REPORT

Partial Discharge Survey of Interruptible and Sub 1 Switchgear

Private and confidential

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8 June 2018	1	T. Erwin	

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Executive summary

This report provides actual customer examples of partial discharge surveys that were done and the subsequent report with data and recommendations for customers to review as part of the overall evaluation of EA Technology's products and services.
The survey was performed on May 15, 2018 on switchgear locations identified as

1) Interruptible Substation
2) Substation 1

Conclusions

C1. Interruptable Substation: No PD activity evident.

C2. Substation 1: Low level surface discharge activity detected on feeder F1A both in the breaker compartment (front) and cable compartment (rear). Classification results, audio capture and phase resolved plots all support the presence of PD.

Recommendations

R1. Interruptable Substation: Retest in 2 years.

R2. Substation 1: Retest every 3-6 months and monitor levels. If switchgear is taken out of service perform additional testing, visual inspection for evidence of PD and/or off line PD testing.

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1. Background & Introduction

EA Technology was requested to perform an online Partial Discharge survey of switchgear located at XYZ facility using the UltraTEV Plus2. Transient Earth Voltage (TEV) and Ultrasonic testing was performed.

The survey was performed on May 15, 2018 on switchgear locations identified as

1) Interruptible Substation
2) Substation 1

This report details the results of the partial discharge survey.

2. Overview of Detection of Partial Discharge Activity

2.1 General

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

Non-intrusive partial discharge detection provides a fast and simple to use test for identifying potential sources of insulation failure, that could result in the loss of supply to customers and a serious health and safety issue to staff and other personnel.

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.

2.2 Electromagnetic Discharge Activity

When partial discharge activity occurs within high voltage switchgear insulation 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. The signal can travel through other insulating materials or components; however, the signal attenuation increases with each surface or medium that it traverses. When the electromagnetic wave propagates outside the switchgear it also impinges on the metal casing of the switchgear producing a transient voltage on the external metal cladding of the switchgear. The Transient Earth Voltage (TEV) is a few millivolts to a few volts 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 capacitive probe on the outside of the switchgear while the switchgear is in service.

2.3 Airborne Ultrasonic Discharge Activity

Acoustic emission from surface discharge activity occurs over the whole acoustic spectrum. Using an instrument to detect the ultrasonic part of the acoustic spectrum has several advantages. Instruments are more sensitive than the human ear, are more directional, are not operator dependent and operate above the audible frequency.

The most sensitive method of detection uses an airborne ultrasonic microphone centred at 40 kHz. This method is very successful at detecting surface discharge activity provided there is an air passage between the source and the microphone. When there is no or very limited air path, a contact ultrasonic microphone can be used to detect ultrasonic activity through the metalwork of the switchgear.

When undertaking ultrasonic surveys, it is important that environmental conditions are also measured. The presence of moisture in the atmosphere can have a direct effect on the presence of surface discharge.

3. Partial Discharge Instrumentation

3.1 UltraTEV Plus2

The UltraTEV Plus2 is a hand-held instrument used for the detection and measurement of partial discharge in switchgear, cables and terminations, overhead insulators, and more. Both TEV and surface discharges can be detected and are displayed as numerical values on a colour screen. The instrument also has the ability to display the number of PD pulses per cycle, severity levels, maximum levels for internal discharges, and a numerical value for ultrasonic emissions, which can be heard with the supplied headphones. Finally, the instrument has built in algorithms used to analyse TEV and Ultrasonic measurements and advise the user if either internal or surface partial discharge is present.

Figure 1 **UltraTEV Plus^2**

4. Interpretation of Results

The interpretation of results is aided by the use of EA Technology's partial discharge measurements database that contains over 15,000 records of surveys of switchgear and other electrical assets using partial discharge detection equipment. A judgement has been made that the top 5% of the switchgear and other assets requires further investigation. It is possible to interrogate the database to determine the criteria for further investigation of different subsets within the data e.g. for particular types of switchgear, different voltage ratings, particular manufacturers etc.

The level for further investigation of ultrasonic measurements is determined more by the knowledge that a source has been found than by the amplitude of the measurement. This is because the amplitude is very dependent on the size of the opening through which the airborne ultrasonic signal can pass and a clear direct line path between the source and the opening. A source is deemed to be found if movement of the ultrasonic microphone across the opening and angling the probe towards and away from the opening shows that the source is within the switchgear.

It is important that the following additional criteria are taken into consideration. Any one of these factors may result in a further investigation being carried out at levels below the general criteria.

- Switchgear component
- History of failures
- Circuit importance
- Level of Risk

5. Results and Discussion

5.1 Results

5.1.1 Sub 1

Facility	XYZ Customer		Report Date; June 8, 2018				
Switchgear	**Sub 1**		Engineer: T. Erwin				
Test Date	5/15/2018		Outdoor - No				
			Temp **31C**			**Humidity: 27**	
TEV							
Equipment and Connection		**Phase Resolved Indication**	**TEV Indication**	**TEV DBmV**	**PPC**	**TEV Conclusion**	**Notes**
52-F1A	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No PD detected	
52-F1B	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No PD detected	
Ultrasonic							
Equipment and Connection		**Phase Resolved Indication**	**Classifier**	**Audio Indication**	**Level**	**Ultrasonic Conclusion**	
52-F1A	Circuit Breaker (Front)	Positive	PD	Positive	0-10 dB	Low level surface PD Possible.	Airborne Ultrasonic
	Cable Box (Rear)	Positive	PD	Positive	0-10 dB	Low level surface PD Possible.	Airborne Ultrasonic
52-F1B	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	0-10 dB	No PD detected	Airborne Ultrasonic

5.1.2 Interruptible Sub:

Facility	XYZ Customer		Report Date: June 8, 2018				
Switchgear	**Interruptible**		Engineer: T. Erwin				
Test Date	5/15/2018		Outdoor - No				
			Temp: **23C**		Humidity: **45% RH**		
TEV							
Equipment and Connection		**Phase Resolved Indication**	**TEV Indication**	**TEV DBmV**	**PPC**	**TEV Conclusion**	**Notes**
52-F3A	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-F4A	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-F1A	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-F2A	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
VT-UA	VT Chamber (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-UMA	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-GMA	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	

	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
VT- BUS A	VT Chamber (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
VT-GEN BUS	VT Chamber (Front)	No Measurment				No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-G1	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-G2	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-G3	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-G4	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-G5	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-GMB	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
VT-UB	VT Chamber (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	

	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
VT-BUS B	VT Chamber (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-UMB	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-F1B	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-F2B	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-F3B	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
52-F4B	Circuit Breaker (Front)	Negative	No Concern	0-10 dB	<1	No internal PD detected	
	Cable Box (Rear)	Negative	No Concern	0-10 dB	<1	No internal PD detected	

Ultrasonic

Equipment and Connection		Phase Resolved Indication	Classifier	Audio Indication	Level	Ultrasonic Conclusion	Notes
52-F3A	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic

52-F4A	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
52-F1A	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
52-F2A	Circuit Breaker (Front)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
VT-UA	VT Chamber (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
52-UMA	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
52-GMA	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
VT- BUS A	VT Chamber (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
VT-GEN BUS	VT Chamber (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic

	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-G1	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-G2	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-G3	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-G4	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-G5	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-GMB	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
VT-UB	VT Chamber (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic

VT-BUS B	VT Chamber (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-UMB	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-F1B	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-F2B	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-F3B	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic
52-F4B	Circuit Breaker (Front)	Negative	Noise	Negative	0-10 dB	No surface PD detected	Airborne Ultrasonic
	Cable Box (Rear)	Negative	Noise	Negative	11-20 dB	No surface PD detected	Airborne Ultrasonic

Key

No PD detected No action required	Low levels of PD detected Action advised	High levels of PD detected Action required

5.2 Assets Where Further Action is Recommended

5.2.1 Substation 1

Substation 1 bays F1A and F1B there were no TEV (internal PD) discharges detected. See Phase Resolved Plots in Appendix I.

Substation 1 bay F1B had no Ultrasonic (surface) PD detected. See Phase Resolved Plots Appendix I.

Substation 1 Bay F1A had evidence of low level Ultrasonic (surface) PD in both the front (figure 3) and rear (figure 2) lower sections. The audio capture also provides supporting evidence that there is activity in the PD spectrum.

As the gear was energized we could not investigate further. The F1A breaker was open at the time of the testing with the load being carried through the F1B breaker. At this time there is no immediate concern, but this gear should be retested in 3-6 months monitoring for any increase in PD levels and during the next outage offline testing and/or a visual inspection of the F1A gear should be performed looking for evidence of surface partial discharge. Considering the age of the gear possible sources can include wear of the breaker components (breaker stabs etc.), surface contaminants on the inside of the gear or age-related deterioration of insulators as can be expected on 50-year-old equipment.

It was noted that the recorded humidity was low at 27%RH. Surface PD is directly influenced by the amount of relative humidity. Retesting at a time when the humidity is higher could result in greater levels of PD. If the measured PD increases with the relative humidity this will further support the presence of surface PD.

