

VLSI based Induction Motor Speed Control Using Auto Tune PID Controller

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Abstract

This is the review work for VLSI based Induction Motor Speed Control using Auto Tune PID controller. The present paper suggested stand alone control device for industrial induction motor speed control. PID tuning is proposed using successive approximation method with hardware and software approach. The interdependency of two approaches certainly makes precise controlling of various rated induction motor.

Keywords

Induction Motor, PID Controller, PID Tuning, Successive Approximation Method, Very Large Scale Integration

I. Introduction

Today, advances in science and technology leads the researchers to think on optimized and precise solution of problems. In this regard, control system problems have been attracted to many researchers to control a system for desired outcome. The desired output is known as Set Point (SP) and the system output is known as Process Value (PV). On line, PV is continuously monitored by controller to achieve the desired output. The performance of control action depends on system dynamics and nature of controller. However, many types of controller are suggested in the literature. So it is very difficult to select appropriate controller for the given system. Various controllers are suggested like ON-OFF, Proportional (P), Proportional Integral (PI), Proportional Integral Derivative (PID), fuzzy, and neural network controller. ON-OFF controller is very simple and easy to implement whereas, the fuzzy and neural network based controllers are complicated in nature. Neural network based controllers require more time for training. PID controller is most popular in industry. In this proposed work PID controller is selected in order to control the speed of Induction Motor (IM). PID controller has shown very good performance when the PID controller tuned properly. The various techniques are available to tune the PID. In this proposed work auto tuning of PID controller is suggested using Successive Approximation Method (SAM) [1].

Speed control of IM can be done using techniques like V to F ratio control, Frequency control, and vector control [2]. Among all, V/F ratio control is most popular. The vector control consists of three PID controllers for control action. IM has quite complicated system dynamics and rigorous to find out relation between current and speed of IM.

IM is working on the principle of transformer action and so that it is also called as rotating transformer, hence the flux developed due to supply current plays very important role to demine the behaviour of IM. Magnetic field which is produced in IM, affects the overall performance of IM and due to this the speed control of IM becomes a bit complicated. The speed control of IM is suggested using auto tune PID controller in order to have smooth control action.

Advent in the field of semiconductor technology and Integrated Circuit (IC) fabrication gives the sophisticated embedded solutions of many industrial and non-industrial problems. Millions of active and passive devices can be fabricated on single silicon chip and

it is possible due to the recent developments in IC technology. Very Large Scale Integration (VLSI) is now able to provide single embedded solution of the IM speed control. VLSI based IM control auto tune PID controller will acts as handheld controlling tools. Next section reviews the work done by researchers in the field of auto tune PID and VLSI implementation of PID controller.

II. An Overview of Related Survey

In the history of PID tuning, Ziegler Nicholas was first who was given optimum settings of PID controller. Step response and frequency response methods were introduced by Ziegler and Nicholas. In step response method, step response of system is calculated and plotted on graph. The point where the slope of the step response has its maximum value is first determined, and the tangent at this point is drawn. The intersections between the tangent and the coordinate axis give the parameters $_a'$ and $_L'$. The PID constants are then obtained from $_a'$ and $_L'$ parameters [3]. In frequency response method, ultimate gain and period is calculated using closed loop response of system, and then the PID constants are calculated using the recommendations. The settings given by Ziegler Nicholas are improper when the system has large transport delay. The Cohen conon method is suitable for the systems having large transport delay. Hence for delayed systems Cohen conon recommendations are used [4].

The Internal Model Control (IMC) PID tuning rule has one user-defined tuning parameter that is directly related to the closed-loop time constant. The IMC-PID controller provides a good set-point tracking but a sluggish disturbance response for the process with a small time- delay [5-6].

In relay auto tuning the controller is replaced by a relay to find out ultimate gain and frequency. The PID constants are then calculated using ultimate gain and frequency. The kappa-tau method is a PID design method developed by Astrom and Hagglund [5-6]. The method is developed based on dominant pole design with criterion on therejection of load disturbance and constraints on the maximum sensitivity (M_s). The relations between the normalized controller parameters and the normalized process parameters are calculated and plotted for a batch of different processes.

In advanced type tuning method, fuzzy logic based PID tuner is implemented to find optimum values of PID constants. Genetic Algorithm (GA) is used for tuning of PID controller [7-8]. Where the three strings assigned to each member of the population, these members will be comprised of a P, I and a D string that will be evaluated throughout the GA processes. An objective function could be created to find a PID controller that gives the smallest overshoot, fastest rise time or quickest settling time. Each of chromosomes in the population is passed into the objective function once at a time and the chromosome is evaluated and assigned a number to represent its fitness. The chromosomes fitness value is used to create a new population consisting of the fittest members. Thus at the every time passes through the Genetic Algorithm selects the optimum settings of PID controller for greater control action.

In correlation auto tuning, the Pseudo Random Binary Sequence (PRBS) signal is used [9]. This signal is given to set point and accordingly measures perturbation in measured value. The Fast

Fourier Transform (FFT) is used to transform into the frequency response, the output of FFT is dependent on current PID parameters. This gives the ultimate gain and frequency. The PID parameters are calculated using Ziegler Nichols method.

Numerical approach is used for the tuning of PID controller. The SAM is used to tune the PID controller [1]. The work was done using microcontroller platform with the application program running on windows platform and developed by using visual basic 2005 express edition. The experimental arrangement requires a separate personal computer used for the experimentation, hence to develop a stand-alone application running without the support of personal computer VLSI approach should prefer.

A VLSI chip realization concern with required total area for the realization of digital hardware is very small. The required area is the functions of the number of Multiply Accumulate Cells (MAC), memory cells (registers) and signal routing. Design is aimed to use the available hardware resources efficiently.

