



IEC 61000-4-36

Edition 1.0 2014-11

INTERNATIONAL STANDARD



BASIC EMC PUBLICATION

**Electromagnetic compatibility (EMC) –
Part 4-36: Testing and measurement techniques – IEMI immunity test methods
for equipment and systems**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XC**

ICS 33.100.20

ISBN 978-2-8322-1904-1

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 abbreviations	9
3.1 Terms and defintions	9
3.2 Abbreviations.....	12
4 General	13
5 IEMI environments and interaction.....	13
5.1 General.....	13
5.2 IEMI environments	14
5.2.1 Technical capability groups	14
5.2.2 IEMI deployment scenarios.....	14
5.2.3 Radiated IEMI environment summary	15
5.2.4 Published conducted IEMI environments.....	15
5.3 Interaction with fixed installations	16
5.3.1 General	16
5.3.2 Protection level.....	17
6 Test methods.....	17
6.1 Derivation of applicable test methods.....	17
6.2 Derivation of transfer functions	18
6.3 Radiated tests using IEMI simulator	19
6.4 Radiated tests using a reverberation chamber	19
6.5 Complex waveform injection (CWI)	19
6.6 Damped sinusoidal injection (DSI)	19
6.7 Electrostatic discharge (ESD)	19
6.8 Electrically fast transient (EFT)	19
6.9 Antenna port injection	20
7 Test parameters	20
7.1 Derivation of immunity test parameters	20
7.2 Radiated test parameters.....	21
7.2.1 Generic hyperband test parameters (skilled capability group)	21
7.2.2 Generic mesoband test parameters (skilled capability group).....	21
7.2.3 Generic hypoband/narrowband test parameters (skilled capability group).....	23
7.3 Generic conducted IEMI test parameters.....	24
7.3.1 General	24
7.3.2 Characteristics and performance of the fast damped oscillatory wave generator.....	25
7.4 Tailored test level derivation	26
7.5 Relevance of EMC immunity data	26
8 Bibliography	27
Annex A (informative) Failure mechanisms and performance criteria	29
A.1 General.....	29
A.2 Failure mechanisms.....	29
A.2.1 General	29

A.2.2	Noise	30
A.2.3	Parameter offset and drifts	30
A.2.4	System upset or breakdown.....	31
A.2.5	Component destruction.....	31
A.3	Effect of pulse width.....	32
A.4	Performance criteria	32
A.5	References	33
Annex B (informative)	Developments in IEMI source environments	35
B.1	General.....	35
B.2	IEMI environment.....	36
B.3	IEMI sources.....	37
B.4	Published radiated IEMI environments	41
B.4.1	IEC 61000-2-13	41
B.4.2	Mil-Std-464C	41
B.4.3	The International Telecommunication Union (ITU)	42
B.4.4	Practical determination of a tailored test level – An example.....	42
B.5	Summary	43
B.6	References	44
Annex C (informative)	Interaction with buildings.....	46
C.1	Building attenuation	46
C.2	Coupling to cables	47
C.3	Low voltage cable attenuation.....	48
C.4	References	49
Annex D (informative)	Relation between plane wave immunity testing and immunity testing in a reverberation chamber.....	51
D.1	General.....	51
D.2	Relation between measurements of shielding effectiveness in the two environments	52
D.3	Relation between immunity testing in the two environments	55
D.4	Additional aspects.....	57
D.5	References	57
Annex E (informative)	Complex waveform injection – Test method.....	60
E.1	General.....	60
E.2	Prediction	60
E.2.1	General	60
E.2.2	Example	64
E.3	Construction	66
E.4	Injection.....	70
E.5	Summary	72
E.6	References	72
Annex F (informative)	Significance of test methodology margins	74
F.1	General.....	74
F.2	Examples.....	74
F.2.1	General	74
F.2.2	Negative contributions	75
F.2.3	Positive contributions.....	77
F.2.4	Summary	79
F.3	References	79
Annex G (informative)	Intentional EMI – The issue of jammers	80

