APECE-302: Radio & Television Engineering

Applied Physics, Electronics & Communication Engineering

Lecture # 03

University of Dhaka | APECE DU

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Date: 2012 Year, 04 Month, 24 Day

Contents

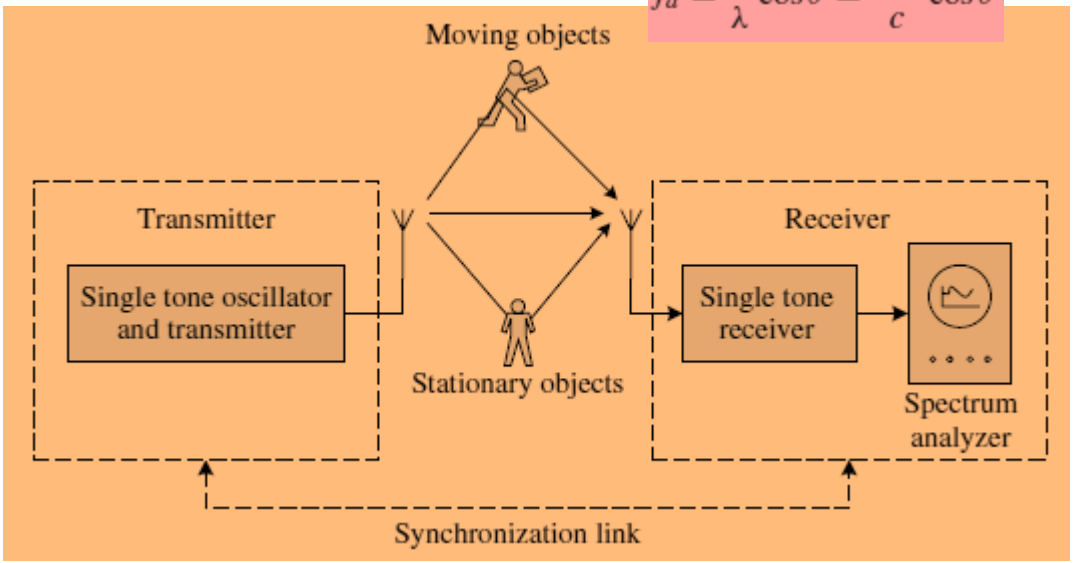
- Narrowband and frequency-domain characteristics of channel
  - Frequency-dispersive channel
- Wideband and time-domain channel characteristics
  - Time-dispersive channel
- Frequency Selectivity of Channel
  - Flat fading
  - Frequency selective fading

NB and frequency-domain channel characteristics

- Experiment-based approach

$$f_d = \frac{v}{\lambda}\cos\theta = \frac{vf_c}{c}\cos\theta$$

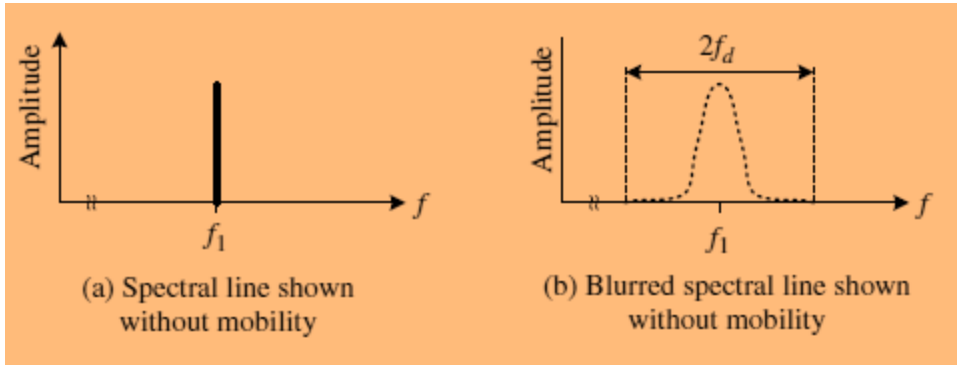
Doppler shift



A generic system setup of a narrowband channel sounding experiment system.

$$r_3(t) = \sin\omega_c t + sin\omega_c(t+\tau) + \sin(\omega_c + 2\pi f_d)(t+\tau)$$

