On-Line PD Measurement Devices

1. Longshot Device (see Figure 1)

The measurement system applied is based around the wideband (0-400 MHz) HVPD-Longshot partial discharge test unit which utilizes a high-speed Digital Storage Oscilloscope (DSO) front-end to make high-resolution measurements of PD signals. Data is captured synchronously with the power cycle. A trigger signal was obtained from a 50Hz mains field detector placed close to the cable under test. The software utilizes a PD event recognition module to find short duration, high frequency pulses and classify them as cable PD, local equipment PD and noise. Phase plots are then created for each of these pulse types. Cable PD pulses are monopolar shape current impulses detected by HFCT sensors, they are integrated and their magnitude given in Pico coulombs (pC), they could originate from the cable, cable termination or transformer. Local PD pulses have a large amount of high frequency content (>5MHz). They are detected from sources very near to the measurement point by both HFCT and TEV sensors; the magnitude of these signals is calculated in dB. An example of the PD event recognition process is shown in Figure 2.

Figure 1 Longshot Partial discharge Detector

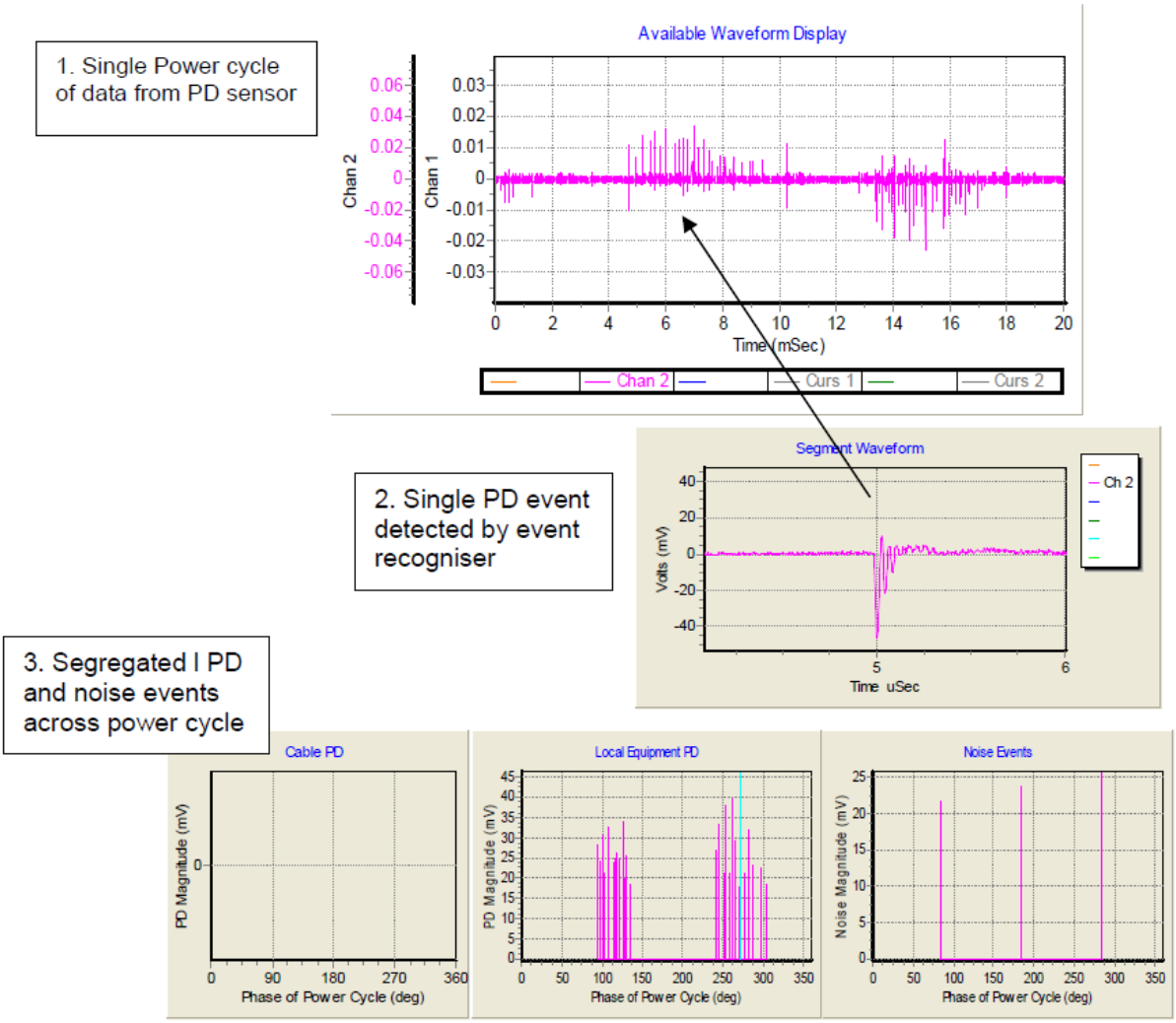

Figure 2 PD and noise data segregation by event recognizer

In addition to the event recognition, signals may be captured synchronously on up to four channels. With distributed sensors it is possible to discriminate locations of PD sites. For example if there is corona or surface discharge interference this can be discriminated by timing the signals between different sensors.

2. PD -Analyzer (see Figure 3)

Figure 3 PD –Analyzer

PD-Analyzer is device which is suitable for testing and analyzing partial discharges in the insulation of high-voltage transformers, cables, GIS and electric machines help diagnose their technical state and find any type of defects more effectively.

This modern method implementation is being slowed down by a limited number of reliable and capable but at the same time easy-to-work measuring devices found in the market. This sensitive method for early defect diagnosis in high-voltage insulation is discredited even by the attempts of using measuring devices of bad quality.

Engineering Capability of PD-Analyzer HF/UHF:

This device has six independent measuring channels in which the signals are measured absolutely synchronously. This function gives the opportunity to see how pulses from partial discharges are distributed and where they are located in high-voltage equipment. The device provides insulation partial discharge measuring in the wide frequency range including HF and UHF and allows partial discharge measuring and analyzing in any type of high-voltage equipment such as transformers, GIS, cables, etc. Pulse frequency in these things is hundred or even thousand times different. It depends on the type of the insulation defect, how far this defect is from the measuring sensor and the design characteristics of the equipment.

