Biography of Dr. Mohammad Nasir Uddin

M. Nasir Uddin (Fellow IEEE) received the B.Sc. and M. Sc. degrees both in electrical & electronic engineering from Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh, and the Ph.D. degree in electrical engineering from Memorial University of Newfoundland, Canada in 1993, 1996, and 2000, respectively. He has been serving as a Professor in the Department of Electrical Engineering, Lakehead University (LU), Thunder Bay, ON, Canada since August 2001. He also served as a visiting Prof. at Univ. of Malaya (2011-2013) and UNITEN(2018-2019), Malaysia; Tokyo University of Science(2010), Japan; Bangladesh, University of South Alabama(2001), USA; North South University(2006), and BUET(1994-1997), Bangladesh. He possesses more than 28 years of teaching experience and has authored/coauthored over 290 papers including 72 papers in IEEE Transactions with more than 20,000 citations in Google Scholar.

Currently, he is serving as a member of the IEEE Transportation Technologies Award Committee (2023-2026). Earlier he served as Advanced Controls Working Group Chair, IEEE-PES Motor Sub-Committee (2005-2010) and IEEE-IAS for 11 years in different capacities including IAS Executive-Board member. He received many awards including the prestigious IEEE Power and Energy Society (PES) Cyril Veinott Electromechanical Energy Conversion Award 2025, EIC (Engineering Institute of Canada) Fellow (2023), IEEE-IAS service Award-2015 and IEEE-IAS Distinguished Lecturer (2026-2027). Lakehead University recognized his outstanding contributions in teaching and research with LU Distinguished Instructor award-2023 (highest teaching award)) and LU Distinguished Researcher Award-2010 (highest research award).

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Recent Advances in Control Techniques for Wind Energy Conversion System

Speaker: Mohammad Nasir Uddin, *Fellow IEEE, Fellow EIC*
Professor and Coordinator, Lakehead University, Barrie campus, ON, Canada

Abstract- Over the last few decades wind energy has emerged as one of the fastest growing mainstream power technologies due to its low cost and environmentally friendly nature compared to conventional fossil fuel based power generation. Considering available options of state-of-the-art generator technologies in wind energy conversion system (WECS), doubly fed induction generator (DFIG) has become popular because of its economic operation, ability to regulate in sub-synchronous or super-synchronous speed and decoupled control of active and reactive power. Harnessing regulated power supply from unpredictable wind blow, extraction of maximum power from intermittent generation and supervision on nonlinear system dynamics of DFIG-WECS are some of the critically challenging issues for wind energy system. Maximization of the power yielded from wind turbine is possible by optimizing tip-speed ratio, turbine rotor speed or torque and blade angle. Traditionally, maximum power point tracking (MPPT) control algorithm is based on the Hill Climb Search (HCS) method due to its simple implementation and turbine parameter-independent scheme. Since the conventional HCS algorithm has few drawbacks such as power fluctuation and speed-efficiency trade-off, a new adaptive step size based HCS controller is developed in this work to mitigate its deficiencies by incorporating wind speed measurement in the controller. Again, conventional feedback linearization controllers are sensitive to system parameter variations and disturbances on grid-connected WECS, which demands advanced control techniques for stable and efficient performance considering the nonlinear system dynamics. An adaptive backstepping based nonlinear control (ABNC) scheme with iron-loss minimization algorithm for DFIG is also developed in this work to obtain both improved dynamic performance and reduced power loss.

In order to verify the effectiveness of the proposed control schemes, simulation models are designed using Matlab/Simulink. The proposed MPPT control, nonlinear control for grid-connected mode of DFIG-WECS has been successfully implemented in real-time using DSP controller board DS1104 for a laboratory 350 W DFIG. In the laboratory environment a 4-quadrant dynamometer is used to emulate the wind turbine to provide variable wind speed to the generator. The performance of the proposed ABNC is also compared with the benchmark tuned proportional-integral (PI) controller under different operating conditions such variable wind speed, grid voltage disturbance and parameter uncertainties and it exhibits excellent grip over the rotor side and grid side converter control.

