APECE-302: Radio & Television Engineering

Applied Physics, Electronics & Communication Engineering

LEC PPT # 01

University of Dhaka | APECE DU

Course Teacher: S.M. Riazul Islam, PhD

Date: 2013 Year, 04 Month, 23Day

Contents

- Course Introduction
- Communication Process, and Communication Resources
- Analog and Digital Types of Communication
- Shannon’s Information Capacity Theorem
- Spectrum Allocation
- Theory of Radio Communication Channels

Course Introduction

- Course Tile: Radio and Television Engineering
- Course Code: APECE-302
- Credits: 3

- **Evaluation**
  - Attendance, HW and Team Project, In-course/Sudden exam: 24 (30%)
  - Final Exam: 56 (70%)

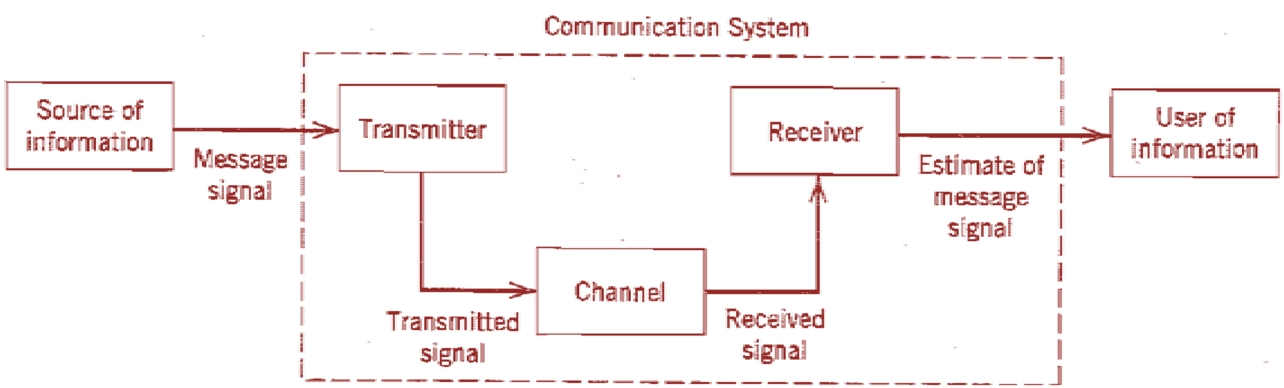
- **Schedule**
  - 15-20 Lectures: Radio
  - In-course after 15/20 Lectures if not assigned by exam committee
  - 10-15 Lectures: TV

Course Introduction

- Reference Books:
  - Communication Systems- Simon Haykin.
  - Next Generation Wireless Systems and Networks- Chen & Guizani.
  - Principles of Communication: System, Modulation and Noise- R.E. Ziemer, W.H. Tranter
  - Wireless Communications- Andrea Goldsmith.
  - Principles of Communication System- Herbert Taub, D.L. Schilling.
  - Monochrome and Colour Television- R.R. Gulati.
  - Fundamental of Digital Television Transmission- Gerald W. Collins.

Communication Process

- Communications applications and area
- Tx-to-Rx
  - Message signals: voice, music, computer date, picture, video, volume data
  - Symbols: Electrical, aural or visual
  - Encoding
  - Decoding and reproduction
  - Re-creation
- Elements? Modes=Broadcast & pt-to-pt



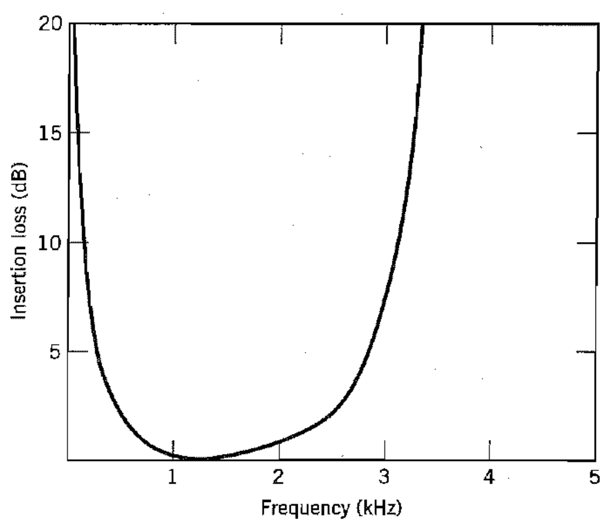
Communication Resources

- Tx power and Channel BW
- Band limited (Telephone circuit) and Power limited (space com link or satellite channel)
- Voice articulation over 300 to 3100 Hz
- Noise(external or internal)
- SNR and dB

