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Speed Control of Induction Motor by V/F Method

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ABSTRACT
This paper presents the design & implementation of voltage & frequency ratio constant & controller based on sinusoidal pulse width modulation technique for a single phase induction motor using fuzzy logic. The work involves implementation of an closed loop control scheme for an induction motor. The technique is used extensively in the industry as it provides the accuracy required at minimal cost. V/f controlled motors fall under the category of variable voltage variable frequency drives. The ratio of voltage & frequency must be constant.
Keywords: Fuzzy controller, induction motor, real time system.

I. INTRODUCTION

Nowadays electric power plays a major role in the increasing needs of the basic human life. Induction motor is used in many application like industry, company, irrigation because of its low maintenance & efficiency.

Many methods are used for the speed control of the induction motor. The speed control of induction motor is the main issue achieves maximum torque & efficiency. Scalar control presents a simple structure characterized by low steady-state error. Therefore, the constant voltage–frequency (*V/f*) scalar control system is there due to its wide application in industrial fields Proportional–integral (PI) control methodology is commonly applied in constant *V/f* control strategy for induction motors. However, in addition to the fact that a mathematical model is desirable for a systematic controller design with conventional methods, conversely, fuzzy-based control methodology has the ability to cope with system nonlinearity, and its control performance is less affected by system parameter variations. Moreover, fuzzy techniques utilize a linguistic rule base that is designed by taking advantage of system qualitative aspects and expert knowledge. Generally, an embedded system may be implemented in microcontroller and digital signal processor (DSP), or in field programmable gate array (FPGA). An integrated circuit dedicated to a particular application can also be used.

Another fully embedded fuzzy system was applied in order to adjust the PI parameters of a direct torque control of the induction motor. In hardware solution for an embedded neural network with a proportional-integral-derivative (PID) controller is also presented.

The speed control can be performed using open loop algorithms or closed loop algorithms. The most commonly used open loop algorithm is voltage/ frequency control methods. Closed loop algorithms include sensor & sensor less feedback using scalar or vector control. The main advantage of v/f control is its simplicity & for this reason it has been traditionally implemented using low cost microcontrollers.

II. RELEVANCE

Speed control of induction motor this is because now a day's many manufacturing industries requires motor for their works process so, speed control of motor is necessary. To achieve that an efficient method is necessary this gives benefits like, energy savings as well as cost effective etc.

Due to flux saturation problems with induction motors with voltage applied to the motor must alter with the frequency. The v/f induction motor drives with inverters are widely used in no. of industrial application leading not only to energy saving but also to improvement in productivity & quality. There are many different way to speed control of induction motor by v/f method. Microcontroller based, DSP based speed control of induction motor, FPGA based, Fuzzy logic based speed control of induction motor using v/f method, neural network based, Adaptive control based methods are also used. Proposed work is intended to achieve good performance by above several methods to speed control of induction motor. In connection to the study topic the following literature has been studied

III. LITERATURE REVIEW

There is many several methods for the speed control of induction motor by v/f method. Method suggested by Roufin Mahmood & Habibur Rehman based on square wave & sine triangle inverter. These two techniques are used for the controlling the inverter below & above base speed for high speed control of induction machine. Square wave inverter is that only the frequency of the output voltage can be

controlled & not the magnitude. Square wave inverter at low frequency is that if volt per hertz speed control is used, it becomes difficult to control the voltage level for maintaining a constant flux operation below the base speed. Therefore, this paper designs a speed controller with a hybrid approach in which a Sine Triangle Pulse Width Modulated (SPWM) inverter is used below the base speed and a square wave inverter is employed above the base speed.[1] Mineo Tsuji, Shinichi Hamasaki present a new simplified v/f control system of induction motor for precise speed operation which is based on the vector control theory. A linear model is derived for analyzing the system stability, including the influences of motor operating states in motoring and regenerating operations, and parameter variation of low pass filter. Stator resistance identification is proposed by using *d* axis current**. [**2**]** Method suggested by Y. Sangsefidi, and A. Shoulaie method needs neither mechanical sensor nor current transducers, so it can be compared with "Variable Voltage Variable Frequency (v/f)" method. High-speed operation of induction motor controlled by this method & it is compared with that of v/f method that leads to the fact that in addition to control of motor dynamic behavior, in this method uses DC-link voltage in a more efficient way. In the stator flux modulus control, the amplitude of electromagnetic torque ripple and average switching frequency are computable and analytical formulas for calculation of them are derived. [3] The suggested methods are the compact embedded fuzzy system for three phase induction motor scalar speed control. The control strategy consists in keeping constant the voltage-frequency ratio of the induction motor supply source. A fuzzy control system is built on a digital signal processor which uses speed error & speed error variation to change both the fundamental voltage amplitude & frequency of a sinusoidal pulse width modulation inverter.[4] Krishna Chandran Vinay and S. Moorthi presents the design and implementation of a Variable-Voltage Variable-Frequency (VVVF) Controller based on Sinusoidal Pulse Width Modulation (SPWM) Technique for a 3 Phase Induction Motor using a Field Programmable Gate Array (FPGA). The ratio of Voltage to frequency must be held constant. For Variable Voltage Variable Frequency (VVVF) drives, there is a need to control the fundamental voltage of the inverter if its frequency (and therefore the frequency of the induction motor), need to be varied. To vary the fundamental component of the inverter, the Modulation Index of the carrier signal has to be changed. The speed at rated supply frequency is normally used as the base speed. At frequencies below the base speed, the supply magnitude needs to be reduced so as to maintain a constant Volt/Hertz. The FPGA controller is used to generate SPWM pulses based on the frequency input, that are used to control the inverter. The VVVF output of the inverter can be used as supply to a three phase induction motor and thereby speed of the motor can be controlled.[5] Method suggested by M. Harsha Vardhan Reddy V.Jegathesan Space Vector Pulse Width Modulation (SVPWM) has become the successful techniques to construct three phase sine wave Voltage Source Inverter (VSI) parallel to control three-phase induction motor using v/f control. VSI fed induction motor produces a pulsating torque due to the application of non sinusoidal voltages. In this method 3 phase voltage source inverter produces eight switching states comprising two zero states & six active states. the torque ripples of induction motor is reduced by hybrid PWM technique. The different space vector based sequences used to generate the switching pulse for hybrid PWM.The implementation of SVPWM technique with other sequence carried out by taking one zero vector instead of two zero vectors as in convectional SVPWM. The applied voltage vector equals the reference voltage vector only in an average sense over the given sub cycle, and not in an instantaneous fashion. The difference between the reference vector and the instantaneous applied voltage vector is the instantaneous error voltage vector. The time integral of the error voltage vector, referred to as 'stator flux ripple vector', is a measure of the ripple in the line current of the converter. In the open loop system the frequency is taken as input to V/f control for all voltage conversion and pulse generation. The sub systems of open loop control are coding for pulse generation, inverter modeling and induction motor modeling.[6]

