Power Diagnostic Service Co., LTD. (PDS), serving industries by providing professional electrical service, including penetration testing, failure detection, on-line monitoring, and solution implementing.

PDS also specializes in on-line Partial Discharge (PD) measurement, over 14,000 apparatus are measured each year, and has successfully prevented numerous failures, which are difficult to discover by conventional measurement.

Customer of PDS are mostly high-tech industries, such as Wafer and Optronic manufactures, where high quality of stable power is required and background noise at field is considerably complicated, hence PDS has put a lot of effort to provide power solution beyond expectation. In 2004, PDS developed an unique method of on-line PDM, which successfully reduced the risk of insulation breakdown to an outstanding level.
Data is collected from industries served by PDS, and on-line PDM was taken as a routine test since 2004.

<table>
<thead>
<tr>
<th>Failure rate per unit-year</th>
<th>1995-2004 Conventional Test</th>
<th>2004-2014 PD Measurement</th>
<th>unit-years*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer</td>
<td>0.258%</td>
<td>0.024%</td>
<td>12354.3</td>
</tr>
<tr>
<td>Cable System</td>
<td>0.143%</td>
<td>0.001%</td>
<td>100967.3</td>
</tr>
<tr>
<td>PT/CT/CB</td>
<td>0.036%</td>
<td>0.000%</td>
<td>74126.0</td>
</tr>
</tbody>
</table>

*unit-years: sum of equipment number times its operation time (in year)
One 10 years old unit is represented by 10 unit-years; a newly installed equipment (3 months) is 0.25 unit-year.

Acquiring adequate experiences from on-site service has prompted PDS to develop the most advanced condition-based monitoring system, including various UHF sensors, integrated power diagnostic equipment and portable PD analyzer which give customer a full range of protection to the HV/MV assets.

Since the first generation of PDsimply, the on-line Partial Discharge monitoring system was introduced in 2012, over 1,800 sets have been installed worldwide, monitoring over 10,000 equipment, including transformer, switchgear, cable, motor, generator and GIS.
Case Study

Periodic On-line PDM on 161 kV GIS

<table>
<thead>
<tr>
<th>Equipment</th>
<th>161 kV GIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>TM type of UHF PD Sensor attaching to grounding wire of cable termination (Fig. 1)</td>
</tr>
<tr>
<td>Method</td>
<td>PD measurement once per year</td>
</tr>
<tr>
<td>Measurement result</td>
<td>PD in the S-phase cable termination (Fig. 2).</td>
</tr>
<tr>
<td>Inspection</td>
<td>Improper workmanship lacked for a series of tapes supposed to be wrapped in the junction of terminal and XLPE (Fig. 3).</td>
</tr>
</tbody>
</table>

Fig. 1  UHF PD Sensor  Fig. 2

Periodic On-line PDM on 22.8 kV cast-resin transformer

<table>
<thead>
<tr>
<th>Equipment</th>
<th>22.8 kV cast-resin transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>Capacitive type of PD Sensor closing to the surface of winding (Fig. 7)</td>
</tr>
<tr>
<td>Method</td>
<td>PD measurement twice per year</td>
</tr>
<tr>
<td>Measurement result</td>
<td>PD in the S-phase winding (Fig. 8).</td>
</tr>
<tr>
<td>Inspection</td>
<td>leading wire of tap change was burnt, caused by improper distance between leading wire and the sections of copper winding (Fig. 9).</td>
</tr>
</tbody>
</table>

Fig. 7  Fig. 8  Fig. 9
PD Monitoring on 161 kV GIS

<table>
<thead>
<tr>
<th>Equipment</th>
<th>161 kV GIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>TM type of UHF PD Sensor attaching to grounding wire of cable termination (Fig. 4)</td>
</tr>
<tr>
<td>Method</td>
<td>Permanent monitoring</td>
</tr>
<tr>
<td>Measurement result</td>
<td>PD in the S-phase cable termination (Fig. 5).</td>
</tr>
<tr>
<td>Inspection</td>
<td>The installation is correct, but the colored XLPE implied there is overstress caused by unknown reason(Fig. 6).</td>
</tr>
</tbody>
</table>

(a) Trend of PD level

(b) PRPD pattern of S-phase cable termination

PD Monitoring on 22.8 kV transformer

<table>
<thead>
<tr>
<th>Equipment</th>
<th>22.8 kV cast-resin transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>TM type of UHF PD Sensor attaching to grounding wire of cable termination (Fig. 10)</td>
</tr>
<tr>
<td>Method</td>
<td>Permanent monitoring</td>
</tr>
<tr>
<td>Measurement result</td>
<td>PD in the R-phase winding (Fig. 11).</td>
</tr>
<tr>
<td>Inspection</td>
<td>Improper degreasing process resulted in the oil stain deposit on the surface of copper conductor(Fig. 12).</td>
</tr>
</tbody>
</table>