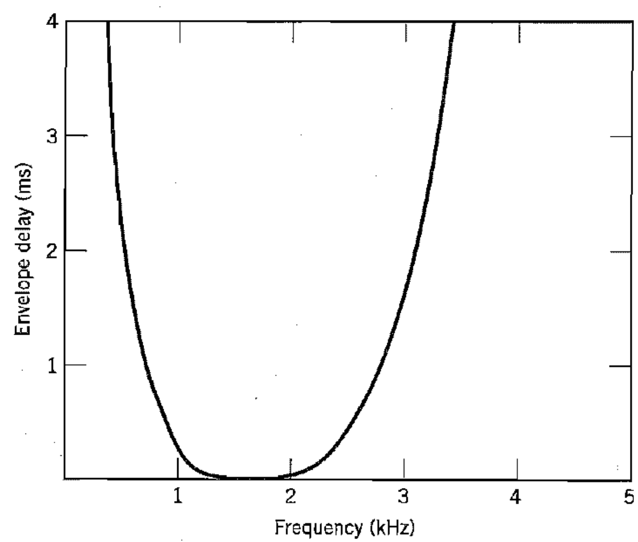
Communication Channels

- ❑ Free space or Guided
- ❑ Telephone channel (Band limited); Coaxial cable, Optical Fiber

EMI Immunity



(a)



(b)

- ❑ Wireless channel, mobile radio, satellite channel

Linearity
Time variance
Resource Limit

Modulation Process

- What and Why?

- How?

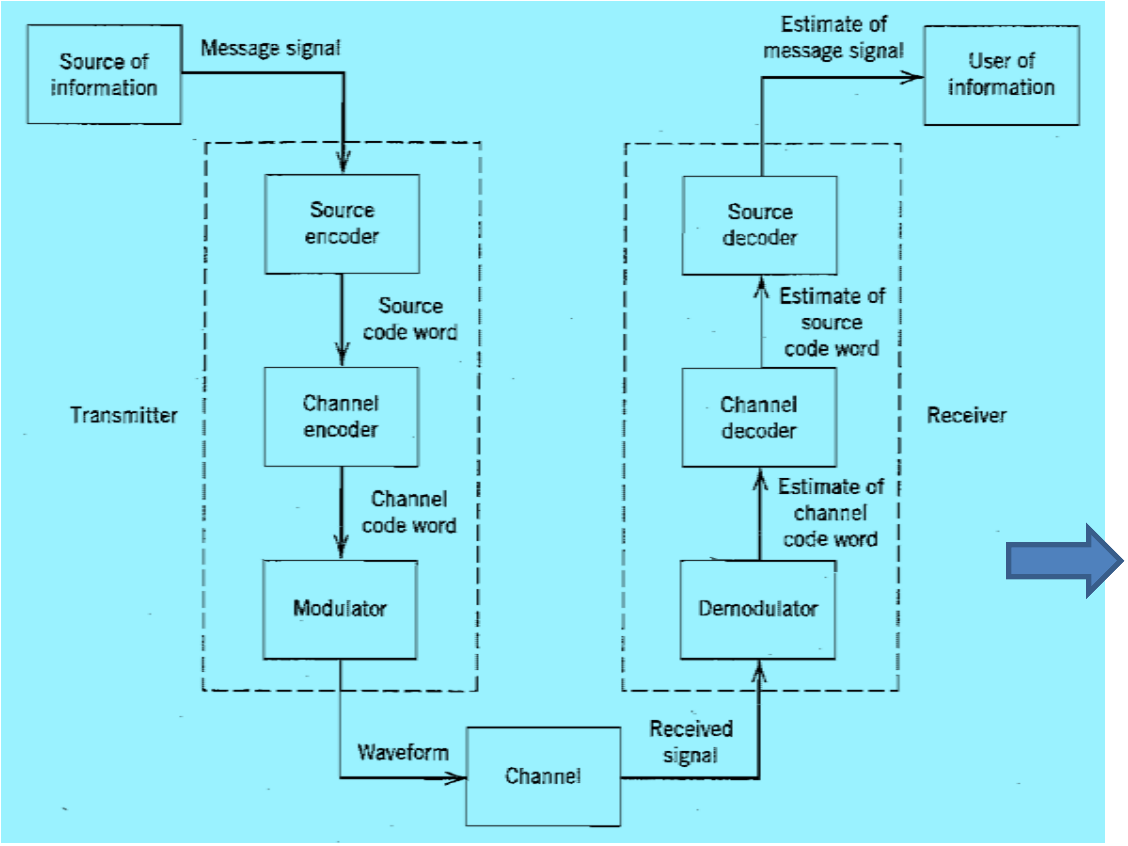
- Continuous Wave Modulation (CWM): AM, FM

- Pulse Modulation: PAM, PDM, PPM (Analog); PCM (Digital)

- Multiplexing: FDM, TDM, CDM

Analog and Digital Communications

- Digital



- Analog?
  - Modulation & Demodulation
  - Simple but stringent requirements: linearity & system adjustment

Channel characteristic matching

Still Analog?

