Part I

Coherent Versus Differential Turbo Detection of Sphere-packing-aided Single-user MIMO Systems

List of Symbols in Part I

General Notation

- The superscript * is used to indicate complex conjugation. Therefore, a^* represents the complex conjugate of the variable a.
- The superscript $^{\mathrm{T}}$ is used to indicate the matrix transpose operation. Therefore, $\mathbf{a}^{\mathrm{T}}$ represents the transpose of the matrix $\mathbf{a}$.
- The superscript $^{\mathcal{H}}$ is used to indicate the complex conjugate transpose operation. Therefore, $\mathbf{a}^{\mathcal{H}}$ represents the complex conjugate transpose of the matrix $\mathbf{a}$.
- The notation $\hat{x}$ represents the estimate of x.

Special Symbols

$a_{l,i}$	The ith coordinate of the lth SP symbol $\mathbf{s}^l$.
$\mathcal{A}$	The area under a curve.
$\mathbf{A}$	The *a priori* probability matrix of a non-binary decoder.
$\mathbf{A}_{ldpc}$	The *a priori* probability matrix of the non-binary LDPC decoder.
$\mathbf{A}_{urc}$	The *a priori* probability matrix of the symbol-based unity-rate decoder.
B	The number of binary bits corresponding to a constellation symbol.
$\mathbf{b}$	A block of B binary bits.
b_i	The binary bit at position i in $\mathbf{b}$.
c	Outer channel coded bits.
$\mathbf{C}$	The space-time signal matrix.
c_t^i	The complex symbol transmitted by transmit antenna i at time slot t.
$\mathbb{C}^n$	The n-dimensional complex space.

$C_{\text{DCMC}}^{\text{STBC-SP}}$ The DCMC capacity of STBC-SP schemes.

D The dimension of a D-dimensional signal set.

$\mathcal{D}$ The depth of the random interleaver.

$\mathbf{D}_{ldpc}$ The *a posteriori* probability matrix of the non-binary LDPC decoder.

$\mathbf{D}_{urc}$ The *a posteriori* probability matrix of the symbol-based unity-rate decoder.

$E[k]$ The expected value of k.

E_b Bit energy.

E_s Symbol energy.

E_{total} The total energy of a constellation set.

f_D The normalized Doppler frequency.

G The feedforward generator polynomial of RSC codes.

G_r The feedback generator polynomial of RSC codes.

$\mathbf{G}_{2^k}$ An orthogonal design of size $(2^k \times 2^k)$.

h_i The channel impulse response from transmit antenna i for single-receive antenna systems.

$h_{i,j}$ The channel impulse response from transmit antenna i to receive antenna j.

I_0 The bit-wise unconditional mutual information.

$I_{3\text{S}}$ The number of three-stage iterations.

I_A The mutual information associated with the *a priori* information.

I_{A_D} The mutual information associated with the *a priori* LLR values $L_{D,a}$ of the outer channel decoder.

I_{A_M} The mutual information associated with the *a priori* LLR values $L_{M,a}$ of the SP demapper.

I_E The mutual information associated with the extrinsic information.

I_{E_D} The mutual information associated with the extrinsic LLR values $L_{D,e}$ of the outer channel decoder.

I_{E_M} The mutual information associated with the extrinsic LLR values $L_{M,e}$ of the SP demapper.

I_{ext} The number of external joint iterations.

I_{int} The number of LDPC internal iterations.

$\mathbf{I}_n$ The identity matrix of size $(n \times n)$.

$\mathcal{K}$ The constraint length of RSC codes.

K	The rank of a matrix.
K_{ldpc}	LDPC output block length.
L	The size of the legitimate modulation constellation S.
$L_{D,a}$	The *a priori* LLR values of the outer channel decoder.
$L_{D,e}$	The extrinsic LLR values of the outer channel decoder.
$L_{D,i,p}$	The LLR values of the original uncoded systematic information bits.
$L_{D,p}$	The *a posteriori* LLR values of the outer channel decoder.
$L_{M,a}$	The *a priori* LLR values of the SP demapper.
$L_{M,e}$	The extrinsic LLR values of the SP demapper.
$L_{M,p}$	The *a posteriori* LLR values of the SP demapper.
N_t	Number of transmit antennas.
N_r	Number of receive antennas.
n_A	The zero-mean Gaussian random variable used for modeling the *a priori* information input.
n_f	A normalization factor.
P	Number of subcodes in a family of subcodes (e.g. IRCCs).
$\mathbf{Q}$	The soft-metric probability matrix produced by the symbol-based SP demodulator.
R	Coding rate.
$\mathbf{R}$	The channel correlation matrix.
r_i	The received sphere packing symbol at time instant t.
$\mathbb{R}^n$	The n-dimensional real-valued Euclidean space.
$\mathbf{s}$	A SP symbol.
S	The legitimate constellation set.
S_0^k	The subset of the legitimate constellation set S that contains all symbols having $b_k = 0$.
S_1^k	The subset of the legitimate constellation set S that contains all symbols having $b_k = 1$.
$\mathbf{s}^l$	The lth SP legitimate symbol.
T	The number of time slots needed for transmitting a specific number of symbols.
T_s	Signaling period.
T_{sp}	The transfer function from SP to complex signals.

T_{sym}	Symbol period.
$\mathbf{v}$	Non-binary LDPC encoded integer symbols.
$\mathbf{w}$	A four-dimensional Gaussian random variable.
W	Bandwidth.
y_t^j	The received complex signal at receive antenna j at time slot t.
z_t^j	The complex Additive White Gaussian Noise (AWGN) noise at receive antenna j at time instant t.
α_i	Weight coefficient of the ith subcode.
ζ_R	The diversity product for time-correlated fading channels having a correlation matrix $\mathbf{R}$.
ζ_{rapid}	The diversity product for rapid fading channels.
ζ_{static}	The diversity product for quasi-static fading channels.
η	Bandwidth efficiency.
θ_i	The phase shift of the channel impulse response h_i.
π	Interleaver.
π^{-1}	Deinterleaver.
ρ	The SNR.
σ_n^2	The complex noise's variance.