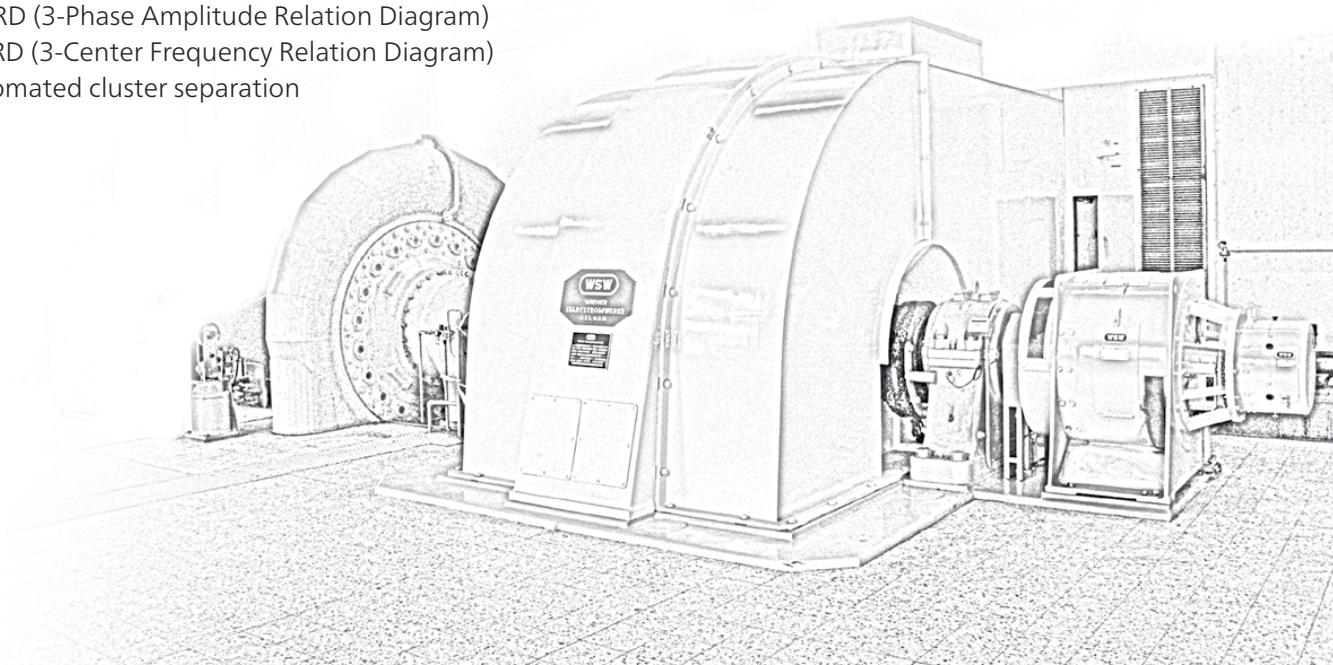
Partial Discharge Measurement on Rotating Machines

Partial discharge (PD) is a reliable parameter to assess the condition of insulation in rotating electrical machines. Partial discharges are electromagnetic impulses that occur in the insulation system of rotating machines, where the local electric field stress exceeds the local electrical strength. Depending on the type of PD activity, its appearance in correlation with the high-voltage signal allows an identification what kind of defect is present.

PD measurement is the only method that can differentiate between the different defects in the high-voltage insulation system without dismantling the machine. Even single faults within the insulation system can be identified and classified according to their criticality. With this information, potential weak spots can be identified long before they become a critical issue.

As the single phenomena have to be identified, a successful PD measurement in stator windings is based on the separation of the PD sources that often occur in parallel. They can either be harmful PD or normal PD occurrences and potential external noise. To achieve this PD source separation, the following techniques are applied:

- Synchronous multi-channel data acquisition
- Advanced noise suppression
- Source separation techniques:
  - 3PARD (3-Phase Amplitude Relation Diagram)
  - 3CFRD (3-Center Frequency Relation Diagram)
  - Automated cluster separation



Depending on the accessibility of the start point, different measurement setups can be chosen. The basic measurement setup for a single-channel PD measurement is shown below in Figure 1. The voltage (value depending on the rating of the machine and the standard being referred to) is applied at the open star point. The measurements are performed phase-per-phase (here phase U1 as shown) where the non-measured terminals are grounded. This setup is as described in the IEC 60034-27 standard.

