Second Edition

Circuit Analysis

for Anna University

ECE Course

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A Nagoor Kani

Founder, RBA Educational Group

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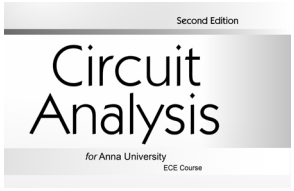

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to

Wife Mrs C Gnanaparanjothi
Elder Son N Bharath Raj
Younger Son N Vikram Raj

PREFACE

The main objective of this book is to explore the basic concepts of circuit analysis in a simple and easy-to-understand manner.

This text has been crafted is accordance with *Anna University 2017 Regulation—ECE course*. Considering the highly mathematical nature of this subject, more emphasis has been given on the problem-solving methodology. Considerable effort has been made to elucidate mathematical derivations in a step-by-step manner. Exercise problems with different levels of complexity are given in the text to help students get an intuitive grasp on the subject.

This book with its lucid writing style and germane pedagogical feature will prove to be a master text for engineering students and practitioners.

Salient Features

- Proof of important concepts and theorems are clearly highlighted by shaded boxes
- Additional explanations for solutions and proofs are provided in separate boxes
- Different types of fonts are used for text, proof and solved problems for better clarity
- Keywords are highlighted bold, italic fonts
- Easy, concise and accurate study material
- Extremely precise edition where concepts are reinforced by pedagogy
- Presentation of multiple techniques in problem solving with additional explanations and proofs
- A good number of figures and examples to enhance students understanding
- MCQs for practice

Pedagogy

- Solved numerical examples: 232
- Short Answer questions: 228
- Figures: 1517
- Practice problems: 143
- Review questions (T/F): 117
- MCQs: 139
- Fill in the blanks: 118

Organization

The book is organized into 5 chapters. The fundamental concepts, steady state analysis and transient state analysis are presented in an easy and elaborative manner. Throughout the book, carefully chosen examples are presented so that the reader will have a clear understanding of the concepts discussed.

Chapter 1 starts with explanation of fundamental quantities, standard symbols and units used in circuit analysis. The basic concepts of circuits are also presented in this chapter. The mesh and node analyses of circuits are discussed in chapter 1 with special attention to dependent sources.

The second half of Chapter 1 is devoted to basic concepts of network topology with detailed explanation about formation of tie-sets and cut-sets and development of mesh and node analysis from tie-sets and cut-sets. The concepts of dual graph and dual circuits are presented at the end of Chapter 1.

The concepts of series, parallel and star-delta network reduction are discussed in Chapter 2. The analysis of circuits using theorems are also presented in Chapter 2.

Chapter 3 starts with fundamental concepts of AC circuits which is a prerequisite for understanding resonance and coupled circuits. The concepts of resonance and analysis of coupled circuits are also discussed.

Transient analysis of circuits are explained in Chapter 4 through Laplace transform. Transient analysis of circuits excited by impulse, step and exponential signals are also presented in Chapter 4.

The concepts of two-port network parameters and its property are presented in Chapter 5.

The relationship between various two-port parameters and symmetrical properties of T and Π network are also presented in Chapter 5.

The Laplace transform has been widely used in the analysis of Electric Circuits. Hence an appendix on Laplace transform is included in this book. All the calculations in this book are performed using calculator in complex mode. An appendix is also included to help the readers to practice calculations in complex mode of calculator.

A Nagoor Kani

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I am grateful to Ms C Mohana Priya, for her passion in book work and typesetting of the manuscript and preparing the layout of the book. It's my pleasure to acknowledge the contributions of our technical editors, Ms E R Suhasini and Ms R Jenniefer Sherine, for editing and proofreading of the book. I thank all my office-staff for their cooperation in carrying out my day-to-day activities.

My sincere thanks to all reviewers for their valuable suggestions and comments that helped me to explore the subject to a greater depth.

I am also grateful to Mr Satish K Jain, CMD, CBS Publishers & Distributors, for his keen interest in publishing this work in CBS banner. My sincere thanks to all team members of CBS Publishers & Distributors, for their concern and care in publishing this work.

Finally, a special note of appreciation is due to my sisters, brothers, relatives, friends, students and the entire teaching community for their overwhelming support and encouragement to my writing.

A Nagoor Kani

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CHAPTER 5: TWO-PORT NETWORKS 5.1–5.70

