clipper

The PyPHS* development team[1]

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1 System netlist

line	label	dictionary.component	nodes	parameters
ℓ_1	input	electronics.source	('#', 'A')	{ type voltage
ℓ_2	d1	electronics.diode	('B', '#')	{ Is ('Is', 2e-09) R ('Rd', 0.5) v0 ('v0', 0.026) mu ('mu', 1.7)
ℓ_3	C	electronics.capacitor	('A', 'B')	{ C ('Csymbol', 1e-09)
ℓ_4	output	electronics.source	('B', '#')	{ type current
ℓ_5	d2	electronics.diode	('#', 'B')	{ Is ('Is', 2e-09) R ('Rd', 0.5) v0 ('v0', 0.026) mu ('mu', 1.7)

"

2 Core dimensions

The system

$\dim(\mathbf{l}) = n_{\mathbf{l}} = 1$

*https://pyphs.github.io/pyphs/

†https://www.ircam.fr/recherche/equipes-recherche/systemes-et-signaux-sonores-audioacoustique-instruments-s3

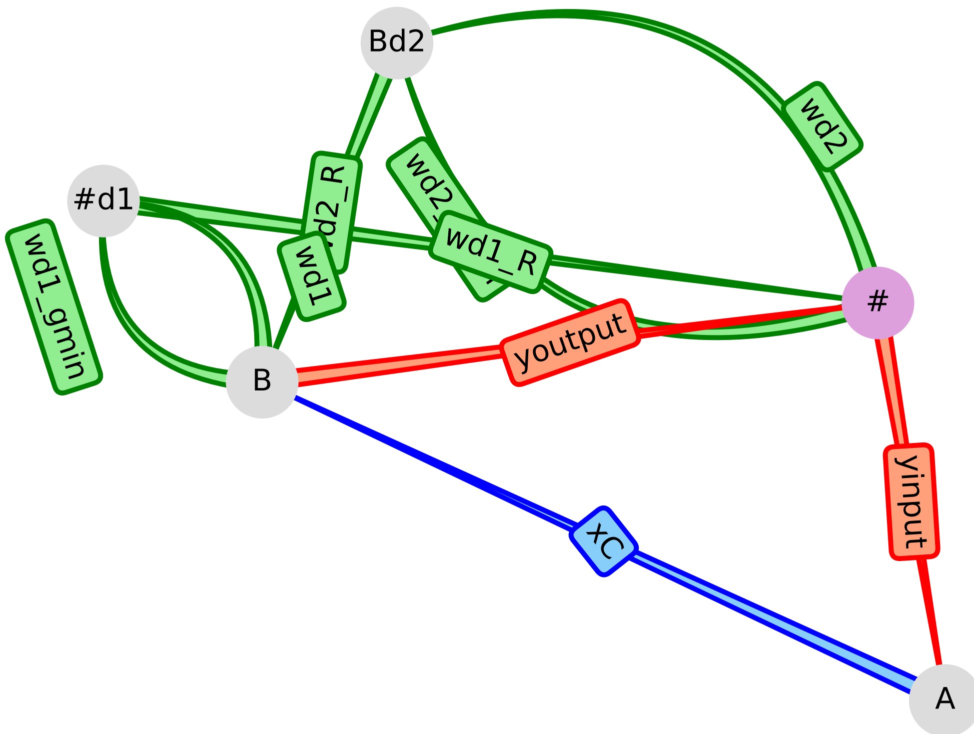

Figure 1: Graph of system `clipper`.

$\dim(\mathbf{n_l}) = n_{\mathbf{n_l}} = 2$

$\dim(\mathbf{x}) = n_{\mathbf{x}} = 1$

$\dim(\mathbf{x_l}) = n_{\mathbf{x_l}} = 1$

$\dim(\mathbf{x_n l}) = n_{\mathbf{x_n l}} = 0$

$\dim(\mathbf{w}) = n_{\mathbf{w}} = 2$

$\dim(\mathbf{w_l}) = n_{\mathbf{w_l}} = 0$

$\dim(\mathbf{w_n l}) = n_{\mathbf{w_n l}} = 2$

$\dim(\mathbf{y}) = n_{\mathbf{y}} = 2$

$\dim(\mathbf{p}) = n_{\mathbf{p}} = 0$

$\dim(\mathbf{o}) = n_{\mathbf{o}} = 0$

$\dim(\mathbf{cy}) = n_{\mathbf{cy}} = 0$

3 Core quantities

3.1 Core constants

parameter	value (SI)
I_{s}	2e-09
R_{d}	0.5
v_0	0.026
m_{u}	1.7
g_{min}	1e-12
C_{symbol}	1e-09

