

## USER AND INSTALLATION MANUAL

### Output Filters FN5420 and Reactors RWK5420



Revision: 05 (February 2023)

English version (original instructions)

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Other technical documentation of our products is also available in the download area of our website [schaffner.com](http://schaffner.com).

Document name:

User and installation manual Output Filters FN5420 and Reactors RWK5420 rev05.pdf

Valid for Output Filters FN5420 and Reactors RWK5420 version:

sine wave filter FN5420 (all versions)

dv/dt filter RWK5420 (all versions)

### Version history

Revision	Date	Description
01	October 2021	Initial version
02	December 2021	Section 2, step 2: mistake in the type of filter to remove common mode interference; <del>differential mode filter</del> -> common mode filter Figure 23 corrected, capacitors connected in delta and not star.
03	March 2022	Table 5 FN5420 IP20 selection table <del>FN5420-13-44-E2FXT</del> -> FN5420-13-33-E2FXT Table 8 and Table 10: Flex wire AWG corrected and metric added
04	December 2022	New Schaffner branding template Section i, <del>The filter reduces</del> -> The reactor reduces Figure 23 and Figure 24 U1,V1,W1 -> U,V,W, U2,V2,W3 -> U',V',W' corrected to reflect the marking on the product.
05	February 2023	Cover picture updated Figure 24 correction of the legend for power capacitor (without resistance) Minor template cosmetic correction

## i. Schaffner output filter

### FN5420 and RWK5420 product highlights

Whenever electricity is used to drive an equipment, in particular when a motor drive is controlling the speed of an electric motor special attention for the noises generated by the motor drives need to be taken into considerations. Schaffner sine wave filters help to avoid problems that can result in purely functional difficulties to very severe motor damage.

Sine wave filters FN5420 series offer state of the art motor protection for the most demanding applications. By installing a sine wave filter between your drive and motor:

- The filter converts the rectangular PWM output voltage of the drive into a **smooth sinusoidal wave form** signal with low residual ripple and without any voltage peaks between phases.
- The filter **eliminates premature damage of the motor** caused by high dv/vt, overvoltage, cable ringing and motor overheating. It improves bearing lifetime by reducing the currents circulating through it<sup>i</sup>.
- It allows **extended motor cable length** to be used between drive and motor.

Dv/dt reactor RWK5420 series offer economical motor protection for various applications. By installing a dv/dt reactor between your drive and motor:

- The reactor reduces the steep dv/dt generated by the IGBT in the inverter to a level making it possible to fulfill standard as IEC 60034-17/25.
- The reactor **reduces premature damage of the motor** caused by high dv/vt, overvoltage, cable ringing, motor overheating and eddy current losses.

This user manual is intended to support designers, installers, and application engineers with filter selection, installation, application, and maintenance. It provides helpful solutions to overcome motor protection challenges and answers frequently asked questions.

If you require additional support, please feel free to contact Schaffner or our local partner.

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<sup>i</sup> In case of problem with bearing current, sine wave filter plus addons type FN5030 would eliminate the flashover created at switching, increasing even more the bearing total lifetime.

#### Performance Guarantee

The remaining voltage and current ripple at motor terminals is reduced to values <5% according to EN 61000-2-2.

## **ii. Minimum system Requirements**

The highest performance levels of the selected filter will be achieved when the following system conditions are met:

- Motor frequency: up to 60Hz without derating and up to 200Hz with derating (see section 2.4.2)
- Maximum surrounding air temperature: 70°C for filter sizes 26 to 1'100A and 100°C for filter sizes 2.3 to 18A, always with derating above 45°C.
- Nominal voltage:  $\pm 10\%$
- Voltage unbalance (at filter input): <3%
- Maximum DC link voltage: 750VDC

## **iii. Important user notice**



Schaffner sine wave filters are designed for the operation on the output (motor) side of converters, such as AC or DC motor drives. Filter suitability for a given application must be determined by the user on a case-by-case basis. Schaffner will not assume liability for any consequential downtimes or damages resulting from use or application of Schaffner sine wave filters beyond their specifications. Schaffner sine wave filters are not designed for single-phase or split-phase applications.

# i. General Safety Notes and Installation Guidelines (Cautions and Warnings)

## 1. Important Information

These general safety notes refer to the group of power quality filters including active and passive harmonic filter (AHF, PHF), 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 Schaffner product until you have a full knowledge of the equipment, safety notes and installation guidelines. The same applies 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	Description
 <b>CAUTION</b>	Follow these instructions to avoid hazardous conditions which could cause minor or moderate injury or may cause damages to the unit.
 <b>WARNING</b>	Follow these instructions to avoid hazardous conditions which could result in death or serious injury.
<b>NOTICE</b>	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, don't 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/slot 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) and neutral terminal (if any) of the filter. The filter label may also indicate LINE (grid side terminals) and LOAD (power electronics terminals).
- ▶ For the electrical connection of the filter terminals, apply the torques 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 terminals, e.g. for over-temperature monitoring. These features have to be properly used before energizing the filter. If uncertain, please consult your local Schaffner representative.
- ▶ Active Harmonic Filters (AHF) are working with current transformers (CTs) which are a 3rd party product and which are typically installed in electrical equipment with lethal high voltage levels. Before attempting to install CTs read the CT installation safety page provided by the CT manufacturer. Always consider transformer as a part of the circuit to which it is connected, and do not touch the leads and terminals or other parts of the transformer unless they are known to be grounded.
- ▶ In order to get the maximum benefit out of your power quality filter, please also consult additional user manuals, installation manuals, whitepaper and other material, published in the download section of [www.schaffner.com](http://www.schaffner.com). These additional guidelines provide helpful hints for equipment related topics as well as technical knowledge.

## 3. Safety Notes and Regulations

1. Label on equipment 2. 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 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 earthing 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 national electric codes when handling, installing, operating or maintaining electrical equipment.
 	Some product may include EMC filters which may cause leakage currents to ground. 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.
 	Using the direct OFF setting in AHF does not disconnect the equipment from mains and is thus not to be used as a safety switch.
 	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.
 	Power quality filters are lossy electrical components. Parts/surfaces of the equipment may get hot under load operating conditions.
<b>NOTICE</b>	At altitudes above 2000m, please contact Schaffner prior to installation.
<b>NOTICE</b>	Filter suitability for a given application must ultimately be determined by the user (the party that is putting the filter into operation) on a case by case basis. Schaffner will not assume liability for any consequential downtimes or damages resulting from use of filters outside their specifications.
 	In case of uncertainty and questions please contact your local Schaffner partner for assistance (details per region available at <a href="http://www.schaffner.com">www.schaffner.com</a> ).

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# 1 Sine wave filter FN5420 designation

## 1.1 Sine wave filter designation

The filter designation is structured from the output filters characteristics.

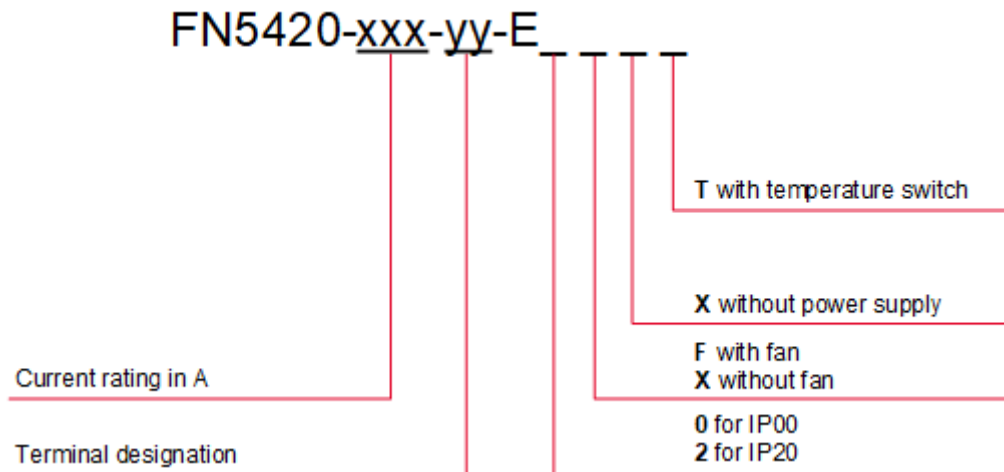


Figure 1 Schaffner sine wave filter designation

- The first part of the designation 'FN5420-xxx-yy-E \_ \_ \_ \_' refer to the sine wave filter from Schaffner output filter products.
- The second part of the designation 'FN5420-xxx-yy-E \_ \_ \_ \_' indicates the current rating at rated voltage and 50Hz (note that it can be rounded to 2 significant digits, please check the exact value in datasheet and section 3.1 below)
- The third part of the designation 'FN5420-xxx-yy-E \_ \_ \_ \_' indicates the filter terminal type. For more details, please consult the datasheet and section 3.1 below.
- The fourth part of the designation 'FN5420-xxx-yy-E \_ \_ \_ \_' contains 4 slots, the first is the IP degree of protection, second, the presence of active ventilation (fan), third the presence of a power supply for the fan (if present) and the last one indicates the presence or not of a temperature switch.

Note that only specific combinations exist, please refer to the selection tables for complete list.

### 1.1.1 Example of sine wave filter designations

**FN5420-90-99-E0XXT**: Output filter type sine wave filter for 50/60Hz, rated 90A at nominal voltage and 50Hz, with terminal type 99 (bus bar), rated IP00, without fan nor power supply and with temperature switch.

**FN5420-13-44-E2FXT**: Output filter type sine wave filter for 50/60Hz, rated 13.2A at nominal voltage and 50Hz (note that the last digit precision on rated current is not visible directly in the designation), with terminal type 44, rated IP20 (enclosure), with fan and no power supply and with temperature switch.



## 1.2 Dv/dt reactor designation

The filter designation is structured from the output filters characteristics.

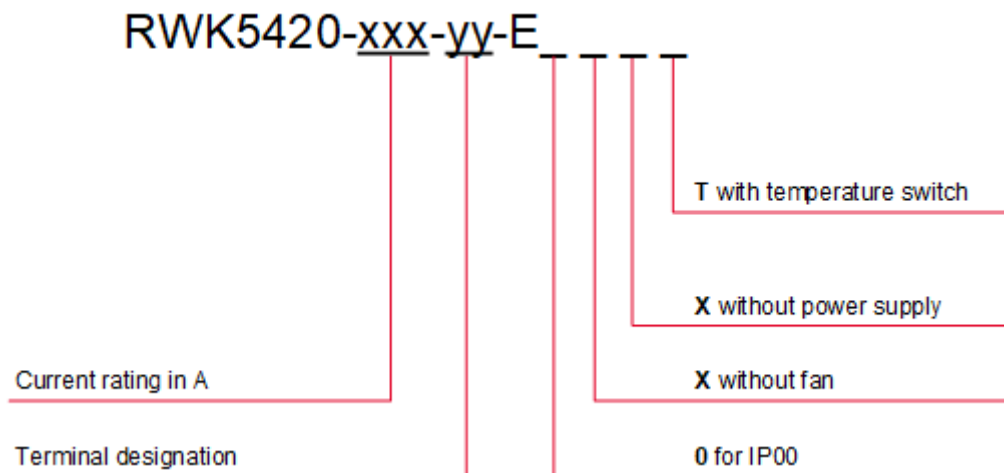


Figure 2 Schaffner output filter reactor designation

- The first part of the designation 'RWK5420-xxx-yy-E\_ \_ \_ \_' refer to the dv/dt reactors 6% from Schaffner output filter products.
- The second part of the designation 'RWK5420-xxx-yy-E\_ \_ \_ \_' indicates the current rating at rated voltage and 50Hz (note that it can be rounded to 2 significant digits, please check the exact value in datasheet and section 3.2 below).
- The third part of the designation 'RWK5420-xxx-yy-E\_ \_ \_ \_' indicates the filter terminal type. For more details, please consult the datasheet and section 3.2 below.
- The fourth part of the designation 'RWK5420-xxx-yy-E\_ \_ \_ \_' contains 4 slots, the first is the IP degree of protection, second, the presence of active ventilation (fan), third the presence of a power supply for the fan (if present) and the last one indicates the presence or not of a temperature switch.

Note that only specific combinations exist, please refer to the selection tables for complete list.

### 1.2.1 Example of sine wave filter designations

**RWK5420-90-99-E0XXT**: Output filter type dv/dt reactor for 50/60Hz, rated 90A at nominal voltage and 50Hz, with terminal type 99 (bus bar), rated IP00, without fan nor power supply and with temperature switch.

## 1.3 Additional Resources

The Schaffner group does provide a number of additional resources available at [schaffner.com](http://schaffner.com) to understand power quality in general and product in particular.

## 1.4 Naming convention

PWM	Pulse width modulation
fPWM	Frequency of the PWM (drive frequency)

## 2 Filter selection

Schaffner output filters need to be selected according to the applications specifications and needs.

### Step 1: motor frequency

Sine wave filter FN5420 series and dv/dt reactor RKW5420 series work at rated current up to a motor frequency of 60Hz and with a derating up to 200Hz, see derating in section 2.4.2.

Table 1 motor frequency

Filter series	Network frequency	Maximum motor frequency at rated current	Maximum motor frequency with a derating
FN5420	50/60Hz	60Hz	200Hz
RWK5420	50/60Hz	60Hz	200Hz

### Step 2: motor cable characteristics

The motor cable length between sine wave filter and the motor, is an important metric for the proper working of the drive, sine wave filter and motor. The maximum cable length is either limited by the drive or the filter. Schaffner sine wave filter FN5420 series bring very few limitations in this regard with a maximum cable length of at least 1000m for all filter size and up to 2000m for larger filters at the minimum fPWM. It is often the case that the drive is more restrictive on the cable length, furthermore the total voltage-drop of the filter plus cable is to be considered, please consult the drive user manual for more information.

The type of cable, whenever it is shielded or unshielded has also an influence on the performance. Using an unshielded cable without addition common mode filter cause common mode interference on the line. Results and behavior might vary for each specific application. Schaffner recommend using shielded cable between the sine wave filter and the motor or unshielded cable with an additional common mode filter, i.e. Schaffner sine wave filter plus FN5030 series (not part of this user manual). For more information, please consult the Schaffner output filter product page at [schaffner.com](http://schaffner.com) or contact your Schaffner representative.

Table 2 motor cable at minimum fPWM

Filter series	Maximum unshielded cable length*	Maximum shielded cable length
FN5420 up to 250A	1000m	1000m
FN5420 from 300A to 630A	1500m	1500m
FN5420 from 710A to 1000A	2000m	2000m
RWK5420	100m**	100m**

\* Usage of shielded cable is still recommended. Drive and system compatibility to be checked.

\*\* See limitation according to drive switching frequency in step 3

For sine wave filter FN5420, the above limits are given at the minimum allowed fPWM. For other frequencies see example in the Figure 3 below. For fPWM limitation see step 3 below.

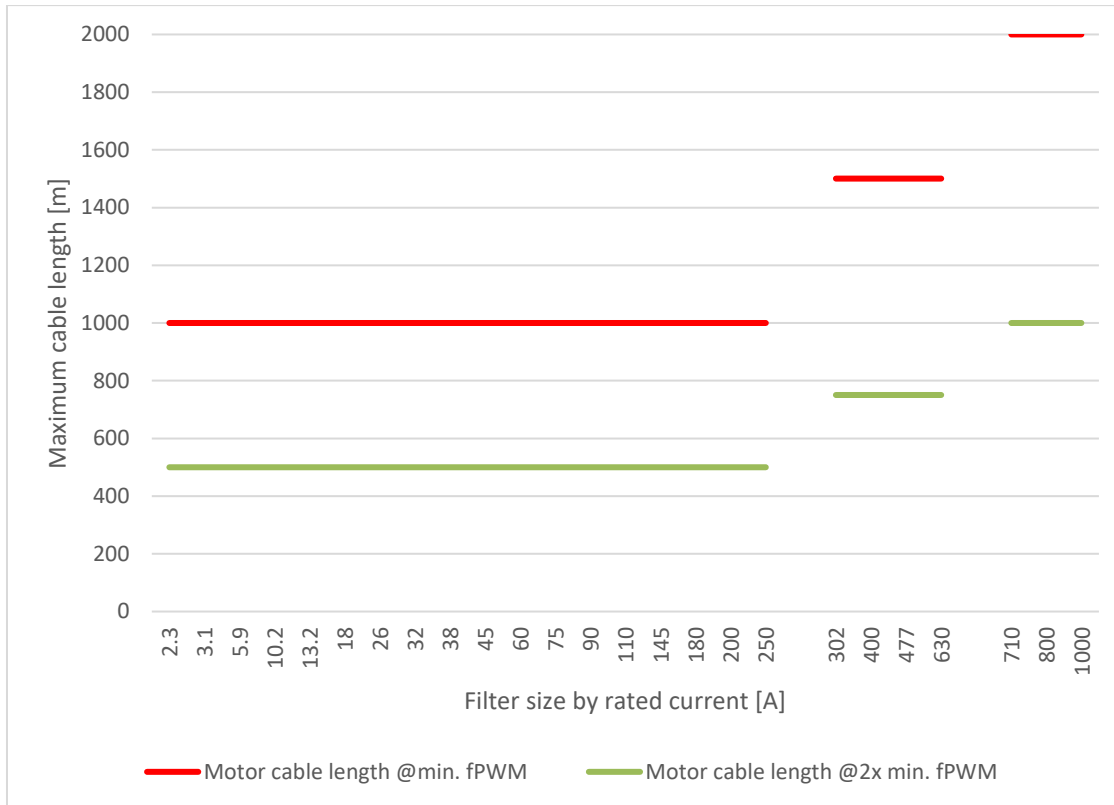


Figure 3 FN5420 maximum cable length by filter size and fPWM

### Step 3: drive switching frequency

The usage of sine wave filter imposes some limit on the switching frequency of the drive (fPWM). The minimum fPWM is dependent on the filter size and the maximum fPWM is the same for the whole series, see Table 3 below.

