

Power Quality Overview

Understanding power disturbance analysis

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Power Quality Sales Expert

Agenda

Introduction to Power Quality

Power Quality Advisor – Energy Management Software

Case Study: Active Harmonic Filter in healthcare facility

Case Study: Voltage Sags






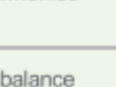





Case Study: Voltage Regulation

Different types of Power Quality problems

In most cases, your Electrical Energy provider provides you *almost* perfect Electrical Power. This is characterized by:

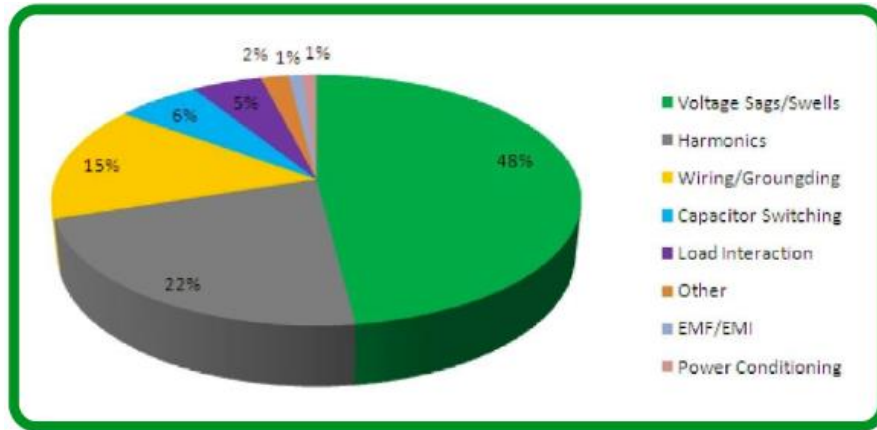
- Nominal **Voltage** on all 3 phases
- Nominal **frequency** (60.00Hz)
- **Waveforms** are perfectly sinusoidal
- **Symmetry** in all phases

If either of these characteristics vary, we have an Electrical Power Quality problem

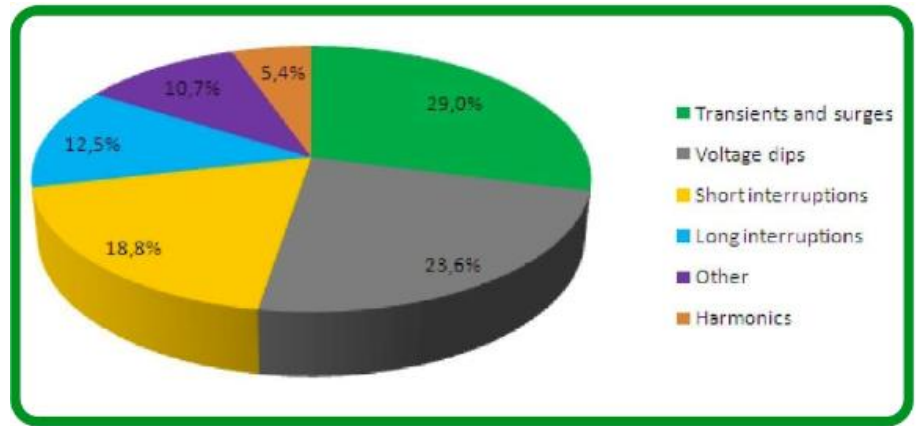
Disturbance category	Waveform	Effects	Possible causes
Transients		Equipment malfunction and damage	Lightning or switching of inductive / capacitive loads
Interruption		Downtime, equipment damage, loss of data possible	Utility faults, equipment failure, breaker tripping
Sag		Downtime, system halts, data loss	Utility or facility faults, startup of large motors
Swell		Equipment damage and reduced life	Utility faults, load changes
Undervoltage		Shutdown, malfunction, equipment failure	Load changes, overload, faults
Overvoltage		Equipment damage and reduced life	Load changes, faults, over compensation
Harmonics		Equipment damage and reduced life, nuisance breaker tripping, power losses	Electronic loads (non-linear loads)
Unbalance		Malfunction, motor damage	Unequal distribution of single phase loads
Voltage fluctuations		Light flicker and equipment malfunction	Load exhibiting significant current variations
Power frequency variations		Malfunction or motor degradation	Standby generators or poor power infrastructure
Power Factor *		Increased electricity bill, overload, power losses	Inductive loads (ex. motors, transformers...)

Power Quality problems are a major source of equipment failure and unplanned downtime

Power Quality problems are the root cause of 30-40% of unplanned downtime



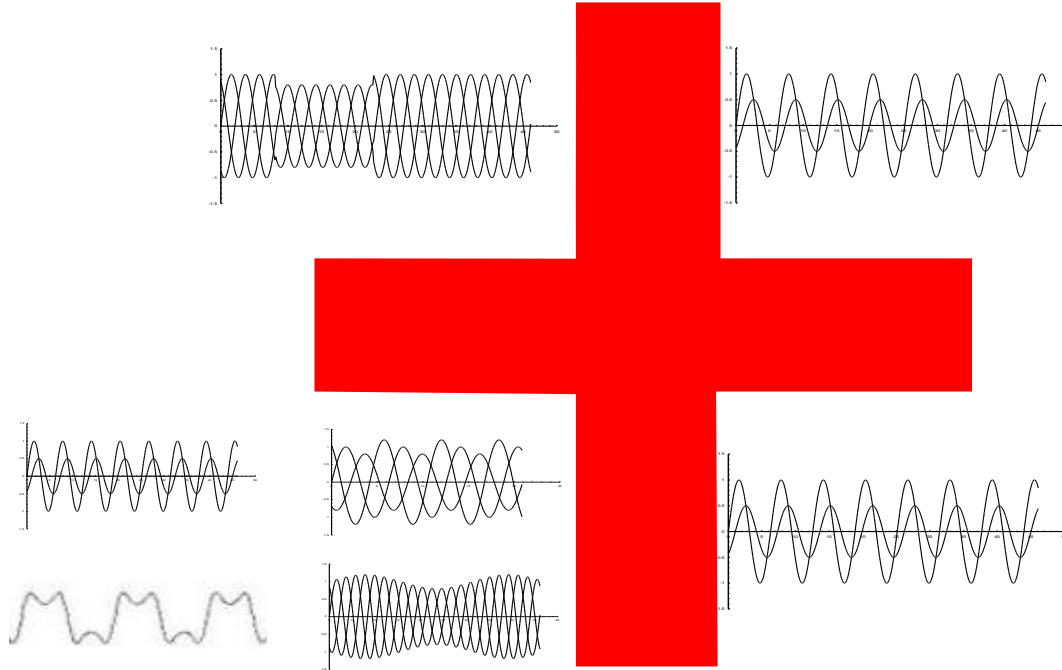
Most common power quality issues (US)