One of the main advantages of this device is its built-in expert system "PD-Expert" used for automatic diagnosis of insulation defects in high-voltage equipment. This intellectual expert System is very important for the personnel with little experience.

Expert and diagnostic characteristics of "PD-Analyzer HF/UHF".

Firstly, this device has hardware and firmware features to solve the problem of noise and crosstalk rejection in the process of partial discharge measuring: to analyze the pulse time and power frequency, to define the difference in the time of pulse arrival to different sensors (in nanoseconds) - "Time of arrival", to compare pulse amplitudes in different channels that helps find pulse location, to analyze pulse frequency which helps separate random pulses and partial discharges.

Secondly, this device can identify the type of the insulation defect and how dangerous it is. It is done with the "PD-Expert" software.

Main specific features of "PD-Expert" system:

It separates stray pulses and partial discharges while comparing their frequency and time of arrival. It uses phase resolved partial discharge (PRPD) and time frequency analysis (PD-Cloud) as shown in figure 4. It has the database of the most popular defect images which can be upgraded with new diagnostic information. It uses special algorithms to estimate if the received data is authentic. It makes reports on the condition of the insulation of the high-voltage object. Each report can be corrected by the user.

Partial discharge measuring in the insulation of power and measuring transformers.

Partial discharges in power and measuring transformers can be measured by a PD-Analyzer in different ways:

- Using complex DB-2 sensors (not enclosed in the standard delivery set) which are put to the test tap of the bushing and the neutral of a three-phase winding.
- Using TEV's sensors (to measure surface current) which are put on the transformer tank.
- Using electromagnetic UHF antennas which are put into the tank through a drain valve or special radio transparent hatch on the surface of the transformer tank.

Partial discharge measuring in the insulation of cables.

For partial discharge measuring in high-voltage cables, their joints the following sensors (enclosed in the standard delivery set) can be used:

- External electromagnetic antennas of different types – directional and rod – to test joint insulation and insulation of the nearby cables.
- High-voltage transformers RFCT made for joint and cable testing.

With "PD-Analyzer HF/UHF" you can locate defects in cable lines. A partial discharge pulse coming from the defect found in the insulation is used as a test pulse. There is one more useful function of this device – it has an on-line reflect meter.

