UltraTEV Plus+

Operating Manual

Product Code: UTP1

Version: 7

April 2012

www.eatechnology.com

Delivering Innovation in **Power Engineering**

Contents

1 Record of Changes

Date	Drawing Number	Changes
March 2012	E493/L/01/7	Specification updated.

2 EA Technology Range of Products

Partial Discharge Instruments

UltraTEV Detector™ - hand held, dual sensor, Partial Discharge (PD) detector, which enables swift and simple 'first pass' identification of potentially damaging HV equipment faults and MV equipment faults before they become failures.

UltraTEV Plus+™ - advanced hand held, dual sensor, Partial Discharge (PD) detector, which enables more detailed identification and comparison of PD activity across multiple substation assets.

UltraMet Plus+™ - simple hand held tool for measuring Partial Discharge (PD) activity by detecting ultrasonic sound. The sounds detected are displayed on screen as decibel readings, as well as relayed to headphones as an audible signal

UltraTEV Locator™ - simple to use tool that can measure and record the exact location of Partial Discharge (PD) activity to within 10cm in any substation assets, including cables and overhead equipment. The most versatile PD investigation unit in the world, it can identify faults before they become failures and deliver an accurate assessment of asset condition

UltraTEV Alarm™ - PD system that combines all the benefits of EA Technology's award winning Partial Discharge (PD) detection and monitoring, in one simple to install, automatic set up. It can monitor over 100 assets simultaneously and raise the alarm if one or more reaches critical PD levels.

UltraTEV Monitor™ - The ultimate system in EA technology's PD instrument range, the UltraTEV Monitor™ is much more than a fault detection and alarm system. It is the most powerful tool ever developed for collecting and recording information on the condition of large numbers of assets. It detects and locates, measures and monitors, records and analyses all the data from all your substation equipment, including cables, to give you unrivalled information on the condition of your assets.

PD Monitor GIS™ - purpose designed, retrofit condition monitoring system for all commonly used pressurised Gas Insulated Switchgear (GIS). It provides 24 hour detection, location and analysis of PD activity to identify faults early and avoid costly failures and repairs.

Ultrasonic Contact Probe™ - high tech detector that can identify the sounds of surface discharge activity in sealed chambers by monitoring the vibrations produced in the chamber walls. Designed to work with EA Technology's extensive portfolio of Partial Discharge instruments, including the UltraTEV Plus™, UltraTEV Locator™ and UltraTEV Monitor™.

UltraTEV Calibration Checker™ - instantly checks whether your UltraTEV Detector or UltraTEV Alarm Nodes are operating within specification

Cable Instruments

CableSniffer™ - Locate underground LV cable Faults in minutes, with fewer excavations, less disruption and lower costs.

Field Instruments

PURL™ - Pole Ultrasonic Rot Locator™ is the world's most effective instrument for accurately establishing the condition of pine poles, producing accurate condition assessments without the guesswork of hammer tests or the intrusion of drill through tests.

Polarity Test Kit ™ - comprises an accurate and versatile Polarity Test Pen and a Test Pen Checker, in one lightweight, portable unit that is essential for safe working around potentially live cables. It detects live cables in all standard 220-250V 50/60Hz supplies, with or without current flow.

Extended Voltstick™ - essential safety tool for identifying low voltage cables that have been damaged during excavations.

3 EA Technology Training Courses

Msc in Power Asset Management

Postgraduate Certificate
Postgraduate Diploma
Master of Science

Substations

Partial Discharge
Insulating Oil Handling & Analysis
Switchgear Technology for Power Systems
SF6 Training
Substation Earthing
Transformers for Power Systems
Substation Design Course

Cables

Power Cable Fault Location
Cables for Power Systems (Part 1)
Cables for Power Systems (Part 2)
Oil Filled Cables

Protection

LV/HV Protection
Power System Protection
Commissioning & Testing

For further information on our complete range of products, services and training courses please contact:

Email: sales@eatechnology.com

4 Declaration of Conformity

Manufacturers Name: EA Technology Ltd

Manufacturers Address: Capenhurst Technology Park
Capenhurst
Chester
CH1 6ES
UK

Type of Equipment: UltraTEV Plus+

Model Number: UTP1

I hereby declare that the equipment specified above conforms to the provisions of the **EC DIRECTIVE 89/336/EEC** on Electromagnetic Compatibility (EMC). Having met the requirements of the following standards;

EN 61000-6-2: 2001
IMMUNITY STANDARD (INDUSTRIAL ENVIRONMENT)

EN 61000-6-3:2001
EMISSION STANDARD (RESIDENTIAL, COMMERCIAL and LIGHT INDUSTRY ENVIRONMENT)

Chris Lowsley
Managing Director
EA Technology ISI Ltd

5 Introduction

Non-Intrusive Detection of Partial Discharge Activity

General

Partial discharges are electric discharges that do not completely bridge the electrodes. The magnitude of such discharges is usually small however they do cause progressive deterioration of insulation that may lead to eventual failure.

Non-intrusive partial discharge detection provides a means for identifying these potential sources of insulation failure that result not only in loss of supply to customers but can also endanger staff.

A partial discharge emits energy in the following ways:

Electromagnetic:
- Radio
- Light
- Heat

Acoustic:
- Audio
- Ultrasonic

Gases:
- Ozone
- Nitrous oxides

The most practical techniques for non-intrusive testing are based on the detection of the radio frequency part of the electromagnetic spectrum and ultrasonic emissions. The UltraTEV Detector has specifically developed to enable electromagnetic and ultrasonic activity to be detected in a single simple to use instrument.

Airborne Ultrasonic Discharge Activity

Acoustic emission from partial discharge activity occurs over the whole acoustic spectra. Audible detection is possible but depends on the hearing ability of the individual. Using an instrument to detect the ultrasonic part of the acoustic spectra has several advantages. Instruments are more sensitive than the human ear, are not operator dependent and operating above the audible frequency are more directional.

The most sensitive method of detection is using an airborne ultrasonic microphone centred at 40 kHz. This method is very successful at detecting partial discharge activity provided there is an air passage between the source and the microphone.

Electromagnetic Discharge Activity

When partial discharge activity occurs within high voltage switchgear it generates electromagnetic waves in the radio frequency range which can only escape from the inside

of the switchgear through openings in the metal casing. These openings may be air gaps around covers, or gaskets, or other insulating components. When the electromagnetic wave propagates outside the switchgear it also impinges on the metal casing of the switchgear producing a transient in the earth potential. The Transient Earth Voltage (TEV) is only a few millivolts and lasts only a short time with a rise time of a few nanoseconds.

