

This is a preview - click here to buy the full publication



IEC 61000-5-6

Edition 1.0 2024-04

# INTERNATIONAL STANDARD



---

**Electromagnetic compatibility (EMC) –  
Part 5-6: Installation and mitigation guidelines – Mitigation of external EM  
influences**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 33.100.01

ISBN 978-2-8322-8687-6

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references .....	9
3 Terms, definitions and abbreviated terms .....	9
3.1 Terms and definitions.....	9
3.2 Abbreviated terms.....	14
4 Overview and general considerations .....	14
4.1 Overview.....	14
4.2 General considerations .....	15
4.2.1 Elementary interference control .....	15
4.2.2 Shields and interfaces .....	15
5 Mitigation of radiated and conducted disturbances.....	17
5.1 Topological concepts .....	17
5.2 Mitigation needs.....	18
5.3 The general concept of enclosure .....	18
5.4 Interactions at the enclosure boundary.....	19
6 Shielding .....	19
6.1 General.....	19
6.2 Classification of protection zones.....	21
6.2.1 General .....	21
6.2.2 Zone 1 – Building shield .....	22
6.2.3 Zone 2 – Room shield.....	22
6.2.4 Zone 3 – Equipment shield .....	22
6.2.5 Zone 4 – Apparatus shield .....	22
6.3 Design principles for screening .....	22
6.3.1 General .....	22
6.3.2 Shielding effectiveness .....	23
6.3.3 Maintaining shielding effectiveness.....	23
6.4 Implementation of screening .....	25
6.4.1 General .....	25
6.4.2 Sensitive apparatus .....	25
6.4.3 Shielding of racks and chassis (zones 4/3 barrier) .....	25
6.4.4 Shielding of cabinets (zones 3/2 barrier).....	25
6.4.5 Shielding of rooms (zones 2/1 barrier) .....	25
6.4.6 Shielding of buildings (zones 1/0 barrier).....	26
6.4.7 Dealing with apertures .....	27
7 Filters.....	29
7.1 General.....	29
7.2 Fundamental filter characteristics.....	30
7.2.1 General .....	30
7.2.2 Attenuation and insertion loss.....	30
7.2.3 Basic types of filters .....	31
7.3 Functional tasks.....	32
7.4 Additional filtering concerns .....	33
7.4.1 Technical aspects .....	33

7.4.2	Economic aspects.....	33
7.5	Selection criteria.....	34
7.5.1	General.....	34
7.5.2	Voltage rating.....	34
7.5.3	Current rating.....	34
7.5.4	Duty-cycle and overload operating conditions.....	34
7.5.5	Operating frequency and range of frequencies to be filtered.....	35
7.5.6	Voltage drop and signal loss.....	35
7.5.7	Ambient temperature range.....	35
7.5.8	Insertion loss and attenuation.....	35
7.5.9	Withstand voltage.....	36
7.5.10	Attenuation of HF transient disturbances.....	36
7.5.11	Leakage current to protective earthing conductor.....	36
7.5.12	Permissible reactive current.....	37
7.6	Filter installation.....	37
7.6.1	General.....	37
7.6.2	Installation and mounting techniques.....	37
7.6.3	Wiring.....	38
7.6.4	Installation of cabinet filters.....	38
7.7	Filter testing.....	39
7.7.1	General considerations.....	39
7.7.2	Insulation to earth and withstand voltage of installed filters.....	40
7.7.3	Insertion loss.....	40
7.7.4	Attenuation of HF transient disturbances.....	40
8	Decoupling devices.....	41
8.1	Isolation transformers.....	41
8.2	Motor-generator sets.....	43
8.3	Engine generators.....	43
8.4	Uninterruptible power supply (UPS).....	43
8.5	Optical links.....	44
9	Surge-protective devices.....	44
9.1	General.....	44
9.2	Direct equipment protection.....	45
9.3	Installation of multiple SPDs.....	46
9.4	Side-effects of uncoordinated cascades.....	47
9.5	Typical protective devices.....	47
9.5.1	General.....	47
9.5.2	Voltage-limiting type SPDs.....	47
9.5.3	Voltage-switching type SPDs.....	47
Annex A (informative) Resilience-based approach for the mitigation of external high-power electromagnetic environments.....		48
A.1	Overview.....	48
A.2	The concept of resilience.....	48
A.2.1	General.....	48
A.2.2	Discussion on the protection-led approach.....	49
A.2.3	Benefits of a resilience-based approach.....	50
A.2.4	Affordability and risk.....	50
A.2.5	Appropriate application of a resilience-based approach.....	51
A.3	EM resilience model and framework.....	52

