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Multi-objective sensor placement using the effective independence model for wireless sensor networks in machine health monitoring

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ABSTRACT

A wireless measurement and monitoring system for an electric drive system is realized using the ZigBee communication wireless standard for safe and economic data communication in industrial fields where the wired communication is either more expensive or impossible due to physical conditions. It is also possible to protect of the electric drive system against some faults such as over current, over voltage, higher temperature in windings. Therefore, controlling, monitoring, and protection of the system are realized in real time and it uses ZigBee wireless standard for remote data transmission along with Internet connectivity for assessment of the network-collected information. Therefore, the measuring devices and their respective sensors are studied accordingly. Algorithms have been developed allowing evaluation of additional parameters using data from the measurements held.

Keywords: Machine health monitoring, Pic16f877a microcontroller, Sensors, MPLAB IDE, Pickit 3.

INTRODUCTION

This paper proposes a design of wireless monitoring system of motor running state such as tilt angle, temperature, Vibration, current. This design adopts the structural health monitoring (SHM) techniques to monitor the state of motor. Although the SHM has been widely applied to civil engineering and building structures subjected to various loadings, there are few applications in the running state monitoring for the power transmission and communication of motors. In this study, micro-electro-mechanical system (MEMS)-based acceleration sensor is used, in which a method is employed for calculating the tilt based on the difference between the acceleration due to combination of gravity and other stresses and the acceleration due to gravity alone. The wireless system uses wireless sensor nodes to transmit the motor running state data to the monitoring server. The wireless sensor node system consists of a short-distance wireless transmission network (ZigBee 2.4GHz).By doing so, the important problem about the communication distance limitation is resolved. The performance of the monitoring system is evaluated through several experiments. The experimental results indicate the wireless monitoring system can accurately monitor the motor running state in real time.

Figure: Circuit diagram of zigbee module

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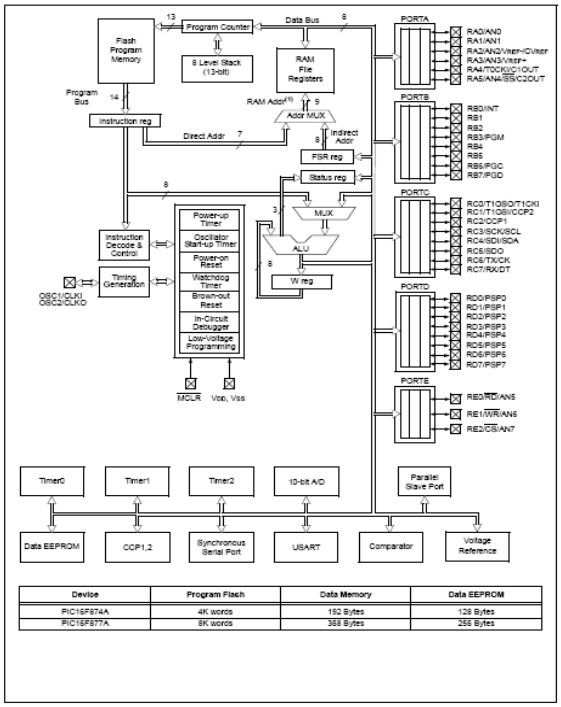
PIC16F877A MICROCONTROLLER

In this project we used PIC 16f877A microcontroller. For most applications, we will be able to find a device within the family that meets our specifications with a minimum of external devices, or an external but which will make attaching external devices easier, both in terms of wiring and programming.

For many microcontrollers, programmers can built very cheaply, or even built in to the final application circuit eliminating the need for a separate circuit. Also simplifying this requirement is the availability of micro-controllers wit SRAM and EEPROM for control store, which will allow program development without having to remove the micro controller from the application circuit.

THE PIC16F877A BLOCK DIAGRAM



Device	Program Flash	Data Memory	Data EEPROM
PIC16F874A	4K words	192 Bytes	128 Bytes
PIC16F877A	8K words	368 Bytes	256 Bytes

WHY PIC16F877A IS USED?

The PIC microcontroller PIC16f877a is one of the most renowned microcontrollers in the industry. This controller is very convenient to use, the coding or programming of this controller is also easier. One of the main advantages is that it can be write-erase as many times as possible because it use FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output. PIC16F877A is used in many pic microcontroller projects. PIC16F877A also have many application in digital electronics circuits.

PIC16f877a finds its applications in a huge number of devices. It is used in remote sensors, security and safety devices, home automation and in many industrial instruments. An EEPROM is also featured in it which makes it possible to store some of the information permanently like transmitter codes and receiver frequencies and some other related data. The cost of this controller is low and its handling is also easy. It's flexible and can be used in areas where microcontrollers have never been used before as in coprocessor applications and timer functions etc.