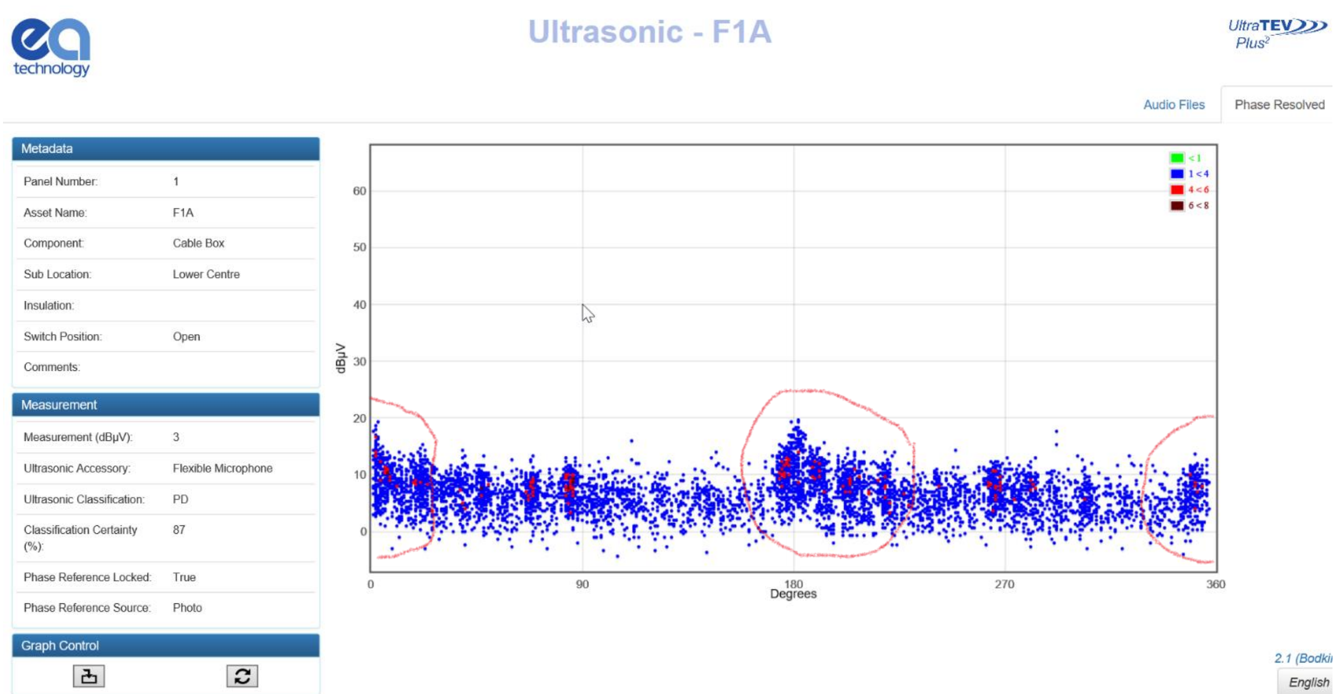

Figure 2 Ultrasonic trace from Sub 1 F1A cable compartment (Rear): Classification- PD (Surface)

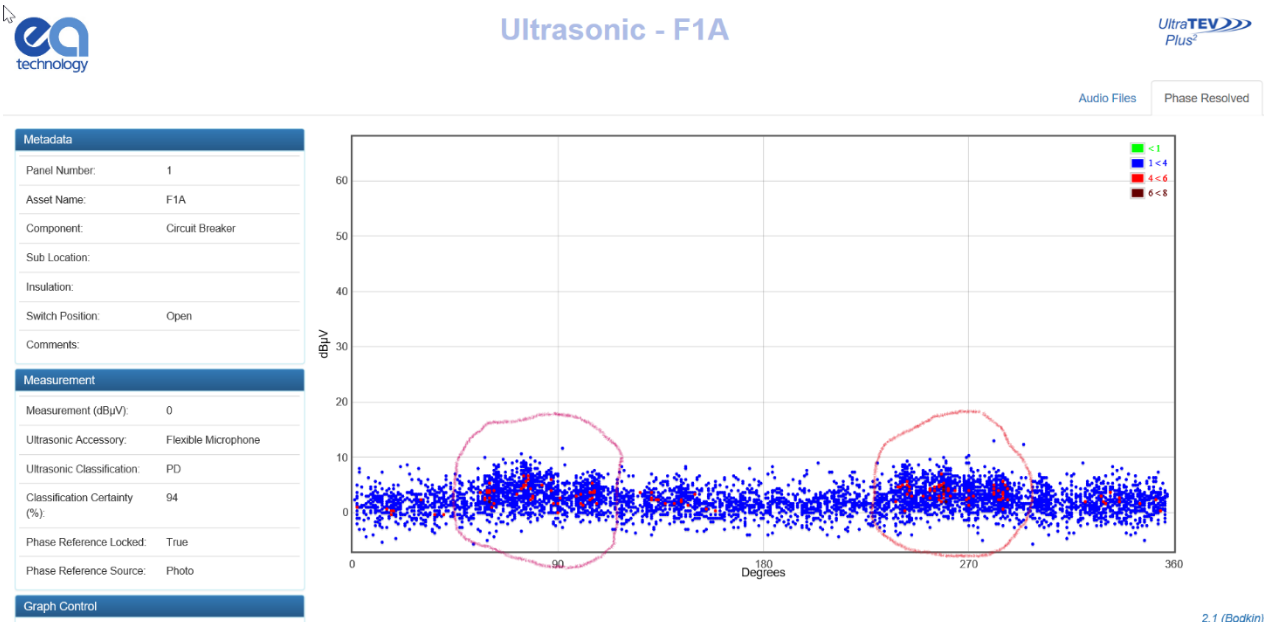

Figure 3 Ultrasonic trace from Sub 1 F1A circuit breaker (Front): Classification- PD (Surface)

6. Conclusions

C1. Interruptable Substation: Had no PD activity evident.

C2. Substation 1: Low level surface discharge activity detected on feeder F1A both in the breaker compartment (front) and cable compartment (rear). Classification results, audio capture and phase resolved plots all support the presence of PD.

7. Recommendations

R1. Interruptible Substation: Retest in 2 years.

R2. Substation 1: Retest every 3-6 months and monitor levels. If switchgear is taken out of service perform additional testing, visual inspection for evidence of PD and/or off-line PD testing.

Appendix I Phase resolved plots

1. Substation 1

technology

Job	
Job Number:	05152018

Substation	
Name:	Sub 1
Type:	ITE
Cable Naming:	

Switchgear	
Manufacturer:	Ite
Type:	
Installation Date:	1967
Rated Voltage:	15
Operating Voltage:	13.8
Busbar Insulation:	

Conditions	
Background Metal (dB):	8
Background Metal (PPC):	0.00
Background Air (dB):	1
Background Air (PPC):	0.00
Temperature (°C):	31
Humidity (%RH):	27

Download
Download Survey Summary CSV

Figure 1 Sub 1 Background readings and switchgear information

1.1 Circuit F1A

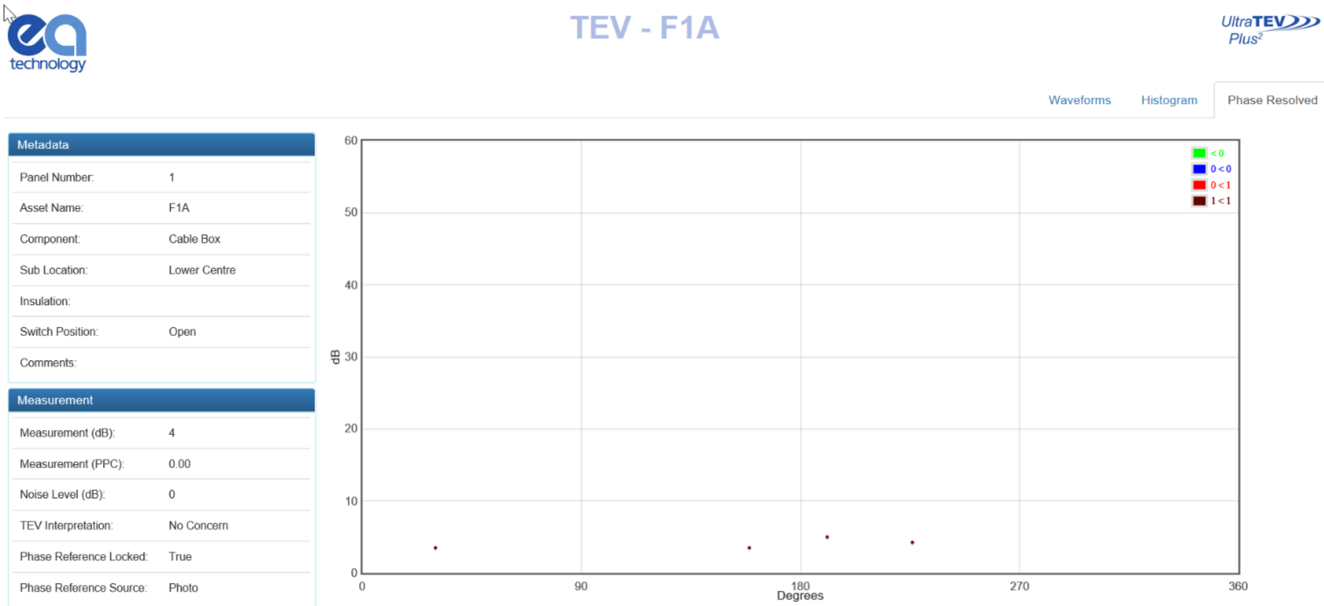

Figure 2 TEV phase resolved plot from Sub 1 F1A cable compartment (rear): No internal PD evident

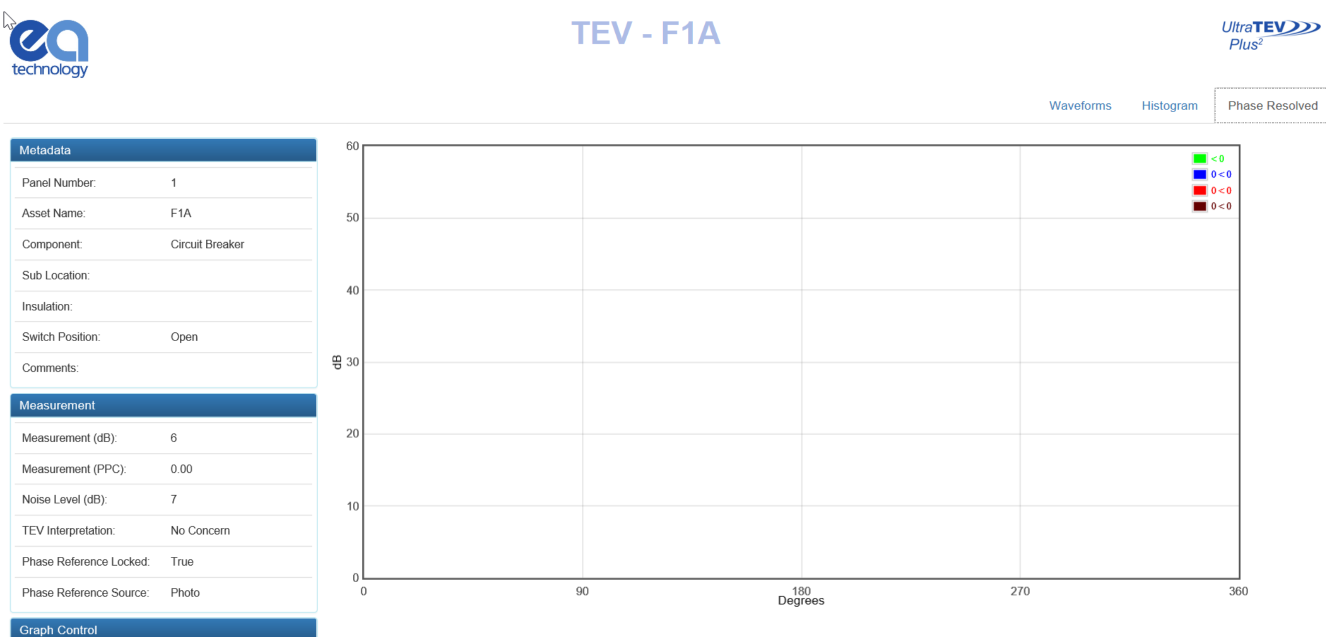

Figure 3 TEV phase resolved plot from Sub 1 F1A breaker compartment (front): No internal PD evident