Shannon's Capacity Theorem

Information capacity of the channel → C

Channel BW → B

$$C = B \log_2(1 + \text{SNR}) \text{ b/s}$$

- Efficiency of a digital com sys $\quad \eta = \dfrac{R}{C}$
- Trade-off between channel BW and SNR
- Idealized framework for performance comparisons

Spectrum Allocation

- FCC, OSM: Office of spectral management (OSM), BTCL, ITU, ETSI
- Spectral auctions?
- License and unlicensed spectrum
- Spectral underlay system: UWB
- Cognitive Radio

Existing Licensed spectrum

AM Radio	535-1605 KHz
FM Radio	88-108 MHz
Broadcast TV (Channels 2-6)	54-88 MHz
Broadcast TV (Channels 7-13)	174-216 MHz
Broadcast TV (UHF)	470-806 MHz
3G Broadband Wireless	746-764 MHz, 776-794 MHz
3G Broadband Wireless	1.7-1.85 MHz, 2.5-2.69 MHz
1G and 2G Digital Cellular Phones	806-902 MHz
Personal Communications Service (2G Cell Phones)	1.85-1.99 GHz
Wireless Communications Service	2.305-2.32 GHz, 2.345-2.36 GHz
Satellite Digital Radio	2.32-2.325 GHz
Multichannel Multipoint Distribution Service (MMDS)	2.15-2.68 GHz
Digital Broadcast Satellite (Satellite TV)	12.2-12.7 GHz
Local Multipoint Distribution Service (LMDS)	27.5-29.5 GHz, 31-31.3 GHz
Fixed Wireless Services	38.6-40 GHz

Unlicensed spectrum

ISM Band I (Cordless phones, 1G WLANs)	902-928 MHz
ISM Band II (Bluetooth, 802.11b WLANs)	2.4-2.4835 GHz
ISM Band III (Wireless PBX)	5.725-5.85 GHz
NII Band I (Indoor systems, 802.11a WLANs)	5.15-5.25 GHz
NII Band II (short outdoor and campus applications)	5.25-5.35 GHz
NII Band III (long outdoor and point-to-point links)	5.725-5.825 GHz

Unlicensed National Info Infrastructure

MICS- Medical implant comm service (401-406 MHz)

Theory of Radio Communication Channel

- ❑ Not only noise and external interference
- ❑ Radio Signal Propagation
  - ❑ Free-space propagation model (SAT, MICRO, Deep Space)

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{16\pi^2 d^2 L}$$

Loss Factor: Tx line, filter attenuation, antenna loss

$$G = \frac{4\pi A_e}{\lambda^2}$$

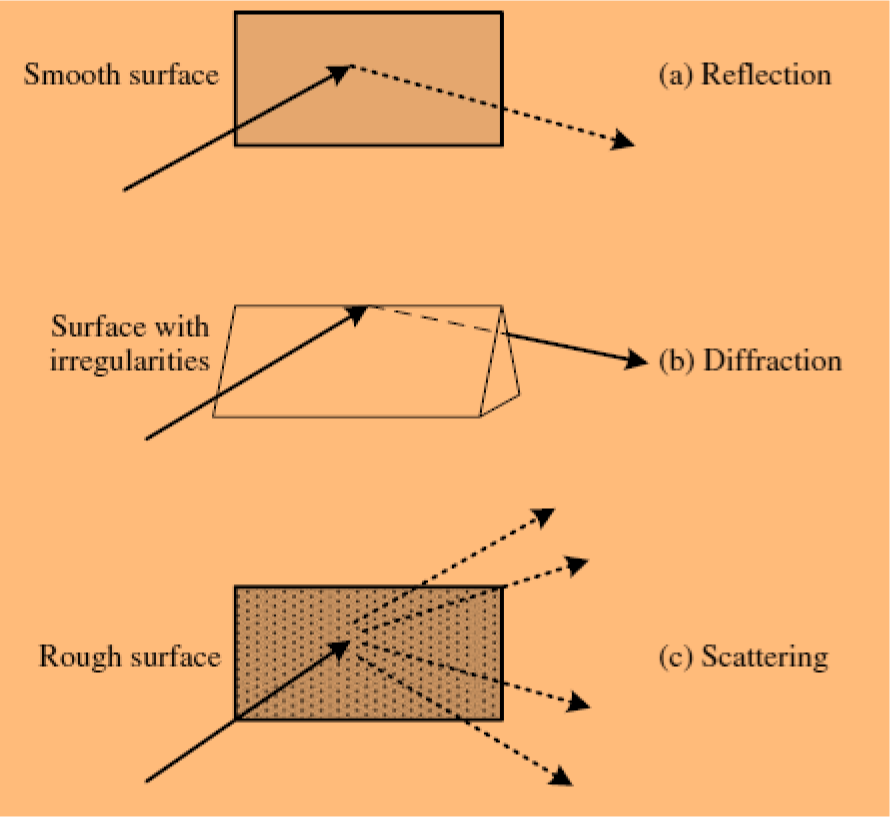
Effective aperture

Effective size of the antenna

$$\lambda = \frac{c}{f} = \frac{2\pi c}{\omega_c}$$

Power of d?

