**Notation, Symbols and Abbreviations**

Version 1.07. 16th June 2012. c D. W. Knight, 2012.

The most recent version of this document can be obtained from the author's website: http://www.g3ynh.info/

**Multiplier prefixes**

" ≡ " means "by definition the same as"   
d ≡ deci ≡ 10-1 ≡ 1/10

c ≡ centi ≡ 10-2 ≡ 1/100

K ≡ Kilo ≡ 103 ≡ 1000   
m ≡ milli ≡ 10-3 ≡ 1/1000

M ≡ Mega ≡ 106 ≡ 1000 000   
μ ≡ micro ≡ 10-6 ≡ 1/1000 000

G ≡ Giga ≡ 109 ≡ 1000 000 000   
n ≡ nano ≡ 10-9 ≡ 1/1000 000 000

T ≡ Tera ≡ 1012 ≡ 1000 000 000 000   
p ≡ pico ≡ 10-12 ≡ 1/1000 000 000 000

P ≡ Peta ≡ 1015 ≡ 1 000 000 000 000 000   
f ≡ femto ≡ 10-15 ≡ 1/1000 000 000 000 000

**The Greek Alphabet**

Alpha Α α Eta Η η Nu Ν ν Tau Τ τ

Beta Β β Theta Θ θ Xi Ξ ξ Upsilon Υ υ

Gamma Γ γ Iota Ι ι Omicron Ο ο Phi Φ φ

Delta Δ δ Kappa Κ κ Pi Π π Chi Χ χ

Epsilon Ε ε Lambda Λ λ Rho Ρ ρ Psi Ψ ψ

Zeta Ζ ζ Mu Μ μ Sigma Σ σ Omega Ω ω

**Fundamental Constants and Relationships**

Figure in brackets () after a number is uncertainty in the last digit. " ≡ " means "by definition"

**Quantity Symbol Definition Accepted value**

Speed of light1 c = 1/√(μ0ε0) ≡ 299 792 458 }0 metres / second

Permittivity of free space ε0 = 8.854187818 × 10-12 Farads / metre

Permeability of free space μ0 ≡ 4π × 10-7 Henrys / metre

Impedance of free space Z0 = √(μ0/ε0) = 376.7303134 Ω

Electron charge q**e** = -1.6021892 × 10-19 Coulombs

Planck's constant *h* = 6.62606896(33) × 10-34 Joule seconds

Dirac's constant *ħ* = *h*/2π

von Klitzing resistance RvK = *h*/q**e**2 = 25812.8056 Ω

Fine-structure constant *α* = Z0 /2RvK = 7.2973525376(50) × 10-3

Boltzmann's constant *k* 1.380662 × 10-23 Joules/Kelvin

1. c is now defined as 299 792 458 m/s exactly.

2

**Unit Symbols**

A Ampere, Amp maxwell ≡ 10-8 Weber

C Coulomb Oe Orsted ≡ 1000 / 4π A turns / m

dB deciBel ≡ Bel/10 S Siemens ≡ 1/Ω

F Farad s second

gauss ≡ 10-4 Tesla T Tesla ≡ 104 gauss

H Henry ≡ Wb turns/A V Volt

Hz Hertz ≡ cycles per second W Watt ≡ J/s

J Joule ≡ W s Wb Weber ≡ 108 maxwell

Kg Kilogram Ω Ohm

m metre

**Mathematical relations and operators**

= conditionally equal to |**x**| modulus (magnitude) of **x**

≡ equivalent to, equal by definition ' prime (denotes modified definition)

→ tends towards " double prime (modified again)

≈ approximately equal to \* complex conjugate

≠ not equal to ! factorial1

≥ greater than or equal to / divided by, per, over, in units of 2

> greater than × vector (cross) product, multiplied by

>> much greater than • scalar (dot) product

≤ less than or equal to √ square root

< less than 3√ cube root

<< much less than n√ n**th** root, n=4, 5, 6 etc.

// in parallel with, i.e., **a**//**b** = **ab**/(**a**+**b**) [ ] encloses units in dimensional analysis

} plus or minus ∞ infinity of positive real numbers

1. Factorial numbers are defined as follows:

Factorial 0! 1! 2! 3! 4! n! (n+1)!

Value 1 1 2×1 3×2×1 4×3×2×1 n(n-1)(n-2)× . . . . . . ×1 (n+1)×n!

2. Dimensions in tables:

In the work of this and other authors you will find tables with headings such as: "Resistance / KΩ"

and "Diameter / mm". This significance of this notation is that the numbers in the table, if they have

no units written next to them, are just numbers, i.e., they are dimensionless. Thus the heading tells

you that the quantity shown has been divided by some unit quantity in order to make it

dimensionless, e.g., a resistance of 10KΩ, divided by KΩ is just the number 10. The slash, often omitted in both writing and pronunciation should, in this context, be read as "***in units of*** ".

3

**Operators** (contd)

**1x 1y 1z** Unit vector

∇ Nabla, Del Vector differential operator. ∇≡ **1x**∂/∂x + **1y**∂/∂y + **1z**∂/∂z

Δ Delta Δx ≡ "the change in x"

δ delta δx ≡ "a small or infinitesimal increment in x"

d Differential operator.

