Application note

Electromagnetic compatibility of lighting equipment

Common mode chokes for lighting

schaffner
energy efficiency and reliability

The EU decision to finally abolish incandescent lamps by 2012, the progress in the luminescent power of light emitting diodes (LED) and the further development of low-pressure and high-pressure discharge lamps are all leading to a sharp increase of electronic modules in lighting technology.

CE marking and conformity declaration

In the implementation of the EMC directive, a harmonisation of standards for lighting technology also ensured that there is a uniform evaluation of EMC in the European community zone. Lamps and lamp accessories may only be marketed in the EU if the manufacturer or its agent confirms this evaluation by an appropriate conformity declaration. Special standards apply with respect to EMC (electromagnetic compatibility) and interference, and differ in certain points from the standards for households and industry,

EN 55015

The standard applies to all lighting equipment and its accessories. Exceptions apply to equipment operating in ISM (industrial, scientific, medical) frequency bands, to lighting technology in aircraft and airports and to other specifically exempted equipment. The limit values for conducted and radiated interference emission for all other lighting equipment are set forth there.

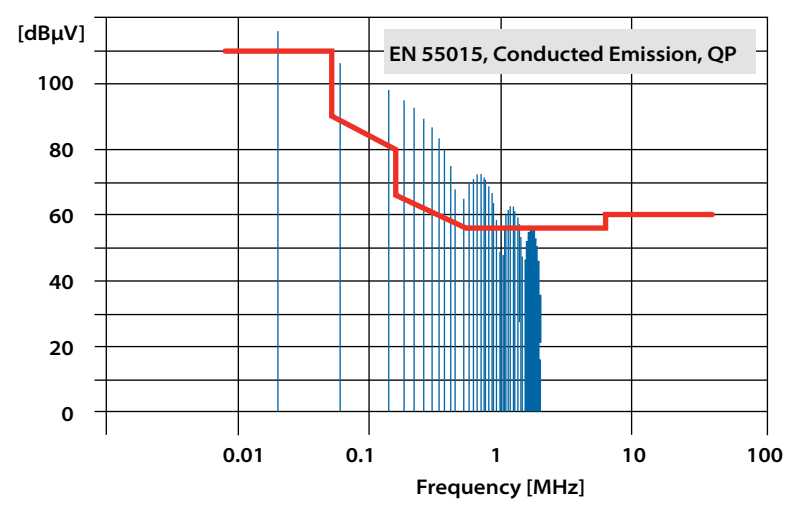

Figure 1:
Limit values with non-suppressed harmonics of a fixed-frequency switching regulator

Conducted noise emission

The following limits apply to the mains connection:
A quasi-peak (QP) of 110 dBµV is permissible between 9 kHz and 50 kHz. From 50kHz to 150kHz, the limit value runs linearly to the logarithm of frequency from 90 to 80dBµV. The limits for QP and average (AV) from 150 kHz and up comply with the generic standard EN 61000-6-3: Emission standard for residential, commercial and light-industrial environments.

Since the electronics and the illuminant do not always form a unit, and interferences can therefore also be emitted through the cable to the lighting means, limit values are also specified for lamp connections. They are QP (AV) 80 (70) dBµV from 150 to 500 kHz and QP (AV) 74 (64) dBµV from 0.5 to 30 MHz. A setup and test with a load emulation of the illuminant are likewise described. Limit values are defined for control inputs, if the electronics have them.

Radiated interference emissions

A QP limit value of 30 dB (µV/m) for field-based noise emission applies between 30 MHz and 230 MHz, and a value of 37 dB applies from 230 to 300 MHz, with a measuring distance of 10m.

EN 61000-3-2

This standard describes the permissible harmonic current emissions for devices with an input current of up to 16 A per phase. Lighting equipment and accessories are assigned to class C.

Up to an effective input power of 25 W, the moderate limit values that can be achieved without a correction of the power factor apply to lighting equipment for discharge lamps (Table 1). For all other lighting equipment (e.g. LED lamps, ignition and starting devices), no limit vales for harmonics are prescribed up to 25 W.

Harmonic order [n]	Permissible maximum value of the harmonic current per W [mA/W]	Permissible value of the harmonic current [A]
3	3,4	2,3
5	1,9	1,14
7	1,0	0,77
9	0,5	0,040
11	0,35	0.,33
13–39	3,85/n	0.15 × 15/n

Table 1

Alternatively to the limit values of the table 1, it is also sufficient if the third-order harmonic current does not exceed 86% of the fundamental oscillation current and the fifth-order harmonic current does not exceed 61%, if the current flow lasts at least from 60° to 90° and the peak value is reached before or at 65°.

The following limits apply to devices with an effective input power of >25 W:

Harmonic order [n]	Permissible maximum value of the harmonic current in percent of the input fundamental oscillation current [%]
2	2
3	30 λ *
5	10
7	7
9	5
11–39	3

Table 2:
*** λ is the power factor of the circuit**

The standard permits the use of several operating devices with <25 W in a lamp with the limit values for <25 W.

