Power Quality Study
Capacitor Bank Failures
Politeknik Seberang Perai

Cawangan Kejuruteraan Elektrik – UiTM Pulau Pinang

Power Quality Team

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Introduction

- Politeknik Seb. Perai was opened on the 1st Sept 1998. The campus was designed to cater for the needs of 2500 people
- Several capacitor bank failures are recorded at MSB No.2 located in Sub-station No.2
- The types of load connected to this MSB are of inductive components i.e. welding equipment, motors etc.

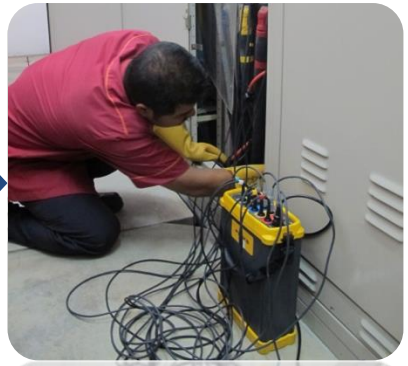
Objective of PQ Study

To identify the causes of the Capacitor Bank failures at the MSB No.2

Workflow Process

Briefing by PSP

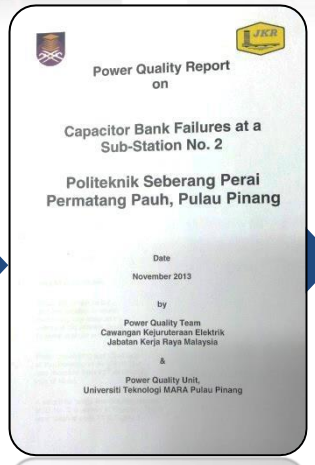
Site inspection



PQ monitoring

Data analysis by JKR

Data analysis by UiTM



Joint venture report

Presentation to PSP

Investigation Procedures

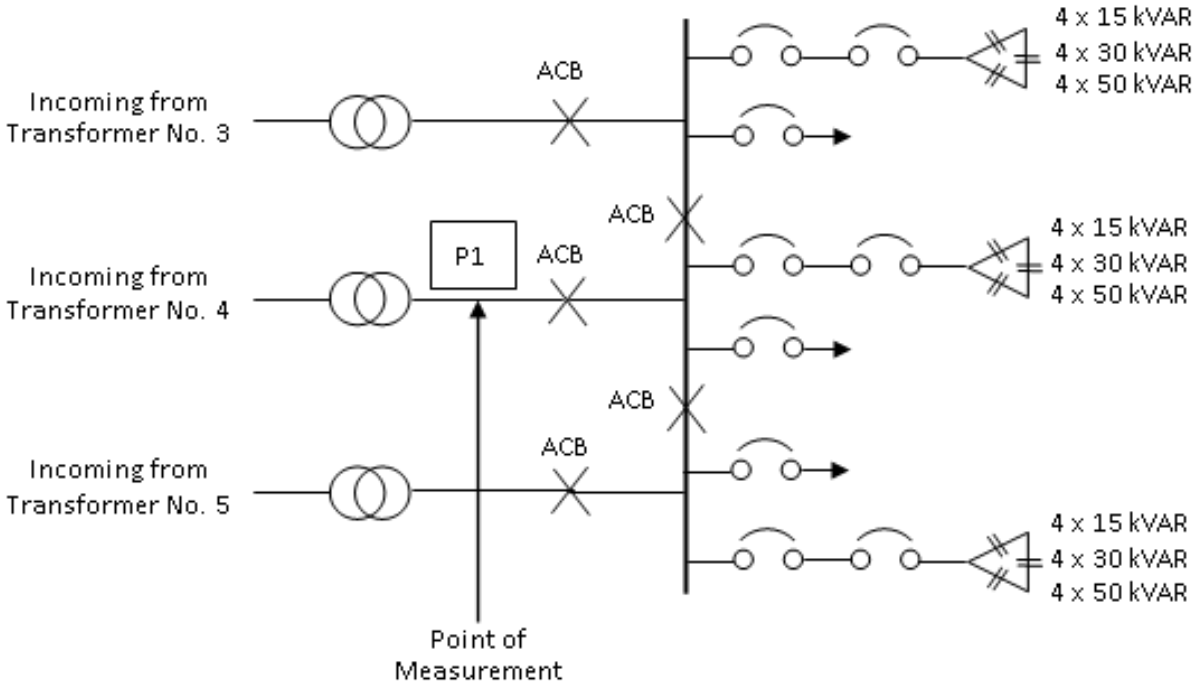
- Visual inspection on the existing electrical wiring installation system was done at the site to identify the points of measurement required

- One set of monitoring was done and a complete data acquisition of voltage and current were taken. The monitoring was conducted from 21st to 31st October 2013

- The instrument used was Fluke 1750 Power Quality Analyzer.

