PD Detector Pro

User Manual

Version 1.4

Read this manual before using the equipment

Retain this manual for future use

Document Information

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Version History

03/08/2023 Version 1.0 – Document creation and initial publication.
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19/08/2024 Version 1.3 – Updates for new software release.
23/01/2025 Version 1.4 – Updated screenshots for new software release and copyright.

Copyright

Intended Purpose

This document provides information for the setting up and operation of the PD Detector Pro.

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Safety Notices

WARNING

Warnings refer to the risk of serious injury or death!

Please take notice of the advice to avoid.

CAUTION

Cautions refer to the risk of injury or damage to the equipment or property!

Please take notice of the advice to avoid.

Other Notices

Note

Notes refer to a recommended method or a useful tip.

NOTICE

Notices bring an important point to attention.

Contents

1 Safety Information

WARNING

Risk of serious injury or death!

Read and understand the following safety information before entering the substation and using the PD Detector Pro's sensors on substation assets.

This section provides an overview of all safety aspects for the protection of people as well as safe and uninterrupted operations. Other task-related safety instructions are included in the specific sections.

1.1 Substation Safety

Always follow the substation owner's high voltage safety rules.
Follow any additional procedures or rules required by the substation owner.

1.1.1 General Safety

When using the PD Detector Pro you must follow the substation owner's safety rules:

- Ensure you are familiar with all site emergency procedures.
- Read and understood the appropriate equipment manuals, including manuals for any additional tools that might be needed for the installation.
- Only appropriately trained personnel should work in or around the substation.
- Ensure that any risk assessments have been properly completed and are in line with both the substation owner and company mandates.
- Do not use any equipment, tools, or safety gear / PPE if it is damaged, or its safety is impaired in any way.
- Wear sensible and proper PPE and ARC-rated clothing, when appropriate to do so or as directed by a risk assessment.

1.1.2 Sensor Installation and Cable Routing

- If routing cables through walls, ensure that you have an accurate and up-to-date diagram of any substation wiring.
- **Never connect the PD Detector Pro and PD sensors to, or put the equipment near, any high-voltage components.** The PD Detector Pro and PD sensors have been designed for use only on the earthed, outer surfaces of metal-clad equipment and earthed connections of cables/switchgear.
- Always select the appropriate sensor and sensor connection for the application.
- **Never disconnect or loosen an earth connection on live equipment to install a PD sensor.**
- Cables connecting PD sensors to the PD Detector Pro do not provide protection against high voltage.
- Do not use the equipment if it is damaged, or if its safety is impaired in any way.
- Inspect and test all ground leads and signal cables for continuity.
- Do not disturb or interfere with the high-voltage equipment in any way.

1.2 Lone Workers

WARNING

Risk of serious injury or death!

Clear and safe procedures MUST be in place before a worker is permitted to work alone.

A lone worker is defined as anyone working without the direct and immediate support of supervisors or colleagues. If an employee cannot be seen or heard by a colleague, they are lone working, whether that be for all or part of their working day.
If lone work is unavoidable workers must be aware of some of the leading causes of accidents in the workplace:

- Slips, trips, and falls.
- Lifting.
- Working in confined spaces.
- Working with hazardous substances.

If a worker is required to work alone, clear procedures must be in place to ensure safety.
These may include:

- Periodic visits.
- Regular contact at agreed intervals.
- Other devices that raise the alarm either manually or automatically.

1.3 Lifting Safety

CAUTION

Risk of injury!

Follow safe practices when lifting large or heavy equipment.

When you are required to lift equipment, read, and follow the local and national Lifting Operations and Lifting Equipment Regulations (LOLER) for the country of operation.

LOLER requires that all lifting operations involving lifting equipment must be:

- Properly planned by a competent person.
- Appropriately supervised.
- Carried out in a safe manner.

In planning any lifting operation, the identification and assessment of risk is key to identifying the most appropriate equipment and method for the job.

1.4 Work Equipment Safety

CAUTION

Risk of injury!

Follow safe practices when operating work equipment.

When you are required to operate work equipment, read, and follow the Provision and Use of Work Equipment Regulations (PUWER) for the country of operation.

PUWER requires that equipment provided for use at work is:

- Suitable for the intended use.
- Safe for use, maintained in a safe condition and inspected to ensure it is correctly installed and does not subsequently deteriorate.
- Used only by people who have received adequate information, instruction, and training.
- Accompanied by suitable health and safety measures, such as protective devices and controls. These will normally include emergency stop devices, adequate means of isolation from sources of energy, clearly visible markings, and warning devices.
- Used in accordance with specific requirements, for mobile work equipment and power presses.

1.5 Environmental Protection

Improper handling or incorrect disposal of hazardous materials can cause serious damage to the environment.
Observe and follow the handling and disposal instructions on containers, product packaging, safety data sheets, and local regulations.
This product contains general electronic components that may be environmentally harmful if improperly disposed. Please follow the local regulations on correct disposal methods.
Alternatively, devices can be returned to IPEC at the end of use for correct disposal.

2 What is the PD Detector Pro?

2.1 About the PD Detector Pro

The PD Detector Pro is a handheld instrument for quickly detecting and quantify Partial Discharge (PD) in Medium Voltage (MV) and High Voltage (HV) assets using a wide range of internal and external sensors.

The large colour touchscreen makes analysis clear and simple. The internal data storage allows the saving of measurement data to give a clear picture of asset health over time.
The PD Detector Pro features advanced noise rejection algorithms to effectively filter out background electrical noise, displaying both PD and Noise level.

Key Features

- Shows both PD and noise level simultaneously.
- Active noise discrimination
- PD sensors: TEV, Ultrasonic, HFCT, UHF, VDS.
- 3.5” widescreen full colour touchscreen.
- Audio on all sensors to hear the PD from any sensor.
- Multiple graph and display options.
- Built-in wireless power frequency synchronization locks onto the 50/60Hz frequency of HV assets.
- Internal storage for saving PD data and reporting.

2.2 PD Detector Pro Parts

1	Touchscreen
2	Ultrasonic Sensor
3	TEV Sensor
4	Multi-Sensor Port
5	Left Context Button *(Hold: Power ON / OFF)*
6	Middle Context Button
7	Right Context Button
8	USB-C Port
9	Headphone Socket

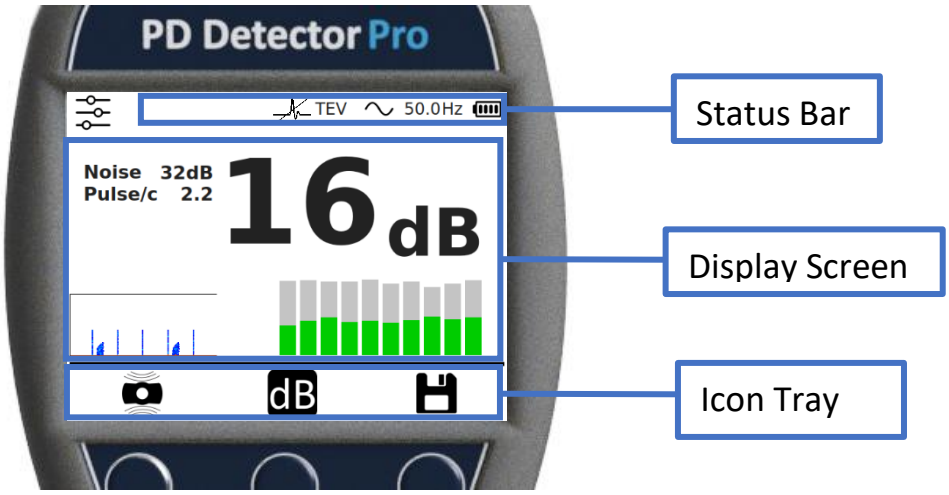


Figure 1 - PD Detector Pro function diagram.

2.3 PD Detector Pro Kit List

The following is included in the standard PD Detector Pro kit:

- 1 x PD Detector Pro
- 1 x Peli™ carry case
- 1 x USB-C charger
- 1 x PD-FT function tester
- 1 x Wired headphones
- 1 x Quick Start Guide

2.3.1 Optional Accessories

The following are additional accessories available for the PD Detector Pro:

- External TEV Sensor
- HFCT Sensor
- VDS Sensor
- Flexible Ultrasonic Probe
- Ultrasonic Parabolic Dish
- Contact Acoustic Sensor
- UHF GIS Barrier Spacer Sensor

For more information about the optional accessories please contact sales@ipec.co.uk.

Figure 2 - Photo of the standard PD Detector Pro kit.

3 Getting Started

This section describes the steps required to start using the PD Detector Pro.

3.1 Charging the PD Detector Pro

The PD Detector Pro is powered by an internal battery that charges via USB-C.
The battery icon in the top-right corner of the screen shows the level of charge of the device.

Figure 3 - Battery icon charge level indication.

Before using the PD Detector Pro, connect the USB-C charger to the USB port on the bottom of the PD Detector Pro to charge the device.

The PD Detector Pro can be charged using the included mains power charger or a 3rd party car charger, battery pack, or any device with a USB socket that can deliver a minimum of 5V 1A.

Figure 4 - The bottom of the PD Detector Pro where the USB-C port is located.

NOTICE

The measurement functions are disabled when charging the PD Detector Pro.

3.2 Turn on the PD Detector Pro

Press ⏻ once to turn ON the PD Detector Pro.

Press and hold ⏻ for at least 2 seconds to turn OFF the PD Detector Pro.

3.3 Changing the Sensors

3.3.1 Built-In Sensors

Press the left icon/context button to switch between the built-in TEV and Ultrasonic sensors.

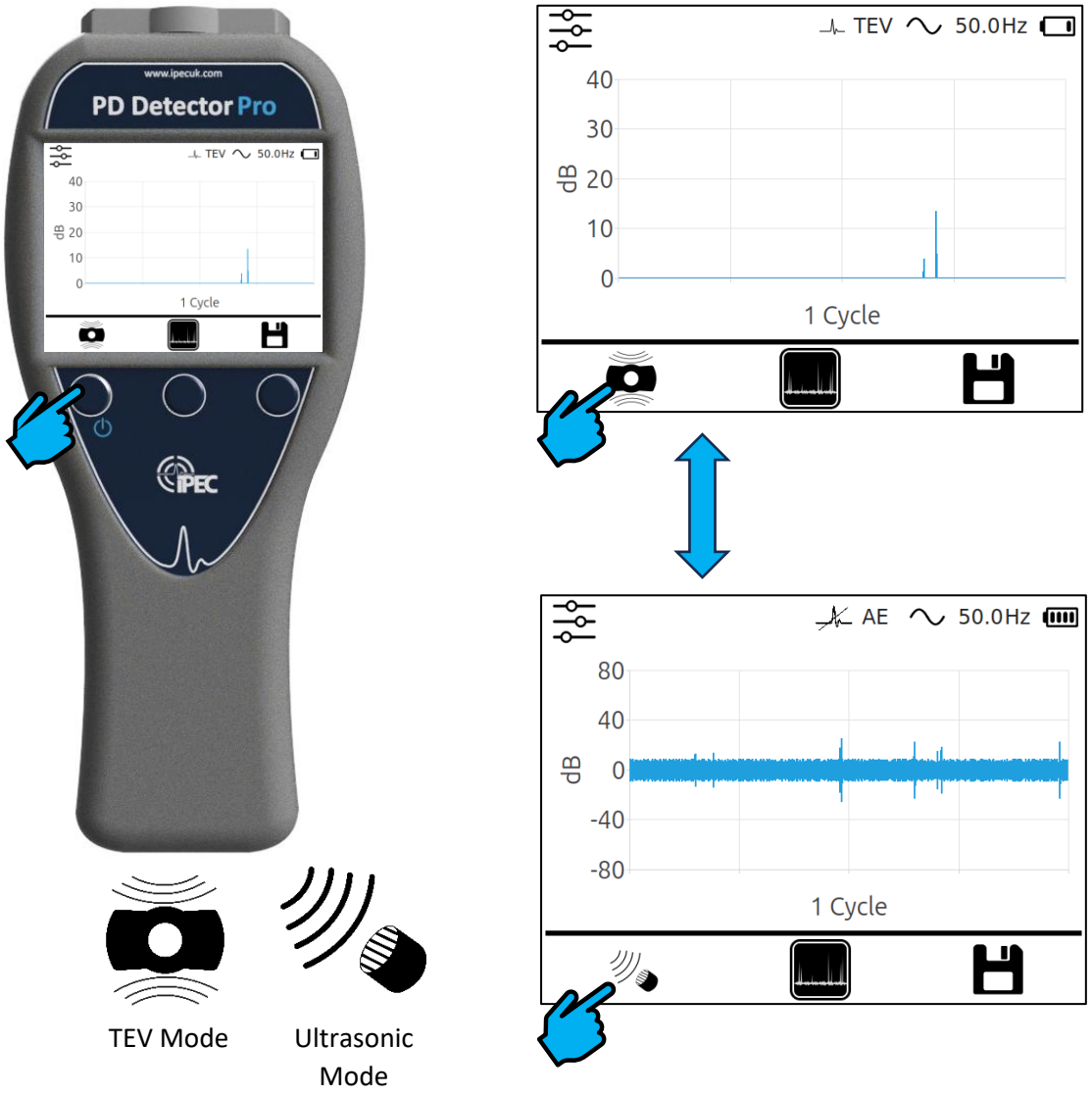


Figure 5 - Diagram showing how to switch between the built-in sensors.

3.3.2 External Sensors

External optional sensors can be connected to the PD Detector Pro's multi-sensor port (see Figure 1) using their included sensor cable. The sensor type will automatically be detected by the PD Detector Pro and the sensor mode switched until the sensor is disconnected.

3.4 Perform a Function Test

Before using the PD Detector Pro, use the PD Function Tester (PD-FT) to check it is operating correctly. The PD-FT is a battery-operated test device for checking the PD Detector Pro TEV and Ultrasonic functions.

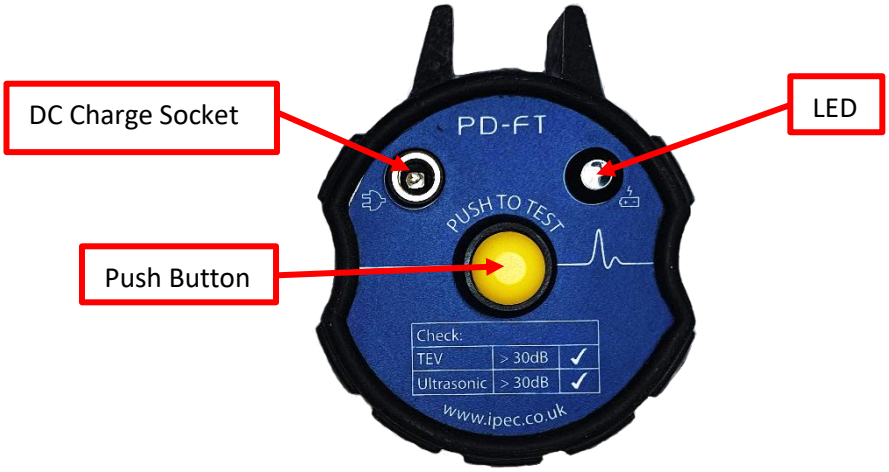


Figure 6 - Labelled diagram of the PD-FT.

CAUTION

The PD-FT is NOT a calibration tool.
The PD-FT only checks that the built-in sensors are functioning.

3.4.1 Charging the PD-FT

The PD-FT is charged using the included USB to DC barrel cable. The LED indicates the battery state:

- Flashing: Please charge the PD-FT.
- Bright Intensity: The PD-FT is charging.
- Normal Intensity: The PD-FT is fully charged.

