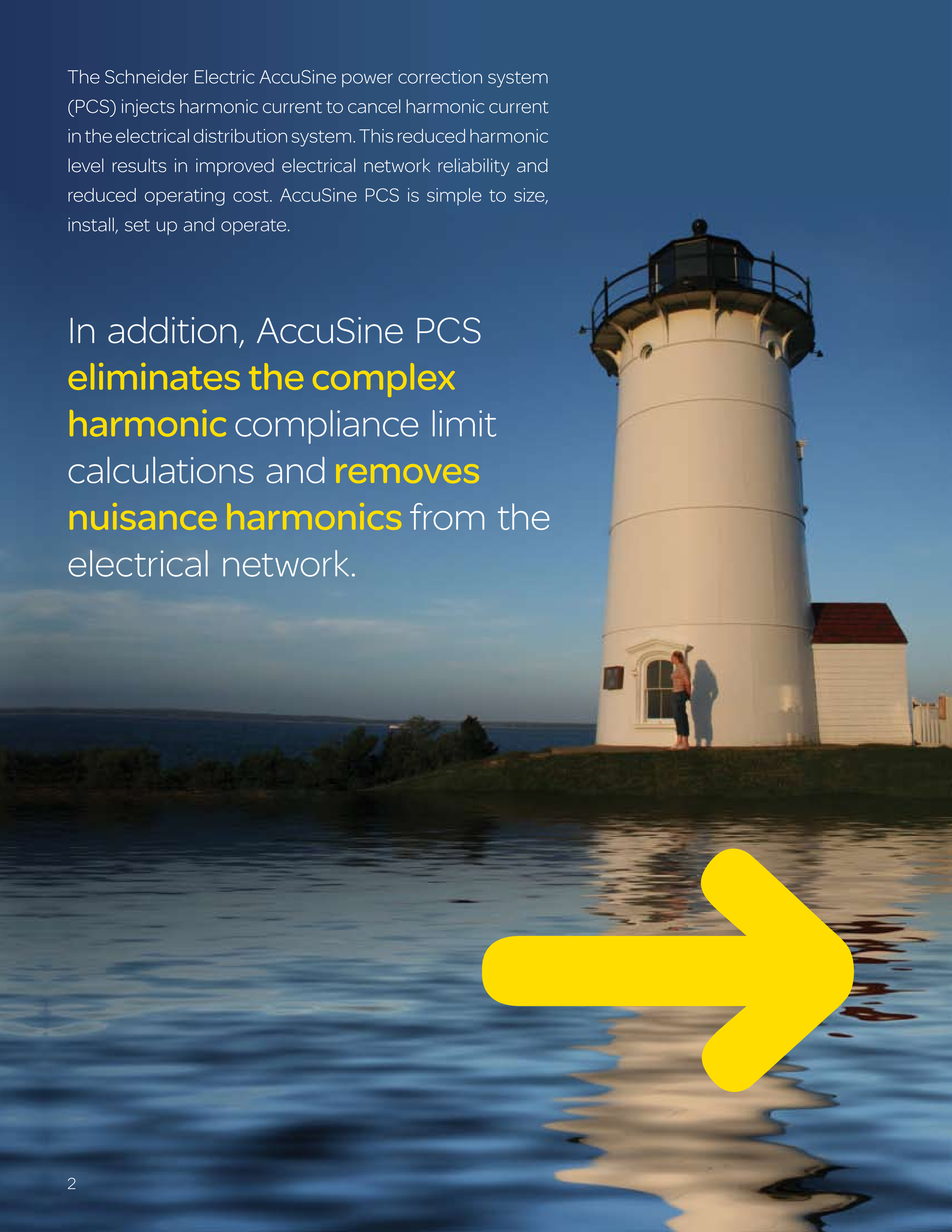
AccuSine® PCS Active Harmonic Filter

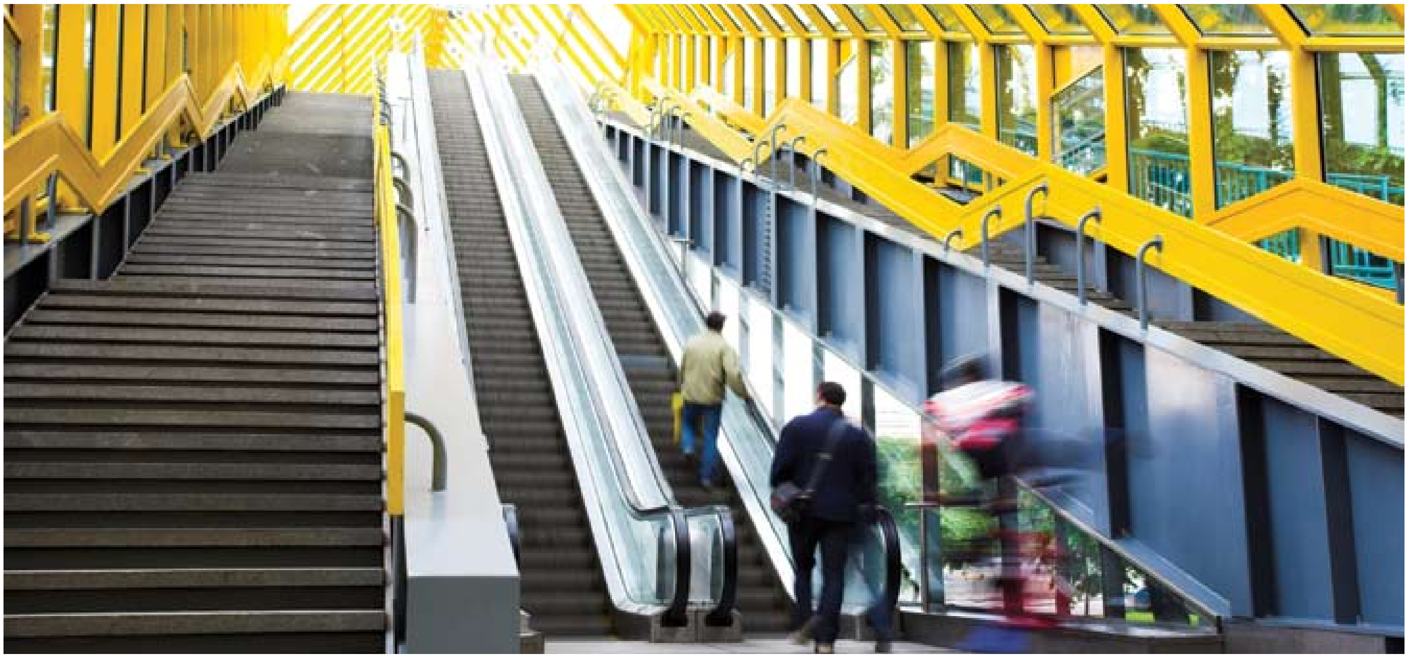
Cruising through rough waves in your electrical network

Schneider Electric

The Schneider Electric AccuSine power correction system (PCS) injects harmonic current to cancel harmonic current in the electrical distribution system. This reduced harmonic level results in improved electrical network reliability and reduced operating cost. AccuSine PCS is simple to size, install, set up and operate.

In addition, AccuSine PCS **eliminates the complex harmonic** compliance limit calculations and **removes nuisance harmonics** from the electrical network.





How can active harmonic filters solve power quality issues in your facility?

Power electronic devices that have rapid and frequent load variations have become abundant today due to their many process control related and energy saving benefits. However, they also bring a few major drawbacks to electrical distribution systems; harmonics and rapid change of reactive power requirement. Harmonics may disrupt normal operation of other devices and increase operating costs. Rapid reactive power changes demand timely reactive power (VAR) compensation.

Symptoms of problematic harmonic levels include overheating of transformers, motors, drives, cables, thermal tripping of protective devices and logic faults of digital devices. In addition, the life span of many devices can be reduced by elevated operating temperature.

