

POWER QUALITY ANALYSIS REPORT

FOR

A Leading Pharmaceuticals Company

By

SAS Powertech Pvt Ltd.

101, Gera's Regent Manor, Survey No. 33, Area No. 39/570,
Behind Opulent Car Care Center Baner, Pune 411045

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Audit Period : : 14th Dec to 18th Dec 2015.

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SITE DETAILS

Site Name	
Contact Person	
Analysis Period	14 th Dec To 18 th Dec 2015
Audit Conducted By	Mr. Vijay Sonawne & Sandesh Biramane
Equipment Used For Analysis	 <p>KRYKARD ALM35 Power Quality Analyzer Chauvin Arnoux,</p>

Methodology of Power quality audit conducted:

After visiting, surveying and understanding above infrastructure, we decided to follow following methodology for this audit.

Audit aim and Methodology:

- Record electrical parameter data at 33KV, 433V LT PCC at both transformers secondary for around 24 hours.
- Record electrical parameter data at feeders identified by maintenance staff, where repeated electronic failures are reported for around 24 hours.
- Record power quality parameter data at all sub distribution feeders and UPS outputs.
- Study above data and if required, recommend harmonic mitigation solutions at various levels in the distribution to suppress the distortion and improve power quality.
- Study above data to know status of reactive power compensation provided at various locations and their effects.
- Record electrical parameter data at all major UPS outputs to know current and voltage harmonic levels of load – as supported by them.
- Conduct meeting with maintenance teams to understand nature of electrical failures / automation failures and their frequency. Study relationship between failures and PQ parameters if any.
- Monitor sub cycle level disturbances at critical levels in the distribution and also at problem areas located by maintenance team.
- Undertake infrared thermography to locate loose contacts, which can cause power quality issues along with elevated temperatures.
- Undertake earthing audit to ensure quality of earthing using loop earthing test method.
- Analyse all above collected data and prepare report based on above to locate issues related power quality and remedies to rectify the same if any.

Audit team:

SAS Powertech Pvt Ltd.

Mr. Narendra Duvedi. – Lead Auditor

- B.E. Electrical with specialization in power electronics
- 35 years experience.
- Bureau Of Energy Efficiency –certified ENERGY AUDITOR
- BVQI certified Lead Auditor for ISO 50001.
- Chartered Engineer.

Mr. Vijay Sonawne. –

- Diploma Electrical Engineering with more than 10 years field experience.
- Data collection engineer.

Mr. Sandesh Biramane

- Diploma Electronics Engineering
- Data collection engineer.

LIST OF ABBREVIATION

MLT	Main LT panel
PQA	Power quality analysis
V _{rm}	Phase to neutral voltage
U _{rm}	Phase to phase voltage
Arm	Current
Avg	Average
Min	Minimum
Max	Maximum
I _{th}	Total harmonics distortion in current
V _{th}	Total harmonics distortion in voltage
PF	Power factor
PCC	Power control circuit/point of common coupling
TDD	Total demand distortion
THD	Total harmonics distortion
DB	Distribution board
DG	Diesel generator
LT	Low tension
IEE	Institute of electrical and electronics engineers
NEC	National electric code
SLD	Single line diagram
UPS	Uninterrupted power supply

COLOUR CODE

Red	R-Phase / Line-1 / Phase-1 / R-Y
Yellow	Y-Phase / Line-2 / Phase-2 / Y-B
Blue	B-Phase / Line-3 / Phase-3 / B-R
Black	Neutral
Total	Green
KW	Red
KVAR	Blue

ACKNOWLEDGEMENT

We are thankful to the management of A Leading Pharmaceuticals Company . For giving us an opportunity to conduct power quality analysis at their premises.

We are also thankful to team of **A Leading Pharmaceuticals Company** for the help and co-operation during Power Quality Analysis.

We do hope you will find our recommendations useful in helping you to improve the power quality of your electrical system

We wish the management success in their Endeavour to improve power quality.

For **SAS Powertech, Pune**

Certification:
Report Certified by:

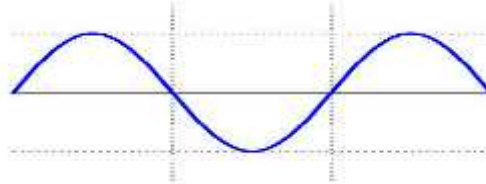


Abhijit Katre
Authorized Signatory

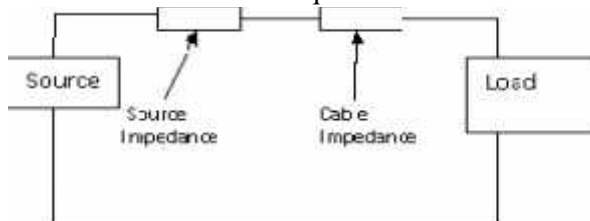
Narendra R. Duvedi.
(B.E. Electrical and Certified Energy Auditor Reg. No: EA 10859)

A note on electrical Power quality, it's importance, effects and remedies.

- Commercially available AC – alternating electric power is usually available in “Sinusoidal” form. The main specifications of this are “Value of Voltage”, “Waveform” and “Frequency”.



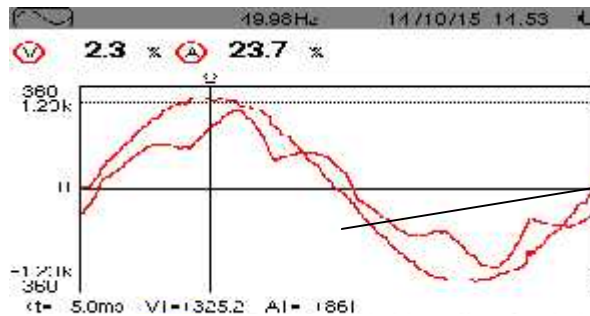
- In case of 50Hz frequency, each cycle takes 20msec to complete. Frequency variation can cause trouble to connected load and as such it should be as constant as possible. Iron losses in motors, transformers etc change with frequency. The Grid power frequency is usually maintained within +/- 1Hz.
- The electric distribution equivalent circuit is as follows



The waveform of voltage available across load may get affected and deviate from Sinewave due to various reasons like drawing non sinusoidal currents containing harmonic components, defects in generators (Alternators or UPS systems), higher source impedance, overloading, etc. If (Source + Cable) impedance is negligible in comparison with Load impedance under all conditions, the source is termed as “Infinite bus” and then the problems are less.

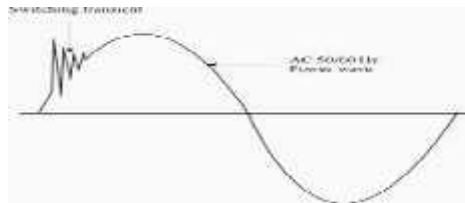
The distorted voltage waveform can affect equipment performance. Such distorted voltages and currents can result into overheating of cables, transformers etc and can also cause excessive voltage drops.

Example of distorted current –



Distorted Current.

- Voltage disturbances could be “sub - cycle” as shown bellow or “Sustained”. Sub - cycle disturbances are known as transients and sustained disturbances are known as “Sags” or “Swells”. A sub classification is also known as “Voltage dip”



- These power quality issues if present in available power supply can affect performance and reliability of critical loads like complex automation systems, communication devices and digitally controlled power electronic circuits and reflect into unwanted resetting digital circuits like PLCs, VFD controllers etc.
- In practise, the source, transmission level transformers, switchgear and part of cabling belongs to utility company and once the feeder enters the premises of consumer, the infrastructure belongs to consumer. If large amount of harmonic currents are demanded by load and are required to be supplied by utility company, the utility company equipment is also subjected to ill effects of these power quality disturbances. In view of limiting commercial impact of this demand raised by consumer, normally utility companies bind consumer into legal compliance requirements related to power quality. Such requirements usually are based on some international standards. One such standard related to harmonic compliance applicable at “Point of common coupling” or PCC is IEEE 519 1992.
- Voltage regulation and dynamic response (Value of Dip or Rise and Time required for correction) are noticeable parameters of small capacity power supplies like DG sets, UPS systems etc, which affect performance of critical loads if found beyond permissible limits. The applicable standard related to assess performance of UPS systems is IEC 62040 – 3
- In view of avoiding effects of power quality on setup, it is required that available quality of power should be matched with specific requirement of critical equipment for smooth and reliable operation. If this is not possible then a suitable power conditioning equipment like UPS / stabilizer / Series voltage correctors etc needs to be added in series after matching UPS output specifications with requirement of critical load.

Visible effects of power quality issues.

- Equipment malfunction.
- Equipment failure, especially related to controlled rectifiers and front end components.
- Control Power supply failures and associated damages to subsequent circuits.
- Abnormal heating of electrical conductors, nuisance tripping.
- Insulation failures.
- Loosing Load and Motor alignment frequently due to harmonic torques developed in the motor.

Electrical compatibility and reliable equipment design.

Although providing good quality of power is important, “Electrical Compatibility” is more critical. It is always advisable that the equipment manufacturer should decide detail power quality and workmanship compatibility requirements, exchange them among all stakeholders – namely

- 1) Critical equipment manufacturer,
- 2) End user,
- 3) UPS / SERVO STABILIZER / TRANSFORMER manufacturer
- 4) Contractors involved in executing the project.

Depending upon project value and seriousness of known issues related to power quality, a third party compliance / validation audit can be called for at the time of commissioning / execution and / or after about one month of operation. During such audits one can also decide periodicity of such inspection along with SOPs for predictive and preventive maintenance to get continual satisfactory performance from the equipment. During such audit, legal compliance as per requirements of utility company can also be checked.

Lastly one should also note that there could be design related issues with the equipment, which can affect reliable operation. Such issues may affect the performance despite of offering good quality power. It is very important to consider this while undertaking root cause analysis of failure of an equipment working on electrical power.

Acceptability of Power quality parameters have been decided in various international standards published by reputed world famous organizations like IEEE, IEC, NEMA etc. If equipment manufacturer commits that he can accept the power as per these standards, then the power quality can be checked as per these standards during the audit, otherwise the compliance has to be ensured against requirements of equipment manufacturer.

Executive Summary of findings and recommendations:

- 1) During this audit 33KV GEB incoming supply power quality was monitored for 24 hours. Large number of voltage alarms and voltage transients were recorded during this monitoring.
- 2) A Leading Pharmaceuticals Company receives 33 KV GEB supply through RMU arrangement located outside the plant. This arrangement involves lot of cables and switches emerging from VERNA substation. This should be thoroughly checked to rule out possibility of loose contacts, adequacy of cable / conductor size and inadequate source capacity.
- 3) IGBT based series voltage correcting devices are now available in the market, which detect a disturbance in 2 msec and correct in 5 msec. They can support the load for few seconds even on phase loss. Such devices have unlimited over load capacity and 98% overall efficiency from 10% to 100% load. These devices can offer current balancing, waveform correction and correction against up to 40% dips. These products are expensive and paybacks will be justified if they are required to cover production loss and associated time value of the same along with expenses towards breakdown maintenance.
- 4) We have carried out Infrared thermography of entire electrical installation and have included the report here with. We understand that plant maintenance team has IR imager and carry out imaging as predictive maintenance practice. It is recommended that the same should be carried out once in six months and a “pre imaging” – Shutdown and maintenance – “post imaging” format should be followed to ensure effectiveness of maintenance.
- 5) We have carried out earthing audit using loop testing method and the report indicates that “TR2 Neutral earthing resistance” is on higher side and needs attention.
- 6) We have recorded all input / output parameters of UPS systems. Total UPS load is around 6% of running load. However almost all UPS systems have thyristor input rectifier stages and as such demand huge harmonic currents. Further the capacity utilization of these UPS systems as appeared during audit was very poor. It is advised that whenever you replace these UPS systems you should opt for transformer less designs with input side power factor and current harmonics corrected as a built in facility.
- 7) Reactive power compensation at present is offered centrally using contactor switched detuned filters. This is automatic and is taking care of maintaining power factor at close to unity and has avoided current harmonic amplification to some extent. This has relieved both the transformers and upstream HT distribution from handling large harmonic currents. However lot of loads are non linear and almost all power control / motor control centers in the plant deliver required harmonic currents to respective loads. The power quality at few loads is disturbed due to this. We have enclosed detail analysis and remedies in for this in this report.
- 8) As per information received during audit, some equipment connected via MCCs and PCCs to transformer 2 have suffered from repeated failures.

9) During specific investigation of point 8, following observations are recorded

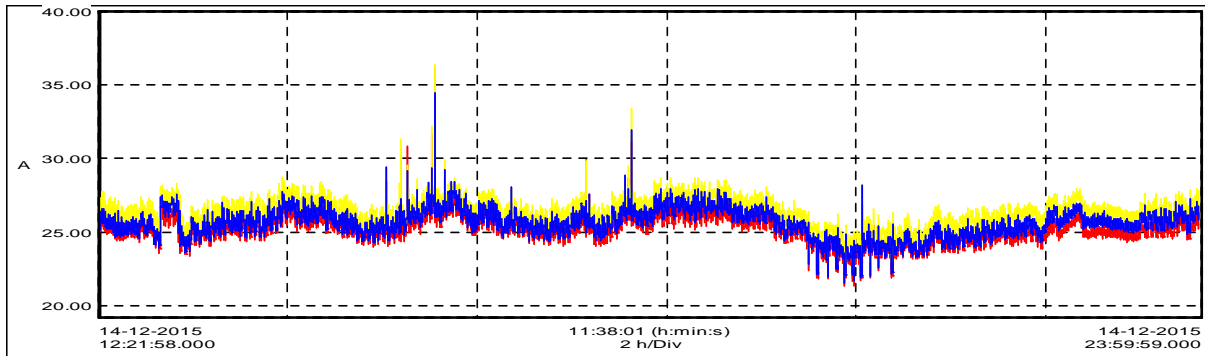
- a) TR 2 neutral earthing should be checked and redone, earthing resistance is 4.6ohms.
- b) TR 2 secondary recorded 63 voltage alarms during 24 hours recording; minimum voltage was 321volts while maximum was 439 volts.
- c) HVAC MCC 2 (GENE 237), HVAC MCC 04, Process MCC 3 (GENE 244), PMCC feeders emerging from TR 2, were monitored for 24 hours. All these feeders recorded voltage alarms and transients.
- d) The loads connected to above feeders are non linear and harmonic currents result into increased voltage distortion, K factor etc. We have recommended active harmonic filters at these feeders to reduce above ill effects. The cables used on incoming side of these feeders should be validated for capacity (with specific reference to harmonic currents) as the voltage distortion increases at downstream end.
- e) Following active filters are recommended, however the implementation may be done for transformer 2 initially.

Sr	Feeder	Suggested Active Filter
1	TR 1 -	
	PADP 4	100A
	Utility MCC3	100A
2	TR 2 -	
	HVAC MCC	60A
	Air Compressor	100A
	PCC 3	100A
	HVAC MCC 2 GENE 237	60 A
	HVAC MCC 04	60A
	Process MCC 3 GENE 244	60A

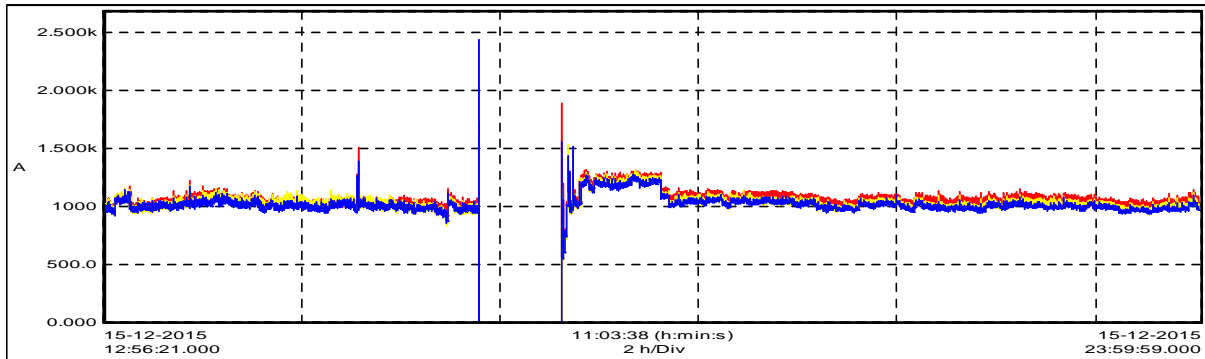
10) Following loads from the load list appear to be large loads. Few of them have VFDs / Soft starters connected where as few of them have DOL or star – delta starters.

