On-line Partial Discharge Theory

1. What is Partial Discharge?

Partial Discharge (PD) is localized electrical discharge that only partially bridges the insulation (solid, oil, gas etc.) between conductors and which can or cannot occur adjacent to a conductor.

Partial discharges are in general a consequence of local electrical stress concentrations in the insulation or on the surface of the insulation. Generally, such discharges appear as pulses having a duration of much less than 1 μs as shown in Figure 1. (Reference: Standard IEC 60270)

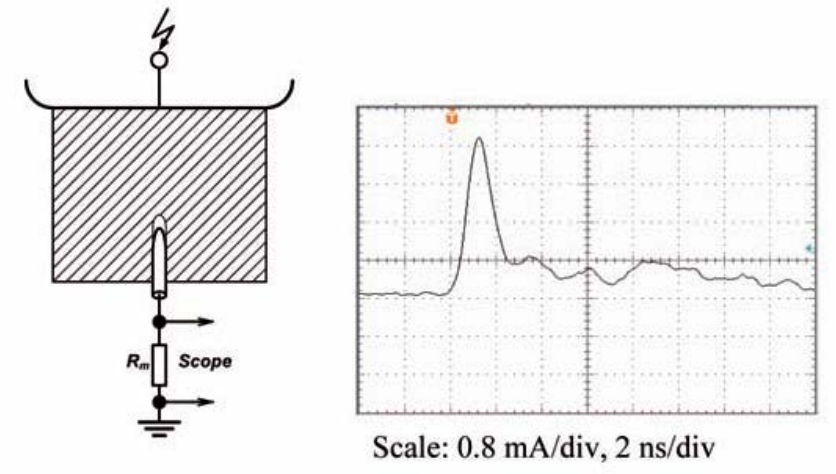

Figure 1. Example PD pulse in the insulation

2. How many types of PD?

There are 2 groups and 7 types of PD are shown in Figure 2 as follows:

1. Internal PD: void in insulation, sharp surface on conductor, tree growth in insulation.
2. External PD: floating metalwork near conductor, corona from sharp, discharges from induced voltage onto sharp point and surface discharge.

