Power Quality Audit

IBA Craft,Noida

P2 Power Solutions Pvt. Ltd.
A-95, Sector-80, Noida, Uttar Pradesh-201305.

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1.Company Profile

P2 Power Solutions Pvt. Ltd. is promoted by a group of IITians with a passion to deliver innovative engineering solutions in the energy efficiency and power quality domain. We are associated with IIT Kharagpur and the Department of Science and Technology, Government of India, for technical support and R&D. Our advisory board consists of eminent members with over 50 years of experience in the electrical industry.

We are an ISO 9001-2008 certified company offering CE and RoHS certified products. We offer a wide range of products & services to our clients that enhance the power quality of the electrical infrastructure. Our comprehensive range of products and services which continues to grow through research and development initiatives includes:

Range of Products:

Power Quality | eMobility | Energy Management

Power Quality Solutions

→ Active Power Filters
→ Active VAr Generators
→ Hybrid Power Factor correction
→ Dynamic Voltage Regulators
→ Passive Harmonic Filter
→ Smart Thyristor based PFC

Power Quality Components

→ Hybrid PFC Controller
→ APFC Controller
→ Smart Thyristor modules
→ Detuned Reactors
→ Sine wave filters
→ dV/dT filters

Electric Vehicle domain

→ AC chargers
→ DC chargers

Range of Services:

→ Power Quality Study
→ Energy Consumption Study
→ Lighting Study
→ Electrical Safety Audit
→ Fire Safety Audit
→ Earth Pit Study
→ Thermography analysis

P2 Power has over 2500 installations and 300+ esteemed clients across the country in almost all sectors, makes it one of the leaders in the power quality domain. We are currently exporting to Indian subcontinent, Africa and Middle east regions. We have won various awards and recognition for our research. Some of them are mentioned below:

Awards & Recognition:

P2 Power Solutions has always focused on in house R&D and our efforts have been recognized by the Department of Science & Technology and now, P2 Power is a DSIR recognized R&D house.

- i3 innovation Awards 2010 sponsored by DST, CII and Agilent Technologies
- IIGP Awards 2010 sponsored by DST Lock-head Martin & FCCI
- Inency Awards organized by India Co ventures
- Sankalp Awards 2011 in Clean tech category

Exceptional functional and technical expertise coupled with extensive industry knowledge makes P2 Power Solutions an ideal choice for any organization to refine their power quality.

Why P2 Power?

→ Our in house R&D and proven record for innovation
→ Our rigorous quality standards
→ Our innovative quality engineering
→ Our quality customer support
→ We not only offer industry leading quality, but also offer a extremely dedicated service and support network
→ We ensure that any request or inquiry is responded to within 24 hrs or less, providing you with world class customer service that will exceed your expectations

Our core competency lies in providing end to end solutions to our esteemed clients with specific focus on power quality and energy management

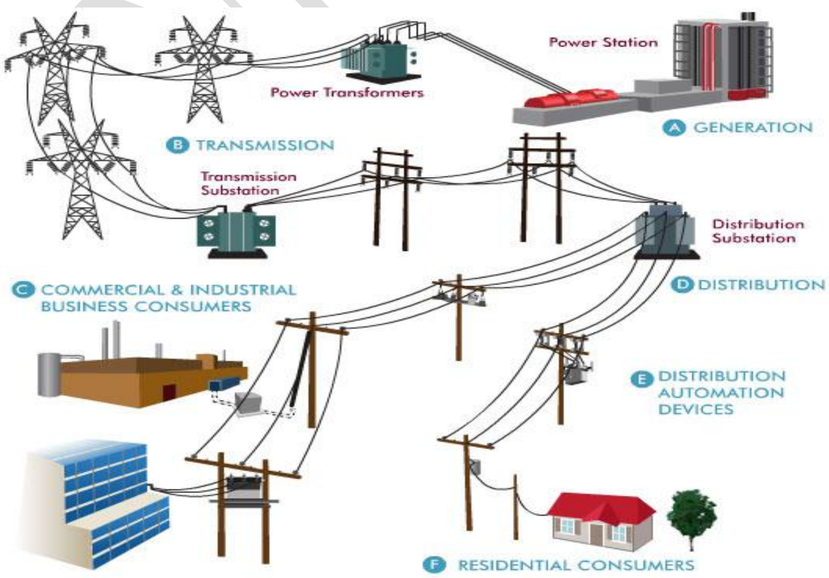
2.Power Quality Problems & Its Solution

2.1. Why should you Care?

We all drink the same water...

We all breathe the same air...

Secure, consistent, affordable, clean, balanced power supply is fundamental to global economic growth, stability and overall development



2.2. IEEE STD 519-2014 Recommended Standards

IEEE recommended practices and requirements for harmonic control in electrical power system. It represents a standard level of acceptable harmonic distortion in a power system.

Point of Common Coupling (PCC)

The limits in this recommended practice are intended for application at a point of common coupling (PCC) between the system owner or operator and a user, where the PCC is usually taken as the point in the power system closest to the user where the system owner or operator could offer service to another user.

- For Industrial users (i.e., manufacturing plants) via a dedicated service transformer, the PCC is at the HV side of the transformer.
- For Commercial users (office parks, shopping malls, etc.) supplied through a common service transformer, the PCC is commonly at the LV side of the service transformer.

Utility and/or Users

The limits in this recommended practice represent a shared responsibility for harmonic control between system owners or operators and users. Maintaining harmonic voltages below these levels necessitates that :

- All users limit their harmonic current emissions to reasonable values determined in an equitable manner based on the inherent ownership stake each user has in the supply system
- Each system owner or operator takes action to decrease voltage distortion levels by modifying the supply system impedance characteristics as necessary

Maximum demand current value is established at the PCC and should be taken as the sum of the currents corresponding to the maximum demand during each of the twelve previous months divided by 12.

Current Distortion Limits

The table given below shows the Harmonic Current Limits for Non-Linear Load at the Point-of-Common-Coupling:

For voltages 120-69,000 Volts						
Individual Harmonic Order (Odd Harmonics)[A,B]						
ISC/IL	3≤h<11	11≤h<17	17≤h<23	23≤h<25	35≤h≤50	TDD
<20 [C]	4	2	1.5	0.6	0.3	5
20<50*	7	3.5	2.5	1	0.5	8
50<100	10	4.5	4	1.5	0.7	12
100<1000	12	5.5	5	2	1	15
>1000	15	7	6	2.5	1.4	20

For voltages 69,000-161,000 Volts						
Individual Harmonic Order (Odd Harmonics)						
ISC/IL	h<11	11≤h<17	17≤h<23	23≤h<25	35≤h	TDD
<20	2	1	0.75	0.3	0.15	2.5
20<50	3.5	1.75	1.25	0.5	0.25	4
50<100	5	2.25	2	0.75	0.35	6
100<1000	6	2.75	2.5	1	0.5	7.5
>1000	7.5	3.5	3	1.25	0.7	10

For voltages > 161,000 Volts						
Individual Harmonic Order (Odd Harmonics)[A,B]						
I_{SC}/I_L	3≤h<11	11≤h<17	17≤h<23	23≤h<25	35≤h≤50	TDD
<25 [C]	1.0	0.5	0.38	0.15	0.1	1.5
25<50	2.0	1.0	0.75	0.3	0.15	2.5
>1000	3.5	1.5	1.15	0.45	0.22	3.75

[A] Even harmonics are limited to 25% of the odd harmonic limits above

[B] Current distortions that result in a DC offset, e.g., half-wave converters, are not allowed

[C] All power generation equipment is limited to these values of current distortion, regardless of actual I_{SC}/I_L

I_{SC} = Maximum short circuit current at point-of-common-coupling

I_L = Maximum demand load current (fundamental frequency) at point of common coupling

TDD = Total demand distortion (RSS) in % of maximum demand.

* For the client, we have assumed I_{SC}/I_L ratio to be in the range of 20<50.

Short-circuit ratio : At a particular location, the ratio of the available short-circuit current, in amperes, to the load current, in amperes.

Total demand distortion (TDD) : The ratio of the root mean square of the harmonic content, considering harmonic components up to the 50th order and specifically excluding inter-harmonics, expressed as a percent of the maximum demand current. Harmonic components of order greater than 50 may be included when necessary.

Total harmonic distortion (THD) : The ratio of the root mean square of the harmonic content, considering harmonic components up to the 50th order and specifically excluding inter-harmonics, expressed as a percent of the fundamental. Harmonic components of order greater than 50 may be included when necessary.

Voltage Distortion Limits

Voltage Distortion Limits governs the amount of voltage distortion that is acceptable in the utility supply voltage at the PCC with a consumer. Table given below lists the harmonic voltage distortion limits as per IEEE 519-2014:

Voltage Distortion Limits		
Bus Voltage V at PCC	Individual Harmonic (%)	Total harmonic Distortion THD (%)
V≤1.0kV	5.0	8.0
1kV≤V≤69kV	3.0	5.0
69kV≤V≤161kV	1.5	2.5
161kV≤V	1.0	1.5 [A]

[A] High-Voltage systems can have up to 2.0% THD where the cause in an HVDC terminal whose effects will have attenuated at points in the network where future users may be connected

Neutral Current and Voltages

- Current: 8-10% of the RMS current
- Voltage: 2V

Unbalance in Current and Voltage

- Current unbalance: 5%
- Voltage unbalance: 4%

2.3. Frequently Used Terms

Linear loads

When a sinusoidal voltage is applied to a certain type of load, the current drawn by the load is proportional to the voltage and impedance and follows the envelope of the voltage waveform. These loads are referred to as linear loads (loads where the voltage and current follow one another without any distortion to their pure sine waves). Examples of linear loads are resistive heaters, incandescent lamps, and constant speed induction and synchronous motors.

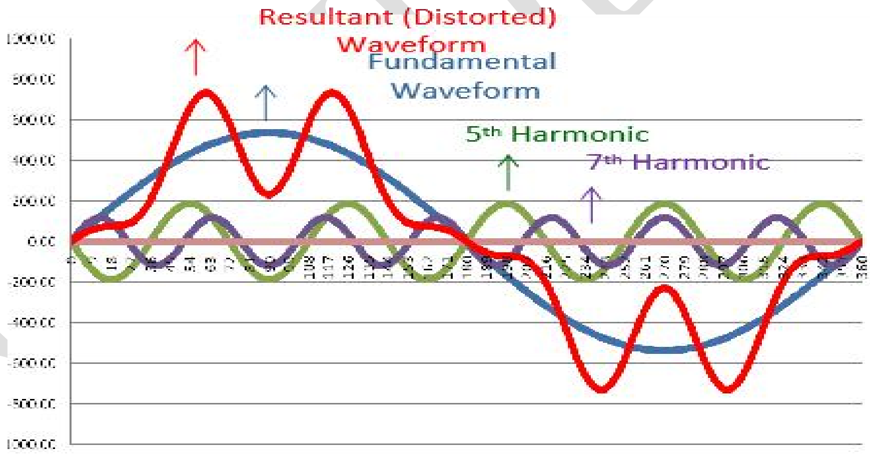
Non Linear Loads

In contrast to linear loads, some loads cause the current to vary disproportionately with the voltage during each half cycle. These loads are classified as nonlinear loads, and the current and voltage have waveforms that are non-sinusoidal, containing distortions, whereby the 50-Hz waveform has numerous additional waveforms superimposed upon it, creating multiple frequencies within the normal 50-Hz sine wave. The multiple frequencies are harmonics of the fundamental frequency. Examples of nonlinear loads are battery chargers, electronic ballasts, variable frequency drives, and switching mode power supplies.

Harmonics

Harmonics are currents or voltages with frequencies that are integer multiples of the fundamental power frequency (50Hz for Indian power and 60Hz for American power). For example, if the fundamental power frequency is 50 Hz, then the 2nd harmonic is 100 Hz; the 3rd is 150 Hz, etc.

When a non-linear load, such as a rectifier, is connected to the system, it draws a current that contains harmonic components overlapped on the fundamental frequency.



Power Factor

Power Factor is the ratio of the Active Power (kW) and the Apparent Power (kVA).

Impedance

Impedance is the measure of the total opposition that an electric circuit presents to an alternating current. It is the measure of the complex resistive and reactive attributes of a component (conductor, machinery, etc.) or of the total system within an AC circuit. Impedance causes electrical loss and is usually manifested in the form of heat.

Eddy Current Losses

Eddy current losses are caused by current circulating in metallic material (core, windings, case, and associated hardware in motors, etc.) as a result of electromotive forces induced by variation of magnetic flux. These losses are a complex function of the square of supply frequency and Inverse Square of the material thickness.

Hysteresis

Hysteresis is a measure of the energy losses in magnet material that results from an alternating magnetic field as the elementary magnets within the material seek to align themselves with the reversing magnetic field.

Iron Losses

The iron losses consist of hysteresis and eddy current losses associated with the metal lamination in motors, transformers, and generators. These losses contribute over 99% of the no load losses in electrical machines.

Copper Losses

Copper losses result from Joule heating and so are also referred to as "I squared R losses", in deference to Joule's First Law. This states that the energy lost each second, or power, increase as the square of the current through the windings and in proportion to the electrical resistance of the conductors.

2.4. Effects of Harmonics on Power Systems

As nonlinear currents flow through a facility's electrical system and the distribution-transmission lines, voltage distortions are produced due to the impedance associated with the electrical network. Very often, the operation of electrical equipment may seem normal, but under a certain combination of conditions, the impact of harmonics is enhanced, with damaging results.

High harmonic currents adversely affect power system equipment and lead to frequent failures and interruptions in production cycle for the end customer. It is thus important to understand the effect of harmonics on different power system equipment.

Motors

Voltage supplied to a motor sets up magnetic fields in the core, which create iron losses in the magnetic frame of the motor. Hysteresis and eddy current losses are part of iron losses that are produced in the core due to the alternating magnetic field. Hysteresis losses are proportional to frequency, and eddy current losses vary as the square of the frequency. Therefore, higher frequency voltage components produce additional losses in the core of AC motors, which in turn, increase the operating temperature of the core and the windings surrounding in the core.

$(I_{rms})^2 = (I_{1rms})^2 + (I_{2rms})^2 + (I_{3rms})^2 + \ldots (I_{nrms})^2$

The I^2R losses in the motor windings vary as the square of the rms current. Due to skin effect, actual losses would be slightly higher than calculated values.

Transformers

Application of non-sinusoidal excitation voltages to transformers increases the iron losses in the magnetic core of the transformer in much the same way as in a motor. A more serious effect of harmonic loads served by transformers is due to an increase in winding eddy current losses. Eddy currents are circulating currents in the conductors induced by the sweeping action of the leakage magnetic field on the conductors. Eddy current concentrations are higher at the ends of the transformer windings due to the crowding effect of the leakage magnetic fields at the coil extremities. The eddy current losses increase as the square of the current in the conductor and the square of its frequency. The increase in transformer eddy current loss due to harmonics has a significant effect on the operating temperature of the transformer. Transformers that are required to supply power to nonlinear loads must be de-rated, based on the percentages of harmonic components in the load current and the rated winding eddy current loss.

One method of determining the capability of transformers to handle harmonic loads is by k factor ratings. The k factor is equal to the sum of the square of the harmonic currents multiplied by the square of the frequencies.

$K = (I_1)^2*1^2 + (I_2)^2*2^2 + (I_3)^2*3^2 + \dots (I_n)^2*n^2$ where $I_1 = I_{1rms}/I_{rms}$, $I_2 = I_{2rms}/I_{rms}$ and so on

$(I_{rms})^2 = (I_{1rms})^2 + (I_{2rms})^2 + (I_{3rms})^2 + \dots (I_{nrms})^2$

By providing additional capacity (larger-size or multiple winding conductors), k factor rated transformers are capable of safely withstanding additional winding eddy current losses equal to k times the rated eddy current loss. Also, due to the additive nature of triple-N harmonic (3, 9, 15, etc.) currents flowing in the neutral conductor, k rated transformers are provided with a neutral terminal that is sized at least twice as large as the phase terminals.

Capacitor Banks

Many industrial and commercial electrical systems have capacitors installed to offset the effect of low power factor. Most capacitors are designed to operate at a maximum of 110% of rated voltage and at 135% of their KVAr ratings. In a power system characterized by large voltage or current harmonics, these limitations are frequently exceeded, resulting in capacitor bank failures. Since capacitive reactance is inversely proportional to frequency, unfiltered harmonic current in the power system find their way into capacitor banks, these banks act like a sink, attracting harmonic currents, thereby becoming overloaded.

A more serious condition, with potential for substantial damage, occurs as a result of harmonic resonance. Resonant conditions are created when the inductive and capacitive reactance become equal in an electrical system. Resonance in a power system may be classified as series or parallel resonance, depending on the configuration of the resonance circuit. Series resonance produces voltage amplification and parallel resonance causes current multiplication within an electrical system. In a harmonic rich environment, both types of resonance are present. During resonant conditions, if the amplitude of the offending frequency is large, considerable damage to capacitor banks would result. And, there is a high probability that other electrical equipment on the system would also be damaged.

