

# POWER QUALITY AUDIT REPORT

FOR

**XXXXXX**

By

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**Audit period: NOV 2016**

### LIST OF ABBREVIATION

MLTP	Main LT panel
PQA	Power quality analysis
Vrms	Phase to neutral voltage
Urms	Phase to phase voltage
Arms	Current
Avg.	Average
Min.	Minimum
Max.	Maximum
Ithd	Total harmonics distortion in current
Vthd	Total harmonics distortion in voltage
PF	Power factor
PCC	Power control circuit/point of common coupling
TDD	Total demand distortion
THD	Total harmonics distortion
MERC	Maharashtra electricity regulatory commission
DB	Distribution board
DG	Diesel generator
LT	Low tension
IEEE	Institute of Electrical and Electronics Engineers
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
KW total	Red
KVAR total	Blue
KVA total	Yellow

### **Highlights of audit findings.**

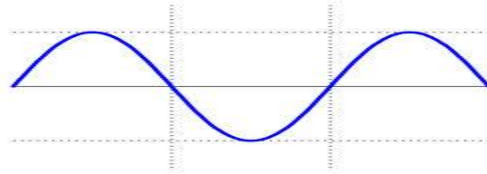
- 1) The current harmonic distortion observed is less than 15% and within limits prescribed by IEEE 519 1992. Management should enquire about regulation and check the compliance.**
  
- 2) Power factor is not maintained at unity.**
  
- 3) Management should take decision about installing lightening arrester system as per IS 2309 (1989)**

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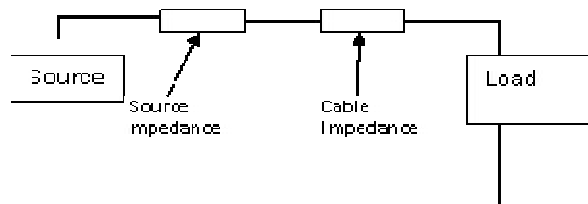
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**A note on electrical Power quality, it's importance, effects and remedies**

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



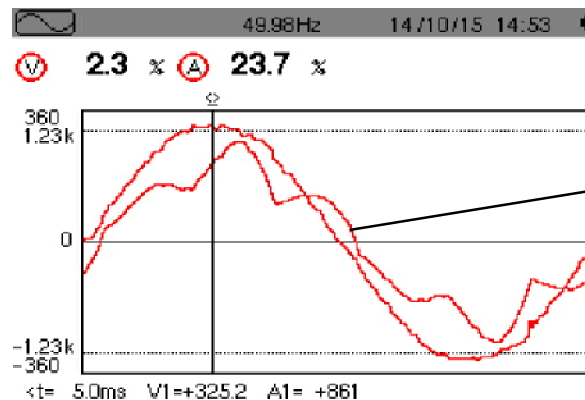
- In case of 50Hz frequency, each cycle takes 20msec to complete. Frequency variation can cause trouble to connected load and as such it should be as constant as possible. Iron losses in motors, transformers etc change with frequency. The Grid power frequency is usually maintained within +/- 1Hz.
- The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



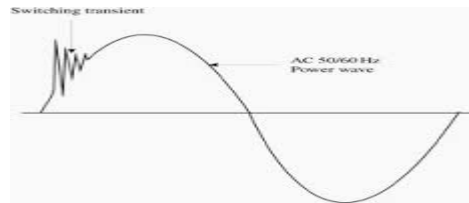
The waveform of voltage available across load may get affected and deviate from Sinewave due to various reasons like drawing non sinusoidal currents containing harmonic components, defects in generators (Alternators or UPS systems), higher source impedance, overloading, etc. If (Source + Cable) impedance 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 –**



- 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 workman ship 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.

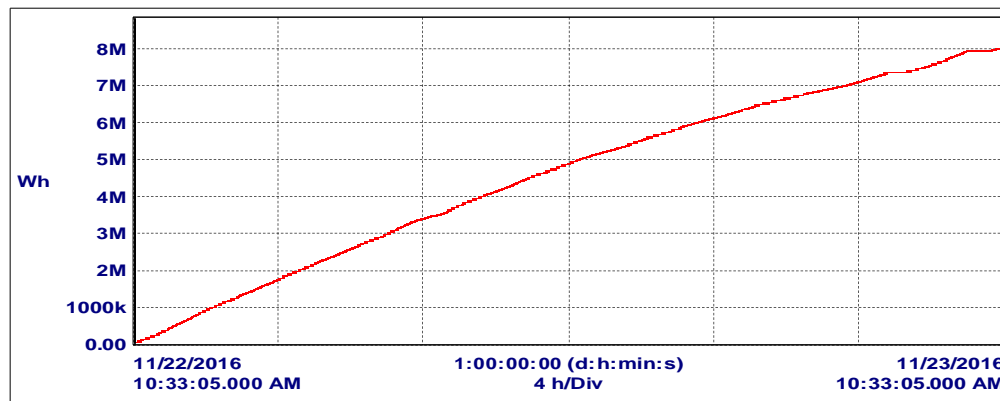
Lastly one should also note that there could be design related issues with the equipment, which can affect reliable operation. Such issues may affect the performance despite of offering good quality power. It is very important to consider this while undertaking root cause analysis of failure of an equipment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

