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Harmonic Measurement
Survey Report

at

Howard Street Filter All 3

Report prepared by:

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ABB Ltd

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Ellesmere Port

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Tel 0151 357 8400

Contents

Terminology

A number of standards, terms and abbreviations are used to compile this report; the full descriptions are detailed below.

Term/abbreviation	Description
BS-EN 50160:2000	Voltage Characteristics of Electricity Supplied by Public Distribution Systems.
BS-EN 61000-4-7: 2002	Electromagnetic Compatibility (EMC) General Guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto
IEC 61000-4-30:2003	Electromagnetic Compatibility (EMC) Testing and measurement techniques – Power quality measurement methods
G5/4-1	Energy Networks Association Engineering Recommendation G5/4-1 Dated October 2005"Planning Levels for Harmonic Voltage Distortion and the Connection of Non-Linear Equipment to Transmission Systems and Distribution Networks in the United Kingdom."
ETR 122	Energy Networks Association Engineering Technical Report ETR122 Dated February 2003 "Guide to the Application of Engineering Recommendation G5/4 in the Assessment od Harmonic Voltage Distortion and Connection of Non-Linear Equipment to the Electricity Supply System in the UK.
EMC	Electromagnetic Compatibility – harmonics are low frequency conducted emissions.
Fault Level	The power that will flow in a short circuit condition in a network, this gives a guide to the network impedance.
Harmonic	The harmonic components in a line voltage or current when subjected to a fourier analysis. Principle harmonics in the public supply network are odd integers and are measured up to the 50^{th}.
NOC	Network Operating Company (the electricity supply company who provide the connection to the network, not necessarily the clients electricity vendor)
MCC	Motor Control Centre
PCC	Point of Common Coupling – the point at which other consumers are connected to the public electricity supply

Harmonic Theory

Basics

Many modern electrical and electronic products incorporate rectifiers, which take a non-linear current from the power supply.

There are a number of different methods of rectification that can be considered, the most common are uncontrolled (a number of diodes connected in a bridge), controlled (a number of thyristors connected in a bridge), and active (a number of IGBTs connected in a bridge).

These currents take the form of repetitive waveforms that can be subject to a fourier analysis to determine the magnitude and angle of each harmonic component. Each type of device will produce a characteristic harmonic spectrum, which will vary with bridge design, levels of filtering and source impedance. As the current will be drawn through the impedance .of the supply network it will generate a complementary voltage distortion spectrum.

Typical effects of harmonics are detailed in the table below:-

Effects of high harmonic currents

- Overheating of conductors
- Insulation failure
- Nuisance tripping of circuit breakers
- Nuisance rupturing of fuses
- Additional significant voltage distortion of networks run from generators
- Overheating and possible resonance on networks using capacitors

- Overloaded neutral
- Neutral earth potential

(generally due to single phase harmonic loads)

- PC/TV monitor stroboscopic effects
- Malfunction of microprocessor based equipment

Effects of high harmonic voltage distortion

- Causes linear devices to draw non linear current (ie- motors)
- Torque pulsations in motors
- Flicker in lighting
- Capacitor di-electric failure
- Insulation breakdown
- PC/TV monitor and power supply failure
- Electronic lighting failure

Current Distortion

Both single and three phase non-linear loads draw harmonic currents. For both controlled and uncontrolled rectifiers the dominant harmonic is generally denoted by n-1, where n is the number of rectifying devices, ie a single phase 4 diode rectifier gives a dominant 3rd. harmonic, and a three phase 6 diode rectifier gives a dominant 5th, harmonic.

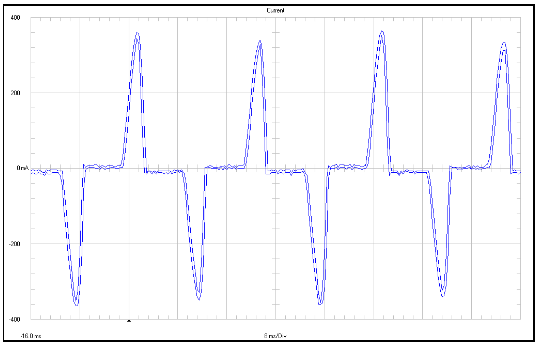


Figure 1

Typical measured current waveform for single phase uncontrolled rectifier

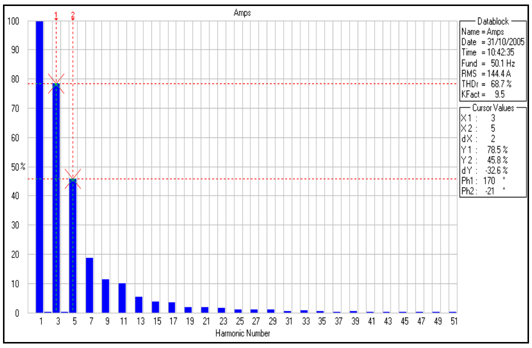


Figure 2

Typical measured harmonic current spectrum for single phase uncontrolled rectifier

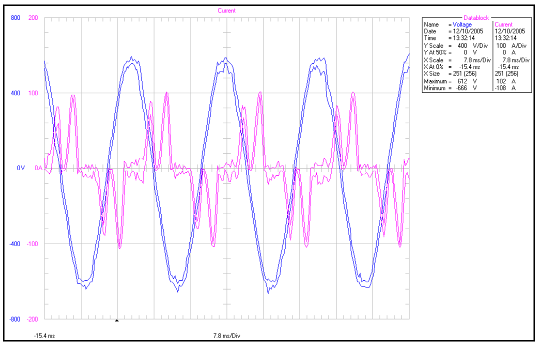


Figure 3

Typical current and voltage waveform for 6 pulse uncontrolled rectifier

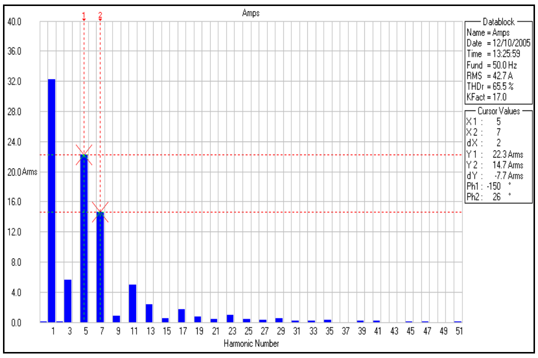


Figure 4

Typical current spectrum analysis for 6 pulse uncontrolled rectifier

Voltage Distortion

Voltage distortion propagates throughout the entire distribution network, and must be regulated by the distributor to avoid the damaging effects.

The magnitude of the distortion is dependent on the current and the network impedance, and the lower the network impedance (higher fault level), the lower the resultant voltage distortion.

The levels of acceptable distortion are laid down in a number of standards including EN 50160, and IEC 61000 series.

Harmonic flow

In theory a current will flow to the lowest impedance, hence it would be expected that harmonic current flow would be up through the increasing voltage levels of the network, however, if there are any resonant components in a network at lower voltage level, such as power factor correction, there can be a flow in this direction.

Limits for Harmonic Voltage & Current

In the UK the network operators are governed by statutory instruments which specify the levels of service and network power quality and forms part of their license agreement.

Part of the power quality requirements are incorporated in an installation standard known as the Energy Networks Association Engineering Recommendation G5/4-1 – Planning levels for harmonic voltage distortion and connection of non-linear equipment to transmission systems and distribution networks in the UK.

This gives a number of Stages that can be applied to connections for consumers, and a guide to its application is available from www.gambica.org.uk.

Introduction

The objective of the survey is to carry out a power quality survey at Howard Street.

Measurements were made for 7 days from 10/06/2013 10:45:20 to 17/06/2013 13:56:38

Site Data

The site is located at main incomer.

Basic Data

1.	**Company (submitting the report)**	**ENW**
2.	**Contact Name and Address**	**John Simpson 07715 428043**
3.	**Site address**	Howard Street
4.	**Metering Point Account Number**	**N/A**
5.	**Network connection (where known)**	**N/A**
6.	**Transformer details (where relevant)**	**N/A**
7.	**Reason for the survey**	*Power Quality Survey*
8.	**Existing non linear load**	**Non-Linear Load**
9.	**Details of new non linear load**	*N/A*
10.	**Point of measurement**	*415V Main Incomer*
11.	**Measurements**	*Power Quality*
12.	**Connection Arrangements**	4 WIRE / 3 PROBE (WYE)
13.	**Measuring instrument**	*Dranetz PX5*
14.	**Start time for measurements**	10/06/2013 10:45:20
15.	**Finish time for measurements**	17/06/2013 13:56:38

Instrument Configuration

Dranetz Power Xplorer Configuration

Firmware	Power Xplorer (c) 2009 Dranetz-BMI Jan 10 2011 @ 09:46:34 Ver.: V 4.2, Build: 9, DB ver.: 0
Serial Number	PX50ZA063
Site/Filename	howd st filt all 3
Measured from	10/06/2013 10:45:20
Measured to	17/06/2013 13:56:38
File ending	OK
Synchronization	Standard A
Configuration	4 WIRE / 3 PROBE (WYE)
Monitoring type	STANDARD PQ
Nominal voltage	240.0 V
Nominal current	31.7 A
Nominal frequency	50.0 Hz
Use inverse sequence	No
Using currents	Yes
Characterizer mode	IEEE 1159

Current probes

Chan A	6000XL, RR6035A (Range2), 600A (Scale=400.00)
Chan B	6000XL, RR6035A (Range2), 600A (Scale=400.00)
Chan C	6000XL, RR6035A (Range2), 600A (Scale=400.00)
Chan D	6000XL, RR6035A (Range2), 600A (Scale=400.00)

Voltage scale factors

Chan A	1.000
Chan B	1.000
Chan C	1.000
Chan D	1.000

Current scale factors

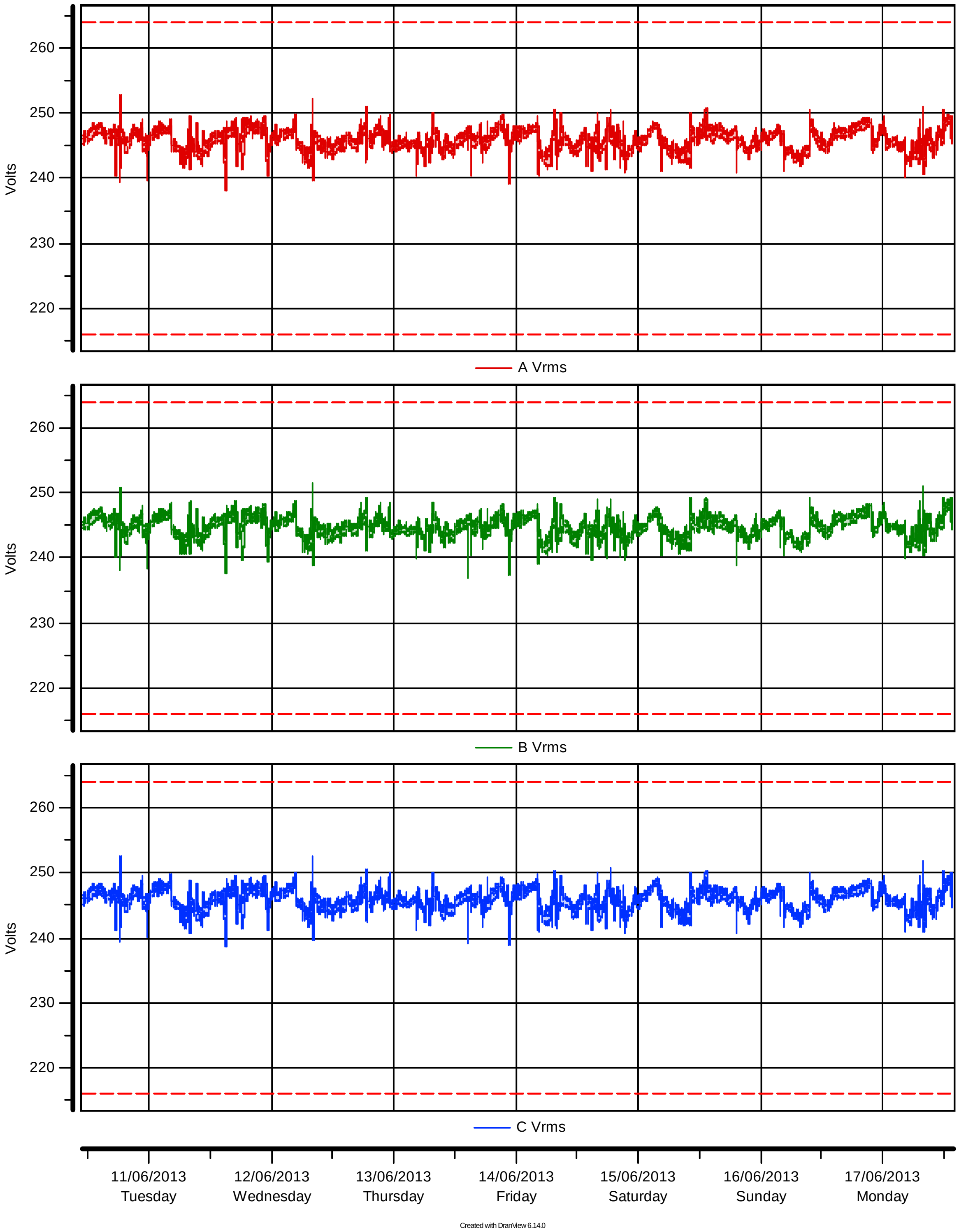
Chan A	1.000
Chan B	1.000
Chan C	1.000
Chan D	1.000

