Dispelling the Myths Associated with Spread Spectrum Radio Technology in Electric Power SCADA Networks

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Introduction

Every year the Electric Power industry deploys more Spread Spectrum communication solutions. As recently as five years ago, the telemetry of electric power data was almost exclusively in the licensed radio realm. However, the scarcity of available licensed channels as well as its improved technology has made the Spread Spectrum radio an increasingly popular choice. With the install base of Spread Spectrum devices rapidly increasing, there have been a number of “Urban Legends” or “Superstitions & Myths” that have circulated. Among the more prevalent of these are the following:

Myth	Summary
Security	Spread Spectrum is not secure; someone can steal your data.
Saturation	Spread Spectrum radios will shut down when there are too many radios on the same frequency.
Range	Spread Spectrum radios are only one watt and won’t perform as well as licensed radios.
Compatibility	If you have licensed radios you have to buy only licensed radios for expansion.
Interference	If you mix licensed radios and Spread Spectrum radios or different brands of Spread Spectrum in the same system they will cause interference and data will be lost
Obstructions	You must have clear line of sight, or Spread Spectrum will not communicate.

With the introduction and advancement of any new technology, misconceptions and misunderstandings will always surface. Spread Spectrum, like any technology, can be an extremely valuable tool when used in the correct environment and with correct deployment. The objective of this article is to explore these “myths” and provide a better understanding of how to use Spread Spectrum technology and also show where you can expect to succeed with Spread Spectrum communication solutions.

Security

Spread Spectrum was originally designed for security purposes. It was invented for the US Navy during World War II to prevent the Germans from “jamming” American radio transmissions for radio guided torpedoes. The technology was invented by Hedy Lamar, a famous movie star of the 1940’s. The original radios contained a roll of paper slotted like a player piano to cause channel switching. Hedy’s close friend Inventor/Musician George Antheil designed the first successful synchronization device that brought Hedy’s idea to fruition. In 1941 Hedy and George were granted a U. S. patent for the first “Secret Communications System.” This original system used merely 88 frequencies. Today, the switching is controlled in embedded software code that enables a radio to change frequencies in excess of 200 times per second and use more than 100 channels.

The technology behind spread spectrum radio is complex enough that anyone trying to intercept a signal would have to match more than 186,000 possible parameters to be on the same channel with the radio and then would only be in sync for about 1/100th or possibly 1/200th of a second. In addition to matching parameters, the entity attempting to intercept data would find that today's Spread Spectrum radios also utilize advanced encryption protocol to insure additional security.

<u>Saturation</u>

The common fear in Spread Spectrum is that as more and more companies go to this "shared" frequency, it will become saturated and unusable. However, if there is a saturation point, it has not yet been reached. In many areas of the country, thousands of Spread Spectrum radios are delivering data to multiple end-users without conflict or data loss. Examples of these networks can be found in various regions around the country and in other industries. In Wisconsin, a major generation and transmission utility is using more than 100 radios in the field with another 300 radios to be deployed over the next year. The end-users' offices and their base stations are in a proximity where repeater towers can be shared by multiple networks, as appropriate. If there were any potential for "saturation," it would happen at these repeater sites where the wireless traffic is at its highest, and the antennas are installed very near to one another.

Over the past several years, considerable research and development has gone into developing Spread Spectrum radios that can work in close proximity to one other and share the same frequency bands. To accomplish this goal, radio networks are programmed to share common bands, but use separate frequencies. Each radio network is programmed to "hop" to a different frequency than the other radio networks in the area. This hopping allows users to build distinct communication networks that will not conflict with other networks in the immediate area. An analogy to this is your car radio in which there are multiple channels available, but you only hear the channel you are actually tuned to. When you change channels, you no longer hear the old channel, only the channel you just switched to. The same is true of Spread Spectrum networks: multiple users can share the Spread Spectrum band as long as they are all set up to use different frequencies at different times.

In the previous Wisconsin example, there are many other organizations in various industries using Spread Spectrum radios. The combined total of radios is growing each day as these companies continue to add more radios to expand their communication networks. It is highly unlikely that this or any other area will achieve "saturation" so long as the networks are managed and deployed properly.

