

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 System

	var	symbol	documentation	type	units	tokens	eqs
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
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

Continued on next page

	var	symbol	documentation	type	units	tokens	eqs
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		[]	
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
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{xy}	dxy	mixed stack of the two accumulation terms	differentialState		[]	34

4 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

Continued on next page

	var	symbol	documentation	type	units	tokens	eqs
60	$M_N^{B,\delta}$	M_B_delta	norming factor token B mechanism delta	constant		[]	54
69	M_N^A	M_A	stack of M matrices token A	constant		[]	55
70	M_N^B	M_B	stack of M matrices token B	constant		[]	56
71	M_N	M	stack of M matrices token A and B	constant		[]	57

5 Control

	var	symbol	documentation	type	units	tokens	eqs
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	xo_N	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		[]	
68	D_A	D_A	event diagonal matrix D	constant		[]	
64	\dot{x}_D	dx	differential state	differentialState	s^{-1}	[]	47
61	m_A	m	measurement	measure		[]	
62	y_{sA}	setpoint	set point	measure		[]	45
63	e_A	e	control error	measure		[]	46
67	y_A	y	controller output	control		[]	49 50

6 System-Properties

	var	symbol	documentation	type	units	tokens	eqs
--	-----	--------	---------------	------	-------	--------	-----

7 Properties–System

	var	symbol	documentation	type	units	tokens	eqs
--	-----	--------	---------------	------	-------	--------	-----

8 System–Control

	var	symbol	documentation	type	units	tokens	eqs
--	-----	--------	---------------	------	-------	--------	-----

9 Control–System

	var	symbol	documentation	type	units	tokens	eqs
--	-----	--------	---------------	------	-------	--------	-----

10 Properties–Control

	var	symbol	documentation	type	units	tokens	eqs
--	-----	--------	---------------	------	-------	--------	-----

11 Control–Properties

	var	symbol	documentation	type	units	tokens	eqs
--	-----	--------	---------------	------	-------	--------	-----

12 Equations

12.1 Model equations

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	$\hat{x}^{A,\alpha}_N := F_{N,A} \overset{A}{\star} \left(K^{A,\alpha}_A \cdot D_{N,A} \overset{N}{\star} \pi^{A,\alpha}_N \right)$	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

Continued on next page

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	$xo_N := \text{Instantiate}(x_N, \#)$	controller state initial condition	Control
45	$ys_A := \text{Instantiate}(m_A, \#)$	set point	Control
46	$e_A := m_A - ys_A$	control error	Control

Continued on next page

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