

Letter symbols to be used in electrical technology —

Part 2: Telecommunications and electronics

The European Standard EN 60027-2:2007 has the status of a
British Standard

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National foreword

This British Standard is the UK implementation of EN 60027-2:2007. It is identical to IEC 60027-2:2005.

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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**Letter symbols to be used in electrical technology -
Part 2: Telecommunications and electronics
(IEC 60027-2:2005)**

Symboles littéraux à utiliser
en électrotechnique -
Partie 2: Télécommunications
et électronique
(CEI 60027-2:2005)

Formelzeichen
für die Elektrotechnik -
Teil 2: Telekommunikation
und Elektronik
(IEC 60027-2:2005)

This European Standard was approved by CENELEC on 2007-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard IEC 60027-2:2005, 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 EN 60027-2 on 2007-04-01 without any modification.

This European Standard supersedes HD 60027-2:2003.

EN 60027-2:2007 includes the following significant technical changes with respect to HD 60027-2:2003:

- it contains a revision of some clauses of HD 245.2 S1:1983 that were not technically revised in HD 60027-2:2003;
- it contains a revision of Clause 8 which is now Clause 10;
- it contains some new clauses dealing with subjects that were not previously considered;
- former Clause 10 will be given in another part of EN 60027;
- former Clause 11 will be revised as EN 60027-6.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2008-04-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2010-04-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60027-2:2005 was approved by CENELEC as a European Standard without any modification.

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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 units.

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.

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

IEC 60027-3:2002, *Letter symbols to be used in electrical technology – Part 3: Logarithmic and related quantities*

IEC 60050-101:1998, *International Electrotechnical Vocabulary – Part 101: Mathematics*

IEC 60050-131:2002, *International Electrotechnical Vocabulary – Part 131 – Circuit theory*

IEC 60050-191:1990, *International Electrotechnical Vocabulary – Part 191: Dependability and quality of service*

IEC 60050-351:1998, *International Electrotechnical Vocabulary – Part 351: Automatic control*

IEC 60050-702:1992, *International Electrotechnical Vocabulary – Part 702: Oscillations, signals and related devices*

IEC 60050-704:1993, *International Electrotechnical Vocabulary – Part 704: Transmission*

IEC 60050-705:1995, *International Electrotechnical Vocabulary – Part 705: Radio wave propagation*

IEC 60050-712:1992, *International Electrotechnical Vocabulary – Part 712: Antennas*

IEC 60050-713:1998, *International Electrotechnical Vocabulary – Part 713: Radiocommunications: transmitters, receivers, networks and operation*

IEC 60050-715:1996, *Telecommunication networks, teletraffic and operation*

IEC 60050-721:1991, *International Electrotechnical Vocabulary – Part 721: Telegraphy, facsimile and data communication*

IEC 60050-722:1992, *International Electrotechnical Vocabulary – Part 722: Telephony*

IEC 60050-723:1997, *International Electrotechnical Vocabulary – Part 723: Broadcasting: sound, television, data*

IEC 60050-725:1994, *International Electrotechnical Vocabulary – Part 725: Space radio-communications*

IEC 60050-726:1982, *International Electrotechnical Vocabulary – Part 726: Transmission lines and waveguides*

IEC 60050-731:1991, *International Electrotechnical Vocabulary – Part 731: Optical fibre communication*

IEC 60122-1:2002, *Quartz crystal units of assessed quality – Part 1: Generic specification*

IEC 60375:2003, *Conventions concerning electric and magnetic circuits*

IEC 60747(all parts), *Semiconductor devices – Discrete devices*

IEC 60747-1:1983, *Semiconductor devices – Discrete devices – Part 1: General*

IEC 60748 (all parts), *Semiconductor devices – Integrated circuits*

IEC 60748-1:2002, *Semiconductor devices – Integrated circuits – Part 1: General*

IEC 61703:2001, *Mathematical expressions for reliability, availability, maintainability and maintenance support terms*

IEC 61931:1998, *Fibre optic – Terminology*

ISO/IEC 2382-16:1996, *Information technology – Vocabulary – Part 16: Information theory*

ISO 31-0:1992, *Reference materials – Contents of certificates and labels*

ISO 31-11:1992, *Quantities and units – Part 11: Mathematical signs and symbols for use in the physical sciences and technology*

NOTE 1 In this part of IEC 60027, complex quantities are denoted by underlining their symbols. However, this does not constitute a compulsory rule in applications (see 1.6 in IEC 60027-1).

