E-PROCEEDINGS

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"Fostering a Culture of Innovation and Entrepreneurial Excellence"

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Editors

Aznilinda Zainuddin

Maisarah Noorezam

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A-ST032: INTERACTIVE REAL-TIME VISUALIZATION OF FAULT TOLERANCE SIMULATION FOR INDUCTION MACHINES

Nooradzianie Muhammad Zin[1], Wan Noraishah Wan Abdul Munim[1], Yusrina Yusof[1], and Mohd Ezwan Mahadan[2]
[1]School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[2]Electrical Engineering Studies, College of Engineering, Universiti Teknologi MARA Johor Branch Pasir Gudang Campus, 81750 Masai, Malaysia

Corresponding author: Nooradzianie Muhammad Zin, adzianie@uitm.edu.my

ABSTRACT

This research presents a novel graphical user interface (GUI) as a research and teaching tool for analyzing fault tolerance in induction machines (IM) under open-phase faults (OPFs). The study focuses on both three-phase and symmetrical six-phase induction machines, with scenarios involving up to three OPFs. The GUI integrates MATLAB-based simulations, enabling real-time visualization of machine performance under pre-fault and post-fault conditions. For symmetrical six-phase IM, the process begins with obtaining balanced stator currents under healthy conditions. Faulty operations are optimized based on maximum torque (MT) or minimum loss (ML) modes using Excel's "Solver," with results displayed through the GUI. For three-phase IM, the tool simulates and visualizes output waveforms under fault conditions, offering valuable insights into fault tolerance. Maximum torque will be applied as well during faulty. This tool enhances understanding of fault-tolerant control techniques, bridging the gap between theoretical concepts and practical applications. It serves as a teaching aid for students and researchers while also offering a diagnostic tool for industrial applications. Its user-friendly design, combined with the flexibility to adapt to multi-phase machines, positions it as a scalable solution with potential commercialization in both academic and industrial.

Keywords: three-phase induction machine, six-phase induction machine, fault tolerance

1. Product Description

The study provides a novel GUI framework integrated with MATLAB, simulating the behavior of induction machines under fault conditions. This tool offers a user-friendly interface that visualizes pre-fault and post-fault conditions, optimizing current references for either maximum torque (MT) or minimum loss (ML) operation modes as per described in **Figure 1**. It allows users to input parameters, analyze performance indicators such as derating factors and copper losses, and compare results under various fault scenarios. In the fault tolerance of symmetrical six-phase induction machines (IM), the first stage involves healthy operation by obtaining six-phase balanced stator currents. For faulty operation, optimization is performed based on two modes—MT) or ML—using Excel's "Solver." This optimization considers fault scenarios involving up to three open-phase faults (OPFs). Subsequently, a graphical user interface (GUI) as in **Figure 2** is developed to display all possible scenarios. While for three-phase IMs, real-time visualization of pre-fault and post-

fault output waveforms is simulated. The MT optimization will be applied during OPF condition.

