Mobile Communications

TCS 455

Dr. Prapun Suksompong

prapun@siit.tu.ac.th

Lecture 22

Office Hours:
BKD 3601-7
Tuesday 14:00-16:00
Thursday 9:30-11:30

Announcements

- Read
  - Chapter 9: 9.1 – 9.5
- HW5 is posted.
  - Due: Feb 5 (Friday after university game)

Chapter 5

OFDM

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OFDM

- Some of you already have seen this presentation (from the 1st OFDM(A) tutorial.)

Chapter 5

OFDM

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Orthogonality in Communication

CDMA

$$s(t)=\sum_{k=0}^{\ell-1} S_k c_k(t) \xrightarrow{\mathcal{F}} S(f)=\sum_{k=0}^{\ell-1} S_k C_k(f) \quad \text{where} \quad c_{k_1} \perp c_{k_2}$$

TDMA

$$s(t)=\sum_{k=0}^{\ell-1} S_k c(t-kT_s) \xrightarrow{\mathcal{F}} S(f)=C(f)\sum_{k=0}^{\ell-1} S_k e^{-j2\pi fkT_s}$$

where $c(t)$ is time-limited to $[0,T]$.

This is a special case of CDMA with $c_k(t)=c(t-kT_s)$

The c_k are non-overlapping in time domain.

FDMA

$$S(f)=\sum_{k=0}^{\ell-1} S_k C(f-k\Delta f)$$

where $C(f)$ is frequency-limited to $[0,\Delta f]$.

This is a special case of CDMA with $C_k(f)=C(f-k\Delta f)$

The C_k are non-overlapping in freq. domain.

OFDM

- Let $S_1, S_2, \ldots, S_N$ be the information symbol.
- The discrete baseband OFDM modulated symbol can be expressed as

$$s(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} S_k \exp\left(j \frac{2\pi kt}{T_s} \right), \quad 0 \le t \le T_s$$

$$= \sum_{k=0}^{N-1} S_k \underbrace{\frac{1}{\sqrt{N}} 1_{[0,T_s]}(t) \exp\left(j \frac{2\pi kt}{T_s} \right)}_{c_k(t)}$$

Note that:

$$\mathrm{Re}\{s(t)\} = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} \left(\mathrm{Re}\{S_k\} \cos\left(\frac{2\pi kt}{T_s} \right) - \mathrm{Im}\{S_k\} \sin\left(\frac{2\pi kt}{T_s} \right) \right)$$

Chapter 5
OFDM

Wireless Channel

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Single Carrier Transmission

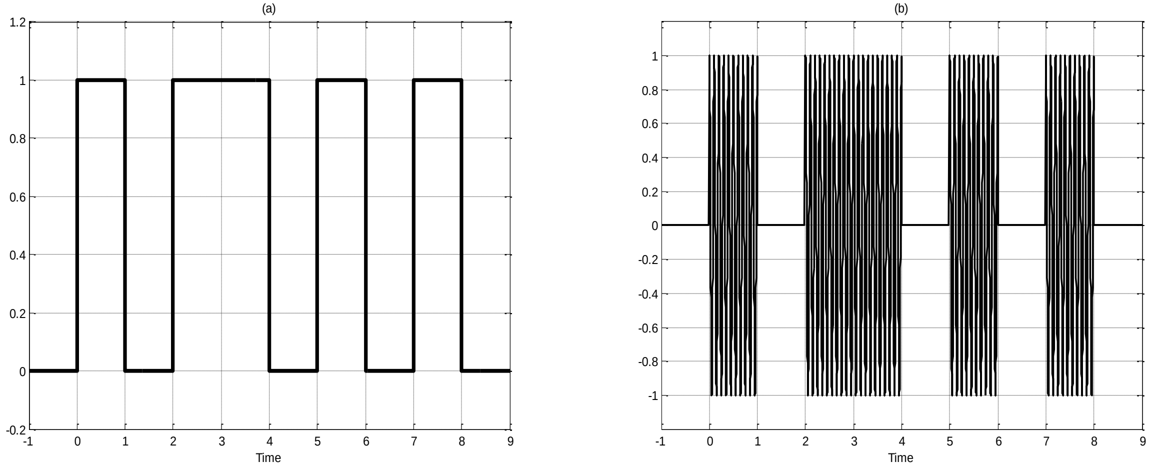
- Baseband:

$$s(t) = \sum_{k=0}^{N-1} s_k p(t - kT_s)$$

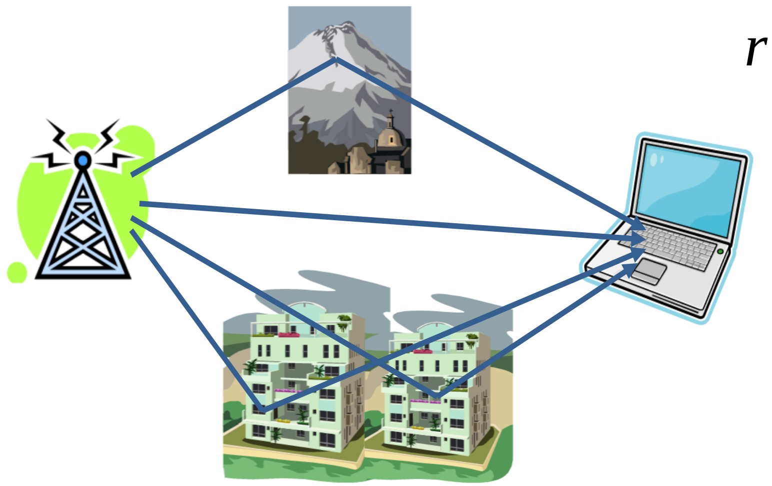
$$p(t) = 1_{[0,T_s)}(t) = \begin{cases} 1, & t \in [0, T_s) \\ 0, & \text{otherwise.} \end{cases}$$

- Passband:

$$x(t) = \mathrm{Re}\left\{ s(t) e^{j2\pi f_c t} \right\}$$



Wireless Comm. and Multipath Fading

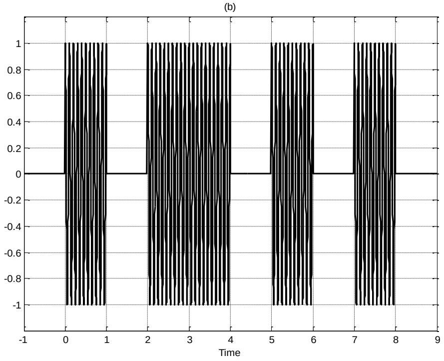


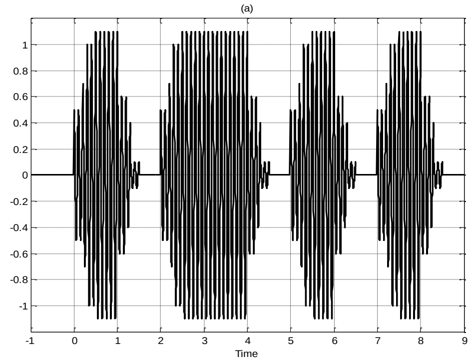
$$r(t) = x(t) * h(t) + n(t) = \sum_{i=0}^{v} \beta_i x(t - \tau_i) + n(t)$$

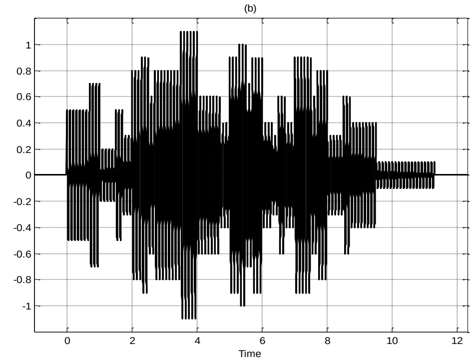
$$h(t) = \sum_{i=0}^{v} \beta_i \delta(t - \tau_i)$$

$$h_1(t) = 0.5\delta(t) + 0.2\delta(t - 0.2T_s) + 0.3\delta(t - 0.3T_s) + 0.1\delta(t - 0.5T_s)$$

$$h_2(t) = 0.5\delta(t) + 0.2\delta(t - 0.7T_s) + 0.3\delta(t - 1.5T_s) + 0.1\delta(t - 2.3T_s)$$







Frequency Domain