国外电子与通信教材系列

电路基础

Introductory Circuits for Electrical and Computer Engineering

英文版

[美] James W. Nilsson
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Prentice Hall

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www.phei.com.cn

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内容简介

本书是我社已出版的《电路（第六版）》一书的英文版简版。全书系统地讲述了电路中的基本概念，基本理论、基本分析和计算方法。全书共分9章，主要内容有电路基本元件，化简电路的常用方法，电路常见分析法，运算放大器基本应用电路，*RL*和*RC*电路的固有响应和阶跃响应，*RLC*电路的固有响应和阶跃响应，正弦稳态分析，拉普拉斯变换介绍，拉氏变换在电路分析中的应用等。书中含有丰富的例题、详尽的图表资料，内容新，讲解透彻，是一本电路分析的优秀教材。

本书是电气、电子、计算机与自动化等本科专业电路课程的教材，也可供相关学科的科技人员自学或参考。

版权贸易合同登记号：图字：01-2002-5830

图书在版编目（CIP）数据

电路基础（英文版）/（美）尼尔森（Nilsson, J. W.）等著. -北京：电子工业出版社，2003.1
（国外电子与通信教材系列）
书名原文：Introductory Circuits for Electrical and Computer Engineering
ISBN 7-5053-8138-5

Ⅰ.电… Ⅱ.尼… Ⅲ.电路理论-教材-英文 Ⅳ.TM13

中国版本图书馆CIP数据核字（2002）第091468号

责任编辑：李秦华 陶淑毅
印 刷 者：北京天竺颖华印刷厂
出版发行：电子工业出版社 http://www.phei.com.cn
北京市海淀区万寿路173信箱 邮编：100036
经 销：各地新华书店
开 本：787 × 980 1/16 印张：36.25 字数：835千字
版 次：2003年1月第1版 2003年1月第1次印刷
定 价：49.00元

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序

2001年7月间，电子工业出版社的领导同志邀请各高校十几位通信领域方面的老师，商量引进国外教材问题。与会同志对出版社提出的计划十分赞同，大家认为，这对我国通信事业、特别是对高等院校通信学科的教学工作会很有好处。

教材建设是高校教学建设的主要内容之一。编写、出版一本好的教材，意味着开设了一门好的课程，甚至可能预示着一个崭新学科的诞生。20世纪40年代MIT林肯实验室出版的一套28本雷达丛书，对近代电子学科、特别是对雷达技术的推动作用，就是一个很好的例子。

我国领导部门对教材建设一直非常重视。20世纪80年代，在原教委教材编审委员会的领导下，汇集了高等院校几百位富有教学经验的专家，编写、出版了一大批教材；很多院校还根据学校的特点和需要，陆续编写了大量的讲义和参考书。这些教材对高校的教学工作发挥了极好的作用。近年来，随着教学改革不断深入和科学技术的飞速进步，有的教材内容已比较陈旧、落后，难以适应教学的要求，特别是在电子学和通信技术发展神速、可以讲是日新月异的今天，如何适应这种情况，更是一个必须认真考虑的问题。解决这个问题，除了依靠高校的老师和专家撰写新的符合要求的教科书外，引进和出版一些国外优秀电子与通信教材，尤其是有选择地引进一批英文原版教材，是会有好处的。

一年多来，电子工业出版社为此做了很多工作。他们成立了一个“国外电子与通信教材系列”项目组，选派了富有经验的业务骨干负责有关工作，收集了230余种通信教材和参考书的详细资料，调来了100余种原版教材样书，依靠由20余位专家组成的出版委员会，从中精选了40多种，内容丰富，覆盖了电路理论与应用、信号与系统、数字信号处理、微电子、通信系统、电磁场与微波等方面，既可作为通信专业本科生和研究生的教学用书，也可作为有关专业人员的参考材料。此外，这批教材，有的翻译为中文，还有部分教材直接影印出版，以供教师用英语直接授课。希望这些教材的引进和出版对高校通信教学和教材改革能起一定作用。

在这里，我还要感谢参加工作的各位教授、专家、老师与参加翻译、编辑和出版的同志们。各位专家认真负责、严谨细致、不辞辛劳、不怕琐碎和精益求精的态度，充分体现了中国教育工作者和出版工作者的良好美德。

