

Report on Reactive Power compensation and current harmonics analysis

After Installation of Distributed – Hybrid - Detuned Harmonic mitigation Solution.

Audit Conducted at

Rubber Industry

Submitted 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

[email: solutions@saspowertech.com](mailto:solutions@saspowertech.com)

**Date of Audit
9th May 2018.**

Index

1. Objective, audit team, details of the equipment and Description of electrical system.	3
2. Executive summary	4
3. Harmonics compliance limits calculations	5
4. TDD calculations for 1250KVA transformer	6
5. TDD calculations for 2500KVA transformer	7
6. Results on 1250 KVA Transformer	8
7. Results on 2500 KVA Transformer	13

Objective and the details of the equipment

Objective:

GBL installed distributed – hybrid – detuned Power factor and Harmonic mitigation solution in the plant as per recommendations from SASPPL after an detailed audit conducted earlier.

This audit is conducted to assess performance of the solution implemented.

Details of Equipment Used:

No.	Name of the equipment	Model	Make	Use
1	Power Analyzer	ALM 36	KRYKARD	Electrical Parameter Measurement

Audit team

SAS Powertech Pvt Ltd.: Mr. Narendra Duvedi, (Certified energy auditor)
Mr. Vijay Sonawane

Certification:

Report Certified by:



Narendra R. Duvedi.

B.E. Electrical and Certified Energy Auditor Reg No: EA 10859)

Description of electrical system

The Rubber Industry plant has connected load of 2362KW and contract demand of 1750KVA. Plant receives HT supply of 33KV and has 1250 KVA and 2500KVA Two Transformer installed in the plant. Following detuned panels and Active harmonic filters were installed recently in place of fixed capacitor correction.

1	Detuned – Fixed Type Panels near various loads – ratings @t525V	150KVAR x 2, 112.5 KVAR x 4 75KVAR x 10
2	Detuned – RTPFC Panels near Transformers– ratings @t525V	300KVAR x 2
3	Active Harmonic filters near Transformers	100Amps AHF x 2

EXECUTIVE SUMMARY OF “BEFORE - AFTER” RESULTS

Sr	Parameter	Value BEFORE	Value AFTER	% favorable change
1250 KVA Transformer LT Secondary				
1	Max current handled	900Amps	900 Amps.	
2	Peak Voltage distortion	11%	3%	72%
3	Average Current distortion	45%	9%	80%
4	5 th Harmonic current	300Amps	40Amps	87%
5	7 th Harmonic current	190Amps	40Amps	79%
6	11 th Harmonic current	27Amps	9Amps	60%
7	13 th Harmonic current	8Amps	8Amps	No change
8	Reactive power	Leading and variable contribution	Stable at - 100KVAR	Unity PF at HT side with minimum leading.
2500 KVA Transformer				
1	Max current handled	1000Amps	1100 Amps.	
2	Peak Voltage distortion	5%	2.5%	50%
3	Average Current distortion	20%	3.9%	80%
4	5 th Harmonic current	75Amps	25Amps	67%
5	7 th Harmonic current	110Amps	20Amps	77%
6	11 th Harmonic current	15Amps	7Amps	50%
7	13 th Harmonic current	5 Amps	5 Amps	No change
8	Reactive power	Leading and variable contribution	Stable at - 100KVAR	Unity PF at HT side with minimum leading.

- Average current distortion is 9% and 3.9% at these transformer secondaries, while keeping power factor at 0.99 LEAD.
- TDD calculated for 1250KVA transformer is 6.83% where as the same for 2500KVA transformer is 3.83%. So at common HT PCC it will be between 6 to 10%.
- Common HT side current distortion could not be measured as GBL does not have a common incomer VCB with CT / PT and metering. However as per our experience, the Total Demand Distortion would be bellow 10% and much bellow your compliance requirement of 15%. (We have enclosed TDD calculations for both transformers on next page)
- ON Load voltage distortion for both the transformers is bellow 3%, this has contributed in appreciable improvement in internal power quality available to all plant equipment.
- Although it is difficult to measure, it can be easily seen that transformer and cable loses must have reduced with reduced current distortion and due to reduced current as now plant loads are operating at optimum current as a result of distributed correction.

Harmonic Compliance Limits as per MSEDCL Supply code 2005 and IEEE 519 1992.

Client: Garware Bestrech Wai	
Parameter	Value
MSEDCL Transformer Capacity MVA	50.00
MSEDCL Transformer % Impedense	10.92
Plant contract Demand KVA	1750.00
Plant Max current as per contract demand on LT Side AMPS	2405.70
MAX Load Current at Plant IL Amps on LT Side AMPS	2000.00
HT System Voltage K Volts	33.00
LT System Voltage	433.00
Full Load current of MSEDCL Transformer Amps	874.80
Short Circuit current of MSEDCL Transformer IscAmps	8013.91
Plant current as per contract demand on HT side	43.74
Plant Average load current on HT side	36.36
Isc / IL Ratio as per contract demand	183.22
Isc / IL Ratio as per Max Plant Current	220.38
Harmonic limits	

Current harmonics level compliance limits as per IEEE 519 – 1992

Maximum harmonic current distortion in percentage of IL for voltages less than 69KV.						
Individual harmonic order (odd harmonics)						
Isc/IL	<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.						

As per MSEDCL requirements (Supply code 2005) and IEEE 519 1992 (International standard regarding harmonic compliance at PCC – adopted by MSEDCL, harmonic index TDD – Total demand distortion is calculated. This is given by

$$TDD = \frac{100\% \cdot \sqrt{(I_2^2 + I_3^2 + \dots + I_n^2)}}{I_{\max \text{ demand}}}$$

Where

$I_2, I_3 \dots I_n$ are harmonic currents recorded at Maximum Fundamental current.

I_{\max} is maximum demand current during measurements.

Once TDD is calculated and I_{SC}/I_L are known, above table can be referred to calculate harmonic compliance limits. (Both transformers are now drawing currents at almost unity power factor, so total LT side current is assumed to be simple addition of both currents.) Applying above, the TDD compliance limit for the plant is 15%.

TR 1 – 1250KVA TDD Calculated :-

Analysis of Current harmonic distortion			Recorded % VTHD at IF Max		
TimeStamp of IF Max	Current Amps	% Distortion		Volts	
09-May-18	IFmax in B	870.3			
3:52:13 PM	lh2	1.7406	0.2	Vh2	0
	lh3	1.7406	0.2	Vh3	0.1
	lh4	0.8703	0.1	Vh4	0
	lh5	43.515	5	Vh5	1.5
	lh6	0	0	Vh6	0
	lh7	37.4229	4.3	Vh7	0.7
	lh8	0	0	Vh8	0.1
	lh9	1.7406	0.2	Vh9	0
	lh10	0	0	Vh10	0.1
	lh11	8.703	1	Vh11	0.7
	lh12	0	0	Vh12	0
	lh13	9.5733	1.1	Vh13	0.3
	lh14	0	0	Vh14	0
	lh15	0.8703	0.1	Vh15	0.1
	lh16	0	0	Vh16	0.1
	lh17	0.8703	0.1	Vh17	0.2
	lh18	0	0	Vh18	0
	lh19	3.4812	0.4	Vh19	0.1
	lh20	0	0	Vh20	0
	lh21	0.8703	0.1	Vh21	0
	lh22	0	0	Vh22	0
	lh23	4.3515	0.5	Vh23	0
	lh24	0	0	Vh24	0
	lh25	0.8703	0.1	Vh25	0.1
	lh26	0	0	Vh26	0
	lh27	0.8703	0.1	Vh27	0
	lh28	0	0	Vh28	0
	lh29	3.4812	0.4	Vh29	0.2
	lh30	0	0	Vh30	0
	lh31	0	0	Vh31	0.2
	lh32	0	0	Vh32	0
	lh33	0	0	Vh33	0
	lh34	0	0	Vh34	0
	lh35	2.6109	0.3	Vh35	0.3
	lh36	0	0	Vh36	0
	lh37	1.7406	0.2	Vh37	0.2
	lh38	0	0	Vh38	0
	lh39	0	0	Vh39	0
	lh40	0	0	Vh40	0
	lh41	0	0	Vh41	0.1
	lh42	0	0	Vh42	0
	lh43	0	0	Vh43	0.1
	lh44	0	0	Vh44	0
	lh45	0	0	Vh45	0
	lh46	0	0	Vh46	0
	lh47	0.8703	0.1	Vh47	0.1
	lh48	0	0	Vh48	0
	lh49	0	0	Vh49	0
	lh50	0	0	Vh50	0
	Sum of sq(A)	3528.829517			
	Sqrt(A)	59.40395203			
	TDD	6.825686779			

