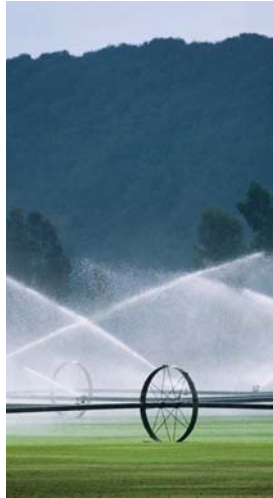




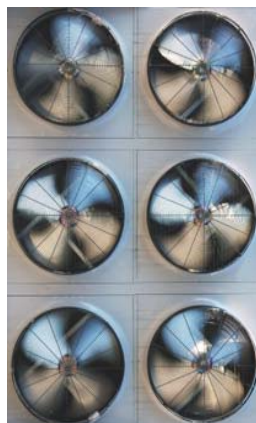
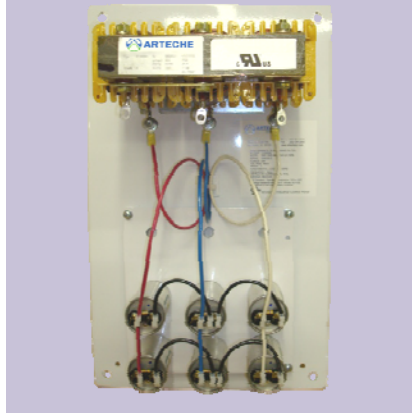
Sine Wave dv/dt Filters



Enclosed versions



Open panel versions



OEM Component kits



Sine Wave Filters—Type SWF

Combined dv/dt Filtering and PWM to Sine Wave Conversion

Sine Wave Filters Exceed Ordinary dv/dt Filters

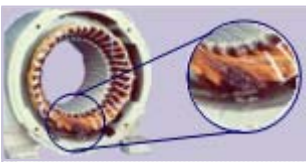
Advanced dv/dt Filtering Plus PWM Voltage to Sine Wave Conversion

SINE WAVE FILTER THEORY

Type SWF Sine Wave Filters utilize passive low pass filter technology to convert inverter Pulse Width Modulated (PWM) voltage to a sine wave. They incorporate a unique PWM rated reactor combined with a rugged harmonic rated capacitor to form a filter network that attenuates the PWM inverter switching frequency. This filter network removes most of the high frequency content (pulses) from the waveform, resulting in a nearly sine wave output voltage. Motors are protected against dv/dt and excessive peak voltage, and the motor will see normal peak voltage (approximately equal to the DC bus voltage).

MOTOR DAMAGE

PWM voltage consists of numerous fast rising (high dv/dt) pulses. When motors are located a long distance (beyond critical cable length as shown in chart) from an inverter, a phenomenon known as voltage reflection occurs, causing the *peak voltage* at the motor terminals to be as high as 2X the inverter DC bus voltage (nearly 3X system voltage). Most of this *excessive peak voltage* is impressed upon the first turns of the motor windings and can cause premature failure.



Damaged by Excessive Peak Voltage

Arteche Type SWF Sine Wave Filters are superior to typical dv/dt filters. Our Type SWF Filters eliminate the threat of *excessive peak voltage* and protect motor windings for any and all cable lengths.

Arteche Sine Wave Filters are superior to typical dv/dt filters. Our Type SWF filters will eliminate the threat of excessive peak voltage and protect motor windings for any and all cable lengths.

SWF FILTER MEETS NEMA STANDARD MG-1, Part 30

Since the **Type SWF Filter** output voltage is nearly a sine wave, virtually *infinite** motor cable lengths are possible (except for voltage drop). The waveform achieved through the proper application of our sine wave filter complies with the requirements of NEMA MG-1, Part 30, for non-inverter duty motors.

