Flux Conference 2012

Analysis of Hybrid Motor and Drive for Automotive Application

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Analysis of Hybrid Motor and Drive for Automotive Application

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- Hybrid motor characteristics
- Hybrid motor control
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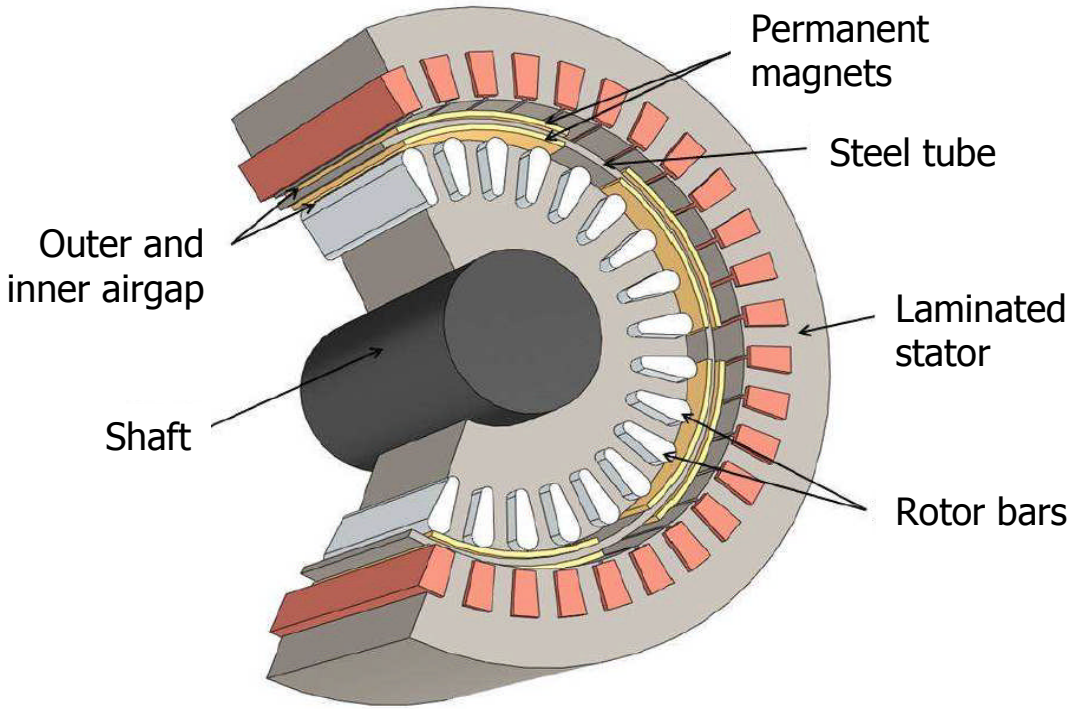
Introduction

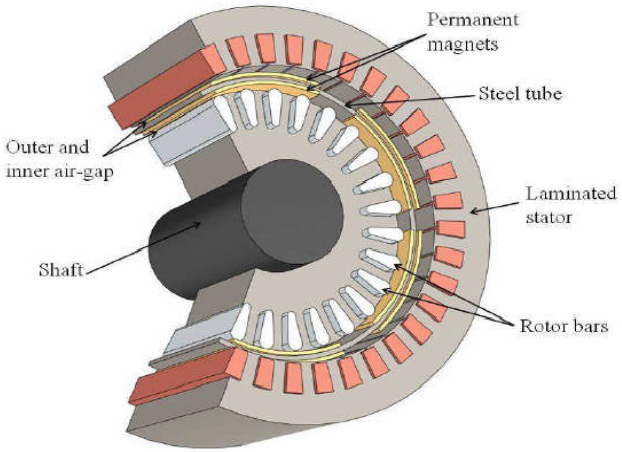
The Hybrid motor is a novel type of machine with dual-rotor (Permanent Magnet + Induction Machine).

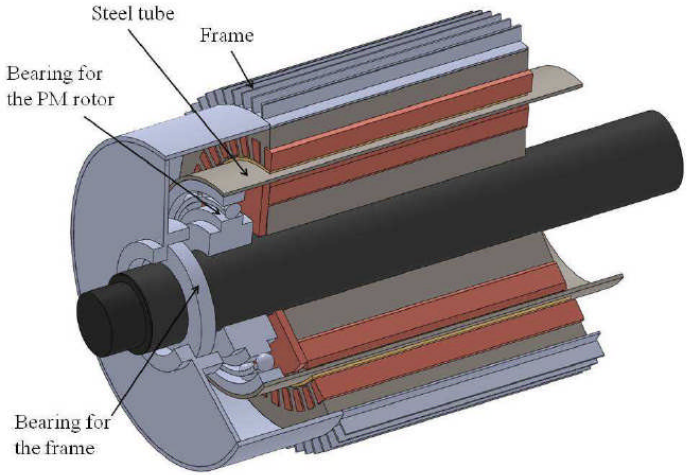


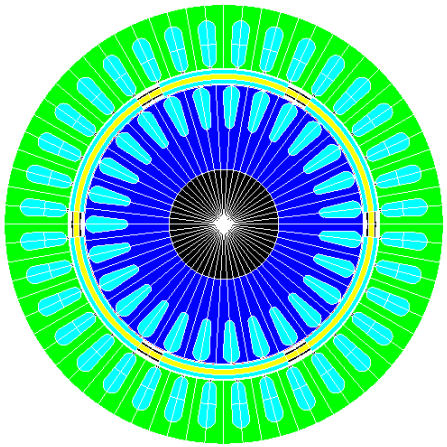
Respect to classical motor

- ✓ More efficiency
- ✓ More power density
- ✓ More torque density

Motor data







MAIN DATA

Rated power	[kW]	6
Synchronous speed	[rpm]	1000
Phase voltage	[V]	230
Rated efficiency	%	90.0
N. poles		6
Outer stator diameter	[mm]	200
Stack length	[mm]	135
Number of stator slots		36
Number of cage rotor slots		27