Investigation Procedures

- **The measurements of voltage and current were taken at point P1**

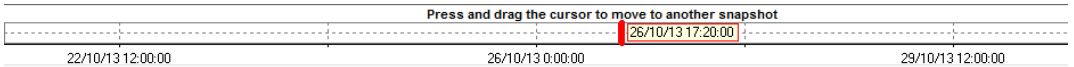


Simplified single line diagram of MSB No.2

Findings

Voltage, Current & Power Summary

- DPF and TPF are 0.879 and 0.861 respectively
- If DPF and TPF differ greatly, this indicates the presence of harmonics
- In this case, the difference is very small

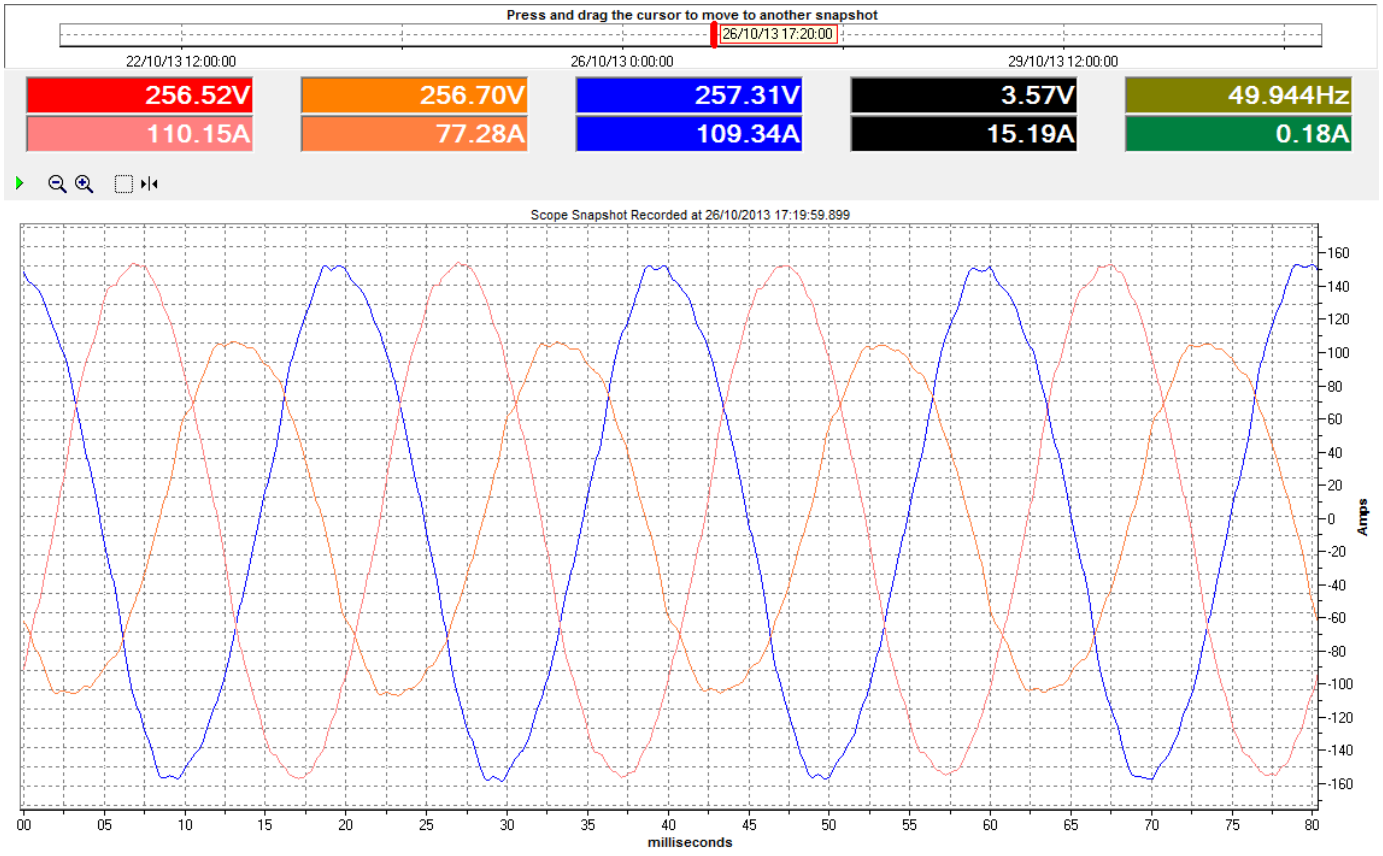


Voltage	L1N	L2N	L3N	NG
V RMS	256.5	256.7	257.3	3.6
V PK	359.2	359.7	361.1	7.7
V CF	1.4	1.4	1.4	2.2
% THD	0.9	0.9	1.0	--
Freq	49.9			
Current	**L1**	**L2**	**L3**	**N**
A RMS	110.2	77.3	109.3	15.2
A PK	158.6	107.0	159.0	32.5
A CF	1.4	1.4	1.5	2.1
% THD	2.8	5.3	4.1	82.2
% TDD	--	--	--	--
K Factor	1.0	1.1	1.1	