3.2 Core variables

The system variables are:

- the *state* $\mathbf{x} : t \mapsto \mathbf{x}(t) \in \mathbb{R}^1$ associated with the system's energy storage:

$$\mathbf{x} = \left(\begin{array}{c} x_{\mathrm{C}} \end{array} \right)$$

- the *state increment* $\mathbf{d_x} : t \mapsto \mathbf{d_x}(t) \in \mathbb{R}^1$ that represents the numerical increment during a single simulation time-step:

$$\mathbf{d_x} = \left(\begin{array}{c} d_{\mathrm{xC}} \end{array} \right)$$

- the *dissipation variable* $\mathbf{w} : t \mapsto \mathbf{w}(t) \in \mathbb{R}^2$ associated with the system's energy dissipation:

$$\mathbf{w} = \left(\begin{array}{c} w_{\mathrm{d1}} \\ w_{\mathrm{d2}} \end{array} \right)$$

3.3 Core inputs

The input (*i.e.* controlled quantities) are:

- the *input variable* $\mathbf{u} : t \mapsto \mathbf{u}(t) \in \mathbb{R}^2$ associated with the system's energy supply (sources):

$$\mathbf{u} = \begin{pmatrix} u_{\text{output}} \\ u_{\text{input}} \end{pmatrix}$$

- the *parameters* $\mathbf{p} : t \mapsto \mathbf{p}(t) \in \mathbb{R}^0$ associated with variable system parameters:

$$\mathbf{p} = \text{Empty}$$

3.4 Core outputs

The output (*i.e.* observed quantities) are:

- the *output variable* $\mathbf{y} : t \mapsto \mathbf{y}(t) \in \mathbb{R}^2$ associated with the system's energy supply (sources):

$$\mathbf{y} = \begin{pmatrix} y_{\text{output}} \\ y_{\text{input}} \end{pmatrix}$$

- the *observer* $\mathbf{o} : t \mapsto \mathbf{o}(t) \in \mathbb{R}^0$ associated with functions of the above quantities:

$$\mathbf{o} = \text{Empty}$$

3.5 Core connectors

The connected quantities are:

- the *connected inputs* $\mathbf{u}_c : t \mapsto \mathbf{u}_c(t) \in \mathbb{R}^0$

$$\mathbf{u}_c = \text{Empty}$$

- the *connected outputs* $\mathbf{y}_c : t \mapsto \mathbf{y}_c(t) \in \mathbb{R}^0$

$$\mathbf{y}_c = \text{Empty}$$

4 Core constitutive relations

4.1 Core storage function

The system's storage function is:

$$\mathrm{H}(\mathbf{x}) = \frac{0.5}{C_{\mathrm{symbol}}} \cdot x_{\mathrm{C}}^{2}$$

The gradient of the system's storage function is:

$$\nabla\mathrm{H}(\mathbf{x}) = \begin{pmatrix} g_{\mathrm{xC}} \end{pmatrix}$$

The elements of the storage function's gradient are given below:

$$g_{\mathrm{xC}} = \frac{1.0}{C_{\mathrm{symbol}}} \cdot x_{\mathrm{C}}$$

The Hessian matrix of the storage function is:

$$\triangle\mathrm{H}(\mathbf{x}) = \begin{pmatrix} \frac{1.0}{C_{\mathrm{symbol}}} \end{pmatrix}$$

The Hessian matrix of the linear part of the storage function is:

$$\mathbf{Q} = \begin{pmatrix} \frac{1.0}{C_{\mathrm{symbol}}} \end{pmatrix}$$

4.2 Core dissipation function

The dissipative function is:

$$\mathbf{z}(\mathbf{w}) = \begin{pmatrix} z_{\mathrm{d1}} \\ z_{\mathrm{d2}} \end{pmatrix}$$

The elements of the dissipation function are given below:

$$z_{\mathrm{d1}} = I_{\mathrm{s}} \cdot \left(e^{\frac{w_{\mathrm{d1}}}{m_{\mathrm{u}} \cdot v_{0}}} - 1\right)$$

$$z_{\mathrm{d2}} = I_{\mathrm{s}} \cdot \left(e^{\frac{w_{\mathrm{d2}}}{m_{\mathrm{u}} \cdot v_0}} - 1\right)$$

