PDetector
Handheld Partial Discharge Detectors

The Future of OLPD

V 1.1
May 2017
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About PMDT

Headquarters:
- Silicon Valley, San Jose, CA, USA

Experiences:
- Have tested more than 20,000 units of high voltage electrical equipment in hundreds and thousands of substations for global electric utilities as well as industrial end users during the last 20 years.

Missions:
- For the safety of power system operation.

Users:
- Utilities
- Industrial power users
- MV & HV Equipment manufacturers
- Electrical Contractors and Service Companies
"The power industry's most advanced Online Partial Discharge test equipment and services."

- Over 20 years of ongoing research and development, we manufacture a complete spectrum of diagnostic and monitoring systems for MV and HV power substations.

- Our manufacturing facility in the heart of Silicon Valley provides local access to high quality American-made circuit boards and components. We provide patented, reliable and robust equipment with state-of-the-art capabilities for insulation testing of energized power equipment.

USA and Global Clients

Electric Utilities
- SDGE
- Southern California Edison
- Seattle City Light
- Colorado Springs Utilities
- CenterPoint Energy
- State Grid Corporation of China

Power Industry Manufacturing
- ABB
- Eaton
- Emerson

Electronics
- Applied Materials
- Samsung
- SDI

Metals & Metallurgy
- Alcoa
- Nucor

Oil & Gas
- ExxonMobil
- Cheniere
- Tesoro
- Saudi Aramco

Chemical
- Dow Corning

Commercial Buildings
- MGM Resorts International
PMDT Across The Globe

Headquarters

Asia Branch Office

- Headquarters
- Branch Offices
- Representatives
International Trainings & Seminars

2015 Korea & Philippines Reps’ Training

2015 Vietnam, Thailand, Hong Kong Reps’ Training

2014 Indonesia & Malaysia Reps’ Training

2016 IEEE Seminar in Hong Kong

2016 Seminar for Vietnam Utility

2014 Seminar for Bangladesh Utility
Global Field Testing in USA

EATON

DOW CORNING
Global Field Testing in USA
Electric Utility
Global Field Testing

Colombia

Korea

Thailand

Bangladesh
Global Field Testing

- Philippines
- Hong Kong
- Vietnam
Find Insulation Breakdown Before It Fails

Switchgear, GIS, Cable and Transformer Failures Could have been prevented...
Wireless Sensors
- HFCT 500kHz - 50MHz
- UHF 300MHz - 1.5GHz

Acoustic Sensors
- Contact Probe  20kHz - 300kHz
- Dish Concentrator  40kHz
- Extension Wand  40kHz

PD Detector - Main Handheld Unit
- Built-in TEV Sensor  3MHz - 100MHz
- Built-in Ultrasonic  40kHz
- PRPD-2D & PRPD-3D Analysis
Applications_Transformer
For Cable On-line Testing
## Hardware Configurations

Five Recommended Kits configured with optimal combinations of TEV, UHF, HFCT, AE, and Ultrasonic sensors.

<table>
<thead>
<tr>
<th>Config.</th>
<th>Application</th>
<th>Internal TEV</th>
<th>UHF</th>
<th>HFCT</th>
<th>AE Contact</th>
<th>Internal Ultrasonic</th>
<th>Ultrasonic Dish</th>
<th>Ultrasonic Microphone</th>
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<tr>
<td>Kit 1</td>
<td><strong>Multi-Function, Five-in-One,</strong> for GIS, MV Switchgear, Power Cables, and Transformers</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Kit 2</td>
<td><strong>AE/Ultrasonic, Two-in-One,</strong> for GIS, MV Switchgear, Cable Accessories, and Transformers</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Kit 3</td>
<td><strong>TEV/Ultrasonic, Two-in-One,</strong> for MV Switchgear</td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Kit 4</td>
<td><strong>UHF/TEV/AE/Ultrasonic, Four-in-One,</strong> for GIS</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kit 5</td>
<td><strong>HFCT/TEV/AE/Ultrasonic, Four-in-One,</strong> for Power Cables and Transformers</td>
<td>✔️</td>
<td></td>
<td></td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AE/Ultrasonic/TEV/UHF/HFCT

Data Types
- TEV amplitude and pulse spectrums
- UHF amplitude, single-cycle, PRPD-2D and PRPS-3D spectrums
- AE & Ultrasonic amplitude, phase, fly, and waveform spectrums
- HFCT amplitude, single-cycle, PRPD-2D and PRPS-3D spectrums

Five-in-One Technology
Kit 2, AE/Ultrasonic, for Multiple Equipment

Data Types

- AE & Ultrasonic amplitude, phase, fly, and waveform spectrums

Two-in-One Technology
Kit 3, TEV/Ultrasonic, for MV Switchgear

Data Types
- TEV amplitude and pulse spectrums
- Ultrasonic amplitude, phase, fly, and waveform spectrums

