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Letter symbols to be used in electrical technology - Part 1: General (IEC 60027-1 Reprint:1995 + A1:1997)

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Letter symbols to be used in electrical technology
Part 1: General
(IEC 60027-1 Reprint:1995 + A1:1997)

Symboles littéraux à utiliser en électrotechnique
Partie 1: Généralités
(CEI 60027-1 Reprint:1995 + A1:1997)

Formelzeichen für die Elektroteknik
Teil 1: Allgemeines
(IEC 60027-1 Reprint:1995 + A1:1997)

This Harmonization Document was approved by CENELEC on 2003-12-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

Up-to-date lists and bibliographical references concerning such national implementation may be obtained on application to the Central Secretariat or to any CENELEC member.

This Harmonization Document exists in three official versions (English, French, German).

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of the International Standard IEC 60027-1:1995 + A1:1997, prepared by IEC TC 25, Quantities and units, and their letter symbols, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as HD 60027-1 on 2003-12-01 without any modification.

This Harmonization Document supersedes HD 245.1 S3:1979.

The following dates were fixed:

- latest date by which the existence of the HD has to be announced at national level (doa) 2004-06-01
- latest date by which the HD has to be implemented at national level by publication of a harmonized national standard or by endorsement (dop) 2004-12-01
- latest date by which the national standards conflicting with the HD have to be withdrawn (dow) 2006-12-01

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Endorsement notice

The text of the International Standard IEC 60027-1:1995 + A1:1997 was approved by CENELEC as a Harmonization Document without any modification.

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Partie 1: Généralités

Letter symbols to be used in electrical technology

Part 1: General

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LETTER SYMBOLS TO BE USED IN ELECTRICAL TECHNOLOGY

Part 1: General

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. 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. The 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 the IEC on technical matters, prepared by technical committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

This standard has been prepared by IEC technical committee 25: Quantities and units, and their letter symbols.

This standard forms the sixth edition of IEC 27-1* and supersedes the fifth edition issued in 1971, Amendments No. 1 (1974), No. 2 (1977), No. 3 (1981), No. 4 (1983) and the first supplement (Publication 27-1A (1976)).

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

DIS	Reports on voting
25(CO)96 25(CO)97 25(CO)98 25(CO)99	25(CO)100 25(CO)101 25(CO)102 25(CO)103

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

Annexes A, B and C of this International Standard are normative; Annexes D, E, F and G are informative:

IEC 27 consists of the following parts, under the generaltitle *Letter symbols to be used in electrical technology:*

- Part 1: General
- Part 2: Telecommunications and electronics
- Part 3: Logarithmic quantities and units
- Part 4: Symbols for quantities to be used for rotating electrical machines

* This reprint (1992) contains a considerable number of editorial corrections compared to the first printing (1992-12).

LETTER SYMBOLS TO BE USED IN ELECTRICAL TECHNOLOGY

Part 1: General

SECTION 0: SCOPE

This part 1 of the International Standard, IEC 27, gives information about general quantities, units and their letter symbols and mathematical symbols that are to be used in electrical technology. It also gives rules for writing and printing these symbols and for the use of additional marks (subscripts, superscripts, etc.) with symbols for quantities.

There are no normative references quoted in this International Standard.

SECTION 1: RECOMMENDATIONS FOR PRINTING SYMBOLS AND NUMBERS

1.1 Symbols for quantities

1.1.1 *Symbols*

The symbols for quantities[1)] are generally single letters of the Latin or Greek alphabet, sometimes with subscripts or other modifying signs. These symbols are printed in italic (sloping) type (irrespective of the type used in the rest of the text).

The symbol is not followed by a full stop except for normal punctuation, e.g., at the end of a sentence.

NOTES

1 Principles that apply to physical quantities and the expression of their values in units of the International System of Units (SI) are described in ISO 31-0, *Quantities and units – Part 0: General principles.*

2 Notations for vectorial and other non-scalar quantities are given in ISO 31-11, *Quantities and units – Part 11: Mathematical signs and symbols for use in the physical sciences and technology.*

3 Exceptionally, symbols made up of two letters are sometimes used for combinations of dimension one of quantities (e.g., Reynolds number: *Re*). If such a two-letter symbol appears as a factor in a product, it is recommended that it be separated from the other symbols.

4 Standardized symbols for quantities and constants generally used in electrical technology are given in section 3, tables 1, 2, 3, 4, and 5.

