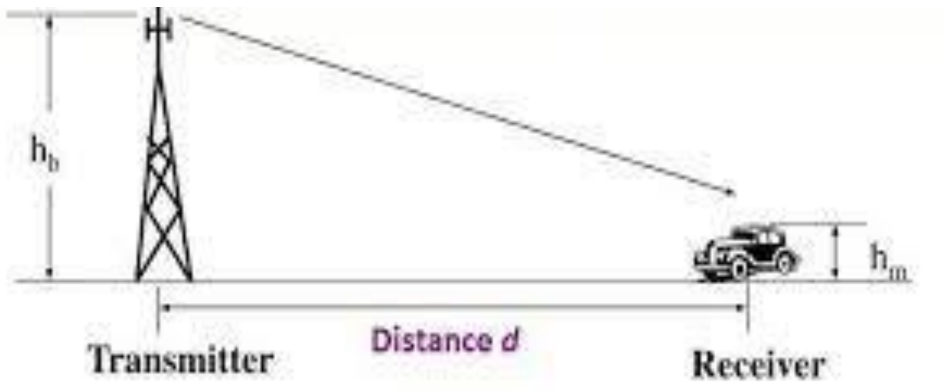
SNS COLLEGE OF ENGINEERING
(Autonomous)
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19EC601 – Wireless Communication

Unit -2
Mobile Radio Propagation

Free space Propagation Model



Large-scale Path loss

- The mobile radio channel places fundamental limitations on the performance of a wireless communication system
- The wireless transmission path may be

  Line of Sight (LOS)

  Non line of Sight (NLOS)
- Radio channels are random and time varying
- Modeling radio channels have been one of the difficult parts of mobile radio design and is done in statistical manner
- When electrons move, they create EM waves that can propagate through space.
- By using antennas we can transmit and receive these EM wave
- Microwave ,Infrared visible light and radio waves can be used.

Properties of Radio Waves

- Are easy to generate
- Can travel long distances
- Can penetrate buildings
- May be used for both indoor and outdoor coverage
- Are omni-directional-can travel in all directions
- Can be narrowly focused at high frequencies(>100MHz) using parabolic antenna

- Frequency dependence

  Behave more like light at high frequencies

  Difficulty in passing obstacle

  Follow direct paths

  Absorbed by rain

Behave more like radio at lower frequencies

- Can pass obstacles
- Power falls off sharply with distance from source

- Subject to interference from other radio waves

  The statistical modeling is usually done based on data measurements made specifically for

  - the intended communication system
  - the intended spectrum

- They are tools used for:
  - Predicting the average signal strength at a given distance from the transmitter
  - Estimating the variability of the signal strength in close spatial proximity to a particular locations

Propagation Models

- Large Scale Propagation Model:

  - Predict the mean signal strength for an arbitrary transmitter-receiver(T-R) separation

  - Estimate radio coverage of a transmitter

  - Characterize signal strength over large T-R separation distances(several 100's to 1000's meters)