3.4.2 Check the TEV Function

1) Use the left icon/context button to set the PD Detector Pro to TEV Mode.
2) Hold the bottom of the PD-FT against the PD Detector Pro sensor head.
3) Press and hold the yellow button on the PD-FT.
4) Confirm the PD Detector displays a signal level of 29dB or greater.

Note

It does not matter if the display is shown as PD or Noise.

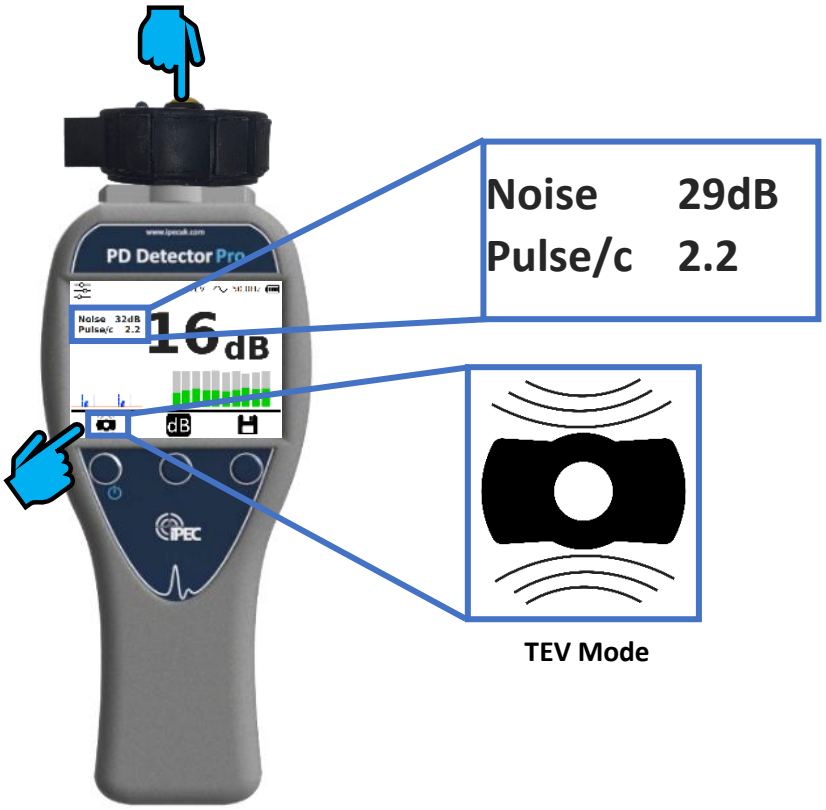


Figure 7 - Testing the TEV function with the PD-FT.

3.4.3 Check the Ultrasonic Function

1) Use the left icon/context button to set the PD Detector Pro to Ultrasonic mode.
2) Hold the PD-FT against the PD Detector Pro's built-in ultrasonic sensor.
   Use the two rubber extensions to set the distance between the PD-FT and the PD Detector Pro.
3) Press and hold the yellow button on the PD-FT.
4) Confirm the PD Detector Pro displays a signal level greater of 30dB or greater.

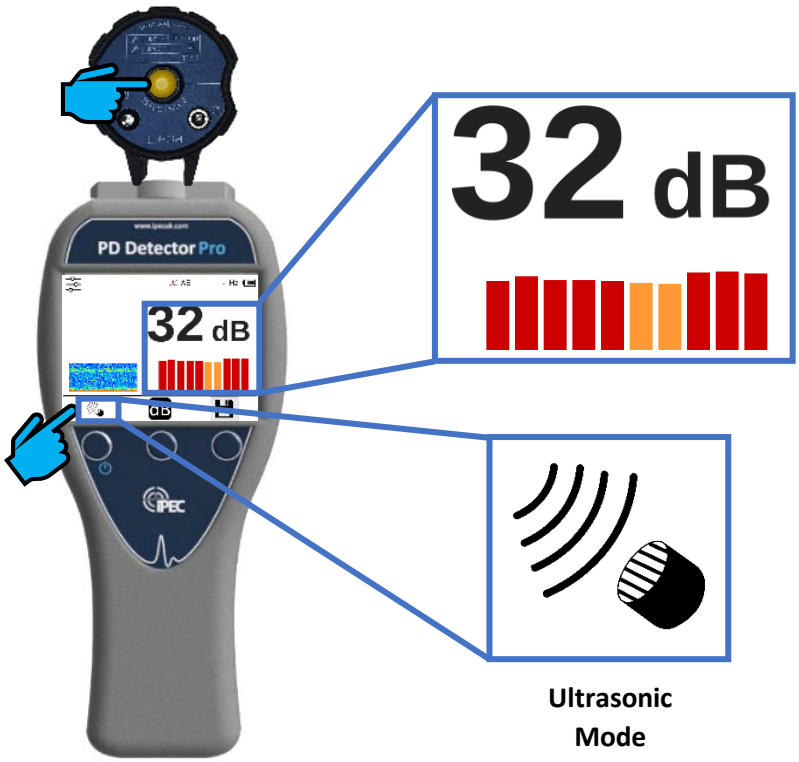


Figure 8 - Testing the Ultrasonic function with the PD-FT.

4 How to Measure PD Activity

This section describes how to use the PD Detector Pro to measure PD activity using the various sensors and display options.

4.1 Changing the display

The PD Detector Pro has three main display types: Level, Live PRPD, and persistent PRPD Heatmap. To cycle between these displays, press the middle context button or tap the on-screen icon.

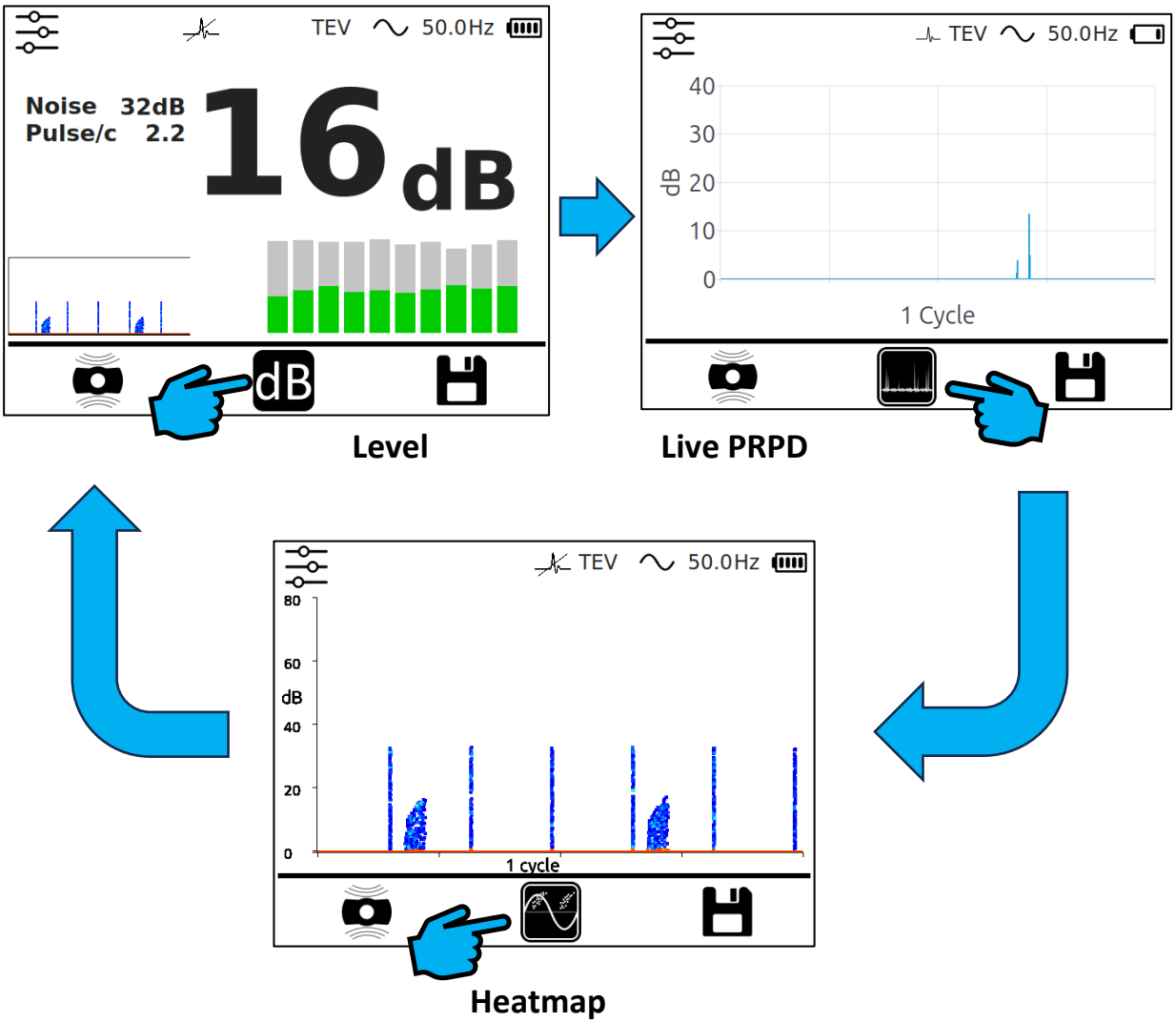


Figure 9 – Diagram showing the cycling between the measurement displays.

4.1.1 Level Display

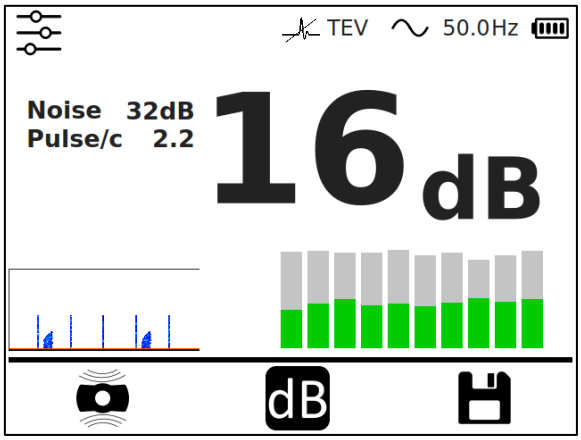


Figure 10 - Screenshot of the Level Display.

This is the default display and shows the real-time signals levels measured in dB. It also gives live values for the noise level using IPEC's noise identification algorithm, pulse count per cycle, and the calculated severity level.

Below these values there are two supplementary graphs.
On the left is a PRPD Heatmap preview window. Tapping on the preview window will automatically switch over to the Heatmap display.
Please see the Heatmap display section 4.1.3 for more information.

On the right, there is a live bar chart that shows colour-coded activity levels of recently acquired data. Please see the table below for the colour-coded activity thresholds.

Sensor	Low (Green)	Medium (Yellow)	High (RED)	Noise (Grey)
TEV	≤19dB	20 to 29dB	≥30dB	n/a
Ultrasonic	≤5dB	N/A	≥6dB	n/a
HFCT	≤99pC	100 to 499pC	≥500pC	n/a
UHF	≤ -41dBm	-40 to -31dBm	≥ -30dBm	n/a

Table 1 - Thresholds of the colour-coded activity levels.

4.1.2 Live PRPD Display

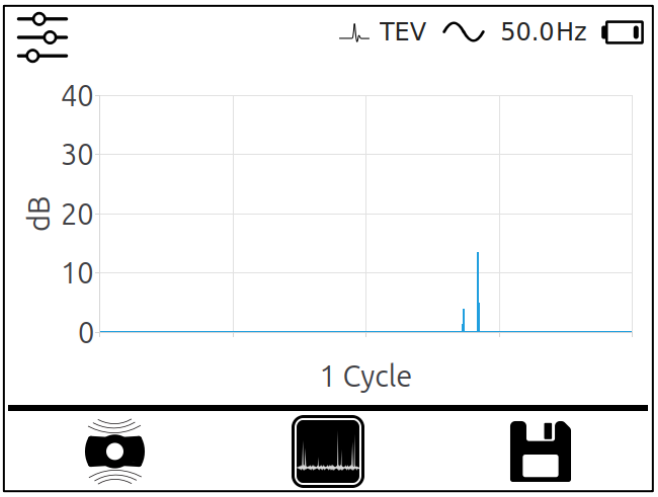


Figure 11 - Screenshot of the Live PRPD Display.

The Phase-Resolved Partial Discharge (PRPD) display shows the activity detected in real time synchronized with the power cycle using IPEC's patented built-in power field detector.
The X-axis represents time and is calibrated to represent a power cycle:

- For a 50Hz system, each power cycle shows 20ms.
- For a 60Hz system, each power cycle shows 16.67ms.

The Y-axis represents the magnitude of the detected pulse. The default unit is dB.
Tap at the top of the Y-axis to increase the scale. Tap at the bottom of the Y-axis to decrease the scale. Both the units and the scale can be changed in the options menu. See Section 4.4.3 for more details.

4.1.3 Heatmap PRPD Display

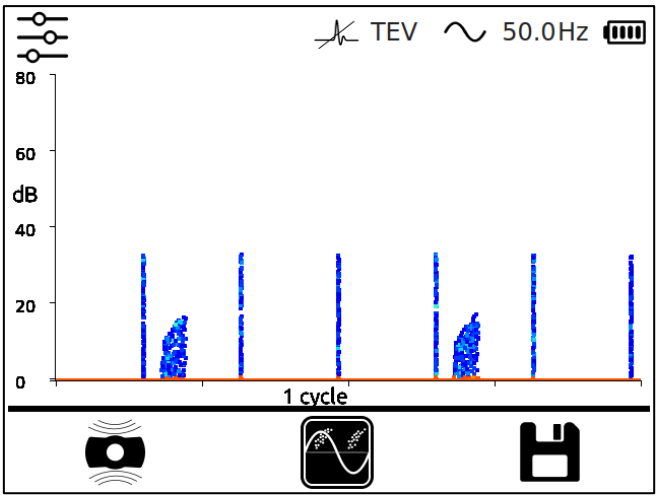


Figure 12 - Screenshot of the Heatmap PRPD Display.

The Heatmap PRPD displays the data as a scatter plot with a colour gradient. For each new reading, a point is plotted on the graph synchronised with the power frequency. With each power cycle recorded, points that are plotted in the same position of the power cycle change colour to indicate activity levels. This PRPD display is cumulative and shows all activity detected from the time when this display was selected or when the display was refreshed.
The Y-axis represents the magnitude of the detected pulse. The default unit is dB.
Tap at the top of the Y-axis to increase the scale. Tap at the bottom of the Y-axis to decrease the scale. Both the units and the scale can be changed in the options menu. See Section 4.4.3 for more details.

4.2 Pause and Resume

The PD Detector Pro allows the user to pause and resume measurement on the PRPD displays.

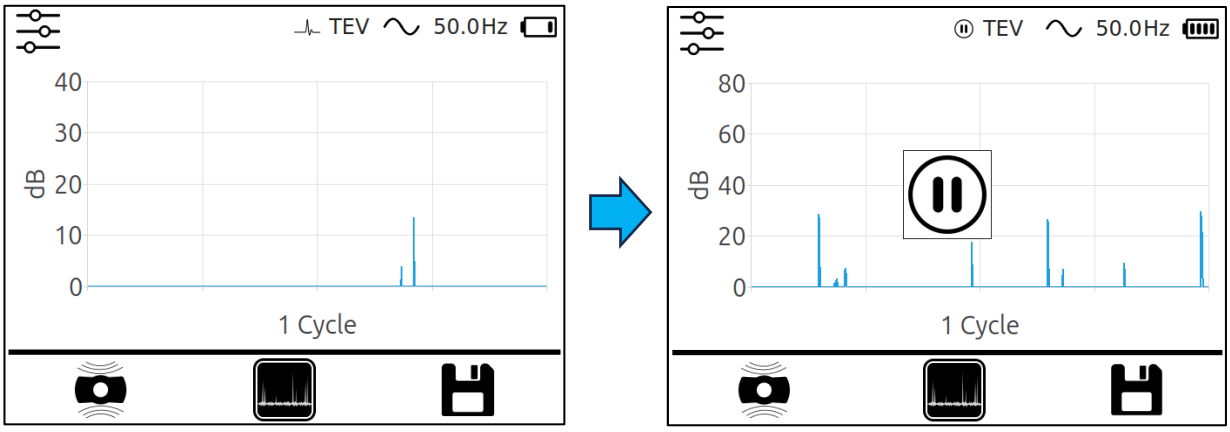


Figure 13 - Diagram showing how to pause the measurement on PD Detector Pro.

