

CONTENTS

	PAGE
<i>PREFACE</i>	v
<i>INTRODUCTION</i>	xvii
PART 1. GENERAL DESCRIPTIONS	
I.I. CLASSIFICATION OF PERIODICALLY INTERRUPTED ELECTRIC CIRCUITS.....	3
1. 1. Introduction to Part One	3
1. 2. Periodically Interrupted Electric Circuit of First Genus.....	4
1. 3. Periodically Interrupted Electric Circuit of Second Genus	4
1. 4. Periodically Interrupted Electric Circuit of Third Genus	5
I.II. GIBBS PHENOMENON.....	6
1. 5. Fourier Theorem	6
1. 6. Dirichlet Conditions.....	8
1. 7. Order of the Terms in the Fourier Series	8
1. 8. Wave Synthesis or Approximation Curve of the Fourier Series.....	9
1. 9. Gibbs Phenomenon.....	12
I.III. MODIFIED HEAVISIDE EXPANSION THEOREM	15
1.10. Heaviside Expansion Theorem	15
1.11. Bromwich Integral	17
1.12. Modified Heaviside Expansion Theorem	18
1.12.1. p_0 is only One Repeated Root of Order s of Equation $M(p)=0$, and $M(\alpha) \neq 0$	20
1.12.2. α is only One Repeated Root of Order s of Equation $M(p)=0$	22
I.IV. SYLVESTER EXPANSION THEOREM	23
1.13. Fundamentals of the Matrix Algebra	23
1.13.1. Definition of a Matrix	23
1.13.2. Equality, Addition, Subtraction and Multiplication of Matrices	24
1.13.3. The Singular Matrix, Degeneracy and Rank of a Matrix	26
1.13.4. The Inverse or the Reciprocal of a Matrix	26
1.13.5. Division of Matrices	27
1.13.6. The Transposed Matrix and the Adjoint Matrix of a Matrix	27
1.13.7. Powers of Matrices and Polynomials of Matrices.....	28
1.13.8. The Characteristic Matrix, the Characteristic Function or Characteristic Polynomial and the Characteristic Equation of a Matrix	28

1.13.9. Function of a Matrix	28
1.14. Cayley-Hamilton Theorem	29
1.14.1. Example	30
1.15. Sylvester Expansion Theorem	31
1.15.1. Example 1	31
1.15.2. Example 2	32
1.15.3. Example 3	33
1.16. Generalized Sylvester Expansion Theorem	34
1.16.1. Example 1	37
1.16.2. Example 2	38
I.V. MODIFIED OPERATIONAL CALCULUS	40
1.17. Note on the Establishment of Differential Equations of an Electric Circuit	41
1.17.1. Example	43
1.18. Classification of Initial Conditions	46
1.19. Abnormal Features of Initial Conditions	48
1.19.1. Example 1	48
1.19.2. Example 2	50
1.20. Determination of Initial Condition of the Second Kind	52
1.21. Modified Operational Calculus	52
1.22. Examples	56
1.22.1. Example 1	56
1.22.2. Example 2	58
1.22.3. Example 3	59
I.VI. SYMBOLIC OPERATIONAL CALCULUS	63
1.23. Determination of Equivalent p -Circuit comprising Operational Currents and Voltages, Mutual Inductance being missing	64
1.24. Symbolic Operational Calculus applied to the Circuit with Mutual Inductance	68
1.25. Examples	74
1.25.1. Example 1	74
1.25.2. Example 2	76
1.25.3. Example 3	77
 PART 2. PERIODICALLY INTERRUPTED ELECTRIC CIRCUITS OF FIRST GENUS 	
II.I. FUNDAMENTALS	81
2. 1. Introduction to Part Two	81
2. 2. Fundamental Formulae for the Periodically Interrupted Electric Circuit of First Genus taking Two Circuit Modes	83

