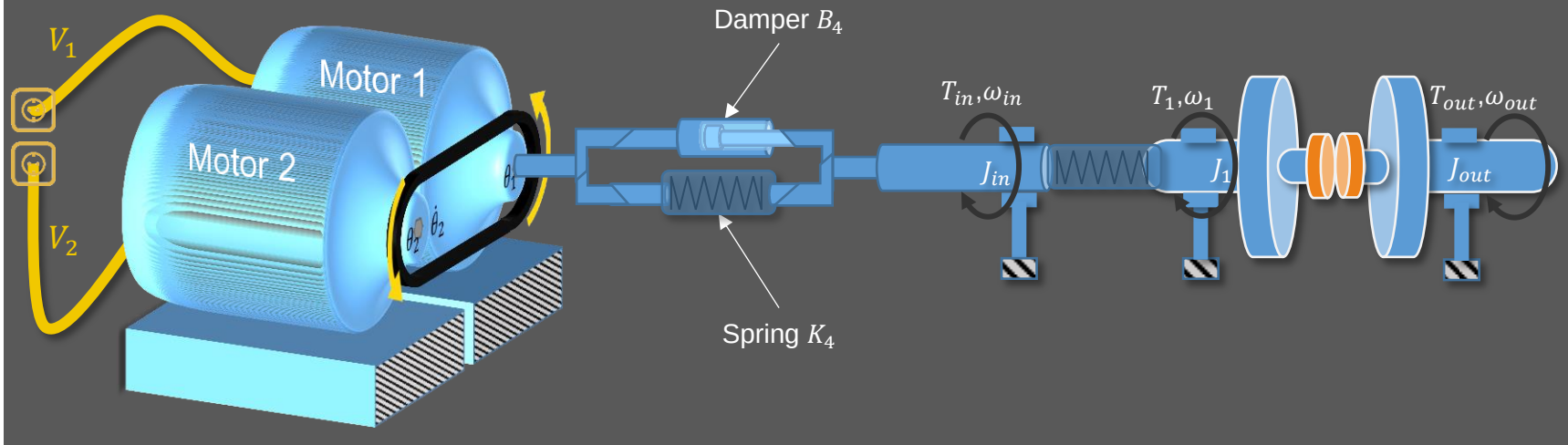
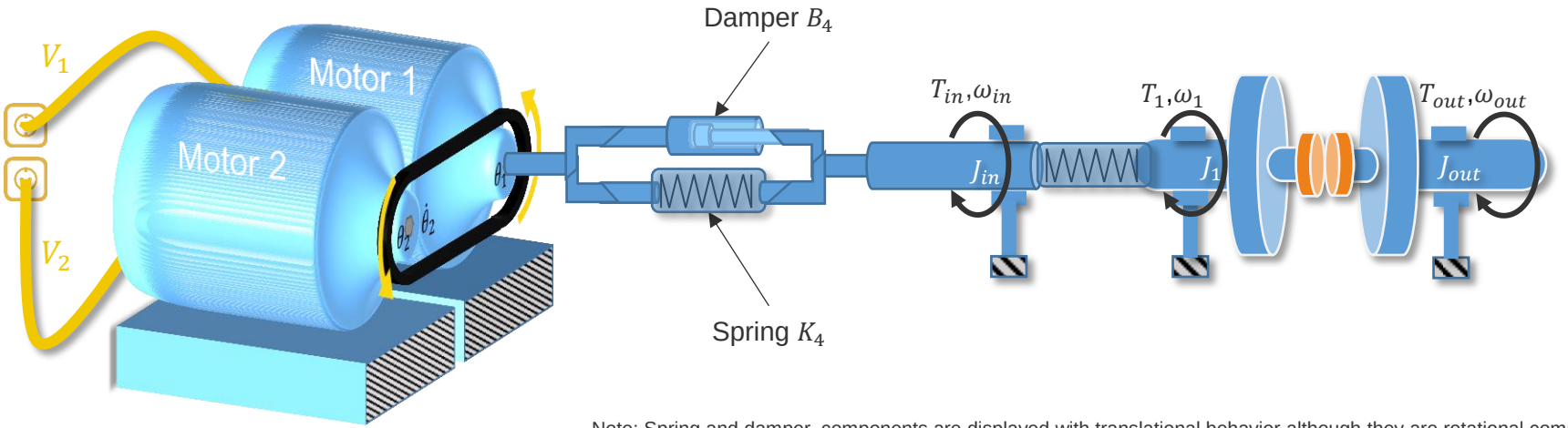
Modeling & Simulation of two DC - motors applied to a plate clutch using solidThinking *Activate*



Two DC-motors applied to a plate clutch

Two armature controlled DC-motors (out of section 7) are applied to the plate clutch (out of section 5).
For more detailed information about the corresponding models see the very section.

