Performance Evaluation between PLC and PID Controllers Used For Speed Control Of Induction Motor

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Abstract - In any industry the induction motor play an important role due to its low cost and simplicity. In existing system motor speed is monitor by HMI (Human machine interface). Also there are different methods to control the speed of induction motor. The intent of this paper is to compare and evaluate between the performance of the speed control of induction motor by using PLC (programmable logic control) and also PID (Proportional integral derivative controller). In most of the industrial application VFD (variable frequency drives) is used to control the speed of induction motor. The combination of PLC and VFD provides an efficient approach for getting a motor with continuous running. It is cost effective method along with huge amount of energy saving. But due the certain development in the PID controller it also becomes a very effective tool for controlling speed of Induction motor.

Keywords - Load (Motor),PLC (Programmable Logic Control), VFD (Variable Frequency Drive), speed reference control.PID (proportional integral derivative controller)

I) INTRODUCTION

Variable Frequency Drive

Variable frequency drive is basically used where the variable speed is essential. It is a device in electrical system which performs the conversion of single phase or three phase supply of Fix frequency into three phase supply with variable frequency. It is used for the application of variable speed requirement .Due to smooth operation it has widely used in the application of speeds control of motor. It can be controlled either manually or automatically.

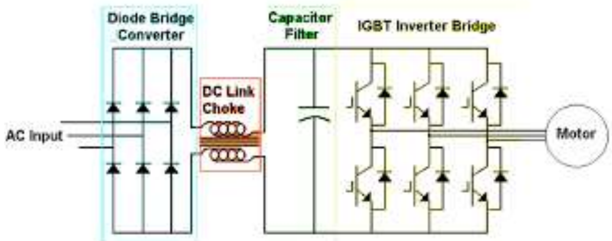

Fig.1. circuit diagram of VFD

In our paper we are comparing two different controllers.
i)PLC (Programmable logic controller)
ii)PID (Proportional integral derivative controller)

II. PLC (programmable logic controller): - It is used in electrical system to improve the reliability and efficiency of electrical equipment (electrical motor) in automation processes. To obtain accurate result PLC is interfaced with converter, PC (Personal computer) and other electrical equipment. In this application PLC of Allen Bradley is used to communicate with VFD and in turn it control 3 phase induction motor. A control program is developed to get required operation of motor and VFD.

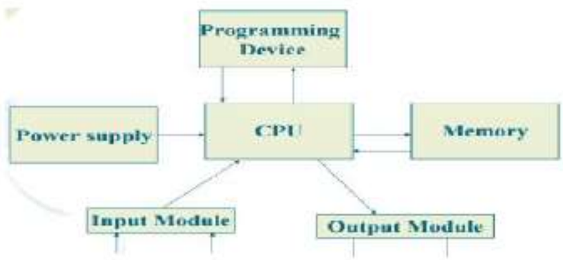

Fig.3. Block diagram of PLC

Advantages of PLC
Reduced space
Energy saving

Ease of maintenance
Economical

III. PROPOSED SYSTEM:- Proposed system block diagram shown in Fig.3 and it consists of two power supplies, one is 230V and other is 440V.The 230V supply from main is converted into 24V DC and it is given to the PLC unit. The second supply from main 440V is directly given to the VFD. The PLC (Programmable Logic Controller) unit in the block diagram is used to control the VFD and through the VFD the motor is controlled.

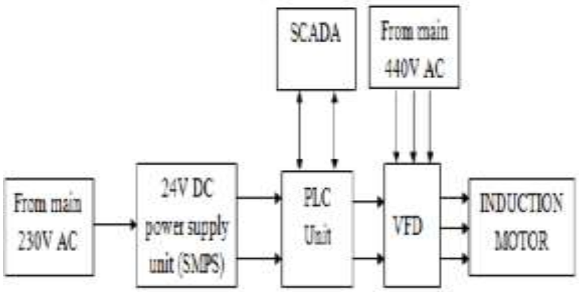

Fig.2. block diagram of overall system

PLC has memory for storing the user program or logic as well as a memory for controlling the operation of a process machine or driven equipment. The PLC is programmed in LADDER LOGIC (A high level, real world, graphic language that is easily understood by engineers).The speed of the motor is controlled by varying the frequency through Pulse width modulation controller. The variable frequency is set by using VFD. The VFD is connected with motor. By changing the output frequency the motor speed can be varied.