Most common power quality issues (EU)

Companies get sued & people get fired when this stuff happens

Different remedies for different Power Quality problems



Power Management Offer Portfolio

Measure

Gather accurate power and energy data from key distribution points, monitor power quality, log events



Interoperability
Standard Industry protocols and form factors
Customization: scalability in size and performance

Understand

Turn data into meaningful, actionable information for you and your stakeholders



Robust, flexible software platform architectures
Real-time energy consumption monitoring
Dynamic control interfaces
Real-time and historical power quality analysis

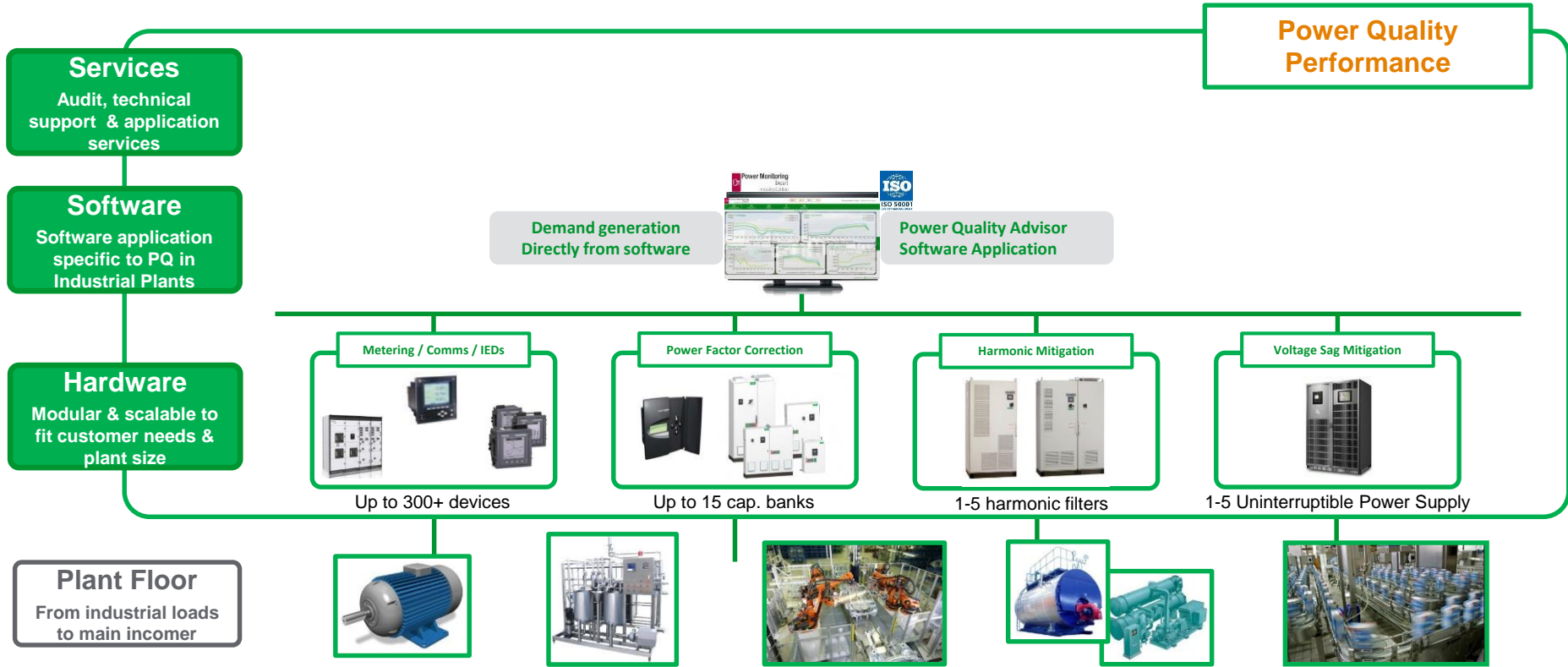
Act

Make timelier, intelligent decisions based on valid, actionable information



Increased energy efficiency and cost savings
Maximize electrical network reliability and availability
Optimize electrical asset performance