随着我国经济建设的发展和科学技术的不断进步，对高校教学工作会不断提出新的要求和希望。我想，无论如何，要做好引进国外教材的工作，一定要联系我国的实际。教材和学术专著不同，既要注意科学性、学术性，也要重视可读性，要深入浅出，便于读者自学；引进的教材要适应高校教学改革的需要，针对目前一些教材内容较为陈旧的问题，有目的地引进一些先进的和正在发展中的交叉学科的参考书；要与国内出版的教材相配套，安排好出版英文原版教材和翻译教材的比例。我们努力使这套教材能尽量满足上述要求，希望它们能放在学生们的课桌上，发挥一定的作用。

最后，预祝“国外电子与通信教材系列”项目取得成功，为我国电子与通信教学和通信产业的发展培土施肥。也恳切希望读者能对这些书籍的不足之处、特别是翻译中存在的问题，提出意见和建议，以便再版时更正。

吴佑寿

中国工程院院士、清华大学教授

“国外电子与通信教材系列”出版委员会主任

出 版 说 明

进入21世纪以来，我国信息产业在生产和科研方面都大大加快了发展速度，并已成为国民经济发展的支柱产业之一。但是，与世界上其他信息产业发达的国家相比，我国在技术开发、教育培训等方面都还存在着较大的差距。特别是在加入WTO后的今天，我国信息产业面临着国外竞争对手的严峻挑战。

作为我国信息产业的专业科技出版社，我们始终关注着全球电子信息技术的发展方向，始终把引进国外优秀电子与通信信息技术教材和专业书籍放在我们工作的重要位置上。在2000年至2001年间，我社先后从世界著名出版公司引进出版了40余种教材，形成了一套“国外计算机科学教材系列”，在全国高校以及科研部门中受到了欢迎和好评，得到了计算机领域的广大教师与科研工作者的充分肯定。

引进和出版一些国外优秀电子与通信教材，尤其是有选择地引进一批英文原版教材，将有助于我国信息产业培养具有国际竞争能力的技术人才，也将有助于我国国内在电子与通信教学工作中掌握和跟踪国际发展水平。根据国内信息产业的现状、教育部《关于“十五”期间普通高等教育教材建设与改革的意见》的指示精神以及高等院校老师们反映的各种意见，我们决定引进“国外电子与通信教材系列”，并随后开展了大量准备工作。此次引进的国外电子与通信教材均来自国际著名出版商，其中影印教材约占一半。教材内容涉及的学科方向包括电路理论与应用、信号与系统、数字信号处理、微电子、通信系统、电磁场与微波等，其中既有本科专业课程教材，也有研究生课程教材，以适应不同院系、不同专业、不同层次的师生对教材的需求，广大师生可自由选择和自由组合使用。我们还将与国外出版商一起，陆续推出一些教材的教学支持资料，为授课教师提供帮助。

此外，“国外电子与通信教材系列”的引进和出版工作得到了教育部高等教育司的大力支持和帮助，其中的部分引进教材已通过“教育部高等学校电子信息科学与工程类专业教学指导委员会”的审核，并得到教育部高等教育司的批准，纳入了“教育部高等教育司推荐——国外优秀信息科学与技术系列教学用书”。

为做好该系列教材的翻译工作，我们聘请了清华大学、北京大学、北京邮电大学、东南大学、西安交通大学、天津大学、西安电子科技大学、电子科技大学等著名高校的教授和骨干教师参与教材的翻译和审校工作。许多教授在国内电子与通信专业领域享有较高的声望，具有丰富的教学经验，他们的渊博学识从根本上保证了教材的翻译质量和专业学术方面的严格与准确。我们在此对他们的辛勤工作与贡献表示衷心的感谢。此外，对于编辑的选择，我们达到了专业对口；对于从英文原书中发现的错误，我们通过与作者联络、从网上下载勘误表等方式，逐一进行了修订；同时，我们对审校、排版、印制质量进行了严格把关。

今后，我们将进一步加强同各高校教师的密切关系，努力引进更多的国外优秀教材和教学参考书，为我国电子与通信教材达到世界先进水平而努力。由于我们对国内外电子与通信教育的发展仍存在一些认识上的不足，在选题、翻译、出版等方面的工作中还有许多需要改进的地方，恳请广大师生和读者提出批评及建议。

