REPORT

Online Partial Discharge Testing of Cables

Private and confidential

Prepared for: Joe Bloggs
Project No: xxxxx
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Version History

Date	Version	Author(s)	Notes
October 3, 2017	1.0	Robert Walker	Initial.
October 5, 2017	2.0	William Higinbotham	Created sample report

Final Approval

Approval Type	Date	Version	EA Technology Issue Authority
	October 5, 2017	1.0	Tim Erwin

Executive summary

EA Technology was requested to carry out analysis of partial discharge measurements by Bruce Wayne for Joe Bloggs, Area 51.

The measurements were carried out on September 22, 2017.

This report details the findings and recommendations following the on-site testing.

Conclusions

C1. Tests of September 22, 2017 were performed on feeder cables listed in the Test Results Sheets, in Appendix II.

C2. PD activity is evident in Circuit 2, all three phases. Location unknown.

C3. PD activity on Circuit 2 yellow phase is significant and requires immediate attention.

C4. PD activity on red and blue phases of circuit 2 may be pickup from yellow phase.

C5. No PD activity is evident in remaining surveyed cables listed in Appendix II.

Recommendations

R1. Circuit 2, yellow phases: verify PD location by other means (visual, ultrasound, TEV, etc.). Repair as needed. Retest in 1 year.

R2. Circuit 2, Red and Blue phases should be retested after yellow phase is resolved.

R3. All surveyed cable circuits should be fully retested in 2 years' time.

Contents

Appendices

1. Background & Introduction

EA Technology was requested to carry out analysis of partial discharge measurements for Grounded Technology, for Colorado School of Mines.

The measurements were carried out on September 22, 2017.

This report details the findings and recommendations following the on-site testing.

2. Online Partial Discharge Testing

2.1 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

2.2 Test Method

Partial discharges occur in medium voltage cable insulation when defects or areas of deterioration cause a partial break down of the insulation layer. Each time these events take place, additional damage to the insulation layer takes place. Eventually, this activity will lead to disruptive failure of the cable feeder.

Partial discharge activity present on the cables was measured using special high frequency inductive sensors (RFCT) on the cable shield grounding strap (see Figure 1). This allowed the detection of small

high frequency signals produced during the partial insulation breakdown. The signals were captured and stored using the EA Technology Cable PD Data Collector (see Figure 2).

These signals were further filtered and digitally processed using an EA Technology software package to determine the magnitude and angular position of each discharge event on the system voltage waveform. Events were also grouped by the software package in terms of their signature similarities.

The magnitude, signature and phase resolved plots were then analyzed to determine the degree of partial discharge activity present on the feeder.

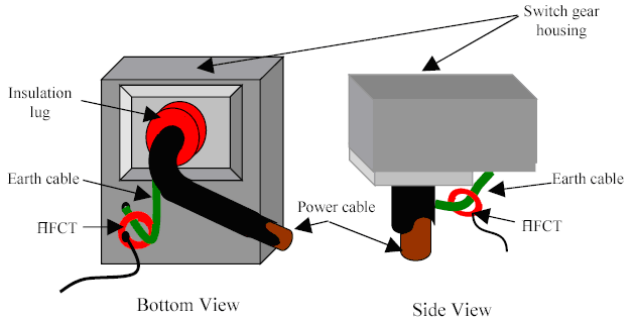


Figure 1: Cable CT Attached to Ground Strap

Figure 2: Cable Data Collector

2.3 Analysis & Recommendations

Many factors must be considered when assessing insulation quality such as age, visual appearance, environmental conditions, partial discharge magnitude, and partial discharge rate of change, partial discharge signature, and comparison of this data to similar insulation installations. Collectively, these factors will provide useful insight to the present condition of the insulation and its projected lifetime.

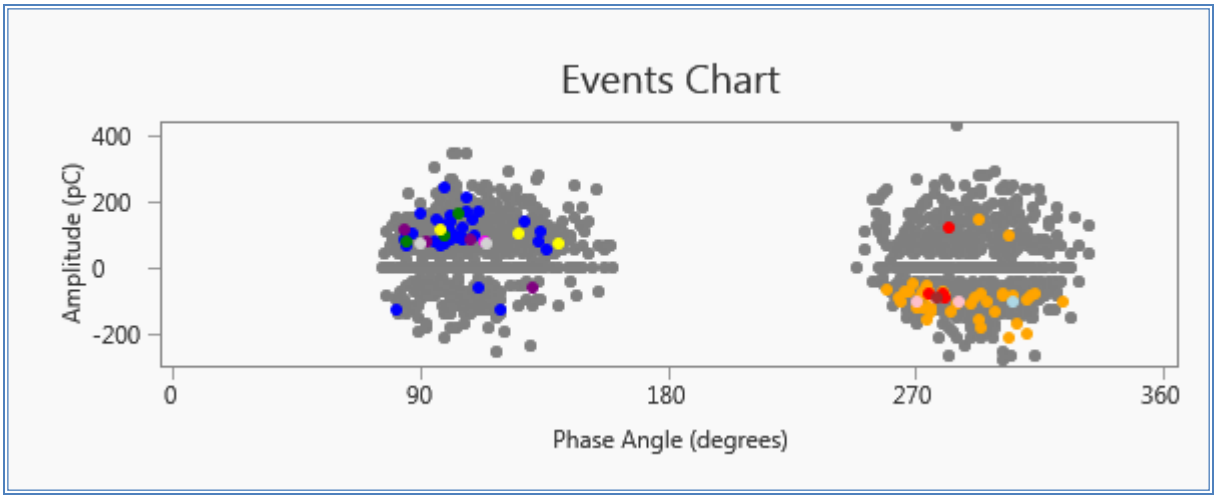
Partial discharge testing is utilized to determine insulation condition and as an early warning of impending failure. However, many sources of background noise can be present including conducted noise from process loads, radiated noise from nearby electronic equipment or radio transmissions, and actual PD reflections coupled to the test object from other components.

