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TO MONITOR AND CONTROL OF VFD USING A FUZZY PID CONTROLLER

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Abstract- This paper presents the Variable Frequency Drive (VFD) varies the frequency of the input power to the motor hereby controlling the speed of the motor. AC voltage input is applied to bridge diode rectifiers that produce a dc output which is then given to the inverter section. The inverter section consists of PWM inverters using IGBTs. SVPWM signals is the train of pulses with fixed magnitude and frequency and a varying pulse width. The output of the PWM inverter is given to the 3 Phase Induction Motor. VFD converts a fixed frequency, fixed voltage sine wave power to a variable frequency, variable output voltage used to regulate the speed of the induction motor. PWM controlling scheme is based on Voltage source inverter type space vector pulse width modulation (SVPWM) and the Conventional-PID controller or Fuzzy-PID controller is employed in closed-loop speed control. It provides better control of motor torque with high dynamic performance. The simulated design is tested using various toolboxes in MATLAB. Simulation results of both controllers are presented for comparison.
Keywords: Space Vector Pulse Width Modulation (SVPWM), PID Controller, Fuzzy Logic Controller (FLC), Indirect Motor (IM), VFD, PWM inverter, bridge diode rectifiers.

1. INTRODUCTION

The monitoring and control of VFD is controlled using Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA). The system also provides Human-Machine Interface so that the entire process can be monitored by human operator [2]. The inverter is used to provide unipolar or bipolar output voltage switching in seven different switching states. Hence the name seven-level inverter. PWM modulation is used to generate the PWM switching signal[4-6]. The control of induction motor by VFD and PLC for the compacting machine is done and monitored. The PLC controls all the operation of the machine using ladder logic and thus increases the efficiency operated at varying speeds leading to the automation [5]. The control system using PLC and SCADA proves a reliable and efficient leading to safeguard from the fault and error condition [7]. The combination of PLC and VFD provides an efficient way to control the speed of three phase of induction motor which provides the continuous running. The mechanical stress on the IM gets reduced due to VFD. It is cost efficient and energy saving technique. It provides the voltage stability and reliability to the system leading to the greater life of the machine [8-10]. The operating speed of a motor connected to a VFD is varied by changing the frequency of the motor supply voltage. This allows continuous process speed control. Provides control as per load requirement and thus leads to energy saving and gives better results.[9-12].

2. SYSTEM SCHEME AND PRINCIPLE

2.1 Design concepts

According to the characteristics of the traditional motor speed control system and the requirements of engineering application, the design concepts are as follows: (1) The system can improve the control strategy of VFD and have friendly man-machine interface, which can realize intelligent control and dynamic measurement of running state of frequency converter speed regulating system; (2) It has perfect system protection, fault alarm and handling performance; (3) The system can be expanded conveniently, and realize industrial networking and remote monitoring of the host computer; (4) It needs to conform to the industry standards and meet the industrial practical application, in order to adapt to the development trend of AC motor speed control system and improve the practical application ability.

2.2 System scheme

This paper presents an intelligent measurement and control system for variable-frequency speed regulating of motor based on PLC and HMI according to the above design ideas and the composition principle of typical electrical control system, which is composed of an industrial touch screen, a PLC control unit, the speed regulating unit 1 and speed regulating unit 2, as shown in Fig. 2.1.

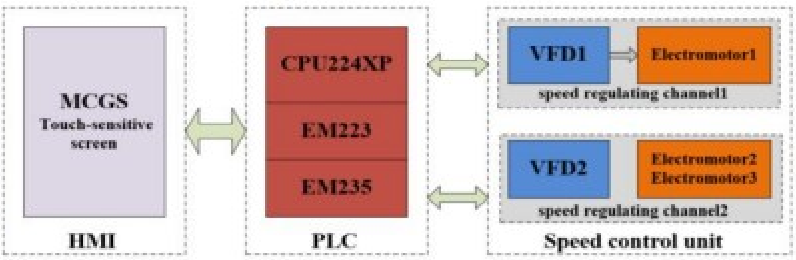


Fig. 2.1 The System Scheme of the Control System

In Fig. 2.1, the MCGS 10-inch color touch-sensitive screen is used as the human-machine interface of the control system, which human-computer interface and monitoring screen is developed by MCGS configuration software (embedded version).

