

An American National Standard

IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering

Sponsor

IEEE Standards Coordinating Committee 14, Graphic Symbols and Designations

Approved September 23, 1982
Reaffirmed March 20, 2003

IEEE Standards Board

Approved May 15, 1984
Reaffirmed August 20, 1997

American National Standards Institute

Abstract: This standard provides letter symbols to represent various quantities (but not units) used in electrical science and technology. The standard is compatible with IEC Publication 27, Letter Symbols to be Used in Electrical Technology.

© Copyright 1984 by

The Institute of Electrical and Electronics Engineers, Inc

345 East 47th Street, New York, NY 10017, USA

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

ACCEPTANCE NOTICE

The above Non-Government standardization document was adopted 12 December 1984 and is approved for use by the DoD. The indicated industry group has furnished the clearances required by existing regulations. Copies of the document are stocked by DoD Single Stock Point, Naval Publications and Forms Center, Philadelphia, PA, 19:120 for issue to DoD activities only. Contractors and industry groups may obtain copies directly from The Institute of Electrical and Electronics Engineers, Inc, 345 East 47th Street, New York, NY 10017.

Title of Document: **IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering**

Document No: **ANSI/IEEE Std 280-1985**

Date of Specific Issue Adopted: **12 December 1984**

Releasing Industry Group: **The Institute of Electrical and Electronics Engineers, Incorporated**

NOTICE: When reaffirmation, amendment, revision, or cancellation of this standard is initially proposed, the industry group responsible for this standard shall inform the military coordinating activity of the proposed change and request participation.

Custodians:

Army — AR
Navy — SH
Air Force — 11

Military Coordinating Activity:

Army — AR

User Activities:

Army — ME, MI, AT
Navy — OS, MC, AS, YD

Project Number DRPR-0254

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE which have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least once every five years for revision or reaffirmation. When a document is more than five years old, and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
345 East 47th Street
New York, NY 10017
USA

Abstract

This standard provides letter symbols to represent various quantities (but not like) used in electrical science and technology. The standard is compatible with IEC Publication 27, Letter Symbols to be Used in Electrical Technology.

Foreword

(This Foreword is not a part of ANSI/IEEE Std 280-1985, IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.)

This standard was developed from three separate standards, ASA Z10.5-1949, Letter Symbols for Electrical Quantities, ASA Y10.9-1953, Letter Symbols for Radio, and 57IRE21S1, Letter Symbols and Mathematical Signs. The first edition of this standard was issued as USAS Y10.5-1968 IEEE Std 280-1968, Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering. In the development of this standard the International Electrotechnical Commission Publication 27, Letter Symbols to be Used in Electrical Technology, has been followed closely.

In this revision the following changes and additions have been made:

- 1) A new section, Scope, has been added.
- 2) A new section, References has been added.
- 3) Section 3.2 on typography has been expanded and clarified.
- 4) Text concerning unit symbols has been expanded and text on the SI system of units added; these now parallel the statements in ANSI/IEEE 268-1982, American National Standard Metric Practice. All units (for example, temperature, pressure, conductance) have been revised to agree with current SI practice.

Celsius temperature replaces the former terms *temperature* and *customary temperature*

Reciprocal degree Celsius replaces *reciprocal kelvin*

References to *cycle per second* have been deleted

In Table 6, 6.59, Subscripts, Semiconductor Devices, the terms *drain terminal* and *source terminal* were added.

In Table 8 the values of the physical constants have been revised to agree with current information.

Attention is called to the following related standards:

ANSI Y10.20-1975, Mathematical Signs and Symbols for Use in Physical Science and Technology.

ANSI/IEEE Std 260-1978, IEEE Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).

ANSI/IEEE Std 268-1982, American National Standard Metric Practice.

When this standard was approved the IEEE Standards Coordinating Committee on Quantities and Units, Subcommittee SCC14.3 on Letter Symbols had the following membership:

Sidney V. Soanes, *Chair*

Bruce B. Barrow

Chester H. Page

Conrad R. Muller

The IEEE Standards Coordinating Committee on Quantities and Units, SCC14 had the following membership:

Bruce B. Barrow, *Chair*

Conrad R. Muller, *Secretary*

Louis E. Barbrow

Robert C. Benoit, Jr†

Andrew F. Dunn

Elwood K. Gannett

Truman S. Gray

Harry Hesse

William R. Kruesi

Jack M. Loudon

Chester H. Page

† Deceased

When the IEEE Standards Board approved this standard on September 23, 1982, it had the following membership:

Irvin N. Howell, Jr., *Chair*
Edward Chelotti, *Vice Chair*
Sava I. Sherr, *Secretary*

