

HARMONIC ANALYSIS REPORT

FOR

Leading Yeast Manufacturing Company

Lote Parshuram

By

SAS Powertech Pvt. Ltd.

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Audit Period: 19th May to 20th May 2017

INDEX

Sr.No	Description	Page No.
1	Index	2
2	Site Details	3
3	List of Abbreviation	4
4	A note on Power factor, Voltage & current distortion	5
5	Description of Electrical Infrastructure	6
6	Transformer wise recommendation	7
5	Power Quality Parameter of all recorded Feeders	8
6	Current and Voltage harmonic compliance limit	9
7	Recorded data and Observation	10 to14
8	Transformer/Feeder Wise Loading	15

SITE DETAILS

<p>SiteName</p>	<p>Leading Yeast Manufacturing Company Lote Parshuram</p>
<p>ContactPerson</p>	
<p>AnalysisPeriod</p>	<p>19th and 20th May 2017</p>
<p>Audit Conducted By</p>	<p>Mr. Narendra Duvedi (BEE Certified Energy Auditor, Chartered Engineer) Mr. Sandesh Biramane(Measurement Engineer)</p>
<p>Equipment Used For Analysis</p>	<div data-bbox="755 787 1153 1291" data-label="Image"> </div> <p>KRYKARD ALM35 Power Quality Analyzer Chauvin Arnoux, France</p>

LIST OF ABBREVIATION

MLTP	MainLTpanel
PQA	Powerqualityanalysis
Vrms	Phasetoneutralvoltage
Urms	Phasetophasevoltage
Arms	Current
Avg.	Average
Min.	Minimum
Max.	Maximum
Ithd	Totalharmonicsdistortionincurrent
Vthd	Totalharmonicsdistortioninvoltage
PF	Powerfactor
PCC	Powercontrolcircuit/pointof commoncoupling
TDD	Totaldemanddistortion
THD	Totalharmonicsdistortion
MERC	Maharashtraelectricityregulatorycommission
DB	Distributionboard
DG	Dieselgenerator
LT	Lowtension
IEEE	Instituteof electricalandelectronicsengineers
NEC	Nationalelectriccode
SLD	Singlelinediagram
UPS	Uninterruptedpowersupply

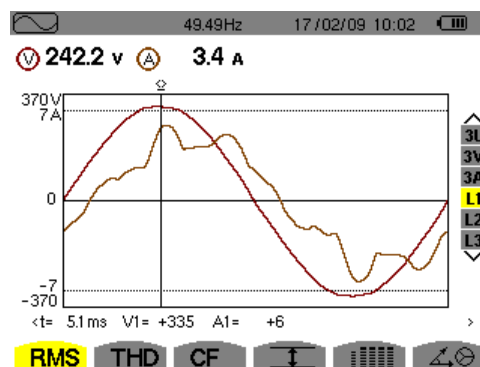
COLOUR CODE

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

A note on Power factor, current and voltage harmonic distortion

1. Power factor is characteristics of load and varies from -1 - 0 +1. Resistive loads like bulbs, heaters etc take current at unity power factor (i.e.1). Other loads like electric motors, computers, UPS systems, tube lights etc take current at power factors which are less than 1.
2. Electrical Power = $V \times I \times \text{Cos}\phi(\text{PowerFactor})$
3. One can take 100 watts of electrical power at 100 volts by taking 1 Amp current, if power factor is 1, while if power factor is 0.5, then the current required will be 2 Amps for delivering same power of 100 watts.
4. One unit of electricity = 1Kilowatt x 1 Hr. If we use 1 KW for 1 hour then the utility meter advances by 1 unit.
5. It is clear from above that if power factor is low, utility company (Like MSEDCL) has to supply us more current while delivering same power but gets same revenue from us.
6. Infrastructure investment done by utility company is more for delivering more current, so for these commercial reasons, they insist on better power factor and offer incentives.

Non linear loads like computer power supplies, VFDs, UPS systems, electrical arc furnaces, Plating rectifiers, and Battery chargers take non sinusoidal current while sinusoidal voltage is applied to them. This is shown in waveforms below.



Mathematically it can be proved that these non sinusoidal currents are made up of sinusoidal currents having frequencies which are integral multiples of fundamental frequency i.e. 50 Hz. These ($3^{\text{rd}} = 150\text{Hz}$, $5^{\text{th}} = 250\text{Hz}$, $7^{\text{th}} = 350\text{Hz}$ etc) currents cause overheating of transformers, cables, switchgears etc due to increased losses requiring their de-rating for normal operation. Excessive current harmonics cause voltage harmonics distorting the voltage waveform. This can further cause harmonic currents in linear loads. This causes increased losses, vibrations in electrical motors, malfunctioning of electronic controls due to generated electromagnetic noise, Unwanted erratic tripping of circuit breakers due to overheating etc.

In electrical distribution networks, having presence of harmonic currents, if only capacitors are added to improve system power factor, there is a possibility of amplification of these harmonics due to resonance created by transformer inductance and these capacitors. This should be avoided by using **detuned L – C filters** or harmonic filters in place of capacitors. Utility companies also make it mandatory for consumer to control harmonics generated by his load as it improves their revenue potential by avoiding de-rating. (MSEDCL document supply code 2005 and IEEE 519 1992). **Active filters** are electronic filters and they suppress harmonics. These are specially designed power electronic circuits, which take anti phase current from source which is equal and opposite of non linear component of load current.

Description of electrical infrastructure at plant:

This plant receives 33KV from MSEDCL and is distributed to 2 x 2500KVA transformers and stepped down to 440volts.

