The right choice for the ultimate yield!

LS ELECTRIC strives to maximize your profits in gratitude for choosing us as your partner.

LOW HARMONIC FILTER

HFS Series

User's Manual

3PH 380 ~ 415VAC 50Hz 1.1KW ~ 250KW
3PH 380 ~ 480VAC 60Hz 0.87KW ~ 224KW

⚠ Safety Instructions

- Read this manual carefully before installing, wiring, operating, servicing or inspecting this equipment.
- Keep this manual within easy reach for quick reference.

LS ELECTRIC

This operation manual is intended for users with basic knowledge of electricity and electric devices.

HFS is the official name for LS ELECTRIC Harmonic Filters.

General Safety Notes and Installation Guidelines (Cautions and Warnings)

Power Quality Filters

1. Important Information

These general safety notes refer to the group of power quality filters including active and passive harmonic filter, AC line chokes and output filters. Do not attempt to install, operate, maintain or inspect power quality filters until you have read through the safety notes and installation guidelines as well as installation manual and product specification. Do not use any LS Electric product until you have a full knowledge of the equipment, safety notes and installation guidelines. The same supplies to all warnings placed on the filters. Please ensure that those are not removed and their legibility is not influenced by external factors.
The following symbols, terms and designations are used in these general safety notes and installation guidelines:

Label in Equipment	Safety Note Regulations
⚠CAUTION	Follow these instructions to avoid hazardous conditions which could cause minor or moderate injuries or may cause damages to the unit.
⚠WARNING	Follow these instructions to avoid hazardous conditions which could result in death or serious injuries.
NOTICE	Indicates content to be noted by the reader.

2. General Installation Notes

- Please read and follow the safety and application notes below.
- Carefully inspect the shipping container and the product prior to the installation. In case of visual damage, do not install the filter and file a claim with the freight carrier involved.
- Filters may be heavy. Follow the instructions for lifting heavy equipment defined by your company.
- Use an appropriately sized threaded bolt for every mounting hole/spot provided by the filter flange. The strength class of the bolt must be determined by the installer, depending upon filter weight and the material of the mounting surface.
- Connect the filter to the protective earth(PE) terminal(s).
- Remove all line side power, then connect the phase terminal(s). The filter label may also indicate LINE (grid side terminals) and LOAD (power electric terminals)
- For the electrical connection of the filter terminals, apply the torque recommended on the filter label and/or in the published filter datasheets
- Cable or busbar cross sections have to be chosen in accordance with national and

international electric codes and applicable product standards governing the equipment that will incorporate the power quality filters and the equipment in use.

- Some filters provide additional terminal, e.g. for over-temperature monitoring. These features have to be properly used before energizing the filter. If uncertain, please consult your local LS Electric representative.
- In order to get the maximum benefit out of your power quality filter, please also consult additional user manuals, installation manual, whitepaper and other material, published in the download section of www.ls-electric.com These additional guidelines provide helpful hints for equipment related topics as well as technical knowledge.

3. Safety Notes and Regulations

Label on Equipment Safety Note Category	Safety Note Regulations
	Equipment installation, start-up, operation and maintenance (if any) have to be carried out by a trained and certified electrician or technician who is familiar with safety procedures in electrical systems. Non-qualified persons are not allowed to use, install, operate or maintain PQ filters.
	High voltage potentials are involved in the operation of power quality equipment. Always remove power supply before handling energized parts of the filter, and let ample time elapse for the capacitors to discharge to safe levels (<42V). Residual voltages are to be measured both line to line and line to earth.
	Correct protective earth of the equipment must be established and the user must be protected against supply voltage in accordance with applicable national and local regulations. Always practice the safety procedures defined by your company and by applicable local electric codes when handling, installing, operating or maintaining electrical equipment.
	Always connect the filter to protective earth (PE) first, then continue with the wiring of phase/neutral terminals. When decommissioning the filter, remove the PE connection at the end.
	Follow the general installation and environmental condition notes closely. Ensure that cooling slots (if any) are free from obstructions that could inhibit efficient air circulation. Operate the filter within its electrical, mechanical, thermal and ambient specifications at all times.
	The internal module of the low harmonic filter is an electrical component that generates heat loss. Internal components and external surfaces of the product may generate heat under load operating conditions. Never remove the cover during operation. Never touch the internal heating part as it may cause burns. It is necessary to beware of human body contact with heating parts even after stopping the operation. Be sure to wear protective gloves when removing and inspecting the cover after stopping operation.

NOTICE	At altitudes above 2000m, please contact LS Electric prior to installation.
NOTICE	Product performance and stable operation are not guaranteed when low harmonic filters are applied to devices other than LS Electric's inverters. In case of application to devices and applications other than LS Electric inverter, please contact local LS Electric representative. LS Electric and the manufacturer will not assume liability for any process downtime, loss or damage resulting from the usage of filters outside their application specifications.
⚠ CAUTION	In case of uncertainty and questions please contact to your local LS Electric partner for assistance

Content

LS Low Harmonic Filter (HFS Series)

1.1. The benefits of the next generation HFS series Low Harmonic Filter

HFS Low Harmonic Filters provide a solution to the problems of current harmonics mitigation of 3-phase non-linear loads. The HFS product line is applicable to 3-phase AC 380V~480V 60Hz and AC 380V~415V 50Hz systems and is suitable for LS Electric inverters. The technology of the HFS Low Harmonic Filter is more advanced than the previous generation harmonic filters and reflects the following new aspects.

HFS Low Harmonic Filter is designed for demanding harmonic attenuation performance and low capacitor current..
HFS Harmonic Filter is designed for 6 phase diodes and thyristor rectifiers to achieve THID less than 5% in drives without DC reactors.
Next generation HFS filters ensure compliance with stringent international power quality standards, including compliance with the stringent requirements of IEEE-519.

HFS Low Harmonic Filter demonstrates superior partial load performance.
The excellent performance of HFS Low Harmonic Filter not only mitigates harmonic currents and lowers the THID to 5% or less at the rating of the diode rectifier, but also lowers reactive power to a minimum under partial or no load conditions. Displacement power factor is maintained at cosφ> 0.98 at 50% load.

HFS Low Harmonic Filters provide the optimal solution with modular options.
HFS harmonic filter includes power supply, fan, TDJ, RC damper modules. The optimum solution can be obtained according to the installation conditions and drive settings.

The world's most compact design, most robust, most reliable and easiest to use.
This user manual is intended to assist designers, installers and application engineers with filter selection, installation and maintenance, and will provide a solution for attenuating inverter load harmonic currents. If you need further assistance, please contact the LS Electric representative.

1.2. Performance guarantee

Selecting and installing the appropriate HFS passive harmonic filter in a variable frequency AC drive application, variable speed drive application within our published technical specifications we guarantee that the input current distortion will be less than or equal to 5% THID for standard HFS series filters at rated power. HFS harmonic filters can also provide similar performance in other drive applications such as constant torque, DC drives or other phase controlled rectifiers, e.g. SCR drives, but actual THID levels can vary by load and/or speed and/or firing angle of thyristors and therefore cannot be guaranteed. Consult your local LS Electric representative for assistance when applying HFS harmonic filters on these types of equipment.

1.3. Minimum system requirements

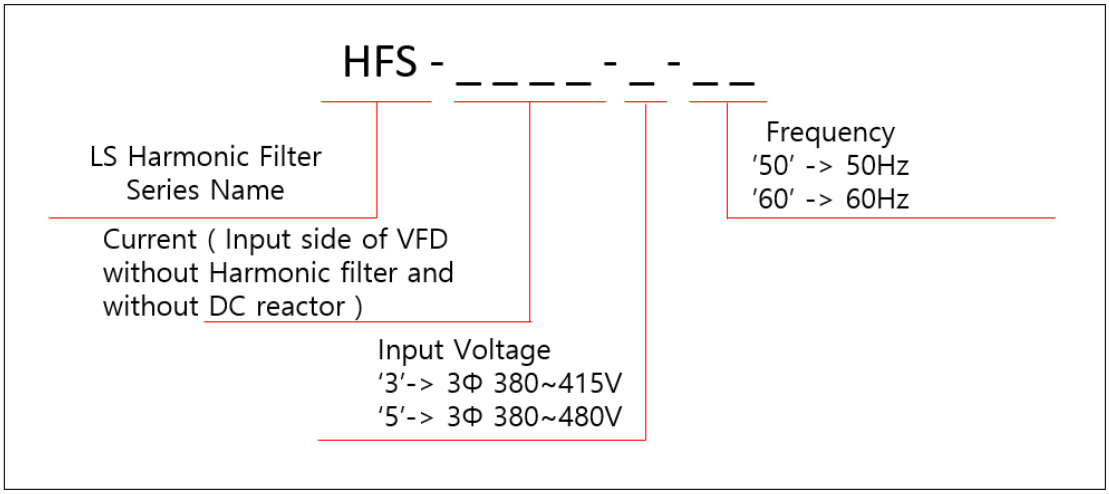
Performance level of this filter is guaranteed when the following system conditions are met:

1) Type of load : Any 3-phase equipment with front-end six-pulse diode rectifier
2) Type of source : 3-phase power line without neutral
3) Line impedance : < 3% (calculated for the rated filter power)
4) Line frequency : 50Hz ±1Hz (HFS-XXXX-3-50), 60Hz ±1Hz (HFS-XXXX-5-60)
5) Line voltage : Nominal line voltage ±10%
6) Line voltage unbalance : < 1%
7) Line voltage distortion : THVD < 2%

1.4. Important user notice

HFS Low Harmonic Filters are designed for the operation on the input (grid) side of LS Electric inverters in a three-phase power system. In addition, filter suitability for a given application should be determined by the user. LS Electric will not assume liability for any process downtime, loss or damage resulting from the usage or application of HFS Low Harmonic Filters that are outside of their specification. HFS Low Harmonic Filter should not be used for single phase or split-phase applications.

1.5. Model name notation of HFS Series



2. Filter Selection

HFS Low Harmonic Filters must be carefully selected and configured for maximum efficiency. For additional product data sheets (catalogs) and technical data, please refer to the website. (www.ls-electric.com)

2.1. Frequency band

Select a filter by checking whether the frequency of the power system to be applied is 50Hz or 60Hz. **The table below is a general reference and may differ depending on the case. Please check the power frequency before selecting a product.**

Frequency	Country (examples)	Name of LS Low Harmonic Filter
50Hz	Europe, China, Thailand, Japan, Indonesia, Australia, etc.	HFS-XXXX-3-50
60Hz	Korea, Japan, Taiwan, Philippines, USA, Canada, etc.	HFS-XXXX-5-60

2.2. Voltage range

Check the required system voltage range and select a filter according to the table below.

Frequency	Voltage range	Configuration	Name of LS Low Harmonic Filter
50Hz	380 ~ 415 VAC	TN, TT, IT configuration	HFS-XXXX-3-50
60Hz	380 ~ 480 VAC	TN, TT, IT configuration	HFS-XXXX-5-60

2.3. Filter Selection Table

1) AC 380V~415V 50Hz

Model	Inverter Input current (without Harmonic filter and DC reactor)	Rated Harmonic filter input current (Overload : 1.6*In for 1min, once per hour)	Applicable motor power 50Hz AC 380V~415V		
			80% load	90% load	100% load
HFS-0003-3-50	3.0 A	1.6 A	1.4 kW	1.2 kW	1.1 kW
HFS-0005-3-50	5.5 A	3.3 A	2.7 kW	2.4 kW	2.2 kW
HFS-0010-3-50	10 A	5.9 A	5.0 kW	4.4 kW	4.0 kW
HFS-0013-3-50	13 A	8.2 A	6.9 kW	6.1 kW	5.5 kW
HFS-0016-3-50	16 A	11.1 A	9.3 kW	8.3 kW	7.5 kW
HFS-0024-3-50	24 A	16.3 A	13.7 kW	12.2 kW	11 kW
HFS-0032-3-50	32 A	22.2 A	18.6 kW	16.6 kW	15 kW
HFS-0038-3-50	38 A	28.2 A	23.7 kW	21.1 kW	19 kW
HFS-0045-3-50	45 A	32.5 A	27.3 kW	24.3 kW	22 kW
HFS-0060-3-50	60 A	44.4 A	37.3 kW	33.2 kW	30 kW
HFS-0075-3-50	75 A	54.8 A	46 kW	41 kW	37 kW
HFS-0090-3-50	90 A	66.7 A	56 kW	50 kW	45 kW
HFS-0110-3-50	110 A	81.6 A	69 kW	61 kW	55 kW
HFS-0150-3-50	150 A	111 A	93 kW	83 kW	75 kW
HFS-0180-3-50	180 A	134 A	113 kW	100 kW	90 kW
HFS-0210-3-50	210 A	164 A	138 kW	122 kW	110 kW
HFS-0260-3-50	260 A	197 A	165 kW	147 kW	132 kW
HFS-0320-3-50	320 A	240 A	202 kW	179 kW	160 kW
HFS-0400-3-50	400 A	300 A	252 kW	224 kW	200 kW
HFS-0530-3-50	530 A	376 A	316 kW	281 kW	250 kW

2) AC 380V~480V 60Hz

Model Name	Inverter Input current (without Harmonic filter and DC reactor)	Rated Harmonic filter input current (Overload : 1.6*In for 1min, once per hour)	Applicable motor power 60Hz AC 380V~480V								
			at 80% load			at 90% load			at 100% load		
			380V	440V	480V	380V	440V	480V	380V	440V	480V
HFS-0002-5-60	2 A	1.4 A	1.1 kW	1.3 kW	1.4 kW	1.0 kW	1.1 kW	1.2 kW	0.9 kW	1.0 kW	1.1 kW
HFS-0004-5-60	4 A	2.8 A	2.2 kW	2.6 kW	2.8 kW	2.0 kW	2.3 kW	2.5 kW	1.7 kW	2.0 kW	2.2 kW
HFS-0007-5-60	7 A	4.6 A	3.6 kW	4.2 kW	4.6 kW	3.2 kW	3.8 kW	4.1 kW	2.9 kW	3.4 kW	3.7 kW
HFS-0011-5-60	11 A	6.9 A	5.5 kW	6.4 kW	7.0 kW	4.9 kW	5.7 kW	6.2 kW	4.4 kW	5.1 kW	5.6 kW
HFS-0014-5-60	14 A	9.3 A	7.4 kW	8.6 kW	9.4 kW	6.6 kW	7.6 kW	8.3 kW	5.9 kW	6.9 kW	7.5 kW
HFS-0021-5-60	21 A	13.8 A	11.0 kW	12.8 kW	13.9 kW	9.8 kW	11.3 kW	12.4 kW	8.7 kW	10.1 kW	11.0 kW
HFS-0027-5-60	27 A	18.5 A	15 kW	17 kW	19 kW	13 kW	15 kW	17 kW	12 kW	14 kW	15 kW
HFS-0034-5-60	34 A	23.1 A	18 kW	21 kW	23 kW	16 kW	19 kW	21 kW	15 kW	17 kW	19 kW
HFS-0044-5-60	44 A	27.8 A	22 kW	26 kW	28 kW	20 kW	23 kW	25 kW	17 kW	20 kW	22 kW
HFS-0052-5-60	52 A	37.2 A	30 kW	34 kW	37 kW	26 kW	31 kW	33 kW	24 kW	28 kW	30 kW
HFS-0066-5-60	66 A	46.2 A	37 kW	43 kW	47 kW	33 kW	38 kW	41 kW	29 kW	34 kW	37 kW
HFS-0083-5-60	83 A	55.6 A	44 kW	51 kW	56 kW	39 kW	46 kW	50 kW	36 kW	41 kW	45 kW
HFS-00103-5-60	103 A	69.3 A	55 kW	64 kW	70 kW	49 kW	57 kW	62 kW	44 kW	51 kW	56 kW
HFS-00128-5-60	128 A	92.5 A	74 kW	85 kW	93 kW	66 kW	76 kW	83 kW	59 kW	69 kW	75 kW
HFS-00165-5-60	165 A	115 A	92 kW	106 kW	116 kW	82 kW	94 kW	103 kW	74 kW	85 kW	93 kW
HFS-00208-5-60	208 A	139 A	111 kW	128 kW	140 kW	99 kW	114 kW	125 kW	89 kW	103 kW	112 kW
HFS-00240-5-60	240 A	184 A	147 kW	170 kW	185 kW	131 kW	151 kW	165 kW	118 kW	137 kW	149 kW
HFS-00320-5-60	320 A	231 A	184 kW	213 kW	233 kW	164 kW	190 kW	207 kW	147 kW	171 kW	186 kW
HFS-00403-5-60	403 A	279 A	223 kW	258 kW	281 kW	198 kW	229 kW	250 kW	177 kW	205 kW	224 kW

3) Example

Information required in advance when selecting a filter is as follows.

