WC

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Assignment-3

Date:

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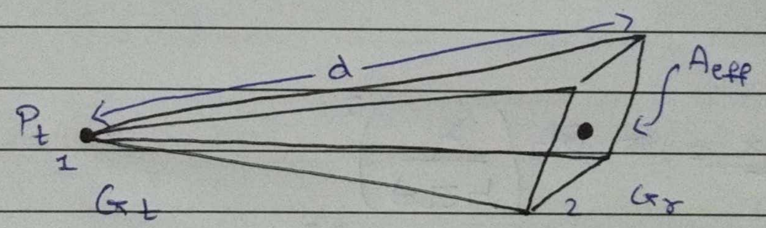
1) Explain Free Space Propagation loss equation in detail.

Ans - The free space propagation model assumes a transmit antenna and a receive antenna to be located in an otherwise empty environment.

- Neither absorbing obstacles nor reflecting surfaces are considered.
- In particular, the influence of the earth surface is assumed to be entirely absent.



$$|S| = \frac{P_t}{4\pi d^2} G_t \text{ : power density}$$

$$P_r = |S| A_{eff} \text{ : Received power}$$

$$A_{eff} = \frac{\lambda^2}{4\pi} \cdot G_r \Rightarrow G = \frac{4\pi A_{eff}}{\lambda^2}$$

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

$EIRP = P_t G_t$ (Effective isotropic radiated Power)

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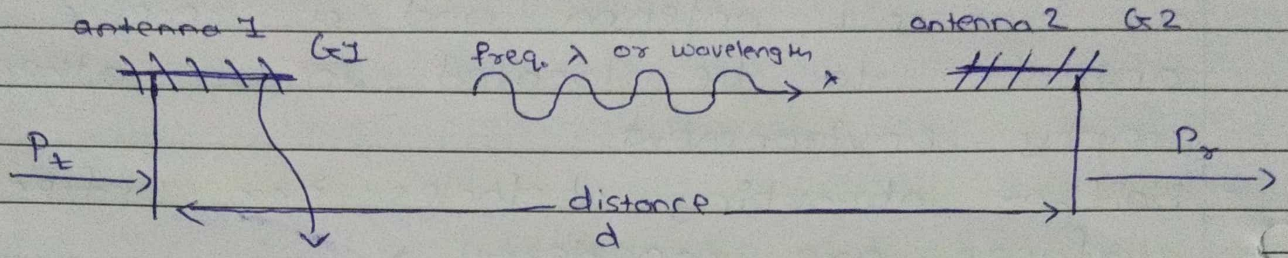
Royal ECO

- A clear, unobstructed Line-of-sight path between them.
  ↳ Satellite communication, Microwave Line--of-sight (Point-to-Point)



EIRP = $P_t G_t$ = (compared to an isotropic radiator) : dB;
ERP = EIRP - 2.15 dB = (compared to an half-wave dipole antenna : dBd

Path Gain

$$gain = \frac{P_r}{P_t} = G_1 G_2 \left(\frac{\lambda}{4\pi d}\right)^2$$

$$= G_1 G_2 \left(\frac{c}{4\pi d f}\right)^2$$

$$= G_1 G_2 \left(\frac{3\times10^8}{4\pi d \cdot 1\times10^3 \cdot f \cdot 1\times10^6}\right)^2$$

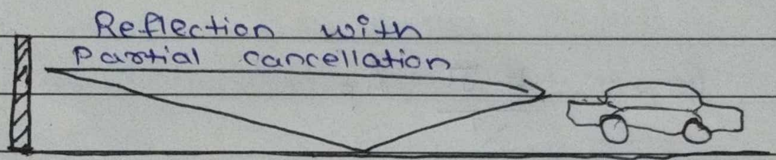
for d in km, f in MHz

Path Loss = $1/(P_r/P_t)$ when antenna gains are included

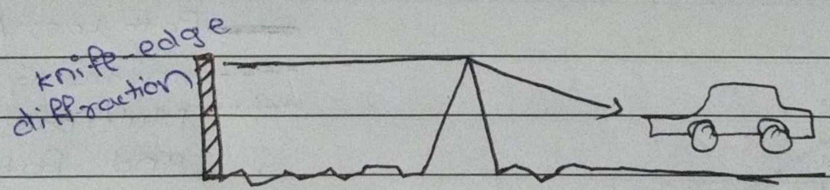
2) Write note on Reflection, Diffraction and Scattering with example.

Ans - In wireless media, Signals propagate using these three principles.

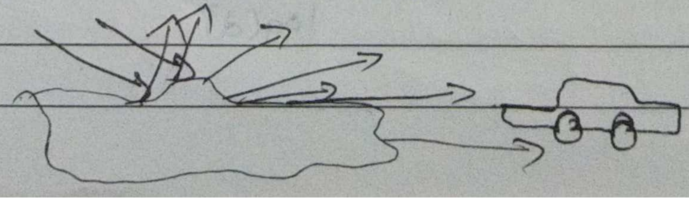
- **Reflection:** It occurs when the signal encounters a large solid surface, whose size is much larger than the wavelength of the signal.
  e.g., a solid wall.



