

# Type PSF Sine Wave Filters

PolyGap<sup>®</sup> Sine Wave Filters

and L-C-L Filters for

Active Front End

(AFE) Converters



*Mangoldt..The Engineer's Choice*

Power Protection for Adjustable Speed Drive Systems



Up to 690 Vac

German Engineering & Quality

Stocked in Wisconsin

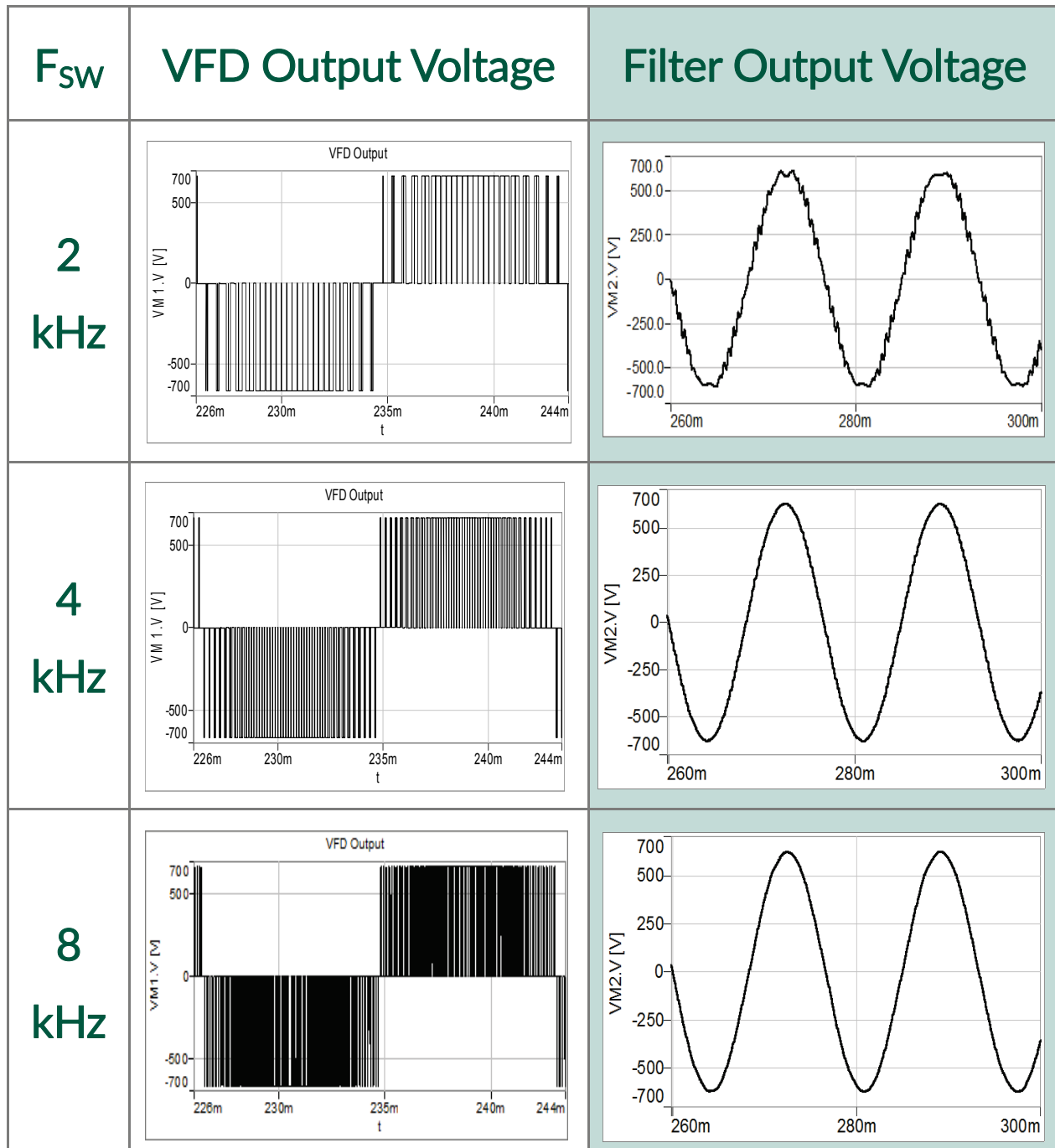
Factory support located in Wisconsin



**MANGOLDT**

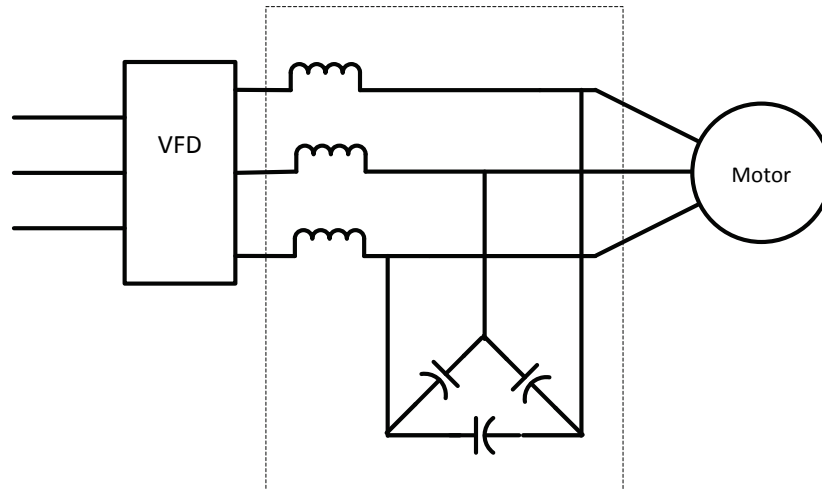
# PolyGap<sup>®</sup> Filter Performance

- Convert PWM to near sine wave voltage
- Extend usable motor cable length
- Eliminate harmful reflected voltage pulses
- Reduce motor voltage waveform dv/dt



Note:  $F_{sw}$  = PWM Switching Frequency

# PolyGap<sup>®</sup> Sine Wave Filter Specifications

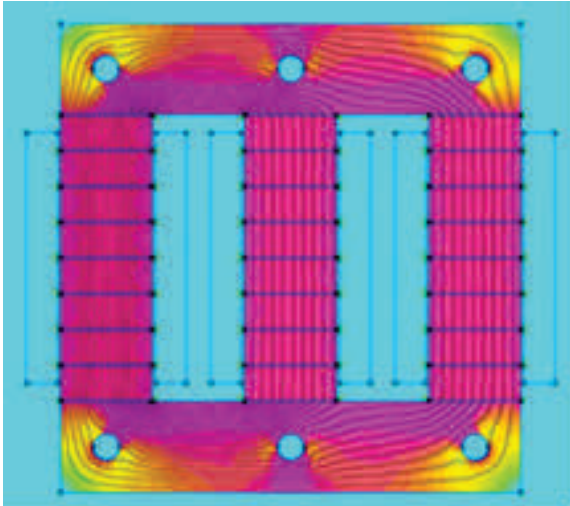


Voltage Distortion	Typically <5% THD-v at rated output frequency (for $F_{sw} < 4\text{kHz}$ ) Typically <3% THD-v at rated output frequency (for $F_{sw} \geq 4\text{kHz}$ )
Voltage Rating / Frequency	500V class: 400V–480V, / 80Hz max. 690V class: 600V / 80Hz max.; 690V / 70Hz max.
PWM Pulse Frequency	$\leq 600\text{V}$ : 2kHz to 10kHz 690V: 1.5kHz to 10kHz
Current Ratings ( $I_N$ )	5 Arms to 1460 Arms
