List of Symbols and Abbreviations

$a_m(t)$	auxiliary signal at the m^{th} correlator branch of the sectional code phase estimator
A_L	lower edge of the estimated section
B_L	upper edge of the estimated section
B_m^{per}	biased signal at the m^{th} correlator branch of the PerDLL
$c(t)$	pseudonoise spreading waveform
$c_m^{pel}(t)$	early-late PN signal, shifted by $2mT_c$
$c_m^{per}(t)$	parallel extended range local PN sequence at the m^{th} correlator branch of the PerDLL
$G_{1,C}$	probability generating function for one round search for the code phase alignment in the correct estimated section given that the correct code phase is detected, where the section contains q_1 cells
$G_{1,CM}$	probability generating function for one round search for the code phase alignment in the correct estimated section given that the correct code phase is missed, where the section contains q_1 cells
$G_{1,E}$	probability generating function for one round search for the code phase alignment in the non-detectable incorrect estimated section, where the section contains q_1 cells
$G_{1,R}$	probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct code phase is detected, where the section contains q_1 cells and the first cell is the correct code phase
$G_{1,RM}$	probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct code phase is missed, where the section contains q_1 cells and the first cell is the correct code phase
$G_{2,C}$	probability generating function for one round search for the code phase alignment in the correct estimated section given that the correct code phase is detected, where the section contains q_2 cells
$G_{2,CM}$	probability generating function for one round search for the code phase alignment in the correct estimated section given that the correct code phase is missed, where the section contains q_2 cells
$G_{2,E}$	probability generating function for one round search for the code phase alignment in the non-detectable incorrect estimated section, where the section contains q_2 cells
$G_{2,R}$	probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct

code phase is detected, where the section contains q_2 cells and the first cell is the correct code phase

$G_{2,RM}$ probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct code phase is missed, where the section contains q_2 cells and the first cell is the correct code phase

$G_{3,R}$ probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct code phase is detected, where the section contains q_1 cells and the last cell is the correct code phase

$G_{3,RM}$ probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct code phase is missed, where the section contains q_1 cells and the last cell is the correct code phase

$G_{4,R}$ probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct code phase is detected, where the section contains q_2 cells and the last cell is the correct code phase

$G_{4,RM}$ probability generating function for one round search for the code phase alignment in the detectable incorrect estimated section given that the correct code phase is missed, where the section contains q_2 cells and the last cell is the correct code phase

H_0 hypothesis of "out of alignment" (in Chapter 4)

H_1 hypothesis of "in alignment" (in Chapter 3)

H_β hypothesis that the incoming code phase τ is in the range $[\beta,\ \beta+1)T_c$

$H(z)$ transfer function representing the transition from an incorrect code phase node to next code phase node

$H_{1,C,i}(z)$ $H_{C,i}(z)$ of a section containing q_1 cells

$H_{1,CM,i}(z)$ $H_{CM,i}(z)$ of a section containing q_1 cells

$H_{1,E,i}(z)$ $H_{E,i}(z)$ of a section containing q_1 cells

$H_{1,R,i}(z)$ $H_{R,i}(z)$ of the first cell of the estimated section with q_1 cells is the correct code phase

$H_{1,RM,i}(z)$ $H_{RM,i}(z)$ of a section containing q_1 cells

$H_{2,C,i}(z)$ $H_{C,i}(z)$ of a section containing q_2 cells

$H_{2,CM,i}(z)$ $H_{CM,i}(z)$ of a section containing q_2 cells

$H_{2,E,i}(z)$ $H_{E,i}(z)$ of a section containing q_2 cells

$H_{2,R,i}(z)$ $H_{R,i}(z)$ of the first cell of the estimated section with q_2 cells is the correct code phase

