REMOTE
Site & Equipment Management
June/July 2005 Volume 5, Issue 4 a webcom publication

New Role for Infrared in T&D: 24/7 Maintenance/Security Monitoring of Substations

Monitoring unit can combine IR and visual cameras with ultrasound. Signal transmitted wirelessly to LAN/WAN for SCADA system

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Infrared thermography is the stuff of legend in the utility industry. Everyone's heard war stories about serious equipment faults averted by early detection with infrared. It's not uncommon for an IR camera to pay for itself in a matter of days, if not the first use. Making those cameras smaller and more affordable has been the goal of the industry, and a new generation of cameras coming to the market by mid-'05 will set a higher-than-ever standard for performance and lost cost.

While IR is a proven predictive maintenance tool, most utilities still use it only for periodic inspection of substations. A 30-90 day cycle is common. However, a number of forces at work in the industry are changing the role of the IR camera:

1. Loads on aging equipment are as high as ever. Problems are more likely to go from minor to critical in a short time, so 30-90 days between checks may be inadequate.
2. Homeland security implies higher physical security for the grid.
3. Replacement costs and lead times for utility equipment are high. A better understanding of equipment health allows more precise timing of expenditures.
4. Leaner organizations must improve utilization of trained thermographers.
5. Improved development tools, such as Visual Studio, have allowed creation of applications for real-time analysis and communication of IR camera output.

As a result, an imperative has developed for round-the-clock remote monitoring of substations with IR cameras, just as it is becoming feasible and cost-effective to do so. Remote thermal imaging is coming of age in time to answer the utility industry's combined needs for increased substation security against terrorist attack, as well as comprehensive maintenance monitoring for aging hardware installations.

The newest generation of these systems combines visual and IR cameras with airborne ultrasound detection. The infrared and visual images can be blended and transmitted to a PC via wireless intranet/internet, enabling clearer, faster identification and pinpointing of both physical incursions and thermal anomalies at remote sites. Ultrasound detection adds another sensor capability to the system, picking up arcing, tracking and corona that might not be detected with the IR camera.

This type of system is currently being integrated with a proven substation data collection system that includes load monitoring. The visual/thermal patterns correlated with actual operating loads on the hardware provide a new tool for better understanding what constitutes a normal and safe state of the equipment.

This system can also perform presence sensing and intruder detection, while monitoring transformers, regulators, bushings, etc., for temperature excursions. New software allows one IR camera to monitor 32 user-

defined regions of interest in the thermal image, each with its own alarm setpoints. Thus, each camera can simultaneously monitor 32 areas of interest on substation hardware, fence lines, gates, access roads, etc.

The software produces a composite IR/visual image, as well as separate images of each. The resulting composite can be viewed in an infinitely blended percentage of visual/IR, simply by moving a slider bar in the software screen. The visual surveillance capability of the system, enhanced with IR imaging, makes it easy to spot intruders 24/7, without supplementary lighting.

Through a secure Internet connection supervisors can view conditions and alarms at a substation. Long-term trend data is easily developed to allow better-informed decisions on crew dispatching, work priorities, maintenance cycles and timing of equipment replacement, ensuring best utilization of capital and manpower.

The DualVision Ultra 724 camera setup consists of separate thermal imaging and video cameras, plus ultrasound sensor, housed in a single environmentally sealed, temperature-controlled enclosure. The front section holds the cameras and has a slanted IR-transparent window to resist snow/dirt buildup.

Software Enables One Camera to Do the Work of 32

The Thermal Data Acquisition and Analysis software is the heart of the system. It allows 32 regions of interest (ROI's) to be defined on the IR camera's thermal image, in any complex shape. In short, the user defines an area of the IR image, and the system constantly monitors its temperature. The emissivity (key to accurate radiometric imaging) of each ROI can be set separately, and each ROI can have its own high/low alarm setpoints. The software can effect a control output, put an alarm on the screen or send an alarm to a SCADA system.