Motor analysis by Flux and Portunus

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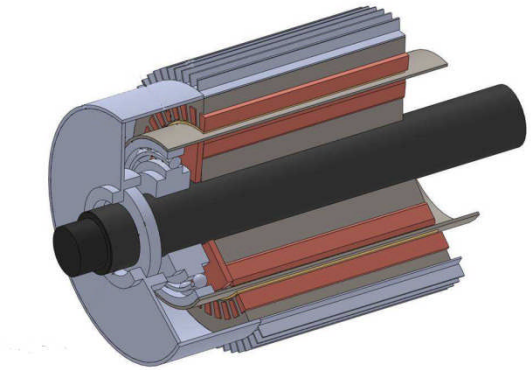
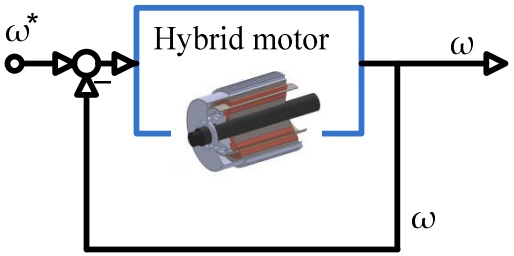
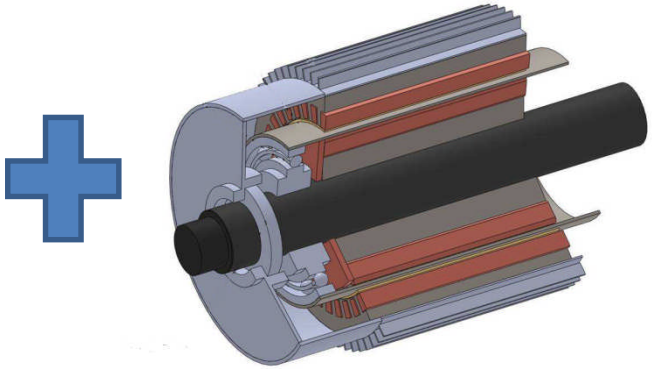
- To characterize the motor
  - ✓ **Flux**
- To verify the control stategy
  - ✓ **Flux + Portunus**







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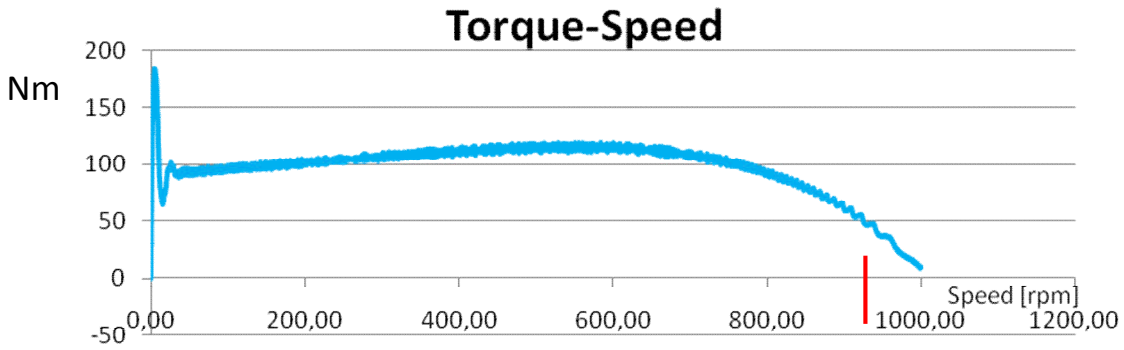
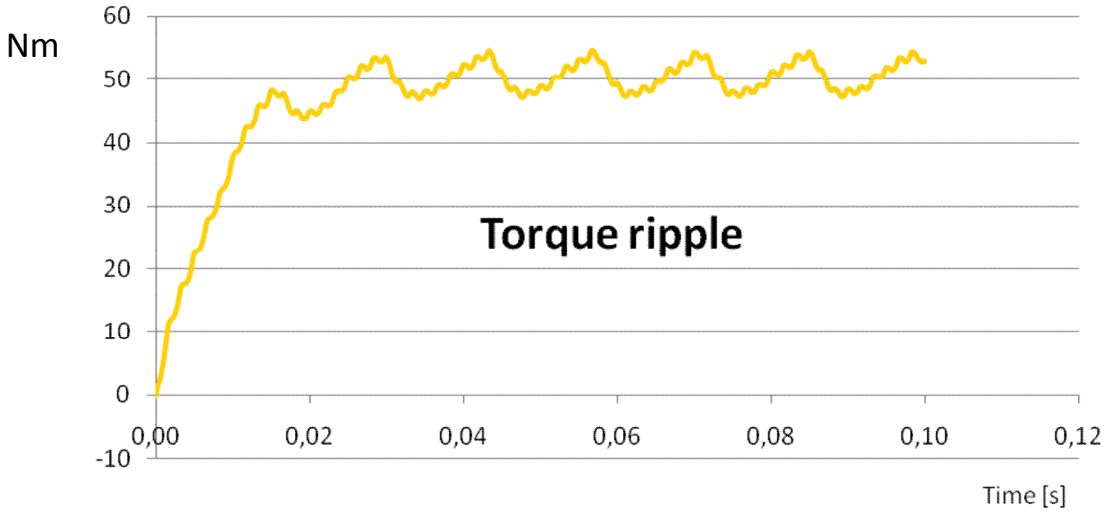
Mechanical characteristics (Flux)



- ✓ Phase current =8.6 Arms (50 HZ)



Flux density with Iq only (Flux)

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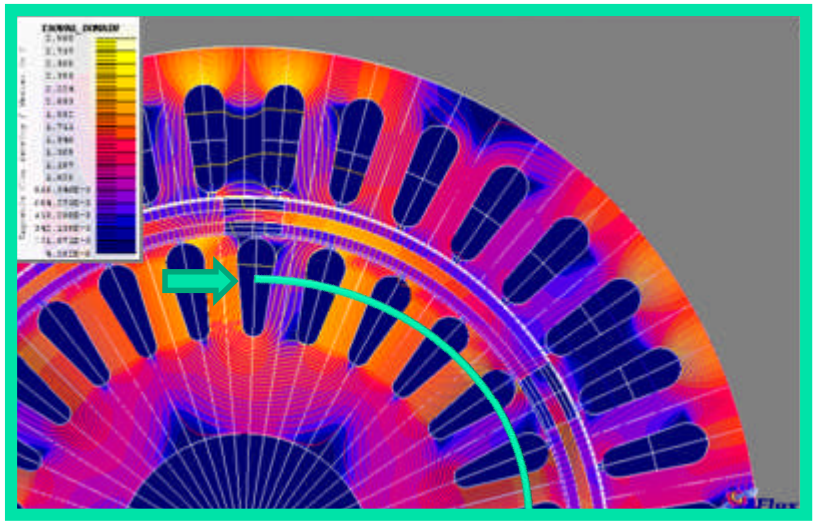