Machine Loss Minimization-based High Performance Control of Interior Permanent Magnet Synchronous Motor Drive

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Abstract- As the motor consumes more than 50% of total electrical energy produced in the world; the efficiency optimization of the motor is a burning issue in terms of saving energy, cost and the environment. In modern days researchers display immense interest in the control of a high performing interior permanent magnet synchronous motors (IPMSM) drive for industrial applications. The IPMSM is largely used for low and medium power applications such as adjustable speed drives, robotics, aerospace and electric vehicles due to its several advantageous features such as high power density, wider flux weakening capability, high power factor, low noise, robustness and high efficiency as compared to the conventional ac motors. Most of the reported research emphasized on the high performance control of IPMSM. However, the efficiency optimization of IPMSM, which is one of the important aspects, is often ignored. Therefore, in this talk the efficiency optimization issues are considered along with high performance control.

Among numerous loss minimization algorithms (LMA), a LMC approach offers a fast response without torque pulsations. However, it requires the accurate loss model and the knowledge of the motor parameters. Therefore, a difficulty in deriving the LMC lies in the complexity of the full loss model. Moreover, the conventional LMC does not pay attention to the performance of the drive at all. In an effort to overcome the drawbacks of the conventional LMC, an adaptive-network-based fuzzy inference system (ANFIS) is also developed for IPMSM drive. The ANFIS based neuro-fuzzy controller (NFC) is integrated with the LMC to achieve both high efficiency and high performance of the drive. Conventional NFCs usually utilize two inputs such as speed error and acceleration, which lead to large number of membership functions and rules and hence, the computational burden increases. Therefore, in this work an ANFIS based simplified NFC with one input, and three membership functions is proposed, which makes it suitable for real-time implementation with low computational burden. An online self-tuning algorithm is also developed in order to adjust the precondition and consequent parameters of the NFC in order to overcome the unknown and nonlinear uncertainties of the drive.

The performances of the proposed loss minimization based ABNC and NFC controllers are investigated in simulation using MATLAB/Simulink. The complete IPMSM drive incorporating loss minimization based NFC is also implemented in real-time using DSP board DS1104 for a laboratory 5 hp motor. The experimental results verify the simulation of the NFC based drive with loss minimization. It is found from the results that the proposed LMC can improve the efficiency by around 3% as compared to without any LMA.

Recent Advances in Direct Torque and Flux Control of IPMSM Drives

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Abstract: With the advancements in magnetic materials and semiconductor technology, interior permanent magnet synchronous motor (IPMSM) is becoming more and more popular in industrial applications due to its high energy density, high power factor, low noise and high efficiency as compared to conventional AC motors. Conventional field oriented vector control (VC) techniques have been widely used for high performance motor drives for many years. As an alternative to VC scheme recently direct torque and flux control (DTFC) technique is developed which is faster and simpler than that of the VC scheme as DTFC doesn't need any coordinate transformation, pulse width modulation and current regulators. The DTFC scheme utilizes hysteresis band comparators for both torque and flux controls. Both torque and flux are controlled simultaneously by the selection of appropriate voltage vectors from the inverter. However, conventional six-sector based DTFC suffers from high torque ripples due to discrete nature of control system and limited voltage vector selection from the inverter. Control techniques have been developed for hysteresis controllers to minimize the torque ripples but the six sectors still limits that improvement. Furthermore, in a conventional DTFC the reference air-gap flux is assumed constant at the rated value to make the control task easier. This produces erroneous results for high performance drives as the air-gap flux changes with the operating conditions and system disturbances. Moreover, if the reference air-gap flux is maintained constant, it is not possible to optimize the efficiency of the drive.

Therefore, this talk presents a novel eighteen-sector based DTFC scheme to achieve high dynamic performance with reduced torque ripples as compared to the conventional 6-sector based DTFC. In addition, a model based loss minimization algorithm is integrated with the proposed DTFC scheme in order to optimize the efficiency along with high dynamic performance. Eighteen sectors are developed to overcome the unbalanced voltage vector selection of conventional six-sector based system that minimizes the torque ripples. Further, a nonlinear controller with virtual torque and flux controls is also developed for IPMSM drive to minimize the drive torque ripples. The complete IPMSM drives incorporating the developed control techniques are successfully implemented in real-time using digital signal processor (DSP) board-DS1104 for laboratory 5-hp motor. The effectiveness of the proposed control techniques are verified in both simulation and experiment at different operating conditions. It is found that the nonlinear controller based IPMSM drive provides the best performance in terms of torque ripples among all the DTFC schemes. The results show that the proposed nonlinear/18-sector based DTFC scheme would have the potentiality to apply for real-time industrial drives.