TECHNICAL WORKSHOP ON
Power Quality in Secondary Steel Industries
"Economic Impact of Poor Quality"

Interactive Workshop

On PQ Application Note for Secondary Steel Industry

Raipur / Nagpur

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ASIA POWER QUALITY INITIATIVE

Power Quality Definition

•P = V x I

Power – product of Voltage and Current

Power Quality

→ Voltage Quality

→ Current Quality

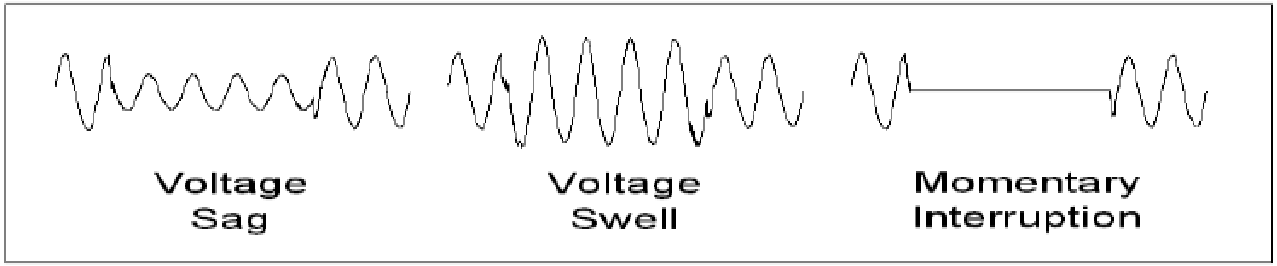
• **Formal definition of PQ:**

IEEE: PQ= the concept of powering equipment in a manner that is suitable to the operation of that equipment.

PQ problem = any power problem manifested in V, I or frequency deviations that result in failure/mal-operation of system and or customer equipments.

Voltage Quality Issues

1. Impulses/Transient: High magnitude for extremely short duration.
2. Voltage Sag: A momentary voltage dip that lasts for a few seconds.
3. Voltage Swell: A momentary voltage rise which lasts for a few seconds

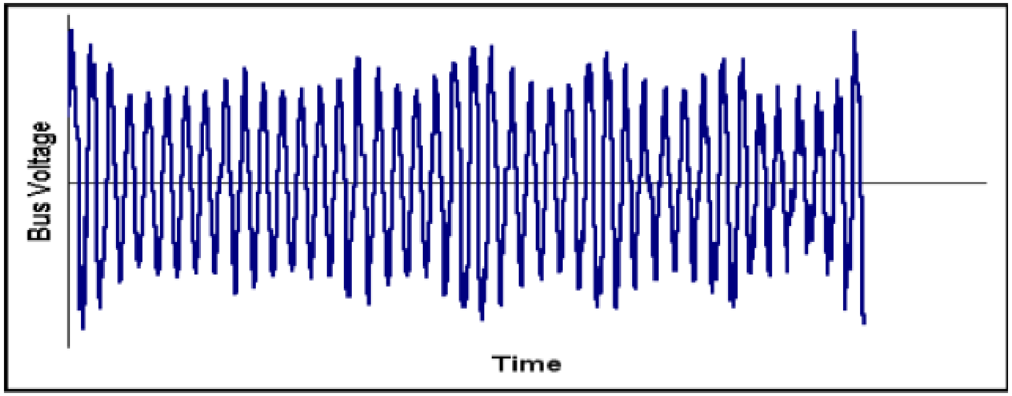


4. Over Voltage: A steady state voltage rise that lasts for SEVERAL seconds

Voltage Quality Issues

5. Under Voltage: A steady state voltage dip lasting for SEVERAL seconds

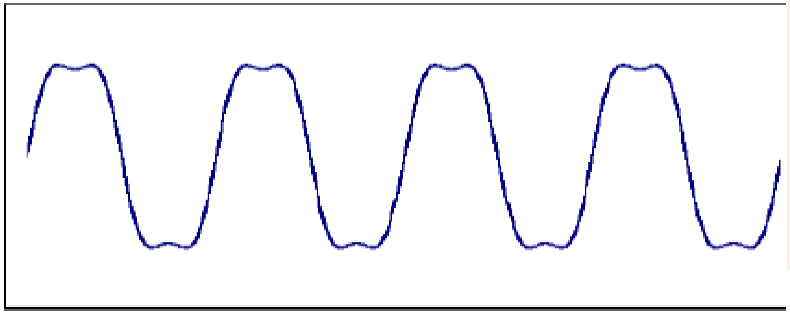
6. Flicker: A perceptible change in lamp output due to a sudden change in voltage



Example: voltage waveform showing flicker created by an arc furnace

Voltage Quality Issues

7. Harmonics: The non-fundamental frequency components of a distorted power frequency waveform.



Distorted Voltage Waveform

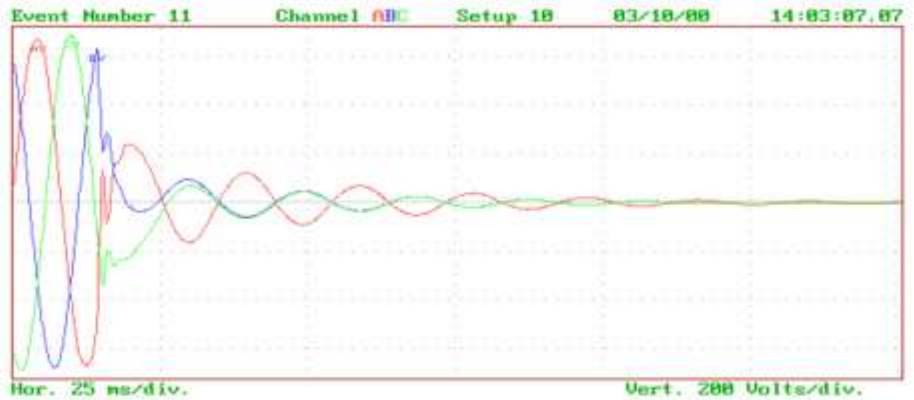
8. Voltage Interruption: A complete loss of voltage for a few seconds to several hours

9. Voltage Notch: Periodic transient that rides on the supply voltage

•

Other Quality Issues

10. Outage: Interruption that has duration lasting in excess of one minute.



11. Frequency Deviation: Variation in frequency from the nominal supply frequency above/below a predetermined level, normally ± 0.1%. (Quite different in India)

12. Unbalance in Systems (not seen like iceberg)

Voltage Unbalance

Motor performance affected by

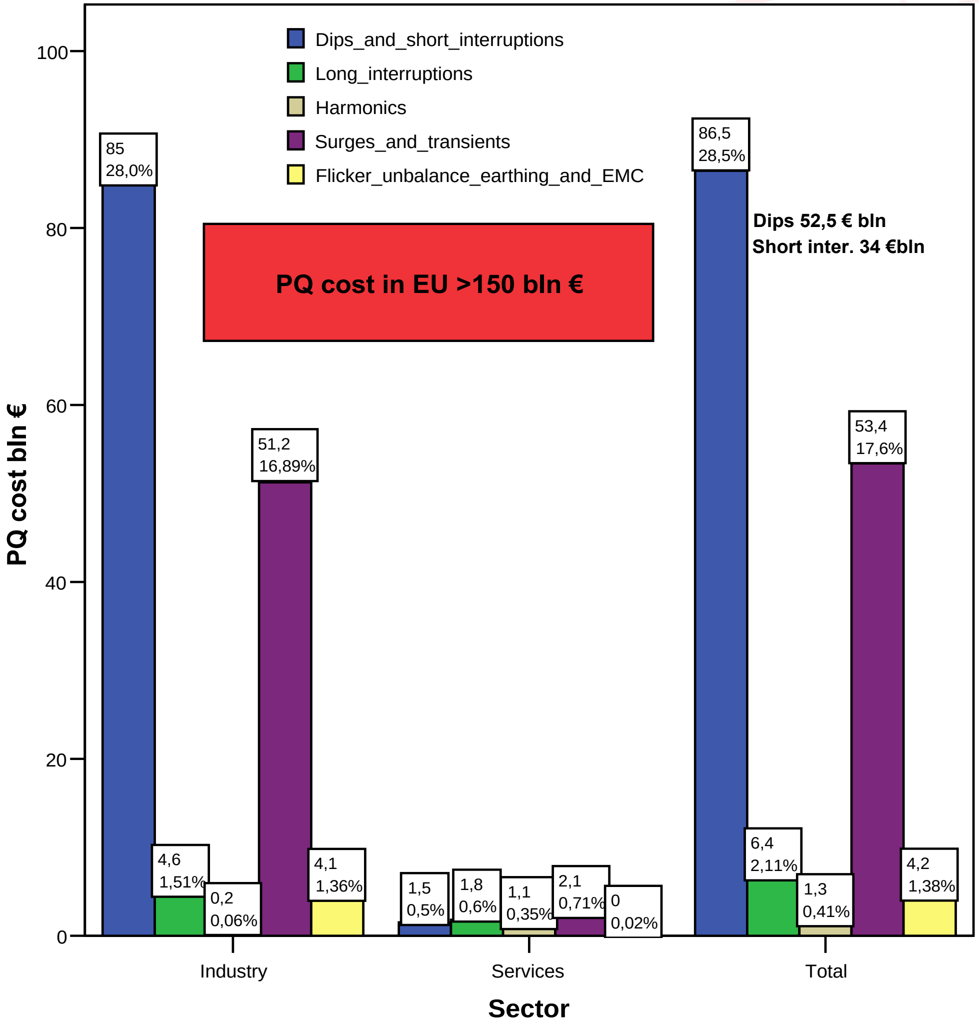
- Poor power quality: too high fluctuations in voltage and frequency
- Voltage unbalance: unequal voltages to three phases of motor

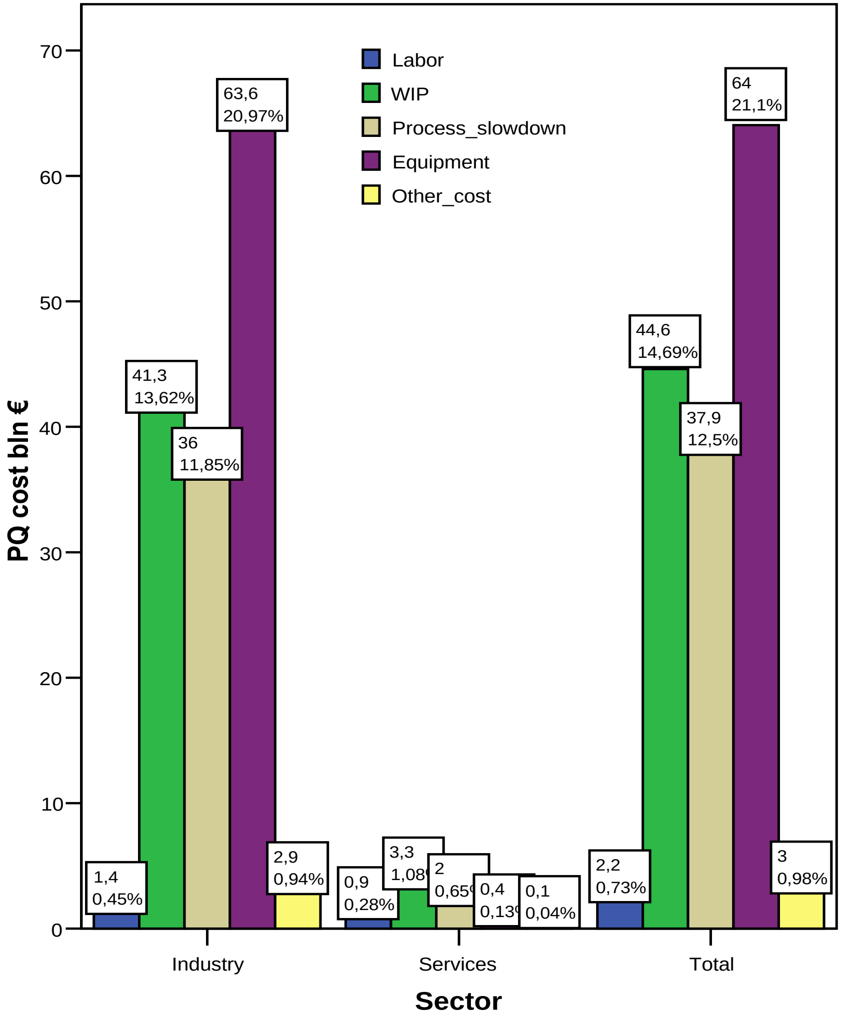
	Example 1	Example 2	Example 3
Voltage unbalance (%)	0.30	2.30	5.40
Unbalance in current (%)	0.4	17.7	40.0
Temperature increase (oC)	0	30	40

Keep voltage unbalance within 1%

- Balance single phase loads equally among three phases
- Segregate single phase loads and feed them into separate line/transformer

