

# CAPACITOR TECHNOLOGIES

## SAMPLE RECORDING

### Main Incomer Power Analysis

**POWER RECORDING ON THE MAIN INCOMER  
MAIN SUPPLY FEEDER IN ORDER  
TO DETERMINE VOLTAGE QUALITY  
AND POWER SYSTEM HARMONIC LEVELS**

*18 January 2008*

**PREPARED FOR :**

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## Sample Recording – Main Incomer

### **EXECUTIVE SUMMARY**

**Capacitor Technologies was requested to measure the power on the Sample Recording Main Incomer LV Supply feeder in order to determine the voltage quality. Power system harmonics were measured in order to evaluate the possible effects on equipment failure.**

**Measurements were undertaken from Friday 12 January to Friday 19 January 2007.**

**Although the harmonic levels measured at Main Incomer were found to fall within the NRS 048 specification of recommended limits for harmonics, the voltage total harmonic distortion levels recorded may be cause early failure of 400 V power factor correction capacitors.**

**The International recommended limit for voltage total harmonic distortion is 5 %. It is generally reported in the literature that values of THD greater than 5 % could lead to failure of electronic equipment, printed circuit boards and computerized equipment.**

**We therefore recommend that Harmonic Filtering equipment and lightning / surge protection should be installed at Main Incomer to prevent further failures. Due to the small amount of reactive power measured on the network, an active harmonic filter is recommended.**

**Dudley G. Stevens**

# Sample Recording – Main Incomer

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- iv) 10-Minute average voltage graphs
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### B : HARMONIC MEASUREMENTS – SUBSTATION A MAIN SUPPLY

- i) Tabled results – average, maximum values
- ii) Harmonic power Flow - Table
- iii) Voltage Harmonic Graphs
- iv) Current Harmonic Graphs

# Sample Recording – Main Incomer

## 1.) INTRODUCTION

A power recording was carried out on the Sample Recording Main Incomer Main Supply Feeder in order to determine voltage quality. Power system harmonic levels were measured in order to evaluate the possible effects on equipment failure.

Current, voltage and frequency measurements were made as part of the power analysis recordings.

## 2.) MEASUREMENTS

CIRCUTOR AR5 power analyser was installed on the Main Incomer Main Supply Feeder from 12 - 19 January 2007

The AR5 recorder measures harmonic current and voltage levels as well as phase angles to allow harmonic power flow to be determined. Current readings were taken in order to determine the symmetry of the power loading. Voltage and frequency measurements have also been reported.

## 3.) RESULTS

### a) Load Recording

The maximum demand recorded on the Main Incomer Main Incomer :

10-Minute Maximum Demand :        60,6 kVA @ Cos  $\phi$  = 0,938

The highest current recorded at was :

	<u>15-Min Average</u>	<u>1-Second Max</u>
Main Incomer :	109,2 A	134,0 A

### b) Quality of Supply

The voltage power quality readings recorded during the test period were:

Nominal Voltage		230.94 V
Voltage Out-of-Balance		0.72%
Maximum Frequency Variation		0.74%
Voltage Regulation	+	4.79%
	-	-0.03%

The load recording results are attached in Appendix A.

b) Power System Harmonics

Transformer No. 8 :

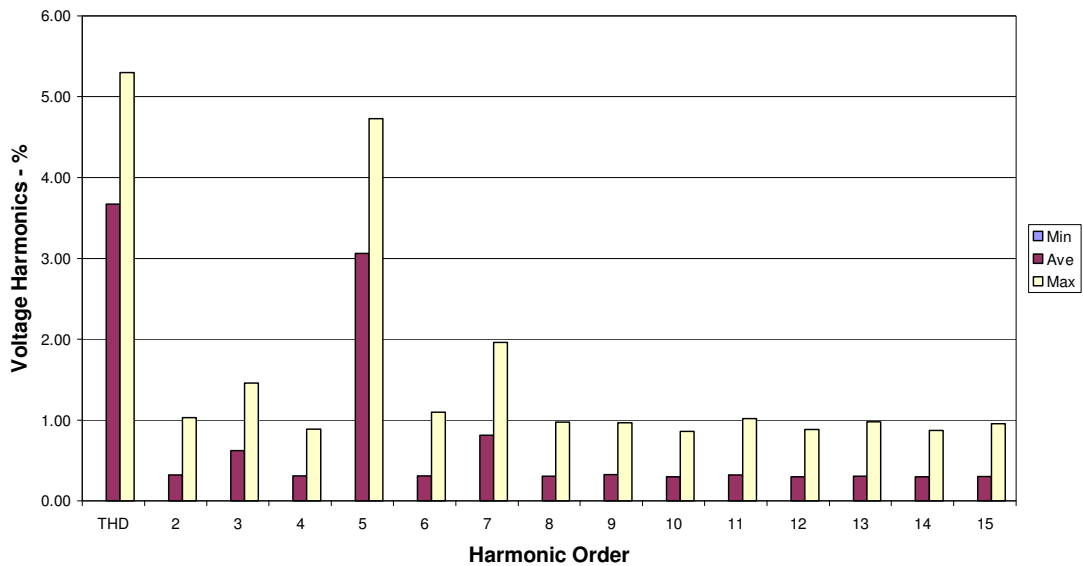
The individual highest values measured on the LV Main Incomer were :

Fundamental	243,00 V	194,92 amps	56,8 kW
<u>Harmonic</u>	<u>Voltage (%)</u>	<u>Current (amps)</u>	<u>Max Power (watts)</u>
3 rd	1,46	11,65	- 13,37
5 th	4,73	10,17	+ 45,35
7 th	1,96	2,70	+ 5,76
9 th	0,97	1,77	+ 2,78
11 th	1,02	1,44	- 1,73
13 th	0,98	1,16	+ 1,27
15 th	0,96	1,43	+ 0,99
THD	5,30 %	30,50 %	

The 5<sup>TH</sup> harmonic power flow is from the supply into the load. The other harmonic loadings are of low magnitude.

Voltage Harmonic Orders

**Sample Recording - Main Incomer**



A complete set of the harmonic recording results is attached in Appendix B.

4) POWER FACTOR CORRECTION EQUIPMENT

No power factor correction equipment is installed at Main Incomer.

5) RECOMMENDED HARMONIC LIMITS

The recommended limit for voltage THD in South Africa is 8 %. The internationally accepted limit for low voltage systems is 5 %. This limit of 5 % is the acceptable limit for computer and data processing power supplies. Microprocessor and computerised equipment (including PLC's) may experience problems if voltage total harmonic distortion exceeds this level.

Although the power system harmonics measured fall within the NRS 048 requirements, failure of electronic equipment has occurred at Main Incomer, which we would attribute to possible harmonic overloading.

6) EFFECTS OF HARMONICS ON THE POWER SYSTEM

Current harmonics generally lead to higher current levels in the system and overheating of equipment. This can lead to early ageing and failure of equipment.

Generally frequently blown fuses and capacitors in the power factor correction equipment is one of the first indications of high harmonic levels in the plant.

HIGH NEUTRAL CURRENT

3 rd harmonic currents are additive in the neutral on LV power networks. In 3-wire delta-connected loads such as motors and power factor correction capacitors, 3 rd harmonic currents are not a problem as the 3 rd harmonic voltages are generally in phase across a delta connected load. Neutral currents should be monitored in single-phase loads such as lighting circuits.

High harmonic neutral currents should not be a problem at Main Incomer

INCREASED PEAK VOLTAGE

Voltage harmonics increase the peak voltage of the voltage waveform. This can lead to voltage overstressing of insulation and capacitor dielectrics, leading to premature ageing and breakdown. Again, at the harmonic levels recorded on the substation, we would not expect any harmonic related problems of this nature.

7) RECOMMENDATIONS

Although the power system harmonics fall within the NRS 048 standard, the total harmonic distortion was in excess of internationally recommended limits. Should failure of computerized and solid-state equipment occur at Main Incomer, harmonic filtering should be installed. Due to the small amount of reactive power on the circuit, an active harmonic filter is the recommended option.

The installation of lightning and surge protection is also recommended in order to prevent premature equipment failure.

8) CONCLUSIONS

The power system harmonics measured at Main Incomer fall within the NRS 048 standard. The highest voltage total harmonic distortion of 5,2 % may be the cause of electronic equipment failure. Harmonic filtering equipment and lightning / surge protection should be installed at Main Incomer.

D.G. Stevens  
Engineering Consultant

# APPENDIX A

## SAMPLE RECORDING – MAIN INCOMER

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## SUMMARY OF RECORDED PARAMETERS

# Sample Recording

## Main Incomer

RECORDING FROM : Friday 12-Jan-2007 TO Friday 19-Jan-2007

RECORDING INTERVAL : 10 mins

				L1	L2	L3	III
10-Min Avr	Max	Voltage	(V)	241.0	242.0	241.0	241.0
10-Min Avr	Min	Voltage	(V)	231.0	234.0	232.0	232.0
1-Sec	Max	Voltage	(V)	243.0	246.0	244.0	
1-Sec	Min	Voltage	(V)	224.0	226.0	225.0	
10-Min Avr	Max	Current	(A)	109.2	93.2	62.7	86.6
1-Sec	Max	Current	(A)	134.0	106.5	101.2	
10-Min Avr	Max	Active Power	(kW)	24.4	20.2	13.6	56.8
10-Min Avr	Max	Ind. Power	(kVAr)	8.5	8.9	7.0	23.1
10-Min Avr	Max	Cap. Power	(kVAr)	1.5	0.1	1.0	2.2
10-Min Avr	Max	App. Power	(kVA)	25.5	21.8	14.6	60.6
10-Min Avr	Max	Power Factor		0.954	0.926	0.928	0.938

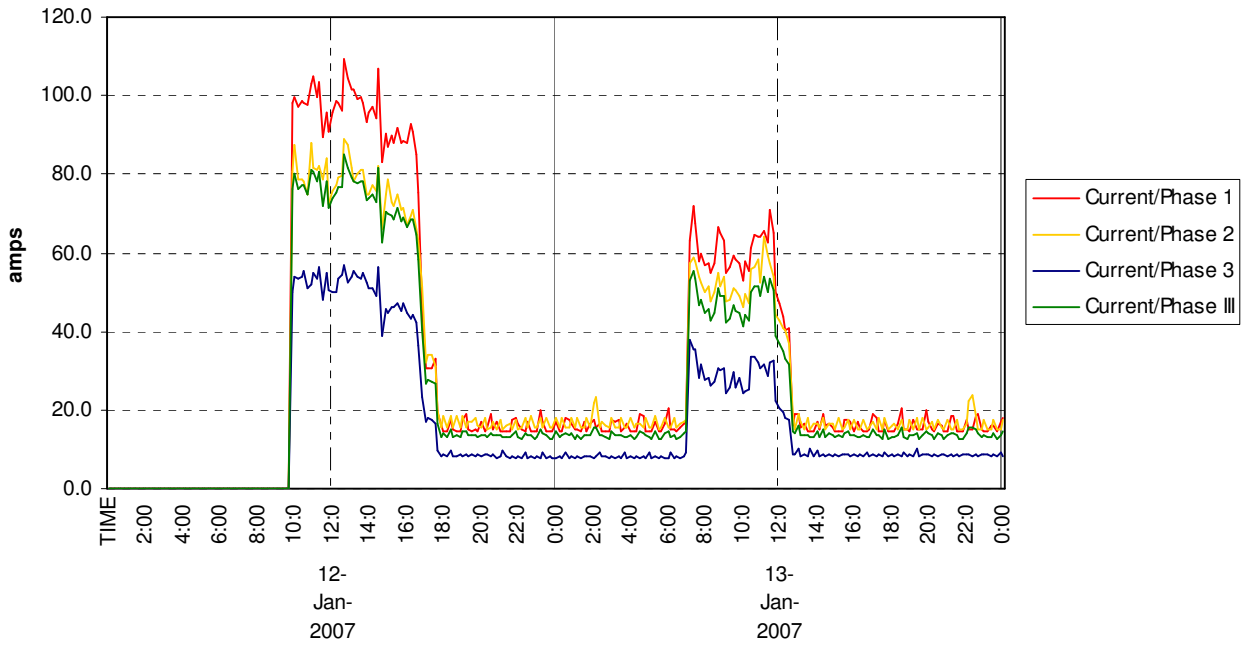
Avr.	Frequency	(Hz)	50.0
Max.	Frequency	(Hz)	50.2
Min.	Frequency	(Hz)	49.6

### Statistics :

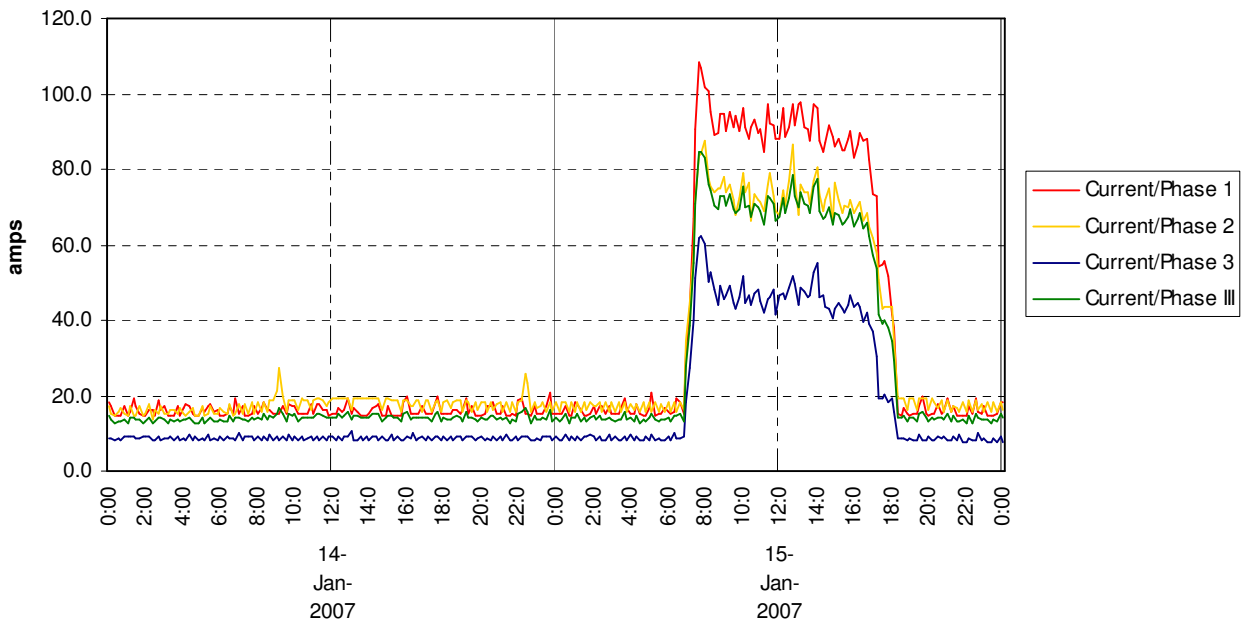
Nominal Voltage	230.94 V
Voltage Out-of-Balance	0.72%
Current Out-of-Balance	54.42%
Maximum Frequency Variation	0.74%
Voltage Regulation	+ 4.79%
	- -0.03%

