Cast of Characters

Some Symbols, Functions, and Variables Used in the Book

Digital Signal Processing and the Microcontroller

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Symbol	Meaning
$\|x\|$	Function: absolute value of x if x is real; magnitude of x if x is complex (p 33)
x*	Function (superscript asterisk): complex conjugate of the (complex) value x. (Just negate the imaginary part.) (p 195)
$\sum_{i=0}^{N-1} x_i$	Function: summation of elements x_1, x_2, ... , x_N, i.e., $x_1 + x_2 + ... + x_N$ (p 123)
$	Symbol: assembly language prefix indicating a numeric value in hexa-decimal (base-16) (p 296)
!	Function: factorial (e.g., $4! = 4 \times 3 \times 2 \times 1 = 24$) (p 440)
#	Symbol: assembly language prefix indicating an immediate data value (p 292)
<<	Function: left bit-wise shift (from the C programming language) (p 291)
>>	Function: right bit-wise shift (from the C programming language) (p 291)
^	Symbol: estimate of variable, as in $\hat{N}$, an estimate of N (p 168)
a	Variable: coefficient of linear congruential generator (a type of pseudo-random number generator) (p 431)
a_i	Variable: coefficients of denominator of IIR H(z), and hence feedback coefficients in IIR filters (p 116, 208)

Symbol	Meaning
A	Variable: parameter of Kaiser window (p 178)
A_i, B_i	Variable: IIR filter coefficients (p 321)
A_{min}	Variable: minimum attenuation of a filter (p 127)
A_p	Variable: filter passband ripple in dB (p 77)
A_s	Variable: filter minimum attenuation in dB (p 77)
b	Variable: bits of resolution in a quantizer (p 119)
b_i	Variable: coefficients of numerator of IIR and FIR H(z), and hence feed-forward coefficients in IIR and FIR filters (p 116, 254)
BW	Variable: bandwidth (e.g., filter) (p 103)
c	Variable: coefficient of linear congruential generator (a type of pseudo-random number generator) (p 431)
C	Variable: capacitance in farads (F) (p 83) Prefix: a capacitor component (e.g., C1 is 10 pF)
C_N	Function: Nth order Chebychev polynomial of the first kind (p 217)
dB	Units: decibel, $10 \cdot \frac{P_a}{P_b}$ where P_a and P_b are measures of power (usually in watts). A reference P_b specified by trailing letter, as in dBm, dBV, etc. (p 41)
D	Variable: decimation factor (integer) (p 415)
e^x	Function: exponential function. If x is real, just the value e raised to the xth power. If x is complex, see Euler's formula. (p 110 and appendix 1)
f	Variable: discrete-time or normalized frequency, no dimension (p 35)
F	Variable: continuous-time ("real world") frequency measured in Hertz (cycles per second) (p 34) Units: farads, measure of electrical capacitance (p 83)
F_a	Variable: aliased frequency (p 98)
F_c	Variable: filter passband cutoff or edge frequency in Hz (p 77) Variable: center frequency of bandpass filter in Hz (p 78)
F_{high} or F_H, F_{low} or F_L	Variable: -3 dB edges of bandpass filter in Hz (p 78)
F_k	Variable: frequency associated with kth output of DFT (p 349)

Symbol	Meaning
F_s	Variable: filter stopband cutoff or edge frequency in Hz (see also F_{stop}) (p 78) Variable: sampling frequency or rate in Hz (p 95)
FS	Variable (full-scale): FSR for ADCs only accepting unipolar (≥ 0) inputs (p 120)
FSR	Variable (full-scale range): range of input voltages for an ADC in volts (p 119)
F_{stop}	Variable: alternative notation for filter stopband edge frequency (see F_s) in Hz (p 78)
G	Prefix: 10^9 or “giga”, as in GHz
G_i	Variable: IIR scaling coefficients (p 321)
h(t)	Function: usually the impulse response of a continuous-time system (p 48)
$h_d(n)$	Function: desired impulse response of a system (filter) (p 172)
$H(e^{j\omega})$	Function: (discrete-time) frequency response function (p 108)
$H(j\Omega)$	Function: frequency response or transfer function of a system (p 49)
H(s)	Function: system function of a system (p 52)
$H(\Omega)$	Function: Fourier transform of the impulse response of a system, similar to $H(j\Omega)$ (p 55)
H(z)	Function: discrete-time system function (p 109)
Hz	Unit: Hertz, i.e. cycles per second. kHz, MHz, GHz. (p 34)
i	Variable: current (not $\sqrt{-1}$!) (p 469)
I	Variable: interpolation factor (integer) (p 418)
$I_0(\ )$	Function: zero-order modified Bessel function of the first kind (not really used in this book) (p 181)
Im(x)	Function; the imaginary part of a complex value x (p 33)
j	Symbol: the quantity $\sqrt{-1}$ (note that “i” is reserved for current in electronics) (p 33)
$j\Omega$	(Symbol): vertical axis of s-plane
k or K	Prefix: 10^3 or “kilo”, as in kHz

