
# Sonus PD-X Ultrasonic Detector

## Operating Manual

| | |
|---|---|
| Distribution: | IRISS Inc. |
| Model: | Sonus PD-X |
| Type: | Multifunction device for leak detection, tightness control and other maintenance tasks |

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# 1 The Sonus PD-X

The Sonus PD-X is a first level Partial Discharge (PD) detection instrument designed for use both in distribution voltage substations and HV Switchyards. It enables Network Operators to carry out simple routine tests that will identify discharge activity in switchgear and accessories.

The battery powered portable device has a live display that shows a quantified level of detected PD activity. A colour coded traffic light system indicates when detected levels exceed the pre-set thresholds.

The Sonus PD-X has a built in TEV sensor for capacitive coupling to switchgear and a built in ultrasonic sensor for detection of surface PD activity and other fault conditions. Headphones are also supplied to help the user when working in noisy environments.

The Sonus PD-X is supplied with a rechargeable Function Tester that can be used for Sensitivity Validation of the unit before testing of electrical assets.

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

# 2 Partial Discharge

Partial Discharge (PD) is an electrical discharge that does not completely bridge the space between two conducting electrodes. The discharge may occur in a gas filled 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. In-service monitoring of equipment for PD gives an advance warning of pending failure. This allows the CBM Technician to take remedial action and the reliability engineer to plan for repairs to be made during an outage.

Partial Discharge often occurs under normal working conditions, gradually deteriorating the dielectric until it can no longer withstand the electrical stress and fails. Levels of PD will increase in activity and amplitude as the insulating materials degrade. By detecting this PD activity while the equipment is in operation, failure can be avoided.

## 2.1 Radiated Energy

A PD event will radiate energy in different forms and this energy can be picked up by the Sonus PD-X in order to detect the source and locate it through it abilities to test in the Transient Earth Voltage, Ultrasound, High Frequency Current Transform or Ultra-High Frequency ranges..

### 2.1.1 Electromagnetic Waves (EM)

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-X and indicate that there is a PD source nearby.

### 2.1.2 Acoustic Emmissions (AE)

Partial Discharge also generates acoustic emissions 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 corona that will produce acoustic emission. Cast insulators are prone to Surface Tracking 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

# 3 Physical Dimensions of Sonus PD-X

## 3.1 Dimensions

The Sonus PD-X has the following external dimensions excluding the carry bag:

- Width: 190 mm
- Height: 90 mm
- Depth: 55 mm

## 3.2 Weight

The Sonus PD-X weighs 210g.

## 3.3 Power Supply

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

| Test Situation | Est. Battery Life |
|---|---|
| Sonus PD-X Only | 8 hours |

## 3.4 Temperature

The Sonus PD-X Field Detector can be used in the following temperature ranges:

- Operation: 0°C to +60°C
- Storage: -20°C to +75°C

## 3.5 Relative Humidity

The Field Detector can be used in the following relative humidity ranges:

- Operation: 0% to 95%

## 3.6 IP Rating

The SONUS PD-X is IP54 rated but is not intended for use in damp conditions.

# 4 CE Compliance

The Sonus PD-X system 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)

# 5 Sonus PD Kit List

The Sonus PD-X Kit includes:

- 1 x Sonus PD-X
- 1 x Sonus PD-X power supply / charger unit
- 1 x USB Charger Cable
- 1 x Car Charging Adapter
- 1 x 3.5mm stereo headband Headset
- 1 x PD-FT Function Tester
- 1 x Moulded carry case

# 6 General Substation Safety Precautions

Before using the Sonus PD-X in the substation or switchyard it is important for the user to read and understand the following general safety information

The test engineer should obey the plant owner's safety rules at all times. The following safety rules which are particular to the Sonus PD-X 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-X are as follows:

1. Avoid working alone.
2. Only authorized 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. Inspect and test all ground leads and signal cables for continuity.
5. The User should have read and understood the appropriate equipment manuals.
6. Always select the appropriate sensor and sensor connection for the application.
7. The instrument has been designed for use only on the grounded, outer surfaces of metal-clad equipment and the ground/neutral connections of cables/switchgear. Under no circumstances should the Sonus PD-X sensors be connected to the any energized equipment.
8. Always maintain Safety Distances between the instrument, PD sensors, the operator and any high voltage components.
9. Do not disturb or interfere with the equipment in any way.
10. The User should wear sensible and appropriate PPE and clothing when in the substation.