# 10-MINUTE AVERAGE CURRENT GRAPHS

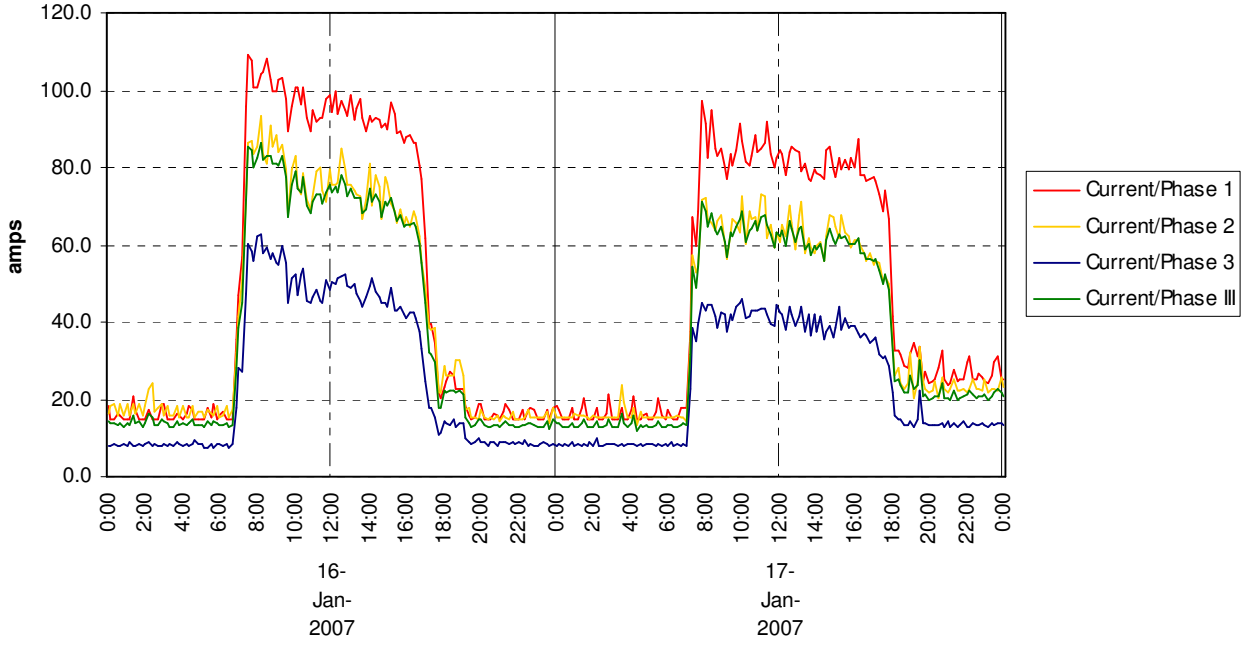
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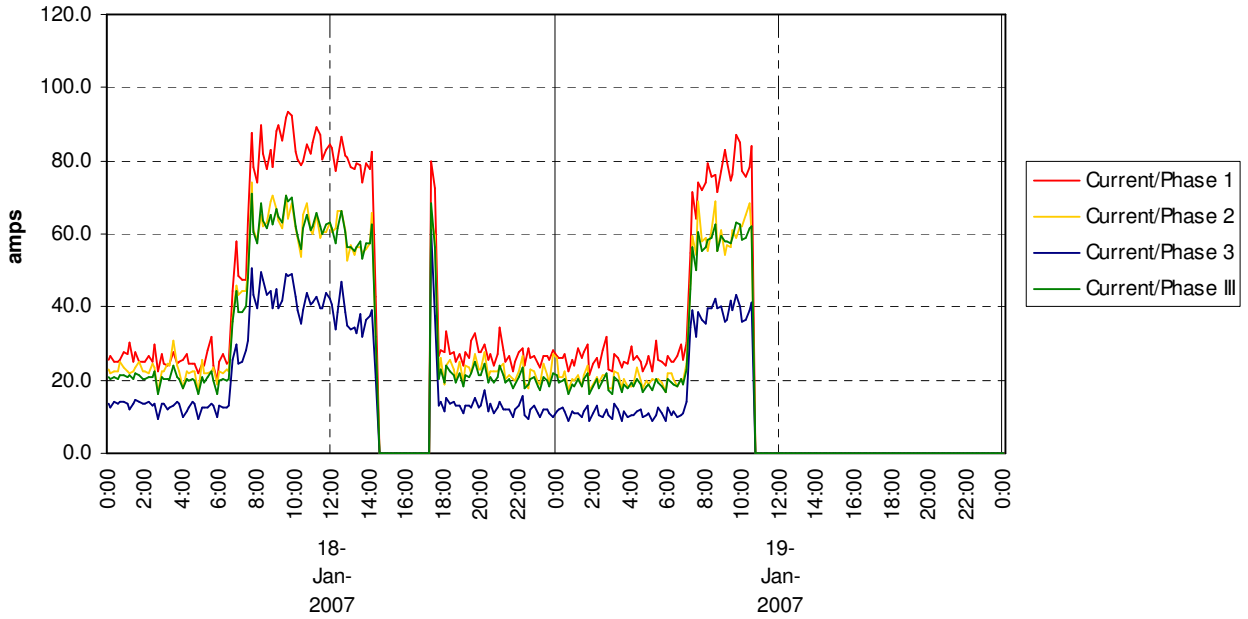
## Sample Recording - Main Incomer



### Sample Recording - Main Incomer

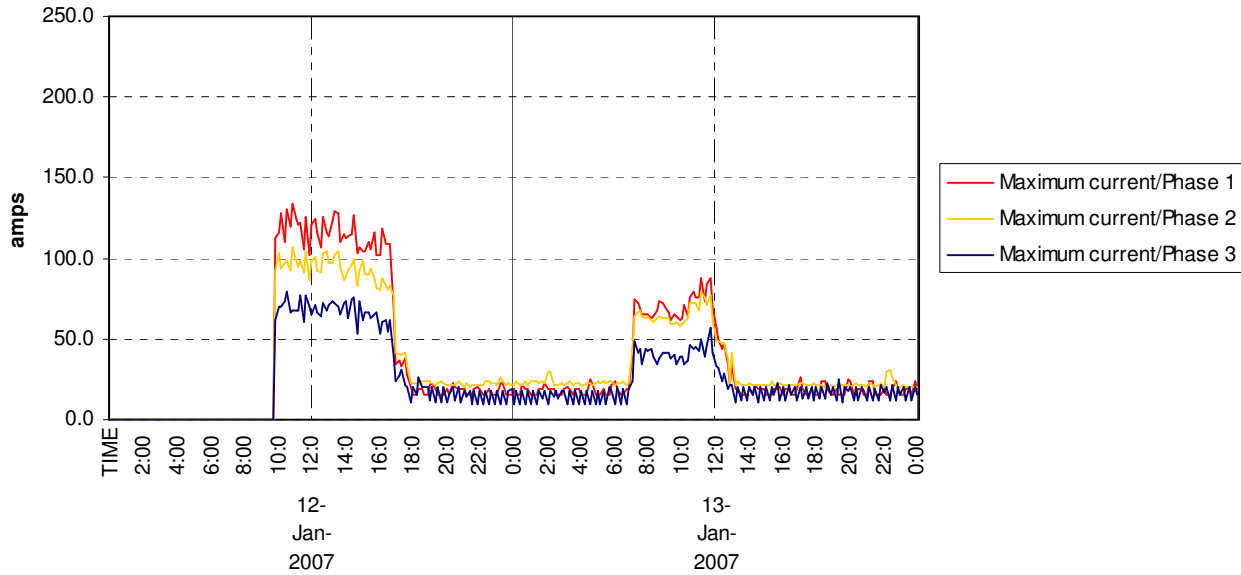


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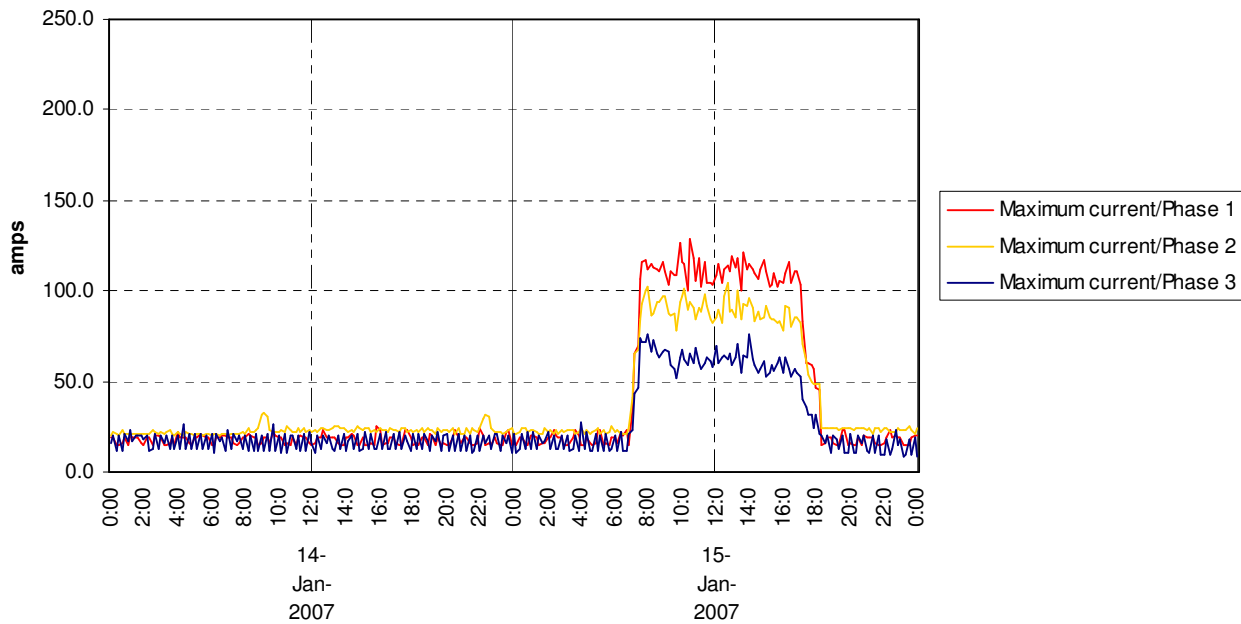


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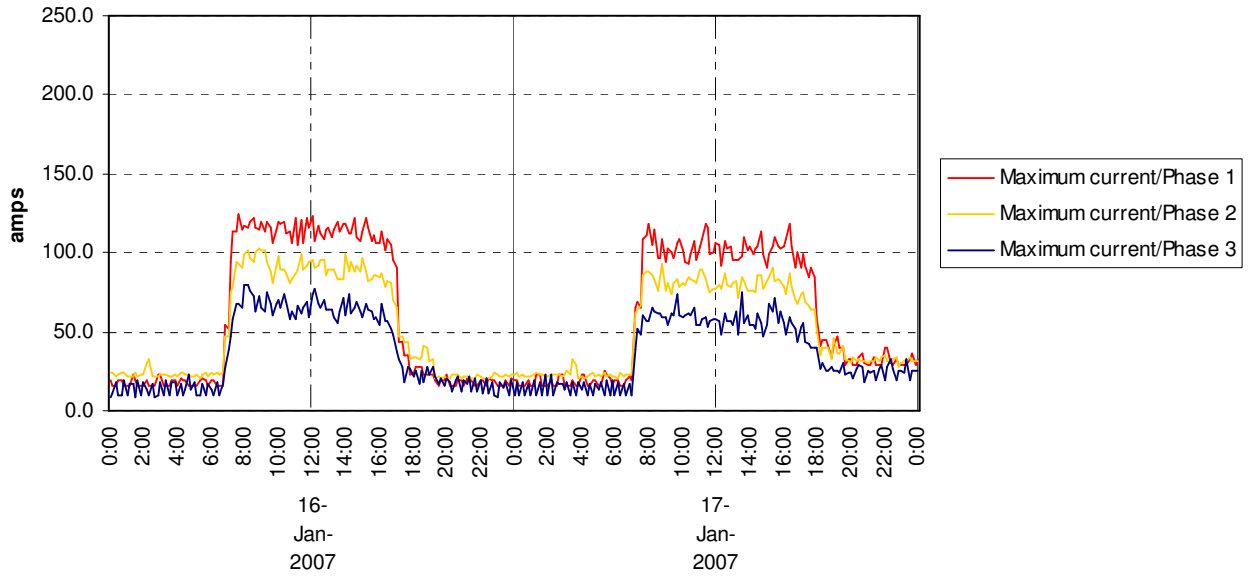
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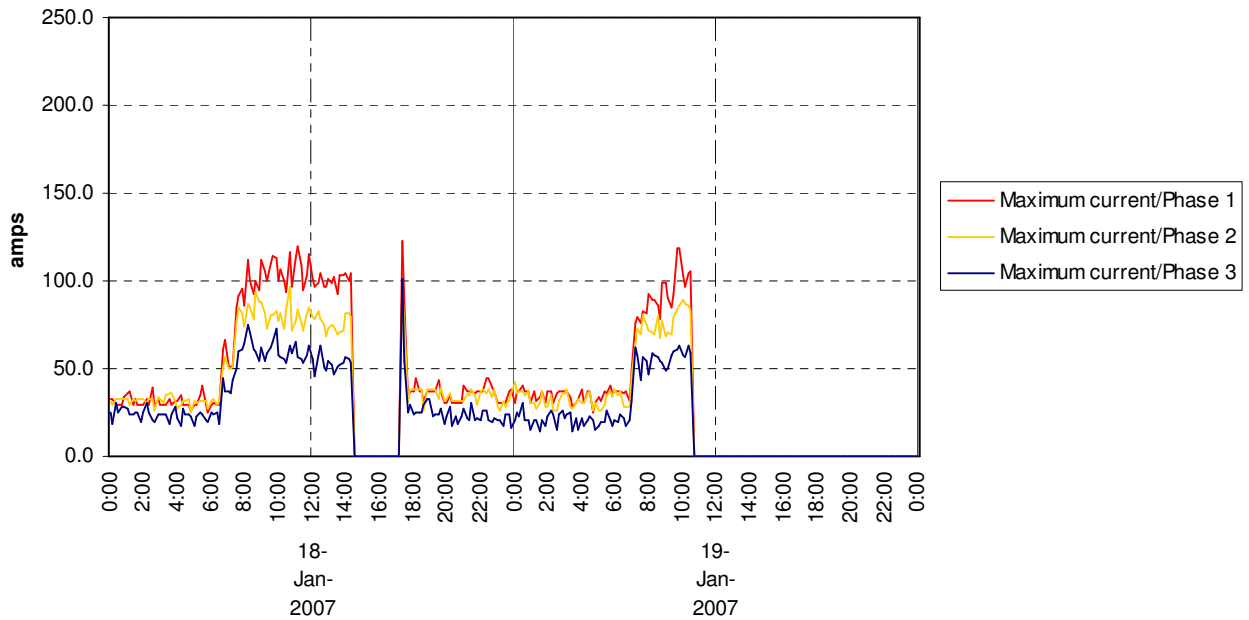
## Sample Recording - Main Incomer



