Sonus PD Pro
Operating Manual

IRISS
ENGINEERED RELIABILITY

Contents

IRISS Inc.
10306 Technology Terrace
Bradenton, FL 34211

Phone: +1 (941) 907-9128
E-mail: info@iriss.com
Web: www.iriss.com

Revision: 1.0, Date: 01-01-2021 Subject to technical modifications!

The Sonus PD Pro

The Sonus PD Pro is a partial discharge (PD) detection instrument designed for use both in distribution voltage substations and EHV Switchyards. It enables Network Operators to carry out routine tests that will identify discharge activity in switchgear (AIS and GIS), cables and high voltage accessories.

The battery-powered portable device has a live display that shows a quantified level of PD activity. A colour-coded traffic light system indicates when detected levels exceed the pre-set thresholds. The Sonus PD Pro has a built-in TEV sensor for the detection of internal discharge in switchgear and a built-in ultrasonic sensor for detection of surface discharge and tracking.

The Sonus PD Pro also supports external HFCT Sensors for detection of cable PD and UHF sensors for detection of PD in GIS and EHV termination.

Headphones are also supplied to help the user when working in noisy environments.

The Sonus PD Pro is supplied with a battery-operated Function Tester that should be used to verify the correct operation of the instrument before use.

The Sonus PD Pro is a non-intrusive test device, therefore, PD can be identified and located whilst the equipment remains live.

Partial Discharge

Partial Discharge (PD) is an electrical discharge that does not completely bridge the space between two conducting electrodes. The discharge may be in a gasfilled void in a solid insulating material, in a gas bubble in a liquid insulator or around an electrode in a gas. When partial discharge occurs in a gas, it is usually known as corona.

Partial discharge is generally accepted as the predominant cause of long-term degradation and eventual failure of electrical insulation. As a result, its measurement is standard as part of the factory testing of most types of high voltage equipment. In-service monitoring of equipment for PD gives an advance warning of pending insulation failure. This allows a plant operator to take remedial action during planned outages.

Partial discharge often occurs under normal working conditions, gradually deteriorating the dielectric until it can no longer withstand the electrical stress and fails. By detecting this PD activity while the equipment is in operation, failure can be avoided.

Radiated Energy

A PD event will radiate energy in different forms and this energy can be picked up and measured by the Sonus PD Pro.

Electromagnetic Radiation

PD creates EM radiation that dissipates in all directions away from the source. Metal components, for instance, the panels around switchgear, will pick up this radiation and small voltages called Transient Earth Voltages (TEVs) are induced on the surface. These very high-frequency signals will be picked up by the Sonus PD Pro and indicate that there is a PD source nearby.

Acoustic Radiation

Partial Discharge also generates acoustic energy across a wide band of frequencies. This acoustic energy can be detected in the ultrasonic range when there is a 'line of sight' between the PD source and the detecting sensor. Sharp points, for instance on air-insulated cable terminations, are typical sources of discharge that will produce acoustic emission. Cast insulators are prone to surface tracking, particularly when dirty or wet, where electrical stress across the insulator's surface causes discharge, and deteriorates the insulator surface and creates carbon tracks. This can lead to flashover and failure of the equipment.

Physical Dimensions of Sonus PD Pro

Dimensions

The Sonus PD Pro has the following external dimensions excluding attachments and aerials:

- Width: 190 mm
- Height: 90 mm
- Depth: 65 mm

Weight

The Sonus PD Pro weighs 220g.

Power Supply

The Sonus PD Pro has a built-in Lithium-Ion battery allowing for long battery life. A battery charger and car charger are included in the kit.

Test Situation	Est. Battery Life
Sonus PD Pro Only	8 hours
Sonus PD Pro with App	6 hours

Table 1: Battery Life Estimate

Temperature

The Sonus PD Pro can be used in the following temperature ranges:

- Operation: -20°C to +60°C
- Storage: -20°C to +75°C

Relative Humidity

The Sonus PD Pro can be installed in the following relative humidity ranges:

- Operation: 0% to 95%

IP Rating

The Sonus PD Pro is IP54 rated but is not intended for use in damp conditions.