Sr as per list given to us	Load	KW	Qty	Type of starting
3	Air Compressor	110	2	Soft Starter
4	Heat Pump	104	1	Starter
5	Chiller	209	1	Starter
7	Primary Chilled water Pump	30	2	Starter
8	Secondary Chilled Water Pump	37	4	Starter
9	Condensor Water Pump	30	2	Starter
10	Condensor Water Pump	37	2	Starter
20	Chiller	365	1	Starter
43	AHU System	30	2	VFD
45	AHU System	45	2	VFD
46	Dehumidifier	35	2	Starter
55	Dehumidifier	41	2	Starter

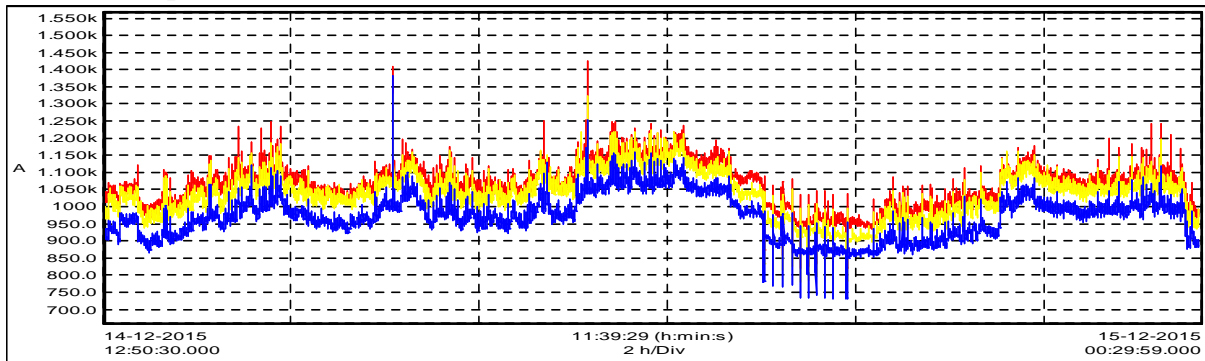
33KV side current pattern



TR 1 current pattern



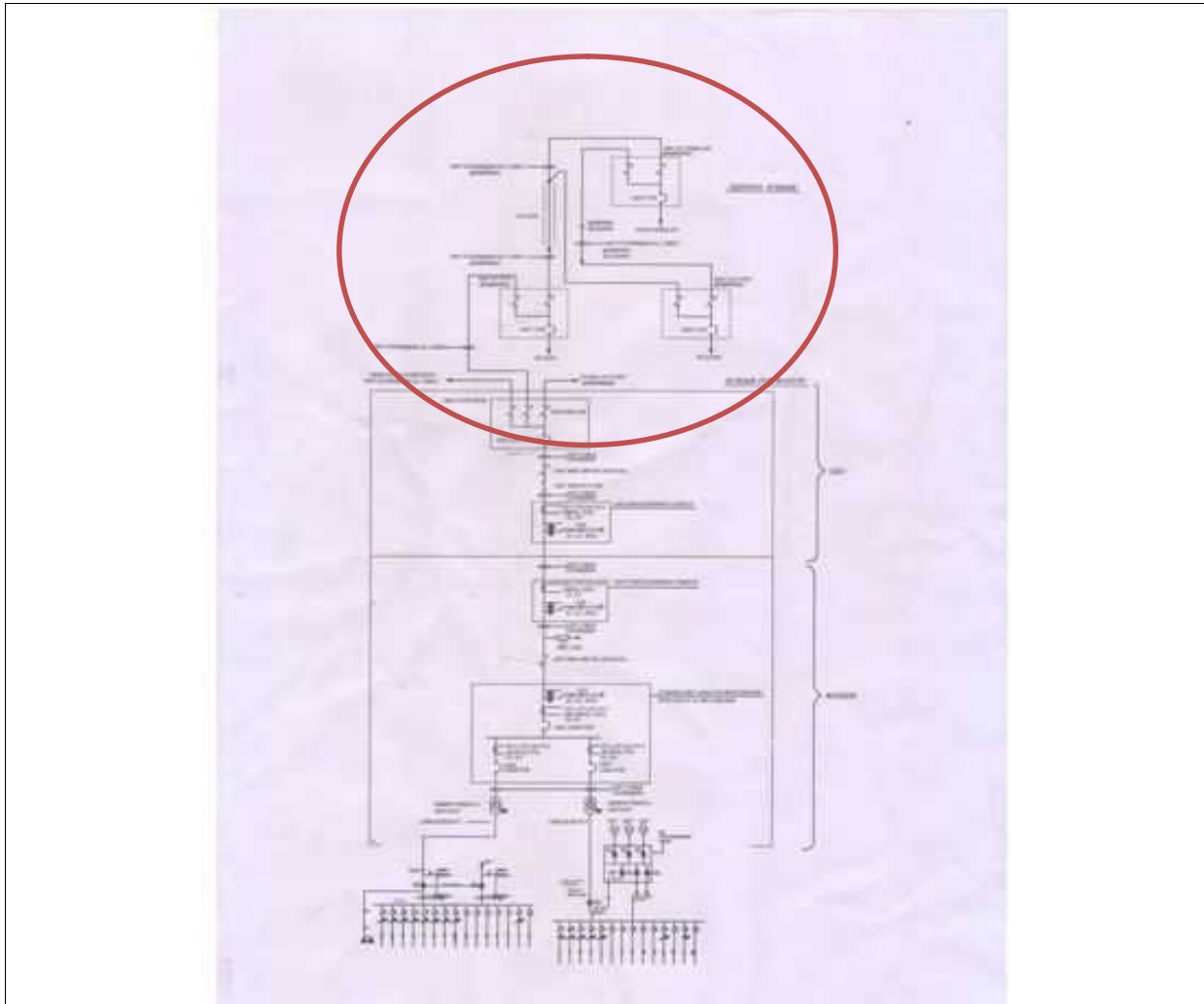
TR2 current pattern



These current pattern show that there are large hiccups in load current, especially in case of transformer 2, where most of the utility equipment are connected. This transformer is delivering about 1000Amps RMS current as base load and on top of this if a large motor starts with Star delta starter, the starting inrush being 6 to 7 times full load current, can give rise to a voltage dip, which may create issues with other sensitive equipments. We recommend all such loads as listed above should have soft starters. Further wherever soft starters and VFDs are installed, **inrush current ramp** is always settable. This facility should be used especially on all thermal systems like HVAC pumps and AHUs, where if these devices take few seconds to attain full speed, it does not affect the process, where as inrush currents get limited.

----- END OF SUMMARY -----

HT infrastructure out of plant



The 33 KV distribution arrangement with various cables and RMUs emerging from VERNA substation as “Circled” above needs to be checked for loose connection along with upstream source capacity.

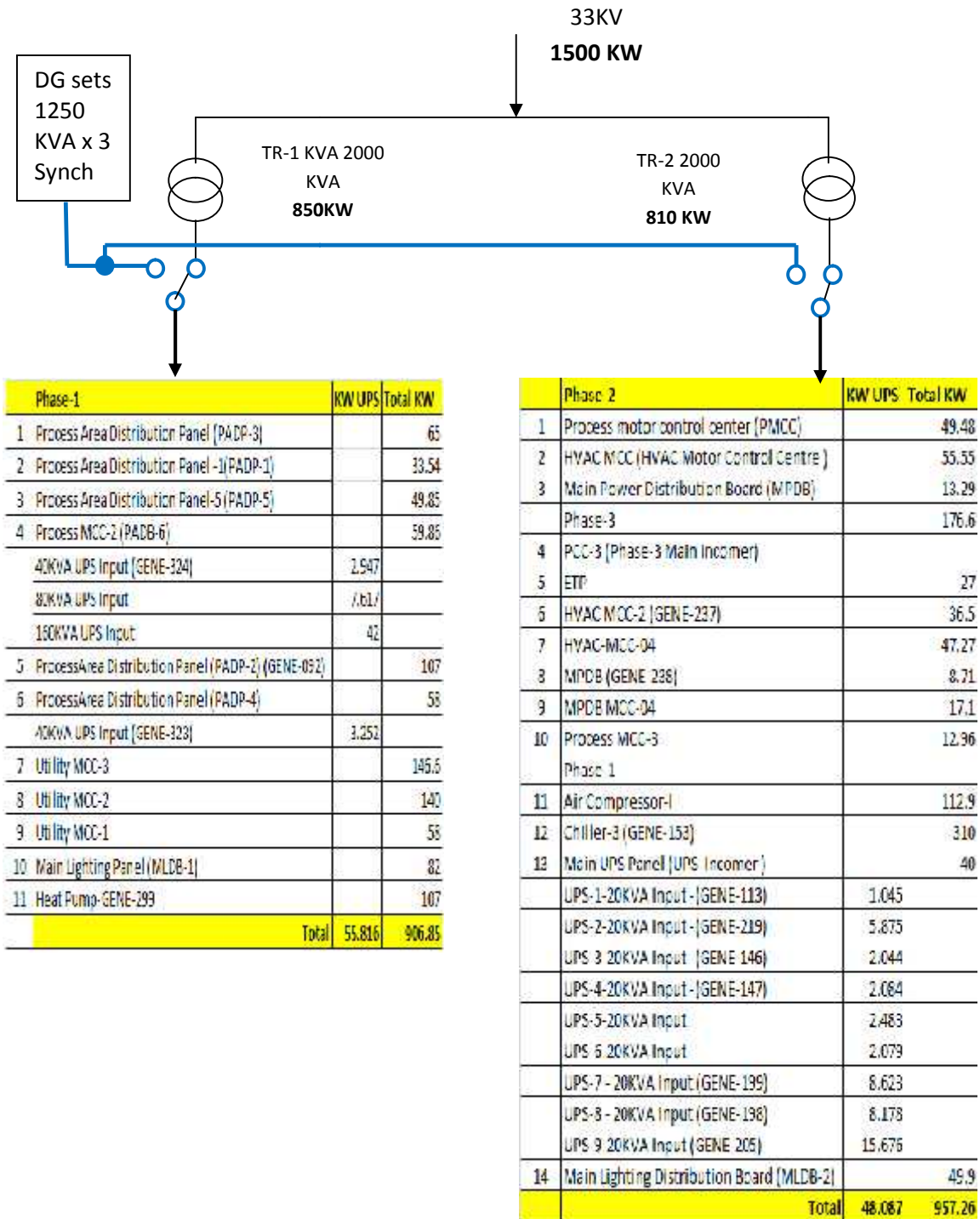
This may throw light on frequent fluctuations observed on 33KV side. The source may occasionally be getting overloaded due to neighbouring Industries.

Another reason could be ill maintained upstream tap changers.

If you can expect co operation from GEB staff, this report may be shared with them and joint survey of upstream electrical infrastructure coupled with maintenance should be planned.

If we know capacity and % impedance of upstream transformer along with it’s normal loading pattern, adequacy of source capacity can at least be ruled out.

Description of electrical infrastructure



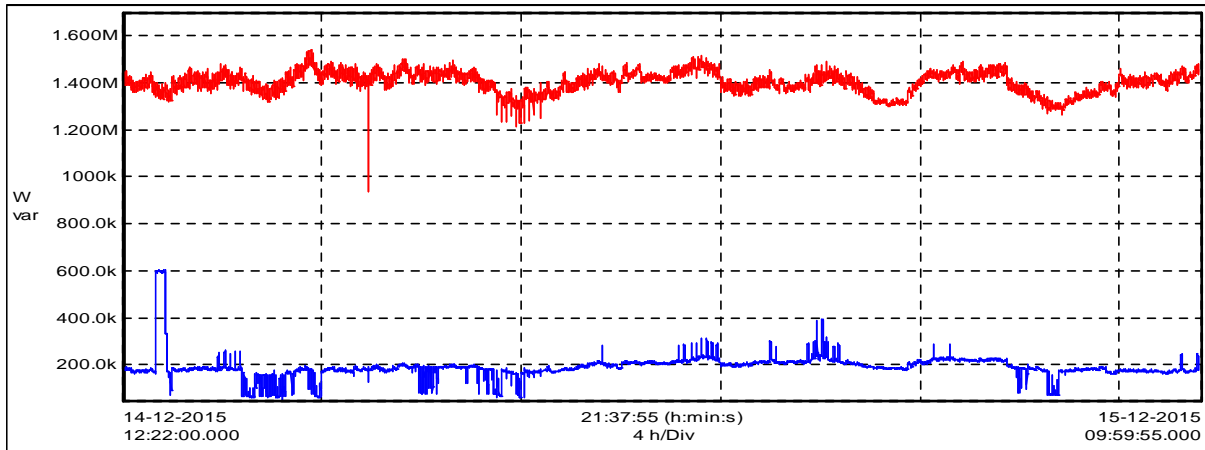
A Leading Pharmaceuticals Company receives 33KV from Goa state Electric Supply Authority at a VCB and pole structure inside the compound. HT cable is laid from this point to HT distribution (1 x 2) inside the plant. This panel has 3 VCBS – arranged as one incoming and two out going. The contract demand is 2500 KVA and the load is further fed through 2 x 2 MVA 33KV/433V transformers. The feeder wise KW load recorded is as shown above. The individual UPS input KW are also mentioned in above diagram. The figures recorded are maximum figures and approximately match with the KWH chart shown below for Months Jan 2015 to Nov 2015.

Monthly KWh consumption chart prepared from electricity bills.

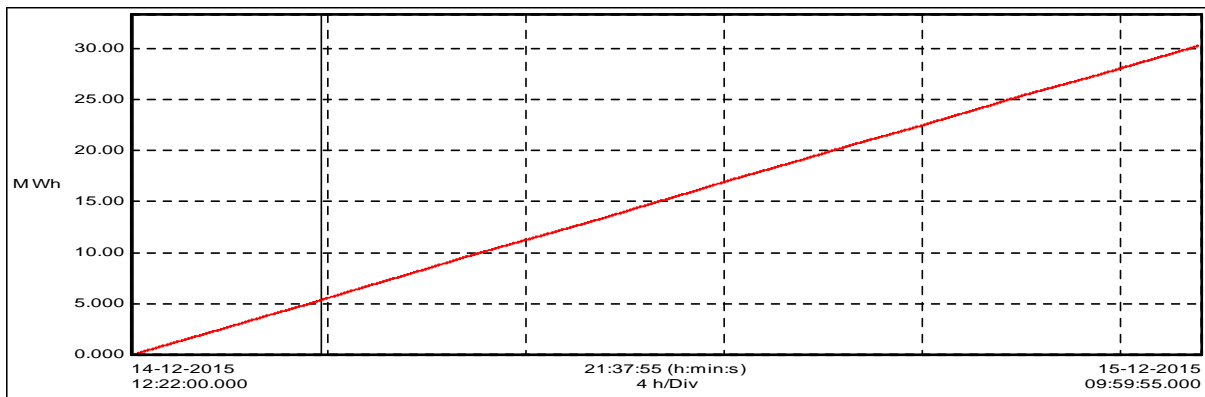
Month	KWh	MD KVA	PF
Jan-15	267860	1416	0.95
Feb-15	831660	1620	1
Mar-15	862080	1548	1
Apr-15	485760	1656	0.99
May-15	989640	1746	0.99
Jun-15	904200	1792	0.99
Jul-15	897360	1675	0.99
Aug-15	1053600	1769	0.99
Sep-15	689400	1650	0.99
Oct-15	1116720	1766	1
Nov-15	878880	1738	1

Peak loading on transformers during the audit matches maximum MD recorded so one can conclude that this the plant load was at it's peak during the audit. The process being of batch processing type, the electrical load varies continuously and the peak demand may not prevail always.

