Efficient Induction Motor Speed Control using ZigBee Wireless Technology

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Abstract

Induction motor speed control plays a significant in industrial applications. The introduction of technologies, likeVFDsand PLCs has greatly enhanced the performance of industrial processes. However, as technology continues to advance, industries face the challenge of efficiently monitoring and controlling induction motors without incurring significant costs to upgrade their existing systems.

This paper focuses on addressing this challenge by proposing a cost-effective solution for real-time monitoring and control of induction motors. The proposed approach utilizes a wireless module (ZigBee) to establish a connection between a remote SCADA system and the induction motor. This allows for convenient monitoring of motor performance even while on the move, using mobile phones. Furthermore, the solution can be easily implemented in industries of any scale and with any type of PLC, as PLCs offer advantages over peripheral interface controllers (PICs) due to their fewer limitations.

Keywords:PLC,ZIGBEE,SCADA,VFD,MODBUS

I. INTRODUCTION

Ensuring the safe-gaurd of induction motors (IMs) in commercial applications is of the utmost importance due to their extensive use as actuators. A new protection method for IMs has been introduced, leveraging Programmable Logic Controllers (PLCs). This method offers several advantages, including the elimination of timers, contactors, relays, and conversion cards. Additionally, it enables the monitoring of voltages, currents, speed, temperature, and any occurring issues in the system, with warning messages displayed on a computer screen. The utilization of PLCs not only provides a safer and visual environment, but also offers higher accuracy.

To implement this technique, a VFD is employed to measure the motor's parameters, and the information is tanto the SCADA base station using ZigBee technology. By utilizing the RS485 interface with the PLC, it becomes possible to start, stop, and protect the motor against faults such as overcurrent and overheating in windings, as well as under/over voltage conditions. The SCADA system records all received parameter data in a historical database, enabling real-time control, monitoring, and protection of the system.

By incorporating a VFD as an intermediary between the induction motor and the PLC, the system achieves efficient and smooth speed control, particularly at higher speeds. SCADA system actively analyses the PLC and manages the operation of the induction motor. ZigBee technology is chosen for wireless communication due to its advantages over other options such as GSM, WPANs, and Bluetooth. These advantages include low data rates, longer battery life, and secure networking.

The SCADA system is designed using Intouch 7, while the ladder logic for the PLC is programmed using WPL Soft 2.3. By adopting this proposed solution, industries can effectively monitor and control induction motors in real time, ensuring improved efficiency and reduced costs without the need for extensive system refurbishment.

II. PROGRAMMABLELOGIC CONTROLLER(PLC)

In an industrial setting, a PLC is a system designed to perform specific functions by utilizing programmable memory. These functions include logic operations, sequencing, timing, counting, and arithmetic. The programmable controller interfaces with machines or processes through digital or analog inputs and outputs to facilitate control.

The programmable controller acts as a computer, where control devices provide incoming control signals to the unit. These incoming control signals are referred to as inputs. The inputs interact with instructions defined in the user program, which dictates how the programmable controller should respond to the incoming signals. Furthermore, the user program guides the programmable controller in controlling field devices such as motor starters, pilot lights, and solenoids. An output refers to a signal sent from the programmable controller to control a field device.

III. SUPERVISORY CONTROL AND DATAACQUISITION SYSTEMS (SCADA)

SCADA is an acronym referring to a computer system employed to collect and analyse real-time data. SCADA systems find application in various industriesfor monitoring and controlling plants or equipment. These systems gather information, such as detecting pipeline leaks, and transmit it back to a central site, notifying the home station of the occurrence. Subsequently, the system performs necessary analysis and control tasks, such as assessing the criticality of the leak, while presenting the information in a logical and systematic manner.

SCADA systems can range from relatively simple implementations, like monitoring environmental conditions in a small office building, to highly intricate setups, such as overseeing the operations of a nuclear power plant or a municipal water system. The inception of SCADA systems dates back to the 1960s.

Various computer features fall under the umbrella of "real-time" technology. Real-time operating systems, which react quickly to incoming input, are one example. These systems are employed in situations where the computer must respond instantly to a continuous stream of fresh data, such as navigation. The majority of general-purpose operating systems, in contrast, may take a few seconds or minutes to respond, making them non-real-time.

