ELECTRIFICATION – DISTRIBUTION SOLUTIONS BUSINESS LINE, 2021

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

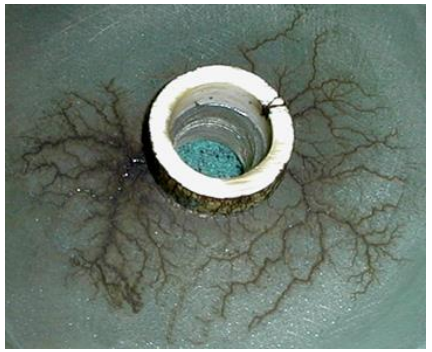
The local breakdown is not able to bridge the full distance between two electrodes or between electrode and ground

IEC 60270 defines the term “partial discharge” as:

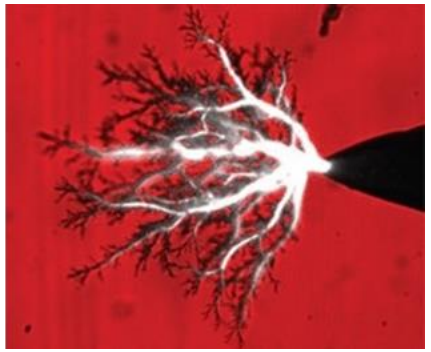
“a localized electrical discharge that only partially bridges the insulation between conductors and which can or can not occur adjacent to a conductor”

Where do PD occur in Medium Voltage equipment?

[Manning0225, CC A-SA3.0]



[Bert Hickman, CC A-SA3.5]



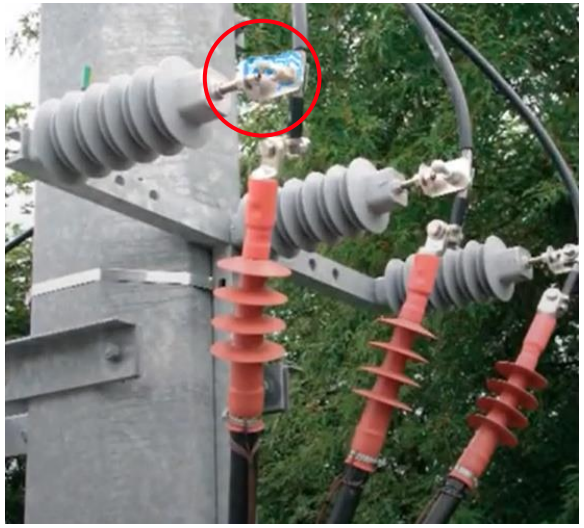
[S. Dodd, U Leicester]

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

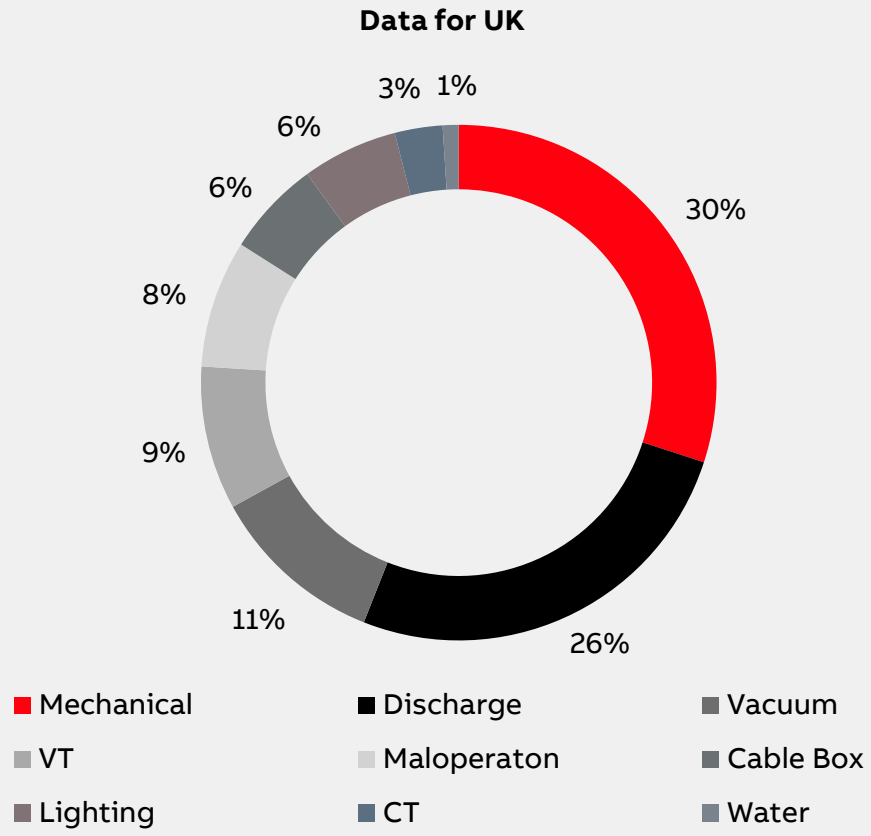
Effects

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]



