

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



IEC TR 61000-1-7

Edition 1.0 2016-02

TECHNICAL REPORT

**Electromagnetic compatibility (EMC) –
Part 1-7: General – Power factor in single-phase systems under non-sinusoidal
conditions**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.01

ISBN 978-2-8322-3196-8

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

CONTENTS

FOREWORD	4
INTRODUCTION	6
0.1 Series overview	6
0.2 Purpose of this document	6
1 Scope	8
2 Normative references	8
3 Terms and definitions	8
4 General	14
5 Electric power quantities under non-sinusoidal conditions	15
5.1 Voltages and currents	15
5.1.1 Instantaneous values	15
5.1.2 Reference fundamental components	16
5.1.3 Total distortion contents	16
5.1.4 RMS values of the voltage and current	16
5.1.5 RMS values of total distortion contents	17
5.1.6 DC ratios	17
5.1.7 Total distortion ratios	17
5.2 Instantaneous power	18
5.3 Definitions related to the active power	18
5.3.1 Active power	18
5.3.2 DC power	18
5.3.3 Fundamental active power	19
5.3.4 Distortion active power	19
5.4 Definitions related to the apparent power	19
5.4.1 Apparent power	19
5.4.2 Fundamental apparent power	20
5.5 Definitions related to the power factor	20
5.5.1 Power factor	20
5.5.2 Fundamental power factor	21
5.5.3 Non-fundamental power factor	21
5.6 Summary	21
6 Electric power quantities with a sinusoidal voltage and a current distorted only with harmonics	22
6.1 Voltages and currents	22
6.1.1 Instantaneous values	22
6.1.2 Fundamental components	22
6.1.3 Harmonic content of the current	23
6.1.4 RMS values of the voltage and current	23
6.1.5 RMS value of the harmonic content of the current	23
6.1.6 Total harmonic ratio of the current	24
6.1.7 Fundamental factor	24
6.2 Instantaneous power	24
6.3 Active power	24
6.4 Definitions related to the apparent power	25
6.4.1 Apparent power	25

6.4.2	Fundamental apparent power	25
6.5	Definitions related to the power factor	25
6.5.1	Power factor	25
6.5.2	Fundamental power factor	26
6.5.3	Non-fundamental power factor.....	26
6.6	Summary	27
Annex A (normative)	Electric power quantities under sinusoidal conditions	28
A.1	Instantaneous values of the voltage and current	28
A.2	Instantaneous power	29
A.3	Active power	30
A.4	Reactive power	30
A.5	Apparent power	30
A.6	Power factor	30
Annex B (informative)	Fundamental active factor.....	32
B.1	Fundamental active factor and its use	32
B.2	Consumer convention	32
Bibliography	34
Figure A.1	– Illustration of the displacement angle (φ) when the voltage leads the current, $\varphi > 0$	28
Figure A.2	– Illustration of the displacement angle (φ) when the voltage lags the current, $\varphi < 0$	29
Figure B.1	– Consumer sign convention of the fundamental active factor, fundamental active power and fundamental reactive power	33
Table 1	– Summary of the power quantities under non-sinusoidal conditions	21
Table 2	– Summary of the power quantities with a sinusoidal voltage and a current distorted only with harmonics	27

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 1-7: General – Power factor in single-phase systems under non-sinusoidal conditions

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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 61000-1-7, which is a Technical Report, has been prepared by subcommittee 77A: *EMC – Low frequency phenomena*, of IEC technical committee 77: *Electromagnetic compatibility*.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
77A/911/DTR	77A/920/RVC

Full information on the voting for the approval of this technical report 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.

INTRODUCTION

0.1 Series overview

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 sections which are to be published either as international standards, technical specifications, or as technical reports.

These standards and reports will be published in chronological order and numbered accordingly (for example, 61000-6-1).

0.2 Purpose of this document

The prevalence of loads drawing non-sinusoidal current from power systems requires clarification of such concepts as power and power factor, in order to avoid confusion due to

implied assumptions of sinusoidal voltage and current. This document specifically addresses the terms related to the power factor of equipment that are applicable regardless of the voltage and current waveforms.

When voltages and currents on power supply networks are perfectly sinusoidal, $\cos \varphi$ corresponds to the power factor. But this is not true anymore when electric quantities are distorted. In some existing documents, $\cos \varphi$ is still used as power factor, leading to an incorrect assessment of the equipment impact to supply networks.

The purpose of this Technical Report is to give clear information on both components in the power factor:

- the fundamental power factor, which is due to the phase difference between the voltage and current at the fundamental frequency ($\cos \varphi_1$), and
- the non-fundamental power factor, which is related to the distortion of the voltage and/or current.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 1-7: General – Power factor in single-phase systems under non-sinusoidal conditions

1 Scope

This part of IEC 61000, which is a Technical Report, provides definitions of various electrical power quantities and the relationship between them under non-sinusoidal conditions, in order to give clear information on both components in the power factor: the fundamental power factor, which is due to the phase difference between the voltage and current at the fundamental frequency, and the non-fundamental power factor, which is related to the distortion of the voltage and/or current. This Technical Report is applicable only to single-phase systems.

This Technical Report provides definitions for the three following cases:

- the general case where the voltage and current are both distorted (Clause 5),
- the case where the voltage is assumed to be sinusoidal and the current is only distorted with harmonic components (Clause 6),
- the particular case where the voltage and current are both sinusoidal (Annex A).

Annex B gives information on the fundamental active factor, which is used to describe the behaviour of a piece of equipment as a load or a generator.

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.

Void.