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## Summary of power quality audit & Recommendations

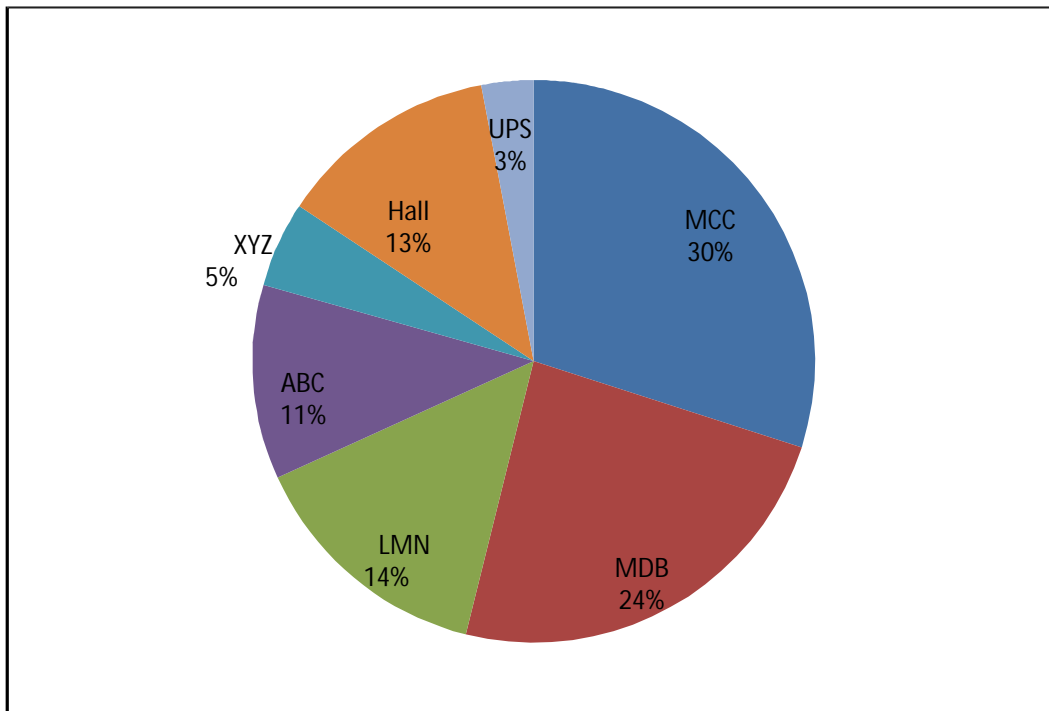
1. The 11KV/415V-1000 KVA transformer secondary was monitored for 24 hours for power quality parameters while major loads were switched ON. Following trend shows that energy consumption was almost linear in nature throughout 24 hours i.e. during the period of measurement except for early morning hours.



2. Reactive power compensation at present is offered using contactor switched detuned filters. The corrections provided were monitored individually which shows that some capacitors are derated and do not provide rated KVAR.
3. We have recorded all input / output parameters of UPS systems. The capacity utilization and overall analysis is elaborated in the report.
4. We have carried out earthing audit and have conducted IR thermography of electrical panels. Loose connections were detected in some panels during thermography test. These causes a temperature rise within that panel. IR thermography report will be submitted as a separate PDF.
5. Earthing resistance was measured using loop method, which shows that some earthings were open and need to be corrected.
6. XXX does not have any LA installed at present. The top most structure is a mobile tower and tallest protruding part of this structure is earthed at present. It is recommended that XXX should use a correctly designed conventional LA system as per IS 2309 (1989 as amended)
7. Though 40 % of total loads are non linear in nature, the voltage distortion remains below 2.7 % i.e. well within the limit suggested by IEEE 519-1992 standard. ( compliance requirements are 5% or less) Hence existing transformer is sufficient for feeding present load. Loading of another 150KW will be allowed if same loading pattern and types of loads are maintained.

## Load Distribution Chart

- pie chart shows the load distribution of XXX. The non linear load is 40 % of total load in the XXX.
- Total of Avg load is 480 KW against transformer capacity of 1000 KVA.



1.

