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Coimbatore – 35
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19ECT311 / Wireless Communication

III ECE/ VI SEMESTER

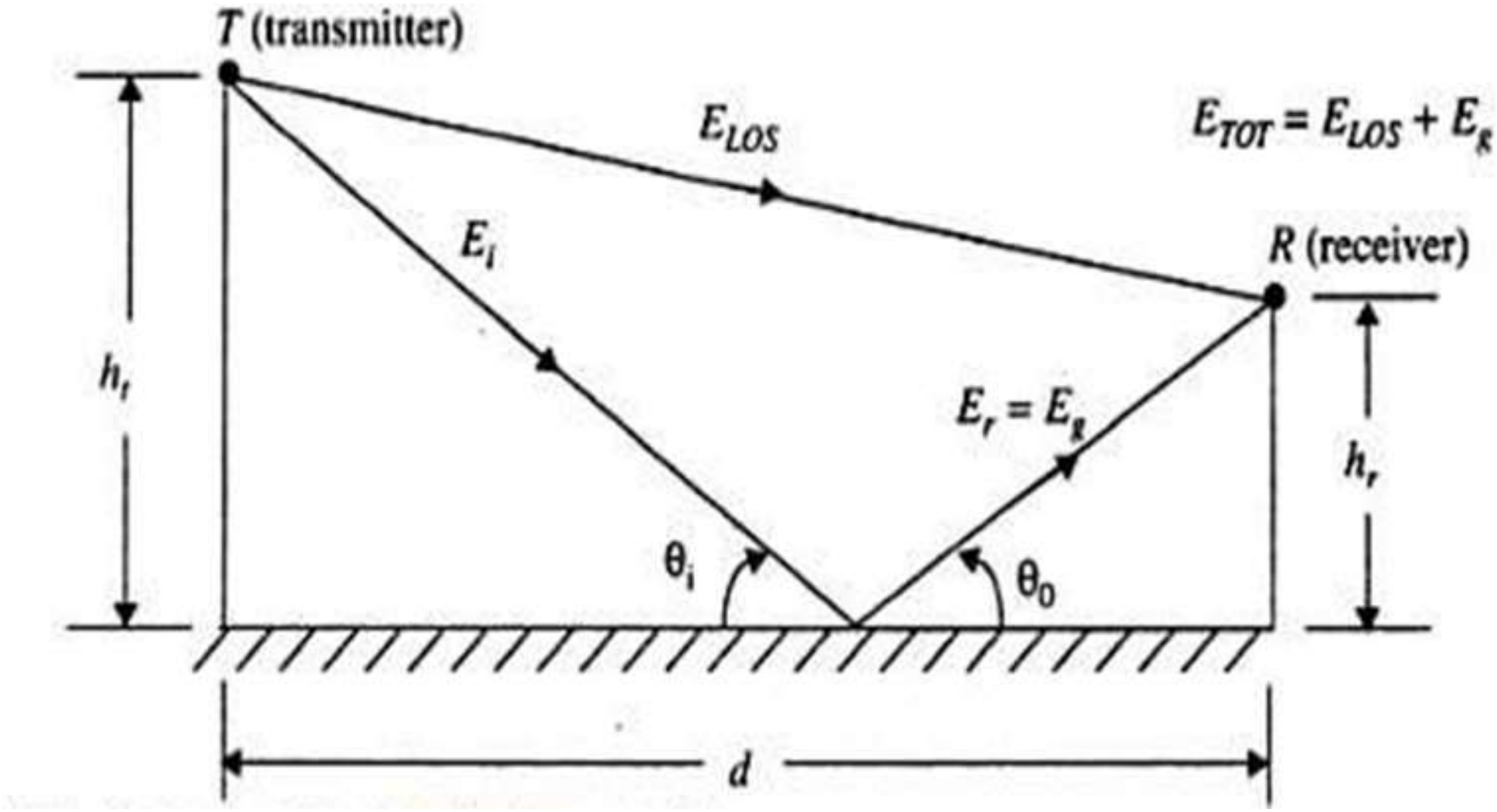
Unit II - **MOBILE RADIO PROPAGATION**

Topic 3 : REFLECTION – TWO RAY MODEL

Introduction

- Free space propagation model is in accurate in many if the cases when used alone
- Ground reflection model or Two ray model is designed for both LOS and Reflected rays
- This model is accurate for predicting the large scale signal strength over distance of several Kilometers
- The earth is assumed to be FLAT

