EEEN 464 – DIGITAL COMMUNICATION

SPREAD SPECTRUM STUDY GUIDE - STUDY GUIDE/REVISION

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1. INTRODUCTION TO SPREAD SPECTRUM

- **What is Spread Spectrum?**

A technique where the transmitted signal is spread over a **wider bandwidth** than the minimum required. Originally developed for military communications (jamming resistance and low probability of intercept), now widely used in civilian applications (Wi-Fi, Bluetooth, GPS).

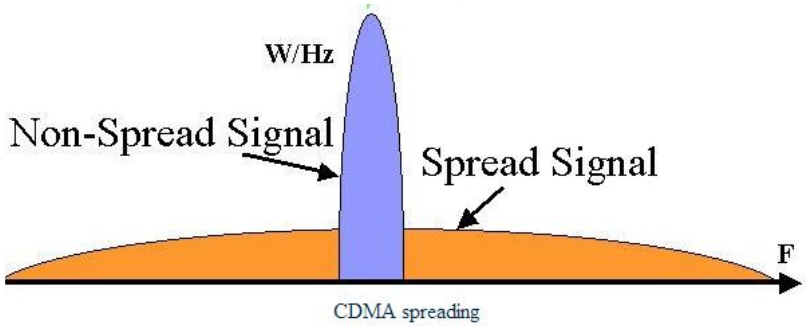

Figure 1. Spread spectrum spreads original signal spectrum over a larger frequency range

- **Goal of Spread Spectrum**

Spread spectrum system trades bandwidth for robustness. By spreading the signal, gains include interference rejection, security, and multi-user capability.

2. KEY CONCEPTS & TERMINOLOGY

1. **Chip**:

   A single pulse in the spreading code (e.g., each bit in a PN sequence).

   ***Chip rate*:** Rate of the spreading code (higher than the data rate).

2. **Processing Gain (G_p)/Spreading factor**:

$$G_p = \frac{\text{Bandwidth of spread signal}}{\text{Bandwidth of original signal}}$$

3. **Pseudorandom Noise (PN) Sequence**:

   Binary sequences with noise-like properties

3. SPREAD SPECTRUM TECHNIQUES

1. **DIRECT SEQUENCE SS (DSSS):**

   - **How it works**:
     Data signal d(t) multiplied by a high-rate PN code c(t)$c(t)$. Each data bit is "chipped" into multiple sub-pulses as shown below.

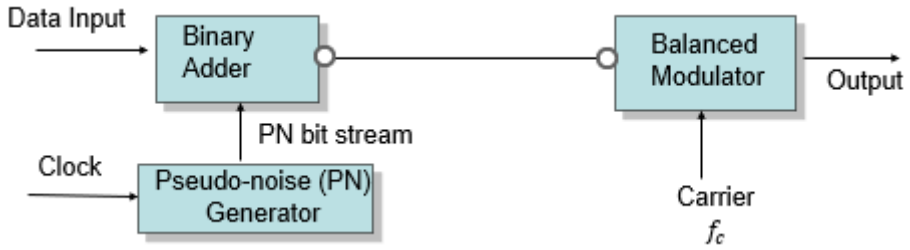

Figure 2. Block diagram of a Direct Sequence Spread Spectrum (DSSS) transmitter

2. **Frequency Hopping SS (FHSS)**:
   - Frequency-hopping spread spectrum (FHSS) is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels.

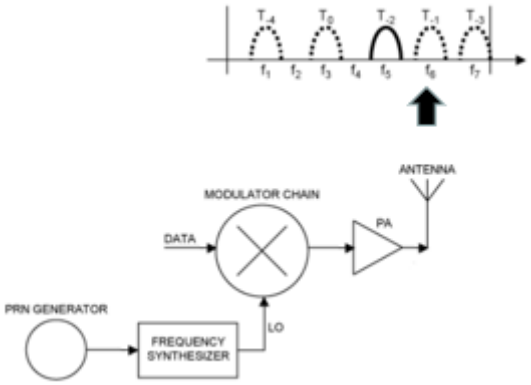

Figure 3. Block diagram of a frequency-hopping spread spectrum (FHSS)

   - **Time Hopping SS (THSS)**:
     Transmitter/receiver **synchronously hop** at different times shown in the figure below

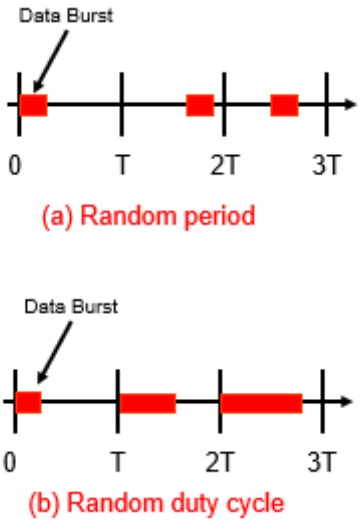

Figure 4. Time Hopping Spread Spectrum alters the period or duty cycle of the transmitted data.

4. WHY USE SPREAD SPECTRUM?

- **Advantages**:

- **Interference Mitigation**: Resists narrowband jamming (DSSS) or follows clear channels (FHSS).
- **Multipath Fading Resistance**: DSSS enables RAKE receivers (used in CDMA).
- **Low Probability of Intercept (LPI)**: Power spectral density is low.
- **Multiple Access**: Many users share bandwidth (CDMA).

6. APPLICATIONS

- **Wireless Communications**:
  - CDMA (3G), IEEE 802.11 (DSSS in early Wi-Fi), Bluetooth (FHSS).
- **GPS**:
  DSSS allows precise timing via correlation.
- **Military**:
  Secure comms, anti-jamming.