$H_{2,RM,i}(z)$ $H_{RM,i}(z)$ of a section containing q_2 cells

$H_{3,R,i}(z)$	$H_{R,i}(z)$ of the last cell of the estimated section with q_1 cells is the correct code phase
$H_{4,R,i}(z)$	$H_{R,i}(z)$ of the last cell of the estimated section with q_2 cells is the correct code phase
$H_{C,i}(z)$	probability generating function of the acquisition time representing the transition from state iC to state F_{iC}
$H_{CM,i}(z)$	probability generating function representing the transition from state iC to state $(i+1)\|C$
$H_{E,i}(z)$	probability generating function representing the transition from state iE to state $(i+1)\|E$
$H_{R,i}(z)$	probability generating function of the acquisition time representing the transition from state iR to state F_{iR}
$H_{RM,i}(z)$	probability generating function representing the transition from state iR to state $(i+1)\|E$
$\mathbf{K}$	covariance matrix
$\mathbf{K}_{nor}$	normalized covariance matrix
K_p	penalty time in unit of nT_c
L_0	time duration in unit of NT_c that the estimator uses for the first estimate, it is positive integer value
L_{i-1}	accumulated time duration in unit of NT_c that the estimator uses for the most recent estimate, it is positive integer value
L_i	accumulated time duration in unit of NT_c that the estimator uses for the present estimate, it is positive integer value
L_{iC}	time duration in unit of NT_c for transition from state S to state iC, it is positive integer value
L_{iE}	time duration in unit of NT_c for transition from state S to state iE, it is positive integer value
L_{iR}	time duration in unit of NT_c for transition from state S to state iR, it is positive integer value
L_{iRE}	average time duration in unit of NT_c between transition from state S to state iR and transition from state S to state iE, it is positive integer value
$L_{C,i}$	time duration in unit of NT_c for transition from state S to state iC, it is positive but not necessary to be integer value
$L_{E,i}$	time duration in unit of NT_c for transition from state S to state iE, it is positive but not necessary to be integer value
$L_{R,i}$	time duration in unit of NT_c for transition from state S to state iR, it is positive but not necessary to be integer value
$L_{i\|C}$	time duration in unit of NT_c for transition from state S to state $i\|C$, positive integer value

$L_{i\|E}$	time duration in unit of NT_c for transition from state S to state $i\|E$, positive integer value
$L_{i\|R}$	time duration in unit of NT_c for transition from state S to state $i\|R$, positive integer value
$L_{1,CM,i}$	number of repeated searches of the cell in the correct estimated section specified by the i^{th} estimate, where a section contains q_1 cells
$L_{1,E,i}$	number of repeated searches of the cell in the non-detectable incorrect estimated section specified by the i^{th} estimate, where a section contains q_1 cells
$L_{1,RM,i}$	number of repeated searches of the cell in the detectable incorrect estimated section specified by the i^{th} estimate, where a section contains q_1 cells and the first cell is the correct code phase
$L_{2,CM,i}$	number of repeated searches of the cell in the correct estimated section specified by the i^{th} estimate, where a section contains q_2 cells
$L_{2,E,i}$	number of repeated searches of the cell in the non-detectable incorrect estimated section specified by the i^{th} estimate, where a section contains q_2 cells
$L_{2,RM,i}$	number of repeated searches of the cell in the detectable incorrect estimated section specified by the i^{th} estimate, where a section contains q_2 cells and the first cell is the correct code phase
$L_{3,RM,i}$	number of repeated searches of the cell in the detectable incorrect estimated section specified by the i^{th} estimate, where a section contains q_1 cells and the last cell is the correct code phase
$L_{4,RM,i}$	number of repeated searches of the cell in the detectable incorrect estimated section specified by the i^{th} estimate, where a section contains q_2 cells and the last cell is the correct code phase
M	number of correlator branch of the sectional code phase estimator (in Chapter 4)
n	integration length of the active correlator
N	period of PN code
N_0	level of power spectrum density of noise
P	average signal power
$P_{1,C,k}$	conditional probability that the k^{th} code phase is correct code phase given that the previous $(k-1)^{\text{th}}$ code phase are not correct code phase in the section containing q_1 cells
$P_{1,CM,k}$	conditional probability that the miss detection occurs at the k^{th} correct code phase given that the previous $(k-1)^{\text{th}}$ code phase are not correct code phase in the section containing q_1 cells

