

## **Contents**

List of Figures.....	3
List of tables.....	5
List of abbreviations.....	6
Nomenclature.....	8
Abstract.....	9
CHAPTER 1 INTRODUCTION.....	10
1. 1 Introduction to Power Window System.....	10
1. 2 Electronic Control Unit.....	16
1. 3 Functions and ECUs Per Vehicle.....	17
1. 4 Types of ECU.....	18
1. 5 ECU Design Concept.....	18
1. 6 Research Motivation.....	19
1. 7 System Requirement.....	20
1. 8 Thesis Outline.....	21
CHAPTER 2 LITERATURE REVIEW.....	23
2. 1 Detailed Literature Survey.....	23
2. 2 Literature Review Summary.....	32
2. 3 Research Gaps.....	33
2. 4 Problem Statement.....	34
2. 5 Objectives.....	34
CHAPTER 3 SYSTEM DESCRIPTION.....	35
3. 1 Power Window.....	35
3. 2 Linear Motor Model.....	37

3.3	Gear Train Model .....	41
3.4	Control System.....	42
3.5	Hardware in Loop (HIL) Simulation.....	44
3.6	Test Bench System .....	50
CHAPTER 4 METHODOLOGY AND SYSTEM DESIGN .....		52
4.1	DC Motor Model.....	52
4.2	MATLAB/Simulink Model.....	55
4.3	Software in Loop Testing.....	58
4.4	Sensor Calibration Model.....	59
4.5	Flexi force Sensor Calibration Model .....	64
4.6	Algorithm For Obstacle Detection .....	66
CHAPTER 5 RESULTS AND DISCUSSION.....		69
5.1	Calibration.....	69
5.2	Software In The Loop Testing .....	77
5.3	Decision Tree Algorithm.....	80
5.4	Hardware in Loop.....	82
5.5	Experimental Setup .....	84
CHAPTER 6 CONCLUSION AND FUTURE SCOPE.....		89
6.1	Conclusion.....	89
6.2	Future Scope.....	91
References.....		92