The partial discharge activity may be detected non-intrusively by placing a probe on the outside of the switchgear whilst the switchgear is in service.

6 Safety Note

The UltraTEV Plus+ is designed to detect partial discharge sources in Medium/High Voltage (MV/HV) Plant. If no discharges are detected, this does not necessarily imply that an item of MV/HV Plant is discharge free. Discharge sites often have dormant periods and insulation structures can fail through causes other than those attributable to partial discharges. If discharges of considerable magnitude are detected in plant that is connected directly to the medium/high voltage power system, the authority responsible for the plant should be notified immediately.

7 Warnings

The UltraTEV Plus+ is designed for use at ground potential only.

- When testing electrical plant ensure that the metalwork is earthed before taking any measurements.
- Maintain safety clearances between structures at high voltage and the instrument, its probes and the operator at all times.
- Adhere strictly to local safety procedures.
- Do not make measurements when there are electrical storms in the vicinity.
- Do not make measurements immediately following the energisation of a circuit.
- Do not disturb plant during measurements either mechanically (e.g. by shaking or striking it), electrically (e.g. by increasing the voltage) or physically (e.g. by applying heat).
- Do not operate the instrument or its accessories in an explosive atmosphere.
- Mains supply voltages are present within the battery charger.
- This unit contains no user serviceable parts, always return to EA Technology or your local distributor for service and repair.
- Care must be taken where work is performed in tight corners, where the proximity of other earth planes will affect the reading. If possible maintain a distance of more than 30cm from metal work which runs perpendicular to the sensor faceplate.
- Strong electromagnetic fields from mobile phones, RF transmitters, VDUs and un-screened electronics in the frequency range DC to 1GHz can have an effect on the readings. A measure of local fields can be obtained by holding the UltraTEV Plus+ in free-air at least 1 metre away from any conducting surface.

If you have any specific requirement or operating conditions then please contact:

Email: product-support@eatechnology.com

8 Kit Contents

UltraTEV Plus+ Kit 1

- UltraTEV Plus+ in protective rubber sleeve
- Function Checker
- Clip-on Headphones
- Battery Charger
- Carry Case
- Operating Manual

UltraTEV Plus+ Kit 2

- UltraTEV Plus+ in protective rubber sleeve
- Function Checker
- Flexible Sensor
- Ultrasonic Contact Probe
- Peltor Neckband Headset
- Battery Charger
- Carry Case
- Operating Manual

UltraTEV Plus+ Kit 3

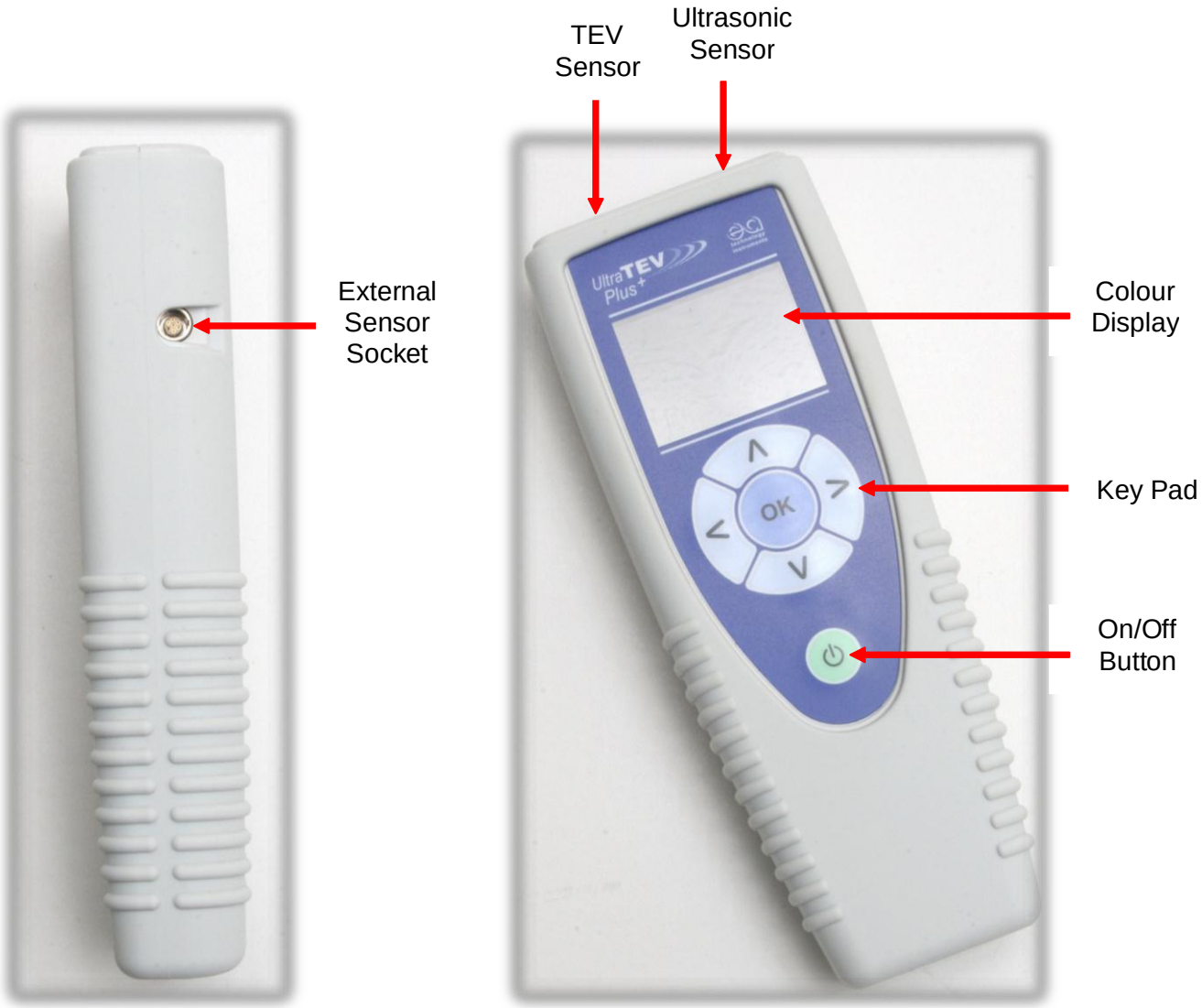
- UltraTEV Plus+ in protective rubber sleeve
- Function Checker
- Flexible Sensor
- Ultrasonic Contact Probe
- Peltor Neckband Headset
- UltraDish
- Battery Charger
- Carry Case
- Operating Manual

