



# **SNS COLLEGE OF TECHNOLOGY**

Coimbatore – 35

**An Autonomous Institution**

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai



## **DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

19ECT311 / Wireless Communication

III ECE/ VI SEMESTER

Unit II - **MOBILE RADIO PROPAGATION**

**Topic 3 : REFLECTION – TWO RAY MODEL**



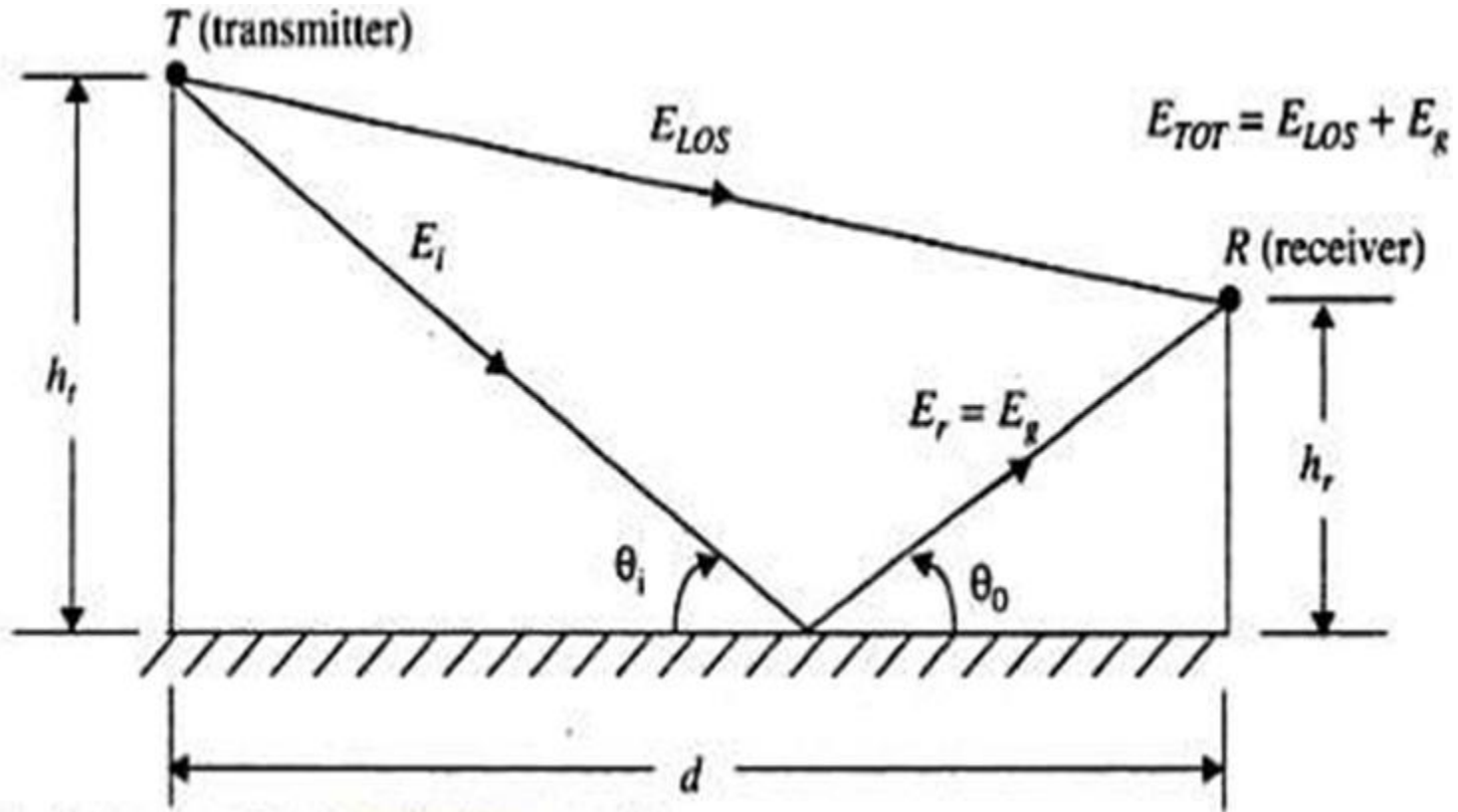
# Introduction



- Free space propagation model is inaccurate in many 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,

