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More Power To You

Video sagometer helps utility companies tap unused capacity from power lines

By Glenn Light, PhD

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National codes require that a safe clearance be kept between transmission lines and other structures or the ground. However, as electric current flows through the lines' metal cables and encounters electrical resistance, the cables themselves heat and expand. Because of that expansion, the spans between towers begin to sag closer to the ground.

Variables such as line tension, weather extremes and anticipated electrical loads are considered in the transmission line design process to ensure that the line, or conductor, can carry enough electricity to satisfy peak demand while still leaving enough ground clearance to comply with codes. Because most transmission lines are not regularly monitored, their design is often conservative in terms of load-induced sag. As a result, lines tend to be built with excess power transmission capacity that is rarely used. Energy industry studies show that transmission lines could carry from 5 percent to 20 percent more power than they do today.

A new device developed by Southwest Research Institute (SwRI), EDM International Inc. and EPRISolutions,with funding from the Electric Power Research Institute (EPRI) and the California Energy Commission , will allow the nation's energy companies to identify the hidden capacity of their transmission lines and significantly increase their power flow. The device, called a video sagometer, is the only technology available that directly measures line "sag" and thus measures available clearance. By relating sag to the volume of power carried by the line, it also provides real-time information regarding the transmission line's unused capacity. By using this product, a utility can provide safe and efficient operation of power lines during peak demand periods. The video sagometer could also change the way transmission lines are designed by reducing some of the conservative design assumptions. When installed on existing power lines, it can reduce or defer the need for construction of new transmission lines by allowing the utility to use the existing lines more efficiently. In addition, other aspects regarding the physical condition of the transmission line, such as ice buildup, can be observed remotely.

Software analyses of video sagometer images are translated into graphic and numeric representations of transmission line clearance that can be monitored in a central control room along with local weather conditions.

Imaging system

The video sagometer's imaging system measures ground clearance by visually monitoring the location of a target attached to the transmission line cable. The system consists of a camera with a power supply, an electronics package containing a data acquisition and analysis system, a communications system and an antenna, and the target on the line. The imaging system is installed either on a transmission line structure or on a structure that offers a view of the span to be monitored. While the image field remains constant, the position of the conductor changes as it moves up and down or horizontally, as in a high wind. The vertical movement, or sag, is directly related to the change in ground clearance. At the time of installation, the location of the conductor or target is calibrated to the measured ground clearance. At any later time, line sag is computed by determining the new location of the conductor using image processing techniques and the above calibration constants. The resulting ground clearance information can be made available in real time using telemetry, or it can be logged for historical study. The image-processing technique used to determine the location of the conductor or the target is a two-dimensional, cross-correlation technique. The algorithm uses a sub-image of the target as the correlation kernel. The kernel is correlated with each acquired image, with the correlation value for each pixel as an indicator of the likelihood that the neighborhood of that pixel is the target. The key to the correlation approach is to have a target with unique features that cannot be found easily in the background.

Maximum power

The video sagometer improves upon existing technology by directly measuring line clearance instead of inferring line clearance from other measurements and the catenary equation, which describes how a wire hangs from two fixed points such as poles. Ground clearance and sag are often the limiting factors, and direct measurement removes any uncertainties associated with the use of the catenary equation and conductor properties. Other major improvements are ease of installation, calibration and operation. Because it is often difficult to take a power line out of service, the ability to install the video sagometer target directly onto an energized conductor makes the system attractive and also less expensive. Another key benefit is the ability to install the device on any span.

The video sagometer is designed to be moved easily to another site if needed. If the critical span is not easily accessible, the video sagometer can be installed on any accessible span in the same ruling span. Video sagometers, once installed, have very low failure rates and need little maintenance.

A remotely monitored video camera (top inset) is mounted on a transmission tower and focused on a target (bottom inset) suspended from a conductor line. Variations in the target's location within the video image correspond to changes in the line's ground clearance.

Conclusion

The video sagometer has been developed to integrate directly with industry's power line software, including EPRI's Dynamic Thermal Circuit Rating and Power Line System's PLS-CADD™ transmission line design software, which has been modified to include a line rating module. Although the video sagometer is primarily concerned with a transmission line's vertical displacement, it also could be used to monitor horizontal displacement and obstacle clearance. This technology also could be applied to monitor personnel or vehicular traffic within a given area.

Knowledge of sag from an initial position, coupled with the known relationship between sag and the temperature of the conductor, also could be used to determine the temperature at which the conductor is operating at any given time. Operating a conductor at a very high temperature for a long duration decreases its life expectancy. Thus, the video sagometer could be used not only to design a transmission line and then operate it more efficiently, but also to track the life expectancy of the conductor.

Comments about this article? Contact Glenn Light at (210) 522-2118 or glenn.light@swri.org.

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