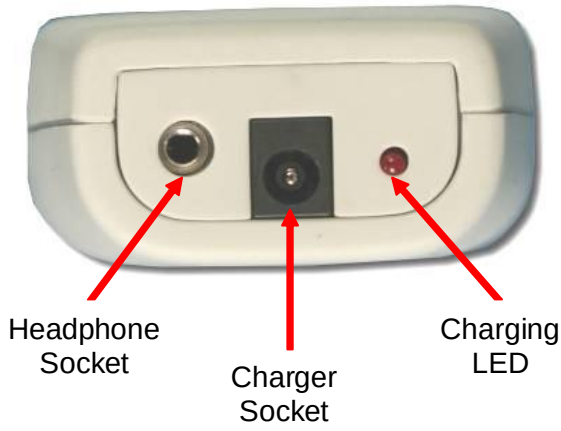
Spares and Accessories

For spares and accessories please contact:

Email: sales@eatechnology.com

9 The UltraTEV Plus+





9.1 Charging the Unit

Before first use the unit should be charged. Full charge time is around 7 hours, however, if the unit is partially charged the charging time will be reduced. The unit automatically stops charging once the battery is full. The charging status is indicated by the LED next to the charger socket.

- If the LED is on the battery is being charged.
- If the LED is off the unit is not charging, i.e. charge complete or charger switched off.
- If the LED is flashing there has been a fault whilst charging and the unit should be returned to EA Technology for inspection / repair.
- Always turn off the UltraTEV Plus+ during charging.
- Do not take measurements with the unit whilst the charger is plugged in.

Not Charging / Charge Complete

Charging

9.2 Turning the Unit On/Off

Push  to turn the unit on. If the beeper is enabled the unit will beep once to confirm power on. A second later the EA Technology Logo will appear on screen for 3 seconds.

Push  to skip the logo screen. To turn the unit off push  .

9.3 System Information and Self Test Screen

After the logo screen the self test screen is displayed for 6 seconds. Push  to skip the self test screen.

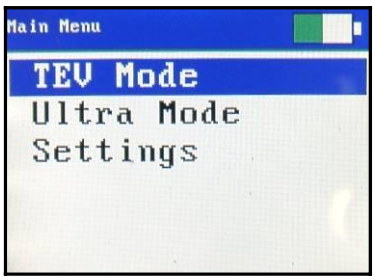
The self test screen displays the following information:

- Self Test Result – This displays the result of the power on self test, it displays either PASS or FAIL If the unit fails the self test on power up it should be returned for repair / calibration.
- Model – This displays the model name and number
- Software – This displays the current version of software installed on the unit
- Serial Number – The serial number of the unit
- Calibration due date – This displays the calibration due date of the unit. The unit should be returned for calibration annually.

The system information screen can also be viewed by selecting:
SETTINGS >> SYSTEM INFO from the main menu.

9.4 Main Menu

After the self test screen, the main menu is displayed, as shown below:



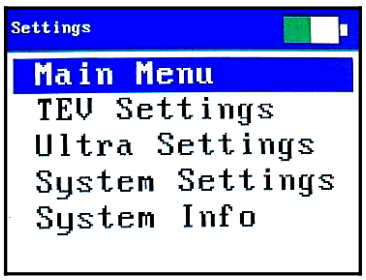
Menu items are highlighted using the v & ^ buttons. Press OK to select the menu item.

- TEV Mode – The TEV measurement screen
- Ultra Mode – The Ultrasonic measurement screen
- Settings – Allows the user to change settings for TEV and Ultrasonic modes as well as system settings and to view the system information shown at unit power up.

9.5 Setting up the Unit

The UltraTEV Plus+ is set to default settings in the factory and is ready to take measurements immediately. Some users may wish to modify the settings according to their preferences or procedures.

From the main menu select SETTINGS and press OK. The Settings menu shows:



- Main Menu – Return to main menu
- TEV Settings – Settings for the TEV measurement screens
- Ultra Settings – Settings for the Ultrasonic measurement screens
- System Settings – Set the backlight and beeper preferences
- System Info – View the system information screen that shows at power on

9.6 Adjusting Settings

In the TEV Settings, Ultra Settings, and System Settings menus, use the 

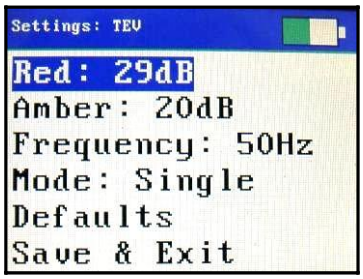
buttons to select the setting you wish to modify. Press 

to modify the value. The setting selected will be highlighted in red. Use the 

buttons to modify the value and then push 

to accept.

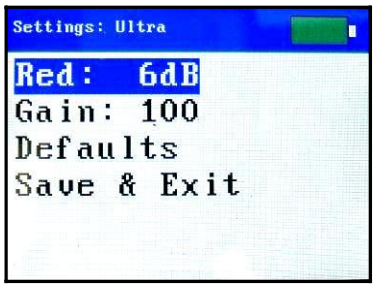
9.7 TEV Settings



- Red – Sets the red ‘traffic light’ threshold (default 29dB)
- Amber – Sets the amber ‘traffic light’ threshold (default 20dB)
- Frequency – Sets the mains frequency reference, used to calculate pulses per cycle (default 50Hz)
- Mode – Sets the measurement mode, Single takes a single measurement when the 

button is pressed (mimics the MiniTEV). Continuous takes measurements continuously without any button presses. (Continuous is the default setting)
- Defaults – Restores the default values for all items on this menu
- Save & Exit – Returns to the main settings menu saving any changes

9.8 Ultrasonic Settings



- Red - Sets the red ‘traffic light’ threshold (default 6dB)
- Gain – Adjusts the gain for measurement, higher gains allow measurement of smaller signals (default 60dB)
- Defaults – Restores the default values for all items on this menu
- Save & Exit – Returns to the main settings menu saving any changes

9.9 System Settings

- Backlight – Allows the user to turn on or off the display backlight. Turning the backlight off will enable the user to see the screen more easily in bright sunlight. (default ON)
- Key Beep – Selects whether the beeper is enabled on key presses. This also mutes the power on beep (default ON)
- Defaults – Restores the default values for all items on this menu
- Save & Exit – Returns to the main settings menu saving any changes

9.10 System information

This option displays the self test and system information screen that is shown at start-up.

