Image courtesy PCTEL

Select the Best SCADA Antenna

Know your antenna options to ensure coverage and an effective remote monitoring network.

By Ana Bakas

Utilities, oil and gas companies, water districts and others are looking for cost-effective and efficient ways to remotely monitor and control commodities across their networks. Wireless technology offers benefits for remote management of supervisory control and data acquisition (SCADA) systems, such as reduced installation and implementation costs, enhanced security and improved reliability. Remote management of a network provides versatility as the network is expanded to meet demand. Savings in labor and material is realized because cabling and trenching aren't required. More components and facilities can be added easily within a wireless network.

Network efficiency is also a benefit of wireless technology because monitoring information can instantly be transmitted from hard-to-access remote terminal units (RTUs) to a central location. This allows more frequent and real-time remote monitoring of sites and results in smaller labor force requirements to operate and repair equipment. Enhancing SCADA designs with wireless connections can provide additional energy savings and protection to equipment, avoiding damage to the network that would result in property damages or risk to human safety.

More frequent or real-time readings can translate into faster human response. Careful management and reduction of the flow of hundreds of millions of gallons of contaminated water dumped into lakes and rivers each year because of sewage overflows would be beneficial to human health and to the environment.

A wireless SCADA system for monitoring is only as effective as the antenna technology used in its design. Antenna applications have undergone massive change with the development of digital technologies. Topography to network size to radio frequency (RF) congestion must be considered in the design stage of a wireless network; the antenna technology's efficiency and durability become crucial to reap the benefits of the wireless network.

A typical wireless SCADA water monitoring system uses central computers to monitor levels in water tanks. In this case, the control room is interconnected to valves, switches and other components installed on RTUs at the water tanks. The information is transmitted and received to and from the control room via RF signals. Each segment of the network includes an antenna that receives and transmits information. In a wireless water meter reading application, a water meter, a service vehicle with monitoring equipment and a utility company are interconnected through the wireless network.

Multiple antennas can be used in wireless water flow systems to manage information. The selection of the correct antenna technology to support these systems depends on a number of factors closely tied to the application. This decision is influenced by considerations that must be weighed to achieve the desired network performance.

Selection Factors

It's important to determine the targeted area of coverage, including areas not included for security or other reasons, as well as the distance between the points of propagation, such as a tower, remote location and control center, to the farthest RTU. This will delineate the area covered. Once determined, various RF technologies can support the wireless system and are selected based on factors such as expected use of the grid, data volume to be transmitted and location of the grid.

A site survey covering the topography, vegetation and climatic characteristics of the target area of coverage should be conducted to account for line-of-sight (LOS) and other potential RF interference issues. The resulting site map should plot the points of propagation, the desired RTUs and potential network expansion areas. An RF link budget must be prepared to calculate power requirements at each access point based on the technology chosen. The equipment must be selected to meet these and FCC requirements.

Once the RF technology is selected, the site map will provide direction for the system's designers to select the optimal antenna solution for a SCADA monitoring system. A typical network will include a combination of directional and omnidirectional antennas with varying form factors, gain requirements and mounting configurations. The type of antenna used will depend on the link budget limits, environmental conditions, aesthetic requirements and other special considerations. If properly selected, the antennas should provide the desired signal directivity and

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strength required to meet the objectives of the network architecture.

Many wireless SCADA monitoring systems employ multiple frequency bands. For meter-reading applications, unlicensed spectrum frequencies simplify the meter reading process and make the system more cost effective. Microwave radio and VHF/UHF LMR technologies are also used in wireless SCADA systems. The RF frequencies have different wavelength and data speeds, and these considerations are taken into account during the site survey and equipment selection stage.

Although SCADA networks operating at 900 MHz or VHF/UHF frequencies may be less susceptible to LOS issues, many systems use spread-spectrum 2.4 GHz and 5.8 GHz frequency bands, providing faster data rate transmissions than other frequencies. Antenna selection for these systems is critical because of the technology's inherent LOS limitations. The location of the propagation antenna should be well above tree lines or other structures because they could absorb or reflect radiated signals.

If the path of the radiated signal is clear of obstructions, short low-density links can be established by using a single omnidirectional antenna with enough gain to reach the RTU's antennas. Omnidirectional antennas with too much gain could propagate over RTU antennas, because as gain increases, the shape of the radiated pattern becomes flatter, reducing coverage directly below the antenna. If a high-gain antenna is needed to reach the RTUs, an omnidirectional antenna with an electrical down tilt should be considered.

Antenna Options

Omnidirectional antennas broadcast RF signal in all directions, while directional antennas focus energy in a single direction. Directional yagi antennas, at the point of a propagation site, have reflector and director elements that send or receive RF signals, offering higher gain. Smaller, low-profile omnidirectional antennas are selected for meter reader installation in wireless water monitoring applications. Vandal-proof mounting is recommended in these cases to deter antenna removal.

For example, the San Antonio Water System (SAWS) uses omnidirectional antennas installed on the top of water towers and other tall structures to communicate information to the SAWS headquarters about flow, pressure and possible shortages. Directional yagi antennas have been used to focus signals between meters and data collection points to facilitate meter reading. SAWS uses frequency hopping spread spectrum (FHSS) technology, sending signals over a narrowband fixed frequency before hopping to a different frequency. Reported benefits include improved system reliability.

Also consider RF congestion in the target area of coverage. In urban settings, large numbers of signals traveling in an area can cross each other and cause signal deficiency or co-channel interference. Highly directional antennas with narrow radiated beams are often selected for these applications because the narrow beam is less likely to cross the signal of other nearby antennas. In these cases, vertical or horizontal orientation adaptability is helpful, because the vertical or horizontally polarized antennas can be used to radiate around the signals of neighboring radiators, reducing exposure to co-channel interference.

Evaluate environmental and climate conditions to which the wireless system will be exposed. All the components of a typical wireless water monitoring system should be designed to withstand fluctuations in temperature, humidity and ultra-violet exposure without degradation. Antennas with vented housings that allow water to drain and not condense inside the antenna are usually a good investment because the removal and re-installation cost of a failed antenna caused by water ingress can be significant.

Antennas attached to outdoor meters should be designed to be impervious to water and moisture and should include a good-quality rubber gasket for added protection to the system. For instances when exposure to impact blows, wind loading and severe vibration are present, antennas with housings constructed of rugged materials featuring superior UV stability are recommended. Heavy-duty mounting structures for antennas installed on masts or towers help avoid antenna movement that could affect the stability of the radiated signal. Efficient mounting designs provide added flexibility and reduced failure to the system because of antenna damage.

Other factors that determine the antenna best suited to a specific function include size, aesthetic requirements and vulnerability to theft or vandalism. Compact designs, versatile mounts and consumer-oriented housings are often used to address these issues. ■

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