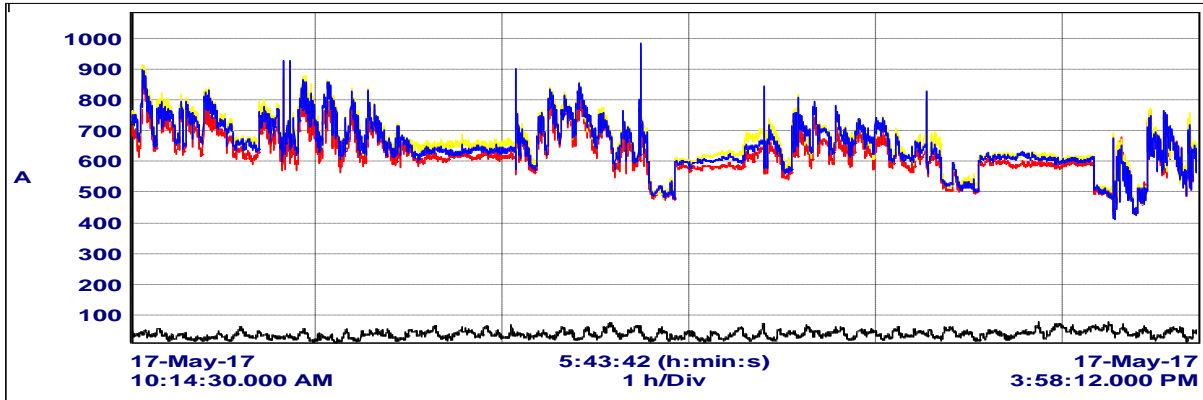
TDD recorded at 1250KVA transformer secondary is 6.83%

TR 2 – 2500KVA TDD Calculated :-

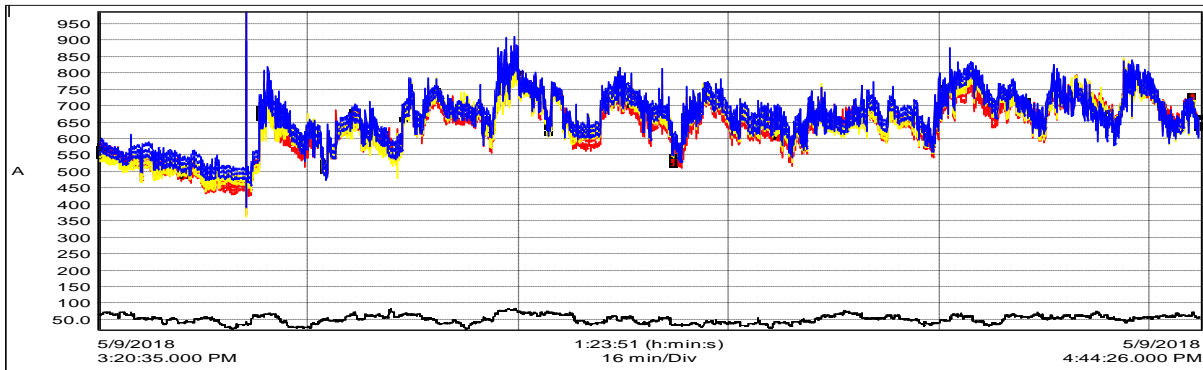
Analysis of Current harmonic distortion			Recorded % VTHD at IF Max	
TimeStamp of IF Max	Current Amps	% Distortion		Volts
09-May-18	IFmax in R	1210.2		
2:07:30 PM	lh2	0	0	Vh2
	lh3	32.6754	2.7	Vh3
	lh4	2.4204	0.2	Vh4
	lh5	21.7836	1.8	Vh5
	lh6	0	0	Vh6
	lh7	19.3632	1.6	Vh7
	lh8	0	0	Vh8
	lh9	7.2612	0.6	Vh9
	lh10	0	0	Vh10
	lh11	0	0	Vh11
	lh12	0	0	Vh12
	lh13	3.6306	0.3	Vh13
	lh14	0	0	Vh14
	lh15	7.2612	0.6	Vh15
	lh16	1.2102	0.1	Vh16
	lh17	8.4714	0.7	Vh17
	lh18	0	0	Vh18
	lh19	2.4204	0.2	Vh19
	lh20	0	0	Vh20
	lh21	1.2102	0.1	Vh21
	lh22	0	0	Vh22
	lh23	1.2102	0.1	Vh23
	lh24	0	0	Vh24
	lh25	2.4204	0.2	Vh25
	lh26	0	0	Vh26
	lh27	0	0	Vh27
	lh28	0	0	Vh28
	lh29	1.2102	0.1	Vh29
	lh30	0	0	Vh30
	lh31	3.6306	0.3	Vh31
	lh32	0	0	Vh32
	lh33	0	0	Vh33
	lh34	0	0	Vh34
	lh35	2.4204	0.2	Vh35
	lh36	0	0	Vh36
	lh37	0	0	Vh37
	lh38	0	0	Vh38
	lh39	0	0	Vh39
	lh40	0	0	Vh40
	lh41	1.2102	0.1	Vh41
	lh42	0	0	Vh42
	lh43	0	0	Vh43
	lh44	0	0	Vh44
	lh45	0	0	Vh45
	lh46	0	0	Vh46
	lh47	0	0	Vh47
	lh48	0	0	Vh48
	lh49	1.2102	0.1	Vh49
	lh50	0	0	Vh50
	Sum of sq(A)	2152.938539		
	Sqrt(A)	46.39976874		
	TDD	3.834057903		

