Wireless Communication CT-2

Part - A

Q1. Far Field Formula

$$dF = \frac{2 \times D^2}{\lambda}$$

dF - Far field Distance
D - Diameter of antenna
λ - wave length of radio wave.

Given D = 1
F = 3000 MHz
w.k.t
$\lambda = \frac{c}{F}$; $F = \frac{c}{\lambda}$
$= \frac{3 \times 10^8}{3000 \times 10^6} = 0.1$

$\lambda = 0.1\ m$

$dF = \frac{2 \times 1^2}{0.1} = 20$. (a)

Reactive near field
$0 < r < 0.62 \sqrt{D^3/\lambda}$
Radiating near field
$0.62 \sqrt{D^3/\lambda} < r < 2D^2/\lambda$

Q2. (d) Scattering.

- Size of rain drop < wavelength - Rayleigh
  > - Mie

Q3. Given
P = 100W

$P_{dBm} = 10 \cdot \log_{10}\left(\frac{P_{mW}}{1\ mW}\right)$

$P_{dBm} = 10 \cdot \log_{10}\left(\frac{100 \times 10^{-3}}{1 \times 10^{-3}}\right) =$

$P_{dBW} = 10 \cdot \log_{10}\left(\frac{P_W}{1W}\right)$

$P_{dBW} = 10 \cdot \log_{10}\left(\frac{100}{10}\right)$
$= 20$

$P_{dBW} = P_{dBm} - 30$

$P_{dBm} = 20 + 30$
$= 50$

(c) 50 and 20.

Q.4. Given,

$G = 2.55dB$, i) ~~length~~ wavelength

$$\lambda = \frac{c}{f}$$

$$\lambda = \frac{3 \times 10^8}{9 \times 10^8} = \frac{1}{3} \text{ meters}$$

(d) 0.083.

ii) Calculate the length of monopole antenna.

$$L_{antenna} = \frac{\lambda}{4} = \frac{0.333}{4} = 0.08325 \text{ m}$$

or 8.3cm.

Q.5 (B) Walfisch and Bertoni

Q.6 (C) Direct RF Pulse.

Q.7 (a) Bandwidth. — Coherence Bandwidth.

Q.8. (b) Frequency Selective Fading.

Q.9. (a) Rayleigh — NLOS

Q.10 (d) $(N-1)\,\Delta t$.

max excess delay is the diff btwn the time of arrival of the earliest and the latest significant multipath component

Part- B |

Q.11 Given,

$\varepsilon_1 = 5$, To calculate the ratio of
$\varepsilon_2 = 6$, the brewster angle.

W.k.t

$$\sin(\theta_B) = \sqrt{\frac{\varepsilon_1}{\varepsilon_1 + \varepsilon_2}} \quad \text{or} \quad \frac{\sqrt{\varepsilon_r - 1}}{\sqrt{\varepsilon_r^2 - 1}}$$

$$= \sqrt{\frac{5}{5+6}}$$

$$= \sqrt{\frac{5}{11}}$$

$\theta_B = 42.39°$.

If $\varepsilon_1 = 6$
then
$\theta_B = 47.607°$

Q.12. The free space propagation model is used to predict the received signal strength when the Tx and Rx have a clear LOS path btwn them.

eg: i) Satellite communication
ii) Microwave LOS Radio Link.

Friis - free space equation.

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

P_t - Tx power

$P_r(d)$ - Rx power.

G_T - Tx antenna gain

G_R - Rx " "

d - T-R separation (m)

L - System loss factor

λ - wave length in m.

The gain of antenna

$$G = \frac{4\pi A_e}{\lambda^2}$$

A_e - effective aperture is related to the physical size of the antenna.

$$\lambda = \frac{c}{f} = \frac{2\pi c}{\omega_c}$$

f - carrier freq in Hz
ω_c - " " in Radians
c - speed of light.

The losses L ($L \geq 1$) are usually due to tx line attenuation, filter losses, and antenna losses in the comm. system. $L = 1$ indicates no loss in system hardware

Isotropic radiator is an ideal antenna which radiates power with unit gain

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

and represents the maximum radiated power available from Tx in the direction of max. antenna gain ~~as compared to~~ an isotropic radiator.

