True power factor control using solid state active harmonic filter

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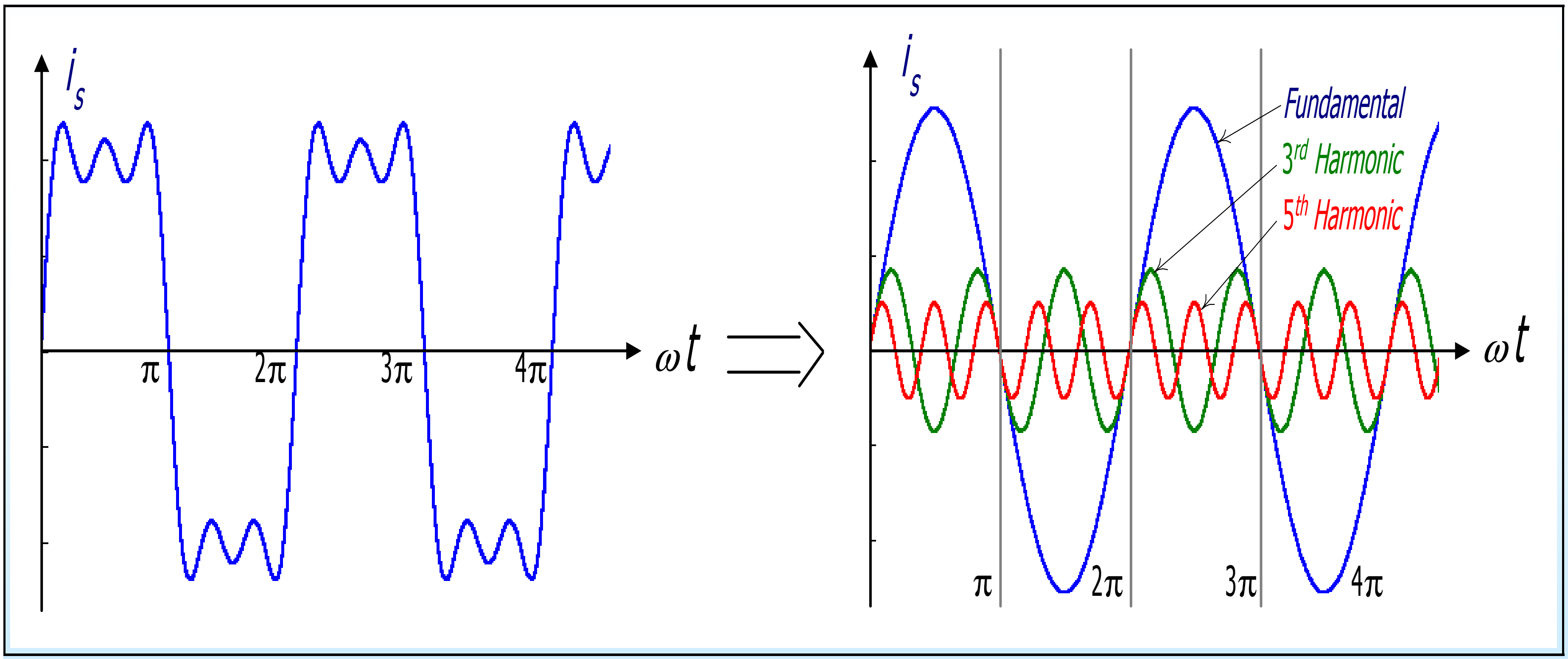
Non linear loads in a power system generate both current as well as voltage harmonics. This can be easily observed when the waveforms get distorted and loses the sine wave profile.



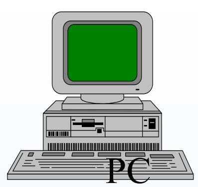
•Non linear loads are the root cause of generating harmonics and deteriorates quality of utility power.