$P_{2,C,k}$	conditional probability that the k^{th} code phase is correct code phase given that the previous $(k-1)^{th}$ code phase are not correct code phase in the section containing q_2 cells
$P_{2,CM,k}$	conditional probability that the miss detection occurs at the k^{th} correct code phase given that the previous $(k-1)^{th}$ code phase are not correct code phase in the section containing q_2 cells
P_{ave}	average probability of correct selection of SelDLL
P_c	unconditional probability of correct sectional estimate
P_{c2}	unconditional probability of correct sectional estimate and the incoming code phase is located at the last section that divided by the phase estimator
$P_{c2\|c}$	conditional probability of correct sectional estimate given that the most recent estimate is correct and the incoming code phase is located at the last section that divided by the phase estimator
$P_{c2\|e}$	conditional probability of correct sectional estimate given that the most recent estimate is incorrect and the incoming code phase is located at the last section that divided by the phase estimator
$P_{c\|c}$	conditional probability of correct sectional estimate given that the most recent estimate is correct
$P_{c\|e}$	conditional probability of correct sectional estimate given that the most recent estimate is incorrect
P_d	probability of code phase detection
P_e	unconditional probability of non-detectable incorrect sectional estimate
P_{e2}	unconditional probability of non-detectable incorrect sectional estimate where the specified section is the last section that divided by the phase estimator
$P_{e2\|c}$	conditional probability of non-detectable incorrect sectional estimate given that the most recent estimate is correct where the specified section is the last section that divided by the phase estimator
$P_{e2\|e}$	conditional probability of non-detectable incorrect sectional estimate given that the most recent estimate is incorrect where the specified section is the last section that divided by the phase estimator
$P_{e\|c}$	conditional probability of non-detectable incorrect sectional estimate given that the most recent estimate is correct
$P_{e\|e}$	conditional probability of non-detectable incorrect sectional estimate given that the most recent estimate is incorrect
P_{fa}	probability of false alarm
P_r	unconditional probability of detectable incorrect sectional estimate
P_{r1}	unconditional probability of detectable incorrect sectional estimate given that the incoming code phase follows the first case specified in Section 4.4.2

P_{r2}	unconditional probability of detectable incorrect sectional estimate given that the incoming code phase follows the second case specified in Section 4.4.2
P_{r3}	unconditional probability of detectable incorrect sectional estimate given that the incoming code phase follows the third case specified in Section 4.4.2
P_{r4}	unconditional probability of detectable incorrect sectional estimate given that the incoming code phase follows the fourth case specified in Section 4.4.2
$P_{r1\|c}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is correct and the incoming code phase follows the first case specified in Section 4.4.2
$P_{r1\|e}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is incorrect and the incoming code phase follows the first case specified in Section 4.4.2
$P_{r2\|c}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is correct and the incoming code phase follows the second case specified in Section 4.4.2
$P_{r2\|e}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is incorrect and the incoming code phase follows the second case specified in Section 4.4.2
$P_{r3\|c}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is correct and the incoming code phase follows the third case specified in Section 4.4.2
$P_{r3\|e}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is incorrect and the incoming code phase follows the third case specified in Section 4.4.2
$P_{r4\|c}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is correct and the incoming code phase follows the fourth case specified in Section 4.4.2
$P_{r4\|e}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is incorrect and the incoming code phase follows the fourth case specified in Section 4.4.2
$P_{r\|c}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is correct
$P_{r\|c}$	conditional probability of detectable incorrect sectional estimate given that the most recent estimate is incorrect
$P_{T_c}(t)$	unit amplitude rectangular pulse shape in the interval $(0,\ T_c]$
$P_{c,\mathrm{tr}}$	unconditional probability of correct estimate given that the incoming code phase locates in the transition region
$P_{c\|c,\mathrm{tr}}$	conditional probability of correct estimate given that the most recent estimate is correct and the incoming code phase locates in the transition region