NB and frequency-domain channel characteristics



(a) Spectral line shown without mobility

(b) Blurred spectral line shown without mobility

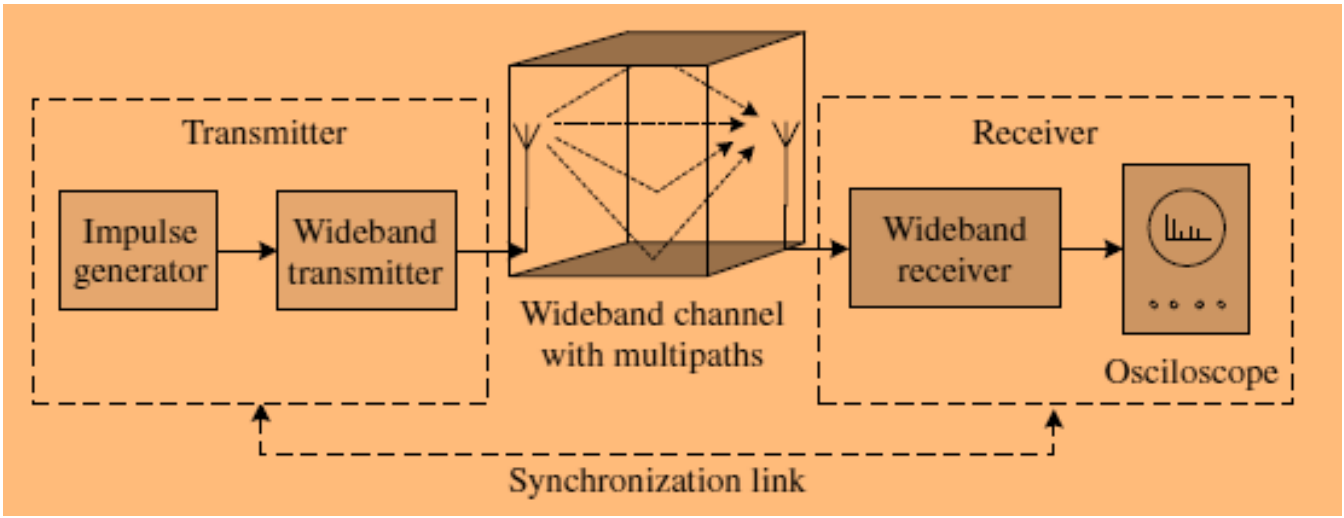
Coherent time ← $T_{co} \cong \frac{1}{\Delta f_d}$ ← Doppler spread

↓

Slow fading channel/fast fading channel

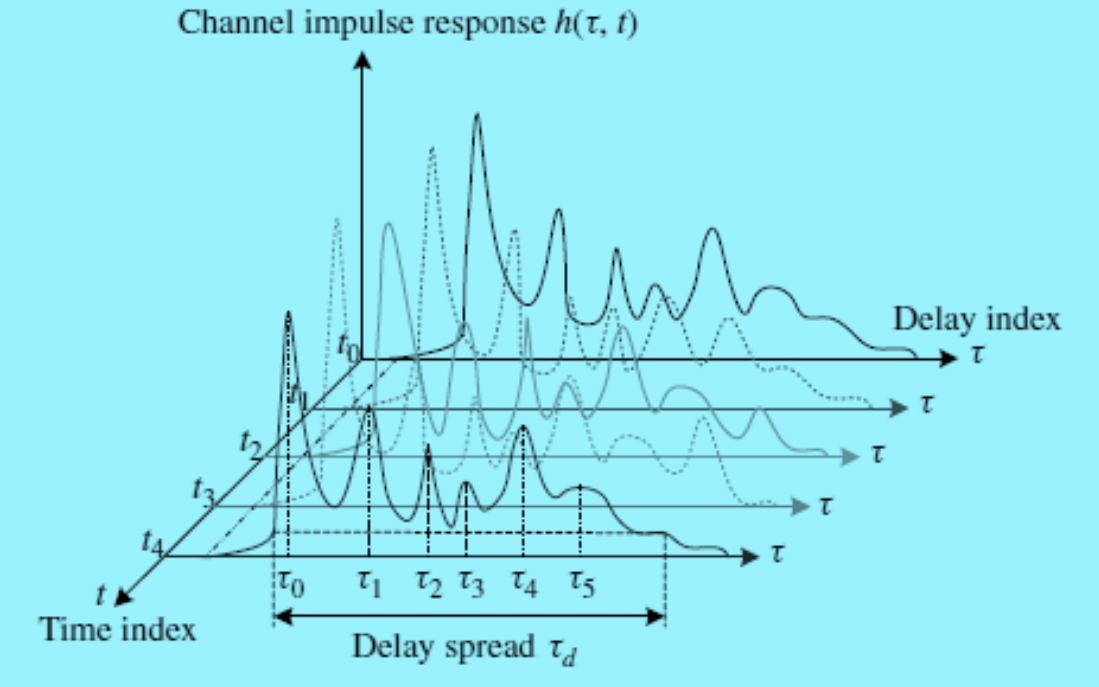
WB and time-domain channel characteristics

