Flux Activate coupling SPM Motor with Regulation

2D Multiphysics Summary

Introduction

This document describes Flux-Activate coupling on the example of SPM motor.

Keywords

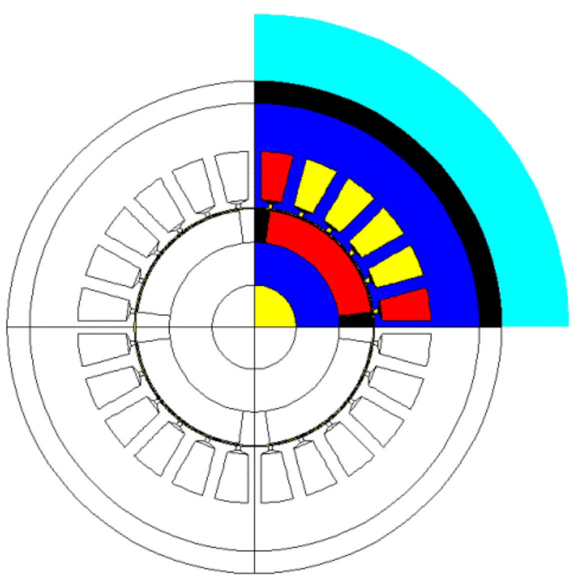
Applications	Flux main functions
• Transient Magnetic	• Co-Simulation • Brushless motor

Studied device

The studied device, a brushless AC with surface mounted permanent magnet motor presented in the figure below, includes the following elements:

- a fixed part (stator) including yoke, slots, and windings
- an air gap
- a movable part (rotor) with embedded magnets

A section of the model of the studied device is presented in the figure below.



Aim and steps

Aim

The aim of this coupling is to do a co-simulation between Flux and Activate. Activate serves to make the system part.

Action	Software
Device modeling	Altair Flux™
Generate the coupling component for Activate	Altair Flux™
Create the Flux connector	
Solve the problem	

Steps

The different steps to realize this coupling are shown in the table below:

Phase	Software	Description
1	Flux	Flux project preparation: • Model description: geometry, mesh and physics • Specific description: creation of the input/output parameters required for the coupling • Generate the coupling component for Activate
2	Flux	Activate opening: • Preparation of the Activate model
3	Activate / Flux	Solve the problem
4	Activate / Flux	Post Processing

Flux model

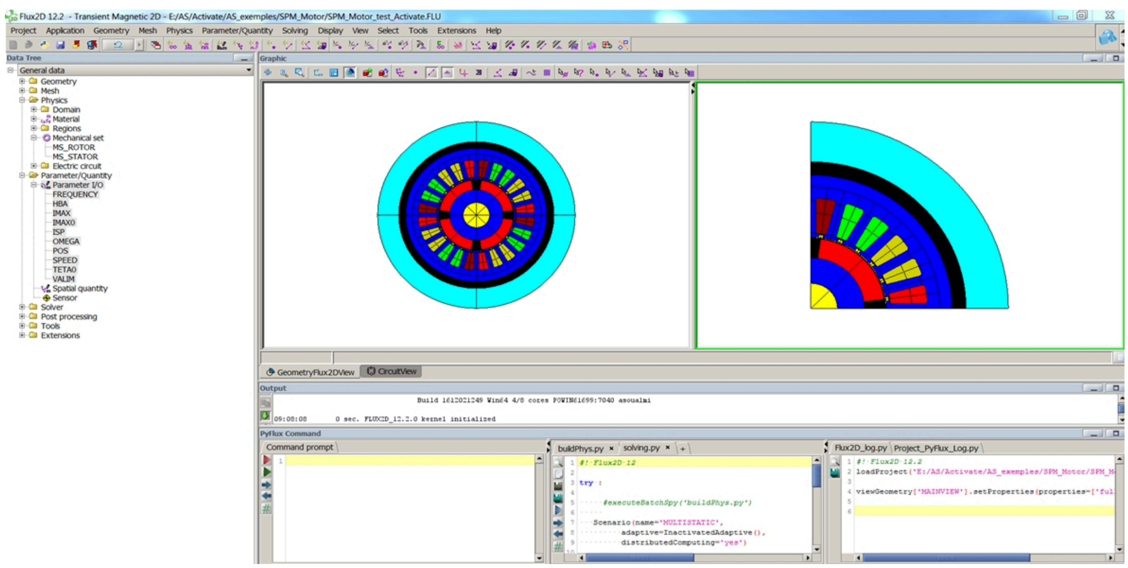
The first step is to prepare the Flux project:

- The geometry, mesh the device and the physics description (materials, regions, non-mesh coils, mechanical sets) and circuit.
- We create the input and output parameter that we use to generate the coupling element between Flux and Activate
- Generate the coupling element

The motor is driven with a 3 phase sine current and running at constant speed. The simulated motor performances are used to compute shaft torque, torque ripples, Magnet losses, phase current, speed and mechanical power.

Flux model: detailed steps

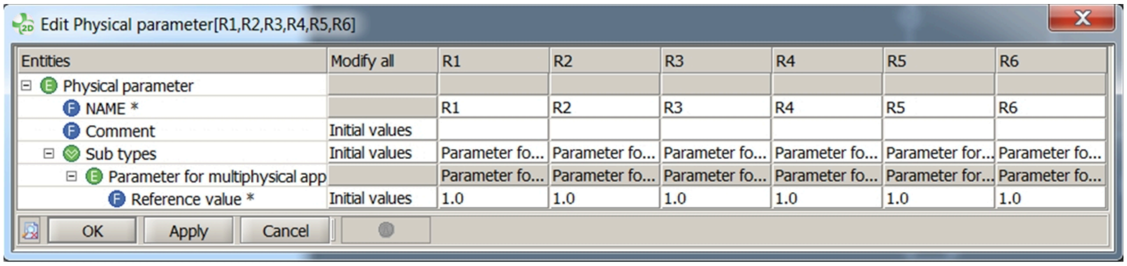
In the first step we create the geometry, mesh and physics. To do it, we open the project: SPM_Motor_Activate.FLU.



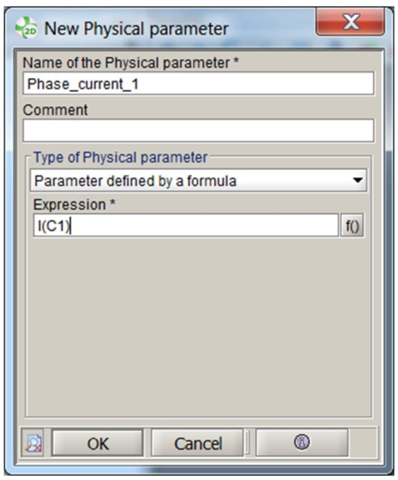
We create input and output parameters

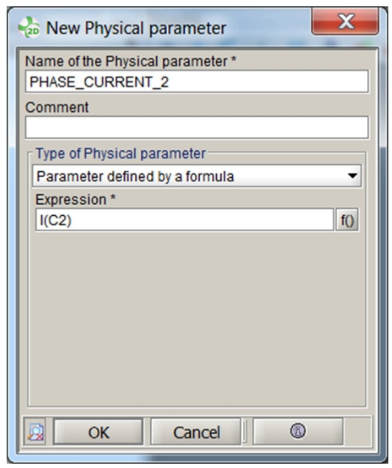
1. Inputs: Multi-Physical I/O Parameters that allow, via formulas to pilot the following:
    - the physical quantities: μr, Bs, Br etc.
    - electrical quantities: resistance, voltage, current etc.
    - mechanical quantities: position, speed, resistant force, resistive torque etc.
2. Outputs: Scalar I/O Settings that allows, via sensors, formulas, parameters to retrieve the values:
    - of sensors
    - of forces, couples etc
    - positions, speeds, accelerations etc.