2. Flowcharts Detail of the Methodology.

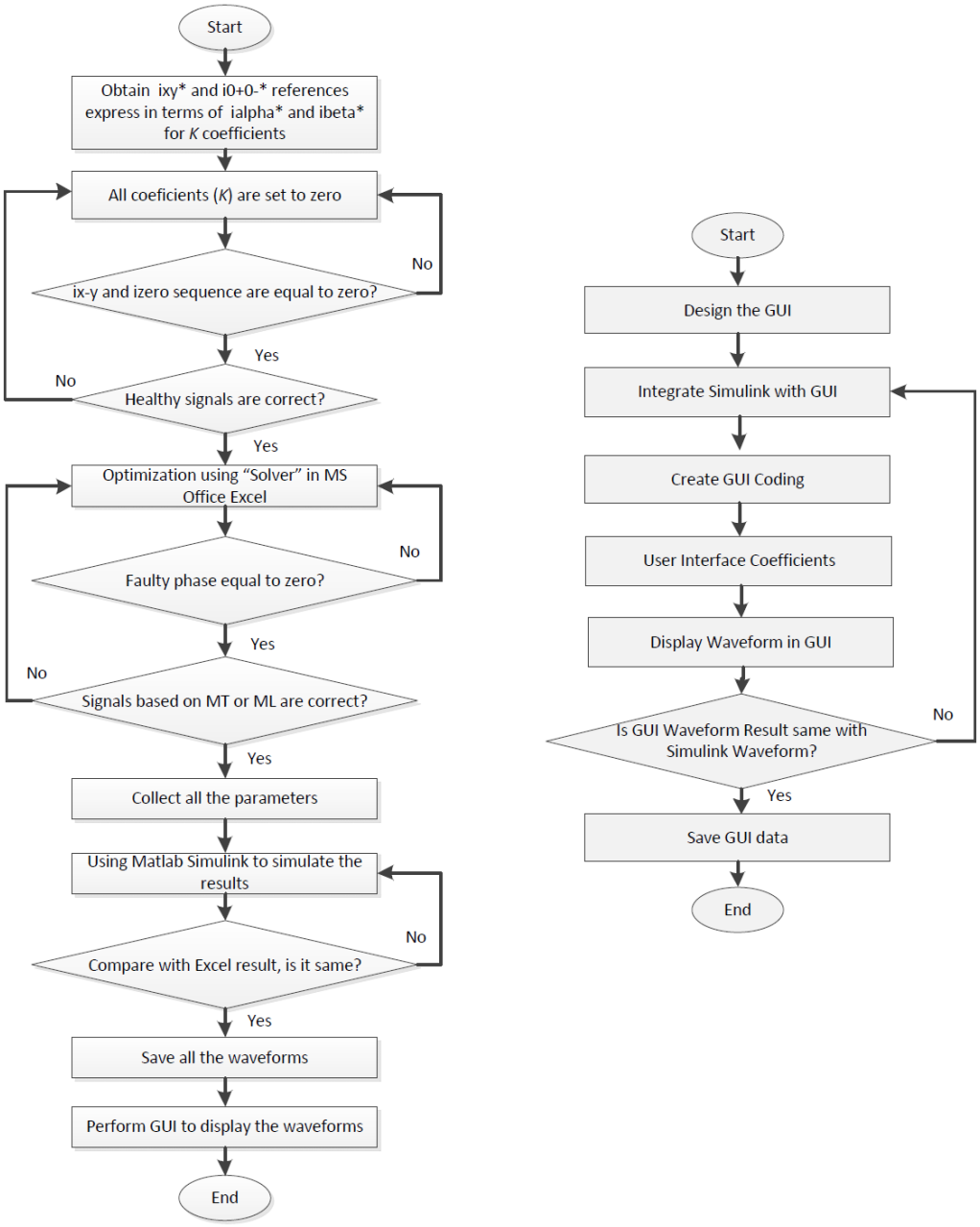

Figure 1. Flowchart of Pre- and Post-Faults Operation For IM

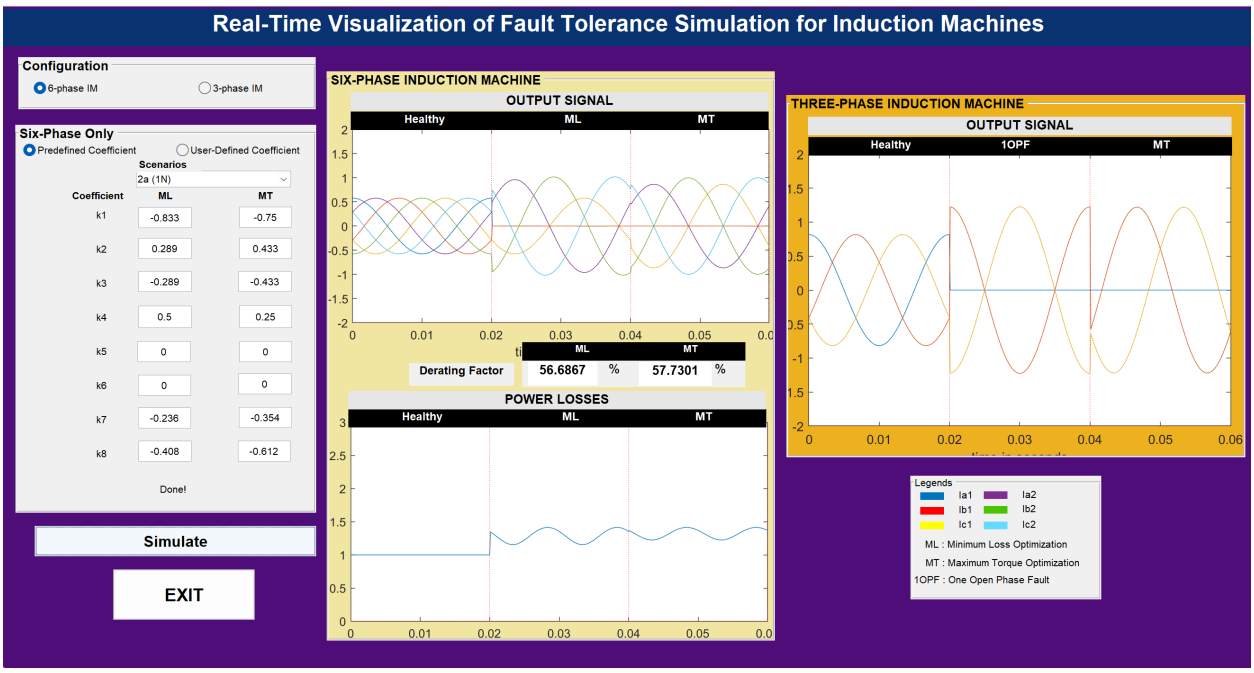

Figure 2. A Successful GUI Simulating a 2OPFs Signal Condition for Symmetrical Six-Phase IM and Three-Phase Induction Machine during 1OPF Condition