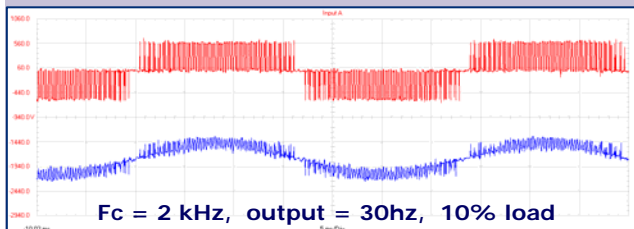
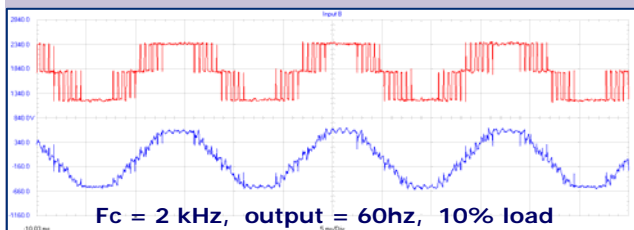


Arteche Type SWF Filters make it possible to use either a non-inverter duty motor or inverter duty motor in a VFD application. Both inverter duty and non-inverter duty motors can experience extended life and reduced power losses when protected by **Sine Wave Filters**.

Critical Motor Cable Length	
PWM Pulse Rise Time	Critical Cable Length
50 nano-sec.	3 Meters (10 ft)
0.1 μ sec.	6 Meters (20 ft)
0.5 μ sec.	31 Meters (100 ft)
1 μ sec.	62 Meters (200 ft)
2 μ sec.	125 Meters (400 ft)
Any with SWF	*Infinite length

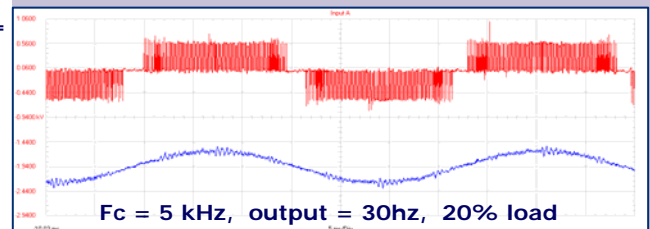
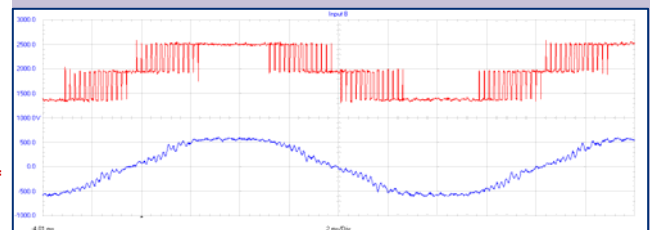
Arteche Sine Wave Filters solve voltage reflection and dv/dt problems

2.0 - 2.5 kHz PWM Frequency



Arteche Type SWF Sine Wave Filters effectively protect motors by filtering both the harsh PWM voltage and reflected voltage, thereby reducing dv/dt to minimal levels and returning the voltage to a sinusoidal waveform.

≥ 5 kHz PWM Frequency



By providing near sine wave voltage for the motor, the motor windings are protected, the motor operates with lower temperature rise and with lower power losses.

When to Use Type SWF Sine Wave Filters

Applications

SUBMERSIBLE MOTORS

Submersible motor applications are unique because the motor cables are immersed in water (or other medium), and the dielectric constant for water is about eighty times greater than for air. This means the inverter output circuit capacitance is much higher than for conductors in air (typical conduit applications), and therefore voltage reflection will be more pronounced. Submersible motors should always be protected by **Type SWF Sine Wave Filters** regardless of cable length.

CONDUCTORS IN AIR

Depending on motor cable length, when conductors (and conduit/raceway) are in air, the survivability of a motor will depend on cable length and system voltage. When motors are operated from low system voltage (200-240V) and with shorter cable lengths, they can typically be protected by a reactor of about 4-5% impedance. Higher system voltages and longer cable lengths require **Sine Wave Filter** protection when motor cables exceed critical cable length (see chart on page 2), reactors or sine wave filters should be applied (as per the chart below).