## 6.1 Access

The CBM Analyst shall only enter the customer's switchyard or substation after they have received permission from an Authorised Person appointed by the Plant Lead Engineer. If in doubt on any matter the Plant Owner's High Voltage safety rules should be consulted by theTest Engineer(s) who will carry out the testing.

## 6.2 Visual Inspection of Substation

On entry to the test area a visual inspection of the area should be carried out by the CBM Analyst. 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. (i.e. Switchgear using CC sensors or Cables using HFCT sensors) Only when this visual inspection has been completed can the equipment be set-up for testing.

# 7 Environmental Protection

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

# 8 Sonus PD-X Overview

## 8.1 Sonus PD-X Outline

The Sonus PD-X has a tough ABS plastic enclosure with rubber protective covering around the PD sensors. Both built in PD sensors are mounted at the front of the instrument so that they can be easily directed at the inspection point. The Sonus PD-X is controlled with two membrane switches on the front panel. An OLED type screen is used for function control and providing both text and graphical output information to the user. In addition the Sonus PD-X has an audio output through both a built in speaker and 3.5mm earphones jack.

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 further.

## 8.2 Sonus PD-X Input/Output

The Sonus PD-X 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 |
| ON/OFF Button | Membrane Switch |
| | |
| Earphone Socket | 3.5mm Jack |
| External AE Sensor | 3.5mm Jack |
| Power Charge Socket | 2.1mm DC Power |

# 9 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 gear where they can be picked up using capacitively coupled transducers.

**Note: TEV is generally only present in equipment rated above 2,500 Volts.**

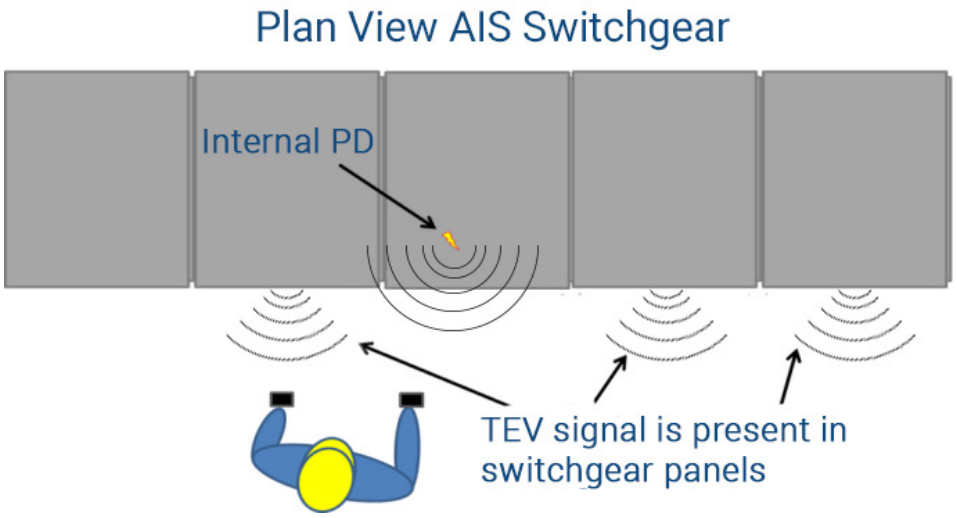


Fig 2a: TEV PD pulse propagation equipment.

## 9.1 Capacitive Coupler Sensor

The built in Capacitive Coupler sensor detects TEVs as they pass over the cladding of the high voltage equipment. The very fast transient signals are detected by the Sonus PD and their magnitude measured and displayed as decibels. A noise cancelling algorithum inside the Sonus PD-X unit seperates background noise from actual TEV.

## 9.2 Specification

| | |
|---|---|
| Frequency Response | 20MHz – 200MHz |
| TEV detection range | 0 – 80dBmV |

# 10 Acoustic Emission (AE)

Acoustic Emission is ultrasonic energy that is emitted by discharges.