CE Compliance

The Sonus PD Pro complies with the following directives:

EN 61000-6-2: 2005	IMMUNITY STANDARD (INDUSTRIAL ENVIRONMENT)
EN 61000-6-3: 2007	EMISSION STANDARD (RESIDENTIAL, COMMERCIAL and LIGHT INDUSTRY ENVIRONMENT)

The Sonus PD Pro Kit List

The Sonus PD Pro Kit includes:

- 1x Sonus PD Pro
- 1x Sonus PD Pro power supply/ charger unit
- 1x USB Charger Cable
- 1x Car Charging Adapter
- 1x Stereo Headphone with 3.5mm Jack
- 1x PD-FT Function Tester
- 1x Moulded carry case
- 1x Sonus PD Pro Companion App Manual

Optional sensors supplied separately

- 1x HFCT sensor for Cable PD
- 1x UHF sensor for GIS PD
- 1x Ultrasonic Parabolic Dish
- 1x AA Ultrasonic Probe

Figure 1: PD Detector kit

General Substation Safety Precautions

Before setting up the Sonus PD Pro in the substation it is important for the user to read and understand the following general safety information.

The engineer should obey the plant owner's High Voltage safety rules at all times. The following safety rules which are particular to the Sonus PD Pro equipment should be applied in addition to the existing safety rules, which are required by the plant owner. General safety rules for the use of the Sonus PD Pro are as follows:

1. Avoid working alone.
2. Only accredited personnel with appropriate Health and Safety Training should use the equipment.
3. Do not use the equipment if it is damaged, or its safety is impaired in any way.
4. The User should have read and understood the appropriate equipment manuals.
5. Always select the appropriate sensor and sensor connection for the application.
6. The instrument has been designed for use only on the earthed, outer surfaces of metal-clad equipment and earthed connections of cables/switchgear. The Sonus PD Pro or PD sensors should never be connected to, or put near, any high voltage components.
7. Never disconnect or loosen an earth connection in order to install a PD sensor
8. Cables connecting PD sensors to the instrument do not provide protection against high voltage.
9. Always maintain Safety Distances between the instrument, PD sensors, the operator, and any high voltage components.
10. Do not disturb or interfere with the high voltage equipment in any way.
11. The User should wear sensible and appropriate PPE and clothing when in the substation.

Access

The Test Engineer shall only enter the customer's switchyard or substation after they have received permission from an Authorised Person appointed by the plant owner and have the relevant training and/or certification.

Visual Inspection of Substation

On entry to the test area, a visual inspection of the area should be carried outby the Test Engineer(s). This should enable the operator to identify any potential hazards in the area and to assess both the type of equipment to be tested and the method of doing so, for instance, Switchgear using CC or AA sensors or Cables using HFCT sensors. Only when this visual inspection has been completed should test equipment be used.

Environmental Protection

This product contains general electronic components that may be environmentally harmful if improperly disposed of. Please use correct disposal methods in accordance with local regulations.

The device can be returned to IRISS at the end of use for proper disposal.

The Sonus PD Pro Overview

The Sonus PD Pro Outline

The Sonus PD Pro has a tough ABS enclosure with rubber protective covering around the built in TEV and ultrasonic PD sensors. Both built-in sensors are mounted at the front of the instrument so that they can be easily directed at the inspection point.

The Sonus PD Pro can also be used with external PD sensors.

The Sonus PD Pro is controlled with three membrane switches on the front panel. When used in standalone mode, an OLED screen displays both text and graphical information to the user. When connected to a mobile device running the Sonus PD Pro App, all information is displayed on the App. The Sonus PD Pro also has an audio output through both a built-in speaker and pluggable earphones.

The unit is powered by a lithium-ion battery giving a long life for hours of use. The software has intelligent power management prolonging battery life.

