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ABSTRACT

Doctoral dissertation

Analysis of a fault-tolerant control system of the vehicle with PM BLDC motors

The doctoral dissertation consists of six chapters, a list of references and an appendix.

The first chapter provides an overview of basic research problems occurring in electric drive with PM BLDC motor and the aim, scope and scientific thesis of the dissertation and the characteristics of the research methodology. The aim of the doctoral thesis is formulated as: *development of a control method of a vehicle with electric drive with PM BLDC motors, providing safe and tolerant to selected faults operation. Moreover, an additional objective of the work is to develop a prototype laboratory vehicle for testing the proposed fault tolerant control methods*. The following thesis of the dissertation is formulated: *application of fault detection, identification and compensation methods, using available measurements of phase currents and rotor position of PM BLDC motor, enables to realize fault tolerant drive system of a vehicle.*

The second chapter presents the issues related to the modeling of the drive system with PM BLDC motors under various conditions, including the operation after an occurrence of selected faults. Developed simulation model and selected simulation results are presented in this chapter. The impact of the faults (transistors in an electronic commutator and rotor position sensors) on waveform deformation of the phase currents and electromagnetic torque and rotational speed is studied.

The developed laboratory setup is described in third chapter. Selected research results, obtained using the experimental setup in various operating conditions of the drive are presented. The impact of rotor position sensor faults and electronic commutator transistor faults on the drive are discussed in detail. Time waveform and spectral analysis of phase currents and mechanical vibrations were used in the analysis.

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The fourth chapter deals with the issues related to fault tolerant control systems. The considerations are illustrated with simulation and experimental research, done on the prepared laboratory setup. This chapter presents methods for detecting and identifying faults of the transistor in electronic commutator and the rotor position sensor. Then, it presents an alternative method for determining rotor position (using sensorless unit or using computational methods: ZOA and HO), intended for use after detecting a complete fault of the sensor. Possible methods for determining the speed of rotation, on the basis on the rotor position sensors are described, also after the occurrence of the fault of one of them. The chapter presents control systems as well, practicable after the detection of the fault in the power unit, by using an additional half-bridge in the electronic commutator or by connecting the phase with a non-conductive transistor to the midpoint of the power supply. The developed algorithms were tested in a prepared simulation model, then implemented in the digital signal processor and tested at a laboratory test-stand.

In the fifth chapter, issues related to the construction of the mechanical parts, electronic and software laboratory prototype of the vehicle are discussed. The prototype was used for testing the movement of the vehicle and the operation under selected faults. The control system utilizes methods, which are developed and tested in detail in chapter four. They are validated for their suitability for usage in a real drive system. This chapter presents also simulation tests of a vehicle moving along a reference trajectory, including the conditions of selected faults.

The sixth chapter contains a summary of the dissertation and general conclusions. Selected directions for further research are also included in this chapter.

Appendix A includes information about PM BLDC motors and the experimental setup, used during laboratory tests.

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