Lecture 17

PRINCIPLES OF SATELLITE COMMUNICATION

CDMA Mobile Communication & IS-95

Outline

- Spread Spectrum Basics
- Spreading Codes
- IS-95 Features- Transmitter/Receiver
- Power Control
- Diversity Techniques
- RAKE Receiver
- Soft Handoff

Spread Spectrum

- A technique in which the transmission bandwidth W and message bandwidth R are related as

$$W >> R$$

- Counter intuitive
- Achieves several desirable objectives for e.g. enhanced capacity

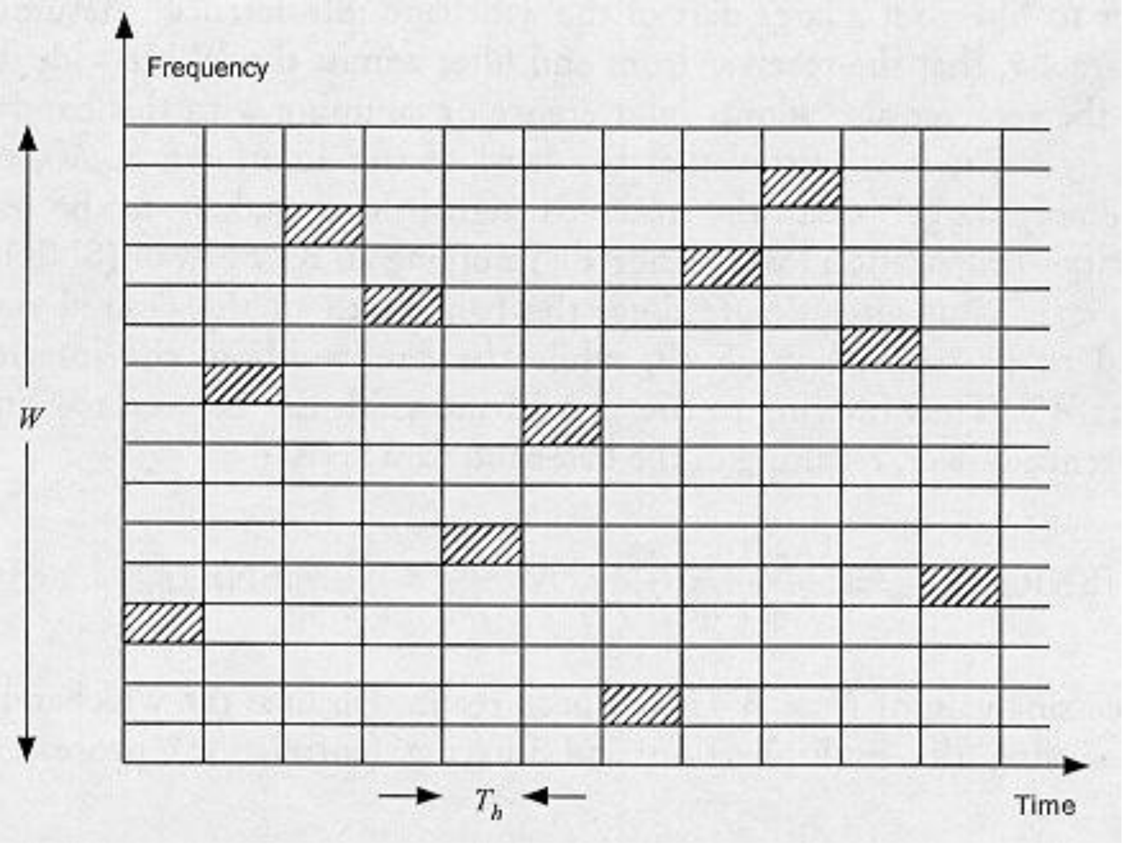
Application of Spread Spectrum Systems

- Antijamming
- Multiple access
- Low detectability
- Message Privacy
- Selective calling
- Identification
- Navigation
- Multipath protection
- Low radiated flux density

