2004 SEATTLE
october 3 – 7, 2004 westin hotel
IEEE / IAS 39TH ANNUAL MEETING

Conference Tutorials for 2004 IAS Annual Meeting

ANALYSIS, DESIGN, AND CONTROL OF INTERIOR PERMANENT MAGNET SYNCHRONOUS MACHINES

Scheduled Presenters
Prof. T.M. Jahns, University of Wisconsin-Madison
Prof. N. Bianchi, University of Padua, Italy
Prof. Silverio Bolognani, University of Padua, Italy
Prof. Alfio Consoli, University of Catania, Italy
Prof. Alfredo Vagati, Politecnico Torino, Italy
Dr. Edward Lovelace, SatCon Technology Corp., USA
Prof. Shigeo Morimoto, Osaka Prefecture Univ., Japan (tentative)
Prof. Robert Lorenz, Univ. of Wisconsin-Madison

Tutorial Abstract
Interior permanent magnet (IPM) synchronous machines are emerging in new commercial, industrial, and transportation applications as one of the most promising means of achieving superior values of efficiency and power density in modern variable-speed drive applications. IPM machine drives are beginning to appear in a variety of important new applications including the powertrain of the Toyota Prius hybrid vehicle where two IPM machines are configured in a high-efficiency motor-generator combination. At least one major manufacturer (Yaskawa Electric) is now offering IPM machines with ratings as high as 200 kW.

Interior PM synchronous machines offer some significant advantages compared to conventional surface PM synchronous machines because of the hybrid nature of their torque production (magnet and reluctance). These advantages include their ability to achieve wide speed ranges of constant power operation, and their natural compatibility with position sensor elimination techniques.

Despite these advantages, IPM machines have been rather slow to gain wide acceptance in marketplace compared to surface PM machines. One of the major contributing factors is the fact that IPM machines are noticeably more difficult to design than surface magnet machines and the resulting torque characteristics are nonlinear. In particular, the impact of magnetic saturation plays a major role in determining the characteristics of IPM machines and must be properly accounted for in the design process. Design rules and tools for developing high-performance IPM machines are far less well developed and limited in their availability compared to those for surface PM machines.

The purpose of this proposed full-day tutorial is to assemble several international experts in the field of IPM synchronous machine technology to present a state-of-the-art review addressing key issues in the areas of design, analysis, and control of IPM machines. This tutorial is designed to appeal to Annual Meeting attendees with professional interests in the areas of electric machines and adjustable-speed drives from both academia and from industry. This tutorial will focus on practical design and control issues that need to be understood in order to successfully develop new IPM machine drive systems.

Major tutorial topics include the following:

1. IPM machine model; IPM machine analysis techniques; typical IPM performance characteristics

2. Alternative IPM machine configurations, describing key features and tradeoffs; IPM machine performance limit envelopes and IPM machine selection.

3. IPM machine electromagnetic, mechanical, and thermal design issues, including optimization.

4. IPM vector control and flux weakening techniques.

5. IPM drive position sensor elimination techniques.

This tutorial provides a unique opportunity to bring together several of the world's most renowned IPM machine experts to present a focused tutorial on this topic in way that has never been done before.

SERVO DRIVES

Scheduled Presenters
Mario Pacas, University of Siegen
Ralph Kennel, Wuppertal University

Tutorial Abstract
The substantial developments in power electronics, motor technology and microelectronics in the last years has brought enormous momentum in the area of servo drives. In the past the servo technique was dominated by the DC-servos and the BLDC-Motors. Presently most servo applications in production machines and processes demand intelligent modular drives with new actuators and sophisticated control strategies.

Departing from the different industrial applications the main electrical and mechanical requirements and design criteria for servo drives will be explained. Further the different technical solutions and their components will be discussed: power electronics, sensors, actuators, control strategies and communication. One main topic of the tutorial is a survey on the sensors for angular position as key components on servos.

For each subsystem the special requirements of servos and the corresponding technologies will be explained considering the state of the art and the ongoing developments. Motion control, multi-axis systems and communication between the numerical control and the intelligent servos will be considered as well. Communications systems with their special futures in servos will be presented as necessary interfaces for this kind of drive. A system comparison shows the capabilities and drawbacks of each system in different practical applications.

The tutorial is intended as a complete survey on the topic and is addressed to engineers involved in the practical design of servo drives in the application of servo drives for new high demanding machines and processes.

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ELECTRIC DRIVES AND THEIR CONTROL: FROM UNDERSTANDING BASICS TO DESIGNING FOR ADVANCED CONTROL AND ENCODER-LESS OPERATION

Scheduled Presenter
Ned Mohan, University of Minnesota

Tutorial Abstract
The objective of this tutorial is two-fold: 1) in the first-half, we will begin with basics and analyze induction and permanent-magnet ac machines in a way that clearly explains how these machines operate on a physical basis, and hence how they ought to be controlled for optimum performance. And, 2) in the second-half of this tutorial we will examine the basis of vector control and encoder-less operation of ac machines in order to design speed and position controllers for such machines. Design of such controller will be demonstrated using MATLAB/Simulink.

