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PLC APPLICATIONS FOR SPEED CONTROL OF INDUCTION MOTOR THROUGH VFD

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Abstract - *The paper is about controlling the speed of a three phase induction motor using variable frequency drive(VFD) through programmable logic controller(PLC). Programmable logic controller is an industrial controlling device and is used to automate machines and factory assembly lines. Main purpose of this paper is to automate the three phase induction motor by controlling the inputs to variable frequency drive through PLC and therefore as a result the inputs to the induction motor will be changed and thus the speed of induction motor will changed accordingly. VFD employed in this experiment is based on V/f method of speed control in which flux remain constant.*

Key Words: Variable frequency drive, Programmable logic controller, Induction motor, V/f method.

1.INTRODUCTION

Three phase induction motors are mostly used AC motors in industry for various operations due to its low cost and simplicity. Many factories use PLCs in automation processes to diminish production cost and to increase quality and reliability. By implementing a monitoring and control system for the speed of motor, the induction motor can be used in high performance variable speed application. 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 surrounding circumstances. For example, a pump delivering cooling liquid supply may require peal load operation only for a requisite period of time and may require only much less amount during remaining time of day. VFD will allow the speed of the pump to run at a lower rate in such case thereby enabling energy saving benefits [1]. Speed control methods of induction motors

- **Stator voltage control method** used have many disadvantages such as it offers control over limited range, its use introduces harmonics content and thus reduces the input supply power factor and can be used for only low power drives like fan, blowers etc.[2]
- **Stator current control method** used have disadvantages such as low starting torque as compared to stator voltage control method.
- **Stator frequency control method** used have disadvantages such as at low frequencies reactance will be low leading to high motor currents, more losses and reduces efficiency, after saturation of magnetic circuit, motor parameters will changes leading to inaccurate speed-torque characteristics.[2]
- All the above mentioned methods of speed control have considerable disadvantages therefore V/f method of speed control is adopted which has advantages such as starting current decreases, however starting torque becomes more.

1.1 Variable frequency drive

A variable frequency drive is used for applications where speed control is important factor due to load changes wherein the speed needs to be increased or decreased accordingly. VFD reduces energy consumption and energy costs, extents equipment life and reduces maintenance cost.

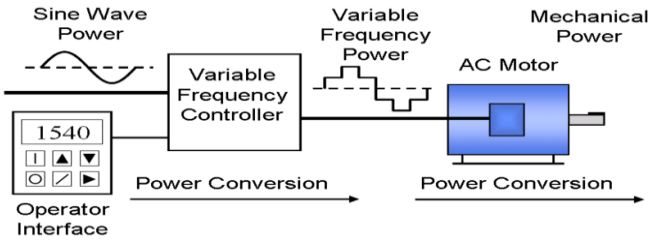

Figure 1: Block diagram of variable frequency drive

1.2 Programmable logic controller

It is used in electrical system to improve the reliability and efficiency of electrical equipment (electrical motor) inn automation processes. In this application PLC of Allen Bradley is used which communicate with VFD and in turn control the speed of induction motor.

Main parts of PLC are

A. Processor –

- It is brain of PLC
- It execute various logical and control function
- Consist of number data processing equipment that facilitates I/O processing.

B. Memory-

- Contains all the programs
- Hold all the data of PLC
- Coordinate I/O operation

C. I/O Module-

- Provide a connections to the process that is to be controlled

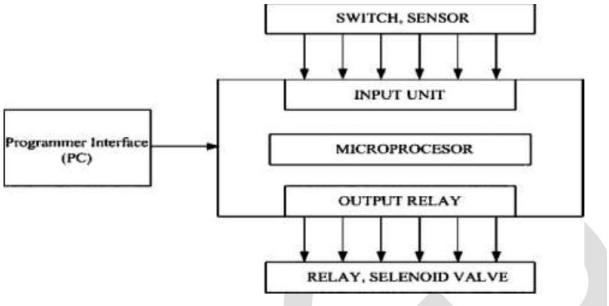

Figure no.2: Block diagram of PLC

2. EXPRIMENTAL WORK

A. Experimental setup

1. The Allen-Bradley PowerFlex 4M AC drive is the smallest and most cost effective drive which provides powerful motor speed control in compact, space saving design

OVERVIEW OF THE PROPOSED MECHANISM

A. V/f method

Variation in supply frequency leads to change in speed. Product of flux and supply frequency is directly proportional to the induced stator voltage. When stator drop consider zero then

$$E \approx V$$

$$V \alpha f \phi$$

If induction motor is to be operated at different frequencies with practically constant value of power factor, efficiency, a constant absolute slip, overload capacity and, then with the iron unsaturated, it is essential that the supply voltage V be varied with the change in frequency accordingly. Both output voltage and frequency vary as the speed if the automatic correction provided.