Cables

The flow of normal 50 Hz current in a cable produces I^2R losses and current distortion introduces additional losses in the conductor. Also, the effective resistance of the cable increases with frequency due to skin effect, where unequal flux linkages across the cross section of the cable causes the AC current to flow on the outer periphery of the conductor. The higher the frequency of the current, the greater is the tendency. It is important to make sure a cable is properly rated because it needs to carry both the fundamental and the harmonic currents.

Power factor

Power factor is the product of displacement and distortion power factor in the electrical system.
Displacement Power Factor = cosine (phase angle between the current and voltage)
Distortion Power Factor = $1/\sqrt{(1+iTHD^2)}$
Thus high harmonics lead to low power factor and increased energy bills.

2.5. Effects of low Power Factor on Power Systems

In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

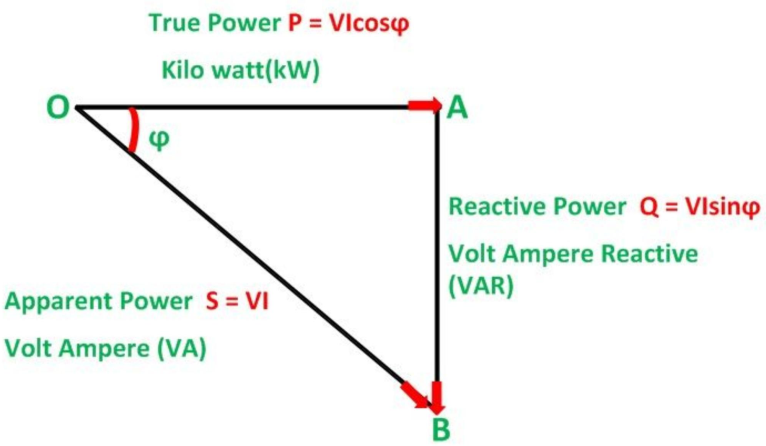
2.6. Power Triangle

Active Power (kW) - Power which is actually consumed or utilized in an AC Circuit is called True power or Active Power or real power

Reactive Power (kVAr) - Power which flows back and forth that means it moves in both the direction in the circuit or react upon it, is called Reactive Power

Apparent Power (kVA) - Product of root mean square (RMS) value of voltage and current is known as Apparent Power

$$\text{Power factor } \cos\varphi = \frac{\text{Active power}}{\text{Apparent power}} = \frac{\text{KW}}{\text{KVA}}$$



Displacement Power Factor - Power Factor (cosΦ) is cosine of the phase gap between fundamental current & voltage drawn by a load.

True Power Factor - True Power Factor is the product of Displacement Power Factor (cosΦ) & Distortion Power Factor. True Power Factor should be kept very close to unity to reduce energy charges.

Distortion Power Factor = 1/√(1+THD2)

Where THD is Total current harmonic distortion

2.7. Reactive Power (Var) Compensation

Reactive Power (Var) compensation is defined as the management of Reactive Power to improve the performance of AC systems. There are two aspects:-

A) Load Compensation- Main objectives are to:

- Increase the power factor of the system
- Balance the real power drawn from the system
- Compensate voltage regulation
- Eliminate current harmonics

B) Voltage Support- Main Purpose is to decrease the voltage fluctuation at a given terminal of transmission line

Therefore the Var compensation improves the stability of AC system by increasing the maximum active power that can be transmitted.

Power is referred as the product of voltage and current i.e., Power = V x I, the portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers.

In an AC transmission, when the voltage and current go up and down at the same time, only real power is transmitted and when there is a time shift between voltage and current both Active and Reactive Power are transmitted.

Effect of Reactive power on electrical system

Harmful effects on appliances and other motorized loads, as well as electrical infrastructure since the current flowing through electrical system is higher than that necessary to do the required work, excess power dissipates in the form of heat as the reactive current flows through resistive components like wires, switches and transformers .

Causes of High kVAr

Majority of electrical loads causes high kVAr are as follows :

- Inductive/capacitive nature
- AC/DC motors
- Welding loads
- Tower cranes
- Furnace loads
- Injection molding
- Lighting loads
- Long cables
- Long Transmission Lines

Effects of High kVAr

On Distribution Company :

- Overloading of DT
- Under utilization of existing capacity
- Drop in supply voltage
- Reduced life of electrical infra
- Increased T & D losses

On Consumers

- Increased electricity bills
- Under utilization of power transformer
- Increased transformer & cable losses
- Increased DG fuel consumption
- DG Hunting
- Overloading of diesel generators

Benefits of Reduced kVAr

- → Reduced demand charges
- → Reduced Energy bills
- → No penalty from EB
- → Reduced DG hunting
- → Higher efficiency of DG
- → Increased load carrying capabilities
- → Voltage improvement
- → Reduced power system losses
- → Optimal capacity utilization of infrastructure
- → Reduced carbon footprint

2.8. Effect of Harmonics on AC Capacitors

AC capacitor banks are designed to operate in harmonic free environments and with linear loads. Installation of AC capacitor banks in harmonic rich environment can lead to catastrophic failure of capacitors as well as installed equipment.

AC capacitors offer low impedance path to high frequency current components (harmonics) and start acting as sinks resulting in harmonic currents flowing into the capacitors. Moreover, It can also draw harmonic current from the electrical grid resulting in increased overloading of transformers.

2.9. Resonance

Resonance is a phenomenon typically associated with significant amplification in the harmonic distortion levels in a facility due to the action of normal AC capacitor banks. The electrical network like loads, bus bars, cables and the transformer all have some impedance (inductive) and this impedance sometimes creates a resonating circuit in the presence of AC capacitors resulting in harmonic amplification.

2.8.1. Effects of resonance

- → Capacitor overload and failures
- → Overheating of transformer
- → Overheating of bus bars, cables,switch gears.
- → Imposition of penalty by utility
- → Failure of sensitive equipment
- → Multiple zero crossing errors in Equipment.
- → Spurious tripping of protective relays
- → Reduced efficiency & reliability
- → Increased power losses

2.10. Detuned Reactors

Detuned reactors are three phase inductors which have been carefully designed to prevent the Harmonic resonance phenomenon.

These are connected in series with AC capacitor banks. The impedance of detuned reactors increase with increase in frequency and they effectively act to block the entering of harmonic currents into the AC capacitor banks.

Moreover, the design of detuned reactors is chosen such that the impedance of the reactor + capacitor combination is less than the frequency of the lowest order harmonic component present in the network.

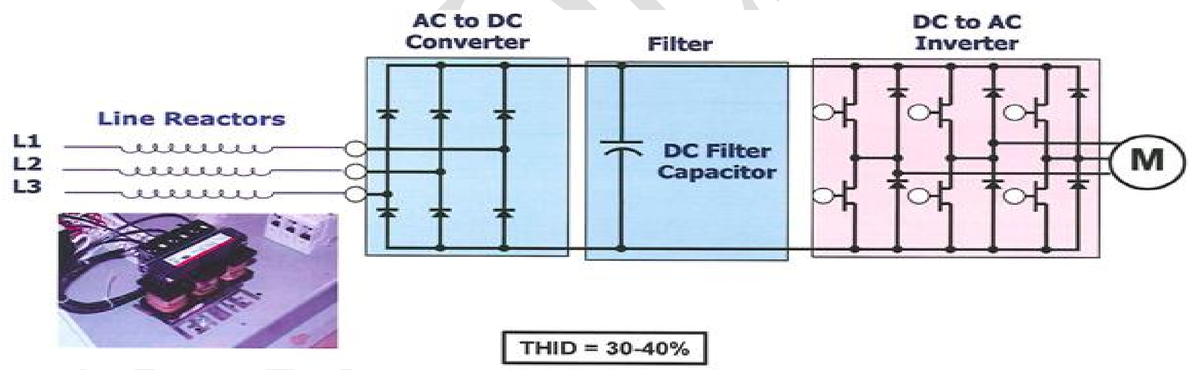
- Detuning prevents the risk of resonance
- It increases the operational life of AC Capacitor banks
- It eliminates the risk of harmonic amplification

2.11. Line Reactor

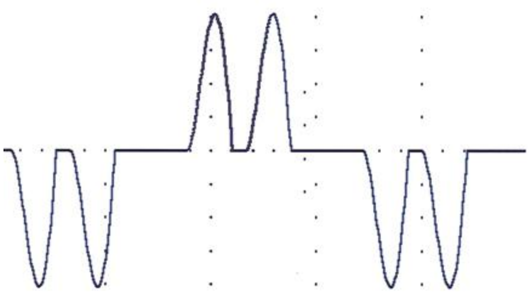
Line Reactors are current-limiting devices and oppose rapid changes in current because of their impedance. They hold down any spikes of current and limit any peak currents. It is widely recommended component that can be added to a drive system to protect the variable frequency drive (VFD) and other devices from power surges and transients

A Line reactor can eliminate about 30-50% of ITHD, which is a vast improvement. High peak currents can also cause fuse degradation and intermittent blowing of fuses or tripping of circuit breakers.

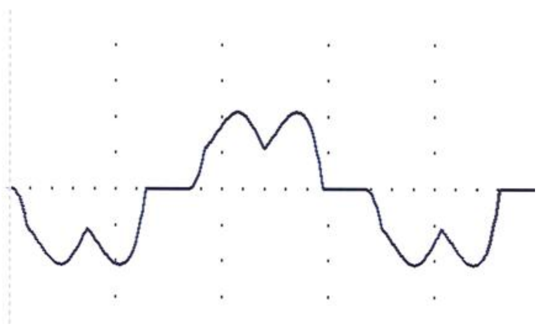
Typical AC line reactors are 3% to 5% impedance, with the 5% models offering better harmonic control and better surge resistance, but at a slightly higher cost when compared to their 3% counterparts.



Current waveform without line reactors



Current waveform with line reactors



3.Audit Instrument

P2 Power conducted the audit with the help of Fluke Power Analyzer . Following are the details of this instrument.

3.1. Fluke Power Analyzer

Name	: FLUKE POWER ANALYZER 434-II Series
Instrument Configuration	: Connection Type: 3-Phase 5-Wire
Current and Voltage Probe	: 3 nos. 0.5 Amp to 100 Amp small CT's
	: 4 nos. 5/6000 Amp Flexible CT's
	: 5 no.s of voltage probe PT's with neutral and earth.

3.1.1. Description

The new Fluke 430 Series II Three-Phase Energy Analyzers offer the best in power quality analysis and introduce, for the first time ever, the ability to monetarily quantify energy losses

3.1.2. Salient Features

→ Measure high and low level voltage and current.

→ Harmonics/ Inter- harmonics up- to 50^{th} order.

→ Measure THD of V, I and KW with K Factor, Transients, Voltage Sag-Swells, All Power Parameters , Inrush Currents, Load Unbalances, Flicker Recording etc.

→ Enabling graphical, vector, numerical representation, trending of data, monitoring of events etc.

→ Logger function: Configure for any test condition with memory for up to 600 parameters at user defined intervals.

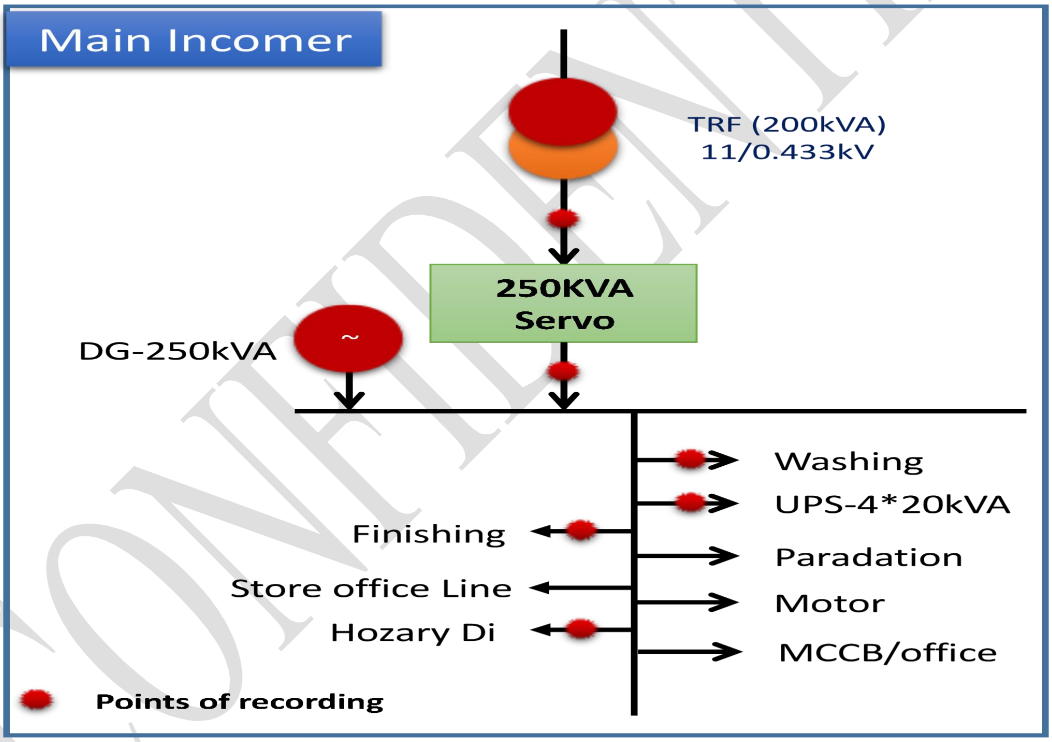
4. Electrical Analysis

P2 Power Solutions conducted a power quality study IBA Craft, Noida to identify various power quality related issues and recommend suitable solution to address the same.

Electrical analysis involves detailed study of data gathered from the site during audit. Based on the detailed examination of recordings gathered, observations are summed up followed by relevant recommendations for various power quality issues identified.

This chapter includes single line diagram, summary of recordings, observations and suitable improvement measures to address various issues identified.

4.1 Single line diagram



4.2 Summary Sheet

Various parameters are highlighted based on the severity of the problem and color coding used is as depicted below:

R Phase	Y Phase	B Phase	Neutral
Critical		Highly Critical	
Leading Power Factor		High Even Harmonic	

4.2.1 Summary of findings are presented below:

Summary of findings is given below:

Summary Sheet																									
S.No.	Feeder Name	CASES	Arms (A)				Aunb	iTHD(%)			Urms (V)			Vrms (V)				vTHD(%)			Power			PF	dPF
			R	Y	B	N	(%)	R	Y	B	R	Y	B	R	Y	B	N	R	Y	B	kW	kVAr	kVA	Mean	Mean
Transformer-200kVA | 11/0.433kV | Servo-250kVA | DG 250kVA																									
1	Servo I/P	I	234	271	296	54	8	8	5	6	379	377	379	221	217	218	1	2	2	2	162	66	176	0.92	0.92
		II	143	186	223	66	14	18	9	9	391	388	388	227	224	223	1	2	2	2	117	38	126	0.93	0.95
1A	Servo O/P	I	197	188	210	37	5	8	9	8	391	402	395	229	228	229	3	4	3	4	132	32	137	0.97	0.97
		II	185	185	199	35	3	9	8	9	394	401	390	227	229	229	2	3	3	4	126	29	129	0.97	0.98
1.1	Washing	I	68	87	65	26	10	4	4	4	390	393	388	227	223	227	2	3	3	3	44	15	48	0.91	0.94
		II	55	62	51	14	4	2	3	3	396	399	395	230	229	229	2	2	2	2	38	8	39	0.96	0.98
1.2	Ups I/P(4*20kVA)	I	24	25	31	23	10	69	75	71	401	405	399	232	232	231	3	3	3	3	12	9	18	0.62	0.80
		II	22	23	30	23	15	73	78	74	400	404	398	232	231	231	3	2	3	3	11	9	18	0.61	0.80
1.3	Finishing	I	43	42	41	3	2	3	3	4	396	400	392	229	229	228	3	3	3	4	29	4.5	29	0.97	0.99
		II	18	17	14	3	6	7	6	10	399	411	395	232	232	232	4	3	3	4	9	6	12	0.84	0.88
1.4	Hozary Di	I	51	22	23	24	34	8	10	12	402	404	400	231	232	233	2	2	3	3	12	20	24	0.47	0.52
		II	39	23	16	17	31	11	11	15	396	400	396	228	229	231	2	3	3	4	9	15	20	0.49	0.54

4.2.2 Individual Current Harmonic Profile:

Individual Current Harmonic Profile												
S.No.	Feeder Name	CASES	Phase	Arms (A)	iTHD (%)	Individual Current Harmonics (%)						
						2nd	3rd	4th	5th	7th	11th	13th
Transformer-200kVA | 11/0.433kV | Servo-250kVA | DG 250kVA												
1	Servo I/P	I	B	296	6	2	5	2	0	1	0	0
		II	B	223	9	6	4	4	1	1	0	0
1A	Servo O/P	I	B	210	8	5	5	2	1	2	0	0
		II	B	199	9	6	5	3	0	1	0	0
1.1	Washing	I	Y	87	4	2	1	1	3	1	1	0
		II	Y	62	3	1	0	1	2	1	1	1
1.2	Ups I/P(4*20kVA)	I	B	31	71	49	31	21	21	18	8	2
		II	B	30	74	53	34	23	17	16	8	2
1.3	Finishing	I	B	41	4	4	1	1	1	1	0	0
		II	B	14	10	9	1	1	2	1	0	0
1.4	Hozary Di	I	R	51	8	6	2	4	3	2	0	0
		II	R	39	11	7	1	4	6	4	0	1

4.3 Electrical Observations

Transformer (200kVA | 11/0.433kV)

4.3.1 Servo I/P

- Maximum running load during the audit is observed to be ~296A/162kW .
- Total Current Harmonics Distortion is observed to be within the limit.
- Total Voltage harmonics Distortion is observed to be within the limit.
- Power factor is observed to be ~0.92.
- Displacement Power Factor is observed to be ~0.92.
- Neutral Current is observed to be abnormally high.