Dv/dt reactor RWK5420 series doesn't have any minimum fPWM but is still limited to the same maximum fPWM than sine wave filter FN5420 series. The maximum switching frequency must be reduced according to the cable length or the cable length must be limited for a given switching frequency. These limits are giving in the Table 3 and Figure 4 below and in the datasheet.

Table 3 minimum and maximum switching frequency

Filter series	Minimum switching frequency (fPWM)	Maximum switching frequency (fPWM)
FN5420 up to 110A	4kHz	16kHz
FN5420 from 145A	2kHz	16kHz
RWK5420 up to 110A	None	4kHz with 100m cable 16kHz with 20m cable Other values see Figure 4
RWK5420 from 145A	None	16kHz

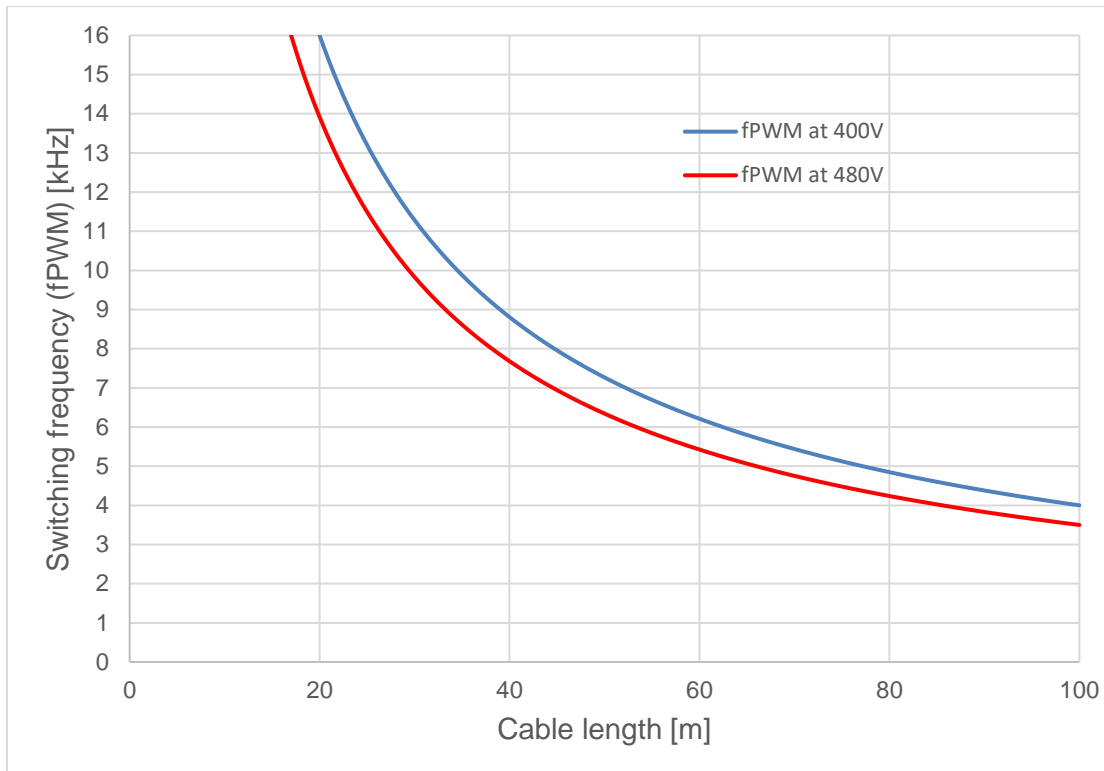


Figure 4 RWK5420 limitation in switching frequency and cable length

#### Step 4: motor protection and acoustic noise

Output filters are meant to filter the signal coming out of the drive feeding the motor. Filter type dv/dt reactor, like RWK5420 series, allow to reduce the voltage rise (dv/dt) visible by the motor. This reduces the stress on the motor insulation, reduce the temperature of the motor and thus increase its total lifetime.

Sine wave filter offers more in terms of motor protection by providing a sinusoidal phase to phase voltage to the motor, this will bring the stress on the insulation and the temperature rise to the minimum physically possible level. In addition, the usage of sine wave filter reduces the current flowing between the rotor and the stator through the motor bearing (i.e. bearing current)<sup>i</sup>, increasing furthermore the service life time of the motor. Finally, sine wave filter reduces motor acoustic noise, improving the comfort at the facility where the motor is installed.

<sup>i</sup> In case of problem with bearing current, sine wave filter plus add-ons type FN5030 would eliminate the flashover created at switching, increasing even more the bearing total lifetime.

## 2.1 Filter selection table FN5420 IP00

Table 4 FN5420 IP00 selection table

Filter	Rated current @ 45°C/up to 60Hz	Typical motor drive power rating @ 400 V*	Typical motor drive power rating @ 480 V**	Nominal inductance	Nominal capacitance**	Min. switching frequency	Power Loss at rated current 400V 50Hz ,45°C, and full load****	Weight	Terminal
	[A]	[kW]	[kW]	[mH]	[μF]	[kHz]	[W]	[kg]	
FN5420-2.3-88-E0XXT	2.3	0.75	0.90	19.2	3x0.47	4	41	1.20	88
FN5420-3.1-88-E0XXT	3.1	1.1	1.3	14.2	3x0.68	4	45	1.55	88
FN5420-5.9-88-E0XXT	5.9	2.2	2.6	7.48	3x1.5	4	76	2.2	88
FN5420-10-88-E0XXT	10.2	4.0	4.8	4.32	3x2.2	4	91	5.1	88
FN5420-13-89-E0XXT	13.2	5.5	6.6	3.34	3x3.0	4	123	5.5	89
FN5420-18-89-E0XXT	18	7.5	9.0	2.45	3x3.7	4	150	6.6	89
FN5420-26-92-E0XXT	26	11	13	1.70	3x5	4	127	9.5	92
FN5420-32-92-E0XXT	32	15	18	1.38	3x6	4	196	11.9	92
FN5420-38-92-E0XXT	38	19	22	1.16	3x8	4	229	12.1	92
FN5420-45-92-E0XXT	45	22	26	0.980	3x8	4	272	13.7	92
FN5420-60-92-E0XXT	60	30	36	0.735	3x12	4	283	18.5	92
FN5420-75-99-E0XXT	75	37	44	0.588	3x15	4	154	21.5	99
FN5420-90-99-E0XXT	90	45	54	0.490	3x20	4	239	25.0	99
FN5420-110-99-E0XXT	110	55	66	0.401	3x20	4	283	28.5	99
FN5420-145-99-E0XXT	145	75	90	0.304	3x100	2	472	56	99
FN5420-180-99-E0XXT	180	90	108	0.245	3x150	2	658	58	99
FN5420-200-99-E0XXT	200	110	132	0.221	3x150	2	707	60	99
FN5420-250-99-E0XXT	250	132	158	0.176	3x200	2	882	76	99
FN5420-300-99-E0XXT	302	160	192	0.146	3x250	2	936	98	99
FN5420-400-99-E0XXT	400	200	240	0.110	3x300	2	1023	128	99
FN5420-480-99-E0XXT	477	250	300	0.092	3x350	2	1318	155	99
FN5420-630-99-E0XXT	630	315	378	0.070	3x500	2	1459	185	99
FN5420-710-99-E0XXT	710	355	426	0.062	3x550	2	1922	220	99
FN5420-800-99-E0XXT	800	400	480	0.055	3x600	2	2062	262	99
FN5420-1000-99-E0XXT	1000	500	600	0.044	3x750	2	2315	366	99

\* General purpose four-pole (1500 r/min) AC induction motor rated 400 V/50 Hz.

\*\* General purpose four-pole (1500 r/min) AC induction motor rated 480 V/50 Hz.

\*\*\* Total capacitance value between phases. Capacitor connection in delta ( $\Delta$ ) for all versions.

\*\*\*\* See section 3.3 for calculation of the filter power loss at other operation point. Exact value depends on the motor cable length and type, switching frequency and further stray parameters of the system.

## 2.2 Filter selection table FN5420 IP20

Table 5 FN5420 IP20 selection table

Filter	Rated current @ 45°C up to 60Hz	Typical motor drive power rating @ 400 V*	Typical motor drive power rating @ 480 V**	Nominal inductance	Nominal capacitance***	Min. switching frequency	Power Loss at rated current 400V 50Hz ,45°C, and full load****	Weight	Terminal	Frame size
	[A]	[kW]	[kW]	[mH]	[μF]	[kHz]	[W]	[kg]		
FN5420-2.3-44-E2XXT	2.3	0.75	0.90	19.2	3x0.47	4	41	2.4	44	A
FN5420-3.1-44-E2XXT	3.1	1.1	1.3	14.2	3x0.68	4	45	2.8	44	A
FN5420-5.9-44-E2FXT	5.9	2.2	2.6	7.48	3x1.5	4	76	4.0	44	B
FN5420-10-44-E2FXT	10.2	4.0	4.8	4.32	3x2.2	4	91	6.8	44	B
FN5420-13-33-E2FXT	13.2	5.5	6.6	3.34	3x3.0	4	123	7.2	33	C
FN5420-18-33-E2FXT	18	7.5	9.0	2.45	3x3.7	4	150	7.9	33	C
FN5420-26-33-E2FXT	26	11	13	1.70	3x5	4	127	11.8	33	C
FN5420-32-33-E2FXT	32	15	18	1.38	3x6	4	196	14.2	33	C
FN5420-38-33-E2FXT	38	19	22	1.16	3x8	4	229	14.4	33	C
FN5420-45-34-E2FXT	45	22	26	0.980	3x8	4	272	21	34	D
FN5420-60-34-E2FXT	60	30	36	0.735	3x12	4	283	25	34	D
FN5420-75-35-E2FXT	75	37	44	0.588	3x15	4	154	30	35	E
FN5420-90-35-E2FXT	90	45	54	0.490	3x20	4	239	34	35	E
FN5420-110-35-E2FXT	110	55	66	0.401	3x20	4	283	37.5	35	E

\* General purpose four-pole (1500 r/min) AC induction motor rated 400 V/50 Hz.

\*\* General purpose four-pole (1500 r/min) AC induction motor rated 480 V/50 Hz.

\*\*\* Total capacitance value between phases. Capacitor connection in delta ( $\Delta$ ) for all versions.

\*\*\*\* See section 3.3 for calculation of the filter power loss at other operation point Exact value of the complete system depends on the motor cable length and type, switching frequency and further stray parameters of the system.

## 2.3 Filter selection table RWK5420

Table 6 RWK5420 selection table

Filter	Rated current @ 45°C/up to 60Hz	Typical motor drive power rating @ 400 V*	Typical motor drive power rating @ 480 V**	Nominal inductance	Typical Power Loss at rated current 400V 50Hz ,45°C, and full load***	Weight	Terminal
	[A]	[kW]	[kW]				
RWK5420-2.3-88-E0XXT	2.3	0.75	0.90	19.2	41	1.05	88
RWK5420-3.1-88-E0XXT	3.1	1.1	1.3	14.2	45	1.40	88
RWK5420-5.9-88-E0XXT	5.9	2.2	2.6	7.48	76	2.0	88
RWK5420-10-88-E0XXT	10.2	4.0	4.8	4.32	91	4.8	88
RWK5420-13-89-E0XXT	13.2	5.5	6.6	3.34	123	5.1	89
RWK5420-18-89-E0XXT	18	7.5	9.0	2.45	150	6.2	89
RWK5420-26-92-E0XXT	26	11	13	1.70	127	8.9	92
RWK5420-32-92-E0XXT	32	15	18	1.38	196	11.2	92
RWK5420-38-92-E0XXT	38	19	22	1.16	229	11.4	92
RWK5420-45-92-E0XXT	45	22	26	0.980	272	12.8	92
RWK5420-60-92-E0XXT	60	30	36	0.735	283	17.5	92
RWK5420-75-99-E0XXT	75	37	44	0.588	154	20.3	99
RWK5420-90-99-E0XXT	90	45	54	0.490	239	23.6	99
RWK5420-110-99-E0XXT	110	55	66	0.401	283	27.1	99
RWK5420-145-99-E0XXT	145	75	90	0.304	472	51	99
RWK5420-180-99-E0XXT	180	90	108	0.245	658	52	99
RWK5420-200-99-E0XXT	200	110	132	0.221	707	54	99
RWK5420-250-99-E0XXT	250	132	158	0.176	882	69	99
RWK5420-300-99-E0XXT	302	160	192	0.146	936	90	99
RWK5420-400-99-E0XXT	400	200	240	0.110	1023	118	99
RWK5420-480-99-E0XXT	477	250	300	0.092	1318	136	99
RWK5420-630-99-E0XXT	630	315	378	0.070	1459	164	99
RWK5420-710-99-E0XXT	710	355	426	0.062	1922	200	99
RWK5420-800-99-E0XXT	800	400	480	0.055	2062	239	99
RWK5420-1000-99-E0XXT	1000	500	600	0.044	2315	339	99

\* General purpose four-pole (1500 r/min) AC induction motor rated 400 V/50 Hz.

\*\* General purpose four-pole (1500 r/min) AC induction motor rated 480 V/50 Hz.

\*\*\* See section 3.3 for calculation of the filter power loss at other operation point Exact value of the complete system depends on the motor cable length and type, switching frequency and further stray parameters of the system.

## 2.4 Derating

Sine wave filter FN5420 and dv/dt reactor RWK5420 might be applied with derated current when it is applied beyond specification. Below is the calculation of temperature derating and motor frequency derating.

### 2.4.1 Temperature derating

All sine wave filter FN5420 series and dv/dt reactor RWK5420 series are able to operate at rated current up to an ambient temperature of 45°C (measured next to the device, i.e. inside a cabinet). It is possible to use the filter and reactor above this limit, but a derating must be applied on the maximum current going through the filter.

The derating calculation is as follow:

$$I_{derated} = I_{nom} \sqrt{\frac{T_{max} - T_{amb}}{T_{max} - T_{nom}}}$$

$I_{derated}$  = current with derating

$I_{nom}$  = nominal rated current

$T_{nom}$  = nominal temperature 45°C

$T_{amb}$  = ambient temperature (maximum that can occur in application), must be  $\geq T_{nom}$

$T_{max}$  = maximum allowed temperature for the filter or reactor (see below)

Please note that the maximum allowed temperature is a fixed value from the product specification, but it is not the same depending on the filter size (smaller filter have a higher tolerance).

Filter type	Maximum allowed ambient temperature ( $T_{max}$ )
FN5420 sizes 2.3A to 18A	100°C
FN5420 sizes 26A to 1000A	70°C
RWK5420 sizes 2.3A to 18A	100°C
RWK5420 sizes 26A to 1000A	100°C

Note that you can use a spreadsheet to easily calculate the result as follow:

$I_{nom}$ [A]	75
$T_{amb}$ [°C]	50
$T_{nom}$ [°C]	45
$T_{max}$ [°C]	70
$I_{derated}$ [A]	<b>Formula</b>

**Formula:** =Inom\*SQRT((Tmax-Tamb)/(Tmax-Tnom))



## 2.4.2 Motor frequency derating

All sine wave filter FN5420 series and dv/dt reactor RWK5420 series can operate at rated current for a motor frequency up to 60Hz. They can also operate in case of increased motor speed with motor frequency up to 200Hz by applying a derating on the maximum current allowed in the filter or reactor.

For motor frequency of 100Hz the maximum allowed current in the filter or reactor must be derated to 90% of its rated value (0.9 times the value from the datasheet or value calculated according to the ambient temperature derating).

For motor frequency of 200Hz the maximum allowed current in the filter or reactor must be derated to 50% of its rated value (0.5 times the value from the datasheet or value calculated according to the ambient temperature derating).

