IEEE PEMC 2026

22nd International Power Electronics and Motion Control Conference
Sept. 23–25, 2026 — Tallinn, Estonia

Power Electronics and Motion Control Conference

PEMC

Tutorial

Practical Aspects of Artificial Intelligence Applications in Fault-Tolerant Electric Drive Systems

Duration: 120 minutes

Abstract. Modern electric drive systems increasingly rely on artificial intelligence (AI) techniques to address key challenges related to control, diagnostics, optimization, and fault-tolerant operation. In particular, the growing interest in fault-tolerant control architectures imposes strict requirements on accuracy, robustness, and fast response to incipient and developed faults, making AI-based solutions highly attractive. However, despite their undeniable potential, many AI approaches reported in the literature are developed with limited consideration of practical implementation constraints, often treating AI models as black-box solutions trained on generic datasets and evaluated using selected performance metrics only.

This tutorial aims to bridge the gap between theoretical AI developments and their real-world application in drive systems. The session will focus on practical aspects of selecting, designing, training, and implementing AI techniques tailored to specific tasks within electric drives, including control, process optimization, and diagnostics. The presented solutions will consider the complete drive system structure from control algorithms and measurement systems, through power electronic converters, to the target machine.

Special attention will be devoted to the implementation and comparison of shallow and deep neural networks, transfer learning strategies, and neuro-fuzzy algorithms in electric drive applications. Furthermore, methods for optimizing neural network architectures and adapting model complexity to real-time and embedded constraints will be discussed. The tutorial will be supported by experimentally validated case studies, demonstrating AI-based solutions implemented and tested in laboratory-scale electric drive systems. Selected examples will be presented live via a remote connection to an external research laboratory, allowing participants to observe real-time system behaviour under realistic operating conditions.

The tutorial is intended for researchers, engineers, and practitioners interested in applying AI methods in modern electric drives, with an emphasis on transparency, interpretability, and practical deployment considerations. Supplementary materials, including presentation slides and selected implementation guidelines, will be made available to participants before or during the session.

Content Outline

Duration	Topics covered
10 min	Intruduction: AI in Modern Electric Drive Systems: Motivation and Challenges
15 min	***Practical Requirements for Fault-Tolerant Control and Diagnostics:*** During this part of the presentation, the practical requirements related to artificial intelligence techniques in the context of fault-tolerant systems will be discussed. Particular emphasis will be placed on the requirements concerning the quality of input information declared by the data acquisition system, the permissible computational complexity of the neural network, machine operating conditions, and the adaptation of AI techniques to drive operation. Furthermore, the integration of AI techniques with the control system will be presented using the example of PMSM and IM motors.
10 min	***System-Oriented Design of AI Solutions for Electric Drives:*** Artificial intelligence systems

	dedicated to specific tasks in drive systems namely fault detection, classification, prediction, and compensation will be discussed. To this end, methods for selecting the type and parameters of the neural network architecture, as well as practical techniques for normalizing input and output data with respect to the functions performed within the system, will be presented.
15 min	***Neural Networks and Neuro-Fuzzy Methods: From Shallow to Deep Models:*** The fundamental characteristics of neural network architectures will be discussed with respect to practical implementation. This part will be devoted to identifying the advantages and limitations of individual neural structures, including classical architectures, deep learning networks, and neuro-fuzzy structures, in fault-tolerant control systems (FTC). The objective of this part of the presentation is to propose a framework for the application of specific AI concepts as components of an FTC structure.
15 min	***Transfer Learning and Model Optimization:*** Transfer learning will be discussed as a means of universalizing fault detection and classification in FTC system. This section is devoted to examining the possibilities for the practical exploitation of system-specific knowledge in the implementation of new functionalities. The application of transfer learning constitutes a key solution for optimizing the training process of deep and shallow neural structures, significantly reducing the time required for the implementation of new system functions.
25 min	***Experimentally Validated Case Studies in Electric Drive Applications:*** This section is devoted to the discussion of practical implementations of AI techniques in drive systems. The part is divided into the application of AI in the diagnostics of power electronic converter systems, irregularities in measurement data acquisition systems, and defects of AC motors. Furthermore, fault compensation techniques based on neural estimation methods and the application of AI in adaptive controllers will be discussed. The objective of this section is to demonstrate the practical advantages and limitations of applying AI techniques in FTC systems.
15 min	***Live Demonstration and Practical Implementation Guidelines:*** During this part, two examples of the application of AI techniques in drive systems equipped with an induction motor and a PMSM will be presented. The demonstration will be conducted via a remote connection to the presenter's research laboratory. The real-time operation of the system will be demonstrated under conditions of induced drive system faults. In the event that a remote connection to the research laboratory is not available, equivalent material based on experimental studies conducted by the presenter will be presented.
15 min	Q&A Session

Maciej Skowron (Member, IEEE) received the **M.Sc.** degree in electrical engineering and the **Ph.D.** degree in automation, electronics, and electrical engineering from Wrocław University of Science and Technology, Wrocław, Poland, in 2018 and 2021, respectively. In 2025, he received the habilitation (**D.Sc.**) degree in the field of automation, electrical engineering, electronics, and space technologies.

He is an Associate Professor at Wrocław University of Science and Technology, where he serves as Head of the Electromobility Laboratory and Leader of the Electric Drive, Power Electronics and Electromobility Research Team.

His research interests include advanced diagnostics of electrical machines and drive systems, with particular emphasis on the application of artificial intelligence techniques, including deep learning and transfer learning. He is an active member of leading international scientific organizations, notably the Institute of Electrical and Electronics Engineers (IEEE) and the IEEE Industrial Electronics Society (IES), as well as several national professional associations.

His scientific excellence has been recognized by numerous prestigious awards, including the Jan Mozrzymas Scholarship, the Best Young Author Award of the Polish IEEE Section, and multiple Best Oral Presentation Awards. Furthermore, he was listed among the TOP 2% of the world's most highly cited researchers in 2024 and 2025. He serves as a reviewer for IEEE, IET, Elsevier, and MDPI journals, and as an Associate Editor of Power Electronics and Drives. (E-mail: maciej.skowron@pwr.edu.pl)