Additionally, the term "real time" can be used to describe computer simulations that mimic the speed at which events happen in the actual world. For instance, a real-time programme in graphics animation would show items moving across the screen at the same speed as they would in reality.

IV. VARIABLE FREQUECY DRIVE

The application of Variable Frequency Drives (VFDs) in HVAC systems has witnessed a remarkable surge, particularly in recent times. VFDs have become widely utilized in diverse HVAC components. Gaining a comprehensive understanding of VFDs is crucial for optimizing equipment selection and enhancing the overall performance of HVAC systems. Therefore, the objective of this paper is to offer a fundamental comprehension of key VFD terminology, VFD operation principles, and associated benefits.

V. VFD OPERATION

Rectifier, DC bus, and inverter are the three main components of a Variable Frequency Drive (VFD), and knowledge of them is crucial to understanding the fundamental principles underpinning their operation. The voltage of an alternating current (AC) power source has a sinusoidal waveform, which makes it possible to transmit significant amounts of energy over considerable distances (see Fig. 1). Current flows in one direction when there is a positive voltage, and the opposite is true when there is a negative voltage.

Direct current (DC) electricity is created within a VFD by the rectifier, which transforms incoming AC power. Two rectifiers are needed for each phase of power, one for positive voltage and the other for negative voltage. Since a minimum of six rectifiers must be used since the majority of big power supply are three-phase, the term "6 pulse" is used to describe a drive with six rectifiers. Multiple rectifier sections, each comprising six rectifiers, are a feature of VFDs that enable "12 pulse," "18 pulse," or "24 pulse" combinations (see Fig. 2). Harmonic section discussed the advantages of multi-pulse VFDs.

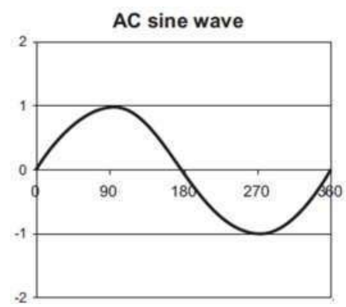


Fig. 3.1. AC sine wave

To rectify power, rectifiers might use transistors, SCRs, or diodes. When the voltage has the proper polarity and is applied to a diode, power can flow through the device. SCRs are helpful for solid-state starters because they have a gate circuit that enables a microprocessor to control the commencement of power flow. The most versatile of three devices is provided by transistors thanks to their gate circuitry. When transistors are used in the rectifier part of a VFD, it is said to have a "active front end."

After the rectifiers, the energy is stored on a dc bus that has capacitors to take in and hold energy from the rectifier section. Inductors, DC links, chokes, and other inductance-introducing devices may be used on a variable frequency drive's (VFD) DC bus. By doing this, the DC bus's incoming power supply is made more uniform. Transistors that are in charge of powering the motor are found in the VFD's final component, the "inverter," which is referred to as such. Insulated Gate Bipolar Transistors (IGBTs), a common component in contemporary VFDs, are used. The precise control of the power supplied to the motor is made possible by these IGBTs' quick switching on and off thousands of times per second. For the purpose of creating a simulated current sine wave at the specified frequency for

Speed (rpm) = Frequency (hertz) x 120 / Number of poles

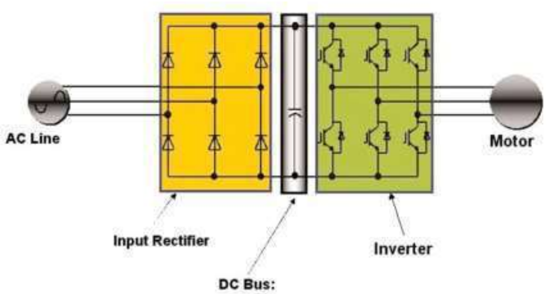


Fig. 3.2. VFD basics: Existing technology

VI. ZIGBEE TECHNOLOGY

Although there are many high-data-rate protocols in use today, none of them are compatible with the communication needs of sensors and control devices. Even at modest bandwidths, these standards call for low latency and energy usage. Zigbee technology, a wireless system that is both affordable and energy-efficient, stands out for its remarkable qualities and iswell-suited for a numerous applications such as industrial control systems,embedded systems , home automation system,etc.

