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Measuring partial discharge in GIS

Adopting new opportunities 06/06/2012 - 4.27 pm

 ASSET MANAGEMENT  DIT  GIS

As customers increasingly push to adopt condition-based maintenance for Gas-Insulated Substations (GIS), new opportunities are arising for periodic or permanent measurement of partial discharge.



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Traditionally, high voltage substations are air insulated. But the clearances required between phases and between phases and earth are huge. This results in rather large installations, making them difficult to house in urban environments where space is at a premium. To overcome this constraint, a parallel technology was developed, the Gas-Insulated Substation (GIS), using a gas, for example sulphur hexafluoride (SF_6), at high pressure. SF_6 has excellent dielectric properties and is used as the insulating medium between the phases and between the phases and earth. As a consequence, a GIS is much more compact. In fact, gas-insulated substations can be down to one-tenth the size of their air-insulated cousins, depending on the voltage level.

The use of gas insulation in the power system network has developed rapidly thanks to its compact nature, low maintenance requirement and reliable operation. But the reliability of the GIS equipment can be undermined by the presence of free particles that originate mainly from the mechanical vibrations, from moving parts in the system such as breakers or disconnectors, or even from the manufacturing process.

According to David Gautschi, Alstom Grid electrical engineer, "they are rare, but can locally generate high electric fields exceeding the structure's

design limits and initiate partial discharges (PD) forming free electrons and ions in the insulation. Repeated partial discharges are capable of triggering a progressive carbonisation of spacers that can slowly build up over years until they produce a flashover, or failure of the switchgear insulation structure resulting in the entire installation, or parts of it, being shut down.” Repairs – often involving the manufacture of specific parts – can take several weeks to complete.

1 __ Measuring partial discharges



When partial discharges occur (resulting in voltage drops of less than a nanosecond), they generate electromagnetic waves that propagate through the switchgear. These waves can be measured by means of different technologies operating in a variety of frequency ranges. Detecting partial discharges in lower frequency ranges can be carried out by taking measurements with acoustic sensors. Says Gautschi, "In the medium frequency range, between a few kHz and a few MHz, measurements are usually made by means of a coupling capacitor. The disadvantage of using this device is that it is large and not suitable for online monitoring. However, partial discharges in pressurised gas can be measured in the Ultra High Frequency (UHF) range between 100 MHz and 2 GHz. The added advantage here is that this allows the whole substation to be permanently monitored and the location of PD activity can also be pinpointed." Demand for this level of monitoring is particularly high in the Middle East, though less pronounced in Europe, where utilities are more hesitant to make the additional outlay required.

