PQS Electrolink (India) Pvt. Ltd.

Power Factor Correction
&
Harmonic Filtering Systems

Cos-One®

Power Factor Correction and Harmonic Filtering products

What is Power Quality ?

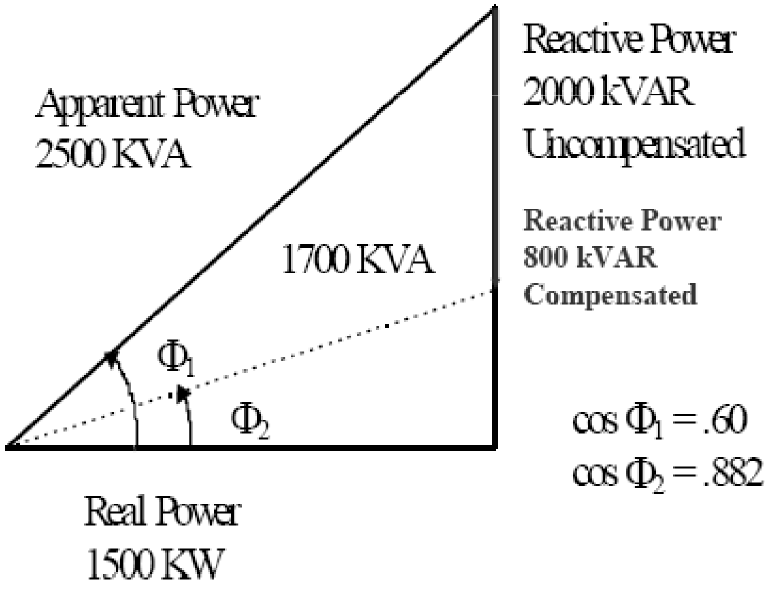
Power Quality means different for different people. But power quality can be better understood in context with relevant International standards e.g. IEC61000-2-4 which is considered to deal with power quality criteria with regards to different electrical power distribution systems.

Power Quality covers four major topics:

1. **Voltage : Voltage sags/swells, variations, transients, etc.**
2. **Frequency : Variations more than 1% e.g. noise**
3. **Harmonic Distortion : Non-linear waveforms**
4. **Power Factor : Differential between active and apparent power**

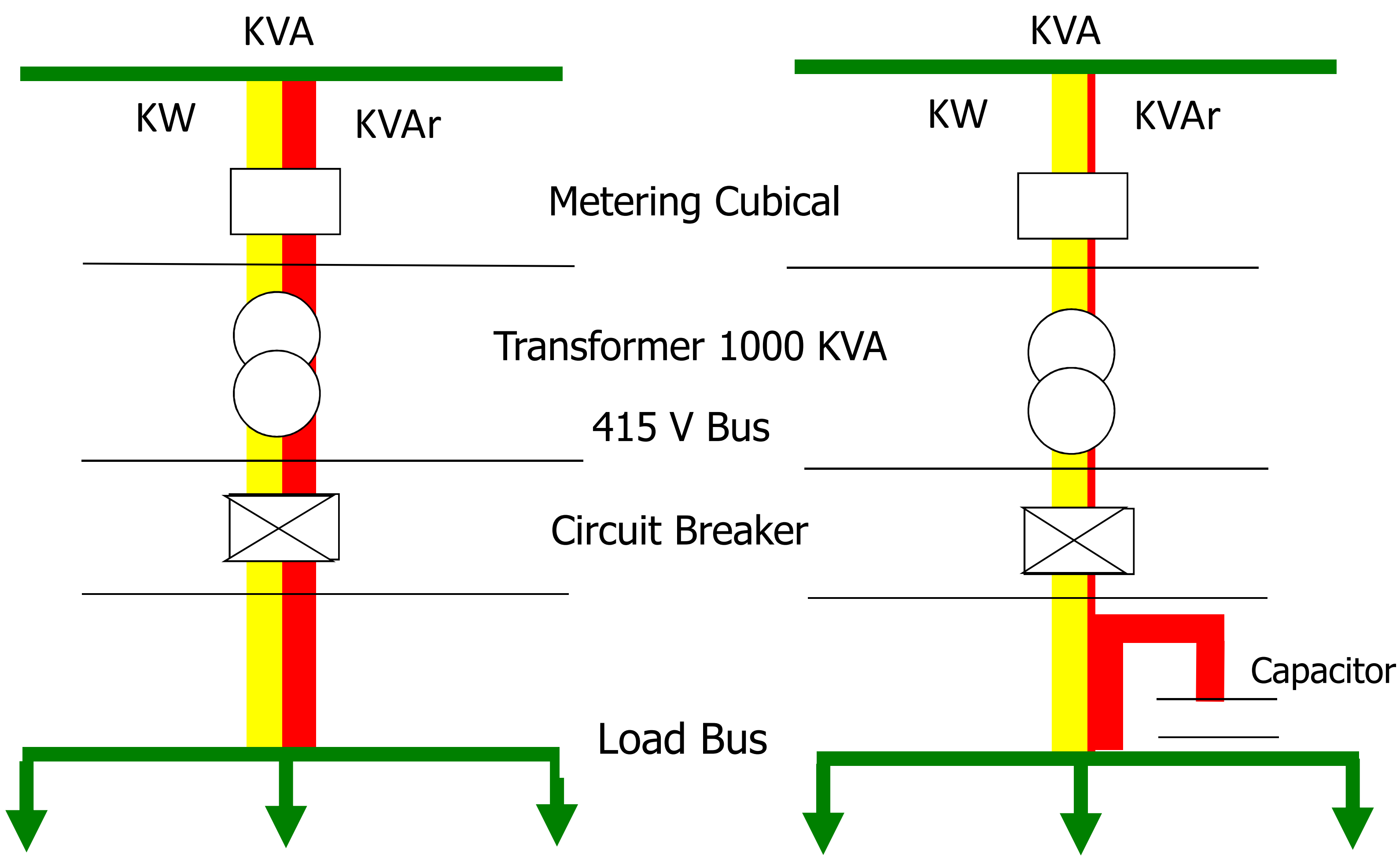
However, power quality covers numerous issues….

1. Reactive Power Compensation – PF Correction

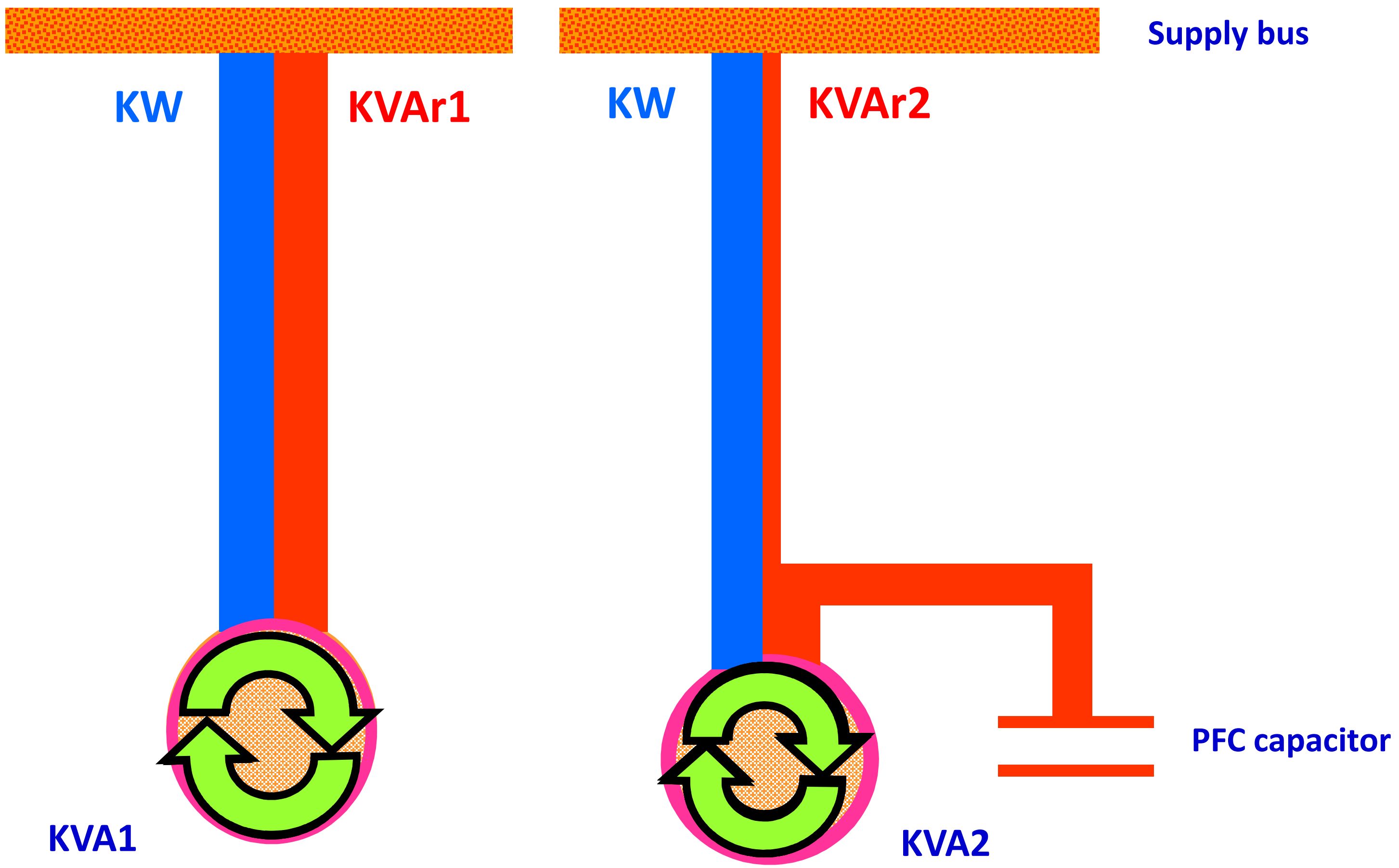


Industry	Percent Uncorrected PF
Brewery	76-80
Cement	80-85
Chemical	65-75
Coal Mine	65-80
Clothing	35-60
Electroplating	65-70
Foundry	75-80
Forge	70-80
Hospital	75-80
Machine manufacturing	60-65
Metal working	65-70
Office building	80-90
Oil-field pumping	40-60
Paint manufacturing	55-65
Plastic	75-80
Stamping	60-70
Steelworks	65-80
Textile	65-75

Basics of Power Factor Correction



Basics of Power Factor Correction

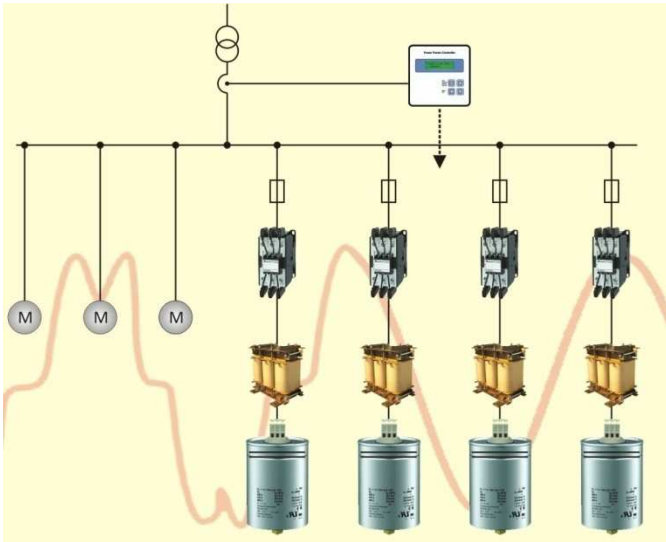


Motor drawing reactive power from supply bus

Motor drawing reactive power from PFC capacitor

Advantages of PF Correction

- Avoid p.f. penalty imposed by electricity board due to poor power factor.
- Reduction of M.D. (KVA demand), thereby reduced bill and increased capacity.
- Avail p.f. rebate on demand & energy charges in elect bill upto 7.5 %.
- Reduced load current, distribution losses, heating of transformers & cables.
- Increased service life of all electrical equipments in the plant.
- Shortest payback period on investment - from 2 to 18 months.