The basis of Zigbee communication is the IEEE 802.15.4 standard for wireless personal area networks (WPANs), which is a technology specifically created for control and sensor networks. This communication standard, created by the Zigbee Alliance, specifies the physical and MAC layers to effectively manage a large number of low-data-rate devices. The frequencies used by Zigbee WPANs are 2.4 GHz, 902-928 MHz, and 868 Mhz. It enables periodic and two-way data transmission between sensors and controllers at a data rate of 250 kbps. Widely used in control and monitoring applications, Zigbee is a low-cost, low-power mesh network that offers coverage over an area of 10 to 100 metres. Zigbee is easier to use and less expensive than other short-range wireless sensor networks like Bluetooth and Wi-Fi.

Various network configurations for master-to-master or master-to-slave communications offered by Zigbee , enabling battery power conservation. It can operate in different modes, enhancing its versatility. By incorporating routers, Zigbee networks can be extended, allowing multiple nodes to interconnect and create a wide area network.

Zigbee handles data handling for both periodic and sporadic data transmission at application-defined rates, allocating time slots appropriately. Periodic data is efficiently managed by the beacon system, while intermittent data, such as light switches, can be handled by a beaconless system or disconnectedly. Additionally, Zigbee offers guaranteed time periods designed expressly for applications requiring low-latency data

VII. PROPERTIES OF ZIGBEE TECHNOLOGY

- An easy to follow the approach andit is widely used.
- Supports a high density of nodes per network, allowing for up to 18,450,000,000,000,000,000 devices and 65,535 networks.

- Reduces power consumption and elongated battery life.
- Supports multiple network topologies
- For low latency applications, it offers a supplemental guaranteed time window
- Offers a typical range of 50 meters (actual range can vary from 5 to 500 meters depending on the environment).

SPEED OF AN INDUCTION MOTOR

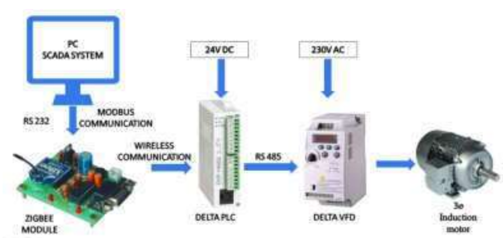
In an induction motor, the rotational frequency(f) and the number of poles (P) on the stator determines the synchronous speed (NS) of the stator magnetic field. It can be calculated using the equation **NS = 120f/P,** where NS is expressed in RPM.

In an induction motor, the rotor's magnetic field, induced by the voltage, is of alternating nature. In order to align with the rotating stator flux, the rotor initiates motion in the same direction as the stator. However, in practical scenarios, the rotor never manages to completely synchronize with the stator field.As a result, the rotor rotates at the Base Speed (Nb), which is slower than the stator field. Slip refers to the variation between NS and Nb. Based on the load circumstances, slide varies in intensity. An increase in load leads to a decrease in rotor speed and an increase in slip. In contrast, a decrease in load prompts the rotor to accelerate, which lowers slip.

RS-485

RS-485, an EIA standard interface widely utilized in the data acquisition domain, is a prevalent choice. It offers a balanced transmission line that can be employed in Multidrop mode, allowing efficient communication. RS-485 excels at enabling high-speed data transmission over extended distances, even in challenging real-world conditions. It surpasses the capabilities of RS-232 by supporting greater baud rates and longer communication spans. As per the standard specifications, a maximum speed of 100 kbit/s is achievable, with a potential distance coverage of up to 4000 feet (1200 meters).