PQ Cost Summary





PQ Event Cost

Cost per event €	Voltage dips	Short interruptions	Long interruptions	Surges and transients
Industry*	4 682	15 484	95 478	186 260
Services*	2 120	19 447	80 326	122 602
Average*	4 177	16 539	91 021	175 871

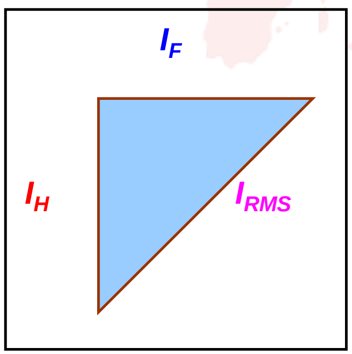
Remark*: 2 out of the 62 companies surveyed (semiconductors and retail) filtered out

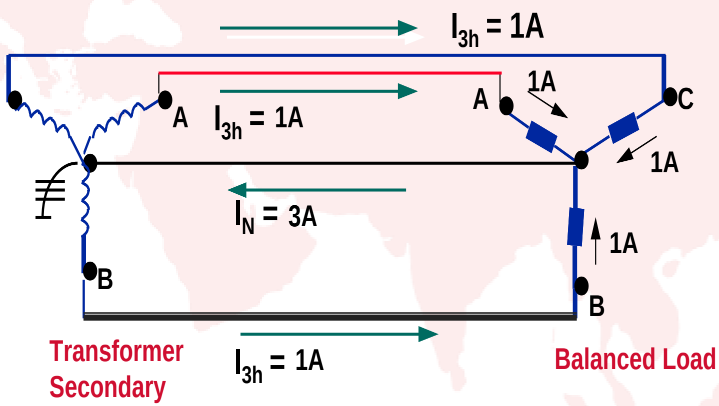
WHAT ARE HARMONICS

Definition & Classification of Harmonics

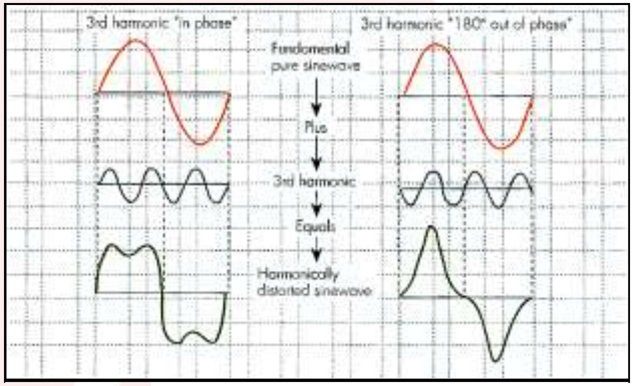
Name	F	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
Frequency (Hz)	*50*	*100*	*150*	*200*	*250*	*300*	*350*	*400*	*450*	*500*	*550*
Sequence	+	-	*0*	+	-	*0*	+	-	*0*	+	-

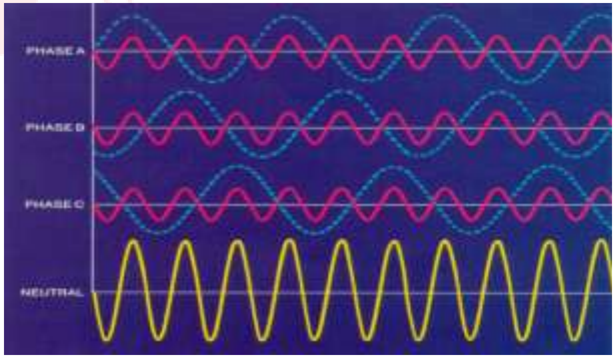
What is Triplen Harmonics?





Harmonically Distorted Waveforms





Classification of Harmonics

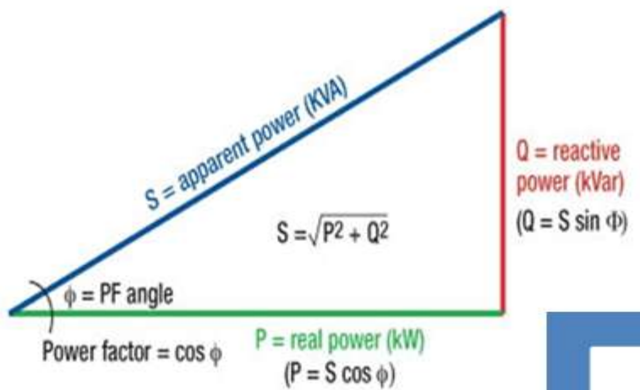
- Positive Sequence
  - Rotates in the same sequence as of fundamental waveform
- Negative Sequence
  - Rotates in opposite sequence to fundamental
- Zero Sequence (Triplen Harmonics)
  - No rotation

Classification of Harmonics

Fundamental	**A** 0^o	**B** 120^o	**C** 240^o	**A-B-C**
3rd harmonic	**A'** 3×0^o (0^o)	**B'** 3×120^o $(360^o = 0^o)$	**C'** 3×240^o $(720^o = 0^o)$	*no rotation*
5th harmonic	**A''** 5×0^o (0^o)	**B''** 5×120^o $(600^o - 720^o - 120^o)$ (-120^o)	**C''** 5×240^o $(1200^o - 1440^o - 240^o)$ (-240^o)	**C-B-A**
7th harmonic	**A'''** 7×0^o (0^o)	**B'''** 7×120^o $(840^o - 720^o + 120^o)$ (120^o)	**C'''** 7×240^o $(1680^o - 1440^o + 240^o)$ (240^o)	**A-B-C**
9th harmonic	**A''''** 9×0^o (0^o)	**B''''** 9×120^o $(1080^o = 0^o)$	**C''''** 9×240^o $(2160^o = 0^o)$	*no rotation*

Power Factor - Perspective

Power Triangle



In the diagram, P is the active power, Q is the reactive power (in this case positive), S is the complex power and the length of S is the apparent power. Reactive power does not do any work, so it is represented as the imaginary axis of the vector diagram. Active power does do work, so it is the real axis

Power Factor - Perspective

- Based on power factor, incentive to the consumer is provided as below.

Sr. No.	Range of Power Factor	Power Factor Level	Incentive
1	0.951 to 0.954	0.95	0%
2	0.955 to 0.964	0.96	1%
3	0.965 to 0.974	0.97	2%
4	0.975 to 0.984	0.98	3%
5	0.985 to 0.994	0.99	5%
6	0.995 to 1.000	1.00	7%

Power Factor – Past & Present

Past:

- The definitions for electrical energy parameters (active, reactive, and apparent powers) that are currently used are based on the knowledge developed and agreed on during the 1940s.

- These definitions still holds good, as long as the current and voltage waveforms remained nearly sinusoidal.

Power Factor – Past & Present

Present:

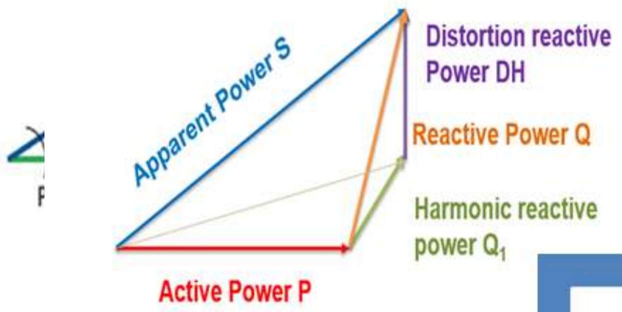
- Power electronics – basically non linear loads have made inroads in the industry.
- Equipments as VFD’s, control devices, CNC machines, computers, CFL/LED’s which are non linear loads are more common in industries
- It has been now well established that energy flow is different for linear and non linear loads.

Power Factor – Past & Present

Present:

Power Triangle

The New Power Triangle is 3 Dimensional



$$S = \sqrt{P^2 + Q^2 + D^2}$$

Nowadays the typical power triangle doesn't fit any more because other parameters like the distortion or harmonic reactive power have to be considered due to more and more non-linear loads (inverter, electronic ballast unit, etc...)

IEEE 1459-2010

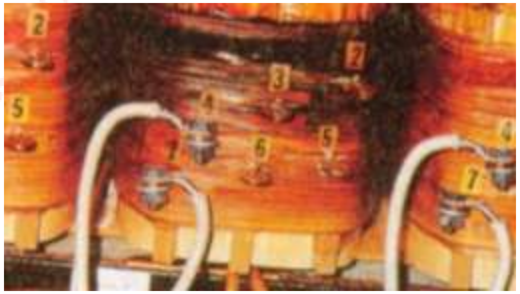
- IEEE 1459 – 2010 scope: This document provides definitions of electric power to quantify the flow of electrical energy in single phase and three-phase circuits *under sinusoidal, non-sinusoidal, balanced, and unbalanced conditions*.
- As per IEEE 1459-2010, under non linear loads, power factor is defined as:

$$PF \approx \frac{1}{\sqrt{1+THD_I^2}} PF_1$$

- Where PF_1 is fundamental power factor and PF is true power factor. (when THDv < 5%)

NON-LINEAR LOADS - POWER SYSTEM HARMONICS - A MAJOR TECHNICAL ISSUE TODAY ?

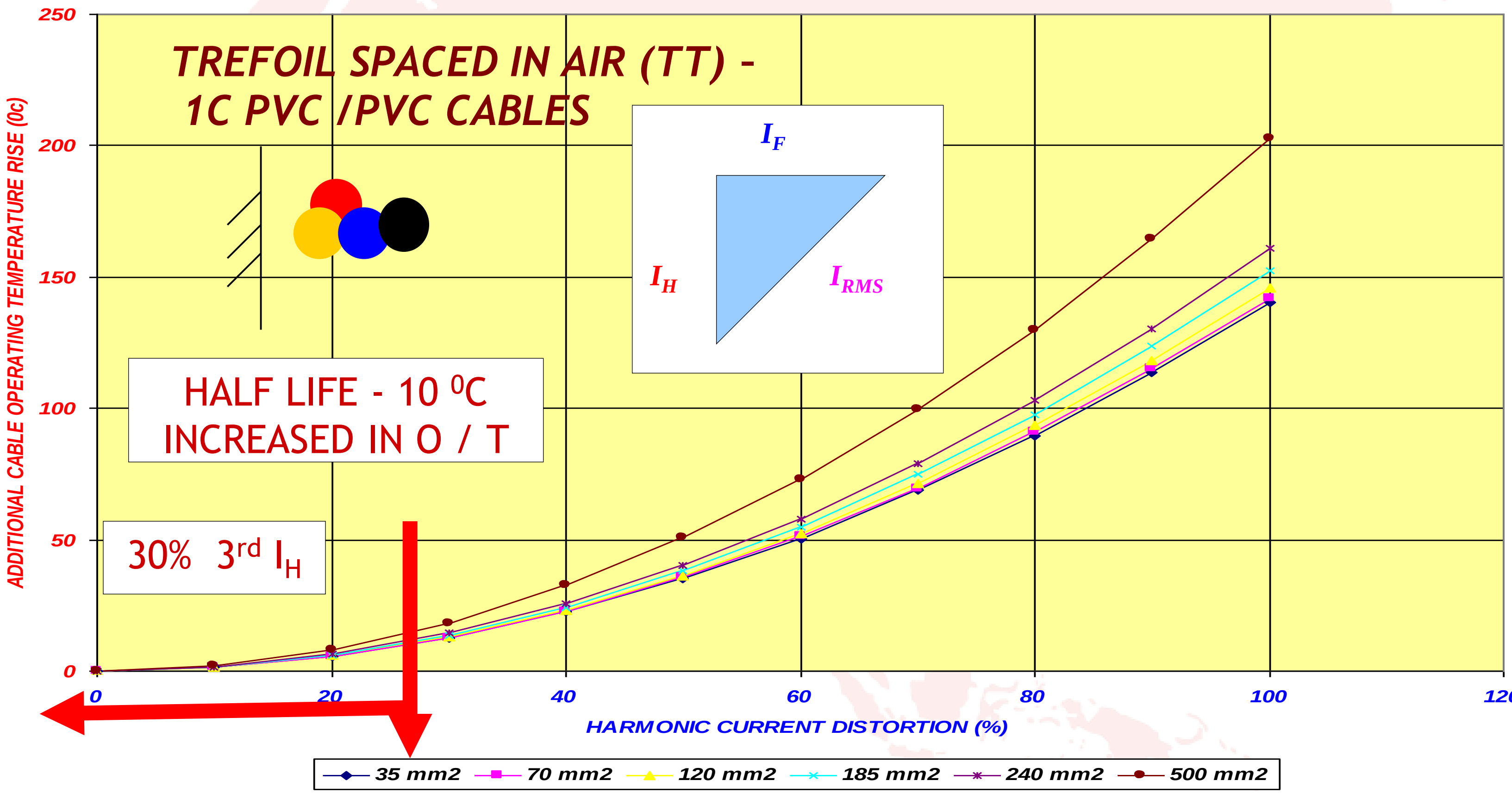
- Unforeseen Harmonic Problems
  - Increased resistance of conductor
  - Overheating
  - Increase Equipment Operating Temperature
  - Reduce Equipment/System Life
  - Premature Failure – Equipment/System
  - Potential Risk of Internal Electrical Fire
  - Emi Interference & Malfunctioning
  - Generate Additional Losses & KVA
  - Failure of capacitor banks



