



## EMC filters for medical devices

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Schaffner, the market leader in EMC filters and power quality, has supplemented its proven IEC inlet filter series FN9222 and FN9233 with an even higher level of filter performance to flexibly meet new requirements.

With identical panel cut-outs and housing the new FN9244 series achieves an 8-10 dB improvement in insertion loss. The EMC filters are tested to ENEC, UL, CSA, and CQC, conform to RoHS and REACH requirements and can be used in devices worldwide.

The FN9244 series was designed especially to meet the requirements of the medical standards like IEC/EN 60601 for equipment with patient contact or other medical environments.

EMC filters play an important role in ensuring reliable operation of medical devices. Besides EMC measures on components as switched-mode power supplies or controller systems, the mains connection remains one of the major points for interference suppression, even with EMC oriented design of the individual components.

Combining an IEC plug with the EMC filter is the optimal way to insert interference suppression directly to the device's incoming AC power cable, and it is usually the most economical solution as well.

The encasing metal housing of the Schaffner IEC inlet filter with its optimized joint-contact to the equipment panel creates an excellent RF shielding between the interior and the outside environment and also prevents from crosstalk with modules or cables in the immediate proximity of the filter.



Figure 1: Schaffner's „High performance“ IEC plug filter FN9244

Several standards are applied for electrical safety in medical devices. IEC/EN 61010 and IEC/EN 60601 are on the current list of EU-harmonised standards of the low voltage directive for electrical safety of medical devices as well as they are worldwide accepted. Which standard to apply depends on the difference between medical devices (MD = medical devices) or diagnostic devices (IVD = in vitro diagnostics).



Figure 2: Electronic syringe pumps in use

Products such as syringe pumps, medical ventilators, lasers or patient monitoring devices with applied parts in direct physical or electrical contact with patients are defined as medical devices (MD). With 250 V AC, 2.5 mm clearance distance and 4 mm creepage distance are required as basic insulation. The maximum permissible leakage current is 0.1 mA in normal operation.

Regarding EMC, IEC/EN 60601 refers to the corresponding limit values of the CISPR standards. Most electrical medical devices are categorised similar to the generic standards into classes according to use in the household, doctor's surgery (B) or in hospitals with separated AC mains (A). Emissions must comply with the limits of CISPR11. For simple electrical components, reference is CISPR14, for lighting facilities CISPR15 and for IT systems CISPR22.

The second device group is the diagnostic units (IVD = in vitro diagnostics), which are used for preparation and analysis of bodily fluids or human tissue. These include centrifuges, hematology analyzers, gas or liquid chromatographs, for example, as well as various laboratory devices which are classified as medical products but not as electrical medical devices. Here IEC/EN61010 is applied. The limit for leakage current is 0.5 mA under normal conditions as well as maximum 3.5 mA in case of failure.

The EMC requirements for so-called IVDs are governed by the harmonised EN 61326.

The table (figure 3) gives a quick application overview. FN 9244 is available from 1-15A and, like the existing series, designed for a maximum permanent operating voltage of 250 V AC with a frequency range of up to 400Hz. All IEC inlet filters with Y-caps (FN92xx) as well as with an integrated earth line choke (FN92xxE) can be used for IVD devices since their leakage current is normally 0.16 mA and max. 0.373 mA at worst. This allows the IEC inlet filters also to be used parallel to device-internal power supplies with integrated filtering. Attention must therefore be paid to the total leakage current.

The B-types contain no Y-caps to fulfill the leakage requirements. All FN92xxB and FN92xxEB (integrated earth line choke) can be used for MD equipment.

