Glossary of Symbols

Throughout this book, a few formulas are repeated for easier reference during reading. In such cases, the repeated earlier equation number is typeset in italics, like in *(4.11)*.

a_k, b_k	Fourier coefficients
A	signal amplitude
A_{pp}	signal peak-to-peak amplitude
$\mathbf{A}^{\mathrm{T}}$	transpose of $\mathbf{A}$
$\mathbf{A}^*$	complex conjugate transpose of $\mathbf{A}$
$\overline{\mathbf{A}}$	complex conjugate of $\mathbf{A}$
B	bandwidth, or the number of bits in a fixed-point number (including the sign bit)
$\mathrm{cov}\{x, y\}$	covariance, page 42
$C(\tau)$	covariance function
d	dither, page 485
$\frac{\mathrm{d}x}{\mathrm{d}t}$	derivative
$\exp(\cdot)$	exponential function, also $e^{(\cdot)}$
$E(f)$	energy density spectrum
$\mathrm{E}\{x\}$	expected value (mean value)
f	frequency
f_{S}	sampling frequency, sampling rate
f_0	center frequency of a bandpass filter
f_1	fundamental frequency, or first harmonic
$f_x(x)$	probability density function (PDF), page 31
$F_x(x)$	probability distribution function, $F_x(x_0) = \mathrm{P}(x < x_0)$
$\Phi_x(u)$	characteristic function (CF): $\Phi_x(u) = \int_{-\infty}^{\infty} f_x(x) e^{jux}\,\mathrm{d}x = \mathrm{E}\{e^{jux}\}$ Eq. (2.17), page 27
$\mathcal{F}\{\cdot\}$	Fourier transform: $\mathcal{F}\{x(t)\} = \int_{-\infty}^{\infty} x(t) e^{-j2\pi f t}\,\mathrm{d}t$ for the PDF–CF pair, the Fourier transform is defined as $\int_{-\infty}^{\infty} f(x) e^{jux}\,\mathrm{d}x$

$\mathcal{F}^{-1}\{\cdot\}$	inverse Fourier transform: $\mathcal{F}^{-1}\{X(f)\} = \int_{-\infty}^{\infty} X(f)e^{j2\pi ft}\,\mathrm{d}f$ for the PDF–CF pair, the inverse Fourier transform is $\frac{1}{2\pi}\int_{-\infty}^{\infty} \Phi(u)e^{-jux}\,\mathrm{d}u$
$h(t)$	impulse response
$H(f)$	transfer function
$\mathrm{Im}\{\cdot\}$	imaginary part
j	$\sqrt{-1}$
k	running index in time domain series
$\lg(\cdot)$	base-10 logarithm
$\ln(\cdot)$	natural logarithm (base e)
M_r	rth moment difference with PQN: $\mathrm{E}\{(x')^r\} - \mathrm{E}\{x^r\}$ Eq. (4.27), page 81
$\widetilde{M}_r$	rth centralized moment difference with PQN: $\mathrm{E}\{(\tilde{x}')^r\} - \mathrm{E}\{\tilde{x}^r\}$
n	pseudo quantization noise (PQN), page 69
n	frequency index (or: summation index in certain sums)
N	number of samples
N_r	small (usually negligible) terms in the rth moment: $\mathrm{E}\{(x')^r\} = \mathrm{E}\{x^r\} + M_r + N_r$, Eq. (B.1) of Appendix B, page 597
$\widetilde{N}_r$	small (usually negligible) terms in the rth centralized moment: $\mathrm{E}\{(\tilde{x}')^r\} = \mathrm{E}\{\tilde{x}^r\} + \widetilde{M}_r + \widetilde{N}_r$
$N(\mu, \sigma)$	normal distribution, page 49
$\mathcal{O}(x)$	decrease as quickly as x for $x \to 0$
p	precision in floating-point
p_i	probability
$\mathrm{P}\{\cdot\}$	probability of an event
q	quantum size in quantization, page 25
q_d	quantum size of a digital dither, page 686
q_h	step size of the hidden quantizer, page 357
Q	quality factor or weighting coefficient
$R(\tau)$	correlation function, Eq. (3.40), page 42
$R_{xy}(\tau)$	crosscorrelation function, $R_{xy}(\tau) = \mathrm{E}\{x(t)y(t+\tau)\}$ Eq. (3.41), page 42
R_r	residual error of Sheppard's rth correction Eq. (B.7) of Appendix B, page 602
$\widetilde{R}_r$	residual error of the rth Kind correction
$\mathrm{Re}\{\cdot\}$	real part
$\mathrm{rect}(z)$	rectangular pulse function, 1 if $\lvert z\rvert \le 0.5$, zero elsewhere
$\mathrm{rectw}(z)$	rectangular wave, 1 if $-0.25 \le z < 0.25$; -1 if $0.25 \le z < 0.75$; repeated with period 1
s	Laplace variable, or empirical standard deviation
s^*	corrected empirical standard deviation
S_r	Sheppard's rth correction, Eq. (4.29), page 82

