REMOTE MONITORING AND CONTROL SYSTEM FOR DC MOTOR USING ZIGBEE PROTOCOL

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Abstract

Wireless based industrial automation is a prime concern in our day-to-day life. The approach to Zigbee Based Wireless Network for Industrial Applications has been standardized nowadays. In this project, a wireless control and monitoring system for a D.C motor is realized using the Zigbee communication protocol for safe and economic data communication in industrial fields where the wired communication is either more expensive or impossible due to physical conditions.

The project involves the design of remotely starting, stopping, controlling and monitoring the D.C motor through computer interface using a Zigbee wireless motor control module. The module also includes the continous online monitoring of the motor parameters such as current, voltage, temperature, speed via radio frequency (RF) data acquisition system and storing them in a database designed using Visual basic. The designed system hence provides continous online monitoring, controlling and protection of the motor in real time. This work is oriented towards improving the remote controlling abilities of the system while keeping the hardware requirements minimum.

The system is fully controlled by the Personal Computer from a remote location through Visual Basics GUI (Graphical User Interface).The GUI is developed based on the requirement of the user. The Personal Computer will continuously monitor all the Data from remote processing unit and will store the received data in its database.

An 8- bit AVR microcontroller has been used in this work to interface the various sensors using the IEEE 802.15.4 standard, Zigbee protocol. Zigbee is a wireless communication protocol which has the characteristics of low power consumption, low cost and self organizing features. The designed embedded system can be used in applications such as food industry, chemical industry, etc.

Keywords: ATMEGA-16 controller, DC Motor, Monitor & Control System, Speed Sensor, WSN, Zigbee.

1. INTRODUCTION

The efficient design and implementation of WSN (Wireless Sensor Networks) has become an emerging area of research in recent years[1]**.** The vast potential of Wireless Sensor Networks is an emerging area of research in recent years. WSN consists of spatially distributed autonomous sensors to monitor physical or environmental conditions like temperature, sound, pressure and to cooperatively pass their data through the network to a main location. The advantage of wireless sensor network is that they can be used with ease in the environment where wired system cannot be used or if used, are to be treated with caution, for example, in medical treatment. The WSN is built of nodes- it may vary from few to several thousand [2]. Each sensor node has typically several parts- radio transceiver with internal or external antenna, a microcontroller for interfacing with the sensors, energy source or battery. Different types of WSN are- Wi-Fi, Bluetooth, Wimax, PAN (Personal Area Network), smart transducers, ZigBee.

This project is to automize the industrial system using an wireless embedded system using advanced

technologies. The purpose of this project is to improve the data acquiring system and also to provide adequate data logging for particular area. Now a day's every system is automated in order to face new challenges[3][4]. In the present days Automated systems have less manual operations, flexibility, reliability and accurate. Due to this demand every field prefers automated control systems. Especially in the field of electronics automated systems are giving good performance. And this is realized by making use of Zigbee technology for communication. Zigbee is new wireless technology guided by IEEE 802.15.4 Personal Area Network standard. It is primarily designed for the wide ranging controlling applications and to replace the existing non-standard technologies. It currently operates in 868MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40kbps in USA, and the 2.4GHz ISM bands Worldwide at a maximum data-rate of 250kbps.

2. ZIGBEE PROTOCOL

Zigbee is a low power spin off of WiFi. It is a specification for small, low power radios based on IEEE 802.15.4 – 2003 Wireless Personal Area Networks standard. The specification was accepted and ratified by the Zigbee alliance in December 2004. Zigbee Alliance is a group of more than 300 companies including industry majors like Philips, Mitsubishi Electric, Epson, Atmel, Texas Instruments etc. which are committed towards developing and promoting this standard. The alliance is responsible for publishing and maintaining the ZIgbee specification and has updated it time and again after making it public for the first time in 2005. Most of the recent devices conform to the Zigbee 2007 specifications has two feature sets– Zigbee and Zigbee Pro. The manufacturers which are members of the Alliance provide software, hardware and reference designs to anyone who wants to build applications using Zigbee[13]

2.1 Architectural Overview

Zigbee bases itself on the IEEE 802.15.4-2003 specifications which lay down standards for the Physical and MAC layers. The protocol stack is completed by adding Zigbee's own Network and Application Layers. Drawing analogies from the OSI protocol stack simplifies the study of Zigbee protocol. In the Figure 1, the two protocols are stacked up side by side to see the similarity of roles of various layers[8].

