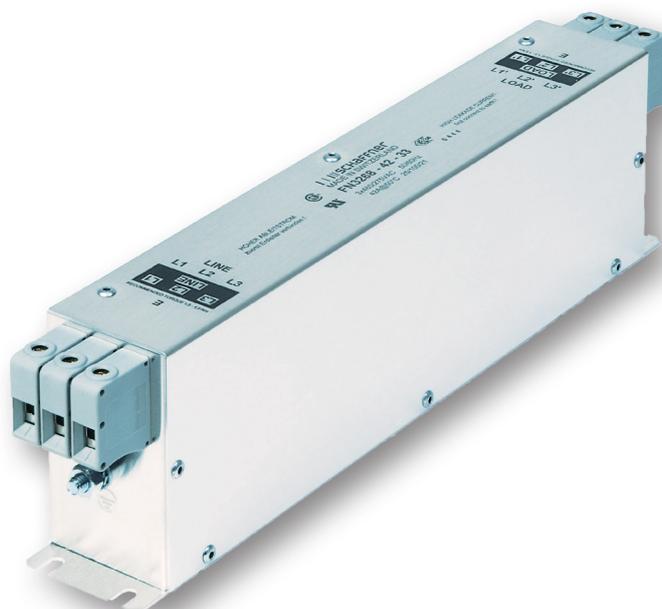


Low leakage current EMC filters

Full compatibility with residual current circuit breakers sensitive to all current types



The innovative low leakage current FN 3268 EMC filters are designed to suppress undesirable leakage currents in drive technology in particular. They guarantee compliance with EMC regulations and support full functionality of residual current circuit breakers sensitive to all current types. The aim is to prevent costly downtimes of machines and the resulting production losses as a result of incorrect tripping of residual current circuit breakers in conjunction with frequency converters.

1 Task

The operation of frequency converters often results in a technical compatibility problem with residual current circuit breakers. Energy-saving frequency converters are increasingly used in building services engineering in conjunction with residual current circuit breakers. For personal protection against electric shocks, 30 mA residual current circuit breakers are prescribed here.

The use of residual current circuit breakers with a threshold value of 300 mA is prescribed in plants in the paper and wood working industry to protect against electric fires (caused by undesirable earth currents)¹. Even when energy-saving frequency converters are used correctly, incorrect tripping of residual current circuit breakers is also caused by elevated leakage currents induced by operating conditions, as the circuit breakers cannot distinguish between leakage currents and genuine residual currents. In addition to leakage currents at system frequency, frequency converters also generate earth currents dependent on the length of the motor cable, the parasitic capacitance of the motors and the switching frequency set. Unnecessary responses of residual current circuit breakers incur significant costs due to production losses and downtimes of production plants.

¹Type B according to VdS guideline 3501

1.1 Situation today

When operating frequency converters, compliance with all standards and guidelines must be ensured, particularly in connection with residual current circuit breakers. EMC filters of the wrong size will not suppress the leakage currents (earth currents) sufficiently or will increase them considerably as a result of resonances with the system impedance. Residual current circuit breakers will be tripped inadvertently as a result of these excessive leakage currents. EMC filters that are too small will be subject to magnetic saturation and the requisite EMC limit values will therefore no longer be met. As a result, reliable function of the protection device and compliance with the EMC directives will consequently no longer be guaranteed.

1.2 System-induced leakage currents in motor drives

Leakage currents vary according to the overall design of the drive system and the drive regulation. The following variables are particularly relevant: system voltage, motor frequency, frequency of pulse width modulation (PWM) in the frequency converter, length of connecting cable, motor type.

The leakage currents are also heavily influenced by the system impedance, resonances in the circuit and the characteristics of the EMC filters used.

The typical use of a drive system is shown below in the form of a block diagram.