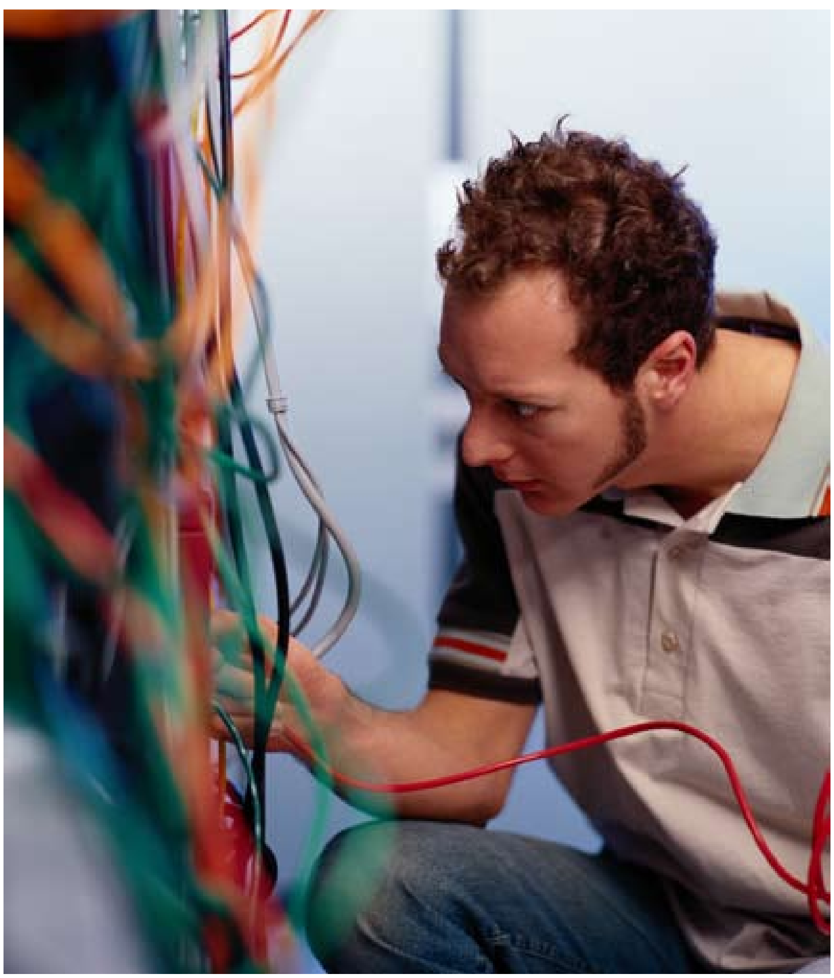
Lack of timely and adequate VAR compensation can lead to voltage fluctuations in the electrical distribution system, impacting equipment operation, as well as product quality.

The AccuSine PCS active harmonic filter (AHF) provides the simplest and most effective means to mitigate harmonics, reduce process-related voltage fluctuations, and improve equipment operating life and system capacity.

AccuSine PCS can be placed in **various locations** within the electrical distribution network

Typical applications

Applications	Requirements	Benefits
Water and wastewater treatment plants, textile mills, paper mills, pharmaceutical facilities, steel mills, package sorting facilities, oil platforms and marine vessels	Total voltage distortion: • THD(V) to be < 5%, • Total Demand Distorsion to meet equipment operating environment to prevent damage to other equipment in the facility	• Reduce harmonics to meet industry standards • Reduce harmonic effects on equipment • Increase system capacity by improving total power factor
Smelters, induction furnaces, DC drives and cranes	Fast reactive power compensation in rich harmonic operating environment	• Eliminate highly-fluctuating harmonic content • Provide real-time supply of reactive power to improve system voltage regulation
Data centers, hospitals and microelectronic manufacturers	Critical uptime requirements incorporate backup power systems with generators, UPS	• Reduce harmonics • Correct leading power factor when blade servers are used on the output of UPS
Welders, linear induction motors, windmills, Solar farms, X-ray and MRI machines	Ultra-fast VAR compensation	• Provide ultra-fast VAR compensation to ensure stable voltage level for the process • Eliminate flicker • Improve diagnostic machine uptime



Key features and benefits

A simple line up, including

- Power rating: 50 A, 100 A and 300 A, universal voltage: 208–480 V, 3-phase/3-wire (3P/3W)
- Enclosure options: NEMA 1, NEMA 12, IP30, IP54
- Worldwide offer: meets UL, CSA, CE, ABS, C-Tick standards

Powerful performance

- Meets all major worldwide harmonic standards; IEEE-519, G5/4-1, GB/T 14549, IEC 61000-3-2/-3-4/ -3-12
- Ultra-fast response to load changes – within microseconds
- Cancels all harmonics from 2nd to 50th order
- 225% VAR current injection to meet instantaneous load requirements and provide voltage support

Expandable capabilities

- Parallel up to ten units with different ratings on one set of current transformers

Easy to control

- Highly-visible QVGA screen, multi-language capability
- Unit operating status, load profiles displayed on 3.8 in. screen
- Clear on screen operating start and stop touch buttons
- Modbus® communication capability

10+

Paralleling **more than ten units is possible**; consult Schneider Electric for details.

Active harmonic filter operating principle

The AccuSine PCS injects harmonic and reactive current to limit the harmonic distortion and improves displacement power factor for the electrical distribution system in any facility. As a full spectrum product, AccuSine PCS measures the entire load current, removes the fundamental frequency component and injects the inverse of the remaining wave form for nearly complete cancellation of harmonic current. AccuSine PCS's full spectrum circuitry is not focused on specific frequencies; rather it creates a waveform "on the fly" based upon the input of its sensing circuitry, regardless of the particular frequencies that the non-linear load current contains.