Economics of PF Correction

For 500 KVA Transformer industrial load

A) Maximum Demand In KVA
KW/PF = 425/0.85 = 500 KVA
Monthly Demand Charges
(Rs. 125)*(500KVA) = Rs 62,500/-

B) Units Consumed
(425Kw)(0.5 LF)(30Days)(24hrs)
= 1,53,000 KWH (units)
Monthly KWH Charges @Rs 5.00
= Rs. 7,65,000/-

C) Penalty
Every 0.01 reduction in PF below 0.9
penal Charges would be 5.5%
(Rs. 8,27,500)* 5.5% = Rs. 45,512/-

D) Total
A+B+C = Rs. 8,73,012/-

A) Maximum Demand In KVA
KW/PF = 425/0.99 = 430 KVA
Monthly Demand Charges
(Rs.125)*(430KVA) = Rs 53,750/-

B) Units Consumed
(425Kw)(0.5 LF)(30Days)(24hrs)
= 1,53,000 KWH
Monthly KWH Charges @ Rs 5.00
= Rs 7,65,000/-

C) Penalty -- Nil

D) Incentive – For every 0.01 increase in PF above 0.95, incentive will be 4.0 %. (Rs. 8,18,750/-) x 4.0%
= Rs. 32,750/-

D) Total
A+B+C-D = Rs. 7,86,000/-

E) Savings Rs. 8,73,012 – Rs. 7,86,000/-
= **Rs. 87,012/-**

Economics of PF Correction

Calculation of payback period

For improving pf from 0.85 to 0.99

Multiplying Factor = 0.47 (from the PF selection table)

Total load = 425 KW.

Capacitor required for improving pf to 0.99
= Total load x Multiplying Factor.
= 425 KW x 0.47 = 200 KVAr.
Cost of a good quality Industrial Duty Capacitor @ Rs. 250/- p
= Rs. 50,000/-.

Savings per month : Rs. 87,012/-

Payback period is less than one month…. !!!

How to select PFC capacitor rating

$Qc = P_A * (\tan \phi 1 - \tan \phi 2)$

$Qc\ [KVAr] = P_A * F$ = active power [kW] * factor "F"

$P_A = S * \cos \phi$ = apparent power * $\cos \phi$

$\tan \phi 1 + \phi 2$ according to $\cos \phi$ values ref. table

Example:

Actual motor power	P = 500 kW
ACTUAL cos φ	0.61
TARGET cos φ	0.96
Factor F from table	1.01

Capacitor reactive power Qc

Qc = 500 * 1.01 = 505 KVAr

Capacitor Selection Chart

TARGET cos φ = 0.96 | Q

cos φ ≤ 1

Q_c

$Q_c = P_A * F (0.96) = ... [KVAr]$

500 * 1.01 = 505.0 KVAr

Current (ACTUAL) tan φ	cos φ	achievable (TARGET) cos φ 0.80	0.82	0.85	0.88	0.90	0.92	0.94	0.96	0.98	1.00
		Factor F									
3.18	0.30	2.43	2.48	2.56	2.64	2.70	2.75	2.82	2.89	2.98	3.18
2.96	0.32	2.21	2.26	2.34	2.42	2.48	2.53	2.60	2.67	2.76	2.96
2.77	0.34	2.02	2.07	2.15	2.23	2.28	2.34	2.41	2.48	2.56	2.77
2.59	0.36	1.84	1.89	1.97	2.05	2.10	2.17	2.23	2.30	2.39	2.59
2.43	0.38	1.68	1.73	1.81	1.89	1.95	2.01	2.07	2.14	2.23	2.43
2.29	0.40	1.54	1.59	1.67	1.75	1.81	1.87	1.93	2.00	2.09	2.29
2.16	0.42	1.41	1.46	1.54	1.62	1.68	1.73	1.80	1.87	1.96	2.16
2.04	0.44	1.29	1.34	1.42	1.50	1.56	1.61	1.68	1.75	1.84	2.04
1.93	0.46	1.18	1.23	1.31	1.39	1.45	1.50	1.57	1.64	1.73	1.93
1.83	0.48	1.08	1.13	1.21	1.29	1.34	1.40	1.47	1.54	1.62	1.83
1.73	0.50	0.98	1.03	1.11	1.19	1.25	1.31	1.37	1.45	1.63	1.73
1.64	0.52	0.89	0.94	1.02	1.10	1.16	1.22	1.28	1.35	1.44	1.64
1.56	0.54	0.81	0.86	0.94	1.02	1.07	1.13	1.20	1.27	1.36	1.56
1.48	0.56	0.73	0.78	0.86	0.94	1.00	1.05	1.12	1.19	1.28	1.48
1.40	0.58	0.65	0.70	0.78	0.86	0.92	0.98	1.04	1.11	1.20	1.40
1.33	0.60	0.58	0.63	0.71	0.79	0.85	0.91	0.97	1.04	1.13	1.33
1.30	0.61	0.55	0.60	0.68	0.76	0.81	0.87	0.94	1.01	1.10	1.30
1.27	0.62	0.52	0.57	0.65	0.73	0.78	0.84	0.91	0.99	1.06	1.27
1.23	0.63	0.48	0.53	0.61	0.69	0.75	0.81	0.87	0.94	1.03	1.23
1.20	0.64	0.45	0.50	0.58	0.66	0.72	0.77	0.84	0.91	1.00	1.20
1.17	0.65	0.42	0.47	0.55	0.63	0.68	0.74	0.81	0.88	0.97	1.17
1.14	0.66	0.39	0.44	0.52	0.60	0.65	0.71	0.78	0.85	0.94	1.14
1.11	0.67	0.36	0.41	0.49	0.57	0.63	0.68	0.75	0.82	0.90	1.11
1.08	0.68	0.33	0.38	0.46	0.54	0.59	0.65	0.72	0.79	0.88	1.08
1.05	0.69	0.30	0.35	0.43	0.51	0.56	0.62	0.69	0.76	0.85	1.05
1.02	0.70	0.27	0.32	0.40	0.48	0.54	0.59	0.66	0.73	0.82	1.02
0.99	0.71	0.24	0.29	0.37	0.45	0.51	0.57	0.63	0.70	0.79	0.99
0.96	0.72	0.21	0.26	0.34	0.42	0.48	0.54	0.60	0.67	0.76	0.96
0.94	0.73	0.19	0.24	0.32	0.40	0.45	0.51	0.58	0.65	0.73	0.94
0.91	0.74	0.16	0.21	0.29	0.37	0.42	0.48	0.55	0.62	0.71	0.91
0.88	0.75	0.13	0.18	0.26	0.34	0.40	0.46	0.52	0.59	0.68	0.88
0.86	0.76	0.11	0.16	0.24	0.32	0.37	0.43	0.50	0.57	0.65	0.86
0.83	0.77	0.08	0.13	0.21	0.29	0.34	0.40	0.47	0.54	0.63	0.83
0.80	0.78	0.05	0.10	0.18	0.26	0.32	0.38	0.44	0.51	0.60	0.80
0.78	0.79	0.03	0.08	0.16	0.24	0.29	0.35	0.42	0.49	0.57	0.78
0.75	0.80		0.05	0.13	0.21	0.27	0.32	0.39	0.46	0.55	0.75
0.72	0.81			0.10	0.18	0.24	0.30	0.36	0.43	0.52	0.72
0.70	0.82			0.08	0.16	0.21	0.27	0.34	0.41	0.49	0.70
0.67	0.83			0.05	0.13	0.19	0.25	0.31	0.38	0.47	0.67
0.65	0.84			0.03	0.11	0.16	0.22	0.29	0.36	0.44	0.65
0.62	0.85				0.08	0.14	0.19	0.26	0.33	0.42	0.62
0.59	0.86				0.05	0.11	0.17	0.23	0.30	0.39	0.59
0.57	0.87					0.08	0.14	0.21	0.28	0.36	0.57
0.54	0.88					0.06	0.11	0.18	0.25	0.34	0.54
0.51	0.89					0.03	0.09	0.15	0.22	0.31	0.51
0.48	0.90						0.06	0.12	0.19	0.28	0.48
0.46	0.91						0.03	0.10	0.17	0.25	0.46
0.43	0.92							0.07	0.14	0.22	0.43
0.40	0.93							0.04	0.11	0.19	0.40
0.36	0.94								0.07	0.16	0.36
0.33	0.95									0.13	0.33

Standard values: selection table for fixed PFC

Individual motors						Transformers	
Motor HP	Capacitor power in kvar (according to RPM) 3 000	1 500	1 000	750	500	Transfomer kVA	Capacitor power kvar
2.5	1	1	1.5	2	2.5	100	5
5	2	2	2.5	3.5	4	160	6.25
7.5	2.5	3	3.5	4.5	5.5	200	7.5
10	3	4	4.5	5.5	6.5	250	10
15	4	5	6	7.5	9	315	12.5
20	5	6	7	9	12	400	15
25	6	7	9	10.5	14.5	500	20
30	7	8	10	12	17	630	25
40	9	10	13	15	21	800	30
50	11	12.5	16	18	25	1 000	40
60	13	14.5	18	20	28	1 250	50
70	15	16.5	20	22	31	1 600	60
80	17	19	22	24	34	2 000	80
90	19	21	24	26	37		
100	21	23	26	28	40		
120	25	27	30	32	46		
150	31	33	36	38	55		
180	37	39	42	44	62		
200	40	42	45	47	67		
225	44	46	49	51	72		
250	48	50	53	65	76		

Schemes of PF Correction

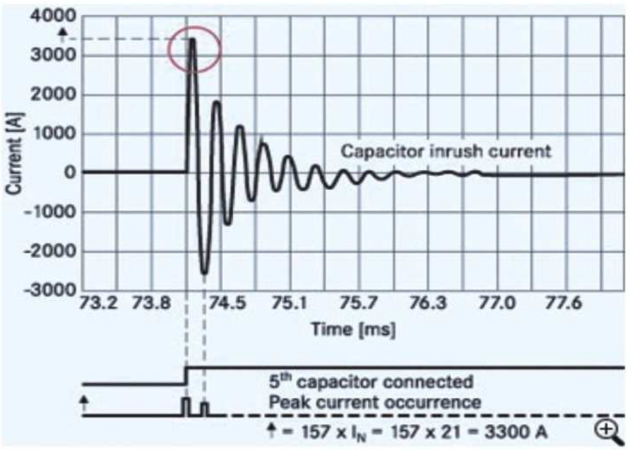
1. **Localised compensation** – Fixed /Auto PF capacitors installed at individual load ends.
2. **Centrallised compensation** – Fixed / Auto PF capacitors installed at main power bus for all loads together.
3. **Hybrid scheme** – Mix of both the two above

- **APFC panels** – Automatic Power Factor Correction Panels installed at main load bus or at feeders of load groups.
  Two types available – Contactor switched (Conventional)
  - Thyristor switched (Latest fast acting)

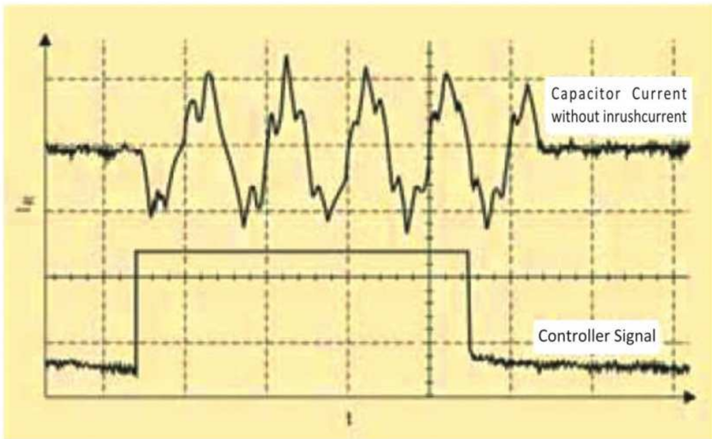
  These both can be designed with or without harmonic filters.