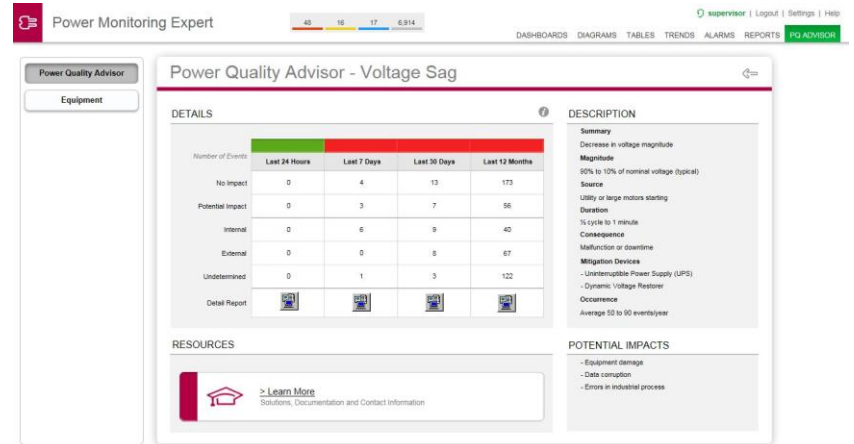
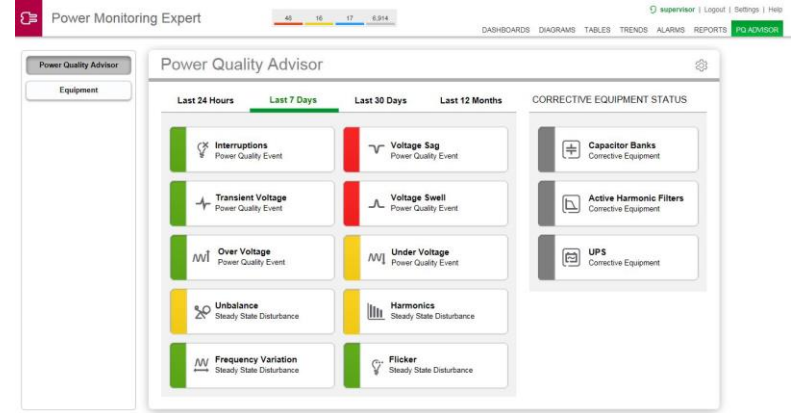
Power management with Power Quality Performance



Power Quality Performance



- **Simple, meaningful power system analytics**
 - Understand business impact of poor power quality
 - View cost impact from low power factor
 - Monitor the evolution of electrical system health



Power System Audits



Investigation of specific problems with your power system



Complete audit including measurement, analysis and reporting of power quality



Recommendations for power quality improvement



Existing harmonic standards

Standards relative to **installations**:

IEC 61000 - a series of standards dealing with power quality issues.

IEC 61000-2-2 harmonic levels at public low-voltage power supply systems

IEC 61000-2-4 harmonic levels at LV and MV industrial installations

IEC 61000-3-6 harmonic levels at MV and HV installations

IEEE 519 – 2014 : requirements on harmonic control in electrical installations (NEMA)

Adjustments at country level may exist (ex. Engineering Recommendation G5/4)



Standards relative to **individual equipment** :

IEC 61000

IEC 61000-3-2 low voltage equipment with rated current under 16A

IEC 61000-3-12 low voltage equipment with rated current higher than 16A and lower than 75A

IEC 61800-3 specific standard for variable speed drives

Harmonic Mitigation Solutions

VSD with ...			VSD with Multi-pulse supply			Active Harmonic Filter	Active Front End VSD
no filter	Choke (3% Z)	passive Filter	12-p	18-p	24-p		
90-120% THDi	30...40% THDi	10...20% THDi	12...15% THDi	5...8% THDi	< 5% THDi	3% to 5% THDi	2% to 5% THDi

Figure 1 THDi levels achieved with various harmonic mitigation methods

Active Harmonic Filter installation in existing hospital

Case Study

Life Is On



Success story: Active Harmonic Filter turnkey project



The existing situation

The hospital's air conditioning system had recently been modernized with a fleet of Variable Speed Drives (VSDs). These VSDs were polluting the hospital's electrical network and were regularly causing the new dialysis machines to malfunction. Diabetic patients were regularly sent home and asked to reschedule their treatment. The hospital's management had visibility on this problem and were eager to find someone with the knowhow to solve the issues. Schneider Electric's senior Power Quality specialists pinpointed the source of the harmonic distortion to be VSDs which were installed throughout the facility to efficiently regulate airflow and air pressure. The harmonic current produced by the VSDs was interacting with distribution transformers throughout the hospital and creating Voltage Distortion. Schneider Electric provided a turnkey proposal to design and implement PQ mitigation within the hospital's facility.

The Solution



Turnkey design & installation proposal

We sold our ability provide a turnkey proposal to comprehensively analyze and mitigate the Power Quality problems afflicting the dialysis machines. These PQ problems were severely impacting the quality of patient care and inhibiting the hospital's ability to manage diabetic patient care.