Transformer 1 secondary is distributed to 17 PCC/MCC/ DBs as per plant – process requirement and is further distributed to last mile loads. Most of these power distribution centers have fixed type power factor improvement capacitors and the transformer main secondary is also equipped with a 250KVAR APFC panel.

Transformer 2 secondary is distributed to 7 PCC/MCC/ DBs as per plant – process requirement and is further distributed to last mile loads. Most of these power distribution centers have fixed type power factor improvement capacitors and the transformer main secondary does not have a APFC arrangement.

Average plant load is about 1680KW while the peak is around 2000KW. Although individual transformers are not compensated closely for reactive power, the combined effect as reflected to 33KV side and as averaged over 30 days billing cycle, gives almost unity PF and plant avails power factor incentive.

The high HP blowers, while recorded were working at around 0.79 and 0.68PF and were underloaded. If as per process demand, they are required to run at this PF and load for most of the time, then it is advised that their reactive power requirement should be compensated partly at load end using fixed detuned filters.

Similarly, RO+ME MCC, ETP MCC and MCC4A also need partial compensation locally. It is advised to use detuned filters to avoid harmonic amplification. Following are transformer wise recommendations.

Following distributed correction offered may be retained.

Tr1			Tr 2		
Feeder	KW	Fixed KVAR	Feeder	KW	Fixed KVAR
Air Comp	28.00	25.00	MCC2A	112	100
MCC 3B	45.00	50.00	MCC 1A	65	75
MCC 1	116.00	75.00	Chiller detuned	28	66
M Dryer	80.00		MCC 6F	42	75
MCC 4B	41.00	50.00			
ETP	50.00				
MCC 4D	20.00	25.00			
Bakery	56.00	25.00			
MCC 4F	173.00	50.00			
MCC2	32.00	75.00			
Total	641.00	375.00		247	316

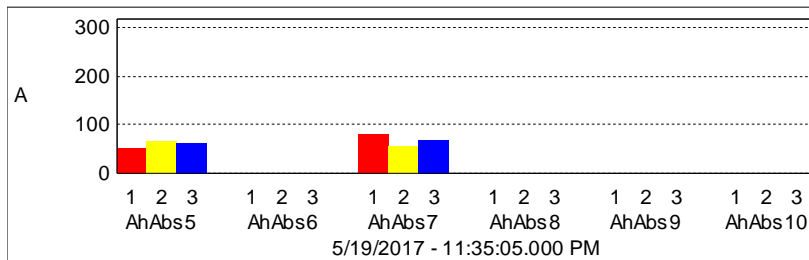
So average 300KVAR may be reduced from actual total requirement for each transformer.

Sr	Feeder	KVAR requirement	Recommendation
1	Tr 1	866KVAR – 300KVAR @1300KW load at 415Volts 950 KVAR@ 525V	850 KVAR@525V
	Blower 2	115	100KVAR@525V
	ETP	40	50KVAR@525V
	MCC 4A	89	100KVAR@525V
	Uncompensated requirement		150KVAR@525V
2	Tr2	850KVAR – 300KVAR @1100KW at 415Volts 900 KVAR@ 525V	1100 KVAR@525V
	RO+ME feeder	130	100KVAR@525V
	Blower	240	100KVAR@525V
	Uncompensated requirement		400KVAR@525V

Recommended new procurement

Tr 1:

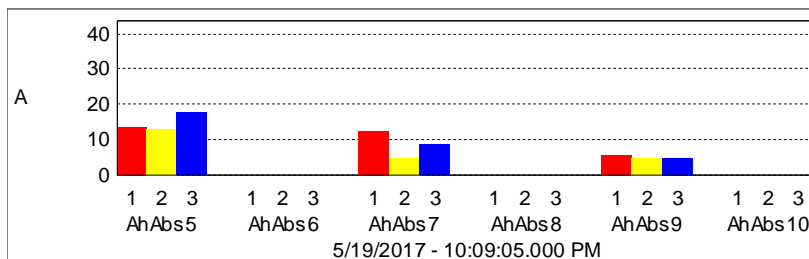
- Centrally: 850KVAR@ 525V x 1
- For Blower 2: 100KVAR@ 525V x 1 Fixed
- For ETP : 50 KVAR@525V x 1 Fixed
- For MCC 4A: 100KVAR@525V x 1 Fixed



In view of compensating these harmonic currents further you may install 1 x 100A active harmonic filter centrally.

Tr2:

- Centrally: 1100KVAR@525V x 1
- For RO+ME 100KVAR@525V x 1 Fixed
- For Blower 3: 100KVAR@525V x 1 Fixed.



In view of compensating these harmonic currents further you may install 1 x 60A active harmonic filter centrally.

