IAS 2003 Tutorial Abstracts

Continuous, Dynamic, & Intermittent Thermal Operation in Electric Motors

Scheduled Presenter
Richard Welch Jr.

Tutorial Abstract

Every electric motor has a maximum continuous operating temperature. Exceed this rated temperature and the motor can suffer irreversible thermal damage. In practice, electric motors are subjected to continuous, dynamic, and even intermittent operating conditions. Dynamic operation occurs when the motor is commanded to produce a time varying motion profile that often times includes a varying torque/force output. Despite these different operating conditions the power dissipation inside each motor must be limited to prevent the motor from overheating. The purpose of this Tutorial is to develop the two-parameter thermal model that allows you to calculate the motor's maximum temperature during all possible operating conditions.

Tutorial Outline:

I. Continuous Operation
   - A. Maximum Continuous Operating Temperature.
   - B. Ambient Condition.
   - C. Total Power Dissipation – Resistance Heating, Viscous Damping, and Friction.
   - D. Thermal Resistance.
   - E. Thermal Capacitance.
   - F. Maximum Continuous Current.
   - G. Maximum Continuous Velocity.
   - H. Safe Operating Area Curve (SOAC).

II. Dynamic & Intermittent Operation
   - A. Two-parameter Thermal Model.
   - B. Dynamic Thermal Equation.
   - C. Heat-up and Cool-down Thermal Time Constants.
   - D. Time Averaged Power Dissipation.
   - E. Operating with a Dynamic Motion Profile.
   - F. Operating with an Intermittent Motion Profile.
   - G. Intermittent Operating Area Curve.
   - H. Thermal Runaway.

III. Forced Cooling
   - A. Air cooling.
   - B. Liquid cooling.

DISTRIBUTED POWER GENERATION - Technology, Application and Interconnection Issues

Scheduled Presenters
K. Rajashekara, Delphi Corporation, USA
G. Joos, Concordia University, Canada
F. Blaabjerg, Aalborg University, Denmark

Tutorial Abstract

Electrical power generation is undergoing major restructuring, one aspect being the transition from large power generating plants to smaller distributed power plants, often based on alternate energy sources. Distributed Power Generation Units (DPGU) today are mostly based on wind turbine systems, photovoltaic systems, micro turbines and fuel cells. The power range of individual units varies from a 100 W to 4 MW or more. Common to all installations is the fact that the DPGUs operate autonomously. However, with a high penetration of DPGUs into the electric grid, power system stability problems may appear. Power Electronics is the enabling technology allowing flexible interconnection of DPGUs to the electric grid. This tutorial gives the audience an overview of the different DPGU solutions employing power electronic interfaces. Converter topologies and control systems, as well as the technological roadmaps for the different DPGU technologies, will be presented. Existing standards for interconnecting DPGUs to the grid will be discussed, as well as utility interconnection concerns. The tutorial covers the following technologies and issues:

1. Distributed Power Generation - An overview
2. Wind Turbines Systems - from stand-alone to wind farms
3. Photovoltaic - solutions for small and medium power
4. Micro turbines - natural gas and biofuel
5. Fuel cell systems - the future for Hydrogen
6. Application issues: economics, reliability, power quality and protection
7. Grid interconnection and relevant standards

IAS 2003 Tutorial Abstracts

Electric Drives and Their Control: From Understanding Basics to Designing for Advanced Control and Encoder-Less Operation

Scheduled Presenter
Ned Mohan

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, Jan 5-7, 2003. www.ece.umn.edu/groups/workshop2003.
[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.

IAS 2003 Tutorial Abstracts

Fluorescent and HID Lamp Electrode Issues

Scheduled Presenters
John F. Waymouth, Consultant
Willem J. van den Hoek, Philips Lighting
Ed Hammer, Consultant
J. Heberlein, University of Minnesota
H. Adler, Osram Sylvania
M. Kettlitz, Greifswald University
T. Uetsuki, Tsuyama National College of Technology

Tutorial Abstract

Issues regarding electrodes have recently gained greater attention due to their importance in determining the lifetime of a lamp. Major new developments have taken place in the last decade at the theoretical and experimental level. This full day tutorial provides a venue for bringing together a number of eminent industrial and academic experts in the field of lamps and electrode design. The purpose of this tutorial is to provide practicing lighting engineers with a review of the state-of-the-art in electrode modeling, electrode plasma interactions, the effects of ballast design on electrode lifetime and methods of enhancing electrode lifetime. The speakers come from both academia and industry and are a blend of experimentalists and theoreticians. The specific topics being addressed and the authors giving the presentations are listed as follows.