Reflection, Diffraction, Scatering



Fading Channel Models

- ❑ Amplitude, phase or both
- ❑ Coherent and non-coherent Rx
- ❑ Local & Global point of view: Complex Gaussian distribution
- ❑ Rayleigh fading

rms value of Rx signal

$$f_{Rayleigh}(r) = \frac{r}{\sigma^2} e^{\left(-\frac{r^2}{2\sigma^2}\right)} \qquad (0 \leq r < \infty)$$ ← Amplitude

Avg power of Rx fading sig

$$f_{Uniform}(\theta) = \frac{1}{2\pi} \qquad (0 \leq \theta \leq 2\pi)$$ ← Phase

Fading Channel

- Rician

$$f_{Rician}(r) = \frac{r}{\sigma^2} e^{-\frac{r^2+A^2}{2\sigma^2}} I_0\left(\frac{Ar}{\sigma^2}\right) \qquad (0 \le r < \infty,\ 0 \le A < \infty)$$

Peak envelope level of dominant LOS component

Phase?

- Nakagami-m fading; m=1/2, m=1, m=infinity?

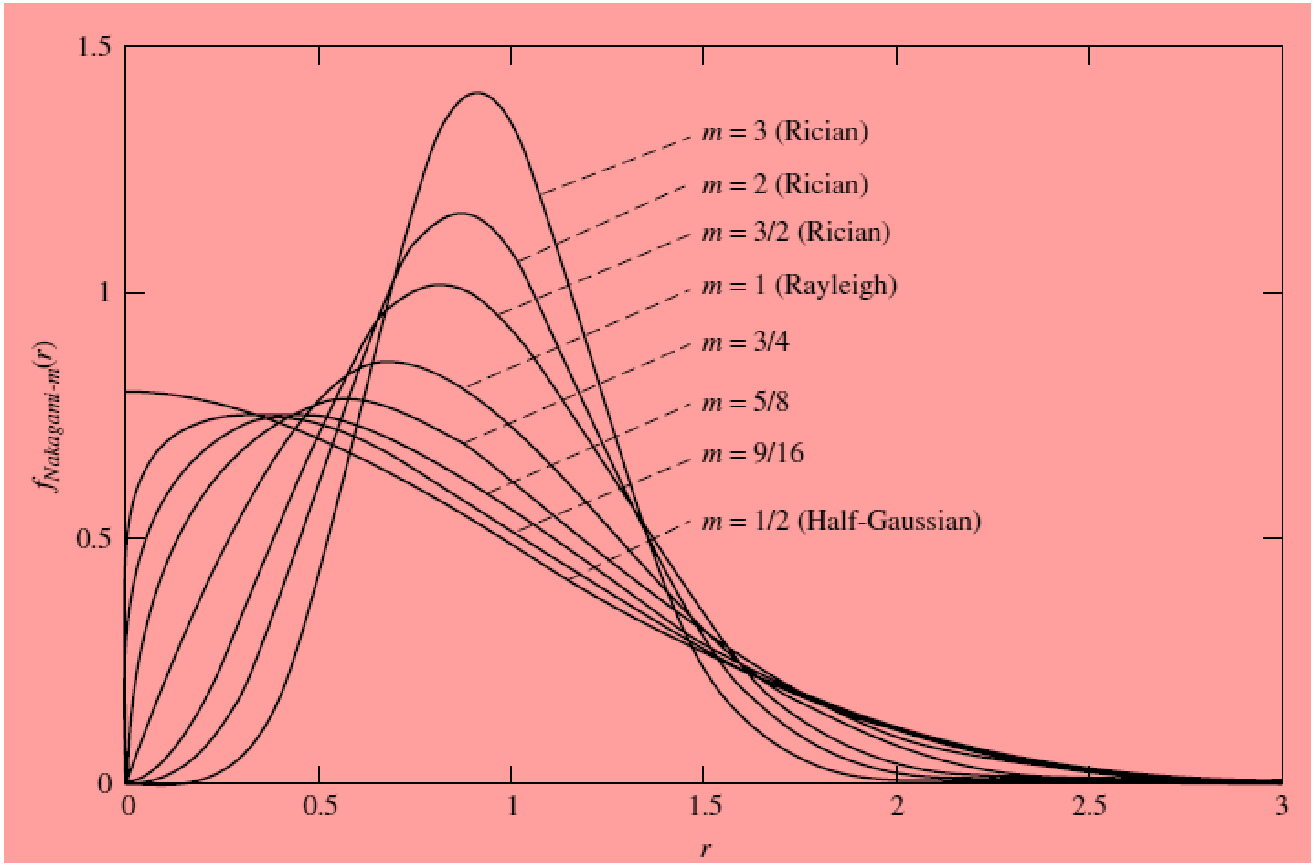
  - Amount of fading (AF) or fading figure

$$AF = \frac{var(r^2)}{\{E[r^2]\}^2} = \frac{E[(r^2 - 2\sigma^2)^2]}{4\sigma^2}$$

$$f_{Nakagami\text{-}m}(r) = \frac{2r^{2m-1}}{\Gamma(m)\Omega^m} e^{-\frac{r^2}{\Omega}} \qquad (0 \le r < \infty)$$

where $\Gamma(\cdot)$ is the Gamma function, $\Omega = \frac{r^2}{m}$ with r^2 being the average received signal power and m representing the inverse normalized variance r^2, which has to satisfy the condition of $m \ge \frac{1}{2}$,

Fading Channel



Fading Channel

- Log-normal fading

$$f_{log\text{-}normal}(r) = \frac{1}{r\sqrt{2\pi\sigma^2}} e^{-\frac{(\ln r-\mu)^2}{2\sigma^2}} \qquad (0 \le r < \infty)$$

Normal?

