Power Quality Study

Voltage Sags (Dips) in Distribution System and Residual Current Circuit Breaker (RCCB) Nuisance Tripping at Distribution Board ISTANA BUDAYA

JKR – UiTM

CAWANGAN KEJURUTERAAN ELEKTRIK

POWER QUALITY TEAM

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INTRODUCTION

ISTANA BUDAYA

- Type of Building : Heritage Theater
- Completion Date :1998
- Floor Space : 21,000 sq m.
- Auditorium Capacity : 1,386 p
  (661:1st floor, 325:2nd floor,
  302:upper circle)

Electrical System :

- 11kV supply from two TNB 11
  incomer
- 6 units dry type cast resin
  transformer

INTRODUCTION

PQ PROBLEM

1. Voltage Sag
2. Nuisance Tripping of RCCB at DB

Type of Loads(MAIN)

- Variable Speed Drives for Stage
- Audio System Power Amplifiers
- Stage Lighting

- Variable Speed Drives for Stage

- Audio System Power Amplifiers

Stage Lighting

Objective of PQ Study

1. To conduct a Power Quality Audit,
2. To identify the source of voltage sags
3. To identify the cause of nuisance tripping of RCCB in the power supply distribution system.

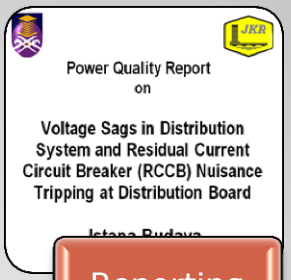
Work Flow Process

Briefing By Istana Budaya

Site Inspection

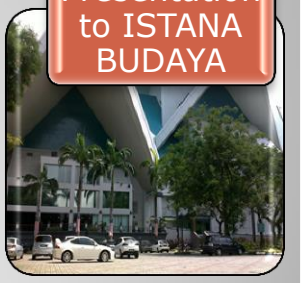
PQ Monitoring

Data Analysis – JKR & UiTM



Reporting

Presentation to ISTANA BUDAYA



Investigation Procedure

- Visual inspection on the existing electrical wiring installation system was done at the site to identify the points of measurement required.
- Two sets of Power Quality Analyzers were installed for power quality monitoring from 21th May 2014 to 29th May 2014 (MSB D and DB)
- Another set of measurements done at INCOMER HT1 (8th ~18th August 2014) and INCOMER HT2 (18th~26th August 2014)
- The instruments used were Fluke 1750 Power Quality Analyzer and Multi 140 Clamp Leaker

Investigation Procedures

SIMPLIFIED SINGLE LINE DIAGRAM OF ISTANA BUDAYA **ELECTRICAL** SYSTEM

Point Of Measurement P2

DB/3F-ALR1

RCCB

ESS. SWITCHBOARD E

NON ESS. SWITCHBOARD E

NON ESS. SWITCHBOARD D

UNDERSTAGE MACHINERY SWITCHBOARD SUPPLIED BY OTHERS

OVERSTAGE DRIVES ROOM

DIMMER ROOM

5 Nos. 1 x 400mm²/3C XLPE/SWA/PVC ON TRAY

TRANSF C

TRANSF A

1.5MVA 11kV/433V Dyn11 Cast Resin

1 x 185mm²/3C XLPE/SWA/PVC

630A VCB

630A VCB

OVERSTAGE OUTGOING 1

630A VCB

OVERSTAGE OUTGOING 2

HT BOARD 2

8 x 15 kVAR

11 Nos. 1 x 240mm²/1C FR CABLE IN TRENCHES

10 x 15 kVAR

3000A ACB

3000/5A

6 x 50 kVAR

3000A ACB

3000/5A

6 x 50 kVAR

3000A ACB

3000/5A

Point Of Measurement P1

ATS

1000A TPN MCCB

650 KVA GENSET NO. 1

7 Nos. 1 x 400mm²/3C XLPE/SWA/PVC IN TRENCHES

5 Nos. 1 x 400mm²/3C XLPE/SWA/PVC IN PERFORATED CABLE TRAY

TRANSF E

TRANSF D

TRANSF B

2.0MVA 11kV/433V Dyn11 Cast Resin

2.0MVA 11kV/433V Dyn11 Cast Resin

2.0MVA 11kV/433V Dyn11 Cast Resin

1 x 185mm²/3C Armoured XLPE/SWA/PVC ON PERFORATED CABLE TRAY

630A VCB

630A VCB

BUS BAR COUPLER

630A VCB

630A VCB

1250A BUSBAR

1250A VCB

1250A VCB

1 x 400mm²/3C XLPE/SWA/PVC PARTLY LAND IN DUCT PARTLY LAND IN TRENCHS

1250/5A CL.5P10

1250/5A CL.5P10

630A VCB

2.0MVA 11kV/433V Dyn11 Cast Resin

MECHANICAL PLANT ROOM

1250A

BUS BAR COUPLER

1250A

1250A BUSBAR

TRANSF F

FROM TNB

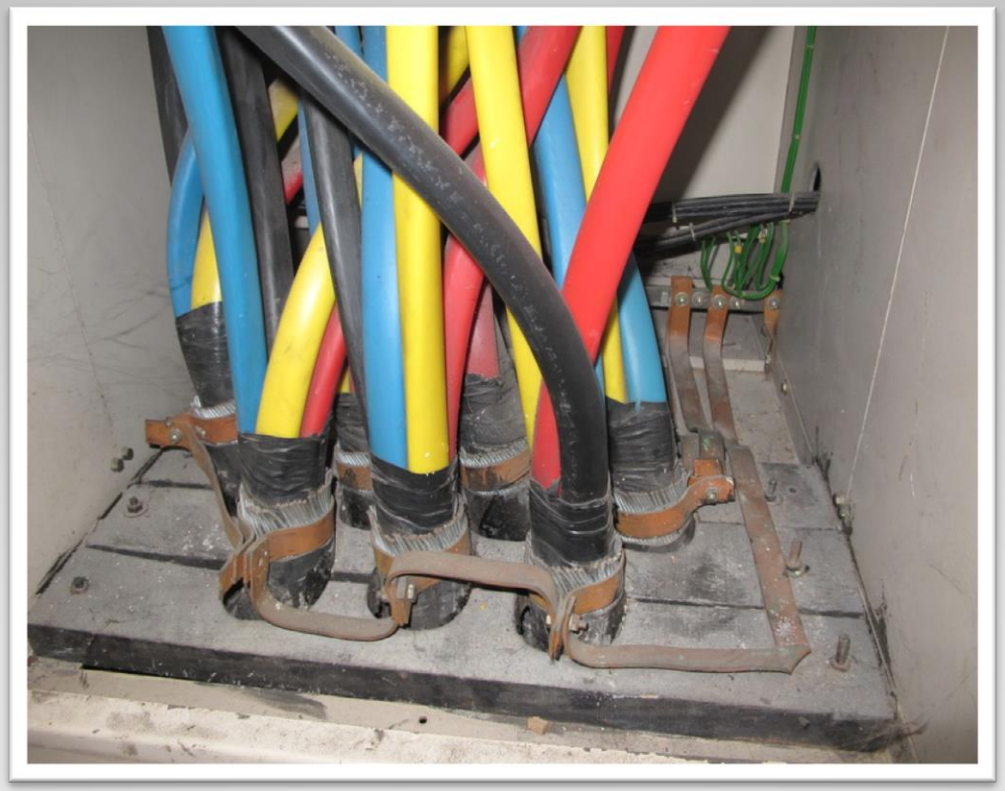
FROM TNB

Point Of Measurement P4

Point Of Measurement P3

Visual Inspection

The sub-main cables connected from MSB to Understage Machinery Switchboard are of type XLPE armoured cables. The steel wire armoured were not terminated properly



Visual Inspection

The grounding conductor is not fastened securely to the ground electrode. Clamp is used to connect ground electrode and copper tape (grounding conductor)