Optional Accessories:
- AE Contact Sensor
- Ultrasonic Wand
- Ultrasonic Dish

Two-in-One Technology
Data Types

- TEV amplitude and pulse spectrums
- UHF amplitude, single-cycle, PRPD-2D and PRPS-3D spectrums
- AE & Ultrasonic amplitude, phase, fly, and waveform spectrums
Kit 5, AE/Ultrasonic/TEV/HFCT, for Power Cables and Transformers

Data Types

- TEV amplitude and pulse spectrums
- HFCT amplitude, single-cycle, PRPD-2D and PRPS-3D spectrums
- AE & Ultrasonic amplitude, phase, fly, and waveform spectrums

Four-in-One Technology
Easy to Transport
Specifications
Handheld Partial Discharge Detector

Sensor Technology
Electromagnetic (EM)
- TEV - Transient Earth Voltage: 3MHz - 100MHz, Built-in to main handheld unit
- UHF - Ultra High Frequency: 300MHz - 1.5GHz
- HFCT - High Frequency Current Transformer: 500kHz - 50MHz

Acoustic Sensors (AE)
- Acoustic Contact: 20kHz - 300kHz
- Internal Ultrasonic: 40kHz
- Ultrasonic Microphone: 40kHz
- Ultrasonic Dish: 40kHz
Specifications

- Resolution: 1dB
- Accuracy: ±1dB
- Size: 7.3” x 4.3” x 1.4” / 185mm x 110mm x 35mm
- Main unit weight: 0.9lbs / 0.4kg
- Display: HD color LCD
- Data Connector: Mini USB
- Power supply: Li-ion, typical operating for 6 hours; Rechargeable
- Operating temperature: 5°F~130°F/-15°C ~55°C
Features

- Light weight, handheld, and easily deployed
- Scrolls 3D-PRPS and 2D-PRPD spectrums in real time
- Multiple sensor technology
- Wireless sensor technology
- Intelligent patrol function
- RFID scanning to read info. of apparatus
- Data storage and powerful data analysis software
- Fast detection suitable for daily monitoring
RFID and Intelligent Patrol

- Radio Frequency Identification is an optional means of recording and trending OLPD test data.

- Standardize the field OLPD testing procedure to improve test efficiency greatly and achieve asset management. Associate POA RFID tags to power equipment.

- RFID tagging automates the data entry process. This method makes it easy to keep records of all PD testing. It also enables historical trending of results.
RFID and Intelligent Patrol

- The RFID tags store information related to each power equipment. Use the PDetector to scan RFID tags and save the data which match with the asset information. Test data can be saved and uploaded to the data management software.

- Environmental-friendly paperless OLPD testing is realized.
PDetector Software

- Data storage, analysis and application
- Automatically generates a variety of analysis and management reports
- Multiple data analysis tools available
Basic and Advanced Diagnostic Modes

**TEV Amp Detection**

Settings

<table>
<thead>
<tr>
<th>Mode</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4- Mode</td>
<td>[Continuous]</td>
</tr>
<tr>
<td>2/4- ALARM</td>
<td>[40 dB]</td>
</tr>
<tr>
<td>3/4- BACKGROUND</td>
<td>[15 dB]</td>
</tr>
<tr>
<td>4/4- Defaults</td>
<td></td>
</tr>
</tbody>
</table>

Max: 45dB

2014/01/01 12:00:00

**UHF Spectrum Detection**

1/12- Mode [Continuous]

Max: 51dB

Range: 70dB

Power Sync

2014/01/01 12:00:00

**UHF PRPD2D&PRPS3D**

Bandwidth [ALL]

Sync Light

2014/01/01 12:00:00

**Amplitude Detection**

Gain [x100]

2014/01/01 12:00:00
Acoustic Amplitude Mode

Amplitude Detection

- Gain [x100]
- CH: Int

- 0mV: MS (10mV)
- 0mV: Peak (20mV)
- 0mV: Spectrum 1 [60 Hz] (2mV)
- 0mV: Spectrum 2 [120 Hz] (2mV)

- 0mV: 2mV
- 0mV: 9mV
- 0mV: 0.9mV
- 0mV: 0.8mV

2014/01/01 12:00:00
Acoustic Phase Spectrum

AE Phase Spectrum

Table:

<table>
<thead>
<tr>
<th>Name</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Name</td>
<td>Bluegrass Generation</td>
</tr>
<tr>
<td>Sample Time</td>
<td>4/28/2015 8:43:34 AM</td>
</tr>
<tr>
<td>Signal Source</td>
<td>Internal</td>
</tr>
<tr>
<td>Gain</td>
<td>X100</td>
</tr>
<tr>
<td>Trigger Amplitude</td>
<td>1mV</td>
</tr>
<tr>
<td>Sync Mode</td>
<td>Power</td>
</tr>
<tr>
<td>Sync Status</td>
<td>Failed</td>
</tr>
<tr>
<td>Phase Shift</td>
<td>0°</td>
</tr>
<tr>
<td>Blocking Time</td>
<td>2min</td>
</tr>
<tr>
<td>Max</td>
<td>17.1mV</td>
</tr>
<tr>
<td>Min</td>
<td>0.9mV</td>
</tr>
<tr>
<td>Avg</td>
<td>2.31mV</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.46</td>
</tr>
</tbody>
</table>

