Electrical Data

Units and Dimensions

The International System of Units (SI) has eitht base units of which the following five are of relevance to electrical engineering

Quantity	Symbol	Unit	Abbreviation
Length	l	metre	m
Mass	m	kilogram	kg
Time	t	second	s
Electric Current	I	ampere (amp)	A
Temperature	T	kelvin	K

metre: 1650763.73 times the wavelength of the orange line in the spectrum of Krypton 86.

kilogram: Mass of a platinum-iridium cylinder kept at the International Bureau of weights and measures, Sevres, near Paris, France.

second: 9192631770 times the period of vibration of Caesium-133 atom.

ampere: The ampere is defined as the current which, when flowing along two infinitely long, parallel, thin conductors a distance of 1 metre apart in free space, will produce a force of 2×10^{-7} Newtons per metre length between them.
kelvin: is 1/273.16 of the thermodynamic temperature of the triple point of water.

SI Derived Units and Dimensions

Quantity	SI Unit	Unit symbol	Typical Symbol	Dimensions
Length	metre	m	x	L
Mass	kilogram	kg	m	M
Time	second	s	t	T
Current	ampere	A	I	I
Frequency	hertz	Hz	$f = t^{-1}$	T^{-1}
Velocity	metre/second	ms^{-1}	$u = x/t$	LT^{-1}
Acceleration	metre/second^2	ms^{-2}	$a = u/t$	LT^{-2}
Force	newton	N	$F = ma$	MLT^{-2}
Plane angle	radian	rad	θ	Dimensionless
Ang. Velocity	radian/second	rad s^{-1}	ω	T^{-1}
Torque	newton metre	Nm	G (orT) = Fx	ML^2T^{-2}
Energy	joule	J	$W = xF$	ML^2T^{-2}
Power	watt	W	$P = W/t$	ML^2T^{-3}
Pressure	pascal	Pa	$p = F/x^2$	$ML^{-1}T^{-2}$
Charge	coulomb	C	$Q = It$	T I
Electric field	volt/metre	Vm^{-1}	$E = F/Q$	$MLT^{-3}I^{-1}$
Electrostatic potential	volt	V	$V = P/I$	$ML^2T^{-3}I^{-1}$
Resistance	ohm	Ω	$R = P/I^2$	$ML^2T^{-3}I^{-2}$
Conductance	siemen	S	$G = R^{-1}$	$M^{-1}L^{-2}T^3I^2$
Capacitance	farad	F	$C = Q/V$	$M^{-1}L^{-2}T^4I^2$
Magnetic flux density	tesla	T	$B = F/Ix$	$MT^{-2}I^{-1}$
Magnetic flux	weber	Wb	$\phi = Bx^2$	$ML^2T^{-2}I^{-1}$
Inductance	henry	H	$L = \phi/I$	$ML^2T^{-2}I^{-2}$
Apparent power	volt ampere	VA	$P_a = VI$	ML^2T^{-3}

Reactive power	volt ampere	VAr	$P_r = VI$	$M L^2 T^{-3}$
Permeability	henry/metre	Hm^{-1}	μ	$M L T^{-2} I^{-2}$
Permittivity	farad/metre	Fm^{-1}	ε	$M^{-1} L^{-3} T^4 I^2$
Magnetic field	ampere turns/metre	Am^{-1}	$H = I/x$	$L^{-1} I$
Electric flux density	coulomb/metre^2	Cm^{-1}	$D = Q/x^2$	$L^{-2} T I$
Absolute temperature	kelvin	K	T	θ

Decimal multipliers

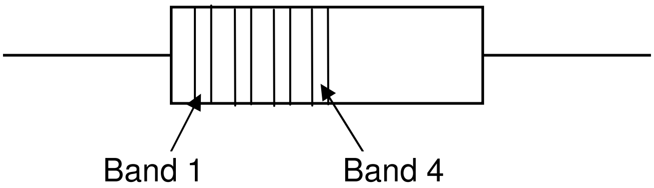
Exa	E	10^{18}
Peta	P	10^{15}
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	k	10^{3}
Hecto	h	10^{2}
Deka	da	10
Deci	d	10^{-1}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}
Femto	f	10^{-15}
Atto	a	10^{-18}

