

INTERNATIONAL STANDARD

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IEC standard voltages

Tensions normales de l'IEC

IEC 60038:2009

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IEC 60038

Edition 7.1 2021-12
CONSOLIDATED VERSION

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.020

ISBN 978-2-8322-4028-1

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IEC STANDARD VOLTAGES

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60038 edition 7.1 contains the seventh edition (2009-06) [documents 8/1260/FDIS and 8/1264/RVD] and its amendment 1 (2021-12) [documents 8/1600/FDIS and 8/1603/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 60038 has been prepared by IEC technical committee 8: System aspects for electrical energy supply.

This seventh edition constitutes a technical revision. The significant technical changes are:

- a clarification of the scope;
- the addition of the values of 230 V (50 Hz) and 230/400 V (60 Hz) to Table 1;
- the update of Table 1 to take into account the end of the transition period for the values of 230/400 V and 400/690 V;
- the replacement of the utilization voltage range at LV by a reference to the relevant standard and an informative annex;
- the addition of the value of 30 kV to Table 3;
- the replacement of the value of 1 050 kV by 1 100 kV in Table 5.
- co-ordination of Table 1 of IEC 60850:2014 and Table 2 of IEC 60038;
- co-ordination of 60 Hz highest and lowest values with major national 60 Hz standards;
- co-ordination of Annex A with IEC 60364-5-52:2009;
- a new table covering single wire earth return systems for remote areas.

It has the status of a horizontal standard in accordance with IEC Guide 108.

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

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under webstore.iec.ch in the data related to the specific publication. At this date, the publication will be

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- amended.

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INTRODUCTION

This publication has been prepared by TC 8, whose scope is to prepare and coordinate, in co-operation with other TC/SCs, the development of international standards and other deliverables with an emphasis on overall system aspects of electricity supply systems and an acceptable balance between the cost and quality for the users of electrical energy. The electricity supply system encompasses transmission and distribution networks and connected user installations (generators and loads including traction systems) with their network interfaces.

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IEC STANDARD VOLTAGES

1 Scope

This publication applies to

- ~~a.c.~~ AC transmission, distribution and utilization systems and equipment for use in such systems with standard frequencies 50 Hz and 60 Hz having a nominal voltage above 100 V;
- ~~a.c.~~ AC and ~~d.c.~~ DC traction systems;
- ~~a.c.~~ AC and ~~d.c.~~ DC equipment having nominal voltages below 120 V ~~a.c.~~ AC or below 750 V ~~d.c.~~ DC, the ~~a.c.~~ AC voltages being intended (but not exclusively) for 50 Hz and 60 Hz applications; such equipment covers batteries (from primary or secondary cells), other power supply devices (~~a.c.~~ AC or ~~d.c.~~ DC), electrical equipment (including industrial and communication), and appliances.

This publication does not apply to voltages representing or transmitting signals or measured values.

This publication does not apply to standard voltages of components and parts used within electrical devices or items of equipment.

This publication has the status of a horizontal standard in accordance with IEC Guide 108. As such, this publication specifies standard voltage values which are intended to serve

- as preferential values for the nominal voltage of electrical supply and utilization systems, and
- as maximum, nominal and minimum reference values for both equipment and ~~system design~~ power supply in both electricity supply and utilization systems so that product and power system committees can co-ordinate their documents.

NOTE 1 Two main reasons have led to the values specified in this standard:

The values of nominal voltage (or highest voltage for equipment) specified in this standard are mainly based on the historical development of electrical supply systems throughout the world, since these values turned out to be the most common ones, and have achieved worldwide recognition;

The voltage ranges mentioned in this standard have been recognized to be the most appropriate ones as a basis for design and testing of electrical equipment and systems.

NOTE 2 It is nevertheless the task of system and product standards to define appropriate testing values, testing conditions and acceptance criteria.

NOTE 3 National Committees and individual systems can set values that differ from, but still comply with, the reference values in this document provided the values they set lie between the highest voltage for equipment and the lowest supply or utilization voltages in this document. Such variations can be required due to legacy or rating issues.

NOTE 4 To comply with this document neither the lowest supply or utilization voltage can be lower than the lowest voltage for equipment.

NOTE 5 Some National committees set different nominal values for supply and utilization.

2 Normative references

The following referenced documents are indispensable for the application 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.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

For alternating voltages, the voltages stated below are ~~r.m.s.~~ RMS values.

3.1

nominal system voltage

a suitable approximate value of voltage used to designate or identify a system

[IEV 601-01-21, modified]

3.2

highest voltage of a system

(excluding transient or abnormal conditions)

the highest value of operating voltage which occurs under normal operating conditions at any time and at any point on the system

NOTE It excludes transient overvoltages, such as those due to switching operations, and temporary variations of voltage.