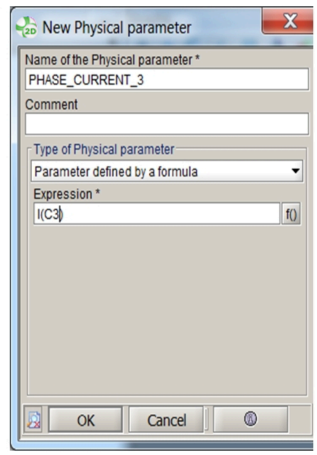
Input parameters:

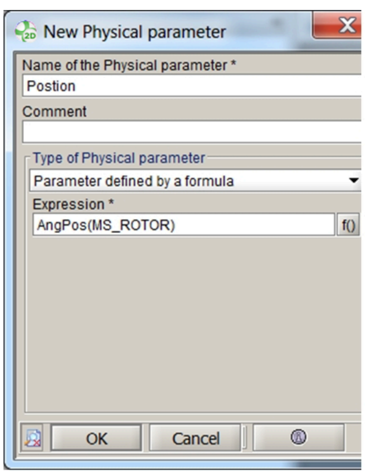


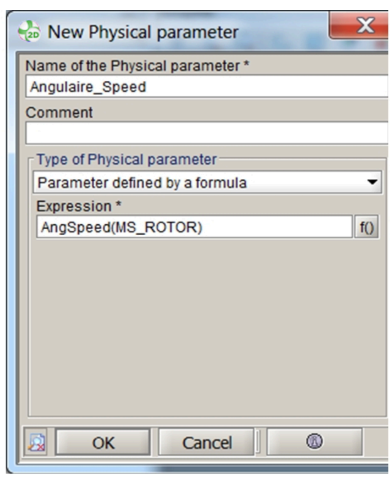
Output parameters:

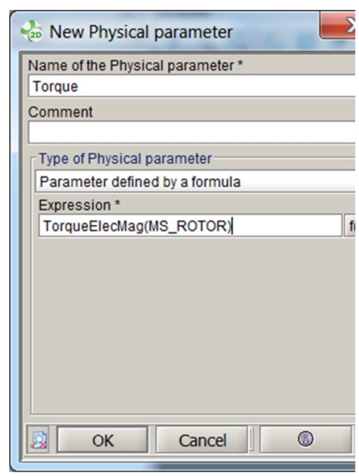






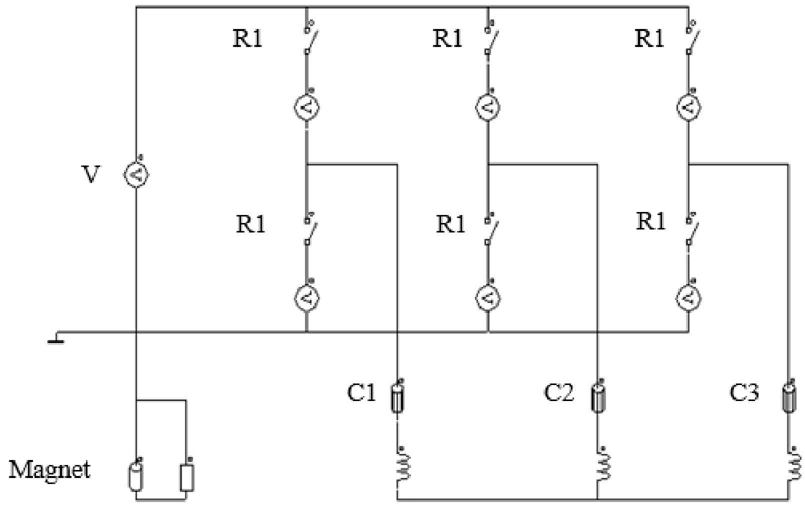






Electrical circuit

The electrical circuit is defined as:

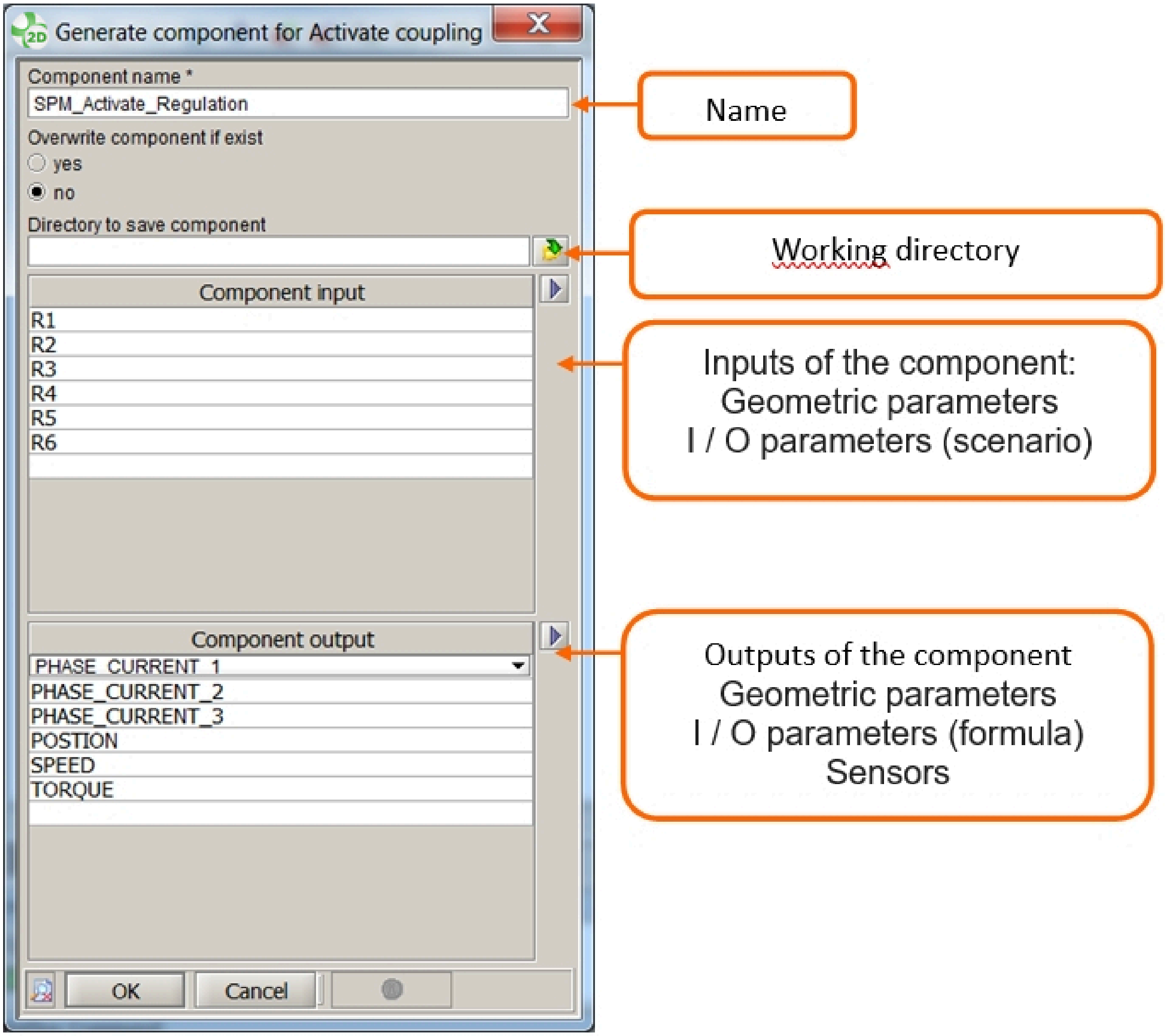


It is composed of:

- Voltage source
- Coil conductor
- Resistor
- Inductance
- Solid conductor
- Switch

In the switches, we put the input parameter (R1, R2, R3, R4, R5 and R6).

Generate component (solving >> generate component for Activate coupling) for Activate coupling in the same working directory.