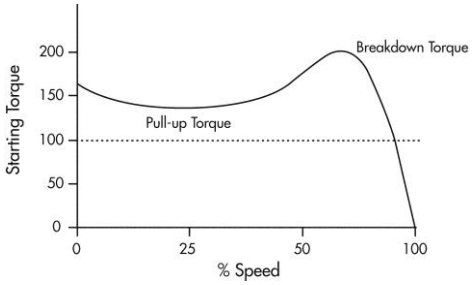

Figure no.5: Torque speed characteristics of Induction Motor

As induction motor follow the relation

$$T \alpha V/f$$

So for constant V/f ratio 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 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 Fig. shows the speed-torque characteristic of IM with V/f control.

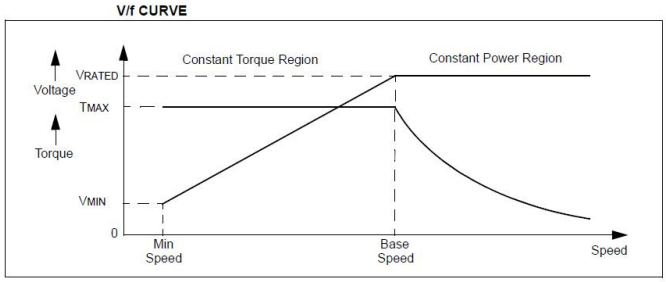

Figure no.3: Torque –speed characteristics with V/f control

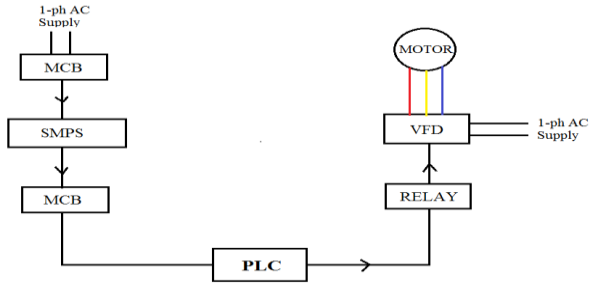

Figure no.4: Block diagram of complete setup

Power Flex 4M AC is used in this experiment which is cost effective and smallest which provides powerful speed control.

Table -1: VFD specifications used in experiment

Motor rating	0.4 kw(.5 H.P)
Output	3 phase,0-240
AC voltage range	0-230V
Continuous AMP	2.3 A
Overload Amp	3.45,60 sec

The PLC used in this project is Allen Bradley Micro Logix 1400 series. The main parts of this PLC are CPU, power supply, output module and input module.

Table-2: PLC specifications

Number of I/O	20 inputs,12 outputs
Power supply voltage	24 V DC
Power supply inrush current	24 V DC,15 A for 20 ms
Power consumption	60 W

Table-3: Motor specifications

KW	0.37(0.5 HP)
RPM	2820
Frequency	50±5%
Voltage	415±10%
Ambient temperature	50˚C
Ampere	1.1
Efficiency	88.6%

Conduction of experiment

Allen Bradley PLC ,Allen Bradley Power Flex 4M VFD, a 3 phase induction motor was connected for conduction of experiment in which for various values of input supply frequencies, the corresponding values of motor speed in RPM were obtained as shown in table 4.

Input supply frequency in Hz	**Motor speed in RPM**
15	900
25	1410
30	1750
45	2500

3. CONCLUSIONS

The present work describe a mechanism to monitor VFD by PLC. A complete study of each and every equipment along with their specification is done. Software platform namely Allen Bradley ladder logic programming RS Linux is implemented. A 0.5 Hp 3-Phase Induction Motor was taken for experimental set-up offered various control modes of motor operation. A PLC program is made and verified in RS Linux software. Therefore, the control method discussed in this paper can be applied in every industry where 3 phase induction motor is used.

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