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GUEST EDITORIAL OPEN ACCESS

Guest Editorial: Advanced Detection Technology for Partial Discharge in Gas Insulated Equipment

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1 | Introduction

Gas-insulated equipment plays a critical role in modern power systems, especially as they scale up in capacity and complexity. However, partial discharge (PD) remains a significant reliability concern due to operational defects, aging and environmental stress and manufacturing defects. Conventional PD detection methods like electrical pulse detection, UHF sensing and acoustic emission often face some limitations in real-world applications, such as low signal-to-noise ratio, low sensitivity and a lack of spatial resolution.

Many scholars are trying to address these limitations from both the perspectives of theory and application. Some innovative work is conducted, such as multi-physical field simulation clarifies partial discharge mechanisms, integrated sensors capture multi-source signals, time-frequency analysis enhances feature extraction and deep learning boosts defect recognition. All the efforts are pushing PD detection technology to move further. The current Special Issue is focused on 'Advanced detection technology for partial discharge in gas insulated equipment', collecting cutting-edge research from related studies to advance the technology's practical application in gas insulated equipment partial discharge monitoring.

2 | Paper in the Special Issue

In this Special Issue, the four eventually accepted papers can be clustered into three main categories. The papers in the first category focus on addressing partial discharge challenges in gas-insulated switchgear (GIS), such as electric field distortion caused by insulation defects and enhancement of partial discharge

detection reliability. The papers in this category are by Gao et al. and Chen et al. The second category offers a solution for recognizing multiple partial discharge sources in switchgear. The paper is by Wang et al. The last category focuses on solving noise interference in converter valve discharge localization to realize accurate positioning. The paper is by Pei et al. A brief presentation of each paper in this special issue follows.

Gao et al. introduce a study on GIS with metal tip defects, integrating multi-physical field coupling simulation and partial discharge experiments. The work involves a 252-kV GIS finite element model considering material-temperature relationships and a metal tip defect model with three structural parameters. A neural network-like analysis explores how defect location and parameters affect electric field distribution, showing that metal tip defects drastically boost field distortion. A UHF-based partial discharge platform verifies the simulation model. This research will advance next-generation GIS insulation defect management and guide GIS manufacturing.

Wang et al. present a method for recognizing multiple partial discharge sources in switchgear by integrating the Generalized S-Transform (GST) with the ResNet-18 network. The work involves a transient earth voltage detection platform, seven typical partial discharge source models and GST for time-frequency analysis—GST shows better resolution than other common methods. ResNet-18 classifies GST-derived images, achieving 99.41% test accuracy and outperforming other models. This research will advance switchgear multi-partial discharge source recognition and guide-related fault diagnosis.

Chen et al. conduct a study on GIS partial discharge detection, focusing on an integrated ultrahigh frequency (UHF) and optical

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sensor. A minimally invasive sensor integrating UHF and detachable optical sensing units has been presented and evaluated. The sensor's performance is assessed through experiments on a 500-kV GIS test platform featuring three typical partial discharge defects. Experiments show the sensor detects partial discharge signals with a minimum apparent charge below 2 pC, while UHF and optical signals have distinct characteristics. This research supports reliable GIS partial discharge detection and optimizes optical sensing applications.

Pei et al. propose an IVMD-MUSIC algorithm for accurate converter valve discharge localization in high-noise environments. The method combines improved variational mode decomposition with spatial spectrum estimation, effectively suppressing interference through adaptive parameter selection. Experimental results show angular errors below 1.8° for multiple discharge types, maintaining robust performance even at -20 dB SNR. A practical eight-element sensor array device has been developed, enabling real-time discharge monitoring and providing reliable technical support for fault diagnosis in HVDC systems.

3 | Summary

The selected papers demonstrate significant advancements in partial discharge detection for gas-insulated equipment. Key innovations include multi-physics coupling simulation, multimodal sensor fusion and intelligent algorithms. These technologies improve detection accuracy and localization, promising more reliable condition monitoring and fault diagnosis in power systems.

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Guest Editor Biographies



Li Simeng, associate professor of the School of Electrical Engineering, Xi'an Jiaotong University, Ph.D., master's supervisor. He mainly engaged in high voltage insulation and testing, intelligent sensing and fault diagnosis of electrical equipment, active protection of power system and other research. He has presided over several national and provincial projects, and more than 10 projects from national leading enterprises. His research results have been applied in many national major projects such as UHV power grid. He has published nearly 20 papers in high-level journals at home and abroad, and is a member of the editorial board and special editor of many international and domestic journals. He has authorized several invention patents, won the second prize of the Electric Power Science Innovation Award of China Electricity Council, and edited a monograph.



Han Xutao, assistant professor and doctor of the School of Electrical Engineering, Xi'an Jiaotong University. Mainly engaged in research on the mechanism and detection diagnosis of partial discharge characteristics of electrical equipment. He has presided over one National Natural Science Foundation project, one provincial and ministerial level project, two State Key Laboratory fund projects, and more than 10 projects from the State Grid Corporation of China and aerospace enterprises. He has published nearly 20 papers in high-level journals at home and abroad, authorized several national invention patents, won one Ningxia Foreign Science and Technology Cooperation Award, one second prize of China Electricity Council Electric Power Science and Technology Innovation Award, and one second prize of China Electric Power Construction Enterprise Association Electric Power Construction Science and Technology Progress Award.



Guo Ruochen, scientist in high voltage physics at Hitachi Energy Research, Sweden. Dr. Ruochen Guo got his Ph.D. in Electrical Engineering from Xi'an Jiaotong University in 2022. From 2021 to 2022, he was a guest Ph.D. researcher at KTH Royal Institute of Technology in the area of Applied Physics in Electrotechnology. From 2023 to 2024, he was a Research Fellow in High Voltage Technology Group at Delft University of Technology in the Netherlands. He is IEEE Member and IEEE DEIS Young Professionals Committee Member. He was awarded as Wiley Outstanding Open Science Author in 2022. He is also a reviewer of 6 IEEE and IET journals. His research interest is High Voltage Physics, Electric Aircraft and New Types of Test Method for Electrical Equipment. Currently, He is working on future innovative HV system design and HVDC products in Hitachi Energy Research.