Voltage Drop	480V: $\leq 10\%$ at rated current 600V: $\leq 12.5\%$ at rated current 690V: $\leq 11.5\%$ at rated current
Dielectric Strength	3kV ( 1 minute ) coil-coil, coil-core
Impulse Voltage Test	4200 Peak Volts
Overload	150% x $I_N$ for 60sec / every 10 minutes ( $T_{amb} \leq 45^\circ\text{C}$ )
Surrounding Air Temperature	45°C maximum (due to capacitors)
Reactor Temperature Rise	115°C, in 50°C surrounding air temperature
Reactor Insulation System	Class H, 180°C
Terminations	Solid copper bar or tin-plated copper pressure plate terminal
Reactor Impregnation	Vacuum Overpressure (VPI)
Relative Humidity	Maximum 95% non-condensing
Maximum Altitude	1000 meters ( derate above this )
Agency Approvals	CUL Listed (E173113), IEC/EN60076-3, VDE0532-76-6

# Review the Facts – Unique features provide

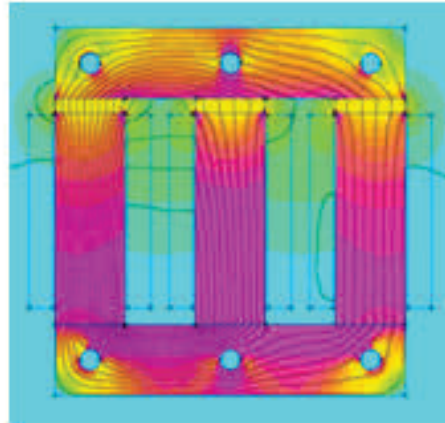
**PolyGap®** is the use of many individual air gaps as opposed to a concentrated air gap

The use of many small air gaps (PolyGap®) virtually eliminates stray magnetic fields and reduces losses and audible noise associated with harmonics and PWM frequencies. Mangoldt reactors are constructed using PolyGap® core technology except where small reactor size is a limiting factor.



