

IEEE Power & Energy Society
Author's Kit

(Appendix A last revised July 2008)

Appendix A: **Symbols and Prefixes**

This appendix of the Author's Kit provides recommendations on prefixes, unit symbols and abbreviations, acronyms, and factors for conversion into units of the International System.

Prefixes

Recommended prefixes indicating decimal multiples or submultiples of units and their symbols are as follows:

Multiple	Prefix	Abbreviation
10^{24}	yotta	Y
10^{21}	zetta	Z
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
10^{-21}	zepto	z
10^{-24}	yocto	y

Avoid using compound prefixes, such as micromicro for pico and kilomega for giga. The abbreviation of a prefix is considered to be combined with the abbreviation/symbol to which it is directly attached, forming with it a new unit symbol, which can be raised to a positive or negative power and which can be combined with other unit abbreviations/symbols to form abbreviations/symbols for compound units. For example:

$$1 \text{ cm}^3 = (10^{-2} \text{ m})^3 = 10^{-6} \text{ m}^3$$
$$1 \text{ }\mu\text{s}^{-1} = (10^{-6} \text{ s})^{-1} = 10^6 \text{ s}^{-1}$$
$$1 \text{ mm}^2/\text{s} = (10^{-3} \text{ m})^2/\text{s} = 10^{-6} \text{ m}^2/\text{s}$$

Abbreviations and Symbols

Whenever possible, avoid using abbreviations and symbols in paragraph text; however, when it is deemed necessary to use such, define all but the most common at first use. The following is a recommended list of abbreviations/symbols for some important units, and it also includes other common abbreviations and acronyms that may be used in tables and figures, and, if deemed necessary, in paragraph text. The form of unit abbreviations/symbols is the same for both singular and plural usage, and they are not followed by a period. The distinction between uppercase and lowercase letters should be carefully observed. When a compound unit is formed by the multiplication of two or more units, its abbreviation/symbol consists of the symbols for the separate units joined by a raised dot, for example, N · m for newton-meter. When a compound unit is formed by division of one unit by another, its abbreviation/symbol consists of the symbols for the separate symbols either separated by solidus (slant) or multiplied using negative powers, for example, m/s or m · s⁻¹ for meters per second.

alternating current	ac	cubic meter per second	m ³ /s
American wire gauge	AWG	cubic yard	yd ³
ampere	A	curie	Ci
ampere-hour	Ah	current transformer	Ct
ampere-turn	At	decibel	dB
amplitude modulation	AM	decibel referred to one milliwatt	dBm
antilogarithm	antilog	degree (temperature) Celsius	°C
atomic mass unit (unified)	U	degree (temperature) Fahrenheit	°F
audio frequency	AF	diameter	dia
automatic frequency control	AFC	direct current	dc
automatic gain control	AGC	double sideband	DSB
automatic volume control	AVC	electrocardiograph	ECG
average	avg	electroencephalograph	EEG
backward-wave oscillator	BWO	electromagnetic compatibility	EMC
bar	bar	electromagnetic unit	EMU
barn	b	electromotive force	EMF
beat-frequency oscillator	BFO	electronic data processing	EDP
bel	B	electronvolt	eV
billion electronvolts	GeV	electrostatic unit	ESU
binary coded decimal	BCD	extra high voltage	EHV
British thermal unit	Btu	extremely high frequency	EHF
calorie	cal	extremely low frequency	ELF
calorie (International Table calorie)	cal _{IT}	farad	F
calorie (thermochemical calorie)	cal _{th}	field-effect transistor	FET
candela	cd	foot	ft
candela per square foot	cd/ft ²	footcandle	fc
candela per square meter	cd/m ²	footlambert	fL
cathode-ray oscilloscope	CRO	foot per minute	ft/min
cathode-ray tube	CRT	foot per second	ft/s
centimeter	cm	foot per second squared	ft/s ²
centimeter-gram-second	CGS	foot poundal	ft·pdl
circular mil	cmil	foot pound-force	ft·lbf
continuous wave	CW	frequency modulation	FM
coulomb	C	frequency-shift keying	FSK
coupling capacitor voltage transformer	ccvt	gal	Gal
cubic centimeter	cm ³	gigaelectronvolt	GeV
cubic foot	ft ³	gigahertz	GHz
cubic foot per minute	ft ³ /min	gram	g
cubic foot per second	ft ³ /s	henry	H
cubic inch	in ³	hertz	Hz
cubic meter	m ³	high frequency	HF

