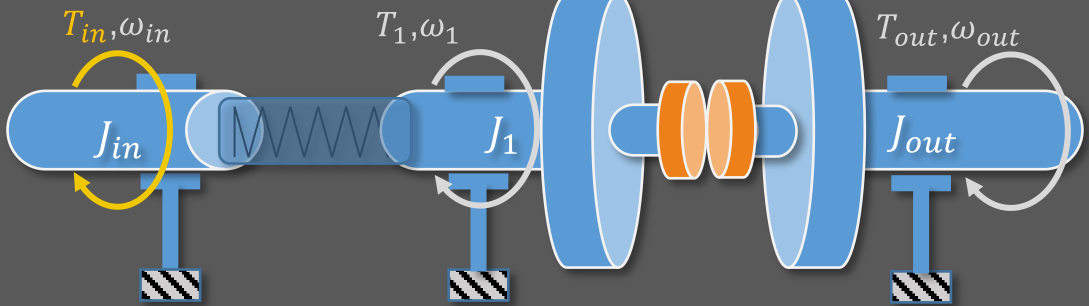
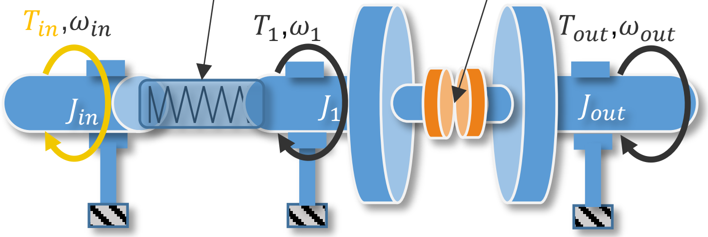
Modeling and Simulation of a plate clutch with crankshaft using solidThinking Activate



Simplified clutch with crankshaft

The "dry" plate clutch is often used in automobile drivetrain applications to transmit power from the engine to the driving wheels.

The input to the clutch is torque T_{in}, and the output is velocity ω_{out} . The implemented crankshaft exhibits a torsional stiffness of K. The clutch is modeled as a variable damper with damping controlled by a clutch pedal angle and a nonlinear "TableLookUp"-relationship between pedal angle and damping.



Objectives

- Learn how to…
  - … create individual functions with a "LookUpTable"-block
  - … dynamically adjust a parameter during the simulation

Creation and Simulation of a simplified clutch with crankshaft

Theoretical background and how to implement it using *Activate*

Step 1: Construction of equations

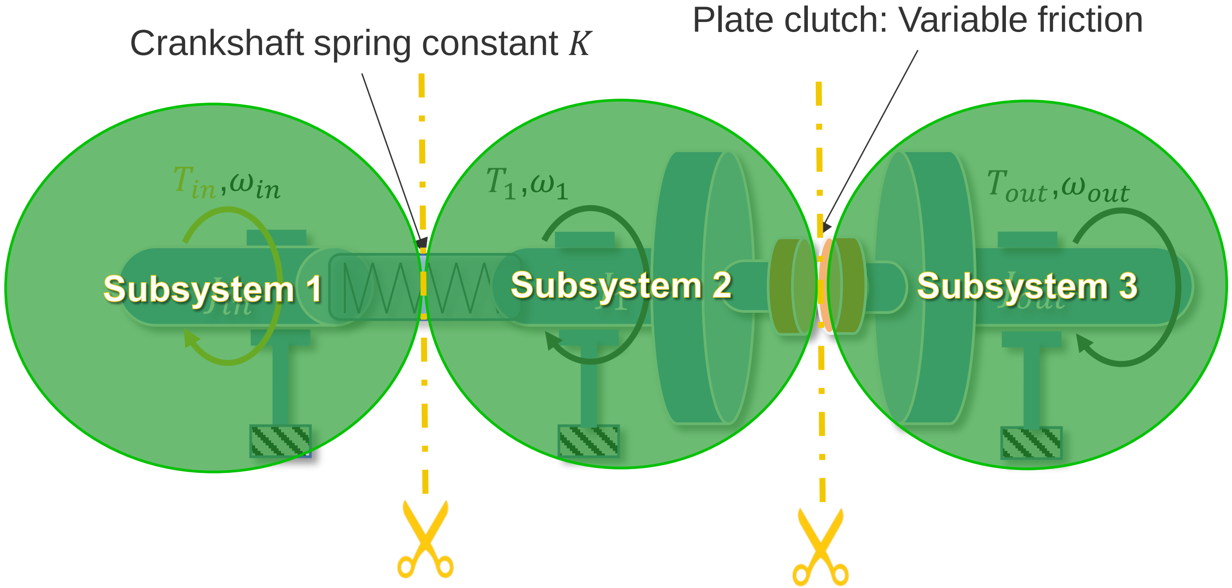
- Step 1.1: Creating subsystems
- Step 1.2: Presentation of equations

