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Power Quality Analysis Report

Site Name:	*"Company"*
Street Address:	*"Street Address"*
Suburb:	"*Suburb*"
State & Post Code:	"*State Post Code*"
Customer Company Name:	*"Company"*
Customer Contact:	*"Company Contact"*
Street Address:	*"Street Address"*
Suburb:	"*Suburb*"
State & Post Code:	"*State Post Code*"

Report Introduction

The purpose of the analysis was to investigate the quality of supply at the installation and to determine the possible correction of any Power Quality problems identified.

The installation was monitored for the period stated on the summary sheet with a CHK PM30 Powermonic power analyser which recorded the energy parameters of the installation throughout the period noted on the attached. The Powermonic measures data 30 times per cycle, averages this data and logs the result at a predetermined recording interval, which in this case was every 60 seconds.

The analysis was carried out with the load representing normal daily patterns of power usage which should reflect the true load profile. A series of graphs of the recorded data has also been included to best illustrate the points made in this report. Specific graphs not included in this report can be provided upon request. The data has been analysed and peak loads extracted and reported on the summary page.

Consideration should be given that this analysis was for a relatively short period only, which is a brief indication of the yearly usage.

About Power Quality

Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load's ability to function properly with that electric power. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power.

The complexity of the system to move electric energy from the point of production to the point of consumption combined with variations in weather, generation, demand and other factors provide many opportunities for the quality of supply to be compromised.

The subject of harmonics is a sub-set of Power Quality (PQ). Other power quality considerations include voltage variations (sags, swells, interruptions, flicker, etc.), transients (surges, lightning, switching events), and grounding.

Harmonic Sources

The general categories of harmonic producing loads (also called non-linear loads) are:

- Power electronic equipment (drives, rectifiers, computers etc.)
- Arcing devices (welders, arc furnaces, fluorescent lights etc.)
- Rotating machines

Symptoms of harmonics

- Erratic electronic equipment operation
- Computer and /or PLC lockups
- Lighting failures
- Voltage notching
- Motor noise and /or vibrations
- Overheating (motors, cables, transformers, neutrals)
- Transformer noise (humming)
- Nuisance tripping of breakers and RCD's
- Electrical fires

Economic considerations of harmonics

- kW losses in cables and transformers
- Low total power factor
- Generator sizing considerations
- Losses and inefficiency (motors)
- Capacity concerns (transformers, cables, switchboards)
- UPS sizing
- Utility imposed penalties

The benefits of installing an Active Harmonic Filter unit are:

- Increase load capability of the existing electrical system. This allows more load to be added to the switchboard without upgrading cables etc.
- Decrease in total harmonic distortion. This improves power quality and efficiency.
- Reduced heating, prolonging serviceability of infrastructure
- Guarantees compliance with IEEE 519-1992
- Provides reactive (var) currents improving system power factor

About Power Factor Correction

Power Factor is a measure of how efficient the electrical power is being used. Higher electrical efficiency results in less electrical generating capacity requirements and smaller transformers, bus bars, cables and other distribution system devices. Therefore, the cost of electricity is reduced and savings are available for the consumer if applicable.

The installation of a Power Factor Correction System (PFCS) will allow a reduction of current loads on switchboards and associated cables and equipment. A microprocessor based regulator, switching a group of capacitors to achieve a preset Power Factor value controls the Power Factor correction (PFC) system.

The benefits of installing a Power Factor Correction unit are:

a) Increase load capability of the existing electrical system. This allows more load to be added to the switchboard without upgrading cables etc.
b) Decrease in total harmonic distortion. This improves power quality and efficiency.
c) Reduced heating
d) Reduction in site kVA usage resulting in potential for energy savings when energy companies charge by kVA.

To fully utilise the benefits of these load current reductions, care must be taken to ensure the PFCS is installed at the correct location and that harmonic levels do not reduce the life span of the PFCS.

Due to rapidly changing technology in electrical equipment, it is anticipated that increased harmonic levels will be generated in the future. Harmonics create additional heat. Also, a major concern arising from the use of capacitors in a power system is the possibility of system resonance. This effect imposes voltages and currents that are considerably higher than would be the case with no resonance. The reactance of a PFC system decreases with frequency, and so the PFCS acts as a sink for the higher harmonic currents.

This effect increases the dielectric stresses and heating within the capacitor. Heating is not such a concern because of the low loss capacitor design that uses film and foil. The dielectric stresses are of concern because the harmonic voltages in the capacitor are additive to the fundamental voltage peak. As a result, the dielectric film in the capacitor is subjected to higher voltages than allowed by the design of the capacitor. This causes reduced life span. Dielectric failure is a result of fatiguing of the insulation over a period of time.

The harmonic levels should be within the limits as defined in Australian standards AS2289/1998 (voltage 5% and current 20%).

Harmonic reactors will protect against these effects thus prolonging the life of the PFC system. In addition, capacitors with a maximum voltage rating of at least 525V used in conjunction with the reactors will provide a long anticipated service life of the system.

Definitions

Item	Definition
Power Factor:	Power Factor is a measure of the efficiency of an electrical network. It is also known as cosφ. It is the ratio of active power to apparent power.
Reactive Power, Q (kVAr):	Reactive Power results from the magnetic flux inherent in electrical systems. It is especially apparent with transformers and induction motors which rely on magnetising currents for the transfer of electrical energy. The magnetic flux causes the current to lag the voltage by 90°. Reactive power is either supplied from the electrical supply company or from capacitors connected to the load or an Active Harmonic Filter.
Apparent Power, S (kVA):	Apparent Power is the mathematical result of adding real power and reactive power.
Real Power, P (kW):	Real Power is measured in Watts (W) or more commonly as kW. It is equal to apparent power in a purely resistive network i.e. when the voltage and current as perfectly in phase. It is the part of the power that actually does the work.
Total Harmonic Distortion, THD:	THD is an indication of how much of the voltage or current is made up of voltage or current resulting from all measured harmonic influences.
Inductive Load:	Examples of inductive loads are: transformers, fluorescent lighting, electrical motors, welding equipment, and arc furnaces. Inductive loads require a magnetic field to operate. The presence of the inductive load causes the current to lag the voltage and so reduces the power factor. The higher the magnetic flux of the device and the greater the proportion of inductive loads on an electrical system, the lower the power factor.
Capacitive Load:	Few loads are capacitive by nature. Capacitive loads are introduced into an electrical system to supply the necessary reactive power to maintain the electromagnetic fields required by inductive loads.
kVAr Compensation:	This is the amount of superficial capacitive load needed to meet the reactive power requirement of inductive loads in an electrical system, this can be supplied by an Active Harmonic Filter.
Over Compensation:	This results from too much kVAr compensation and results in the current leading the voltage. The net effect is power being supplied back into the grid. This is particularly important for sites with generator supply as the generator is forced to absorb this energy and in most cases, it has limited ability to do so.
Harmonics:	Harmonics are multiples of the fundamental frequency (50Hz) distortions found in electrical power, subjected to continuous disturbances. For example, the 5^{th} Harmonic = 250Hz. Harmonics result from switch mode power supplies typical of non-linear devices such as: UPS systems, VSDs, rectifiers, welders, arc furnaces, fluorescent ballasts, and computers. High levels of harmonics result in over-voltages and over-currents.
Active Harmonic Filter:	Device used to generate an inverted harmonic current signal to that which is being measured and injecting that signal into the electrical system to minimise the impact of harmonics.