① Input power voltage (380V, 440V, 480V)

② Input power frequency (50Hz or 60Hz)

③ Applicable motor capacity (kW)

④ Continuous operation maximum load rate (%)

- When selecting a filter at a site where an inverter is already installed

Continuous operation maximum load rate (%)

= Power at input side of inverter / Nominal motor power(Kw) * 100 (%)

Since the Low Harmonic Filter has an overload tolerance of 160% for one minute and (once per hour), if the load factor is selected in consideration of an instantaneous load increase during startup or an instantaneous overload condition during operation, the higher harmonic filter capacity can be selected. Therefore, appropriately judge and select the load factor after measurement.

- In case of new installation of inverter and harmonic filter

  = Estimated load factor (%) based on motor rated capacity (kW)

  or

  = Rated required shaft power design value of load / Rated motor capacity (kW) * 100 (%)

After checking the four information in items A to D, select the column corresponding to the input power voltage and load factor from the 2.3 filter selection table, and select the row that is greater than or equal to the applied motor capacity to select the applicable Low Harmonic Filter model.

(Selection example) How to select a harmonic filter product when the input power voltage is 380V 60Hz, the motor capacity is 22kW, and the maximum load rate of continuous operation is 90%.

Model Name	Applicable motor power 60Hz AC 380V~480V								
	at 80% load			at 90% load			at 100% load		
	380V	440V	480V	380V	440V	480V	380V	440V	480V
HFS-0002-5-60	1.1 kW	1.3 kW	1.4 kW	1.0 kW	1.1 kW	1.2 kW	0.9 kW	1.0 kW	1.1 kW
HFS-0004-5-60	2.2 kW	2.6 kW	2.8 kW	2.0 kW	2.3 kW	2.5 kW	1.7 kW	2.0 kW	2.2 kW
HFS-0007-5-60	3.6 kW	4.2 kW	4.6 kW	3.2 kW	3.8 kW	4.1 kW	2.9 kW	3.4 kW	3.7 kW
HFS-0011-5-60	5.5 kW	6.4 kW	7.0 kW	4.9 kW	5.7 kW	6.2 kW	4.4 kW	5.1 kW	5.6 kW
HFS-0014-5-60	7.4 kW	8.6 kW	9.4 kW	6.6 kW	7.6 kW	8.3 kW	5.9 kW	6.9 kW	7.5 kW
HFS-0021-5-60	11.0 kW	12.8 kW	13.9 kW	9.8 kW	11.3 kW	12.4 kW	8.7 kW	10.1 kW	11.0 kW
HFS-0027-5-60	15 kW	17 kW	19 kW	13 kW	15 kW	17 kW	12 kW	14 kW	15 kW
HFS-0034-5-60	18 kW	21 kW	23 kW	16 kW	19 kW	21 kW	15 kW	17 kW	19 kW
HFS-0044-5-60	22 kW	26 kW	28 kW	20 kW	23 kW	25 kW	17 kW	20 kW	22 kW
HFS-0052-5-60	30 kW	34 kW	37 kW	26 kW	31 kW	33 kW	24 kW	28 kW	30 kW
HFS-0066-5-60	37 kW	43 kW	47 kW	33 kW	38 kW	41 kW	29 kW	34 kW	37 kW
HFS-0083-5-60	44 kW	51 kW	56 kW	39 kW	46 kW	50 kW	36 kW	41 kW	45 kW
HFS-00103-5-60	55 kW	64 kW	70 kW	49 kW	57 kW	62 kW	44 kW	51 kW	56 kW
HFS-00128-5-60	74 kW	85 kW	93 kW	66 kW	76 kW	83 kW	59 kW	69 kW	75 kW
HFS-00165-5-60	92 kW	106 kW	116 kW	82 kW	94 kW	103 kW	74 kW	85 kW	93 kW
HFS-00208-5-60	111 kW	128 kW	140 kW	99 kW	114 kW	125 kW	89 kW	103 kW	112 kW
HFS-00240-5-60	147 kW	170 kW	185 kW	131 kW	151 kW	165 kW	118 kW	137 kW	149 kW
HFS-00320-5-60	184 kW	213 kW	233 kW	164 kW	190 kW	207 kW	147 kW	171 kW	186 kW
HFS-00403-5-60	223 kW	258 kW	281 kW	198 kW	229 kW	250 kW	177 kW	205 kW	224 kW

In the 90% load 380V column, if you select the 26kW row that is greater than or equal to 22kW of the motor capacity applied, you can select the harmonic filter corresponding to the model name column on the left.

In the table above, applicable motor capacity of 26kW is that the applicable harmonic filter model HFS-0052-5-60 is a model capable of continuous operation at a load rate of 90% of the maximum 26kW rating based on 380V power supply voltage.

3. Product Specification

3.1. General Specification

1) Product line HFS-XXXX-3-50 50Hz

Nominal operating voltage	3x 380V - 415V AC
Voltage tolerance range	3x 342V - 457V AC
Operating frequency	50 Hz ±1 Hz
Network	TN, TT, IT
Nominal motor drive input power rating	1.1 kW - 250kW
THID 2)	<5% @ rated power 1)
TDD 2)	According to IEEE 519
Efficiency	>98% @ nominal line voltage and power
Drive dc-link voltage 3)	-5% ~ +10% nominal DC voltage
High potential test voltage 4)	P → E 2160 VAC (1s)
SCCR 5)	100kA, fuses according UL class J
Protection category (IP)	IP 20
Pollution degree	PD3 (according to standard IEC 60664-1)
Cooling	Internal fan cooling (self cooling for small capacity)
Overload capability	1.6x rated current for 1 minute, once per hour
Capacitive current @ no load	<20% of rated input current, at 400 V AC
Ambient temperature range	-25°C to +45°C fully operational
	+45°C to +70°C derated operation 6)
	-25°C to +85°C transportation and storage
Flammability class	UL 94V-2
Insulation class	N (200°C), H (180°C)
Design corresponding to	Filter : UL 61800-5-1, EN 61800-5-1
	Chokes : EN 61558-2-20 or EN 60076-6
MTBF (Mean Time Between Failure)	>200,000 hours
MTTR (Mean Time To Repair)	<15 minutes (capacitor modules and fan modules)
Lifetime (calculated)	≥10 years The cooling fan and capacitor should be periodically inspected and replaced according to the regular maintenance guidelines.
Safety monitor output signal	Thermal switch NC 180° C (UL-approved) to detect overload of chokes

① THID ~5% at rated power for filter <4kW.

② System requirements: THVD <2%, line voltage unbalance <1%
Performance specification for six-pulse diode rectifiers. SCR rectifier front-ends produce different results, depending upon the firing angle of the thyristors.

③ Conditions: line impedance <3%

④ Repetitive tests to be performed at max. 80% of above levels, for 2 seconds.

⑤ External UL-rated fuses required.

⑥ $I_{derated} = I_{nominal} \times \sqrt{((70°C - T_{amb})/25°C)}$

2) Product line HFS-XXXX-5-60 60Hz

Nominal operating voltage	3x 380 to 480 V AC
Voltage tolerance range	3x 342 to 528 V AC
Operating frequency	60 Hz ±1 Hz
Network	TN, TT, IT
Nominal motor drive input power rating	0.87 kW to 177kW @ 380V, 100% load

	1.0 kW to 205 kW @ 440V, 100% load
	1.1 kW to 224 kW @ 480V, 100% load
THiD 2)	<5% @ rated power 1)
TDD 2)	According to IEEE 519
Efficiency	>98% @ nominal line voltage and power
Drive dc-link voltage 3)	-5% ~ +10% nominal DC voltage
High potential test voltage 4)	P → E 2160 VAC (1s)
SCCR 5)	100kA, fuses according UL class J.
Protection category (IP)	IP 20
Pollution degree	PD3 (according to standard IEC 60664-1)
Cooling	Internal fan cooling
Overload capability	1.6x rated current for 1 minute, once per hour
Capacitive current @ no load	<20% of rated input current, at 400 V AC
Ambient temperature range	-25°C to +45°C fully operational
	+45°C to +70°C derated operation 6)
	-25°C to +85°C transportation and storage
Flammability class	UL 94V-2
Insulation class	N (200°C), H (180°C)
Design corresponding to	Filter : UL 61800-5-1, EN 61800-5-1
	Chokes : EN 61558-2-20 or EN 60076-6
MTBF (Mean Time Between Failure)	>200,000 hours
MTTR (Mean Time To Repair)	<15 minutes (capacitor modules and fan modules)
Lifetime (calculated)	≥10 years The cooling fan and capacitor should be periodically inspected and replaced according to the regular maintenance guidelines.
Safety monitor output signal	Thermal switch NC 180° C (UL-approved) to detect overload of chokes

① THID ~5% at rated power for filter <4kW.

② System requirements: THVD <2%, line voltage unbalance <1%
Performance specification for six-pulse diode rectifiers. SCR rectifier front-ends produce different results, depending upon the firing angle of the thyristors.

③ Conditions: line impedance <3%

④ Repetitive tests to be performed at max. 80% of above levels, for 2 seconds.

⑤ External UL-rated fuses required.

⑥ $I_{derated} = I_{nominal} \times \sqrt{((70°C - T_{amb})/25°C)}$

3.2. Electrical specification according to the altitude of the installation site

HFS Low Harmonic Filter general electrical specifications refer to operating altitudes up to 2000m a.s.l. (6600ft). Operation between 2000m and 4000m (6600ft and 13123ft) requires a derating for current and clearance according to IEC 60664-1, hereafter enclosed

Altitude correction factors

Altitude (m)	Normal barometric pressure (kPa)	Multiplication factor for clearances
2000	80.0	1.00
3000	70.0	1.14
4000	62.0	1.29
5000	54.0	1.48
6000	47.0	1.70
7000	41.0	1.95

8000	35.5	2.25
9000	30.5	2.62
10000	26.5	3.02
15000	12.0	6.67
20000	5.5	14.5

Warning: Please contact LS Electric before installing at altitudes above 2000m.

3.3. Mechanical frame sizes

HFS Low Harmonic Filter consists of frames from Frame A to J. In particular, Frames A to C are self-cooling, so no separate fans are installed, and built-in fans are applied in Frames D to J.

1) HFS-XXXX-3-50 50Hz Series

Model	Dimension				Weight [kg]
	Frame	W[mm]	H[mm]	D[mm]	
HFS-0003-3-50	A	160	360	185	8
HFS-0005-3-50	A	160	360	185	11
HFS-0010-3-50	B	180	425	206	15
HFS-0013-3-50	C	210	483	221	19
HFS-0016-3-50	C	210	483	221	23
HFS-0024-3-50	D	260	560	252	33
HFS-0032-3-50	D	260	560	252	36
HFS-0038-3-50	D	260	560	252	40
HFS-0045-3-50	E	290	705	318	54
HFS-0060-3-50	E	290	705	318	59
HFS-0075-3-50	E	290	705	318	67
HFS-0090-3-50	E	290	705	318	74
HFS-0110-3-50	E	290	705	318	76
HFS-0150-3-50	G	353	960	396	129
HFS-0180-3-50	G	353	960	396	150
HFS-0210-3-50	H	462	1150	456	180
HFS-0260-3-50	H	462	1150	456	197
HFS-0320-3-50	H	462	1150	456	223
HFS-0400-3-50	H	462	1150	456	229
HFS-0530-3-50	J	550	1455	555	350

2) HFS-XXXX-5-60 60Hz Series

Model	Dimension				Weight [kg]
	Frame	W[mm]	H[mm]	D[mm]	
HFS-0002-5-60	A	160	360	185	7
HFS-0004-5-60	A	160	360	185	9
HFS-0007-5-60	B	180	425	206	12
HFS-0011-5-60	B	180	425	206	14
HFS-0014-5-60	C	210	483	221	18
HFS-0021-5-60	C	210	483	221	20
HFS-0027-5-60	D	260	560	252	31
HFS-0034-5-60	D	260	560	252	35
HFS-0044-5-60	D	260	560	252	40
HFS-0052-5-60	E	290	705	318	53
HFS-0066-5-60	E	290	705	318	58
HFS-0083-5-60	E	290	705	318	66
HFS-00103-5-60	F	340	752	343	68
HFS-00128-5-60	F	340	752	343	91
HFS-00165-5-60	G	353	960	396	128
HFS-00208-5-60	G	353	960	396	149
HFS-00240-5-60	H	462	1150	456	191
HFS-00320-5-60	H	462	1150	456	208
HFS-00403-5-60	H	462	1150	456	273

※ For other detailed dimensions, refer to 4.4.2 External Dimensions by Frame and External Dimensions CAD file provided.