9.11 TEV Measurement Screen

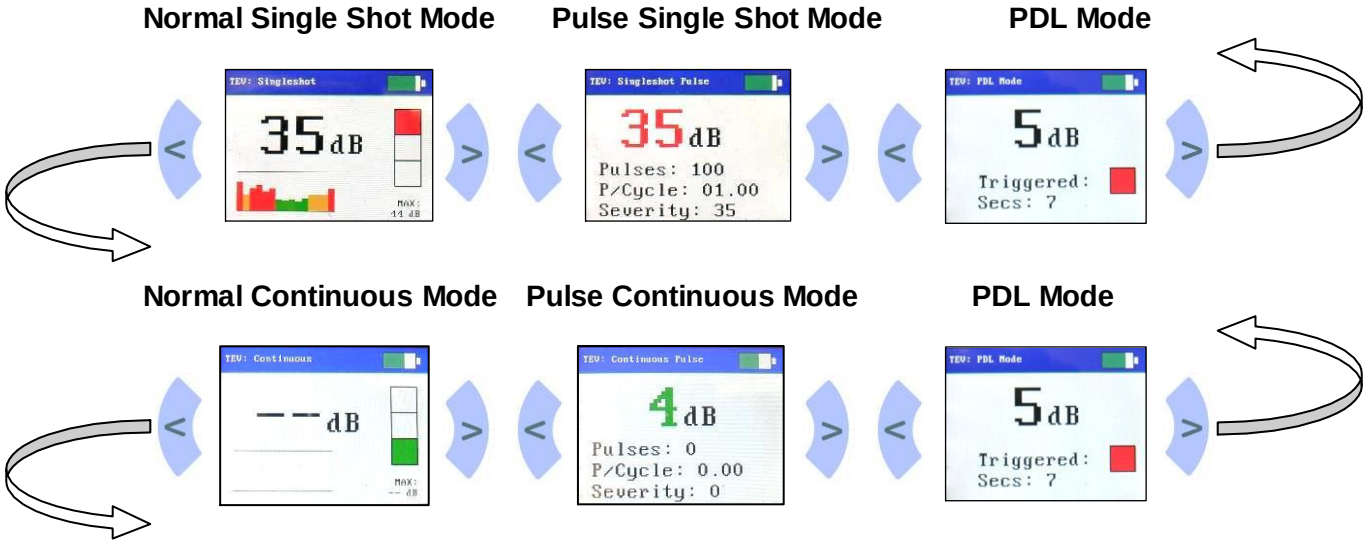
By default the standard TEV measurement screen is shown when TEV Mode is selected. This is shown below.

- Measurement Mode – informs the user whether the device is in single shot mode (push ^ to take a measurement), or continuous mode where measurements are updated continuously.
- TEV Reading – shows the current measured TEV level in dB
- Historic Reading – shows the last 15 measured values on a scrolling histogram, colour coded as per the traffic lights.
- Traffic Light Display – Shows the status of the current TEV level as either, Green, Amber, or Red, and is determined in the settings. The default is the same as the UltraTEV Detector (less than 20 dB = green, 20-29 dB = amber, and greater than 29dB = red).

- Maximum Reading - the maximum reading obtained since entering the TEV measurement mode. This can be reset by pushing V.
- Push OK to exit back to the main menu
- To change between TEV mode screens use < & > as described below

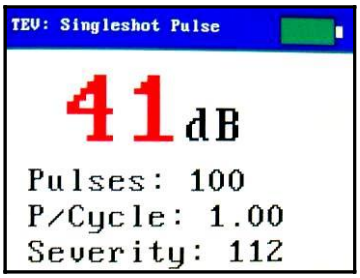
9.12 Switching between TEV Modes

TEV measurement has 3 modes of operation, normal mode (as shown above), pulse mode, and PDL mode (as shown below). Both the Normal mode and the Pulse mode can work in either Single or Continuous modes selectable in the Settings menu (section 6.7) or by holding the ^ button and pressing the OK button. By default, selecting TEV mode from the main menu shows the normal TEV Screen. To Change between modes use the left and right buttons to cycle through the different mode screens



9.13 TEV Pulse Mode Screen

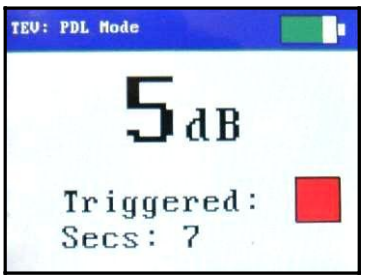
The TEV pulse screen shows more advanced information about the TEV levels detected, both in Single shot mode, and Continuous mode. The pulse mode screen is shown below:



- Pulses – Shows the pulse count over a 2 second period. (The UltraTEV+ measures pulses over a half second period and multiplies this by 4 to provide the same readout as a MiniTEV).
- P/Cycle – Shows the pulses per cycle based on either a 50 or 60Hz mains frequency.
- Severity – Shows the short term severity (Calculated by TEV magnitude (mV) x Pulses Per Cycle)
- Push OK to exit back to the main menu
- To change between TEV mode screens use < & > as described above

9.14 TEV PDL Mode Screen

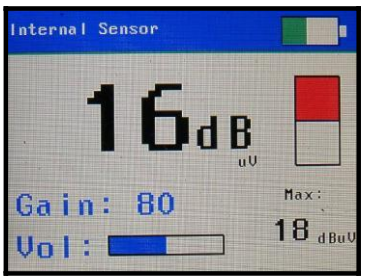
The PDL Mode screen offers a similar interface to that on the PD Locator where the user can manually increment the TEV level and monitor value at which the device triggers. This is indicated by a Red square.



- Use the ^ & v buttons to increase or decrease the TEV level shown as a large number
- Triggered – shows whether the UltraTEV Plus+ is triggering at that TEV level.
- To work out the TEV level, increase the trigger to the point where the device stops triggering and then decrease to the point where the device just triggers, with at least 1 pulse every 2 seconds
- Secs – Counts the seconds since the last change to the TEV level

9.15 Ultrasonic Measurement Screen

The ultrasonic measurement screen is shown below:



- The reading is displayed in dB microvolts (µV)
- The 'traffic light' indicator shows if the reading is above the threshold set in the 'Ultrasonic Settings'. The default value is the same as the UltraTEV, i.e. >1dB = RED.
- The gain is adjusted from 60 to 100 dB in 20dB steps using ^ & v .If the red up arrow next to the gain is flashing (as shown above), increase the gain setting to improve the accuracy of the reading. If a down arrow is flashing, decrease the gain.
- The volume of the heterodyne signal to the supplied headphones can be adjusted using < & > .
- The peak hold reading is displayed below the traffic lights.

10 Function Checker

The UltraTEV Plus+ is supplied with a Function Checker. The purpose of this accessory is to verify the UltraTEV Plus+ is operational before taking a measurement on switchgear. It is not intended to check the calibration of the instrument.

The function checker consists of a combined discharge and ultrasonic source which is energised via the charger socket on the UltraTEV Plus+.

