



Sine Wave (dv/dt) FILTERS

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General Data Sheet

Combined dv/dt and Sine Wave Filters

Three Phase



200V thru 690V

50Hz / 60Hz





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POPULAR OPTIONS

- Enclosures Available** : Nema 1, Nema 3R, Nema 4, Nema 12
- Mounting Configurations** : Open Panel, OEM Kit (Reactors + Capacitors)

For a review of our technical application bulletins, visit our website: www.artechepq.com

For a comprehensive review of Arteche products and capabilities, visit www.artech.com



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Sine Wave Filter Theory

SINE WAVE FILTER Concept

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).



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). Critical motor cable length is defined in the chart below.

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

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. Artech 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.



NEMA STANDARD MG-1, PART 30 & 31

Artech 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



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Benefits of Using ARTECHE Sine Wave Filters

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.

SUBMERSIBLE MOTORS ARE PROTECTED BY SWF FILTERS

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. Artech Type SWF filters protect submersible motors against peak overvoltage (caused by voltage reflection), fast rising pulses, and dv/dt.

SWF FILTERS IN SEVERAL CONVENIENT CONFIGURATIONS

OEM Component Kit

By using our OEM Component Kits, you gain total flexibility to adapt the Type SWF Sine Wave Filter to your available panel space. The OEM Component Kit contains either one or two inductors (4/5kHz use 1, 2.5kHz uses 2) plus all capacitor cells necessary to construct our standard Sine Wave Filter.

-Inductors available with optional temperature switch.

-Capacitor wiring harnesses are also available.

Open Panel Assembly

ARTECHE will assemble and wire the complete filter onto an open construction back panel that you can mount into your own enclosure.

NEMA Enclosed Filter

ARTECHE will completely assemble and wire the filter into a NEMA (Nema 1, Nema 3R) style enclosure of your choice. This version makes it convenient for you to drop ship a complete filter right to the job site.

SWF FILTERS ARE AVAILABLE FOR ANY PWM FREQUENCY

Standard SWF Filters .handler the most common PWM frequencies but cn also be produced for any PWM frequency desired. The 5KHZ type represents the optimized filter, based upon cost, size and power losses. This optimized filter is suitable for all PWM frequencies of 5KHZ and higher.



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Product Technical Specifications

ELECTRICAL	
System Voltage	208-240, 380-415, 440-480, 550-600 and 660-690 volts
Voltage Tolerance	+/- 10%
Frequency	60Hz / 50Hz
PWM Frequency	5 – 20kHz (for 5KHZ Types) 2 – 2.5kHz (for 2.5KHZ Types) 4 – 20kHz (for 4KHZ types) any available
Fundamental frequency	5Hz to 90Hz standard, others available on request
Phases	3-phase
Input Current Ratings	3 to 3000 amps
Input power ratings (standard)	1.1kW to 2500kW (1.5HP to 3000HP) typical
Total Harmonic Voltage Distortion	≤ 5% THD-v (5KHZ and 4KHZ types) typical ≤ 10% THD-v (2.5KHZ types) typical
Reflected Voltage at motor	Virtually none
Voltage Drop (at rated load)	Optimized for 5% voltage drop at 70% Load Full load drop ≤ 7% (for 2.5KHZ and 5KHZ Types) Full load drop ≤ 9% (for 4KHZ types)
Efficiency	99.5% at rated load (typical)
Dielectric Strength	Reactors: 3000 volts (1min) Capacitors: 2 x rated + 1000 volts (1min)
Capacitance & Inductance	Capacitance is minimized (and inductance maximized) for lowest capacitor current and lowest dv/dt.
Overload Capability	1.5 x rated current (1 minute, 1 time per hour)
Damping	Self damping reactors (no power resistors required)
Life Expectancy	> 480,000 hours at 50C, rated power
ENVIRONMENTAL	
Motor Cable Length (maximum)	Unlimited
Ventilation	Natural convection (No fans required)
Enclosures Available	Indoors, Industrial, Outdoors, Open Panels, Kits
Ambient Temperature	-30C to + 50C
Relative Humidity	< 99% non-condensating
Altitude	3300ft (1000 meters) derate for higher altitude
STANDARDS	
Underwriters Laboratories (UL)	Assemblies are UL-508A approved (600V and less) Components offered in kits are UL component recognized Complies with UL1531
IEC / EN	Complies with EN60289, EN60076-3
CE (Low Voltage Directive)	LVD certificate available

