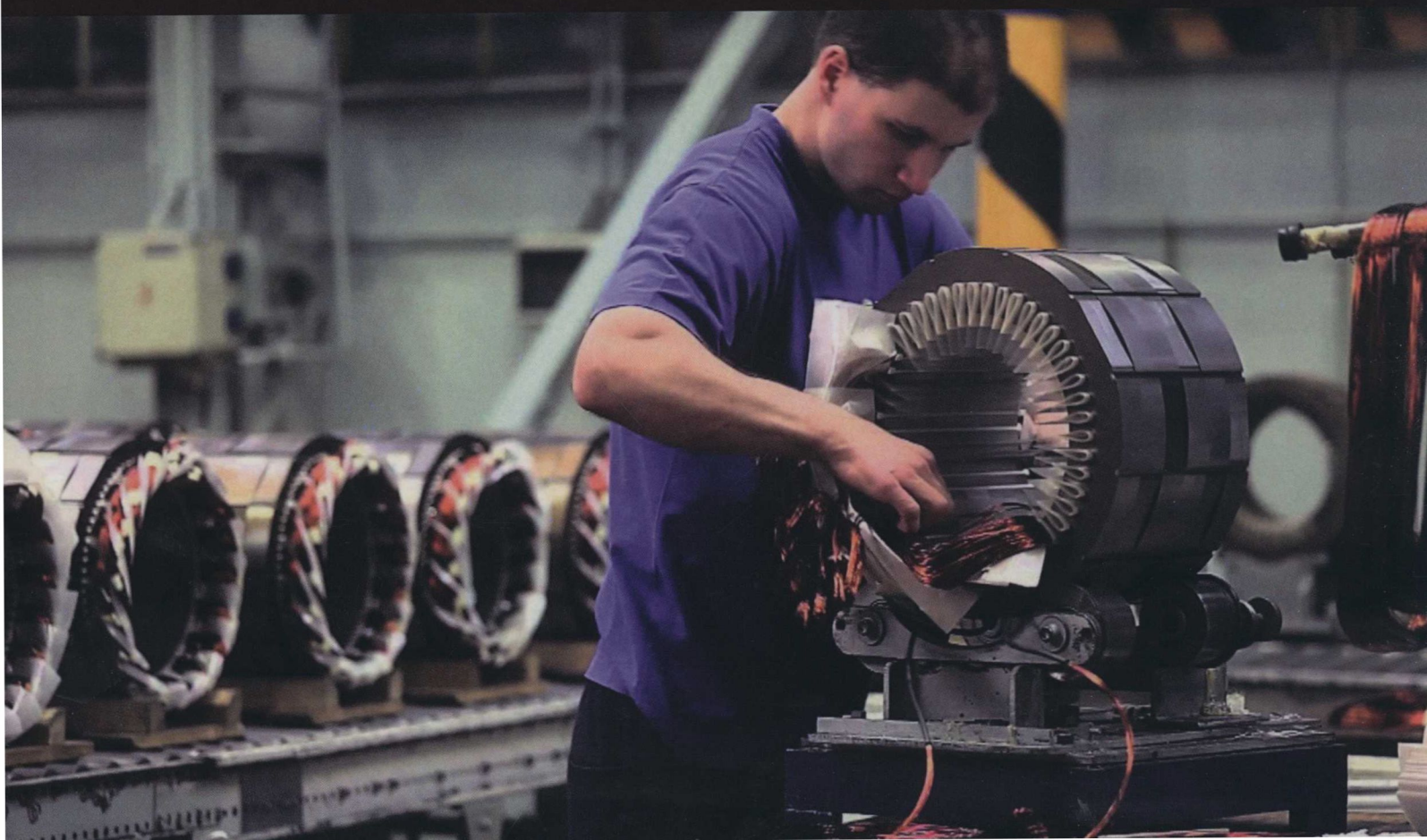




Electric Machines: Principles, Applications, and Control

Nelson Bolívar, Ph.D



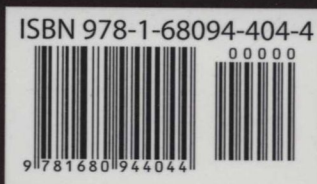
Electric Machines: Principles, Applications, and Control