PQ Parameters of all recorded feeders

HT 33KV															
Sr.No	Feeder Name	Voltage L-L		Voltage THD%		Current		Current THD%		KW		KVAR		PF	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	HT 33KV	33.8	34.5	1.8	2.3	30.1	45.6	4.0	8.0	1683	2095	247	1630	0.976	0.999

Transformer-01																	
Sr.No	Feeder Name	Voltage L-N		Voltage L-L		Voltage THD%		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 Tr-01	247.9	255.3	429.4	440.6	2.9	3.9	1331	1761	7.3	19.8	944	1284	-205	156	0.972	0.998
2	Air compressor (86TR)	243.9	245.4	414.2	423	3.2	3.7	46	87.5	5.9	11.5	48.4	56.9	6.6	10.7	0.990	0.992
3	ETP	248.6	250.4	430.1	434.3	2.9	3.1	91.4	94.5	5.3	5.8	49.7	51.7	40.1	41.1	0.778	0.794
4	Intigrated & bakery Plant	251.9	253.1	435.3	437.9	2.8	3	134.5	153.7	20.7	27.9	56.3	66.3	3.2	14	0.979	0.990
5	Maleshian S3 Dry	245.5	248	424	428	2.9	3.5	123.8	125.5	3.7	4.2	80.3	81.3	36.8	37.3	0.909	0.910
6	MCC 4 F	252	252.6	435.3	436.5	2.8	2.9	251.4	253.9	2.4	2.7	173.5	175.3	61.2	61.6	0.943	0.944
7	MCC 1	243.4	247.4	418.4	419.8	2.9	2.8	167.8	176.1	4.1	4.8	116.1	121.9	28.2	31.1	0.972	0.973
8	MCC 1 B	248.9	250.4	429	432.2	2.8	3.4	188.3	211	26.3	28.3	45.1	66.2	-131	-147	0.390	0.376
9	MCC 3B	243.1	247.6	420.1	423.8	3.3	2.8	77.4	119.6	12	18.8	45.3	62.4	15.7	57.9	0.863	0.987
10	MCC 4E	249.9	252.6	435.1	440.1	2.7	3.3	25.1	25.4	4.3	5.2	14	14.3	11.4	11.8	0.774	0.783
11	MCC-02	251.7	256.1	432.4	435.8	2.6	2.7	75	90.1	14.8	22.1	30.6	33.6	-24	26.8	0.603	0.989
12	MCC-3A	246.1	248.1	419.6	424.8	3	3.7	58.9	69.2	23.9	27.9	32.5	37.8	0.46	31.4	0.858	0.950
13	MCC-4A	252.4	253.3	434.6	436.9	2.7	2.9	183.3	186.8	5.1	5.5	120	122	64.7	65.7	0.880	0.885
14	MCC-4B	246.5	248	425.5	428.1	2.9	3.1	64	117.9	3.8	6	41.3	67	6.9	43.1	0.974	0.983
15	MCC-4D	250.5	253.3	431	435.5	2.7	3	81.1	87.7	16.5	19.6	20.4	21	-50	13.2	0.389	0.907
16	MLDB 1	252.1	255.4	433	440	2.7	3.2	67.7	62.7	6.8	8	27.4	31	13.2	16	0.886	0.904
17	Root blower 2	243.1	245.1	418	420	3.2	3.5	220.9	222.4	7.8	8.4	105.1	106.6	114.9	116.2	0.675	0.680

Transformer-02																	
Sr.No	Feeder Name	Voltage L-N		Voltage L-L		Voltage THD%		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 Tr-02	250.3	256.7	432	443.1	1.8	2.3	1104	1860	2.9	4.8	750	1105	250	420	0.919	0.985
2	150TR Chilling 3	251.8	252.8	434.1	436.3	2.1	2.3	55.8	59.7	10.4	12.5	28.5	32.7	-27	25.2	0.680	0.777
3	Blower No.3	251.9	252.3	433.8	436.1	2.1	2.3	280	298	3	8.2	176.7	179.1	119.9	125	0.82	0.830
4	MCC 1A	250.9	252	432.7	434.9	2.1	2.3	105.5	111.9	4.4	4.9	65.3	68.8	37.1	68.8	0.868	0.878
5	MCC 6F	251.2	254.1	435.4	437.9	1.9	2.2	79.4	155.5	10.2	22.7	40.5	42	8.4	47.8	0.750	0.975
6	MCC-2A	251.1	251.6	432.6	434.5	2	2.3	150.7	153.5	5.7	6.1	112.7	113.7	-1.7	-1.9	0.997	0.998
7	RO + MEE	250	252.8	432.2	434.5	2	2.3	319	365.3	9.7	13.7	201.3	222.4	120	151	0.858	0.862
i)	MEE Plant	251.1	253	433	436.8	2.1	2.5	79.3	105.1	4.8	5.8	46.2	59.4	36.1	49	0.787	0.865
ii)	PTRO 1	250	251	431.6	433.4	2.4	2.6	184.4	185.3	10.2	10.7	118.9	119.4	63.5	63.8	0.882	0.883

Current and voltage Harmonics compliance limits:

- As per international standard practice and the practice followed by MSEDCL, 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.
- This ratio decides % loading of MSEDCL transformer by consumer load. Obviously lesser is the ratio, lesser harmonics are allowed as consumer becomes larger part of the distribution system formed by MSEDCL transformer and has more capacity to pollute the same due to harmonics.
- As per the standard, % total harmonic distortion (THDI %) under this consideration is called TDD i.e. Total Demand Distortion.