Schaffner IEC Inlet Filter			Application		
<b>Approvals*</b>    <b>Filter family</b>	<b>current range [A]</b>	<b>max. voltage [Vac]</b>	<b>attenuation performance</b>	<b>MD (medical equipment)</b>	<b>IVD (In Vitro Diagnostics)</b>
FN9222E	1-15	250	standard		✓
FN9222B	1-20	250	standard	✓	
FN9222EB	1-15	250	standard	✓	
FN9233	1-15	250	high		✓
FN9233E	1-15	250	high		✓
FN9233B	1-15	250	high	✓	
FN9233EB	1-15	250	high	✓	
FN9244	1-15	250	very high		✓
FN9244E	1-15	250	very high		✓
FN9244B	1-15	250	very high	✓	
FN9244EB	1-15	250	very high	✓	
<b>Safety recommendation: use always option R!</b>					

Figure 3: Application overview of IEC inlet filter series FN92xx

The consistently identical design of these series is also characteristic. Besides the classic flange mounting, all IEC inlet filters are available for snap-in mounting as well. The snap-in type is pressed into the panel cut-out and latches permanently without additional screwing with a defined contact pressure through the metal clips. This saves mounting time and improves device safety.

The panel cut-out is identical for all products with the same mounting type. With the IEC plug type C14 in the design with or without earth line choke, an additional range of requirements is covered essentially with two housing sizes. EMC filters for higher currents up to 20A with type C20 or type C16 (hot inlet) are also available.

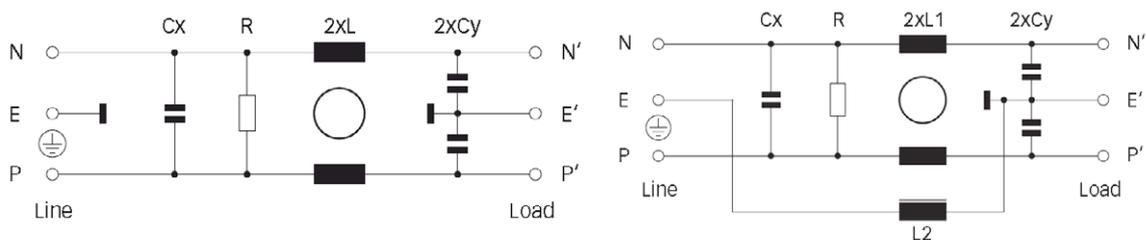


Figure 4a: schematic of EMC filter 4b schematic of EMC filter with earth line choke

Figure 4 shows the typical schematic of the Schaffner IEC inlet filters. As already mentioned, X-caps as well as Y-caps are used. The X-caps are located between the active conductors, the Y-caps between the active conductors and the earth. They have to comply with increased requirements for electric strength, self-healing, insulation, life time, etc., as described in IEC/EN 60384-14 due to their direct and constant connection to the AC mains.

Conducted interferences are basically distinguished in two types: Noise, which occurs between the active conductors, is designated as symmetrical interference (DM = differential mode). All interference on the active conductors whose current path returns over the earth is so-called asymmetric interference (CM = common mode). So the Y-caps suppress mainly the CM noise and the X-caps the DM noise.

A further core element of the EMC filters is thus the common mode choke. It attenuates asymmetric interference running from the device to the AC mains and forms a low-pass filter for symmetrical interference with its leakage inductance and the mains-sided X-cap. Further it also suppresses mains disturbances and so contributes to improved device immunity.

The B types of the Schaffner IEC inlet filters are designed without Y-caps due to the above mentioned leakage-current requirements of MDs. All filter families are also available with an earth line choke (E-design) in order to suppress ground loops in devices which are linked up to an additional connecting cable, such as interface or bus. The resistance R ensures that the caps are discharged and no shock-hazard voltage remains on the poles, when the equipment is unplugged. Thus the selection of Option R (bleed resistor) is always recommended if no additional measures were taken inside the device.

According to CISPR 17 the insertion loss of EMC filters is measured both with 50 ohms input and termination impedance. The frequency response curve is displayed in all Schaffner data sheets. These diagrams are helpful for an initial orientation. The real insertion loss of an EMC filter depends on the impedance situation in the application. These are not always 50 ohms and are mostly of a complex nature. In practice, an inductive part on the mains side and a capacitive part on the load side are added.