The connection is realized via a parallel connection of a spring with a stiffness of K_4 and a rotational damper with a damping factor of B_4

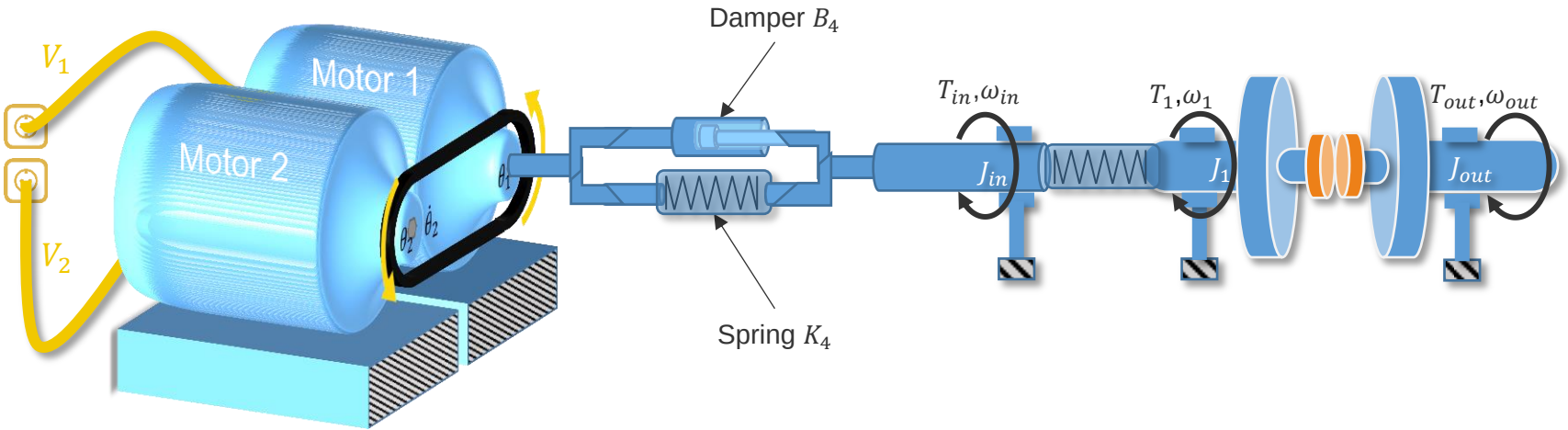


Note: Spring and damper components are displayed with translational behavior although they are rotational components.

Two DC-motors applied to a plate clutch

Objectives

- Learn how to…
  - … connect two complex systems by feedback loops



Creation and Simulation of two DC-motors(7) applied to a plate clutch(5)

Theoretical background and how to implement it using *Activate*

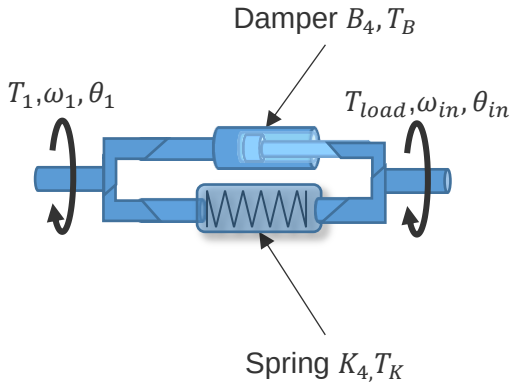
Step 1: Connecting the systems (Two DC motors ⇔ clutch)

Step 2: Implementation using *Activate*

Step 3: Validation of the results

Step 1: Connecting the systems (Two DC motors ⇔ clutch)

- $T_{load} = T_K + T_B$
- $T_{load} = (\theta_1 - \theta_{in})K_4 + (\omega_1\text{-}\omega_{in})B_4$