<u>Range</u>

Another common myth associated with Spread Spectrum is that it is good only for short-range communication. To the contrary, Spread Spectrum can be deployed as a complete (long-range and short-range) communication network solution. This technology is a result of the lower maximum output power of a Spread Spectrum radio. By federal regulation, a Spread Spectrum radio can only have an output of 1 Watt of radiated power at the radio and 4 Watts at the antenna. Licensed radios, by contrast, can have higher output power, typically 5 Watts at the radio and 20 Watts at the antenna. In a contest of which radio will broadcast the furthest in a straight line, the licensed radio will clearly win the distance contest, however it is extremely rare to have a line of sight range exceed 20 miles. Typically, an obstruction such as a building, valley, hill, or vegetation will interrupt a signal in longer-range applications. Spread Spectrum radios can easily establish links of 20 miles and they have even been able to link at distances greater than 60 miles. Spread Spectrum radios have been used in relay protection schemes and for utility SCADA applications where data must be passed accurately over many miles of obstructions. At great distances, the curve of the earth becomes one of the major obstacles to overcome. In order to establish a 30-mile link in an application, the end user will have to have radio antennas mounted at least 100 feet above the ground to compensate for the curve of the earth.

Mountains often create the opposite challenge. In mountainous regions, Spread Spectrum radios have been used to establish radio communication at distances of 60 miles. This link is from a mountain top at a 9500 feet elevation down to a valley floor where the elevation was 5000 feet.

Another factor influencing complete long-range communication is repeaters. With a licensed radio system, there is only one repeater in a network. All slave sites must communicate to either the Master unit directly or though a maximum of one repeater. However, with Spread Spectrum technology, it is possible to have multiple repeaters. These repeaters can either be arranged in series (serial repeater) to extend the range or in parallel to improve coverage around obstacles such as hills, buildings, or vegetation. It is also possible to mix repeaters in parallel and series to provide the benefit of all capabilities in large systems. Some manufacturers produce products where the use of repeaters is unlimited, meaning there are no limits to the number of repeaters you can have in a single network. Some complex networks actually use more than 100 repeaters in a single network.

Another Spread Spectrum feature offered by a limited number of manufacturers is the ability to have the radio to operate as a slave and repeater simultaneously. This feature provides both a network extended capability and a cost reducing tool. The slave/repeater function eliminates the need for multiple dedicated repeaters while also reducing installation costs. The “magic” here is that any PLC (programmable Logic Controller), RTU (Remote Terminal Unit), or other intelligent devices can multitask as both a slave unit, sending data back to the host and as a repeater for other devices further down the network hierarchy. Spread Spectrum radio systems can track and control Utility SCADA systems and/or delivery systems for hundreds of miles using a wireless “daisy chain” to bring data through a series of repeaters back to the host in a distant location. Spread Spectrum can also move data in a “micro-network” that is set up to work around a mountain or any other obstruction and ultimately deliver data to a host that is not within line of site.

<u>Compatibility</u>

Many people believe that if they install a base of licensed radios, they must use the same manufacturer and model of radio they originally purchased. However, it is possible to mix Spread Spectrum radios into an existing licensed radio system enabling features such as multiple repeater functionality and reduced deployment costs. This network can be accomplished by placing a new repeater in the existing system. You simply need to take an existing slave site and put a Spread Spectrum (Master) radio back-to-back with the licensed slave and join the two radios together by using a ‘Null Modem” cable between their respective RS-232 ports.

When the licensed master transmits to the licensed slave, the request is passed through the licensed slave’s RS 232 port to the Spread Spectrum radio’s RS 232 port. The Spread Spectrum Master will then retransmit the message to the Spread Spectrum “network extension” down stream from the Spread Spectrum master. This “Hybrid” system offers many advantages over any single system network.

It is also possible to create hybrid systems by combining CDPD (Cellular Digital Packetize Data), Satellite, Cell Phones, and landline telephone modems individually with Spread Spectrum. The beauty of these systems is that the end user can use a communication device, such as a landline, to cover a long distance of 100 miles and then “mate” to a Spread Spectrum network to gather data over a wide area network (WAN). This configuration would allow an end-user to gather data from 100 devices through a single telephone connection. Since landline telephones, cell phones, and satellite communication come with monthly charges, it is much more cost effective to spread these cost over multiple devices in the field. Combining these technologies will produce the most efficient and cost effective solution.

<u>Interference</u>

Another common misconception is that Spread Spectrum and other radio communications will interfere with each other. The most common Spread Spectrum band in the United States is 902 Megahertz to 928 Megahertz. This frequency band is set aside by the federal government to be allocated for Spread Spectrum devices and the rules are structured to allow the band to be shared by multiple users. The official designation for this band is ISM, which implies this was established for Industrial, Scientific, and Medical usage.

