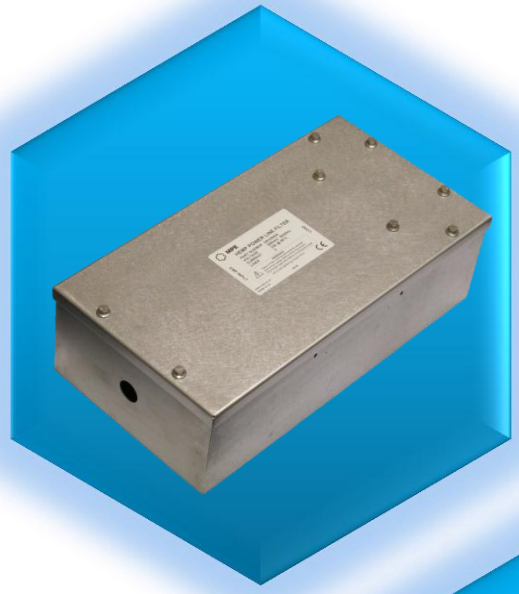
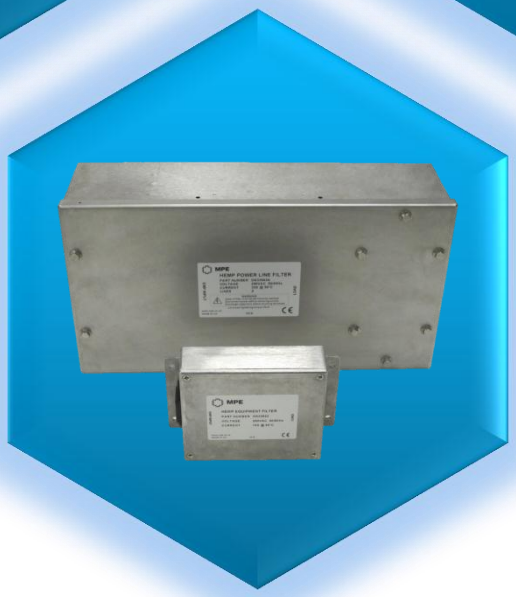
HEMP PROTECTION FILTERS FOR COMMERCIAL APPLICATIONS





FILTERS FOR POWER LINE PROTECTION MEETING RESIDUAL CURENT REQUIREMENTS OF IEC 61000-4-24 FOR SEVERITY LEVEL 1 (INDUSTRIAL) AND SEVERITY LEVEL 2 (COMMERCIAL CRITICAL INFRASTRUCTURE)

bsi. ISO 9001 Quality Management
FM00699

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HEMP POWER LINE PROTECTION FILTERS FOR COMMERCIAL INFRASTRUCTURE APPLICATIONS

CONTENTS

Additional HEMP Filter Types Available for Full-Threat, Mission Critical Applications requiring protection to Mil-Std-188-125 -1 and -2 , Def Stan 59-188 parts 1 and 2, and IEC 6100-4-24 severity level 3

For HEMP Power Line Filters 6A - 400A	See separate brochure
For HEMP Control Line Filters 1A- 5A	See separate brochure
For HEMP Telephone Line Filters	See separate brochure
For 800A, single line for single or three phase	See separate brochure
For 800A, 4 line (TPN) extended performance	See separate brochure
For 1200A, single line for single or three phase	See separate brochure
For 1200A, 4 line (TPN) extended performance	See separate brochure

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OVERVIEW OF COMMERCIAL INFRASTRUCTURE PROTECTION AGAINST HEMP

The HEMP threat consists of a fast high energy radiated pulse of up to 50kV/m which will damage electrical and electronic equipment both by direct coupled radiation effects and from high energy conducted pulses coupled onto power and signal cables.

Protection of electrical equipment has to cover three key aspects

1. Shielding against the radiated field
2. Filtering and transient suppression of pulses induced onto incoming cables
3. Low impedance earth connection to conduct away heavy pulse currents

Critical military installations will normally have a shielded room to shield against direct radiation effects with each penetrating electrical conductor being protected with a full performance HEMP filter complying with the requirements of Mil-Std-188-125-1 or Def-Stan 59-188 part 1. These HEMP filters are covered in other MPE catalogues. The Mil-Std-188-125 protection approach assumes that equipment to be protected has no immunity level at all so must be fully protected to the highest level to avoid damage or malfunction, so the shield and the filters have to offer the maximum level of protection based on this assumption. This approach is also valid for certain critical commercial infrastructure applications and this is covered by IEC 61000-4-24 residual current severity level 3 which is equivalent to the above Mil-Standard requirement.

In a real commercial environment, most items of equipment will have some immunity, partly as a result of mandatory EMC requirements, so it may not be necessary to protect against the worst case scenario. Also, in a commercial installation it may be acceptable for equipment to be disrupted to some extent by a HEMP event as long as it can recover afterwards, so the level of protection need not be as great as for military applications. However, the threat from a HEMP event is the same whether the application is military or commercial so measures must be taken to reduce the very significant magnitude of the radiated field and conducted pulses to levels which are acceptable to the equipment being protected.