TDD recorded at 2500 KVA transformer secondary is 3.83 %

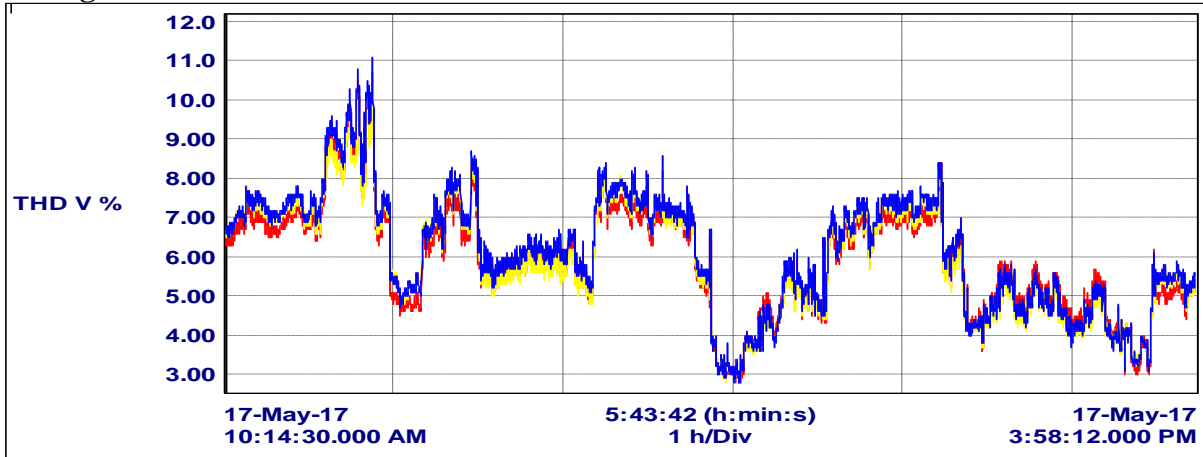
**1250KVA Transformer Main Incomer
Current BEFORE**



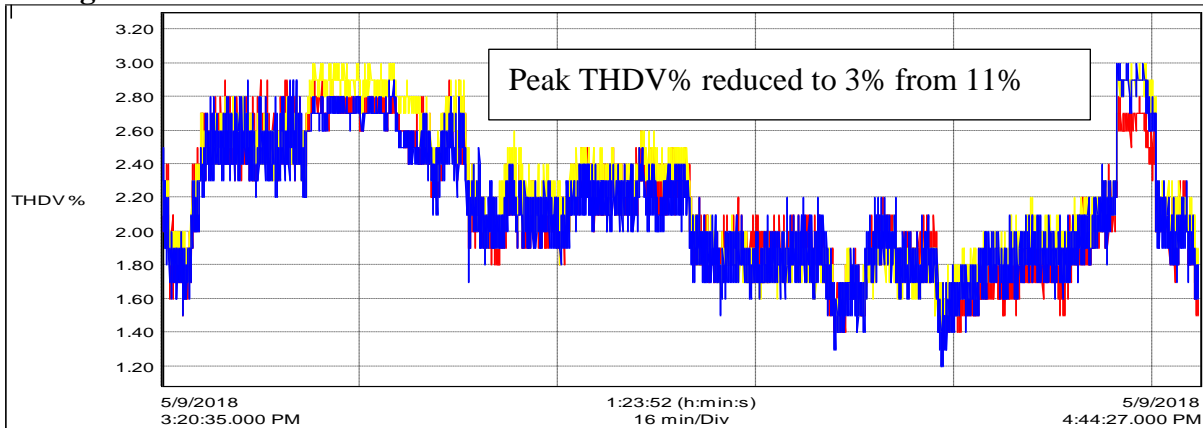
Current AFTER



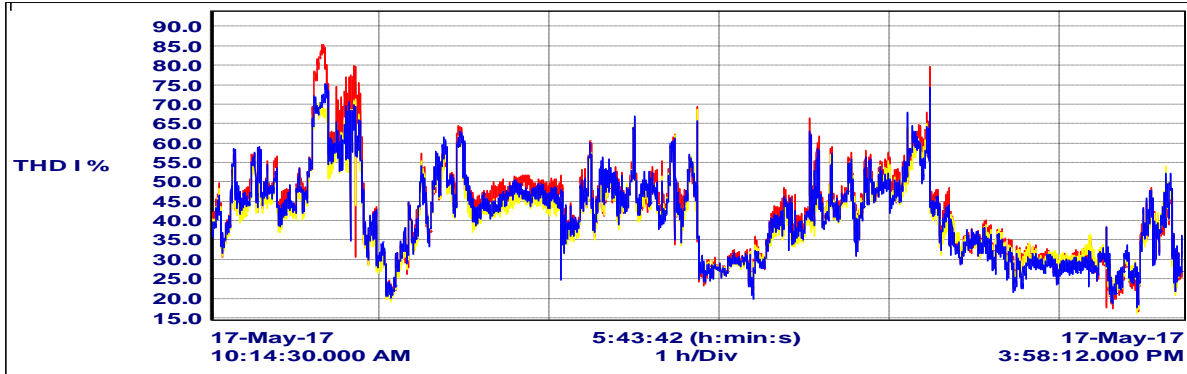
Voltage harmonic distortion BEFORE



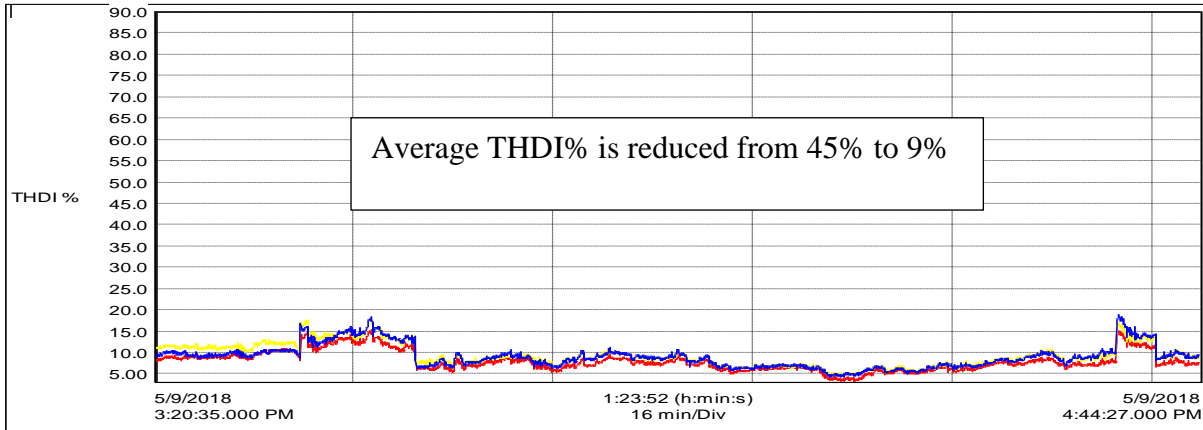
Voltage harmonic distortion AFTER



Current Harmonic Distortion BEFORE



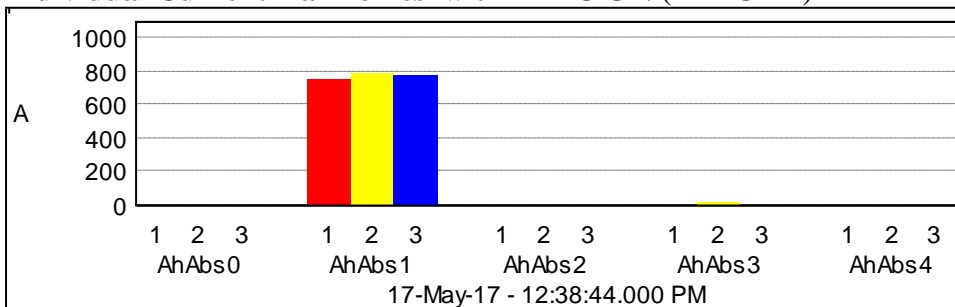
Current Harmonic Distortion: AFTER



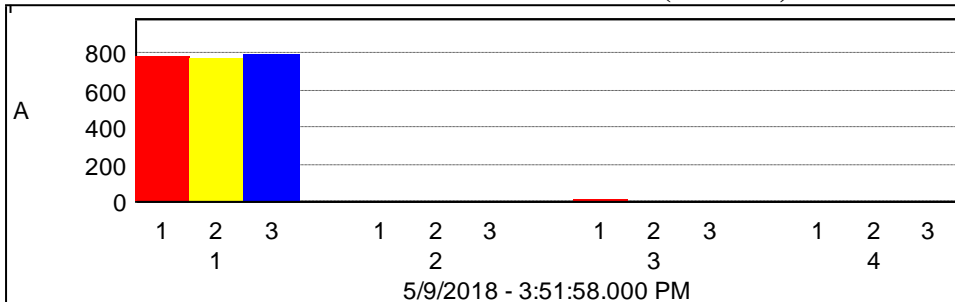
Current harmonics – Total harmonic distortion %

