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Application of capacitors, resistors, inductors and complete filter units for electromagnetic interference suppression - General rules and safety requirements

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CONTENTS

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FOREWORD

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IEC 60940 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) new title to change the document from “guidance” into “general rules and safety requirements;
b) new content added (Clause 5 to Clause 9);
c) the previous edition is partly contained in Clause 4.

The text of this International Standard is based on the following documents:

Draft	Report on voting
40/3300/FDIS	40/3314/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,
– withdrawn, or
– revised.

1 Scope

This document establishes general rules and safety requirements on the application of capacitors, resistors, inductors, and complete filter units for electromagnetic interference suppression which will be connected to an AC mains or other supply (DC or AC) with a nominal voltage not exceeding 1 000 V AC having a nominal frequency not exceeding 400 Hz, or 1 500 V DC.

It facilitates drafters of product safety standards and other stakeholders such as designers, manufacturers, service providers, policy makers and regulators to consider safety aspects for the intended use and the reasonably foreseeable misuse of these components in its products and systems and apply risk reduction measures to achieve a tolerable risk level.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60384-14, *Fixed capacitors for use in electronic equipment - Part 14: Sectional specification - Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*
IEC 60664-1:2020/AMD1:2025

IEC 60939-3:2024, *Passive filter units for electromagnetic interference suppression - Part 3: Passive filter units for which safety tests are appropriate*

IEC 61140:2016, *Protection against electric shock - Common aspects for installation and equipment*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

IEC Guide 116, *Guidelines for safety related risk assessment and risk reduction for low voltage equipment*

CISPR 17, *Methods of measurement of the suppression characteristics of passive EMC filtering devices*

ISO/IEC Guide 51, *Safety aspects - Guidelines for their inclusion in standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC Guide 51, IEC Guide 104, IEC Guide 116, IEC 60664-1:2020 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Voltage terms

3.1.1
overvoltage category
numeral defining a transient overvoltage condition

Note 1 to entry: Overvoltage categories I, II, III and IV are used, see IEC 60664-1:2020, 4.3.2.

[SOURCE: IEC 60050-426:2020, 426-04-48]

3.1.2
transient overvoltage
short duration **overvoltage** of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60664-1:2020, 3.1.13]

3.1.3
recurring peak voltage
maximum peak value of periodic excursions of the voltage waveform resulting from distortions of an AC voltage or from AC components superimposed on a DC voltage

Note 1 to entry: Random overvoltages, for example due to occasional switching, are not considered to be recurring peak voltages.

[SOURCE: IEC 60664-1:2020, 3.1.10]

3.1.4
slash rating
voltage in 3-phase systems indicated where the lower value represents the line-to-ground and the higher value the line-to-line voltage

Example: 230/400 V (50 Hz).

3.2 Safety terms

3.2.1
fault protection
protection against electric shock under single fault conditions

[SOURCE: IEC 61140:2016, 3.1.2]

3.2.2
single fault condition
condition in which one means for protection against electric shock is defective or one fault is present which could cause a hazard

Note 1 to entry: If a single fault condition results in one or more other fault conditions, all are considered as one single fault condition.

[SOURCE: IEC 61140:2016, 3.1.4]

3.2.3
clearance
shortest distance in air between two conductive parts

[SOURCE: IEC 60050-581:2008, 581-27-76]

3.2.4
creepage distance
shortest distance along the surface of a solid insulating material between two conductive parts

[SOURCE: IEC 60050-151:2001, 151-15-50]

3.2.5
earth leakage current
current flowing from the live parts of an installation to earth, in the absence of an insulation fault

[SOURCE: IEC 60050-442:1998, 442-01-24]

4 Electromagnetic and radio frequency interference suppression (EMI/RFI)

4.1 General

Electromagnetic interference (EMI) is any electromagnetic disturbance which causes an undesirable response, malfunctioning or degradation in the performance of electrical equipment. Radio frequency interference (RFI) is any electrical energy within the frequency range dedicated to radio frequency transmission.

The lower frequency range up to 30 MHz is often analysed by means of voltage or current measurements. The measured spectra are called “conducted interference” at certain points in a circuit. The higher frequency range up to many GHz is often analysed by means of field measurements like electric field E, magnetic field H or radiated power. The measured spectra are called “radiated interference” as they are measured with special antennas for each field type and frequency range instead of a voltage or current probe. Radiated interference is always analysed in a defined distance to the device under test.

Electrical machines and apparatus can generate EMI which is fed back into its power supply mains. This electromagnetic interference can be picked up by apparatus connected to the same power system up to a certain distance from the machine or apparatus. EMI-filters limit this interference to certain levels which do not make any harm.

Differential-mode interference occurs symmetrically between lines of different polarity. Common-mode interference occurs asymmetrically between line(s) and ground. These two types of interference have different sources and different propagation paths and need different counter measures.

EMI can be suppressed by providing a low impedance path for interference currents providing a short path back to its source by means of EMI-capacitors in accordance with IEC 60384-14. This can be combined with a high impedance element in series to prevent interference from taking this way. Such a high impedance can be a choke according to IEC 60938 series. Using the principle of current compensation makes so-called common-mode chokes very effective against common-mode interference.

Besides filtering with capacitors and chokes, shielding with metal enclosures can be very effective against interference.

4.2 Limits of interference

In Europe and many other countries, mandatory limits are set for both emission of interference and immunity against interference by EMC standards. The compatibility levels are defined for different applications and apparatus in the CISPR standards or other product standards for different environments like household or industrial surroundings.