
PREFACE

Like its predecessors, the third edition of this book is intended primarily for non-specialist users and students of electric motors and drives. My original aim was to bridge the gap between specialist textbooks (which are pitched at a level too academic for the average user) and the more prosaic ‘handbooks’, which are full of useful detail but provide little opportunity for the development of any real insight or understanding. The fact that the second edition was reprinted ten times indicated that there had indeed been a gap in the market, and that a third edition would be worthwhile. It was also gratifying to learn that although the original book was not intended as yet another undergraduate textbook, teachers and students had welcomed the book as a gentle introduction to the subject.

The aim throughout is to provide the reader with an understanding of how each motor and drive system works, in the belief that it is only by knowing what should happen that informed judgements and sound comparisons can be made. Given that the book is aimed at readers from a range of disciplines, introductory material on motors and power electronics is clearly necessary, and this is presented in the first two chapters. Many of these basic ideas crop up frequently throughout the book, so unless the reader is well-versed in the fundamentals it would be wise to absorb the first two chapters before tackling the later material. In addition, an awareness of the basic ideas underlying feedback and closed-loop control is necessary in order to follow the sections dealing with drives, and this has now been provided as an Appendix.

The book explores most of the widely used modern types of motors and drives, including conventional and brushless d.c., induction motors (mains and inverter-fed), stepping motors, synchronous motors (mains and converter-fed) and reluctance motors. The d.c. motor drive and the induction motor drive are given most importance, reflecting their dominant position in terms of numbers. Understanding the d.c. drive is particularly important because it is still widely used as a frame of

reference for other drives: those who develop a good grasp of the d.c. drive will find their know-how invaluable in dealing with all other types, particularly if they can establish a firm grip on the philosophy of the control scheme.

Younger readers may be unaware of the radical changes that have taken place over the past 40 years, so perhaps a couple of paragraphs are appropriate to put the current scene into perspective. For more than a century, many different types of motors were developed, and each became closely associated with a particular application. Traction, for example, was seen as the exclusive preserve of the series d.c. motor, whereas the shunt d.c. motor, though outwardly indistinguishable, was seen as being quite unsuited to traction applications. The cage induction motor was (and still is) the most widely used but was judged as being suited only for applications that called for constant speed. The reason for the plethora of motor types was that there was no easy way of varying the supply voltage and/or frequency to obtain speed control, and designers were therefore forced to seek ways of providing speed control within the motor itself. All sorts of ingenious arrangements and interconnections of motor windings were invented, but even the best motors had a limited range of operating characteristics, and all of them required bulky control equipment gear-control, which was manually or electromechanically operated, making it difficult to arrange automatic or remote control.

All this changed from the early 1960s when power electronics began to make an impact. The first major breakthrough came with the thyristor, which provided a relatively cheap, compact and easily controlled variable-speed drive using the d.c. motor. In the 1970s, the second major breakthrough resulted from the development of power-electronic inverters, providing a three-phase variable-frequency supply for the cage induction motor and thereby enabling its speed to be controlled.

These major developments resulted in the demise of many of the special motors, leaving the majority of applications in the hands of comparatively few types, and the emphasis has now shifted from complexity inside the motor to sophistication in supply and control arrangements.

From the user's point of view this is a mixed blessing. Greater flexibility and superior levels of performance are available, and there are fewer motor types to consider. But if anything more than constant speed is called for, the user will be faced with the purchase of a complete drive system, consisting of a motor together with its associated power electronics package. To choose wisely requires not only some knowledge of motors, but also the associated power-electronics and the control options that are normally provided.

Development in the world of electrical machines tends to be steady rather than spectacular, which means that updating the second edition has called for only modest revision of the material covering the how and why of motors, though in most areas explanations have been extended, especially where feedback indicated that more clarity was called for. After much weighing the pros and cons I decided to add a chapter on the equivalent circuit of the induction motor, because familiarity with the terminology of the equivalent circuit is necessary in order to engage in serious dialogue with induction motor suppliers or experts. However those who find the circuit emphasis not to their liking can be reassured that they can skip Chapter 7 without prejudicing their ability to tackle the subsequent chapter on induction motor drives.

The power electronics area has matured since the 1993 edition of the book, but although voltage and current ratings of individual switching devices continue to improve, and there is greater integration of drive electronics and power devices, there has been no strategic shift that would call for a radical revision of the material in the second edition. The majority of drive converters now use IGBT or MOSFET devices, but the old-fashioned bipolar transistor symbol has been retained in most of the diagrams because it has the virtue of showing the direction of current flow, and is therefore helpful in understanding circuit operation.

The style of the book reflects my own preference for an informal approach, in which the difficulty of coming to grips with new ideas is not disguised. Deciding on the level at which to pitch the material was originally a headache, but experience suggested that a mainly descriptive approach with physical explanations would be most appropriate, with mathematics kept to a minimum to assist digestion. The most important concepts (such as the inherent e.m.f. feedback in motors, or the need for a switching strategy in converters) are deliberately reiterated to reinforce understanding, but should not prove too tiresome for readers who have already 'got the message'. I had hoped to continue without numbered headings, as this always seems to me to make the material seem lighter, but cross referencing is so cumbersome without numbering that in the end I had to give in.

I have deliberately not included any computed magnetic field plots, nor any results from the excellent motor simulation packages that are now available because experience suggests that simplified diagrams are actually better as learning vehicles. All of the diagrams have been redrawn, and many new ones have been added.

Review questions have been added at the end of each chapter. The number of questions broadly reflects my judgement of the relative

importance of each chapter, and they are intended to help build confidence and to be used selectively. A drives user might well not bother with the basic machine-design questions in the first two chapters, but could benefit by tackling the applications-related questions in subsequent chapters. Judicious approximations are called for in most of the questions, and in some cases there is either insufficient explicit information or redundant data: this is deliberate and designed to reflect reality.

Answers to the numerical questions are printed in the book, with fully worked and commented solutions on the accompanying website <http://books.elsevier.com/companions/0750647183>. The best way to learn is to make an unaided attempt before consulting a worked solution, so the extra effort in consulting the website will perhaps encourage best practice. In any event, my model solution may not be the best!

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