Speed Control of Induction Motor using V/F Technique Drives using PLC for various Applications

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Abstract— This paper presents the need of Speed Control in Induction Motors. Out of the various methods of controlling Induction motors, V/f Control has proven to be the most versatile. The overall scheme of implementing V/f control has been presented. One of the basic requirements of this scheme is the PWM Inverter. In this, PWM Inverters have been modelled and their outputs fed to the Induction Motor drives. The uncontrolled transient and steady state response of the Induction Motor has been obtained and analyzed. The speed of the motor is controlled by varying the frequency through triggering the VFD i.e. PWM technique. Thus it causes the output voltage of the VFD according to its turn on time. The inverter converts DC power to AC power at the required frequency and amplitude. By this the variable frequency is set by VFD and the motor speed can be changed to the required speed. The entire control system is switched by using PLC. Thus the main Aim of this paper is the monitoring, speed control of motor based on VFD and programmable logic controller, and SCADA system is developed which shows the parameters of IM on the GUI Application Software.

Key words: PWM Generator, IGBT"s, Universal Bridge, Uncontrolled PWM Inverter, Pulse Width Modulation (PWM), PLC, VFD, SCADA, Automation

I. INTRODUCTION

Electrical Energy already constitutes more than 30 % of all energy usage on Earth. And this is set to rise in the coming years. Its massive popularity has been caused by its efficiency of use, ease of transportation, ease of generation, and environment-friendliness. Part of the total electrical energy production is sued to produce heat, light, in electrolysis, arc-furnaces, domestic heating etc. Another large part of the electrical energy production is used to be converted into mechanical energy via different kinds of electric motors- DC Motors, Synchronous Motors and Induction Motors. Induction Motors are often termed the "Workhorse of the Industry". This is because it is one of the most widely used motors in the world. It is used in transportation and industries, and also in household appliances, and laboratories. The major reasons behind the popularity of the Induction Motors are:

- Induction Motors are cheap compared to DC and Synchronous Motors. In this age of competition, this is a prime requirement for any machine. Due to its economy of procurement, installation and use, the Induction Motor is usually the first choice for an operation.
- Squirrel-Cage Induction Motors are very rugged in construction. There robustness enables them to be used in all kinds of environments and for long durations of time. III. Induction Motors have high efficiency of energy conversion. Also they are very reliable. IV. Owing to their simplicity of construction, Induction Motors have very low maintenance costs.

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 [2]. The analysis on the performance of induction motor is done with its characteristics. A linear curve is obtained on the graph plotted between frequency and speed. The control system using PLC and SCADA proves a reliable and efficient leading to safeguard from the fault and error condition [3]. 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 [4]. 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

II. PROGRAMMABLE LOGIC CONTROLLER

A Programmable Logic Controller (PLC) used for Automation. A programmable controller is a digital electronic device which usually uses a programmable memory system for the internal storage of instructions. It can perform various specific functions, such as logical operation, sequencing, timing operation, counting and arithmetical operation, to control various machines or processes through digital or analog input and output devices. [2] PLC is designed for multiple inputs and output system arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibrations and impacts.

Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results are produced in response to input conditions within a bounded time, otherwise unintended operation results.

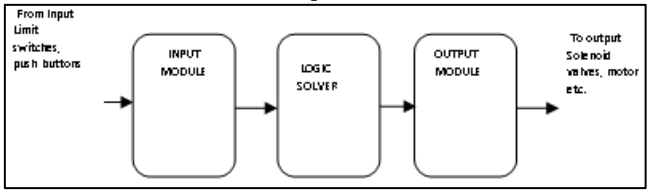

Fig. 1: Basic Block Diagram of PLC

A. Basic Components of PLC

1) CPU and Memory module.

CPU is used to store and process the PLC program. The programming functions depends on the size and type of CPU. Size of logic available, amount of memory, and processing speed.

2) Power supply

The power supply provides power for the PLC system. In order to operate the CPU logic circuitry internal DC current is given. Voltage levels required by the PLC are 24Vdc, 120Vac, 220Vac.

