

Contents		Pages
Acknowledgement		v-vi
Contents		vii-xii
List of Figures		xiii-xviii
Preface		xix-xx
Chapter 1	Introduction	01-36
§1.1	Dynamical Systems	01
	▪ 1.1.1 Mathematical definition of dynamical systems	01
§1.2	Types of Dynamical Systems	01
	▪ 1.2.1 Linear System	02
	▪ 1.2.2 Nonlinear System	03
	▪ 1.2.3 Autonomous and Non-Autonomous systems	03
§1.3	Stability Theory	03
	▪ 1.3.1 Equilibrium points of a system	03
	▪ 1.3.2 Stability of the system	04
	▪ 1.3.3 Lyapunov's First Method	05
	▪ 1.3.4 Lyapunov's Second Method	06
§1.4	History of Chaos	07
	▪ 1.4.1 Definition of chaos	08
	▪ 1.4.2 Attractor and strange attractor	09
	▪ 1.4.3 Lyapunov Exponent	10

	<ul style="list-style-type: none"> ▪ 1.4.4 Chaos in fractional order systems 	11
§1.5	Chaos Synchronization <ul style="list-style-type: none"> ▪ 1.5.1 Types of synchronization ▪ 1.5.1.1 Complete synchronization ▪ 1.5.1.2 Anti synchronization ▪ 1.5.1.3 Lag or Anticipating synchronization ▪ 1.5.1.4 Phase synchronization ▪ 1.5.1.5 Modified projective synchronization ▪ 1.5.1.6 Dual synchronization ▪ 1.5.1.7 Combined or Combination synchronization ▪ 1.5.1.8 Dual combination synchronization 	11 12 12 13 13 14 14 14 16 16
§1.6	Methodology of chaos synchronization <ul style="list-style-type: none"> ▪ 1.6.1 Active Control Method ▪ 1.6.2 Nonlinear Control Method 	17 18 18
§1.7	Basic of Fractional Calculus <ul style="list-style-type: none"> ▪ 1.7.1 Some results on fractional derivatives ▪ 1.7.1.1 Grunwald-Letnikov fractional derivative ▪ 1.7.1.2 Riemann-Liouville fractional derivative ▪ 1.7.1.3 Caputo fractional derivative ▪ 1.7.1.4 Relation between Riemann-Liouville and Caputo derivatives ▪ 1.7.1.5 Leibniz rule 	20 21 21 22 23 24 25
§1.8	Numerical Methods <ul style="list-style-type: none"> ▪ 1.8.1 Adams-Bashforth-Moulton Method 	25 26

§1.9	Review of Literature	27
Chapter 2	Dual phase synchronization of chaotic systems using nonlinear observer based technique	37-52
§2.1	Introduction	37
§2.2	Problem formulation	40
§2.3	Systems' descriptions	42
	▪ 2.3.1 Qi chaotic system	42
	▪ 2.3.2 Newton-Leipnik system	43
§2.4	Dual phase synchronization of chaotic systems	44
§2.5	Numerical simulation and results	50
§2.6	Conclusion	51
Chapter 3	Difference synchronization among three chaotic systems with exponential term and its chaos control	53-94
§3.1	Introduction	53
§3.2	Difference synchronization scheme	57
§3.3	Routh-Hurwitz Criterion	58
§3.4	Systems' descriptions and control of chaos	60
	▪ 3.4.1 Ten-ring chaotic system	60
	▪ 3.4.1.1 Control of chaos	62
	▪ 3.4.2 3D chaotic system	67

	<ul style="list-style-type: none"> ▪ 3.4.2.1 Control of chaos ▪ 3.4.2 New 3D chaotic system ▪ 3.4.3.1 Control of chaos 	69 73 75
§3.5	Application of difference synchronization scheme among chaotic systems <ul style="list-style-type: none"> ▪ 3.5.1 Difference synchronization among chaotic systems with exponential terms ▪ 3.5.2 Difference synchronization among discrete time chaotic systems 	81 81 84
§3.6	Numerical simulation and discussion	88
§3.7	Conclusion	93
Chapter 4	Exponential synchronization of a class of fractional order complex chaotic systems and application through digital cryptography	95-128
§4.1	Introduction	95
§4.2	Some preliminaries and lemma <ul style="list-style-type: none"> ▪ 4.2.1 Fractional order dynamical system 	99 104
§4.3	Systems' descriptions <ul style="list-style-type: none"> ▪ 4.3.1 Fractional order complex Lorenz system ▪ 4.3.2 Fractional order complex Lu system 	103 103 105
§4.4	Exponential synchronization <ul style="list-style-type: none"> ▪ 4.4.1 Exponential synchronization of identical fractional order complex chaotic systems 	107 107

	<ul style="list-style-type: none"> ▪ 4.4.2 Exponential synchronization of non-identical fractional order complex chaotic systems ▪ 4.4.3 Numerical simulations 	114 118
§4.5	Application <ul style="list-style-type: none"> ▪ 4.5.1 Synchronized systems and cryptography ▪ 4.5.2 Fibonacci Q- matrix ▪ 4.5.3 The process of generation of the secret keys ▪ 4.5.4 Security analysis of the scheme 	122 122 122 123 127
§4.6	Conclusion	128
Chapter 5	Stability analysis, control of Simple chaotic system and its hybrid projective synchronization with fractional Lu system	129-154
§5.1	Introduction	129
§5.2	Systems' description and stability condition <ul style="list-style-type: none"> ▪ 5.2.1 Fractional order Simple system ▪ 5.2.1.1 Stability analysis ▪ 5.2.2 Fractional order Lu chaotic system 	132 132 134 135
§5.3	Chaos control of Simple system using nonlinear control method <ul style="list-style-type: none"> ▪ 5.3.1 Results based on numerical simulation for the points E_1 and E_2 	136 138
§5.4	Hybrid projective synchronization between fractional order Simple and Lu systems using nonlinear control method	139

§5.5	Numerical results and discussion	140
§5.6	Conclusion	154
Chapter 6	Function projective synchronization of fractional order satellite systems and its stability analysis for incommensurate case	155-180
§6.1	Introduction	155
§6.2	Some Preliminaries	159
	▪ 6.2.1 Function projective synchronization	159
§6.3	Systems' description, stability analysis and control of chaos	159
	▪ 6.3.1 Satellite system	159
	▪ 6.3.2 Stability analysis of fractional order satellite system	160
	▪ 6.3.3 Control of Chaos	166
	▪ 6.3.3.1 Stabilizing the points E_0, E_1, E_2, E_3 and E_4	168
§6.4	Function projective synchronization of incommensurate fractional order satellite system	171
§6.5	Numerical simulation and results	178
§6.6	Conclusion	178
Bibliography		181-204
List of Publications		