ADDRESSING IN-BAND AND OUT-OF-BAND INTERFERENCE

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Executive Summary

This paper addresses the issue of interference with other licensed exempt systems operating in the same band as Redline products, as well as the issue of interference into disparate systems operating out of band.

Redline Products – Designed to address interference

Introduction

Redline develops broadband fixed wireless systems that operate in the License Exempt (LE) band of 5.725-5.825 GHz, where the potential for interference can arise as users are free to deploy systems without special permission or consideration from the regulatory agency. In recognition of this, Redline has designed technology with inherent tolerance to interference and has put in place deployment strategies to address interference from disparate co-existent systems operating within the LE band.

Although license exempt systems differ from their licensed counterpart, in that they do not have radio specifications for in-band operation by which to adhere, regulators have put in place strict guidelines regarding out of band emissions to protect other systems and services operating outside the LE band. Such services include navigation radars for commercial airlines, surveillance radars for military and security applications, satellite sensors, etc. Redline's products have been designed to exceed the standard to avoid interference into these 'adjacent band' systems.

This white paper provides an overview of Redline's technology in addressing in-band and out-of-band interference.

Interference from other systems within the LE band (In-Band)

Redline's products feature a host of techniques and inherent design to address interference from adjacent systems operating within the LE band. This coupled with proper cell planning provides an effective means of promoting co-existence amongst multiple systems operating within the same geographical region. These techniques include:

- Orthogonal Frequency Division Multiples (OFDM) + Adaptive Coding
- Multiple Channels and Time Division Duplex (TDD)
- Narrow beam antennas with high side/back lobe rejection
- Cross-polarization
- Automatic Repeat Request (ARQ) Correction
- Adaptive Modulation (burst to burst)

1. OFDM + Adaptive Coding

The underlying physical layer of Redline's product offering is based on an advanced form of Orthogonal Frequency Division Multiplex (OFDM), along with adaptive temporal coding, including Forward Error Correction (FEC), to provide significant robustness against co-channel narrow band interference. The technique essentially spreads the content signal across multiple narrowband sub-carriers and repeats the same information over time (redundancy), as graphically illustrated in Figure 1.

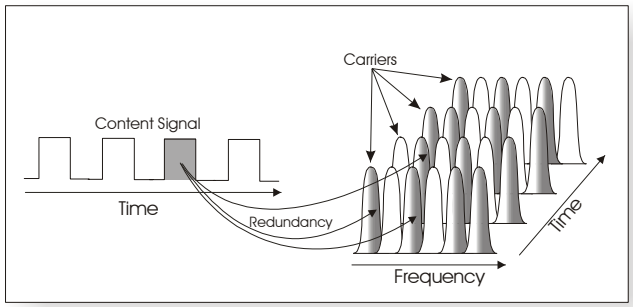

Figure 1 Signal spread over multiple carriers and time.

Should interference arise which adversely affects some of the sub-carriers (as show in Figure 2), then the signal is recovered by the remaining carriers and processed over time to maintain relatively the same performance. A slight degradation in data rate may occur depending on the extent of the interference i.e., the number of carriers affected and the precise nature and duration of the interference. Note that this technique is also effective against severe multipath fading, which can create nulls or frequency 'suck outs' in the spectrum (i.e. carriers removed due to destructive cancellation).

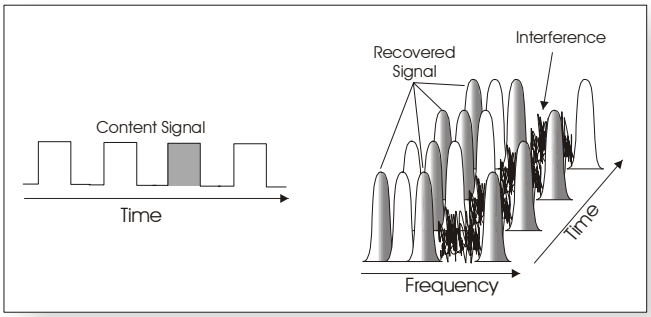

Figure 2 Redundant signal recovers information despite lost carriers.

The technique also provides exceptional Adjacent Channel Interference (ACI) rejection. For example, the product can tolerate an ACI that is 18 dB greater (36 times stronger) than the desired signal in 16 Quadrature Amplitude Modulation (QAM) mode, as shown in Figure 3 below. With such robustness, the redline product can be deployed in a highly congested environment and still operate effectively.