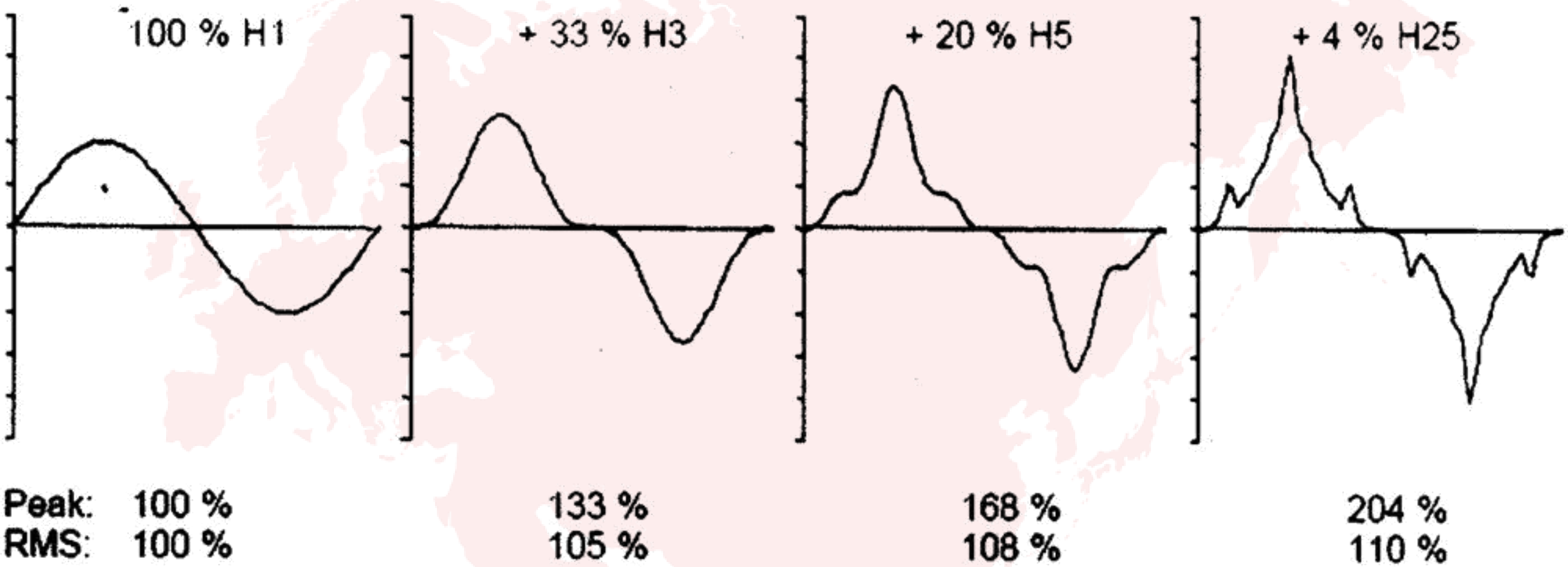
EFFECTS OF HARMONICS –

CABLE PERFORMANCE 1C PVC CABLES

ADDITIONAL O/T RISE - 3RD HARMONIC CURRENT DISTORTION



Impact of Harmonics on RMS and Peak Values



Be alert for **Total Demand Distortion (TDD)** factor

>>>> Applies for current distortion only

>>>> The total RMS harmonic current distortion in % of the maximum demand Load Current I_L (15 or 30 mins demand)

HARMONICS VS TRANSFORMER OVER LOAD CAPABILITY

- TWO MAJOR EFFECTS OF HARMONICS ON TRANSFORMER

- WEIGHTED RMS CURRENT

$$I_{RMS} = \sqrt{\sum_{H=1}^{N} I_H^2 \, H^2}$$

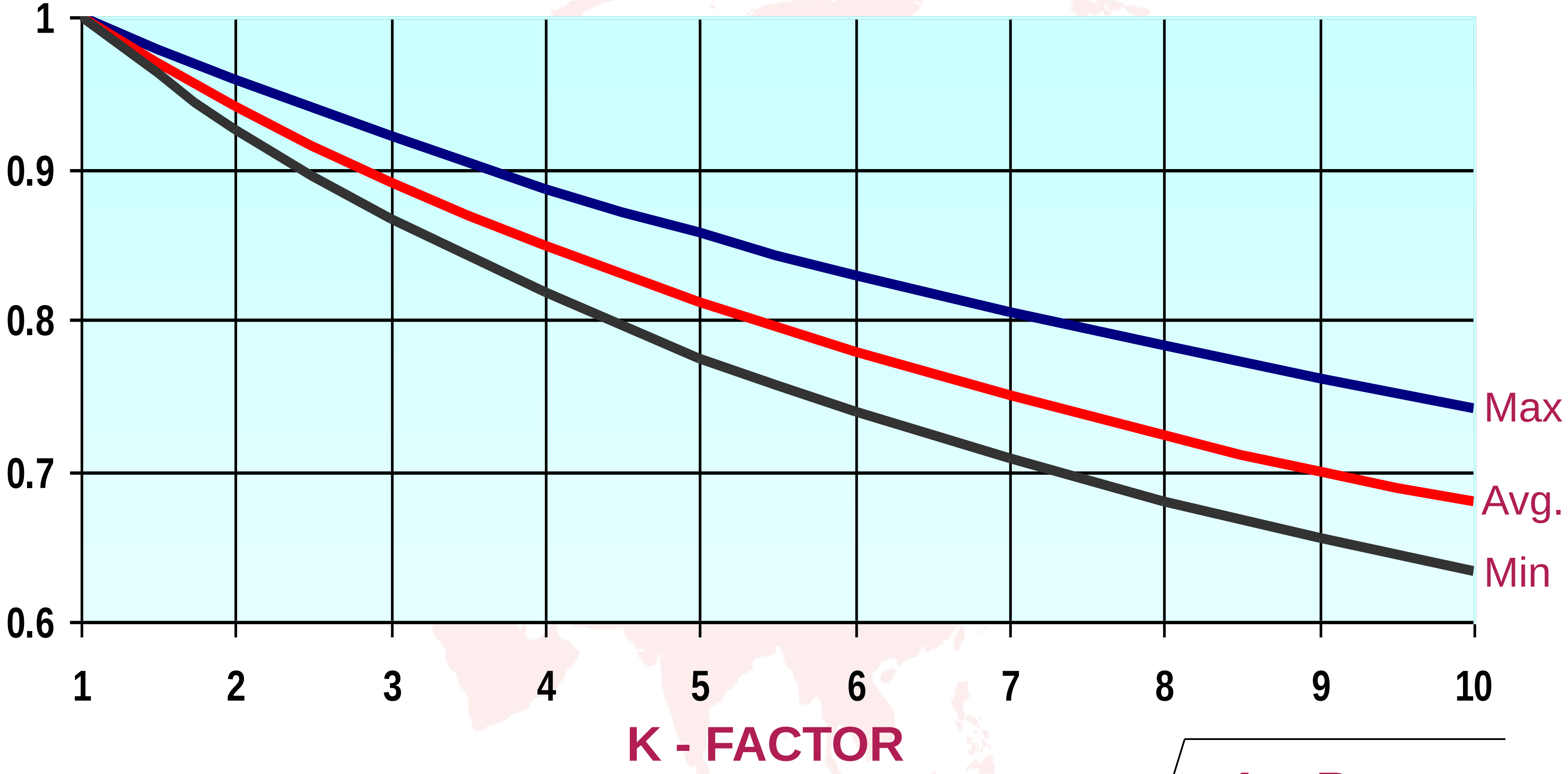
INCREASED RMS CURRENT ⇒ INCREASED COPPER LOSS

- EDDY CURRENT LOSS

  - DUE TO FLOW OF INDUCED CURRENTS IN WINDING, CORE AND OTHER CONDUCTING BODIES SUBJECTED TO MAGNETIC FLUX

  - LOSS $\alpha \; I^2 \; F^2$

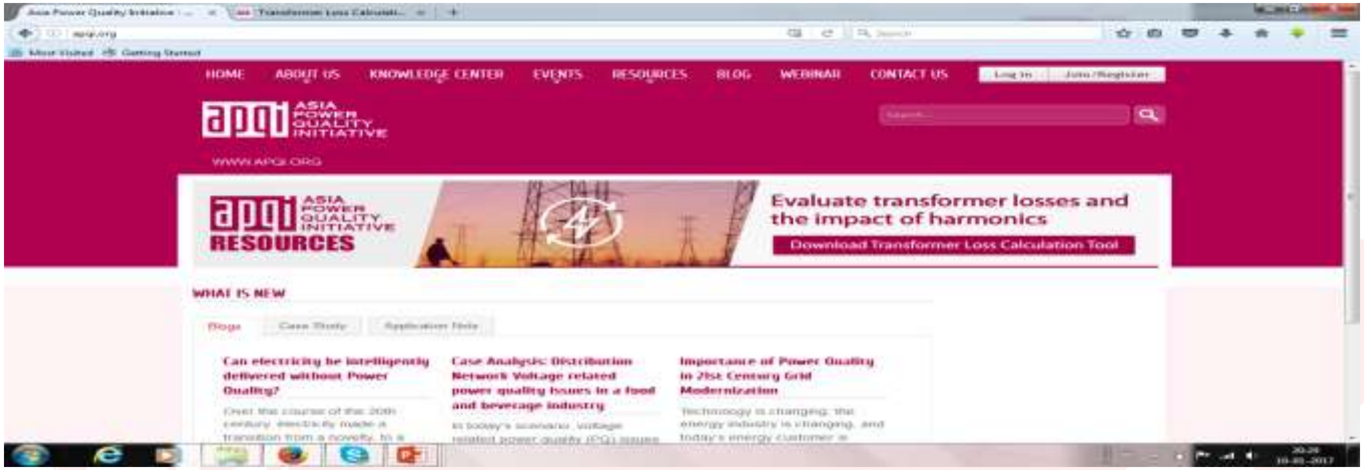
EDDY CURRENT LOSS FACTOR - P_{EC}



- **DERATING FACTOR (DF)**

$$DF = \sqrt{\frac{1 + P_{EC}}{1 + P_{EC} K_F}}$$

Demonstration transformer tool



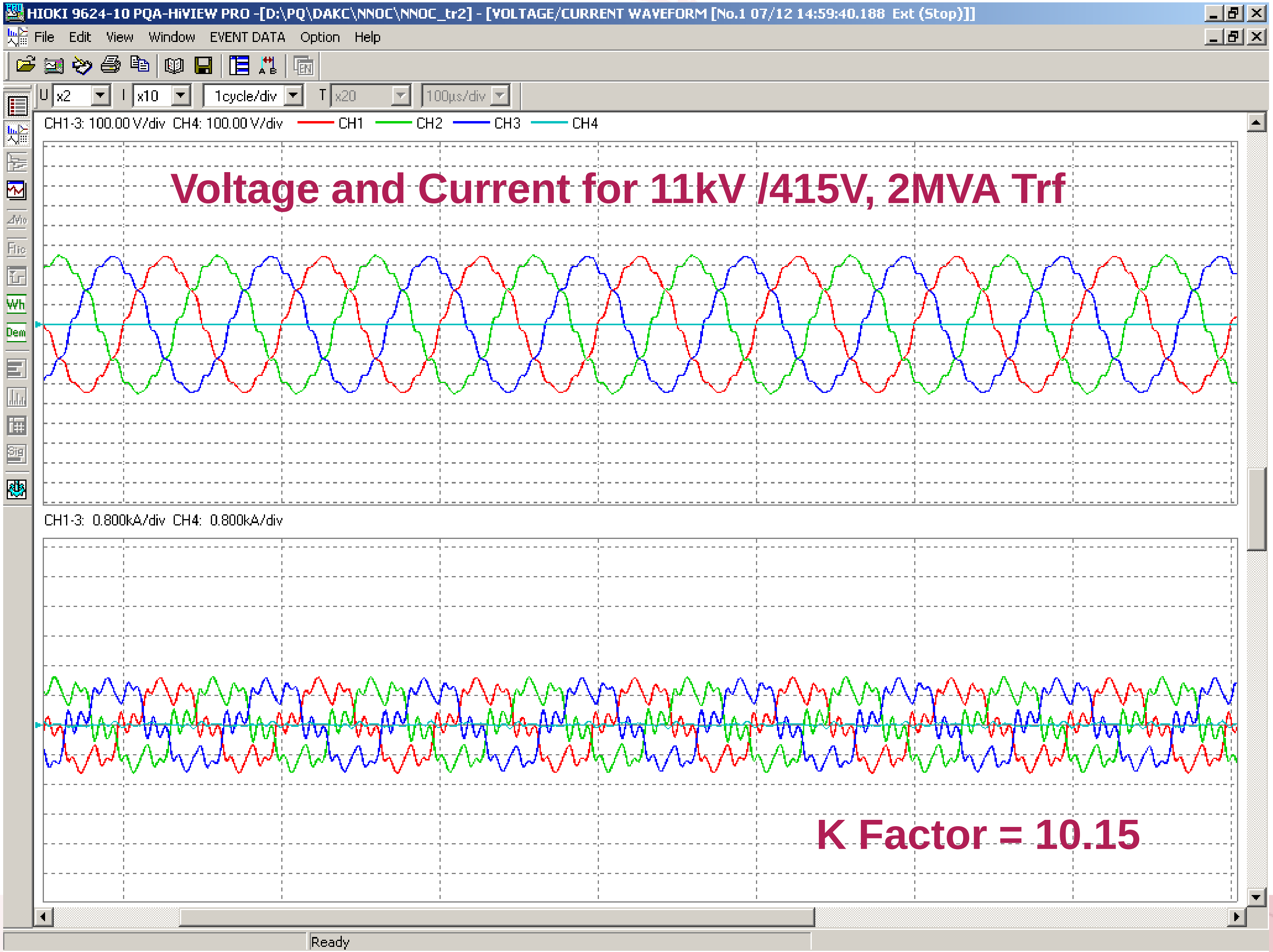
- When purchasing transformers, it is important to compare the cost of the losses over the entire lifetime of the various types considered.
- DNV GL's Transformer Loss Calculation Tool enables the user to choose the economically most efficient transformer based on lifetime parameters such as capitalized cost, CO_2 emissions, payback time and internal rate of return.
- In a clear summary table and intuitive graphs, the tool provides the user with additional information about the no-load and load loss evaluation (A and B factors), in case these are not known in advance. It calculates transformer losses when there are harmonics in the loading.