## Power quality parameters

Power Quality Parameters																	
Sr.No	Feeder Name	L-N Voltage		L-L Voltage		Voltage THD%		Line Current		Current THD%		KW		KVAR		PF	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Main Incomer	245.00	276.00	430.00	478.00	1.10	2.70	492.00	828.00	8.50	14.80	335.00	581.00	26.40	221.10	0.981	0.998
2	DG Incomer 1	238.02	239.10	411.90	414.70	2.02	2.40	271.81	343.80	5.63	8.40	157.64	208.08	87.61	107.67	0.872	0.91
	DG Incomer 2	238.03	239.10	411.83	414.70	2.04	2.40	251.59	344.50	6.16	9.40	165.23	215.67	34.25	50.82	0.978	0.979
3	Banquet hall (Main LT)	236.10	237.40	411.59	413.80	1.80	2.10	96.60	121.90	13.89	20.70	61.20	81.36	-3.00	6.54	0.985	0.994
	a) MCC 2	240.60	241.60	418.40	419.60	1.40	1.70	13.75	14.08	80.00	81.00	6.22	6.26	-1.21	-1.15	0.744	0.747
	b) MDB (GYM & SPA)	240.50	242.10	420.78	427.30	1.40	1.70	82.55	109.80	21.50	25.70	50.44	69.88	16.81	18.97	0.944	0.971
4	Dish Washer Panel	247.65	248.00	429.61	430.80	1.40	1.70	44.74	62.12	1.20	6.60	20.96	29.49	1.07	2.05	0.9	0.955
5	MDB 1 Laundry	242.03	248.30	418.85	429.00	1.30	1.70	60.72	104.13	1.73	17.60	32.78	56.65	2.16	20.22	0.869	0.995
6	MDB Laundry	241.00	247.00	421.00	429.00	1.10	2.20	30.52	101.72	8.60	152.10	36.40	153.10	6.20	52.00	0.92	0.991
7	MCC 2 (LT Room)	242.29	243.80	419.45	422.10	1.3	1.50	12.38	12.63	2.27	2.70	3.72	3.76	7.88	8.07	0.428	0.436
8	MCC -7 Terrace Floor (Main LT)	243.08	247.20	421.52	428.80	1.50	1.90	184.75	235.20	10.78	16.70	75.34	106.34	98.21	122.75	0.608	0.698
	a) MCC -7 Terrace Floor (Terrace Panel Main)	233.44	234.40	404.23	405.60	2.10	2.20	165.90	181.30	11.19	13.60	74.86	86.07	86.20	91.74	0.652	0.732
	b) MCC-7 Terrace floor -Single VRV	232.95	235.60	403.32	407.80	2.20	2.40	26.70	36.50	28.06	38.90	11.11	17.63	12.15	16.98	0.665	0.765
9	MCC -8 Terrace Floor (Main LT)	239.73	243.40	415.30	421.90	1.50	1.90	130.21	165.60	8.60	16.70	49.35	70.67	70.65	94.97	0.571	0.687
10	MCC-1 Basement Floor	235.72	236.80	408.55	410.30	1.70	1.90	14.21	14.35	3.49	3.80	3.23	3.26	9.39	9.50	0.325	0.328
11	MCC-5 Stilt Floor	243.77	245.10	421.95	424.30	1.30	1.50	9.73	10.94	51.40	53.40	5.04	5.74	4.07	4.53	0.775	0.791
12	MCC-10 Terrace Floor	235.67	239.00	408.69	414.10	1.70	2.10	11.36	12.60	4.17	4.50	7.98	8.52	-0.627	-0.609	0.997	0.997

- The voltage distortion is less than 2.7 %, which is well within the limit specified by IEEE 519-1992.
- The maximum KVAR requirements with capacitors OFF, is 221 KVAR at 410volts.
- UPS & Feeder 3,6,8,20 demand nonlinear load and their total load is 228 KW, which is 40 % of total load. But overall effect of these harmonic at upstream is not harmful.

## UPS Input & Output parameters

UPS Input Parameter																	
Sr.No	Feeder Name	L-N Voltage		L-L Voltage		Voltage THD%		Line Current		Current THD%		KW		KVAR		PF	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	10KVA UPS Input (3-1)	238.00	238.80	418.24	419.70	2.00	2.20	2.63	2.65	22.00	24.90	1.48	1.48	0.18	0.17	0.939	0.94
2	20KVA UPS 1 Input (UPS Room)	241.60	243.40	418.22	421.50	1.50	1.80	12.33	13.30	68.21	69.50	5.91	6.47	6.23	6.66	0.687	0.698
3	20KVA UPS 2 Input (UPS Room)	235.30	236.70	409.30	411.90	1.60	1.90	12.70	13.90	64.32	66.00	6.45	6.88	6.39	6.68	0.709	0.721
4	20KVA UPS Input (Banquet Hall)	243.12	244.10	420.36	421.80	1.30	1.50	1.90	1.90	140.00	141.00	0.70	0.72	1.28	1.30	0.481	0.481

All the UPS appear to have thyristor based input rectifiers as input current distortion is substantial. Whenever these UPS are replaced, you may replace them with UPS having Active Front End type rectifiers, which will not draw heavy harmonic currents.

