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Abstract of the PhD dissertation entitled:

Stability analysis of selected estimators of an induction motors speed in various operations of drives

In this PhD thesis, problems related to an estimation of induction motor speed by MRAS type estimators are investigated. Current-based speed estimators: AFO, $MRAS^{CC}$ and $MRAS^{CV}$ are the subject of detailed considerations, for which a thorough stability analysis is carried out, methods for improving stability are proposed and a wide range of theoretical, simulation and experimental tests are made. Moreover, the analysis of the impact of incorrect identification of induction motor parameters on classic and modified versions of current MRAS type speed estimators is presented. Additionally, due to the modern microprocessor implementation of the control system, a comparative analysis of the influence of four numerical integration methods on the stability and quality of the estimation of selected current-based speed estimator, $MRAS^{CC}$, is performed. Based on the above comparison, in order to analyse the properties (including stability) resulting from the research conducted for the continuous form, the results for the discrete form of modified versions of the $MRAS^{CC}$ estimator are presented. The dissertation consists of nomenclature and list of abbreviations used in the work, 7 chapters, a list of literature and five appendixes.

First chapter presents a review of methods for estimating the speed of an induction motor used in sensorless drive systems. A main attention is devoted to the most widespread group in the literature, in other words, estimators using the adaptive systems technique, i.e. MRAS-type estimators. The main part of this chapter deals with current-based speed estimators: AFO, $MRAS^{CC}$ and $MRAS^{CV}$, for which the worldwide literature related to stability analysis, the proposed stability improvement methods and sensitivity analysis of IM parameters changes on mentioned estimators are presented in detail. The second part of this chapter is devoted to the literature analysis on the discretization methods and in particular the issue of the digital implementation of state variable estimators. Based on the literature

analysis and problems related to state variable estimators, the objective, thesis and range of the dissertation are presented.

The next chapter describes the idea of MRAS type estimators and the process of the derivation of the speed adaptation algorithm, which is made using the Lyapunov stability theory.

Unified approach of writing the mathematical model of an induction motor and current-based speed MRAS-type estimators is presented in third chapter.

A stability analysis of current-based speed MRAS type estimators is shown in next chapter. The first part of this chapter deals with a step-by-step presentation of general algorithm for stability analysing of speed estimators. Next, a detailed stability analysis of the AFO, MRAS^{CC} and MRAS^{CV} estimators is presented. The further part shows detailed derivations of three stability improvement methods for AFO and MRAS^{CC} estimators. The fourth part of this section is devoted to the presentation of a wide range of simulation and experimental tests for classic and modified versions of current-based speed MRAS-type estimators, cooperating with the DRFOC control structure in open- and closed-loop, in motoring and regenerating modes. The above analysis is also the subject of a qualitative and quantitative assessment (the ITAE criterion is used). The last part of this chapter consists of the analysis of worldwide literature related to stability of other MRAS-type estimators. The entire chapter is finished with a short summary.

The fifth chapter deals with detailed analysis of the impact of incorrect identification of three main parameters of induction motor: stator resistance, rotor resistance and main inductance on the stability and quality of estimation of classic and modified current-based speed MRAS-type estimators. Detailed simulation tests, made in motoring and regenerating mode, are presented. For each of the estimators, a detailed discussion is presented. This chapter is concluded with an analysis of the impact of incorrect parameters identification on other MRAS-type estimators and a with short summary.

In sixth chapter, a special attention is paid to the digital implementation of the MRAS^{CC} estimator. The first part of the section is devoted to two approaches for discretization and a detailed analysis of four methods of numerical integration. These methods are compared in detail on the basis of the operation of the discrete MRAS^{CC} estimator. On the basis of the presented comparison, two simpler implementation methods are selected for which an analysis of the properties of the proposed before, discretized versions of the modified MRAS^{CC} speed estimators is performed.

In the seventh chapter the conclusions and comments resulting from the conducted research are discussed. In the appendixes the following information is given: induction motor parameters, base units, gains of all analysed estimators, mathematical models of other MRAS-type estimators, DRFOC control structure used during tests and a detailed description of the laboratory set-up.

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