### Sample Recording - Main Incomer

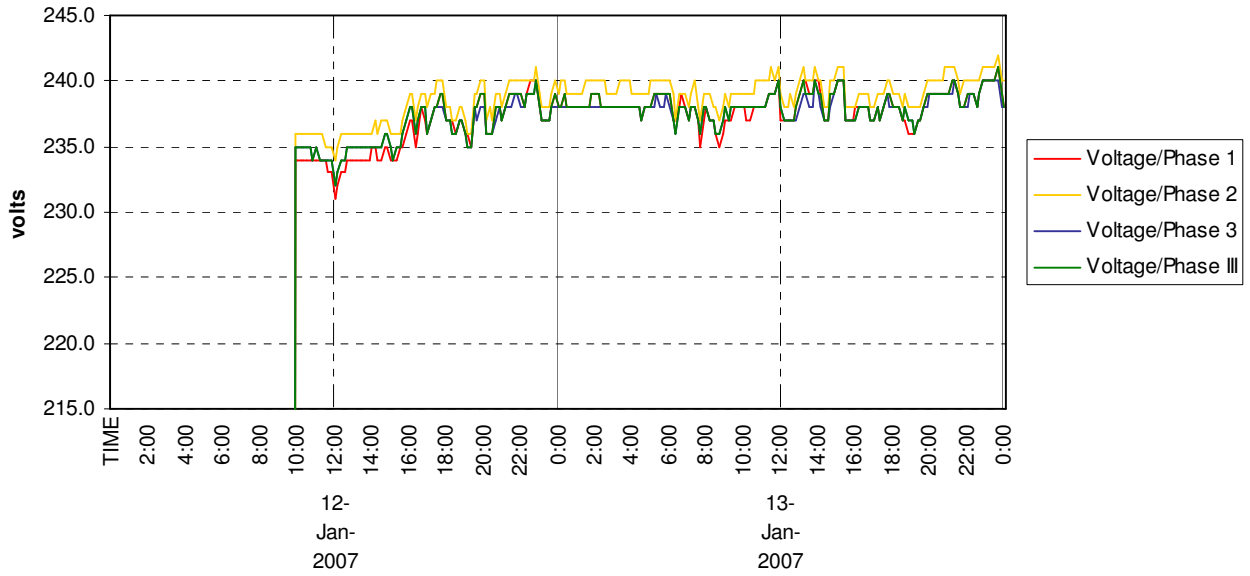


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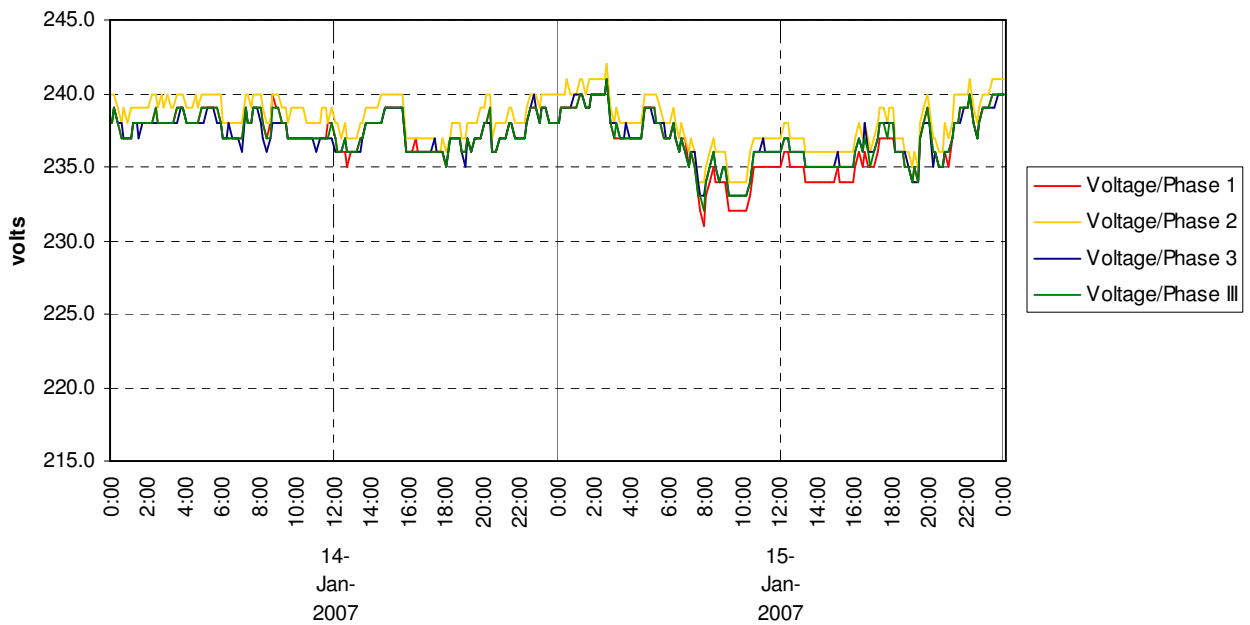


# 10-MINUTE AVERAGE VOLTAGE RECCORDING

## Sample Recording - Main Incomer



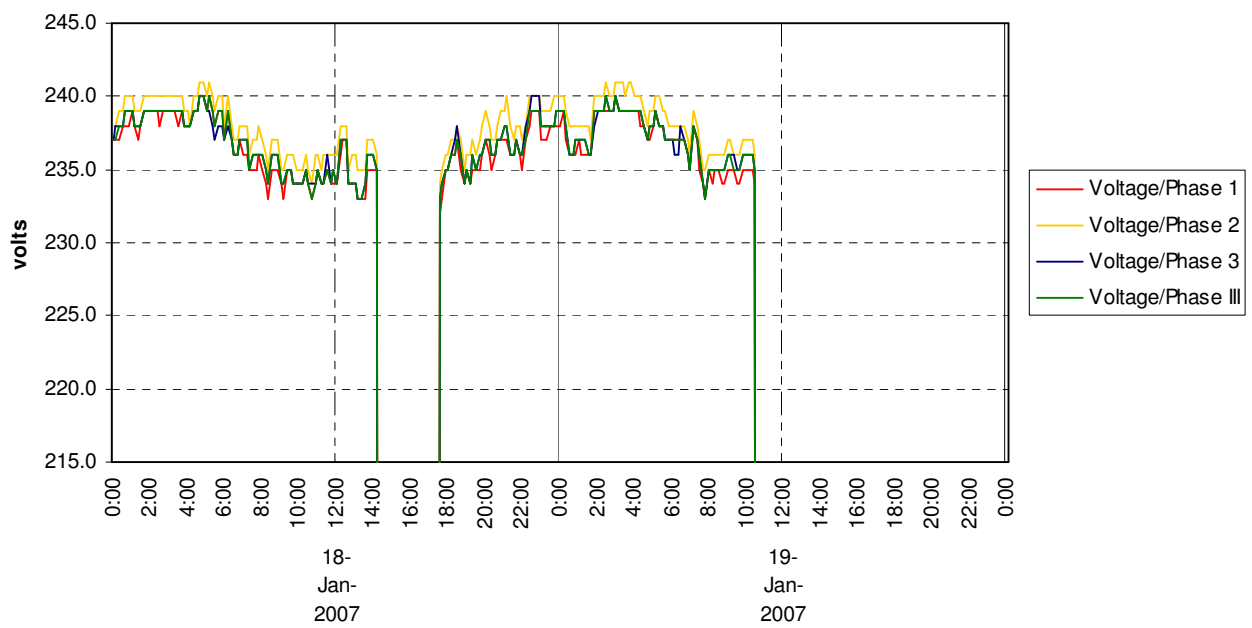
## Sample Recording - Main Incomer



### Sample Recording - Main Incomer

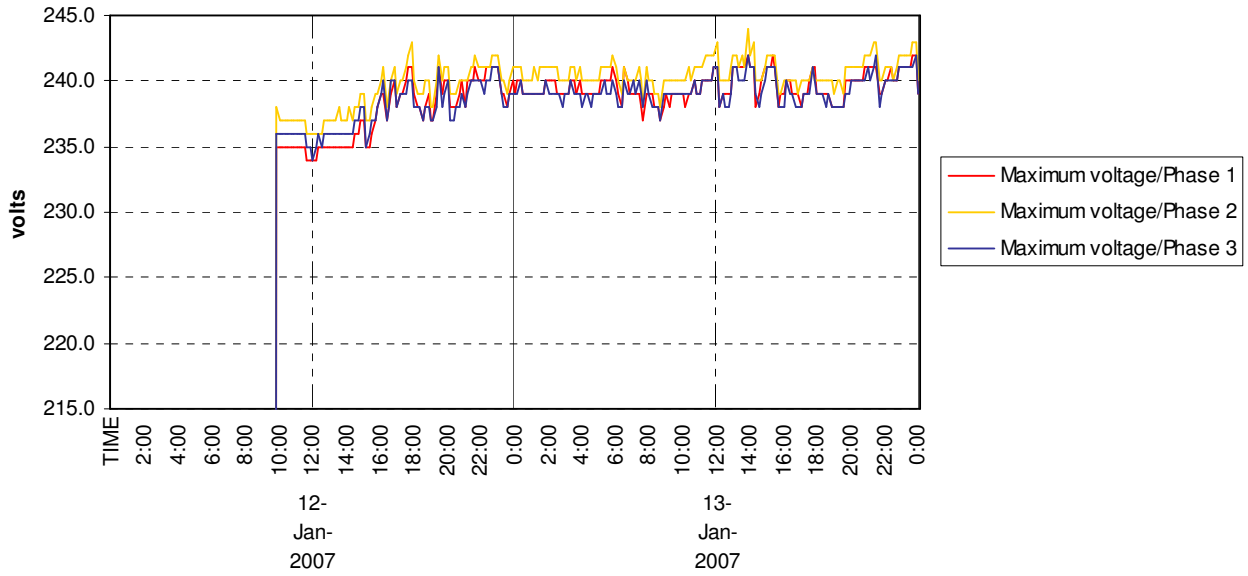


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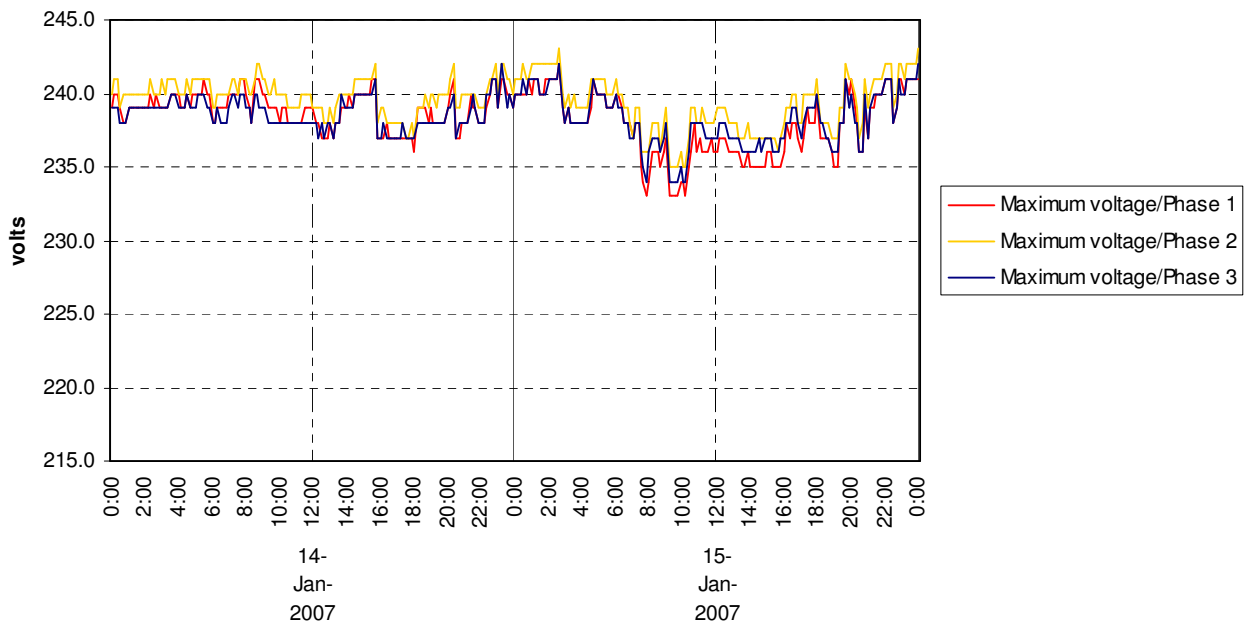


# 1-SECOND MAXIMUM VOLTAGE

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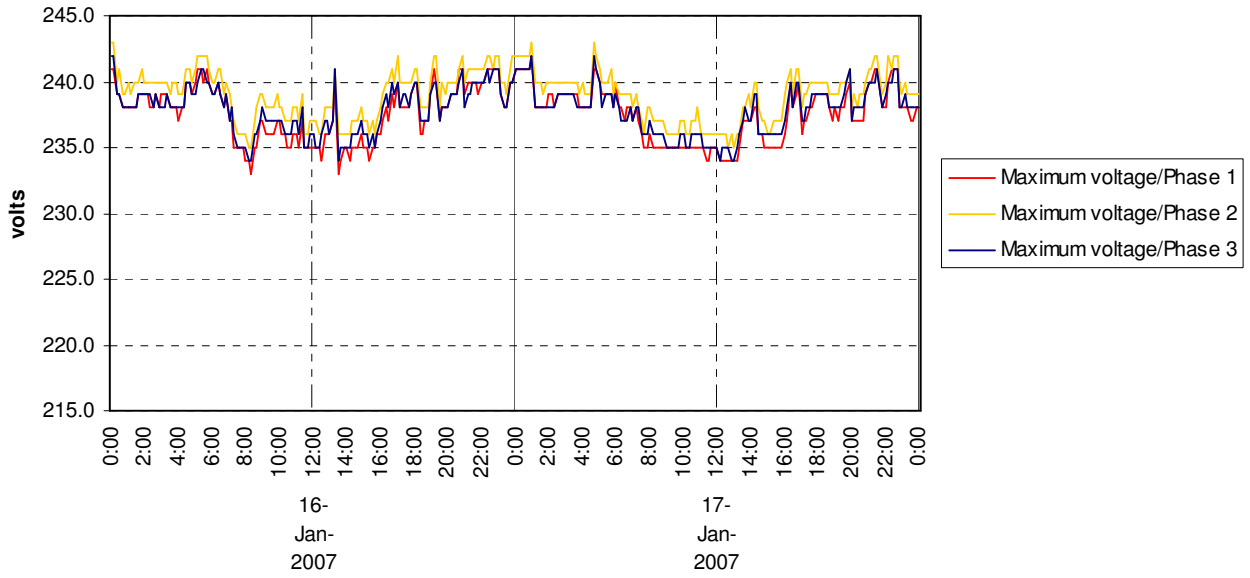


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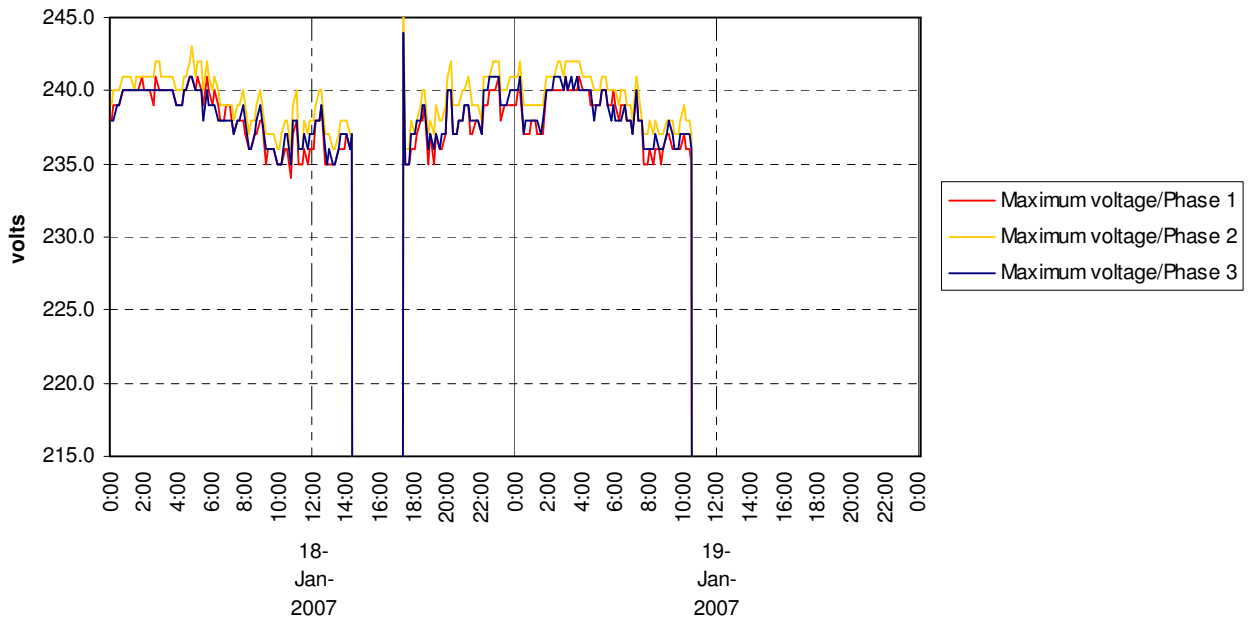