- **Diffraction:** It occurs when the signal encounters an edge or a corner, whose size is larger than the wavelength of the signal,
  e.g., an edge of a wall.



- **Scattering:** It occurs when the signal encounters small objects of size smaller than the wavelength of the signal.



3) Write about Empirical formula for path loss in detail.

Ans - Power is distributed equally to spherical area $4\pi d^2$.

- The received power depends upon the wavelength.
- If the Receiver collects power from area A_R:

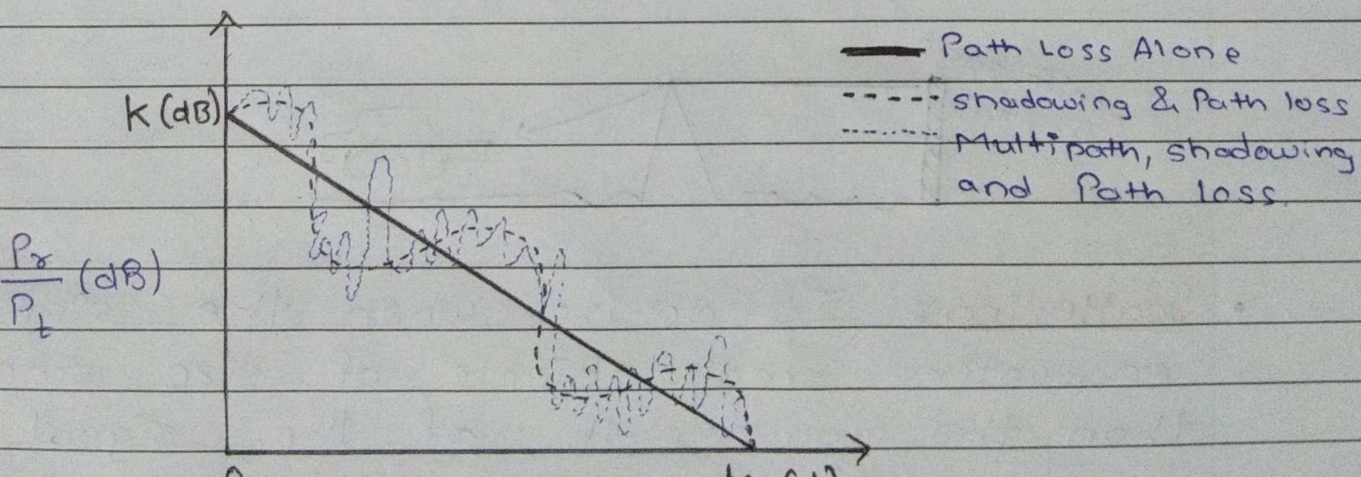
$$P_R = P_T G_T \frac{1}{4\pi d^2} A_R$$

- Receiving Antenna Gain

$$G_R = \frac{4\pi}{\lambda^2} A_R$$

$$\boxed{P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2}$$

- This is known as Frii's Law



4) Explain Small scale multipath propagation in detail.

Ans - Rapid fluctuation of the amplitude of a radio signal over a short period of time or travel distance.

- Fading is caused by multipath waves
  ↳ Transmitted signal which arrive at the receiver at slightly different times.
- Effects: factors influencing small-scale fading.
  ↳ Rapid changes in signal strength over a small travel distance or time interval

  ↳ Random freq. modulation -> varying doppler shift
  ↳ Speed of the mobile or speed of surrounding objects.

  ↳ Time dispersion -> multipath delay: depends on bandwith.

- Fading:

  ↳ No single line-of-sight (LOS): mobile antennas are below the height of surround structures
  ↳ With LOS, multipath still occurs.
  ↳ Multipath -> random distributed amplitude, phases and angles.
  ↳ A mobile is stationary, the signal may fade due to movement of surrounding objects.
  ↳ A receiver moving at high speed can

pass through several fades in a small of time.
↳ Doppler shift.

- Multipath Fading

- Slow Fading
  ↳ over large distances, due to gross changes in path
  ↳ also called shadowing, log-normal fading

- Fast Fading
  ↳ over distances on the order of a wavelength
  ↳ also called Rayleigh fading.

- Assumptions for above types:
  ↳ many waves of roughly equal amplitude arrive
  ↳ Rayleigh distributed amplitude
  ↳ uniformly distributed phase
  ↳ spatial angle of arrive
  ↳ azimuth is uniformly distributed.
  ↳ elevation: PDF has mean of 0°, biased toward small angles, does not extend to infinity, and has no discontinuities

- Rician Fading:
  ↳ there is a LOS or dominant path, producing fewer deep fades occurs in small cells