3.4. Product appearance (examples)

Appearance example (Frame C)

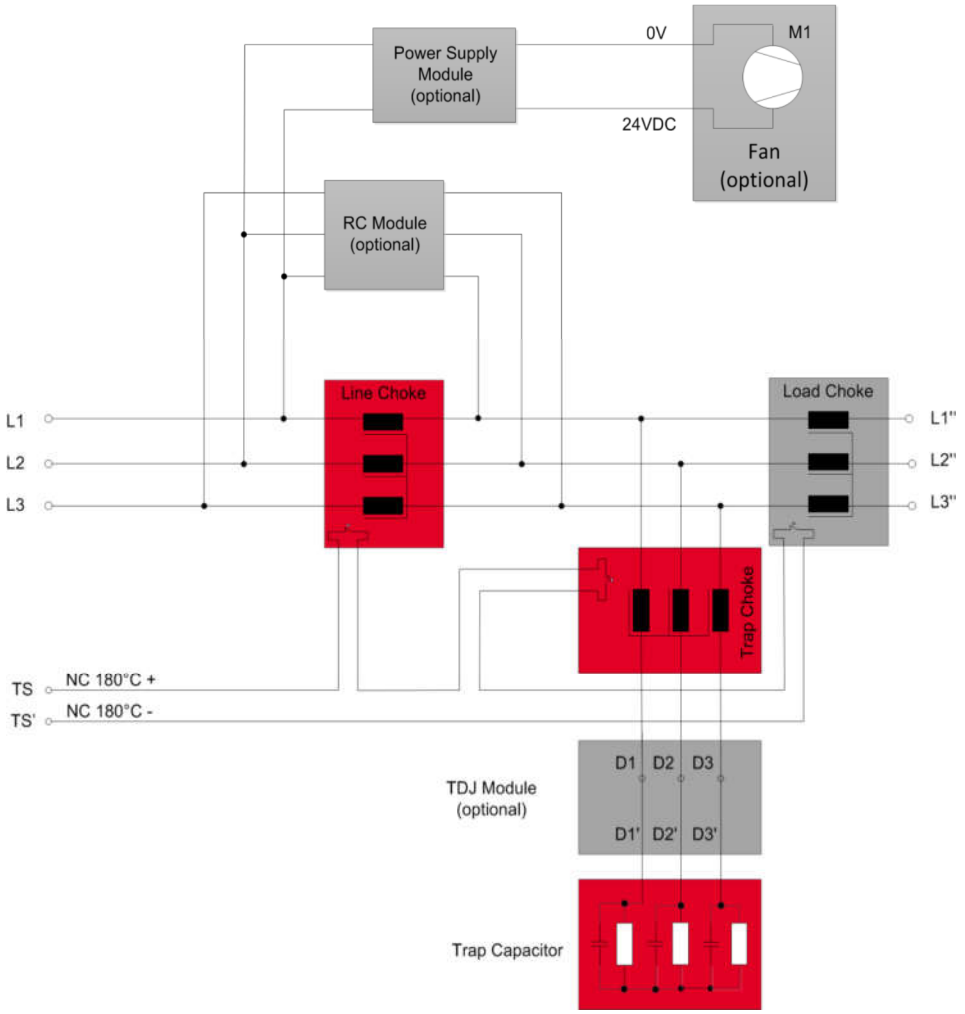
Appearance example (Frame F)

Appearance example (Frame J)

3.4.1. Parameters of finger guard of IP 20 enclosure

Frame	Finger guard cross-section width/diameter (mm)	Material
A	5.5	Plastic
B	8.0	Plastic
C	8.0	Plastic
D	11	Plastic
E	14	Metal
F	14	Metal
G	18.5	Metal
H	30	Metal
J	42	Metal

3.4.2. Functional diagram



Filter terminals	Line L1/L2/L3	Line side 3phase terminal
	Load L1'/L2'/L3'	Load side 3phase terminal
	Overheating alarm TS / TS'	Connected to Thermal Switch 180℃ to detect overload (Normal Closed) and output non-power contact
	PE	Ground terminal (Protective Earth)
	TDJ module Trap Capacitor terminals D1 / D2 / D3 D1' / D2' / D3'	2 sets of 3-phase terminals Trap Disconnection Jumper terminal Switches (MCs) are installed at both ends and are turned on when the inverter starts. When power is supplied to the inverter but it is stopped, or when operating with a load of less than 20%, the harmonic filter input terminal capacitor current is reduced and the leading power factor is prevented. The lifespan of the capacitor may be reduced when power is supplied in a long term stopped condition without installing a switch (MC).
Function blocks	Chokes	Power magnetic components incl. temperature sensors
	Capacitors	Power capacitors incl. discharge resistors
	Fan	Field replaceable fan for choke air cooling
	Power Supply Module	Internally generate 24 V DC source for fan supply
	RC Module	Attenuation of high-order harmonic current and avoidance function of resonance with EMC filter

3.5. Product performance

1) HFS Low Harmonic Filter satisfies the THID of 5% or less under the following conditions when applied to the rated voltage and power when applying the load of the 6-Pulse diode rectifier circuit.

   ① Line impedance : < 3% (calculated for the rated filter power)
   ② Line voltage unbalance : < 1%
   ③ Line voltage distortion : THVD < 2%

2) The RC damper module built in the HFS Low Harmonic Filter is required to prevent mutual resonance with the capacitor inside the EMC filter and to reduce the high order harmonics when the EMC filter is built in the inverter.

   Typical expected EMI filter capacitance (phase to star point) are the following.

   - HFS-XXXX-3-50

Volume	Model	Capacitance
1.1Kw	HFS-0003-3-50	1.5μF
2.2kw	HFS-0005-3-50	2.2μF
4 ~ 11kw	HFS-0010~0024-3-50	3.3μF
15 ~ 45kw	HFS-0032~0090-3-50	4.7μF
55 ~ 250kw	HFS-0110~0530-3-50	10μF

- HFS-XXXX-5-60

Volume	Model	Capacitance
0.87 ~ 1.1Kw	HFS-0002-5-60	1.5μF
1.7 ~ 2.2kw	HFS-0004-5-60	2.2μF
2.9 ~ 15kw	HFS-0007~0027-5-60	3.3μF
15 ~ 45kw	HFS-0034~0083-5-60	4.7μF
44 ~ 224kw	HFS-0103~0403-5-60	10μF

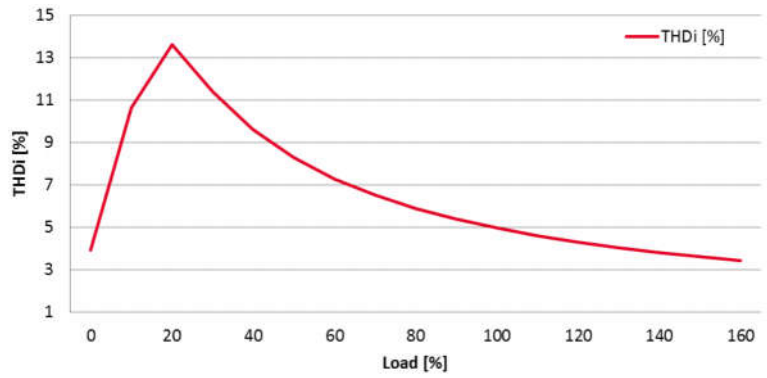
3) Capacity range that does not require RC damper module

   RC damper module is not built in products in the range of HFS-0260-3-50 ~ HFS-0530-3-50 and products in the range of HFS-0320-5-60 ~ HFS0403-5-60 because the EMI filter's Capacitance (Phase to star point) that products generally correspond to is greater than 10μF.

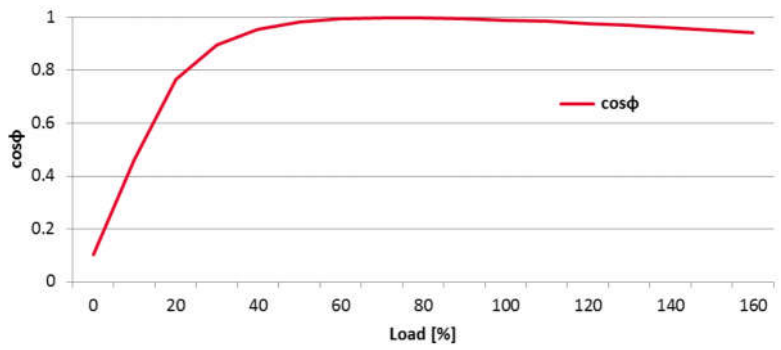
4) In a rectification application circuit where all 6-pulse is a thyristor, THID 5% may not be guaranteed depending on the firing angle of the thyristor.

5) General characteristics related to harmonic current, power factor and DC link voltage according to the load factor of HFS Low Harmonic Filter are the following.

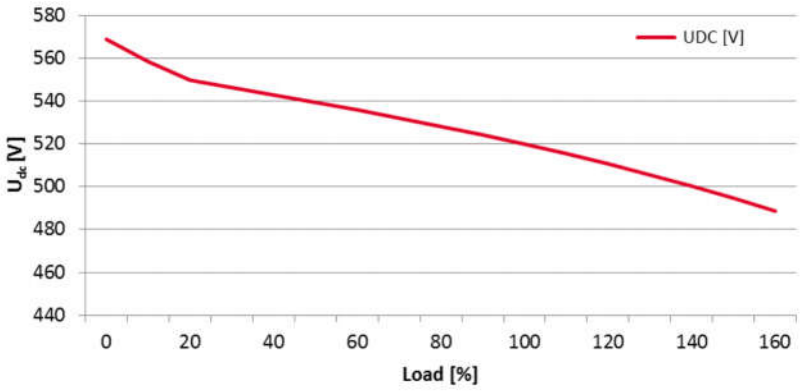
- THiD% according to load factor



- Power factor according to load factor



- DC-LINK voltage according to load ratio (based on 400VAC 50Hz)



4. Installation

Please follow the simple steps below to ensure a safe and reliable filter function for many years. Please do also always follow the general safety and installation guidelines provided within this document as well as relevant local, local or international standards that are applicable.

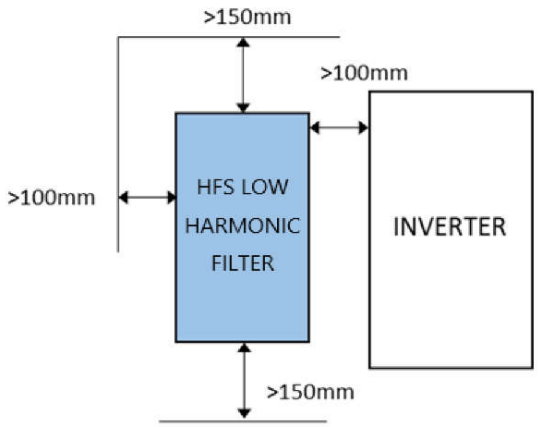
4.1. Step 1: Visual inspection

HFS Low Harmonic Filters have undergone rigorous testing before they left our ISO 9001:2008 certified factories. They are packaged with great care in a sturdy container for international shipment. However, carefully inspect the shipping container for damage that may have occurred in transit. Then unpack the filter and carefully inspect for any signs of damage. In the case of damage, please file a claim with the freight forwarder involved immediately and contact your local LS Electric partner for support. Under no circumstances install and energize a filter with visible transportation damage. If the filter is not going to be put in service upon receipt, store within the original container in a clean, dry location, free of dust and chemicals.

4.2. Step 2: Mounting

HFS Low Harmonic Filter is best to install as close as possible to the inverter. It is ideal to install it next to the electrical panel or the inverter inside the control room. The next generation HFS Low Harmonic Filter is designed to be wall mounted for all frames.

1) Peripheral separation distance during installation
As shown in the figure below, when installing the HFS harmonic filter, secure the surrounding distance to ensure sufficient air flow.

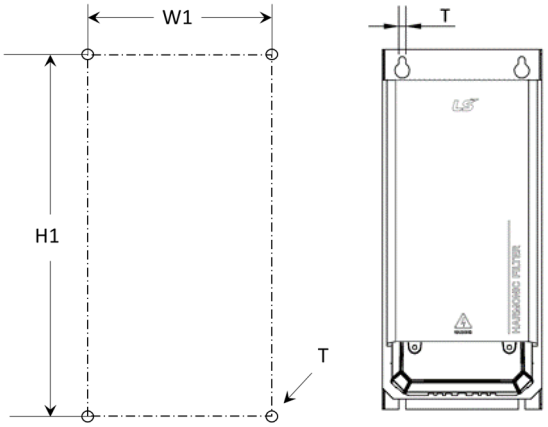


Install the product in consideration of the access space for removing the front cover when inspecting and maintaining the product.

2) Ambient temperature
Close the panel door and take measures to circulate air and cool the panel so that the

ambient temperature around the filter inside the panel can be maintained below 45℃ even after a sufficient period of time has elapsed. When the filter is operated in an environment with high temperature inside the panel, the rated current is derating, so an overheating alarm may be output from the temperature sensor built into the filter even at a low load rate.

3) Screw hole positions for wall mounted filters

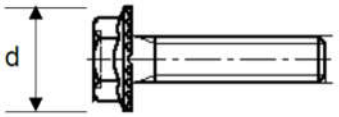


All dimensions in : [mm], 1inch = 25.4mm

Frame	W1 [mm]	H1 [mm]	T [hole diameter, mm]
A	120	340	7
B	120	405	7
C	150	460	7
D	180	540	11
E	220	680	11
F	250	730	11
G	280	920	11
H	390	1115	11
J	480	1350	11

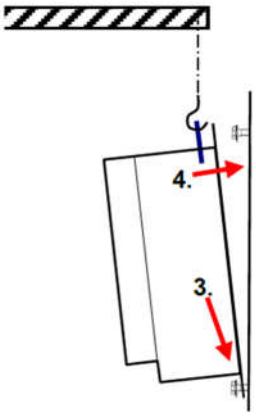
4) Screw selection

LS Electric recommends zinc coated hex ribbed flange steel bolts. Respect filters weight for appropriate choice of screws. Head diameters must not exceed these dimensions :
M6: d ≤14.2mm, M10: d ≤21.2mm



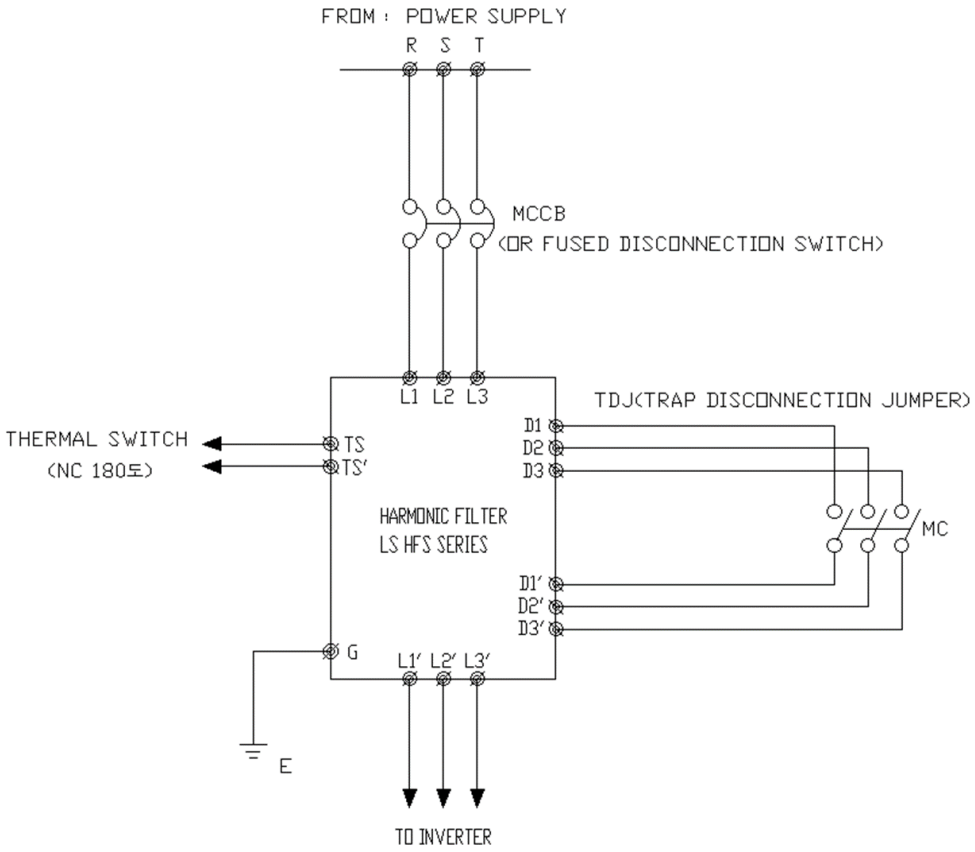
5) Filter placement:

① Set screws loose into wall, leave 5mm distance from head to wall.
② Lift filter with appropriate crane, smallest types (up to 25kg) may be lifted manually by two persons
③ Place filter first onto lower screws
④ then position it through backplane head openings on upper screws.
⑤ Fix screws with appropriate torque (depending upon the material of the back plane and local standards).