G. Y. R. Allen
J. J. Archambault
James H. Beall
John T. Boettger
J. V. Bonucchi
Edward J. Cohen
Len S. Corey

Donald C. Fleckenstein
Jay Forster
Kurt Greene
Joseph L. Koepfinger
Irving Kolodny
John E. May
Donald T. Michael*

A. R. Parsons
John P. Riganati
Frank L. Rose
Robert W. Seelbach
Jay A. Stewart
Clifford O. Swanson
Robert E. Weiler

* Member emeritus

CLAUSE	PAGE
1. Scope	1
2. References	1
3. General Principles of Letter Symbol Standardization.....	1
3.1 Letter Symbols	1
3.2 Alphabets and Typography	2
3.3 Quantity Symbols.....	3
3.4 Unit Symbols.....	3
3.5 The International System of Units (SI)	4
4. Special Principles for Quantity Symbols in Electrical Science and Electrical Engineering.....	6
4.1 Phasor Quantities	6
4.2 Conventions	6
5. Introduction to the Tables	8
6. Symbols for Quantities.....	9

An American National Standard

IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering

1. Scope

This standard covers letter symbols used to represent physical quantities in the field of electrical science and electrical engineering. These symbols are independent of the units (see ANSI/IEEE Std 260-1978 [2]¹) employed or special values assigned. Also included are selected symbols for mathematics and for physical constants.

2. References

When the following American National Standards referred to in this standard are superseded by a revision approved by the American National Standards Institute, the latest version shall be used.

[1] ANSI Y10.17-1961 (R1973), American National Standard Guide for Selecting Greek Letters Used as Letter Symbols for Engineering Mathematics.

[2] ANSI/IEEE Std 260-1978, IEEE Standard Letter Symbols for Units of Measurement.

[3] ANSI/IEEE Std 268-1982, American National Standard Metric Practice.

3. General Principles of Letter Symbol Standardization

3.1 Letter Symbols

Letter symbols² include symbols for physical quantities (*quantity symbols*) and symbols for the units in which these quantities are measured (*unit symbols*).

A quantity symbol is, in general, a single letter³ (for example, *I* for electric current) specified as to general form of type, and modified when appropriate by one or more subscripts or superscripts. In a given work the same letter symbol

¹The numbers in brackets correspond to those of the references in Section 2..

²*Letter symbol* as a technical term does not have the same meaning as either *name* or *abbreviation*. An abbreviation is a letter or a combination of letters (plus sometimes an apostrophe or a full stop) which by convention represents a *word* or a *name* in a particular language; hence an abbreviation may be different in a different language. A symbol represents a *quantity* or a *unit* and is, therefore, independent of language.

EXAMPLE: For electromotive force, the symbol is *E*, whereas the abbreviation is *emf* in English, *fern* in French, and *EMK* in German. The word *ampere* is sometimes abbreviated *amp*; the symbol for this unit is *A*.

³Symbols comprising two letters are sometimes used for numerical transport parameters such as Reynolds number *Re*.

should appear throughout for the same physical quantity, regardless of the units employed or of special values assigned.

A unit symbol⁴ is a letter or group of letters (for example, mm for millimeter), or in a few cases a special sign, that may be used in place of the name of a unit.

3.2 Alphabets and Typography

Letter symbols are mainly restricted to the English and Greek alphabets.⁵ The type families that are used for text in modern book and journal publishing all include italic (*sloping*) type faces and related roman (*upright*) type faces. The former are used for quantity symbols, and the latter, for unit symbols—the distinctions are discussed more fully in the following paragraphs. (In the context of this standard, the term *roman* is used simply to mean upright in contrast with sloping and carries no connotation regarding serifs, line widths, or the like.) In situations where roman and italic are not both available, care shall be taken to avoid confusion between quantities and units. For example, an underline is frequently used to indicate italic type, and where an underline can be provided, as in manual typewriting, this practice is often helpful.

Unconventional type faces should generally not be used for letter symbols. Script and Old English faces, for example, are not appropriate for unit symbols. Such special faces have seen limited use for quantity symbols, but good modern practice avoids them (see 3.3, last paragraph).