3. MATHEMATICAL MODELING OF VFD

A variable frequency drive is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. VFD an also termed as variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, micro drive, and inverter. Frequency (or hertz) is directly related to the motor's speed (RPMs). [6] In other words, the faster the frequency, the faster the RPMs go. If an application does not require an electric motor to run at full speed, the VFD can be used to ramp down the frequency and voltage to meet the requirements of the electric motor's load. As the application's motor speed requirements change, the VFD can simply turn up or down the motor speed to meet the speed requirement.

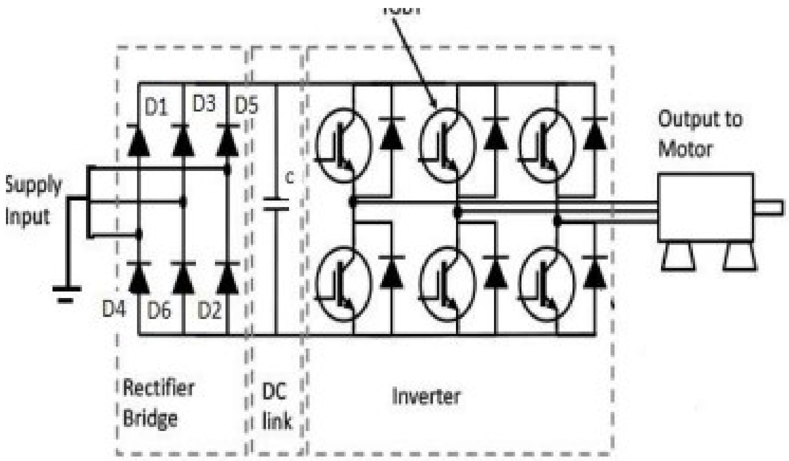


Fig. 3.1 Basic diagram of Variable Frequency Drive

The VFD performs the operation in the following three stages.

3.1 Rectifier Stage

When a fixed AC supply is given to the rectifier it converts the fixed Ac to variable dc voltage. Mostly 3 phase supply is used as it consists of 6 diodes which is termed as 6-pulse bridge rectifier.

3.2 DC Link Bus

After the rectification process there is a chance of small amount of ripple is produced along with dc voltage. It causes harmonic distortion. So a large value of the capacitor is connected parallel between the rectifier and inverter shown in the fig above. It removes ripple and protects the inverter, the chances of occurrence is very less.

3.3 Inverter Stage

In this stage, harmonic-free dc voltage is converted into variable ac voltage. In other words, the inverter converts the fix or variable dc voltage to variable ac voltage. IGBT is used as the switching device as IGBT is the common choice for switching in modern VFD as it can switch ON and OFF
several thousand times per second and control the power to the induction motor.
The hardware model of the complete system the PLC circuit along with the phase conversion circuit and the VFD connected to the induction motor has been implemented and shown in figure 3.2 below,