Date	Time PM	Phase	AVG	Min	Max
5/9/2018	3:20:35.000	R	8.023%	3.4%	15.5%
5/9/2018	3:20:35.000	Y	9.367%	4.4%	18%
5/9/2018	3:20:35.000	B	9.091%	4.3%	19%

Individual Current Harmonics with APFC ON (BEFORE)

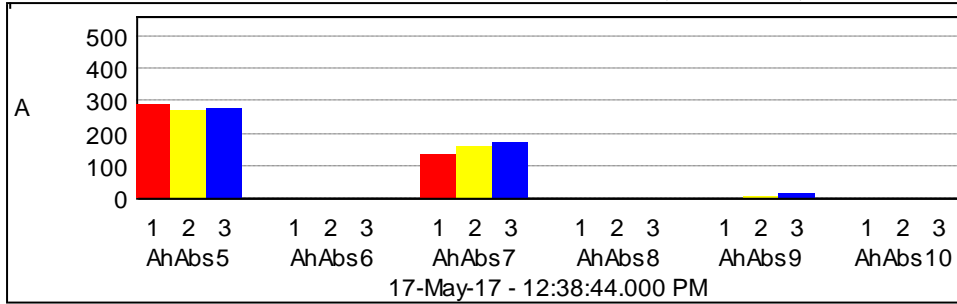


Individual Current Harmonics with APFC ON (AFTER)



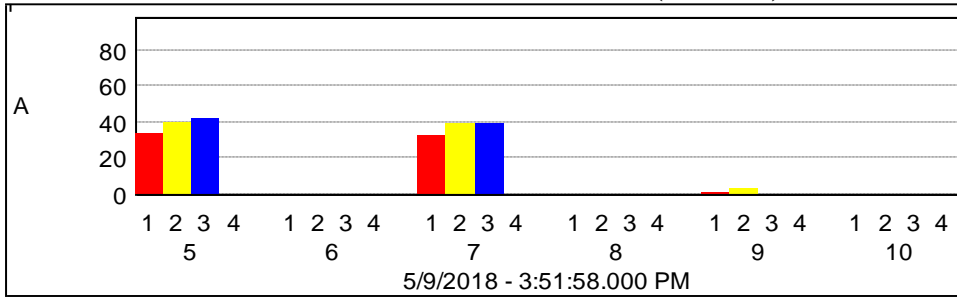
Fundamental current same in both cases.

Individual Current Harmonics with APFC ON (BEFORE)



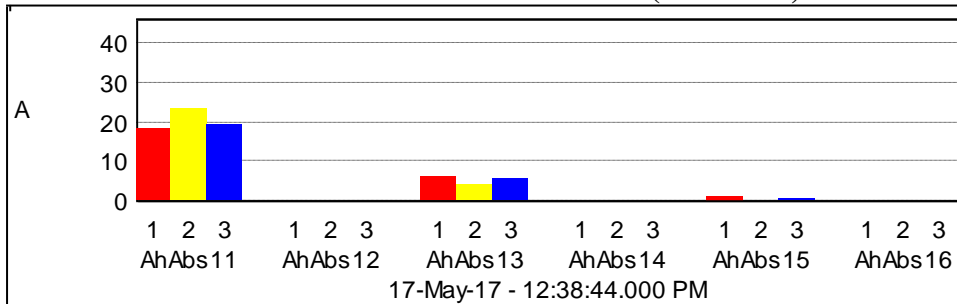
Reduction in 5th Harmonic current = 87% (300A to 40A)

Individual Current Harmonics with APFC ON (AFTER)



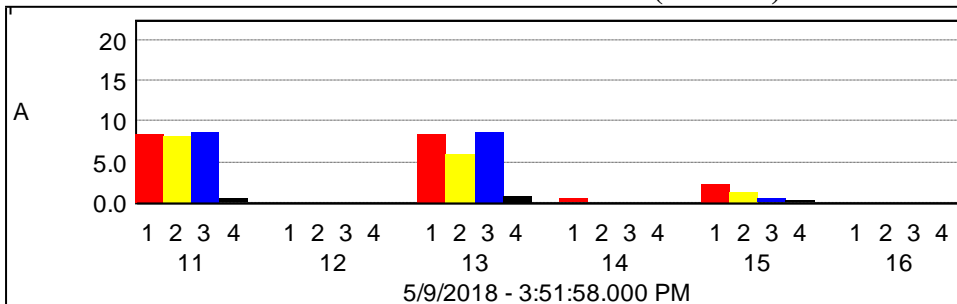
Reduction in 7th Harmonic current = 79% (190A to 40A)

Individual Current Harmonics with APFC ON (BEFORE)



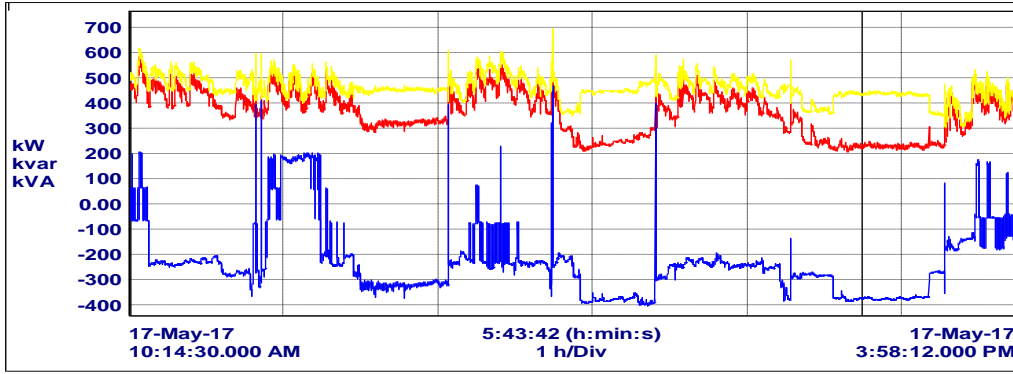
Reduction in 11th Harmonic current = 60% (22A to 9A)

Individual Current Harmonics with APFC ON (AFTER)



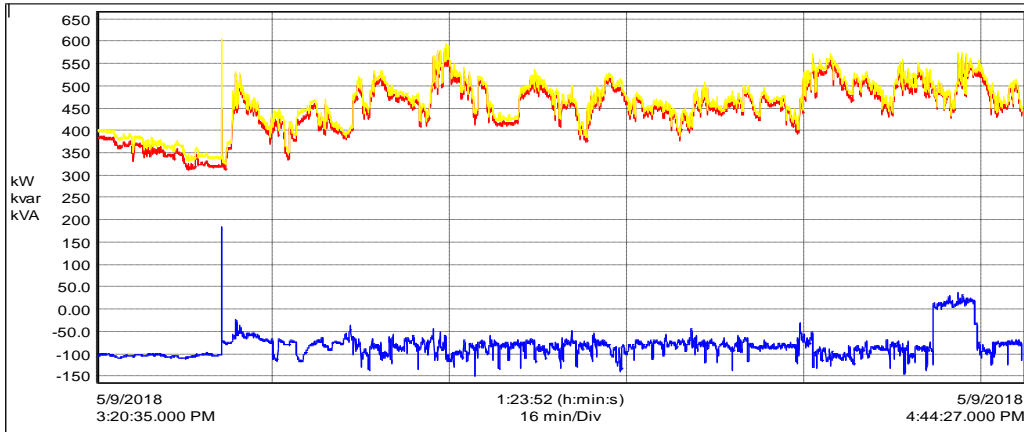
Reduction in 13th Harmonic current = No reduction