$P_{c\|e,\mathrm{tr}}$	conditional probability of correct estimate given that the most recent estimate is incorrect and the incoming code phase locates in the transition region
P_{de}	unconditional probability of detectable estimate given that the incoming code phase locates in the transition region
$P_{de\|c}$	conditional probability of detectable estimate given that the most recent estimate is correct and the incoming code phase locates in the transition region
$P_{de\|e}$	conditional probability of detectable estimate given that the most recent estimate is incorrect and the incoming code phase locates in the transition region
P_{ave}^{pel}	average probability of correct selection of PelDLL
P_{ave}^{per}	average probability of correct selection of PerDLL
$\hat{P}$	estimated power of the received signal
q	sampled time in unit of T_c (in Chapter 3 and 4)
q	number of code phases in an estimated section (in Chapter 5)
q_1	number of code phases in an estimated section which is equal to $2^{\lambda-M}+2$
q_2	number of code phases in an estimated section which is equal to $2^{\lambda-M}+1$
$r(t)$	received signal
$R_m(\tau)$	periodic cross-correlation function between the PN signal with code phase τ and m^{th} auxiliary signal
$\bar{R}_m(\tau)$	hard decision value of $R_m(\tau)$
$\mathbf{s}^{per}$	column matrix of s_m^{per}
s_m	sampled signal of the received signal at the m^{th} correlator branch of the SelDLL
s_m^{pel}	sampled signal of the received signal at the m^{th} correlator branch of the PelDLL
s_m^{per}	sampled signal of the received signal at the m^{th} correlator branch of the PerDLL
$s_m^{pel,+}$	chip normalized partial correlation between the received PN sequence and the delayed version of local PN sequence in the m^{th} branch
$s_m^{pel,-}$	chip normalized partial correlation between the received PN sequence and the advanced version of local PN sequence in the m^{th} branch
$S(\tau)$	discriminator characteristic of the DLL
T_c	chip duration
T_i	mean acquisition time of the proposed scheme given that accomplish at i^{th} estimate
$\bar{T}$	mean acquisition time of the proposed scheme
$U_{iC}(z)$	transfer function of the transition from state S to state F_{iC}
$U_{iR}(z)$	transfer function of the transition from state S to state F_{iR}

$w_{m,L}(\tau)$	output of the accumulator in the m^{th} branch of the sectional code phase estimator with the incoming code phase τ and the accumulated time duration LNT_c
$W_{iC}(z)$	transfer function of transition from node 1 to iC
$W_{iE}(z)$	transfer function of transition from node 1 to iE
$W_{iR}(z)$	transfer function of transition from node 1 to iR
$W_{i\|C}(z)$	transfer function of transition from node 1 to $i\|C$
$W_{i\|E}(z)$	transfer function of transition from node 1 to $i\|E$
y	sample of the received signal in the code phase alignment detector
y_m	sample of the received signal at the m^{th} correlator branch of the SelDLL
y_m^{pel}	sample of the received signal at the m^{th} correlator branch of the PelDLL
y_m^{per}	sample of the received signal at the m^{th} correlator branch of the PerDLL
$\mathbf{y}^{per}$	column matrix of y_m^{per}
z	elapse time of nT_c
α	integer part of $\hat{\tau}$
β	integer part of τ
δ	half of early-late spacing (in Chapter 3)
δ	value $0.5/(N+1)$ (in Chapter 4)
ε	error signal in the DLL
η	sample of real part of noise of the received in the code phase alignment detector
η_m	sample of real part of noise of the received signal at the m^{th} correlator branch of the SelDLL
$\eta_{m,L}$	sample of real part of noise of the received signal at the m^{th} correlator branch of the sectional code phase estimator with the accumulated time duration LNT_c
η_m^{pel}	sample of real part of noise of the received signal at the m^{th} correlator branch of the PelDLL
η_m^{per}	sample of real part of noise of the received signal at the m^{th} correlator branch of the PerDLL
$\eta(t)$	complex envelope of zero mean white Gaussian noise with two-sided power spectral density $2N_0$
γ	fractal value of τ
$\gamma_+^+(r,s)$	summation of the cross-correlations between $a_{r,i}$ and $(N+1)/2^{s-1}$ PN signals with positive coefficients and consecutive code phases causing the positive values of both $R_s(\tau)$ and $R_r(\tau)$

$\gamma_+^-(r,s)$ summation of the cross-correlations between $a_{r,i}$ and $(N+1)/2^{s-1}$ PN signals with positive coefficients and consecutive code phases causing the positive values of $R_s(\tau)$ and the negative values of $R_r(\tau)$

$\gamma_-^+(r,s)$ summation of the cross-correlations between $a_{r,i}$ and $(N+1)/2^{s-1}$ PN signals with negative coefficient and consecutive code phases causing the negative values of $R_s(\tau)$ and the positive values of $R_r(\tau)$

$\gamma_-^-(r,s)$ summation of the cross-correlations between $a_{r,i}$ and $(N+1)/2^{s-1}$ PN signals with negative coefficients and consecutive code phases resulting in both the negative values of $R_s(\tau)$ and $R_r(\tau)$

$\gamma_+^{\text{beg}}(r,s)$ summation of the cross-correlations between $a_{r,i}$ and the PN signals with the code phases locating in the first flat region of $R_s(\tau)$