Trigger Response Setups

Summary Pre-trigger cycles	6 cycles
Summary Post-trigger cycles IN-TO-OUT	6 cycles
Summary Post-trigger cycles OUT-TO-IN	6 cycles
Waveform Pre-trigger cycles	2 cycles
Waveform Post-trigger cycles	2 cycles

VOLTAGE TIMEPLOTS

Site: howd st filt all 3
Measured from 10/06/2013 10:55:00.0 to 17/06/2013 13:55:00.0



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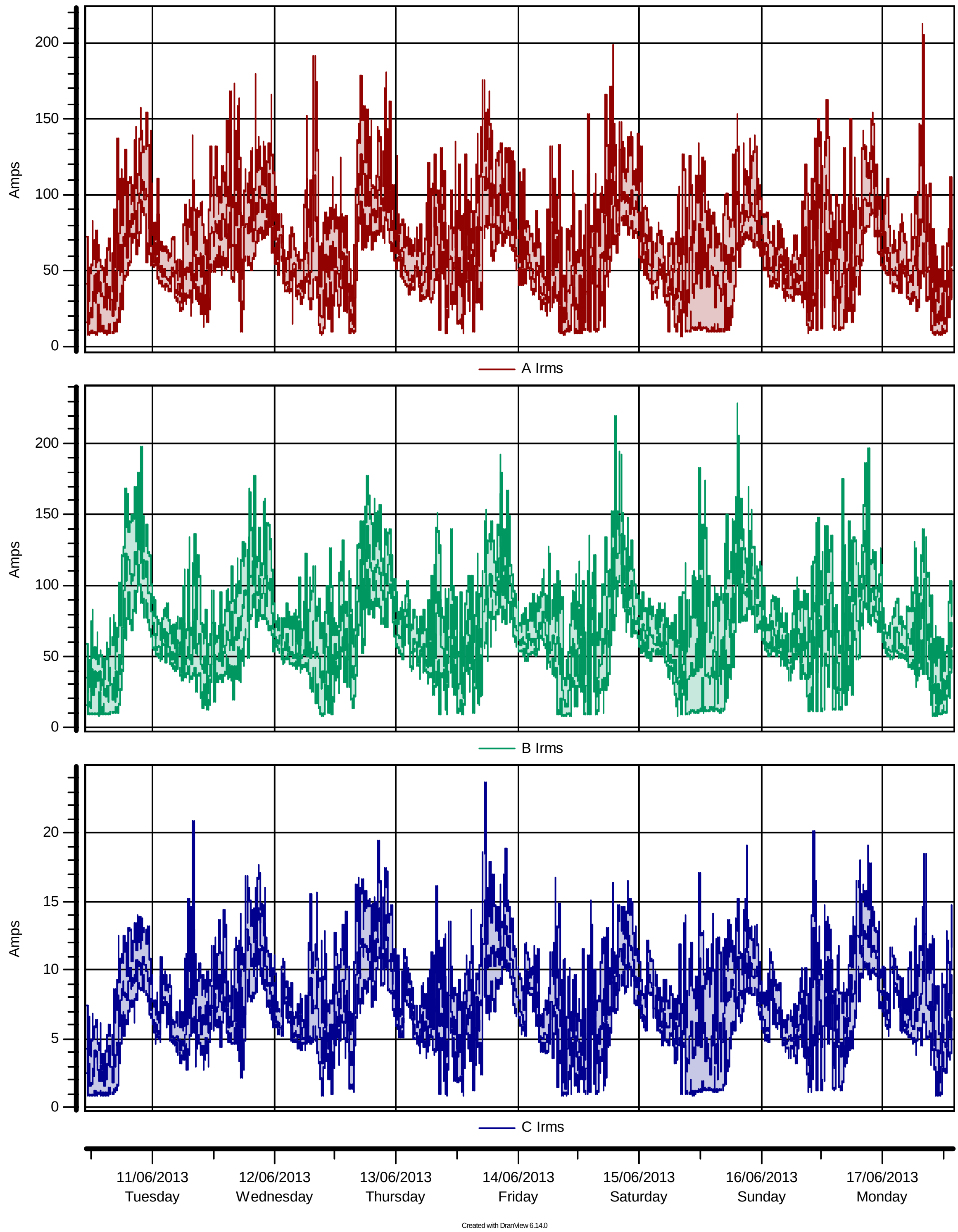
CURRENT TIMEPLOTS

Site: howd st filt all 3

Measured from 10/06/2013 10:55:00.0 to 17/06/2013 13:55:00.0



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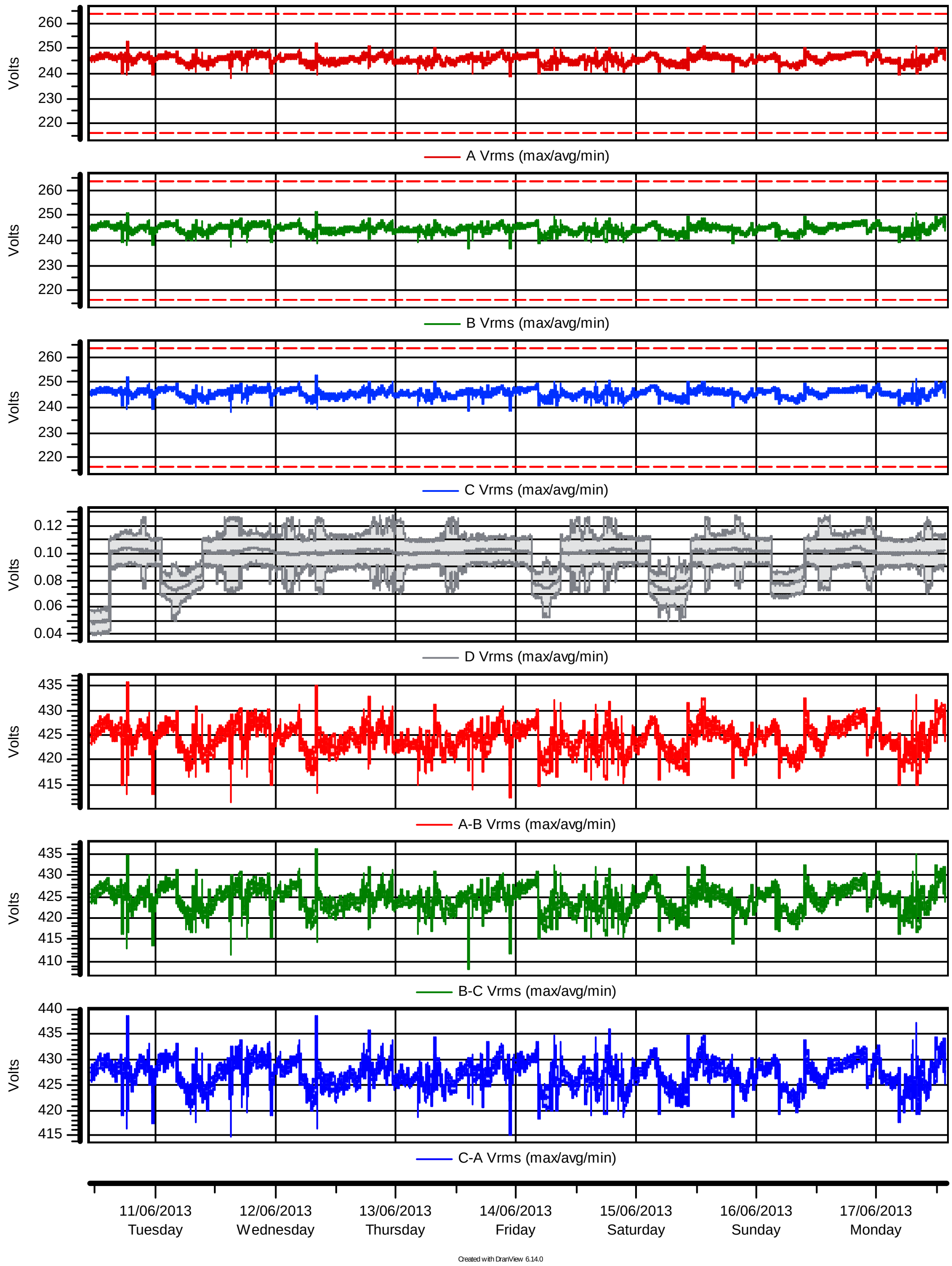
Timeplot
Voltage RMS value



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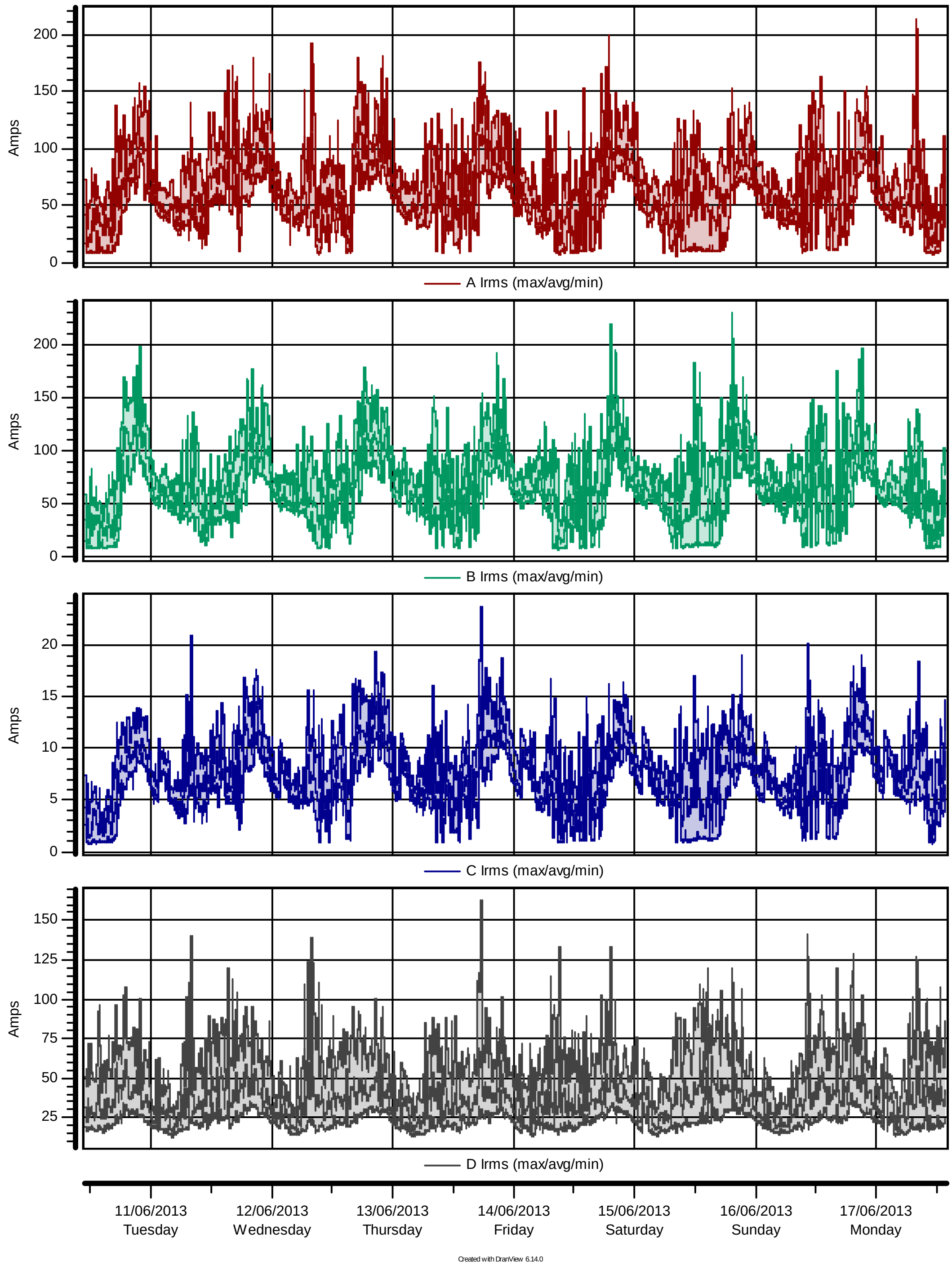
Timeplot
Current RMS value



