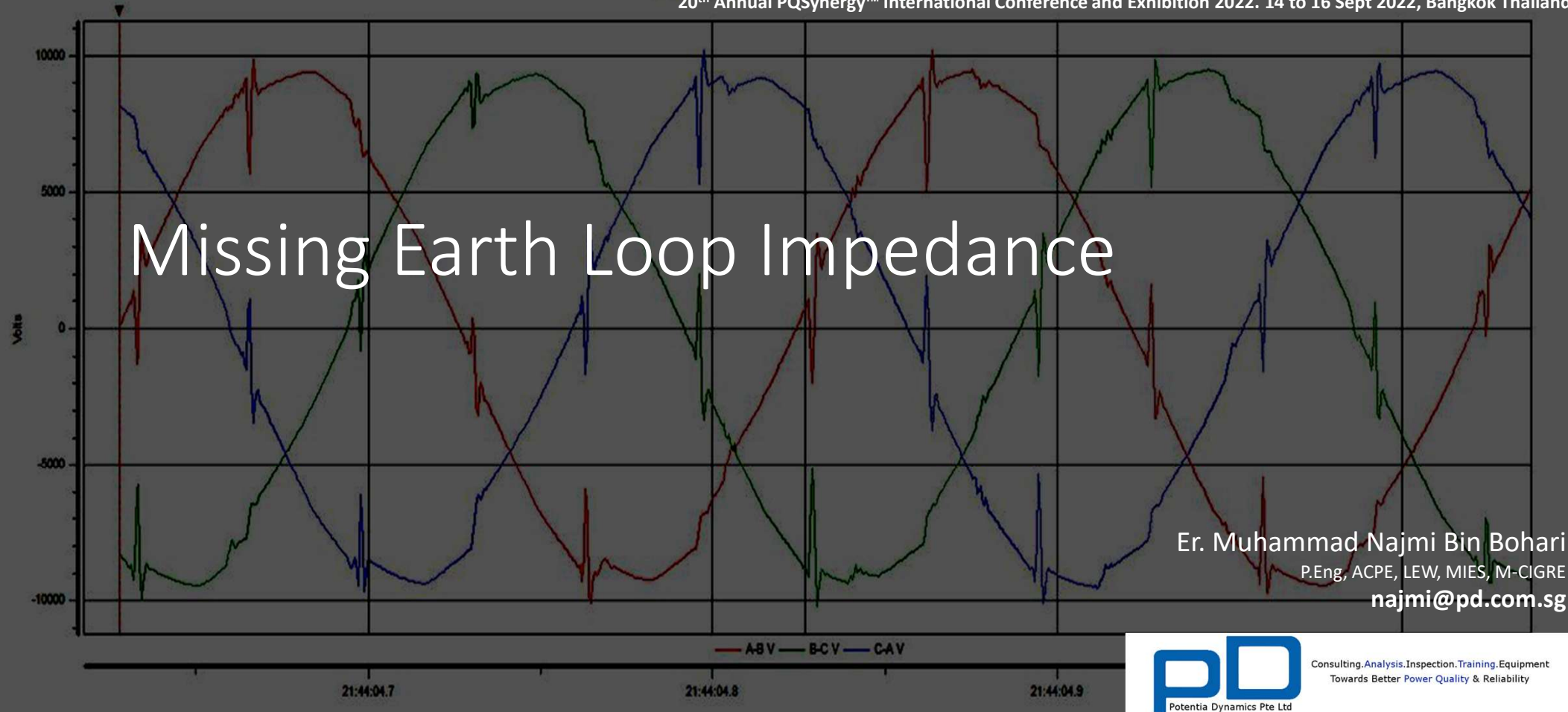


## Event Details/Waveforms

20<sup>th</sup> Annual PQSynergy™ International Conference and Exhibition 2022. 14 to 16 Sept 2022, Bangkok Thailand

# Missing Earth Loop Impedance



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# Outline

- Planning Steps
  - Verify initial information given
  - To know the Electrical Setup
  - Site Walkthrough, gathering of more facts and information to have a more 'complete' picture
- Preparatory Steps
  - Defining / selecting test equipment to use
  - Know each equipment's purpose and limitations
  - Form up a Test Plan
- Inspect / Monitor (as per test plan)
  - Visual and physical inspection
  - On-site test measurements
- Analysis / Findings



# The Problem

- A shopping mall in the Eastern of Singapore was re-opened after a multi-million dollars 'make-over'.
- Unusual cases of failing to obtain an earth loop reading and failing to test trip the residual current circuit breaker (RCCB) for new incoming tenants to this shopping mall.



30mA Residual Current Circuit Breaker (RCCB)  
or Residual Current Device (RCD)

# Failed Electrical Installation Inspection

**ELECTRICAL INSTALLATION INSPECTION REPORT FOR**

Application no.:  Inspection date/time:

Account no.:  Supply Source:

Approved Load:  Supply Voltage:

LEI:  Cable Size:

Type of Application:  Incoming Breaker Size:

Metering Scheme:  Turn On Reading:

Meter No.:  LEW License:

LEW Name:

**INSPECTION RESULT: FAIL**

**Installation Items Details**

Item	Qty
13A SSO	<input type="text"/>
Lamp Point	<input type="text"/>

**Insulation Resistance (MΩ)**

Phase to Neutral:  Phase to Earth:  Neutral to Earth:

**RCCB Test Satisfactory:**

**Earth Fault Loop Impedance (Ω):**

**Polarity Check Satisfactory:**

**Remarks**

If inspection result Fail or Not Tested, add after remarks: The installation does not comply with requirements due to the following items. A re-inspection is required.