Current harmonics level compliance limits as per IEEE 519 – 1992

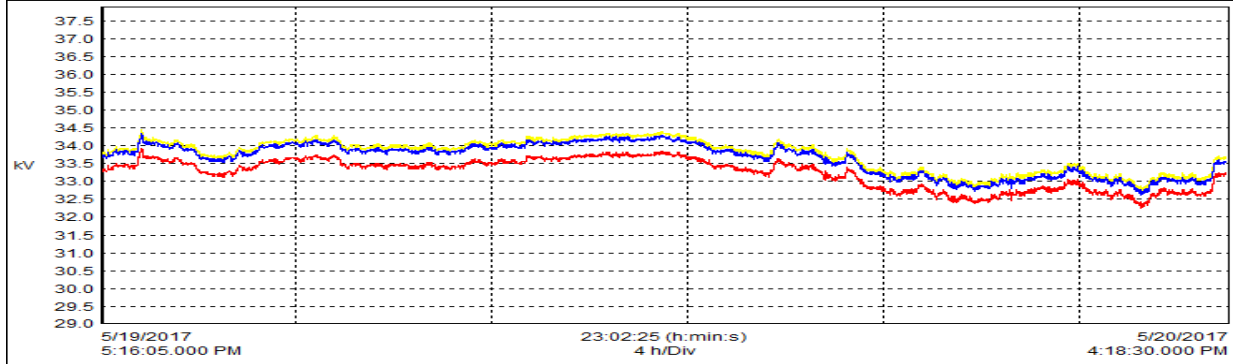
Maximum harmonic current distortion in percentage of I_L						
Individual harmonic order (odd harmonics)						
I_{sc}/I_L	<11h	11≤h<17	17≤h<23	23≤h<35	35≤h<49	TDD
<20	4	2	1.5	0.6	0.3	5
20<50	7	3.5	2.5	1	0.5	8
50<100	10	4.5	4	1.5	0.7	12
100<1000	12	5.5	5	2	1	15
>1000	15	7	6	3.5	1.4	20
Even harmonics are limited to 25% of odd harmonic limits above.						

Parameter	Value
MSEDCL Transformer Capacity MVA	20
HT Primary Voltage - kV	220
HT Secondary Voltage - kV	33
Z % (Impedance)	6.7
Contract Demand KVA	3251
Max Load Current I_L Amps on LT Side	3429
Max current as per contract demand on LT Side AMPS	4334.921
Max Load Current I_L Amps percentage on LT Side	79.10
Full Load current of MSEDCL Transformer Amps	349.92
Short Circuit current of MSEDCL Transformer I_{sc} Amps	5222.68
Plant current as per contract demand on HT side	56.95
Plant Average load current on HT side	45.04
I_{sc} / I_L Ratio as per contract demand	91.71
I_{sc} / I_L Ratio as per Average Plant Current	115.94

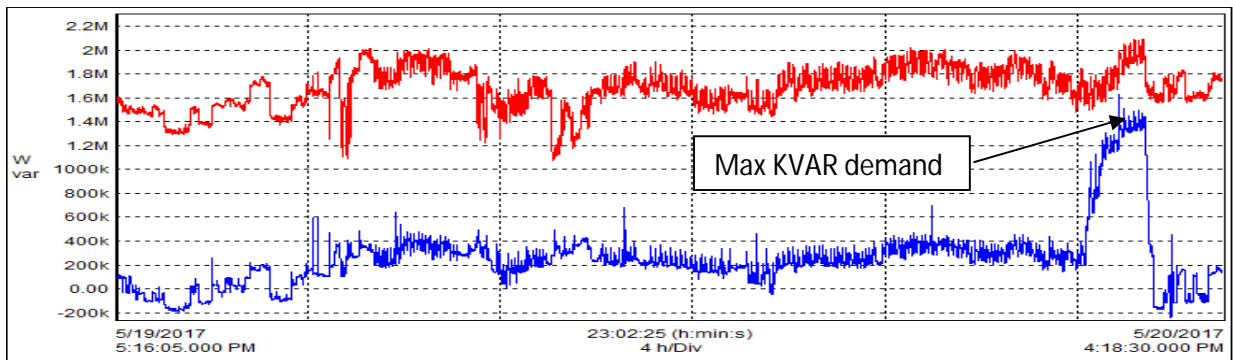
As per Contract Demand current harmonics compliance limit is 12% and plant Max current the current harmonics compliance limit is 15%. It is advised to control the same below 12%.

