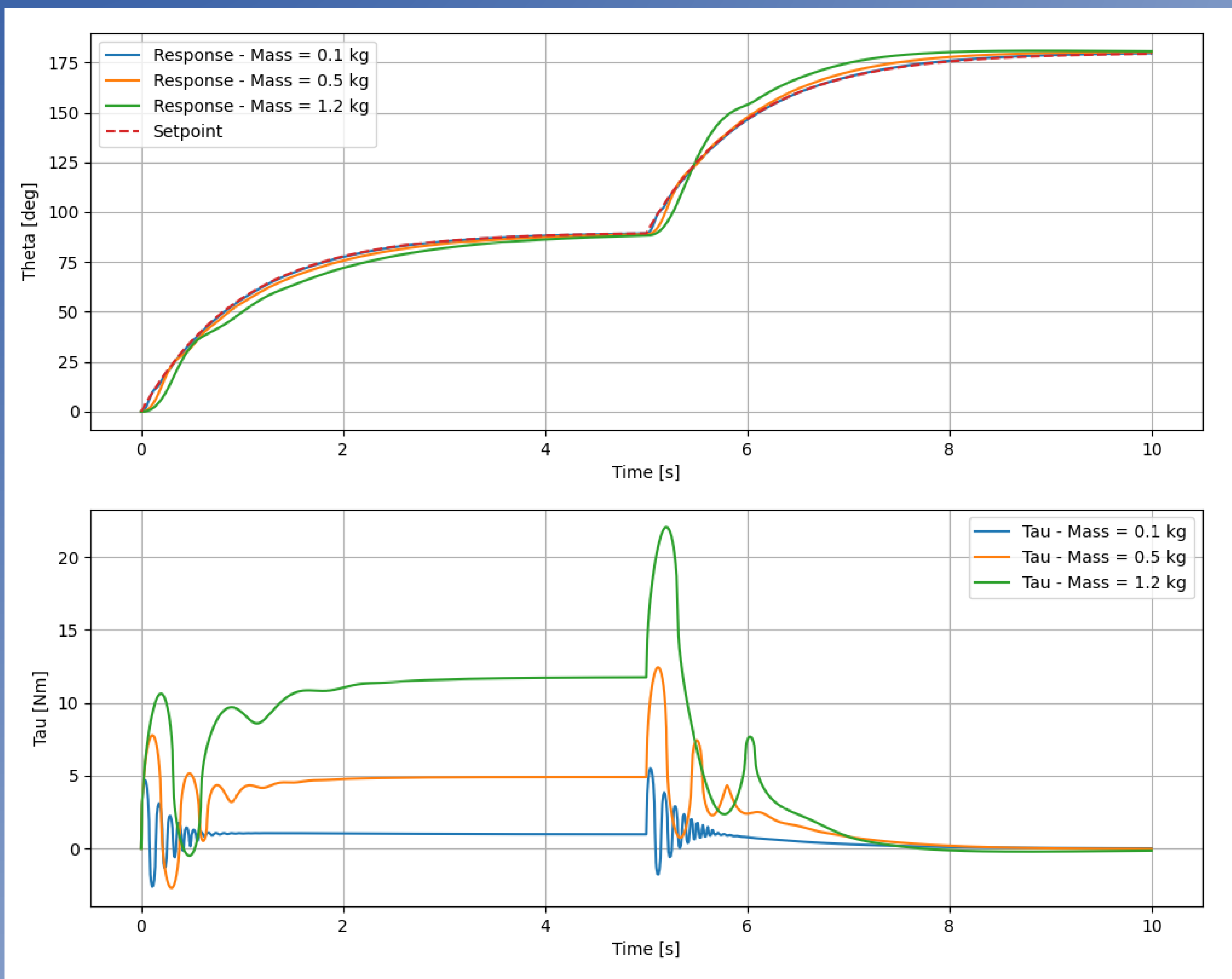
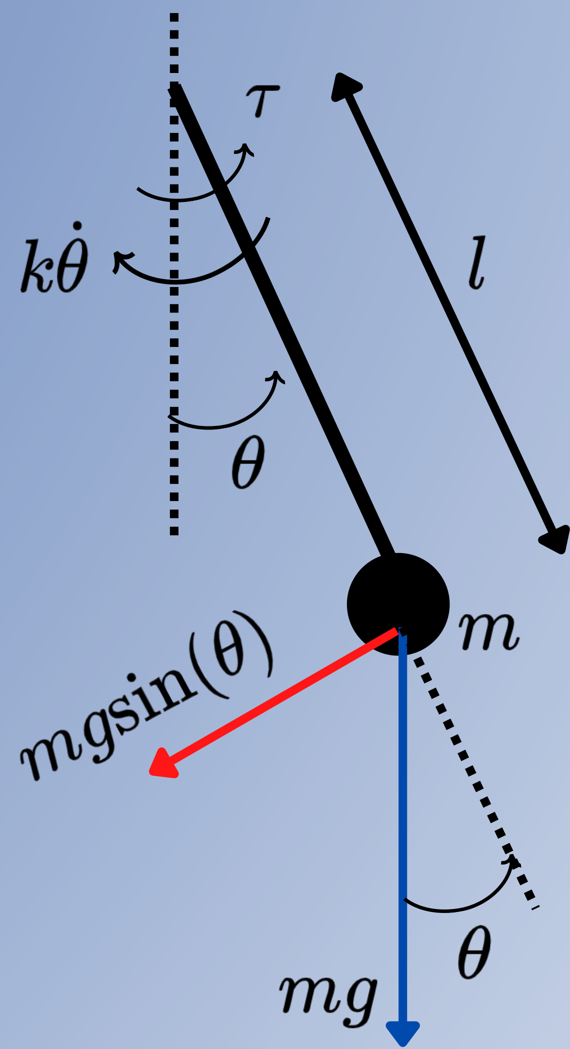