Comparision between contactor & thyristor switched panels

Sr.	Contactor Switched APFC	Thyristor Switched RTPFC "Cos-One" Brand
1.	High Inrush switching currents - upto 200 times rated	No Inrush currents - switching at zero voltage, no surges
2.	Slow response to changing loads - contactors need upto 3 min to switch on again due to discharge cycle	Fast acting - cycle to cycle correction in 40 to 60 msec Correction will match load changes accurately
3.	Maintenance if high - contactor coil / contact replacement	Negligible maintenance due to static switches - no moving parts
4.	Short term peak loads remain uncompensated	Even momentarily loads of few seconds can be compensated
5.	Limitation of the minimum correction step in panel due to limited operations of contactors	No limitation to minimum correction step due to infinite switching of thyristors
6.	Less accurate p.f. regulation - difficult to maintain over 0.985	Very accurate due to very smaller correction step - unity p.f. possible
7.	Not suitable for DG set application due to load p.f. conditions	Suitable for DG set and harmonic filter applications
8.	Life - of PFC capacitors shortened due to inrush currents	Longer capacitor life due to transient free switching
9.	Cost - Higher cost for larger rating of panels	Economical
10.	Not suitable for welding, crane, lift applications	Suitable for all applications



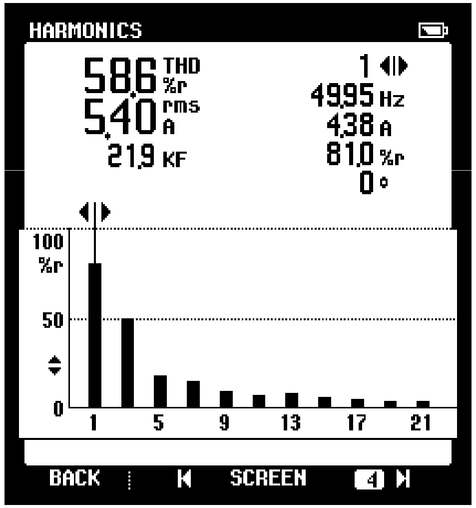
Contactor Switching



Zero Voltage Switching

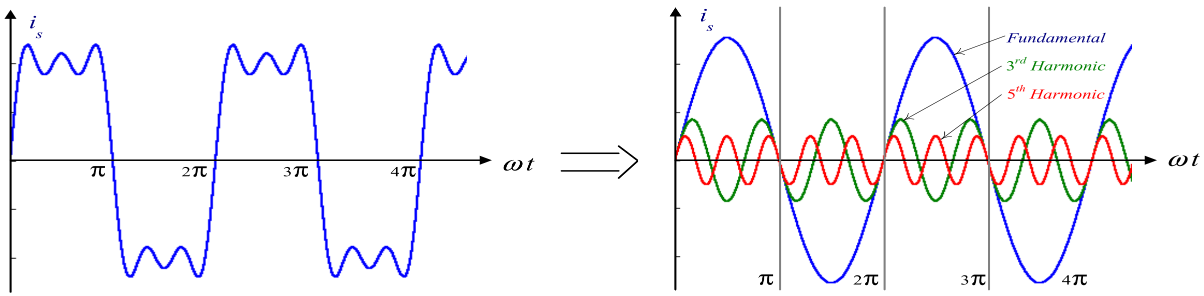
2. Harmonics

What does harmonics mean ?



Harmonic currents or voltages are integer (whole number) multiples of the fundamental frequency.

Harmonic order	F	3rd	5th	7th
Frequency	50	150	250	350



Origin of Harmonics

Non linear loads

Loads which have non linear voltage-current characteristics are called non linear loads. When connected to a sinusoidal voltage, these loads produce non-sinusoidal currents. Modern power electronic systems result into non-sinusoidal currents when connected to the sinusoidal networks.

The non linear devices can be classified under the following three major categories:

1. Power Electronics: e.g. rectifiers, variable speed drives, UPS systems, inverters, ...

2. Ferromagnetic devices: e.g. transformers (non linear magnetizing characteristics)

3. Arcing devices: Arcing devices, e.g. arc furnace equipment, generate harmonics due to the non linear characteristics of the arc itself.

Harmonic disturbances are created by non-linear loads !!!

Why more Harmonics now ?

Changing load structure

<u>Past Loads :</u> mostly "linear" – induction motors

<u>Today's - loads:</u> most loads act "non linear"

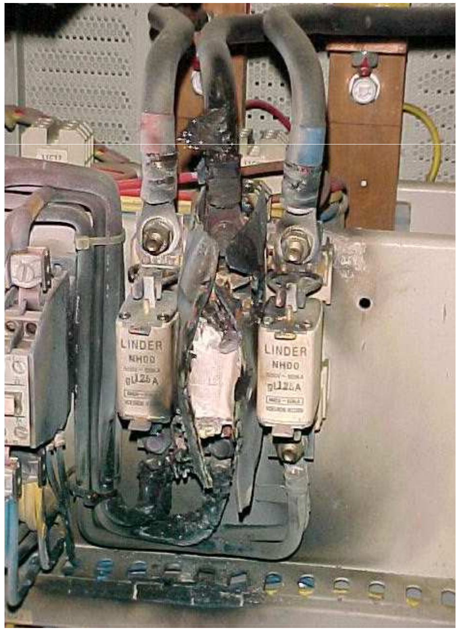
- Computer, motor-control, drives, etc.
- Current is pulse shaped
- Current is no longer following the sinusoidal wave shape
- Result: Harmonics

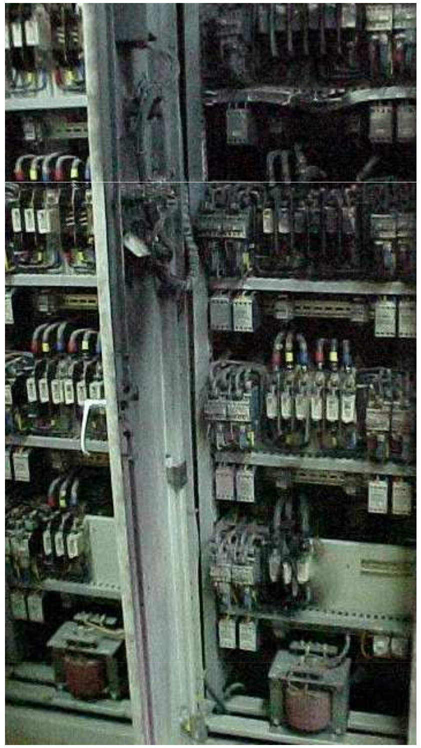
- Increasing number of sources causing disturbances

- Equipment become more and more sensitive

- De-regulated energy market

Problems caused by Harmonics

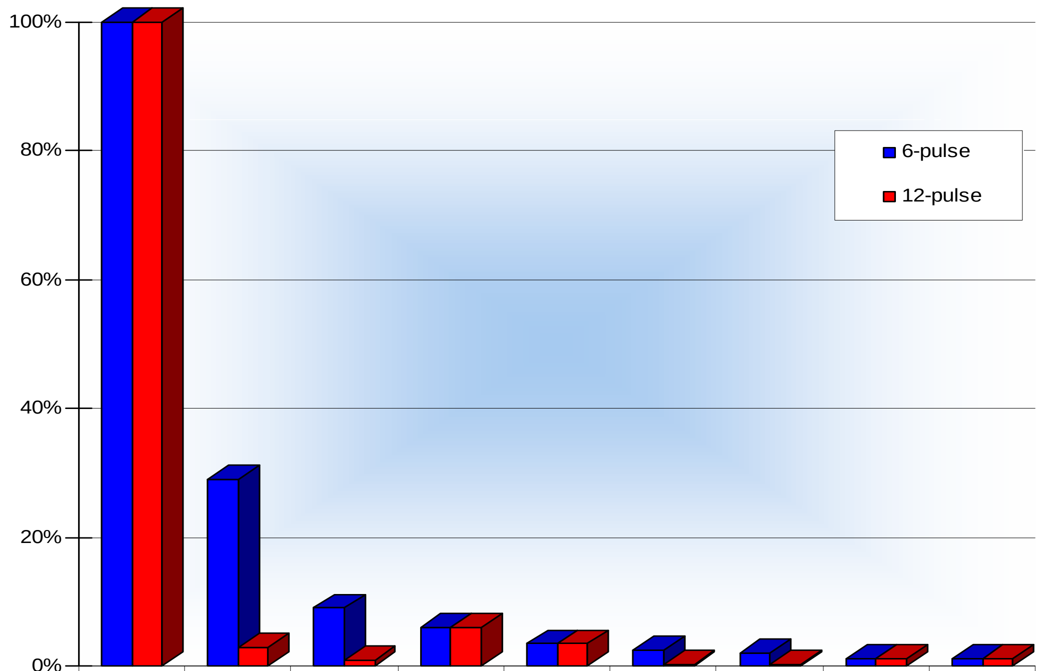




$$\Rightarrow I_{THD} = \frac{\sqrt{I_2^{\,2} + I_3^{\,2} + I_4^{\,2} + \cdots}}{I_1} \times 100\% = \frac{\sqrt{\sum_{h=2}^{\infty} I_h^{\,2}}}{I_1} \times 100\%$$

Examples of Harmonics generating loads

6/12 pulse rectfier

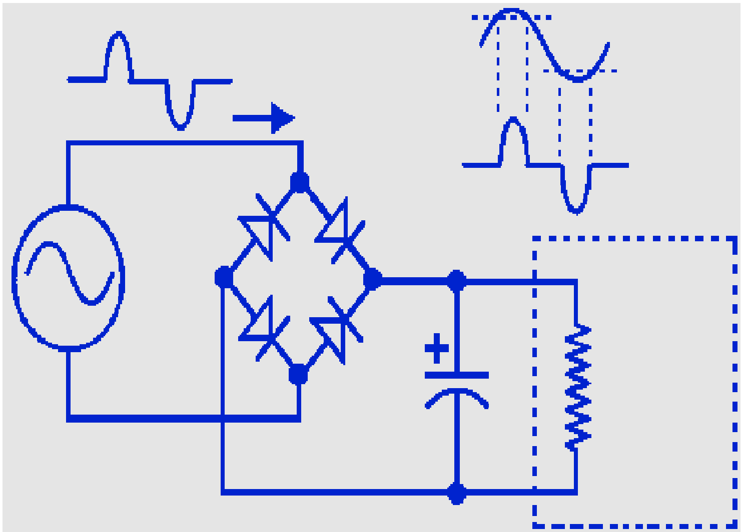


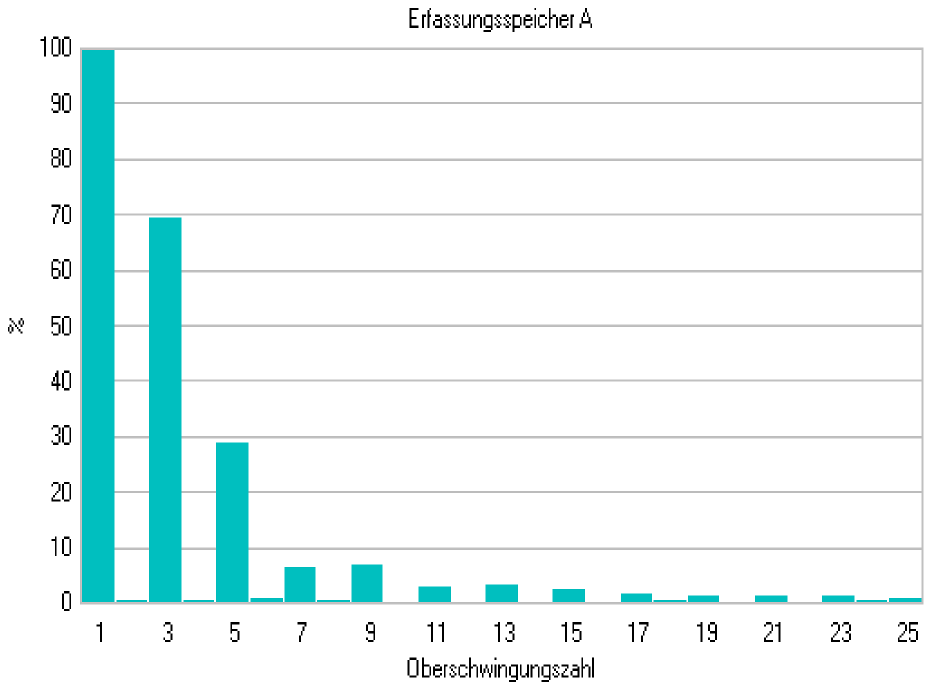
	1	5	7	11	13	17	19	23	25
6-pulse	100,00%	29,00%	9,00%	6,00%	3,50%	2,50%	2,00%	1,20%	1,10%
12-pulse	100,00%	2,90%	0,90%	6,00%	3,50%	0,25%	0,20%	1,20%	1,10%