Propagation Models

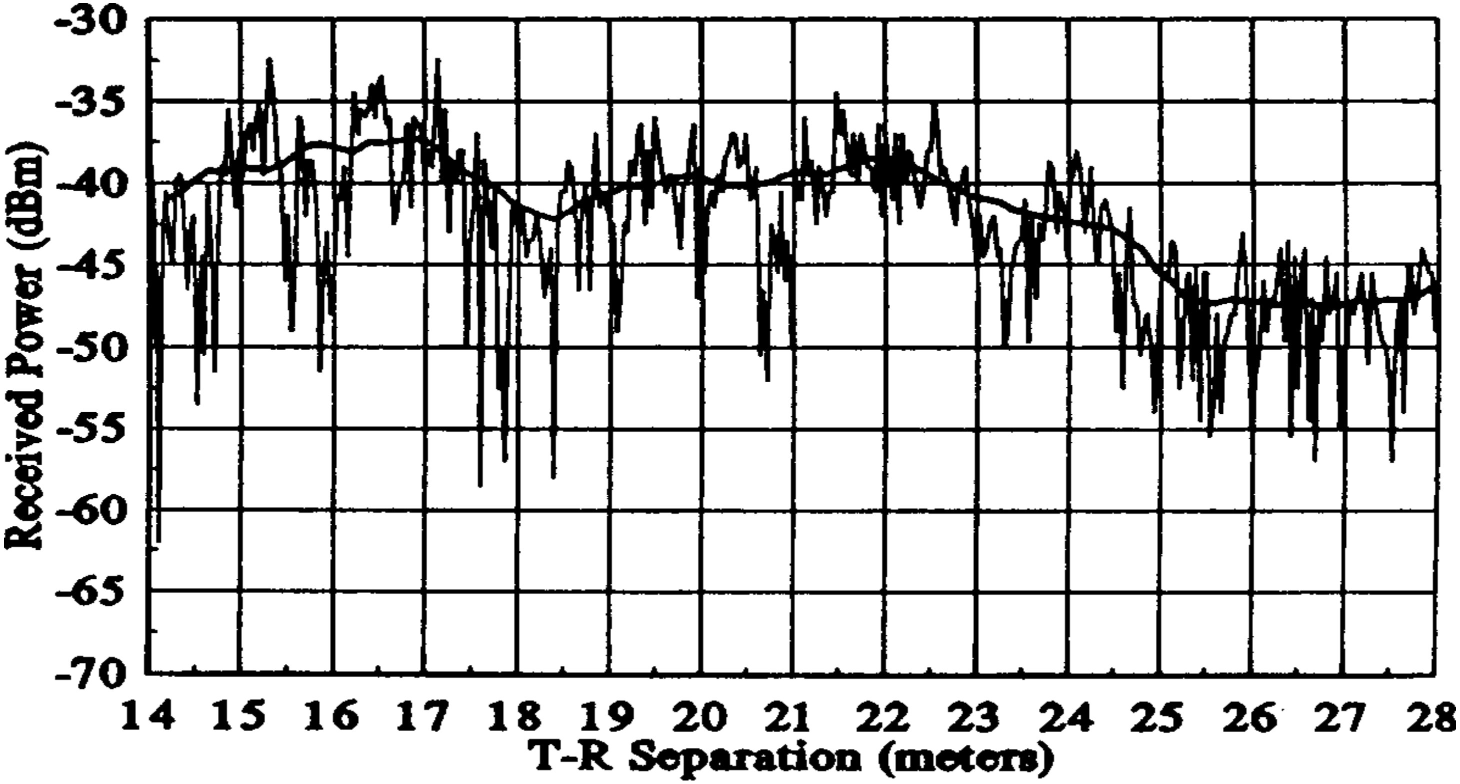
- Small Scale or Fading Models:

  - Characterize rapid fluctuations of received signal strength over

    - Very short travel distances(a few wavelengths)

    - Short time durations(on the order of seconds)

Small-scale and large-scale fading



Free Space Propagation Model

- For clear LOS between T-R
- Ex: satellite & microwave communications

- Assumes that received power decays as a function of T-R distance
- separation raised to some power.

- Given by Friis free spac

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

'L' is the system loss factor

- L >1 indicates loss due to transmission line attenuation, filter losses & antenna losses
- L = 1 indicates no loss in the system hardware
- Gain of antenna is related to its effective aperture A_e by
  - $G=4\pi A_e/\lambda^2$

- Effective Aperture A_e is related to physical size ofantenna.
  - $\lambda = c/f$.
- c is speed of light,
- P_t and P_r must be in sameunits
- G_t ad G_r aredimensionless

- An isotropic radiator, an ideal radiator which radiates power with unit gain uniformly in all directions, and is often used as reference

- Effective Isotropic Radiated Power (EIRP) is defined as
  - EIRP= Pt Gt
- Represents the max radiated power available from a transmitter in direction of maximum antenna gain, as compared to an isotropic radiator

- In practice Effective Radiated Power (ERP) is used instead of (EIRP)

- Effective Radiated Power (ERP) is radiated power compared to half wave dipole antennas

- Since dipole antenna has gain of 1.64(2.15 dB)

$$ERP=EIRP-2.15(dB)$$

- the ERP will be 2.15dB smaller than the EIRP for same Transmission medium

- Path Loss (PL) represents signal attenuation and is defined
as difference between the effective transmitted power and received power