2.4 Example Data

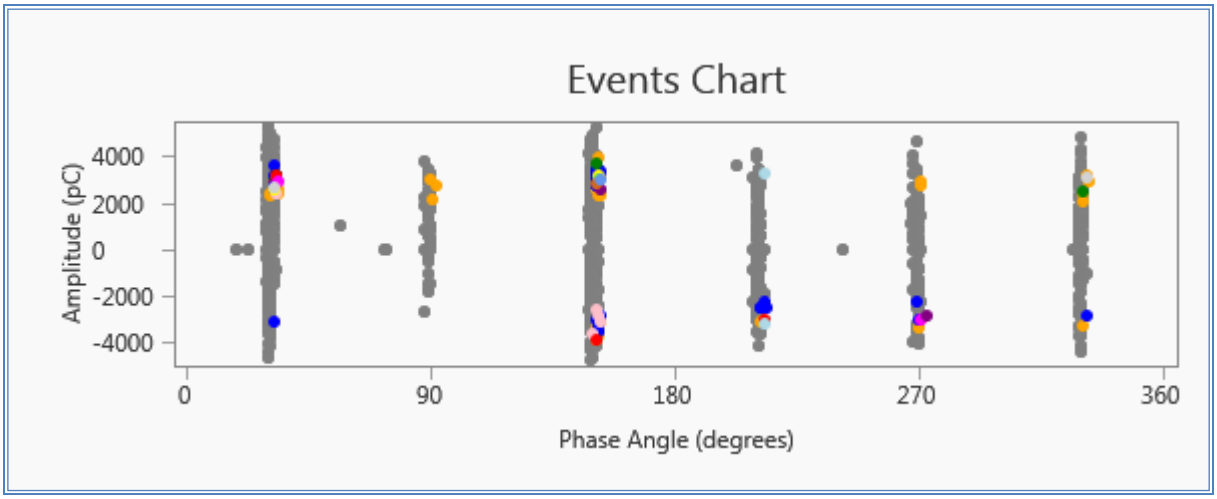
Below are some example phase resolve plots indicating the differences between background noise and partial discharge activity within the cable circuit.

Note:- The colored dots indicate groups of waveforms used for waveform analysis, do not give any indication of severity.

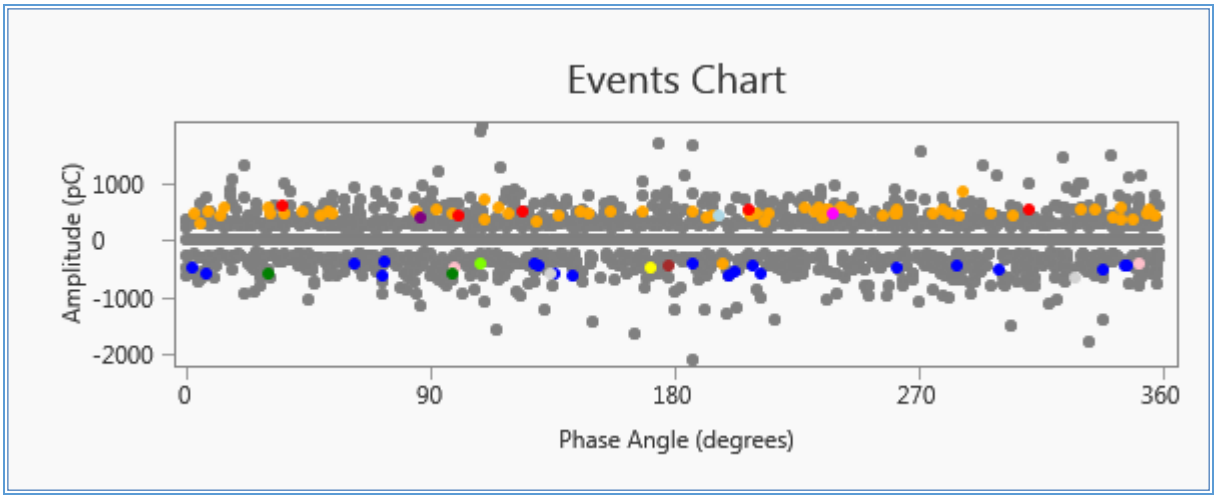
PD activity: - Identified by two cloud like clusters of activity 180º apart.