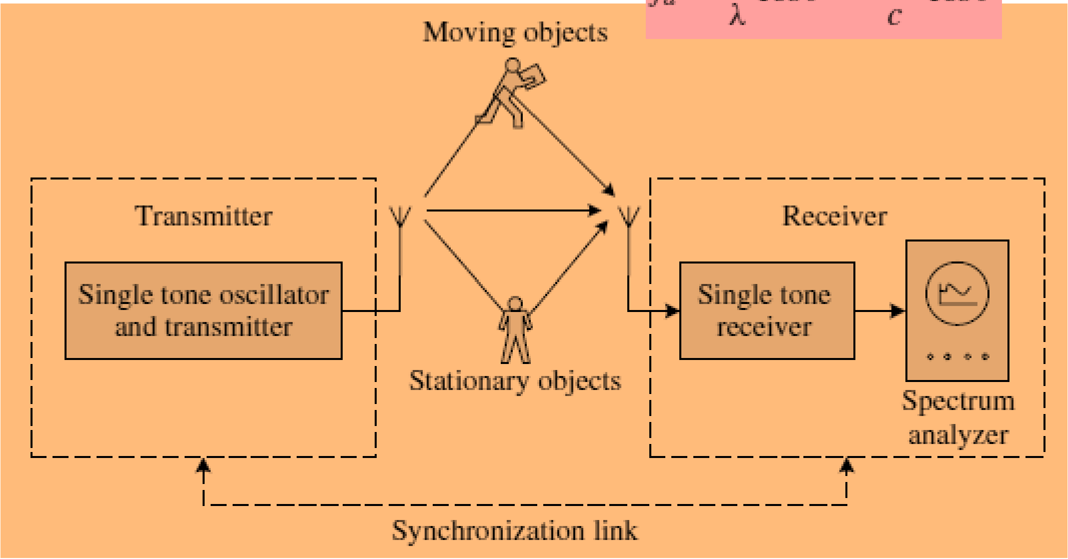
$$f_{log\text{-}normal}^{(dB)}(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (0 \le x < \infty)$$

NB and frequency-domain channel characteristics

- Experiment-based approach

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

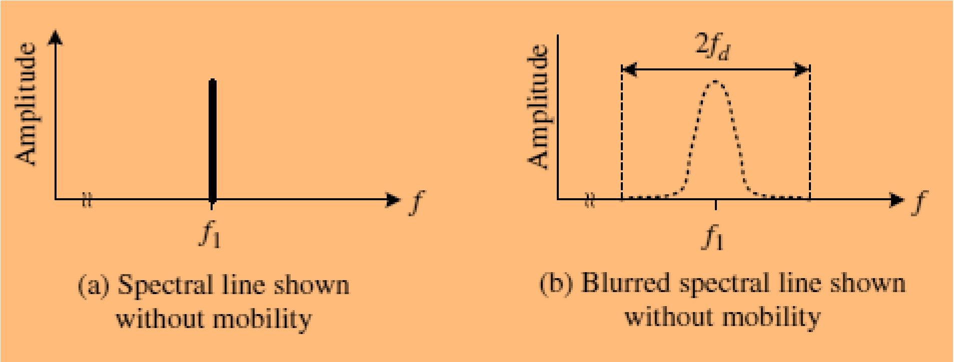
Doppler shift



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



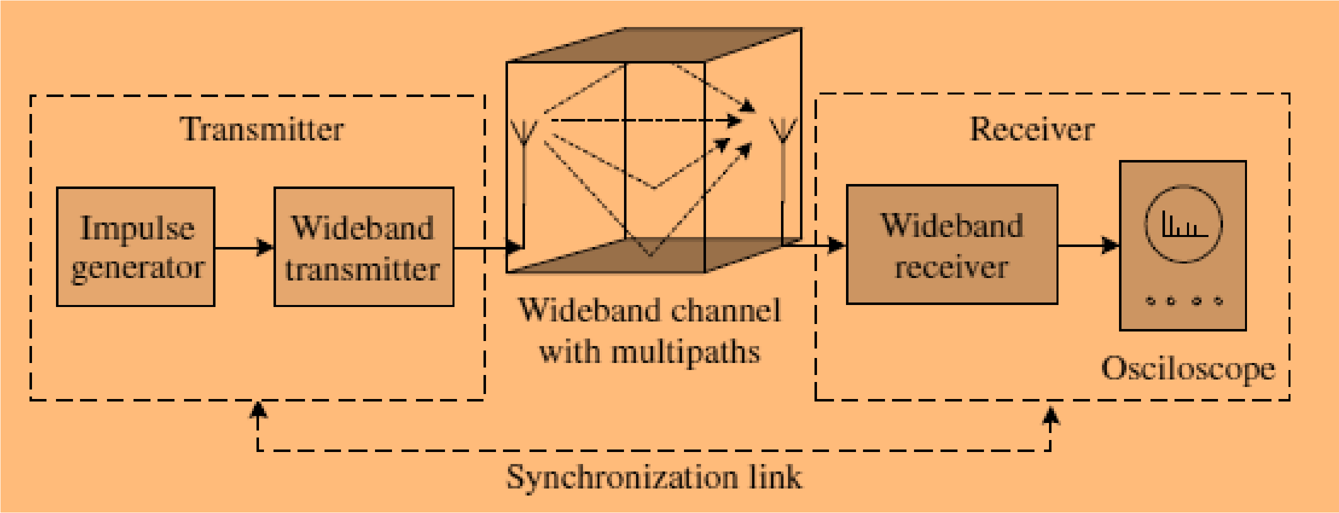
Coherent time ← $T_{co} \cong \frac{1}{\Delta f_d}$ ← Doppler spread