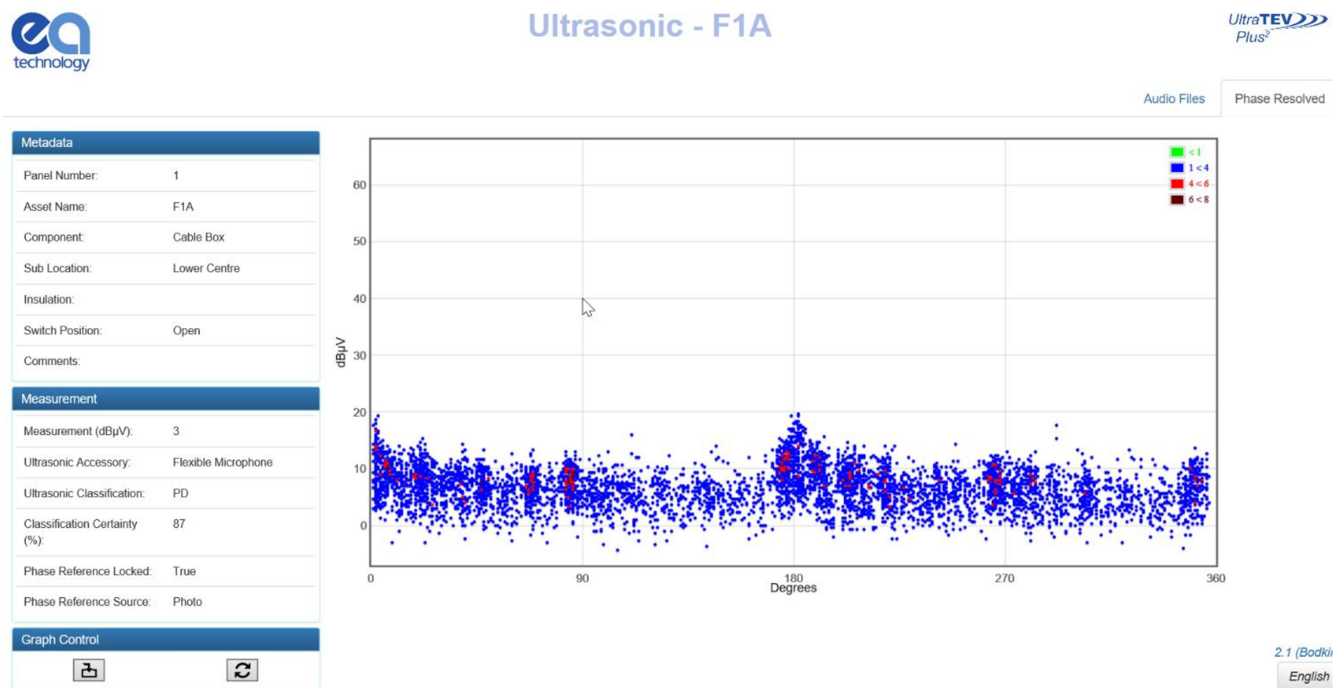

Figure 4 Ultrasonic phase resolved plot from Sub 1 F1A cable compartment (rear): Classification- PD (Surface)

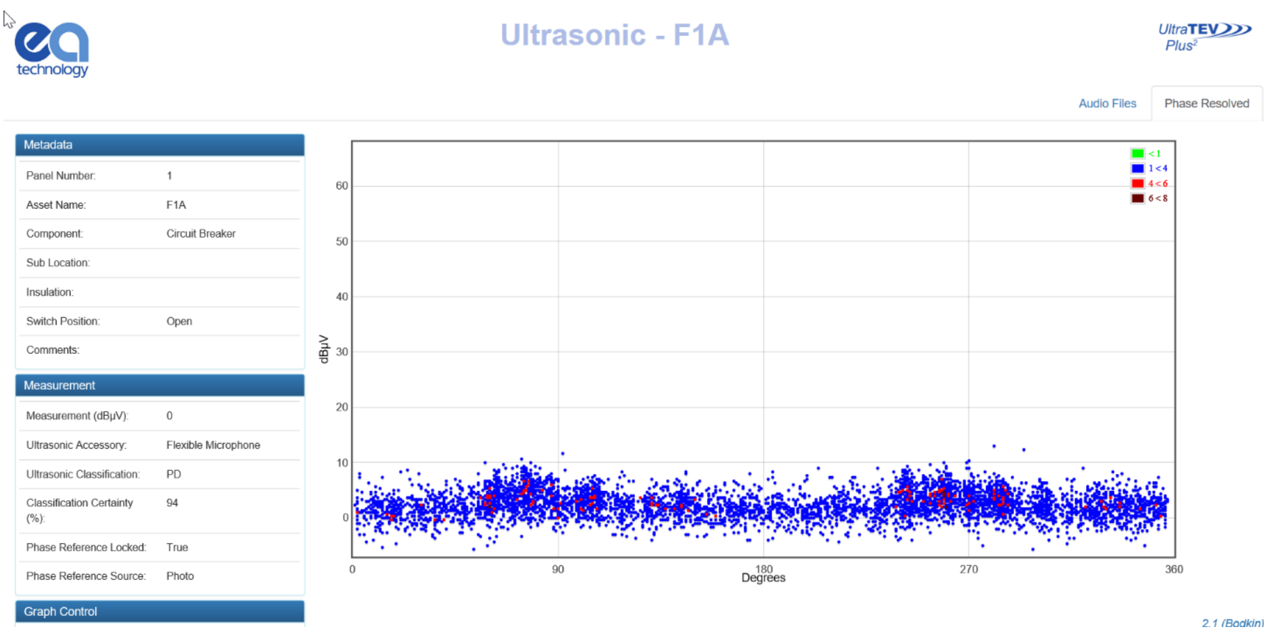

Figure 5 Ultrasonic phase resolved plot from Sub 1 F1A circuit breaker (front): Classification- PD (Surface)

1.2 Circuit F1B

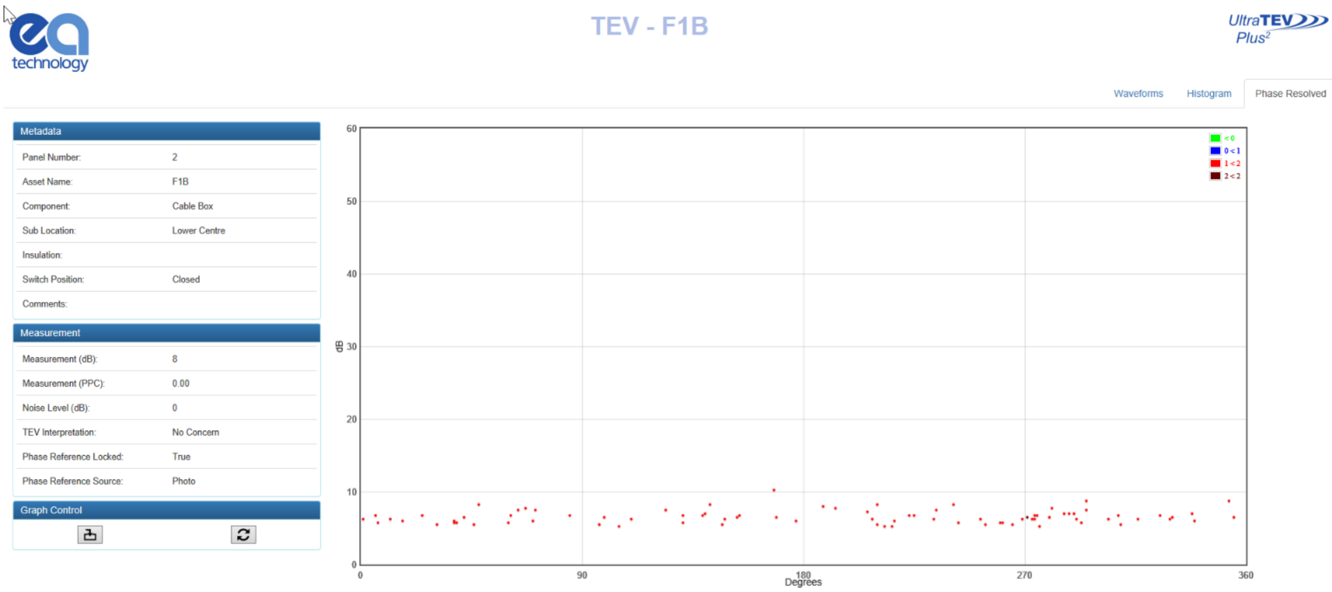

Figure 6 TEV phase resolved plot from Sub 1 F1B cable compartment (rear): No internal PD evident