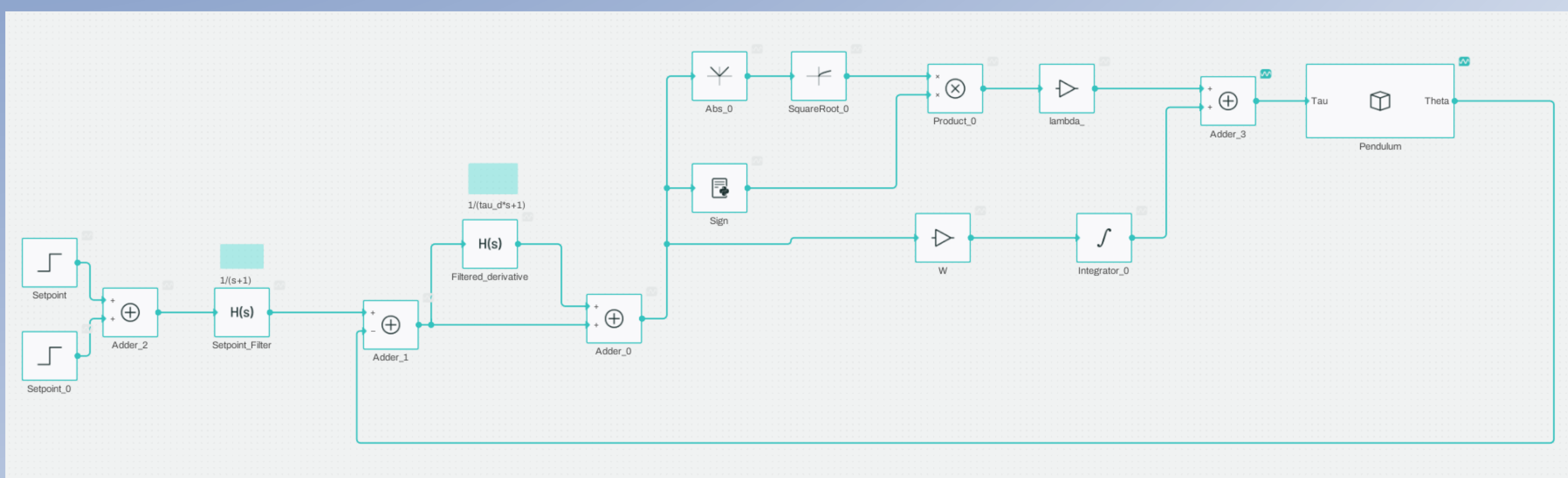
Sliding Mode Control







