Handbook of Rotating Electric Machinery

Donald V. Richardson

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Donald V. Richardson, MME, PE

Electrical Engineering Technology
Waterbury State Technical College

Consulting Engineer

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Preface

The generation since World War II has seen some major changes of emphasis in the education of an electrical engineer on one hand and the requirement to work with actual apparatus on the other. The graduate of the traditional four-year engineering course, by virtue of the curriculum that was presented, has become able to analyze the result of transient conditions by the use of differential equations and the LaPlace transformation. This analysis required the treatment of motor transient conditions by using a transfer function or mathematical expression of the motor that approximately accounts for its inertia and its accelerating torque, but that does not address how or why the motor responds as it does.

The same engineers may never have actually worked "hands on" with a motor in a laboratory situation. The technician who actually works with the motor or generator usually has not had the training in transient analysis and has had to work with older texts that were limited to an algebraic treatment of motor and generator analysis. Another approach has been to apprentice under an experienced worker who knows the connection and operation of electrical machines, but who has never been trained in analysis.

Another condition is that of the applications engineer or the plant engineer who at the present time must work from manufacturers' literature and various code requirements. Then there is the senior worker in the field, whose education dates from an era of the algebraic approach to steady-state conditions, which was then slightly spiced with the calculus whose added flavor has dissipated.

This handbook is specifically prepared to enable the practitioner in the field to recognize, understand, analyze, specify, connect, control, and satisfactorily apply the various existing types of electric motors and generators.

In the current and still worsening energy crisis, there is a new emphasis on the efficiency of all machine processes. For this reason, strong emphasis is placed upon the production and measurement of horsepower or its watt equivalent and the isolation of the accompanying losses. The intended result is that the reader who is

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Introduction

Some major electrical developments that took place nearly a century ago started a chain of interlocking developments that have permanently changed our lives. Thomas Alva Edison experimentally developed a useful electric light. He immediately foresaw that widespread and effective use of his light would require a practical source and distribution of large amounts of electric power. His development work on steam-engine-driven direct-current (dc) generators enabled the commercial expansion of electric lighting. Figure 1-1 shows a very early dc generator.

Overlapping the early use of electric lighting was the development by Sprague and others of practical dc motors and motor speed controls. This enabled the building of what would now be called urban electric railroad systems. These early trolley cars enabled mass commuting to work and business toward the end of the last century. An early trolley car using dc motors is shown in Fig. 1-2.

1-1 CHANGE OF MAJOR USE TO ALTERNATING CURRENT

The widespread distribution of direct-current electric power has virtually disappeared. The single-unit street-surface electric rail car, as distinguished from the multiple-unit subway car, is about gone. Alternating-current electric distribution became nearly universal by the second half of the twentieth century.

The advantage of alternating current over direct current in power distribution is based on the ease of changing the ac voltage level. High-voltage power lines carry their energy with a correspondingly lower current. From the very basic Ohm's law, the voltage drop in a resistance is related to the current and the resistance. Since the resistance of a power line, or any conductor, is related to its cross-sectional area, a larger-sized wire will have less resistance. On the other hand, a long-distance line will cost a prohibitive amount if it is made of a large cross section. A modern high-voltage ac distribution line is shown in Fig. 1-3.