The jacobian matrix of the dissipation function is:

$$\mathcal{J}_{\mathbf{z}}(\mathbf{w}) = \begin{pmatrix} \frac{I_{\mathrm{s}} \cdot e^{\frac{w_{\mathrm{d1}}}{m_{\mathrm{u}} \cdot v_0}}}{m_{\mathrm{u}} \cdot v_0} & 0 \\ 0 & \frac{I_{\mathrm{s}} \cdot e^{\frac{w_{\mathrm{d2}}}{m_{\mathrm{u}} \cdot v_0}}}{m_{\mathrm{u}} \cdot v_0} \end{pmatrix}$$

The jacobian matrix of the linear part of the dissipation function is:

$$\mathbf{Z}_{\mathrm{l}} = \begin{pmatrix} g_{\mathrm{min}} & 0 & 0 & 0 \\ 0 & g_{\mathrm{min}} & 0 & 0 \\ 0 & 0 & R_{\mathrm{d}} & 0 \\ 0 & 0 & 0 & R_{\mathrm{d}} \end{pmatrix}$$

5 Core structure

$$\begin{pmatrix} \frac{\mathrm{d}\,\mathbf{x}}{\mathrm{d}t} \\ \mathbf{w} \\ \mathbf{y} \end{pmatrix} = \begin{pmatrix} \mathbf{M_{xx}} & \mathbf{M_{xw}} & \mathbf{M_{xy}} \\ \mathbf{M_{wx}} & \mathbf{M_{ww}} & \mathbf{M_{wy}} \\ \mathbf{M_{yx}} & \mathbf{M_{yw}} & \mathbf{M_{yy}} \end{pmatrix} \cdot \begin{pmatrix} \nabla \mathrm{H} \\ \mathbf{z} \\ \mathbf{u} \end{pmatrix}$$

$$\underbrace{\begin{pmatrix} \mathbf{M_{xx}} & \mathbf{M_{xw}} & \mathbf{M_{xy}} \\ \mathbf{M_{wx}} & \mathbf{M_{ww}} & \mathbf{M_{wy}} \\ \mathbf{M_{yx}} & \mathbf{M_{yw}} & \mathbf{M_{yy}} \end{pmatrix}}_{\mathbf{M}} = \underbrace{\begin{pmatrix} \mathbf{J_{xx}} & \mathbf{J_{xw}} & \mathbf{J_{xy}} \\ -^{\intercal}\mathbf{J_{xw}} & \mathbf{J_{ww}} & \mathbf{J_{wy}} \\ -^{\intercal}\mathbf{J_{xy}} & -^{\intercal}\mathbf{J_{wy}} & \mathbf{J_{yy}} \end{pmatrix}}_{\mathbf{J}} - \underbrace{\begin{pmatrix} \mathbf{R_{xx}} & \mathbf{R_{xw}} & \mathbf{R_{xy}} \\ ^{\intercal}\mathbf{R_{xw}} & \mathbf{R_{ww}} & \mathbf{R_{wy}} \\ ^{\intercal}\mathbf{R_{xy}} & ^{\intercal}\mathbf{R_{wy}} & \mathbf{R_{yy}} \end{pmatrix}}_{\mathbf{R}}$$

5.1 Core M-structure

$$\mathbf{M} = \begin{pmatrix} -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 1.0 & -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \\ -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 0 & 0 & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \\ \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 0 & -\frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 0 & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \\ -1.0 & 0 & 0 & 0 & -1.0 \\ -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 1.0 & -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{xx}} = \begin{pmatrix} -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{xw}} = \begin{pmatrix} \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{xy}} = \begin{pmatrix} 1.0 & -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{xcy}} = \mathrm{Empty}$$

$$\mathbf{M_{wx}} = \begin{pmatrix} -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \\ \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{ww}} = \begin{pmatrix} -\frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 0 \\ 0 & -\frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{wy}} = \begin{pmatrix} 0 & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \\ 0 & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{wcy}} = \mathrm{Empty}$$

$$\mathbf{M_{yx}} = \begin{pmatrix} -1.0 \\ -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{yw}} = \begin{pmatrix} 0 & 0 \\ \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{yy}} = \begin{pmatrix} 0 & -1.0 \\ 1.0 & -\frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{M_{ycy}} = \mathrm{Empty}$$

$$\mathbf{M_{cyx}} = \mathrm{Empty}$$

$$\mathbf{M_{cyw}} = \mathrm{Empty}$$

$$\mathbf{M_{cyy}} = \mathrm{Empty}$$

$$\mathbf{M_{cycy}} = \mathrm{Empty}$$

5.2 Core J-structure

$$\mathbf{J} = \begin{pmatrix} 0 & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 1.0 & 0 \\ -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 0 & 0 & 0 & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \\ \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 0 & 0 & 0 & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \\ -1.0 & 0 & 0 & 0 & -1.0 \\ 0 & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & 1.0 & 0 \end{pmatrix}$$

