# Model Documentation of the Hysteresis System

## 1 Nomenclature

### 1.1 Nomenclature for Model Equations

| | |
|---|---|
| $s_1$ | switching treshold down |
| $s_2$ | switching treshold up |
| $y_i$ | output values of the hysteresis system for i = 1, 2 |
| $T_{storage}$ | time constant of the internal linear first order system (PT1) |
| $w$ | input signal |
| $x_1$ | state signal |
| $a_i$ | auxiliary signals for i = 1, 2, 3, 4, 5 |

## 2 Model Equations

Input Vector:

$$u = w$$

Equations:

$$a_1 = \begin{cases} -1, & \text{for } w < 4 \\ 0, & \text{for } w \geq 4 \end{cases} \tag{1a}$$

$$a_2 = \begin{cases} 0, & \text{for } w < 8 \\ 1, & \text{for } w \geq 8 \end{cases} \tag{1b}$$

$$a_3 = a_1 + a_2 + x_1 \tag{1c}$$

$$a_4 = \begin{cases} 0, & \text{for } w < 4 \\ & \quad \text{or } w < 8 \text{ in case w decreased under 4} \\ & \quad \text{and did not rise over 8 since then} \\ 1, & \text{for } w > 8 \\ & \quad \text{or } w > 4 \text{ in case w increased over 8} \\ & \quad \text{and did not sink under 4 since then} \end{cases} \tag{1d}$$

$$x_1 = [0, 1] \tag{1e}$$

$$a_5 = [2, 11] \tag{1f}$$

Parameters: $s_1$, $s_2$, $y_1$, $y_2$, $T_{storage}$
Outputs: $y$

### 2.1 Exemplary parameter values

| Symbol | Value |
|---|---|
| $s_1$ | 4 |
| $s_2$ | 8 |
| $y_1$ | 2 |
| $y_2$ | 11 |
| $T_{storage}$ | 0.0001 |

## 3 Derivation and Explanation

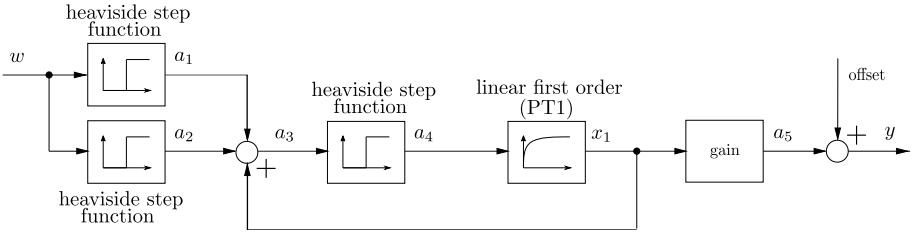


Figure 1: Block Diagram

## 4 Simulation

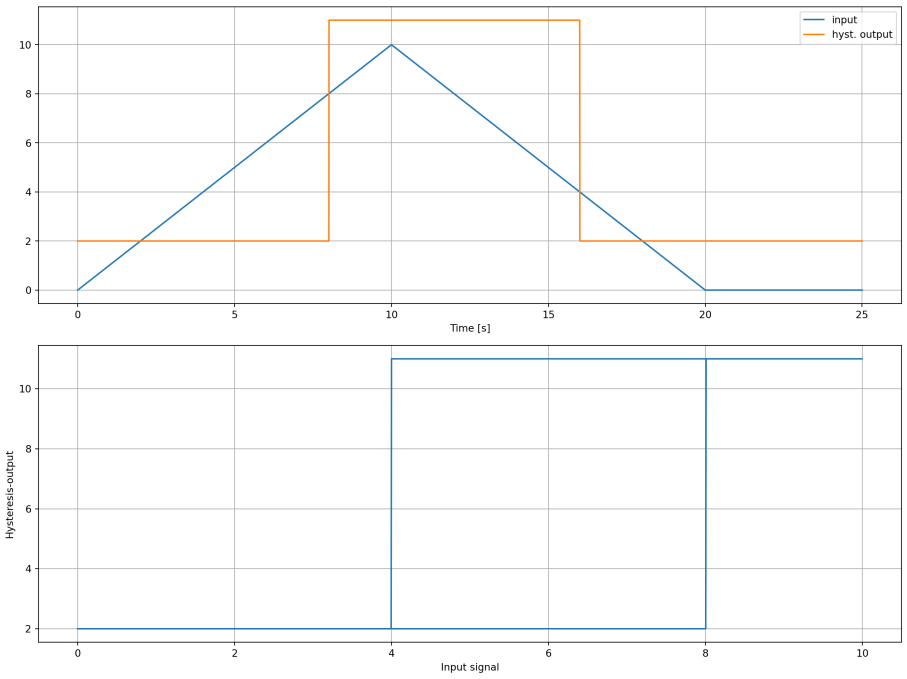


Figure 2: Simulation of the hysteresis system.

# References

[1] Knoll, Carsten: *Approximation of a simple hysteresis system.*, Python script published 2021.
`https://github.com/TUD-RST/pyblocksim/blob/master/examples/example-hysteresis.py`