Sonus PD Pro Input/Output

The Sonus PD Pro has inputs and outputs as detailed in the tables below:

Front Panel	Type
Display	OLED
Display	6 x PD level LEDs
Control button MODE	Membrane switch
Control button DISPLAY SELECT	Membrane switch
ON/OFF button	Membrane switch
Earphone socket	3.5mm Jack
External AE sensor	3.5mm Jack
UHF/HFCT/Power charge port	2.1mm DC power
Bluetooth module	Bluetooth 4.0 LE

Table 2: Sonus PD Pro Input/Output

Transient Earth Voltage (TEV)

Partial discharge activity inside a metal-clad high voltage plant induces small voltage impulses called Transient Earth Voltages on the surface of the metal cladding. These TEVs travel around the cladding surface to the outside of the equipment where they can be picked up using capacitively coupled transducers.

The TEV signals will not pass through the metal panels but instead emerge at the joins between the metal panels and it is at these points that the highest readings are generally detected.

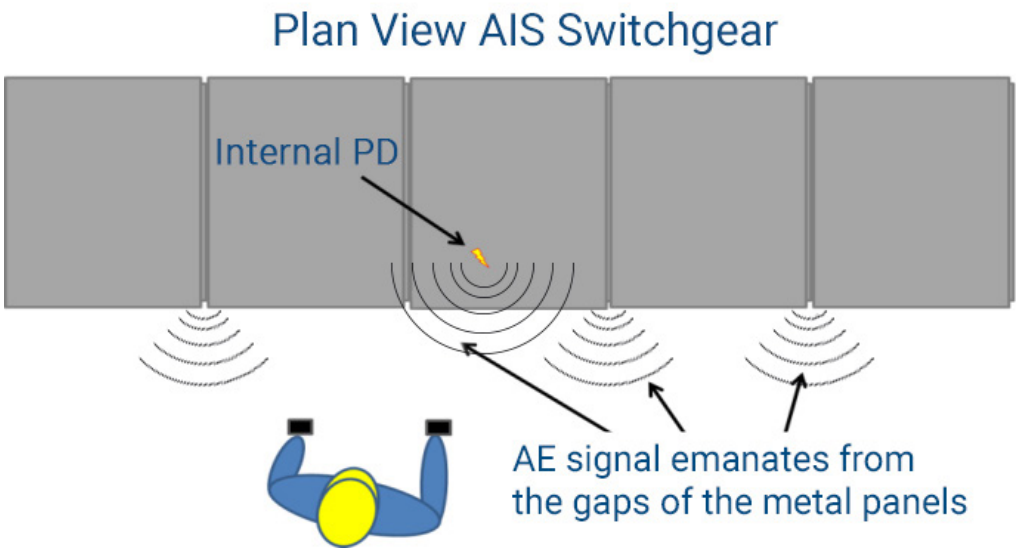

Figure 2: PD pulse propagation in AIS panels

Capacitive Coupler Sensor

The built in Capacitive Coupler sensor detects TEVs as they pass over the panels of the high voltage equipment. The very fast transient signals are detected by the PD Detector and their magnitude measured and displayed.

Specification

Frequency Response	3MHz – 400MHz
TEV detection range	0 – 80dB

Refer to dedicated specification document for full information

Acoustic Emission (AE)

Acoustic Emission is ultrasonic sound energy that is emitted by discharges on electrical insulating surfaces often caused by Surface Tracking or Corona.

Surface Tracking

Surface Tracking is the formation of a permanent conducting path across an insulator surface. Usually the conduction path results from degradation of the insulation. Tracking most readily occurs when the insulation is a carbon-based compound.

A high voltage plant is often very difficult to clean, so dirt and contaminants can build up over time. In the presence of moisture, these contaminating layers give rise to leakage current over the insulator surface. This heats the surface and through evaporation causes interruption in the moisture film. Large potential differences are generated over the gaps in the moisture film and small sparks can bridge the gaps. Heat from the sparks causes carbonisation of the insulation and leads to the formation of permanent carbon tracks on the surface. Under such conditions this process will develop over time and eventually lead to flashover and full breakdown of the insulation.

Acoustic Sensor

The ultrasonic acoustic Sensor is designed for use on air insulated terminations where there is a clear sound path between the electrically stressed insulation and the probe. The sensor is extremely sensitive when pointed directly at the discharge source.

The transducer is embedded into the rubber moulded cover at the front of the instrument so it can be easily directed towards the parts of electrical plant where tracking may occur.

