

Methods of current sensors faults detection and compensation for induction and synchronous motor drives based on modified state variable observers

In recent years, there has been a significant increase in interest in the applications of electric propulsion systems, not only in industrial automation and robotics, but also in the broadly understood transport of people and things (transport carts, drones, planes, ships, passenger cars and trucks). This is due to ecological requirements and a common demand to reduce the consumption of liquid fuels and the emission of harmful gases into the atmosphere, as well as noise and maintenance costs. Therefore, new requirements have also appeared in relation to electric drive systems, such as: low weight and compactness of construction, low cost, high efficiency, maintenance-free and reliability. Modern designs and technological solutions of induction motors (IMs), and in particular permanent magnet synchronous motors (PMSMs), meet these requirements, and thanks to the use of power electronics and modern control methods, they create electric drive systems that are perfectly suited for the above-mentioned applications. However, like all technical systems, electric drives can also be damaged. One of the weaker links in such systems are current sensors. Without information on the stator current of the IM or PMSM, automatic control of electromagnetic torque and angular velocity of the motor cannot operate. Moreover, the reconstruction of the state variables that are not available in measurements, which are necessary for the implementation of the vector control algorithms used for precise torque control of the IM and PMSM is also not possible. Therefore, in recent years, not only effective methods of current sensor faults detection but especially methods for compensation of their damages are searched for, so that the drive system can retain its full functionality despite the damage and enable safe stopping of the driven device (e.g. access a bus to a stop, a car to a parking lot etc.) or a controlled industrial process (e.g. a production line).

The aim of the project is to develop and test, in simulation and experimental studies, drive systems with AC motors (IMs and PMSMs) controlled with vector methods, tolerant to stator current sensors faults.

The implementation of this goal will be possible thanks to the development of new methods for detection and compensation of damage to current sensors in the stator windings of the tested motors, using modified estimators of the state variables and parameters of the motor, including neural networks. The developed methods for compensation of the stator current sensors damages will enable uninterrupted operation of the vector control structures of the IM or PMSM drives in the "current-sensorless" mode until, due to the safety requirements of the controlled process, it will be possible to smoothly stop the drive system.

Various failures of the current sensors will be considered, including complete signal loss, which in the case of only two current sensors used for the three-phase motor drives (which is now common practice in industrial solutions) is the most serious problem because it precludes the operation of the vector control methods of AC motor torque and rotor speed/position. Until recently, the approach used was to switch the control structure to the so-called scalar control, which does not ensure full functionality of the drive system. The innovative solutions proposed in this project will use state variable observers, Kalman filters and neural networks, equipped with algorithms for adapting selected parameters (including those using neural models) to ensure good quality of the stator current reconstruction in the event of failure of one or even both stator current sensors. The planned research works are part of the current world research and development trends related to the issues of diagnostics and fault tolerant control in drive automation systems and fit well into the rapidly developing field of fault-tolerant control methods of complex mechatronic systems.