电子工业出版社

教材出版委员会

About the Authors

Professor James W. Nilsson taught at Iowa State University for 39 years. Since retiring from Iowa State, he has been a visiting professor at Notre Dame, California Polytechnic at San Luis Obispo, and the United States Air Force Academy. In 1962, he co-authored (with R.G. Brown) " Introduction to Linear Systems Analysis" (John Wiley &Sons). In 1968, he authored " Introduction to Circuits, Instruments , and Electronics" (Harcourt Brace and World). Professor Nilsson received a Standard Oil Outstanding Teacher Award in 1968, the IEEE Undergraduate Teaching Award in 1992, and the McGraw-Hill Jacob Millman Award in 1995. In 1990, he was elected to the rank of Fellow of the Institute of Electrical and Electronics Engineers.

Professor Susan A. Riedel has been a member of the Department of Electrical and Computer Engineering at Marquette University since 1981. She also holds a clinical research appointment in the Department of Orthopaedics at the Medical College of Wisconsin and was a visiting professor in the Bioengineering Unit at the University of Strathclyde, Glasgow, Scotland, as a Fulbright Scholar during the 1989–1999 academic year. She has received two awards for teaching excellence at Marquette, and was recognized for her research contributions with an award from the Chicago Unit of the Shriner's Hospitals.

Preface

Introductory Circuits for Electrical and Computer Engineering is a one-semester version of the most widely used introductory circuits text of the past 15 years. Importantly, the underlying teaching approaches and philosophies remain unchanged. The goals are:

- *To build an understanding of concepts and ideas explicitly in terms of previous learning.* The learning challenges faced by students of engineering circuit analysis are prodigious; each new concept is built on a foundation of many other concepts. In *Electric Circuits*, much attention is paid to helping students recognize how new concepts and ideas fit together with those previously learned.

- *To emphasize the relationship between conceptual understanding and problem-solving approaches.* Developing the students' problem-solving skills continues to be the central challenge in this course. To address this challenge, examples and simple drill exercises are used to demonstrate problem-solving approaches and to offer students practice opportunities. We do so not with the primary aim of giving students procedural models for solving problems; rather, we emphasize problem solving as a thought process in which one applies conceptual understanding to the solution of a practical problem. As such, in both the textual development and in the worked-out examples, we place great emphasis on a problem-solving process based on concepts rather than the use of rote procedures. Students are encouraged to think through problems before attacking them, and we often pause to consider the broader implications of a specific problem-solving situation.

- *To provide students with a strong foundation of engineering practices.* There are limited opportunities in a sophomore-year circuit analysis course to introduce students to real-world engineering experiences. We continue to emphasize the opportunities that do exist by making a strong effort to develop problems and exercises that use realistic values and represent realizable physical situations. We have included

many application-type problems and exercises to help stimulate students' interest in engineering. Many of these problems require the kind of insight an engineer is expected to display when solving problems.

WHAT'S NEW IN *INTRODUCTORY CIRCUITS FOR ELECTRICAL AND COMPUTER ENGINEERING*

The condensation of *Electric Circuits* to a one-semester textbook on introductory circuits for electrical and computer engineers has been accomplished by showing how the basic techniques of circuit analysis are used to analyze circuits of particular interest in the world of digital computation. Hence, after introducing circuit variables and basic circuit elements in Chapter 1 some circuit simplification techniques are introduced in Chapter 2 that are then used to facilitate the analysis of a digital-to-analog resistive ladder circuit.

The digital-to-analog resistive ladder is the first of a series of Practical Perspectives that supports the orientation of the textbook toward digital systems. The others are:

Chapter 4	The Operational Amplifier
Practical Perspective	The Flash Converter
Chapter 5	The Natural and Step Response of *RL* and *RC* Circuits
Practical Perspective	Dual Slope Analog-to-Digital Converter
Chapter 6	Natural and Step Response of *RLC* Circuits
Practical Perspective	Parasitic Inductance
Chapter 8	Introduction to the Laplace Transform
Practical Perspective	Two-Stage *RC* Ladder
Chapter 9	The Laplace Transform in Circuit Analysis
Practical Perspective	Creation of a Voltage Surge

Integration of Computer Tools

Computer tools cannot replace the traditional methods for mastering the study of electric circuits. They can, however, assist students in the learning process by providing a visual representation of a circuit's behavior, validating a calculated solution, reducing the computational burden of more complex circuits, and iterating toward a desired solution using parameter variation. This computational support is often invaluable in the design process.