For commercial infrastructure applications, it may not be necessary to go to the expense of a full shielded room. Sensitive equipment is likely to be inside a normal commercial building within a metal cabinet.
Both commercial buildings and equipment cabinets will have a certain amount of natural shielding which will reduce the magnitude of the radiated pulse to some extent but to nowhere near the levels of a fully shielded room so some additional shielding measures may be necessary. Incoming conducted pulses will be carried straight into the equipment via power and signal cables with little or no attenuation so HEMP filtering on incoming lines is essential.

Where the installation is critical, and for upgrade of existing buildings, a review of the installation should be undertaken to ascertain the level of natural shielding provided by the building and equipment enclosures, to estimate the likely induced pulse currents entering the building on cables based on the length and routing of incoming cables, and to assess the immunity of equipment to be protected.

Sometimes where a lot of equipment needs protecting the most cost effective approach may still be to enclose it all inside a full specification HEMP shielded and filtered enclosure in a similar manner as for military installations but alternative options are described in this brochure.
To help with estimating required protection levels of shielding and filtering, guidance can be taken from IEC standards. IEC 61000-5-10, shortly to be published, will offer practical guidance on overall requirements including shielding attenuation and IEC61000-4-24 can be used for guidance of HEMP filter performance level required based on severity level of protection required.

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HEMP E1 & E2 Pulse Components

A HEMP pulse comprises short, E1, intermediate, E2, and Long, E3, time components

E1 is the short pulse which, when coupled into a cable, will typically have a double exponential pulse shape of 20/500ns. This will readily couple onto even short lengths of cable and will penetrate into equipment through even the tiniest aperture to cause damage. The peak current induced on cables will depend on a number of factors including cable orientation, cable length, and coupling factor but could be as high as 2500A.

E2 is the intermediate component of the pulse which again is a double exponential pulse with an induced waveform of 1.5/400us with a peak current of up to 250A. Although much lower amplitude than the E1 pulse this pulse has much higher energy because of the longer timeframe. However, because of the frequency, it will only effectively couple into long lines typically greater than 200m, and the radiated field will not penetrate small apertures.

E3 is the long-time component which is almost dc and can typically last for 0.2s up to 25s at up to 1000A. It is very similar to pulses induced by severe geomagnetic storms. It can only be coupled into very long lines such as long range power grid lines and cannot be addressed by filtering or transient suppressors and is not relevant to local commercial HEMP protected applications, outside the grid itself, so is outside the scope of this brochure.

PROTECTION SEVERITY LEVELS BASED ON IEC61000-4-24

IEC 61000-4-24 Severity Level 3 (Equivalent to Mil-Std-188-125-1 and Def-Stan 59-188 part 1)
This is ideal for military and the most stringent critical infrastructure protection, and offers the best approach using a full shielded room offering at least 80dB of shielding performance to 1GHz for HEMP only (or 10GHz to cover IEMI as well) with full performance HEMP filters as detailed in other MPE catalogues. It offers full threat protection even when the immunity of equipment is unknown.

IEC61000-4-24 Severity Levels 1 & 2
Severity levels 1 & 2 are defined in IEC61000-4-24 for less critical commercial applications. The level required is selected by the user depending on his application and the level of protection required.
Level 2 is recommended for commercial critical infrastructure.
Level 1 is for industrial applications with a greater level of intrinsic immunity, and/or less critical requirements.
Protection of commercial systems is best achieved either by protecting individual items of equipment in their own enclosures, or by use of a staged protection system where both the radiated and conducted pulses are reduced in stages, as defined in the following pages.

IEC61000-4-24 Protection Levels – Residual pulse requirements for conducted pulse
IEC61000-4-24 gives recommendations on the residual pulse performance for HEMP filters for protection against conducted pulses. It does not define shielding requirements to protect against the radiated pulse and this must also be considered based on the application. However, as a guide, good target figures would be 80dB for severity 3 and 60dB for severity 1 and 2 for new buildings and 40dB for severity 1 and 2 for existing buildings over the frequency range 1MHz to 1GHz.

Comparative examples of peak residual current levels for HEMP power filters for different severity levels based on IEC61000-4-24 are given below. These are for 250V AC HEMP power filters with a 2Ω nominal load when subjected to a conducted E1 pulse. IEC61000-4-24 should be consulted for full guidance and recommendations including testing procedures, wiring configurations, applied pulse details, and other residual pulse requirements such as risetime and energy content.

