ABB Ability™ Condition Monitoring for switchgear

PDCOM partial discharge monitoring of SWICOM system
Partial Discharge

01. What is Partial Discharge?
02. Where do they occur?
03. Effects of Partial Discharge
04. How to measure Partial Discharge?
Partial Discharge
What is Partial Discharge?

**Partial Discharge**: umbrella term for a number of related phenomena, which are still different in the physical details.

Common to all phenomena is a **local breakdown** in a part of the electrical installation.

The local breakdown is not able to bridge the full distance between two electrodes or between electrode and ground.

IEC 60270 defines the term “partial discharge” as:
“a localized electrical discharge that only partially bridges the insulation between conductors and which can or can not occur adjacent to a conductor.”

Where do PD occur in Medium Voltage equipment?
Where do PD occur?

Medium voltage

Where do PD occur in Medium Voltage equipment?

- Around an electrode in gas (air) – “corona”
- On the surface of insulating parts
- Inside components insulation – delamination – voids
Partial Discharge phenomena
Examples, metal parts discoloration, surface tracking, insulation whitish traces

Physical signs of pd
- Odor (smell) of Ozone
- Burning wire Odor
- Metallic
- Discolored trails/lines
- Carbon tracks
Effects of Partial Discharge

In case of a flash over

- Serious safety implications
- Collateral damage
- Major disruption
- Human lives at stake
- Economical loss
Partial Discharge phenomena

Effects
Why measure PD?
Statistical data

Partial discharge plays a role in insulation failure

- in high-voltage:
  up to 95% [IEEE Gold book]

- in medium-voltage:
  ca. 85% [ea. technology]

Data for UK

- Mechanical
- VT
- Discharge
- Maloperaton
- Vacuum
- Cable Box
- Lighting
- CT
- Water

- 30%
- 26%
- 11%
- 9%
- 8%
- 6%
- 6%
- 3%
- 1%
Measurement techniques

Different sensing approaches

Partial Discharges can be detected and measured using several measurement approaches.

The choice of the method depends often strongly on the environment, the type of installation tested, etc.

Type of PD measurement systems:
- Classical PD Lab system
- Monitoring in the field
- Temporary measurement in the field
- Diagnostic tests
Methodology according to application
Many basic measurement principles

In lab setup the direct measurement techniques are mostly used
- Direct access to the high voltage
- Simple relation towards the physical phenomena, direct measurement of (apparent) charge

In the field the indirect methods are more common
- No access to the high voltage required
- Suitable in case of temporary measurement
01. Measuring principle
PDCOM measurement principle

Capacitive measurement principle

- PDCOM is based on the capacitive measurement principle
- Advantage:
  - Direct measurement, higher sensitivity possible
  - Measurement of the line voltage to acquire phase information
  - Long-range measurement across different panels
  - Close to standardized approach in normal testing
  - Three-phase system to identify problematic phase
  - Possibility to use calibrated values
Easy to install in green and brown field application

Reuse of the existing VIS coupler

- 10 panels require only one PDCOM
- Cost effective solution
- In order to simplify the PDCOM system, an existing VIS coupler can be reused
- The installation kit is a simple splitter with a built-in failsafe mechanism
- The measurement impedance is built into the PDCOM system
- Three phases are measured both at high-frequency (PD) and power frequency for phase reference
PDCOM “PD detector” of SWICOM system

IEC 60270 defines quantities related to partial discharge pulses analysis

**Global:** mainly $Q_{IEC}$
- Largest repeatedly occurring apparent charge
- Weighted expression, taking into account strength and frequency

**Phase resolved analysis:** Allows for a detailed analysis, which can be used to identify the type of discharge

**PDCOM Methodology:**

- $Q_{IEC}$: largest repeatedly occurring PD (apparent charge) amplitude (IEC 60270)
- $Q_{IEC}$ gradient
- Pulse rate
- SWICOM provides alert indication for further off-line investigation
01. Short introduction to IEC 60270 Partial Discharge

02. PDCOM KPI
PD measurements

Peak discharge magnitude

IEC 60270: 3.4 largest repeatedly occurring PD magnitude

Largest magnitude recorded by a measuring system which has the pulse train response as specified in 4.3.3. The concept of the largest repeatedly occurring PD magnitude is not applicable to tests with direct voltage.