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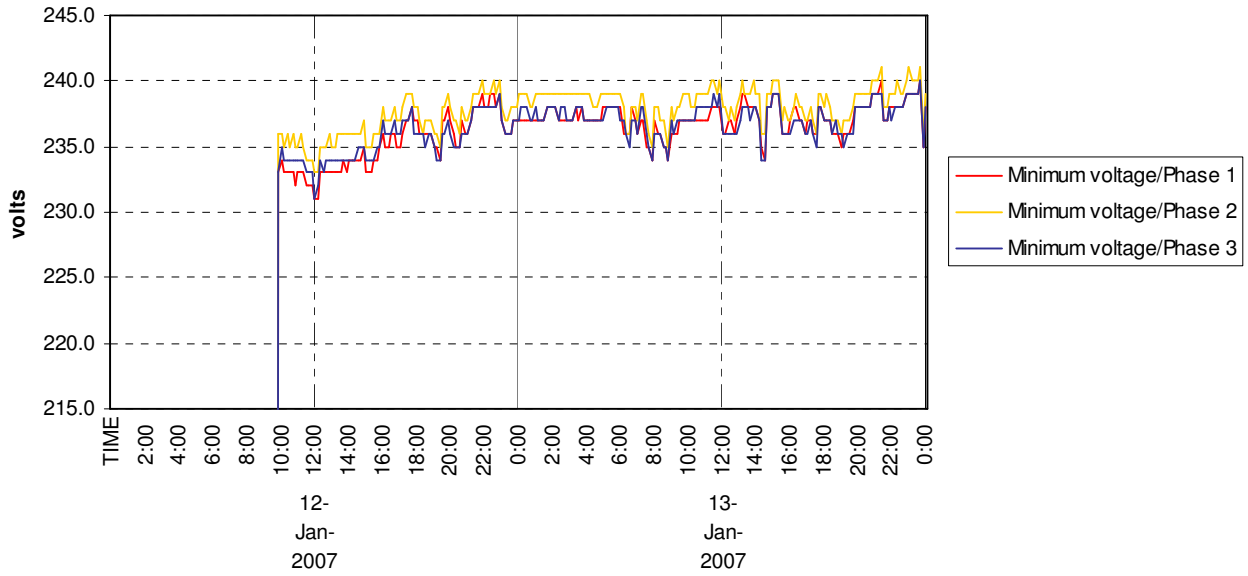


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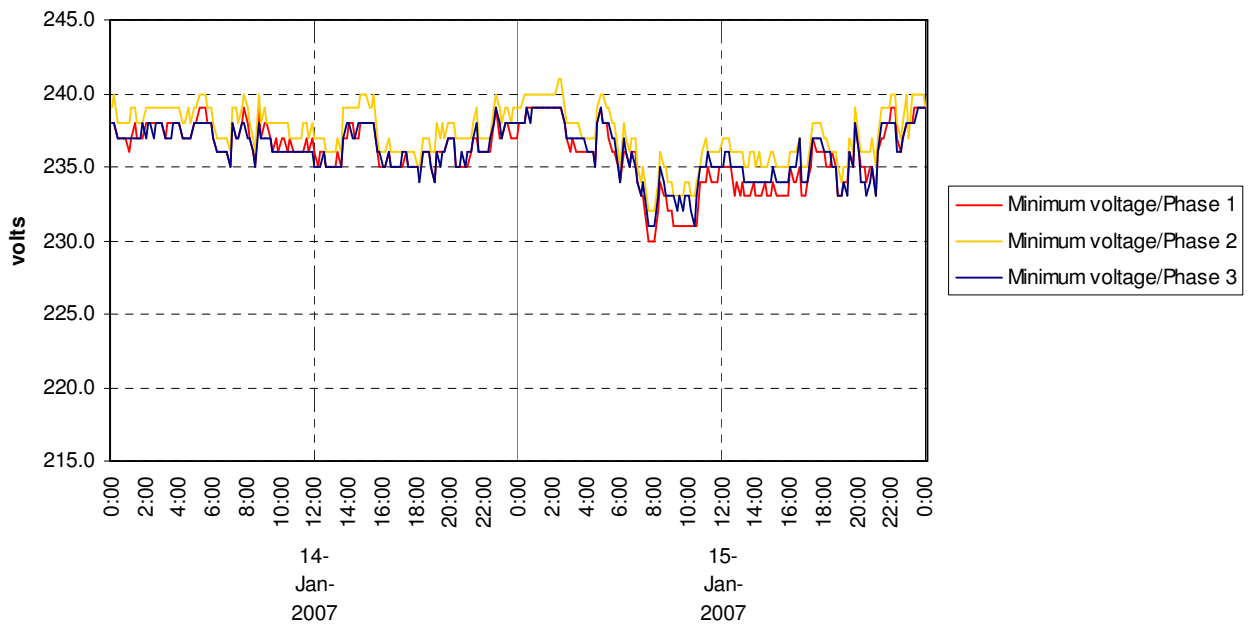


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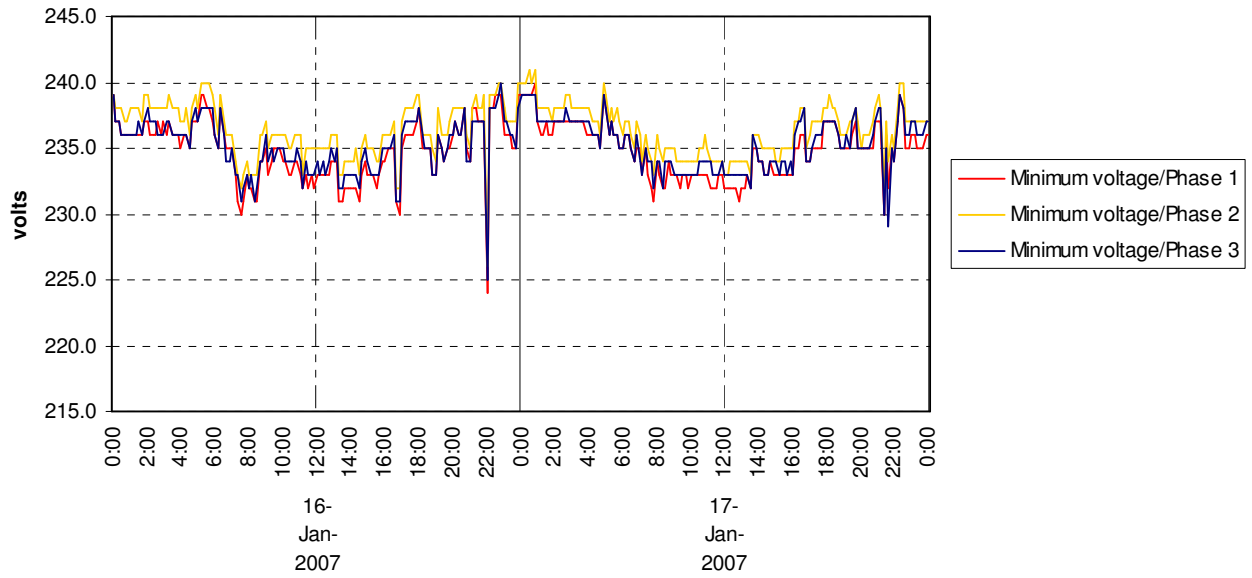
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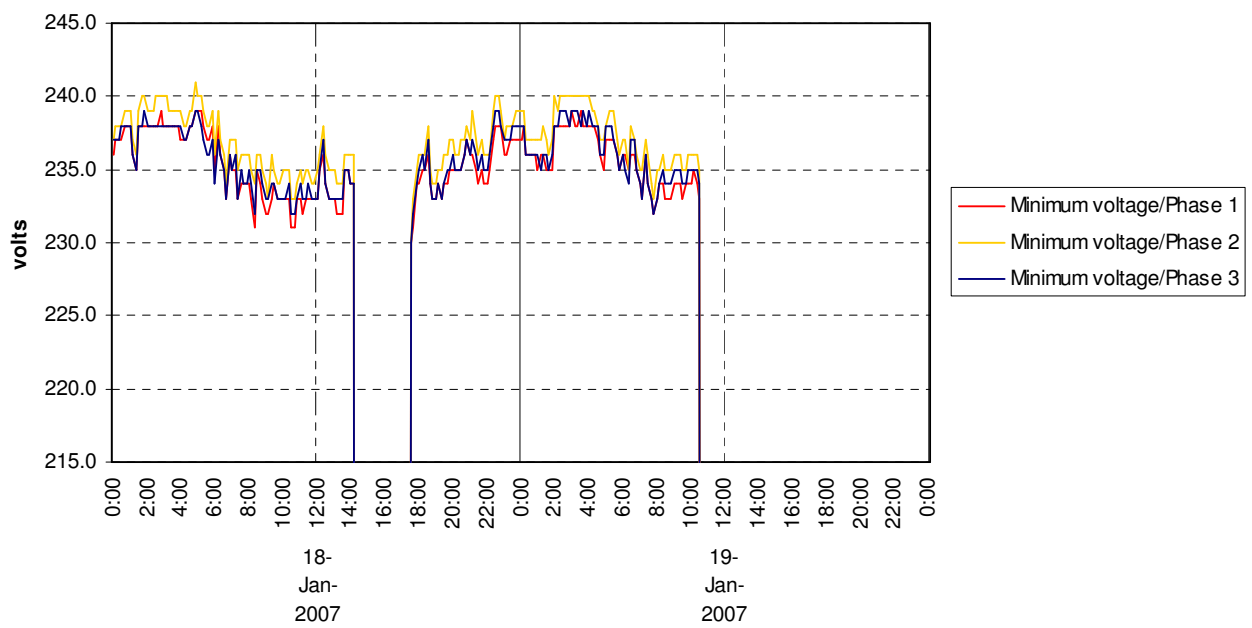
## Sample Recording - Main Incomer



### Sample Recording - Main Incomer

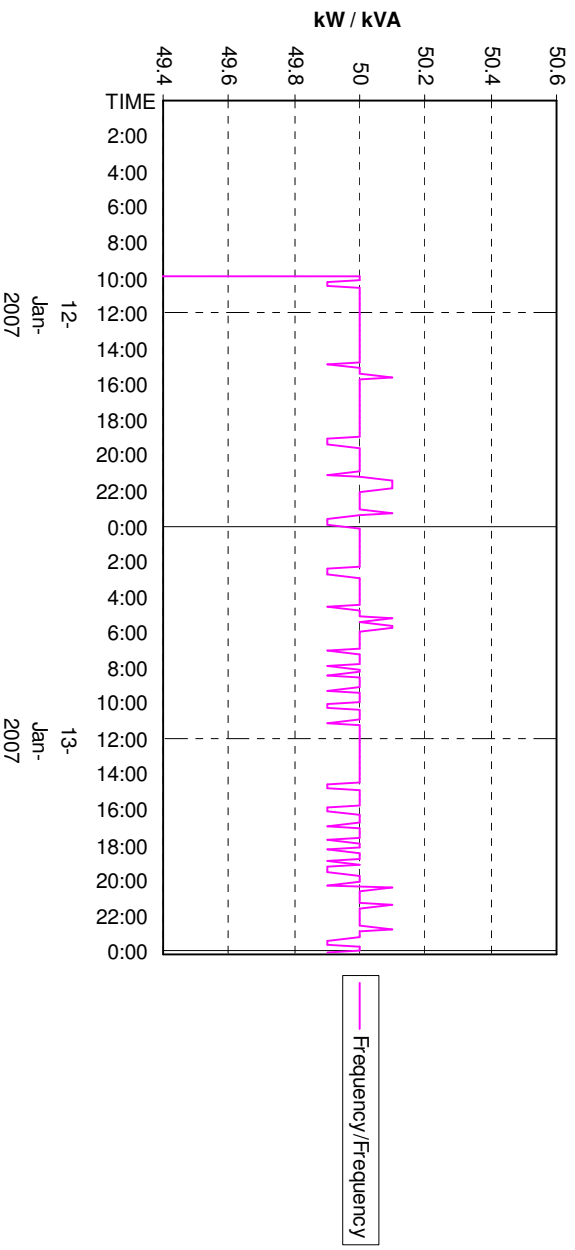


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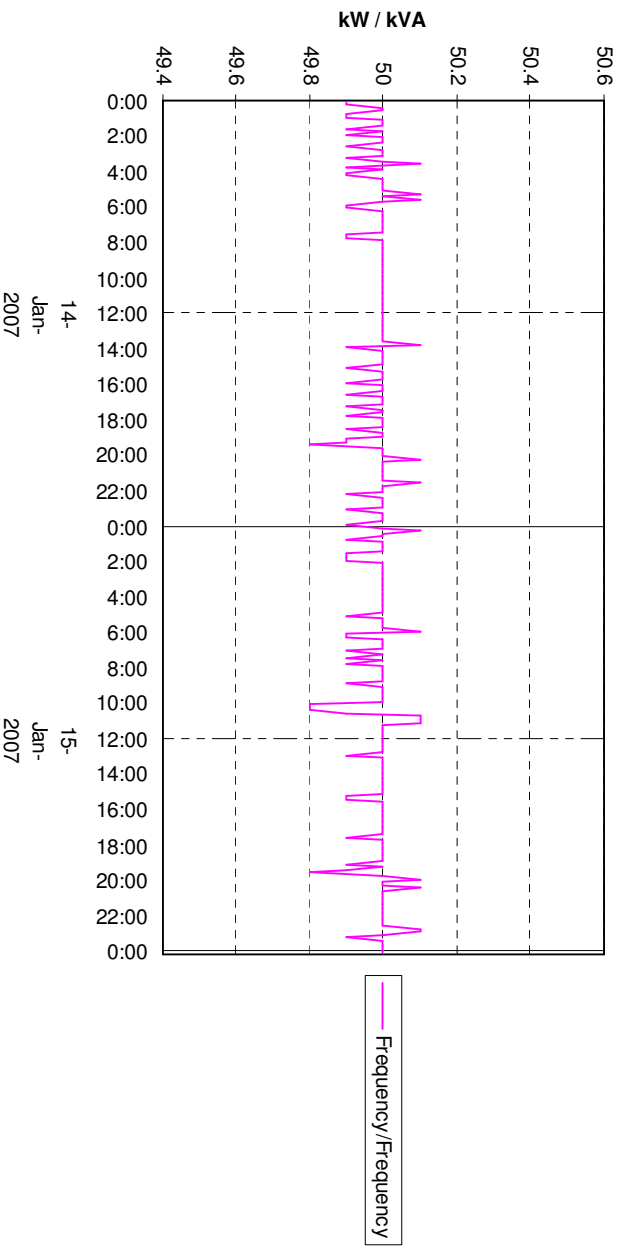