NOTE 2 The heading in the tables "Unit, coherent with the SI" covers SI units and other units coherent with the SI, such as bar and neper.

3 General concepts

3.1 General

For logarithmic quantities defined as a logarithm of the ratio of two power or field quantities, respectively, the neper, Np, is coherent with the SI and is a special name for the unit one. In practice, however, the submultiple decibel, dB, of the bel, B, is generally used. The bel is not explicitly mentioned in the table. See IEC 60027-3.

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
101	101-12-02 702-04-01 351-12-16	signal (generic term)	S, s		The value of a signal is proportional to a physical quantity considered as representing information, with an arbitrary scale. In this document, S_1 and S_2 are used for input and output signals respectively; see IEC 60027-1:1992 for 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 field quantity (see IEC 101-14-71, Note 1).	watt	W			In a physical system, a signal power is always a physical power.
103		signal level	L	L_s, L_{sig}	$L = \log \left \frac{S}{S_{\text{ref}}} \right $ where S and S_{ref} are two signals of the same kind, S_{ref} being a reference					In practice, a base for the logarithm has to be specified.
103.1	702-07-04	absolute power level; power level	L_P		$L_P = \frac{1}{2} \ln \frac{P}{P_{\text{ref}}} \quad \text{Np} = 10 \lg \frac{P}{P_{\text{ref}}} \quad \text{dB}$ where P is a power and P_{ref} is a reference power	neper	Np	decibel	dB	

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
103.2	702-07-06	absolute voltage level; voltage level; absolute tension level; tension level	L_U		$L_U = \ln \frac{U}{U_{\text{ref}}} \quad \text{Np} = 20 \lg \frac{U}{U_{\text{ref}}} \quad \text{dB}$ where U is a voltage and U_{ref} is a reference voltage	neper	Np	decibel	dB	
103.3	702-07-05	relative power level	L_r		$L_{r,x} = L_{P,x} - L_{P,0}$ x refers to the measuring point and 0 to the reference point	neper	Np	decibel	dB	
103.4	101-14-71 702-04-50	power spectral density (for a signal or noise)	$w(f)$	N_0 is used for the power spectral density of a white noise	$P = \int_0^\infty w(f) df$ where f is frequency. 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 field quantity (see IEV 101-14-71, Note 1).	watt per hertz	W/Hz			In a physical system, the power spectral density is always a physical power spectral density.
104	101-14-63 702-08-03	noise (generic term)	N, n	S_n, s_n	Concerning upper-case and lower-case letters, see IEC 60027-1:1992, 2.1. "n" (lower case, upright) is used as subscript for "noise". The value of a noise is proportional to a physical quantity apparently not conveying information, with an arbitrary scale. 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.					The unit depends on the kind of quantity constituting the noise (electric current, voltage, pressure, etc.).
105.1	702-08-51	equivalent noise voltage; equivalent noise tension	U_n		Applies to a one-port network.	volt	V			



Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
105.2	702-08-52	equivalent noise resistance; noise resistance	R_{eq}, R_n		Applies to a one-port network. $R_{\text{eq}} = \frac{U_n^2}{4kT_{\text{ref}}\Delta f}$ where k is the Boltzmann constant, T_{ref} is a reference temperature and Δf is the frequency bandwidth considered.	ohm	Ω			
106	702-08-54	spot noise temperature	$T(f)$		Applies to a one-port network. f is frequency	kelvin	K			
106.1	702-08-55	mean noise temperature	$\bar{T}$		Applies to a one-port network.	kelvin	K			
107	702-08-56	equivalent spot noise temperature	$T_{\text{eq}}(f)$		Applies to a two-port network. f is frequency	kelvin	K			
107.1	702-08-58	mean equivalent noise temperature; mean noise temperature	$\bar{T}_{\text{eq}}$		Applies to a two-port network.	kelvin	K			
107.2	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 of output noise to the power spectral density which would be present at the output if the only source of noise were input thermal noise at a reference temperature T_{ref} : $F(f) = 1 + \frac{T_{\text{eq}}(f)}{T_{\text{ref}}}$ where f is frequency.	one	1			

