Development of Partial Discharge On-Line Monitoring and Diagnosis System for Generator Power

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1. Background

Generators are crucial and critical equipment in power systems, according to statistics from the CIGRE study committee, which analyzed 1,199 fault events. Electrical insulation breakdown accounts for 56% of the causes. Unforeseen trip accidents resulting from generator and auxiliary equipment failures due to insulation issues can cause equipment damage and disrupt the power supply. The analysis of the causes shows that the insulation materials of power equipment undergo physical and chemical changes due to thermal stress, mechanical stress, electric fields, and environmental factors, gradually degrading and eventually collapsing.

Partial discharge activities caused by internal defects and insulation system degradation can be detected through online monitoring, analysis, and diagnostic techniques during generator unit operation. This enables the analysis of the evolution and development of insulation degradation, serving as a significant indicator for evaluating insulation aging performance.

TPRI (Taiwan Power Research Institute) has installed partial discharge online monitoring hosts at Unit 1 of Daguan First Power Plant, Units 1-6 of Mingtan Power Plant, ST4 generator of Tunghsiao Power Plant, Unit 4 of Wanda Power Plant, and Units 5-8 of Tashan Power Plant. To establish proprietary generator partial discharge online monitoring and diagnostic technology, a self-made monitoring host system was developed. This system utilizes a high-speed oscilloscope card to capture partial discharge pulse signals during generator operation for real-time intelligent online monitoring and the establishment of a discharge defect database. It analyzes insulation conditions and accumulates the ability to judge the threat posed by the evolution trend of partial discharge to equipment operation. This can assist on-site personnel in formulating insulation maintenance plans and preventing major losses caused by insulation breakdown accidents.

2. Research Content

This project collects IEC and IEEE online partial discharge monitoring technologies for generators to establish a partial discharge monitoring and diagnostic early warning system for generator sets. It utilizes contact sensors to capture partial discharge signals, as shown in Figure 1.

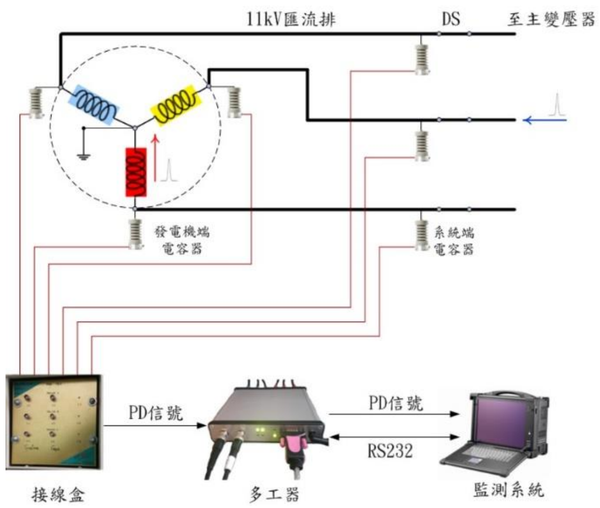

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Figure 1. Schematic Diagram of the Online Monitoring System

The system incorporates information capture and interference signal suppression technology, featuring functions that include capturing discharge signals. After setting initial measurement parameters, each measurement will perform waveform capture, waveform comparison, array establishment, and data storage, as shown in Figure 2.

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Figure 2. Original Waveform Captured by the Sensor

After signal source separation, the system determines whether the signal waveform originates from the generator side or is system noise. By looping and extracting the maximum discharge amount, positive and negative polarities, and occurrence time, stacking them allows for the drawing of a PRPD (Phase Resolved Partial Discharge) pattern for identification. In long-term monitoring data, moving the cursor on the trend graph can recall historical data, providing PRPD patterns, maximum discharge amplitude, pulse count, discharges per second, and other data as shown in Figure 3.