# Possible scenarios? Missing earth cable(s)? Theft?

Planning

today Singapore World Minute Big Read Gen Y Speaks Adulting 101 Commentary Voices Watch Brand Spotlight

## Man stole copper wires from mall to finance wife's chemotherapy



iStock file photo

BY KELLY NG

Published March 7, 2017  
Updated March 7, 2017



Source: Today Online

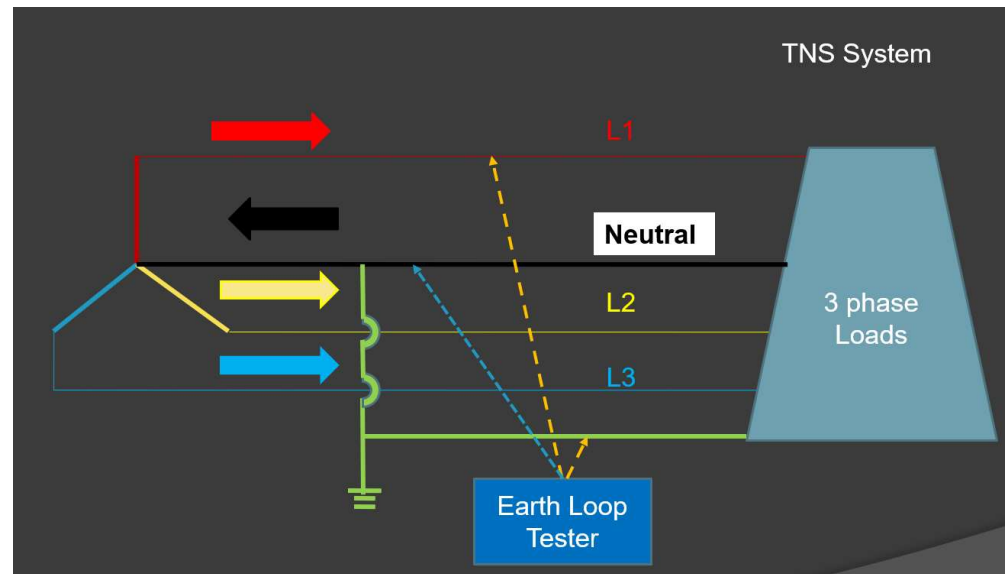
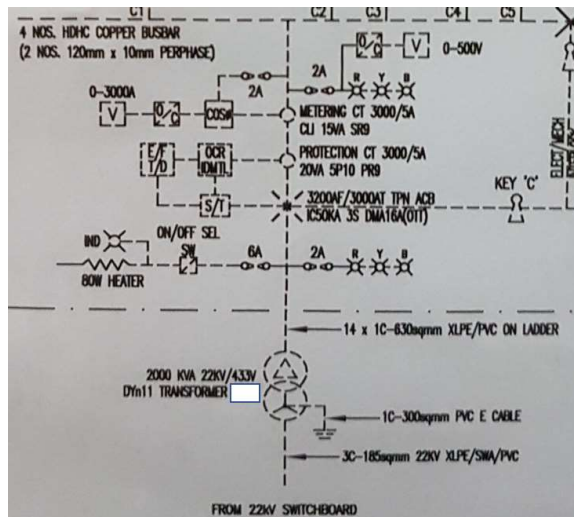
Follow us on [Instagram](#) and [TikTok](#), and join our [Telegram](#) channel for the latest updates.

SINGAPORE — At his wits' end because his wife's chemotherapy bills were taking a toll on his finances, a technician stole [earth](#) cables fixed to the ceiling of Golden Landmark

POPULAR

# Electrical Setup at the Shopping Mall

- MSB-X: 400V Main Switchboard served by a 2MVA 22kV/LV transformer
- TN-S Earthing System





# Additional Information

- 'Make-over' includes a new more efficient chiller system.
- Chiller switchboard is connected to MSB-X.
- Previously, MSB-X is dedicated to chiller and its associated equipment only.
- All affected tenants are connected to this MSB-X.



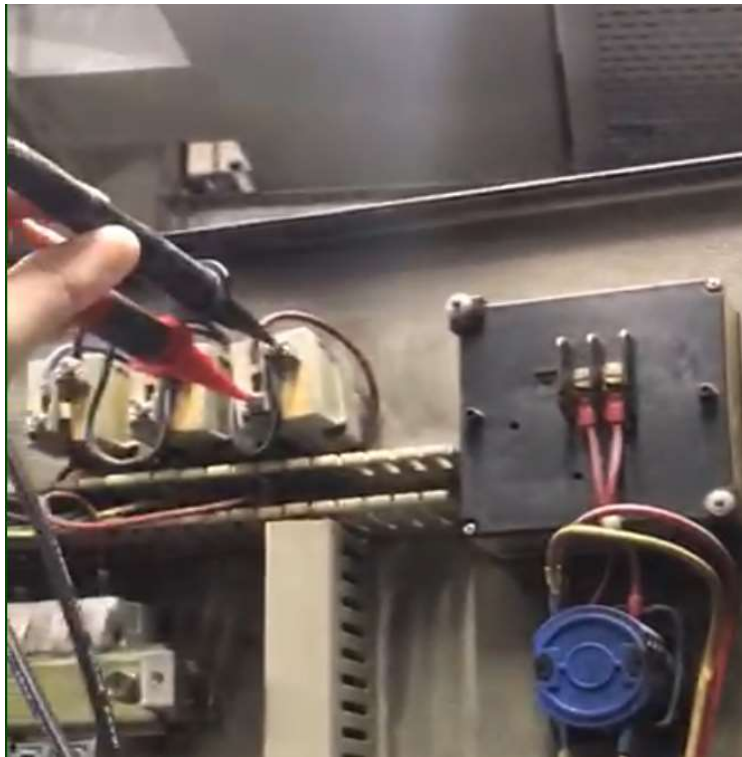
# Initial Works from the Building's Engineers

- Unable to achieve an earth loop impedance value when measured between 'Phase L1' and Earth (for most cases, some cases on other phases), at both tenants' side and landlord's side.
- "OL" or some error codes.
- Puzzling as value could be achieved when measured at other two phases (for most cases)
  - Between 'Phase L2' and Earth
  - Between 'Phase L3' and Earth
- Similar results for trip tests on the RCCB at Landlord's owned distribution boards.