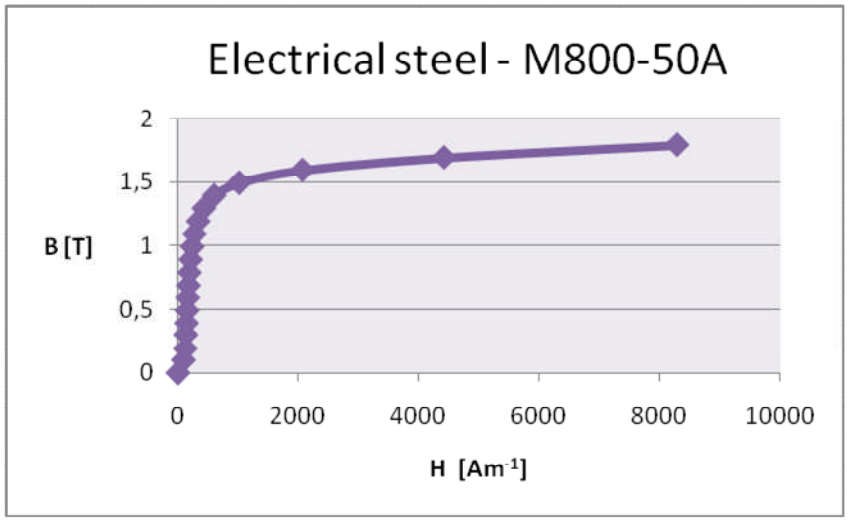

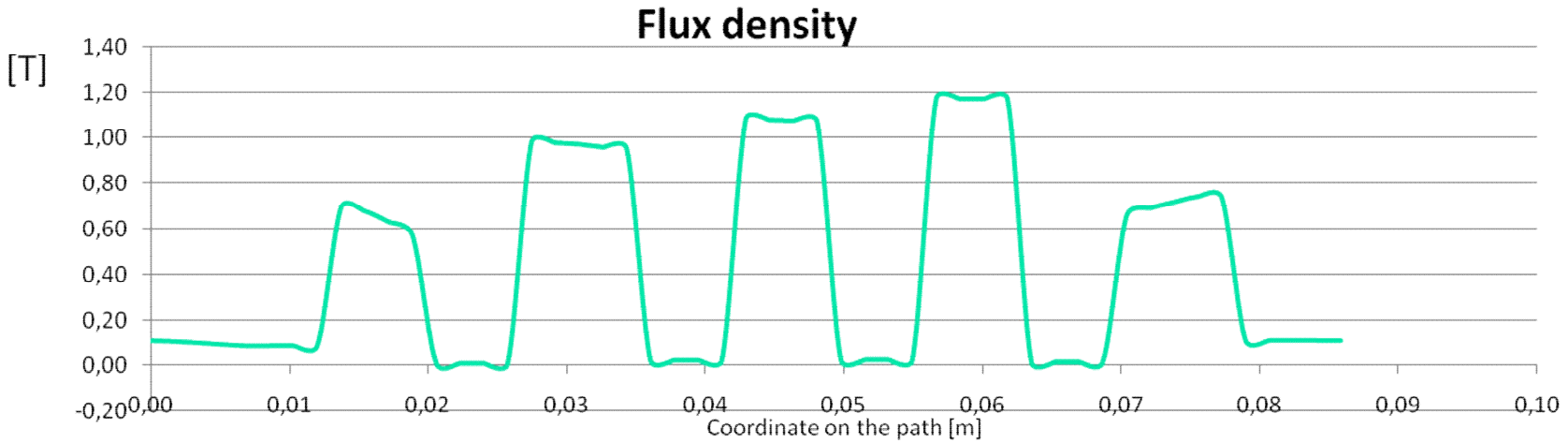

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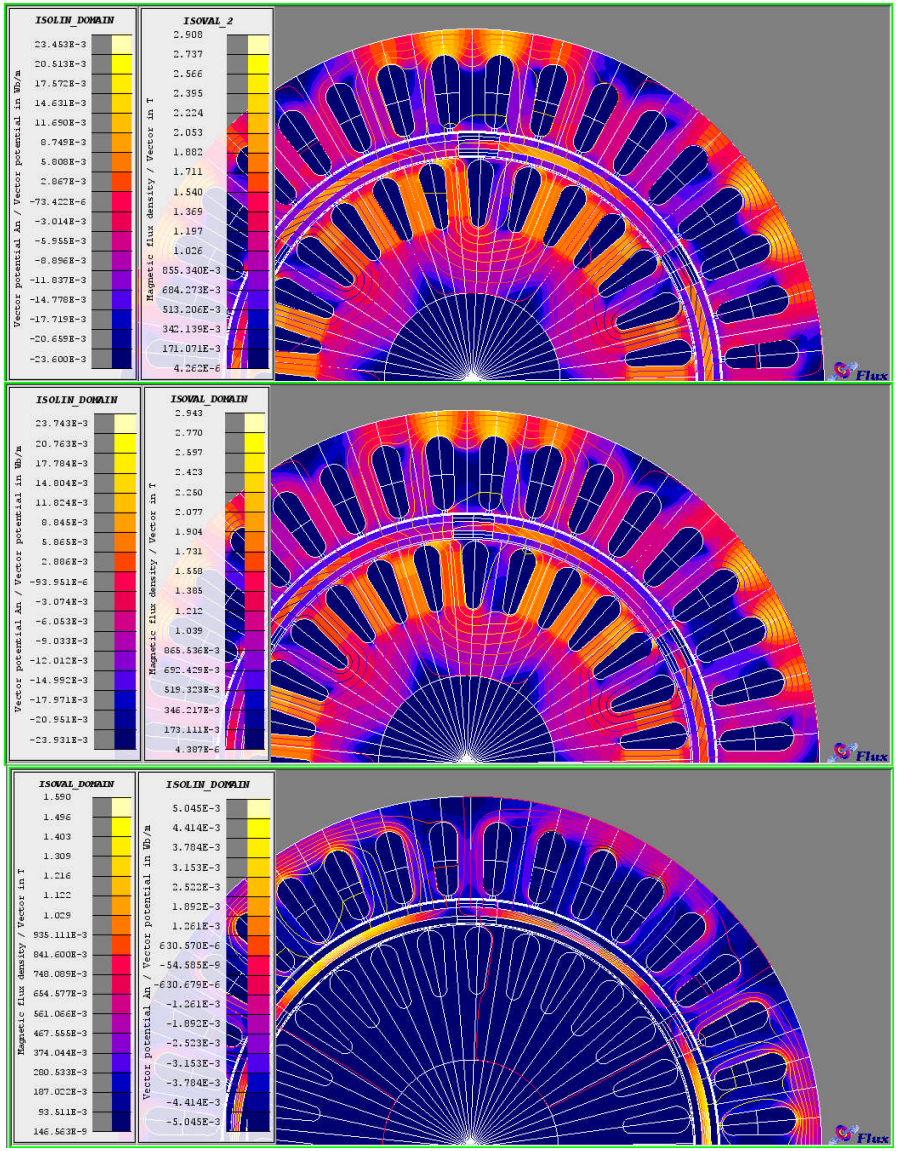
- Iq + PM
- PM only
- Stator current only