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
107.3	702-08-57 (Note 2)	spot noise factor	$F_n(f)$		$F_n(f) = \frac{1}{2} \ln F(f)$ Np = 10 lg $F(f)$ dB where f is frequency. In English, the term “noise factor” is generally used for the arithmetic expression and term “noise figure” is used for the logarithmic expression.	neper	Np	decibel	dB	
107.4	702-08-59	mean noise factor; noise factor	$\bar{F}$		Applies to a two-port network. $\bar{F} = 1 + \frac{\bar{T}_{eq}}{T_{ref}}$ where T_{ref} is a reference temperature.	one	1			
107.5	702-08-59 (Note 2)	mean noise figure; noise figure	$\bar{F}_n$		$\bar{F}_n = \frac{1}{2} \ln \bar{F}$ Np = 10 lg $\bar{F}$ dB In English, “noise factor” is generally used for the arithmetic expression and “noise figure” is used for the logarithmic expression.	neper	Np	decibel	dB	
108	702-08-60	effective noise bandwidth	B_n		$B_n = \frac{1}{g_{max}} \int_0^{\infty} g(f) df$ Applies to a two-port network where $g(f)$ is the available power gain factor as a function of frequency f (see IEV 702-07-12).	hertz	Hz			
109	702-08-61	signal-to-noise ratio; SNR (abbreviation)	k_{SN}		Signal power divided by noise power. In practice, the symbol S/N is generally used.	one	1			
109.1		signal-to-noise logarithmic ratio	K_{SN}		$K_{SN} = \frac{1}{2} \ln k_{SN}$ Np = 10 lg k_{SN} dB In practice, the symbol S/N is generally used.	neper	Np	decibel	dB	

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
110	702-07-27 351-14-07	transfer function	$\underline{H}$	$\underline{T}$	$\underline{H} = \frac{\underline{S}_2(\omega)}{\underline{S}_1(\omega)}$ where $\underline{S}_1$ and $\underline{S}_2$ are the complex representations of the signals as functions of the angular frequency ω . When the signals are of the same kind, the transfer function is sometimes called gain factor.					The unit of the quantity $\underline{H}$ is equal to the quotient of the unit of $\underline{S}_2$ by the unit of $\underline{S}_1$.
111		transfer exponent	$\underline{\Gamma}$		$\underline{\Gamma} = A + jB$ If the transfer function $\underline{H}$ is of dimension one: $\underline{H} = \exp(-\underline{\Gamma})$	one	1			Special units are only used when the real and imaginary parts are treated separately.
112		logarithmic attenuation	A		$A = \text{Re}(\underline{\Gamma}) \text{ Np} = 20 (\lg e) \text{ Re}(\underline{\Gamma}) \text{ dB}$	neper	Np	decibel	dB	
113		phase change	B	φ	$B = \text{Im}(\underline{\Gamma}) \text{ rad}$	radian	rad	degree	°	$1^\circ = \frac{\pi}{180} \text{ rad}$
114		voltage attenuation factor; tension attenuation factor	a_U		$a_U = \frac{U_1}{U_2}$ Subscripts 1 and 2 may for example designate the input port and the output port, respectively, of a two-port network.	one	1			
114.1		logarithmic voltage attenuation; logarithmic tension attenuation	A_U		$A_U = \ln \frac{U_1}{U_2} \text{ Np} = 20 \lg \frac{U_1}{U_2} \text{ dB}$ Subscripts 1 and 2 may, for example, designate the input port and the output port, respectively, of a two-port network.	neper	Np	decibel	dB	
115		voltage gain factor, tension gain factor	g_U		$g_U = \frac{U_2}{U_1}$ Subscripts 1 and 2 may, for example, designate the input port and the output port, respectively, of a two-port network.	one	1			