Observations, Conclusions & Recommendations

Phase imbalance

This analysis has revealed that there is phase imbalance during load periods. The phase current imbalance peaked at 1157% and averages at 118% (for more details refer to the Summary page) with “A”phase carrying the bulk of the load.<u>Load sharing between the phases is highly recommended to bring the phases back into a balanced state and connectingfuture single phase loads to the lesser loaded phase.</u>
This action will also reduce the neutral current.

Voltage

The supply appears to be weakand subject to load variations. The load changes are from within the reticulation system measured but can also be from shared loads at the supply transformer.There are 1276 table captures (Voltage sags) during the recorded period, this is considered a large amount and is possibly a by-product of a heavily loaded supply transformer, all recorded sags occurred during business hours when the load is at its greatest.

Current

The average current throughout the recorded period is 14.53 Amps per phaseduring business hours and 6.70 Amps during non-business hours. Maximum load of 58.00 Amps was recorded on Wed 12 June at 08:26:06. The maximum neutral current is 16.30Amps which is 139% of the average phase current. This is a strong indicator of an unbalanced load and harmonics from threephase and single phase non-linear loads e.g. computer switch mode power supplies, air-conditioning and lighting loads. During non-business hours there is constant switching of a load (unknown) that is not balanced and it also includes the neutral current (see graph “Current only, low load”). Whether this switching is creating any power problems is also unknown.

Harmonic Trend

Harmonic trends indicate single phase and three phase non-linear loads are present with Lighting, Switch Mode Power Supplies and Air-conditioning as a possibility. Voltage harmonics are considered high and the most likely to effect the system.

PowerFactor Correction

With an average kVAr requirement of 5.64 and a peak of 20.35 it is deemed non-commercial to consider a standalone power factor correction system.

RMS Captures (Transients and rolling)

A total of 26 captures were recorded (see graphs “Transients #5, 6 & 11” for sample of the captures). Transients #5 & 6 both show very large start up currents with associated voltage drops. The origin of this apparent start up load is unknown.
Transient #11 shows a power outage or a collapse of the Voltage at 13:06:17 on the 19th of June, the origin of this is unknown.

Conclusion
It would seem that the supply transformer is either under sized or heavily loaded and not capable of supplying a consistent and steady supply but without knowing the electrical reticulation system on either the primary or secondary sides of the transformer the problems may well be load induced.
The questions that need answering are,

1. What neighbouring loads share the supply transformer?
2. What is the nature of these loads?
3. What harmonics do these loads induce?
4. What effect are they having on "*Company*" systems?

Recommendations for Hardware

Active Harmonic Filtering Equipment

The reduction of the harmonic currents to recommend levels within IEEE 519-1992 at the switchboard (IEEE 519-1992 refers to the PCC and not the switchboard) will also reduce the Voltage sine wave distortion and significantly assist with any component failures being experienced within the sub-circuits of the switchboard being monitored, any unexplained PLC interruptions, lighting failures, electric motor failures, indiscriminate tripping of breakers and RCD's etc.

<u>The application of a 25 Amp 4 wire Active Harmonic Filter at the MSB will help with harmonic mitigation, load balancing and power factor correction.</u>

Please note: this report does not in any way account for any up-stream harmonics or power quality issues already present but not yet presented.

David Gale
Business Manager - Power Quality | **FUSECO**

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Table Capture Summary Sample of Total Data

Date	Time	Cause	Channel	Dur. (m.s.ms)	Min/Max (V)
Wed 12 Jun 2013	8:09:12	Sag (U/V)	VA	'03:54.230	222
Wed 12 Jun 2013	8:15:55	Sag (U/V)	VA	'00:00.150	222.4
Wed 12 Jun 2013	8:16:30	Sag (U/V)	VA	'00:00.110	224.7
Wed 12 Jun 2013	8:26:09	Sag (U/V)	VA	'00:06.330	180.2
Wed 12 Jun 2013	8:29:21	Sag (U/V)	VA	'00:00.310	221.9
Wed 12 Jun 2013	8:37:52	Sag (U/V)	VA	'00:00.320	222.3
Wed 12 Jun 2013	8:41:57	Sag (U/V)	VA	'00:00.060	224.8
Wed 12 Jun 2013	8:42:27	Sag (U/V)	VA	'00:00.050	225.5
Wed 12 Jun 2013	8:45:06	Sag (U/V)	VA	'00:00.300	222.4
Wed 12 Jun 2013	8:46:48	Sag (U/V)	VA	'00:04.930	223.1
Wed 12 Jun 2013	8:47:00	Sag (U/V)	VA	'00:00.340	224
Wed 12 Jun 2013	8:47:01	Sag (U/V)	VA	'00:00.460	223.8
Wed 12 Jun 2013	8:47:02	Sag (U/V)	VA	'00:00.190	223.9
Wed 12 Jun 2013	8:52:55	Sag (U/V)	VA	'00:00.330	220.5
Wed 12 Jun 2013	9:00:49	Sag (U/V)	VA	'00:00.310	223.2
Wed 12 Jun 2013	9:01:49	Sag (U/V)	VA	'00:03.320	225.4
Wed 12 Jun 2013	9:05:04	Sag (U/V)	VA	'00:00.310	221.4
Wed 12 Jun 2013	9:11:48	Sag (U/V)	VC	'00:00.160	224.7
Wed 12 Jun 2013	9:11:48	Sag (U/V)	VA	'00:00.310	221.8
Wed 12 Jun 2013	9:19:30	Sag (U/V)	VA	'00:00.780	219.4
Wed 12 Jun 2013	9:28:42	Sag (U/V)	VC	'00:00.290	224.6
Wed 12 Jun 2013	9:28:30	Sag (U/V)	VA	'01:32.880	216.9
Wed 12 Jun 2013	9:37:54	Sag (U/V)	VA	'00:00.300	221.6
Wed 12 Jun 2013	9:43:59	Sag (U/V)	VA	'00:00.290	223
Wed 12 Jun 2013	9:47:32	Sag (U/V)	VA	'00:05.500	224.8
Wed 12 Jun 2013	9:50:36	Sag (U/V)	VA	'00:00.350	219.4
Wed 12 Jun 2013	9:57:22	Sag (U/V)	VA	'00:00.330	222.3
Wed 12 Jun 2013	10:05:58	Sag (U/V)	VA	'00:00.310	223.3
Wed 12 Jun 2013	10:14:55	Sag (U/V)	VA	'00:00.300	222.5
Wed 12 Jun 2013	10:16:51	Sag (U/V)	VA	'00:43.490	220.1
Wed 12 Jun 2013	10:26:12	Sag (U/V)	VA	'01:24.450	219.2
Wed 12 Jun 2013	10:27:56	Sag (U/V)	VA	'00:41.430	224.9
Wed 12 Jun 2013	10:35:08	Sag (U/V)	VC	'00:00.290	224.8
Wed 12 Jun 2013	10:31:06	Sag (U/V)	VA	'16:28.030	215.5