Order number

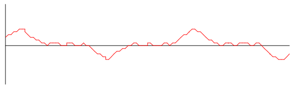
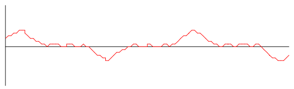
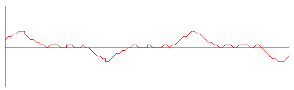
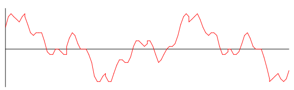
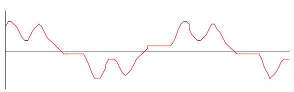
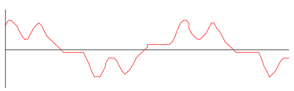
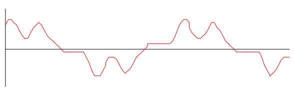
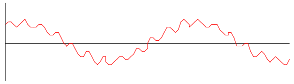
Examples of Harmonics generating loads

Single phase loads - SMPS



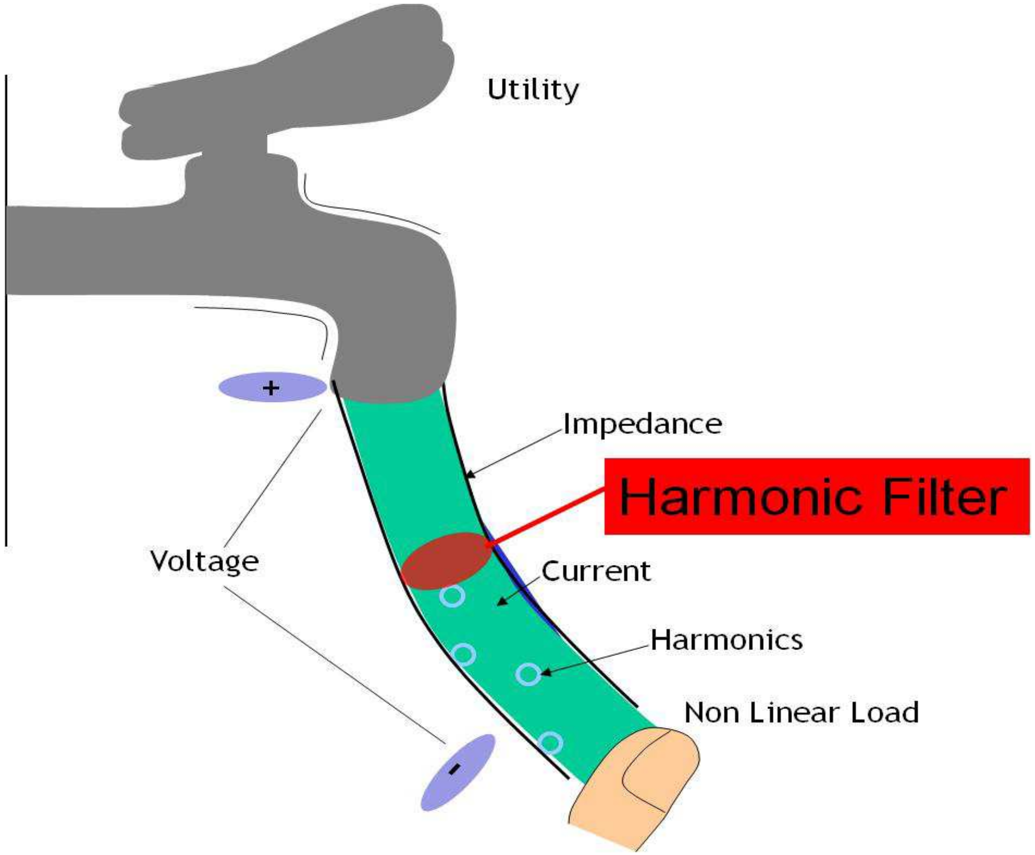


Predominant harmonic spectrums for common loads

Load	Load Type	3rd	5th	7th	9th	11th	13th	Distorted Composite Waveform
Personal Computer	Single Phase							
Office equipment	Single Phase							
Electronic Lighting	Single Phase							
High-bay Lighting	Single Phase							
Main frame computer	Three Phase							
UPS	Three Phase							
6-pulse VFD	Three Phase							
12-pulse VFD	Three Phase							

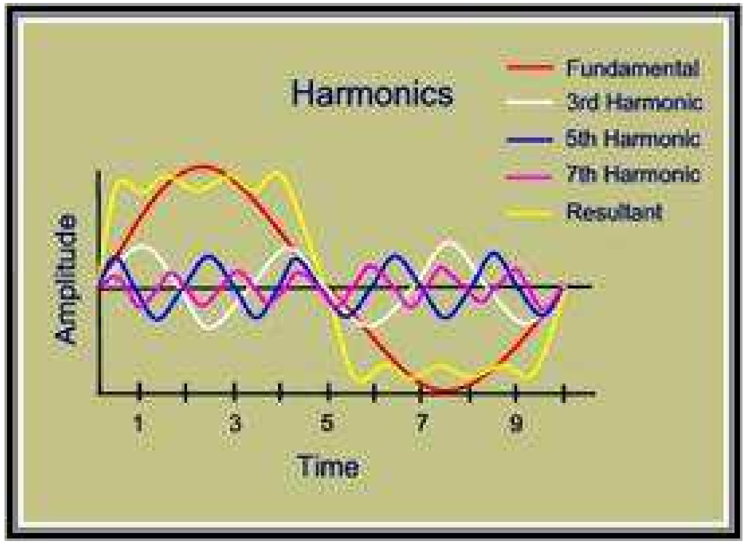
Note: loads shown above produce smaller amounts of harmonics not specifically highlighted

Harmonics is electricity pollution !!!



Problems caused by Harmonics

- Overheating of transformers (K-Factor), and rotating equipment
- Increased hysteresis losses
- Neutral overloading / unacceptable neutral-to-ground voltages
- Distorted voltage and current waveforms
- Failed capacitor banks
- Breakers and fuses tripping
- Unreliable operation of electronic equipment, and generators
- Erroneous register of electric meters
- Wasted energy / higher electric bills - KWD & KWH
- Wasted capacity - Inefficient distribution of power
- Increased maintenance cost of equipment and machinery



Effects of Harmonics

Tripping of circuit breakers and fuses

Due to resonance effects, the current levels may rise to multifold levels which results into tripping of circuit breakers and melting fuses. This situation results into serious problems in industries which rely on the quality of power for the continuous operation of their sensitive processes (e.g. semiconductor)

Overloading / decrease of life time of transformers

Transformers are designed to deliver power at network frequency (50/60Hz). The iron losses are composed of the eddy current loss (which increase with the square of the frequency) and hysteresis losses (which increase linearly with the frequency). With increasing frequencies the losses also increase, causing an additional heating of the transformer.

Overloading of the capacitors

Capacitive reactance decreases with the frequencies. Even smaller amplitudes of the harmonic voltages result into higher currents which are detrimental to the capacitors: $I = U * 2 * 3.14 * f * C$.

Losses in distribution equipment

Harmonics in addition to the fundamental current cause additional losses in the cables, fuses and also the bus bars.

Effects of Harmonics

Excessive currents in the neutral conductor

Under balanced load conditions without harmonics, the phase currents cancel each other in neutral, and resultant neutral current is zero. However, in a 4 wire system with single phase non linear loads, odd numbered multiples of the third harmonics (3^{rd}, 9^{th}, 15^{th}) do not cancel, rather add together in the neutral conductor.

In systems with substantial amount of the non linear single phase loads, the neutral currents may rise to a dangerously high level. There is a possibility of excessive heating of the neutral conductor since there are no circuit breakers in the neutral conductors like in the phase conductors.

Malfunctioning of the electronic controls and computers

Electronic controls and computers rely on power quality for their reliable operation. Harmonics result into distorted waveforms, neutral currents and over voltages which affect the performance of the these gadgets.

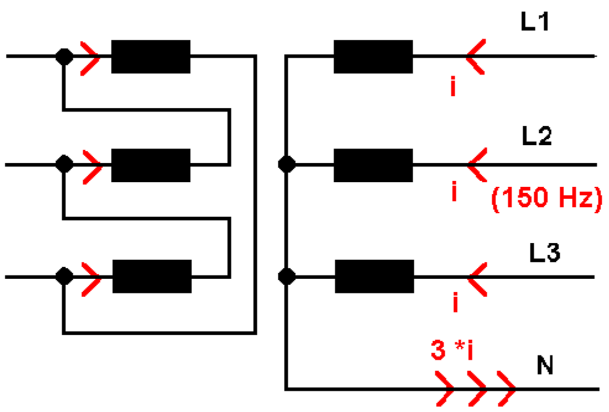
Measurement errors in the metering systems

The Accuracy of metering systems is affected by the presence of harmonics. Watt-hour meters accurately register the direction of power flow at harmonic frequencies, but they have magnitude errors which increase with frequency.

The accuracy of demand meters and VAr meters is even less in the presence of harmonics.

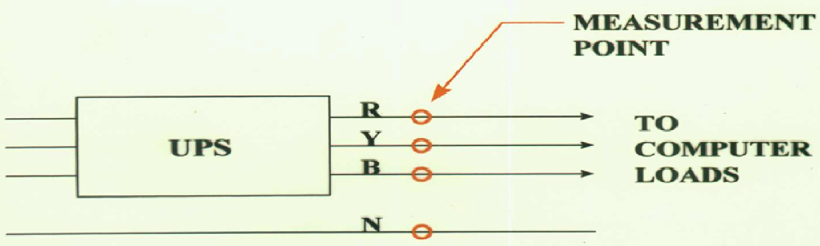
Wrong multi meter readings. Use true RMS meter!

Practical example of harmonics in a Commercial bank in KL - Malaysia



MEASURED CASE

IN A COMMERCIAL BANK (KL)

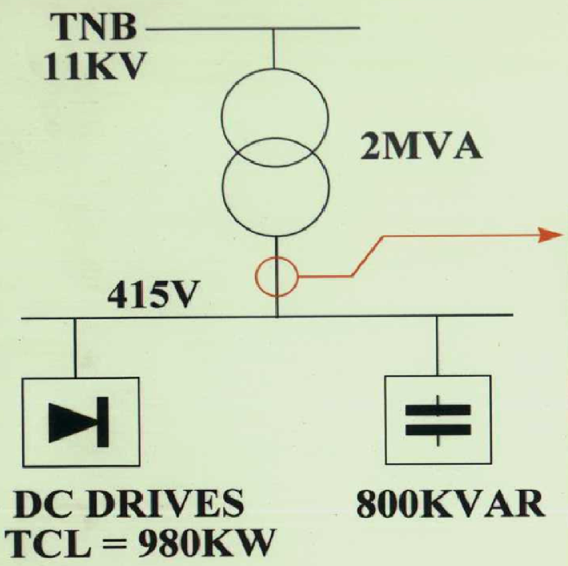


PHASE	50HZ CURRENT	3RD HARMONIC CURRENT
R	68A	42A
Y	66A	40A
B	67A	40A
N	2A	121A

RMS CURENT AT NEUTRAL = $\sqrt{2^2 + 121^2}$

= 121.02A

Practical example parallel resonance in a Industry in KL - Malaysia



MEASURED CASE

HARMONIC CURRENT	WITHOUT CAPACITOR	WITH CAPACITOR
1	1200A	740A
5	265A	668A
7	70A	80A
11	50A	60A
VTHD	5.12%	10.14%
PF	0.617	0.95

Limits of harmonics as per IEEE 519 standards

Voltage Distortion 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.

