ANALYSIS OF ELECTRIC MACHINERY AND DRIVE SYSTEMS

SECOND EDITION

Paul C. Krause
Oleg Wasynczuk
Scott D. Sudhoff

IEEE SERIES ON POWER ENGINEERING

Mohamed E. El-Hawary, *Series Editor*

ZHONGSHAN BROAD OCEAN MOTOR CO., LTD.
Exhibit 1008

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.

ANALYSIS OF ELECTRIC MACHINERY AND DRIVE SYSTEMS

Second Edition

PAUL C. KRAUSE
OLEG WASYNCZUK
SCOTT D. SUDHOFF
Purdue University

IEEE Power Engineering Society, *Sponsor*

IEEE Press Power Engineering Series
Mohamed E. El-Hawary, *Series Editor*

IEEE
PRESS

A JOHN WILEY & SONS, INC. PUBLICATION

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.

This book is printed on acid-free paper. ♾

Copyright © 2002 by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except as permitted under Sections 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008.

For ordering and customer service, call 1-800-CALL WILEY.

Library of Congress Cataloging-in-Publication is available.

ISBN 0-471-14326-X

Printed in the United States of America.

13 14 15 16 17 18 19 20

DOCKET ALARM Find authenticated court documents without watermarks at docketalarm.com.

CONTENTS

PREFACE xi

Chapter 1 BASIC PRINCIPLES FOR ELECTRIC MACHINE ANALYSIS 1

1.1 Introduction / 1
1.2 Magnetically Coupled Circuits / 1
1.3 Electromechanical Energy Conversion / 11
1.4 Machine Windings and Air-Gap MMF / 35
1.5 Winding Inductances and Voltage Equations / 47
References / 58
Problems / 58

Chapter 2 DIRECT-CURRENT MACHINES 67

2.1 Introduction / 67
2.2 Elementary Direct-Current Machine / 68
2.3 Voltage and Torque Equations / 76
2.4 Basic Types of Direct-Current Machines / 78
2.5 Dynamic Characteristics of Permanent-Magnet and Shunt dc Motors / 88
2.6 Time-Domain Block Diagrams and State Equations / 92
2.7 Solution of Dynamic Characteristics by Laplace Transformation / 98
References / 104
Problems / 105

DOCKET ALARM Find authenticated court documents without watermarks at docketalarm.com.

Chapter 3 REFERENCE-FRAME THEORY 109

3.1 Introduction / 109
3.2 Background / 109
3.3 Equations of Transformation: Changes of Variables / 111
3.4 Stationary Circuit Variables Transformed to the Arbitrary Reference Frame / 115
3.5 Commonly Used Reference Frames / 123
3.6 Transformation Between Reference Frames / 124
3.7 Transformation of a Balanced Set / 126
3.8 Balanced Steady-State Phasor Relationships / 127
3.9 Balanced Steady-State Voltage Equations / 130
3.10 Variables Observed from Several Frames of Reference / 133
References / 137
Problems / 138

Chapter 4 SYMMETRICAL INDUCTION MACHINES 141

4.1 Introduction / 141
4.2 Voltage Equations in Machine Variables / 142
4.3 Torque Equation in Machine Variables / 146
4.4 Equations of Transformation for Rotor Circuits / 147
4.5 Voltage Equations in Arbitrary Reference-Frame Variables / 149
4.6 Torque Equation in Arbitrary Reference-Frame Variables / 153
4.7 Commonly Used Reference Frames / 154
4.8 Per Unit System / 155
4.9 Analysis of Steady-State Operation / 157
4.10 Free Acceleration Characteristics / 165
4.11 Free Acceleration Characteristics Viewed from Various Reference Frames / 172
4.12 Dynamic Performance During Sudden Changes in Load Torque / 174
4.13 Dynamic Performance During a 3-Phase Fault at the Machine Terminals / 181
4.14 Computer Simulation in the Arbitrary Reference Frame / 184
References / 187
Problems / 188

Chapter 5 SYNCHRONOUS MACHINES 191

5.1 Introduction / 191
5.2 Voltage Equations in Machine Variables / 192
5.3 Torque Equation in Machine Variables / 197

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.