Summary

Project Details

Project:	*"Company"*
Location:	*"Suburb"*
Switchboard:	MSB
Reference No.:	MSB No.1
Date:	12-June-2013

Data Logging Statistics

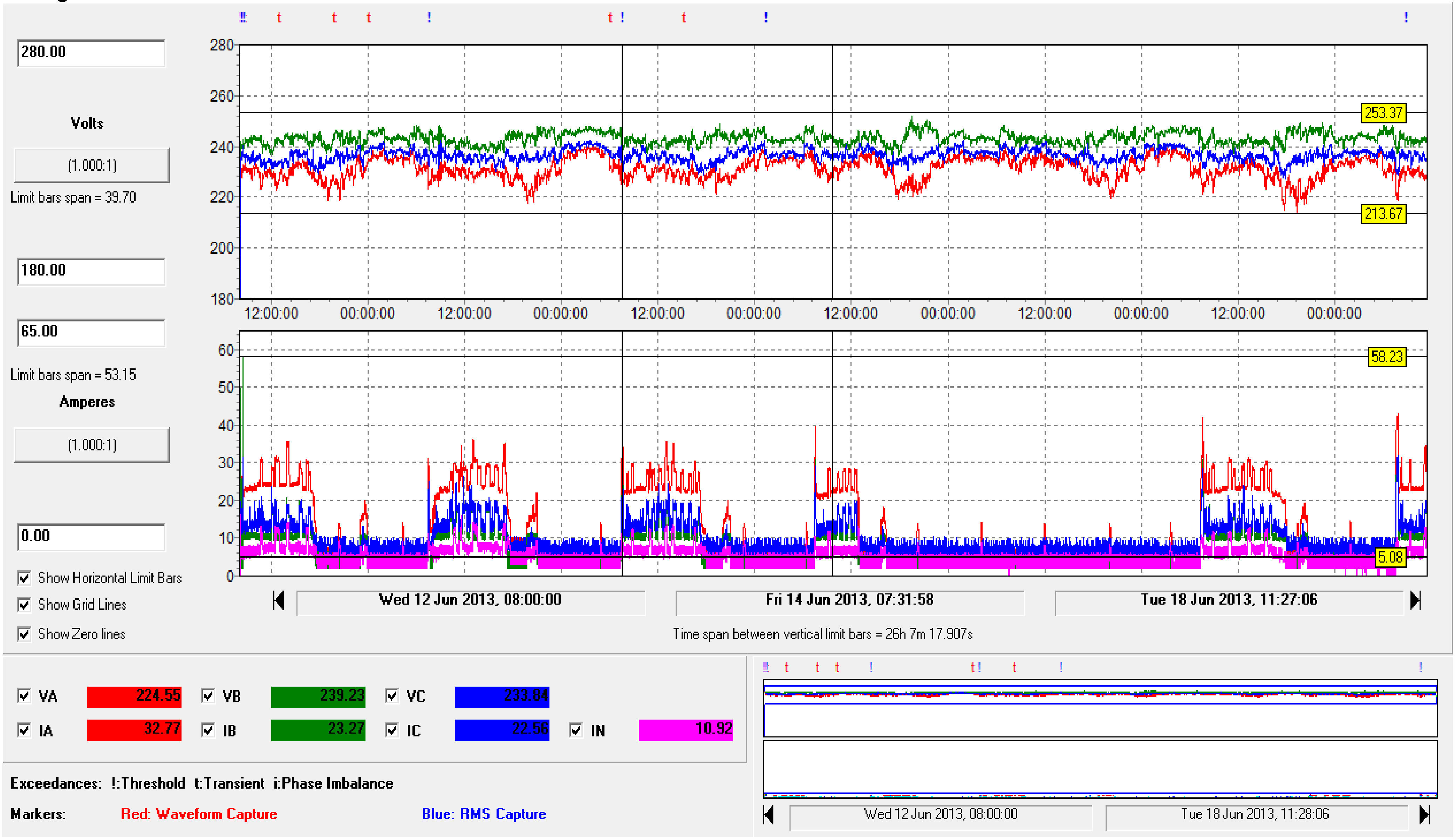
First Log (Date):	Wed 12 Jun 2013
First Log (Time):	8:00:00
Last Log (Date):	Tue 18 Jun 2013
Last Log (Time):	11:27:06