Measurement techniques

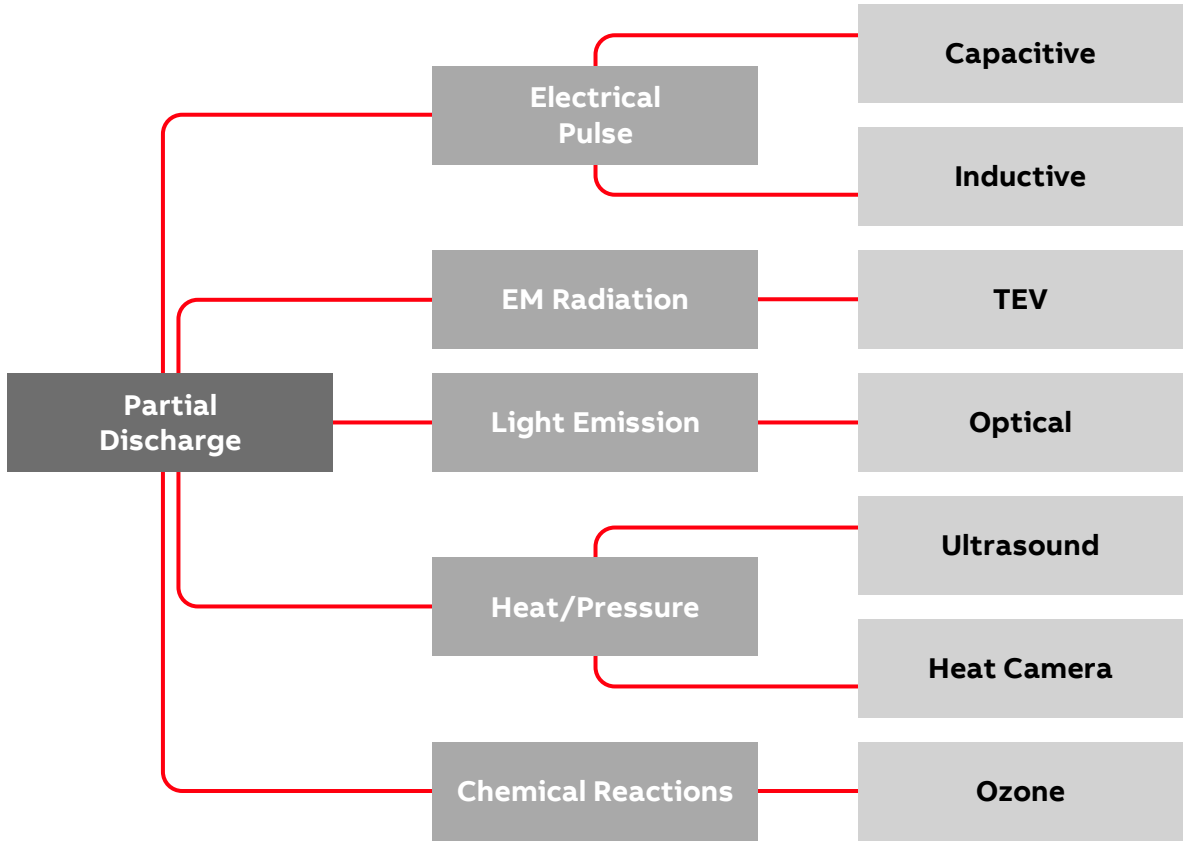
Different sensing approaches

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

High Voltage

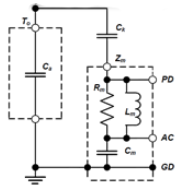
Ground

Inductive

Chemical

Optical

Acoustic



Capacitive

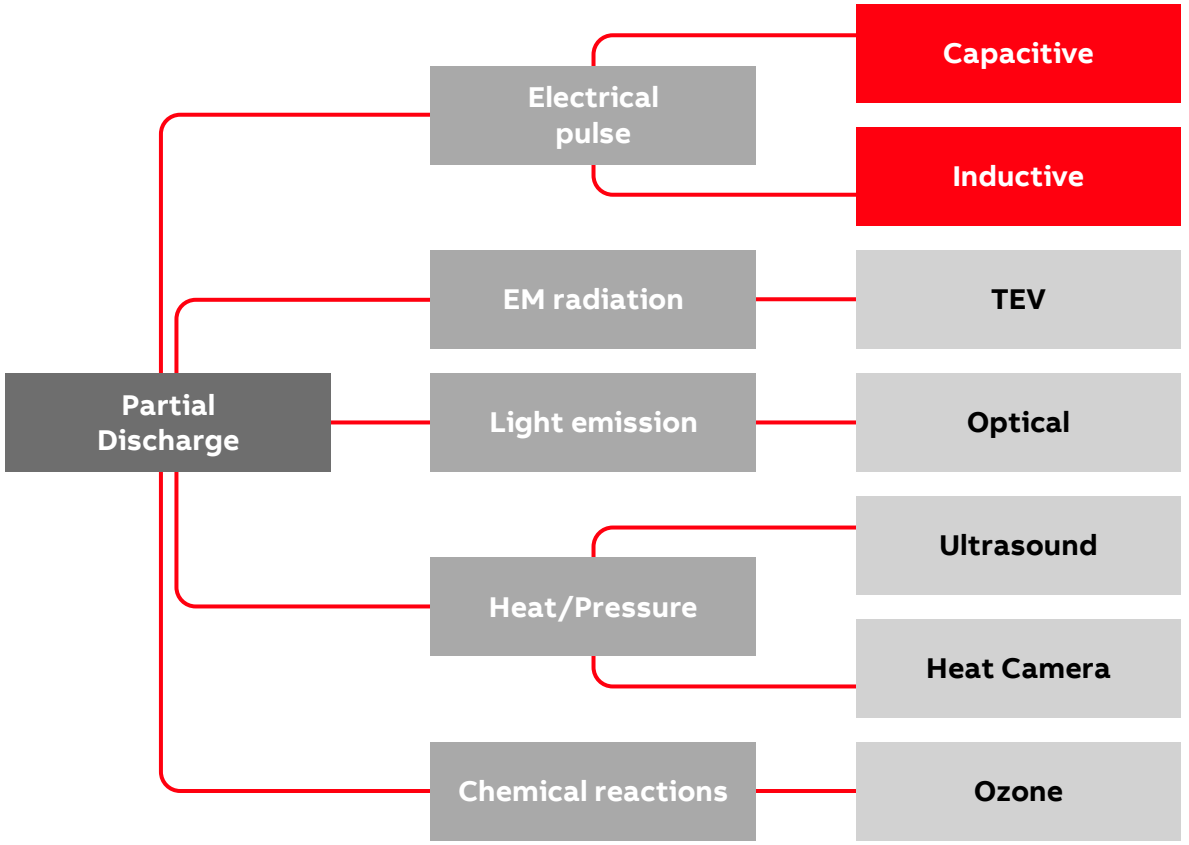
PDCOM

01. Measuring principle

PDCOM measurement principle

Capacitive measurement principle