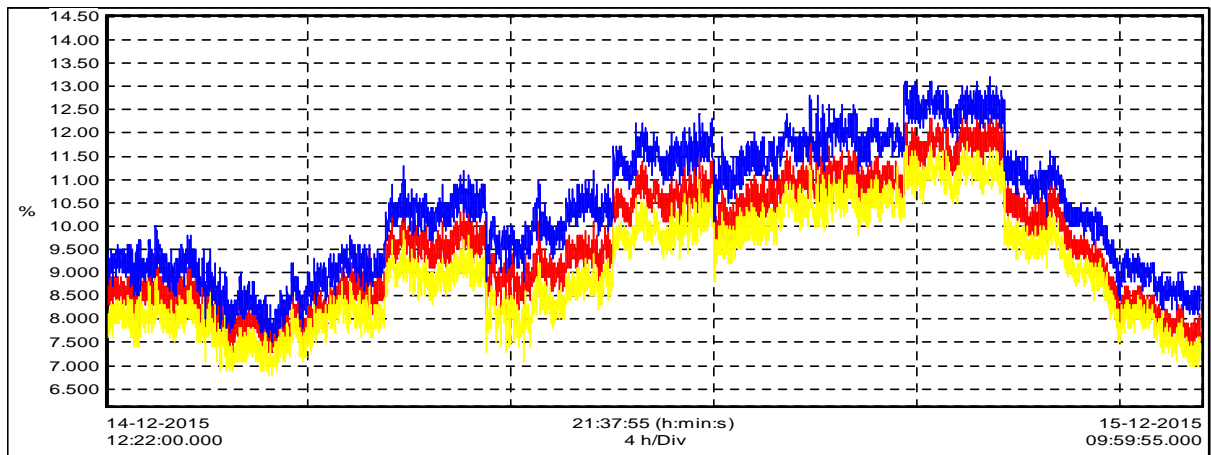
Major observations during Power quality audit.



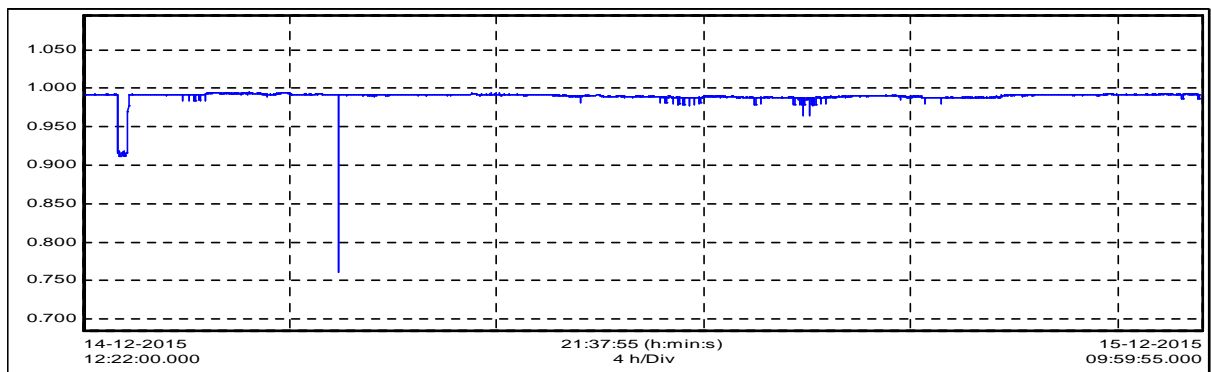
1) Above trend shows that the KW load varies between 1200KW to 1600KW depending upon process needs.



2) Above trend shows that during recording period of 21 hours and 38 minutes the plant consumed 30320Kwh. This makes it 33636 Kwh / day or approximately 874561 Kwh per month. Most of the utility feeders receive direct raw power, where as critical loads receive power through UPS. The installed UPS capacity is 500 KVA and the peak loading observed during audit was 100KW. Few most critical loads are fed through “Parallel Redundant” UPS configurations.



3) Current harmonic distortion varies from 7% to 13%. The compliance requirement as per IEEE 519 1992 – may turn out to be 10 to 12%. (This is a guess as per our experience of capacity of upstream infrastructure created by various electricity boards in other states)



4) The power factor as above is maintained close to unity. The plant has installed detuned filters, which are contactor switched. These filters work in automatic mode and maintain the power factor close to unity irrespective of load variation.

Major Harmonic Loads				Harmonic Current Amps				Total Harmonic Current Amps
TR 1 - Phase 1	I Avg Amps	I Thd %	KW Max	3rd	5th	7th	11th	
PADP 4	96	52	58	10	30	20	10	70
Utility MCC 3	267	27.5	146.6		40	20	8	68
TR 2 Phase 2								
HVAC MCC	96	42.1	55.55		25	15	5	45
Air Compressor 1	126	32.9	112.9		40	15	15	70
Main UPS Panel	114	15	40					60
HVAC MCC 2	65	48.5	36.5		22	15	5	47
PCC 3	302	28.5	176.6		50	10	8	68

Above table shows major load centers which demand harmonic currents. Based on above data and plant areas where maintenance issues are located, some power quality mitigation solutions are suggested in this report.

5) We have monitored ‘Alarms and Transients’ at critical locations while recording power quality parameters for 24 hours. The Alarm was set at +/- 10% of nominal voltage whereas

the transient threshold was set at 33% of respective Line to neutral voltage. Following is summary of recorded observations.

Feeder Name	Alarms	Transients	Source
33KV PCC	49	12	Raw power Input
TR1 LT main	99	6	Partial DG operation
TR 2 LT Main	63	NIL	Raw power Input
HVAC MCC2 GENE 237	26	9	Mixed Source
HVAC MCC 4	11	9	Mixed Source
PMCCC 3 GENE 244	27	7	Mixed Source
PMCC TR 2	13	7	Mixed Source

- In 90% of the cases, HT 33KV side alarms are voltage dips as shown bellow. They are not always associated with increase in plant loading due to inrush currents etc. Following table shows a sample. 33KV input dropped for about 620msecs, i.e. 31 cycles to 16KV. Such dips could be because of source capacity of input, loose contacts in HT service connection external to the plant, or inrush loading of industries in neighbourhood.

U3	16	kV	MIN	0.62	14-Dec-15	5:17:37.21
U2	15	kV	MIN	2.58	14-Dec-15	5:17:37.61
U3	16	kV	MIN	2.58	14-Dec-15	5:17:37.63

- Plant loads have few high inrush current motor loads, which become ON and OFF as per process requirement. As per the list made available to us, Chillers and Heat pump do not have VFDs or Soft starters. They require high inrush currents. Air compressor has a soft starter. All soft starter ramps should be adjusted as “Soft” as possible to avoid inrush currents. Most of other motor loads have VFDs connected to them. Acceleration time should be adjusted to suit load torque requirement, but as “Soft” as possible to avoid inrush currents.
 - These frequent voltage dips can cause maintenance issues in automation systems employing electronics, VFDs etc. One can also note that transients - “Sub cycle disturbances” are also present on above feeders, which are remarkable in numbers.
- 6) Voltage harmonic distortion recorded at all feeders is below 4% on raw power and between 4 to 5% on DG sets, which is within acceptable limits.
- 7) Both the transformers are loaded around 40% if average loading is concerned and around 60% if peak loading is considered. This is within acceptable limits, but considering that most of the load is nonlinear, you should increase the loading by maximum 10%. Further non linear loading might result into increase in voltage distortion.

Current and voltage Harmonics compliance limits:

- We tried to locate harmonic compliance requirements from JERC website, which is joint electricity regulatory commission for Goa and other Union territories. We could not locate a document giving exact requirements.
- As per international standard practice and the practice followed by most of the states in India, an international standard - IEEE 519 1992 is referred for harmonic compliance between a utility company and a consumer. The procedure given in this standard requires calculating a ratio I_{sc}/I_L where:
 - I_{sc} = short circuit current of upstream utility company EHT supply transformer from which the consumer gets HT supply.
 - I_L = Average load current of load running at consumer premises.
- Once this ratio is known, one can refer following table to know % total current harmonics compliance limits.

Maximum harmonic current distortion in percentage of I_L for voltages less than 22KV.						
Individual harmonic order (odd harmonics)						
I_{sc}/I_L	<11h	11 h<17	17 h<23	23 h<35	35 h<49	TDD
<20	4.00	2.0	1.5	0.6	0.3	5.00
20<50	7.00	3.5	2.5	1.0	0.5	8.00
50<100	10.00	4.5	4.0	1.5	0.7	12.00
100<1000	12.00	5.5	5.00	2.0	1.0	15.00
>1000	15.00	7.00	6.00	3.5	1.4	20.00
Even harmonics are limited to 25% of odd harmonic limits above.						

- The code also says that the % total voltage harmonics should be less than 5% for voltages up to 66KV.
- Following table shows calculations for I_{sc}/I_L .

Client: A Leading Pharmaceuticals Company	
Parameter	Value
GEB Transformer Capacity MVA	40
GEB Transformer % Impedance	8
GEB Transformer full load current @33 KV	699.84
GEB Transformer SC current @33 KV = I_{sc}	8747.99
Wattson contract Demand KVA	2500
Max current as per contract demand on 33KV side	3436.71
Max measured current on 33KV side at normal load	2393.10
I_{sc} / I_L Ratio as per contract demand	194
I_{sc} / I_L Ratio as per Max Plant Current	278

As per Contract Demand and plant Max current the current harmonics compliance limit is 15% as the ratio is between 100<1000.

Analysis of historical data collected at Site.

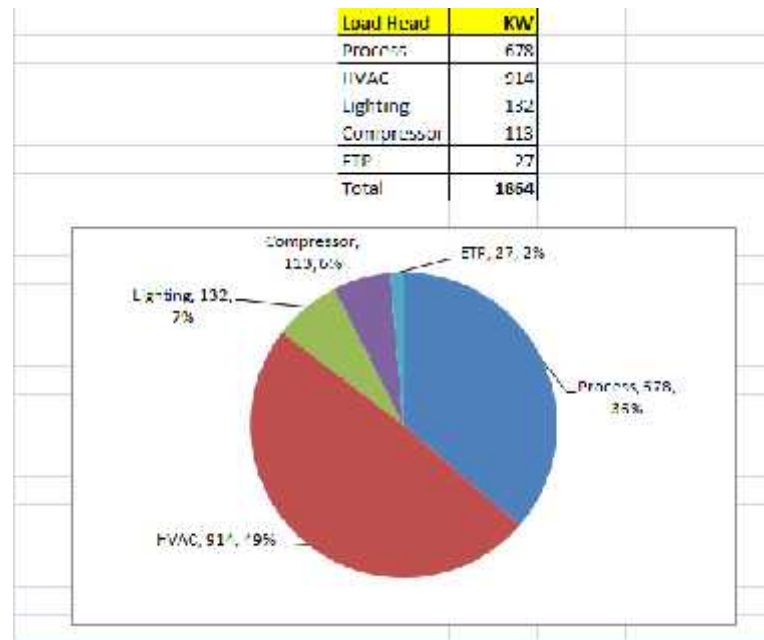
Monthly KWh consumption Since Jan 2015

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Aug-15	1053600	1769	0.99
Sep-15	689400	1650	0.99
Oct-15	1116720	1766	1
Nov-15	878880	1738	1

This table shows that electrical consumption during Oct 2015 was maximum in the year. This is a typical pharmaceutical setup. Above figures indicate peak running KW load of around 1800KW. The audit was conducted with around same peak load working. The plant consumed around 33000Kwh in 24 hours during audit, indicating average loading of about 1400KW.

This information confirms that the audit was conducted at loading which is almost same as average loading throughout the year.

Division of loading



- Above pie chart shows contribution of various sections into total electrical consumption.
- Such pie charting helps in implementing recommendations if any, as sections which contribute significantly, can be taken up first to get more impact.
- 55% consumption is related to HVAC and compressors and appears to be significant area.
- Critical load of 80KW is supported on various UPS with stand alone and parallel redundant configurations.

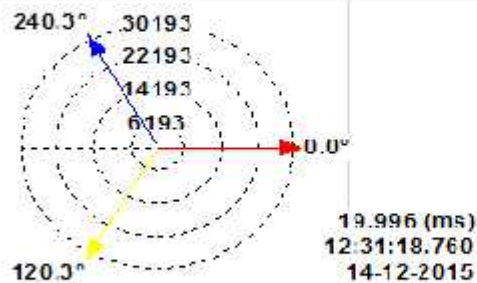
Load profile and Power Quality Parameters for 24 hours at 33 KV PCC

Parameter with Unit	Unit	Average	Minumum	Maximum
Load profile				
Active Load	KW	1402	938	1543
Reactive Power Demand	KVAR	190	51	606
Apperant Demand	KVA	1416	1064	1554
Line current RMS A 1	Amps	24.41	21.36	27.44
Line current RMS A 2	Amps	25.541	22.32	28.2
Line current RMS A 3	Amps	24.786	21.56	27.64
Current total harmonic distortion A1	%	9.621	7.3	12.4
Current total harmonic distortion A2	%	9.075	6.8	11.8
Current total harmonic distortion A3	%	10.36	7.5	13.2
Current Imbalance I unB	%	2.791	1.6	4.1
K Factor Line 1		1.305	1.18	1.47
K Factor Line 2		1.264	1.16	1.41
K Factor Line 3		1.328	1.15	1.49
Power factor 1		0.989	0.882	0.995
Power factor 2		0.993	0.914	0.996
Power factor 3		0.986	0.486	0.994
Power factor mean		0.99	0.761	0.995

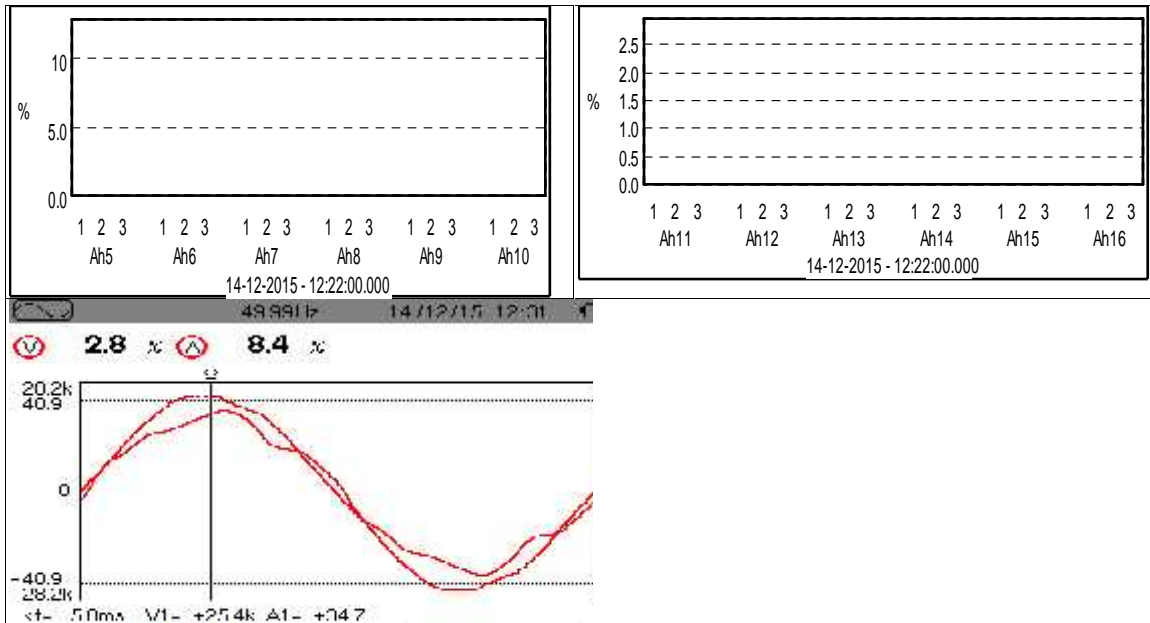
Power Quality Parameters while supporting above load