Logged Data Statistics

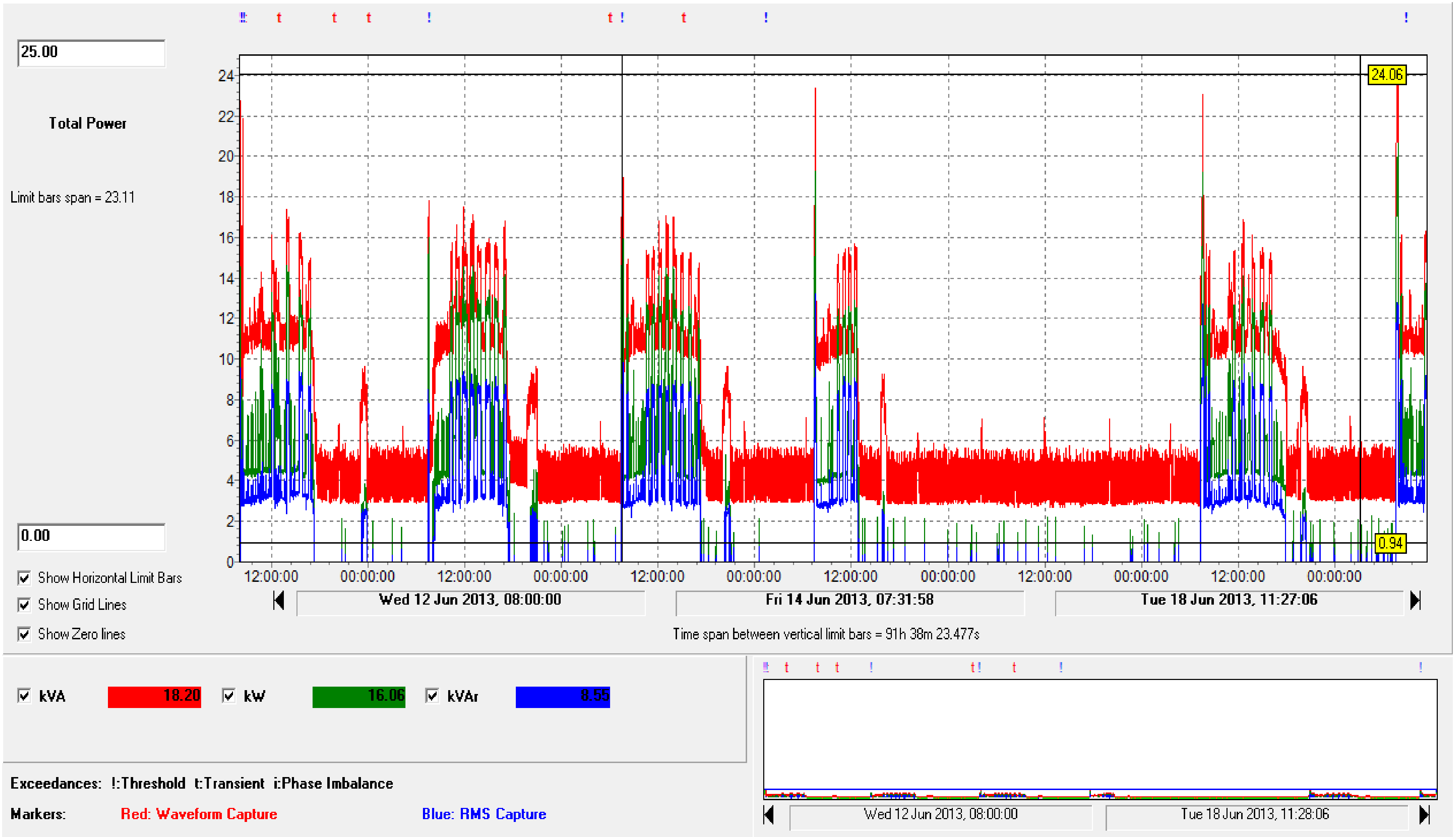
Data	Value	Date	Time
Maximum Voltage (V):	252	Sat 15 Jun 2013	19:28:06
Minimum Voltage (V):	214.4	Mon 17 Jun 2013	19:16:06
Voltage Tolerance - 240Vac (%):	+5% -10.7%	[Aust Standard: +10%, -6%]	
Maximum Current (A):	58.00	Wed 12 Jun 2013	8:26:06
Minimum Current (A):	2.10	Wed 12 Jun 2013	8:13:07
Normal Hours (8:00-17:30) Average Current (A):	14.53		
After Hours (17:30-8:00) Average Current (A):	6.70		
24 hour Average Current (A):	9.91		
Minimum Phase Current Imbalance:	9%	Wed 12 Jun 2013	8:27:06
Worst Phase Current Imbalance:	1157%	Wed 12 Jun 2013	8:14:07
Average Phase Current Imbalance:	118%		
Maximum Neutral Current (A):	16.30	Wed 12 Jun 2013	8:00:00
Maximum Neutral Current % of Phase Average (A):	139%	Fri 14 Jun 2013	21:21:06
Minimum Neutral Current % of Phase Average (A):	0%	Sun 16 Jun 2013	7:33:07
Peak Apparent Power (kVA):	24.27	Tue 18 Jun 2013	7:51:06
Current at Peak Power (A):	33.77		
Power Factor at Peak Power:	0.85		
Minimum Apparent Power (kVA):	2.70	Sun 16 Jun 2013	8:48:06
Peak Real Power (kW):	20.66	Tue 18 Jun 2013	7:51:06
Minimum Real Power (kW):	0.10	Wed 12 Jun 2013	17:18:06
Best Power Factor:	0.91	Thu 13 Jun 2013	7:31:06
Worst Power Factor:	0.01	Thu 13 Jun 2013	7:37:06
Target Power Factor:	0.98		
Largest kVAr Requirement for Target PF:	20.35	Wed 12 Jun 2013	8:26:06
Smallest kVAr Requirement for Target PF:	2.23	Thu 13 Jun 2013	17:32:06
Average kVAr Requirement for Target PF:	5.64		
Maximum Current Capacity Improvement (A):	24.35	Wed 12 Jun 2013	8:26:06
Maximum Current Capacity Improvement (%):	99%	Thu 13 Jun 2013	7:37:06
Maximum Harmonic Voltage (A Phase)	7.08%	Thur 13 June 2013	1:33:25
Maximum Harmonic Current (A Phase)	194.69%	Thur 13 June 2013	6:33:11
Peak Neutral Harmonic Current (3rd Harmonic)	875%	Sun 16 June 2013	12:20:29

