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Speed Control of Induction Motor using PLC and VFD

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***Abstract*—Automation is the need of today's world in all fields of technology. This paper presents a novel approach to provide automation in the field of Electrical Engineering. Here we use the combination of PLC and VFD to control the speed of three-phase induction motor since it provides an efficient approach for getting a motor with continuous running. By this method the variable frequency is set by VFD and speed can be changed as per requirement. The entire control system is switched by PLC. Therefore, the main contribution of this paper is monitoring, controlling the speed of the induction motor by using PLC.**

***Index Terms*— PLC, VFD, Speed control, Automation.**

I. INTRODUCTION

Nowadays Automation plays a major role in industries. Industries are reaching new heights only because of the advancement of automation technology. Plant automation is the necessity for the manufacturing industry to survive in today's globally competitive market. Growth of industries leads to the reduction of manual controls day by day. One such contribution to the growing era is made through this paper. This paper is about controlling the speed of induction motor, which is most economical motor, using Variable Frequency Drive (VFD) through Programmable Logic Controller (PLC).

The revolution per minute of the driven shaft needs to be increased and decreased depending on load changes, application requirements, or other circumstances. The Siemens S7-1200 PLC is used which is interfaced with the help of software known as Totally Integrated Automation (TIA). The PLC has been connected to control a VFD which acts as a go-between the three-phase induction motor and PLC. The PLC process the inputs according to the ladder logic programming which initiates corresponding output to the VFD. The VFD in turn once again processes the PLC input to it and accordingly controls the speed of the three-phase induction motor.

Ladder logic programming is carried out in TIA on the personal computer. A PLC-based control system was set up comprising of Siemens S7-1200 PLC, Siemens micromaster 420 Variable Frequency Drive, three-phase induction motor.

II. PROGRAMMABLE LOGIC CONTROLLER (PLC)

Richard E. Morley, who was the founder of the modicum corporation, invented the first PLC in 1969. A PLC is a solid-state device designed to perform the logic functions previously accomplished by components such as electromechanical relays, drum switches, mechanical timers/counters, etc for the control and operation of

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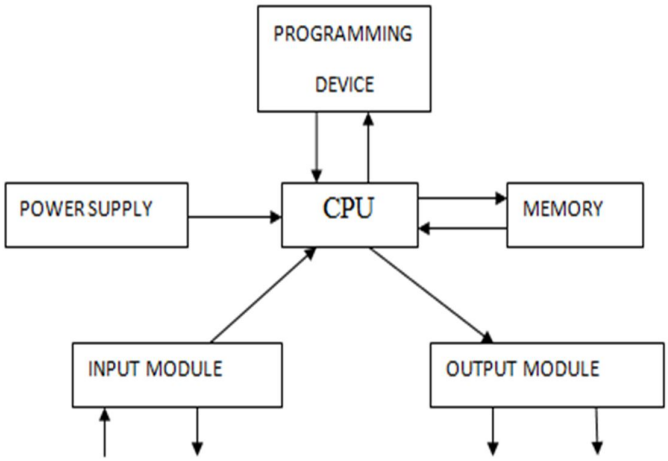
manufacturing process equipment and machinery. Even though the electromechanical relay has served well for many generations often under adverse conditions, the ever-increasing sophistication and complexity of modern processing equipment require faster-acting, more reliable control functions that electromechanical relays or timing devices cannot offer.

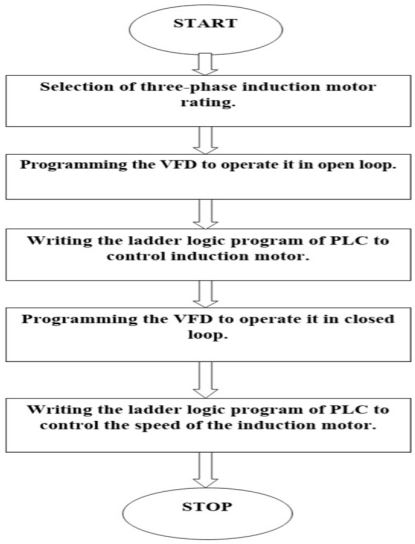


III. Variable Frequency Drive (VFD)

A variable frequency drive is used for applications wherein speed control is of essential importance due to load changes wherein speed needs to be increased or decreased accordingly. V/F method of speed control, the motor speed can be controlled by varying the supply frequency of the motor. The voltage induced in the stator is directly proportional to the product of supply frequency and air gap flux in it. If stator drop is neglected, the terminal voltage can be considered proportional to the product of frequency and flux Vt □f.□. Effect of supply frequency change without a change in the voltage terminal:

1. Reduction of supply frequency without change in terminal voltage will cause an increase in the air gap flux by saturating the motor. This will cause an increase in magnetizing current, and stator copper loss and cause distortion in line current and voltage and produce high-pitch noise.
2. An increase of supply frequency without change in terminal voltage will cause a decrease in flux, therefore leading to a reduction of torque capability of the motor.