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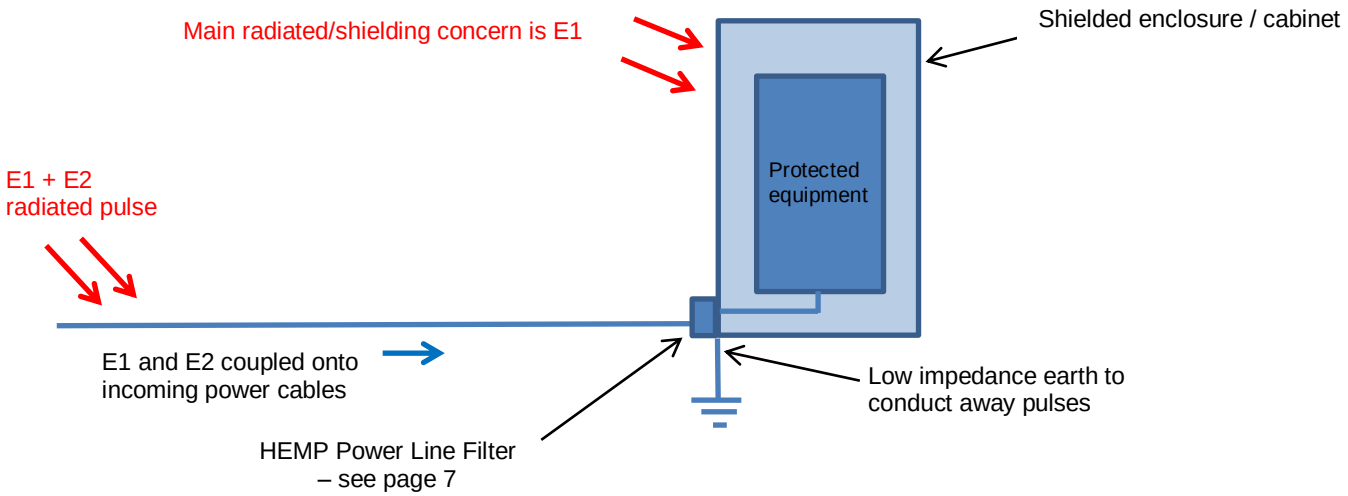
Comparative E1 peak residual currents for 250VAC HEMP power line filters for different severity levels based on IEC61000-4-24		
Severity Level	Protection Concepts	Peak residual current into nominal 2Ω load (A)
Level 1	Industrial	353
Level 2	Critical Infrastructures	50
Level 3	Special (based on Mili-Std-188-125)	10

EQUIPMENT PROTECTION OPTIONS

Single Layer Protection Only

Protection can be achieved locally by putting each item of equipment in a shielded enclosure fitted with a commercial HEMP filter meeting IEC61000-4-24 severity level 1 or 2 as offered in this catalogue, or a full performance HEMP filter meeting severity level 3 as offered in other MPE brochures.



As a guide, for single or several small items of equipment, the cabinet should offer 80dB of shielding for severity 3, and 40 - 60dB for severity 1 & 2.
For multiple items of equipment, it may be more cost-effective for the cabinet to become a full shielded room containing all items of equipment.
The filter needs to protect against E1 and E2 conducted pulses as the incoming power cables are likely to be longer than 200m

(For severity level 1 protection, for very resilient items only requiring a minimal level of protection it may be considered that the standard metal box housing the equipment plus the limited additional shielding from the building plus a HEMP filter meeting severity level 1 is all that is needed.)