Power	**L1**	**L2**	**L3**	**Total**
kW	23.418	17.214	26.069	66.700
kVA	28.256	19.837	28.134	77.425
kvar	15.811	9.859	10.580	39.316
PF	0.829	0.868	0.927	0.861
DPF	0.829	0.869	0.927	0.879
	Lag	Lag	Lag	

Findings

Current Waveforms

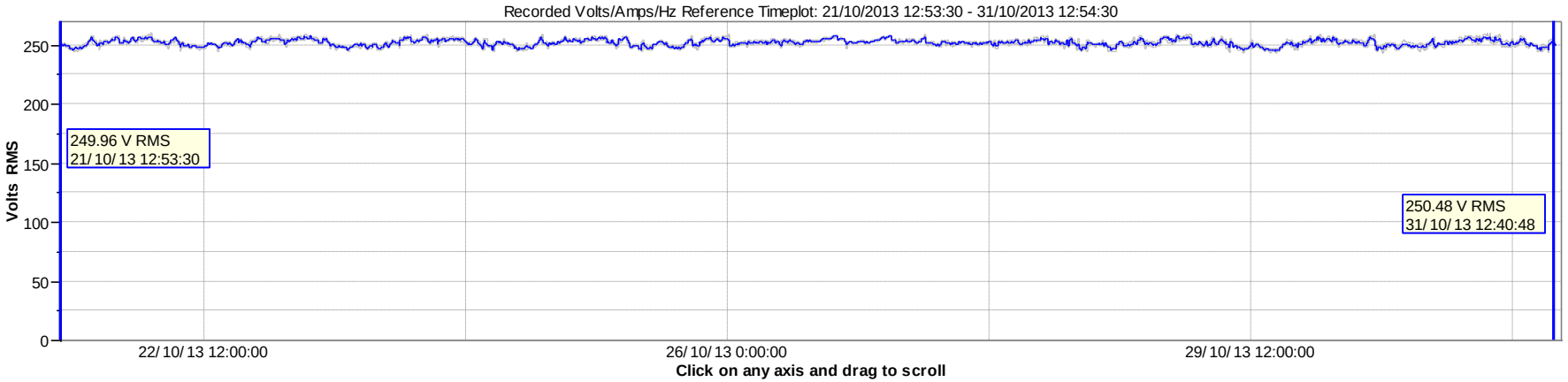
- The current waveforms are slightly distorted



Findings

Voltage Summary

- The recorded 10 minutes trend data average RMS phase voltage V_{L1N}, V_{L2N} and V_{L3N} at P1 are 256.88V (11.69%), 257.18V (11.82%) and 257.71V (12.05%) respectively. These voltages exceed +10% limit of the nominal voltage

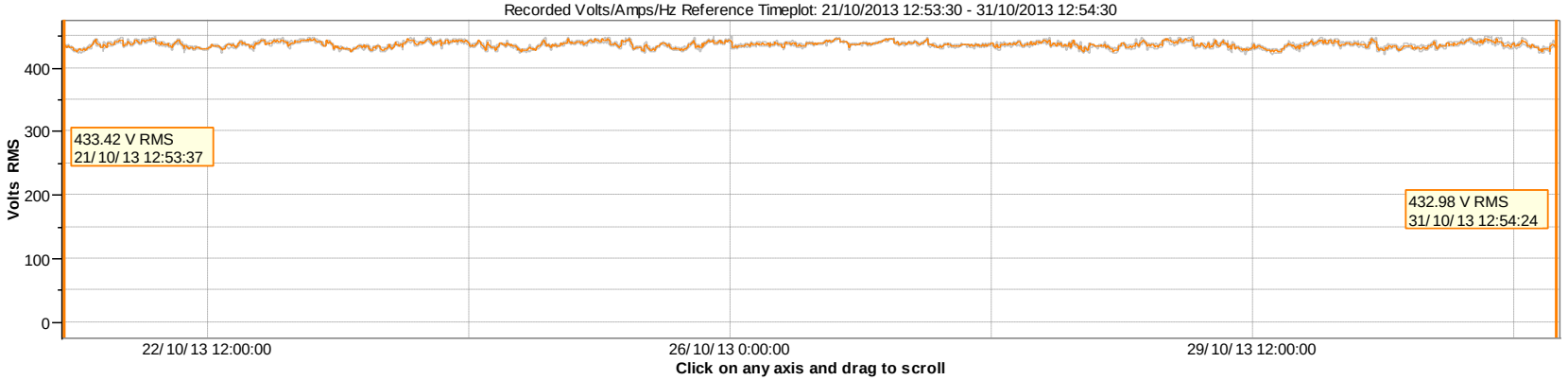


Phase	Max	Time	Min	Time
V RMS Avg L3N	257.71 V RMS	26/10/2013 17:20:00	245.13 V RMS	29/10/2013 16:00:00