## 10.1 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.

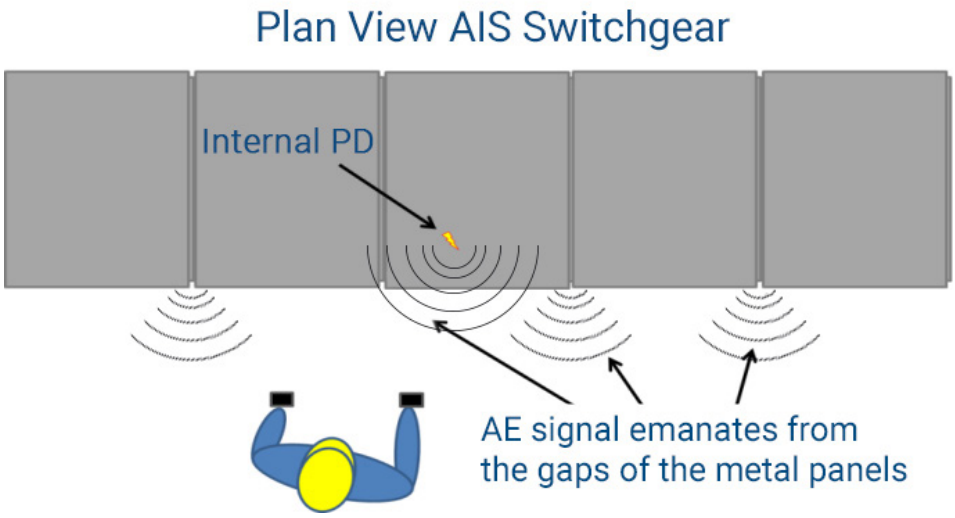


Fig 2b: AE PD pulse propagation in equipment.

## 10.2 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. It is generally recommended that equipment be kept in a closed and guarded condition at all times. IRISS recommends the use of ultrasound ports built into the equipment to take AE readings safely and efficiently. The unit can even be used with a parabolic dish, Contact module or flex probe. Adapter cabling and additional modules are required for this operational mode.

## 10.3 Specification

| | |
|---|---|
| Frequency response | 40KHz ± 1KHz |
| Detection | 0 - 70 dB's |

# 11 Operational Control

## 11.1 Control Buttons

The Sonus PD-X is controlled by two buttons on the instrument as shown in **Figure 3**.


Fig 3: Sonus PD-X Controls

## 11.2 Power

The POWER button is used to turn the Sonus PD-X 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.

### 11.2.1 Battery level

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

## 11.3 Operating Modes


The MODE button is used to toggle the instrument between TEV Mode and AE Mode. The MODE button should be pressed for about half a second in order switch between the two modes

### 11.3.1 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 detected signal magnitude in dB and mV is shown in the Table below;

| 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 1: Relationship between mV and dB for TEV signals

### 11.3.2 TEV Noise Detection

In TEV Mode, the Sonus PD-X can identify high frequency signals that are from a noise source and are not PD. When noise is detected, the display will show both the true TEV value in dB and the noise dB level as shown in the figure 4 below.


Fig 4: Noise Indication

The noise detection algorithm is only applied to signals with a magnitude greater than 20dB as noise signals below this level are relatively common.

It should be noted that when high noise is detected, it can mask genuine TEV. It is advisable to use more sophisticated PD detection instruments that can detect PD even in the presence of high noise. Or use the Sonus Vue Phone APP and Sonus Vue Desktop Software to record the sound waves for further analysis.

### 11.3.3 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 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 2: Relationship between µV and dB for AE signals

## 11.4 Display

### 11.4.1 Level Display

Fig 5 shows the default display for both TEV and AE Modes and shows the real-time signal levels measured in dB as a single number.

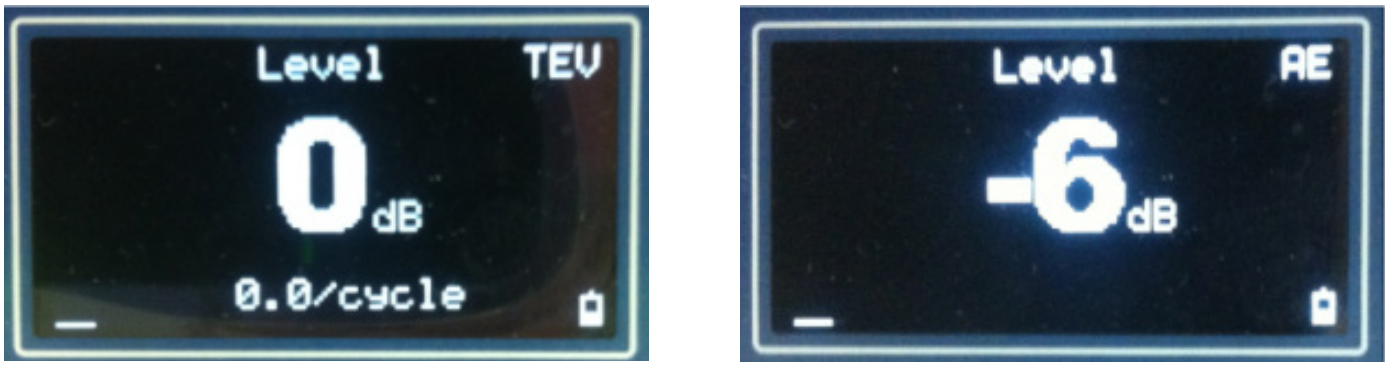


Fig 5: LEVEL Mode for TEV and AE

In TEV mode, the Count is also shown. The Count is the average number of pulses detected in a single power cycle and reflects the intensity of the detected activity.

