Appendix A

# NOTATION, SYMBOLS, AND ACRONYMS

| Notation | Meaning |
|---|---|
| $t$ | Continuous-time variable |
| $f(t)$ | Continuous-time signal |
| $k$ | Discrete-time variable |
| $\{f[k]\}$ | Discrete-time sequence |
| $\Delta$ | Sampling period |
| $f(k\Delta)$ | Sampled version of $f(t)$ |
| $\delta$ | Delta operator |
| $q$ | forward shift operator |
| $\delta_K(k)$ | Kronecker delta |
| $\delta(t)$ | Dirac delta |
| $\mathcal{E}\{...\}$ | Expected value of ... |
| $\Gamma_c$ | Controllability matrix in state space description |
| $\Gamma_o$ | Observability matrix in state space description |
| $\Lambda\{...\}$ | Set of eigenvalues of matrix ... |
| $\mu(t-t_o)$ | unit step (continuous time) at time $t = to$ |
| $\mu[k-k_o]$ | unit step (discrete time) at time $k = k_o$ |
| $f^s(t)$ | Dirac impulse-sampled version of $f(t)$ |
| $\mathcal{F}[...]$ | Fourier transform of ... |
| $\mathcal{L}[...]$ | Laplace transform of ... |
| $\mathcal{D}[...]$ | Delta-transform of ... |
| $\mathcal{Z}[...]$ | Z-transform of ... |
| $\mathcal{F}^{-1}[...]$ | inverse Fourier transform of ... |
| $\mathcal{L}^{-1}[...]$ | inverse Laplace transform of ... |
| $\mathcal{D}^{-1}[...]$ | inverse Delta-transform of ... |

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| Notation | Meaning |
|---|---|
| $\mathcal{Z}^{-1}[...]$ | inverse Z-transform of ... |
| $s$ | Laplace-transform complex variable |
| $\omega$ | angular frequency |
| $\gamma$ | Delta-transform complex variable |
| $z$ | Z-transform complex variable |
| $F(j\omega)$ | Fourier transform of $f(t)$ |
| $F(s)$ | Laplace transform of $f(t)$ |
| $F_\delta(\gamma)$ | Delta-transform of $\{f[k]\}$ |
| $F_q(z)$ | Z-transform of $\{f[k]\}$ |
| $f_1(t) * f_2(t)$ | Time convolution of $f_1(t)$ and $f_2(t)$ |
| $F_1(s) * F_2(s)$ | Complex convolution of $F_1(s)$ and $F_2(s)$ |
| $\Re\{...\}$ | real part of ... |
| $\Im\{...\}$ | imaginary part of ... |
| $\mathbb{C}^{m\times n}$ | set of all $m \times n$ matrices with complex entries |
| $\mathcal{H}_2$ | Hilbert space of those functions square-integrable along the imaginary axis and analytic in the right-half plane |
| $\mathcal{L}_1$ | Hilbert space of those functions absolutely integrable along the imaginary axis |
| $\mathcal{L}_2$ | Hilbert space of those functions square-integrable along the imaginary axis. |
| $\mathcal{H}_\infty$ | Hilbert space of those functions bounded along the imaginary axis and analytic in the right-half plane |
| $\mathcal{RH}_\infty$ | Hilbert space of those **rational** functions bounded along the imaginary axis and analytic in the right-half plane |
| $\mathcal{L}_\infty$ | Hilbert space of those functions bounded along the imaginary axis. |
| $\mathbb{N}$ | set of all natural numbers |
| $\mathbb{R}^+$ | set of real numbers larger than zero |
| $\mathbb{R}^-$ | set of real numbers smaller than zero |
| $\mathbb{R}^{m\times n}$ | set of all $m \times n$ matrices with real entries |
| $\boldsymbol{\mathcal{S}}$ | set of all real rational functions with (finite) poles strictly inside the LHP |
| $\mathbb{Z}$ | set of all integer numbers |
| $[\alpha_{ik}]$ | Matrix where the element in the $i^{th}$ row and $k^{th}$ column is denoted by $\alpha_{ik}$ |
| $[\mathbf{A}]_{ik}$ | element in the $i^{th}$ row and $k^{th}$ of matrix $\mathbf{A}$ |
| $[\mathbf{A}]_{i*}$ | $i^{th}$ row of matrix $\mathbf{A}$ |
| $[\mathbf{A}]_{*k}$ | $k^{th}$ columm of matrix $\mathbf{A}$ |

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|---|---|
| Notation | Meaning |
| $(...)^*$ | complex conjugate of ... |
| $G_{h0}(s)$ | transfer function of a zero-order hold |
| $G_{h1}(s)$ | transfer function of a first-order hold |
| $H\langle ...\rangle$ | operator notation, i.e. $H$ operates on ... |
| $H_1 \otimes H_2\langle ...\rangle$ | composite operators, i.e., $H_1\langle H_2\langle ...\rangle\rangle$ |
| $\mathbf{I_k}$ | identity matrix in $\mathbb{R}^{k\times k}$ |
| d.c. | *direct current*, i.e., zero-frequency signal |
| d.o.f. | degrees of freedom |
| CTARE | Continuous-Time Algebraic Riccati Equation |
| DTARE | Discrete-Time Algebraic Riccati Equation |
| CTDRE | Continuous-Time Dynamic Riccati Equation |
| DTDRE | Discrete-Time Dynamic Riccati Equation |
| IMC | Internal Model Control |
| IMP | Internal Model Principle |
| LHP | left half-plane |
| OLHP | open left half-plane |
| RHP | right half- plane |
| ORHP | open right-half plane |
| NMP | nonminimum phase |
| MFD | Matrix fraction description |
| LMFD | Left matrix fraction description |
| RMFD | Right matrix fraction description |
| LTI | Linear time invariant |
| LQR | Linear quadratic regulator |
| w.r.t | with respect to ... |

**Table A.1.** Notation, symbols and acronyms