(a) PD location

(b) Defect on the copper conductor
Case Study

PD Monitoring on 22.8 kV switchgear

<table>
<thead>
<tr>
<th>Equipment</th>
<th>22.8 kV Switchgear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>TEM type of UHF PD Sensor (Fig. 13)</td>
</tr>
<tr>
<td>Method</td>
<td>Permanent monitoring</td>
</tr>
<tr>
<td>Measurement result</td>
<td>surface discharge in the CT (Fig. 14).</td>
</tr>
<tr>
<td>Inspection</td>
<td>The metal seal is too close to the ground leading surface discharge (Fig. 15).</td>
</tr>
</tbody>
</table>

Fig. 13 (a) Trend of PD level  
Fig. 14 (b) PRPD pattern  
Fig. 15

PD Monitoring on 22.8 kV transformer

<table>
<thead>
<tr>
<th>Equipment</th>
<th>22.8 kV cast-resin transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>TM type of UHF PD Sensor attaching to grounding wire of cable termination (Fig. 16)</td>
</tr>
<tr>
<td>Method</td>
<td>Permanent monitoring</td>
</tr>
<tr>
<td>Measurement result</td>
<td>Surface discharge in the wedges of the winding (Fig. 17).</td>
</tr>
<tr>
<td>Inspection</td>
<td>Moisture issue, and the improper material of wedges (Fig. 18).</td>
</tr>
</tbody>
</table>

Fig. 16 (a) Trend of PD level  
Fig. 17 (b) PRPD pattern  
Fig. 18
Why PD Monitoring

Cause of Partial Discharge

Partial Discharge (PD) activity is an electrical discharge, which does not bridge the electrodes between an insulation system completely under high electric field stress, causing dielectric breakdown. The dielectric breakdown process can take from days to years, and PD can be caused by contamination, system aging, moisture, loose stator winding, poor manufacture, poor installation, thermal deterioration, and etc.

Effect of Partial Discharge

Breakdown caused by PD is always catastrophic in the sense that it is irreversible and destructive. It causes deterioration of components which will lead up to serious outcomes, such as unplanned outage, employee injury, production loss and manufacture damage. These failure outcomes do not happen individually, they usually come in consequences, which causes a loss much more than the cost of the already expensive equipment.

By adopting cost effective condition based monitoring, severe failure can be predicted and prevented.

Benefits of Partial Discharge Monitoring

- Maximizing equipment lifecycle
- Predicting insulation failure
- Avoiding unscheduled downtimes
- Assessing equipment condition precisely
- Plan maintenance based on actual condition
- Reducing overall maintenance cost
- Identifying failure mechanism
- Improving operation safety
- Accessing historical data easily
PDS has developed various UHF PD sensors corresponding to different HV equipment, all designated sensors are compatible with PDSimply and PDSimply Portable for PDCare On-line Monitoring Service through multiple communication channels.
PD Care Feature

- 24/7 Real time monitoring by PD experts
- Trend, pps and PRPD, in graph and dynamic pattern
- Data can be accessed anytime with any smart device
- PD expert analyzing service avoids complicated PD interpretation by user
- Periodical report presents up-to-date operating condition
- Alert notification will be sent whenever abnormal activity is detected

When PD signal is confirmed, risk assessment will be made

- Smart algorithm* enables optimized setting to be applied for equipment
- Extra-wide band feature and UHF component suppress background interference
- Featuring three communication modes: standalone mode, local mode and network mode.
  All three modes feature data exporting function

*Smart algorithm will suggest the most appropriate setting for the monitoring system, based on the equipment operation condition and background interference.
The PDS PDCare service is beyond conventional PD monitoring system, it eliminates the complex PD recognition and high cost of system implementing. PDCare provides not just an automatic alert function and fault categorization, PD recognition by field engineers, who have PD experience for longer than any PD monitoring system adds inestimable value to the service.

- Distinguish PD signal and interference more effectively
- Recognize PD types
- Risk assessment while PD signal is detected
- Suggest the most appropriate response to prevent failure
- Discover “hidden” PD signal - sometimes PD may lead to failure with low discharge signal, which system is not able to discover before failure. PDS monitoring team reviews even healthy equipment by looking its trend and pattern to prevent such incident.

PDCare is an economic service, offered at different plans, upon customer’s maintenance budget, PDCare plan can be customized and offered at low cost to meet expectations.
Web Interface

PDCare web interface can be accessed through any kind of smart device with internet browsing capability, which makes the condition monitoring boundaryless: data can be interpreted remotely and provide professional advice accordingly.

The system overview indicates the status of each site or station, and triggers alarm with highlights if PD is detected. It allows user to quickly access to the abnormal equipment and run a comparison with other monitored equipment.

The informative monitoring page shows the most detail required for PD analysis, including:

- Real time trend or selected period with zoom function showing trend plot up to each minute
- Indicating different phases in different color with selective display
- Showing discharging level, pulse-per-second (pps), and time in graph and digital
- Click any point on the trend to view PRPD pattern, and one click to generate Dynamic PRPD
- Click any two points to compare PRPD at different time or choose different devices to run a cross comparison
- Exporting current view in designated file
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