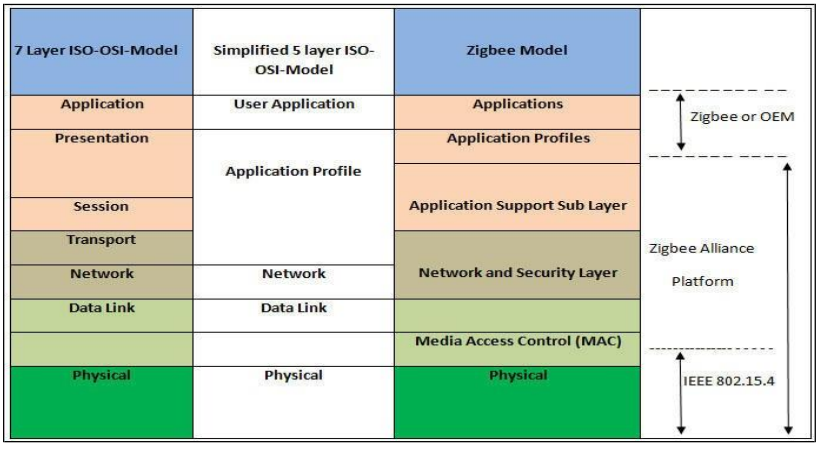


Figure 1 Zigbee Architecture [2]

A brief overview of each layer is as follows:

- Physical Layer: Zigbee uses three frequency bands for transmission- 868 MHz band with a single channel has a raw data rate of 20 kb/s.
- MAC Layer: Channel access is primarily through Carrier Sense Multiple Access- Collision Avoidance (CSMA- CA). On a node hop to hop basis, the MAC layer can take care of transmitting data.
- Network and Security Layer: The network layer takes care of network startup, device configuration, topology specific routing, and providing security.
- Application Support Sub-Layer: It interfaces the network layer and application layer providing a general set of services through two entities, the APS Data Entity (APSDE) and APS Management Entity (APSME) accessed through their respective Service Access Points (SAP). These provide services like binding management, making application level PDU, group filtering, and managing Object database called APS Information Base, providing reliability of transaction etc. which are the necessary functions for an application to work properly.

2.2 Zigbee Network Topologies

Zigbee is a standard for low-power, short range wireless devices based on an IEEE 802 standard for personal area networks(PAN). Zigbee modules work in unlicensed ISM(Industrial Scientific Medical) band. Zigbee devices are capable of peer-to-peer, point-to-multipoint and mesh communication as shown in Figure 2. They offer convenient low power wireless solutions for embedded systems where power consumption is a critical factor. A Zigbee network consist of three different types of ZigBee devices: coordinator, router, end-device. Each network has a 16bit PAN ID. All devices in a Zigbee network is assigned a single PAN ID.