Machine Noise: - Generally caused by rotating machines characterised by tight linear stripes on the phase resolved plot.



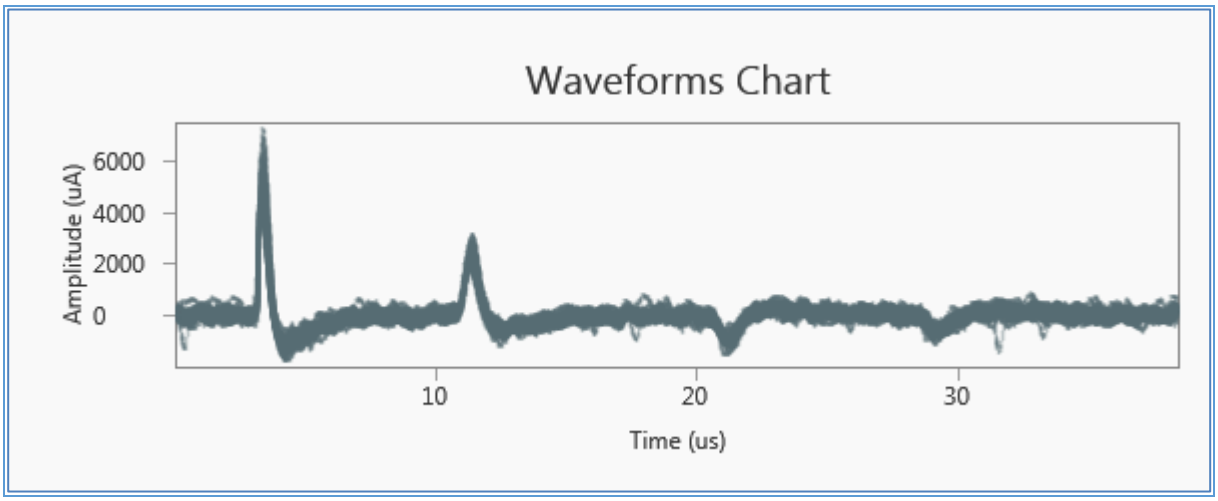
Background interference: - Easily identified as it occurs randomly on the phase event plot as it not referenced to the mains frequency. This may include activity from radio masts, DC light fittings etc…



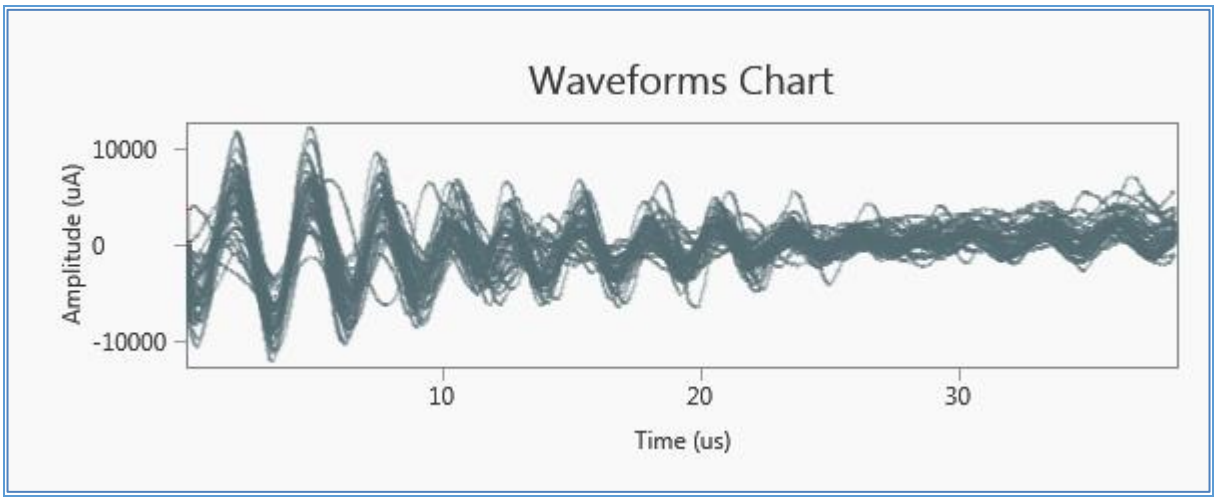
Following analysis of the events chart the waveforms associated with the coloured dots are analysed to determine if they are characteristic of partial discharge activity.

Below are two examples of waveforms.

PD Activity – Sharp short initial pulse followed by two further pulses lower in amplitude and wider.



Noise – sinusoidal no sharp pulses



2.5 Partial Discharge Limitations

Partial Discharge Testing is one of the best tools available today to prevent electrical failures. Reliability statistics indicate that up to 85% of all insulation failures can be detected with this technology.

