HOMEWORK #2 :

1. Consider a user of wireless personal communications set moving slowly in a residential area having many random paths arriving at many random angles so the envelope variations of the small scale multipath variation is well approximated by a Rayleigh distribution. Over the distance interval of motion there is no large scale (shadow) signal variation, i.e. the mean of the small scale variation does not change over the interval. Also, assume that from subjective listening tests it has been determined that users judge the radio link to be acceptable under these conditions if only 2% of the time the signal level falls below the minimum usable signal level threshold.

How many dB must the median signal level exceed the minimum usable signal level threshold in order to insure that the signal does not fall below that threshold more than 2%. (i.e., how much signal margin must be allowed relative to the median to insure that only 2% of the distance moved through will have signal level below the minimum threshold.) Do the problem for no receiving diversity.

2. Large scale signal variation can be approximated by a log-normal distribution with a standard deviation, σ_s. Interference also can be approximated by a log-normal distribution with a different standard deviation, σ_i. Let signal power be represented by S and interference power by I, then, if we define

$$s = 10 \log S$$

$$i = 10 \log I$$

then s and i are normally distributed with means $\bar{s}$ and $\bar{i}$ and standard derivations σ_s and σ_i. Then the S/I ratio becomes s-i and a quantity of interest often is

$$P_1 = P\{s - i < \gamma\}$$

where γ is a signal-to-interference threshold for a system in decibels. Derive a relationship for P_1 in terms of $\bar{s}$, $\bar{i}$, σ_s, σ_i and γ.

[Hint: the final expression will contain a variable v-function of ($\bar{s}$, $\bar{i}$, σ_s, σ_i and γ)]

3. Consider a wireless system with the following parameters:

transmitter power of +20 dBm (20 dB greater than 1 milliwatt)

minimum usable received power of -100 dBm (100dB less than 1 milliwatt)

gain of transmitting antenna=10 dB

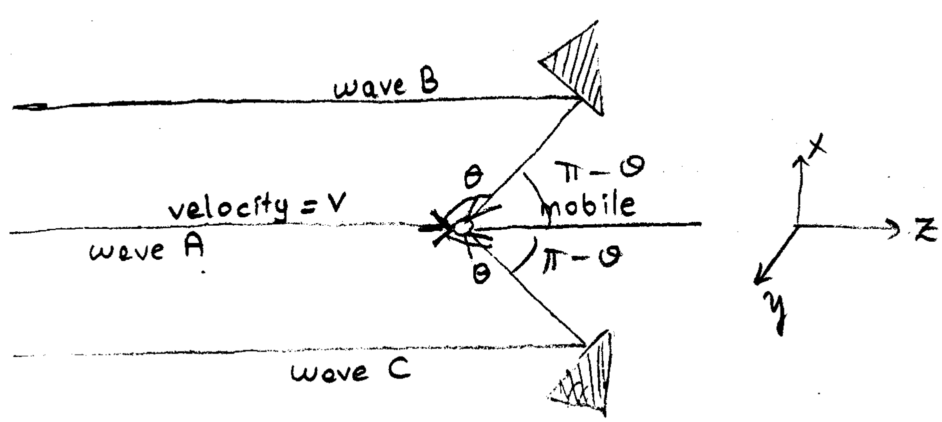
gain of receiving antenna=0 dB

frequency=2 GHz

a) What is the distance in free space over which the wireless system will work?

b) Assume propagation over a flat earth with ideal reflection coefficient of -1. For h_t=30 ft and h_r=5 ft, what is the distance over which the wireless systems will work? (h_t is height of transmitting antenna, h_r is height of receiving antenna). Compare this distance with the distance in free space in a.

4.



Consider the situation in Figure above where mobile station is moving in the vicinity of two local scatterers.

[redacted] each of which has [redacted] a reflection coefficient of 0.5. The reflecti coefficient is the ratio of the amplitudes of the reflectec and incident electric fields.

a) Derive an expression for the resultant signal from paths A, B, and C?

b) Plot the amplitude variation due to multipath fading and calculate the doppler frequency. (Assume $\tau_A = \tau_B = \tau_C$, i.e. time delays of all paths are same, $\theta = 30^\circ$, $v = 30 km/hour$, $f_c = 900 MHz$)

5. Consider a zero-mean complex Gaussian random process $r(t)$ having the autocorrelation function $\phi_{rr}(\tau)$. Determine the correlation function of $z(t) = |r(t)|^2$. Write the expression for $\phi_z(\tau)$ when $r(t)$ is the signal received at isotropic scattering case for a mobile with constant speed v_z.