20PW14 - Karthickpranav S N

Mobile Computing assignment presentation

Spread Spectrum

Introduction

Spread spectrum is a technique used for transmitting radio or telecommunications signals. The term refers to the practice of spreading the transmitted signal to occupy the frequency spectrum available for transmission. The advantages of spectrum spreading include noise reduction, security and resistance to jamming and interception.

Direct Sequence Spread Spectrum

DSSS is a method of transmitting radio signals by spreading the signal over a wide frequency band.

- This is done by performing an XOR operation between the user bit sequence and a chipping sequence.
- The chipping sequence has smaller pulses than the user bit duration and if generated properly, it may appear as random noise, sometimes called pseudo-noise (PN).
- The ratio of the user bit duration to the chipping sequence pulse duration is known as the spreading factor and determines the bandwidth of the resultant signal.

So in conclusion, Direct Sequence Spread Spectrum (DSSS) is a technique where the signal is XORed with a pseudo-random number (chipping sequence). This results in many chips per bit (e.g., 128), leading to a higher bandwidth of the signal.

Advantages of DSSS

DSSS has several advantages such as reducing frequency selective fading and allowing base stations in cellular networks to use the same frequency range. Additionally, several base stations can detect and recover the signal, allowing for soft handover.

Disadvantages of DSSS

However, DSSS also has some disadvantages such as requiring precise power control.

DSSS Transmit/Receive

The process of transmitting and receiving a signal using Direct Sequence Spread Spectrum (DSSS) involves several steps: (Refer **Figure 1**)

1. First, the user data is combined with a chipping sequence using an XOR operation.
2. This spread spectrum signal is then modulated onto a radio carrier and transmitted.
3. At the receiver end, the received signal is demodulated and the radio carrier is removed.
4. The chipping sequence is then used to *de-spread* the signal through another XOR operation.
5. The resulting lowpass filtered signal is then passed through an integrator and correlator to produce sampled sums.
6. These are then fed into a decision block to recover the original user data.

Frequency Hopping Spread Spectrum

FHSS is a method of transmitting a signal over a series of seemingly random radio frequencies.

- The signal hops from one frequency to another at fixed intervals, with the channel sequence determined by a spreading code.
- The receiver synchronizes its frequency hopping with the transmitter to pick up the message.
- It makes eavesdropping difficult, as an eavesdropper would only hear unintelligible blips.
- Any attempts to jam the signal on one frequency would only succeed in knocking out a few bits.

FHSS is a wireless communication technique that involves discrete changes of carrier frequency.

- The sequence of frequency changes is determined via a pseudo-random number sequence.
- There are two versions of FHSS: **Fast Hopping**, which involves several frequencies per user bit, and **Slow Hopping**, which involves several user bits per frequency.

Advantages of FHSS

Frequency-selective fading and interference are limited to short periods of time. Additionally, FHSS has a simple implementation and uses only a small portion of the spectrum at any given time.

Disadvantages of FHSS

FHSS is not as robust as DSSS (Direct Sequence Spread Spectrum) and is simpler to detect.

Slow and Fast FHSS

Refer to **Figure 2.**

Figure 1:

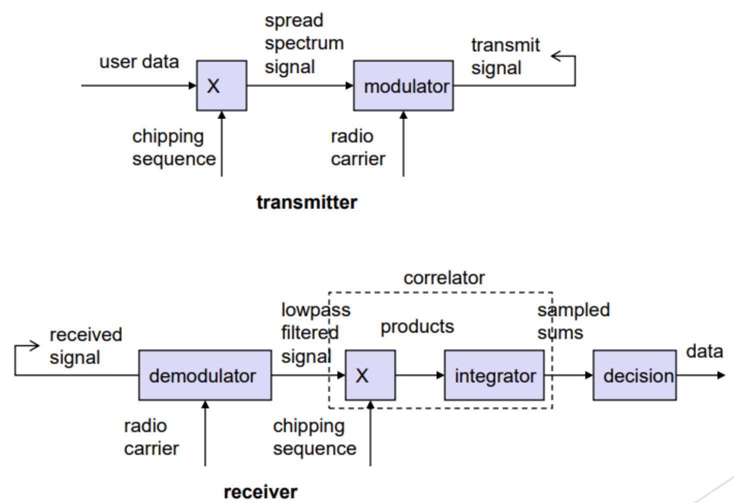
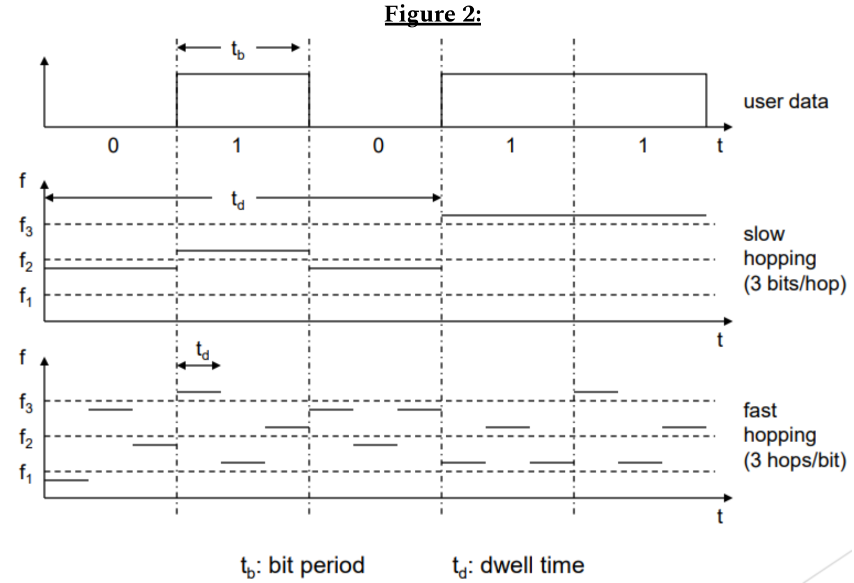


Figure 2:



DOUBTS THAT MAY ARISE:

1. What is the spread spectrum and what are its advantages?
   Spread spectrum is a technique for transmitting data over a communication channel by spreading the signal over a wide bandwidth. This technique involves modulating the data signal with a high-frequency carrier signal that changes rapidly in a pseudo-random pattern. The advantages of spread spectrum include improved resistance to interference and jamming, increased privacy, and better overall signal reliability.

2. What is the difference between direct sequence spread spectrum (DSSS) and frequency hopping spread spectrum (FHSS)?
   DSSS spreads the signal by multiplying the data signal with a high-speed pseudo-random chipping code, while FHSS hops the carrier frequency rapidly in a pseudo-random pattern. DSSS spreads the signal over a wider frequency band, while FHSS spreads the signal over time. DSSS is typically more robust against interference, while FHSS is simpler to implement and uses less spectrum at any given time.

3. How is the chipping sequence generated and what is its role in DSSS?
   The chipping sequence in DSSS is generated using a pseudo-random sequence generator, which produces a sequence of binary bits that are used to modulate the data signal. The chipping sequence is multiplied with the data signal to spread the signal across a wide frequency band. The chipping sequence plays a critical role in DSSS because it enables the receiver to distinguish the spread signal from noise and other interference.

4. How is the spreading factor calculated and what does it determine?
   The spreading factor in DSSS is calculated as the ratio of the chipping rate to the data rate. It determines the amount of bandwidth that the spread signal occupies. A higher spreading factor results in a wider spread signal, which provides greater resistance to interference and jamming, but also requires a larger amount of spectrum.