AccuSine PCS monitors the load through current transformers mounted on the AC line (figure A below), feeding the loads of concern. This information is analyzed by the logic to determine the amount of correction to be injected into the AC lines from the parallel installed AccuSine PCS.

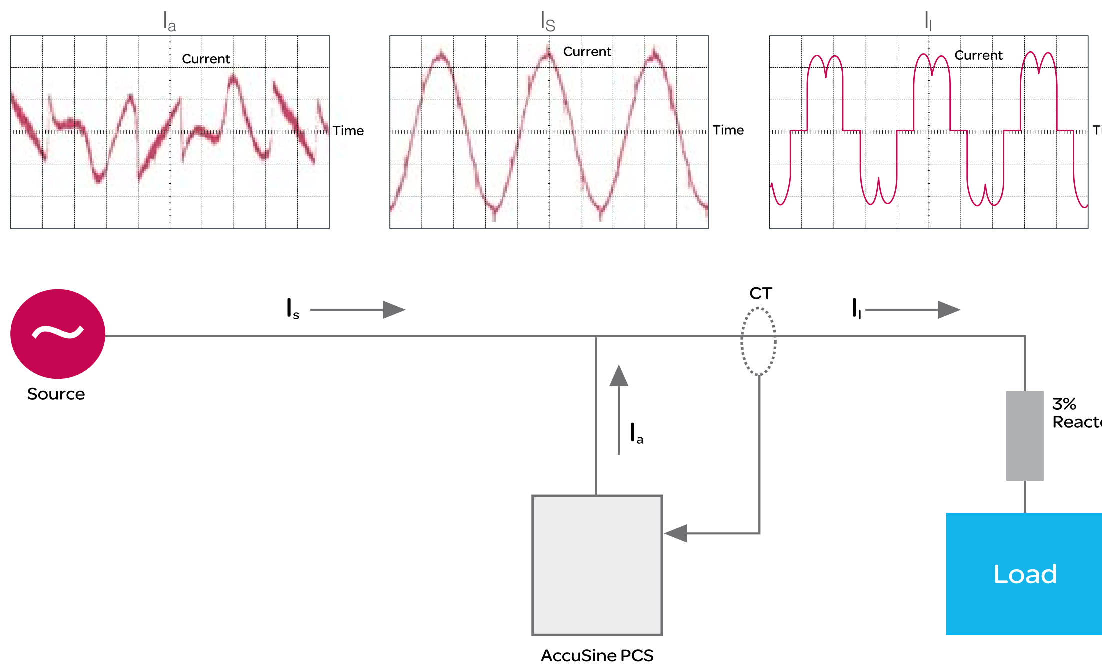


Figure A

Most active harmonic filters today are designed with two types of control schemes. One uses Fast Fourier Transforms (FFT) to calculate the amplitudes and phase angle of each harmonic order. The power devices are directed to produce a current of equal amplitude but opposite phase angle for specific harmonic orders. This limits the response to specific harmonic orders and may require up to two or more cycles (> 33 milliseconds) before responding.

The other control scheme (as used by AccuSine PCS) is called a full spectrum cancellation. This control scheme doesn't perform FFT. The control algorithms are analog. The logic acquires the current sample from the current transformer, removes the fundamental frequency component and starts injecting the correction within several hundred microseconds. In this manner, all non-fundamental "noise" is removed for the electrical source. This "noise" may contain non-integer frequencies, also known as inter-harmonics.

Application Guide

AccuSine PCS can easily be applied to various applications. It can be used in conjunction with other power quality correction equipment, such as tuned harmonic filters, capacitor banks, etc. However, as with any electrical equipment, we need to examine each application carefully to ensure proper selection and application.

AccuSine PCS can be placed in various locations within the electrical distribution network (figure B below). Multiple units (up to ten) can be connected in parallel to provide higher compensation current to meet the TDD levels defined in IEEE519-1992 standard or in the plant operating requirements.

An important prerequisite when applying AccuSine PCS is to **install a 3% or higher impedance line reactor** or equivalent in front of each non-linear load, such as VFD, UPS or SCR power supply.

