

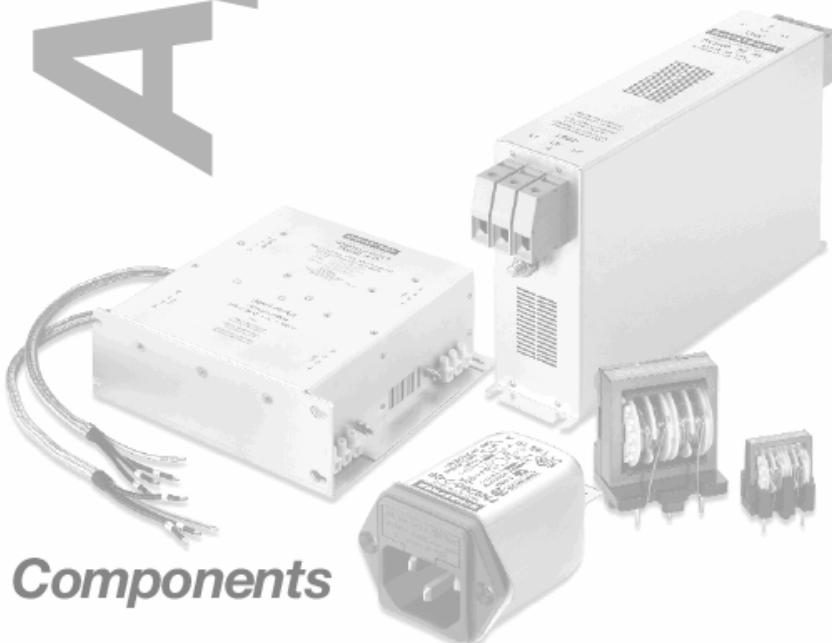
Application
Note

EMC IN MACHINERY ENGINEERING

RELIABILITY

WITH CONCEPT

(Diese Applikationsnotiz ist auch auf Deutsch erhältlich)



Components

EMC in Machinery Engineering – Reliability with Concept

Stefan Melly, Product Marketing, July 2003

The new product family standard EN50370 for machine tools will force a re-thinking in the industrial sector of machinery engineering. As soon as the standard comes into force, electromagnetic compatibility, and hence EMC filters, will become an integral part of product development for the machinery engineer. With new components tailored to the differing requirements of machinery engineering from Schaffner, manufacturers do not need to worry any more about the electromagnetic compatibility of their equipment.

1. EMC in machinery engineering

1.1 The current situation

In the past, there had not been any standards laid down for the area of industrial machinery engineering; the result of this was that EMC filters at the mains input of machines were used only to a very limited extent.

So far, EMC filters were often viewed only in conjunction with the drive system of the machine, i.e. frequency converters. The factor that was mainly counted upon was that the inverters used were either interference-suppressed internally, or were supplied with the corresponding drive filters.

Although that does basically ensure the electromagnetic compatibility of the drive, the question is whether all the relevant aspects of the machinery engineer are taken into consideration with this procedure.

1.2 The product family standard for machine tools EN50370-1 / -2

With the new product family standard EN50370, EMC is not assumed to be subordinate to the drive system alone, but a clear reference is made to the entire machine. The equipment as a whole must then achieve the interference voltage limiting values, regardless of the drives used and their degree of compliance. The limiting values laid down refer to the standard EN61800-3 for variable speed electrical power drives. Here, the environment of utilization of the machine, the relevant low-voltage network as well as the protection of the neighboring installation play a significant role for determining the permissible limits.

Essentially, a distinction is made between the following situations:

1. The drives used are not interference-suppressed at all.
In this case, the entire subject of EMC is the matter for the machinery manufacturer. A suitable filter in the mains supply input of the machine must ensure the compliance with the limiting values according to EN50370 for the entire machine.
2. The drives used are interference-suppressed internally or externally for EN61800-3-A11.
This, however, need not necessarily mean that EN50370 is also fulfilled. Owing to the complexity of a machine, its physical size and the mostly very tight space availability conditions, an EMC-compatible cabinet structure cannot be implemented in every case. Radiations, coupling and reflections, both in the immediate vicinity of sources of interference as well as in the entire equipment require the additional use of suitably dimensioned mains filters.
3. The drives used are compliant with EN61800-3-A11 and the machine is constructed in an EMC-conscious fashion.
However, since the machine will be connected to a low-voltage supply network that also supplies residential areas, the electromagnetic compatibility has to be improved to Class B. EMC filters with the corresponding ratings can balance out this difference.

1.3 Limiting values according to EN50370

The EN50370 is subdivided into part 1 for emission and part 2 for immunity. The limiting values for the emission in the frequency band from 150kHz to 30MHz refer to EN61800-3. Here, however, it must be remembered that for use in the first environment, the more stringent limits continue to apply as before.