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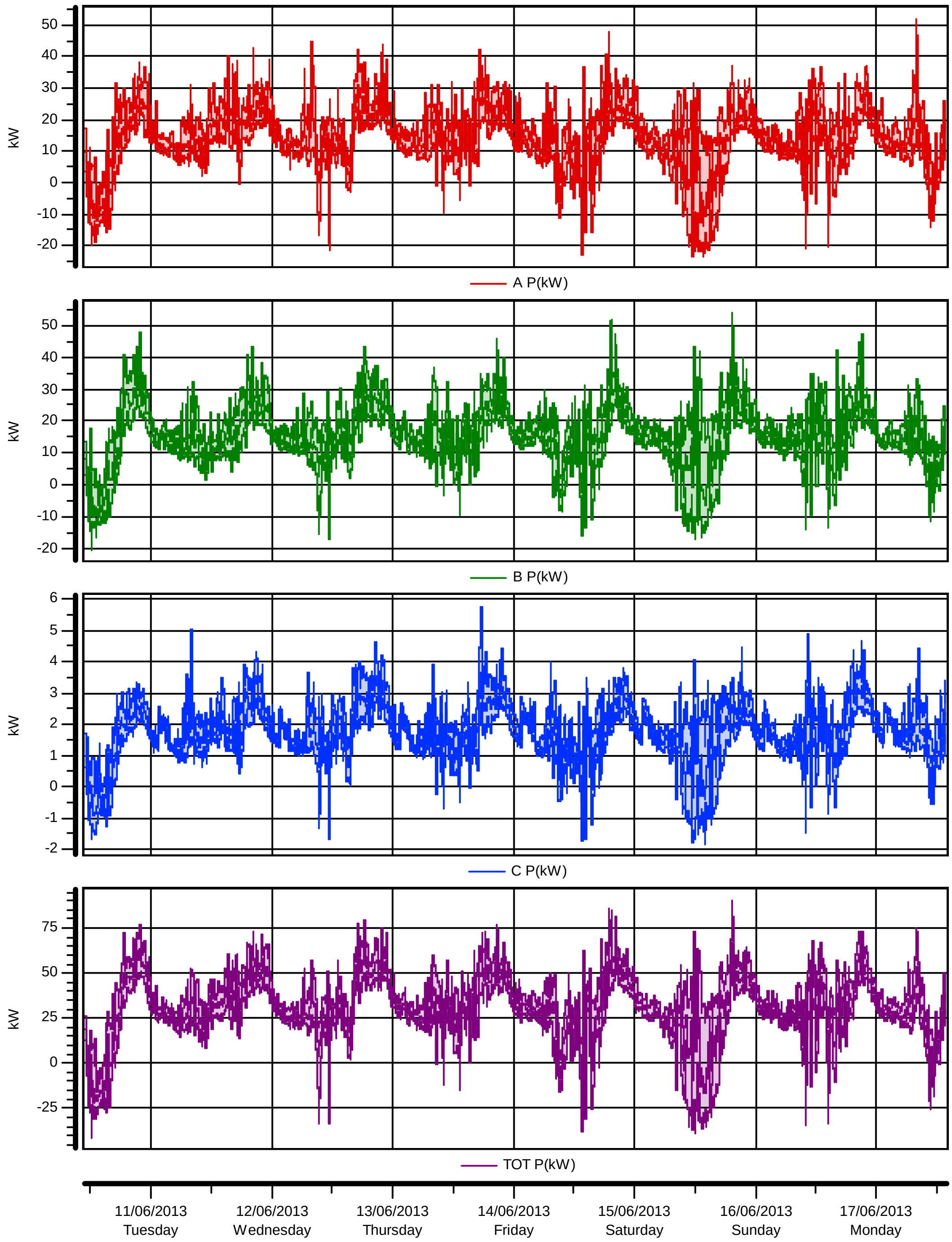
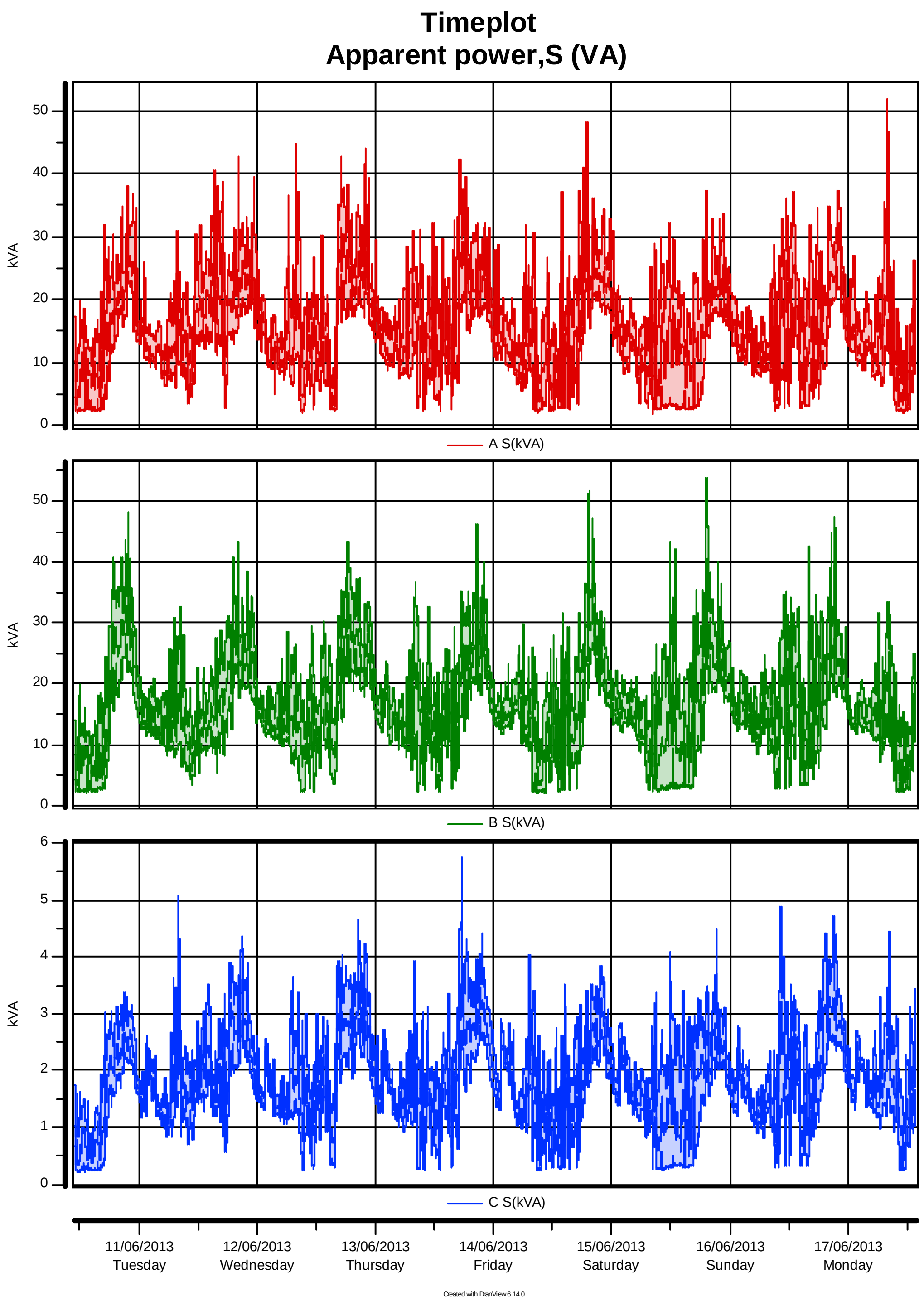
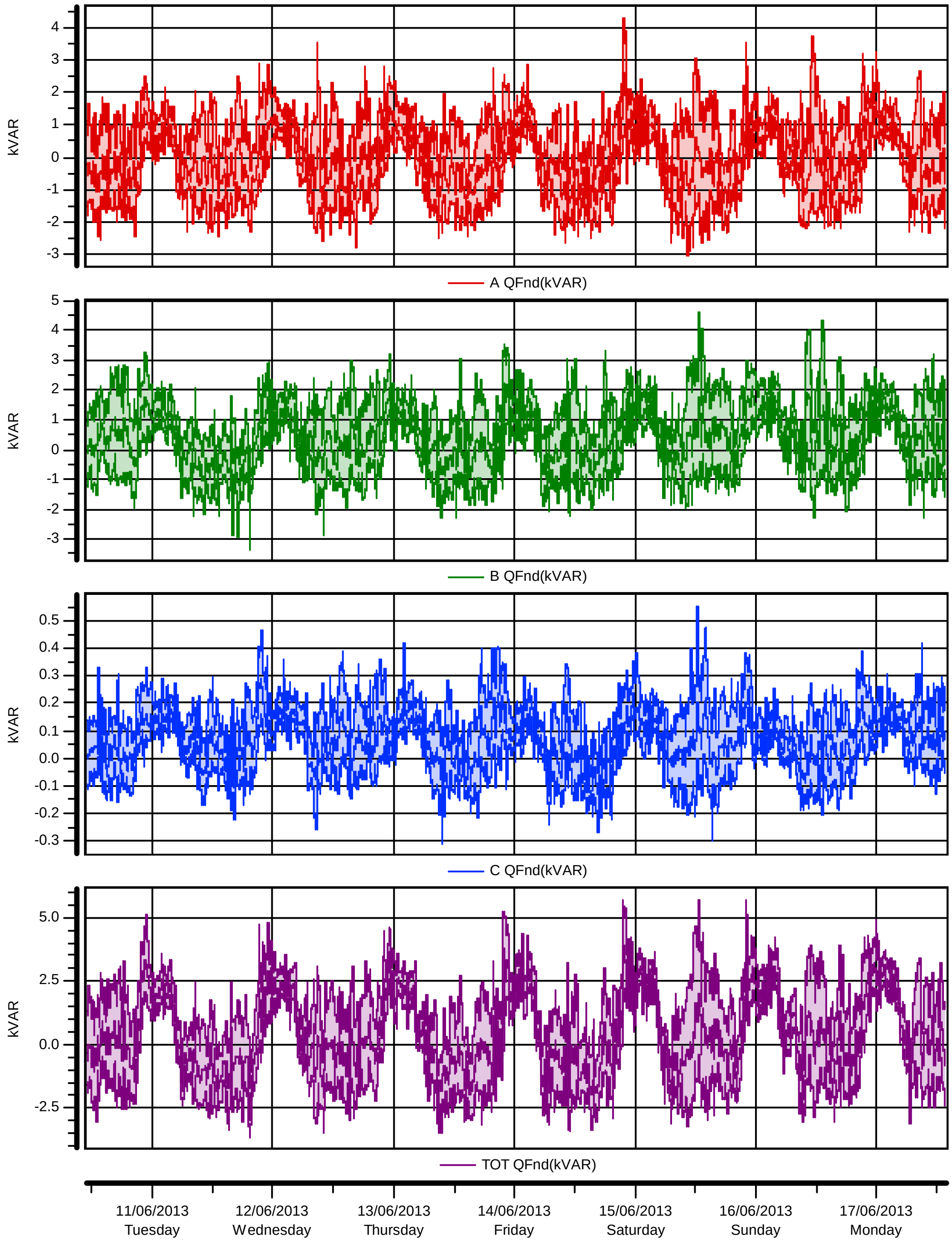
Timeplot
Active power, P (W)



Created with DranView 6.14.0

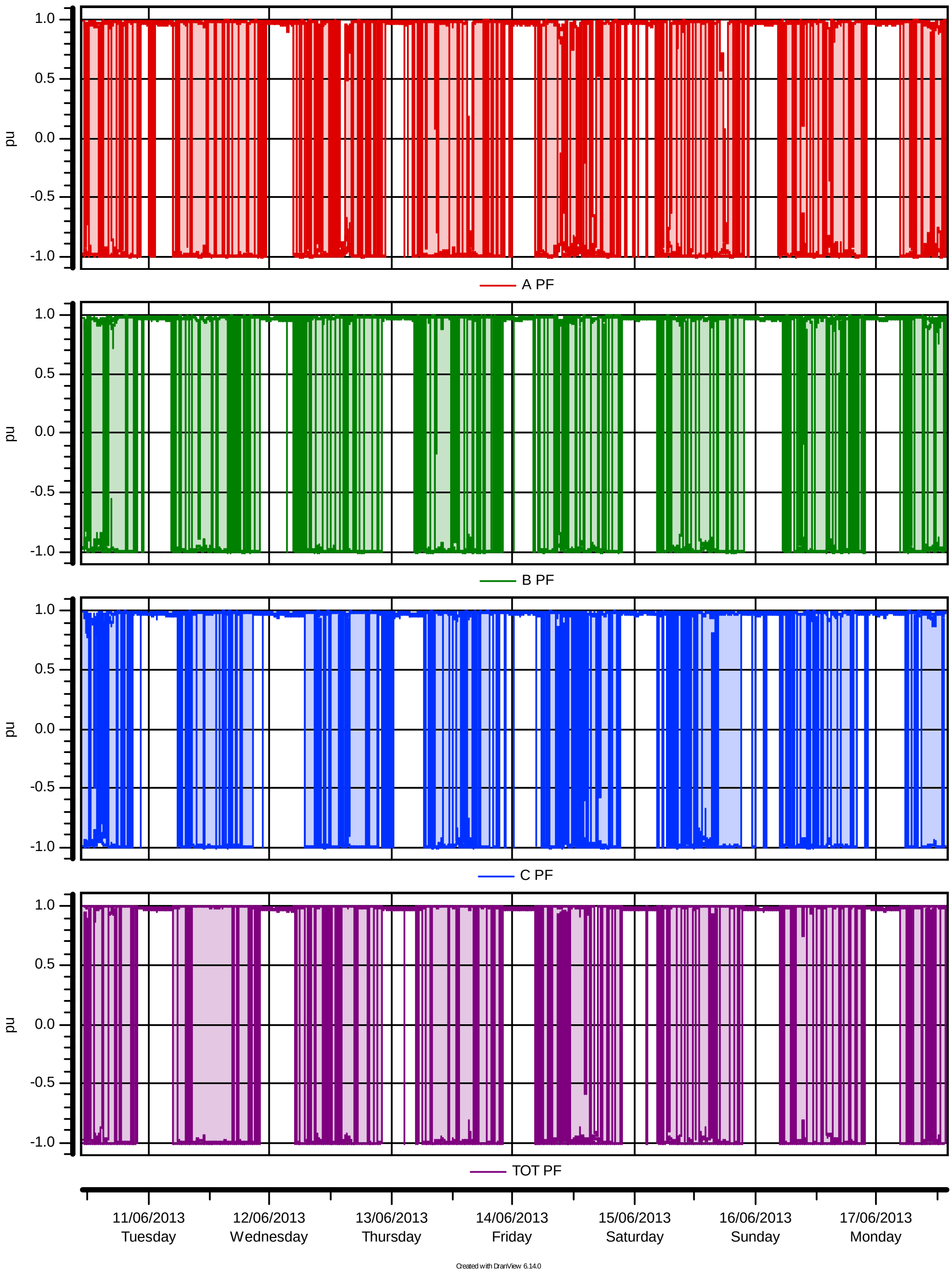

Timeplot
Apparent power,S (VA)
kVA
A S(kVA)
B S(kVA)
C S(kVA)
11/06/2013 Tuesday
12/06/2013 Wednesday
13/06/2013 Thursday
14/06/2013 Friday
15/06/2013 Saturday
16/06/2013 Sunday
17/06/2013 Monday