APPENDICES A.1–A.22

LIST OF SYMBOLS AND ABBREVIATIONS

P	Active power
$\overline{Y}$	Admittance
AC, ac	Alternating current
A	Ampere
ω	Angular frequency
ω_r	Angular resonance frequency
S	Apparent Power
I_{ave}	Average value of current
V_{ave}	Average value of voltage
β	Bandwidth
B	Branch
C	Capacitance
X_C	Capacitive reactance
B_C	Capacitive susceptance
Q	Charge
k	Coefficient of coupling
j	Complex operator ($j = \sqrt{-1}$)
$\overline{S}$	Complex Power
G	Conductance
C	Coulomb
k_C	Critical coefficient of coupling
R_C	Critical resistance
I	Current
$i(0^+)$	Current at $t = 0^+$
$i(0^-)$	Current at $t = 0^-$
$i(\infty)$	Current at $t = \infty$
CC	Current Coil
$\bar{I}(j\omega), \bar{I}$	Current in frequency domain
I(s)	Current in Laplace domain
i(t)	Current in time domain
ζ	Damping ratio
E	DC source voltage
Δ	Determinant of matrix
DC, dc	Direct current
Y	Driving point admittance
Z	Driving point impedance
η_B	Efficiency of battery
W	Energy
R_{eq}	Equivalent resistance
F	Farad
ϕ	Flux
Ψ	Flux linkage
k_f	Form factor
π	Half period
H	Henry
Hz	Hertz
ω_h	Higher cut-off angular frequency
f_h	Higher cut-off frequency
j	Imaginary part
$\overline{Z}$	Impedance
θ	Impedance angle
L	Inductance
X_L	Inductive reactance
B_L	Inductive susceptance
e, e(t)	Instantaneous value of ac source voltage
q	Instantaneous value of charge
i, i(t)	Instantaneous value of current in time domain
i_C	Instantaneous value of current through capacitor
i_L	Instantaneous value of current through inductor
i_R	Instantaneous value of current through resistor
w	Instantaneous value of energy

p	Instantaneous value of power
v_C	Instantaneous value of voltage across capacitor
v_L	Instantaneous value of voltage across inductor
v_R	Instantaneous value of voltage across resistor
v, $v(t)$	Instantaneous value of voltage in time domain
J	Joule
K	Kelvin
kWh	kilowatt-hour
KCL	Kirchhoff's Current Law
KVL	Kirchhoff's Voltage Law
$\mathcal{L}$	Laplace operator
L	Links
I_L	Load Current
V_L	Load Voltage
R_L	Load Resistance
ω_l	Lower cut-off angular frequency
f_l	Lower cut-off frequency
Z	Magnitude of impedance
Y	Magnitude of admittance
I_m	Maximum value of current
V_m	Maximum value of voltage
m	Mesh
℧	Mho
M	Mutual inductance
ω_n	Natural frequency
$\bar{I}_N$	Neutral current
N	Neutral point
N	Nodes
Ω	Ohm
Ω-m	Ohm-metre
OC	Open circuit
k_p	Peak factor
ϕ	Phase difference between voltage and current
pf	Power factor
ϕ	Power factor angle
P	Power or active power
PC	Pressure coil
Q	Quality factor
Q_r	Quality factor at resonance
rad/s	Radians/second
X	Reactance
Q	Reactive Power
R	Resistance
ρ	Resistivity
f_r	Resonance frequency
s	Second
SC	Short circuit
S	Siemen
SPDT	Single Pole Double Throw
R_S	Source Resistance
B	Susceptance
T	Tesla
t	Time
τ	Time constant
V	Volt
VAR	Volt-Ampere-Reactive
V	Voltage
$v(0^+)$	Voltage at $t = 0^+$
$v(0^-)$	Voltage at $t = 0^-$
$v(\infty)$	Voltage at $t = \infty$
$\bar{V}(j\omega)$, $\bar{V}$	Voltage in frequency domain
V(s)	Voltage in Laplace domain
W	Watt
W-h	Watt-hour
W-s	Watt-second
Wb	Weber/Weber-turn

ROADMAP TO THE SYLLABUS

Circuit Analysis (Code: EC8251)

UNIT I: BASIC CIRCUITS ANALYSIS AND NETWORK TOPOLOGY

Ohm's Law–Kirchhoff's laws–Mesh current and node voltage method of analysis for DC and AC circuits–Network terminology–Graph of a network–Incidence and reduced incidence matrices–Trees–Cutsets–Fundamental cutsets–Cutset matrix–Tie sets–Link currents and tie set schedules–Twig voltages and cutset schedules, duality and dual networks.

GO TO:
CHAPTER 1: Basic Circuit Analysis and Network Topology

UNIT II: NETWORK THEOREMS FOR DC AND AC CIRCUITS

Network theorems–Superposition theorem, Thevenin's theorem, Norton's theorem, reciprocity theorem, Millman's theorem, and maximum power transfer theorem, application of network theorems–Network reduction: voltage and current division, source transformation–star delta conversion.

GO TO:
CHAPTER 2: Network Theorems for DC and AC Circuits

UNIT III: RESONANCE AND COUPLED CIRCUITS

Resonance–Series resonance–Parallel resonance–Variation of impedance with frequency–Variation in current through and voltage across L and C with frequency–Bandwidth–Q factor–Selectivity. Self inductance–Mutual inductance–Dot rule–Coefficient of coupling–Analysis of multiwinding coupled circuits–Series, parallel connection of coupled inductors–Single tuned and double tuned coupled circuits.

GO TO:
CHAPTER 3: AC Circuits, Resonance and Coupled Circuits

UNIT IV: TRANSIENT ANALYSIS

Natural response–Forced response–Transient response of RC, RL and RLC circuits to excitation by step signal, impulse signal and exponential sources–Complete response of RC, RL and RLC circuits to sinusoidal excitation.

GO TO:
CHAPTER 4: Transient Analysis

UNIT V: TWO PORT NETWORKS

Two port networks, Z parameters, Y parameters, transmission (ABCD) parameters, hybrid (H) parameters, interconnection of two port networks, symmetrical properties of T and π networks.

GO TO:
CHAPTER 5: Two-Port Networks