Path loss for free space with antenna gains

$$P_L(dB) = 10 \log \frac{P_t}{P_r} = -10 \log \left[\frac{G_t G_r \lambda^2}{(4\pi)^2 d^2} \right]$$

when antenna gains are excluded-

$$P_L(dB) = -10 \log \left(\frac{\lambda^2}{(4\pi)^2 d^2} \right)$$

The far field region of transmitting antenna is defined as the region beyon the far-field distance

$$d_F = \frac{2D^2}{\lambda}$$ D is the largest physical dimension of the antenna.

$d_F \gg D$ and $d_F \gg \lambda$. must be satisfied.

Furthermore the following eqs. does not hold tho for $d=0$.

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

We use in distance d_0 and known received power $P_r(d_0)$ at that point.

$$P_r(d) = P_r(d_0)\left[\frac{d_0}{d}\right]^2 \qquad d \geq d_0 \geq d_F$$

or

$$P_r(d)\,dBm = 10\log\left[\frac{P_r(d_0)}{0.001\,W}\right] + 20\log\left[\frac{d_0}{d}\right]$$ //

Q.13 In wireless Communication, the concept of an amoeba cell refers to a dynamic and adaptive cell structure that can change its size and shape based on real time conditions, similar to how an amoeba changes form. Traditional networks had fixed cells, leading to inefficiences in high density areas (overcrowding) and low traffic areas (wasted resources).

with technologies like Self-Organising Networks (SON), massive MIMO and beamforming modern networks like (5G) can adjust parameters such as coverage area, power and spectrum use dynamically. These adaptive cells allow for efficient handling of varying traffic loads and interference, providing better user exp. and spectrum utilization. This concept is key in heterogeneous networks and AI-driven networks where real time optimization become critical

---

Part- B2

Q.14. Small Scale Fading is the rapid fluctuations of amplitudes, phases or multipath delays of a radio signal over a short period of time or travel distance so that large scale path loss effects may be ignored.

Factors influencing small scale fading:

i) Multipath propagation - Presence of reflecting objects at ~~random phase and~~ scatters in the channel. Multipath lengthens time required for base band portion of the signal to reach the receiver.

ii) Speed of Mobile - Doppler shift +ve, -ve moving towards or away from BS relative motion between BS and MS results in random frequency modulation.

iii) Speed of surrounding objects.

they induce time varying doppler shift on multipath components. Surrounding objects move at a greater rate than mobile → effect dominates

Tc - staticness of channel - $\propto$ imposed by DS.

iv) Transmission BW: Tx sig BW > BW of multipath channel, reads signal will be distorted, but received signal will not fade much over a local area.

B_c - measure of max. freq. diff for which signals are still strongly correlated in BW (Coherence BW)

diff in path length travels by wave from S to mobile at X and Y $\Delta l = d\cos\theta = v\Delta t\cos\theta$

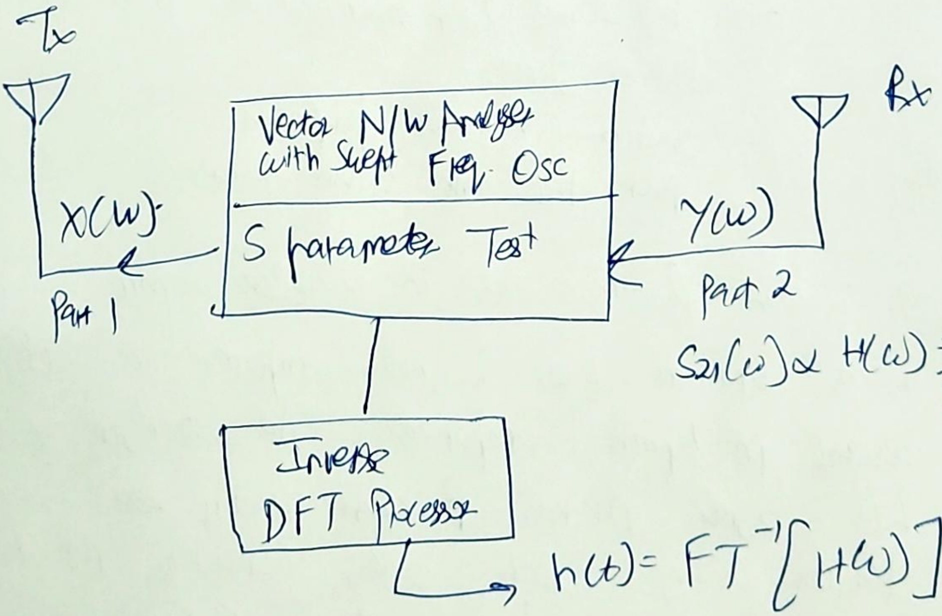
$\Delta\phi = \frac{2\pi\Delta l}{\lambda} = \frac{2\pi v\Delta t}{\lambda}\cos\theta$