4.3. Step 3: Wiring

< Reference for wiring >

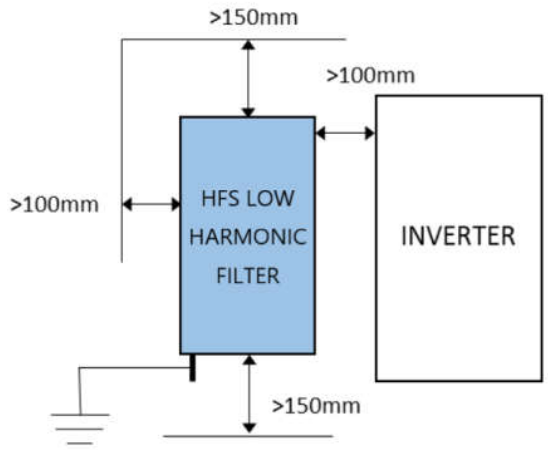


1) **Verify safe disconnection of all line side power.**

Consult your local safety instructions

2) **Carefully connect protective earth (PE) cable to adequate earth potential close to filter.**

Use a wire diameter of equal or bigger size as foreseen for line/load side power cables – according to your local codes and safety instructions.



3) **Connect PE wire of harmonic filter**

with appropriate cable lug to threaded stud.

- M5 Torque : 2.2 Nm
- M6 Torque : 4 Nm
- M8 Torque : 9 Nm
- M10 Torque : 19 Nm
- M12 Torque : 25 Nm

4) **Connect HFS harmonic filter load side terminals L1', L2', L3' to respective inverter inputs**

See Table 1 for the recommended wire size and torque. Use stranded copper wire with a temperature rating of 75°C or higher.

An optional workflow to connect power terminals without having the TDJ module in way is applied. You might consider following these steps

Connecting power terminals of passive harmonic filters ordered with TDJ module can be facilitated by removing the trap disconnect wires while connecting the cables to the main terminals. Afterwards the trap disconnect jumper cables need to be applied to the original position again. Please follow these steps: Open terminals D1- D1', D2- D2'and D3- D3', remove the wires, add main terminals and then fix wires on terminals D1- D1', D2- D2'and D3- D3' again. The recommended torques given on the terminal label must be applied.

① To connect HFS line side and load side terminals, the finger guard has to be removed as a first step, and be installed again when the line and load side terminals are connected. The screw thread and torque value for all the frame sizes are:

| Screw thread: M5

| Screw torque value: 4 Nm

② The metal finger guard for frame sizes E, F and G are equipped with grommets, whilst finger guard H is equipped with stepped collars. Modify the stepped collars according to the cable isolated diameter, 5-10mm margin is recommended to feed the cable easier.

Frame H Terraced Collars

③ Note that if the cable lug is wider than the cross-section width/diameter of the finger guard (see 3.4.1), do not add cable lugs before feeding all cables though the finger guard. Crimp cable lug when the cables are fed through the finger guard.

④ Install shrinking tube for the uninsulated cable lug to fulfill the clearance and creepage requirement.

⑤ To install finger guard for frame size J, firstly connect the load and line side terminals, then install the upper part of the finger guard by placing the cables through the slots and tightening the screw on the top, thirdly close the other part of the finger guard. The bottom part of the finger guard shall be pushed as close as possible to the cable, and tighten the other two screws on the sides.

Terminal block protective cover (Finger Guard) for Frame J

Table 1. Recommended wire size and torque.

Frame	Bolt thread	Cable standard		Tightening torque [Nm]	Cable Lug Maximum diameter [mm]**
		AWG	mm^2		
A	M3	14-22	0.4-2.5	0.5	7
B,C	M4	10-22	0.4-6	1.2	10
D	M6	6-18	0.75-16	3	15
E,F	M8	1/0-8	10-50	8	15
G	M8	3/0-8	10-95	8	17
H	M10	3/0-500kcmil	95-240	10	35
J	M16	350-750kcmil	185-400	10	48

Note. ** It is recommended to use cable lugs when wiring.

Cable lug compliance is required for creepage and clearance to meet UL 61800-5-1 without additional insulation protection. However, creepage and clearance may vary depending on the installation site and local regulations.

Terminal	Bolt thread	Tightening torque [Nm]	Frame
Signal (overheating alarm)	M3 **	0.5	Total
Grounding (PE)	M5	2.2	A
	M6	4	B
	M6	4	C
	M8	9	D
	M8	9	E
	M10	17	F
	M10	17	G
	M10	17	H
	M12	25	J

Note ** Overheating alarm signal terminal (Maximum diameter of M3 cable lug: 7mm)

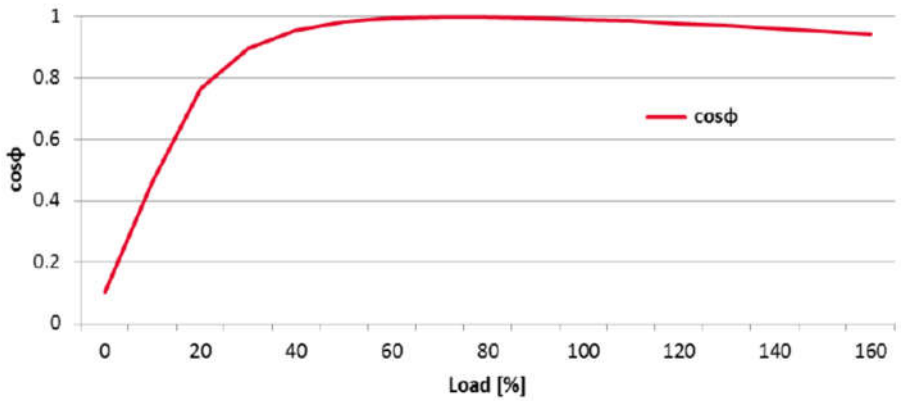
5) **Use wired trap circuit or install external capacitive current control.**

For configurations with TDJ terminals D1- D1', D2- D2'and D3- D3' are delivered with installed jumpers. When interconnected via an external capacitor contactor (not supplied by LS Electric) they allow for load dependent disconnection of the trap circuit, if needed. Thus capacitive current can be minimized for low load operation.

The recommended MC capacity should be calculated as 20% or more of the rated capacity. In the case of jumper without connecting MC to TDJ (Trap Disconnection Jumper)

THE USE OF CAPACITIVE SWITCHES/CONTACTORs IS REQUIRED.
OTHERWISE CAPACITOR LIFETIME MAY BE REDUCED.

The relationship between power factor and load factor is as follows.



When the trap circuit is cut off, cosφ returns to ~0.98. At the same time, THID increases. This value can be neglected because the absolute value is low due to the reduced load

output. External MC sequence configuration is required and does not come with HFS filter. When configuring the MC sequence, there are two types of MC starting conditions: using the inverter's RUN status contact and using the inverter's output frequency detection function to start the MC when operating above a certain frequency. Refer to the inverter manual for how to set the inverter parameters.

Note: It is necessary to consider the power factor correction of the overall concept. The installation of harmonic filters can cause system PFC correction units with large capacitor banks to be obsolete or reduced in large quantities. In this case, it may not be necessary to install the trap circuit separation feature.

It is recommended that the HFS harmonic filter is disconnected from the trap circuit under the following load conditions.

Trap circuit condition	Recommendations
Open	When the inverter stops or the load factor falls below 10 to 15%
Close	When the inverter starts or the load factor rises 20 to 25% or more

6) **Connect monitor switch TS- TS'**

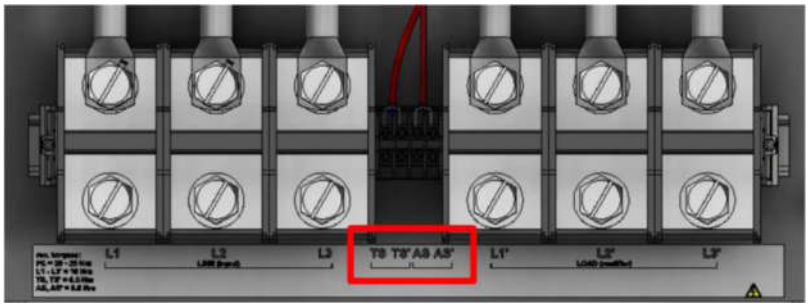
The monitor switch is a relay contact, which is open in ALARM state. It is constituted by a thermal switch NC 180°C (UL-approved) to detect overload of chokes. It may either be used to remotely disconnect the drive's load via respective input of drive control (check drive manual) or as alarm sensor for system control unit.

AN ENGAGED MONITOR SWITCH MUST LEAD TO IMMEDIATE LOAD SHUTDOWN AND INVESTIGATION OF THE PROBLEM.

7) **Connect auxiliary switch AS- AS' (only relevant for frame J)**

AN ENGAGED AUXILIARY SWITCH MUST LEAD TO IMMEDIATE LOAD SHUTDOWN AND INVESTIGATION OF THE PROBLEM.

The auxiliary switch is a contact, which indicates state of circuit breaker. It is closed under normal operation (CB on) and is open in abnormal condition (CB off). Abnormal condition can be a short circuit in the trap capacitors, overcurrent in the trap circuit, too hot ambient temperature or switch-off status in low load condition (use of motor mechanism together with the circuit breaker – check relevant section in user manual).



8) **Connect HFS line side terminals L1, L2, L3**

Connect HFS line side terminals L1,L2,L3 to power input protection (current limiting fuses – see below). Note: For IP 20 filter versions the IP 20 finger guard must be installed in order to achieve. IP 20 protection. When the finger guard is not installed, LS Electric do not guarantee IP 20 protection.

9) **Fuses**

LS HFS passive harmonic filters need external over-current protection for compliance with UL/cUL standard. Fuses and associated fuse holders must be UL listed and rated for 100kA SCCR supplies. Table 22 and Table 23 show requested fuse current ratings for UL class J and, where UL compliance is not mandatory, for IEC class gG. The fuse rating is independent of the supply voltage.

- HFS-XXXX-3-50 FUSE current rating

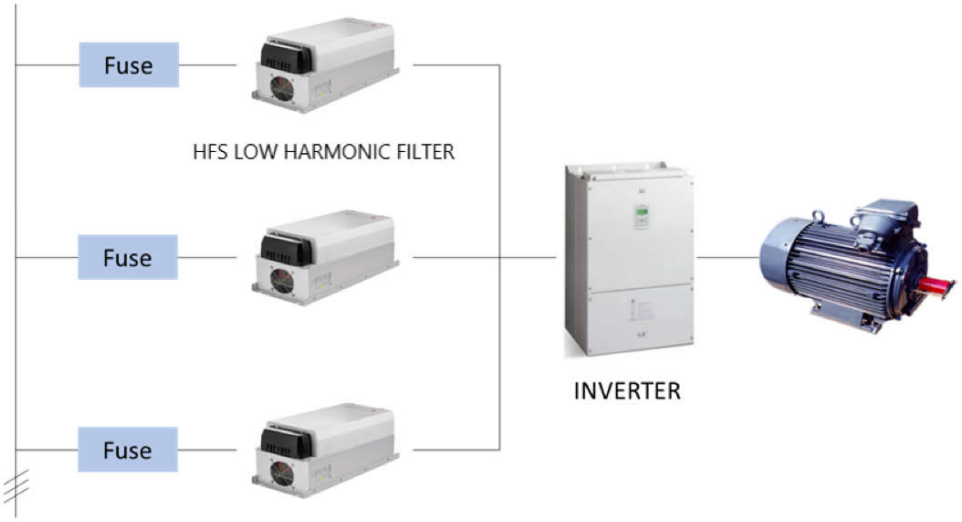
Model	Standard	Fuse Class J [A]	Fuse Class Gg [A]
HFS-0003-3-50	380~415V 50Hz 1.1kW	2.5	2
HFS-0005-3-50	380~415V 50Hz 2.2kW	8	8
HFS-0010-3-50	380~415V 50Hz 4kW	10	10
HFS-0013-3-50	380~415V 50Hz 5.5kW	15	10
HFS-0016-3-50	380~415V 50Hz 7.5kW	20	16
HFS-0024-3-50	380~415V 50Hz 11kW	25	20
HFS-0032-3-50	380~415V 50Hz 15kW	35	35
HFS-0038-3-50	380~415V 50Hz 19kW	40	35
HFS-0045-3-50	380~415V 50Hz 22kW	50	50
HFS-0060-3-50	380~415V 50Hz 30kW	75	63
HFS-0075-3-50	380~415V 50Hz 37kW	80	80
HFS-0090-3-50	380~415V 50Hz 45kW	100	100
HFS-0110-3-50	380~415V 50Hz 55kW	150	125
HFS-0150-3-50	380~415V 50Hz 75kW	175	160
HFS-0180-3-50	380~415V 50Hz 90kW	200	200
HFS-0210-3-50	380~415V 50Hz 110kW	250	224
HFS-0260-3-50	380~415V 50Hz 132kW	300	250
HFS-0320-3-50	380~415V 50Hz 160kW	350	300
HFS-0400-3-50	380~415V 50Hz 200kW	400	400
HFS-0530-3-50	380~415V 50Hz 250kW	600	600

