GLOBAL EDITION

Electrical Engineering

Principles and Applications

SEVENTH EDITION

Allan R. Hambley

Pearson

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Electrical Engineering

Principles and Applications

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To my family Judy, Tony, Pam, and Mason
and to my special friend, Carol

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Preface

As in the previous editions, my guiding philosophy in writing this book has three elements. The first element is my belief that in the long run students are best served by learning basic concepts in a general setting. Second, I believe that students need to be motivated by seeing how the principles apply to specific and interesting problems in their own fields. The third element of my philosophy is to take every opportunity to make learning free of frustration for the student.

This book covers circuit analysis, digital systems, electronics, and electromechanics at a level appropriate for either electrical-engineering students in an introductory course or nonmajors in a survey course. The only essential prerequisites are basic physics and single-variable calculus. Teaching a course using this book offers opportunities to develop theoretical and experimental skills and experiences in the following areas:

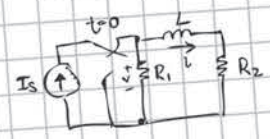
- Basic circuit analysis and measurement
- First- and second-order transients
- Steady-state ac circuits
- Resonance and frequency response
- Digital logic circuits
- Microcontrollers
- Computer-based instrumentation
- Diode circuits
- Electronic amplifiers
- Field-effect and bipolar junction transistors
- Operational amplifiers
- Transformers
- Ac and dc machines
- Computer-aided circuit analysis using MATLAB

While the emphasis of this book is on basic concepts, a key feature is the inclusion of short articles scattered throughout showing how electrical-engineering concepts are applied in other fields. The subjects of these articles include anti-knock signal processing for internal combustion engines, a cardiac pacemaker, active noise control, and the use of RFID tags in fisheries research, among others.

I welcome comments from users of this book. Information on how the book could be improved is especially valuable and will be taken to heart in future revisions. My e-mail address is `arhamble@mtu.edu`

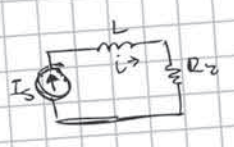
your work...

PART A



Given:
$I_S = 51.0\ mA$
$R_1 = 54.0\ k\Omega$
$R_2 = 51.0\ k\Omega$
$L = 51.0\ mH$

Find:
initial current $i(0^-)$ before break switch



$I_S = i$

$\boxed{i = 51.0\ mA}$

Assume when circuit is in steady state, inductor acts as a short $m \to —$

Use Kirchhoff's current law

$I_S = i + i_R$ $\qquad V = iR$

$I_S = i + \frac{V}{R}$ $\qquad i = \frac{V}{R}$

$I_S = i + \frac{iR_1}{R_2}$

$I_S = i\left(1 + \frac{R_1}{R_2}\right)$

$\frac{I_S}{\left(1 + \frac{R_1}{R_2}\right)} = i$

$i = \frac{51.0\ mA}{\left(1 + \frac{54.1\ k\Omega}{51\ k\Omega}\right)} = \boxed{24.77\ mA}$

your answer specific feedback

Express your answer to three significant figures and include the appropriate units.

Incorrect; Try Again; 5 attempts remaining

Note that elements in series have the same current but the inductor is not in series with the current source. Use Kirchhoff's current law or the current divider to find the initial inductor current.

Express your answer to three significant figures and include the appropriate units.

Incorrect; Try Again; 4 attempts remaining

It appears you have found the current through the resistor, R_1. Find the current through the resistor in series with the inductor.

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ON-LINE STUDENT RESOURCES

- **MasteringEngineering.** Tutorial homework problems emulate the instructor's office-hour environment, guiding students through engineering concepts with self-paced individualized coaching. These in-depth tutorial homework problems are designed to coach students with feedback specific to their errors and optional hints that break problems down into simpler steps. Access can be purchased bundled with the textbook or online at www.masteringengineering.com.
- **The Companion Website.** Access is included with the purchase of every new book or can be purchased at www.pearsonglobaleditions.com/hambley. The Companion Website includes:
  - Video Solutions that provide complete, step-by-step solution walkthroughs of representative homework problems from each chapter.
  - A Student Solutions Manual. A PDF file for each chapter includes full solutions for the in-chapter exercises, answers for the end-of-chapter problems that are marked with asterisks, and full solutions for the Practice Tests.
  - A MATLAB folder that contains the m-files discussed in the book.

INSTRUCTOR RESOURCES

Resources for instructors include:

- **MasteringEngineering.** This online Tutorial Homework program allows you to integrate dynamic homework with automatic grading and personalized feedback. MasteringEngineering allows you to easily track the performance of your entire class on an assignment-by-assignment basis, or the detailed work of an individual student.
- A complete Instructor's Solutions Manual.
- PowerPoint slides with all the figures from the book.

Instructor Resources are available for download by adopters of this book at the Instructors Resource Center: `www.pearsonglobaleditions.com/hambley`. If you are in need of a login and password, please contact your local Pearson representative.