2 __ UHF range measurements

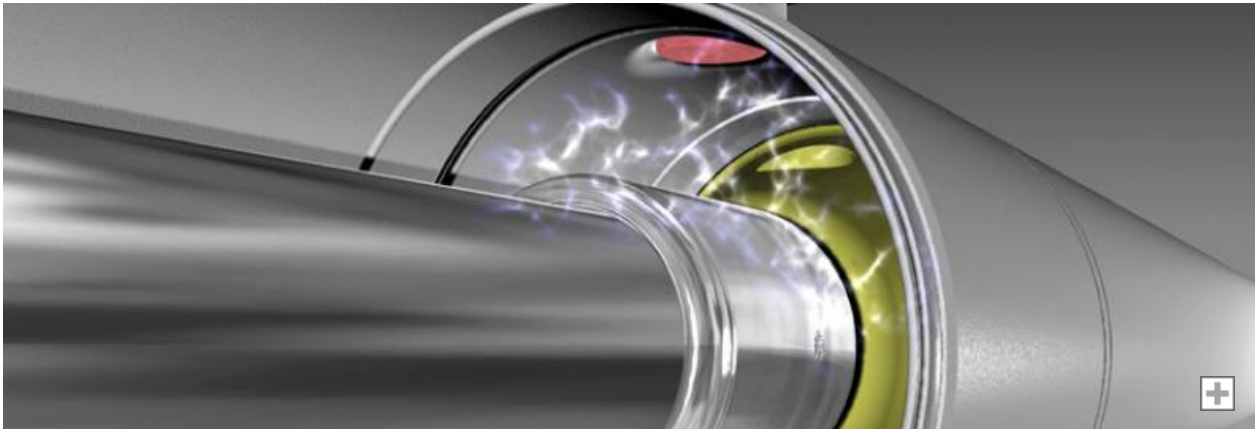


Different types of equipment are available to carry out measurements in the UHF range. Alstom Grid has developed its own solution, called PDwatch. The centre of competence for the PDwatch product is located in the BHT unit in Aix-les-Bains, France. The PDwatch system can be used either for periodic measurement (PDwatch portable) or for permanent (online) condition monitoring. The second method has the obvious advantage of tracking all partial discharge activity over time and therefore offering a better basis on which to decide when maintenance is required rather than relying only on spot checks using a portable system. “The benefit of measurements in the UHF range is the effective avoidance of external noise,” explains Jean-François Penning, PDwatch project manager.

« The PDwatch Portable offers frequency spectrum and time analysis. »

The frequency range can be chosen to measure in a band with low external noise. The suppression of external noises, for example in the GSM mobile phone range, can be achieved in the following way: the measurements made by the sensors fitted in the GIS are compared with the results of those installed in other compartments or those of an additional external antenna. This method avoids using additional band stop filters on the input ports, as generally required by standard wide band monitoring systems. It also maintains a good signal level. Once the partial discharge activity has been measured, the next task – and the more complicated one – is to interpret the partial discharge patterns and classify them into degrees of severity.

“Part of the complexity is that partial discharge patterns will vary according to the switchgear design,” notes Gautschi. “So it is essential to have access to the manufacturer's database to make sure that partial discharge information will be accurately interpreted. Alstom Grid is going to make its databases available to customers.”



3 __ PDwatch online partial discharge monitoring



The PDwatch Online UHF monitoring system records and displays the UHF signals generated by partial discharges in a gas insulated substation. It is permanently fitted into the substation and can be interrogated remotely at any time. This makes it possible to detect and eliminate emerging dielectric faults before a flashover can occur. Used with suitable sensors, this system can detect critical defects such as particles, coronas, free potentials and insulator voids. It can also be programmed to generate alarms at specified

absolute value and time thresholds. “The latest system is very advanced,” points out Gautschi, “and uses fast algorithms to provide very high accuracy.”

4 __ PDwatch portable UHF detector



PDwatch Portable is designed to measure campaigns in substations at the commissioning stage or periodically in the course of the substation's life. It is a two-in-one device, offering frequency spectrum analysis and time analysis. By using this equipment at regular intervals, developing dielectric faults can also be detected and eliminated before complete breakdown occurs. The portable UHF detector and its laptop PC are fitted into a travelling case and supplied with all necessary cables and accessories.



5 __ PDwatch Manager



This software tool enables event records to be managed while at the same time facilitating defect recognition. It can be used locally on the central unit's human machine interface (HMI) PC or run from a remote PC via the Internet. It includes a constantly

updated library of partial discharges that helps to identify PD patterns. It has the added advantage of saving users a considerable amount of time by generating test reports automatically.

Sensors for measuring partial discharge activity

Different types of sensor can be used to measure partial discharges in a gas-insulated substation. Alstom Grid's latest design uses a conical antenna with a small footprint. Its sensitivity has been tested under laboratory conditions in different calibration cells as well as after having been installed in the switchgear. It offers an extremely high degree of accuracy and high linearity. Furthermore, the cost of the device has been dramatically reduced and its small footprint now allows it to be retrofitted to older substations. Its output has an integrated low frequency cut-off so that no power frequency voltage is visible on the sensor connector. The output can also be adapted to meet customer needs, and it can, for example, be used as a conventional voltage detector to detect whether a particular phase is energised or not.

The new sensor has been fitted in all types of Alstom Grid gas-insulated substation and tested for use in retrofit projects. These latest developments have resulted in an adapted version of the sensor being used in large power transformers to monitor partial discharges in oil. This version has been installed in 800 MVA transformer poles of the Swiss utility Alpiq. The transformers have been in service since 2011.

During the development of the sensor, the existing calibration methods for GIS sensors were tested, and a new high performance calibration cell has been developed to carry out tests when no bays are available to carry out this procedure in situ.

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David Gautschi

Grid Solutions electrical engineer



Jean-François Penning

PDwatch project manager



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