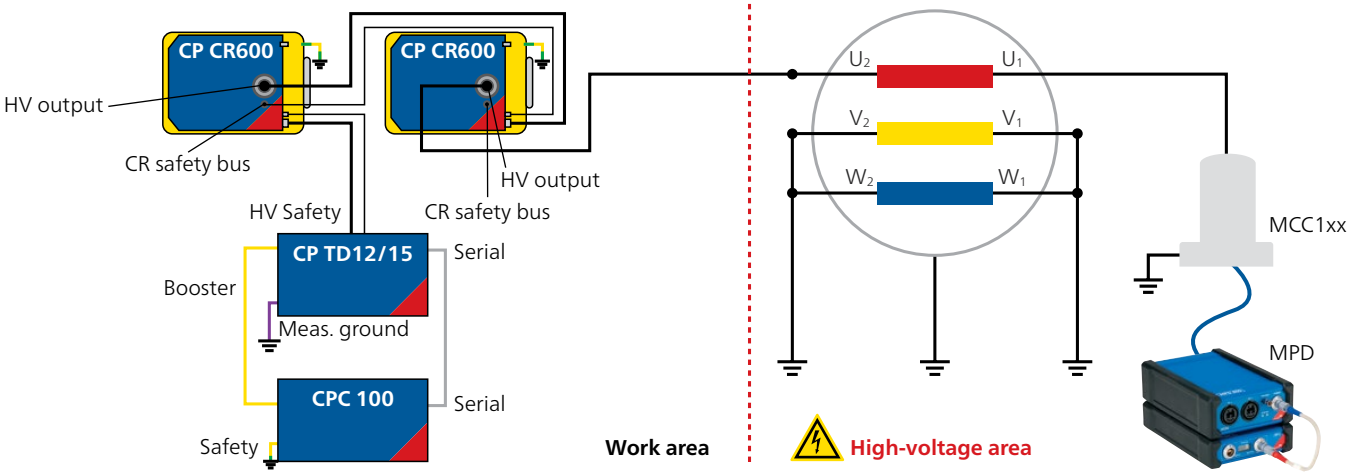


Figure 1: Basic setup for PD measurement on open star rotating machine

The measurement system setup can also be extended to get more information for an easier separation of potential multiple sources (Figure 2). The BLI on top of the coupling capacitor is used as a blocking impedance to filter undesired PD from the voltage supply (CP TD12/15) in the standard IEC measurement frequencies 100-400 kHz.

This measurement setup brings us many advantages, such as a lightweight and portable voltage source due to the compensation of the capacitive load, the possibility to measure C and PF/DF prior to the PD measurement without any additional setup effort, and a comprehensive information about the condition of the winding insulation.