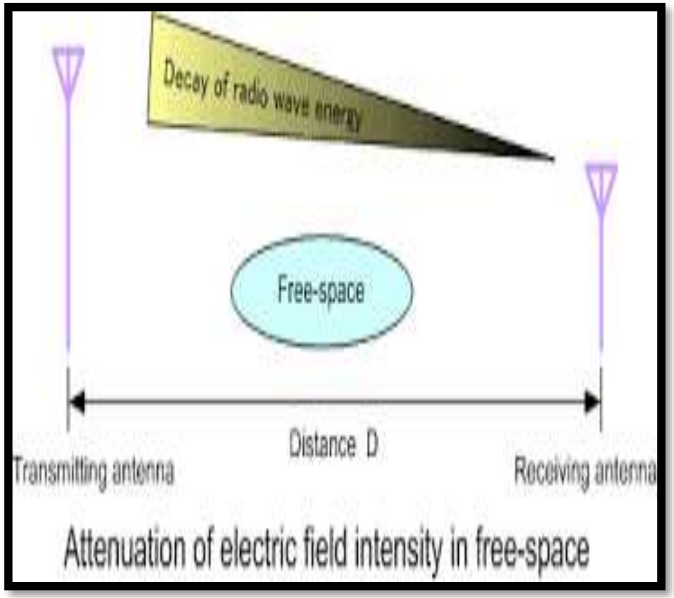
Two ray model



E field – free Space

E Field in Free space Propagation is

$$E(d,t) = E_0 \frac{d_0}{d} \cos\left(2\pi f_c \left(t - \frac{d}{c}\right)\right)$$



Where,

E_o - Free Space E Field

d_o - Reference Distance

Considering,

ht - Transmitting antenna height

hr - Receiving antenna height

E field- LOS path

E Field in Line of Sight path is

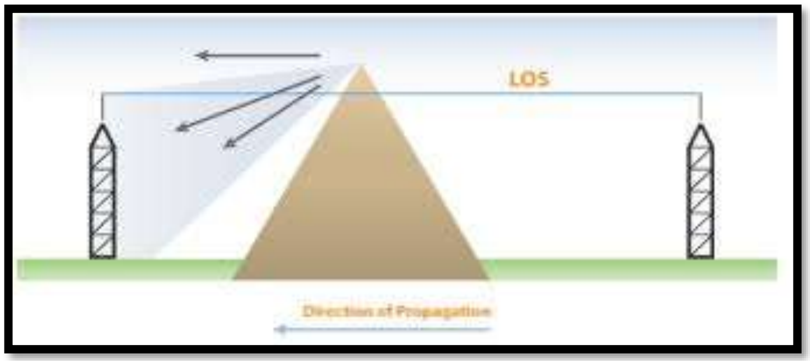
$$E_{LOS}(d',t) = \frac{E_0 d_0}{d'} \cos\left(\omega_c\left(t - \frac{d'}{c}\right)\right)$$

Where,

d' - Separation distance in the ground

C - Speed of light in vacuum

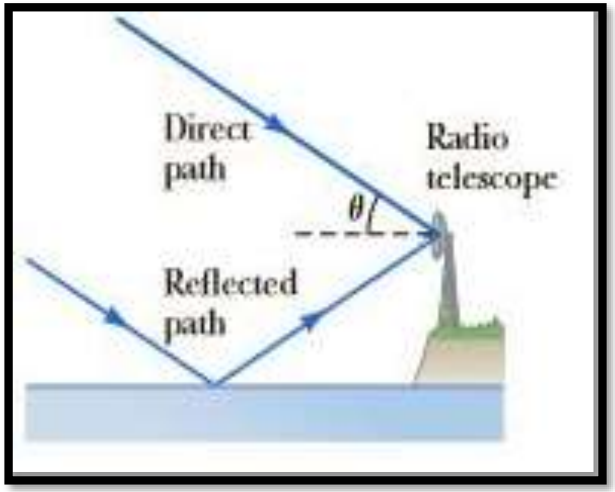
ώc - Carrier frequency



E field- reflected path

E Field in reflected path is

$$E_g(d'',t) = \Gamma \frac{E_0 d_0}{d''} \cos\left(\omega_c\left(t - \frac{d''}{c}\right)\right)$$