UPS Output Parameter																	
Sr.No	Feeder Name	L-N Voltage		L-L Voltage		Voltage THD%		Line Current		Current THD%		KW		KVAR		PF	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	10KVA UPS Output (3-1)	231.39	231.50			0.84	8.70	3.57	3.58	37.11	39.30	0.69	0.63	-0.45	-0.46	0.832	0.834
2	20KVA UPS 1 Output (UPS Room)	229.34	229.50	397.86	398.00	0.98	1.00	8.04	8.30	51.60	53.60	4.95	5.49	1.00	1.50	0.887	0.9
3	20KVA UPS 2 Output (UPS Room)	229.36	229.40	396.50	397.90	0.90	1.00	8.51	10.28	50.98	52.50	5.48	5.89	1.10	1.10	0.9	0.911

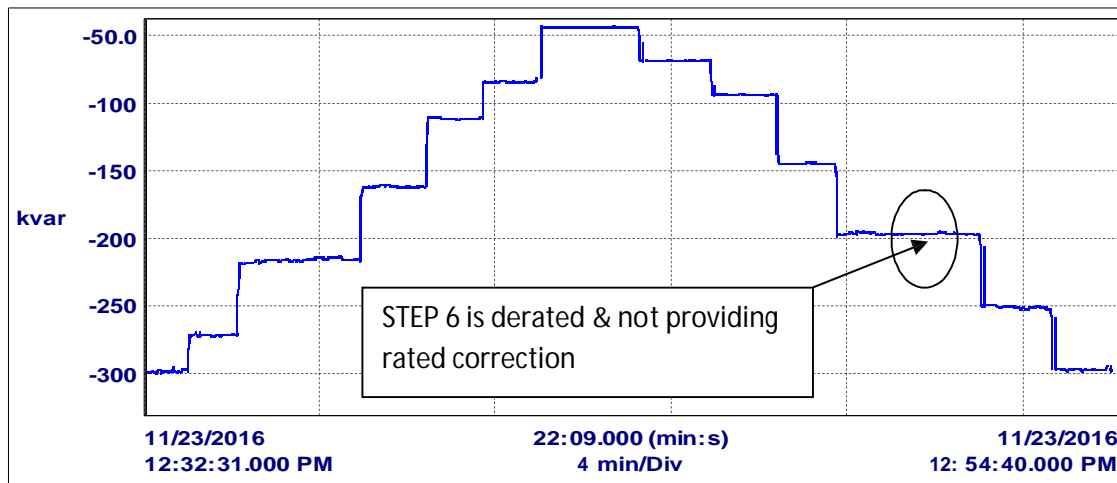
## Analysis of UPS systems performance

Performance of UPS installed in Hotel								
Sr no	Make	Rating (KVA)	Location	In KW	Out KW	THD I %	PF	Efficiency (%)
				MAX	MAX	MAX	MAX	
1	Emerson	20	UPS Room	6.47	5.49	69.5	0.698	84.85
2	Emerson	20	UPS Room	6.88	5.89	66	0.727	85.61
3	Emerson	10	Gym & Spa	1.48	0.63	24.9	0.94	42.57
	<b>Total</b>	<b>50</b>		<b>14.83</b>	<b>12.01</b>			

**Observations:**

- The total installed UPS capacity is 50 KVA and it is supplying 12.01 KW load. This is only 24 % utilization.
- The input power required to generate 12.01 KW uninterrupted power is 14.83 KW, hence total loss is 2.8 KW.
- Underutilized UPS systems demand large harmonic currents.

**Performance of APFC panels**



XXX has contactor based APFC Panel (with reactor) of 400 KVAR ,Which consist of 8 steps of 50 KVAR each. Bellow table shows KVAR correction provided by each step. It is seen that STEP 6 is derated and providing only 6 % KVAR correction. STEP 8 & STEP 3 are providing 58 & 60 % correction respectively. It is recommended that these capacitors should be replaced to achieve required KVAR.

## Earthing on LT side feeders in XXX

SR NO.	PANEL NAME	RESISTANCE ( $\Omega$ )	REMARK
1	<b>Transformer</b>		
	Body	0.15	OK
		0.18	OK
	Neutral	4.3	OK
2	DG Body	0.045	OK
3	<b>Main LT Room</b>		
	Capacitor Panel	0.22	OK
	Distribution panel	0.25	OK
4	<b>UPS Room</b>		
	MDB -1	0.075	OK
	UMDB-1	0.091	OK
	UPS 1 I/O	0.94	OK
	UPS 2 I/O	0.93	OK
5	<b>Stilt Floor</b>		
	MDB-2	0.15	OK
	Dimmer panel	0.070	OK
	UPS DB	OPEN	Need Correction
6	MCC-3 (Bomb Area)	0.026	OK
7	<b>First Floor</b>		
	MDB-3	0.20	OK
	MDB-4	0.080	OK
8	<b>Second Floor</b>		
	MDB-5	0.093	OK
	MDB-6	0.11	OK
9	<b>Third Floor</b>		
	MDB-7	0.12	OK
	MDB-8	0.075	OK
10	<b>Terrace Area</b>		
	MCC-7-AVRV	OPEN	Need Correction
	MCC-8-AVRV	0.19	OK
11	<b>MDB</b>		
	Gym & Spa	OPEN	Need Correction
	Changing Room	OPEN	Need Correction
12	Banquet Hall Panel	0.31	OK
13	New Temp Banquet Hall	0.42	OK
14	MCC-5	0.083	OK
15	MCC-6	0.23	OK
16	Feeder Piller New Temp Banquet	1.30	OK
17	Tent Banquet MCC Panel	OPEN	Need Correction

### Observations & Recommendation

Earthing resistance was measured at strategic points in electrical distribution of XXX using loop testing method and the results are tabulated above. Some earthing was found open and remarks for the same are mentioned above. It is recommended that the 'open' earthing should be corrected as soon as possible.

