
ELECTROMECHANICAL DESIGN HANDBOOK

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Severn, Maryland*

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PREFACE

This third edition of the *Electromechanical Design Handbook* is again presented as a useful working tool for product designers, design engineers, and others who are involved directly in the product design disciplines and those in the design support groups throughout industry. The data in this handbook cover a broad range of subjects because of the nature of electromechanical design engineering practice.

Product designers who possess general and specific practical engineering knowledge are valuable to their particular company or organization. Those who have a broad range of practical electromechanical design knowledge not only are more secure in their jobs but can acquire the ability to find new jobs more easily and quickly if the need arises.

I have tried to consolidate enough basic and application-specific design data and procedures to allow the electromechanical designer to initiate many of the design calculations and procedures required to begin the development of mechanical, electrical, and electronic parts, mechanisms, assemblies, and processes. Most of the equations and techniques presented in this handbook have been previously used and accepted as standard practice throughout industry. At the same time, the experienced designer and student should understand that mathematical solutions to complex industrial design engineering problems are approximations at best in many cases. The mathematical solutions to problems in some areas of design are exact, while the solutions in others are unattainable with standard analytical procedures. There are no problem solution substitutes more effective than the prototype and *definitive testing* in proving the adequacy of a particular design or product. Some products cannot have a prototype stage, and in these cases we rely upon accepted standards and procedures formulated by the American standards organizations, and calculations and experience. The prototype and testing stages of product design are of prime importance to the industrial electromechanical product designer.

The intent of this handbook is to show practical, working design data and procedures; little emphasis is placed on theory. Successful industrial design engineers do not dwell on theory; rather, they use their practical engineering training, their intelligence, and testing and experience to solve actual industrial design problems quickly and effectively, with any means at their disposal. This handbook does not attempt to cover all subjects relevant to design engineering, only those that are used in most common and some specialized electromechanical design applications.

This third edition contains an expanded amount of information and design data that will prove even more useful than the first edition, which was so widely accepted in the design engineering community.

For those designers who are interested in or must have information concerning the manufacturing practices and processes directly related to electromechanical design engineering practices and also modern manufacturing procedures, the author recommends his *McGraw-Hill Machining and Metalworking Handbook* (1999), which, together with the *McGraw-Hill Electromechanical Design Handbook*, gives the product designer or design engineer an unprecedented amount and source of practical and effective design procedures and data, as well as manufacturing procedures and industrial processes.

American industry today, more than ever, needs people in the engineering professions who are trained in the multiple integrated disciplines of mechanical, electrical, and electronic

engineering design practices (called *electromechanical design engineering*, not *mechatronics*). See the introduction to Chap. 6 and its contents for how to effectively implement these disciplines. America needs more highly trained electromechanical design engineers and fewer specialists in order to more effectively compete in the national and international markets. This has been the author's purpose and goal in writing this volume and its companion, the *McGraw-Hill Machining and Metalworking Handbook*.

Ronald A. Walsh

INTRODUCTION

If you are involved in the design of industrial, military, or consumer products and perform mechanical, electrical, and electronic design functions, this handbook will be of value in your work.

The handbook is not intended for specialists in the various engineering disciplines, but rather for those designers who create the majority of general products, parts, mechanisms, and assemblies used throughout industry.

The handbook does not attempt to show an individual how to be a designer, but does present the basic reference data and techniques used to perform the various design functions.

The term *electromechanical designer* is appropriate today because many designers are involved with components and assemblies that contain elements that are mechanical, electrical, and electronic in nature, all dependently combined to form the finished product.

In many small companies, the electromechanical or product designer is responsible for the entire product—all aspects included. It is to the designer's advantage to be proficient in or to have reference data pertaining to as many of the disciplines involved in product design as possible.

Aside from containing a formidable amount of design data, the references listed in the bibliographies at the ends of chapters will be of assistance to many designers in carrying out their work, as will the listings of specification and standards authorities shown in Chap. 15. As stated in the handbook, the accumulation of accurate data is one of the basic design functions.

It was not my intent to show as many aspects of product design as possible, but to show those methods and data that are used again and again in the course of product-design engineering work. I have attempted to cover those subjects and areas which are of prime importance to the product designer, with emphasis on procuring additional information from various expert sources, which have been listed.

The handbook also will be of value to students of engineering attending technical teaching facilities, as it provides them with a good view of what is involved in modern product design and how to approach many basic design problems.

Electromechanical designers today have many technological advantages over their predecessors. In modern manufacturing facilities, the designer has access to accurate measuring and testing equipment, computer-aided design stations, and high-speed and accurate manufacturing equipment, such as computer-controlled machining centers and multistation punch presses, and highly accurate sheet-metal cutting and bending machines. Facilities such as these allow parts to be made consistently more accurately and at a higher rate of production than in the past.

Modern test and measuring equipment and devices, such as computers, digital oscilloscopes, digital multimeters and counters, pressure transducers, load cells, strain gauges, thermocouples, accelerometers, and high-speed cameras, allow the modern designer to acquire accurate answers to many design problems that would have been difficult or impossible to solve mathematically in the past, and that are still beyond the scope of engineering design manuals.

This equipment allows designers today to design and develop a particular product quickly, send it onto its prototype stage, and run definitive tests to prove the adequacy and safety of the design. Cost analyses can then be made and implemented, the prototype again tested, and finally, the product set up for production after the engineering documentation has been completed.

Using this handbook will enable you to perform many preliminary design studies and calculations that are necessary to define the basic requirements of the various parts, mechanisms, and assemblies that represent or make up the designer's concepts of the anticipated product.

On complex products, you will consult with specialists in the various engineering and scientific disciplines who will assist you in your efforts. It is good design practice to also consult the various manufacturers of purchased parts and the outside vendor producers of your designed parts or processes, such as springs, castings, molded-plastic parts, gears, bearings, plating, special finishes, and fabricating materials. These manufacturers are all willing and able to assist the designer in their particular specialties.

As a conclusion to this introduction, it must be said that the majority of the credit for this handbook is not due the author, but the thousands of individuals and companies who originated and developed the data and equations that fill the pages of this handbook. A consolidation of all their efforts can only be beneficial to the practicing product designer and to American industry.

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