

1 Variables

2 root

| | var | symbol | documentation | type | units | tokens | eqs |
|---|-----------|--------------|---------------------------------|----------|-------|--------|----------|
| 8 | $F_{N,A}$ | F | directed graph incidence matrix | network | | [] | |
| 1 | t | t | time | frame | s | [] | |
| 6 | t_o | to | starting time | frame | s | [] | 3 |
| 7 | t_e | te | end time | frame | s | [] | 4 |
| 3 | $\#$ | value | numerical value | constant | | [] | |
| 4 | 1 | one | numerical value 1 | constant | | [] | 1 |
| 5 | 0 | null | numerical value 0 | constant | | [] | 2 |

3 Properties

| | var | symbol | documentation | type | units | tokens | eqs |
|----|------------------|-----------|--|----------|-------|--------|--------------------|
| 57 | $M^{A,\alpha}_N$ | M_A_alpha | norming factor token A mechanism alpha | constant | | [] | 51 |
| 58 | $M^{A,\beta}_N$ | M_A_beta | norming factor token A mechanism beta | constant | | [] | 52 |
| 59 | $M^{B,\gamma}_N$ | M_B_gamma | norming factor token B mechanism gamma | constant | | [] | 53 |
| 60 | $M^{B,\delta}_N$ | M_B_delta | norming factor token B mechanism delta | constant | | [] | 54 |
| 69 | M^A_N | M_A | stack of M matrices token A | constant | | [] | 55 |
| 70 | M^B_N | M_B | stack of M matrices token B | constant | | [] | 56 |
| 71 | M_N | M | stack of M matrices token A and B | constant | | [] | 57 |

4 Control

| | var | symbol | documentation | type | units | tokens | eqs |
|----|-------------|----------|---|-------------------|----------|--------|-------|
| 67 | y_A | y | controller output | controlOut | | [] | 49 50 |
| 61 | m_A | m | measurement | measureIn | | [] | 61 62 |
| 65 | $I_{N,D}$ | I_N_D | Identity to shift from differential space to integral space | network | | [] | |
| 66 | $I_{A,D}$ | I_A_D | identity to shift from differential space to arc | network | | [] | |
| 55 | x_N | x | controller state | state | | [] | 48 |
| 56 | x_N^o | xo | controller state initial condition | state | | [] | 44 |
| 50 | $A_{N,D}$ | A | dynamic matrix A | constant | s^{-1} | [] | |
| 51 | $B_{A,D}$ | B | input matrix C | constant | s^{-1} | [] | |
| 52 | $C_{N,A}$ | C | output matrix C | constant | | [] | |
| 53 | $D_{N,A}$ | D | event matrix D | constant | | [] | |
| 62 | y_{sA} | setpoint | set point | constant | | [] | 45 |
| 63 | e_A | e | control error | constant | | [] | 46 |
| 68 | D_A | D_A | event diagonal matrix D | constant | | [] | |
| 64 | \dot{x}_D | dx | differential state | differentialState | s^{-1} | [] | 47 |

5 System

| | var | symbol | documentation | type | units | tokens | eqs |
|----|------------------------|-----------------|---|--------------------|-----------|--------|-----|
| 76 | u_A | u | [0-1]-normed control signal | controlIn | | [] | |
| 74 | z_N | measure | normed measurement of pi A alpha | measureOut | | [] | 59 |
| 75 | \underline{z}_A | measure_set_A | measurement vector for A | measureOut | | [] | 60 |
| 25 | $\hat{x}^{A,\alpha}_N$ | fx_A_alpha | netflow of token A due to mechanism alpha | transport | ms^{-1} | [] | 11 |
| 26 | $\hat{x}^{A,\beta}_N$ | fx_A_beta | net flow of token A due to mechanism beta | transport | ms^{-1} | [] | 12 |
| 27 | $\hat{y}^{B,\gamma}_N$ | fy_B_gamma | netflow of token B due to mechanism gamma | transport | s^{-1} | [] | 14 |
| 28 | $\hat{y}^{B,\delta}_N$ | fy_B_delta | netflow of token B due to mechansim beta | transport | s^{-1} | [] | 15 |
| 73 | $I_{zN,A}$ | I_measure | unidirectional graph for interface connection | network | | [] | |
| 36 | $D_{N,A}$ | D | difference operator | differenceOperator | | [] | |
| 9 | x_N | x | state token A | state | m | [] | 20 |
| 10 | y_N | y | state token B | state | | [] | 21 |
| 11 | x^o_N | xo | initial condition for state x | state | m | [] | 5 |
| 12 | y^o_N | yo | initial condition for state y | state | | [] | 6 |
| 34 | s | s | mixed state | state | | [] | 31 |
| 13 | $K^{A,\alpha}_A$ | K_A_alpha | conductivity token A mechanism alpha | constant | s^{-1} | [] | |
| 14 | $K^{A,\beta}_A$ | K_A_beta | conductivity token A mechanism beta | constant | s^{-1} | [] | |
| 15 | $K^{B,\gamma}_A$ | K_B_gamma | conductivity token B mechanism gamma | constant | s^{-1} | [] | |
| 16 | $K^{B,\delta}_A$ | K_B_delta | conductivity token B mechanism delta | constant | s^{-1} | [] | |
| 17 | $M^{A,\alpha}_N$ | M_A_alpha | norming factor token A mechanism alpha | constant | | [] | |
| 18 | $M^{A,\beta}_N$ | M_A_beta | norming factor token A mechanism beta | constant | | [] | |
| 19 | $M^{B,\gamma}_N$ | M_B_gamma | norming factor token B mechanism gamma | constant | | [] | |
| 20 | $M^{B,\delta}_N$ | M_B_delta | norming factor token B mechanism delta | constant | | [] | |
| 72 | $\pi^{A,\alpha,o}_N$ | pi_A_alpha_norm | norming factor for pi A alpha | constant | m | [] | 58 |