SIMPLIFIED SINGLE LINE DIAGRAM OF ISTANA BUDAYA
ELECTRICAL SYSTEM

Point Of Measurement P2

Point Of Measurement P1

1st phase of monitoring :21st to 29th May 2014

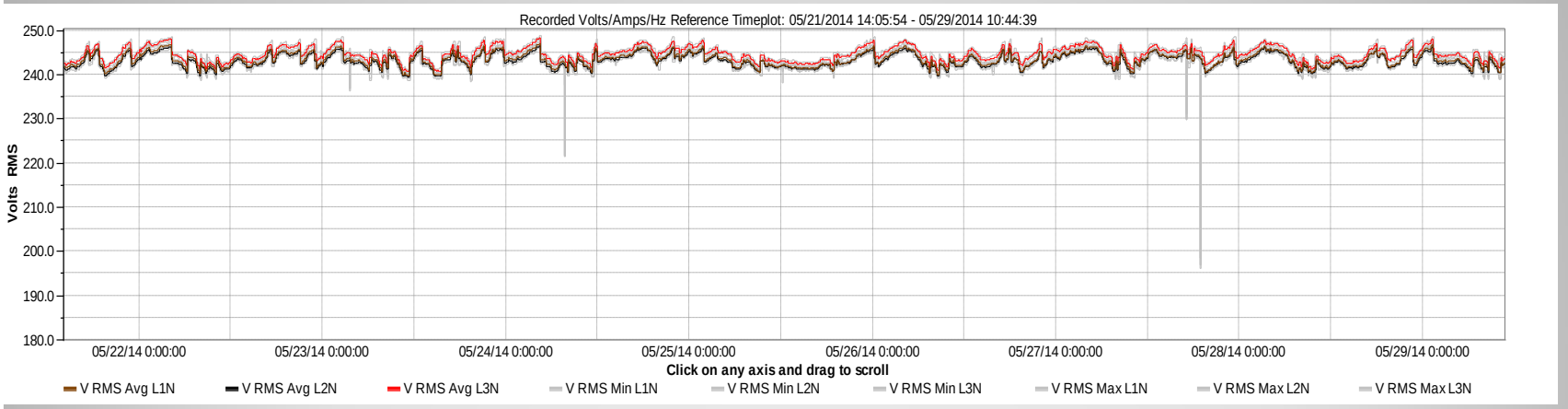
Point of Measurement P1 : MSB-D

Point Of Measurement P2 : DB/ELP/3F-ALR-1

Voltage

10 minutes trend data of MSB-D

Phase	Max	Time	Min	Time
V RMS Avg L1N	246.99 V RMS	05/24/2014 04:30:00	239.85 V RMS	05/23/2014 11:20:00
V RMS Avg L2N	246.50 V RMS	05/24/2014 04:30:00	239.39 V RMS	05/23/2014 11:20:00
V RMS Avg L3N	248.24 V RMS	05/24/2014 04:30:00	240.67 V RMS	05/23/2014 11:20:00
V RMS Avg NG	4.61 V RMS	05/27/2014 10:40:00	2.04 V RMS	05/21/2014 23:30:00

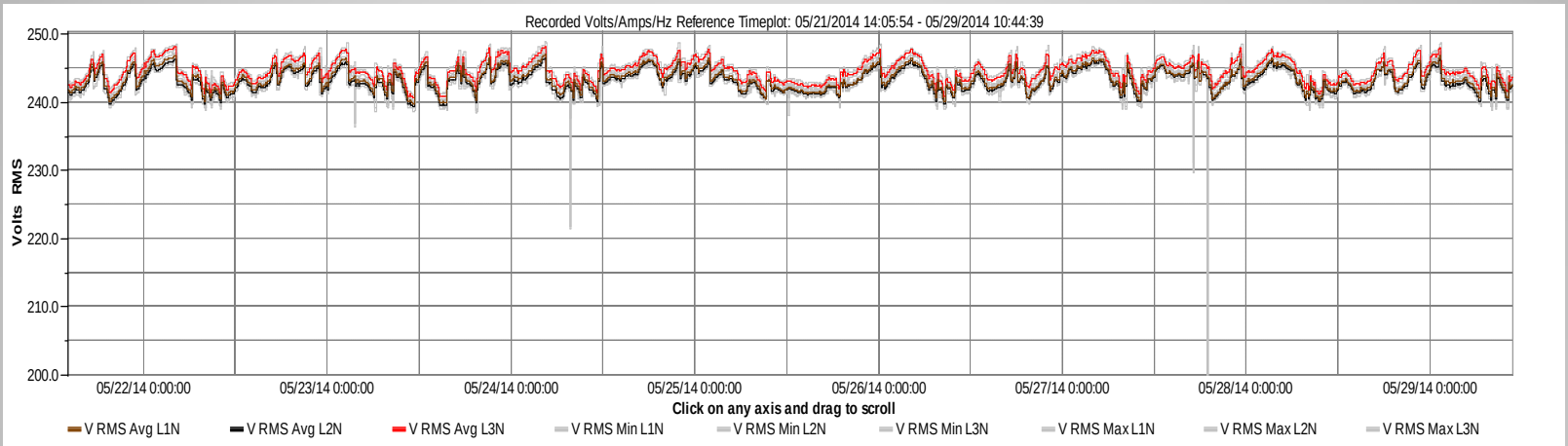


10 minutes trend data average RMS Voltage at MSB-D is within limits (230 V +10%, -6%) (216 V to 253 V)

Voltage

10 minutes trend data of DB/ELP/3F-ALR-1

Phase	Max	Time	Min	Time
V RMS Avg L1N	246.32 V RMS	05/24/2014 04:30:00	238.87 V RMS	05/23/2014 15:20:00
V RMS Avg L2N	246.22 V RMS	05/24/2014 04:30:00	239.05 V RMS	05/23/2014 11:20:00
V RMS Avg L3N	247.86 V RMS	05/24/2014 04:30:00	239.68 V RMS	05/23/2014 15:20:00
V RMS Avg NG	4.73 V RMS	05/26/2014 10:20:00	2.16 V RMS	05/21/2014 23:30:00

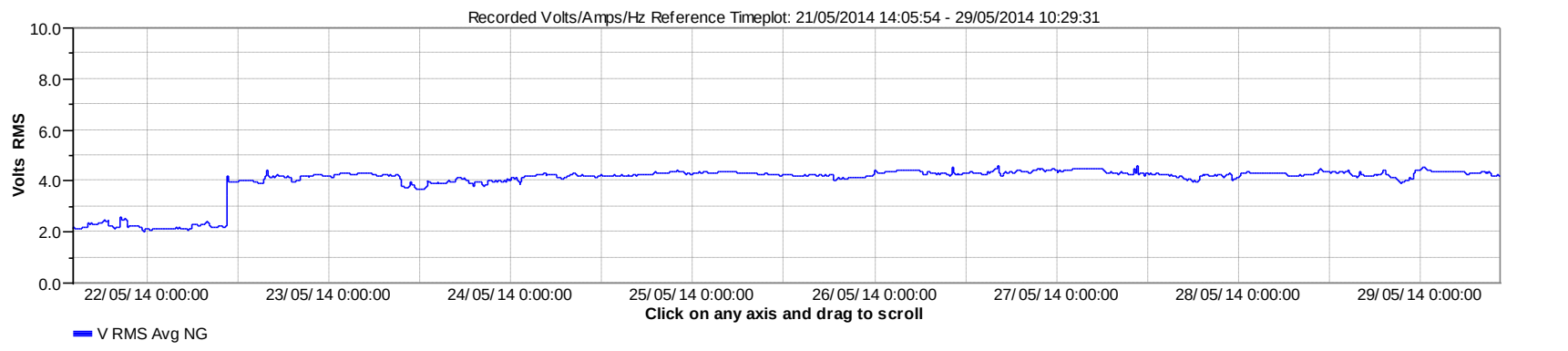


10 minutes trend data average RMS Voltage at MSB-D is within limits (230 V +10%, -6%) (216 V to 253 V)