Step 2: Implementation using *Activate*

Step 3: Validation of the results

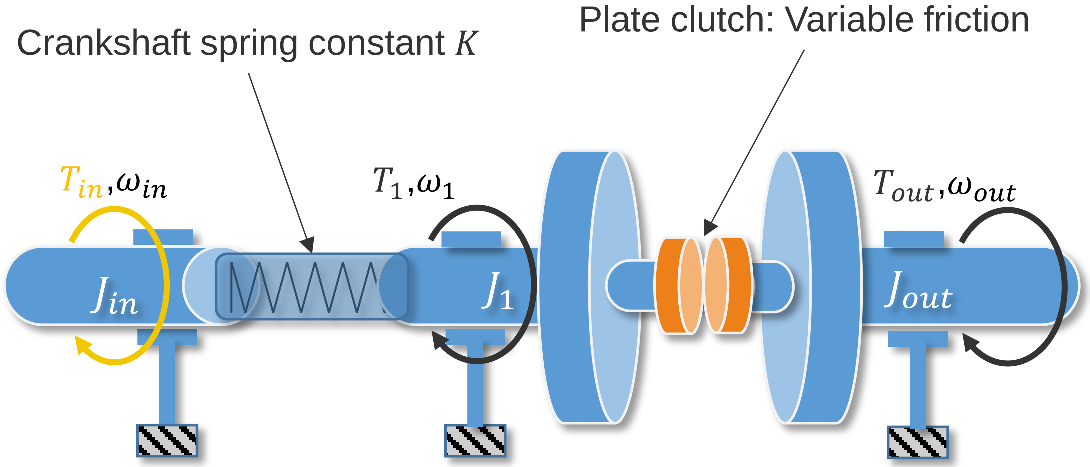
Step 1: Construction of equations

- Step 1.1: Creating Subsystems



Step 1: Construction of equations

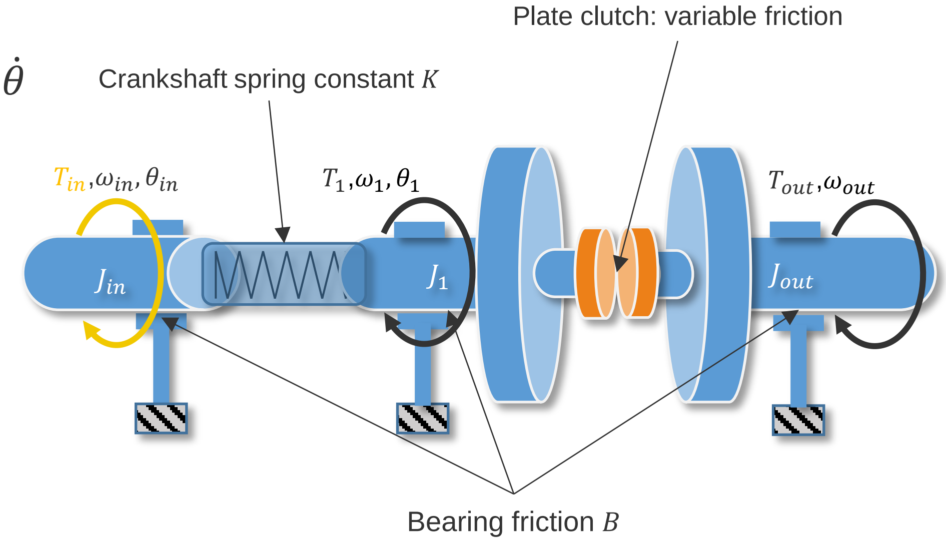
- Step 1.1: Creating Subsystems



Step 1: Construction of equations *(Subsystem 1)*

- Step 1.2: Presentation of equations

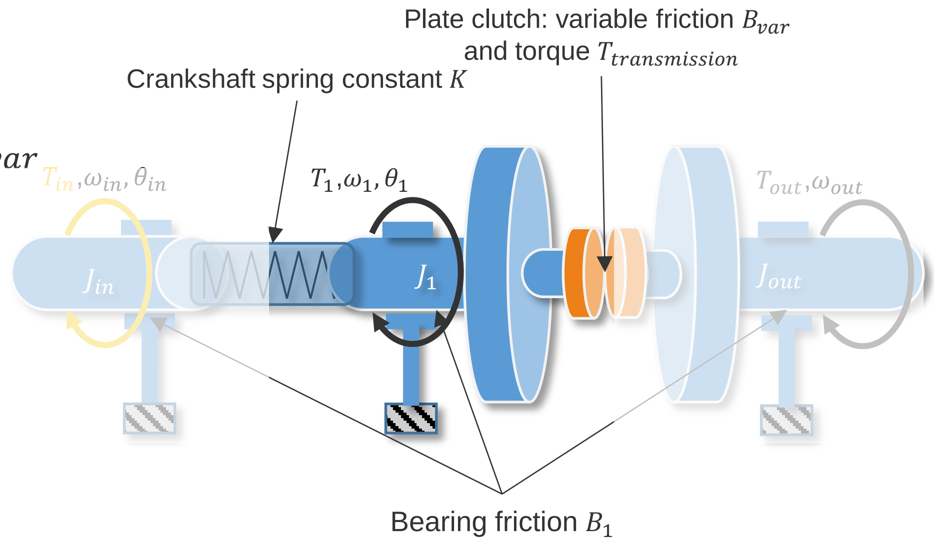
- Equations:
- $T_{Bearing} = \omega_{in} B$
- Coupling term 1: $T_K = (\theta_{in} - \theta_1)K, with\ \omega = \dot{\theta}$
- $J_{in}\dot{\omega_{in}} = T_{in} - T_{Bearing} - T_K$



Step 1: Construction of equations *(Subsystem 2)*