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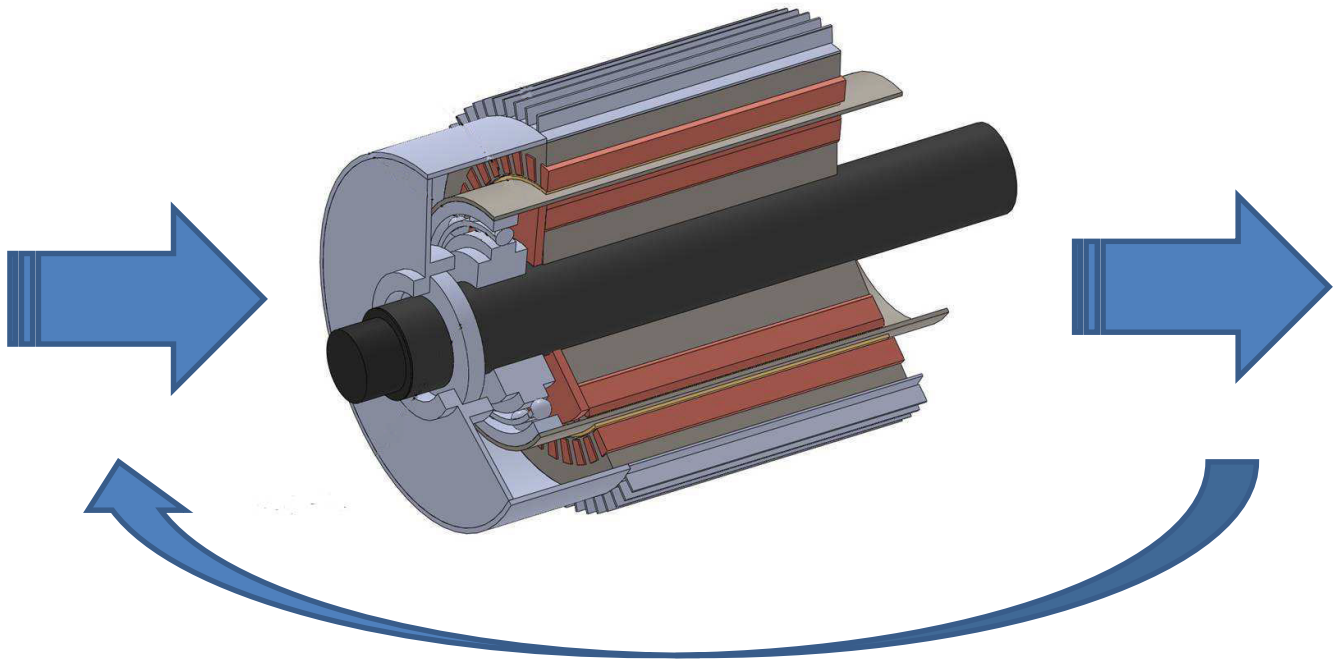
Hybrid motor control

Control of the motor speed in different operating conditions



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The growing demand of motors with high dynamic performance requires not only an adequate (and more efficient) designs procedure but also a fine motor analysis taking into account the driving control.

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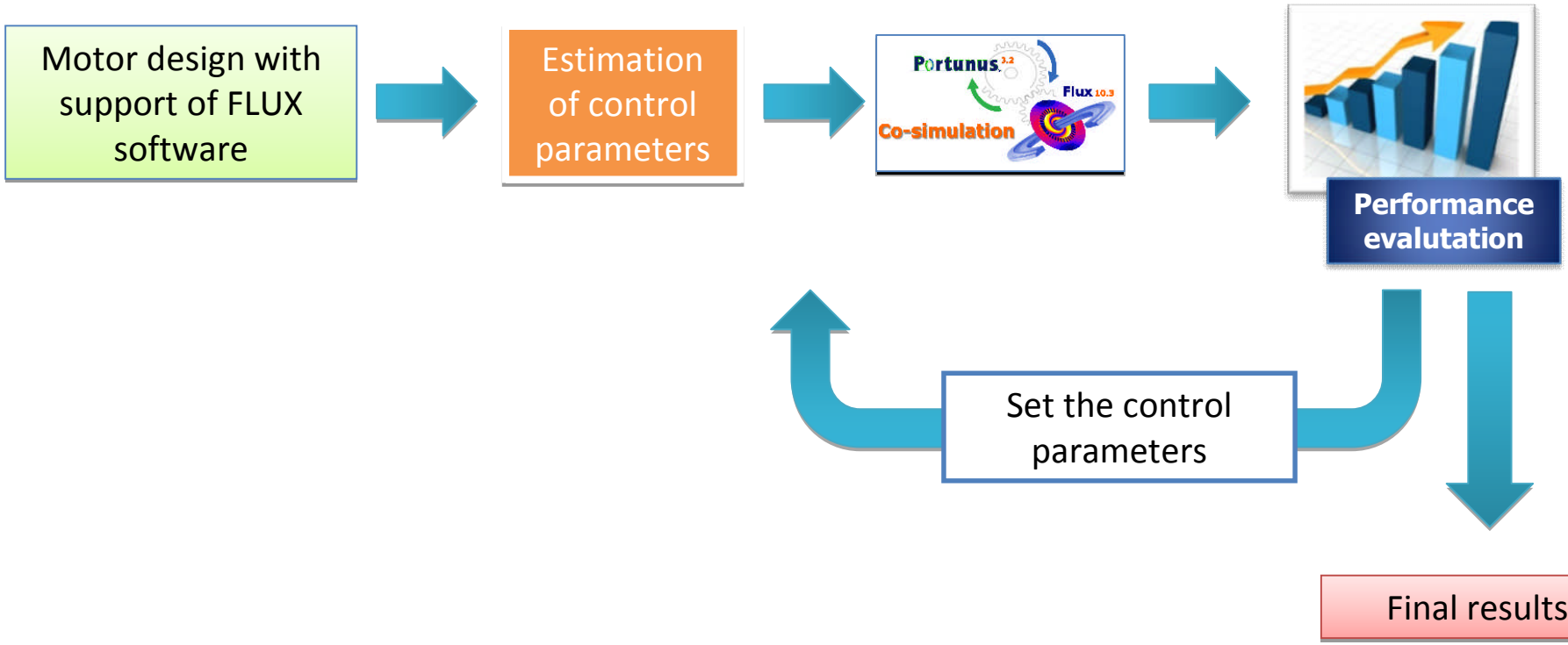
The control strategy has been tested through a co-simulation between **Portunus + Flux** in order to optimization the whole system performance.