Neutral to Ground Voltage Events

10 minutes trend data of MSB-D

Phase	Max	Time	Min	Time
V RMS Avg L1N	246.99 V RMS	05/24/2014 04:30:00	239.85 V RMS	05/23/2014 11:20:00
V RMS Avg L2N	246.50 V RMS	05/24/2014 04:30:00	239.39 V RMS	05/23/2014 11:20:00
V RMS Avg L3N	248.24 V RMS	05/24/2014 04:30:00	240.67 V RMS	05/23/2014 11:20:00
V RMS Avg NG	4.61 V RMS	05/27/2014 10:40:00	2.04 V RMS	05/21/2014 23:30:00



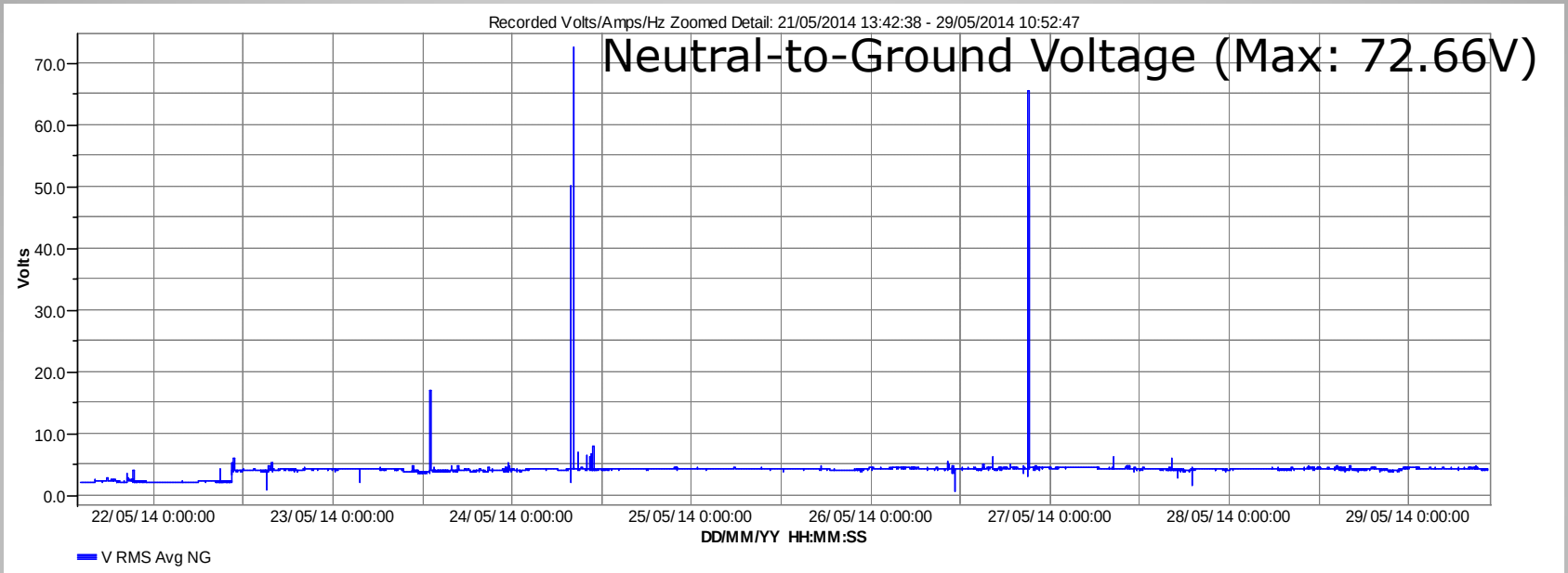
Maximum steady state neutral-to-ground Voltage at MSB-D=4.61V

Indicate that there is poor termination of earthing conductor and earth electrode

Neutral to Ground Voltage Events

Neutral to Ground Voltage(V_{NG}) at MSB-D (Detailed View Data)

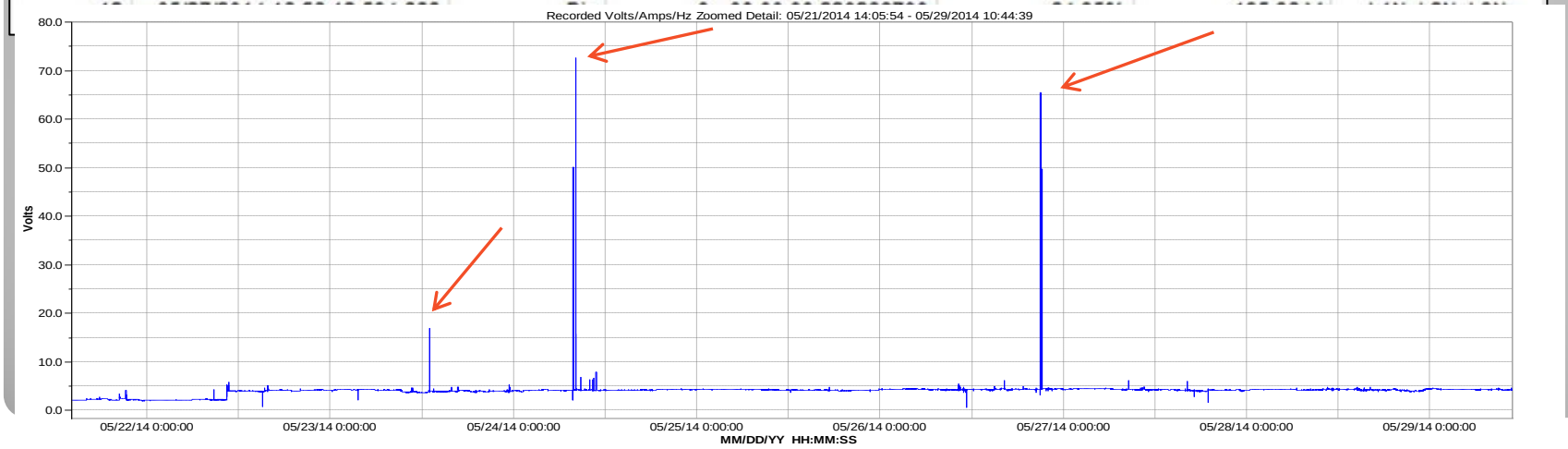
Phase	Max	Time	Min	Time
V RMS Avg NG	72.66 V	05/24/2014 08:06:08	0.59 V	05/26/2014 11:16:17



Indicates 'Intermittent Single Line-to-Ground Fault (SLG)' within electrical supply distribution system

Neutral to Ground Voltage Events – MSB D

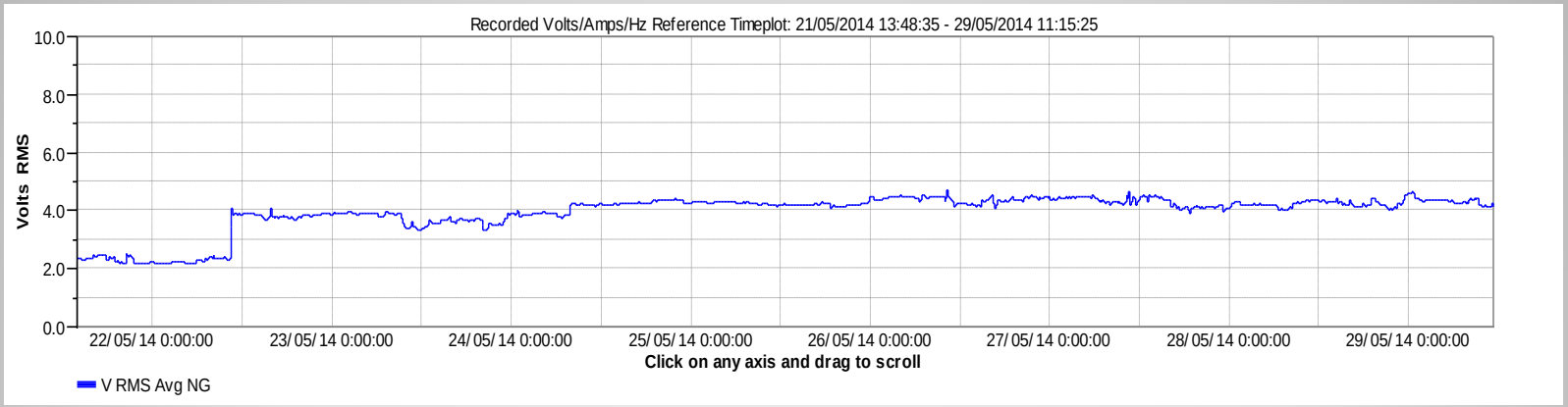
# /	Date/Time	Type	Duration (Days - Hrs:Min:Sec)	% of Nominal	Absolute	Triggered Phase
1	05/23/2014 03:37:47.892.421	Dip	0 - 00:00:00.040357700	86.70%	199.42 V	L1N, L2N
2	05/23/2014 12:56:00.563.069	Swell	0 - 00:00:00.019982600	7.35%	16.914 V	NG
3	05/24/2014 07:45:49.057.740	Dip	0 - 00:00:00.070601200	73.46%	168.96 V	L1N, L2N
4	05/24/2014 07:46:01.139.000	Swell	0 - 00:00:00.020036900	21.79%	50.107 V	NG
5	05/24/2014 08:05:43.689.709	Swell	0 - 00:00:00.019993600	31.59%	72.655 V	NG
6	05/24/2014 08:05:44.159.551	Swell	0 - 00:00:00.019993300	10.18%	23.409 V	NG
7	05/24/2014 08:05:45.579.030	Swell	0 - 00:00:00.020070400	4.72%	10.847 V	NG
8	05/24/2014 08:05:55.735.217	Swell	0 - 00:00:00.019990800	5.43%	12.485 V	NG
9	05/24/2014 08:06:08.031.341	Swell	0 - 00:00:00.019996900	6.87%	15.809 V	NG
10	05/26/2014 20:58:42.395.956	Swell	0 - 00:00:00.109997000	28.50%	65.544 V	NG
11	05/26/2014 21:08:36.996.792	Swell	0 - 00:00:00.029956900	21.69%	49.889 V	NG