KW- KVAR-KVA BEFORE

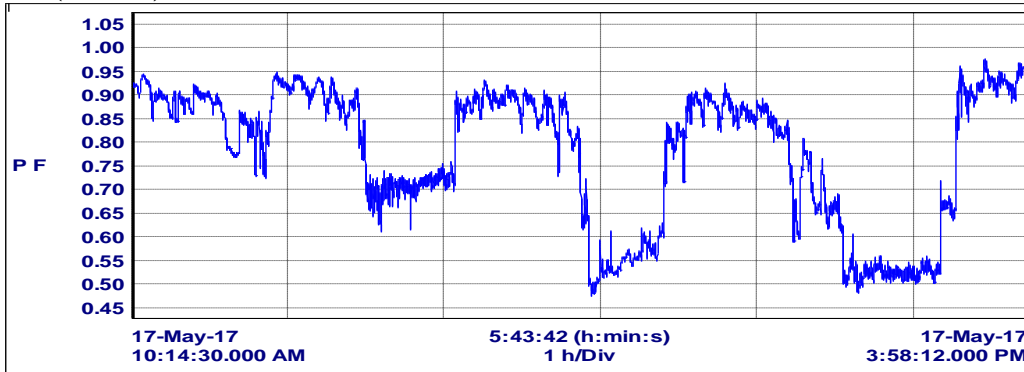


KW / KVAR now almost track each other as the values are very close. The reactive power is almost stable at -100KVAR irrespective of load

KW- KVAR-KVA AFTER

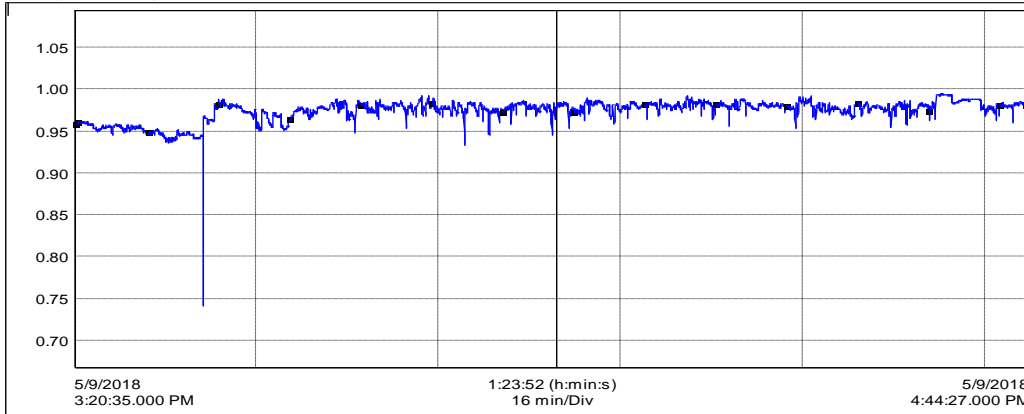


PF (Before)

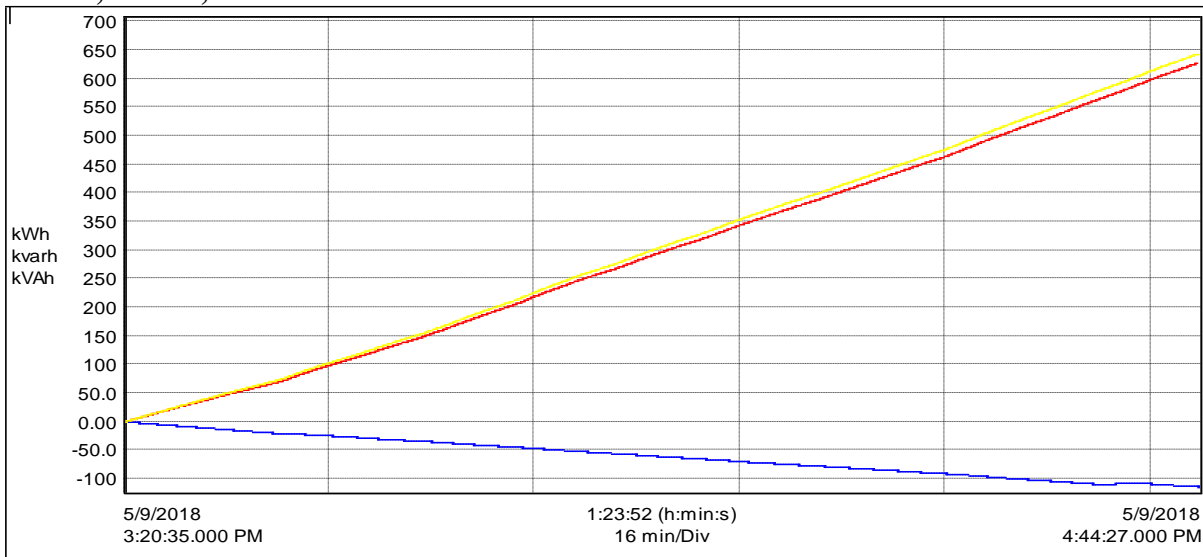


PF is now almost stable at 0.98 Lead irrespective of load. The lead component will compensate for transformer impedance on HT side.

PF (After)