Findings

Voltage Summary

- For recorded 10 minutes trend data of 3-phase voltage, average RMS 3-phase voltage V_{L1L2}, V_{L2L3} and V_{L3L1} at P1 are 444.81 V (11.20 %), 446.33 V (11.58 %) and 445.61 V (11.40 %) respectively. These voltages exceed the rated voltage of the capacitor (440 V)

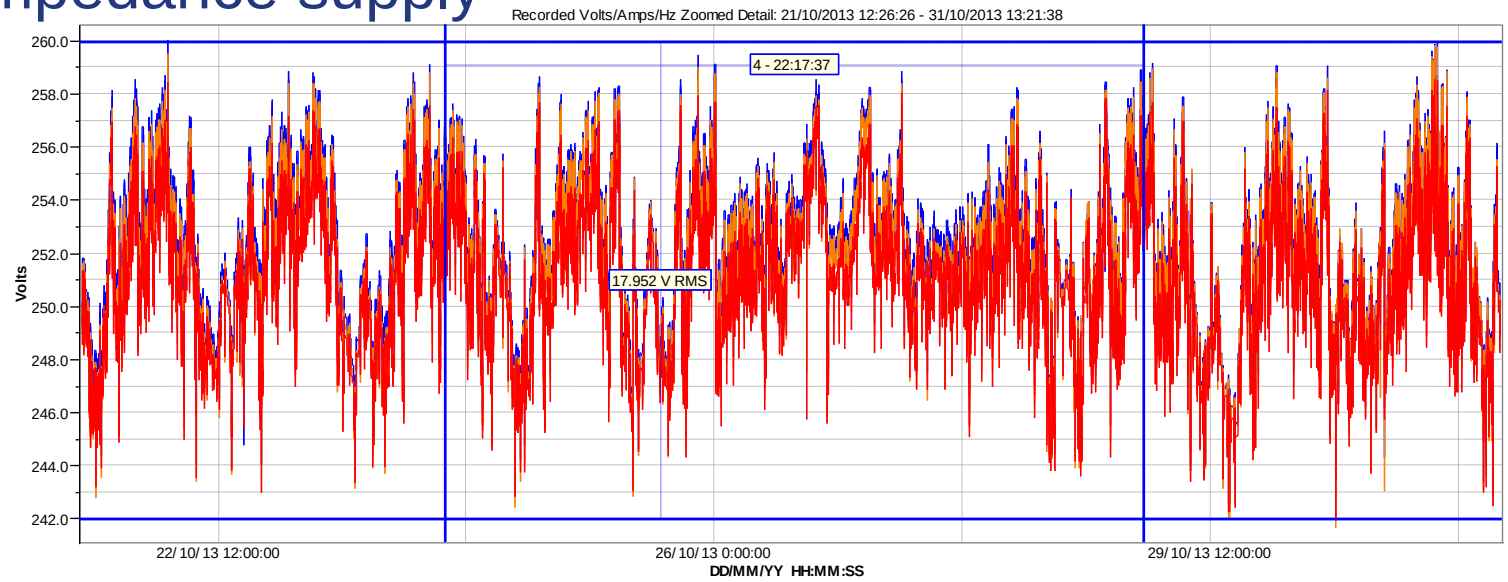


Phase	Max	Time	Min	Time
V RMS Avg L23	446.33 V RMS	27/10/2013 02:00:00	425.28 V RMS	29/10/2013 16:00:00