Neutral to Ground Voltage Events

10 minutes trend data of DB/ELP/3F-ALR-1

Phase	Max	Time	Min	Time
V RMS Avg L1N	246.32 V RMS	05/24/2014 04:30:00	238.87 V RMS	05/23/2014 15:20:00
V RMS Avg L2N	246.22 V RMS	05/24/2014 04:30:00	239.05 V RMS	05/23/2014 11:20:00
V RMS Avg L3N	247.86 V RMS	05/24/2014 04:30:00	239.68 V RMS	05/23/2014 15:20:00
V RMS Avg NG	4.73 V RMS	05/26/2014 10:20:00	2.16 V RMS	05/21/2014 23:30:00



Maximum steady state neutral-to-ground Voltage at DB/ELP/3F-ALR-1=4.73V

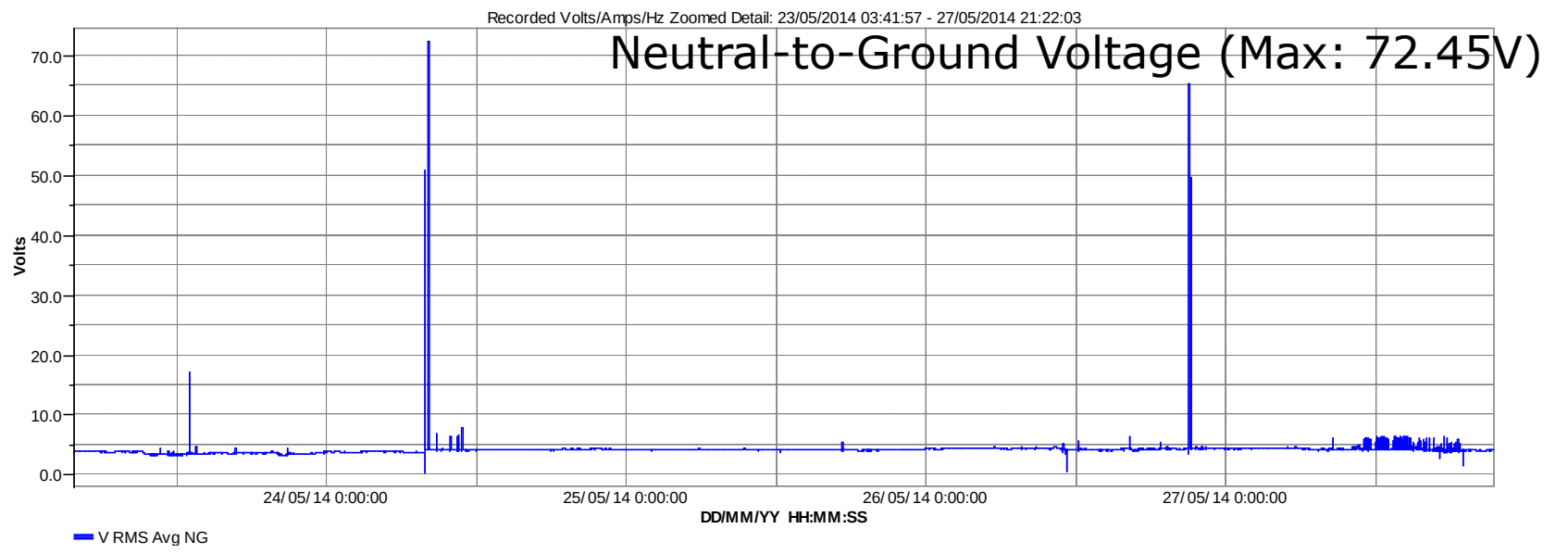
Value is higher than at MSB D (4.61V) < DB (4.73V)

Indicate <u>loose termination</u> at location between MSB and DB

Neutral to Ground Voltage Events

Neutral to Ground Voltage (VNG) at DB/ELP/3F-ALR-1 (Detailed View Data)

Phase	Max	Time	Min	Time
V RMS Avg NG	72.45 V RMS	05/24/2014 08:05:48	0.31 V RMS	05/24/2014 07:45:51



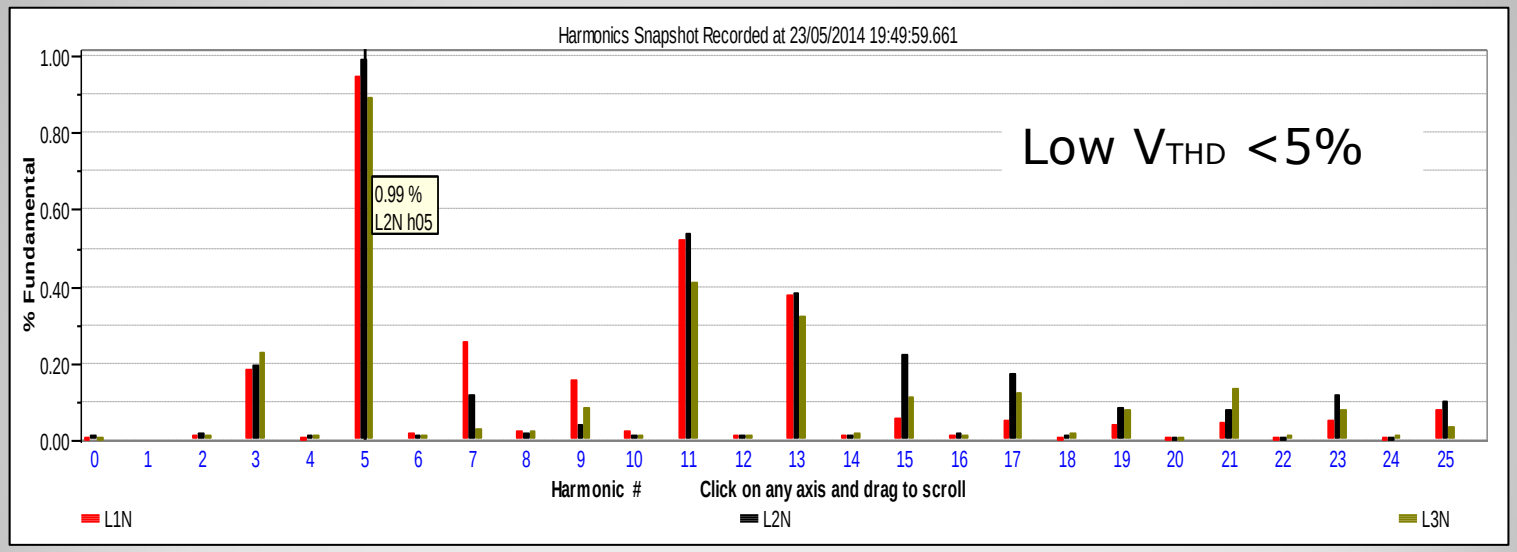
- Indicates 'Intermittent Single Line-to-Ground Fault (SLG)' within electrical supply distribution system.
- Can cause damage to electronic equipment and nuisance tripping of RCCB.

