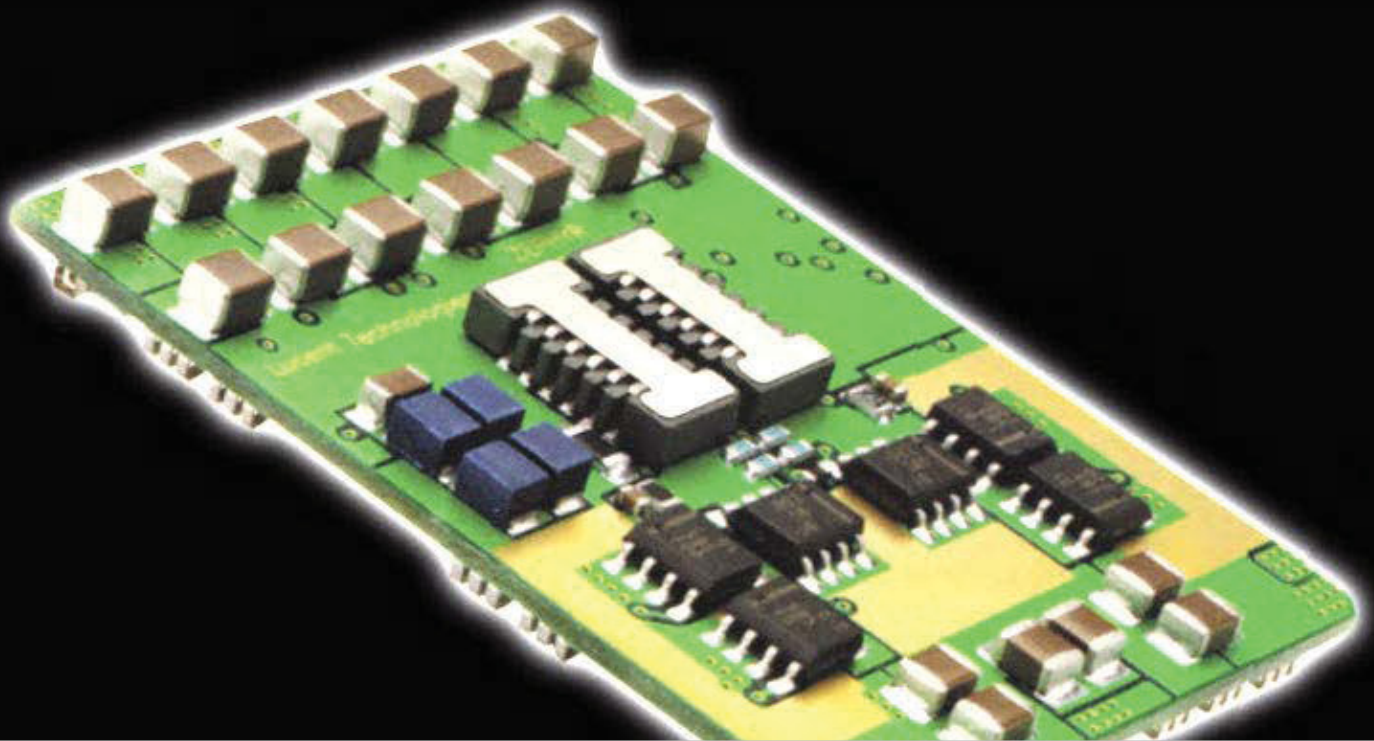


ROBERT W. ERICKSON
Dragan Maksimović

Fundamentals of Power Electronics

Second Edition



Fundamentals of Power Electronics

SECOND EDITION

**Robert W. Erickson
Dragan Maksimović
University of Colorado
Boulder, Colorado**

Distributors for North, Central and South America:

Kluwer Academic Publishers
101 Philip Drive
Assinippi Park
Norwell, Massachusetts 02061 USA
Telephone (781) 871-6600
Fax (781) 871-6528
E-Mail <kluwer@wkap.com>

Distributors for all other countries:

Kluwer Academic Publishers Group
Distribution Centre
Post Office Box 322
3300 AH Dordrecht, THE NETHERLANDS
Telephone 31 78 6576 000
Fax 31 78 6576 254
E-Mail services@wkap.nl>



Electronic Services <<http://www.wkap.nl>>

Library of Congress Cataloging-in-Publication

Erickson, Robert W. (Robert Warren), 1956-
Fundamentals of power electronics / Robert W. Erickson, Dragan Maksimovic.--2nd ed.
p. cm.
Includes bibliographical references and index.
ISBN 978-1-4757-0559-1 ISBN 978-0-306-48048-5 (eBook)
DOI 10.1007/978-0-306-48048-5
I. Power electronics. I. Maksimovic, Dragan, 1961- II. Title.