Where,

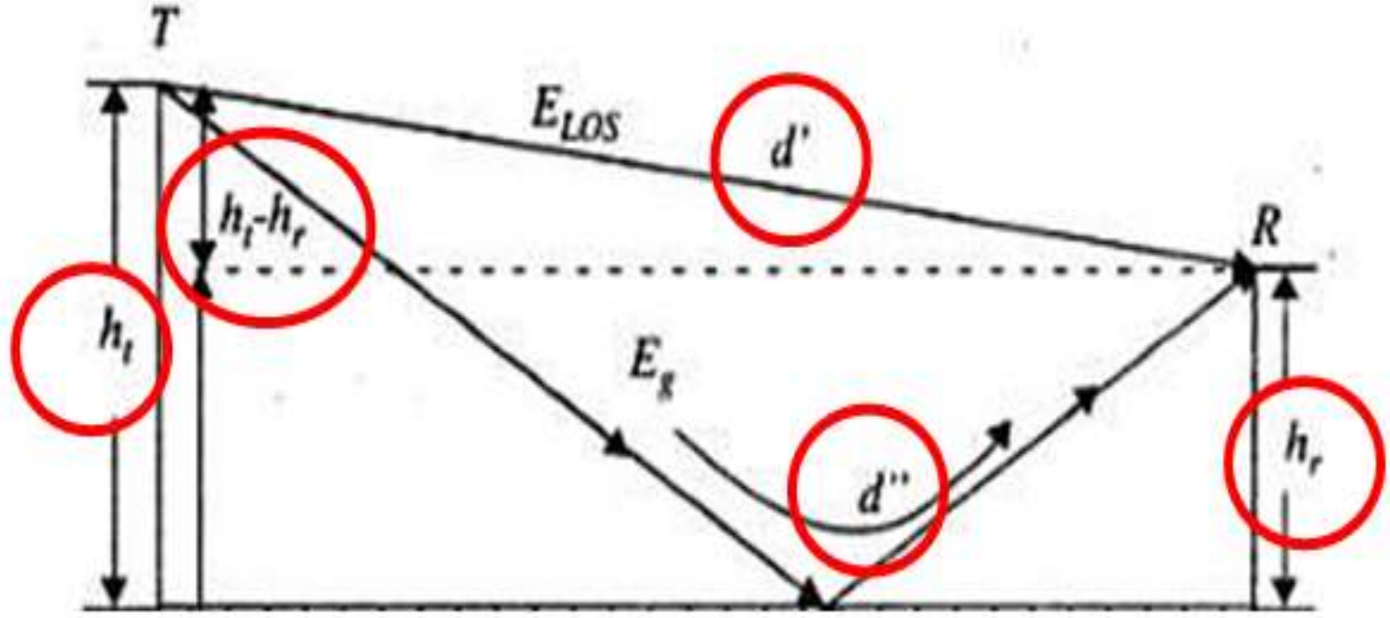
d‘’ - Separation distance in the reflected path

C - Speed of light in vacuum

ώc - Carrier frequency

Ί - Reflection coefficient

Two paths



ACTIVITY

- Recall the incident happened during last birthday for those who wear red colour wardrobe.