Coloured LEDs on either side of the display indicate whether the activity detected is Low, Medium or High.


Fig 6: LEVEL Mode for TEV and AE

Thresholds for TEV measurements are set according to the levels shown in the table below;

| | |
|---|---|
| Low | <20dB |
| Medium | 20- 29dB |
| High | >29dB |

Table 3: TEV activity level thresholds

Thresholds for AE measurements are set according to the levels shown in the table below;

| | |
|---|---|
| Low | <20dB |
| Medium | 20- 29dB |
| High | >29dB |

Table 4: AE activity level thresholds

# 12 Check Sonus PD-X Function

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


## 12.1 Function Tester

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

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

## 12.2 Check The TEV Function

With the Sonus PD-X in TEV mode, hold the PD-FT up against the sensor head of the Sonus PD-X and press the blue button as shown in Fig 10 below. The bottom surface of the PD-FT should be held directly against the sensor head.

The Sonus PD-X should record noise value of greater than 30dB to confirm correct operation.

**Note: The Level value may read as 0dB during the function test. the PD-FT unit is not generating TEV that is in sequence with a normal electrical system at 50Hz or 60Hz so the Sonus PD-X registers this as noise due to its filtering algorithum.**

Fig 10: Testing TEV function with PD-FT

## 12.3 Check The AE Function

Wit the Sonus PD-X in AE mode, hold the PD-FT up against the sensor head of the Sonus PD-X and press the blue button and release as shown in Figure 11 below. 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-X as shown in the picture.

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


Fig 11: Testing AE function with PD-FT

# 13 Surveying Switchgear Panels For PD - TEV

## 13.1 Step 1- Check TEV Activity Levels

1. Switch the Sonus PD-X 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-X 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.
1. Record the results for future reference and comparison. An example of a form for doing this is shown in Appendix A.