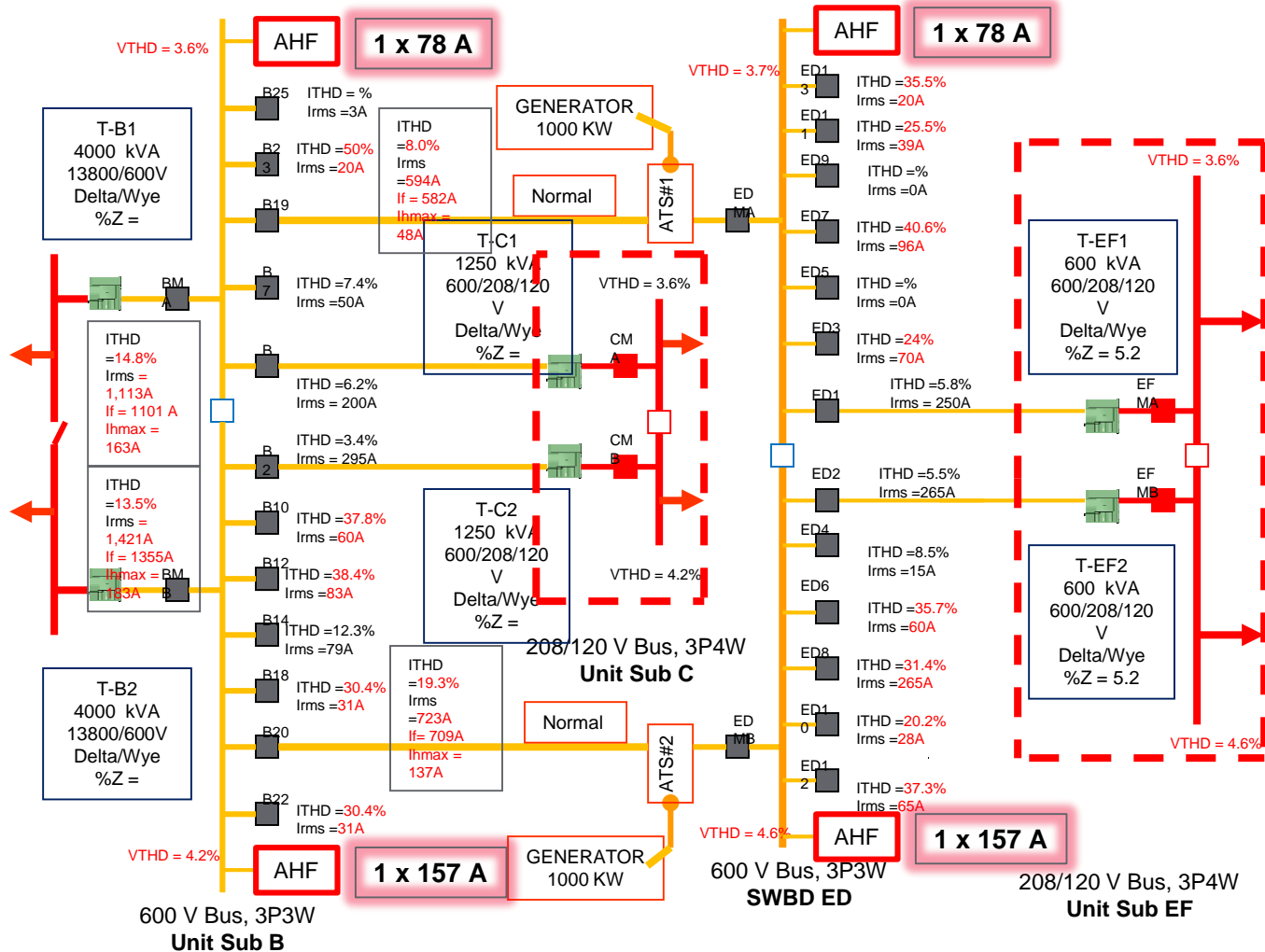
Customer Profile

In late 2013 a mid-size hospital reported the malfunction of several dialysis machines which were significantly impacting the quality of patient care. Schneider Electric's PQ Engineer performed a first PQ Audit in January. This PQ Audit led to the sale of a **PME 7.2** (Power Monitoring Expert) Power Monitoring system which was utilized, in conjunction with a fleet of PM800 Meters, sold as part of the initial construction, to measure the harmonic current produced by VSDs added throughout the facility as part of an Energy Efficiency project.



Possible solutions


Solution	Pros	Cons	Mitigates Voltage Distortion on Dialysis Machine	Mitigates Voltage Sag on Dialysis Machine	Mitigates Multiple Zero Crossings on Dialysis Machine	Estimate	Recommended
1. Active Harmonic Filter	Will solve Vthd problem in the entire distribution system	Requires further analysis to size correctly				TBD	
2. SagFighter	Protects the Dialysis Machines	No effect on PQ problems				64,000\$ + installation	
3. UPS	Protects the Dialysis Machines	No effect on PQ problems				120,000\$ + installation	



Our Value Proposal

Life Is On





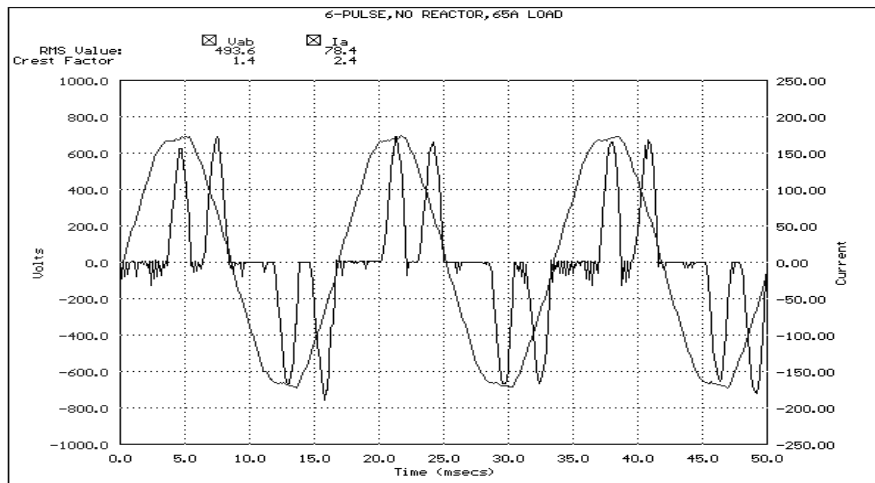
Schneider Electric offers a unique value proposal for Power Quality solutions

1. Investigate PQ problems anywhere in Canada
2. Diagnose and quantify problems onsite or remotely
3. Produce comprehensive engineering reports
4. Simulate network behavior as necessary
5. Design and deliver custom PQ mitigation solution
6. Validate performance
7. Support equipment through extended warranty and preventative maintenance

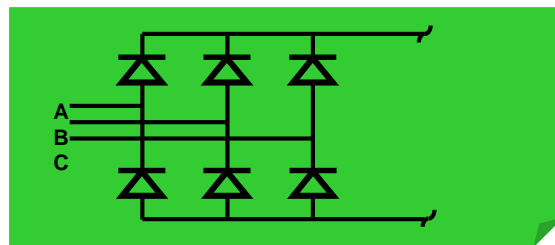
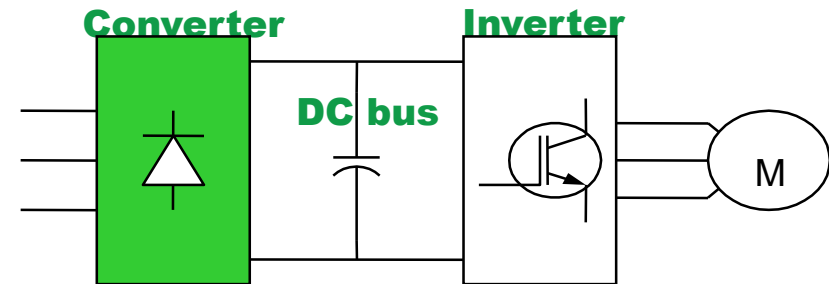
PWM VFD without 3% Line Reactance