### Lightning Arrestor

1. The tallest structure on XXX terrace is a mobile tower. On physical inspection it was found that the tallest protruding part of this structure is earthed. It is recommended that XXX should use a correctly designed conventional LA system as per IS 2309 (1989 as amended)

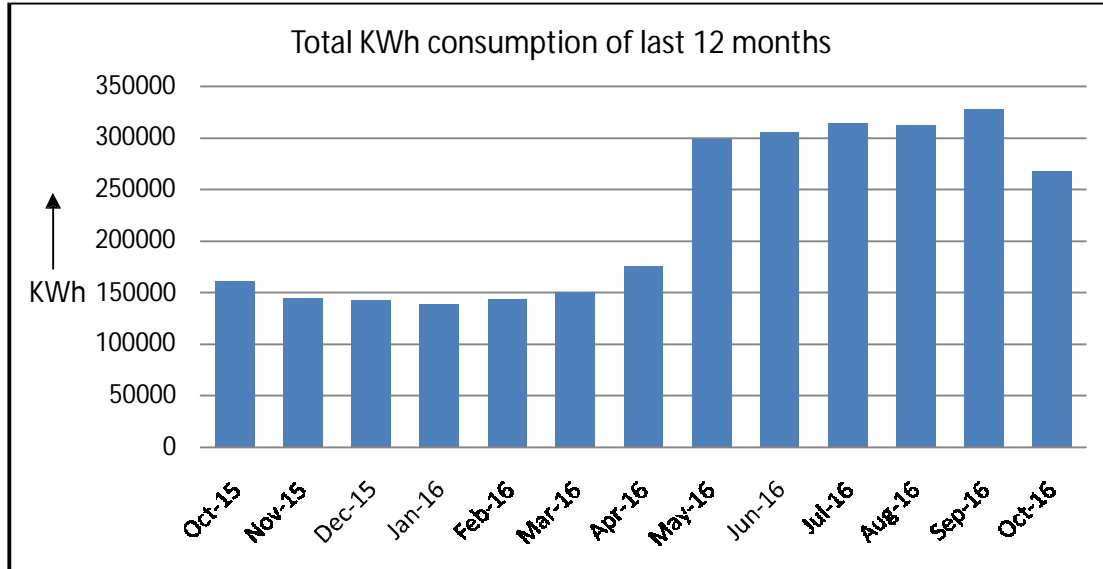
### Current and voltage Harmonics compliance limits:

- 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	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
<b>100&lt;1000</b>	<b>12</b>	<b>5.5</b>	<b>5</b>	<b>2</b>	<b>1</b>	<b>15</b>
>1000	15	7	6	3.5	1.4	20

