



BSI Standards Publication

Letter symbols to be used in electrical technology

Part 2: Telecommunications and electronics

National foreword

This British Standard is the UK implementation of EN IEC 60027-2:2019. It is identical to IEC 60027-2:2019. It supersedes BS EN 60027-2:2007, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee SS/7, General metrology, quantities, units and symbols.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Letter symbols to be used in electrical technology - Part 2:
Telecommunications and electronics
(IEC 60027-2:2019)

Symboles littéraux à utiliser en électrotechnique - Partie 2:
Télécommunications et électronique
(IEC 60027-2:2019)

Formelzeichen für die Elektrotechnik - Teil 2:
Telekommunikation und Elektronik
(IEC 60027-2:2019)

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

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European foreword

The text of document 25/635/FDIS, future edition 4 of IEC 60027-2, prepared by IEC/TC 25 "Quantities and units" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60027-2:2019.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2019-11-12
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-02-12

This document supersedes EN 60027-2:2007.

This edition constitutes a technical revision and includes the following significant changes with respect to the previous edition:

- a) former Subclauses 3.8 and 3.9 are cancelled and replaced by EN 80000-13:2008;
- b) former Subclause 3.10, now 4.8, is revised in accordance with IEC 60050-192:2015;
- c) former Subclause 3.11, now 4.9, is revised in accordance with IEC 60050-561:2014;
- d) former Subclause 3.13, now 4.11, is revised in accordance with EN ISO 80000-8:2007, IEC 60050-801:1994 and IEC 60050-802:2011;
- e) technical and editorial corrections have been carried out, mainly in Subclause 4.1.
- f) tables are simplified, mainly by deleting useless columns.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60027-2:2019 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60027-3	NOTE	Harmonized as EN 60027-3
IEC 60747 (series)	NOTE	Harmonized in EN 60747 (series)
IEC 61703:2001	NOTE	Harmonized as EN 61703:2002 (not modified)
ISO 80000-1:2009	NOTE	Harmonized as EN ISO 80000-1:2013 (not modified)
ISO 80000-8:2007	NOTE	Harmonized as EN ISO 80000-8:2007 (not modified)
IEC 80000-13:2008	NOTE	Harmonized as EN 80000-13:2008 (not modified)

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60027-1	1992	Letters symbols to be used in electrical technology - Part 1: General		
+ A1	1997		EN 60027-1	2006
+ A2	2005		+ A2	2007

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LETTER SYMBOLS TO BE USED IN ELECTRICAL TECHNOLOGY –

Part 2: Telecommunications and electronics

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.
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International Standard IEC 60027-2 has been prepared by IEC technical committee 25: Quantities and units.

This fourth edition cancels and replaces the third edition published in 2005. This fourth edition constitutes a technical revision.

This edition includes the following significant changes with respect to the previous edition:

- a) former Subclauses 3.8 and 3.9 are cancelled and replaced by IEC 80000-13:2008;
- b) former Subclause 3.10, now 4.8, is revised in accordance with IEC 60050-192:2015;
- c) former Subclause 3.11, now 4.9, is revised in accordance with IEC 60050-561:2014;
- d) former Subclause 3.13, now 4.11, is revised in accordance with ISO 80000-8:2007, IEC 60050-801:1994 and IEC 60050-802:2011;
- e) technical and editorial corrections have been carried out, mainly in Subclause 4.1.
- f) tables are simplified, mainly by deleting useless columns.

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

FDIS	Report on voting
25/635/FDIS	25/640/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

A list of all parts in the IEC 60027 series, published under the general title *Letter symbols to be used in electrical technology*, 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 "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

LETTER SYMBOLS TO BE USED IN ELECTRICAL TECHNOLOGY –

Part 2: Telecommunications and electronics

1 Scope

This part of IEC 60027 is applicable to telecommunications and electronics. It gives names and symbols for quantities and their units.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60027-1:1992, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60027-1:1992/AMD1:1997

IEC 60027-1:1992/AMD2:2005

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

4 Introduction to tables

In this part of IEC 60027, complex quantities are in general denoted by underlining their symbols. However, this does not constitute a compulsory rule in applications (see IEC 60027-1).