All intermediary values can be obtain from the curve in Figure 5

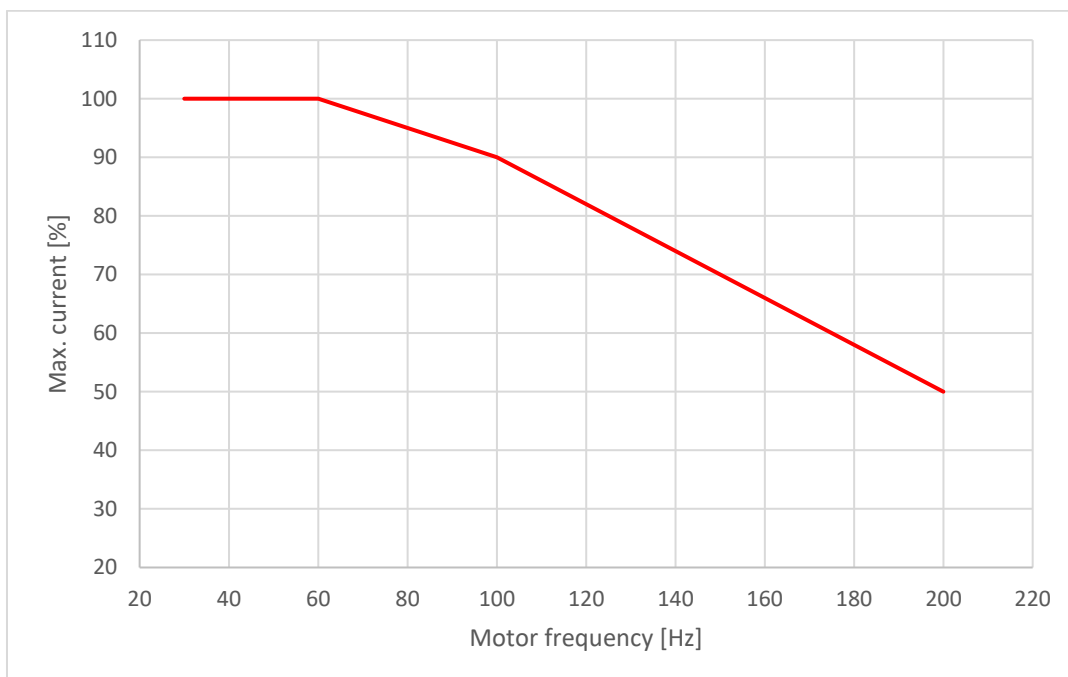


Figure 5 Curve of the current derating according to the motor frequency

## 2.4.3 Calculation example of derating

Example 1: to select a 10A sine wave filter for a 400V 50Hz application that will be running in a cabinet where the ambient temperature can reach up to 60°C. The 10.2A will obviously not fit as we need to apply a derating due to the ambient temperature higher than 45°C. We would select the size above, 13.2A to make the calculation.

$$I_{derated} = I_{nom} \sqrt{\frac{T_{max} - T_{amb}}{T_{max} - T_{nom}}} = 13.2 \sqrt{\frac{100 - 60}{100 - 25}} = 11A$$

## 3 Filter description

### 3.1 General electrical specifications FN5420

Nominal operating voltage:	3x 480 V AC
Rated operating voltage:	3x 530 V AC
Operating frequency:	Up to 60 Hz (up to 200Hz with derating)
Network:	TN, TT, IT
Minimum switching frequency	2.3 to 110A = 4kHz 145 to 1000A = 2kHz
Maximum switching frequency	16 kHz
Residual ripple voltage	<5% at nominal operation
High potential test voltage: <sup>1)</sup>	P → E 2480 VAC (1s)
Overvoltage Category (IEC60664-1):	III
Protection category:	IP 00, IP 20
Pollution degree:	PD3 (according to standard IEC 60664-1)
Cooling:	IP00: AN IP20: AF 2m/s
Overload capability:	1.5x rated current for 1 minute, once per hour
Capacitive current @ no load:	<20% of rated input current, at 400 V AC
Ambient temperature range:	-40°C to +45°C fully operational -40°C to +70°C with derating <sup>3)</sup> for sizes ≥ 26A -40°C to +100°C with derating <sup>3)</sup> for sizes ≤ 18A -40°C to +85°C transportation and storage
Climatic Class (IEC60068-1):	40/070/21
Flammability class:	UL 94V-0
Insulation class of magnetic components:	N (200°C)
Design corresponding to:	UL 61800-5-1, EN 61800-5-1
MTBF @ 45°C/400 V (Mil-HB-217F):	>500,000 hours
MTTR:	IP00: 20 min (capacitor replacement) IP20: 30 min (capacitor and fan replacement)
Lifetime (calculated):	≥10 years with maintenance
Safety monitor output signal:	Thermal switch NC 180° C (UL-approved) to detect overload of chokes

<sup>1)</sup> Repetitive tests to be performed at max. 80% of above levels, for 2 seconds.

<sup>2)</sup> Magnetic current gives the limit of saturation, above this value the performance cannot be guarantee.

<sup>3)</sup> See applicable derating in section 2.4.1

### 3.2 General electrical specifications RWK5420

Nominal operating voltage:	3x 480 V AC
Rated operating voltage:	3x 530 V AC
Operating frequency:	Up to 60 Hz (up to 200Hz with derating)
Network:	TN, TT, IT
Minimum switching frequency	None
Maximum switching frequency	16 kHz
Residual ripple voltage	<5% at nominal operation
High potential test voltage: <sup>1)</sup>	P → E 2480 VAC (1s)
Overtoltage Category (IEC60664-1):	III
Protection category:	IP 00
Pollution degree:	PD3 (according to standard IEC 60664-1)
Cooling:	Natural cooling (AN)
Overload capability:	1.5x rated current for 1 minute, once per hour
Ambient temperature range:	-40°C to +45°C fully operational -40°C to +100°C with derating <sup>3)</sup> -40°C to +100°C transportation and storage
Climatic Class (IEC60068-1):	40/100/21
Flammability class:	UL 94V-0
Insulation class of magnetic components:	N (200°C)
Design corresponding to:	EN 61558-2-20 or EN 60076-6
MTBF @ 45°C/400 V (Mil-HB-217F):	>500,000 hours
Lifetime (calculated):	≥10 years with maintenance
Safety monitor output signal:	Thermal switch NC 180° C (UL-approved) to detect overload of chokes

<sup>1)</sup> Repetitive tests to be performed at max. 80% of above levels, for 2 seconds.

<sup>2)</sup> Magnetic current gives the limit of saturation, above this value the performance cannot be guarantee.

<sup>3)</sup> See applicable derating in section 2.4.1

### 3.3 Power losses

The typical power losses given in Table 4, Table 5 and Table 6 are valid for the rated current at 400V 50Hz. Other measurement points can be calculated for partial load and various frequency usage according to Figure 6.

Motor speed 100% is matching the nominal speed at 50Hz. For reduced motor speed, use the curves given at 90%, 50% or 10%, select the closest one.

Nominal current is given at 100% (right of the chart), for reduced current follow the curve to the left.

For each combination of relative motor speed and relative current, you get a relative power loss in percentage. Apply this percentage to the typical power losses given in Table 4, Table 5 and Table 6 to get the matching typical power loss at the selected operation point. See also an example below.

Note the influence from the voltage between 400V and 500V is minimal and could be ignored in this calculation.

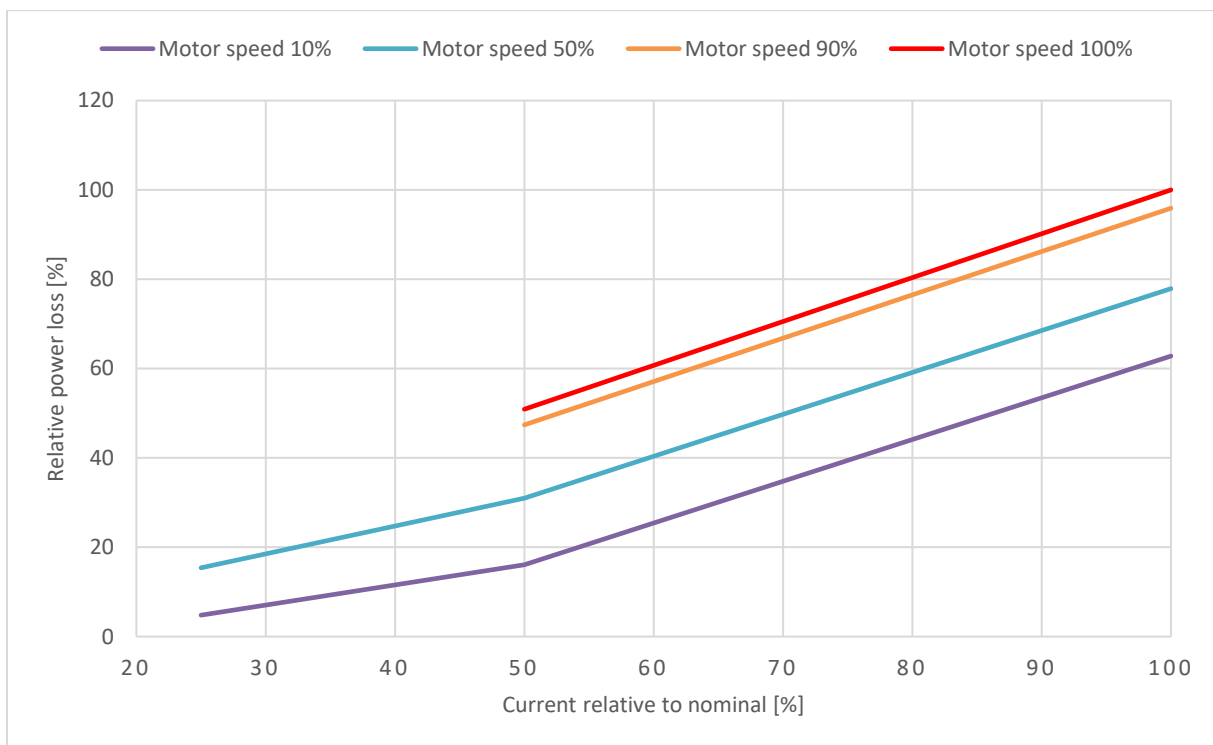


Figure 6 power loss calculation chart

#### 3.3.1 Power loss calculation example

For a system using a sine wave filter type FN5420-45-92-E0XXT you take the typical power loss given in Table 4, 272W. This typical power loss is for 400/500V 50Hz at nominal current of 45A.

If you want to calculate the typical power loss at 25Hz motor speed and 36A operation point, you select the motor speed 50% curve (25/50=50%) and follow the curve up to 80% (36/45=80%) and read the relative value matching on the vertical axis. You get 60% of relative power loss. You apply 60% to the typical power loss given in the Table 4,  $272 \times 60\% = 163\text{W}$ .

In this example the typical power loss at 25Hz, 36A will be 163W.

### 3.4 Additional electrical specifications

Schaffner output filter type sine wave filter FN5420 and dv/dt reactor type RWK5420 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 on clearance according to IEC 60664-1 (table A.2), hereafter enclosed:

Table 7 Altitude correction factors

**Table A.2 – Altitude correction factors**

Altitude m	Normal barometric pressure kPa	Multiplication factor for clearances
2 000	80,0	1,00
3 000	70,0	1,14
4 000	62,0	1,29
5 000	54,0	1,48
6 000	47,0	1,70
7 000	41,0	1,95
8 000	35,5	2,25
9 000	30,5	2,62
10 000	26,5	3,02
15 000	12,0	6,67
20 000	5,5	14,5

Additionally a derating on current is applied in this range. The following chart summarize both the multiplication factor on creepage and the current derating for usage between these altitudes.

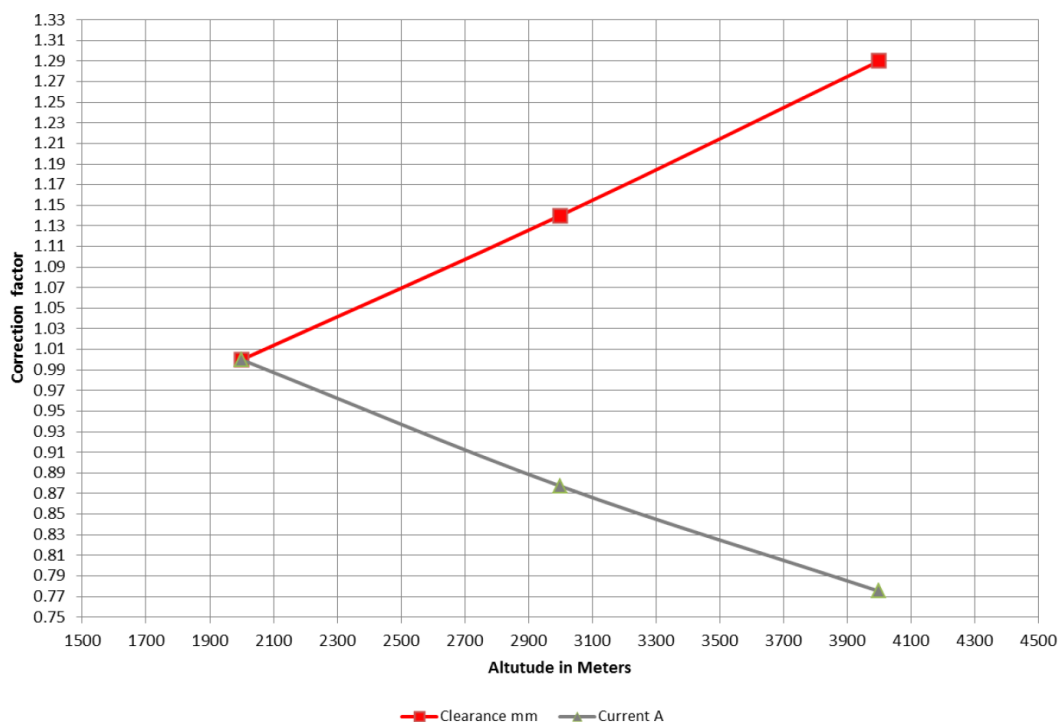


Figure 7 chart of altitude correction factors and current derating

**Remark:** Do not use these filters in altitudes above 4000m without consulting Schaffner first.

Note that clearance of the product itself are compliant at least up to 4000m but customer has to take care of respecting the clearance by selecting cable lug and installing them properly.

## 3.5 Screw size, torque and cable cross-section requirement

### 3.5.1 Power terminals

The cable cross-section must be selected according to the rated filter current, the maximum current, the environment and other special requirement of the application. It should be stranded copper wire cable with a temperature rating of  $\geq 75^{\circ}\text{C}$ . Recommended cable cross-section is given in Table 8 and Table 9. In many applications a shielded motor cable may not be required when a sine wave filter is applied with a motor drive. Anyhow, due to other possible influences of common mode disturbances Schaffner does recommend using shielded motor cables. This is to avoid back-coupling of radiated interferences to the mains cable at the frequency range from 1–30 MHz. This EMC measure however can only be considered efficient, if both ends of the cable shield of the motor cable are put in proper HF low-impedance contact with the ground of the motor and the frequency converter.



Figure 8 Example of proper grounding of the shielding (many other solutions are possible)

The customer is fully responsible to define the most appropriate conductor type according to the application and ensure a proper connection of the filter.

Table 8 FN5420 IP00 and RWK5420 power terminals designation

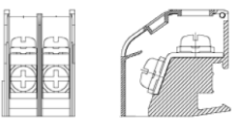
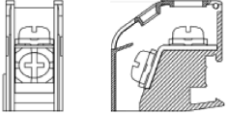
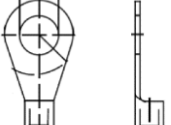
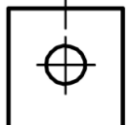
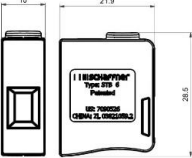
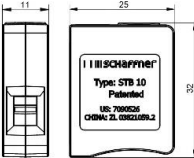
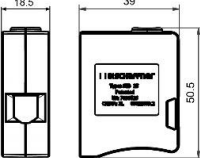
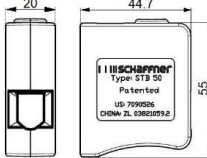
				
Type	<b>-88</b>	<b>-89</b>	<b>-92</b>	<b>-99</b>
Ring cable shoe	-	-	M6	M8 / M10 / M12
Fork cable shoe	M3.5 width max. 6.4mm	M4 width max. 8.0mm	-	-
Flex wire [AWG]	20 - 16	18 - 12		
Flex wire [mm <sup>2</sup> ]	0.5 – 1.5	0.5 – 2.5		
Rec. torque [Nm]	0.78	1.76	-	-

Table 9 FN5420 IP20 power terminals designation

				
Type	<b>-44</b>	<b>-33</b>	<b>-34</b>	<b>-35</b>
Flex wire [AWG]	20 - 8	20 - 6	10 - 2	6 – 1/0
Solid wire [mm <sup>2</sup> ]	0.5 - 10	0.5 - 16	6 - 35	10 - 50
Flex wire [mm <sup>2</sup> ]	0.5 - 6	0.5 - 10	6 - 25	16 - 50
Recomm. torque	1.0 - 1.2Nm	1.5 – 1.8Nm	4.0 - 4.5Nm	7.0 - 8.0Nm

### 3.5.2 Auxiliary signal and earth terminals

The auxiliary signal from temperature sensor and earth terminals screw size and torque are given in Table 10, Table 11 and Table 12 Auxiliary signal terminals on FN5420 IP20

Frame size	Function	Connector type	Solid wire [mm <sup>2</sup> ]	Flex wire AWG	Flex wire [mm <sup>2</sup> ]	Screw torque value [Nm]
All sizes	Thermal switch signal	No connector	0.5 - 6	24 - 10	0.5 - 4	0.7 - 0.8
All sizes	24V fan power input	No connector	0.5 - 6	24 - 10	0.5 - 4	0.7 - 0.8

Table 13.

Table 10 Auxiliary signal terminals on FN5420 IP00 and RWK5420

Type	2.3A & 3.1A	5.9A to 18A	26A to 1000A
Fork cable shoe	M3.5 width max. 6.4mm	M4 width max. 8.0mm	-
Flex wire AWG	20 - 16	18 - 12	20 - 14
Flex wire [mm <sup>2</sup> ]	0.5 - 1.5	0.5 - 2.5	0.5 - 2.5
Rec. torque	0.78Nm	1.76Nm	0.4Nm

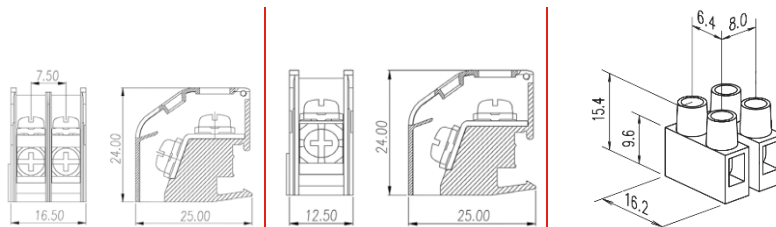


Table 11 Earth terminals on FN5420 IP00 and RWK5420

Size	Thread size	Torque [Nm]
2.3 - 5.9A	M3	0.6
10 - 13A	M4	1.7
18 - 75A	M6	4.0
90 - 1000A	M8	9.0



Table 12 Auxiliary signal terminals on FN5420 IP20

Frame size	Function	Connector type	Solid wire [mm <sup>2</sup> ]	Flex wire AWG	Flex wire [mm <sup>2</sup> ]	Screw torque value [Nm]
All sizes	Thermal switch signal	No connector	0.5 - 6	24 - 10	0.5 - 4	0.7 - 0.8
All sizes	24V fan power input	No connector	0.5 - 6	24 - 10	0.5 - 4	0.7 - 0.8

Table 13 Earth terminals on FN5420 IP20

Frame size	Thread size	Torque [Nm]
A, B, C and D	M5	2.2
E	M8	9.0

### 3.6 Thermal protection switch specifications

The central choke (phase V) is equipped with a thermal protection switch (temperature switch). The switch is connected in series to the auxiliary terminal TS-TS'. If the temperature switch reaches the nominal switching temperature (NST), the switch will open.