high voltage	HV	microsiemens	μS
horsepower	hp	microwatt	μW
hour	h	mil	mil
inch	in	mile per hour	mi/h
inch per second	in/s	mile (statute)	mi
inductance-capacitance	LC	milliampere	mA
infrared	IR	millibar	mbar
inside diameter	ID	millibarn	mb
intermediate frequency	IF	milligram	mg
joule	J	millihenry	mH
joule per kelvin	J/K	milliliter	mL
kelvin	K	millimeter	mm
kiloelectronvolt	keV	millimeter of mercury, conventional	mmHg
kilogram	kg	millisecond	ms
kilohertz	kHz	millisiemens	mS
kilohm	kΩ	millivolt	mV
kilojoule	kJ	milliwatt	mW
kilometer	km	minute (time)	min
kilometer per hour	km/h	nanoampere	nA
kilovar	kvar	nanofarad	nF
kilovolt	kV	nanometer	nm
kilovoltampere	kVA	nanosecond	ns
kilowatt	kW	nanowatt	nW
kilowatthour	kWh	nautical mile	nmi
knot	knot	neper	Np
liter	L	newton	N
liter per second	L/s	newton meter	Nm
logarithm	log	newton per square meter	N/m ²
logarithm, natural	ln	ohm	Ω
low frequency	LF	ounce (avoirdupois)	oz
lumen	lm	outside diameter	OD
lumen per square foot	lm/ft ²	pascal	Pa
lumen per square meter	lm/m ²	phase modulation	PM
lumen per watt	lm/W	picoampere	pA
lumen second	lm·s	picocoloumb	pC
lux	lx	picofarad	pF
magnetohydrodynamics	MHD	picosecond	ps
magnetomotive force	MMF	picowatt	pW
medium frequency	MF	pint	pt
megaelectronvolt	MeV	pound	lb
megahertz	MHz	poundal	pdl
megavolt	MV	pound-force	lbf
megavar	Mvar	pound-force foot	lbf·ft
megawatt	MW	pound-force per square inch	lbf/in ²
megohm	MΩ	pound (force) per square inch	lbf/in ²
metal-oxide semiconductor	MOS	power factor	PF
meter	m	private branch exchange	PBX
meter-kilogram-second	MKS	pulse-amplitude modulation	PAM
mho	mho	pulse-code modulation	PCM
microampere	μA	pulse-count modulation	PCM
microbar	μbar	pulse-duration modulation	PDM
microfarad	μF	pulse-position modulation	PPM
microgram	μg	pulse-repetition frequency	PRF
microhenry	μH	pulse-repetition rate	PRR
micrometer	μm	pulse-time modulation	PTM
micrombo	μmho	pulse-width modulation	PWM
micron	μm	quart	qt
microsecond	μs	rad	rd

radian	rad	ton, short	ton
radio frequency	RF	ton, metric	ton
radio-frequency interference	RFI	transverse electric	TE
rem	rem	transverse electromagnetic	TEM
resistance-capacitance	RC	transverse magnetic	TM
resistance-inductance-capacitance	RLC	traveling-wave tube	TWT
revolution per minute	r/min	ultrahigh frequency	UHF
revolution per second	r/s	ultraviolet	UV
roentgen	R	(unified) atomic mass unit	u
root-mean-square	rms	vacuum-tube voltmeter	VTVM
second (time)	s	var	var
short wave	SW	variable-frequency oscillator	VFO
siemens	S	very high frequency	VHF
signal-to-noise ratio	SNR	very low frequency	VLF
semiconductor controlled rectifier	SCR	vestigial sideband	VSB
silicon controlled rectifier	SCR	volt	V
single sideband	SSB	voltagecontrolled oscillator	VCO
square foot	ft ²	voltage standing-wave ratio	VSWR
square inch	in ²	voltage transformer	vt
square meter	m ²	voltampere	VA
square yard	yd ²	volume unit	vu
standing-wave ratio	SWR	watt	W
steradian	sr	watthour	Wh
superhigh frequency	SHF	watt per steradian	W/sr
television	TV	watt per steradian square meter	W/(sr m ²)
television interference	TVI	weber	Wb
tesla	T	yard	yd
thin-film transistor	TFT		

Conversion Factors

The following are some factors for conversion into units of the International System.