The internal PD is very serious more than external PD

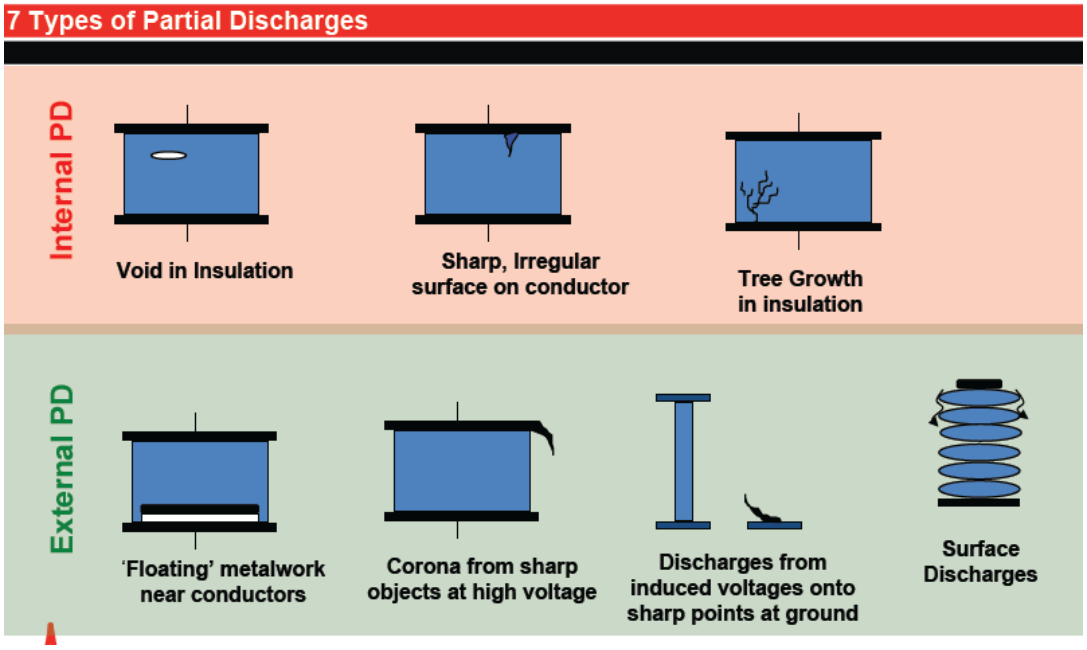

Figure 2. Types of PD

3. How to detect PD?

When insulation is degenerate or defect then the PD can be detected in a different way due to the fact that it generates certain reactions according to the insulation materials. The reactions of PD are released in electrical charge PD energy, acoustic PD energy, optical PD energy, electromagnetic PD energy and Chemical energy as shown in Figure 3. Therefore we can detect the reactions of PD energy by the sensors in Table 1.

Table 1.

Reaction of PD energy	Detection Sensor
Electrical Charge	HFCT(inductive), Coupling Capacitor
Acoustic	Airborne Acoustic Acoustic Emission
Electromagnetic	TEV,VHF,UHF
Optical PD	Visible Detector
Chemical	Dissolved Gas Analysis (DGA) Visual Inspection
Thermal	Thermal imager

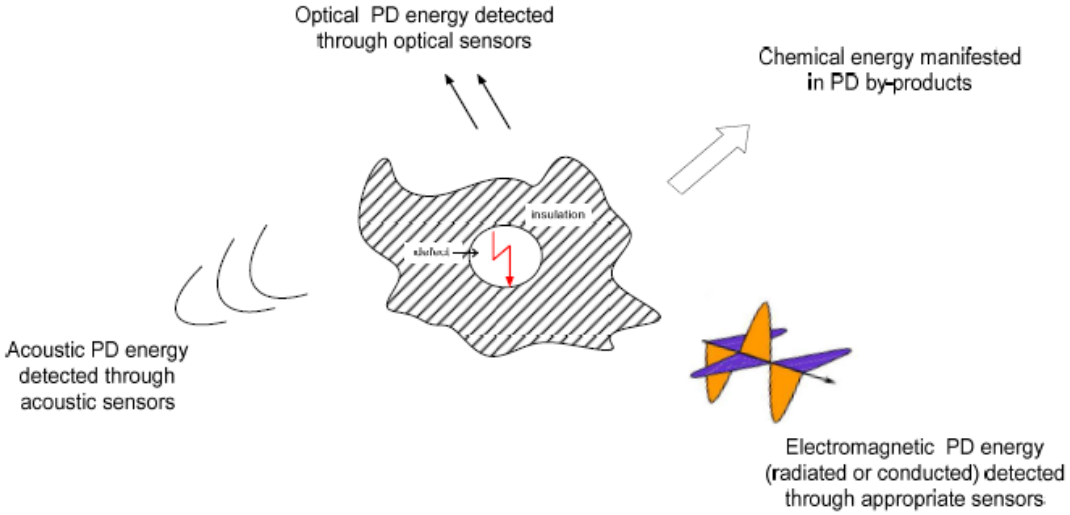

Figure 3. PD energy

4. On-line PD sensors

High Frequency Current Transformer sensor (HFCT. see Figure 4.)

This sensor is one of the most popular inductive sensors for all kind of applications on power system equipment. The HFCT is suitable to detect electrical charge which can be installed either around ground lead or directly around main conductor of the cable or high voltage equipment.

Figure 4. HFCT sensor

Transient Earth Voltage sensor (TEV, see Figure 5.)

TEV is a capacitive probe which can detect the current pulses traveling on the outer box surface. Indeed, when PD occur inside the tank, transient currents can be induced in the inner tank surface. The TEV sensor can detect electromagnetic emission as well. The frequency range is 4 MHz – 100 MHz (Very High Frequency/VHF).

