It's not a Cable, It's an Antenna!

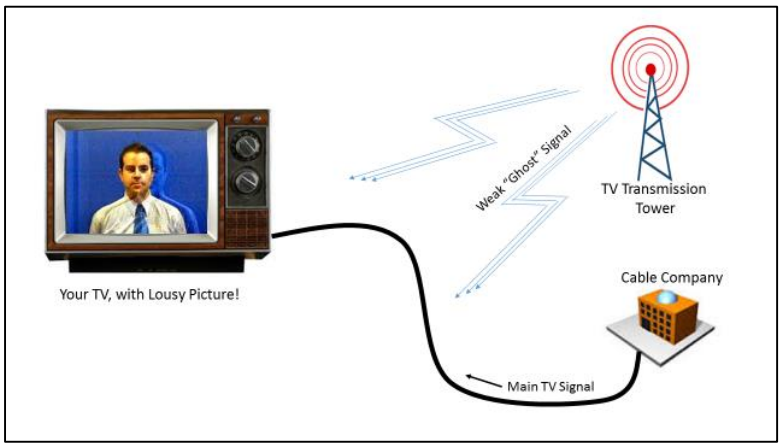
By Keith Blodorn

Why would someone want a cable that acts like an antenna? After all, much research and development has gone into improving cable shields precisely to prevent this! As it turns out, there are several conditions in industrial communication systems where using a radiating cable as an antenna offers major benefits. The most common cases are for communicating to equipment moving along a track, replacing slip rings in rotating equipment, and providing a clear radio frequency (RF) signal where obstructions or plant floor layout prevent a clear "Line-of-Sight" to transmit from a traditional antenna.

What is a Radiating Cable?

A radiating cable is a long, flexible antenna with slots to radiate RF signals that can be installed around corners, along monorail systems and through tunnels to propagate wireless data signals in situations that are tough or impossible for traditional antennas. Since the radiating cable antenna can be mounted within inches of where the signal needs to be received, it isolates the wireless signal from going to other machines that may be on the plant floor. And, the cable comes in multiple lengths to meet the needs of most applications.

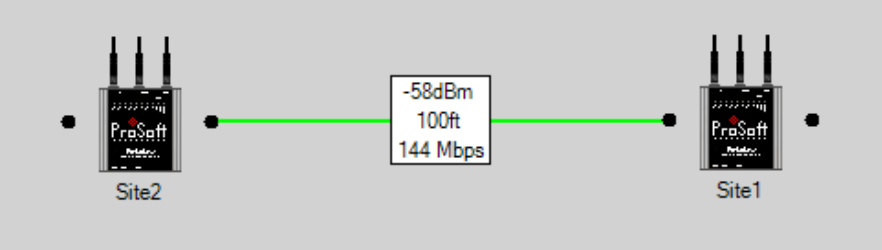
In a typical coaxial cable, a metallic shield wrapped around the cable isolates the signals transmitted on the cable from the electromagnetic waves in the air around the cable. This helps to maintain a strong signal on the cable, and prevents that signal from creating interference with RF equipment nearby. Without the shield, the cable would act like an antenna, transmitting the signal it carries into the air, and receiving radio waves from other RF devices. For those who remember analog cable TV, we experienced this phenomenon when we saw "ghost" images on certain channels. Instead of just receiving the video signal sent from the cable company along the coaxial cable, we were also receiving that channel's over-the-air broadcast of the same video signal as picked up by the coaxial cable working like an antenna. This was an *unintentional* use of radiating cable, and produced undesirable results.



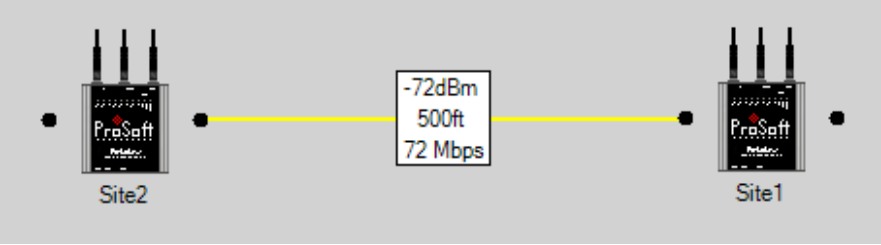
The same principle that gave us blurry television pictures back then is used to make a cable that *intentionally* radiates signals. This is called a radiating cable, or leaky feeder cable. The difference between radiating cable and poorly shielded TV cables is that the shield on a radiating cable is designed with exacting slots that allow for the transmission of signals at a specific frequency. In this way, these cables are tuned to the RF equipment to which they are connected. The cable's shield still works to block unwanted RF, but will allow signals of the correct frequency to emit from, and be received by the cable inside. That makes a radiating cable act just like an antenna.

Overhead Cranes

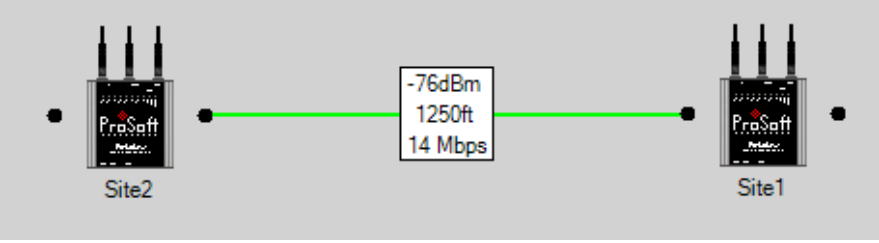
One way radiating cable improves communications is by providing a consistently strong signal along a long track, such as an overhead crane path or an assembly line conveyor. The transmitted RF power from a traditional antenna attenuates over distance. This is called "free space loss" and determines how strong of a signal one radio can detect from another based on the distance between their antennas. For example, consider a connection between two IEEE 802.11 a/b/g/n industrial hotspots using 7dBi MIMO (Multiple In / Multiple Out) antennas. Using the ProSoft Wireless Designer software, we can estimate the signal strength and data throughput for this system at different distances. At 100 feet apart, the data connection can maintain a very fast 144 Mbps data rate.