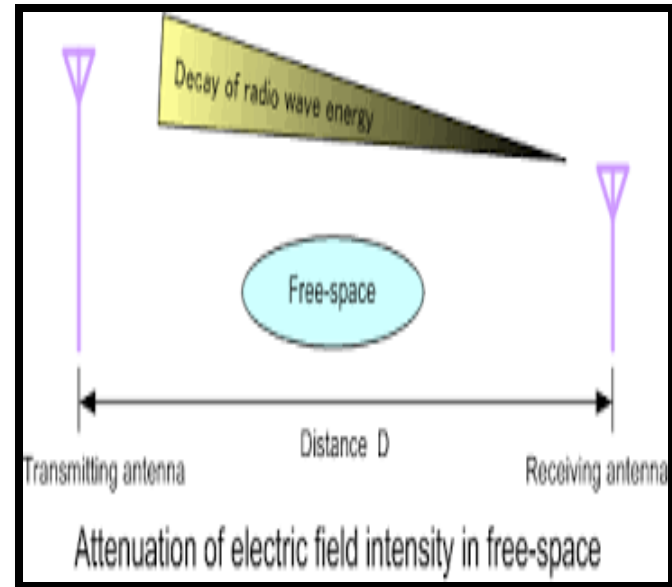
$E_0$  - Free Space E Field

$d_0$  - 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

$\omega_c$  - Carrier frequency

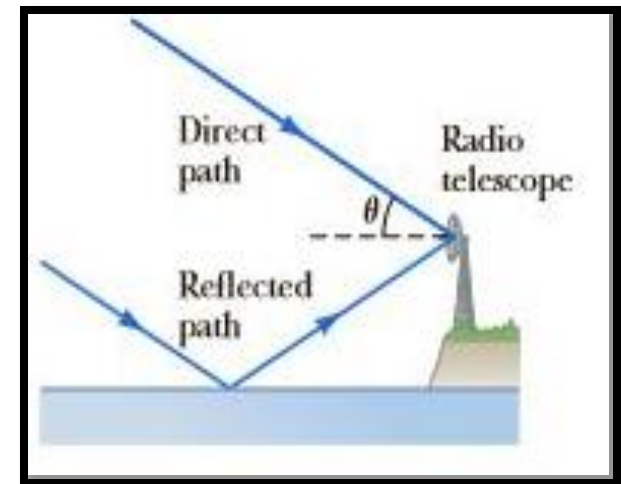




# E field- reflected path

E Field in reflected path is

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



Where,

$d''$  - Separation distance in the reflected path

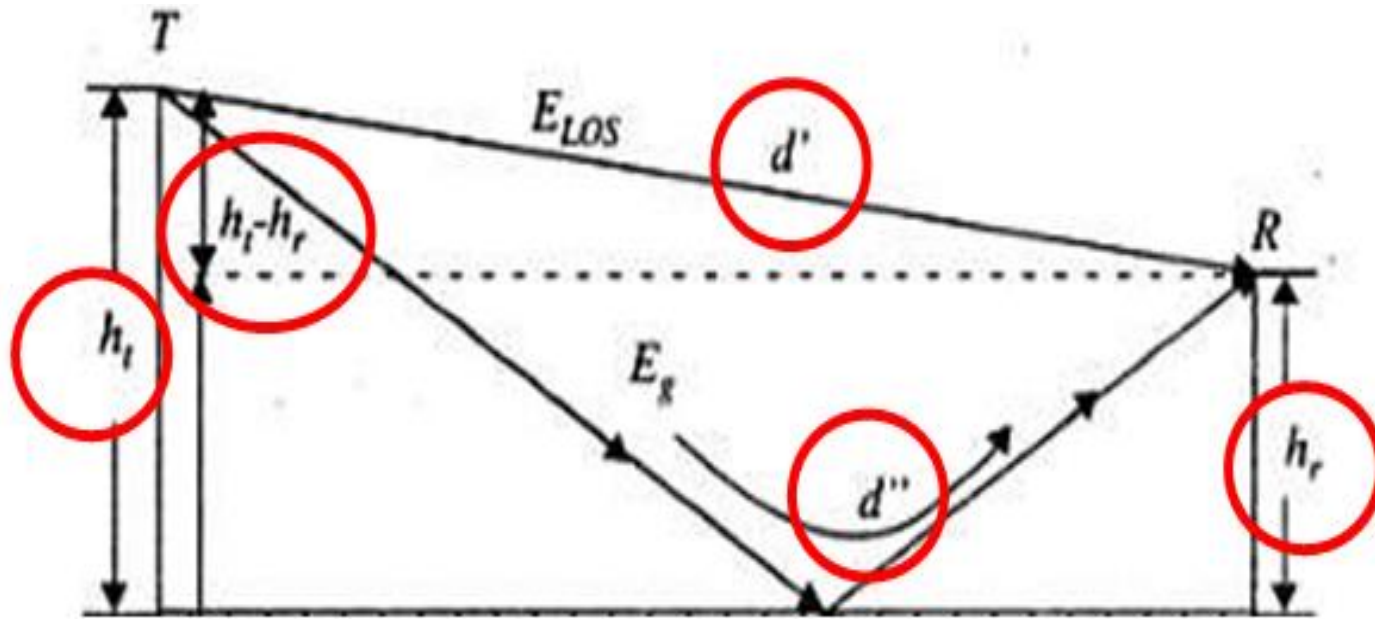
$C$  - Speed of light in vacuum

$\omega_c$  - Carrier frequency

$\Gamma$  - 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