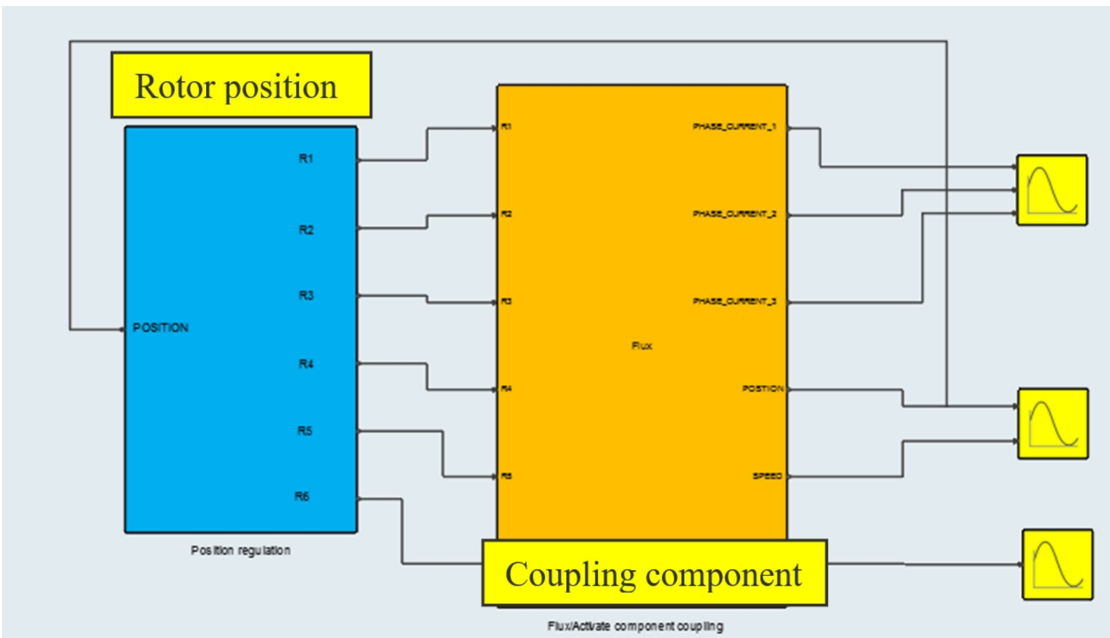

Generate component for Activate coupling
Component name *
SPM_Activate_Regulation
Overwrite component if exist
yes
no
Directory to save component
Component input
R1
R2
R3
R4
R5
R6
Component output
PHASE_CURRENT_1
PHASE_CURRENT_2
PHASE_CURRENT_3
POSTION
SPEED
TORQUE
OK
Cancel
Name
Working directory
Inputs of the component:
Geometric parameters
I / O parameters (scenario)
Outputs of the component
Geometric parameters
I / O parameters (formula)
Sensors