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)						
Isc/I_L	< 11	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h$	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 of actual Isc/I_L

Where

Isc = 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 demand load current (15 or 30 min demand).

PCC = Point of common coupling.

Remedial measures for harmonics

Filter circuits, which are in series connected reactors and capacitors, form a series resonance circuit. Design and dimensioning of the components has to be done in such a way, that one of the following points will be fulfilled:

De-tuned filter circuit

The main purpose of de-tuned filter is to avoid resonance condition of the capacitor with the transformer inductance. Depending of the de-tuning frequency more or less harmonic currents will be sucked from the grid. Very common is a de-tuning to a frequency of 189 Hz (7 %) with a reduction of harmonics of app. 30-50 %.

Tuned filter circuit

The tuning has to be done for each harmonic frequency, means each harmonic frequency requires its own filter circuit. The harmonic current will be reduced by approximately 90 %.

Active filter circuit

AHF generates signals in phase opposition to the harmonic signals present in the system and hence nullifies the distortion. It can be applied for both, power factor correction as well as harmonic filtering.

Does harmonic mitigation & pf correction gives advantage ? Example in transformer

	Normal (Delta-Wye)	Harmonic Mitigating Transformer
Designed For	Linear Load (Loads of Yesterday)	Non-Linear Loads (Today's Loads)
Efficiency	96.1%	98.3%
Heat	Runs Hot Reduced Life	Runs Cool Long Life

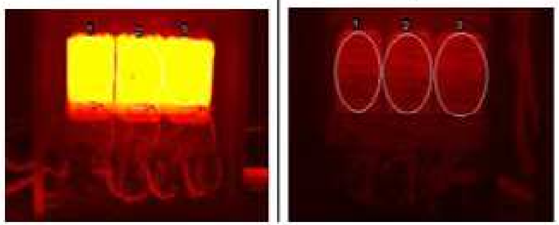


Figure 4 – Infrascan of Standard TP-1 Transformer vs. HMT with 100% Harmonic Load

Figure 2 – Transformer Losses with 100% Resistive Load and 100% Harmonic Loads

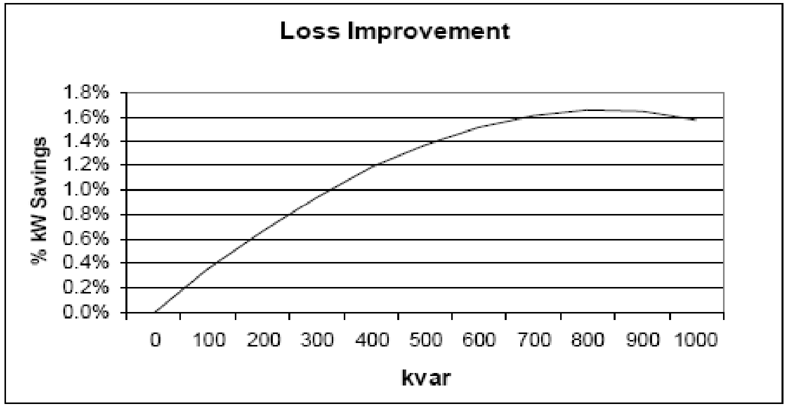


Figure 5 – Loss Savings Opportunity using PF Correction Capacitors

Does harmonic mitigation & pf correction gives advantage ? Example in motor

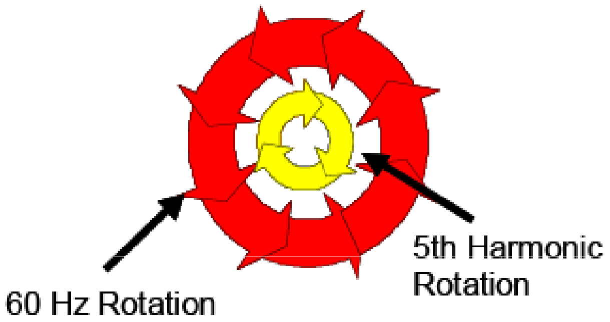
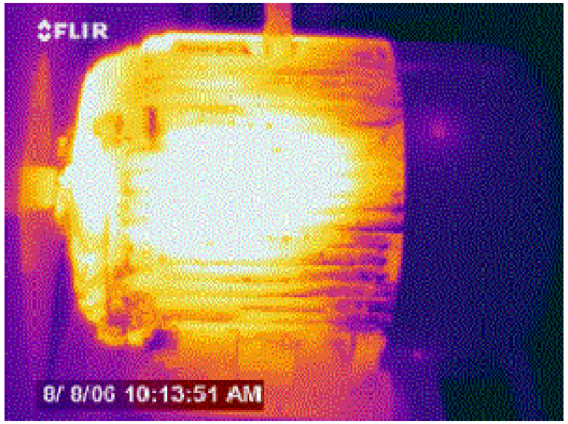
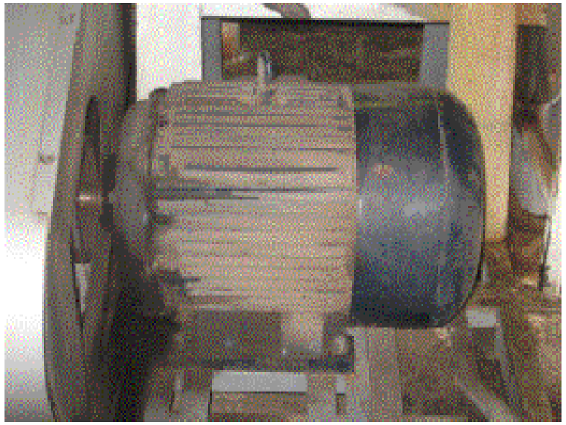


Figure 1 – Negative Sequence Current and Motors

Products that Reduce Negative Sequence Currents in Motors

Description: Voltage unbalance or negative sequence voltage harmonics (i.e. 2^{nd} or 5^{th} harmonic, typically) cause the rotor of an induction motor to resist its normal rotation. This resistance causes inefficient operation in the motor, vibrations and heat that may cause premature failure. Linear loads (motors) will draw a "non-linear" current with components of current proportional to the voltage distortion.





Above thermal and daylight images show a three phase motor which has overheated.
Power quality analysis proved condition was caused by negative sequence harmonics.

HARMONICS

HARM

Means "DAMAGE"

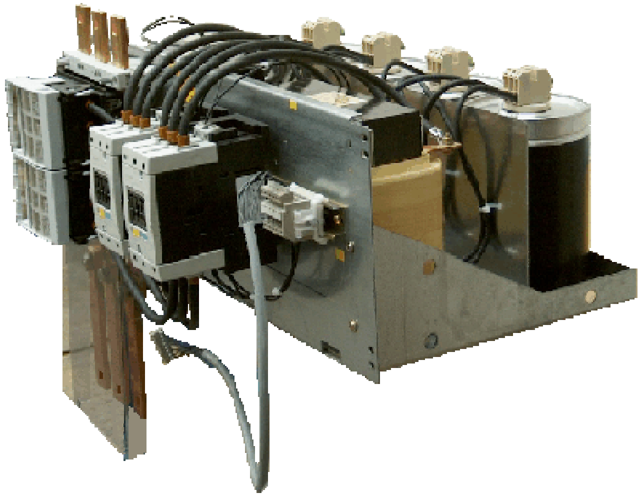
ONICS

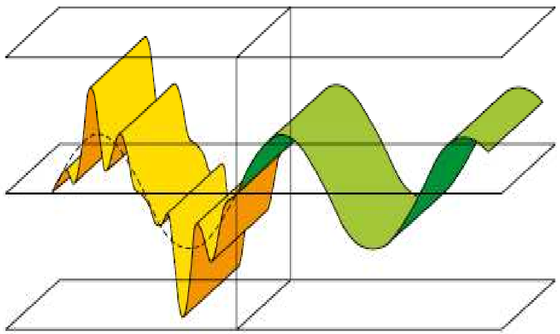
Means "ORGANS"

i.e. Harmonics damages the organs of the industries

Customer benefits of harmonics filteration

- Improvement of Power Factor
- Reduction of harmonics
- Reduction of ohmic losses, real kW energy savings
- Elimination of reactive energy consumption
- Elimination of power utilities penalties on low power factor
- Power Quality improvement
- Climatic protection, reduction of greenhouse gas emissions
- Reduction of new investment for distribution equipment (transformers, LV switchgear,)
- Reduction of equipment maintenance cost and down time of production equipment
- Improvement of production process stability





Typical example of benefit of power quality system

4.1 Harmonic filter and APFC for the plant

Before:

- Harmonic level at main panel 12%
- At feeder level as high as 48%
- Power factor was maintained at 0.91 to 0.93

After:

Provided the harmonic filter at 3 identified locations

- Current harmonic content at main panel reduced 'to 4.9 % and at feeder level to less than 15%
- Power factor improved to 0.99

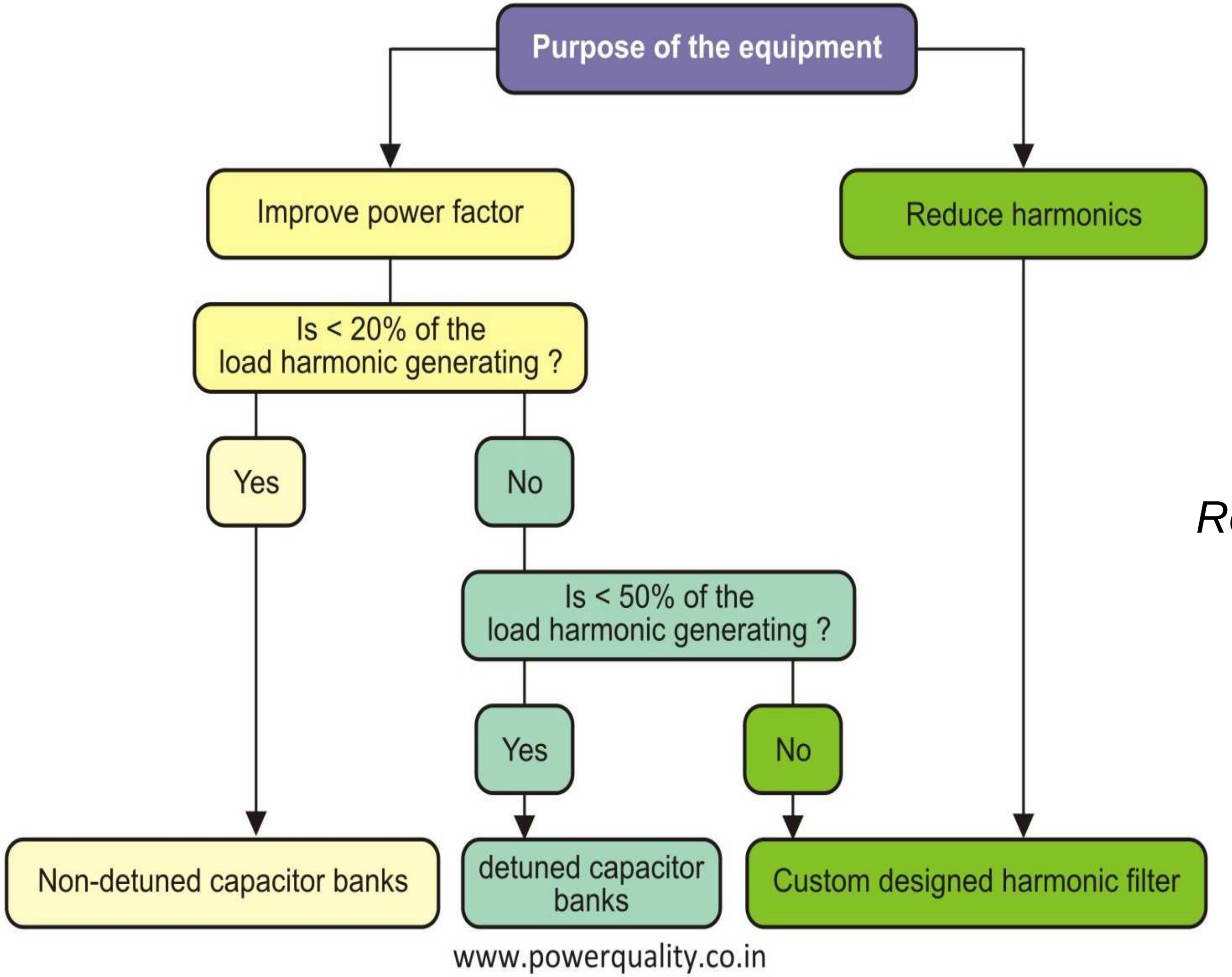
Results:

- Energy saved per annum: 1.38 Lakh kWh /annum
- Cost saving per annum: Rs 12.48 Lakhs
- Payback period 1.12 yrs

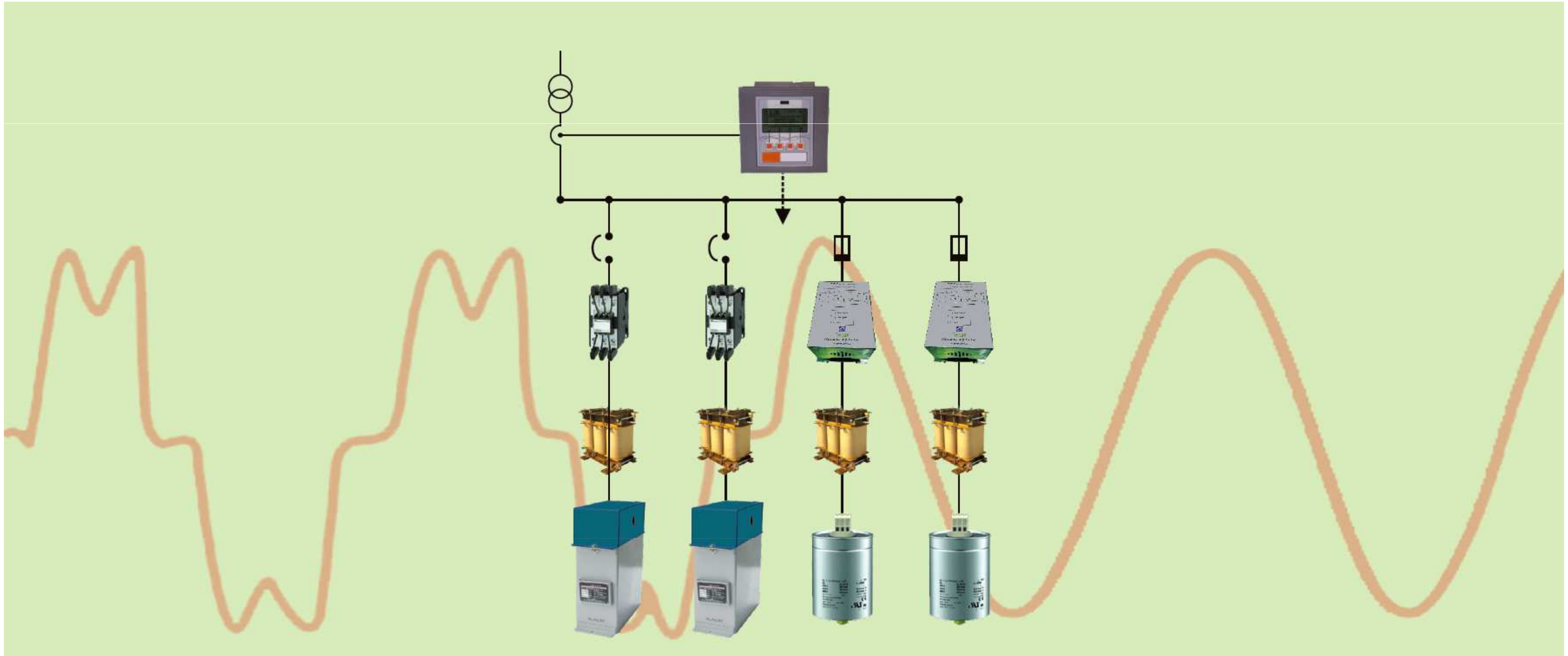
Investment:

Rs.14 lakhs

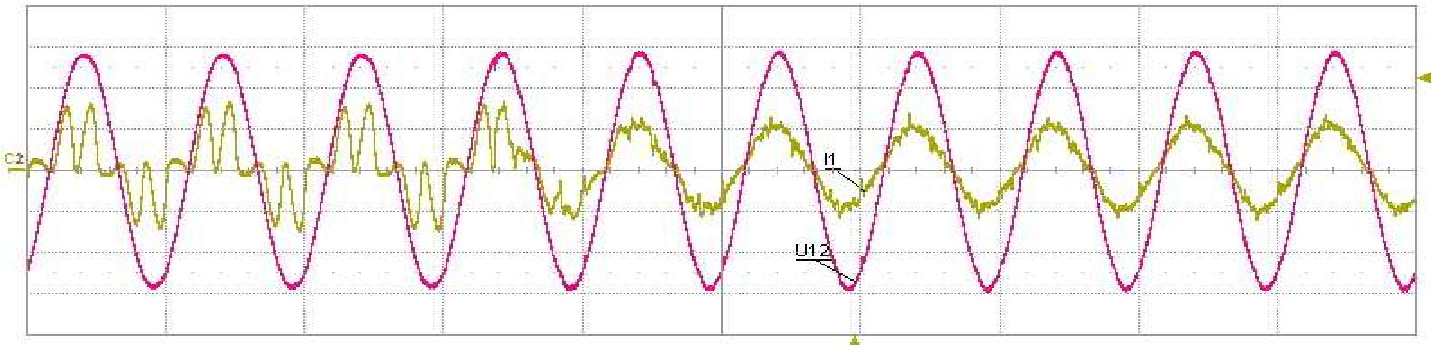
Guide to selection of system

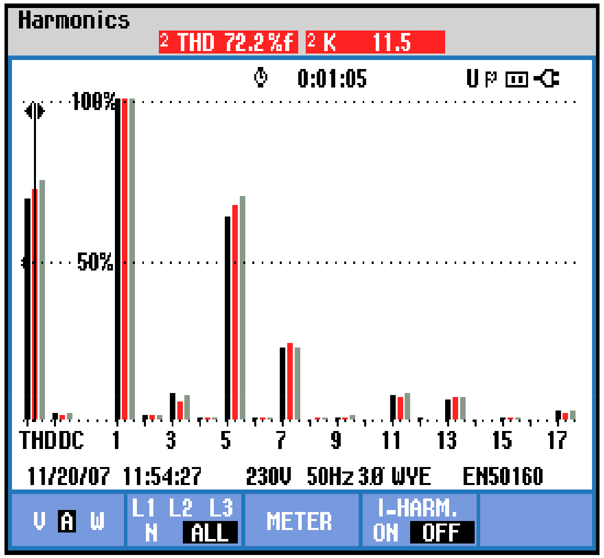


Typical Passive Harmonics Filter system



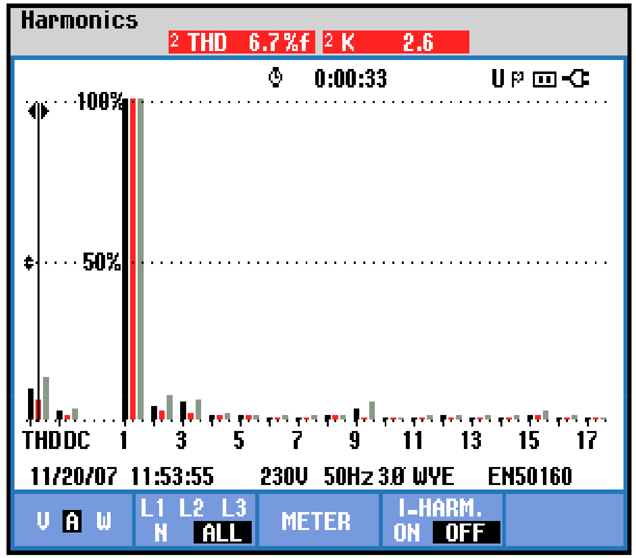
Active Harmonics Filter system





Actual system harmonics

AHF



After installation of AHF

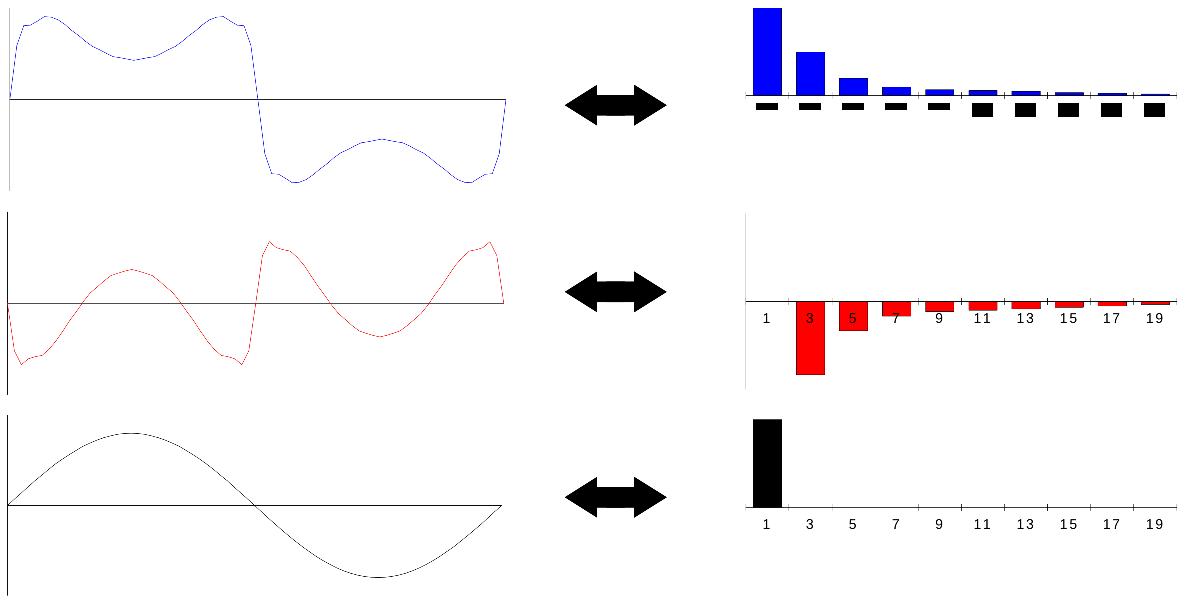
Basics of Active Harmonics Filter system

Composite

+ 180º Phase

Shifted harmonics

=Fundamental



Comparision of various filtering systems

Parameters	Detuned filter	Tuned filter	Active filter
Type	Passive	Passive	IGBT based digitally controlled
Compensation	Only compensates power factor	Compensates Harmonic Multiple tuned filters are required, one for each harmonic	Compensates PF and Harmonics. One filter can compensate multiple harmonics simultaneously
Suitability	Not suitable in case of more voltage distortion and current distortion	Performance varies over frequency variation and variation in voltage distortion. Performance is dependent on load level	Performance remains constant over frequency and voltage variation. Suitable in any type of environment
Resonance	Possibility of resonance. This results in premature failure of capacitor.	Possibility of resonance if tuned at higher frequency. Performance depends on source impedance	No possibility of resonance. Stable operation
Size and weight	Bulky in size	Bulky in size when multiple harmonics are to be compensated	Light weight. Size does not change even if required to compensate more harmonics
Life	Limited life in case of more voltage and current harmonics	More life as compared to capacitor filter	Longer life, since performance remains constant and resonance is avoided
Cost	Cheap	Costlier as compared to capacitor filter	Initial cost is more as compared to both the filters
No load condition	Imposes capacitive PF when load is reduced. Contactors are required to compensate for leading pf.	Imposes leading PF at fundamental frequency. So not suitable for generator source. Compensated filter is required for generator. Performance is tuned at full load	No capacitive PF at no load. Smooth PF compensation. No problem to Generator source. Performance remains constant over load variation
3rd harmonic compensation	Not possible	Becomes very bulky	Same filter can be used to compensate 3rd harmonic without increasing the size
Selectivity And harmonic Compensation	No selectivity	Physical components are required to be changed	Stability through software. Cost vs. performance is easily possible. This makes it more cost effective and flexible
Capacity increase	Possible by adding more capacitor	Redesigning is required for change of load.	More units can be added later on for increasing capacity
Safety	To take care of resonance problem, lot of fuses must be used. Also resonance causes failure of other sensitive circuits	Breakers and fuses must be added per tuned filter. Also transient voltage absorbers must be used to avoid failure of other circuitry in case of resonance	Only one set of Breakers and fuses are required for all harmonics
Power loss	Low loss	More loss	Moderate losses