4.3.1A Servo I/P

- Maximum running load during the audit is observed to be ~210A/132kW .
- Total Current Harmonics Distortion is observed to be ~8%.
- Total Voltage harmonics Distortion is observed to be ~4%.
- Power factor is observed to be ~0.97.
- Displacement Power Factor is observed to be ~0.97.
- Neutral Current is observed to be abnormally high.
- Even harmonics is observed to be abnormally high.

4.3.1.1 Washing

- Maximum running load during the audit is observed to be ~87A/44kW .
- Total Current Harmonics Distortion is observed to be within the limit.
- Total Voltage harmonics Distortion is observed to be ~3%.
- Power factor is observed to be ~0.91.
- Displacement Power Factor is observed to be ~0.94.
- Neutral Current is observed to be abnormally high.

4.3.1.2 UPS I/P(4*20kVA)

- Maximum running load during the audit is observed to be ~31A/12kW .
- Total Current Harmonics Distortion is observed to be ~71%.
- Total Voltage harmonics Distortion is observed to be ~3%.
- Power factor is observed to be ~0.62.
- Displacement Power Factor is observed to be ~0.80.
- Neutral Current is observed to be abnormally high.
- Current Unbalance is observed to be abnormally high.
- Even harmonics is observed to be abnormally high.

4.3.1.1 Finishing

- Maximum running load during the audit is observed to be ~53A/29kW .
- Total Current Harmonics Distortion is observed to be within the limit.
- Total Voltage harmonics Distortion is observed to be ~3%.
- Power factor is observed to be ~0.97.
- Displacement Power Factor is observed to be ~0.99.
- Even harmonics is observed to be abnormally high.

4.3.1.1 Hozary Di

- Maximum running load during the audit is observed to be ~51A/12kW .
- Total Current Harmonics Distortion is observed to be ~8%
- Total Voltage harmonics Distortion is observed to be within the limit.
- Power factor is observed to be ~0.47.
- Displacement Power Factor is observed to be ~0.52.
- Neutral Current is observed to be abnormally high.
- Current Unbalance is observed to be abnormally high.
- Even harmonics is observed to be abnormally high.

5.Electrical Recommendations

Overall major issues observed at entire facility are:
Low Power Factor: Electrical utilities will usually charge a higher cost to commercial customers where there is a low power factor.

Summary Sheet		Assumptions		Proposed Recommendation			
S.No.	Feeder Name	MD (A)	P.F	Comments	Rating	Order Code	Type of Compensation
Transformer-200kVA | 11/0.433kV | Servo-250kVA | DG 250kVA				Target (at PCC): dPF>0.99			
1	Servo I/P	250	0.92	-	100kVAr HPFC4 (70A APF4+ 50kVAr Passive)	p2p-415-hpfc4-100k	R+N
1(A)	Servo O/P	-	-	-	-	-	-
1.1	Washing	-	-	-	-	-	-
1.2	Ups I/P(4*20kVA)	-	-	-	-	-	-
1.3	Finishing	-	-	-	-	-	-
1.4	Hozary Di	-	-	-	-	-	-

R= Reactive compensation N=Neutral Compensation

"We have proposed advanced IGBT based Hybrid Filter for the reactive compensation as well as for neutral compensation at main LT. "

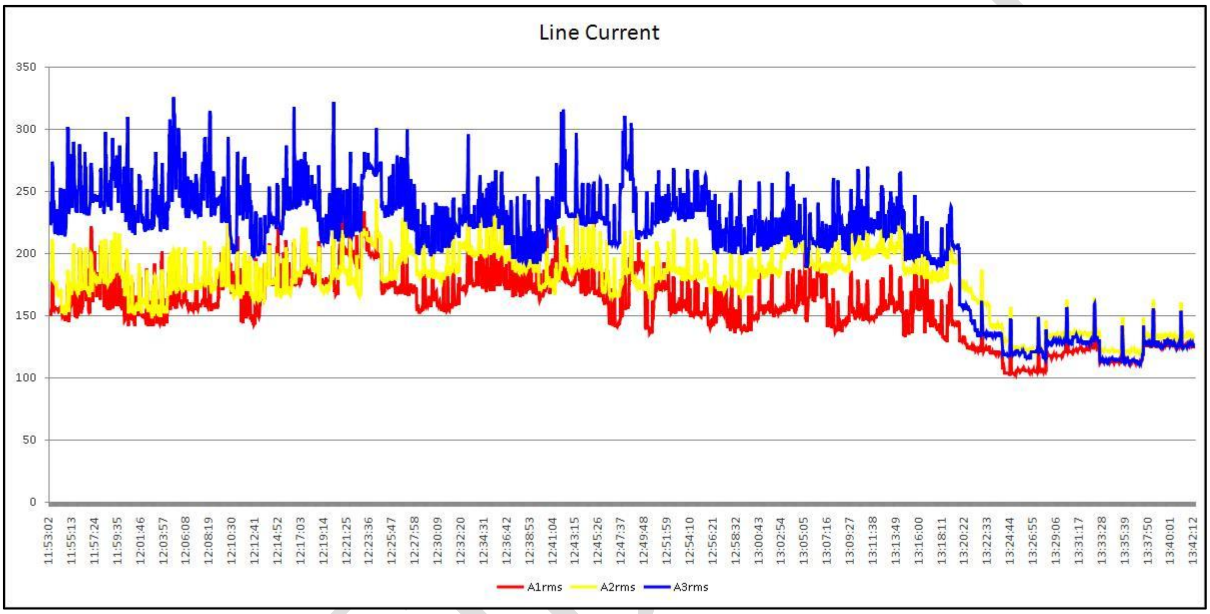
Note:

- ***All non-linear loads must have adequate 4% effective input impedance at the designed peak load (MD).***
- ***Capacitor Banks (if any) must be suitably detuned to prevent resonance.***
- ***Please verify the assumptions taken as any changes in them might change the rating of proposed solution scheme.***