2. 3. Transient Currents and Voltages on the n -th Stage of the Periodically Interrupted Electric Circuit of First Genus consisting of Alternative Two Circuit Modes, the Duration of Each Mode being independent of n	92
2. 4. Stability Criterion	97
2. 5. Summary	100
2. 6. Periodically Interrupted Electric Circuit of First Genus taking m Circuit Modes	104
2. 7. Characteristics of the Latent Roots of the Matrix $[B_r]$	107
2.7.1. When $[\chi_r]$'s are Non-singular Square Matrices	108
2.7.2. When Some of the Matrices $[\chi_r]$'s are Rectangular or Singular Matrices	109
2.7.3. Diagonal Matrix of the Latent Roots	113
2. 8. Example for Steady-state Phenomena	115
2. 9. Numerical Examples for Steady-state Phenomena	123
2.10. Example for Transient Phenomena	126
2.10.1. General Solution	127
2.10.2. Determination of the Elements of $[w_{1n}^{-0}]$	132
2.10.3. Numerical Examples	135
II.II. CONTACT MODULATED AMPLIFIERS	140
2.11. Introduction	140
2.12. Performance of the Input Circuit of a Contact Modulated Amplifier for Constant D-C Signals	141
2.13. Illustrative Numerical Examples	147
2.14. Performance of the Input Circuit of a Contact Modulated Amplifier for Sinusoidal Input Signals	151
2.15. Numerical Examples	153
II.III. SAMPLING SERVO-MECHANISMS	157
2.16. Introduction	157
2.17. Fundamentals	158
2.18. Example	162
II.IV. INVERTER CIRCUITS	167
2.19. Introduction	167
2.20. Performances of the Inverters	168
2.21. Single-phase Series Inverter Circuit with a Resistive Load	171
2.21.1. Steady-state Phenomena in the Case of $f_0 > f$	174
2.21.2. Steady-state Phenomena in the Case of $f_0 = f$	184
2.21.3. Transient Phenomena in the Case of $f_0 > f$	185
2.22. Single-phase Series Inverter Circuit with an Inductive Load	192
2.22.1. Steady-state Phenomena in the Case of $f_0 > f$	192

2.22.2. Transient Phenomena in the Case of $f_0 > f$	208
2.23. Self-excited Three-phase Capacitor-commutated Bridge Type Inverter	210
II.V. DIAL IMPULSE CIRCUITS	219
2.24. Introduction	219
2.25. Fundamentals	219
2.25.1. When the Interrupter is open	222
2.25.2. When the Interrupter is closed	222
2.26. Cut-off Operator	223
2.27. Deduction of the Fundamental Formulae	225
2.27.1. The First Circuit Mode of the n -th Stage, where the Interrupter is open	229
2.27.2. The Second Circuit Mode of the n -th Stage, where the Interrupter is closed	231
2.28. Stability Criterion and Steady-state Solutions	233
2.29. Analysis of Dial Impulses	234
2.29.1. Incoming Second or Third Selector Circuit	235
2.29.2. First Selector Circuit	238
2.29.3. Connector Circuit	239
 PART 3. PERIODICALLY INTERRUPTED ELECTRIC CIRCUITS OF SECOND GENUS 	
III.I. FUNDAMENTALS	245
3. 1. Introduction to Part Three	245
3. 2. Fundamental Formulae	245
3.2.1. Transient Currents and Voltages	245
3.2.2. Steady-state Currents and Voltages	251
3. 3. Tables of $\{E_n(p)\}$ and $\{S_n(p)\}$	253
3. 4. Stability Criterion	256
3. 5. Summary	260
III.II. AMPLIFIERS FOR PERIODIC IMPULSIVE SIGNALS	264
3. 6. Introduction	264
3. 7. Resistance-coupled Amplifiers	264
(1) Elements of $\{F(p)\}$	266
(2) Elements of $\{f(t)\}$	267
(3) Elements of $\{\chi(t)\}$	267
(4) Elements of $\{\varphi(t)\}$	267
(5) Elements of $\{[U] - [\chi(t_0)]\}^{-1} \{[U] - [\chi(t_0)]^{n-1}\}$	268
(6) Elements of $\begin{pmatrix} i_n \\ [v_n] \end{pmatrix}_{t=t_0}$	270

3. 8. Numerical Examples	272
3. 9. Tuned Amplifier	277
(1) Elements of $[F(p)]$	279
(2) Elements of $[f(t)]$	279
(3) Elements of $[\chi(t)]$	279
(4) Elements of $\{[U]-[\chi(t_0)]\}^{-1}\{[U]-[\chi(t_0)]^{n-1}\}$	279
(5) Elements of $\begin{pmatrix} [E_n(p)] \\ [S_n(p)] \end{pmatrix}$	280
3.9.1. Application of Periodic Rectangular Input Signal	281
(1) Elements of $[\varphi(t)]$	281
(2) Elements of $\begin{pmatrix} [i_{n-1}] \\ [v_{n-1}] \end{pmatrix}_{t=t_0}$	281
3.9.2. Application of Periodic Rectangularly Modulated Input Signal	283
(1) Elements of $[\varphi(t)]$	283
(2) Elements of $\begin{pmatrix} [i_{n-1}] \\ [v_{n-1}] \end{pmatrix}_{t=t_c}$	283
3.10. Numerical Examples	285
3.10.1. Envelope of the Output Voltages due to Periodic Rectangular Input Signal	285
3.10.2. Envelope of the Output Voltages due to Periodic Rectangularly Modulated Input Signal	286
3.11. Steady-state Performance of a Multi-stage Amplifier for Periodic Impulsive Signals	288
3.11.1. General Case	288
(1) Elements of $[F(p)]$	290
(2) Elements of $[\chi(t)]$	291
(3) Elements of $\{[U]-[\chi(t_0)]\}^{-1}$	291
(4) Latent Roots of $[\chi(t_0)]$	292
3.11.2. When Each Circuit Stage has the Same Connections	292
(1) Elements of $[F(p)]$	293
(2) Elements of $[\chi(t)]$	293
(3) Elements of $[B]=\{[U]-[\chi(t_0)]\}^{-1}$	293
(4) Latent Roots of $[\chi(t_0)]$	293
3.12. Performance of Resistance-coupled Three-stage Amplifier for Periodic Impulsive Signals	294
(1) Elements of $[F(p)]$	296
(2) Elements of $[\chi(t)]$	296
(3) Elements of $\{[U]-[\chi(t_0)]\}^{-1}$	297
(4) Elements of $[\varphi(t)]$	297
3.12.1. Ultimate Values of the System Variables at the End of Each Circuit Mode in Steady-state Running	298

