Innovative Wireless System Monitors
Power Line Lights

Largest wireless system of its kind monitors FAA-required lights on power lines installed in remote mountainous areas.

Summary

- A utility installed a 150-mile power transmission line across rugged mountainous terrain
- FAA regulations required the utility to continuously monitor the lights on the towers
- Some of the towers are virtually inaccessible, and checking manually would have been difficult and expensive
- By designing a system using Phoenix Contact’s wireless Ethernet radios, Sterling Engineering has saved the customer money and time

Customer Profile

The Federal Aviation Administration (FAA) requires Steady Beacon Obstruction Lights to be installed on power lines to warn aircraft of the presence of high voltage power lines. What’s more, FAA regulations require that the operation of those lights be continuously monitored.

A utility in West Virginia built a 150-mile power transmission line that crosses rugged, mountainous terrain, and installed the necessary lights on the tall towers. They were faced with the problem of how to monitor operation of the lights. Some of the towers are virtually inaccessible, Figure 1, so sending a crew out to check the lights manually would have been difficult and expensive.

Challenge

The 500 kV transmission line runs in three corridors through mountains from Southwestern Pennsylvania to West Virginia to Northern Virginia.

The new line is necessary to meet the demand for electricity in the Mid-Atlantic region, and to prevent overloading the grid. The line will forestall electrical problems on the regional grid which might have resulted in blackouts, rolling blackouts and brownouts. The power line has 661 structures and cost nearly $1 billion to build.

The utility chose 500 kV as the operating voltage because all substations along the three transmission corridors contain 500
kV components. However, they used 765 kV line construction techniques to allow for future conversion if dictated by system needs. Upgrading operation to 765 kV at a later date will just entail adding the proper transformers and associated equipment at the substations.

Building the power line wasn’t a challenge, but meeting the FAA requirement to monitor the Steady Beacon Obstruction Lights was. No utility had ever built such an FAA light monitoring system on this scale before, and this system presented particular problems because of the mountainous terrain. The path of the transmission line did not allow for a typical master/multiple repeater topology, so many radios had to serve as repeaters for other radios down the line.

Sterling Engineering, based in Salem, Virginia, is an engineering company specializing in instrumentation, controls and communications for municipal, utility, industrial, military and manufacturing applications. Sterling is an expert in applying wireless and licensed radio communications systems including 900 MHz, VHF and UHF — so it was called upon to solve the tower transmission problem.

In addition to supplying the communication and monitoring equipment for the project, Figure 2, Sterling assisted the owner and contractor in engineering the system, and also provided relevant documentation and drawings. Engineering activities included software path analysis for determining locations for the repeaters.

**Solution**

Several wireless telemetry technologies including satellite, cellular and license-free radio were considered. In the final analysis, license-free radios in the 900MHz band provided the lowest cost of ownership.

Phoenix Contact wireless Ethernet radios are used, and these 900MHz radios have onboard Modbus TCP I/O modules. The I/O modules monitor current delivered to each light, and send outputs to each of two lights on each tower to alternate their operation.

The radios have onboard Modbus registers for Received Signal Strength Indication and voltage to the lights, and these registers are polled by a remote terminal unit (RTU). Variables from these registers are trended for monitoring operation of the overall system.

Nearly 100 radios were installed. There’s a radio on each of the 70 lit structures (towers with FAA lights), and the rest of the radios are used as repeaters. Some radios communicate through as many as seven repeaters, and the system has 15 separate radio networks. Some of those networks are connected to each other via fiber optic ground wire cables run along the transmission line corridors.

The lights on the towers don’t flash. Instead, a pair of lights on each structure alternate operation daily so that each light operates for an equal amount of time over its life. Two RTUs installed at substations send signals to alternate operation of the lights. Each RTU polls its radios for operational data, and sends commands to each lit structure to determine which light of the pair will operate.

If one light on a structure fails, the operations department notifies maintenance that repairs are needed. If both lights on a structure are out of service, the FAA is contacted to issue a “Notice to Airmen.”

RTUs in the substations are connected via redundant serial MODBUS interfaces to the SCADA system in each substation. They use two ports for redundancy.
Local paging systems operating at just over the 928MHz frequency caused interference, so RF notch filters were installed at each radio to limit exposure to the interfering frequencies. Solar power was used at all of the sites, so the radios had to operate reliably at voltages down to 12Vdc. The radios aren’t in air conditioned enclosures, Figure 3, so they are subject to extreme heat and cold and are rated accordingly to operate at temperatures from 0 to 65°C (32 to 149°F).

Phoenix Contact also provided surge arrestors along with the antennas and associated cable systems.

Results

The system was in operation for two months prior to the official opening of the line on July 1, 2011. Since that time, the system has performed as designed, saving the utility money and time by eliminating the need to manually monitor each tower’s lighting system.

Figure 3: Each monitoring station includes a Phoenix Contact radio and Phoenix Bussable I/O modules, all capable of operating at 12 V DC.

Sterling Engineering provided on-site support including radio configuration and testing, system troubleshooting, and programming for RTUs, fiber devices and HMIs. The HMIs are provided by Red Lion and are installed with the two RTUs.