Current Distortion:

THDi \approx 90%



Basic PWM VSD



Pre-installation: Preliminary harmonic study

Voltage where AccuSine system is attached: 600 V

Point of Common Coupling (PCC) MCC Transformer - Secondary

Harmonic Standard for current limits is IEEE 519-2014 (optional)

Applied operational mode(s):

Harmonic Mitigation:	x	THDI Required:	
Power Factor Correction:	x	DPF (Cos ϕ) Required:	0.95
Percent of AccuSine PCS system assigned for Harmonic Mitigation:			

Equipment list for NONLINEAR LOADS

Item	Quantity	Size	Unit of Measure	Type of Equipment	Rectifier pulses	Installed Impedance (%Z)	Maximum Capacity Utilized	Full Load Displacement PF
1	3	75	HP	PWM VFD	6	3.00%	100.0%	
2	1	75	HP	PWM VFD	6	3.00%	50.0%	
3	1	15	HP	PWM VFD	6	3.00%	100.0%	
4	2	20	HP	PWM VFD	6	3.00%	100.0%	
5	1	5	HP	PWM VFD	6	3.00%	100.0%	
6	1	1.5	HP	PWM VFD	6	3.00%	100.0%	
7	1	30	HP	PWM VFD	6	3.00%	100.0%	
8								
9								
10								

AC Motors Operating Direct-on-Line

Item	Quantity	Size	Unit of Measure	Rated Full Load PF (Nameplate)	Maximum Capacity Utilized
11	1	41	HP	0.800	80.0%
12	1	45	HP	0.800	50.0%
13	1	52.48	HP	0.800	80.0%
14	1	2.5	HP	0.800	50.0%
15					

IEEE 519-2014 Table 2

I_{L2}/I_{FLA}	% TDD
<20	5%
<50	8%
<100	12%
<1000	15%
>=1000	20%

Equivalent installed impedance: 3.00%

Selection adjustment factor according to installed impedance: 1.20

System Short Circuit Ratio (ShCR) @ selected PCC: 39.8:1

Uncorrected System				
Type of RMS Current	Original System Current Amplitudes & Total Harmonic Current Distortion		Power	
Total I_{rms}	430.1	amps	447.02	KVA
Total I_{fund}	420.3	amps	402.43	KW

AccuSine+ rating required @ system bus voltage:	81.7	amps
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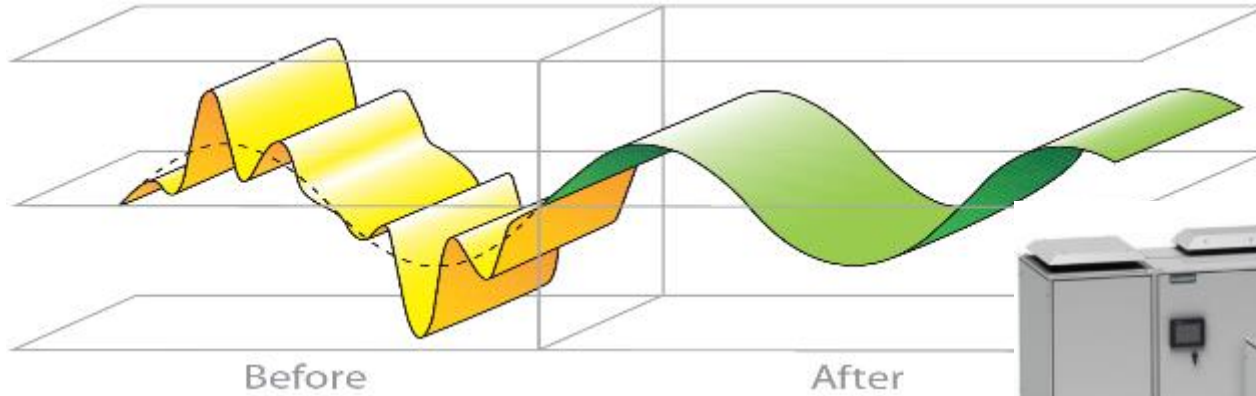
AccuSine+ rating required @ unit base voltage:	81.7	amps
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User Selected AccuSine+ rating @ unit base voltage:	94.0	amps
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Corrected System				
Type of RMS Current	Corrected Current Amplitudes & Total Harmonic Current Distortion		Corrected Power	
Total I_{rms}	420.9	amps	437.41	KVA
Total I_{fund}	420.3	amps	402.43	KW
Total I_h	22.4	amps	0.9986	Distortion PF
Total $I_{reactive}$	141.1	amps	146.68	KVAR
% THDi (achieved)	5.33%		0.9395	Displacement PF
			0.9382	Total PF

(Displacement PF)