To avoid any ambiguity, some quantity names are followed by a specific use, enclosed in angle brackets "<...>" after a comma.

When several symbols are indicated for a given quantity, the first is the preferred symbol and the others are reserve symbols, unless otherwise stated.

When several units are indicated for a given quantity, the first is the coherent SI unit, unless otherwise stated. For logarithmic ratios, the first mentioned unit is the decibel.

For quantities defined as a logarithm of the ratio of two power quantities or two root-power quantities (also known as field quantities), the submultiple decibel (dB) of the bel (B) is generally used, rather than the neper (Np). The bel is not explicitly mentioned in the tables. See IEC 60027-3 and ISO 80000-1:2009, Annex C.

5 Quantities and units

5.1 General concepts

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
101	101-12-02	signal	S s	A signal is any physical phenomenon whose presence, absence or variation is considered as representing information. In general, a signal is a quantity, one or more parameters of which represent information. In this document, S_1 and S_2 are used for input and output signals respectively. See IEC 60027-1 for other suitable subscripts. In cases where the type of signal quantity is known, for example, electric current, voltage, pressure, etc., use the appropriate symbol. With respect to capital and lower-case letters, see IEC 60027-1:1992, 2.1.			The unit depends on the kind of quantity constituting the signal (electric current, voltage, pressure, etc.).
102		signal power	P_s P_{sig}	"s" (lower case, upright) is used as subscript for "signal". In signal theory, the term "instantaneous power" is by convention used for the square of the instantaneous value of a signal. This square is proportional to a physical power if the signal is a root-power quantity (or field quantity) (see Note 1 to entry of IEC 60050-103:2009, 103-09-05). In a physical system, a signal power is always a physical power.	watt	W	
103		signal level	L L_s L_{sig}	$L = 10 \lg \left \frac{S}{S_{ref}} \right \quad \text{dB} = \frac{1}{2} \ln \left \frac{S}{S_{ref}} \right \quad \text{Np}$ where S and S_{ref} are two signals of the same kind, S_{ref} being a reference signal.	decibel neper	dB Np	
104	702-07-04	absolute power level; power level	L_p	$L_p = 10 \lg \frac{P}{P_{ref}} \quad \text{dB} = \frac{1}{2} \ln \frac{P}{P_{ref}} \quad \text{Np}$ where P is a power and P_{ref} is a reference power.	decibel neper	dB Np	
105	702-07-06	absolute voltage level; voltage level	L_U	$L_U = 20 \lg \frac{U}{U_{ref}} \quad \text{dB} = \ln \frac{U}{U_{ref}} \quad \text{Np}$ where U is a voltage and U_{ref} is a reference voltage. The synonym "voltage level" may be used only where there is no ambiguity.	decibel neper	dB Np	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
106	702-07-05	relative power level	$L_{r,x}$ L_r	$L_{r,x} = L_{p,x} - L_{p,0}$ where $L_{p,x}$ and $L_{p,0}$ are the absolute power levels (104) at the measuring point and at a reference point, respectively.	decibel neper	dB Np	
107	702-08-03	noise	N n S_n s_n	A noise is any variable physical phenomenon, generally a quantity, apparently not conveying information and which can be superimposed on, or combined with, a wanted signal. Concerning upper and lower-case letters, see IEC 60027-1:1992, 2.1. "n" (lower case, upright) is used as subscript for "noise". In cases where the type of noise quantity is known, use the appropriate symbol (for example, I , i for electric current) with n as subscript (e.g. I_n , i_n).			The unit depends on the kind of quantity constituting the noise (electric current, voltage, pressure, etc.).
108	103-09-05	power spectral density, <for a signal or noise>	$w(f)$	$P = \int_0^{\infty} w(f) df$ where f is the frequency and P is the total power. In signal theory, the term "instantaneous power" is by convention used for the square of the instantaneous value of a signal or noise. This square is proportional to a physical power if the signal or the noise is a root-power (or field quantity). See Note 1 to entry of 103-09-05 in IEC 60050-103:2009. In a physical system, the power spectral density is always a physical power spectral density.	watt per hertz	W/Hz	
109		power spectral density of white noise	N_0	The power spectral density (108) is frequency-independent: $w(f) = N_0$	watt per hertz	W/Hz	
110	702-08-51	equivalent noise voltage	U_n	Applies to a one-port network. U_n is an RMS voltage.	volt	V	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
111	702-08-52	equivalent noise resistance; noise resistance	R_{eq} R_n	Applies to a one-port network. $R_{eq} = \frac{U_n^2}{4kT_{ref}\Delta f}$ where U_n is the equivalent noise voltage (110), k is the Boltzmann constant, T_{ref} is a reference temperature and Δf is the frequency bandwidth (154) considered. The synonym "noise resistance" may be used only where there is no ambiguity.	ohm	Ω	
112	702-08-54	spot noise temperature	$T(f)$	Applies to a one-port network. f is frequency.	kelvin	K	
113	702-08-55	mean noise temperature	$\bar{T}$	Applies to a one-port network.	kelvin	K	
114	702-08-56	equivalent spot noise temperature	$T_{eq}(f)$	Applies to a two-port network. f is frequency.	kelvin	K	
115	702-08-58	mean equivalent noise temperature; mean noise temperature	$\bar{T}_{eq}$	Applies to a two-port network. The synonym "mean noise temperature" may be used only where there is no ambiguity.	kelvin	K	
116	702-08-57	spot noise factor	$F(f)$	Applies to a two-port network. The noise factor is the ratio of the exchangeable power spectral density (108) of output noise to the power spectral density that would be present at the output if the only source of noise were input thermal noise at a reference temperature T_{ref} : $F(f) = 1 + \frac{T_{eq}(f)}{T_{ref}}$ where $T_{eq}(f)$ is the equivalent spot noise temperature (114). For exchangeable power, see IEC 60050-702:1992, 702-07-11.	one	1	