Timeplot
Reactive power Q, at fund. freq. (VAR)



Created with DranView 6.14.0

Timeplot
Power Factor, PF



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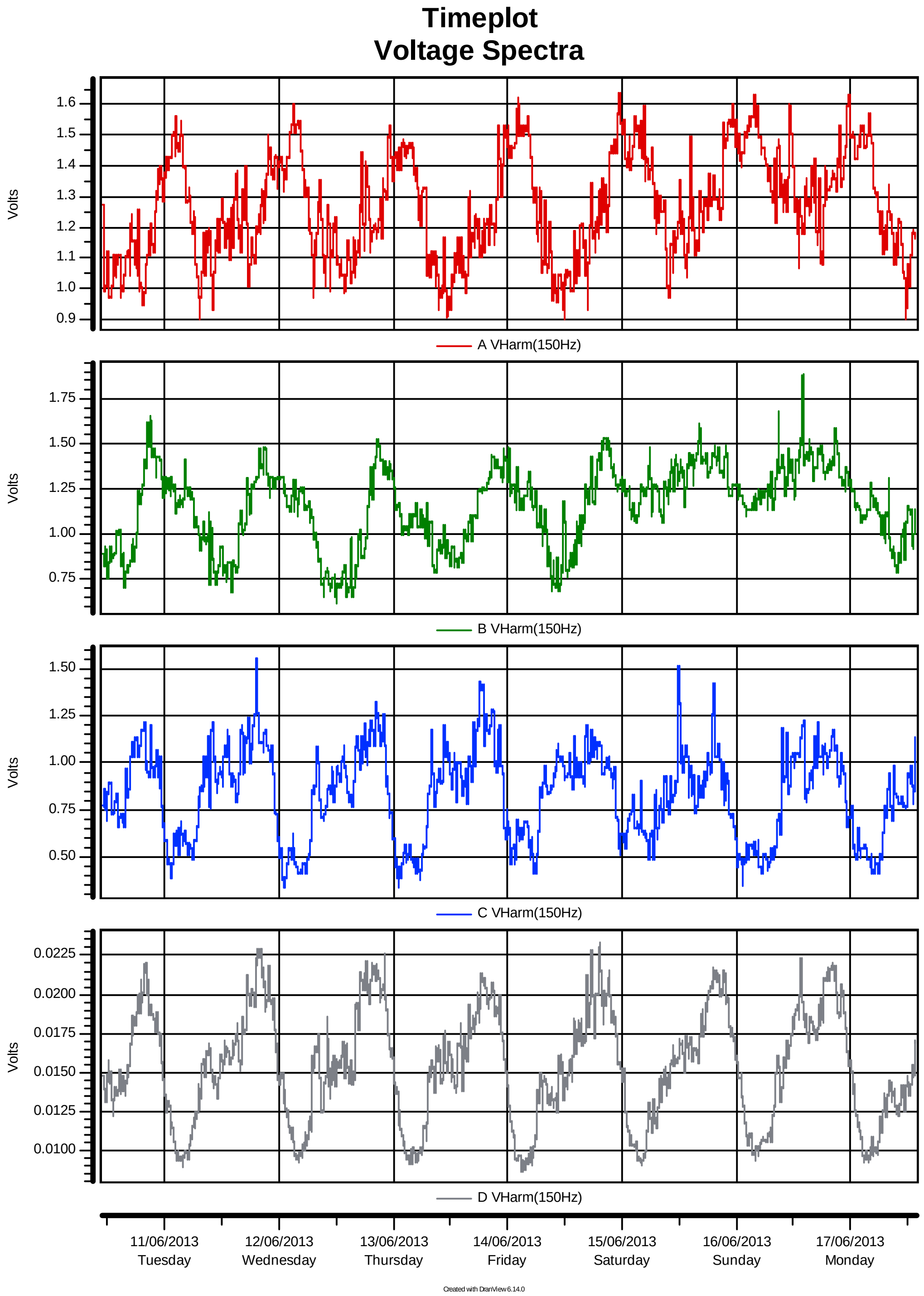

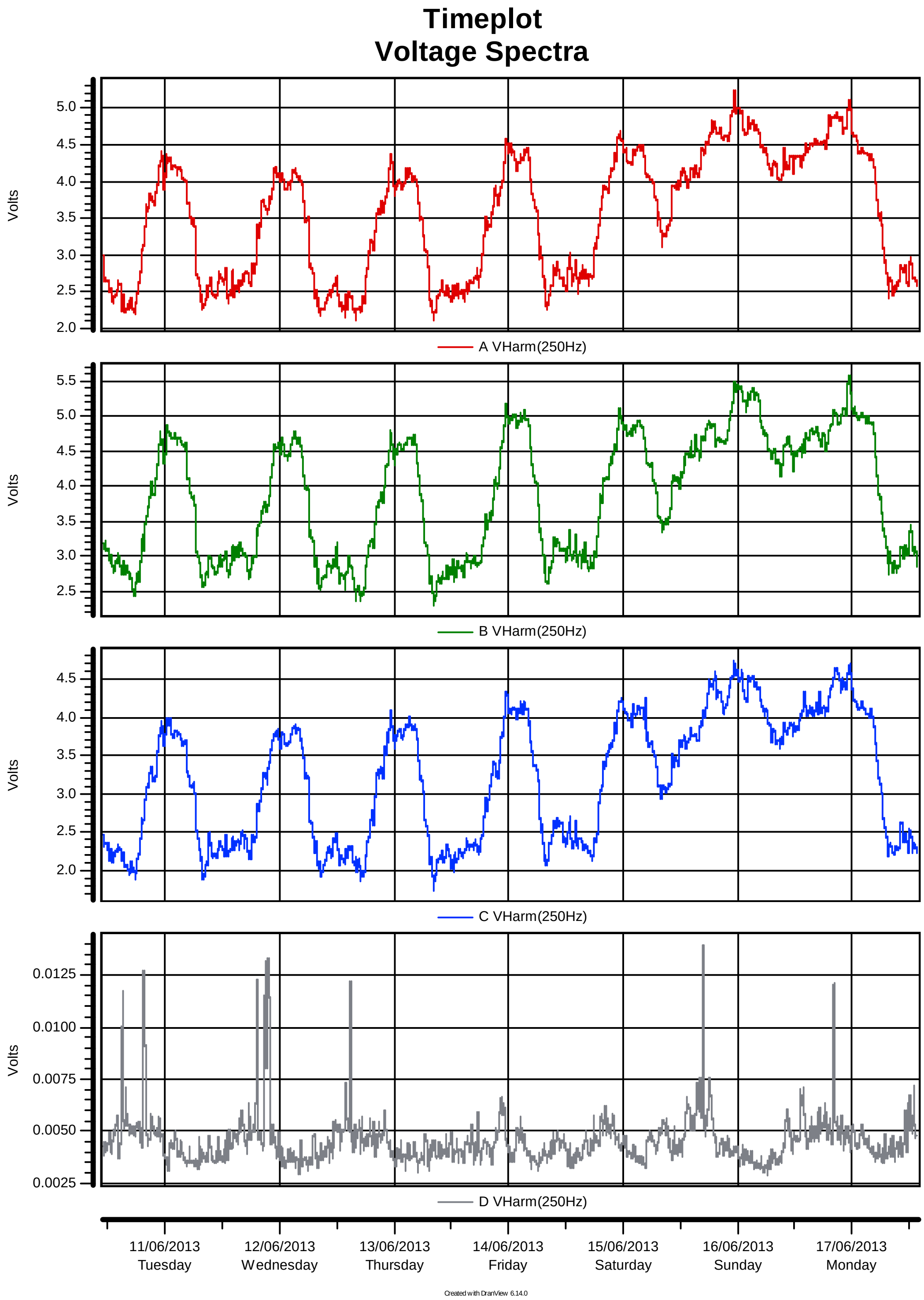
Timeplot
Voltage Spectra
Volts
5.0
4.5
4.0
3.5
3.0
2.5
2.0
A VHarm(250Hz)
Volts
5.5
5.0
4.5
4.0
3.5
3.0
2.5
B VHarm(250Hz)
Volts
4.5
4.0
3.5
3.0
2.5
2.0
C VHarm(250Hz)
Volts
0.0125
0.0100
0.0075
0.0050
0.0025
D VHarm(250Hz)
11/06/2013 Tuesday
12/06/2013 Wednesday
13/06/2013 Thursday
14/06/2013 Friday
15/06/2013 Saturday
16/06/2013 Sunday
17/06/2013 Monday
Created with DranView 6.14.0

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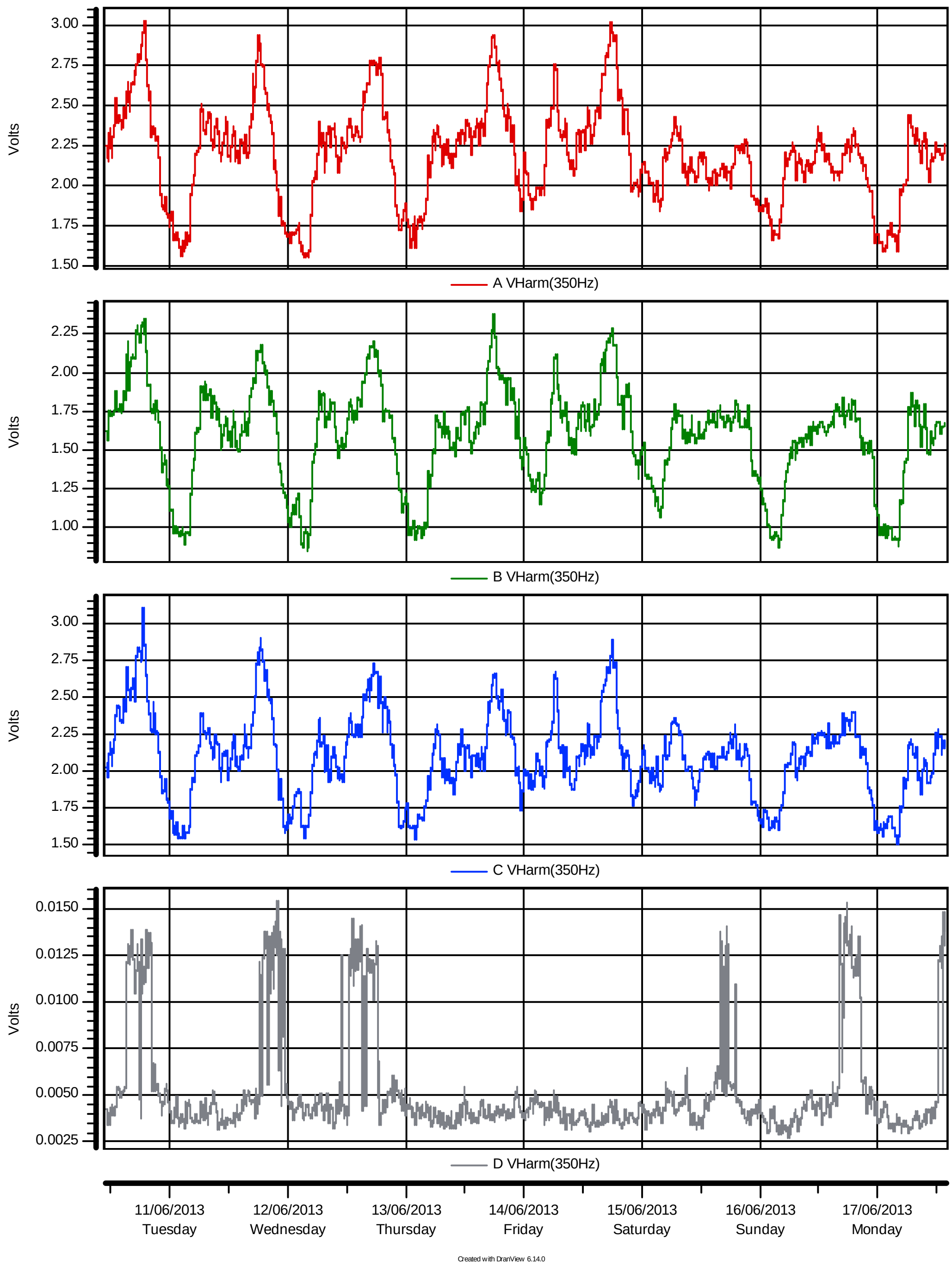
Timeplot
Voltage Spectra