Note: Type SWF Filters are intended for use with single motor loads.



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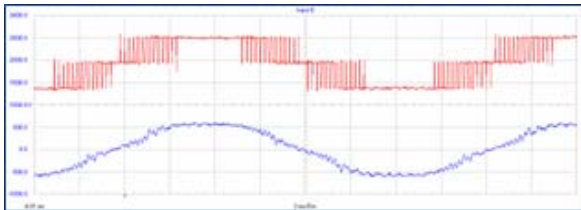
Product Performance Characteristics

SWF Optimized for Real Life Applications

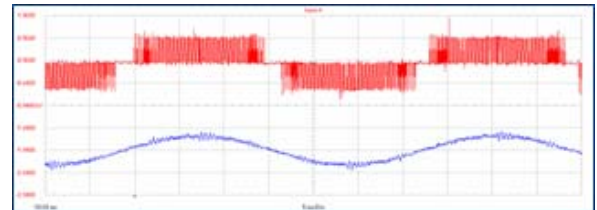
Arteche Type SWF Sine Wave (dv/dt) Filters are intended for motor protection especially in applications with long motor cable lengths. They virtually eliminate the harmful effects of voltage reflection by establishing a near sine wave for the motor. Typical applications involve fans and pumps. Due to the nature of these variable torque applications, average motor speeds are often in the range of 50% to 70% speed, resulting in extended operation at reduced load current. SWF filters are optimized for real life conditions, with typical 5% voltage drop at 70% load current.

5KHZ and 4KHZ Type Filters

Upper (red) waveform is VFD output voltage.
Lower waveform (Blue) is Filter output waveform.



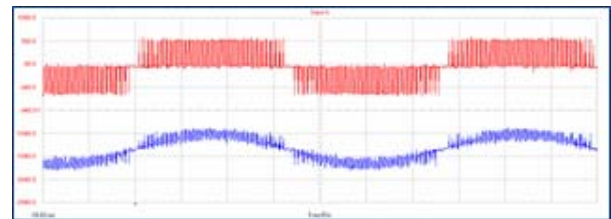
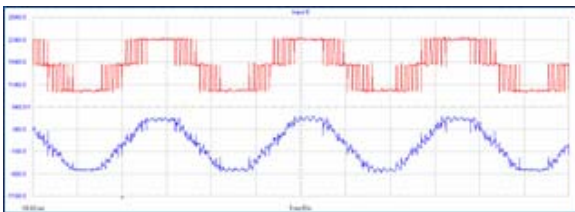
60Hz output frequency



30Hz output frequency

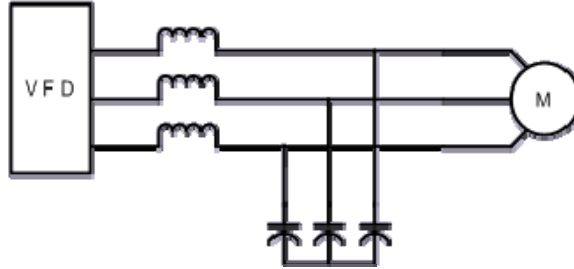
2.5KHZ Type Filters

Upper (red) waveform is VFD output voltage.
Lower waveform (Blue) is Filter output waveform.