Parameter with Unit	Unit	Average	Minumum	Maximum
Frequency	Hz	49.973	49.74	50.31
Line to Line Voltage U 1 RMS	KV	32.824	31.23	34.53
Line to Line Voltage U 2 RMS	KV	32.934	23.4	34.62
Line to Line Voltage U 3 RMS	KV	32.713	23.61	34.41
Maximum Line voltage observed	KV			35.82
Minimum Line Voltage observed	KV	14.82		
Voltage total harmonic Distortion U1	%	1.825	1.2	2.4
Voltage total harmonic Distortion U2	%	1.735	1.2	4.1
Voltage total harmonic Distortion U3	%	1.786	1.2	6.8
Voltage imbalance V unB	%	0.385	0.2	
Fliker Pst U1		0.367	0.28	5.94
Fliker Pst U2		0.41	0.31	6.99
Fliker Pst U3		0.333	0.26	4.72

Phase difference as recorded at even time



Voltage transient occurrence recording. Transient threshold set at +/- 100V of Line to Neutral instantaneous voltage.	No of Transients	12
Voltage Alarm recording. Threshold set at +/- 10% of 33 KV	No of Alarms	49



Comments and Remarks

- 1) 33KV supply to plant is derived from a RMU fed from different lines originating from VERNA substation. The information regarding origin of these lines is not clear and the loading details with respect to time are also not available. This observation is noted here as we tried to co relate the fact shared indicating that the maintenance issues were negligible when the utility company was a private player rather than GED. As lot of cables / cable terminations / joints are involved in this distribution, there are chances of cable / transformer capacity issues and loose contacts, which need through checking of GED infrastructure. **We are highlighting this as number and level of voltage fluctuations observed on 33KV side within 24 hours are abnormal.**
- 2) This is most upstream point in electrical distribution system in the plant. This point on the distribution is also monitored by utility company supply code. Harmonics compliance limits here are decided by applying provisions of IEEE 519 1992. If the harmonic levels are excessive here, they can harm infrastructure installed by utility company prior to this PCC – Point of common coupling. (Theoretically PCC is defined as such nearest upstream point on utility distribution from which they can feed another consumer. It is not practical to get access to such point so this point within plant premises is considered for monitoring.)
- 3) It can be seen that the **reactive power requirement on continuous basis** is negligible and average power factor is 0.99. Average current harmonic distortion is around 10%, which may be border case.
- 4) It appears from bills that utility company charges for 75% of contract demand, if actual MD is less than that. This has happened in all the months. There is 5% incentive on energy charges if power factor is maintained at 0.99 and above. A Leading Pharmaceuticals Company has claimed this incentive in all the months.
- 5) Maintaining unity power factor by controlling reactive compensation and harmonic distortion goes hand in hand and in turn can affect power quality, if executed using a wrong method.
- 6) Power factor control is achieved using contactor switched detuned filters. Due to this harmonic amplification is observed to be negligible.

Sr	Parameter	Compliance Requirement	Actual Value recorded
1	Total % current harmonic distortion	15%	13.2%
2	% current harmonic distortion for harmonic orders less than 11	12%	8%
3	Total % voltage harmonic distortion	< 5%	1.8% (6.8%)

- 7) List of alarms and transients is quite alarming. We have tried to match 33KV side alarms with LV side voltage disturbances recorded on one of the transformers. Even if we consider them as load generated and reflecting on primary side, the reason would be larger source impedance or inadequate source capacity.
- 8) During discussions with plant staff, we were given to understand that the utility power fails couple of times every day in abrupt manner. Abrupt power interruption is also a power quality issue. It was also informed to us that most of the failures are observed in plant area, where Raw power is supplied and the problems were minimum when the Raw power was available from Reliance.
- 9) Considering point 6 and 7 above, we advise you to take “Power Quality Requirements” from machine manufacturers in detail. A specific enquiry also should be made highlighting power failures. Once these details are received, we can check compliance against now available power quality data and then conclude about cause of failures. We are highlighting this because as per our experience, there is a possibility of fragile design which can cause such failures. Generally machine manufacturer should give following data.

Sr	Parameter	Value / Range
1	Sine AC Voltage – Nominal + / - %	
2	Voltage Wave form distortion THDV allowed %	
3	Frequency – Nominal + / - %	
4	Source impedance ohms	
5	Nominal current / Max current	
6	Nominal KVA / Max KVA	
7	Specify allowable limits for sub cycle and RMS voltage dips and recovery time for which machine performance will not be adversely affected.	
8	Do you specify any input breaker and cable capacity for the machine, if yes, give ratings.	
9	Max current distortion caused due to nature of load THDI%	
10	Connection – 1ph/2,3 wire or 3 ph/ 3,4,5 wire	
11	Dedicated earthing required / not required	
12	Can abrupt power failure cause electrical / electronic part failure?	
13	Does machine always require un interrupted power and orderly shut down	
14	What is the temperature and humidity range for reliable operation of machine electrical and electronic parts	
15	Do you recommend dust free air-conditioned atmosphere for reliable machine performance	

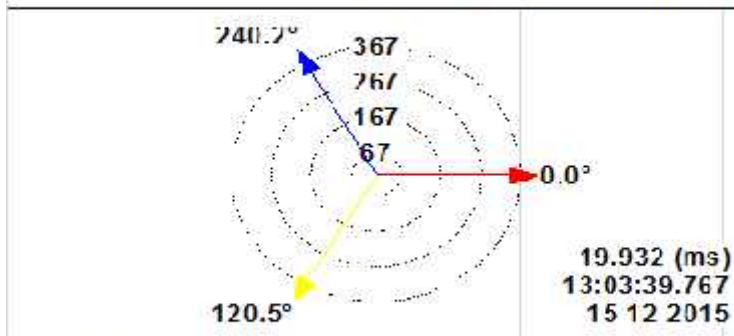
Load profile and Power Quality Parameters for 24 hours at TR 1 Secondary

Parameter with Unit	Unit	Average	Minumum	Maximum
Load profile				
Active Load	KW	707.86	0	872.59
Reactive Power Demand	KVAR	64.86	-83.93	321.89
Apperant Demand	KVA	712.16	0	876.76
Line current RMS A 1	Amps	1014	0	1266
Line current RMS A 2	Amps	988	0	1270
Line current RMS A 3	Amps	966	0	1240
Current total harmonic distortion A1	%	6.351	0	9.7
Current total harmonic distortion A2	%	8.364	0	12.5
Current total harmonic distortion A3	%	7.708	0	11.5
Current Imbalance I unbal	%	2.031	0.2	8.1
K Factor Line 1		1.128	0	1.35
K Factor Line 2		1.183	0	1.48
K Factor Line 3		1.173	0	1.44
Power factor 1		0.995	0.326	0.998
Power factor 2		0.993	0.332	0.997
Power factor 3		0.993	0.332	0.997
Power factor mean		0.994	0.328	0.997

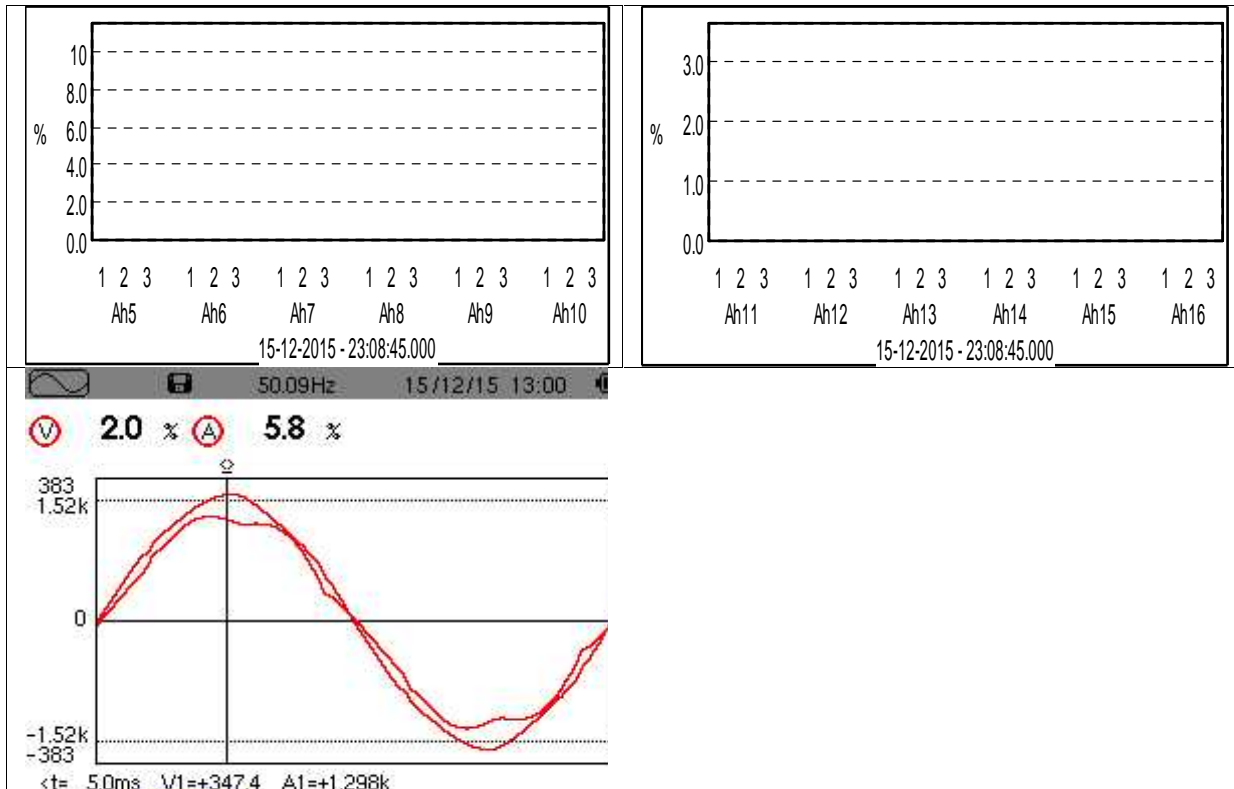
Power Quality Parameters while supporting above load

Parameter with Unit	Unit	Average	Minumum	Maximum
Frequency	Hz	49.938	49.69	50.17
Line to Line Voltage U 1 RMS	V	416.66	0	438.8
Line to Line Voltage U 2 RMS	V	416.31	1.3	437.1
Line to Line Voltage U 3 RMS	V	414.04	0	435
Maximum Line voltage observed	V			469
Minimum Line Voltage observed	V		N.A	
Voltage total harmonic Distortion U1	%	1.966	0	3.2
Voltage total harmonic Distortion U2	%	2.02	0	3.5
Voltage total harmonic Distortion U3	%	2.068	0	4.9
Voltage Imbalance V unbal	%	0.395	0.2	1.8
Fliker Pst U1		0.326	0.26	0.37
Fliker Pst U2		0.291	0.26	0.45
Fliker Pst U3		0.283	0.25	0.37

Phase difference as recorded at even time



Voltage transient occurrence recording. Transient threshold set at +/- 33% of line to Neutral instantaneous voltage.	No of Transients	6
Voltage Alarm recording. Threshold set at +/- 5% of 420V	No of Alarms	99



Comments and Remarks

- 1) This is most upstream point in transformer 1 secondary circuit. The average loading here is 700KW, while peak loading is 872KW.
- 2) It can be seen that the **reactive power requirement on continuous basis** is negligible and average power factor is 0.99. Average current harmonic distortion is below 10%.
- 3) Maintaining unity power factor by controlling reactive compensation and harmonic distortion goes hand in hand and in turn can affect power quality, if executed using a wrong method.
- 4) Power factor control is achieved using contactor switched detuned filters. Due to this harmonic amplification is observed to be negligible.
- 5) List of alarms and transients is quite alarming. 99 alarms are recorded during which the voltage has crossed +/- 5% of 420volts. Few of these alarms have lasted for less than a cycle whereas few have lasted for several cycles.
- 6) K factor observed is less than 2 and transformer peak loading is 50%. This has resulted in on load voltage harmonic distortion to be less than 2.5%.

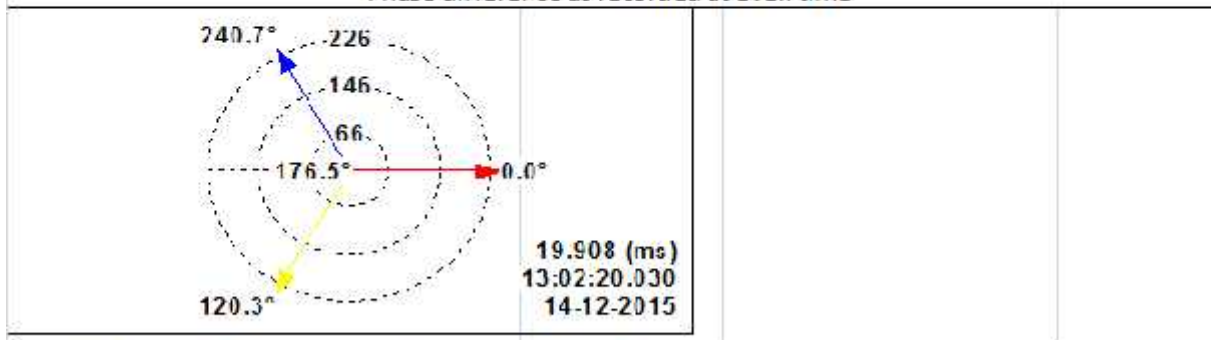
Load profile and Power Quality Parameters for 24 hours at IR 2 Secondary

Parameter with Unit	Unit	Average	Minimum	Maximum
Load profile				
Active Load	KW	701.7	541.66	818.86
Reactive Power Demand	KVAR	95.138	-108.85	252.41
Apperant Demand	KVA	710.24	546.24	824.83
Line current RMS A 1	Amps	1034	810	1209
Line current RMS A 2	Amps	1006	768	1206
Line current RMS A 3	Amps	939	723	1116
Current total harmonic distortion A1	%	11.902	7.5	16.2
Current total harmonic distortion A2	%	12.89	8.4	17.5
Current total harmonic distortion A3	%	13.858	9.6	18.8
Current imbalance unbalanced	%	3.146	2.000	4.500
K Factor Line 1		1.5	1.22	1.83
K Factor Line 2		1.547	1.26	1.91
K Factor Line 3		1.674	1.38	2.11
Power factor 1		0.99	0.943	0.996
Power factor 2		0.988	0.939	0.995
Power factor 3		0.986	0.932	0.993
Power factor mean		0.988	0.938	0.995

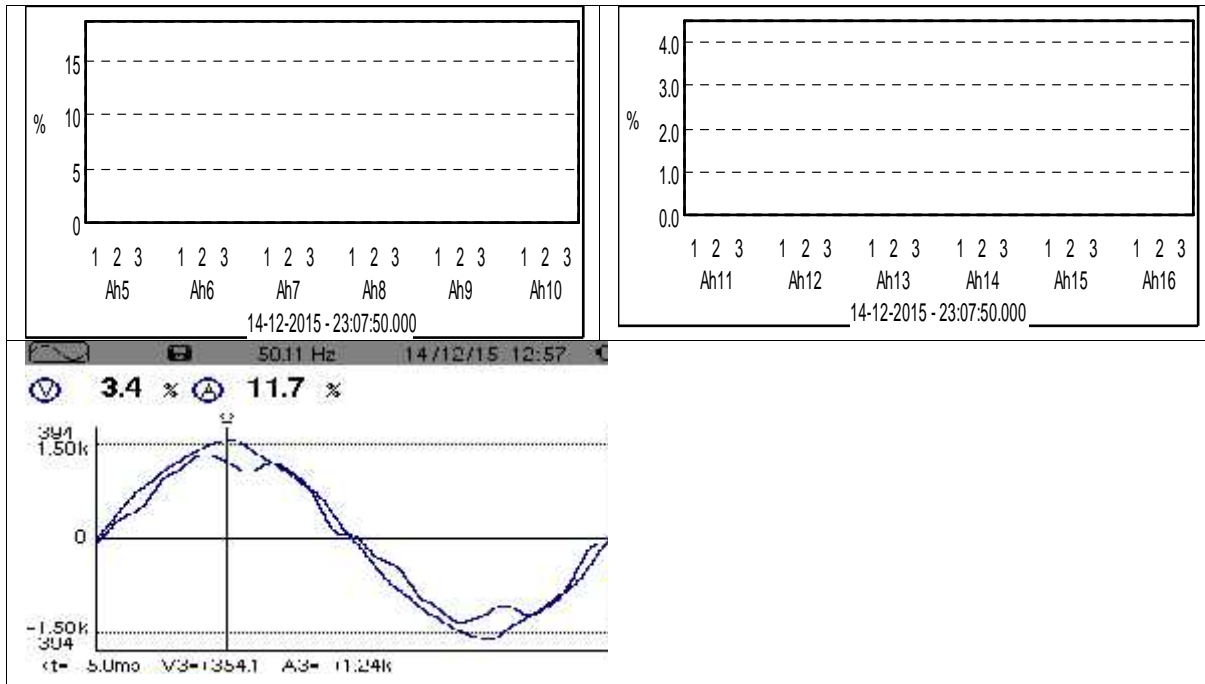
Power Quality Parameters while supporting above load

