CHAPTER 1 INTRODUCTION

1.1 Introduction

Motors & Drives are used in Electro mechanical plant in modern Industries such as Automotive, Aerospace, Industrial Automation Equipment and Instrumentation. Direct current motors & A.C. Induction Motors are very commonly used as variable speed drives in applications like actuators for motion control, robot arms, conveyor belts, dc switching converters, process control systems, electrolytic process, welding processes. Variable speed motors & drives require wide speed range and fast torque response in presence of load variation, parameter variation and un-modeled dynamics. This encourages use of advanced control methods for the design & development of controller. Controller can be designed for current control, speed control, position control, Torque control, sensor and sensor less control of electric motors & drives [5-7].Different control techniques of Induction motor drives includes scalar control, vector or field oriented control, direct torque and flux control and adaptive control. Scalar control is comparatively easy to implement but the inherent coupling effect of torque and flux results in slow output response time and prone to instability of the control system. The scalar V/f method fails to provide real time control in transient condition. Vector control technique controls amplitude and the phase of ac excitation voltage. Vector or field oriented control solves the problems of scalar control as in this approach induction motor can be controlled like a separately excited dc motor [1, 8]. Vector control approach along with signal processing is more complex in practical implementation so it encourages the use real time processor with powerful controller like DSP. Vector control methods can be classified as direct or feedback method and indirect or feed forward method. From the practical implementation point of view indirect method is easy to implement. Vector controlled Induction motors replaces use of dc motors in industrial applications.

Classical controller design techniques are normally used for linear time invariant control system design. Ideally vector controlled ac drive can be considered linear but controller cannot be designed using classical controller design techniques as load variation, parameter variation exist in the real time system. For Non linear control system with plant parameter variation, adaptive control system design techniques are more effective. Adaptive Control Techniques can be classified as self tuning control, MRAC, Sliding mode or variable structure control, Expert System control, Fuzzy logic

Control, Neural network Control [1]. The limited use of Self tuning control technique as it poses with non availability of unique mathematical model, computational complexity and corresponding time delay for online updating parameters of the controller. In MRAC control technique with fixed machine converter power rating, the drive will fail to meet the desired acceleration deceleration profile with increase in actual inertia then the maximum inertia. If actual inertia is less than maximum inertia, results in suboptimal transient response. Chattering is also problem in MRAC.

One of the popular robust adaptive control techniques for control of motors & drives is sliding mode control or Variable structure control (VSC). It gives optimum control performance of a drives or motors in presence of parameter variation and load torque disturbance. SMC is non linear and can be applied to a linear or non linear plant. The variable structure system with sliding modes is the recent research domain in control of servo drives with dc motors, induction motors and synchronous motors for the speed control and position control applications. SMC can also be used for power converter control and also for drive regulation [2, 3, 4].

1.2 State of Art

Controller design approach integrates variable structure control (VSC)- direct torque control (DTC) with Space Vector modulation(SVM) & Sliding Mode Observer(SMO) to ensure high performance of induction motor drive under steady state and transient condition. VSC-DTC and conventional DTC control approaches were compared for low speed operation. Experiments performed using hardware ADSP 21062 & ADMCF328 DSP Motor Controller [9, 11, 26, 27]. Robust decoupling mechanism and Total Sliding Mode Controller implemented using direct rotor field oriented control (DRFO) approach for Induction motor rotor speed control. The angle of rotor flux estimated using sliding mode current estimator. The control algorithm designed for current-controlled pulse width modulation voltage-source inverter (PWM VSI) implemented by an intelligent-power-module (IPM) switching component (PM50RSA060) along with servo control card with a switching frequency of 15 kHz [10]. Continuous sliding mode control algorithm based on current and flux observer developed for sensor less speed control of induction motor using indirect field oriented control approach. This estimation algorithm tested for high & law amplitude trapezoidal speed references [11]. In paper [12] controller designed using discretized current control approach along with continuous sliding mode and the Lyapunov design technique for PWM generation. Experiment results were obtained using DSP TMS320C32 and PWM unit with FPGA. In paper [13] two Sliding mode MRAS based observers designed for speed control of Induction motor. Sliding mode control algorithms based on observers implemented using DSP TMS320F2407PGEA.The controller software implemented using two interrupts, one for feedback signals and another to regulate the rotor speed through PWM commands. In this design speed is estimated using Low pass filter or by algebraic equations of the system. In paper [14] sensor less direct field oriented control of three phase induction motor for washing machine application presented with sliding mode flux observer, sliding mode speed regulator and rotor speed estimator applied to washing machine speed profile. This system consist of observers, sliding mode speed controllers, PI based current regulators and PWM generators and implemented using DSP Controller. In paper [15] proposes the strategy to obtain more accuracy of SVPWM-VSI output voltage by the variation of dc link converter voltage for low speed applications. This paper [16] presents fuzzy sliding mode control using adaptive tuning technique of induction motor position control. It also shows the effectiveness of fuzzy technique to remove the chattering problem of SMC based controller design for indirect field oriented control approach. The proposed adaptive fuzzy sliding mode control algorithm realized with the current controlled PWM VSI, IPM switching component (PM50RSA060) and TMS320C31 DSP module. In paper [17] hybrid proportional + fuzzy PI controller designed for indirect vector control of Induction motor and real system designed and implemented using DS 1103 board, PLC, FPGA. In paper [18] proposes sensor less sliding mode speed controller design and its robustness tested on experimental set up located at IRCCyN (Nantes, France). In papers [19, 22] adaptive switching gain incorporated with control law of sliding mode controller design and implemented using PWM based inverter control approach to track the speed resulted in less high frequency chattering. In paper [20] presents superior performance of dual component sliding mode controller compare to single component and fixed parameter controller design approach with indirect field oriented control of induction motor. In paper [21] controller is designed combining Field Oriented Control (FOC) method with sliding mode control method with output feedback for current fed Induction motor drives and experimental results obtained & validated on control benchmark experimental setup. In papers [23-25, 32] design & performance comparison of different sliding surfaces based on simulation study were discussed. Classical sliding mode controller, integration surface based sliding mode controller and fuzzy logic based sliding mode controller were designed and simulation study carried out, which shows fuzzy logic based sliding mode controller had faster and robust speed response and batter overall performance. In paper [28] FPGA based predictive sliding mode speed controller design and implemented using three phase inverter. This paper [29] presents adaptive dynamic sliding mode controller with recurrent redial basis function network observer design for indirect field oriented control of induction motor. Control algorithms implemented and results obtained using control board dSPACE DS1102 based on TMS320C31 and TMS320P14 DSPs and current regulated PWM VSI.

