A MICROCONTROLLER BASED PROTECTION AND CONTROL OF A LOW VOLTAGE MOTORS BY USING ZIGBEE TECHNOLOGY

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ABSTRACT

In this paper describes, a low voltage motors are critical assets in today’s industrial applications. This paper reviews the applications of microcontroller-based protection and control on low voltage motors less than 600V AC in industrial facilities. It will review the principles of low voltage motor protection (thermal overload, ground fault and unbalance). Communications play key role in the starting and stopping of low voltage motors. This paper will also discuss several different starting/ stopping controls using communication protocol i.e., ZIGBEE technology.

Keywords: Low voltage motors, ZIGBEE, RS-232 and Communication Protocol, Keil uVision Software.

1. INTRODUCTION

An induction machine plays a vital role in industry and there is a strong demand for their reliable and safe operation. They are generally reliable but eventually do wear out. Faults and failures of induction machines can lead to excessive downtimes and generate large losses in terms of maintenance and lost revenues, and this motivates the examination of condition monitoring. On condition monitoring involves taking measurements on a machine while it is operating in order to detect faults with the aim of reducing both unexpected failures and maintenance costs. This paper surveys the current trends in on-line fault detection and diagnosis of induction machines and identifies future research areas.

Condition monitoring of electric machinery can significantly reduce the cost of maintenance and the risk of unexpected failures by allowing the early detection of potentially catastrophic faults. In condition based maintenance, one does not schedule maintenance or machine replacement based on previous records or statistical estimates of machine failure. Rather, one relies on the information provided by condition monitoring systems assessing the machine’s condition. Thus the key for the success of condition based maintenance is having an accurate means of condition assessment and fault diagnosis.

Wireless sensor network for condition monitoring uses measurements taken while a machine is operating to determine if a fault exists. Different types of sensors can be used to measure signals to detect these faults. Various signals processing techniques can be applied to these sensors signals to extract particular features which are sensitive to the presence of faults. Finally, in the fault detection stage, a decision needs to be made as to whether a fault exists or not. This paper is to monitor the operating conditions of single-phase induction motors. This system is based on a low cost electronic device that can acquire and pre-process current, voltages and temperatures, and transmit processed key-information related to the motor operation condition using ZIGBEE wireless technology.

2. EXISTING SYSTEM

During the past two decades, the progress in microelectronics and VLSI technology drove the cost of many consumer electronic products down to an acceptable level for average people. Only in the 1st quarter of 2001, over 32.5 million PC’s were sold. The number of cellular phones is predicted to reach 1 billion in 2005. With the increase of the number of these devices, so does the need of connecting them together. Today numerous kinds of special cables are used for interconnection. It’s cumbersome not interchangeable and expensive. Present we are using two types of wireless technologies to control and monitor the low voltage motors i.e.; Bluetooth and Infrared.

2.1. BLUETOOTH TECHNOLOGY

Bluetooth is a device to replace these cables. It is a low cost, low power, radio frequency technology for short range communications. It can be used to replace the cables connecting portable/fixed electronic devices, build ad-hoc network or provide data/voice access points.

The advancement in microelectronics makes it possible to integrate complex functions into one small chip and thus achieve a low cost. With its low cost, low power consumption and low profile, you can virtually put one anywhere you want. This will make many concepts like smart appliances and embedded internet possible. The development gained support from many companies. Currently, there were about 2500 companies joined the Bluetooth Special Internet Group (SIG). There are some commercial products available, and much more are
rolling out. A new standard for Wireless Personal Area Network (WPAN)-IEEE802.15 is being developed, and to a large extent, it’s an extension of Bluetooth. Despite its advantages, one of its key limitations so far is its speed. With a maximum data rate of 720KBps, it cannot be used to connect DVD players or HDTV, and it takes a long time to transfer large picture files to a printer. New version of Bluetooth may address this issue and have much higher data rate.

2.2. INFRARED TECHNOLOGY
Infrared radiation is the region of the electromagnetic spectrum between microwaves and visible light. In infrared communication an LED transmits the infrared signal as bursts of non-visible light. At the receiving end a photodiode or photoreceptor detects and captures the light pulses, which are then processed to retrieve the information they contain. Some common applications of infrared technology are augmentative communication devices, car locking systems, computers, emergency response systems, headphones, navigation systems, home security systems, telephones, toys, TV’s, VCR’s, stereos etc.,

2.3. DISADVANTAGES
Bluetooth and infrared having following disadvantages.
- Line of sight: Transmitters and receivers must be almost directly aligned for infrared.
- Blocked by common materials: People, walls, plants etc. can block transmission.
- Short range: Performance drops off with longer distances.
To rectify the above drawbacks we use ZIGBEE technology today and future.