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
115.1		logarithmic voltage gain; logarithmic tension gain	G_U		$G_U = \ln \frac{U_2}{U_1} \quad \text{Np} = 20 \lg \frac{U_2}{U_1} \quad \text{dB}$ When the logarithmic voltage gain is negative, its absolute value is the logarithmic voltage attenuation.	neper	Np	decibel	dB	
116	702-02-10	power loss 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 loss.	one	1			
116.1	702-02-10	logarithmic power loss	A_P		Use subscript S instead of P in the case of apparent powers. $A_P = \frac{1}{2} \ln \frac{P_1}{P_2} \quad \text{Np} = 10 \lg \frac{P_1}{P_2} \quad \text{dB}$ When the logarithmic power loss is negative, its absolute value is the logarithmic power gain.	neper	Np	decibel	dB	
117	702-02-11	power 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.	one	1			

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
117.1	702-02-11	logarithmic power gain	G_P		Use subscript S instead of P in the case of apparent powers. $G_P = \frac{1}{2} \ln \frac{P_2}{P_1}$ Np = $10 \lg \frac{P_2}{P_1}$ dB When the logarithmic power gain is negative, its absolute value is the logarithmic power loss.	neper	Np	decibel	dB	
118	702-02-13	propagation coefficient	$\underline{\gamma}$		$\underline{\gamma} = \alpha + j\beta$	metre to the power minus one	m^{-1}			Special units are only used when the real and imaginary parts are treated separately. See 119 and 120.
119	702-02-14	attenuation coefficient	α		$\alpha = \text{Re } \underline{\gamma}$	neper per metre	Np/m	decibel per metre	dB/m	
120	702-02-15	phase change coefficient	β		$\beta = \text{Im } \underline{\gamma}$	radian per metre	rad/m	degree per metre	°/m	
121	702-02-16	phase delay	t_φ	τ_φ		second	s			
122	702-02-20	group delay	t_g	τ_g		second	s			
123	702-02-17	phase velocity	c_φ, v_φ c, 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. $ c_\varphi = f\lambda = \frac{\omega}{k}$ where f is frequency, λ is wavelength, ω is angular frequency, and k is angular wavenumber.	metre per second	m/s			

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
124	702-02-17	group velocity	c_g, v_g		Group velocity is defined for waves only. If both waves and moving particles are involved, use c for the former and v for the latter. $ c_g = \left \frac{df}{d\frac{1}{\lambda}} \right = \left \frac{d\omega}{dk} \right $ where f is frequency, λ is wavelength, ω is angular frequency, and k is angular wavenumber.	metre per second	m/s			
125	702-02-18	wavelength	λ		$\lambda = \frac{ c_\varphi }{f}$	metre	m			
126	702-07-24 726-07-08	complex reflection factor; reflection factor	$\underline{r}$		$\underline{r} = \frac{\underline{S}_r}{\underline{S}_i}$ where $\underline{S}_i$ and $\underline{S}_r$ are the complex amplitudes of the incident and reflected wave, respectively. $\underline{r} = \frac{\underline{Z}_2 - \underline{Z}_1}{\underline{Z}_2 + \underline{Z}_1}$ where $\underline{Z}_1$ is the characteristic impedance of a transmission line ahead of a discontinuity or the impedance of the source; and $\underline{Z}_2$ is the impedance after the discontinuity or the load impedance seen from the junction between the source and the load. The sign is for the reflection factor for voltage.	one	1			
127		standing wave ratio	s		$s = \frac{S_{\max}}{S_{\min}} = \frac{1 + \underline{r} }{1 - \underline{r} }$	one	1			



Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
128	726-07-07	complex transmission factor; transmission factor	$\underline{\tau}$		$\underline{\tau} = \frac{\underline{S}_t}{\underline{S}_i}$ where $\underline{S}_i$ and $\underline{S}_t$ are the complex amplitudes of the incident and transmitted wave, respectively.	one	1			
129	101-14-37	complex angular frequency	$\underline{s}$	$\underline{p}$	$\underline{s} = \sigma + j\omega = -\delta + j\omega$	second to the power minus one	s ⁻¹			Special units are only used when the real and imaginary parts are treated separately.
130		growth coefficient	σ		example: $u(t) = \hat{u} e^{\sigma t} \sin \omega t$	neper per second	Np/s	decibel per second	dB/s	
131		damping coefficient	δ		$\delta = -\sigma$	neper per second	Np/s	decibel per second	dB/s	
132		reference frequency	f_{ref}	f_0		hertz	Hz			
133		resonance frequency	f_r, f_{rsn}			hertz	Hz			
134		cut-off frequency	f_c			hertz	Hz			
135	702-01-03 702-01-04	frequency bandwidth; bandwidth	$f_B, B, \Delta f$			hertz	Hz			
136	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; ω is the angular frequency of the modulation oscillation.	one	1			