Findings

Voltage Fluctuations

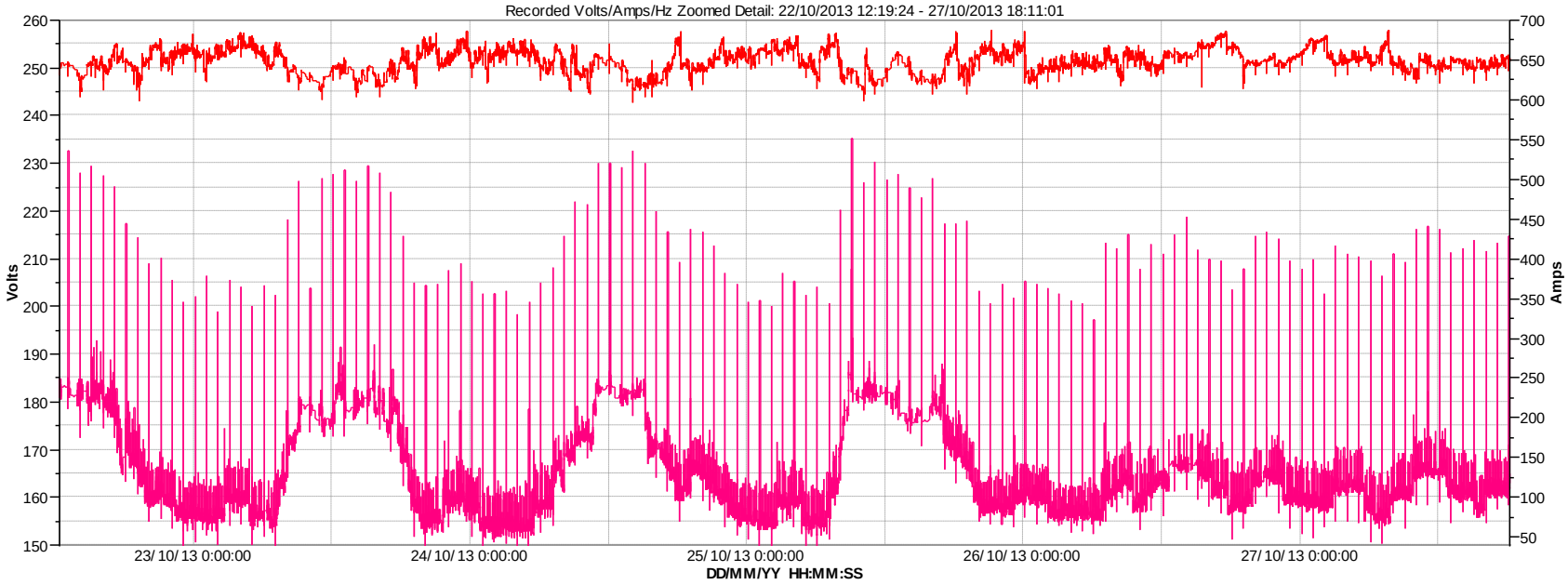
- The voltage profiles experience voltage fluctuations. The voltage fluctuation is 18 V (7.8 %). This voltage fluctuation is considered high (above 6 % of nominal voltage, i.e. >13.8 V).
- This indicate the voltage is a weak supply or high system impedance supply



Findings

Voltage Fluctuations

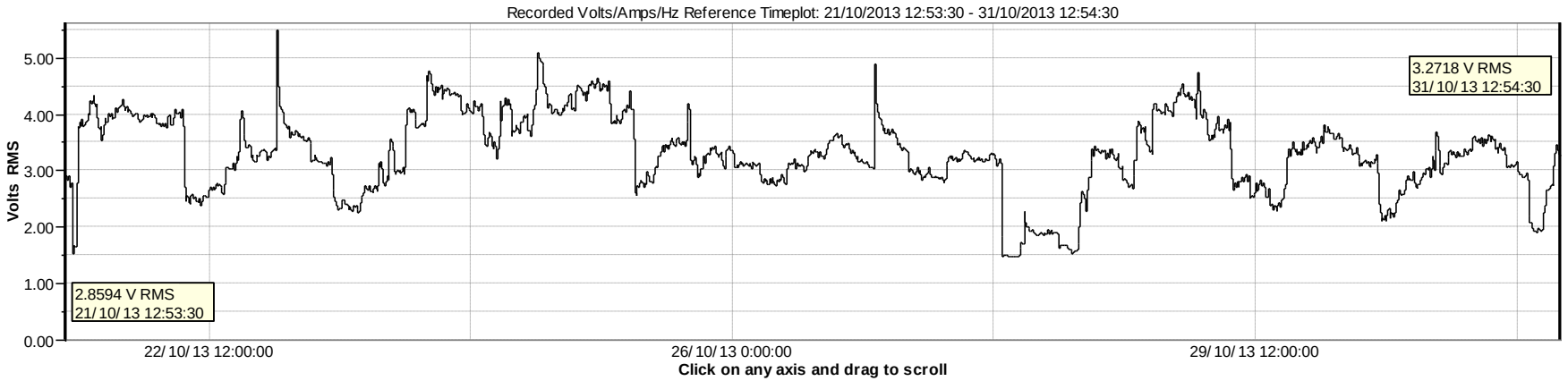
- The voltage fluctuations can be related to undersize cable, loose or defective wiring, such as insufficiently tightened screws connection on power conductors.



