Temperature based AC Drive Controller Using PLC

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Abstract

An AC drive or variable frequency drive (VFD) is a device that is used to control the speed of an electrical motor. The speed of is controlled by changing the frequency of electrical supply of the motor. It converts the frequency of the network to anything between 0 to 300Hz or even higher and thus controls the speed of motor proportional to the frequency. The benefit of an AC drive is that it controls are normally operating at constant speed. It enables the user to control the speed of motor proportionally that gives him various benefits in terms of process control, system stress and energy savings. PLC or programmable logic controller is a digital computer used for the automation of various electromechanical processes in industries. It consists of microprocessor which is programmed using the computer language. This proposed paper discusses various applications of AC drives and controlling mechanism of PLC.

Keywords: *PLC, variable frequency drives, v/f method, AC drives, speed controller, frequency based controller.*

1. INTRODUCTION

To fulfil high control performance requirements and advanced control, the control engineering method used in industries was the proportional, integral and derivative (PID) controller that is widely used since the last four decades. To simplify the controlling in manufacturing system, process control system etc, PLC is widely used as industrial control. A computer control system consisting of PLC is designed to improve the level of automation. By using the PC, desired temperature or set point (SP) is set by the user and the process temperature based on the SP temperature is maintained by the controller within the PLC. A Variable Frequency Drive is used for applications wherein speed control is of an essential importance due to load changes wherein the speed needs to be increased or decreased accordingly. VFD provides a flexible approach as compared to traditional methods of speed control especially for certain applications which do not require a constant speed at all times. Variable frequency drives are generally required because in many applications it is not desired to run the motor at same speed all the time due to its surrounding circumstances. The revolution per minute of the driven shaft need to be increased or decreased depending on load changes, application requirement or other circumstances. The input signal to the VFD is an electrical signal which is come from sensor output. The speed control is performed by continuous feedback provided by output of VFD to PLC as illustrated in figure 1. The output obtained is in the form of signal or waveform displayed on pulse width modulator (PWM).

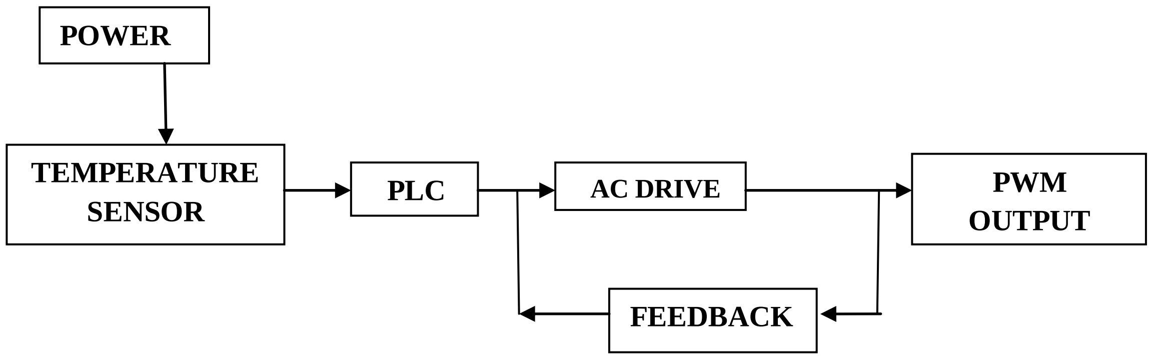

Fig-1. Basic block diagram of AC Drive Controller

1.1 Overall Basic Concept

The overall process is to controlling the speed of the A.C. Drive with varying temperature by using Programmable Logic Controller. A.C. Drive is nothing but a Variable Frequency Drive, which varies its speed when load is varying. Here load is the temperature. The closed loop system is introduced here, where input and output is connected by a feedback path, so stability will be improved. P.L.C. uses ladder logic which is easy to learn as compare to the assembly language program of microcontroller and also it is very much immune to noise. The Programmable Logic Controllers are having more no. Of input output ports, so more no. Of devices can interface to this at a time.

A device which is called thermocouple will sense the temperature of the object and convert it into the form of digital signal. It works on cold junction compensation and detect a very small voltage change for every degree in change of temperature. To analyse the speed response of the system P.W.M. module is used here. P.W.M. is the abbreviation of Pulse Width Modulator. With the help of this P.W.M. screen the on time, off time and duty cycle of the response can be calculated.

2. PROCEDURE

2.1 Temperature Sensing

The very first operation is temperature sensing with the help of thermocouple. It works on cold junction compensation and detect a very small voltage for every degree in change of temperature.