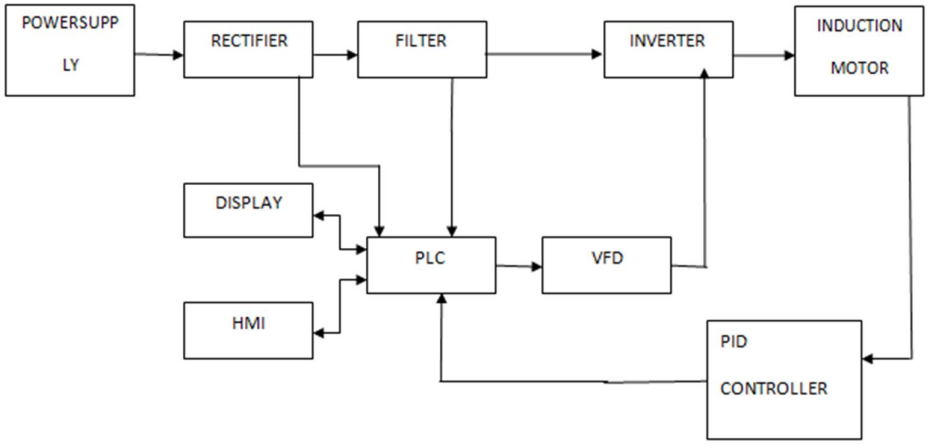
IV. Methodology



A. Methodology Followed

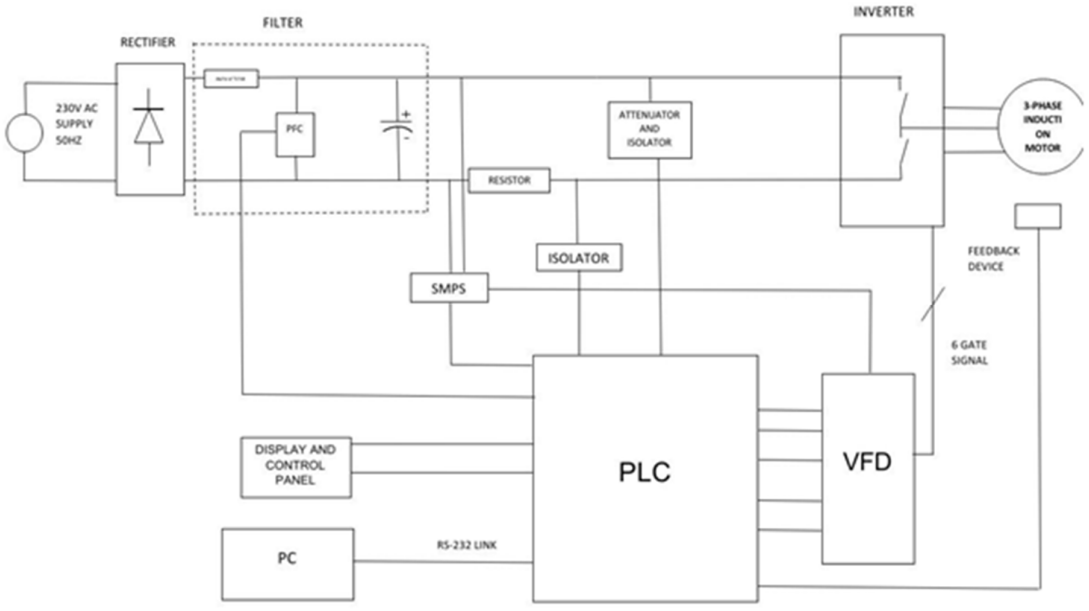
The primary and the basic step is to select the rating of the induction motor for the project and according to it control devices are selected and the circuit is meant accordingly and eventually, the programming is done in the PLC according to inputs applied and the outputs required in the operation of the induction motor.
The Software used for this work is TIA (Totally Integrated Automation) in which the ladder programming is done considering the methodology required to be followed.