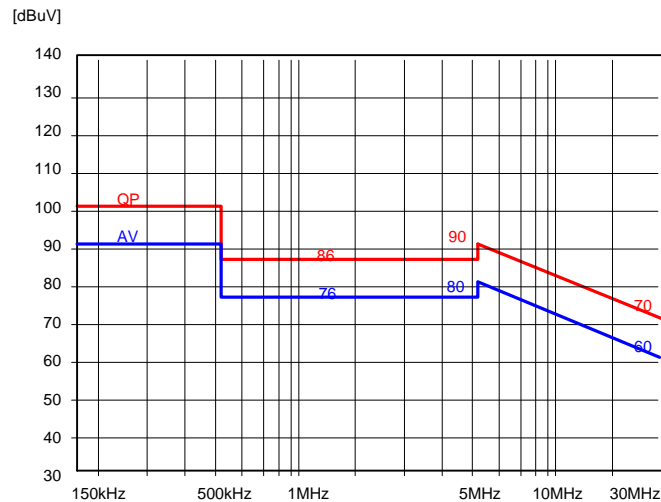


Fig. 1: Limiting values according to EN50370-1 for machine tools in industrial environments

(Detailed information on the subject of EN61800-3 can be obtained from the application note "Motor Drives – EMC filters in industrial applications" from Schaffner)

Particular attention must be paid to the concept of immunity. Adherence to the standard is only a half-truth.

Machine tools, in the present day, with up to 12 or more axes, are highly complex systems. It is the responsibility of the manufacturer to guarantee the function and fault-free operation at all times. These days, this quality standard must be fulfilled to prevail in the competitive market.

Now, e.g., if a high-frequency interference from the outside results in a temporary downtime of the machine, this can cause a significant loss of production and costly service personnel deployment at the customer site. By using suitably designed mains filters, this aspect can also be covered and the reliability and availability of the machine can be guaranteed.

2. Consequences for the machinery manufacturer

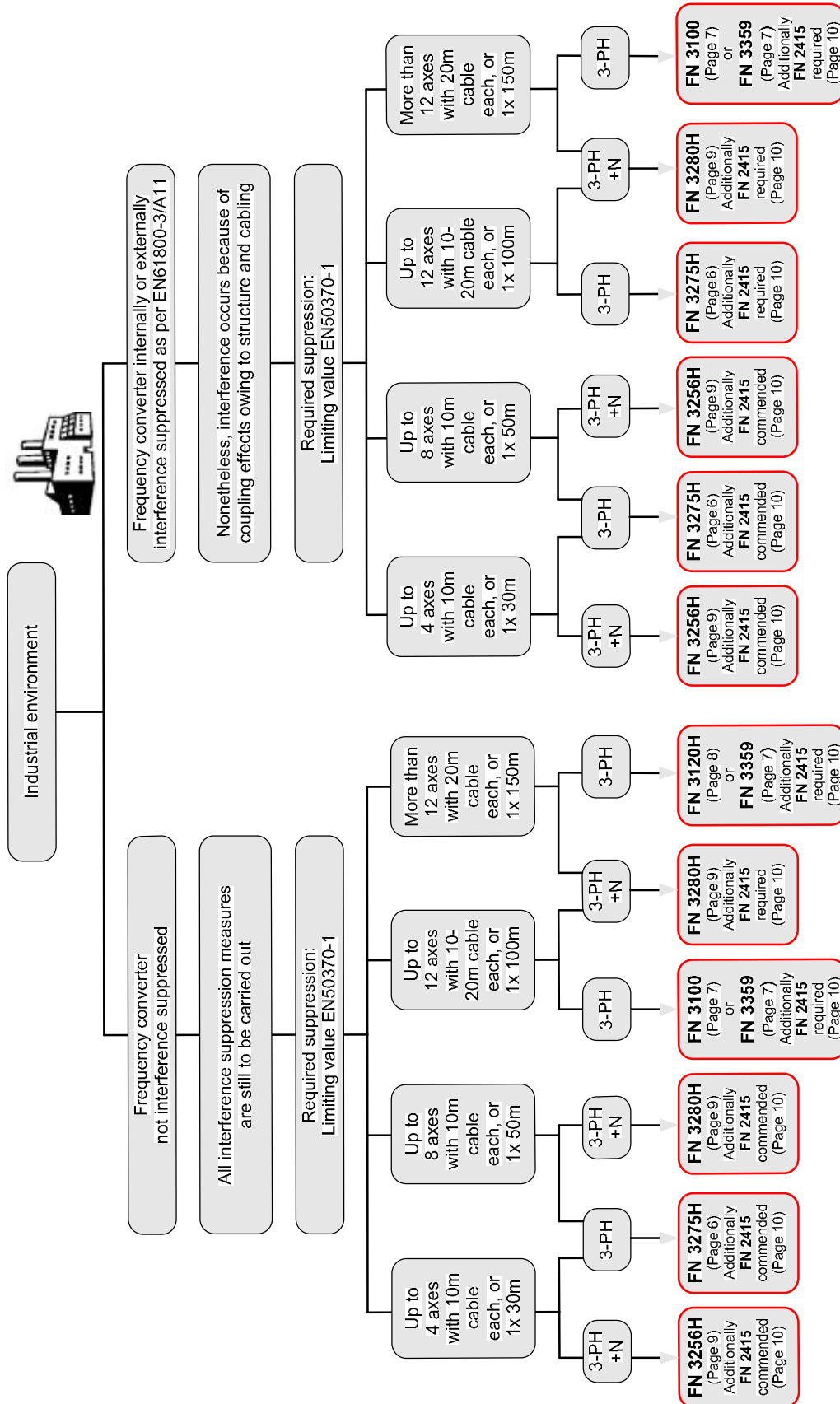
With the introduction of the EN50370, all the responsibility with respect to EMC is transferred to the machinery manufacturer, who is answerable to the customer and to the government as regards the reliability and compatibility of his equipment. This is not really a simple task, when you consider that especially in the smaller companies and even in many medium-scale companies the necessary EMC equipment and the in-house specialists are not available.