Item number	Quantity				Units	
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol
117	702-08-57	spot noise figure	$F_n(f)$	$F_n(f) = 10 \lg F(f) \text{ dB} = \frac{1}{2} \ln F(f) \text{ Np}$ where $F(f)$ is the spot noise factor (116). In English, "noise factor" is generally used for the arithmetic expression and "noise figure" is used for the logarithmic expression. See IEC 60050-702:1992, 702-08-57, Note 2. In French, "facteur de bruit" is generally used in both cases.	decibel neper	
118	702-08-59	mean noise factor; noise factor	$\bar{F}$	Applies to a two-port network. $\bar{F} = 1 + \frac{\bar{T}_{\text{eq}}}{T_{\text{ref}}}$ where $\bar{T}_{\text{eq}}$ is the mean equivalent noise temperature (115) and T_{ref} is a reference temperature. The synonym "noise factor" may be used only where there is no ambiguity.	one	1
119	702-08-59	mean noise figure; noise figure	$\bar{F}_n$	$\bar{F}_n = 10 \lg \bar{F} \text{ dB} = \frac{1}{2} \ln \bar{F} \text{ Np}$ where $\bar{F}$ is the mean noise factor (118). In English, "noise factor" is generally used for the arithmetic expression and "noise figure" is used for the logarithmic expression. See IEC 60050-702:1992, 702-08-59, Note 2. In French, "facteur de bruit" is generally used in both cases and the adjective "logarithmique" is omitted in practice. The synonym "noise figure" may be used only where there is no ambiguity.	decibel neper	
120	702-08-61	signal-to-noise ratio; SNR	k_{SN}	Signal power (102) divided by noise power. In practice, the symbol S/N is generally used.	one	1