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

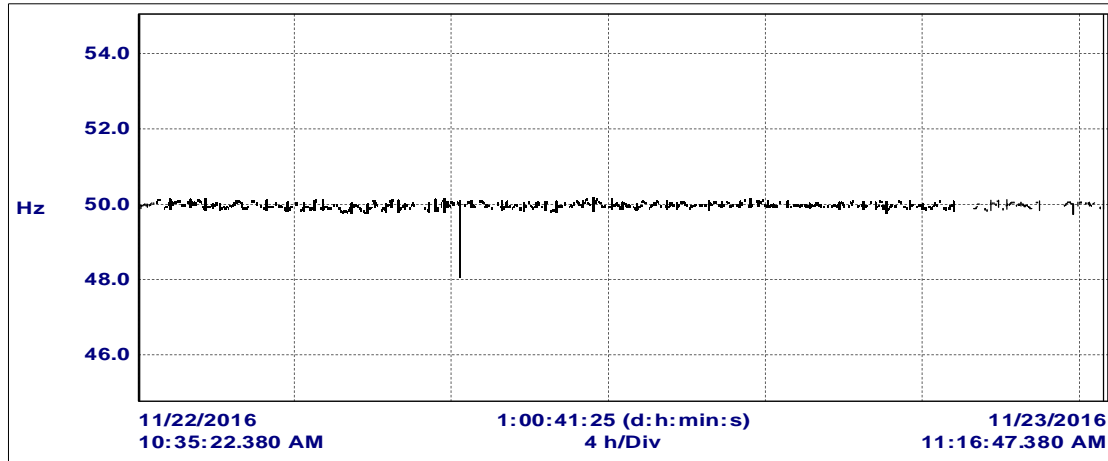
## Electricity Bill & PF History



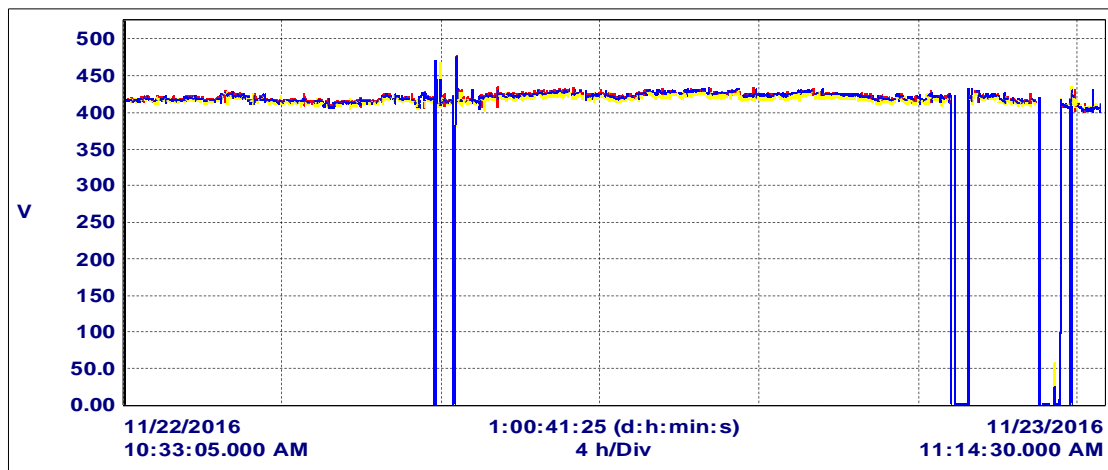
The data of total energy consumption of XXX for 12 months are plotted above. Till April 16 the Avg Monthly energy consumption was 150070 KWh. But after May 16, it has increased to 304588 KWh i.e. twice of previous Avg Monthly energy consumption.

