IHF *Series*

Input Harmonic Filters

for use with adjustable speed drives

and other 6-pulse rectifiers

Superior Filtering options for Adjustable Speed Drive Systems

c UL US

Up to 690 Vac

German Engineering & Quality

Stocked in USA and Canada

Factory support located in Wisconsin

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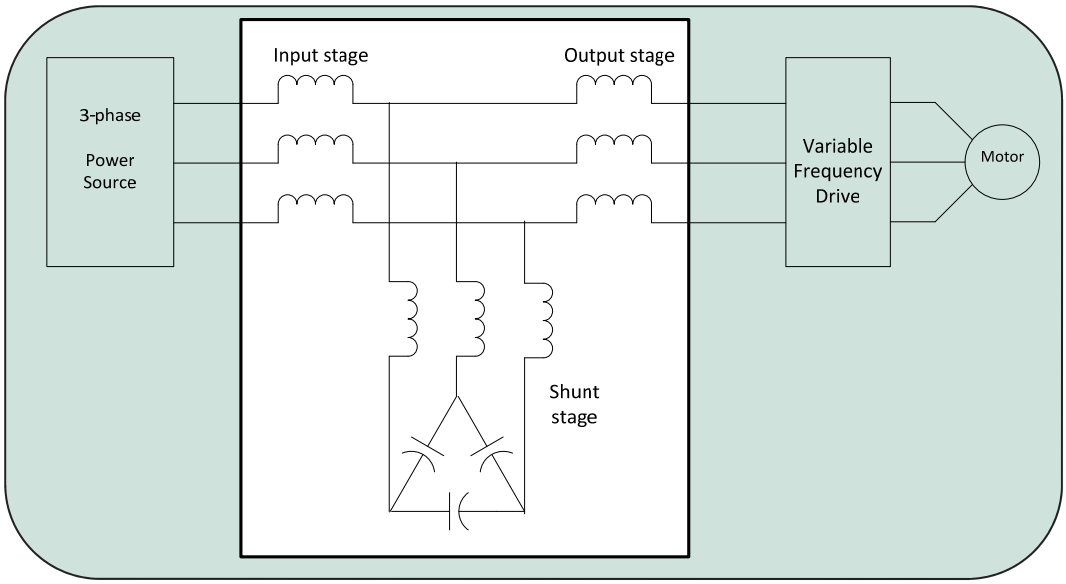
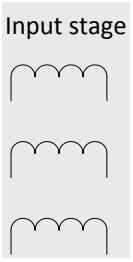
Wide Band Harmonic Filtering



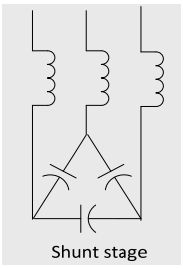
Three Stages of Filtering

Mangoldt's Type IHF Input Harmonic Filters provide three full stages of filtering to achieve low residual harmonic distortion levels, enabling electrical power systems to comply with the limits of IEEE-519 and other international power quality standards. They are referred to as wide band (low pass) harmonic filters. Low frequency current, such as 60Hz or 50hz, passes easily through the filter, while the harmonic currents are attenuated (filtered). All harmonic currents which are characteristic of a 3-phase, 6-pulse rectifier are significantly reduced. The Input Stage and Shunt Stage are the same whether a filter is to achieve 5%, 8% or 12% THDi. Only the Output Stage inductor changes to achieve the various THD performance levels.



Input stage

In addition to adding to the series inductive reactance, which helps to reduce each individual harmonic, this stage also blocks harmonics from other loads that are connected to the same electrical bus.



Shunt Stage

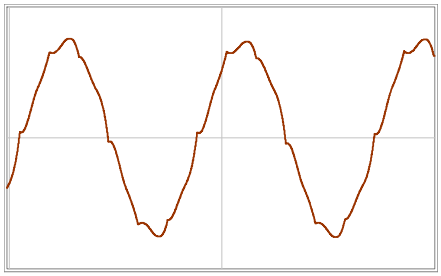
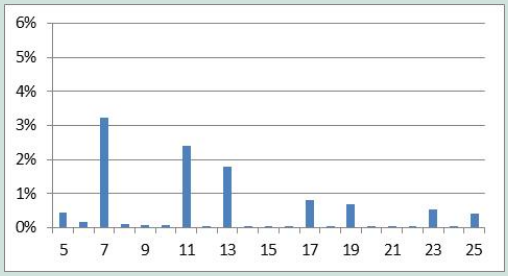
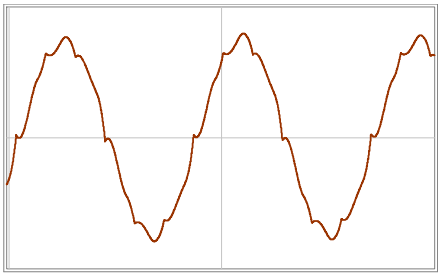
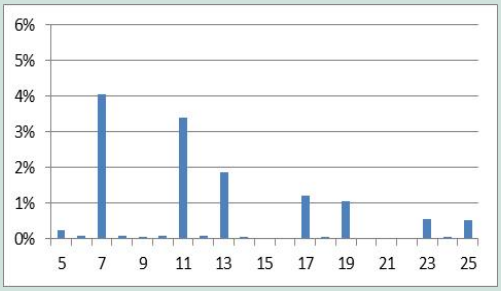
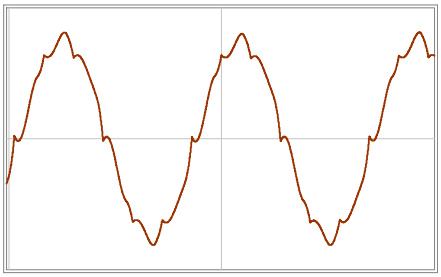
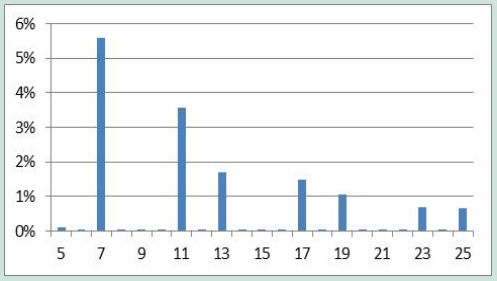
This stage essentially attacks the 5th harmonic, which is the most predominant harmonic associated with 6-pulse rectifiers.