Item number	Quantity				Units	
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol
121	702-08-61	signal-to-noise logarithmic ratio	K_{SN}	$K_{\text{SN}} = 10 \lg k_{\text{SN}} \text{ dB} = \frac{1}{2} \ln k_{\text{SN}} \text{ Np}$ where k_{SN} is the signal-to-noise ratio (120). In practice, the term "signal-to-noise ratio" and the symbol S/N are generally used.	decibel neper	dB Np
122	103-07-17	growth coefficient	σ	Example: $u(t) = \hat{u} e^{\sigma t} \sin \omega t$ where $u(t)$ is a sinusoidal function of time t, with angular frequency ω and amplitude $\hat{u}$.	decibel per second neper per second	dB/s Np/s
123	103-05-24	damping coefficient	δ	$\delta = -\sigma$ where σ is the growth coefficient (122).	decibel per second neper per second	dB/s Np/s
124	103-07-16	complex angular frequency; complex frequency	$\underline{s}$ $\underline{p}$	$\underline{s} = \sigma + j\omega = -\delta + j\omega$ where ω is the angular frequency, σ is the growth coefficient (122) and δ is the damping coefficient (123).	second to the power of minus one	s^{-1} Special units are only used when the real and imaginary parts are treated separately.

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
125	131-15-20	transfer function	$\underline{H}$ $\underline{T}$	$\underline{H}(\underline{s}) = \frac{\underline{S}_2(\underline{s})}{\underline{S}_1(\underline{s})}$ where $\underline{S}_1$ and $\underline{S}_2$, respectively, are the complex representations of the input and output signals, respectively, as functions of the complex angular frequency $\underline{s}$ (124). The complex quantities are generally the Laplace transforms of the time-varying quantities: $\underline{H} = \frac{\underline{L}_{S_2}(t)}{\underline{L}_{S_1}(t)}$ where $\underline{L}_{S_1}(t)$ and $\underline{L}_{S_2}(t)$ are the Laplace transforms of the signals $s_1(t)$ and $s_2(t)$ and t is time.			The unit of the quantity $\underline{H}$ is the quotient of the unit of $s_2(t)$ by the unit of $s_1(t)$.
126		transfer gain	$G(\omega)$	$G(\omega) = H(j\omega) $ where $H(\sigma + j\omega)$ is the transfer function (125).			The unit is the same as for $\underline{H}$.
127		transfer attenuation	$A(\omega)$	$A(\omega) = 1 / G(\omega)$ where $G(\omega)$ is the transfer gain (126).			The unit is the reciprocal of the unit of $\underline{H}$.
128		transfer exponent	$\underline{I}$	If the transfer function $\underline{H}$ (125) is of dimension one (see IEC 60050-112:2010, 112-01-13): $\underline{H}(j\omega) = G(\omega)\exp[-jB(\omega)] = \exp[\underline{I}(\omega)]$ $\underline{I} = A - jB \quad (\text{see 129 and 130}).$ See also image transfer coefficient (IEC 60050-131:2002, 131-15-25).	one	1	Special units are only used when the real and imaginary parts are treated separately.
129		logarithmic transfer attenuation	A	$A = 20 (\lg e) \operatorname{Re}(\underline{I}) \quad \text{dB} = \operatorname{Re}(\underline{I}) \quad \text{Np}$ where $\underline{I}$ is the transfer exponent (128) and e is the base of the natural logarithm. In practice, "transfer attenuation" is used.	decibel neper	dB Np	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
130		phase change; phase shift	B_{φ}	$B(\omega) = \text{Im}(\underline{I}) = -\arg \underline{H}(j\omega)$ where $\underline{H}(\sigma + j\omega)$ is the transfer function (125) and $\underline{I}$ is the transfer exponent (128).	radian degree	rad °	$1^{\circ} = \frac{\pi}{180} \text{ rad}$
131		voltage attenuation factor	a_U	$a_U = \frac{U_1}{U_2}$ where U_1 and U_2 are two voltages. Subscripts 1 and 2 can for example designate the input port and the output port, respectively, of a two-port network. The inverse of the voltage attenuation factor is the voltage gain factor (133). In practice, "voltage attenuation" is used.	one	1	
132		logarithmic voltage attenuation	A_U	$A_U = 20 \lg a_U$ dB = $\ln a_U$ Np where a_U is voltage attenuation factor (131). When the logarithmic voltage attenuation is negative, its absolute value is the logarithmic voltage gain (134). In practice, "voltage attenuation" is used.	decibel neper	dB Np	
133		voltage gain factor	g_U	$g_U = \frac{U_2}{U_1}$ where U_1 and U_2 are two voltages. Subscripts 1 and 2 can, for example, designate the input port and the output port, respectively, of a two-port network. The inverse of the voltage gain factor is the voltage attenuation factor (131). In practice, "voltage gain" is used.	one	1	