V. Block Diagram



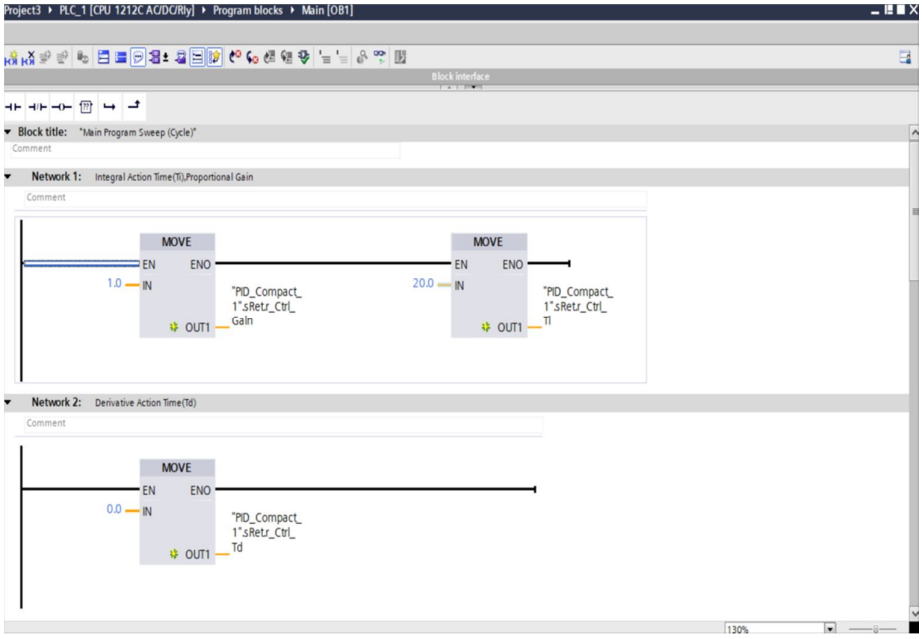
The above figure shows the block diagram of PLC-based control for induction motor. Firstly, the AC power supply is converted to a DC supply which is then supplied to all other equipment. The supply is also given to SMPS (Switched Mode Power Supply). It is then given to the PLC unit when the automation mode of operation is selected on the selective switch. With the help of HMI, the PLC then controls the VFD and then the VFD gives the supply to the contactors and from contactors, the supply is fed to the induction motor. The feedback is taken through the PID controller and encoder and given back to PLC.