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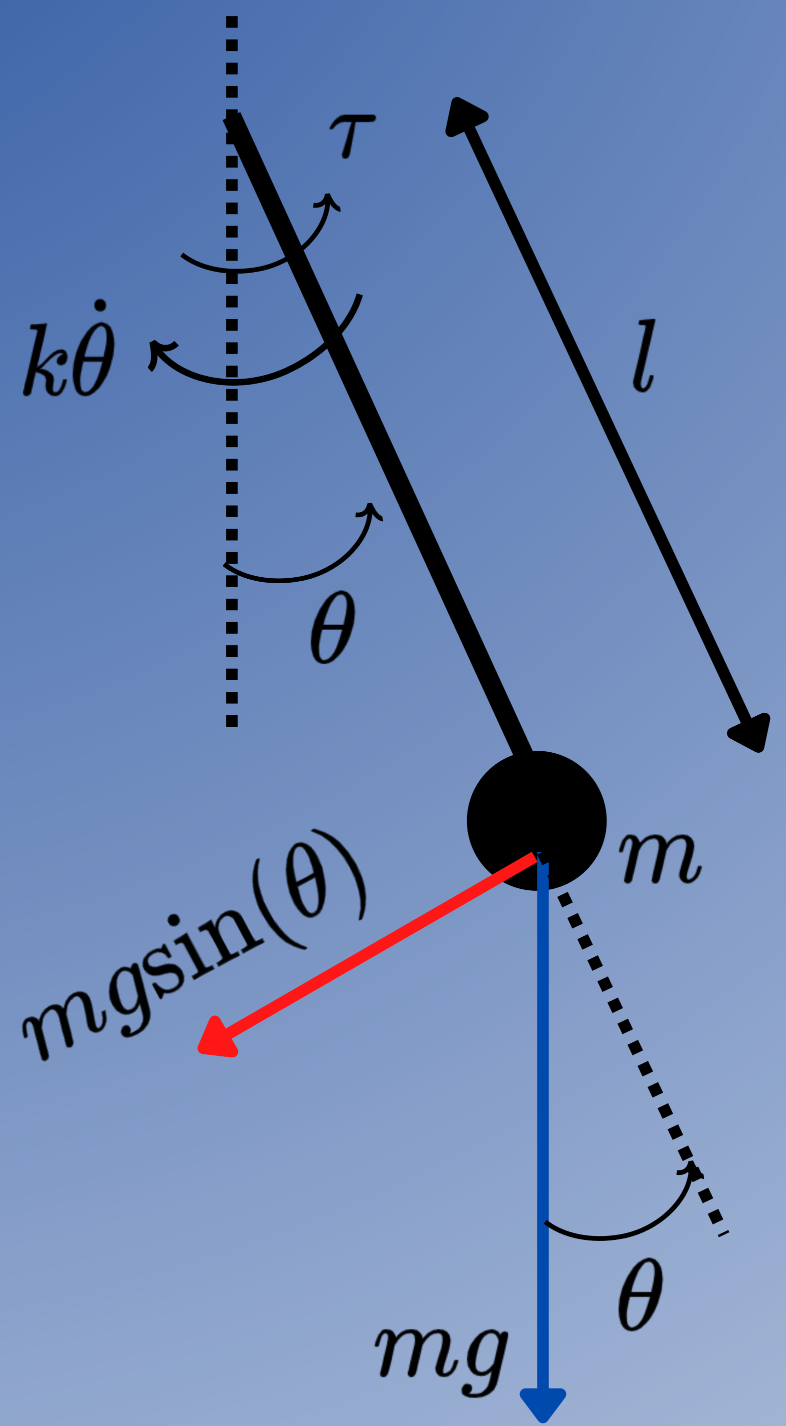
Code
https://github.com/simorxb/SMC-Pendulum

