THE ANALYSIS AND DESIGN OF LINEAR CIRCUITS

Eighth Edition

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WILEY

ELECTRIC QUANTITIES

Quantity	Symbol	Unit	Unit Abbreviation
Time	t	second	s
Frequency (cyclic)	f	hertz	Hz
Frequency (radian)	ω	radian/sec	rad/s
Phase angle	θ, ϕ	degree or radian	° or rad
Energy	w	joule	J
Power	p	watt	W
Charge	q	coulomb	C
Current	i	ampere	A
Electric field	$\mathscr{E}$	volt/meter	V/m
Voltage	v	volt	V
Impedence	Z	ohm	Ω
Admittance	Y	siemen	S
Resistance	R	ohm	Ω
Conductance	G	siemen	S
Reactance	X	ohm	Ω
Susceptance	B	siemen	S
Inductance, self	L	henry	H
Inductance, mutual	M	henry	H
Capacitance	C	farad	F
Magnetic flux	ϕ	weber	wb
Flux linkages	λ	weber-turns	wb-t
Power ratio	$\log_{10}(p_2/p_1)$	Bel	B

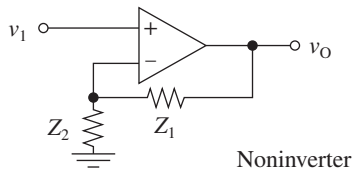
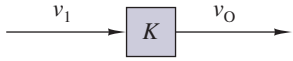
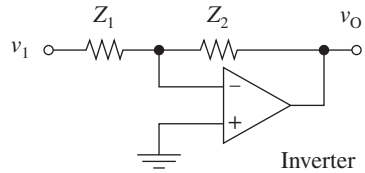
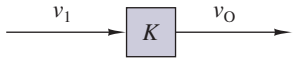
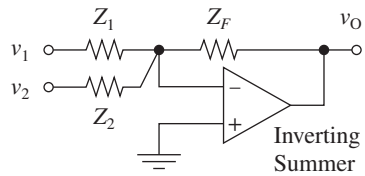
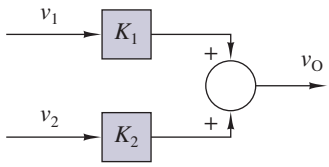
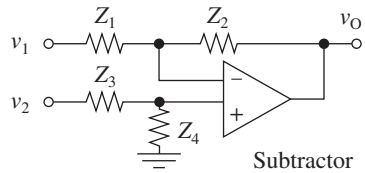
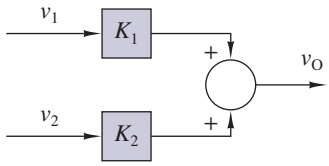
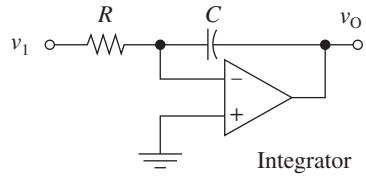
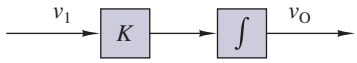
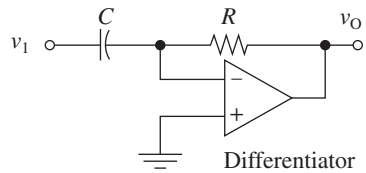
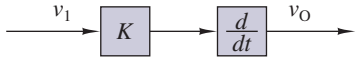
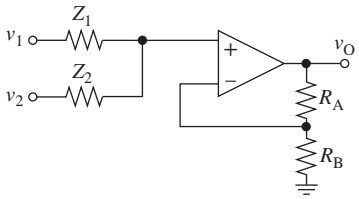
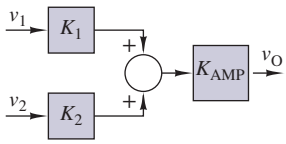
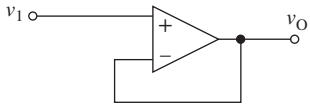
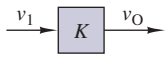
STANDARD DECIMAL PREFIXES