Total Electric field

E Field in total by considering LOS and reflected path is

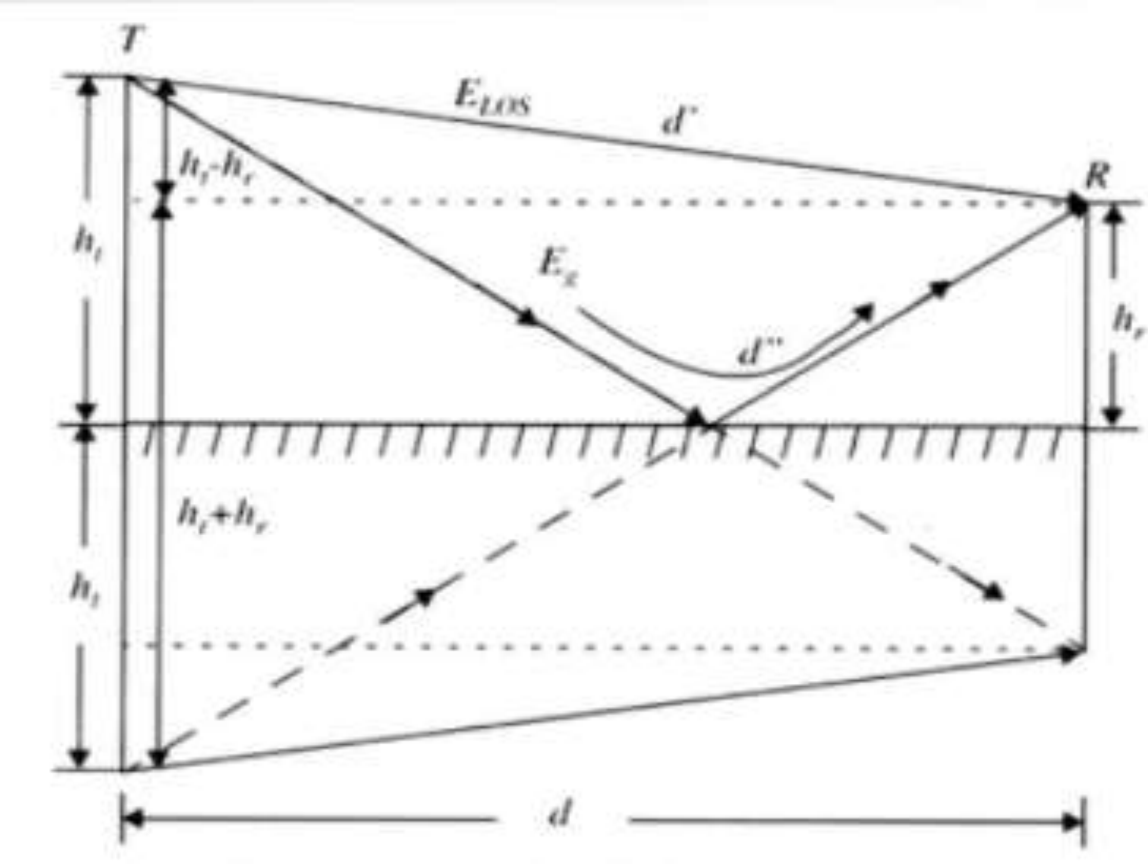
$$E_{TOT}(d,t) = \frac{E_0 d_0}{d'} \cos\left(\omega_c\left(t - \frac{d'}{c}\right)\right) + (-1)\frac{E_0 d_0}{d''} \cos\left(\omega_c\left(t - \frac{d''}{c}\right)\right)$$

$$\Gamma_{\perp} = -1$$

Where,

d	- Distance in the ground
C	- Speed of light in vacuum
ὠc	- Carrier frequency
do	- reference point
d'	- Separation distance in the ground
d‘’	- Separation distance in the reflected path

Method of images



△ abc

$bc = d''$

$$d'' = \sqrt{(h_t+h_r)^2 + d^2}$$

△ a'b'c'

$bc' = d'$

$$d' = \sqrt{(h_t-h_r)^2 + d^2}$$

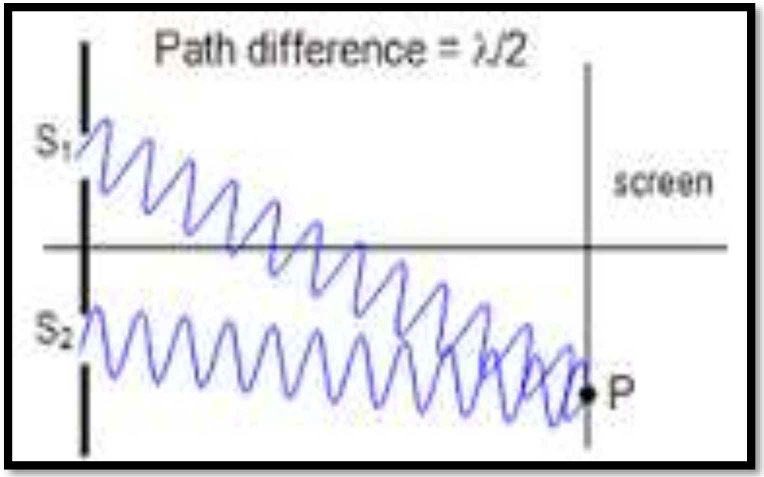
Method of images

Path difference Δ is

$$\Delta = d'' - d' = \sqrt{(h_t + h_r)^2 + d^2} - \sqrt{(h_t - h_r)^2 + d^2}$$

- When T-R Separation is very large compared to $h_t + h_r$ the equation can be simplified by using Taylor's series approximation