(1) In the Case of Periodic Rectangular Input Signal	299
(2) In the Case of Periodic Triangular Input Signal	299
3.12.2. Steady-state Values of v_{1n} , v_{2n} and v_{3n}	299
(1) In the Case of Periodic Rectangular Input Signal	299
(2) In the Case of Periodic Triangular Input Signal	300
3.13. Numerical Examples compared with Experimental Results	301
3.14. Feedback Amplifiers for Periodic Impulsive Signals	306
3.15. Performance of Resistance-coupled Feedback Amplifier	308
III.III. MECHANICAL AND THERMAL SYSTEMS DRIVEN	
BY PERIODIC IMPULSES	312
3.16. Physical Systems with Periodically Varying Forcing Functions	312
3.17. Analogs of Electrical, Mechanical and Thermal Systems	313
3.18. Continuous Driving Forces or Continuous Forcing Functions in General Physical Systems	317
3.19. Impulsive Driving Forces in Physical Systems	319
3.20. Formulation of Operational Equations, considering Impulsive Driving Forces	320
3.21. Table representing Electric Analogs of Mechanical and Thermal Systems	327
3.22. Modified Thevenin Theorem	327
3.23. Simplified Analytical Method of Physical Systems acted upon by Periodically Varying Driving Forces	330
3.23.1. Physical System acted upon by Periodically Varying Continuous Driving Force	330
3.23.2. Physical System acted upon by Impulsive Periodically Varying Driving Force	336
3.24. Motion of a Frame mounted on a Vibrating Floor	337
3.25. Motion of a Frame due to Periodical Shots of a Gun	340
3.26. The Current Response of a Seismometer due to Periodical Impulsive Motion of a Floor	342
3.27. Vertical Motion of an Automobile running along the Road with Periodically Zigzag Surface	345
3.28. Composite Periodically Interrupted Electric Circuits of First and Second Genera	351
PART 4. PERIODICALLY INTERRUPTED ELECTRIC CIRCUITS OF THIRD GENUS	
IV.I. FUNDAMENTALS	355

4. 1. Introduction to Part Four.....	355
4. 2. Periodic Solutions of the Periodically Interrupted Electric Circuits of Third Genus	356
4. 3. Stability Criterion for Periodic Solution.....	357
4. 4. Effects of Δt 's	359
IV.II. HARMONIC PRODUCER CIRCUITS	361
4. 5. Introduction	361
4. 6. Analysis of the Basic Circuit.....	366
4.6.1. Circuit Modes	366
4.6.2. Transient Solutions in Permeable Region.....	366
4.6.3. Transient Solutions in Positively Saturated State	369
4.6.4. Steady-state Solutions considering the Over-all Characteristics.....	369
4. 7. Effect of Shunt Condenser.....	372
4.7.1. Circuit Modes	372
4.7.2. Transient Solutions in Permeable Region	373
4.7.3. Transient Solutions in Positively Saturated State	375
4.7.4. Steady-state Solutions	376
4.7.5. $f_n(\tau)$, $\varphi_n(\tau)$, $f_{ns}(\tau)$ and $\varphi_{ns}(\tau)$	379
4. 8. Numerical Examples.....	381
4.8.1. Basic Circuit	381
4.8.2. Effect of Shunt Condenser	385
4.8.3. Experimental Results	389
IV.III. POLYPHASE RECTIFIER CIRCUITS	393
4. 9. Introduction.....	393
4.10. Circuit Modes of an N -phase Rectifier in Steady-state Operation.....	394
4.11. Steady-state Performance of an N -phase Rectifier Circuit	395
4.11.1. In the Case of Cutting-off being present	395
4.11.2. In the Case of Cutting-off being absent	397
4.12. Examples	401
INDEX.....	405