

PTPD S200G

PTPD S200M and PTPD P100/P200

**For AI Trending and Early Warning
AI-Based PD Measurement and Diagnostic System
for Large Generators and Motors**



**Operation and Maintenance Solution
for the AI era**

AI Trending and Early Warning featuring PD Sources

- AI Trending and Early Warning Based on LSTM Autoencoder Algorithm
- AI-Based Partial Discharge Source Classification
- Online charge integration measurement: Charge Integration Mode (CIM)
- Online Three-Phase Signal Discrimination (TPSD)
 - : Distinguishes PD generated in each phase, inter-phase interference PD, and external noise
- Peak Phase Dispersion Analysis (Cross and Cactus) of online PRPD pattern
 - : Real-time trending of PD deterioration status by sources: 54 parameters

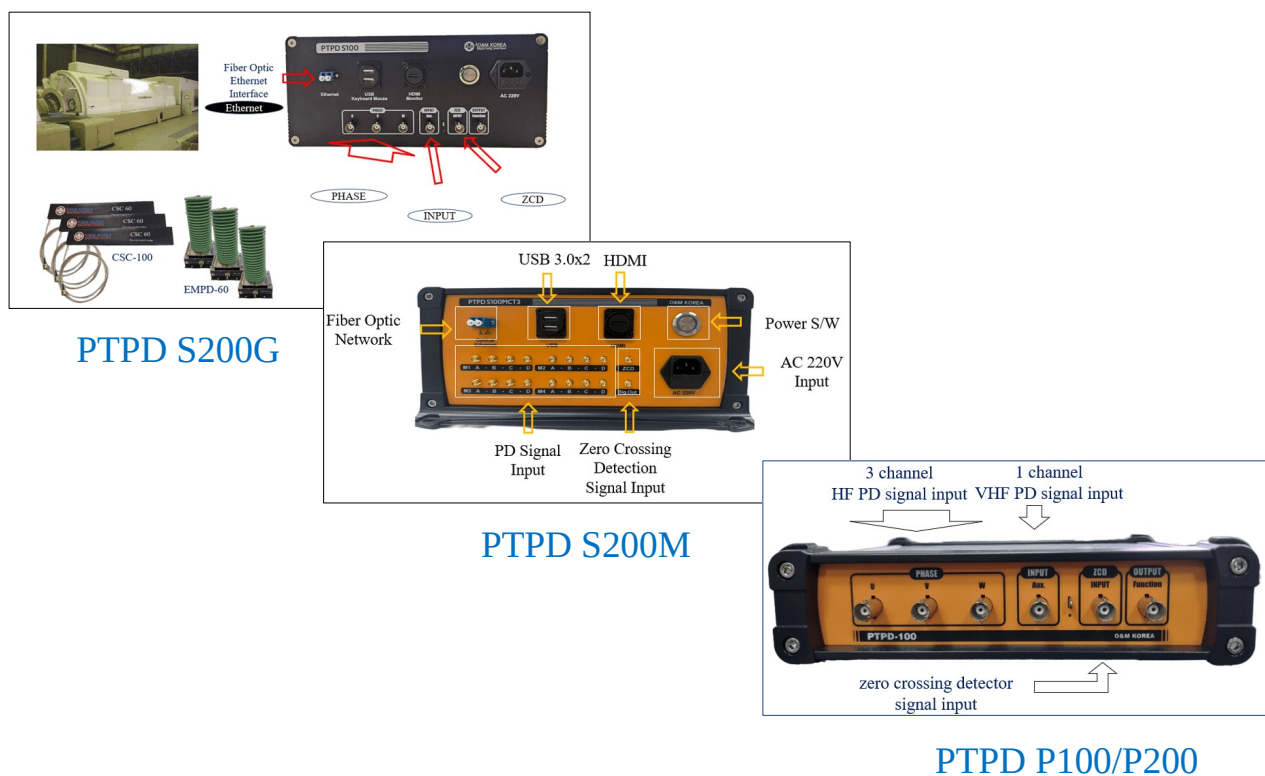
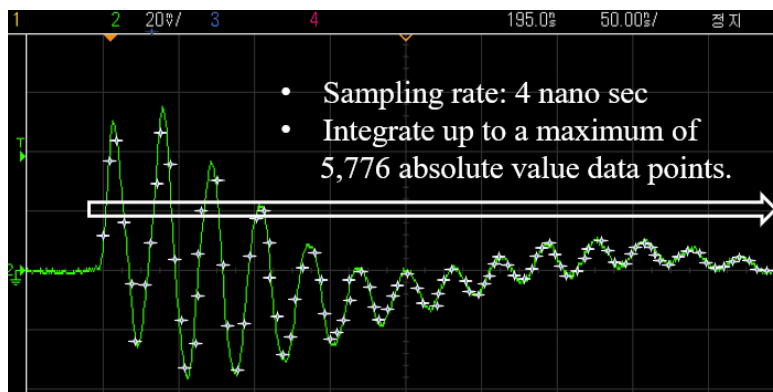