Suggested Motor Filter Application Chart

Motor	Motor Cable Length				
	100 ft	300 ft	500 ft	1,000 ft	15,000 ft
Submersible Pumps	SWF	SWF	SWF	SWF	SWF
230 V motors	4-5% Impedance	4-5% Impedance	4-5% Impedance	5% Impedance	n/a
400 V motors	4-5% Impedance	4-5% Impedance	5% Impedance	SWF	SWF
460 V motors	4-5% Impedance	4-5% Impedance	SWF	SWF	SWF
575 V motors	SWF	SWF	SWF	SWF	SWF
690 V motors	SWF	SWF	SWF	SWF	SWF

Background

VOLTAGE REFLECTION

Voltage reflection is caused when fast rising voltage pulses, such as those produced by PWM inverters, travel on an electrical conductor that is terminated by a high impedance load (motor). The magnitude of the reflected pulse is a function of the characteristic (or surge) impedance of both the cable and motor. The greater the mismatch between motor and cable surge impedance the greater the reflected voltage pulse. The safe distance for the motor cable length is a function of both the impedance mismatch (between motor and cable) and the pulse voltage rise time (IGBT characteristic). See the critical cable length chart on page 2.

NEMA STANDARD MG-1, PART 30 & 31

Arteche Type SWF Filters meet the requirements of both Nema standard MG-1, Part 30 (non-inverter duty motors) and Part 31 (inverter duty motors). **Type SWF Sine Wave Filters** protect motors against premature insulation breakdown caused by excessive peak over-voltage and dv/dt. Nema standard MG-1, Part 30 requires 1000V peak or less and the rise time must be 2 micro-seconds or slower. **Type SWF Sine Wave Filters** achieve this for all VFDs and motors rated 690 volts or less.

Nema Std MG-1 limits

Part 30: $\leq 1000 V_{pk}$ and $\geq 2 \mu\text{sec}$ rise time
 Part 31: $\leq 3.1 \times V_{rated}$ and $\geq 0.1 \mu\text{sec}$ rise time



Component Construction

Arteche Type SWF Sine Wave Filters are produced with precision reactors and high performance capacitor cells. They are designed for natural convection cooling, so they only require adequate ventilation and can operate in ambient temperatures up to 50 degrees Celsius. They do not require damping resistors or fans, and therefore offer both high efficiency and high reliability.

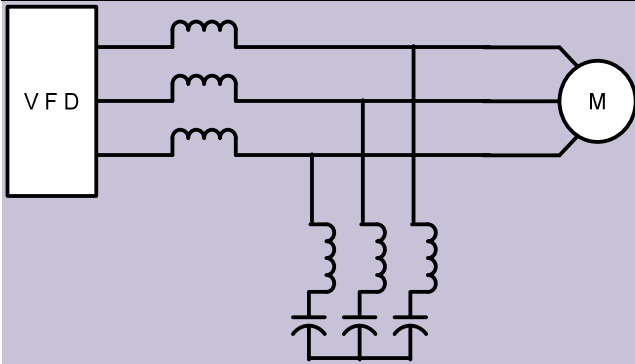
Type SWF Filter reactors are specially constructed for PWM waveforms using PolyGap™ core technology for low power losses as well as balanced inductance. The inductance (mH) of our reactors is within +/- 3% for all three phases, assuring balanced voltage drop.



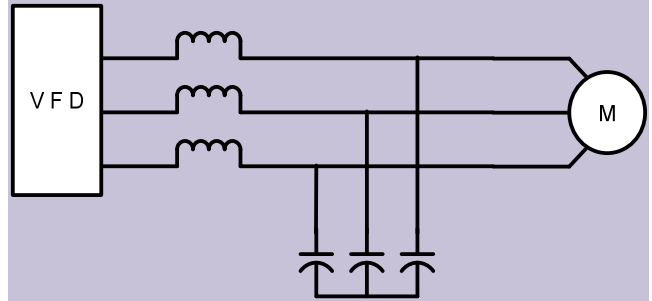
Type SWF Filter capacitors are constructed using metallized polypropylene elements which are encased in metallic canisters and filled with high performance, biodegradable dielectric fluid (free of PBCs). Capacitors used in our filters are self-protecting and self-healing. In the event that the capacitor experiences an insulation breakdown, (possibly caused by excessive voltage or over-current), a UL approved internal pressure-sensitive switch will interrupt the internal electrical connections to prevent the case from rupturing. Our UL approved self-protecting and self-healing features eliminate the need for fuses in the filter capacitor circuit.