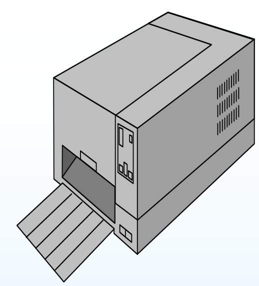
adjustable speed drives

thyristor convertors

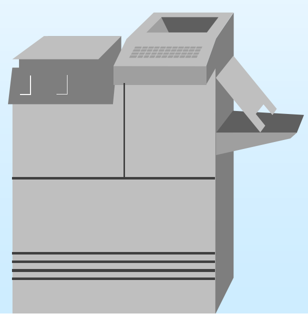
switched mode power supply

uninterrupted power supply





- Fax Machines

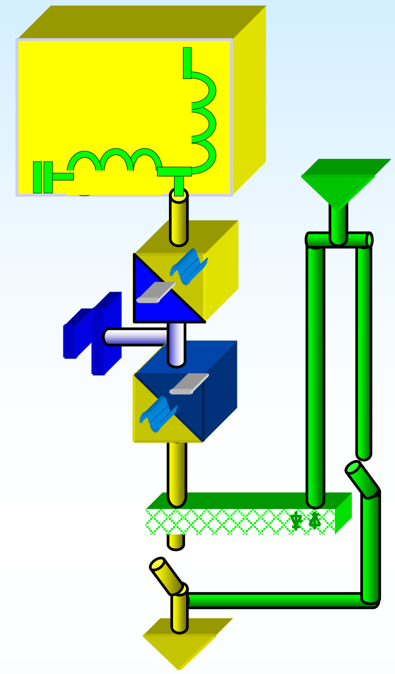


- Copiers

problems caused by poor power quality:

- Erroneous measurement of electrical parameters like power factor
- Malfunctioning or failure of critical equipments
- Production loss due to interruption/outages of utility power
- Increased T&D losses, increased KVA demand and total cost of electric power
- Reduced effective utilization of generation, transmission and distribution equipments
- Poor power quality and voltage regulation
- Interference with communication systems

Conventional Filtering Solution



Passive Filter (Tuned L/C Filter) is the earliest Harmonics Filter use to eliminate harmonics. It is very low cost and use simple design consisting of Inductors & Capacitors, but…

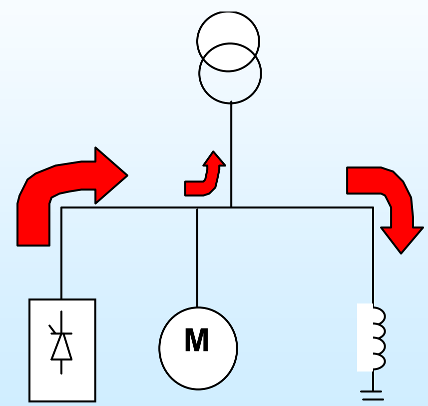
They can only eliminate 1 single offending harmonics

For example, a 250Hz tuned Filter can elimiate 5th harmonics only.

Require detailed network study to identify the culprit harmonics before designing the correctly tuned filter.

May cause Resonance problem if Capacitor banks are use together in the same network.

Sensitive to Main Utility Frequency & impedance change



Total Harmonic Distortion :

As per IEEE definition,

$$\frac{\textbf{RMS value of the harmonic content of a periodic wave}}{\textbf{RMS value of the fundamental content of the wave}}$$

while IEC, defines

$$\frac{\textbf{RMS value of the harmonic content of a periodic wave}}{\textbf{RMS value of the wave.}}$$

For an example, assuming a wave has third and fifth harmonic of RMS value, I3 = 30, I5 = 10, and fundamental I1 = 50.

$$\text{THD as per IEEE definition} = \frac{\sqrt{(I_3)^2 + (I_5)^2}}{I_1} * 100\,\% = 63.2\%$$

$$\text{THD as per IEC definition} = \frac{\sqrt{(I_3)^2 + (I_5)^2}}{\sqrt{(I_1)^2 + (I_3)^2 + (I_5)^2}} * 100 = 53.4\%$$