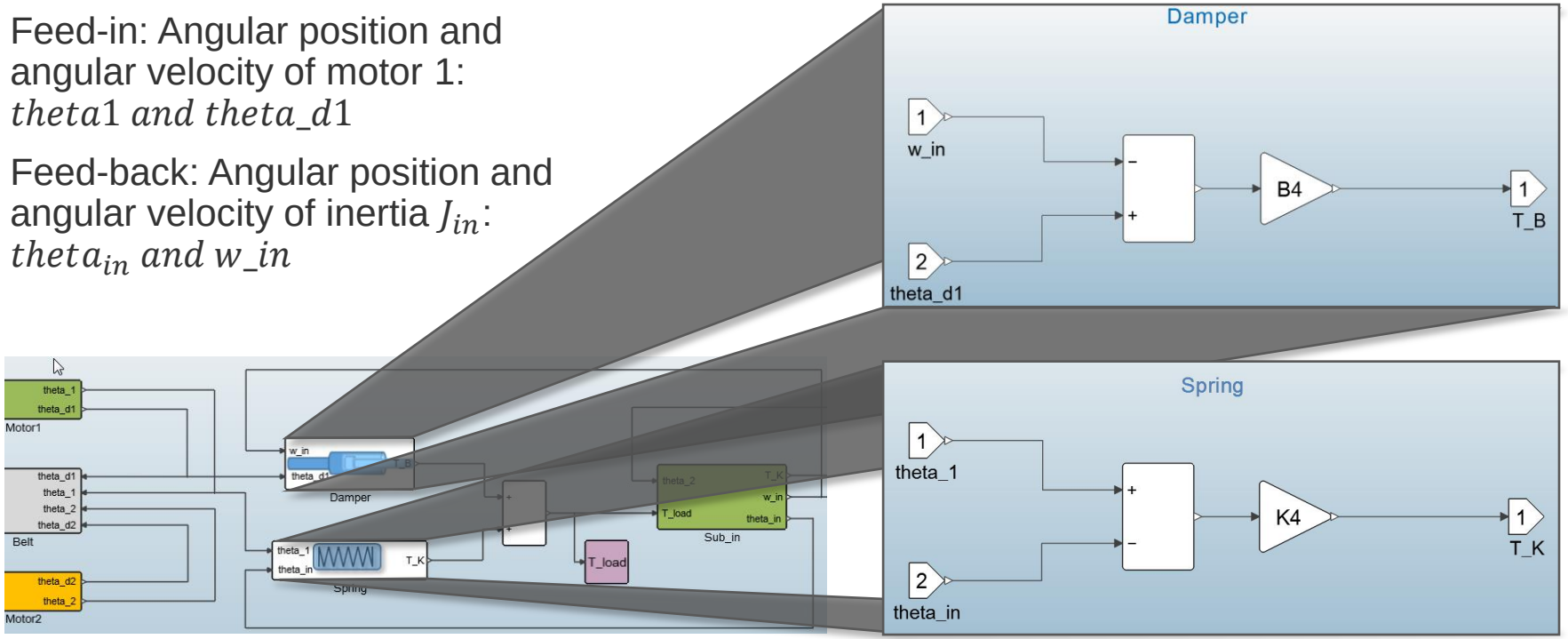


- Additionally:
- Motor 1 and 2 are not frictionless anymore *(compare section 6: DC motor)*
  - Friction factor = B
  - $J_1\ddot{\theta_1} = K_1 i_1 - B\dot{\theta_1} - T_{load} - \mathrm{T_{Belt}}$
  - $J_2\ddot{\theta_2} = K_2 i_2 - B\dot{\theta_2} + T_{Belt}$

- The time dependent variable friction B_{var} begins disengaging at $20s$.