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Nelson Bolivar has a PhD. in physics from the University of Lorraine in France finished in 2014. His expertise is in quantum systems and condensed matter. His interest includes spintronic devices and correspondences between general relativity and condensed matter. He is currently an associate professor at the Central University of Venezuela

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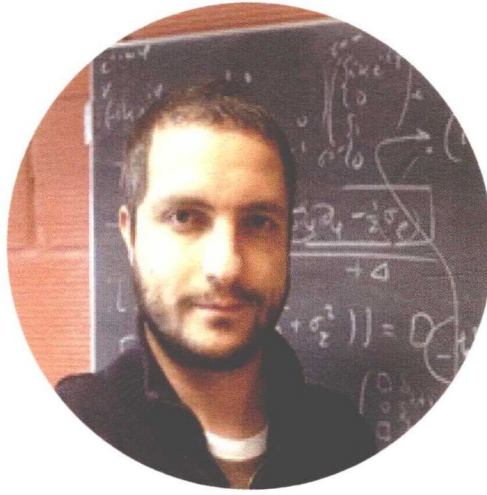
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About the Editor

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Preface

Electric machines are often synonyms for electric motors and electric generators. The term refers to those devices that has certain mobility but furthermore, to those that transform electric currents into motion or motion into electric currents. The modern society depends upon energy to subsist, this energy comes from a number of different sources, some very polluting, like burning fossil fuels, others very low polluting - at least during energy harvesting – like solar cells, and in between, lies the inductive generators. This machines take advantage of mechanical energy, for instance water sources and wind power, and convert part of this energy in electric currents.

The synchronization and control of these machines is complex, not only from the mechanical point view, but electronically. The engineer accounts for duty cycles, torque potential, cost, efficiency and magnetic core assembly among others, and the advances in these fields is growing fast. *Electric Machines Principles, Applications, and Control* is intended for students and engineers, as well as materials scientists will find this book to be a good comprehensive resource for learning about the fundamental control and functioning of these machines, focusing on specific examples that are also top research material in the area, suitable for the interested reader. Content coverage of the book is as follows. First chapter provides an overview of non-rare earth permanent magnets for traction motors and generators. The purpose of second chapter is to investigate the feasibility of using surface magnetic Barkhausen noise for the evaluation of AC core loss, and further, to examine potential origins of magnetic loss in non-oriented electrical steel. Third chapter presents the fault-tolerant control problem of DC motors. In fourth chapter, the application of type-2 fuzzy logic concepts to the position control of a simple DC motor were illustrated. Fifth chapter covers dynamical simulation of a nonlinear stepper motor system. Sixth chapter describes the performance of DI-BSCCO superconducting electric motor. In seventh chapter, work power factor and total harmonic distortion of separately excited DC motor controlled with AC-DC converter has been analyzed at-load. Eighth chapter proposes a method for the identification of inductive motors load partition based on coherence and ninth chapter aims to present dissimilar stator faults which are classified under electrical faults using motor current signature analysis (MCSA) and the comparison of simulation and hardware results. The aim of tenth chapter is to provide energy efficient control of three-phase induction motor drive and eleventh chapter deals with performance analysis and implementation of a three phase inverter fed induction motor (IM) drive system. The purpose of twelfth chapter is to propose a fuzzy logic speed controller of induction motor where flux and torque decoupling strategy is decoupled in terms of magnetizing current instead of stator current to alleviate the effects of core loss. Thirteenth chapter focuses on Ethernet control AC motor via programmable logic controller (PLC) using LabVIEW. Fourteenth chapter presents the capacity variation effect, speed of drive and load as function of the wind system without and with analogical regulator. Fifteenth chapter proposes a new type of the synchronous capacitive machine operated on a principle of the electric field effect. In sixteenth chapter calculations of the varying inductances profile for a synchronous linear surface mounted permanent magnet generator has been presented and seventeenth chapter explores on the steady state analysis of a double-fed induction generator (DFIG) adopted for wind power generation. Eighteenth chapter deals with high efficiency double-fed induction generator applied to wind power generator technical analyses and nineteenth chapter highlights new development in the performance improvement synchronous motor. Twentieth chapter describes a converter control to contribute to enhancing the synchronizing torque. In last chapter, a model of a variable speed wind turbine using a permanent magnet synchronous generator (PMSG) is presented and the control schemes are proposed.