Harmonics

MSB- D Harmonics at High Load

Voltage	L1N	L2N	L3N	NG
% THD	1.2	1.3	1.1	--
% Odd Harm	1.2	1.3	1.1	--
% Even Harm	0.0	0.0	0.0	--

Current	L1	L2	L3	N
% THD	8.6	6.1	6.7	101.6
% Odd Harm	8.6	6.1	6.7	101.5
% Even Harm	0.3	0.5	0.5	3.5

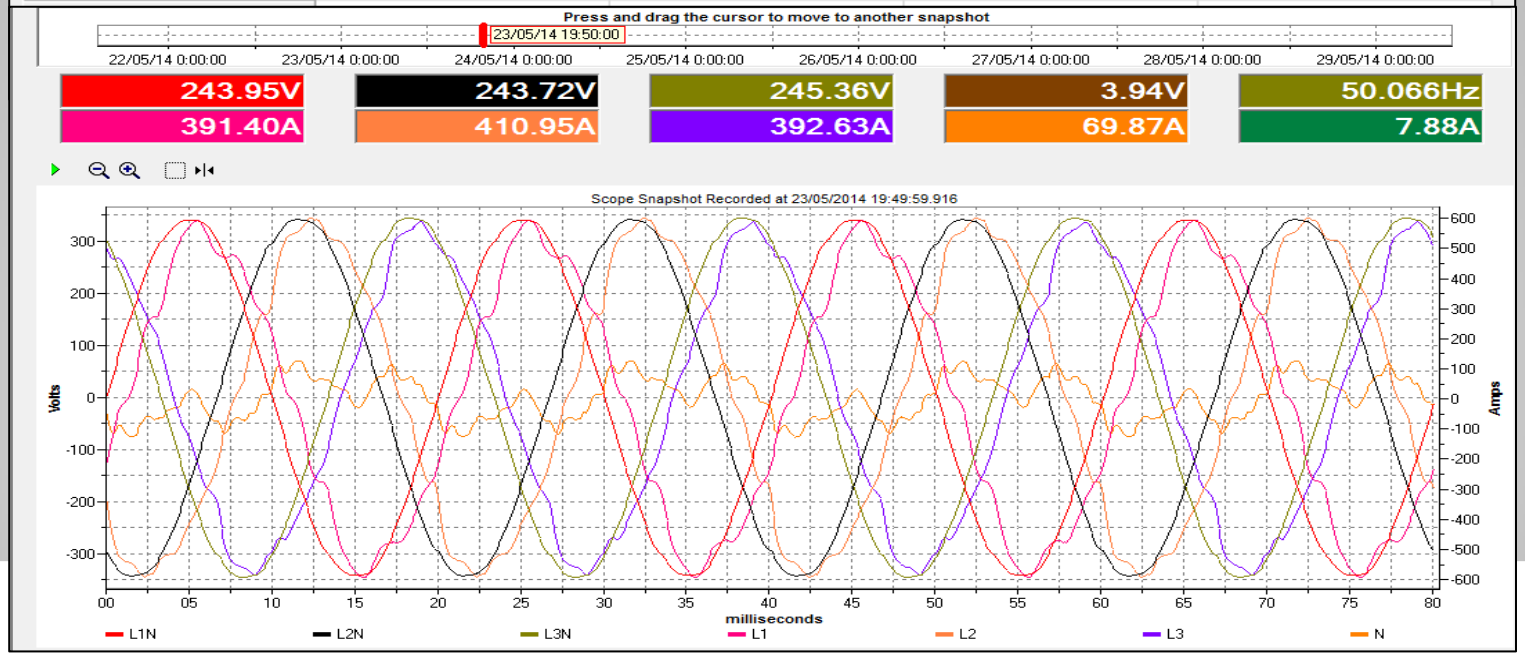


Harmonics- Waveform

MSB- D Harmonic at high Load

Voltage	L1N	L2N	L3N	NG
% THD	1.2	1.3	1.1	--
% Odd Harm	1.2	1.3	1.1	--
% Even Harm	0.0	0.0	0.0	--

Current	L1	L2	L3	N
% THD	8.6	6.1	6.7	101.6
% Odd Harm	8.6	6.1	6.7	101.5
% Even Harm	0.3	0.5	0.5	3.5
% TDD	--	--	--	--

