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Radio in industrial environments

By Brian Cunningham

Wireless in the plant, part 2.

Last month in this department we delineated the reasoning for opting for frequency hopping spread spectrum (FHSS) radio as the best choice for wireless industrial applications.

We analyzed the factors that radio must contend with in factories, including the environment, the file sizes of the data transfers involved, the trade-off between speed and security, and future interference.

FHSS is the solution.

The next issue to look at is a concept referred to as the energy per bit. There is an inverse linear relationship between the data rate and the distance or range of an FHSS radio. When comparing two FHSS radios, the range specifications do not appear as standardized, however the data rate is.

A 1-watt FHSS radio operating in outer space (perfect vacuum) can transmit for thousands of miles. However here on earth with air molecules as an obstruction, the range is typically 15 to 20 miles. A much more standardized method to compare one FHSS radio range to another is to look at the baud rate.

The next specification to consider is the receiver sensitivity. The more sensitive the receiver, the weaker the transmitted signal can be yet still get through. In other words, the distance and obstructions between a transmitter and receiver can be greater.

One other aspect of radio to consider is the frequency of choice. With 2.4 gigahertz (GHz) also available as a license-free spread spectrum band, the questions often posed are what are the differences between 900 megahertz (MHz) and 2.4 GHz, and why should I select one over the other? Both are capped at 1 watt of transmit power.

Here basic radio frequency (RF) engineering comes into play. With the same amount of power, there is an inverse relationship between frequency and range. In other words, because the 2.4-GHz frequency is almost three times higher than the 900 MHz, a 2.4-GHz radio will have about one-third the range of a 900-MHz radio—when the transmit power is equal.

Another major consideration is rain fade. The microwave ovens that we use in our kitchen operate at

2.4 GHz. Why? Because water absorbs RF energy very efficiently at that frequency. Therefore a 2.4-GHz radio will have a very short range under heavy precipitation conditions (although the rain in the area will be infinitesimally warmer—yuk, yuk, that's RF humor).

So, when we add up the factors that promote reliable industrial radio design we get:

- Lowest available frequency
- Lowest possible data rate (baud rate or throughput)
- Highest transmit power (1 watt)
- Highly sensitive receiver (lowest decibel number)
- Utilization of error detection and identification system
- Frequency hopping—changing the frequencies to avoid interference

For the shorter range installations in industrial facilities, a common question is, "Is line of sight required for radio links? The answer is often, "No, but . . . ." The reason for the but is that radio waves can travel through a variety of objects with different levels of attenuation.

Radio waves also tend to bounce off surfaces, and this is often how the signal gets to the receiver when there is no line of sight. All of this bouncing and passing through attenuates a signal, and here energy per bit comes into play again in determining how a radio will operate without line of sight.

Multipathing is the enemy of fixed frequency radio propagation, some say. We have all experienced multipathing with automobile radios. You may have noticed it when your perfect radio reception drops to static as you roll to a stop at a red light. If you roll your car ahead a few feet, reception seems to pick up again. This is caused by one radio wave traveling direct from the tower to your car antenna and another radio wave bouncing off a building or mountain and arriving at your car antenna 180 degrees out of phase of the direct signal. This cancels the signal, and you hear only static.

This is a real problem in industrial environments with machinery moving about. FHSS radios overcome this difficulty by changing frequency, so the next transmission on a different wavelength will not arrive 180 degrees out of phase.

This means a FHSS radio can reliably operate in an environment with cranes moving about, machinery operating, and vehicles traveling across a plant.

Behind the byline

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