Table 14 thermal protection switch specifications

Contact type	Normally closed (NC)
Nominal switching temperature (NST)	180°C
Resetting temperature (RST)	145°C (indication only)
Operating voltage	Up to 250V AC
Rated current AC I <sub>nom</sub>	2.5A                      cosφ                      =                      1.0 1.6A                      cosφ                      =                      0.6 1.8A cosφ = 0.4-0.5

### 3.7 Cooling requirement

Sine wave filter FN5420 IP20 come with embedded ventilation when needed. Thus, it is important to install the filter in a way that the air channels are not blocked and within an ambient temperature according to the specifications from section 2.2.



**Important: Blocking of air channel might cause overheating of filter components.**

## 3.8 Mechanical data

### 3.8.1 Dimensions FN5420 IP00

The drawings of each design is presented below. Dimensions are given in Table 15.

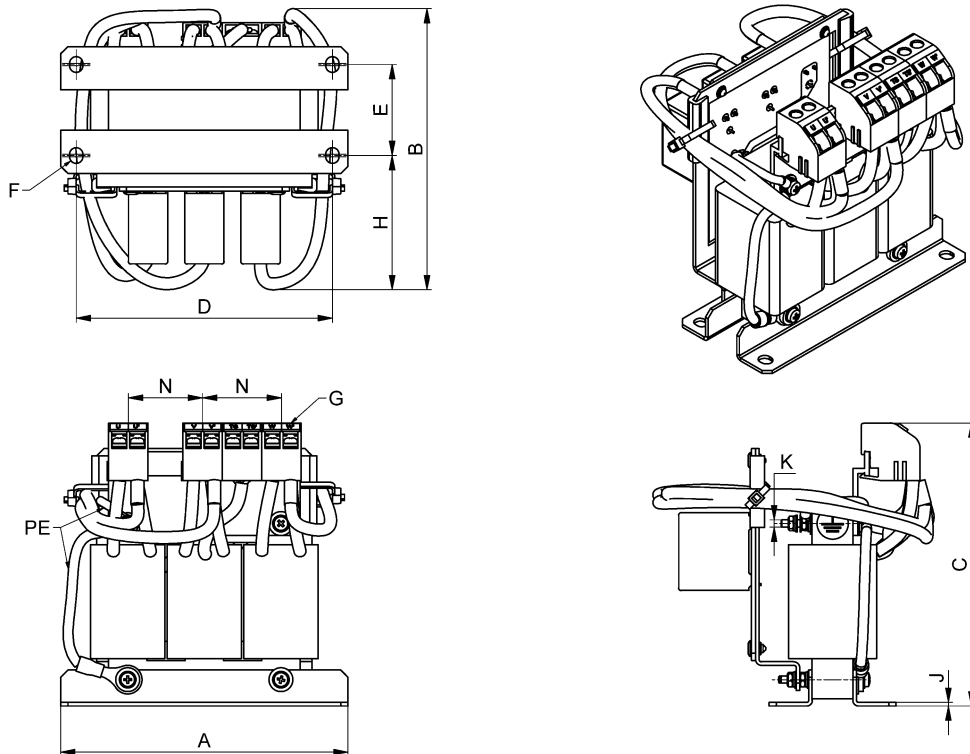


Figure 9 drawings FN5420 IP00 sizes 2.3A to 3.1A

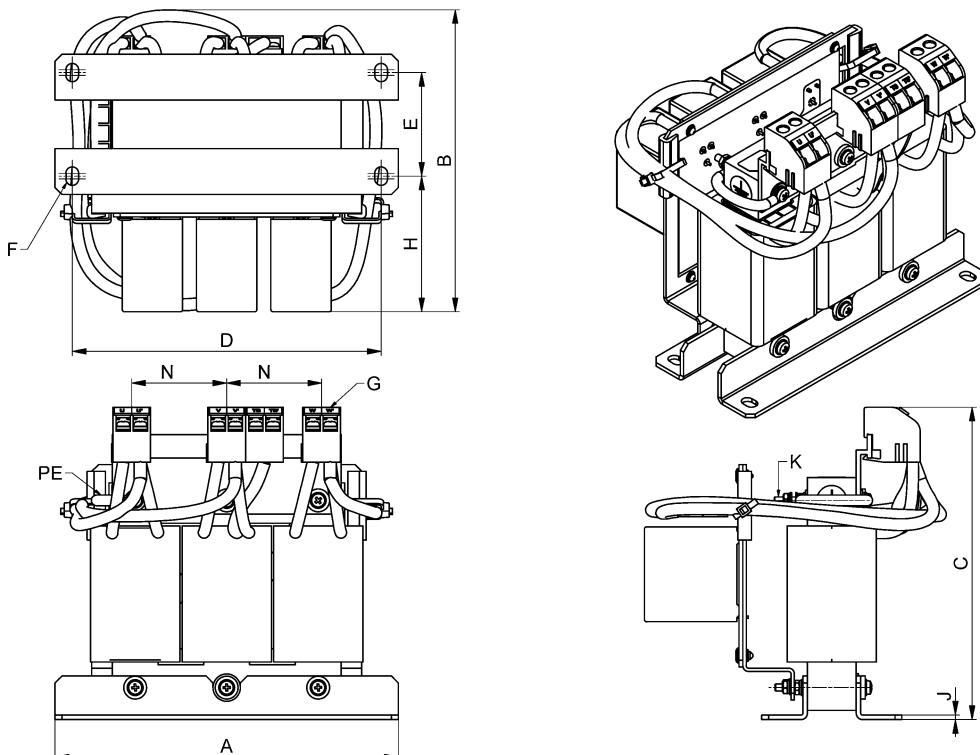


Figure 10 drawings FN5420 IP00 sizes 5.9A to 18A

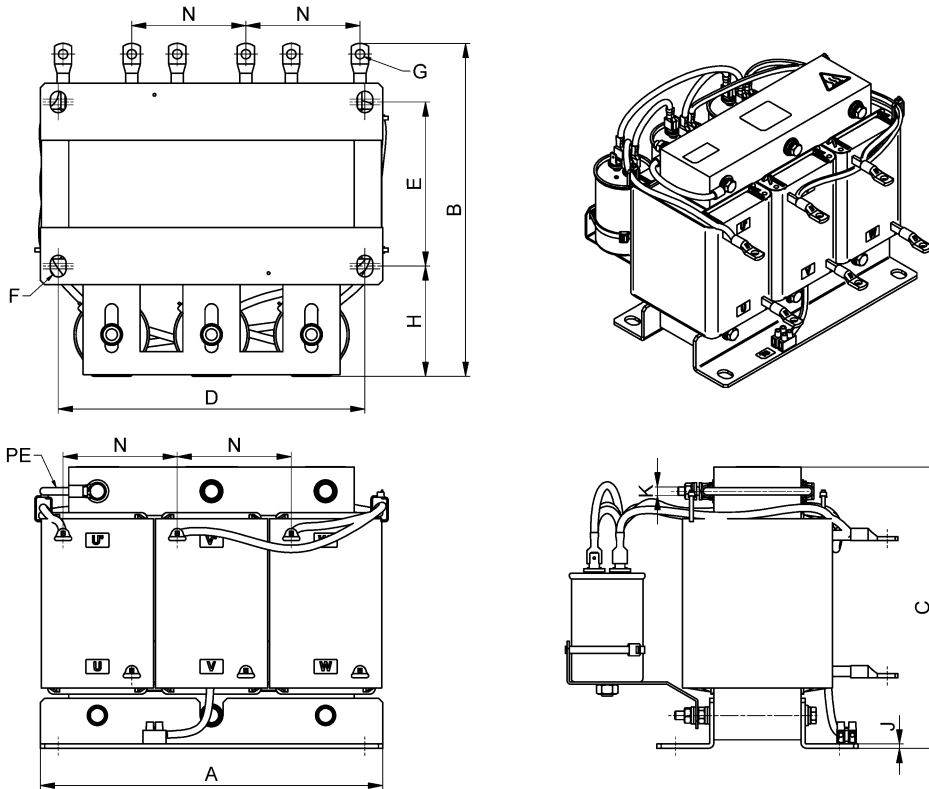


Figure 11 drawings FN5420 IP00 sizes 26A to 60A

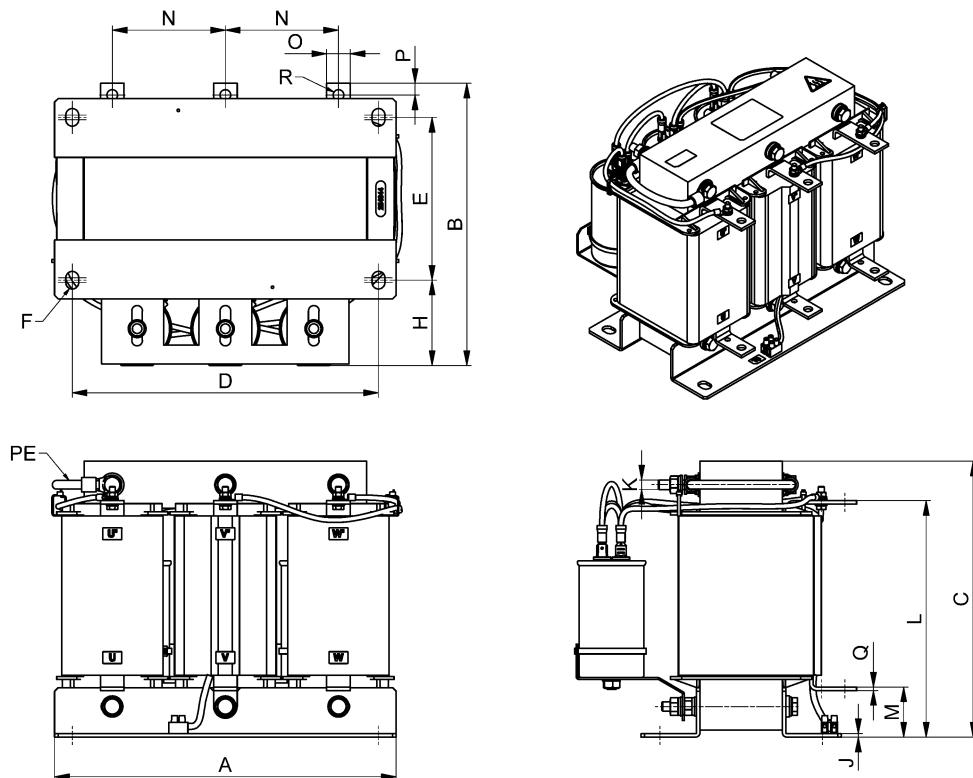


Figure 12 drawings FN5420 IP00 sizes 75A to 110A

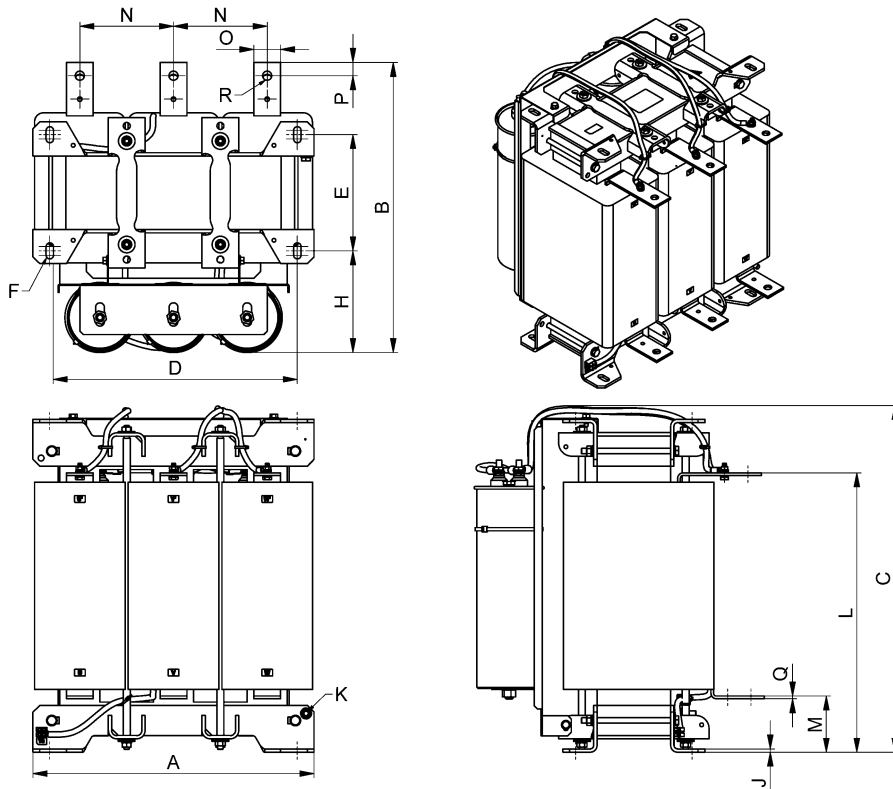


Figure 13 drawings FN5420 IP00 sizes 145A to 400A

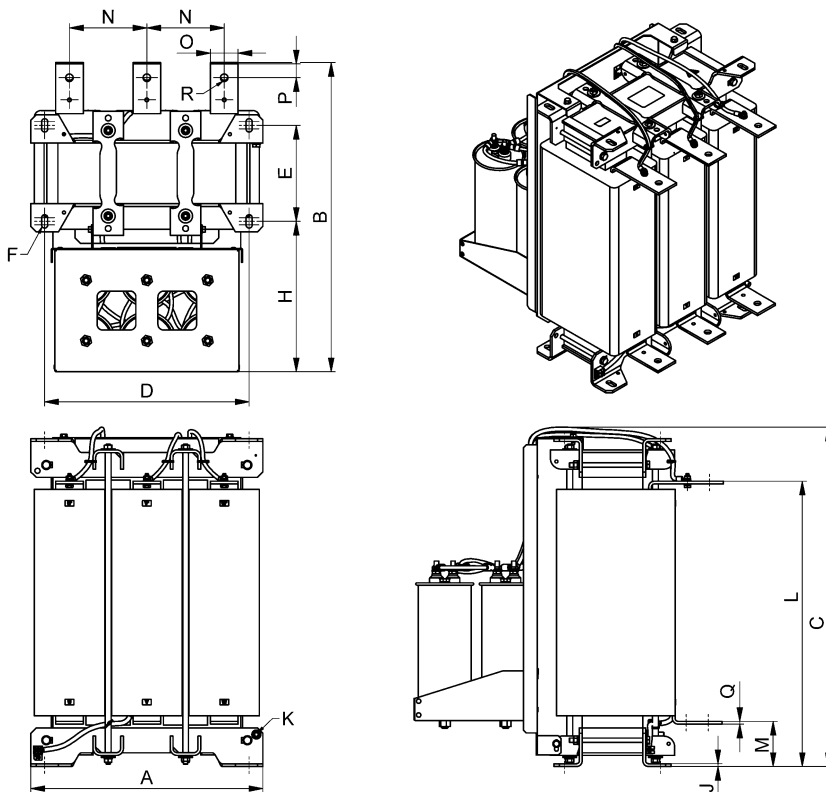


Figure 14 drawings FN5420 IP00 sizes 480A to 800A

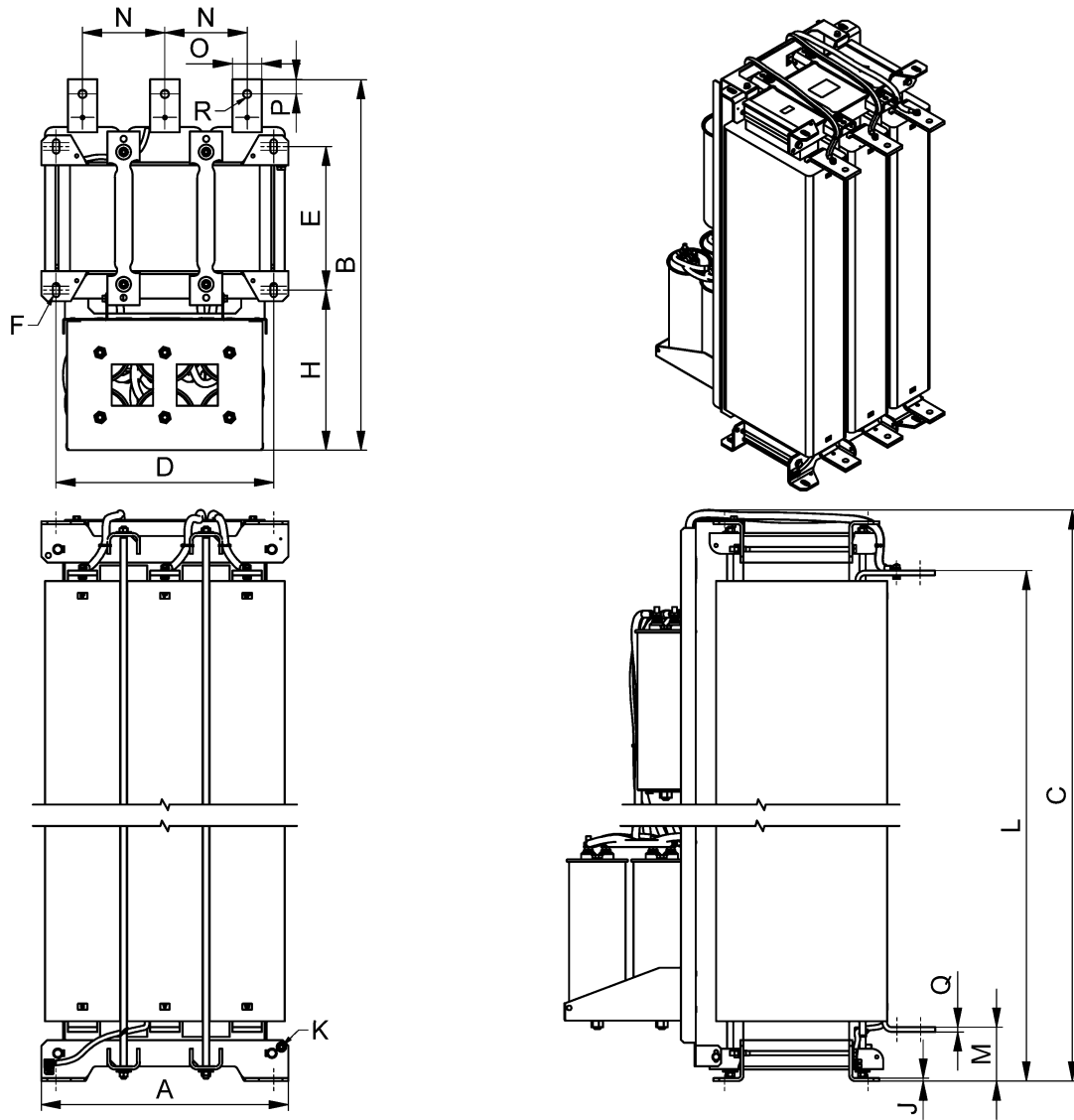


Figure 15 drawings FN5420 IP00 size 1000A

Table 15 dimensions FN5420 IP00

Rating	A	B±5	max. C	D	E	F	G	H±5	J	K	L±5	M±5	N±5	O	P	Q	R
<b>2.3</b>	120	115	118	107	38	6.5x5.5	-88	56	1.5	M3	-	-	32	-	-	-	-
<b>3.1</b>	120	120	118	107	47.2	6.5x5.5	-88	50	1.5	M3	-	-	32	-	-	-	-
<b>5.9</b>	150	130	137	135	45.3	8x5.5	-88	60	2.0	M3	-	-	42	-	-	-	-
<b>10.2</b>	195	158	159	170	71.5	12x9	-88	64	2.5	M4	-	-	50	-	-	-	-
<b>13.2</b>	195	158	160	170	71.5	12x9	-89	65	2.5	M4	-	-	50	-	-	-	-
<b>18</b>	220	150	183	200	57.5	12x9	-89	70	2.5	M6	-	-	60	-	-	-	-