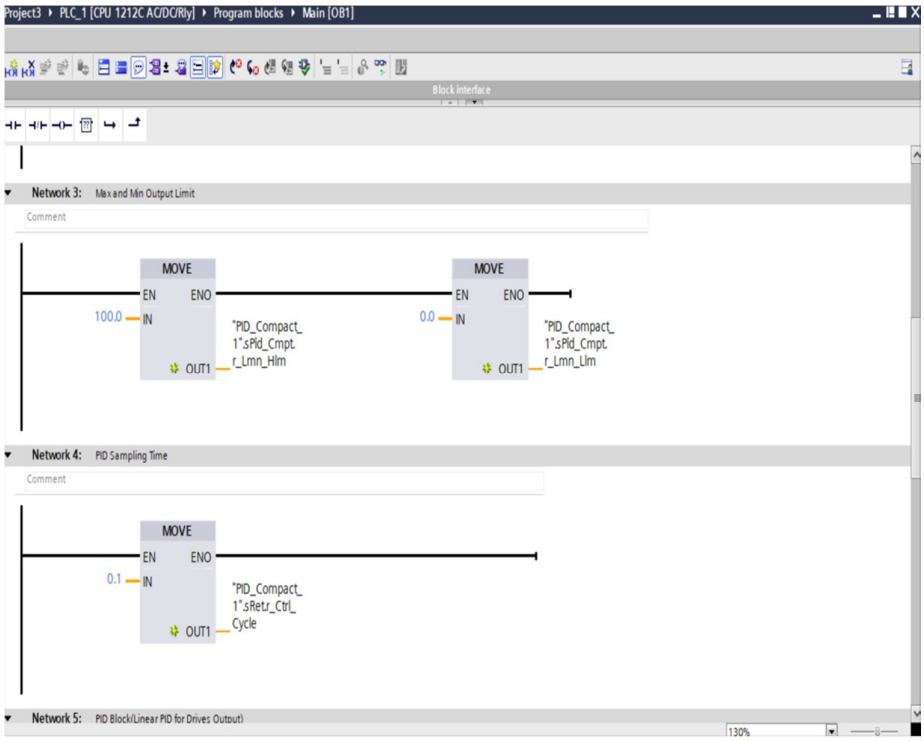
VI. Circuit Diagram

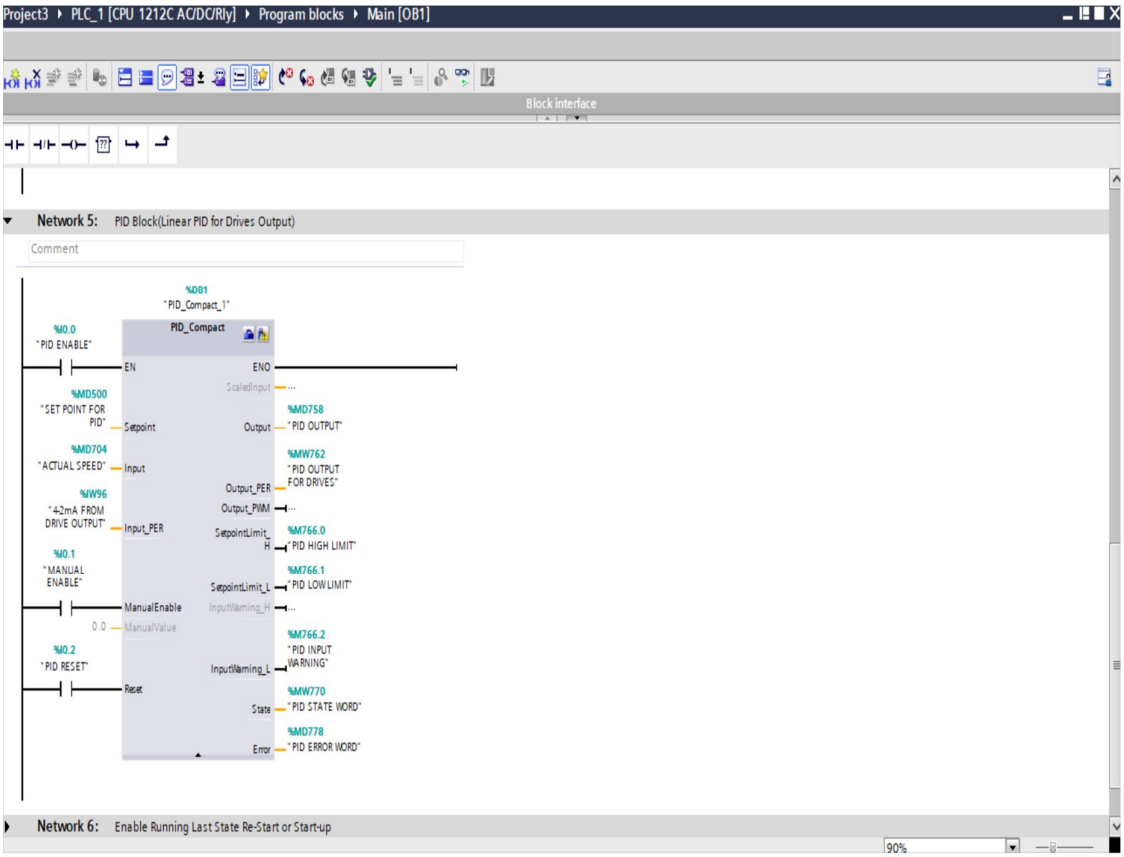


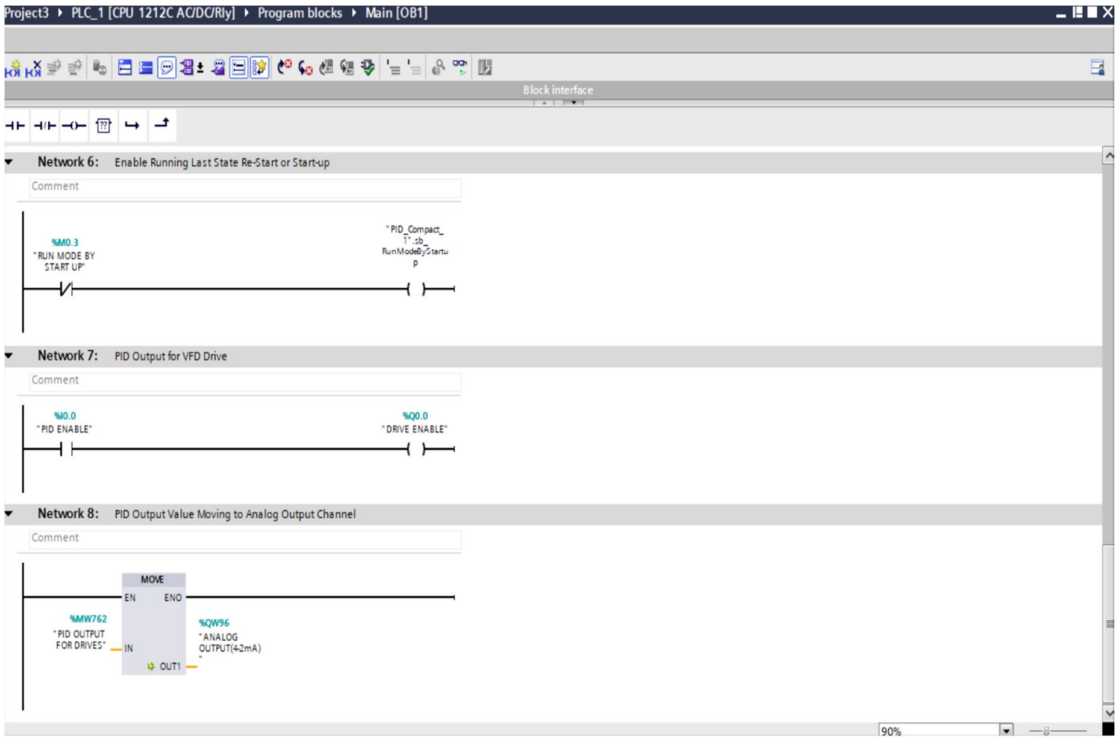
VII. LADDER LOGIC

Ladder logic is a widely used language to program PLCs, there are different methods available to program PLC but one of the most common and easiest programming is ladder logic programming. Other methods of programming cannot be diagnosed or debugged when online, but ladder logic provides a way to debug online.
The following ladder logic diagram is to control the speed of the three-phase induction motor using different logic.






Project3 ▸ PLC_1 [CPU 1212C AC/DC/Rly] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 5: PID Block(Linear PID for Drives Output)
Comment
%DB1
"PID_Compact_1"
PID_Compact
%I0.0
"PID ENABLE"
EN
ENO
ScaledInput
%MD500
"SET POINT FOR PID"
Setpoint
Output
%MD758
"PID OUTPUT"
%MD704
"ACTUAL SPEED"
Input
%MW762
"PID OUTPUT FOR DRIVES"
Output_PER
%IW96
"4-20mA FROM DRIVE OUTPUT"
Input_PER
Output_PWM
SetpointLimit_H
%M766.0
"PID HIGH LIMIT"
%I0.1
"MANUAL ENABLE"
SetpointLimit_L
%M766.1
"PID LOW LIMIT"
ManualEnable
InputWarning_H
0.0
ManualValue
%I0.2
"PID RESET"
InputWarning_L
%M766.2
"PID INPUT WARNING"
Reset
State
%MW770
"PID STATE WORD"
Error
%MD778
"PID ERROR WORD"