A.3.1	General .....	52
A.3.2	Identify function .....	52
A.3.3	Protect function .....	52
A.3.4	Detect function .....	53
A.3.5	Respond function.....	53
A.3.6	Recover function.....	53
A.3.7	Adaptation of the NIST framework to HPEM resilience.....	53
A.4	HPEM resilience framework implementation.....	53
A.4.1	Overview .....	53
A.4.2	Identify .....	53
A.4.3	Protect.....	55
A.4.4	Detect.....	60
A.4.5	Respond.....	68
A.4.6	Recover.....	69
A.5	Summary .....	69
	Bibliography.....	70
	Figure 1 – System barrier topology .....	15
	Figure 2 – Generalized system topology .....	17
	Figure 3 – Ports of an apparatus or facility.....	19
	Figure 4 – Topological concept of shields with interfaces at penetration points .....	20
	Figure 5 – Zones of protection of shielding and earthing systems .....	21
	Figure 6 – Example of performance of high-efficiency shielded enclosure .....	26
	Figure 7 – Honeycomb inserts for different cut-off frequencies.....	27
	Figure 8 – Typical screening attenuation of honeycomb inserts.....	28
	Figure 9 – Parameters for attenuation and insertion loss.....	30
	Figure 10 – Prevention of interference on installed equipment .....	32
	Figure 11 – Reduction of electromagnetic disturbances in the power network and the environment.....	32
	Figure 12 – Examples of insertion loss characteristics of AC/DC power port filters.....	36
	Figure 13 – Mounting of filters .....	38
	Figure 14 – Connection of screened cables .....	38
	Figure 15 – Example of integration of filters inside an equipment cabinet.....	39
	Figure 16 – Example of filter mounting in a dedicated unit .....	39
	Figure 17 – Laboratory measurement showing the propagation of a 0,5 µs to 100 kHz ring wave, applied in differential mode, through an ordinary isolation transformer .....	41
	Figure 18 – Propagation of a 0,5 µs to 100 kHz ring wave operating in the differential mode through a "line isolator" transformer .....	42
	Figure 19 – Inter-winding coupling in an isolation transformer .....	42
	Figure A.1 – Protection-led approach.....	49
	Figure A.2 – Resilience-based approach.....	49
	Figure A.3 – The five functions of the NIST cyber security framework .....	52
	Figure A.4 – Protection scheme utilising shielded cables and shielded cabinets .....	58
	Figure A.5 – IEMI detector developed by Fraunhofer INT, Germany.....	65
	Figure A.6 – TOTEM detector developed by QinetiQ Ltd., UK .....	66

Figure A.7 – Example of some HPEM events detected during a field-trial installation ..... 67

  

Table 1 – Measured shielding effectiveness of a 2 m × 2 m cage made of concrete building armour, against a 20 ns rise-time pulse (equivalent frequency less than 20 MHz) ..... 26

Table A.1 – Protection levels based on operational criticality ..... 50

Table A.2 – Appropriate application of the resilience-based approach ..... 51

Table A.3 – Identify function of the HPEM resilience framework ..... 54

Table A.4 – Protect function of the HPEM resilience framework ..... 56

Table A.5 – Detect function of the HPEM resilience framework ..... 60

Table A.6 – Some advantages and limitations of different technologies for HPEM detection applications ..... 63

Table A.7 – Respond function of the HPEM resilience framework ..... 68

Table A.8 – Recover function of the HPEM resilience framework ..... 69

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### **ELECTROMAGNETIC COMPATIBILITY (EMC) –**

### **Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences**

#### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 61000-5-6 has been prepared by subcommittee 77C: High power transient phenomena, of IEC technical committee 77: Electromagnetic compatibility. It is an International Standard.

This first edition cancels and replaces the first edition of IEC TR 61000-5-6 published in 2002. This edition constitutes a technical revision.

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

- a) updating the whole document to include other HPEM environments including IEMI;
- b) adding a new Annex A which provides details on the concept of EM resilience and includes information on HPEM detectors, recovery and restoration.

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

Draft	Report on voting
77C/339/FDIS	77C/340/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

A list of all parts in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC)*, can be found on the IEC website.

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](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

**IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## INTRODUCTION

IEC 61000 is published in separate parts according to the following structure:

### **Part 1: General**

General considerations (introduction, fundamental principles)

Definitions, terminology

### **Part 2: Environment**

Description of the environment

Classification of the environment

Compatibility levels

### **Part 3: Limits**

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

### **Part 4: Testing and measurement techniques**

Measurement techniques

Testing techniques

### **Part 5: Installation and mitigation guidelines**

Installation guidelines

Mitigation methods and devices

### **Part 6: Generic standards**

### **Part 9: Miscellaneous**

Each part is further subdivided into several parts, published either as international standards or as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

## **ELECTROMAGNETIC COMPATIBILITY (EMC) –**

### **Part 5-6: Installation and mitigation guidelines – Mitigation of external EM influences**

#### **1 Scope**

This part of IEC 61000 covers guidelines for the mitigation of external electromagnetic influences impinging upon a facility or installation, aimed at ensuring electromagnetic compatibility (EMC) among electrical and electronic apparatus or systems. These influences include lightning, RF transmitters, power-line and telecom transients, high-altitude electromagnetic pulse (HEMP) and other high-power electromagnetic transients such as those from intentional electromagnetic interference (IEMI).

This document is intended for use by installers, manufacturers and users of sensitive electrical or electronic installations or systems. It applies primarily to new installations but, where economically feasible, it can be applied to extensions or modifications to existing facilities.

While the technical principles are applicable to individual equipment or apparatus, such application is not included in the scope of this document.

#### **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 60364 (all parts), *Low-voltage electrical installations*

IEC TR 61000-5-2, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*

IEC 61508-1, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*

IEC 62305 (all parts), *Protection against lightning*

IEEE Std 1848-2020, *Techniques and Measurement to Manage Functional Safety and Other Risks with Regards to Electromagnetic Disturbances*