Findings

Neutral-to-Earth Voltage

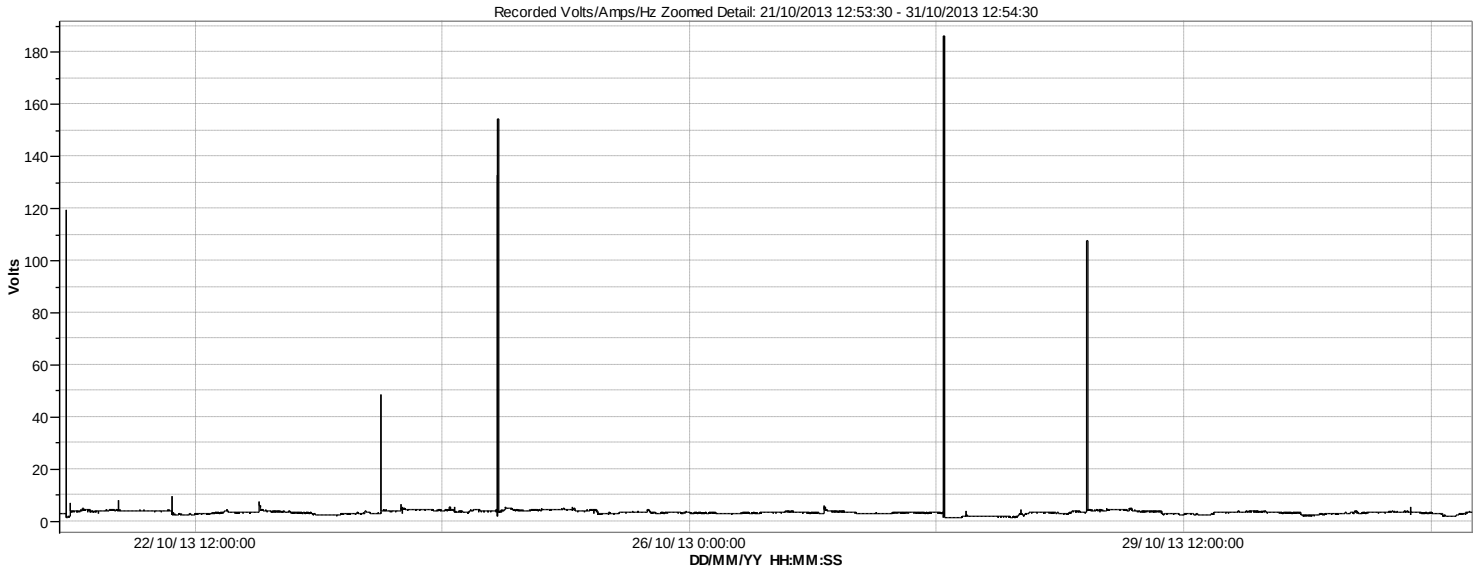
- The 10 minutes trend data average RMS neutral-to-earth voltage V_{NE} at P1 is 5.50 V.
- The high levels of V_{NE} indicates a loose connection at the earth electrode.



Findings

Neutral-to-Earth Voltage

- The detail view data average RMS neutral-to-earth voltage V_{NE} is 186.47 V. The magnitude of the V_{NE} is high therefore it contributes to the power quality problem.



Findings

Neutral-to-Earth Voltage

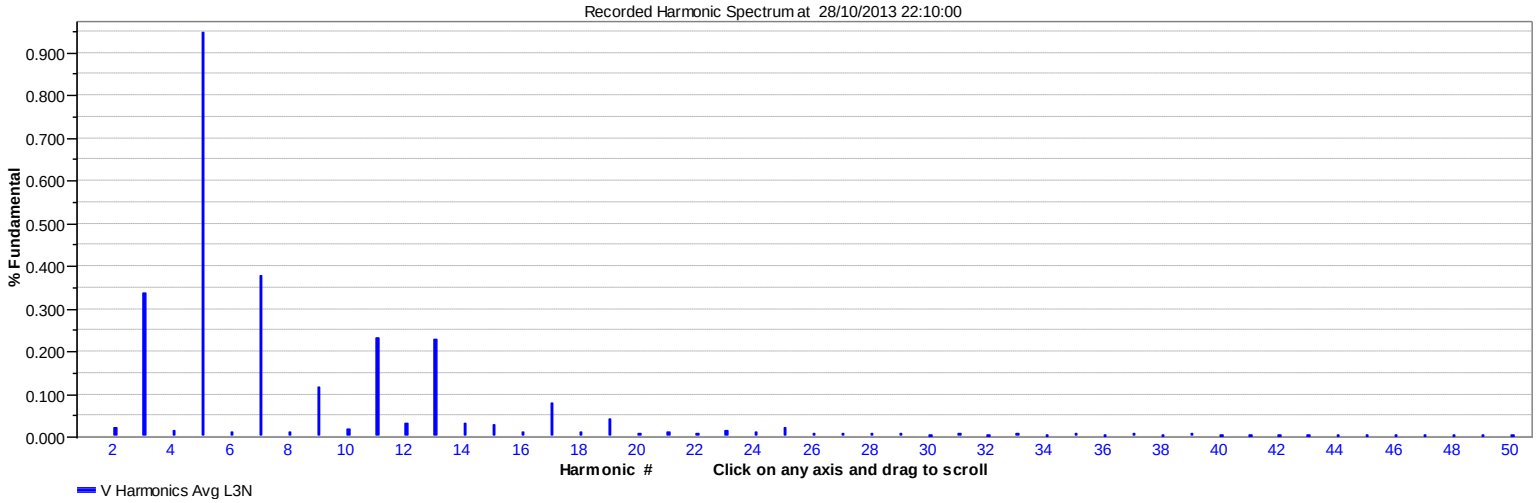
- The neutral-to-earth impulses indicate that there are wiring errors in the electrical wiring installation (intermittent single line-to-earth fault)
- These neutral-to-earth impulses can result in equipment damage over time and also can cause nuisance tripping of RCCB