Company Schaffner has therefore taken it upon itself to rid the machinery manufacturer of this worry. The idea behind this is to put the manufacturer in a position to determine the best possible EMC solution approach regardless of the type and number of inverters used as well as of the degree of their interference suppression, according to the application.

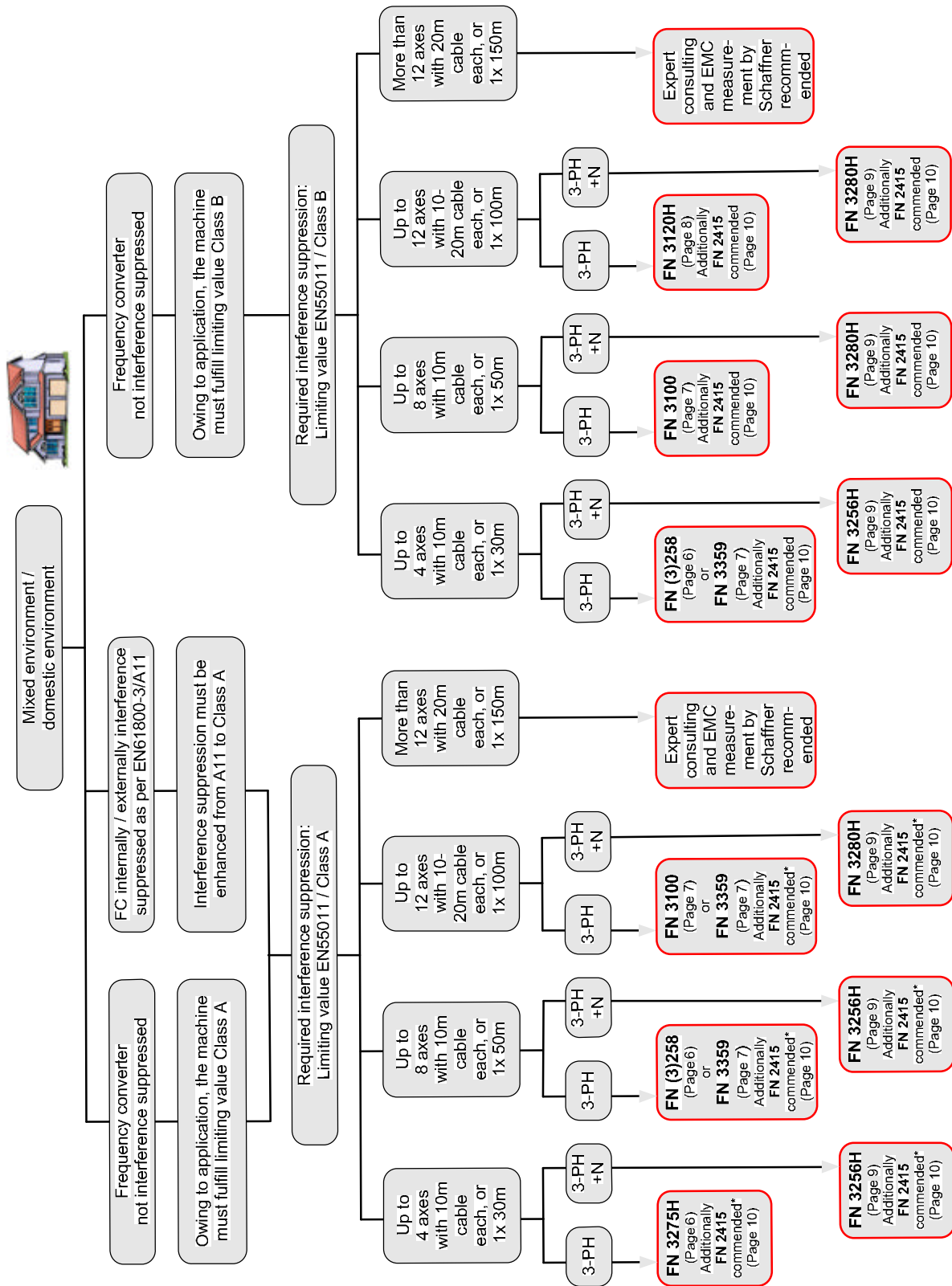
The following pages contain some selection help as well as a brief description of every filter. Additional technical details can be found in the relevant filter datasheet. Of course, Schaffner staff is ready to provide advice at any time.