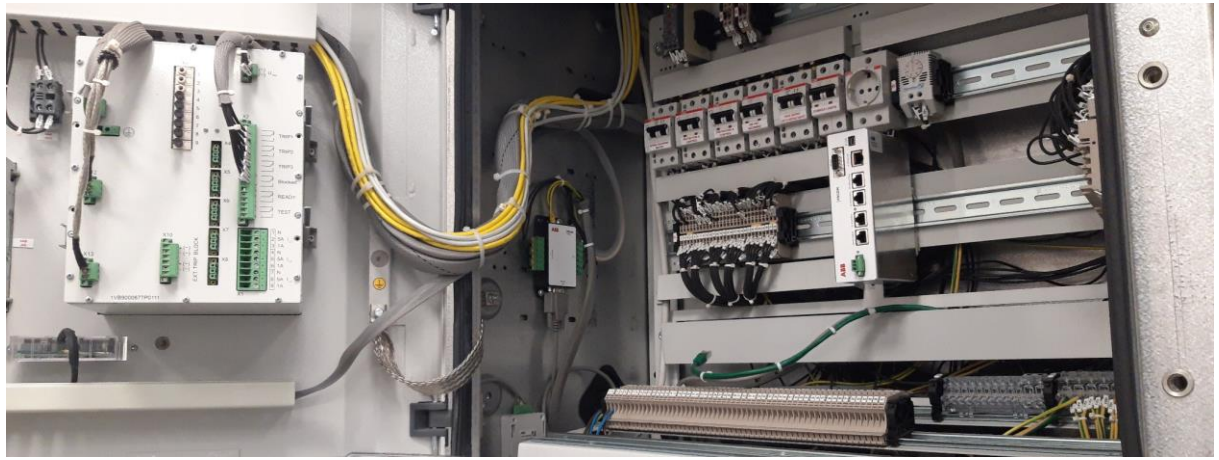
- PDCOM is based on the capacitive measurement principle
- Advantage:
  - Direct measurement, higher sensitivity possible
  - Measurement of the line voltage to acquire phase information
  - Long-range measurement across different panels
  - Close to standardized approach in normal testing
  - three-phase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