Figure 1. PTPD S200G, PTPD S200M, PTPD P100/P200

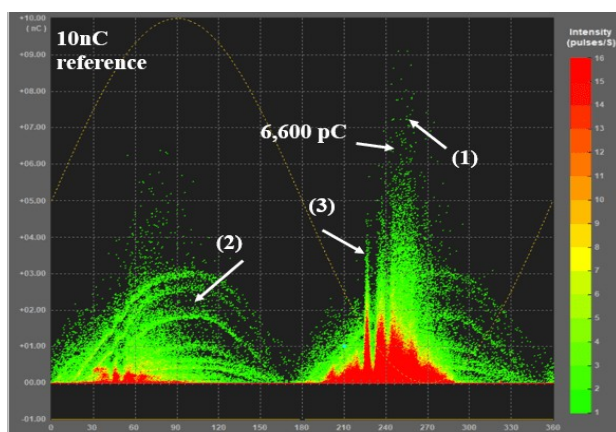
- PTPD S200G: Remote online partial discharge diagnosis system for large generators
- PTPD S200M: Remote online partial discharge diagnosis system for multiple motors
- PTPD P100/P200: Portable online partial discharge diagnosis system for generators and motors

Charge Integration Mode (CIM)

- After three-phase calibration (100 kHz to 3 MHz) using the same method as IEC 60270, real-time online charge integration measurement (CIM) is performed (quasi-pC)
- Trending with quasi-pC provides a more reliable diagnostic solution.
- Integration of 5,776 digital data points at a 4-nanosecond sampling rate



CIM



IEC 60270

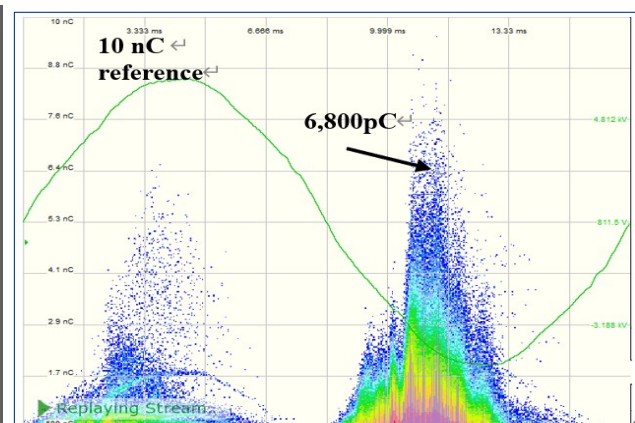


Figure 2. PRPD measured in real time using an online CIM and offline IEC 60270
(1) Surface Discharge, (2) Inter-turn Discharge, (3) End Winding Gap Discharge

Three-Phase Signal Discrimination (TPSD)

- Distinguishes partial discharge generated in three phases, inter-phase interference PD, and external noise.
- By comparing the relative magnitude of real-time three-phase measurement signals on a 0% to 100% scale, it identifies crosstalk among three-phase PD signals and external noise.

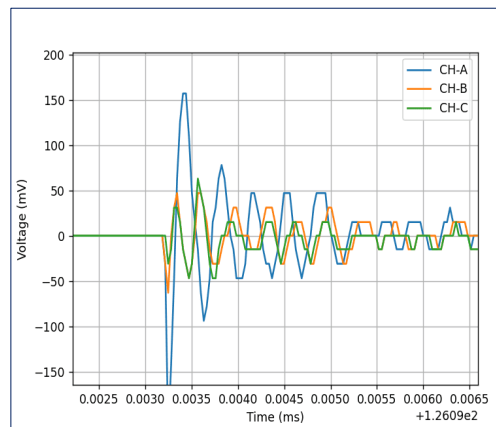


Figure 3. Relative magnitude comparison using real-time online three-phase PD measurement (Simultaneous three-phase sampling rate: 8 nanoseconds)