Since electrical insulation failure mechanisms are a very complex phenomenon, there is a possibility that an electrical component may fail before the next annual partial discharge survey is conducted. Some possibilities include:

- Human error-accidents
- Lightning, transient or switching surges
- Mechanical failure
- Insulation damage due to rodents or other animals
- The defect is at an advanced stage – the defect may already be "conducting" through a carbon path, which acts electrically as a resistor and no abnormal signals will occur.
- The Partial Discharge source may be inactive at the time of test – certain defects may vary with humidity, temperature or other conditions.
- XLPE cable may contain water trees. For the most part, these water trees do not present an immediate concern. However, certain electrical events, such as lightning

or switching surges may initiate the water trees into a rapidly occurring fault. Supplemental off-line tests can be performed to evaluate cables for water treeing.

- Continuous monitoring should be considered for all critical circuits.

Appendix I Comments on selected results

NOTE: Analysis results for all of the surveyed cables/phases are shown in Appendix II of this report.

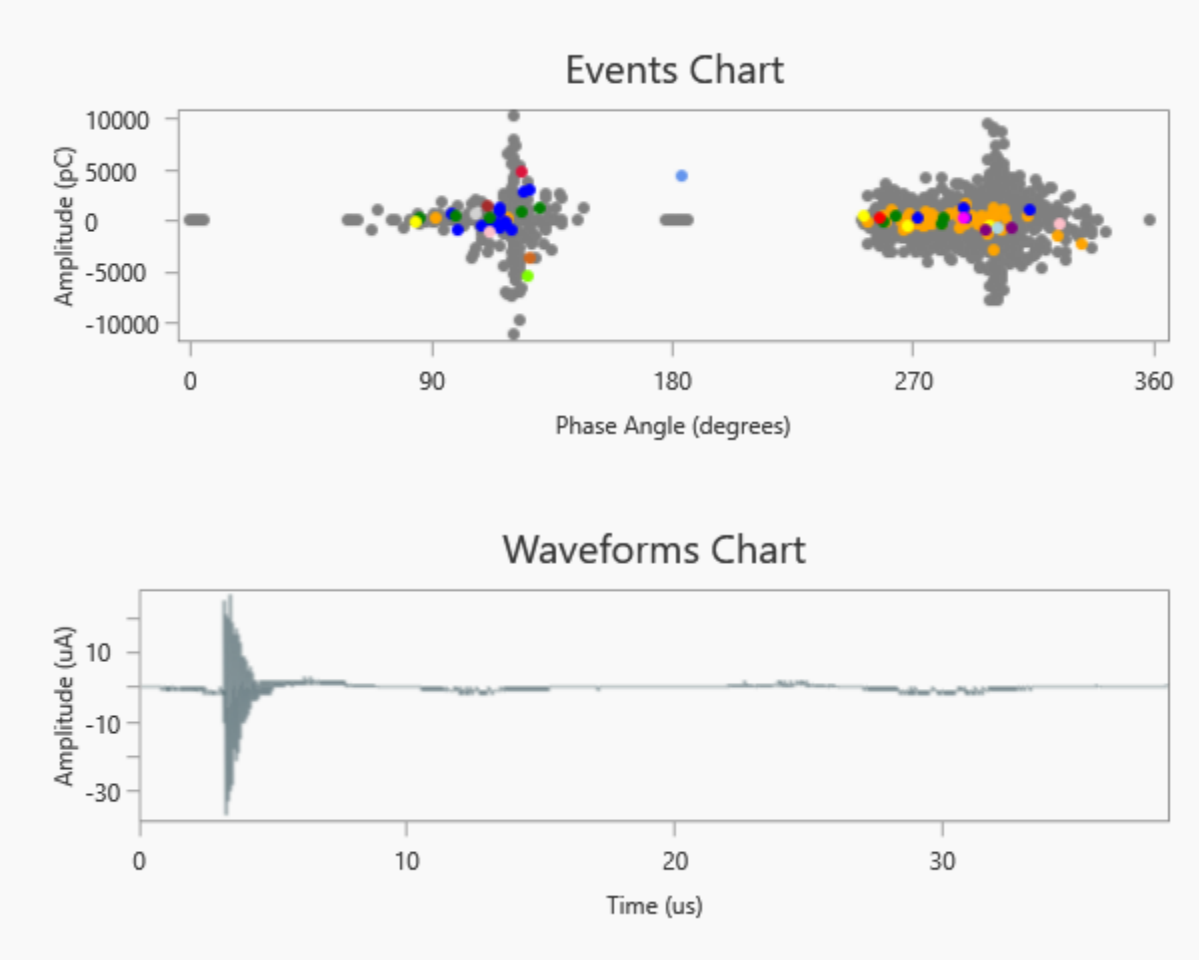
This section, Appendix I, includes additional comments on a few selected measurements, which are most representative of all measurements in the set, to provide further background information.

