Charles Poynton
+1 416 535 7187
charles @ poynton.com
www.poynton.com

Writing SI units and symbols 1

This note explains how I write quantities and units in the *Système international d'unités* (SI), loosely called the *metric system*. I catalog the power-of-ten prefixes, and I list some important units.

Write a numeric value with units in either the journalistic style, using prefix and unit *names* (four kilohertz); or the scientific style, using prefix and unit *symbols* (4 kHz). Don't mix these styles: Do not mix a prefix name with a unit symbol (Wrong: kiloHz), or a prefix symbol with a unit name (Wrong: kHertz). Avoid "abbreviations" for units (Wrong: sec., amp); use either SI unit names or SI symbols instead.

If you are writing for an international audience, express values in the metric (SI) system used by the majority of the world's population. If appropriate, follow an SI value with the equivalent Imperial value in parentheses. Express the Imperial value with an accuracy comparable to the original: write 5 m (16 feet), not 5 m (16.4042 feet). Spell out inch, foot, pound and so on: Do not abbreviate to in, ft, and lb unless space is an overriding concern. Do not use " and ' symbols for inch and foot; these symbols are unfamiliar to a large fraction of the world's population, and they are easily lost in reproduction.

An inch is defined as exactly 25.4 mm.

Journalistic style

In free text, use journalistic style for units and measurements: Spell out numbers one through ten in words; express numbers larger than that in numerals. Follow a number by a space, then the prefix name and unit name spelled out entirely in lower case and without spaces: four megahertz, 2.2 microfarads, 3.5 megahertz, 75 ohms. (The C in Celsius is capitalized.)

Use *hundred*, *thousand, million,* and so on, only for pure numbers. For a number with a unit, spell out the SI prefix: *four kilowatts* (not *four thousand watts*). Avoid using words for extreme quantities larger than a million, because *billion*, *trillion,* and so on, have different numerical values in different countries. If you absolutely must use words, avoid ambiguity by following the example of the BBC World Service: Say *thousand million* or *million million*.

Use a hyphen between a numeral and its unit only when necessary to form a compound modifier, and only with a unit name, not a unit symbol: 3.5-inch diskette, 35-millimeter film (Wrong: 35-mm film). To avoid the confusion of two hyphens when a negative number is involved, as in –12-volt power, use a space instead of a second hyphen.

In many countries a comma indicates the decimal: In these countries the notation 10,000 indicates precisely ten, not ten thousand! Some of your readers will find it ambiguous if you use a comma as a separator between three-digit groups. In a numeric value having four or more consecutive digits, use a space to separate groups of three digits, both left and right of the decimal point.

Scientific style

In a table, an illustration or a technical text, use the scientific style for measurements and units. Write the number in figures, followed by a nonbreaking space. Then write the prefix symbol and the unit symbol with appropriate capitalization and no spaces: 3.58 MHz, 2.2 µF, 75 Ω. Use nonbreaking spaces to prevent clumsy line breaks such as the break between 2.2 and µF above.

SI prefix symbols are capitalized for multipliers 10^6 and larger, and lower case for multipliers 10^3 and smaller.

A unit symbol is written in lower case, except that its initial letter is capitalized if the unit is named after a person. These are symbols, not abbreviations or contractions: Do not use periods or other punctuation. To avoid confusion with math symbols ("variables"), do not italicize unit symbols.

Use appropriate capitalization. The symbol k for *kilo* – a multiplier of 1000 – combines with *hertz* as kHz; the symbol for *decibel* is written dB. A popular computer in 1987 had a nameplate stating its memory capacity as 1 mb. In fact it had a megabyte of memory, properly written as 1 MB, not a millibit!

When you write a negative sign, use a nonbreaking hyphen instead of a regular hyphen so as to prevent the sign from being left stranded: -*400 V power* results from using a conventional hyphen; however, -*400 V power* results from a nonbreaking hyphen. The former, at the very least, is confusing to your reader; at its worst, it could compromise personal safety.

Dates

Different countries have different conventions for writing dates. A reader in the U.S.A. takes 08/04/50 to be August 4th, but a U.K. reader takes it to be the 8th of April. Is 01/02/03 the first, second or third day of the month? Avoid ambiguity. Write dates in the international ISO/IEC 8601 form: 2006-08-17.

Unit combinations

Use a raised dot between units combined by multiplication, to avoid ambiguity. N·m for newton·meter avoids potential confusion with nanometer, nm.

per Use the *per* notation for everyday units formed by division, such as miles per hour, mph; revolutions per minute, rpm; dots per inch, dpi; and bits per second, bps.

slash In a scientific or engineering unit formed by division, set off a single-element denominator with a slash: write m/s for meters per second.

exponents For a compound unit having a complex denominator, use exponent notation: write $m{\cdot}s^{-2}$ for meters per second squared (NOT m/s/s). Write m*s^-2 when typographic characters or superscripts are not available.

ohm Use *ohm* when the Ω symbol is unavailable (for example, in ASCII plain text).

degrees The temperature unit kelvin, K, properly has no degree sign. The symbols for the non-SI units celsius (°C) and fahrenheit (°F) have degree signs in order to avoid ambiguity with SI units coulomb C and farad F. The term *centigrade* is obsolete; the proper term is *celsius*.

Computing units

b, B Use little b for bit, big B for Byte. Spell these out where necessary to avoid ambiguity.

k Little k – pronounced *KEY-loh* or *kill-oh*, spelled-out *kilo* – is the standard SI prefix for 10^3 (1000). It is not often used in computing; where capital-K is more common (see below).