# FREQUENCY

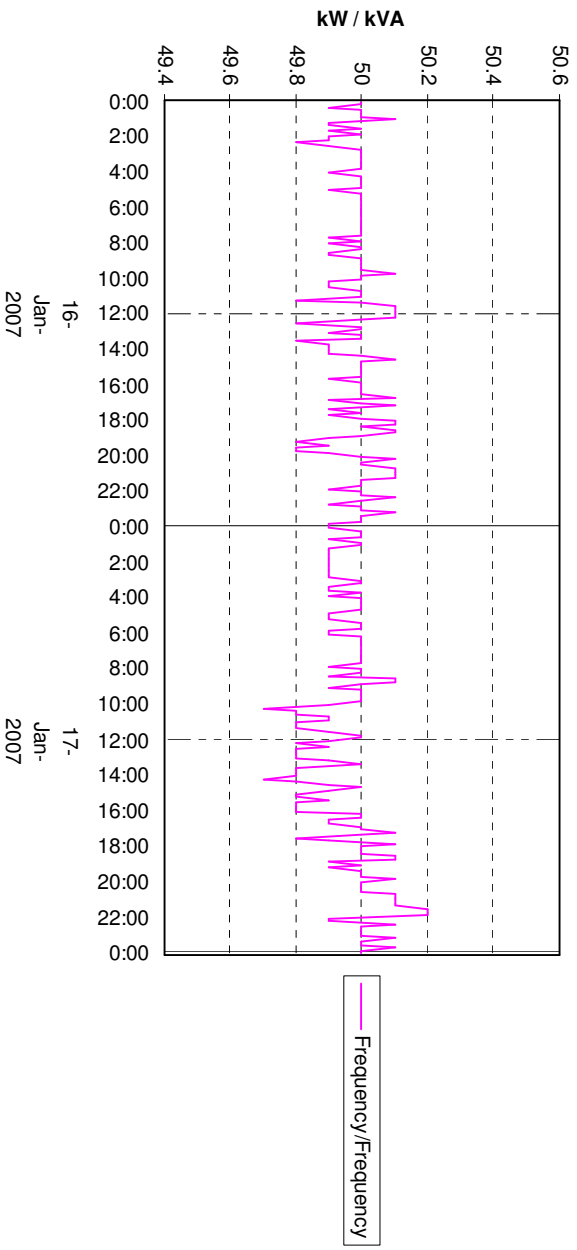
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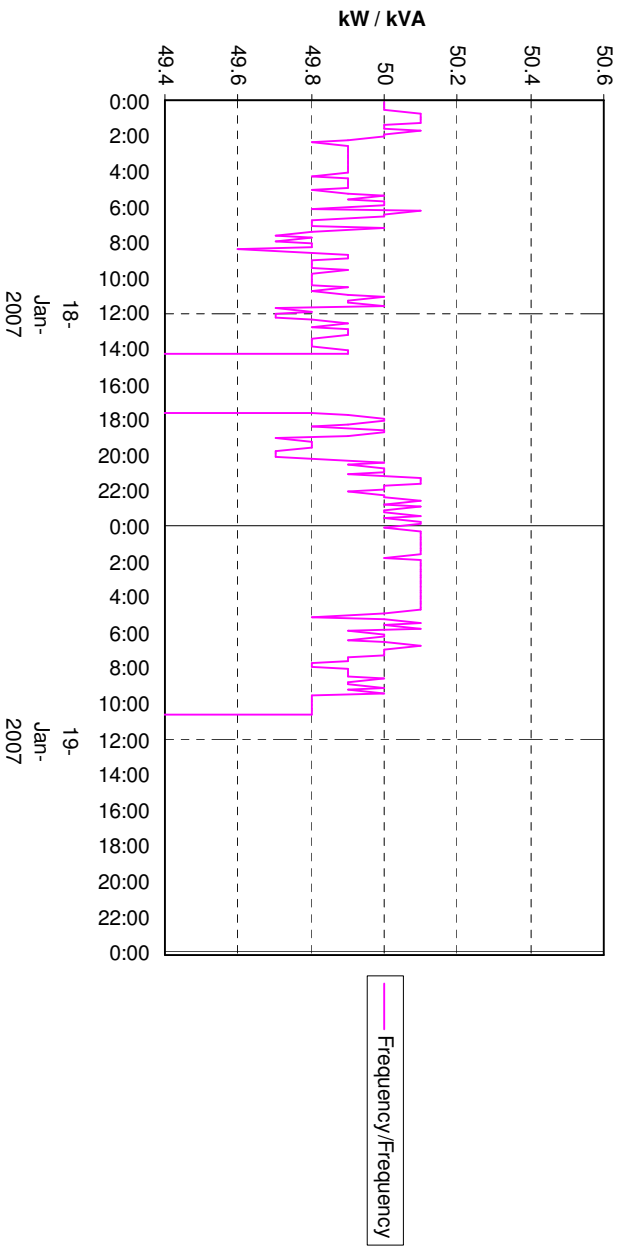
## Sample Recording - Main Incomer



### Sample Recording - Main Incomer

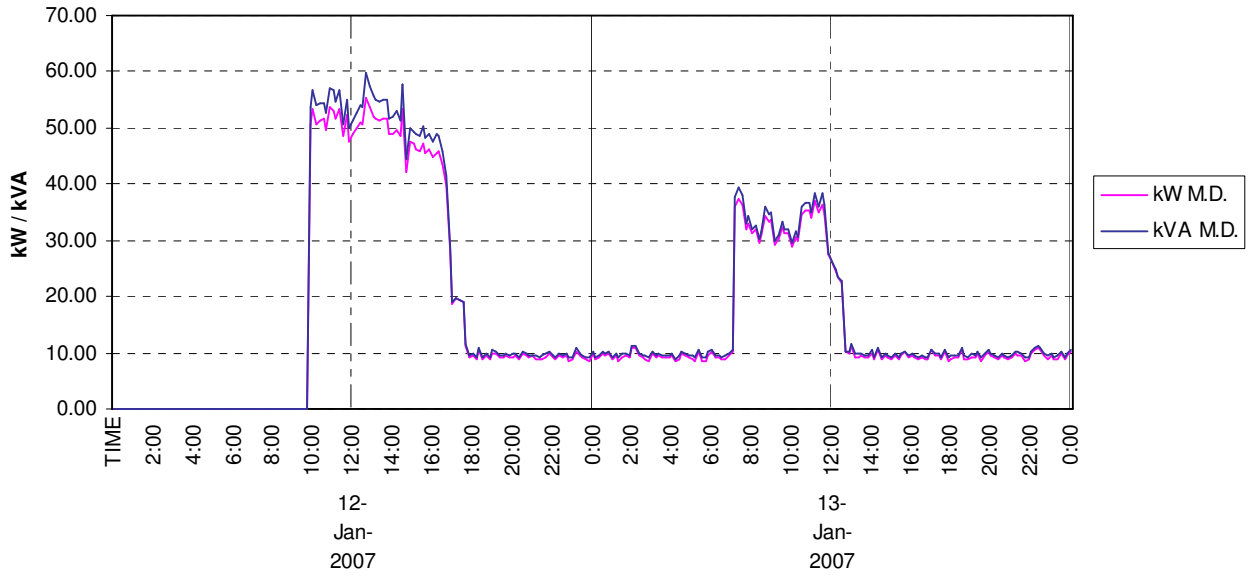


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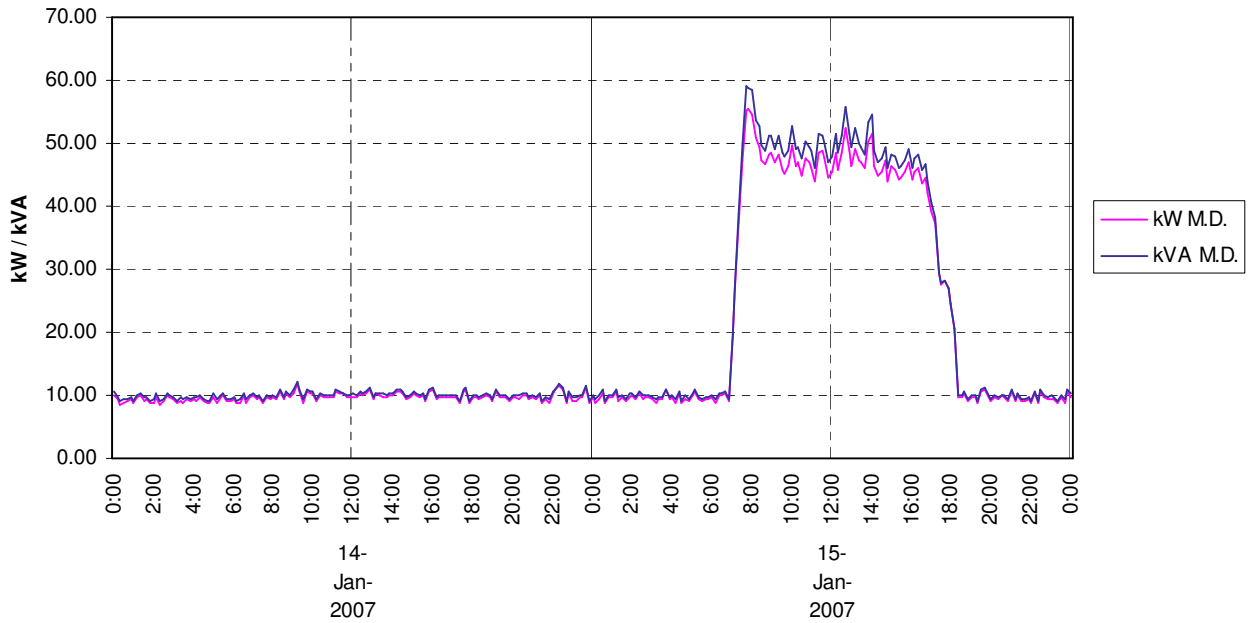


# 10-MINUTE AVERAGE KW / KVA LOAD PROFILE

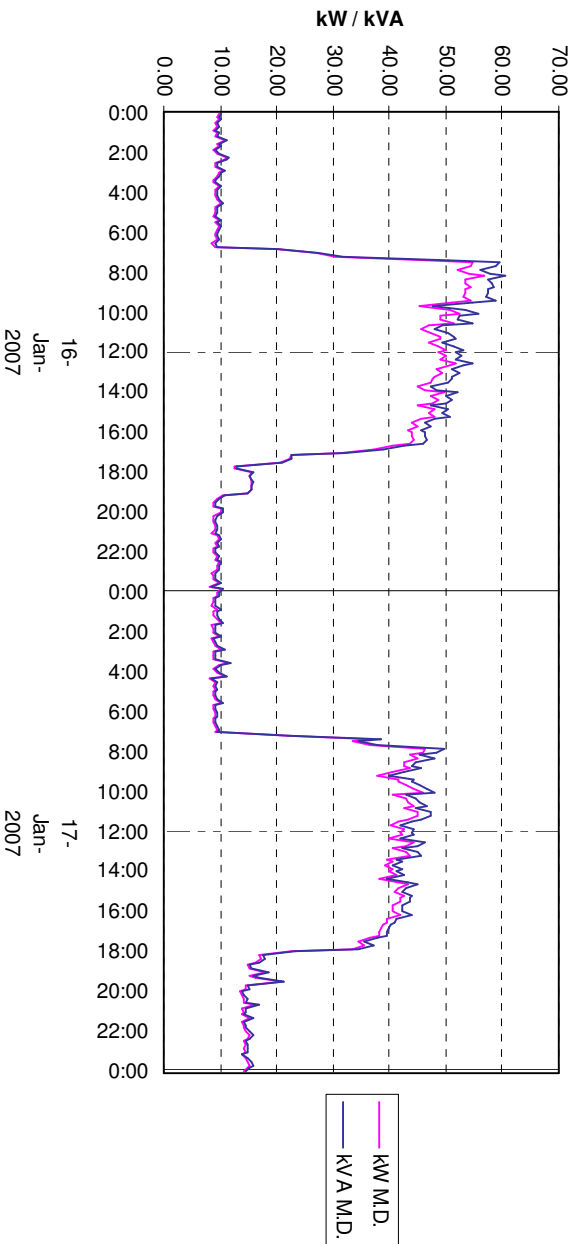
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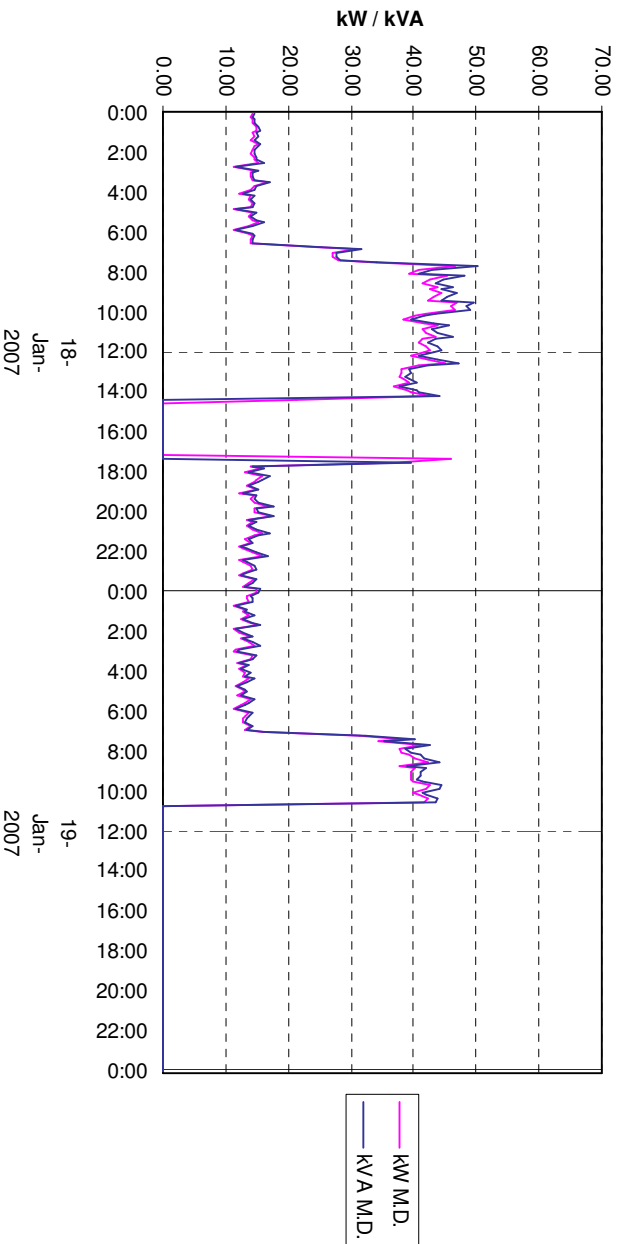
## Sample Recording - Main Incomer



### Sample Recording - Main Incomer



### Sample Recording - Main Incomer



# APPENDIX B

MAIN INCOMER HARMONIC RECORDING		Page
1)	Summary of Results – Average & Maximum Voltage & Current .....	24
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3)	Voltage Graphs .....	26 - 30
	a) Voltage Total Harmonic Distortion	
	b) Fundamental Voltage	
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	e) 7 th Harmonic Voltage	
	f) 9 th Harmonic Voltage	
	g) 11 th Harmonic Voltage	
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	a) Current Total Harmonic Distortion	
	b) Fundamental Current	
	c) 3 rd Harmonic Current	
	d) 5 th Harmonic Current	
	e) 7 th Harmonic Current	
	f) 9 th Harmonic Current	
	g) 11 th Harmonic Current	
	h) 13 th Harmonic Current	
	i) 15 th Harmonic Current	



# SUMMARY OF CURRENT AND VOLTAGE HARMONICS

## Main Incomer

### Sample Recording

JANUARY 2007

#### AVERAGE

	VOLTAGE			
	L1	L2	L3	
RMS	V	232.81	234.14	233.03
Fundamental	V	232.63	233.97	232.87
2 nd	%	0.32	0.33	0.31
3 rd	%	0.70	0.60	0.56
4 th	%	0.31	0.31	0.30
5 th	%	3.14	3.09	2.93
6 th	%	0.31	0.31	0.31
7 th	%	0.78	0.82	0.83
8 th	%	0.32	0.31	0.30
9 th	%	0.33	0.33	0.32
10 th	%	0.30	0.30	0.30
11 th	%	0.31	0.34	0.30
12 th	%	0.29	0.31	0.30
13 th	%	0.30	0.32	0.31
14 th	%	0.29	0.30	0.30
15 th	%	0.29	0.31	0.30
THD	%	3.75	3.70	3.55

	CURRENT		
	L1	L2	L3
A	42.04	34.54	21.18
A	41.78	34.21	21.03
A	0.16	1.21	0.15
A	2.10	2.01	1.08
A	0.06	0.10	0.05
A	1.99	2.03	0.84
A	0.07	0.11	0.06
A	0.51	0.59	0.23
A	0.07	0.08	0.06
A	0.27	0.32	0.23
A	0.07	0.07	0.05
A	0.24	0.29	0.13
A	0.06	0.06	0.05
A	0.21	0.20	0.16
A	0.05	0.05	0.04
A	0.08	0.07	0.14
%	7.54	10.71	9.06

#### MAXIMUM

	VOLTAGE			
	L1	L2	L3	
RMS	V	242.00	244.00	242.00
Fundamental	V	242.00	243.00	242.00
2 nd	%	1.03	0.97	0.87
3 rd	%	1.46	1.38	1.33
4 th	%	0.89	0.84	0.86
5 th	%	4.73	4.58	4.55
6 th	%	1.10	0.94	0.90
7 th	%	1.96	1.76	1.86
8 th	%	0.97	0.91	0.83
9 th	%	0.91	0.97	0.92
10 th	%	0.77	0.87	0.82
11 th	%	0.91	1.02	0.88
12 th	%	0.85	0.87	0.89
13 th	%	0.90	0.98	0.94
14 th	%	0.74	0.83	0.87
15 th	%	0.93	0.87	0.96
THD	%	5.20	5.30	5.00

