OPTICAL TECHNOLOGY: A NEW GENERATION OF INSTRUMENT TRANSFORMER

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In recent years, electric utilities have been evaluating optical sensors to measure current and voltage. These devices are proving their value, especially in applications where accurate measurement over wider dynamic range, ability to retrofit, and improved safety are of main concern. They are well suited for the advanced functionality of leading-edge protective relays and meters and for compatibility with digital communications in modern substations.

The NxtPhase NXVCT optical voltage and current sensor, for example, combines voltage and current sensing (protection and metering) in a single instrument for each of several voltage classes over the range from 115kV to 765kV.

Primary advantages of this optical technology over conventional inductive and capacitive measurement transformers include:

- High accuracy (exceeds IEC Class 0.2 and IEEE Class 0.3 accuracy requirements)
- Wide dynamic range
- High bandwidth
- Reduced size and weight
- Safe and environmentally friendly (avoids oil or SF_6)
- Low maintenance

SUBSTATION INSTALLATIONS

In May 2000, BC Hydro installed a 230kV NXVCT optical voltage and current sensor at the Ingledow substation located in Surrey, BC. BC Hydro has used this installation to monitor and verify the performance of the sensors continuously over changing temperatures and other environmental conditions. Extensive metering and data acquisition have allowed engineers at BC Hydro to track performance in real time and perform long-term trending analysis.

In October 2001, Hydro Québec installed a three-phase 138kV optical voltage and current sensor system at the Rolls Royce gas-turbine generating station on the Island of Montreal. More recently, Arizona Public Service installed a 230kV system, and BC Hydro installed both a second 230kV system and a 500kV system. Also, Northern California Power Authority is installing a three-phase system (current sensing only).

These current sensors utilize the Faraday effect: current flowing through a conductor induces a magnetic field that affects the propagation of light traveling through an optical fibre encircling the conductor. The magnetic field produced by the current changes the velocity of the circularly polarized light waves in the sensing fibre. By measuring change in light velocity in an interferometric scheme and processing the information, an extremely accurate measurement of current is obtained.

VOLTAGE SENSING TECHNOLOGY

Voltage sensing technology at these installations combine the typical benefits of optical sensing technology with some additional benefits: the technology does not use SF_6 or oil-paper insulation, making it more environmentally friendly and much safer to use. The NXVT uses multiple miniature electric field sensors to measure the electric field at several points and dynamically combine the results (based on patented techniques) to give a very accurate measure of the voltage difference across the terminals.

	Current	Voltage
Digital Metering or Relaying	Defined by IEC 61850-9-1	Defined by IEC 61850-9-1
Low Energy Analog Metering or Relaying	200 mV for protection 4 V for metering Burden: 2k Ohm, 2nF	4 V for protection & 4 V for metering Burden: 2k Ohm, 2nF
High Energy Analog Metering	1 A Burden: 2.5 VA	120 V / 69.3 V Burden: 2.5 VA

Figure 1: Typical Interfaces Available On Optical CTs and VTs

PROTECTION APPLICATIONS

During fault conditions a well-known phenomenon called "saturation" occurs in conventional CTs; the iron core in a transformer "saturates" when high fault currents induce a large magnetic field. In effect, the transformer can no longer accurately represent the primary current in the current transformer secondary. Utilities must therefore select oversized CT ratios in order to avoid false relay operation (Figure 1 shows an example of a CT with a saturated output plotted against actual current).

An optical CT does not face the same saturation challenges. It uses light travelling through glass (an optical fibre in the case of the NXCT) to measure the magnetic field around a current-carrying conductor, which gives a measure of the current flowing in the conductor. If configured correctly, the optical voltage and current sensor has the ability to measure fault currents exceeding 400 kA_{peak}. Additionally, using advanced techniques, both AC and DC currents can be measured accurately throughout this range.

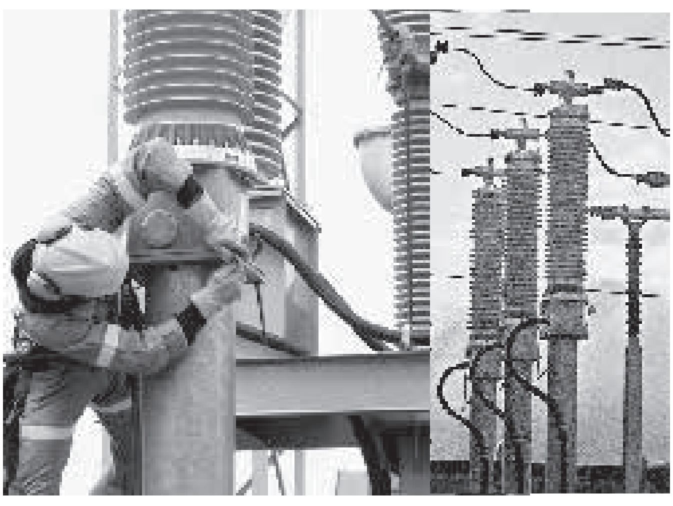
INTERFACING WITH OPTICAL SENSORS

Instrument transformers interface to IEDs, revenue meters and relays in three formats: high-energy analog, low energy analog and digital. For protection applications, it is not cost effective to amplify a signal for 5A output. In order to meet standards, a very large and expensive amplifier is required for fault currents ranging up to 40pu. Low energy signals, more suitable for relaying applications, are available from each sensor in several formats, each tailored to its specific sensor and end use. Signal processing inside the current and voltage electronics is inherently digital in nature and is accessible in a format consistent with IEC standard 61850-9-1 (and 60044-8).

These standards define the format of digital data from the sensor electronics merging unit. Those who specify conventional current transformers use IEC and IEEE standards to assist in the writing of a specification.

FINANCIAL CONSIDERATIONS

Fibre-optic based current and voltage sensors are an increasingly vital part of measurement and control systems throughout North America. Any utility's decision to adopt optical technology should entail a step back to examine an overall business case. Since capital cost is actually a fraction of the overall cost of substation equipment, cost comparisons must also consider: substation costs; installation costs; maintenance costs; explosion mitigation costs; safety costs; environmental costs; and operating returns.



Installation of NXVCT Optical Voltage and Current Sensors At Hydro-QuébecRolls Royce Gas-turbine Generating Station On The Island of Montreal

CONCLUSION

Our industry is changing and innovation from a range of fields will influence its future. We will benefit from technical advances in fibre optics, electronic design, power engineering and software design.

Optical sensor technology could truly revolutionize the transmission and distribution industry. With an inherently digital signal, optical sensors can be utilized in ways that are not possible with conventional analog signals. Imagine an all-encompassing digital substation with digital communication between voltage and current sensors, relays, meters, controls, SCADA functions, breakers and switches. Design, maintenance, testing and commissioning within a substation could be streamlined considerably.

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He has served as project manager, marketing manager, and general manager on various power systems, protection and control, and automation systems projects.

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