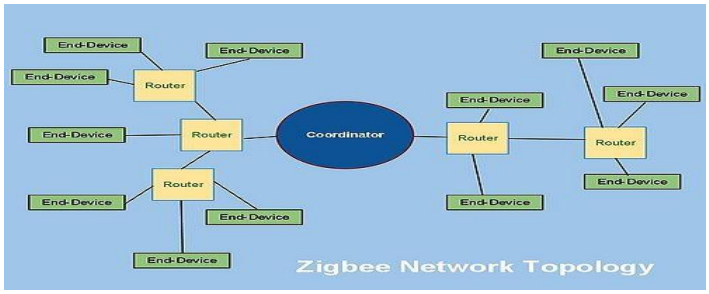


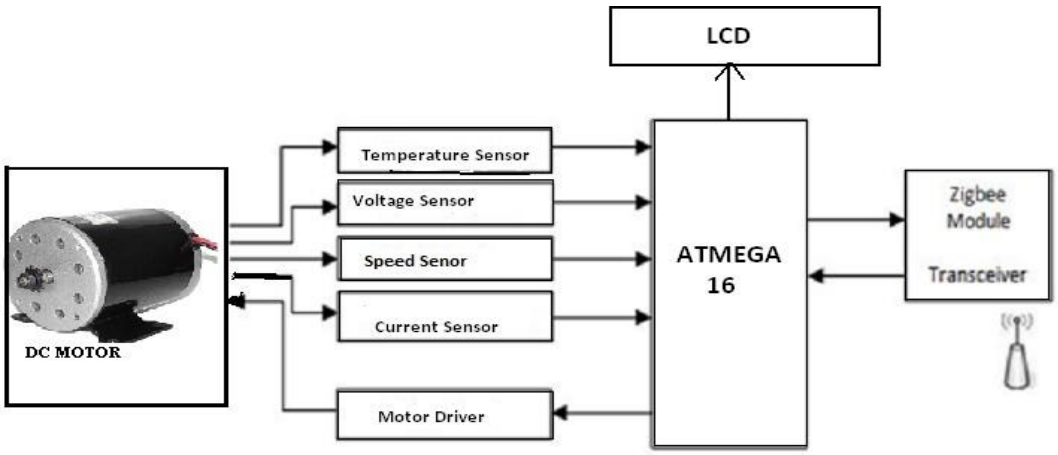
Figure 2: Zigbee Network Topology [13]

Security: There are three types of security modes defined: unsecured mode, access control list and secured mode.

1. Unsecured mode: No security used.
2. Access control list: No encryption used, but the network rejects frames from unknown devices.
3. Secured mode: In the secured mode the devices can use the following security services. Access control list. Data encryption using the Advanced Encryption Standard (AES) 128 bit encryption algorithm.

3. SYSTEM BLOCK DIAGRAM

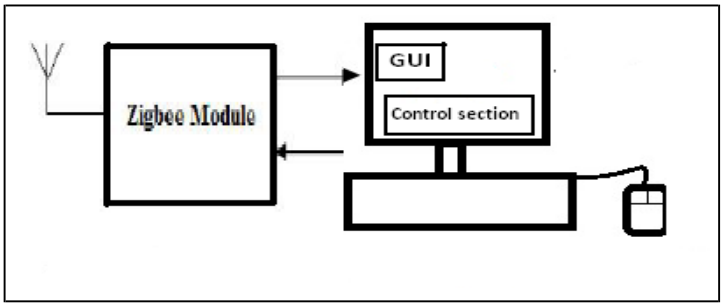
The block diagram for Transmitter and Receiver is as shown in Figure 3&4.In this system the D.C motor parameter such as speed, voltage, temperature winding and current rating are monitored and controlled[5]. At the transmitter side voltage, temperature, current are continuously monitored by the



appropriate sensors. The speed sensor is used to monitor the speed(rpm) of the motor.

Figure 3 Block Diagram of Transmitter Module

The driver is used to drive the D.C motor. The sensed signals are inputted to the microcontroller, which triggers the Zigbee module to transmit the signals. microcontroller will decode and analyze it[6]. Thus, the sensed signals will be displayed with the help of a LCD. and depending on the various sensor inputs output devices will be driven using the other The Zigbee will transmit the signal to



Personal Computer. For the interface between the Zigbee and the PC USB Cable is used, to connect zigbee to PC. The data will be displayed on PC through Zigbee protocol[10][11].

Figure 4 Block Diagram Receiver Module

PC will consists of Data logger which will have monitored data of all sensors with date and time [7]. The system is fully controlled by the Personal Computer through Visual Basics GUI (Graphical User Interface).Signal to the control section is given from PC. The GUI is developed based on application by the user. All the processor and controllers are interconnected to personal computer through Zigbee.

4. Software Design for Proposed System

The software design for system is proposed which incorporates measuring the DC motor parameter by sensors and convert them into digital form through microcontroller and displaying the parameters on

LCD[9]. It also includes the serial transmission of data to the receiver end wirelessly, using Zigbee protocol and storing the data on visual basics database and controlling the system wirelessly .The flowchart for transmitter and receiver is as shown in figure 5 & 6.

