# 1.4 PARAMETERS OF MOBILE MULTIPATH CHANNELS

Power delay profiles are found by averaging instantaneous power delay profile measurements over a local area in order to determine an average small-scale power delay profile.

**Time dispersion parameters**

The time dispersive properties of wide band multipath channels are most commonly quantified by their mean excess delay and rms delay spread.

The mean excess delay is the first moment of the power delay profile and is defined as

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

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

The rms delay spread is the square root of the second central moment of the power delay profile and is defined as

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

where

$$\overline{\tau^2} = \frac{\sum_k a_k^2 \tau_k^2}{\sum_k a_k^2} = \frac{\sum_k P(\tau_k)\tau_k^2}{\sum_k P(\tau_k)}$$

These delays are measured relative to the first detectable signal arriving at the receiver at τo = 0.

Typical values of rms delay spread are on the order of microseconds in outdoor mobile radio channels and on the order of nanoseconds in indoor radio channels.

Note that the rms delay spread and mean excess delay are defined from a single power delay profile which is the temporal or spatial average of consecutive impulse response

measurements collected and averaged over a local area. Typically, many measurements are made at many local areas in order to determine a statistical range of multipath channel parameters for a
mobile communication system over a large-scale area .

The maximum excess delay (X dB) of the power delay profile is defined to be the time delay during which multipath energy falls to X dB below the maximum.

Figure 1.4.1, illustrates the computation of the maximum excess delay for multipath components within 10 dB of the maximum.

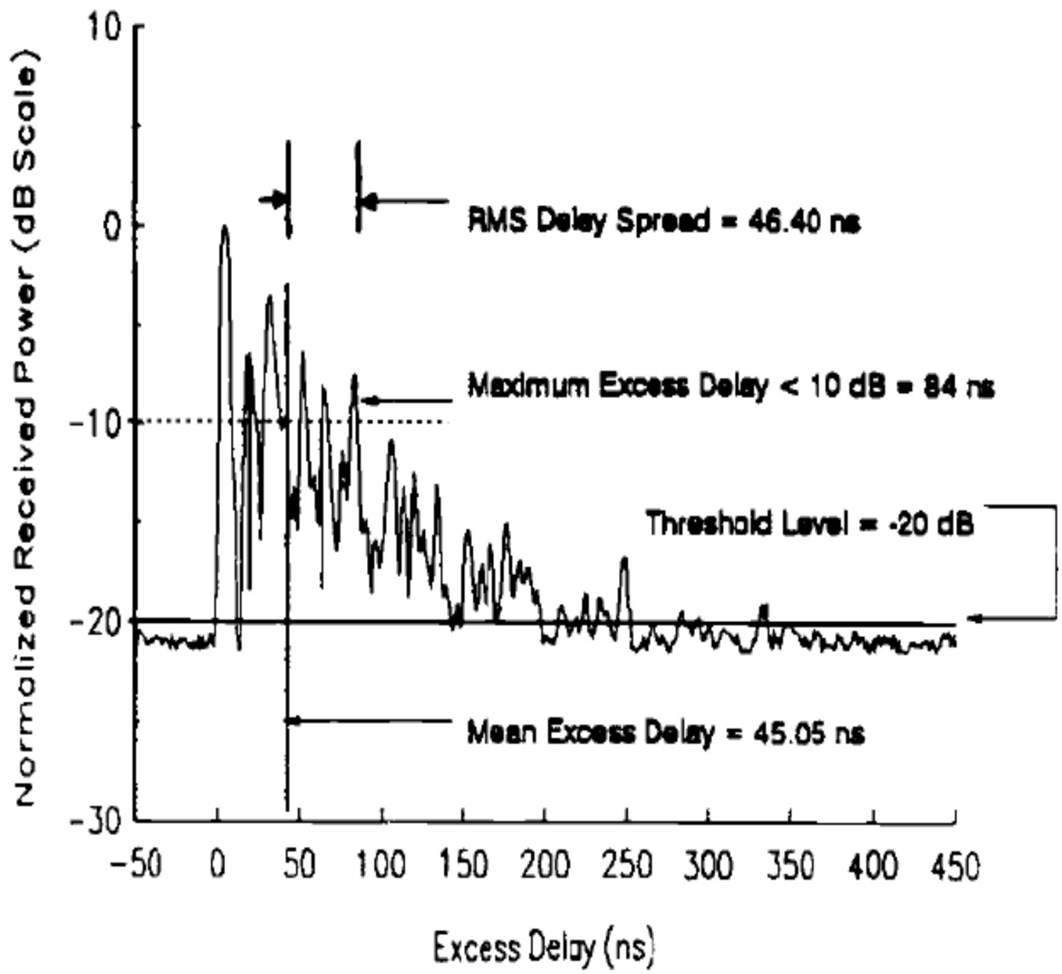


**Fig 1.4.1: Power Delay Profile**

*[Source :" Wireless communications "by Theodore S. Rappaport,Page-163]*

The values of time dispersion parameters also depend on the noise threshold
(the level of power below which the signal is considered as noise).

In practice, values of $\overline{\tau}, \overline{\tau^2}, \sigma_\tau$ depend on the choice of noise threshold used to process P (t).

The noise threshold is used to differentiate between received multipath components and thermal noise. If the noise threshold is set too low, then noise will be processed as multipath, thus giving rise to values of t, P. and that are artificially high.

### Coherence Bandwidth (BC)

It is a measure of the range of frequencies over which the channel can be considered flat(i.e. channel passes all spectral components with equal gain and linear phase). It is a definition that depends on RMS Delay Spread. Two sinusoids with frequency separation greater than Bc are affected quite differently by the channel. If we define Coherence Bandwidth (BC) as the range of frequencies over which the frequency correlation is above 0.9, then

$$B_C = \frac{1}{50\sigma}$$ σ is rms delay spread.

If we define Coherence Bandwidth as the range of frequencies over which the frequency correlation is above 0.5, then, This is called 50% coherence bandwidth.

$$B_c \approx \frac{1}{5\sigma_\tau}$$

### Doppler Spread and Coherence time

Doppler Spread and Coherence time are parameters which describe the time varying nature of the channel in a small-scale region.

Measure of spectral broadening caused by Motion Doppler spread, BD, is defined as the maximum Doppler shift: fm= v/λ If the baseband signal bandwidth is much greater than BD, then effect of Doppler spread is negligible at the receiver.

Coherence time is the time duration over which the channel impulse response is essentially invariant. If the symbol period of the baseband signal (reciprocal of the baseband signal bandwidth) is greater the coherence time, then the signal will distort, since channel will change during the transmission of the signal.

The Doppler spread and coherence time are inversely proportional to one another. That is,

$$T_c = \frac{1}{f_m}$$

In other words, coherence time is the time duration over which two received signals have a strong potential for amplitude correlation. If the reciprocal bandwidth of the baseband signal is greater than the coherence time of the channel, then the channel will change during the transmission of the baseband message, thus causing distortion at the receiver.

If the coherence time is defined as the time over which the time correlation function is above 0.5, then the coherence time is approximately given by.

$$T_C = \sqrt{\frac{9}{16\pi f_m^2}} = \frac{0.423}{f_m}$$

The definition of coherence time implies that two signals arriving with a time separation greater than $T_c$ are affected differently by the channel.
For example, for a vehicle traveling 60 mph using a 900 MHz carrier, a conservative value of $T_c$ can be shown to be 2.22 ms.

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