The Licensed radios utilize frequencies outside of this band. No licenses are granted for any frequencies inside the ISM band. Consequentially, there will be no overlap between licensed systems and Spread Spectrum systems. These two technologies will always broadcast on separate frequencies and thus cohabitate without negative results.

The closest frequencies to the ISM bands 902 Megahertz to 928 Megahertz range are cell phones and microwave signals. If the power of one of these two communication devices is high enough and the device is not precisely tuned to its licensed frequency, it is possible for the signal to “bleed over” into the ISM band. The cure for this occurrence is an inexpensive Band Pass Filter. This filter will block any noise or interference that is outside the 902 MHz to 928 MHz range.

<u>Obstructions</u>

Many times you might hear that radios must have clear “Line of Sight” (LOS). It is also a common myth that Spread Spectrum radios are more restricted by line of sight than other communications devices. However, while line of sight is always preferred, Spread Spectrum radios will indeed pass data through obstacles such as buildings, trees, and in many cases over hills. What happens to a radio signal in these environments is that the obstacles introduce “attenuation” into the signal path. Attenuation is a resistance that reduces the strength of the signal. Attenuation occurs over a distance: the greater the distance the greater the attenuation. Attenuation also increases with the presence of tree branches and foliage. A radio may transmit for 20 miles with clear line of sight, but it may not be able to do so if the 20 mile path is through a dense forest. The signal loss over the distance combined with the signal loss or attenuation of the forest would be too great. While the radio can often transmit through one or the other obstacles, the combination of the two may be too great to overcome.

Buildings offer a challenge similar to that of a forest. Radio signals will often transmit through buildings, but not through both a building and then a distance of 20 miles. There are many applications where Spread Spectrum radios are used to gather data from multiple floors in a building and bring it to a central collection point in the basement or lowest level. The signal is weakened with each concrete floor that is penetrated. After some finite number of floors, the signal will become so weak that it will not penetrate any more floors. Even in this case, the radio may sometimes find a path (elevator shafts) that allows the signal to continue. This illustrates an example in which there is no clear "Line of Sight" for the transmitted signal, yet the signal still reaches its destination. A radio will communicate through multiple floors depending on the environment and the antennas being used; the limitation may be 5 floors, 6 floors, or even more than 10 floors. The common term for this degradation of signal is "Path Loss" or "Signal Fade." In outdoor field applications, this point can be computed by the use of software programs. The common mistake many end-users make is not preparing a 'Path Study" prior to starting installation. This is the quintessential case of "an once of prevention being worth a pound of cure".

Performing a "path study" prior to starting a project will create a network design that allows you to work around any obstacle and insure a solid robust communication system, regardless of "line of sight" in the area.

<u>Conclusion</u>

Spread Spectrum is a relatively new technology for data communication. As with any new technology, there are many misconceptions about the best way to utilize its features. In the case of Spread Spectrum radios, there are still many people who are quick to tell the myths, yet have never actually used the product. In practical application, Spread Spectrum can be used in almost any data acquisition system that would work with licensed radios. Spread Spectrum systems are designed to perform and be trusted, but they are dramatically different from licensed systems.

Remember that the use of multiple repeaters and slave/repeaters allows for long-range, flexible, and secure networks. When you add the option of "Hybrid" communication to the mix, you now have the opportunity to match the "best fit" technologies for your data network.

In building a communication system, its effectiveness will increase with the more tools you have at your disposal. Spread Spectrum radios enable both a reduced communication cost while also increasing both the reliability and throughput of any system.

It was only a few years ago that radio systems used Bell 202 modems and a 1200-baud throughput was commonplace. Spread Spectrum radios are capable of delivering data at speeds up to 115 K-baud. Speed and error-free results (accomplished by utilizing CRC up to 32-bit) provide a viable communication option for applications never before thought to be within the realm of wireless communication.

The natural evolution of data communications has brought us to understand the benefits of Spread Spectrum radios and the power of their versatility. Spread Spectrum's ability to be coupled with other communication mediums adds yet another layer of versatility never before imagined.

It is reasonable to foresee the day when Spread Spectrum radios and their closest relative, the Ethernet radio, will be the dominant communication device in data collection.