Δt - time for $x \to y$

$\theta \to$ Same at x and y

$f_d = \frac{v}{\lambda}\cos\theta$

Q.15. Frequency domain Channel Sounding. (FDCS)



$S_{21}(\omega) \propto H(\omega) = \frac{Y(\omega)}{X(\omega)}$

$h(t) = FT^{-1}[H(\omega)]$.

- FDCS represents dual relationship btwn time and frequency - Channel IR in freq. domain measurement

- A vector Network analyst Controls a Synthesized freq. osc.
- S parameter test set is used to monitor the freq. resp. of the channel.
- Freq Sweeper scans a particular freq band by stepping through discrete freqs. / start or stop freq.
- Synchronization needed betwn Tx and Rx to avoid table losses.
- Its not real time.
- lot of measurement needed, for every step.
- For every freq. point, channel changes and averaging needed.
- Response is converted to time domain by IDFT.

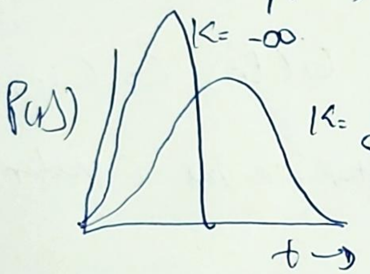
Disadvn. - Post processing needed + System requires careful calibration
- hardwired Synchronization btwn Tx and Rx -
- distance limited.
- Indoor channels preferred
- Non-real time giving errors.

Q.16. Ricean fading occurs in wireless Comm. when there is a dominant LOS signal component in addition to several multipath Components. The strength of the LOS signal makes Ricean fading less severe than Rayleigh fading, which only considers multipath without any direct LOS. Ricean fading is characterized by the K-Factor, which represents the ration of the power in the LOS path and the power in scattered path.

$K = \frac{A^2}{2\sigma^2}$ - ratio btw deterministic signal power and variance of multipath.

Ricean fading degenerates into Rayleigh fading when the LOS components becomes negligible or completely blocked, resulting in only scattered multipath signals. This typically happens in environments with dense obstructions, such as urban area, where direct path is obstructed and the comm. relies solely on multipath propagation.

$K \rightarrow \infty$ $A \rightarrow 0$ degrades into Rayleigh.



Part - C

17. (b). Okumura's model is one of the most widely used models for signal predictions in urban areas. This model is applicable for frequencies in the range 150 MHz to 1920 MHz (although it is typically extrapolated up to 3000 MHz) and distances of 1 km to 100 km.

antenna h = 30m to 1000m

Okumura developed a set of curves giving the median attenuation relative to free space (Amu), in an urban area over a quasi-smooth terrain with a base station effective antenna height (hte) of 200m and mobile antenna height (hre) of 3m.

These curves were developed from extensive measurements using vertical omni-directional antennas at both the base and the mobile, and are plotted as a function of frequ. in range 100 MHz to 1920 MHz and a function of distance from the BS in the range 1km to 100 km

To determine the path loss using Okumura's model, the free space path loss between the points of interest is first determined, and then the value of $A_{mu}(f,d)$ (as read from the curves) is added to it along with correction factors to account for the type of terrain. The model can be expressed as

$$L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{AREA}$$

L_{50} - 50% value of propagation path loss (median)

L_F = free space propagation loss.

$A_{mu}(f,d)$ = median attenuation relative to free space.

$G(h_{te})$ = base station antenna height gain factor.

$G(h_{re})$ = mobile antenna height gain factor.

G_{AREA} = Gain due to environment.