$$\Delta = d'' - d' \approx \frac{2h_t h_r}{d}$$



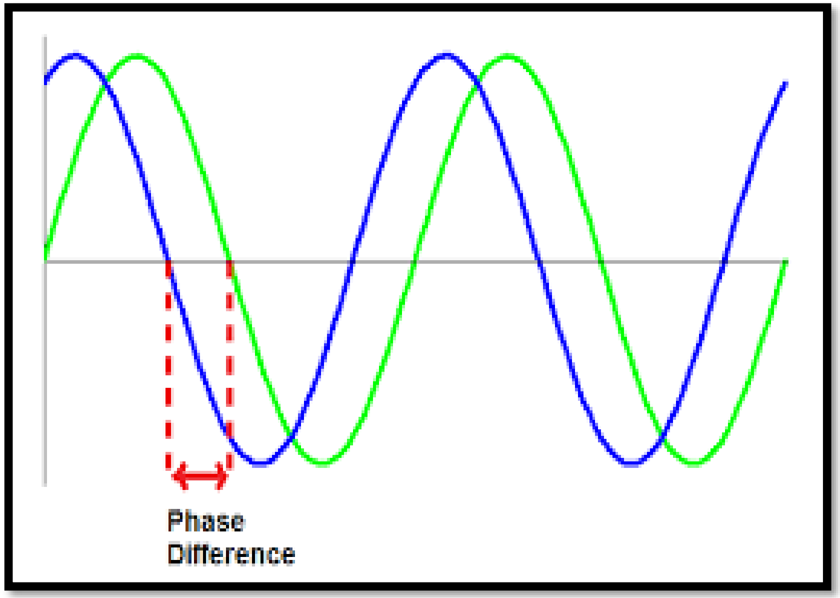
Method of images

- Once the path difference is known,

The **Phase Difference** between the two E Field Components and **Time Delay** between the arrival of the two components can be computed

$$\theta_\Delta = \frac{2\pi\Delta}{\lambda} = \frac{\Delta\omega_c}{c}$$

$$\tau_d = \frac{\Delta}{c} = \frac{\theta_\Delta}{2\pi f_c}$$



LOS Vs Reflected path

- When “d” becomes larger and larger the differences between the d’ and d” becomes very small.

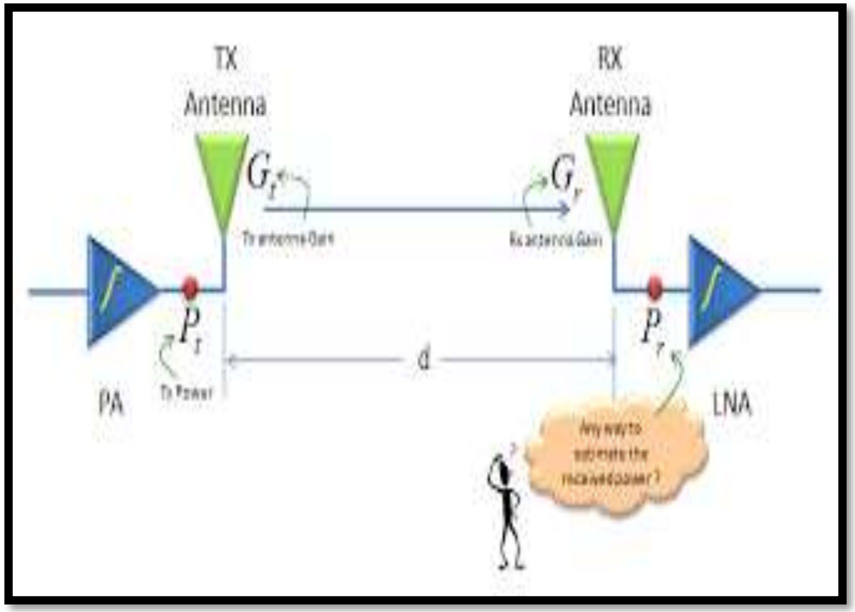
- In this case the amplitude levels of both LOS and Reflected Rays are virtually identical.

$$\left|\frac{E_0 d_0}{d}\right| \approx \left|\frac{E_0 d_0}{d'}\right| \approx \left|\frac{E_0 d_0}{d''}\right|$$

Received Power, Path Loss

- Received power at the distance d from the transmitter for the two ray model is given by:

$$P_r = P_t G_t G_r \frac{h_t^2 h_r^2}{d^4}$$



- The **Path Loss** is Defined as:

$$PL(\mathrm{dB}) = 40\log d - (10\log G_t + 10\log G_r + 20\log h_t + 20\log h_r)$$

Assessment

1. What does path loss exponent indicates?

a) Rate at which path loss decreases with distance

b) Rate at which path loss increases with distance

c) Rate at which path loss decreases with power density

d) Rate at which path loss increases with power density

2. Difference between the direct path and the diffracted path is called _______

a) Average loss

b) Radio path loss

c) Excess path loss

d) Wavelength