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| | var | symbol | documentation | type | units | tokens | eqs |
|----|-------------------------|------------|---|-------------------|-----------|--------|-------|
| 29 | \dot{x}_N | dx | diferential balance for token A | differentialState | ms^{-1} | [] | 16 32 |
| 30 | \dot{y}_N | dy | differential balance for token B | differentialState | s^{-1} | [] | 17 33 |
| 35 | $\dot{x}y$ | dxy | mixed stack of the two accumulation terms | differentialState | | [] | 34 |
| 21 | $\pi^{A,\alpha}_N$ | pi_A_alpha | effort for A mechanism alpha | secondaryState | m | [] | 7 27 |
| 22 | $\pi^{A,\beta}_N$ | pi_A_beta | effort for A mechanism beta | secondaryState | m | [] | 8 28 |
| 23 | $\pi^{B,\gamma}_N$ | pi_B_gamma | effort for B mechanism gamma | secondaryState | | [] | 9 29 |
| 24 | $\pi^{B,\delta}_N$ | pi_B_delta | effort for B mechanism delta | secondaryState | | [] | 10 30 |
| 31 | $\underline{\pi}^A_N$ | pi_A_stack | effort for token A stack | secondaryState | m | [] | 24 |
| 32 | $\underline{\pi}^B_N$ | pi_B_stack | effort for token B stack | secondaryState | | [] | 25 |
| 33 | $\underline{\pi}^{A,B}$ | pi_stack | effort for token A, B stack | secondaryState | | [] | 26 |

6 Equations

7 Generic

| no | equation | documentation | layer |
|----|--|---|--------|
| 1 | $1 := \text{Instantiate}(\#, \#)$ | numerical value 1 | root |
| 2 | $0 := \text{Instantiate}(\#, \#)$ | numerical value 0 | root |
| 3 | $t_o := \text{Instantiate}(t, \#)$ | starting time | root |
| 4 | $t_e := \text{Instantiate}(t, \#)$ | end time | root |
| 5 | $x_N^o := \text{Instantiate}(x_N, \#)$ | initial condition for state x | System |
| 6 | $y_N^o := \text{Instantiate}(y_N, \#)$ | initial condition for state y | System |
| 7 | $\pi^{A,\alpha}_N := M^{A,\alpha}_N \cdot x_N$ | effort for B mechanism alpha | System |
| 8 | $\pi^{A,\beta}_N := M^{A,\beta}_N \cdot x_N$ | effort for A mechanism beta | System |
| 9 | $\pi^{B,\gamma}_N := M^{B,\gamma}_N \cdot y_N$ | effort for B mechanism gamma | System |
| 10 | $\pi^{B,\delta}_N := M^{B,\delta}_N \cdot y_N$ | effort for B mechanism delta | System |
| 11 | $\hat{x}^{A,\alpha}_N := F_{N,A} \overset{A}{\star} \left(u_A \cdot K^{A,\alpha}_A \cdot D_{N,A} \overset{N}{\star} \pi^{A,\alpha}_N \right)$ | netflow of token A due to mechanism alpha | System |
| 12 | $\hat{x}^{A,\beta}_N := F_{N,A} \overset{A}{\star} \left(K^{A,\beta}_A \cdot D_{N,A} \overset{N}{\star} \pi^{A,\beta}_N \right)$ | net flow of token A due to mechanism beta | System |
| 14 | $\hat{y}^{B,\gamma}_N := F_{N,A} \overset{A}{\star} \left(K^{B,\gamma}_A \cdot D_{N,A} \overset{N}{\star} \pi^{B,\gamma}_N \right)$ | netflow of token B due to mechanism gamma | System |
| 15 | $\hat{y}^{B,\delta}_N := F_{N,A} \overset{A}{\star} \left(K^{B,\delta}_A \cdot D_{N,A} \overset{N}{\star} \pi^{B,\delta}_N \right)$ | netflow of token B due to mechansim beta | System |