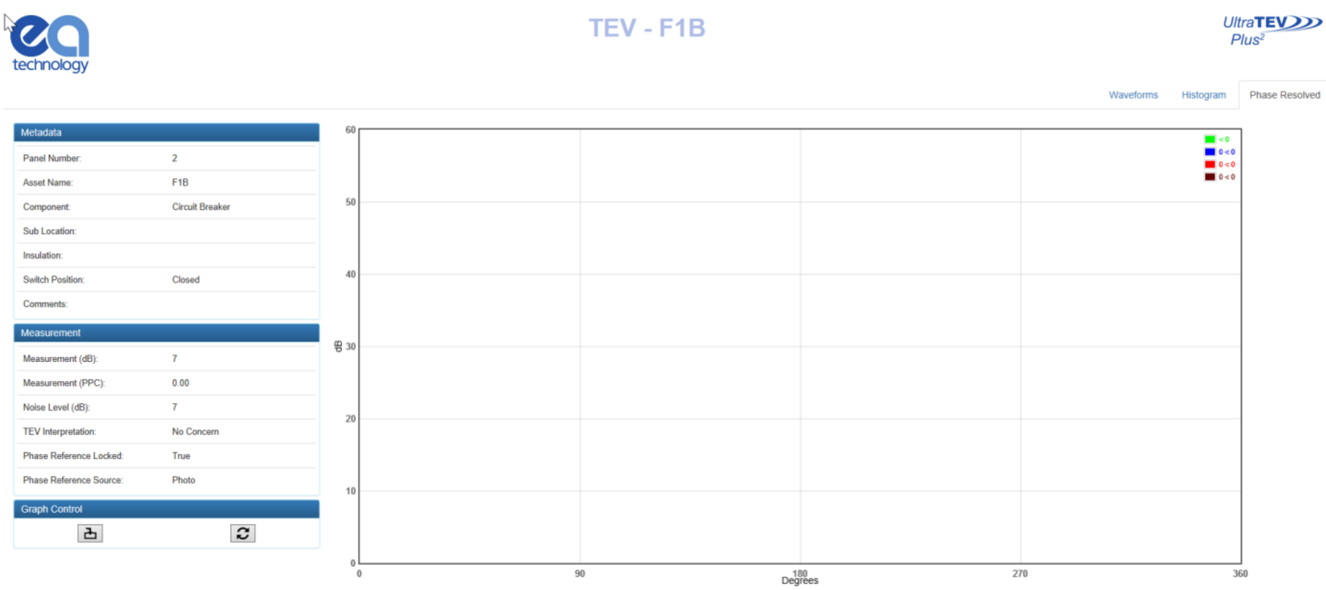

Figure 7 TEV phase resolved plot from Sub 1 F1B breaker compartment (front): No internal PD evident

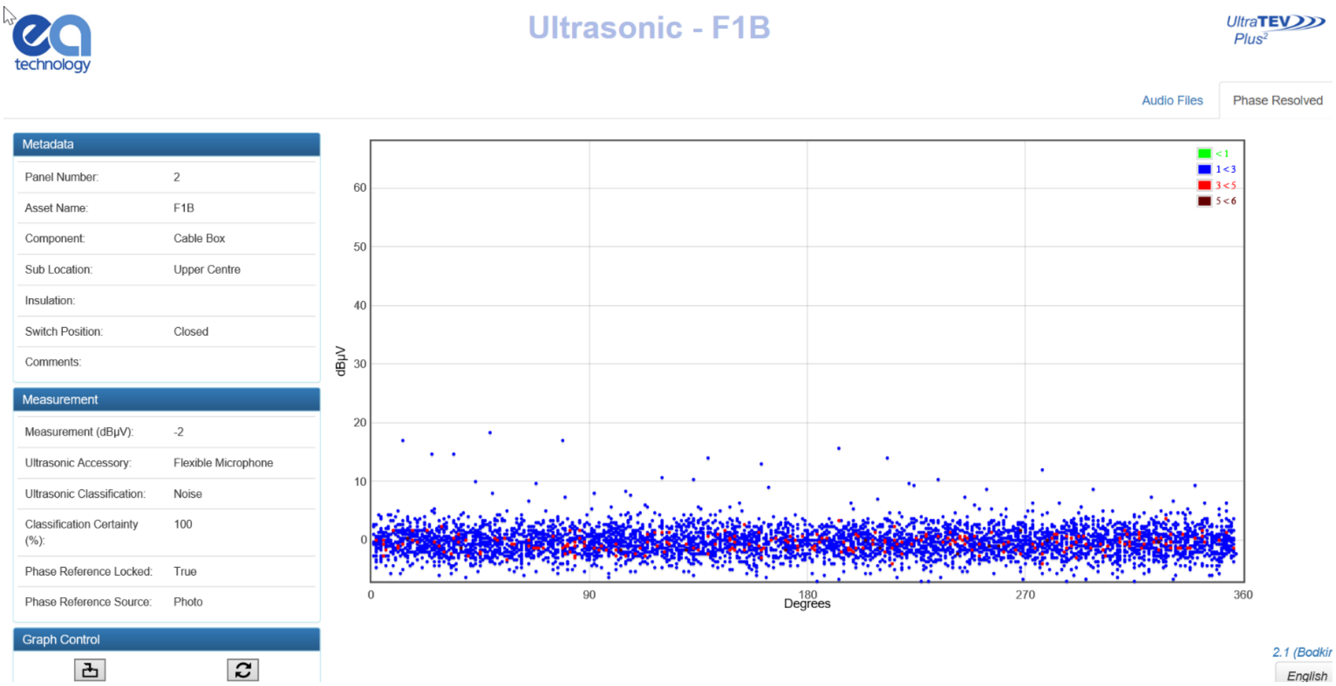

Figure 8 Ultrasonic phase resolved plot from Sub 1 F1B cable compartment (rear): Classification- Noise

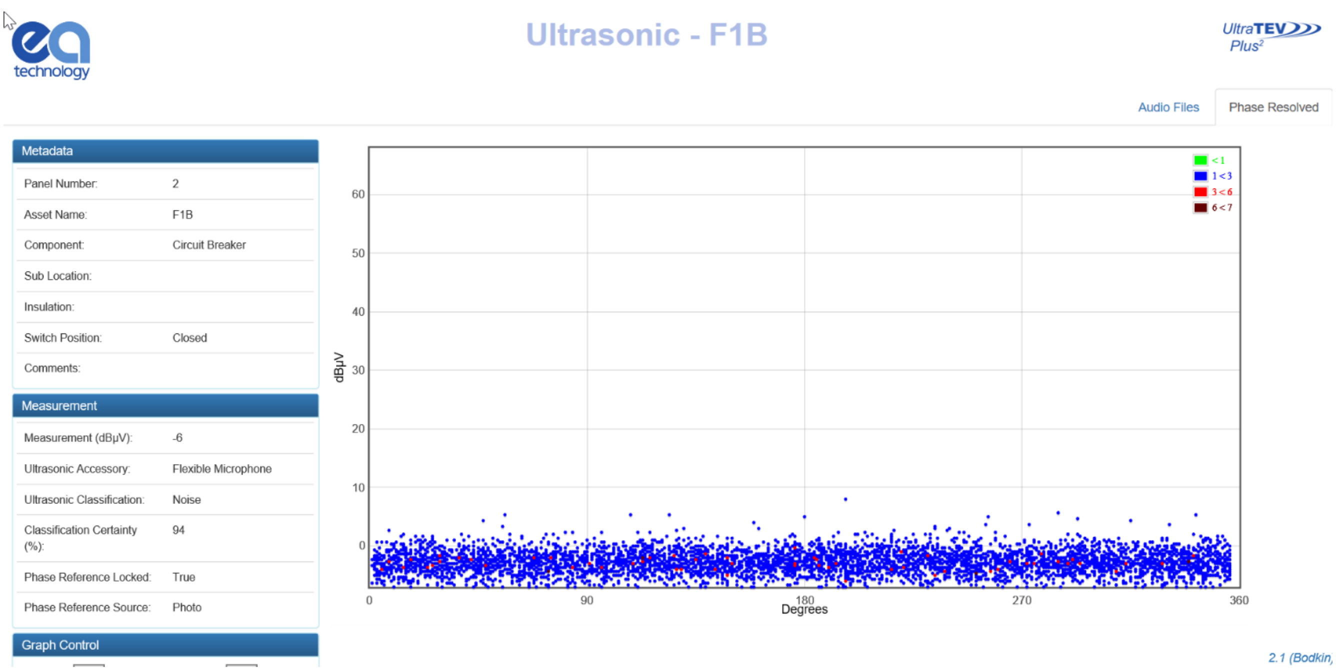

Figure 9 Ultrasonic phase resolved plot from Sub 1 F1B circuit breaker (front): Classification- Noise

2. Interruptible Substation:

The following are representative samples from each section of gear. Please refer to UltraTEV Plus2 survey files for all test results.

Figure 10 Sub 1 Background readings and switchgear information

2.1. Circuit 52-F3A

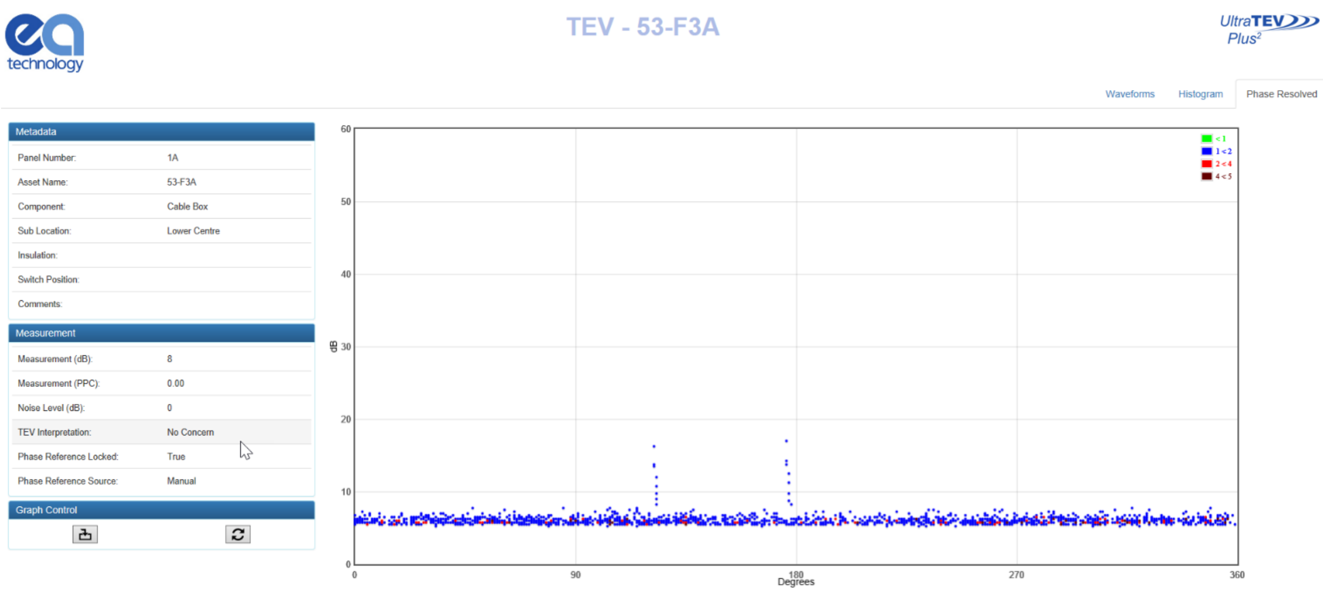

Figure 11 TEV phase resolved plot from Interruptible 52-F3A cable compartment (rear): No internal PD evident