Length

- 1 inch = 2.54 centimeters (exactly)
- 1 foot = 0.3048 meter (exactly)
- 1 mile = 1609.3 meters
- 1 nautical mile = 1852 meters (exactly)
- 1 micron = 1 micrometer (exactly)
- 1 angstrom = 0.1 nanometer (exactly)

Area

- 1 square inch = 6.4516 square centimeters (exactly)
- 1 square foot = 0.092 903 square meter
- 1 circular mil = 5.0671×10^{-4} square millimeter
- 1 acre = 4046.9 square meters
- 1 barn = 10^{-28} square meter (exactly)
- 1 hectare = 10 000 square meters (exactly)

Volume

- 1 cubic inch = 16.387 cubic centimeters
- 1 cubic foot = 0.028 317 cubic meter
- 1 fluid ounce (UK) = 28.413 cubic centimeters
- 1 fluid ounce (US) = 29.574 cubic centimeters
- 1 gallon (UK) = 4546.1 cubic centimeters
- 1 gallon (US) = 3785.4 cubic centimeters

1 barrel (US) (for petroleum; etc) = 0.158 99 cubic meter
1 acre foot = 1233.5 cubic meters
1 liter = 1000 cubic centimeters (exactly)

Speed

1 foot per minute = 5.08 millimeters per second (exactly)
1 mile per hour = 0.44704 meter per second (exactly)
1 knot = 0.514 44 meter per second
1 kilometer per hour = 0.277 78 meter per second

Mass

1 ounce (avoirdupois) = 28.350 grams
1 pound = 0.453 59 kilogram
1 slug = 14.594 kilograms
1 short ton = 907.18 kilograms
1 long ton = 1016.0 kilograms
1 tonne = 1000 kilograms (exactly)

Density

1 pound per cubic foot = 16.018 kilograms per cubic meter
1 pound per cubic inch = 27 680 kilograms per cubic meter

Force

1 poundal = 0.138 25 newton
1 ounce-force = 0.278 01 newton
1 pound-force = 4.4482 newtons
1 kilogram-force = 9.806 65 newtons (exactly)
1 dyne = 10^{-5} newton (exactly)

Pressure

1 poundal per square foot = 1.4882 pascals (newtons per square meter)
1 pound-force per square foot = 47.880 pascals
1 pound-force per square inch = 6894.8 pascals
1 conventional foot of water = 2989.1 pascals
1 conventional millimeter of mercury = 133.32 pascals
1 torr = 133.32 pascals
1 standard atmosphere (760 torr) = 101 325 pascals (exactly)
1 technical atmosphere (1 kgf/cm^2) = 98 066.5 pascals (exactly)
1 bar = 100 000 pascals (exactly)

Energy, Work

1 foot poundal = 0.042 140 joule
1 foot pound-force = 1.3558 joules
1 British thermal unit (thermochemical) = 1054 joules
1 British thermal unit (International Table) = 1055 joules
1 calorie (thermochemical) = 4.184 joules (exactly)
1 calorie (International Table) = 4.1868 joules (exactly)
1 electronvolt = 1.602×10^{-19} joule
1 erg = 10^{-7} joule (exactly)

Power

1 foot pound-force per second = 1.3558 watts
1 horsepower (metric) = 735.50 watts
1 horsepower (British) = 745.70 watts
1 horsepower (electrical) = 746 watts (exactly)
1 British thermal unit (International Table) per hour = 0.2931 watt
1 erg per second = 10^{-7} watt (exactly)

Quantities of Light

1 footcandle = 10.764 lux (lumens per square meter)

1 footlambert = 3.4263 candelas per square meter

Quantities of Electricity and Magnetism

1 ESU of current $\approx 3.3356 \times 10^{-10}$ ampere

1 EMU of current = 10 amperes (exactly)

1 ESU of electric potential ≈ 299.79 volts

1 EMU of electric potential = 10^{-8} volt (exactly)

1 ESU of capacitance $\approx 1.1126 \times 10^{-12}$ farad

1 EMU of capacitance = 10^9 farads (exactly)

1 ESU of inductance $\approx 8.9876 \times 10^{11}$ henrys

1 EMU of inductance = 10^{-9} henry (exactly)

1 ESU of resistance $\approx 8.9876 \times 10^{11}$ ohms

1 EMU of resistance = 10^{-9} ohm (exactly)

1 gilbert ≈ 0.79577 ampere

1 oersted ≈ 79.577 amperes per meter

1 maxwell = 10^{-8} weber (exactly)

1 gauss = 10^{-4} tesla (exactly)

Note that ESU means electrostatic CGS unit; EMU means electromagnetic CGS unit. In this list, the sign \approx is to be read "corresponds to." Since the change from either CGS system to the International System of Units involves a change in quantities, conversion of units by multiplication by a pure number is not, strictly speaking, possible. However, a physical situation which can be described as a "current" of 1 abampere can also be described as a current of 10 amperes.