OVERALL DESIGN



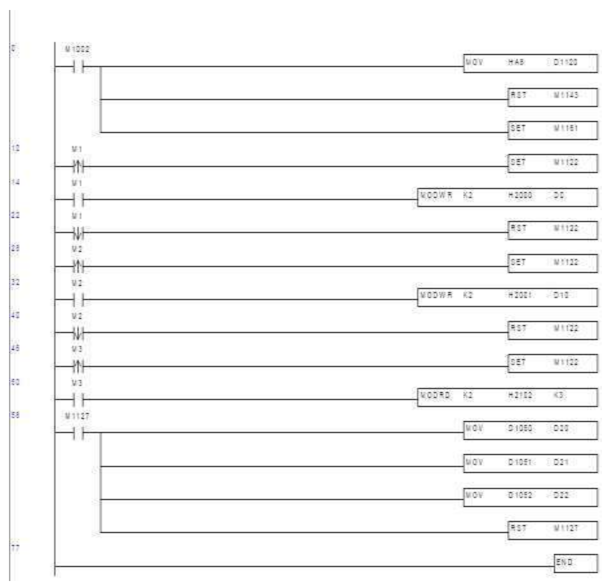
WORKING OF THE SYSTEM

The speed regulation of the IMs is got through the utilization ofVFD. To establish communication between the drive and the programmable logic controller (PLC), an RS-485 cable is employed. This communication method relies on the Modbus driver for serial data transmission. In addition, ZigBee technology is employed to facilitate communication between the SCADA system and PLC, offering a wireless solution that surpasses the limitations of wired connections. This wireless system provides real-time capabilities, making it a viable option for various industrial applications. Furthermore, the proposed system can be seamlessly integrated into existing industrial setups for enhanced operational efficiency.

HARDWARE CONFIGURATION

SOFTWARE CONFIGURATION

LADDER LOGIC PROGRAMMING



VIII. CONCLUSION

This paper presents a comprehensive solution for small industries seeking an efficient wireless control and monitoring system for induction motors. The proposed system offers fast and reliable operation with minimal faults, providing real-time data for efficient decision-making. The inclusion of a robust database facility ensures easy access to historical information for future reference. The seamless integration with process computers for SCADA further enhances the system's versatility and usability. With its low power consumption and minimal maintenance requirements, this wireless control and monitoring solution offers a successful and sustainable approach. By adopting this system, small industries can optimize their operations, improve productivity, and streamline their processes effectively.

REFERENCE

1. D. Sowmiya, IEEE2012, “Monitoring and Control of a PLC Based VFD Fed Three Phase Induction Motor for Powder Compacting Press Machine”
2. Maria G. Ioannides, IEEE2004, “Design and Implementation of PLC-Based Monitoring Control System for Induction Motor”
3. Ashraf Salah El Din Zein El Din, IEEE2006, “PLC-Based Speed Control of DC Motor”
4. Sethupriyan, Selvaraj, Surendar, IJAREEIE/2014, “A Wireless Speed Control of Ac Drive System”
5. Mr. Manoj M Kharade ,Prof. Dr. Mrs. N.R.Kulkarni, IJISET/2015, “ V/F Speed Control Of Three Phase Induction Motor By Using Plc And Scda “
6. Ayman SeksakElsaid, Wael A. Mohamed, Salah Ghazy Ramadan, IJERA/2016,”Speed Control of Induction Motor Using PLC and SCADA System”
7. S. Takiyar and B. K. Chauhan, IJCEE/2013,”Hybrid Method for Customized Control of Induction Motor”
8. Anshul Tiwari, Abhay Pratap Singh, Aditi Dixit, Debojyoti Sen, GJAET/2016,”PLC APPLICATION FOR SPEED CONTROL OF INDUCTION MOTORS THROUGH VFD”
9. 1Syed Usama Hassan, 2Hafiz Bilal Akram, Student Research Paper Conference/2015,” Speed and Frequency Control of AC Induction Motor Using Variable Frequency Drive “
10. RinchenGeongmitDorjee , IJRITCC/2014,”Monitoring and Control of a Variable Frequency Drive Using PLC and SCADA”
11. Arun Nadh, Lakshmi Praba N., IEEE/2013, “Automatic speed and torque monitoring in induction motors using ZigBee and SMS”
12. YASAR BIRBIR*, H.SELCUK NOGAY, IJSAED/2008, “Design and Implementation of PLC-Based Monitoring Control System for Three-Phase Induction Motors Fed by PWM Inverter”