Basics of Spread Spectrum in Measurement Systems

Technical Data

What is spread spectrum?

Spread spectrum is a radio transmission technique used in radio frequency (RF) data communications. Developed originally for military use, spread spectrum technology could ensure secure communications for intelligence, tactical, and command groups and provide non-jammable data links for guidance and delivery systems. The key feature behind the success of spread spectrum in military applications was its high degree of immunity to electrical interference from either natural or man-made sources. Spread spectrum technology is now available to commercial markets and has promising applications in electrically noisy industrial areas.

Spread spectrum transmission also has the ability to send data at rates much higher than standard radio transmissions. These higher data rates approach 10 Mb per second and provide a better foundation for digital data communications than previous transmission formats.

The combination of noise immunity and high data rate transmission makes spread spectrum transmission technology suitable for wireless data communication networks in electrically noisy environments. As a result, spread spectrum is now being utilized by a wide range of industries in wireless networks on production lines, in processing facilities, and in office buildings throughout industry, around the world.

Spread spectrum permits reliable data communication in electrically noisy environments.

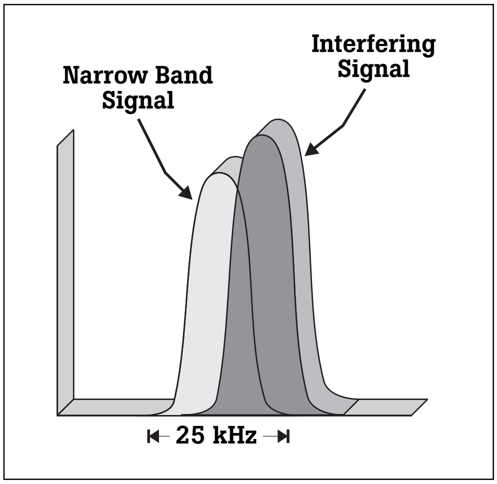

Figure 1: Signals which occur on or near a narrow band carrier frequency can interfere with the narrow band transmission.

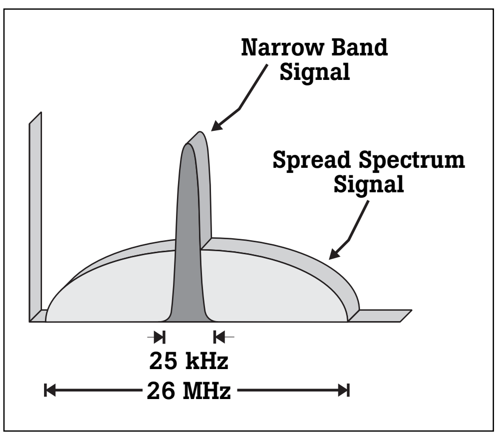

Figure 2: Spread spectrum spreads its data signal over a carrier frequency band which can be as much as 1,000 times broader than that used in narrow band.

How does spread spectrum work?

To understand spread spectrum technology better, it may help to compare it with its narrow band counterpart. Narrow band, as its name implies, transmits a relatively narrow data signal with an information bandwidth of typically 25 kHz on a specific carrier frequency. The narrow band receiver, tuned to this single frequency, detects the carrier and performs a simple demodulation which extracts the information from the carrier frequency. Electrical "noise" is not filtered out and appears as a valid signal to the receiver. Therefore, narrow band transmissions can be susceptible to interference from signals which occur on or near the narrow band carrier frequency (Figure 1).

Spread spectrum differs from narrow band in that it disperses or "spreads" a relatively small data signal over a carrier frequency band which is, in some cases, 1,000 times broader than that used in narrow band. This broader carrier frequency band can be up to 26 MHz wide between 902-928 MHz (Figure 2).

The transmitter uses a pseudo-random sequence and coded data signal to phase-modulate the data signal across this broad carrier frequency. This modulation technique is commonly referred to as direct sequence modulation.