[IEV 601-01-23, modified]

3.3

lowest voltage of a system

(excluding transient or abnormal conditions)

the lowest value of operating voltage which occurs under normal operating conditions at any time and at any point on the system

NOTE It excludes transient voltages, such as those due to switching operations, and temporary variations of voltage.

[IEV 601-01-24, modified]

3.4

supply terminals

point in a transmission or distribution network designated as such and contractually fixed, at which electrical energy is exchanged between contractual partners

3.5

supply voltage

the phase-to-phase or phase-to-neutral voltage at the supply terminals

NOTE An equivalent definition is: the line-to-line or line-to-neutral voltage at the supply terminals.

3.6

supply voltage range

the voltage range at the supply terminals

3.7

utilization voltage

the phase-to-phase or phase-to-neutral voltage at the outlets or at the points where utilisation equipment is intended to be connected to the fixed installation

NOTE An equivalent definition is: the line-to-line or line-to-neutral voltage at the outlets or at the points where utilisation equipment is intended to be connected to the fixed installation.

3.8 utilization voltage range

the voltage range at the outlets or at the points where utilisation equipment is intended to be connected to the fixed installation

NOTE Attention is drawn to the fact that in some equipment standards (for example, IEC 60335-1 and IEC 60071), the term "voltage range" has a different meaning.

3.9 highest voltage for equipment

highest voltage for which the equipment is specified regarding:

- a) the insulation;
- b) other characteristics which may be linked to this highest voltage in the relevant equipment recommendations.

NOTE Equipment may only be used on systems having a highest system voltage less than or equal to its highest voltage for equipment.

3.10 electric power system

electricity supply system (in a broad sense)

all installations and plant provided for the purpose of generating, transmitting and distributing electricity

[SOURCE: IEV 601-01-01]

3.11 lowest voltage for equipment

lowest voltage for which the equipment is specified regarding characteristics which may be linked to this lowest voltage in the relevant equipment recommendations

Note 1 to entry: Equipment should only be used on systems having a lowest supply or utilization voltage greater than or equal to its lowest voltage for equipment.

3.12 low voltage

LV

- 1) a set of voltage levels used for the distribution of electricity where the nominal voltage is generally accepted to be up to 1 000 V for alternating current and 1 500 V for direct current
- 2) the lowest of two or more voltages in an apparatus or installation

[SOURCE: IEV 601-01-26, modified and IEV 151-15-04]

3.13 high voltage

HV

- 1) in a general sense, the set of voltage levels in excess of low voltage
- 2) in a restrictive sense, the set of upper voltage levels used in power systems for bulk transmission of electricity
- 3) the highest of two or more voltages in an apparatus or installation

[SOURCE: IEV 601-01-27 and IEV 151-15-06]

4 Standard voltages

4.1 AC systems having a nominal voltage between 100 V and 1 000 V inclusive and related equipment

The nominal voltage of an ~~a.c.~~ AC system in the range from 100 V to 1 000 V should be selected from the values given in Table 1.

Table 1 – AC systems having a nominal voltage between 100 V and 1 000 V inclusive and related equipment

Three-phase four-wire or three-wire systems		Single-phase three-wire systems
Nominal voltage V		Nominal voltage V
50 Hz	60 Hz	60 Hz
–	120/208	120/240 ^d
230 ^c	240 ^c	–
230/400 ^a	230/400 ^a	–
–	277/480	–
–	480	–
–	347/600	–
–	600	–
400/690 ^b	–	–
1 000	–	–

^a The value of 230/400 V is the result of the evolution of 220/380 V and 240/415 V systems which has been completed in Europe and many other countries. However, 220/380 V and 240/415 V systems still exist.

^b The value of 400/690 V is the result of the evolution of 380/660 V systems which has been completed in Europe and many other countries. However, 380/660 V systems still exist.

^c The value of 200 V or 220 V is also used in some countries.

^d The values of 100/200 V are also used in some countries on 50 Hz or 60 Hz systems.

In Table 1, the three-phase four-wire systems and single-phase three-wire systems include single-phase circuits (extensions, services, etc.) connected to these systems.

The lower values in the first and second columns are voltages to neutral and the higher values are voltages between phases. When one value only is indicated, it refers to three-wire systems and specifies the voltage between phases. The lower value in the third column is the voltage to neutral and the higher value is the voltage between lines.

Voltages in excess of 230/400 V are intended for heavy industrial applications and large commercial premises.

Concerning supply voltage range, under normal operating conditions, the supply voltage should not differ from the nominal voltage of the system by more than $\pm 10\%$.

For the utilization voltage range, in addition to the voltage variations at the supply terminals, voltage drops may occur within the consumer's installations. For more information, see IEC 60364-5-52. This utilization voltage range should be taken into account by product committees.