- Experiment-based approach
- Indoor environment for simplicity



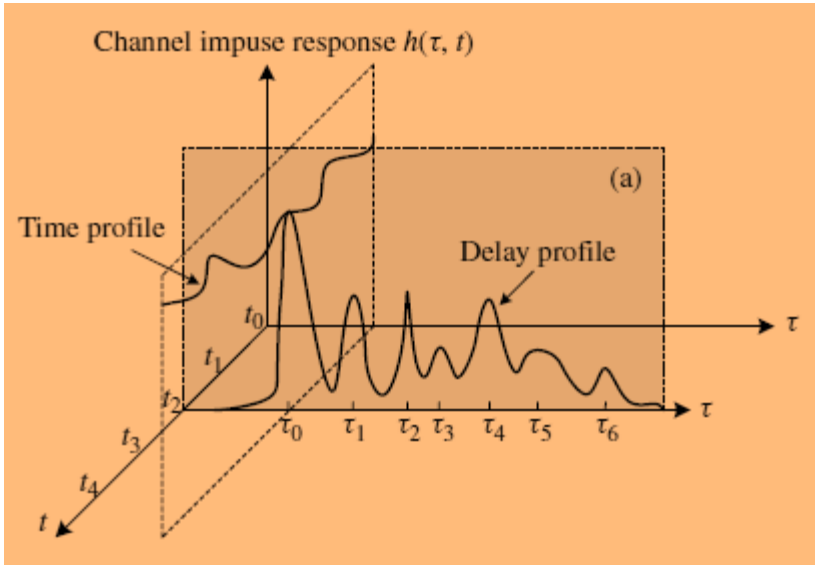
- Perfect synchronization

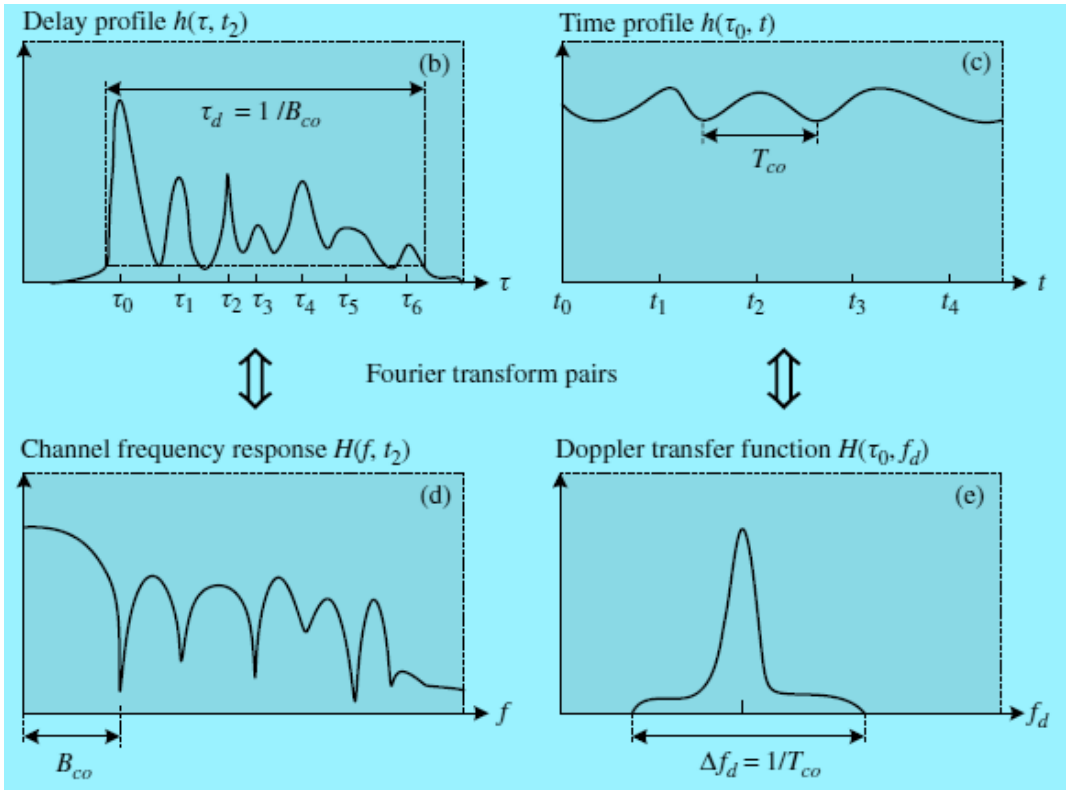
WB and time-domain channel characteristics



Time dispersive channel

WB and time-domain channel characteristics





$\tau_d = \frac{1}{B_{co}}$.