TK7881.15 .E75 2000
621.381--dc21

00-052569

Copyright © 2001 by Kluwer Academic Publishers. Sixth Printing 2004.

Cover art Copyright © 1999 by Lucent Technologies Inc. All rights reserved. Used with permission.

Softcover reprint of the hardcover 2nd edition 2001 978-0-7923-7270-7

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, mechanical, photo-copying, recording, or otherwise, without the prior written permission of the publisher, Kluwer Academic Publishers, 101 Philip Drive, Assinippi Park, Norwell, Massachusetts 02061

Contents

Preface	xix
1 Introduction	1
1.1 Introduction to Power Processing	1
1.2 Several Applications of Power Electronics	7
1.3 Elements of Power Electronics	9
References	
I Converters in Equilibrium	11
2 Principles of Steady State Converter Analysis	13
2.1 Introduction	13
2.2 Inductor Volt-Second Balance, Capacitor Charge Balance, and the Small-Ripple Approximation	15
2.3 Boost Converter Example	22
2.4 Ćuk Converter Example	27
2.5 Estimating the Output Voltage Ripple in Converters Containing Two-Pole Low-Pass Filters	31
2.6 Summary of Key Points	34
References	34
Problems	35
3 Steady-State Equivalent Circuit Modeling, Losses, and Efficiency	39
3.1 The DC Transformer Model	39
3.2 Inclusion of Inductor Copper Loss	42
3.3 Construction of Equivalent Circuit Model	45

$$0 = \frac{1}{T_s} \int_0^{T_s} i_C(t) dt = \langle i_C \rangle \quad (2.27)$$

The average value, or dc component, of the capacitor current must be zero in equilibrium.

This should be an intuitive result. If a dc current is applied to a capacitor, then the capacitor will charge continually and its voltage will increase without bound. Likewise, if a dc voltage is applied to an inductor, then the flux will increase continually and the inductor current will increase without bound. Equation (2.27), called the principle of *capacitor amp-second balance* or *capacitor charge balance*, can be used to find the steady-state currents in a switching converter.

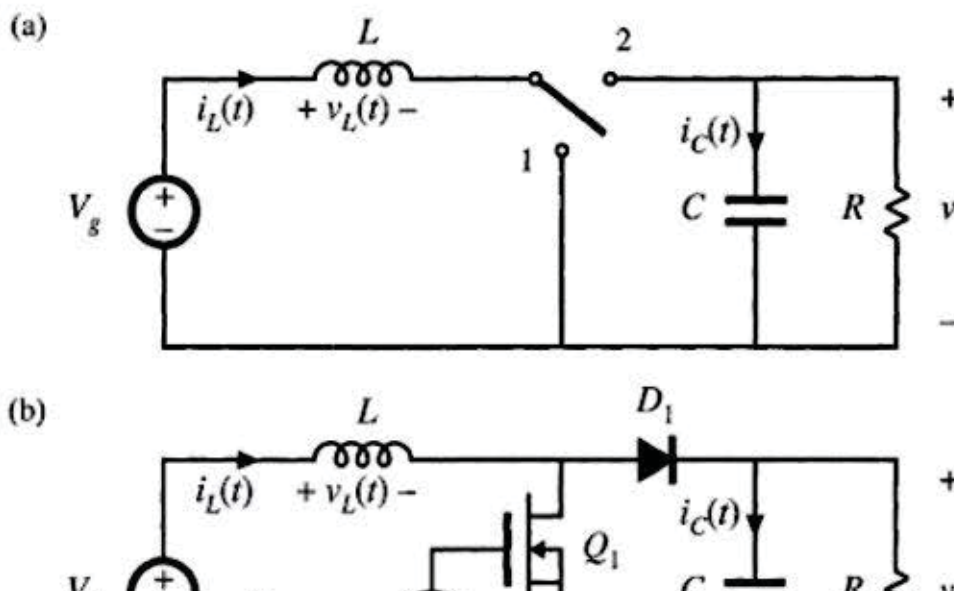
2.3 BOOST CONVERTER EXAMPLE

The boost converter, Fig. 2.13(a), is another well-known switched-mode converter that is capable of producing a dc output voltage greater in magnitude than the dc input voltage. A practical realization of the switch, using a MOSFET and diode, is shown in Fig. 2.13(b). Let us apply the small-ripple approximation and the principles of inductor volt-second balance and capacitor charge balance to find the steady-state output voltage and inductor current for this converter.

With the switch in position 1, the right-hand side of the inductor is connected to ground, resulting in the network of Fig. 2.14(a). The inductor voltage and capacitor current for this subinterval are given by

$$\begin{aligned} v_L &= V_g \\ i_C &= -\frac{v}{R} \end{aligned} \quad (2.28)$$

Use of the linear ripple approximation, $v \approx V$, leads to



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.