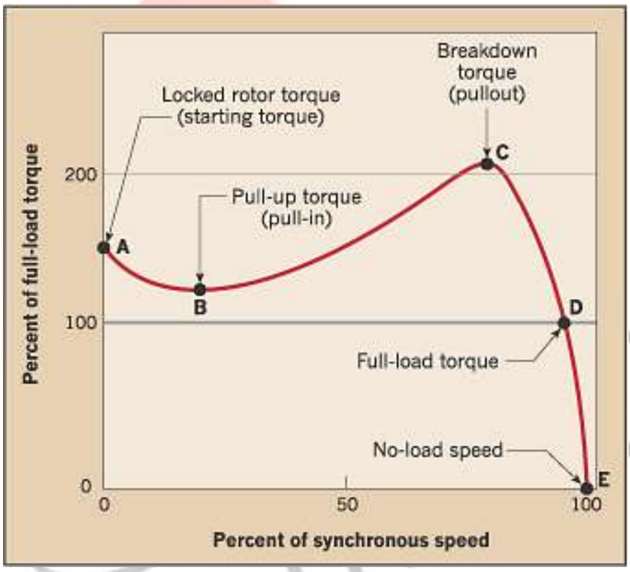

Fig.4. Torque speed characteristics of induction motor.

As induction motor follow the relation

$T \propto V/F$

So for constant v/f ration a constant torque can be achieved. However, this control scheme focus to ensure that any particular torque can be obtained at the same flux as operating at normal frequency and voltage.

$Ns = 120f/p$

From above relation the induction motor speed can be changed by varying the frequency of supply given because poles are inbuilt and cannot contribute in speed control. So for constant v/f ratio torque developed is constant in entire operation. It is the only focus of this method.

PID (Proportional integral derivative controller): - The PID controllers (proportional integral derivative controller) are widely used in industries for the speed control purpose. A PID controller calculates an "error" value as the difference between the measured process value and the desired set point. The PID controller calculation involves three separate constants and is accordingly sometimes called three-term control i.e. the proportional, the integral and derivative value which is denoted by P, I and D

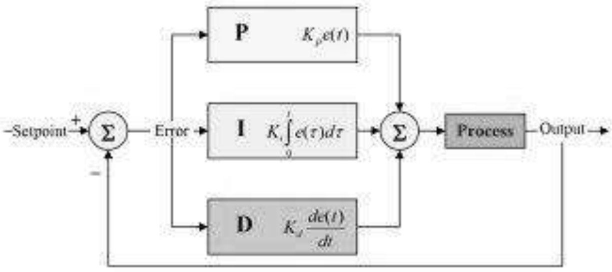

Fig.5. PID block diagram

A proportional controller may not give steady state error performance which is needed in the system. An integral controller may give steady state error performance but it slows a system down. So the addition of a derivative term helps to cure both of these problem. The final form of PID algorithm is

$$U(t) = MV(t) = K_p U(t) + K_i \int_0^t e(t)dt + K_d \frac{d}{dt} e(t)$$

Proportional term:- Process variables for different K_p values (Ki and Kd held constant) are shown in Figure 6 below. The proportional term makes a change to the output that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant Kp called the proportional gain.

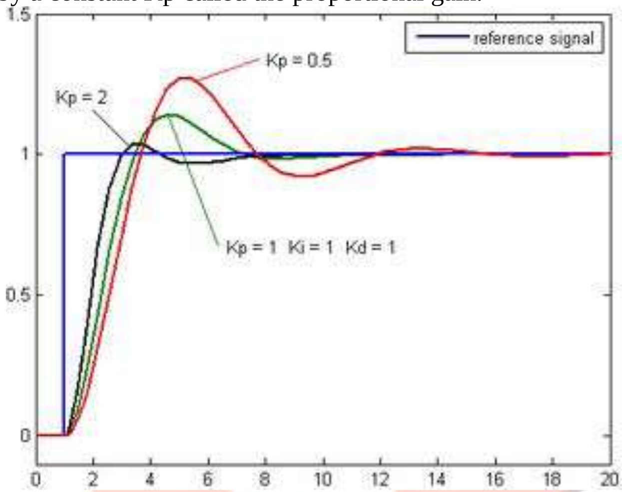

Fig.6. Process variables for different Kp

Process variables for different K_p values (K_i and K_d held constant) are shown in Figure 6. The proportional term makes a change to the output that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant Kp, called the proportional gain.