A. Example of Captures Indicating Partial Discharge.

Review of Cable Circuit 2 Yellow Phase

- Events analysis indicates the characteristic phase-correlated groupings of PD events.
- Waveform analysis does show characteristic reflection pattern of PD.
- Waveform analysis does not show characteristic reflection pattern of PD. Location of discharge cannot be determined

Conclusion: Partial Discharge present. [Image via unfiltered]



Appendix II Test results sheets

Circuit 1

Circuit Details

Substation ID:	Main Substation
Tested End:	Circuit 1
Remote End:	Sub No.1
Rated Voltage:	15kV
Cable Length:	1075 Feet
Cable Type:	EPR
Switch Position:	Closed

Comments on Results

Phase Red - Motor Drive Noise - No PD Detected

Phase Yellow - Motor Drive Noise - No PD Detected

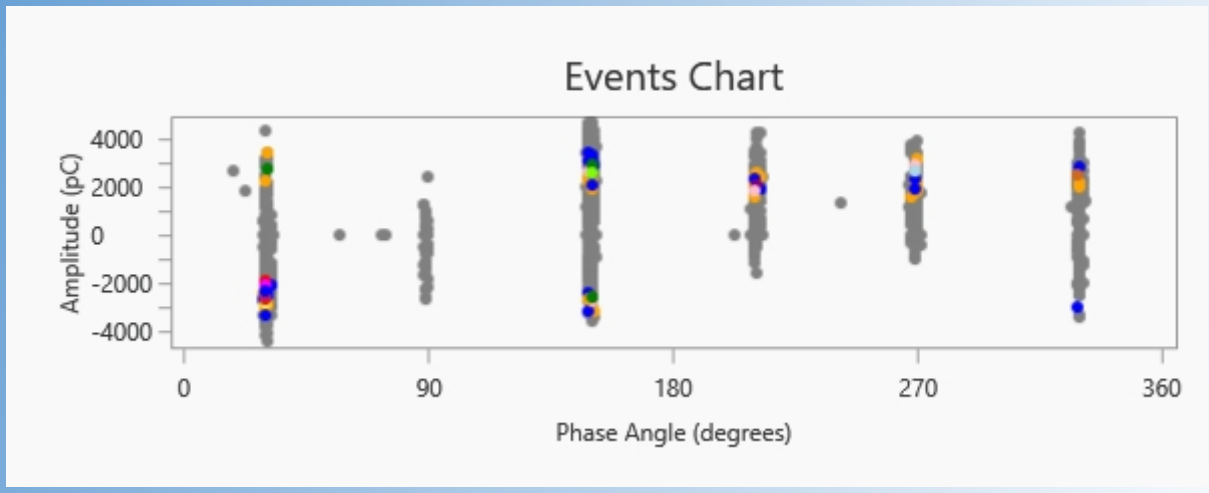
Phase Blue - Motor Drive Noise - No PD Detected