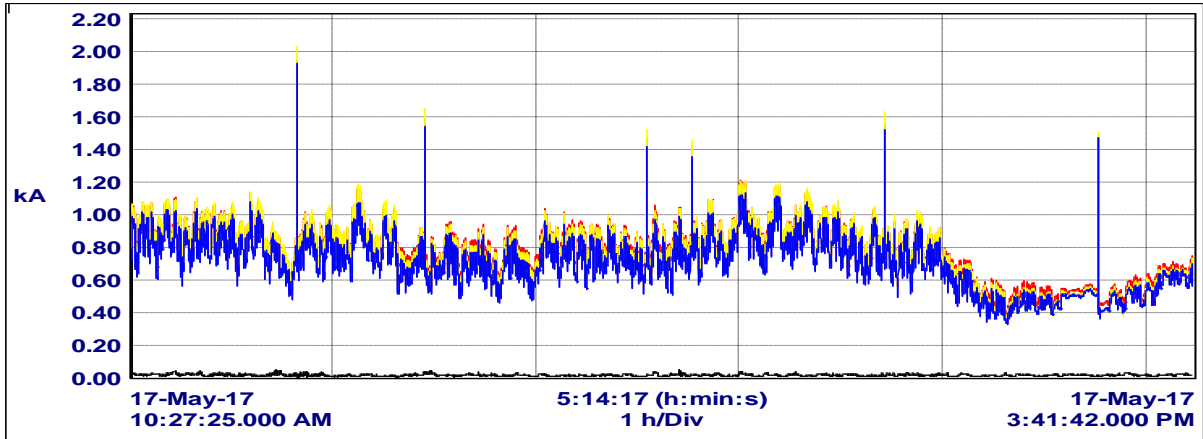
KWh, KVAh, KVARh - AFTER



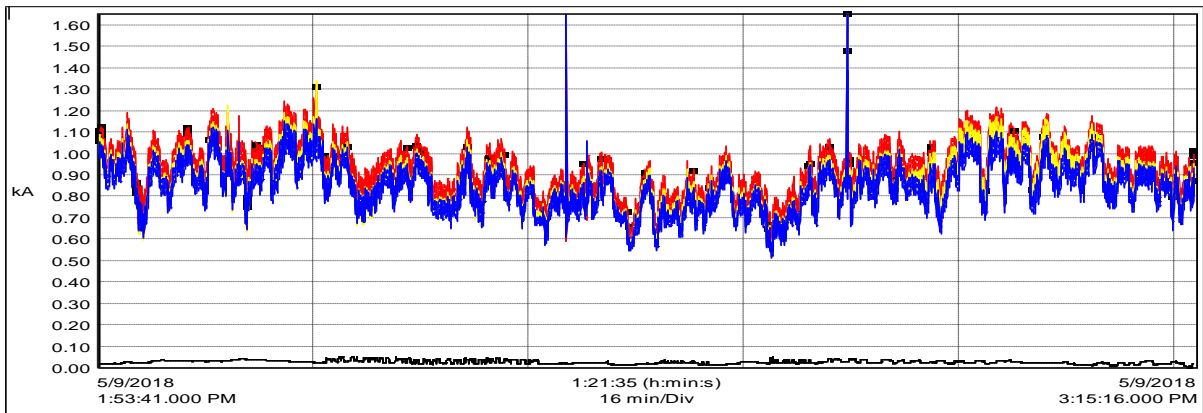
KWh(Red), KVA (Yellow) track each other, offering close to unity PF.
 KVARh (Blue) is very low and always remains slightly negative – i.e.
 capacitive.

