

## RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

**Field:** Energy, Processes

**Subfield:** Electrical Engineering

**Title:** Sensorless Control for Integrated Multiphase Drives applied to Transportation Systems Using Artificial Intelligence Potentiality

**ParisTech School:** Arts et Métiers Sciences et Technologies

**Advisor(s) Name:** Prof. Eric Semail

**Advisor(s) Email:** Dr. Ngac Ky Nguyen

**Research group/Lab:** Laboratory of Electrical Engineering and Power Electronics (L2EP)

**Lab location:** ENSAM, 8 Boulevard Louis XIV, 59046 Lille, France

**(Lab/Advisor website):** <http://l2ep.univ-lille.fr/?lang=en>

**Short description of possible research topics for a PhD:**

This project aims to study a **compact** and **performant integrated multiphase drive**, including **fault modes**, for **automotive mass market**. In this context, price, reliability and compacity are the main criteria. Among the sensors, the end-shaft mechanical position sensor is the most expensive one and is consuming space. Using only current measurement could lead to a suppression of the end-shaft position sensor. **Sensorless control algorithms** have been proposed for three-phase drives since several decades with the increase of power calculation for signal processing. With multiphase machines, it is possible to use additionally magnetic sensors to increase the number of data of the rotor position which will be used for vector control even in fault modes.

**Artificial Intelligence (AI)** will be investigated for sensorless algorithm development. With multiphase machines using numerous current and magnetic sensors, we propose, by **coupling AI with expert knowledges on electrical multiphase machines**, to obtain reliable and real-time estimation of the rotor position for a use in the vector control in healthy but also in fault mode operation.

**Required background of the student:**

Beside a good level of English, the recruited student must have:

- A strong background of electrical machines
- A good general culture of scientific research, i.e a Master Research Diploma is helpful
- A good skill for working autonomously and within a team

**A list of 5 (max.) representative publications of the group (related to the topic):**

1. X. Kestelyn and E. Semail, "A Vectorial Approach for Generation of Optimal Current References for Multiphase Permanent-Magnet Synchronous Machines in Real Time," IEEE Transactions on Industrial Electronics, vol. 58, pp. 5057-5065, Nov 2011.
2. N. K. Nguyen, F. Meinguet, E. Semail, and X. Kestelyn, "Fault-Tolerant Operation of an Open-End Winding Five-Phase PMSM Drive with Short-Circuit Inverter Fault," Industrial Electronics, IEEE Transactions on, vol. 63, pp. 595-605, 2016.
3. N. K. Nguyen, E. Semail, F. D. Belie, and X. Kestelyn, "Adaline Neural Networks-based sensorless control of five-phase PMSM drives," in IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society, 2016, pp. 5741-5746.
4. Y. Mini, N. K. Nguyen, E. Semail, "A novel Sensorless Control Strategy Based on Sliding Mode Observer for Non-Sinusoidal Seven-phase PMSM", The 10th International Conference on Power Electronics, Machines and Drives, December 2020 (accepted)
5. D. A. T. Guzman, N. K. Nguyen, M. Trablesi, and E. Semail, "Low Speed Sensorless Control of Non-Salient Poles Multiphase PMSM," in 2019 IEEE International Conference on Industrial Technology (ICIT), 2019, pp. 1563-1568.