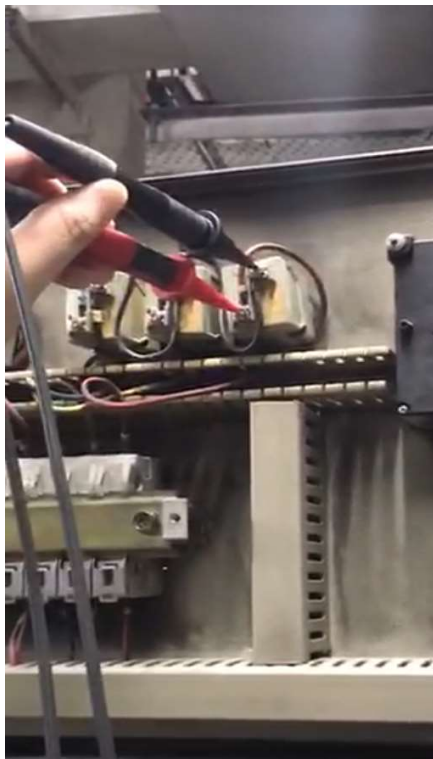
# Unable to Get Earth Loop Reading (Landlord Main Switchboard)

Planning



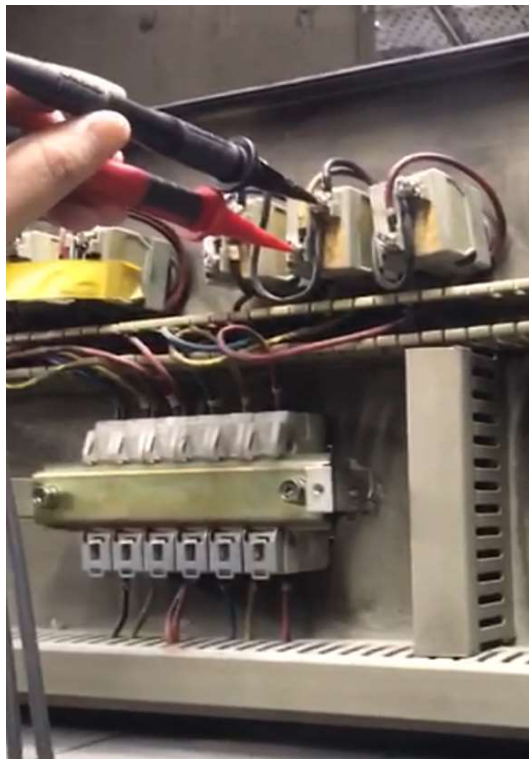
# Unable to Get Earth Loop Reading (Landlord Main Switchboard)

