Wideband electrical machines monitoring for practical diagnostics

Summary

Overall goal of the project is to investigate the electric machine diagnostics using wideband transient traces of the PWM switching transients, in order to detect the imminent faults in the machine. Such condition monitoring would require more detailed analysis (especially in wide bandwidth) of the quantities of the electric machine, preferably at the output terminals of the frequency converter output. Within this research project, the capabilities of such system will be investigated, targeting for example, insulation failure and winding short-circuit failure.

Research field:	Electrical power engineering and mechatronics
Supervisors:	Dr. Lauri Kütt Dr. Toomas Vaimann
Availability:	This position is available.
Offered by:	School of Engineering Department of Electrical Power Engineering and Mechatronics
Application deadline:	Applications are accepted between October 01, 2022 00:00 and October 23, 2022 23:59 (Europe/Zurich)

Description

Electric machines in drives are connected to the frequency converters that feed the electric machines with the supply power by outputting the controlled voltage and current, generally responding to the machine rotational characteristics such as rotation speed and torque applied. The frequency converters themselves are using switching operation and their output is defined through specific PWM-synthesised waveforms.

In the research the individual PWM-switching pulse transients are investigated to provide information on the rotating machine operating conditions. The switching pulses provide frequency range response in MHz range, offering more insight to the full circuit, including the frequency converter but also the machine windings, connections etc. Research tasks include measurement and monitoring of the considered transients, including practical measurement system specification, signal processing and detection criteria outlining.

The thesis is heavily experimental and should address the following questions: 1) How are the fault traces distinguishable in the wide bandwidth monitoring application? 2) Which are the requirements of the system to monitor the transient traces considered? 3) How to process the signals in order to detect the appropriate fault traces from the other transient spurious noise? 4) How accurate and capable is the designed processing algorithm to detect the upcoming faults?

Supervisors:

Main supervisor: Dr. Toomas Vaimann
Co-supervisor: Dr. Lauri Kütt

Responsibilities and foreseen tasks

- Conduct the tests to detect the electric machine faults under consideration
- Propose the measurement and observation system layout, capable to provide data acquisition to meet the specified data processing levels
- Collect data and conduct case studies on the selected field applications, including the real working frequency converter and electric machine under various loading conditions.
- Define and elaborate algorithms efficient for the fault detection, using short- and long-term processing of the measured data.
- Contribute to the organization of research and practitioner workshops where project findings are presented

Applicants should fulfil the following requirements:

- a master's degree in electrical engineering sciences (preferably in electromagnetics, electric machines and electric drives)
- good grades in calculus and physics subjects
- good comprehension of Matlab and practical programming skills
- a clear interest in the topic of the position
- excellent command of English
- strong and demonstrable writing and analytical skills
- capacity to work both as an independent researcher and as part of an international team
- capacity and willingness to provide assistance in organizational tasks relevant to the project

The following experience is beneficial:

- Instrumentation and measurement
- Programming in C++
- Working knowledge of SQL
- Working knowledge of statistics
- Working with cells

The candidate should submit a research plan for the topic, including the overall research and data collection strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

We offer:

- 4-year PhD position in the leading electrical machines research group in Estonia with a large portfolio of dedicated research, industrial and study-oriented projects
- The chance to do high-level research in one of the most dynamic Universities and research groups in the region
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of electrical machines and diagnostics

About the department

The Department of Electrical Power Engineering and Mechatronics of Tallinn University of Technology is an interdisciplinary research center that focuses on socially relevant and future-oriented research and teaching issues related to power engineering and mechatronics. The mission of the Department is to be a leader in electrical engineering and technical studies and development projects in Estonia, known and valued in society, and a respected partner in both national and international cooperation networks and organizations.

The department educates future energy leaders and engineers at the bachelor's, master's and doctoral level. Through training courses, the department ensures lifelong learning and continuous development.

The department carries out large-scale interdisciplinary scientific research, development and professional projects, thanks to which the competence in the field of electrical energy and mechatronics continues to grow. With research, application and development services, the department increases the competitiveness of companies in both the domestic and international markets, keeping knowledge in Estonia. The department has coordinated or been a partner in numerous international projects, such as Horizon 2020, INTERREG, 7FP, Nordic Energy Research, etc.

The Department of Electrical Power Engineering and Mechatronics conducts research within seven research groups and operates state of the art laboratories with high end equipment, offering also accredited services in the fields of lighting and different electrical measurements.

The departments' focus areas are related to both domestic and global developments, such as increasing digitalization and decarbonization, decentralization and decentralization of electricity generation, and the increasing use of renewable energy sources. The department conducts research in the following relevant areas tackling the energy transition:

- optimization of electrical systems and system analysis to find possibilities for electrification and decarbonization

- diagnostics and monitoring of equipment and systems
- cyber security, 5G data communications and artificial intelligence
- energy networks and research on hydrogen technologies, including energy storage, renewable energy, low carbon technologies, consumption management, IoT applications in energy
- implementation of smart industry, including industrial robotics, automation, 3D printing, machine vision
- implementation of energy and resource efficiency, including digitization of supply chains, mapping of opportunities to optimize systems and reduce energy consumption
- development of smart city solutions, including environmentally friendly and self-driving vehicles / drones, digital twin applications.

Additional information

For further information, please contact Dr. Toomas Vaimann toomas.vaimann@taltech.ee and Dr. Lauri Kütt lauri.kutt@taltech.ee or visit https://taltech.ee/en/electrical-machine-group

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