WHAT'S NEW IN THIS EDITION

- We have continued and added items to the popular Practice Tests that students can use in preparing for course exams at the end of each chapter. Answers for the Practice Tests appear in Appendix D and complete solutions are included in the on-line Student Solutions Manual files.
- New examples have been added in Chapters 1 through 7.
- Approximately half of the end-of-chapter problems have been replaced or modified.
- Coverage of computers, microcontrollers and computer-based instrumentation has been merged from two chapters into Chapter 8 for this edition.
- Appendix C has been modified to keep up with new developments in the Fundamentals of Engineering Exam.

- We have updated the coverage of MATLAB and the Symbolic Toolbox for network analysis in Chapters 2 through 6.
- Relatively minor corrections and improvements appear throughout the book.

PREREQUISITES

The essential prerequisites for a course from this book are basic physics and single-variable calculus. A prior differential equations course would be helpful but is not essential. Differential equations are encountered in Chapter 4 on transient analysis, but the skills needed are developed from basic calculus.

PEDAGOGICAL FEATURES

The book includes various pedagogical features designed with the goal of stimulating student interest, eliminating frustration, and engendering an awareness of the relevance of the material to their chosen profession. These features are:

- Statements of learning objectives open each chapter.
- Comments in the margins emphasize and summarize important points or indicate common pitfalls that students need to avoid.
- Short boxed articles demonstrate how electrical-engineering principles are applied in other fields of engineering. For example, see the articles on active noise cancellation (page 316) and electronic pacemakers (starting on page 414).
- Step-by-step problem solving procedures. For example, see the step-by-step summary of node-voltage analysis (on pages 96–100) or the summary of Thévenin equivalents (on page 272).
- A Practice Test at the end of each chapter gives students a chance to test their knowledge. Answers appear in Appendix D.
- Complete solutions to the in-chapter exercises and Practice Tests, included as PDF files on-line, build student confidence and indicate where additional study is needed.
- Summaries of important points at the end of each chapter provide references for students.
- Key equations are highlighted in the book to draw attention to important results.

MEETING ABET-DIRECTED OUTCOMES

Courses based on this book provide excellent opportunities to meet many of the directed outcomes for accreditation. The Criteria for Accrediting Engineering Programs require that graduates of accredited programs have “an ability to apply knowledge of mathematics, science, and engineering” and “an ability to identify, formulate, and solve engineering problems.” This book, in its entirety, is aimed at developing these abilities.

Furthermore, the criteria require “an ability to function on multi-disciplinary teams” and “an ability to communicate effectively.” Courses based on this book contribute to these abilities by giving nonmajors the knowledge and vocabulary to communicate effectively with electrical engineers. The book also helps to inform

electrical engineers about applications in other fields of engineering. To aid in communication skills, end-of-chapter problems that ask students to explain electrical-engineering concepts in their own words are included.

CONTENT AND ORGANIZATION

Basic Circuit Analysis

Chapter 1 defines current, voltage, power, and energy. Kirchhoff's laws are introduced. Voltage sources, current sources, and resistance are defined.

Chapter 2 treats resistive circuits. Analysis by network reduction, node voltages, and mesh currents is covered. Thévenin equivalents, superposition, and the Wheatstone bridge are treated.

Capacitance, inductance, and mutual inductance are treated in Chapter 3.

Transients in electrical circuits are discussed in Chapter 4. First-order *RL* and *RC* circuits and time constants are covered, followed by a discussion of second-order circuits.

Chapter 5 considers sinusoidal steady-state circuit behavior. (A review of complex arithmetic is included in Appendix A.) Power calculations, ac Thévenin and Norton equivalents, and balanced three-phase circuits are treated.

Chapter 6 covers frequency response, Bode plots, resonance, filters, and digital signal processing. The basic concept of Fourier theory (that signals are composed of sinusoidal components having various amplitudes, phases, and frequencies) is qualitatively discussed.

Digital Systems

Chapter 7 introduces logic gates and the representation of numerical data in binary form. It then proceeds to discuss combinatorial and sequential logic. Boolean algebra, De Morgan's laws, truth tables, Karnaugh maps, coders, decoders, flip-flops, and registers are discussed.

Chapter 8 treats microcomputers with emphasis on embedded systems using the Freescale Semiconductor HCS12/9S12 as the primary example. Computer organization and memory types are discussed. Digital process control using microcontrollers is described in general terms. Selected instructions and addressing modes for the CPU12 are described. Assembly language programming is treated very briefly. Finally, computer-based instrumentation systems including measurement concepts, sensors, signal conditioning, and analog-to-digital conversion are discussed.

Electronic Devices and Circuits

Chapter 9 presents the diode, its various models, load-line analysis, and diode circuits, such as rectifiers, Zener-diode regulators, and wave shapers.

In Chapter 10, the specifications and imperfections of amplifiers that need to be considered in applications are discussed from a users perspective. These include gain, input impedance, output impedance, loading effects, frequency response, pulse response, nonlinear distortion, common-mode rejection, and dc offsets.

Chapter 11 covers the MOS field-effect transistor, its characteristic curves, loadline analysis, large-signal and small-signal models, bias circuits, the common-source amplifier, and the source follower.