#	Date/Time	Type	Duration (Days - Hrs:Min:Sec)	% of Nominal	Absolute	Triggered Phase /
2,667	31/10/2013 12:24:23.145.688	Swell	0 - 00:00:47.317901700	111.36%	256.14 V	L3N
2,668	31/10/2013 12:27:05.945.791	Swell	0 - 00:00:05.990256900	110.01%	253.02 V	L3N
2,669	31/10/2013 12:27:20.921.901	Swell	0 - 00:00:44.917607300	110.22%	253.51 V	L3N
1	21/10/2013 13:59:25.390.465	Swell	0 - 00:00:00.050000400	52.12%	119.86 V	NG
651	24/10/2013 15:22:00.889.792	Swell	0 - 00:00:00.030026800	57.71%	132.74 V	NG
652	24/10/2013 15:22:12.286.630	Swell	0 - 00:00:00.039936300	67.98%	156.36 V	NG
653	24/10/2013 15:22:19.928.222	Swell	0 - 00:00:00.030004600	40.50%	93.146 V	NG
654	24/10/2013 15:22:32.491.978	Swell	0 - 00:00:00.010004200	52.76%	121.35 V	NG
1,557	27/10/2013 19:10:06.070.141	Swell	0 - 00:00:00.050085600	81.07%	186.47 V	NG
1,824	28/10/2013 19:32:25.088.731	Swell	0 - 00:00:00.060067600	29.83%	68.611 V	NG
1,825	28/10/2013 19:32:25.489.252	Swell	0 - 00:00:00.069996600	32.83%	75.505 V	NG
1,826	28/10/2013 19:32:25.589.285	Swell	0 - 00:00:00.060145300	51.40%	118.23 V	NG

Findings

Harmonic Summary

- The average VTHD of phase L1N, phase L2N and phase L3N at P1 are 1.03 %, 1.09 % and 1.14 % respectively.
- The values of VTHD are acceptable and within the limit (8 % based on IEC 61000-2-2).

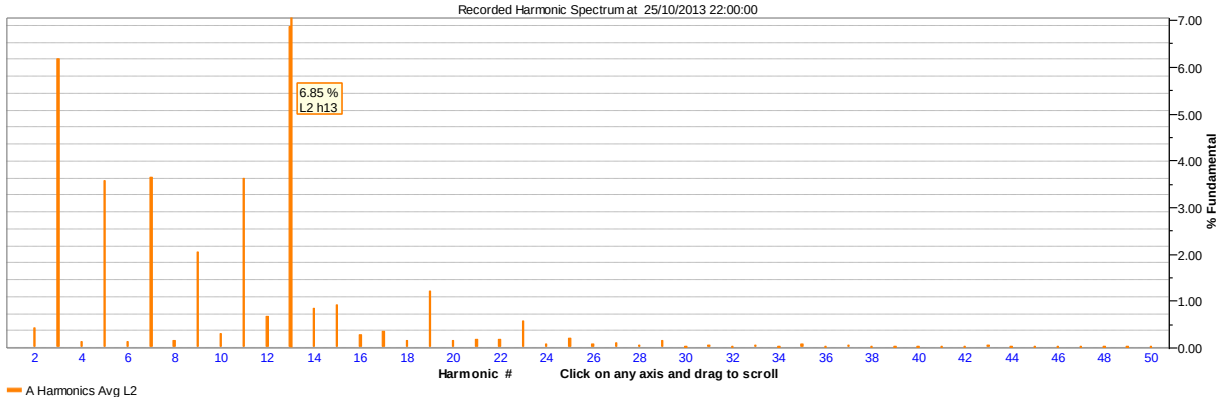


Phase	Max	Time	Min	Time
V THD Avg L3N	1.14 % THD	28/10/2013 22:20:00	0.59 % THD	28/10/2013 08:30:00

Findings

Harmonic Summary

- The average ITHD of phase L1, phase L2 and phase L3 at P1 are 2.88 %, 3.43 % and 2.75 % respectively. The values of ITHD are low therefore they do not contribute to the distortion of the supply voltage
- Evaluation of the results clearly shows that the capacitor failures at MSB No. 2 are not caused by harmonics.