## PolyGap® Reactor

Mangoldt PolyGap® cores minimize the length of each individual air gap and thereby minimize the magnetic flux across the air gaps. This prevents circulating currents in the coil windings due to the air gap fringing flux, as well as the power losses due to PWM frequencies and virtually eliminates stray magnetic fields outside of the reactor.



## Typical Reactor

Yellow color in the windings and outside of the reactor itself is undesirable. Magnetic field (yellow) for typical reactor cores penetrate into the windings and increases the heating caused by harmonics. The magnetic field also strays outside of the reactor and can interfere with electronic equipment.

## Low Losses, especially due to PWM Frequencies

Reactors used in sine wave filters can produce significant heat in the core due to the PWM frequencies and in the coils due to current, skin effect and also circulating currents due to fringing flux that penetrates the windings.

Mangoldt's combination of many tiny air gaps (PolyGap®), unique coil design and flux density control, minimizes the overall reactor losses, especially those losses due to harmonics or PWM frequencies.

## Balanced Inductance in all three phases

Reactors with PolyGap® construction offer Inductance that is balanced in all three phases. With a tolerance of  $\pm 3\%$  of the reactor rated inductance in all three phases. Consistent filtering is achieved in all three phases and equivalent voltage drops in all three phases help not keep motor voltages balanced for best performance.

# benefits that set Mangoldt above the rest!

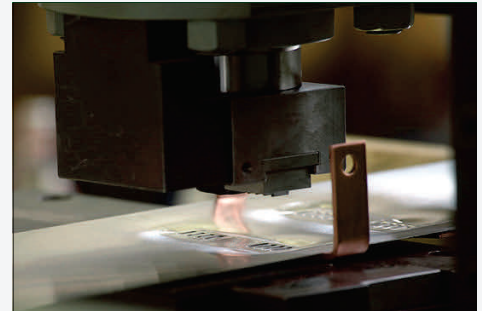


## Computerized winding, core production & testing

Production & testing are highly automated, enabling Mangoldt to offer high-performance reactors with precise inductance, at economical prices. All Mangoldt reactors are 100% tested and serialized. Test reports are always available for individual serial numbers upon request.

## Copper terminals are cold pressure welded

Copper terminals are attached to the winding conductors using a cold pressure welding process pioneered by Mangoldt over two decades ago. Permanently attached terminals, with minimal contact resistance, offer a lifetime of trouble free and low power loss connections.



## Vacuum and over-pressure impregnation

All Mangoldt reactors are impregnated with UL Class H varnish in a process involving vacuum, varnish, apply over-pressure and then bake. The result is a long life and a quiet operating reactor.



UL Listed for USA & Canada

File E173113





# 480V Motor Filters

## Convert PWM to Sinewave



Mangoldt PolyGap® Sine Wave Filters are typically selected based upon motor FLA when known, otherwise by motor HP or kW rating. Check with our local Technical Support Office for advice when applying reactors at other voltages or frequencies.

Cat. No.	Arms	HP	kW	mH	uF	Terminal	Watts Loss	Weight kg/lbs
PSF53-0005	5	3	2.2	14.5	1.5	t/b	45	6.4 / 14
PSF53-0008	8	5	3.7	9	2.2	t/b	70	7.6 / 17
PSF53-0011	11	7.5	5.6	6.5	3	t/b	90	10.8 / 24
PSF53-0015	15	10	7.5	4.8	4.7	t/b	110	12.7 / 28
PSF53-0021	21	15	11.2	3.4	6.8	t/b	140	15.8 / 35
PSF53-0027	27	20	14.9	2.7	6.8	Cu bar	170	23.8 / 52
PSF53-0035	35	25	18.7	2	10	Cu bar	180	24.4 / 54
PSF53-0040	40	30	22.4	1.8	10	Cu bar	220	28.9 / 64
PSF53-0052	52	40	29.8	1.38	15	Cu bar	260	30.9 / 68
PSF53-0065	65	50	37.3	1.1	20	Cu bar	310	41.5 / 91
PSF53-0077	77	60	44.8	0.93	20	Cu bar	350	40.4 / 89
PSF53-0100	100	75	56.0	0.72	33	Cu bar	410	58.7 / 129
PSF53-0125	125	100	74.6	0.57	33	Cu bar	450	68.9 / 152
PSF53-0156	156	125	93.3	0.46	47	Cu bar	550	78.4 / 172
PSF53-0187	187	150	111.9	0.39	47	Cu bar	620	91.9 / 202
PSF53-0240	240	200	149.2	0.3	66	Cu bar	850	121 / 266
PSF53-0302	302	250	186.5	0.24	94	Cu bar	935	158 / 348
PSF53-0360	360	300	223.8	0.2	94	Cu bar	1050	175 / 385
PSF53-0420	420	350	261.1	0.17	94	Cu bar	1200	195 / 429
PSF53-0480	480	400	298.4	0.15	141	Cu bar	1350	216 / 475
PSF53-0520	520	450	335.7	0.138	141	Cu bar	1400	244 / 537
PSF53-0590	590	500	373.0	0.12	141	Cu bar	1500	259 / 570
PSF53-0720	720	600	447.6	0.1	188	Cu bar	1750	302 / 664
PSF53-0840	840	700	522.2	0.085	188	Cu bar	1850	338 / 744
PSF53-1000	1000	850	634.1	0.07	282	Cu bar	2650	415 / 913
PSF53-1220	1220	1000	746.0	0.06	282	Cu bar	3100	469 / 1032
PSF53-1460	1460	1200	895.2	0.05	376	Cu bar	3500	565 / 1243

