Opponent Review of Doctoral Dissertation Thesis

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Theme: Application of Genetic Algorithms in Control of Induction Motor Drives

Opponent: Prof. Ing. Jiri Lettl, CSc.  
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The Ph.D. thesis of Mr. Ing. Thinh Cong Tran deals with the very important and highly current problems of the genetic algorithm application in control of Induction motor drives. The suitability of the generated genetic algorithms is firstly tested by simulation, then the algorithms are implemented into a real laboratory system and their functionality is verified.

A. Stipulated objectives and their fulfilment

A clear summary of the objectives set out is presented on pages 19 and 20 of the dissertation. In addition to the theoretical analysis of the genetic algorithms (see chapter 3), a choice of suitable applications for the speed control and parameter estimation of the vector controlled induction motor drive, creation of mathematical models and simulation of control structures in MatLab/Simulink environment, development and implementation of the selected genetic algorithms (see chapter 4) and choice of the proper control microcomputer system, design of the laboratory stand for the chosen genetic algorithm experimental verification, experimental measurement on the laboratory model, evaluation, comparison of the results with theoretical assumptions and simulation (see chapter 5) have been performed. The results obtained from the simulations and experiments, as well as their consensus, prove conclusively that the set objectives have been met.

B. Approach to solving the problem, results and concrete contribution of the dissertation work

The utilized methods include review of the current control methods of induction motor drives with emphasis on the vector control and genetic algorithm application, theoretical description and analysis of the problem, creation of the system mathematical models, design and implementation of suitable control algorithms, simulation and experimental verification of the developed control system functionality. Overall, the results of simulations and experiments and their mutual agreement have proved the legitimacy of the procedures and tools used.

In addition to the theoretical analysis of the problem, the creation of simulation models of the system including the control structures, their practical testing and especially verification by comparison with the results of experimental measurements can be considered as the main contribution of the thesis. The results of simulations and experiments provide a detailed practical view of the problem solved and a comparison of the behaviour of the studied system with different implemented control algorithms in different working modes and their comparison with each other.
The candidate should state, explain or evaluate:

- significant delays in the motor responsiveness added by a modulator (see page 22, 12th line from bottom),

- not including the motion equation to the induction motor state-space matrix representation (see page 23, relationships 3.2 - 3.3),

- the induction motor current model "iS - ωm" without ωm (see pages 26-27 and figure 3.3),

- an induction motor model in the FOC structure (see page 28, chapter 3.3.2, figures 3.6 - 3.8 and page 67, figure 5.9),

- fitness functions used in chapter 4.1.2 (see page 37),

- parameters P, F and difference between KT and kT in chapter 4.3.1 (see pages 45 - 47),

- which block of the structure in figure 4.17 uses the relation 4.39 (see chapter 4.4.1, page 50),

- the cause of continuous, irregular ripple in actual rotor speed responses in figures 5.10, 5.12, 5.14, 5.16, 5.19, 5.22 (see chapter 5.2, pages 67 - 74),

- the basic difference between cost function given by the relation 4.37 (see page 49) and cost function given by the relation 5.4 (see page 84).

C. Importance for practice and the scientific discipline development

The theme of the dissertation is highly topical and is of considerable importance for practice application of new, extra sophisticated control algorithms in the field of induction motor drives. These are applications of control methods such as: PID speed controller optimization using online genetic algorithm, induction motor rotor time constant estimation using online PI adaptive and genetic algorithm adaptive model, estimation of induction motor parameters using artificial neuron network and genetic algorithm, PI based speed controller for induction motor drive vector control model using fuzzy algorithm tuned by genetic algorithm, estimation of sensorless controlled induction motor parameters using modified genetic algorithm and Cuckoo search algorithm and experimentally verified speed control with field oriented control for different speed levels using encoder, online genetic algorithm PID controller for field oriented control of induction motor drive, estimation of induction motor parameters using genetic algorithm and artificial neural network. In all mentioned cases, the positive influence of genetic algorithm application in induction motor drive control system has been proved. The large number of graphically processed results of simulations and especially the results of experimental verification confirms the quality of the submitted doctoral dissertation.

D. Formal adjustment, language level, terminology and graphical carrying out

Besides the acknowledgement, abstract, contents, list of used symbols and abbreviations, list of figures, list of tables, introduction, Ph.D. thesis objectives, summary, references, list of author’s publications and list of author’s projects, the thesis is clearly divided into three parts - Theory, Application of Genetic Algorithm in Control of Induction Motor Drive, Experimental Results. These three chapters are logically divided into three levels of subchapters. The work has a clear composition and a coherent character. The author does not deal with unnecessary details; he appropriately refers to the used literature. The list of used symbols and abbreviations, as well as a list of pictures and a list of tables, contribute to the comprehensibility of the work, nevertheless
some of the more familiar abbreviations can be involved in the list, too, for example ANN - Artificial Neural Network (see chapter 4.3, page 45). Some formal and stylistic errors are not serious. Some grammatical errors and misspellings (for example on pages 20-21 in listing implementation methods, the items "Observer-based speed sensorless control" and Model reference adaptive systems" are listed 2 times, etc) could be avoided by more careful correction of the clean copy. I have found no fundamental terminology discrepancies. The overall graphical level of work is very good.

E. Appraising the published works

The list of author's publications given on pages 96 and 97 of the dissertation contains in total 21 published scientific and professional papers including 4 papers published in journals indexed in databases Web of Science or Scopus (3 times Advances in Electrical and Electronic Engineering and 1 time Journal of Heat and Mass Transfer), 12 papers in international conference proceedings indexed in databases Web of Science or Scopus (10 times the conference AETA and 2 times the conference ELEKTRO), and 5 other publications (Annual Workshop of FEECS WOFEX). The number of the works published by Ing. Thinh Cong Tran can be considered to be appropriate in the given field. It is obvious that the core of the Ph.D. thesis has been published to a sufficient extent and on a reasonable level.

F. Conclusion

Mr. Ing. Thinh Cong Tran has fulfilled the objectives of his doctoral thesis. The dissertation work contains the new scientific knowledge and meets the generally accepted requirements for doctoral dissertation. The PhD student has proved the ability to independent scientific work. For the reasons above, I recommend the PhD thesis

\textbf{to be admitted to a defence.}

In Prague on November 20\textsuperscript{th}, 2018

\signature

Prof. Ing. Jiri Lettl, CSc.