Parameter with Unit	Unit	Average	Minimum	Maximum
Frequency	Hz	49.964	49.71	50.31
Line to Line Voltage U 1 RMS	V	414.244	392.8	437.3
Line to Line Voltage U 2 RMS	V	414.078	393	436.8
Line to Line Voltage U 3 RMS	V	411.913	391.3	434.8
Maximum Line voltage observed	V			439.1
Minimum Line Voltage observed	V		321.1	
Voltage total harmonic Distortion U1	%	2.962	2	3.9
Voltage total harmonic Distortion U2	%	2.972	2.2	3.8
Voltage total harmonic Distortion U3	%	3.188	2.4	4.1
Voltage imbalance unbalanced	%	0.367	0.2	0.6
Fliker Pst U1		0.353	0.22	0.64
Fliker Pst U2		0.443	0.22	1.19
Fliker Pst U3		0.347	0.21	0.71

Phase difference as recorded at even time

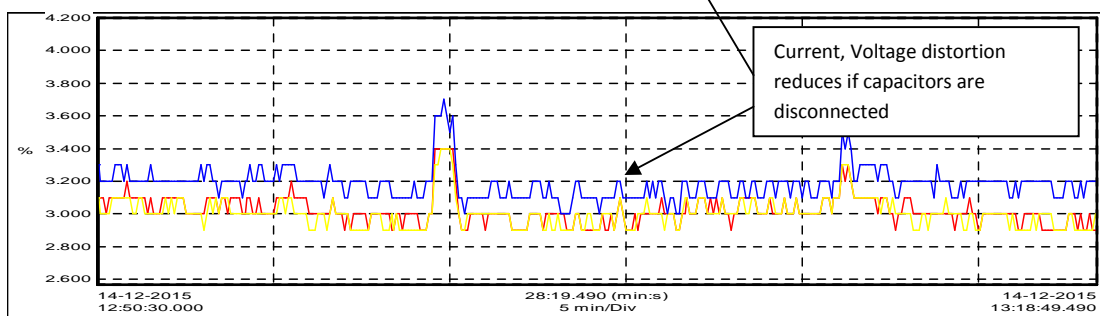
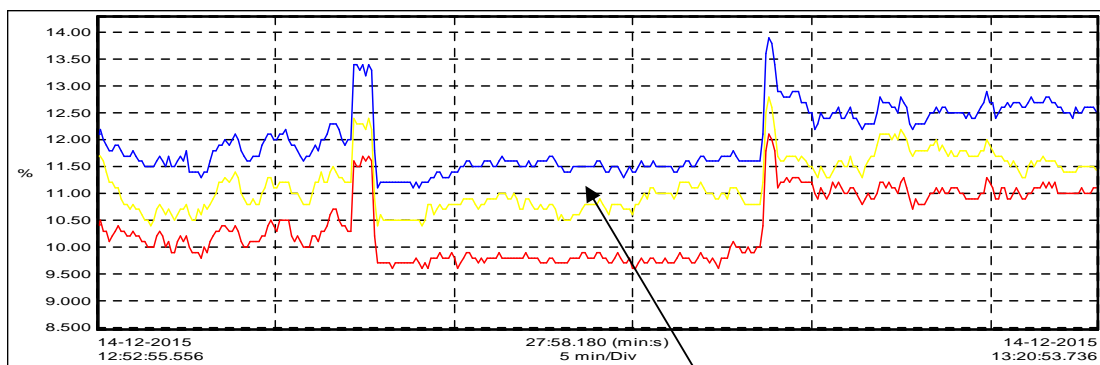


Voltage transient occurrence recording. Transient threshold set at +/- 33% of Line to Neutral instantaneous voltage.	No of Transients	NIL
Voltage Alarm recording. Threshold set at +/- 5% of 420V. Prolonged sags lasting upto 2 mins were observed	No of Alarms	63



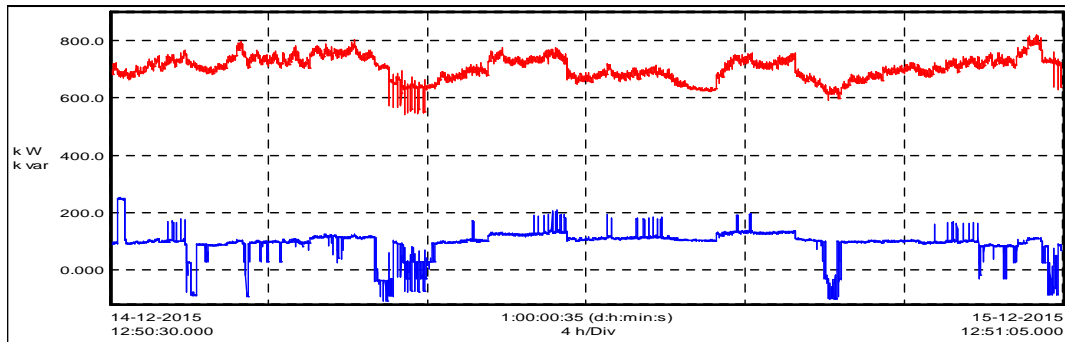
Comments and remarks:

- 1) This is most upstream point in transformer 2 secondary circuit. The average loading here is 700KW, while peak loading is 818 KW.
- 2) It can be seen that the **reactive power requirement on continuous basis** is negligible and average power factor is 0.98. Average current harmonic distortion is up to 13% and there is amplification of harmonics. Occasionally voltage distortion also touches 4%.



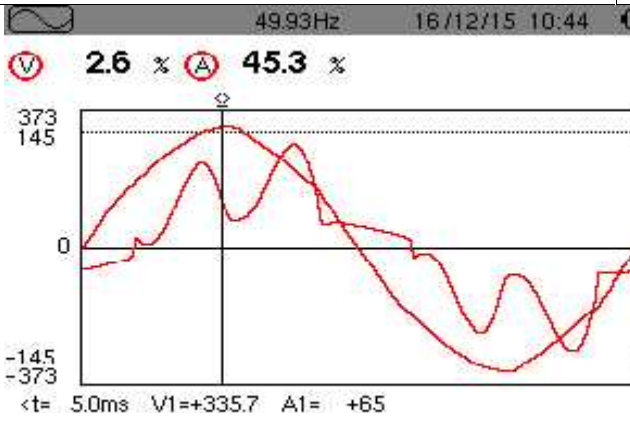
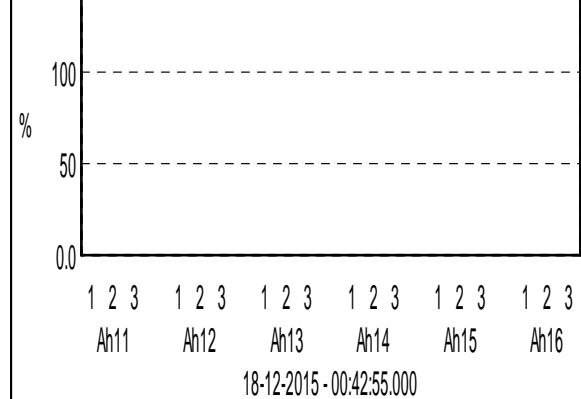
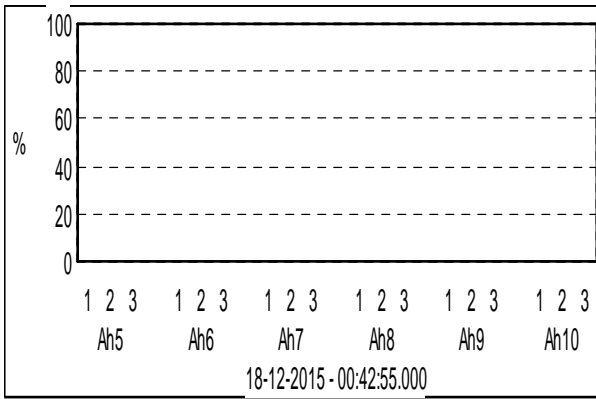
- 3) Maintaining unity power factor by controlling reactive compensation and harmonic distortion goes hand in hand and in turn can affect power quality, if executed using a wrong method.

- 4) Power factor control is achieved using contactor switched detuned filters. Due to this harmonic amplification is observed to be less, but in case of Tr2, load fluctuations are more and due to this contactor switched detuned filters do not provide continuous and exact correction (This is result of inherent delay in contactor switching).



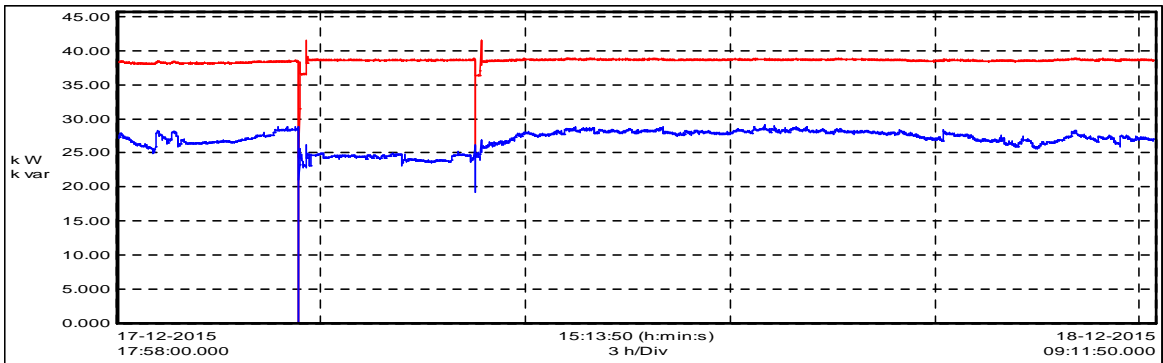
- 5) Chiller forms almost 33% of total load on this transformer and has a separate detuned filter panel connected to it for power factor improvement.
- 6) 99 alarms are recorded during which the voltage has crossed +/- 5% of 420volts. Few of these alarms have lasted for less than a cycle whereas few have lasted for several cycles. Actual alarms recorded were much more, we have neglected all those alarms which were recorded at exactly 399 volts and have considered those alarms which were bellow 399V.
- 7) If transformers tap – changers and secondary side connections are not checked / serviced in recent past, we recommend this to be done to rule out possibility of any lose connection.
- 8) During audit – HT side alarms are also recorded in large numbers. Lowest alarm conditions observed on HT side are even 50% of nominal voltage of 33KV.
- 9) K factor observed is less than 2 and transformer peak loading is slightly more than 50%.
- 10) Most of the feeders on which electronic failures are observed are associated with transformer 2. Hence we have also recorded power quality parameters on these feeders for 24 hours. These feeders were suggested by A Leading Pharmaceuticals Company maintenance team.

Load profile and Power Quality Parameters for HVAC MCC 2 GENE 237					Remark
Parameter with Unit	Unit	Average	Minumum	Maximum	
Load profile					
Active Load	KW	38.439	0	41.525	
Reactive Power Demand	KVAR	26.9	0	29.04	
Apperant Demand	KVA	47	0	49.441	
Line current RMS A 1	Amps	55.909	0	72.24	
Line current RMS A 2	Amps	55.943	0	71.64	
Line current RMS A 3	Amps	58.047	0	73.32	
Peak current demand	Amps	330	304	303	Inrush
Current total harmonic distortion A1	%	38.843	0	43.5	Current distortion is on higher side
Current total harmonic distortion A2	%	40.84	0	46.9	
Current total harmonic distortion A3	%	41.737	0	48.5	
Current imbalance I unB	%	3.581	1.907	7.200	
K Factor Line 1		6.875	0	7.88	K factor is on higher side
K Factor Line 2		6.706	0	8.48	
K Factor Line 3		7.119	0	8.23	
Power factor 1		0.81	0.425	0.849	
Power factor 2		0.84	0.417	0.865	
Power factor 3		0.807	0.412	0.803	
Power factor mean		0.819	0.413	0.858	
Power Quality Parameters while supporting above load					
Parameter with Unit	Unit	Average	Minumum	Maximum	
Frequency	Hz	49.938	49.37	50.24	
Line to Line Voltage U 1 RMS	V	407.0	0	415.8	
Line to Line Voltage U 2 RMS	V	408.04	0	415.8	
Line to Line Voltage U 3 RMS	V	405.175	0	412.4	
Maximum Line voltage observed	V			424.8	
Minimum Line Voltage observed	V		NA		
Voltage total harmonic Distortion U1	%	2.930	0	5.8	Max distortion is on higher side.
Voltage total harmonic Distortion U2	%	3.03	0	6.6	
Voltage total harmonic Distortion U3	%	3.201	0	5.9	
Voltage imbalance V unB	%	0.437	0.1	1	
Fliker Pst U1		0.356	0.23	0.83	
Fliker Pst U2		0.399	0.25	0.81	
Fliker Pst U3		0.391	0.25	0.78	
Phase difference as recorded at even time					

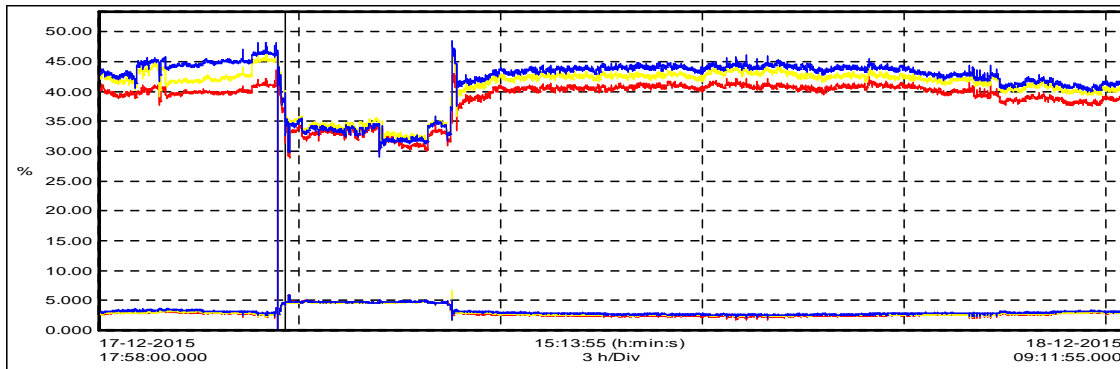


Comments and remarks:

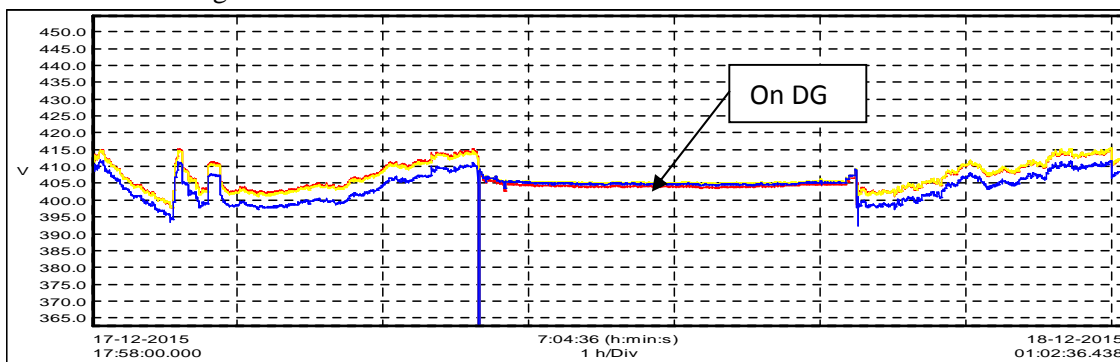
KW / KVAR load on the feeder



Current and voltage harmonic distortion

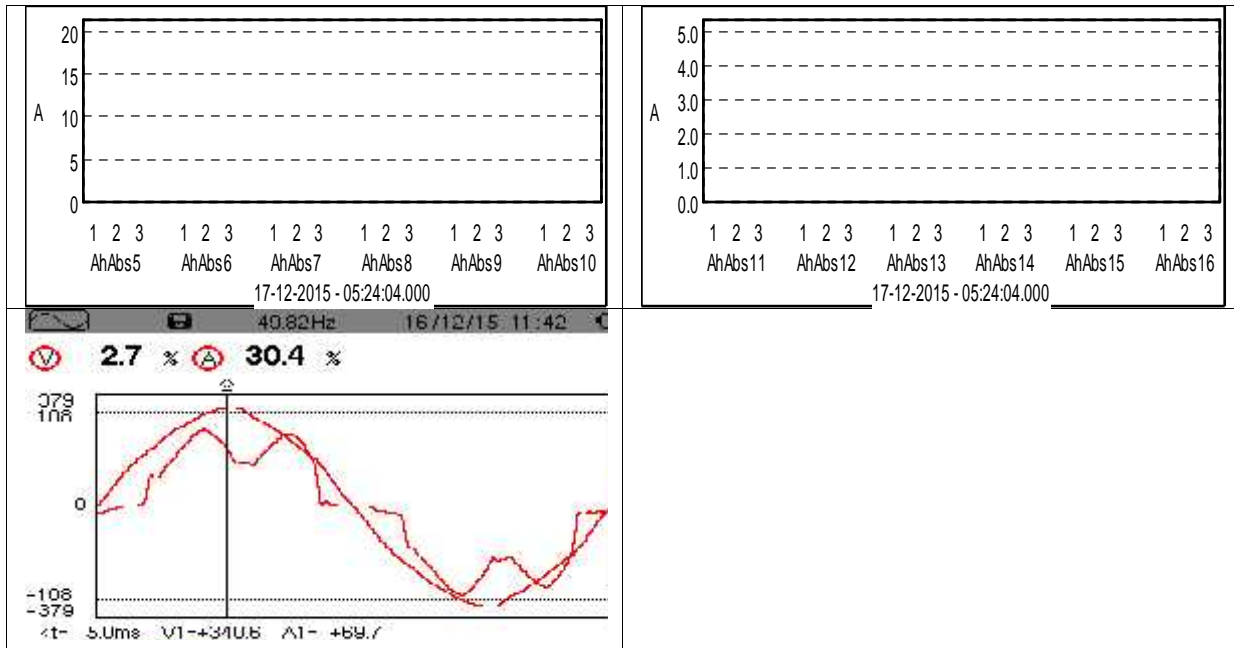


Line to Line voltage

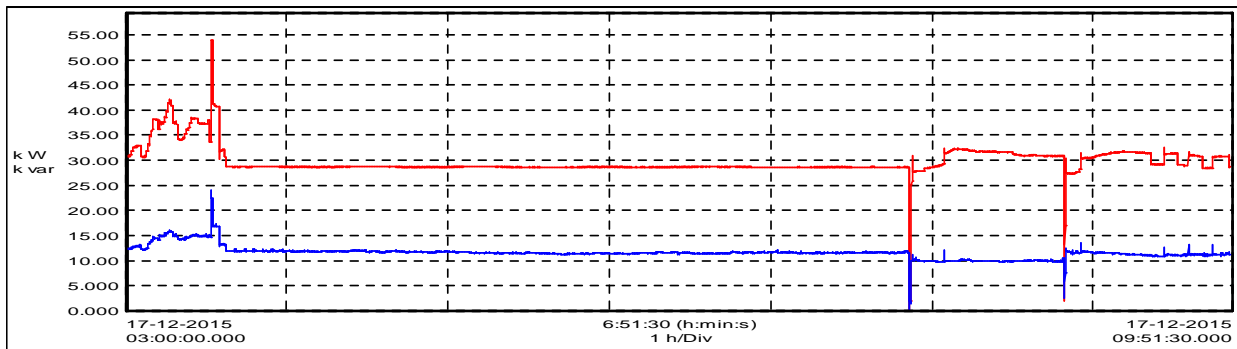


- 1) The load on this feeder is more or less constant as the same is mostly HVAC AHU / water pump load.
- 2) The current harmonic distortion is too high pertaining to VFD load. The voltage distortion on DG is on higher side and touches 6.6% max. This can trouble VFDs and other sensitive electronic equipment.
- 3) The input voltage available from raw power is not stable, while the same appears to be stable on DG.
- 4) Abrupt power failure and change over to DG has generated large number of alarms and transients. These disturbances can trouble critical loads.
- 5) K factor is also on higher side. It is recommended that incoming cable size for this MCC should be checked for this type of load.
- 6) 60Amps active harmonic filter may be installed across the main incomer of this feeder. This will help in reducing voltage distortion as well as K factor of this load and in turn power quality available to this load will improve.

Load profile and Power Quality Parameters for HVAC-MCC-04					Remark
Parameter with Unit	Unit	Average	Minumum	Maximum	
Load profile					
Active Load	KW	29.807	0	53.929	
Reactive Power Demand	KVAR	11.607	0	24.042	
Apperant Demand	KVA	32.011	0	58.488	
Line current RMS A 1	Amps	46.474	0	80.8	
Line current RMS A 2	Amps	45.551	0	83.52	
Line current RMS A 3	Amps	44.213	0	81.6	
Peak current demand	Armps	48.153	0	131.84	
Current total harmonic distortion A1	%	34.017	0	87.5	Current distortion is on higher side
Current total harmonic distortion A2	%	35.181	0	143.3	
Current total harmonic distortion A3	%	37.332	0	120	
Current Imbalance I unb	%	0.813	0.2	15	
K Factor Line 1		6.385	0	18.72	K factor is on higher side
K Factor Line 2		6.356	0	23.24	
K Factor Line 3		6.779	0	24.93	
Power factor 1		0.939	0.459	0.962	
Power factor 2		0.935	0.363	0.96	
Power factor 3		0.918	0.298	0.947	
Power factor mean		0.931	0.375	0.955	
Power Quality Parameters while supporting above load					
Parameter with Unit	Unit	Average	Minumum	Maximum	
Frequency	Hz	49.36	46.77	50.84	
Line to Line Voltage U 1 RMS	V	407.333	0	418.1	
Line to Line Voltage U 2 RMS	V	407.058	0	417.6	
Line to Line Voltage U 3 RMS	V	405.293	0	416.3	
Maximum Line voltage observed	V			422.2	
Minimum Line Voltage observed	V		NA		
Voltage total harmonic Distortion U1	%	2.827	0	4.6	Voltage distortion is on higher side
Voltage total harmonic Distortion U2	%	2.931	0	4.6	
Voltage total harmonic Distortion U3	%	3.107	0	4.9	
Voltage imbalance V unb	%	0.348	0	0.7	
Fliker Pst U1		0.303	0	3.02	
Fliker Pst U2		0.34	0	2.89	
Fliker Pst U3		0.333	0	2.91	
Phase difference as recorded at even time					
					Disturbances are recorded around DG changeover during power failure
Voltage transient occurrence recording. Transient threshold set at +/- 33% of Line to Neutral instantaneous voltage.		No of Transients	12		
Voltage Alarm recording. Threshold set at +/- 5% of 400V. Prolonged sags		No of Alarms	16		

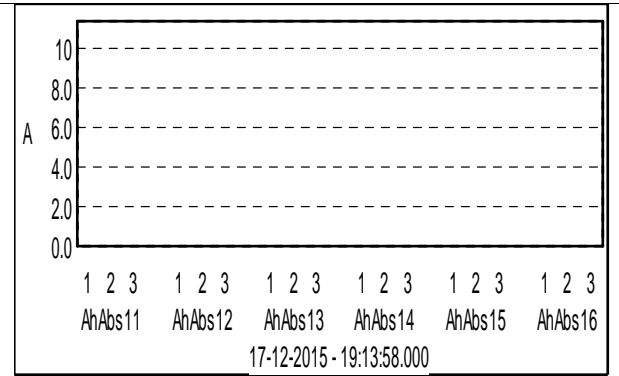
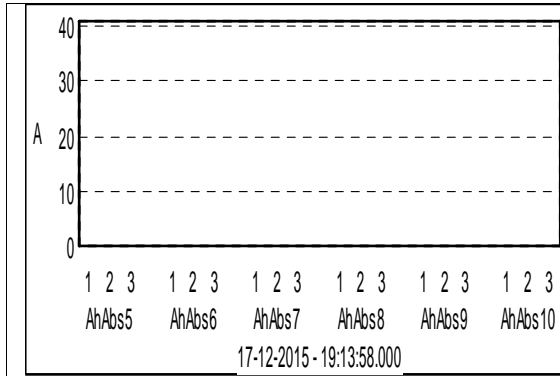


Comments and remarks



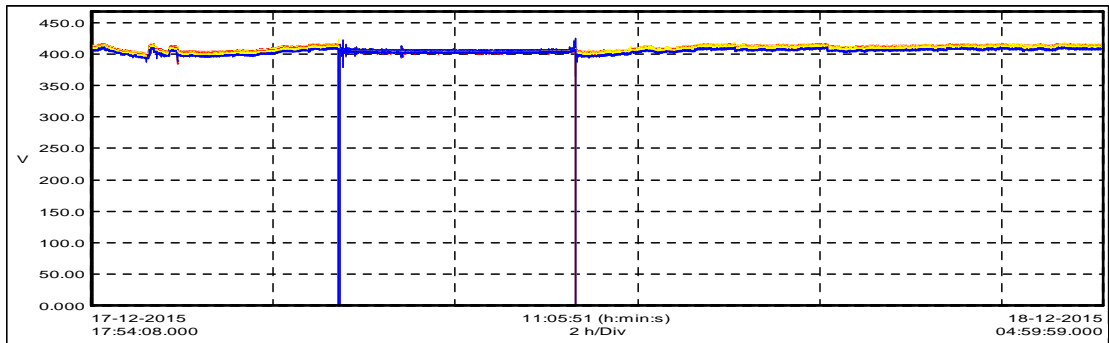
- 1) The load on this feeder is more or less constant.
- 2) The current harmonic distortion is too high pertaining to VFD load. The voltage distortion on DG is on higher side and touches 5.5% max. This can trouble VFDs and other sensitive electronic equipment.
- 3) Abrupt power failure and change over to DG has generated large number of alarms and transients. These disturbances can trouble critical loads.
- 4) K factor is also on higher side. It is recommended that cable size for incoming supply to this MCC should be checked for this type of load.
- 5) 60Amps active harmonic filter may be installed across the main incomer of this feeder. This will help in reducing voltage distortion as well as K factor of this load and in turn power quality available to this load will improve.

Load profile and Power Quality Parameters for Process MCC 3 (GENE 244)					Remark
Parameter with Unit	Unit	Average	Minumum	Maximum	
Load profile					
Active Load	KW	21.687	0	52.192	
Reactive Power Demand	KVAR	14.678	0	42.099	Widely variable
Apperant Demand	KVA	26.809	0	74.737	load
Line current RMS A 1	Amps	39.163	0	108.96	
Line current RMS A 2	Amps	37.796	0	103.92	
Line current RMS A 3	Amps	36.917	0	107.64	
Peak current demand	Amps	39.711	0	178.58	
Current total harmonic distortion A1	%	17.125	0	70.5	Current
Current total harmonic distortion A2	%	20.590	0	85.4	harmonics are
Current total harmonic distortion A3	%	17.655	0	75.1	on higher side
Current Imbalance I unB	%	7.624	0	45.9	High imbalance
K Factor Line 1		4.842	0	31.88	
K Factor Line 2		5.118	0	28.38	Higher Non
K Factor Line 3		4.402	0	19.5	linear load
Power factor 1		0.815	0.596	0.956	
Power factor 2		0.835	0.584	0.97	
Power factor 3		0.83	0.629	0.99	
Power factor mean		0.827	0.583	0.958	
Power Quality Parameters while supporting above laod					
Parameter with Unit	Unit	Average	Minumum	Maximum	
Frequency	Hz	50.010	43.29	51.03	
Line to Line Voltage U 1 RMS	V	408.229	0	415.7	
Line to Line Voltage U 2 RMS	V	408.362	0	415.7	
Line to Line Voltage U 3 RMS	V	405.375	0	412.1	
Maximum Line voltage observed	V			425.5	
Minimum Line Voltage observed	V		NA		
Voltage total harmonic Distortion U1	%	3.027	0	8.6	Very high
Voltage total harmonic Distortion U2	%	3.108	1.1	6.3	voltage
Voltage total harmonic Distortion U3	%	3.261	0	7.9	distortion
Voltage imbalance V unB	%	0.515	0	2.1	
Fliker Pst U1		0.4	0	3.41	
Fliker Pst U2		0.419	0	3.55	
Fliker Pst U3		0.354	0	3.41	
Phase difference as recorded at even time					
Voltage transient occurrence recording. Transient threshold set at +/- 33% of Line to Neutral Instantaneous voltage.			No of Transients	10	During DG Changcover
Voltage Alarm recording. Threshold set at +/- 5% of 400V. Prolonged sags			No Of Alarms	30	



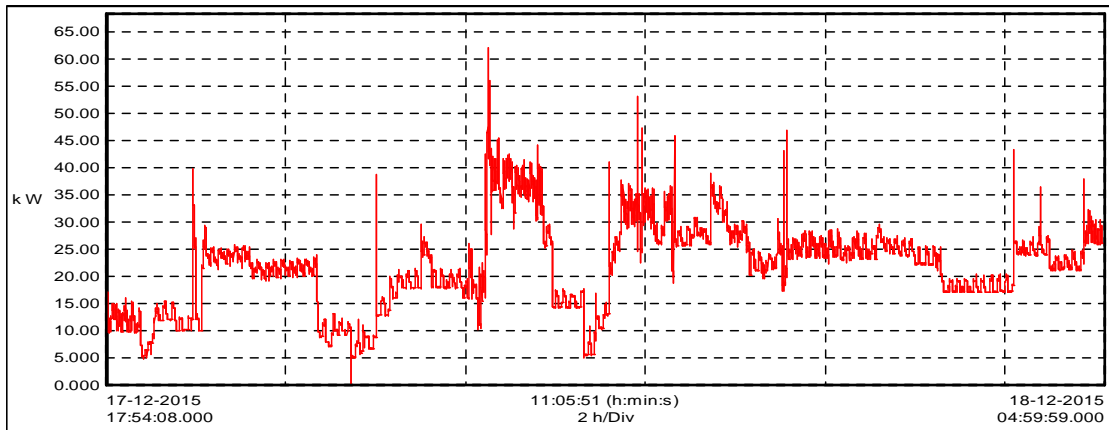
Comments and Remarks

Line to Line voltage



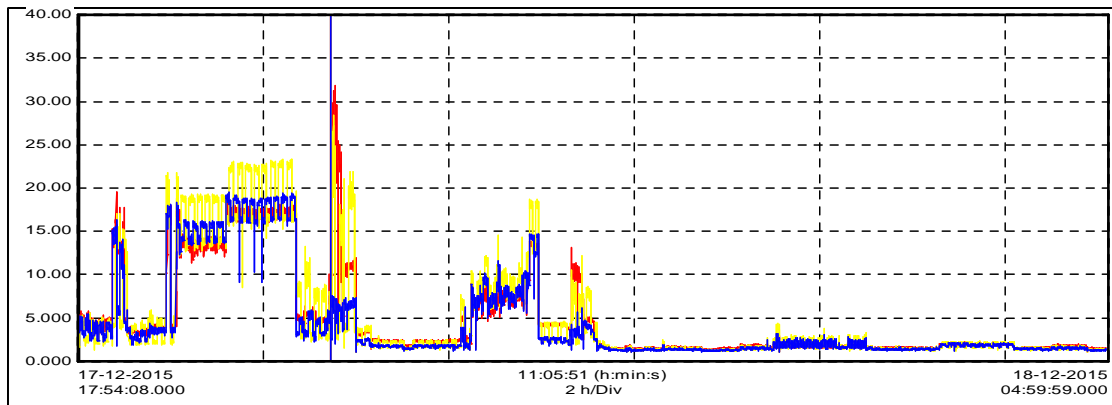
There was a power failure during recoding time. The voltage is more stable during the period when DG is ON.