As the radios move further apart, the data rate that can be sustained at reduced signal strength values declines. At 500 feet apart, this system can move data at 72 Mbps, or half the speed as before.



At 1,250 feet, the data rate falls to 14 Mbps.



As you can see, the transmission speed of the wireless connection is dependent on the strength of the signal, and declines as the distance between the radios increases. In an industrial application, this can lead to poor performance or even lost connections.

Placing RF Signals Precisely in Crowded Plants

Another benefit of using radiating cables comes from the ability to place RF power very precisely. The use of wireless communication equipment in factories is growing rapidly, which means that factory floors are becoming crowded with radio waves on all the common frequencies. For machine builders who need to use wireless, this creates a real problem. With a radiating cable solution, new machines can co-exist within the crowded plant RF space without adding to the cacophony. This is because radiating cable emits RF in one direction, and only needs as much power as it takes to link with another antenna at a relatively fixed distance. While the plant's general wi-fi network is screaming to everyone who will listen, the equipment on the new machine can operate at a whisper.

This benefit is especially important in rotating machinery which traditionally used slip rings to conduct communication signals from I/O on the moving part of the machine to a controller on the fixed part. Slip rings are expensive to install, require regular maintenance, and even still suffer from poor communication speeds due to noise on the rings and in the pick-ups that ride on the rings. Traditional wireless solutions can work, but often the motion of the machine will obstruct the wireless link, requiring higher gain antennas that result in greater RF "noise pollution". Radiating cable is used in these applications to provide a clear, consistent path to the rotating antenna, without interfering with other nearby wireless systems.

Flexibility

Radiating cable also benefits from its inherent flexibility. Since it is a cable, it can follow almost any path to provide wireless signal in places where antennas just can reach. One of the early applications for radiating cable was to enable two-way radio connectivity for emergency workers inside highway and rail tunnels. In the industrial setting, there are many hard-to-reach places, whether those are actual tunnels or "RF tunnels" created by obstructions. An example of that would be a warehouse, where the metal racks and merchandise on those racks can cause obstruction and reflection issues for a traditional antenna. Radiating cable can be installed along the aisle ways to provide strong signal just where it's needed.

Things to Consider for a Successful Radiating Cable Installation

Performance of the wireless connection is of prime concern for industrial applications. To determine the optimum system components, ProSoft Technology tested the performance of radiating cable with RLX2 high-speed industrial hotspots, in several different configurations. In addition to measuring the radio data rate (in Mbps), we also looked at the performance of a typical industrial Ethernet application using Ethernet/IP (EIP), measuring performance in EIP packets per second. This second measure is more important as it indicates the kind of data rates an industrial application is likely to see.

The results of these test cases, as well as the real world applications that ProSoft Technology has deployed, show that radiating cable performance can support high speed industrial data applications. The next challenge is to make sure to choose the right components for the application at hand. There are several criteria to consider:

How much bandwidth is available?

For RF applications in general, it is important to understand what the RF environment in the area looks like. Often, a company's IT department will designate certain wireless 802.11 channels for use in the facility. Having a dedicated channel for industrial applications helps reduce the chance of interference. A spectrum analyzer can show the specific frequency bands that are used in the exact location of the intended radiating cable installation. In some cases, selecting a 2.4GHz or 5GHz system will result in more "clear air" for the application.

Are multiple segments required?

Determine the length of the system to deploy. Depending on the type and speed of communications required, it is important to avoid radiating cable segments that are too long. For higher speed applications, limiting cable segments to 150m will produce good results. One radio can support two segments (as in Test Case 2 above), so applications up to 300m can be deployed with one radio and two cable segments.

How fast will the mobile part move along the radiating cable path?

For a single linear segment, this is not an important consideration. However, in applications where the mobile radio will traverse from one segment to another, or in rotating applications, the cable from the two segments should overlap to ensure consistent coverage. The amount of overlap depends on the speed that the mobile radio is moving, as the mobile radio should be in range of both segments for a period of time to make sure the next segment is picked up.

Will the system need multiple fixed radios?

In cases where the radiating cable path length or number of clients requires more than two segments, the mobile radios will need to "roam" from one fixed station to the next as they move along the path. It is very important in these applications to choose radios with very fast roaming performance. In our tests, we achieved roaming times under 40ms, which allowed the Ethernet/IP connection to stay active with no faults at the PLC.

There are other factors to consider before choosing a radiating cable system, including cable mounting method, termination requirements, and post-installation test plan. The best way to ensure

a complete plan and trouble-free installation is to speak with a company that has experience with radiating cable systems.

Summary

For certain industrial communication challenges, radiating cable offers unique advantages. Radiating cable provides consistent data rates over a long distance, can be shaped to provide signal in difficult to reach environments, and reduces plant RF congestion by constraining its RF signal to the exact area where it's needed. These benefits are especially valuable in applications where machines move along a pre-defined path, where the terrain of a facility is particularly difficult to reach with broad coverage, and where signals on rotating equipment are otherwise transmitted through slip rings. Care must be taken in selecting and installing the components of a radiating cable solution, however with a bit of preparation and advice from an experience industrial RF vendor, a radiating cable system can provide trouble-free communications for your toughest applications.

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