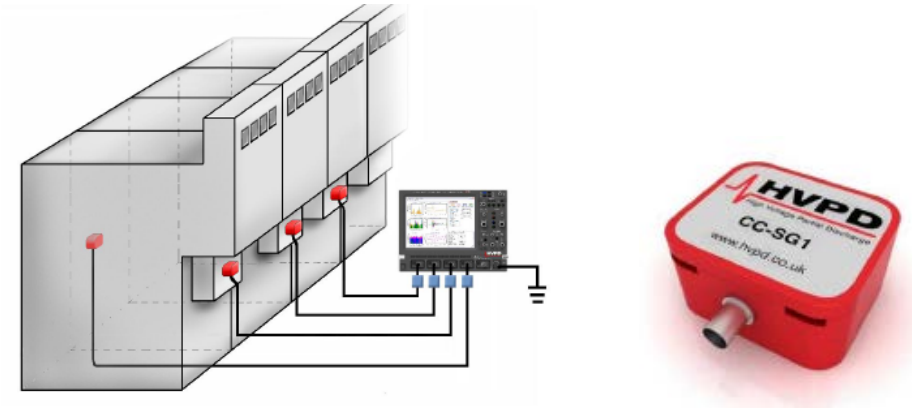

Figure 5. TEV sensor

Airborne Acoustic sensor (AA, see Figure 6, Figure 7.)

PD signals are generated by partial discharges into air and are detected using in 40 kHz airborne acoustic (ultrasonic) sensor. The Airborne Acoustic sensor is very useful when testing Air Insulated Switchgear and has been designed with high sensitivity to pick-up small discharges into air which are inaudible to the human ear. This sensor is suitable to detect external PD such as corona PD, surface discharge PD.

Figure 6. Airborne Acoustic sensor (AA) sensor

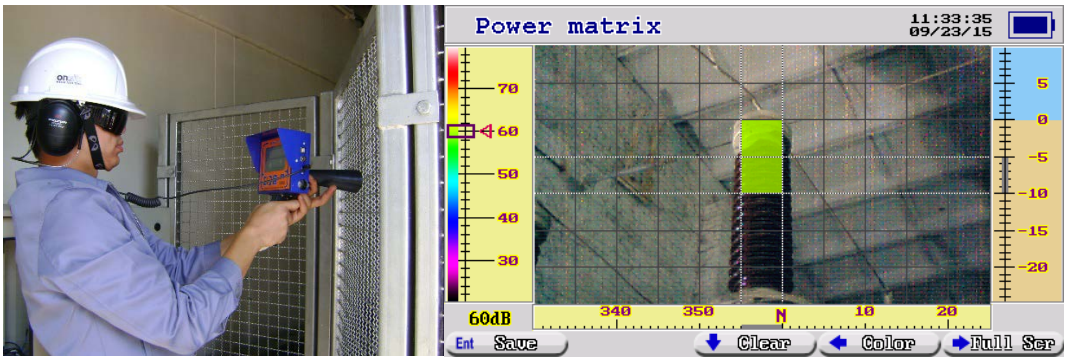

Figure 7. Airborne Acoustic sensor (AA) sensor with picture detector

Acoustic Emission sensor (AE) (Figure 8.)

The AE sensor is device which detect acoustic PD energy. The AE senor is commonly used for PD detection and localization in HV transformers and GIS, through the measurement of the acoustic waves generated by PD activities within the equipment. The frequency range is about 30 kHz – 300 kHz.

Figure 8. AE sensor

Ultra-High Frequency sensor (UHF, Figure 9.)

The UHF sensor is device which detect electromagnetic discharge in frequency range about 200 MHz to 1.5 GHz. The UHF is suitable to detect PD signal in high voltage gas insulated switchgear or power transformer.

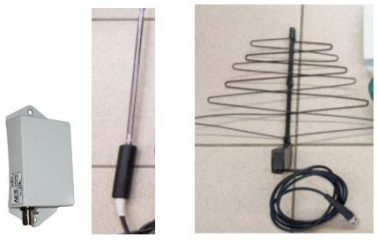

Figure 9 UHF sensor