

# Table of Contents

---

---

ACKNOWLEDGEMENT	i
ABSTRACT	iii
TABLE OF CONTENTS	vi
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF SYMBOLS AND ABBREVIATIONS	xvii
<b>CHAPTER 1:INTRODUCTION</b>	<b>1</b>
1.1    INTRODUCTION	1
1.2    PRIMARY CONTROL	5
1.2.1    Primary Control Basics	6
1.3    SECONDARY CONTROL	8
1.3.1    Principle of Secondary Controller	10
1.3.2    Control Hierarchy and Organization	11
1.4    TERTIARY CONTROL	12
1.5    MEASURES FOR EMERGENCY CONDITIONS	13
1.6    VARIOUS TECHNIQUES TO TACKLE	
LFC PROBLEM	13
1.6.1    Optimal Control	13
1.6.2    Adaptive Control	14

1.6.3	Pole Placement Technique	14
1.6.4	Intelligent Techniques	15
1.6.4.1	Fuzzy Logic	15
1.7	OBJECTIVES OF THE THESIS	17
1.8	ARRANGEMENT OF THE THESIS	18
<b>CHAPTER 2: LITERATURE SURVEY ON LFC</b>		20
2.1	INTRODUCTION	20
2.2	CLASSICAL TECHNIQUES	21
2.3.	ADAPTIVE AND SELF-TUNING LFC SCHEMES	28
2.4	CONCEPTS OF AI TECHNIQUES	28
2.5	OTHER LFC SCHEMES	32
2.6	SUMMARY	34
<b>CHAPTER 3: PROBLEM IDENTIFICATION AND</b>		
<b>SYSTEM MODELING</b>		35
3.1	INTRODUCTION	35
3.2	PROBLEM IDENTIFICATION	36
3.3	SYSTEM MODELING	38
3.3.1	Generator Model	39
3.3.2	Load Model	43
3.3.3	Governor Model	45

3.3.4	Prime Mover Model	47
3.4	DIVISION OF POWER SYSTEM INTO CONTROL AREAS	49
3.4.1	Definition of Control Area	49
3.4.2	LFC in Multi-Area System	49
3.4.3	Tie-Line Bias Control	52
3.5	COMPLETE SYSTEM DYNAMIC MODEL	53
3.5.1	Dynamic System in State Variable Form	57
3.6	SUMMARY	65
<b>CHAPTER 4: PROPOSED CONTROL STRATEGIES</b>		66
4.1	INTRODUCTION	66
4.2	LINEAR QUADRATIC OPTIMAL CONTROL REGULATOR	68
4.2.1	System States	72
4.2.2	Performance Index	72
4.2.3	Optimal Controller	73
4.3	FUZZY LOGIC CONTROLLER	75
4.3.1	Normalization of Controller Inputs and Output	76
4.3.2	Fuzzification	77
4.3.3	Fuzzy Conditional Statements and Control Rules	78
4.3.4	Defuzzification	80

4.3.5	Steps in Designing of Proposed Fuzzy Controller for Multi-area LFC	80
4.4	SUMMARY	83
<b>CHAPTER 5: SIMULATION RESULTS AND ANALYSIS-</b>		
	<b>TWO AREA SYSTEMS</b>	84
5.1	INTRODUCTION	84
5.2	RESULTS WITH LQR TECHNIQUE	85
5.3	RESULTS WITH FUZZY LOGIC CONTROLLER	90
5.3.1	Two Area System with Non-Reheat Turbine	90
5.3.2	Two Area System with Reheat Turbine	94
5.3.3	Two Area System with Non-Reheat with GRC	97
5.3.4	Two Area System with Reheat with GRC	100
5.3.5	Two Area System with one Non-reheat and one Hydro Turbine	103
5.3.6	Two Area System with one Reheat and one Hydro Turbine	104
5.4	RESULTS WITH PARALLEL AC/HVDC TRANSMISSION LINK	105
5.4.1	Two Area System with Reheat Turbines	106
5.4.2	Two Area System with one Reheat and one Hydro Turbine	108
5.5	SUMMARY	109

<b>CHAPTER 6: SIMULATION RESULTS AND ANALYSIS-</b>	
<b>THREE AREA SYSTEMS</b>	110
6.1    INTRODUCTION	110
6.2    THREE AREA SYSTEM WITH NON-REHEAT TURBINES	111
6.3    THREE AREA WITH NON-REHEAT TURBINES AND DIFFERENT PARAMETERS	115
6.4    THREE AREA WITH REHEAT TURBINES AND GRC	116
6.5    THREE AREA WITH TWO NON-REHEAT TURBINES AND ONE HYDRO TURBINE	125
6.6    THREE AREA WITH A NON-REHEAT, A REHEAT AND A HYDRO TURBINE	126
6.7    SUMMARY	128
<b>CHAPTER 7: CONCLUSIONS AND SCOPE FOR FUTURE WORK</b>	129
7.1    CONTRIBUTIONS AND CONCLUSIONS	129
7.2    SCOPE FOR FUTURE WORK	133
<b>REFERENCES</b>	134
<b>APPENDIX A</b>	151
<b>APPENDIX B</b>	152
<b>LIST OF PUBLICATIONS</b>	153
<b>BRIEF BIOGRAPHY OF THE CANDIDATE</b>	154
<b>BRIEF BIOGRAPHY OF THE SUPERVISOR</b>	155