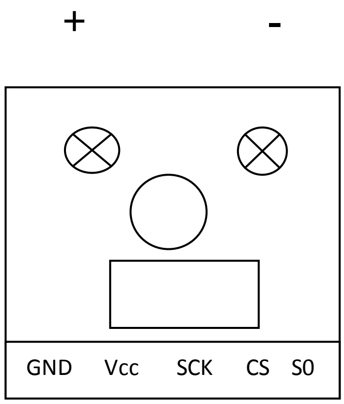

Fig 2. Block Diagram of MAX6675K I.C.

GND : For grounding.

Vcc : Power supply of 5V

SCK : Serial clock (an input from software)

CS : Chip Select(setting low, selects the module and tell it to supply an output that is synchronise with a clock.)

SO : Series output of module(software will read this output)

Conversion	Temperature to digital
Output type	Voltage
Sensing accuracy range	-3'c to +3'c
Temperature sensing range	0'c to 1024'c
Supply voltage range	3V to 5.5V
No. of pins	8
Resolution in bits	12 bit
Operating current	50 mA

Table-1 Parameters of MAX6675K I.C.

2.2 Coding of the process

Then the output of the thermocouple IC is directly fed to the PLC. The algorithm for controlling the speed of AC drive has already burnt to the PLC using logix Pro software .This software is a stimulation software of ladder diagram used in P.L.C.With the help of this one can check that the ladder logic has written correctly or not. It can perform a no. of operation regarding to arithmetic, logical, timer based, counter based etc.