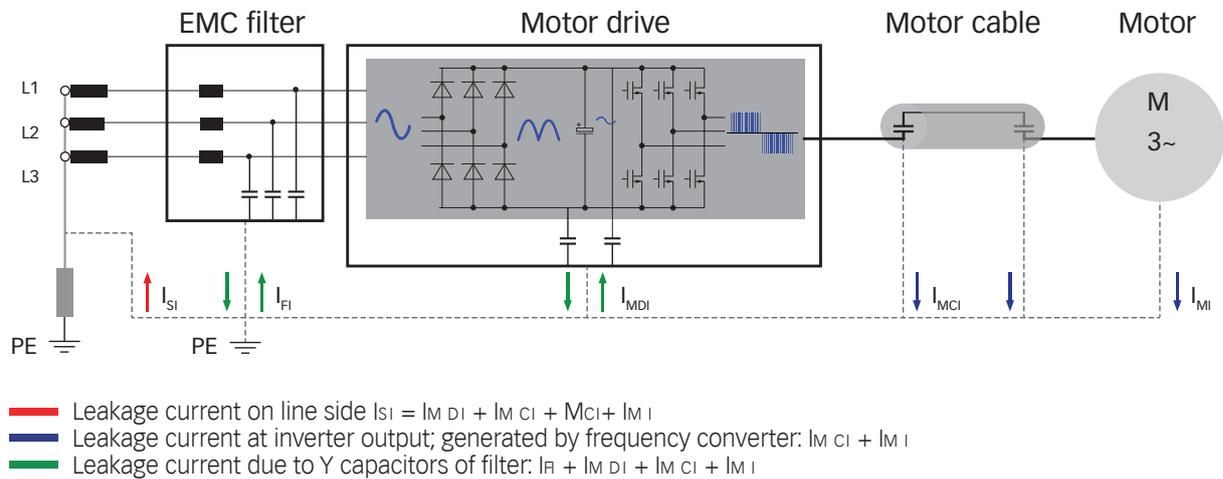


Figure 1: Typical real leakage currents in motor drive systems

As the currents have capacitive, inductive and ohmic parts, they should be viewed vectorially and added as such. This means that the metrological recording of the currents is not without its problems. In addition, the different frequency parts must also be taken into account.

1.3 Residual current circuit breaker

The main task of a residual current circuit breaker or a residual current protection device in general is to interrupt a circuit in the event of a malfunction. The electronic switch measures the incoming and outgoing current of a device or system. If it establishes that these two currents are not identical, it will interrupt the circuit, as the current flow has (possibly) taken a hazardous direction somewhere – due to an insulation failure.

This residual current can be caused by a person touching a conductor and the body of this person directing the circuit towards the earth. The residual current circuit breaker protects the person by very quickly interrupting the circuit, thereby preventing any further injury.

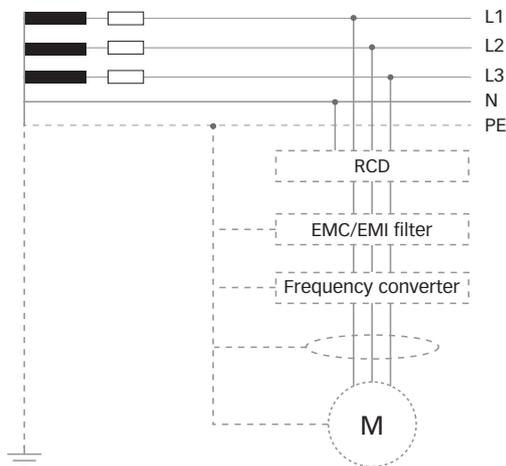
Residual current circuit breakers are classified according to their sensitivity:

Class		Values	Application
HS	High sensity	6 – 10 – 30mA	Direct contact; life-threatening
MS	Medium sensity	100 – 300 – 500 – 1000mA	Protection against fire
LS	Low sensity	3 – 10 – 30A	Typical protection for machines

Table 2: Classification of residual current circuit breakers (IEC 61008)

1.4 Applications for residual current circuit breakers

A typical application for residual current circuit breakers in conjunction with drive technology is shown below.