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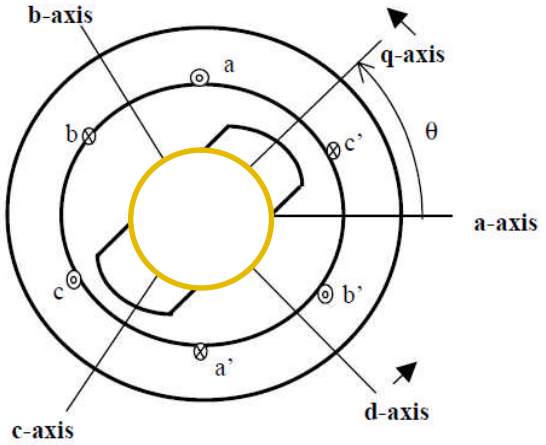
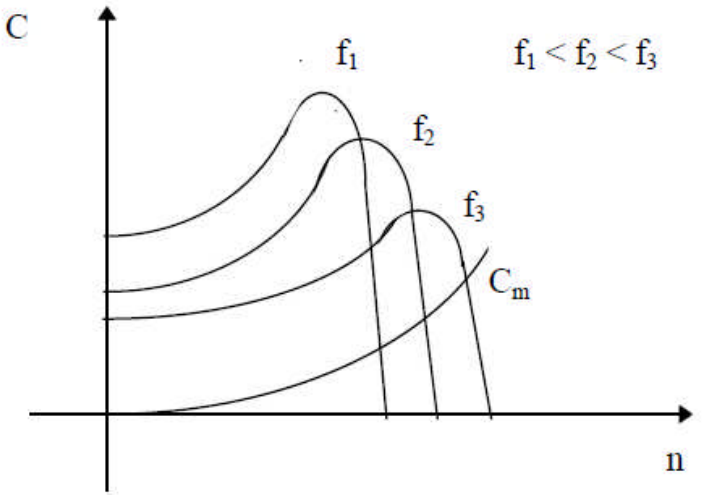
Control strategy

A certain cage-rotor speed (asynchronous motor) is assigned and the control changes the synchronous speed (stator currents and PM rotor) in order to satisfy the imposed value.

In this way, it is possible to obtain a desired cage-rotor speed in different load conditions.





Control scheme by Portunus

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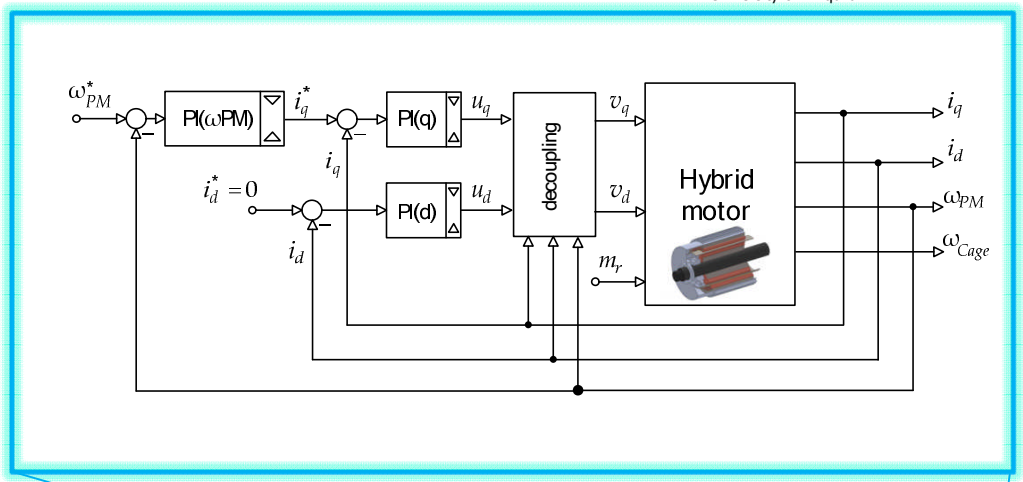
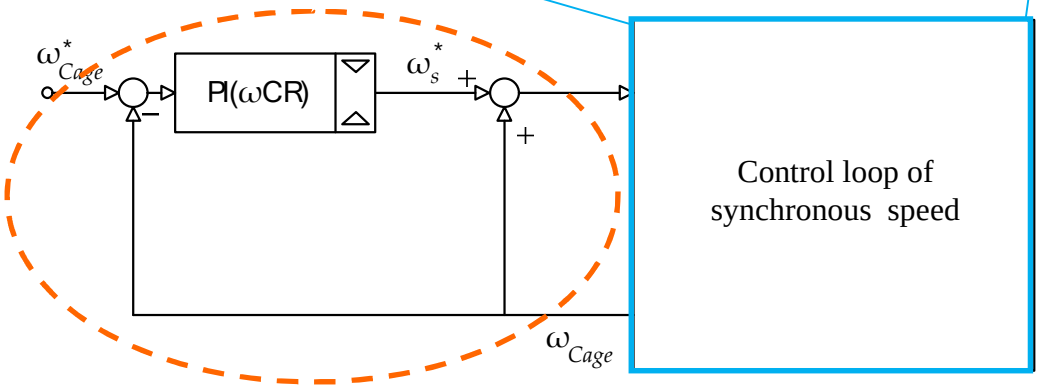
- The inner control loops impose the synchronous speed by field-oriented control (FOC).

  The motor performance are calculated by Flux.



- The outer control loop compares the imposed cage-rotor speed with the actual value calculated by Flux.