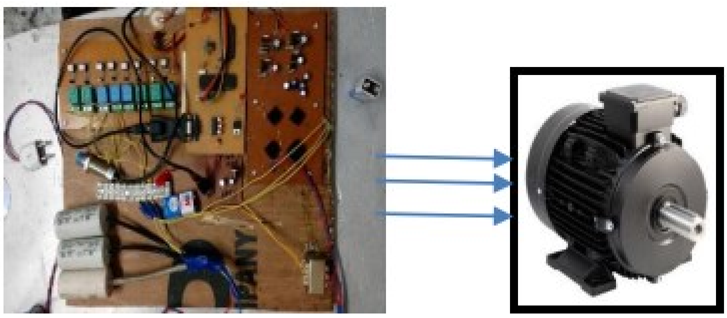


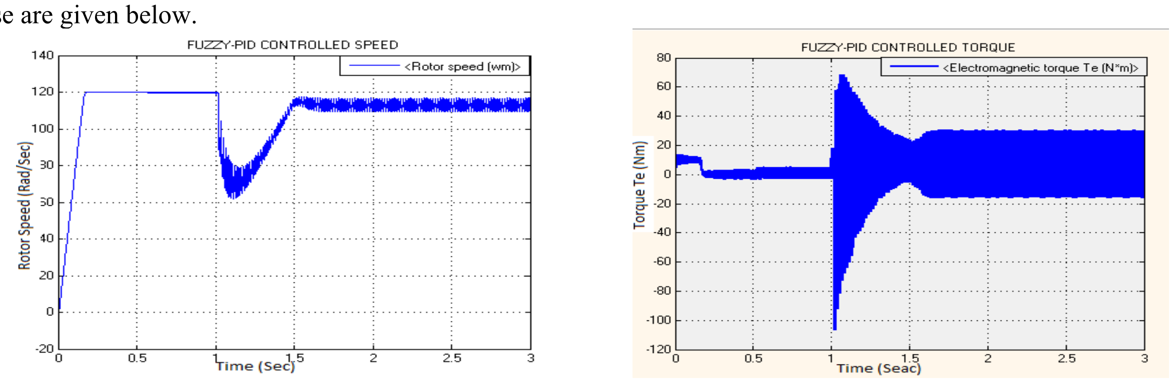
Fig. 3.2 Hardware Connected to Motor

The whole system consist of the system application software which act as a SCADA system for measuring the various parameters of the motor which is connected via communication protocol unit i.e. RS 232 connector pin to send and receive the signals which is to be displayed which sends the signal to pins of max 232 IC to Rx and

Tx pin which constitutes a logical unit for signal sending via system for various operations from the AT89C51 microcontroller IC, to which the ADC is connected which gives digital signal to the circuit for the no. of sensors. The various sensors such as current, temperature and speed sensors are used for measurement purpose. Sensors connected to load to read the various parameters according to load status. Switching mechanism connected to VFD to trigger and to control the motor for 3 phase conversion. It uses the relay circuit along with the Opto-coupler connected to the microcontroller which receives the signal thus operating the relay and starts the motor.