Applications for residual current circuit breakers

- 3-phase drive with servo drive and inverter
- Equipment for machine and process automation
- Building automation, HVAC
- Pumps, ventilation, lifts
- Conveyors, process and warehouse systems, cranes
- Machine tools, printing presses and wood working machines

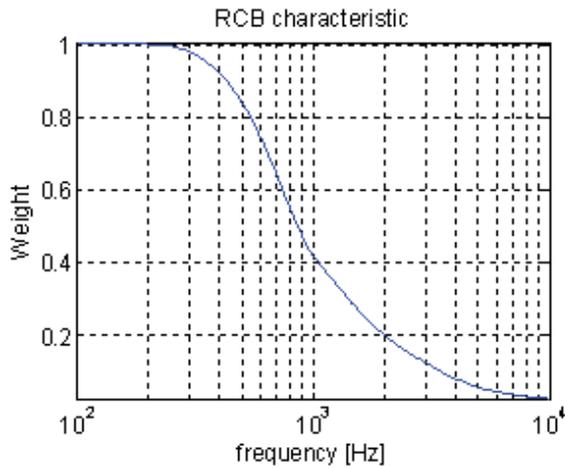
Figure 3: Residual current circuit breaker (RCD) in typical application for motor drive

1.5 Difficulties/requirement in applications with residual current circuit breakers

A basic problem is the unnecessary deactivation of a system when the residual current circuit breaker trips incorrectly. The residual current circuit breaker does not distinguish between leakage currents and real residual currents! Residual current circuit breakers should be used in wood working machines and printing presses to protect against fire. In heating, ventilation and air conditioning applications in buildings or in lifts and escalators, residual current circuit breakers protect persons against an electric shock. The reliable function of electrical installations and equipment must be guaranteed through the EMC directive.

Unsuitable EMC filters will not suppress the parasitic currents sufficiently at the switching frequency or will even cause an elevated leakage current due to resonances with the system impedance. The filters can become subject to magnetic saturation and as a result will no longer provide the required damping quality. The protection aims will therefore no longer be met with EMC filters of the wrong size as the residual current will be unintentionally switched off.

Diagram 4 shows the tripping characteristics of a residual current circuit breaker. The current ratio (weighting) as a factor of the frequency is specified. A current ratio of 1 means a standardised tripping current (i.e. 30 mA or 300 mA, for example). The test conditions and the standards are also listed.



Conditions:

- | Residual current circuit breaker in accordance with IEC 6100
- | Residual current circuit breaker type B+ in accordance with new standard VDE 0664-110 up to 20 kHz (Extended precautionary protection against fire)
 - | Protection against electric shock, IEC 60364-4-41
 - | Protection against thermal effects (fire risks); in accordance with IEC 60364-4-24

Diagram 4: Tripping characteristics of residual current circuit breaker: current ratio across the frequency

The above considerations give rise to the following requirements:

Innovative EMC filters with small leakage currents are required in order to:

- | suppress undesirable leakage currents
- | comply with EMC regulations
- | ensure full functionality of the residual current circuit breakers

1.6 Innovative FN 3268 EMC filter – compatible with residual current circuit breakers sensitive to all current types

The distinctive features of the new FN 3268 EMC filters from Schaffner are as follows:



- | Patented filter design prevents premature saturation and resonance effects in the power system
 - | Significant reduction of leakage currents caused by long motor cables
 - | Inadvertent incorrect tripping of residual current device in machines and process automation systems is prevented
 - | Designed for applications with 3-phase frequency converters and servo drives
- Excellent performance data:
- | C1 limit with 30 mA residual current circuit breaker; up to 30-metre motor cable; for 7 – 75 A
 - | C2 limit with 300 mA residual current circuit breaker; up to 100-metre motor cable; for 100 – 180 A
- | Identical in design to FN3258 series: users of the popular FN3258 series can easily change over to the new technology thanks to the identical design.

1.7 Comparison of a conventional EMC filter with the new FN 3268

- | Tests under real conditions
- | Setup:
 - | Output of motor drive and motor: 3 kW
 - | Switching frequency: 4 kHz
 - | Motor cable length: 30 m, screened
 - | Measuring system for leakage current: DCR1
 - | Residual current circuit breaker: 30 mA

The measuring report for the leakage current with a filter that is too small based on the residual current frequency band is shown below. 318 mA was measured at the switching frequency (4 kHz).