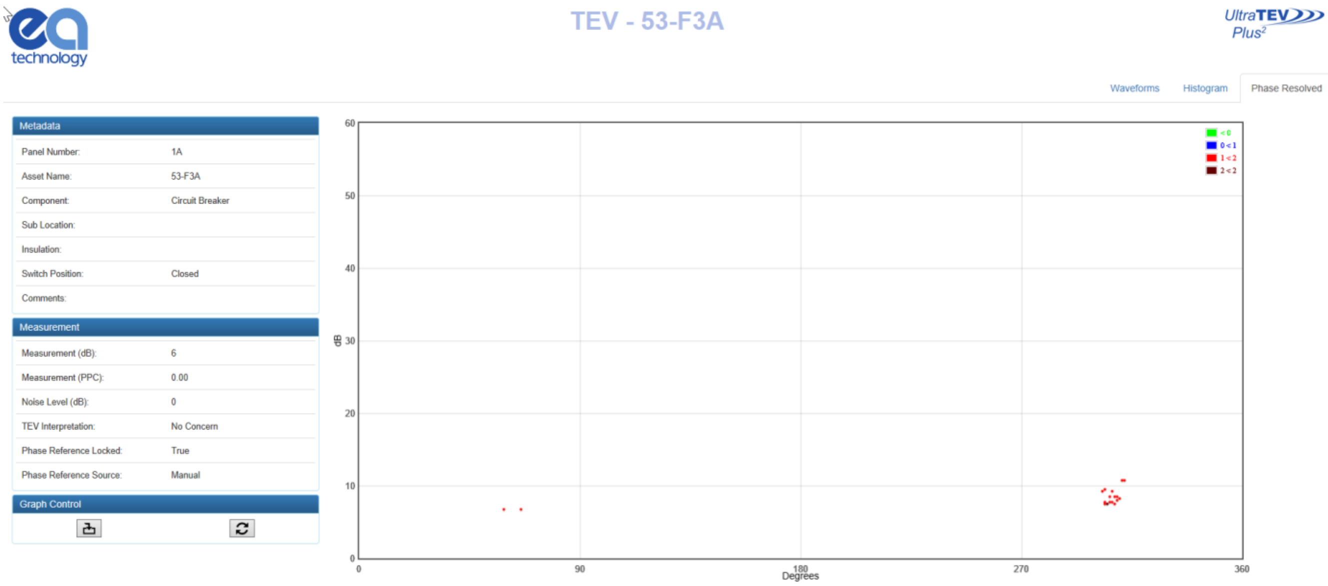

Figure 12 TEV phase resolved plot from Interruptible 52-F3A breaker compartment (front): No internal PD evident

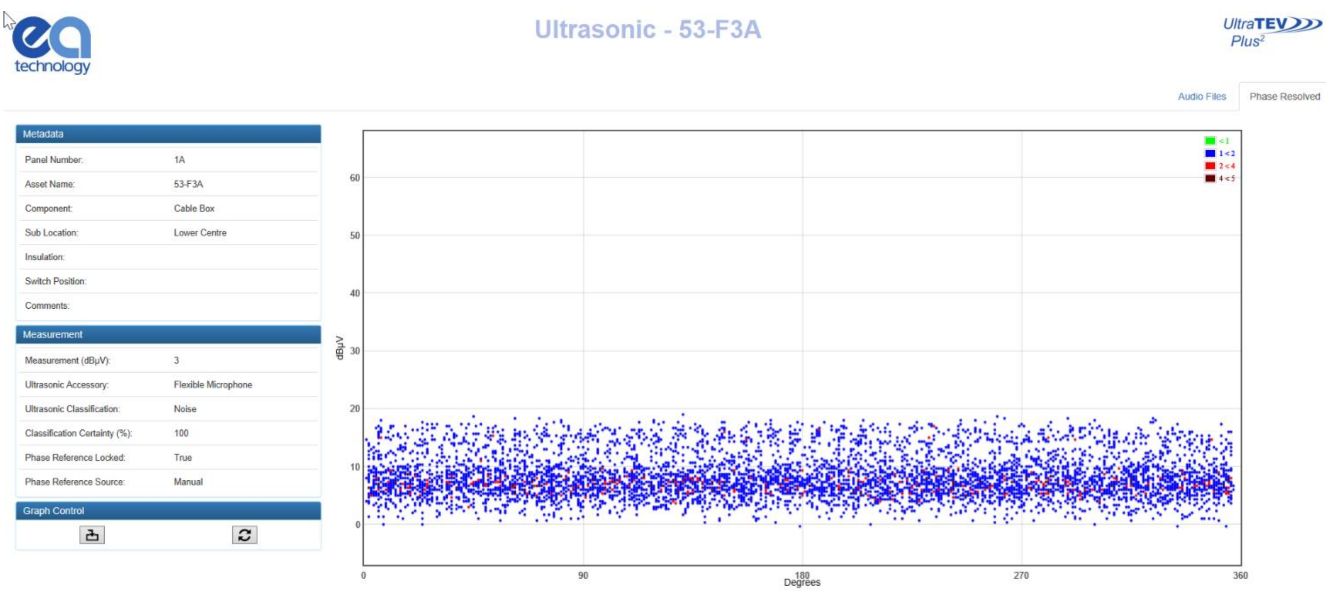

Figure 13 Ultrasonic phase resolved plot from Interruptible 52-F3A cable compartment (rear): Classification- Noise

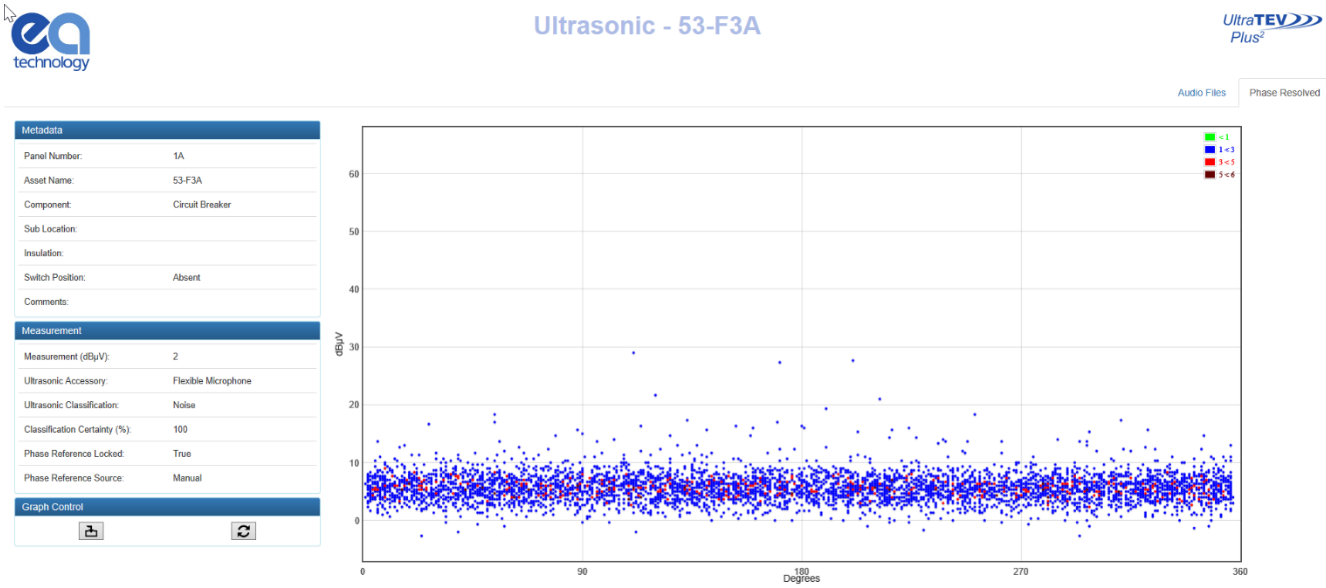

Figure 14 Ultrasonic phase resolved plot from Interruptible 52-F3A breaker compartment (front): Classification- Noise

2.2. Circuit VT-UA

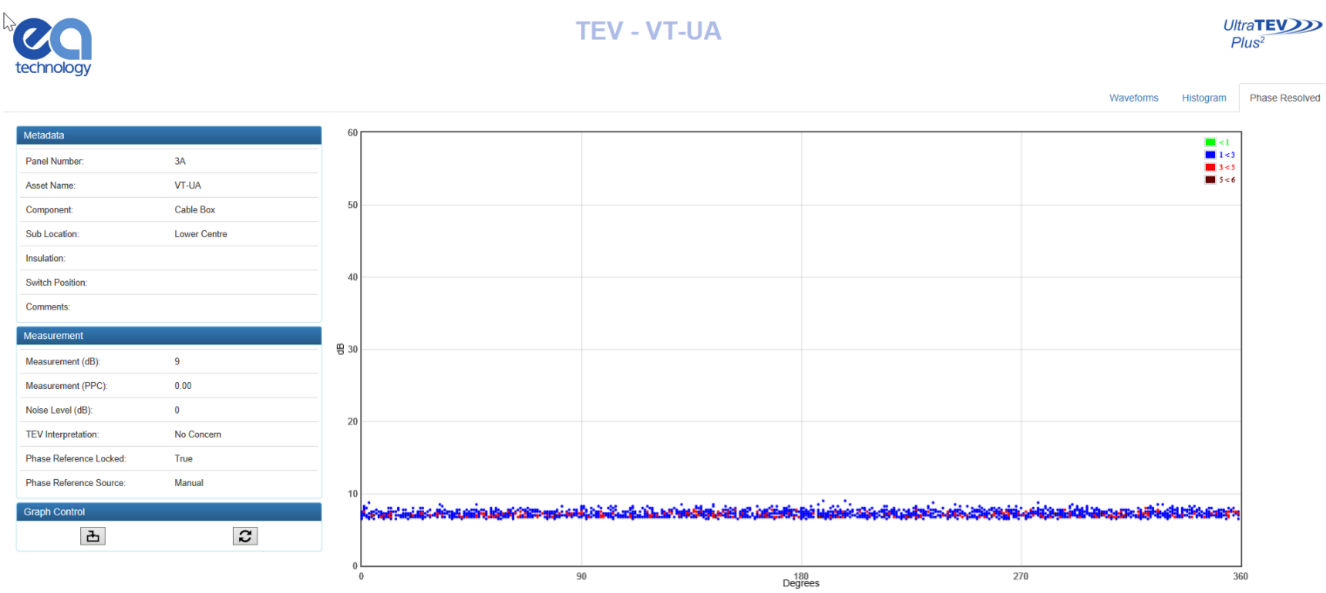

Figure 15 TEV phase resolved plot from Interruptible VT-UA cable compartment (rear): No internal PD evident