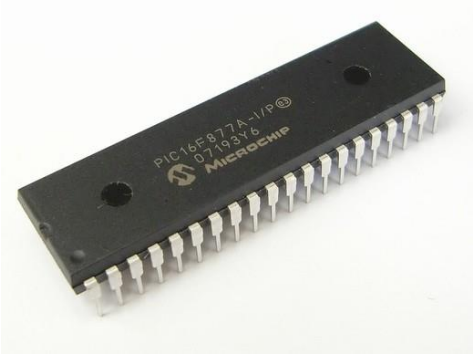


FIGURE: PIC16F877A

WHAT IS WSN MODULE?

Wireless sensor network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind, and so on.

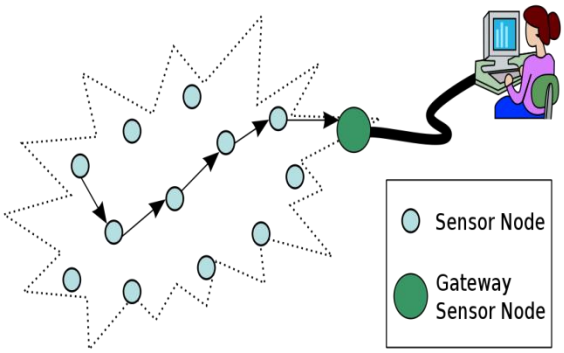


Figure: Block diagram of WSN architecture

WHAT IS SENSOR?

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing.

TYPES OF SENSORS

Temperature sensor

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the to obtain convenient Centigrade scaling. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ºC).

Figure:Temperature Sensor

Mems sensor

Acceleration is a measure of how quickly speed changes. Just as a speedometer is a meter that measures speed, an accelerometer is a meter that measures acceleration. The MMA7361L is a low power, low profile capacitive accelerometer featuring signal conditioning. The MMA7361L includes a Sleep Mode that makes it ideal for handheld battery powered electronics.

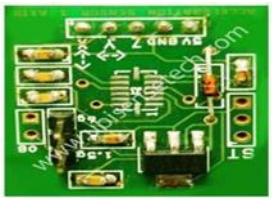


Figure: Mems Sensor

Current sensor

A current sensor (CT1270) is a device that detects electric current (AC or DC) in a wire, and generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output When a current flows through a wire or in a circuit, voltage drop occurs. Also, a magnetic field is generated surrounding the current carrying conductor. Both of these phenomena are made use of in the design of current sensors. Thus, there are two types of current sensing: direct and indirect. Direct sensing is based on Ohm's law, while indirect sensing is based on Faraday's and Ampere's law. Direct Sensing involves measuring the voltage drop associated with the current passing through passive electrical components.

Indirect Sensing involves measurement of the magnetic field surrounding a conductor through which current passes. Generated magnetic field is then used to induce proportional voltage or current which is then transformed to a form suitable for measurement and/or control system.

Figure: Current Sensor

RELAY

Relays are simple switches which are operated both electrically and mechanically. Relays consist of a n electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit.

It is also used in places where only one signal can be used to control a lot of circuits. They were used to switch the signal coming from one source

to another destination. The high end applications of relays require high power to be driven by electric motors and so on. Such relays are called contactors.

Figure: Single Relay Board

UART CABLE

The USB_RS232 cables are a family of USB to RS232 levels serial UART converter cables incorporating FTDI's FT232RQ USB to serial UART interface IC device which handles all the USB signaling and protocols. The cables provide a fast, simple way to connect devices with a RS232 level serial UART interface to USB. Each USB-RS232 cable contains a small internal electronic circuit board, utilizing the FT232R, which is encapsulated into the USB connector end of the cable. The integrated electronics also include the RS232 level shifter plus transmitter and receiver. LEDs which give a visual indication of traffic on the cable

Figure: USB to RS232 converter.

PIC ASSEMBLED PCB+UART+LCD

This board is build with PIC16F877A as a microcontroller unit. The input supply to the board can be fed from both ac and dc. It uses a crystal oscillator for generating frequency. A serial communication is achieved by an UART protocol. This board is specially designed for connecting digital and analog sensors which has input voltage range 5 or $12V_{DC}$ as well as it can be interfaced with serial communication devices, relay boards etc. The output can be monitored in LCD as well as pc. Data EEPROM is used to store data defined by the user. PCB design. When a variable is defined it is stored in program memory and the value of the variable is stored in data EEPROM Synchronous serial ports are used to communicate with other peripheral devices like serial EEPROMS, A/D converters and shift registers.

Figure: Pic Assembled PCB

SOFTWARES USED

Microchip has a large suite of software and hardware development tools integrated within one software package called MPLAB Integrated Development Environment (IDE). MPLAB IDE is a free, integrated toolset for the development of embedded applications on Microchip's PIC and dsPIC microcontrollers. It is called an Integrated Development Environment, or IDE, because it provides a single integrated environment to develop code for embedded microcontrollers.

MPLAB IDE runs as a 32-bit application on MS Windows, is easy to use and includes a host of free software components for fast application development and super-charged debugging. MPLAB IDE also serves as a single, unified graphical user interface for additional Microchip

and third party software and hardware development tools. Moving between tools is a snap, and upgrading from the free software simulator to hardware debug and programming tools is done in a flash because MPLAB IDE has the same user interface for all tools.

