Electronics and the metric system

Australia is now well on the way to using metric units for all forms of measurements. It is important, therefore, that we not only now use metric units exclusively, but that we also express these units in accordance with accepted standards. This article is intended to guide those in the electronics industry on the correct use of metric units.

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The International System of Units (SI) is the most modern system of units of measurement available in the world today. Almost every country either uses this system or is committed to its use. Australia, by virtue of the Metric Conversion Act of 1970, is converting to SI and it is expected that this will be its sole system of measurement (with a few exceptions) by 1980. Already much of industry is converted.

Unfortunately there are some who do not know, or do not apply, the rules. Microfarad, to quote one example, can be seen presented as mf, mfd, μf, μF, μ and u. Only one is correct (μF) and only one should be used to provide ease of reading and recognition and to prevent error.

To help all those involved in specifying or describing electronic circuitry and components the following notes are provided to show how units should be stated. In addition, a selection of commonly used units and typical applications has been compiled.

Correct presentation of metric units

The following points should be noted when using metric units.

- Instead of using a comma to denote a thousand in numbers leave a space between each group of three digits:
  3 000 000 NOT 3,000,000
  Numbers with four digits may be written with or without a space: 4200 or 4 200. Except in tables, the former is preferred.
- A thin space should be left between number and unit symbol:
  20 A NOT 20A
  An exception is when expressing temperature:
  25°C NOT 25 °C
- All unit names and prefixes are written in small letters and without initial capitals. The degree Celsius is the only exception:
  metre, watt, volt
  NOT Metre, Watt, Volt.
- All symbols use small letters:
  m (metre), g (gram), s (second)
  except those derived from proper names:
  H (henry), Hz (hertz), V (volt), °C (degree Celsius)
  and the symbols for the prefixes:
  M (mega), G (giga), T (tera),
  and L for litre
  thus metre (m), volt (V), megawatt (MW), millilitre (mL)
  NOT
  metre (M), volt (v), megawatt (mW), millilitre (ML)
- Some symbols derived from proper names incorporate two letters to distinguish them from other symbols:
  thus Hz (hertz), H (henry)
  Wb (weber), W (watt)
  The second letter so used is lower case:
  Hz, Wb NOT HZ, WB
  but F (farad), A (ampere)
  NOT Fd, Amp
- The prefix symbol is attached directly to the units symbol and a space or dot is not used between them:
  mm NOT m.m.; kg NOT k g
- The prefix symbol should always be accompanied by the symbol on which it operates:
  μF NOT μ; kΩ NOT k NOR K
- A prefix symbol should not be attached to a unit name:
  μWb NOT μweber
- Full stops are not used following unit symbols except at the end of a sentence —
  e.g. kg, mm etc NOT kg., mm., etc.
- The product of two units in compound symbols is indicated by a dot or space:
  A.h, kW.h NOT Ah, kWh.
- The correct pronunciation of kilometre is 'kill-o-metre' not 'k'lom-etre'.

The Metric Conversion Board would be pleased to check any draft material before publication or use to ensure that metric usage is correct.

Alternative symbols

In some typesetting systems, some symbols may be unavailable. In such cases, the following alternative symbols should be used:

micro	u
square millimetre	sq mm
cubic centimetre	cu cm
cubic metre	cu m
revolution per minute	rpm
degree Celsius	C
ohm	ohm
kilohm	kilohm
megohm	megohm

Prefixes

A prefix is attached to a unit to indicate a multiple or sub-multiple of the unit:
milliwatt is one thousandth of a watt
kilowatt is one thousand watts

Prefixes likely to be encountered include:

Prefix	Symbol	Meaning
giga	G	10^9
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

'giga' is pronounced with a hard 'g' as in 'give'.

Rounding

If conversion of imperial quantities is necessary, try not to make the metric numbers any more precise than the original numbers. If the existing number is a rounded 10 inch, then a rounded 250 millimetres is usually accurate enough, rather than 254 mm. Decimal places should be avoided unless they are significant.