EN 61000-3-3

This standard describes the limit values for voltage fluctuations and flicker in low-voltage supply systems up to 16 A per phase. No limit values apply to lamps. Lighting fixtures with incandescent lamps up to 1000 W rated power and lighting fixtures with discharge lamps up to 600 W rated power need not be tested.

EN 61547

The interference immunity requirements for devices for generic lighting purposes are established here. The reader is referred to the relevant generic standards EN 61000-4-x for tests such as electrostatic discharge, HF-EM field, LF-EM field, burst, surge and voltage dips; the intensity of the tests as well as the criteria for the various types of lighting devices (e.g. starter units, discharge lamps, emergency lighting) are set individually.

EMC filters in lighting technology

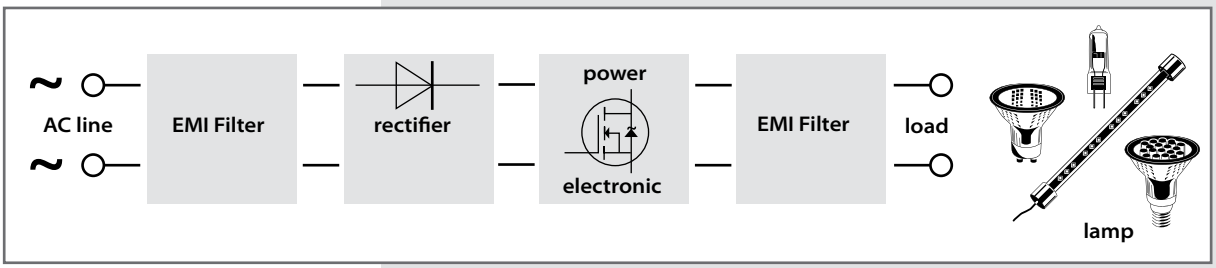

Figure 2:
Block schematic with an EMI filter

The objective of the noise-elimination measure is avoid propagation of the interference currents generated in the electronics. Conducted interference is primarily emitted via the mains line and the line to the illuminant. For lighting devices with lager power, the use of IEC power entry modules or single-phase EMC filters on the mains side is possible.

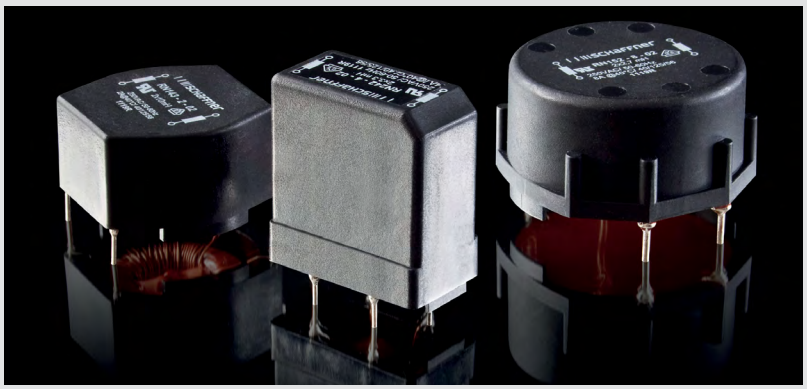

Figure 3:
Current-compensated toroidal core chokes from Schaffner for 0.3 to 10 A

The integration of the filters on the circuit board using current-compensated chokes is advisable for lower powers. The RN series makes the construction of EMC filters with high power density possible due to the use of toroidal cores, and has high saturation resistance as well as outstanding thermal behavior.

RN chokes are less sensitive to electromagnetic coupling than other designs because of the closed toroidal core and the compact design of the magnetic circuit.

Mains filter design for lighting technology

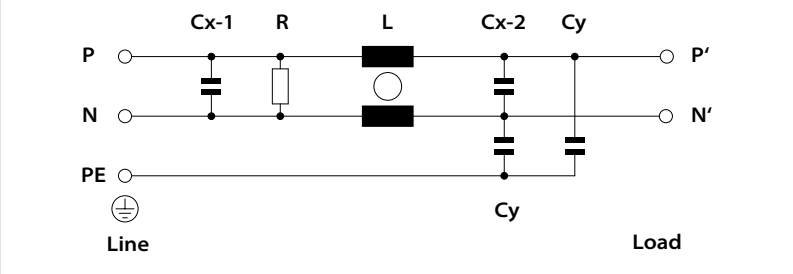

Figure 4:
Typical arrangement of a mains filter

The mode of operation of the individual components will be briefly explained with reference to a typical mains filter. The parasitic capacitances of the interference source to earth are one propagation path for interference. The heat sink is a typical example of this for power electronics. The noise currents flow via the parasitic capacitor to ground and back to the interference source via the mains lines or other lines. This noise is called common-mode or asymmetric interference.

To avoid propagation via the mains line, the load-side Y-capacitors in the filter form a noise sink. At the same time, the impedance of the mains line is increased by a current-compensated choke. For low power, small parasitic capacitance to earth or high requirements for leakage currents as in medical technology, noise elimination with Y-capacitors can also be left out.

The second path for propagating noise is differential mode or symmetrical interference. The typical source for this is the voltage ripple caused by the switching process and impedances of parallel components such as capacitors and the circuit path to their terminals.