Measurement: 318 mA at 4 kHz, measured without residual current; tripping of residual current circuit breaker at 30 mA; motor drive 5 Hz (weighted measured values as a factor of the frequency band)

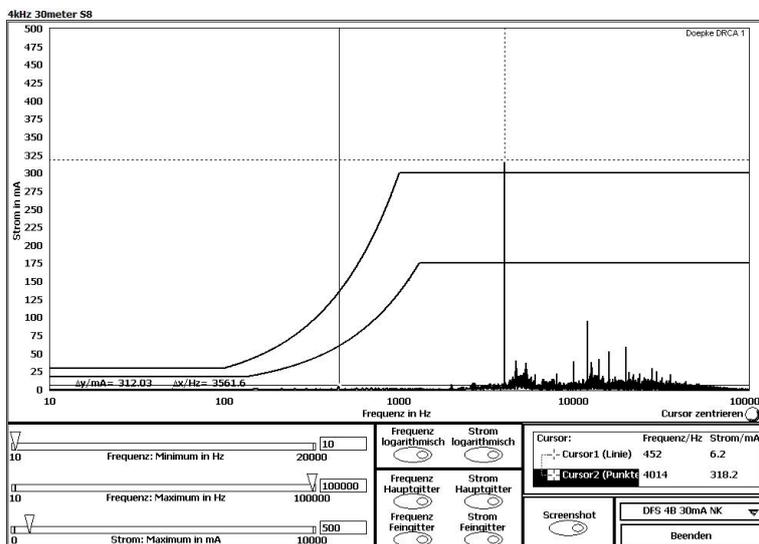


Diagram of current in peak-to-peak representation (peak = 3 A)

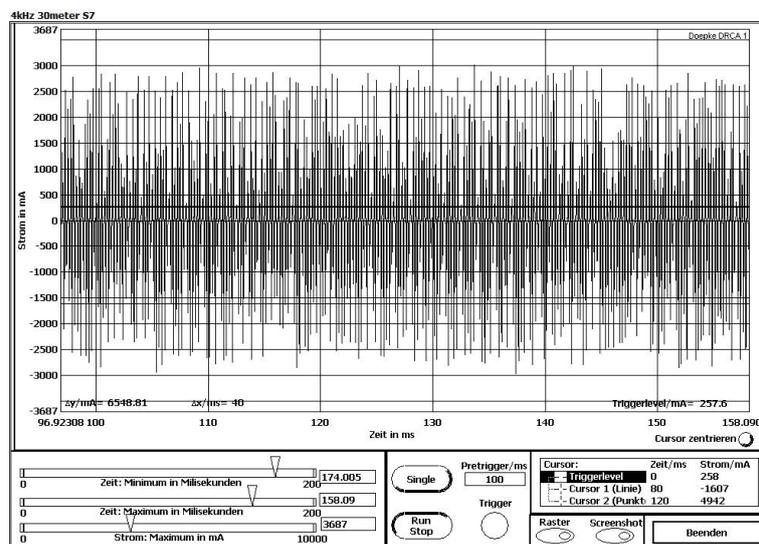


Diagram 6: Leakage current with EMC filter that is too small; peak-peak

The comparative measurement with the correctly sized FN 3268 filter for the drive system shows significantly lower leakage current values. All system requirements are therefore met. The EMC directives are observed and, on the basis of the lower leakage currents, the requisite protective measures with a residual current circuit breaker are possible without incorrect tripping.