To check whether the UltraTEV Plus+ is operating plug the function checker into the charger socket on the instrument with the unit turned on and select either TEV or Ultrasonic mode. Hold the checker adjacent to the front face of the UltraTEV Plus+. As the function checker is brought closer to the plate the readings should increase to indicate the device is working as shown in the pictures below. Verify operation of the instrument in both TEV mode and Ultrasonic mode.

Disconnect the function checker after checking the UltraTEV Plus+; do not attempt to use the UltraTEV Plus+ with the checker plugged in.

It is recommended that the UltraTEV Plus+ is checked before each use and periodically thereafter.

11 TEV Measurement Procedure

11.1 Background Noise

Electromagnetic signals from sources outside the switchgear can also produce transient earth voltages on the outside of the switchgear. These sources may be from overhead line insulators, transformer bushings, strong radio signals, and even traffic on a nearby Motorway. These sources also produce TEV signals on metalwork not connected to the switchgear such as metal substation doors or fencing. The background noise must therefore be measured on such surfaces before measurements are made on the switchgear. If the background noise is <10dB then the UltraTEV Plus+ pulse counter is not incremented and will read zero.

Measure the background noise level on metalwork which is not part of the switchgear, e.g. a metal door, a metal fence, etc. Record three consecutive values of dB and counts on the metalwork and take the middle amplitude reading as the background measurement.

10.2 Making a Measurement

Turn on the unit ensuring the TEV sensor is in free air away from metalwork as this may affect the self test. Select TEV Mode. To take a measurement hold the TEV probe squarely in contact with the metalwork on which the measurement is to be taken (preferably keeping the UltraTEV Plus+ body away from neighbouring metalwork as shown below). If the unit is in continuous measurement mode it will display a reading immediately, however the reading will not stay on screen once the TEV probe is removed from the metalwork. If in single shot mode push  . The unit will beep on pressing the button and will beep again once the measurement has been taken. In this mode the reading will remain on the screen. You may wish to repeat the measurement a few times to ensure consistency.

Correct

Incorrect

Measurements on switchgear are made at the centre of each component of each panel e.g. cable box, CT chamber, busbar chamber, circuit breaker and VT. The position of the circuit breaker or other MV/HV switch is recorded, because if these are in the off position certain

components will not be energised and therefore readings will not be valid on such components.

Record the first set of readings at each position unless the amplitude is greater than 10dB above the background, and greater than 20dB, and greater than 50 counts. If this is the case, record three consecutive sets of readings.

12 Ultrasonic Measurement Procedure

Turn on the unit and select Ultra Mode from the menu, plug in the supplied headphones and adjust the volume. The reading will continuously update on screen. A measurement of the background noise should be taken. Turn the gain to maximum to start with and reduce the gain if the reading becomes too high. To survey the switchgear point the ultrasonic sensor towards any air gaps in the switchgear, particularly breaker spouts, air filled cable boxes, VT and busbar chambers. At all times ensure safety distances are adhered to.

Ultrasonic activity above the background level may be significant. Genuine discharge can be identified by a crackling sound (like a sizzling frying pan) in the headphones.

To convert from dBµV to dB SPL (sound pressure level) subtract 19dB from the reading.

13 Accessories

13.1 UltraDish

The UltraDish provides a means of detecting discharge sources at a distance. It comprises a transparent parabolic reflector that focuses the ultrasonic sound on to a sensor mounted at the focus point of the reflector. The UltraDish gives an effective increase in gain compared to the built in sensor. The UltraDish can be aimed at the target by using either the optical sight or the built in laser pointer activated by a switch on the handle.

To use an UltraDish the connector must be plugged in to the external sensor input on the side of the UltraTEV Plus+. The UltraDish is aimed at the point of interest with either the optical sight or by switching on the laser pointer with the button on the handle and using the laser dot to aim the UltraDish.

Note: Readings taken with the UltraDish **cannot** be compared to readings taken with the Internal Sensor, the Flexible Sensor or the Contact Probe.

13.2 Flexible Sensor

The Flexible Sensor provides a means of reaching inaccessible parts on the switchgear. The sensor is mounted at the end of a flexible goose-neck which allows the angle of the sensor to the handle to be adjusted. This allows the user to make measurements where it would be difficult to use the built in sensor and still be able to read the display.

To use a Flexible Sensor the connector must be plugged in to the external sensor input on the side of the UltraTEV Plus+. The Flexible Sensor is used in the same manner as the Internal Sensor, but, can be used in more confined spaces.

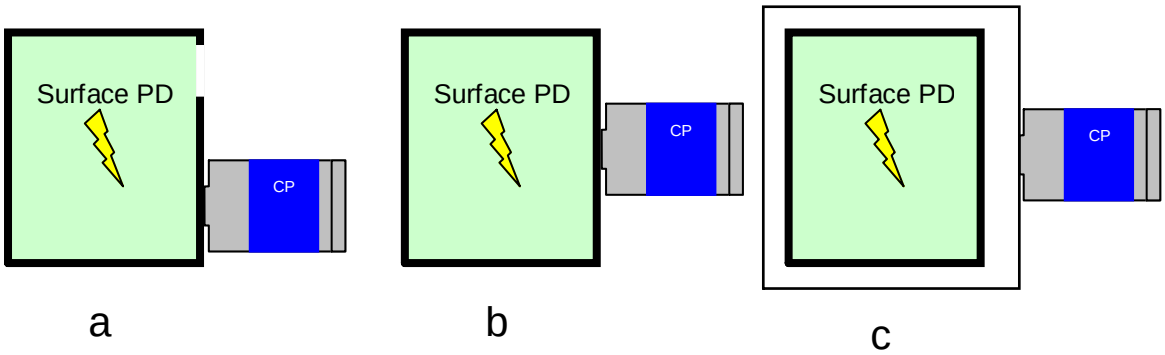
Note: Readings taken with the Flexible Sensor **cannot** be compared to readings taken with the UltraDish or the Contact Probe, but can be compared to readings from the Internal Sensor.

13.3 Ultrasonic Contact Probe

The Ultrasonic Contact Probe is provided to enable discharges to be detected in enclosed areas where there is no direct air path from the discharge source to the sensor. The Probe connects to the external sensor connector and is clamped on to the area or interest using the magnets surrounding the sensor plate. The probe will detect discharge sources inside the enclosed area by detecting the energy transmitted to the enclosure. Care must be taken to eliminate other sources that could cause the signals from discharges to be masked, e.g. accidental movement of the probe itself.