Fuse current rating to satisfy UL Class J

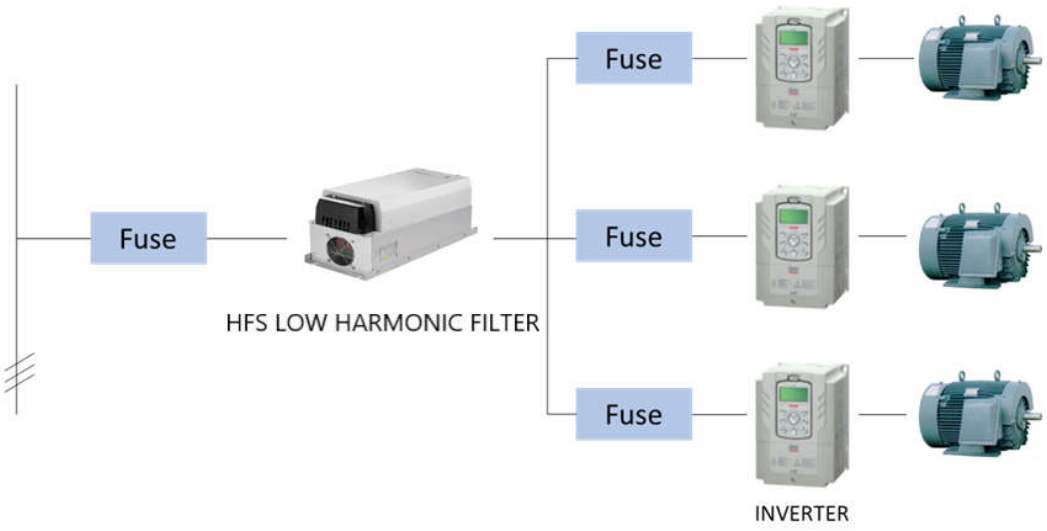
- HFS-XXXX-5-60 FUSE current rating

Model	Standard	Fuse Class J [A]	Remark
HFS-0002-5-60	380~480V 60Hz 0.87kW~1.1kW	2	
HFS-0004-5-60	380~480V 60Hz 1.74kW~2.2kW	4	
HFS-0007-5-60	380~480V 60Hz 2.93kW~3.7kW	7	
HFS-0011-5-60	380~480V 60Hz 4.4kW~5.6kW	10	
HFS-0014-5-60	380~480V 60Hz 5.9kW~7.5kW	15	
HFS-0021-5-60	380~480V 60Hz 8.7kW~11kW	20	
HFS-0027-5-60	380~480V 60Hz 12kW~15kW	30	
HFS-0034-5-60	380~480V 60Hz 15kW~19kW	35	
HFS-0044-5-60	380~480V 60Hz 17kW~22kW	40	
HFS-0052-5-60	380~480V 60Hz 24kW~30kW	50	
HFS-0066-5-60	380~480V 60Hz 29kW~37kW	60	
HFS-0083-5-60	380~480V 60Hz 36kW~45kW	80	
HFS-00103-5-60	380~480V 60Hz 44kW~56kW	90	
HFS-00128-5-60	380~480V 60Hz 59kW~75kW	125	
HFS-00165-5-60	380~480V 60Hz 74kW~93kW	150	
HFS-00208-5-60	380~480V 60Hz 89kW~112kW	175	
HFS-00240-5-60	380~480V 60Hz 118kW~149kW	250	
HFS-00320-5-60	380~480V 60Hz 147kW~186kW	300	
HFS-00403-5-60	380~480V 60Hz 177kW~224kW	400	

A system with multiple LS HFS harmonic filters paralleled for a high power load need each a separate 3-phase line side fuse block, corresponding to the respective filter and according to above table. The drive's application manual may prescribe line-side fuse protection as well, which in this case either corresponds to the sum of the filter fuse ratings or, if lower, would request separate drive fuses at its input.



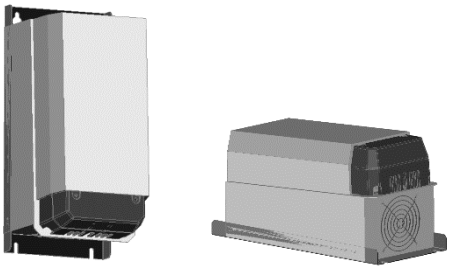
An application, having one HFS harmonic filtering harmonics of several drives, requires in any case line side fuse protection of the drives as well as the correct filter protection.



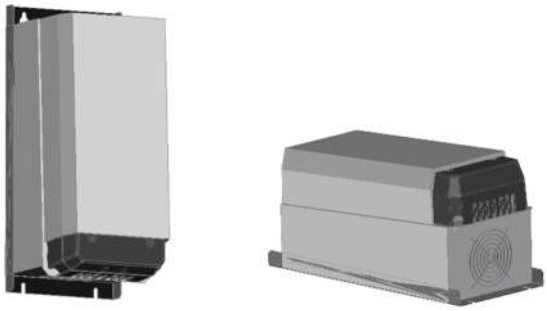
4.4. Outdrawing

Please refer to the “3.3 Mechanical frame sizes” table for the frame by product capacity.

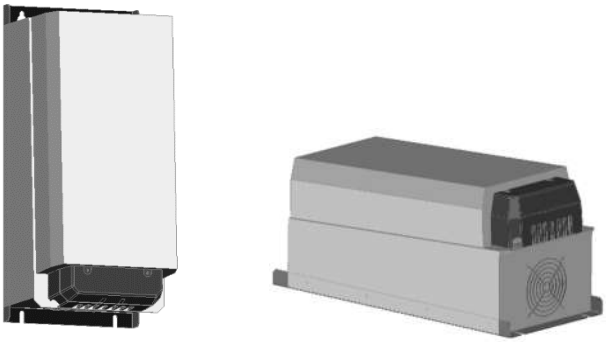
- A Frame



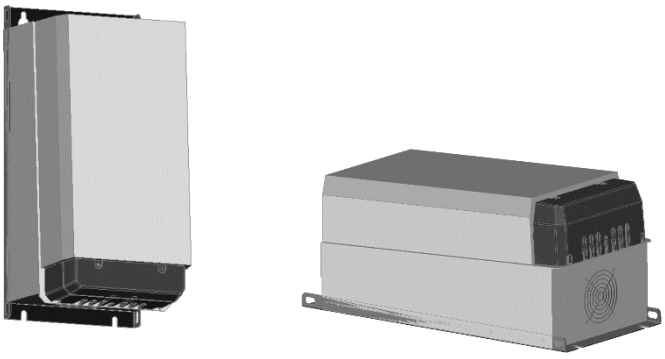
- B Frame



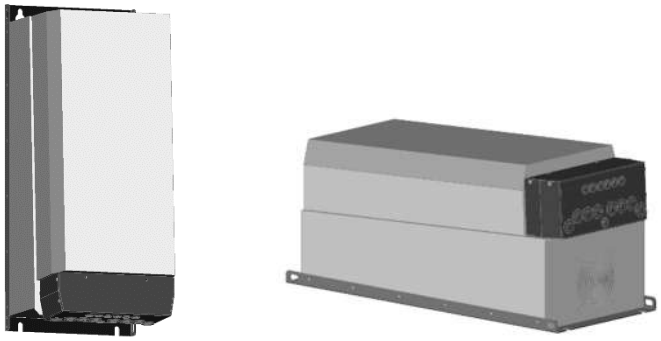
- C Frame



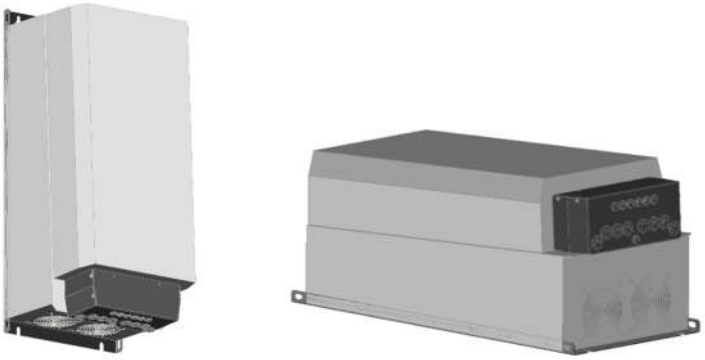
- D Frame



- E Frame



- F Frame



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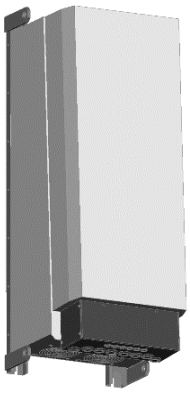
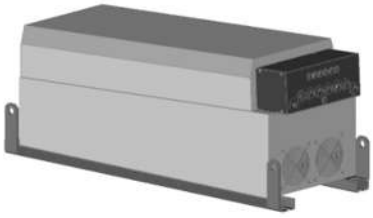
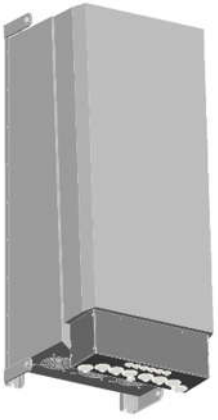