Metric Quantities and Units for Electronic Applications

QUANTITY	EXAMPLES OF APPLICATIONS	METRIC UNIT	SYMBOL	CONVERSION FACTOR AND REMARKS
Length	Cable Wavelength Antennae	metre	m	1 ft = 0.3048 m
	Instrument cases Speaker boxes Speakers Printed circuit boards Panel meters Amplifiers Turntables Sheet thickness	millimetre	mm	1 in = 25.4 mm For overall dimensions state height x width x depth e.g. 40 mm x 125 mm x 200 mm For surface dimensions state length x width e.g. 100 mm x 50 mm Do not use gauge
	Groove depth Surface finish texture	micrometre	μm	1 μin = 0.0254 um
	Distance	kilometre	km	1 mile = 1.609 km
Area	Panel space	square millimetre	mm^2	1 in^2 = 645.2 mm^2
Volume	Freight volumes	cubic metre cubic centimetre	m^3 cm^3	1 ft^3 = 0.028 32 m^3 1 in^3 = 16.39 cm^3
	Capacity Liquid volume	litre millilitre	L mL	1 ft^3 = 28.32 L 1 gal = 4.546 L 1 pt = 568.3 mL 1 fl oz = 28.41 mL
Volume Flow	General use Gas and liquid	cubic metre per second litre per second millilitre per second	m^3/s L/s mL/s	1 ft^3/s = 0.028 32 m^3/s 1 gal/s = 4.546 L/s 1 in^3/s = 16.39 mL/s
Time	Elapsed time	second millisecond	s ms	
	Pulse width	microsecond nanosecond	μs ns	
Rotational Speed	Turntables Records Electric motors	revolution per second	r/s	
		revolution per minute	r/min	r/s is preferred wherever possible
Frequency	Operating frequency Response Range	hertz kilohertz megahertz gigahertz	Hz kHz MHz GHz	the plural of hertz is hertz
Velocity	Motor speed Tape speed	metre per second millimetre per second	m/s mm/s	1 ft/s = 0.3048 m/s 1 in/s = 25.4 mm/s
Mass	Freight mass	kilogram	kg	1 lb = 0.4536 kg
	Small instruments Cartridges	gram	g	1 oz = 28.35 g
Force	Spring force	newton	N	1 lbf = 4.448 N
Pressure Stress	General use	pascal kilopascal megapascal gigapascal	Pa kPa MPa GPa	1 lbf/ft^2 = 47.88 Pa 1 lbf/in^2 = 6.895 kPa 1 $tonf/ft^2$ = 0.1073 MPa 1 $tonf/in^2$ = 0.015 44 GPa
Temperature	Temperature value	degree Celsius	°C	°C = 5/9 (°F -32)
	Temperature interval	kelvin	K	°C should not be used in compound units e.g. W/m.K NOT W/m°C; 1 K = 1°C
Thermal Rating	General use	kelvin per watt	K/W	
Energy	General use	joule kilojoule megajoule	J kJ MJ	1 ft.lbf = 1.356 J 1 Btu = 1.055 kJ 1 kW.h = 3.6 MJ

Metric Quantities and Units for Electronic Applications

QUANTITY	EXAMPLES OF APPLICATIONS	METRIC UNIT	SYMBOL	CONVERSION FACTOR AND REMARKS
Power	General use	watt milliwatt	W mW	
	Motor ratings	kilowatt	kW	1 hp = 0.7457 kW
	Residual noise	microwatt	μW	
Current	General use	ampere milliampere	A mA	
	Sensitivity	microampere	μA	
Potential Difference	Voltage	volt millivolt kilovolt	V mV kV	
Resistance Impedance	General use Impedance	ohm kilohm megohm gigohm	Ω kΩ MΩ GΩ	NOT kiloohm NOT megaohm NOT gigaohm
Capacitance	General use	farad microfarad nanofarad picofarad	F μF nF pF	
Electric Charge	General use	coulomb	C	
	Storage batteries	kilocoulomb ampere hour	kC A.h	1 A.h = 3.6 kC
Inductance	Self-inductance Mutual inductance	henry millihenry microhenry nanohenry	H mH μH nH	The plural of henry is henrys
Conductance	Admittance Susceptance	siemens	S	The plural of siemens is siemens The siemens replaces the mho
Magnetic Flux	Magnetic circuits	weber milliweber	Wb mWb	1 Mx (maxwell) = 10 mWb
Magnetic Field Strength	Magnetic circuits	ampere per metre	A/m	
Magnetic Flux Density	Magnetic induction	tesla millitesla	T mT	1 G (gauss) = 0.1 mT 1 Wb/m² = 1 T
Electric Field Strength	Testing of electrical parameters such as dielectric strength	volt per metre	V/m	
Luminous Intensity	Bulbs and tubes	candela	cd	Not changed
Luminous Flux	General use	lumen	lm	Not changed
Quantity of Light	General use	lumen second	lm.s	Not changed
Luminance	Measured brightness	candela per square metre	cd/m²	1 foot-lambert = 3.426 cd/m² 1 stilb (sb) = 10^4 cd/m² 1 cd/ft² = 10.76 cd/m² 1 lambert = 3183 cd/m²
Illuminance	Ambient lighting Illumination	lux	lx	1 lm/ft² = 10.76 lx 1 lm/ft² = 1 foot-candela
Luminous Efficacy	General use	lumen per watt	lm/W	Not changed