Partial discharge measuring in GIS.

For this type of systems we use AES sensors which are put in between two GIS enclosures where the insulator spacers are. Partial discharges inside GIS can be measured through this radio-transparent gap. TEV's sensors are suitable too. They are put on the enclosure surface especially when there are no radio-transparent spacers.

Partial discharge measuring in the insulation of electric machines.

There are two ways for partial discharge measuring in stator winding insulation in HV motors and generators:

- Using coupling capacitors (as partial discharge sensors) which are able to work at maximum voltage of the stator winding.
- Using various electromagnetic antennas put inside the stator, such as temperature sensors in the winding or special antennas put in the stator slots or circular antennas put near end connections of the winding.

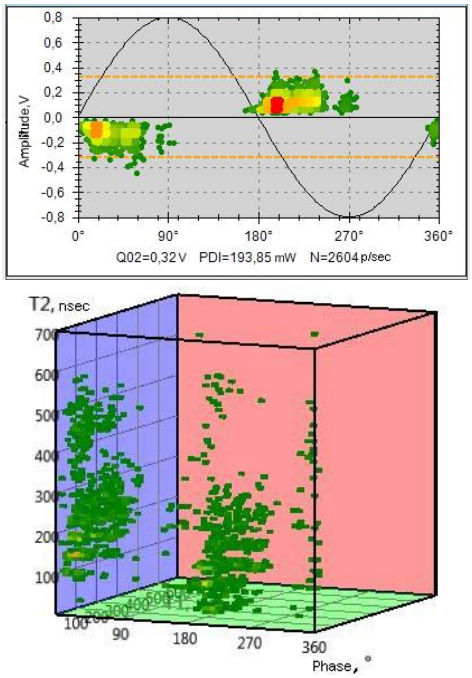

Figure 4 PRPD and PD Cloud Technic to separate noise

3. PDS Air Device (see Figure 5)

The PDS Air™ partial discharge surveying tool incorporates a digital TEV-dB display and external HFCT and airborne acoustic probes, in addition to internal TEV and acoustic sensors, providing the first-line of defense for the early detection of PD activity in MV cables and plant from 3.3 kV to 45 kV. It is a portable, hand-held device suitable for use by all operational staff in the substation. The PDS Air is thus intended to be used as a first-line PD 'screening' device ("the first line of defense") for testing MV cables and plant, providing the user with the ability to test the insulation condition of the equipment in seconds. The unit's simple, 7-level, color-coded, real-time PD level indicators (displayed as a range of LEDs from green (OK) to yellow to orange to red (high PD)) allows the user to quickly identify potential insulation defects and incipient faults. By using the PDS Air as a PD screening device, large numbers of MV plant items can be scanned for PD activity in a fraction of the time required by other commercially available systems.

Figure 5 PDS Air discharge Detector

4. AR-700 (see Figure 6)

The AR700 device is used for measurement and analysis of acoustic signals on the external surface of oil-filled transformers tanks, connecting and terminal joints, gas-insulated switchgear and other high-voltage equipment. The 4 synchronic channels for signal measuring in the device allow not only to reveal the defects, but also to locate the place of their origin. The device allows keeping the measured signals in FLASH memory for the following storing and analyzing by PC. The device controls provide “user friendly” interface and consistency of its operation.