These interferences would mainly propagate via the connected mains conductors P and N to mains.

The load-side x-capacitor Cx-2) is an interference sink for these noise currents. With a load-side inductor (PFC choke or DC reacror) the x-capacitor forms a first low-pass filter and symmetrises the noise level on the two mains lines. The stray inductance of the current-compensated choke, together with mains-side capacitor Cx-1, forms another low-pass filter to suppress the propagation of symmetrical interference to mains.

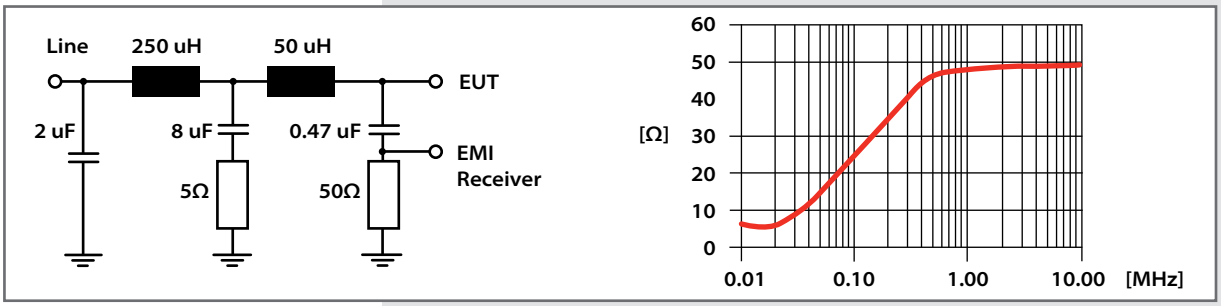

Figure 5:
Network emulation with impedance curve

In general a structure as shown in Figure 4 is sufficient. The requirement for damping can be found by measuring the module without interference suppression with the network emulation

As shown in Figure 1, the harmonics of the switching process can exceed the permissible limit values from EN 55015. The selection of the switching frequency determines the third, fifth, through n-th harmonics. EN 55105 allows 110 dBuV as the limit up to 50 kHz, and after that the limit value runs linearly to the logarithm of frequency from 90 to 80 dBµV. It is therefore advisable to keep the switching frequency below 50 kHz.

For example, if 48 kHz is selected as the switching frequency in consideration of the bandwidth of the quasipeak measurement, no interference below this frequency will be caused by the switching process. Thus a value of 110 dBµV applies to the first harmonic, and then 81 dBµV for the third harmonic at 144 kHz.

If measurement of the non interference-suppressed module containing the load-side x-capacitor shows that limit values have been exceeded, an appropriate preselection can be made based on the damping curves of the RN choke (see Figure 6).

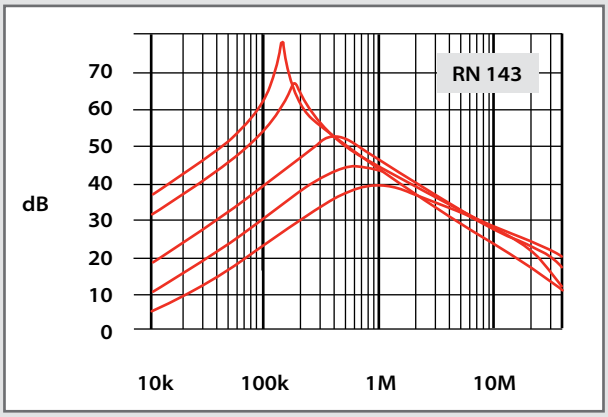

Figure 6:
Damping curves of the Schaffner RN143 series

The rated value for the choke current must be measured for the lowest possible mains voltage and the largest load case and the highest permissible temperature under full load. By matching the resonant frequency to the spectrum of the switching processes, it is possible to damp the third harmonic at 144 kHz by about 70 dB with an RN143-05-02, if that is necessary. The decisive factor is ultimately the measurement with the network emulator, however.

Current-compensated chokes for the load and control terminals

In addition to their use as mains filters, current-compensated chokes can also be used for noise suppression of the load terminal. For ballasts with an ignition voltage, this level must match the rated voltage of the choke.
For control terminals, RN chokes can not only help suppress the propagation of interference but can also improve interference immunity in order to meet the criteria of the interference immunity tests "Fast transients" (EN 61000-4-4) and "Surge voltages/surge currents" (EN 61000-4-5).

RN chokes – proven quality

The UL-tested RN chokes can be used from 40°C to +125°C, have an MTBF of >4 million h and meet the requirements for RoHS and REACH.
RN chokes are available from stock anywhere through a world-wide distribution and sales network:
Inventory
Datasheet

More information on EMC

More information on noise suppression for power electronic modules is provided by our EMC brochure "Basics in EMC and Power Quality"
Shorform-Catalog
Basics in EMC und Power Quality

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Headquarters, global innovation and development center

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

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

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07/2011en

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

Finnland
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, Kamiuma, 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
Antonio Bello
Calle Caléndula 93,
Miniparc III, Edificio
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

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