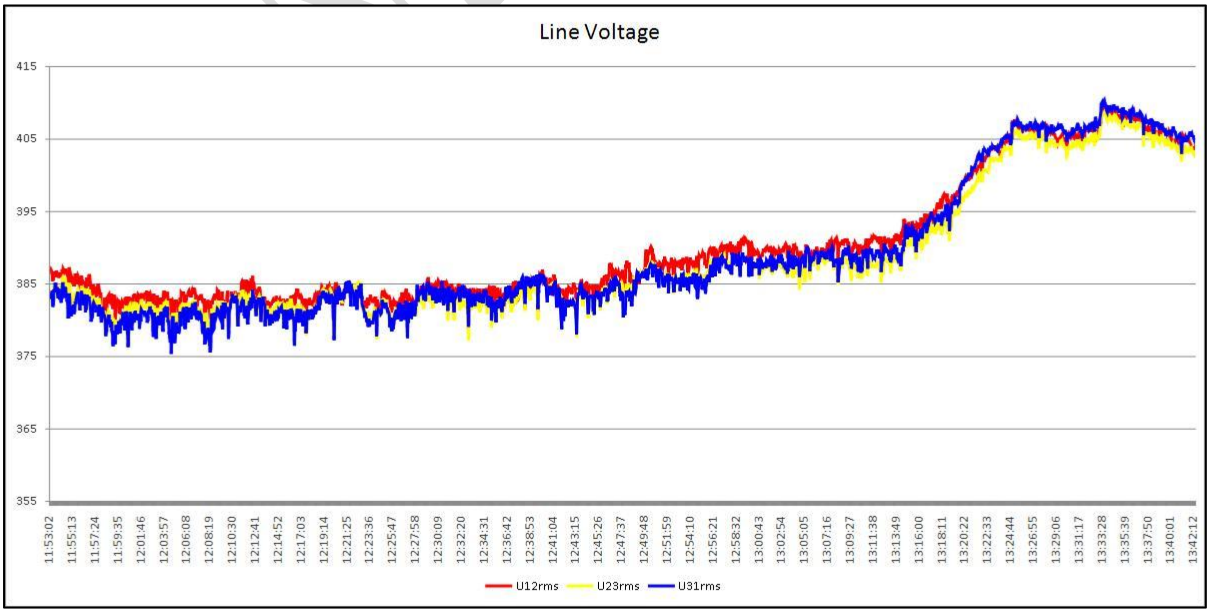
6.Electrical Datasets

6.1 Servo I/P

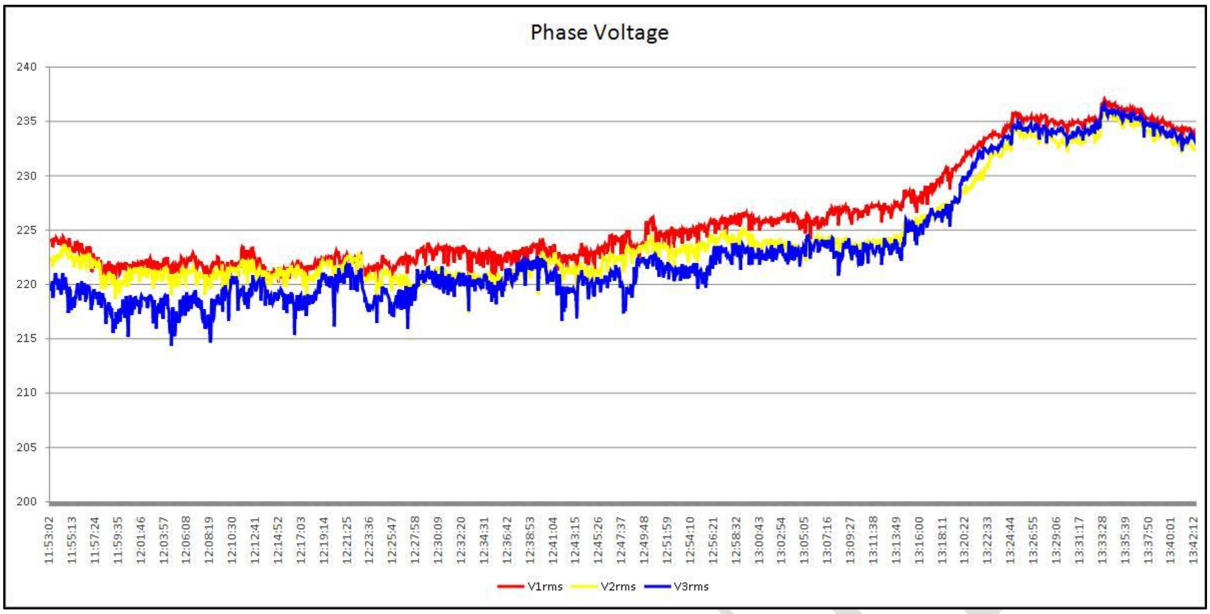
Line Current



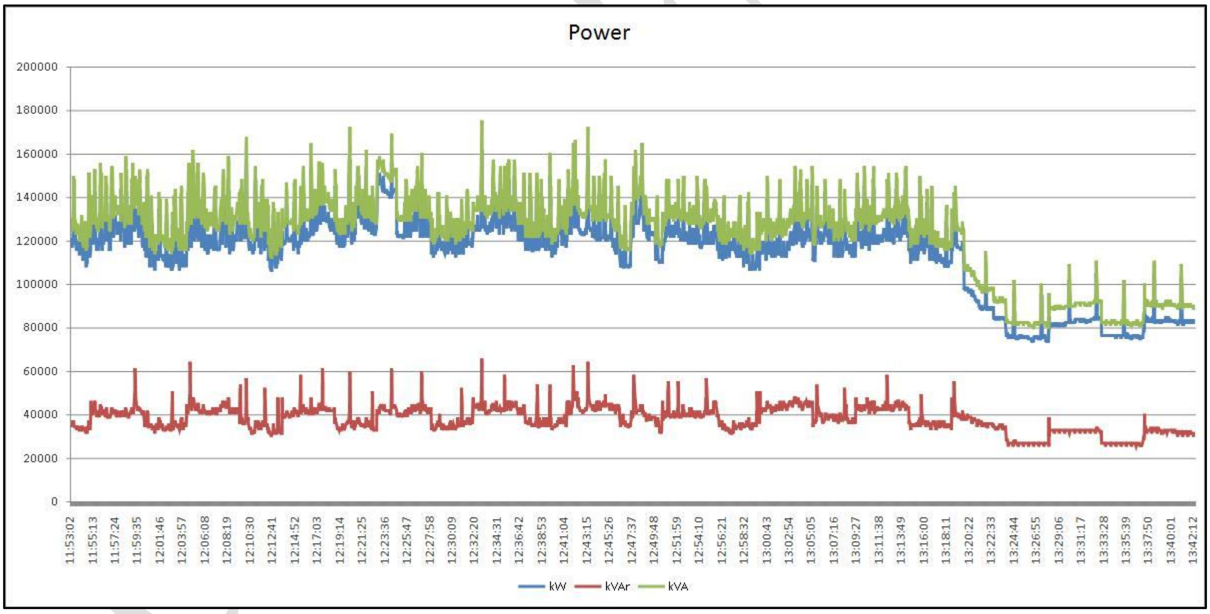
Line Voltage



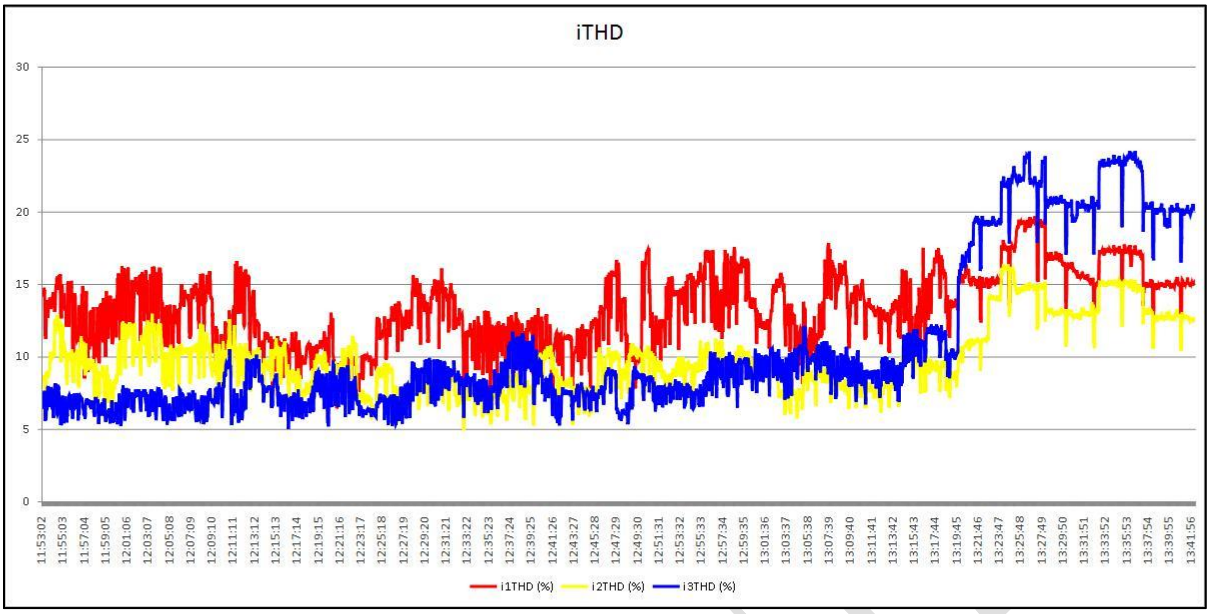
Phase Voltage



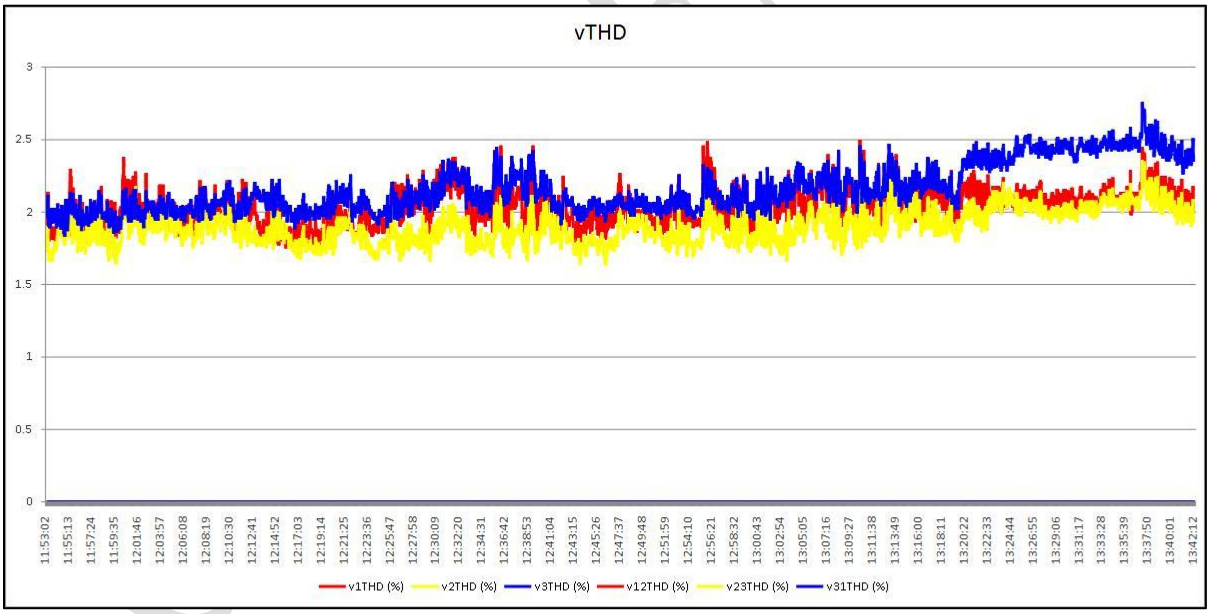
Power



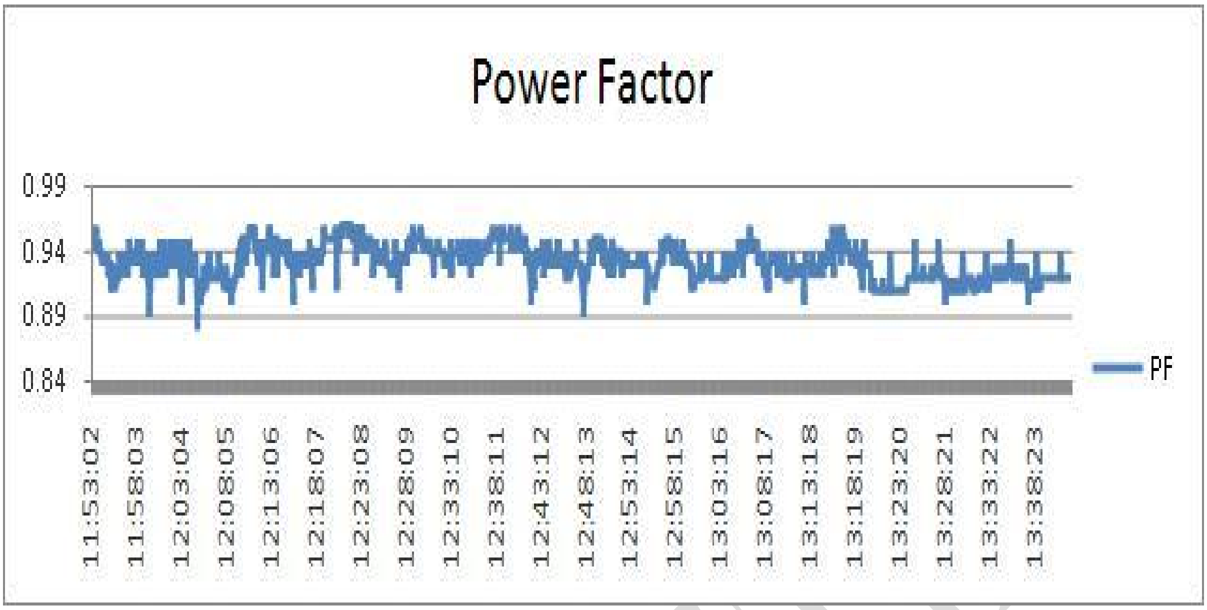
Total Current Harmonic Distortion (%iTHD)



Total Voltage Harmonic Distortion (%vTHD)