Time
Acoustic Waveform

Acoustic waveform mode (2 cycle domain)
UHF Phase-Resolved 2D & 3D and Single-Cycle Spectrums
Analysis: Determine PD Type

- PRPS and PRPD can determine the type of PD based on the phase distribution of PD pulses.
- Once in this window we can view past data in one window all together to show how the signal is progressing in this particular equipment.
- This is the Test Table view of the Test Query
- This is the Chart view of Test Query
- This allows us to compare on contrast data that was taken during this test
How to Use PDetector

GIS

- External UHF Sensor
- AE Contact Sensor
- HFCT Sensor
- Internal Ultrasonic Sensor
- PDetector
How to Use PDetector

Transformer

- Internal UHF Sensor
- External UHF Sensor
- AE Contact Sensor
- Valve UHF Sensor
- HFCT Sensor
- Internal Ultrasonic Sensor

PDetector
How to Use PDetector

MV Switchgear

Diagram showing the connection between PDetector and different sensors:
- External UHF Sensor
- Internal TEV Sensor
- Internal Ultrasonic Sensor
- AE Contact Sensor
How to Use PDetector

Power Cable

External UHF Sensor

HFCT Sensor

AE Contact Sensor

Internal Ultrasonic Sensor

PDetector
Partial Discharge Cases

1. Floating Electrode

MV Switchgear: Bus Bar Bushing

GIS: Joints

Transformer: Bushing
2. Void

GIS: Basin-type Insulator
3. Surface

Power Cables

Switchgear: Contact of CB
4. Corona

GIS:
Insulator Support Part
Key Technologies for PD Detection & Location

- UHF
- TEV
- AE
- Ultrasonic
- HFCT

A Combination of Acoustic-Electric Technology

*Five-in-One*

- Compares the multiple types of signals
- Excludes the disturbance signals
- Determines the PD type
- Locates the PD accurately
1. Excludes the Disturbance Signals

- Selects the right time or shut down the disturbance source

- Equips a proper wave filter to filter the disturbance signals of a certain frequency

- Analyzes the correlation between the detected signals and sinusoidal power phase
  - If there is no correlation, it should mostly be disturbance signals;
  - If there is correlation, it might be PD or disturbance signals from the power system, such as light, air conditioner, meter cabinet, and second circuit.

- Location method
  - After analyzing the frequency content, conduct a simple location and analysis through Time Difference Method to check whether the signal comes from inside of the electrical equipment or the external environment.
2. Time Difference Method

\[ \Delta t = t_2 - t_1 = \frac{L - 2x}{c} \]

\[ x = \frac{L - c\Delta t}{2} \]
3. 3D Localization Method
4. Phase Location

- Employs HFCT method to detect the ground strap/body of the adjacent three phases of the power cables.
- The signals of the defected phase have larger amplitude and opposite phase position, in comparison to the other two phases.
5. Determines the type of the PD

Typical PD Characteristic Spectrums

Corona

Floating Electrode

Surface

Particle

Void
<table>
<thead>
<tr>
<th>Type of Signals</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Void</strong></td>
<td>The discharge signals have obvious symmetry between the positive and negative half cycles of a single frequency cycle. There are a larger quantity of discharge pulses.</td>
</tr>
<tr>
<td><strong>Corona</strong></td>
<td>There are only one bunch of discharge signals in a single frequency cycle. The discharge signals are quite dense.</td>
</tr>
<tr>
<td><strong>Floating Electrode</strong></td>
<td>There are few discharge signals in each frequency cycle. The signals are quite intermittent, the amplitude are usually bigger and stable, and have high correlation with sinusoidal phase.</td>
</tr>
<tr>
<td>Type of Signals</td>
<td>Characteristics</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Particle</td>
<td>There are few discrete discharge signals. They are quite random and have low correlation with sinusoidal phase.</td>
</tr>
<tr>
<td>Mobile Phone</td>
<td>The frequency of the pulses are usually between 2.2～217 Hz and the width are usually 0.57 ms.</td>
</tr>
<tr>
<td>Lighting</td>
<td>Similar to the floating electrode signals, however the amplitude is not stable and changes greatly.</td>
</tr>
<tr>
<td>Electronic fence</td>
<td>The repetition rate of the pulses is of seconds. It displays as a series of pulse signals when extending to 20us.</td>
</tr>
</tbody>
</table>
6. Determines the severity

- Amplitude
- Position
- The type of the PD

Maintenance Plans
Pay attention or
Repair Immediately
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