Preliminary

# 600V Motor Filters

## Convert PWM to Sinewave



Mangoldt PolyGap<sup>®</sup> Sine Wave Filters are typically selected based upon motor FLA when known, otherwise by motor HP or kW rating. Type PSF63 sine wave filters may be applied at up to 690V, up to rated current. Check with our local Technical Support Office for advice when applying reactors at other voltages or frequencies.

Preliminary

Cat. No.	Arms	HP	kW	mH	uF	Terminal	Watts Loss	Weight kg/lbs
PSF63-0005	5	3	2.2	23	1.5	t/b	80	7.1 / 16
PSF63-0007	7	5	3.7	17	2.2	t/b	110	8.4 / 19
PSF63-0009	9	7.5	5.6	13	2.2	t/b	125	11.7 / 26
PSF63-0012	12	10	7.5	10	3	t/b	150	15.8 / 35
PSF63-0018	18	15	11.2	6.5	4.7	t/b	190	22.8 / 50
PSF63-0027	27	25	18.7	4.3	6.8	t/b	230	32.5 / 72
PSF63-0035	35	30	22.4	3.3	10	t/b	300	41.8 / 92
PSF63-0042	42	40	29.8	2.8	10	Cu bar	375	50.6 / 111
PSF63-0055	55	50	37.3	2.1	15	Cu bar	470	62.1 / 137
PSF63-0065	65	60	44.8	1.8	15	Cu bar	520	
PSF63-0080	80	75	56.0	1.5	20	Cu bar	650	91.1 / 200
PSF63-0100	100	100	74.6	1.2	20	Cu bar	710	110 / 242
PSF63-0125	125	125	93.3	0.94	33	Cu bar	780	126 / 277
PSF63-0144	144	150	111.9	0.81	33	Cu bar	850	156 / 343
PSF63-0192	192	200	149.2	0.61	47	Cu bar	1050	183 / 403
PSF63-0242	242	250	186.5	0.48	66	Cu bar	1250	236 / 519
PSF63-0290	290	300	223.8	0.41	66	Cu bar	1500	253 / 557
PSF63-0340	340	350	261.1	0.35	94	Cu bar	1700	
PSF63-0390	390	400	298.4	0.30	94	Cu bar	1850	326 / 717
PSF63-0480	480	500	373.0	0.24	141	Cu bar	2100	
PSF63-0580	580	600	447.6	0.20	141	Cu bar	2400	
PSF63-0680	680	700	522.2	0.17	141	Cu bar	2650	
PSF63-0780	780	800	596.8	0.15	200	Cu bar	2900	
PSF63-0880	880	900	671.4	0.13	200	Cu bar	3250	
PSF63-0960	960	1000	746.0	0.12	200	Cu bar	3500	
PSF63-1160	1150	1200	895.2	0.10	300	Cu bar	4000	

690V: Use PSF63 by selecting PSF63 amp rating based upon motor FLA.