Planning



# Able to Get Earth Loop Reading (Landlord Main Switchboard)

Planning



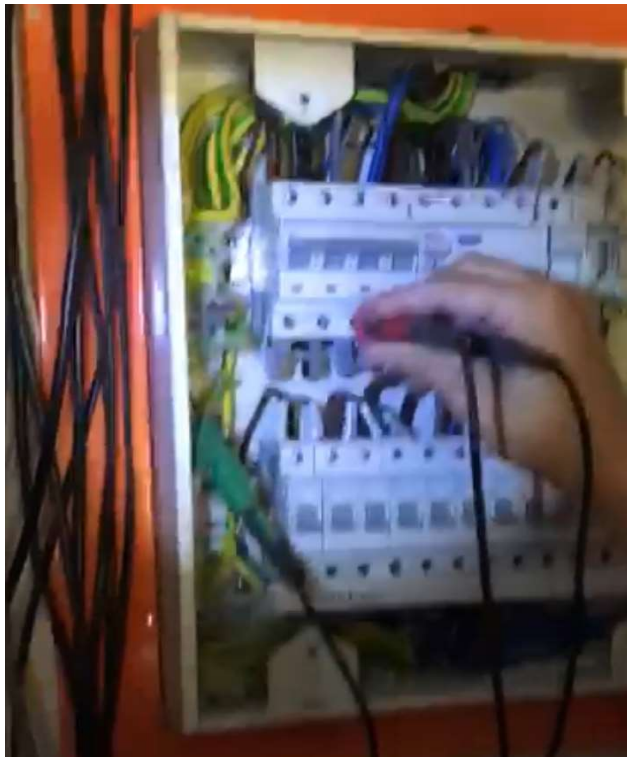
L2-E = 0.18 ohm

L3-E = 0.16 ohm



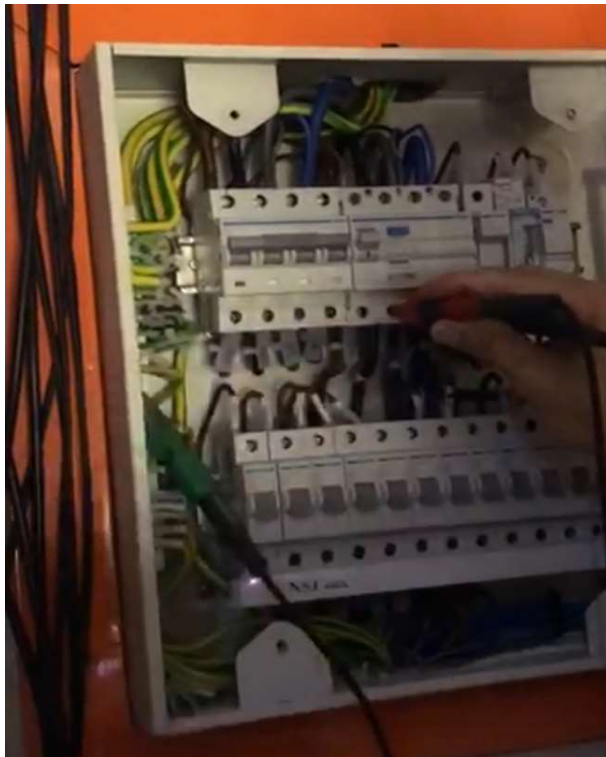
Planning

# Unable to Get Earth Loop Reading (Tenant)

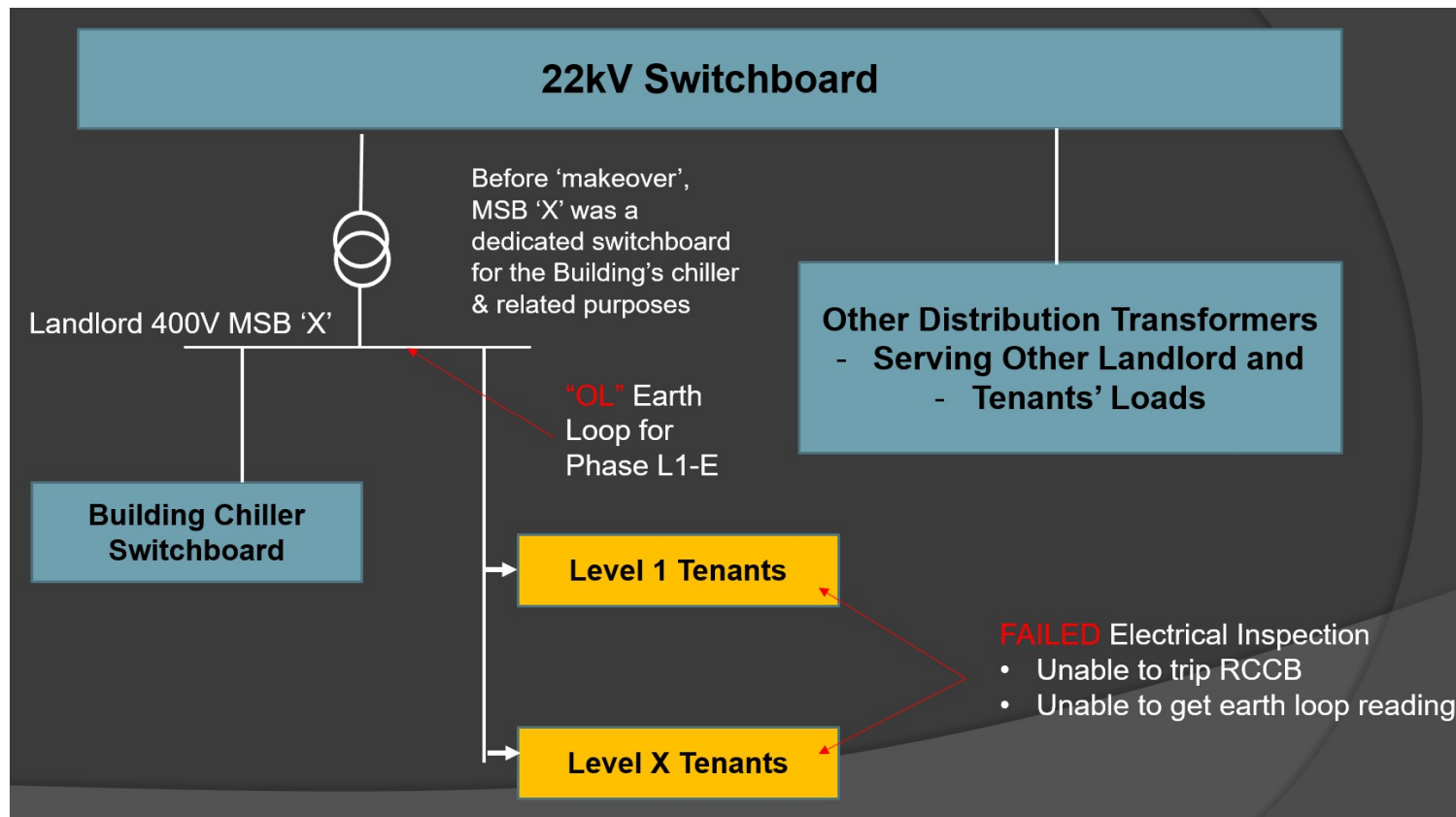


Planning

# Unable to trip the RCCB (Tenant)

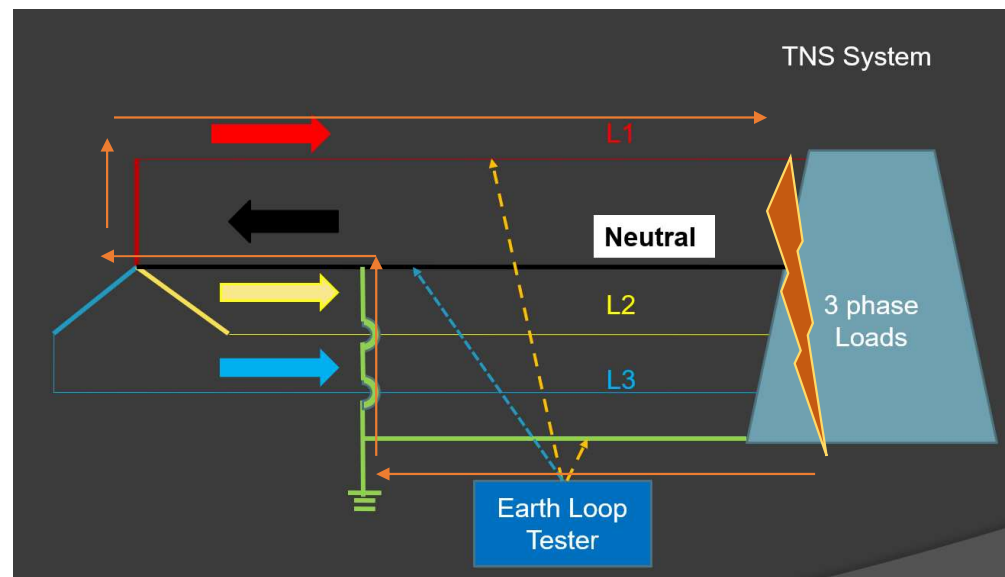


# Forming The Complete Picture



# Earth Loop Impedance Test

- To ensure when an earth fault occurs in an electrical installation, sufficient current will flow to operate the associated protective device within a predetermined time.





# Earth Loop Impedance Tester

- Operates by **inducing** a current from the **Supply system**, by
  - introducing a calibrated load
  - between the phase conductor and the protective earth
- And then monitors the voltage difference [  $Z = V / I$  ]

# Earth Loop Impedance Tester



- Multifunction Tester
- Dedicated Loop Tester
- 3-wire types  
L + N + E
- 2-wire types  
L + E
- High/Low Current Type

# Checking Quality of Supply

- Short-term monitoring via a Power Quality Analyzer.
- IEC 61000-4-30 Class A Dranetz HDPQ Guide.