↓

Slow fading channel/fast fading channel

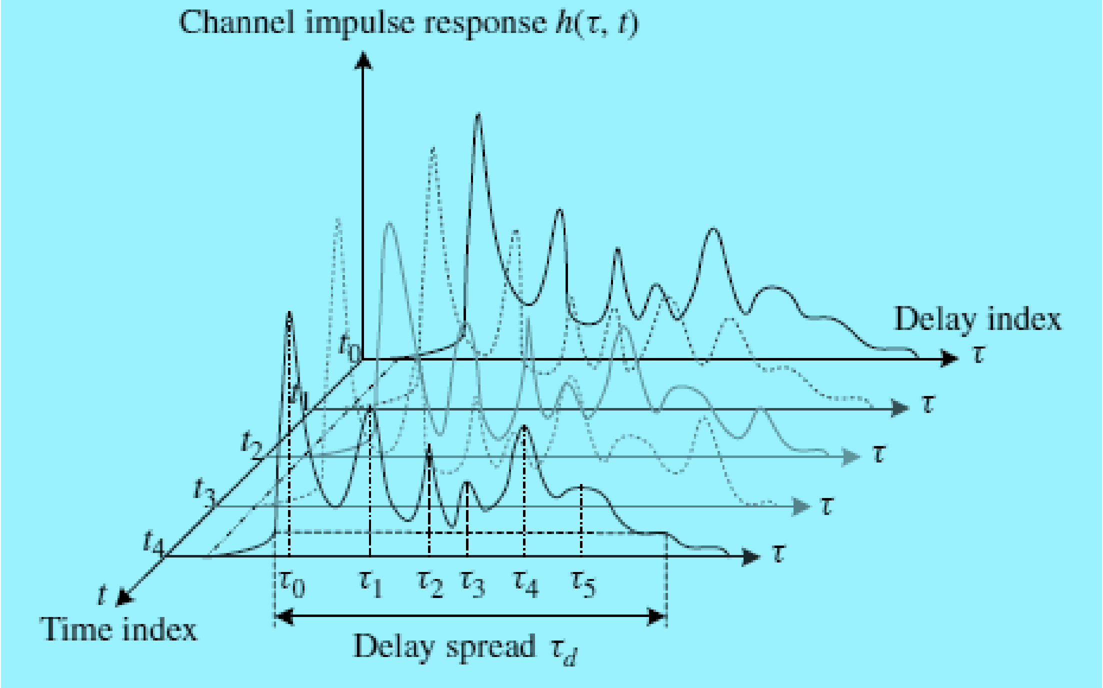
WB and time-domain channel characteristics

