

CONTENTS

ENDORSEMENT PAGE	ii
PAGE OF DEDICATION	iii
STATEMENT	iv
PREFACE	v
ABSTRACT	vii
INTISARI	ix
CONTENTS	x
LIST OF FIGURES	xiii
LIST OF TABLES	xvi
CHAPTER I Introduction	1
1.1 Research Background	1
1.2 Problem Statement	3
1.3 Research Objective	3
1.4 Research Constraint	3
1.5 Research Benefit	3
1.6 Research Novelty	3
1.7 Thesis Organization	4
CHAPTER II Literature Review and Theoretical Framework	8
2.1 Literature Review	8
2.1.1 Mathematical Model of Synchronous Generator	8
2.1.2 Lyapunov-Stability-based Controller Design	8
2.2 Theoretical Framework	9
2.2.1 Lyapunov-based Stability Analysis	9
CHAPTER III Research Methodology	16
3.1 Materials and Tools	16
3.2 Research Process	16
3.3 System Design	16
3.3.1 Internal Dynamic Modeling Of Synchronous Generator	16
3.3.1.1 Park's Transformation	19
3.3.1.2 Electrical Dynamics	20
3.3.1.3 Mechanical Dynamics	30
3.3.1.4 General State Space of Synchronous Generator	31
3.3.2 Single Machine Infinite Bus (SMIB) Modeling	32
3.3.3 Stability Analysis of Open Loop System	38
3.3.4 Input-to-State Stability	46
3.3.5 Input-Output Stability	48
3.3.6 Controller Design	51
3.3.6.1 Controller Type 1	51
3.3.6.2 Background of Choosing Controller Type 2	54
3.3.6.3 Controller Type 2	57
3.3.7 Internal Dynamics Stability	57
3.3.7.1 Stability of Internal Dynamics as Linear Time-Varying System	58

3.3.7.2	Stability of Internal Dynamics when ω_e is in Steady State	61
3.3.7.3	Stability of Zero Dynamics.....	64
3.4	Analysis Method	66
CHAPTER IV	Results and Analysis.....	68
4.1	Fourth order system for $\omega_{ed} = 60\pi \text{ rad/s}$, $V_{td} = 220\sqrt{3} \text{ V}$, $T_s = 10^{-4} \text{ s}$...	69
4.1.1	RL-const-TR Configuration	69
4.1.2	RL-const-SS Configuration	70
4.1.3	RL-vary-TR Configuration	72
4.1.4	RL-vary-SS Configuration	74
4.1.5	SMIB-TR Configuration	77
4.1.6	SMIB-SS Configuration	78
4.2	Sixth order system for $\omega_{ed} = 60\pi \text{ rad/s}$, $V_{td} = 220\sqrt{3} \text{ V}$, $T_s = 10^{-4} \text{ s}$	80
4.2.1	RL-const-TR Configuration	80
4.2.2	RL-const-SS Configuration	82
4.2.3	RL-vary-TR Configuration	83
4.2.4	RL-vary-SS Configuration	85
4.2.5	SMIB-TR Configuration	89
4.2.6	SMIB-SS Configuration	91
4.3	Instability condition for $\omega_{ed} > 60\pi \text{ rad/s}$ with $T_s = 10^{-4} \text{ s}$	92
4.3.1	Fourth Order System	92
4.3.2	Sixth Order System	94
4.4	Sixth order system for $\omega_{ed} = 120\pi \text{ rad/s}$, $V_{td} = 220\sqrt{3} \text{ V}$, $T_s = 10^{-5} \text{ s}$...	95
4.4.1	RL-const-TR Configuration	95
4.4.2	RL-const-SS Configuration	97
4.4.3	RL-vary-TR Configuration	99
4.4.4	RL-vary-SS Configuration	101
4.4.5	SMIB-TR Configuration	105
4.4.6	SMIB-SS Configuration	107
4.5	Sixth order system for $\omega_{ed} = 120\pi \text{ rad/s}$, $V_{td} = 10\sqrt{3} \text{ MV}$, $T_s = 10^{-5} \text{ s}$..	108
CHAPTER V	Conclusion and Future Work	111
5.1	Conclusion	111
5.2	Future Work	112
REFERENCES	113
APPENDIX	L-1
L.1	Computing $T_p \frac{dT_p^{-1}}{dt}$	L-1
L.2	Computing vector in Equation	L-3
L.3	Computing $T_p L_{11} T_p^T$	L-5
L.4	Computing $T_p L_{12}$	L-10
L.5	Python Code for Sixth Order Synchronous Generator's Internal Dynamics Parameters	L-12
L.6	Python Code for Parameters of SMIB System of Sixth Order Synchronous Generator	L-15
L.7	Python Code for Fourth Order Synchronous Generator's Internal Dynamics Parameters	L-18
L.8	Python Code for Parameters of SMIB System of Fourth Order Synchronous Generator	L-19

L.9	Python Code for Closed Loop System of Fourth Order Synchronous Generator	L-20
L.10	Python Code for Closed Loop System of Sixth Order Synchronous Generator	L-26
L.11	Python Code for JSON Reader of Recorded Simulated Closed Loop System of Fourth Order Synchronous Generator	L-32
L.12	Python Code for JSON Reader of Recorded Simulated Closed Loop System of Sixth Order Synchronous Generator	L-33