Conventional power factor :

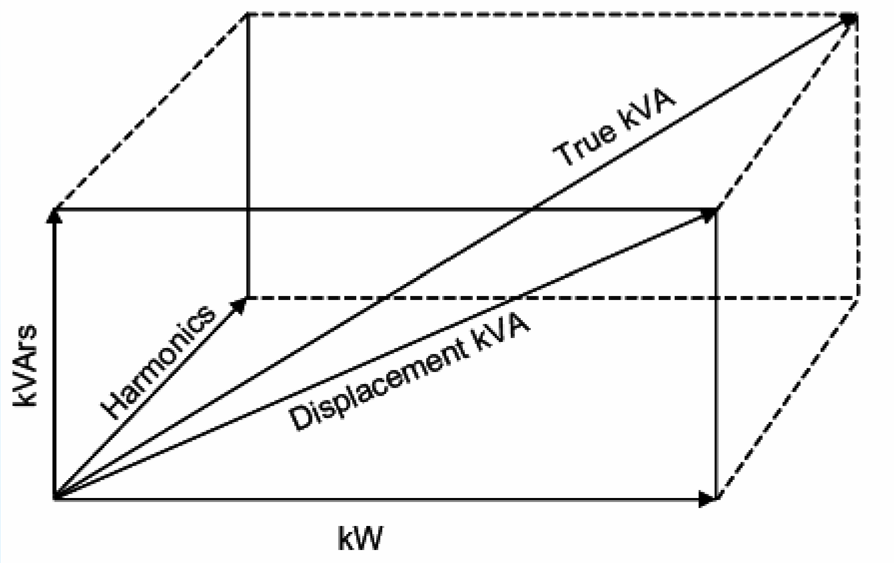
$$\frac{\textbf{Active power (watts) of the fundamental wave}}{\textbf{Apparent power (volt amperes) of the fundamental wave}}$$

As per this definition, harmonics are neglected.

