CH4: Unguided Modes of Wave Propagation

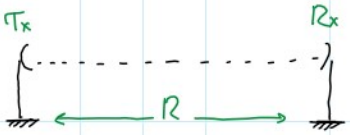
Saturday, January 22, 2022 12:09 AM

- there are 3 types:

i) Direct waves ii) Tropospheric waves iii) Ionospheric waves

1) Direct waves:

→ in this mode the wave path is straight line, the medium is called Free space medium.
the medium thickness extend from earth surface up to 1 km



→ there are two types of antenas used:

Isotropic, $G=1$

Directional, $G>1$

→ the received power by an antena seperated by a distance r from a Tx antena:

$$W_R = \left(\frac{W_T}{4\pi r^2} G_T\right) A_{EFF} \quad \text{watt}$$

→ $A_{EFF} \propto G_R$

$$A_{EFF} = \frac{\lambda^2}{4\pi} G_R \qquad "A_{EFF} < A_{actual}"$$

$$\therefore W_R = \left(\frac{W_T}{4\pi r^2}\right) G_T \cdot \frac{\lambda^2}{4\pi} G_R$$

$$\therefore \frac{W_T}{W_R} = \left(\frac{4\pi r}{\lambda}\right)^2 \cdot \frac{1}{G_T} \cdot \frac{1}{G_R}$$

the free space path loss (FSL):

$$FSL = 10\log_{10}\left(\frac{W_T}{W_R}\right) = 20\log\left(\frac{r}{\lambda}\right) + \underbrace{20\log(4\pi)}_{21.98} - G_{T_{dB}} - G_{R_{dB}}$$

→ it's important to note the FSL is invatble, and it's due to the Communication System not the medium, the FSL is another kind of losses different from that cased by α.

→ Path loss:

$$PL = 20\log(4\pi) + 20\log\left(\frac{r}{\lambda}\right)$$

* Max Line of sight (r_0):

→ due to the earth surface curvture nature "not flat" there will be a max distance after which the Tx & Rx will lose line of sight.

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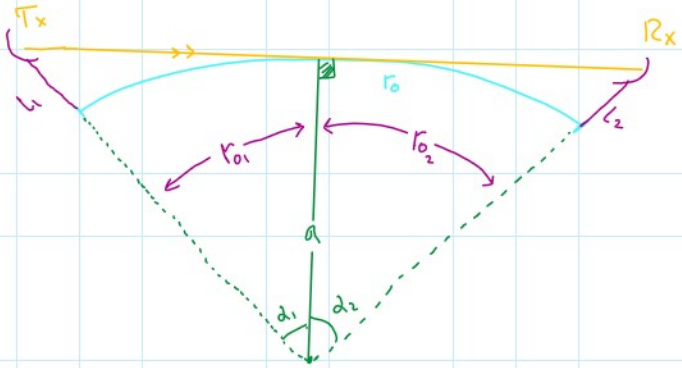

- $a = 6.37 * 10^6$ m "radius of earth"
- $r_o = r_{o_1} + r_{o_2}$

$r_{o_1} = a\alpha_1$, $r_{o_2} = a\alpha_2$

$\because \cos\alpha_1 = \frac{a}{a+L_1} = \frac{1}{1+L_1/a} = (1+\frac{L_1}{a})^{-1}$, "$\frac{L_1}{a}$ ↓↓"

$\therefore \cos\alpha_1 \simeq 1 - \frac{L_1}{a}$ → (1)

$\because \alpha$ ↓↓ ⇝ $\therefore \cos\alpha_1 \simeq 1 - \frac{\alpha_1^2}{2!}$ → (2)

From 1,2 ⇝ $\therefore 1 - \frac{L_1}{a} = 1 - \frac{\alpha_1^2}{2!}$

$\therefore \alpha_1 = \sqrt{\frac{2L_1}{a}}$, $\because r_{o_1} = a\alpha_1$ ⇝ $\therefore r_{o_1} = \sqrt{2aL_1}$

Similarly ⇝ $r_{o_2} = \sqrt{2aL_2}$

$\because r_o = r_{o_1} + r_{o_2}$

$\therefore r_o = \sqrt{2a}\left[\sqrt{L_1} + \sqrt{L_2}\right]$ — max distance between Tx, Rx for direct waves without reflection.