IEC 60270: 3.5 specified partial discharge magnitude

Largest magnitude of any quantity related to PD pulses permitted in a test object at a specified voltage following a specified conditioning and test procedure. For alternating voltage tests, the specified magnitude of the apparent charge $q$ is the largest repeatedly occurring PD magnitude.

$$\rightarrow \text{Peak discharge magnitude: } q_{\text{max}} = \max(q_1, \ldots, q_M)$$

where $M$ is the number of discharges during the measuring interval $\Delta t$.
PD measurements
Repetition Rate

IEC 60270: 4.5.2 Instruments for the measurement of pulse repetition rate $n$

An instrument for the determination of the pulse repetition rate shall have a sufficiently short pulse resolution time $T_r$ to resolve the highest pulse repetition rate of interest. Magnitude discriminators which suppress pulses below an adjustable, predetermined magnitude, may be required to avoid counting of non-significant signals. Several discriminator levels can be suitable to characterize PD, for example, in tests with direct voltage.

It is recommended that the counter input is connected to the output of a PD measuring system as described in 4.3. If a pulse counter is used with a PD measuring system with oscillatory or bi-directional response, suitable pulse shaping must be done to avoid obtaining more than one count per pulse.

$$\rightarrow n = \frac{M}{\Delta t}$$

where $M$ is the number of discharges during the measuring interval $\Delta t$
PDCOM Signal Processing and Base KPIs

“PDLIKE” Signal

- A number of basic KPIs is calculated from the list of PD events
- QIEC (corresponds to “largest repeatably occurring PD discharge magnitude)
- Pulse rate
- In online application distinguishing PD from external disturbances is an important task
- The avoidance of false alarm is critical
- Therefore, PDCOM uses a PDLIKE-signal approach to detect specific features that are strong indicators of the presence of a real PD event
- Several features of the signal are combined that are looking at specific properties of a PD signal
SWICOM Aggregation and Time Series Analysis

Beyond the base KPIs

SWICOM collects the data and makes them available in a compressed form as a time series

- PDCOM is produces KPIs every five minutes based on the data acquired during that period
- PDCOM calculates base KPIs (Signals) at fixe time intervals
- SWICOM computes PDLIKE as instantaneous logical signal
- Measurements are compressed time series of PDevents, predominantly used for display
- Indicators are logical values used as input for the alert system (also for display)
- The alert system convert the indicators to two levels of alert warning and alarms
PDCOM Signal Processing and Base KPIs
Phase-Resolved Partial Discharge Pattern

- One of the most common approaches to judge the PD event is through the Phase-Resolved Partial Discharge Pattern
- Is a 2D histogram of phase position vs strength
- Can be plotted in different ways: scatter plot, density plot
- PDCOM is foreseen to provide in addition PRPD pattern
- The possibility of getting this is one of the major advantages of a capacitive measurement approach
01. Monitoring and diagnostic Eco-System
Available offerings

1. Breaker monitoring through Relion relays
2. Partial Discharge detection through PDCOM
   a) Capacitive coupling methodology
   b) Most cost-effective PD solution available in the market (1 PDCOM for up to 10 panels)
   c) Suitable for IEC and ANSI, AIS and GIS, ABB and non-ABB, green and brown field switchgear
   d) UHF possible in case coupler are not present
3. Wireless Temperature monitoring
   a) Suitable for IEC and ANSI, AIS and GIS-(cables), ABB and non-ABB, green and brown field switchgear
4. Data visualization
   a) SCADA
   b) MyRemoteCare Cloud
   c) Local HMI/Mobile APP
Different sensor connection

- IEC61850
- ModBus
- CAN Bus

- REF615
- SWICOM
- PDCOM
- Temperature reader

VIS Interface
Why ABB
Technical advantages

One integrator for sensors which gives overall health

First to propose partial discharge detection through a cost effective solution accessible for everyone
Balance between costs and benefits, with a competitive price

Breaker diagnostic without any additional sensor
We are the forefront in our sector, using protection relays already installed in the switchgear

Wireless sensors and without batteries
Lifecycle up to 30 years
Inspection free (every 15 years)