FN 3268 leakage currents; 30 mA residual current circuit breaker (the residual current is no longer switched off) (weighted measured values as a function of the frequency band)

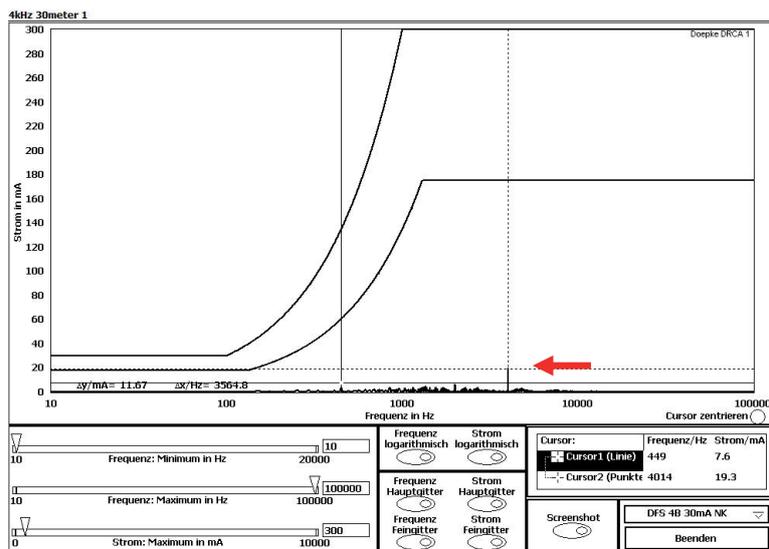


Diagram 7: Leakage current with FN 3268-30-44

FN 3268 leakage currents; 19.4 mA; 30 mA residual current circuit breaker (the residual current is no longer switched off) (weighted measured values as a function of the frequency band)

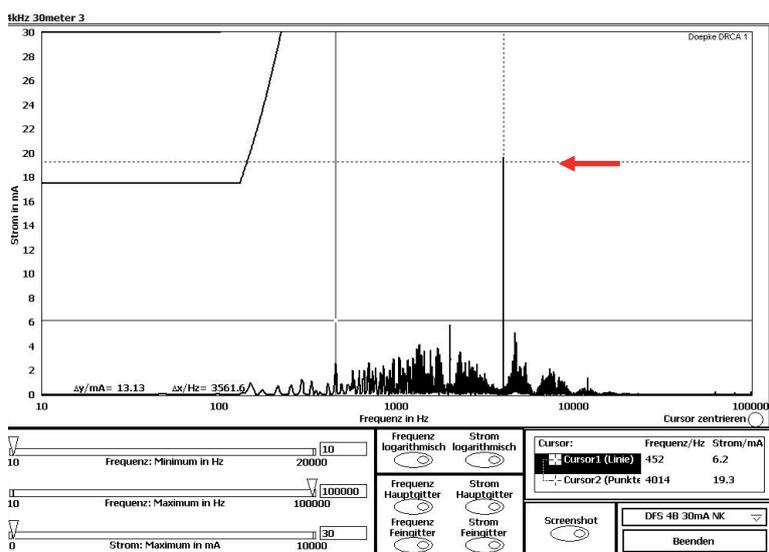


Diagram 8: Leakage current with FN 3268-30-44; 19.4 mA

Diagram of FN 3268 current in peak-to-peak representation (peak = 110 mA)

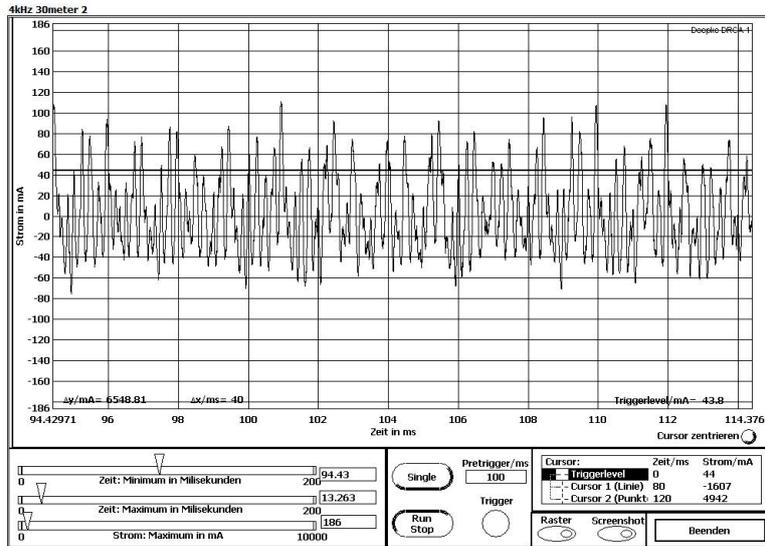


Diagram 9: Leakage current with FN 3268-30-44, peak-to-peak; peak: 110 mA

Recommendations

Important:

- ! The pulse width modulation (PWM frequency) of the drive regulation must be permanently set to 4 kHz.
 - ! Other switching frequencies may generate higher leakage currents
 - ! Special filters for other (fixed) switching frequencies can be designed on request.
- ! All capacitors to earth (referred to as Y capacitors) in the internal EMC filters of the motor drive should be interrupted, as these capacitors can generate additional leakage currents.
- ! It is possible that high harmonic voltages may also generate additional leakage currents. If necessary, additional appropriate measures must also be taken to reduce these.

1.8 Explanations/terms

EMC

Electromagnetic compatibility: ability of an electric device to function satisfactorily in its electromagnetic environment without affecting this environment, which also includes other devices, in impermissible ways.

EMI

Electromagnetic interference

EMC filters

Combinations of inductors and capacitors. Used to both reduce high-frequency disturbance variables of converters to a certain level and also protect the converters against the effects of disturbance variables. Often also referred to as line filters.

Residual current circuit breaker or residual current protection device

Device (electronic switch) to offer protection through automatic cutoff. Disconnects the connected circuits from the system if a residual current (also referred to as differential current) flows through earthed conductive parts of the system not belonging to the operating circuit or through a human body. This residual current must exceed a certain threshold value or rated differential current in order to cause the circuit breaker to trip (and switch off the current). The circuit breaker is tripped magnetically. It is intended to be used for protecting persons and equipment.

It should be remembered that the residual current circuit breaker cannot distinguish between real leakage currents (residual currents induced as a result of insulation failures) and leakage currents caused by operating conditions!

RCD

Residual current device; residual current protection device in general (or RCCB: residual current circuit breaker specifically)

Electronic converters

Non-linear electrical consumers. These electronic circuits generate harmonic currents as well as elevated leakage currents. Converters can include, for example, frequency converters in motor drives, uninterruptible power systems (UPS) or electronic power converters.

PWM

Pulse width modulation

FC

Frequency converter

PDS

Power drive system; motor drive system (drive, regulation)

HVAC

Heating, ventilation and air conditioning

1.9 Literature sources:

- | Leitfaden für Fehlerstrom-Schutzeinrichtungen und elektrische Antriebe
ZVEI – Zentralverband Elektrotechnik- und Elektronikindustrie e.V.; Frankfurt; 2009
- | Datenblatt FN 3268, Schaffner EMV AG
- | New EMC-Filters FN3268; Präsentation U.Stitz; PMM EMV; Schaffner AG
- | Isolations-Fehlerschutz in elektrischen Anlagen mit elektronischen Betriebsmitteln RCD/FU
Richtlinien zur Schadenverhütung; VdS 3501: 2006-04 (01); VdS Verlag (Verein deutscher Sachversicherer);
Köln 2006

1.10 Literature on EMC:

- | Elektromagnetische Verträglichkeit; A.J.Schwab; Springer-Verlag
- | Elektromagnetische Verträglichkeit; E.Habiger; Hüthig-Verlag
- | Elektromagnetische Verträglichkeit von Automatisierungs-Systemen; H.G.Meyer (Hrsg);
VDE-Verlag Berlin; 1992
- | EMV90; EMV92, EMV94; Tagungsbände; H.R.Schmeer; VDE-Verlag Berlin
- | EMV-gerechtes Gerätedesign; G.Durchansky; Franzis-Verlag
- | EMV-Störfestigkeits-Prüfung; Fischer,Balzer, Lutz; Franzis-Verlag
- | EMV-Vorschriften, D.Rahmes; Franzis-Verlag
- | CE-Konformitäts-Kennzeichnung; A. Kohling; VDE-Verlag Berlin; 1995