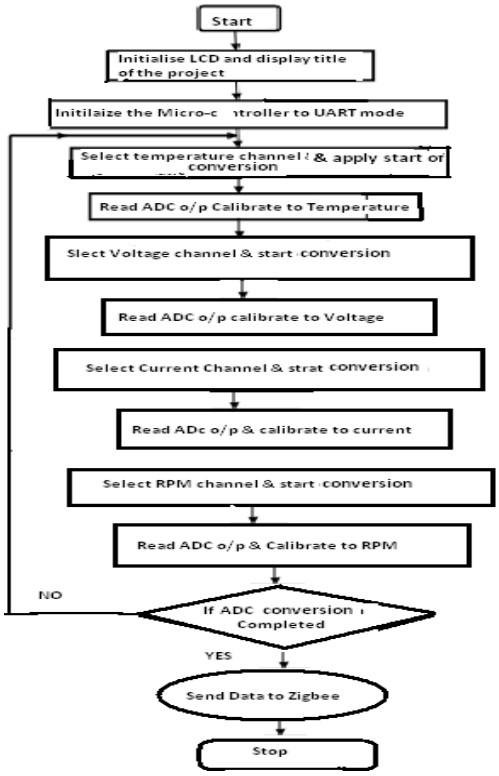


Figure 5 Flowchart for Transmitter section

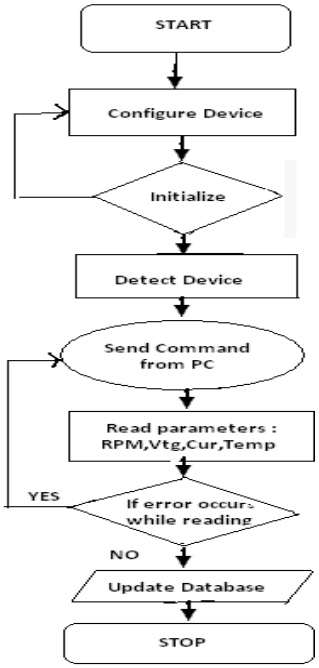


Figure 6 Flowchart for receiver section

5. IMPLEMENTATION

The complete hardware implementation of the system is as shown in Figure 7.

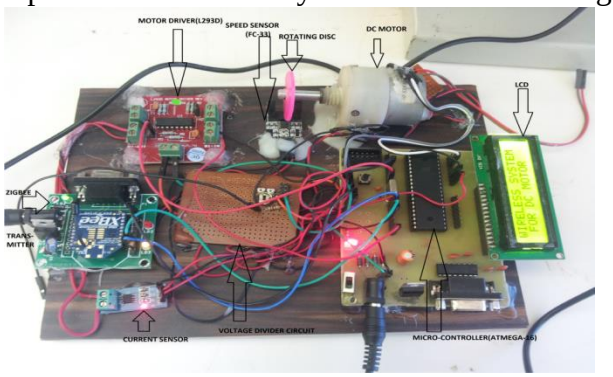


FIGURE 7 HARDWARE IMPLEMENTATION

The following components are used in the designed system:

1. Temperature Sensor(LM35): It is used tomeasure temperature more accurately at which the motor is running[12].

2. Voltage Sensor: It is used to sense the voltage at which the motor is running.
3. Current Sensor (ACS712ELC): It is use to measure the current at which the running. This sensor can measure the positive and negative 20A, corresponding to the analog output 100mV / A.
4. Electric speed sensor(FC-33): It is used to measure the rotations of the motor per seconds. It outputs low level when there is not block in the groove, otherwise it output high level. With the help of using timer then we calculate the RPM of the motor.
5. Power Supply: It is used in order to provide supply to Controller, Zigbee and Driver
6. Zigbee: It is a trans-receiver. ZigBee is used in applications that require a low data rate, long battery life, low power consumption, low cost and secure networking. ZigBee has a defined rate of 250 kbit/s
7. ATMEGA16 Controller: The controller will detect the analog input from the sensor and convert into digital[14].
8. LCD: It is use to display the value of sensor after it has been digitized.
9. DC Motor: 1000 rpm 12V motor is used in system whose parameters can be monitored.
10. Driver: A driver is used to drive the D.C motor .
11. PC: The monitored values will be displayed on PC on GUI and data logger formed helps in storing data.