Circuit Diagrams

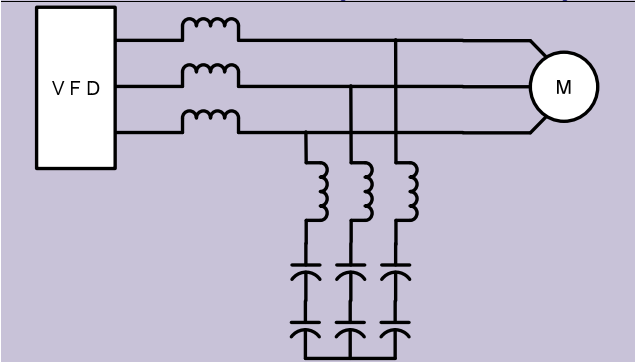
2.5kHz SWF (200V – 480V)



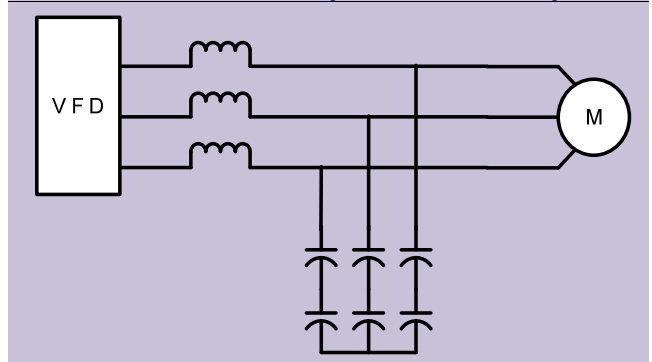
5kHz SWF (200V – 480V)



2.5kHz SWF (600V – 690V)



5kHz SWF (600V – 690V)



Type SWF Sine Wave Filters offer motor protection for long motor lead installations such as mining, submersible pumping, and other applications.

Selection Tables for 2.5kHz Sine Wave dv/dt Filters (50/60 Hz)

Select **Type SWF Sine Wave Filters** based on three phase motor voltage and FLA ratings. If FLA is not known, then filters may be selected based on motor HP rating. Consult factory for use at fundamental frequencies above 60Hz, other voltage or power ratings, or other PWM carrier frequencies.

Type SWF Sine Wave Filters are available for any voltage, frequency, ampere or HP / kW rating. Consult factory for special ratings. OEM kit, panel mounted, and enclosed versions available by adding * appropriate suffix to the catalog number. See suffixes below chart.