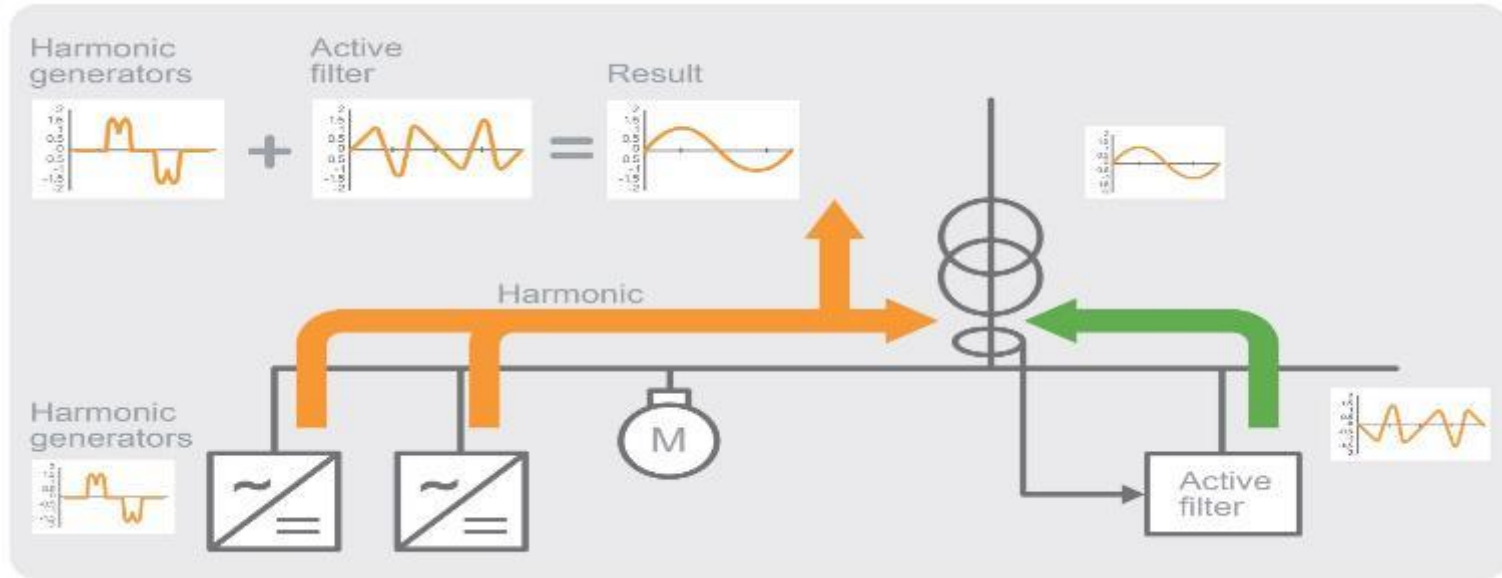
AccuSine PCS+



This selection meets or exceeds the harmonic objective of	8.00% THDi
This selection fails to meet the objective displacement PF [Cos ϕ] of	0.9500 DPF (Cos ϕ)

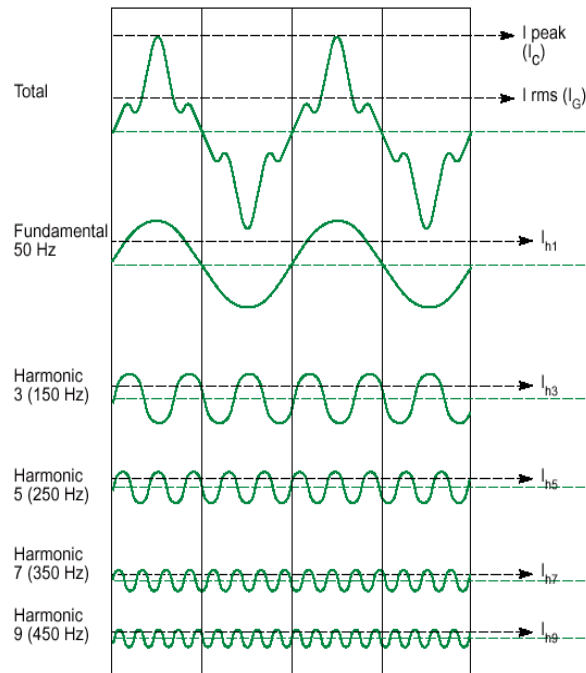
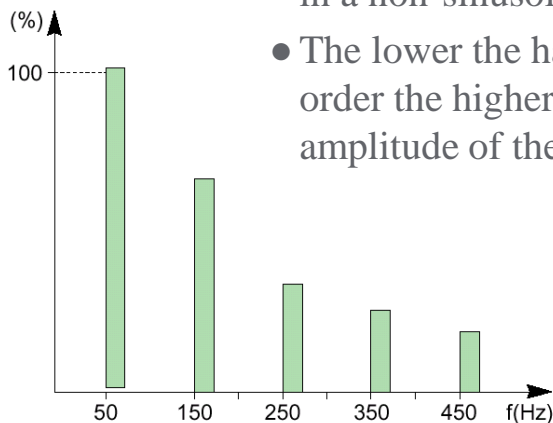
AccuSine PCS+ theory of operation

- AccuSine PLUS is a power electronic converter utilizing digital logic to inject corrective currents into a 3-phase power-source. These injected currents will compensate for existing harmonic currents from the 2nd to the 50th harmonic order drawn by non-linear loads connected to that grid.



Harmonics: Fundamentals (cont.)

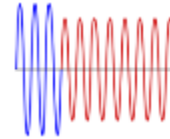
- Power source supplies the current the loads require for proper operation
- Harmonic current (I_h) is produced when an electrical device uses (draws) current in a non-sinusoidal manner
- The lower the harmonic order the higher the amplitude of the current



Voltage Problems – Basics

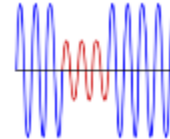
Chronic Voltage Problems

- Voltage outside $\pm 10\%$ for > 60 seconds



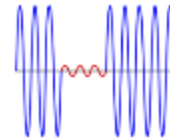
Voltage Sag

- Voltage $< 90\%$ for $\frac{1}{2}$ cycle to 1 minute



Interruption

- Voltage $< 10\%$ for > 3 cycles



A Sub-Cycle problem

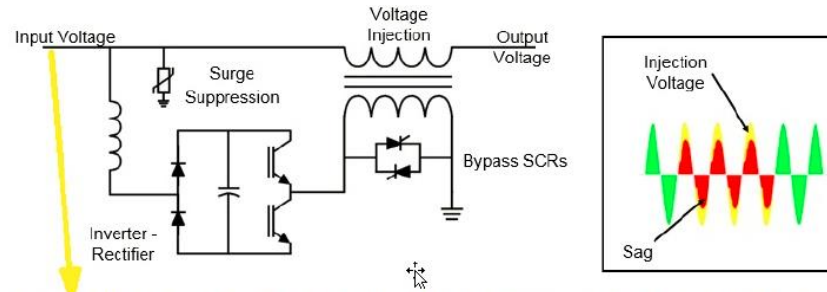
Voltage Power Quality Case Study: Sag Fighter

Large factory in Greater Toronto Area suffering from process line shut downs.