13.3.1 Using the Ultrasonic Contact Probe

The Ultrasonic Contact Probe should be used if there is not a direct path between the PD source and instrument sensor (Figure 1b). However, it must not be used if the tank containing the expected PD source is separated with another layer (see Figure 1c). In cases where there is a direct air path between the source of PD and the instrument, an airborne sensor should be used (Figure 1a). Due to the physics of ultrasound, in some cases the Ultrasonic Contact Probe may offer better sensitivity than that obtained using an airborne sensor.



a) Ultrasonic signal can propagate through the air path. The Ultrasonic Contact Probe can be used; however, better results may be obtained using the airborne sensor.

b) No available air gaps - using an Ultrasonic Contact Probe is the best practice.

c) There is no access to the tank containing PD source, neither the airborne sensor nor the Ultrasonic Contact Probe will provide a valid reading.

Figure 1 – Use of the Ultrasonic Contact Probe

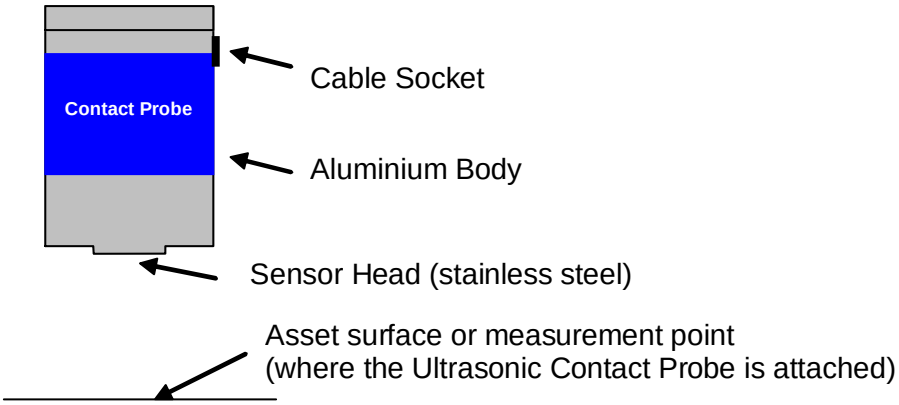


Figure 2 - Ultrasonic Contact Probe Construction

13.3.2 Detection, Measurement and Localisation of the Partial Discharge

Detection of the Partial Discharge using the Ultrasonic Contact Probe is based on the PD pattern recognition carried out by operators. The audio signature of a Partial Discharge detected by the UCP is similar to those obtained using airborne sensors. Special care has to be taken to distinguish phantom signals from genuine signals caused by surface PD.

Before carrying out measurements the surroundings should be made as quiet as is reasonably practicable to allow detection of 'quiet' sources. In loud or noisy industrial environments measurements may be compromised. The conditions under which measurements are taken should be carefully recorded to allow relative comparisons to be made.

Due to the differing propagation paths of the ultrasonic signals, measurements carried out using the UCP cannot be compared against measurements carried out using airborne sensors. In general signals detected by the UCP are smaller as a result of the physical properties of the asset and propagation path. Comparisons between two UCP measurements should only be made on assets of the same type using the same configuration of the UCP.

13.3.3 Mounting Practices

The Ultrasonic Contact Probe was designed to provide sufficient sensitivity to allow it to be used to detect low level ultrasonic noise sources. As it is a very sensitive device the best results are obtained in a working environment which is as 'quiet' as possible.

Figure 3 shows scenarios where the Ultrasonic Contact Probe is mounted ineffectively to the asset enclosure.

Any air gap between Sensor Head and measurement point will effectively attenuate signals to a level where even strong discharges will not be detected. Therefore before any permanent or temporary installation, the Sensor Head and asset surface need to be cleaned of any loose or unstable material. If the assets surface is very rough and uneven this will create air gaps which will result in poor contact between the Sensor Head and the asset.

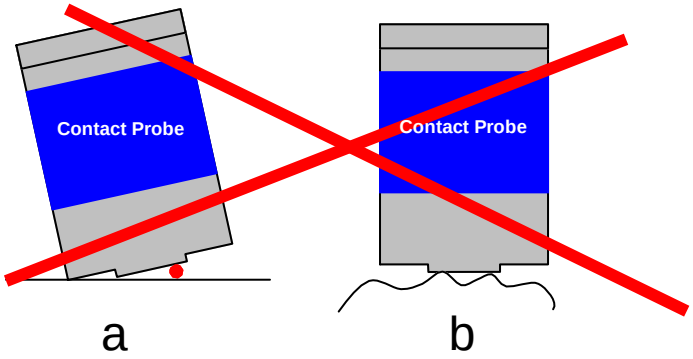


Figure 3 - Incorrect Mounting Scenarios

a) Dust ingress between Ultrasonic Contact Probe Sensor Head and the asset surface.
b) A rough or uneven surface will drastically decrease the amount of signal being transferred to the Sensor Head.

Figure 4a shows the correct way of mounting the Ultrasonic Contact Probe to the asset in order to take a valid measurement. Ideally the Ultrasonic Contact Probe will be attached to

a relatively flat surface using its magnetic clamp. This will eliminate any phantom noises which are described in the section below.

Figure 4b shows a case where the surface is very rough and uneven. One of the following couplants may be used:-

- Water based – suitable for quick measurement offers very good coupling.
- Oil based – suitable for long term monitoring as the oil will not evaporate quickly.
- Solid state – suitable for long term monitoring but does not offer as good coupling as oil based.

Figure 4c shows the application of pressure to the Ultrasonic Contact Probe against the asset under investigation. This can improve the signal transfer and increases its detection abilities. Please note, when the instrument dB values are read for comparison purposes, always use the same type of the sensor, in the same position as previously used. The asset measuring point can be marked on the plant item to facilitate easy location in future.

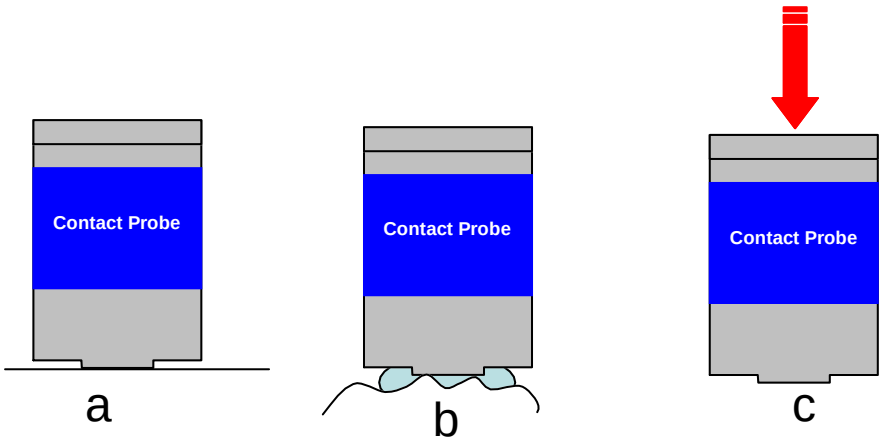


Figure 4 – Correct Mounting Scenarios

a) Relatively flat and smooth surface.
b) Using suitable couplant in the case of a rough surface.
c) Carefully pressing the Ultrasonic Contact Probe towards the asset to increase coupling may eliminate the need to use a couplant.

