Second Edition

AC Motor Control and Electrical Vehicle Applications

Kwang Hee Nam

$$v_d^e = \omega_e L_q i_q^e$$
$$v_q^e = \omega_e L_d i_d^e + \omega_e \psi_m.$$

$$\frac{B}{\mu_{PM}} 2h_m + \frac{B}{\mu_0} 2g + \frac{B}{\mu_{Fe}} \ell_{core} = Ni_d$$

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Contents

Preface

The importance of motor control technology has resurfaced recently, since electrification of various power sources reduces green house gas. Autonomous vehicle technology opens a new world of unmanned delivery with the expansion of drone applications. Sooner or later, electric planes and flying cars are popularly used for passenger transport. The motor application is more accelerated as the battery costs are reduced.

Control engineers need to understand many motor design issues to meet the challenging design specifications. From this point of view, various aspects including motor control, motor design, practical manufacturing, testing, and programming are considered in this book. This book was written as a textbook for a graduate level course on AC motor control and electric drive. Not only the motor control, but also some motor design basics are covered to give a comprehensive view in the multidisciplinary age. Theoretical integrity in the modeling and control of AC motors is pursued throughout the book.

In the second edition, many EV projects and teaching experiences at POSTECH and industrial sites are reflected. The contents become richer by adding more exercises and problems that utilize Excel spreadsheet and MATLAB Simulink.

There is a little barrier for the beginners to understand the principles of the AC rotating machine, because many physical phenomena are interpreted in the moving frame. The essential machinery is the ability to understand voltage to current dynamics in the rotating frame. Firstly, this book is focused on illustrating how the rotating field is synthesized with the three phase winding. Also, the benefits of coordinate transformation are stressed in the dynamic modeling of AC motors. For example, many mathematical tools are utilized to show how the voltage and current limits affect the torque maximization. Loss minimizing and sensorless controls are also covered.

In the second part of this book, many issues regarding EV motor design and fabrication are expressed. In Chapter 11 and 12, a motor design method is suggested based on the requirements of power, torque, power density, etc. under voltage and current limits. In addition, experimental procedure and inverter programming technique are introduced that provide an optimal current control strategy under varying (battery) voltage conditions. In the last part, the basics of vehicle dynamics and EV power trains are shown including calculation methods of driving range and efficiency of the vehicle.

This book is intended to bring combined knowledge and problems to the students who wish to learn the electric power train. So a fusing approach is attempted while covering control, signal processing, electro-magnetics, power electronics, material properties, vehicle dynamics, etc. Many control issues that can lead to on-going research are discussed.

Finally, the authors would like to say a word of thanks to the family who supported me and encouraged me. Also, many thanks are given to Jongwon Choi, Yoonjae Kim, Bonkil Koo, Jeonghun Lee, Minhyeok Lee, Taeyeon Lee, Pooreum Jang, and Heekwang Lee who helped me by providing many solutions, simulation results, and interesting reflections.