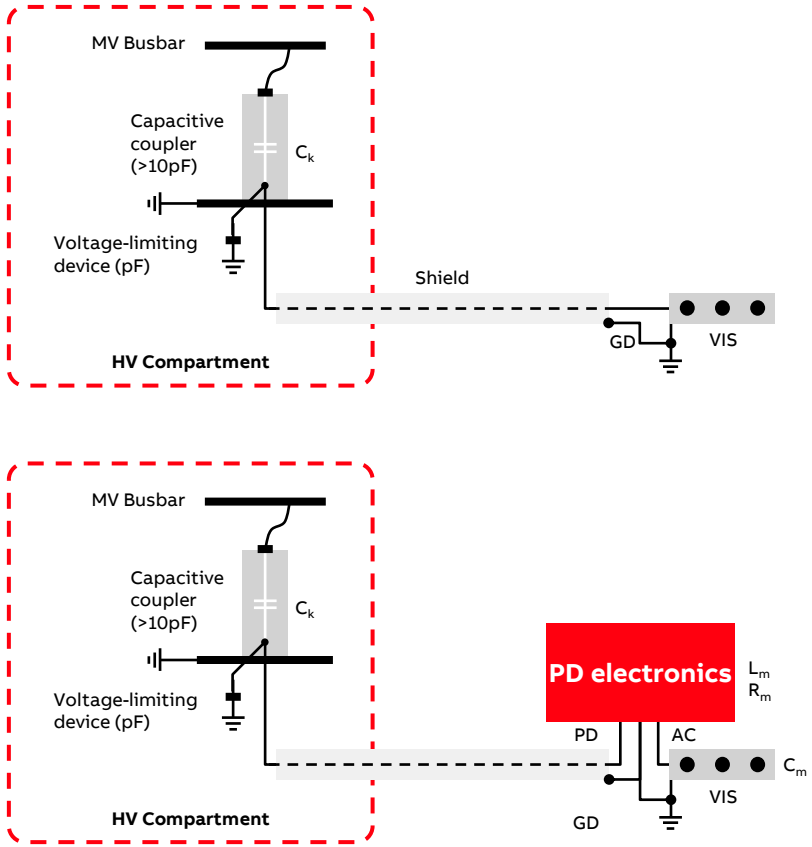


Easy to install in green and brown field application

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

Indicator

PDCOM “PD detector” of SWICOM system

IEC 60270 defines quantities related to partial discharge pulses analysis

Global: mainly Q_{IEC}

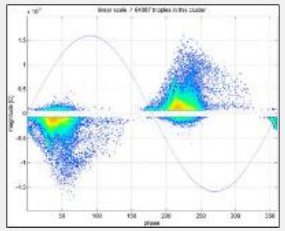
- Largest repeatedly occurring apparent charge
- Weighted expression, taking into account strength and frequency

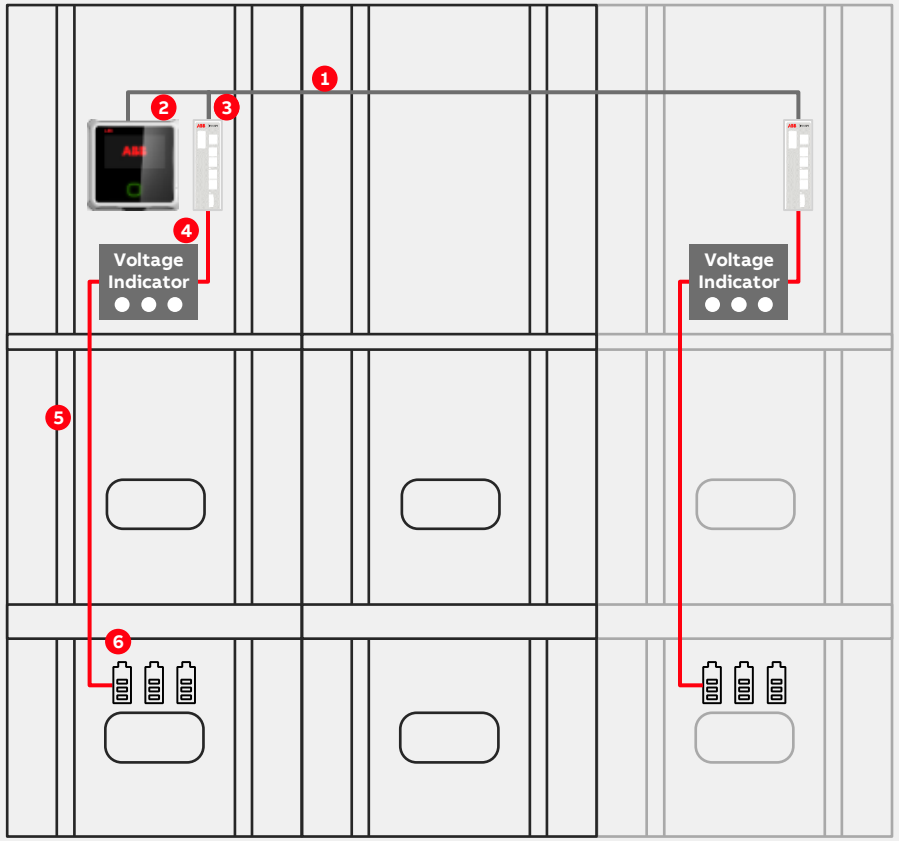
Phase resolved analysis: Allows for a detailed analysis, which can be used to identify the type of discharge