# The Test Plan

- To conduct earth loop impedance tests using the two different brand/model of earth loop tester.
- To conduct RCCB trip tests via a test bulb.
  - Standard 30mA RCCB Tests:
    - 50% (15mA) of rating (No Trip)
    - 100% (30mA) of rating (Trip within 100ms)
    - 500% (150mA) of rating (Trip within 40ms)
    - **RCCB can trip for any value >50% of its rating**
- To conduct a short survey of the quality of supply via a PQ Analyzer.

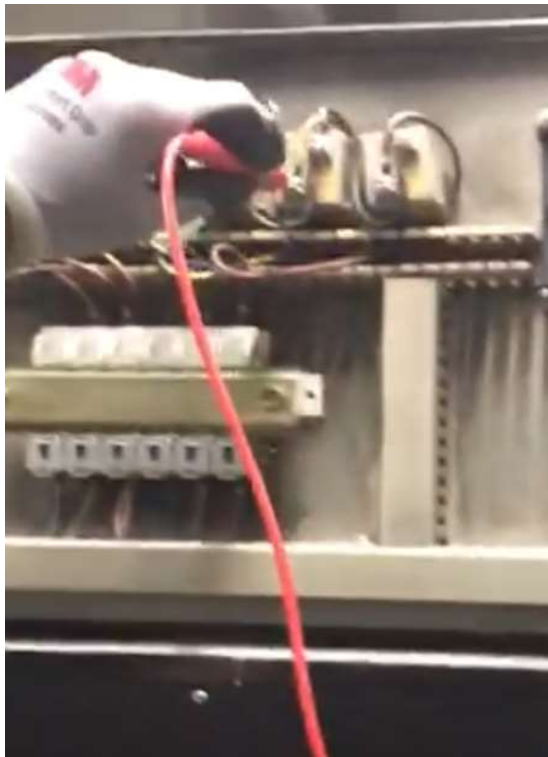
Inspect / Monitor

# Site Test & Measurements



Inspect / Monitor

# Site Test & Measurements





Inspect / Monitor

# Site Test & Measurements





Inspect / Monitor

# Monitoring Quality of Supply at MSB-X



- **For Short Monitoring**
- Harmonics: 3s
- Voltage/Current/Power: 1 min
- Snapshot: On

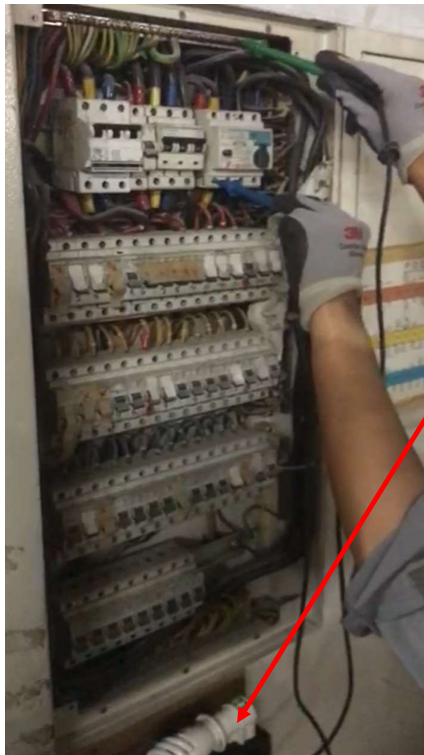
Characterizer Mode

☒ Full (all saved data)

☐ Triggered (events only)

☐ Raw (disabled)