Tap on the middle of the screen to pause the measurement. A pause icon will appear as a temporary pop-up and a small pause icon will be shown in the status bar at the top of the screen.

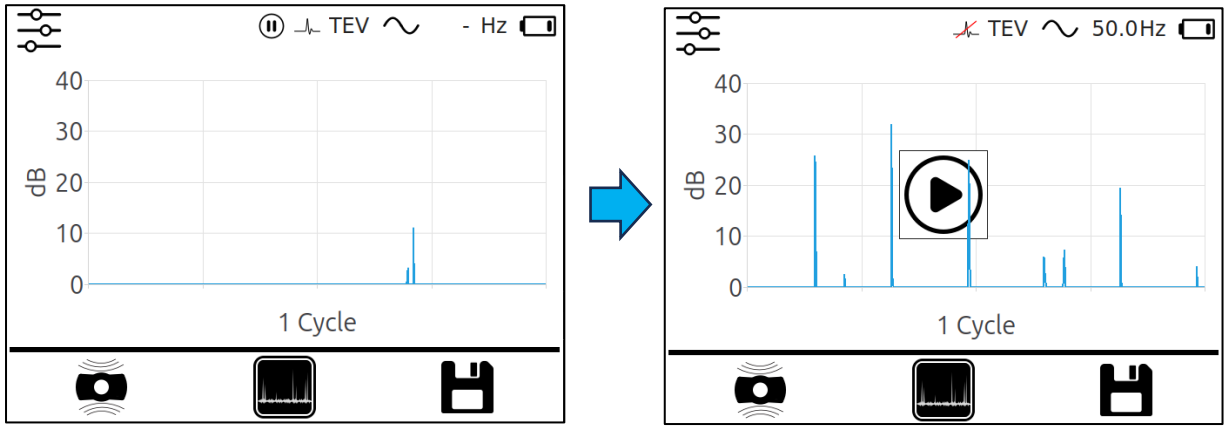


Figure 14 - Diagram showing how to resume the measurement on PD Detector Pro.

Tap again on the middle of the screen to resume the measurement.
Switching sensor or switching display screen will also resume measurement.
On the Heatmap display, pausing then resuming will refresh the display.

4.3 Power Frequency Synchronization

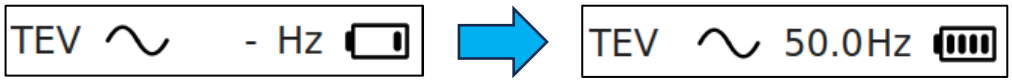


Figure 15 - Cropped screenshots showing the Sync icon and measured power frequency.

When the PD Detector Pro detects and locks to the ambient power field from the HV assets, it displays the ∿ icon in solid black and the measured power frequency in the top right corner of the status bar.
If the ∿ is red or blinking the PD Detector Pro has not locked to the ambient power field.

4.4 Display Options

Tapping the options icon in the top-left corner of the screen opens the display options menu.

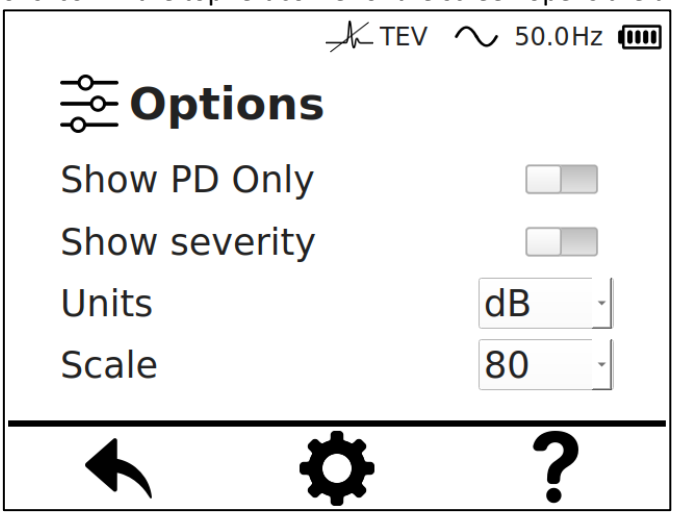


Figure 16 - Screenshot of the display options menu.

Tapping on the gear icon at the bottom of the screen opens the device settings menu. For more information on device settings, please see Section 6.

4.4.1 Show PD Only

"Show PD Only" is a toggle switch which enables and disables the PD noise filtering algorithm. This highly-effective algorithm uses multiple parameters to analyse the activity recorded on the sensors and then remove noise signals from the Live PRPD and Heatmap displays.
There is an icon in the top status bar which indicates if the noise algorithm is enabled or disabled, as shown below.

Algorithm Enabled | Algorithm Disabled

Figure 17 - PD Noise Algorithm icons.

For an example of the PD Noise Algorithm in use, please see Section 4.5.2.

4.4.2 Show Severity

Show Severity is a toggle to enable displaying the calculated severity level.
Severity is an industry measure value that is calculated via the following equation:

$$Severity = Count\ per\ cycle\ \times maximum\ pulse\ amplitude\ (mV)$$

Equation 1 - How to calculate Severity.

In general, a high severity indicates a high PD activity. However, this measure should be used in conjunction with checking the PRPD pattern. This will verify if the high activity present is being caused by PD or noise. Please see Section 4.5.1.

4.4.3 Units

This is a drop-down list with different measurement unit options depending on which sensor is being used. Please see the table below for a list of the units for the level display.

Sensor	Unit 1 (Default)	Unit 2
TEV	dB	mV
Ultrasonic	dB	µV
HFCT	dB	pC*
UHF	dB	mV

**pC is calculated from the mV level and can be adjusted to suit "calibration" requirements.*

Table 2 - Table of options for the displayed units for each sensor type.

4.4.4 Scale

This is a drop-down list where the maximum value for the PRPD graphs can be set.
Please see below for a table of the scale settings for each unit type.

Unit	Settings						
dB	30dB	40dB	60dB	80dB			
mV	10mV	20mV	50mV	100mV	500mV	1000mV	5000mV

Table 3 - Table of options for the maximum scale of each unit type.

4.5 How to verify activity as PD or Noise

To help distinguish between partial discharge activity and background noise there are analytical methods that can be used. For more information about PD Diagnosis training or PD Analysis services that IPEC provides, please contact sales@ipecuk.com.

4.5.1 PRPD Patterns

Follow the guides for using the PD Detector Pro's sensors in sections 4.6, 4.7, 4.8, 4.9, and 4.10.
After observing the activity on the Level display, switch to the Heatmap PRPD displays.
This display will show a PRPD pattern to aid in verifying the activity as PD or Noise.

PD Example

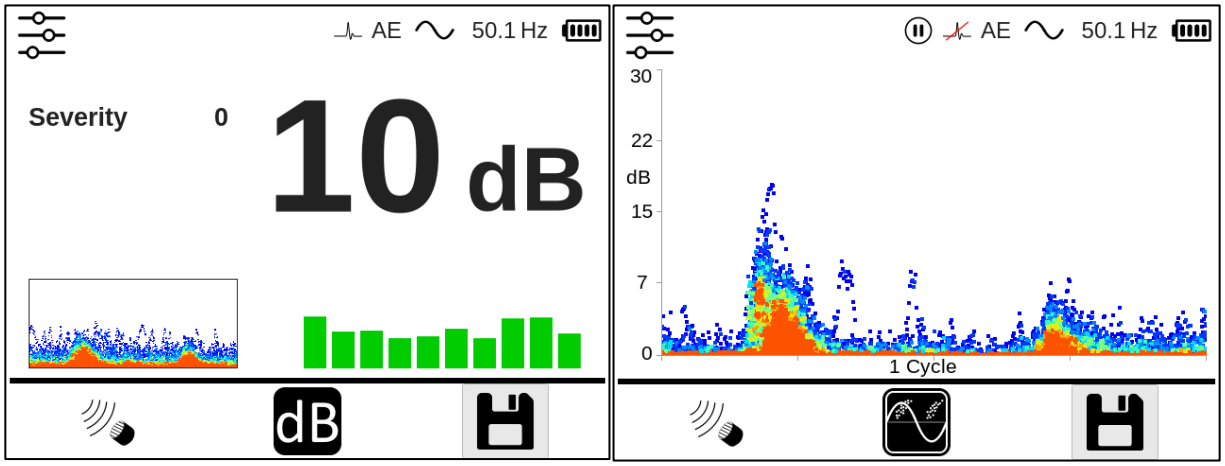


Figure 18 - Screenshots of the Level and PRPD displays showing ultrasonic PD activity.

Above is an example of a PRPD pattern observed when using the internal ultrasonic sensor. On the left is the level screen showing a 10dB activity level. On the right is the Heatmap PRPD screen and here there is a clear PD pattern forming. The PD pattern shows two peaks that are 180 degrees apart in the power cycle. This indicates ultrasonic energy is being produced at the same point in the positive and negative portions of the power cycle and therefore, this activity is likely to be caused by partial discharge.

4.5.2 Using the PD Noise Algorithm

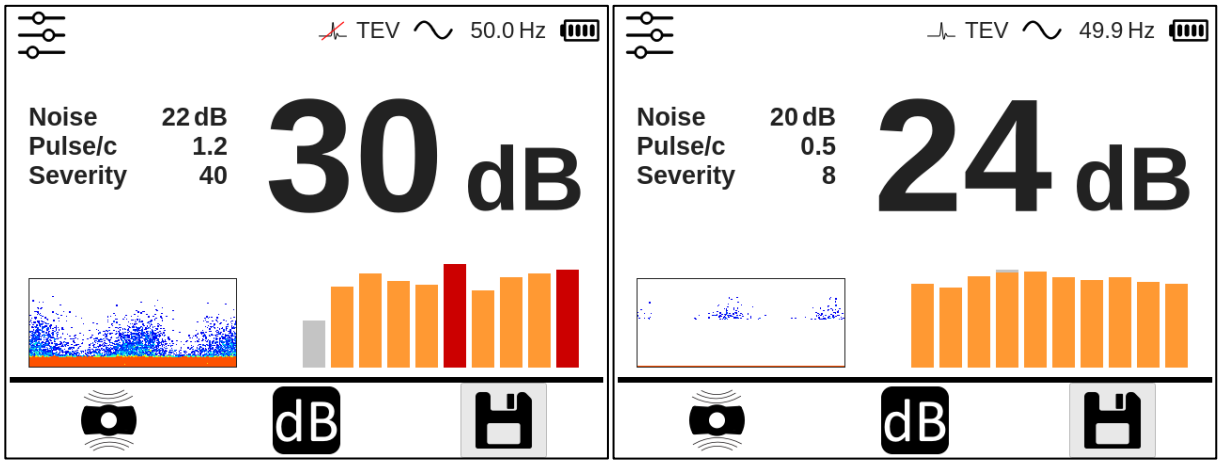


Figure 19 - Screenshots of the Level screen with the PD Noise Algorithm disabled (right) and enabled (left).

The screenshots above show the effectiveness of the PD Noise Algorithm which removes signals classified as background noise from the mini PRPD Heatmap display in the bottom-left corner. When removed, the peaks of activity 180 degrees apart become more obvious and it is therefore easier to characterise this as PD activity.

Toggling the PD Noise Algorithm option “Show PD Only”, as shown in section 4.4.1, is another effective way to verify if the activity is partial discharge or background noise.

4.6 How to do a TEV measurement

In TEV mode, the PD Detector Pro detects high-frequency signals travelling around the metallic enclosure of switchgear. For more information about partial discharge TEV signals please refer to Appendix A.2.
The PD Detector Pro is able to distinguish between PD and noise and shows each value separately. For more information about how to verify if the activity recorded is PD or noise, please refer to Section 4.5.

1) Switch the PD Detector Pro to TEV Mode and Level Display.
   a) Select TEV Mode using the left icon/context button.
   b) Select Level display using the middle icon/context button.
2) Starting at one end of the switchgear, check each panel for activity.
   a) Depending on the type of switchgear, the PD Detector Pro may need to be placed near the top, middle or bottom section.
   b) Record the dB level shown on the PD Detector display.
   c) If a single switchgear unit has more than one metal panel, then do the test on each panel.
3) Record the results by saving a screenshot or saving the data. See section 5 for more details.
4) Confirm the activity recorded is PD. Please refer to Section 4.5 for more information.

Figure 20 - Photos showing the PD Detector Pro surveying a switchgear panel in TEV mode.

4.6.1 Using the External TEV Sensor

Optional Accessory

The external TEV Sensor is an optional accessory for the PD Detector Pro purchased separately or as part of a kit. Please contact sales@ipecuk.com for more information.

Figure 21 - An external TEV Sensor for use with the PD Detector Pro.

An external TEV sensor can be connected to the PD Detector Pro to measure TEV signals in harder to reach areas. To use the external TEV sensor, insert the external TEV cable into the multi-sensor socket. The PD Detector Pro will display a “External TEV Sensor Connected” pop-up message and will switch to TEV mode automatically.

4.7 How to do an Ultrasonic measurement

In Ultrasonic Mode, the PD Detector displays the magnitude of ultrasonic acoustic signals detected. For more information about ultrasonic signals, please refer to Appendix A.2.

> IPEC recommends using the included headphones when performing ultrasonic measurements.

1) Switch the PD Detector Pro to Ultrasonic Mode and Level Display.
   a) Select Ultrasonic Mode using the left icon/context button.
   b) Select Level display using the middle icon/context button.
2) Starting at one end of the switchboard, check each panel for activity.
   a) Point the sensor towards any HV points, for example, cable terminations and exposed insulators around HV points, resin bushings or spouts on a removable breaker.

      > The best method for detecting ultrasonic activity in enclosed assets is to aim the sensor at gaps in the metal cladding or ventilation grills.

   b) If activity is found, move the transducer around until the highest level is detected and note the dB level shown on the display.
3) Record the results by saving a screenshot or saving the data. See section 5 for more details.
4) Confirm the activity recorded is PD. Please refer to Section 4.5 for more information.

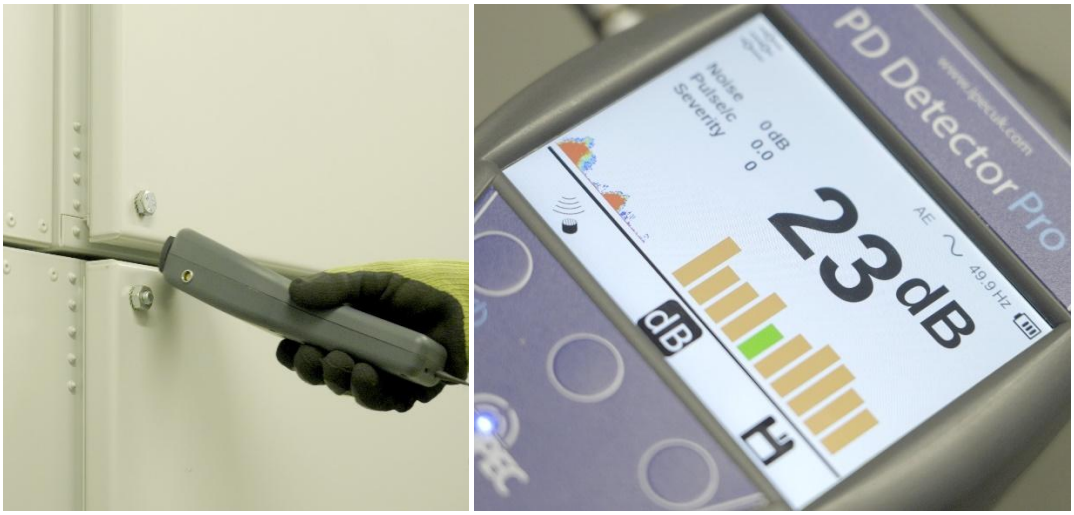


Figure 22 - Photos showing a switchgear panel gap being surveyed in Ultrasonic mode.