Output Stage

The output stage provides inductive reactance in series with the drive to attenuate individual harmonics. This reactor provides significant inductive reactance which impedes the flow of harmonic currents. Its effectiveness increases as the harmonic frequency increases.

Wide Band Filter Performance

Mangoldt Input Harmonic Filters (Type IHF) offer predictable and reliable performance for 6-pulse variable frequency drive systems. They significantly attenuate all harmonic frequencies associated with 6-pulse VFDs. They may also be used for DC drive and other SCR or Thyristor type converters, but will achieve different results based upon a number of factors. For more information about SCR/Thyristor converters, please consult our TechNotes.

Performance levels	Typical Input Current Waveform at 100% Load	Typical Harmonic Current Spectrum at 100% Load
5% THDi		
8% THDi		
12% THDi		

Harmonic Current:

Mangoldt input harmonic filters significantly reduce the magnitude of harmonic current generated by adjustable speed drives. The table below indicates the typical harmonic current spectrum for the various standard filters.

Typical Harmonic Current Spectrum at input terminals of filters (at 100% load)										
	I_1	I_5	I_7	I_{11}	I_{13}	I_{17}	I_{19}	I_{23}	I_{25}	%THDi
5% THDi	100%	<1%	3.5%	2.4%	1.8%	1%	0.75%	0.6%	0.5%	≤5% THDi
8% THDi	100%	<1%	5%	4%	3%	2%	1.25%	1%	1%	≤8% THDi
12% THDi	100%	<1%	8%	6%	4%	2.5%	1.5%	1%	1%	≤12% THDi

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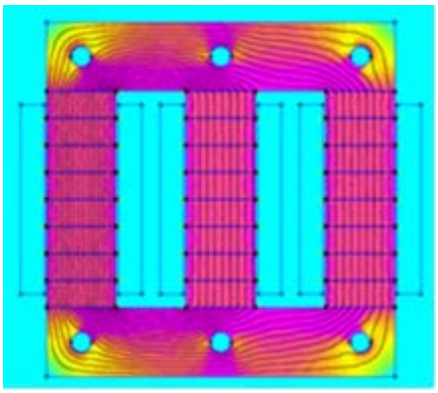
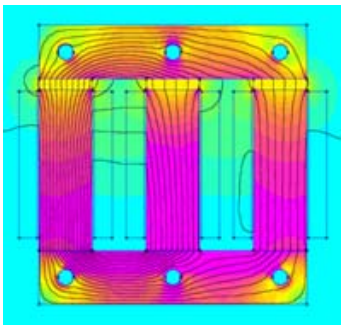
Review the Facts – Unique features provide

PolyGap® Reactors = low losses

Mangoldt PolyGap® cores are constructed using many tiny air gaps as opposed to cores with a single or only a few air gaps. The use of many tiny air gaps (PolyGap®) virtually eliminates stray magnetic fields that cause circulating currents in the coil windings. PolyGap® reduces heat losses and audible noise associated with harmonics. Mangoldt line/load reactors are constructed using PolyGap® core technology except where small reactor size is a limiting factor.



Mangoldt PolyGap® reactor cores minimize power losses, circulating currents and stray magnetic fields, which results in optimized reactor performance and efficiency.



Typical reactors have a single air gap that causes magnetic fields and circulating currents in coil windings. The magnetic field for typical reactors also strays outside the reactor where it may interfere with electronic equipment.

Precise & balanced inductance & capacitance

Optimum filtering requires that inductance and capacitance be precise and balanced in all three phases Reactors with PolyGap® construction offer Inductance that is balanced in all three phases and each phase is within -/+ 3% of the nominal inductance rating. The capacitors used in our filters have a tolerance band of –0%, +5%. The precise tuning of our filter, in all three phases, helps to assure the performance of our filters is reliable and repeatable.

Low losses, especially due to harmonics

Reactors will be the major source of heat loss in a filter, but Mangoldt minimizes this through the use of PolyGap® cores. Mangoldt reactors incorporate three key design elements including: PolyGap® cores, special coil design plus flux density control. This unique combination minimizes the power losses, especially those due to harmonic frequencies. PolyGap® core construction virtually eliminates stray magnetic fields which can cause circulating current in the reactor coils, leading to higher power (heat) losses. Mangoldt Input Harmonic Filters can achieve efficiency as high as 99%. Capacitors used in our filters are constructed with optimized geometry, for low internal temperature rise and low power loss.

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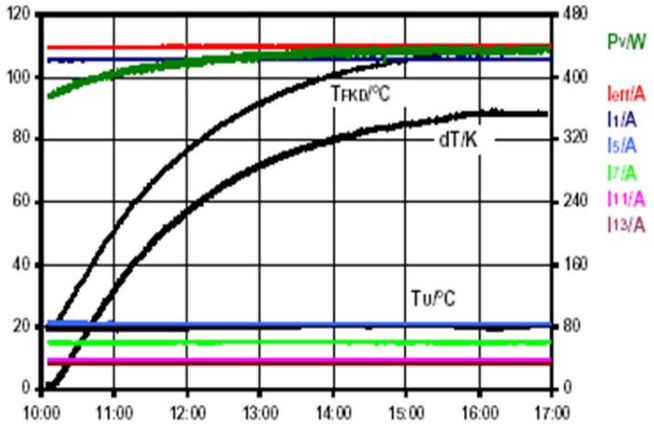
benefits that set Mangoldt above the rest!