Introductory Circuits for Electrical and Computer Engineering continues the support for two popular computer tools, PSpice and MATLAB, into the main text with the addition of icons identifying chapter problems suited for exploration with one or both of these tools. The icon P identifies those problems to investigate with PSpice, while the icon M identifies problems to investigate with MATLAB. Instructors are provided with computer files containing the PSpice or MATLAB simulation of the problems so marked.

DESIGN EMPHASIS

We continue to support the emphasis on design of circuits in two ways. First, design oriented chapter problems have been explicitly labeled with the icon ❖, enabling students and instructors to identify those problems with a design focus. Second, the identification of problems specifically suited to exploration with PSpice or MATLAB suggests design opportunities using one or both of these computer tools.

Text Design and Pedagogical Features

Introductory Circuits for Electrical and Computer Engineering continues the successful design introduced in the sixth edition of *Electric Circuits*, including the following features:

- *Practical Perspective introductions* are located opposite eight chapter opening pages and are highlighted with a second-color background.
- *Practical Perspective examples* at the end of these eight chapters are set apart in an easy-to-identify separate section.
- *Practical Perspective problems* in the Chapter Problem sets are indicated with an icon ◆ for easy reference.
- *Key terms* are set in boldface when they are first defined. They also appear in boldface in the chapter summaries. This makes it easier for students to find the definitions of important terms.
- *Design problems* in the Chapter Problem sets are indicated with an icon ❖ for easy reference.
- *PSpice problems* in the Chapter Problem sets are indicated with an icon P for easy reference.
- *MATLAB problems* in the Chapter Problem sets are indicated with an icon M for easy reference.

EXAMPLES, DRILL EXERCISES, AND HOMEWORK PROBLEMS

Solved Numerical Examples

Solved numerical examples are used extensively throughout the text to help students understand how theory is applied to circuit analysis. Because many students value worked examples more than any other aspect of the text, these examples represent an important opportunity to influence the development of student's problem-solving behavior. The nature and format of the examples in *Introductory Circuits for Electrical and Computer Engineering* are a reflection of the overall teaching approach of the text. When presenting a solution, we place great emphasis on the importance of problem solving as a thought process that applies underlying concepts, as we discussed earlier. By emphasizing this idea—even in the solution of simple problems—we hope to communicate that this approach to problem solving can help students handle the more complex problems they will encounter later on. Some characteristics of the examples include:

- encouraging the student to study the problem or the circuit and to make initial observations before diving into a solution pathway;
- emphasizing the individual stages of the solution as part of solving the problem systematically, without suggesting that there are rote procedures for problem solving;
- exploring decision making, that is, the idea that we are often faced with choosing among many different solution approaches; and
- suggesting that students challenge their results by emphasizing the importance of checking and testing answers based on their knowledge of circuit theory and the real world.

Drill Exercises

Drill exercises are included in the text to give students an opportunity to test their understanding of the material they have just read. The drill exercises are presented in a double-column format as a way of signaling to students that they should stop and solve the exercises before proceeding to the next section.

Homework Problems

The homework problems are one of the book's most attractive features. The problems are designed around the following objectives (in parentheses are the corresponding problem categories identified in the *Instructor's Manual* and an illustrative problem number):

- To give students practice in using the analytical techniques developed in the text (Practice; see Problem 3.7)
- To show students that analytical techniques are tools, not objectives (Analytical Tool; see Problem 3.2)
- To give students practice in choosing the analytical method to be used in obtaining a solution (Open Method; see Problem 3.48)
- To show students how the results from one solution can be used to find other information about a circuit's operation (Additional Information; see Problem 3.65)
- To encourage students to challenge the solution either by using an alternate method or by testing the solution to see if it makes sense in terms of known circuit behavior (Solution Check; see Problem 5.12)
- To introduce students to design oriented problems (Design; see Problem 4.30)
- To give students practice in deriving and manipulating equations where quantities of interest are expressed as functions of circuit variables such as R, L, C, ω, and so forth; this type of problem also supports the design process (Derivation; see Problem 7.27)
- To challenge students with problems that will stimulate their interest in both electrical and computer engineering (Practical; see Problem 9.76)

PREREQUISITES

In writing the first seven chapters of the text, we have assumed that the reader has taken a course in elementary differential and integral calculus. We have also assumed that the reader has had an introductory physics course, at either the high school or university level, that introduces the concepts of energy, power, electric charge, electric current, electric potential, and electromagnetic fields. In writing the final two chapters, we have assumed the student has had, or is enrolled in, an introductory course in differential equations.