Ten different shapes are available to define the ROI's, including freehand. And all 32 ROI's are monitored simultaneously by the software, with multiple camera systems being supported by one software installation. An operator can view the output from any one of the systems with the click of a mouse, and the software will automatically jump to any camera with an alarm condition. In addition, the software displays the temperature for any point of interest when the cursor is swept over the image, or it can be directed to do a "peak search," where the cursor will go to the hottest spot in the image.

The software blends the visual and IR camera feeds into a single image with correct aspect ratio and spatial area. By applying an isotherm color pallet to the IR image, hot spots are easily identified while still viewing the scene as a visual image. To the operator, it appears as if a temperature reading is being taken on a visual image.

Temperature values from the ROI's can be output to utility process systems using single-point I/O modules, so a specific ROI channel can have a min/max or average temperature setting, and the 4-2 ma outputs are mapped to this. Thus, each channel is programmable to what the user wants 4 and 20 to equal, and the range in between is fully linearized.

For utilities running PLCs or ACS systems, the camera can be configured to interface with a PLC, rather than I/O modules. The technology is not restricted to using a field point system to interface the software with the plant.

Currently, the software can record up to 75 minutes of blended visual and IR video to a hard drive when capturing every frame from a camera set at a frame rate of 30 Hz. Total record time can be greatly extended by capturing images at intervals, rather than continuously. Video capture can be triggered by a temperature alarm from one of the ROI's or by direct input from the PC.

Reprinted from the June/July 2005 issue of Remote Site & Equipment Management Magazine

A user-selectable prebuffer of video allows the operator to also capture what happened in a scene before an event trigger.

Inexpensive Camera Technology Makes it Possible

The camera setup consists of separate thermal imaging and video cameras housed in a single environmentally sealed, temperature-controlled enclosure. Ultrasound detection can be added to the housing as an option. The ultrasonic sensor and both cameras have Internet IP addresses and offer password protection, allowing control from any computer using wired or wireless Ethernet.

The visual camera can be color or b/w. Cameras can be fixed focus or have auto iris and remote focus. The standard IR camera uses state-of-the-art uncooled UFPA microbolometer technology, providing measurement accuracy of ±2% or 2°C. It can be set manually or automatically for three different temperature ranges. Two image update rates (30Hz/60Hz) are selectable. Standard field of view is 28.9°(H) x 21.9°(V), with autofocus from 30 cm to infinity. Telephoto and wide angle lenses are available.

The housing has a hinged back section containing all the interface connections, including RJ45 Ethernet, RS170 video, connection for a high-resolution LCD, and a power termination strip. The front section holds the cameras and has a slanted IR-transparent window to resist snow/dirt buildup. Cameras are supported on an internal shelf, with space underneath for power supplies, wiring, etc. A remote-controlled pan-and-tilt head is also available.

In addition to substations, this system is ideal for telecom/broadcast facilities, coal piles, hydrocarbon processing plants and similar facilities. Cost depends on configuration. The level of technology, too, should be integrated by a single-source provider on a turnkey basis to limit the variables involved

In developing any remote monitoring system, keep in mind the need for secure communications. A SCADA system is a fantastic tool, but when remote communication devices are involved, it's important to know the vulnerabilities and address them with proper security technologies.

Jon Chynoweth has been involved in the development and marketing of thermal imaging cameras and related software for 20 years. He has been instrumental in development of smaller, higher-resolution thermal cameras, as well as technology advances for safer inspections of high-voltage electrical panels, remote substation monitoring for utilities, and critical vessel monitoring in the petrochemical industry. Starting out in sales of thermal cameras, he ultimately began developing imaging software needed for process control and utility applications, leading to a stint at Raytheon as manager of sales and marketing for uncooled cameras in North America. He later formed his own business - ultimately acquired by Mikron Infrared - to develop thermal cameras and software.

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