Reactors UL tested with Harmonic Currents

UL testing of Mangoldt reactors was performed with actual harmonic current flowing during the duration of testing. Temperature rise, power loss and inductance were measured under real world harmonic conditions.



Vacuum and over-pressure impregnation

Long life and quite operation are the key benefits of Mangoldt's varnish impregnations process. All Mangoldt reactors are impregnated with UL Class H varnish in a process involving vacuum, varnish, apply over-pressure and then baked. The result is a long life and a quiet operating reactor.

Low Capacitance

IHF filters are constructed using AC power capacitors with small kVAR ratings, but with robust voltage and current capability. This makes our filters suitable for use in generator applications. Capacitors also have high temperature capability, making them suitable for use in surrounding air temperatures up to 60C.

Reactor Over-Temperature Protection

The shunt circuit reactors (ACS43-xxxx) are equipped with a N.C. over-temperature switch in the center coil. The switch opens at 180°C (-/+ 6C) and resets at 120°C to 170°C. The over-temperature switch is rated for 250V maximum and 2.5 Amps maximum at 1.0 power factor, or 1.6 Amps at 0.60 power factor.

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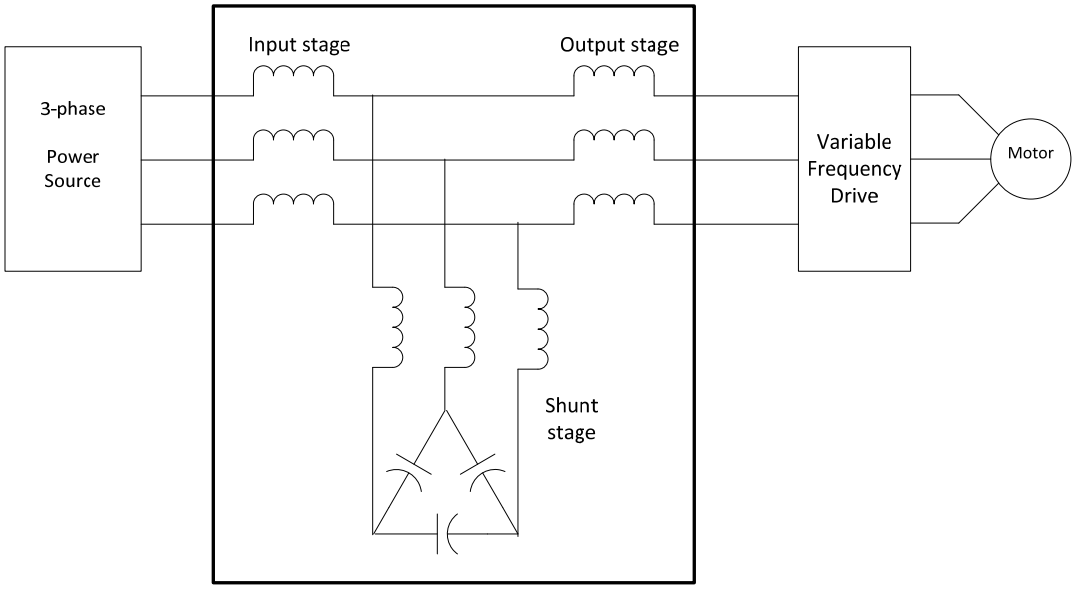
Standard Filter Configurations

Flexibility by Design

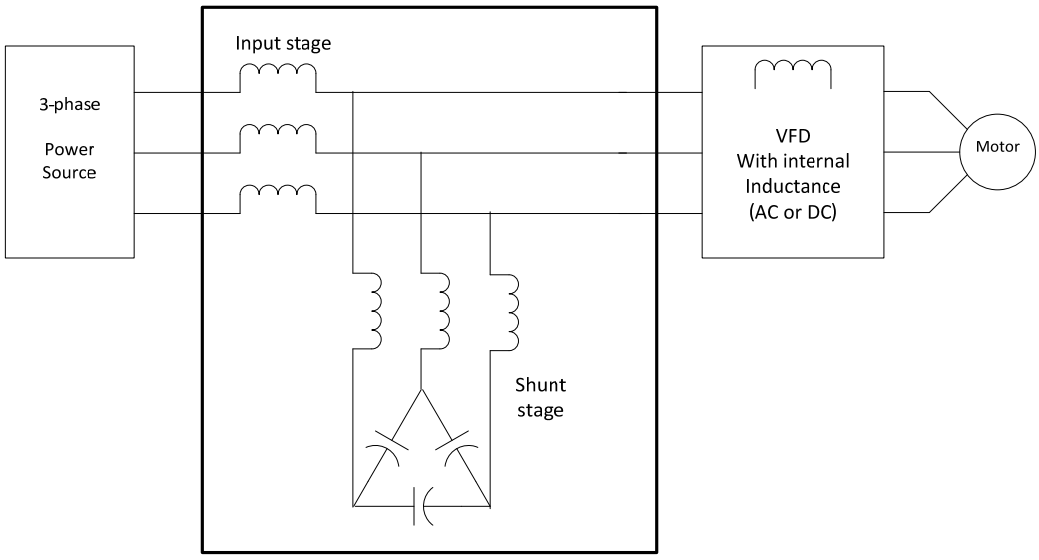
Mangoldt's Input Harmonic Filters offer a high degree of flexibility. Whether it is to accommodate internal inductance, for a VFD, to have adjustability of the shunt circuit reactance or when using a single filter to serve multiple drives, Mangoldt offers simple methods to accomplish all of these using standard products..