3. Solutions for machinery engineering

3.1. Selection chart for the use of machinery in industrial environments



3.2. Selection chart for the use of machinery in domestic or mixed supply networks



* In case of interference suppressed converters, the additional use of FN 2415 for achieving Class A is not required in most situations.

Should you have problems in selecting with this selection chart, or your special case cannot be effectively pinpointed, please get in touch with your local Schaffner representative or agent. They will be able to help you further and, if required and desired, provide on-site consulting as well.

3.3 EMC-filters

The various filters that can be found in the selection chart are explained below in brief. Detailed technical datasheets and support for selection are available on request from any Schaffner branch or from the head office in Luterbach (Switzerland).

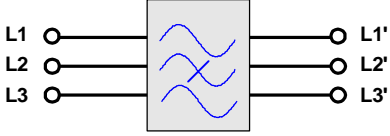

3.3.1 FN 3275H – Three-phase high-current filters for EN50370-1

<p>Application</p> <p>This series of filters is eminently suitable for use in the industrial environment for ensuring compliance with the limiting values according to EN50370-1, regardless of whether the drives used have already been interference-suppressed or not. Regarding the suppression capacity, the FN 3275H meets the requirements of the most varied machine tools with up to 8 driving axes and ~10m motor cable each.</p>	
<p>Specifications</p> <p>Max. operating voltage: 3x520VAC Operating frequency: DC to 60Hz Current range: 10 - 1000A at 50°C Min. performance: 50m (A11) Climatic classification: 25/100/21 Approvals: UL, CSA, ENEC</p>	<p>Block schematic diagram</p>
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Compact construction with a small mounting surface ■ Solid, touch-safe connection technology according to EN60204-1 ■ Transparent plastic protective covers (optionally available) ■ Reduces interference emission according to the limiting value of EN50370-1 ■ Increases the immunity of equipment significantly ■ Facilitates time-saving and space-saving mounting in the control cabinet 	<p>Fig: FN 3275H-150-99</p>

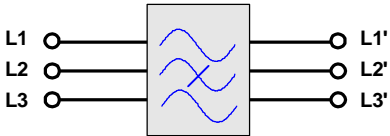

3.3.2 FN 258 & FN 3258 – Three-phase filters for Class A / (B)

<p>Application</p> <p>FN 258 and FN 3258 meet all the requirements in mixed/domestic environments for achieving limiting value Class A for various machines with up to 4 driving axes and ~10m motor cable each. With EMC-compliant construction of the control cabinet and the entire machine, even Class B is possible.</p>	
<p>Specifications</p> <p>Max. operating voltage: 3x480VAC (also 520V) Operating frequency: DC to 60Hz Current range: 7 - 250A at 50°C Min. performance: 50m (Class A) Climatic classification: 25/100/21 Approvals: C-US, ENEC</p>	<p>Block schematic diagram</p>
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Slim book-style with low weight requires the minimum control cabinet area ■ Makes compliance with Class A possible, to some extent even Class B (measurement by Schaffner recommended) ■ Also increases the immunity of the equipment ■ Excellent sym. & asym. attenuation performance ■ Guaranteed saturation-resistant up to 50m cable 	<p>Fig: FN 258-30-07</p>

3.3.3 FN 3359 – Three-phase high-current filters for Class A / (B)

<p>Application</p> <p>FN 3359 filters are used especially when really high currents flow. These filters, for achieving Class A (or with approval measurement, even Class B), can normally be shipped directly ex-stock up to 2500A. Ideal for machines with up to 8 driving axes with ~10 to 20m cables each. The filters in the current range >320A are also suitable for regenerative drive systems. Furthermore, the FN 3359 are designed according to the requirements of IT-networks (IT-versions available as 690VAC versions).</p>	
<p>Specifications</p> <p>Max. operating voltage: 3x500 / 690VAC Operating frequency: DC to 60Hz Current range: 150 - 2500A at 50°C Min. performance: 100m (Class A) Climatic classification: 25/100/21 Approvals: UL, ENEC</p>	<p>Block schematic diagram</p> 
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Extremely compact construction for a high-current filter with very high attenuation performance ■ Makes compliance with Class A possible, sometimes even Class B (with EMC-compliant control cabinet construction and the corresponding approval measurement) ■ Also increases the immunity of equipment ■ Very high saturation resistance ■ Optionally with plastic protective covers as contact-protection for the copper busbars 	<p>Fig: FN 3359-1000-99</p> 