3) Input and output module

Inputs transfers all signals to the controller from the field (process). Various types of inputs are switches, pressure sensors, transmitters etc. This signals are then receives by the help of output devices from PLC. These are used to control the process, motors, lights, relays, pumps, etc.

Two major types of Input/output modules are-

- Digital - binary devices which must be in state of on or off states.
- Analog - continuous devices - sense and respond to a range of values parameters.

4) Programming device

The PLC is programmed using software that uses computer or hand Held Terminal (HHT) that loads the program and can change the logic anytime.

5) Sinking and Sourcing Operation:-

- Sourcing operation is carried out when the device is in on state in the system.
- This received current in its true state, is called as sinking current.

III. VARIABLE FREQUENCY DRIVE

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.

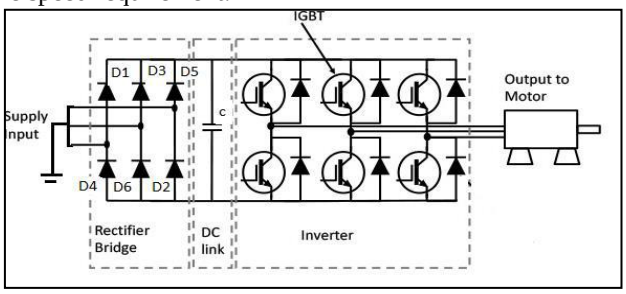

Fig. 2: Basic diagram of variable frequency drive

The VFD performs the operation in following three stages,

1) Rectifier stage.

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

2) Dc link bus

After 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 capacitor is connected parallel between the rectifier and inverter shown in the fig above. It removes ripple and protect the inverter, chances of occurrence is very less.

3) Inverter stage

In this stage, harmonic free dc voltage is converted into variable ac voltage. In other words inverter converts the fix or variable dc voltage to variable ac voltage. IGBT is used as the switching devices as IGBT is the common choice for the switching in modern VFD as it can switch ON and OFF several thousand times per seconds and control the power to the induction motor.

IV. DESIGN AND IMPLEMENTATION OF HARDWARE

The hardware model of 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 below,

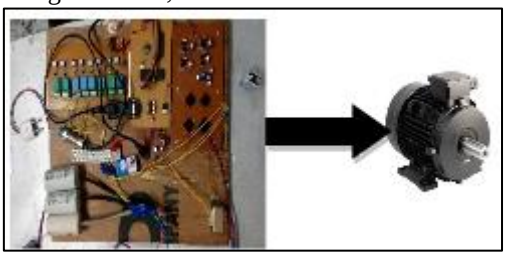

Fig. 3: Hardware connected to motor.

The whole system contained 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 its 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 measuring purpose. Sensors which are connected to load to read the various parameters of system 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 device connected to the microcontroller which receives the signal thus operating the relay and starts the motor.

Kiel micro vision software is an integrated development environment (IDE), in which a text editor is provided to write programs, and then it convert your source code to hex file using compiler.

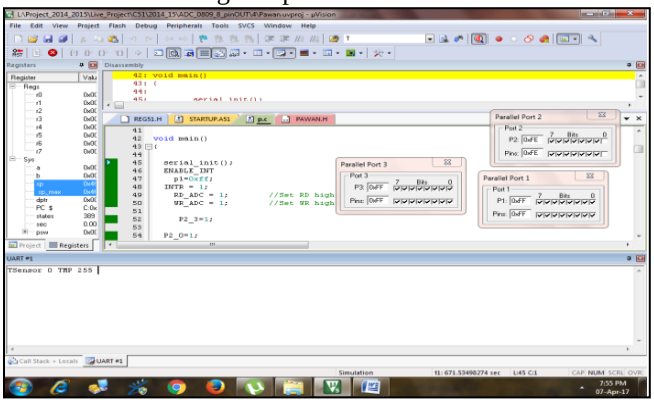

Fig. 4: Programming window of Kiel micro vision.

The Microcontroller programming is done for operating the hardware i.e. sending the signal to operate the system using the Kiel micro vision software. It is used to load the assembly language program in IC.

The Vb.net software is an object-oriented computer language that can be viewed as an evolution of Microsoft's Visual Basic. VB.NET provides a graphical environment in which you visually design the to forms and controls that become the building blocks of your applications. So a GUI form is developed using Vb.net for the monitoring of parameters on the Application Software.