Standard 3-stage Filter Configuration



Standard 2-stage Filter Configuration—for VFDs with internal inductance (AC or DC)

This configuration is popular for use with VFDs that include internal inductance (AC or DC). When the VFD's internal inductance is of sufficient value, (3% or 5% impedance) and depending on the %THDi needed, the VFD inductance can eliminate the need for the normal output stage reactor. This is now referred to as a 2-stage filter. Refer to product selection tables on pages 10-11 for VFDs having internal inductance.



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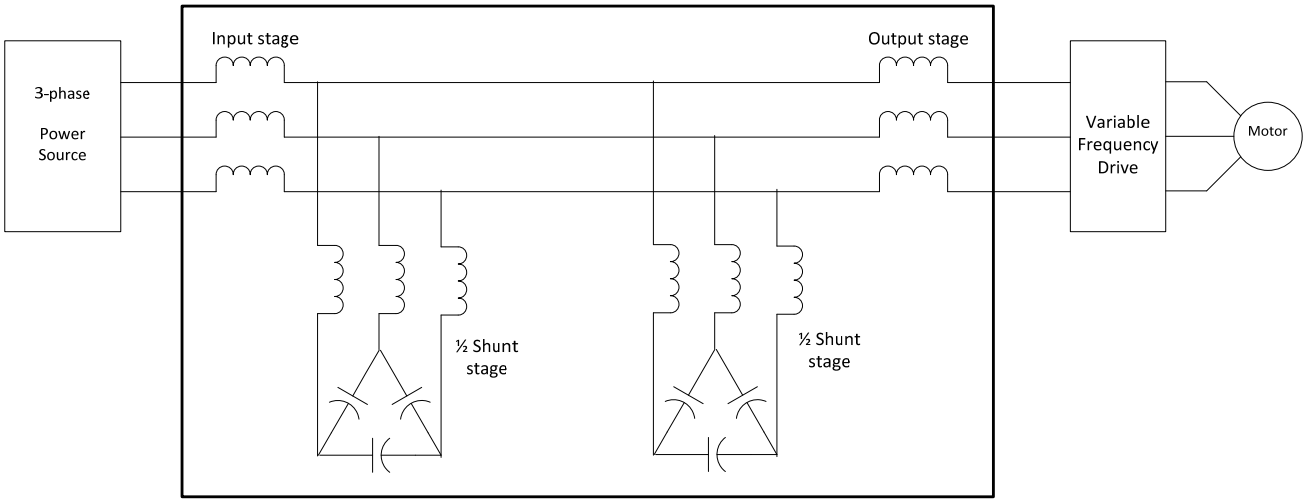
Optional Filter Configurations

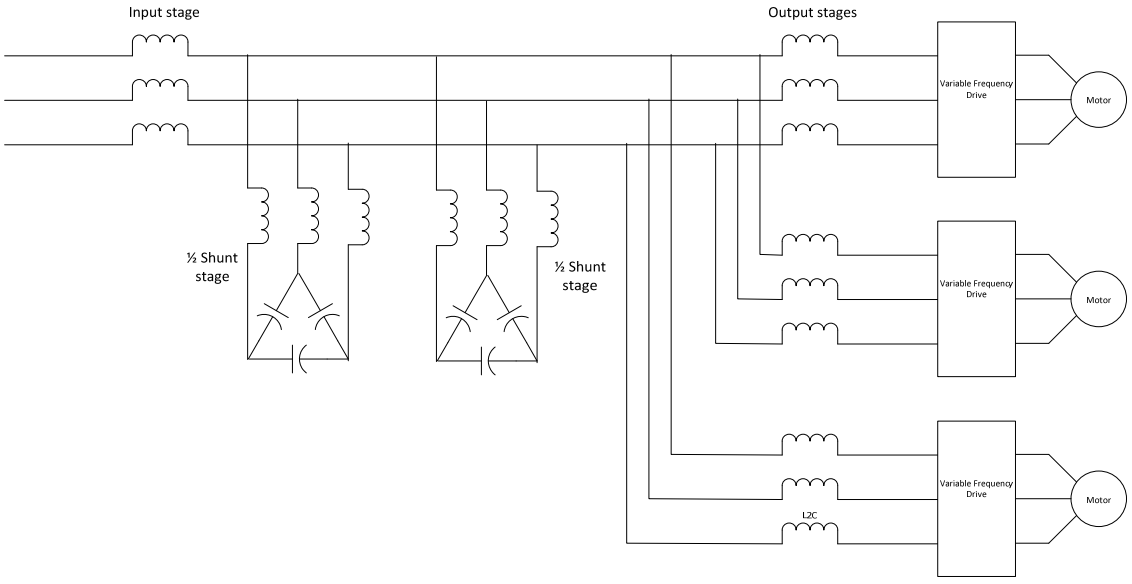
Multiple Shunt Circuits

In some cases, it may be desirable to reduce the reactive power of the shunt circuit when operating at reduced load. This can be accomplished by using multiple shunt circuits and using contactors to switch them on/off individually as needed. Please contact the Technical Support office for assistance.



Multiple Drives served from a Single Filter

Mangoldt's standard filters may also be configured to serve multiple drives using a single filter. Output stage reactors will need to be selected based upon the ratings of the drives they serve. Performance may vary based on the specific operating conditions. Please contact the Technical Support office for assistance.



Selecting the Appropriate IHF Filter

The basic Catalog Number defines a Two Stage (2-stage) filter. This basic catalog number may be followed by a suffix letter which identifies a specific output stage inductance. The absence of a suffix letter (A, B, C) indicates the absence of an output stage inductor (which keeps the filter as a 2-stage filter).