# MAIN TRANSFORMER INCOMER

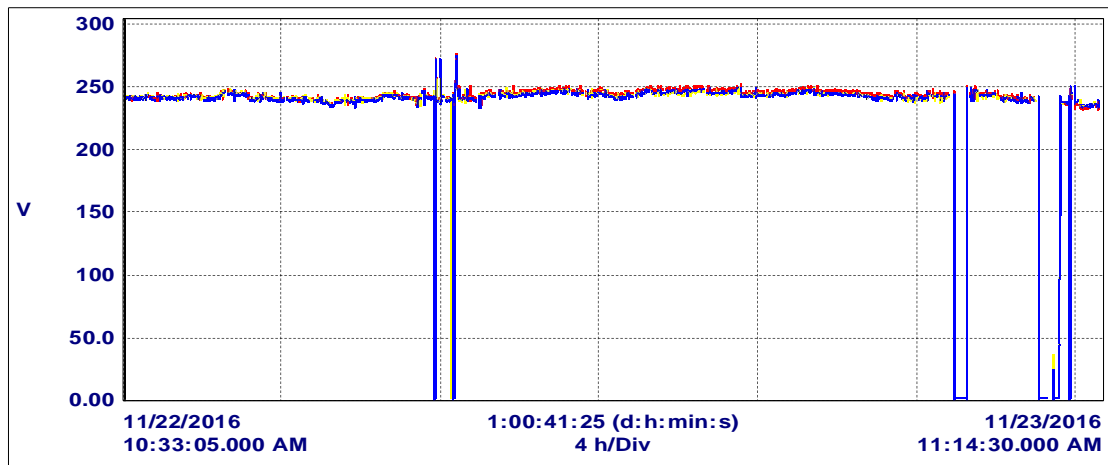
Frequency



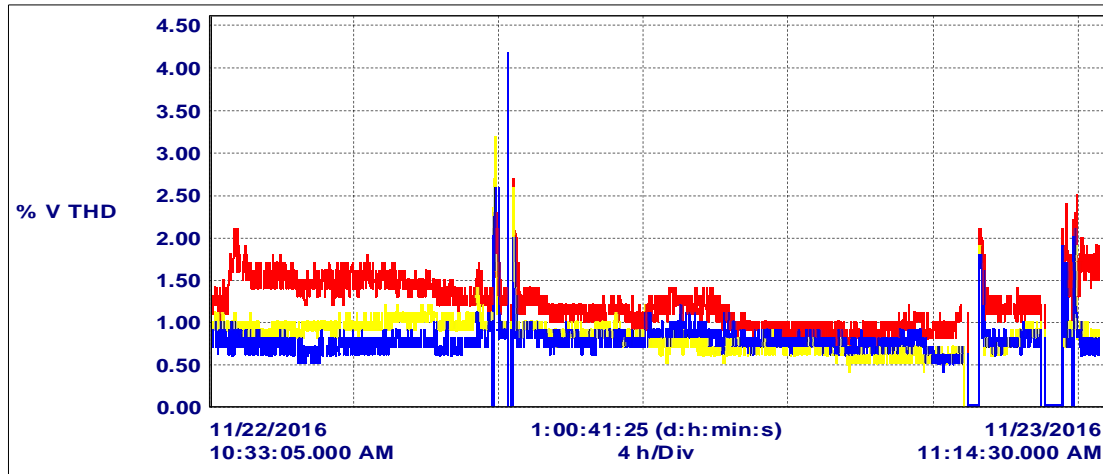
Voltage L-L



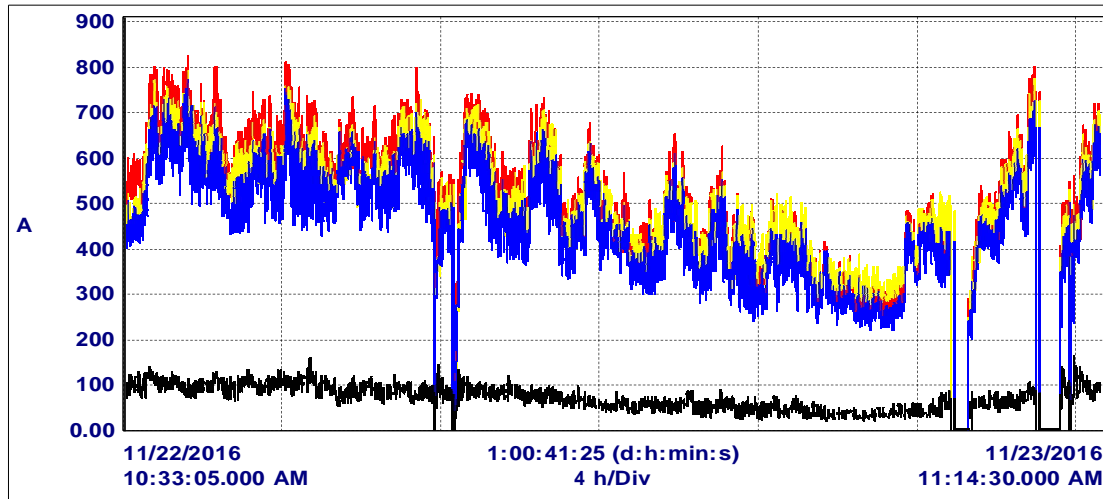
Voltage L-N



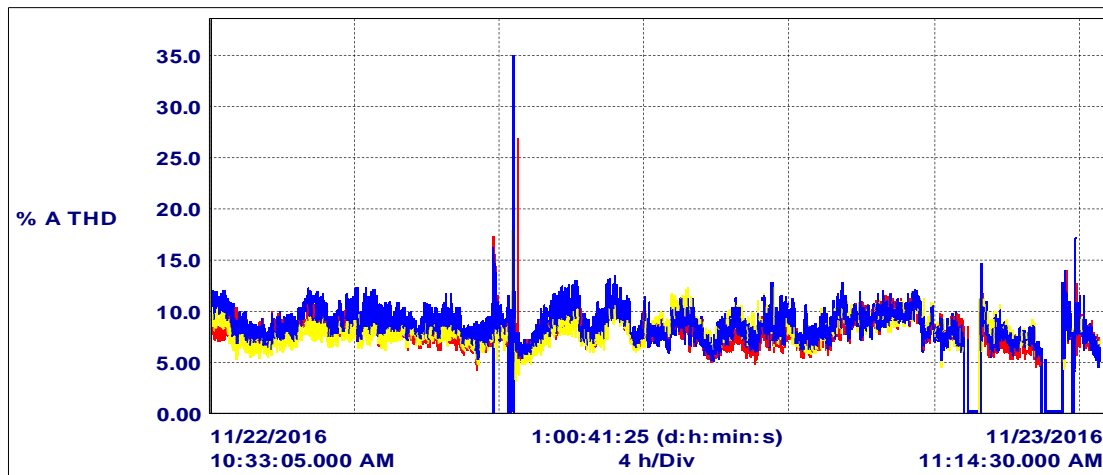
### Voltage Harmonic distortion



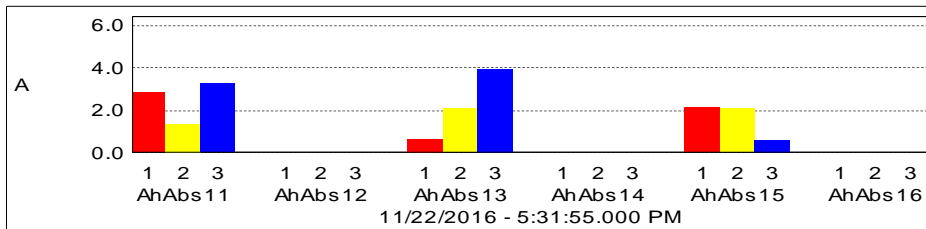
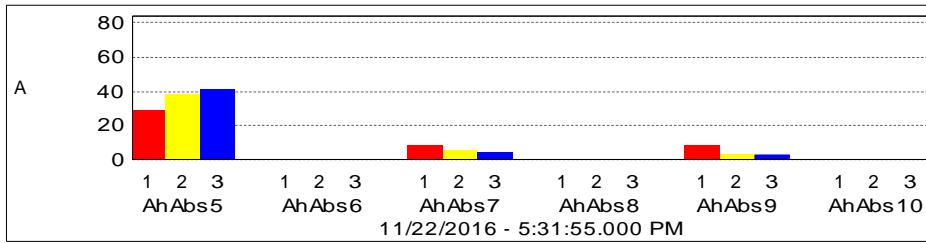
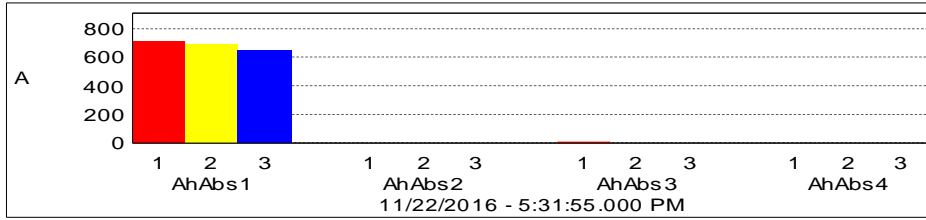
### Current