Md. Shabiul Islam and other describe the designing of PID-type controller based on Fuzzy algorithm using VHDL to use in transportation cruising system [10]. The cruising system with Fuzzy concept has been developed to avoid the collisions between vehicles on the road. The developed Fuzzy Logic Controller (FLC) provides a reference for controlling the vehicle speed either increase or decrease.

The behavioral of the PID-type FLC algorithm is simulated using VHDL language. The developed and designed Fuzzy based PID-type cruising controller is cheaper in cost compare to conventional PID controller system.

Burton B. and other suggested an Artificial neural networks (ANNs) can be trained continually on-line to identify an inverter-fed induction motor and controlling its stator currents [11]. The time to complete one training cycle is extremely small. In this work proposed and evaluated a new form of the Random Weight Change (RWC) algorithm, which is based on the method of random search for the error surface gradient. A VLSI implementation completes one training cycle in 8 μ s.

Da Zhang, Hui Li proposed a single FPGA to implement the field-oriented control of induction motor drive based on stochastic theory and neural network algorithm [12]. A stochastic neural network structure is proposed for a feed forward neural network to estimate the feedback signals in an induction motor drive. A new stochastic PI speed controller is developed with anti-windup function to improve the speed control performance. By applying the stochastic theory and neural network structure, the proposed algorithms enhance the arithmetic operations of the FPGA, save digital resources, simplify the algorithms, significantly reduce the cost and provide design flexibility and extra fault tolerance for the system.

FPGA can program to control IM using ANN and stochastic method. Very little attention was given for FPGA implementation of IM speed control.

By developing FPGA chip for IM speed control, it will reduce the complicated hardware, overall cost and become more flexible. The auto tune PID controller can be implemented to control the speed of IM.

IM speed control is vital problem in the industrial and non industrial areas, where the precise control of IM is needed. The various methods were developed which requires hardware and software platform. The methods are complicated and not economical for the small applications. The stand alone solution of the speed control of IM is the demand of new technology. In this present work, the speed control of IM is suggested using VLSI approach.

PID control is used for speed control of IM. The PID control algorithm is simple to implement. Performance of PID controller is good after tuned properly. The various tuning methods are available for tuning of the PID controller. The recent tuning method is successive approximation method. In this proposed work tuning of PID is achieved using successive approximation method.

The stand alone solution for IM speed controller is useful in small as well as complicated applications. The present module will be the first module of this kind where the controller is having auto tuning feature. The present module is useful for all types and ratings of IM and hence not necessary to design the controller for every ratings of IM.

III. The Methodology of the Proposed Research

Fig. 1 shows the basic outline for the proposed work consists of various blocks that are field programmable gate array (FPGA) a VLSI based hardware, IM drive, IM, speed sensor and signal conditioning, analog to digital converter, keyboard, and display. FPGA is the development solution for realization of digital hardware. The Hardware Description Language (HDL) is programmed language for realization of digital hardware. The Verilog Hardware Description Language (VHDL) is developed by verilog and popularly used by developers and researchers. The binary image is burning in to FPGA and real time monitoring is possible of realized hardware. In this proposed work, the PID algorithm, and auto tune SAM algorithm is proposed to implement using VLSI for speed control of IM. Speed of IM is obtained using suitable speed sensor. IM drive is designed based on selected IM ratings and properties. The keyboard and display is used for data or command entry and display of PV and SP.

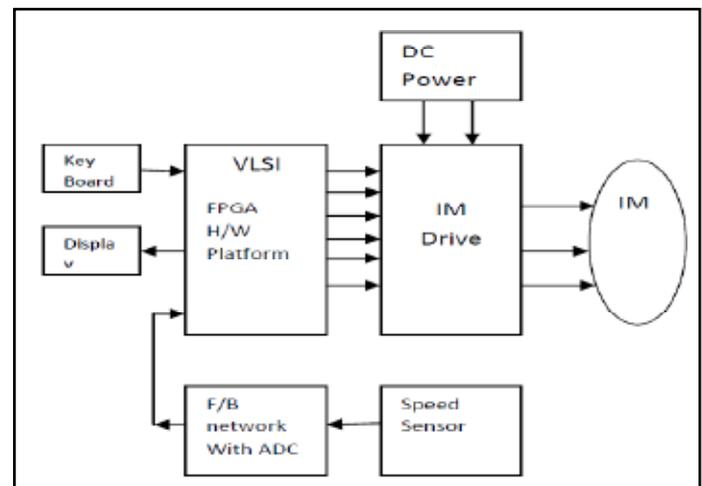


Fig. 1: Block Diagram of Proposed Work

A. Algorithm of Proposed Work

1. Start
2. default SP is 255
3. if key press detected then call keyboard algorithm
4. Calculating error, $e = SP - PV$
5. If auto tune is not done then Call auto tune algorithm
6. Call PID algorithm
7. Display SP and PV
8. Go to step 3

B. Keyboard Algorithm

1. Wait until key release
2. Read key code
3. Store key code in memory

4. Increment key code pointer
5. Convert key code into ASCII and display
6. Is exit key detected then return from subroutine
7. Wait for key press

C. Auto Tune Algorithm

1. Read the previous value of KP, KI, KD
2. Use SAM for calculation of KP, KI, and KD
3. Store PID parameters in the memory
4. Return from subroutine

D. PID Algorithm

1. Read the value of error, KP, KI, and KD from memory
2. Calculate PID output using PID equation
3. If output is greater than saturation value then output is saturation value and reset the integral action
4. If output is less than zero then output is zero
5. Return from subroutine

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