Specification

Frequency response	40KHz ± 1KHz
Detection range	-6 dBµV to 70 dBµV

Refer to dedicated specification document for full information

Operational Control

Control Buttons

The Sonus PD Pro is controlled by three buttons on the instrument as shown in Figure 4.

Figure 4: Instrument control buttons

Power

The POWER button is used to turn the Sonus PD Pro ON and OFF. By pressing the button once the instrument will toggle between these states.

Note: that the POWER button should be pressed and held down for two seconds before the power is switched.

Battery level

The remaining charge in the battery is indicated by the small icon in the bottom right-hand side of the display screen.

Operating Modes

The Sonus PD Pro can be set-up to operate in 2-channel mode or in 4-channel mode. If the Sonus PD Pro will be used with either of the external PD sensors, HFCT or a UHF PD sensor, then it should be set to 4-channel mode. If the Sonus PD Pro is only going to be used with the built in TEV and ultrasonic sensors, then it should be set to 2-channel mode. The Sonus PD Pro can be toggled between 2-channel mode and 4-channel mode by using the Sonus PD Pro App. The option to change this is in Settings.

Mode Selection

The MODE button is used to toggle the instrument between the different sensors. In 2-channel mode, pressing the MODE button will switch the instrument between the TEV and AE. In 4-channel mode, pressing the MODE button will switch the instrument between TEV, AE, HFCT and UHF.

TEV Mode

In TEV Mode the instrument measures and displays the magnitude of TEV signals detected. The measured value is shown in dBmV such that 0dB = 1mV. The relationship between the detected signal magnitude in dB and mV is shown in the Table 3.

mV	dB
1	0
2	6
5	14
10	20
20	26
35	31
50	34
100	40
1,000	60
10,000	80

Table 3: Relationship between mV and dB for TEV signals

TEV Noise Detection

In TEV Mode, the Sonus PD Pro will detect HF signals that are from both PD sources and from noise sources. An algorithm processes the detected signals and distinguishes between the PD and noise so that the level of each can be shown separately. The magnitude of pulses recognised as PD are displayed in large text in the centre of the screen in dB. The magnitude of pulses recognised as noise are displayed on the right-hand side of the screen in dB as shown in Figure 5

Figure 5: PD & Noise indication

It should be noted that when high levels of noise are detected, it can mask genuine PD. It is advisable to use more sophisticated PD detection instruments that can detect PD even in the presence of high noise. A level bar on the left-hand side of the screen gives a graphical indication of magnitude of the PD detected.

AE Mode

In AE Mode the instrument measures and displays the magnitude of ultrasonic acoustic signals detected. The measured value is shown in dBµV such that 0dB= 1µV. The relationship between the detected signal magnitude in dB and mV is shown in the table below.

µV	dB
0.5	-6
1	0
2	6
5	14
10	20
20	26
35	31
50	34
100	40
1,000	60
3,100	70

Table 4: Relationship between µV and dB for AE signals

The magnitude of detected ultrasonic activity is displayed in large text in the centre of the screen in dB as shown in Figure 6

Figure 6: Ultrasonic indication

HFCT Mode

For the detection of PD in cables, the Sonus PD Pro can be used with a High Frequency Current Transformer, HFCT. The HFCT is connected to the instrument using the BNC-2.1mm Jack cable as shown in Figure 7.

Figure 7: PD Detector connected to the HFCT

PD Detection Using HFCT

Partial discharge in cables induces small high frequency currents in the earth and the cable core. These impulses travel along the cable to the termination where they can be picked up using an HFCT. The HFCT sensor is hinged so it can be opened and put around the cable earth or around the core if the earth is passing back thorough the HFCT as shown in Figure 8 and Figure 9