∂ de, dey partial differential operator. Jacobi's delta. Cursive Cyrillic "dey"

exp exponentiation operator, exp(x) ≡ e**x**

*f* (*italic*) function operator; e.g., y = *f*(x)

**j** (in **bold**) ≡ √(-1) , 90° rotation operator.

ln Loge , Naperian logarithm

Π Pi product operator

Σ Sigma summation operator.

∫ long s Integral operator

**Parameter symbols**

Notes:

1) **Bold typeface** denotes a vector or complex number.

2) For some symbols, the *italic form* denotes division by length; e.g., L is inductance, *L* is

inductance per unit length.

**Greek**

α alpha Temperature coefficient

Γ Gamma reflection coefficient.

δ delta The loss-angle of a reactive impedance. δ=90-φ.

δ**i** Skin depth

**ε** ε epsilon Permittivity. Complex (i.e., includes losses) when bold. **ε** = ε0 **εr**

ε0 epsilon nought Permittivity of free space

**εr** ε**r** Relative permittivity. Dielectric constant.

**η** η eta Efficiency, dimensionless transfer function (complex when bold)

Θ Theta Internal inductance factor, L**i** = (μ**(i)**/8π) Θ

Λ Lambda Flux linkage

λ lambda Electrical wavelength (i.e., when v is not defined as equal to c). λ ≡ v/f

λ0 lambda nought Free-space wavelength. λ0 ≡ c/f

*μ mu* (*italic*) parent mean.

**μ** μ mu permeability. Complex (i.e., includes losses) when bold. **μ** = μ0 **μr**

μ0 mu nought permeability of free space

μi Initial relative permeability of a magnetic material.

μ**(i)** Internal permeability (of a conductor)

**μr** μ**r** Relative permeability.

4

*ν nu (italic)* the number of degrees of freedom of a data set

Ξ Xi AC resistance factor defined such that R**ac** = R**dc** Ξ

π pi Ratio of circumference to diameter of a circle = 3.14159265.......

ρ rho volume resistivity

*ρ rho* (*italic*) density, charge density.

σ sigma conductivity. σ ≡ 1/ρ

*σ sigma (italic)* standard deviation, estimated standard deviation.

*σ*2 *sigma* squared statistical variance

Φ Phi Magnetic flux

φ phi Phase angle

**χ** χ chi Magnetic susceptibility

χ2 chi-squared The normalised square error sum

χ2/ν reduced χ2 χ2 divided by the number of degrees of freedom in the data

Ψ Psi Proximity factor

ψ psi Pitch angle (of a helix)

ω omega Angular frequency = 2πf [ radians / second ]

**Roman**

A Area

***A*** Vector potential (electromagnetic wave momentum).

AL Inductance factor [Henrys per turn-squared]

B Susceptance. The imaginary part of an admittance.

***B*** (***italic bold***) Magnetic induction (flux density) vector.

*B* (*italic*) Magnetic induction (flux density). *B* = μ *H*

BC The susceptance of a capacitance. BC = 2πfC

BL The susceptance of an inductance. BL = -1/(2πfL)

**C** C Capacitance. Complex (i.e., includes losses) when bold

*C* (*italic*) capacitance per unit length

c Velocity of light = 299 792 458 m/s

*c* (*italic*) constant of integration

D Greater diameter. Diameter of a cylinder or solenoid. Denominator.

d Smaller diameter. Diameter of a wire, etc.

***D*** (***italic bold***) Electric flux density (vector)

*D* (*italic*) Electric flux density. *D* = ε *E*

E Energy

***E*** (***italic bold***) Electric field (vector)

*E* (*italic*) Electric field strength [Volts / metre]

e Euler's or Napier's number = 2.7182818.......

**F** F Magnetomotive force [Ampere turns]

f frequency

G Conductance. The real part of an admittance.

g Geometric Mean Distance

5

***H*** (***italic bold***) Magnetic field (vector)

*H* (*italic*) Magnetic field strength [Ampere turns / metre]

h height

*h* Planck's constant. *h* = 6.62606896(33) × 10-34 Joule seconds

**I** I Current phasor, Current.

**J** J Current density

k Coupling factor. Empirical parameter when used with subscript.

*k* Boltzmann's constant. *k* = 1.380662 × 10-23 Joules/Kelvin

**L** L Inductance. Complex (i.e., includes losses) when bold.

L' (L prime) Apparent inductance

*L* (*italic*) Inductance per unit length.

*ℓ* (*cursive italic l*) length

*ℓ*'' (*ℓ* prime) Electrical length, i.e., *ℓ*c/v

M Mutual inductance

N The number of turns in a coil. Numerator. A number.

N (N tilde) Effective number of turns (<N)

n Refractive index. The number of observations in a data set.

P Power

***P*** Poynting vector. Power per unit area.

Q Quality. The ratio of reactance to resistance of an impedance in series form.

R Resistance. The real part of an impedance.