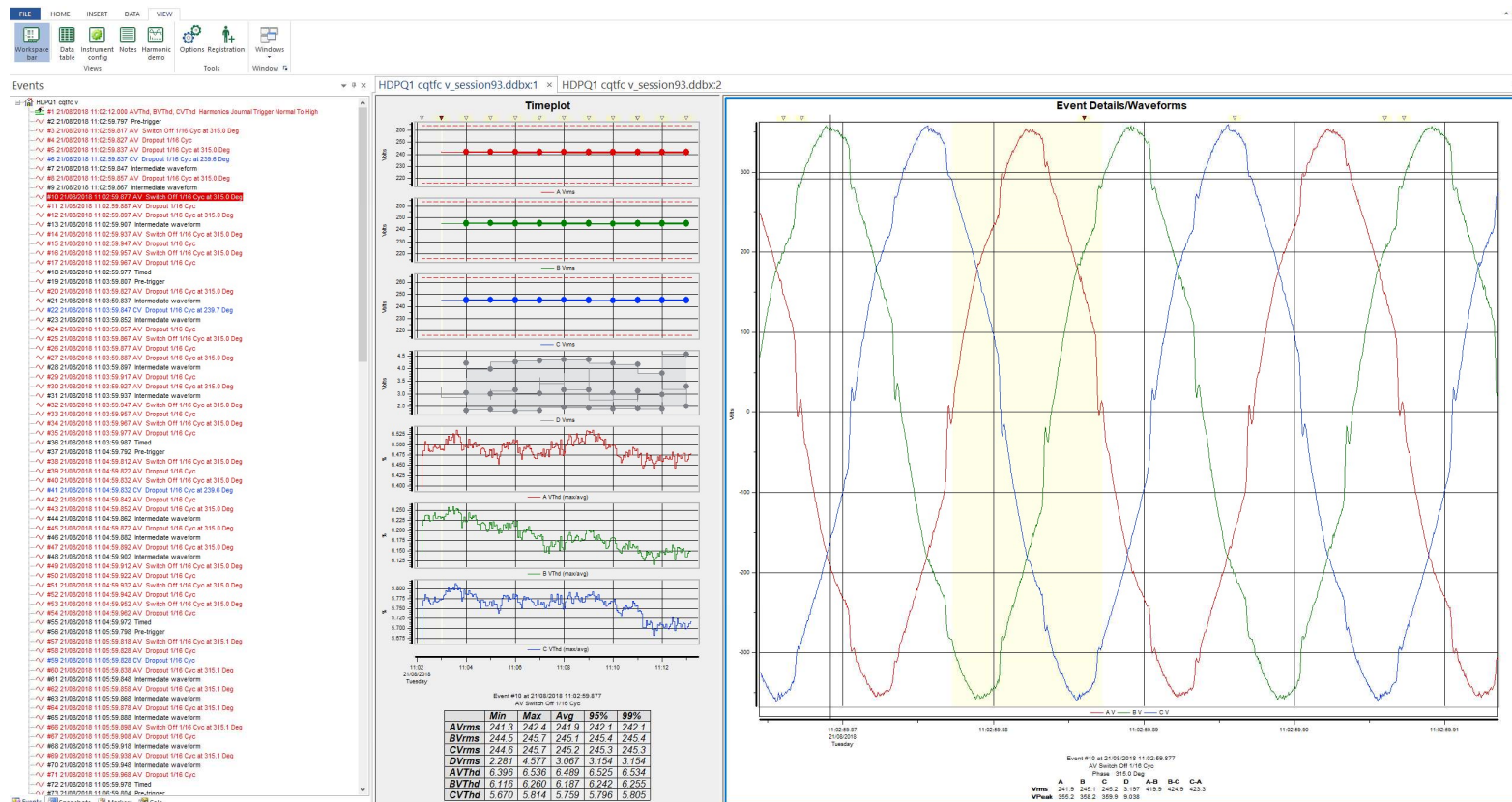
# Summary of Test Results



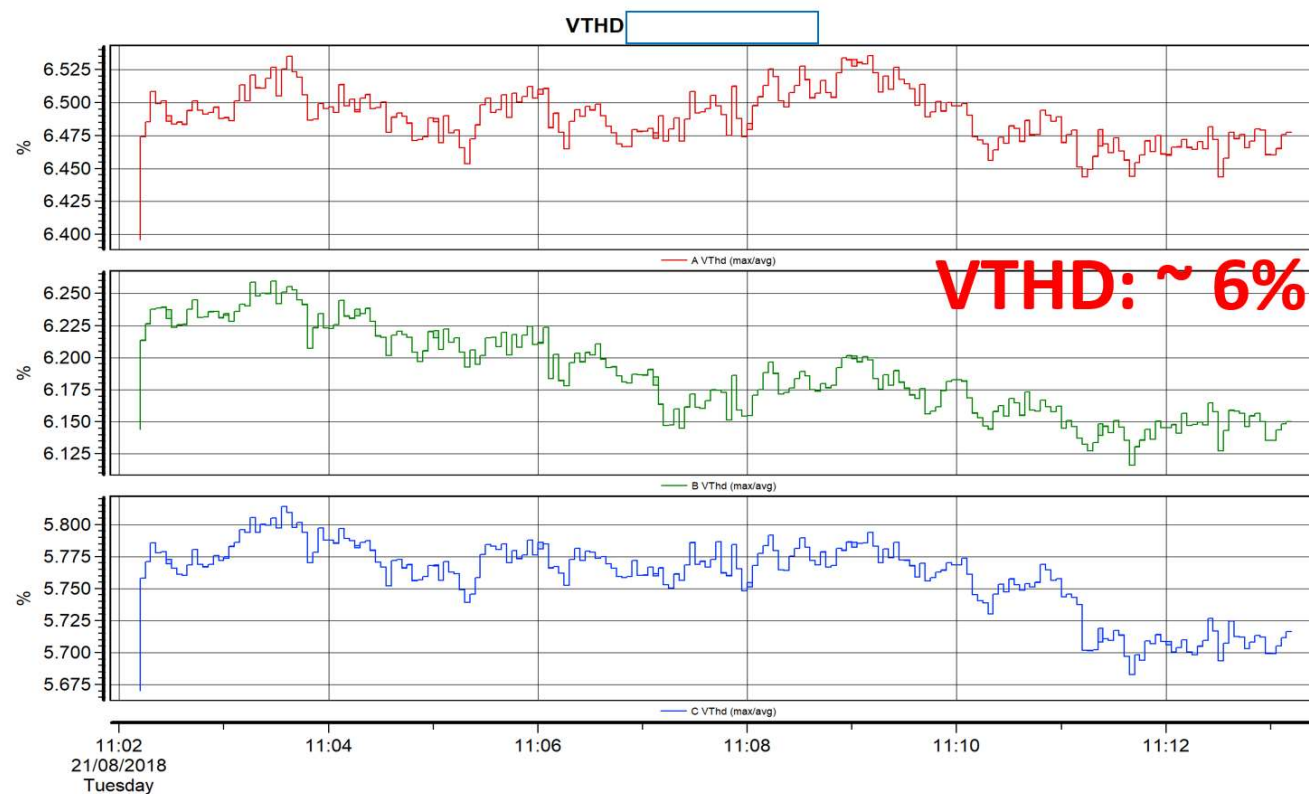
S/N	Circuit	Test Equipment	Value (ohm)	Remarks
1	DB-X (taking from MSB-X)	Test Bulb rated at 110mA	-	100mA RCCB/RCD tripped on all phases
2	MSB-X	Megger LTW425	L1: 0.20 L2: 0.13 L3: 0.18	Values were similar and consistent when repeated at MSB-X and DB-X
3	DB-X	Fluke 1652c		First earth loop test failed to get a value for L1-E. Subsequent tests showed similar values obtained as per using LTW425