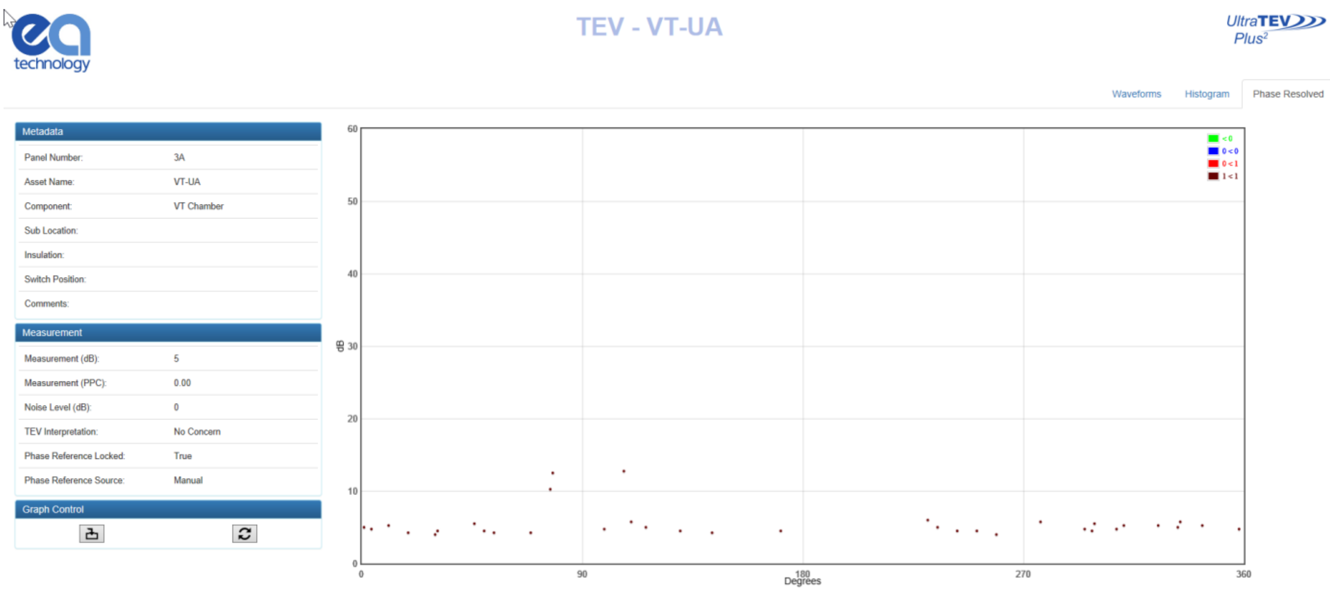

Figure 16 TEV phase resolved plot from Interruptible VT-UA PT compartment (Front): No internal PD evident

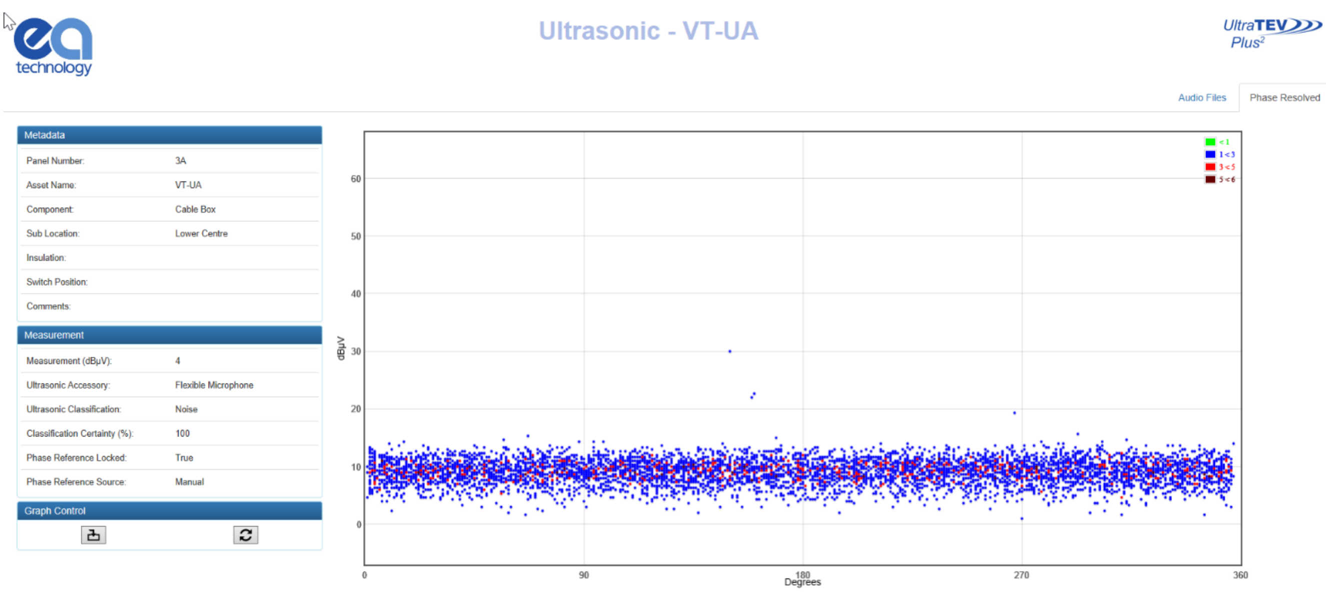

Figure 17 Ultrasonic phase resolved plot from Interruptible VT-UA cable compartment (rear): Classification- Noise

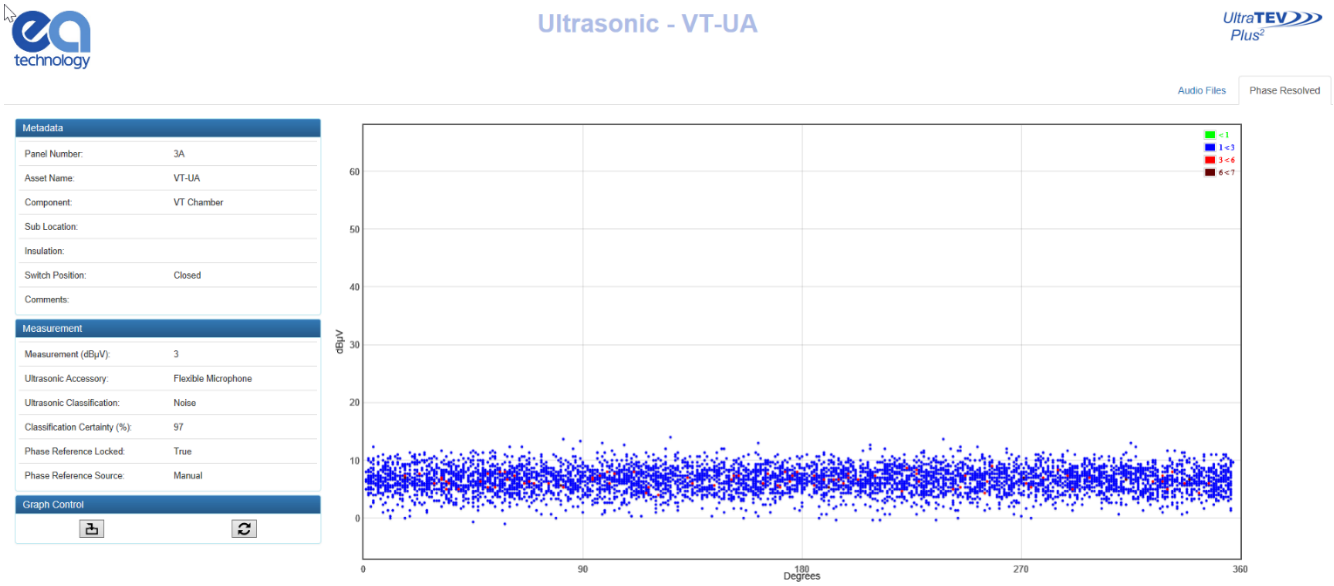

Figure 18 Ultrasonic phase resolved plot from Interruptible VT-UA PT compartment (front): Classification- Noise

2.2. Circuit VT-UA

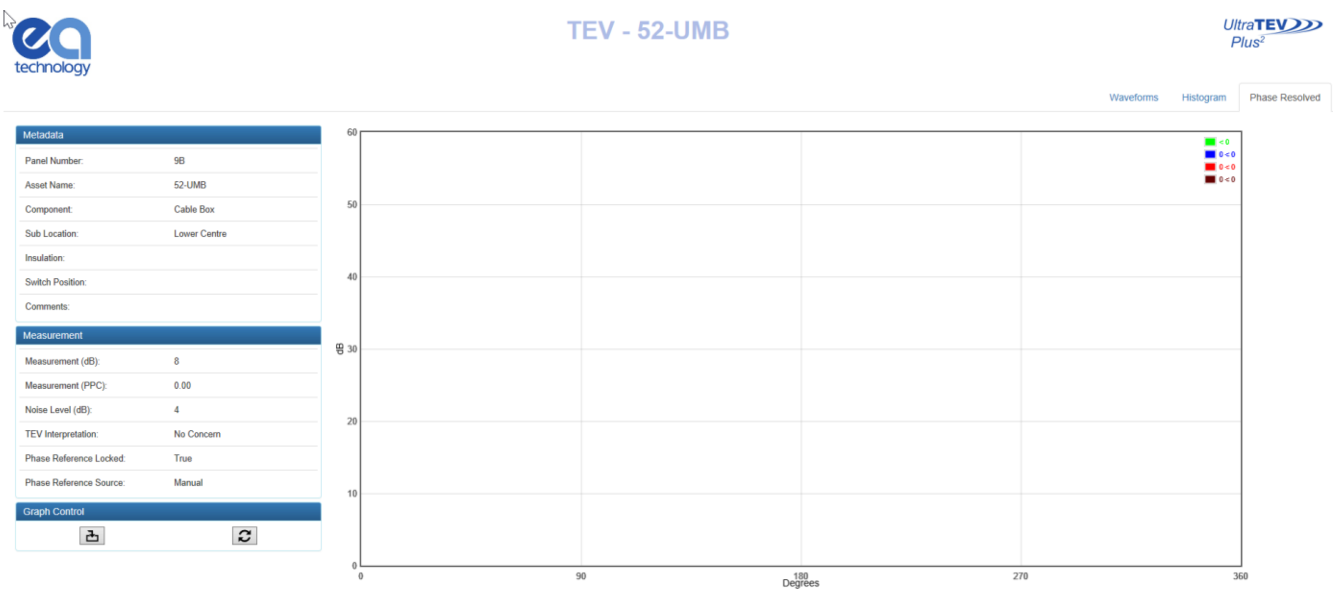

Figure 19 TEV phase resolved plot from Interruptible 52-UMB cable compartment (rear): No internal PD evident