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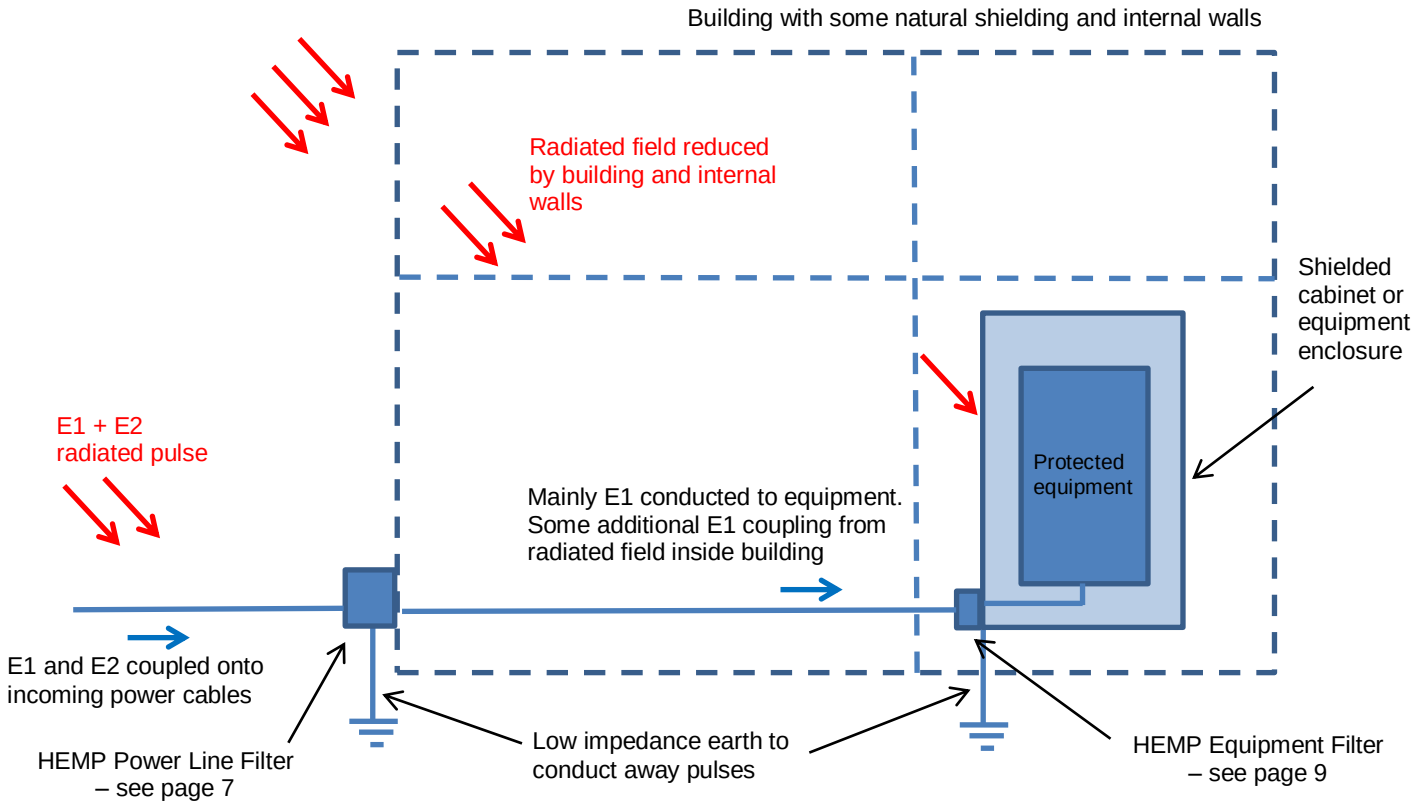
Layered Protection - Building plus Equipment Level Protection

This makes use of existing building shielding and rooms within buildings plus equipment cabinets to give additive levels of shielding protection. This may in some cases be augmented by architectural shielding such as foil wallpaper, metal backed panels, conductive paint on walls, and shielded windows.
A good quality commercial building with rebars could have a shielding of typically 15dB. This would reduce a worst case radiated field of 50kV/m to below 10kV/m. If equipment is already fitted in an EMC cabinet, it may already have sufficient shielding but if not an extra cabinet may be needed. For example, a cabinet with 40dB shielding would reduce the radiated field further to less than 100V/m, or a 60dB cabinet would reduce this to less than 10V/m. These are levels which are unlikely to cause permanent damage to most items of equipment provided that the incoming cables are suitably protected against incoming pulses with HEMP filters. Examples of other building shielding would be wood or concrete without rebars <5dB, metal 20-25dB. Most damage is caused by conducted energy getting into sensitive circuitry rather than the effects of direct radiation, and even if a room is well shielded, conducted pulses will be carried directly into the equipment unless cables are effectively filtered. To minimise coupling, incoming cables are best routed underground where possible and contained within steel conduit or trunking up to the point at which they enter the filter. The E2 pulse will couple well into any cables longer than 200m and the E1 pulse will couple well onto even very short lengths of cable.
A power HEMP filter should normally be fitted at the point at which the power enters the building. This will remove both the E1 and the high energy E2 pulses which have been induced on incoming cables and short them to ground thus keeping them outside the building. However, because of the lack of shielding at this point, some of the E1 pulse will by-pass the filter and further E1 coupling will occur inside the building. A HEMP equipment filter at the entry to the equipment will remove the remaining E1 pulse to an acceptable level to avoid damage and also preserve the integrity of the shielding of the cabinet. The HEMP equipment filter would have the benefit of also providing a high level of EMC filtering thus reducing the need for an input EMC filter on the equipment. A low impedance earth connection is required at each filter to divert the high speed high current pulses directly to ground.



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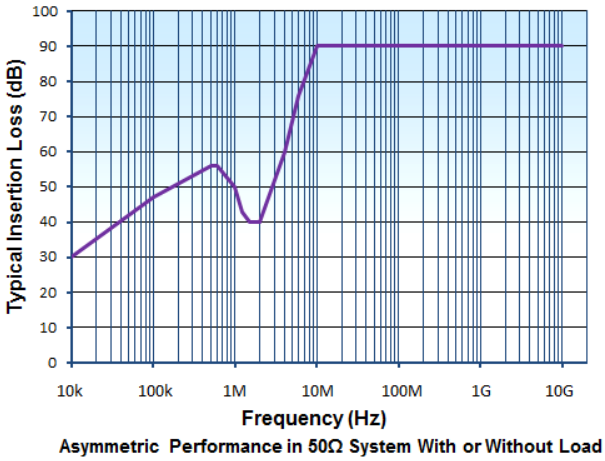
COMMERCIAL HEMP PROTECTION FILTERS

Commercial HEMP Power Line Range



Asymmetric Performance in 50Ω System With or Without Load

Description

A range of 2 line and 4 line (single & three phase) Power Line HEMP filters meeting the pci requirements of IEC61000-4-24 pulses for severity levels 1 and 2. All lines are individually filtered and feature inductive input to offer both good continuous wave EMC performance and superior transient handling performance even on supplies with low source impedance. The filters provide protection against both E1 and E2 pulses.