Increasingly, electric machines are being used as a part of electric drives for controlling speed and position of the associated mechanical systems in applications such as robotics and in flexible production, transportation, harnessing of wind energy, and so on. As electric machines and drives become commodity items, the role of engineers in industry today and in the future will be as consultants, designers and system integrators in manufacturing processes. Therefore, the decades-old circuit-oriented approach that is suited only for uncontrolled line-fed ac machines, and that unfortunately continues to be taught by most universities, is no longer appropriate.

The first-half of this tutorial will present a unique step-by-step physical understanding of induction and permanent-magnet ac machines that will clearly explain how these machines operate, and hence how they ought to be controlled for optimum performance. This approach is based on the space-vector theory that is traditionally reserved for advanced graduate-level courses. However, as this tutorial will explain, by introducing space vectors on a physical basis, they can be utilized from the very beginning, thus providing a seamless continuity to the discussion of advanced topics [1].

The above approach is based on two textbooks [2, 3] that have been adopted as textbooks at 23 small and large U.S. universities, and at several well-known universities in Europe and Asia in a span of just two years. These textbooks are backed-up two CDs with nearly 450 PowerPoint-based slides, each with an audio-clip recorded by the author that highlights the material being presented. These CDs are ideal for preparing lectures in a very short time and for self-study. Attendees in this tutorial will get these two CDs as a part of the lecture notes.

[1] NSF/ONR-Sponsored Faculty Workshop on Teaching of Power Electronics and Electric Drives, www.ece.umn.edu/groups/PowerElectronics_Drives, Las Vegas, Feb 20-21, 2004.
[2] N. Mohan, “Electric Drives: An Integrative Approach”, Minneapolis, MN: MNPERE, 2001. Website: www.mnpere.com.
[3] N. Mohan, “Advance Electric Drives: Analysis, Design and Modeling using Simulink”, Minneapolis, MN: MNPERE, 2001. Website: www.mnpere.com.

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UNDERSTANDING FAILURE MODES, PROTECTION, AND RELIABILITY OF INDUSTRIAL POWER CONVERTERS

Scheduled Presenters
Leon M. Tolbert, The University of Tennessee
Chris Melhorn, EPRI-PEAC
Doug Dorr, EPRI-PEAC
Bill Brumsickle, Soft-Switching Technologies

Tutorial Abstract
A successful product in today's industrial market must not only deliver on its electrical input/output specifications and manufacturing cost targets but also meet expectations of product reliability and safety. Understanding failure modes--and methods of protecting against ancillary damage when they occur--in semiconductor devices, capacitors, transformers, inductors, connectors, laminated bus structures, fans, etc., is a critical skill for industrial converter designers. This tutorial will include discussion of failure modes and protection methods, taught by experienced engineers. The instructors will also discuss basic reliability calculations and how they are applicable in the real world.

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AC AND DC DRIVE/MOTOR SELECTION IN INDUSTRIAL APPLICATIONS

Scheduled Presenters
Brian Boulter, ApICS LLC
Robert Lockhart, ApICS LLC

Tutorial Abstract
This tutorial will provide the attendee with an analytical toolset that will enable him/her to identify the best motor/drive combination for a given industrial application. Topics to be covered include

1) A description of typical industrial drive/motor applications.
2) Guidelines for deciding when to use an AC drive, and when to use a DC drive.
3) Specifying AC/DC drives for torque, speed, tension and positioning applications.
4) Specifying AC/DC drives for pressure, flow, mixing & other process applications.
5) Communication Protocols & Specifications, including a discussion on the effects of feedback & communication transport delays, and sampling, effects on loop stability and performance.
6) Guidelines for making trade-offs between footprint size, maintenance, and initial cost considerations.
7) Drives in motion control applications, and the special needs of these applications..
8) Conclusions and questions/answer period..

A CD with the PowerPoint presentation, and pertinent technical papers and worksheets will be supplied, along with hard copies of all worksheets, and equation data sheets.

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FORENSIC ELECTRICAL ENGINEERING: ENGINEERING, MEDICAL, AND LEGAL ASPECTS

Scheduled Presenters
Robert E. Nabours, Consultant
Paul F. Hill, Attorney-Law School Librarian-Retired

Tutorial Abstract
A forensic electrical engineering presentation to cover the functions of an EE, as an investigator and expert witness will be presented. An explanation of the relationship between attorneys and engineers, legal terminology, voluntary and obligatory standards, electrical codes and regulations will be given. The effects of electrical energy on humans, electrical products and failures, electrical fires, illumination and lightning will be discussed. Case studies illustrating the forensic electrical engineering process will be given. Legal principles involved with electricity, product liability and strict liability as viewed by various legal jurisdictions will be covered. Electric utility liability for PQ will be illustrated with case studies.