Step 2: Implementation using *Activate*

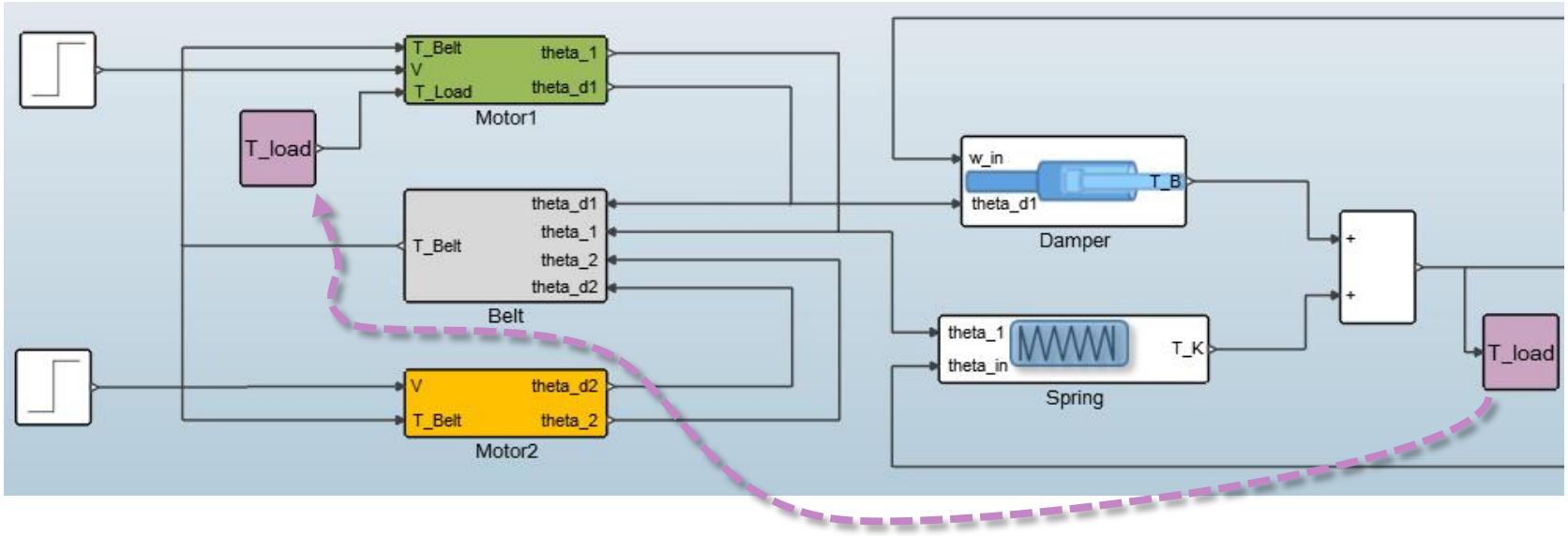
- Feed-in: Angular position and angular velocity of motor 1: $theta1\ and\ theta\_d1$
- Feed-back: Angular position and angular velocity of inertia J_{in}: $theta_{in}\ and\ w\_in$



Step 2: Implementation using *Activate*

- The Torque *(produced by spring and damper)* influences the motor as a load torque and is fedback to motor 1.

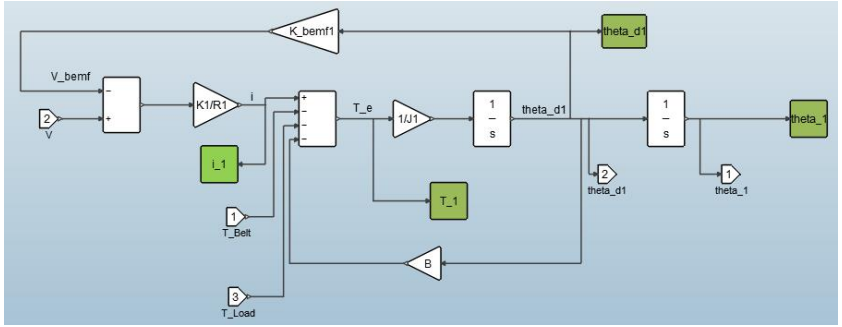
- *Note:* To prevent interactions, implement *GetSignal* and *SetSignal* blocks.



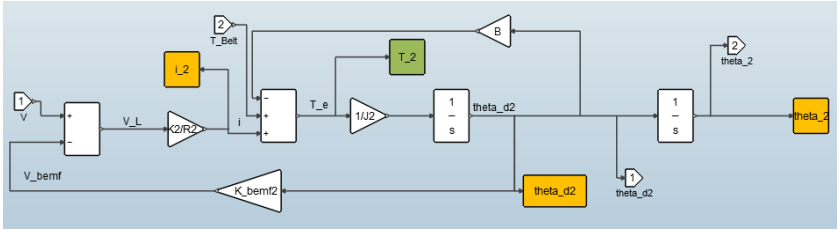
Step 2: Implementation using *Activate*

- Implementation of Friction into motor 1 and 2

- Motor 1:
- $J_1\ddot{\theta}_1 = K_1 i_1 - B\dot{\theta}_1 - T_{load} - \mathrm{T_{Belt}}$