Schaffner EMV AG

Low leakage current EMC filters

Full compatibility with residual current circuit breakers sensitive to all current types



Headquarters and global innovation and development center

Schaffner Group
Nordstrasse 11
4542 Luterbach
Switzerland
T +41 32 681 66 26
F +41 32 681 66 30
info@schaffner.ch
www.schaffner.com

Sales and application centers

China
Schaffner EMC Ltd. Shanghai
Building 11, Lane 1365
East Kangqiao Road
Shanghai 201319
T +86 21 6813 9855
F +86 21 6813 9811
cschina@schaffner.com
www.schaffner.com

Germany
Schaffner Deutschland GmbH
Schoemperlenstrasse 12B
76185 Karlsruhe
T +49 721 56910
F +49 721 569110
germanysales@schaffner.com

Finland
Schaffner Oy
Tynninkuja 7
08700 Lohja
T +358 19 35 72 71
F +358 19 32 66 10
finlandsales@schaffner.com

France
Schaffner EMC S.A.S.
112, Quai de Bezons
95103 Argenteuil
T +33 1 34 34 30 60
F +33 1 39 47 02 28
francesales@schaffner.com

Italy
Schaffner EMC S.r.l.
Via Galileo Galilei, 47
20092 Cinisello Balsamo (MI)
T +39 02 66 04 30 45/47
F +39 02 61 23 943
italysales@schaffner.com

Japan
Schaffner EMC K.K.
Mitsui-Seimei Sangenjaya Bldg. 7F
1-32-12, Kamiyama, Setagaya-ku
Tokyo 154-0011
T +81 3 5712 3650
F +81 3 5712 3651
japansales@schaffner.com
www.schaffner.jp

Sweden
Schaffner EMC AB
Turebergstorg 1, 6
19147 Sollentuna
T +46 8 5792 1121/22
F +46 8 92 96 90
swedensales@schaffner.com

Switzerland
Schaffner EMV AG
Nordstrasse 11
4542 Luterbach
T +41 32 681 66 26
F +41 32 681 66 41
sales@schaffner.ch

Singapore
Schaffner EMC Pte Ltd.
Blk 3015A Ubi Road 1
05-09 Kampong Ubi Industrial
Estate
T +65 6377 3283
F +65 6377 3281
singaporesales@schaffner.com

Spain
Schaffner EMC España
Calle Caléndula 93,
Miniparc III, Edificio E
El Soto de la Moraleja,
Alcobendas
28109 Madrid
T +34 618 176 133
spainsales@schaffner.com

Taiwan
Schaffner EMV Ltd.
6th Floor, No 413
Rui Guang Road
Neihu District
Taipei City 114
T +886 2 87525050
F +886 2 87518086
taiwansales@schaffner.com

Thailand
Schaffner EMC Co. Ltd.
Northern Region Industrial Estate
67 Moo 4 Tambon Ban Klang
Amphur Muang P.O. Box 14
Lamphun 51000
T +66 53 58 11 04
F +66 53 58 10 19
thailandsales@schaffner.com

UK
Schaffner Ltd.
5 Ashville Way
Molly Millars Lane
Wokingham
Berkshire RG41 2PL
T +44 118 9770070
F +44 118 9792969
uksales@schaffner.com
www.schaffner.uk.com

USA
Schaffner EMC Inc.
52 Mayfield Avenue
Edison, New Jersey 08837
T +1 732 225 9533
F +1 732 225 4789
usasales@schaffner.com
www.schaffner.com/us

To find your local partner within Schaffner's global network, please go to

www.schaffner.com

© 2010 Schaffner EMC.
Specifications are subject to change without notice. The latest version of the data sheets can be obtained from the website. All trademarks recognized.

Schaffner is an ISO-registered company. Its products are designed and manufactured under the strict quality and environmental requirements of the ISO 9001 and ISO 14001 standards.

This document has been carefully checked. However, Schaffner does not assume any liability for errors or inaccuracies.