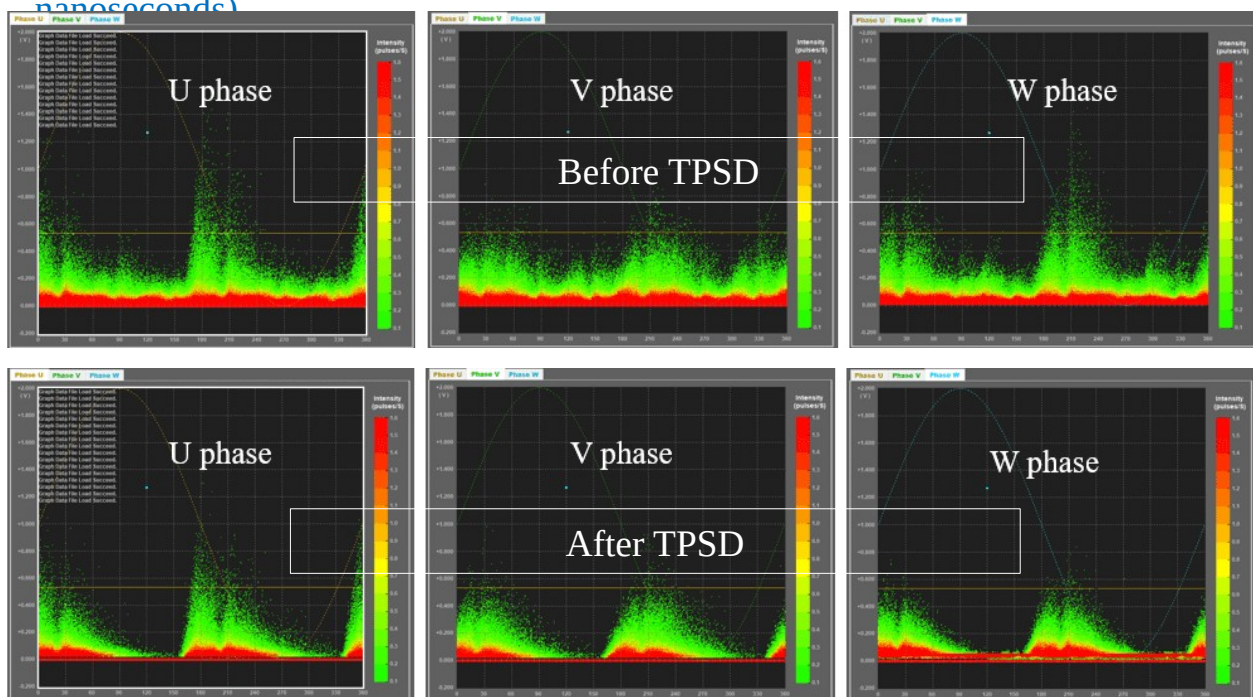
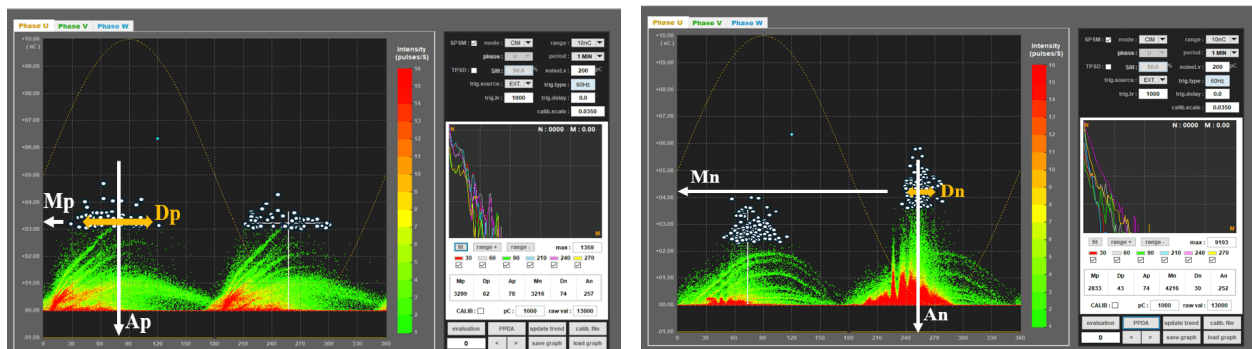


Figure 4. PRPD before and after TPSD
(High-voltage three-phase motor, measured with VHF CT PD sensor)

Peak Phase Dispersion Analysis (PPDA) Cross

- Extracts 6 parameters per phase from real-time PRPD patterns (18 parameters for three phases).
- PPDA Cross parameters are used to determine the cause and deterioration level of partial discharge through an AI LSTM Autoencoder algorithm.