Download the Tool

CASE STUDY

NNOC

SERVER LOADS



For K Factor = 10.15

P_{EC} : FROM GRAPH = 0.68

- **DERATING FACTOR (DF)**

$$DF = \sqrt{\frac{1 + P_{EC}}{1 + P_{EC} K_F}}$$

DF = 0.46

The load of a 2000 kVA transformer had to be restricted to 900 kVA !

SITE SURVEY RESULTS OF A DATA CENTRE

SITE SURVEY IN DATA CENTRE

Transformer Rating	K Factor (*)	Transformer to be loaded to
11/0.415kV, 2 MVA	10.15	0.93 MVA
11/0.415kV, 2 MVA	1.31	1.8 MVA
11/0.415kV, 2 MVA	1.53	1.8 MVA
11/0.415kV, 2.5 MVA	1.49	2.2 MVA
11/0.415kV, 2.5 MVA	1.7	2 MVA
11/0.415kV, 2.5 MVA	5.5	1.4 MVA

A Case of DT in Kerala

A projection of saving for KSEB based on a Lab based experiment to convert DY into YYD for tackling ill effect of harmonics :

Approximate number of distribution transformers: 50,000

Assuming an average capacity of 200 kVA each for distribution transformers, the total capacity of transformers = 10,000 MVA

Assuming an average load of 30% of the capacity and a 2% improvement (actually it could be more) in operational efficiency, the power that could be saved = 60 MW

Annual energy saving: 60,000 x 24x 365x 6 = Rupees 315.36 x 10^7 i.e (315 Crores)

Actual number of transformers connected in the grid (including that of HT consumers) is more than this figure. Financial benefits of the system by improvement in power factor, reduction in harmonics related losses etc. are not accounted in this calculation.

Paper Published

P.S.Chandramohanan Nair and Preetha P.K., "A novel method for recovery of drainage power from distribution transformers", **IEEE International Conference** on Innovative Smart Grid Technologies (ISGT 2011), December 5 – 7, 2011, **Manchester, U.K.** – This paper is available online in *IEEE Xplore*.

Harmonic Limits

Bus Voltage at PCC	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV through 161 kV	1.5	2.5
161.001 kV and above	1.0	1.5
NOTE: High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.		

- Stricter limits at higher voltage
- Individual harmonics limited to lower levels than THD

Current Distortion Limits for General Distribution Systems
(120 V Through 69000 V)

Maximum Harmonic Current Distortion in Percent of I_L

Individual Harmonic Order (Odd Harmonics)

I_{SC} / I_L	< 11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

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

Current distortions that result in a dc offset, e.g. half wave converters, are not allowed

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

Where

I_{SC}	=maximum short circuit current at PCC
I_L	=Maximum demand load current (fundamental frequency component) at PCC
TDD	= Total demand distortion (RSS), harmonic current distortion in % of maximum load current (15 or 30 min demand)
PCC	= Point of common coupling

Total Demand Distortion (TDD)

- Current harmonic limits do not use common harmonics definitions
  - TDD (Total Demand Distortion)
    - Not THD (Total Harmonic Distortion)
  - Individual harmonics in % of I_L
    - Not in % of I1 (fundamental)
- Harmonics meters measure THD and % of I_1
- TDD and THD definitions are similar
  - Only difference is the denominator

$$THD_I = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots}}{I_1}$$

$$TDD_I = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots}}{I_L}$$

CASE STUDIES

CASE STUDY – 1

Productivity improvement and SEC reduction by improving Power Quality

PRODUCTIVITY IMPROVEMENT AND REDUCTION IN SEC

- Regular failure in a Steel Wire Rope Mill
  - High Failure Rate of Motors
  - High Failure rate of control cards
  - Nuisance tripping of circuit breakers
  - Failure of SWG
- SEC was 173 kWh/Ton
- Production cost – INR 1064 per ton

Before……

- High harmonic content – Vthd and Ithd

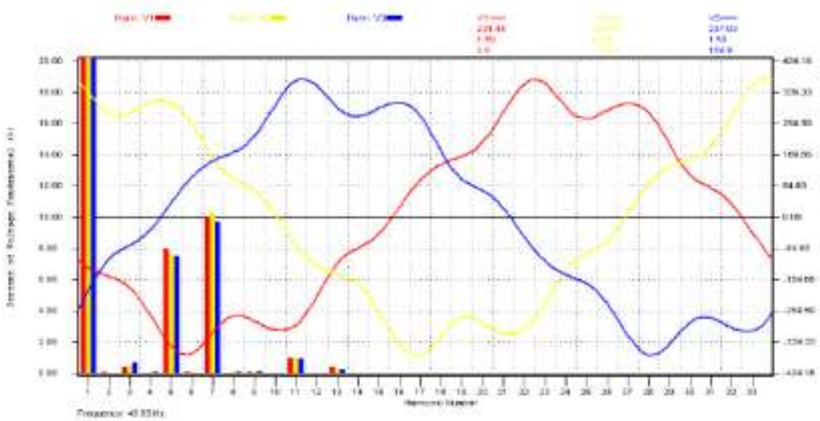
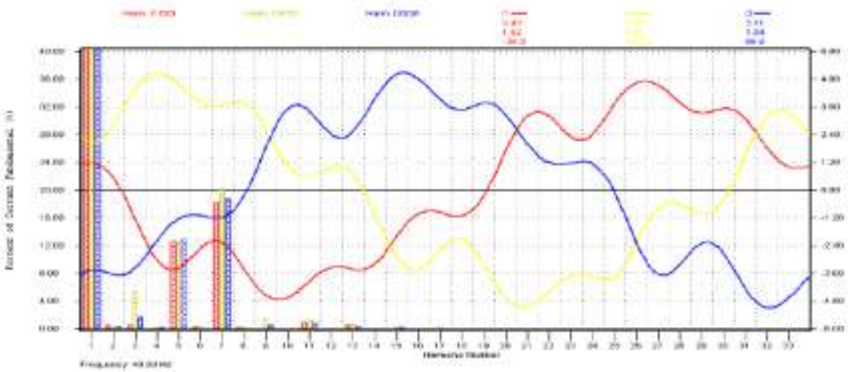


Figure – 3A Vthd and Voltage waveform without harmonic filter at T

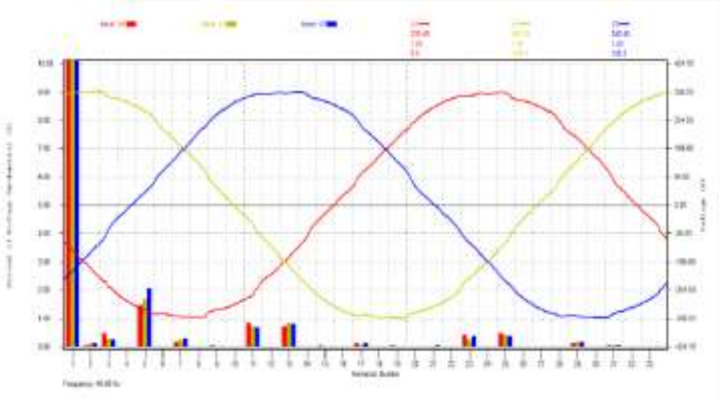
Vthd - Transformer A – 12%
Transformer B - 15%

Ithd - Transformer A – 21%
Transformer B - 60%



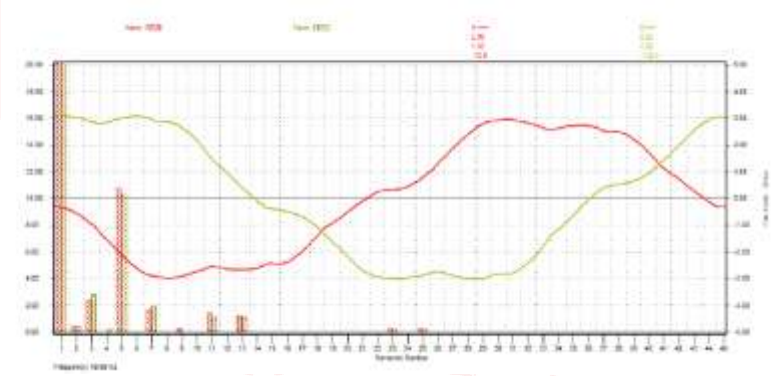
After ……

- After installation of passive filter



Vthd - Transformer A – 2.1%
Transformer B - 1.2%

Ithd - Transformer A – 11.2%
Transformer B - 7.2%



BREAK DOWN ANALYSIS

Component Failure Trend										
		Before HF			After HF					
Component	Ratings	FY 13	APR 13	MAY 13	JUN 13	JUL 13	AUG 13	SEP 13	OCT 13	NOV 13
No of Motors Failed	< 3 KW	14	2	1	0	0	1	0	0	0
	3-5 KW	11	1	1	0	0	0	0	1	0
	5-10 KW	2	1	1	0	0	0	0	0	0
	10-25 KW	4	4	2	1	0	0	1	0	0
	>25 KW	2	3	1	0	0	0	0	0	0
	Total	**33**	**11**	**6**	**1**	**0**	**1**	**1**	**1**	**0**
No of Drives Failed	< 1 KW	4	0	0	0	0	1	0	0	0
	1-11 KW	45	2	1	0	1	0	1	0	0
	> 11 KW	7	1	1	0	0	1	0	0	0
	Total	**56**	**3**	**2**	**0**	**1**	**2**	**1**	**0**	**0**
No of PLCs Failed	< 1 KW	9	0	0	0	0	1	0	0	0
	1-11 KW	6	0	2	1	0	0	0	0	0
	> 11 KW	8	1	0	0	1	0	0	1	0
	Total	**23**	**1**	**2**	**1**	**1**	**1**	**0**	**1**	**0**

SUMMARY OF BREAKDOWN ANALYSIS

Component	Annual failure rate before Harmonic filter – FY 2012-13	June-Nov 2013 Failures	Extrapolated - Annual failure rate after harmonic filter	Change in failure rate	
Motors	43	4	8	-81%	Reduced by 81%
Drives	52	4	8	-85%	Reduced by 85%
PLC's	22	4	8	-64%	Decreased by 64%

- Average monthly cost saving of 240,000
- Average increase in production time 98 hours per month

SPECIFIC ENERGY CONSUMPTION & PRODUCTIVITY

SPECIFIC ENERGY CONSUMPTION			
Parameter	**Monthly Average - FY13**	**Monthly Avg Jun-Oct13**	**% Change**
Finish Machine Production in tons	10935	11632	↑ by 6.4%
KWH/Ton of Production (JSEB)	173	153	↓ by 11.6%
Rs/Ton of Production	1064	951	↓ by 10.6%

