

Direct Sequence vs. Frequency Hopping

A Comparison of Spread Spectrum Methods and Performance

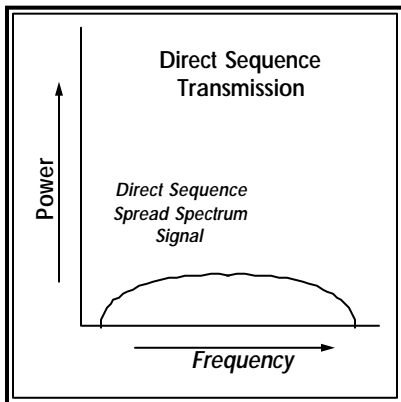
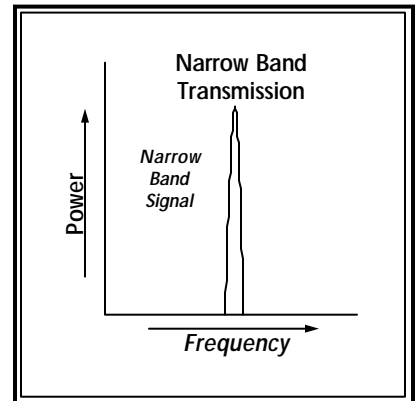
The IEEE 802.11 specifications define standards for three unlicensed wireless methods. Two of these methods use radio waves and the third uses infrared light. As infrared is a limited technology that is only capable of transmitting relatively short distance vs. radio-based methods, in this document we will explore the two RF options, known as Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS). To analyze which technology is better suited for your application, it is important to understand the vast differences in the technologies and the performance they will provide.

Technology Overview

Direct Sequence

Direct Sequence Spread Spectrum uses a carrier that remains fixed to a specific frequency band. The data signal, rather than being transmitted on a narrow band as is done in microwave communications, is spread onto a much larger range of frequencies (RF bandwidth) using a specific encoding scheme. This encoding scheme is known as a Pseudo-noise sequence, or PN sequence.

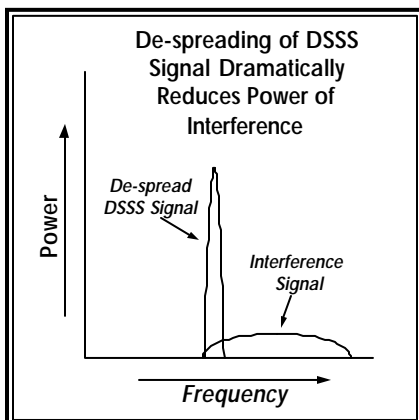
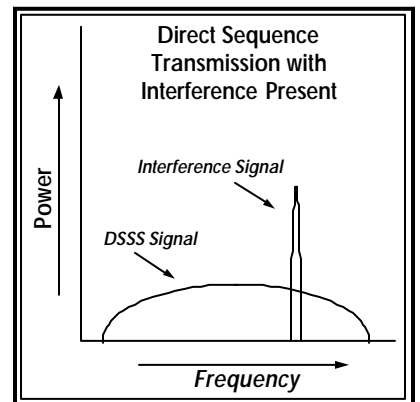
Please note the narrowband signal and the spread spectrum signal both use the same amount of transmit power and carry the same information. However, the power density of the spread spectrum signal is much lower than the narrowband signal (power density is the amount of power over a certain frequency). As a result, it is much more difficult to detect the presence of the spread spectrum signal. This enables DSSS devices to provide a very secure communications link.



The algorithm used by the PN sequence generates a pseudo-random number that is then combined, through a binary encoding process, with the binary information from the data stream. The resulting signal is spread over a much larger amount of bandwidth than would normally be used for a data transmission but at a much lower power level. This DSSS signal also has a redundancy factor built into it, as it actually transmits at least 10 fully redundant copies of the original data at the same time. This redundancy in the signal is a key advantage of DSSS.

The signal redundancy helps to provide immunity to interference, as only one of the 10 redundant signals needs to be received and assembled correctly. This

signal will provide the full data transmission bandwidth of the radio either through the receipt of a single copy of the data or through the assembly of one copy of the data from portions of one or more copies. The built-in signal redundancy makes DSSS transmissions a very robust communications solution.