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





1. CANBUS
2. SWICOM
3. PDCOM
4. VIS
5. Existing wiring
6. Cap. Coupl.

PDCOM

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**

⟶ Peak discharge magnitude: $q_{max} = \max(q_1 \dots q_M)$

where M is the number of discharges during the measuring interval Δt

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

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

where M is the number of discharges during the measuring interval Δt

PDCOM Signal Processing and Base KPIs

“PDLIKE” Signal

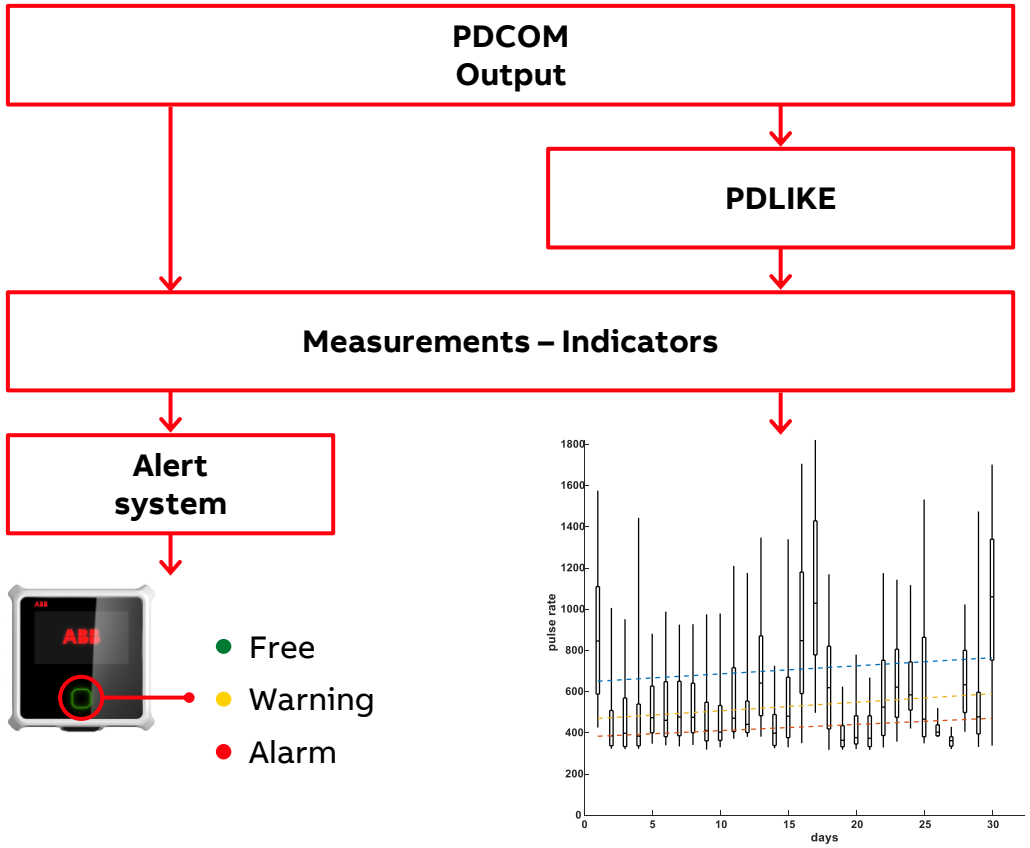
- A number of basic KPIs is calculated from the list of PD events
- QIEC (corresponds to “largest repeatably occurring PD discharge magnitude)
- Pulse rate
- In online application distinguishing PD from external disturbances is an important task
- The avoidance of false alarm is critical
- Therefore, 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