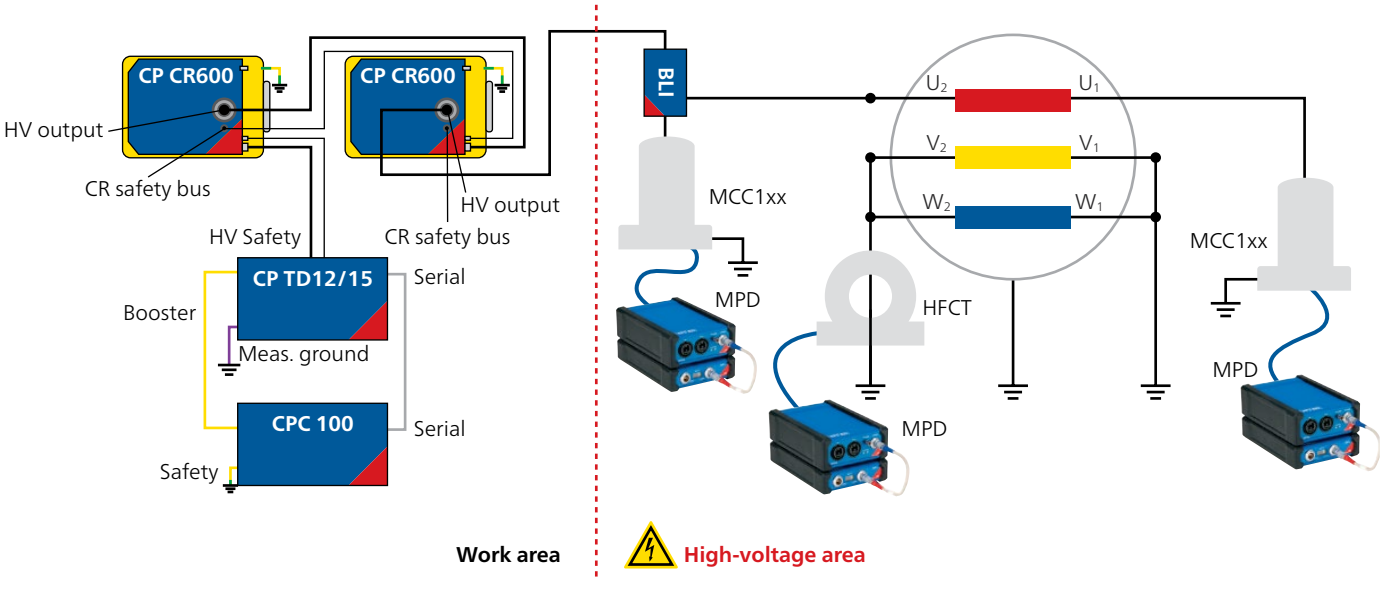


Figure 2: Multi-channel synchronous measurement on a rotating machine

Interpretation of the results

As mentioned above, the PD measurement can identify single insulation defects via the **P**hase **R**esolved **P**artial **D**ischarge diagram (PRPD diagram). How this works is explained in Figure 3, where two potential issues for rotating machine windings are displayed together with their correlating PRPD diagram.

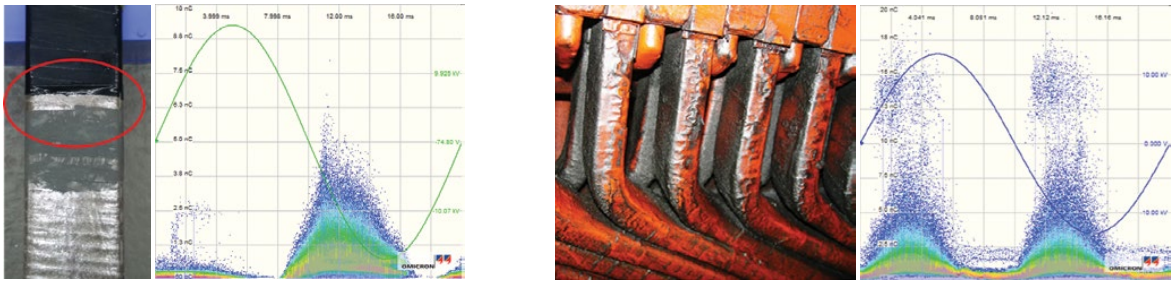


Figure 3: Potential issues in a rotating machine insulation system with correlating PRPD diagram. The left cause represents a disconnected end potential grading from the outer corona protection. The right one represents a polluted endwinding area and the resulting surfaces as well inter-phase discharges.

The shape of the different defects is known and verified by international publications and standards. For example, the IEC 60034-27-1 identifies the different phenomena and offers a risk assessment in its informative annex. State-of-the-art PD measurement software can identify the different phenomena and interpret them automatically. Figure 4 gives a summary about the different phenomena and their resulting PRPD patterns.