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Co-simulation results

Speed of cage-rotor

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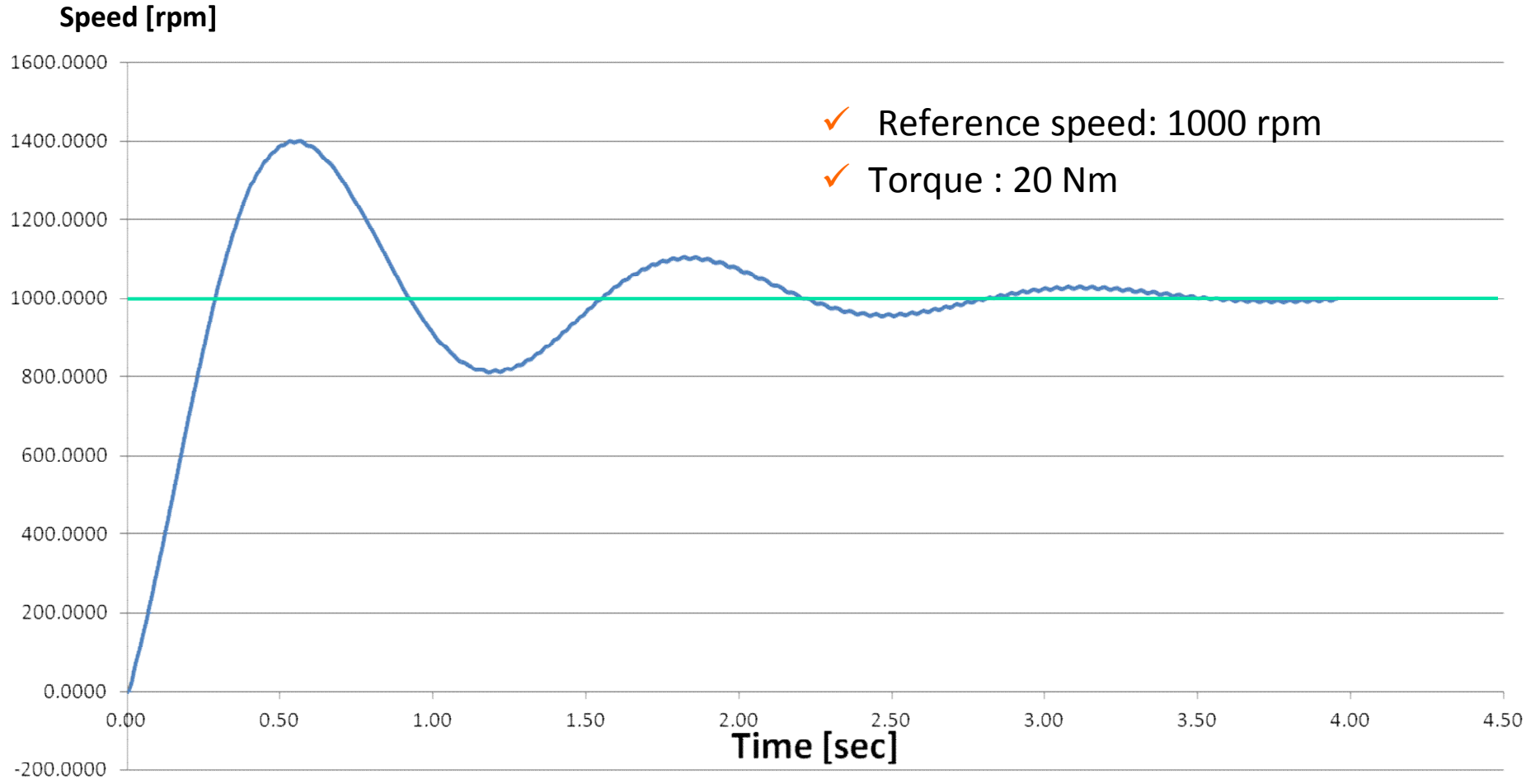

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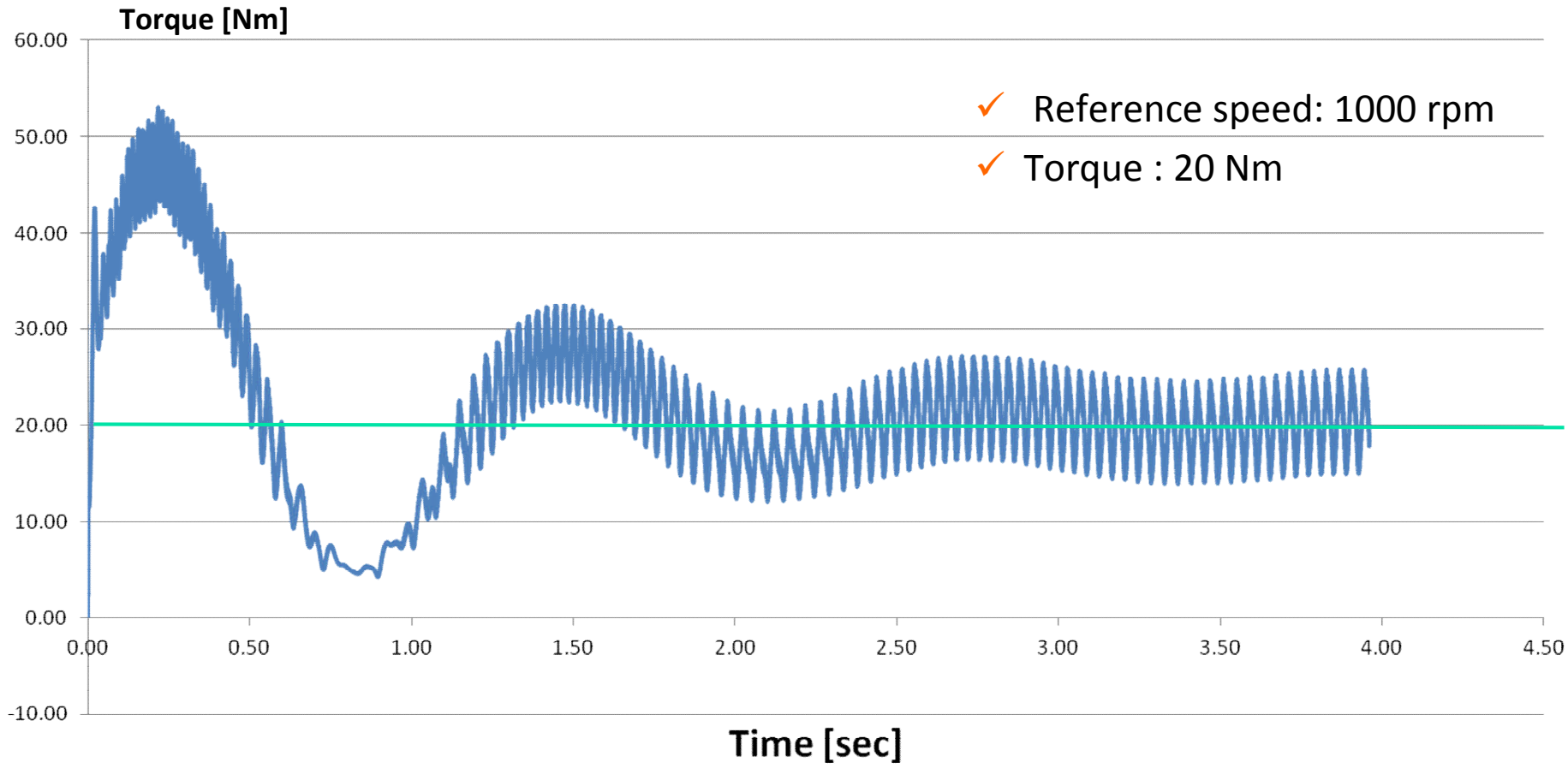
Torque