The transmitted data is effectively obscured, or "locked," within this frequency band and can only be recovered, or "unlocked," at the receiver by decoding the carrier signal using the same code sequence, or "key," utilized by the transmitter. The receiver section matches this code sequence in its demodulator stage and reconstructs the signal in its original form (Figure 3). The coding of information at the transmitter and associated decoding at the receiver permits communication only with receiving stations programmed with the same (carrier-encrypted) code sequence. A coded sequence also permits multiple satellite stations to communicate to a discrete host transceiver (Figure 4) while operating in the same frequency band. This form of discrete, code selective transmission is referred to as code-division multiplexing.

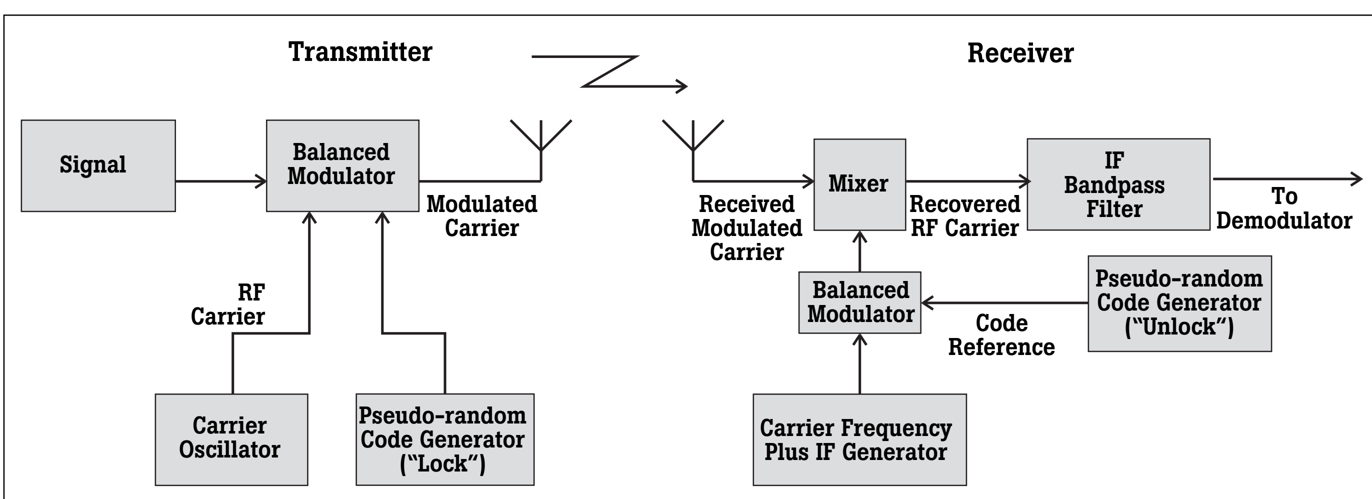

Figure 3: This spread spectrum block diagram shows how data is "locked" before transmission and "unlocked" at the receiver.

Why is spread spectrum nearly immune to electrical interference?

Spread spectrum's encrypted, broad band modulation and demodulation scheme is the key to its ability to reject noise. Spread spectrum distributes a relatively small amount of data over a frequency band that is up to 1,000 times larger than required to handle the amount of information being transmitted. The information is modulated with a pseudo random code pattern which distributes minute parts of the original signal across the entire frequency band. Noise from electro-magnetic interference (EMI) or radio frequency interference (RFI) is typically generated in industrial areas by electrical sources such as electric motor brushes, arcing high voltage, arcing relays, solenoids, induction heaters, natural lightning, and walkie-talkies. Noise from these devices tends to concentrate energy in random spikes through a particular portion of a frequency band. These spikes are very narrow and relatively random within that band when compared to the spread spectrum bandwidth. A noise spike radiated onto a portion of the spread spectrum frequency band has little effect, if any, on the actual information carried within the frequency band. Once the signal has gone through the demodulation process at the receiver and remaps the original signal using the correct randomized code, the signal remains, retaining all its salient attributes.

The spreading technique used in spread spectrum not only helps to reduce the effects of signal interference, but it is also less likely to create interference for other electronic devices. The broad carrier frequency limits the peak radiated power at any one area within the frequency band (Figure 2). As a result, this limited energy nearly eliminates the possibility that spread spectrum transmissions will create interference for other electronic instrumentation.

How do modems use spread spectrum to communicate?

