Setting the Standard for Automation™
InTech provides the most thought-provoking and authoritative coverage of automation technologies, applications, and strategies to enhance automation professionals' on-the-job success.
InTech

01 March 2004

Radio in industrial environments

By Brian Cunningham

With increasing demands placed on plant managers to reduce operating costs, wireless is presenting attractive alternatives to buried cable and conduit runs.

The issue at stake in choosing this alternative is reliability.

In industry, the requirements for radio differ from those typically governing commercial or residential applications. With cellular phones, for instance, the design requirement is best effort in terms of coverage and reliability.

With industrial applications, the design requirement becomes must work 100%. Typical industrial applications include extracting tank levels in storage facilities, controlling pump stations in municipalities, and in general replacing cable and conduit where the cost of materials and associated installation exceed the cost of a radio system.

However the question remains when replacing a tried and true cable and conduit system with a new technology: will it be as reliable?

The first step is to analyze the requirements.

Environment: How much control do you have over interference? Contrast, for example, a typical office environment and that of a chemical refinery. In the office it is possible to control the number and type of radios in use. There are four walls surrounding the office that will help keep out radio waves from external sources. Therefore, the use of radios with low interference handling capability is practical in the office.

However in the chemical refinery, there are often multiple electrical shops, each with different responsibilities, and the right hand may not know what equipment the left hand has recently installed. Contractors can visit the site for a few days and use a radio product—which shows up as interference one day but not the next.

There are also many other sources of interference, motors, drives, power lines—in other words, it is very difficult to know what other types of radios and interference you will encounter. A radio that cannot tolerate interference is likely of little use here.

File size: How much data do you need to transfer? In our Internet happy world, often people will compare baud rates of radios and think the fastest one is the best. However it is important to realize that unlike our offices where we regularly send megabytes of data, most industrial analog signals are two bytes, and discrete data makes up a single bit. Therefore the data throughput requirements of most industrial customers is far lower than that of an office worker.

Speed vs. security: You need to analyze which is more important, because there is a trade off. Design restrictions often dictate that you cannot find a radio that has both characteristics. Generally, ensuring that your tank high-level alarm gets through to your pump controller to shut it down reliably before thousands of gallons of your product are wasted is more important than an update speed of 1000 times per second.

Future interference: To be reliable, you need to consider the very real possibility that the radio you install now will not be the last. Therefore, using a robust technology capable of coexisting with other radios is important.

Different types of radio

The radio frequency (RF) technology that is right for a certain situation depends on where the sensors in that situation live, and how much they have to say.

Fixed-frequency radio: Original radio is fixed-frequency radio. Today, the process for commissioning one of these involves making an application to the Federal Communications Commission (FCC), noting your location. In terms of reliability and living in an ideal world, these work very well.

Spread spectrum: Due to the lack of available fixed frequencies, in 1987 the FCC opened the first spread-spectrum (SS) frequency bands and also created some rules governing SS radios. The first rule was that license free frequency bands would exist at 900 megahertz (902 to 928 megahertz), 2.4 gigahertz, and 5.8 gigahertz. The second was that the transmission power would cap at one watt. The third was that the radios allowed to operate within these frequency bands must be one of two designs, frequency hopping or direct sequence. And lastly, if interference is encountered, do not contact the FCC —they will not regulate this frequency band nor guarantee interference free operation.

Direct sequence spread spectrum (DSSS): These radios spread their one watt of power across a very wide portion of the allocated frequency band. The advantage of wider bandwidth is the ability to move data at higher baud rates, often in the millions of bits per second. The disadvantage is that with power spread across so many frequencies and devoted to so many bits of information, the range is reduced and the receiver filters must be set quite wide. Therefore, there is a greater possibility of interference. DSSS radios overcome this interference using coding/processing gain. In other words, DSSS radios use software processing to filter out interference that gets by their hardware filters. This method can be very effective, and some DSSS radios can tolerate substantial interference. When interference breaches its jamming margin, a DSSS becomes ineffective. Like a fixed-frequency radio, DSSS performance is all or nothing (apart from the fact that it outperforms fixed-frequency radios due to processing gain).

Frequency hopping spread spectrum (FHSS): A frequency hopping radio operates by constantly changing frequencies in a pseudorandom fashion throughout the entire 902 to 928 megahertz bandwidth. It has the opposite characteristics of a DSSS radio—it has a very narrow bandwidth, low baud rate, and due to the narrow filter settings and frequency agility, a high tolerance for interference. It also differs in the sense that its performance doesn't have an abrupt end point; performance decreases as interference across the frequency band it is operating in increases. The advantage of this is that small files of redundant data—pressure, temperature, level, discrete alarms—can transmit over and over again on a FHSS. Even though some updates may be lost to interference on specific frequencies, many updates get through. An FHSS radio updating the level measurements of a tank 40 times per second can often afford to loose a high percentage of the updates and still accurately report tank status. On the other hand, if this same radio was responsible for moving large data files it would be considered inappropriate because it accepts the loss of some data.

Theoretically, all 26 megahertz of the 902 to 928 megahertz frequency band must be jammed to stop a FHSS radio—a task typically left to military technology.

To summarize, while staying within the FCC's regulations of one watt of transmit power; you can either get a fast radio with short range and high susceptibility to interference, or get a slow radio with long range and low susceptibility to interference.

Referring back to the earlier discussion of parameters to consider when selecting a radio link, DSSS radios work very well in office environments where there are short distances, high data rate requirements, and low interference levels. FHSS radios work best in industrial environments where there are long distances, low data rate requirements, and higher levels of interference.

Comparing all three types of radios (fixed frequency, DSSS, and FHSS) operating in the same high-interference industrial environment, the fixed frequency would be the most vulnerable, the DSSS would have a limited tolerance, and the FHSS the highest tolerance. ?

Behind the byline

Brian Cunningham is a fourteen-year member of ISA. He works in applications support and training at OMNEX Control Systems Inc. in Port Coquitlam, British Columbia. Write him at bcunningham@omnexcontrols.com. He will discuss FHSS radio networking further in this department in April 2004 *InTech*.