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# Application Data

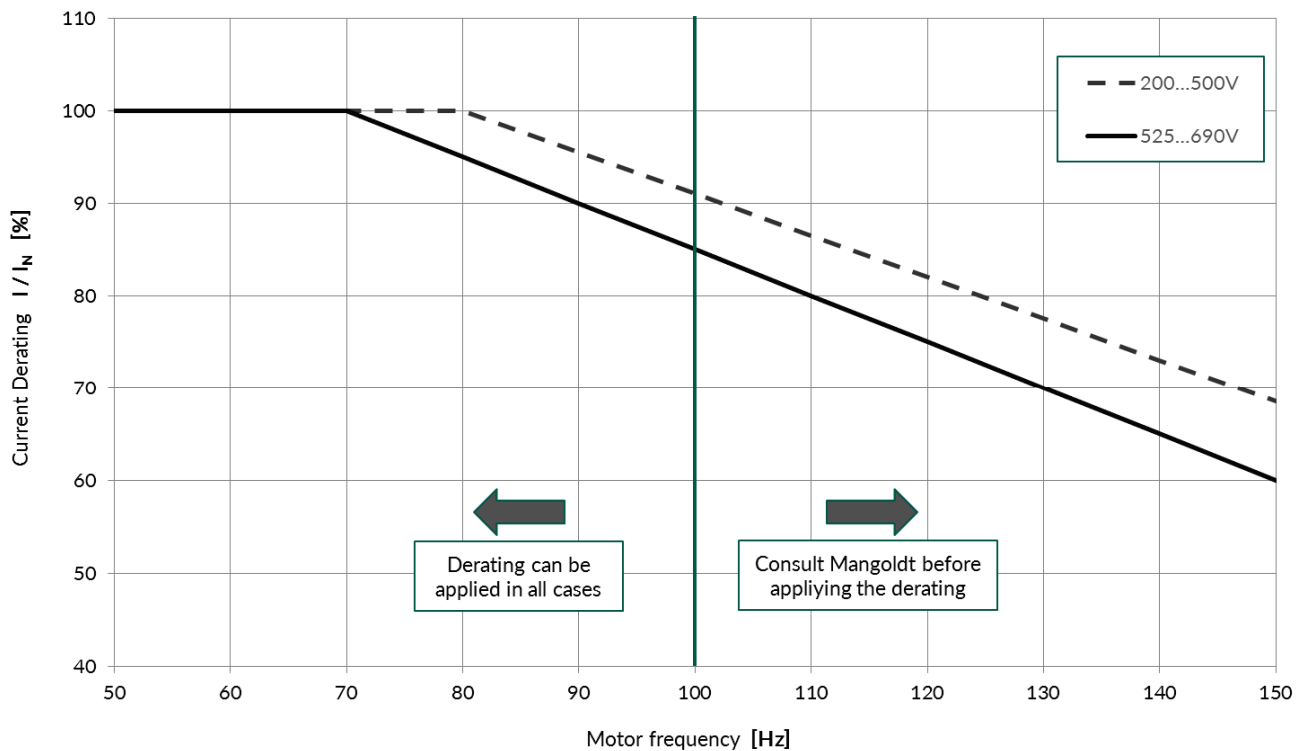


## Apply PSF filters at lower voltage

Type PSF filters may be applied at a lower voltage, by selecting the filter based on a rated current that is twice the required current. By doing this, the proper impedance values are maintained.

## Type PSF filters for use at higher frequency

For high speed motor applications where the fundamental frequency exceeds the general specification for that voltage rating and is up to 150hz, apply the filter at reduced current per the chart below. For fundamental frequencies above 150kHz, consult factory. These “medium frequency” sine wave filters are offered as custom products.



## Application Engineering Support

Mangoldt has several decades of experience in the design and application of filters and filter reactors and offers App Notes on a wide variety of topics. If you have any questions regarding an application - please feel free to contact our Technical Support Office.