4.7.1 Using the Flexible Probe

Optional Accessory

The flexible probe is an optional accessory for the PD Detector Pro purchased separately or as part of a kit. Please contact sales@ipecuk.com for more information.

Figure 23 - The Flexible Probe for use with the PD Detector Pro.

The Flexible Probe can be used with the PD Detector Pro for recording ultrasonic measurements in hard-to-reach areas such as gaps between panels high up and low down on assets. To use the Flexible Probe, insert the sensor cable into the multi-sensor socket. The PD Detector Pro will display a “Ultrasonic Sensor Connected” pop-up message and will switch to ultrasonic mode automatically.

Please refer to Section 4.7 for steps on how to perform an ultrasonic measurement.

4.7.2 Using the Parabolic Dish

Optional Accessory

The Parabolic Dish is an optional accessory for the PD Detector Pro purchased separately or as part of a kit. Please contact sales@ipecuk.com for more information.

Figure 24 - The parabolic dish for use with the PD Detector Pro.

The Parabolic Dish can be used with the PD Detector Pro for recording ultrasonic measurements on overhead lines and bushings out of reach. To use the Parabolic Dish, insert the sensor cable into the multi-sensor socket. The PD Detector Pro will display a “Ultrasonic Sensor Connected” pop-up message and will switch to ultrasonic mode automatically.

Aiming the Parabolic Dish

There are two built-in ways to aim the Parabolic Dish at the desired asset; the laser pointer and the post-sights.

To use the laser pointer, press and hold the button on the Parabolic Dish handle. This will project a red laser dot from the centre of the dish antenna. The power for the laser pointer is provided by the PD Detector Pro.

To use the post-sights, look through the parabolic dish with your dominant eye and line up the point of the front sight-post with the V-shaped groove of the rear sight-post and the desired asset.

Please refer to Section 4.7 for steps on how to perform an ultrasonic measurement.

4.7.3 Using the Contact Ultrasonic Sensor

Optional Accessory

The Contact Ultrasonic Sensor is an optional accessory for the PD Detector Pro purchased separately or as part of a kit.
Please contact sales@ipecuk.com for more information.

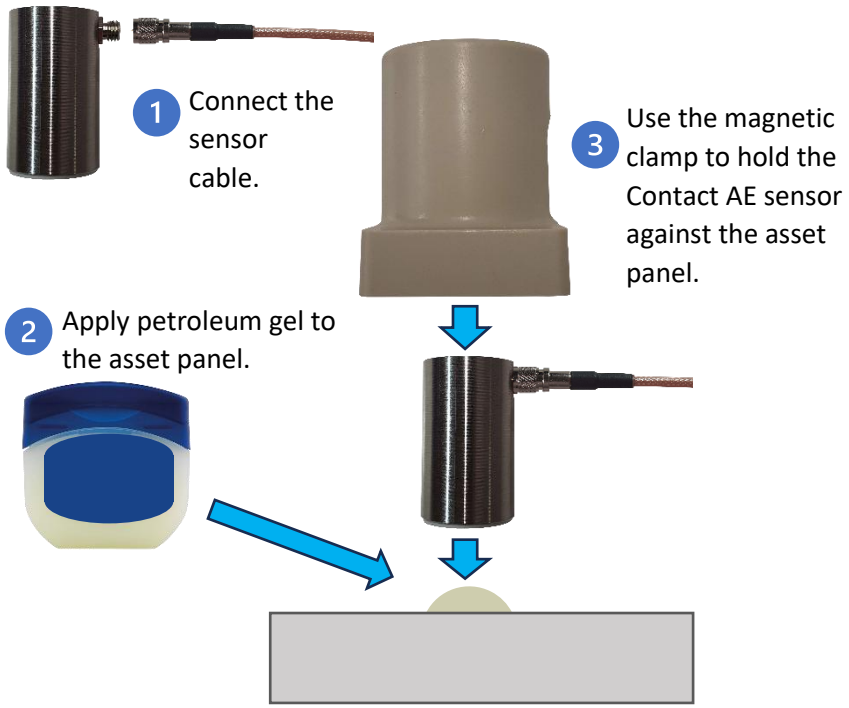


Figure 25 - The Contact Ultrasonic Sensor for use with the PD Detector Pro.

The Contact Ultrasonic Sensor is used for recording ultrasonic measurements in sealed assets where airborne ultrasonic sensors have no direct air path to the high-voltage stress points and therefore are unable to detect the partial discharge activity.
To use the Contact Ultrasonic Sensor, insert the sensor cable into the multi-sensor socket. The PD Detector Pro will display a “Contact Sensor Connected” pop-up message and will switch to ultrasonic mode automatically.
Please refer to Section 4.7 for steps on how to perform an ultrasonic measurement.

Asset types for Contact Ultrasonic Sensor.

In air-insulated switchgear, PD can be detected with a contact acoustic sensor. However, over 99.9% of the signal is reflected at the enclosure interface therefore a reading of no PD does not guarantee there is no PD present.

4.8 How to do a HFCT Measurement

Optional Accessory

The HFCT is an optional accessory for the PD Detector Pro purchased separately or as part of a kit.
Please contact sales@ipecuk.com for more information.

Figure 26 - The HFCT sensor for use with the PD Detector Pro.

The PD Detector Pro can be used with a High-Frequency Current Transformer (HFCT) to detect PD pules from defects in cables. For more information about how PD occurs and how the pulses propagate along the cables, please refer to Appendix A.2.

In HFCT mode, the PD Detector Pro detects high-frequency signals that are from both partial discharge sources and noise sources. An algorithm processes the detected signals and distinguishes between the partial discharge and noise so that the level of each can be shown separately.
The magnitude of pulses recognised as partial discharge and as noise is displayed in pC. The units can also be displayed as dB.

To use the HFCT sensor, insert the sensor cable plug into the multi-sensor socket. The PD Detector Pro will display a “HFCT Sensor Connected” pop-up message and will switch to HFCT mode automatically.

WARNING

Risk of serious injury or death!

DO NOT disconnect a cable earth to fit the HFCT sensor around it.

The HFCT does not provide electrical isolation for the HFCT. Therefore, the HFCT sensor must never be placed near to high-voltage components and ONLY ever be coupled around fully-earthed components away from areas of high-voltage stress.

Once the HFCT is connected to the PD Detector Pro then couple the HFCT around the cable under test. To ensure this is done safely, please refer to sections 4.8.2 and 4.8.3.

For more information about why it is important to couple the HFCT “above the earth” please refer to Appendix A.2.

4.8.1 Using the HFCT

1) Connect the HFCT cable to the BNC port on the HFCT.
2) Connect the HFCT cable to the multi-sensor port on the PD Detector Pro.
   The PD Detector Pro will automatically switch to HFCT mode.
3) Select Level display using the middle icon/context button.
4) Clamp the HFCT around the cable earth braid. See section 4.8.2 for more details.
5) Starting at one cable, check each cable earth for activity.
   a) Record the level shown on the PD Detector display.
   b) If a single switchgear unit has more than one cable, then do the test on each cable earth.
6) Record the results by saving a screenshot or saving the data. See section 5 for more details.
7) Confirm the activity recorded is PD. Please refer to Section 4.5 for more information.

Figure 27 - Photos showing the HFCT sensor being coupled around the cable earth and connected to the PD Detector Pro.

4.8.2 Safely Coupling the HFCT Around the Cable Earth

Often the most convenient place to couple the HFCT on a cable is around the cable earth strap. To do this please follow the diagrams below.

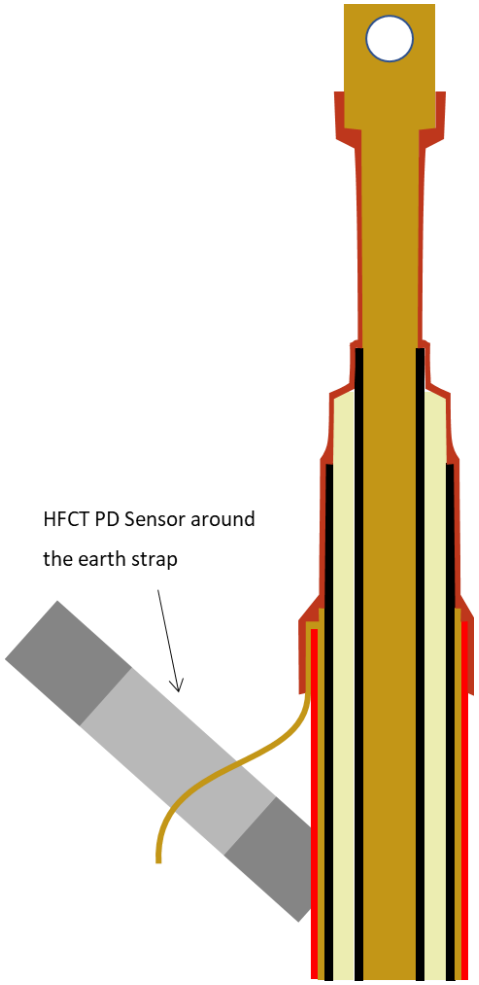


Figure 28 - Diagram showing the correct coupling of the HFCT sensor around the cable earth.

The HFCT sensor may also be installed on an earthing bus bar or a shared cable earth strap, however this means PD signals cannot be traced to a single cable.

4.8.3 Safely Coupling the HFCT Around a Cable Core

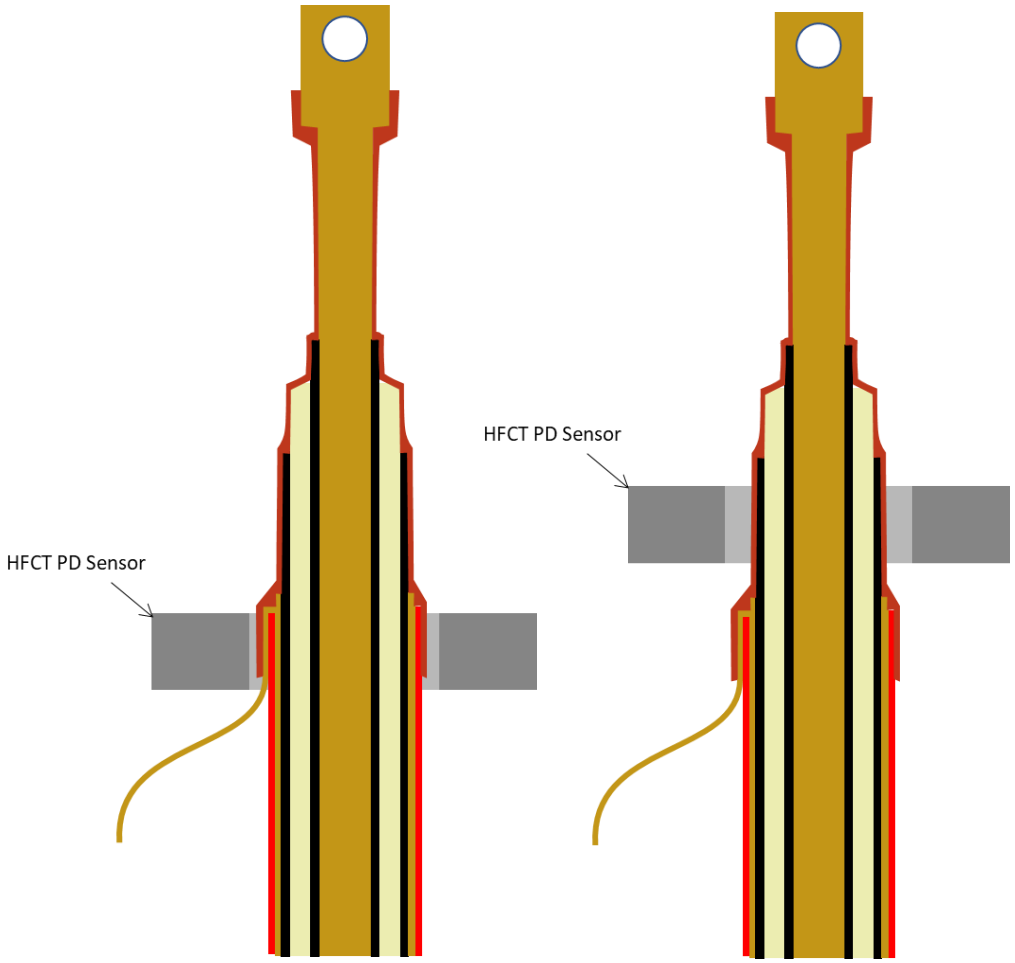
DANGER!

Risk of serious electric shock or death!

Ensure the cable asset is **DE-ENERGIZED** and there is **NO VOLTAGE** present before attempting to couple a HFCT around it!

Please also refer to the site/asset operator's safety guidelines.

The HFCT can safely couple to a cable around the cable core and "above the earth" by following the diagrams below.



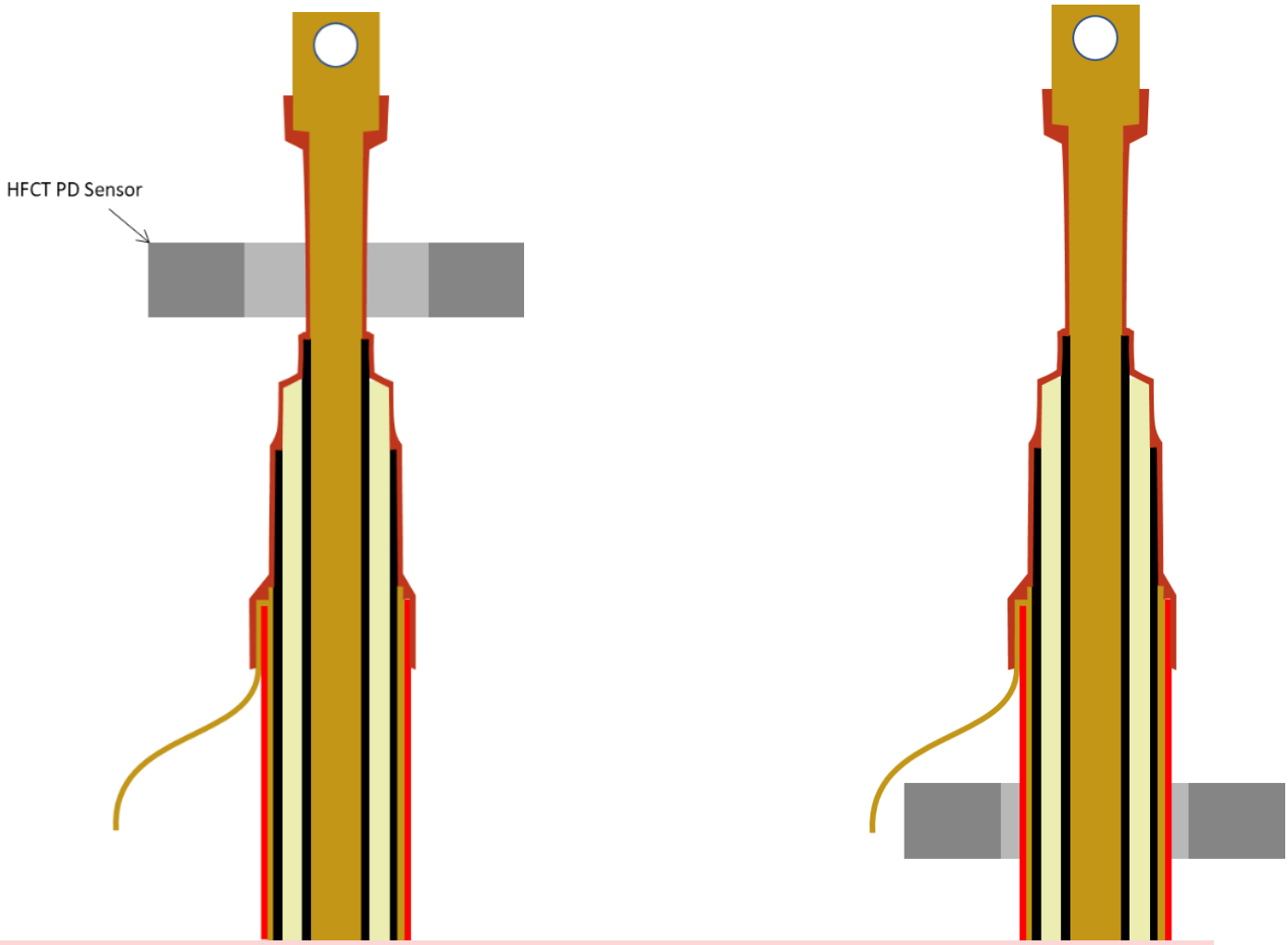
Correct HFCT Core Coupling

Here the HFCT can be installed around the core either on the thickest part of the cable which has the earth sheathing or slightly above where the outer semiconductor is present. Both of these regions do not have electrical stress and are therefore safe to couple an HFCT.