Features

- 250V/440Vac with 16A – 100A current ratings
- 2 or 4 individually filtered lines
- Utilise MPE self-healing feedthrough capacitors
- Compact size
- Low heat dissipation
- RoHS compliant
- Built-in transient suppressors
- UL94-V0 insulating materials used
- Exceeds IEC 950 and UL1283 requirements for voltage proof for safety and reliability
- Cost-effective
- Offers protection against HEMP and IEMI
- Meets IEC61000-4-24 residual current requirement for severity levels 1 & 2

Ratings and Characteristics

Rated Voltage	All filters	250Vac 50/60Hz or 300V dc each line to case
	4 line (3 phase) filters	250/440Vac 50/60Hz (277V/480Vac on request)
Test Voltage (Prior to fitting transient suppressors)		2250Vdc each line to case
Discharge Resistors		Fitted internally from each line to case
Discharge Time to below 34V		<30s
Maximum Temperature Rise on Full Load		25ºC
Full Load Operating Temperature Range		-40ºC to +50ºC
Maximum Leakage Current at 250Vac 50Hz		See table
Peak Surge Current		40kA (8/20µs)
Insertion Loss & Shielding Effectiveness of Enclosure		See graph

Transient Suppression Performance

Pulse current injection performance, short E1 pulse wave shape 20/500ns					
Input pulse amplitude	250A	500A	1000A	1800A	2500A
IEC61000-4-24 residual requirement -severity level 1	<353A	<353A	<353A	<353A	<353A
IEC61000-4-24 residual requirement -severity level 2	<50A	<50A	<50A	<50A	<50A
Typical filter residual let-through	Compliant with severity level 2				

Intermediate E2 pulse current injection, wave shape 1.5/3000µs	
Input pulse amplitude	250A
IEC61000-4-24 requirement	No filter damage or performance degradation
Typical filter response	No filter damage or performance degradation

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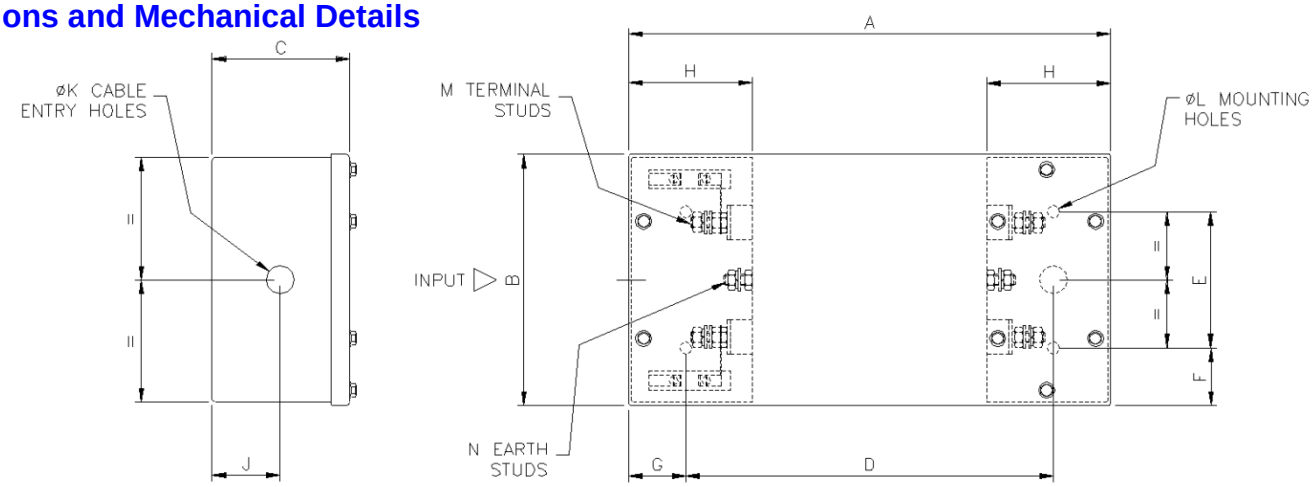
COMMERCIAL HEMP PROTECTION FILTERS