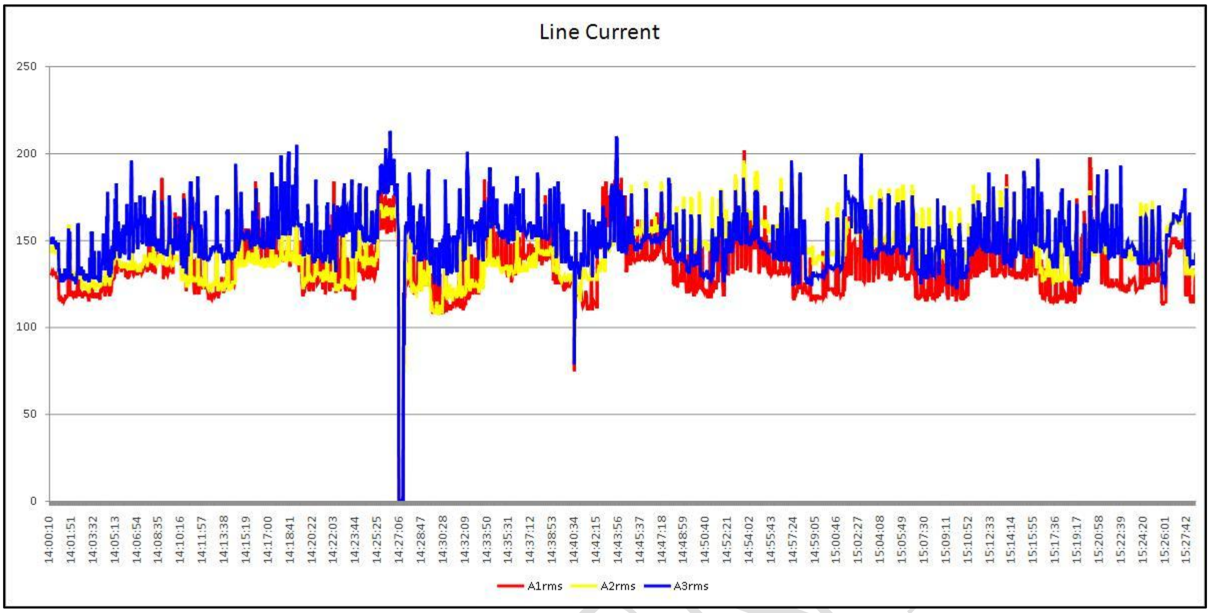


Power Factor

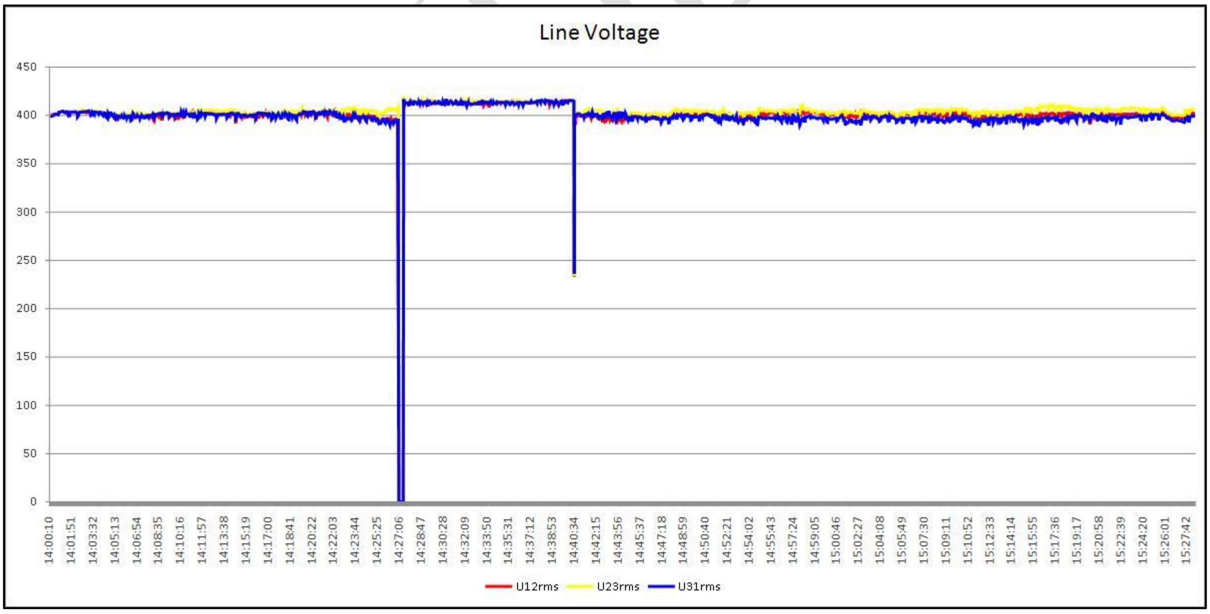


6.1 A Servo O/P

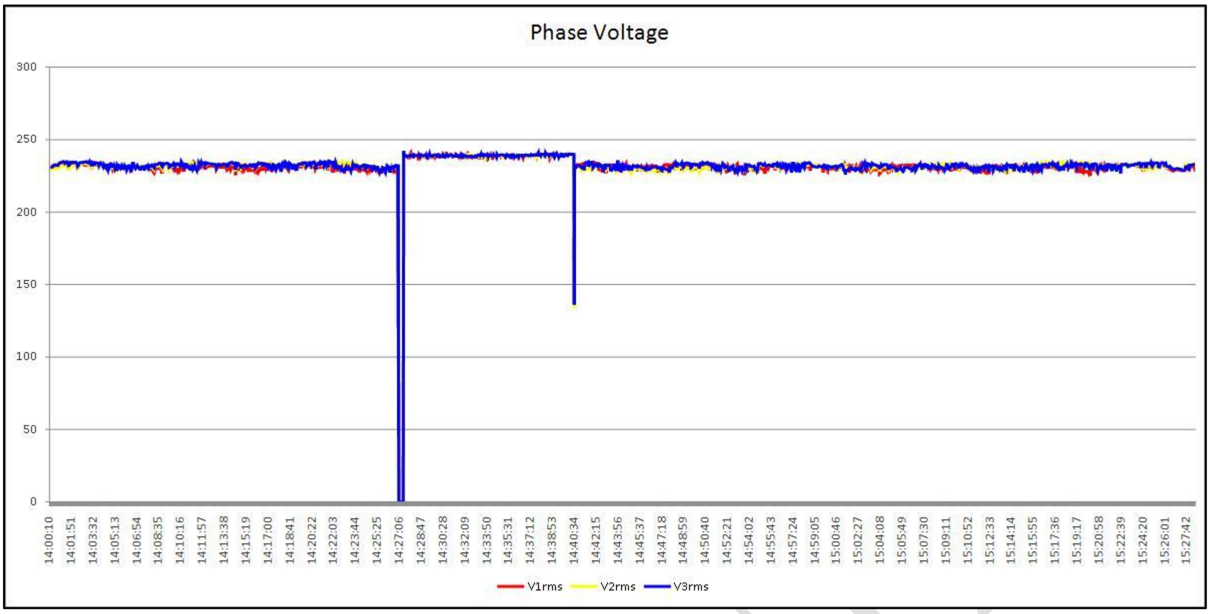
Line Current



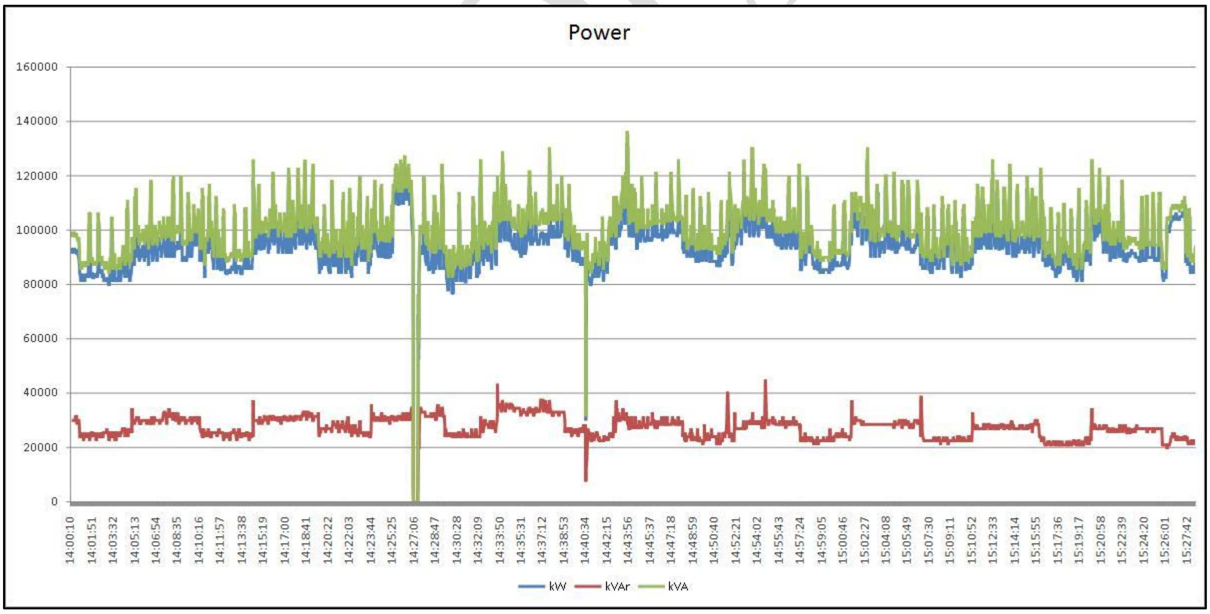
Line Voltage



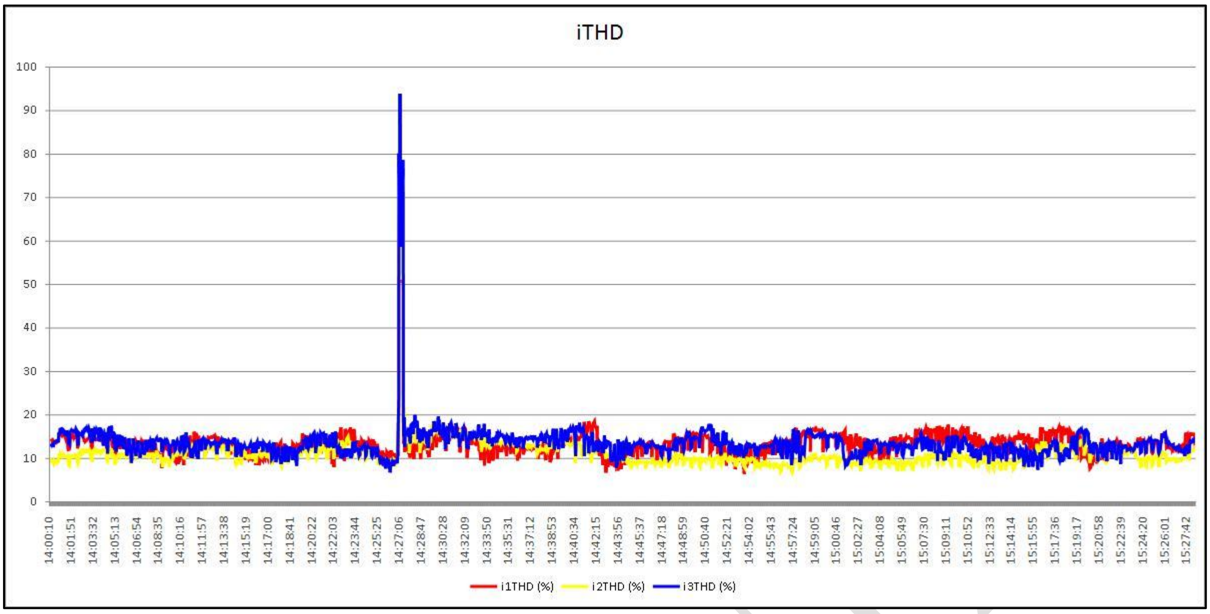
Phase Voltage



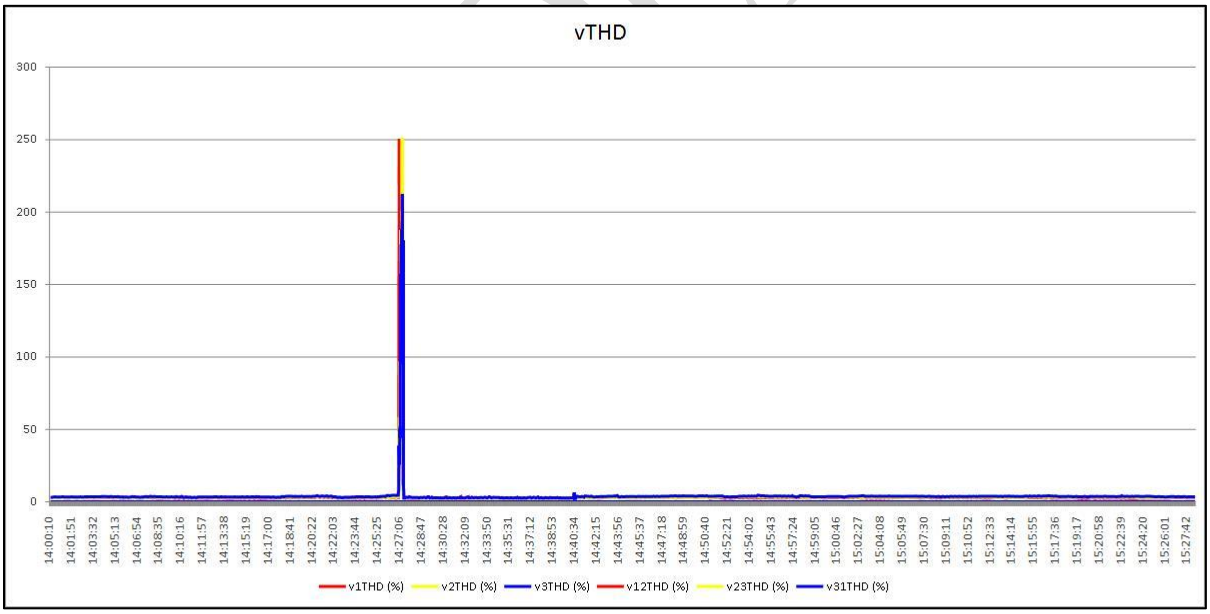
Power



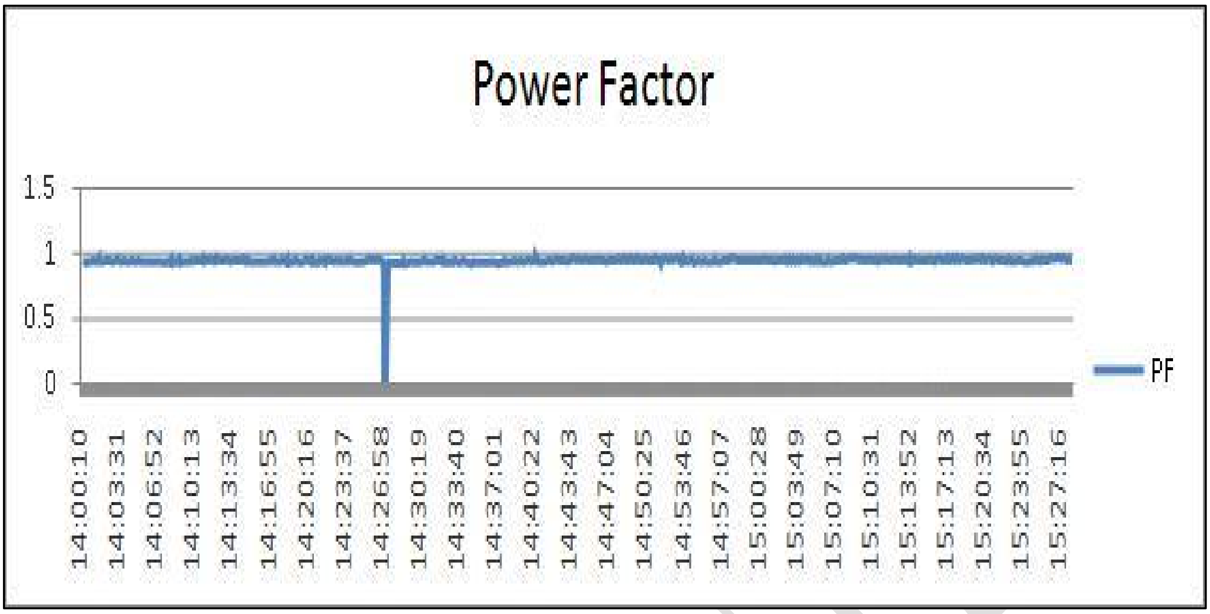
Total Current Harmonic Distortion (%iTHD)



Total Voltage Harmonic Distortion (%vTHD)