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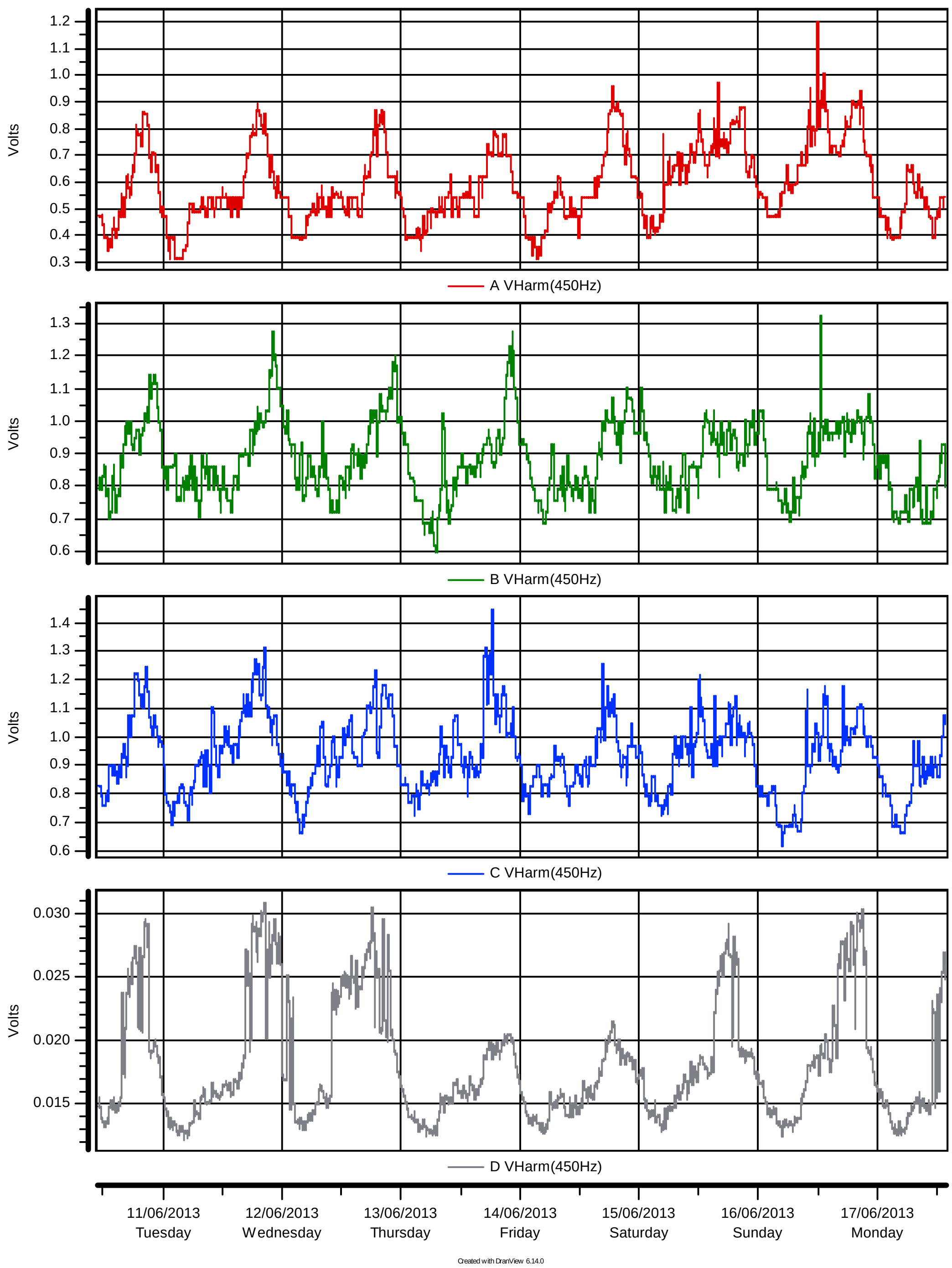
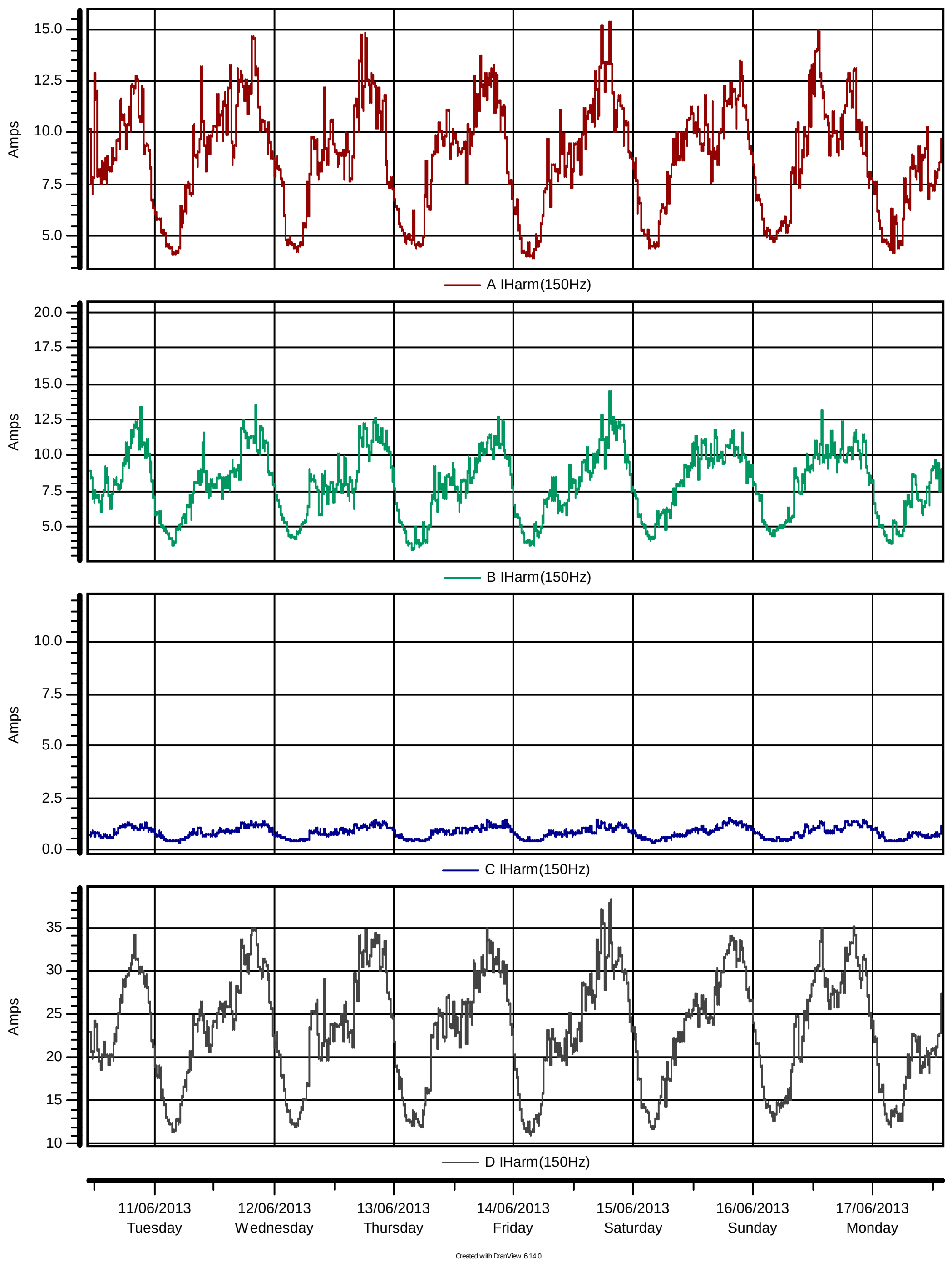
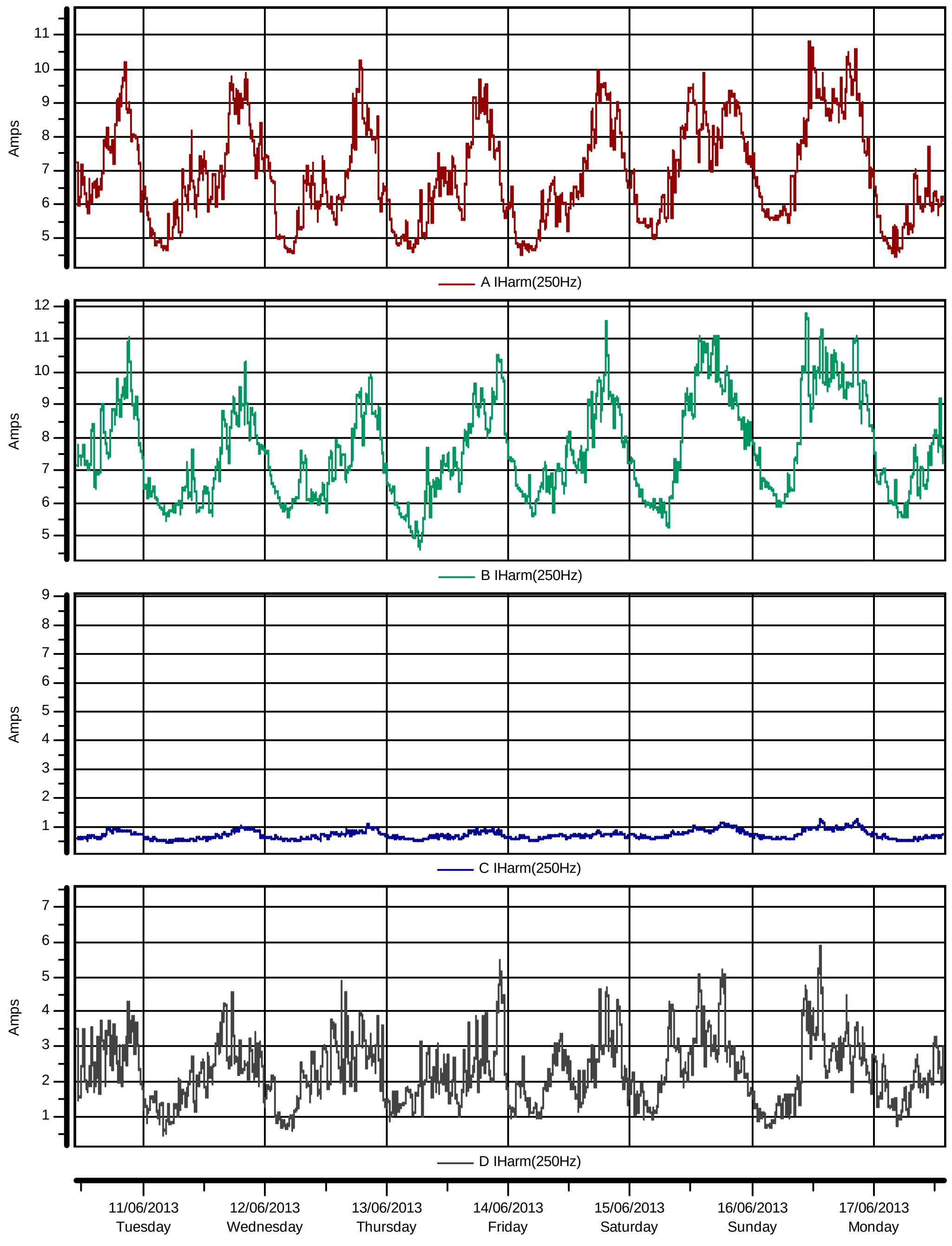
Timeplot
Voltage Spectra