Power Quality Analysis - Graphs

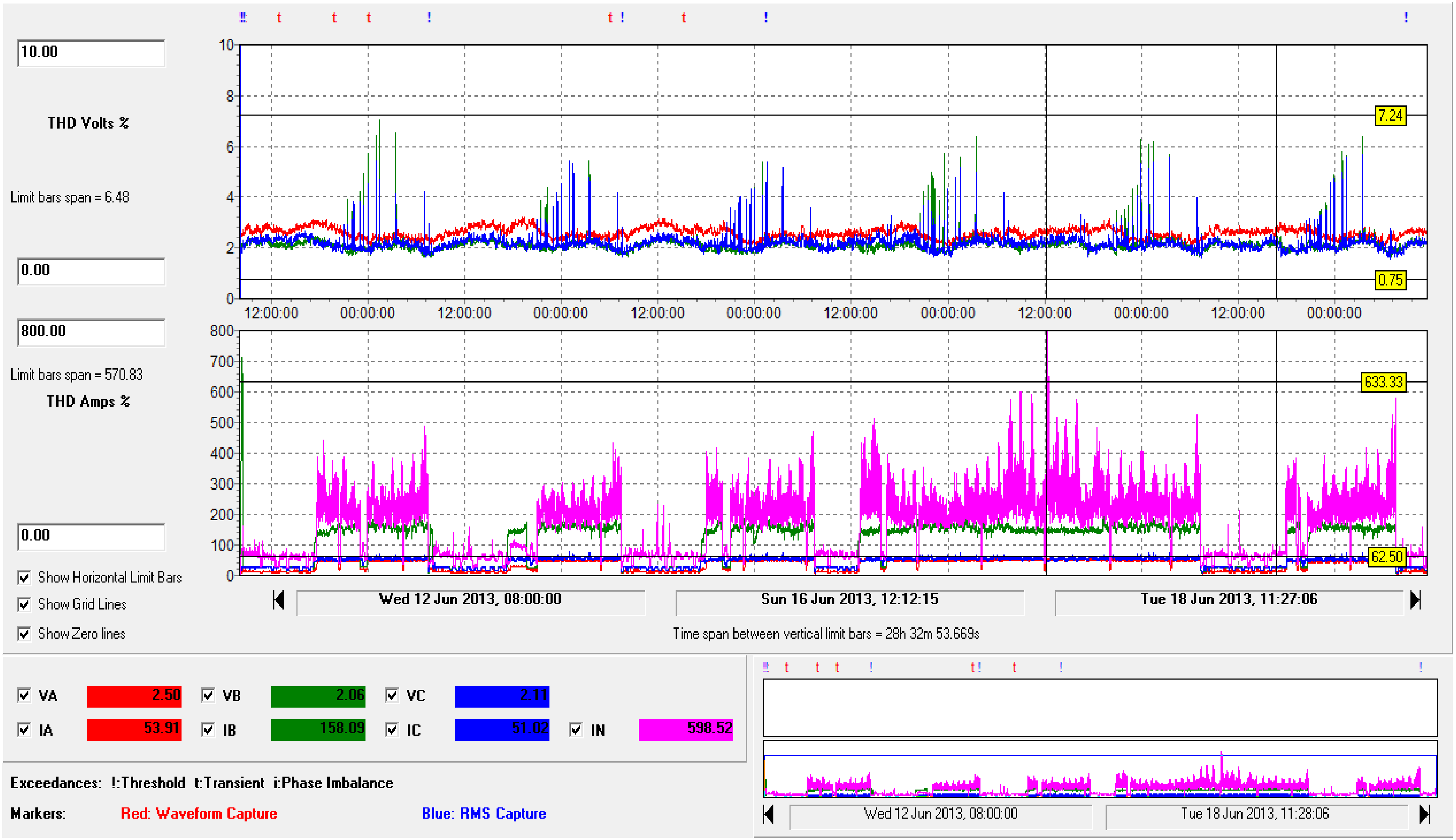
Voltage and Current



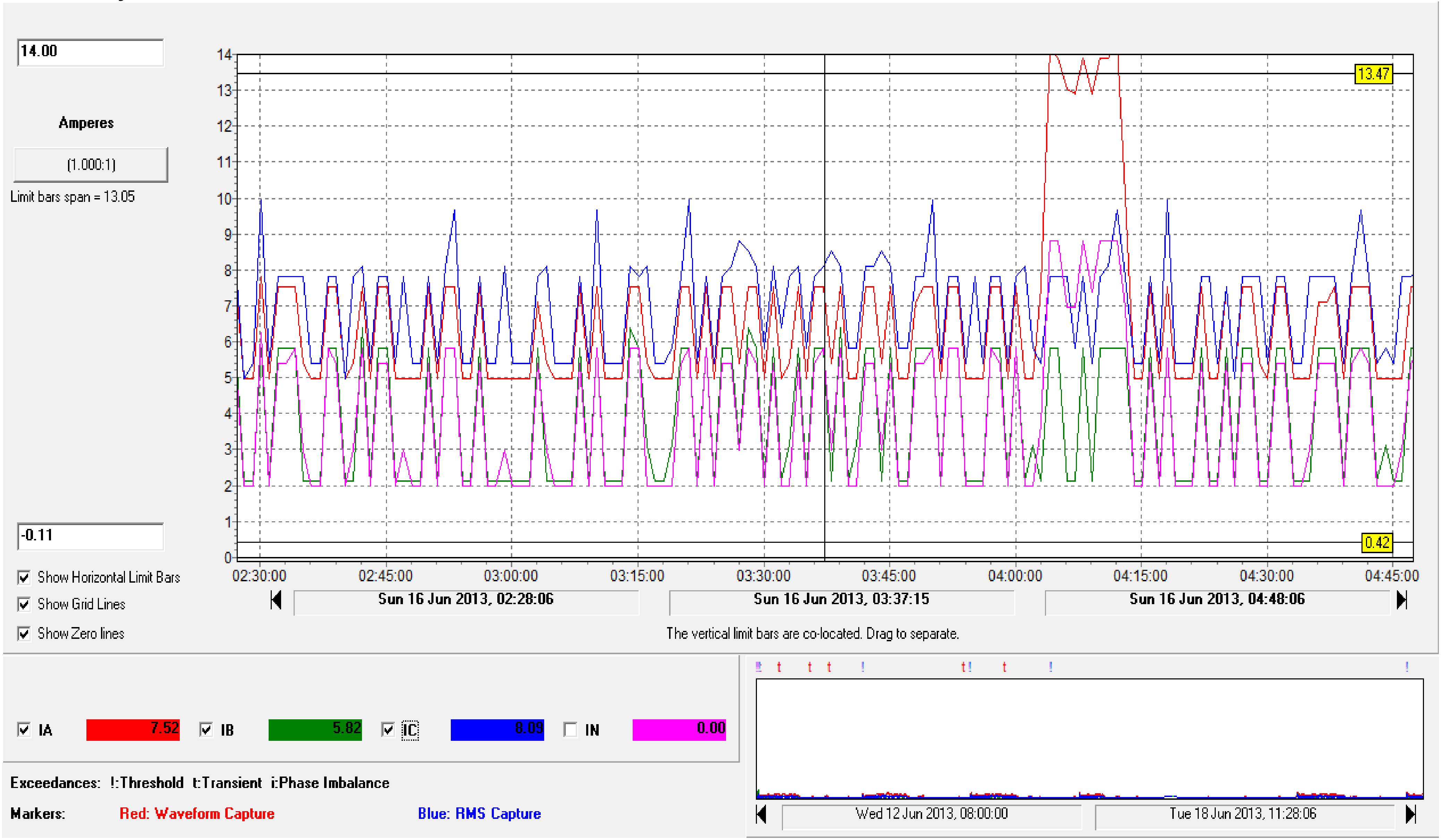
Power


25.00
Total Power
Limit bars span = 23.11
0.00
Show Horizontal Limit Bars
Show Grid Lines
Show Zero lines
24.06
0.94
Wed 12 Jun 2013, 08:00:00
Fri 14 Jun 2013, 07:31:58
Tue 18 Jun 2013, 11:27:06
Time span between vertical limit bars = 91h 38m 23.477s
kVA 18.20
kW 16.06
kVAr 8.55
Exceedances: !:Threshold t:Transient i:Phase Imbalance
Markers: Red: Waveform Capture Blue: RMS Capture
Wed 12 Jun 2013, 08:00:00
Tue 18 Jun 2013, 11:28:06