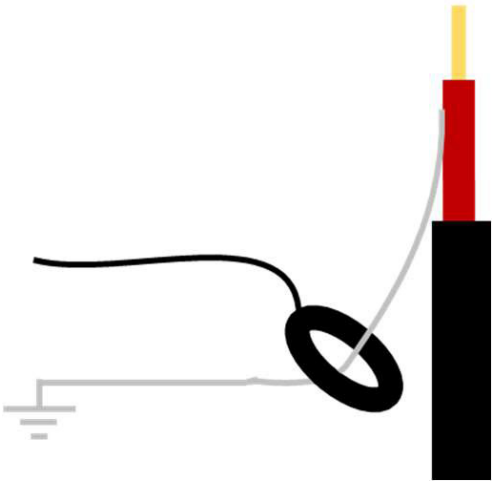

Figure 8: HFCT around earth

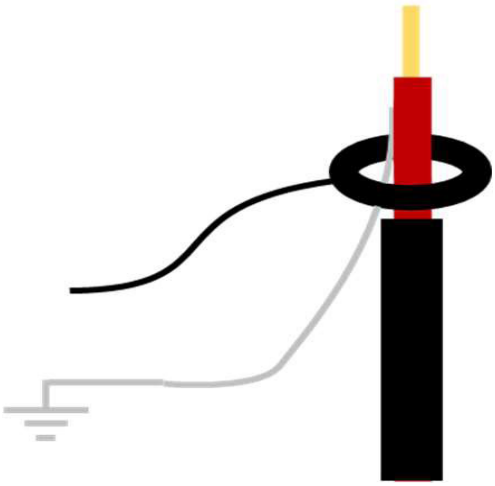

Figure 9: HFCT around core and earth

In HFCT mode, the screen shows the measured signal in pico-Coulombs (pC) for values between 0-999pC and in nano-Coulombs for values between 1-7nC as shown in Figure 10.

Figure 10: HFCT screen display

In HFCT Mode, the Sonus PD Pro will detect HF signals that are from both PD sources and from noise sources. An algorithm processes the detected signals and distinguishes between the PD and noise so that the level of each can be shown separately.

The magnitude of pulses recognised as PD are displayed in large text in the centre of the screen in pC/nC. The magnitude of pulses recognised as noise are displayed on the right-hand side of the screen in pC/nC.

IMPORTANT

The HFCT signal cable does not provide electrical isolation for the HFCT. The HFCT sensor should therefore never be placed near to high voltage components, it should only ever be placed around fully earthed components. Never disconnect a cable earth to fit the HFCT sensor around it.

UHF Mode

For the detection of PD in Gas Insulated Switchgear (GIS) the Sonus PD Pro can be used with a UHF PD Sensor. The UHF sensor is connected to the instrument using the BNC-2.1mm Jack cable connected via the UHF power decoupler as shown in Figure 11.

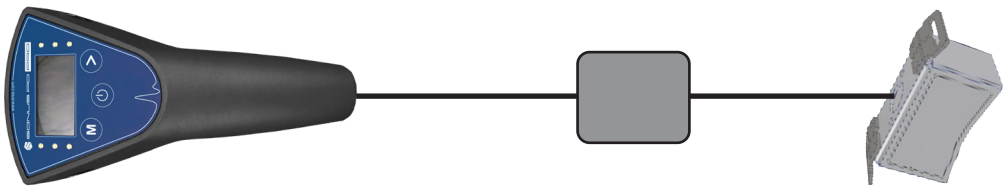

Figure 11: Sonus PD Pro connected to the UHF and power decoupler

PD Detection Using UHF Sensor

GIS is made from large steel tubes that effectively form a Faraday cage. This means that when PD occurs inside the GIS, the high frequency electromagnetic pulses propagate through the inside of the GIS until they come to a break in the conducting shield and they can escape. By placing the UHF sensor up against the barrier insulators that separate individual sections of GIS, internal PD can be detected.

In UHF Mode the instrument measures and displays the magnitude of UHF signals detected. The measured value is shown in dBmV where 0dB = 1mV.