$\widetilde{S}_r$	rth Kind correction
$S(f)$	power spectral density
$S_c(f)$	covariance power spectral density
$\mathrm{sign}(x)$	sign function
$\mathrm{sinc}(x)$	$\sin(x)/x$
T	sampling interval
T_{m}	measurement time
T_{p}	period length
T_{r}	record length
$\mathrm{tr}(z)$	triangular pulse function, $1-\lvert z\rvert$ if $\lvert z\rvert \le 1$, zero elsewhere
$\mathrm{trw}(z)$	triangular wave, $1-4\lvert z\rvert$ if $\lvert z\rvert \le 0.5$, repeated with period 1
u	standard normal random variable
$u(t)$	time function of voltage
U	effective value of voltage
U_{p}	peak value
U_{pp}	peak-to-peak value
$\mathrm{var}\{x\}$	variance, same as square of standard deviation: $\mathrm{var}\{x\} = \sigma_x^2$
$w(t)$	window function in the time domain
$W(f)$	window function in the frequency domain
x	random variable
x'	quantized variable
$x' - x$	quantization noise, ν
$\tilde{x}$	centralized random variable, $x - \mu_x$, Eq. (3.13), page 34
$x(t)$	input time function
$X(f)$	Fourier transform of $x(t)$
$X(f, T)$	finite Fourier transform of $x(t)$
z^{-1}	delay operator, $e^{-j2\pi fT}$
δ	angle error
Δf	frequency increment, f_{s}/N in DFT or FFT
ϵ	error
ϵ_{c}	width of confidence interval
ϵ_{r}	relative error
φ	phase angle
$\gamma(f)$	coherence function: $\gamma(f) = \frac{S_{xy}(f)}{\sqrt{S_{xx}(f)S_{yy}(f)}}$
μ	mean value (expected value)
ν	quantization error, $\nu = x' - x$
Ψ	quantization fineness, $\Psi = 2\pi/q$
ω	radian frequency, $2\pi f$
Ω	sampling radian frequency, page 17
ρ	correlation coefficient (normalized covariance, $\frac{\mathrm{cov}\{x,y\}}{\sigma_x\sigma_y}$) Eq. (3.39), page 42

$\rho(t)$	normalized covariance function
σ	standard deviation
Σ	covariance matrix
τ	lag variable (in correlation functions)
ξ	$\xi = d + \nu$, total quantization error (in nonsubtractive dithering) Eq. (19.16), page 491
$\in$	element of set, value within given interval
$\star$	convolution: $\int_{-\infty}^{\infty} f(z)g(x-z)\,\mathrm{d}z = \int_{-\infty}^{\infty} f(x-z)g(z)\,\mathrm{d}z$
$\triangleq$	definition
$\dot{\Phi}$	first derivative, e. g. $\dot{\Phi}_x(l\Psi) = \left.\frac{\mathrm{d}\,\Phi(u)}{\mathrm{d}(u)}\right\vert_{u=l\Psi}$
$\ddot{\Phi}$	second derivative, e. g. $\ddot{\Phi}_x(l\Psi) = \left.\frac{\mathrm{d}^2\,\Phi(u)}{\mathrm{d}(u)^2}\right\vert_{u=l\Psi}$
x'	quantized version of variable x
$\tilde{x}$	centralized version of variable x: $\tilde{x} = x - \mu_x$, Eq. (3.13), page 34
$\hat{x}$	estimated value of random variable x
$\lfloor x \rfloor$	nearest integer smaller than or equal to x (floor(x))
$\breve{x}$	deviation from a given value or variable