Symbols for physical quantities, mathematical variables, indices, and general functions⁶ are printed in italic (*sloping*) type. For example,

A, A	area
e	charge of an electron
x, y, z	Cartesian coordinates
i, j, k, n	indices
$f(x)$	function of x

Symbols for physical units, mathematical constants, specific mathematical functions, operators, and numbers used as indices are printed in roman type. For example,

cm	centimeter
e	base of natural logarithms
$\sin x$	sine of x
$J_2(z), J_n(z)$	Bessel functions
dx	differential of x

Subscripts and superscripts are governed by the above principles. Those that are letter symbols for quantities or for indices are printed in italic type, while all others are printed in roman type, for example,

C_p	heat capacity at constant pressure p
a_{ij}, a_{45}	matrix elements
I_i, I_o	input current, output current
x_{av}	average value of x

For indicating the vector character of a quantity, boldface italic type is used. For example,

⁴Formerly it was common to treat unit symbols in the same manner as general abbreviations, but the current recommendations of the International Organization for Standardization (ISO), and of many other international and national bodies concerned with standardization, emphasize the symbolic character of these designations and rigidly prescribe the manner in which they shall be treated. The concept of the unit symbol is therefore adopted in this standard.

⁵Greek letters that are easily confused with English letters are avoided. See ANSI Y10.17-1961 (1973), [1].

⁶The term *general functions* is used here to contrast with *specific mathematical functions*, for which roman type is to be used.

<i>F</i>	force
<i>H</i>	magnetic field strength

Ordinary italic type is used to represent the magnitude of a vector quantity. It is also commonly used for a vector quantity when there is no need to draw attention to the vector character of the quantity.

When tensor quantities of second or higher order are to be represented by a single letter, sans-serif type should be used (for example, *A*, *B*).

3.3 Quantity Symbols

Quantity symbols may be used in mathematical expressions in any way consistent with good mathematical usage. The product of two quantities *a*, *b*, is indicated by writing *ab*. The quotient may be indicated by writing

$$\frac{a}{b}, a/b, \text{ or } ab^{-1}$$

If more than one solidus (/) is used in any algebraic term, parentheses shall be inserted to remove any ambiguity. Thus one may write $(a/b)/c$, or $a/(b/c)$, but not $a/b/c$.

Subscripts and superscripts are widely used with quantity symbols. Several subscripts or superscripts, sometimes separated by commas, may be attached to a single letter. But, so far as logical clarity permits, subscripts and superscripts should not be attached to other subscripts and superscripts. A symbol that has been modified by a superscript should be enclosed in parentheses before an exponent is attached.

Conflicts that occur because different quantities are assigned identical symbols in the same or different standard symbol lists should be resolved in one of the following ways:

- 1) By use of a reserve symbol (alternative symbol) if one is listed
- 2) By use of a subscript or superscript selected by the author for one or more of the conflicting requirements
- 3) By use of uppercase letters as variants for lowercase letters and *vice versa*, but only if no ambiguity results.

3.4 Unit Symbols

Roman type, in general lowercase, is used for unit symbols, except for a very few that use special signs (such as ° for degree). If, however, the symbol is for a unit whose name is derived from a proper name, uppercase roman type is used for the first letter.⁷ As a further exception to the general rule, the symbol L is used for liter to avoid confusion between the lowercase letter l and the numeral 1. Some additional exceptions arise in the special cases where symbols are joined, as in eV, the symbol for electronvolt, and in mmHg, the symbol for conventional millimeter of mercury, a unit of pressure. The distinction between upper- and lowercase letters should be followed, even if the symbol appears in applications where the other lettering is in uppercase style. The form of unit symbols is the same for singular and plural, and they are not followed by a period except at the end of a sentence.

In the complete expression for a quantity, a space should be allowed between the numerical value and the unit symbol. For example, write 35 m, not 35mm, and 2.371 m, not 2.371m. When the quantity is used in an adjectival sense, a hyphen is often used instead of a space between the number and the unit name or between the number and the symbol (except when the first character of the symbol is not a letter, as in °C).

⁷Prefixes are considered separately.

EXAMPLES

A 3-meter pole	The length is 3 meters.
A 35-mm film	The width is 35 min.

EXCEPTION: No space is left between the numerical value and the symbols for degree, minute, and second of plane angle.

When a compound unit is formed by multiplication of two or more other units, its symbol consists of the symbols for the separate units joined by a raised dot (for example, N·m for newton meter). The dot may be omitted in the case of familiar compounds such as watt-hour (symbol Wh) if no confusion would result.⁸ Hyphens should not be used in symbols for compound units. Positive and negative exponents may be used with the symbols for units.

When a compound unit is formed by division of one unit by another, its symbol is constructed in one of the following forms:

$$\text{m/s or m} \cdot \text{s}^{-1} \text{ or } \frac{\text{m}}{\text{s}}$$

In simple cases use of the solidus (slash) is preferred, but in no case should more than one solidus, or a solidus followed by a product, be used in the same expression unless parentheses are inserted to avoid ambiguity. For example, write:

$$\text{J / (mol} \cdot \text{K) or J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \text{ or (J / mol) / K}$$

but *not* J / mol / K or J / mol·K.