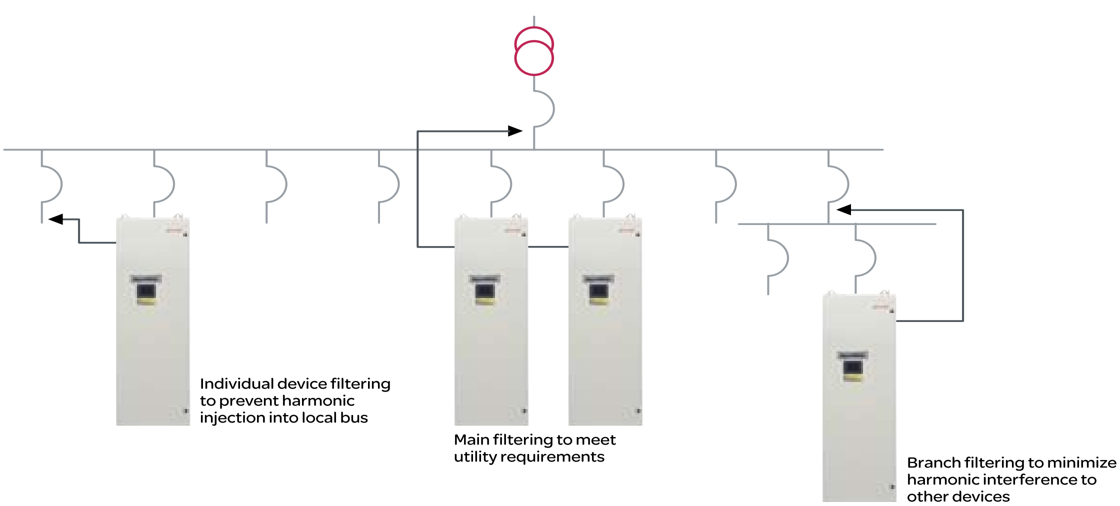


Figure B

Unit rating determination

For a new facility or facility with a known load list, we can use the AccuSine PCS selection program to calculate the AccuSine system rating required to meet the system objective. An Excel™-based tool, the AccuSine PCS selection program can be downloaded from our website www.reactivar.com.

For example, an industrial facility has a requirement to meet a current total demand distortion (TDD) level of 8%. We collect the system information as follows:

Transformer rating	2,000 kVA, with 5% impedance
System voltage	480 V
Desired TDD level	8%
Non-linear load list	2 x 150 kVA UPS (Diode converter) 6 x 50 HP VFD (PWM) 6 x 20 HP VFD (PWM) 20 x 10 HP VFD (PWM) 2 x 100 HP VFD (PWM)
Total linear load	400 kVA

The following summary is from the AccuSine PCS selection program.

Electrical system voltage	480 V
All loads total	1,828.3 A
All linear loads total	481.1 A
Original displacement power factor	0.950
Objective displacement power factor	0.950
TDD of the electrical system before AccuSine PCS	17.06% TDD
Objective TDD	8.00% TDD
Required rating of the AccuSine PCS system	245.9 A of correction

The AccuSine PCS selection program calculates that, in order to meet the 8% TDD requirement, an AccuSine PCS-rated 245.9 A RMS is required. In this case, a 300 A rated unit should be specified (in this example, 5% TDD can be achieved due to 300 A unit is selected or additional VAR compensation capacity can be obtained).

For an existing facility where a detailed load list is not available, but the historic harmonic and load current data of the system can be obtained through advanced metering, please contact a Schneider Electric sales office for sizing assistance.

AccuSine Product specification

Standard RMS output current ratings	50 A, 100 A, 300 A
Nominal voltage	208–480 V ±10% auto-sensing
Other voltages	With transformer
Nominal frequency	50/60 Hz ±3 Hz auto-sensing
Number of phases	3P/3W, 3P/4W
Power electronics	IGBT
Topology	Analog/digital interface
Operation with single-phase loads	Yes
Current transformers (CT)	1,000/5, 3,000/5, 5,000/5 (400 Hz)
Number of CTs required	2 or 3
Normal spectrum of compensation	2^{nd} to 50^{th} harmonic global
Attenuation ratio	> 10:1
Parallel multiple units	Yes, up to 10 per set of CTs (any rating combinations)
CT location	Either source or load sensing
Power factor correction	Yes, leading or lagging injection to target power factor
Response time	100 microseconds for step load changes, 1 cycle full response
Overload	Limited to nominal output, continuous operation
Dynamic current injection	Up to 2.25 times rated current
Display	High quality 3.8 in. QVGA screen
Languages	English, with other language capability
Operators	Magelis XBT graphic touch screen terminal
Display parameters	• AC line voltage, DC bus voltage, load power factor, output power factor • Load harmonic current, load reactive current, output harmonic current, corrected load current • Various fault codes, set up parameter points, start/stop control screen
Communication capability	Modbus, Modbus TCP/IP
Heat losses	• N1 unit: 1,800 W for 50 A, 3,000 W for 100 A, 9,000 W for 300 A • N12, IP units: 2,150 W for 50 A, 3,700 W for 100 A, 10,000 W for 300 A
Noise level (ISO 3746)	< 80 db at one meter from unit surface
Color	NEMA 1 quartz gray, all others RAL7032
Operating temperature	0° C to 40° C continuous
Relative humidity	0–95% non-condensing
Seismic qualification	IBC and ASCE7
Operating altitude	< 1,000 m (derating factors apply for higher altitudes @10% per 1,000 m)
Protection (enclosure)	NEMA 1, NEMA 12, IP30, IP54
Optional: CE EMC certification	IEC/EN60439-1, EN61000-6-4 Class A, EN61000-6-2