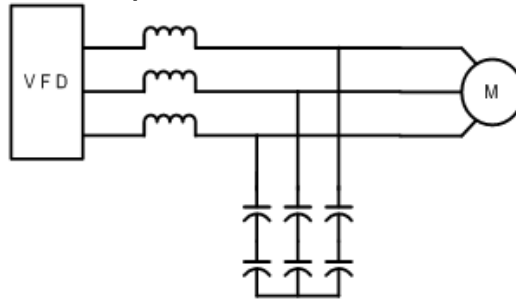


Circuit Diagrams

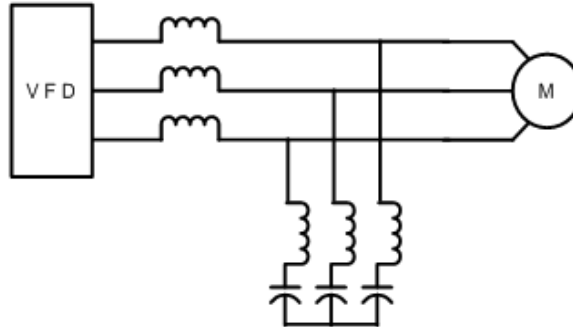
Type 5KHZ and 4KHZ (200V – 480V)



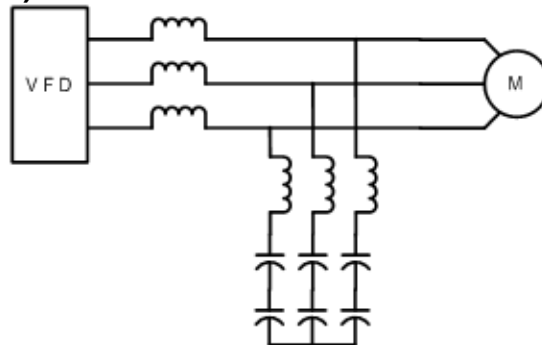
Type 5KHZ and 4KHZ (600V – 690V)



Type 2.5KHZ (200V – 480V)



Type 2.5KHZ (600V – 690V)





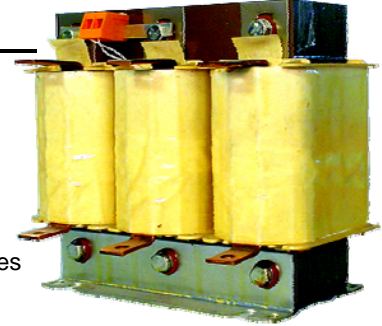
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Major Component Specifications

Reactor Specifications

Inductance Tolerance:	+3% / -3% (balanced in all three phases)
Maximum Voltage:	600V (Except 690V filters)
Maximum Current:	125% of rated AC current, one minute
Power Loss:	typically less than 0.5% of rated load
Dielectric Strength	
Coil to coil:	3000V AC for one second
Coil to core:	3000V AC for one second
Core construction:	PolyGap™, Low audible noise, low harmonic losses
Impregnation:	Vacuum, overpressure varnish impregnation
Operating Temperature:	-40 degrees C to +50 degrees C
Over temperature Protection:	Temperature switch included in shunt reactor (center leg)
Life Expectancy:	Over 20 years at 40 degrees C operation
Terminals:	Copper
Agency Approval:	UL Component Recognized (File # E173113)



Capacitor Specifications

Capacitance Tolerance:	+4% / -4%
Maximum Voltage:	110% of rated AC voltage
Maximum Current:	135% of rated AC current
Power Loss:	0.4 watts per kVAR
Dielectric Strength	
Terminal to case:	2 x rated AC voltage + 1000 volts, for one second
Terminal to terminal:	1.75 x rated AC voltage for one second
Construction:	Impregnated Metalized Polypropylene (MPP)
Operating Temperature:	-40 degrees C to +80 degrees C
Life Expectancy:	Over 1,000,000 hours at 40 degrees C operation
Terminals:	Brass
Agency Approval:	UL Component Recognized (File # E71645)



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