3. PROPOSED SYSTEM
The proposed section consists of two sections i.e. monitoring section and motor section

3.1. MONITORING SECTION
In this monitoring section, consists of Power Supply section, Microcontroller section, ZIGBEE Transceiver, PC, MAX 232. The monitoring section block diagram shown below figure 1.

![Fig 1: Monitoring Section](image)

- **POWER SUPPLY SECTION:**
  This section is meant for supplying power to all the sections mentioned above. It is basically consists of a Transformer to step down the 230V AC to 12V AC followed by diodes. Here diodes are used to rectify the AC to DC. After rectification the obtained rippled DC is filtered using a Capacitor Filter. A positive voltage regulator is used to regulate the obtained DC voltage.

- **MICROCONTROLLER SECTION:**
  This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

- **ZIGBEE TRANSCEIVER:**
  Transceiver is a device which acts as both transmitter and receiver. This operates with 2.8V to 3.4V. Range of the transceiver module is 30-70m in urban areas and 1-1.5km in outdoor (LOS). The transceiver has an on-chip wire antenna and it operates at a frequency of 2.4GHz. The data received from the microcontroller is organized based on the ZIGBEE protocol standards and then modulated. Along with the data, source address and destination address are added and sent. This organized data is send to the receiver through RF antenna.

- **MAX -232:**
  To allow compatibility among data communication equipment made by various manufactures, an interfacing standard called RS-232 was set by the Electronic Industries Association (EIA). This RS-232 standard is used in PCs and numerous types of equipment. However, since the standard was set long before the advent of the TTL logic family, its input and output voltage levels are not TTL compatible. In RS-232, a1 is represented by -3V to -25V, while a0 bit is +3V to +25V, making -3V to +3V undefined. For this reason, to connect any RS-232 to a microcontroller system we must use voltage converters such as MAX-232 to convert the TTL logic levels to the RS-232 voltage levels and vice-versa. So here we are using this MAX-232 to have compatibility between the PC and microcontroller.
The schematic diagram for monitoring section shown below in figure 2

![Schematic diagram for monitoring section](image)

**Fig 2: Schematic diagram for monitoring section**

### 3.2. MOTOR SECTION

In this motor section, consists of Power Supply section, Microcontroller section, ZIGBEE Transceiver, PC, MAX 232, LCD display, ADC, Motor driver, Motor, Sensors. The motor section block diagram shown below figure 3.

![Motor Section](image)

**Fig 3: Motor Section**

- **LCD DISPLAY SECTION:**
  This section is basically meant to show up the status of the module. This module makes use of Liquid Crystal Display to display/prompt for necessary information.

- **SENSORS:**
  This part of the system consists of various sensors, temperature, Ground fault, Voltage and Current. These sensors sense various parameters of motor temperature, voltage and current and these are then sent to the Analog to Digital Converter. Here Microcontroller will send obtained data from ADC to remote areas using Zigbee Transmission and this data which is received at the receiver side is displayed on PC.

- **ADC:**
  ADC is a device converting signals from analog to digital form. This is used to convert the sensor values which are in analog form to digital for and provide it to microcontroller.

- **RELAY:**
  In this paper Relays are used to trip the motor and boiler. A relay is an electrical switch the opens and closes under control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or more sets of contacts.

- **MOTORS:**
  In many industries using induction motors for their applications as loads. In this module also we used induction motor. Here it is protected by using microcontroller based protection and controlled by ZIGBEE transceiver.

The schematic diagram for monitoring section shown below in figure 4.

### 3.3. SCHEMATIC DIAGRAM DESCRIPTION:

Firstly, the required operating voltage for Microcontroller 89C51 is 5V. Hence the 5V DC power supply is needed by the same. This regulated 5V is generated by first stepping down the 230V to 12V by the step down transformer. In the power supply the step downed AC voltage is being rectified by the bridge rectifier. The diodes used are IN4007. The rectified AC voltage is now filtered using s ‘C’ filter. Now the rectified, filtered DC voltage is fed to the voltage regulator. In power supply the voltage given to Microcontroller 5V is generated.
using 7805. The rectified, filtered and regulated voltage is again filtered for ripples using an electrolytic capacitor 100μF. Now the output from the first section is fed to 40th pin of 89C51 Microcontroller to supply operating voltage and from other power supply to circuitry.

![Schematic diagram for motor section](image)

**Fig 4: Schematic diagram for motor section**

The Microcontroller 89C51 with pull up resistors at port0 and crystal oscillator of 11.0592MHz crystal in conjunction with couple of capacitors is placed at 18th pin and 19th pin of 89C51 to make it work properly.