Figure 29 - Diagram showing the correct ways to couple the HFCT around the cable core.

DANGEROUS
High Electrical Stress. Risk of serious electrical shock and death.

Warning
The HFCT is coupled below the earth and will not function correctly**.**



Incorrect HFCT Core Coupling

The installation on the left is **DANGEROUS** as the HFCT is at ground potential. With no cable insulation present the HFCT is now in an area of **high electrical stress**.
The installation on the right is not dangerous, however the HFCT will not detect PD pulses as it "below the earth".

Figure 30 - Diagram showing the incorrect ways to couple the HFCT around the cable core.

4.9 How to do a UHF Measurement

Optional Accessory

The UHF sensor is an optional accessory for the PD Detector Pro purchased separately or as part of a kit.
Please contact sales@ipecuk.com for more information.

Figure 31 - The UHF sensor for use with the PD Detector Pro.

The PD Detector Pro can be used with a passive Ultra-High-Frequency (UHF) sensor to detect PD pules in gas-insulated switchgear (GIS). For more information about how PD occurs and how the UHF pulses propagate within GIS, please refer to Appendix A.2.

In UHF mode, the PD Detector Pro detects UHF signals that are from both partial discharge sources and noise sources. An algorithm processes the detected signals and distinguishes between the partial discharge and noise so that the level of each can be shown separately.
The magnitude of pulses recognised as partial discharge and as noise is displayed in dB.

To use the UHF sensor, insert the sensor cable plug into the multi-sensor socket. The PD Detector Pro will display a “UHF Sensor Connected” pop-up message and will switch to UHF mode automatically.

Hold the UHF sensor against the barrier insulators that separate the sections of GIS. The PD Detector displays the magnitude of UHF signals detected. The measured value is shown in dBm.

4.9.1 Using the UHF Sensor

1) Connect the UHF cable to the BNC port on the UHF sensor.
2) Connect the UHF cable to the multi-sensor port on the PD Detector Pro.
   The PD Detector Pro will automatically switch to UHF mode.
3) Select Level display using the middle icon/context button.
4) Secure the UHF sensor against the barrier spacer. See section 4.9.3 for more details.
5) Check each barrier spacer for activity.
   a) Record the level shown on the PD Detector display.
   b) Repeat for each barrier spacer.
6) Record the results by saving a screenshot or saving the data. See section 5 for more details.

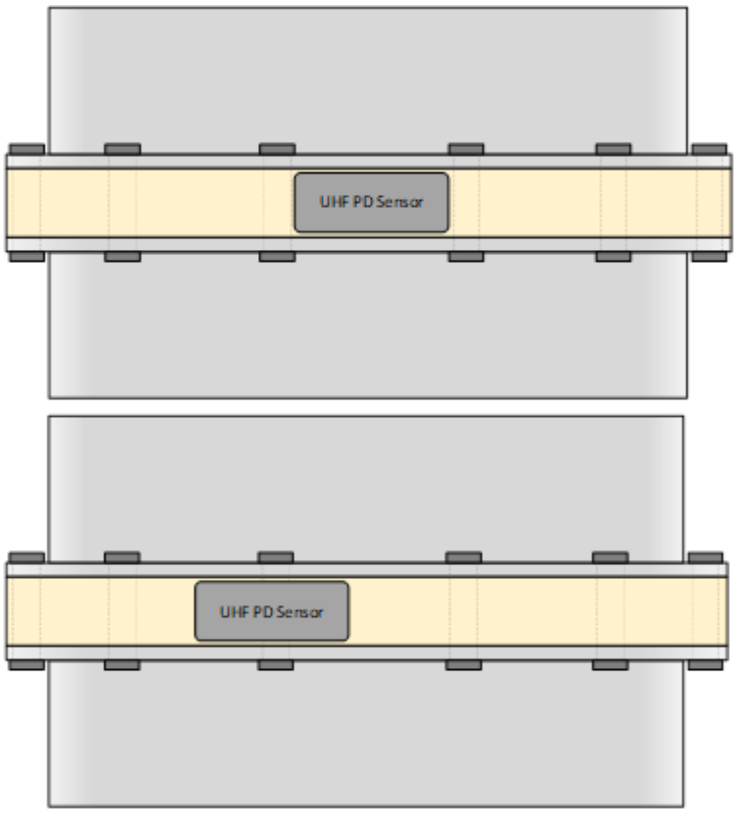
Confirm the activity recorded is PD. Please refer to Section 4.5 for more information.

4.9.2 Active UHF Adaptor

To connect to an IPEC Active UHF Barrier sensor or Embedded UHF sensors, use the Active UHF Adaptor which provides power from the PD Detector Pro to the active UHF sensor.
For more information, please contact sales@ipecuk.com.

4.9.3 Correct placement of the UHF sensor.

The ideal position for the UHF sensor to be positioned on a GIS barrier spacer is in the centre of the spaces **between the barrier spacer bolts**. If the sensor is positioned over a barrier spacer bolt it will attenuate the escaping UHF signal.



Correct Barrier Spacer Placement

The UHF sensor should be placed in the middle of the barrier spacer between the bolts that secure GIS components together.

Incorrect Barrier Spacer Placement

As the barrier spacer bolts are metallic, they will attenuate the UHF signal escaping through the barrier spacer.

Figure 32 - Diagram showing the correct and incorrect positioning of the UHF sensor on a GIS barrier spacer.

4.10 How to do a VDS measurement

Optional Accessory

The VDS sensor is an optional accessory for the PD Detector Pro purchased separately or as part of a kit.
Please contact sales@ipecuk.com for more information.

Figure 33 - The VDS sensor for use with the PD Detector Pro.

Voltage Detection Systems (VDS) and Voltage Prescence Indication Systems (VPIS) are built-in devices for switchgear that allow the operator to connect a voltage presence indicator light or multimeter to check if the switchgear is energised. These systems do this by employing a capacitive coupler for each phase bus-bar which steps down the voltage to safer levels and makes this safer voltage available to the operator via a banana connector socket.

IPEC's VDS sensor can be connected to these VDS banana sockets and the PD Detector Pro to detect partial discharge signals that are present on each of the switchgear bus-bars.

Using banana leads to connect to the VDS sensor to the VDS/VPIS and the included BNC to multi-sensor connector cable to connect to the PD Detector Pro.

4.10.1 Using the VDS Sensor

1) Connect the VDS cable to the multi-sensor port on the PD Detector Pro.
   The PD Detector Pro will automatically switch to VDS mode.
2) Select Level display using the middle icon/context button.
3) Connect the red banana connector on the VDS sensor to the first phase port on the switchgear VDS using a banana cable.
4) Connect the black banana connector on the VDS sensor to the ground port on the switchgear VDS using a banana cable.
5) Starting at the first phase, check each phase on the switchgear VDS for activity.
   a) Record the level shown on the PD Detector display.
   b) Repeat for each phase on the switchgear VDS.
6) Record the results by saving a screenshot or saving the data. See section 5 for more details.

Confirm the activity recorded is PD. Please refer to Section 4.5 for more information.

5 How to Record Measurements

This section covers how to save a screenshot, measurement data, and download the saved files from the PD Detector Pro onto a computer.

5.1 Save a Screenshot and Measurement Data

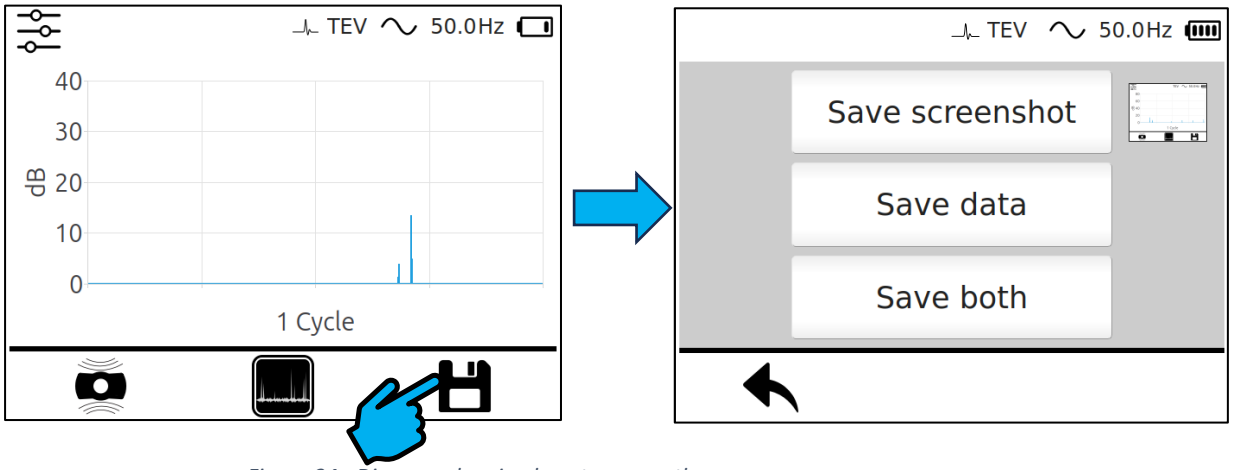


Figure 34 - Diagram showing how to access the save menu.

Pressing the "Save" icon using the touchscreen or the right context button. This will bring up the save menu with the following options:

- "Save Screenshot" - Saves a copy of the screen as a PNG image.
- "Save Data" – Saves the recorded levels as an entry in a CSV file.
- "Save Both" – Save measurement as both a PNG screenshot and an entry in a CSV file.

The CSV and PNG files can be accessed and viewed when the PD Detector Pro is connected to a computer.

Once a save option is selected a reference name text box and keyboard will appear.

Figure 35 - Screenshot of the reference box and keyboard when saving a measurement.

Enter a memorable or useful reference for the measurement such as the asset name.
Press the save button to save the measurement with the reference name.

5.2 Download Saved Data and Screenshots

Connect the PD Detector Pro to a computer using the included USB-C cable.

On the PD Detector Pro, select to go to the options menu, select to go to the settings menu, then tap “Data Download”.

This will bring up the Data Download screen and the computer will recognise the connected PD Detector Pro as a USB storage device.

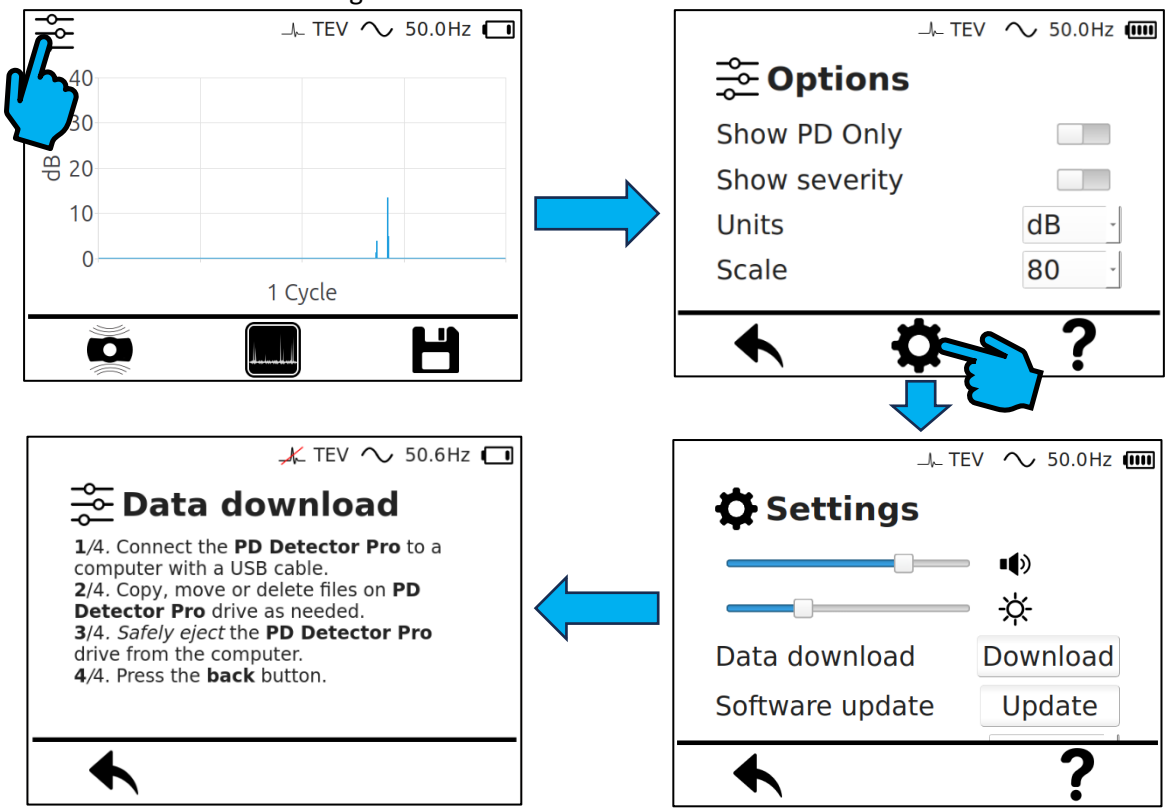


Figure 36 - Diagram of how to access the Data Download screen on the PD Detector Pro.

Using the computer’s file explorer, open the device labelled “PDD”.

Inside there will be dated folders which contain the recorded screenshots and CSV files available to open and copy to your computer.

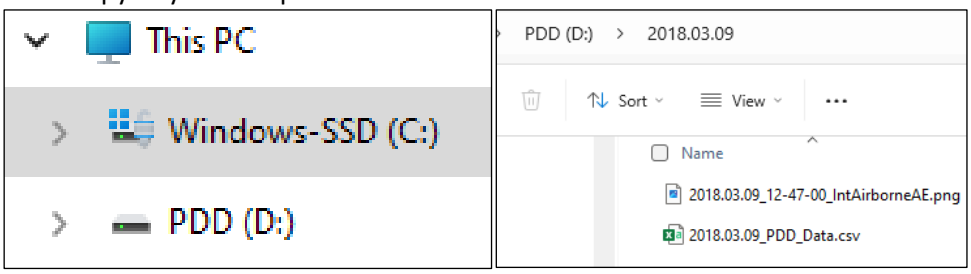


Figure 37 - Screenshots of the PD Detector Pro in the file explorer.