3. Novelty and uniqueness

The integration of a GUI for fault tolerance in induction machines represents a novel contribution, especially in the educational and research domains. Unlike traditional methods, this interface simplifies fault analysis, allowing visualization of current waveforms and performance metrics in real-time. The dual focus on MT and ML modes further enhances its uniqueness, offering insights into operational trade-offs under different fault conditions.

4. Benefit to mankind

The enhanced understanding of fault tolerance in induction machines fosters reliability and safety in industrial applications. The GUI serves as an educational tool for students and researchers, simplifying complex fault-tolerant control techniques and encouraging their application in energy-efficient motor drives.

5. Innovation and Entrepreneurial Impact

By automating fault analysis and incorporating optimization techniques within a GUI, the study introduces a marketable tool for motor manufacturers, educators, and industrial researchers. The simplicity of the interface reduces the need for specialized programming knowledge, broadening its accessibility and potential user base.

6. Potential commercialization

The GUI tool can be commercialized as a software package for academia and industry. It has potential applications in motor diagnostics, predictive maintenance, and educational training modules for courses on electrical machines and drives. The GUI has significant potential for commercialization as both an educational and industrial tool. In academia, it can be marketed to universities and training centers as a teaching aid for courses such as electrical machines and drives, enabling students to visualize and analyze fault tolerance in real-time. For industry, it serves as a diagnostic tool for monitoring and optimizing induction machine performance under fault conditions, reducing downtime and maintenance costs. The tool's adaptability to different machine configurations, user-friendly interface, and focus on operational efficiency make it a useful product, with applications in motor manufacturing, industrial automation, and predictive maintenance systems.

7. Acknowledgment

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8. Authors' Biography

Nooradzianie Muhammad Zin was born in Kedah, Malaysia, in 1987. She received the B.S. degree and M.Sc. degree in Electrical Engineering from Universiti Tun Hussein Onn Malaysia, in 2011 and 2016 respectively. She is currently a Ph.D. student in the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia. Since 2016, she has been a lecturer with Universiti Teknologi MARA, Malaysia. Her current research interests include the area of power electronics and motor drives control. She can be contacted at email: adzianie@uitm.edu.my.

Wan Noraishah Wan Abdul Munim received the diploma in Electrical Engineering (telecommunication) from University Teknologi Malaysia, Johor Bahru, Malaysia, in 2003, the B.Eng. Technology degree in Electrical Engineering from Universiti Kuala Lumpur, Kuala Lumpur, Malaysia, in 2007, and the M.Sc. degree In Electrical Power Engineering with business from the University of Strathclyde, Glasgow, U.K., in 2009. Since 2010, she is currently working as a senior lecturer at School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia. Her research interests include multiphase machines, fault tolerant control, and renewable energy. She received the 2014 Ministry of Education Malaysia Skim Latihan Akademik IPTA (SLAI) Scholarship

Award for her Ph.D. study. She received Ph.D. degrees in Electrical Engineering from the University of Malaya in 2020. She can be contacted at email: aishahmunim@uitm.edu.my.

Yusrina Yusof received her BSc in Electrical Engineering from Widener University, Chester Philadelphia, USA in 1999 and Master of Engineering (Electrical Power) from Universiti Teknologi Malaysia, Skudai, Johor. She is now a lecturer at School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Malaysia. Her research interest is in power electronic, renewable energy and power quality. She can be contacted at email: yusrin262@uitm.edu.my.

Mohd Ezwan Mahadan is a lecturer in Electrical Engineering at Universiti Teknologi MARA (UiTM) Johor, Pasir Gudang Campus. He obtained his Bachelor's degree in Electrical Engineering from Universiti Tun Hussein Onn Malaysia (UTHM) in 2009. He later earned his Master's degree in Electrical Engineering from Universiti Teknologi Malaysia (UTM). Since joining UiTM in March 2013, he has served as a lecturer. His research interests include renewable energy, power electronics, and power systems. He can be contacted at email: ezwan7101@uitm.edu.my.