Network 6: Enable Running Last State Re-Start or Start-up
90%


Project3 ▸ PLC_1 [CPU 1212C AC/DC/Rly] ▸ Program blocks ▸ Main [OB1]
Block interface
Network 6: Enable Running Last State Re-Start or Start-up
Comment
%M0.3
"RUN MODE BY START UP"
"PID_Compact_1".sb_RunModeByStartup
Network 7: PID Output for VFD Drive
Comment
%I0.0
"PID ENABLE"
%Q0.0
"DRIVE ENABLE"
Network 8: PID Output Value Moving to Analog Output Channel
Comment
MOVE
EN
ENO
%MW762
"PID OUTPUT FOR DRIVES"
IN
%QW96
"ANALOG OUTPUT(4-20mA)"
OUT1
90%

VIII. CONCLUSION

In this paper, the planning of a VFD hardware system for changing the speed of the motor by changing the output frequency is presented. Finally, it is concluded that the method of speed control of a three-phase induction motor using variable frequency drive is the effective and efficient method. When the operation of VFD is controlled by PLC, the whole system gives the operation a level of accuracy, ability and totally with maximum safety. It is possible that the speed control system is often implemented to control multiple motors with the same drive and programmable logic controller, the PLC system which is used in this paper also used for monitoring and controlling the other parameter of the motor with the same drive.

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