NOTICE

Press the “Back” arrow on the PD Detector Pro before disconnecting from the computer.

6 PD Detector Pro Settings

This section will cover the settings menu of the PD Detector Pro.

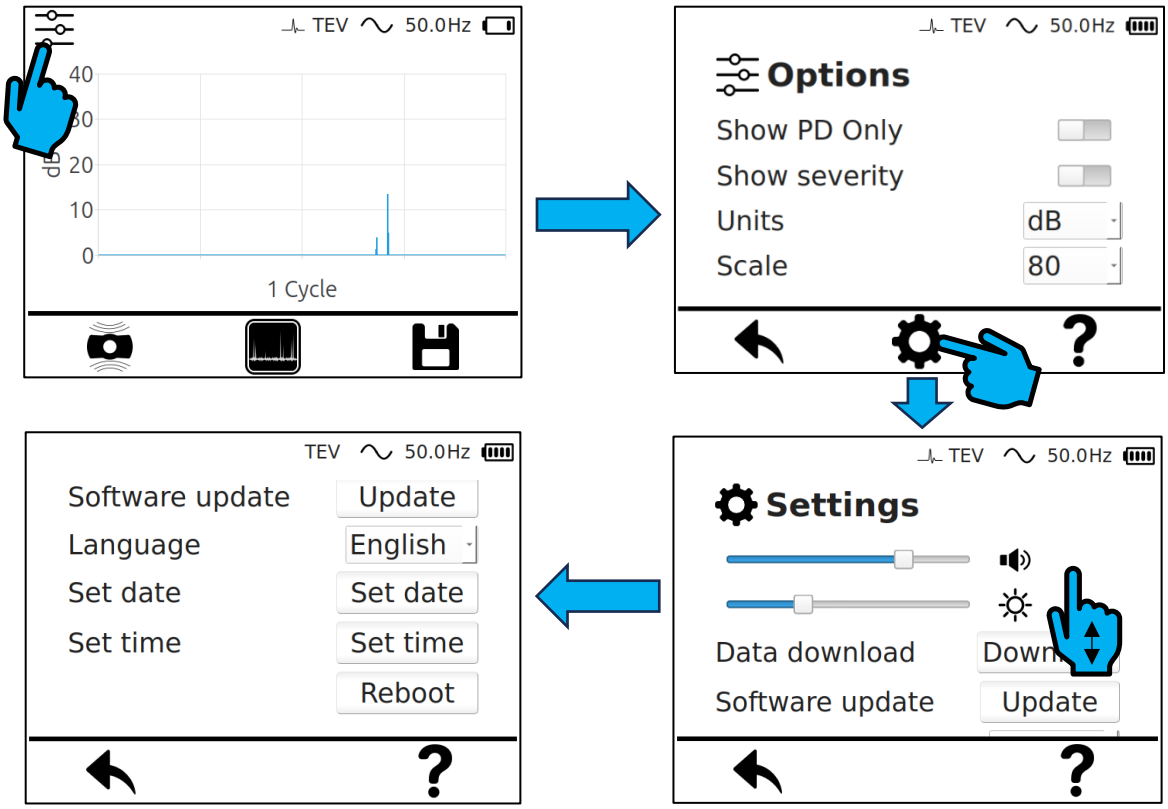


Figure 38 - Diagram showing how to access the PD Detector Pro settings menu.

On the PD Detector Pro, select to go to the options menu and select to go to the settings menu. Once in the settings menu, touching and scrolling will show more settings options.

6.1 Adjusting the volume

The slider next to the speaker icon controls the volume level of the built-in speaker and headphone socket.

6.2 Adjusting the screen brightness

The slider next to the light icon controls the level of screen brightness.

6.3 Changing the language

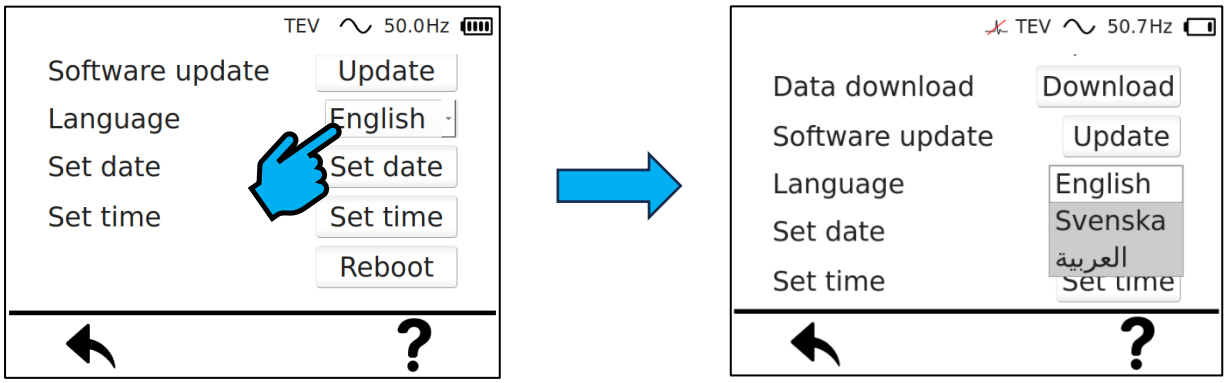


Figure 39 - Screenshots of the language drop-down menu.

Scrolling down to the “Language” option there is a drop-down menu which, when selected, shows a list of the available languages. Select a language and it will automatically be applied.
Changing the language here will also update the language used for the keyboard.

6.4 Changing the data and time

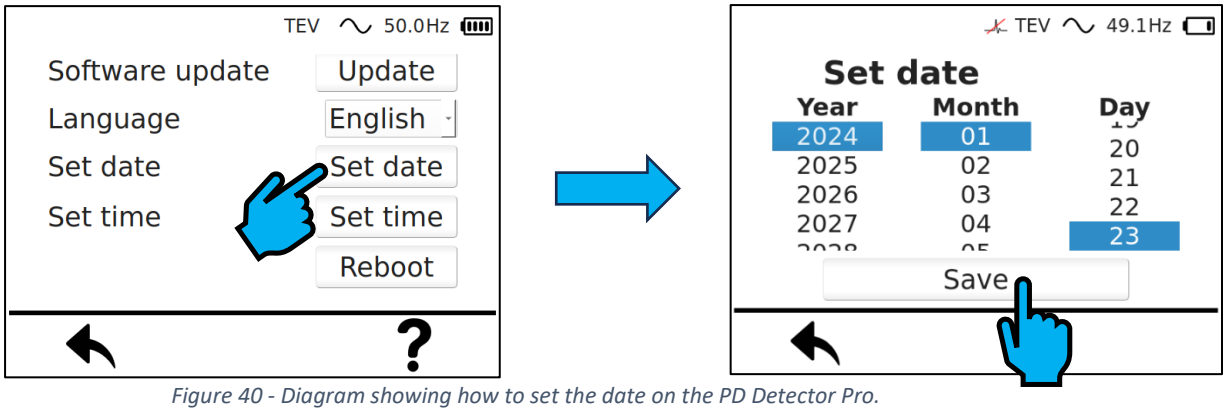


Figure 40 - Diagram showing how to set the date on the PD Detector Pro.

Tapping on “Set Date” brings up the date menu where the date can be entered. Save the new date setting by tapping the “Save” button.

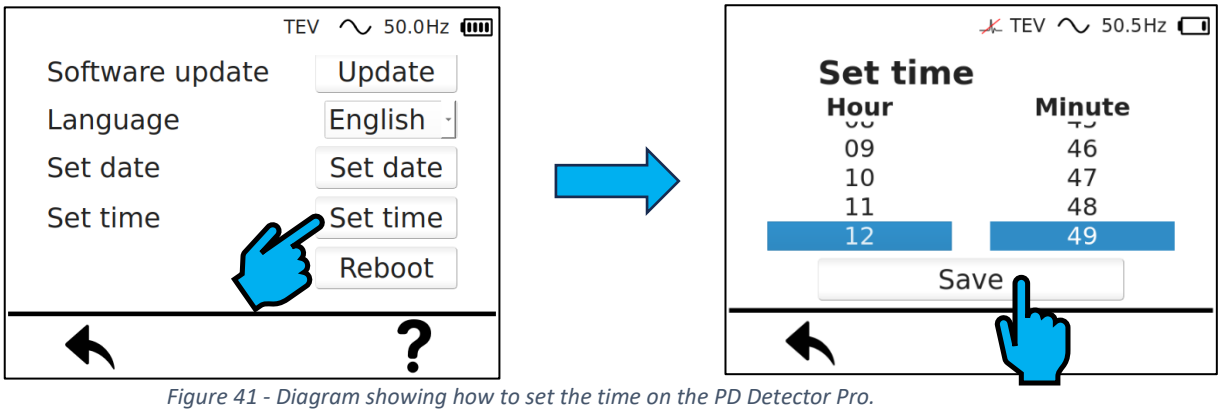


Figure 41 - Diagram showing how to set the time on the PD Detector Pro.

Tapping on “Set Time” brings up the time menu where the PD Detector Pro device time can be set.

6.5 Mains Frequency

This sets the frequency of the power grid the PD Detector Pro will synchronize with for the Live and Heatmap PRPD displays.

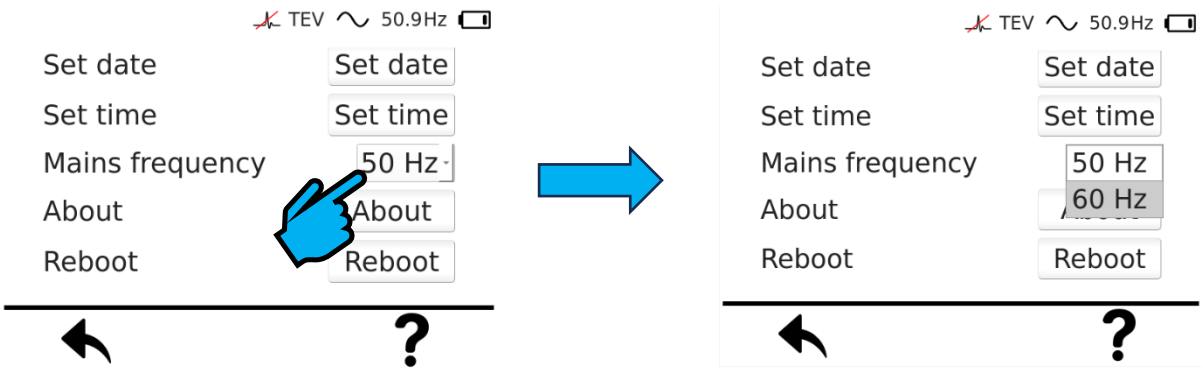


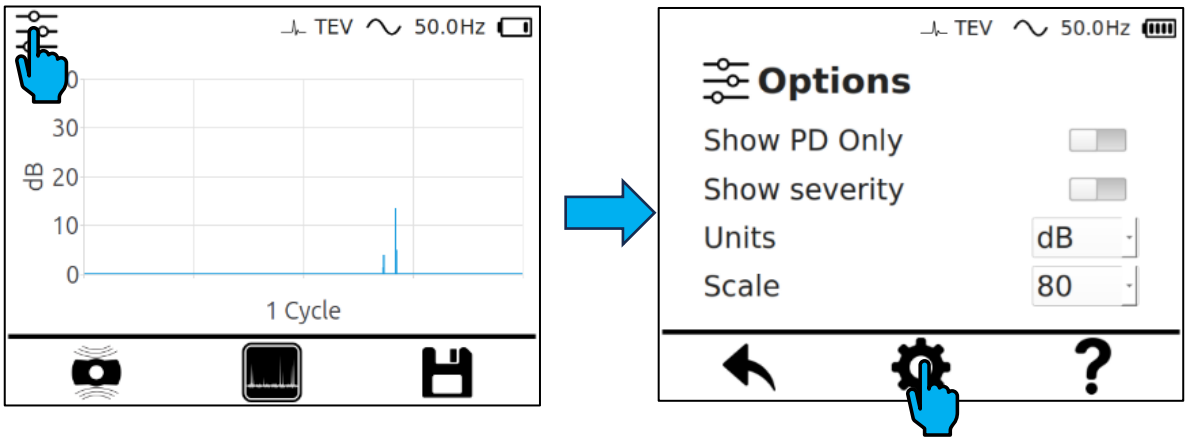
Figure 42 - Screenshot of the mains frequency setting on the PD Detector Pro.

Tap on the frequency to select the desired mains frequency from the drop down menu.
The PD Detector Pro will also automatically update this setting when it detects either 50Hz or 60Hz from the built-in power field sensor.

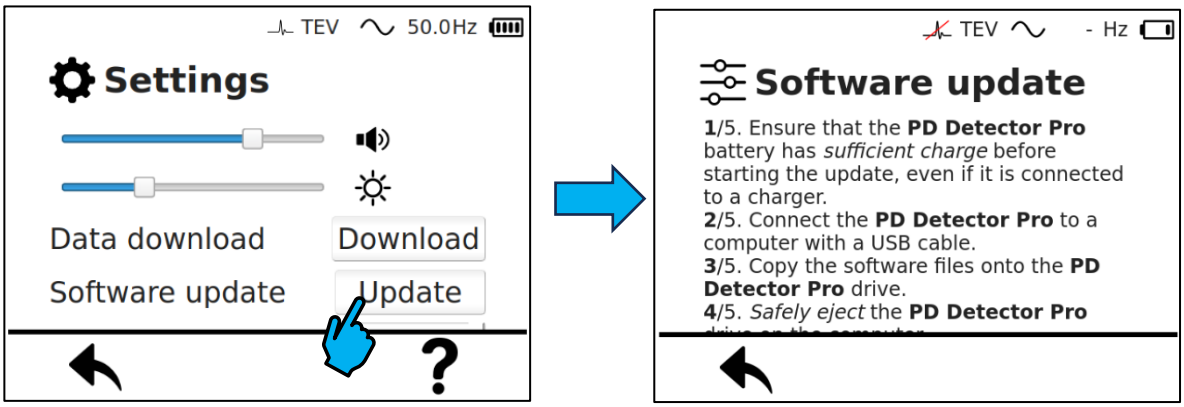
7 Updating the Software

This section covers the process of updating the PD Detector Pro software.
To update the software, follow the steps below.

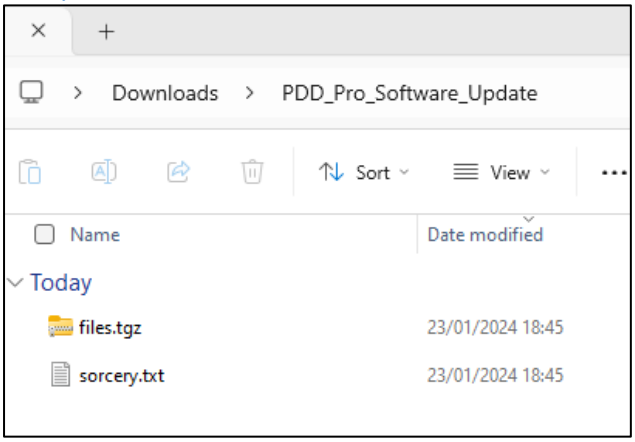
1. Connect the PD Detector Pro to a computer using the included USB-C cable.
2. On the PD Detector Pro, select to go to the options menu and select to go to the settings menu.