SUPPLEMENTS

Students and professors are constantly challenged in terms of time and energy by the confines of the classroom and the importance of integrating new information and technologies into an electric circuits course. Through the following supplements, we believe we have succeeded in making some of these challenges more manageable.

PSpice for Introductory Circuits for Electrical and Computer Engineering

This supplement is published as a separate booklet to facilitate its use at a computer. This supplement presents topics in PSpice in the same order as those presented in the text, and expressly supports the use of OrCad PSpice Release 9.2.

Student Workbook

This new supplement is provided for those students who might benefit from some additional "coaching" in their problem solving skills. Each solution technique is presented as a recipe, or a series of solution steps, and illustrated for several example problems. Then problems are presented for the students to solve, and each step in the solution is prompted individually. Finally, students are directed to additional Chapter Problems from the text to which the technique may be applied. The workbook is available as a PDF document on the companion web site so students can print and use whatever sections of the workbook they need.

Instructor's Manual

The Instructor's Manual enables professors to orient themselves quickly to this text and the supplement package. This supplement can be found on the book's web site

http://www.prenhall.com/nilsson.

For easy reference, the following information is organized for each chapter:

- a chapter overview
- problem categorizations
- problem references by chapter section
- a list of examples

Solutions Manual

The solutions manual is available on CD, it contains solutions with supporting figures to each of the nearly 650 end-of-chapter problems. These solutions are presented on the CD in both PDF and LaTeX™ format. This supplement is available free to all adopting faculty, it is not available to students. Files for the PSpice solutions and MATLAB solutions for all indicated problems are included on the CD.

Companion Web Site

The companion web site to accompany the text is located at *http://www.prenhall.com/nilsson*. The following materials are available on the web site:

- Power Point slides and key figures from the text
- student workbook
- instructor's manual
- Syllabus Manager™
- sample chapters
- dynamic message board

Acknowledgments

We continue to express our appreciation for the contributions of Norman Wittels of Worcester Polytechnic Institute. His contributions to the Practical Perspectives greatly enhanced both this edition and the previous one.

There were many hard-working people behind the scenes of our publisher who deserve our thanks and gratitude for their efforts on behalf of this book. We thank Tom Robbins, Irwin Zucker, Jody McDonnell, and Alice Dworkin for all their hard work.

We are deeply indebted to the many instructors and students who have offered positive feedback, suggestions for improvement. Gary E. Ford and James McNames have been very helpful in shaping the contents of this book. We are especially thankful to Ken Kruempel who spent considerable time and effort proofreading and verifying the accuracy of content in the text and the solutions manual.

An Abbreviated List of Laplace Transform Pairs

TYPE	$f(t)(t > 0^-)$	$F(s)$
(impulse)	$\delta(t)$	1
(step)	$u(t)$	$\frac{1}{s}$
(ramp)	t	$\frac{1}{s^2}$
(exponential)	e^{-at}	$\frac{1}{s+a}$
(sine)	$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
(cosine)	$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
(damped ramp)	te^{-at}	$\frac{1}{(s+a)^2}$
(damped sine)	$e^{-at}\sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
(damped cosine)	$e^{-at}\cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$