<b>26</b>	220	202	158	200	77.5	12x9	ø6.5	76	2.5	M6	-	-	60	-	-	-	-
<b>32</b>	240	216	179	220	84.5	12x9	ø6.4	85	2.5	M6	-	-	68	-	-	-	-
<b>38</b>	240	216	179	220	84.5	12x9	ø6.4	85	2.5	M6	-	-	68	-	-	-	-
<b>45</b>	240	213	198	215	95	15x11	ø6.4	78	3	M6	-	-	80	-	-	-	-
<b>60</b>	240	233	198	215	115	15x11	ø6.4	77	3	M6	-	-	80	-	-	-	-
<b>75</b>	240	242	223	215	129	15x11	-	77	3	M6	170	37	80	20	10	3	ø9
<b>90</b>	265	243	218	240	126	15x11	-	79	3	M8	185	42	88	20	10	3	ø9
<b>110</b>	290	240	234	260	138	15x11	-	72	3	M8	201	43	96	20	10	3	ø9
<b>145</b>	420	max. 338	371	370	134	24x11	-	max. 140	5	M8	263	79	140	25	12.5	4	ø11
<b>180</b>	420	max. 343	370	370	134	24x11	-	max. 142	5	M8	263	79	140	25	12.5	4	ø11
<b>200</b>	420	max. 356	371	370	134	24x11	-	max. 142	5	M8	263	79	140	25	12.5	4	ø11
<b>250</b>	420	max. 387	436	370	134	24x11	-	max. 152	5	M8	321	87	140	40	20	4	ø13.5
<b>302</b>	420	max. 430	422	370	174	24x11	-	max. 152	5	M8	314	80	140	40	20	4	ø13.5
<b>400</b>	420	max. 434	531	370	174	24x11	-	max. 152	5	M8	418	84	140	40	20	4	ø13.5
<b>477</b>	420	560	627	370	174	24x11	-	273	5	M8	517	82	140	50	25	5	ø13.5
<b>630</b>	420	560	755	370	174	24x11	-	273	5	M8	631	96	140	50	25	5	ø13.5
<b>710</b>	420	600	726	370	214	24x11	-	273	5	M8	617	82	140	50	25	5	ø13.5
<b>800</b>	420	602	854	370	214	24x11	-	273	5	M8	734	96	140	50	25	8	ø13.5
<b>1000</b>	420	631	1050	370	244	24x11	-	273	5	M8	930	92	140	50	25	8	ø13.5

### 3.8.2 Dimensions FN5420 IP20

The drawings of each design is presented below. Dimensions are given in Table 16.

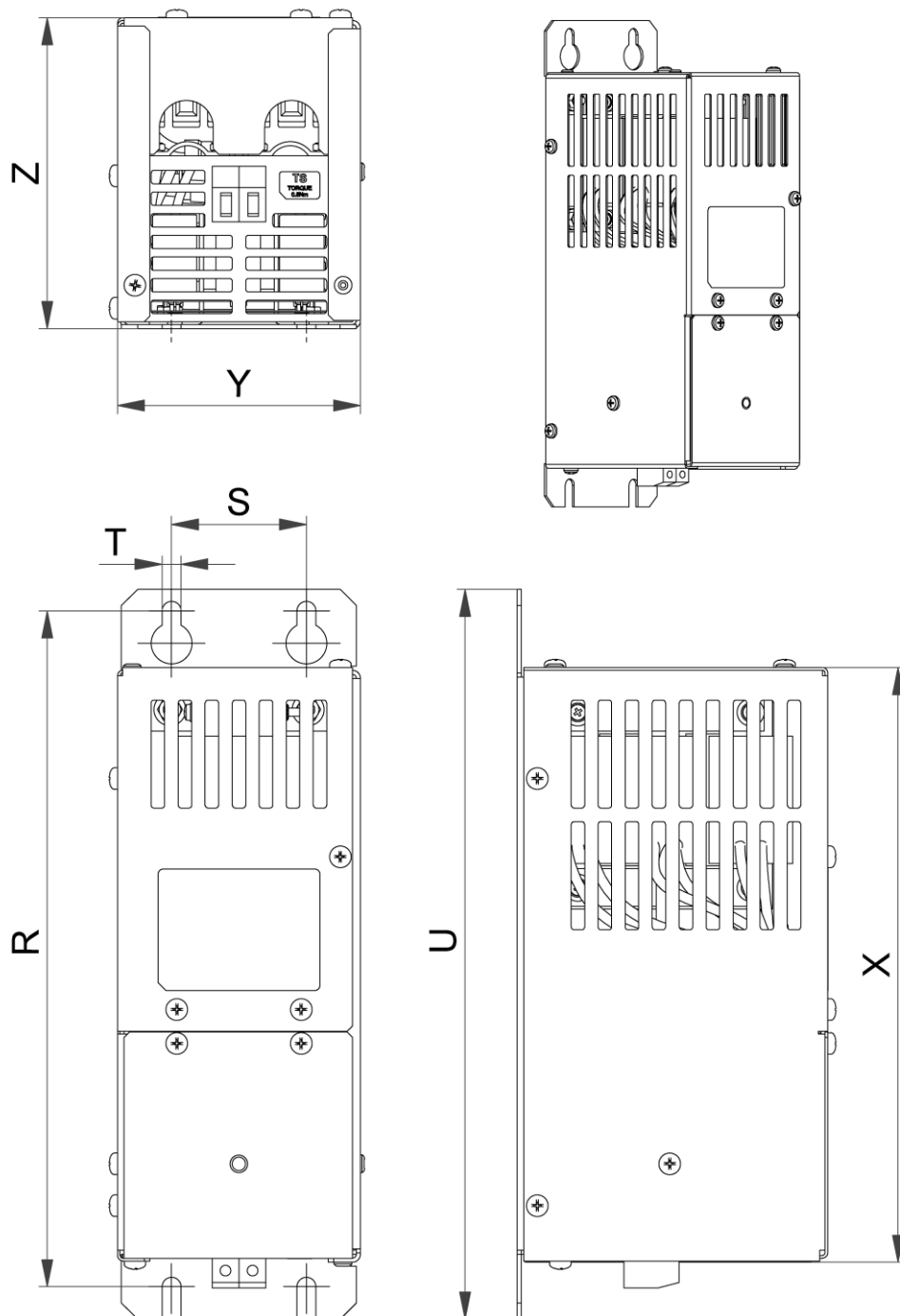


Figure 16 FN5420 IP20 sizes 2.3A to 38A

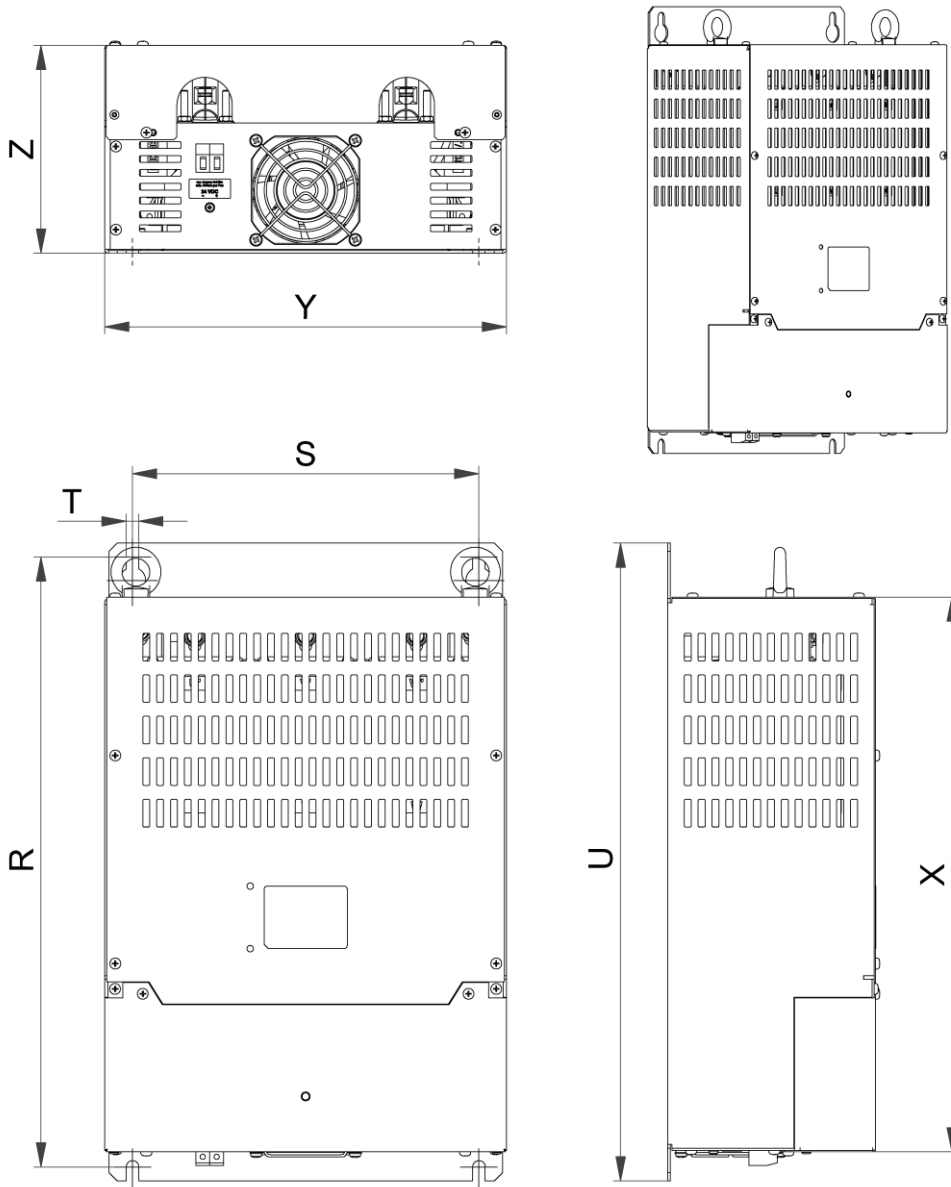


Figure 17 FN5420 IP20 sizes 45A to 110A

Table 16 dimensions FN5420 IP20

Frame	Drill pattern			Base	Box size			
	Type	R +2/0	S		T	U	X ±2	Y
A	A	250	50	7	270	220	90	115
B	B	310	60	7	330	280	100	165
C	C	405	90	7	425	375	130	225
D	D	440	250	9	460	400	290	150
E	E	510	290	9	530	470	330	170

Dimensions in mm

For Dimensions without Tolerances: ISO2768-m/EN22768-m applies



### 3.8.3 Dimensions RWK5420

The drawings of each design is presented below. Dimensions are given in Table 17.