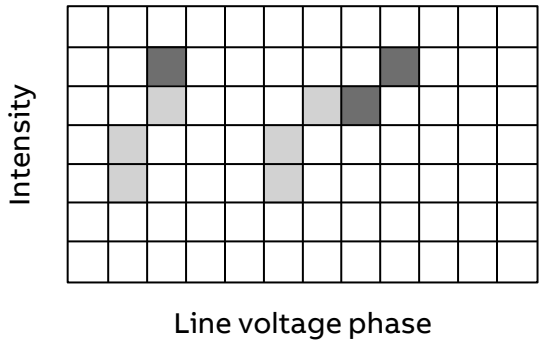
- PDCOM is produces KPIs every five minutes based on the data acquired during that period
- PDCOM calculates base KPIs (Signals) at fixe time intervals
- SWICOM computes PDLIKE as instantaneous logical signal
- Measurements are compressed time series of PDevents, predominantly used for display
- Indicators 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

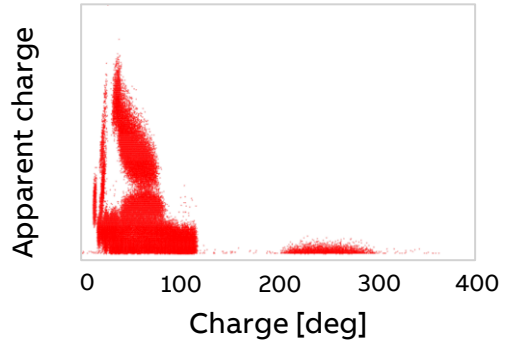


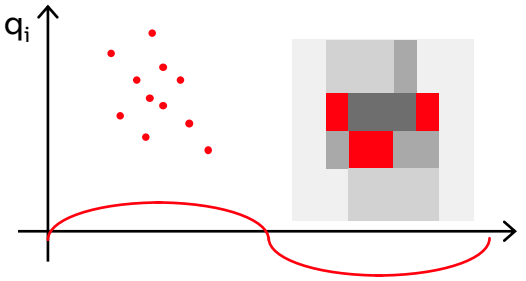
PDCOM Signal Processing and Base KPIs

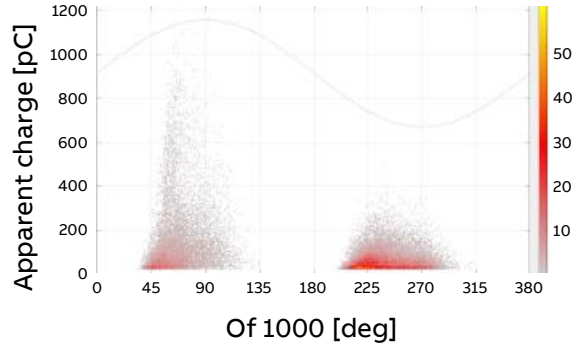
Phase-Resolved Partial Discharge Pattern

