

MULTIPATH CHANNEL

2.1 Types of multipath channels:

Many multipath models have been proposed to explain the observed statistical nature of a practical mobile channel. Both the first order and second order statistics have been examined in order to find out the effective way to model and combat the channel effects. The most popular of these models are Rayleigh model, which describes the NLoS propagation. The Rayleigh model is used to model the statistical time varying nature of the received envelope of a flat fading envelope. Below, we discuss about the main first order and second order statistical models.

i. AWGN channel:

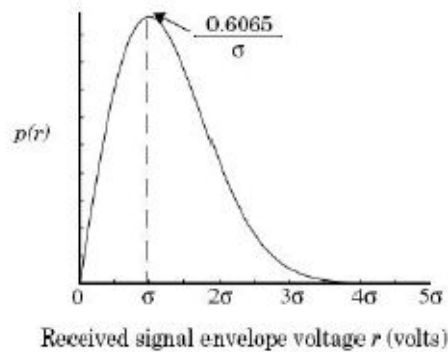
Additive white Gaussian noise (AWGN) is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple and tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered. Wideband Gaussian noise comes from many natural sources, such as the thermal vibrations of atoms in conductors (referred to as thermal noise or Johnson-Nyquist noise), shot noise, black body radiation from the earth and other warm objects, and from celestial sources such as the Sun. The AWGN channel is a good model for many satellite and deep space communication links. It is not a good model for most terrestrial links because of multipath, terrain blocking, interference, etc. However, for terrestrial path modeling, AWGN is commonly used to simulate background noise of the channel under study, in addition to multipath, terrain blocking, interference, ground clutter and self interference that modern radio systems encounter in terrestrial operation.

ii. Rayleigh Fading channel:

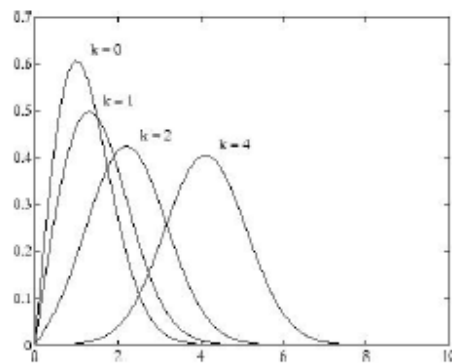
$$f_R(r) = \frac{r}{\sigma^2} e^{-\frac{r^2}{2\sigma^2}} \quad (1.13)$$

Where r = amplitude of received signal

σ^2 = average power of received signal



$$f_R(r) = \frac{r}{\sigma^2} e^{-\frac{(r^2 + A^2)}{2\sigma^2}} I_0\left(\frac{Ar}{\sigma^2}\right) \quad (1.14)$$



2.2 Multipath Channel Parameters:

To compare the different multipath channels and to quantify them, we define some parameters. They all can be determined from the power delay profile. These parameters can be broadly divided into two types.

2.2.1 Time Dispersion Parameters:

These parameters include the mean excess delay, rms delay spread and excess delay spread. The mean excess delay is the first moment of the power delay profile and is defined as

$$\bar{\tau} = \frac{\sum a_k^2 \tau_k}{\sum a_k^2} = \frac{\sum P(\tau_k) \tau_k}{\sum P(\tau_k)} \quad (1.15)$$

where a_k is the amplitude, τ_k is the excess delay and $P(\tau_k)$ is the power of the individual multipath signals.

The mean square excess delay spread is defined as

$$\tau^2 = \frac{\sum P(\tau_k) \tau_k^2}{\sum P(\tau_k)} \quad (1.16)$$

Since the rms delay spread is the square root of the second central moment of the power delay profile, it can be written as

$$\sigma_\tau = \sqrt{\tau^2 - (\bar{\tau})^2} \quad (1.17)$$

As a rule of thumb, for a channel to be at fading the following condition must be satisfied

$$\frac{\sigma_\tau}{T_S} \leq 0.1 \quad (1.18)$$

where T_S is the symbol duration. For this case, no equalizer is required at the receiver.

2.2.2 Frequency Dispersion Parameters:

To characterize the channel in the frequency domain, we have the following parameters.

a) Coherence bandwidth:

It is a statistical measure of the range of frequencies over which the channel can be considered to pass all the frequency components with almost equal gain and linear phase. When this condition is satisfied then we say the channel to be at.

Practically, coherence bandwidth is the minimum separation over which the two frequency components are affected differently. If the coherence bandwidth is considered to be the bandwidth over which the frequency correlation function is above 0.9, then it is approximated as

$$B_C \approx 1/(50\sigma_\tau) \quad (1.19)$$

However, if the coherence bandwidth is considered to be the bandwidth over which the frequency correlation function is above 0.5, then it is defined as

$$B_C \approx 1/(5\sigma_\tau) \quad (1.20)$$

The coherence bandwidth describes the time dispersive nature of the channel in the local area. A more convenient parameter to study the time variation of the channel is the coherence time. This variation may be due to the relative motion between the mobile and the base station or the motion of the objects in the channel.

b) Coherence time:

This is a statistical measure of the time duration over which the channel impulse response is almost invariant. When channel behaves like this, it is said to be slow faded. Essentially it is the minimum time duration over which two received signals are affected differently. For an example, if the coherence time is considered to be the bandwidth over which the time correlation is above 0.5, then it can be approximated as

$$T_C \approx \frac{9}{16\pi f_m} \quad (1.21)$$

where f_m is the maximum doppler spread given by $f_m = v/\lambda$