AccuSine selection information

AccuSine PCS selection table

Rated current	Max. reactive power (kvar)			Catalog number	Enclosure information		Frame size	Weight[f]
A (RMS)	208 V	400 V	480 V		Rating	Style/cable entry	Figure #	Lbs (kg)
50	18	34.6	41.6	PCS050D5N1x	NEMA 1	Wall-mount/ bottom[a]	1	250 (114)
				PCS050D5N15Sx[b]				
				PCS050D5N16Sx				
				PCS050D5N12Dx[e]	NEMA 12	Floor-standing[d]/ top or bottom	4	661 (300)
				PCS050D5N125SCx[e]				
				PCS050D5N126SDx[e]				
				PCS050D5CE305SCx[ce]	IP30 (CE certified)			
				PCS050D5CE545SCx[ce]	IP54 (CE certified)			
				PCS050D5IP305SCx[e]	IP30			
				PCS050D5IP545SCx[e]	IP54			
100	36	69.2	83.1	PCS100D5N1x	NEMA 1	Wall-mount/ bottom[a]	2	350 (159)
				PCS100D5N15Sx				
				PCS100D5N16Sx				
				PCS100D5N12Dx[e]	NEMA 12	Floor-standing[d]/ top or bottom	5	771 (350)
				PCS100D5N125SCx[e]				
				PCS100D5N126SDx[e]				
				PCS100D5CE305SCx[ce]	IP30 (CE certified)			
				PCS100D5CE545SCx[ce]	IP54 (CE certified)			
				PCS100D5IP305SCx[e]	IP30			
				PCS100D5IP545SCx[e]	IP54			
300	108	207.8	249.4	PCS300D5N1x	NEMA 1	Floor-standing[d]/top	3	775 (352)
				PCS300D5N15Sx				
				PCS300D5N16Sx				
				PCS300D5N12Dx[e]	NEMA 12	Floor-standing[d]/ top or bottom	6	1,212 (550)
				PCS300D5N125SCx[e]				
				PCS300D5N126SDx[e]				
				PCS300D5CE305SCx[ce]	IP30 (CE certified)			
				PCS300D5CE545SCx[ce]	IP54 (CE certified)			
				PCS300D5IP305SCx[e]	IP30			
				PCS300D5IP545SCx[e]	IP54			

x = 5 for 50 Hz; x = 6 for 60 Hz. N1/N12 version are rated 50/60 Hz
a: Floor stand can be ordered with part number – FSPCS100N1
b: "S" model is used outside of U.S.
c: CE certified units meet EMC Directive 89/336 EEC
d: Floor-standing units include a door-interlocked main disconnect
e: C = 380–415 V fan, D = 480 V fan
f: Weight information is subject to change without notice

Round split-core CT selection table

Ampacity	Catalog number	Dimensions (in.)		Weight (lbs)	Accuracy (%)	Burden capacity (VA)	Secondary current (A)
		A (ID)	D (OD)				
1,000	CT1000SC	4.0	6.5	3.50	1	5	5
3,000	CT3000SC	6.0	8.5	4.25	1	45	5
5,000	CTFCL500058	8.0	10.5	5.50	1	45	5

Three CTs required for networks with single-phase loads. Two CTs required for three-phase loads. For installations requiring parallel connection of multiple AccuSine units, special considerations is required, and additional CT may be needed. Contact Schneider Electric for details.

Installation guidelines

AccuSine PCS is provided in enclosures with four different ratings: NEMA 1, NEMA 12, IP30 and IP54. They are suitable for indoor, well-ventilated, clean environments with ambient temperature ranging from 0° C to 40° C.

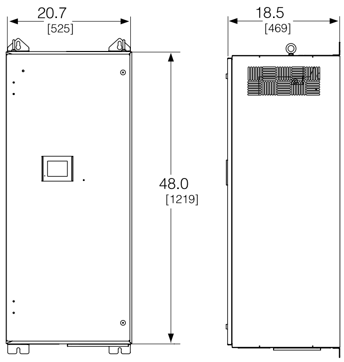
For dusty environments (such as mining operations, steel factories, paper mills), a filtered and air-conditioned utility room is required (to maintain ambient temperature and remove conductive dust), and a NEMA 12 or IP54 unit is recommended.