	CURRENT		
	L1	L2	L3
A	195.25	171.14	100.65
A	194.92	170.53	100.50
A	1.70	4.90	2.26
A	11.65	11.44	6.52
A	0.49	0.56	0.82
A	10.17	7.81	4.24
A	0.40	0.60	0.73
A	2.29	2.44	2.70
A	0.46	0.51	0.67
A	1.77	1.64	1.24
A	0.51	0.46	0.60
A	1.27	1.44	1.11
A	0.45	0.41	0.54
A	1.16	1.14	1.08
A	0.47	0.41	0.42
A	0.52	0.67	1.43
%	15.20	17.40	30.50

# SUMMARY OF HARMONIC POWER

## Main Incomer

### Sample Recording

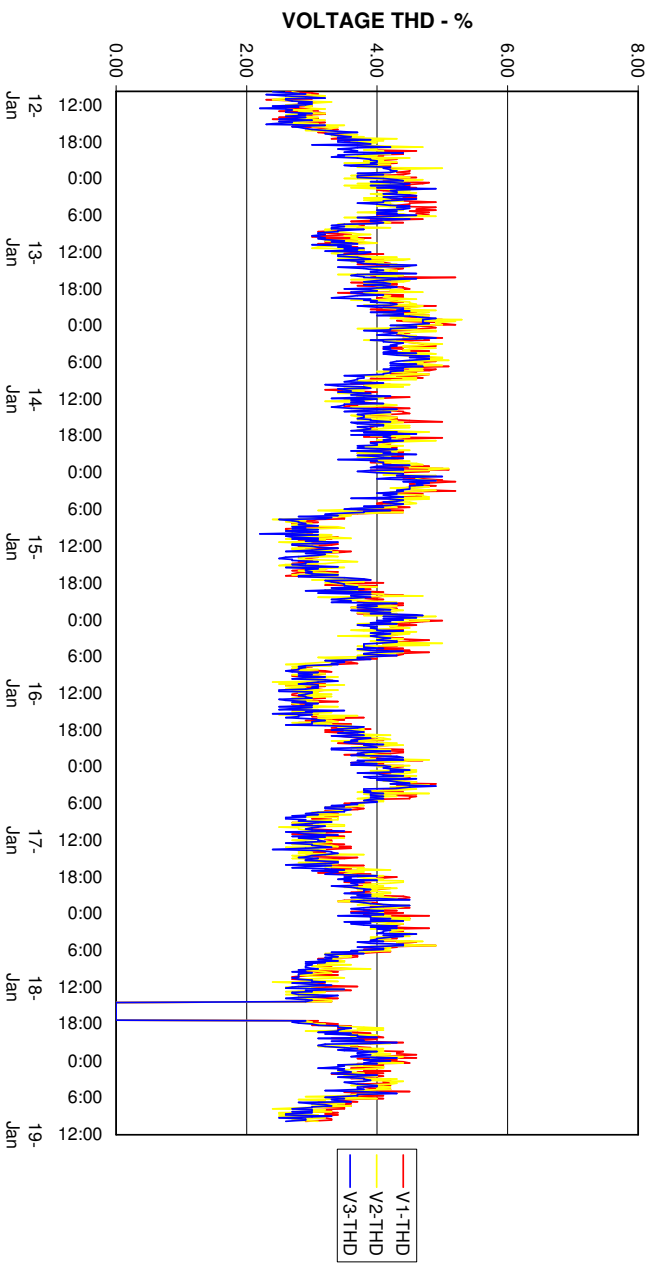
JANUARY 2007

### HARMONIC POWER FLOW

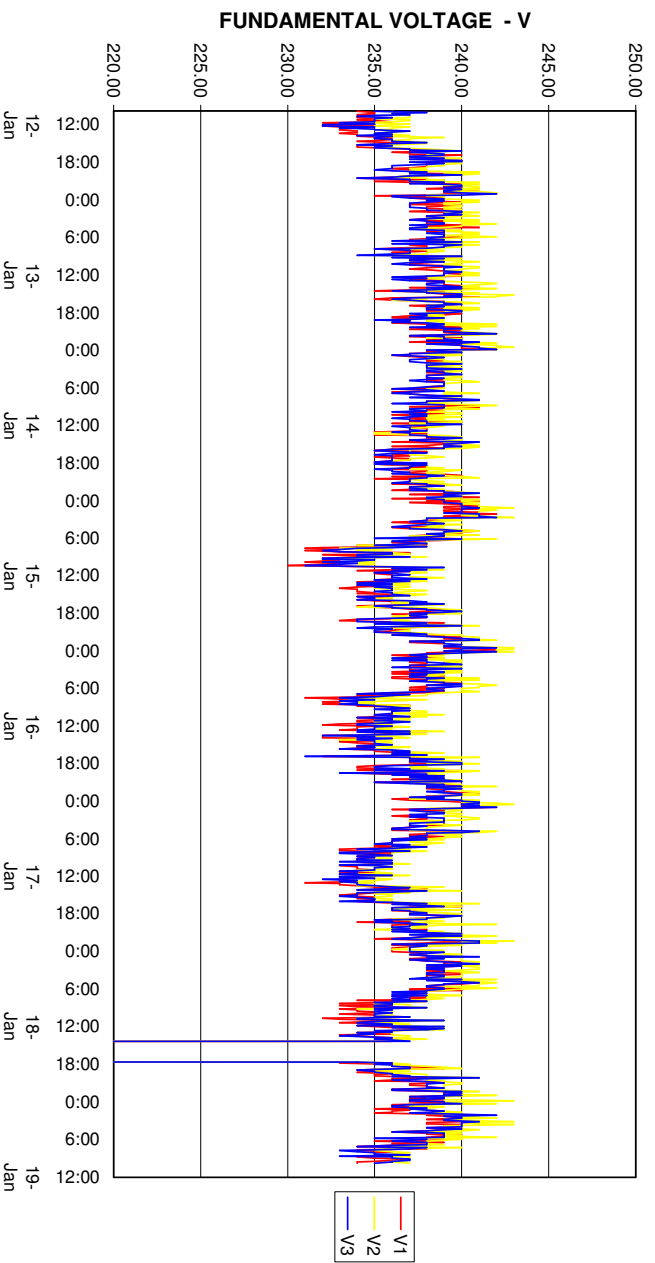
		AVERAGE POWER							MAXIMUM POWER		
		L1	L2	L3					L1	L2	L3
3 rd	W	0.62	0.42	0.21	W	-13.37	12.26	8.94			
5 th	W	10.22	5.26	2.67	W	45.35	30.60	-18.13			
7 th	W	0.18	-0.58	0.01	W	5.76	-3.43	4.27			
9 th	W	0.01	0.01	0.00	W	2.78	2.01	-1.67			
11 th	W	-0.02	-0.02	0.00	W	1.07	-1.73	0.81			
13 th	W	0.00	-0.01	0.01	W	-1.22	1.27	0.85			
15 th	W	0.00	0.00	0.01	W	-0.34	-0.46	0.99			