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

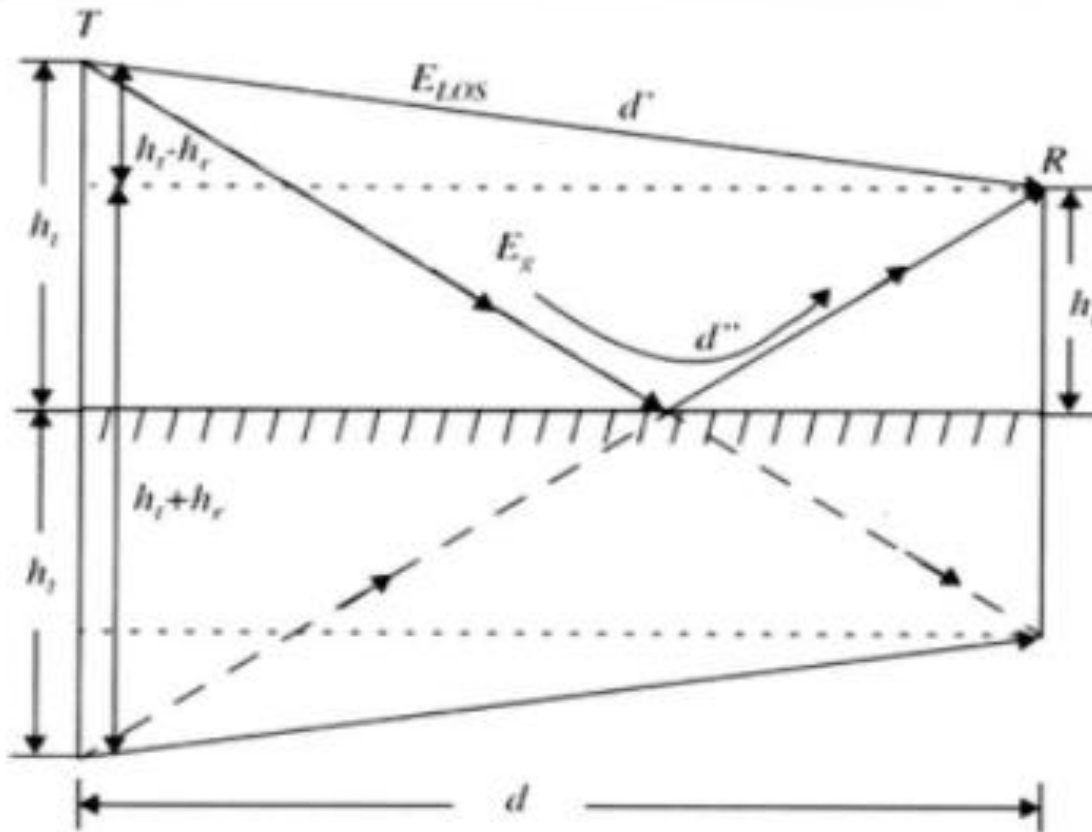
$$\Gamma_{\perp} = -1$$

Where,

- d - Distance in the ground
- C - Speed of light in vacuum
- $\omega_c$  - Carrier frequency
- $d_0$  - reference point
- $d'$  - Separation distance in the ground
- $d''$  - Separation distance in the reflected path



# Method of images



$$\begin{aligned} \Delta abc \\ bc = d'' \\ d'' &= \sqrt{(h_t + h_r)^2 + d^2} \\ \Delta a'b'c' \\ bc' = d' \\ d' &= \sqrt{(h_t - h_r)^2 + d^2} \end{aligned}$$