FINANCIAL ANALYSIS

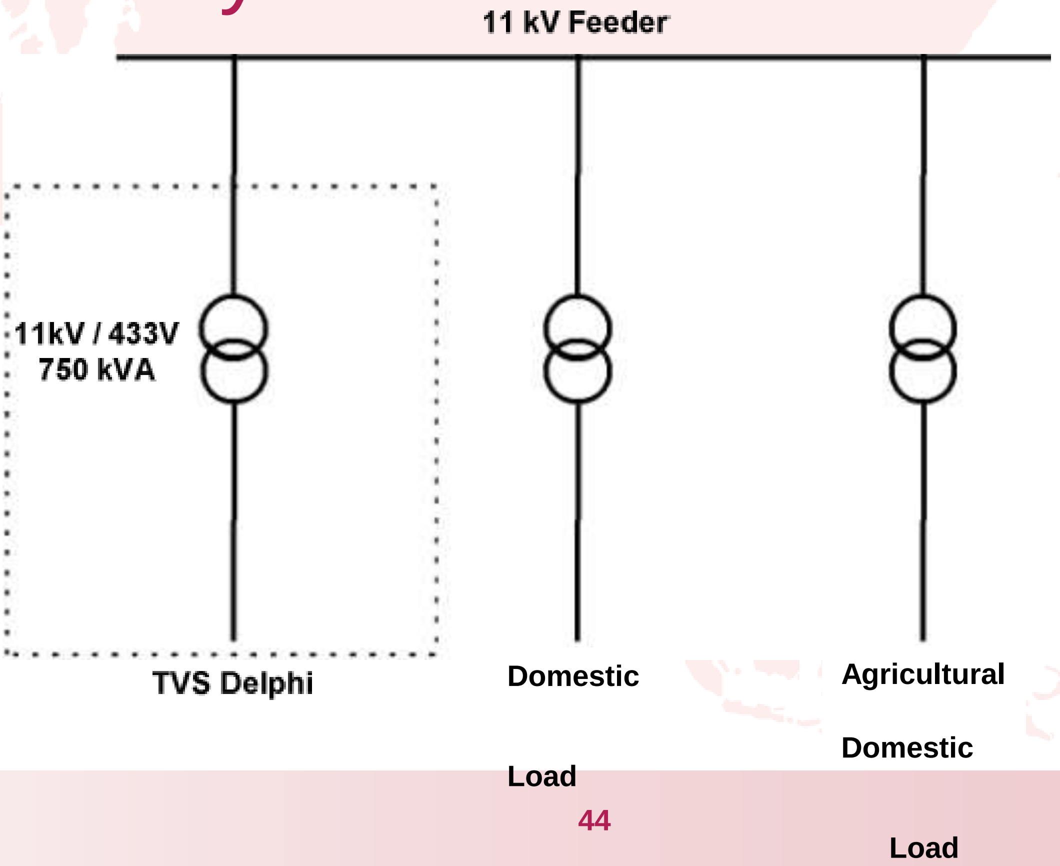
Financial Analysis		
Part A - Reduction in specific energy consumption		Unit of Measurement
Rs/Ton of Production in FY13	1,064.00	INR/Ton
Rs/Ton of Production on 31.10.13	951.00	INR/Ton
Net Gain in Rs/Ton of Production	113.00	INR/Ton
If Avg Monthly Production remains	11,000.00	Tons
Avg Monthly Monitory Gain	1,242,226.00	INR
Average annual monitory gain - A	**14,906,714.00**	**INR**
Part B - Reduction in maintenance, repair and replacement		
Average monthly reduction in maintenance cost	240,000.00	INR/Month
Annual reduction in maintenance cost - B	**2,880,000.00**	**INR/Year**
Total (A+B)	**17,786,714.00**	**INR/year**
Investment	9,800,000.00	INR
Simple Payback	7	Months

CASE STUDY 2

Total Power Quality Management – TVS Delphi

Total Power Quality Management – TVS Delphi

- TVS Delphi – Manufacturer of Diesel Fuel Injection System established in 1990



Problem Faced – External issues

- Frequent interruptions due to un scheduled loads by agricultural sector and various natural issues
- Un balanced voltage
- Voltage variation – 8 kV to 12 kV
- Change in phase sequence after restoration of lines
- Surges and transient due to failure of lightning arrestor

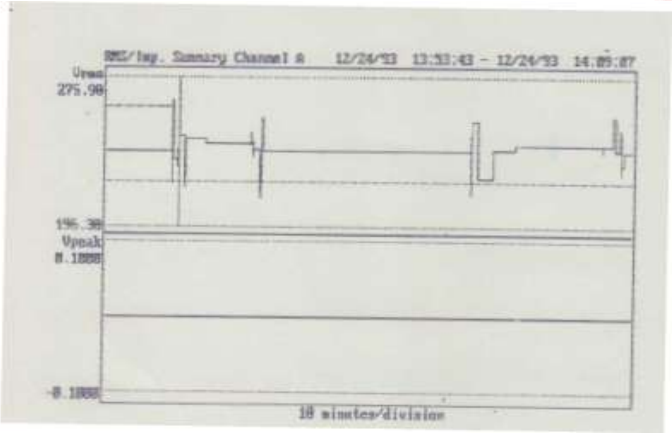
Problem Faced – Internal issues

- Frequent Tripping of Sensitive Equipments
- Failure of Power Supply in the CNC Equipments
- Burning of neutral at R&D
- Software corruption of CNC programs

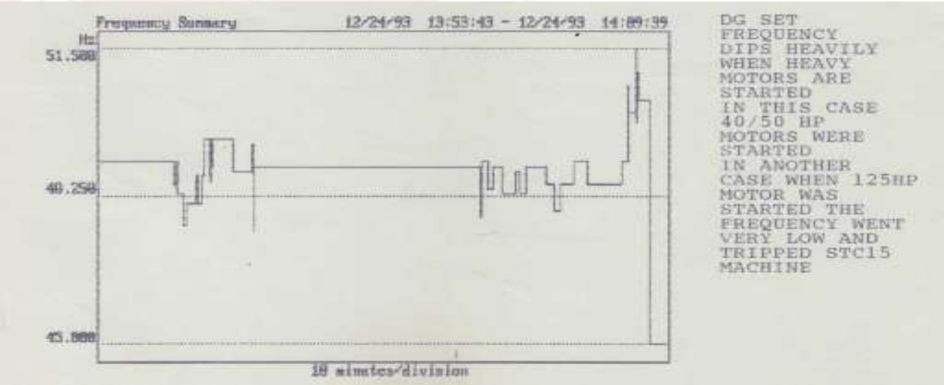
Impact on business

- Customer dispatch was seriously affected.
- Purchase of costly tools resulting in increased M/C tools.
- Too Many Electronics Failures resulting in increased down time.
- Increase in Scrap & Rejection cost

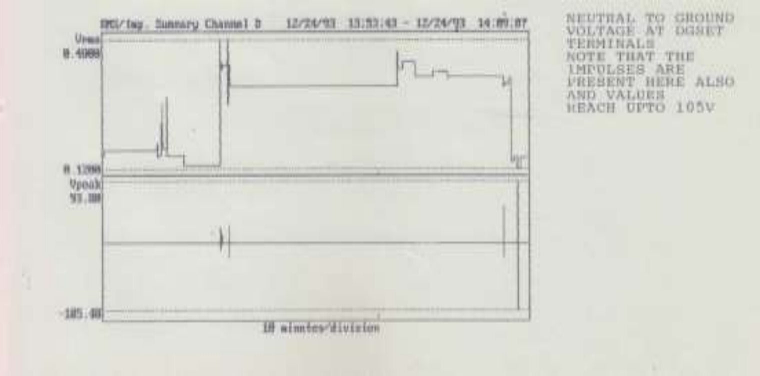
Various power quality issues



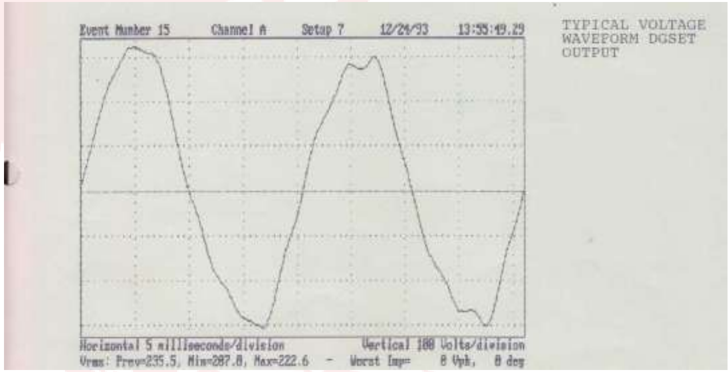
Voltage profile



Frequency profile



Neutral to Ground Voltage



Voltage Waveform

Various PQ issues and adopted mitigation techniques

Sr. No	Power Quality issue	Solution adopted
1.	Non reliability of power	DG sets
2	Noise	Isolation Transformer
		Filter
		Re-design of equipment to suit power quality
3	Voltage quality	Improved operating practice
		Higher capacity of DG sets
4	Cost of electricity	Adopting low cost fuel
		Improving efficiency of system
		Better utilization of available grid power by installing AVR
5	Reliability of operation	Installed UPS system – 2690 kVA
		Bus bar trunking 40 no's each of 5m long
		Higher size of neutral conductor
		Lower size of capacitors for APFC

Expenditure on PQ Mitigation

Capex cost	**INR**
Cost of 1000 kVA DG set	130,000,000.00
Voltage stabilizers	2,500,000.00
UPS system	143,000,000.00
AVR	5,000,000.00
Captive power plant	45,000,000.00
Total	**325,500,000.00**

Expenditure on PQ Mitigation

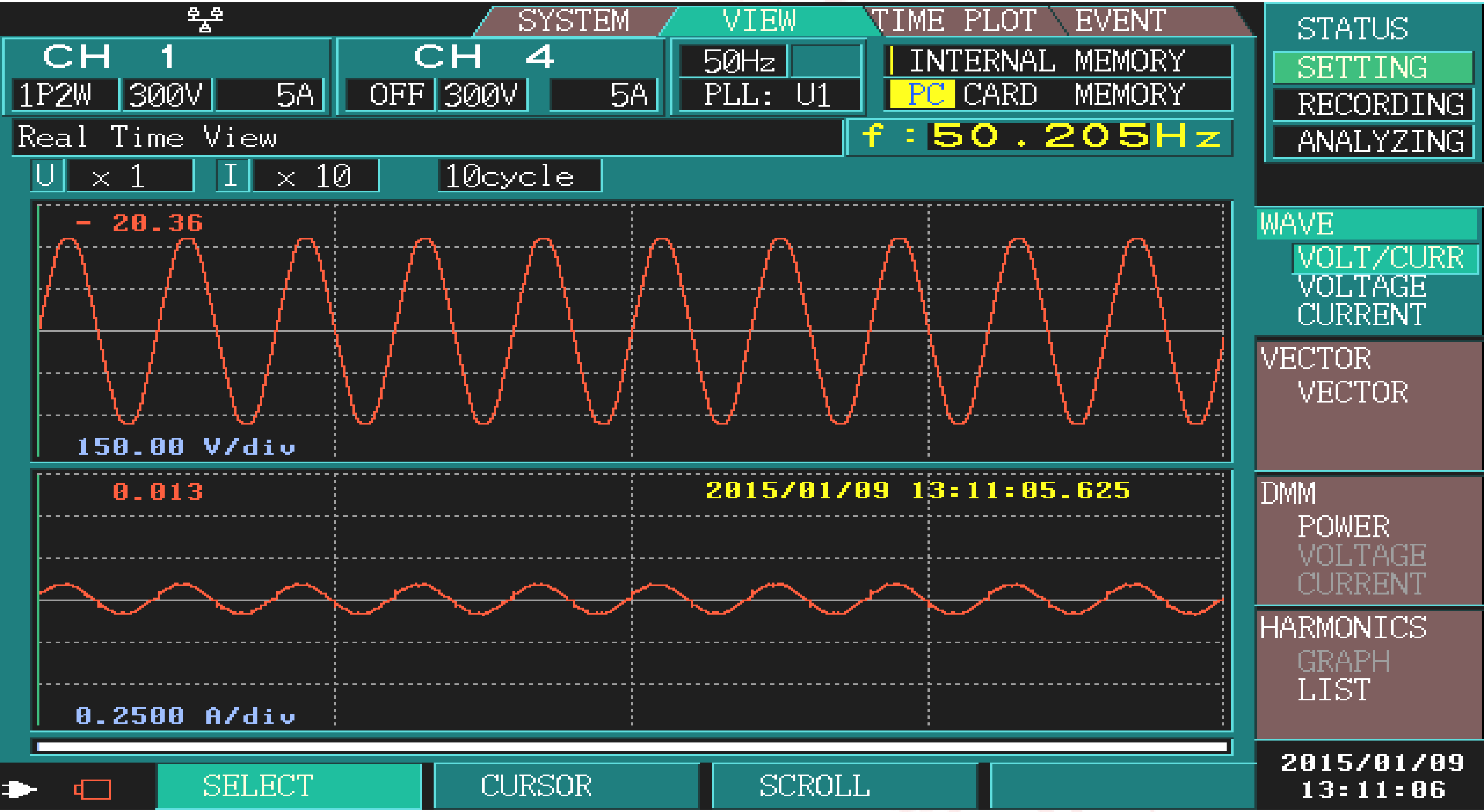
Parameter	Before	Now	In case if mitigation measures were not adopted	
Total Consumption	1200000	2500000	2500000	kWh
DG	840000	0	1750000	kWh
Captive	0	750000		kWh
EB	360000	1750000	750000	kWh
Cost of power generation through DG	22	22	22	INR/kWh
Captive	12	12	12	INR/kWh
EB	7	7	7	INR/kWh
With SEB as base, annual loss:	**151,200,000.00**	**45,000,000.00**	**315,000,000.00**	**INR per year**