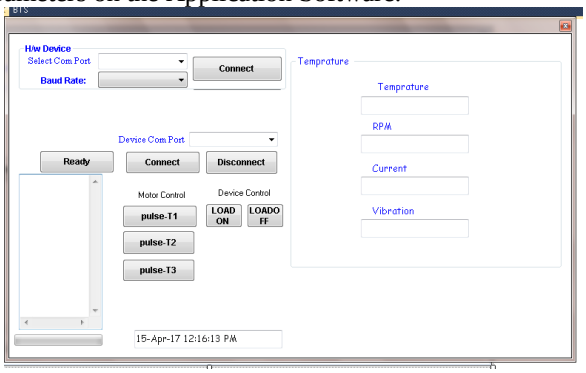

Fig. 5: Window based application software (GUI) using .net.

Rated Power in (KW)/(HP)	0.76/1
Rated Voltage in (volts)	425
Rated Current in (ampere)	2.0
Rated Speed in (rpm)	1480
Rated Frequency in (Hz)	50
Power Factor	0.85
Efficiency (%)	77

Table 1: Induction motor specifications

V. RESULT

The experimental test has to be performed and the given results for the parameters of IM obtained are shown in the fig below,

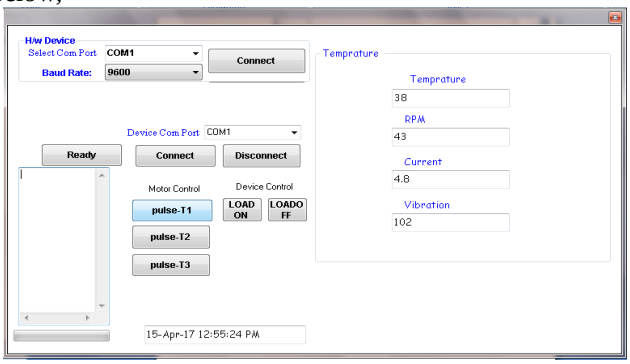

Fig. 6: Parameters at speed 1 on application software.

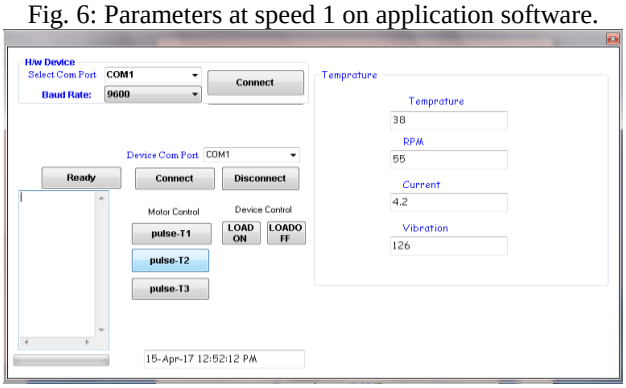

Fig. 7: Parameters at speed 2 on application software.

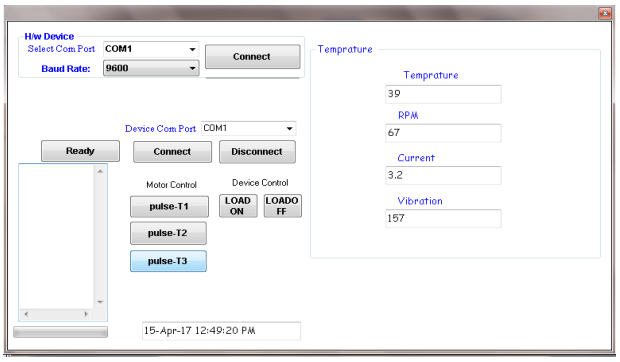

Fig. 8: Parameters at speed 3 on application software.

VI. CONCLUSION

Thus the speed control of 3-phase induction motors is done with the help of all necessary experimental test. The various parameters of the induction motor are obtained on the GUI window based Application software screen in home desktop. In industries area where motors and pumps used to satisfy all basic necessities can used the VFD controlled motors lead to increased reliability and improve performance of motor providing the automated control which results in higher energy saving.

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