5. What are the two versions of FHSS and how do they differ?
   The two versions of FHSS are slow hopping and fast hopping. Slow hopping involves several user bits per frequency, while fast hopping involves several frequencies per user bit. In slow hopping, the transmitter switches between frequencies relatively slowly, while in fast hopping, the transmitter switches between frequencies rapidly. The main difference between the two is the rate at which the carrier frequency is changed.

6. How does FHSS reduce frequency-selective fading and interference?
   FHSS reduces frequency-selective fading and interference by hopping between different carrier frequencies in a pseudo-random pattern. Since the carrier frequency changes rapidly and unpredictably, the effects of interference and fading are spread out over time, reducing their impact on the signal. Additionally, FHSS uses only a small portion of the spectrum at any given time, reducing the likelihood of interference from other signals.

Stupid ones:

1. **The advantages of spread spectrum include improved resistance to interference and jamming, increased privacy, and better overall signal reliability. How ?**
   Spread spectrum techniques have several advantages, including improved resistance to interference and jamming. Spread spectrum signals are spread over a wide frequency band, making them more difficult to jam or interfere with than narrowband signals. The use of unique codes for each user in CDMA and the random frequency hopping in FHSS also provide increased privacy and better overall signal reliability.
2. **frequency selective fading?**
   Frequency selective fading occurs when different frequencies in a signal experience different amounts of attenuation or delay due to interference or physical obstacles. This can result in some frequencies being more severely affected than others, leading to distortion or loss of the signal.
3. **several base stations can detect and recover the signal, allowing for soft handover. What? And How ?**
   Soft handover refers to the ability of a mobile device to maintain a connection to multiple base stations simultaneously during a call. This is achieved through the use of sophisticated algorithms that allow the device to monitor the signal quality of each base station and select the strongest one.
4. **However, DSSS also has some disadvantages such as requiring precise power control. Control of what power ? How is it power-controlled ?**
   DSSS requires precise power control to maintain the desired spreading factor. The spreading factor determines the amount of signal spreading, and the power level of the transmitted signal must be carefully controlled to ensure that the spreading factor remains within the desired range. This is typically achieved through the use of automatic gain control (AGC) circuitry in the transmitter.
5. **Modulated, demodulated, carrier, integrator, correlator, decision block. What do each of these do in DSSS Transmission/Receival?**
   In DSSS transmission, the data signal is modulated onto a carrier wave and then spread using a unique chipping sequence. In the receiver, the spread signal is demodulated and integrated to recover the original data signal. The chipping sequence is generated using a pseudo-random number generator, and is used in both the transmitter and receiver to correlate the spread signal.
6. **Frequency-selective fading and interference are limited to short periods of time. Additionally, FHSS has a simple implementation and uses only a small portion of the spectrum at any given time. - How and what implementation?**
   FHSS reduces the impact of frequency-selective fading and interference by rapidly hopping between different frequencies in a pseudo-random sequence. This makes it more difficult for interference to affect the signal, as it is only present on any given frequency for a short period of time. The simple implementation of FHSS involves using a frequency synthesizer to rapidly switch between frequencies in a predetermined sequence.
7. **FHSS is not as robust as DSSS (Direct Sequence Spread Spectrum) and is simpler to detect. Expand and Explain.**
   FHSS is not as robust as DSSS because it is easier to detect and disrupt. In FHSS, the signal is only present on any given frequency for a short period of time, making it more vulnerable to interference or jamming. Additionally, the use of a fixed hopping sequence in FHSS makes it easier to predict and disrupt the signal.
8. **Slow and Fast FHSS ?**

Slow and Fast FHSS refer to two different modes of frequency hopping. Slow FHSS involves hopping between frequencies at a rate that is slower than the data rate, meaning that multiple bits are transmitted on each frequency. Fast FHSS involves hopping between frequencies at a rate that is faster than the data rate, meaning that multiple frequencies are used to transmit each bit. Fast FHSS is generally used in applications that require higher data rates, while slow FHSS is used in applications that require lower data rates but greater resistance to interference.