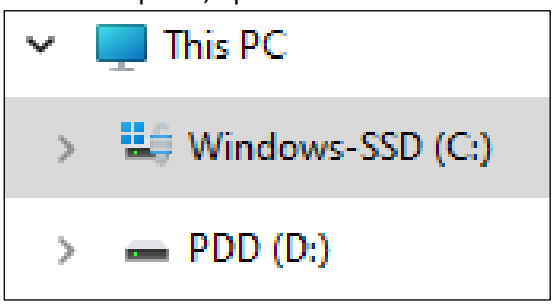
3. Select “Update” next to Software Update. This then brings up the software update screen and the computer will detect the PD Detector Pro has been connected as USB storage.

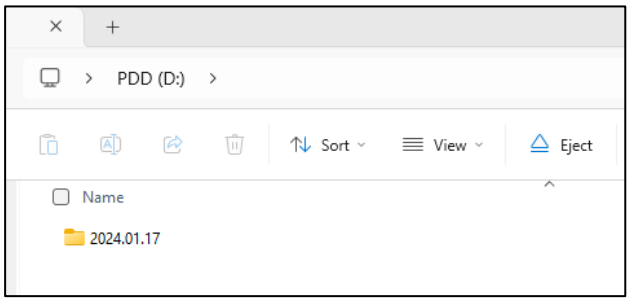


4. Download the software update files from IPEC. There are two files; a “.tgz” zip folder and a “.txt file.” Please contact sales@ipecuk.com for more information.

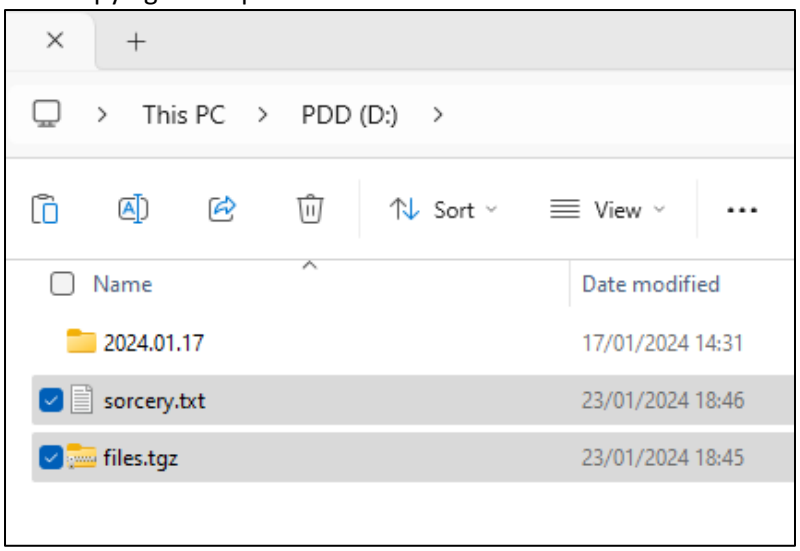


5. On the computer, open the PDD device to view the stored files on the device.

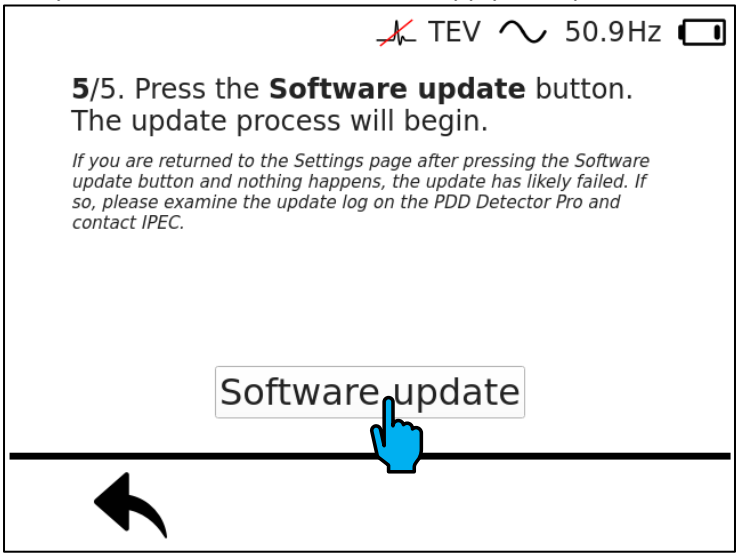




6. Drag and drop the software update file onto the PD Detector Pro and into the “Software Update” folder. Wait until the copying is completed.



7. On the PD Detector Pro, scroll down on the software update instructions to the bottom of the page and press the “Software Update" button.
This will automatically reboot the PD Detector Pro to apply the update.



8 Troubleshooting

The table below contains some issues and the steps to resolve them.

Symptom	Possible Cause	Remedial Action
PD Detector Pro not turning on	Battery out of charge	Connect the PD Detector Pro to the USB charger and leave to charge up.
	Electronics failure	Contact IPEC.
PD Detector Pro not charging	Charger not suitable	Use a USB charger that can deliver 5V 2A or 5V 1A minimum.
	3rd party cable not suitable	Use the included USB-C cable.
	Damaged cable	Contact IPEC.
	Battery fault	Contact IPEC.
Unable to see the screen	Screen brightness too low	Go to display options -> settings and increase the screen brightness on the slider.
Unable to hear sensor audio	Volume is too low	Go to display options -> settings and increase the volume on the slider.
	Electronics failure	Contact IPEC.
Unable to switch sensor	External sensor connected	Disconnect the external sensor.
Device not responding to button or touchscreen input	Software crash	Press and hold the power button to shut down the device. Press the power button to turn the device on.
	Electronics failure	Contact IPEC.
No signal from sensor	Wrong sensor	Check that the PD Detector Pro is in the correct sensor mode.
	Wrong external sensor cable	Check the correct external cable has been connected to the PD Detector Pro.
	Algorithm	Go to Display Options. Disable “Show PD Only”
	Loose connection	Use the PD-FT to check TEV/Ultrasonic level. If less than 29/30dB, contact IPEC.
	Damaged cable	Contact IPEC.

Table 4 - Troubleshooting table of causes and possible solutions.

A Appendix

To get the most from your PD Detector pro, IPEC has provided supplementary information about partial discharge and the device itself.
This appendix contains information about Partial Discharge, understanding criticality levels, and determining if the activity is partial discharge or noise. This appendix also contains the device specifications, regulatory compliance, and a declaration of conformity.

A.1 What is Partial Discharge?

Figure 43 - The types of insulation where partial discharge activity occurs.

Partial Discharge (PD) is an electrical discharge that does not completely bridge the space between two conducting electrodes.
The discharge may be 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.
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 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.

A.2 How do the sensors detect Partial Discharge?

A Partial Discharge (PD) event will dissipate energy in different forms depending on the insulation material type and this energy can be picked up and measured by the PD Detector Pro using the range of sensors available.

Transient Earth Voltages (TEV)

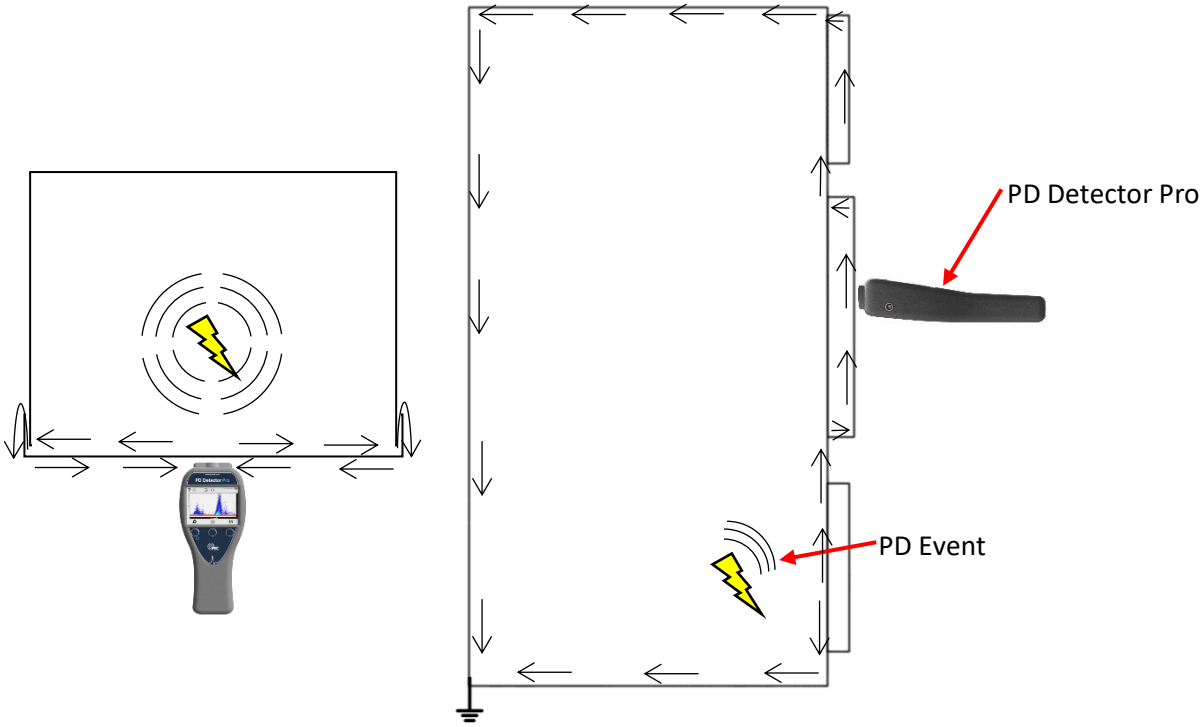


Figure 44 - Diagrams of how TEV pulses propagate from a PD event inside switchgear to the internal TEV Sensor on the PD Detector Pro.

PD creates electromagnetic radiation that dissipates in all directions away from the source. Metal components, for example, the panels around switchgear, pick up this radiation and small voltages called Transient Earth Voltages (TEVs) are induced on the surface.
These TEV signals then travel along the inner surface and emerge at the joints between the metal panels and then travel along the outer surface, as shown in the figure above.
These high-frequency signals can be picked up by the PD Detector Pro and indicate that there is a PD source nearby. The PD Detector Pro accomplishes this using the built-in TEV plate which acts as one side of a capacitor that is formed with the metal switchgear panels, allowing these small high-frequency signals to be detected.

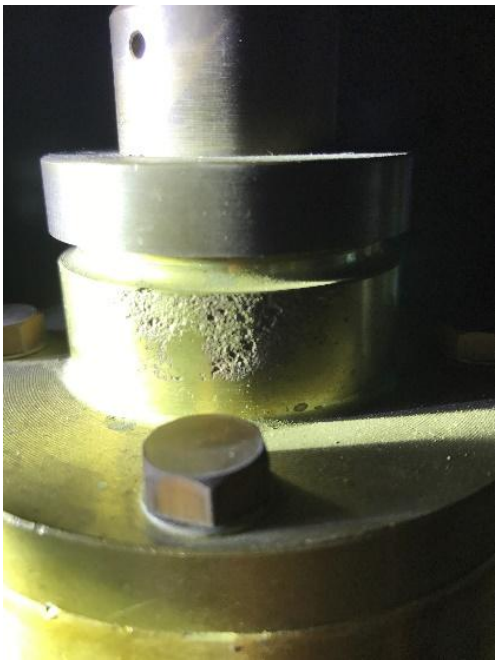


Figure 45 - Photo of pitting on a VT chamber spout which produced TEV signals.

The above figure shows a damaged chamber spout in a VT switchgear. The pitting seen on the damaged component produced TEV signals that propagated through the whole of the switchgear panels. The TEV signals were located to a specific VT chamber where visual inspection revealed this damaged component.

Ultrasonic Acoustic Emissions (AE)

Partial Discharge also generates acoustic energy across a wide band of frequencies.

Airborne Acoustic Emissions (AA)

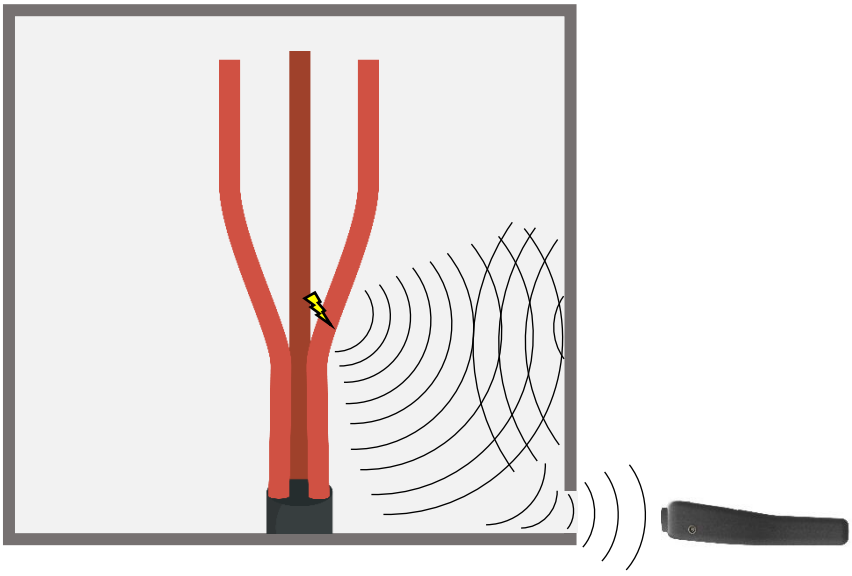


Figure 46 - Diagram showing a cable termination within an enclosure with a surface tracking PD radiating acoustic emissions.

This acoustic energy can be detected in the ultrasonic range in air-insulated switchgear when there is a 'line of sight' between the PD source and the detecting ultrasonic sensor. This is known as airborne acoustic emissions (AA) or airborne ultrasonics. In switchgear, gaps between the metal panels allow the acoustic emissions to be detected externally.

Sharp points, for example, on air-insulated cable terminations, are typical sources of discharge that produce airborne acoustic emissions.
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 flash-over and failure of the equipment.

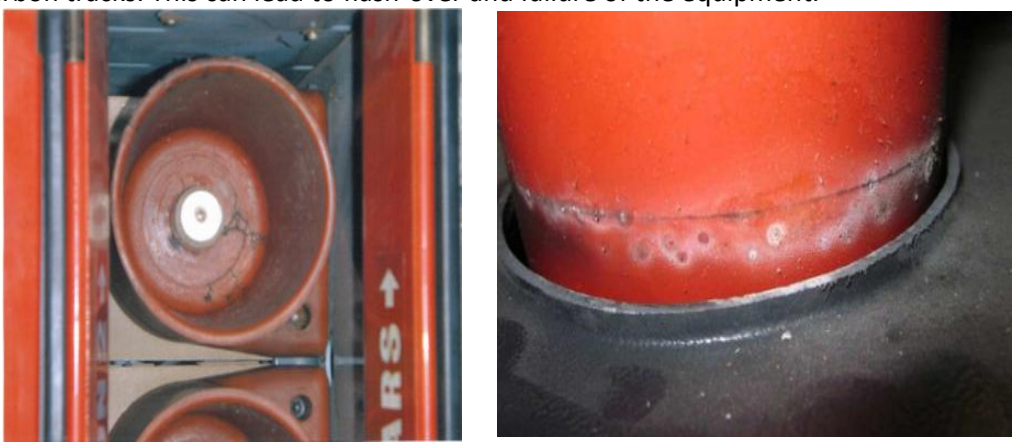


Figure 47 - Photos of surface tracking where black carbonisation (left) and white discolouration (right) can be seen.