Antenna gain varies at rate of 20 dB or 10 dB per decade

$$G(h_{te}) = 20 \log \frac{h_{te}}{200} \qquad 10m < h_{te} < 1000m.$$

$$G(h_{re}) = 10 \log \frac{h_{re}}{3} \qquad h_{re} \leq 3m.$$

$$G(h_{re}) = 20 \log \frac{h_{re}}{3} \qquad 3m < h_{re} < 10m.$$

model corrected for

Δh = terrain undulation height, isolated ridge height, average terrain slope and mixed land/sea parameter

Given,

$d = 50\ km$,

$h_{te} = 50\ m$

$h_{re} = 5\ m$

$EIRP = 1\ KW$

$f = 900\ MHz$, Find the EIRP in dBm and P_r at the receiver where $G(h_{re}) = 20\ dB$.

$A_{mu}(f,d) = 43\ dB$

$G_{area} = 9\ dB$.

$$\text{Path loss} = 10 \log \left[\frac{\lambda^2}{(4\pi)^2 d^2} \right] = 10 \log \left[\frac{(3\times 10^8 / 900 \times 10^6)^2}{(4\pi)^2 \times (50 \times 10^3)^2} \right]$$

$$= 125.5\ dB$$

$A_{mu} = 43\ dB$

$$G(h_{te}) = 20 \log \left[\frac{h_{te}}{200} \right] = -6\ dB$$

$$G(h_{re}) = 20 \log \left[\frac{h_{re}}{3} \right] = \cancel{20}\ 10.46\ dB$$

$$L_{50}(dB) = L_f + A_{mu} - G(h_{te}) - G(h_{re}) - G_{area}$$

$$= 125.5\ dB + 43\ dB - (-6)\ dB - 10.46\ dB - 9\ dB$$

$$= 155.04\ dB.$$

$\therefore$ The median power received power is

$$P_r(d) = EIRP\ (dBm) - L_{50}\ (dB) + G_r\ (dB).$$

$$= 50\ dBm - 155.04\ dB + 0\ dB = -95.04\ dBm.$$

(11)

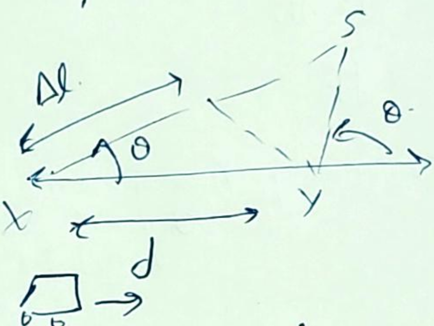
Q. 18(b)

Consider a mobile moving at a constant velocity V along a path segment length d between points X and Y. While it receives signal from a remote source S.

Difference in path length travelled by the ~~sig~~ wave from S to the mobile at points X and Y is

$\Delta l = d \cos\theta$

$\Delta l = V \Delta t \cos\theta$



Δt - time req for mobile to travel from X to Y.

$\theta \rightarrow$ assumed to be the same at points X and Y since source is assumed to be very far away.

The phase change in the received signal due to diff. in path length is

$$\Delta\phi = \frac{2\pi \Delta l}{\lambda} = \frac{2\pi V \Delta t}{\lambda} \cos\theta$$

and hence the apparent change in freq on Doppler shift is given by f_d.

$$f_d = \frac{1}{2\pi} \frac{\Delta\phi}{\Delta t} = \frac{V}{\lambda} \cos\theta$$

this relates the Doppler shift to the mobile velocity and the spatial angle b/w direction of motion of mobile.

If mobile moving towards the direction of arrival of wave fd is positive, away it is negative.

Given $\theta = 25$ deg

$V = 1000$ km/hr. $\quad f = 200$ MHz.

w.k.t

$$f_d = \frac{1}{2\pi}\frac{\Delta\phi}{\Delta t} = \frac{V}{\lambda}\cos\theta$$

$f = \frac{c}{\lambda}$

$\lambda = \frac{c}{f}$

$$= \frac{\frac{1000 \times 10^3}{60 \times 60}}{\frac{3 \times 10^8}{200 \times 10^6}} \times \cos 25$$

$$= \frac{277.77}{1.5} \times 0.906$$

$$= 167.77$$

$f_d = 167.77$ Hz