Selection Chart for VFD with Carrier Frequency set to 2-2.5 kHz

		380-415 Volts		440-480 Volts		550-600 Volts		660-690 Volts	
KW	HP	FLA	Catalog No.	FLA	Catalog No.	FLA	Catalog No.	FLA	Catalog No.
1.5	2	5.8	SWF 005.8A 400 2.5KHZ *	3.4	SWF 003.4A 480 2.5KHZ *	2.7	SWF 002.7A 600 2.5KHZ *	1.7	SWF 001.7A 690 2.5KHZ *
2.2	3	6.3	SWF 006.3A 400 2.5KHZ *	6.3	SWF 006.3A 480 2.5KHZ *	3.9	SWF 003.9A 600 2.5KHZ *	2.5	SWF 002.5A 690 2.5KHZ *
3.7	5	12	SWF 0012A 400 2.5KHZ *	7.6	SWF 007.6A 480 2.5KHZ *	6.1	SWF 006.1A 600 2.5KHZ *	4.1	SWF 004.1A 690 2.5KHZ *
5.5	7.5	15	SWF 0015A 400 2.5KHZ *	11	SWF 0011A 480 2.5KHZ *	8.6	SWF 008.6A 600 2.5KHZ *	7.0	SWF 0007A 690 2.5KHZ *
7.5	10	22	SWF 0022A 400 2.5KHZ *	14	SWF 0014A 480 2.5KHZ *	11	SWF 0011A 600 2.5KHZ *	8.3	SWF 008.3A 690 2.5KHZ *
11	15	29	SWF 0029A 400 2.5KHZ *	21	SWF 0021A 480 2.5KHZ *	17	SWF 0017A 600 2.5KHZ *	13.8	SWF 0014A 690 2.5KHZ *
15	20	36	SWF 0036A 400 2.5KHZ *	27	SWF 0027A 480 2.5KHZ *	22	SWF 0022A 600 2.5KHZ *	17	SWF 0017A 690 2.5KHZ *
18.5	25	43	SWF 0043A 400 2.5KHZ *	34	SWF 0034A 480 2.5KHZ *	27	SWF 0027A 600 2.5KHZ *	21	SWF 0021A 690 2.5KHZ *
22	30	58	SWF 0058A 400 2.5KHZ *	40	SWF 0040A 480 2.5KHZ *	32	SWF 0032A 600 2.5KHZ *	24	SWF 0024A 690 2.5KHZ *
30	40	68	SWF 0068A 400 2.5KHZ *	52	SWF 0052A 480 2.5KHZ *	41	SWF 0041A 600 2.5KHZ *	35	SWF 0035A 690 2.5KHZ *
37	50	80	SWF 0080A 400 2.5KHZ *	65	SWF 0065A 480 2.5KHZ *	52	SWF 0052A 600 2.5KHZ *	41	SWF 0041A 690 2.5KHZ *
45	60	97	SWF 0097A 400 2.5KHZ *	77	SWF 0077A 480 2.5KHZ *	61	SWF 0061A 600 2.5KHZ *	52	SWF 0052A 690 2.5KHZ *
55	75	132	SWF 0132A 400 2.5KHZ *	96	SWF 0096A 480 2.5KHZ *	72	SWF 0072A 600 2.5KHZ *	59	SWF 0059A 690 2.5KHZ *
75	100	167	SWF 0167A 400 2.5KHZ *	124	SWF 0124A 480 2.5KHZ *	99	SWF 0099A 600 2.5KHZ *	87	SWF 0087A 690 2.5KHZ *
90	125	201	SWF 0201A 400 2.5KHZ *	156	SWF 0156A 480 2.5KHZ *	125	SWF 0125A 600 2.5KHZ *	104	SWF 0104A 690 2.5KHZ *
110	150	274	SWF 0274A 400 2.5KHZ *	180	SWF 0180A 480 2.5KHZ *	144	SWF 0144A 600 2.5KHZ *	122	SWF 0122A 690 2.5KHZ *
150	200	319	SWF 0319A 400 2.5KHZ *	240	SWF 0240A 480 2.5KHZ *	192	SWF 0192A 600 2.5KHZ *	156	SWF 0156A 690 2.5KHZ *
185	250	388	SWF 0388A 400 2.5KHZ *	302	SWF 0302A 480 2.5KHZ *	236	SWF 0236A 600 2.5KHZ *	208	SWF 0208A 690 2.5KHZ *
220	300	456	SWF 0456A 400 2.5KHZ *	361	SWF 0361A 480 2.5KHZ *	289	SWF 0289A 600 2.5KHZ *	243	SWF 0243A 690 2.5KHZ *
260	350	525	SWF 0525A 400 2.5KHZ *	414	SWF 0414A 480 2.5KHZ *	326	SWF 0326A 600 2.5KHZ *	278	SWF 0278A 690 2.5KHZ *
300	400	593	SWF 0593A 400 2.5KHZ *	480	SWF 0480A 480 2.5KHZ *	382	SWF 0382A 600 2.5KHZ *	312	SWF 0312A 690 2.5KHZ *
335	450	639	SWF 0639A 400 2.5KHZ *	515	SWF 0515A 480 2.5KHZ *	412	SWF 0412A 600 2.5KHZ *	365	SWF 0365A 690 2.5KHZ *
375	500	776	SWF 0776A 400 2.5KHZ *	590	SWF 0590A 480 2.5KHZ *	471	SWF 0471A 600 2.5KHZ *	400	SWF 0400A 690 2.5KHZ *
450	600	913	SWF 0913A 400 2.5KHZ *	720	SWF 0720A 480 2.5KHZ *	576	SWF 0576A 600 2.5KHZ *	486	SWF 0486A 690 2.5KHZ *
525	700	1027	SWF 1027A 400 2.5KHZ *	840	SWF 0840A 480 2.5KHZ *	672	SWF 0672A 600 2.5KHZ *	556	SWF 0556A 690 2.5KHZ *
600	800	1164	SWF 1164A 400 2.5KHZ *	960	SWF 0960A 480 2.5KHZ *	761	SWF 0761A 600 2.5KHZ *	643	SWF 0643A 690 2.5KHZ *
675	900	1278	SWF 1278A 400 2.5KHZ *	1080	SWF 1080A 480 2.5KHZ *	864	SWF 0864A 600 2.5KHZ *	730	SWF 0730A 690 2.5KHZ *