Interturn discharge

Interturn and surface gap discharges

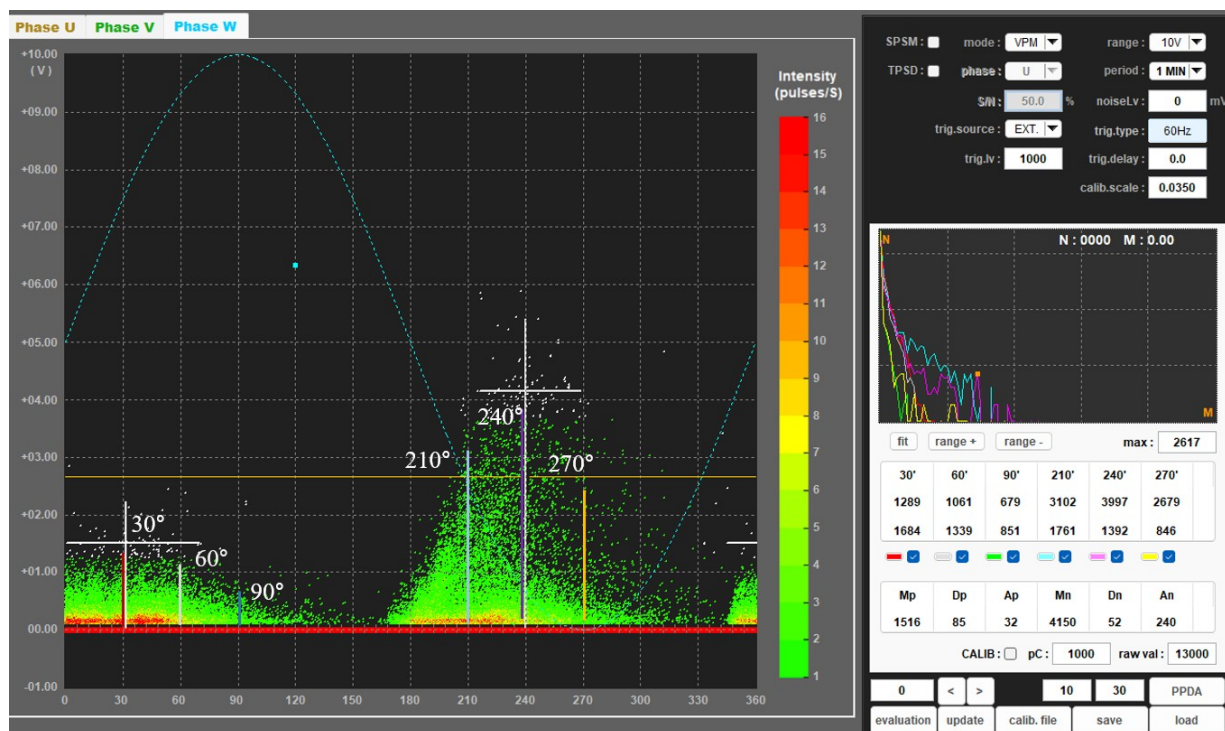
Mp	Dp	Ap	Mn	Dn	An	Mp	Dp	Ap	Mn	Dn	An
3,299 pC	62°	78°	3,216 pC	74°	257°	2,833 pC	43°	74°	4,216 pC	30°	252°

Figure 5. Real-time online PPDA Cross analysis (Examples)

- In general, PD analysis experts determine the cause and deterioration level of PD by analyzing PRPD pattern factors such as maximum PD magnitude, polarity distribution comparison, skewness, and kurtosis.
- PPDA Cross (+ symbol) extracts and evaluates real-time online parameters:
 - Average value of the largest 100 partial discharges (Mp, Mn)
 - Center phase of Mp and Mn (Ap, An)
 - Phase dispersion of Mp and Mn (Dp, Dn)

Peak Phase Dispersion Analysis (PPDA) Cactus

- PPDA Cross analyzes the 100 largest partial discharges in the PRPD pattern.
- Medium- and low-level discharges below the largest PD values can be analyzed to assess the current PD deterioration status and future changes in the PRPD pattern.
- PPDA Cactus extracts the maximum PD magnitude and occurrence count for each of the six phase axes: 30°, 60°, 90°, 210°, 240°, and 270°.
- It extracts 12 parameters from each phase axis of the PRPD pattern, including maximum PD values 30M, 60M, 90M, 210M, 240M, and 270M, and PD counts 30N, 60N, 90N, 210N, 240N, and 270N (36 parameters for three phases).
- PPDA Cactus parameters predict future changes in PD occurrence through an AI LSTM Autoencoder algorithm.