Our manufacturing set-up

Manufacturing Unit and Reg. Office :

At Moraiya – 15 kms from Ahmedabad city

Total Shop floor area : Around 10,000 sq ft

ISO 9001
BUREAU VERITAS
Certification
BUREAU VERITAS 1828

NABCB
QM 003

APFC – Contactor switched Auto PF correction panels

Intelligent microprocessor control - Contactor switched APFC

Product range : 10 to 2400 KVAR / 110 to 850 VAC / 1 or 3 ph

Available with /without harmonic filters

Outstanding features:

- Intelligent APFC with microprocessor based controller and SIEMENS/EPCOS components
- Automatic switching of PFC capacitors based on load variations of plant and KVAr required.
- Designed to achieve p.f. near to unity to get the optimum power utilization and reduced demand
- Systems available for balanced as well as un-balanced loads, 1-ph an 3-phase
- Less maintenance by optimized design, low loss and has long service life
- Display of all major electrical parameters like KW, KVAr, KVA, p.f., harmonics, V, I , Hz, etc.
- Alarm output for low p.f., capacitor failure, overcompensation, over temp., undervoltage, etc.
- Auto/Manual Mode facility, back-up fuse/MCCB protection for each capacitor feeders
- Data logging /operational facility through GSM mobile, ethernet, RS485/232
- Iron core harmonic filter reactors with Copper/Aluminum winding, low loss, high linearity
- Intelligent MP based APFC / RTPFC controllers, Capacitor duty contactors, Thyristor switches

RTPFC - Thyristor switched PF correction panel

Thyristor switched Real time PFC - High speed electronically switched

Product range : 18 to 1800 KVAR / 110 to 525 VAC / 1 or 3 phase

Available with /without harmonic filters

Outstanding features:

- Latest thyristor zero-voltage switching system – cycle-to-cycle correction
- High speed – transient free switching of PFC capacitors within 40 to 60 millisec.
- Designed to achieve precisely unity p.f. near to unity to get max pf rebate and avoid leading p.f.
- Suitable for rolling mills, welding loads, DG set loads, ports, steel mills, cement and paper, etc
- Systems available for balanced as well as un-balanced loads, 1-ph an 3-phase
- Enhanced capacitor life due to transient-free, zero inrush current switching
- Maintenance-free because of static switching, no wear and tear of contactors
- Display of all major electrical parameters like KW, KVAr, KVA, p.f., harmonics, V, I , Hz, etc.
- Alarm output for low p.f., capacitor failure, overcompensation, over temp., undervoltage, etc.
- Auto/Manual Mode facility, back-up fuse/MCCB protection for each capacitor feeders
- Hybrid version also available – contactor + thyristor switching for cost effectiveness.
- Enclosures with CRCA sheet steel, pretreated for anti-rust and powder coated
- Data logging /operational facility through GSM mobile, ethernet, RS485/232 - optional

MV (upto 11 KV) APFC panel

MV APFC Panels and Capacitor Banks

Product range : Upto 10,000 KVAR / 132 KV AC, 1-ph and 3-ph.

Outstanding features:

- Intelligent APFC with microprocessor based controller
- HT capacitor banks upto 10,000 KVAR, 132 KV voltage class, indoor as well as outdoor type
- HT APFC panels with 3 to 8 step switching as per the load variations
- APP (All Polypropylene) type low loss capacitors with detuned / tuned harmonic filter reactors
- All accessories like NCT, RVT, isolator, VCB, HRC fuses, LA, protection relays, etc. available optionally
- Long service life of more than 10 years
- 15 KVAR to 400 KVAR in single unit and voltage upto 3.3 KV to 132 KV
- Outdoor type mounting GI structures, HT CT and PT set, VCB panels available as accessories

Detuned Harmonic Filter Reactors

Unique HLLL technology
(High Linearity Low Loss)
5 to 250 KVAR upto 850 Vac

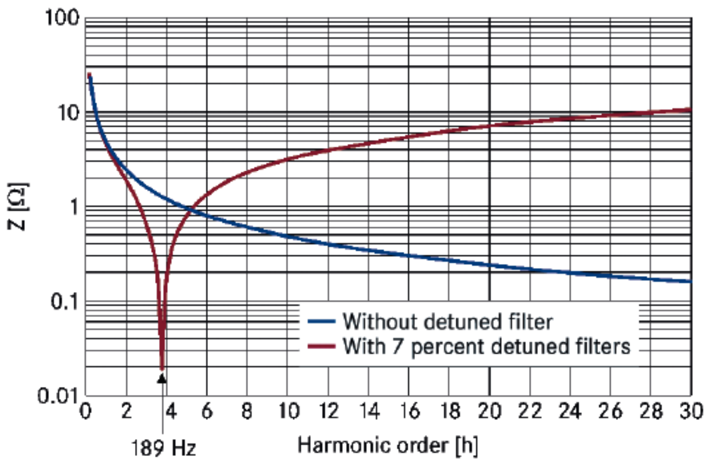
- Available detuning factors p : 7%, 14%, 5.67%
- Anti-resonance series reactors I_1 = 1.06*Ic
- High Linearity : 200%
- Low loss design
- Overload capacity : 130% continuous
- Insulation : Class H 185°C
- Noise level : Max 60 dB
- Insulation Level : 2.5 KV
- Ambient Temperature : 50° C
- Enclosure : IP00
- Cooling : Natural
- Over-temperature protection : Microswitch (NC)
- Inrush current limiting reactors 0.2% also available
- Tuned Reactors for 5^{th}, 7^{th}, 11^{th}, 13^{th} harmonics available

Why use a harmonic filter reactor in a power factor correction capacitor bank ?

1. Capacitors are required to improve power factor and possible harmonic interaction may occure with the installation of a plain capacitor bank.
2. Permissible distortion limits of the local utility of IEEE-519 are exceeded and filters are required to reduced them.
3. A comination of PFC capacitors with detuned harmonic filter reactors will result in limiting harmonics.

Benifits of using detuned reactors

1. Prolongs life of PFC capacitors by reducing harmonic overloading with respect to voltage & current.
2. Reduces amplification of system harmonics thereby restoring sinusoidal waveform.
3. Reduce over heating of busbars, cables & transformer.



Detuned Harmonic Filter Reactors

COPPER WOUND

415/ 440V, 3-Ph, Iron core, Class F, Linearity 200%

Rating in KVAr	7%	14%	5.67%
Product code	(fr=189Hz)	(fr=135Hz)	(fr=210Hz)
5	DR7C005	DR14C005	DR6C005
7.5	DR7C007	DR14C007	DR6C007
10	DR7C010	DR14C010	DR6C010
12.5	DR7C012	DR14C012	DR6C012
15	DR7C015	DR14C015	DR6C015
20	DR7C020	DR14C020	DR6C020
25	DR7C025	DR14C025	DR6C025
30	DR7C030	DR14C030	DR6C030
50	DR7C050	DR14C050	DR6C050
75	DR7C075	DR14C075	DR6C075
100	DR7C100	DR14C100	DR6C100
125	DR7C125	DR14C125	DR6C125
150	DR7C150	DR14C150	DR6C150

ALUMINUM WOUND

415/ 440V,3-Ph, Iron core, Class F, Linearity 200%

Rating in KVAr	7%	14%	5.67%
Product code	(fr=189Hz)	(fr=135Hz)	(fr=210Hz)
5	DR7A005	DR14A005	DR6A005
7.5	DR7A007	DR14A007	DR6A007
10	DR7A010	DR14A010	DR6A010
12.5	DR7A012	DR14A012	DR6A012
15	DR7A015	DR14A015	DR6A015
20	DR7A020	DR14A020	DR6A020
25	DR7A025	DR14A025	DR6A025
30	DR7A030	DR14A030	DR6A030
50	DR7A050	DR14A050	DR6A050
75	DR7A075	DR14A075	DR6A075
100	DR7A100	DR14A100	DR6A100
125	DR7A125	DR14A125	DR6A125
150	DR7A150	DR14A150	DR6A150

Selection chart for Capacitor – Reactor for detuned circuit

p =7% - Resonant frequency 189 Hz

Net output required @ 415 V, 50 Hz in **KVAr**	Detuning factor **p** in %	Rated current in **A**	Reactor Inductance **L** in **mH**	Rated voltage of capacitor in **V**	Rated value of capacitor in **KVAr**
5	7	6.96	8.257	480	6.30
10	7	13.91	4.128	480	12.5
12.5	7	17.39	3.303	480	15.7
15	7	20.87	2.752	480	18.7
20	7	27.82	2.064	480	25.0
25	7	34.78	1.651	480	31.0
30	7	41.74	1.376	480	37.5
40	7	55.65	1.032	480	50.0
50	7	69.56	0.823	480	62.5
60	7	83.47	0.688	480	75.0
75	7	104.34	0.550	480	94.0
100	7	139.12	0.412	480	125.0

p =14% - Resonant frequency 135 Hz

Net output required @ 415 V, 50 Hz in **KVAr**	Detuning factor **p** in %	Rated current in **A**	Reactor Inductance **L** in **mH**	Rated voltage of capacitor in **V**	Rated value of capacitor in **KVAr**
5	14	6.96	16.51	525	7.5
10	14	13.91	8.256	525	15.0
12.5	14	17.39	6.606	525	18.8
15	14	20.87	5.504	525	22.5
20	14	27.82	4.128	525	30.0
25	14	34.78	3.302	525	37.5
30	14	41.74	2.752	525	45.0
40	14	55.65	2.064	525	60.0
50	14	69.56	1.646	525	75.0
60	14	83.47	1.376	525	90.0
75	14	104.34	1.100	525	112.5
100	14	139.12	0.824	525	150.0

Thyristor Switch Modules (TSM) for high-speed capacitor switching

Unique UFS Design
(Ultra Fast Switching)
5 to 250 KVAR upto 850 Vac

- Suitable for real-time capacitor switching
- Available in 1800, 2200 & 4000 PIV
- Two-leg control, thyristors - SEMIKRON make
- Most advanced thyristor firing card with MOVs
- Compact and heat efficient design
- LED indication : ON/OFF/Supply ON/Signal ON
- Auto Fan operation : 60° C
- Ambient Temperature : 50° C
- Over temperature protection : thermal cut-off switch
- Supply voltage : 230 Vac, Control voltage : 24/12 Vdc
- Enclosure : IP00
- Cooling : Natural/Forced
- Easy to install and maintenance free
- No inrush current limiting reactors required
- No fast discharge resistors required

TSM Rating 440V, 3-Ph, 50 Hz	Product Code		Frame Size	Weight
	1800 PIV	2200 PIV		
5 - 15 KVAR	TS4S015	TS4A015	1	4.7 kg
20 - 25 KVAR	TS4S025	TS4A025	1	5.0 kg
30 - 35 KVAR	TS4S035	TS4A035	1	5.0 kg
40 - 50 KVAR	TS4S050	TS4A050	1	5.0 kg
60 KVAR	TS4S060	TS4A060	1	5.2 kg
75 KVAR	TS4S075	TS4A075	2	5.5 kg
100 KVAR	TS4S100	TS4A100	2	6.5 kg
125 KVAR	TS4S125	TS4A125	2	6.7 kg
150 KVAR	TS4S150	TS4A150	3	7.5 kg

PFC capacitors and accessories – LV & MV

APP Capacitors

MPP Capacitors

APFC Controllers

Contactors

MV Power Factor Correction capacitors, series reactors
Outdoor & Indoor type

A Polypropylene Film Dielectric, with extended / folded. Al. Foil and impregnment with Non-PCB Oil confirming to IS-13925 Part I-1998, suitable for all types of electric loads and applications.