6. RESULTS

COM Port Selection

Figure 8 shows the com port selected when zigbee is connected to com port of PC or Laptop

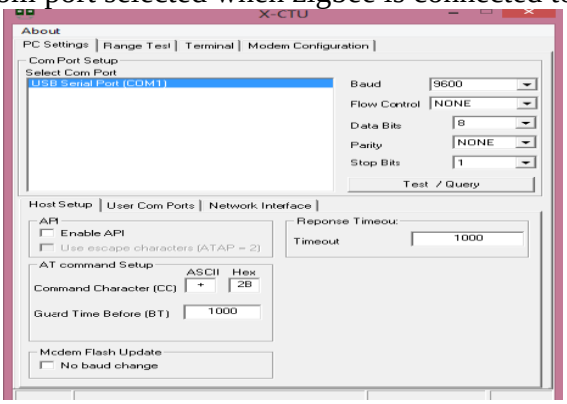


Figure 8 Zigbee Com port Selection

Serial communication

Figure 9 shows serial communication between zigbee and reception of data on X-CTU.

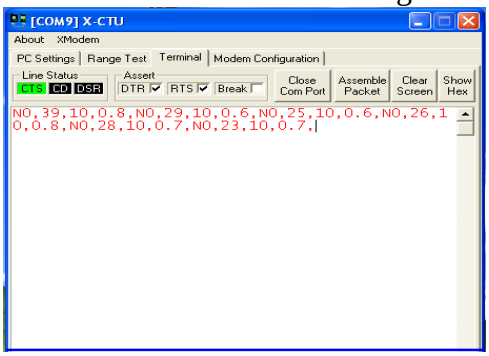


Figure 9 Serial communication between Zigbee Trans-Receiver

2.4 Visual basic form

The visual basic form with data and control buttons is as shown in
Figure 10 where : Yellow : Motor is running low speed
Green : Motor is running at medium speed
Blue : Motor is running at high speed

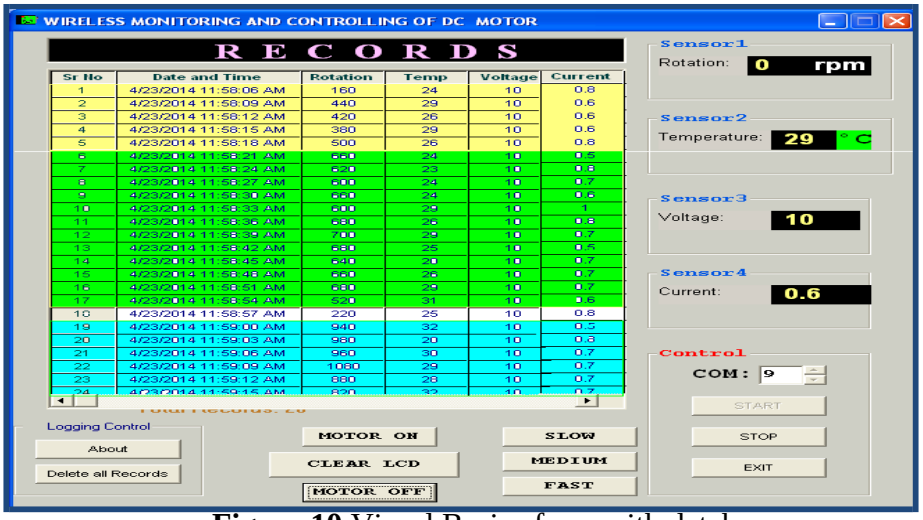


Figure 10 Visual Basics form with database

7. Conclusion and Future Work

This system will help in monitoring and control the D.C motor parameters which is widely used in industries. Use of Zigbee communication protocol helps in reducing the wires and hardware significantly. Remote monitoring and controlling is possible. Large network capacity: One ZigBee network contains one master device and maximum 254 slave devices. There can be as many as 100 ZigBee networks within one area. When not required zigbee goes into stand by mode and it also uses less power for communication hence power is conserved.

The future work includes increasing the distance between monitoring and control section by increasing the number of nodes i.e creating star, mesh topology etc. The other parameters of DC motor such as torque can also be monitored and automatic control of the system can be included in future work.

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