# VOLTAGE HARMONIC GRAPHS

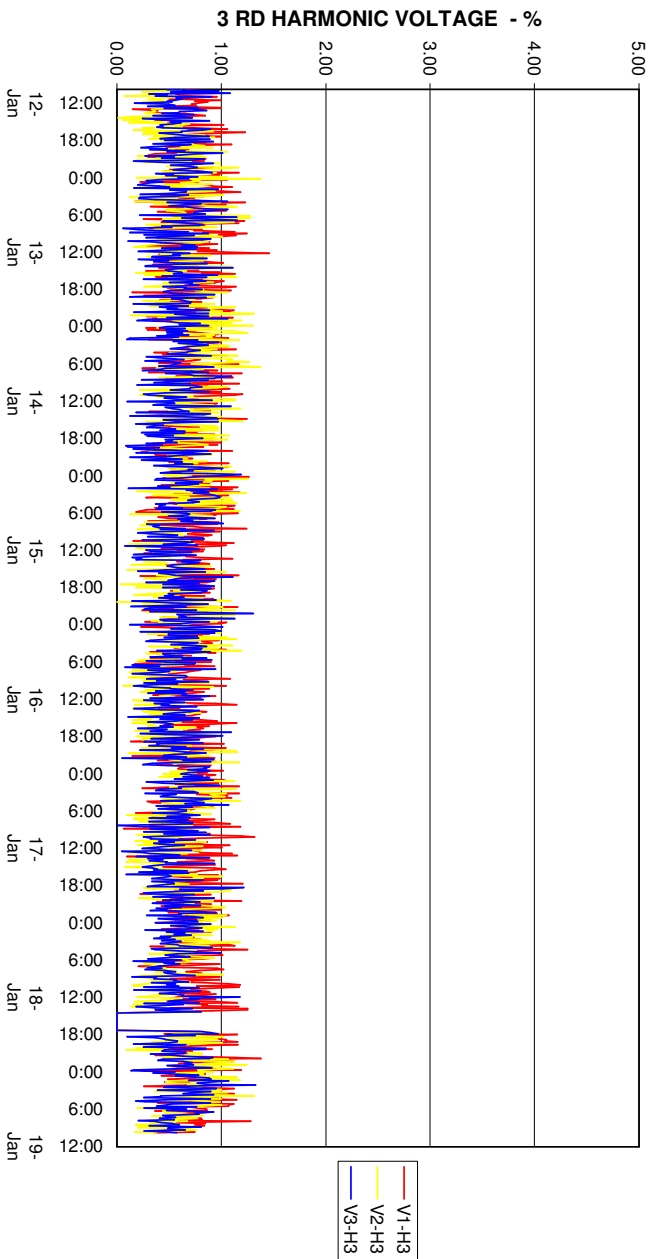
## Sample Recording - Main Incomer



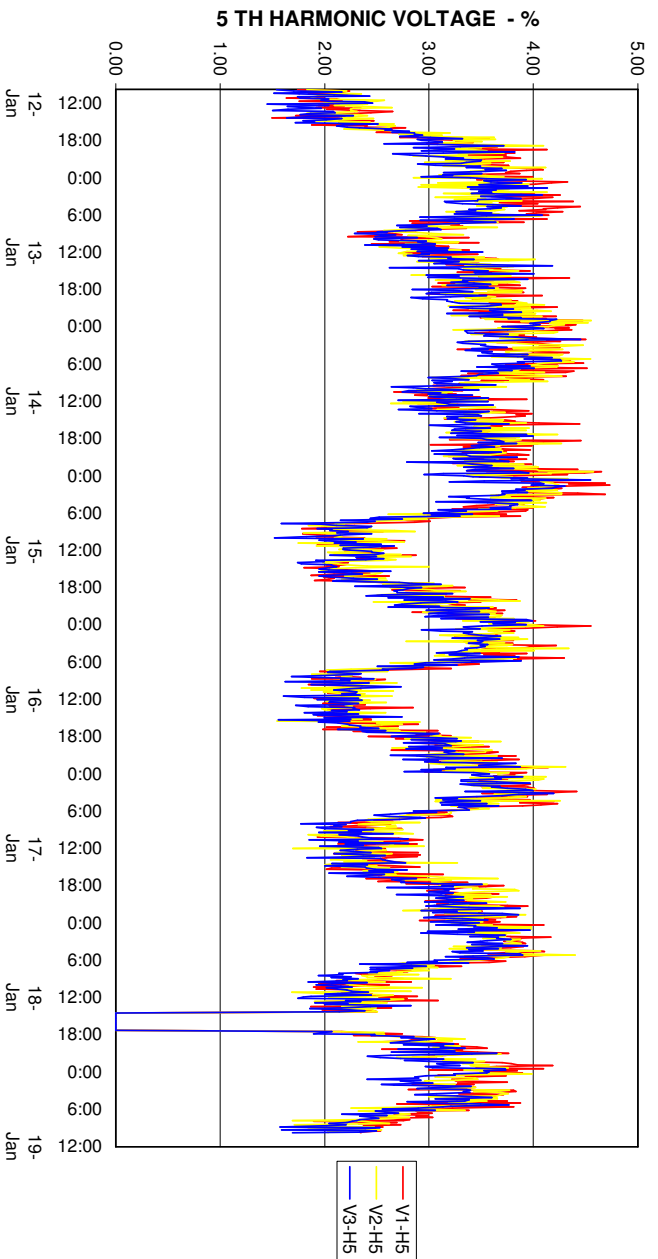
## Sample Recording - Main Incomer



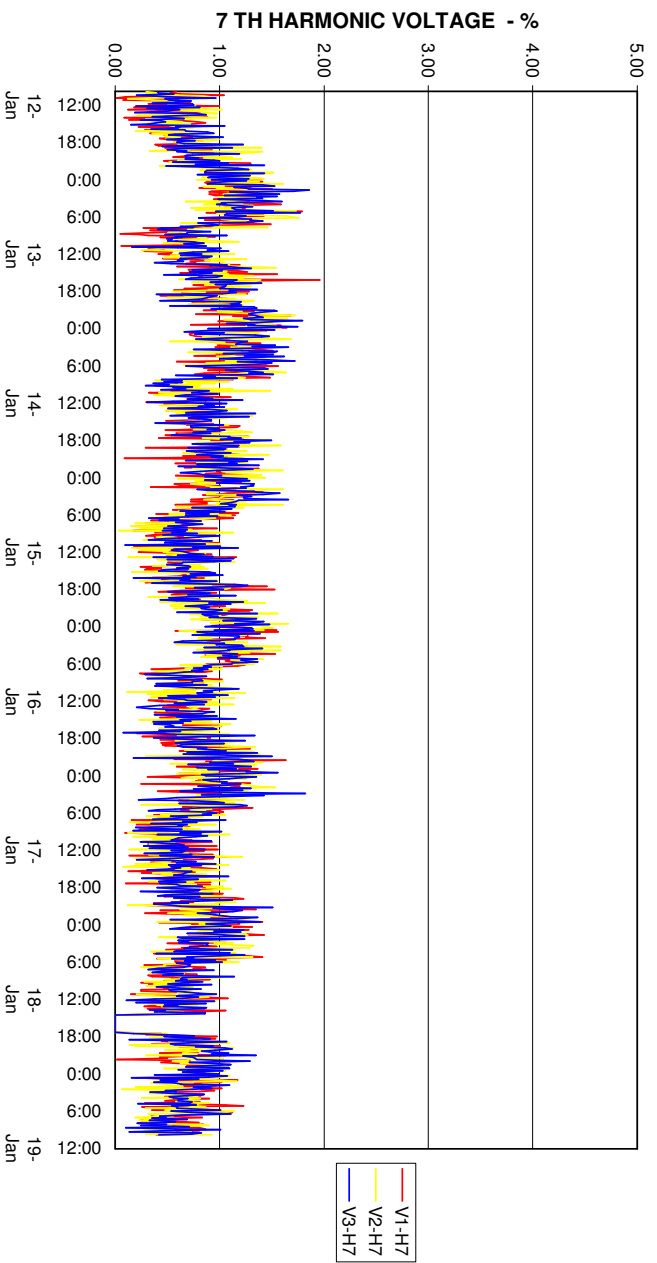
### Sample Recording - Main Incomer



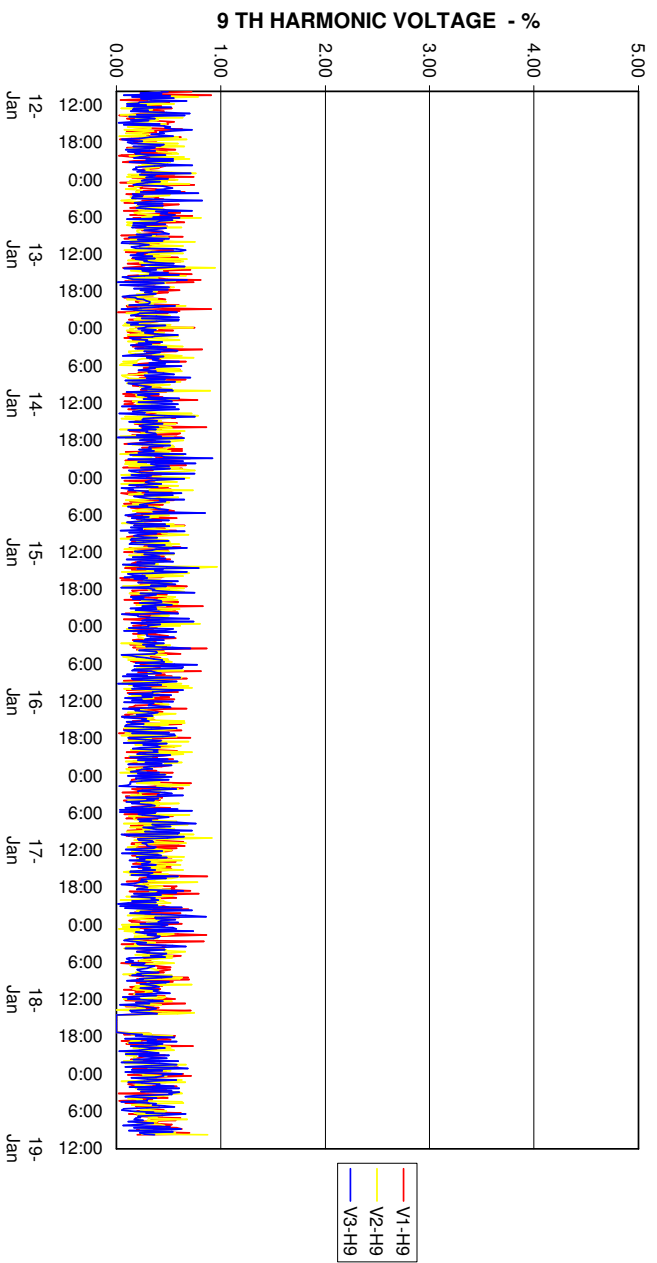
### Sample Recording - Main Incomer



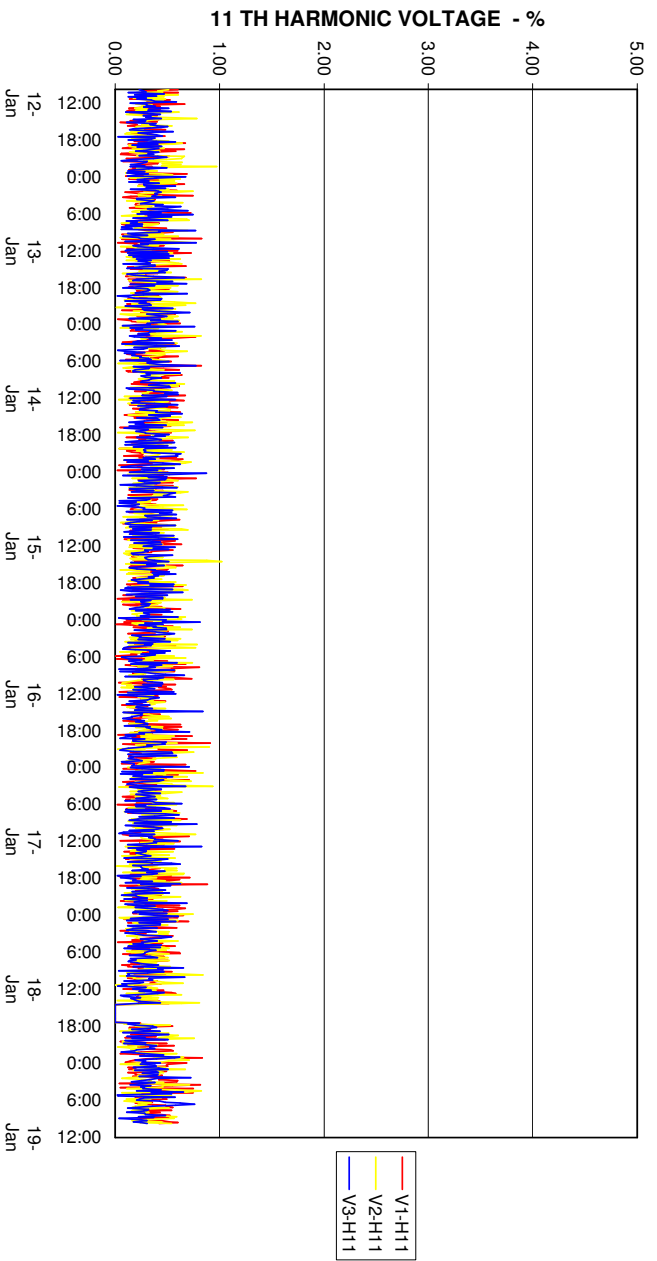
## Sample Recording - Main Incomer



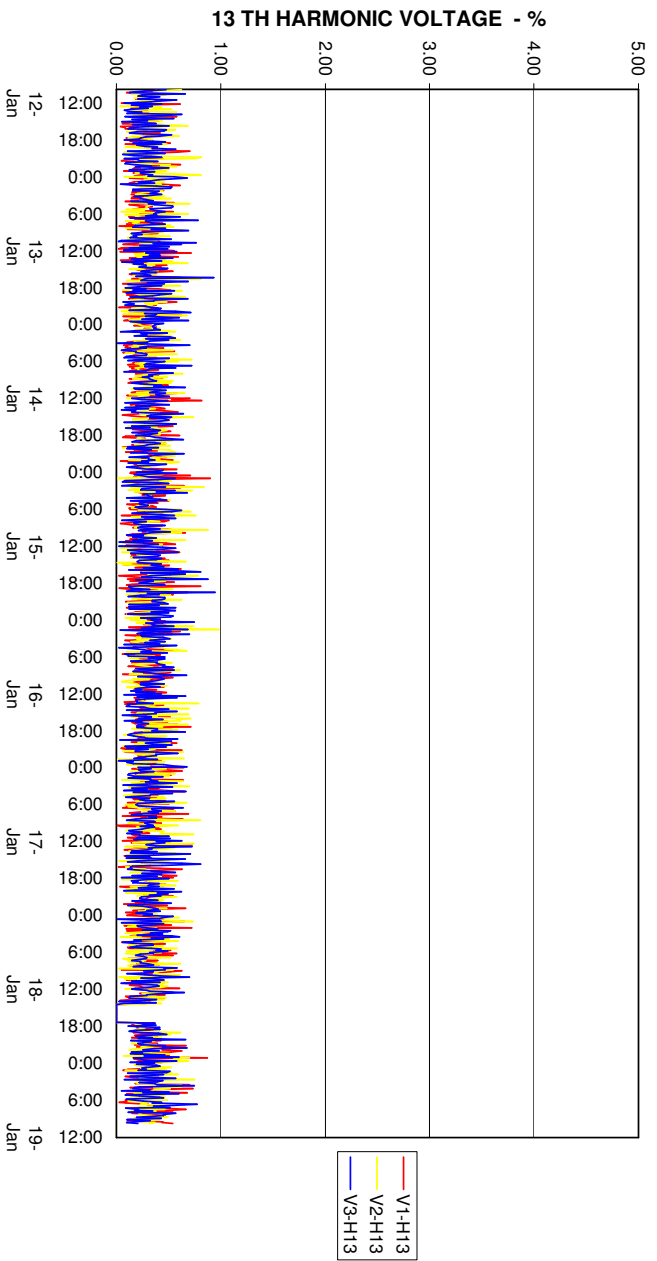
## Sample Recording - Main Incomer



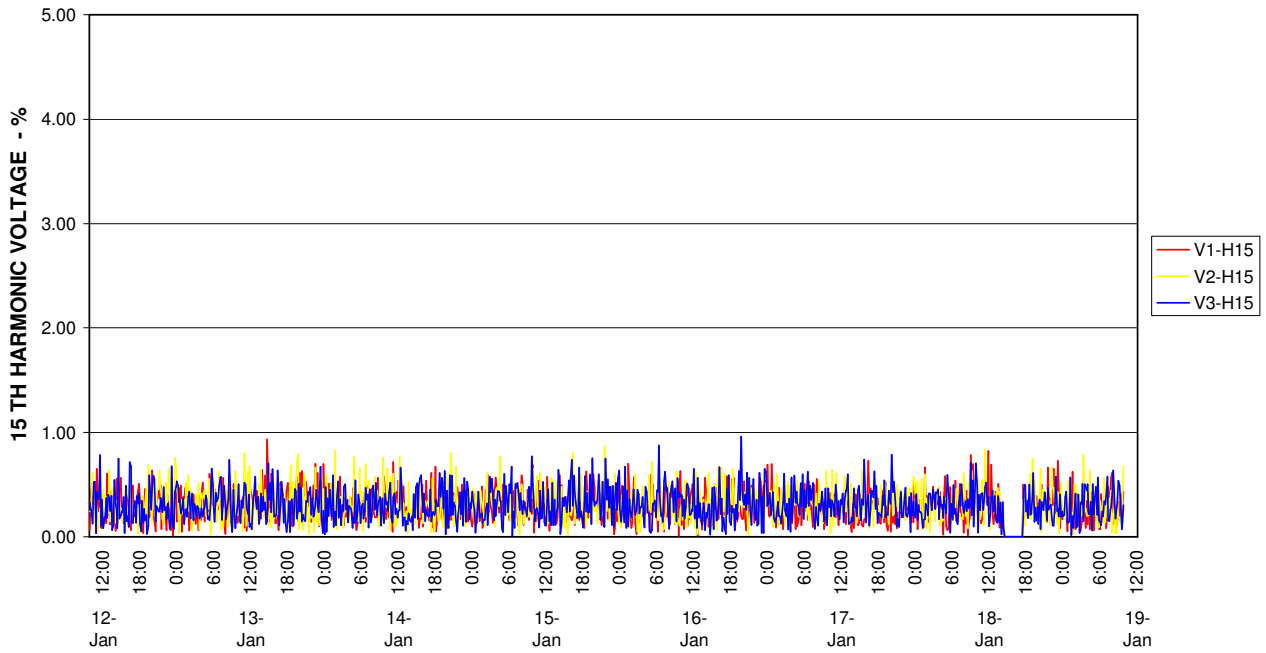
# Sample Recording - Main Incomer



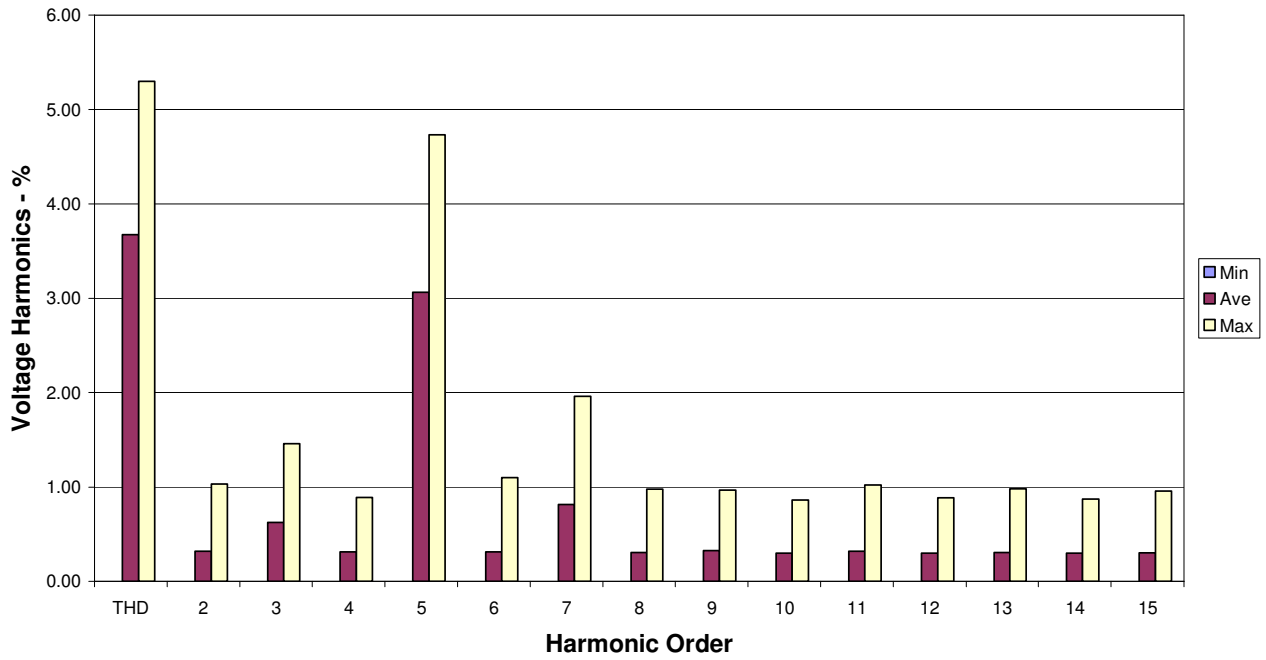
