

Second Edition

# Circuit Analysis

*for Anna University*

ECE Course

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# Circuit Analysis

*for Anna University*

ECE Course

**A Nagoor Kani**

Founder, RBA Educational Group  
Chennai

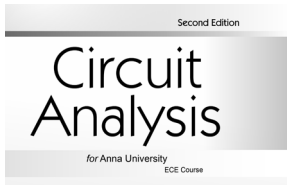


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*to*

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



# PREFACE

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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 in 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  $\Pi$  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**



## ACKNOWLEDGEMENTS

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I express my heartfelt thanks to my wife Ms C Gnanaparanjothi Nagoor Kani and my sons N Bharath Raj alias Chandrakani Allaudeen and N Vikram Raj, for the support, encouragement and cooperation they have extended to me throughout my career. I thank Ms T A Benazir, for the affection and care on my day-to-day activities.

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

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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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**ANNA UNIVERSITY QUESTION PAPERS**

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## LIST OF SYMBOLS AND ABBREVIATIONS

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

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

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## 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

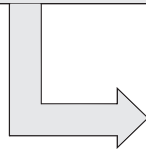
Resonance–Series resonance–Parallel resonance–Variation of impedance with frequency–Variation in current through and voltage across L and C with frequency–Bandwidth–Q factor–Selectivity. Self inductance–Mutual inductance–Dot rule–Coefficient of coupling–Analysis of multiwinding coupled circuits–Series,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

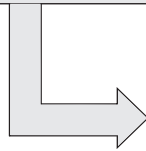


GO TO:

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  $\pi$  networks.



GO TO:

CHAPTER 5: Two-Port Networks