	Volts	Hz	Amperes	Output stage inductor	Pkg
IHF	4 5 6 7	6 5	- XXXX	-A -B -C none	none CH PM

Basic Catalog Number: IHF56-0100

IHF: PolyGap Input Harmonic Filter

Voltage class;

4 = 380-415,

5 = 480V,

6 =600V,

7 =690V

Frequency; 5 = 50Hz, 6 = 60Hz

XXXX : ampere rating

Output Stage Inductor: - y

-A, -B, -C: indicates stage 3 inductance

No alpha suffix = no inductance here

Packaging Suffix:: -zz

-none: kit

-CH: chassis (for MCC or VFD panels)

-PM: Open type panel mounted/wired

Determine which "suffix: filter you need

VFD internal inductance	5% THDi	8% THDi	12% THDi
NONE	IHF56-xxxx-A	IHF56-xxxx-B	IHF56-xxxx-C
3% Z	IHF56-xxxx-B	IHF56-xxxx-C	IHF56-xxxx
5% Z	IHF56-xxxx-C	IHF56-xxxx	IHF56-xxxx

IEEE-519-2014 Limits	
I_{SC} /I_L	TDD
<20	5%
20 < 50	8%
50 < 100	12%
100 < 1000	15%
1000 +	20%

Selection Tables — 480V, 60Hz

For VFDs without internal inductance

Mangoldt standard Input Harmonic Filters provide 3 stages of filtering to minimize the residual harmonic distortion level for adjustable speed drive systems. First, select from the appropriate column based on your %THDi requirement. Choose from 5% , 8% or 12% THDi to achieve your desired performance level. Then, select the catalog number based upon the motor full load amperes (FLA) or by horsepower (HP). If you are selecting by HP, make sure the filter rated current (FLA) is adequate for your application and if not, select an appropriate higher rating. Contact our Technical Support Office for advice when applying filters at other voltages or frequencies.

HP	FLA	5% THDi (3-stage)	8% THDi (3-stage)	12% THDi (3-stage)
5	8	IHF56-0008-A	IHF56-0008-B	IHF56-0008-C
7.5	11	IHF56-0011-A	IHF56-0011-B	IHF56-0011-C
10	14	IHF56-0014-A	IHF56-0014-B	IHF56-0014-C
15	21	IHF56-0021-A	IHF56-0021-B	IHF56-0021-C
20	27	IHF56-0027-A	IHF56-0027-B	IHF56-0027-C
25	34	IHF56-0034-A	IHF56-0034-B	IHF56-0034-C
30	40	IHF56-0040-A	IHF56-0040-B	IHF56-0040-C
40	52	IHF56-0052-A	IHF56-0052-B	IHF56-0052-C
50	65	IHF56-0065-A	IHF56-0065-B	IHF56-0065-C
60	77	IHF56-0077-A	IHF56-0077-B	IHF56-0077-C
75	100	IHF56-0100-A	IHF56-0100-B	IHF56-0100-C
100	125	IHF56-0125-A	IHF56-0125-B	IHF56-0125-C
125	156	IHF56-0156-A	IHF56-0156-B	IHF56-0156-C

HP	FLA	5% THDi (3-stage)	8% THDi (3-stage)	12% THDi (3-stage)
150	185	IHF56-0185-A	IHF56-0185-B	IHF56-0185-C
200	240	IHF56-0240-A	IHF56-0240-B	IHF56-0240-C
250	302	IHF56-0302-A	IHF56-0302-B	IHF56-0302-C
300	361	IHF56-03601A	IHF56-03601B	IHF56-03601C
350	415	IHF56-0415-A	IHF56-0415-B	IHF56-0415-C
400	480	IHF56-0480-A	IHF56-0480-B	IHF56-0480-C
450	515	IHF56-0515-A	IHF56-0515-B	IHF56-0515-C
500	590	IHF56-0590-A	IHF56-0590-B	IHF56-0590-C
600	720	IHF56-0720-A	IHF56-0720-B	IHF56-0720-C
700	840	IHF56-0840-A	IHF56-0840-B	IHF56-0840-C
800	960	IHF56-0960-A	IHF56-0960-B	IHF56-0960-C
900	1166	IHF56-1166-A	IHF56-1166-B	IHF56-1166-C

VFDs with internal inductance:

For VFDs with 5% impedance internal inductance (AC or DC), use the selection tables on page 10.

For VFDs with 3% impedance internal inductance (AC or DC), use the selection tables on page 11.

Selection Tables — 480V, 60Hz

Filters for VFDs with ≥3% internal inductance

In some cases, the VFD's internal inductance may be a substitute for or reduce the inductance requirement for the standard filter output stage inductor. In thee cases, it is still possible to achieve desired harmonic distortion values of 5%, 8% or 12% THDi. Use the selection tables to select filters for use on VFDs that have internal inductance that is equivalent or greater than 5% impedance . Make the proper selection based upon your desired %THD level.

Mangoldt standard Input Harmonic Filters provide 3 stages of filtering to minimize the residual harmonic distortion level for adjustable speed drive systems. First, select from the appropriate column based on your %THDi requirement. Choose from 5% , 8% or 12% THDi to achieve your desired performance level. Then, select the catalog number based upon the motor full load amperes (FLA) or by horsepower (HP). If you are selecting by HP, make sure the filter rated current (FLA) is adequate for your application and if not, select an appropriate higher rating. Contact our Technical Support Office for advice when applying filters at other voltages or frequencies.

