1.5 FADING EFFECTS DUE TO MULTIPATH TIME DELAY SPREAD

Flat Fading

If the mobile radio channel has a constant gain and linear phase response over a bandwidth which is greater than the bandwidth of the transmitted signal, then the received signal will undergo flat fading.

In flat fading, the multipath structure of the channel is such that the spectral characteristics of the transmitted signal are preserved at the receiver. However the strength of the received signal changes with time, due to fluctuations in the gain of the channel caused by multipath.

The characteristics of a flat fading channel are shown in Figure 1.5.1.

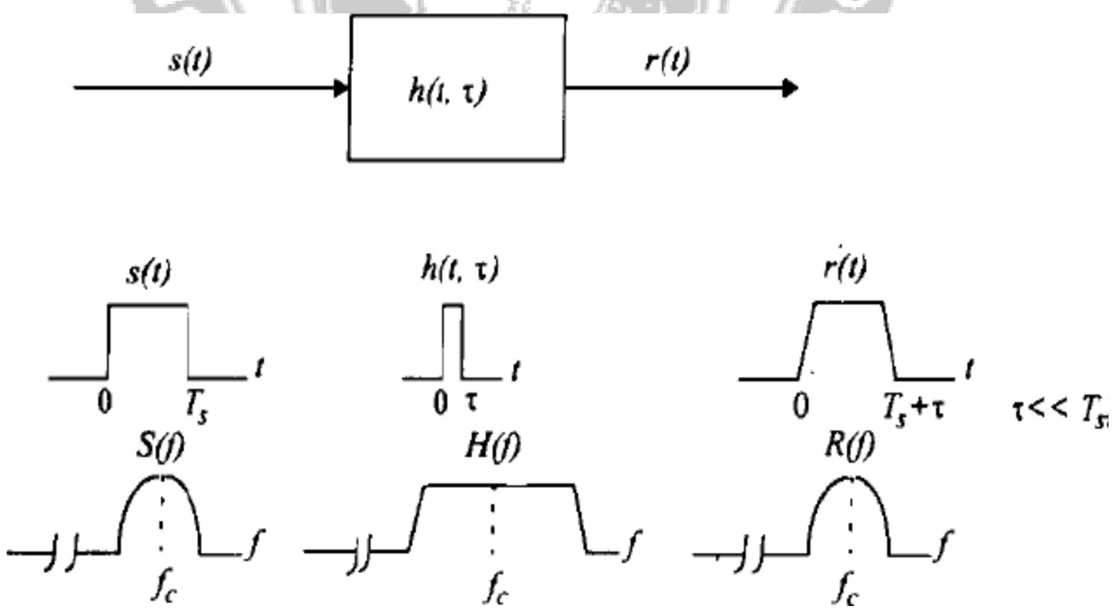

Fig 1.5.1: Characteristics of a Flat Fading Channel.

[Source : "Wireless communications "by Theodore S. Rappaport,Page-168]

It can be seen from Figure 1.5.1 ,that if the channel gain changes over time, a change of amplitude occurs in the received signal.

The received signal r (t) varies in gain, but the spectrum of the transmission is preserved.

Flat fading channels are also known as amplitude varying channels and are sometimes referred to as narrowband channels, since the bandwidth of the applied signal is narrow as compared to the channel flat fading bandwidth.
Flat fading occurs when the bandwidth of the transmitted signal is less than the coherence bandwidth of the channel. we can say that flat fading occurs when

$$\boldsymbol{B_s \ll B_c}$$

where BS is the signal bandwidth and BC is the coherence bandwidth.

$$\boldsymbol{T_s \gg \sigma_\tau}$$

where TS is the symbol period and σ_τ is the rms delay spread. And in this case, mobile channel has a constant gain and linear phase response over its bandwidth.

Frequency Selective Fading

If the channel maintains a constant-gain and linear phase response over a bandwidth that is smaller than the bandwidth of transmitted signal, then the channel creates frequency selective fading on the received signal.

Under such conditions the channel impulse response has a multipath delay spread which is greater than the reciprocal bandwidth of the transmitted message waveform. When this occurs, the received signal has multiple versions of the transmitted waveform which are attenuated (faded) and delayed in time, and hence the received signal is distorted. Frequency selective fading is due to time dispersion of the transmitted symbols within the channel.