13.3.4 Sources of Noise and Phantom Signals

Figure 5 presents some examples of how unwanted signals may be introduced during the PD detection process when using the Ultrasonic Contact Probe. These can be categorised as sources of noise and sources of phantom PD signals. The difference between the two is that noise decreases our detection capabilities by masking the PD signal, whereas phantom signals may be confused as a PD source.

Figure 5a shows that when the UCP is kept in the hand during measurements, even tiny movements of the hand can introduce significant noise to measurements through surface noise. In cases where it is necessary to hold the Ultrasonic Contact Probe during measurements (e.g. pushing the sensor to obtain more signal or non-magnetic asset enclosure), a coupling fluid may help to reduce this type of noise.

Any vibrations of the asset surface caused for example by rain in outdoor assets or vibration of transformers may cause phantom signals. In such cases the audible signal may be appear exactly the same as a genuine PD source. These two examples are shown in Figure 5b and 5c.

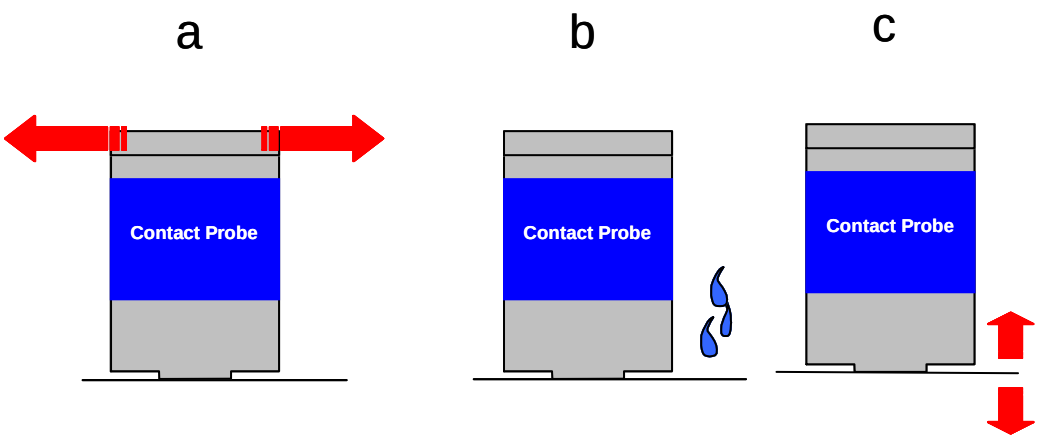


Figure 5 - Sources of Noise and Phantom Signals

a) Shaking Ultrasonic Contact Probe, e.g. when held in the hand.
b) Rain in outdoor assets.
c) Vibration (including transformers) of asset enclosure where the Ultrasonic Contact Probe is attached.

13.3.5 UltraTEV Plus Mute Button

Handling or moving the Ultrasonic Contact Probe when in use can produce an uncomfortable level of audible ‘noise’ through the headphones. To temporarily mute the volume press the ‘OK’ button. Pressing the ‘OK’ button again brings the unit out of mute. This is indicated on the VOL bar at the bottom of the screen.

To exit the ultrasonic mode press the ‘OK’ button until the unit returns to the main menu (>0.5 seconds).

13.4 Guide to Interpretation of UltraTEV Plus+ TEV Readings

TEV Reading	Conclusion
1. High background reading, i.e. greater than 20dB.	(a) High levels of background noise can mask discharges within the switchgear (b) Possibly due to an external influence. If possible remove the external source and re-test alternatively re-survey using the PD Monitor to identify any discharges in switchgear.
2. If all the readings on the switchgear and the background reference are less than 20dB.	No significant discharging. Re-survey annually.
3. For switchgear readings greater than 10dB above the background and if the reading is greater than 20dB (absolute), i.e. not 20dB above the background level, and with a pulse count greater than 50.	Strong possibility of internal discharge activity within the switchgear. Recommend further testing using the UltraTEV Locator or UltraTEV Monitor.
4. For readings with a pulse count greater than 1000.	There may be transmitted background electromagnetic activity in the region. If the readings are greater than 20dB then it is recommended that a PD Monitor be installed to identify external electromagnetic activity. A high number of pulses may be caused by surface discharges. If this is the case, ultrasonic emissions will be present which can be detected with the UltraTEV Plus+ provided an air path is present.

14 Relating TEV Reading (in dB) to Discharge Magnitude (in pC)

Conventional Partial Discharge detection according to IEC60270, measures the apparent charge transfer from the high voltage conductor system when a discharge occurs. Thus the discharge magnitudes are normally expressed in pico-coulombs (pC). At the detection frequencies used by conventional PD detectors (typically 10 - 300 kHz), all items of high voltage plant, with the exception of long cables, can be considered to be lumped capacitors.

The TEV measurement works over the frequency range 3 - 100MHz. At these frequencies high voltage power plant items behave like transmission lines rather than capacitors. The area under the voltage/time curve would be proportional to the charge transfer during the discharge process.

TEV sensors measure the peak voltage of the detected transient, rather than the area under the curve. Therefore, it does not measure the charge directly.

Furthermore, it is the peak of the wave detected on the external surface of the metal-cladding that is measured and this will be a fraction of that within the cladding.

As the pulse travels along the external surfaces of the metal-cladding it disperses, i.e. spreads out. This has the effect of reducing the peak amplitude whilst maintaining the area under the curve. Therefore, the further away from the discharge source the pulse is detected, the greater the attenuation.

Clearly the relation between dB and pC is dependent on many factors, most of which are difficult to quantify.

Some recent laboratory tests undertaken by an independent party, and field measurements undertaken by EA Technology, on various system components, combining both conventional discharge detection and TEV measurements, yielded the results detailed in the tables on pages 30 and 31.

14.1 Surface Discharges

The most successful way of detecting surface discharges is using ultrasonic techniques. Surface discharges produce very low TEV signals compared to internal discharges. In addition, the electromagnetic signals produced by surface discharges are lower in frequency than the operating band of the TEV instruments. This is due to the slower rise times of the waveforms. In many cases the signals will not be picked up by TEV only instruments as they will be lower than the ambient noise levels.