Editor
Nelson Bolívar, Ph.D

INTRODUCTION

An electric machine is a device that produces electricity or does work using electricity. It usually has a motor that drives a set of gears and belts. An electric machine may not have any moving parts at all. One example of an electric machine is the electrical generator, which produces electricity using a source of mechanical energy, such as an engine running on a fossil fuel, a turbine, an electric motor, steam, wind, or water.

Electrical generators may be either alternating current (AC) or direct current (DC) generators. Power utilities produce AC voltages in several thousands of volts that are then distributed and stepped down using a transformer. Cars and other means of transportation use DC generators to generate about 13.8 volts direct current (VDC) to power up built-in equipment, such as ignition systems, stereos, two-way radios, and laptops.

An electric machine may use either an AC or DC motor. AC motors are very popular where AC power is available. In homes, they are used in fans, air conditioners, washing machines, dishwashers, and other appliances. DC motors are popular in smaller equipment and where only DC power is available. In cars, DC motors are used in power windows, wipers, engine starters, and blower fans.

Electric motors are used in all industries, and range from simple machines that shape materials to machines that create miniaturized high-density circuit boards. Either humans or computers act as the controller. Computers are able to repeat processes under tight tolerances, whereas humans are normally unable to work in such conditions.

Special machines are capable of storing energy as kinetic energy (KE) in satellites. Using a magnetic bearing, a KE storage device is able to bear a 331 lb (150 kg) rotating flywheel at about 3,600 revolutions per minute. The flywheel spins while suspended in a vacuum. When the satellite in orbit is in view of the sun, solar photovoltaic panels generate the needed electricity for the satellite and to maintain the spin of the flywheel. During dark times, the battery system takes over. At prolonged darkness, the battery voltage drops below cut off, which is where the flywheel is engaged to generate electricity.

New electric machines are also foreseen in the nanotechnology field. Very small machines are thought to be one day capable of closed surgical processes, for example. The impact is that patients may undergo major surgery from outside the body, and it would be like nothing is happening.

Generator

A generator is an electrical machine which converts mechanical form of energy into electrical form. Generator works on the principle that whenever a conductor moves in a magnetic field, an emf gets induced in the conductor. This principle is called as generator action.

Generators have generally two basic parts named “Stator” and “Rotor”. Mechanical energy is provided to the rotor of a generator by means of a prime mover (i.e. a turbine). Turbines are of different types like steam turbine, water turbine, wind turbine etc. Mechanical energy can also be provided by IC engines or similar other sources.

To learn more about how generators work, read the following articles.

- AC Generator (converts mechanical energy into Alternating Current (AC) electricity)
- DC Generator (converts mechanical energy into Direct Current (DC) electricity)

Motor

A motor is an electrical machine which converts electrical energy into mechanical energy. When a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force and this is the principle behind motoring action.

Just like generators, motors also consists two basic parts, stator and rotor. In a motor, we give electric supply to both the stator and rotor windings which causes a mechanical force between the stator and rotor. This force causes the rotor to rotate.

To learn more about electric motors, read the following articles.

- AC motors: (i) Induction motors and (ii) Synchronous motor
- DC motors: (i) Brushed DC motor and (ii) Brushless DC motor

Transformers

Transformers do not actually make conversion between mechanical and electrical form, but they transfer electric power from one circuit to another circuit. They can decrease or increase the voltage while transferring the power without changing the frequency, but with the corresponding increase or decrease in the current. Transformers also belong to electrical machines.

Step up transformers increases the voltage level from primary to secondary but with the corresponding decrease in the current and vice versa.

Classification of Electric Machines

There are several methods of classifying electric machines:

Electric Power Supply

Electric machines are classified as D.C. and A.C. machines as well as according to their stator and rotor constructions as shown in Figure 1.