- Each time there is an unplanned shut down, system shuts down and powder coating spreads across the factories, requiring a thorough cleaning every time.
- Existing ION meters installed on site.

Event #	Duration (s)	Magnitude Phase1	Magnitude Phase2	Magnitude Phase3	Event Type	# phases affected	SagFighter will correct ?	Flywheel UPS will ride through ?	Timestamp
1	0.767000	0%	0%	0%	Interuption	3	No	YES	09/07/2016 8:00:08.565 AM
2	0.000065	0%	0%	135%	Interuption	2	No	YES	09/05/2016 9:48:33.482 AM
3	0.000048	127%	0%	0%	Interuption	2	No	YES	09/04/2016 12:14:18.558 PM
4	0.000065	0%	130%	0%	Interuption	2	No	YES	09/03/2016 8:40:46.923 AM
5	0.000016	0%	0%	119%	Interuption	2	No	YES	09/01/2016 6:26:46.531 AM
6	0.000016	118%	0%	0%	Interuption	2	No	YES	8/27/2016 8:08:53.866 AM
7	0.083000	48%	46%	32%	Sag	3	YES	YES	8/26/2016 5:24:38.765 PM
8	0.900000	0%	0%	0%	Interuption	3	No	YES	08/07/2016 6:44:22.174 AM
9	0.880000	0%	0%	0%	Interuption	3	No	YES	7/29/2016 6:16:42.307 AM
10	0.941000	0%	0%	0%	Interuption	3	No	YES	07/03/2016 6:55:05.439 AM
11	0.925000	0%	0%	0%	Interuption	3	No	YES	07/01/2016 6:48:08.814 AM
12	0.109000	50%	49%	56%	Sag	3	YES	YES	6/24/2016 4:27:54.614 AM
13	0.867000	0%	0%	0%	Interuption	3	No	YES	5/30/2016 12:16:31.980 AM
14	0.033000	45%	47%	31%	Sag	3	YES	YES	5/29/2016 6:58:31.446 AM
15	0.000065	133%	0%	0%	Interuption	2	No	YES	5/23/2016 11:20:57.288 AM
16	0.075000	48%	53%	52%	Sag	3	YES	YES	5/17/2016 10:01:39.796 AM
17	0.125000	55%	48%	48%	Sag	3	YES	YES	05/06/2016 7:46:17.937 AM
18	0.000016	120%	0%	0%	Interuption	2	No	YES	05/01/2016 9:53:51.004 AM

Solution: Sag fighter and UPS



Draws extra current from the "healthy" phases to create an injection voltage

Figure 3 : SagFighter sketch

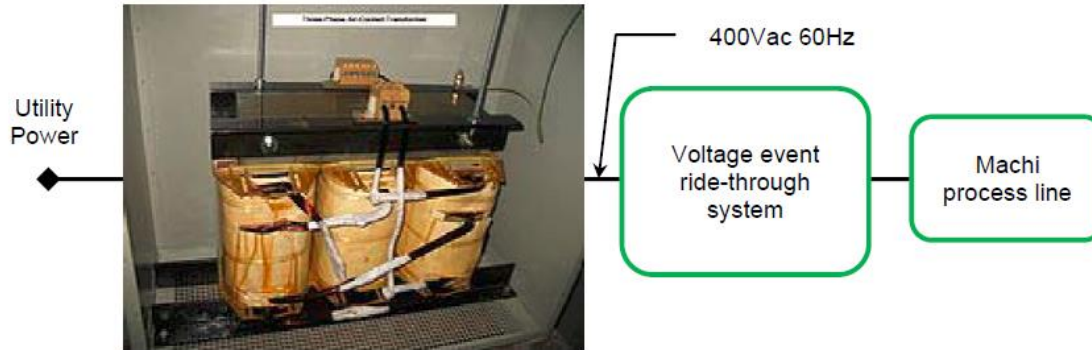
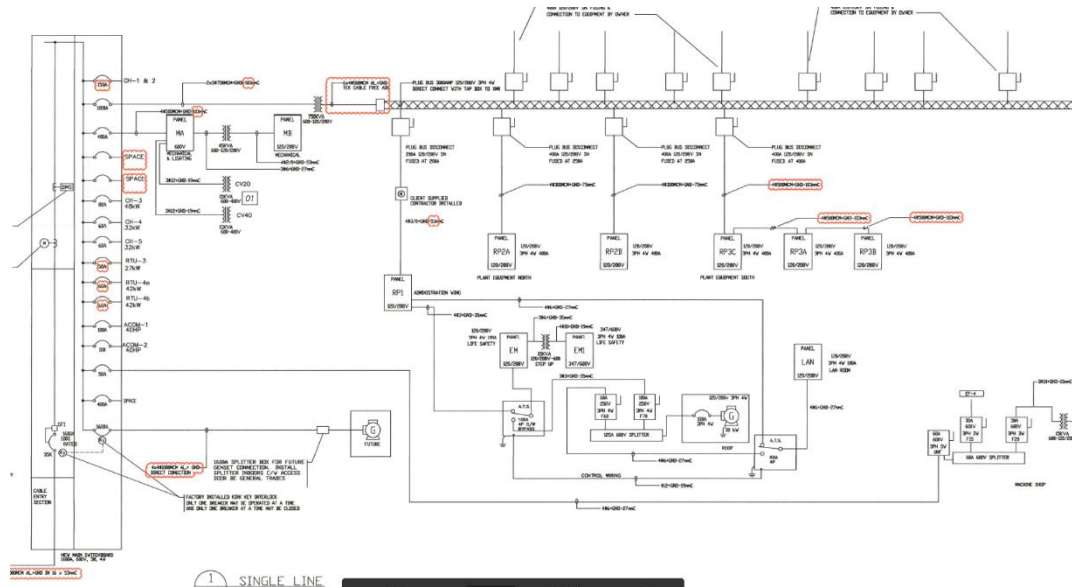


