Digital optics put control and protection systems in the picture

By P-A Monfils, Alstom

Current and voltage transducers are a critical component of Alstom Grid's 800 kV HVDC project. Their open-ended optical technology has taken measurement to new levels of accuracy up to higher frequency ranges.

There is growing interest worldwide in High Voltage Direct Current (HVDC) electric power transmission. The main reasons are lower losses than in ac transmission (they are unaffected by eddy current) and the fact that most renewable power resources – eg hydroelectric, wind power and solar – lie far from energy end-users. HVDC networks are also more cost-effective because they can transport a large amount of electrical power over long distances without intermediate sub-stations. Additional factors driving the use of HVDC are the rise in bulk electricity trading and the flexible coupling of networks to control load flows and reduce network failures. Central to all these factors is measurement – to optimise the control of thyristors in converter stations, to improve efficiency, to monitor the energy flow and quality, and to improve EMC perturbations and prove compliance with environmental emission regulations. On the economical front, measurement ensures fair trade between grid operators.

Measurement is a focal point in Alstom Grid's 800 kV HVDC project. The company is looking to differentiate itself by optimising the performance and size of the system's transducers for control and measurement. It is one of the most challenging tasks in developing HVDC systems. The technology behind the transducers is optical sensors: The current transducer looks like a set of rings hanging from the voltage busbar. Alternatively it can be installed as a self-supporting device between the busbar and the ground. It responds at temperatures between 60°C and - 40°C with a scale factor error of less than 0,1%, and boasts a frequency bandwidth from dc to 5 kHz. Other technologies, though powerful, had inherent limitations. Voltage insulation restricts the use of zero flux sensors to 500 kV, while resistance shunt technology does not measure harmonics accurately enough. The optical current transducer has emerged as the right solution: Simple, rugged, and very, very accurate.

Enlightening measures

The optical current transducer that Alstom's team has developed uses a Faraday optical sensor mounted on the primary conductor. In this way it forms an optical circuit round the conductor carrying the measured current. A beam of light produces a polarised optical wave that enters the ring. The properties of glass are such that it produces a Faraday Effect shifting the polarisation angle according to the current under measurement. Optical signals are processed by the digital primary converter to current signals and transmitted digitally through the optical fibre links to the merging unit. This device merges the digital signals from different current transducers for transmission to the controller and protection system. The controller, according to the measured data, makes decisions and drives the thyristor valves to respect the power flow setpoint. It might also transmit messages to other peer IEDs and systems, like the protection system, for them to take action, both on the ac and dc fields. The transducers supply measurements that enable monitoring of a wide range of critical conditions, such as overvoltage, dc current imbalance, thermal overload, unexpected breaker movement.

Among the advantages of the optical sensor are its very wide frequency band – up to 5 kHz – and simple optical fibre data links that make it slimmer and shorter than conventional transducers. Moreover, it is unaffected by electromagnetic radiation and perturbations. The signal transmission link uses no insulating fluid, which rules out

leakage and explosions. The digital transmission of the measured data complies with IEC standard 61850-9-2 [1], an Ethernet-based protocol that allows devices in a substation to communicate with each other. The result? It can be used as part of an open and versatile communications network for substation automation. One such example is within Chinese operators. These operators would never purchase a complete control system, but with its open-ended electronics, this transducer could fit and interface with their systems.

Testing times

A prime function of tranducers is to transmit voltage insulation readings to the controller. To ensure that the information is transmitted safely, transducers have to demonstrate their own dielectric strength – ie that their insulation can withstand the highest operating voltage without breakdown. To that end, they undergo a range of demanding withstand tests to ensure their dielectric strength meets requirements. An important dielectric test parameter is rated insulation voltage, which must always be higher that the operating voltage, including any kind of overvoltage. The author's company has successfully conducted withstand tests its high voltage test laboratory in Graz, Austria, including lightning impulse and dc wet withstand tests, both ac and dc withstand tests with partial discharge measurement, as well as dc polarity reversal tests and radio interference voltage tests on ac and dc equipment.