134		logarithmic voltage gain	G_U	$G_U = 20 \lg g_U$ dB = $\ln g_U$ Np where g_U is the voltage gain factor (133). When the logarithmic voltage gain is negative, its absolute value is the logarithmic voltage attenuation (132). In practice, "voltage gain" is used.	decibel neper	dB Np	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
135	702-02-10	power loss factor; power attenuation factor	a_p	Use subscript S instead of P in the case of apparent powers. $a_p = \frac{P_1}{P_2}$ Subscripts 1 and 2 are used to designate the power of a signal at two points, for example, input and output of a two-port network, or the power of a signal in two specified conditions, for example, for defining insertion attenuation or insertion loss (IEC 60050-131:2002, 131-15-30). The inverse of the power loss factor is the power gain factor (137). In practice, "power loss" or "power attenuation" are used.	one	1	
136	702-02-10	logarithmic power loss; logarithmic power attenuation; loss; attenuation	A_p	Use subscript S instead of P in the case of apparent powers. $A_p = 10 \lg a_p \text{ dB} = \frac{1}{2} \ln a_p \text{ Np}$ where a_p is the power loss factor (135). When the logarithmic power loss is negative, its absolute value is the logarithmic power gain (138). In practice, "logarithmic" is omitted in the terms.	decibel neper	dB Np	
137	702-02-11	power gain factor; gain factor	g_p	Use subscript S instead of P in the case of apparent powers. $g_p = \frac{P_2}{P_1}$ Subscripts 1 and 2 are used to designate the power of a signal at two points, for example, input and output of a two-port network, or the power of a signal in two specified conditions, for example, for defining available power gain (IEC 60050-702:1992, 702-07-12). The inverse of the power gain factor is the power loss factor (135). In practice, "factor" is omitted in the terms.	one	1	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
138	702-02-11	logarithmic power gain; logarithmic gain	G_P	Use subscript S instead of P in the case of apparent powers. $G_P = 10 \lg g_P \text{ dB} = \frac{1}{2} \ln g_P \text{ Np}$ where g_P is the power gain factor (137). When the logarithmic power gain is negative, its absolute value is the logarithmic power loss (136). In practice, "logarithmic" is omitted in the terms.	decibel neper	dB Np	
139	702-08-60	effective noise bandwidth	B_n	Applies to a two-port network. $B_n = \frac{1}{g_{\max}} \int_0^\infty g(f) ^2 df$ where $g(f)$ is the available power gain (IEC 60050-702:1992, 702-07-12) as a function of frequency f and $g_{\max}$ is the maximum available power gain.	hertz	Hz	
140	103-10-18	propagation coefficient	$\underline{\gamma}$	Coefficient of the distance in the complex representation of a wave $A_0 \exp(-\underline{\gamma}x + j\omega t + j\vartheta_0)$ where x is the distance in the direction of propagation, ω is the angular frequency, t is time and ϑ_0 is the initial phase (IEC 60050-103:2009, 103-07-05). $\underline{\gamma} = \alpha + j\beta$ (see 141 and 142).	metre to the power of minus one	m^{-1}	Special units are only used when the real and imaginary parts are treated separately. See 119 and 120.
141	103-10-19	attenuation coefficient	α	$\alpha = \text{Re} \underline{\gamma}$ where $\underline{\gamma}$ is the propagation coefficient (140).	neper per metre decibel per metre	Np/m dB/m	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
142	103-10-20	phase change coefficient; phase coefficient	β	$\beta = \text{Im } \underline{\gamma}$ where $\underline{\gamma}$ is the propagation coefficient (140).	radian per metre degree per metre	rad/m °/m	
143	702-02-16	phase delay	t_ϕ τ_ϕ		second	s	
144	702-02-20	group delay	t_g τ_g	See also 608.	second	s	
145	103-10-13	phase velocity	c_ϕ v_ϕ $\mathbf{c}$ $\mathbf{v}$	Phase velocity is defined for waves only. If both waves and moving particles are involved, use c for the former and v for the latter. The phase velocity is a vector quantity with magnitude $ \mathbf{c}_\phi = f \lambda = \frac{\omega}{k}$ where f is the frequency, λ is the wavelength (147), ω is the angular frequency (IEC 60050-103:2009, 103-07-03), and k is angular wavenumber (IEC 60050-103:2009, 103-10-12).	metre per second	m/s	