3.3.4 FN 3100 – Three-phase filters for machines with regenerative drives

<p>Application</p> <p>FN 3100 can demonstrate its full strengths mainly when used in machines with regenerative drives, and this with up to 8 driving axes with ~10 to 20m motor cable each. With a corresponding approval measurement, even achieving Class B is conceivable. It must be kept in mind that in case of regenerative operation, an additional commutation-reactor (regenerative line-impedance) from Schaffner is required for avoiding short-circuits to the mains.</p>	
<p>Specifications</p> <p>Max. operating voltage: 3x520VAC Operating frequency: DC to 60Hz Current range: 35 - 300A at 50°C Min. performance: 120m (Class A) Climatic classification: 25/100/21 Approvals: C-US, UL, SEMKO</p>	<p>Block schematic diagram</p> 
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Thanks to the slim design, requires minimal control cabinet space ■ Regeneration-capable (with line-impedance) ■ Makes compliance with Class A possible, to some extent even Class B (measurement by Schaffner recommended) ■ Also increases the immunity of equipment ■ Outstanding broadband attenuation performance ■ Very high saturation resistance ■ Solid connector technology according to EN60204-1 	<p>Fig: FN 3100-80-35</p> 

3.3.5 FN 3120H – High-performance three-phase filters for energy regeneration

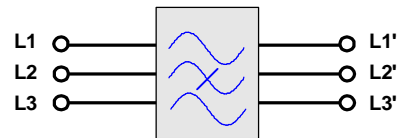
Application

FN 3120H is the high-end filter for regenerative machines with up to 12 driving axes and ~10 to 20m motor cable each. The extraordinarily high attenuation performance allows the limiting value Class B to be reached even under adverse conditions. This makes the filter the first choice for all machines that are connected to low-voltage supply networks that also supply electricity to residential areas. In case of regenerative operation, an additional line-impedance (regenerative line-reactor) is necessary here as well. Of course, the FN 3120H is also eminently suitable for conventional use.

Specifications

Max. operating voltage: 3x520VAC
 Operating frequency: DC to 60Hz
 Current range: 25 - 230A at 50°C
 Min. performance: 120m (Class B)
 Climatic classification: 25/100/21
 Approvals: UL, CSA, ENEC

Block schematic diagram



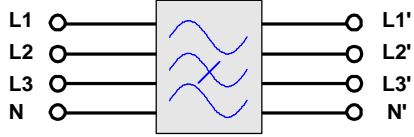

Advantages & main features

- Regeneration-capable (with line-impedance)
- Makes compliance with Class B possible (measurement by Schaffner recommended)
- Also increases the immunity and reliability of the machine significantly
- Outstanding broadband attenuation performance
- Very high saturation resistance
- Solid, contact-protected connections according to EN60204-1

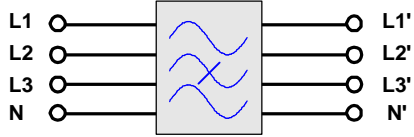

Fig: FN 3120H-110-35



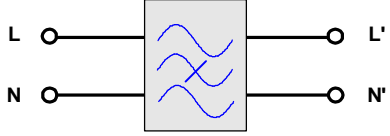

3.3.6 FN 3256H – Three-phase + neutral line filters

<p>Application</p> <p>FN 3256H, as the mains input filter for 3-PH+N, takes into account the constructional conditions at the mains input on numerous machine tools with its cubic shape. It is mainly suitable for industrial deployment for machines with up to 8 driving axes with ~10m motor cable each. Simplest assembly and solid connection technology make this filter the first choice when it comes to ensuring noise suppression across three phases and the neutral conductor.</p>	
<p>Specifications</p> <p>Max. operating voltage: 520VAC Operating frequency: DC to 60Hz Current range: 8 - 160A at 50°C Min. performance: 50m (Class A) Climatic classification: 25/100/21 Approvals: UL, CSA, ENEC</p>	<p>Block schematic diagram</p> 
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Filter for noise suppression right at the mains input ■ Ensures compliance according to EN50370-1 ■ Even Class A is possible (approval measurement by Schaffner recommended) ■ Increases the immunity and reliability of the complete machinery ■ Distinguished by an optimized, space-saving construction ■ Provides solid connection technology according to EN60204-1 ■ Current ratings according to fuse protection values 	<p>Fig: FN 3256H-8-29</p> 