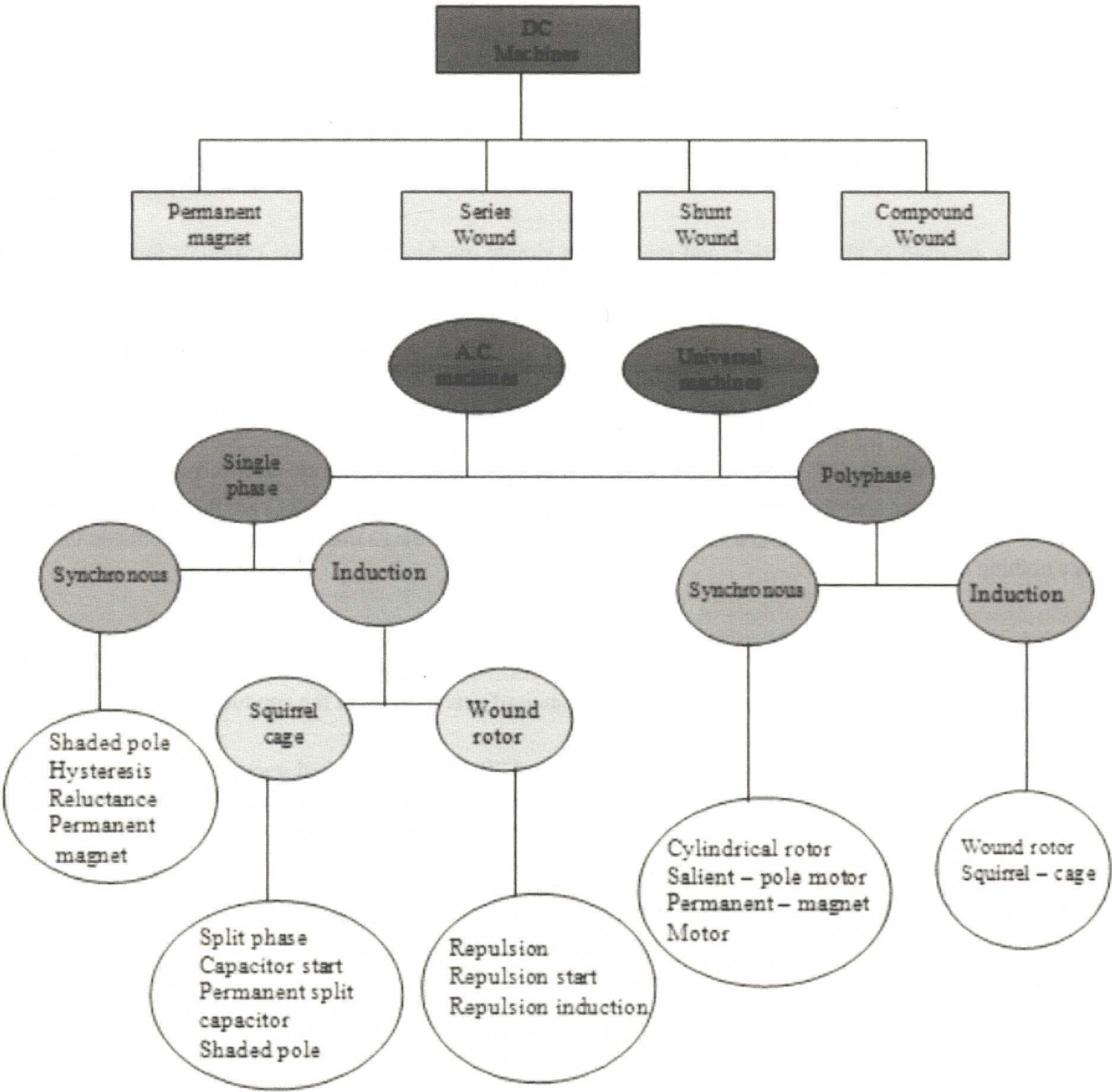


Figure 1: Classification of Electric Machines.