	30°	60°	90°	210°	240°	270°
M (mV)	1,289	1,061	679	3,102	3,997	2,679
N (PD counts)	1,684	1,339	851	1,761	1,392	846

Figure 6. Real-time online PPDA Cactus analysis (Example)

PTPD S200G

- EMPD 80 installed on the IPB of a large generator, or CSC 60 inserted into the stator slot, transmits PD data for remote, real-time AI diagnosis and trending of PD deterioration.
- Through real-time AI diagnosis and trending of the PD deterioration status of large generators can be remotely monitored (e.g., from the control room), with early warning.

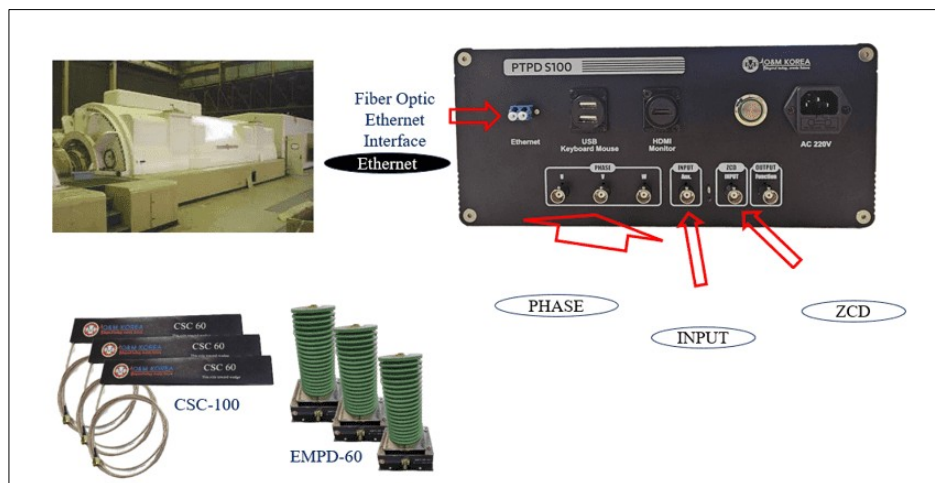


Figure 7. PTPD S200G

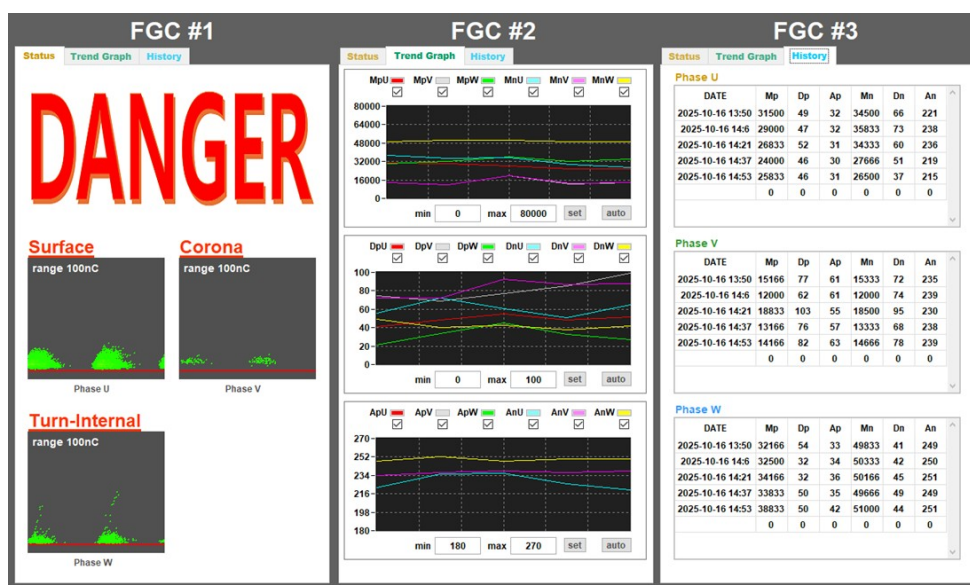


Figure 8. Screen of the remote control room showing real-time trends in PD deterioration status

PTPD S200M

- Remote real-time PD deterioration diagnosis is performed through VHF CTs and Input Units permanently installed in the terminal boxes of multiple large motors.
- Up to four large motors can be measured and diagnosed through multiplexing.
- Through real-time diagnosis, trends in PD deterioration status for multiple large motors can be remotely monitored (e.g., from the control room).