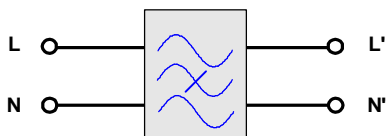

3.3.7 FN 3280H – High-performance three-phase + neutral line filters

<p>Application</p> <p>FN 3280H is the more powerful alternative to the previously described FN 3256H. Additional components ensure, even with up to 12 driving axes with 10 - 20m motor cable each, the compliance with Class A. Deployment in residential areas (Class B) is also possible with a corresponding EMC measurement. Despite the better performance, FN 3280H requires only an insignificant amount of additional space and is thus eminently suitable for use in machinery engineering.</p>	
<p>Specifications</p> <p>Max. operating voltage: 520VAC Operating frequency: DC to 60Hz Current range: 8 - 200A at 50°C Min. performance: 120m (Class A) Climatic classification: 25/100/21 Approvals: UL, CSA, ENEC</p>	<p>Block schematic diagram</p> 
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Filter for noise suppression right at the mains input ■ Ensures compliance with limit Class A ■ With EMC-compliant construction, even Class B is possible (approval measurement necessary) ■ Increases the immunity and reliability of equipment quite significantly ■ Distinguished by an optimized, space-saving design ■ Provides solid connection technology according to EN60204-1 ■ Current ratings according to fuse protection values 	<p>Fig: FN 3280H-80-35</p> 

3.3.8 FN 2410 – Single-phase EMC filters

<p>Application</p> <p>With the development of the FN 2410 series, a high-quality, powerful filter is now made available for single-phase applications as well, which meets the stringent requirements of industrial machinery engineering, drive technology as well as numerous other applications. FN 2412 DIN-rail mounting filters are equally suitable. With their time-saving mounting concept they are ideal for electrical control cabinets comprising common TS 35 DIN-rails.</p>	
<p>Specifications</p> <p>Max. operating voltage: 250VAC Operating frequency: DC to 60Hz Current range: 8 - 100A at 50°C Min. performance: 25m (Class A) Climatic classification: 25/100/21 Approvals: UL, CSA, ENEC</p>	<p>Block schematic diagram</p> 
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Makes possible compliance with limiting value Class A for single-phase machines and drives ■ With EMC-compliant construction, even Class B is possible (approval measurement recommended) ■ Increases the immunity and reliability of equipment quite significantly ■ Provides solid connection technology according to EN60204-1 ■ Compact filter solution with minimal space requirement 	<p>Fig: FN 2410-32-33</p> 

3.3.9 FN 2415 – Single-phase control line filters

<p>Application</p> <p>Especially in the case of large, complex machines with 8 or more driving axes and very long motor cables, it can happen that emissions get coupled to the supply lines of the machine control within the machine itself. Not seldom, this results in failure of the '(C)NC', 'PLC' or 'Motion Control'. An additional control line filter, such as the FN 2415, is an optimal supplement to the mains filter and increases the operational safety and reliability of the complete system quite significantly. Since similar problems can also occur in the case of machines with less than 8 axes, it is advisable, in case of doubt, to have Schaffner carry out an analysis by means of EMC measurements directly on the machine.</p>	
<p>Specifications</p> <p>Max. operating voltage: 250VAC Operating frequency: DC to 60Hz Current range: 6 - 16A at 50°C Climatic classification: 25/100/21 Approvals: UL, CSA, ENEC</p>	<p>Block schematic diagram</p> 
<p>Advantages & main features</p> <ul style="list-style-type: none"> ■ Additional filter for the control lines of complex systems and machines ■ Ensures fault-free operation of the machine controls ■ Increases the immunity, operational safety and reliability of the complete plant quite significantly ■ Provides solid connection technology according to EN60204-1 ■ Compact filter solution with minimal space requirement 	<p>Fig: FN 2415-10-29</p> 

3.4 Interference suppression in machinery engineering – examples of circuitry

3.4.1 Interference suppression at the noise source (drive system)

Using an example of a machine tool with up to 12 axes and ~10m motor cable each, we shall show that in the case of large, complex systems, interference suppression should be done just before the drive system. In order to avoid radiated emissions from getting coupled to the control lines and hence neutralizing the EMC measures that have been taken, or adversely affecting the functioning of the controls, often, another filter is provided in the supply line of the machine control unit; here, it is a 4-conductor filter. This procedure is efficiently preventing unwanted interference propagation within the machine.