- 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







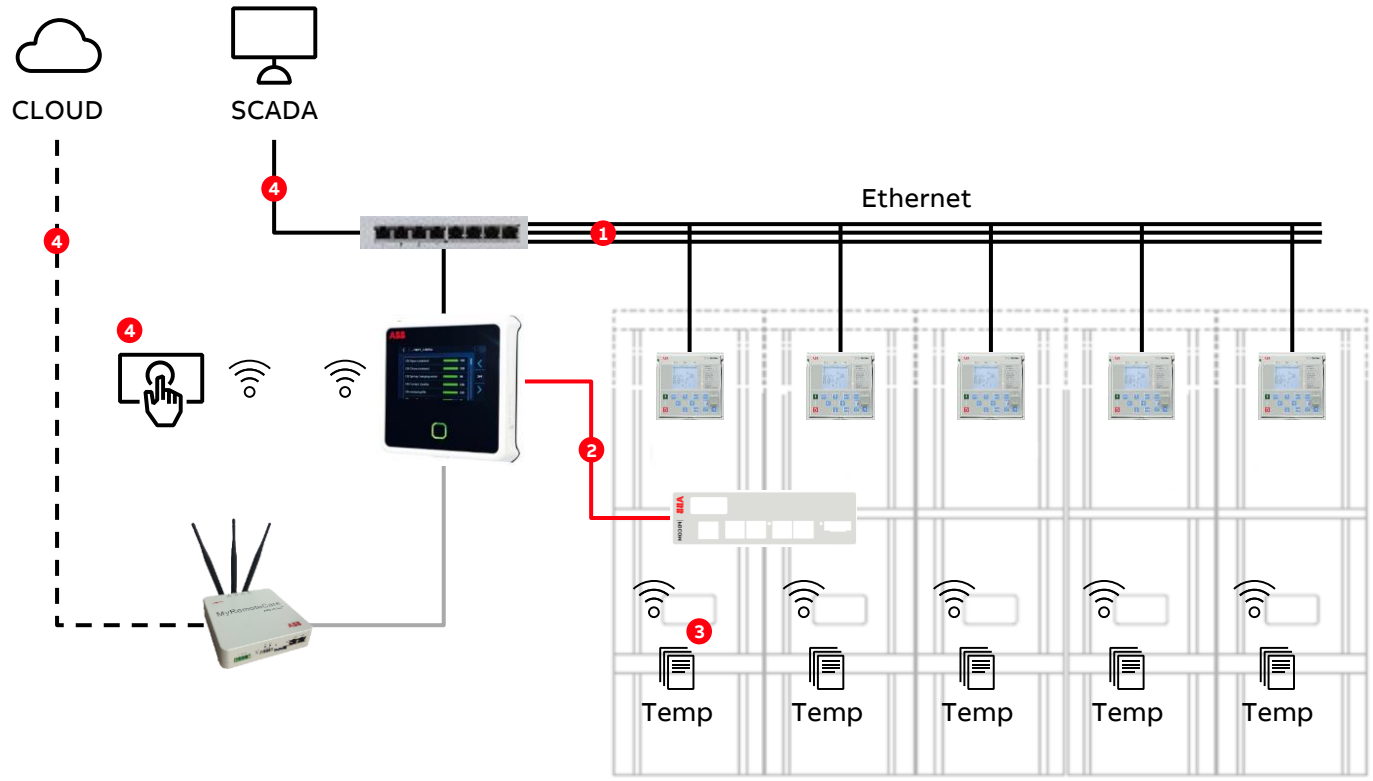


SWICOM

01. Monitoring and diagnostic Eco-System

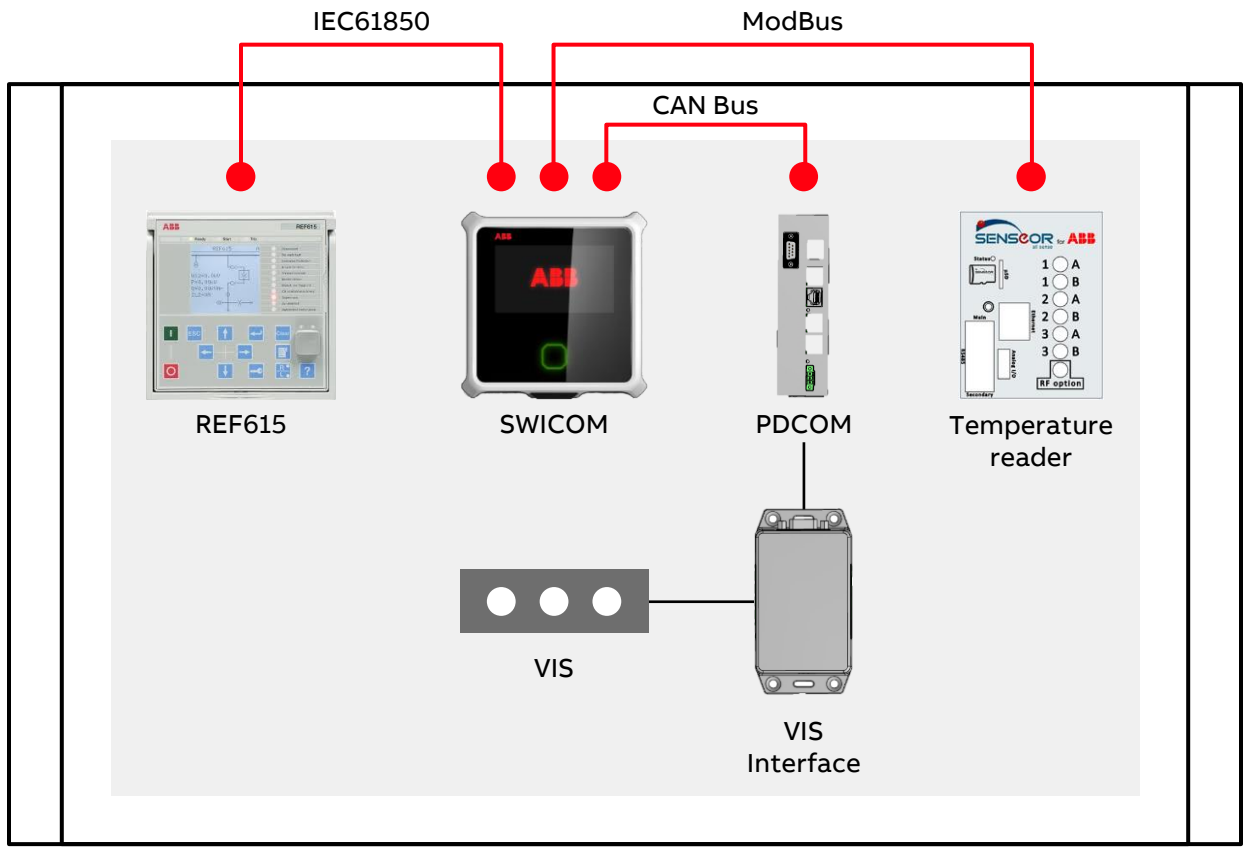
Available offerings

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



MV Switchgear monitoring & diagnostic