Item number	Quantities					Units				
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
137.1	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 IEV 702-04-52).					The unit depends on the kind of quantity constituting the signal or noise (electric current, voltage, pressure, etc.).
137.2	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 IEV 702-04-52).	radian	rad	degree	°	$1^\circ = \frac{\pi}{180} \text{ rad}$
138	702-06-38	modulation index (in frequency modulation); frequency deviation ratio; deviation ratio	δ	η	$s(t) = \hat{s} \sin(\Omega t + \delta \sin \omega t)$ where Ω is the angular frequency of the carrier oscillation; ω is the angular frequency of the modulation oscillation.	radian	rad	degree	°	$1^\circ = \frac{\pi}{180} \text{ rad}$
139	702-04-56	instantaneous frequency	$f(t)$		$f(t) = \frac{1}{2\pi} \frac{d\vartheta(t)}{dt}$	hertz	Hz			
140	702-06-33	instantaneous frequency deviation; frequency deviation	$\Delta f(t)$		$\Delta f(t) = (\Delta f)_{\text{mm}} \cos \omega t$	hertz	Hz			
141	702-06-34	peak frequency deviation; peak deviation	$(\Delta f)_{\text{mm}}$	f_d	$(\Delta f)_{\text{mm}} = \omega \delta / 2\pi$	hertz	Hz			
142	702-06-31	instantaneous phase deviation; phase deviation	$\Delta \vartheta(t)$		$\Delta \vartheta(t) = (\Delta \vartheta)_{\text{mm}} \sin \omega t$	radian	rad	degree	°	$1^\circ = \frac{\pi}{180} \text{ rad}$
143	702-06-32	peak phase deviation; peak deviation	$(\Delta \vartheta)_{\text{mm}}$	ϑ_d	$s(t) = \hat{s} \sin(\Omega t + (\Delta \vartheta)_{\text{mm}} \sin \omega t)$	radian	rad	degree	°	$1^\circ = \frac{\pi}{180} \text{ rad}$

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	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Other units		Remarks
						Name	Symbol	Name	Symbol	
144	101-14-55 702-04-51	total harmonic factor; harmonic factor	d	k	$d = \frac{\sqrt{U^2 - U_1^2}}{U}$ where U is the r.m.s value of a periodic quantity and U_1 is the r.m.s 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 IEV 702-07-62.	one	1			

3.2 Linear networks

3.2.1 General

Quantities considered in this clause are generally complex; however, they are not underlined.

For indicating the matrix character of a quantity, bold face italic type for letter symbols is recommended, for example $\mathbf{Z}$. If such type is not available, parentheses may be placed around the letter symbol, for example (Z_{ij}) (see ISO 31-11, item 11.1).

3.2.2 Two-port linear networks under sinusoidal conditions

For determining signs of matrix elements, the convention indicated in Figure 1 below is used, as specified in IEC 60375.

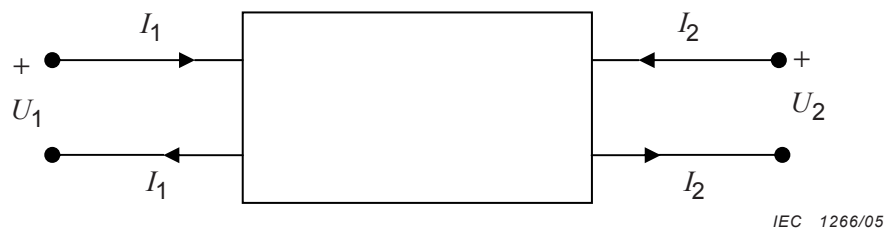


Figure 1 – Conventions concerning signs in electric circuits

For the representation of two-port matrices, capital letter symbols are preferred in the general case. If a two-port network contains internal two-ports (such as electronic devices), preference is given to lower-case symbols for the internal two-ports. See also IEC 60747-1:1983 (chapter V, 3.2).