Plant – Pendulum



$m = 0.5\ kg$

$l = 1\ m$

$k = 0.5\ Nms$

$$\tau = ml^2\ddot{\theta} + k\dot{\theta} + mglsin(\theta)$$

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Sliding Surface

Sliding Mode Control (SMC) is a non-linear control technique, which aims to drive the system onto a specific surface in the state space, called sliding surface or manifold.

Once reached, the control strategy keeps the states close to the sliding surface.

A common choice is to use a sliding surface that is a function of the control error ($e(t) = \theta_{ref}(t) - \theta(t)$ in our case) and its derivatives.

The number of derivatives of the error to include in the definition of the surface is the input-output relative degree of the system (i.e. the number of states needed to describe the system in state-space form). In our case the relative degree is 2, therefore we need to use $e(t)$ and $\dot{e}(t)$.

We choose:

$$\sigma(t) = e(t) + \dot{e}(t)$$

In the Laplace domain we have:

$$\Sigma(s) = E(s) + sE(s) \rightarrow \frac{E(s)}{\Sigma(s)} = G(s) = \frac{1}{s+1}$$

Therefore, if we steer $\sigma(t)$ to 0, $e(t)$ will go to 0 following $G(s)$'s dynamics.

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Super Twisting Algorithm

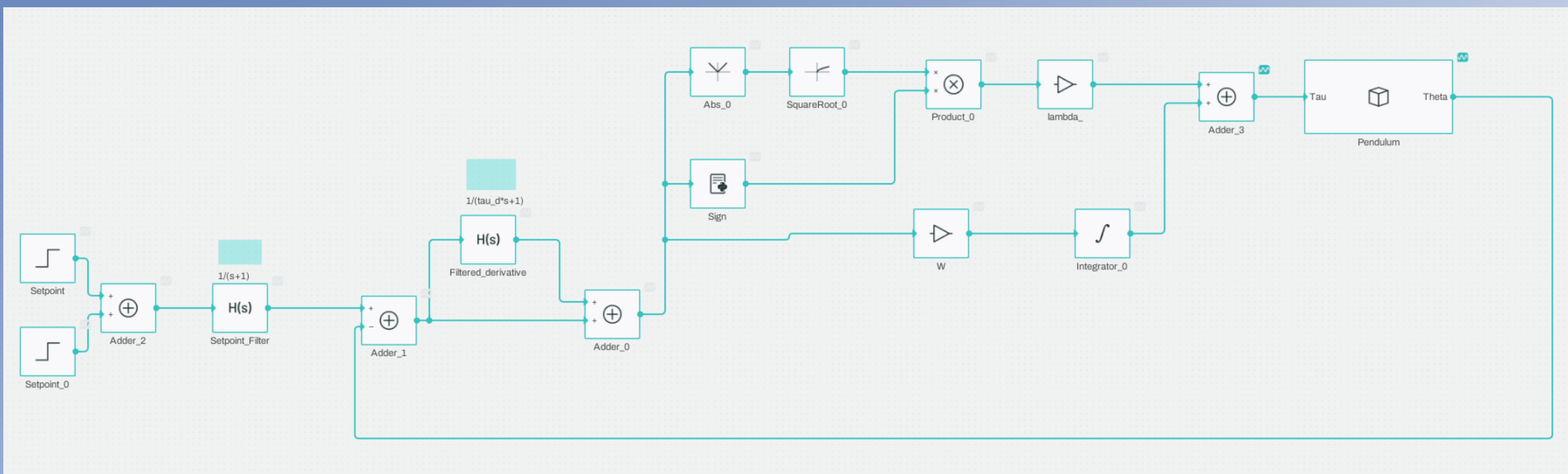
There are various options to choose the control law used to steer σ to 0.

In this case we choose a second-order SMC algorithm called Super Twisting Algorithm:

$$
\begin{aligned}
u &= \lambda\sqrt{|\sigma|}\,\mathrm{sign}(\sigma) + w \\
\dot{w} &= W\,\mathrm{sign}(\sigma)
\end{aligned}
$$

Where λ and W are tuneable parameters.

Implementation – Collimator



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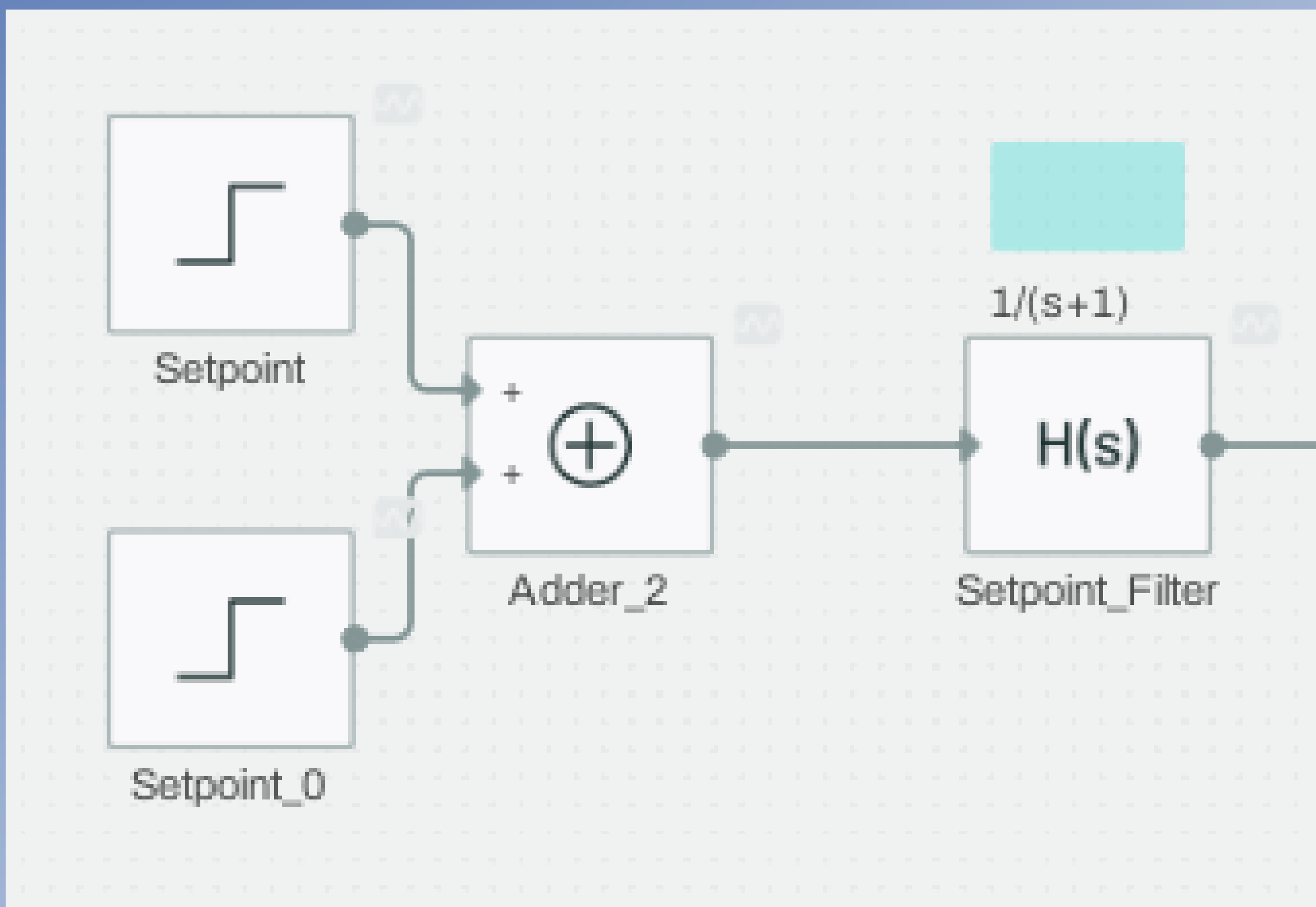
Implementation Detail – Setpoint Generation