*** Add appropriate suffix - For OEM Kit, Open Panel or Nema enclosed filters:**

CMP = OEM Kit, PNL = (Open Panel), N1 = (Nema 1), N3R = (Nema 3R), N12 = (Nema 12)

Selection Tables for 5kHz Sine Wave dv/dt Filters (50/60 Hz)

Select **Type SWF Sine Wave Filters** based on three phase motor voltage and FLA ratings. If FLA is not known, then filters may be selected based on motor HP rating. Consult factory for use at fundamental frequencies above 60Hz, other voltage or power ratings, or other PWM carrier frequencies.

Type SWF Sine Wave Filters are available for any voltage, frequency, ampere or HP / kW rating. Consult factory for special ratings. OEM kit, panel mounted, and enclosed versions available by adding * appropriate suffix to the catalog number. See suffixes below chart.

Selection Chart for VFD with Carrier Frequency set to 5 kHz or higher

		380-415 Volts		440-480 Volts		550-600 Volts		660-690 Volts	
KW	HP	FLA	Catalog No.	FLA	Catalog No.	FLA	Catalog No.	FLA	Catalog No.
1.5	2	5.8	SWF 005.8A 400 5KHZ *	3.4	SWF 003.4A 480 5KHZ *	2.7	SWF 002.7A 600 5KHZ *	1.7	SWF 001.7A 690 5KHZ *
2.2	3	6.3	SWF 006.3A 400 5KHZ *	6.3	SWF 006.3A 480 5KHZ *	3.9	SWF 003.9A 600 5KHZ *	2.5	SWF 002.5A 690 5KHZ *
3.7	5	12	SWF 0012A 400 5KHZ *	7.6	SWF 007.6A 480 5KHZ *	6.1	SWF 006.1A 600 5KHZ *	4.1	SWF 004.1A 690 5KHZ *
5.5	7.5	15	SWF 0015A 400 5KHZ *	11	SWF 0011A 480 5KHZ *	8.6	SWF 008.6A 600 5KHZ *	7.0	SWF 0007A 690 5KHZ *
7.5	10	22	SWF 0022A 400 5KHZ *	14	SWF 0014A 480 5KHZ *	11	SWF 0011A 600 5KHZ *	8.3	SWF 008.3A 690 5KHZ *
11	15	29	SWF 0029A 400 5KHZ *	21	SWF 0021A 480 5KHZ *	17	SWF 0017A 600 5KHZ *	13.8	SWF 0014A 690 5KHZ *
15	20	36	SWF 0036A 400 5KHZ *	27	SWF 0027A 480 5KHZ *	22	SWF 0022A 600 5KHZ *	17	SWF 0017A 690 5KHZ *
18.5	25	43	SWF 0043A 400 5KHZ *	34	SWF 0034A 480 5KHZ *	27	SWF 0027A 600 5KHZ *	21	SWF 0021A 690 5KHZ *
22	30	58	SWF 0058A 400 5KHZ *	40	SWF 0040A 480 5KHZ *	32	SWF 0032A 600 5KHZ *	24	SWF 0024A 690 5KHZ *
30	40	68	SWF 0068A 400 5KHZ *	52	SWF 0052A 480 5KHZ *	41	SWF 0041A 600 5KHZ *	35	SWF 0035A 690 5KHZ *
37	50	80	SWF 0080A 400 5KHZ *	65	SWF 0065A 480 5KHZ *	52	SWF 0052A 600 5KHZ *	41	SWF 0041A 690 5KHZ *
45	60	97	SWF 0097A 400 5KHZ *	77	SWF 0077A 480 5KHZ *	61	SWF 0061A 600 5KHZ *	52	SWF 0052A 690 5KHZ *
55	75	132	SWF 0132A 400 5KHZ *	96	SWF 0096A 480 5KHZ *	72	SWF 0072A 600 5KHZ *	59	SWF 0059A 690 5KHZ *