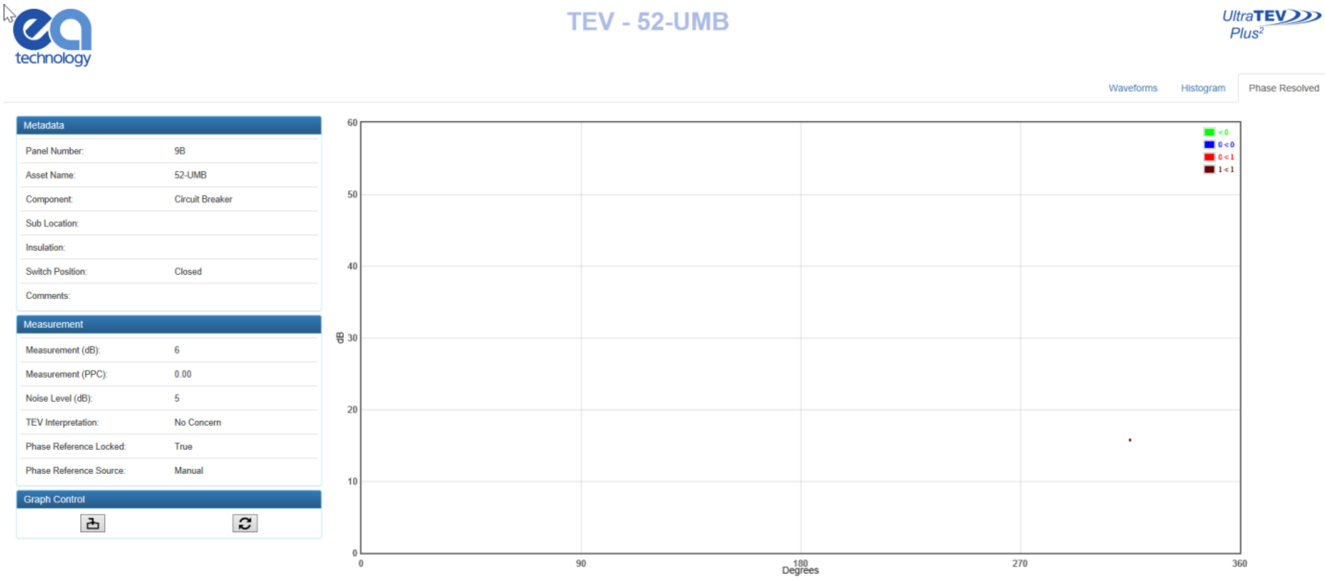

Figure 20 TEV phase resolved plot from Interruptible 52-UMB breaker compartment (front): No internal PD evident

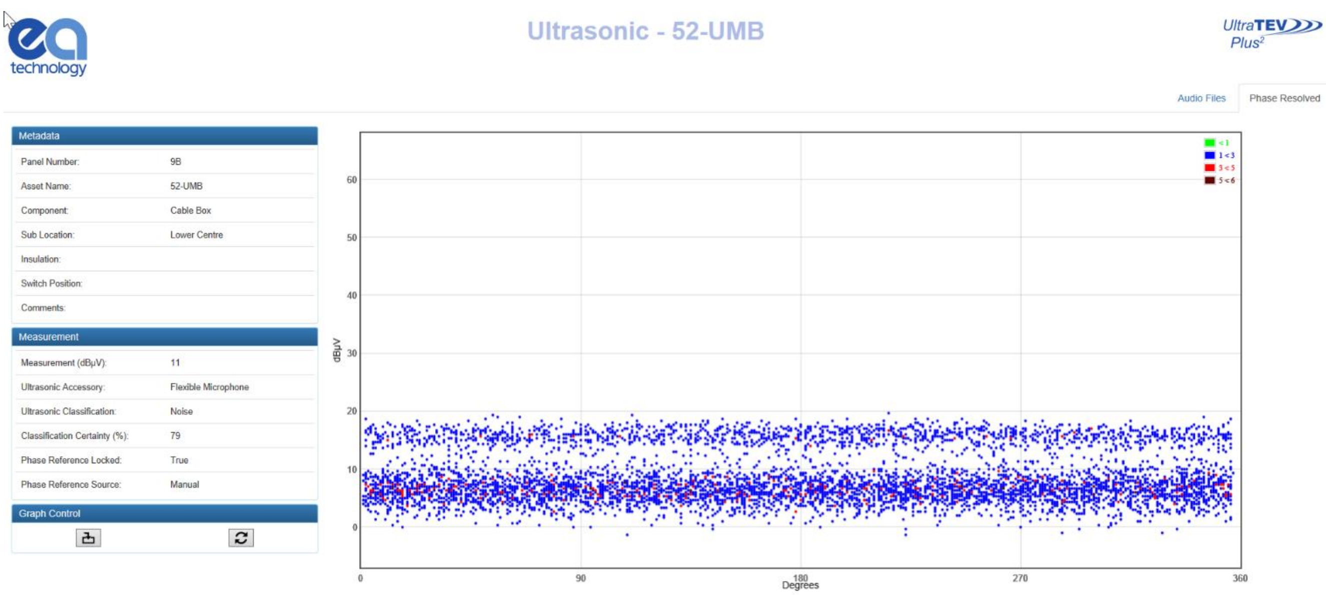

Figure 21 Ultrasonic phase resolved plot from Interruptible 52-UMB cable compartment (rear): Classification- Noise

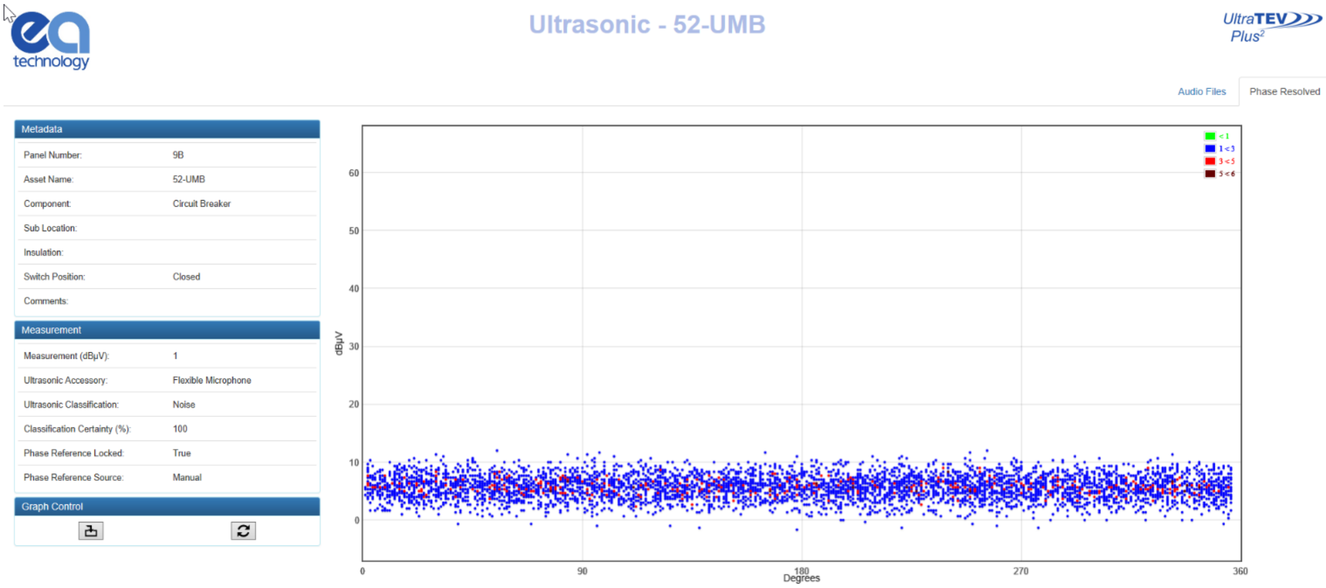

Figure 22 Ultrasonic phase resolved plot from Interruptible 52-UMB breaker compartment (front): Classification- Noise

Appendix II Investigation of surface discharge activity

Evidence of surface discharge activity evidence should be visible on the surface insulation and metallic components. In most circumstances it can be easily observed using a strong light source, however for early stage discharge activity a magnifying glass may be required.

Inspection of components normally requires an outage however some switchgear models have inspection windows around the switchgear and therefore an initial inspection can sometimes be carried out with the switchgear in service.

For general investigations the presence of white powder in the base of the switchgear or on horizontal surfaces is a good initial indication that a discharge source is present within a particular switchgear panel. A subsequent closer examination of adjacent components often then reveals the precise location. Evidence of activity is often identified by the presence of white powder, carbonisation, tracking, nitric acid looking like condensation and staining of metallic surfaces, etc.

The following section describes the procedures for investigation of specific components such as the cable box, circuit breaker spouts, VTs and bus sections. Note however that some points are applicable to investigations carried out on most components

Discharge activity detected within cable box / terminations

Since surface partial discharge activity most often occurs at surface interfaces, cable terminations are one of the most common areas for discharge activity to occur. Problems can often arise due to poor installation practice, in particular where the cable stress relief sleeving has been cut back too far and/or the phase cables have been crossed. Under these circumstances discharge activity can occur between the phases. Detection and subsequent identification of discharge activity in this region nearly always results in the cable box being re-terminated. This is because the cable sheath is permanently damaged and if allowed to remain in service will ultimately fail.

The cable box should be inspected (using a strong light source) looking for evidence of surface discharge activity, with particular attention being paid to the polymeric surfaces of the terminations. Often white powder (nitrous oxide) is observed between the cables, generally at the crutch of the cable around the stress relief sleeving. This is formed due to chemical breakdown of the insulation during the early stages of discharge activity. At more advanced stages a nitric acid (Nitrous Oxide combined with humidity) solution is formed, looking like condensation on the surfaces of internal components. This acid formation leads to significant staining and corrosion of the steel box and copper components.