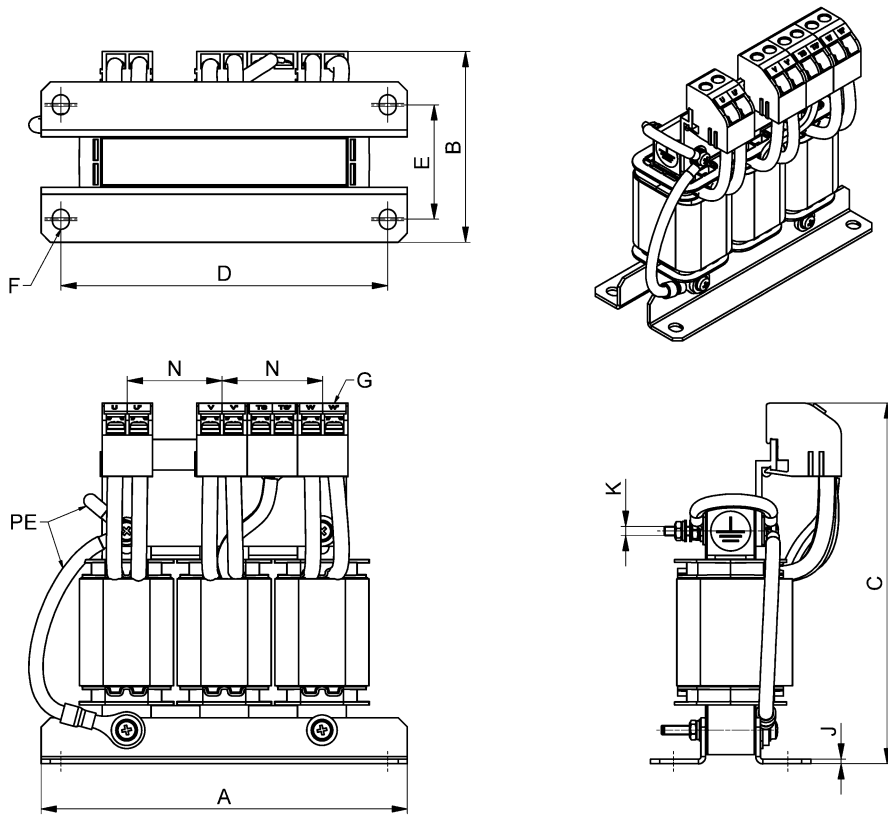


Figure 18 RWK5420 sizes 2.3A to 3.1A

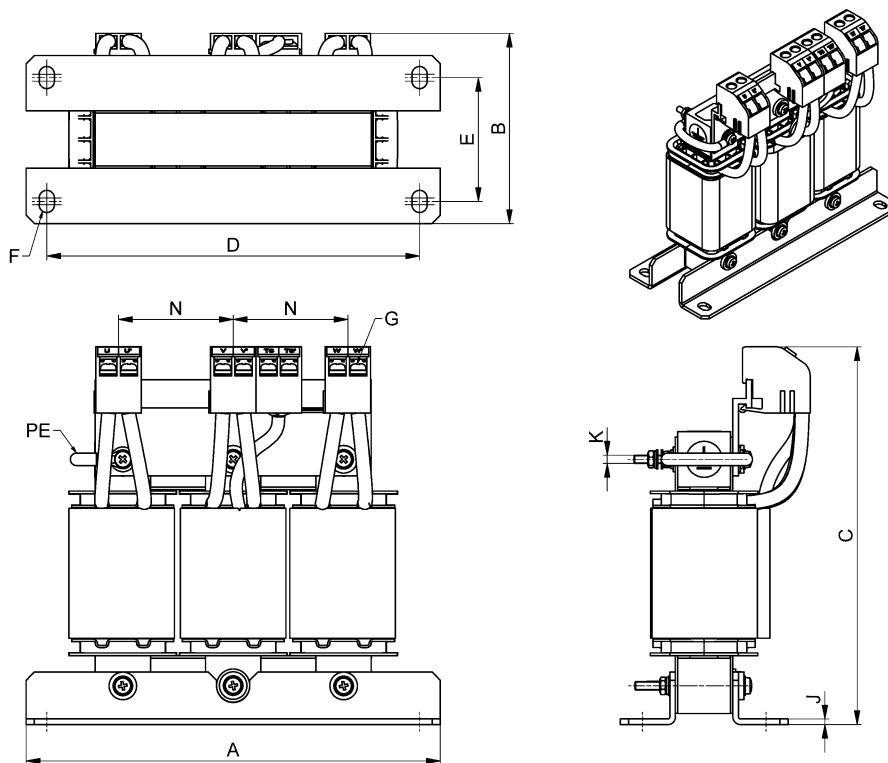


Figure 19 RWK5420 sizes 5.9A to 18A

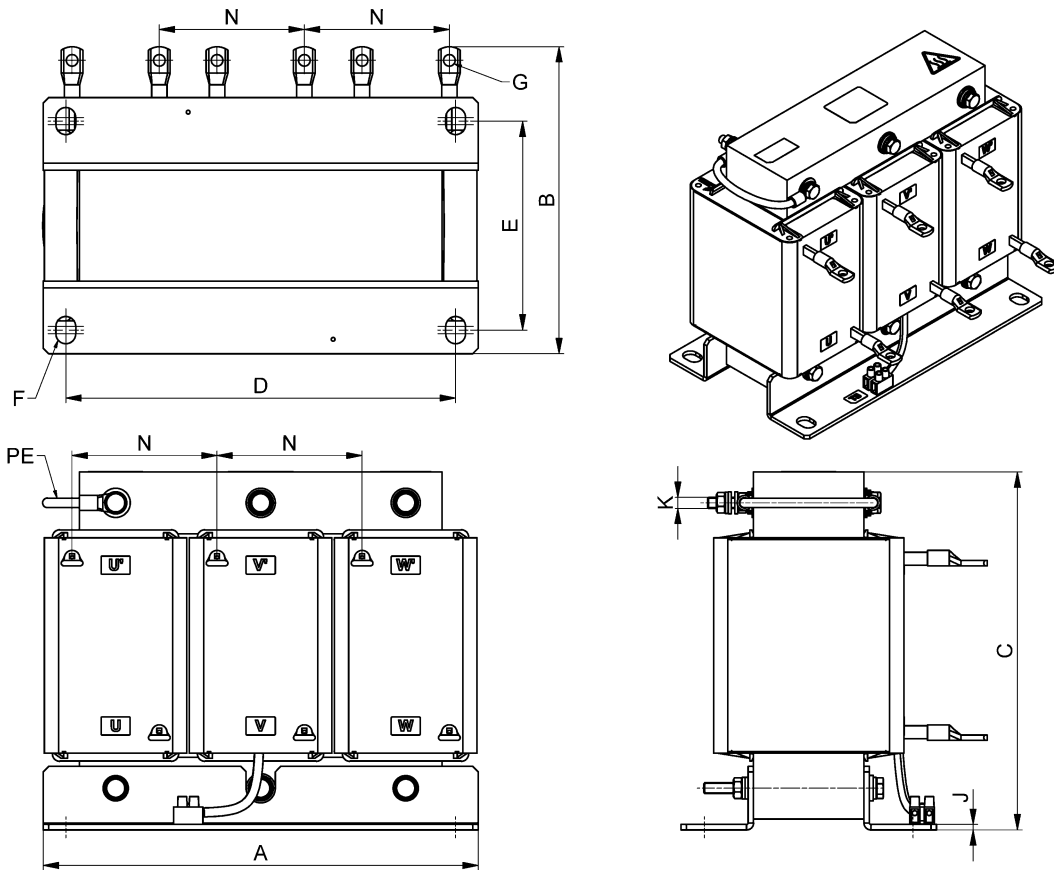


Figure 20 RWK5420 sizes 26A to 60A

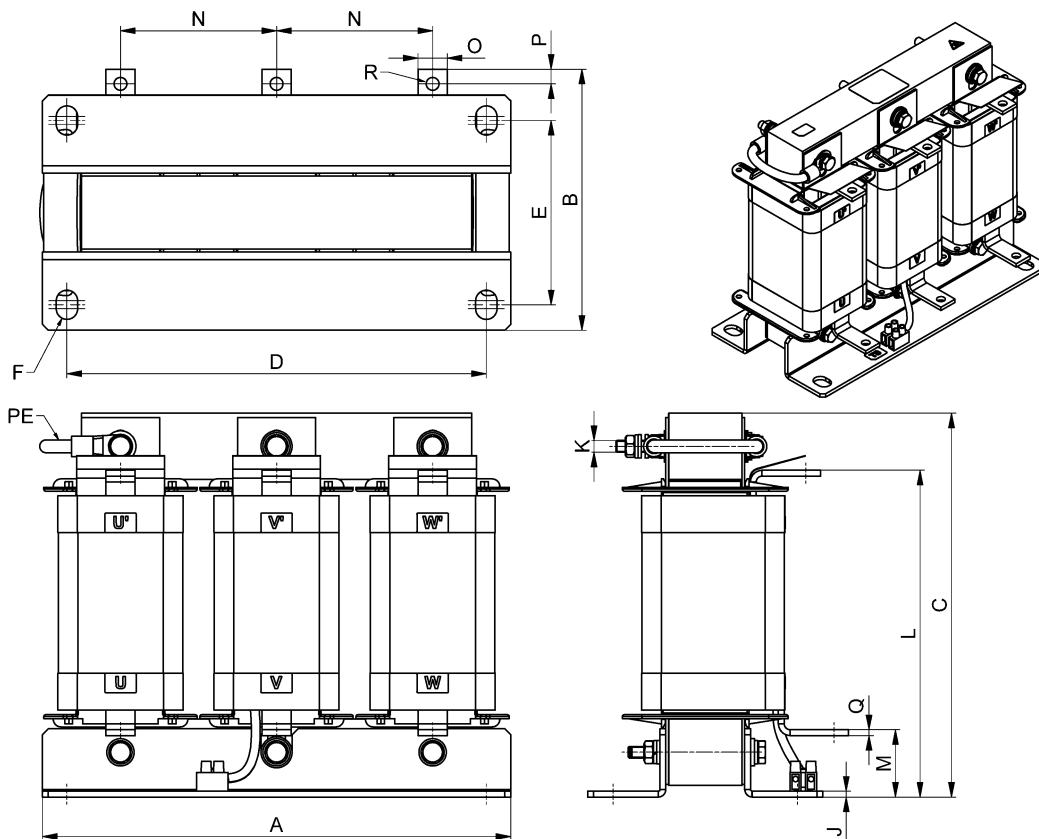


Figure 21 RWK5420 sizes 75A to 110A

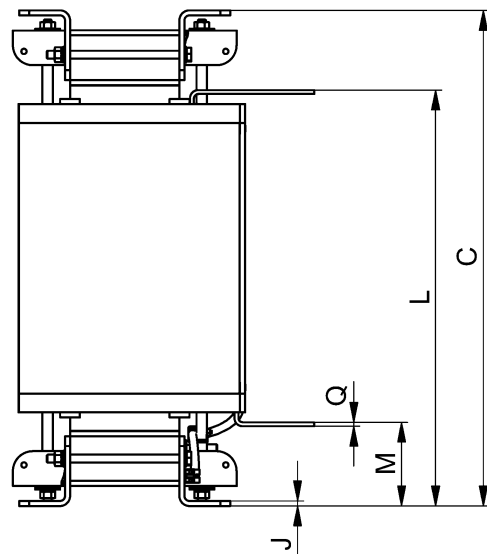
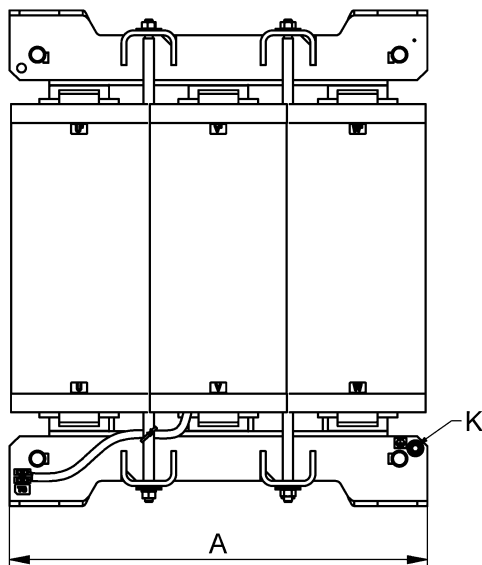
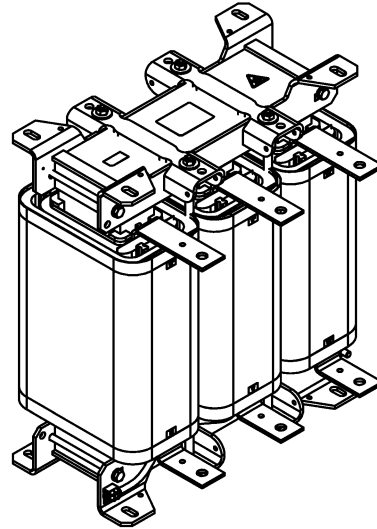
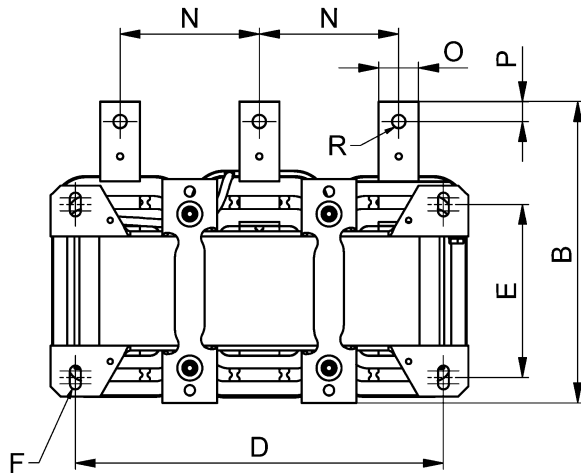


Figure 22 RWK5420 sizes 145A to 1000A

Table 17 dimensions RWK5420

Rating	A	B±5	C±5	D	E	F	G	H	J	K	L±5	M±5	N±5	O	P	Q	R
2.3	120	63	118	107	38	6.5x5.5	-88	-	1.5	M3	-	-	32	-	-	-	-
3.1	120	72	118	107	47.2	6.5x5.5	-88	-	1.5	M3	-	-	32	-	-	-	-
5.9	150	69	137	135	45.3	8x5.5	-88	-	2	M3	-	-	42	-	-	-	-
10.2	195	95	159	170	71.5	12x9	-88	-	2.5	M4	-	-	50	-	-	-	-
13.2	195	95	160	170	71.5	12x9	-89	-	2.5	M4	-	-	50	-	-	-	-
18	220	84.5	183	200	57.5	12x9	-89	-	2.5	M6	-	-	60	-	-	-	-
26	220	139	157	200	77.5	12x9	∅6.5	-	2.5	M6	-	-	60	-	-	-	-
32	240	142	178	220	84.5	12x9	∅6.4	-	2.5	M6	-	-	68	-	-	-	-
38	240	142	178	220	84.5	12x9	∅6.4	-	2.5	M6	-	-	68	-	-	-	-
45	240	149	197	215	95	15x11	∅6.4	-	3	M6	-	-	80	-	-	-	-
60	240	169	197	215	115	15x11	∅6.4	-	3	M6	-	-	80	-	-	-	-
75	240	178	198	215	129	15x11	-	-	3	M6	170	37	80	20	10	3	∅9
90	265	177	218	240	126	15x11	-	-	3	M8	185	42	88	20	10	3	∅9
110	290	183	234	260	138	15x11	-	-	3	M8	201	43	96	20	10	3	∅9
145	420	223	338	370	134	24x11	-	-	5	M8	263	79	140	25	12.5	4	∅11
180	420	226	338	370	134	24x11	-	-	5	M8	263	79	140	25	12.5	4	∅11
200	420	239	338	370	134	24x11	-	-	5	M8	263	79	140	25	12.5	4	∅11
250	420	263	403	370	134	24x11	-	-	5	M8	321	87	140	40	20	4	∅13.5
302	420	303	389	370	174	24x11	-	-	5	M8	314	80	140	40	20	4	∅13.5
400	420	308	498	370	174	24x11	-	-	5	M8	418	84	140	40	20	4	∅13.5
477	420	313	594	370	174	24x11	-	-	5	M8	517	82	140	50	25	5	∅13.5
630	420	313	722 +/-10	370	174	24x11	-	-	5	M8	631	96	140	50	25	5	∅13.5
710	420	353	693 +/-10	370	214	24x11	-	-	5	M8	617	82	140	50	25	5	∅13.5
800	420	355	821 +/-10	370	214	24x11	-	-	5	M8	734	96	140	50	25	8	∅13.5
1000	420	384	1013 +/-10	370	244	24x11	-	-	5	M8	930	92	140	50	25	8	∅13.5

### 3.9 Functional diagram

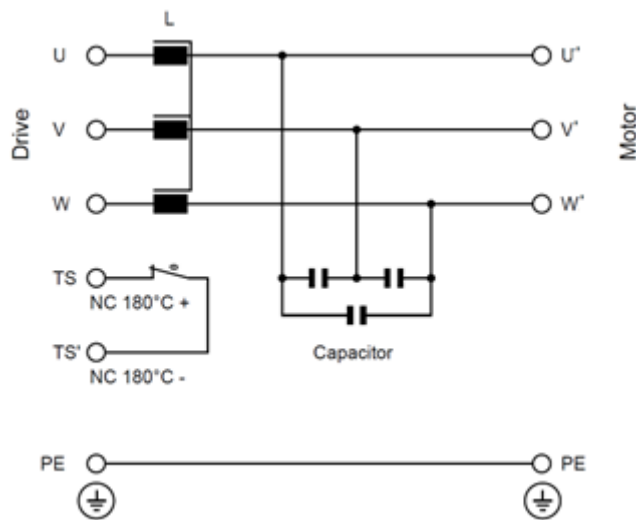


Figure 23 Functional sine wave filter FN5420

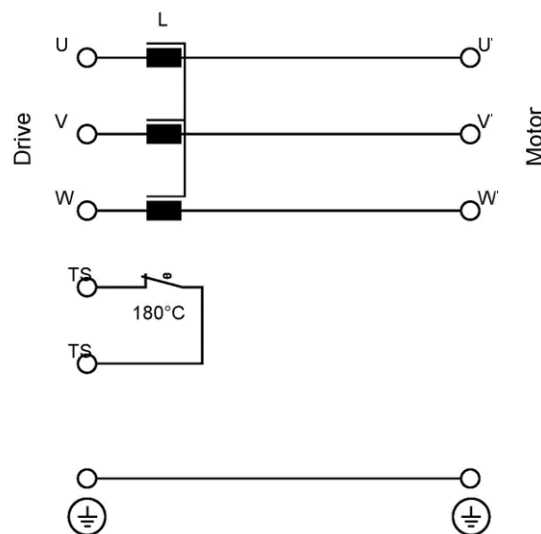


Figure 24 Functional diagram dv/dt reactor RWK5420

Filter terminals	Drive U/V/W	3 terminal blocks
	Motor U'/V'/W'	3 terminal blocks
	Signal TS	Connecting terminals to thermal switch NC 180°C (UL-approved) to detect overload in chokes
	PE	Protective earth. Threaded stud with washer and nut
Function blocks	Chokes L	Power magnetic components incl. temperature sensors
	Capacitors C	Power capacitors
	Fan	Field replaceable fan for choke air cooling
	Power supply	Internally generate 24 V DC source for fan supply

## 4 Filter appearance and elements

Sine wave filter FN5420 series and dv/dt reactor RWK5420 series come in three different base designs depending on the filter type and size. See section 3.8 for a complete list of all designs and their differences. Some selected examples of design will be detailed in this chapter to help the user locate the important parts of the product.

Example of design of sine wave filter FN5420 and RWK5420 are shown in Figure 25 to Figure 33 with relevant elements indicated on the drawing.

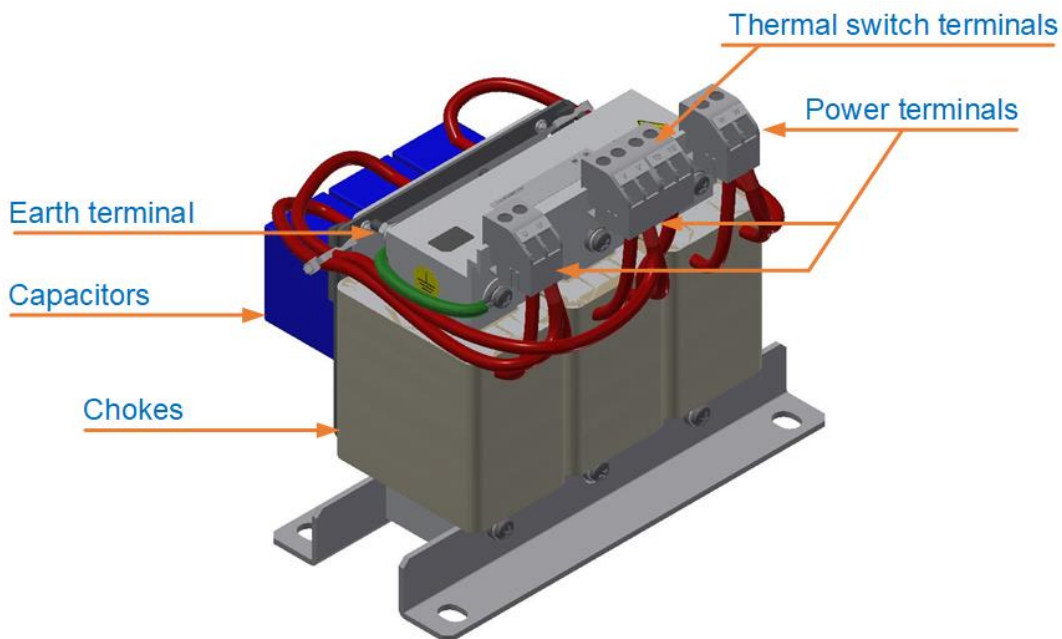


Figure 25 Design of FN5420 IP00 10A (apply for 2.3A to 18A)