Product Range

Part Number	Current Rating per Line @ 50ºC (A) *	Number of Lines	Max Leakage Current per Line (mA) @240V 50Hz	Max DC Volt Drop per Line (mV)	Major Dimensions (mm)			Approx. Weight (kg)
					Length A	Width B	Depth C	
DS33941	16	2	1300	30	350	180	100	7
DS33942	32	2	1300	36	350	180	100	7
DS33943	63	2	1300	45	350	180	100	7.5
DS33944	100	2	1300	65	380	220	100	10
DS33951	16	4	1300	30	350	360	100	14
DS33952	32	4	1300	36	350	360	100	14
DS33953	63	4	1300	45	350	360	100	15
DS33954	100	4	1300	65	380	440	100	20

* Current derating between 50ºC and 85ºC $I_\theta = I_R\sqrt{(85-\theta)/35}$

Dimensions and Mechanical Details



Case material: Stainless steel
Finish: Unpainted
Terminals: Nickel plated brass

Part Number	Dimensions (mm)												
	A*	B*	C*	D	E	F	G	H	J	K	L	M	N
DS33941	350	180	100	270	100	40	40	90	50	20.5	9	M8	M8
DS33942	350	180	100	270	100	40	40	90	50	20.5	9	M8	M8
DS33943	350	180	100	270	100	40	40	90	50	20.5	9	M8	M8
DS33944	380	220	100	300	140	40	40	90	50	32.5	9	M8	M8
DS33951	350	360	100	270	220	70	40	90	50	20.5	9	M8	M8
DS33952	350	360	100	270	220	70	40	90	50	20.5	9	M8	M8
DS33953	350	360	100	270	220	70	40	90	50	20.5	9	M8	M8
DS33954	380	440	100	300	260	90	40	90	50	32.5	9	M8	M8

*Dimensions A, B, & C exclude lid projections beyond box

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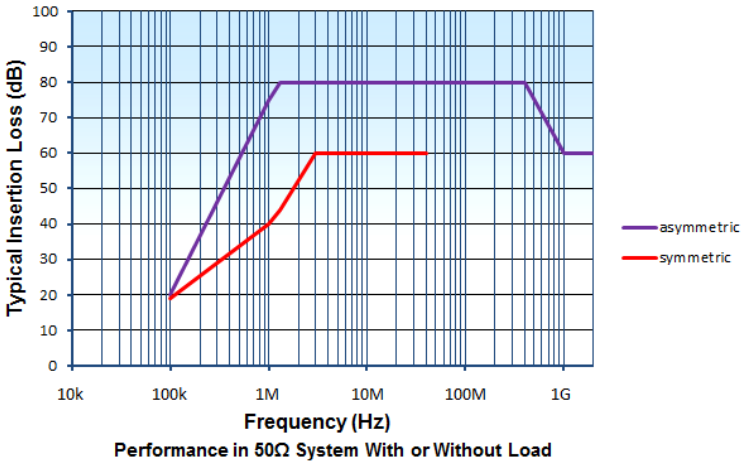
Commercial HEMP/EMC Equipment Filter



Performance in 50Ω System With or Without Load

Description

A 10A HEMP equipment filter meeting the pci requirements of IEC61000-4-24 pulses for severity levels 1 and 2. Both lines feature individual inductive input to offer both good continuous wave EMC performance and superior transient handling performance even on supplies with low source impedance. The filter includes HEMP and EMC filtering components thus reducing the need for a separate EMC input filter for the equipment. If additional EMC filtering is needed, it can readily be provided at board level. This filter is primarily designed to protect individual items of equipment against the E1 pulse as part of a staged protection system as described earlier in this catalogue.

Features

- 250V 50/60Hz 10A rating
- 120V and 277V versions on request
- Utilise MPE self-healing feedthrough capacitors
- Compact size
- RoHS compliant
- Built-in transient suppressors
- UL94-V0 insulating materials used
- Exceeds IEC 950 and UL1283 requirements for voltage proof for safety and reliability
- Cost-effective
- Offers HEMP protection and aids EMC compliance
- Meets IEC61000-4-24 residual current requirement for severity levels 1 & 2

Ratings and Characteristics

Rated Voltage	250Vac 50/60Hz (120V and 277V on request)
Test Voltage (Prior to fitting transient suppressors)	2250Vdc each line to case, 1250Vdc line to line
Discharge Resistors	Fitted internally between lines
Discharge Time to below 34V	<30s
Maximum Temperature Rise on Full Load	25ºC
Full Load Operating Temperature Range	-40ºC to +50ºC
Maximum Leakage Current at 250Vac 50Hz	See table
Peak Surge Current	15kA (8/20µs)
Insertion Loss and Shielding Effectiveness	See graph

Transient Suppression Performance

Pulse current injection performance, short E1 pulse wave shape 20/500ns					
Input pulse amplitude	250A	500A	1000A	1800A	2500A
IEC61000-4-24 residual requirement -severity level 1	<353A	<353A	<353A	<353A	<353A
IEC61000-4-24 residual requirement -severity level 2	<50A	<50A	<50A	<50A	<50A
Typical filter residual let-through	Compliant with severity level 2 requirements				