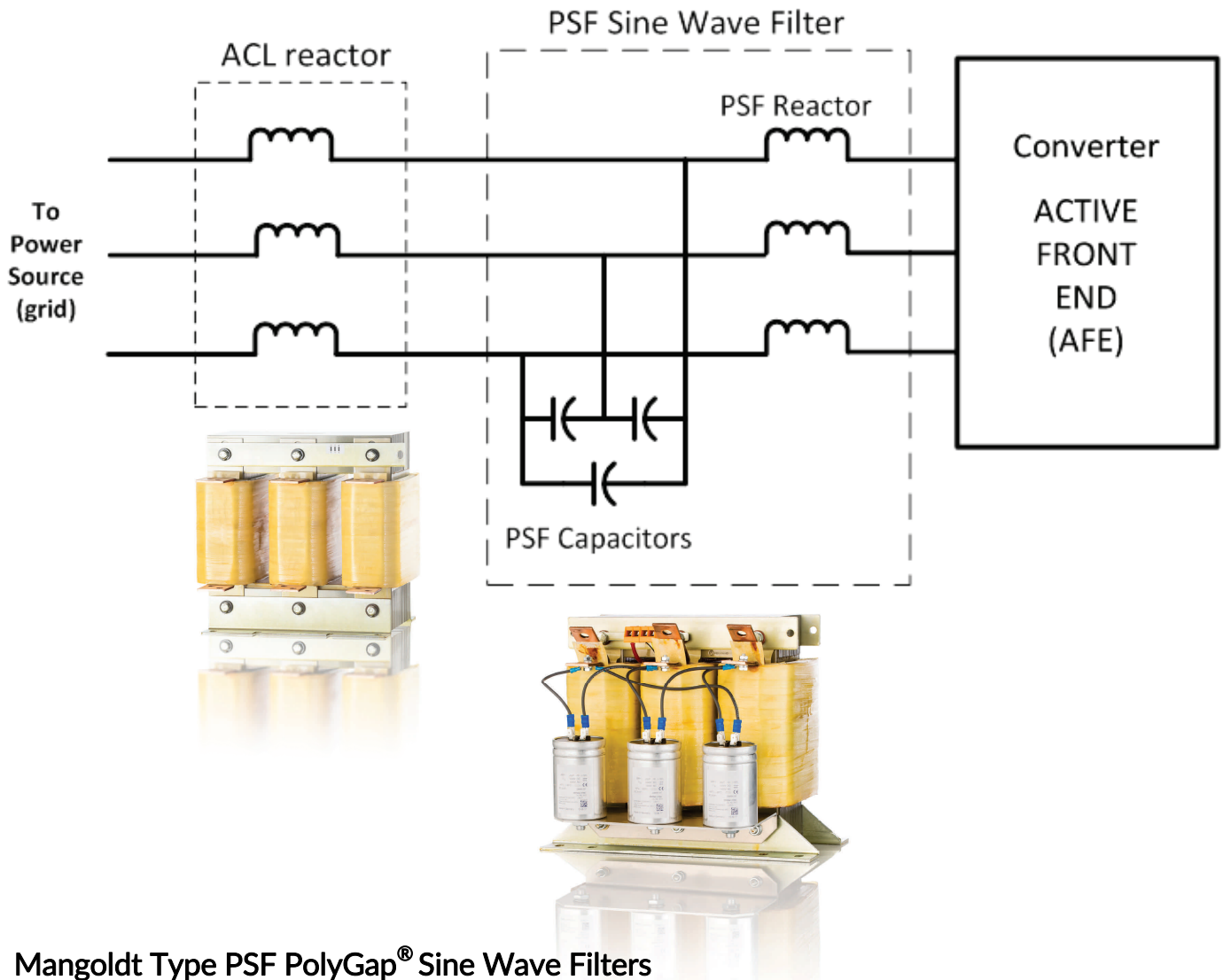






# L-C-L Filters For Active Front End Converters

L-C-L type filters for use at the input to PWM Active Front End Converters (used in renewable energy and AFE motors drives) may be accomplished using a combination of one Type PSF sine wave filter plus one Type ACL 5% impedance 5-in-1 reactor. The following pages include selection tables for L-C-L filters for active front ends. Select both the appropriate PSF number and ACL number for one complete L-C-L filter.



## Mangoldt Type PSF PolyGap<sup>®</sup> Sine Wave Filters

PolyGap<sup>®</sup> Sine Wave Filters have been designed for dual purposes. In addition to being designed for use in a VFD motor drive application to improve the motor voltage waveform, they can also be used as part of a front end L-C-L filter for converters with active (IGBT) front end converters. The purpose of these L-C-L filters is to remove harmonic current and voltage associated with the PWM switching frequency of the IGBTs. For a complete L-C-L filter, both a PSF sine wave filter plus an ACL line reactor is required.

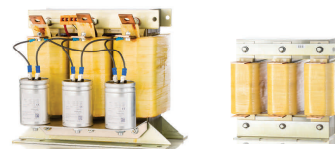


# 480V L-C-L Filter Selection For Active Front End Converters

Note: Two catalog numbers are required. L-C-L type filters for use at the input to PWM Active Front End Converters (used in renewable energy and AFE motors drives) may be accomplished using a combination of one Type PSF sine wave filter plus one Type ACL 5% impedance 5-in-1 reactor.

Preliminary

480V	For LCL FILTER (Use 1 of each)		Rated Current	Losses
HP	PSF	+ ACL	A rms	(watts)
3	PSF53-0005	+ ACL45-0005	5	80
5	PSF53-0008	+ ACL45-0008	8	110
7.5	PSF53-0011	+ ACL45-0011	11	135
10	PSF53-0015	+ ACL45-0014	14	160
15	PSF53-0021	+ ACL45-0021	21	210
20	PSF53-0027	+ ACL45-0027	27	250
25	PSF53-0035	+ ACL45-0034	34	290
30	PSF53-0040	+ ACL45-0040	40	340
40	PSF53-0052	+ ACL45-0052	52	390
50	PSF53-0065	+ ACL45-0065	65	450
60	PSF53-0077	+ ACL45-0080	77	530
75	PSF53-0100	+ ACL45-0106	100	620
100	PSF53-0125	+ ACL45-0129	125	685
125	PSF53-0156	+ ACL45-0159	156	810
150	PSF53-0187	+ ACL45-0185	185	915
200	PSF53-0240	+ ACL45-0243	240	1240
250	PSF53-0302	+ ACL45-0302	302	1375
300	PSF53-0360	+ ACL45-0366	360	1560
350	PSF53-0420	+ ACL45-0429	420	1770
400	PSF53-0480	+ ACL45-0488	480	2010
450	PSF53-0520	+ ACL45-0530	520	2150
500	PSF53-0590	+ ACL45-0615	590	2300
600	PSF53-0720	+ ACL45-0731	720	2620
700	PSF53-0840	+ ACL45-0848	840	2840
800	PSF53-1000	+ ACL45-0975	975	3700
1000	PSF53-1220	+ ACL45-1224	1220	4400



# 600V L-C-L Filter Selection For Active Front End Converters



Note: Two catalog numbers are required. L-C-L type filters for use at the input to PWM Active Front End Converters (used in renewable energy and AFE motors drives) may be accomplished using a combination of one Type PSF sine wave filter plus one Type ACL 5% impedance 5-in-1 reactor.