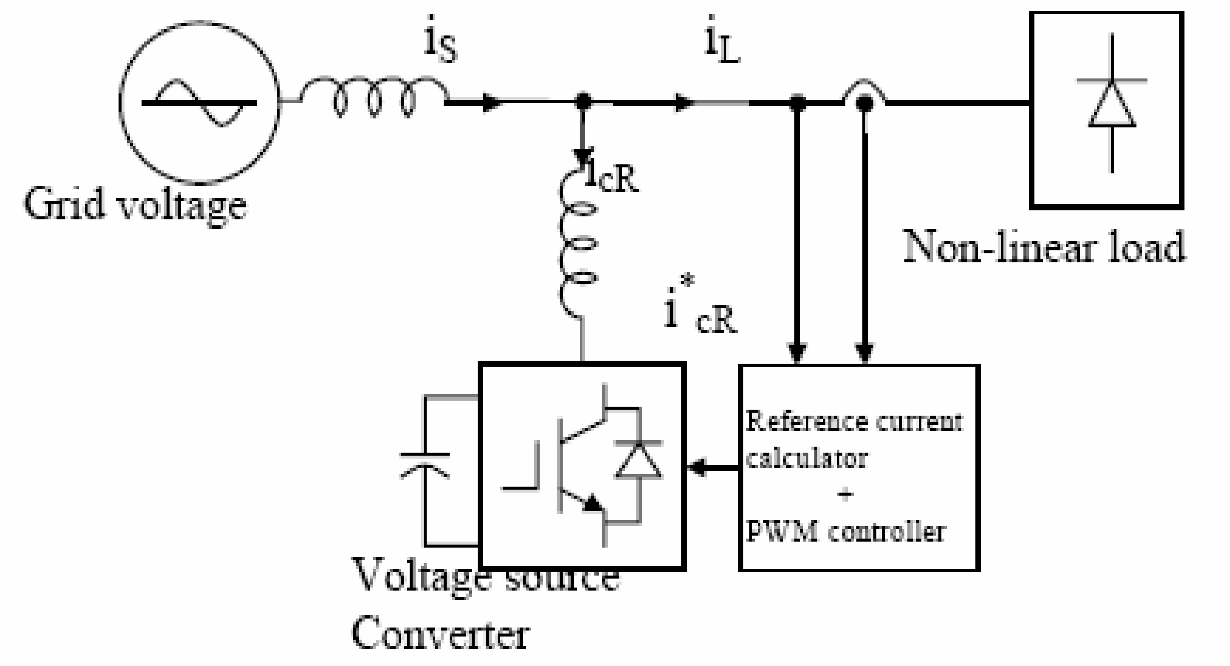
True power factor

$$\frac{\textbf{Total active power (watts)}}{\textbf{Total apparent power (volt amperes) of the composite wave}}$$

Including the harmonics and unbalance..

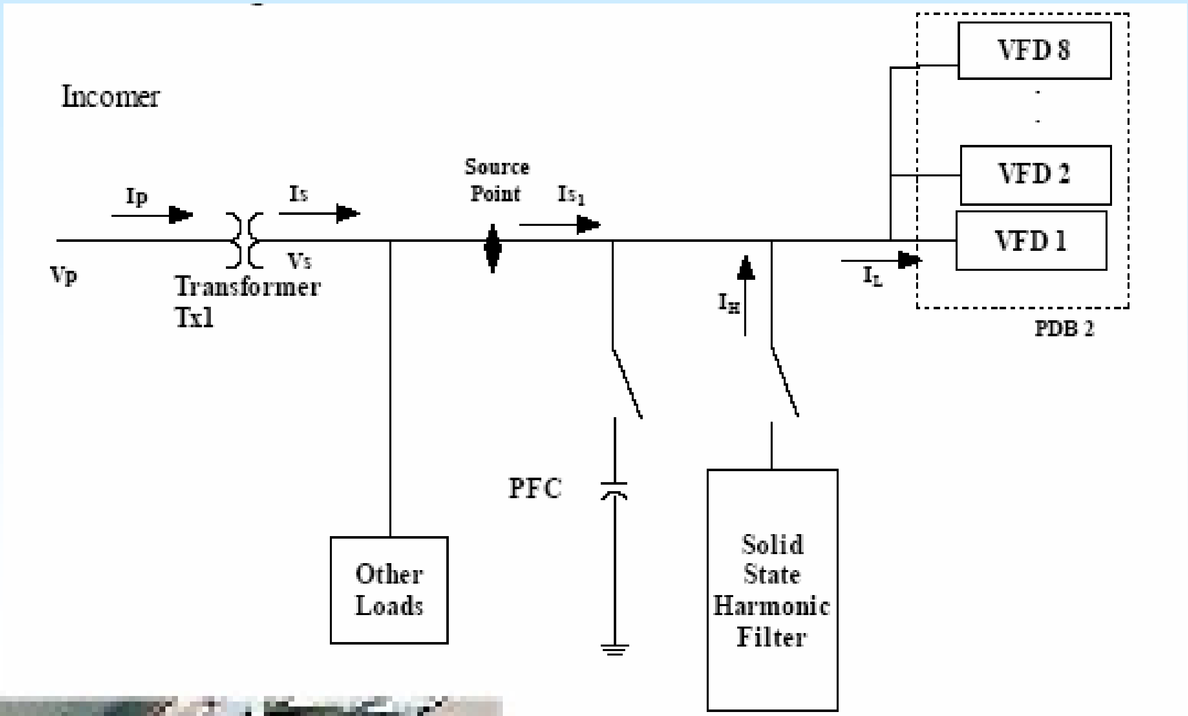


Solid state active harmonic filter:



Block diagram of solid state harmonic filter

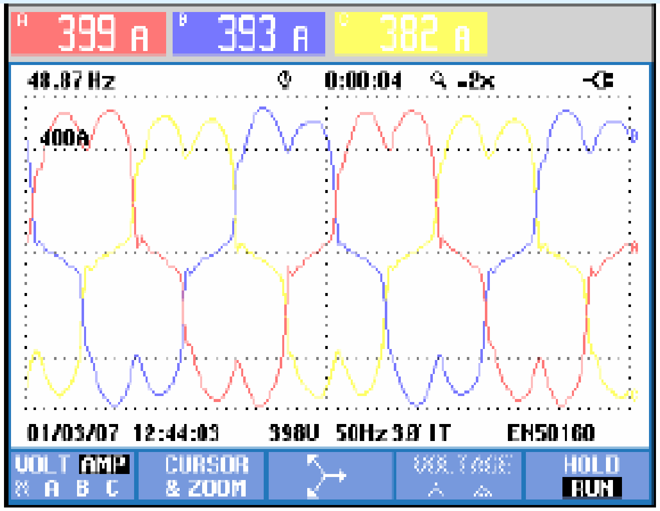
Case Study:

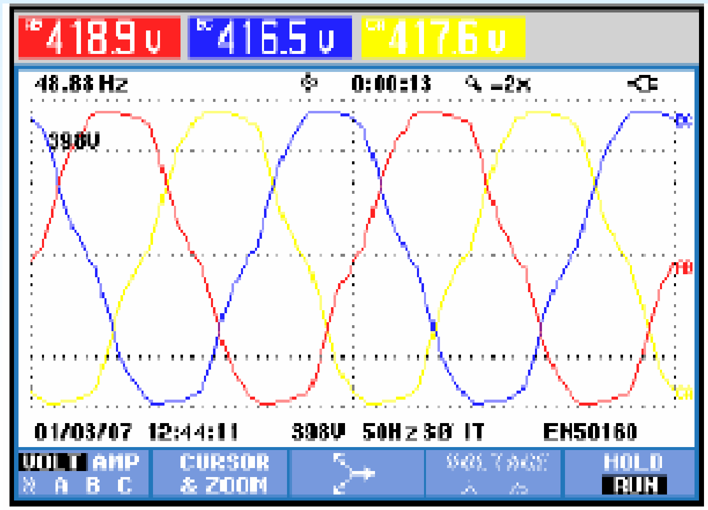


Single Line Diagram of Spinning line in Textile mill

Ring Frame:

Results Before Installation of Solid state Active Filter





HARMONICS TABLE

0:00:05

Amp	A	B	C
THD%f	22.0	23.6	25.0
H3%f	2.2	2.8	1.2
H5%f	20.1	21.5	22.9
H7%f	4.2	4.5	5.1
H9%f	0.7	0.3	0.5
H11%f	5.1	5.8	6.2
H13%f	2.9	2.9	2.7
H15%f	0.6	0.5	0.3