G.1	General.....	80
G.2	Effects	80
G.3	Published accounts of jamming.....	81
G.4	Risk assessment.....	81
G.5	Mitigation	81
G.6	References	82
Figure 1	– Example of radiated and conducted IEMI interaction with a building.....	16
Figure 2	– Assessment options	18
Figure 3	– Examples of ports	20
Figure 4	– Typical hyperband waveform.....	21
Figure 5	– Typical mesoband waveform	23
Figure 6	– Typical hypoband/narrowband waveform.....	24
Figure 7	– Waveform of the damped oscillatory wave (open circuit voltage)	25
Figure A.1	– IEMI induced offset of sensor output – Corruption of information	30
Figure A.2	– Collision of an induced disturbance with data bits [1]	31
Figure A.3	– Examples of destruction on a chip [2]	31
Figure A.4	– Generic failure trend as a function of pulse width.....	32
Figure B.1	– A comparison of HPEM and IEMI spectra [6].....	35
Figure B.2	– Representation of typical IEMI radiation and coupling onto systems [3].....	37
Figure B.3	– Parameter space in power/frequency occupied by sophisticated IEMI (i.e. DEW) sources [1].....	38
Figure B.4	– Peak power and energy from continuous and pulsed (durations shown) microwave sources, narrowband and wideband	38
Figure B.5	– Peak powers of various types of pulsed HPM sources [1].....	39
Figure B.6	– Peak vs. average power for microwave sources with duty factors indicated.....	39
Figure B.7	– Phase coherence leading to a compact HPM source with N^2 scaling of output power.....	40
Figure B.8	– Briefcase mesoband UWB source sold by Diehl-Rheinmetall [3]	40
Figure B.9	– A do-it-yourself electromagnetic weapon made from an oven magnetron [13]	41
Figure B.10	– Plot of entire narrowband system weight as a function of output microwave power for land-mobile and land-transportable systems	43
Figure C.1	– Typical unprotected low-rise building plane wave E-field attenuation collected from references.....	46
Figure C.2	– Cable coupling – Resonance region.....	48
Figure C.3	– Mains cable attenuation profile	49
Figure E.1	– LLSC reference field measurement set-up	61
Figure E.2	– LLSC induced current measurement set-up	62
Figure E.3	– Typical LLSC magnitude-only transfer function	62
Figure E.4	– Prediction of induced current using minimum phase constraints.....	63
Figure E.5	– IEC 61000-2-9 early-time (E1) HEMP environment	64
Figure E.6	– Overlay of transfer function and threat (frequency domain)	65
Figure E.7	– Predicted current	65
Figure E.8	– Example of de-convolution result	67

Figure E.9 – Damped sinusoidal waveforms – Ten-component fit.....	67
Figure E.10 – Approximated and predicted transient	68
Figure E.11 – Approximated and predicted transient (0 ns to 100 ns).....	68
Figure E.12 – Approximation and prediction transient – Frequency domain comparison	69
Figure E.13 – Variation in error for increasing number of damped sinusoids	70
Figure E.14 – Complex injection set-up.....	71
Figure E.15 – Amplifier requirements for various current levels.....	71
Figure E.16 – Comparison of predicted (green) and injected (red) current.....	72
Figure F.1 – Variation in induced currents as a result of configuration	75
Figure F.2 – Comparison of HPD and VPD induced currents.....	76
Figure F.3 – System variability.....	76
Figure F.4 – Comparison of single- and multi-port injection.....	77
Figure F.5 – Example transfer functions and worst-case envelope	78
Figure F.6 – Comparison of individual and worst-case transfer function predictions	78
Figure F.7 – Comparison between predicted and measured induced currents	79
Table 1 – Possible IEMI Deployment Scenarios	15
Table 2 – Summary of radiated IEMI source output (rE_{far}) by capability group.....	15
Table 3 – Example protection levels.....	17
Table 4 – Generic hyperband test parameters (skilled capability group)	21
Table 5 – Generic mesoband test parameters (skilled capability group)	22
Table 6 – Generic hypoband/narrowband test parameters (skilled capability group).....	23
Table 7 – Conducted IEMI test levels	24
Table 8 – Open circuit specifications.....	25
Table 9 – Short Circuit Specifications	26
Table A.1 – Recommended performance criteria.....	33
Table B.1 – IEMI environments from IEC 61000-2-13.....	41
Table B.2 – Hypoband/narrowband HPM environment.....	42
Table B.3 – Hyperband/wideband HPM environment.....	42
Table C.1 – Shielding effectiveness measurements for various power system buildings and rooms.....	47
Table E.1 – Time waveform norms	66

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –**Part 4-36: Testing and measurement techniques –
IEMI immunity test methods for equipment and systems**

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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61000-4-36 has been prepared by subcommittee 77C: High-power transient phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms part 4-36 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

The text of this standard is based on the following documents:

CDV	Report on voting
77C/231/CDV	77C/236/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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 4-36: Testing and measurement techniques – IEMI immunity test methods for equipment and systems

1 Scope

This part of IEC 61000 provides methods to determine test levels for the assessment of the immunity of equipment and systems to intentional electromagnetic interference (IEMI) sources. It introduces the general IEMI problem, IEMI source parameters, derivation of test limits and summarises practical test methods.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-12, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC 61000-4-18, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*