Analysis

# Monitoring Quality of Supply at MSB-X



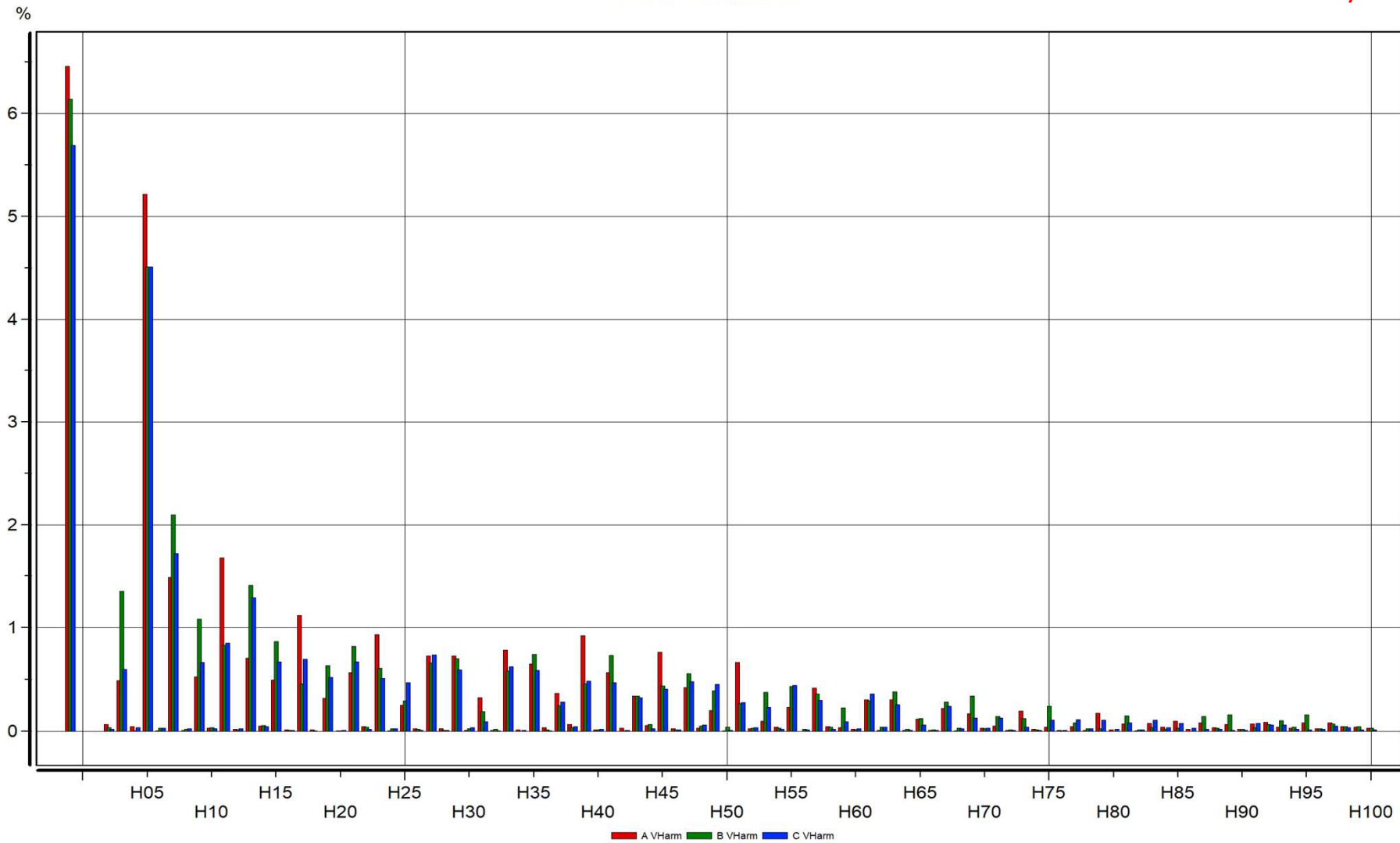
# VTHD Trend at MSB-X



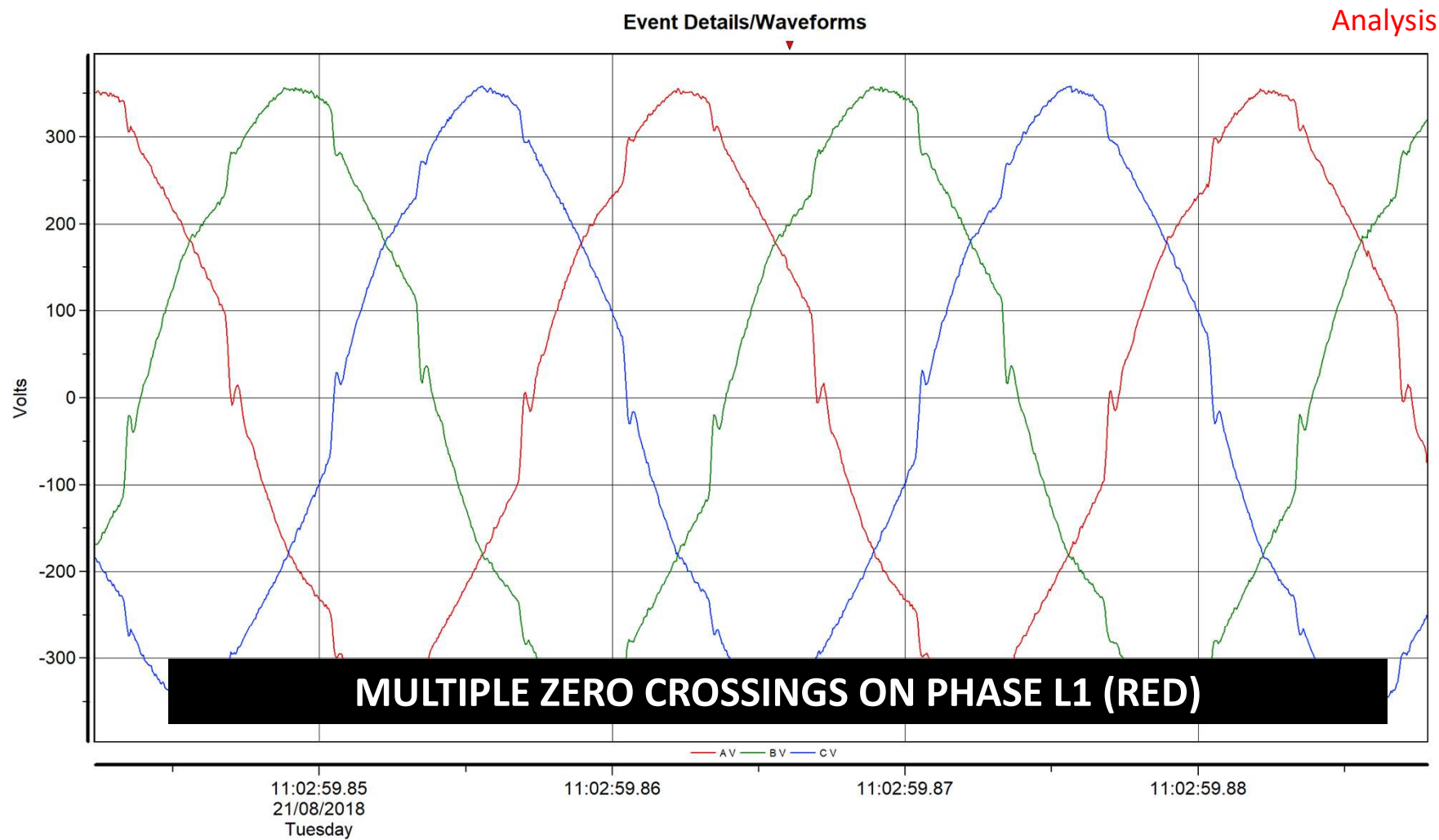
	Min	Max	Avg	95%	99%
<b>AVThd</b>	6.396	6.536	6.489	6.525	6.534
<b>BVThd</b>	6.116	6.260	6.187	6.242	6.255
<b>CVThd</b>	5.670	5.814	5.759	5.796	5.805