01/03/07 12:46:08 398V 50Hz 3Ø IT EN50160

V A % V&A | BACK | TREND | HOLD RUN

HARMONICS TABLE

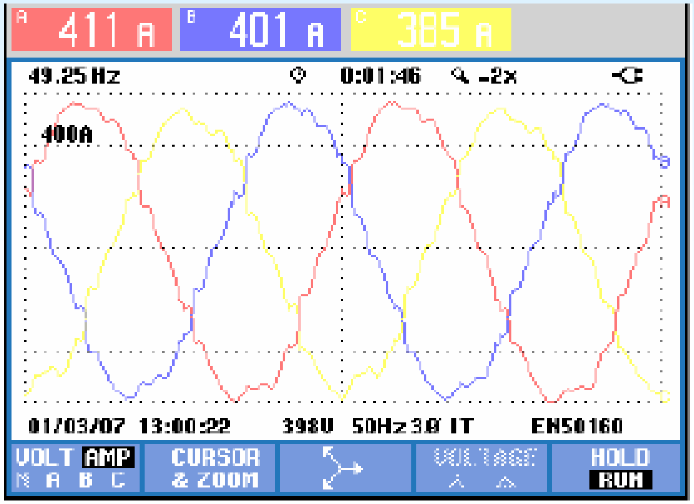
0:00:15

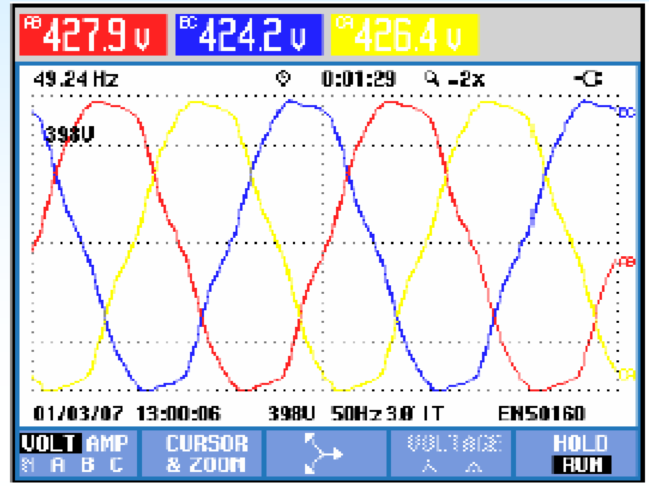
Volt	AB	BC	CA
THD%f	6.7	6.5	6.8
H3%f	0.5	0.3	0.4
H5%f	5.8	5.8	6.1
H7%f	3.1	2.7	2.7
H9%f	0.2	0.0	0.2
H11%f	0.7	0.5	0.5
H13%f	0.2	0.2	0.2
H15%f	0.1	0.0	0.0

01/03/07 12:45:56 398V 50Hz 3Ø IT EN50160

V A % V&A | BACK | TREND | HOLD RUN

Results After Installation of Solid state Active Filter





HARMONICS TABLE

0:00:06

Amp	A	B	C
THD%f	5.7	6.3	7.4
H3%f	0.7	1.3	1.1
H5%f	2.8	3.5	4.5
H7%f	2.2	1.5	2.9
H9%f	0.5	0.2	0.7
H11%f	0.8	0.5	0.9
H13%f	0.5	0.8	0.6
H15%f	0.4	0.5	0.2

01/03/07 13:01:12 398V 50Hz 3Ø IT EN50160

V A V&A BACK TREND HOLD RUN

HARMONICS TABLE

0:00:02

Volt	AB	BC	CA
THD%f	5.6	5.4	5.5
H3%f	0.5	0.4	0.3
H5%f	4.6	4.6	4.8
H7%f	3.1	2.7	2.6
H9%f	0.2	0.2	0.1
H11%f	0.5	0.5	0.4
H13%f	0.2	0.2	0.1
H15%f	0.1	0.0	0.0

01/03/07 13:00:55 398V 50Hz 3Ø IT EN50160

V A V&A BACK TREND HOLD RUN

The source current THD:

Before Installation of solid state filter : 31% (with capacitors)
After installation of solid state filter : 5.6%

The source voltage THD was also reduced from 7% to 4.5%.

True power factor improved from 0.94 to 0.995.

Areas (Scope) of Saving:

1.Transformer Eddy current losses & I2R losses saved.
2.Cable I2R losses saved.
3. KVA Saving.
4. P.F Improvement Saving.
5. Maintenance & Breakdown cost saved.

Advantages of solid state filter to the utilities

- Reduction in T&D losses
- Unity power factor
- Effective and efficient harmonic current filtering
- Enhancement of Equipment Life
- Dynamic and step less reactive and harmonic power compensation

Advantages for the electric power user

- Prevent PF penalty & Harmonics Penalty if applicable
- Increased productivity
- Energy saving
- Reactive power compensation
- Active harmonic current filtering

Thank You