HP	FLA	5% THDi (3-stage)	8% THDi (3-stage)	12% THDi (2-stage)
5	8	IHF56-0008-B	IHF56-0008-C	IHF56-0008
7.5	11	IHF56-0011-B	IHF56-0011-C	IHF56-0011
10	14	IHF56-0014-B	IHF56-0014-C	IHF56-0014
15	21	IHF56-0021-B	IHF56-0021-C	IHF56-0021
20	27	IHF56-0027-B	IHF56-0027-C	IHF56-0027
25	34	IHF56-0034-B	IHF56-0034-C	IHF56-0034
30	40	IHF56-0040-B	IHF56-0040-C	IHF56-0040
40	52	IHF56-0052-B	IHF56-0052-C	IHF56-0052
50	65	IHF56-0065-B	IHF56-0065-C	IHF56-0065
60	77	IHF56-0077-B	IHF56-0077-C	IHF56-0077
75	100	IHF56-0100-B	IHF56-0100-C	IHF56-0100
100	125	IHF56-0125-B	IHF56-0125-C	IHF56-0125
125	156	IHF56-0156-B	IHF56-0156-C	IHF56-0156

HP	FLA	5% THDi (3-stage)	8% THDi (3-stage)	12% THDi (2-stage)
150	185	IHF56-0185-B	IHF56-0185-C	IHF56-0185
200	240	IHF56-0240-B	IHF56-0240-C	IHF56-0240
250	302	IHF56-0302-B	IHF56-0302-C	IHF56-0302
300	361	IHF56-0361-B	IHF56-0361-C	IHF56-0361
350	415	IHF56-0415-B	IHF56-0415-C	IHF56-0415
400	480	IHF56-0480-B	IHF56-0480-C	IHF56-0480
450	515	IHF56-0515-B	IHF56-0515-C	IHF56-0515
500	590	IHF56-0590-B	IHF56-0590-C	IHF56-0590
600	720	IHF56-0720-B	IHF56-0720-C	IHF56-0720
700	840	IHF56-0840-B	IHF56-0840-C	IHF56-0840
800	960	IHF56-0960-B	IHF56-0960-C	IHF56-0960
900	1166	IHF56-1166-B	IHF56-1166-C	IHF56-1166

Selection Tables — 480V, 60Hz

Filters for VFDs with ≥5% internal inductance

In some cases, the VFD's internal inductance may be a substitute for or reduce the inductance requirement for the standard filter output stage inductor. In these cases, it is still possible to achieve desired harmonic distortion values of 5%, 8% or 12% THDi. Use the selection tables to select filters for use on VFDs that have internal inductance that is equivalent or greater than 5% impedance . Make the proper selection based upon your desired %THD level.

Mangoldt standard Input Harmonic Filters provide 3 stages of filtering to minimize the residual harmonic distortion level for adjustable speed drive systems. First, select from the appropriate column based on your %THDi requirement. Choose from 5% , 8% or 12% THDi to achieve your desired performance level. Then, select the catalog number based upon the motor full load amperes (FLA) or by horsepower (HP). If you are selecting by HP, make sure the filter rated current (FLA) is adequate for your application and if not, select an appropriate higher rating. Contact our Technical Support Office for advice when applying filters at other voltages or frequencies.

HP	FLA	5% THDi (3-stage)	8% THDi (2-stage)	12% THDi (2-stage)
5	8	IHF56-0008-C	IHF56-0008	IHF56-0008
7.5	11	IHF56-0011-C	IHF56-0011	IHF56-0011
10	14	IHF56-0014-C	IHF56-0014	IHF56-0014
15	21	IHF56-0021-C	IHF56-0021	IHF56-0021
20	27	IHF56-0027-C	IHF56-0027	IHF56-0027
25	34	IHF56-0034-C	IHF56-0034	IHF56-0034
30	40	IHF56-0040-C	IHF56-0040	IHF56-0040
40	52	IHF56-0052-C	IHF56-0052	IHF56-0052
50	65	IHF56-0065-C	IHF56-0065	IHF56-0065
60	77	IHF56-0077-C	IHF56-0077	IHF56-0077
75	100	IHF56-0100-C	IHF56-0100	IHF56-0100
100	125	IHF56-0125-C	IHF56-0125	IHF56-0125
125	156	IHF56-0156-C	IHF56-0156	IHF56-0156

HP	FLA	5% THDi (3-stage)	8% THDi (2-stage)	12% THDi (2-stage)
150	185	IHF56-0185-C	IHF56-0185	IHF56-0185
200	240	IHF56-0240-C	IHF56-0240	IHF56-0240
250	302	IHF56-0302-C	IHF56-0302	IHF56-0302
300	361	IHF56-0361-C	IHF56-0361	IHF56-0361
350	415	IHF56-0415-C	IHF56-0415	IHF56-0415
400	480	IHF56-0480-C	IHF56-0480	IHF56-0480
450	515	IHF56-0515-C	IHF56-0515	IHF56-0515
500	590	IHF56-0590-C	IHF56-0590	IHF56-0590
600	720	IHF56-0720-C	IHF56-0720	IHF56-0720
700	840	IHF56-0840-C	IHF56-0840	IHF56-0840
800	960	IHF56-0960-C	IHF56-0960	IHF56-0960
900	1166	IHF56-1166-C	IHF56-1166	IHF56-1166