K Use big K for the multiplier 2^{10} (1024) common in computing. Do not write or pronounce big K as *kilo*; to do so invites confusion with little k, 1000. Simply write it as uppercase K and pronounce it *kay*. (Unfortunately, K conflicts with K for kelvin, the unit of absolute temperature.)

baud The term *baud* does not apply to data rate, but to *symbol rate*. When you see the unit *baud* used in computing, the unit b/s (bit per second) is nearly always meant.

mega, giga When applied to a base unit other than bit, byte or pixel, M (mega) and G (giga) refer to the SI power-of-ten multipliers 10^6 and 10^9. Standard data communication rates are based on powers of ten and use the SI multipliers, not power-of-two multipliers: 1.544 Mb/s denotes 1 544 000 bits per second; 19 200 bits per second is properly written 19.2 kb/s (not 19.2 Kb/s).

disk storage When applied to bytes of disk storage capacity:

- M (mega) denotes $10^3 \cdot 2^{10}$ (1000 K); and
- G (giga) denotes $10^6 \cdot 2^{10}$ (1 000 000 K).

bits, bytes, or pixels When applied to raw bits, bytes or pixels:

- M (mega) denotes 2^{20} (1024 K); and
- G (giga) denotes 2^{30}.

In computing, M (mega) and G (giga) are ambiguous. M could denote 1 000 000, 1 024 000, or 1 048 576. G could denote 1 000 000 000, 1 024 000 000, or 1 073 741 824. The value of the giga prefix in computing varies more than 7 percent depending on its context. If an exact value is important, write out the whole number!

SI prefix names, symbols and multipliers

The table below contains a complete list of SI prefix multiplier names, symbols, and power-of-ten values, standardized by the Bureau International des Poids et Measures (BIPM, www.bipm.fr). The symbol μ alone, and the term *micron*, have been abolished: Use μm for *micrometer*. Use lower-case *u* for 10^{-6} if the micro symbol μ is unavailable.

	prefix name	*prefix symbol*	*power-of-ten*	
	yocto	y	10^{-24}	(not *yokto*)
	zepto	z	10^{-21}	
	atto	a	10^{-18}	
	femto	f	10^{-15}	
	pico	p	10^{-12}	
	nano	n	10^{-9}	
	micro	μ	10^{-6}	
	milli	m	10^{-3}	
lower case prefix symbols	centi	c	10^{-2}	The prefix centi (0.01) should be avoided, except for centimeter. The prefix deci (0.1) should be avoided, with the exception of *decibel*, dB. (A liter is a cubic decimeter.) The prefixes deka (10) and hecto (100) should be avoided completely.
	deci	d	10^{-1}	
	[unity]	[none]	10^{0}	
	deka	da	10^{+1}	
	hecto	h	10^{+2}	
	kilo	k	10^{+3}	

	prefix name	prefix symbol	power-of-ten	
upper case prefix symbols	mega	M	10^{+6}	
	giga	G	10^{+9}	
	tera	T	10^{+12}	
	peta	P	10^{+15}	
	exa	E	10^{+18}	
	zetta	Z	10^{+21}	
	yotta	Y	10^{+24}	
binary units, standardized but not yet in common use	kibi	Ki	2^{+10}	1,024
	mebi	Mi	2^{+20}	1,048,576
	gibi	Gi	2^{+30}	1,073,741,824
	tebi	Ti	2^{+40}	1,099,511,627,776
	pebi	Pi	2^{+50}	1,125,899,906,842,624
	exbi	Ei	2^{+60}	1,152,921,504,606,846,976

Basic SI unit names and symbols

The table below includes some important SI units and their derivations, and the names of a few individuals whose names have been given to units. The seven base SI units have blank in the *derived from* column; other units are derived as indicated. A more complete list is found in the *SI brochure* of the BIPM.

	unit name	unit symbol	derived from	quantity	named after
all lower case unit symbols	meter	m		length	
	kilogram	kg		mass	
	second	s		time	
	candela	cd		luminous intensity	
	mole	mol		amount of substance	
	liter	ℓ, L	$10^{-3}\cdot m^3$	volume	
	ohm	Ω	$W\cdot A^{-2}$	resistance	Georg Simon Ohm
leading capital letter in unit symbol	ampere	A		electric current	André-Marie Ampère
	kelvin	K		thermodynamic temperature	William Thomson (Lord Kelvin)
	hertz	Hz	s^{-1}	frequency	Heinrich Hertz
	newton	N	$kg\cdot m\cdot s^{-2}$	force	Sir Isaac Newton
	joule	J	$N\cdot m$	energy	James Joule
	watt	W	$J\cdot s^{-1}$	power	James Watt
	volt	V	$W\cdot A^{-1}$	voltage	Alessandro Volta

Further information

<http://www.bipm.fr/enus/3_SI/> Information about SI is available at BIPM.

<http://physics.nist.gov/cuu/Units/> Information about SI is also available at NIST, See *Guide for the Use of the International System of Units (SI)* [NIST Special Publication 811], *Typefaces for symbols in scientific manuscripts*, and *SI Unit rules and style conventions – Check List for Reviewing Manuscripts.*

<http://www.bipm.fr/enus/3_SI/> Concerning date and time notation, see the note *A summary of the international standard date and time notation* by Markus Kuhn.