COMPONENTS OF MPLAB IDE

The MPLAB IDE has both built-in components and plug-in modules to configure the system for a variety of software and hardware tools.

Project Manager

The project manager provides integration and communication between the IDE and the language tools.

Editor

The editor is a full-featured programmer's text editor that also serves as a window into the debugger.

Assembler/Linker and Language Tools

The assembler can be used stand-alone to assemble a single file, or can be used with the linker to build a project from separate source files, libraries and recompiled objects. The linker is responsible for positioning the compiled code into memory areas of the target microcontroller.

Debugger

The Microchip debugger allows breakpoints, single stepping, watch windows and all the features of a modern debugger for the MPLAB IDE. It works in conjunction with the editor to reference information from the target being debugged back to the source code.

Execution Engines

There are software simulators in MPLAB IDE for all PIC micro MCU and dsPIC DSC devices. These simulators use the PC to simulate the instructions and some peripheral functions of the PIC micro MCU and dsPIC DSC devices. Optional in-circuit emulators and in-circuit debuggers are also available to test code as it runs in the applications hardware.

Figure: MPLAB IDE

PICkit 3

Microchip has gone on to manufacture the PICkit 3, a variation of the PICkit 2 with the same form factor and a new translucent case. It features a faster 16-bit PIC24F processor and a wider voltage regulation range. There are some complaints of it not being as reliable as the Pickit 2 .Both PICkit 2 and PICkit 3 have internal, switch-mode voltage regulators. This allows them, in the case of the PICkit 2, to generate voltages from 2.5 to 5 volts, or in the case of the PICkit 3, 2.5 to 5.5 volts, from a 5 V USB supply, at around 100 mA. Both have options for calibrating the output with a multimeter, for increased accuracy. Additionally, for some PICs, the MCLR programming voltage can be generated, at around 13 to 14 volts. This voltage is required to reprogram the flash memory.

FIGURE: PICKIT3

WORKING OF PROPOSED SYSTEM

The general structure of the developed wireless sensor system is presented in below. It consists of one wireless data collection module (ZigBee coordinator device), end-devices (measuring devices), database server which is accessed via local server and a module for system control and data visualization. The coordinator device reads data measured from remote end-devices and retransmits them to the database server. The wireless connection between end-devices and the coordinator device is facilitated through their ZigBee modules. The database server and the coordinator device can be connected in through a personal computer.

Working of relay

When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a fixed contact.

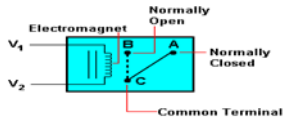


Figure: Working Of Relay

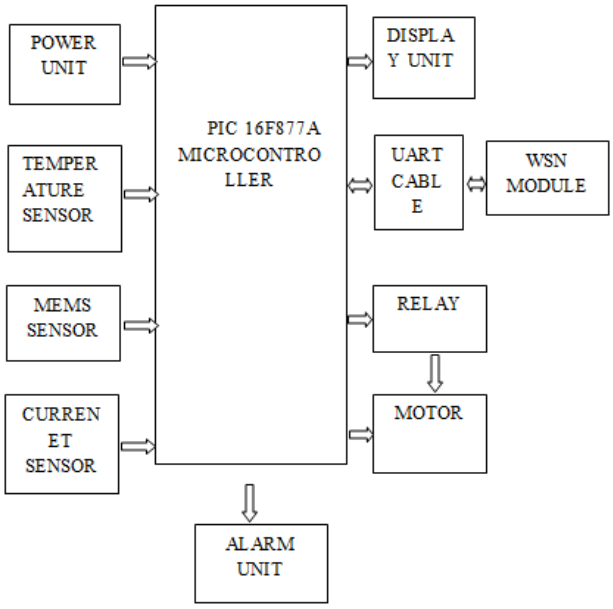


Figure: Block diagram of proposed system

ADVANTAGES

1. This System operates at a low cost.
2. Low power consumption.
3. Very Flexible and easy to manufacture.
4. ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. It is typically used in low data rate applications that require long battery life and secure networking.

RESULT

A prototype is developed which is used to monitor the health conditions of the AC induction motor. Analog sensors are used as input devices to sense some of the parameters of AC induction motors such as current, temperature and vibration. The results of the observation can be viewed in LCD display and in the PC by Visual Basics. If any abnormalities are detected the motor can be stopped when the buzzer rings.

CONCLUSION

In this paper, we presented an integrated WSN hardware software platform for machine and structural monitoring. The custom module was based on a wireless IEEE 802.15.4- compatible microcontroller, with MEMS sensors for capturing vibration and audio data, and a humidity/temperature sensor for environmental conditions. Although the experiments performed in both motor test rigs showed a reliable data collection, the long download times make it interesting to explore the feasibility of using compression algorithms or basic fault detection mechanisms on the node itself, to avoid sending a large amount of data that contributes to battery depletion.

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