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| no | equation | documentation | layer |
|----|--|---|---------|
| 16 | $\dot{x}_N := \hat{x}^{A,\alpha}_N + \hat{x}^{A,\beta}_N$ | diferential balance for token A | System |
| 17 | $\dot{y}_N := \hat{y}^{B,\gamma}_N + \hat{y}^{B,\delta}_N$ | differential balance for token B | System |
| 20 | $x_N := \int_{t_o}^{t_e} \dot{x}_N dt + x_o_N$ | state token A | System |
| 21 | $y_N := \int_{t_o}^{t_e} \dot{y}_N dt + y_o_N$ | state token B | System |
| 24 | $\underline{\pi}^A_N := \text{Stack}(\pi^{A,\alpha}_N, \pi^{A,\beta}_N)$ | effort for token A stack | System |
| 25 | $\underline{\pi}^B_N := \text{Stack}(\pi^{B,\gamma}_N, \pi^{B,\delta}_N)$ | effort for token B stack | System |
| 26 | $\underline{\pi}^{A,B} := \text{MixedStack}(\underline{\pi}^A_N, \underline{\pi}^B_N)$ | effort for token A, B stack | System |
| 27 | $\pi^{A,\alpha}_N := \text{Instantiate}(\pi^{A,\alpha}_N, \#)$ | effort for B mechanism alpha | System |
| 28 | $\pi^{A,\beta}_N := \text{Instantiate}(\pi^{A,\beta}_N, \#)$ | effort for A mechanism beta | System |
| 29 | $\pi^{B,\gamma}_N := \text{Instantiate}(\pi^{B,\gamma}_N, \#)$ | effort for B mechanism gamma | System |
| 30 | $\pi^{B,\delta}_N := \text{Instantiate}(\pi^{B,\delta}_N, \#)$ | effort for B mechanism delta | System |
| 31 | $s := \text{MixedStack}(x_N, y_N)$ | mixed state | System |
| 32 | $\dot{x}_N := \text{Instantiate}(\dot{x}_N, 0)$ | diferential balance for token A | System |
| 33 | $\dot{y}_N := \text{Instantiate}(\dot{y}_N, 0)$ | differential balance for token B | System |
| 34 | $\dot{xy} := \text{MixedStack}(\dot{x}_N, \dot{y}_N)$ | mixed stack of the two accumulation terms | System |
| 44 | $x_o_N := \text{Instantiate}(x_N, \#)$ | controller state initial condition | Control |
| 45 | $y_{sA} := \text{Instantiate}(m_A, \#)$ | set point | Control |
| 46 | $e_A := m_A - y_{sA}$ | control error | Control |

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| no | equation | documentation | layer |
|----|---|--|------------|
| 47 | $\dot{x}_D := A_{N,D} \overset{N}{\star} x_N + B_{A,D} \overset{A}{\star} e_A$ | differential state | Control |
| 48 | $x_N := \int_{t_o}^{t_e} I_{N,D} \overset{D}{\star} \dot{x}_D dt$ | controller state | Control |
| 49 | $y_A := C_{N,A} \overset{N}{\star} x_N + I_{A,D} \overset{D}{\star} \left(I_{N,D} \overset{N}{\star} D_{N,A} \overset{A}{\star} e_A \right)$ | controller out put | Control |
| 50 | $y_A := C_{N,A} \overset{N}{\star} x_N + D_A \cdot e_A$ | controller out put | Control |
| 51 | $M^{A,\alpha}_N := \text{Instantiate}(M^{A,\alpha}_N, \#)$ | norming factor token A mechanism alpha | Properties |
| 52 | $M^{A,\beta}_N := \text{Instantiate}(M^{A,\beta}_N, \#)$ | norming factor token A mechanism beta | Properties |
| 53 | $M^{B,\gamma}_N := \text{Instantiate}(M^{B,\gamma}_N, \#)$ | norming factor token B mechanism gamma | Properties |
| 54 | $M^{B,\delta}_N := \text{Instantiate}(M^{B,\delta}_N, \#)$ | norming factor token B mechanism delta | Properties |
| 55 | $M^A_N := \text{Stack}(M^{A,\alpha}_N, M^{A,\beta}_N)$ | stack of M matrices token A | Properties |
| 56 | $M^B_N := \text{Stack}(M^{B,\gamma}_N, M^{B,\delta}_N)$ | stack of M matrices token B | Properties |
| 57 | $M_N := \text{Stack}(M^A_N, M^B_N)$ | stack of M matrices token A and B | Properties |
| 58 | $\pi^{A,\alpha,o}_N := \text{Instantiate}(\pi^{A,\alpha}_N, \#)$ | norming factor for pi A alpha | System |
| 59 | $z_N := (\pi^{A,\alpha,o}_N)^{-1} \cdot \pi^{A,\alpha}_N$ | normed measurement of pi A alpha | System |
| 60 | $\underline{z}_A := I_{zN,A} \overset{N}{\star} z_N$ | measurement vector for A | System |
| 61 | $m_A := \text{Instantiate}(m_A, \#)$ | measurement | Control |

8 Interface Link Equation

| no | equation | documentation | layer |
|----|--------------------------|--------------------|-------------------|
| 62 | $m_A := \underline{z}_A$ | interface equation | System »> Control |