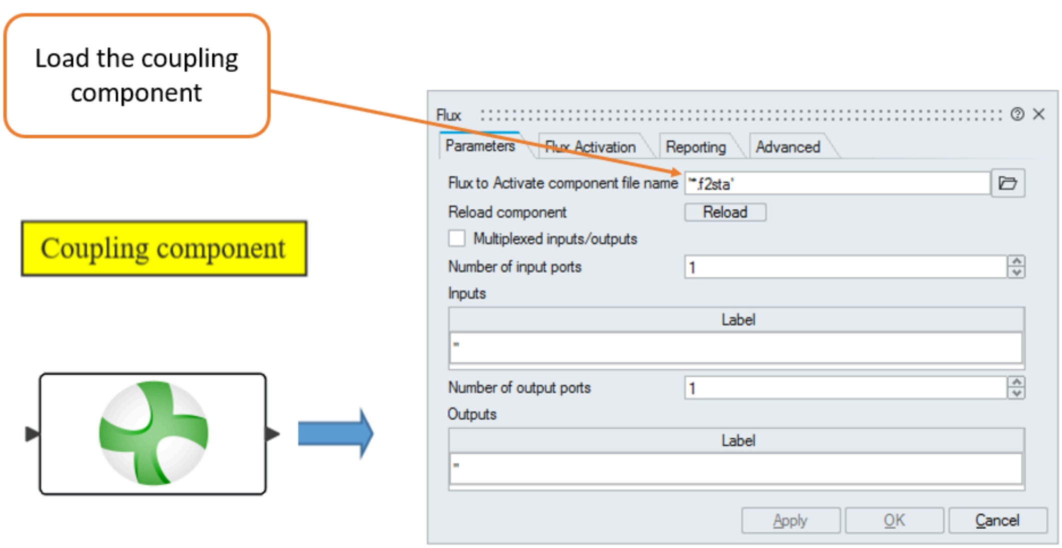
Model activation

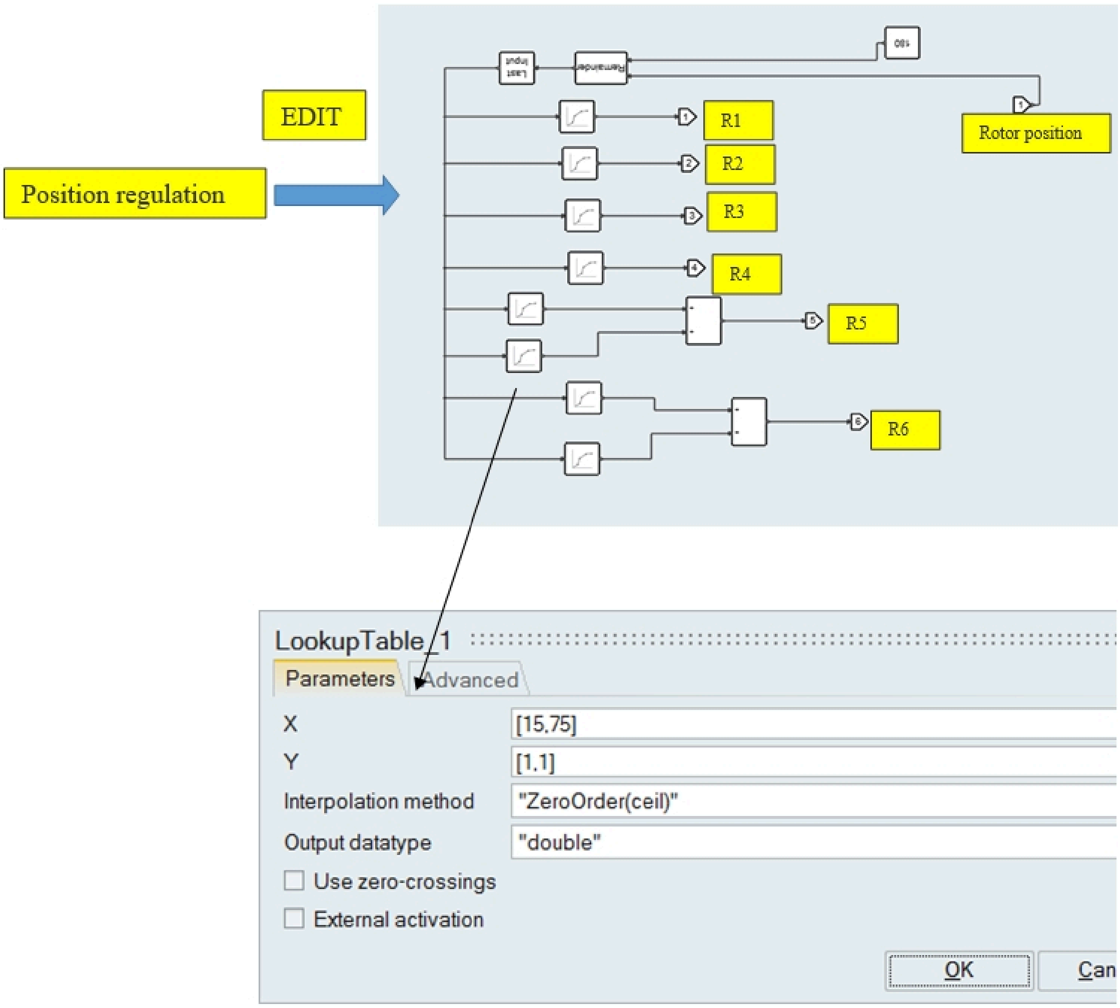
Activate model

The user must prepare the Activate model by adding and characterizing the coupling block but also the blocks needed to build the desired model. We have two parts:

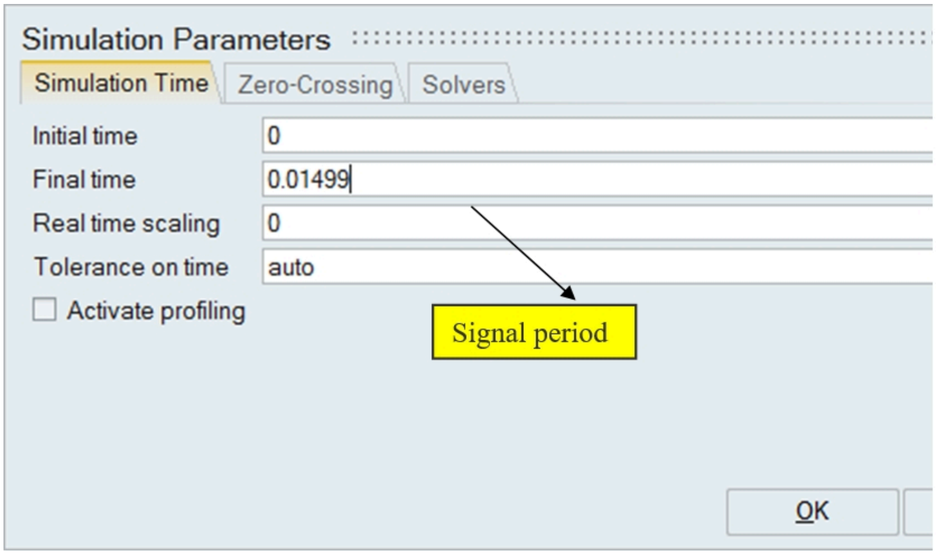
- Coupling component
- The command

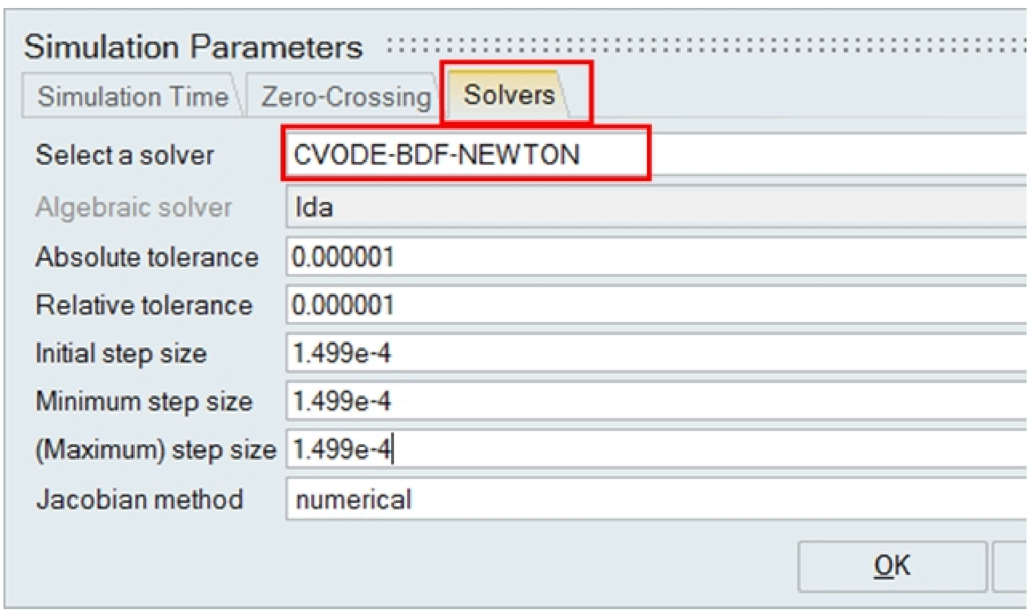






The choice of solver and the step:


Simulation Parameters
Simulation Time
Zero-Crossing
Solvers
Initial time
0
Final time
0.01499
Real time scaling
0
Tolerance on time
auto
Activate profiling
Signal period
OK


Simulation Parameters
Simulation Time
Zero-Crossing
Solvers
Select a solver
CVODE-BDF-NEWTON
Algebraic solver
Ida
Absolute tolerance
0.000001
Relative tolerance
0.000001
Initial step size
1.499e-4
Minimum step size
1.499e-4
(Maximum) step size
1.499e-4
Jacobian method
numerical
OK

Simulation results

No load test with constant speed (N=1000 rpm):

Properties	Value	unite
Moment of inertia	0	$Kg.m^2$
Constant friction coefficient	0	N.m
Viscous friction coefficient	0	N.m.s/deg
Friction coefficient proportional to the square speed	0	
speed	1000	Tr/min
Position at time 0	0	degg

Figure 1: The current (A) in each phase

Figure 2: The position (deg) and speed (rpm)

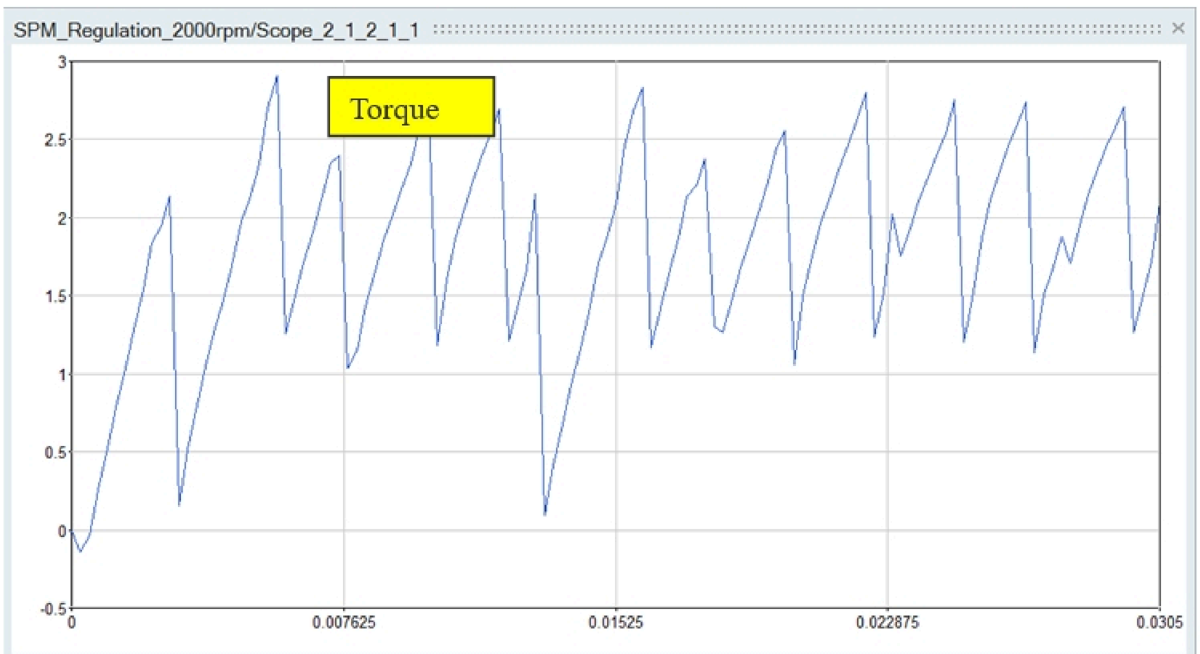


Figure 3: Torque (N.m)