Vijay Babu Koreboina, A. B. Raju,presents VSI fed 3-phase induction motor drive system with constant 'v/f' control method is modeled, simulated and is implemented using PC and an add-on card, The actual speed of the induction motor is sensed and is compared with the reference speed. The error so obtained is processed in a Proportional Integral (PI) controller and its output sets the inverter frequency as well as the modulation index. In order to simulate the drive system using Scilab/Scicos, it is required to model the various components of the system in terms of their mathematical equations.[7]

Guohai Liu, Xiao Xiao, Yan Jiang, Yue Shen presents 2 methods are combined for speed control of the induction motor in v/f mode. These two methods are neural network inverse system &internal model control. AC variable frequency speed control system working on the condition of constant proportion of voltage to frequency (v/f), a modified internal model control combined with the method of neural network generalized inverse system On the basis of reversibility analysis of original system, the generalized inverse model approximated by the dynamical BP neural network was cascaded with the original system. Then the robust stability can be

improved by introducing modified internal model control to generalized pseudo-linear system.[8]

Prof. J. G. Chaudhari Dr. M.V. Aware present a (intelligent power module) IPM module which is the three diode bridge rectifier with capacitors is provided which gives the rectified DC voltage to IGBT based IPM. The DSP PWM testing unit is used to verify programs based on Micro-2407 trainer. In this program for fixed PWM, which can be executed in the Micro-2407 DSP trainer and its output waveforms with load can be observed using this testing Unit. The DSP is programmed to generate the pulse width modulated signal of 5 KHz with 20% of duty cycle, with micro-2407 trainer. The generation of PWM can be verified by using an oscilloscope.[9]

Xiang-Dong Sun, Kang-Hoon Koh, presents a Fuzzy-logic-based *V/f* control of the induction motor is proposed for the speed sensorless power-leveling system. The flywheel power leveling system using fuzzy logic speed picking-up & fuzzy logic PI regulator is used.[10] K. Sandeep kumar, K. Pritam satsangi presents deals with variable speed drives of induction motor for constant torque using V/F ratio method. The above system is designed with closed loop where the actual speed of motor is compared with the reference speed. The difference in the speed is adjusted by changing firing angles of switching devices and there by obtaining variable speeds. As the motor is running, the microcontroller 89C54 reads the speed value, voltage and frequency set by the user, at the same time, the speed sensor circuit obtains actual speed through speed sensor and accordingly variation required in voltage and frequency are made through respective switches.[11]

Method suggested by Md. Nurul Islam and M. Bashir Uddin the control strategy can be implemented by scalar control and vector control.in closed loop speed control the speed loop error signal controls the PWM inverter frequency & voltage of a VSI fed induction machine. A fuzzy controller is used which can directly map the change of speed to the change of frequency & change of modulation index. One algorithm is used for determine the switching points of 3 phase inverter. Numerical solution of differential equation to estimate flux in scalar control with flux loop. [12]

IV. SCOPE

There are several methods to control the speed of induction motor but still v/f method is a challenging task in order to obtain better accuracy so, keeping in view a robust system so here main objective is to fuzzy logic based speed control of induction motor by v/f method

So the proposed work is to develop & implement:

1. To control the speed of induction motor by v/f method.
2. To improve the efficiency of entire system.
3. Performance improvement included accuracy, robustness & with energy saving system.

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