UNISTAR®

POWER CAPACITORS

Active Harmonic Filters

- Essentil to reduce harmonic levels under IEEE 519 limits
- Available from 30 to 600 A, 415 & 690 V, 50/60 Hz
- Available in both versions : 3P3W & 3P4W
- Operation modes : Harmonic filtering, power factor correction, and phase balancing
- Programmable selective harmonic elemination
- Interface : RS485 (Modbus RTU), TCP/IP (Ethernet)
- IGBT base power electronic technology
- Neutralizes harmonic currents by phase opposition signals
- Capable to filter 2nd to 50th harmonic orders
- Ultra fast reaction time : < 200 milisec
- Noise level : < 60 dB
- Switching frequency : 24 kHz
- Control frequency : 48 kHz
- Flicker compensation feature
- Standards : IEEE 519, IEC 61000-3-6, ER G5/4
- Enclosure : IP00
- Ambient temperature : -10 to 50° C
- Power loss : < 3% of rated power
- Humidity : 95% non-condensing
- Cooling : Forced air
- Easy to install and maintenance free

COMPARISION – Thyristor vs Contactor switching

Sr.	Contactor Switched APFC	Thyristor Switched RTPFC "Cos-One" Brand
1.	High Inrush switching currents - upto 200 times rated	No Inrush currents - switching at zero voltage, no surges
2.	Slow response to changing loads - contactors need upto 3 min to switch on again due to discharge cycle	Fast acting - cycle to cycle correction in 40 to 60 msec Correction will match load changes accurately
3.	Maintenance if high - contactor coil / contact replacement	Negligible maintenance due to static switches - no moving parts
4.	Short term peak loads remain uncompensated	Even momentarily loads of few seconds can be compensated
5.	Limitation of the minimum correction step in panel due to limited operations of contactors	No limitation to minimum correction step due to infinite switching of thyristors
6.	Less accurate p.f. regulation - difficult to maintain over 0.985	Very accurate due to very smaller correction step - unity p.f. possible
7.	Not suitable for DG set application due to load p.f. conditions	Suitable for DG set and harmonic filter applications
8.	Life - of PFC capacitors shortened due to inrush currents	Longer capacitor life due to transient free switching
9.	Cost - Higher cost for larger rating of panels	Economical
10.	Not suitable for welding, crane, lift applications	Suitable for all applications

Clients

ROHA Colours you choose, we provide
JSW Steel
Dalmia Cement TRUSTED BY EXPERTS
WELSPUN
BAYER
Zydus Cadila
SIEMENS
ArcelorMittal
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HITACHI Inspire the Next
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PRESENT IN 11 COUNTRIES

KENYA | SAUDI ARABIA | GUINEA | NEPAL | ZAMBIA | JORDAN | MALAYSIA | UAE | NIGERIA | OMAN | TANZANIA

Fast Return on Investment

Cos-One

Savings

Power Quality

1 - Reduces KW Demand
2 - Reduces KWH Consumption
3 - Eliminates Power Factor Penalty
4 - Reduces Monthly Electricity Bill
5 - Reduces Maintenance & Downtime

+

1 - Improves Voltage
2 - Balances Three Phases
3 - Damps Surges, Transients
4 - Filters Harmonics
5 - Improves Power Factor

Up to 34% Savings
Less than 2 Year Payback

Enhanced Power Quality
Reduced Downtime & Maintenance

Satisfied Customer

Certifications

BUREAU VERITAS
Certification

PQS ELECTROLINK (INDIA) PRIVATE LIMITED

SURVEY NO. 431/2, PLOT NO. A-13, STEEL TOWN, B/H SHUBHLAXMI ESTATE,
SARKHEJ-BAVLA HIGHWAY, MORAIYA, AHMEDABAD – 382 213, GUJARAT, INDIA

Bureau Veritas Certification certify that the Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standard detailed below

Standard

ISO 9001:2008

Scope of certification

DESIGN, MANUFACTURE & SALE OF
1) ELECTRICAL POWER & CONTROL PANELS UP TO 15 kV;
POWER FACTOR CORRECTION & HARMONIC FILTER SYSTEMS.
2) POWER & DISTRIBUTION TRANSFORMERS (UPTO 2.5MVA), CURRENT TRANSFORMERS (UP TO 4000/ 5 AMPERES), CONTROL TRANSFORMERS (15kVA) & CHOKES (UP TO 150KVAr).

Certification cycle start date: **06 January 2013**

Subject to the continued satisfactory operation of the organisation's Management System, this certificate expires on: **05 January 2016**

Original certification date: **06 January 2010**

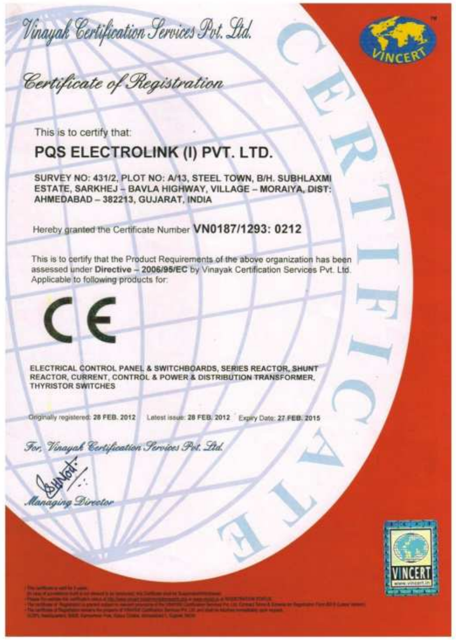
Certificate No. IND12.5713N Version : 1 Revision date: **22 December 2012**

Certification Authority
R. K. SHARMA – Director

NABCB
QM 003

Local office: "Marwah Centre" 6th Floor, Krishanlal Marwah Marg, Opp. Ansa Industrial Estate, Off Saki Vihar Road, Andheri (East), Mumbai – 400 072, India.

Further clarifications regarding the scope of this certificate and the applicability of the management system requirements may be obtained by consulting the organization. To check this certificate validity please call +91 22 6695 6300.



Vinayak Certification Services Pvt. Ltd.

VINCERT

Certificate of Registration

CERTIFICATE

This is to certify that:

PQS ELECTROLINK (I) PVT. LTD.

SURVEY NO: 431/2, PLOT NO: A/13, STEEL TOWN, B/H. SUBHLAXMI ESTATE, SARKHEJ – BAVLA HIGHWAY, VILLAGE – MORAIYA, DIST: AHMEDABAD – 382213, GUJARAT, INDIA

Hereby granted the Certificate Number **VN0187/1293: 0212**

This is to certify that the Product Requirements of the above organization has been assessed under **Directive – 2006/95/EC** by Vinayak Certification Services Pvt. Ltd. Applicable to following products for:

CE

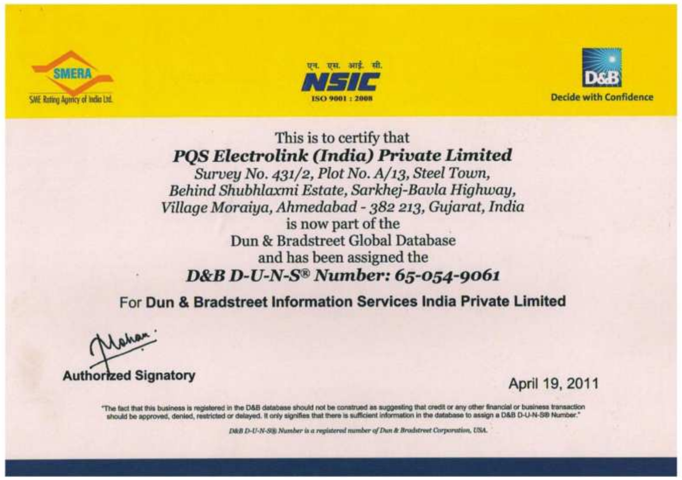
ELECTRICAL CONTROL PANEL & SWITCHBOARDS, SERIES REACTOR, SHUNT REACTOR, CURRENT, CONTROL & POWER & DISTRIBUTION TRANSFORMER, THYRISTOR SWITCHES

Originally registered: **28 FEB. 2012** Latest issue: **28 FEB. 2012** Expiry Date: **27 FEB. 2015**

For, Vinayak Certification Services Pvt. Ltd.

Managing Director

VINCERT
www.vincert.in



SMERA
SME Rating Agency of India Ltd.

एन. एस. आई. सी.
NSIC
ISO 9001 : 2008

D&B
Decide with Confidence

This is to certify that
PQS Electrolink (India) Private Limited
Survey No. 431/2, Plot No. A/13, Steel Town,
Behind Shubhlaxmi Estate, Sarkhej-Bavla Highway,
Village Moraiya, Ahmedabad - 382 213, Gujarat, India
is now part of the
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Authorized Signatory

April 19, 2011

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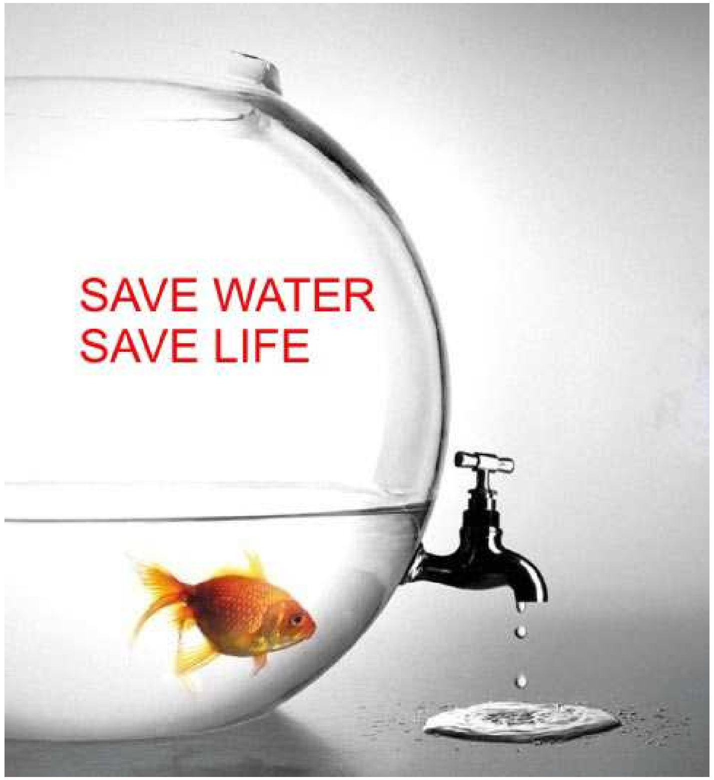
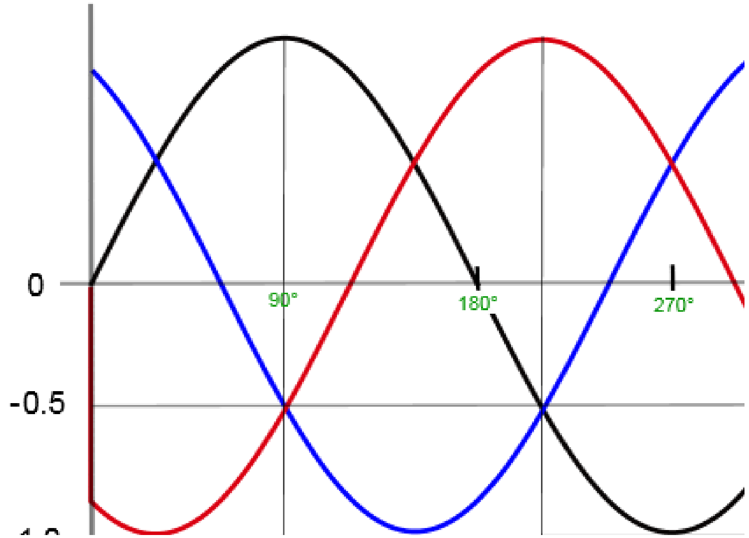

SAVE WATER
SAVE LIFE


Save the
Earth


Save the Girl Child
Save the Nation

Now its time to say



save "Sine Wave"

For further details, please write to sales@powerquality.co.in

or call 09825007261