Path loss PL(dB) = 10 log [Pt/Pr]

= -10 log {GtGr λ^2/(4π)^2d^2}

- Without antenna gains (with unit antenna gains)

PL = - 10 log { λ^2/(4π)^2d^2}

Friis free space model is valid predictor for P_r for values of d which are in the far-field of transmitting antenna

- The far field or Fraunhofer region that is beyond far field distance d_f given as : $d_f=2D^2/\lambda$
- D is the largest physical linear dimension of the transmitter antenna
- Additionally, $d_f >> D$ and $d_f >> \lambda$
- The Friis free space equation does not hold for d=0
- Large Scale Propagation models use a close-in distance, d_o, as received power reference point, chosen such that $d_o >= d_f$
- Received power in free space at a distance greater then do

$$Pr(d)=Pr(do)(do/d)^2 \qquad d>d_o>d_f$$

Pr with reference to 1 mW is represented as

$$Pr(d)=10\log(Pr(do)/0.001W)+20\log(do/d)$$

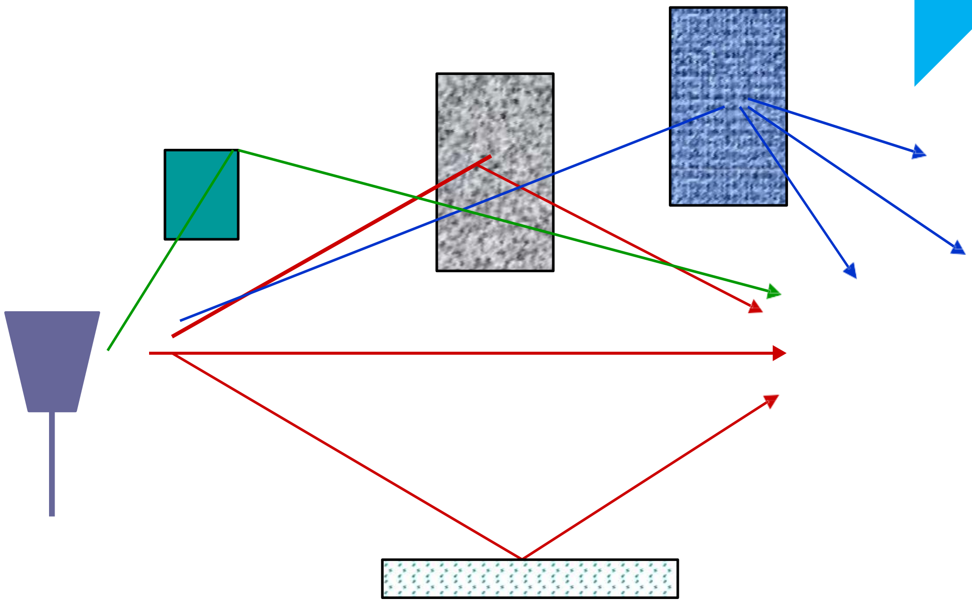
Electrostatic,inductive and radiated fields are launched, due to flow of current from anntena.

Regions far away from transmitter electrostatic and inductive fields become negligible and only radiated field components are considered

Propagation Mechanisms

- Three basic propagation mechanism which impact propagation in mobile radio communication system are:

  - Reflection
  - Diffraction
  - Scattering



Propagation Mechanisms

- Reflection occurs when a propagating electromagnetic wave impinges on an object which has very large dimensions as compared to wavelength e.g. surface of earth , buildings,walls