2500KVA Transformer Main Incomer

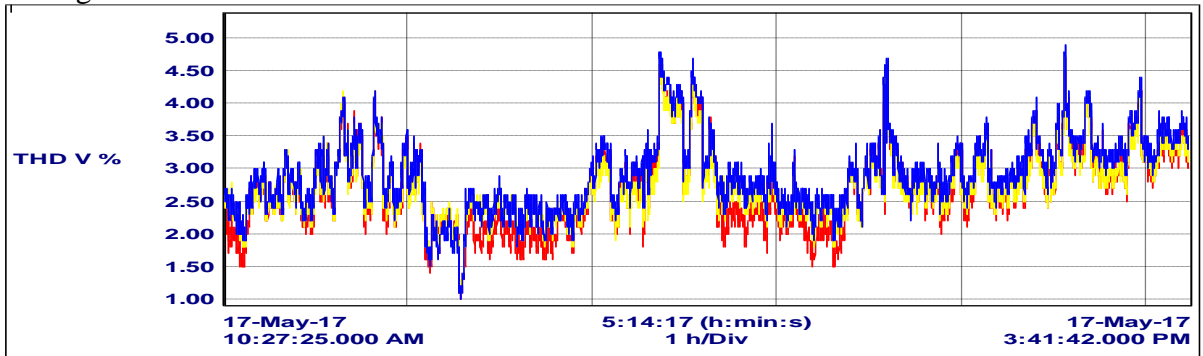
Current – BEFORE



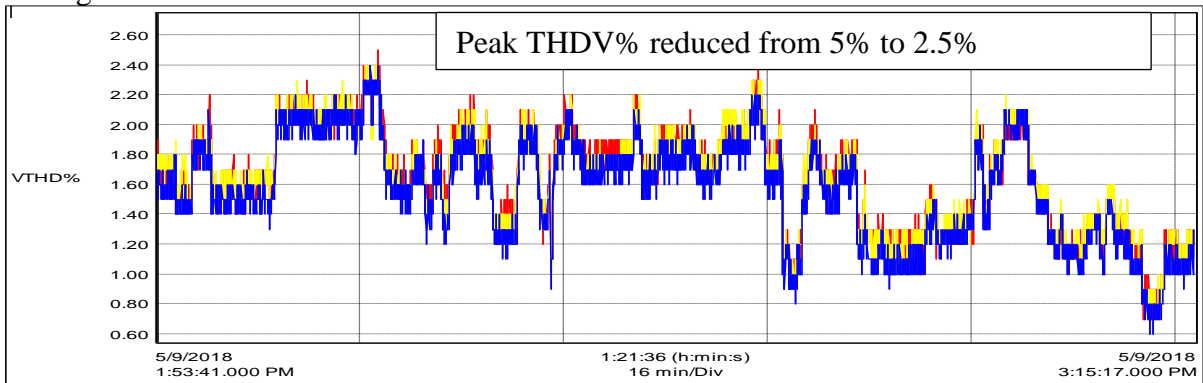
Current AFTER



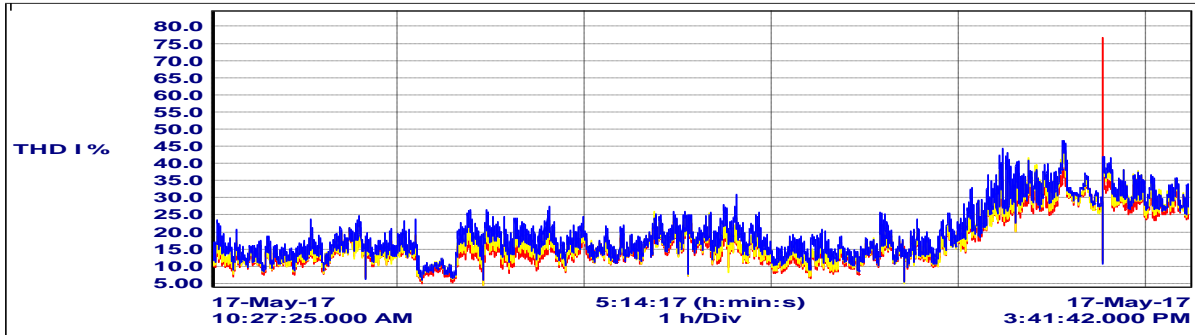
Voltage harmonic distortion % BEFORE



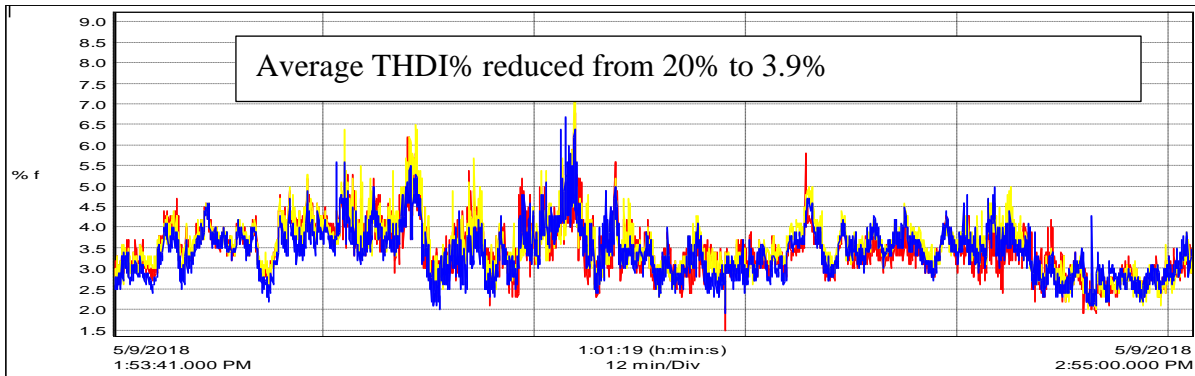
Voltage harmonic distortion % AFTER



Current THD % BEFORE

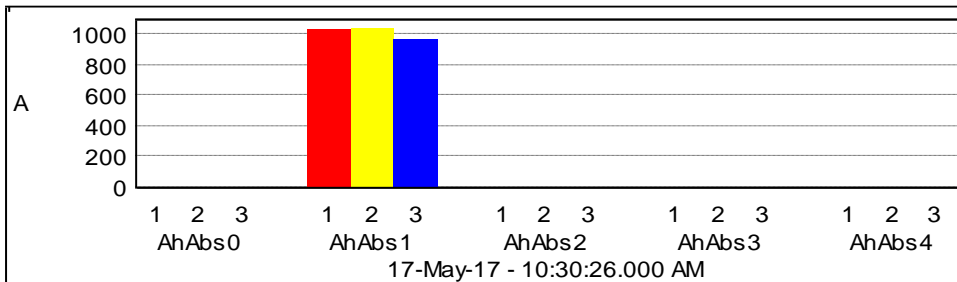


Current THD % AFTER

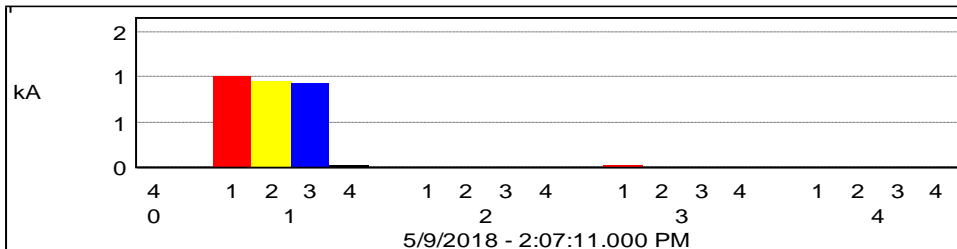


Current harmonics – Total harmonic distortion %					
Date	Time PM	Phase	AVG	Min	Max
5/9/2018	1:53:41.000	R	3.772%	1.5%	7.4%
5/9/2018	1:53:41.000	Y	3.893%	2.0%	8.6%
5/9/2018	1:53:41.000	B	3.752%	1.9%	8.0%

Individual Current Harmonic with APFC ON: BEFORE

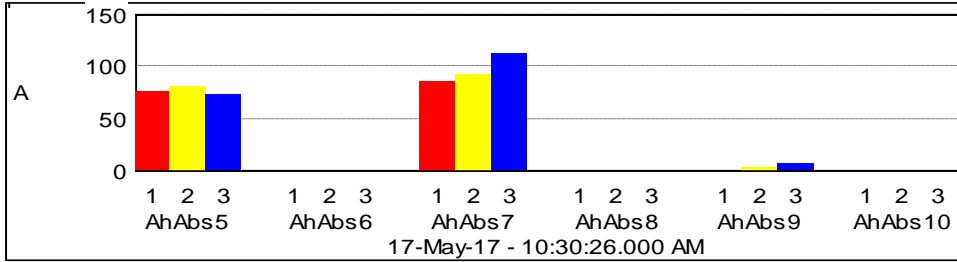


Individual Current Harmonic APFC on as follows: AFTER



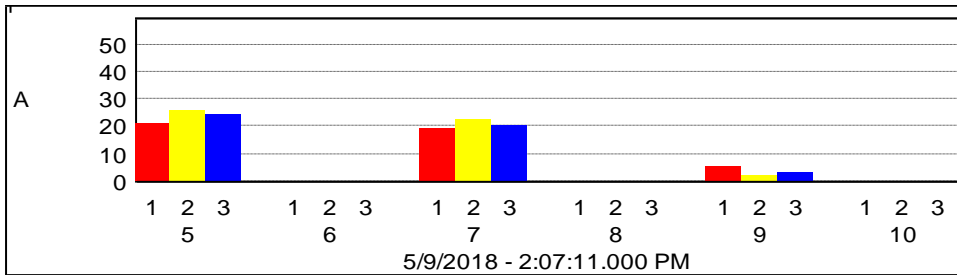
**Fundamental
Frequency
current is
same in both
cases =
1000Amps.**

Individual Current Harmonic with APFC ON: BEFORE



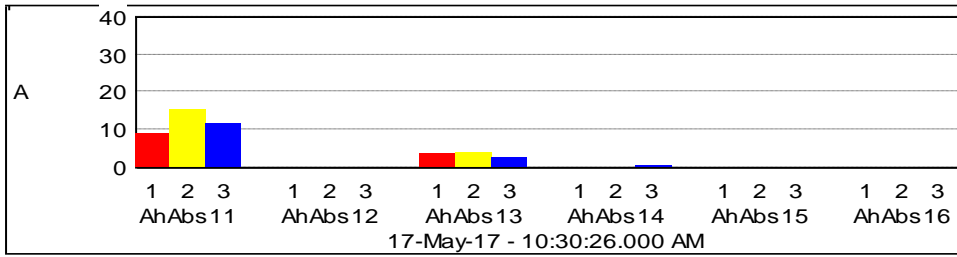
**5th harmonic current reduced by 67%
Reduced from 75 Amps to 25 Amps.**

Individual Current Harmonic with APFC ON: AFTER



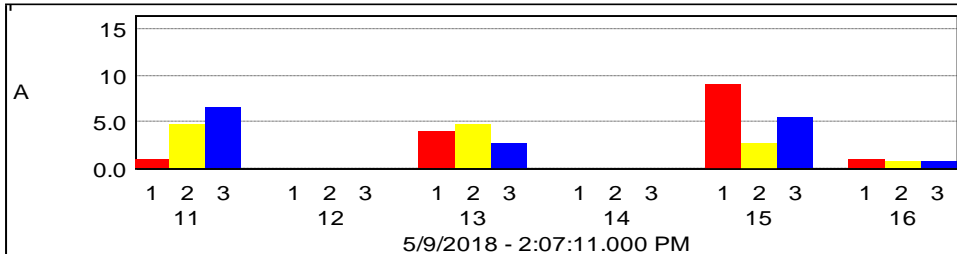
**7th harmonic current reduced by 77%
Reduced from 110 Amps to 25 Amps.**

Individual Current Harmonic with APFC ON: BEFORE



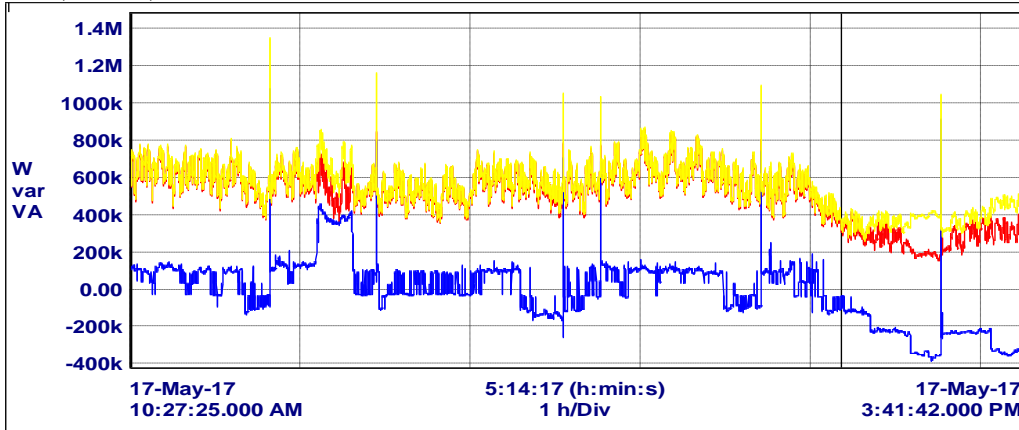
**11th harmonic current reduced by 50%
Reduced from 15 Amps to 7 Amps.**