Contact Acoustic Emissions

In solid and liquid insulation, PD events caused by voids and contamination in the insulation produce ultrasonic energy travels through these insulation mediums. When this ultrasonic energy encounters the interface between the insulation and the metallic enclosure, the majority of the energy is reflected back. However, a small portion of this ultrasonic energy is transmitted into the metallic enclosure and be detected by a contact ultrasonic sensor.

The PD Detector Pro can make use of a contact acoustic sensor to detect PD in these insulation mediums where airborne ultrasonic detection is not possible, for example in oil-filled transformers.

High-Frequency Current Transformers (HFCTs) for Conducted Pulses

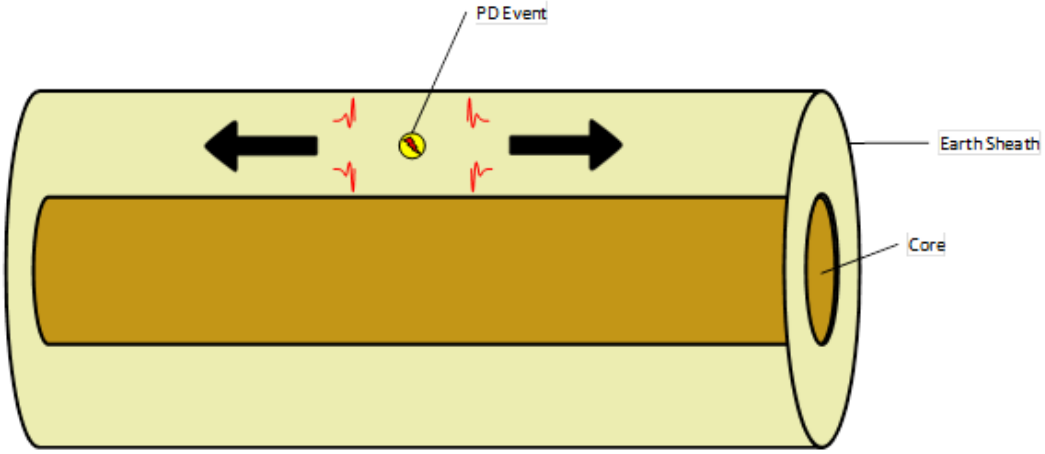


Figure 48 - Diagram of PD pulses propagating along a cable core and earth sheath.

When a PD occurs in cable insulation or in a cable joint, a current pulse is induced both on the cable core and the sheath.
This pulse propagates away from the defect site in both directions along the cable.
HFCTs can detect these pulses where the cable core and earth are separated. For MV cables this is usually at the cable termination. HFCTs can be coupled around the cable earth or safely coupled around the cable core above the cable earth.

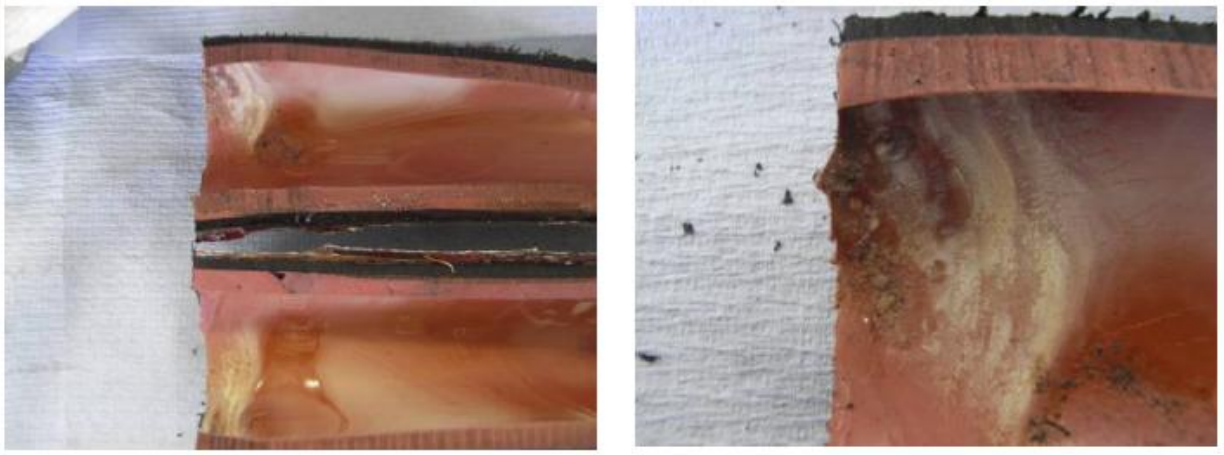


Figure 49 - Example of a defect in an MV cable.

What is meant by “Above the Earth”?

When the current pulse is travelling along the cable it travels on the ‘inside’ of the earth sheath and the outside of the core via the skin-effect. When it reaches the cable termination, the pulse traveling along the ‘inside’ of the earth sheath now is travelling along the ‘outside’ via the skin-effect before passing through the HFCT and down to the earth termination.

This means that for the HFCT to detect the pulses, the HFCT must be coupled around a point in the cable that is before the earth voltage potential termination, hence the term “above the earth” potential.

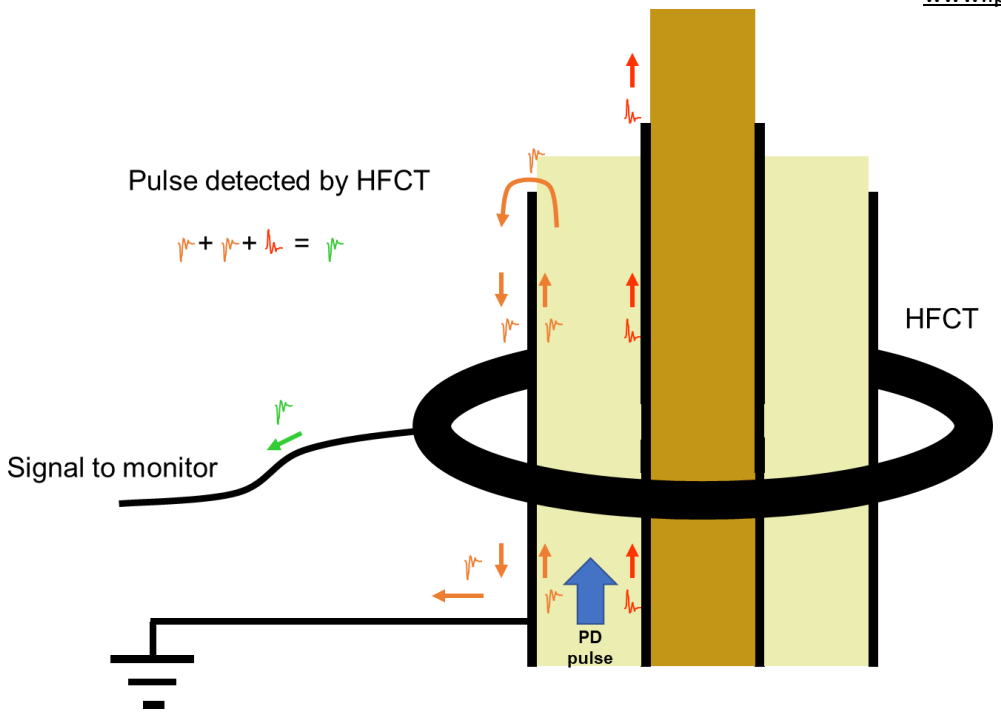


Figure 50 - Diagram showing the PD pulse propagation with the HFCT coupled.

Figure 50 above shows the HFCT coupled around the cable core is “above the earth” and therefore the waveforms can be detected. Figure 51 below shows the HFCT coupled around the cable earth and installed “above the earth” potential.

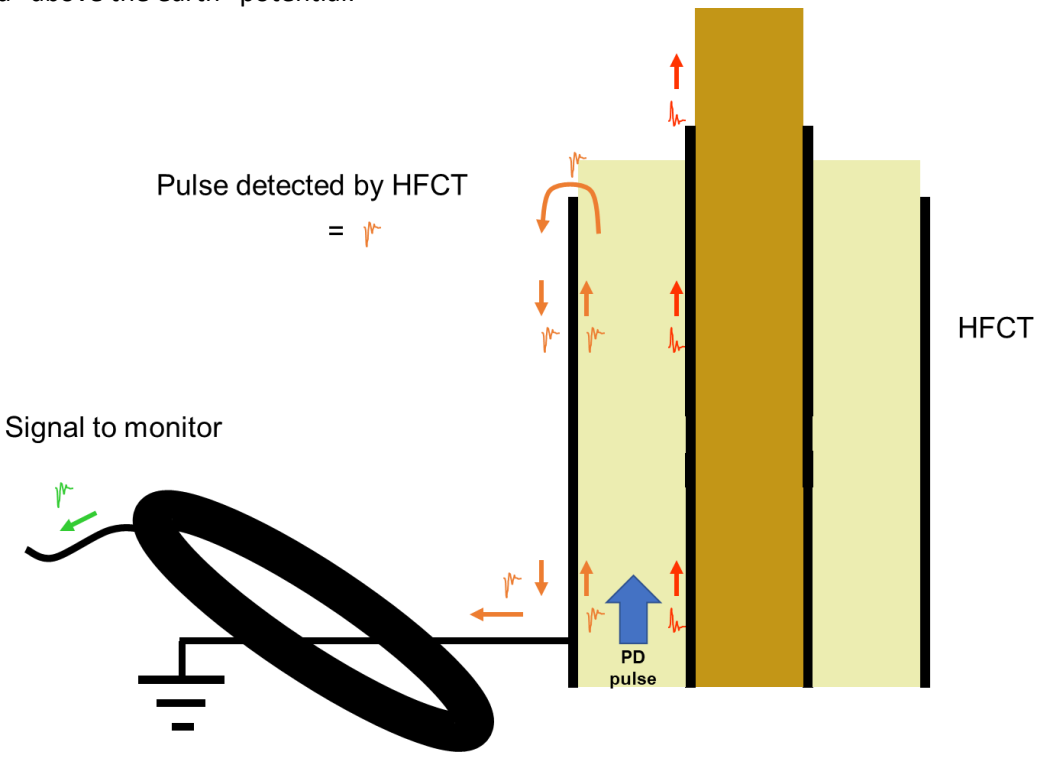


Figure 51 - Diagram showing the PD pulse propagation with the HFCT installed.

Ultra-High Frequency (UHF) Radiation

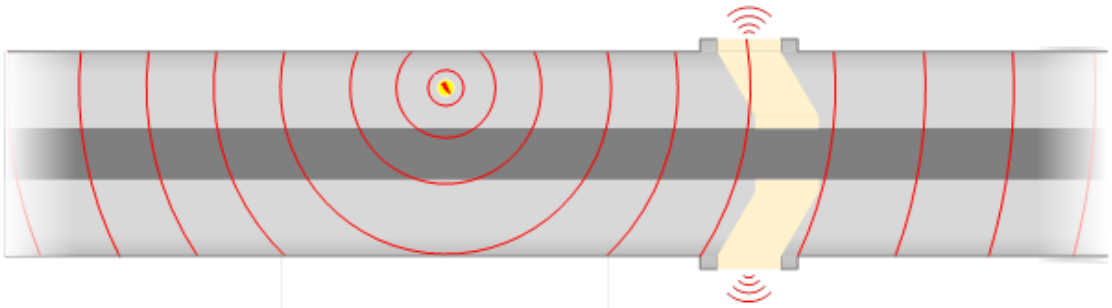


Figure 52 - Diagram of UHF radiation from a PD event being reflected within GIS.

When a PD event occurs, it will radiate energy in two main forms: Ultrasonic and Electromagnetic. This ultra-high frequency (UHF) electromagnetic radiation dissipates in all directions away from the source. When this UHF radiation encounters metallic components such as enclosure panels on air-insulated switchgear a portion is absorbed and propagates over the surface as a transient earth voltage.
The other portion is reflected off the metallic surface and bounces around internally as the metallic enclosure acts like a faraday cage.

In Gas Insulated Switchgear (GIS) the metallic walls are much thicker and thus the UHF signal is almost entirely reflected back into the GIS components. The UHF signal is only able to escape through non-metallic components such as barrier spacers.

Partial Discharge in Gas Insulated Switchgear

Different causes of PD on different types of assets will influence what type of sensors should be used and where to apply those sensors. There are some common causes of PD in GIS:

1) Free moving/floating particles.
2) Protrusion and particles on housing.
3) Protrusion on conductor.
4) Particle or defect on insulator.
5) Defect in the insulator/delamination

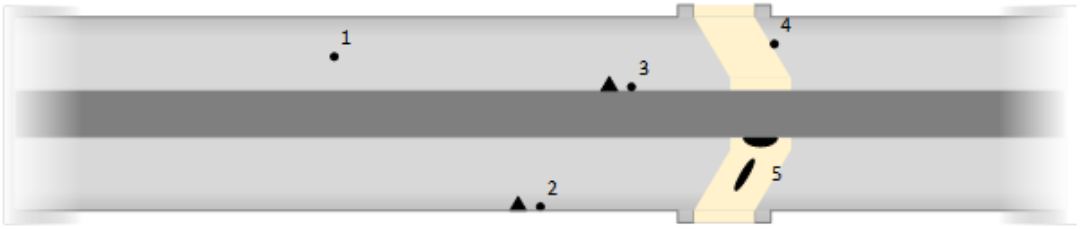


Figure 53 - Diagram of common causes partial discharge in GIS.

A.3 Understanding Partial Discharge Levels

It is important to know how serious and what actions are required when assessing partial discharge measurements.

Criticality

The Criticality of a high voltage asset, for example, 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.

The Criticality of an asset has many different contributing factors and partial discharge is an important part.
Discharge activity causes small but very localised damage to the insulation. Over time this damage can develop to the point where it causes a 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 rough guide to PD activity levels and the associated severity.

Sensor	Low (Green)	Medium (Yellow)	High (RED)	Noise (Grey)
TEV	≤19dB	20 to 29dB	≥30dB	n/a
Ultrasonic	≤5dB	N/A	≥6dB	n/a
HFCT	≤99pC	100 to 499pC	≥500pC	n/a
UHF	≤ -41dBm	-40 to -31dBm	≥ -30dBm	n/a

A.4 Specifications

Description		Specification
Measurements		
PD Sensors		Transient Earth Voltages (TEV)
		Ultrasonic Airborne Acoustics (AA)
		High-Frequency Current Transformer (HFCT)
		Ultra-High Frequency (UHF)
		Voltage Detection System (VDS)
Hardware		
Enclosure		Injection moulded plastic case
Display		High Resolution Colour Touchscreen
Control		Membrane Buttons
Connectors	USB-C	Charging and Data Transfer
	Headphone Socket	Audio out
	Multi-Sensor Port	External Sensors with Auto Detection
Operating Environment		
Operating Temperature		-20°C to 50°C
Humidity		0 to 95% RH non-condensing
IP Rating		54
Application		
Communication		USB-C
Data Storage	Internal	4GB
	External	Local PC
Data Access	External	Local PC via USB-C
Results		PD Level, Nosie Level, Live PRPD, Heatmap

A.5 Regulatory Directives

The PD Detector system complies with the following directives:

- EN 61000-6-2: 2005 - Immunity standard (Industrial environment)
- EN 61000-6-4: 2007 - Emission standard (Residential, commercial, and light industry environment)

A.6 Declaration of conformity

Manufacturer's Name:	IPEC Limited
Manufacturer's Address:	IPEC Limited Carrington House 39 Carrington Field Street Stockport, Manchester SK1 3JN
Description of Product(s):	PD Detector Pro Partial Discharge Handheld Instrument

I declare that the listed product(s) complies with the following standards/directives:

EN 61000-6-2: 2005 - Immunity standard (Industrial environment)

EN 61000-6-4: 2007 - Emission standard (Residential, commercial, and light industry environment)

Signed:  18th December 2023

Dr Colin Smith

Managing Director
IPEC Limited