Preliminary

600V HP	LCL FILTER (USE 1 EACH)			Rated Current	Losses
	PSF	+	ACL	A rms	(watts)
5	PSF63-0005	+	ACL65-0006	6.1	120
7.5	PSF63-0007	+	ACL65-0006	6.1	160
10	PSF63-0009	+	ACL65-0009	9	185
15	PSF63-0012	+	ACL65-0011	11	230
20	PSF63-0018	+	ACL65-0017	17	280
25	PSF63-0027	+	ACL65-0027	27	340
30	PSF63-0035	+	ACL65-0034	34	420
40	PSF63-0042	+	ACL65-0041	41	515
50	PSF63-0055	+	ACL65-0052	52	640
60	PSF63-0065	+	ACL65-0066	65	710
75	PSF63-0080	+	ACL65-0081	80	870
100	PSF63-0100	+	ACL65-0106	100	970
125	PSF63-0125	+	ACL65-0129	125	1080
150	PSF63-0144	+	ACL65-0148	144	1190
200	PSF63-0192	+	ACL65-0192	192	1450
250	PSF63-0242	+	ACL65-0244	242	1750
300	PSF63-0290	+	ACL65-0291	290	2090
350	PSF63-0340	+	ACL65-0339	339	2370
400	PSF63-0390	+	ACL65-0382	382	2510
450	PSF63-0480	+	ACL65-0488	480	2810
500	PSF63-0580	+	ACL65-0577	577	3210
600	PSF63-0680	+	ACL65-0673	673	3590
700	PSF63-0780	+	ACL65-0774	774	4000
800	PSF63-0880	+	ACL65-0869	869	4300
900	PSF63-0960	+	ACL65-0975	960	4650
1000	PSF63-1160	+	ACL65-1166	1160	5400



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# Specifications for L-C-L Filters

## For Active Front End Converters

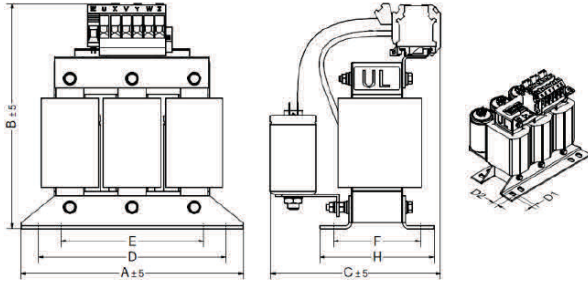


Phases	3-phase
Voltage Rating	400V, 50Hz / 480V, 60Hz and 600V, 60Hz / 690V/50Hz
Frequency	0-60 Hz
PWM Pulse Frequency	3kHz to 10kHz
Current Ratings ( $I_N$ )	5 Arms to 1150 Arms
Dielectric Strength	3kV ( 1 minute ) coil-coil, coil-core
Impulse Voltage Test	4200 Peak Volts
Overload	150% x $I_N$ for 60sec / every 10 minutes ( $T_{amb} \leq 45C$ )
Surrounding Air Temperature	50°C maximum
Temperature Rise	115°C, in 50°C surrounding air temperature
Insulation System	Class H, 180°C
Terminations	Solid copper bar or tin-plated copper pressure plate terminal
Reactor Impregnation	Vacuum Overpressure (VPI)
Relative Humidity	Maximum 95% non-condensing
Maximum Altitude	1000 meters ( derate above this )
Agency Approvals	CUL Listed (E173113), IEC/EN60076-3, VDE0532-76-6

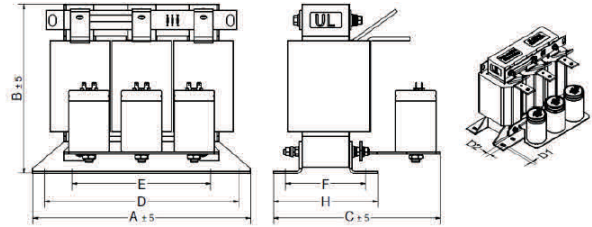
# Sine Wave Filter Configurations

## 480V Configurations

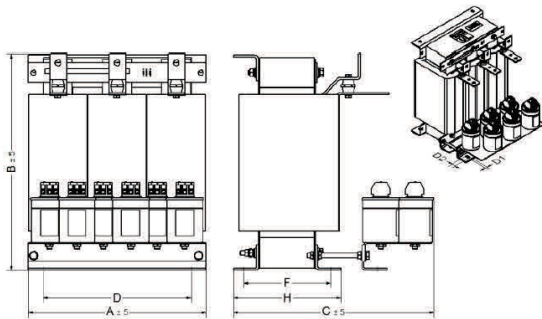
### 5...21 A Types (Terminal Block)