# Sample Recording - Main Incomer



## Sample Recording - Main Incomer

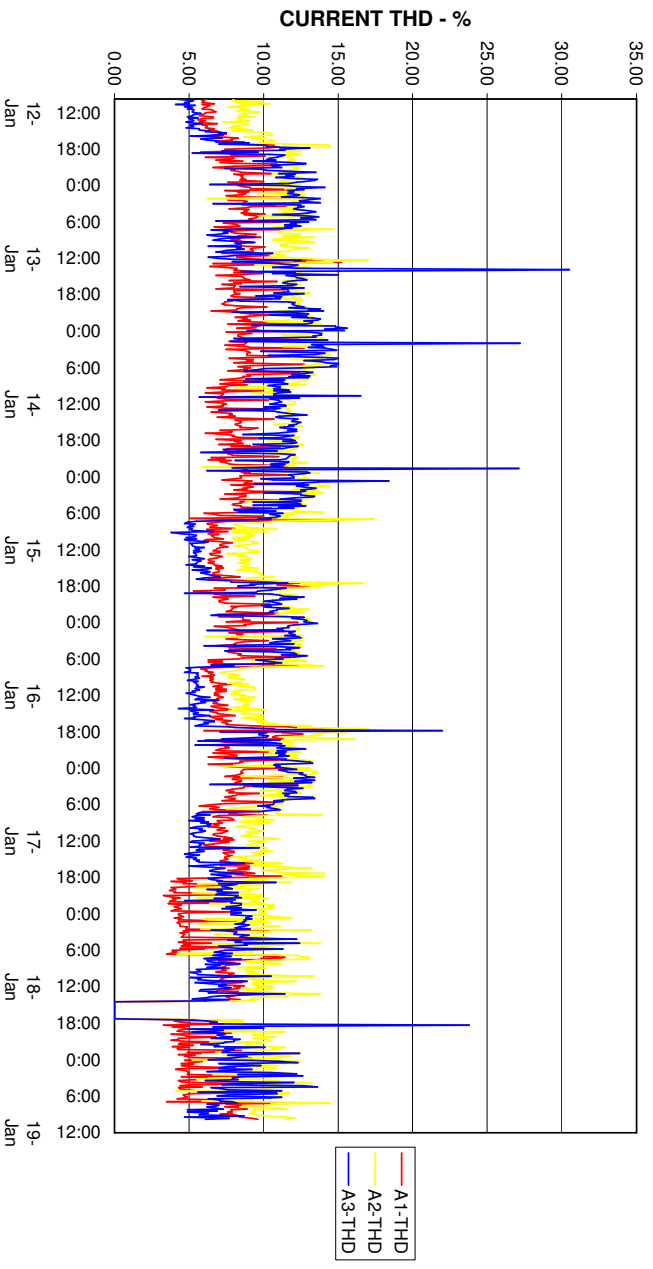


## Sample Recording - Main Incomer

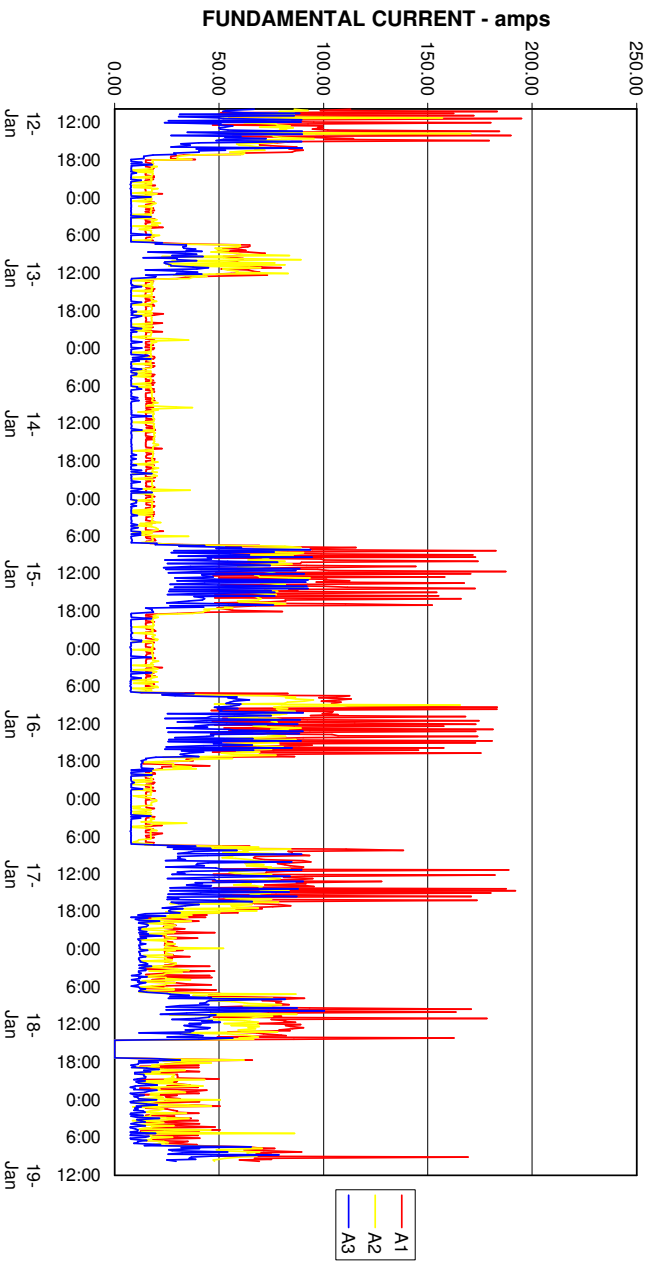


# CURRENT HARMONIC GRAPHS

## Sample Recording - Main Incomer



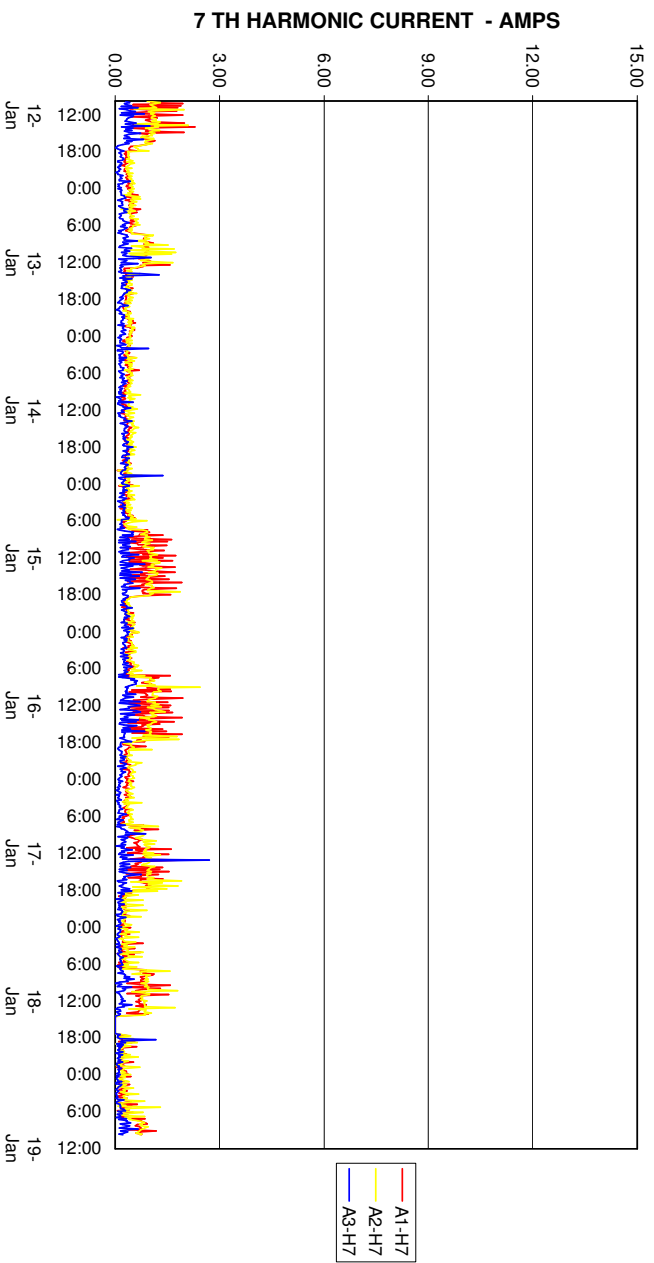
## Sample Recording - Main Incomer



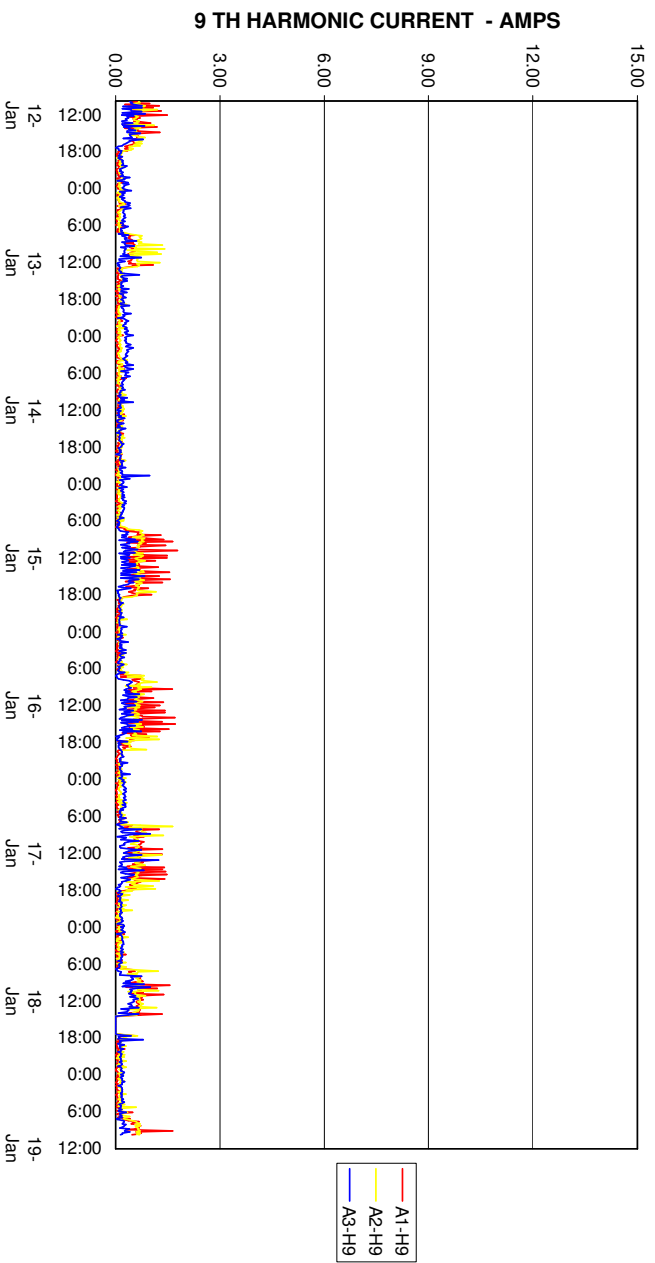




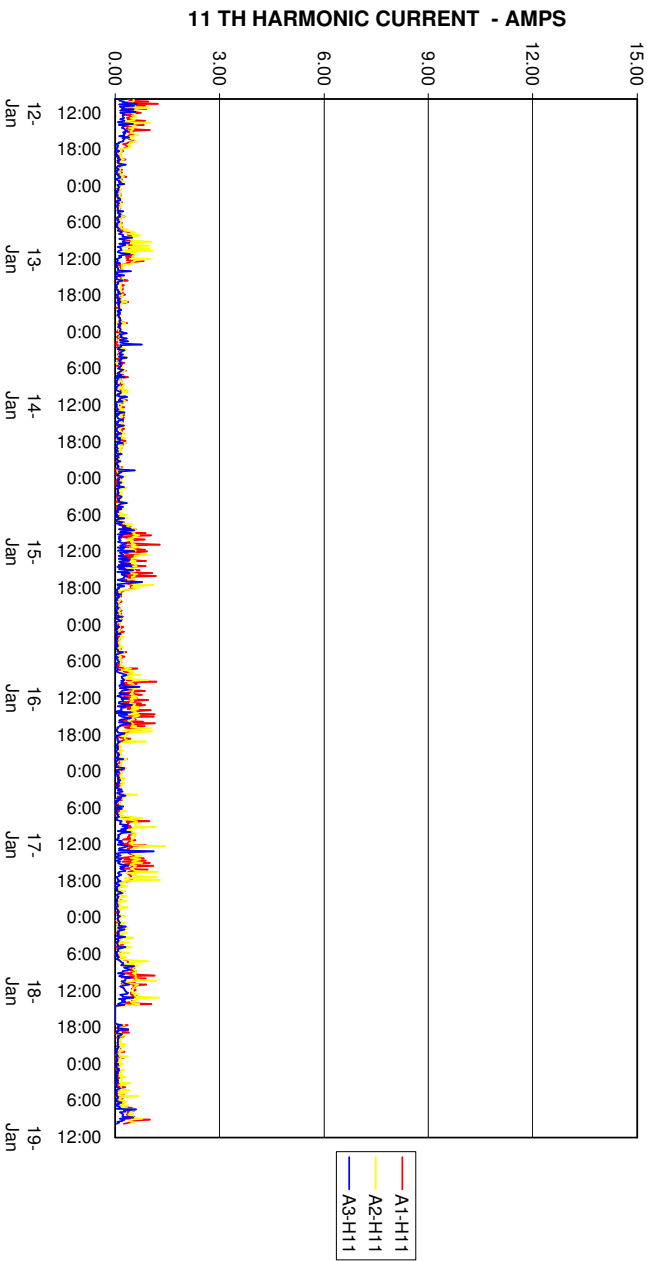
## Sample Recording - Main Incomer



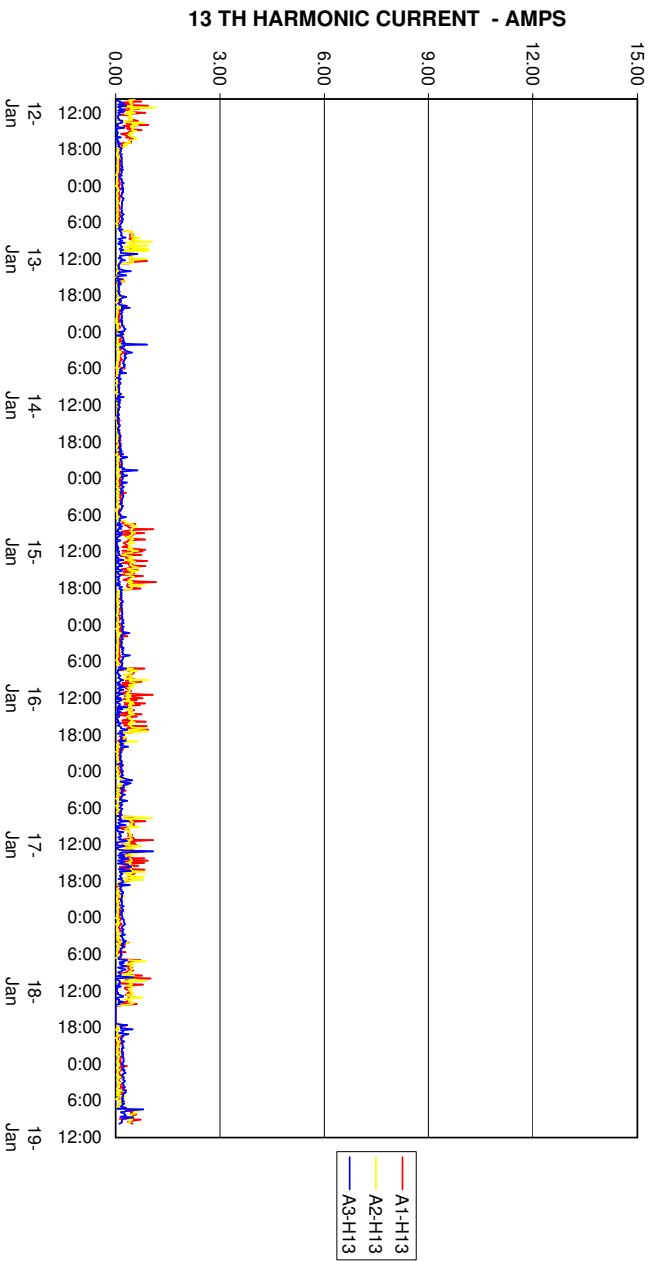
## Sample Recording - Main Incomer



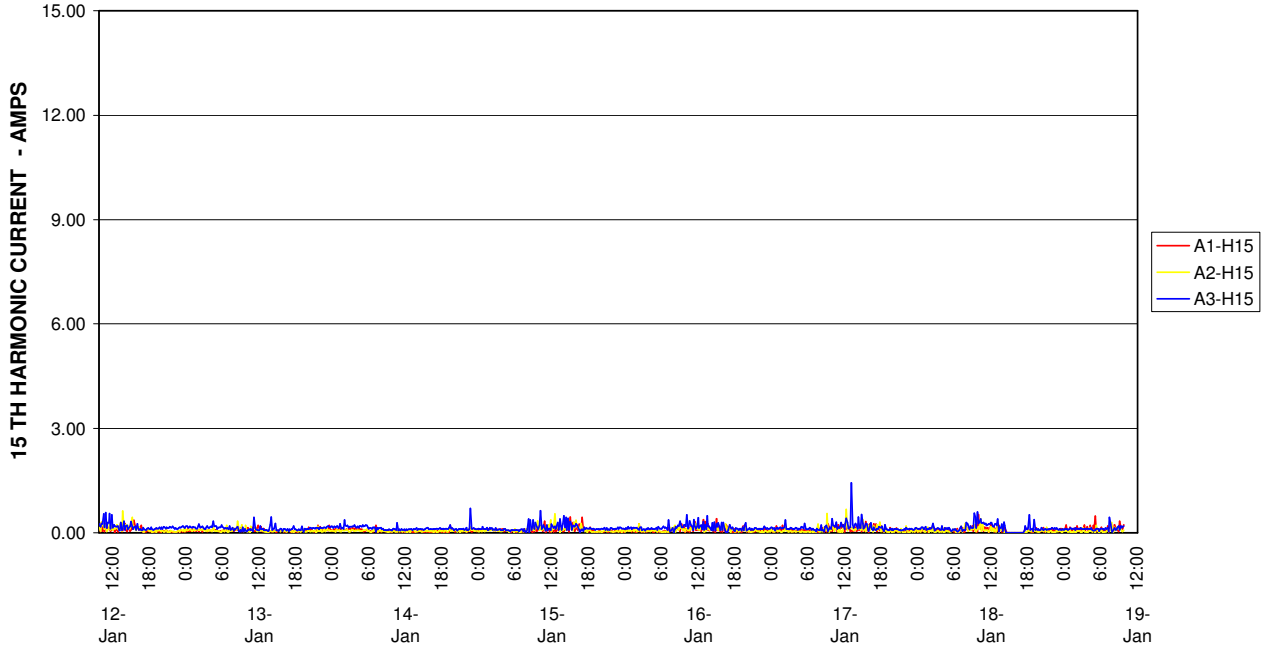
## Sample Recording - Main Incomer



## Sample Recording - Main Incomer



## Sample Recording - Main Incomer



## Sample Recording - Main Incomer