NOTE The highest and lowest voltage values at supply terminals and at utilization terminals, as they can be derived from the above and from IEC 60364-5-52:2001+2009, are provided for information in Annex A.

4.2 DC and ~~a.c.~~ AC traction systems

The voltages of a ~~d.c.~~ DC or ~~a.c.~~ AC traction system should be selected from the values given in Table 2.

Table 2 – DC and ~~a.c.~~ AC traction systems ^a

	Voltage			Nominal frequency of a.c. systems Hz
	Lowest V	Nominal V	Highest V	
DC systems	(400) 500 1 000 2 000	(600) 750 1 500 3 000	(720) 900 1 800 3 600 ^b	
AC single-phase systems	(4 750) 12 000 19 000	(6 250) 15 000 25 000	(6 900) 17 250 27 500	50 or 60 16 2/3 50 or 60

~~a The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in future. In particular for a.c. single-phase systems, the nominal voltage 6 250 V should be used only when local conditions make it impossible to adopt the nominal voltage 25 000 V.~~

~~The values indicated in the table above are the values agreed by the international mixed committee on electric traction equipment (C.M.T.) and by IEC technical committee 9, Electrical equipment and systems for railways.~~

~~b In certain European countries, this voltage may reach 4 000 V. The electrical equipment of vehicles operating international services in these countries shall be capable of withstanding this absolute maximal voltage for brief periods of up to 5 min.~~

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	Voltage			Nominal frequency of AC systems Hz
	Lowest V	Nominal V	Highest V	
DC systems	500 1 000 2 000	750 1 500 3 000	900 1 800 3 600	
AC single-phase systems	12 000 19 000	15 000 25 000	17 250 27 500	16 2/3 50 or 60

^a The values indicated in the table are the values agreed by IEC technical committee 9, Electrical equipment and systems for railways. See IEC 60850:2014, Table 1 and Table B.1 for duration details.

4.3 AC three-phase systems having a nominal voltage above 1 kV and not exceeding 35 kV and related equipment

The voltages for an ~~a.c.~~ AC three-phase system having a nominal voltage above 1 kV and not exceeding 35 kV should be selected from the values given in Table 3.

Table 3 – AC three-phase systems having a nominal voltage above 1 kV and not exceeding 35 kV and related equipment ^a

Series I			Series II	
Highest voltage for equipment kV	Nominal system voltage kV		Highest voltage for equipment kV	Nominal system voltage kV
3,6 ^b	3,3 ^b	3 ^b	4,40 ^b	4,16 ^b
7,2 ^b	6,6 ^b	6 ^b	–	–
12	11	10	–	–
–	–	–	13,2 ^c	12,47 ^c
–	–	–	13,97 ^c	13,2 ^c
–	–	–	14,52 ^b	13,8 ^b
(17,5)	–	(15)	–	–
24	22	20	–	–
–	–	–	26,4 ^{c,e}	24,94 ^{c,e}
36 ^d	33 ^d	30 ^d	–	–
–	–	–	36,5 ^c	34,5 ^c
40,5 ^d	–	35 ^d	–	–

NOTE 1 It is recommended that in any one country, the ratio between two adjacent nominal voltages should be not less than two.

NOTE 2 In a normal system of series I, the highest voltage and the lowest voltage do not differ by more than approximately $\pm 10\%$ from the nominal voltage of the system. In a normal system of series II, the highest voltage does not differ by more than $+5\%$ and the lowest voltage by more than -10% from the nominal voltage of the system.

^a These systems are generally three-wire systems, unless otherwise indicated. The values indicated are voltages between phases.
 The values indicated in parentheses should be considered as non-preferred values. It is recommended that these values should not be used for new systems to be constructed in future.

^b These values should not be used for new public distribution systems.

^c These systems are generally four-wire systems and the values indicated are voltages between phases. The voltage to neutral is equal to the indicated value divided by 1,73.

^d The unification of these values is under consideration.

^e The values of 22,9 kV for nominal voltage and 24,2 kV or 25,8 kV for highest voltage for equipment are also used in some countries.

Two series of highest voltages for equipment are given above, one for 50 Hz and 60 Hz systems (series I), the other for 60 Hz systems (series II – North American practice). It is recommended that only one of the series should be used in any one country.

It is also recommended that only one of the two series of nominal voltages given for series I should be used in any one country.

The voltages in Table 7 have been derived from three-phase highest voltage for equipment voltages of 24 kV and 36 kV respectively. The highest voltage of the system and nominal voltages are based on the three-phase systems that supply 50 Hz SWER systems.

Table 7 – AC single wire earth return (SWER) systems

Highest voltage for equipment kV	Highest voltage of system kV	Nominal voltage of system kV
24	13,9	12,7
36	20,8	19,1