TECHNOLOGY

Overview

Lynx® Digital Microwave Radios: Understanding & Overcoming Radio Interference

When evaluating wireless technology, the possibility of radio frequency interference disturbing a wireless network link sometimes poses a concern. Interference can block the flow of data, severing communications and disrupting an entire organization. This paper provides background on interference, describes the licensed and license-exempt approaches towards interference, and explains how the right design and deployment, when combined with optimal technology, can overcome interference. Lynx digital microwave radios provide reliable data transmission by minimizing the possibility of interference with a proven combination of well-engineered deployment practices and robust fixed wireless technology.

The Interference Challenge

Radio interference results from unwanted radio frequency (RF) signals disrupting system communications. Typically these signals are at or near the same frequency as the receive frequency of an established system, and are often similar or higher in RF power than the desired receive signal of the impacted system. This effectively blocks out the reception of the desired receive signal. Interference can affect all types of radio frequencies, although the topic is most frequently raised in the context of license-exempt systems.

Evaluating the Technology: License-exempt vs. Licensed

The terms "license-exempt" (also called "license-free" or "unlicensed") and "licensed" refer to the radio frequency spectrum rules defined by the U.S. Federal Communications Commission (FCC) or equivalent national government regulatory body. In the United States, FCC Rules Part 15 governs the license-exempt frequency spectrum, and Rules Part 101 governs the licensed frequency spectrum. Licensed products require regulatory approval before deployment while license-exempt products can be deployed without any regulatory approval.

License-exempt Systems

A "license-exempt" system can be installed virtually anywhere within a given country without obtaining a license to operate from the regulatory authorities. Such a system must already be certified to operate as license-exempt in that country. Manufacturers desiring license-exempt certification must apply to the FCC or equivalent national authority for approval to operate the particular product in specific radio frequency bands. FCC rules encourage efficient use of RF bandwidth and harmonious co-existence of different systems using the same radio spectrum. The FCC (or equivalent authority outside of the US) process helps to isolate the opportunity for interference by requiring all license-exempt devices to conform to the same standards. Once a product adheres to specific national regulations and the manufacturer obtains certification by the appropriate governing authority, anyone can deploy that manufacturer's equipment anywhere in the country without further regulatory approvals.

Licensed Systems

"Licensed" RF transmitters communicate using a specific transmit and receive frequency combination that is assigned to the user (licensee). The frequency assignment is coordinated with other users of the same spectrum in the same geographical area. This process provides full disclosure of the frequency assignment and typically avoids interference from any existing licensee already assigned in the area. If licensed radios encounter interference, it is typically resolved with the assistance of the regulatory body. The application, assignment and coordination process with the FCC (or equivalent regulatory body) constitutes the licensing process. The licensing process requires planning to accommodate the time needed for all three steps in the process. In addition, licensing requires payment of fees to the FCC or equivalent authority.

A second type of licensed spectrum, as defined by the FCC, can be purchased by a license-holder, usually at auction. Examples of these are the LMDS frequencies in the 28-31 GHz band, and MMDS frequencies at 3.5 GHz. The license-holder "owns" a particular block of frequency spectrum in a given geographical area. While no one can use these licensed frequencies without the license-holder's consent, the license-holder is responsible for managing his or her own usage as well as any "subcontracted" usage.

The Differences Between Them

A common belief is that systems operating with licensed frequencies are ensured 100% protection against RF interference. Likewise, it is thought that operating in the license-exempt frequency bands increases the potential for interference. These are two common but flawed positions. Achieving 100% protection is not possible even with licensed systems. The primary difference between licensed and license-exempt systems is that licensed radio users have a regulatory body that will assist them in overcoming any interference issues that may arise, while license-exempt users must resolve interference issues without governmental assistance. In both cases, proper selection of the frequencies and methodical engineering of the path are key to implementing a microwave path whose potential for interference is greatly reduced.