33KV common PCC

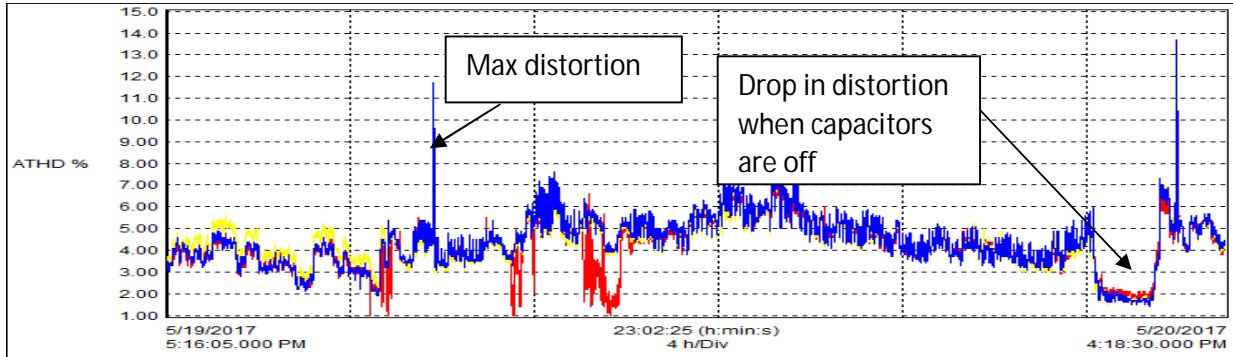
KV



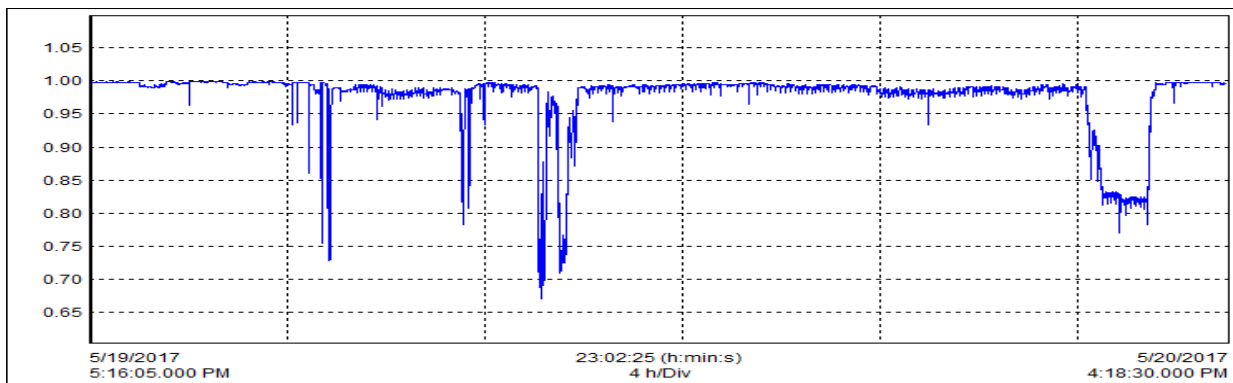
KW and KVAR



Total Current harmonic distortion

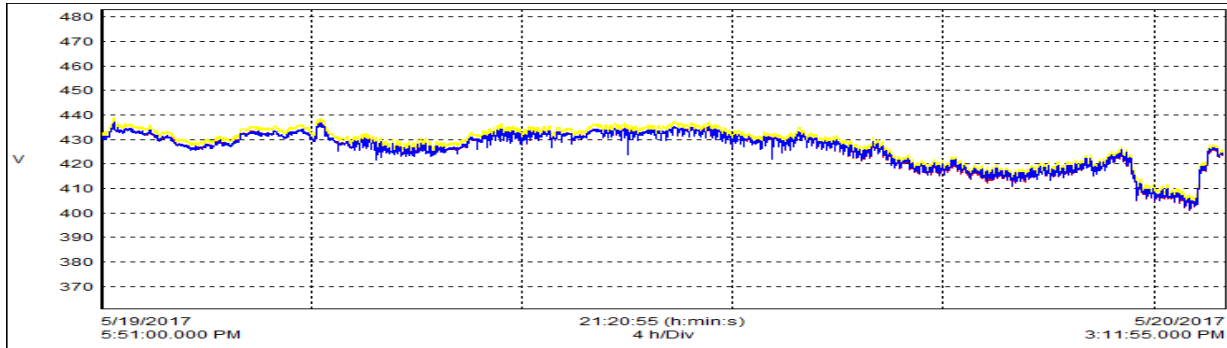


Power factor