75	100	167	SWF 0167A 400 5KHZ *	124	SWF 0124A 480 5KHZ *	99	SWF 0099A 600 5KHZ *	87	SWF 0087A 690 5KHZ *
90	125	201	SWF 0201A 400 5KHZ *	156	SWF 0156A 480 5KHZ *	125	SWF 0125A 600 5KHZ *	104	SWF 0104A 690 5KHZ *
110	150	274	SWF 0274A 400 5KHZ *	180	SWF 0180A 480 5KHZ *	144	SWF 0144A 600 5KHZ *	122	SWF 0122A 690 5KHZ *
150	200	319	SWF 0319A 400 5KHZ *	240	SWF 0240A 480 5KHZ *	192	SWF 0192A 600 5KHZ *	156	SWF 0156A 690 5KHZ *
185	250	388	SWF 0388A 400 5KHZ *	302	SWF 0302A 480 5KHZ *	236	SWF 0236A 600 5KHZ *	208	SWF 0208A 690 5KHZ *
220	300	456	SWF 0456A 400 5KHZ *	361	SWF 0361A 480 5KHZ *	289	SWF 0289A 600 5KHZ *	243	SWF 0243A 690 5KHZ *
260	350	525	SWF 0525A 400 5KHZ *	414	SWF 0414A 480 5KHZ *	326	SWF 0326A 600 5KHZ *	278	SWF 0278A 690 5KHZ *
300	400	593	SWF 0593A 400 5KHZ *	477	SWF 0477A 480 5KHZ *	382	SWF 0382A 600 5KHZ *	312	SWF 0312A 690 5KHZ *
335	450	639	SWF 0639A 400 5KHZ *	515	SWF 0515A 480 5KHZ *	412	SWF 0412A 600 5KHZ *	365	SWF 0365A 690 5KHZ *
375	500	776	SWF 0776A 400 5KHZ *	590	SWF 0590A 480 5KHZ *	471	SWF 0471A 600 5KHZ *	400	SWF 0400A 690 5KHZ *
450	600	913	SWF 0913A 400 5KHZ *	720	SWF 0720A 480 5KHZ *	576	SWF 0576A 600 5KHZ *	486	SWF 0486A 690 5KHZ *
525	700	1027	SWF 1027A 400 5KHZ *	840	SWF 0840A 480 5KHZ *	672	SWF 0672A 600 5KHZ *	556	SWF 0556A 690 5KHZ *
600	800	1164	SWF 1164A 400 5KHZ *	960	SWF 0960A 480 5KHZ *	761	SWF 0761A 600 5KHZ *	643	SWF 0643A 690 5KHZ *
675	900	1278	SWF 1278A 400 5KHZ *	1080	SWF 1080A 480 5KHZ *	864	SWF 0864A 600 5KHZ *	730	SWF 0730A 690 5KHZ *

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CMP = OEM Kit, **PNL** = (Open Panel), **N1** = (Nema 1), **N3R** = (Nema 3R), **N12** = (Nema 12)

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Harmonic Distortion and Low Power Factor
Low Voltage, Medium Voltage and High Voltage Solutions**



Harmonic Filters

**Low Pass Harmonic Filters (5%THD-i)
Tuned Harmonic Filters
Active Harmonic Filters
Automatic Harmonic Filters
12 & 18 Pulse Rectifier Upgrade Kits
Soft Switching Harmonic Filters**

Power Factor Improvement

**Fixed Capacitor Systems
De-Tuned Capacitor
Active PF Compensation
Automatic Capacitors
Dynamic VAR Compensation
Soft Switching Capacitor Systems**

Form No. C02-2003



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