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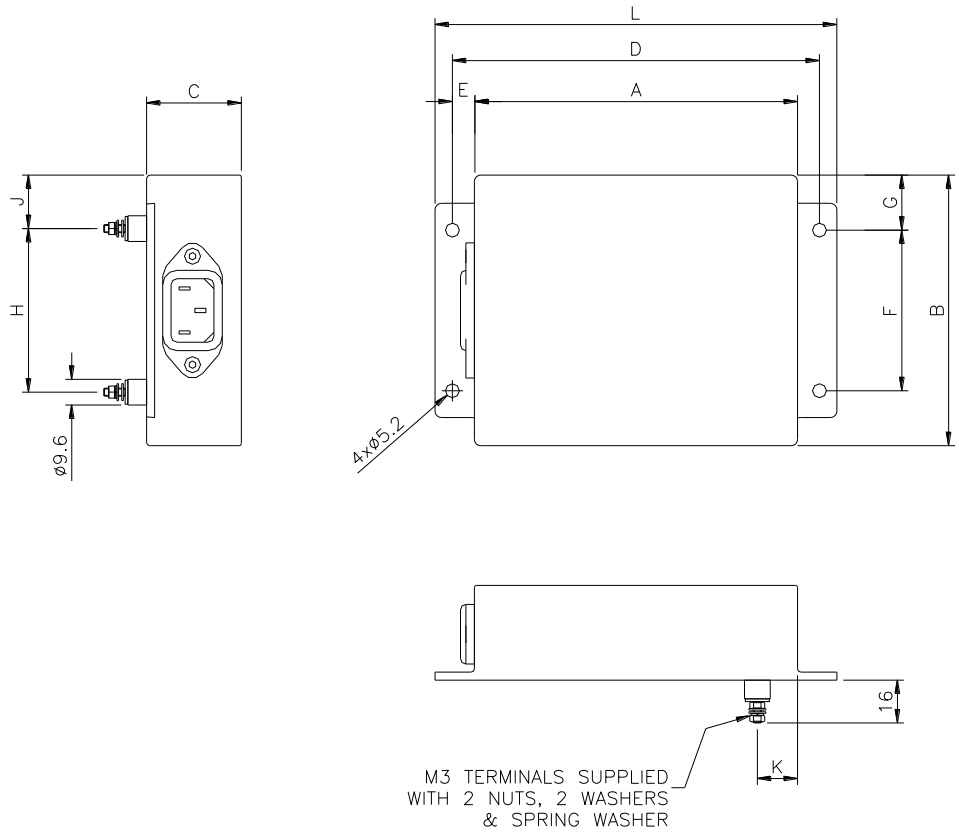
COMMERCIAL HEMP PROTECTION FILTERS

Product Range

Part Number	Current Rating per Line @ 50ºC (A) *	Number of Lines	Max Leakage Current per Line @ 240V 50Hz (mA)	Max DC Volt Drop per Line (V)	Max Heat Dissipation (W)	Major Dimensions (mm)			Approx Weight (g)
						Length A	Width B	Depth C	
DS33823	10	2	3.5	0.15	4	120	100	35	750

* Current derating between 50ºC and 85ºC $I_\theta = I_R\sqrt{(85-\theta)/35}$

Dimensions and Mechanical Details



Case material: Aluminium
Finish: Unpainted
Terminals: Nickel plated brass

Part Number	Dimensions (mm)										
	A	B	C	D	E	F	G	H	J	K	L
DS33823	120	100	35	137	8	60	20	60	20	15	150

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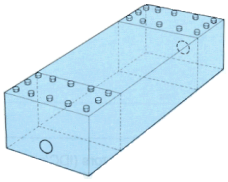
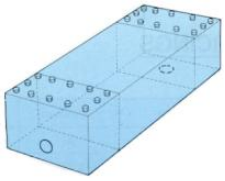
Cable Entry Options (Power Line Filters)