*R* (*italic*) Resistance per unit length.

r radius

R0 The characteristic resistance, or surge resistance, of a transmission line. The real part of **Z**0.

A reference or standard resistance. The target or design load resistance.

R**r** Radiation Resistance.

S SWR

*S* (*italic*) Reluctance. *S*=1/A**L**

T temperature

t time

**V** V Voltage phasor (bold), Voltage.

v velocity.

w width, statistical weight

x Independent variable, abscissa.

x (x bar) sample mean.

X Reactance

X0 The characteristic reactance of a lossy transmission line (always negative).

The reactance of a standard or reference capacitor

XC The reactance of a capacitance. XC = -1/(2πfC)

XL The reactance of an inductance. XL = 2πfL

**Y** Admittance. The reciprocal of impedance. **Y** = G + **j**B

y Dependent variable, ordinate.

6

**Z** Impedance. **Z** = R + **j**X

**Z**0 Characteristic impedance of a lossy transmission line. **Z**0 = R0 + **j**X0 . (X0 is negative).

Z0 The impedance of free space (real for a Lorentzian vacuum, hence not bold).

Z0 = 376.7303134 Ω

**Abbreviations and acronyms**

ABS Acrylonitrile-butadiene-styrene copolymer

AC Alternating current

ACA Asymptotically-correct approximation

A-D Analog to Digital

Ae Antenna

AFC Automatic frequency control

Ag Silver (Argentum)

AGC Automatic Gain Control.

AGM Arithmetico-geometric mean

Al Aluminium, Aluminum

ALC Automatic Level Control

AM Amplitude modulation

AMU Antenna matching unit.

ATU Antenna tuning unit

AVC Automatic volume control

B+ B- Battery (DC power)

BWO Backward-wave oscillator

cf. confer (i.e., compare with)

Co Cobalt

CRAB Capacitor ratio-arm bridge

Cu Copper (Cuprum)

CVS Capacitive voltage-sampling

D-A Digital to Analog

DC Direct current

DF Direction finder

DFM Digital frequency meter

DMM Digital multi-meter

DUT Device under test

DVM Digital Voltmeter.

EHT Extra-high tension (i.e., very-high voltage)

EMC Electromagnetic compatibility

EMF Electromotive force (the voltage produced by a generator).

ERP Effective radiated power

ESD Estimated Standard Deviation (can also stand for electrostatic discharge).

7

ESL Equivalent series inductance

ESR Equivalent series resistance

ETFE Ethylene-tetrafluoroethylene (Tefzel)

Fe Iron (Ferrum)

FET Field-efect transistor

FM Frequency modulation

FSD Full-scale deflection (of a meter)

Ge Germanium

GDO Grid-dip oscillator

GMD Geometric Mean Distance

Goof Goodness of fit (scalar composite error function)

Gnd Ground, Earth, Mass, Chassis, 0V

H2S Home sweet home. World War II 10cm airborne radar system.

HF High-frequency. Frequency in the 1.6 to 30MHz (short-wave) range.

HT High-tension (i.e., high voltage)

HV High voltage

IF Intermediate frequency

IFT Intermediate-frequency transformer

IR infra-red

LF Low frequency

LNA Low-noise amplifier

MDB Magnitude-Difference Bridge

MEK Methyl-ethyl-ketone (butanone, CH3-CO-C2H5), an industrial solvent.

ML Modified Lorentzian function (e.g., the electrical resonance curve)

MMF Magnetomotive force

Ni Nickel

PAD Pico-Amp diode (low reverse-leakage diode)

Pb Lead (Plumbum)

PC Polycarbonate

PD Potential difference

PE Polyethylene, Polythene

PET Polyethylene terephthalate (polyester)

PF Power-factor

PP Polypropylene

PS Polystyrene

PSU Power-supply unit

PTFE Polytetrafluoro ethylene (Teflon)

PVC Polyvinyl chloride

radar Radio Direction And RAnge (nowadays often written lower-case).

RF Radio frequency

RFC Radio-frequency choke

RMS square-Root of the Mean of Squares

8

RVS Resistive voltage-sampling

RX Receiver

Si Silicon

Sn Tin (Stannum)

SMPS Switched-mode power supply

SRBF Synthetic-resin-bonded fabric

SRBP Synthetic-resin-bonded paper

SRF self-resonance frequency

SS stainless steel

SWR Standing Wave Ratio

TCA Thick-conductor approximation

TED Truncated exponential decay

TL Transmission-line

TP Test point

TRAB Transformer ratio-arm bridge

TVS Transformer voltage-sampling

TWT Travelling-wave tube

TX Transmitter

UHF ultra-high frequency (> 300MHz. Upper limit definition is variable, but ≤ 3GHz)

uPVC un-plasticised PVC

UV ultraviolet

VHF very-high frequency (30 - 300MHz)

VCA Voltage-controlled amplifier

VCF Voltage-controlled filter

VCO Voltage-controlled oscillator

+Ve Positive

-Ve Negative

VFO Variable-frequency oscillator

x (prefix) trans

xtal crystal (humorously derived from Xmas ≡ Christmas)

Z Impedance