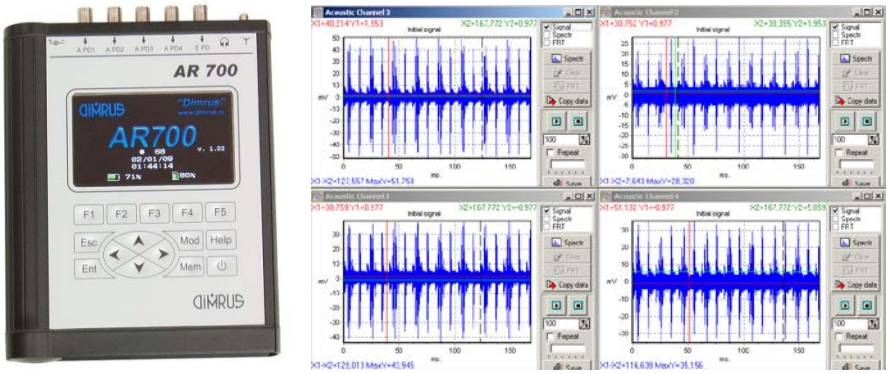

Figure 6 AR-700

5. UltraTest Device (see Figure 7)

The UltraTest is designed to detect acoustic signals from partial discharges in the ultrasonic frequency range and operational remote location of various defects in the equipment, the occurrence of which is accompanied by acoustic emission. The device allows you to save the measurement results in long-term non-volatile memory (Flash) for later viewing and transfer to the database through the PC USB port by of specialized software. The UltraTest can draw a two-dimensional “acoustic activity graph” of the object online at the device screen. At the horizontal axes the sensor axes angle of slope to the magnetic pole will be shown, at the vertical axes –the angle of slope to the horizon. The intensity of the processes will be shown at the graph by color.

An acoustic activity graph can be laid over the photo of the controlled object. Thus, the operator can definitely diagnose and analyze the cause of the “acoustic defect”. For that purpose the digital photo of the object should be made from the very point of the acoustic measurements, and the borders of the “acoustic activity graph” should coincide to the linear dimensions of the object.

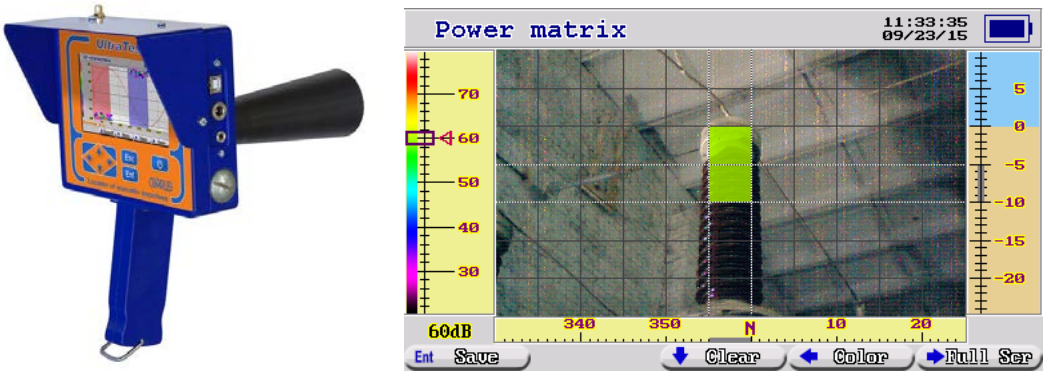

Figure 7 UltraTest Device

6. Thermal imager Device (see Figure 8)

The thermal imager devices usually use to detect thermal from abnormal of high voltage equipment.

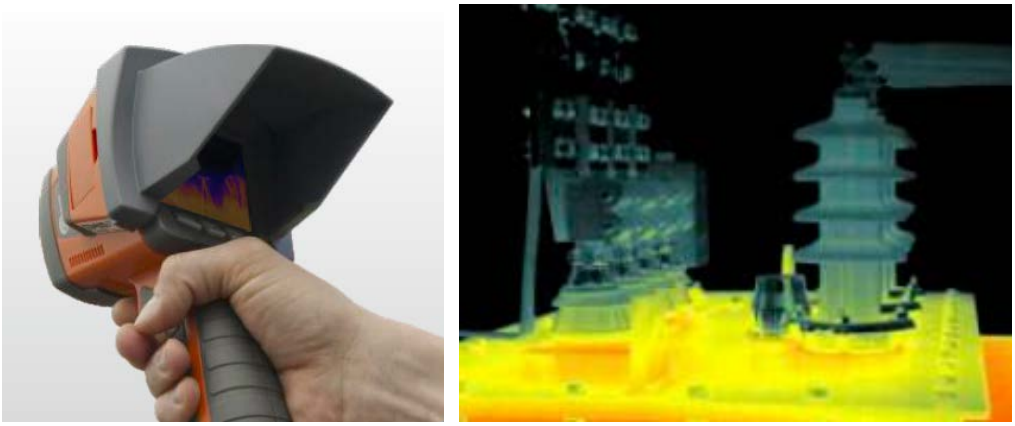

Figure 8 Thermal imager Device