

CIGRE Study committee D1

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG D1.83

NAME OF THE CONVENOR

Ju Dengfeng (CHINA)

TITLE

Optical Spectral Sensing Technologies for Partial Discharge (PD) and Arc Detection in Gas-Insulated Equipment

THE WG APPLIES TO DISTRIBUTION NETWORKS: YES

ENERGY TRANSITION

3 / Digitalization
4 / Sustainability and Climate Change

POTENTIAL BENEFIT OF WG WORK

2 / potential interest from a wide range of stakeholders
3 / likely to contribute to new or revised industry standards
4 / state-of-the-art or innovative solutions or directions

STRATEGIC DIRECTION

1 / The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-of-the-art technological advances

SUSTAINABLE DEVELOPMENT GOAL

9 / Industry, innovation and infrastructure

BACKGROUND :

Partial Discharge Monitoring (PDM) in power equipment is an important technology to support reliable operation, with detection methods relying on physical phenomena (electrical, acoustic or optical) generated during PD. However, decades of field applications have revealed that single-modality detection technologies (e.g., electromagnetic wave or ultrasonic-based systems) excel at identifying typical severe discharges but struggle in substations with complex electromagnetic interference. These technologies face dual challenges: enhancing sensitivity while overcoming interference.

Recent advancements in optoelectronic materials, particularly the significant sensitivity improvement of silicon-based semiconductor optoelectronic devices, have enabled the emergence of ultraviolet (UV) spectral band optical sensing for PD in equipment (e.g. GIS, gas-filled cable terminations, gas-filled transformers, or metal-clad switchgear). Institutions such as Technical University of Darmstadt (Germany), Technical University of Berlin (Germany), China Electric Power Research Institute (CEPRI), and Shanghai Jiao Tong University (China) have conducted research and field trials in the application of optical PD detection systems in transmission projects. Major European grid technology suppliers have applied optical arc detection systems for fault localization in gas-filled equipment. Distinct from established electrical PD detection methods, optical technology can offer novel detection pathways with advantages in sensing sensitivity, detection efficiency, and electromagnetic interference immunity, depending on the type and the location of a defect. It also enables miniaturized in-situ sensing for electrical equipment, demonstrating substantial potential in gas-insulated systems. However, practical application guidelines remain insufficient.

The working group will focus on optical spectral sensing technologies for gas-filled equipment. Its activities will include examining technical approaches, assessing the applicability of these technologies for partial discharge (PD) and/or arc fault detection, consolidating practical knowledge suitable for field deployment, and characterizing user requirements related to installation and operation.

PURPOSE / OBJECTIVE / BENEFIT OF THIS WORK :

This work aims to summarize the application potential of optical spectral sensing technologies for partial discharge (PD) and/or arc fault in the power industry, outline methods for installation, data acquisition, and data analysis, and elaborate on the opportunities and limitations of the technology. This work also includes comparative experimental studies with conventional PD and arc fault detection technologies.

SCOPE :

The working group will investigate and report on:

1. **State-of-the-Art Review:** Comprehensive analysis of optical spectral sensing technologies for PD detection and arc fault localization in gas-filled equipment or metal-clad switchgear.
2. **System Architecture:** Composition and characteristics of optical systems for gas-insulated equipment, particularly arc detection and PD detection systems, including light guiding components, photodetectors (e.g., Avalanche Photodiode (APD), Silicon Photomultiplier (SiPM/MCCP)), data acquisition units, and analytical modules.
3. **Photodetectors Survey:** Classification, performance metrics, and applications of key sensing components, with detailed discussions on APD/SiPM technologies.
4. **Sensitivity verification:** Proposal of routine and on-site deployment testing procedures for optical sensors.
5. **Diagnostic Methods:** Spectrogram-based PD diagnosis, defect characteristic analysis, fault localization techniques, and comparative studies with established electric (IEC 60270, UHF) and acoustic PD detection methods.

DELIVERABLES AND EVENTS

Deliverables Types

Annual progress and activity report to Study Committee
Technical Brochure and Executive Summary in Electra
Tutorial
Webinar

Time schedule

- | | | |
|----|------|---|
| Q4 | 2025 | Recruit members (National Committees, Wie, NGN) |
| Q2 | 2026 | Develop final work plan |
| Q4 | 2027 | Draft TB for Study Committee Review |
| Q4 | 2028 | Final TB |
| Q4 | 2028 | Webinar |

APPROVAL BY TECHNICAL COUNCIL CHAIRMAN:

Rannveig Loken
November 06th, 2025