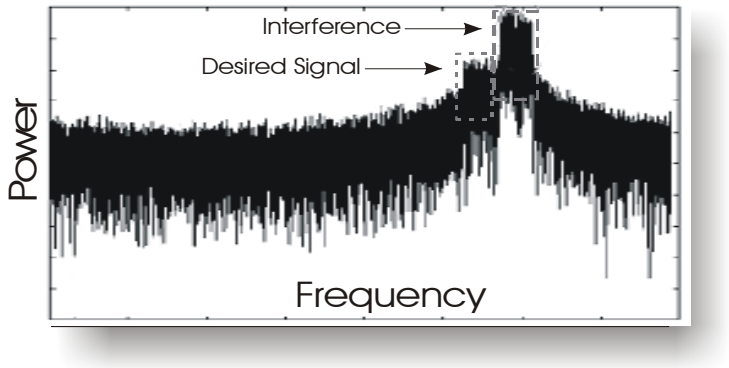

Figure 3 Adjacent channel interference rejection.

2. Multiple Channels and Time Division Duplex (TDD)

Redline's products feature multiple channels to maximize flexibility in cell planning and to avoid interference with other co-located systems. A total of seventeen (17) different channels (five of which are non-overlapping) within the LE band are available to operate the system should other radios be within the vicinity. Note each channel is separated by 5 MHz, providing full flexibility in dealing with co-existent systems. During initial deployment, an operator must undertake proper cell planning by choosing a channel that is not utilized by any other system(s) that may fall within the main beam of the Redline antenna. Redline's products also have the advantage of operating in TDD mode, providing the added benefit of not requiring a guard band between transmission and reception, as opposed to competing Frequency Division Duplex (FDD) systems, that waste as much as 40 MHz of precious spectrum to satisfy the requirements of the radio's diplexer.

3. Narrow beam antennas with high side lobe and back lobe rejection

The antennas used with Redline's products feature high side lobe and backlobe rejection to minimize or eliminate interference from systems operating within the same region but are not within the main beam of the Redline antenna. To maximize frequency reuse and minimize interference, narrow beam antennas are strongly recommended. For example, a 4.5 degree antenna is suggested for point-to-point deployments while 60 or 90 degree sectorized antennas are recommended at the base station. In

general, omni antennas are not recommended, as they are vulnerable to interference in all directions.

To avoid interference, a combination of narrow beam antennas and multiple channels is an effective strategy for supporting multiple deployments. Figure 4 illustrates a sample deployment with both Point to Multipoint (PMP) and Point to Point (PTP) systems co-existing within a geographical area. A PMP base station is linked to two Subscriber Stations (SS) operating on channel 3, while several PTP systems are operating in co-channel and adjacent channels. The PTP 1 link is in parallel to the PMP link, and therefore, to avoid interference, operates on channel 1. Meanwhile PTP 2 and PTP 3 links, which are perpendicular to the PMP link, are operating on channel 2 and 1, respectively. PTP 3 is co-channel to the PMP link; however, a narrow antenna beam is used to close the link, preventing any cross-talk or interference.

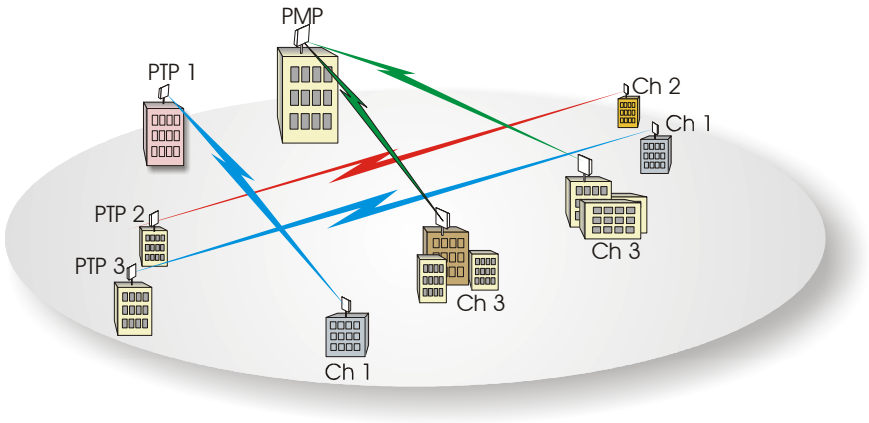

Figure 4 Multiple systems co-existing without interference.

Thousands of Redline's systems have been installed throughout the world, of which many co-exist with other license exempt systems without any interference issues. It is important to recognize that although the band is license free, and users are permitted to freely install equipment whenever and wherever they wish, they are also faced with the same potential interference issue, and hence must take the necessary steps to measure the spectral environment and avoid operating on channels where other systems exist. In this manner, deployments and the issue of interference are essentially self-regulated.