Input Harmonic Filter General Specifications

Voltage Rating		480V, 3-phase
Frequency		60Hz (Please contact us for 50Hz filters)
Current Ratings		3 A_{rms} thru 1166 A_{rms}
Current Overload		150% current (up to 1 minute, 3x per hour)
Harmonic Current Distortion	5% THDi	≤5% THDi at 100% load; ≤10% THDi at 20% load
	8% THDi	≤8% THDi at 100% load; ≤12% THDi at 20% load
	12% THDi	≤12% THDi at 100% load; ≤15% THDi at 20% load
Input Power Factor	5% THDi	≥0.99/100% load; ≥0.99/80% load; ≥0.96/60% load
	8% THDi	≥0.99/100% load; ≥0.98/80% load; ≥0.95/60% load
	12% THDi	≥0.99/100% load; ≥0.98/80% load; ≥0.96460% load
Efficiency		Typically >99%
Voltage Regulation		Typically -/+ 2.5%
Dielectric Strength		3kV (1 minute) coil-coil, coil–core
Surrounding Air Temperature		50°C maximum
Over-Temperature Protection	N.C.	Temperature switch included in each shunt reactor (ACS43-xxxx)
Terminations		Solid copper bars or tin-plated copper pressure plate terminals
Relative Humidity		Maximum 95% non-condensing
Agency Approvals		CUL Listed (E173113), IEC/EN60076-3, VDE0532-76-6, CE marked
		Suitable for generator applications

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Harmonic Current Distortion at PCC

The harmonic current at the Point of Common Coupling (PCC) will depend on the total linear vs non-linear loads that are operating on the power system. The chart below indicates the expected %THDI at the PCC for various non-linear load contents, assuming all of the non-linear loads are using the same type of filter.

Filter Type (%THDi)	20% VFDs	40% VFDs	60% VFDs	80% VFDs	100% VFDs
5 %	1.0%	2.0%	3.6%	4%	5%
8 %	1.6%	3.2%	4.8%	6.4%	8%
12 %	2.4%	4.8%	7.2%	9.6%	12%

Harmonic Current Distortion (%THD-i) at Filter Input Terminals

The harmonic current spectrum measured for a single drive is very predictable as shown in the chart below. Expect the measured %THD-i to be the lowest at the filter rated current and to increase slightly as filter load current is reduced. Although the %THD-i increases as load is reduced, the amperes of harmonic current will typically decrease as load current is reduced. This means that harmonic voltage distortion, which is a function of harmonic current and upstream impedance, will also typically reduce as the load current is reduced.

Filter Type %THDi	40% Load	60% Load	80% Load	100% Load
5%	8%	6%	5.5%	≤ 5%
8%	10%	8%	7%	≤ 8%
12%	13%	11%	9%	≤ 12%

Generator Applications

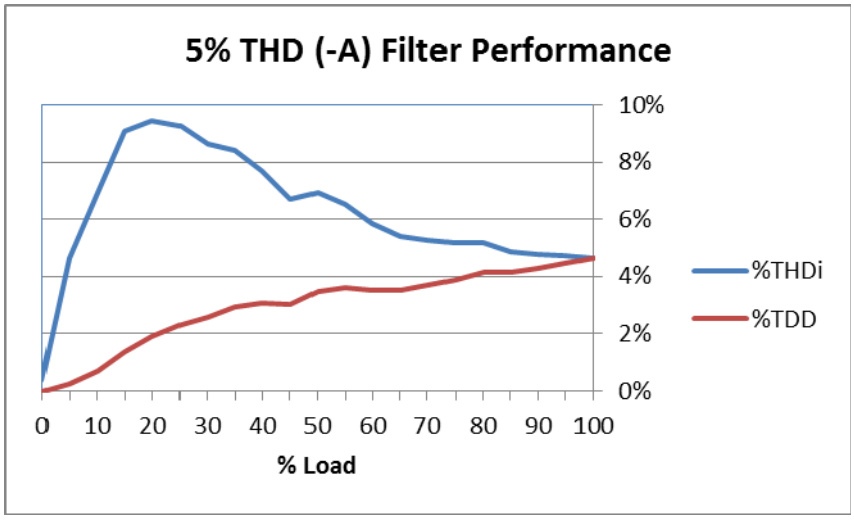
Consult factory for optimized filters for generator applications. The generator optimized filters may be used on a 1:1 generator to VFD/filter applications. However, if you are using a standard IHF56–xxxx filter with a generator, the generator capacity in kVA should be at least 2.5 times the filter rated kVA. For filter rated kVA, multiply 480 x filter rated amperes x 1.732.

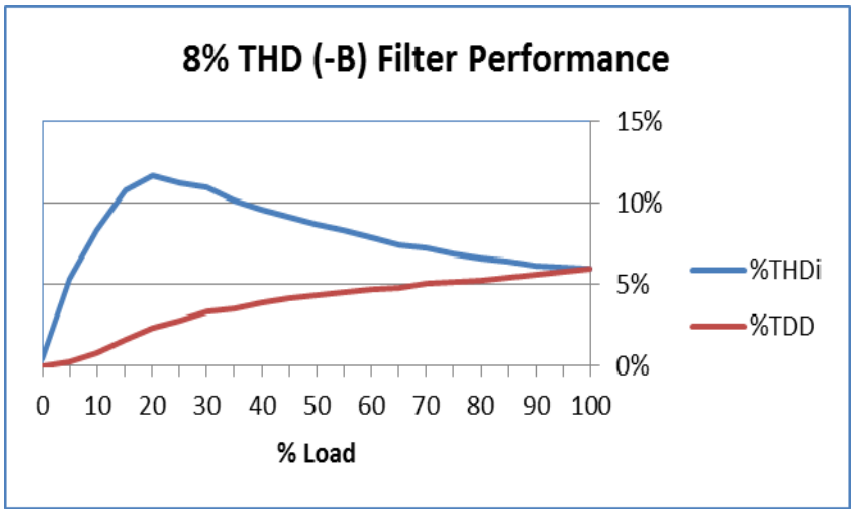
For generator kVA capacity multiply 480 x filter rated amperes x 1.732 x 1.20.