Coding of the process using Logix Pro software

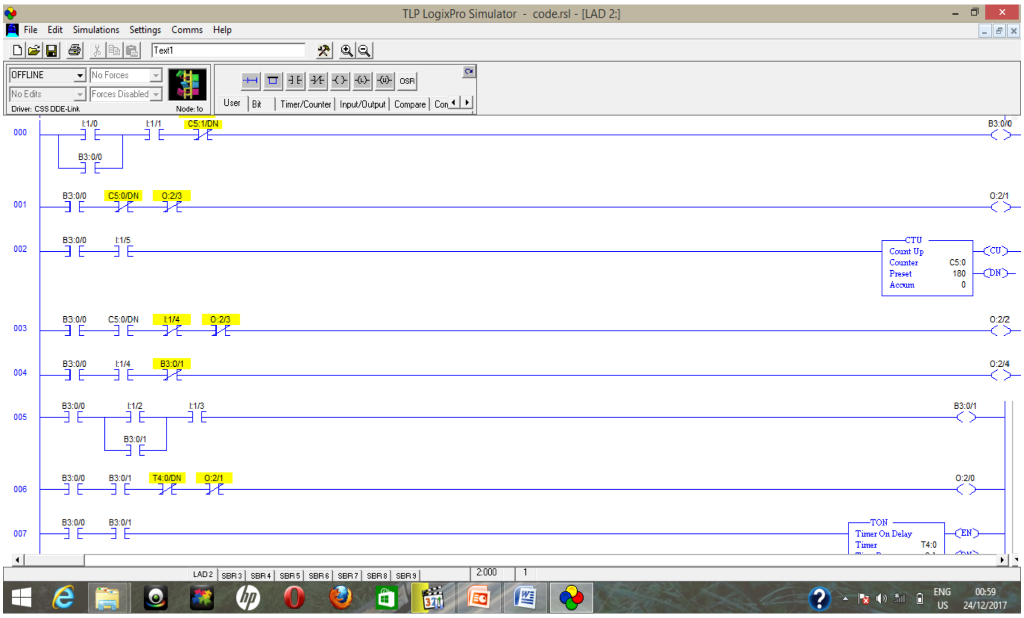

Fig 3 Ladder logic of process part-1

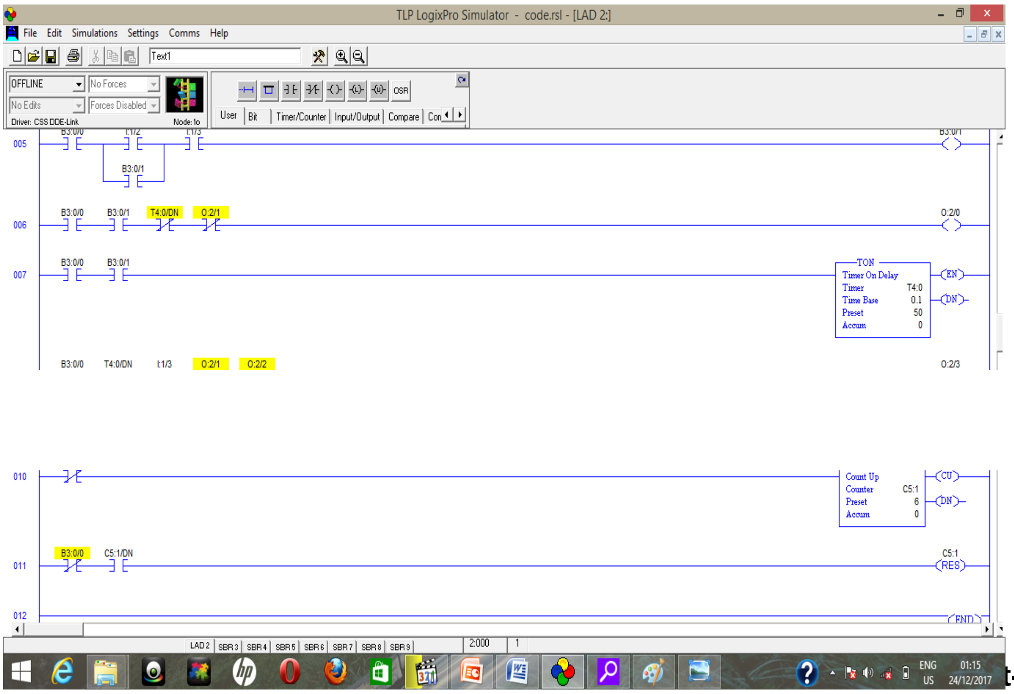

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Fig-4 Ladder logic of process part-2

2.3 Speed control of A.C. Drive

AC drive is connected to the output of the PLC. This is used for controlling the speed of an AC motor by controlling the frequency of the voltage supplied to the motor. It does this by first converting 3 phase 60 Hz AC power to DC power. Then, by various switching mechanisms, it inverts this DC power into a pseudo sine wave 3 phase adjustable frequency alternating current for the connected motor. The frequency coming in to the converter has a fixed frequency of 60 Hz. However, the adjustable frequency coming out of the inverter and going to the motor can be varied to suit the application.

Input	Single phase A.C.
Frequency rating	50/ 60 Hz
Voltage rating	240 V
Current rating	8.3 Amp
Output	3 phase A.C.
Output frequency	320 Hz
Output Current	3.7 Amp
Power	0.75 KW/ 1 HP
Features	Integral Keypad 1* analog input 1* anolog output 6* digital outputs 2* relay contact set 1* digital output (open collector)

Table 2 Parameters of A.C. Drive

The speed of A.C. Drive or Variable frequency drive is controlled by using P.L.C. The speed of the drive is changed proportionally with changing in frequency. The controlling action of P.L.C. is in the form of some electrical signal or voltage, so for proper controlling, the ratio of voltage and frequency should be maintained constant.

Volts per Hertz Ratio:-

- For example, if the frequency is 60 Hz and the voltage is 460 V, then the volts per Hertz ratio (460 divided by 60) would be 7.6 V/Hz.
- So, at half speed on a 460 V supplied system, the frequency would be 30 Hertz and the voltage applied to the motor would be 230 V and the ratio would still be maintained at 7.6 V/Hz

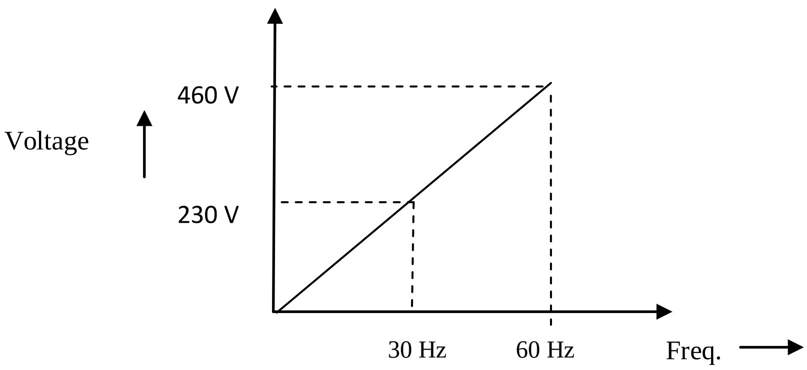

Fig- 5. volts per hertz ratio of A.C .Drive

460V / 60Hz = 7.6 V/ Hz

230V / 30Hz = 7.6 V/ Hz

Hence V / Hz ratio is constant for all values in an AC Drive.