- ✓ Reference speed: 1000 rpm
- ✓ Torque : 20 Nm

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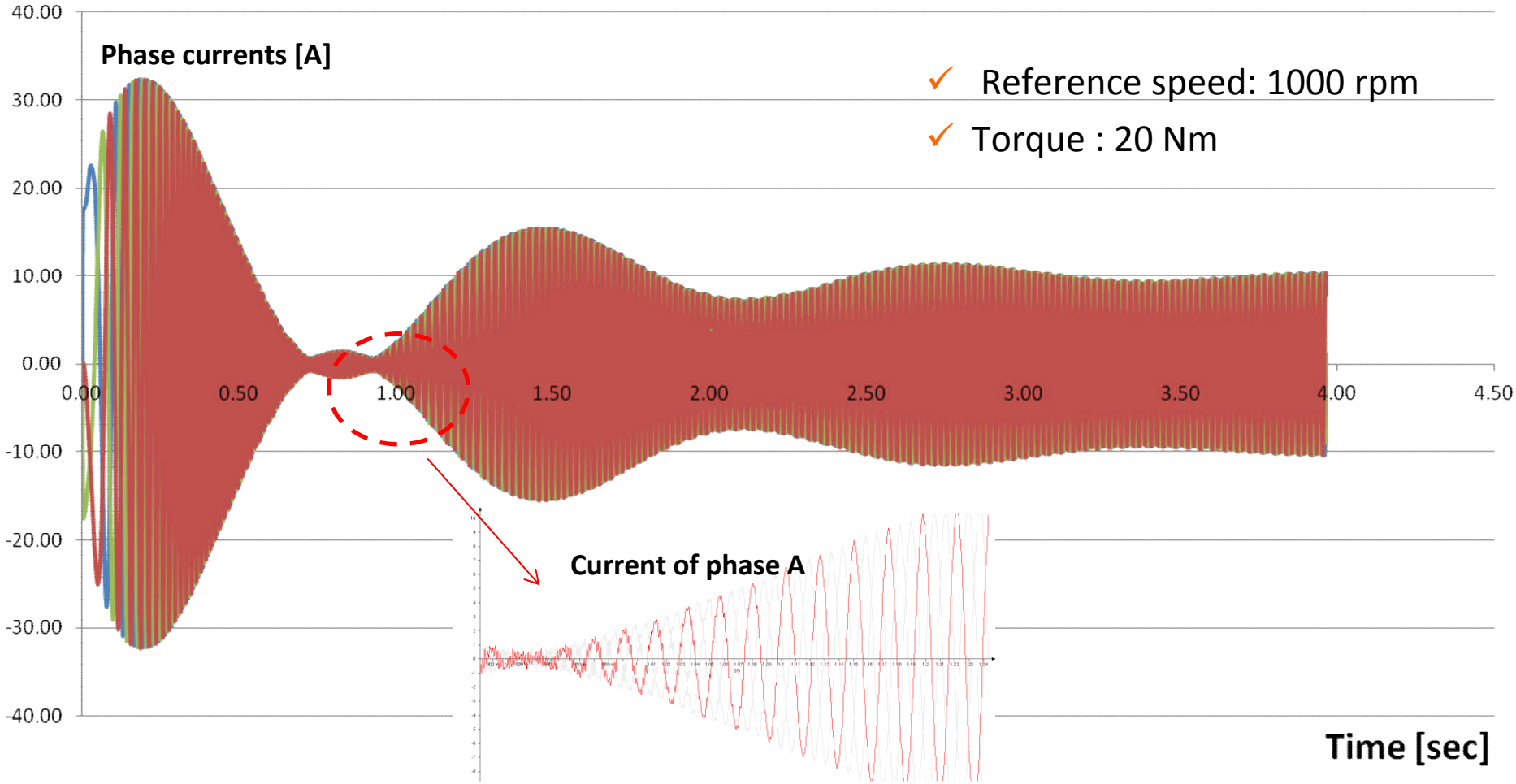
Phase currents