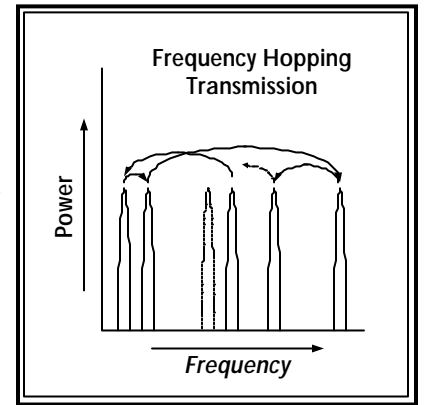
If there is an interfering signal present in the same band, it will typically appear as a higher power, narrow band signal. Because of the processing gain used by DSSS devices, the interference will be spread out during the de-spreading process at the receiving end.

The de-spreading process causes a dramatic reduction in the power density of the interference, usually greater than 90%. As a result, the impact of the interference is greatly reduced or eliminated. This is how DSSS devices fight and avoid interference.

Frequency Hopping

Frequency Hopping Spread Spectrum (FHSS) attempts to achieve the same result by sending its transmissions over a different carrier frequency at different times. The FHSS carrier will hop on a predetermined, pseudo random pattern defined using a pool of 1 MHz sub-channels defined across the entire band. The FCC requires the band to be divided into at least 75 sub-channels. FHSS radios are limited to sending only small amounts of data on each channel for a designated time period before they must hop to the next channel in the sequence. This time element is called dwell time. FHSS devices are limited to a dwell time of 400 microseconds. After each "hop", the device must re-synchronize with the other radio before it can resume any data transmission.

The intent of the pseudo-random hopping pattern is to avoid interfering signals by not spending very much time on any specific frequency. If interference is present on any of the channels in the hopping pattern, even though the RF signal will experience interference from time to time, it will be minimized by the small amount of time spent transmitting on that frequency.



Comparisons

Frequency hopping does not employ any processing gain, since there is no spreading of the signal. Processing gain, which provides the decrease in power density when a signal is processed for transmission and the increase in power density when the signal is de-spread, improves the received signal's S/N ratio (Signal to Noise ratio). Because FHSS does not use any processing gain, the frequency hopper needs to transmit using more power in order to have the same S/N as a direct sequence radio. However, since the unlicensed RF bands have the same overall power limit defined for both types of radios, the FHSS systems cannot achieve the same S/N ratio as DSSS systems.

Using frequency hopping, it is also more difficult to synchronize the receiver to the transmitter because both the time and frequency need to be in tune. A direct sequence device on the other hand, needs only the timing of the chips to be synchronized. As a result, FHSS radios must spend more time to search for the signal, and then lock on to it. This greatly increases the latency time between data transmissions.

Because DSSS radios can lock in the chip sequence in just a few bits, and only require this exercise one time after power up, DSSS devices will have a much lower latency for all data transmissions. This lower latency is one of the reasons that DS provides much higher bandwidth utilization (data throughput) compared to FH systems.

Summary Points

Direct Sequence		Frequency Hopper
Short Latency Time	vs.	Long Latency Time
Constant Processing Gain = A Better Signal to Noise Ratio.	vs.	No Processing Gain
Quick Lock-in as Radios Synchronize	vs.	Slow Lock-in, Must Search a Channel
No Dwell Time	vs.	400 Microsecond Dwell Time
No Re-sync with Other Radio Necessary	vs.	Must Re-sync with Other Radio After Every Hop
Short Indoor Range	vs.	Short Indoor Range
Long Outdoor Range (40km)	vs.	Short Outdoor Range (10km)
Greater Overall Data Throughput	vs.	Lower Overall Data Throughput

Summary Statement

In searching for an outdoor, fixed-wireless broadband communications solution, it is important to find a product that is secure, robust, and can provide the performance necessary for today's bandwidth intensive applications. Between the competing spread spectrum technologies, Direct Sequence is the clear winner on all of these points.

For this reason, Wave Wireless Networking uses Direct Sequence Spread Spectrum radios in all of its broadband wireless communications products. When combined with the benefits of our CampusPRC wireless multi-point protocol, SPEEDLAN bridges and routers present a solid line of high performance solutions for ISPs, Enterprise, and private-data applications throughout the world.