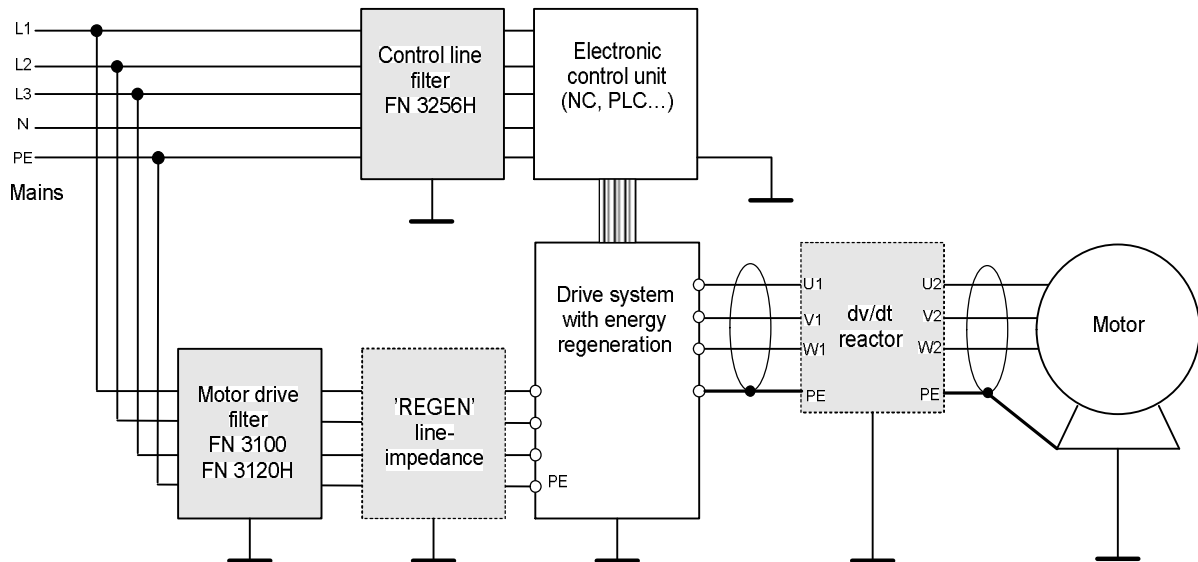


Fig. 2: Machine with max. 12 axes and 10m motor cable each (Use in residential area: Class B)

3.4.2 Interference suppression with a 3-phase+neutral filter (sum filter)

Often, for small and medium-sized machines, a sum filter is placed directly at the mains input, which takes care of a significant part of the EMC. However, particularly with modern regenerative drives with high noise levels, this is not always enough, which makes necessary an additional inverter filter immediately before the drives. A 3-ph+n sum filter placed directly at the input of the machine is a good way of increasing immunity and protecting the whole system against interferences from outside.

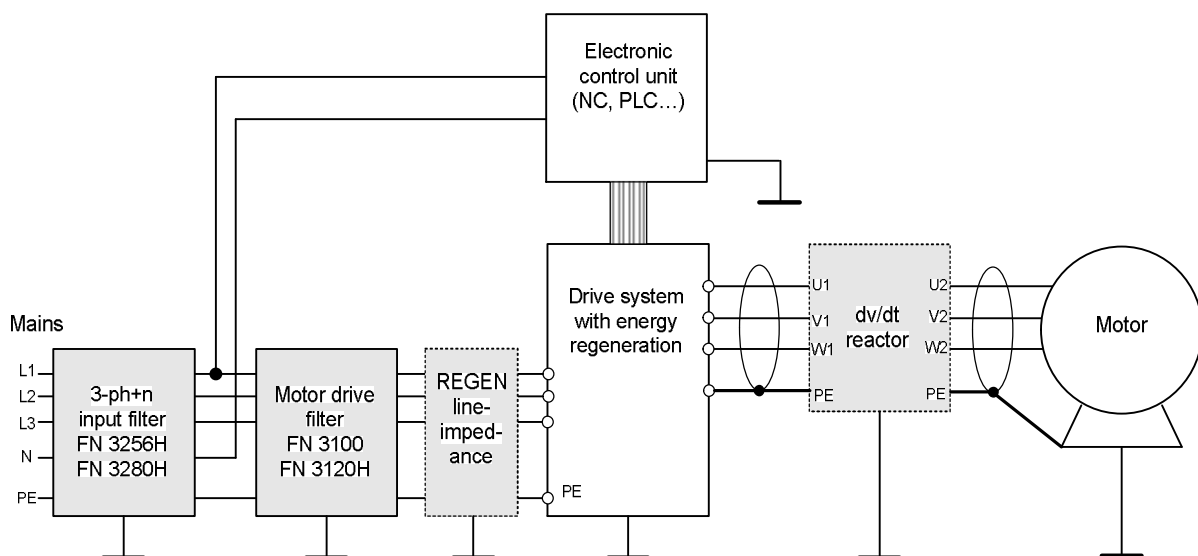


Fig. 3: Machine with ~5 axes and ~15m motor cable each (use in residential area: Class B)

3.4.3 Interference suppression at the mains input

In the case of very large, complex systems, sum interference suppression directly at the mains is not advisable, or is not possible because of the power consumption or space conditions. In this case, it is advisable to use an inverter filter directly before the source of interference, i.e. the drive system. In the depicted situation, the 1-phase supply line of the machine control unit can be effectively protected with an FN 2415 control line filter, in order to ensure fault-free functioning and hence the reliability of the complete machine.