- ✓ Reference speed: 1000 rpm
- ✓ Torque : 20 Nm

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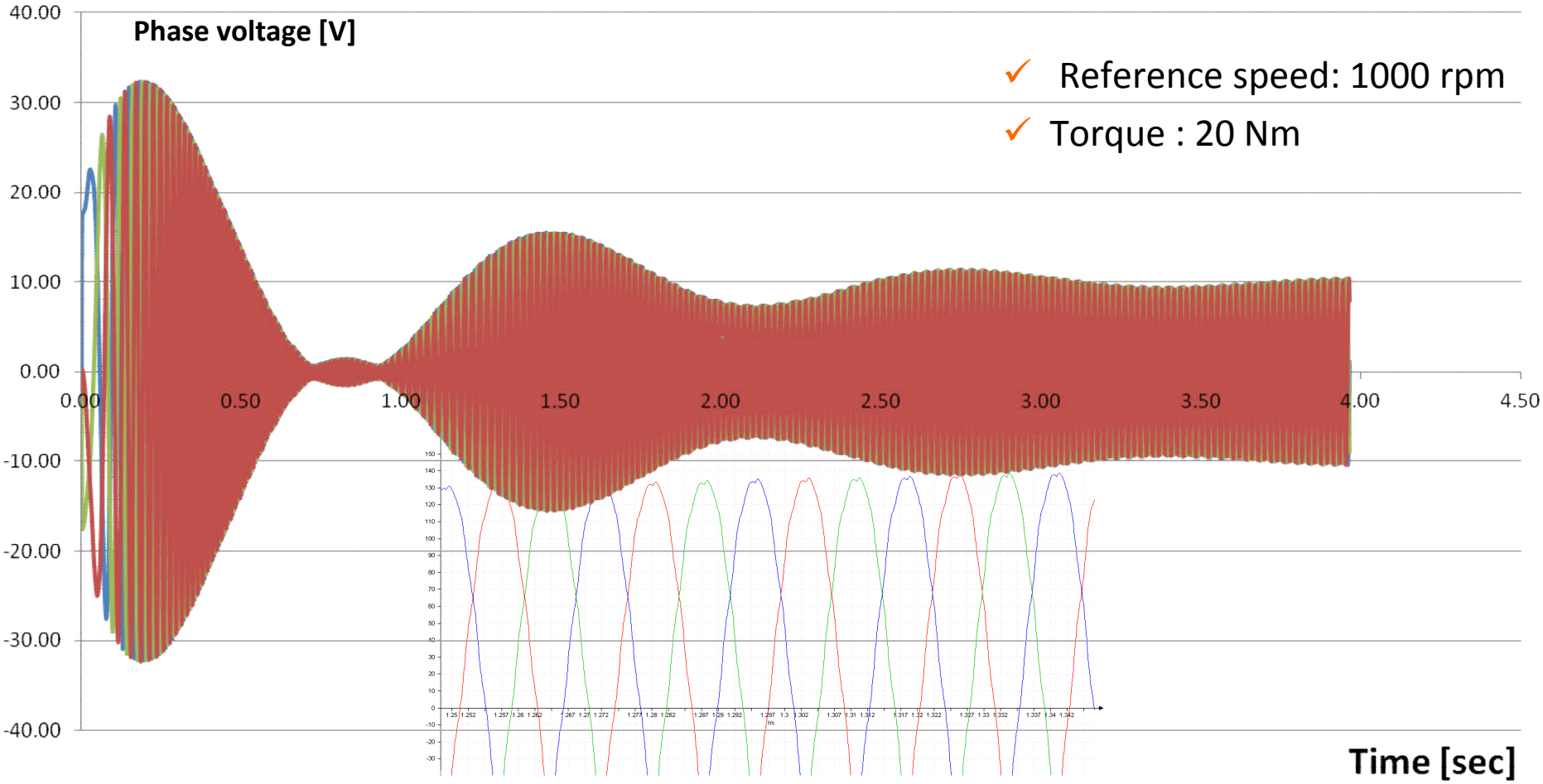
Phase voltage



- ✓ Reference speed: 1000 rpm
- ✓ Torque : 20 Nm

d and q axis currents

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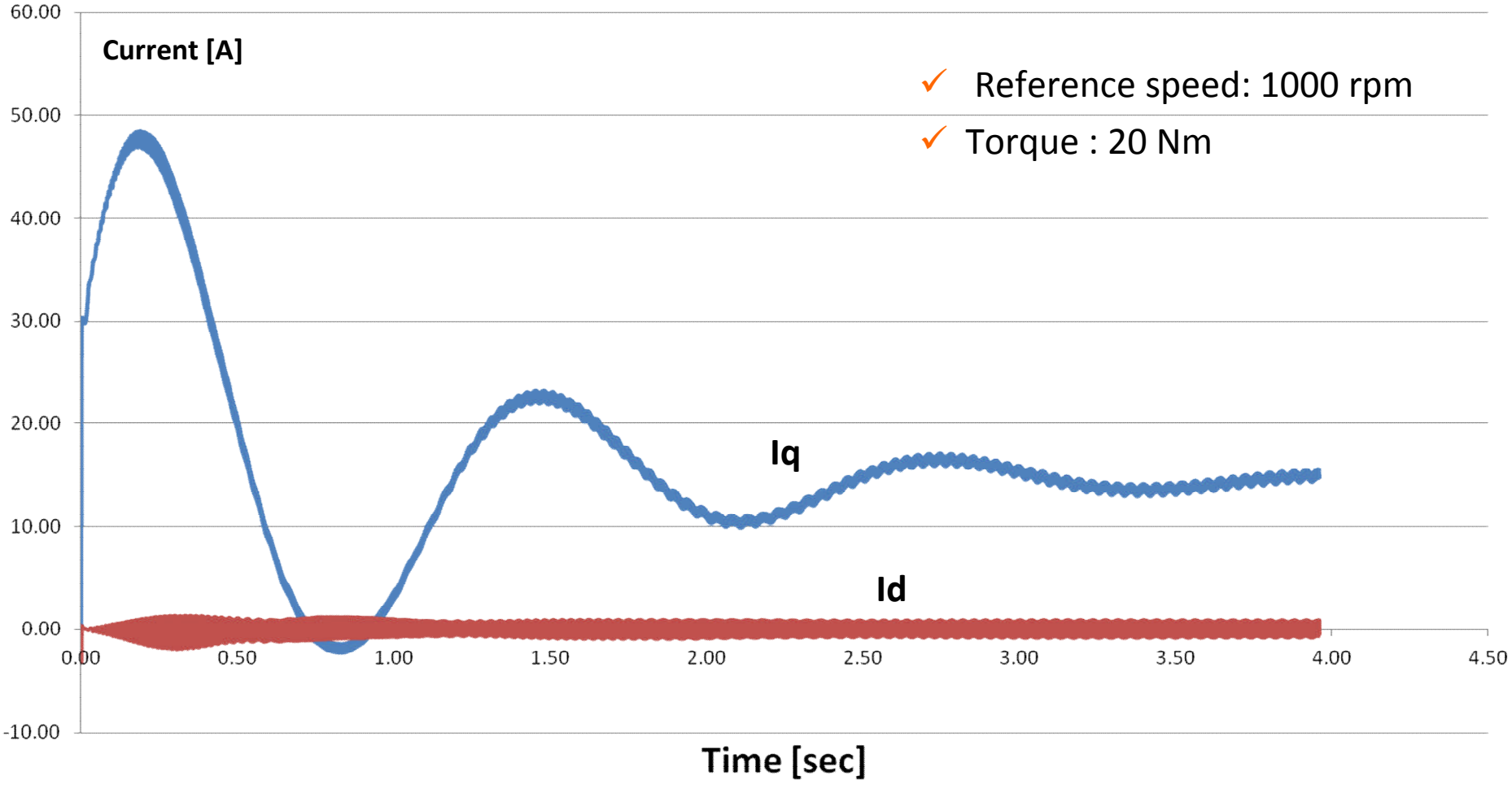

- ✓ Reference speed: 1000 rpm
- ✓ Torque : 20 Nm

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Conclusions

The Hybrid Motor with double rotor for automotive application has been simulated by Flux software.

The co-simulation **Portunus + Flux** has allowed to analyze the Hybrid Motor performance by taking into account the control strategy in order to verify the dynamic motor behavior.

This approach can be defined like as a "Virtual Experimental Test" and could represent an effective tool for the analysis of motor performance and the refinement of motor design in order to improve and optimise the dynamic performance.