ELC 5396: Digital Communications

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Signaling over Fading Channels

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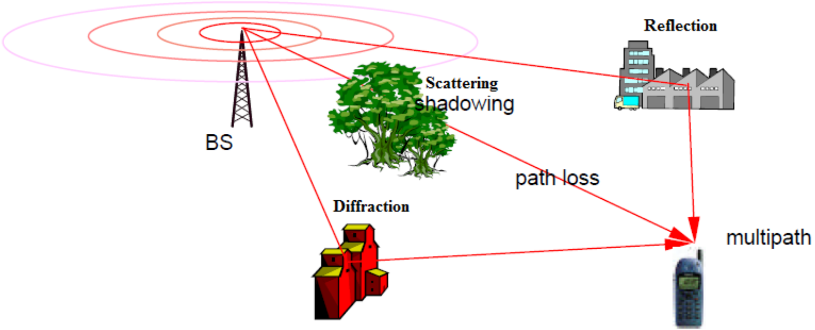
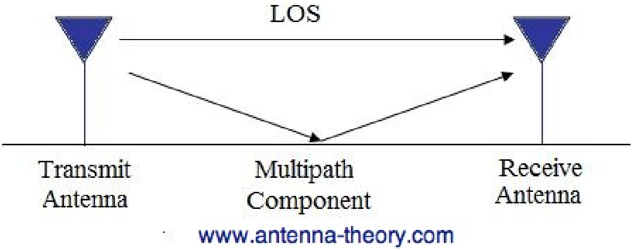
- Fading refers to the fact that even though the distance separating a mobile receiver from the transmitter is essentially constant, a relatively small movement of the receiver away from the transmitter could result in a significant change in the received power.
- How to combat the degrading effect of multipath and thereby realize reliable communication over a fading channel. *Space Diversity*

Propagation Effects



Propagation Effects



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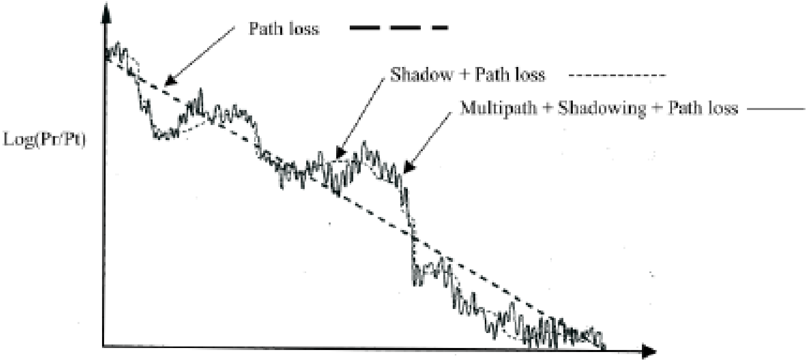
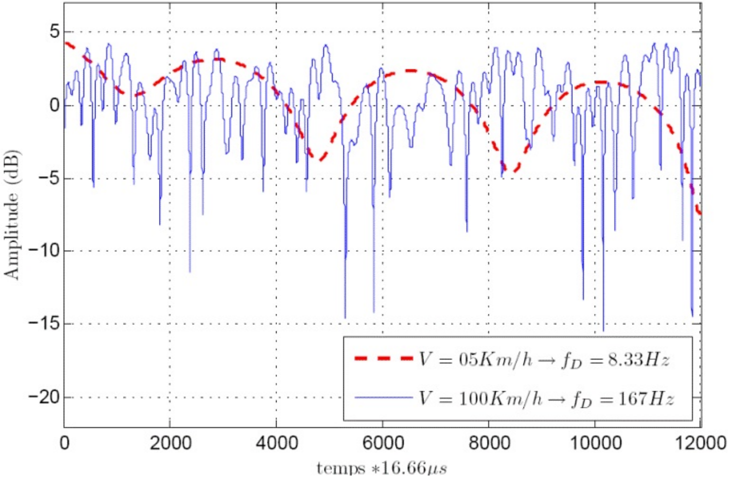
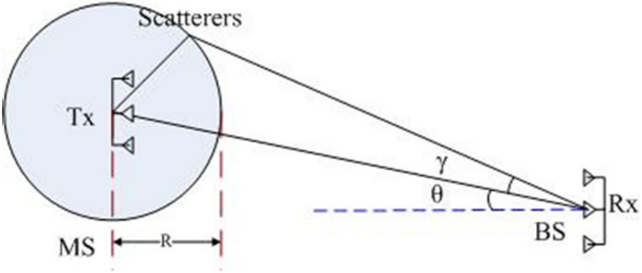


Small-scale Multipath Fading



Jakes Model



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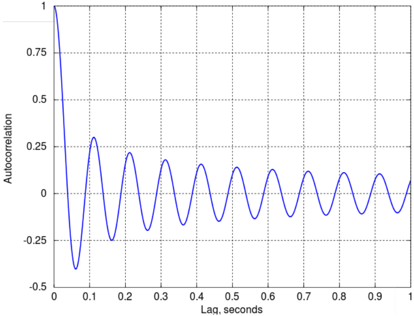

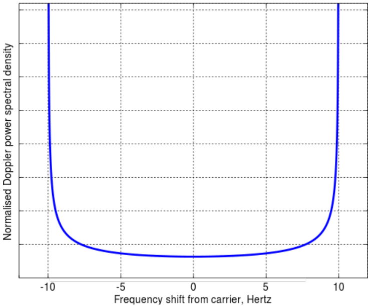

Rayleigh fading with Doppler frequency 10 Hz.

Statistical Characterization of Wideband Wireless Channels

- Signal bandwidth vs. The reciprocal of the spread in propagation path delays
- Coherence bandwidth

$$B_c \approx \frac{1}{D}$$

- "Wideband" when the signal bandwidth significantly exceeds the coherence bandwidth of the channel

Statistical Characterization of Wideband Wireless Channels

$$y(t) = \int_{-\infty}^{\infty} h(\tau; t) x(t-\tau) d\tau$$

$$H(f; t) = \int_{-\infty}^{\infty} h(\tau; t) e^{-j2\pi f \tau} d\tau$$

Channel assumptions:

- $h(\tau; t)$ is wide-sense stationary.
- Uncorrelated Scattering: Contributions from two or more scatterers with different propagation delays are uncorrelated.

$$\begin{aligned} R_h(\tau_1, t_1; \tau_2, t_2) &= \mathbb{E}[h^*(\tau_1; t_1) h(\tau_2; t_2)] \\ &= \underbrace{r_h(\tau_1; \Delta t)}_{\text{multipath correlation profile}} \delta(\tau_1 - \tau_2) \end{aligned}$$

Classification of Multipath Channels

Channel is viewed in the frequency domain.

- A multipath channel is said to be *frequency selective* if the coherence bandwidth of the channel is small compared with the bandwidth of the transmitted signal.
- A multipath channel is said to be *frequency nonselective*, or *frequency flat*, if the coherence bandwidth of the channel is large compared with the transmitted signal bandwidth.

Classification of Multipath Channels

Channel is viewed in the time domain.

- The fading is *time selective* if the coherence time of the channel is small compared with the duration of the received signal (i.e., the time for which the signal is in flight).
- If the channel's coherence time is large compared with the received signal duration, then the fading is said to be *time nonselective*, or *time flat*.

Channel coherence time is inversely proportional to the Doppler spread.

$$\tau_c = \frac{1}{\sigma_{fd}}$$