Part No DS XXXXXA
End entry end exit

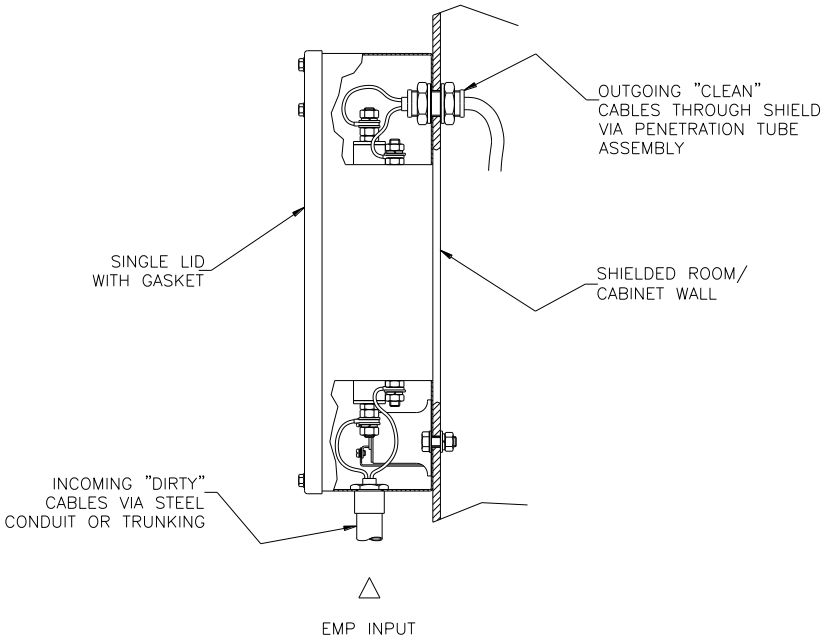


Part No DS XXXXXA
End entry base exit

Two different cable entry options are available as shown.
Suffix A - end entry, end exit for plain wall mounting.
Suffix C - end entry base exit for shielded enclosure mounting

Installation Details (Power Line Filters)

Typical Installation (cable entry option C shown)



If mounted on an earthed metal wall such as a shielded room, the mounting surface should be clean and unpainted to ensure a low impedance earth bond and good RF seal.
If mounted on a normal building wall or adjacent to a distribution board, the filter should be securely mounted with appropriate fixings.
It is essential that these filters are solidly and permanently earthed via a short, heavy duty, low impedance earth path, both for safe operation and to achieve optimum pulse performance in the event of a HEMP pulse.
For a normal building wall, this should ideally be a heavy strap or braid connection made directly to an earth spike, or the main building incoming earth busbar connection.
For a shielded enclosure, the same standard of earth should be achieved via the enclosure wall.
Incoming cables to the filter should ideally be in steel conduit or trunking to minimise coupling and optimise performance in case of a HEMP event. They should also be routed underground where possible.
The user should check material compatibility between the filter case and the enclosure to minimise possible gaslvanic corrosion effects

Fixing screws and penetration tube assemblies can be supplied as an optional extra.

Recommended tightening torque figures:
M5 lid fixings: 1N-m
M8 terminals: 5N-m

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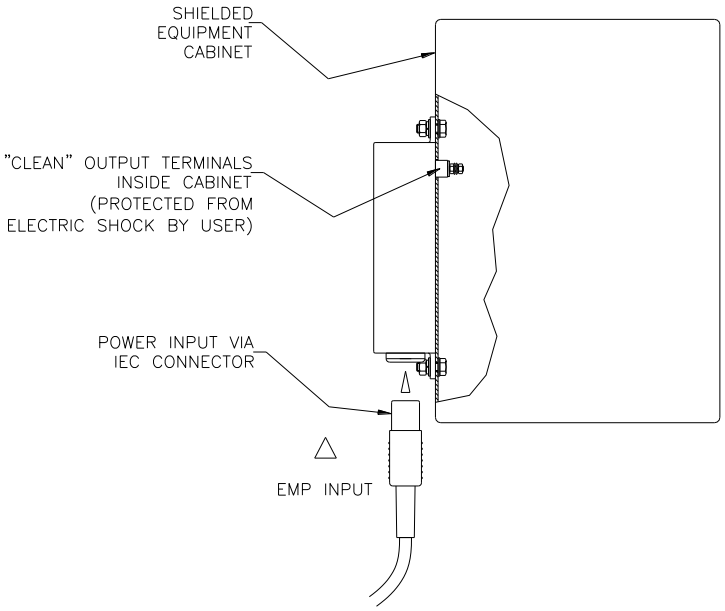
Installation Details (Equipment Filter)

Equipment filters should ideally be mounted on the outside of the metal equipment enclosure with the bulkhead terminals protruding through the enclosure to provide shielding between input and output of filter. This method will achieve the best shielding benefit from the cabinet and will also help to achieve to lowest possible earth bond connection to the earthed cabinet which is essential for optimum performance and for safety.
It is important that the equipment cabinet has a very good low impedance earth connection to a local earth.
Terminals inside the cabinet should be enclosed by the user for safety.
The user should check material compatibility between the filter case and the enclosure to minimise possible gaslvanic corrosion effects.



Safety

Relevant safety standards have been adhered to in the design and manufacture of these products. However, all capacitors will store charge after power has been removed and must be treated with respect as a shock can be lethal if the voltage and charge are high enough.
Even though discharge resistors are fitted to this range of filters, terminals should always be shorted to earth prior to touching to ensure the capacitors are fully discharged.
The user should ensure he is familiar with restrictions on capacitance value, earth leakage current, test voltage, and safety labelling requirements, which may be applicable to his particular installation.

Custom Designs

MPE offers a rapid design service for custom designs where special packaging, mounting, terminations, or multiple lines are required. Over 50% of the filters manufactured by MPE are custom designs and this can offer a very cost effective installation solution. Please ask to see examples of previously offered solutions.

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