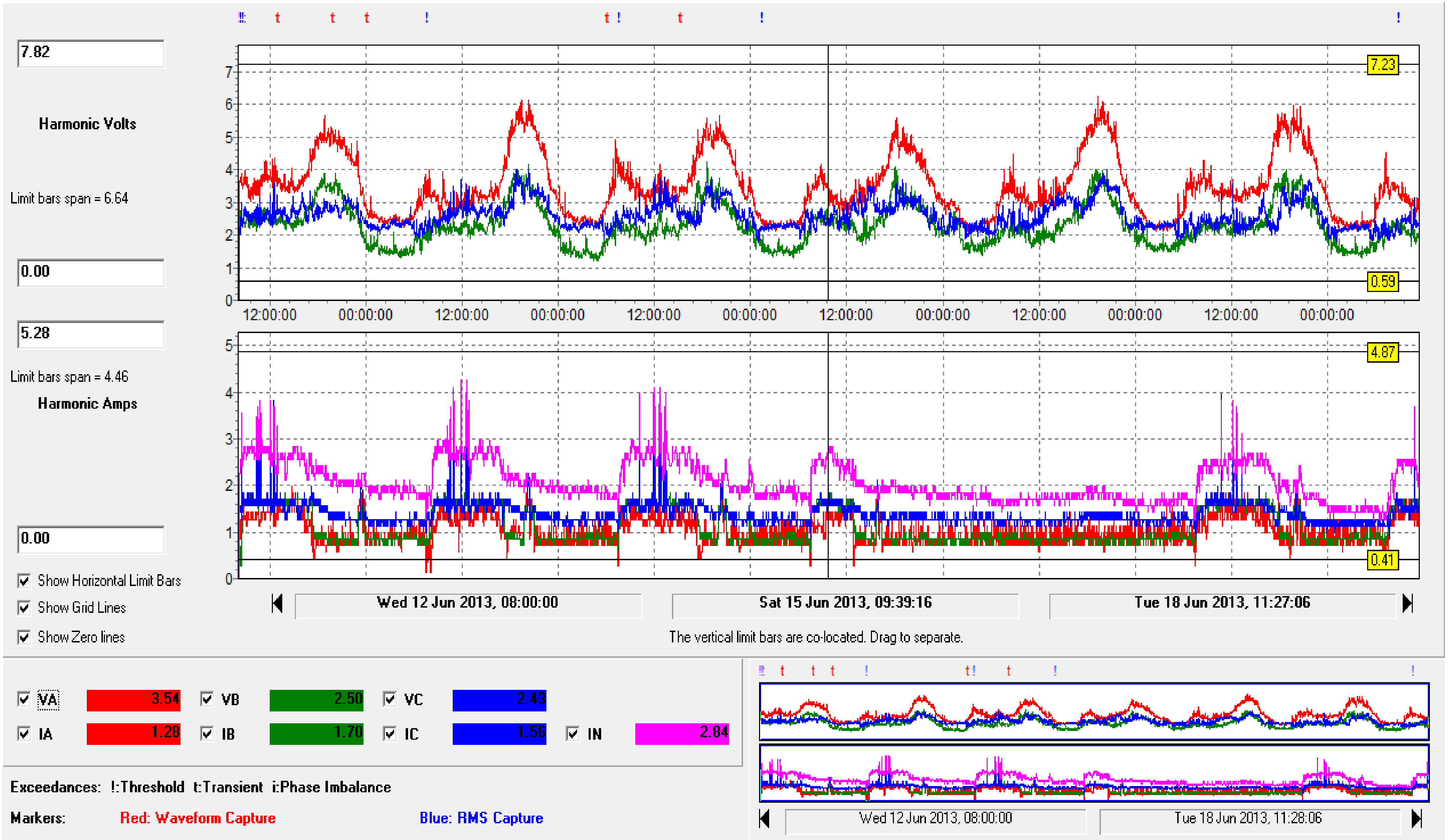
Total Harmonic Distortion



Current only, low load

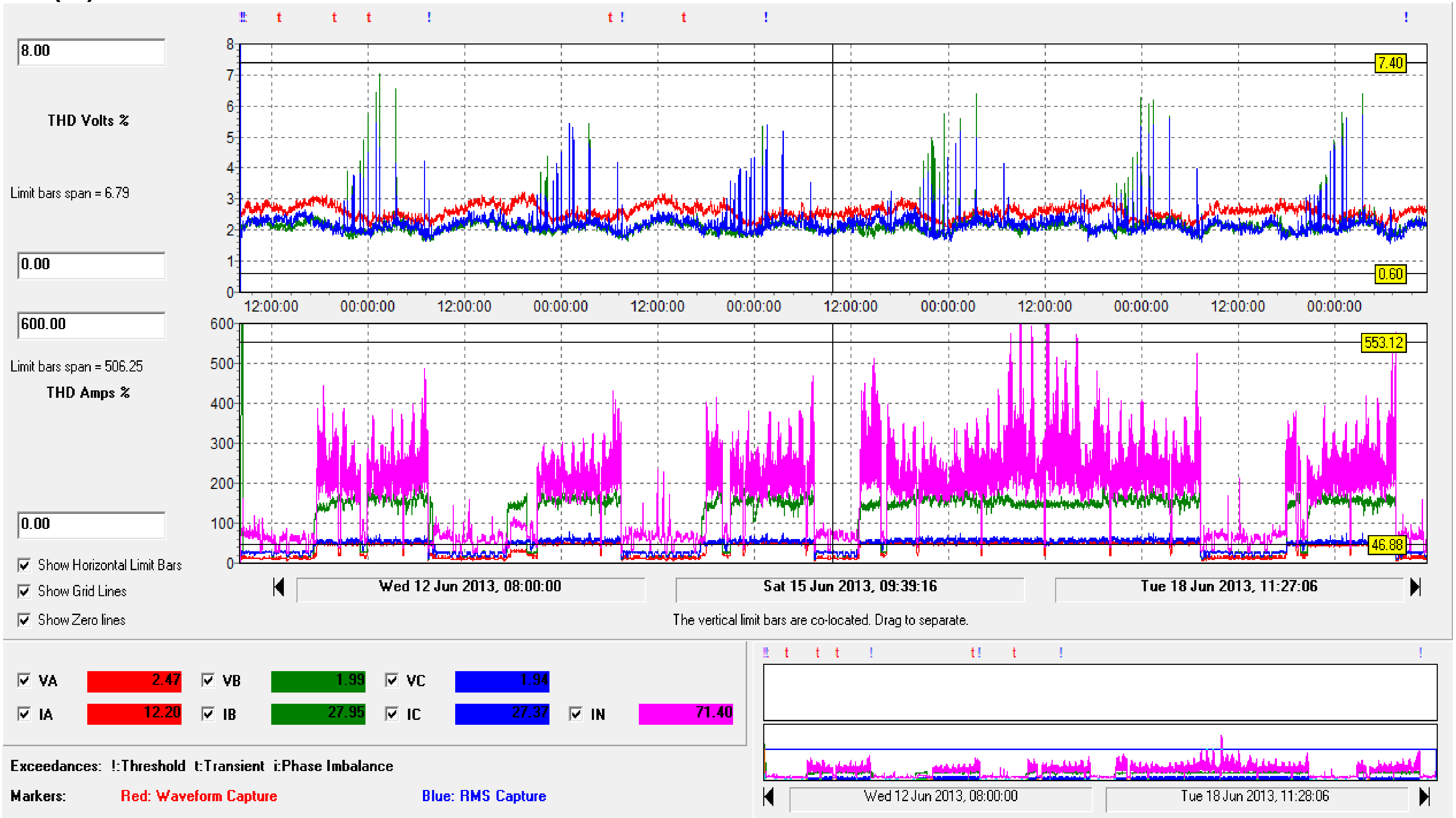