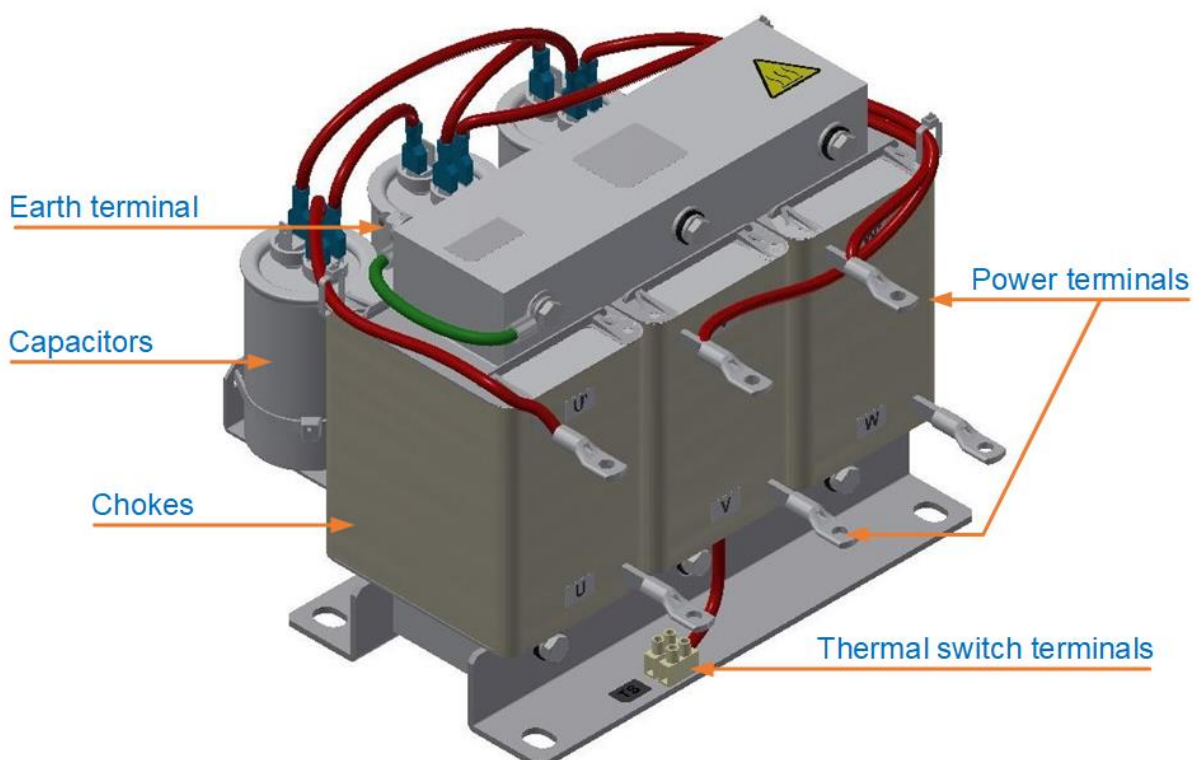


Figure 26 Design of FN5420 IP00 60A (apply for 26A to 60A)

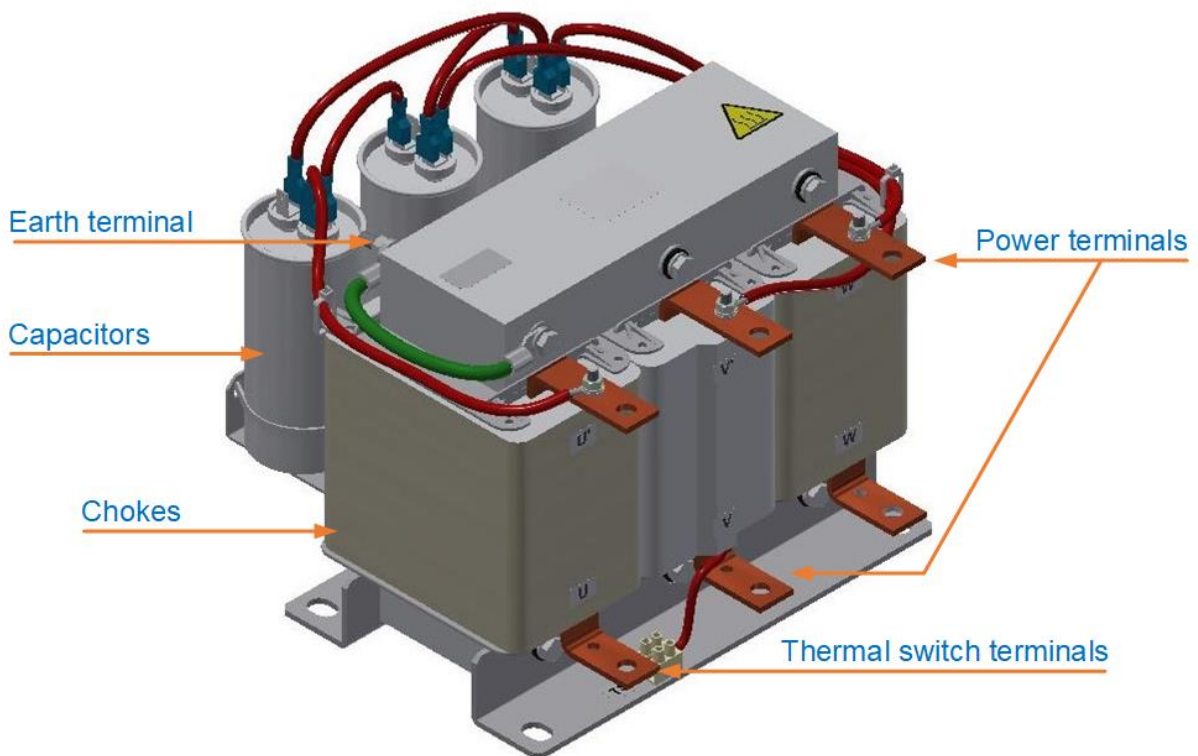


Figure 27 Design of FN5420 IP00 75A (apply for 75A to 110A)

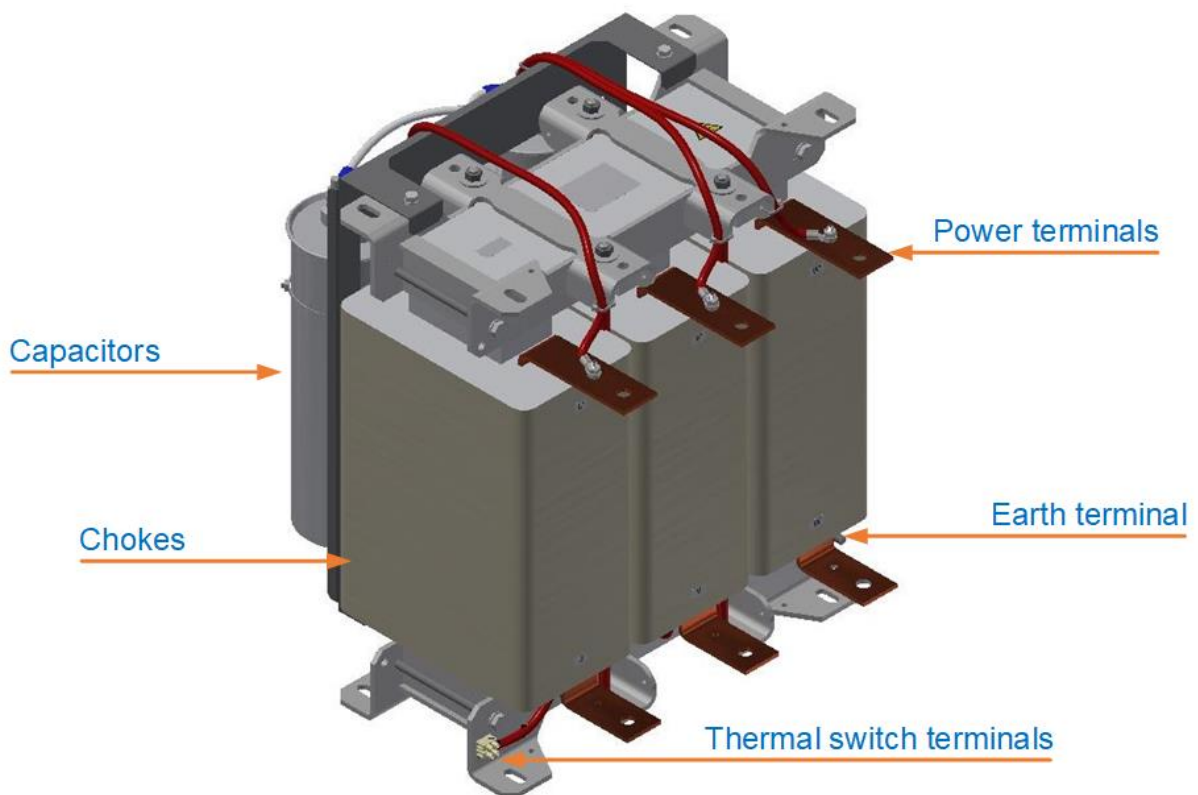


Figure 28 Design of FN5420 IP00 400A (apply for 145A to 1000A)



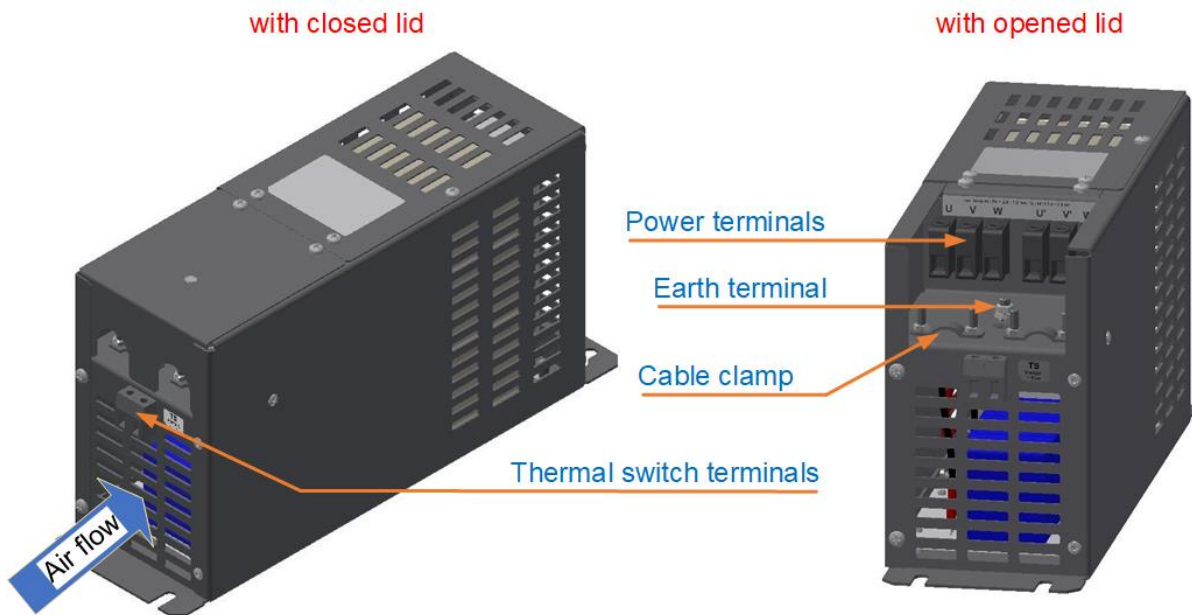


Figure 29 Design of FN5420 IP20 frame B (apply for frame A and B, 2.3A to 10A)

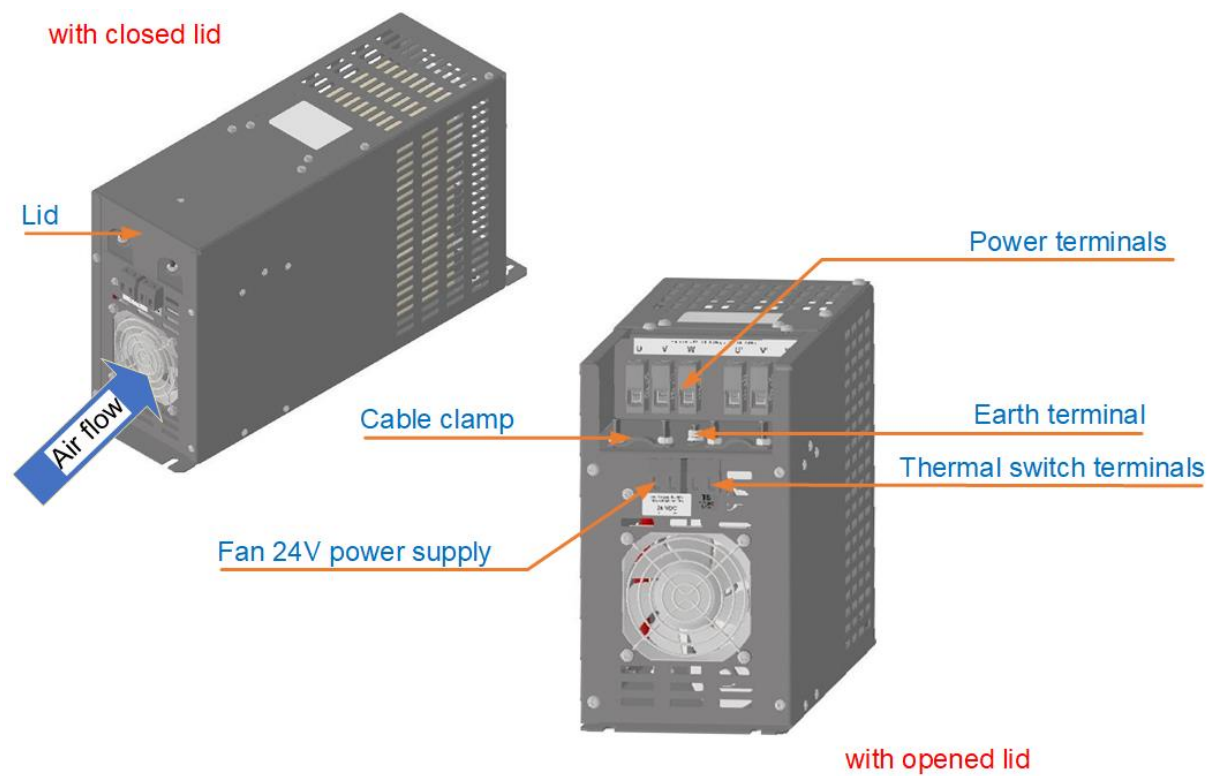


Figure 30 Design of FN5420 IP20 frame C (apply for frame C 13A to 38A)



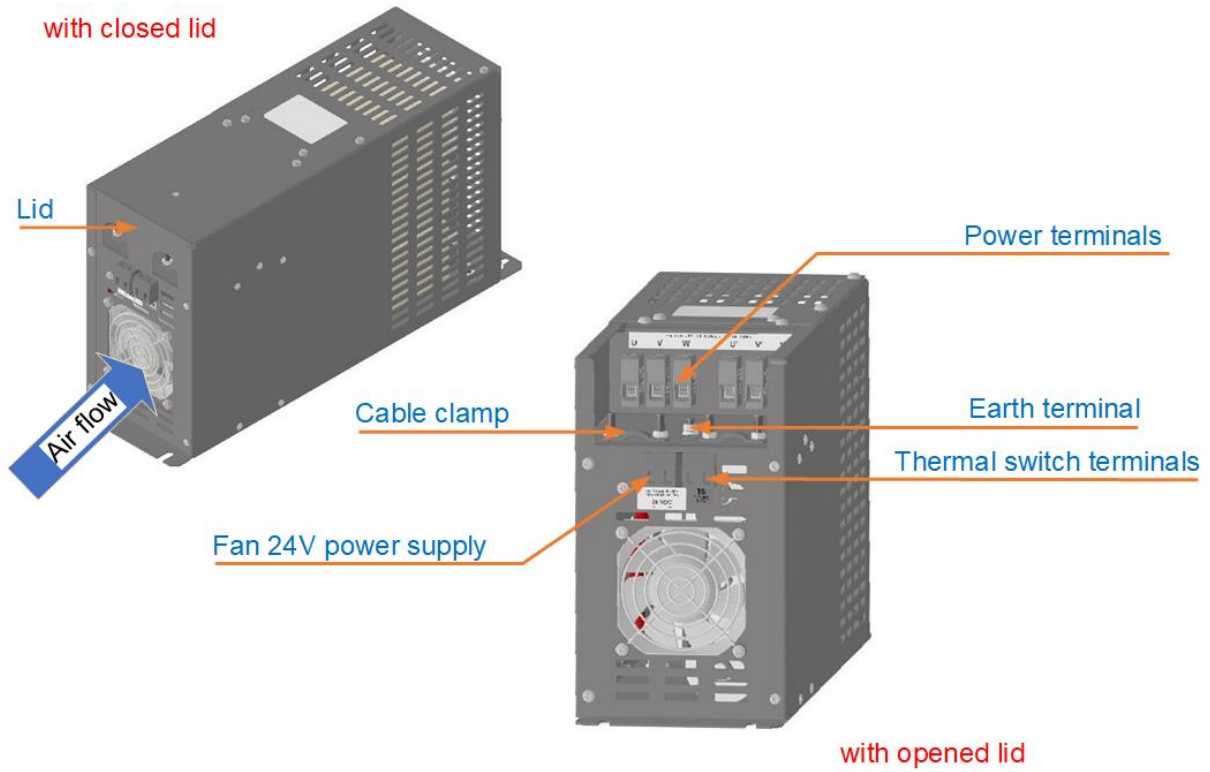


Figure 31 Design of FN5420 IP20 frame D (apply for frame D and E, 45A to 110A)