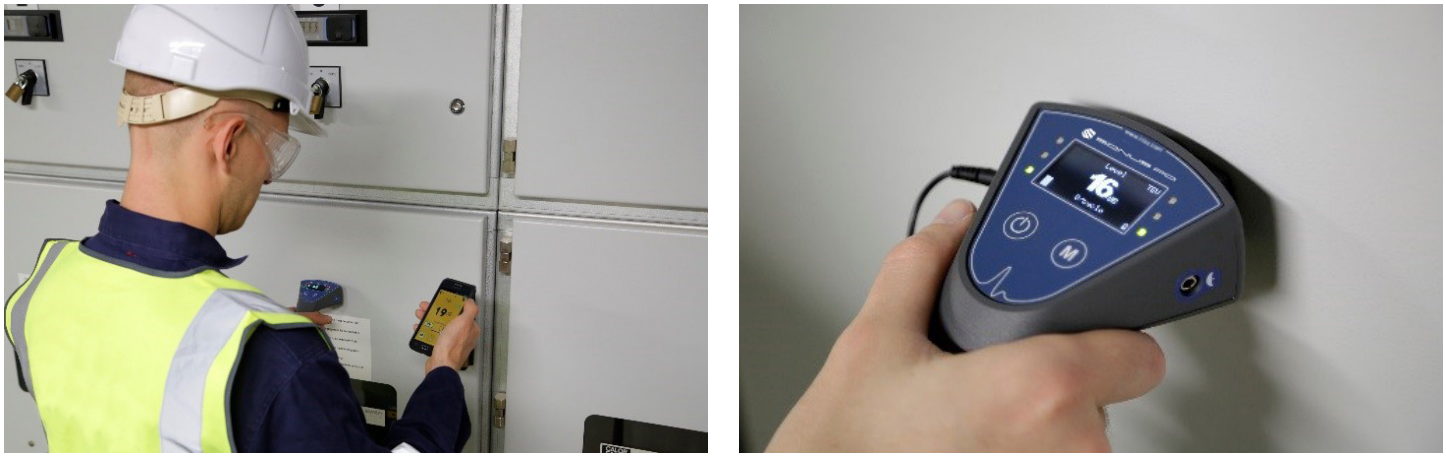

Fig 12: Checking activity levels on each panel

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

### 13.1.1 Example 1 – Component 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 13.

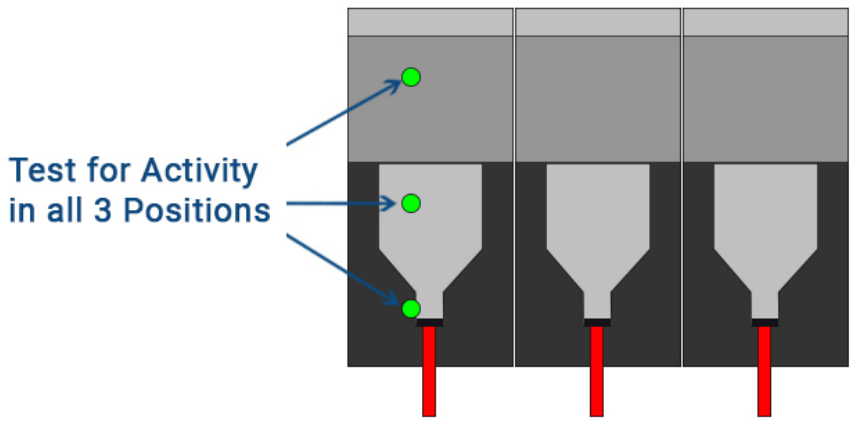


Fig 13: Sonus PD-X placement on Component switchgear

### 13.1.2 Example 2 – Fully Enclosed Switchgear

Where the switchgear has enclosed 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 14.

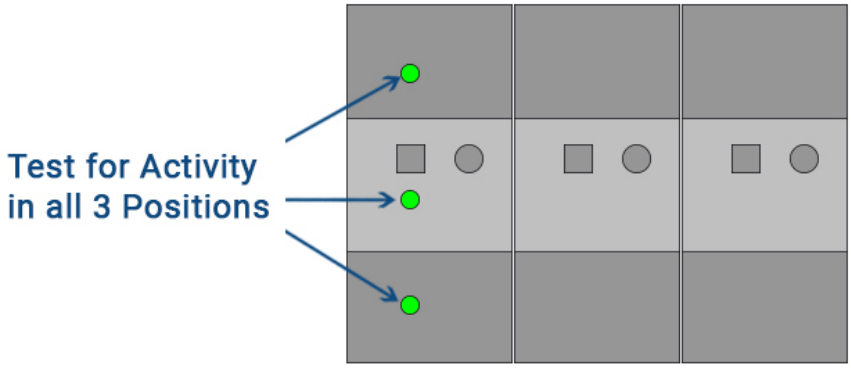


Fig 14: Sonus PD-X placement on fully enclosed switchgear

## 13.2 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-X. 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-X 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.

# 14 Surveying Switchgear Panels for PD - Acoustic Emissions

## 14.1 Step 1- Check Acoustic Activity Levels

1. Switch the Sonus PD-X 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 or through dedicated ultrasound ports.
    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-X screen.
3. Record the results for future reference and comparison. An example of a form for doing this is shown in Appendix A.

Fig 15: Checking acoustic activity between switchgear panels

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

# 15 Appendix A: Example Test Sheet

| Substation Name | | Test Engineer | |
|---|---|---|---|
| Location | | Test Date | |
| Panel No. | Panel Section | TEV Level (dB) | Acoustic Level (dB) |
| 1 | Top | | |
| | Middle | | |
| | Bottom | | |
| 2 | Top | | |
| | Middle | | |
| | Bottom | | |
| 3 | Top | | |
| | Middle | | |
| | Bottom | | |
| 4 | Top | | |
| | Middle | | |
| | Bottom | | |
| 5 | Top | | |
| | Middle | | |
| | Bottom | | |
| 6 | Top | | |
| | Middle | | |
| | Bottom | | |
| 7 | Top | | |
| | Middle | | |
| | Bottom | | |
| 8 | Top | | |
| | Middle | | |
| | Bottom | | |
| 9 | Top | | |
| | Middle | | |
| | Bottom | | |

# 16 Appendix B: The Relationship Between PD and Criticality

## Criticality

The Criticality of a medium or 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;

| TEV Measurement | Low | Medium | High |
|---|---|---|---|
| MV Switchgear | < 20dB | 20- 29dB | > 29dB |

| AE Measurement | Low | High |
|---|---|---|
| MV Switchgear | < 6dB | > 6dB |

***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 onset of PD can be between a few days and many months.