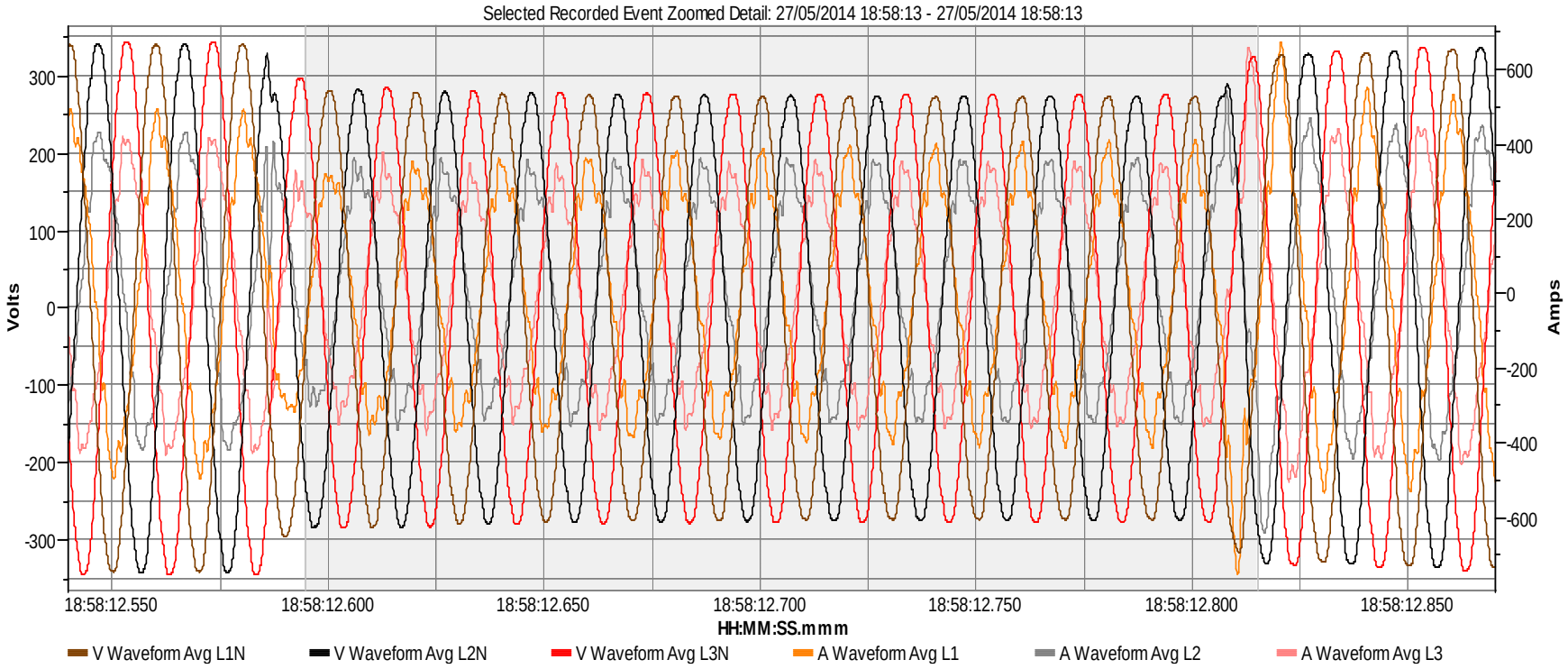


Voltage Sags

Voltage Sag at MSB-D

Voltage Sag of 195.38 V
Duration : 220 ms

No Increase in Current:
Voltage Sag Originates from the upstream*



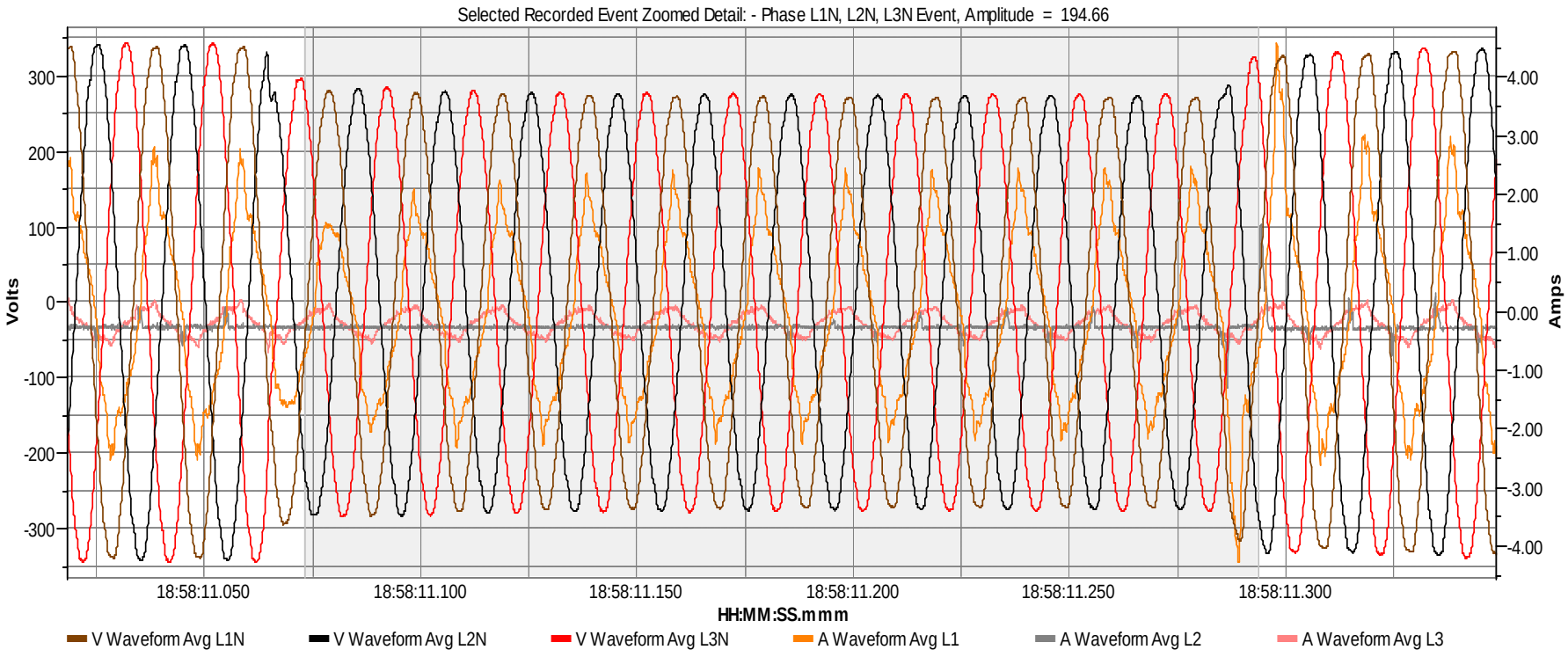
*Reference: J.C.GOMEZ,2005,"A Novel Methodology to Locate Originating Points of Voltage Sags in Electrical Power Systems",18th International Conference on Electrical Distribution

Voltage Sags

Voltage Sag at DB/ELP/3F-ALR-1

Voltage Sag of 194.65 V
Duration : 220 ms

No Increase in Current:
Voltage Sag Originates from the upstream *



*Reference: J.C.GOMEZ,2005,"A Novel Methodology to Locate Originating Points of Voltage Sags in Electrical Power Systems",18th International Conference on Electrical Distribution

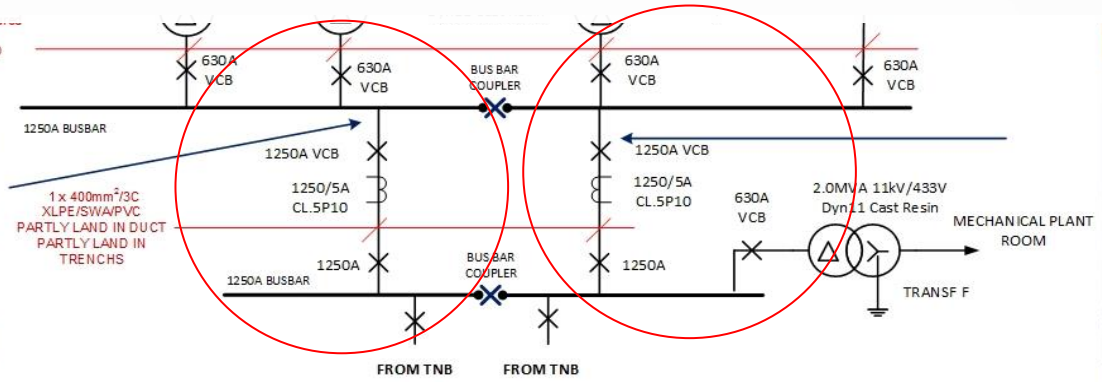
Voltage Sags

To determine the source of voltage sags (whether from Electrical Supply Authority or within the electrical installation system), another set of measurements done at Incomer HT1 and Incomer HT2