3Rd Harmonic

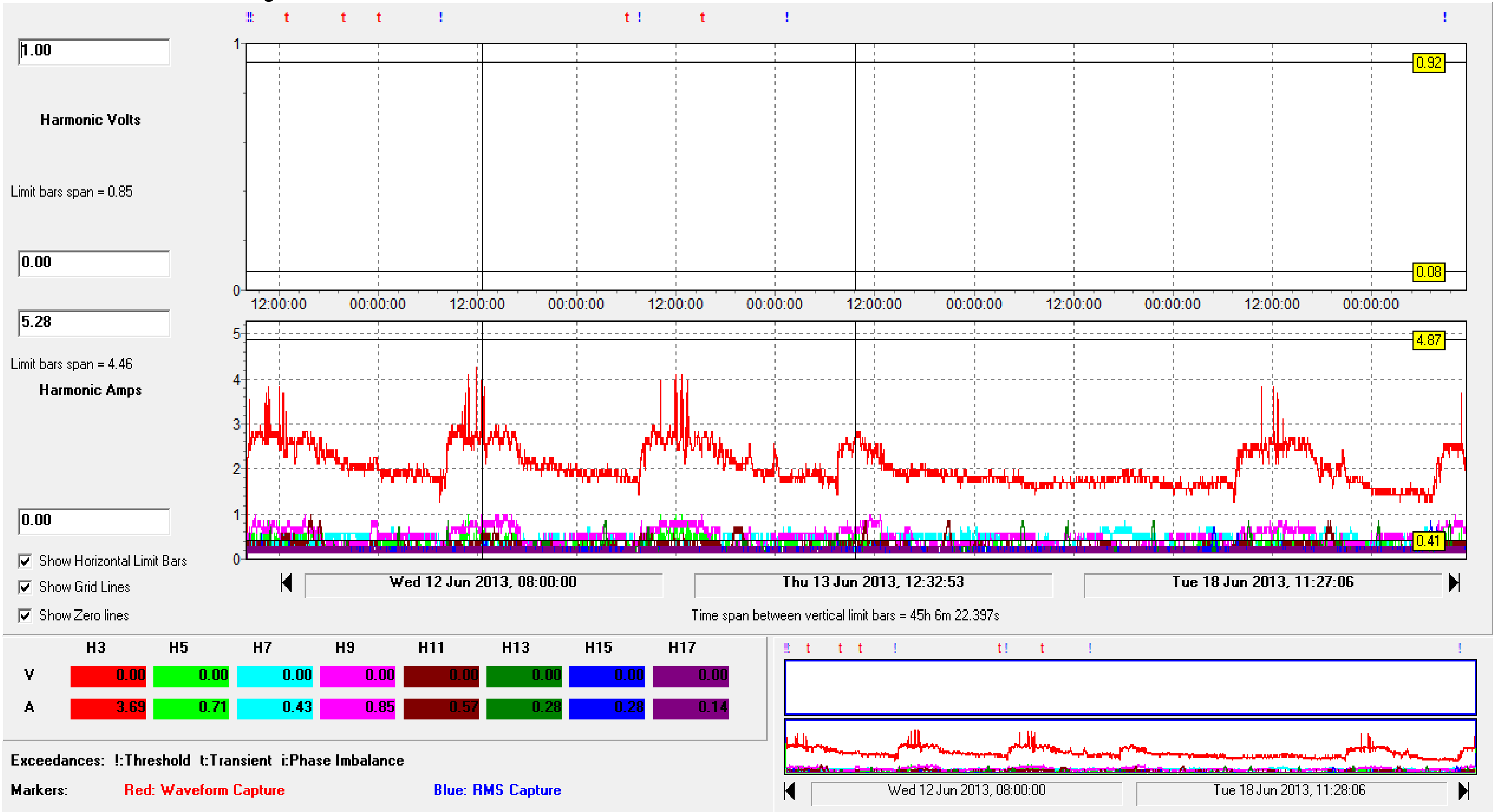


Power Quality Analysis - Graphs

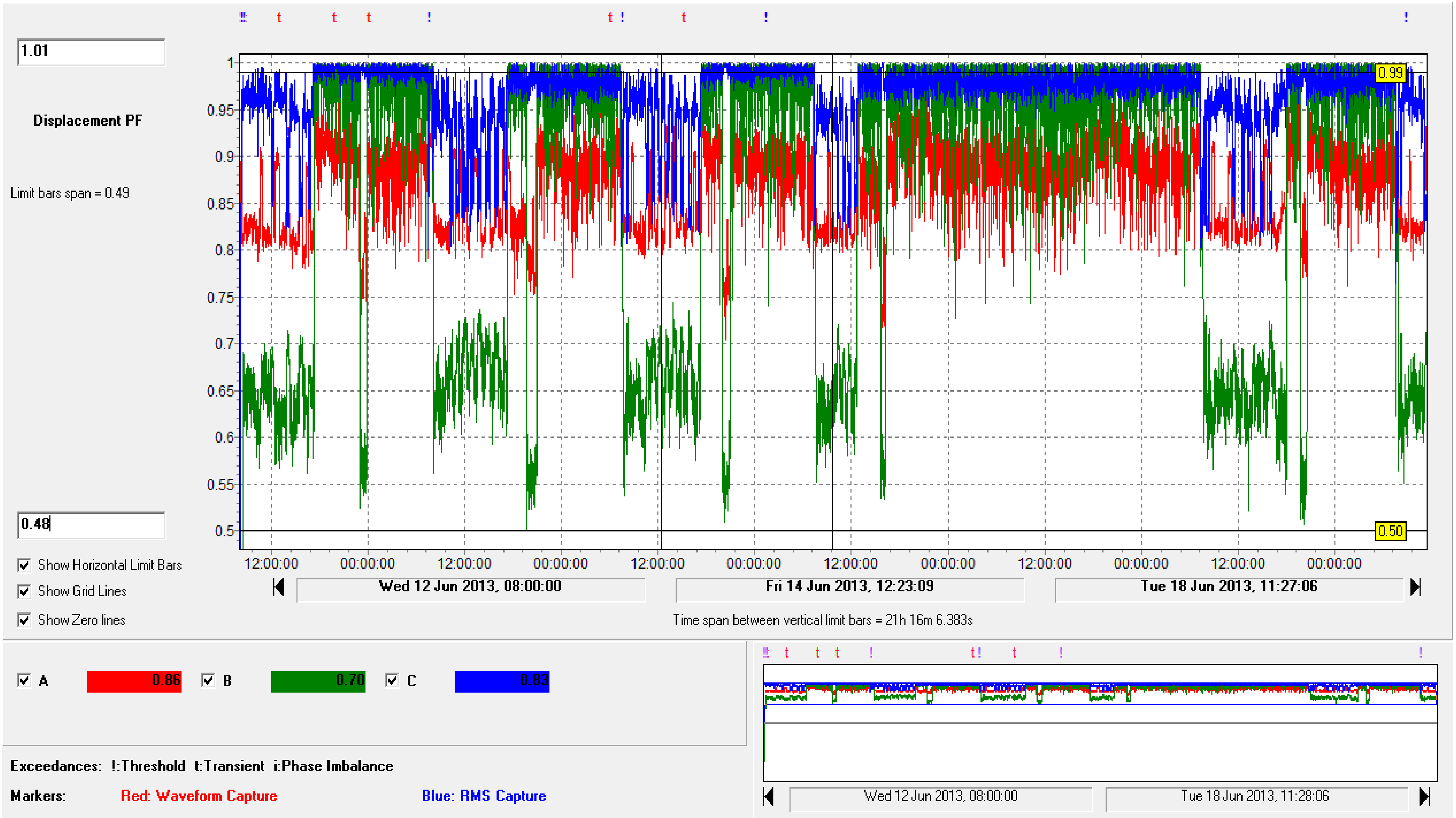
THD (%)