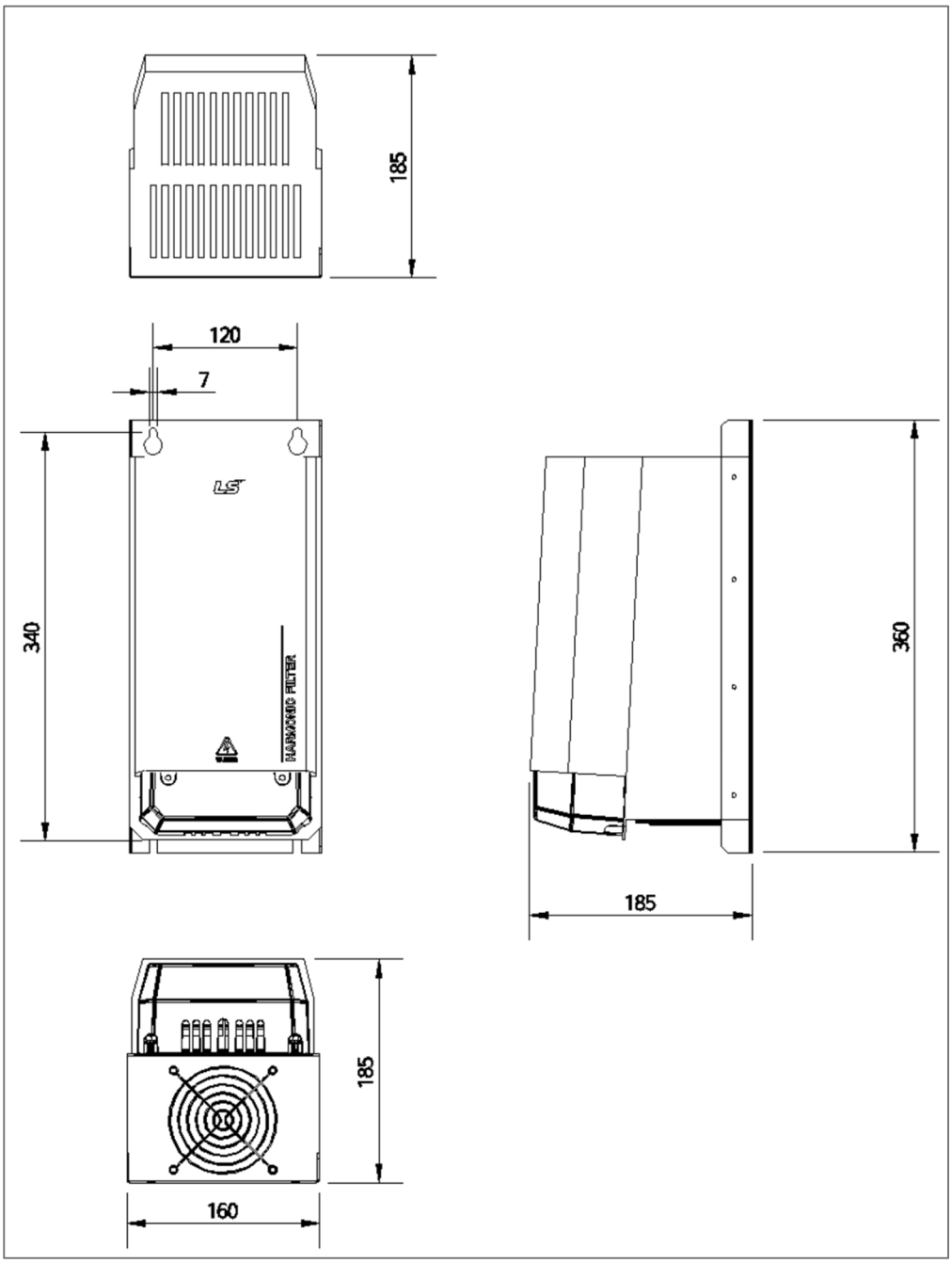
- H Frame



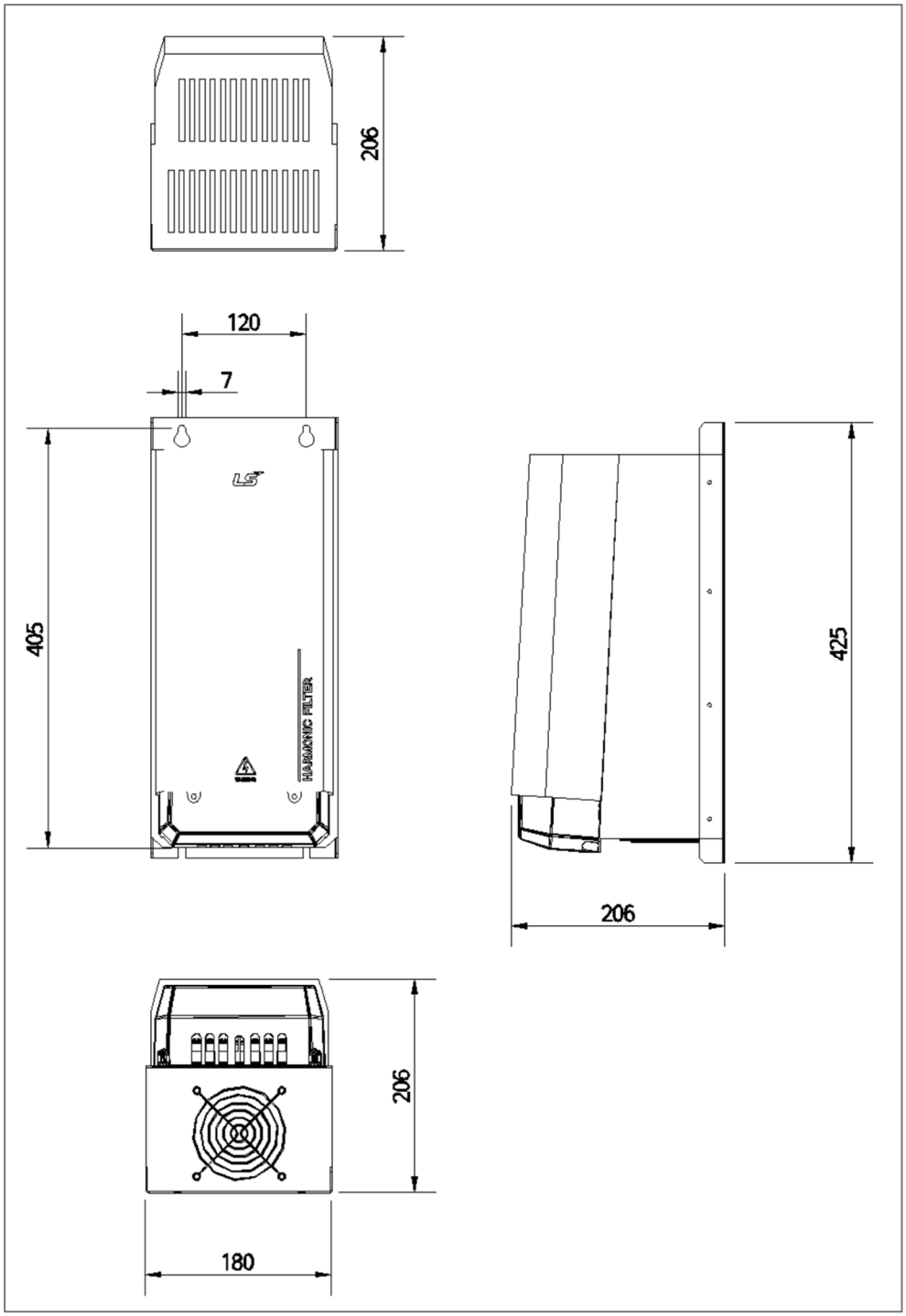
- J Frame

1) Dimension

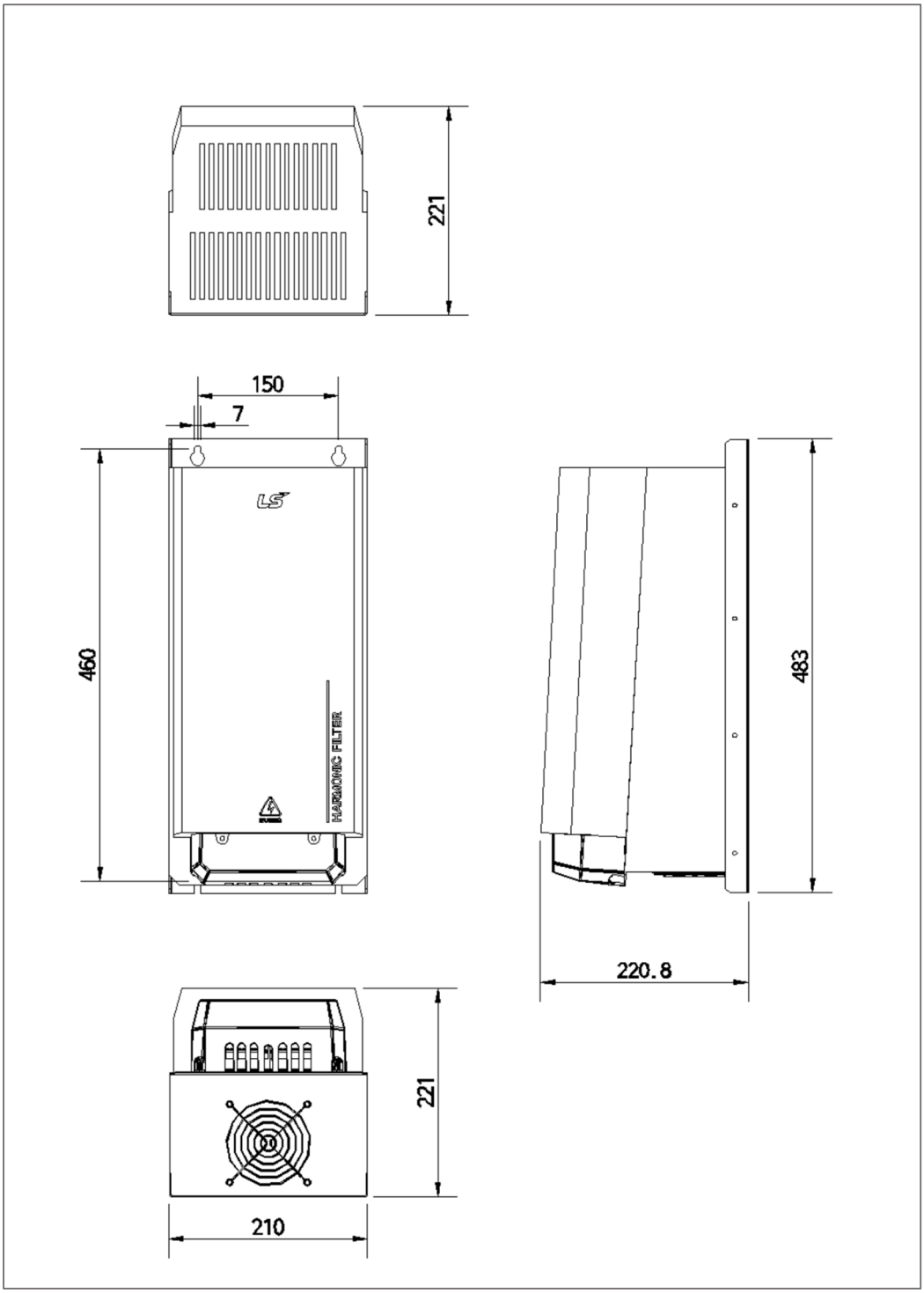
Frame A



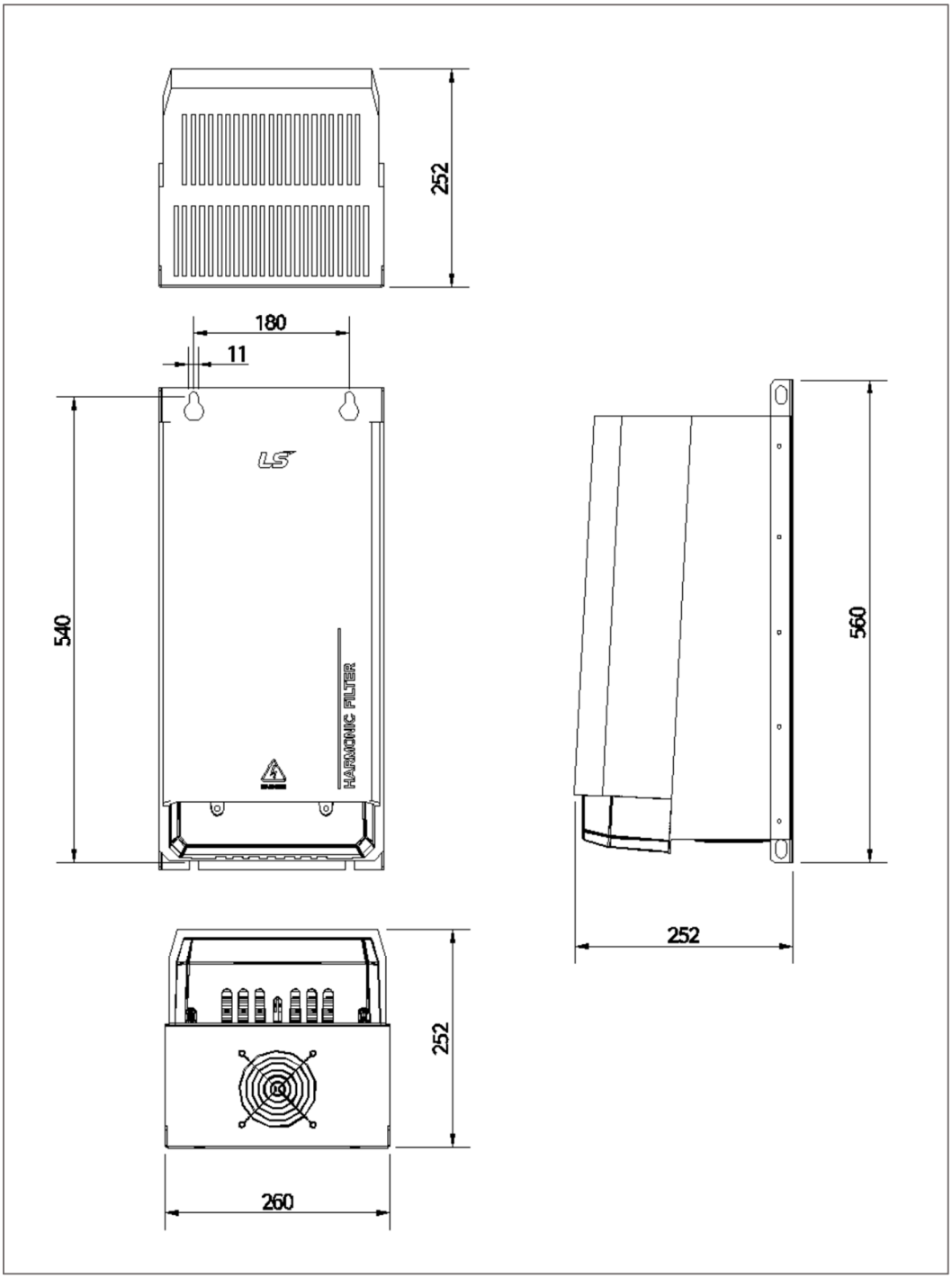
Frame B



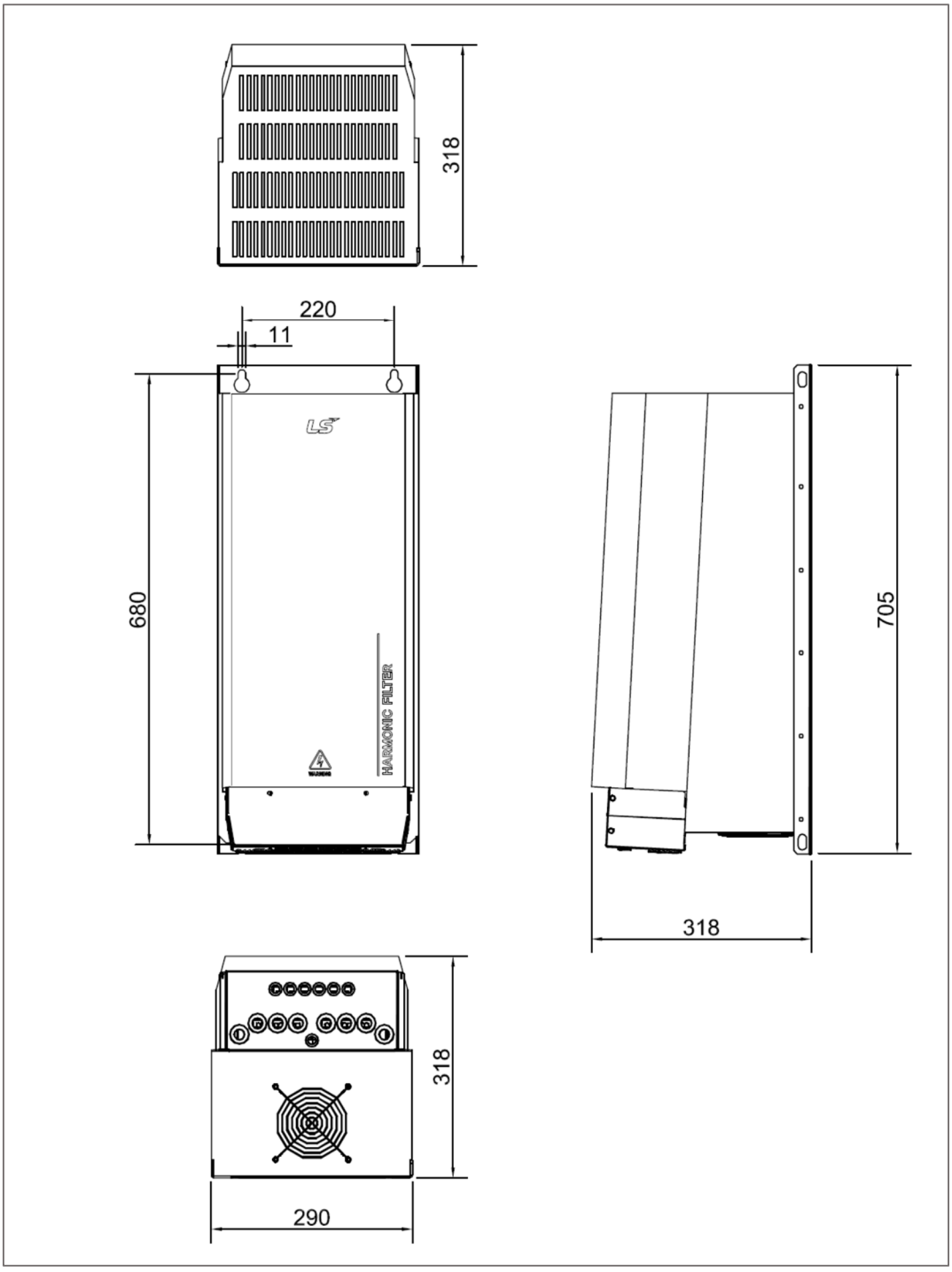
Frame C



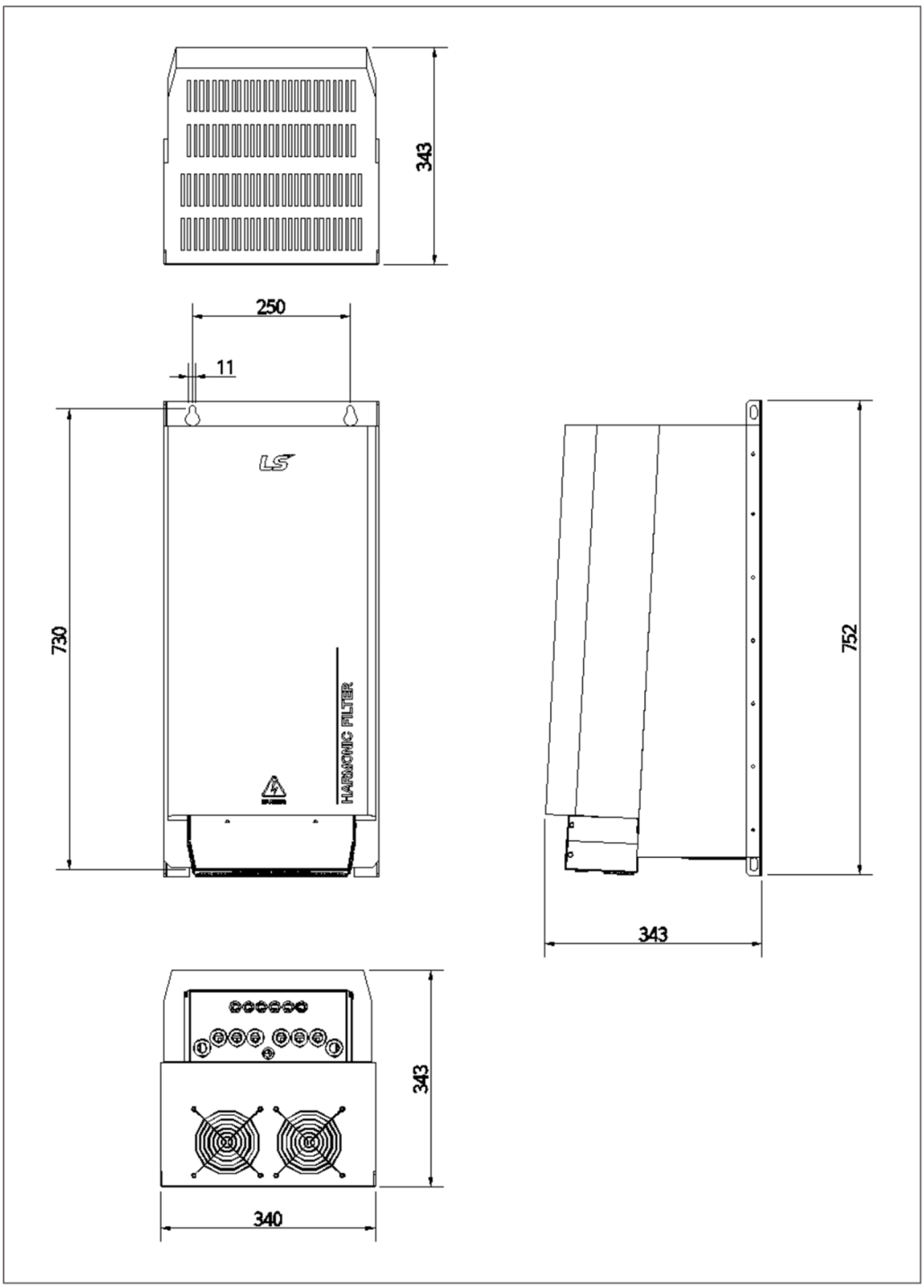
Frame D



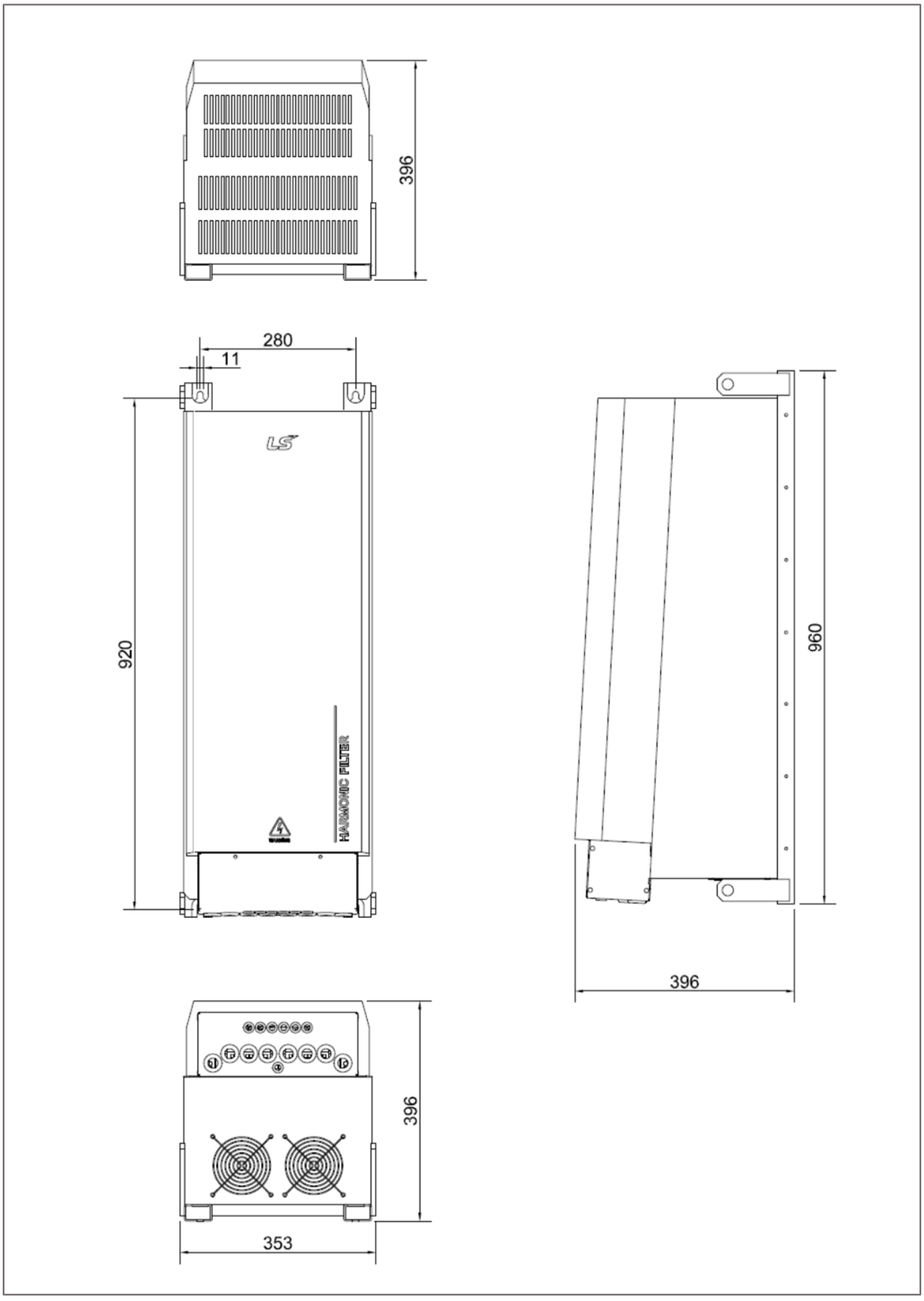
Frame E



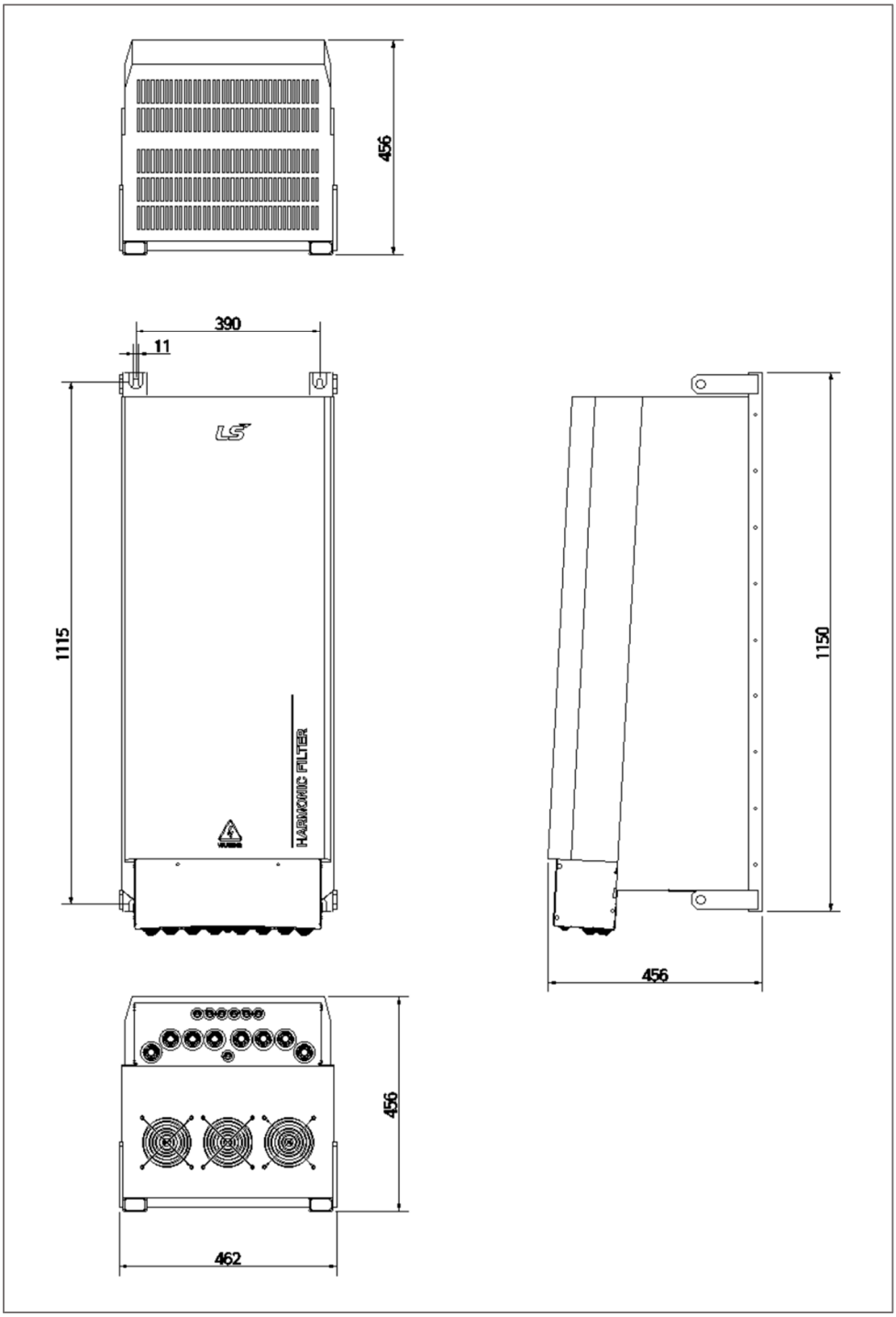
Frame F



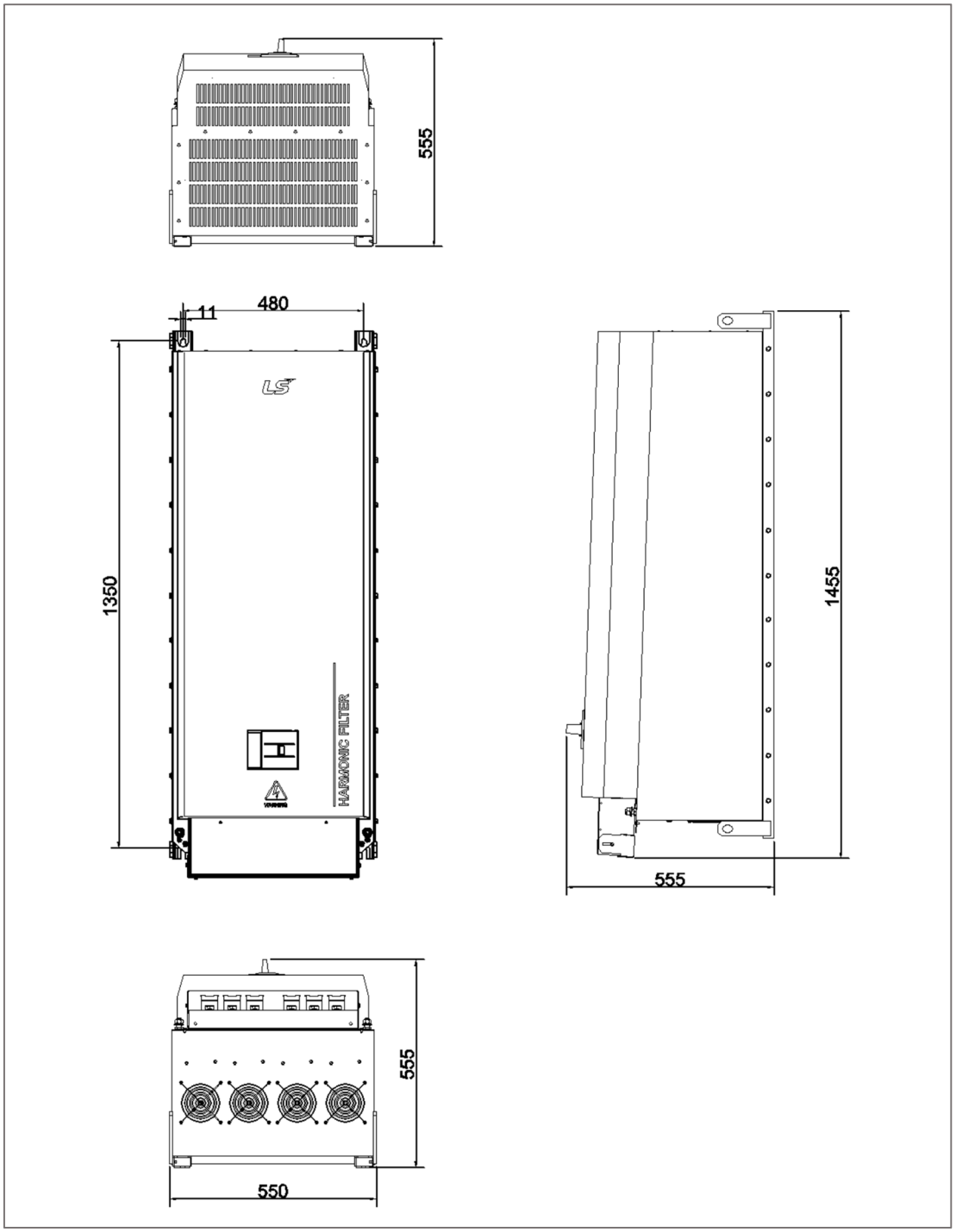
Frame G



Frame H



Frame J



2) Dimension size by product frame

[mm]

Frame	W	H	D	W1	H1	H2	T
A	160	360	185	120	340	302	7
B	180	425	206	120	405	370	7
C	210	483	221	150	460	430	7
D	260	560	252	180	540	491	11
E	290	705	318	220	680	635	11
F	340	752	343	250	730	684	11
G	353	960	396	280	920	863	11
H	462	1150	456	390	1115	1053	11
J	550	1455	555	480	1350	1300	11

5. Maintenance

HFS Low Harmonic Filters described in this manual are equipped with long life components that ensure a satisfactory function for many years under normal operating conditions. Any operation under extreme conditions such as over-temperatures, overvoltage situations, polluted environments etc. reduces the life expectancy. Following recommendation will help maximizing filter lifetime.

High voltage potentials are involved in the operation of this product. Always remove line side power before attempting for maintenance, and let ample time elapse for the capacitors to discharge to safe levels (<42 V). Residual voltages are to be measured both line to line and line to earth.

Line side power must be disconnected prior to replacement of any part.

5.1. Maintenance schedule

Year	1	2	3	4	5	6	7	8	9	10	11	12
check and clean fan(s)	X	X	X	X	X	X	X	X	X	X	X	X
replace fan(s)				X				X				
check & tighten el. Connections 1)	X	X	X	X	X	X	X	X	X	X	X	X
check el. values of capacitors and harmonics		X		X		X		X		X		X
replace power capacitors							X					

Note: 1) Only external connections need to be checked.