Table 1 dB-pC guidance for 25kV close to termination

TEV Reading (dB)	PD Conventional Measurement (pC)
0	32
5	56
10	100
15	178
20	316
25	560
30	1,000
35	1,780
40	3,160
45	5,600
50	10,000
55	17,800
60	31,600

Table 2 gives some empirical results for a phase to earth discharge in a compound-filled 11kV cable end box.

Table 2 dB-pC guidance for compound-filled 11kV distribution cable end box

TEV Reading (dB)	PD Conventional Measurement (pC)
0	100
5	178
10	316
15	562
20	1,000
25	1,780
30	3,160
35	5,620
40	10,000
45	17,800
50	31,600
55	56,200
60	100,000

Table 3 gives some empirical results for a phase to earth discharge in a SRBP bushing in an Oil Circuit Breaker.

Table 3 dB-pC guidance for SRBP Bushing in Oil Circuit Breaker

TEV Reading (dB)	PD Conventional Measurement (pC)
0	134
5	239
10	423
15	753
20	1,340
25	2,390
30	4,230
35	7,530
40	13,400
45	23,900
50	42,300
55	75,300
60	134,000

Table 4 gives some empirical results for an internal discharge in a Cast Resin CT at 11kV.

Table 4 dB-pC guidance for Cast Resin CT at 11kV

TEV Reading (dB)	PD Conventional Measurement (pC)
0	224
5	399
10	708
15	1,260
20	2,240
25	3,990
30	7,080
35	12,600
40	22,400
45	39,990
50	70,800
55	126,000
60	224,000

It must be stressed that the tables above should only be used as a rough guide. Whilst it is generally correct that increasing pC levels equates to increasing dB levels, factors such as

the source of the discharge activity and the attenuation path all have significant influence on calibrating results.

15 Instrument Specification

15.1 TEV Measurements

Sensor: Capacitive
Measurement Range: 0 – 60dBmV
Measurement Bandwidth: 2 – 80 MHz
Resolution: 1dB
Accuracy: ±1dB
Max Number of Pulses/Cycle: 655
Min Pulse Rate: 10Hz (rolling displays only)

15.2 Ultrasonic Measurements

Measurement Range: -7dBµV to 68 dBµV
Resolution: 1dB
Accuracy: ±1dB
Transducer Sensitivity: -65dB (0dB = 1volt/µbar RMS SPL)
Transducer Centre Frequency: 40 kHz
Transducer Diameter: 16mm
Heterodyning Frequency: 38.4 kHz

15.3 Hardware

Enclosure: Self-coloured injection moulded plastic case
Indicators: Colour back-lit LCD
Charging indicator LED
Controls: Membrane keypad
Connectors: 2.1mm LV DC Charger Input
3.5mm stereo headphone socket
External Ultrasonic Sensor Input
Headphones: Min. 8 ohms

15.4 Environmental

Operating Temperature: 0 – 55 degrees C
Humidity: 0 – 90 % RH non-condensing
IP Rating: 54

15.5 Dimensions

Size: 205mm x 72mm x 35mm
Weight: 0.3kg

15.6 Power Supplies

Internal Batteries: 3.7V 3.6Ah Lithium-Ion
Typical Operating Time: approx. 5 hours
Battery Conservation: Automatic 'switch off' when low battery voltage detected or 60 minutes elapsed.

15.7 Battery Charger

Rated Voltage: 90 – 264V AC
Frequency: 47 - 63Hz
Charging Voltage: 6V DC
Charging Current: 500 mA
Time for Full Charge: 7 hours
Dimensions: 74mm x 44mm x 34 mm
Weight: 0.12 kg
Operating Temperature: 0 - 40 degrees C
Humidity: 20 – 85% RH non-condensing

15.8 UltraDish

Measurement Gain: 16dB (compared to internal sensor @ 2.5m)
Transducer Centre Frequency: 40 kHz
Transducer Diameter: 16mm
Laser Power: 4.5 mW Class IIIR
Laser Spot Size: 6mm at 5m
Dish External Diameter: 275mm
Dish Nominal Diameter: 250mm
Weight: 0.6 kg
Operating Temperature: -10 to 50 degrees C
Humidity: 0 – 90 % RH non-condensing
IP Rating: 54

16 Maintenance

It is important that the UltraTEV Plus+ is kept clean and dry. It is not weatherproof. Avoid storage in damp and humid conditions and do not subject it to temperature extremes, excessive vibration or shocks. Do not stand on the case.

Internal, rechargeable batteries power the instrument.

No attempt should be made to gain access to the internal circuitry of the instrument, or its accessories. Advice should be sought from the manufacturer, or the supplier, if any doubt exists over the equipment's performance or operation.

The UltraTEV Plus+ should be cleaned with a damp cloth. If more heavily soiled, a foam cleanser may be used, provided care is taken not to allow fluid to enter the instrument. Abrasive cleaners must not be used. Take care not to scratch the plastic overlay of the front panel.

17 Warranty Policy

What Does the Warranty Policy cover?

EA Technology products and accessories are warranted against defects in material and workmanship for twelve months from the date of despatch from our premises.

During the warranty period, EA Technology will, at its option, either repair or replace products, parts or accessories which prove defective.

What is not covered by the Warranty Policy?

The following are not covered: damage caused by accident, misuse, abuse, product modification or neglect; damage resulting from failure to follow instructions contained in your operating manual; damage resulting from the performance of repairs by someone not authorised by EA Technology.

Warranty Policy for repairs

Repaired products are warranted against defects in workmanship and materials for a period of six months, or the remainder of the original warranty period, whichever is greater.

For warranty repair, please contact EA Technology Product Support:

Email: product-support@eatechnology.com

Telephone: +44 (0)151 347 2293

18 Calibration

Calibration interval: 12 months

Your application may require a different calibration interval dependant on the frequency of use. The calibration interval should begin on the date the instrument is placed in service.

19 Repair

For information on our repair procedure please contact EA Technology Product Support:

Email: product-support@eatechnology.com

20 Waste Electrical and Electronic Equipment Directive (WEEE)

EA Technology is a member of an approved compliance scheme as defined by the WEEE directive. When an EA Technology product reaches the end of its operational life, it must be recycled by a licensed waste management operator, or returned to EA Technology for recycling.

21 Note

EA Technology has a policy of continual product development and enhancement. Consequently, there may be minor variations in specifications or operation that are not covered in this operating manual.

Every effort has been made to ensure that the information provided in this operating manual is accurate at the time of going to print.

If any errors or omissions are noticed, please notify: product-support@eatechnology.com

22 Product Support

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