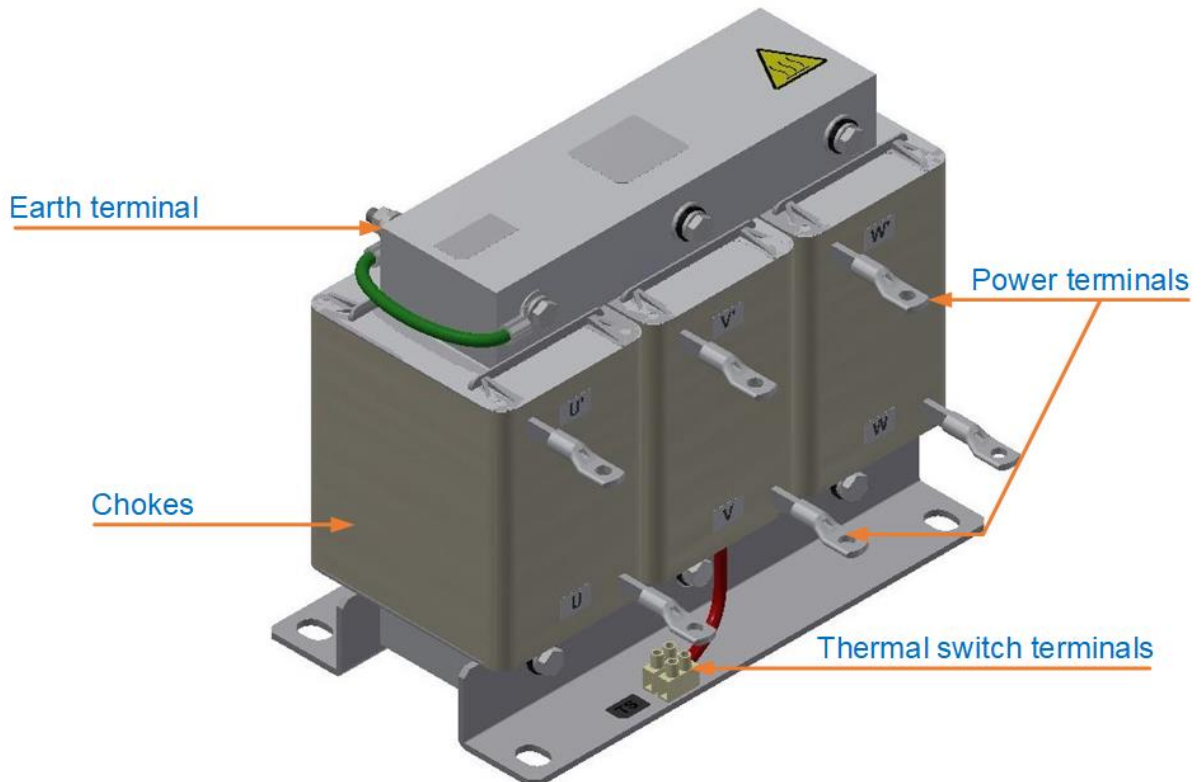


Figure 32 Design of RWK5420 60A (apply for 26A to 60A)

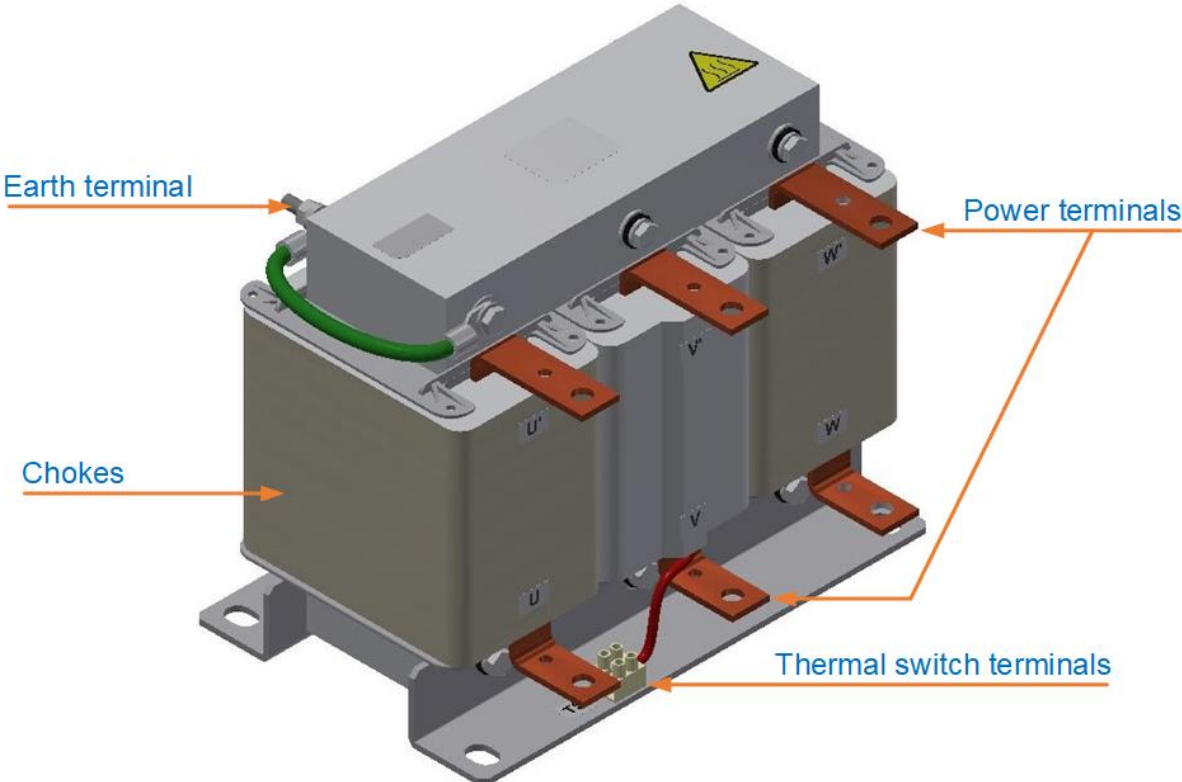


Figure 33 Design of RWK5420 75A (apply for 75A to 1000A)

## 5 Filter 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, national or international standards that are applicable. Please note that the following installation steps are applicable for sine wave filter FN5420 series IP00 and IP20 as well as dv/dt reactor RWK5420 series.

### 5.1 Step 1: Visual inspection

All Schaffner output 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. Keep the shipping container for future transportation of the filter.

In the case of damage, please file a claim with the freight forwarder involved immediately and contact your local Schaffner 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 and with respect to named temperature limits, see section 3.1 and 3.2.

### 5.2 Step 2: Mounting

Output filters are best installed as close as possible to the drive. Ideally, they are mounted next to the inverter or motor drive inside the electrical cabinet or control room. An adequately long cable must connect the output filter to the motor, in respect with the drive and filter specification.

FN5420 IP 00 and RWK5420 are designed for floor mounting while FN5420 IP20 are designed for wall mounting. These are the recommended mounting positions (IP00 only) but different mounting positions might be permitted.

Recommended mounting positions:

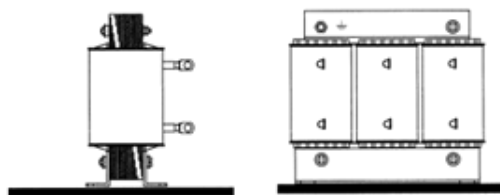


Figure 34 Recommended mounting positions for FN5420 IP00 and RWK5420

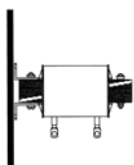


Figure 35 Permitted mounting positions for FN5420 2.3A to 18A and RWK5420 **up to 25kg only**

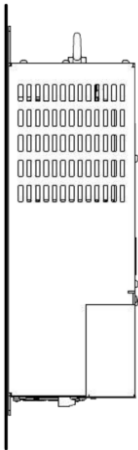


Figure 36 Mandatory mounting positions FN5420 IP20

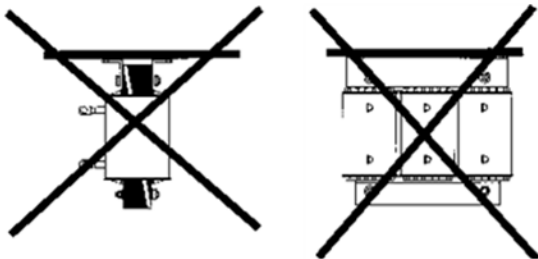


Figure 37 Prohibited mounting positions

The pictures above show permitted and prohibited mounting positions. The mounting on a vertical plate (see picture for permitted mounting positions) is limited to IP00 products with a maximum weight of 25 kg or for IP20 products. Use all available mounting holes and select the correct screws and washers in order to ensure a reliable mounting and to do justice to the weight of these products. Apply torques appropriate for the strength class of the screws and washers you are using. Specifications can be obtained from the supplier of the screws and washers.



It is forbidden to mount the filter in any other position than stated in this manual.

**Important:**

In order to ensure sufficient air flow, keep a clearance between the device, wall and other components of minimum 150mm above, 100mm on the side and for wall mounted ones 150mm below the filter.

Additional work to access the device, caused by not respected clearance distances, will be accounted separately.

It must be ensured that the environmental temperature is kept below the maximum allowed temperature (see section 3) with appropriate thermal management (e.g. cabinet cooling). Filter operation in environments with higher temperatures require a temperature derating (see section 2.4.1).

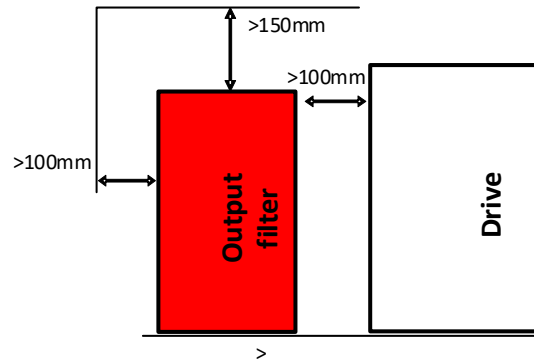


Figure 38 Minimum distance for floor mounted devices

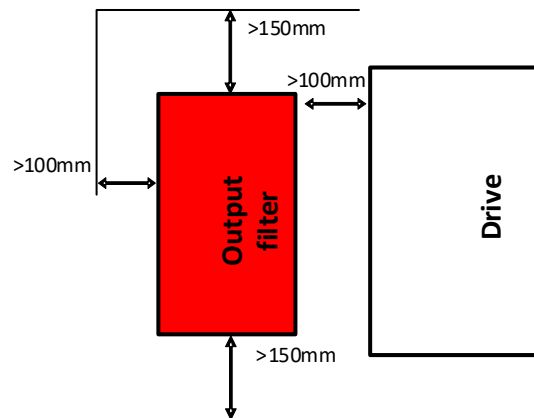


Figure 39 Minimum distance for wall mounted devices

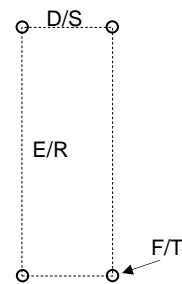
### 5.2.1 Prepare the fixation

Prepare the fixation plan, rails or any other suitable fixation system compatible according to the given positions of the fixation points.

For sine wave filters FN5420 IP00 series refer to the dimensions E, D and F from the matching drawing and table in section 3.8.1.

For sine wave filters FN5420 IP20 series refer to the dimensions R, S and T from the matching drawing and table in section 3.8.2.

For dv/dt reactors RWK5420 series refer to the dimensions E, D and F from the matching drawing and table in section 3.8.3.

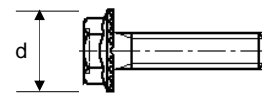


### 5.2.2 Screw selection

Schaffner recommends zinc coated hex ribbed flange steel bolts. Respect filters weight for appropriate choice of screws!

Head diameters must not exceed these dimensions:

M6:  $d \leq 14.2\text{mm}$ , M10:  $d \leq 21.2\text{mm}$



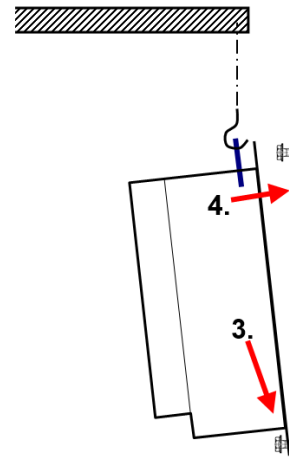
### 5.2.3 Filter placement

#### 5.2.3.1 For FN5420 IP00 and RWK5420

1. Lift filter with appropriate crane, smallest types (up to 25kg) may be lifted manually by two persons.
2. Place the filter in position by aligning the fixation point on the filter and the support (plane, rails with nuts or other system).
3. Place 2 screws diagonally opposed and engage them with completely tight, leave about 2-3mm distance from head to the filter.
4. Adjust the position if necessary and engage the remaining screws.
5. Fix screws with appropriate torque (depending upon the material of the support and local standards).

### 5.2.3.2 For FN5420 IP20

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).



## 5.3 Step 3: Wiring

### 5.3.1 Verify safe disconnection of all line side power

Consult your local safety instructions.

### 5.3.2 Carefully connect protective earth (PE) wire to adequate earth potential close to the device

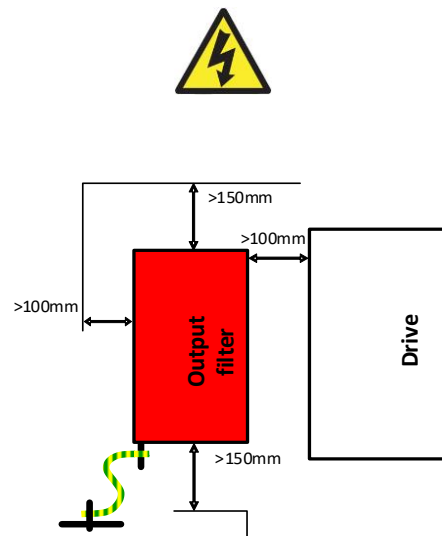
Use a wire diameter of equal or bigger size as foreseen for drive/load side power cables – according to your local codes, drive requirement and safety instructions.

### 5.3.3 Connect PE wire on the device

with appropriate cable lug to threaded stud according to torque given in section 3.5.2.

### 5.3.4 Connect shielding for shielded cables

When using shielded cables, the customer must ensure to properly connect the shielding of the cables between input and output. Proper continuity of shielding is important for EMC purpose and cannot be only connected through the PE of the filter/reactor. The customer must ensure that the cable shielding is connected with as much surface as possible to a wide connector like a bus bar or rail both on the input and output cable. An example shielding connection system is given in Figure 8 in section 3.5.





### **5.3.5 Connect shielding for shielded cables**

When using shielded cables, the customer must ensure to properly connect the shielding of the cables between input and output. Proper continuity of shielding is important for EMC purpose and cannot be only connected through the PE of the filter/reactor. The customer must ensure that the cable shielding is connected with as much surface as possible to a wide connector like a bus bar or rail both on the drive side cable and motor side cable. An example shielding connection system is given in Figure 8 in section 3.5, other EMC compliant system are possible.

### **5.3.6 Connect the device on drive side**

Connect the device on drive side terminals U, V, W to respective motor drive or rectifier outputs. The third part of the output filter/reactor designation is a number contains two digits, i.e. FN5420-10-88-E0XXT, which indicates power terminal type.

See section 3.5.1 for the recommended wire size and torque. Use stranded copper wire with a temperature rating of 75°C or higher.

### **5.3.7 Connect output filter motor side**

Connect output filter motor side terminals U', V', W' to respective motor inputs. Output filter input and output terminals are the same type.

See section 3.5.1 for the recommended wire size and torque. Use stranded copper wire with a temperature rating of 75°C or higher.

### **5.3.8 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.

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

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## 6 Filter maintenance

Schaffner output 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 maintenance recommendation will help maximizing filter lifetime.

### Warnings:

	High voltage potentials are involved in the operation of this product. Always remove line side power before attempting to perform 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.

### 6.1 Maintenance schedule

Table 18 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 <sup>1)</sup>	X	X	X	X	X	X	X	X	X	X	X	X
check el. values of capacitors		X		X		X		X		X		X
replace power capacitors										X		

<sup>1)</sup> Only external connections need to be checked.

### 6.2 Fan

Schaffner output filters are reliable low maintenance products. Many products like power supplies, inverters or motor drives utilize fans for forced cooling to minimize size and weight. Schaffner output filters are designed with a similar temperature management concept and therefore, fans, when present, may have to be maintained and replaced in certain intervals to sustain the function and value of the product. Please note that it might be necessary to disconnect and remove the filter to replace the fan, depending on the filter frame size and the available space around its installation.

Forced cooling devices are needed for the operation of Schaffner output filters up to their nominal rating. Such cooling devices must be checked and cleaned regularly (if installed) to ensure sufficient air flow at all times.

**Note:** increased audible noise is a typical indicator of a fan that needs maintenance or replacement also outside of a maintenance schedule.

Before cleaning or replacing the cooling devices, make sure to consult the recommended maintenance procedures and schedules of the supplier of the cooling device in use.

### 6.3 Power capacitors

The power capacitors supplied with the filters are high quality components with an expected lifetime of up to 100'000 hours (11 years). Nevertheless, their useful service life can be shortened by electrical or thermal stress beyond their specification.

Power capacitor damage may also be caused by severe abnormal supply voltage peaks (i.e. lightning – depending upon system protection), but may only be recognizable through the measurement of line side harmonics distortion. This may be checked with a modern energy meter or by regular checkup with a power quality analyzer. According to the above considerations, a 2-years inspection interval is advisable.

**Note:** an inspection should as well be performed after extreme overvoltage situations in the system.

Note: Storage of capacitors

Up to 3 years-long storage, electrolytic capacitors can be operated without any restriction and the nominal voltage can be applied without any preliminary preparation. System reliability and life-time expectancy are not affected.

On the other side, a longer (>3 years) storage of electrolytic capacitors without applying any voltage can weaken the dielectric properties because of dissolution processes. The electrolytic solution is aggressive and it can affect and weaken the dielectric in the timeframe between production and product commissioning. The weak points are responsible for the higher leakage current shortly after the device turn-on on site.

The residual current of electrolytic capacitors depends upon time, voltage and temperature. The residual current increases after long storage without applying voltage.

The amplitude of resulting residual current during unit commissioning can be up to 10 times larger on short term. The capacitor's residual current assumes the typical expected value at steady state for nominal voltage.

During commissioning after long storage, it is recommended to restore the dielectric characteristics by applying voltage progressively and with respect to the time frame the filters have been stored.

### 6.4 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, Schaffner recommends checking and tighten all electrical connections on the occasion of a regular scheduled maintenance of the entire device that incorporates the filter. Check of internal connections within the filters is not needed or should be conducted by a Schaffner service representative.

## 7 Troubleshooting

Schaffner output 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 Schaffner partner for assistance.

To find your local partner within  
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