An example of a challenging deployment scenario in which Redline's product co-exists with other systems in the same band, can be found in the mountains of Idaho (see Figure 5). In this scenario, Redline's AN-50 operated at a range of 118 Km at 'over the air' rates of 24 Mega Bits Per Second (Mbps) while two other systems from different vendors were operating in the vicinity (as can be seen, one of the other system's antenna is co-located on the same pole as the AN-50 antenna). Although the range at which the AN-50 is operating is impressive in itself, the fact that it can also

withstand adjacent channel emissions from co-located systems (keep in mind the receiver is 'wide open' at this range) is a testimony of the interference rejection capability of Redline's products.

Figure 5 Long range deployment co-existing with co-located in-band systems.

4. Cross-polarization

Antennas used for fixed wireless are typically linearly polarized, operating in either the horizontal or vertical plane. Cross polarization refers to antennas that are installed at opposite polarization, i.e. one is deployed with horizontal polarization, while the other with vertical polarization. Cross polarization provides an effective means of isolating two systems that are operating co-channel or in adjacent channels. The antennas offered by Redline provide additional isolation of greater than 20 decibel (dB) (100 times) simply by using cross-polarized antennas, hence providing an effective strategy for addressing potential interference between co-located systems.

5. Automatic Repeat Request (ARQ) Correction

Redline's products feature a highly effective error correction scheme called Automatic Repeat and Request (ARQ) to address quick bursts of interference that may occur in the environment. ARQ error correction occurs at the physical layer, involving the re-transmission of bits that have been compromised, rather than at the Transport Control Protocol (TCP) layer, which involves significantly more overhead to implement the same level of correction. It is worth noting that the re-transmitted bits are sent at the lower modulation level, to ensure successful communication.

6. **Adaptive Modulation (burst to burst)**

   Redline's products feature adaptive modulation, performed on a burst-to-burst basis and in both directions. Although adaptive modulation does not in itself mitigate interference, it does allow the system to continue to operate, albeit at a lower data rate, during periods of interference. Redline's suite of products range from BPSK (very robust) to 64 QAM modulations.

Interference into other systems outside the LE band

Redline's products have been specifically designed to prevent interference into radio systems operating adjacent to the LE band, including those associated with emergency services, military services, commercial airlines and fixed satellite sensors. Redline's products have received regulatory approvals from key government agencies around the world including the FCC, IC, ETSI, and MII[1], who have set extremely high 'out-of-band' radio standards to prevent interference, and promote co-existence amongst disparate radio systems and services.

Redline's products operate in the band of 5.725 to 5.825 GHz (LE band), which has been allocated by leading regulatory authorities to provide broadband services to business and residential users. As such, other systems that support emergency services including radio communication, radar surveillance, air traffic control, etc., typically operate outside of this band. Redline's products have been engineered to minimize out of band emissions, or energy into these sensitive bands. Hence, Redline's products can be safely co-located next to an 'Emergency Service' radio system without introducing interference. There are several deployment examples throughout the world in which Redline antennas currently share space on several towers and buildings with other police radios, military communication and surveillance systems, without any co-existence issues.

Redline has also recently developed a Dynamic Frequency Selection (DFS) capability to meet the regulatory requirements of select countries seeking to protect their military navigation radars operating in portions of the LE band. The DFS technique measures all signals being received and upon detecting the known parameters of the navigation radar, automatically switches the Redline system to a new channel to avoid any possible interference.

Conclusion

In summary, Redline's products have been designed to meet vigorous Government standards to avoid interference with other radio systems operating both in-band and out-of-band. The thousands of deployments around the world, in which

[1] - FCC Part 15.247
- IC RSS210
- UL 60950 / ETSI EN 60950 3rd edition
- ETSI EN 301 489-3 V1.4.1 (EMC)

Redline's products co-exist with other systems, verify that these standards are met and that Redline's design is an effective solution in addressing interference.

About Redline Communications Inc.

Founded in 1999, Redline Communications, a privately held Canadian company, is an innovative provider of second-generation broadband fixed wireless systems for service providers and enterprise markets. Redline has introduced an unprecedented product portfolio incorporating several novel technologies to deliver exceptionally high-speed data rates, under complete Non Line Of Sight (NLOS) and challenging multipath deployment conditions, and at significant ranges – all at competitive prices to quickly maximize operator return on investment. Redline's inaugural product, the AN-50, has already received a number of Industry accolades, including the prestigious SuperQuest award honored at Supercomm in Atlanta for 'Most Promising Transport Technology'.

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