Individual Current Harmonic with APFC ON : AFTER



**No reduction in 13th harmonic current
Remains at 5 Amps**

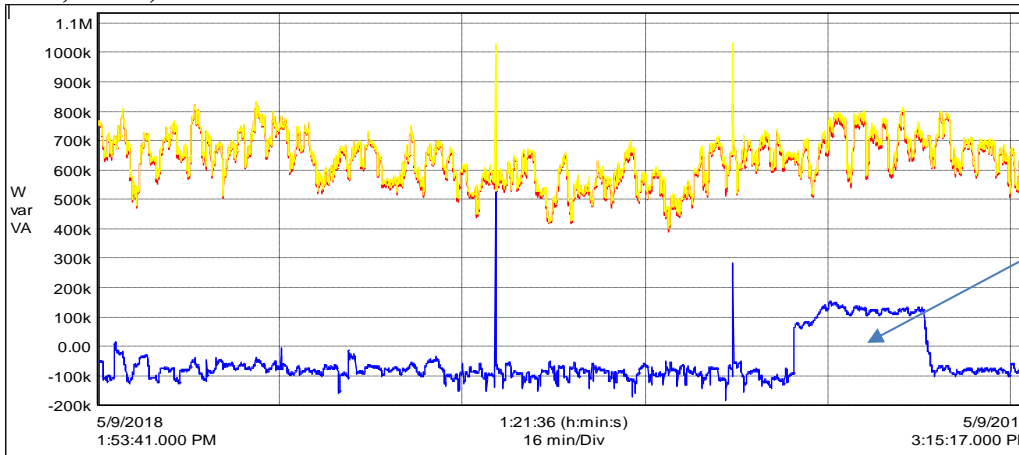
KW, KVA, KVAR - BEFORE



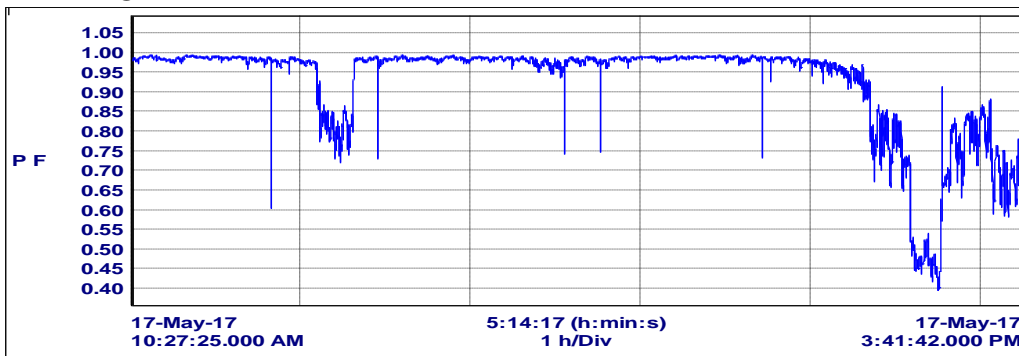
KW / KVAR
now almost track each other as the values are very close. The reactive power is almost stable at -100KVAR irrespective of load

RTPFC Panel was put OFF during this period

KW, KVA, KVAR - AFTER

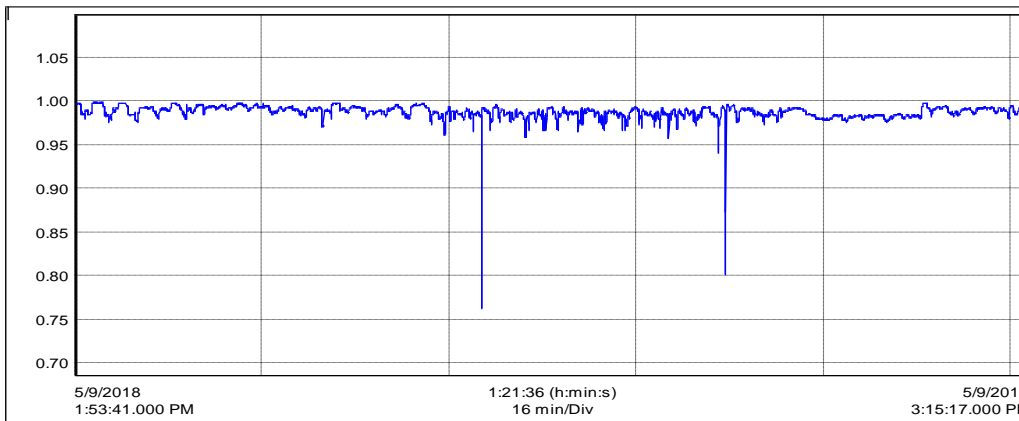


PF BEFORE

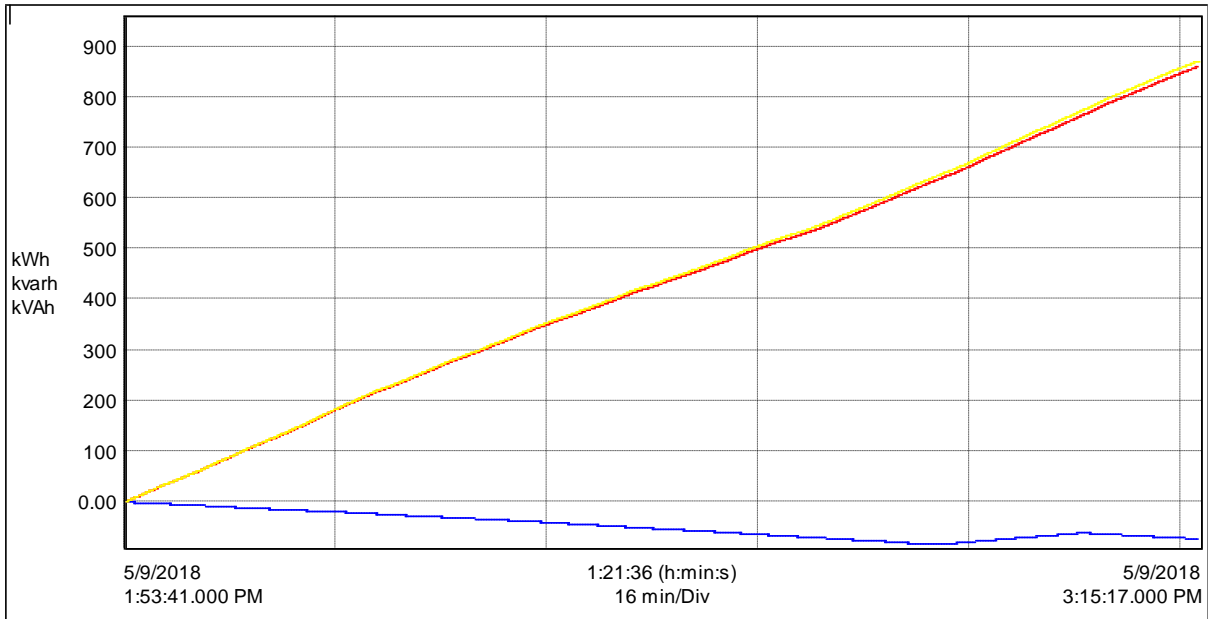


PF is now almost stable at 0.99 Lead irrespective of load. The lead component will compensate for transformer impedance on HT side.

PF AFTER



KWh, KVAh, KVARh - AFTER



KWh(Red), KVA (Yellow) track each other, offering close to unity PF.
 KVARh (Blue) is very low and always remains slightly negative – i.e. capacitive.