This paper [30] presents sliding mode direct torque control method of induction motor, chattering is reduced using sign function with continuous approximation. This paper [31] describes real time implementation of discrete Neural network base sliding mode control algorithm for Induction motor position control system using dSPACE DS1104 board.

1.3 Scope of the Thesis

Aim of proposed research work is to design & implementation of control algorithms with SMC approaches to solve the control problem with use of soft techniques. The features and discussion of research carried out in the thesis includes:

- Design & Implement sliding mode control algorithm using multi-rate output feedback approach [34]
- Design & simulation of Multi segment Sliding Mode controller of Induction motor drive and intelligent controller as fuzzy logic controller [36]
- Signal processing based Implementation of Multi segment sliding mode controller for Induction motor drive
- Design & simulation of Pulse Width Modulation (PWM) base control algorithm for Induction motor drive system.
- Digital signal processor based Pulse Width Modulation (PWM) drive signal generation of three phase voltage source inverter for motors & drives [35]
- Design, simulation & Implementation of Sine Pulse Width Modulation (SPWM) based control algorithm for Induction motor drive.
- Design & implementation of close loop control algorithm for induction motor drive with PWM & SPWM approach using Digital Signal Processer (DSP)

1.4 Thesis Organization

The present Chapter: 1 provides an overview and the context for the remainder of the thesis. It also gives the motivation & objective of the research work related to controller design for motors & drives.

Chapter: 2 presents, a conventional vector control, scalar control approaches for controller design. It also discusses the prevailing controller design approaches and the modifications suggested by researchers for different control applications. It also describes the survey of recent trends in control of motors & drives. This section gives overview & theoretical back ground of variable structure systems, continuous time sliding mode control, equivalent control & reaching law approach, discrete time sliding mode control and concept of multi rate output feedback based discrete time sliding mode control technique for controller design. This chapter also presents design and development of Multi rate output feedback (MROF) based controller design.

Chapter:3.This chapter reviews & discuses existing close loop system design approaches and the modifications suggested by the researchers for motors & drives systems. It also describes simulation study carried out by different controllers for motors & drives. It also presents design and implementation of various control techniques using signal processing algorithms. This chapter also presents design and development of multi segment sliding mode control (MSMC) based controller design

Chapter:4 This chapter reviews & discusses the control techniques and its hardware implementation using DSP controllers by different Pulse width modulation approaches. It contains design methodology for real time control pulse generation. It also describes in detail the real time control pulse generation with PWM & SPWM approach using MATLAB simulink & Digital Signal Processor (DSP) TMS 320F28335 for three phase Inverter fed ac motor drives.

Chapter: 5 This chapter discusses & gives overview of implementation of various controller techniques. It also presents step by step procedure for controller implementation using Hardware in Loop technique. The designed controllers implemented using hardware emulation.

Chapter: 6 presents discussion on results and summarizing the contribution of research work carried out by author. The limitations and assumptions are also described in this chapter. Directions for future research work are suggested.