- Step 1.2: Presentation of equations

- Equations:
- $T_{Bearing} = \omega_1 B$
- Coupling term 1: $T_K = (\theta_{in} - \theta_1)K,$
- Coupling term 2: $T_{transmission} = (\omega_1 - \omega_{out})B_{var}$
- $J_1 \dot{\omega}_1 = T_K - T_{Bearing} - T_{transmission}$

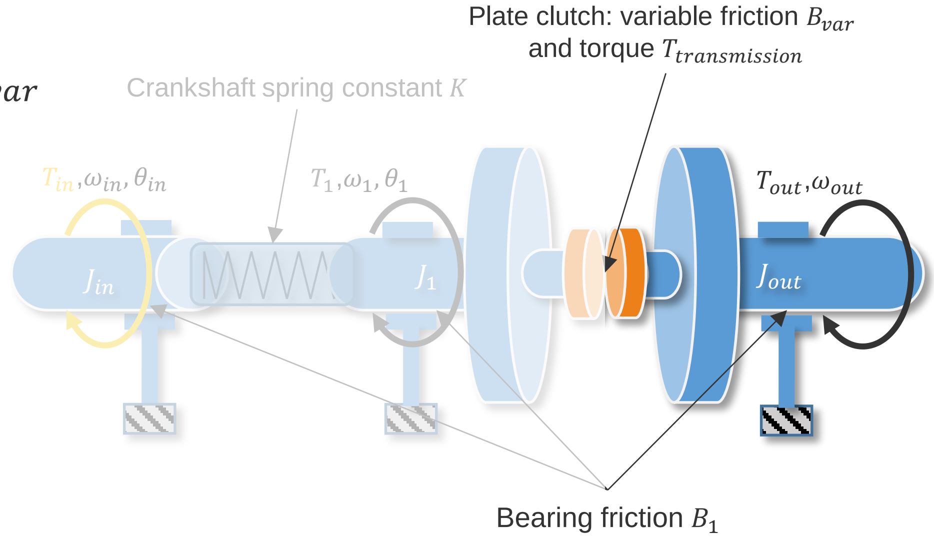


Step 1: Construction of equations *(Subsystem 3)*

- Step 1.2: Presentation of equations

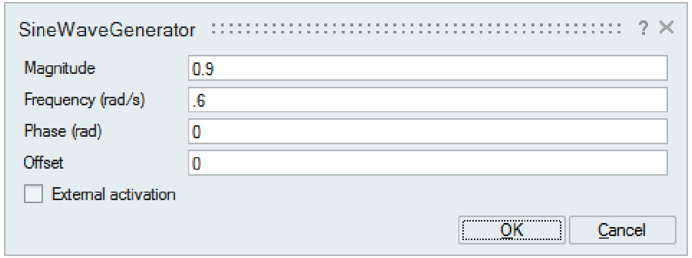
- Equations:
- $T_{Bearing} = \omega_{out} B$
- Coupling term 2: $T_{transmission} = (\omega_1 - \omega_{out}) B_{var}$
- $J_{out}\dot{\omega}_{out} = T_{transmission} - T_{Bearing}$