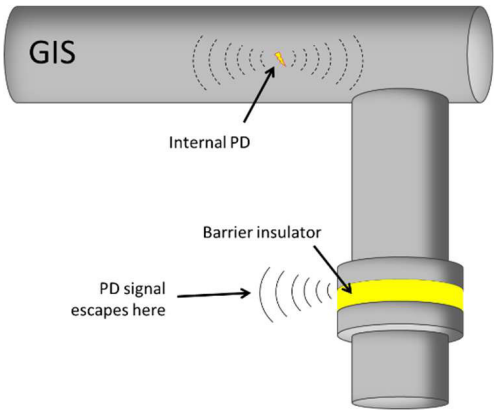

Figure 12: PD in GIS

Display

Display Selection

The DISPLAY SELECT button is used to toggle between the different display modes. Each time the button is pressed the screen display will change between the following screens in a loop: Level Display, Live PRPD Display and Persistent PRPD Display.

Level Display

This is the default display and shows the real-time signal levels measured in dB as a single number, see example in Figure 13.

Figure 13: Level Display

Colored LEDs on either side of the display indicate whether the detected PD activity is Low, Medium or High. Thresholds for TEV measurements are set according to the levels shown in the table below;

Sensor	LOW	MEDIUM	HIGH
TEV	<=19dB	20 - 29dB	>=30dB
AE	<=5dB	N/A	>=6dB
HFCT	<=99pC	100-499dB	>=500pC
UHF	<=39dB	40-54dB	>=54dB

Live PRPD Display

Live PRPD Display shows the activity detected phase resolved against the power cycle. The power cycle synchronisation is picked up from the built-in field detector. This type of display is often called Phase Resolved Partial Discharge (PRPD).

Figure 14: AE and TEV Live PRPD Mode

In the Live PRPD Mode, the X axis represents time and is calibrated to represent one power cycle. Therefore, when used on a 50Hz system it shows 20ms and on a 60Hz system it shows 16.67ms. The Y axis represents the magnitude of each detected PD pulse.

Synchronisation

In order to display the PRPD in time synchronisation with the HV power cycle, an internal field detector is used to pick up the field generated by the high voltage.

When this signal has been correctly detected a Sine Wave symbol appears in on the screen next to the level reading. If the instrument has not picked up the synchronisation signal, the Sine Wave symbol will not appear.

Persistent PRPD Mode

The third mode under each sensor displays PRPD in a persistent mode. In the ‘live’ display the data is shown as a bar chart and in the persistent display it is represented as a scatter plot.

Figure 15: Examples of Persistent PRPD Display

The persistent display is cumulative and shows all activity detected from the point at which this mode is selected. In order to clear and re-start the cumulative display, cycle through the modes until the user is returned to the correct persistent display.

Sonus PD Pro App

The Sonus PD Pro can be connected via Bluetooth to a smart mobile device running the IRISS Sonus PD Pro App. The App compatible with Android devices is available from Google Play Store, and the App compatible with iOS devices is available from Apple App Store.

The Sonus PD Pro will automatically connect to a smartphone once it receives a Bluetooth connection request from the Sonus PD Pro App. The user can take and store readings in real-time.

Once the Instruments and App have been paired, the Sonus PD Pro will display only a Bluetooth Symbol and all reading and monitoring functionality will transfer to the Sonus PD Pro App. For further information please refer to the Sonus PD Pro App User Manual

Figure 16: Sonus PD Pro App

Synchronisation Indication

Not Synchronised

Synchronised

Figure 17: Synchronisation indication

When the Sonus PD Pro is connected to a mobile device, the synchronisation status is indicated both on the screen and on the LEDs. The Green LEDs indicate that the instrument has synchronised, and the red LEDs indicate that it is not synchronised.

Check Sonus PD Pro Function

Before carrying out any test work with the Sonus PD Pro it should be tested to check it is operating correctly.

Function Tester

The Function Checker PD-FT is a small batteryoperated test device for checking the correct performance of the PD Detector. When the switch is pressed it generates both TEV signal and AE signal.

The Function Checker PD-FT is a small batteryoperated test device for checking the correct performance of the Sonus PD Pro. When the switch is pressed it generates both TEV signal and AE signal.

The PD-FT should only be used for checking functionality and not calibration. The output of the PD-FT is not calibrated and may vary.

The PD-FT is battery operated. When the battery level is low, the Power LED will flash. The Sonus PD Pro charger can be used to recharge the battery. Whilst charging, the LED will be bright and when fully charged the LED will return to normal intensity.