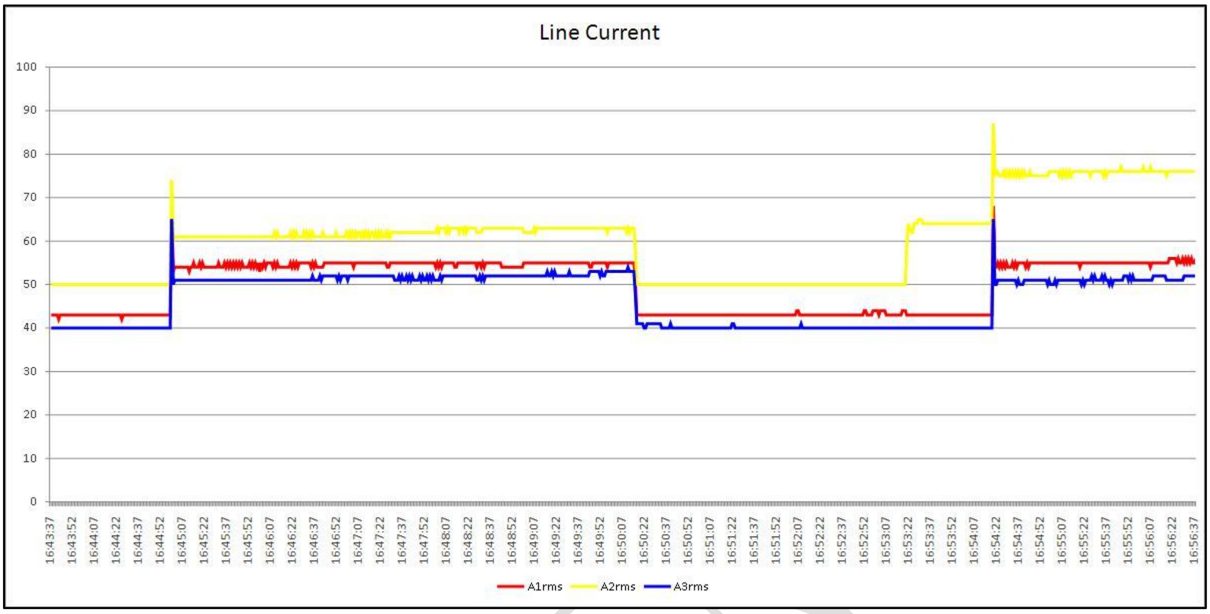


Power Factor

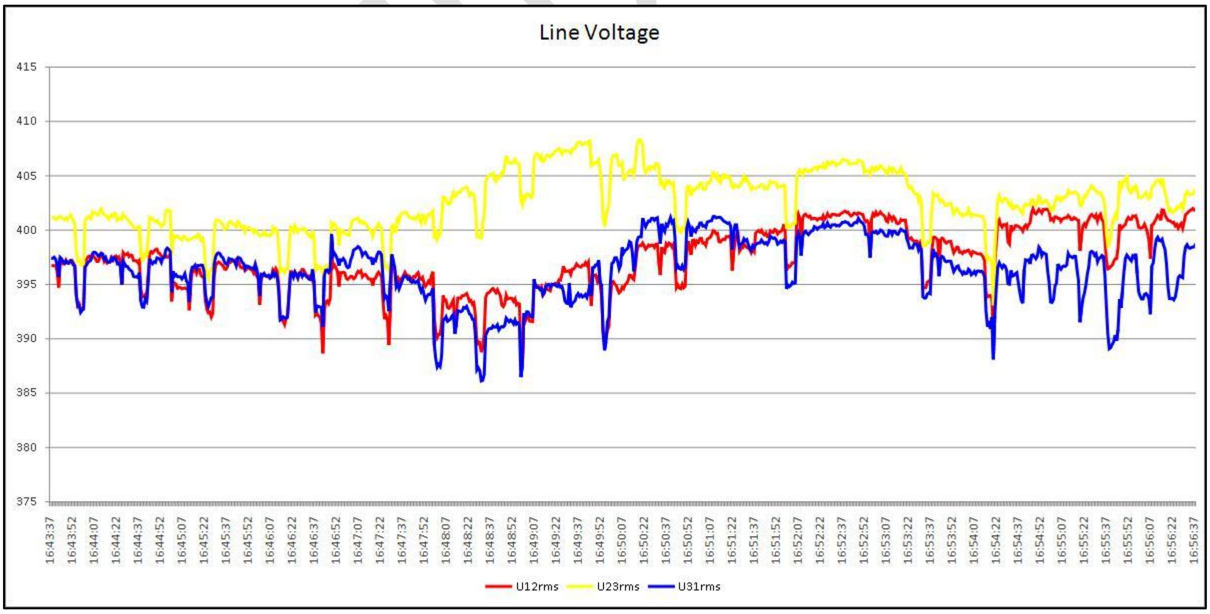


6.1.1 Washing

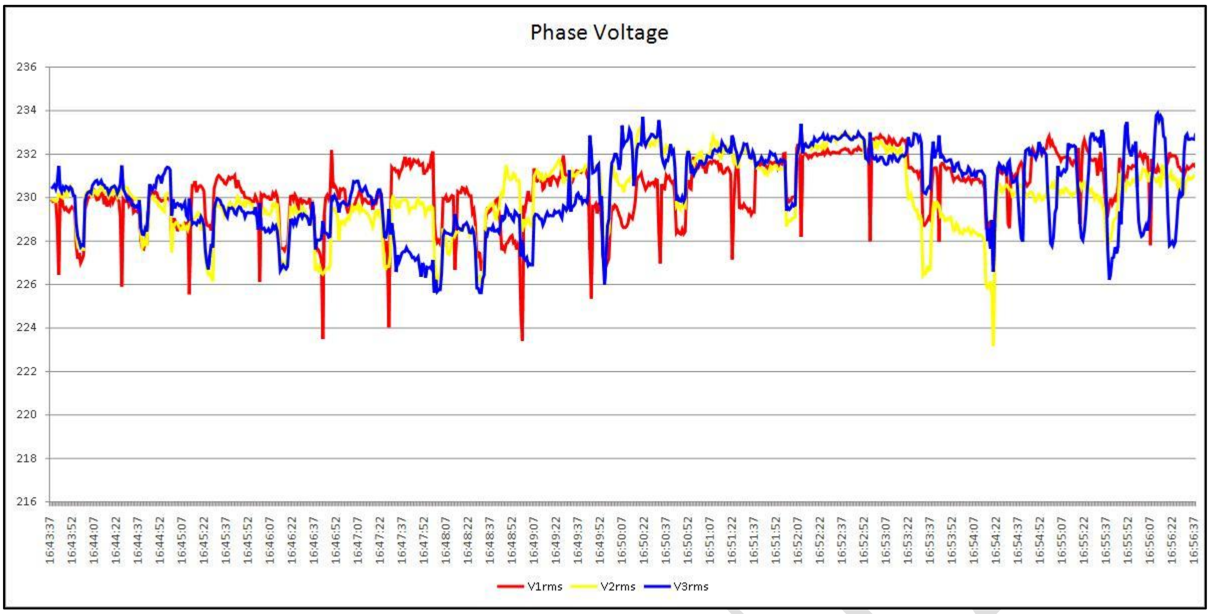
Line Current



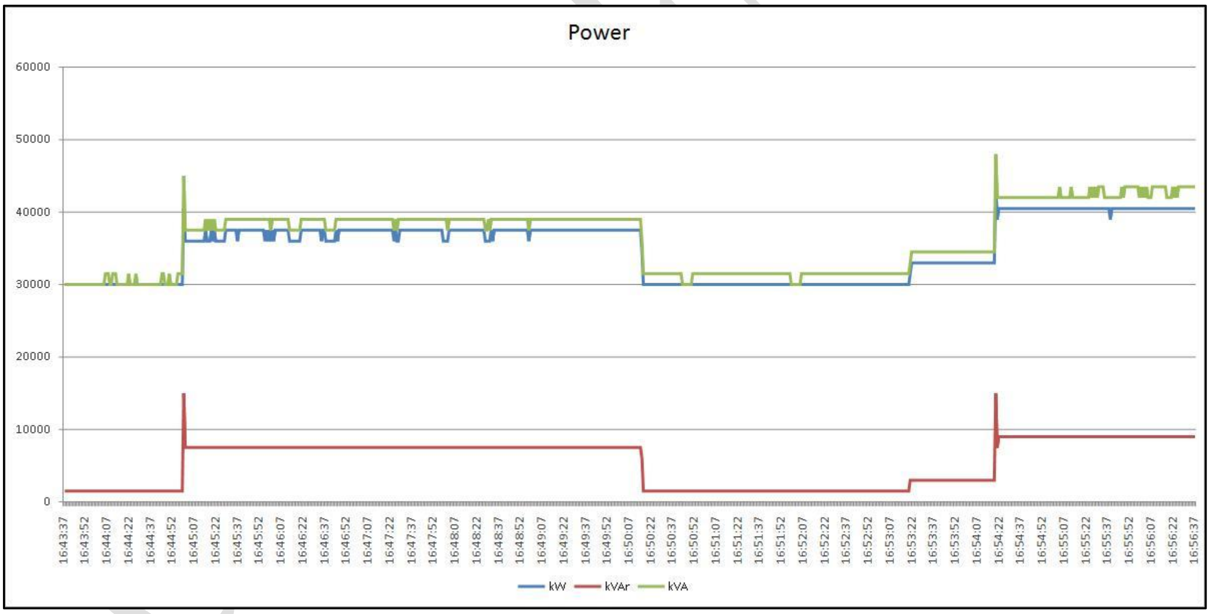
Line Voltage



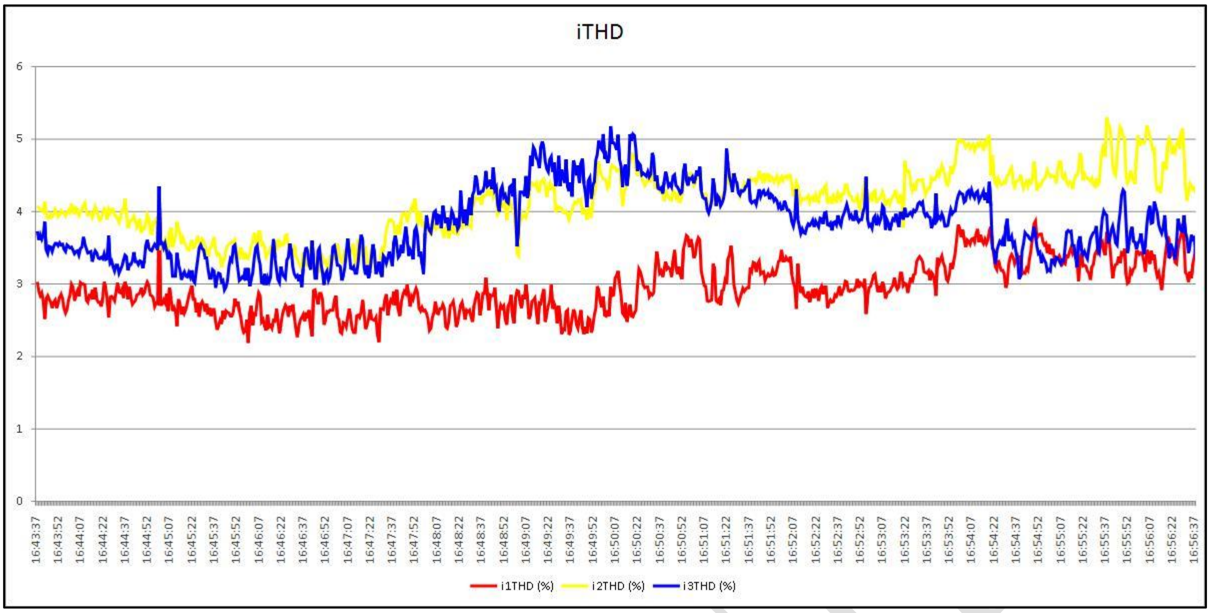
Phase Voltage



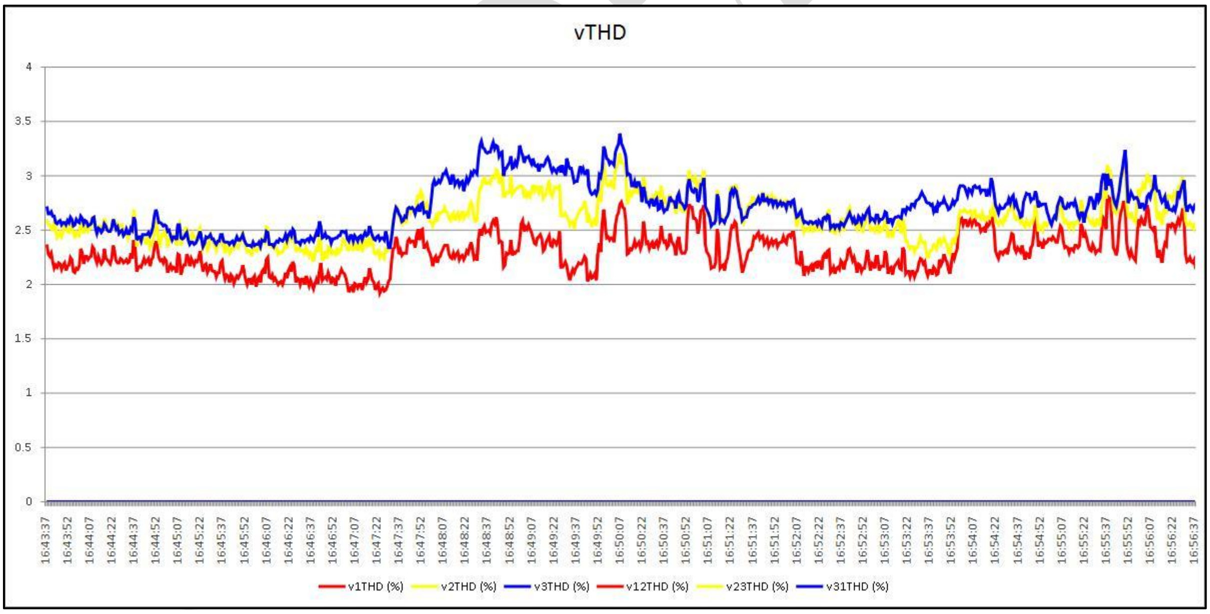
Power



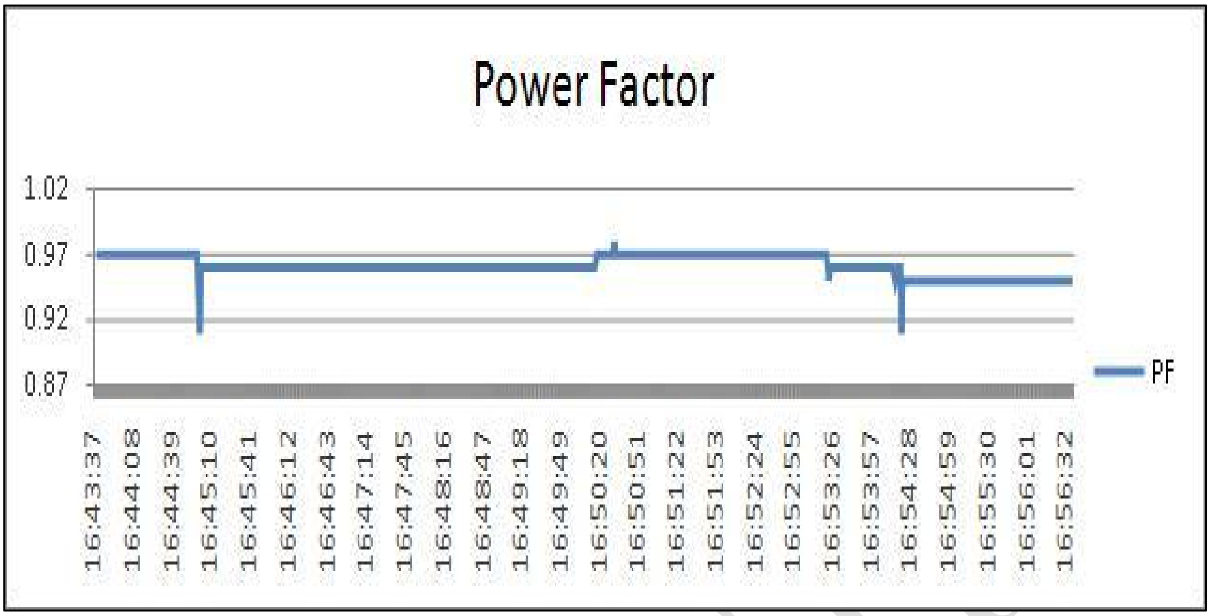
Total Current Harmonic Distortion (%iTHD)



Total Voltage Harmonic Distortion (%vTHD)