1. Chemistry and physics of electron-emitting cathodes for fluorescent lamps: Presenter: Dr. Waymouth, Marblehead, USA
2. Electrode aspects of fluorescent lamps Presenter: Dr. Willem J. van den Hoek, Philips Lighting Central Labs, Netherlands
3. General Guidelines for Fluorescent Signature Analysis And Other Performance Characteristics Presenter: Dr. Ed Hammer, Consultant formerly with GE Lighting
4. The anode region of high-intensity arcs Presenter: Prof. J. Heberlein, University of Minnesota, USA
5. Diagnostics of HID electrodes Presenter: Dr. H. Adler, Osram Sylvania, USA
6. Investigations of the plasma sheath near the electrodes of high-pressure lamps Presenter: Dr. M. Kettlitz, Greifswald University, Germany
7. Influence of the operating frequency in the vicinity of the cathode Presenter: Dr. T. Uetsuki, Tsuyama National College of Technology, Japan formerly with Lighting R&D Center, Matsushita, Japan.

IAS 2003 Tutorial Abstracts

Understanding Electromagnetic Compatibility (EMC) in Power Electronics Circuits

Scheduled Presenters
Alexander L. Julian, Power Engineering Consultant
Giovanna Oriti, Power Engineering Consultant

Tutorial Abstract
This tutorial will focus on explaining fundamental concepts that guide EMC planning in product development, especially related to power electronic circuits.

I. Introduction: Fundamental Definitions and Concepts (2 hours) EMC includes managing the electromagnetic interference (EMI) emanating from circuits and managing the susceptibility of circuits. The EMI can be conducted current that couples into other parts of an electrical system or radiated electrical and magnetic fields that can potentially couple into nearby circuits. The emissions that couple into a circuit from other sources may interfere with a circuit's normal operation. This is the susceptibility of a circuit to design against. When every circuit doesn't emit interference above the limits and every circuit is not susceptible to electromagnetic emissions below the allowable limits then every circuit is electromagnetically compatible in the system!

II. Emissions and Susceptibility: Explanation of What is Measured and Why (3 hours) The test methods for conducted and radiated EMI are similar in most standards. Conducted emissions are evaluated by the voltage on the power source interface to the equipment under test (EUT). This measurement is made at an output port of a line impedance stabilization network (LISN). Radiated emissions are measured using antennas near the EUT to pick up radiated energy. In contrast to a LISN, which easily blocks conducted EMI pollution from entering the EUT, it is difficult to block radiated pollution from other sources entering the test environment. Radiated EMI measurements are performed in a shielded room that blocks external radiated noise from entering the test environment. A comparison between emission limits (radiated and conducted) and measurement methods for CE marking, FCC compliance and US military applications will be presented to show their similarities. Description of CE marking requirements: EC Directive 89/336/EEC specifies how manufacturers can certify their products in order to add the 'CE conformity marking'. This Directive is interpreted in guidelines published by the EC and CENELEC, which will be provided with the course material. These guidelines clearly identify the applicable EN standards, in the form of a requirements matrix, that must be met in order to certify conformity. Description of US military applications: MIL-STD-461E contains a requirements matrix which identifies which tests need to be done for different military applications. MIL-STD-461E defines and explains motivation for tests. - Explanation of a LISN (Matlab program) - How to predict CE101, CE102 conducted EMI (Matlab program) - Measurement of common mode and differential mode conducted EMI separately helps identify noise source that needs to be filtered - How to predict RE101, RE102 radiated EMI Description of FCC compliance: FCC CFR 47, Part 15 defines measurements and tests - Description of standard and test methods.

III. Design Examples to Mitigate EMI and Reduce Susceptibility (3 hours) Consideration of EMC requirements early in the product design process will avoid 'patching' the product later if EMC requirements are not met, reducing the product development cycle. - Discussion of candidate filter topologies to attenuate conducted EMI. - Analysis and modeling of coupled magnetics (common mode chokes). - Input filter design example including LISN (Matlab program). - Packaging techniques to mitigate radiated EMI. - Design issues to address susceptibility. - Comparison of Design Example to Several conducted and radiated EMI limits: EN standards for CE marking, MIL-STD-461E, FCC CFR 47, Part 15.

IV. Course Materials on CD ROM:
   1. Matlab/Simulink design examples.
   2. CE Marking Directive and Guidelines in pdf or html format
   3. MIL-STD-461E in pdf format
   4. FCC CFR 47, Part 15 in pdf format

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5. Tutorial presentation slides in MS PowerPoint format