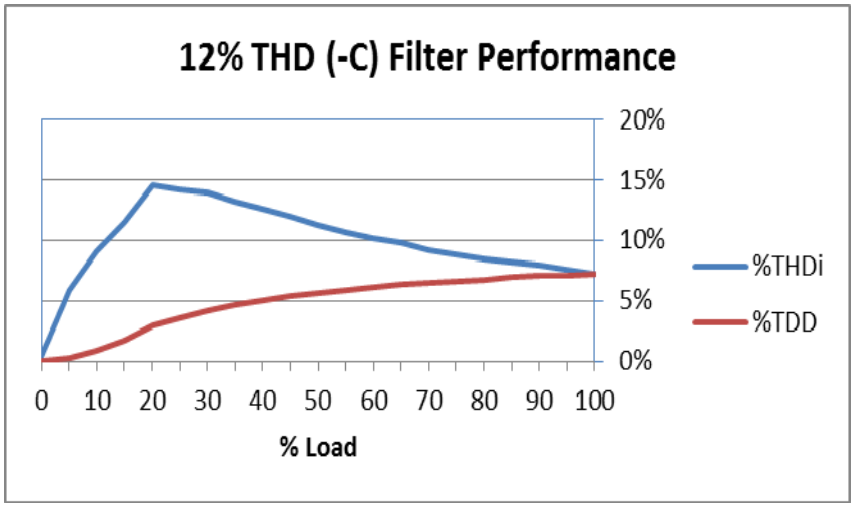
For application engineering: Contact the Technical Support Office—see back cover.

Current Distortion vs load

Pre-existing voltage distortion will add to these values







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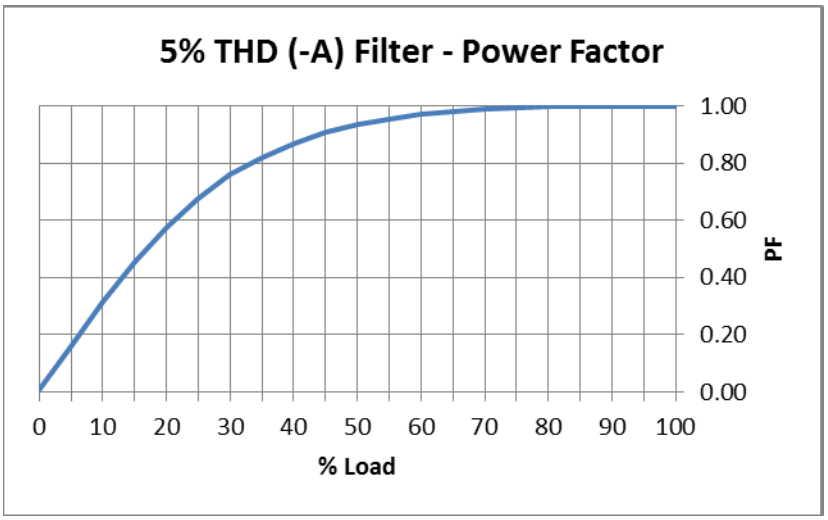
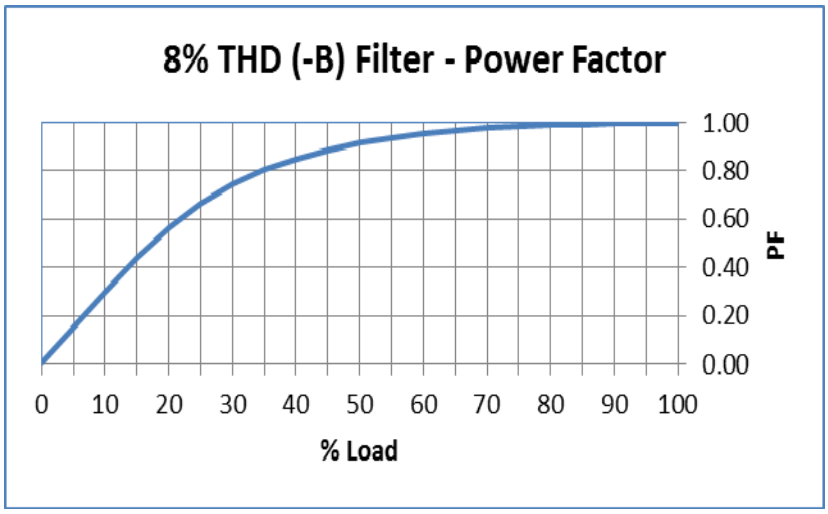
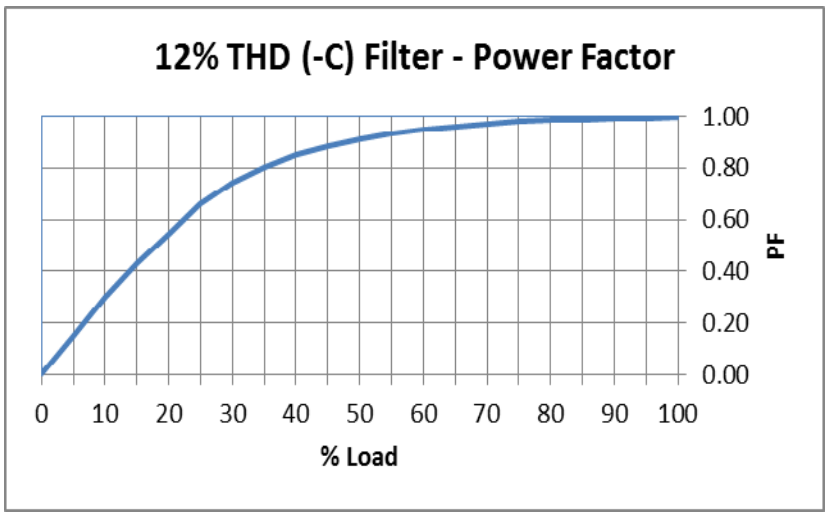
Input Power Factor vs Load







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