**MOTOR SECTION:**

In this paper we are using the ADC0808, which is interfaced to the microcontroller. The output lines or data lines of the ADC are connected to port1, ALE pin is connected to pin P3.4, which enables the address, SC pin is connected to P3.5, which indicates the start conversion to the ADC, EOC is connected to P3.6, which indicates the End of Conversion. Here A, B pins of the ADC is connected to P3.2, P3.3 respectively, which is used to select a particular channel of the ADC. The parameters like temperature sensor, voltage sensor and current sensor are given to IN0, IN1 and IN2 respectively which are acting as the analog inputs.

The motor is connected with a main supply, but it is switched and controlled with Relay which is connected to P2.0 of Microcontroller pin. Boiler Section through relay and ground fault detection circuit through transistor logic are connected to P2.2 and P2.1 respectively.

**3.4. CIRCUIT DESCRIPTION:**

This section gives an overview of the whole circuitry and hardware involved in the module made in this paper. In this paper we are giving power supply to all units, it basically consists of a transformer to step down the 230V AC to 18V AC followed by diodes. Here diodes are used to rectify the AC to DC. After rectification the obtained rippled DC is filtered using a capacitor filter. S positive voltage regulator is used to regulate the obtained DC voltage. But here in this paper two power supplies are used one is meant to supply operation voltage for Microcontroller and the other separate supply for boiler section.

In this paper a ZIGBEE communication system was developed to monitor the operation conditions of Single-Phase Induction Motor. This system is based on a low cost electronic device that can acquire and pre-process current, ground fault, voltages and temperatures and transmit processed key information related to the motor operation conditions. Information about operating parameters of motor can be sent to a central processing unit allowing knowledge of key information of the motor in the plant. If the parameters like voltage, current etc., exceed the threshold value automatic motor is off. The various parameter data is displayed on PC. This data can be used in the implementation of effective motor management strategies targeting motor efficiency optimization, proper replacement and sizing and optimized rewinding. In motor section, sensors are placed to monitor the operating conditions of motor parameters like current, voltage, ground fault and temperature sensors. These sensors will measure the current, voltage, ground fault detection and temperature of motor respectively.

**4. RESULTS**

**Software Results:**
1. Click on the Keil uVision Icon on Desktop. Then it will show following figure 5.

![Keil uVision open](image)

**Figure 5: Keil uVision open**
2. Click on the project menu from the title bar and select on New project.

Figure 6: Open project menu

3. Save the project by typing suitable project name with no extension in your own folder sited in either C:\ or D:\. Then click on save button.

Figure 7: Enter project name

4. Select the component for your project i.e. Atmel and click on the + symbol beside the Atmel.

Figure 8: Select component Atmel

5. Select AT89C51 and click on “OK”.

Figure 9: Select AT89C51

6. Click either “YES” or “NO”. Now new project is ready to use

Figure 10: Project ready

7. Now double click on the Target 1, and select Source group 1.

Figure 11: Select Source
8. Click on the file option from menu bar and select “new”.

9. Now start writing program in either in “C” or “ASM”. For a program written in Assembly, then save it with extension “.asm” and for “C” based program save it with extension “.c”.

10. Now right click on source group1 and click on “Add files to group source”.

11. Now you will get another window, on which by default “C” files will appear.

12. Now select as per your file extension given while saving the file. Click only one time on option “ADD”. Now press function key F7 to compile. Any error will appear if so happen.
13. If the file contains no error, then press ctrl+F5 simultaneously. The new window is as follows. Then click “OK”.

![Figure 18: No errors](image1)

14. Now click on the peripherals from menu bar, and check your required port as shown in figure below.

![Figure 19: Select port](image2)

15. Drag the port a side and click in the program file. Now keep pressing function key “F11” slowly and observe. You are running your program successfully.

![Figure 20: Program performance](image3)

**HARDWARE RESULTS**

**STEP 1: Motor section**

![Fig 21: Motor Section](image4)
STEP 2: Monitor Section

Fig 22: Monitor Section

STEP 3: Motor Section Results Display in LCD

Fig 23: Motor Section Results Display in LCD

STEP 4: Result in Monitor

Fig 24: Result in Monitor

5. ADVANTAGES AND APPLICATIONS

ADVANTAGES
- High efficiency
- Load factor improved

APPLICATIONS
- To control speed and protection of a motor is used the following industrial applications
  - Machine tools
  - Cranes, Elevators, Vehicles
  - Pumps, Fans, Compressors
  - Rolling mills, Bending machines
  - Metal cutting machine tools
  - Slow speed vehicles
CONCLUSIONS
This paper “a microcontroller based protection and control of a low voltage motors by using ZIGBEE technology” has been successfully designed and tested. Integrating of all the hardware components used has developed it. Presence of every module has been reasoned out and placed carefully. Thus contributing to the best working of the unit. Secondly, using highly advanced IC’s and with the help of growing technology. By using ZIGBEE wireless technology we can control a low voltage motors with in the distance between 10 meters to 100 meters successfully.

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This paper is dedicated to my parents

AUTHOR’s BIOGRAPHY