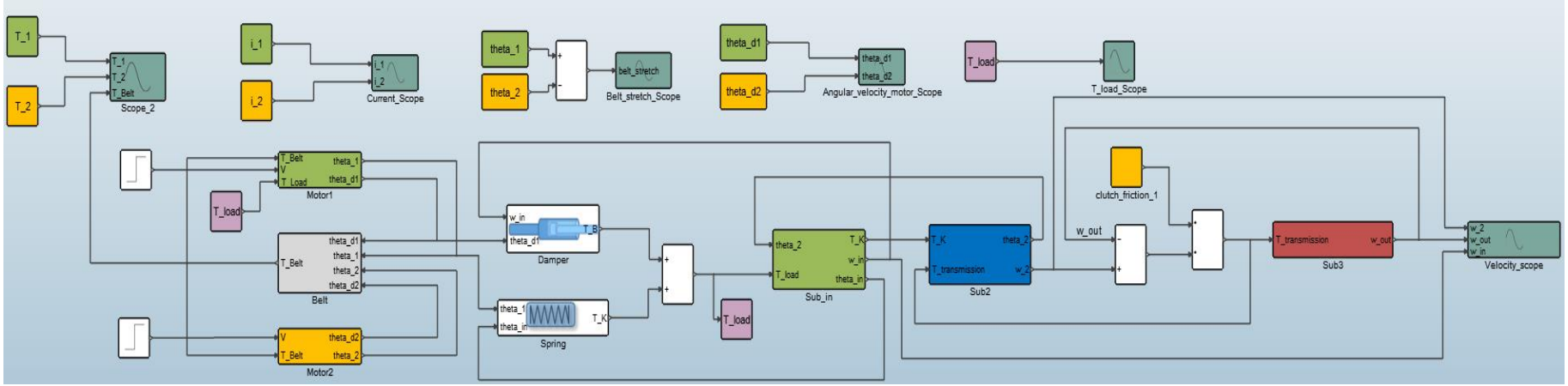


- Motor 2:
- $J_2\ddot{\theta}_2 = K_2 i_2 \ - B\dot{\theta}_2 + T_{Belt}$



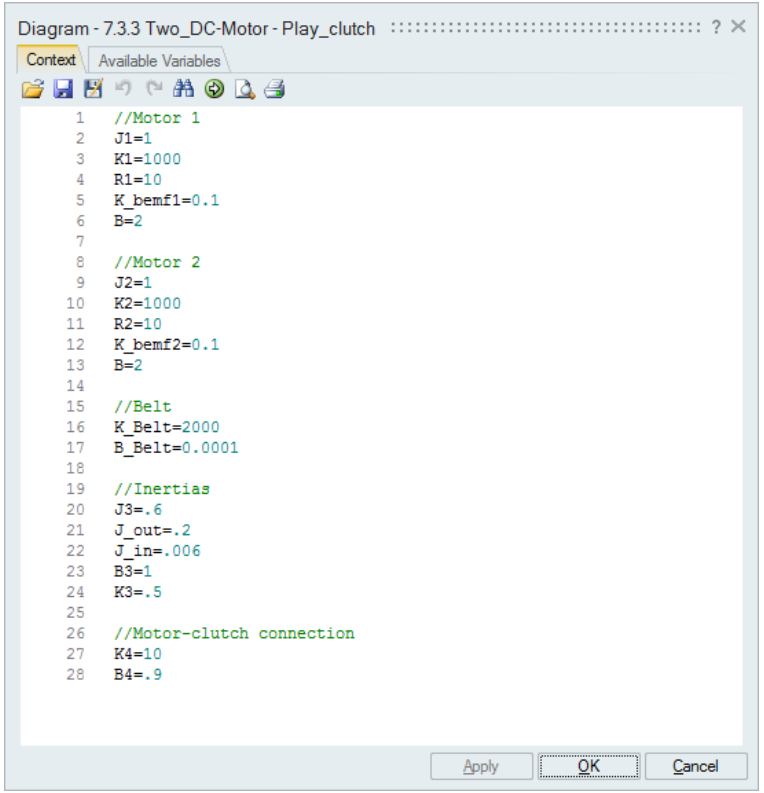
Step 2: Implementation using *Activate*

Complete model:



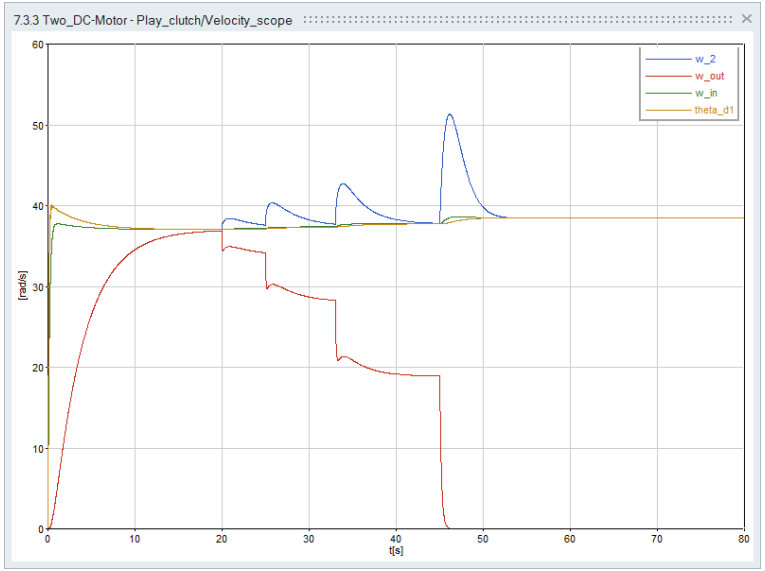
Step 2: Implementation using *Activate*

- Initialization of parameters

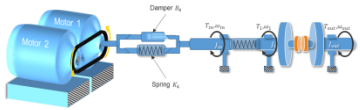


Step 3: Validation of the results

- The clutch is fully engaged during the first $20s$.
  - Motor 1 runs up to $40\frac{rad}{s}$ quickly $(orange\ line)$.
  - J_{in} $(green\ line)$ responds faster than $J_{out}(red\ line)$, because the spring between $motor\ 1$ and J_{in} $(K_4 = 10)$ is stiffer than the spring between J_{in} and J_2 $(K_3 = .5)$.
- The clutch begins disengaging at $20\ s$.
  - As the clutch disengages the load torque decreases.
  - As the load torque decreases, the motor speed increases $(orange\ line)$.
- The overshoot amplitude of w_2 $(blue\ line)$ is governed by the shaft spring constant.
  - The smaller the spring constant the larger the overshoot.



Legend:
green: angular velocity of J_{in}
red: angular velocity of J_{out}
blue: angular velocity of J_2
orange: rotor speed of $motor\ 1$



J_{in}

J_{in} J_2 J_{out}

Step 3: Validation of the results

- Friction between motors and belt and within the motors itself produces a permanent belt stretch when running at a constant speed
  - The belt stretch reaches a steady state of $0.08m$ stretch after the clutch is fully disengaged because the motor speed has increased slightly.

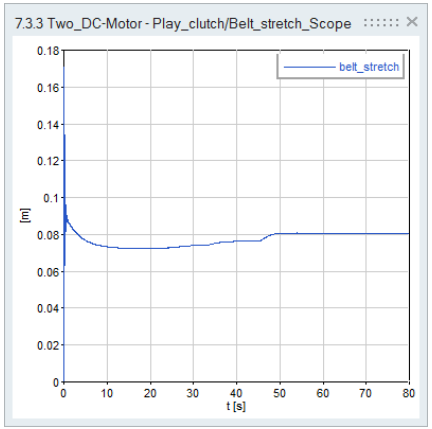


Fig. 1: Belt stretch

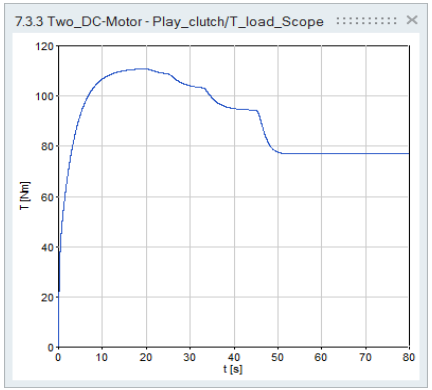


Fig. 2: Load Torque