CASE STUDY – 3

Selection of LED Lights & Harmonics

LED (15W) LAMP

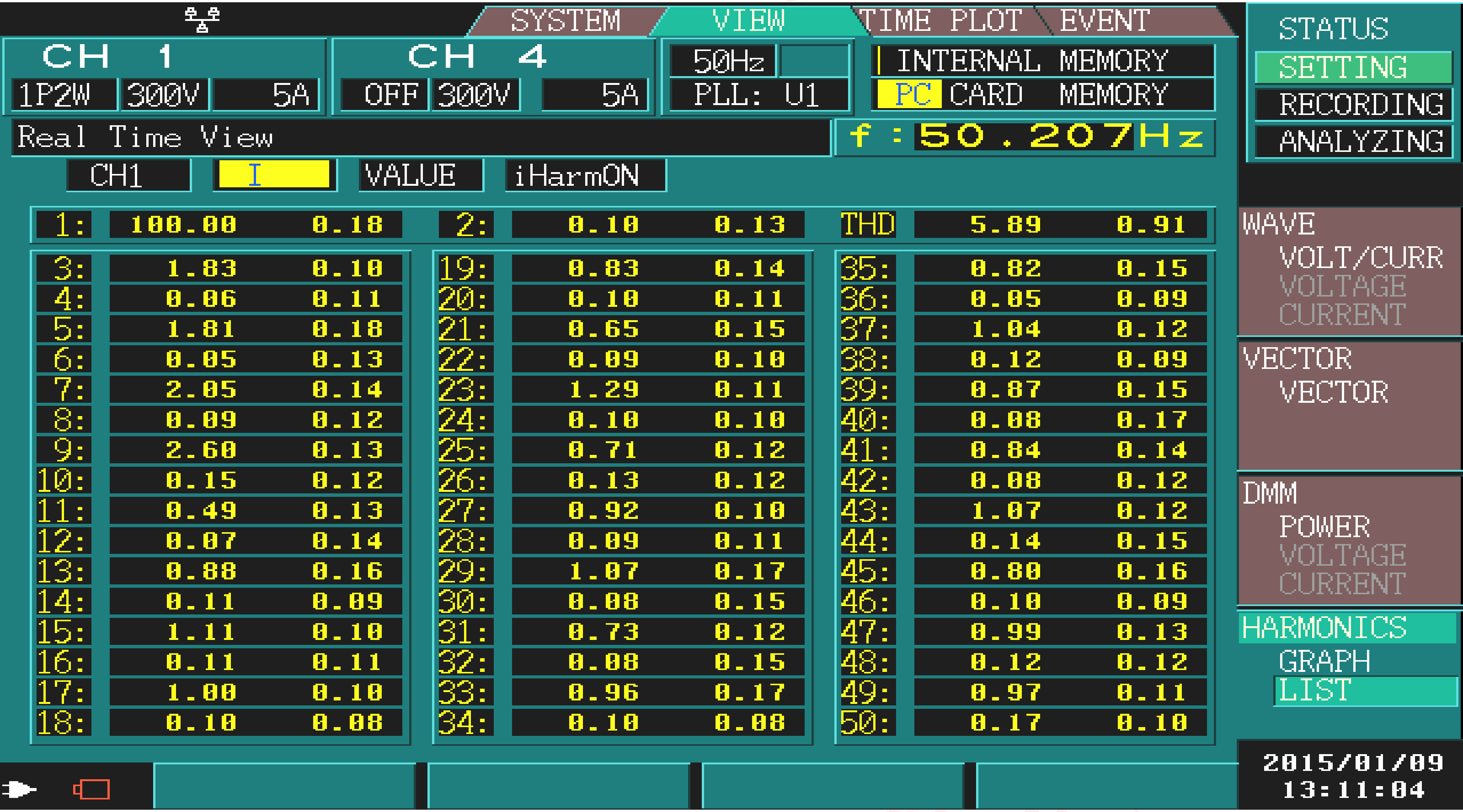
HIGH WATTAGE LOW THD



ASIA POWER QUALITY INITIATIVE

LED (15W) LAMP

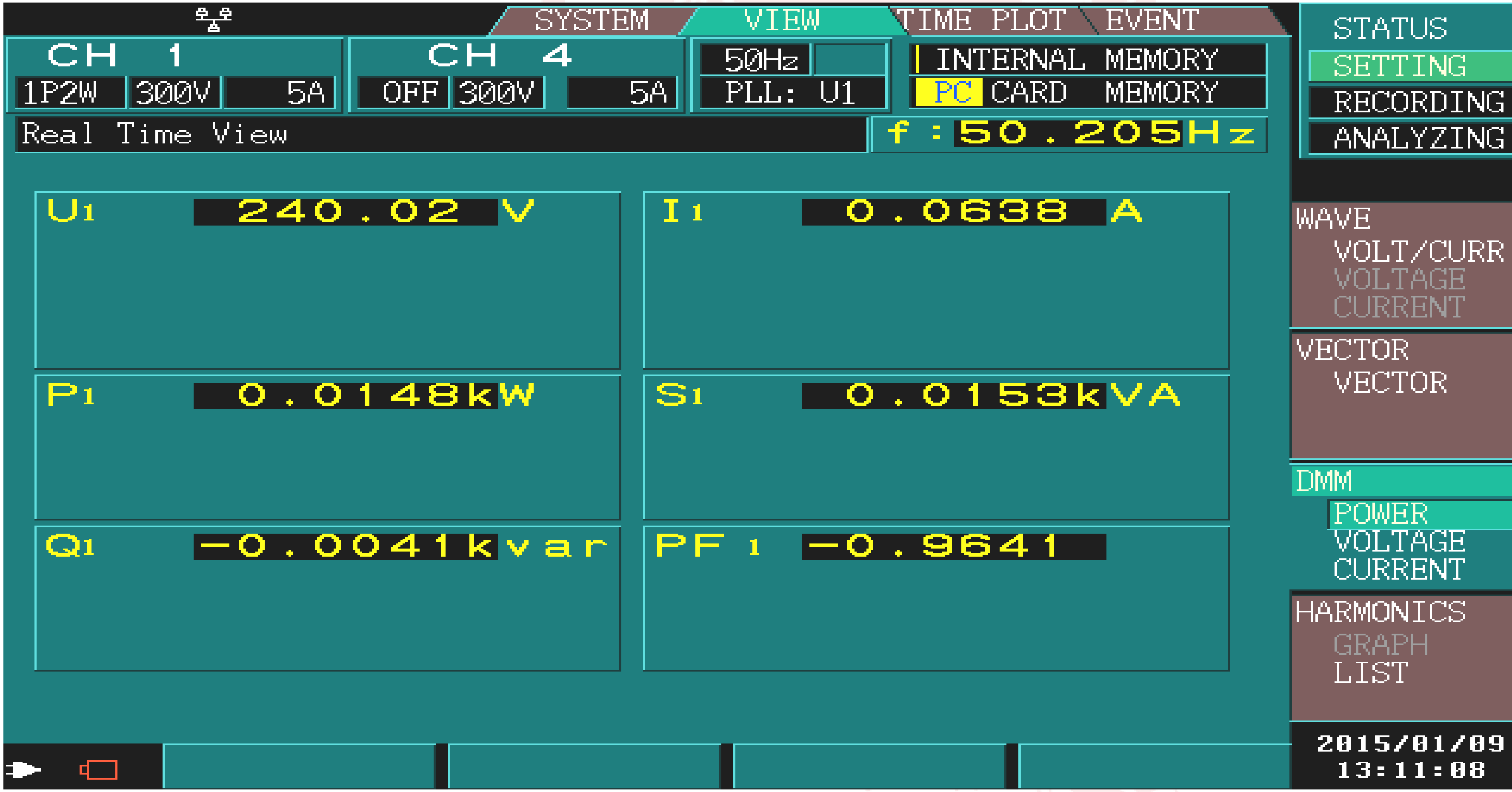
HIGH WATTAGE LOW THD: 5.89%



1:	100.00	0.18	2:	0.10	0.13	THD	5.89	0.91
3:	1.83	0.10	19:	0.83	0.14	35:	0.82	0.15
4:	0.06	0.11	20:	0.10	0.11	36:	0.05	0.09
5:	1.81	0.18	21:	0.65	0.15	37:	1.04	0.12
6:	0.05	0.13	22:	0.09	0.10	38:	0.12	0.09
7:	2.05	0.14	23:	1.29	0.11	39:	0.87	0.15
8:	0.09	0.12	24:	0.10	0.10	40:	0.08	0.17
9:	2.60	0.13	25:	0.71	0.12	41:	0.84	0.14
10:	0.15	0.12	26:	0.13	0.12	42:	0.08	0.12
11:	0.49	0.13	27:	0.92	0.10	43:	1.07	0.12
12:	0.07	0.14	28:	0.09	0.11	44:	0.14	0.15
13:	0.88	0.16	29:	1.07	0.17	45:	0.80	0.16
14:	0.11	0.09	30:	0.08	0.15	46:	0.10	0.09
15:	1.11	0.10	31:	0.73	0.12	47:	0.99	0.13
16:	0.11	0.11	32:	0.08	0.15	48:	0.12	0.12
17:	1.00	0.10	33:	0.96	0.17	49:	0.97	0.11
18:	0.10	0.08	34:	0.10	0.08	50:	0.17	0.10