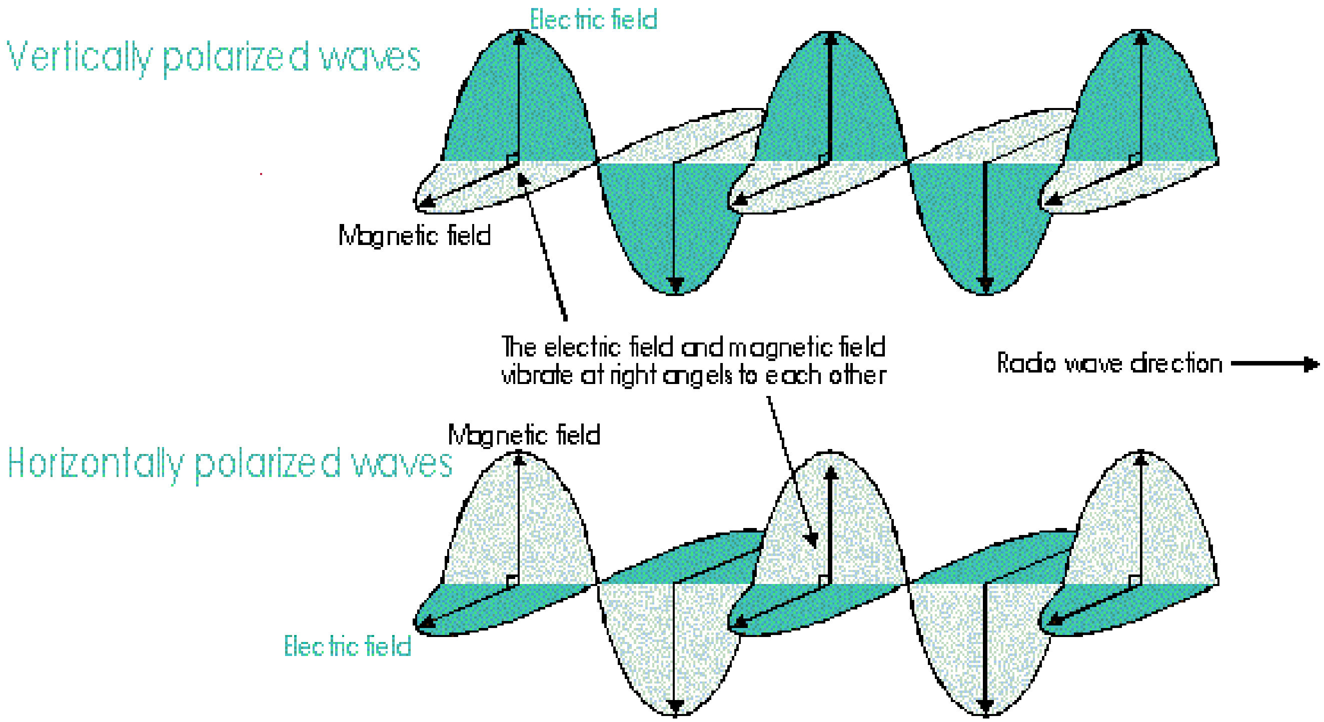
- Diffraction occurs when the radio path between the transmitter and receiver is obstructed by a surface that has sharp irregularities(edges)
  - Explains how radio signals can travel urban and rural environments without a line of sight path

- Scattering occurs when medium has objects that are smaller or comparable to the wavelength (small objects, irregularities on channel, foliage, street signs etc)

Reflection

- Occurs when a radio wave propagating in one medium impinges upon another medium having different electrical properties
- If radio wave is incident on a perfect dielectric Part of energy is reflected back
  - Part of energy is transmitted
- In addition to the change of direction, the interaction between the wave and boundary causes the energy to be split between reflected and transmitted waves
- The amplitudes of the reflected and transmitted waves are given relative to the incident wave amplitude by Fresnel reflection coefficients