Four Parameters

- The delay spread τ_d is defined as the widest delay span, over which all multipath returns are higher than a certain threshold. The delay spread is approximately equal to the reciprocal of the coherent bandwidth B_{co}.
- The coherence bandwidth B_{co} is defined as the smallest frequency range, within which all signals can pass without suffering serious frequency-selective fading. It is also equal to the reciprocal of the delay spread τ_d.
- The Doppler spread Δf_d is defined as the width of Doppler spectrum caused by mobility in the channel. The Doppler spread is equal to the reciprocal of the coherent time T_{co}.
- The coherent time T_{co} is defined as the time duration, beyond which two signal samples separated longer than T_{co} can usually be considered independent of each other. The coherent time can also be obtained by measuring the average cycle of the signal change in the time profile function $h(\tau_0, t)$, and is equal to the reciprocal of the Doppler spread Δf_d.

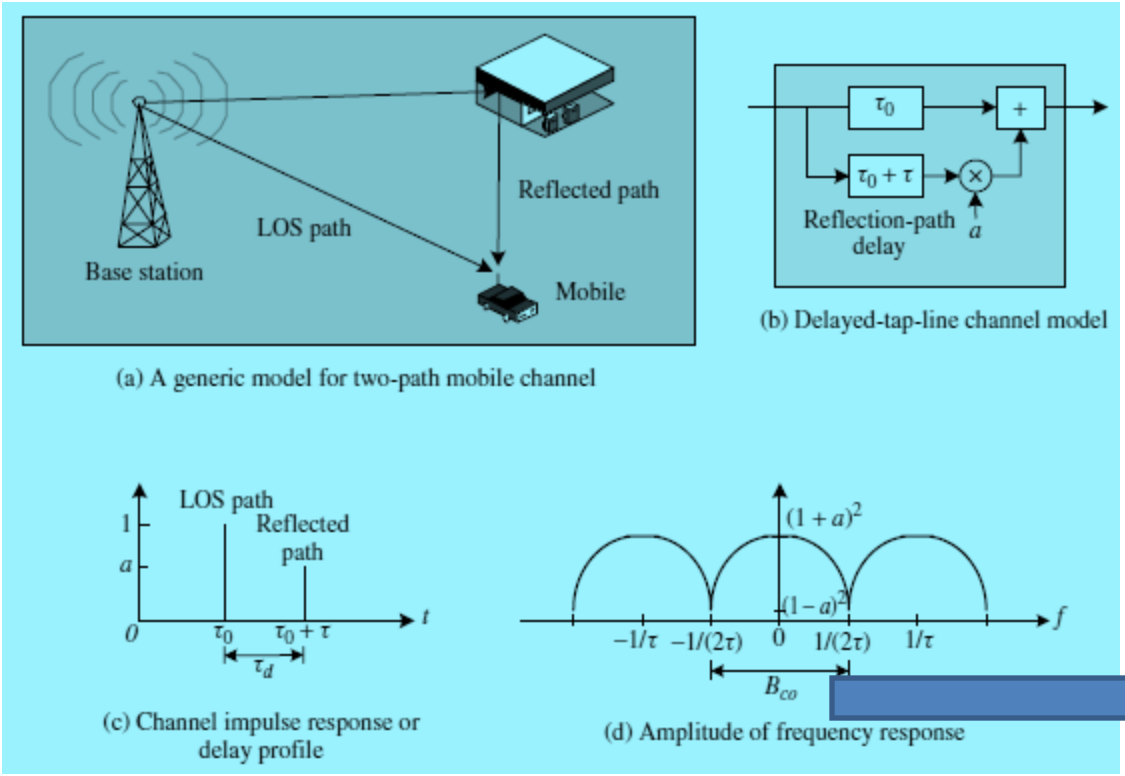
Flat Fading Channel

- Flat fading or frequency nonselective fading channel
- Still multipath effect exist but spectral characteristics of Tx signal are preserved at Rx
- Signal fluctuation due to MP?
- Flat fading in time domain: symbol duration >> delay spread; no ISI
- 20 dB to 30 dB more power to compensate deep fade time to time