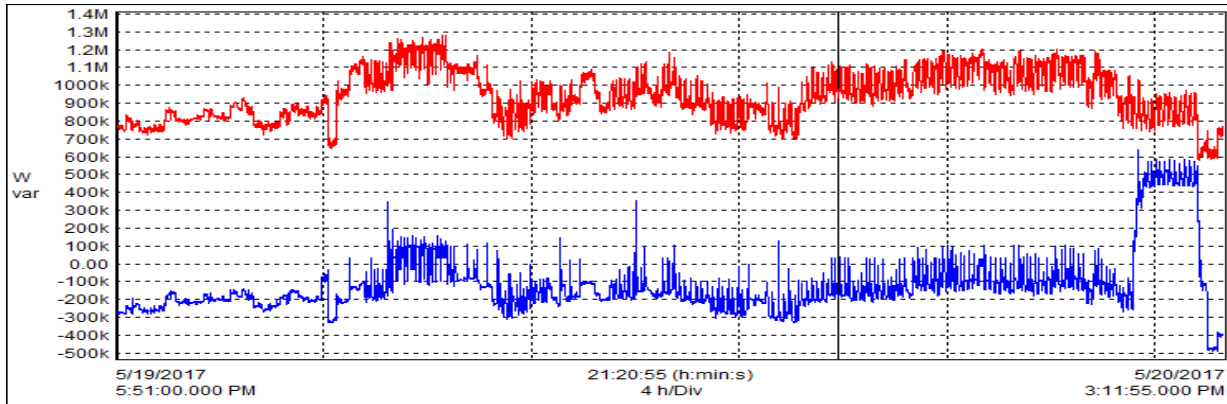


TR1

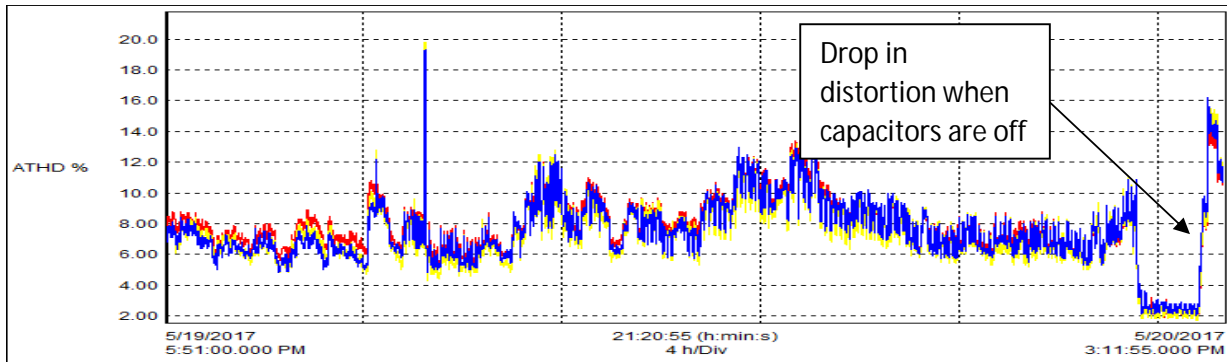
Voltage L-L



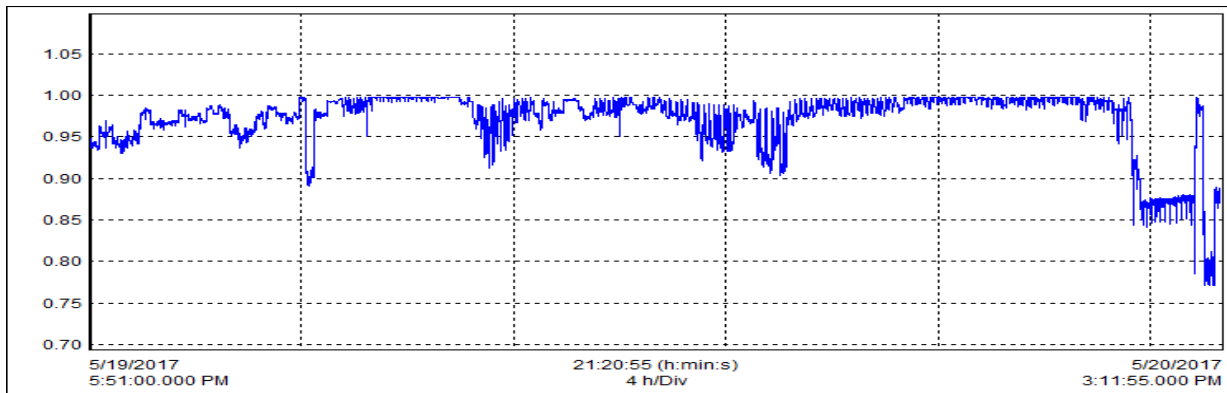
KW, KVAR



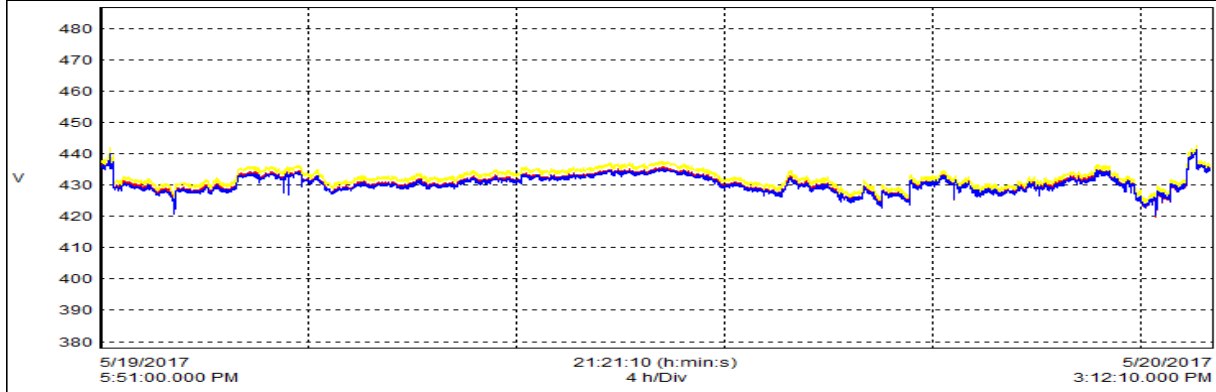
THDI %



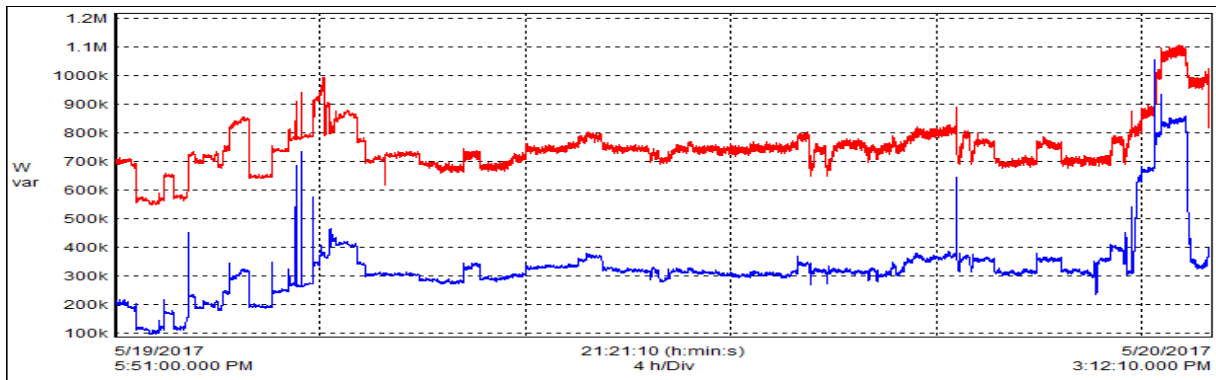