$$\mathbf{J_{xx}} = \mathrm{Zeros}$$

$$\mathbf{J_{xw}} = \begin{pmatrix} \frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\mathrm{min}}+1} \end{pmatrix}$$

$$\mathbf{J_{xy}} = \begin{pmatrix} 1.0 & 0 \end{pmatrix}$$

$$\mathbf{J_{xcy}} = \text{Empty}$$

$$\mathbf{J_{wx}} = \begin{pmatrix} -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\min}+1} \\ \frac{1.0}{R_{\mathrm{d}} \cdot g_{\min}+1} \end{pmatrix}$$

$$\mathbf{J_{ww}} = \text{Zeros}$$

$$\mathbf{J_{wy}} = \begin{pmatrix} 0 & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\min}+1} \\ 0 & \frac{1.0}{R_{\mathrm{d}} \cdot g_{\min}+1} \end{pmatrix}$$

$$\mathbf{J_{wcy}} = \text{Empty}$$

$$\mathbf{J_{yx}} = \begin{pmatrix} -1.0 \\ 0 \end{pmatrix}$$

$$\mathbf{J_{yw}} = \begin{pmatrix} 0 & 0 \\ \frac{1.0}{R_{\mathrm{d}} \cdot g_{\min}+1} & -\frac{1.0}{R_{\mathrm{d}} \cdot g_{\min}+1} \end{pmatrix}$$

$$\mathbf{J_{yy}} = \begin{pmatrix} 0 & -1.0 \\ 1.0 & 0 \end{pmatrix}$$

$$\mathbf{J_{ycy}} = \text{Empty}$$

$$\mathbf{J_{cyx}} = \text{Empty}$$

$$\mathbf{J_{cyw}} = \text{Empty}$$

$$\mathbf{J_{cyy}} = \text{Empty}$$

$$\mathbf{J_{cycy}} = \text{Empty}$$

5.3 Core R-structure

$$\mathbf{R} = \begin{pmatrix} \frac{2.0 \cdot g_{\min}}{R_{\mathrm{d}} \cdot g_{\min}+1} & 0 & 0 & 0 & \frac{2.0 \cdot g_{\min}}{R_{\mathrm{d}} \cdot g_{\min}+1} \\ 0 & \frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\min}+1} & 0 & 0 & 0 \\ 0 & 0 & \frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\min}+1} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \frac{2.0 \cdot g_{\min}}{R_{\mathrm{d}} \cdot g_{\min}+1} & 0 & 0 & 0 & \frac{2.0 \cdot g_{\min}}{R_{\mathrm{d}} \cdot g_{\min}+1} \end{pmatrix}$$

$$\mathbf{R_{xx}} = \begin{pmatrix} \frac{2.0 \cdot g_{\min}}{R_{\mathrm{d}} \cdot g_{\min}+1} \end{pmatrix}$$

$$\mathbf{R_{xw}} = \text{Zeros}$$

$$\mathbf{R_{xy}} = \begin{pmatrix} 0 & \frac{2.0 \cdot g_{\min}}{R_{\mathrm{d}} \cdot g_{\min}+1} \end{pmatrix}$$

$$\mathbf{R_{xcy}} = \text{Empty}$$

$$\mathbf{R_{wx}} = \text{Zeros}$$

$$\mathbf{R_{ww}} = \begin{pmatrix} \frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}} + 1} & 0 \\ 0 & \frac{1.0 \cdot R_{\mathrm{d}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}} + 1} \end{pmatrix}$$

$$\mathbf{R_{wy}} = \text{Zeros}$$

$$\mathbf{R_{wcy}} = \text{Empty}$$

$$\mathbf{R_{yx}} = \begin{pmatrix} 0 \\ \frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}} + 1} \end{pmatrix}$$

$$\mathbf{R_{yw}} = \text{Zeros}$$

$$\mathbf{R_{yy}} = \begin{pmatrix} 0 & 0 \\ 0 & \frac{2.0 \cdot g_{\mathrm{min}}}{R_{\mathrm{d}} \cdot g_{\mathrm{min}} + 1} \end{pmatrix}$$

$$\mathbf{R_{ycy}} = \text{Empty}$$

$$\mathbf{R_{cyx}} = \text{Empty}$$

$$\mathbf{R_{cyw}} = \text{Empty}$$

$$\mathbf{R_{cyy}} = \text{Empty}$$

$$\mathbf{R_{cycy}} = \text{Empty}$$