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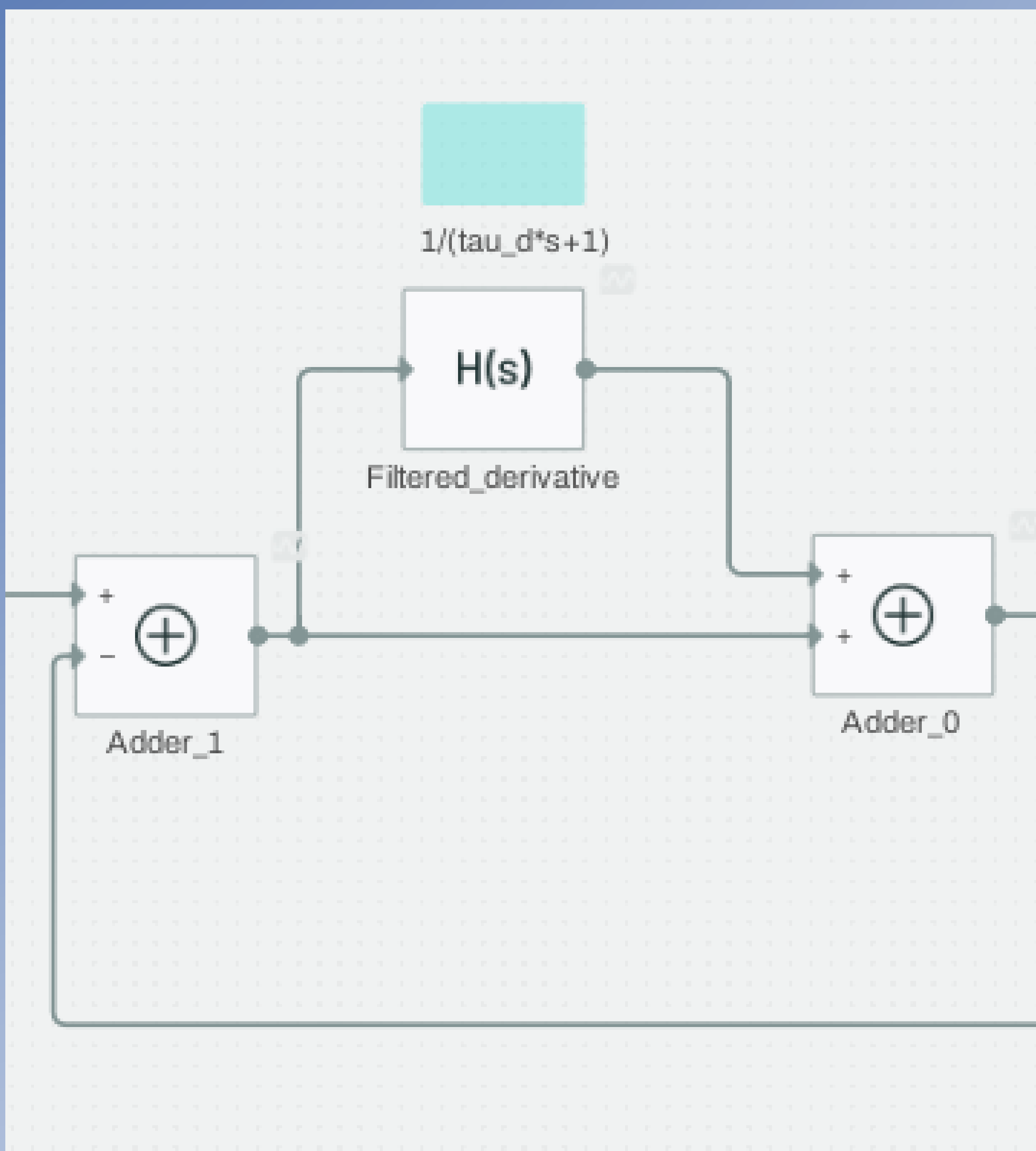
Implementation Detail – Sliding Surface