Modems are available today which utilize spread spectrum communications. These modems exhibit high noise immunity and are well suited for office and industrial applications. Modems allow flexible network topologies that let users set up data communications networks to meet their needs. Point-To-Point is an example of a common network scheme. In this scheme, pairs of modems are set to communicate only with each other. Other units, which do not have the correct code, will ignore signals not intended for them. Another network scheme is called broadcast mode. In this mode, all modems are set with the same code and all receive the information sent from a single broadcast station (Figure 4).

Other common topologies integrating modems may also be constructed. For example, the Fluke Wireless Logger™ uses a system where one "base station" modem receives signals from all "satellite" modems in the network and transmits only to specific satellites (directed transmissions). Spread spectrum modems range in power output from 100 mW to the Federal Communications Commission (FCC) imposed limit of 1 Watt.

Where can spread spectrum be used?

Like all RF devices, spread spectrum transmitters are affected by the environment they are used in. Limitations are relatively stable and predictable, usually caused by physical surroundings such as buildings and other structures, and can often be circumvented by a little planning. For example, spread spectrum modems, like any other radio wave transmitter, cannot transmit through a solid metal enclosure. A window or door opening, however, is often enough to allow the spread spectrum signals to pass "through" a metal wall. A spread spectrum modem of 500 mW, as is used with Fluke's Wireless Logger, will work indoors over distances of up to 800 feet. The distances may be somewhat less in buildings with significant metal content, and could be much greater in open-field, line-of-sight applications.

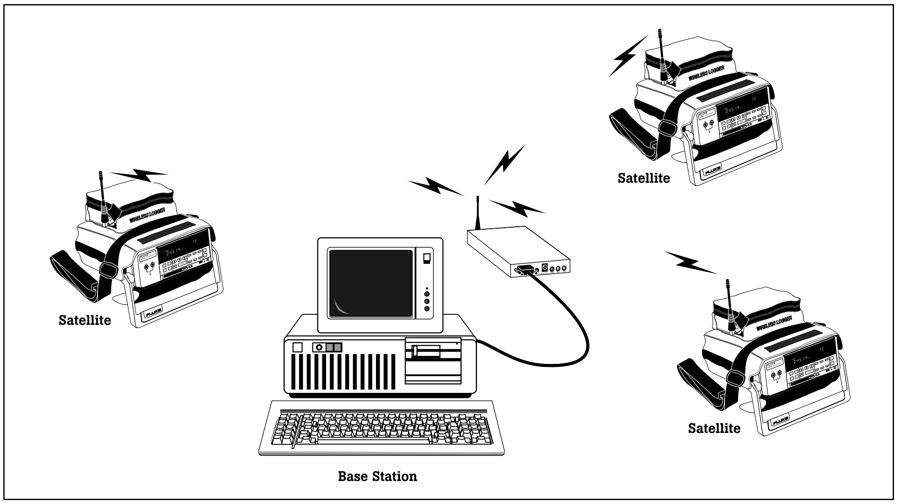

Figure 4: Multiple satellite stations use spread spectrum to communicate with a discrete host transceiver while operating in the same frequency band.

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Do spread spectrum transmitters require FCC licensing?

Spread spectrum operation with an effective radiated power (ERP) up to 1 watt does not require site licensing by the FCC. The primary reason behind this non-licensing approach is spread spectrum's limited power levels and non-intrusive transmission style.

How can spread spectrum technology be used in data acquisition?

Spread spectrum can free data acquisition applications from the "wire tethers" that have bound them up to now. Wireless data links provide flexibility and open a new arena of application possibilities. For example, small portable data acquisition units like the Fluke 2625A/WL Wireless Logger, with Wireless Logger for Windows™ application software, can be used to monitor a wide array of parameters in testing, process improvement or other verification-based applications without the need for expensive and time consuming wiring. The high degree of noise immunity provided by spread spectrum allows reliable data acquisition through physical barriers and from areas that were previously too electrically noisy for all but the most hardened hard-wired systems. Now a remote test or monitoring system can be set up at a moment's notice, sending data across several physical boundaries without the costs or concerns of installing cabling to a host computer, giving you the freedom to gather the data you need where and when you need it.

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