Maximum Signal Level per Phase

- Max pC (Red) - 4746
- Max pC (Yellow) - 7168
- Max pC (Blue) - 5334

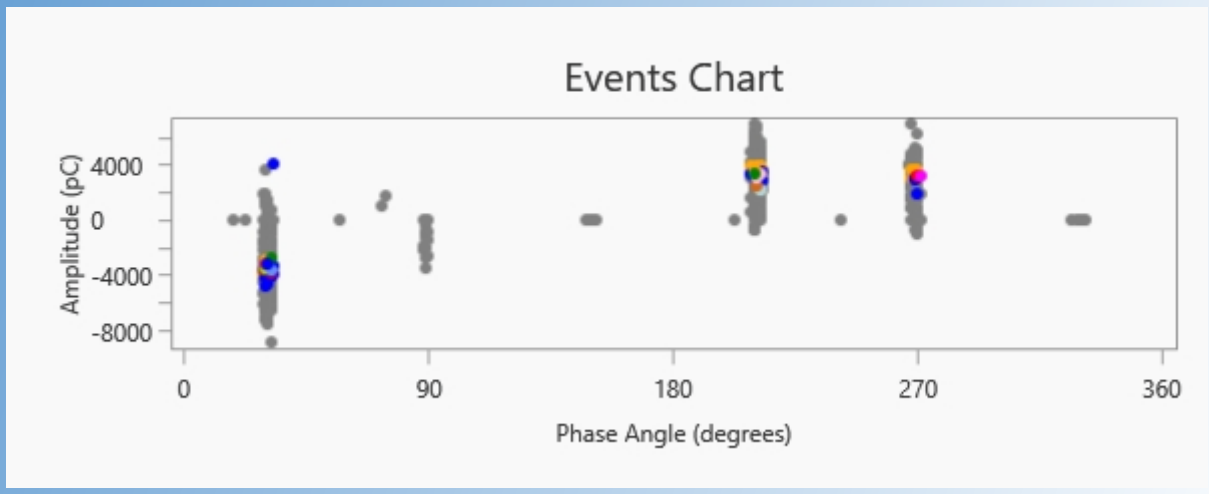
Circuit 1

Phase Red



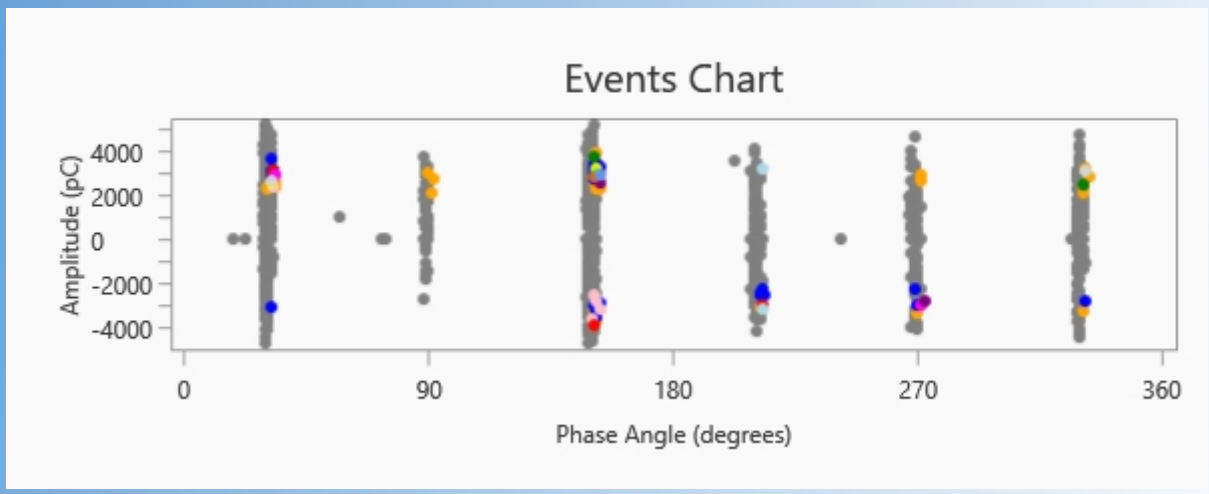
No Action

Phase Yellow



No Action

Phase Blue



No Action

Circuit 2

Circuit Details

Substation ID:	Main Substation
Tested End:	Circuit 2
Remote End:	Sub No.2
Rated Voltage:	15kV
Cable Length:	1000 Feet
Cable Type:	EPR
Switch Position:	Closed

Comments on Results

Phase Red - Cable PD Detected - re-evaluate in 3 months to establish trend.

Phase Yellow - Cable PD Detected - Take immediate action

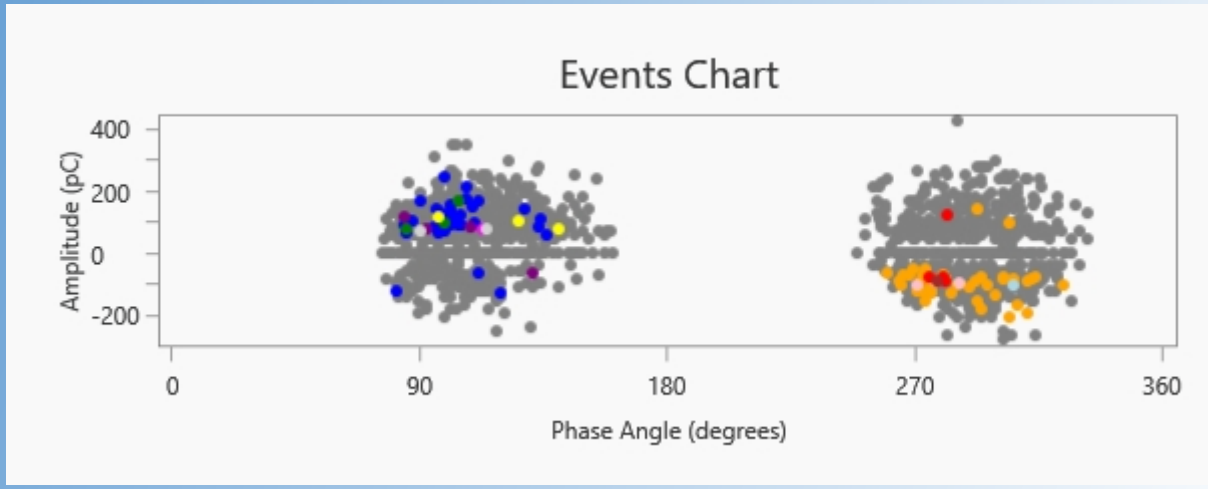
Phase Blue - Cable PD Detected - re-evaluate in 3 months to establish trend.