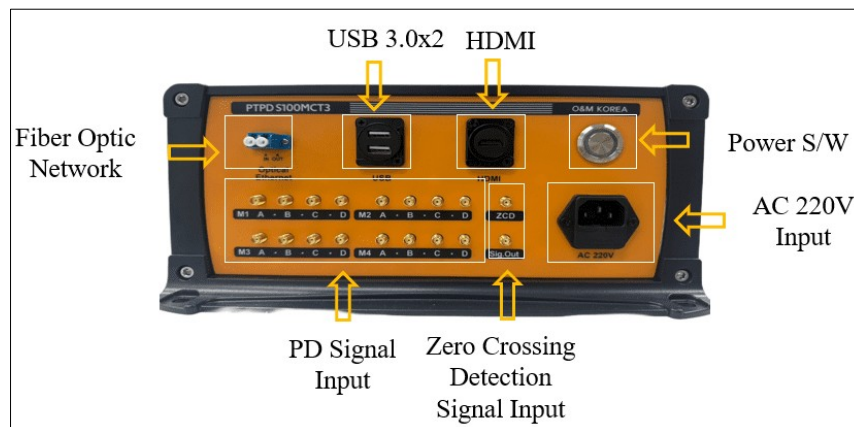


Figure 9. PTPD S200M

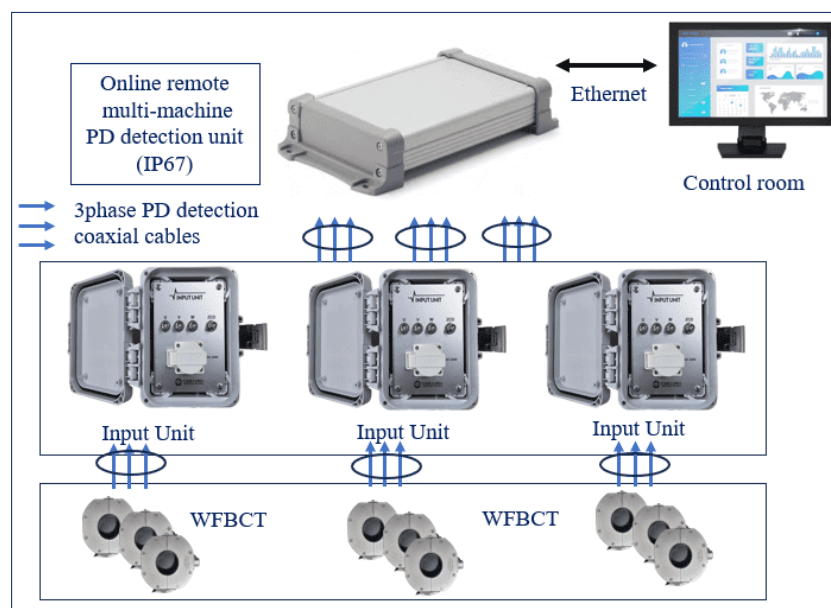


Figure 10. PTPD S200M remote real-time online diagnostic system configuration

PTPD P100/P200

- Portable real-time online PD deterioration diagnosis is performed through VHF CTs and Input Units permanently installed in the terminal boxes of large motors.
- For large motor terminal boxes without installed VHF CTs, ACP sensors can be temporarily mounted on the terminal box surface, and the TPSD algorithm is applied to eliminate external noise and interference between large motors, enabling real-time online PD deterioration diagnosis.