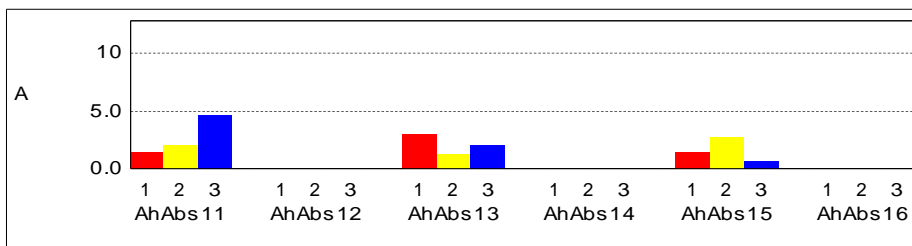
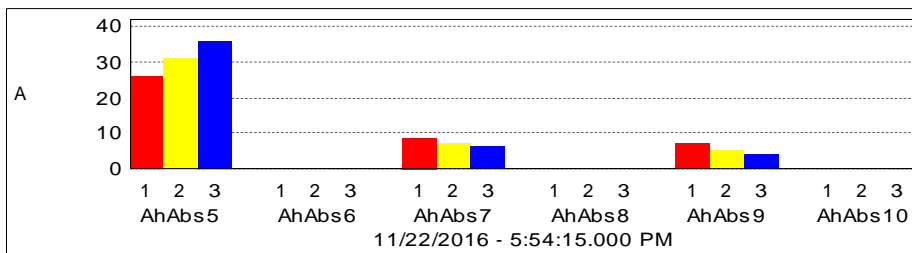
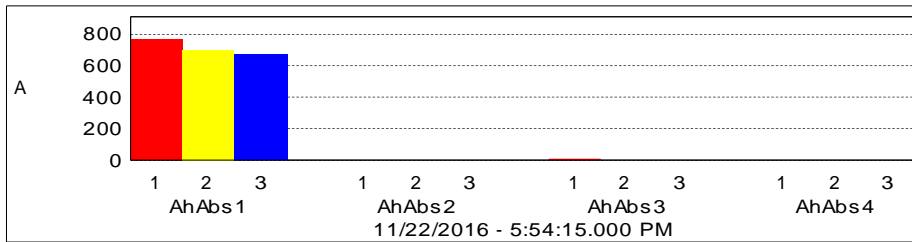
### Current Harmonic Distortion



### Individual Current Harmonics With APFC Panel ON

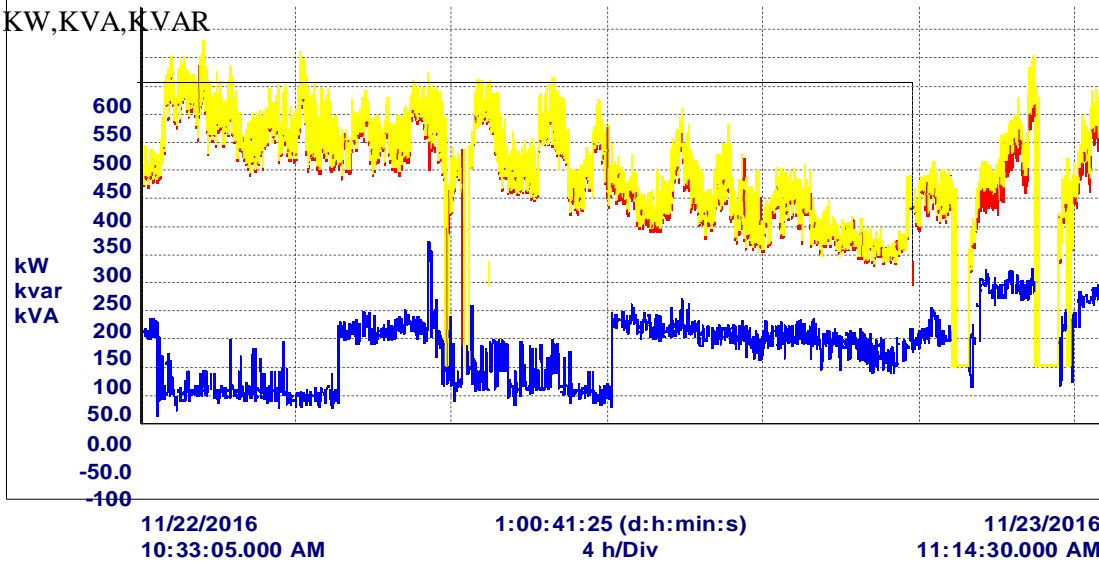


### Individual Current Harmonics With APFC Panel OFF





KW,KVA,KVAR



PF