Item number	Quantities					Units		
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Remarks
						Name	Symbol	
201		input impedance	Z_1		Term and symbol for general use. The symbol for the corresponding admittance has the same subscript. Z_1 is the input impedance at port 1. Z_2 is the input impedance at port 2. When 1 and 2 are not suitable subscripts for input and output, see IEC 60027-1:1992, Table 6.	ohm	Ω	
202		output impedance	Z_2		Term and symbol for general use. The symbol for the corresponding admittance has the same subscript. Z_1 is the input impedance at port 1. Z_2 is the input impedance at port 2. When 1 and 2 are not suitable subscripts for input and output, see IEC 60027-1:1992, Table 6.	ohm	Ω	
203		characteristic impedance	Z_0, Z_c	Z_{ch}	The symbol for the corresponding admittance has the same subscript.	ohm	Ω	
204		image impedance	Z_i	Z_{im}	The symbol for the corresponding admittance has the same subscript.	ohm	Ω	
205		iterative impedance	Z_k, Z_{it}		The symbol for the corresponding admittance has the same subscript.	ohm	Ω	
206		impedance matrix	$\mathbf{Z}$	$\mathbf{z}$	$\begin{bmatrix} U_1 \\ U_2 \end{bmatrix} = \mathbf{Z} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$ where $\mathbf{Z} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}$			
206.1		open-circuit input impedance	Z_{11}	z_{11}	$\left(\frac{U_1}{I_1} \right)_{I_2=0}$ Other symbols can be derived by using suitable subscripts for open-circuit conditions, as given in IEC 60027-1.	ohm	Ω	
206.2		open-circuit input reverse transfer impedance	Z_{12}	z_{12}	$\left(\frac{U_1}{I_2} \right)_{I_1=0}$	ohm	Ω	
206.3		open-circuit input forward transfer impedance; open-circuit input transfer impedance	Z_{21}	z_{21}	$\left(\frac{U_2}{I_1} \right)_{I_2=0}$	ohm	Ω	

Item number	Quantities					Units		
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Remarks
						Name	Symbol	
206.4		open-circuit output impedance	Z_{22}	z_{22}	$\left(\frac{U_2}{I_2}\right)_{I_1=0}$ Other symbols can be derived by using suitable subscripts for open-circuit conditions, as given in IEC 60027-1.	ohm	Ω	
207		admittance matrix	$\mathbf{Y}$	y	$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \mathbf{Y} \begin{bmatrix} U_1 \\ U_2 \end{bmatrix}$ where $\mathbf{Y} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}$			
207.1		short-circuit input admittance	Y_{11}	y_{11}	$\left(\frac{I_1}{U_1}\right)_{U_2=0}$ Other symbols can be derived by using suitable subscripts for short-circuit conditions, as given in IEC 60027-1.	siemens	S	
207.2		short-circuit reverse transfer admittance	Y_{12}	y_{12}	$\left(\frac{I_1}{U_2}\right)_{U_1=0}$	siemens	S	
207.3		short-circuit input forward transfer admittance; short-circuit input transfer admittance	Y_{21}	y_{21}	$\left(\frac{I_2}{U_1}\right)_{U_2=0}$	siemens	S	
207.4		short-circuit output admittance	Y_{22}	y_{22}	$\left(\frac{I_2}{U_2}\right)_{U_1=0}$ Other symbols can be derived by using suitable subscripts for short-circuit conditions, as given in IEC 60027-1.	siemens	S	