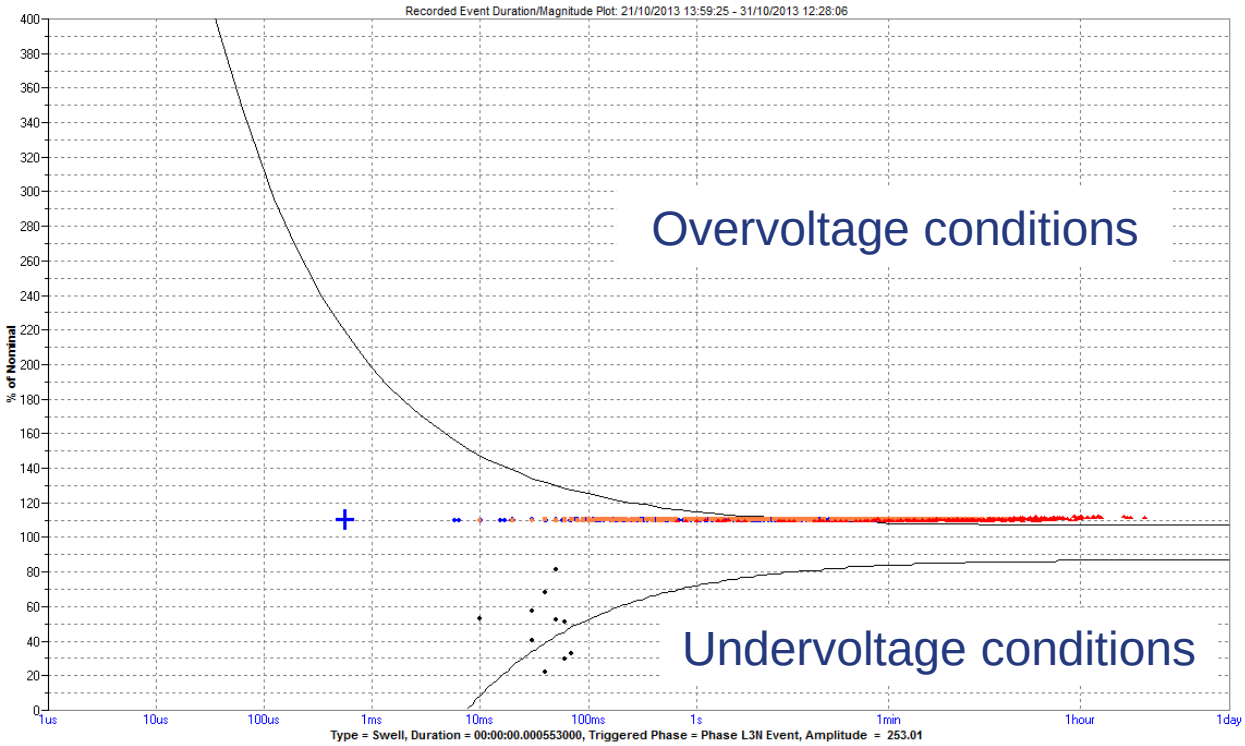


Phase	Max	Time	Min	Time
A THD Avg L2	12.07 % THD	25/10/2013 22:10:00	3.43 % THD	25/10/2013 09:10:00

Findings

Event Summary

- There are a total of 2670 recorded events, all of which are overvoltages.
- These overvoltages will stress the insulation of the equipment and can significantly shorten the lifespan of the equipment.



Computer and Business Electronic Manufacturers Association (CBEMA) tolerance curve

Conclusion

- The supply voltage exceeds the rated voltage of the capacitor (440 V) and this overvoltage has caused the damage to the capacitors. It also shortens the life expectancy of the capacitors
- When the capacitor case expands upward, it indicates that the capacitor has reached end of service life (damage due to ageing).

Recommendations

Improvement of Electrical Wiring Installation

a) Check the wiring installation of the electrical system and correct all the wiring errors such as improper neutral-to-earth bond, intermittent single line-to-earth fault and improper cable joint.

b) Check for loose neutral connections.

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

d) Use exothermic welding connection between earthing conductor to the earth electrode.

Recommendations

Immediate Action to be taken

- Reduce the supply voltage to the nominal value by changing the position of the tap-changer of the transformer.
- At a supply of 400 V (3-phase), use power capacitors with a rated voltage of 525 V.

Thank You

PQ Team, CKE