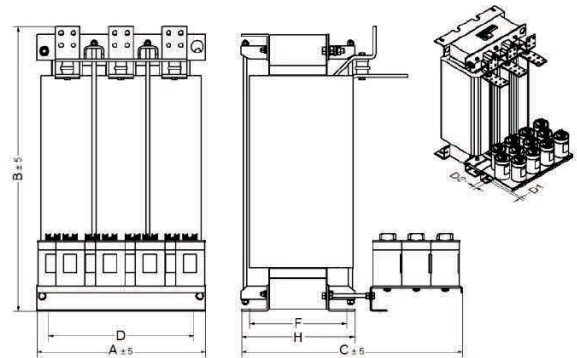
### 35...187 A Types (Copper Bus Bars)



### 240...360 A Types (Copper Bus Bars)



### 480...1460 A Types (Copper Bus Bars)



## 600V Configurations

# Sine Wave Filter Dimensions & Weight 480V

# Preliminary

Cat. No.	A [mm]	B [mm]	C [mm]	Terminal	Fig.	Torque [Nm]	Weight kg/lbs
PSF53-0005	178	188	136	t/b	-	0.5 - 0.8	6.4 / 14
PSF53-0008	219	214	149	t/b	-	0.5 - 0.8	7.6 / 17
PSF53-0011	219	215	169	t/b	-	0.5 - 0.8	10.8 / 24
PSF53-0015	243	233	164	t/b	-	1.5 - 1.8	12.7 / 28
PSF53-0021	243	242	179	t/b	-	2.3 - 3.0	15.8 / 35
PSF53-0035	291	214	246	cu bar	1	45	24.4 / 54
PSF53-0052	316	250	250	cu bar	1	45	30.9 / 68
PSF53-0077	352	266	270	cu bar	1	45	40.4 / 89
PSF53-0100	360	314	297	cu bar	1	45	58.7 / 129
PSF53-0125	360	314	314	cu bar	1	45	68.9 / 152
PSF53-0156	420	369	330	cu bar	1	45	78.4 / 172
PSF53-0187	420	367	349	cu bar	1	45	91.9 / 202
PSF53-0240	420	472	419	cu bar	1	45	121 / 266
PSF53-0302	420	506	444	cu bar	2	75	158 / 348
PSF53-0360	420	508	424	cu bar	2	75	175 / 385
PSF53-0480	480	641	539	cu bar	2	75	216 / 475
PSF53-0520	480	607	563	cu bar	2	75	244 / 537
PSF53-0590	480	643	569	cu bar	2	75	259 / 570
PSF53-0720	480	748	524	cu bar	2	75	302 / 664
PSF53-0840	480	758	549	cu bar	3	75	338 / 744
PSF53-1000	550	912	575	cu bar	4	75	415 / 913
PSF53-1220	550	922	600	cu bar	4	75	469 / 1032
PSF53-1460	550	931	720	cu bar	4	75	565 / 1243

Bus Bar 30 mm

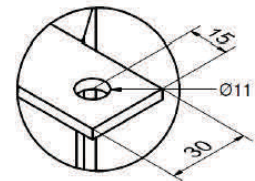


Fig. 1

Bus Bar 40 mm

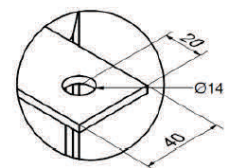


Fig. 2

Bus Bar 50 mm

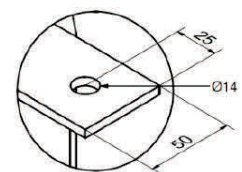


Fig. 3

Bus Bar 80 mm

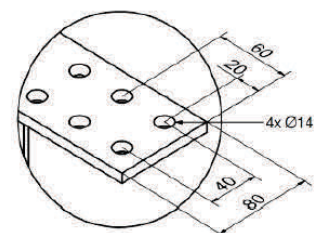


Fig. 4

## 2D & 3D drawings

Mangoldt can provide both 2D and 3D drawings. Please contact the Technical Support Office or the Stocking Partner Sales Office for PDF, DWG or STP files.

# Sine Wave Filter Dimensions & Weight

## 600V

Preliminary

### 2D & 3D drawings

Mangoldt can provide both 2D and 3D drawings. Please contact the Technical Support Office or the Stocking Partner Sales Office for PDF, DWG or STP files.

# Reactor Technology at its Best

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Current Limiting Inductors

PWM Sinusoidal Filter Inductors

Water-Cooled Inductors

Smoothing Reactors

Active Filter Reactors

PWM Reactors

dv/dt Limiting Inductors

## Sales & Technical Support Locations

### Stocking Partner Sales Office

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### Technical Support Office

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PSF001.19.0601-001

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