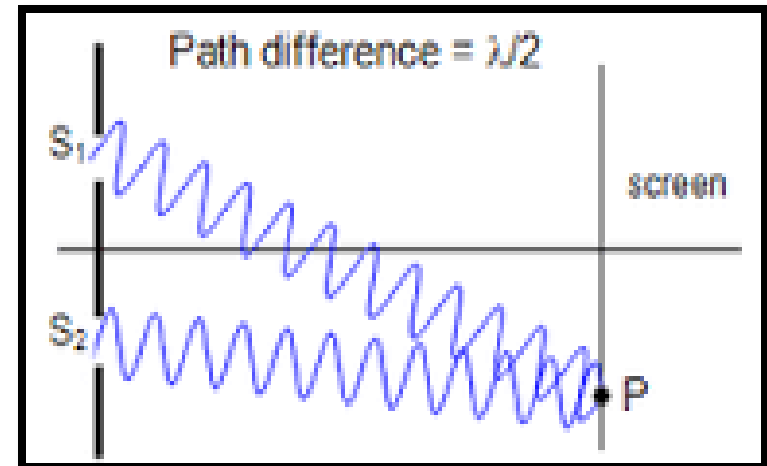
# Method of images

Path difference  $\Delta$  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**

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



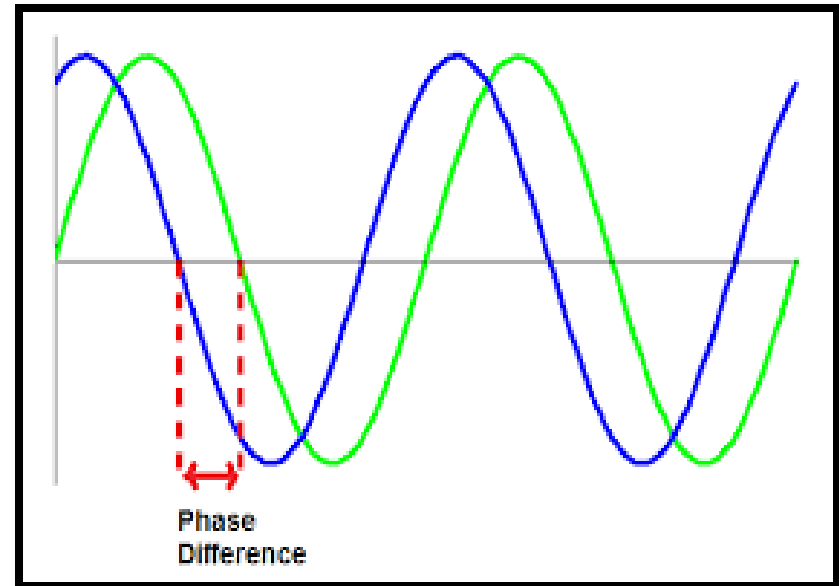


# Method of images

- 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.

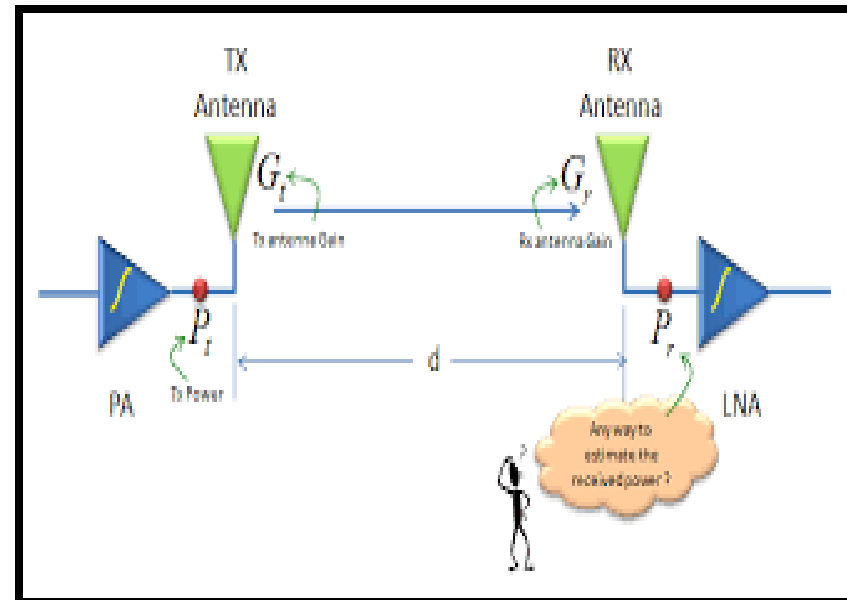
$$\left| \frac{E_0 d_0}{d} \right| \approx \left| \frac{E_0 d_0}{d'} \right| = \left| \frac{E_0 d_0}{d''} \right|$$



# 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:

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