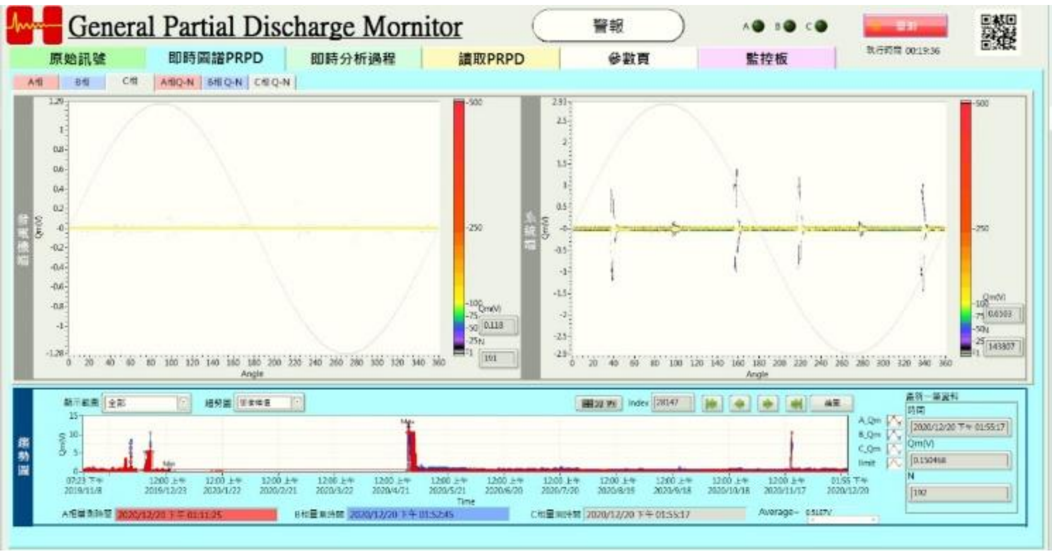

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Figure 3. Real-time PRPD Pattern and Trend Graph

3. Conclusion

This project establishes a long-term online partial discharge monitoring system to track the trend of partial discharge in stator coil insulation status and compare it with typical partial discharge patterns, thereby building an analysis and early warning system. The discharge pulse signals are displayed as generator-side discharge patterns and system-side discharge patterns, and the measurement data is transmitted to the TPRI's central server. This data can be compared with known discharge patterns in international standards to serve as a basis for determining defect type. As shown in Figure 4, the discharge characteristic pattern exhibited by the generator side is similar to that of internal discharge, and it does not conform to the characteristics of other surface discharges, slot discharges, or void discharges. This indicates that the risk of the stator coil insulation system of this generator during operation is relatively low. For the development of partial discharge technology, it is expected that this project will accumulate relevant technology and experience.

By conducting long-term online partial discharge monitoring on generator sets, this research experience and results can be applied in the future to long-term online monitoring and analysis of critical power equipment such as power transformers, circuit breakers, and power cables, aiming for a technological breakthrough in the preventive diagnosis of power equipment insulation status.

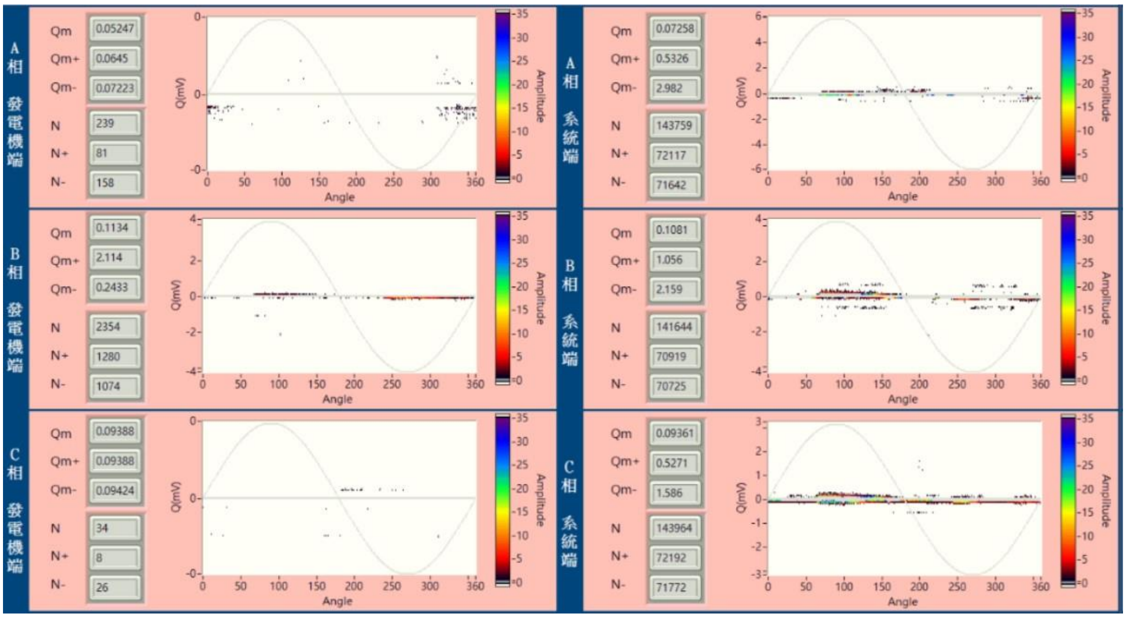

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Figure 4. Partial Discharge Pattern of Mingtan Power Plant Unit 3 Generator