Types of Spread Spectrum Systems

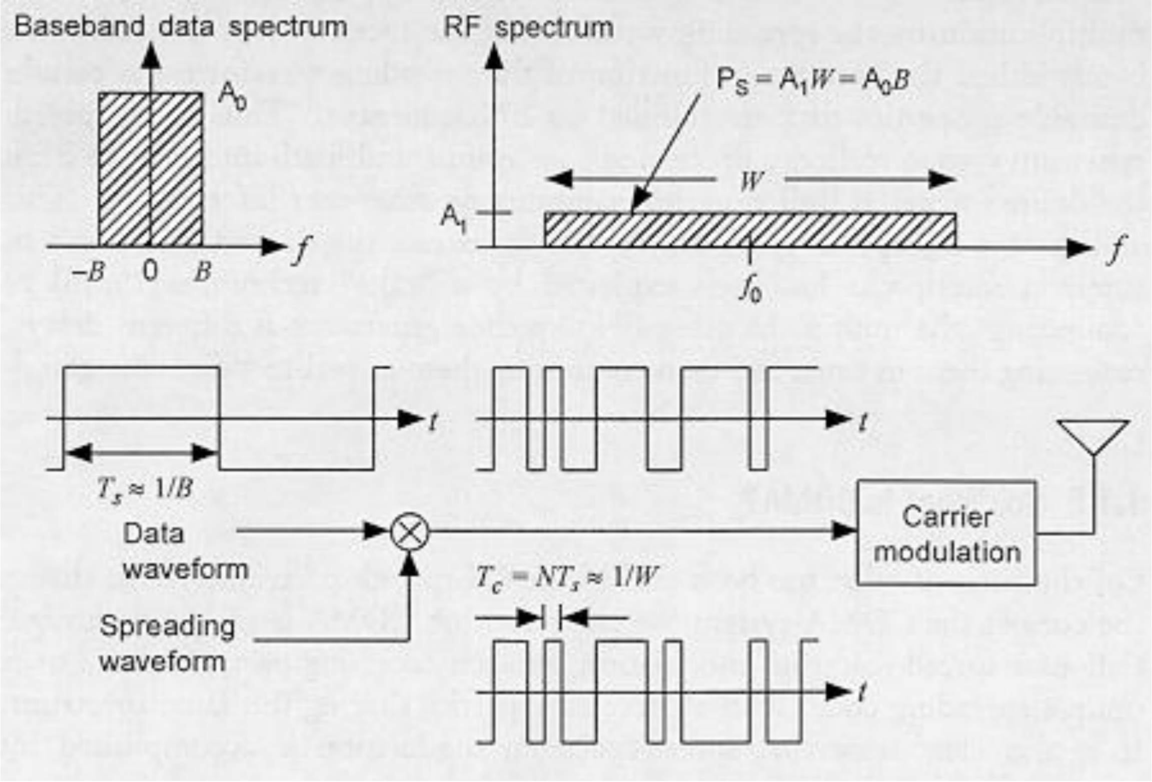
- Frequency Hopping
- Direct Sequence
- Frequency Hopping
  - Slow Frequency Hopping - multiple symbols per hop
  - Fast Frequency Hopping - multiple hops per symbol
- Care is taken to avoid or minimize collisions of hops from different users