AccuSine PCS AHF unit dimensions

Frame size (Figure)	Exterior dimensions					
	Height		Width		Depth	
	in.	mm	in.	mm	in.	mm
1	48.0	1,219	20.7	525	18.5	469
2	64.9	1,648	20.7	525	18.5	469
3	75.3	1,913	31.5	801	19.6	497
4/5	75.0	1,905	31.5	801	23.8	605
6	90.7	2,303	39.4	1,000	31.7	805

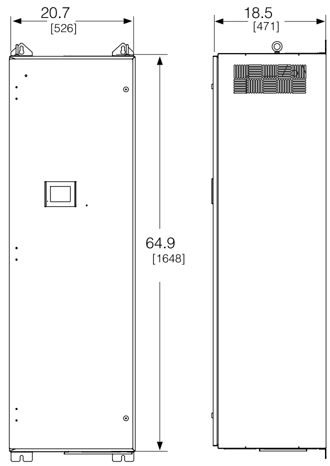
For detailed installation instructions, please refer to installation bulletin 5820IB0802.
Chassis unit information is available upon request.

Frame size 1



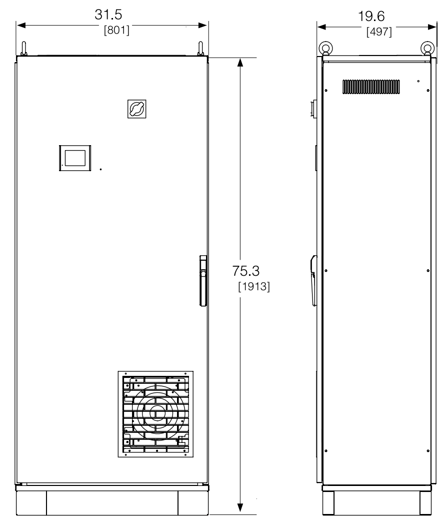
Front view Side view

Frame size 2



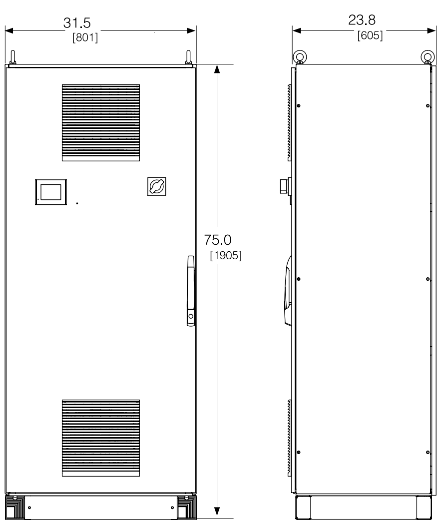
Front view Side view

Frame size 3



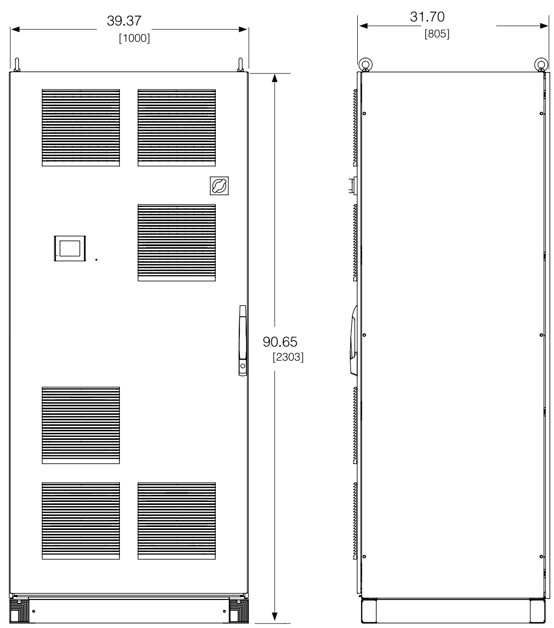
Front view Side view

Frame size 4 & 5



Front view Side view

Frame size 6



Front view Side view

* Consult factory approval or record drawing with final dimensions.

Harmonic-related information and definitions

Definitions

Harmonics in the electrical network is a phenomenon gaining more attention in recent years. To help the reader follow the terminologies used in this brochure, the definitions of different terms related to harmonic phenomena are described below.

