Give Your Machines a Voice

SmartDiagnostics® Application Note

Wireless Communication Best Practices

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KCF Technologies, Inc.

Overview

This application note provides an overview of best practices and practical tips that will help users optimize their wireless network performance and avoid problems that may occur in the field. It also covers the basics of wireless electromagnetic waves and how they propagate within an environment.

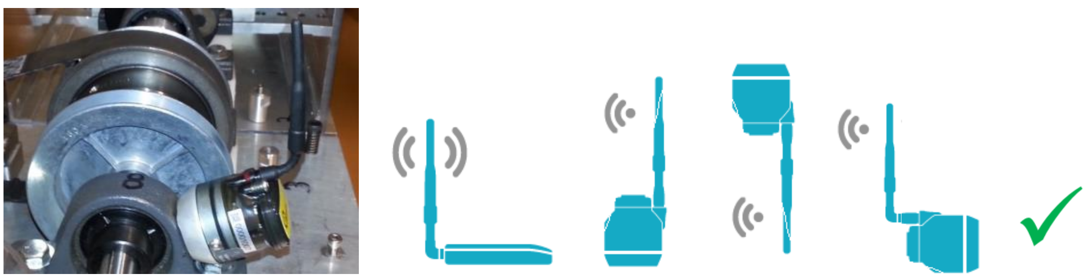
336 S. Fraser Street
State College, PA 16801
www.kcftech.com

Sales and Support
(814) 867-4097
(814) 690-1579 Fax
sales@kcftech.com

Give Your Machines a Voice

Wireless Network Setup Best Practices

- Redundant transmission paths between the sensors and receivers is recommended in most cases. Doing so minimizes the chances of temporary wireless signal loss due to unanticipated conditions in which, for example, a forklift blocks the primary Radio Frequency (RF) path. Redundancy also helps avoid multipath fading (discussed below). Since each PRN (SmartDiagnostics® receivers) at a given Collection Server uses a different frequency, multiple PRNs allows sensors to automatically adapt and communicate on the best frequency channel that minimizes interference from other wireless systems.
- When possible, locate the sensor or PRN so that the antenna is one foot or greater distances from walls or objects. This is generally considered the far field where the RF is less susceptible to issues such as the antenna reflecting energy back into itself, etc.
- Orient the antennas vertically. If this is not possible, at a minimum, orient the sensors and the PRN antennas such that they are all parallel. The antennas are dipoles with a null zone along the center axis of the antenna. The highest signal strength is perpendicular to the antenna center axis.



- Moisture absorbs RF energy and acts to attenuate signals. Damp, moist air environments will reduce signal strength and the PRN should be located away from such locations. Similarly, obstructions such as the human body and dense foliage may reduce communication range in certain cases.
- For outdoor installations, additional margin in PRN coverage area is recommended, especially if operating during periods of precipitation is required.
- A clear, straight line of sight between system antennas is recommended for long range outdoor communications. This is the case because of the absence of reflections from ceilings and walls.
- Generally, mounting the PRN at elevated heights relative to the sensors and obstructions such as machinery maximizes the coverage area of the PRN.