KW Load



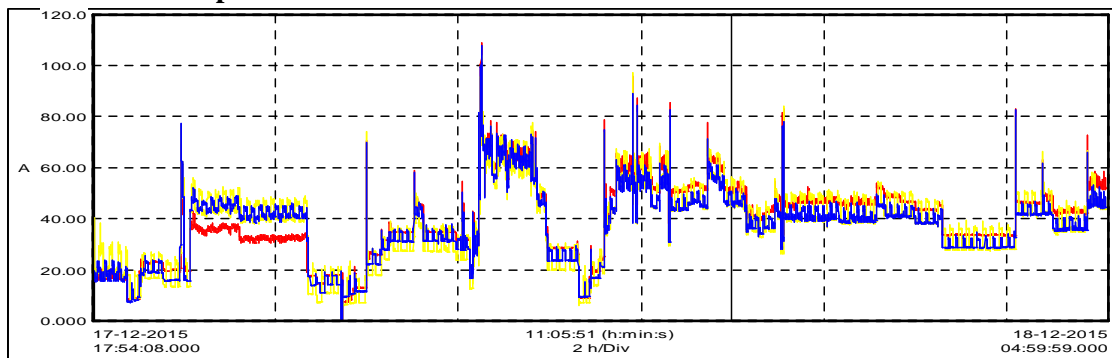
This is process MCC and the load is continuously variable.

K Factor



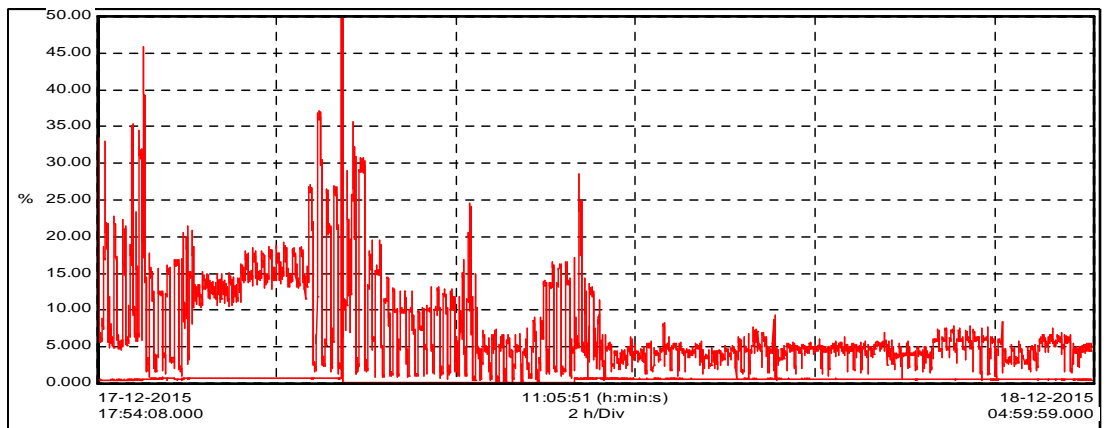
The load is variable and Non linear in nature. Load current in all three phases is not equal. Load exhibits large K factor ranging from 2.5% to 30%.

Line current Amps



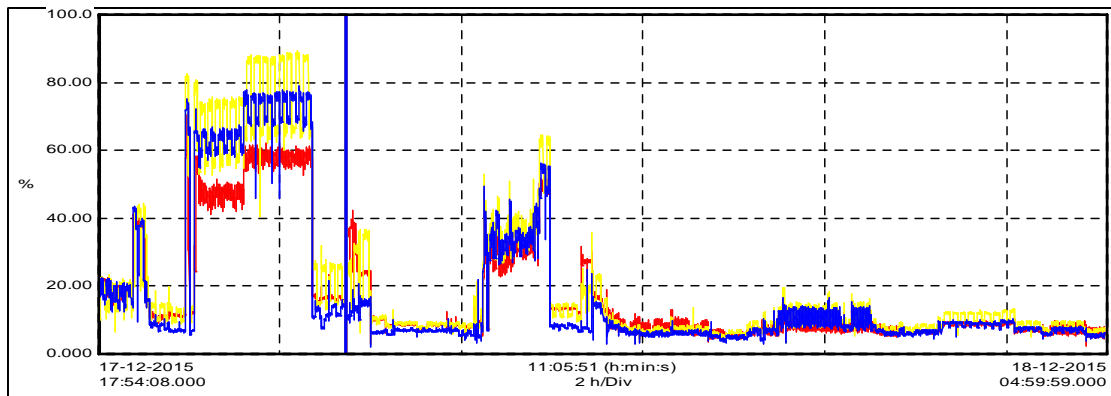
Line current is not balanced and also fluctuates continuously

Current imbalance



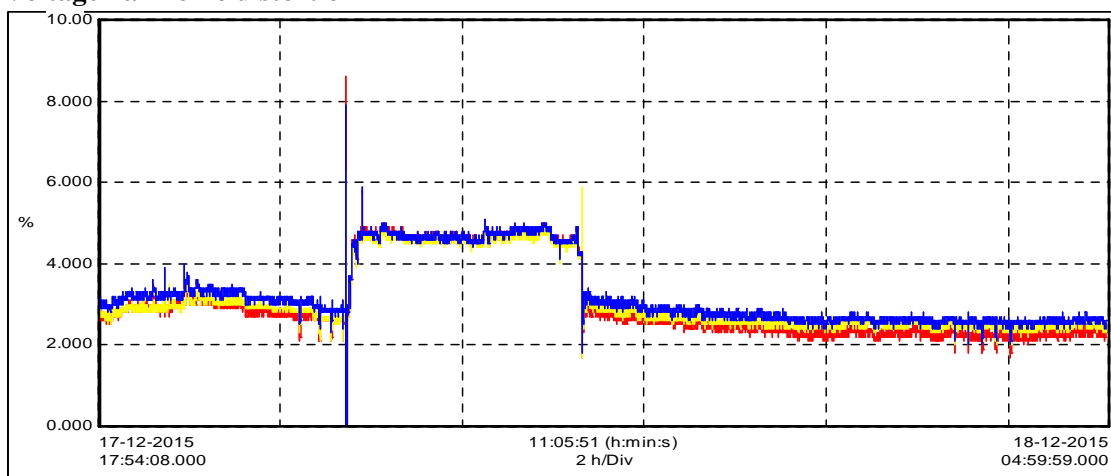
There is substantial current imbalance as a result of nature of load.

Current harmonic distortion



Current distortion ranges from 10% to 90%.

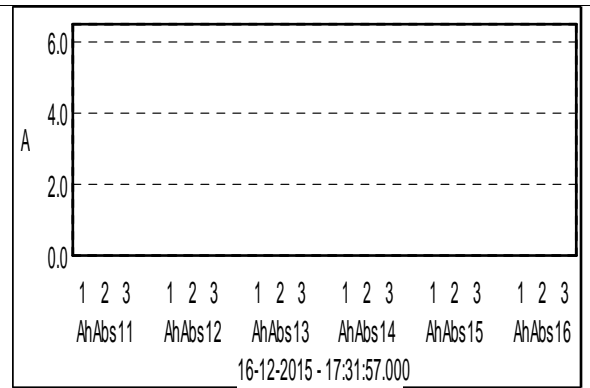
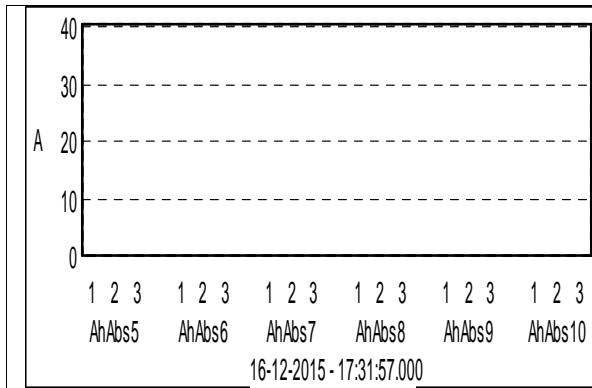
Voltage harmonic distortion



Corresponding voltage harmonic distortion ranges from 3% to 6%.

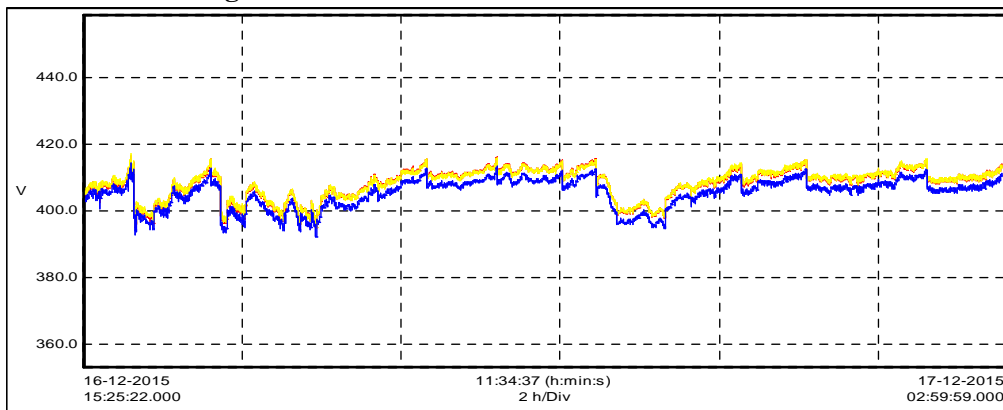
- 1) The load on this feeder is continuously variable and also largely nonlinear. The load is not same on all the phases – may be as requirement of process machines.
- 2) The current harmonic distortion is too high. The voltage distortion on DG is on higher side and touches 5% max. This can trouble VFDs and other sensitive electronic equipment.
- 3) Abrupt power failure and change over to DG has generated large number of alarms and transients. These disturbances can trouble critical loads.
- 4) K factor is also on higher side. It is recommended that incoming cable size for this MCC should be checked for this type of load.
- 5) 60Amps active harmonic filter may be installed across the main incomer of this feeder. This will help in reducing voltage distortion as well as K factor of this load and in turn power quality available to this load will improve.

Load profile and Power Quality Parameters for Process motor control center (PMCC)					Remark
Parameter with Unit	Unit	Average	Minimum	Maximum	
Load profile					
Active Load	KW	40.946	17.673	78.448	
Reactive Power Demand	KVAR	16.22	-3.833	66.018	
Apperant Demand	KVA	44.743	18.761	86.471	
Line current RMS A 1	Amps	52.534	24.5	123	
Line current RMS A 2	Amps	52.825	25.3	122.4	Load is
Line current RMS A 3	Amps	55.139	28.2	123	variable.
Peak current demand	Amps	55.914	25.7	318	Low High
Current total harmonic distortion A1	%	32.147	8.5	46.1	Current
Current total harmonic distortion A2	%	33.314	10	46.7	distortion is on
Current total harmonic distortion A3	%	31.436	9.5	41.8	Higher side
Current Imbalance I unB	%	3.935	0.8	10.9	
K Factor Line 1		5.364	1.43	10.63	
K Factor Line 2		5.389	1.45	9.49	
K Factor Line 3		5.151	1.45	3.53	
Power factor 1		0.91	0.621	0.941	
Power factor 2		0.922	0.657	0.956	
Power factor 3		0.921	0.650	0.959	
Power factor mean		0.918	0.645	0.949	
Power Quality Parameters while supporting above load					
Parameter with Unit	Unit	Average	Minimum	Maximum	
Frequency	Hz	49.979	49.77	50.27	
Line to Line Voltage U 1 RMS	V	408.174	394.9	416.6	
Line to Line Voltage U 2 RMS	V	408.231	395	417	
Line to Line Voltage U 3 RMS	V	415.378	397.7	414.4	
Maximum Line voltage observed	V			416.1	
Minimum Line Voltage observed	V		382.3		
Voltage total harmonic Distortion U1	%	2.675	2	3.4	
Voltage total harmonic Distortion U2	%	2.713	2.2	3.3	
Voltage total harmonic Distortion U3	%	2.835	2.3	3.6	
Voltage imbalance V unB	%	0.433	0.3	0.7	
Fliker Pst U1		0.351	0.22	3.55	
Fliker Pst U2		0.373	0	3.32	
Fliker Pst U3		0.324	0.2	3.55	
Phase difference as recorded at even time					
Voltage transient occurrence recording. Transient threshold set at +/- 33% of line to Neutral instantaneous voltage.		No of Transients	13	Appeared during normal operation	
Voltage Alarm recording. Threshold set at +/- 5% of 400V. Prolonged sags		No of Alarms	18		



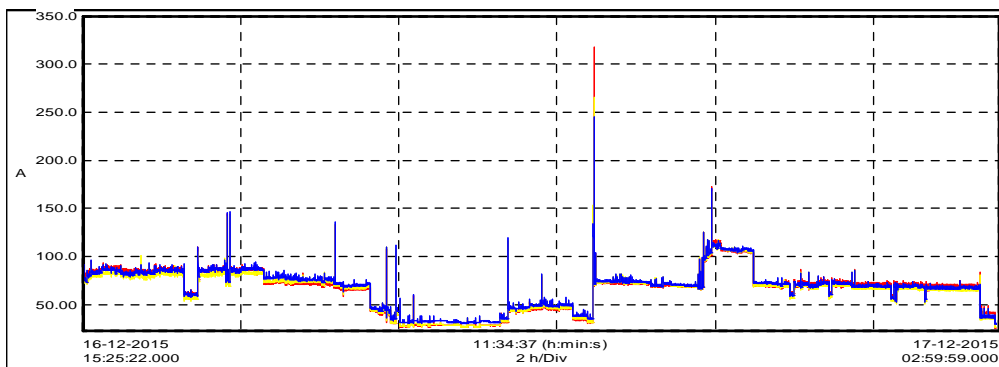
Comments and remarks

Line to Line voltage

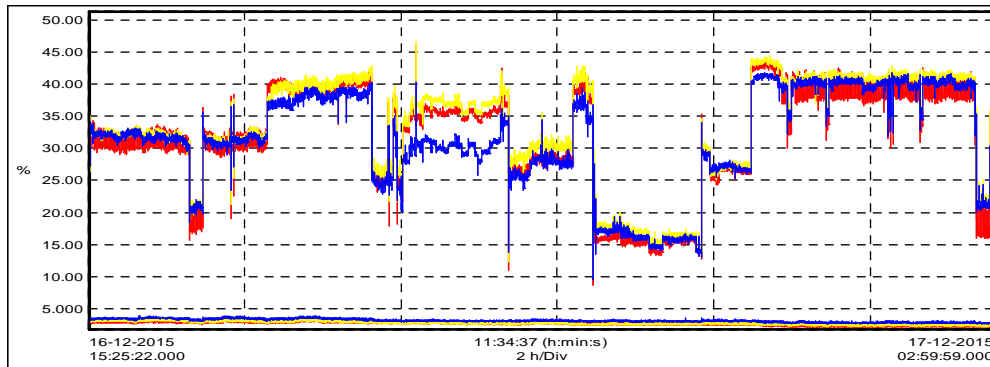


Voltage varies continuously. One can see many operations of tap changer.

Load current:



Current harmonic distortion

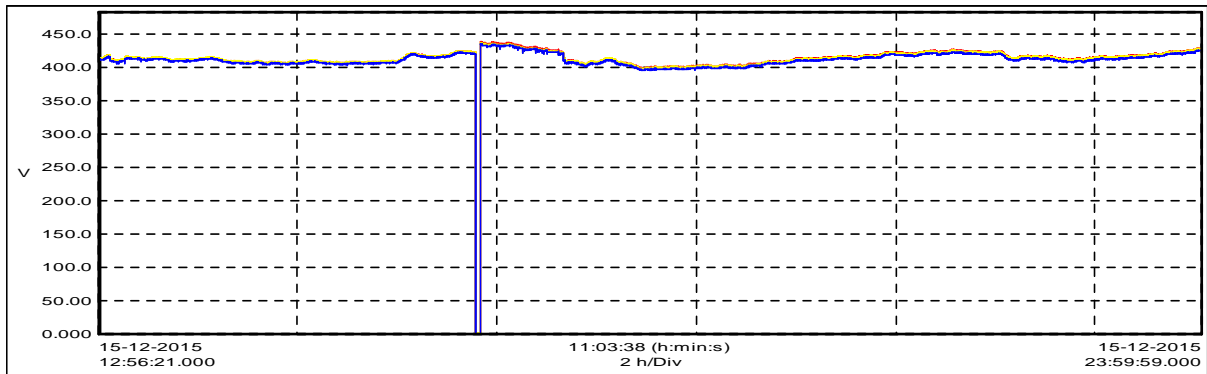


Current harmonic distortion varies from 5% to 45%.