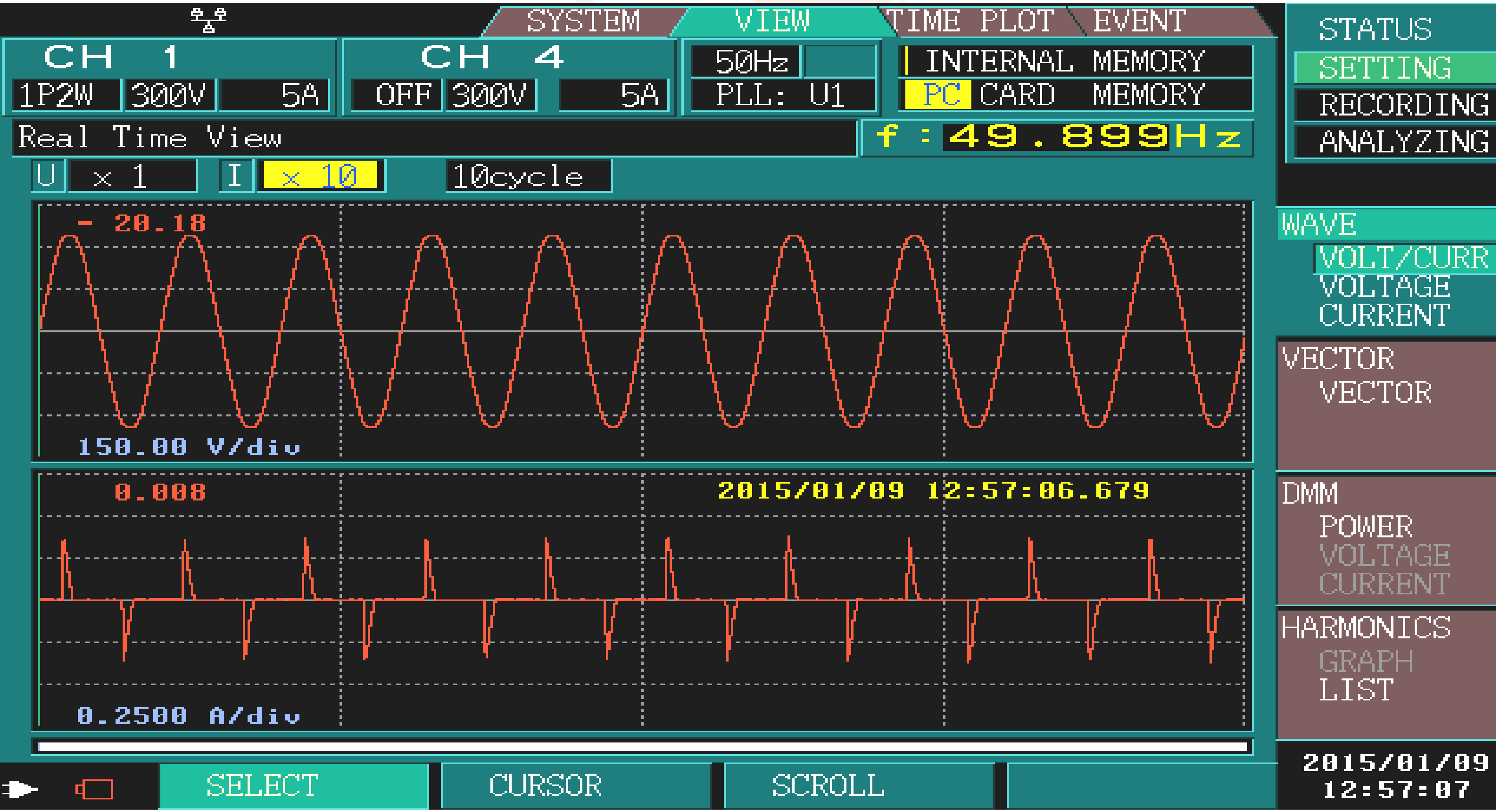
LED (15W) LAMP

Power factor – 0.96



LED (10W) LAMP

MEDIUM HIGH WATTAGE HIGH THD



LED (10W) LAMP

MEDIUM HIGH WATTAGE HIGH THD: 166%

SYSTEM | VIEW | TIME PLOT | EVENT

STATUS | SETTING | RECORDING | ANALYZING

CH 1: 1P2W 300V 5A

CH 4: OFF 300V 5A

50Hz PLL: U1

INTERNAL MEMORY
PC CARD MEMORY

Real Time View

f : 49.889Hz

CH1 | I | VALUE | iHarmON

1:	100.00	0.19	2:	1.13	0.22	THD	166.04	2.80

3:	93.25	0.30	19:	21.65	0.38	35:	7.71	0.40
4:	1.22	0.23	20:	2.32	0.54	36:	1.65	0.28
5:	81.08	0.40	21:	18.22	0.38	37:	7.24	0.28
6:	1.64	0.33	22:	2.26	0.53	38:	1.61	0.28
7:	65.84	0.54	23:	14.74	0.36	39:	7.07	0.30
8:	2.24	0.40	24:	2.35	0.60	40:	1.45	0.26
9:	50.10	0.49	25:	12.39	0.41	41:	6.64	0.25
10:	2.90	0.45	26:	2.30	0.57	42:	1.40	0.32
11:	37.02	0.47	27:	11.40	0.44	43:	5.88	0.29
12:	3.01	0.41	28:	2.20	0.53	44:	1.43	0.20
13:	29.00	0.38	29:	10.86	0.46	45:	5.00	0.40
14:	3.02	0.38	30:	1.93	0.51	46:	1.37	0.27
15:	25.82	0.36	31:	9.89	0.48	47:	4.24	0.40
16:	2.77	0.37	32:	1.86	0.42	48:	1.33	0.35
17:	24.09	0.36	33:	8.71	0.38	49:	3.99	0.43
18:	2.50	0.39	34:	1.78	0.34	50:	1.22	0.44

WAVE
VOLT/CURR
VOLTAGE
CURRENT

VECTOR
VECTOR

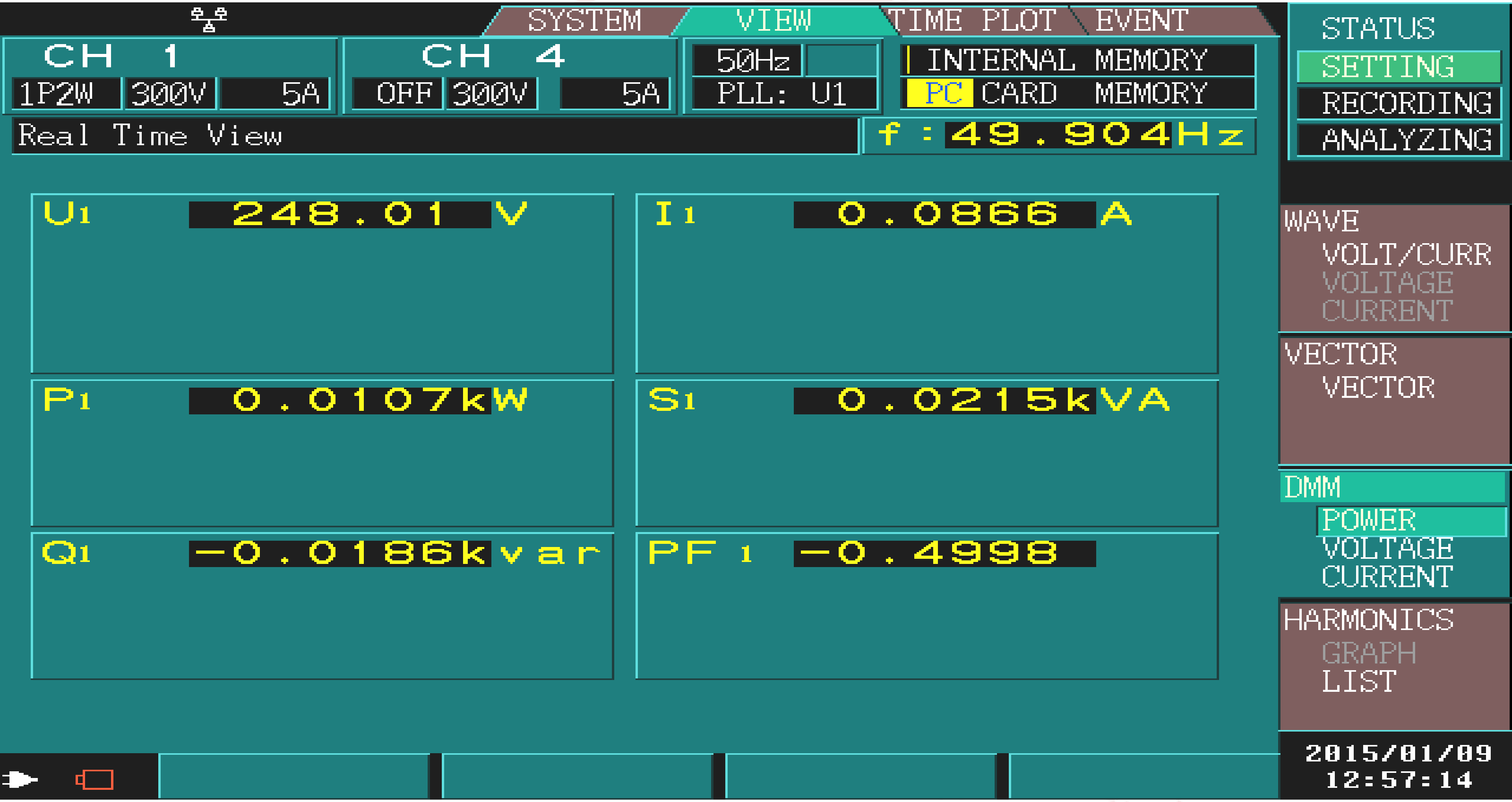
DMM
POWER
VOLTAGE
CURRENT

HARMONICS
GRAPH
LIST

2015/01/09
12:57:33

LED (10W) LAMP

Power factor – 0.5



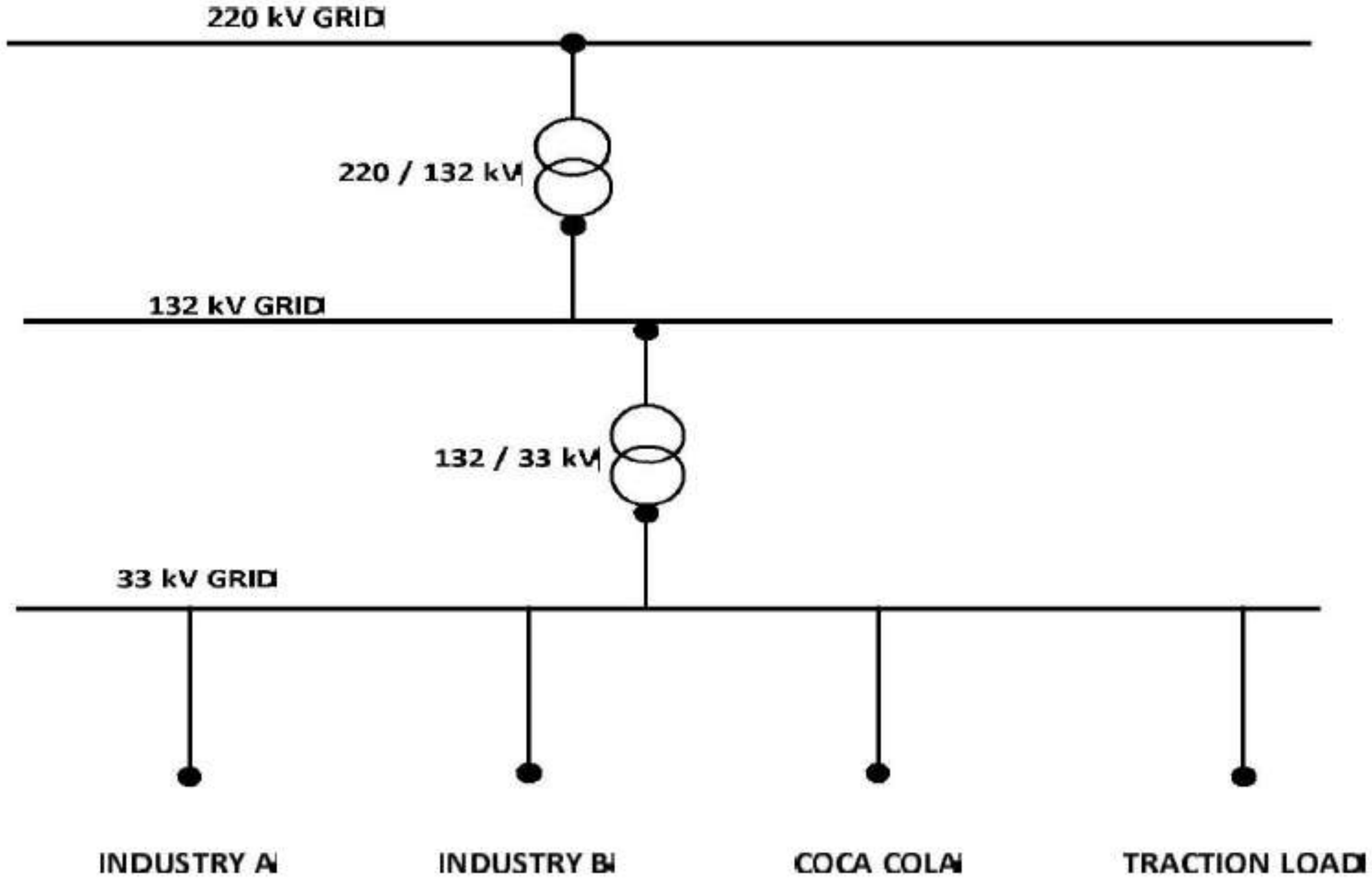
CASE STUDY - 4

Distribution Network Voltage Related Power Quality Issues

Distribution Network Voltage Issues Coca Cola

- Coca Cola – Leading beverage manufacturer, one of the plant at Khurda, Orissa
- Receives power from 220 kV grid – 25 KM from plant
- Same grid also supplies to traction load