1.1.2 *Rules for printing of subscripts and use of subscripts in electrical technology*

When, in a given context, different quantities have the same letter symbol or when, for one quantity, different applications or different values are of interest, a distinction can be made by use of subscripts.

The following principles for the printing of subscripts are recommended:

A subscript that represents a symbol for a physical quantity is printed in italic (sloping) type.

Other subscripts are printed in roman (upright) type.

1) See annex E concerning names for quantities and units.

Examples:

Roman (upright) subscripts

C_g (g: gas)
g_n (n: normal)
μ_r (r: relative)
E_k (k: kinetic)
χ_e (e: electric)
$T_{1/2}$ (1/2: half)

Italic (sloping) subscripts

C_p (*p:* pressure)
$\Sigma_n a_n \vartheta_n$ (*n:* running number)
$\Sigma_x a_x b_x$ (*x:* running number)
g_{ik} (*i, k:* running numbers)
p_x (*x: x* coordinate)
I_λ (*λ:* wavelength)

NOTES

1 Numbers as subscripts shall be printed in roman (upright) type. However, letter symbols representing numbers are printed in italic (sloping) type.

2 For use of subscripts, see also special remarks to ISO 31-6 and ISO 31-10.

3 Standardized subscripts for use in electrical technology are given in section 3, tables 6 and 7.

In most cases, subscripts should be used as distinguishing means but in some cases other distinctions such as typographical signs or variants in type are suitable.
In a few cases, it is permissible to use different but related letter symbols.

EXAMPLES:

Subscripts:
magnetic flux density in vacuum B_0
intrinsic magnetic flux density B_i
current in different conductors I_a, I_b, I_c, etc.
minimum value of frequency f_{min}.

Type variants:
instantaneous value of current i
root-mean-square value of current I
force vector $\boldsymbol{F}$.

Typographical signs:
peak value of current $\hat{I}$, $\hat{f}$.

Different but related letter symbols:
three different angles α, β and γ.

1.1.3 *Rules*

1.1.3.1 *Order of preference*

Subscripts and other distinguishing means that are independent of language (Sub-clause 1.1.3.2) and subscripts of international character (Sub-clause 1.1.3.3) should, as far as possible, be chosen in preference to other subscripts (Sub-clause 1.1.3.4).

1.1.3.2 *Subscripts and other distinguishing means which are independent of language*

a) *Subscripts*

Subscripts that are independent of language may be numbers, mathematical symbols and signs, sequences of letters, reference letters, letter symbols for quantities and units and symbols for chemical elements.

b) *Numbers*

Numbers may represent for instance: order, degree of importance, and reference. The subscript 0 (zero) is used not only as a number, but also for basic, initial, or reference conditions.

Roman numerals as subscripts should be used sparingly.

The letter "l" and the numeral "1" are often identical. Care should be taken to avoid ambiguity.

EXAMPLES:

$i_1\, i_2\, i_3$ the fundamental and the second and third harmonic components of a current; or current in conductors 1, 2 and 3, or current in the same conductor at three different moments
R_{50} resistance at a temperature of 50 °C
R_{50} resistance at a frequency of 50 Hz
U_{99} sparkover voltage with 99 % probability.

c) *Mathematical signs*

EXAMPLE:

i_∞ current at infinite time.

d) *Sequence of letters*

There are occasions when samples of the same physical quantity that are classified in a sequence may be distinguished by letter subscripts rather than by number subscripts. Both capital and lower-case letters may be used, but lower-case letters are preferred.

EXAMPLES:

$Q_a\, Q_b\, Q_c$ three different electric charges.

e) *Reference letters*

The subscript indicates the applicability of a symbol in some way, for instance restrictions to particular location, to particular points of time, to particular pieces of apparatus or parts of apparatus, to particular processes, to particular substances, to particular fields (electrical, mechanical, etc.). The following few examples illustrate the point.

EXAMPLES:

E_B could denote electric field strength at point B
s_{EF} could denote length of path from point E to point F
A_{KLM} could denote the area of a triangle with the corners K, L and M
I_u could denote current in phase u.

f) *Quantity or unit symbols used as subscripts*

A letter symbol for a quantity (or for a unit) when used as a subscript, shall be printed in the same style as when used as a quantity symbol (or as a unit symbol).