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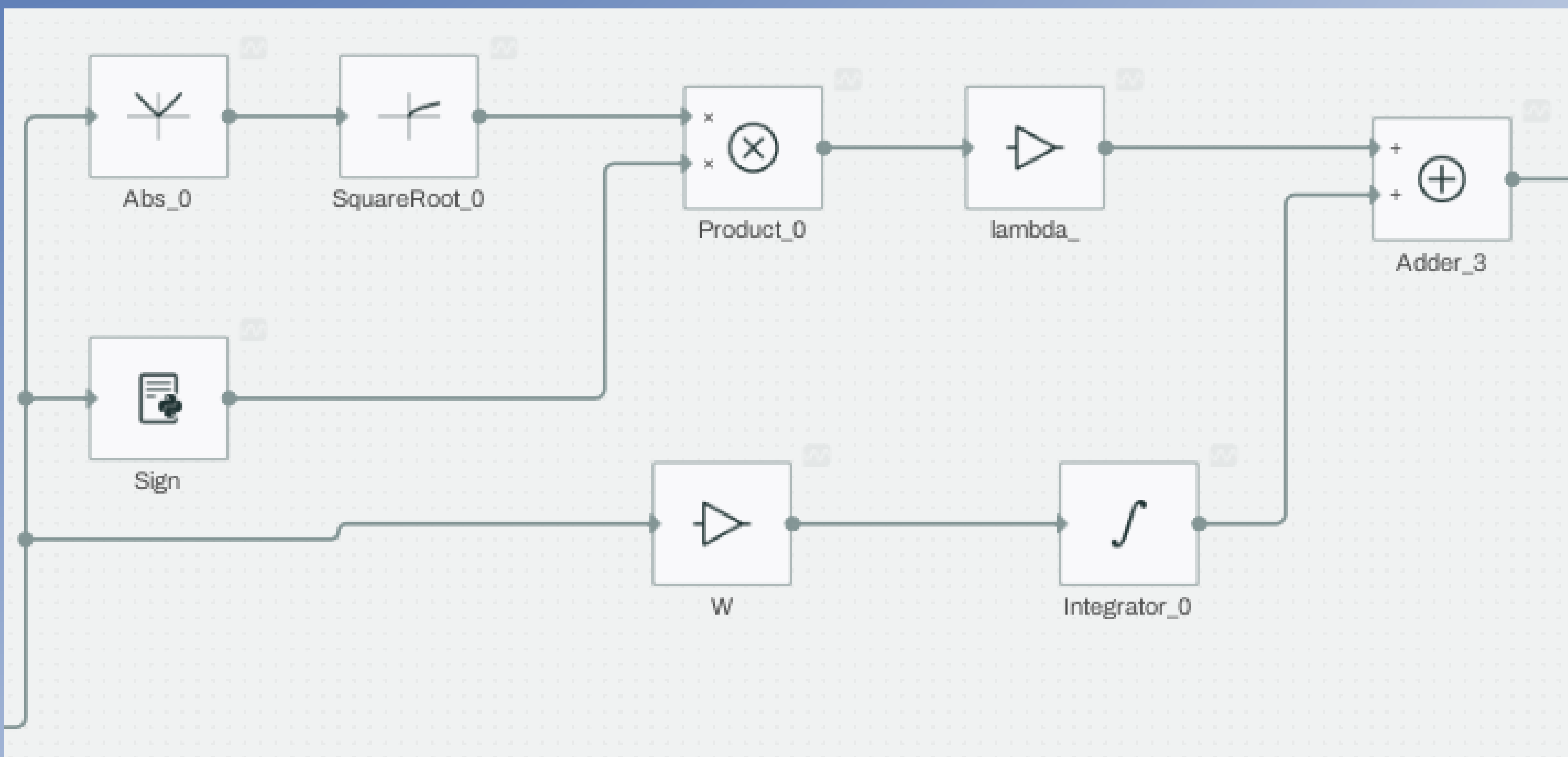
Implementation Detail – Super Twisting Algorithm