Discharge activity detected within circuit breaker spouts

Partial discharge activity often occurs within the circuit breaker spouts due to surface contamination, misalignment of circuit breaker or manufacturing defects. Surface discharge activity is most common for resin rather than porcelain insulation due to its increased sensitivity to surface contamination.

Surface discharge activity in the spouts is best detected from the front of the switchgear with the panel door open to improve the air path. By careful use of the instrument, the discharging phase can often be identified.

Prior to any investigation of partial discharge activity consideration should be given to the de-energisation and racking out process. Failure of switchgear tends to occur during the switching and racking out process due to the creation of electrical transients in the system. Furthermore, since partial discharge activity has been detected within the spouts, there is an increased risk of plant failure and danger to operational personnel. For safety reasons therefore, consideration should be given to remote switching of the circuit breakers. Also, where high levels of activity have been detected it would be prudent to de-energise the switchboard remotely prior to any switching operation.

Once de-energised the circuit breaker spouts and contacts should be visually inspected using a strong light source and signs of partial discharge activity should be noted such as:

- The presence of green verdigris on the non plated area of the isolating contact.
- Black staining on the resin surface of the spout moulding.
- Mottling of the metallic surfaces.
- Formation of nitric acid, which looks like condensation on the surface of the spout.
- Evidence of carbon tracking and tree formations.

The extent of the remedial action will depend upon the results of the visual examination. Minor sources of discharge activity caused by surface contamination such as dust and moisture may be successfully removed by simply cleaning the insulation using an appropriate cloth and cleaning fluid. However, it should be noted that discharge activity often returns within the same location and in such cases can rapidly increase in severity over a relatively short period of time. More advanced deterioration i.e. surface etching and carbonisation of the cast resin surfaces may require components such as spouts, contacts and sometimes the entire removable truck to be replaced.

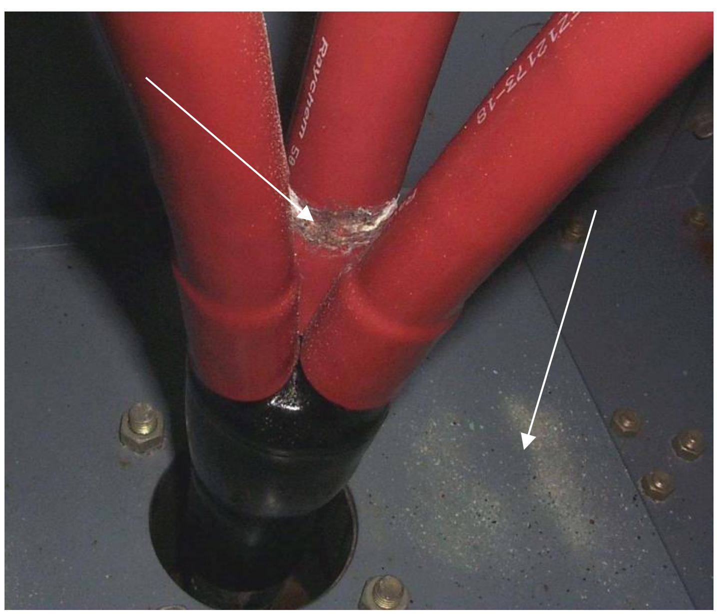

Figure 1 **Surface discharge activity between cable phases.**

Note that white power in the base of the cable box or on horizontal surfaces is a good indication that discharge activity is present within switchgear.

Figure 2 Evidence of advanced discharge activity within an 11kV switchgear air insulated cable box.

Note the extensive rusting of steel box due to the formation of nitric acid within box as a result of partial discharge activity.

**Figure 3 Discharge activity between cable phases within an air insulated cable box.
Note white powder deposit on polymeric surfaces.**

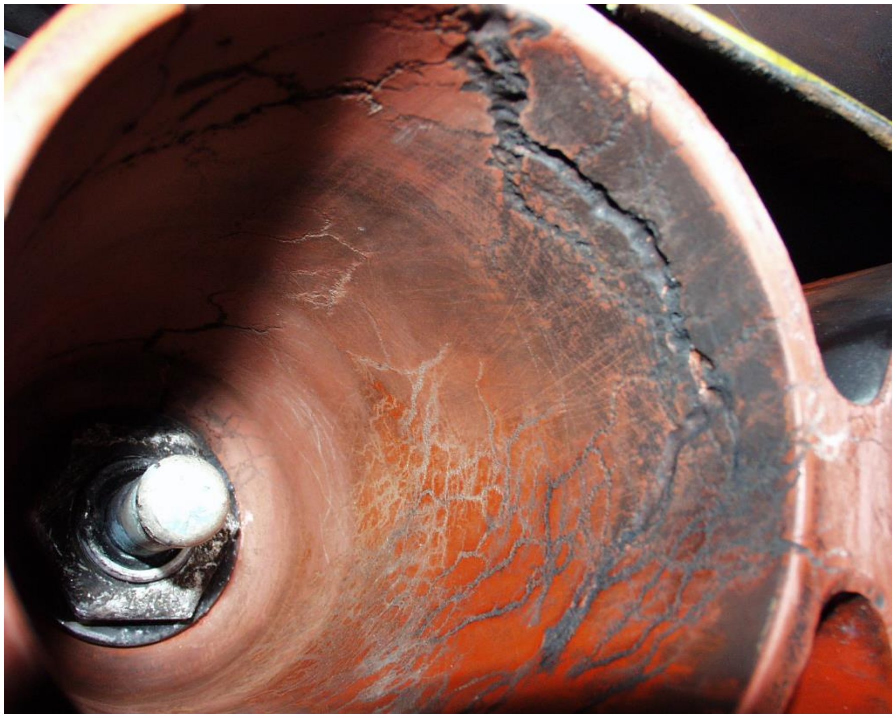

Figure 4 Advanced surface discharge activity within the resin spout of an 11kV circuit breaker.

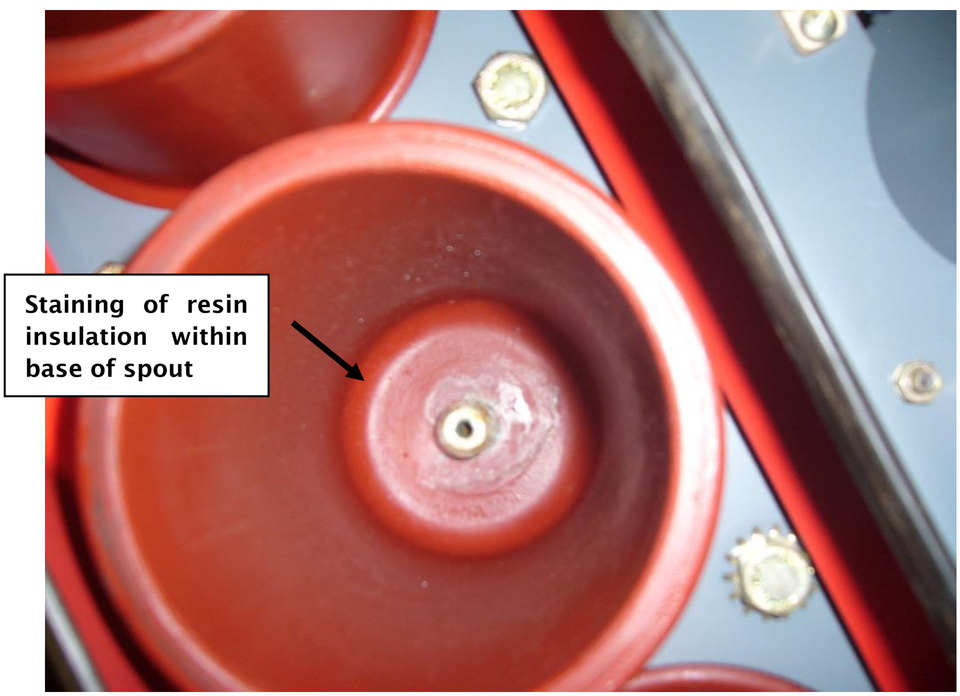

Figure 5 Staining of resin insulation within 11kV circuit breaker spout caused by the effects partial discharge activity

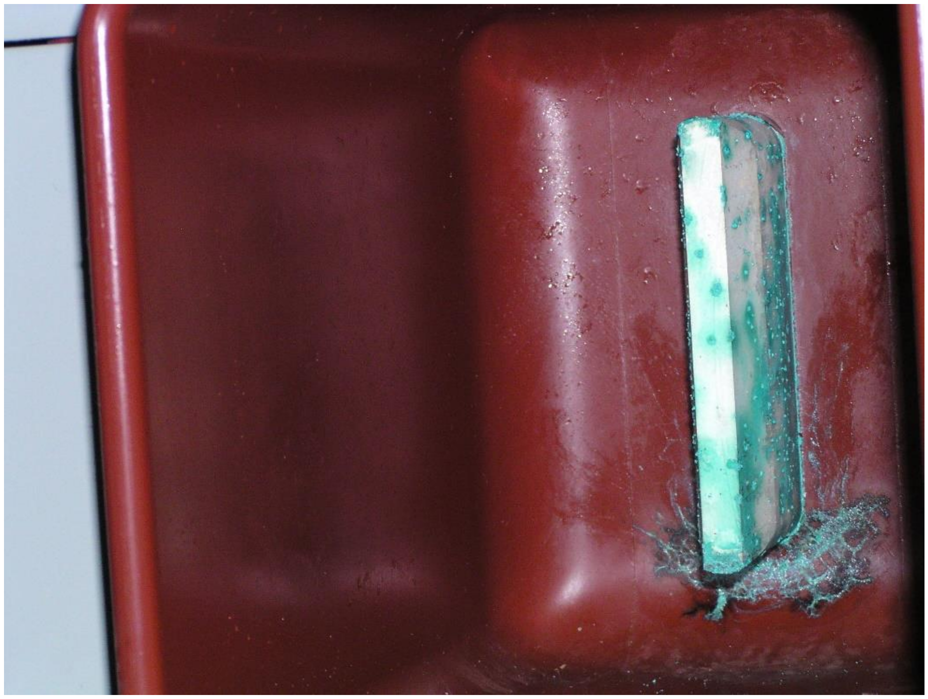

Figure 6 Evidence of surface discharge activity within fixed portion resin spout of an 11kVcircuit breaker.

Figure 7 Evidence of discharge activity within a porcelain contact cluster of an 11kV circuit breaker.
Note the green corrosion product on the surface of the contact cluster.

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