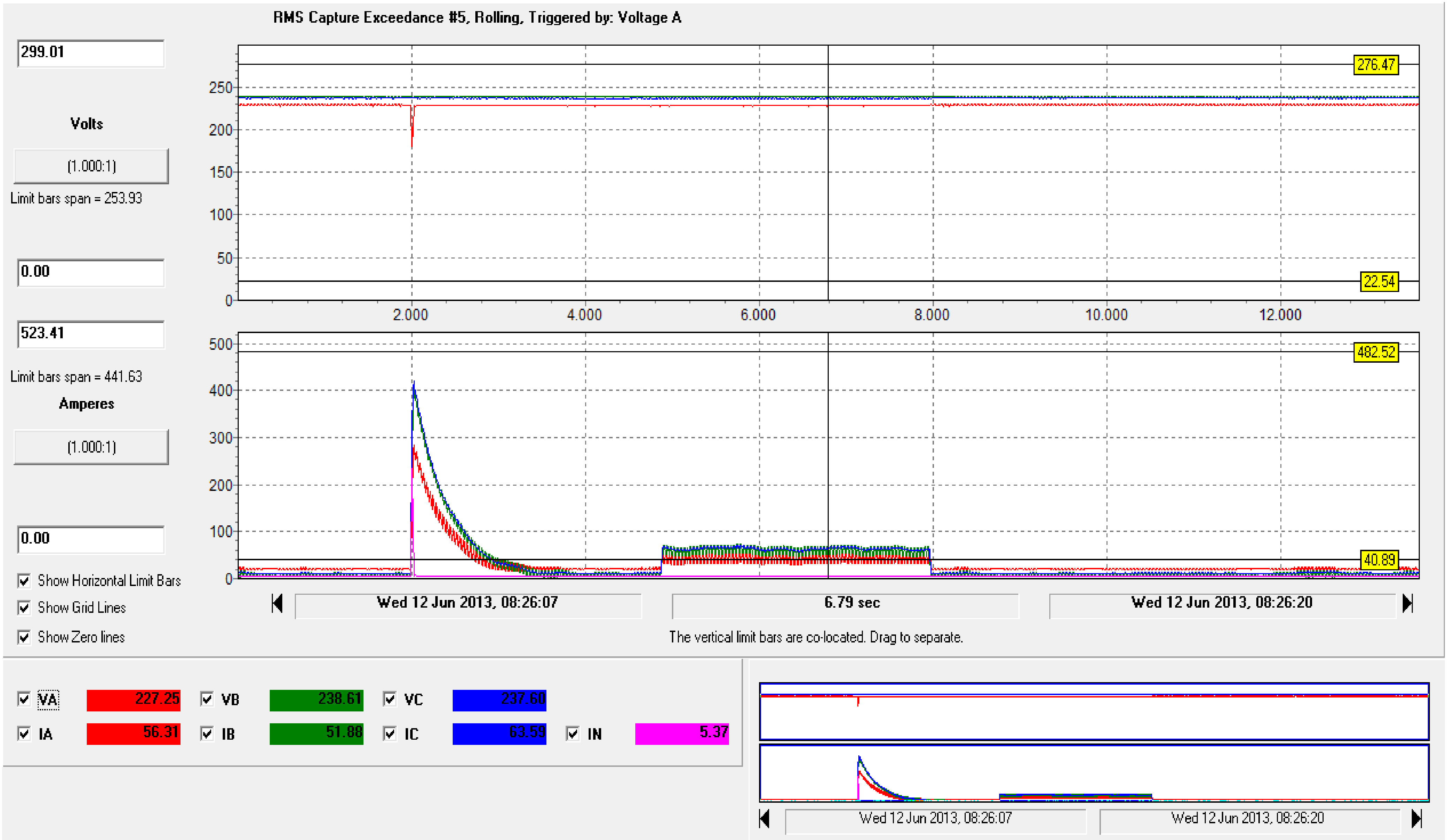
Harmonics Neutral Voltage & Current Total RMS



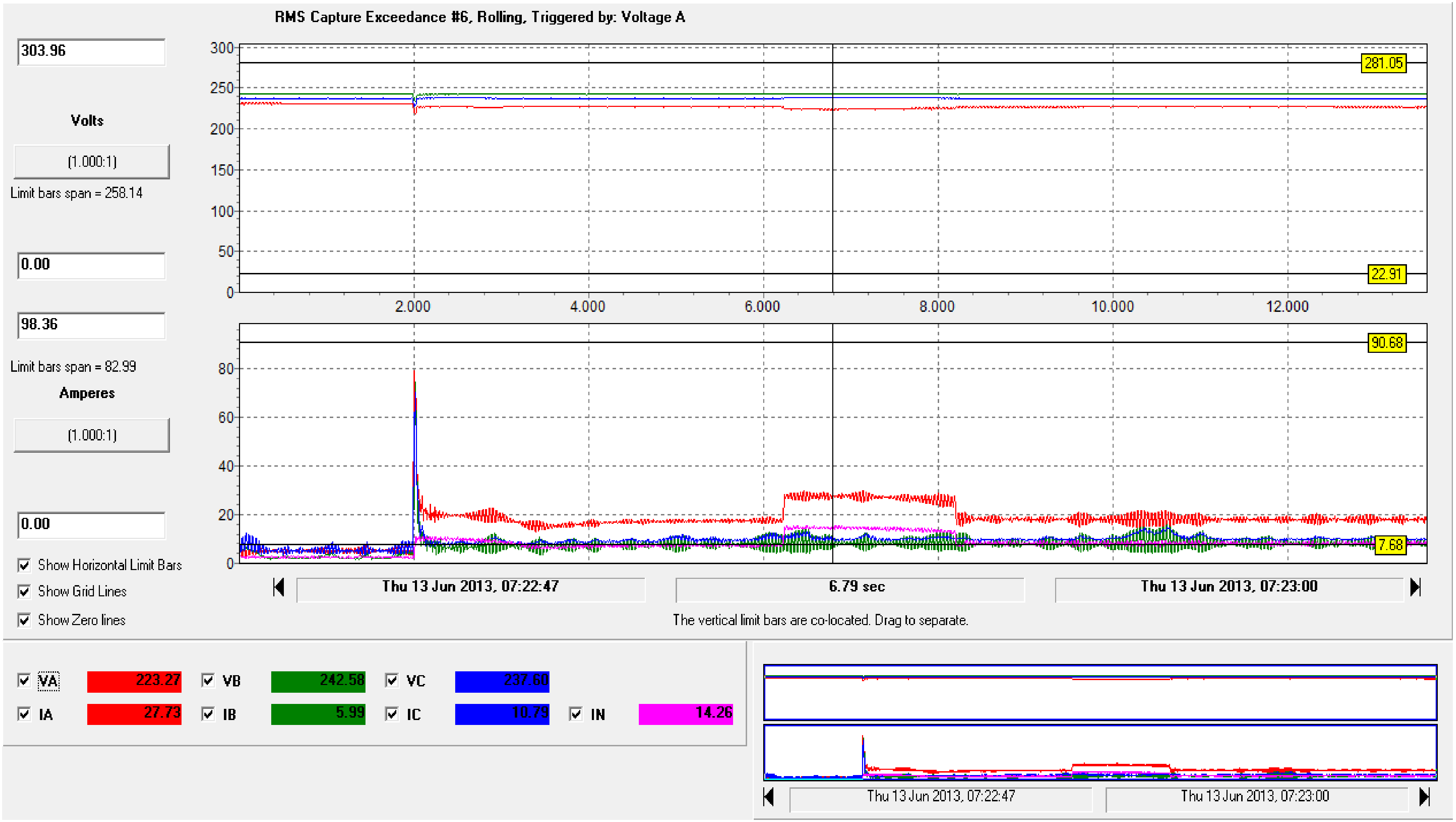
Power Factor



Transient #5, Rolling, triggered by Voltage "A"



Transient #6, Rolling, triggered by Voltage "A"



Transient #11, Rolling, triggered by Voltage "C"

Power Quality Analysis - Graphs