more in wet ground medium.

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