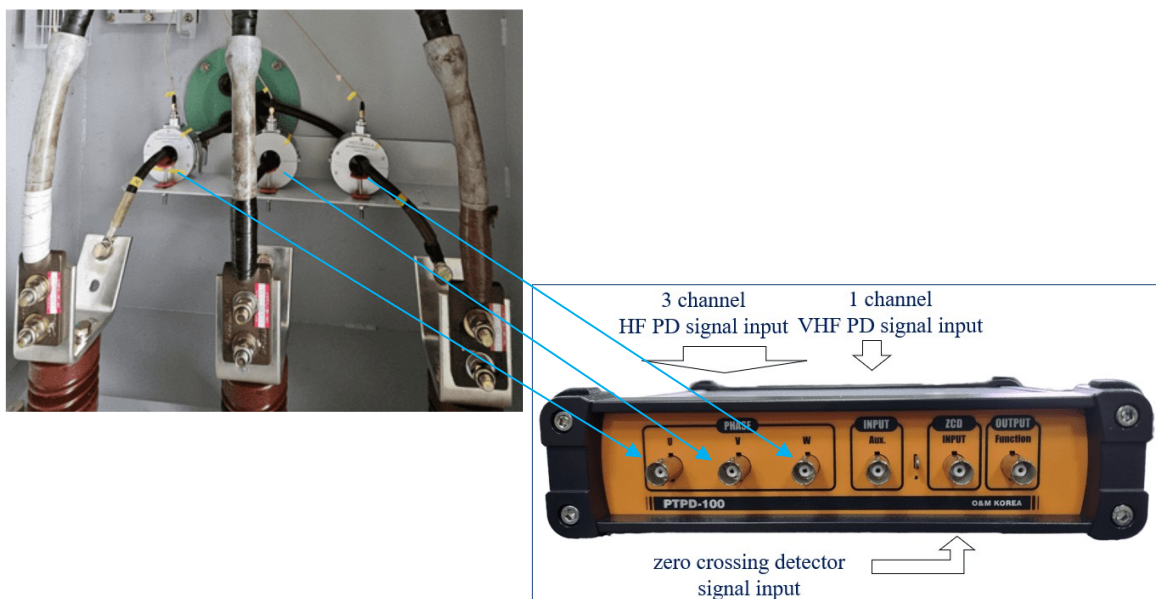


Figure 11. Online PD deterioration diagnosis using PTPD 200 and VHF CT

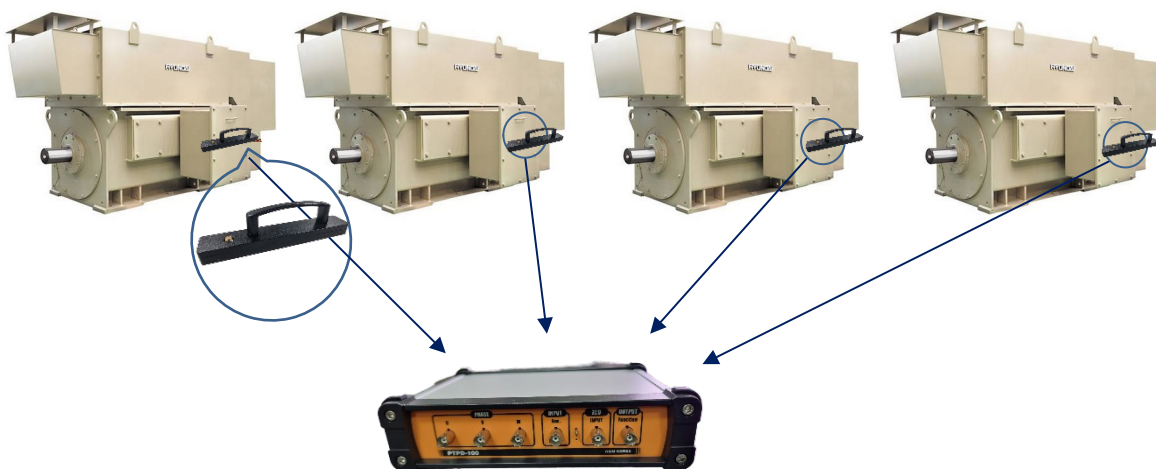


Figure 12. PD deterioration diagnosis using PTPD 200 and TEV sensors

LSTM Autoencoder Workflow for Rotating Machine Diagnosis

Step 1: Data Collection

PRPD data are collected to assess the insulation condition of a rotating machine. The data provide a basis for identifying partial discharge patterns.

Step 2: Feature Extraction

Principal component analysis (PCA) is applied to extract 54 features from the collected data using the PPDA Cross and Cactus algorithms. These features organize the key information supplied to the diagnostic model.

Step 3: Pattern Analysis

The extracted features are fed into an LSTM autoencoder to analyze patterns in the data. The results support condition classification and anomaly score calculation.

Step 4: Condition Classification

The model classifies the results into six categories: Normal, Internal PD, Slot PD, Surface PD, Corona, and Interturn PD.