- Experiment-based approach
- Indoor environment for simplicity



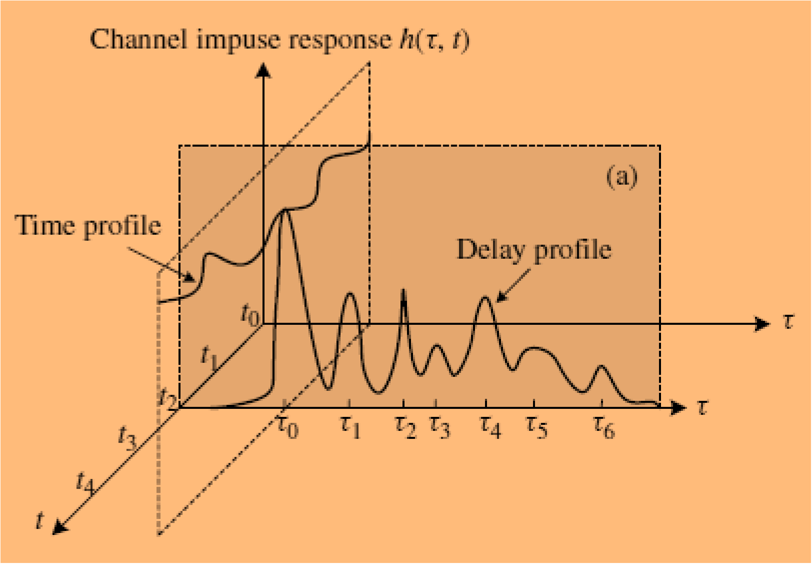
- Perfect synchronization

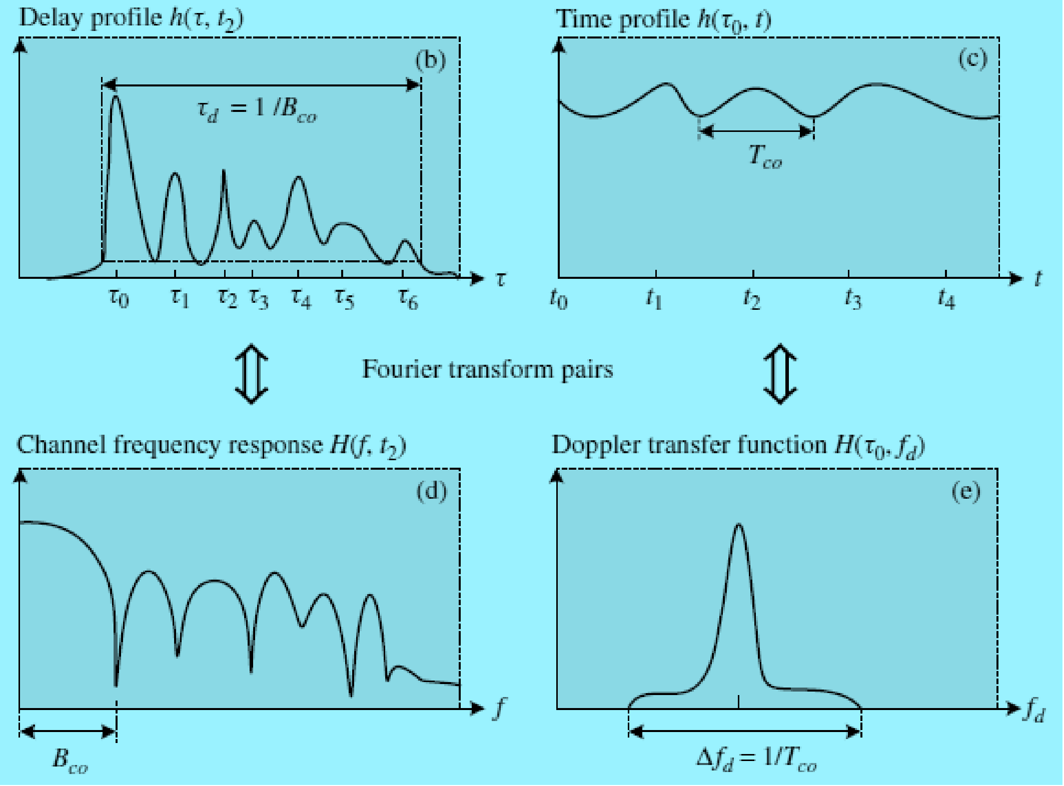
WB and time-domain channel characteristics