Today in AC industrial electrical distribution networks, the variation of current and voltage with time is considerably different from that of a pure sine wave. The actual waveform is composed of a number of sine waves of different frequencies, including one at the generating power frequency, referred to as the fundamental component.

a. Harmonic component: any one of the sinusoidal components in which frequency is an integer multiple of the fundamental component.

b. Harmonic order: the harmonic order is the ratio of the frequency of the harmonic component to that of the frequency of fundamental. By definition, the harmonic order of the fundamental f_1 is equal to 1. Note that the harmonic of order n is often referred to simply as the nth harmonic.

$$n = \frac{f_n}{f_1}$$

c. Spectrum: the spectrum is the distribution of the amplitudes of the various harmonics as a function of their harmonic order, often illustrated in the form of a histogram.

d. Expression of distorted wave: the Fourier series expression of distorted wave is as follows:

$$y(t) = y_0 + \sum_{n=1}^{n=\infty} y_n \sqrt{2} \sin(n\omega t - \varphi_n)$$

where;

y_0 = the amplitude of the DC component, which is generally zero in AC distribution systems.
y_n = the rms value of the nth harmonic component.
φ_n = phase angle of the nth harmonic component when $t = 0$.

e. RMS value of a distorted wave: harmonic quantities are generally expressed in terms of their rms value since the heating effect depends on this value of the distorted waveform. For distorted quantity, under steady-state conditions, the energy dissipated by the Joule effect is the sum of the energies dissipated by each of the harmonic components:

$$RI^2t = RI_1^2t + RI_2^2t + ... + RI_n^2t$$

i.e.: where; $I = \sqrt{\sum_{n=1}^{n=\infty} I_n^2}$ if the resistance can be considered as constant.

f. Individual harmonic ratio and total harmonic distortion: the individual harmonic ratio and total harmonic distortion ratio quantify the harmonic disturbances present in the distribution network. The individual harmonic ratio expresses the magnitude of each harmonic with respect to the fundamental.

Typically referred to as THD, total harmonic distortion quantifies the thermal effect of all the harmonics. It is the ratio of the rms value of all the harmonics to that of the fundamental. IEEE 519-1992 has defined THD in mathematic formula below:

$$THD = \sqrt{\frac{\sum_{n=2}^{n=\infty} Y_n^2}{Y_1^2}} \times 100\%$$

where; y_1 is the fundamental component.

g. Total demand distortion (TDD): TDD is defined in IEEE519-1992 as:

$$TDD = \frac{\sqrt{\sum_{n=2}^{n=\infty} Y_n^2}}{Y_l} \times 100\%$$

where; y_1 is the maximum demand load current of the facility within 15 or 30 minute demand window.

Harmonic effects on electrical distribution network

a. Instantaneous effects

- Electronic devices
  - Harmonics can disrupt controllers used in electronic systems and can adversely affect thyristor switching due to displacement of the zero-crossing of the voltage wave
  - Harmonics can cause vibrations and noise in electrical machines (motors, transformers, reactors)
  - Harmonics also reduce available system capacity

b. Long-term effects

- Capacitor heating and degradation (capacitance loss)
- Heating due to additional losses in transformers
- Heating of cables and equipment
- Thermal damage to induction motors and generators

Standards

Most equipment have limits on the permissible harmonic content in the electrical system during operation. These limits can be found in the library of various standards. The following are general limits on various electrical equipment:

a. Synchronous machines: permissible stator current distortion < 1.4%

b. Asynchronous machines: permissible stator current distortion; 1.5% to 3.5%

c. Cable: permissible core-shielding voltage distortion < 10%

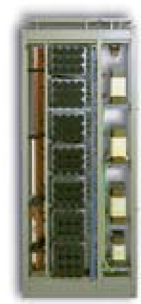
d. Electronic equipment: 5% voltage distortion with a maximum individual percentage of 3% depending on the equipment

e. Transformer: permissible current distortion < 5% at full load

Most utilities have adopted standards to limit the harmonic content at the point of common coupling (PCC). Standards adapted around the world include, but not to limit to:

- US/Canada ....IEEE 519
- International IEC61000 3-2, 3-4, 3-12
- United Kingdom G5/4-1
- China ....GB/T 14549

A wide range of Power Quality products meet your facility solution needs



● Low Voltage Capacitor banks

○ Varset classic or comfort : suitable for networks with low or medium harmonic level

○ Varset harmony : suitable for networks with high harmonic level

○ Varset fast : suitable for applications requiring real-time correction and/or transient free capacitor switching

○ Passive filtering :
- From 230 V to 690 V
- Harmonic orders : H5, H7, H11
- Reactive power : up to 265 kVA

● Medium Voltage Capacitor banks

○ CP 200 series of capacitor bank :
- Fixed or automatic medium voltage capacitor bank
- Range suitable for any type of network

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