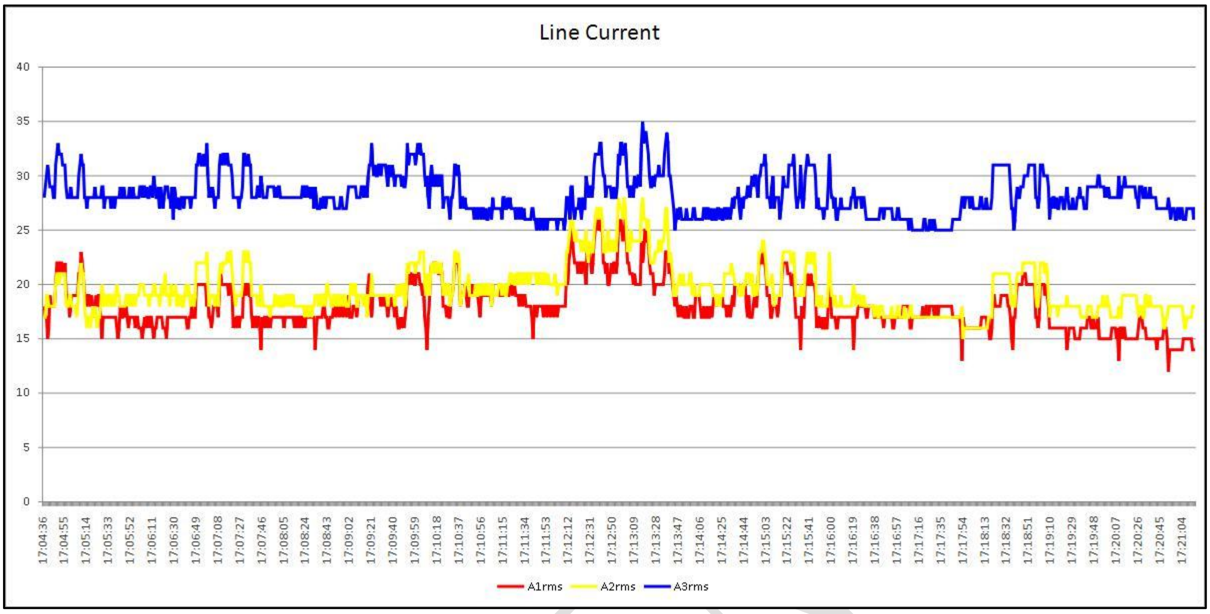


Power Factor

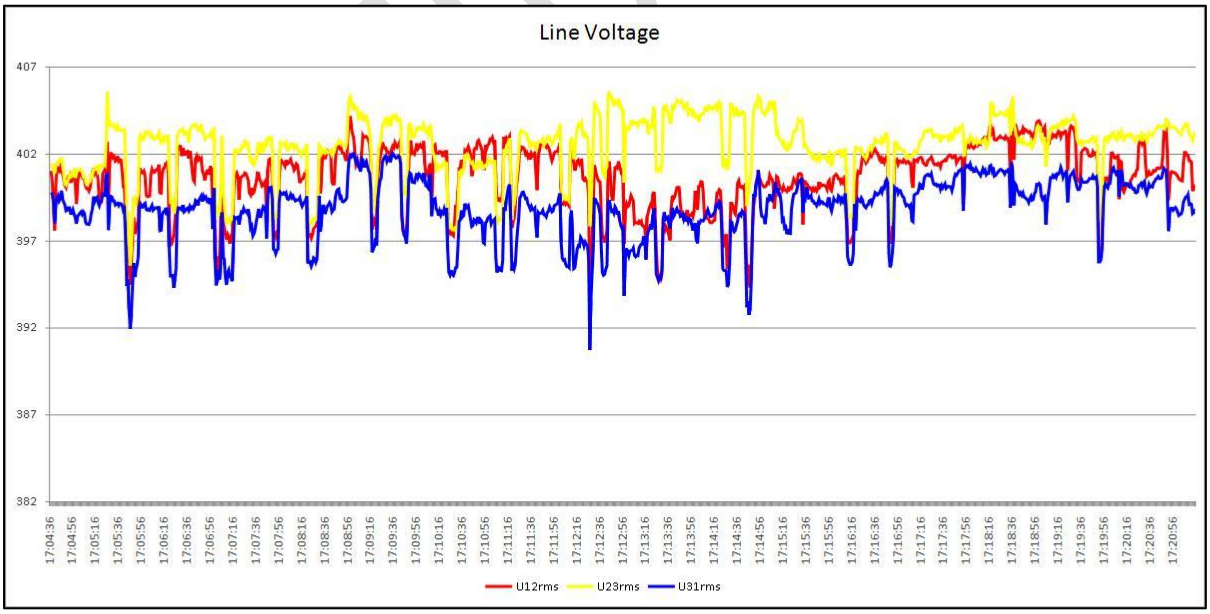


6.1.2 Ups I/P(4*20kVA)

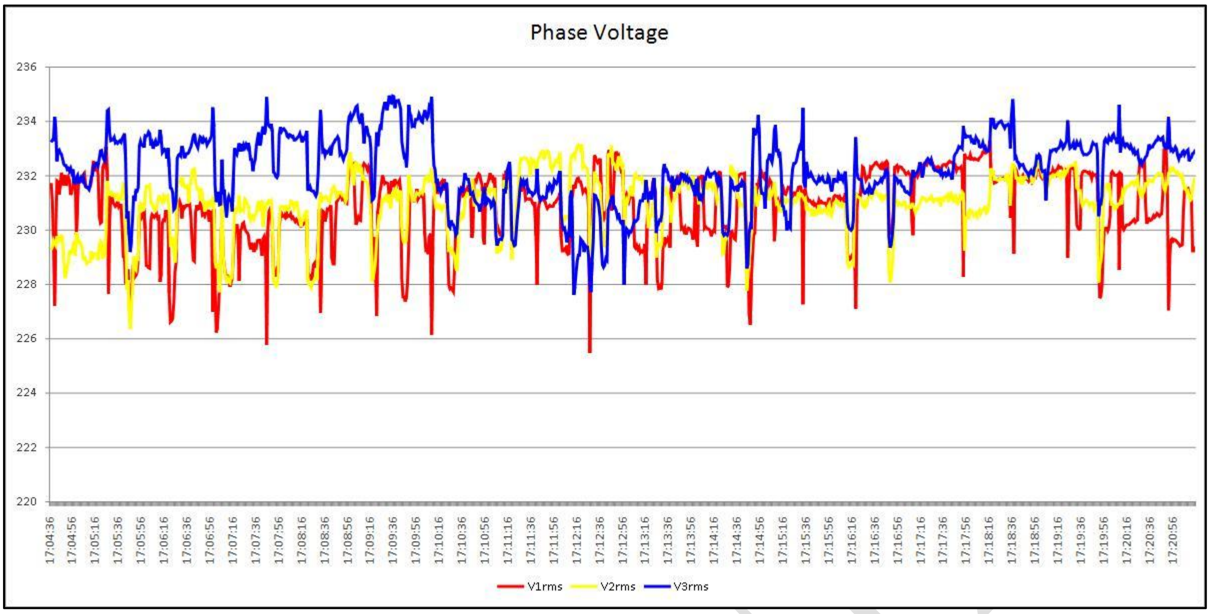
Line Current



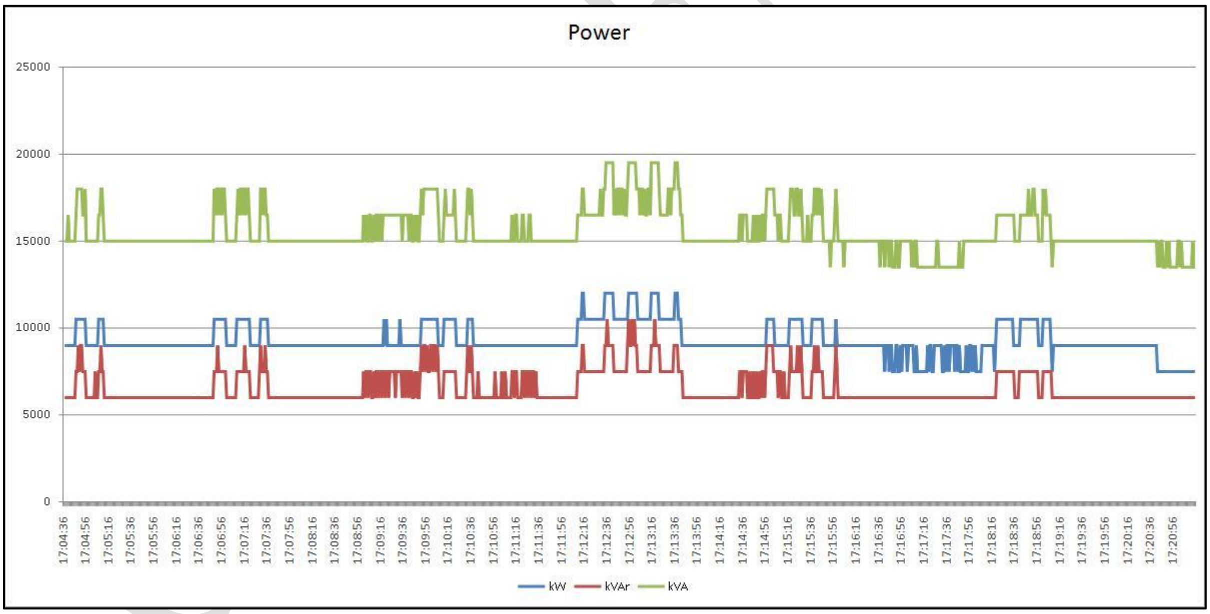
Line Voltage



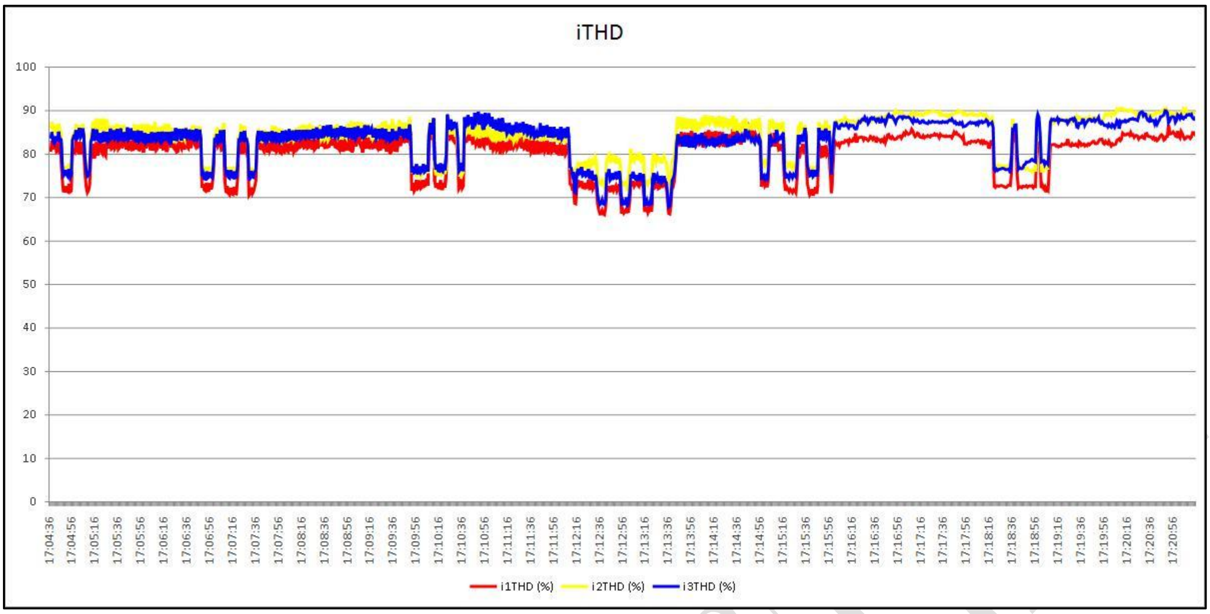
Phase Voltage



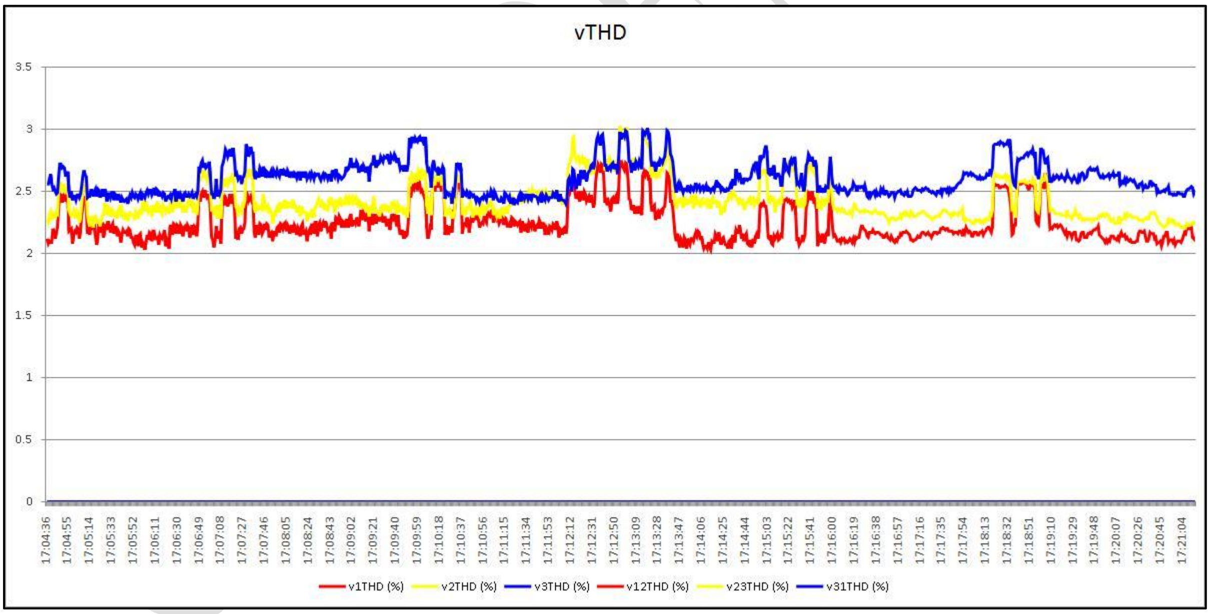
Power



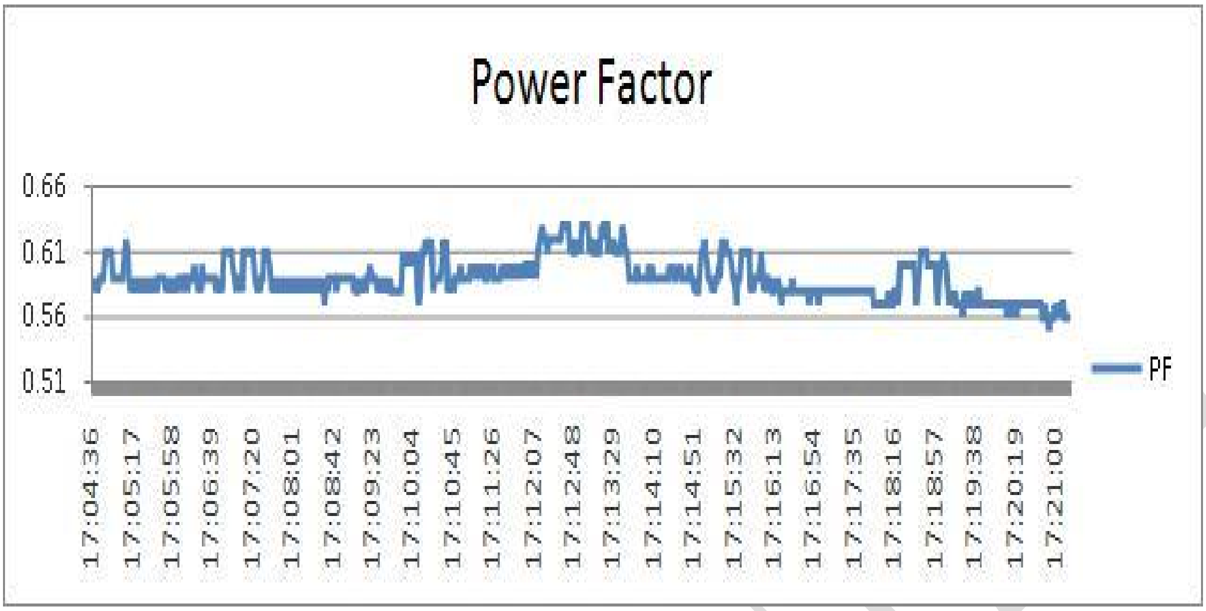
Total Current Harmonic Distortion (%iTHD)



Total Voltage Harmonic Distortion (%vTHD)