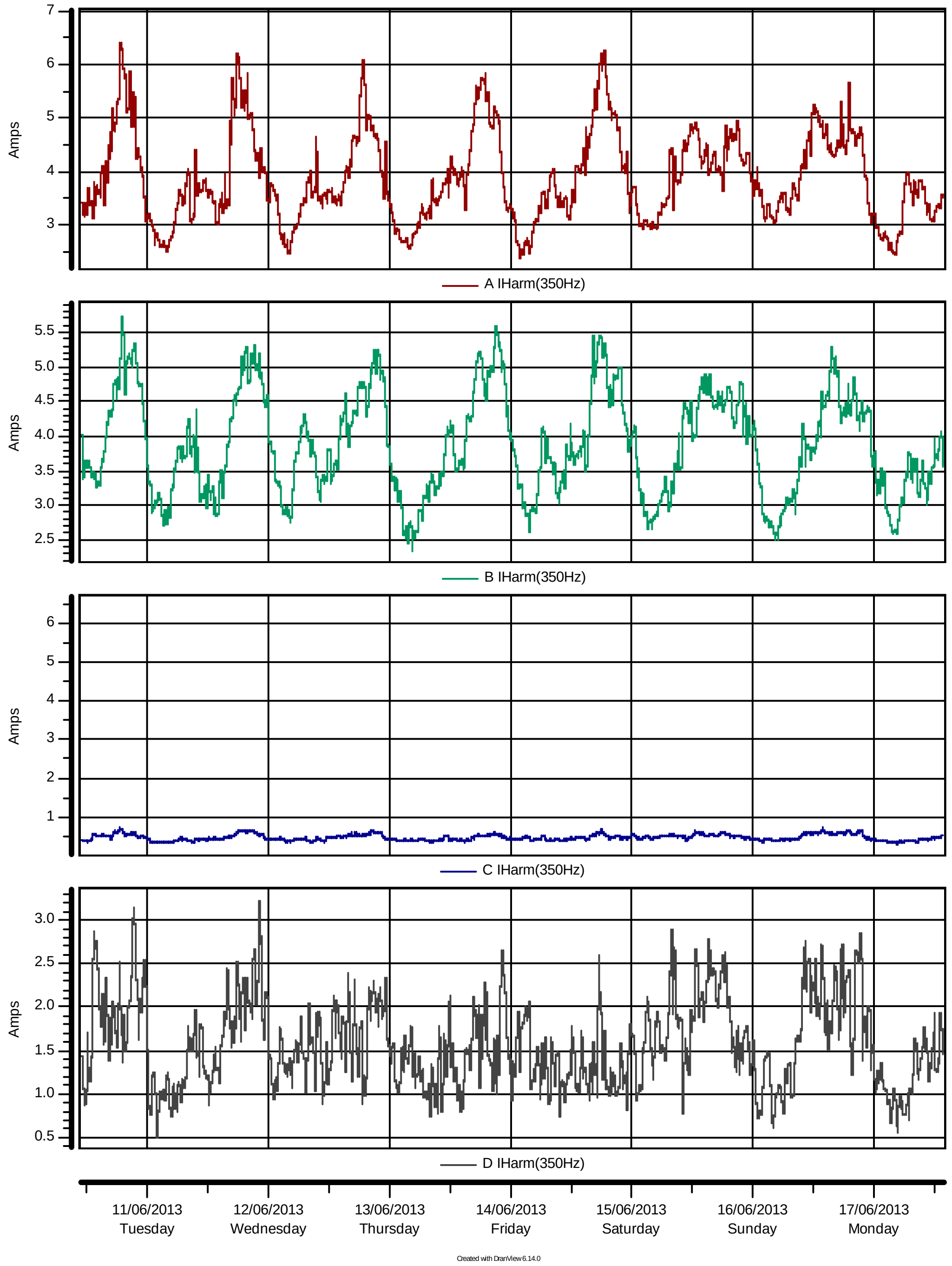
Timeplot
Current Spectra



Timeplot
Current Spectra



Timeplot
Current Spectra



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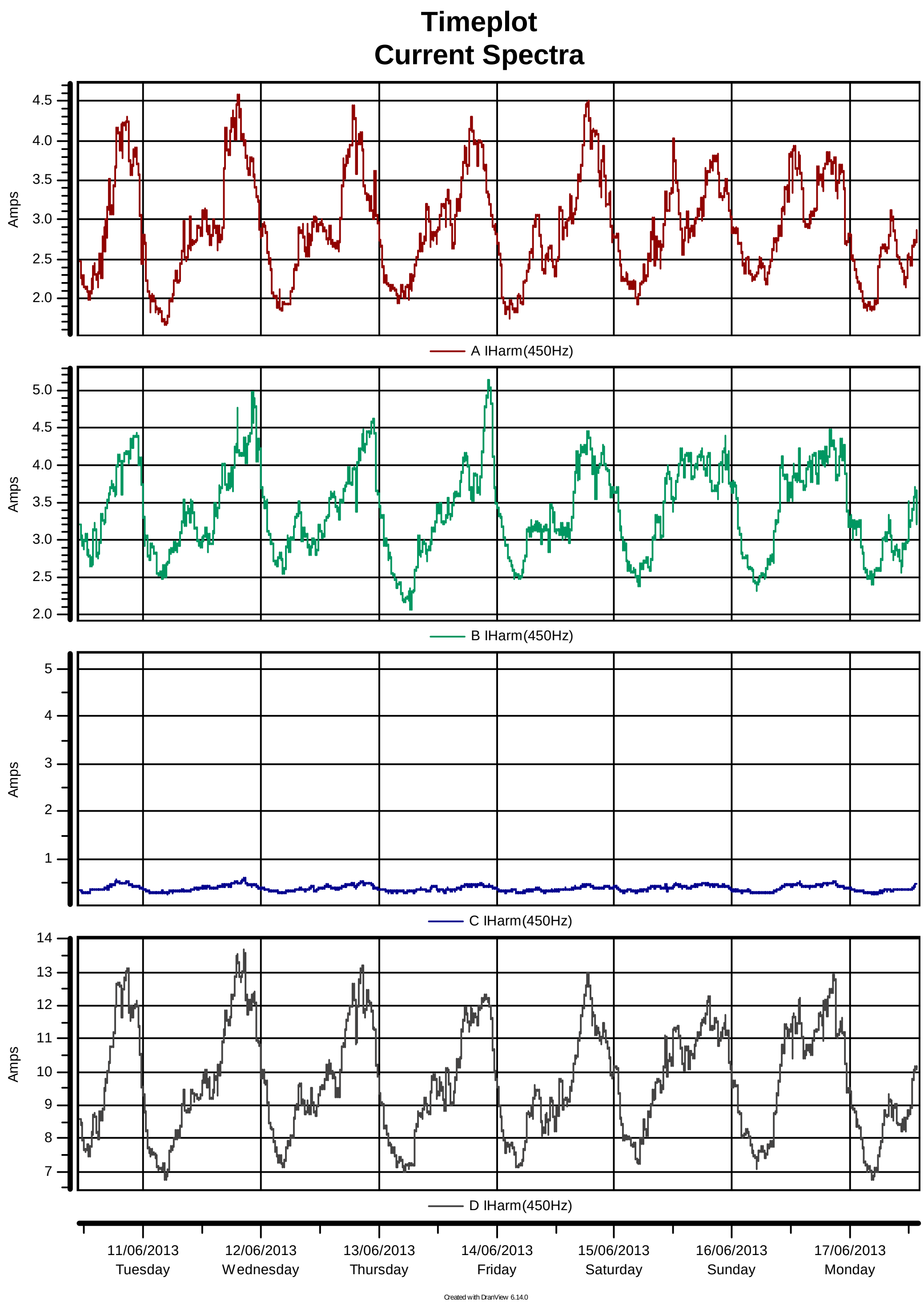

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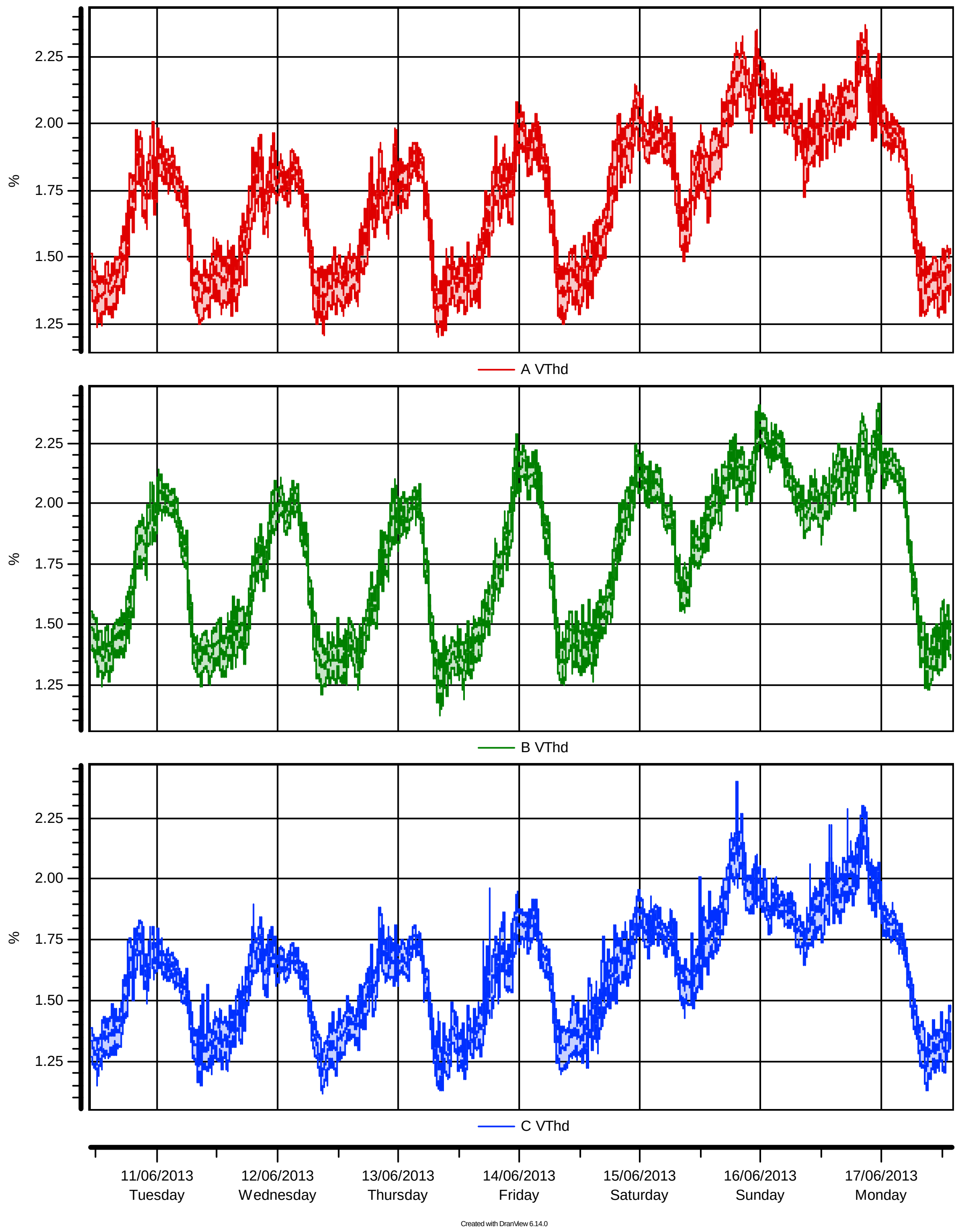
VTHD TIMEPLOTS

Site: howd st filt all 3
Measured from 10/06/2013 10:55:00.0 to 17/06/2013 13:55:00.0



MIN/MAX/AVG POWER REPORT

Site: howd st filt all 3
Measured from 10/06/2013 10:55:00.0 to 17/06/2013 13:55:00.0

POWER

ACTIVE POWER, P (W)

	A	B	C	TOTAL
Min kW	-22.75	-19.75	-1.766	-40.46 on 10/06/2013 12:20:00
Max kW	51.78	53.68	5.732	89.90 on 15/06/2013 19:20:00
Median kW	13.87	14.89	1.729	30.57
Average kW	14.01	15.57	1.751	31.32

APPARENT POWER,S (VA)

	A	B	C	TOTAL
Min kVA	1.99	2.28	0.239	5.13 on 14/06/2013 09:00:00
Max kVA	51.86	53.80	5.751	90.23 on 15/06/2013 19:20:00
Median kVA	14.23	15.18	1.758	31.17
Average kVA	15.29	16.45	1.828	33.57

REACTIVE POWER Q, AT FUND. FREQ. (VAR)

	A	B	C	TOTAL
Min kVAR	-2.987	-3.295	-0.303	-3.599 on 11/06/2013 19:30:00
Max kVAR	4.283	4.596	0.551	5.661 on 15/06/2013 12:50:00
Median kVAR	-0.159	0.393	0.065	0.125
Average kVAR	-0.033	0.432	0.068	0.467

POWER FACTOR, PF

	A	B	C	TOTAL
Min	-0.999	-0.998	-0.998	-1.000 on 10/06/2013 11:10:00
Max	0.999	0.998	0.998	1.000 on 10/06/2013 11:40:00
Median	-0.921	0.977	0.984	0.979
Average	-0.100	0.266	0.559	0.120