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

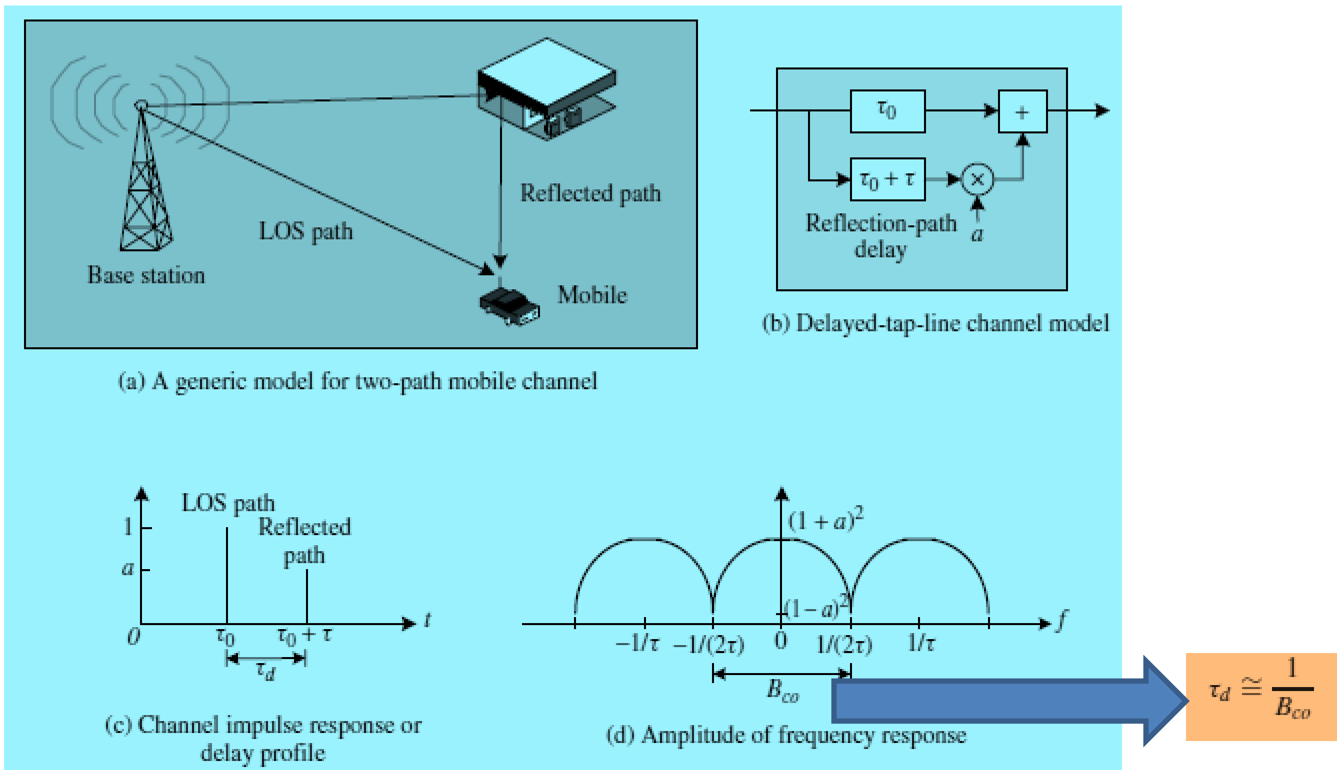
Frequency Selective Fading Channel

- 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



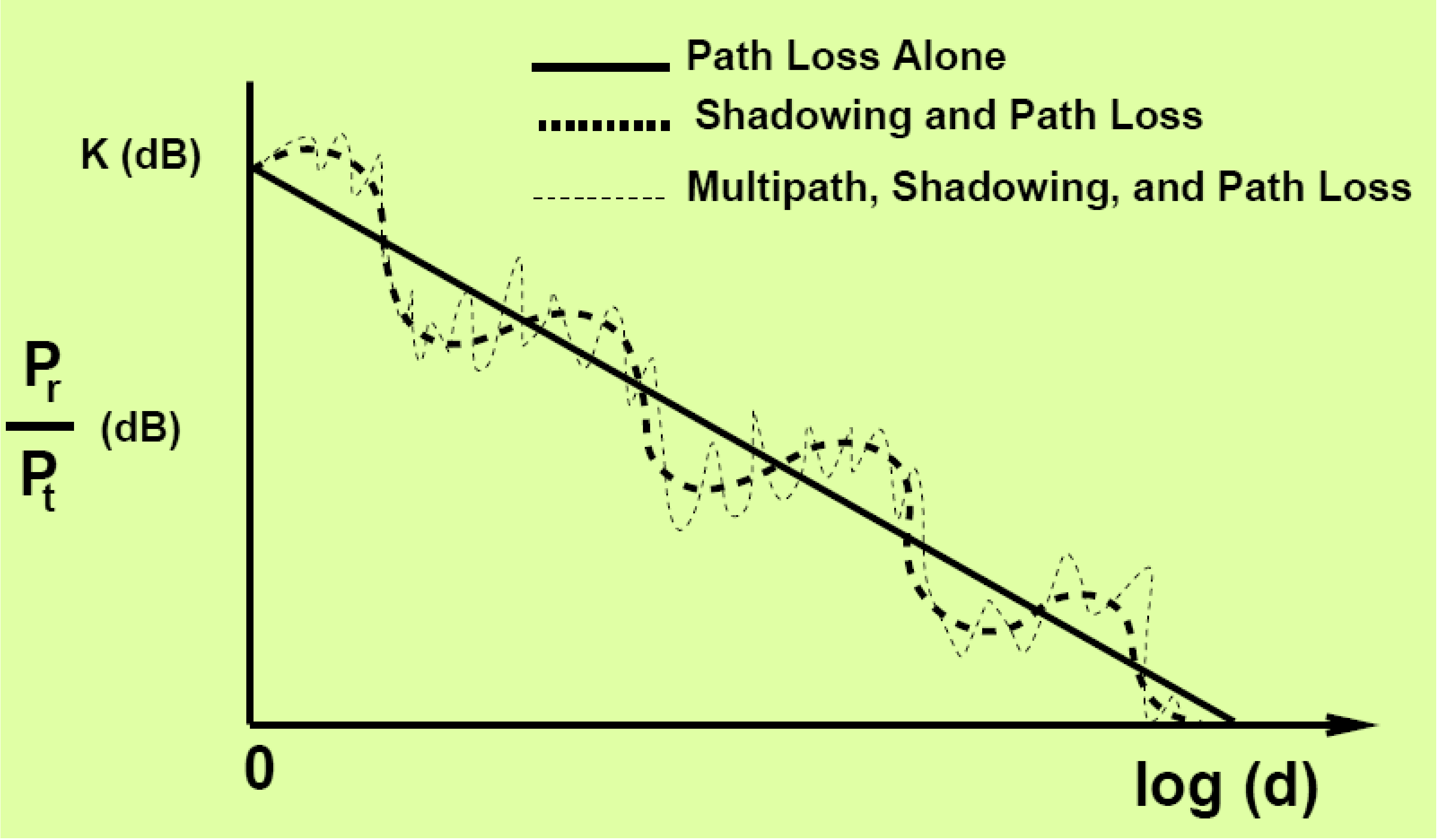
(a) A generic model for two-path mobile channel

(b) Delayed-tap-line channel model

(c) Channel impulse response or delay profile

(d) Amplitude of frequency response

Channel: Path loss, Shadowing & MP



Q & A