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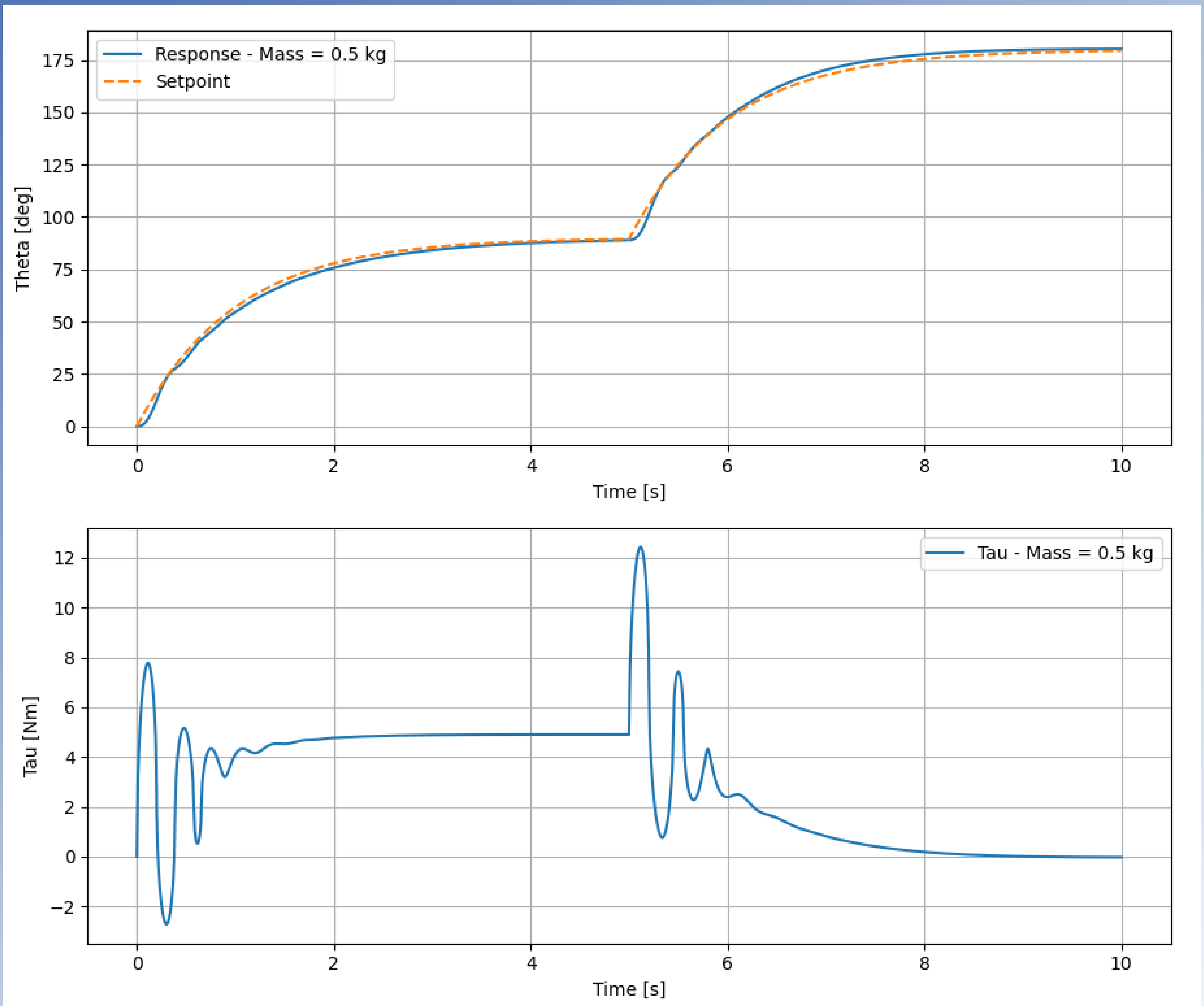
Simulation – Nominal Response