Glasses that go beyond specs

This optical current transducer has met fundamental dc accuracy and measurement range specifications. Accurate ripple measurement is challenging because it requires a very wide frequency bandwidth. The optical current sensor can measure accurately up to 5 kHz compared to the 50 Hz range of the classic transducer. Ripple measurement is critical because it tells the controller how thyristors are operating. The 12-pulse thyristors in the 800 kV HVDC system are designed to reduce harmonics, which can lead to overheating, resonance problems, interference with ICT resources, and even affect control systems. This transducer's ripple measurement gives the control system a high-precision image of the thyristors. It can then fine-tune them or change control mode accordingly. The overall purpose of the optical current transducer is to provide the controller with a perfect digital image of the current's measured value.

Conclusion

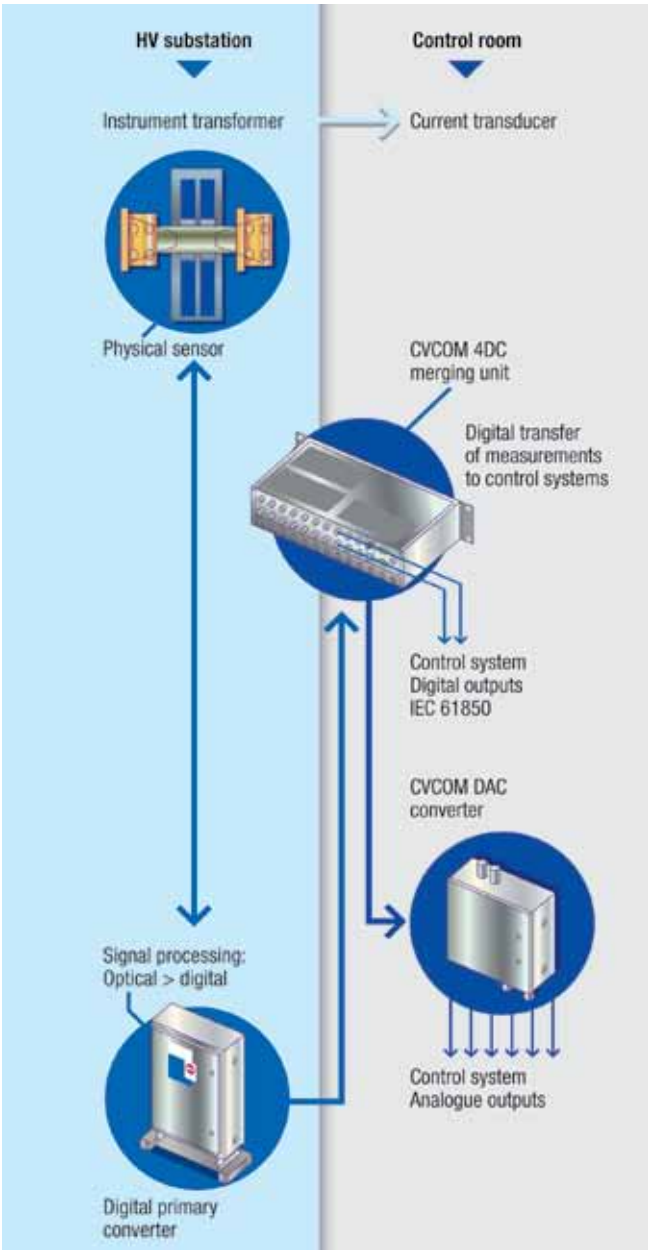
The company has achieved a very high-precision accuracy of 0,1% of rated current up to 4,500 A which is the normal current value in China. It even goes on measuring fault currents of up to 30,000 A in the event of short-circuit or thyristor fault.

Reference

[1] IEC 61850-9-2 Ed. 2.0 b:2011 Communication networks and systems for power utility automation - Part 9-2: Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3.

EMC - Electromagnetic Compatibility
HVDC – High Voltage Direct Current
IED – Intelligent Electronic Device

Abbreviations



Current Transducer functions.

Pierre-André Monfils has more than 30 years' experience in research and development in the field of electricity transmission and distribution. He is currently strategic R&D projects director within the R&D function at Alstom Grid, an active member of the French Technical Committee 'CEI – TC 38' and president of the Belgian sister association 'Comité 38'. Pierre-André holds a degree in electrical engineering.
Enquiries: Email pierre-andre.monfils@alstom.com.

About the author