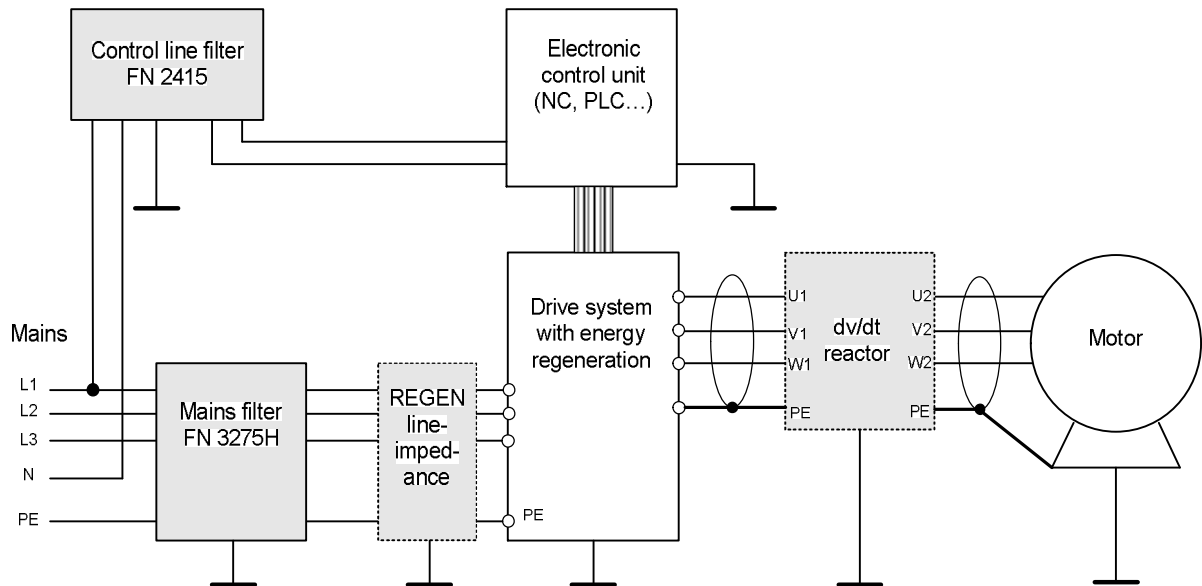


Fig. 4: Machine with ~8 axes and ~10m motor cable each (use in industrial area: EN50370-1)

Which configuration is best suited for a particular case and which filter(s) can be ideally used can hardly be determined with finality. In cases of doubt, it is advisable to make use of competent consulting with the corresponding measurements and EMC planning by a specialist.

Author's note:

In all the three cases depicted, it is of utmost importance that a suitable regenerative line-impedance is used immediately before the regenerative drives, which then de-couples and smoothens the regenerative switching towards the mains and in fact, ensuring the proper function of the 'regen-mode' in the first place.

Furthermore, on all machines, a dv/dt-choke or a dv/dt-filter has to be provided at the inverter output to preserve the life of the connected motors (mostly servo motors and torque motors). Further information on this can be obtained from any Schaffner representative.

4. Schaffner – more than just filters

Owing to the many years of experience and competence in the industrial sector, Schaffner is in a position to offer filter solutions that give the machinery manufacturer real advantages. The knowledge from innumerable on-site measurements is continuously incorporated in the development of new filters and guarantees their practical utility. For the user, this means no unpleasant surprises after the installation and hence, the utilization of EMC components without any worries.

All the aforementioned components are standard catalog products with high availability, which have proven themselves with a large number of the most varied machine types. Nonetheless, in certain cases, it may be necessary to customize the existing filter design according to the requirements of special applications. This facility is available, of course, both for the electrical as well as the mechanical parameters and can, upon inquiry, be developed in close cooperation between Schaffner and the machinery engineer.

Be it a standard or customer specific solution, Schaffner is the ideal partner for carrying out EMC measurements on-site and in the application, for verifying the capability of the filters, the immunity and the electromagnetic compatibility of the entire installation. In addition, there are Schaffner specialists on call all over the world to support you right from the development stage in matters related to EMC, when the requirement is to plan the construction of the overall plant to be as EMC-compliant as possible.

Apart from an incomparable range of EMC solutions, Schaffner can provide consulting and active support to the machinery manufacturer in the area of line-reactors, harmonics filters and output filters as well as the corresponding products and hence offer synergistic total solutions.

For more detailed information, data sheets, consulting or measurement services, please contact your local Schaffner representative or the head office in Luterbach, Switzerland. The corresponding contact addresses can be found at www.schaffner.com