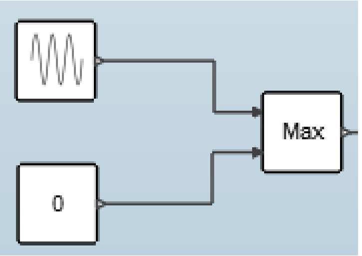
$ransmission = (\omega_1 - \omega_{out}) B_{var}$

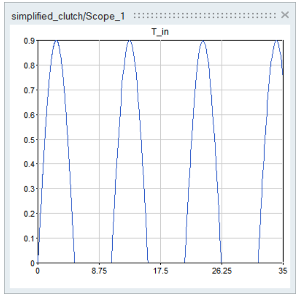


Step 2: Implementation using *Activate*

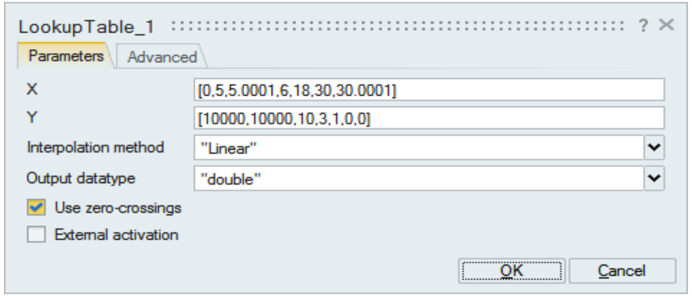
- Input signal: Positive sine wave torque with a frequency of $\approx 3\ Hz$:

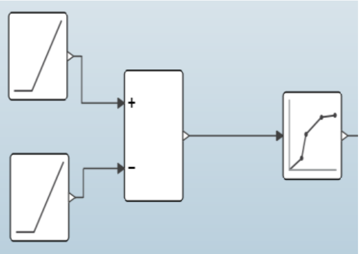


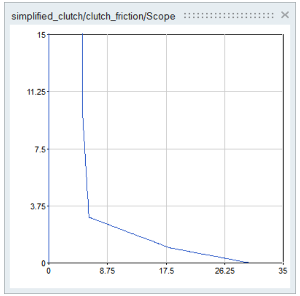




- Plate clutch friction via "LookUpTable"-block: Ramp slope(s) = 1, Second rope start time=30