PF



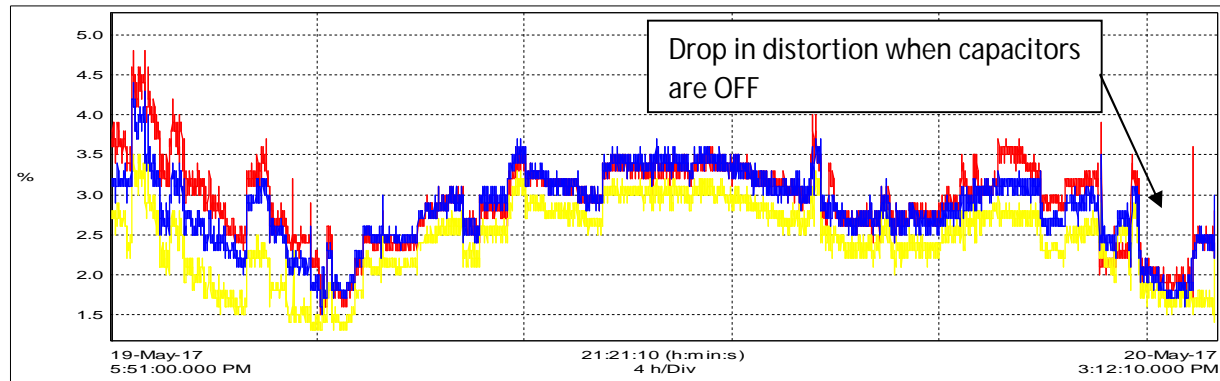
TR2
Voltage



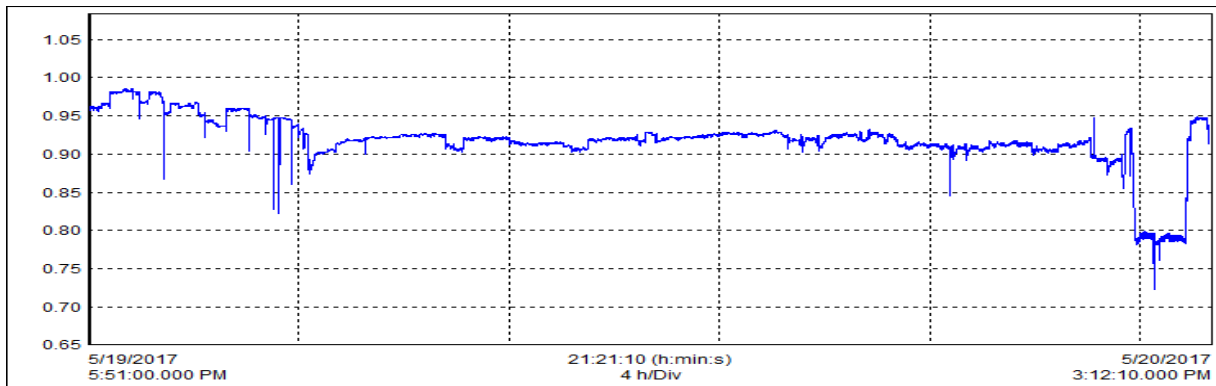
KW KVAR



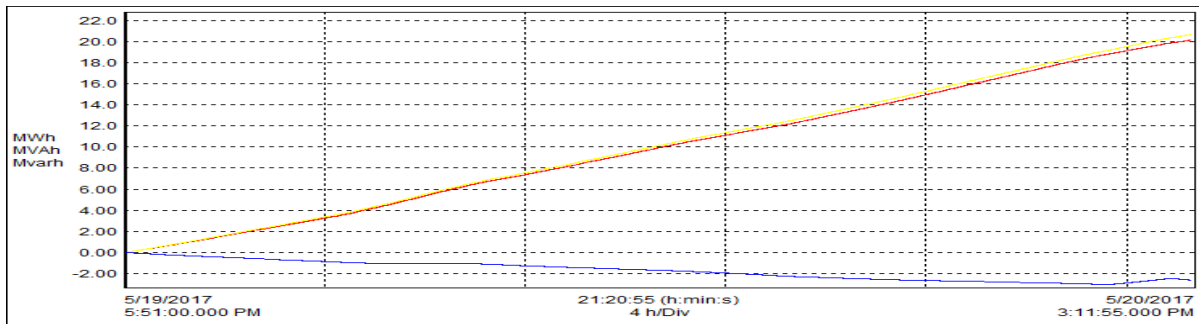
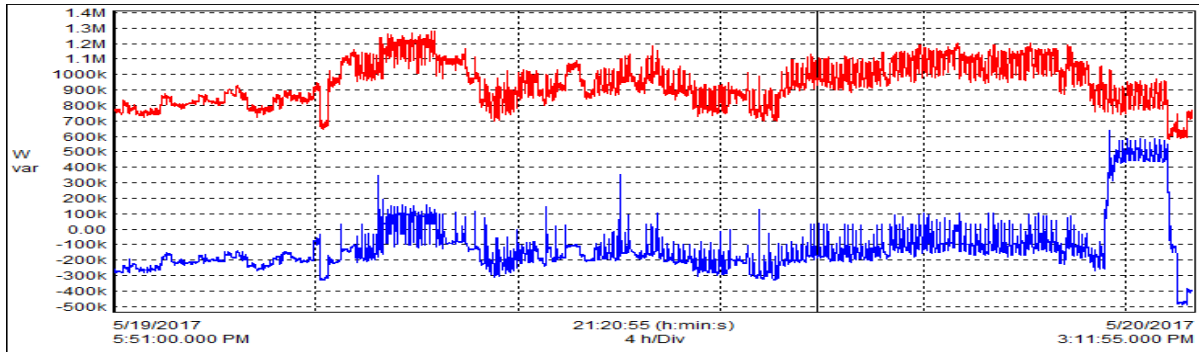
THDi%