Figure 18: PD-FT

Check The TEV Function

Hold the PD-FT up against the sensor head of the Sonus PD Pro and press the yellow button as shown in Figure 19. The bottom surface of the PD-FT should be held directly against the sensor head. The Sonus PD Pro should record a signal level value of greater than 30dB to confirm correct operation. This may be recorded as PD or noise.

Figure 19: Testing TEV function with PD-FT

Check The AE Function

Hold the PD-FT up against the sensor head of the Sonus PD Pro and press the yellow button as shown in Figure 20. The AE sensor end of the PD-FT should be held up against the sensor head using the two rubber extensions to regulate the distance between the PD-FT and the Sonus PD Pro as shown in the picture.

The Sonus PD Pro should record a value of greater than 30dB to confirm correct operation.

Figure 20: Testing AE function with PD-FT

Surveying Switchgear Panels for PD - TEV

Step 1- Check TEV Activity Levels

1. Switch the Sonus PD Pro to TEV Mode and LEVEL display.
2. Starting at one end of the switchboard, check each panel for activity;
   a. Place the sensor in the centre of the panel and record the dB level shown on the Sonus PD Pro screen.
   b. If a single switchgear unit has more than one metal panel, then the test should be carried out on each of them individually.
3. Record the results using the Sonus PD Pro App.

Figure 21:Checking activity levels on each panel

Note: Always maintain Safety Distances between the instrument, PD sensors, the operator and any high voltage components.