Item number	Quantities					Units		
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Remarks
						Name	Symbol	
208		H -matrix; hybrid matrix	H	h	$\begin{bmatrix} U_1 \\ I_2 \end{bmatrix} = H \begin{bmatrix} I_1 \\ U_2 \end{bmatrix}$ where $H = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}$			The elements of the matrix are quantities which are not all of the same dimension. When they are of different dimension, they have different units.
208.1		short-circuit input impedance	H_{11}	h_{11}	$\left(\frac{U_1}{I_1} \right)_{U_2=0}$ Other symbols can be derived by using suitable subscripts for short-circuit conditions, as given in IEC 60027-1.	ohm	Ω	
208.2		open-circuit reverse voltage transfer ratio; open-circuit reverse tension transfer ratio	H_{12}	h_{12}	$\left(\frac{U_1}{U_2} \right)_{I_1=0}$	one	1	
208.3		short-circuit forward current transfer ratio; short-circuit current transfer ratio	H_{21}	h_{21}	$\left(\frac{I_2}{I_1} \right)_{U_2=0}$	one	1	
208.4		open-circuit output admittance	H_{22}	h_{22}	$\left(\frac{I_2}{U_2} \right)_{I_1=0}$ Other symbols can be derived by using suitable subscripts for open-circuit conditions, as given in IEC 60027-1.	siemens	S	
209		K -matrix; inverse hybrid matrix	K	k	$\begin{bmatrix} I_1 \\ U_2 \end{bmatrix} = K \begin{bmatrix} U_1 \\ I_2 \end{bmatrix}$ where $K = \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \end{bmatrix}$			The elements of the matrix are quantities which are not all of the same dimension. When they are of different dimension, they have different units.

Item number	Quantities					Units		
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Remarks
						Name	Symbol	
209.1		open-circuit input admittance	K_{11}	k_{11}	$\left(\frac{I_1}{U_1}\right)_{I_2=0}$ Other symbols can be derived by using suitable subscripts for open-circuit conditions, as given in IEC 60027-1.	siemens	S	
209.2		short-circuit reverse current transfer ratio	K_{12}	k_{12}	$\left(\frac{I_1}{I_2}\right)_{U_1=0}$	one	1	
209.3		open-circuit forward voltage transfer ratio; open-circuit voltage transfer ratio; open-circuit forward tension transfer ratio; open-circuit tension transfer ratio	K_{21}	k_{21}	$\left(\frac{U_2}{U_1}\right)_{I_2=0}$	one	1	
209.4		short-circuit output impedance	K_{22}	k_{22}	$\left(\frac{U_2}{I_2}\right)_{U_1=0}$ Other symbols can be derived by using suitable subscripts for short-circuit conditions, as given in IEC 60027-1.	ohm	Ω	
210		chain matrix	A	a	$\begin{bmatrix} U_1 \\ I_1 \end{bmatrix} = A \begin{bmatrix} U_2 \\ -I_2 \end{bmatrix}$ where $A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}$			The elements of the matrix are quantities which are not all of the same dimension. When they are of different dimension, they have different units.

Item number	Quantities					Units		
	Entry number in IEV	Name of quantity	Chief symbol	Reserve symbol	Remarks	Unit, coherent with the SI		Remarks
						Name	Symbol	
211		reverse chain matrix	$\mathbf{B}$	$\mathbf{b}$	$\begin{bmatrix} U_2 \\ I_2 \end{bmatrix} = \mathbf{B} \begin{bmatrix} U_1 \\ -I_1 \end{bmatrix} \text{ where } \mathbf{B} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}$ The reverse chain matrix $\mathbf{B}$ is not the inverse of the forward chain matrix $\mathbf{A}$. When using the inverse $\mathbf{A}^{-1}$ of $\mathbf{A}$, the following matrix equation will hold: $\begin{pmatrix} U_2 \\ -I_2 \end{pmatrix} = \mathbf{A}^{-1} \begin{pmatrix} U_1 \\ I_1 \end{pmatrix}$. The inverse $\mathbf{A}^{-1}$ is sometimes called "forward transfer matrix" or "transfer matrix".			The elements of the matrix are quantities which are not all of the same dimension. When they are of different dimension, they have different units.
211.1		reciprocal of open-circuit reverse voltage transfer ratio; reciprocal of open-circuit reverse tension transfer ratio	B_{11}	b_{11}	$\left(\frac{U_2}{U_1} \right)_{I_1=0}$	one	1	
211.2		negative of reciprocal of short-circuit reverse transfer admittance	B_{12}	b_{12}	$\left(\frac{U_2}{-I_1} \right)_{U_1=0}$	ohm	Ω	
211.3		reciprocal of open-circuit reverse transfer impedance	B_{21}	b_{21}	$\left(\frac{I_2}{U_1} \right)_{I_1=0}$	siemens	S	
211.4		negative of reciprocal of short-circuit reverse current transfer ratio	B_{22}	b_{22}	$\left(\frac{I_2}{-I_1} \right)_{U_1=0}$	one	1	