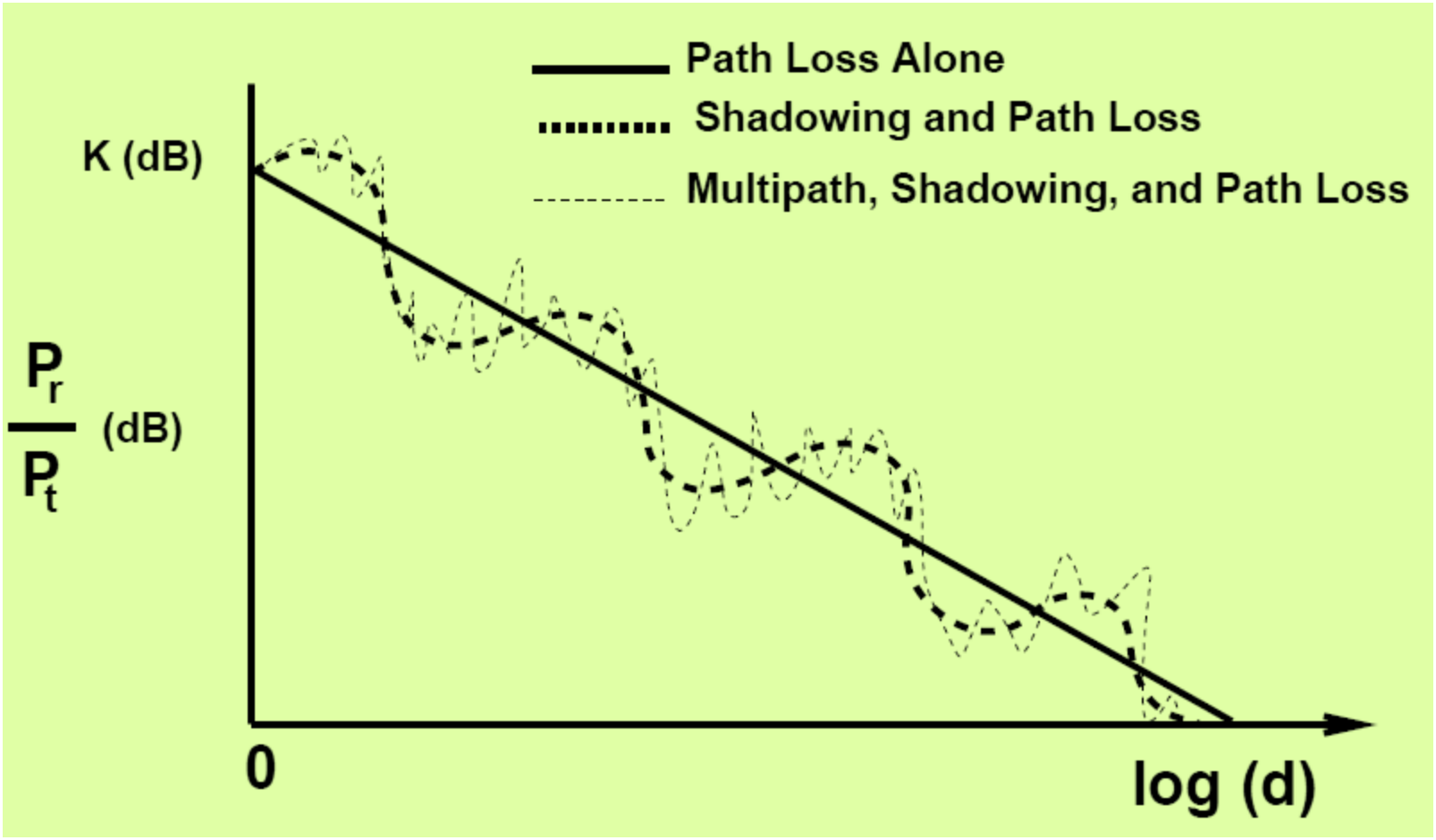
Frequency Selective Fading Channel

- Different attenuation at the Rx signal at different frequencies
- Not only distorts the signal in both time and frequency domain but also ISI; MI
- Clustered arrival at Rx? Many replicas; MP fading: constructive & destructive interference (fast and short-term variation)

MP Modeling


Base station
LOS path
Reflected path
Mobile
(a) A generic model for two-path mobile channel
τ_0
$\tau_0 + \tau$
+
×
Reflection-path delay
a
(b) Delayed-tap-line channel model
LOS path
Reflected path
1
a
0
τ_0
$\tau_0 + \tau$
τ_d
t
(c) Channel impulse response or delay profile
$(1+a)^2$
$(1-a)^2$
$-1/\tau$
$-1/(2\tau)$
0
$1/(2\tau)$
$1/\tau$
f
B_{co}
(d) Amplitude of frequency response
$\tau_d \cong \frac{1}{B_{co}}$

Channel: Path loss, Shadowing & MP



Q & A