Vertical and Horizontal polarization



Reflection- Dielectrics

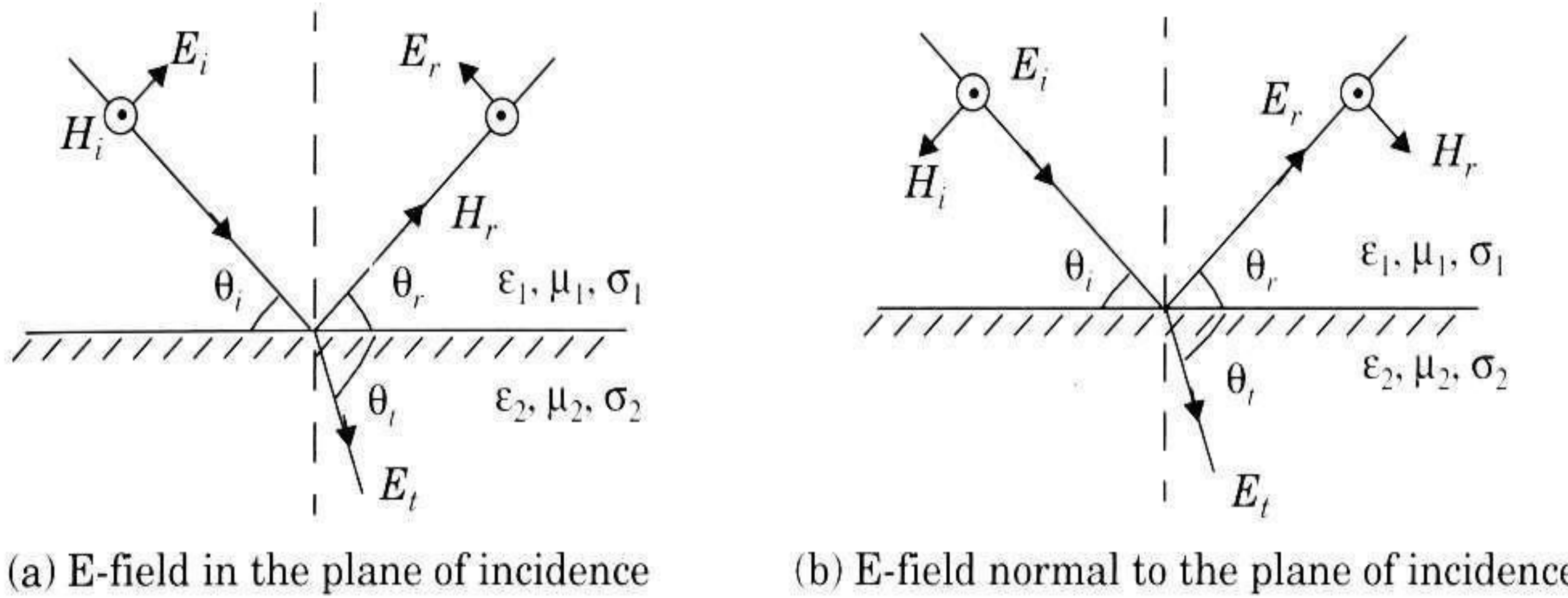


Figure 4.4 Geometry for calculating the reflection coefficients between two dielectrics.

Reflection

- $\Gamma(\parallel) = \frac{E_r}{E_i} = \frac{\eta_2 \sin\theta_t - \eta_1 \sin\theta_i}{\eta_1 \sin\theta_t + \eta_1 \sin\theta_i}$ (Paralell E-field polarization)

- $\Gamma(\perp) = \frac{E_r}{E_i} = \frac{\eta_2 \sin\theta_i - \eta_1 \sin\theta_t}{\eta_1 \sin\theta_i + \eta_1 \sin\theta_t}$ (Perpendicular E-field polarization)

- These expressions express ratio of reflected electric fields to the incident electric field and depend on impedance of media and on angles

- η is the intrinsic impedance given by $\sqrt{(\mu/\varepsilon)}$

- μ=permeability,ε=permittivity

Reflection-Perfect Conductor

- If incident on a perfect conductor the entire EM energy is reflected back
- Here we have $\theta_r = \theta_i$
- $E_i = E_r$ (E-field in plane of incidence)
- $E_i = -E_r$ (E field normal to plane ofincidence)
- Γ(parallel)= 1
- Γ(perpendicular)= -1

Reflection - Brewster Angle

- It is the angle at which no reflection occur in the medium of origin. It occurs when the incident angle θ_B is such that the reflection coefficient Γ(parallel) is equal to zero.
- It is given in terms of θ_B as given below

$$Sin\ \theta_B = \sqrt{\frac{\varepsilon_1}{\varepsilon_1 + \varepsilon_2}}$$

- When first medium is a free space and second medium has an relative permittivity of ε_r *then*

$$Sin\ \theta_B = \frac{\varepsilon_{r-1}}{e^2 - 1}$$


Thank you