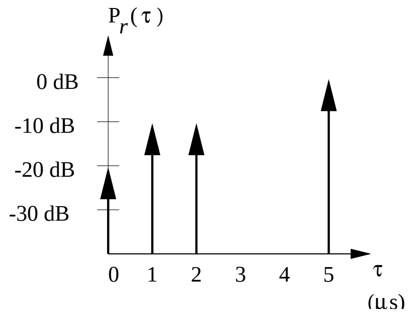
Examples on Fading Channels

Example 1

- Calculate the mean excess delay, rms delay spread, and the maximum excess delay (10 dB) for the multipath profile given in the figure below.
- Estimate the 50% coherence bandwidth of the channel.
- Given that signal bandwidths of AMPS, GSM and IS-95 are 30 kHz, 200 kHz and 1.25 MHz respectively, determine if a signal under those systems will experience frequency selective or flat fading.



Example 1: Solution

- The mean excess delay for the given profile

$$\bar{\tau} = \frac{(1)(5) + (0.1)(1) + (0.1)(2) + (0.01)(0)}{0.01 + 0.1 + 0.1 + 1} = 4.38\ \mu\text{s}$$

- The second moment for the given power delay profile is calculated as

$$\bar{\tau^2} = \frac{(1)(5)^2 + (0.1)(1)^2 + (0.1)(2)^2 + (0.01)(0)}{0.01 + 0.1 + 0.1 + 1} = 21.07\ \mu\text{s}^2$$

Therefore, the rms delay spread,

$$\sigma_\tau = \sqrt{21.07 - (4.38)^2} = 1.37\ \mu\text{s}$$

Example 1: Solution (continued)

- The coherence bandwidth is obtained as

$$B_c \approx \frac{1}{5\sigma_\tau} = \frac{1}{5(1.37\ \mu s)} = 146 \text{ kHz}$$

- Since $B_c > B_s^{\text{AMPS}} = 30$ kHz an AMPS signal will experience flat fading.
- Since $B_c < B_s^{\text{GSM}} = 200$ kHz and $B_c < B_s^{\text{IS-95}} = 1.25$ MHz, both GSM and IS-95 signals will experience frequency selective fading.

Example 2

- For a vehicle travelling 50 m/s using a 1900 MHz carrier, find the coherence time of the channel. Use the popular rule of thum to define the coherence time.
- Given the duration of an IS-95 frame is 20 ms, determine the number of fades (number of times the channel will vary) within a frame.

Example 2: Solution

- The popular rule of thumb to define coherence time T_{C} is

$$T_{\mathrm{C}} = \frac{0.423}{f_m}$$

where f_m is the maximum Doppler shift given by

$$f_m = \frac{v}{\lambda} = \frac{v f_c}{c} = \frac{(50)(1900)(10^6)}{(3)(10^8)} = 316.7 \text{ Hz}$$

- Therefore $T_{\mathrm{C}} = \dfrac{0.423}{316.7} = 1.336$ ms.

Example 2: Solution (continued)

- The number of fades in an IS-95 frame is

$$n = \frac{20}{T_{\mathrm{C}}} = \frac{20}{1.336} = 15$$