Step 5: Anomaly Detection

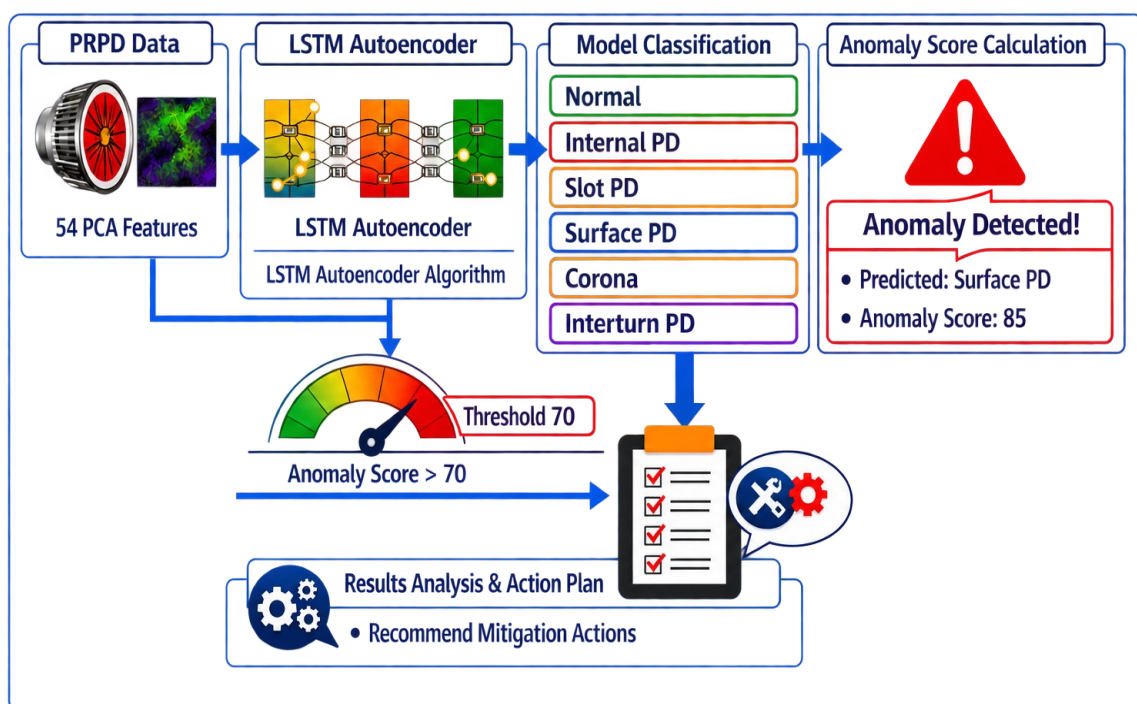
The anomaly score is calculated and compared with the preset threshold of 70. A score above 70 indicates an abnormal condition.

Step 6: Diagnostic Results

In the illustrated example, the anomaly score of 85 exceeds the threshold, and the predicted category is Surface PD. The system therefore reports an anomaly.

Step 7: Action Planning

Finally, the classification and anomaly score are reviewed together to develop an inspection and mitigation plan suited to the machine's condition.



PD sensors: VHF CT, CSC-60, EMPD-80

	Technical Specification	Application
VHF CT	70 kHz~50MHz (-3dB) 60Hz AC300A	- high voltage motors - clamp CT
CSC-60	10MHz~270MHz - Capacitive Slot Coupler	- large generators - inserted between stator coil and wedge
EMPD-80	30MHz~270MHz 80pF, 25kV - HV Coupling Capacitor	global VPI generators
ACP	2.5 MHz~14.5 MHz - Sensitivity (> -6dB)	TEV sensor



PTPD-Series Technical Specification

- Portable/installed real-time online partial discharge deterioration diagnostic device
- PD sensors: 70 kHz to 50 MHz (VHF CT), 10 MHz to 270 MHz (CSC-60), 30 MHz to 270 MHz (EMPD-80), 2.5 MHz to 14.5 MHz (ACP)
- Simultaneous three-phase real-time online PD measurement: VPM (mV), CIM (quasi-pC)
- Three-Phase Signal Discrimination (TPSD)
 - Distinguishes PD generated in three phases, inter-phase interference PD, and external noise
- Peak Phase Dispersion Analysis (PPDA) Cross and Cactus
 - AI Trending and Early Warning Based on the LSTM-Autoencoder algorithm with classification of PD sources using 54 parameters extracted from PRPD patterns



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