2nd phase of monitoring :8th to 18th August 2014
18th to 26th August 2014

Point of Measurement P3 : INCOMER HT 1
Point of Measurement P4 : INCOMER HT 2

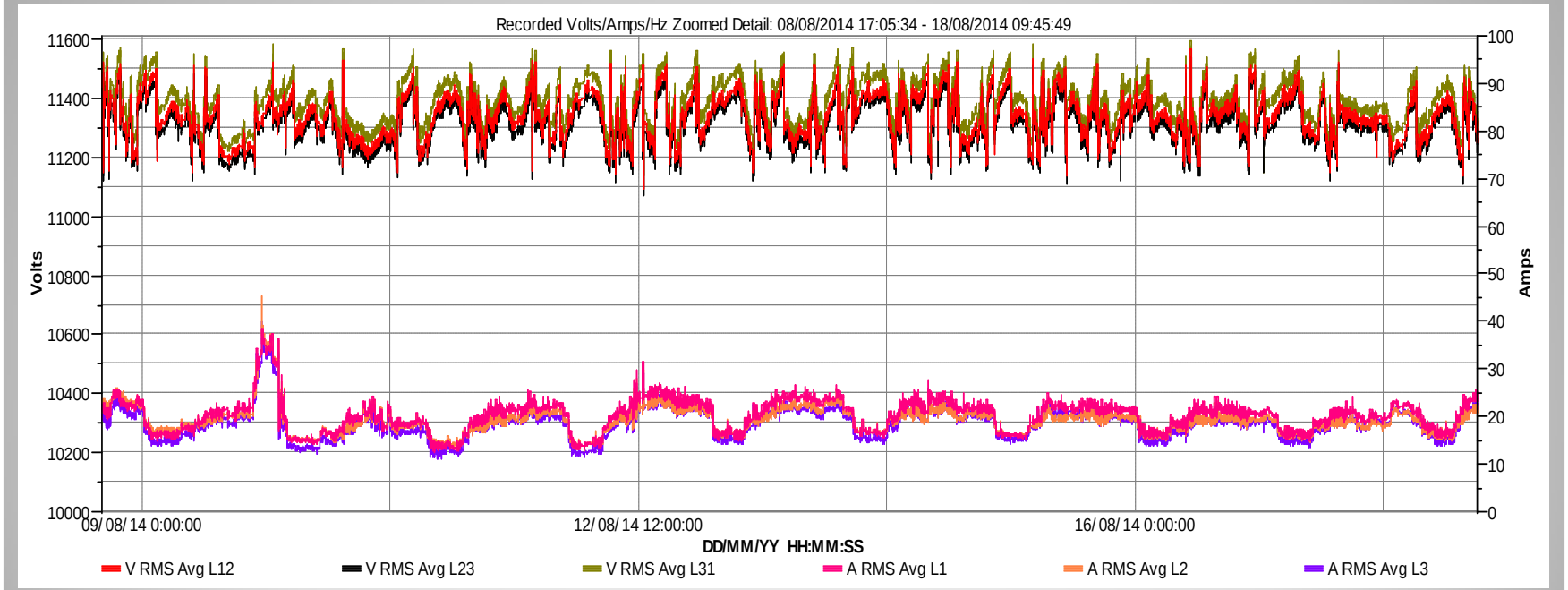
Point Of Measurement P4



Point Of Measurement P3

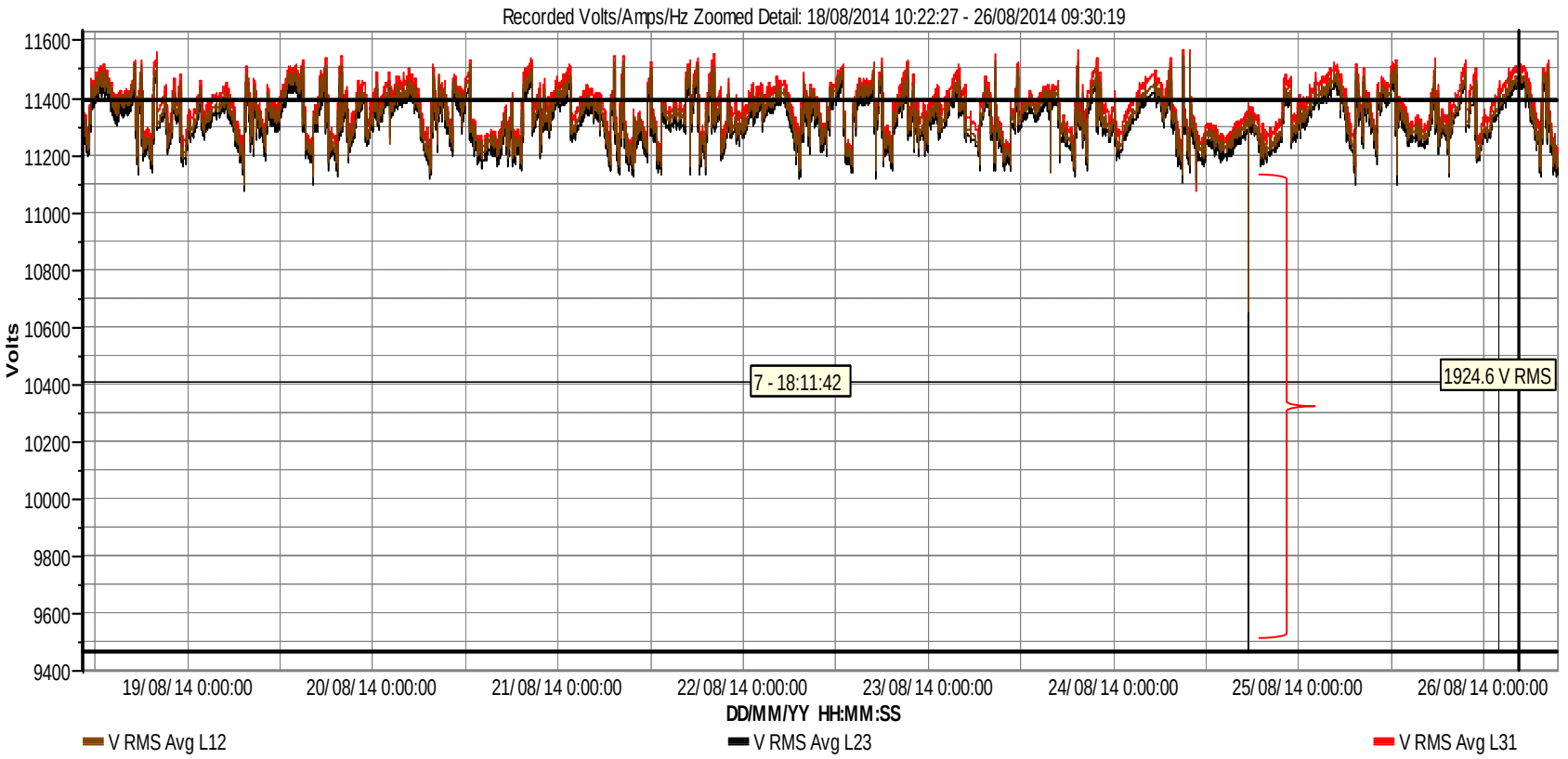
Voltage Sags

No voltage sags recorded at the TNB INCOMER HT1



Voltage Sags

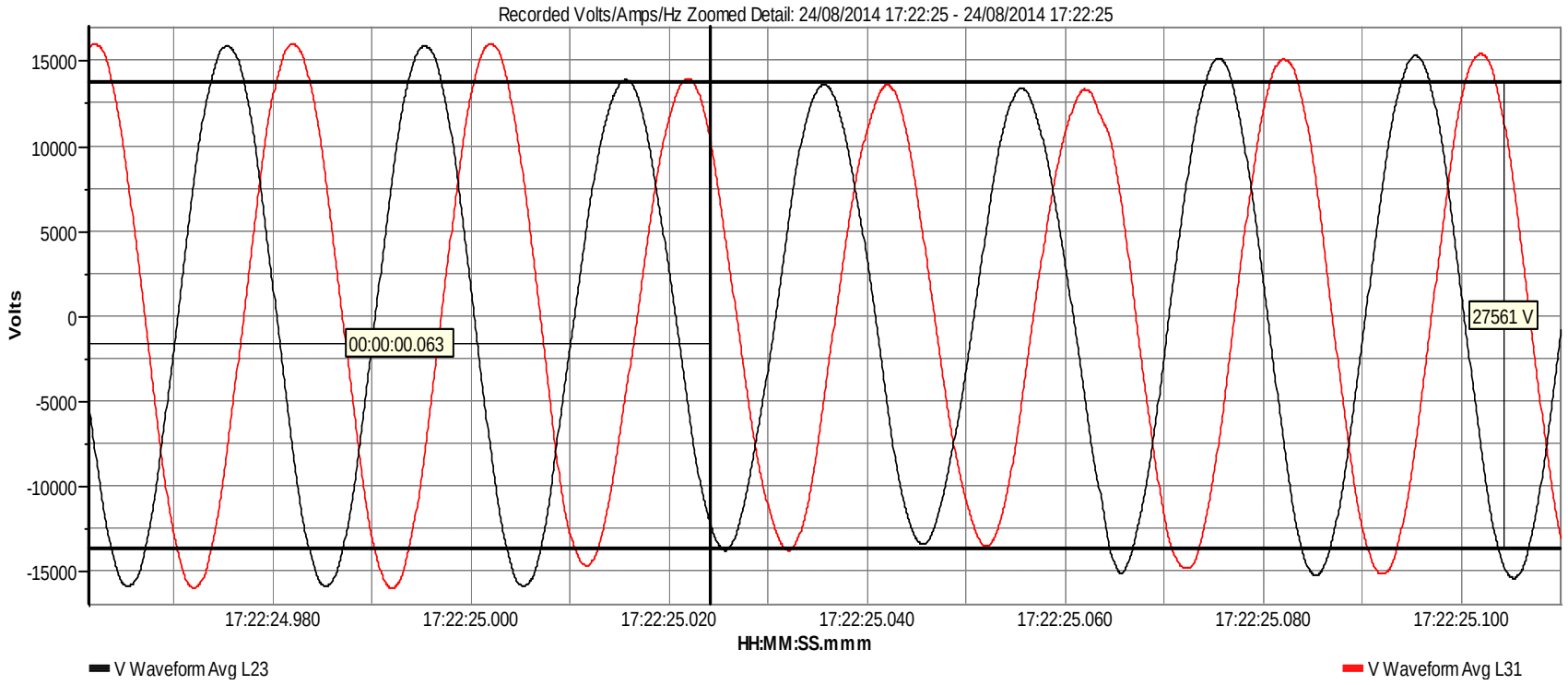
Voltage Sag Event at TNB Incomer HT2



Voltage Sags

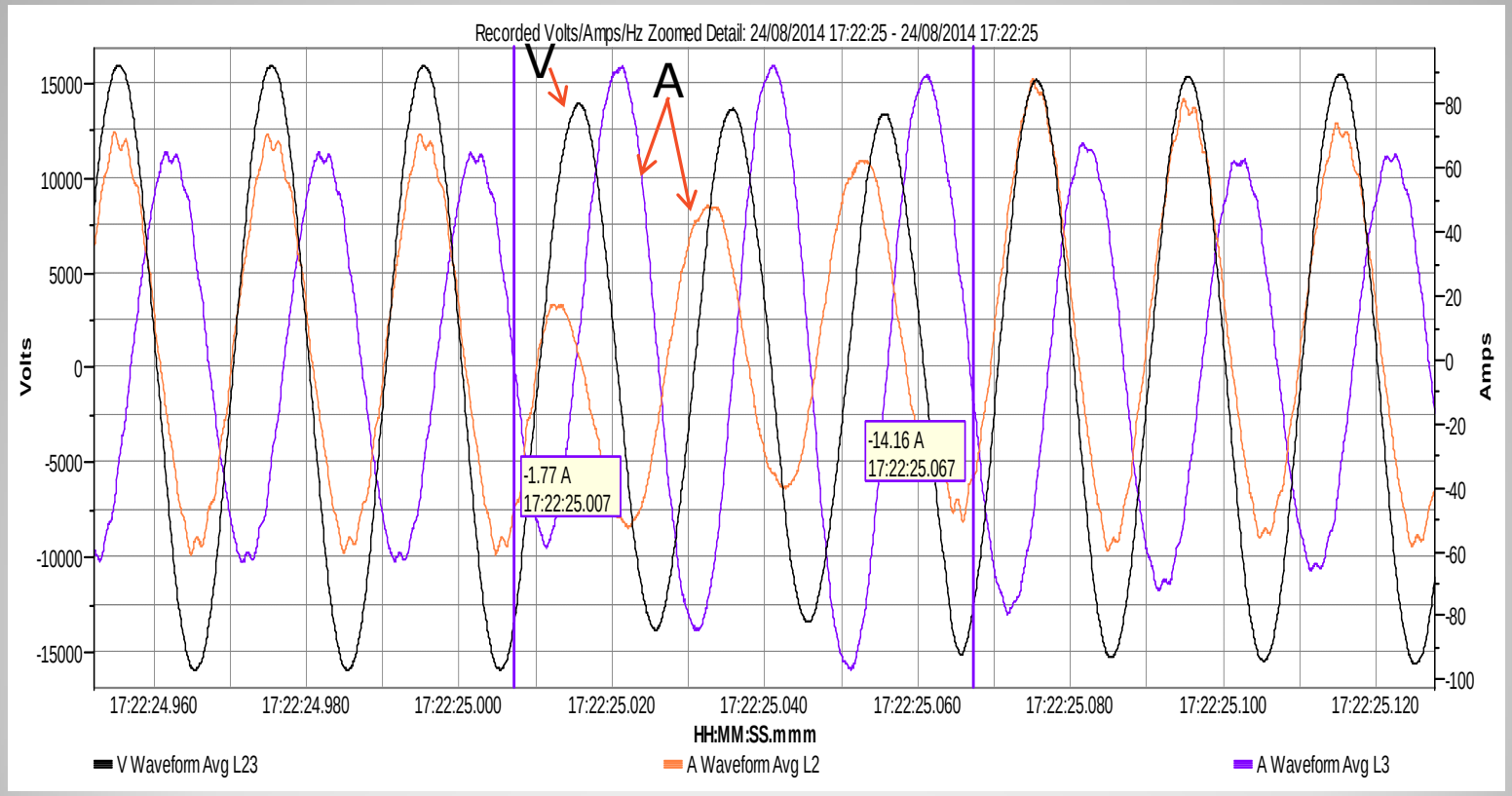
TNB INCOMER HT2 shows a voltage sag for duration of 3 cycle (60 ms) of phase L23 and L31 occur on 24th August 2014

Voltage Sag Values : 9464.6 V(L23)and 9520.0V (L31)



Voltage Sags

Since there is no sudden increase in the current magnitudes, the voltage sag is originated upstream of the measurement point



*Reference: J.C.GOMEZ,2005,"A Novel Methodology to Locate Originating Points of Voltage Sags in Electrical Power Systems",18th International Conference on Electrical Distribution

Conclusion

- Since the voltage THD at the MSB-D is low (< 5%), therefore the electrical harmonics will not cause any problems to electrical supply system.
- The voltage sags that occurred at MSB-D came from upstream (supply side).
- The voltage sag that occurred at TNB INCOMER HT2 came from upstream (i.e. Electricity Supply Authority)
- High neutral to ground voltage impulses have led to the damage and malfunction of the electronic loads and nuisance tripping of the RCCB.