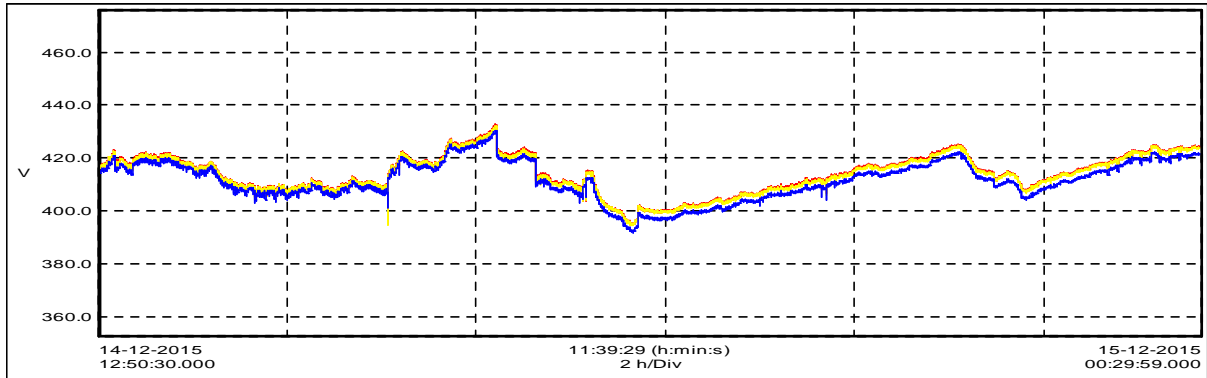
- 1) The load on this feeder is continuously variable and also largely nonlinear.
- 2) The current harmonic distortion is too high. The voltage distortion caused due to this is not very alarming as the same is below 5%.
- 3) This recording is done purely on raw power and not on DG. As shown on next page Tr2 secondary voltage (which is source for this feeder) follows 33KV input. Incoming 33KV is corrected frequently by upstream utility side tap - changer and the associated voltage variations are reflected on transformer secondary and further they reach this feeder.
- 4) Frequent peak inrush current requirements ranging from 150Amps to 380Amps are observed on this feeder, whereas average requirement is below 100Amps. If possible these loads may be identified and provided with soft starters. (If they are motor loads)
- 5) The majority of the load catered by this feeder is non linear and current distortion ranges from 15% to 45%. We recommend 60Amps active harmonic filter across the main incomer of this feeder. This will help reducing high frequency currents carried by long incoming cables.

Voltage trends recorded at 33KV, Tr1 secondary and Tr2 secondary.

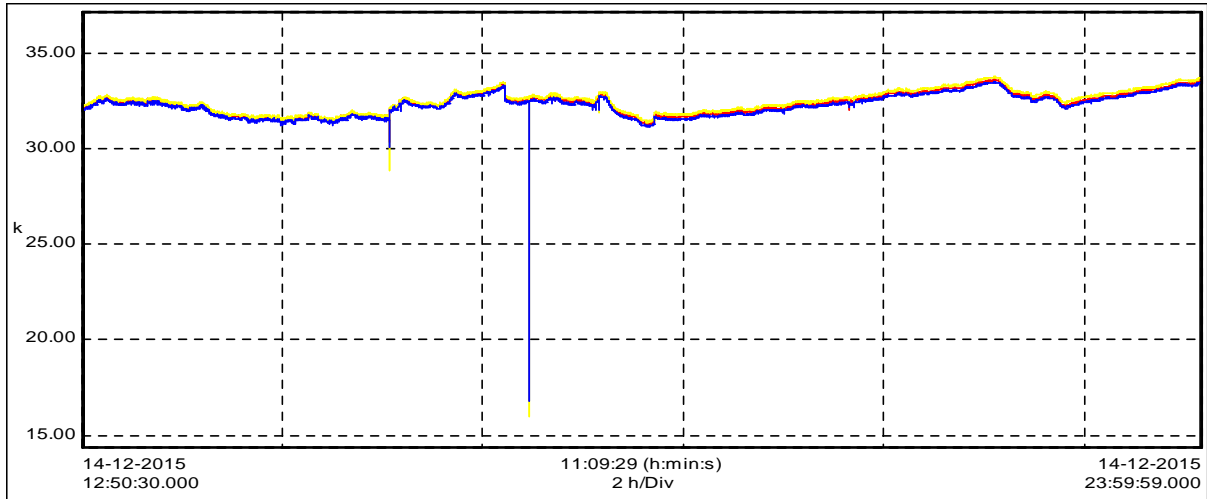
TR 1



TR 2



33KV



33KV and TR2 secondary trends are recorded on independent power analysers, simultaneously. The trend is presented above with same START TIME. One can see that source of most of the voltage variations seen on TR2 secondary is variation on 33KV incoming line.

Feeder wise Power Quality Report

Feeder / Feeder Group ID	Power Quality Parameters							Harmonic Current Amps				Active Filter Recommendation
	U Avg	V Avg	U thd %	V thd %	I Avg Amps	I thd %	KW Max	3rd	5th	7th	11th	
TR 1 - Phase 1												
PADP 3	404	232	2.7	2.9	93	32	65		15	7	3	
PADP 1	410	242	2.4	2.6	60	16.6	33.54		6	6	3	
PADP 5	411	237	2.5	2.2	60	10.9	49.65		4	3	1	
PADP 6	400	234	2.5	2.7	101	23.8	59.89		13	8	4	
PADP 2	401	232	2.7	3	170	22.7	107		20	5	5	
PADP 4	401	232	2.9	3.4	96	52	58	10	30	20	10	100Amps
						Total	173.25					
Fleet Pump GENE 200	407	234	2.5	2.6	183	4.1	107		6			
Main Lighting MLUB 1	402	232	2.7	3.1	130	12.6	82	10	4	8	2	
Utility MCC 1	413	235	2.8	3	105	5.3	53		2	1		
Utility MCC 2	413	239	2.5	2.7	284	7.3	140		4	4	2	
Utility MCC 3	405	236	2.5	3	267	27.5	146.5		40	20	8	100Amps
1250KVAR APFC Delivering 280 KVAR							2.4		42	10		
						Total	530					
						Total	909.25					
Phase 1 On DG												
PADP 6	404	234	4.1	4.2	91	31.4	60.93		15	5	11	
PADP 3	405	233	4.1	4.2	102	26.5	55		13	5	1.5	
PADP 4	407	235	3.4	3.8	122	54.8	77		46	22	7	300 Amps
PADP 2					120	31.2	60		10	5	2	
						Total	252.93					
TR 2 - Phase 2												
HVAC MCC	408	235	3.7	3.7	96	42.1	55.55		25	15	5	60 Amps
MPDR	412	238	3.5	4.2	22	9.9	13.29		1.5	1	1.5	
FMCC	407	236	3.1	3.3	70	41.4	49.68		22	10	2	
						Total	118.52					
Tr 2 Common feeders												
Air Compressor 1	405	235	3.1	3.2	120	32.9	112.9		40	15	15	100 Amps
Chiller 3	407	235	3.5	3.7	505	3.6	310		14	10	4	
MIDR 2	372	214	3.5	3.9	93	14.7	49.9	10	4	6	2	
Main UPS Panel					114	19.2	40					
						Total	512.8					
Tr 2 Phase 3												
ETP	410	236	3	3.2	46	68.3	27		15	12	6	
HVAC MCC 2	402	230	3.2	3.5	65	48.5	36.5		22	15	5	
HVAC MCC 4	410	236	3.1	3.4	76	38.2	47.27		17	10	4	
MPDB GLNL 2JB	404	232	3.1	3.3	18	30.42	8.71		2	1	1.5	
MPDB MCC 01	412	230	3	3.2	33	30	17.1		6	5	2.5	
PCC 3	402	230	3.2	3.3	302	28.5	176.5		50	10	8	100 Amps
Preload MCC 3	410	235	2.9	3.2	20	30	12.95		1.5	1	1.5	
						Total	126.14					
						Total	957.46					

This column clearly shows that majority of the load is non linear and demands harmonic current.

These harmonic currents generate electrical noise which travels through the distribution in either conducted or radiated mode or both. At present the reactive power compensation at transformer main LT, being of detuned type, avoids resonance and harmonic amplification while correcting the power factor, but these harmonic currents travel to their respective common bus bars, get added vectorially and travel further upstream. Their presence is damped only due to phase cancellation at each common point. In case the maintenance issues are at bothering level, these harmonic currents need to be constrained to flow upto possible downstream level. This can be achieved by connecting active harmonic filters at respective PCCs which help in cancelling the harmonic currents by drawing antiphase currents from source. We have recommended active filters at various feeders in above table. TR 2 implementations may be done on priority and TR 1 may be compensated subsequently as per available budgets.

UPS Input side Power Quality Parameters and Overall efficiency.

Sr no	UPS Input	Voltage Max V	Voltage L L Max V	THD V % Max	Current Max A	THDI % Max	KW Max	Output KW	efficiency %
1	UPS-1-20KVA Input - (GENE-113)	235.7	412.7	3	10.9	57.5	1	0.176	17.50
2	UPS-2-20KVA Input - (GENE-219)	237.1	407.1	3.5	9.1	40.7	5.9	5	81.75
3	UPS 3 20KVA Input (GENE 146)	233.2	403.4	3.4	3.1	20.4	2	1	24.39
4	UPS 4 20KVA Input (GENE 147)	232.5	401.6	3.4	3.2	22.7	2.1		
5	UPS-5-20KVA Input	234.2	404.5	4.4	3.8	26.2	2.5	2.1	45.55
6	UPS-6-20KVA Input	233.6	403.9	4.5	3.2	28.7	2.1		
7	UPS-8 - 20KVA Input (GENE-198)	232	399.5	3.2	12.5	10.3	3.2	13.8	82.14
8	UPS-7 - 20KVA Input (GENE-199)	232.7	398.9	3.4	13.1	15.4	3.6		
9	UPS 9 20KVA Input (GENE 205)	238	394.5	3.1	18.2	8.9	12.1	9.9	81.82
10	40KVA UPS Input (GENE 323)	238.8	411.7	2.3	9.4	118.1	3.2		
11	40KVA UPS Input (GENE 324)	236.2	408.2	2.8	8.2	122.2	2.9	4.1	
12	80KVA UPS Input	235.9	412.4	2.7	13.8	44.2	7.6	6.5	85.53
13	160KVA UPS Input	235.1	403	2.7	56.6	22.4	42.1	39.1	92.37
Total							100.3	81.676	81.43

Almost all UPS systems have Thyristor input stages and hence draw harmonic currents from source. The UPS load is hardly 5% of total plant load, so this is not major matter of concern.

Due to part load conditions, overall efficiency is about 80% and plant spends 20Kwh / hour on conditioning the power and supplying uninterrupted power to various critical loads.

UPS output side PQ parameters

Sr no	UPS Output	Voltage Max V	Voltage L L Max V	THD V % Max	Current Max A	THDI % Max	KW Max
1	UPS-1-20KVA Output	230.4		1	1.2	74	0.176
2	UPS-2-20KVA Output	220.3		1.3	23.2	14.3	5
3	UPS-3 & 4 -20KVA Output	233.7		0.7	4.3	156	1
4	UPS 5 & 6 20KVA Output	234		1	9.2	23.6	2.1
5	UPS 7 & 8 20KVA Output	219.4		2.3	66.5	32.4	13.8
6	UPS 9 20KVA Output	228.6		1	48.6	61.9	9.9
7	40KVA UPS Output	230.5	399.1	0.1	13.7	35.5	4.1
8	80KVA UPS output	232.7	401.6	0.5	15.3	49.9	6.5
9	160KVA UPS Output (GENE-308)	231.2	393.7	1	86.8	46.4	39.1
Total							81.676

UPS installed capacity is 480KVA, while their outputs supply 81KW to various loads which are nonlinear. The UPS output voltage distortion is less than 2% while supplying load.

Earthing Resistance

Earth Resistances check			Earth Resistances check		
Feeder Name	Earth loop resistance ohm	Comment on earth resistance	Feeder Name	Earth loop resistance ohm	Comment on earth resistance
TR-1	N 1.5 & B 0.01	OK	APFC panel H4	0.041	OK
TR-2	N 4.5 & B 0.061	N earthing should be Improved	MPDB	0.025	OK
PCC 1 (main LT Panel)	0.45	OK	MPDB MCC-04	0.048	OK
PCC 2 (main LT Panel)	0.055	OK	ETP	0.028	OK
DC-1	0.12	OK	HVAC MCC-04	0.46	OK
DC-2	0.15	OK	Phase-2		
DC-3	0.13	OK	Process Motor control centre (PMCC)	0.027	OK
DC changeover Panel	0.059	OK	HVAC MCC	0.055	OK
BESS Panel	0.052	OK	MPDB-2	0.27	OK
APFC Panel In-1 (1050KVAIR)	0.076	OK	MPDB	0.028	OK
APFC Panel In-2 (1050KVAIR)	0.81	OK			
Changeover Switch No 01	0.052	OK	Main UPS Panel	0.084	OK
Changeover Switch No 05	0.084	OK	UPS-7 & 8 Output Panel	0.06	OK
Changeover Switch No 04	0.081	OK	UPS-9 Output Panel	0.37	OK
Changeover Switch No 05	0.11	OK	UPS-5 & 6 Output Panel	1.2	OK
APFC Panel-04	0.063	OK	UPS-1 Output Panel	0.41	OK
Changeover Switch No 01	0.15	OK	UPS-3 & 4 Output Panel	0.038	OK
Utility MCC	0.52	OK	UPS-1	0.011	OK
Utility MCC-2	0.5	OK	UPS-2	0.2	OK
Utility MCC-3	0.065	OK	UPS-3	0.16	OK
Air Compressor-I	0.072	OK	UPS-4	0.16	OK
Air Compressor-II	0.47	OK	UPS-5	0.57	OK
Process Area Distribution Panel-1 PADP-1	0.035	OK	UPS-6	0.57	OK
Process Area Distribution Panel-2 PADP-2	0.044	OK	UPS-7	0.51	OK
Process Area Distribution Panel-3 PADP-3	0.037	OK	UPS-8	0.51	OK
Process Area Distribution Panel-4 PADP-4	0.047	OK	UPS-9	0.36	OK
Process Area Distribution Panel-5 PADP-5	0.026	OK	150KVA UPS Output Panel	0.6	OK
Process Area Distribution Panel-5 PADP-6	0.063	OK	150KVA UPS	0.068	OK
Phase-3			150KVA Isolation Transformer	0.41	OK
PCC-3	1.4	OK	30KVA UPS	0.028	OK
Process MCC-3	0.055	OK	30KVA Isolation Transformer	0.025	OK
HvAC MCC-2	0.08	OK	10 KVA UPS (GENE-323)	0.025	OK
APFC panel -H4	0.041	OK	10 KVA UPS (GENE-324)	0.024	OK
MPDB	0.025	OK	10KVA UPS (GENE-324) Input Switch	0.051	OK
MPDB MCC-04	0.048	OK	10KVA UPS (GENE-323) Input Switch	0.069	OK
ETP	0.028	OK	10KVA UPS output switch	0.039	OK
HVAC MCC-04	0.46	OK	30KVA UPS Output	0.96	OK
			30KVA Input Switch	0.037	OK

Above table shows earthing resistance measured within loop. The Neutral Earthing Resistance for transformer 2 is slightly on higher side and should be attended. Rest all earthings are in good condition.