2.4 Formula used

The relation between torque and force applied to the lever arm is:

T = F * L

Where**:** T is torque, in ft-lbs;

F is force or weight, in lbs applied at end of lever arm;

L is lever length in feet.

RPM = S / [3.14 * D]

RPM = mph * D / 336

RPM = fps * D / 229

Where: S is cable linear speed**,** inches / minute;

D is drum or wheel diameter, in inches;

And mph is miles per hour;

And fps is feet per second;

And rpm is resolution per minute.

Calculation based on formula:

Here D = 4”

- S = 0 inch/min

Speed = 0/ 3.14*4 = 0 rpm

- S = 19.32 inch/min

Speed = 19.82/ 3.14*4 = 249.1 rpm

- S = 49.25 inch/min

Speed = 49.25/3.14*4 = 619 rpm

- S = 74.64 inch/min

Speed = 74.64/ 3.14*4 = 938 rpm

- S = 98.67 inch/min

Speed = 98.67/ 3.14*4 = 1240 rpm

Input Supply Freq.(Hz)	Motor Speed by Freq.(rpm)	Linear Speed S(inch/min)	Motor Speed (given D = 4”)
0	0	0	0
5	250	19.82	249.1
10	620	49.25	619
15	940	74.64	938
20	1240	98.67	1240
25	1495	118.92	1494.5
30	1809	143.71	1806
35	2100	166.95	2098
40	2350	186.21	2340
45	2590	205.94	2588
50	2800	222.65	2798
55	3200	253.85	3190

Table-3 frequency and corresponding speed of AC drive

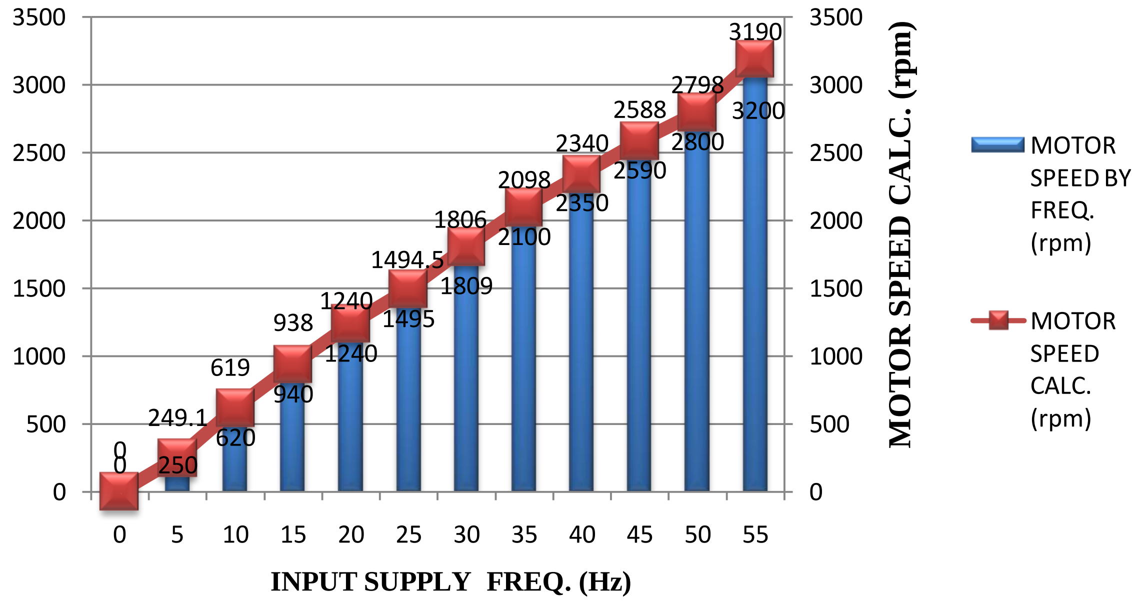

Fig-6 Graph plotted between frequency and Speed of AC Drive

3. RESULT

The observed speed by frequency is more efficient as compare to the calculated frequency, so the efficiency is improved in AC Drive controller using PLC.The feedback phenomenon will increase the stability of the above system.

4. CONCLUSION

The speed of variable frequency drive or AC drive is controlled using PLC. This PLC getting the signal from feedback path connected with output of the AC drive, hence continuous speed control is obtained. The benefit of using AC drive is that the types of motors, which control by it are normally at constant speed. It enables the user to control the speed of the motor proportionally that gives him various benefits in terms of process control, system stress and energy savings.

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