Figure 2 : positioning of the "Voltage Event Ride-Through System"

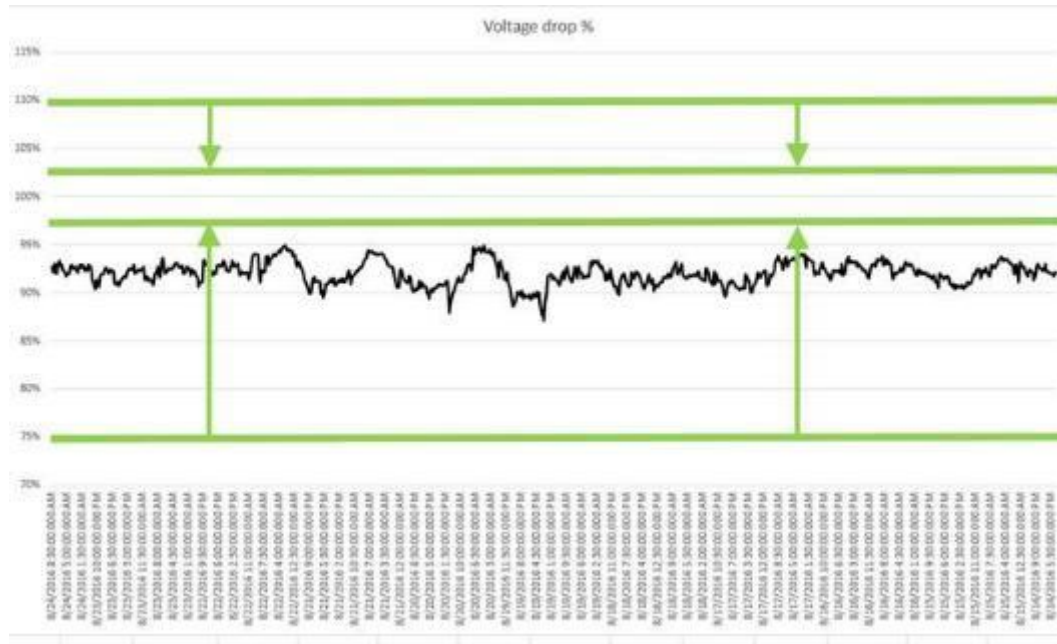
Voltage Power Quality Case Study: Sure Volt

- Pharmaceutical company with highly sensitive electronics.
- End of a utility line, suffering voltage drops during peak demand.
- Sensitive equipment goes offline, unplanned downtime



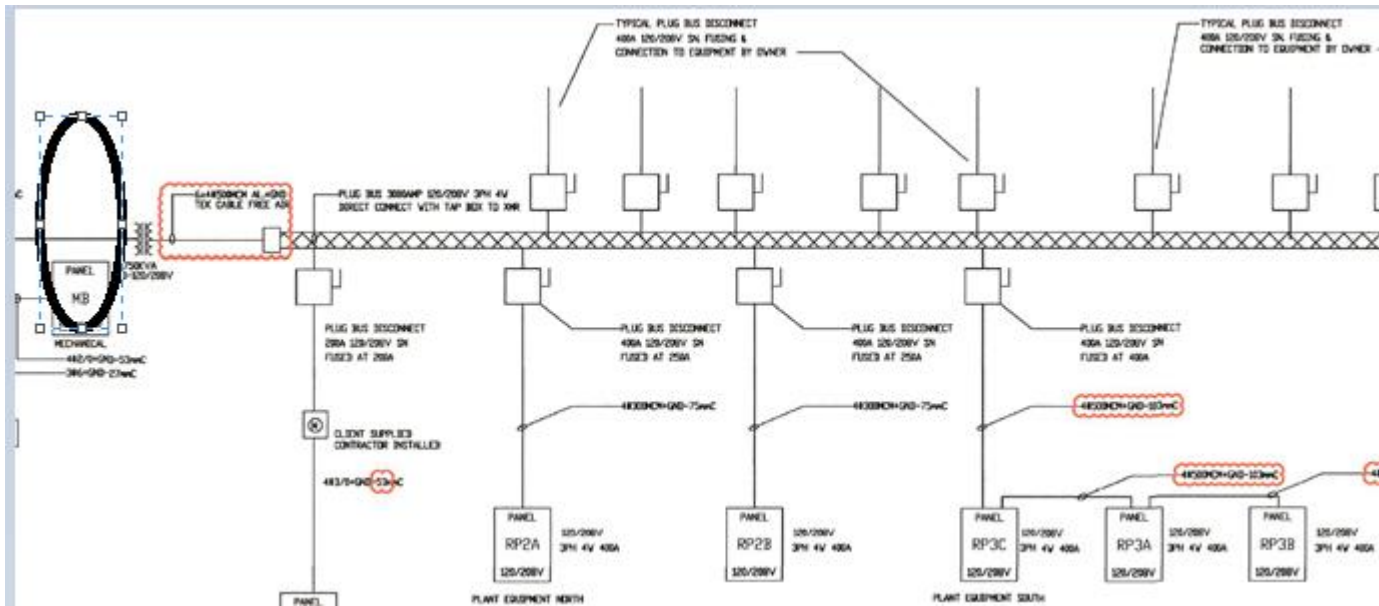
Data extracted from ION meter

- Lowest recorded voltage in past year: 75% of nominal voltage
- Recommended range: +-10% nominal voltage



Proposed solution: Sure-Volt

- 500kVA Sure-Volt proposed at artery where sensitive equipment is failing.
- Regulates voltage $\pm 3\%$



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