Inspection is based on the above standard inspection cycle. However, if there is a surge in the input/output voltage system or a serious overvoltage condition, the inspection is performed irregularly. In addition, parts are replaced according to the above standard replacement cycle, but if it is determined that replacement is necessary according to the results of regular and irregular checks, please replace the parts.

1) Fan

The LS HFS Low Harmonic Filter is a highly reliable product and requires very low

maintenance cost. Many products such as power supplies, inverters or motor drives use fans for cooling to minimize size and weight. HFS filters are designed with a similar temperature management concept, so fans may need to be maintained and replaced at regular intervals to maintain the functionality and value of the product. Fans are 100% field replaceable without the need to remove. Forced cooling is required for operation of the harmonic filter up to its nominal rating. These cooling units should always be checked and cleaned regularly to ensure sufficient airflow. (if installed)

Note: If noise increases from the cooling fan, please replace the fan regardless of the regular maintenance schedule.

2) Power Capacitor

The capacitor built into the filter is a high-quality component with an average lifespan of up to 100,000 hours (about 10 years or more), but it can be shortened by the operating environment and electrical and thermal stress. Also, power capacitor damage can be caused by serious abnormal supply voltage peaks (i.e. lightning, depending on system protection), but can only be verified by measuring the amount of harmonic distortion on the power side. This can be checked regularly using a modern energy meter or using a power quality analyzer. According to the above considerations, a two-year maintenance interval is desirable.
* Inspection should be performed after a surge in the input/output voltage system or a serious overvoltage condition occurs..

Electrolytic capacitors can be stored for up to 3 years and can be used without any restrictions. After storage, the rated voltage can be applied without any additional work, and system reliability and life expectancy are not affected.
However, if the capacitor is stored for a longer period (more than 3 years) without applying voltage, the dielectric properties may be weakened due to the decomposition process of the electrolytic capacitor.

If the time between installation and commissioning after production is prolonged, electrolytic capacitors can affect the dielectric within the capacitor and reduce its performance.
This shortcoming causes the leakage current to increase immediately after turning on the device in the field. The residual current of a capacitor depends on time, voltage and temperature. Residual current can increase especially when stored for long periods without voltage applied. The amplitude of residual current generated during product commissioning can be up to 10 times greater in the short term. When using after long-term storage, it is necessary to increase the input voltage step by step to restore the dielectric properties of the capacitor.

3) Electrical connections

Depending upon the environment and application, electrical connections, in particular threaded bolts and nuts, can degrade over time by means of losing their initial tightening torque. This holds true not only for the filter, but for any such joint within an electrical installation.
Therefore, it is recommended that all cable wiring be checked and tightened according to the recommended tightening torque during regular or irregular maintenance of the entire

unit incorporating the filter.

6. International standards related to harmonic filters

6.1. IEEE 519-2014

Recommended current distortion limits for systems nominally rated 120 V through 69 kV

The limits in this subclause apply to users connected to systems where the rated voltage at the PCC is
120 V to 69 kV. At the PCC, users should limit their harmonic currents as follows:

–Daily 99th percentile very short time (3 s) harmonic currents should be less than 2.0 times the values given in Table 2.
-Weekly 99th percentile short time (10 min) harmonic currents should be less than 1.5 times the values given in Table 2.
-Weekly 95th percentile short time (10 min) harmonic currents should be less than the values given in Table 2.

All values should be in percent of the maximum demand current, I_L. This current value is established at the PCC and should be taken as the sum of the currents corresponding to the maximum demand during each of the twelve previous months divided by 12. Table 2 applies to harmonic currents whose frequencies are integer multiples of the power frequency.

Table 2 —Current distortion limits for systems rated 120 V through 69 kV

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)[a, b]						
I_{SC}/I_L	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	TDD
< 20[c]	4.0	2.0	1.5	0.6	0.3	5.0
$20 < 50$	7.0	3.5	2.5	1.0	0.5	8.0
$50 < 100$	10.0	4.5	4.0	1.5	0.7	12.0
$100 < 1000$	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

[a] Even harmonics are limited to 25% of the odd harmonic limits above.

[b] Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

[c] All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L.
where
I_{sc} = maximum short-circuit current at PCC
I_L = maximum demand load current (fundamental frequency component)
at the PCC under normal load operating conditions

For interharmonic current components with frequencies that are not integer multiples of the power frequency, users should limit the components to sufficiently low levels so as to not

produce undesirable effects on the power system and connected equipment. Limiting values and appropriate statistical indices should be developed on a case-by-case basis starting from the guidance of Annex A and considering the specifics of the supply system, connected user loads, and provisions for other users.

6.2. EN 61000-3-12 current harmonic limits:

Table 3 – Current emission limits for balanced three-phase equipment

Minimal R_{sce}	Admissible individual harmonic current I_n/I_1 [a] %				Admissible harmonic current distortion factors %	
	I_5	I_7	I_{11}	I_{13}	*THD*	*PWHD*
33	10,7	7,2	3,1	2	13	22
66	14	9	5	3	16	25
120	19	12	7	4	22	28
250	31	20	12	7	37	38
≥350	40	25	15	10	48	46
NOTE 1 The relative values of even harmonics up to order 12 must not exceed 16/n %. Even harmonics above order 12 are taken into account in *THD* and *PWHD* in the same way as odd order harmonics. NOTE 2 Linear interpolation between successive R_{sce} values is permitted. See also Annex B.						
[a] I_1 = reference fundamental current; I_n = harmonic current component.						

Table 4 – Current emission limits for balanced three-phase equipment under specified conditions

Minimal R_{sce}	Admissible individual harmonic current I_n/I_1 [a] %				Admissible harmonic current distortion factors %	
	I_5	I_7	I_{11}	I_{13}	*THD*	*PWHD*
33	10,7	7,2	3,1	2	13	22
≥120	40	25	15	10	48	46
NOTE 1 The relative values of even harmonics up to order 12 must not exceed 16/n %. Even harmonics above order 12 are taken into account in *THD* and *PWHD* in the same way as odd order harmonics. NOTE 2 Linear interpolation between successive R_{sce} values is permitted. See also Annex B						
[a] I_1 = reference fundamental current; I_n = harmonic current component.						

Conditions to use Table 4:

1. The phase angle of the 5th harmonic current related to the fundamental phase voltage is in the range of 90° to 150°.

Note: This condition is normally fulfilled by equipment with an uncontrolled rectifier bridge and capacitive filter, including a 3% AC or 4% DC reactor.

2. The design of the equipment is such that the phase angle of the 5th harmonic current has no preferential value over time and can take any value in the whole interval (0°…360°).

Note: This condition is normally fulfilled by converters with fully controlled thyristor bridges.

3. The 5th and 7th harmonic currents are each less than 5% of the reference fundamental current.

Interpolation of current harmonic limits:

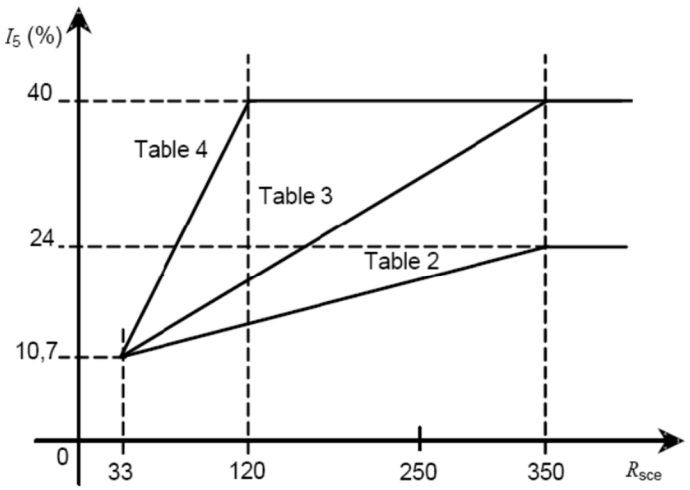


Figure A.1 – Limits of the 5th harmonic current as functions of R_{sce}

Product documentation according to EN 61000-3-12:

For equipment complying with the harmonic current emission limits corresponding to R_{sce} = 33, the manufacturer shall state in his instruction manual or literature:

"Equipment complying with IEC 61000-3-12"

For equipment not complying with the harmonic currents emission limits corresponding to R_{sce} = 33, the manufacturer shall:

- determine the minimum value of R_{sce} for which the limits given in Table 3 or 4 are not exceeded,
- declare the value of the short-circuit power S_{sc} corresponding to this minimal value of R_{sce} in the equipment instruction manual
- and instruct the user to determine, in consultation with the distribution network operator, that the equipment is connected only to a supply of that S_{sc} value or more. For that purpose, the statement in the instruction manual shall be:

"This equipment complies with IEC 61000-3-12 provided that the short-circuit power S_{sc} is greater than or equal to xx at the interface point between the user's supply and the public system. It is the responsibility of the installer or user of the equipment to ensure, by consultation with the distribution network operator if necessary, that the equipment is connected only to a supply with a short-circuit power S_{sc} greater than or equal to xx."

Where xx is the value of S_{sc} corresponding to the minimum value of R_{sce} for which the limits given in Table 3 or 4 are not exceeded.

6.3. Engineering recommendation G5/4-1

Definitions:

Non-linear load or equipment	A load or equipment that draws a non-sinusoidal current when energized by a sinusoidal voltage.
Aggregate load	Non-linear load equal to the sum of the individual non-linear equipment ratings.
Fault level	A value expressed in MVA of the symmetrical short-circuit power at a point in the supply system. It is defined as the product of the symmetrical short-circuit current (I_{sc}) and the nominal system voltage ($U_{ph\text{-}ph}$ or $U_{ph\text{-}n}$): $F = I_{sc} \cdot U_{ph-ph} \cdot \sqrt{3} = I_{sc} \cdot U_{ph-n} \cdot 3$
Harmonic current (I_h)	The RMS value of a harmonic current, of order *h*, expressed in amperes.
Harmonic distortion	The cyclic departure of a waveform from the sinusoidal shape. This can be described by the addition of one or more harmonics to the fundamental.
Point of common coupling (PCC)	The point in the public supply system, electrically nearest to a customer's installation, at which other customers' loads are, or may be, connected.
Total harmonic voltage distortion (THD)	$THD = \sqrt{\frac{\sum_{h=2}^{h=50} V_h^2}{V_1^2}}$

G5/4-1 planning levels for harmonic voltages:

Table 2: Planning Levels for Harmonic Voltages in 400V Systems

Odd harmonics (Non-multiple of 3)		Odd harmonics (Multiple of 3)		Even harmonics	
Order 'h'	Harmonic voltage (%)	Order 'h'	Harmonic voltage (%)	Order 'h'	Harmonic voltage (%)
5	4.0	3	4.0	2	1.6
7	4.0	9	1.2	4	1.0
11	3.0	15	0.3	6	0.5
13	2.5	21	0.2	8	0.4
17	1.6	>21	0.2	10	0.4
19	1.2			12	0.2
23	1.2			>12	0.2
25	0.7				
>25	$0.2 + 0.5(^{25}/_{h})$				

The Total Harmonic Distortion (THD) level is 5%.

G5/4-1 current harmonic limits for loads rated >16A per phase:

Table 7: Stage 1 Maximum Permissible Harmonic Current Emissions in Amperes RMS for Aggregate Loads and Equipment Rated >16A per phase

Harmonic order, h	Emission current, I_h	Harmonic order, h	Emission current, I_h	Harmonic order, h	Emission current, I_h	Harmonic order, h	Emission current, I_h
2	28.9	15	1.4	28	1.0	41	1.8
3	48.1	16	1.8	29	3.1	42	0.3
4	9.0	17	13.6	30	0.5	43	1.6
5	28.9	18	0.8	31	2.8	44	0.7
6	3.0	19	9.1	32	0.9	45	0.3
7	41.2	20	1.4	33	0.4	46	0.6
8	7.2	21	0.7	34	0.8	47	1.4
9	9.6	22	1.3	35	2.3	48	0.3
10	5.8	23	7.5	36	0.4	49	1.3
11	39.4	24	0.6	37	2.1	50	0.6
12	1.2	25	4.0	38	0.8		
13	27.8	26	1.1	39	0.4		
14	2.1	27	0.5	40	0.7		

These limits are based on a typical fault level of 10 MVA; see Table 9 and Application Guide ETR 122.

7. Troubleshooting

LS HFS harmonic filters are high quality products and have undergone rigorous testing and qualification procedures. Every unit runs through suitable tests in our ISO 9001:2000 factories. Due to this reason no major issues need to be expected if the filter is installed, operated, and maintained as described in this document. In the unlikely event of a problem, please contact your local LS Electric partner for assistance.

Disclaimer

This document has been carefully checked. However, LS Electric does not assume any liability for errors or inaccuracies. Published specifications are subject to change without notice. Product suitability for an area of application must ultimately be determined by the customer. In all cases, products must never be operated outside their published specifications. LS Electric does not guarantee the availability of all published products. Latest publications and a complete disclaimer can be downloaded from the LS Electric website. All trademarks recognized.

EC DECLARATION OF CONFORMITY

We, the undersigned,

Representative:	**LS ELECTRIC Co., Ltd.**
Address:	**LS Tower, 127, LS-ro, Dongan-gu, Anyang-si, Gyeonggi-do, Korea**
Manufacturer:	**LS ELECTRIC Co., Ltd.**
Address:	**56, Samseong 4-gil, Mokcheon-eup, Dongnam-gu, Cheonan-si, Chungcheongnam-do, Korea**

Certify and declare under our sole responsibility that the following apparatus:

Type of Equipment:	**Passive harmonic filter**
Model Name:	**HFS series**
Trade Mark:	**LS ELECTRIC Co., Ltd.**

The **HFS** harmonic filters conform to the following standards:

Standards	Edition	Title
IEC 61800-5-1	2: 2007-07	Adjustable Speed Electrical Power Drive Systems –
UL 61800-5-1	1: 2015-03	Part 5-1 : Safety Requirements – Electrical, Thermal and Energy
CSA C22.2 No. 274-13	1: 2013-03	Adjustable speed drives
IEC 61800-3	2.1: 2012-03	Adjustable Speed Electrical Power Drive Systems – Part 3: EMC requirements and specific test methods

These harmonic filters have been type-tested by an independent Notified Body.
This equipment is designed, manufactured and fully tested in Luterbach, Switzerland.

This equipment conforms to the European Economic Community Low Voltage Directive 2014/35/EU (Elect rical Safety) and RoHS Restriction of Hazardous Substances Directive 2011/65/EU.

박창근 2021. 2. 22 (Signature & Date)

Mr. Chang Keun Park / Senior Manager
(Full name / Position)

UL Mark

The UL mark applies to products in the United States and Canada. This mark indicates that UL has tested and evaluated the products and determined that the products satisfy the UL standards for product safety. If a product received UL certification, this means that all components inside the product had been certified for UL standards as well.

CE mark

The CE mark indicates that the products carrying this mark comply with European safety and environmental regulations. European standards include the Machinery Directive for machine manufacturers, the Low Voltage Directive for electronics manufacturers and the EMC guidelines for safe noise control.

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