Example 1 – Component Switchgear

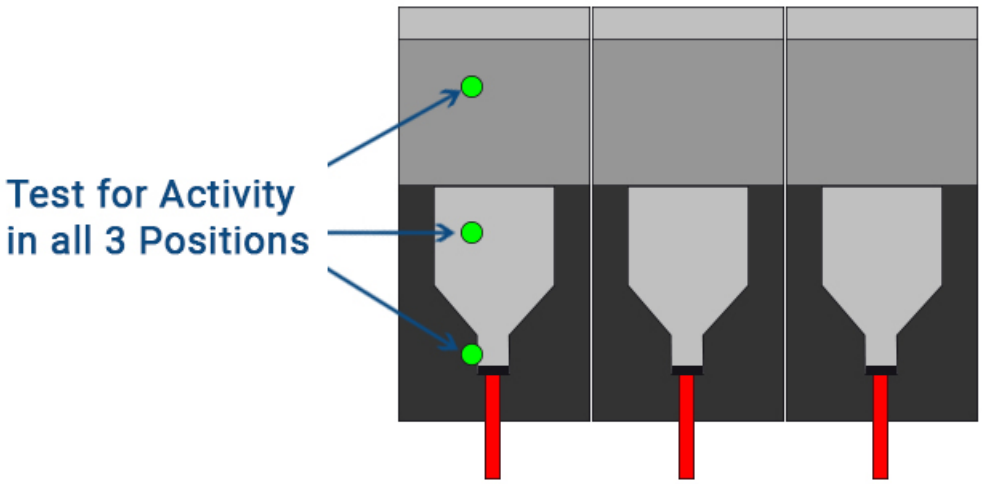

Figure 22: Sonus PD Pro placement on Component switchgear

Example 2 – Fully Enclosed Switchgear

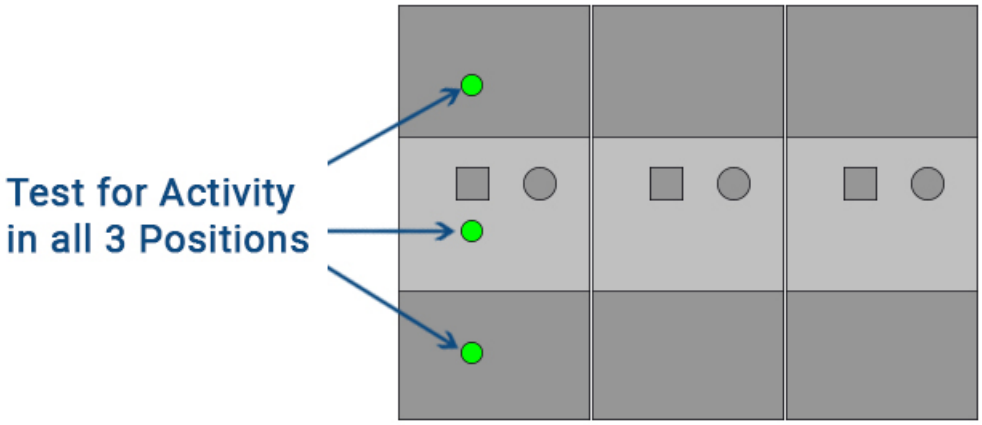

Figure 23: Sonus PD Pro placement on fully enclosed switchgear

Where the switchgear has exposed components such as the bus bar chamber, CT or VT chamber, circuit breaker and cable box, then each part should be tested for activity as shown in the diagram in Figure 23

Step 2 – Verify Whether Detected Activity is Noise or PD

Substations are very often electrically noisy environments and this noise can be picked up by the Sonus PD Pro. Noise levels often reach or exceed 15dB, in some harsh industrial environments levels can be as high as 30 or even 40dB. A simple check can be carried out to help identify whether the activity detected is coming from the switchgear or is noise from surrounding plant.

1. Measure the highest level of activity on the switchgear panel.
2. Measure background noise in the substation by placing the Sonus PD Pro sensor up against a metallic object that is not electrically coupled to the switchgear under test. This will give a background reference level.
3. If the activity level measured on the switchgear is more than 6dB higher on the switchgear than it is on the reference object then there is a high likelihood that the activity is discharge coming from within the switchgear. Further investigative tests should be carried out using more sophisticated PD test equipment.

Surveying Switchgear Panels for PD - Acoustic

Step 1- Check Acoustic Activity Levels

1. Switch the Sonus PD Pro to AE Mode and LEVEL display.
2. Starting at one end of the switchboard check each panel for activity:
   a. Point the sensor towards any exposed HV points like cable terminations or exposed insulators around HV points, for instance resin bushings or spouts on a withdrawable breaker. This may mean aiming the sensor though gaps in the metal cladding or through ventilation grills.
   b. If activity is found, move the transducer around until the highest level is detected and record the dB level shown on the Sonus PD Pro screen..
3. Record the results using the Sonus PD Pro App.

Figure 24: Checking acoustic activity between switchgear panels

Note: Always maintain Safety Distances between the instrument, PD sensors, the operator, and any high voltage components.

Appendix A: The Relationship Between PD and Criticality

Criticality

The Criticality of a high voltage asset (e.g. a cable circuit or switchgear panel) is a measure of how likely it is to fail. The Criticality is therefore very important for the Asset Manager in order to know when and where to carry out maintenance and repair work.

Partial Discharge

The Criticality of an asset has many different contributing factors and partial discharge is an important part. Discharge activity will cause small but very localised damage to the insulation. Over time this damage can develop to the point where it causes full breakdown. Partial discharge is a good indication of weak insulation and an increased probability of failure. Both the magnitude and repetition rate are important in determining the influence of the PD and the following table is based upon the average total discharge activity per power cycle. The table below is a guide to PD activity levels and the associated severity;

Sensor	LOW	MEDIUM	HIGH
TEV	<=19dB	20 - 29dB	>=30dB
AE	<=5dB	N/A	>=6dB
HFCT	<=99pC	100-499dB	>=500pC
UHF	<=39dB	40-54dB	>=54dB

Note that in XLPE cables the insulation does not withstand any PD for very long so the figures quoted are for PD in the cable accessories.

The appropriate actions for these severities are as given in the table below;

LOW	No further action required
MEDIUM	Test again within 3 months
HIGH	Locate PD and repair

It should be noted that the lead time to failure after on-set of PD can be between a few days and many months.

North Ameriaca (HQ)
+1 (941) 907 9128
info@iriss.com

LATAM
+1 (941) 704-4445
info-latam@iriss.com

EMEA
+44 (0) 1245-399-713
info-emea@iriss.com

APAC
+1 (941) 524-3340
info-apac@iriss.com

iriss.com