## Waveform harmonics

Analysis



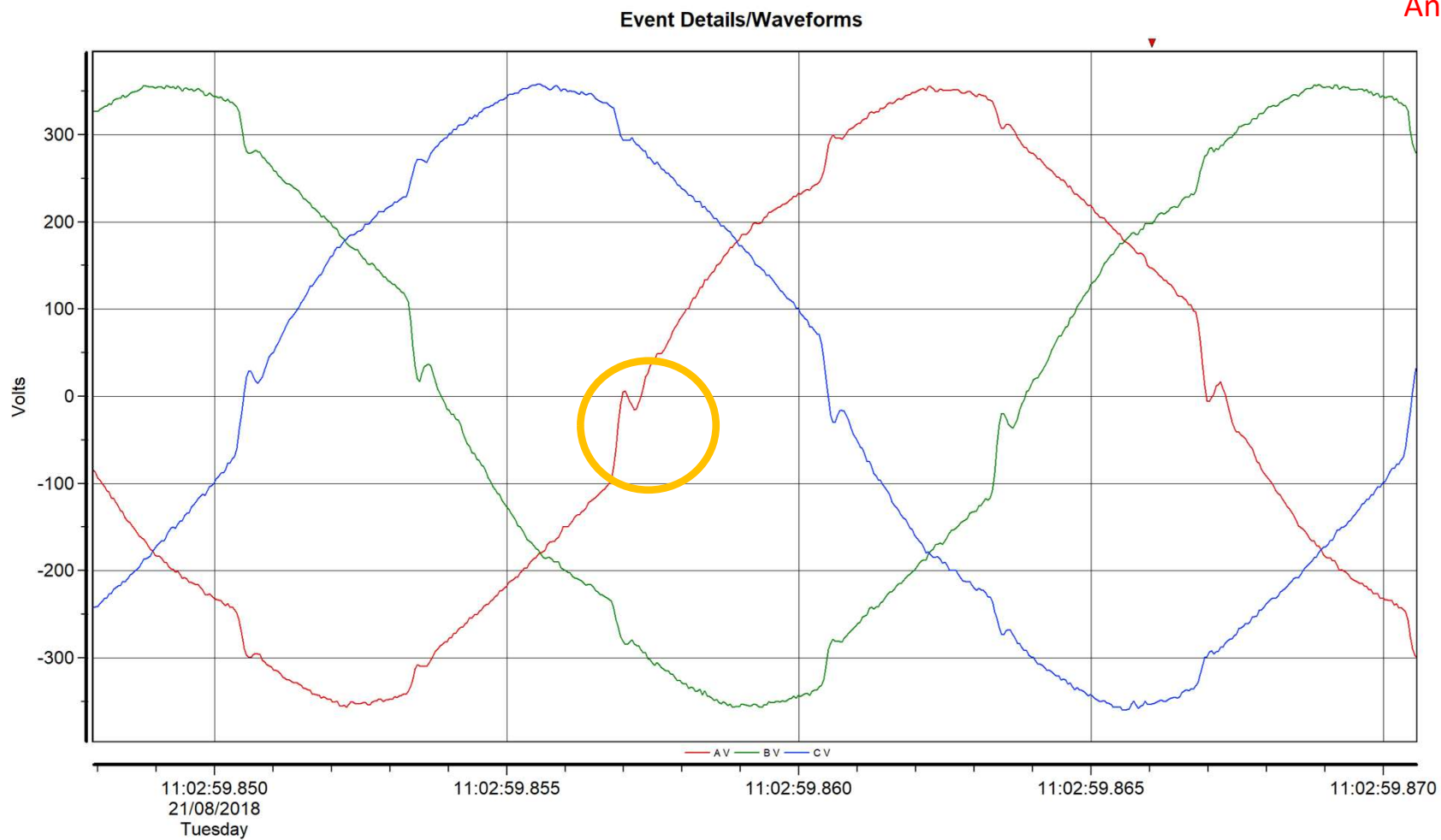




Event #8 at 21/08/2018 11:02:59.857  
AV Dropout 1/16 Cyc  
Phase 315.0 Deg

	A	B	C	D	A-B	B-C	C-A
Vrms	241.9	245.2	245.1	3.127	419.9	424.8	423.3
VPeak	356.6	358.1	358.7	9.502			

## Analysis



Event #8 at 21/08/2018 11:02:59.857  
AV Dropout 1/16 Cyc  
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	A	B	C	D	A-B	B-C	C-A
Vrms	241.9	245.2	245.1	3.127	419.9	424.8	423.3
VPeak	356.6	358.1	358.7	9.502			



# Findings / Lessons Learnt

- The quality of supply waveform on Phase L1 affected / influenced the operability of the other earth loop testers, resulting in “OL” or other error code readings.
- Newer earth loop testers do have ‘harmonic component’ to cater for (IEC 61557-3:2007).
- When the chiller system is not in operation, earth loop values were able to be obtained, regardless of the earth loop test equipment model used.
- RCCB / RCD testers work in similar manner like an earth loop impedance tester but are designed to induce “fault current” at a much smaller value, in terms of milliamperes. Hence, affected in the similar manner.

Thank You