

# Vehicular Electric Power Systems

Land, Sea, Air,  
and Space Vehicles

**Ali Emadi**

*Illinois Institute of Technology  
Chicago, Illinois, U.S.A.*

**Mehrdad Ehsani**

*Texas A&M University  
College Station, Texas, U.S.A.*

**John M. Miller**

*J-N-J Miller Design Services, P.L.C.  
Cedar, Michigan, U.S.A.*



MARCEL DEKKER, INC.

NEW YORK • BASEL

UUSI, LLC  
Exhibit 2021

WEBASTO ROOF SYSTEMS, INC.  
Petitioner

v.  
UUSI, LLC  
Patent Owner

Case:  
IPR2014-00648  
Patent: 8,217,612

# Vehicular Electric Power Systems

Land, Sea, Air,  
and Space Vehicles

**Ali Emadi**

*Illinois Institute of Technology  
Chicago, Illinois, U.S.A.*

**Mehrdad Ehsani**

*Texas A&M University  
College Station, Texas, U.S.A.*

**John M. Miller**

*J-N-J Miller Design Services, P.L.C.  
Cedar, Michigan, U.S.A.*



MARCEL DEKKER, INC.

NEW YORK • BASEL

Although great care has been taken to provide accurate and current information, neither the author(s) nor the publisher, nor anyone else associated with this publication, shall be liable for any loss, damage, or liability directly or indirectly caused or alleged to be caused by this book. The material contained herein is not intended to provide specific advice or recommendations for any specific situation.

Trademark notice: Product or corporate names may be trademarks or registered trademarks and are used only for identification and explanation without intent to infringe.

**Library of Congress Cataloging-in-Publication Data**

A catalog record for this book is available from the Library of Congress.

**ISBN: 0-8247-4751-8**

This book is printed on acid-free paper.

**Headquarters**

Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016, U.S.A.  
tel: 212-696-9000; fax: 212-685-4540

**Distribution and Customer Service**

Marcel Dekker, Inc., Cimarron Road, Monticello, New York 12701, U.S.A.  
tel: 800-228-1160; fax: 845-796-1772

**Eastern Hemisphere Distribution**

Marcel Dekker AG, Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland  
tel: 41-61-260-6300; fax: 41-61-260-6333

**World Wide Web**

<http://www.dekker.com>

The publisher offers discounts on this book when ordered in bulk quantities. For more information, write to Special Sales/Professional Marketing at the headquarters address above.

**Copyright © 2004 by Marcel Dekker, Inc. All Rights Reserved.**

Neither this book nor any part may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming, and recording, or by any information storage and retrieval system, without permission in writing from the publisher.

Current printing (last digit):

10 9 8 7 6 5 4 3 2 1

**PRINTED IN THE UNITED STATES OF AMERICA**

## Contents

<i>Preface</i> .....	vii
1 Introduction to Electrical Power Systems.....	1
1.1 Fundamentals of Electric Circuits.....	1
1.2 Control Systems.....	8
1.3 Electrical Systems.....	11
1.4 References.....	13
2 Fundamentals of Power Electronics.....	15
2.1 AC/DC Rectifiers.....	16
2.2 DC/DC Converters.....	25
2.3 DC/AC Inverters.....	39
2.4 Selected Readings.....	47
3 Electric Machines.....	49
3.1 Electro-mechanical Power Transfer Systems.....	49
3.2 Fundamentals of Electromagnetism.....	53
3.3 DC Machines.....	55
3.4 Induction Machines.....	59
3.5 Synchronous Machines.....	63
3.6 Selected Readings.....	65
4 Automotive Power Systems.....	67
4.1 Conventional 14V Electrical System Architecture.....	70
4.2 Advanced Electrical Loads.....	72
4.3 Increasing the System Voltage to 42V.....	73
	xi



4.4	Advanced Distribution Systems .....	77
4.5	Starter, Alternator, and Integrated Starter/Alternator .....	78
4.6	Automobile Steering Systems .....	120
4.7	Semiconductors for Automotive Applications .....	132
4.8	Automotive Communication Networks and Wireless Techniques .....	139
4.9	References .....	183
5	Electric and Hybrid Electric Vehicles .....	189
5.1	Principles of Hybrid Electric Drivetrains .....	190
5.2	Architectures of Hybrid Electric Drivetrains .....	194
5.3	Electrical Distribution System Architectures .....	195
5.4	More Electric Hybrid Vehicles .....	197
5.5	Hybrid Control Strategies .....	198
5.6	Hybridization Effects .....	206
5.7	42V System for Traction Applications .....	208
5.8	Heavy Duty Vehicles .....	211
5.9	Electric Dragsters .....	219
5.10	Modeling and Simulation of Automotive Power Systems .....	224
5.11	References .....	229
6	Aircraft Power Systems .....	231
6.1	Conventional Electrical Systems .....	231
6.2	Power Generation Systems .....	234
6.3	Aircraft Electrical Distribution Systems .....	235
6.4	Stability Analysis .....	237
6.5	References .....	238
7	Space Power Systems .....	241
7.1	Introduction .....	242
7.2	International Space Station .....	242
7.3	Spacecraft Power Systems .....	251
7.4	Modeling and Analysis .....	257
7.5	Real-Time State Estimation .....	272
7.6	Stability Assessment .....	282
7.7	References .....	290
8	Sea and Undersea Vehicles .....	295
8.1	Power System Configurations in Sea and Undersea Vehicles .....	295
8.2	Power Electronics Building Blocks (PEBBs) .....	298
8.3	Controller Architecture for Power Electronic Circuits .....	300
8.4	Power Management Center (PMC) .....	303
8.5	Electrical Distribution System in Sea and Undersea Vehicles .....	304
8.6	Advanced Electrical Loads in Sea and Undersea Vehicles .....	307

# 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.