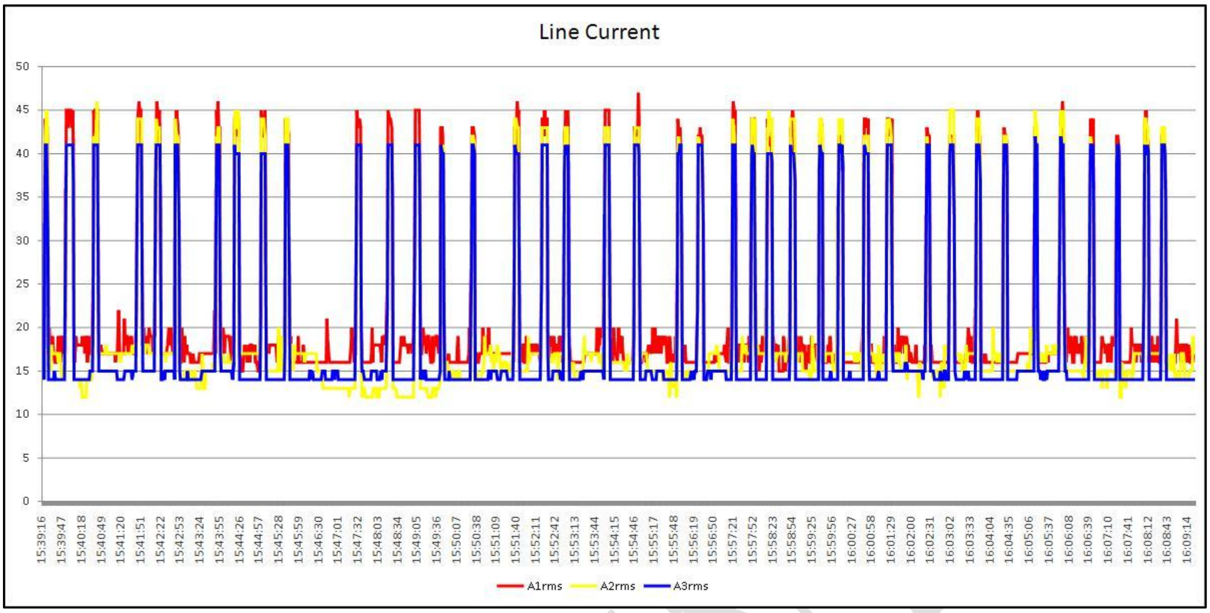


Power Factor

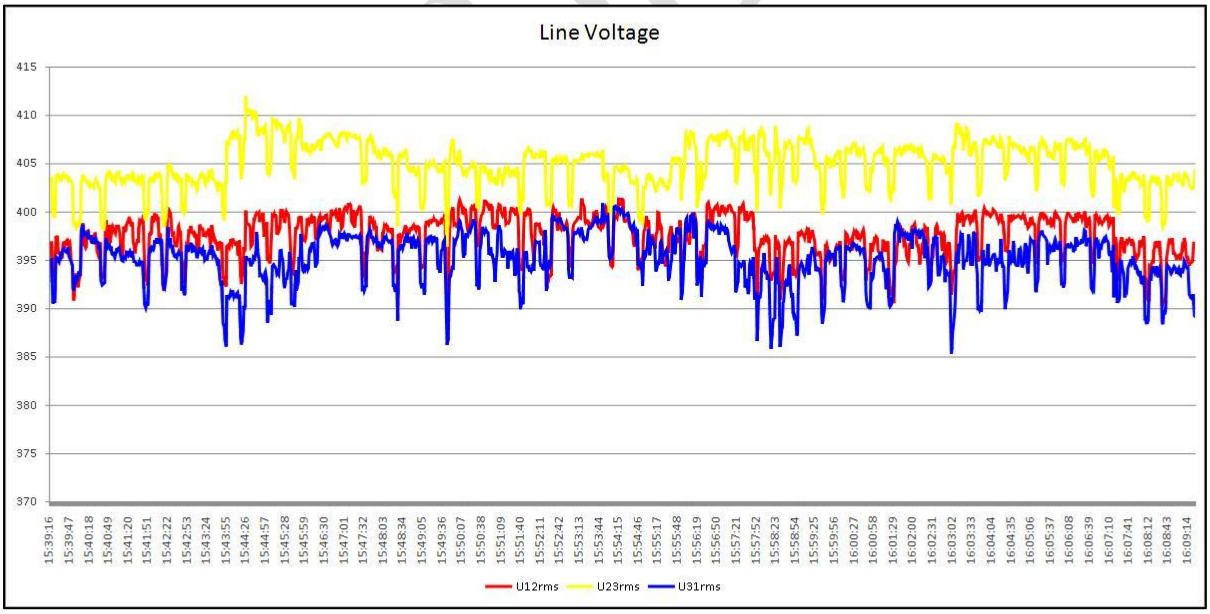


6.1.3 Finishing

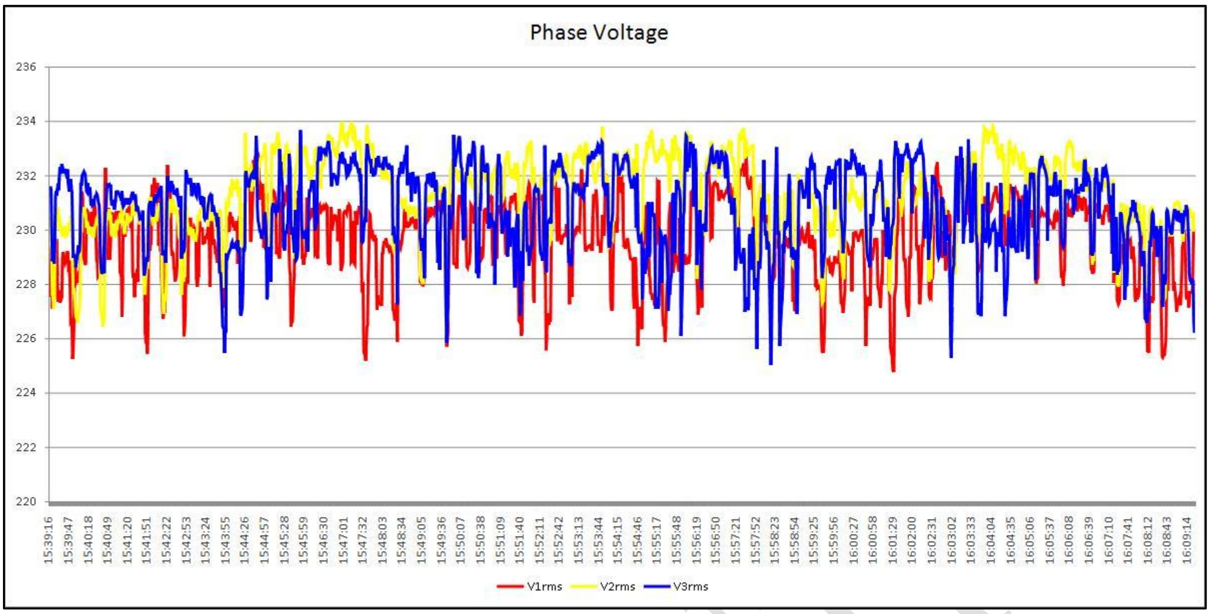
Line Current



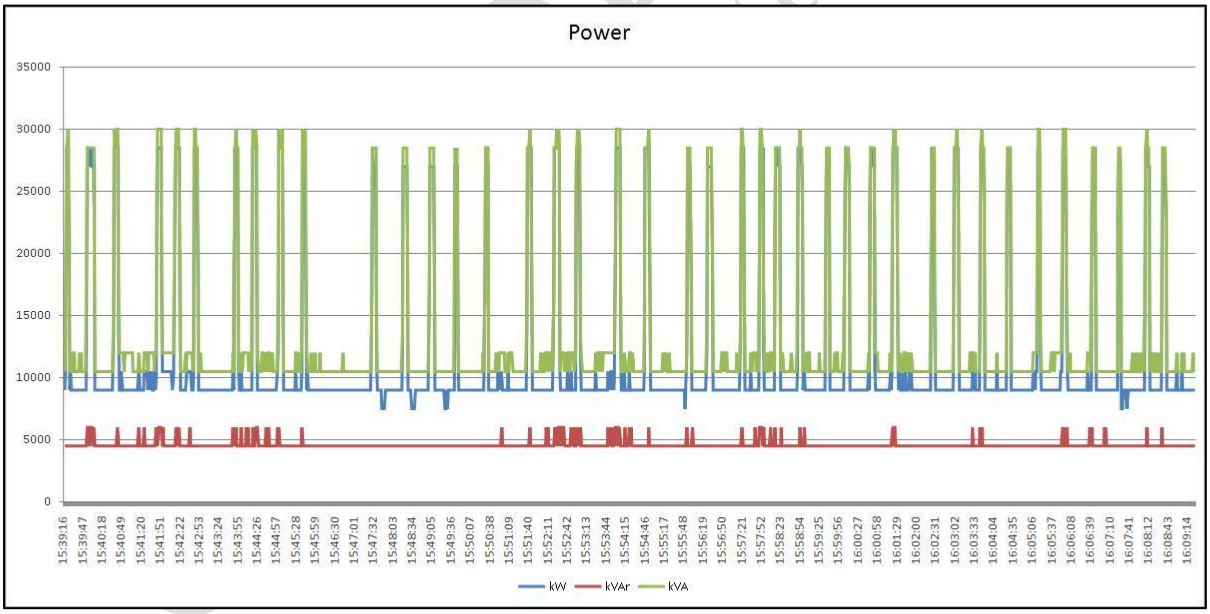
Line Voltage



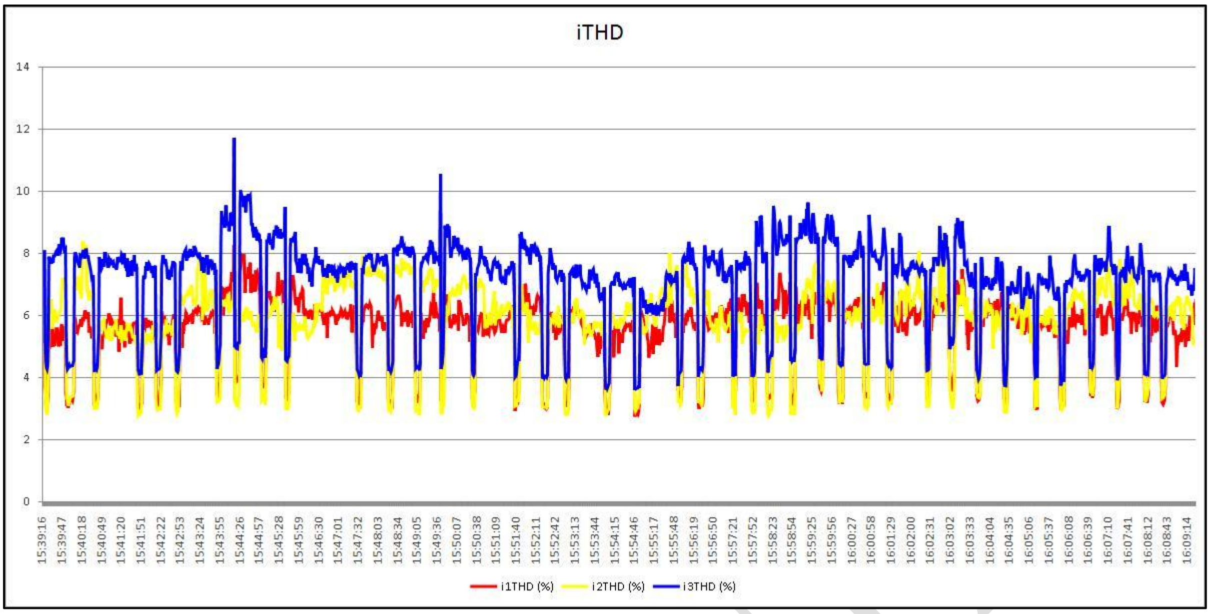
Phase Voltage



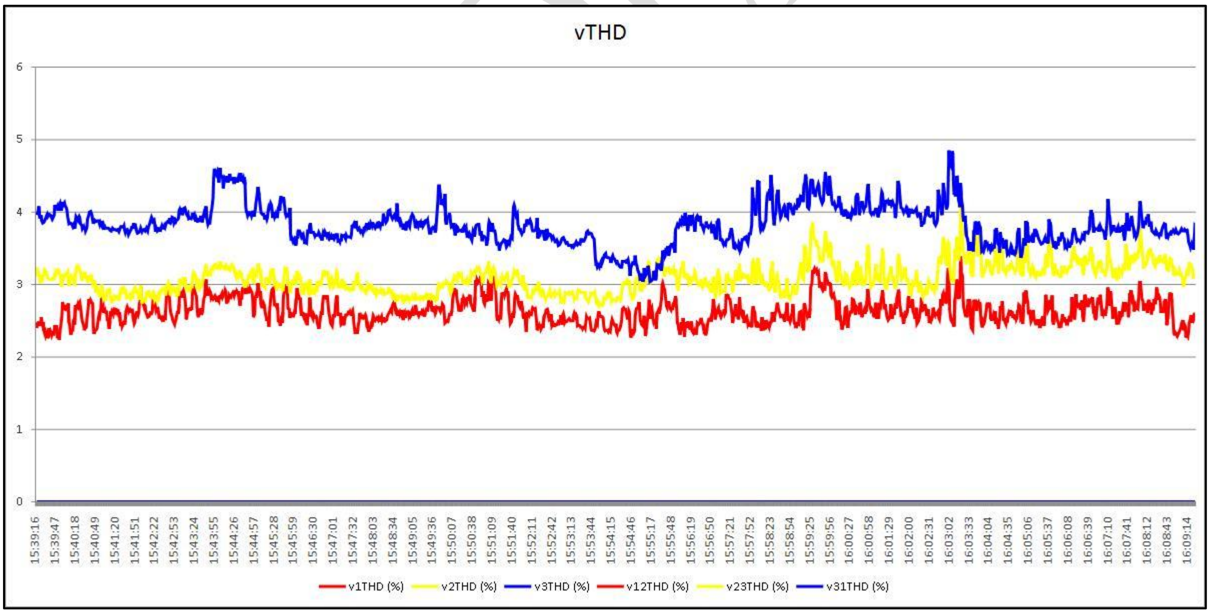
Power



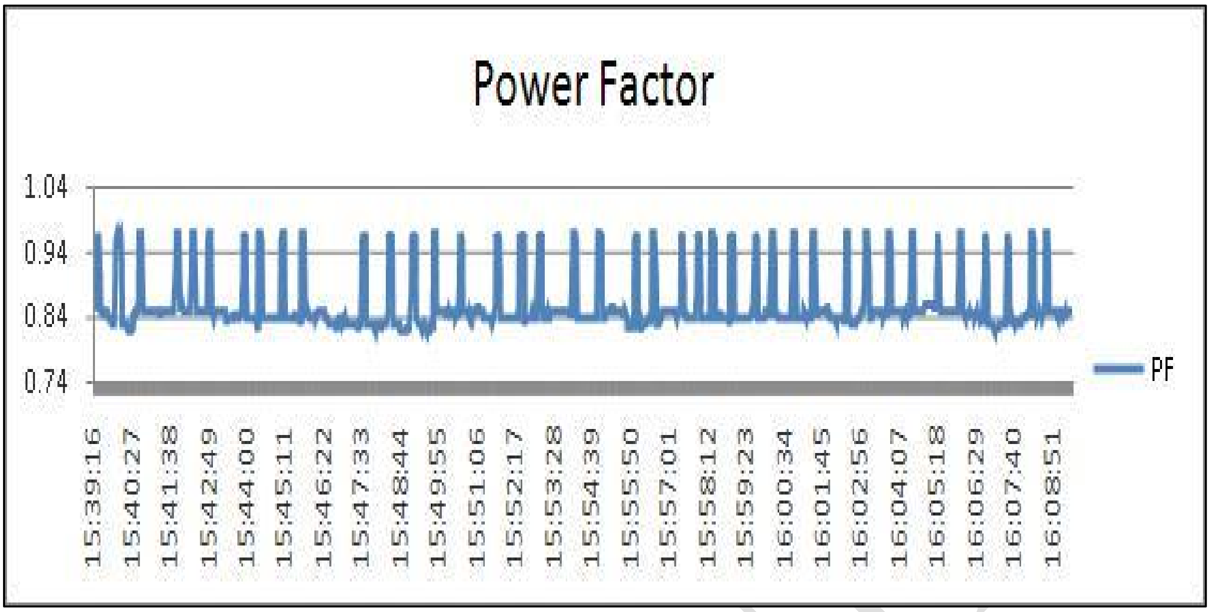
Total Current Harmonic Distortion (%iTHD)



Total Voltage Harmonic Distortion (%vTHD)

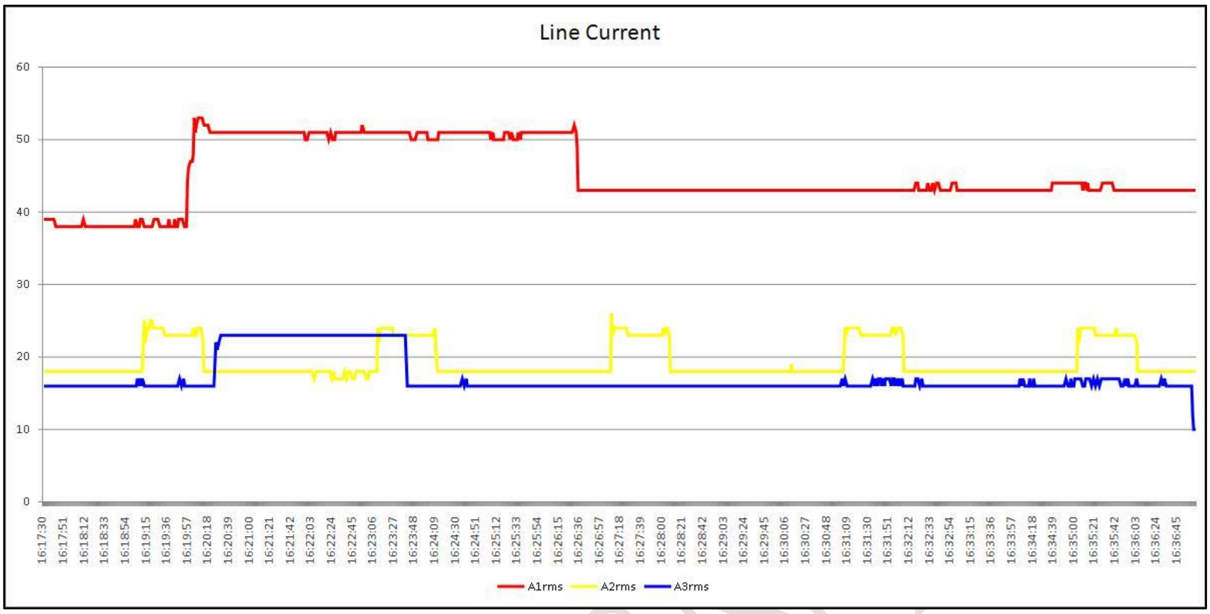


Power Factor

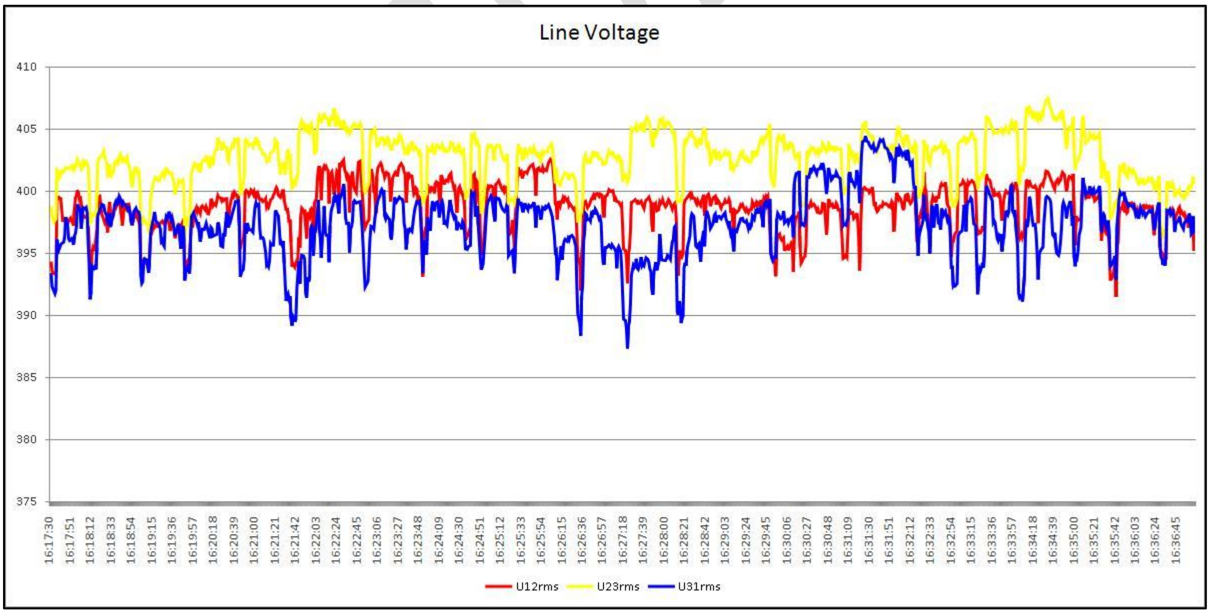


6.1.4 Hozary Di

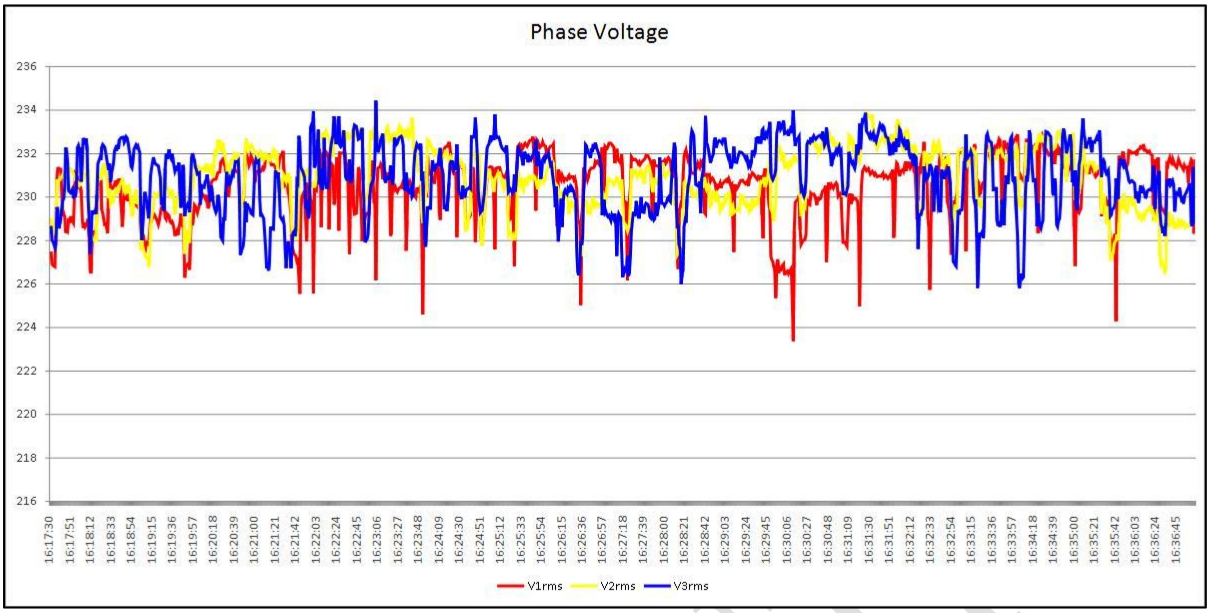
Line Current



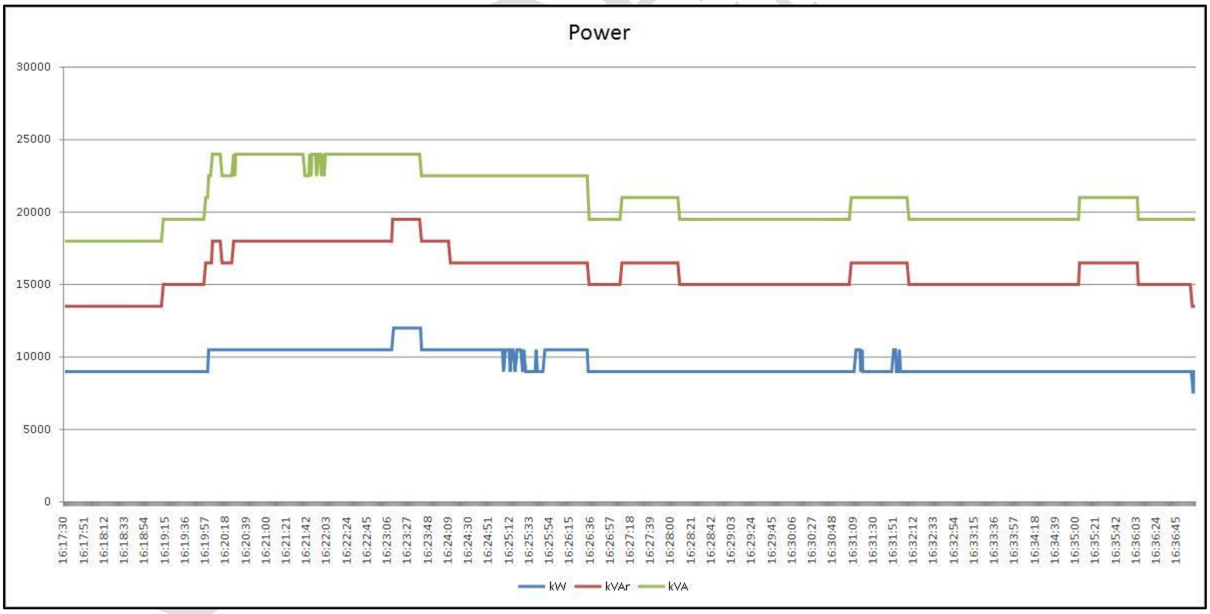
Line Voltage



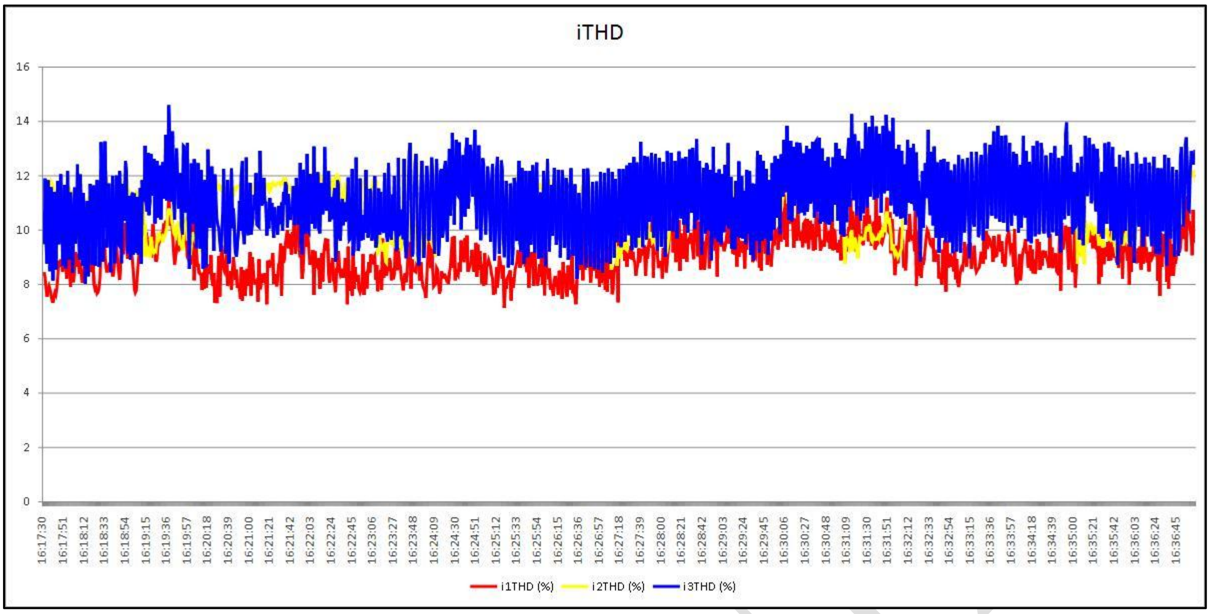
Phase Voltage



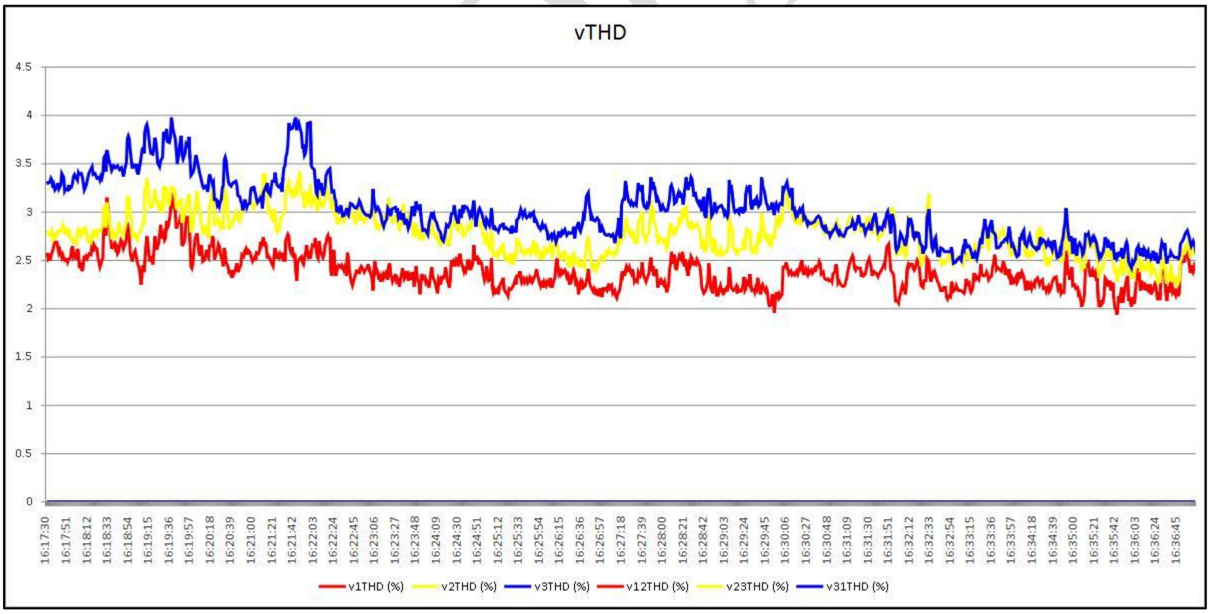
Power



Total Current Harmonic Distortion (%iTHD)



Total Voltage Harmonic Distortion (%vTHD)



Power Factor