Another difference between licensed and license-exempt is that licensing requires an additional step called "Prior Coordination." This step formally reviews the neighboring spectrum users to coordinate the assignment of the new transmit frequency with other systems already operating in that geographical area. The new transmit frequency is selected and existing users are allowed a 30 day period to review and comment on the selection. This process "coordinates" the assignment of new frequencies to minimize possibilities for interference with existing transmitters. Once the review period is completed, the new transmit frequency is formally granted in a license. For license-exempt systems, there is no government provided service – customers wishing to perform this review must do so themselves.

Proxim provides both point-to-point licensed products and license-exempt point-to-point fixed wireless products. Depending on an organization's requirements, Proxim can help customers intelligently select and efficiently deploy the best technology to fit their needs.

Designing and Deploying an Optimal Wireless Link

Proper design and deployment are the most critical elements in avoiding potential interference. In fact, an appropriately configured license-exempt system can provide the same or better reliability than a licensed system, even in the face of potential interference.

There are two key factors in deploying a successful wireless network: 1) achieving a strong Received Signal Level (RSL), and 2) minimizing the receiving antenna's beamwidth. The higher the RSL of the intended transmission, the less likely a system will be affected by interference. A stronger signal cuts its way through the clutter of interference so it can be "seen" more clearly at the receiving end of the link. Higher received signals are obtained by optimizing a given link. This can be achieved by using robust radio technology, properly-sized antennas, and low loss transmission lines between the Lynx radios and the antennas.

Selecting the right antenna

Antennas frequently play a key role in mitigating the potential for interference. Antennas come in a variety of sizes and shapes that have different performance characteristics in the area of "gain" and directionality. In radio parlance, gain refers to the ability of an antenna to increase the transmitted and received signal while directionality refers to the antenna's ability to focus on a specific aperture for transmitting and receiving signals. Antennas can transmit/receive in all directions (omni-directional) or transmit/receive in one specific direction (directional). Lynx digital microwave radios use directional antennas that transmit and receive a focused beam of radio energy for optimal performance between two points. Directional antennas come in flat panel and parabolic designs, both of which offer considerable gain and directionality. Deploying a high-gain antenna results in improved RSL and consequently improved signal reception. Larger sized antennas offer increased gain.

Focusing the received RF beamwidth reduces the likelihood that surrounding RF clutter might interfere with a system's reception. Antennas vary in the aperture to which they can "see" signals. The larger the antenna the narrower its beamwidth. A narrower beamwidth increases the desired energy of the transmitted signal while reducing the reception of interfering sources not directly aligned to the antenna.

Smaller antennas may be aesthetically preferable, but larger antennas offer a number of benefits, including:

- Increased strength of the transmitted signal
- Increased strength of the Received Signal Level (RSL) that is aimed directly at the antenna
- Delivery of more focused RF signals (narrower beamwidth)
- Improved selectivity of desired signal in the face of signals from slightly different bearings

For example, an 8-foot antenna can boost a signal by over 375% over a 2-foot antenna. In addition to the improved RSL, larger antennas offer a narrower beamwidth that can focus on the incoming signal and avoid extraneous transmissions. A 2-foot antenna may have a 6.1 degree beamwidth while an 8-foot antenna has a 1.6 degree beamwidth – nearly four times more focused. Where a 2-foot antenna might encounter interference, an 8-foot antenna will reduce the incoming level of interference substantially and may not "see" an interfering signal unless it was within the 1.6 degree target area. If the interfering signal is outside the 1.6 degree target area, its reception is diminished. A narrower antenna beamwidth reduces the interfering signal while increasing the desired