A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the system can become unstable (see the section on loop tuning). In contrast, a small gain results in a small output response to a large input error, and a less responsive or less sensitive controller. If the proportional gain is too low, the control action may be too small when responding to system disturbances. Tuning

Theory and industrial practice indicate that the proportional term should contribute the bulk of the output change. A pure proportional controller will not always settle at its target value, but may retain a steady-state error. Specifically, drift in the absence of control, such as cooling of a furnace towards room temperature, biases a pure proportional controller. If the drift is downwards, as in cooling, then the bias will be below the set point, hence the term "droop. Droop is proportional to the process gain and inversely proportional to proportional gain. Specifically the steady-state error is given by

$e = G / Kp$

Droop is an inherent defect of purely proportional control. Droop may be mitigated by adding a compensating bias term (setting the set point above the true desired value), or corrected by adding an integral term.

Integral Term

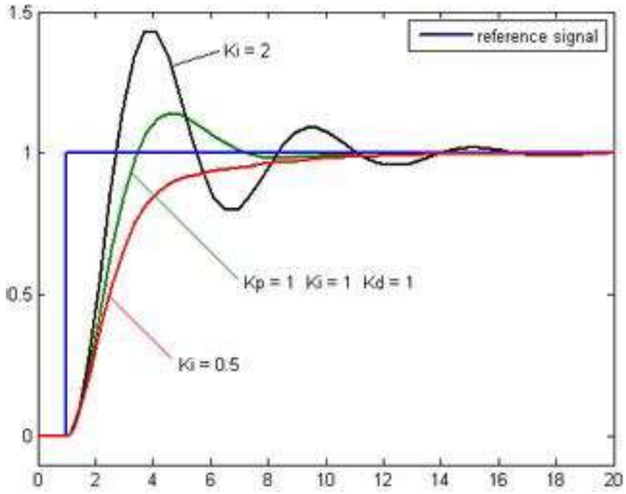

Fig.7. Process variable for different Ki

Process variables for different Ki values (Kp and Kd held constant) are shown in figure 7 above The contribution of the integral term is proportional to both the magnitude of the error and the duration of the error. The integral in a PID controller is the sum of the instantaneous error over time and gives the Accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain (Ki) and added to the controller output.
The integral term is given by the Equation

I_{out} = Ki $\int_0^t e(t)\,dt$

The integral term accelerates the movement of the process towards set point and eliminates the residual steady-state error that occurs with a pure proportional controller. However, since the integral term responds to accumulated errors from the past, it can cause the present value to overshoot the set point.

Derivative term

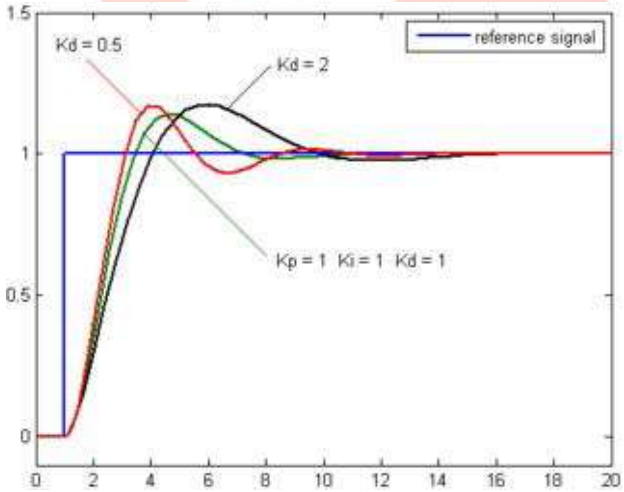

Fig.8. Process variable for different Kd

The derivative term is given by the Equation

$D_{out} = K_d \frac{d}{dt} c(t)$

The derivative term slows the rate of change of the controller output. Derivative control is used to reduce the magnitude of the overshoot produced by the integral component and improve the combined controller process stability. However, the derivative term slows the transient response of the controller. Also, the differentiation of a signal, amplifies noise and thus this term in the controller is highly sensitive to noise in the error term, and can
Cause a process to become unstable if the noise and the derivative gain are sufficiently large. Hence an approximation to a differentiator with a limited bandwidth is more commonly used. Such a circuit is known as a phase-lead compensator.

Advantages of PID controller include the following:

i. Very less oscillation.

ii. Low overshoot.
iii. Faster and no offset.
iv. An integral term gives zero steady state error for step input.
v. An derivative term often produce faster response.

CONCLUSION

The conclusion of the study demonstrates that it can control the speed of induction motor easily and effectively by both of these methods but as far as cost is concerned the preference in controlling by using PID controllers outweigh as the cost of PLC is high. As the PLC's are made up of semiconductor material its operation is affected by temperature and it accounts for another drawback of PLC and as there is considerable development in PID controller where the cost is main constrains we will prefer PID controller.

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