Physical constants and Relations

Electronic charge	e	-1.602×10^{-19} C
Electronic rest mass	m_e	9.109×10^{-31} kg
Electronic charge/mass ratio	e/ m_e	1.759×10^{11} C kg^{-1}
Proton rest mass	m_p	1.673×10^{-27} kg $\approx 1836\ m_e$
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	8.854×10^{-12} F m^{-1}
Velocity of EM radiation in free space	c	2.998×10^{8} m s^{-1}
Planck's constant	h	6.626×10^{-34} J s
Boltzmann's constant	k	1.3805×10^{-23} J K^{-1}
Stefan's constant	σ	5.670×10^{-8} W m^{-2} K^{-4}
Acceleration due to gravity	g	9.806 m s^{-2}

Resistor and Capacitor Colour Code

For resistors the bands should be placed towards one end of the casing. If this is the case hold the resistor in such a way as the bands are on the left hand side as you read it.
Many resistors have bands across the middle, in which case the give-away is that the fourth band is silver or gold (colours which are only used for tolerance – see below) and hence you can read it accordingly. Often the final band (for tolerance) is spaced slightly apart from the other bands.



Band 1 is the 1st digit
Band 2 is the 2nd digit
Band 3 is the number of zeros after the second digit to give the value in ohms.
Band 4 is the tolerance (or uncertainty), normally to 3 standard deviations.

Increasingly resistors having 5 bands are becoming more widespread in use. If there are 5 bands then Band 3 is the 3rd digit, Band 4 the number of zeros after the 3rd digit and Band 5 the tolerance. In this case the tolerance band will normally be either brown or red (see table below). If you are unsure which way to read the resistor the tolerance band may again be slightly separated from the other four.

Colour	Bands 1,2,3 (and 4 for 5 band)	Tolerance band
Black	0	
Brown	1	1%
Red	2	2%
Orange	3	
Yellow	4	
Green	5	
Blue	6	
Violet	7	
Grey	8	
White	9	
Gold		5%
Silver		10%

For example a resistor having the following coloured bands

red, red, orange, gold = $2 \times 2 \times 10^3\ \Omega$ (5%) = 22000 Ω (5%)

yellow, violet, brown, silver = $4 \times 7 \times 10^1\ \Omega$ (10%) = 470 Ω (10%)

Preferred values: You can not buy resistors with any value you require, only with certain values. To cover the large range of resistor values frequently used (1 Ω to $10^6\ \Omega$), a 'preferred' range of values that step up logarithmically are produced. Thus for each power of ten multiplier, the following values are commonly available: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82. For instance with the 56 preferred number the following resistor values are readily obtained: 5.6Ω, 56Ω, 560Ω, 5.6kΩ, 56kΩ etc.
In choosing a resistor, it is also very important to note its maximum power rating (typically 1/3W, 1/2W, 1W, etc. are used), which is not marked on the case but is implied in its size.

Capacitors

Capacitors come in various types shapes and sizes for different applications. For example, some are 'electrolytic' and must be connected with the correct polarity in the circuit – they are marked with a '+' sign at one end.

Another point to be aware of is the voltage rating, for example electrolytics usually have a fairly low maximum allowable voltage – typically 25V.

A similar colour coding to that for resistors exists for capacitors. The metal contacts (leads) are at the bottom of the casing and the bands are read from top to bottom. It is becoming rarer to see such banding as values are now normally stamped on the case, for example 47μF (or 47μ) is 47 micro-Farrads or 47×10^{-6}F.

For those using coloured bands:

Band 1 (top band) is the 1st digit

Band 2 is the 2nd digit

Band 3 is the number of zeros after the second digit to give the value in picofarads (pF=10^{-12}F).

Band 4 is the tolerance.

Band 5 is the maximum working voltage (Red = 250V dc, Yellow = 400V dc)