An Abbreviated List of Operational Transforms

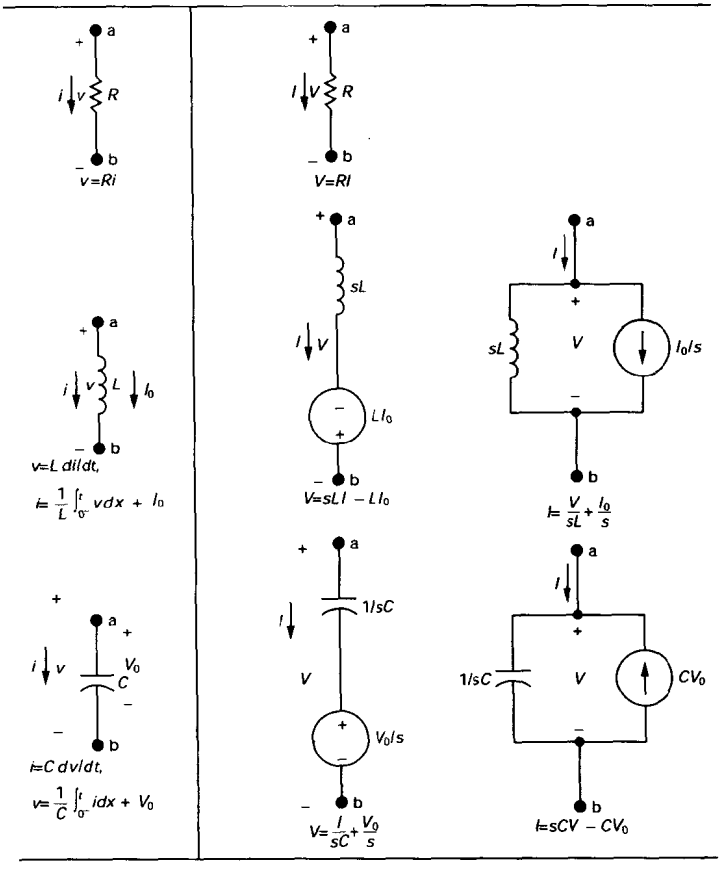
OPERATION	$f(t)$	$F(s)$
Multiplication by a constant	$Kf(t)$	$KF(s)$
Addition/subtraction	$f_1(t) + f_2(t) - f_3(t) + \cdots$	$F_1(s) + F_2(s) - F_3(s) + \cdots$
First derivative (time)	$\frac{df(t)}{dt}$	$sF(s) - f(0^-)$
Second derivative (time)	$\frac{d^2f(t)}{dt^2}$	$s^2F(s) - sf(0^-) - \frac{df(0^-)}{dt}$
nth derivative (time)	$\frac{d^nf(t)}{dt^n}$	$s^nF(s) - s^{n-1}f(0^-) - s^{n-2}\frac{df(0^-)}{dt} - s^{n-3}\frac{df^2(0^-)}{dt^2} - \cdots - \frac{d^{n-1}f(0^-)}{dt^{n-1}}$
Time integral	$\int_0^t f(x)\,dx$	$\frac{F(s)}{s}$
Translation in time	$f(t-a)u(t-a), a > 0$	$e^{-as}F(s)$
Translation in frequency	$e^{-at}f(t)$	$F(s+a)$
Scale changing	$f(at), a > 0$	$\frac{1}{a}F\left(\frac{s}{a}\right)$
First derivative (s)	$tf(t)$	$-\frac{dF(s)}{ds}$
nth derivative (s)	$t^nf(t)$	$(-1)^n\frac{d^nF(s)}{ds^n}$
s integral	$\frac{f(t)}{t}$	$\int_s^\infty F(u)\,du$

FOUR USEFUL TRANSFORM PAIRS

PAIR NUMBER	NATURE OF ROOTS	$F(S)$	$f(t)$
1	Distinct real	$\frac{K}{s+a}$	$Ke^{-at}u(t)$
2	Repeated real	$\frac{K}{(s+a)^2}$	$Kte^{-at}u(t)$
3	Distinct complex	$\frac{K}{s+\alpha-j\beta}+\frac{K^*}{s+\alpha+j\beta}$	$2\lvert K\rvert e^{-\alpha t}\cos(\beta t+\theta)u(t)$
4	Repeated complex	$\frac{K}{(s+\alpha-j\beta)^2}+\frac{K^*}{(s+\alpha+j\beta)^2}$	$2t\lvert K\rvert e^{-\alpha t}\cos(\beta t+\theta)u(t)$

Note: In pairs 1 and 2, K is a real quantity, whereas in pairs 3 and 4, K is the complex quantity $|K| \angle\theta$.

SUMMARY OF THE S-DOMAIN EQUIVALENT CIRCUITS



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