Maximum Signal Level per Phase

- Max pC (Red) - 434
- Max pC (Yellow) - 10514
- Max pC (Blue) - 9366

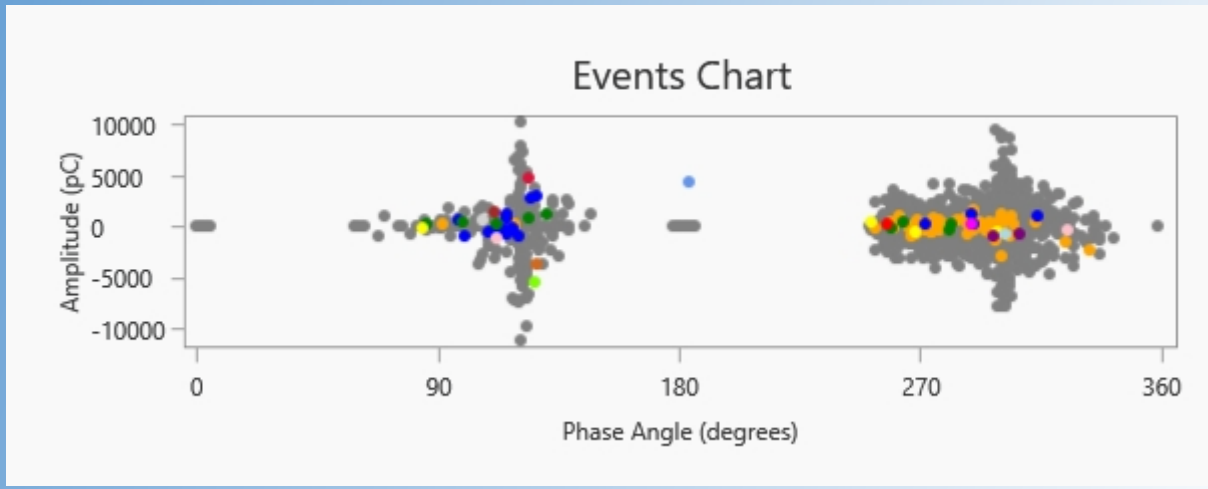
Circuit 2

Phase Red



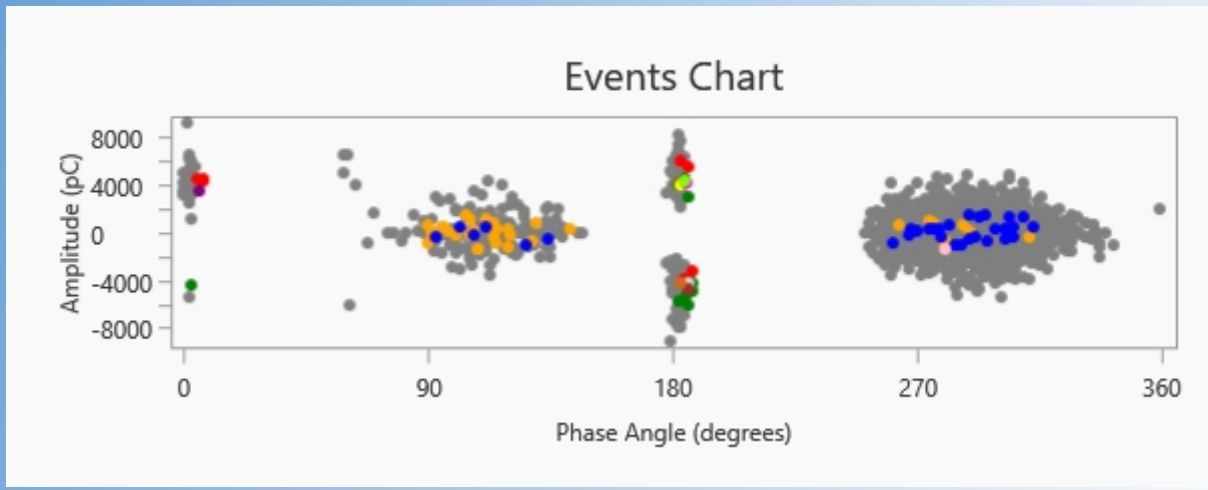
Action Advised

Phase Yellow



Action Required

Phase Blue



Action Advised

Circuit 3

Circuit Details

Substation ID:	Main Substation
Tested End:	Circuit 3
Remote End:	Sub No.3
Rated Voltage:	11.0kV
Cable Length:	150 Feet
Cable Type:	EPR
Switch Position:	Closed

Comments on Results

Phase A - Random Noise - No PD Detected, Retest in 2 years

Phase B - Random Noise - No PD Detected, Retest in 2 years

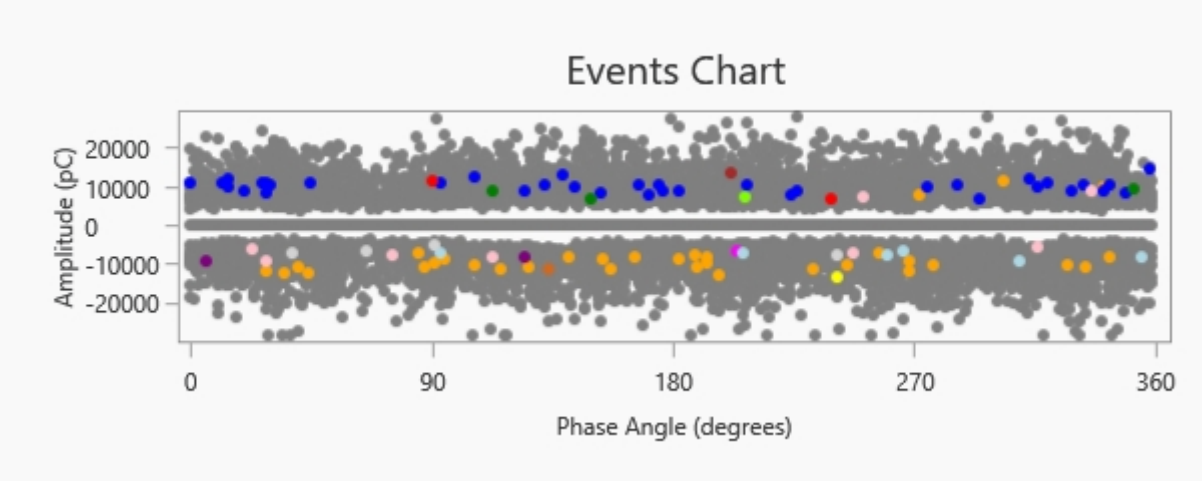
Phase C - Random Noise - No PD Detected, Retest in 2 years