Different sensor connection



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

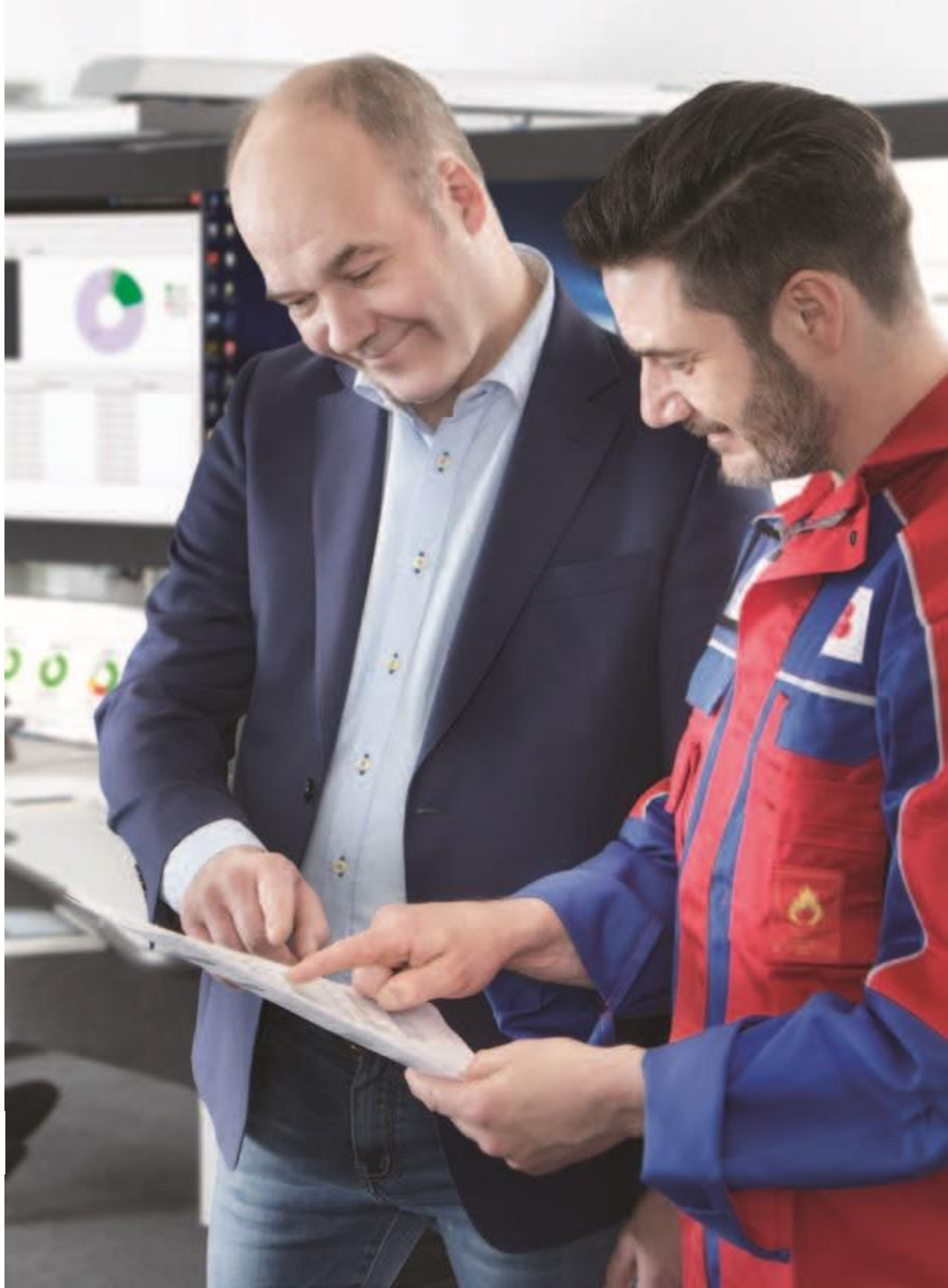
Balance between costs and benefits, with a competitive price

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)

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