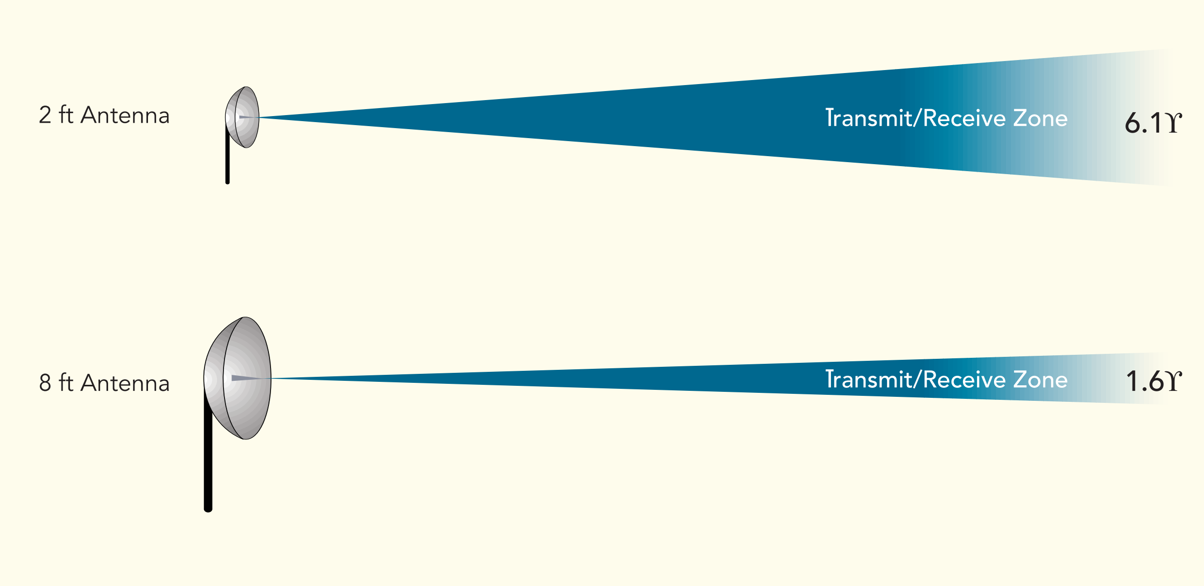

Figure 1: 2 foot vs 8 foot antenna radio frequency (RF) beamwidth

signal.

A good deployment practice is to "scan" the antenna locations for potential interference prior to deployment. A spectrum analyzer and antenna can be used to determine if there are any interference signals that might need to be "steered around," and to measure their direction, strength, frequencies and polarizations. This is roughly equivalent to the prior coordination that is performed for licensed radio designs. This tactic is not always necessary because frequency changes can be made during deployment; however, it is a recommended step to take in system design. Such scanning can be particularly useful in dense metropolitan areas where one is more likely to encounter interference.

When Lynx digital microwave radios are combined with larger sized, highly directional antennas, interference is rare and reliability of these wireless systems is maintained at the highest levels.

Lynx Digital Microwave Radio Technology: Designed to Deliver

While good deployment practices reduce or eliminate the potential for interference, a well-designed transceiver system can result in an increased degree of tolerance to interference as well as easier deployment. A key Lynx strength is the radio technology engineered by Proxim. Lynx digital microwave radios offer one of the highest output power levels in the industry. High output power raises the RSL and consequently reduces the potential for interference since any interference source would have to be stronger to interrupt the signal.

A simple way to reduce interference is to change, or "frog," the frequency channel pair of the radio hop. Many Lynx models allow the transmit and receive frequencies to be exchanged, effectively swapping the two radios in a hop. Lynx also provides the same data capacity (e.g. 10 Mbps, 45 Mbps, etc) in multiple frequency bands. This allows the user to completely move out of the RF band which may be subject to interference.

Interference: The Myth and Reality of First Come, First Served

Interference typically impacts both the "interferee" and the "interferer." An established system encountering interference may be interrupted, but the new system causing the interference will often not be able to fully function or function properly. A new system cannot displace an established system. Once a system is operational, any future systems will have to "steer around" the existing signals so that both systems can live in harmony.

When one encounters interference while deploying a new system, it is frequently possible for the established system and the new systems to arrive at some sort of mutual accommodation enabling both systems to coexist while avoiding interference. This can be done through tactics such as reducing the transmitting power of one link so it does not interfere with the other link.

The Proxim Experience

Proxim has successfully installed more than 45,000 nodes worldwide. Many Proxim customers select wireless, license-exempt systems so that they may deploy them quickly and inexpensively without compromising reliability. The rapid growth and long-term success of these wireless networked installations is achieved through the use of the methods and practices described in this paper to minimize interference and optimize overall system performance and availability.

Proxim Corporation
2115 O'Nel Drive
San Jose, CA 95131

tel: 800.229.1630
tel: 408.731.2700
fax: 408.731.3675