Frequency Hopping



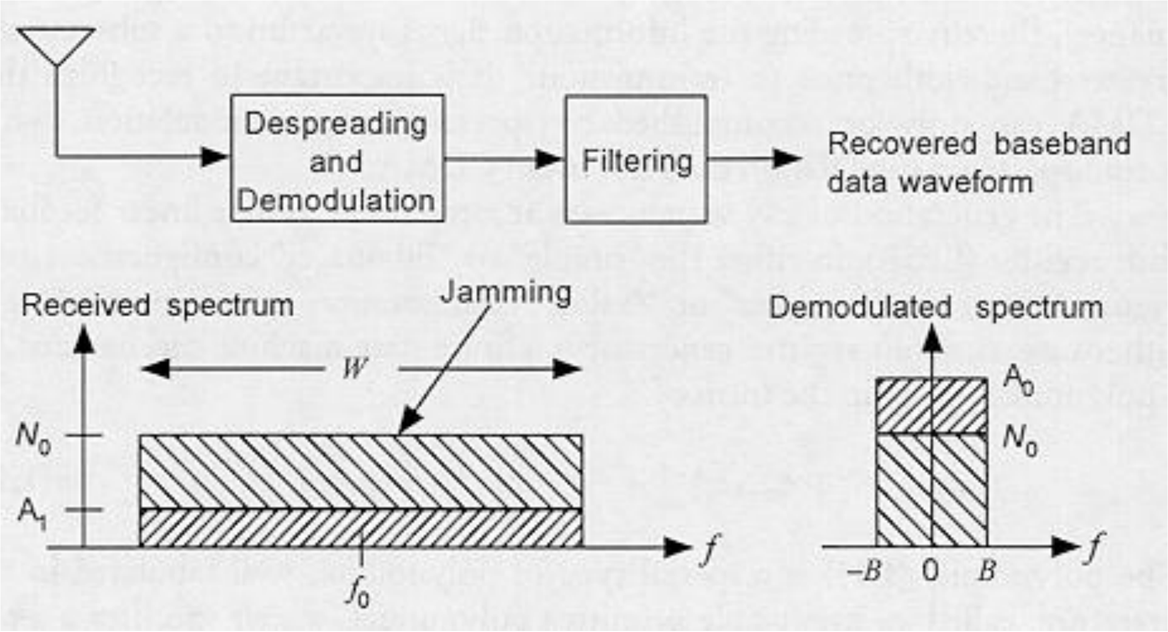
Typical frequency-hopping waveform pattern

Direct Sequence



Transmitter side of system

Direct Sequence (contd…)



Receiver side of system

Code Division Multiple Access - CDMA

- Multiple users occupying the same band by having different codes is known as a CDMA - Code Division Multiple Access system

Let

W - spread bandwidth in Hz

R = 1/T_b = Date Rate (data signal bandwidth in Hz)

S - received power of the desired signal in W

J - received power for undesired signals like multiple access users, multipath, jammers etc in W

E_b - received energy per bit for the desired signal in W

N_o - equivalent noise spectral density in W/Hz

CDMA (contd...)

What is the tolerable interference over desired signal power?

CDMA (contd…)

- In conventional systems $W/R \approx 1$ which means, for satisfactory operation $J/S < 1$

- Example Let R = 9600; W = 1.2288 MHz
  $(E_b/N_o)_{min}$ = 6 dB (values taken from IS-95)
  Jamming margin (JM) = $10\log_{10}(1.2288*106/9.6*103) - 6$
  = 15.1 dB ≡ 32

- This antijam margin or JM arises from Processing Gain (PG) = W/R = 128

- If $(E_b/N_o)_{min}$ is further decreased or PG is increased, JM can be further increased

CDMA (contd...)

- JM is a necessary but not a sufficient condition for a spread spectrum system. For eg. FM is not a spread spectrum system
- JM can be used to accommodate multiple users in the same band
- If $(E_b/N_0)_{min}$ and PG is fixed, number of users is maximized if perfect power control is employed.
- Capacity of a CDMA system is proportional to PG.

Universal Frequency Reuse

- Objective of a Wireless Communication System
  - Deliver desired signal to a designated receiver
  - Minimize the interference that it receives

- One way is to use disjoint slots in frequency or time in the same cell as well as adjacent cells - Limited frequency reuse

- In spread spectrum, universal frequency reuse applies not only to users in the same cell but also in all other cells

- No frequency plan revision as more cells are added

Universal Frequency Reuse (contd…)

- As traffic grows and cells sizes decrease, transmitted power levels in both directions can be reduced significantly
- Resource allocation of each user's channel is energy (instead of time and frequency)
- Hence interference control and channel allocations merge into a single approach