Partial Discharge Monitor for GIS

The Partial Discharge Monitor

DMS introduced the world's first on-line Partial Discharge Monitor (PDM) in 1993, and they are now installed world-wide in more than 45 GIS at voltages of 230-800kV. In service they have proved to be sensitive and reliable, and on numerous occasions have detected potentially dangerous defects in GIS before failure could occur. Increasingly the PDM is also being used as an integral part of the 1 min overpotential test on new GIS, where it enables defects to be found as the voltage is raised to the test level.

A 400kV GIS in the UK

The cost benefits of using PDM

The dramatic reduction in failure rates when using PDM is seen by comparing the in-service failure statistics of GIS in the years 1967-1992 [ref: Electra, no 176, Feb 1998] with the DMS service records of GIS fitted with PDM in the years 1996-2004. In the latter, 'failures prevented' refers to GIS which were opened, and the defect removed before failure could occur. It includes defects found during the HV commissioning tests on a new GIS, and in the plant associated with it.

An in-service breakdown in a GIS typically takes more than a week to repair, and the costs of this, the consequent circuit disruption and loss of supply in a single outage far outweigh the initial cost of the PDM.

<table>
<thead>
<tr>
<th>Years</th>
<th>PDM installed</th>
<th>No. of failures in service</th>
<th>No. of failures prevented</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967 – 1992</td>
<td>No</td>
<td>165</td>
<td>0</td>
</tr>
<tr>
<td>1996 – 2004</td>
<td>Yes</td>
<td>2</td>
<td>138</td>
</tr>
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Statistics showing the reduction of failures achieved by using a PDM system
**PDM installation**

The PDM is an on-line and permanently installed UHF monitoring system, which continuously collects and stores data from all couplers in the GIS. The partial discharge signals are picked up by UHF couplers on all 3 phases, spaced at approximately 20m intervals along the chambers, and passed by coaxial cables to the Optical Converter Units. These are mounted near ground level, and their stainless steel enclosures with silicone rubber door seals make them equally suitable for indoor or outdoor use, even in the most severe conditions. The electronic circuits are totally protected against transient overvoltages arising from switching and disconnector operations.

Each OCU takes the UHF signals from a 3-phase set of couplers, and applies filtering to reject interference from broadcast signals or discharges in air-insulated equipment. The amplitude of the UHF pulse is then digitised, and transmitted by a radial optical fibre to the equipment cubicle in the control room. Additional radial fibres in the cable are used to control the OCU, and initiate the integrated self-test procedure that automatically checks and logs the condition of each channel at pre-set intervals.

At the control room, the PD signals are further conditioned and transferred over a communications link to the PC, giving an almost real-time display of the PD activity.

**UHF Couplers**

In new GIS the couplers are usually fitted on the inside of the hatch cover plates (internal couplers). Since an internal coupler picks up high transient overvoltages when disconnectors or circuit breakers operate, it needs to be fitted externally with a DMS protector, as shown. This removes the overvoltages, which would otherwise damage the sensitive electronics of the PDM.

Alternatively, external couplers can often be used. These are fitted over either windows or the exposed edges of insulating barriers, and can have a sensitivity as high as internal couplers. External couplers can be mounted without degassing the chambers, and are the first choice when a PDM is retrofitted to an existing GIS.

For optimum sensitivity, the frequency response of the couplers needs to match the UHF characteristics of the GIS and the ports where they are fitted. DMS designs internal & external couplers for particular applications, and calibrates them to ensure they meet the user’s specification of sensitivity & bandwidth.
**In-service operation**

The PDM system operates simultaneously in different modes, and will capture isolated PD events even while displaying the current on-line data. The latter is usually shown in point-on-wave (2D) format when recording intermittent or developing signals, and in single-cycle (3D) format when the defect is being identified.

Having condensed the PD data from all the nodes, it is stored on a hard drive for a year so that it may be accessed rapidly. In addition all new data is archived each day, to form a permanent record. The display, control and setting functions may also be carried out via a communications link from a remote terminal, normally at the utility’s headquarters.

**Data Interpretation**

All single-cycle data is automatically classified by a range of analytical and statistical techniques, such as multiple neural networks and distance classification. A system of redundancy then assesses the analytical results, and gives the probability that a particular type of defect is present. In addition, trend analysis searches for any regular changes in the levels of the parameters defining the PD activity, and alerts the operator should the defect develop towards breakdown.

Of course, many engineers will in addition want to look at the data and make their own judgement on the condition of the GIS. This is readily done using the point-on-wave and single-cycle displays that give an instant impression of the PD characteristics.

**HV commissioning test**

CIGRE has recommended a new HV commissioning test procedure for GIS, based on the use of diagnostics. Its main requirement is that the GIS should be discharge free at 80% of the recommended 1 min test voltage, with the measurements being made at a sensitivity of 5pC apparent charge. When used with UHF couplers meeting the required levels of sensitivity and bandwidth, the PDM-R system completely satisfies the CIGRE requirements. DMS also verifies the measurement sensitivity in a particular GIS, following the procedure recommended by CIGRE.

**Customer support**

The experience of the many utilities using DMS on-line condition monitoring systems is that the number of enforced outages is drastically reduced; condition-based maintenance techniques can be introduced; and the justification for reliable plant life extension provided. While other utilities see these as convincing reasons for installing condition monitoring, they see further benefits in DMS operating the PDM systems and reporting the condition of the GIS.

DMS also provides additional services on site as required. For example, we can locate a defect accurately by the time of flight method; or survey a GIS using a portable monitor and report on its condition - in fact our extensive experience is there for you to use.
### Partial Discharge Monitor, Model PDM-R.02

**Optical Convertor Unit**
- supply voltage: 110V, 50/60Hz
- supply current: 100mA
- ambient temp: -25°C to + 55°C
- humidity: 100% condensing
- input channels: 3
- dynamic range: -80 to -15dBm
- characteristic: logarithmic
- bandwidth: 100-1500MHz (without filters)

**Equipment cabinet**
- Radial base unit
  - max number of channels: 480
  - automatic self test with logging

**Power Control Unit**
- PC watchdog
- GIS switch signal interface
- VT interface for system synchronisation to busbar voltage
- alarm indicators and interface

**Local & remote MMI interfaces**
- PC, 17 inch flat screen monitor
- USB backup system
- HP deskjet colour printer
- GPS interface

**EMC compliance and dynamic tests**
- Industrial Generic Immunity and Industrial Emission Standards

**Software**
- **Platform**
  - Windows XP or 2000 operating system with SmartSUB & SmartHQ application software

**In-service operation**
- on-line point-on-wave & single-cycle data displays
- periodic storage of point-on-wave displays for trend analysis
- Event Mode captures single events
- data stored on hard disk for up to 1 year
- data library of typical defects
- automatic daily backup of data
- automatic self-check of PDM, with faults logged and alarmed
- automatic synchronisation with busbar voltage
- transfer of data to remote site by modem or company LAN

**Data interpretation**
- trend analysis
- multiple ANN classification of events
- statistical distance classification

**PD alarms**
- programmable alarm criteria
- WARNING of PD activity
- ALARM of high or increased PD activity
- automatic communication of warning/alarm condition to the headquarter's PC

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