$\gamma_+^{\text{edge}}(r,s)$ summation of the cross-correlations between $a_{r,i}$ and $(N+1)/2^{s-1}$ PN signals with positive coefficients and having consecutive code phases locating in the positive flat region of $R_s(\tau)$ and around the transition region of $R_r(\tau)$

$\gamma_+^{\text{fin}}(r,s)$ summation of the cross-correlations between $a_{r,i}$ and the PN signals with the code phases locating in the last flat region of $R_s(\tau)$

$\gamma_-^{\text{edge}}(r,s)$ summation of the cross-correlations between $a_{r,i}$ and $(N+1)/2^{s-1}$ PN signals with negative coefficients and having consecutive code phases locating in the negative flat region of $R_s(\tau)$ and around the transition region of $R_r(\tau)$.

Γ threshold in the code phase alignment detector

$\tilde{\Gamma}$ normalized threshold in the code phase alignment detector

λ degree of m-sequence

$\Phi(x)$ cumulative density function of standard Gaussian random variable defined as $\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x} e^{-t^2/2}dt$

$\rho_{m,k}$ correlation coefficient between y_m and y_k of the SelDLL

$\rho_{r,s}(L_{i-1},L_i)$ correlation coefficient between $w_{r,L_{i-1}}$ and w_{s,L_i} of the sectional code phase estimator

$\rho_{m,k}^{pel}$ correlation coefficient between y_m and y_k of the PelDLL

$\rho_{m,k}^{per}$ correlation coefficient between y_m and y_k of the PerDLL

$\tilde{\rho}_{m,k}$ approximate correlation coefficient between y_m and y_k of the SelDLL

σ_η^2 variance of real part of noise of the received signal in the code phase alignment detector

σ_m^2 variance of real part of noise of the received signal at the m^{th} correlator branch of the SelDLL

$\sigma^2_{m,L}$	variance of real part of noise of the received signal at the m^{th} correlator branch of the sectional code phase estimator
$\sigma^2_{pel,m}$	variance of real part of noise of the received signal at the m^{th} correlator branch of the PelDLL
$\sigma^2_{per,m}$	variance of real part of noise of the received signal at the m^{th} correlator branch of the PerDLL
τ	code phase delay of the received signal
$\hat{\tau}$	estimated code phase delay
$\theta^+_+(r,s)$	the first code phase that makes the PN signals follow the definition of $\gamma^+_+(r,s)$
$\theta^-_+(r,s)$	the first code phase that makes the PN signals follow the definition of $\gamma^-_+(r,s)$
$\theta^+_-(r,s)$	the first code phase that makes the PN signals follow the definition of $\gamma^+_-(r,s)$
$\theta^-_-(r,s)$	the first code phase that makes the PN signals follow the definition of $\gamma^-_-(r,s)$
$\theta^{\text{edge}}_+(r,s)$	the first code phase that makes the PN signals follow the definition of $\gamma^{\text{edge}}_+(r,s)$
$\theta^{\text{edge}}_-(r,s)$	the first code phase that makes the PN signals follow the definition of $\gamma^{\text{edge}}_-(r,s)$

AC	autocorrelation function
ANE	average number of estimate for the successful code phase detection
CC	cross-correlation function
C-DLL	coherent delay locked loop
DLL	delay locked loop
ESNR	estimated per-chip signal-to-noise ratio
MAT	mean acquisition time
NC-DLL	noncoherent delay locked loop
PelDLL	parallel early-late delay locked loop
PerDLL	parallel extended range delay locked loop
PN	pseudonoise
SelDLL	correlation branch selection delay locked loop
SNR	per-chip signal-to-noise ratio
$\hat{\text{SNR}}$	estimated per-chip signal-to-noise ratio
VAT	variance of the acquisition time

!	factorial operation
$(\cdot)^{-1}$	inverse operation
$(\cdot)^{\text{T}}$	transpose operation

$\binom{M}{k}$	binomial coefficient defined as $\frac{M!}{k!(M-k)!}$
$Cov(.)$	covariance
$\min(\cdot,\cdot)$	minimum value between arguments
$\mathrm{Re}\{\cdot\}$	real part
$\mathrm{sgn}(\cdot)$	signum function
$\lvert\cdot\rvert$	absolute value
$\lfloor\cdot\rfloor$	integer part of argument
$\lceil\cdot\rceil$	smallest integer ≥ argument