

The Power of Optics

IMPROVING SUBSTATION MEASUREMENTS // BY SALVATORE SALAMONE

AS POWER DEMANDS GROW, THERE ARE inevitable strains on the grid, transmission and delivery systems.

These strains drive up the need for more frequent and better measurements of the state of equipment deployed at distribution points and in substations. Additionally, utilities want more frequent measurements than were taken in the past, whether the measurements were possible or not with the then-current technology. At the same time, many providers are initiating intelligent-network or smart-grid strategies to improve reliability, reduce costs, and use facilities and resources more efficiently.

Reliable current metering in electric power substations is needed to satisfy these requirements and maintain the integrity of high-voltage networks. In particular, the metering is needed in high-voltage substations. In such facilities, it is critical to have accurate and frequent data on the actual current being transmitted both for protection and control of generators and substation capacitor banks.

Traditionally, the way to make measurements is to use large and costly oil- or gas-filled transformers to step down high currents and voltages to measurable levels. Such transformers are expensive to install. Also, they frequently overheat, and their weight often must be factored into structural design considerations.

Additionally, these devices make use of copper or coaxial cables. This makes them susceptible to electromagnetic interference, ground loops and lightning damage – all of which are quite common in substations. The potential for the failure of instruments used by a utility to monitor its equipment to increase reliability works counter to the reliability goal. To address these issues, there has been a slow, but growing interest, in electrically isolated measurement devices.

Fiber the key

Many communications systems suffer similar electrical interference problems. Frequently, the solution selected with these systems is to replace copper or coaxial cabling with optical fibers.

A similar approach is being eyed for the current metering gear in substations – but with a twist. In communications systems, only data needs to be sent over the cable. In the current measurement applications, power must also be carried. The way this is accom-

plished is to use devices that incorporate special photovoltaic cells made of gallium arsenide, indium phosphide, or indium gallium arsenide that provide a way to carry electricity over fiber.

The devices, called optically powered current transducers, provide a novel way to deliver power to remote sensors and monitoring devices using fiber-optic cable instead of copper wiring. These devices operate in two directions. They send an optically powered signal to a sensor at the transducer, where a laser returns a data signal with the current measurement back over the same fiber.

Optically powered current transducers are being used to measure currents in high-voltage installations such as those found in substations. They let utilities measure high currents by placing a transducer directly on the line. The transducer eliminates the need to use transformers to overcome voltage differences because the power-over-fiber system converts electricity directly to light. As noted, the transformers are large and often heat up. This is the reason oil and gas are used as insulators to prevent equipment temperatures from rising to high and dangerous levels.

The use of power over fiber has “enabled much more lightweight and agile measurement systems,” said Jan-Gustav Werthen, head of the Photonic Power Business Unit at JDSU.

Industry experts believe optically powered current transducers will be able to increase the accuracy of measurements by virtue of being digital versus traditional analog. They are also expected to be more reliable since they are rugged and designed to withstand harsh conditions.

The work in this area goes back many years. But competition in this market has been limited for one reason: The photovoltaic chips used in these systems are hard to make. Cells comprised of gallium arsenide, indium phosphide or indium gallium arsenide materials are more costly and harder to produce than cells based on silicon. Production yields are typically lower, making the price per cell even higher.

Use of these devices in the electric utility industry may be helped by growing interest in the product from other markets. The market research firm IDC estimates that power-over-fiber revenue today is about \$15 million. But as development scales up, IDC estimates the total market could quickly grow to hundreds of millions of dollars.