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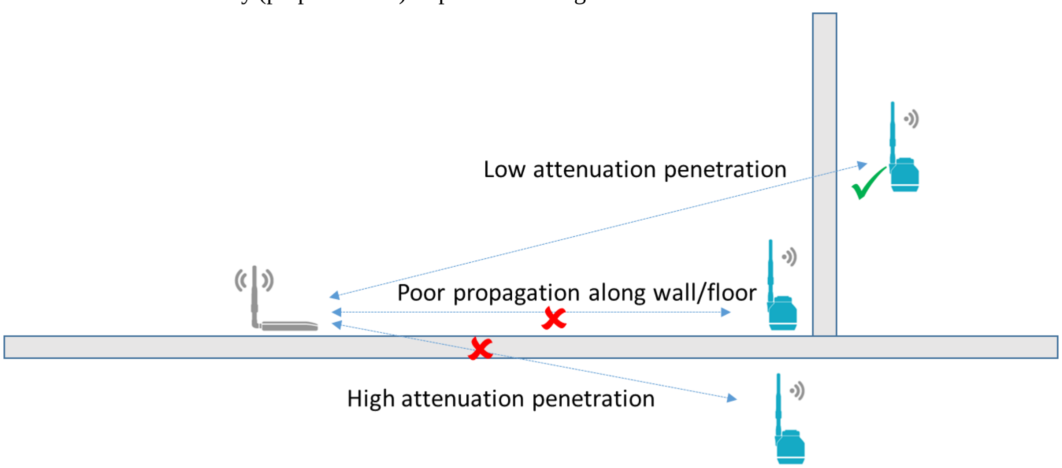
- Objects made of metal, such as metallic separation walls and metal inserted ceilings, wall reinforcements and the metal foil of heat insulations, reflect electromagnetic waves and create a sort of shadowing effect behind the metal object.
- Reflection can enhance the coverage area in certain cases because it enable the coverage area to extend beyond line of sight and in cases where the signal would otherwise be attenuated. For example, RF can follow long metal walled corridors with multiple 90 degree bends.
- Reflection and refraction can cause an RF signal to arrive at a receiver via multiple paths. These different paths take different amounts of time for the signal to arrive at the receiver. Considering that the RF signals are waves, they can add constructively or destructively depending on a particular location in space. This is known as multipath interference. In such situations, using multiple PRNs that are located in different locations, with separations as little as 4" apart, minimizes the chances that both antennas are at a null point in space.
- Walls constructed using metal studs (e.g. the metal studs of a gypsum dry wall) have a small effect on attenuating or reflecting RF waves.
- The angle at which the transmitted signal hits a wall is important. To penetrate a wall, signals should be transmitted as directly (perpendicular) as possible through the wall.



Understanding Electromagnetic Waves

Radio waves are a small subset of the entire electromagnetic spectrum (FM radio, light, X-Ray, etc.). Electrically conductive sources, also known as antennas, propagate these waves outwards from their surface at roughly the speed of light. The amplitude of these waves decrease by the square of the distance from these sources.

The figure below is the ellipsoid radiation pattern created by a dipole antenna. Such antennas are typically on the order of half of the radio frequency wavelength (in the case of the 2.4GHz ISM band this is approximately 2.4"). The particular type of antenna and its environment shape the signal strength and radiation pattern.

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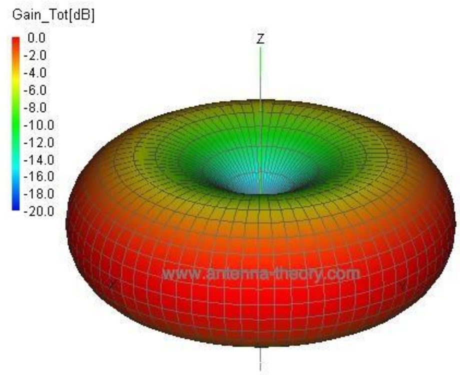
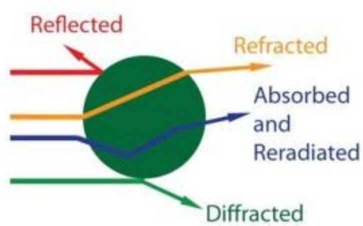


Like all waves, electromagnetic radio waves diffract, reflect, refracts, absorb or any combination of the aforementioned.



At any point in space, these interactions combine, which ultimately translate into good and bad RF communication. The material properties of the incident object determine the particular outcome of the RF interaction. Metallic objects act as reflectors and diffractors (a form of bending energy around a surface edge). They create electrical currents on the metallic surfaces which reflect the energy back towards the source (i.e. this is how an antenna transforms RF into electrical signals). On the other hand, there are insulating materials, also known as dielectrics. These materials allow electric fields to exist within them. This means they will absorb RF energy and, depending on the thickness of the material, will re-transmit (known as refraction) some of the wave out the other side. Of course, part of the wave will also be reflected similar to metal.