Thus the channel induces inter symbol interference (ISI). Frequency selective fading channels are much more difficult to model than flat fading channels since each multipath signal must be modelled and the channel must be considered to be a linear filter. It is for this reason that wideband multipath measurements are made, and models are developed from these measurements.

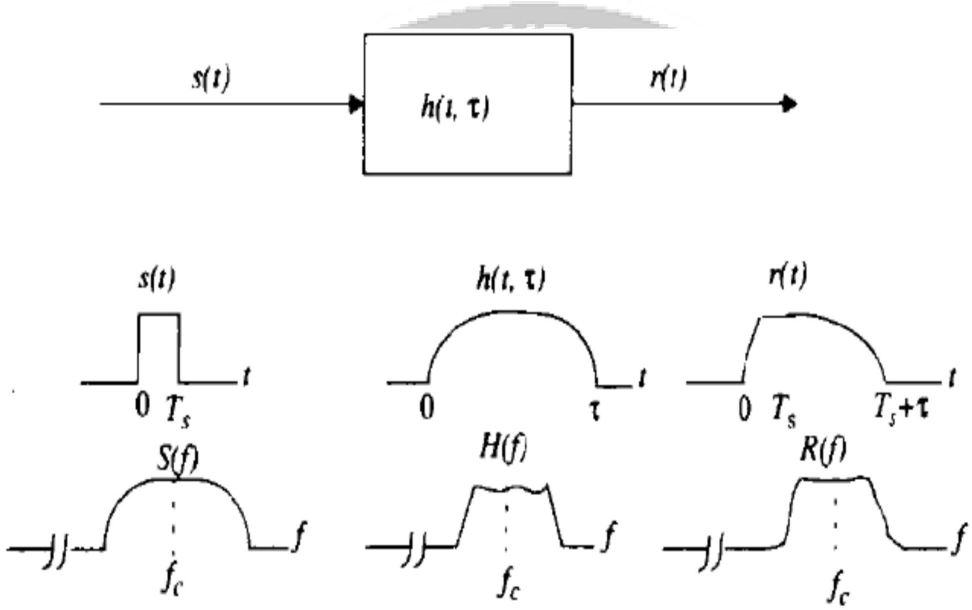

Fig 1.5.2: Characteristics of a Frequency Selective Fading Channel.

[Source :" Wireless communications"by Theodore S. Rappaport,Page-170]

For frequency selective fading as in figure 1.5.2, the spectrum S (f) of the transmitted signal has a bandwidth which is greater than the coherence bandwidth Bc of the channel. Viewed in the frequency domain, the channel becomes frequency selective, where the gain is different for different frequency components. Frequency selective fading is caused by multipath delays that exceed the symbol period of the transmitted symbol.

Frequency selective fading occurs when the signal bandwidth is more than the coherence bandwidth of the mobile radio channel or equivalently the symbol duration of the signal is less than the rms delay spread.

$B_S \gg B_C$ and

$T_S \ll \sigma_\tau$

A channel is frequency selective if , $T_s \leq 10\ \sigma_\tau$.

Fading Effects Due to Doppler Spread

Fast fading

In a fast fading channel, the channel impulse response changes rapidly within the symbol duration. That is, the coherence time of the channel is smaller than the symbol period of the transmitted signal. This causes frequency dispersion (also called time selective fading) due to Doppler spreading, which leads to signal distortion.

Viewed in the frequency domain, signal distortion due to fast fading increases with increasing Doppler spread relative to the bandwidth of the transmitted signal. Therefore, a signal undergoes fast fading if

$$\boldsymbol{T_s > T_c} \quad \text{and} \quad \boldsymbol{B_s < B_D}$$

In practice, fast fading only occurs for very low data rates.

Slow Fading

In a slow fading channel, the channel impulse response changes at a rate much slower than the transmitted baseband signal s(t). In this case, the channel may be assumed to be static over one or several reciprocal bandwidth intervals. In the frequency domain, the Doppler spread of the channel is much less than the bandwidth of the baseband signal. Therefore, a signal undergoes slow fading if

$$T_s \ll T_c \quad \text{and} \quad B_s \gg B_D$$

The velocity of the mobile (or velocity of objects in the channel) and the baseband signalling determines whether a signal undergoes fast fading or slow fading.