



TECHNICAL REPORT



**Electromagnetic compatibility (EMC) –
Part 3-18: Limits – Assessment of network characteristics for the application of
harmonic emission limits – Equipment connected to LV distribution systems
not covered by IEC 61000-3-2 and IEC 61000-3-12**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10

ISBN 978-2-8322-8219-9

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

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms, definitions and abbreviated terms	7
3.1 Terms and definitions.....	8
3.2 Abbreviated terms.....	10
4 General	10
5 State of existing IEC standards.....	12
5.1 Overview of existing standards	12
5.2 Voltage gaps.....	12
5.3 Frequency gaps	13
5.4 System impedance considerations	13
6 General approach.....	14
7 Detailed implementation of the methodology.....	15
7.1 Overview.....	15
7.2 European reference network model (RNM).....	15
7.2.1 History.....	15
7.2.2 Adjusted RNM for assessing harmonic sensitivity	16
7.3 Harmonic current model.....	18
7.4 Methodology for adapting IEC equipment harmonic emission limits.....	20
7.4.1 General	20
7.4.2 Conversion factor (C_{fh}).....	21
7.5 Sensitivity ratio S_R	22
8 Simulation considerations.....	22
8.1 Overview.....	22
8.2 Simulation model adjustment	23
8.3 Studies with only the maximum harmonic distortion of each feeder	23
8.4 Sampling the feeders of the entire power system	24
9 Statistical analysis.....	24
10 Conclusions.....	25
Annex A (informative) Other methods studied for comparing feeder harmonic sensitivity.....	27
A.1 General.....	27
A.2 Voltage droop	27
A.2.1 Explanation	27
A.2.2 Voltage droop simulation	27
A.2.3 Concept of the voltage droop approach	28
A.2.4 Validation of the voltage droop method.....	29
A.2.5 Clustering.....	30
A.2.6 Feeder parameters	33
Annex B (informative) Power distribution systems in Canada	36
B.1 Overview.....	36
B.2 Conversion factor.....	37
Annex C (informative) Power distribution systems in Japan	40

C.1	Background for harmonics limits	40
C.2	Outlook on a typical distribution system in Japan	40
C.3	Power supply to customers in Japan	42
C.4	Distribution system impedance in Japan	42
C.5	Case study of 95 th percentile and conversion factor in Japan	43
C.6	Comparing the 95 th percentile distortion level of Japan vs. EU RNM	43
Annex D (informative) Example of a Python script used with CYMDIST software		46
Bibliography.....		57
Figure 1 – Reference network medium-voltage power system		17
Figure 2 – LV network of 153 customers supplied by a 400 kVA transformer.....		17
Figure A.1 – Scatter plot of voltage harmonic levels (3 rd and 5 th) as function of the voltage droop.....		28
Figure A.2 – Comparison of the 95 th percentile harmonic levels obtained from simulation and calculated from the voltage droop.....		30
Figure A.3 – $q = 1$, Manhattan distance.....		31
Figure A.4 – $q = 2$, Euclidian distance		31
Figure A.5 – Two-parameter k-means clustering example		32
Figure A.6 – Illustration of SSE.....		33
Figure A.7 – Harmonic distortion levels at cluster centroids		35
Figure B.1 – Low-voltage system in Canada		36
Figure B.2 – Multi-unit building of 32 customers.....		37
Figure B.3 – Buildings with > 1 000 residential customers.....		37
Figure C.1 – Overview of the power system in Japan [11]		41
Figure C.2 – Standard neutral grounding systems for HV and MV distribution system in Japan		41
Figure C.3 – Distribution transformer for HV/MV in Japan		41
Figure C.4 – Popular LV distribution systems in Japan.....		42
Table 1 – Modelled RNM voltage distortion compared with compatibility levels		18
Table 2 – 5 th harmonic current (h5) per household proposed by [4].....		19
Table 3 – 7 th harmonic current (h7) per household proposed by [4].....		19
Table 4 – Harmonic load injection at each customer POI in the modelled network.....		20
Table 5 – Creating the cumulative data function.....		25
Table A.1 – Coefficients of linear regression obtained from the harmonic and droop data		29
Table B.1 – LV feeder impedance in Canada		36
Table B.2 – Data for assessing the Canada 240 V limits		38
Table B.3 – Limits for Class A Equipment		39
Table C.1 – Impedance survey results for MV distribution lines (Ω).....		42
Table C.2 – Results of long-range survey of MV distribution lines (km)		43
Table C.3 – Impedance survey results for LV distribution lines (m Ω).....		43
Table C.4 – Data and calculated limits at 100 V in Japan.....		44

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 3-18: Limits – Assessment of network characteristics for the application of harmonic emission limits – Equipment connected to LV distribution systems not covered by IEC 61000-3-2 and IEC 61000-3-12

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 TR 61000-3-18 has been prepared by subcommittee 77A: EMC – Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
77A/1197/DTR	77A/1202/RVDTR

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 Technical Report 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.

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 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 levels

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 3-18: Limits – Assessment of network characteristics for the application of harmonic emission limits – Equipment connected to LV distribution systems not covered by IEC 61000-3-2 and IEC 61000-3-12

1 Scope

This part of IEC 61000, which is a technical report, reports on the development of a methodology for adapting IEC equipment emission limits from IEC 61000-3-2 and IEC 61000-3-12 for use in regions not covered by these documents. It identifies gaps in the existing equipment emission limit standards concerning their international applicability and identifies public power system characteristics important for the evaluation of harmonic voltage performance.

The purpose of adapting the above-mentioned IEC equipment harmonic emission standards in a particular region is to maintain similar electromagnetic compatibility (EMC) of equipment up to 75 A per phase in the public power systems in those regions.

NOTE The boundaries between the various voltage levels differ amongst different countries (see IEC 60050-601:1985, 601-01-28). This document uses the following terms when referring to 50 Hz and 60 Hz system voltages:

- low voltage (LV) refers to $U_n \leq 1$ kV;
- medium voltage (MV) refers to 1 kV $< U_n \leq 35$ kV;
- high voltage (HV) refers to 35 kV $< U_n \leq 230$ kV.

EMC requirements can have economic and societal impacts; these have not been considered in the development of this document. The consideration of these factors generally occurs in the technical committees working on development and maintenance of emission limit standards.

2 Normative references

There are no normative references in this document.