- The high neutral to ground voltage impulses are due with an inadequate wiring installation, improper termination and improper grounding configuration

Recommendations

A. **To improve electrical wiring installation**

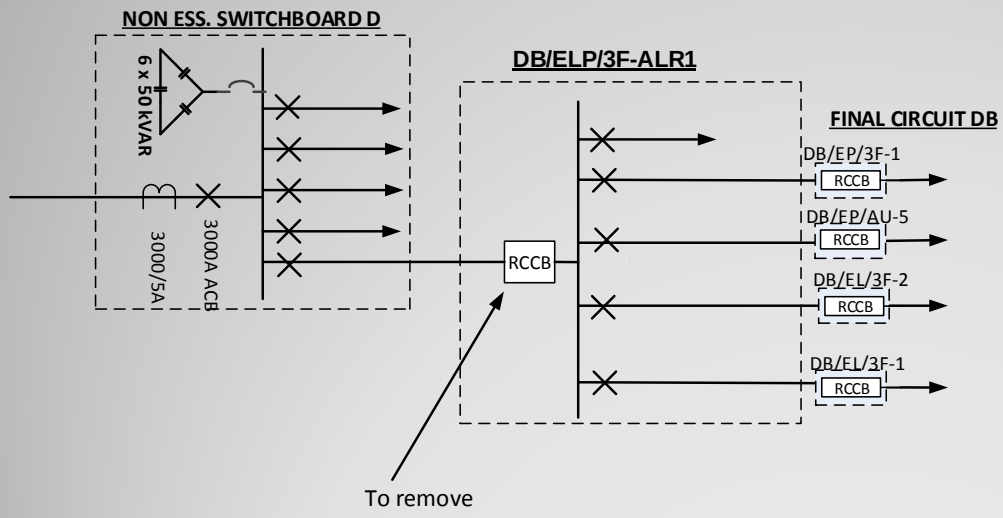
i. Check the wiring installation of the electrical system and correct all the wiring errors such as intermittent single line-to-ground fault and improper cable joint.

ii. Check for loose neutral connections.

iii. Inspect the wiring for other equipment, light fittings etc. for loose joints and terminations.

Recommendations

iv. Remove the RCCB located at DB/ELP/3F-ALR-1 and replace with circuit breaker



If there is any earth leakage at the final circuit DB, these RCCBs would see the same fault, and both would trip at the same time thus disrupting the electrical supply to the other area. Also, if there is any neutral-to-ground voltage disturbance occurs, RCCB located at the DB/ELP/3F-ALR-1 will trip first since the total leakage current at DB/ELP/3F-ALR-1 is higher than at the final circuit DBs.

Recommendations

B. **To improve earthing system**

i. Use exothermic welding connection between grounding conductor to the ground electrode.

C. **Voltage Sag**

i. Make a complaint to the Electricity Supply Authority.

THANK YOU

PQ TEAM , CAWANGAN KEJURUTERAAN ELEKTRIK