As a result, the effectiveness of an EMC filter must be tested inside the equipment. Schaffner has a worldwide network of engineering organisations and can offer support. Besides the standard program, customer-specific solutions can also be implemented on request. Versions with smaller Y-caps with leakage current  $< 0.1$  mA are also feasible.

As the measured curves (Fig. 5) for the insertion losses show, the attenuation for asymmetric interference of the B-version declines due to the lack of Y-caps in the higher frequency range. This depends on the resonance point, which is determined by the main inductance of the CM choke and the parasitic internal winding capacitance parallel to it.

The approximately 5-fold increased inductance values of the FN9244 series move this resonance point upward and thus improve the insertion loss over the entire range.

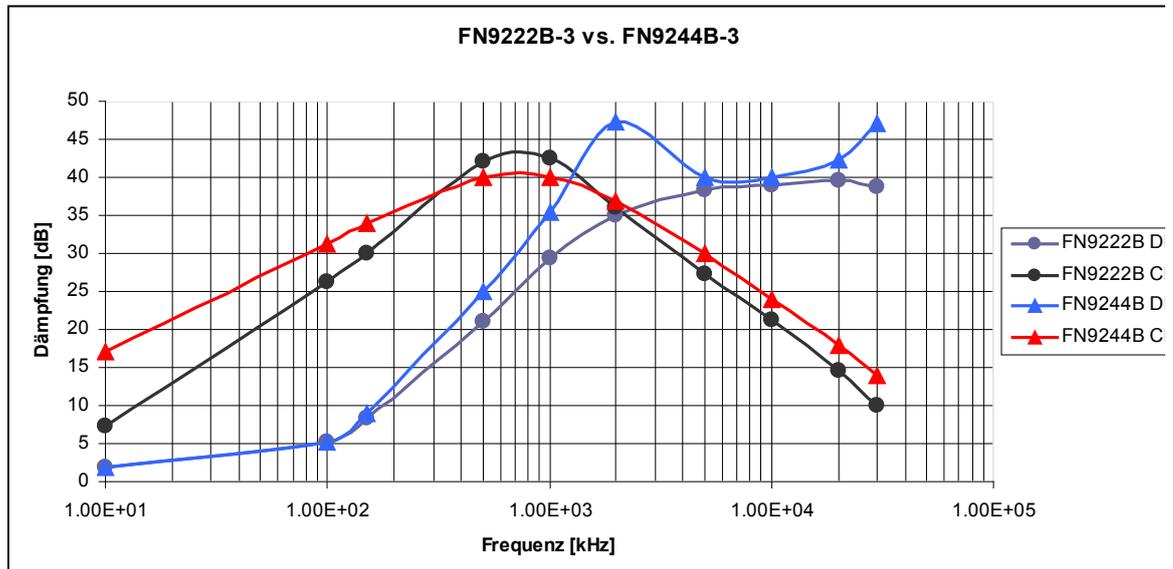


Figure 5: Insertion loss FN9222B-3-06 and FN9244B-3-06

With the expansion of the IEC inlet filter family with the FN9244 series, Schaffner sets a new benchmark for high-performance filters in the existing size and opens up further application areas, which previously could only be serviced with larger-size filters. As a result, designers' demands are met far more flexibly with interference suppression and the possibility of an even more compact design of the equipment. Especially for MD equipment, highly efficient IEC inlet filters are now available with the B- and EB-versions.



**The Schaffner Group** is the international leader in development and production of solutions that ensure efficient and reliable operation of electronic systems. The versatile product range includes EMC components, harmonic filters and magnetic components as well as development and implementation of customer-specific solutions. Schaffner components are used in energy-efficient drive systems and electronic motor controllers, in wind and photovoltaic plants, in railway technology, in machine tools and robots as well as in the power supply for numerous electronic devices, such as in medical technology or telecommunications. With its powerful global organisation, Schaffner serves customers locally throughout the world and is consistently expanding its internationally leading market position with continuous investments in research and development, production and sales.

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