

# 1 Variables

## 2 root

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

# 3 System

	var	symbol	documentation	type	units	tokens	eqs
25	$\hat{x}^{A,\alpha}_N$	<b>fx_A_alpha</b>	netflow of token A due to mechanism alpha	transport	$ms^{-1}$	[]	<b>11</b>
26	$\hat{x}^{A,\beta}_N$	<b>fx_A_beta</b>	net flow of token A due to mechanism beta	transport	$ms^{-1}$	[]	<b>12</b>
27	$\hat{y}^{B,\gamma}_N$	<b>fy_B_gamma</b>	netflow of token B due to mechanism gamma	transport	$s^{-1}$	[]	<b>14</b>
28	$\hat{y}^{B,\delta}_N$	<b>fy_B_delta</b>	netflow of token B due to mechansim beta	transport	$s^{-1}$	[]	<b>15</b>
36	$D_{N,A}$	<b>D</b>	difference operator	differenceOperator		[]	
9	$x_N$	<b>x</b>	state token A	state	$m$	[]	<b>20</b>
10	$y_N$	<b>y</b>	state token B	state		[]	<b>21</b>
11	$x^o_N$	<b>xo</b>	initial condition for state x	state	$m$	[]	<b>5</b>
12	$y^o_N$	<b>yo</b>	initial condition for state y	state		[]	<b>6</b>
34	$s$	<b>s</b>	mixed state	state		[]	<b>31</b>

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	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		[]	
58	$M^{A,\beta}_N$	M_A_beta	norming factor token A mechanism beta	constant		[]	
59	$M^{B,\gamma}_N$	M_B_gamma	norming factor token B mechanism gamma	constant		[]	

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	var	symbol	documentation	type	units	tokens	eqs
60	$M^{B,\delta}_N$	M_B_delta	norming factor token B mechanism delta	constant		[]	

## 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
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## 7 Properties–System

	var	symbol	documentation	type	units	tokens	eqs
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## 8 System–Control

	var	symbol	documentation	type	units	tokens	eqs
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## 9 Control–System

	var	symbol	documentation	type	units	tokens	eqs
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## 10 Properties–Control

	var	symbol	documentation	type	units	tokens	eqs
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## 11 Control–Properties

	var	symbol	documentation	type	units	tokens	eqs
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## 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

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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	$xo_N := \text{Instantiate}(x_N, \#)$	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