Maximum Signal Level per Phase

- Max pC (A) - 28532
- Max pC (B) - 27510
- Max pC (C) - 28322

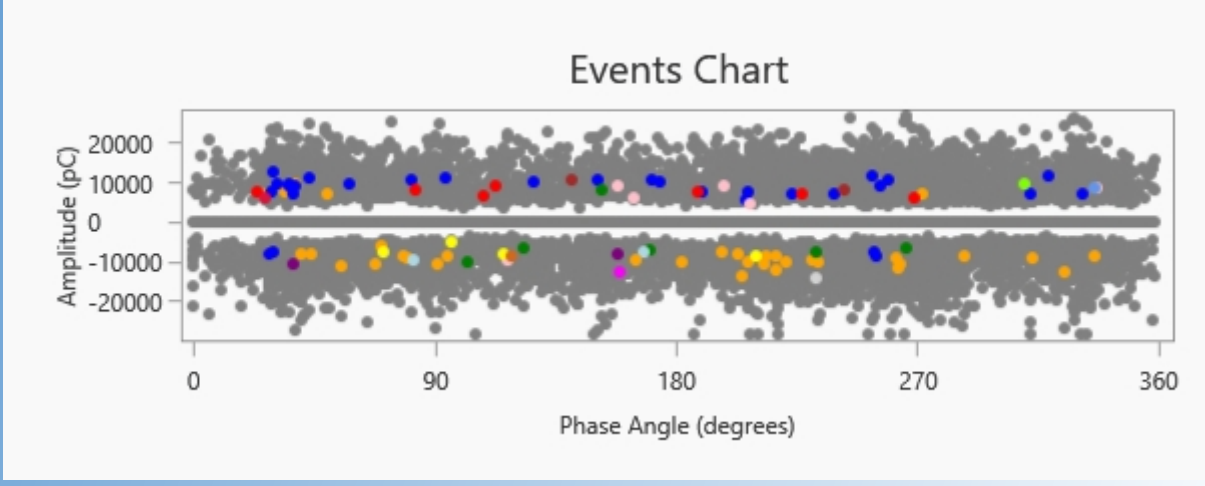
Circuit 3

Phase A



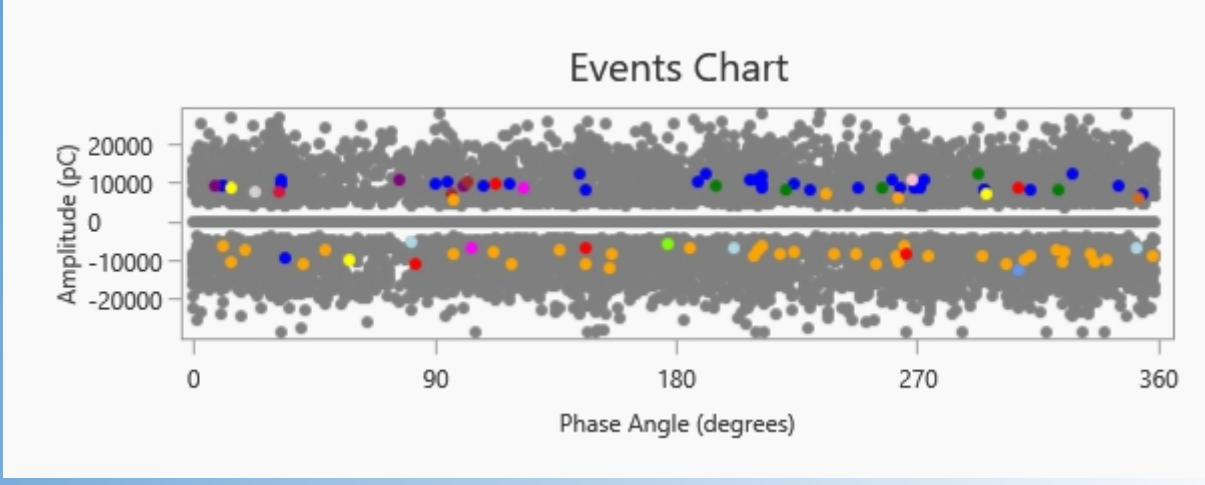
No Action

Phase B



No Action

Phase C



No Action

Global Footprint

We provide products, services and support for customers in 90 countries, through our offices in Australia, China, Europe, Singapore, UAE and USA, together with more than 40 distribution partners.

Our Expertise

We provide world-leading asset management solutions for power plant and networks.

Our customers include electricity generation, transmission and distribution companies, together with major power plant operators in the private and public sectors.

- Our products, services, management systems and knowledge enable customers to:
- Prevent outages
- Assess the condition of assets
- Understand why assets fail
- Optimise network operations
- Make smarter investment decisions
- Build smarter grids
- Achieve the latest standards
- Develop their power skills