EXAMPLES:

C_p heat capacity at constant pressure p
δ_C loss angle of capacitor of capacitance C
W_{3h} energy capacity of a battery at three hours (3 h) discharge.

g) *Symbols for chemical elements*

Internationally adopted symbols for chemical elements are independent of language and may be used as subscripts.

EXAMPLE:

ϱ_{Cu} resistivity of copper (Cu).

NOTE – Symbols for chemical elements are given in ISO 31-8, *Quantities and units – Part 8: Physical chemistry and molecular physics.*

h) *Other distinguishing means*

For distinguishing between different types of values (e.g. instantaneous value, root-mean-square value, peak value, minimum value, average value) capital and lower-case letters and some signs ($\hat{}$ $\check{}$ $\tilde{}$ $\bar{}$) should be used as recommended in 2.1. Other recommendations are given for vector quantities and for complex representation of quantities (1.6).

EXAMPLES:

i instantaneous value of current
I root-mean-square value of current
$\overline{Q}$ average value of electric charge
$\hat{\Phi}$ peak value of magnetic flux
H magnetic field strength as a vector
ε' real part of complex permittivity.

1.1.3.3 *Subscripts of international character*

a) *Proper names*

Abbreviations of proper names are, with extremely few exceptions, the same or practically the same in all languages. Such abbreviations are therefore of international character, and they may be used as subscripts.

EXAMPLES:

T_C Curie temperature
R_H Hall coefficient.

b) *Words derived from Latin and Greek*

Latin and Greek serve as a basis for most scientific and technical words, and abbreviations of such words are suitable as subscripts.

EXAMPLES:

P_{el} *el*ectrical power
p_{cr} *cr*itical pressure
v_i *i*nitial velocity
B_i *i*ntrinsic magnetic flux density
T_{ext} *ext*ernal thermodynamic temperature
R_{eq} *eq*uivalent resistance
g_n standard (*n*ormal) acceleration of free fall
M_v luminous (*v*isual) exitance.

c) *International words not derived from Latin and Greek*

Many words which have been coined for scientific and industrial purposes have an international character. Examples of such words are gas, radar, maser. Abbreviations of such words are suitable as subscripts.

EXAMPLE:

C_g heat capacity in the gas phase.

1.1.3.4 *Other subscripts*

If it is not possible in a specific case to find Latin, Greek, or other international words from which to derive an acceptable subscript, arbitrarily chosen letters or numbers are preferred. If such a choice is not convenient, subscripts derived from words that are common to many languages are the next best choice.

1.1.3.5 *Some observations*

When a subscript is not self-explanatory, its meaning should be stated.

Subscripts, whether they conform to these recommendations or not, may be ambiguous; thus i (roman, upright) may mean *i*nitial, *i*nduced or *i*ntrinsic. Ambiguity can often be avoided by the use of longer subscripts, as ini for initial, ind for induced, and intr for intrinsic.

Subscripts which are abbreviations of words other than proper names are, as a rule written with lower-case letters. Sometimes it is practical to use both capital and lower-case letters for such

making a difference in their significance which must be defined. Thus, in a certain context a capital letter subscript may be used for the total value of a quantity and lower-case letter subscripts for its components. In another context capital letter subscripts may be used for external quantities and lower-case letter subscripts for internal ones.

1.1.3.6 *Multiple subscripts*

The use of a subscript consisting of several parts, a multiple subscript, should be avoided if possible. When a multiple subscript is used the parts should be placed on the same level. The only exception may be when a letter symbol consisting of a letter with a subscript is used as subscript, e.g. for the temperature coefficient (α) of reluctance (R_m), then the total symbol can be written either non-simplified α_{R_m} or simplified α_{Rm}.

For the sake of clarity, the different parts of a multiple subscript may be separated by thin spaces. Commas should usually be avoided between parts of a subscript, but may be used if this is necessary to avoid ambiguity. For the same purpose part of a subscript may be put within parentheses. No general rule for the order between parts of a subscript can be given, but, for guidance, a part indicating the kind of quantity should be placed first, a part indicating special circumstances last. The order may thus depend upon the point of view.