Response with m = 0.5 kg - used for tuning



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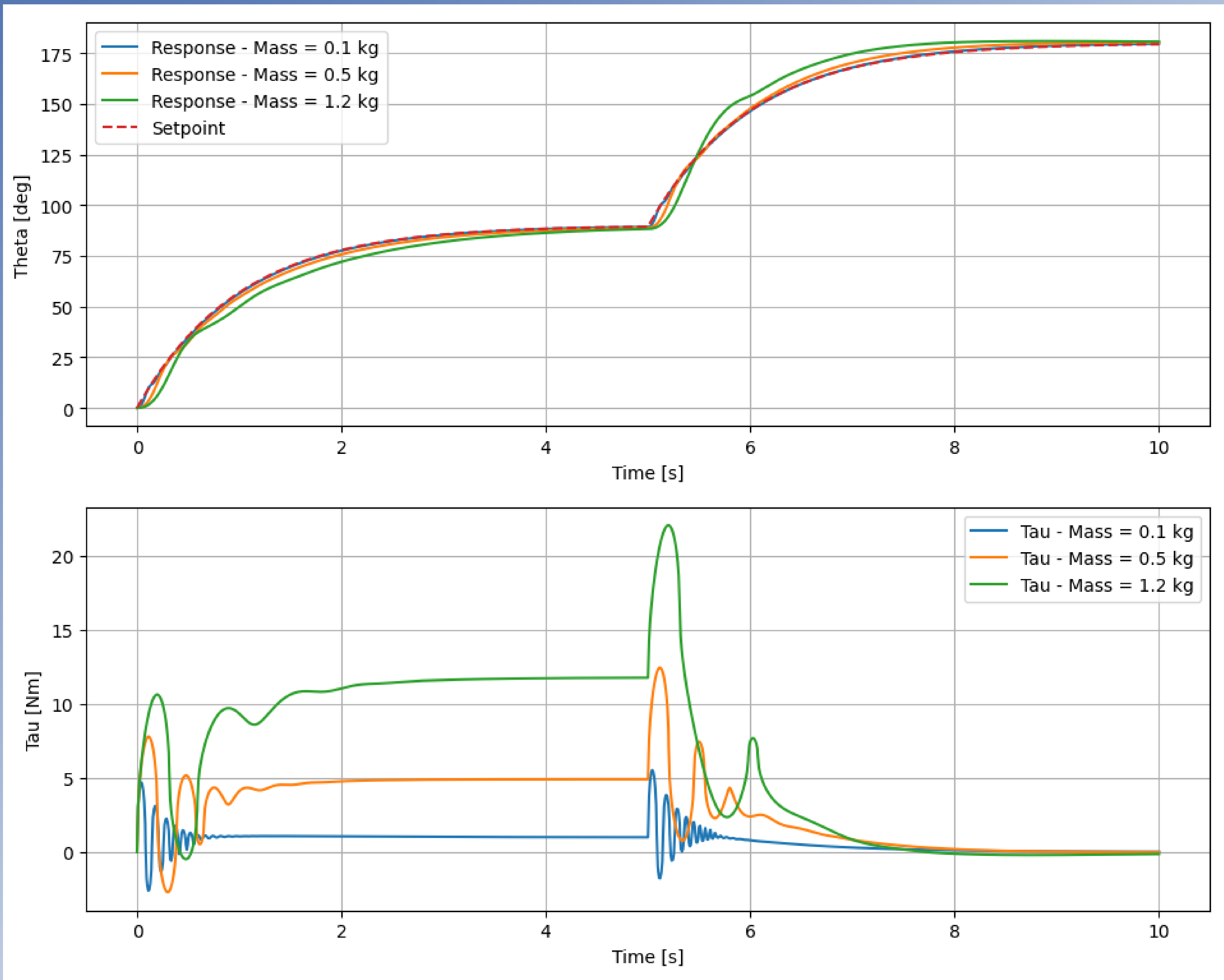
Simulation – Robustness

Robustness analysis for

m = 0.1 kg, m = 0.5 kg, m = 1.2 kg



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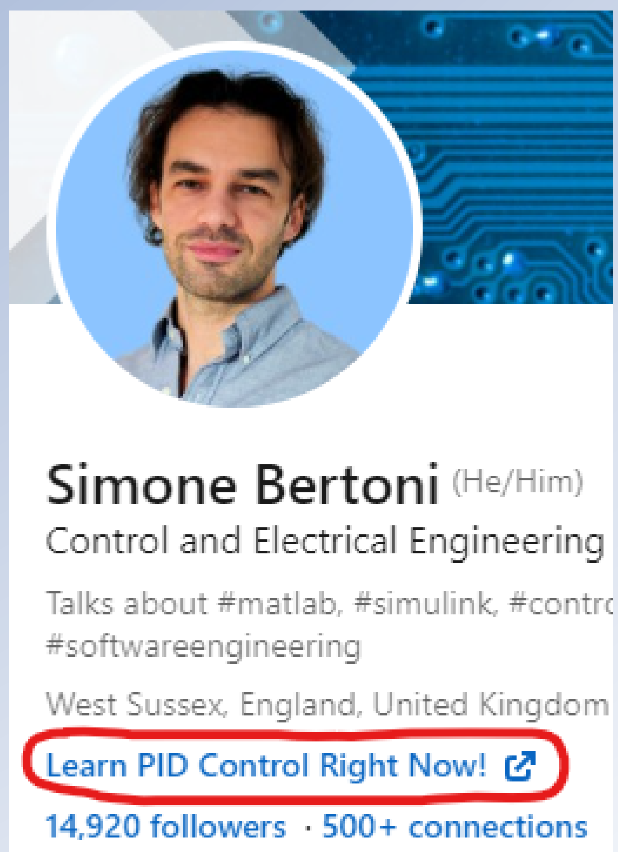
PID Control

Interested in PID Control? Check out my digital course:

https://simonebertoni.thinkific.com/

Find the link here!



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