Symbol	Meaning
l	Variable (lower case L): lag in correlation (p 384)
ln( )	Function: logarithm function base e (i.e., $\ln(e^2)=2$)
log( )	Function: logarithm function, usually taken as base 10 (i.e., log(100)=2). See also ln( ), $\log_2( )$
$\log_2( )$	Function: logarithm function base 2 (i.e., $\log_2(8)=3$)
m	Variable: coefficient of linear congruential generator (a type of pseudo-random number generator) (p 431) Prefix: 10^{-3} or “milli”, as in mV (p 124)
M	Variable: number of zeros in a comb filter (p 187) Prefix: 10^6 or “mega”, as in MHz
N	Variable: number of samples in a signal (p 123)
$\hat{N}$	Variable: estimate of N, the number of coefficients in an FIR filter (p 168)
n	Variable: usually an integer, often an index into a discrete-time signal (p 103)
n_p	Variable: number of poles in a system (p 116)
n_z	Variable: number of zeros in a system (p 116)
p	Variable (often subscripted): a pole of a system (p 86) Prefix: 10^{-12} or “pico”, as in pF
P	Variable: power, usually in W (watts) (p 41)
P_N	Variable: noise power, in watts (p 122)
P_S	Variable: signal power, in watts (p 122)
Q	Variable: “Quality” factor of bandpass or bandstop filter (no units) (p 79)
r	Variable: magnitude of the complex variable z (p 110)
r_{12}	Function: crosscorrelation between signals 1 and 2 (p 384)
r_{xx}	Function: autocorrelation (p 396)
rad	Unit: radians, an angular measure like degrees (p 34)
R	Variable: resistance in ohms (Ω) (p 83) Prefix: a resistor component (e.g., R1 is 100 ohms)
Re(x)	Function: the real part of a complex value x (p 33)

Symbol	Meaning
s	Units: seconds (p 35) Variable: a variable in the “s” or complex-frequency plane, $s=\sigma+j\omega$ (p 53)
s_i	Variable: scaling terms in IIR filter (p 319)
SNR	Variable (signal to noise ratio): ratio of signal to noise in dB (p 122)
t	Variable: time in seconds (p 21)
t_d	Variable: time delay in seconds (p 36)
T	Variable: period in seconds (p 35)
T_s	Variable: sampling period in seconds (p 95)
V	Variable: voltage (electrical potential) in V (volts) (p 42)
w(n)	Function (“w”, not ω!): window function (p 179) Variable: intermediate storage variables in IIR filter (p 254)
W_N	Variable: “twiddle” factors in DFT, FFT (p 355)
x(n)	Function: discrete-time input of a system (p 116)
x(t)	Function: continuous-time (input) signal (p 58)
X(k)	Function: frequency domain output of DFT/FFT (p 354)
X(z), Y(z)	Function: z-transform of the input and output signals of a discrete-time system (p 111)
y(n)	Function: discrete-time output of a system (p 116)
y(t)	Function: continuous-time (output) signal (p 58)
z_i	Variable: a zero of a system (p 86)
z	Variable: variable in the z or discrete-time complex frequency plane (p 109)
z^{-1}	(Symbol): a delay of one sample period in a discrete-time system (p 153)
Z	Variable: impedance, a complex-valued, often frequency-dependent electrical measure (p 84)
β	Variable: parameter of Kaiser window (p 178)
δ(t)	Function (lower case delta): impulse function (p 48)
δ_m	Variable: minimum stopband attenuation in a window function (p 182)
δ_p	Variable (lower case delta): filter passband deviation (p 77)

Symbol	Meaning
δ_s	Variable (lower case delta): filter stopband ripple (p 77)
Δ	Variable: step size in an analog-to-digital quantizer (p 119)
Δf	Variable: width of transition band in a filter, e.g., f_s-f_p (p 168)
Δx	Variable: increment in radians between table entries in a first-order sine table (p 444)
ε	Variable: error in polynomial estimate of the sine function (p 444)
ε_p	Variable (lower case epsilon): alternative expression of filter passband deviation (p 77)
μ	Prefix: 10^{-6} or "micro", as in μV (p 124)
π	Symbol (lower-case "pi"): the constant 3.14159265... (p 34)
θ	Variable (lower-case "theta"): usually an angle or phase angle (p 33)
ρ_{12}	Function (lower case rho): normalized crosscorrelation (p 385)
σ	Variable (lower case sigma): exponential factor in complex frequency (see "s") (p 53) Symbol: horizontal axis of s-plane
τ	Variable (lower case tau): time constant in seconds (p 125)
τ_a	Variable: aperature time in a sample and hold amplifier (p 132)
ω	Variable (lower case omega--not "w"!): discrete-time or normalized frequency, units of radians (p 35)
Ω	Variable (upper-case "omega"): continuous-time ("real world") frequency measured in radians per second (p 34) Units: ohms, measure of electrical resistance (p 83)
Ω_c	Variable (upper case omega): filter passband cutoff or edge frequency in rad/sec (p 77) Variable: center frequency of bandpass filter in rad/sec (p 78)
Ω_s	Variable (upper case omega): filter stopband cutoff or edge frequency in rad/sec (p 78) Variable: sampling frequency or rate in rad/sec (p 95)
∞	Symbol: infinity (p 77)
$\propto$	Symbol: "is proportional to" (p 40)
$\angle x$	Function: angle of complex value x (p 33) Symbol: quantity that follows is an angle (often in radians) (p 33)