

Electric Circuits

An Introduction

Robert Brown
Darby Hewitt

February 5, 2019

Dedicated to some cool people.

Contents

1	Underlying Fundamentals	3
1.1	Review of Algebra	3
1.2	Units	3
1.2.1	What is charge?	3
1.2.2	Current, Voltage, Resistance	3
1.3	A Word on Graphs	3
1.4	What is a Circuit?	3
1.5	Vector Mathematics	3
1.6	Complex Numbers	3
1.7	Linear Algebra	3
1.8	Computer Resources - Matlab	3
1.8.1	Setting up Matlab/Octave	3
1.8.2	Using Matlab to Solve Problems	3
1.9	Computer Resources - Python	3
1.9.1	Setting up Python	3
1.9.2	Using Python to Solve Problems	3
I	DC Circuit Analysis	5
2	The First Laws	7
2.1	Ohm's Law on a Single Resistor	7
2.2	Ohm's Law on a Simple Circuit	7
2.3	Kirchoff's Current Law	7
2.4	Watt's Law	7
3	Circuit Simplification and Re-Expansion	9
3.1	Resistors in Series	9
3.2	Resistors in Paralle	9
3.3	Reorganizing Complex Circuits	9
3.4	Using Voltage Division	9
3.5	Using Current Division	9

4	Extra Uses for Voltage Dividers	11
4.1	Maximum Power Transfer	11
4.2	Nonlinear Circuit Elements	11
5	Operational Amplifiers	13
5.1	What is an Op-Amp?	13
5.2	Golden Rules	13
5.3	Analyzing Circuits with Op-Amps	13
II	Alternating Current	15
6	AC Circuits	17
6.1	Phasor Notation	17
6.2	Capacitors	17
6.3	Inductors	17
6.4	Impedance and Ohm's Law	17
7	Passive Filters	19
7.1	Frequency Response	19
7.2	First Order Filters	19
7.3	Second Order Filters	19
8	Active Filters	21
8.1	Op-Amps in AC	21
8.2	First Order Filters	21
8.3	Second Order Filters	21
III	Analysis of Complex Circuits	23
9	Node Voltage Method	25
10	Mesh Current Method	27

Preface

This book is made in reaction to many introductory Electrical Engineering texts, which tend to assume a Sophomore- or even Junior-level understanding of Mathematics. In contrast, we aim our text at Freshmen, who may or may not have completed Calculus I.

Acknowledgements

- To Robert and Darby, who are awesome!
- To the students, who are awesome!
- To circuits, which is awesome!

1

Underlying Fundamentals

1.1 Review of Algebra

1.2 Units

1.2.1 What is charge?

1.2.2 Current, Voltage, Resistance

1.3 A Word on Graphs

1.4 What is a Circuit?

1.5 Vector Mathematics

1.6 Complex Numbers

1.7 Linear Algebra

1.8 Computer Resources - Matlab

1.8.1 Setting up Matlab/Octave

1.8.2 Using Matlab to Solve Problems

1.9 Computer Resources - Python

1.9.1 Setting up Python

1.9.2 Using Python to Solve Problems

Part I

DC Circuit Analysis

2

The First Laws

2.1 Ohm's Law on a Single Resistor

2.2 Ohm's Law on a Simple Circuit

2.3 Kirchoff's Current Law

2.4 Watt's Law

3

Circuit Simplification and Re-Expansion

3.1 Resistors in Series

3.2 Resistors in Paralle

3.3 Reorganizing Complex Circuits

3.4 Using Voltage Division

3.5 Using Current Division

4

Extra Uses for Voltage Dividers

4.1 Maximum Power Transfer

4.2 Nonlinear Circuit Elements

5

Operational Amplifiers

5.1 What is an Op-Amp?

5.2 Golden Rules

5.3 Analyzing Circuits with Op-Amps

Part II

Alternating Current

6

AC Circuits

6.1 Phasor Notation

6.2 Capacitors

6.3 Inductors

6.4 Impedance and Ohm's Law

7

Passive Filters

7.1 Frequency Response

7.2 First Order Filters

7.3 Second Order Filters

8

Active Filters

8.1 Op-Amps in AC

8.2 First Order Filters

8.3 Second Order Filters

Part III

Analysis of Complex Circuits

9

Node Voltage Method

10

Mesh Current Method