Remote Temperature Monitoring and Recording Using Bluetooth Wireless Technology

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Abstract

This paper presents a Remote temperature monitoring and recording system that allows the user to continuously monitor temperature condition at two different places in a room and Database maintenance. The enhancement from the existing system is that, the proposed system monitors and records the temperature from the remote location that allows the user to retrieve data from the database, using which the average temperature at a particular time instant of the room can be calculated. This paper, proposes a network which contains a temperature sensor which is connected to a ATmega 16 microcontroller, data received form the sensor to be displayed in real time LCD that has been transmitted to the PC via HC05 Bluetooth module, and the receiver side Bluetooth USB Dongle is connected to the USB port of the computer. The data received by the PC is displayed in Hyper Terminal. The received data is maintained in the MS Access database management system and displayed using VB as front end.

Keywords: *Temperature Sensor, Bluetooth, Visual Studio, Hyper Terminal private Edition.*

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1. Introduction

Wireless technology for the remote temperature monitoring and recording system is proposed for mobility, low cost, low power, small size and communication over short distances in a home or industrial environment [1]. ISM band communication technologies, such as infrared, Zigbee and Bluetooth, are of particular interest in these features. The drawback of infrared technology is the requirement of a line of sight between sender and receiver. This makes infrared a reluctant choice for the transmission medium in a sensor network scenario, particularly in the home and industrial environments, because it is very easy for the transmission path to be blocked. Zigbee is an ideal technology for this application; however, it is not yet available for real application, due to the relatively short time. Bluetooth has been used in a wide range and the technology is available in the market. These encourage us to introduce it to remote temperature monitoring and recording system. The system will continuously monitor the temperature condition of the different places in a selected room and the data can be accessed at anytime from the Database which shows the average temperature at particular time instantof that selected room. The temperature monitoring is widely used in various processes like in automotive industries, air conditioning, power plant and other industries that need the data to be saved and analyzed. The main purpose of this system model is to make it easy for the user to analyse temperature condition based on recorded temperature data. The paper is organized as follows. Section II discusses the description about temperature sensor characteristics. In section III, the description about the general Structure of the system, briefly explaining about the microcontroller and ports, Bluetooth communication is presented. Section IV, presents the Serial Bluetooth module interfacing, and temperature storage into the database. In Section V, experimental results obtained are shown and, finally, in Section VI, conclusions are presented.

2. Lm35 Temperature Sensor

Temperature measurement is done through, a temperature sensor IC LM 35 device. A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For measuring remote temperature LM35 sensor has been preferred over thermocouple and other sensor devices mainly because of accuracy [2]. The Temperature sensor LM35 produces an output voltage which is directly proportional to its surrounding temperature. For every $1°C$ of rise/fall in temperature, the output voltage of the sensor varies by 10mV. Three pins, +Vs, GND and Vout are defined for the sensor. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract large constant voltage from its output to obtain convenient Centigrade scaling. It can measure temperature values ranging from $-55°$ to $+150°C$. The LM35's low output impedance, linear output, and precise calibration make interfacing to readout or control circuitry especially easy.

3. System Description

The module has a transmitter section and a receiver section. The transmitter section consists of LM35 temperature sensor Board, Microcontroller and HC05 Serial Bluetooth Module. The Temperature Sensor board, soldered with LM35 temperature sensor, senses the temperature according to the surrounding room temperature. In this paper, two temperature sensor has been used which are placed at certain distance to measure average temperature condition of a selected room. The output of the temperature sensor is a analog value, which is converted to digital using the inbuilt ADC of the microcontroller [3]. For every 1°C, it produces output voltage of 10mv. The output of the temperature sensor is connected to micro-controller; the microcontroller receives the signal from the temperature sensor board and displays in LCD [4, 5]. The Data from Temperature sensors are collected by the microcontroller and transmitted to the wireless serial HC05 Bluetooth module, through USART serial port features of the microcontroller. In the receiver section, a USB dongle is connected to the USB port of the computer to receive the data from Bluetooth transmitter module. The received data is displayed in PC through HyperTerminal Software.
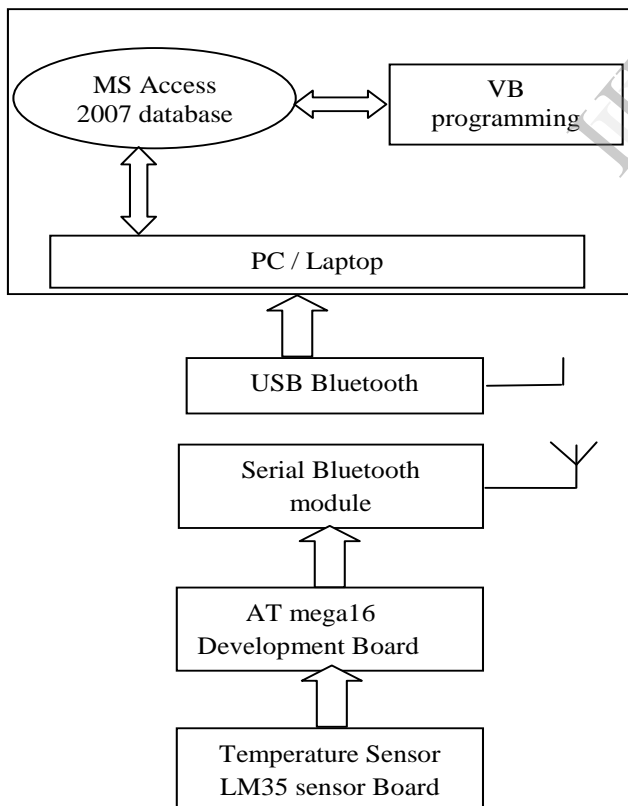