The following examples may be mentioned:

$R_{m\,max}$	maximum value of reluctance
$\hat{u}_{bv}$	peak value of variable part of voltage at b
$i_{4(2)}$	instantaneous value of the second harmonic of current in conductor 4. To make a distinction the harmonic number has been placed within parentheses
L_{mn}	mutual inductance
$Z_{12,13}$	element in the twelfth row and the thirteenth column of an impedance matrix
J_{3y}	y-component of the third harmonic of current density J
J_{y3}	third harmonic of the y-component of current density J

Multiple subscripts can sometimes be avoided by expressing the quantity in functional form, e.g. W(3 h, −40 °C) for the energy capacity of an accumulator battery for a three-hour discharge at a temperature of −40 °C.

1.1.4 *Combination of symbols for quantities; elementary operations with quantities*

When symbols for quantities are combined in a product, this process of combination may be indicated in one of the following ways:

ab, $a\,b$, $a \cdot b$, $a \times b$

NOTES

1 In some fields, e.g., in vector analysis, distinction is made between $\boldsymbol{a} \cdot \boldsymbol{b}$ and $\boldsymbol{a} \times \boldsymbol{b}$.

2 For multiplication of numbers, see 1.3.

3 In systems with limited character sets a dot on the line is used instead of a half-high dot.

Division of one quantity by another may be indicated in one of the following ways:

$$\frac{a}{b},\ a/b$$

or by writing the product of a and b^{-1}, e.g., $a \cdot b^{-1}$

The procedure can be extended to cases where the numerator or the denominator, or both, are

themselves products or quotients, but in such a combination a solidus (/) should not be followed by a multiplication sign or a division sign on the same line unless parentheses be inserted to avoid all ambiguity.

EXAMPLES:

$\frac{ab}{c} = ab/c = abc^{-1}$

$\frac{a/b}{c} = (a/b)/c = ab^{-1}c^{-1}$; but not $a/b/c$;

however, $\frac{a/b}{c/d} = \frac{ad}{bc}$

$\frac{a}{bc} = a/(b \cdot c) = a/bc$, but not $a/b \cdot c$

The solidus (/) can be used in cases where the numerator and the denominator involve addition or subtraction provided parentheses (or brackets or braces) be employed.

EXAMPLES:

$(a + b)/(c + d)$ means $\frac{a+b}{c+d}$;

the parentheses are required.

$a + b/c + d$ means $a + \frac{b}{c} + d$;

misunderstanding may, however, be avoided by writing it as

$a + (b/c) + d$.

Parentheses should also be used to remove ambiguities which may arise from the use of certain other signs and symbols for mathematical operations.

1.1.5 *Substitution of letters*

Capital letters may be used as variants for lower-case letters (and vice versa) only if no ambiguity could result.

The chief symbol for length is l and for inductance L, but l and L may also be used for two lengths or two inductances. If length and inductance appear together, then l should preferably be used only for length and L for inductance and any necessary distinction should be made by means of subscripts.

1.2 Names and symbols for units

1.2.1 *International symbols for units*

When international symbols for units exist, they, and no other, shall be used. They should be printed in roman (upright) type (irrespective of the type used in the rest of the text), should remain unaltered in the plural, should be written without a final full stop (period) except for normal punctuation, e.g., at the end of a sentence.

Any attachment to a unit symbol as a means of giving information about the special nature of the quantity under consideration is incorrect.

EXAMPLE:

$U_{max} = 500$ V (not $U = 500$ V_{max})

The unit symbols shall in general be printed in lower-case letters except that the first letter is printed in upper case when the name of the unit is derived from a proper name.

EXAMPLES:

m metre
s second
A ampere
Wb weber

1.2.2 *Combination of symbols for units*

When a compound unit is formed by multiplication of two or more units, this may be indicated in one of the following ways:

N·m, N m

NOTES

1 In systems with limited character sets a dot on the line is used instead of a half-high dot.

2 The last form may also be written without a space provided that special care is taken when the symbol for one of the units is the same as the symbol for a prefix.

EXAMPLE:

mN means millinewton, not metre newton.

When a compound unit is formed by dividing one unit by another, this may be indicated in one of the following ways:

$\frac{m}{s}$, m/s, $m \cdot s^{-1}$.

A solidus (/) shall not be followed by a multiplication sign or a division sign on the same line unless parentheses are inserted to avoid all ambiguity. In complicated cases negative powers or parentheses shall be used.

1.2.3 *Printing of symbols for units*

No recommendation is made or implied about the font of upright type in which symbols for units are to be printed.

NOTE – In this series of publications the font used in such cases happens generally to be that of the associated text, but this does not constitute a recommendation.