Item number	Quantity				Units	
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol
146	103-10-15	group velocity	c_g v_g	Group velocity is defined for waves only. The group velocity is a vector quantity with magnitude $ c_g = \frac{df}{d\frac{1}{\lambda}} = \frac{d\omega}{dk}$ where f is the frequency, λ is the wavelength (147), ω is the angular frequency (IEC 60050-103:2009, 103-07-03), and k is the angular wavenumber (IEC 60050-103:2009, 103-10-12). See also 607, where the group velocity is defined as the speed of light in vacuum divided by the group index (606).	metre per second	m/s
147	103-10-10	wavelength	λ	$\lambda = \frac{ c_\phi }{f}$ where c_ϕ is the phase velocity (145) and f is the frequency. See also 602.	metre	m
148	702-07-24	complex reflection factor; reflection factor	r_-	$r_- = \frac{S_r}{S_i}$ where S_i and S_r are the complex amplitudes (IEC 60050-103:2009, 103-07-13) of the incident and reflected wave, respectively. $r_- = \frac{Z_2 - Z_1}{Z_2 + Z_1}$ where Z_1 is the characteristic impedance (307, 407) of a transmission line ahead of a discontinuity or the impedance of a source; and Z_2 is the impedance after the discontinuity or the load impedance seen from the junction between the source and the load.	one	1