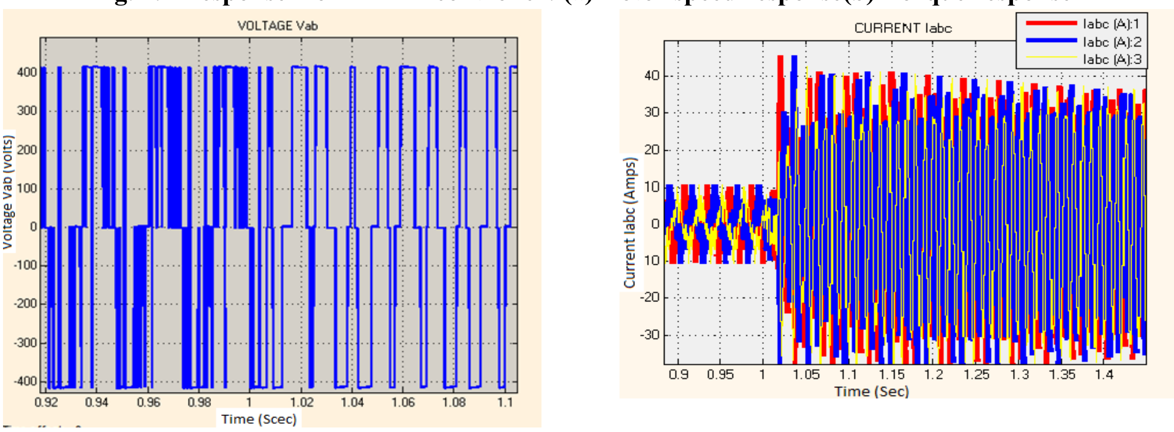
4. RESULTS AND DISCUSSION

In this paper shows the proposed system performance on induction motors using fuzzy-PID logic controller. System results was accomplished based upon many aspects but with emphasis on the speed response, torque response, and others detailed herein. The analysis aspect paper focused on the sensitivity of this driving methods to the mechanical load change, reference speed change and power interruption.
For this case reference speed set to 120 rad/sec and torque is changed from 0 N-m to 7 N-m at 1.0 sec for both Fuzzy PID controller model and PID controller model. Model is simulated for 3 sec and simulation plots for this case are given below.



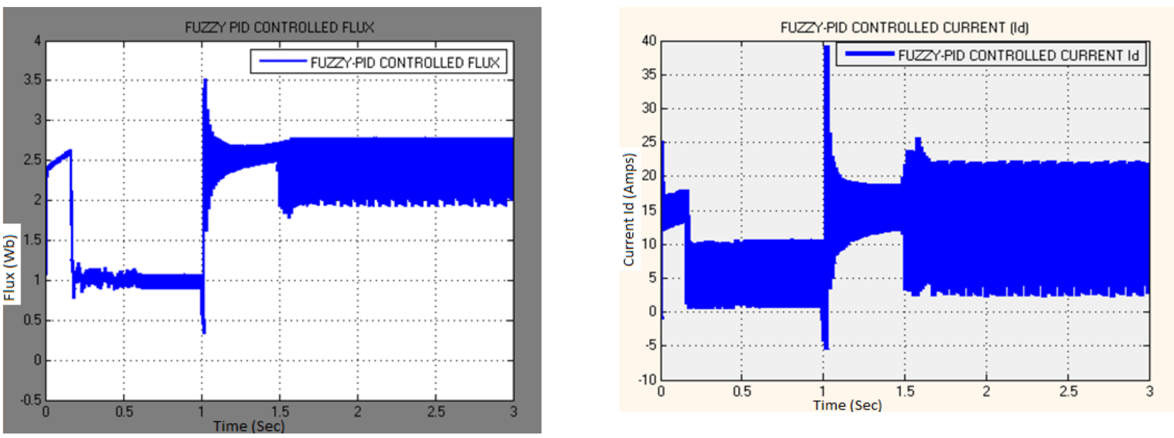
(a) **(b)**

Fig. 4.1 Response from F-PID controller: (a) Rotor speed response(b) Torque response



(a) **(b)**

Fig. 4.2 Response from F-PID controller (a) Inverter voltage V_{ab} (b) Rotor current I_{abc}



(a) **(b)**

Fig. 4.3 Response from F-PID controller (a) Flux (b)Current I_d

From the above Fig. 4.1, we can see that Fuzzy-PID controller shows steady state speed performance when load it suddenly changed. As we can see that when at 1.0 sec torque changes from 0 N.m to 7 N-m F-PID speed controller shows very good dynamic performance and speed remain in steady state without any ripple and overshoot. Also, from Fig. 4.2. We can see torque response which also very smooth. Fig. 4.3 shows the rotor current.

CONCLUSION

The present paper is carried out on induction motors using fuzzy-PID logic controller. The proposed drive system show better performance compared to PID controller. The software used for implementation and verification has been the Xilinx Integrated Software Environment tool (ISE). The simulations have shown that the proposed strategy has better performances than the Conventional. In fact, it allows a significant reduced torque steady state speed and stator flux ripples and a good starting behavior. Thus, the effectiveness of the Fuzzy-PID controller for vector control of the VFD is verified by experimental results. These results validate the good functionality of the designed vector control F-PID controller hardware architecture.

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