Brushless PM and Induction Motor Design using Modern Design Techniques and Packages

1 Day Tutorial Proposal for IECON 2007

Abstract

This tutorial will address the need for a machine design tutorial. It will cover the specification, basic topology, sizing and operational aspects of the brushless permanent magnet motor and also the 3-phase induction motor. In many applications (such as pump and drive applications) they are alternatives. Hence the two machines are considered within the same tutorial to allow engineers to get a full appreciation of their operation and design. Materials and computer CAD methods will also be covered. The full day tutorial is divided into two parts. The first half-day is devoted to the design of brushless PM machines, while second half-day is devoted to the design of three-phase induction motors. For both the machine types, electromagnetic, mechanical and thermal problems will be analysed giving theoretical and practical solutions to the machine designer.

Organizers

The organization is split between two people; Dr Dorrell will act as the corresponding organizer. The organizers are:

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Presenters

The two organizers will present the work. Dr Dorrell will be aided in his material preparation by Dr David Staton of Motor Design Ltd. Dr. Cavagnino will be supported by Prof. Aldo Boglietti (of the Politecnico di Torino) for the tutorial material preparation. Prof. Boglietti will be present at the tutorial too.

Motivation and objectives

Many companies are involved in the manufacture of small brushless permanent magnet and induction machines. Engineers may not be experts in the design of these machines but will be involved in their partial design or analysis as part of their duties. In addition, many universities no longer teach electrical machine theory to any great depth. Machine designers may be appointed to posts that involve machine design with little experience and expected to learn machine design in-post, or new research students may begin projects involving electrical machines with limited

undergraduate study. This tutorial aims to provide to the audience the basic knowledge concerning the approach to the design of brushless PM and induction motors. In addition there are several modern CAD packages available to help the designer so that the need to have many years of design experience is no long completely necessary; these will be used during the tutorial to aid understanding.

List of Topics to be Covered

The two tutorials will cover various aspects for the design of brushless PM machines and induction motors. Topics that will be covered include:

Brushless PM Machines

- Outline design considerations: applications; sizing, topology; A.C. or D.C. control; thermal aspects and thermal ratings
- Topologies – surface magnets, embedded magnets, etc; and winding strategies
- Machine equations – voltage constant and torque constant; cogging torque, skew, slot number; power Electronic control
- Materials – magnet and steel characteristics
- Losses and efficiency: control of iron losses and copper losses; steel selection; frequency consideration; stator and rotor topology
- Use of analytical and finite element CAD packages (e.g., SPEED, Motor CAD, Cedrat Flux 2D, Portunus)

Three-phase Induction Motor Design

- Geometrical approach to the electromagnetic design
- Electrical and magnetic material stresses.
- Magnetic material use
- Design criteria for the rotor lamination on the base of the required torque
- Design criteria for the stator lamination
- Stator winding determination
- Determination of the equivalent circuit parameters on the base of the design results
- Magnetic material non-linearity and simulation of the no-load test
- Rotor bar skin effect and simulation of the short circuit test
- Determination of the electromechanical performances by non-linear equivalent circuit
- Motor design check taking into account the thermal constrain

Primary and secondary audience

The primary audience is for the younger engineer, working in the area of electrical machine specification, manufacture and operation, wanting to know more about the electrical machine operation and design and improve their knowledge of modern CAD methods. It will also serve as a refresher for more established motor engineer who requires further training or retraining.
A secondary audience will be for research students or assistance wanting to learn more about the specialised area of motor design.
Taiwan has a large electrical machine manufacturing base and it is hoped to attract several engineers from local industry and academia as well as an international audience.