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
149	726-07-09	standing wave ratio	s	$s = \frac{S_{\max}}{S_{\min}} = \frac{1+ r }{1- r }$ where $S_{\max}$ and $S_{\min}$ are the maximum and minimum amplitudes, respectively, of the superposition of two waves and r is complex reflection factor (148).	one	1	
150	726-07-07	complex transmission factor; transmission factor	$\underline{z}$	$\underline{z} = \frac{S_t}{S_i}$ where S_i and S_t are the complex amplitudes (IEC 60050-103:2009, 103-07-13) of the incident and transmitted wave, respectively.	one	1	
151		reference frequency	f_{ref} f_o	Frequency used as a reference.	hertz	Hz	
152		resonance frequency	f_r f_{sn}	Frequency of a forced oscillation at resonance (see IEC 60050-103:2009, 103-05-07).	hertz	Hz	
153	151-13-54	cut-off frequency	f_c	See also 402.	hertz	Hz	
154	103-09-02	frequency bandwidth; bandwidth	f_B B Δf	The bandwidth of the frequency interval (f_1, f_2) is $f_B = f_2 - f_1$.	hertz	Hz	
155	702-06-19	modulation factor, <in amplitude modulation>	m	$s(t) = \hat{s}(1 + m \sin \omega t) \sin \Omega t$ where Ω is the angular frequency of the carrier oscillation and ω is the angular frequency of the modulation oscillation.	one	1	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
156	702-04-54	amplitude, <of a signal>	$A(t)$	$\underline{S}(t) = A(t)e^{j\vartheta(t)}$ where $\underline{S}(t)$ is the analytic signal associated with the given real signal (see IEC 60050-702:1992, 702-04-52).			The unit depends on the kind of the quantity constituting the signal or noise (electric current, voltage, pressure, etc.).
157	702-04-55	phase, <of a signal>	$\vartheta(t)$ $\psi(t)$	$\underline{S}(t) = A(t)e^{j\vartheta(t)}$ where $\underline{S}(t)$ is the analytic signal associated with the given real signal (see IEC 60050-702:1992, 702-04-52).	radian degree	rad °	$1^\circ = \frac{\pi}{180}$ rad
158	702-04-56	instantaneous frequency	$f(t)$	$f(t) = \frac{1}{2\pi} \frac{d\vartheta(t)}{dt}$ where $\vartheta(t)$ is the phase (157) of the signal.	hertz	Hz	
159	702-06-33	instantaneous frequency deviation; frequency deviation	$\Delta f(t)$	$\Delta f(t) = f(t) - Q$ where $f(t)$ is the instantaneous frequency (158) and Q is the angular frequency of the carrier oscillation.	hertz	Hz	
160	702-06-34	peak frequency deviation; peak deviation	$(\Delta f)_{\text{mm}}$ f_0	$(\Delta f)_{\text{mm}} = \max \Delta f(t)$ where $\Delta f(t)$ is the instantaneous frequency deviation (159). The synonym "peak deviation" may be used only where there is no ambiguity.	hertz	Hz	
161	702-06-38	frequency deviation ratio; deviation ratio	δ η	$\delta = \frac{2\pi(\Delta f)_{\text{mm}}}{\omega}$ where $(\Delta f)_{\text{mm}}$ is the peak frequency deviation (160) and ω is the angular frequency of the modulating oscillation. The synonym "deviation ratio" may be used only where there is no ambiguity.	one	1	

Item number	Quantity				Units		
	Entry number in IEC 60050	Name	Symbol	Definition and remarks	Name	Symbol	Remarks
162	702-06-31	instantaneous phase deviation; phase deviation	$\Delta g(t)$	In angular modulation, difference between the phase of the modulated signal and the phase of the carrier in the absence of modulation: $s(t) = \hat{s} \sin(\Omega t + \Delta g(t))$ where $s(t)$ is an angular modulated signal with peak value $\hat{s}$ and Ω is the angular frequency of the carrier oscillation.	radian degree	rad °	$1^\circ = \frac{\pi}{180} \text{ rad}$
163	702-06-32	peak phase deviation; peak deviation	$(\Delta g)_{\text{pm}}$ $\mathcal{S}_d$	$(\Delta g)_{\text{pm}} = \max \Delta g(t)$ where $\Delta g(t)$ is the instantaneous phase deviation (162). The synonym "peak deviation" may be used only where there is no ambiguity.	radian degree	rad °	$1^\circ = \frac{\pi}{180} \text{ rad}$
164	103-07-32	total harmonic factor	d_k	$d = \frac{\sqrt{(U^2 - U_1^2)}}{U}$ where U is the RMS value of a periodic quantity and U_1 is the RMS value of its fundamental component. The given symbols are also recommended for quantities characterizing distortion in general without regard to the cause or the kind of the distortion considered. In special cases, it shall be mentioned explicitly which kind of distortion is meant, using the given symbols with suitable subscripts if necessary. Example: total harmonic distortion d_h (or k_h), see IEC 60050-702:1992, 702-07-62.	one	1	