Multiplier	Prefix	Abbreviation	Multiplier	Prefix	Abbreviation
10^{18}	exa	E	10^{-2}	centi	c
10^{15}	peta	P	10^{-3}	milli	m
10^{12}	tera	T	10^{-6}	micro	μ
10^{9}	giga	G	10^{-9}	nano	n
10^{6}	mega	M	10^{-12}	pico	p
10^{3}	kilo	k	10^{-15}	femto	f
10^{-1}	deci	d	10^{-18}	atto	a

FUNDAMENTAL RELATIONSHIPS

	i-v Relationships		Impendence		
				Phasor-Domain	*s*-Domain
Resistor	$v_R(t) = i_R(t)R = \frac{i_R(t)}{G}$	$i_R(t) = \frac{v_R(t)}{R} = v_R(t)G$	Z_R	R	R
Inductor	$v_L(t) = L\frac{di_L(t)}{dt}$	$i_L(t) = \frac{1}{L}\int_0^t v_L(x)dx + i_L(0)$	Z_L	$j\omega L$	Ls
Capacitor	$v_C(t) = \frac{1}{C}\int_0^t i_C(x)dx + v_C(0)$	$i_C(t) = C\frac{dv_C(t)}{dt}$	Z_C	$\frac{1}{j\omega C}$	$\frac{1}{Cs}$

BASIC OP AMP MODULES

CIRCUIT	BLOCK DIAGRAM	GAINS
 Noninverter		$K = \dfrac{Z_1 + Z_2}{Z_2}$
 Inverter		$K = -\dfrac{Z_2}{Z_1}$
 Inverting Summer		$K_1 = -\dfrac{Z_F}{Z_1}$ $K_2 = -\dfrac{Z_F}{Z_2}$
 Subtractor		$K_1 = -\dfrac{Z_2}{Z_1}$ $K_2 = \left(\dfrac{Z_1 + Z_2}{Z_1}\right)\left(\dfrac{Z_4}{Z_3 + Z_4}\right)$
 Integrator		$K = -\dfrac{1}{RC}$
 Differentiator		$K = -RC$
 Noninverting Summer		$K_1 = Z_2/(Z_1+Z_2)$ $K_2 = Z_1/(Z_1+Z_2)$ $K_{AMP} = (R_A+R_B)/R_B$
 Follower		$K=1$

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To our wives
Juanita, Kathleen, and Tricia

PREFACE

What Is Different about This Text?

Our approach to the art of teaching circuits in our textbook differs from most others. We realize that electric circuits are intimately integrated into so much of our modern technology that many students from different disciplines need to learn about them. Studying circuits can be daunting, but interesting, practical, and rewarding. This can be true even for students who are not majoring in electrical or computer engineering. We believe that most students who pursue engineering studies wish to be creative and design things. Most circuits texts do not focus on this basic desire, rather spend their pages teaching why and how electric circuits work without affording the student an opportunity to put this learning into practice. The longer it takes students to try their hand in designing things, the more likely it is that they will become disillusioned and frustrated—perhaps even to the point of changing to a different major.

We have long believed that an early introduction to design and design evaluation raises the excitement level and greatly increases student interest in their chosen discipline. Over 50 years of combined teaching experience at the USAF Academy, the University of Denver, the University of Colorado at Denver, and the Air Force Institute of Technology, has only served to strengthen our belief. This new edition furthers this strategy by adding more design and evaluation examples, exercises, homework problems, and real-world applications. In addition, students today solve problems using computers, by hand, and with a calculator. Access to personal computers, laptops, notebook computers, and "smart" devices is nearly ubiquitous, and key software used in circuit analysis and design has become available for free or at very deep discounts for students. This edition of our text includes more software examples, exercises, and discussions geared to making the study of circuits more in line with the interests of today's students. Our text has always included software, but generally as an extension for solving circuits by hand. This edition continues our effort begun with the sixth edition by integrating software intimately into the solution of circuit problems whenever and wherever it really helps to solve the problems. It still recognizes that using software does not replace the intuition that engineers must develop to analyze, design, and make smart judgments about different working solutions or designs.

The eight edition of *The Analysis and Design of Linear Circuits* improves on the seventh edition and remains friendly to users who prefer a Laplace-Early approach championed in our first edition, or those favoring the more traditional Phasor-First approach to AC circuits. A later section discusses how to use this text to pursue either approach using three different focuses. In this edition, we have added more skill-level examples, exercises, and problems that can help develop the student's confidence in