SLD of Grid Distribution System



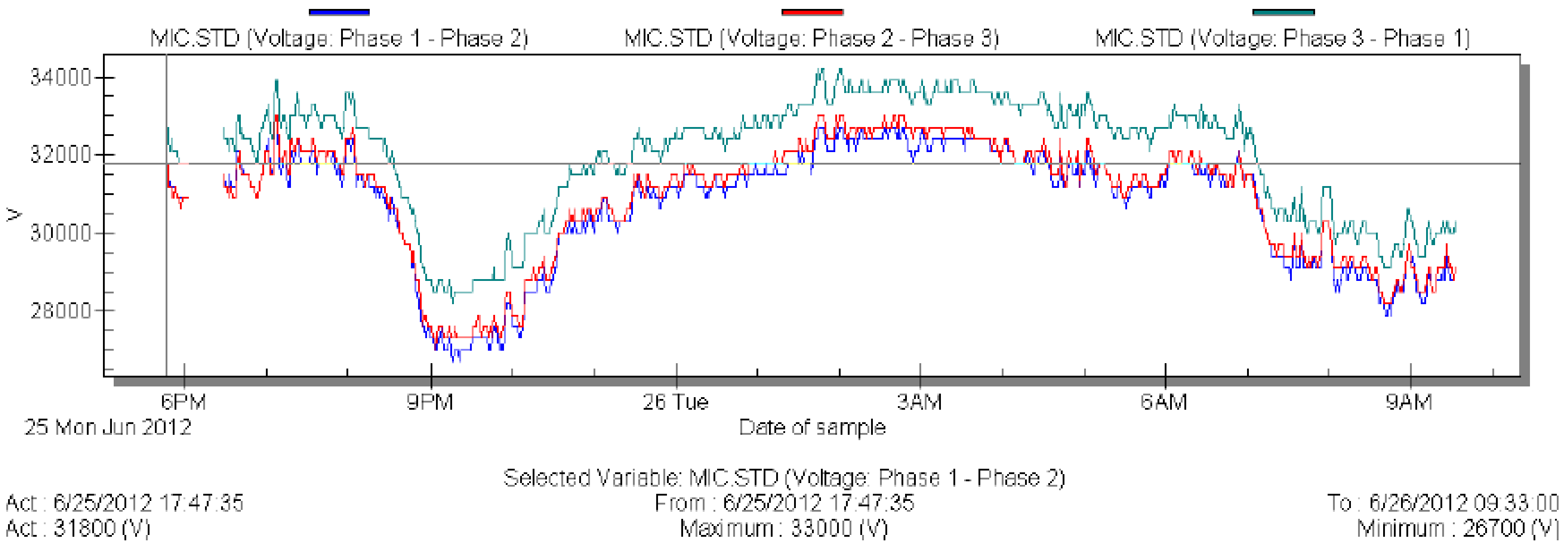
Problem Faced

- Unscheduled power cuts and voltage unbalance
- Un balanced voltage

Month	Unscheduled Power cut	Unbalanced Voltage	Total No of Occurrences
	No. of Occurrences	No. of Occurrences	
January'14	10	9	19
February'14	17	8	25
March'14	45	42	87
April'14	68	51	119

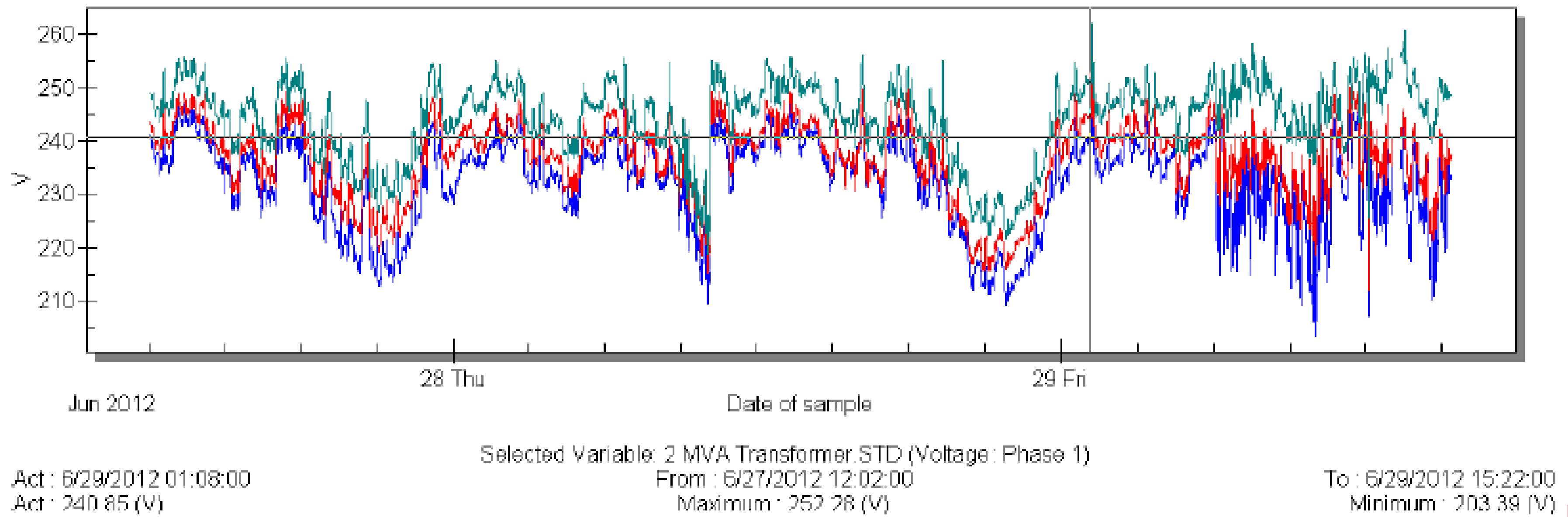
Problem Faced …contd

- Voltage variation – On 33 kV incomer variation is from 26.7 to 34.2 kV



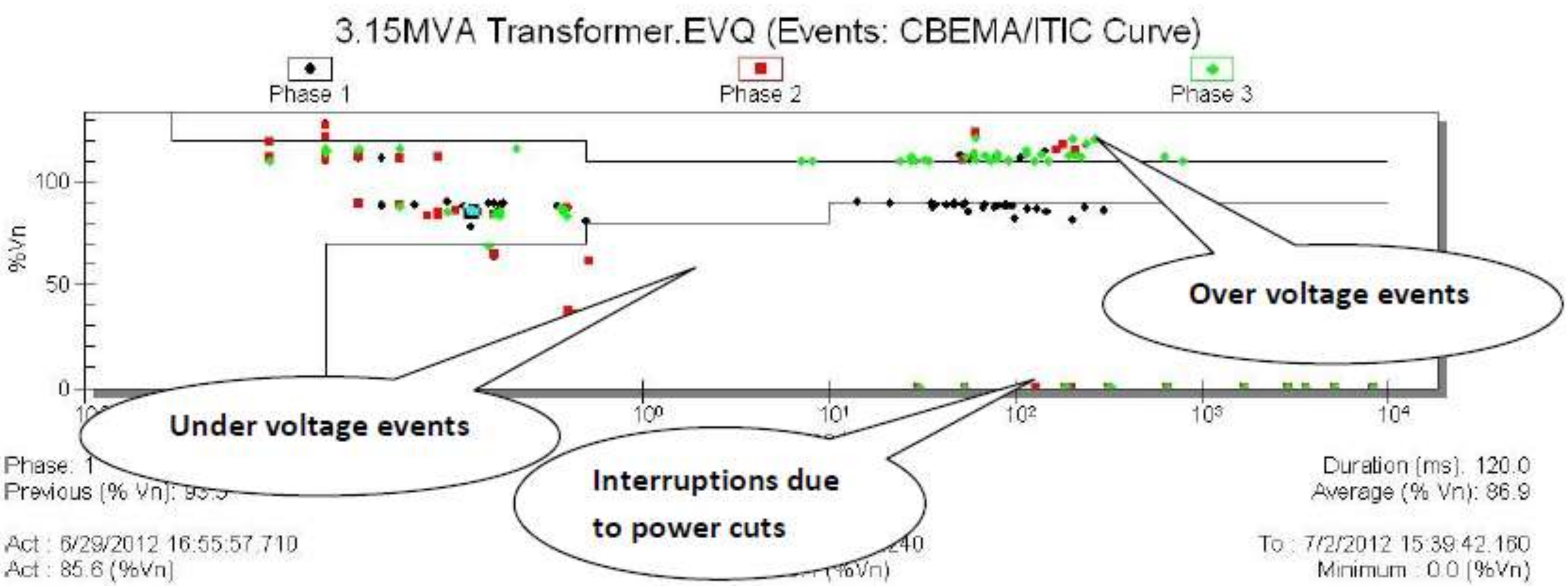
Problem Faced …contd

- Voltage variation – On LT Side incomer variation is from 203 to 252 V
- SCADA recorded voltage dips as low as 20 Volts



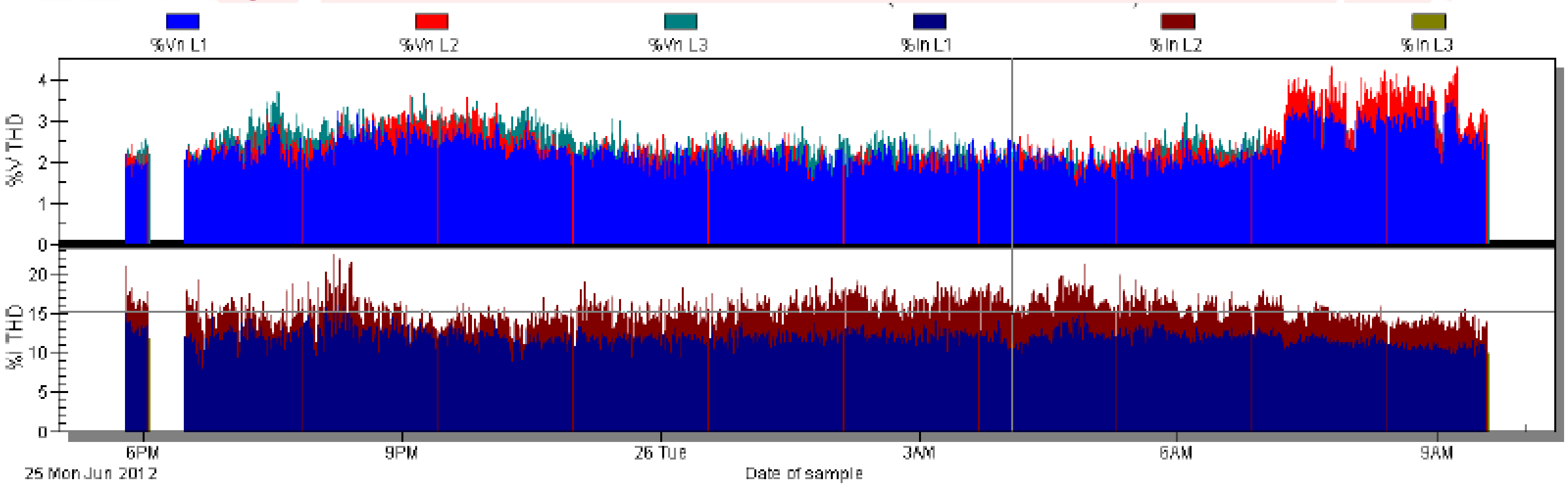
Problem Faced …contd

- Voltage Sags and Swells



Problem Faced …contd

- Voltage & Current Harmonics 4.3% & 22.7%



- Voltage harmonics close to limit specified by IEEE – 519 as 5%
- Current Harmonics on higher side

Impact on Productivity and Financial Loss

- With each interruption and event of power quality, plant was facing production loss

Sl No	Line	Line running time after power resume in mins	Production Capacity per hour (No of cases per hour)	Load factor	Actual Cases Lost	Monetary Loss in Rs per event
1	Krones	15	1500	80%	300	3168
2	Maaza	12	1500	80%	240	2534.4
3	RGB	10	1500	80%	200	2112
4	Kinley	10	300	80%	40	422.4
5	PET-140	15	933	80%	187	1970.496
Total Loss						10207

Temporarily PQ Mitigation Adopted

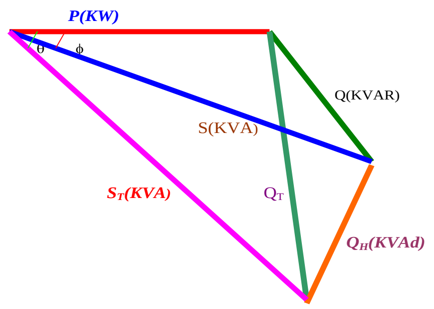
- Use of DG set instead of grid power
- Use of UPS for critical machines – almost 1.8 MVA

Annual Monetary Loss

- Annual loss is through:
  - Loss in productivity
  - Additional cost due to continuous operation of DG set
- Annual loss suffered by plant in terms of loss in productivity and higher energy cost is **INR 62.5 Million** per year.

Cost of Power Quality

- Economic
  - Loss of Revenue
  - Tie up equipment capacity
  - Increased Electricity bill
  - Loss of opportunities
- How does one evaluate
  - Downtime
    - Revenue per hour
    - The cost of production
  - Equipment Problem
    - Troubleshoot the root cause
    - Determine the actual costs
  - Energy Cost
    - Actual Power
    - Reactive Power (PF) Penalties
    - MD Charge structure



The High PQ approach

A PQ audit or design analysis identifies possible threats that may impact PQ

↓

Mitigation technique propositions are made

↓

Solutions investment scenario & choice

↓

Implementation

↓

PQ control through Reliability Centred Maintenance

Conclusion

- Remember PQ is an Issue we have to live with in digital society
- Understand the issues
- Measure n Manage
- Capture financial impact – COST of poor PQ
- Evaluate options
- Adopt HIGH PQ approach
- Share your learning

Pursue Energy Efficiency
but do not forget
Power Quality

Ensuring High Power Quality is every professional's responsibility

High Power Quality benefits all

It increases productivity, profitability & competitiveness,

It improves customer relationship & ensures better employee loyalty

Visit : **www.apqi.org**