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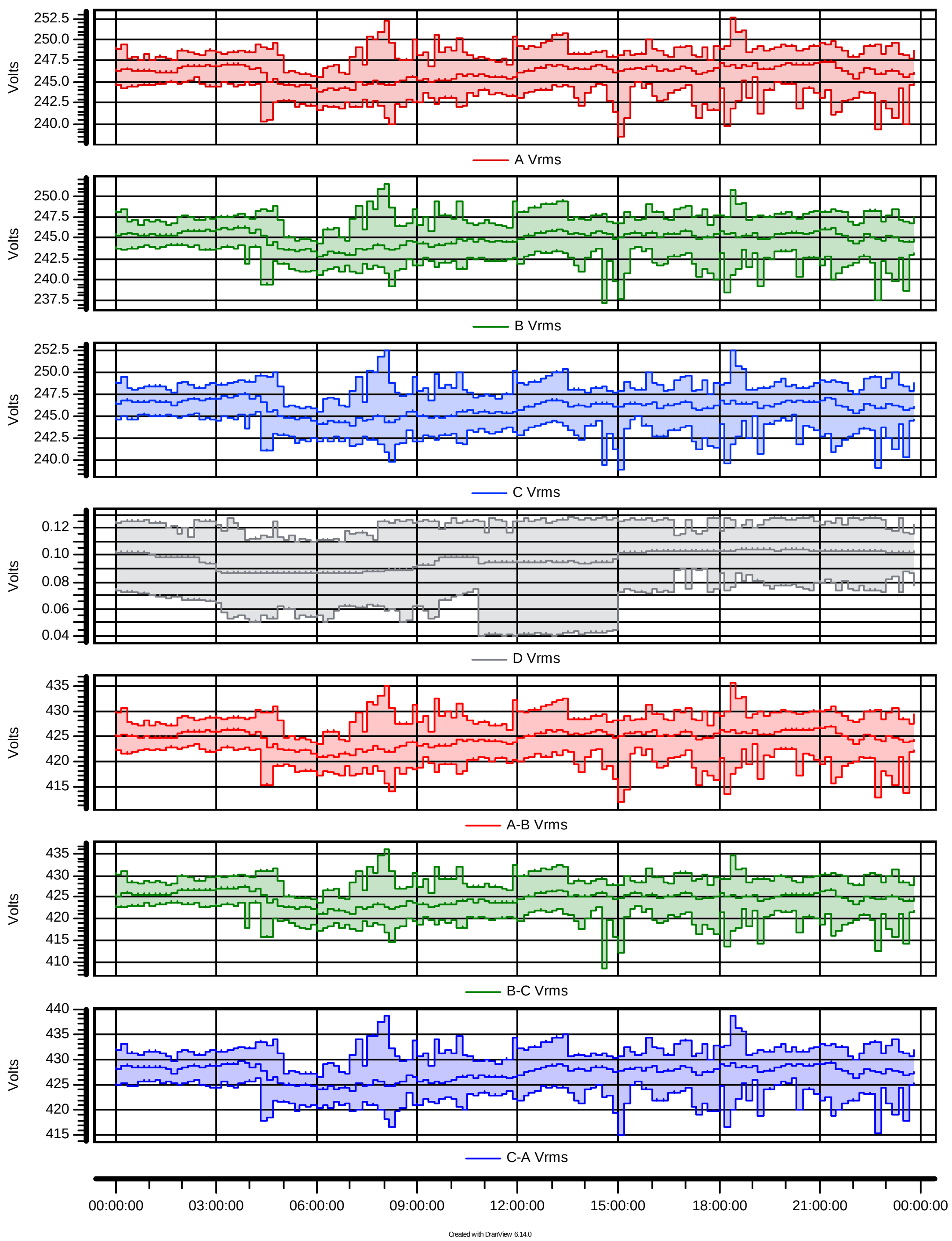
Load Profile
Voltage RMS value



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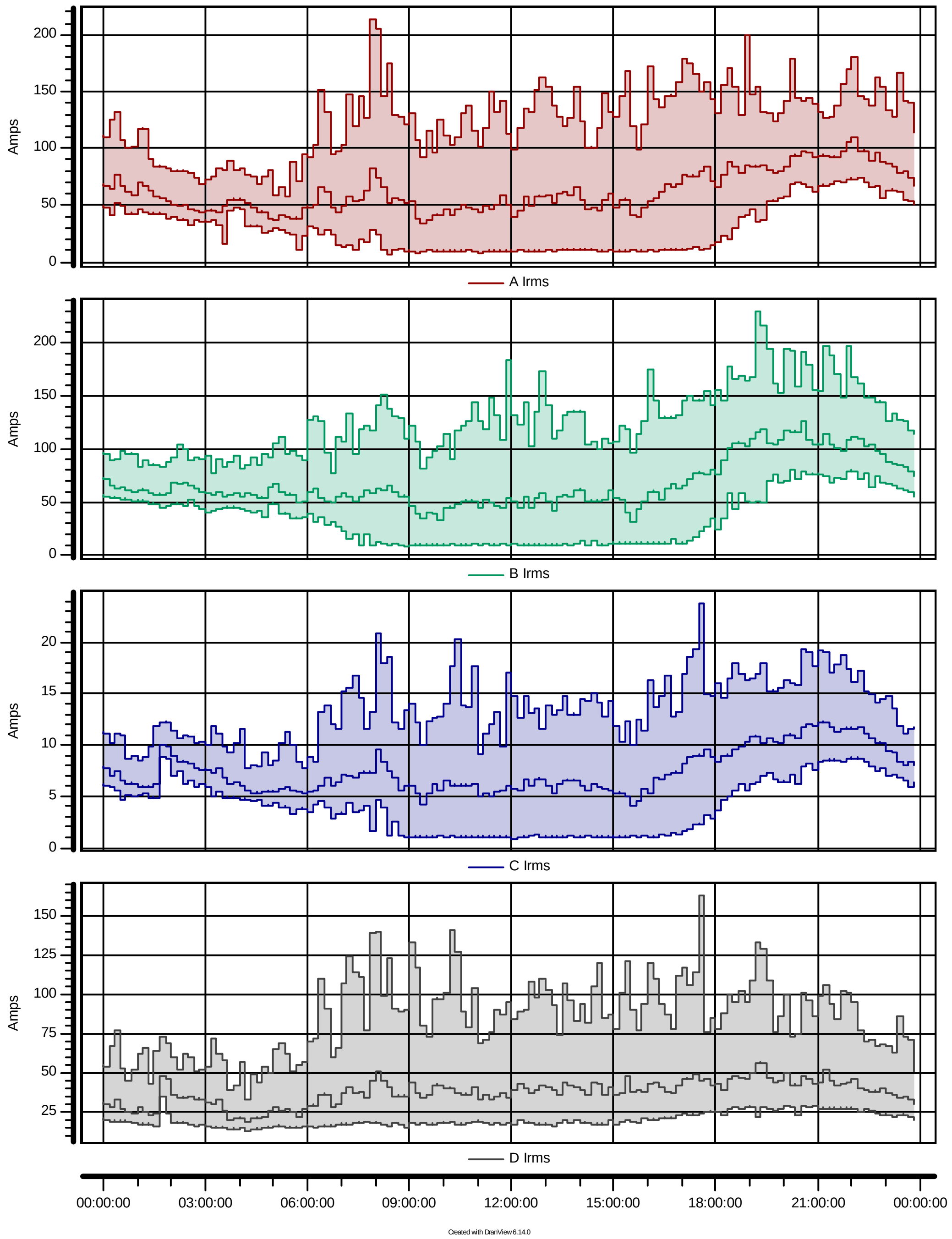
Load Profile
Current RMS value



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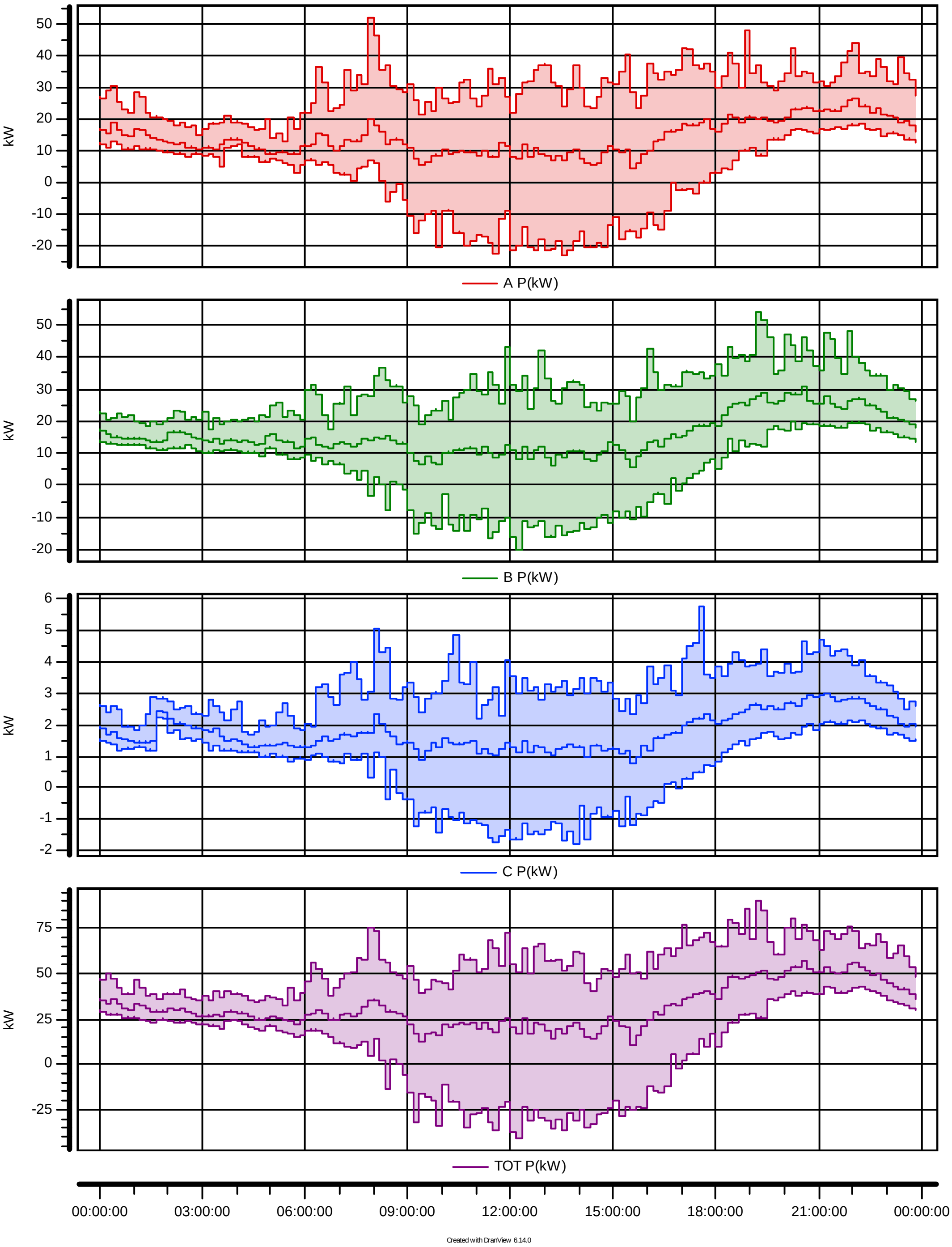
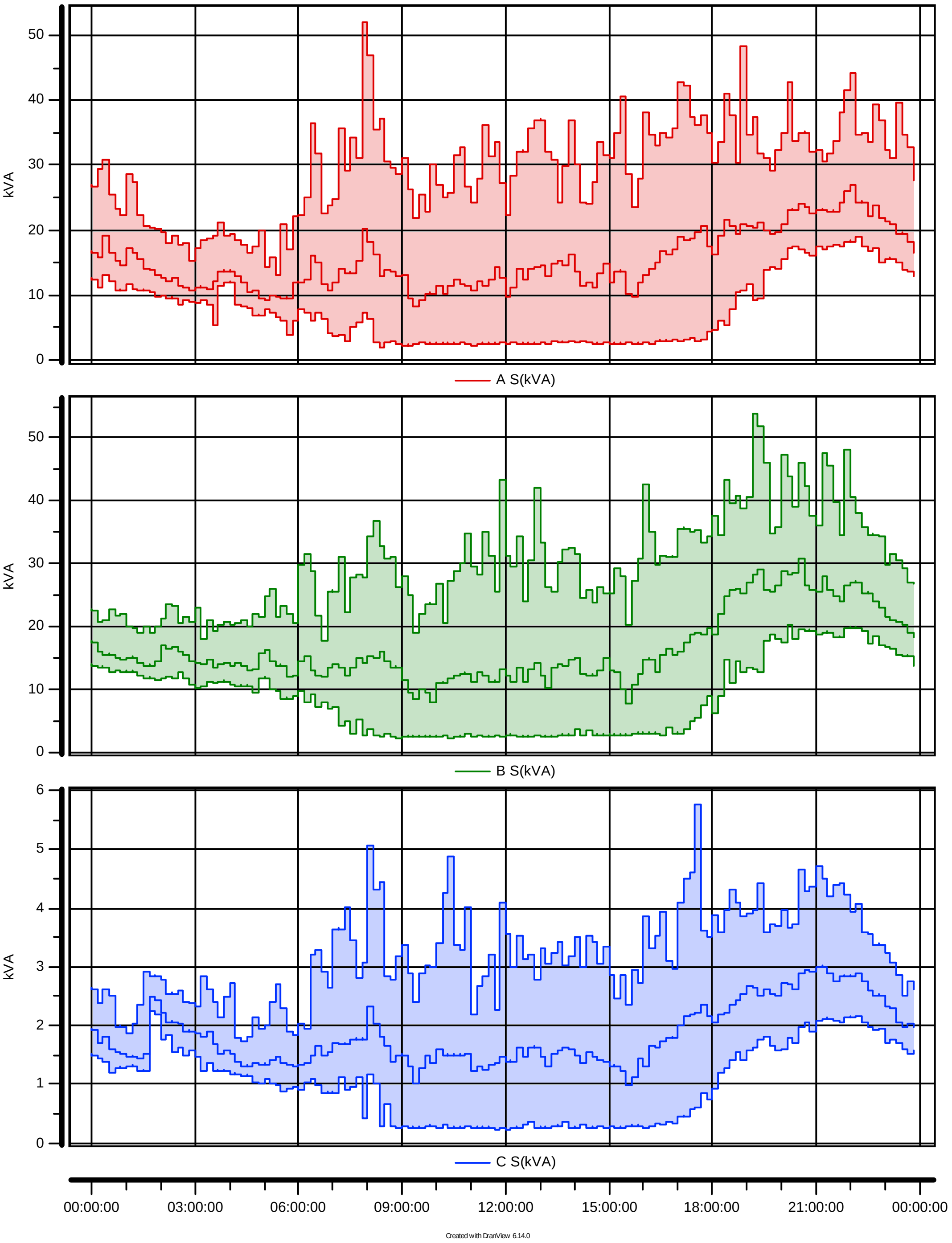
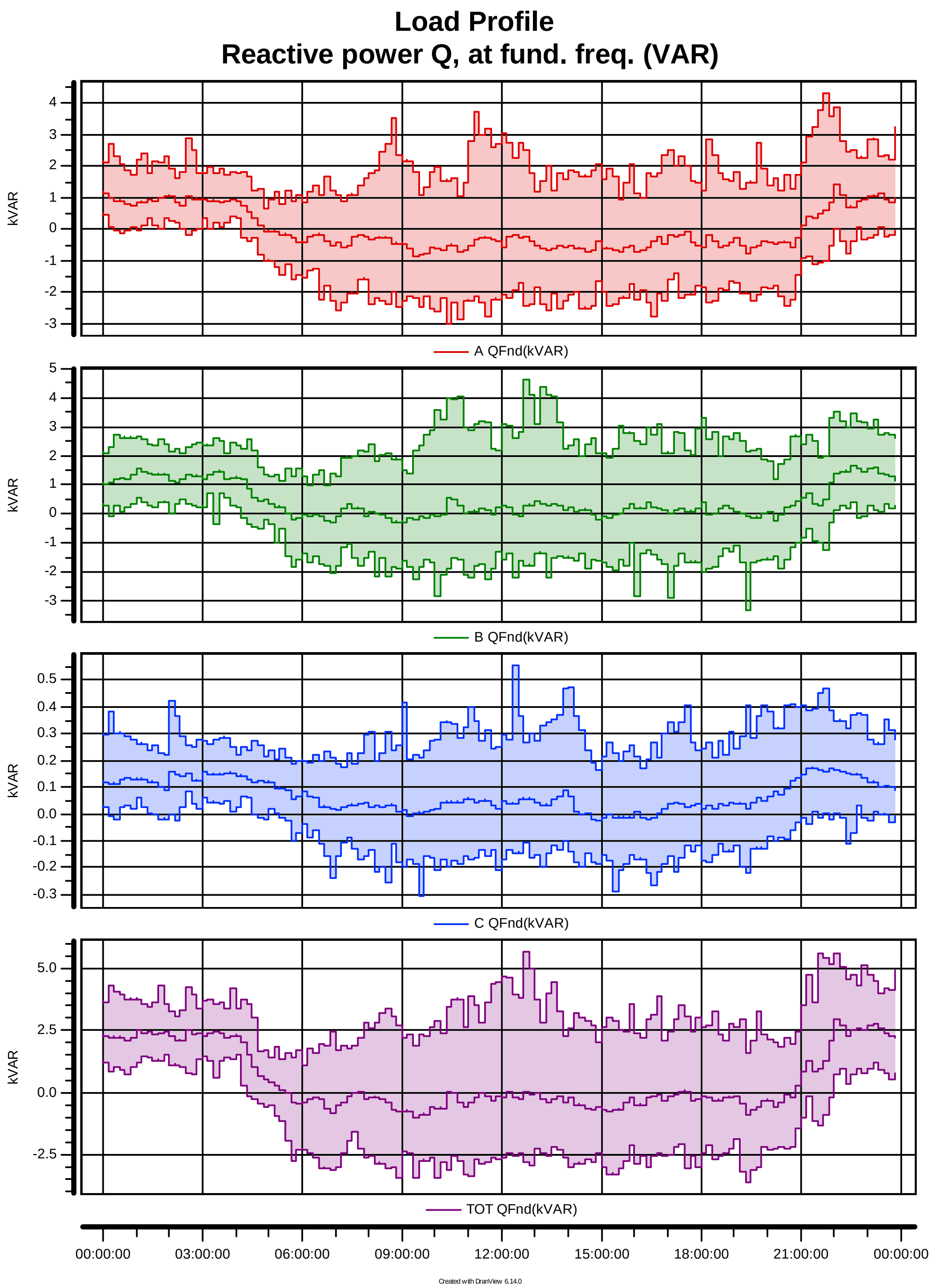
Load Profile
Active power, P (W)