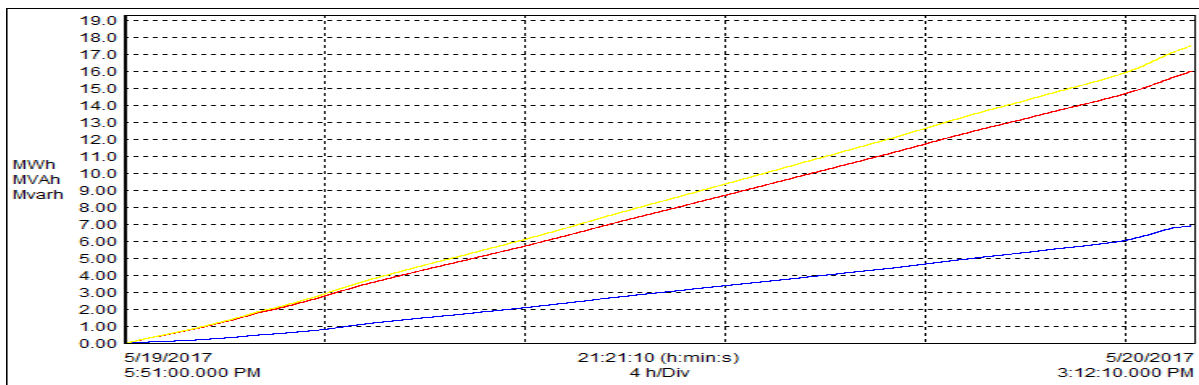
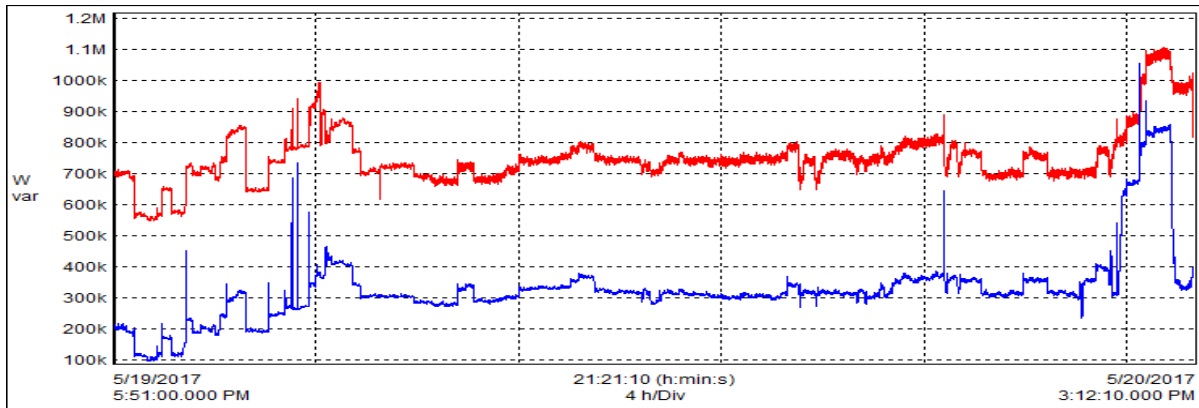
PF



Tr1
KW, KVAR



Tr2
KW, KVAR



Location	KW	KVAR	THDi %	PF	KWh	KVArh
33KV	1683	247	7.2	0.976 lag	38773	5693
Tr 1	944	-123	11.5	0.972 Lead	20145	-282
Tr 2	750	324	4.5	0.919 Lag	16010	6919
Tr 1+ Tr2	1694	201			36155	6637

Observations:

- 1) Average load on day of audit as seen from 33KV side is around 1683KW and about 247 KVAR remain uncompensated giving average PF of 0.976 Lag. The consumption in approximately 24 hours is 38773 Kwh.
- 2) At 2000KW peak load with all capacitors in the plant in OFF mode, the reactive power requirement is about 1600KVAR and the current distortion is around 7.2%
- 3) Transformer 1 is over compensated for reactive power when all downstream – last mile capacitors and the 250KVAR panel is ON. The power factor is 0.972 lead and current distortion is around 11.5%.
- 4) Transformer 2 is under compensated for reactive power when all downstream – last mile capacitors are ON. The power factor is 0.919 Lag and current distortion is around 4.5%.

Transformer / feeder wise loading

Tr1

Tr1					Proposed	Uncompensated
Feeder	Fixed KVAR	KW	KVAR	THDi%	Detuned KVAR	KVAR
Air Comp	25	28	6.62	11	0	31
MCC 3B	50	45	16	17	0	66
MCC 1	75	116	28	4.7	125	0
Root Blower	50	105	115	8.5	175	0
M Dryer		80	36	4	0	36
MCC 3A	75	32	0.462	28	0	75
MCC 4B	50	41	7	8	0	50
ETP		50	40	5.5	0	40
MCC 1B	182	52	-142	25	50	0
MCC 4D	75	20	-57	17	0	25
Ingred Bakery	25	56	3	27	0	25
MLDB 1		27	13	8	0	13
MCC 4E		14	11	5	0	11
MCC 4A	25	120	64	5.5	100	0
MCC 4F	50	173	61	2.5	125	0
MCC2	75	32	-52	22	0	25
		991			575	397

As shown in table above, MCC1, Root blower, MCC1B, MCC4A, MCC4F form almost 60% KW load on this transformer. At present, almost all the feeders have last mile fixed PF compensation. We advise that 5 feeders mentioned as above can have fixed detuned correction as given in "proposed detuned KVAR" column above and rest can be removed. 400KVAR detuned with suitable steps