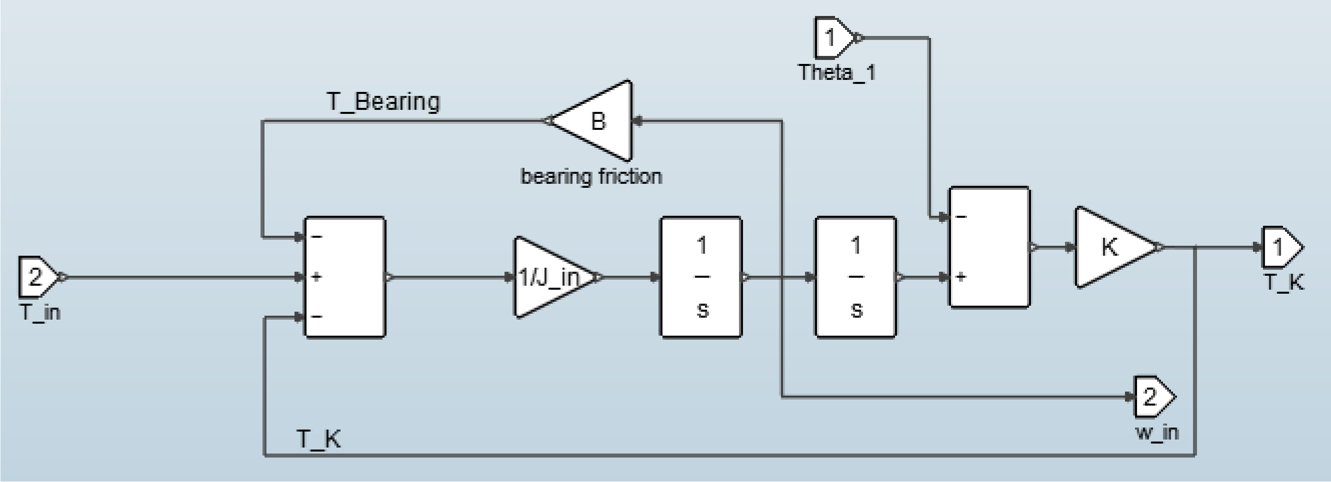






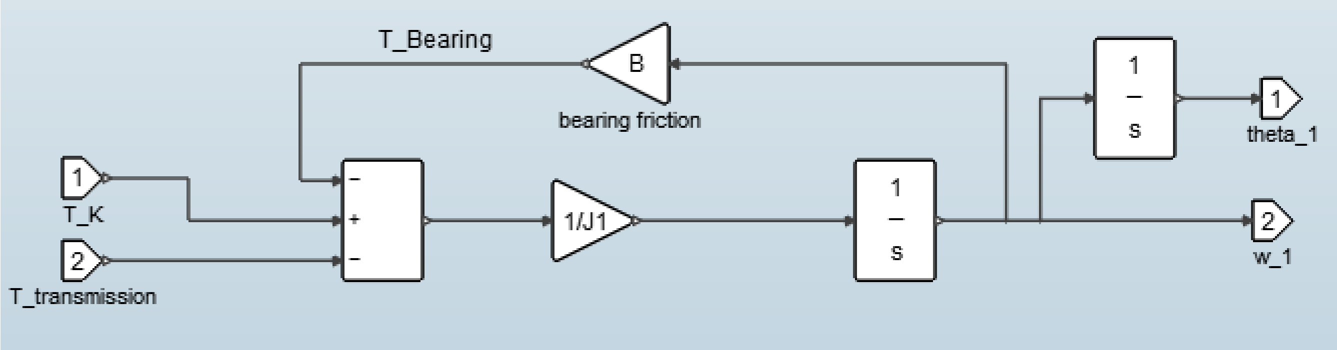
Step 2: Implementation using *Activate*

- *Subsystem 1*
- $J_{in}\dot{\omega}_{in} = T_{in} - T_{Bearing} - T_K$



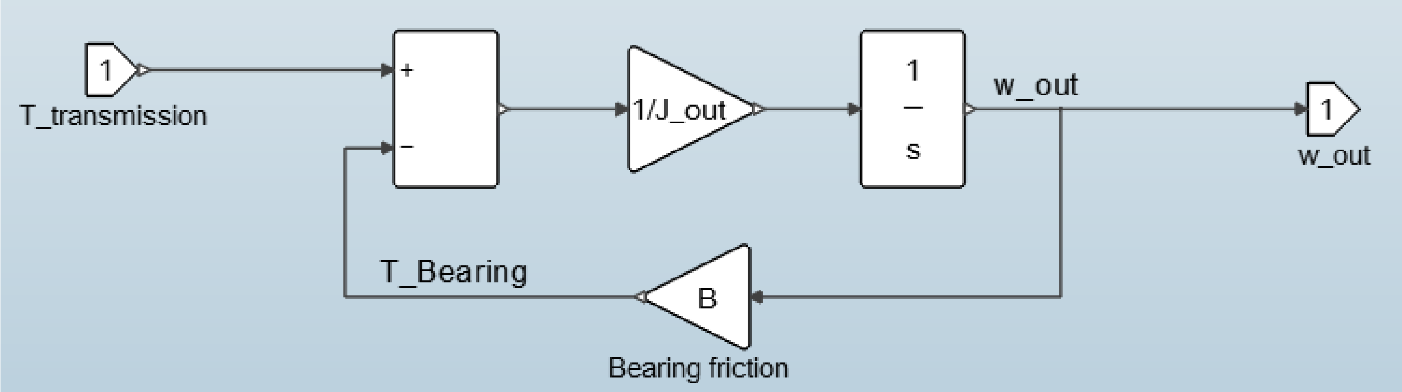
Step 2: Implementation using *Activate*

- *Subsystem 2:*
- $J_1 \dot{\omega}_1 = T_K - T_{Bearing} - T_{transmission}$



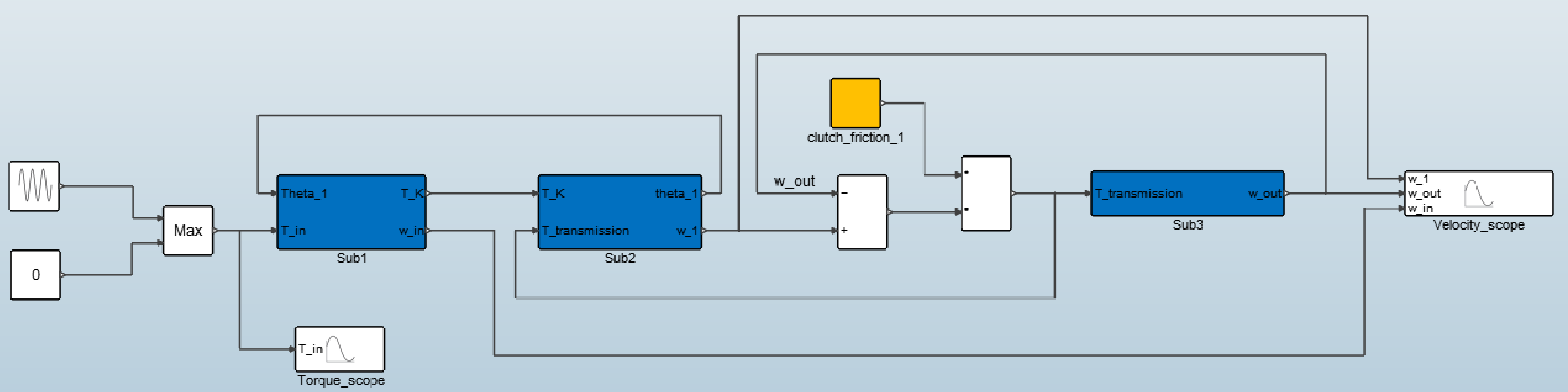
Step 2: Implementation using *Activate*

- *Subsystem 3:*
- $J_{out}\dot{\omega}_{out} = T_{transmission} - T_{Bearing}$



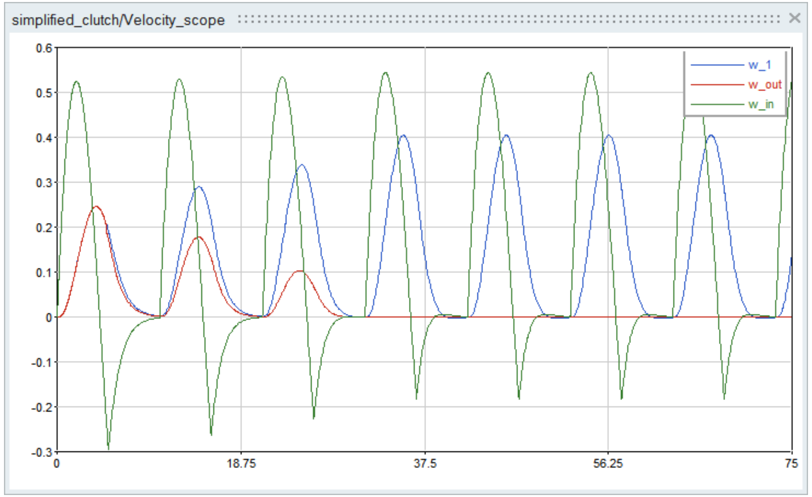
Step 2: Implementation using *Activate*

- *Complete model:*
- $J_{in}\dot{\omega_{in}} = T_{in} - T_{Bearing} - T_K$
- $J_1\dot{\omega_1} = T_K - T_{Bearing} - T_{transmission}$
- $J_{out}\dot{\omega}_{out} = T_{transmission} - T_{Bearing}$



Step 3: Validation of the results

- Simulation time: 75 sec.
- When the clutch is fully engaged, the torque transmitted to inertia J_{out} and its velocity ω_{out} nearly reaches the value of velocity ω_1.
- The greater the friction ($B_{var} \gg 0$) of the clutch plate is, the higher is the transmitted torque.



Step 3: Validation of the results

- However, when the clutch is fully disengaged the torque and velocity ω_{out} becomes 0.
  - At this moment, the input velocity ω_{in} only affects the velocity ω_1. Due to the spring behavior of the crankshaft the velocity ω_1 crosses zero and reverses its direction briefly.