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RECENT INNOVATIONS IN SPREAD SPECTRUM RADIO TECHNOLOGY FOR GAS MEASUREMENT

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During the last five years, we have seen important introductions of innovative spread spectrum radio technologies that dramatically optimize the performance and reliability of a telemetry network, while at the same time lowering the total deployment cost of the same. By migrating to these newer technologies, gas companies can now, more than ever, seamlessly monitor and control all of their geographically dispersed gas measuring devices and gain unprecedented access to real-time information, to enhance their ability to make “just-in-time” decisions.

Background:

- At its most fundamental level, spread spectrum technologies allow for the transmission of a signal on a particular bandwidth, which is spread throughout the specified band (i.e. 900MHz or 2.4GHz). This technology was originally developed for military purposes to establish secure communication that was resistant to noise, jamming and interference. In the 1980s, the technology was approved for used in “Industrial, Scientific and Medical” (ISM) applications by the FCC.

- Today there are many variations of spread spectrum technology; however, the two best known are FHSS (frequency hopping spread spectrum) and DSSS (direct sequence spread spectrum). The main difference between these two variations is the way in which the signal is modulated and spread throughout the assigned band. FHSS transmits signals by quickly switching the frequencies within the assigned band, thus the term ” frequency hopping” and uses a pseudorandom pattern that is known to both the transmitter and the receiver. In contrast, DSSS transmits signals over pre-determined static channels, within the assigned band, and does not use pseudorandom hopping patterns to spread the signal. Both FHSS and DSSS have specific niche uses and have given birth to many of our modern communication technologies like cellular, Bluetooth, ZigBee, WiFi and WiMax, to name a few. However, this paper will focus specifically on FHSS and how FHSS radios are used in industrial applications to monitor and control critical infrastructure remote devices.

Today, FHSS radios are widely used in telemetry applications that required long distance and highly reliable communication and control of remote devices. FHSS radios have proven to be extremely valuable and allow for the total automation of forward-deployed devices in diverse applications like seismic (remote monitoring of volcanos or earthquake hot-spots), O&G (monitoring/control of oil well and pipeline devices), and WWW (monitoring and control of water tanks and pumping stations), to name a few. However, as with many other technologies, we are now seeing that FHSS radio technology is evolving to meet the modern communication demands for “just-in-time”, highly secure and reliable telemetry networks.

So what are some of these innovations and their associated benefits?

- Dual Antenna:
  - Traditional industrial radios come only with one antenna port. Either a directional or an omnidirectional antenna can be connected to this port to allow the radio to receive and transmit. The

choice as to which type of antenna to use is dependent on the type of link that one is trying to achieve and the desired coverage area. In general a directional antenna is better for point-to-point links, as this type of antenna focuses the greater part of the signal in the desired direction and thus allows for longer and more reliable links.

- For some networks, omnidirectional antennas must be used at points where the corresponding radio has to establish links with other radios that are displaced in many different directions – like in the case of a Master or a Repeater. Omnidirectional antennas propagate the entire signal in all directions; however, as a result of this 360 degree propagation, omnidirectional antennas can lose 40-60% of their directional coverage capability.
- A recent innovation now allows radios to have two operational antenna ports. The addition of a second antenna port on the radio allows switching between two antennas in a time division multiplexed way. When the dual antenna capability is enabled, it permits the radio to behave as if it was two radios (an upstream and downstream radio). This feature can then be used by system designers to use combinations of directional and/or omnidirectional antennas on one radio (bridge) to maximize signal reliability and extend the overall coverage of that radio.
- Radios with this capability allow users to extend network coverage by as much as 60% by simply using dual directional antennas to focus the radiated energy of the radio in the desired direction. For example, switching from a 6 dBd Omni antenna to a 10 dBd Yagi on the upstream or downstream path from a Bridge repeater will provide a 4 dB improvement in receive signal level. In addition to the increase range, the dual antenna capability can increased reliability on any path due to greater fade margin and reduced cost, as only one radio required at the Dual Antenna site.

- Single Radio Dual Data Rate/Sensitivity:
  - Some spread spectrum radios now have a new feature that allows a single radio to operate in two separate data rates/sensitivity (upstream and downstream).
  - This new feature allows a single radio to have an upstream data rate for example of 512 Kbps and associated sensitivity of -92 dBm and downstream data rate of 64 Kbps and associated sensitivity of -106 dBm.
  - This feature allows users to establish longer distance and more reliable links, when Repeaters are used and to lower the total deployment cost of a network, in terms of less infrastructure and fewer radios and accessories.
  - Together, the “Single Radio Dual Data Rate/Sensitivity” and “Dual Antenna” features provide users dramatic increases in network reliability and area coverage.
- Advance Redundancy/Meshing:
  - Some spread spectrum radios can now be programed to selectively drop their main link to a radio and then to seek another link with another radio. The user can now program several parameters to control the conditions when and if this link will be dropped and the conditions to be met for the new link.

    - This innovation, now allows users to establish highly resilient and advance redundant networks that provide flexible communication that can seek alternate paths to ensure the flow of communication is not interrupted by a temporary disruption, at any one point. Taken to its extreme, this feature will allow a FHSS radio network to operate similar to a "Mesh-Self-Healing" network.

- Automatic Data-Rate Mode:

    - Some radio manufacturers are now developing spread spectrum radios that have an "Automatic-Data-Rate" mode to allow the Master radio to operate in two separate data rates and communicate with radios that are operating in one of the two data rates

    - For example, an Ethernet radio may have the ability to operate at either 500kbps Mbps (-92dBm sensitivity) or 256 kbps (-102dBm). Selecting one of these data rates will determine the amount of data the radio can transfer in a given second but it will also determine the radio's sensitivity and thus have a dramatic impact on the radio's ability to achieve a long distance link.

    - An increase in 10 dB will triple the distance that the radio can link, all other things being equal. In the above example there is a 10 dB difference between the two available data rates, which means that when this radio operates at the lower data rate it will cover a radius 3 times larger than when it operates at the higher data rate.

As these new RF innovations go "main stream" we can expect gas distribution companies to migrate their telemetry networks to the newer technologies to achieve the following benefits:

- Increased network reliability: Critical infrastructure applications require the highest degree of RF reliability possible. By taking advantage of new spread spectrum innovations like advance redundancy and meshing, users can significantly increase the reliability and survivability of a critical infrastructure network.

- Increased network coverage and lower deployment costs: In most critical infrastructure projects, field devices are deployed over a large geographical area and may be scattered over hundreds of square miles of diverse and rugged terrain. In other cases, the devices may be deployed in a relative small geographical area but the geography or other "man-made" structures may not permit an adequate line-of-sight (LOS). In both scenarios, it is imperative to use a high quality, long-range, industrial radio that uses the latest advanced technology to enhance the radio's ability to link to all of the deployed devices, regardless of the physical (LOS) or RF environment. By using spread spectrum radios with advance "Dual Antenna and Sensitivity" features, users can extend the traditional range of a radio network and can reduce the overall structural cost of deployment of a wireless network.

The future of RF communication is not always clear. However, there is a clear need to continue to forward deploy "smart field devices" and to fully automate field operations and processes. It is also very clear that using the most recent innovations in spread spectrum technology to provide users "real time information" that allows them to make the best decision and thus fully realize the promise of a fully automated operation.