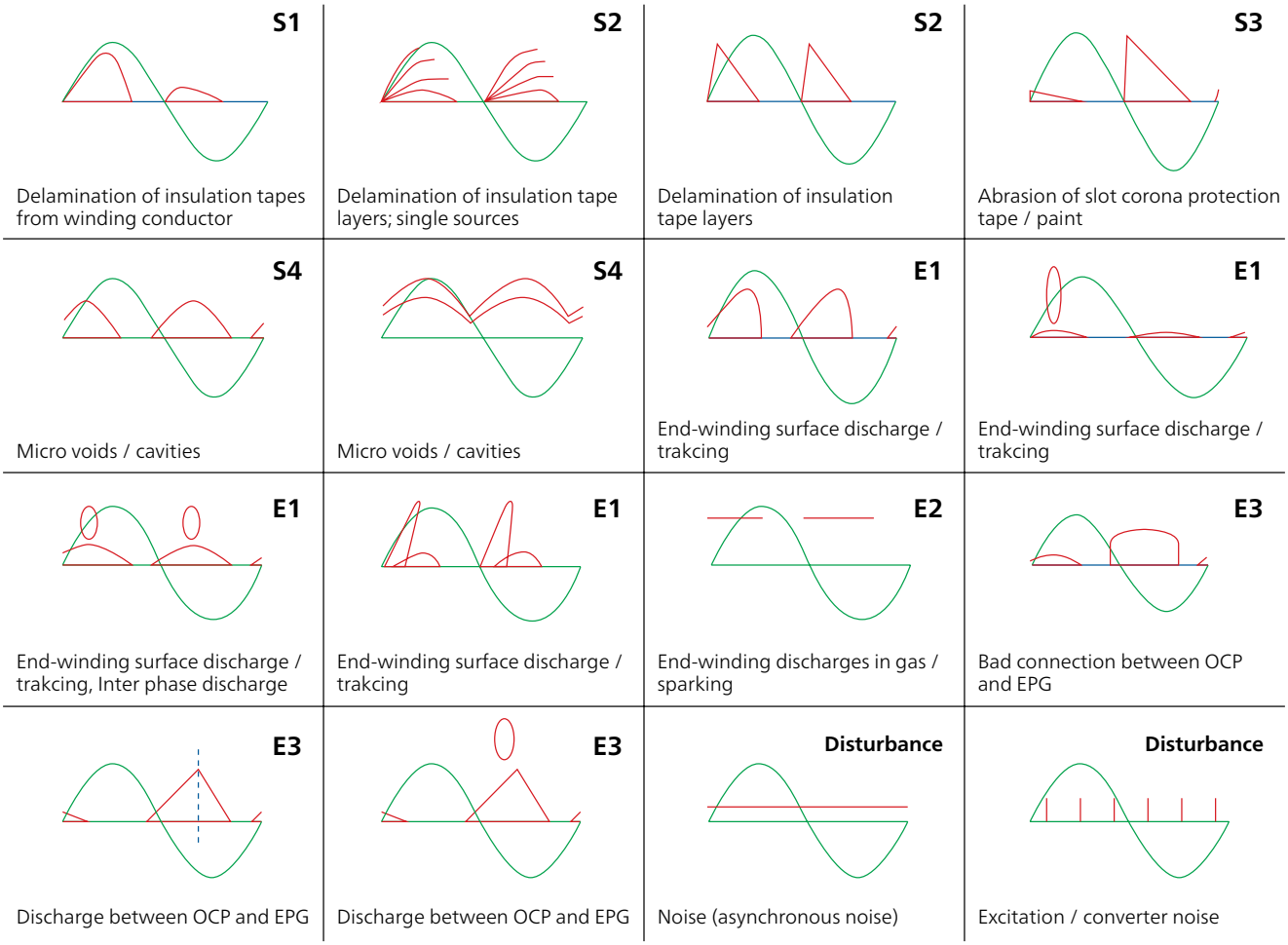


Figure 4: Different PD patterns and the correlating defects in rotating machines. They can be found in the IEC 60034-27-1 standard together with a risk assessment of their impact on insulation aging. While "S" indicates different issues in the winding, "E" stands for a problem in the end winding area.