In complicated cases negative powers should be used.⁹

Letter symbols and mathematical notation should not be mixed with unit names in the same expression. For example, write joules per kilogram or J / kg. Do not write joules / kilogram or joules / kg, or J / kilogram.

3.5 The International System of Units (SI)

In this standard some units are identified as SI units. These units belong to the International System of Units (Système International d'Unités), which is the name given in 1960 by the General Conference on Weights and Measures (Conférence Générale des Poids et Mesures) to the coherent system of units based on the following base units and quantities:

Unit	Quantity
meter	length
kilogram	mass
second	time
ampere	electric current
kelvin	thermodynamic temperature
mole	amount of substance
candela	luminous intensity

⁸It may also be omitted where symbols are separated by an exponent as in N·m²kg⁻²

⁹The notation for products and quotients of unit symbols is intentionally made more explicit than that given in 3.3 for quantity symbols because some unit symbols consist of more than one letter.

SI includes as subsystems the MKS system of units, which covers mechanics, and the MKSA system, which covers mechanics and electricity.

The spellings *meter* and *liter* are recommended. This is in accordance with guidance given by the Department of Commerce, which is given the responsibility of interpreting SI for the United States under the Metric Conversion Act of 1975. The variant spellings *metre* and *litre* are also used, especially in British English.

The following prefixes are used to indicate decimal multiples or submultiples of SI units:¹⁰

Multiple	SI Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Compound prefixes, formed by the juxtaposition of two or more SI prefixes, are not to be used. For example, use

1 cm *not* 1 m μ m

1 pF, *not* $\mu\mu$ F

If values are required outside the range covered by the prefixes, they should be expressed using powers of ten applied to the base unit.

An exponent attached to a symbol containing a prefix indicates that the multiple or submultiple of the unit (the unit with its prefix) is raised to the power expressed by the exponent. For example:

$$\begin{aligned}
 1 \text{ cm}^3 &= (10^{-2} \text{ m})^3 &= 10^{-6} \text{ m}^3 \\
 1 \text{ ns}^{-1} &= (10^{-9} \text{ s})^{-1} &= 10^9 \text{ s}^{-9} \\
 1 \text{ mm}^2/\text{s} &= (10^{-3} \text{ m})^2/\text{s} &= 10^{-6} \text{ m}^2/\text{s}
 \end{aligned}$$

For further information concerning metric practice and the SI, refer to ANSI/IEEE Std 268-1982 [3].

¹⁰The use of SI prefixes with US customary units is not recommended, except in the case of the microinch and kilopound-force.

4. Special Principles for Quantity Symbols in Electrical Science and Electrical Engineering

4.1 Phasor Quantities

Phasor quantities, represented by complex numbers or complex time-varying functions, are extensively used in certain branches of electrical engineering. The following notation and typography are to be used:

	Notation*	Remarks
Complex quantity	Z	$Z = Z e^{j\phi}$ $Z = \text{Re } Z + j \text{Im } Z$
Real part	$\text{Re } Z, Z'$	
Imaginary part	$\text{Im } Z, Z''$	
Conjugate complex quantity	Z^*	$Z^* = \text{Re } Z - j \text{Im } Z$
Modulus of Z	$ Z $	
Phase of Z , Argument of Z	$\arg Z$	$\arg Z = \phi$

*The following alternative notation has been used in electrical power engineering: Complex quantity, $\hat{Z}$; Conjugate complex quantity, $\hat{Z}^*$; Modulus of complex quantity, Z . Further use of this notation for this purpose is not recommended.

4.2 Conventions

4.2.1 Time Varying Quantities

When upper and lowercase type faces are available to represent a time-varying quantity, the lowercase letter may be used for the instantaneous value of the quantity and the uppercase letter may be used as convenient for one of the characterizing values associated with the quantity. For example, V , I , and Q are conventionally used to denote the root-mean-square values of voltage, current, and charge, while v , i , and q denote the instantaneous values. For time-varying power, P is used to denote the average value, and p , the instantaneous power.

When, as an alternative to the above, subscripts are used to denote various values associated with a quantity, the subscripts (for the values indicated) shall conform with the following list:

	Preferred	Reserve
Instantaneous value	i	I
Average value	av	AV
Root-mean-square value*	rms	RMS
Maximum (peak) value	max, m	MAX, M
Minimum (valley, nadir) value	min, n	MIN, N

*The subscript "f" has been adopted by the IEC but is not recommended in this standard.