Load Profile
Apparent power,S (VA)





Load Profile
Reactive power Q, at fund. freq. (VAR)
kVAR
A QFnd(kVAR)
B QFnd(kVAR)
C QFnd(kVAR)
TOT QFnd(kVAR)
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

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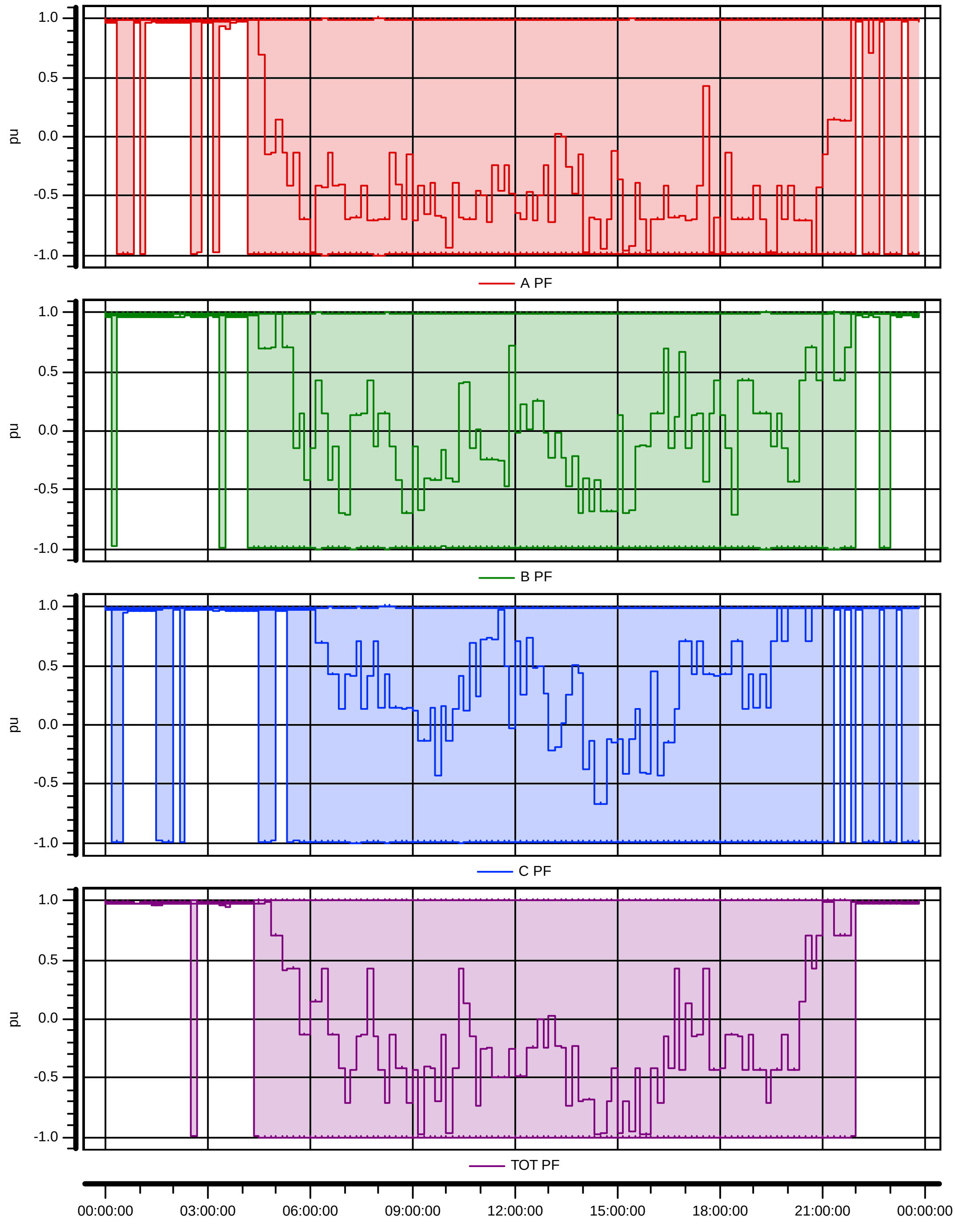
Load Profile
Power Factor, PF



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HARMONICS COMPARED AGAINST LIMITS

Site: howd st filt all 3
Measured from 10/06/2013 10:55:00.0 to 17/06/2013 13:55:00.0
G5/4 Stage 1 Curr. Harm. >16A per Phase
Measured Current Harmonics

	Limit	CHA	CHB	CHC	Status
H02	28.90 A	5.80	4.84	0.69	PASSED
H03	48.10 A	12.70	11.59	1.29	PASSED
H04	9.00 A	1.42	2.53	0.37	PASSED
H05	28.90 A	9.01	10.00	1.15	PASSED
H06	3.00 A	0.88	1.85	0.12	PASSED
H07	41.20 A	5.81	5.31	0.64	PASSED
H08	7.20 A	1.01	1.29	0.18	PASSED
H09	9.60 A	4.15	4.55	0.55	PASSED
H10	5.80 A	0.51	1.08	0.12	PASSED
H11	39.40 A	2.16	2.26	0.25	PASSED
H12	1.20 A	0.48	0.78	0.08	PASSED
H13	27.80 A	2.79	2.50	0.34	PASSED
H14	2.10 A	0.38	0.69	0.07	PASSED
H15	1.40 A	2.41	2.37	0.29	**FAILED**
H16	1.80 A	0.41	0.51	0.06	PASSED
H17	13.60 A	2.27	2.35	0.24	PASSED
H18	0.80 A	0.34	0.44	0.04	PASSED
H19	9.10 A	2.46	2.25	0.29	PASSED
H20	1.40 A	0.25	0.42	0.03	PASSED
H21	0.70 A	0.95	0.90	0.10	**FAILED**
H22	1.30 A	0.19	0.24	0.03	PASSED
H23	7.50 A	1.08	0.95	0.10	PASSED
H24	0.60 A	0.11	0.15	0.02	PASSED
H25	4.00 A	1.04	0.79	0.10	PASSED
H26	1.10 A	0.10	0.11	0.01	PASSED
H27	0.50 A	0.49	0.48	0.05	PASSED
H28	1.00 A	0.09	0.08	0.01	PASSED
H29	3.10 A	0.57	0.53	0.07	PASSED
H30	0.50 A	0.05	0.06	0.02	PASSED
H31	2.80 A	0.44	0.35	0.05	PASSED
H32	0.90 A	0.05	0.04	0.02	PASSED
H33	0.40 A	0.27	0.29	0.03	PASSED
H34	0.80 A	0.04	0.03	0.02	PASSED
H35	2.30 A	0.26	0.24	0.03	PASSED
H36	0.40 A	0.03	0.03	0.02	PASSED
H37	2.10 A	0.24	0.22	0.03	PASSED
H38	0.80 A	0.03	0.03	0.03	PASSED
H39	0.40 A	0.15	0.15	0.03	PASSED
H40	0.70 A	0.03	0.03	0.03	PASSED
H41	1.80 A	0.16	0.16	0.03	PASSED
H42	0.30 A	0.03	0.03	0.03	PASSED
H43	1.60 A	0.16	0.14	0.03	PASSED
H44	0.70 A	0.03	0.03	0.03	PASSED
H45	0.30 A	0.08	0.07	0.02	PASSED
H46	0.60 A	0.03	0.03	0.03	PASSED
H47	1.40 A	0.06	0.06	0.03	PASSED
H48	0.30 A	0.03	0.03	0.03	PASSED
H49	1.30 A	0.05	0.04	0.03	PASSED
H50	0.60 A	0.00	0.00	0.00	PASSED