1 Variables

2 root

	var	symbol	documentation	type	units	tokens	eqs
8	$F_{N,A}$	`F`	directed graph indicence 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	${x^o}_N$	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		[]	
62	$y_{s\,A}$	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
74	z_N	measure	normed measurement of pi A alpha	measureOut		[]	59
75	$\underline{\mathbf{z}}_A$	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

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	var	symbol	documentation	type	units	tokens	eqs
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
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
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

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	var	symbol	documentation	type	units	tokens	eqs
33	$\underline{\pi}^{A,B}$	`pi_stack`	effort for token A, B stack	secondaryState		[]	26

6 Properties–Control

	var	symbol	documentation	type	units	tokens	eqs

7 Control–Properties

	var	symbol	documentation	type	units	tokens	eqs

8 Properties–System

	var	symbol	documentation	type	units	tokens	eqs

9 System–Properties

	var	symbol	documentation	type	units	tokens	eqs

10 Control–System

	var	symbol	documentation	type	units	tokens	eqs

11 System–Control

	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	${x^o}_N := \text{Instantiate}(x_N, \#)$	initial condition for state x	System
6	${y^o}_N := \text{Instantiate}(y_N, \#)$	initial condition for state y	System
7	${\pi^{A,\alpha}}_N := {M^{A,\alpha}}_N \,.\, x_N$	effort for B mechanism alpha	System
8	${\pi^{A,\beta}}_N := {M^{A,\beta}}_N \,.\, x_N$	effort for A mechanism beta	System
9	${\pi^{B,\gamma}}_N := {M^{B,\gamma}}_N \,.\, y_N$	effort for B mechanism gamma	System
10	${\pi^{B,\delta}}_N := {M^{B,\delta}}_N \,.\, y_N$	effort for B mechanism delta	System
11	${\hat{x}^{A,\alpha}}_N := F_{N,A} \overset{A}{\star} \left({K^{A,\alpha}}_A \,.\, D_{N,A} \overset{N}{\star} {\pi^{A,\alpha}}_N\right)$	netflow of token A due to mechanism alpha	System
12	${\hat{x}^{A,\beta}}_N := F_{N,A} \overset{A}{\star} \left({K^{A,\beta}}_A \,.\, D_{N,A} \overset{N}{\star} {\pi^{A,\beta}}_N\right)$	net flow of token A due to mechanism beta	System
14	${\hat{y}^{B,\gamma}}_N := F_{N,A} \overset{A}{\star} \left({K^{B,\gamma}}_A \,.\, D_{N,A} \overset{N}{\star} {\pi^{B,\gamma}}_N\right)$	netflow of token B due to mechanism gamma	System
15	${\hat{y}^{B,\delta}}_N := F_{N,A} \overset{A}{\star} \left({K^{B,\delta}}_A \,.\, D_{N,A} \overset{N}{\star} {\pi^{B,\delta}}_N\right)$	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	$\underline{\pi}^A{}_N := \text{Stack}\left(\pi^{A,\alpha}{}_N, \pi^{A,\beta}{}_N\right)$	effort for token A stack	System
25	$\underline{\pi}^B{}_N := \text{Stack}\left(\pi^{B,\gamma}{}_N, \pi^{B,\delta}{}_N\right)$	effort for token B stack	System
26	$\underline{\pi}^{A,B} := \text{MixedStack}\left(\underline{\pi}^A{}_N, \underline{\pi}^B{}_N\right)$	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	$s := \text{MixedStack}\left(x_N, y_N\right)$	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	$\dot{xy} := \text{MixedStack}\left(\dot{x}_N, \dot{y}_N\right)$	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 output	Control
50	$y_A := C_{N,A} \overset{N}{\star} x_N + D_A \, . \, e_A$	controller output	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	$M^A{}_N := \text{Stack}\left(M^{A,\alpha}{}_N, M^{A,\beta}{}_N\right)$	stack of M matrices token A	Properties
56	$M^B{}_N := \text{Stack}\left(M^{B,\gamma}{}_N, M^{B,\delta}{}_N\right)$	stack of M matrices token B	Properties
57	$M_N := \text{Stack}\left(M^A{}_N, M^B{}_N\right)$	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	$z_N := \left(\pi^{A,\alpha,o}{}_N\right)^{-1} . \, \pi^{A,\alpha}{}_N$	normed measurement of pi A alpha	System
60	$\underline{\mathbf{z}}_A := I_{z\,N,A} \overset{N}{\star} z_N$	measurement vector for A	System
61	$m_A := \text{Instantiate}(m_A, \#)$	measurement	Control