Fig -3.1: Block diagram of the system

To record the temperature values, the VB. NET application form need to be developed to display the temperature data by appropriate selection of COM Ports, Data Bits, Parity bit and stop bit selection in serial communication. Once the data has displayed it hass been saved in and   maintain a database MS Access has been used as the back end and VB as the front end application [6]. A SQL command Query is required to retrieve the data which are already stored into the database from that the user calculate the average temperature of a selected room at particular instant of the time.

3.1 ATMega16 Microcontroller

ATmega16 is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. Atmega16 is based on enhanced RISC (Reduced Instruction Set Computing) architecture with 131 powerful instructions. The Atmega 16, being an AVR core, can execute upto 16 million instruction per second. This is due to the fact that AVR instructions are executed on a single clock cycle. Atmega16 can work on a maximum frequency of 16MHz. ATmega16 is a 40 pin microcontroller. There are 32 I/O (input/output) lines that are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD ATmega16 has various in-built peripherals like USART, ADC, and JTAG etc.

3.1.1 Analog to Digital Converter

ATmega16 consists of 8 channels ADC (PA0-PA7) with a maximum resolution of 10 bits. So the analog input is converted into a discreet value within a range of 0 to 1023 (2^{10} discrete values). The ADC also has a Reference Voltage (ARef). When there is no input, the output is 0 and when input voltage is equal to ARef the output voltage is 1023. So the input range is 0-ARef and digital output is 0-1023. The ADC is multiplexed with PORTA that means the ADC channels are shared with PORTA. The ADC needs a clock pulse to do its conversion. The ADC requires a frequency between 50KHZ to 200KHZ. Analog voltage from the sensor are fetched to ADC of microcontroller and converted to temperature using following conversion:

Value =ADCRead(0);
Voltage =((value/255.0)*5)
Temp= ((value/1023)*5*100)); // temp is in degree centigrade

Fig - 3.2: AT mega16 Pin Description

In this, ATMega16 Microcontroller, the blocks used in implementing the work are ADC pin from PORTA (PA0-PA7), USART pin from PORTD (RXD, TXD), GND and power supply pins(VCC). The sensor output voltage is connected to ADC pins of two channels, and for Bluetooth communication lines are connected to USART pins of Microcontroller.

3.1.2 Bluetooth

Bluetooth is a wireless technology standard for exchanging data over short distances using short-wavelength radio transmissions in the ISM band from 2400–2480 MHz from fixed and mobile devices. Bluetooth operates in the range of 2400–2483.5 MHz (including guard bands). This is in the globally unlicensed Industrial, Scientific and Medical ISM 2.4 GHz short-range radio frequency band. Bluetooth uses a radio technology called frequency-hopping spread spectrum. The transmitted data is divided into packets and each packet is transmitted on one of the002079 designated Bluetooth channels [5], [7], [8]. Each channel has a bandwidth of 1 MHz The first channel starts at 2402 MHz and continues up to 2480 MHz in 1 MHz steps. It usually performs 1600 hops per second. Bluetooth is a packet-based protocol with a master-slave structure. One master may communicate with up to 7 slaves in a piconet; the main difference is the introduction of an Enhanced Data Rate (EDR) for faster data transfer. The nominal rate of EDR is about 3 Megabit/s, although the practical data transfer rate is 2.1 Megabit/s.

4. Hardware Setup

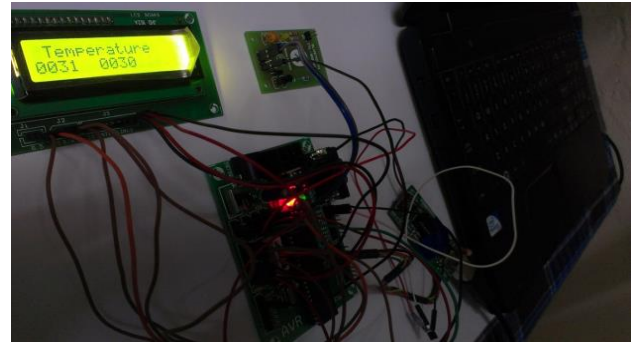The figure given below gives the hardware setup:

Fig - 4.1: Hardware setup

4.1 Microcontroller programming

AVR studio4 software is used for Writing embedded C Language program into the microcontroller. The Coding was developed to read temperature sensor data, to interface with ADC and USART communication is implemented. Then the basic program translates the computer readable format to machine level language. To Burn the embedded C coding into the microcontroller Progisp tool has been used. It has an advantage of erasing the EEPROM memory in microcontroller and load it again into the microcontroller and flash the device output in the microcontroller.
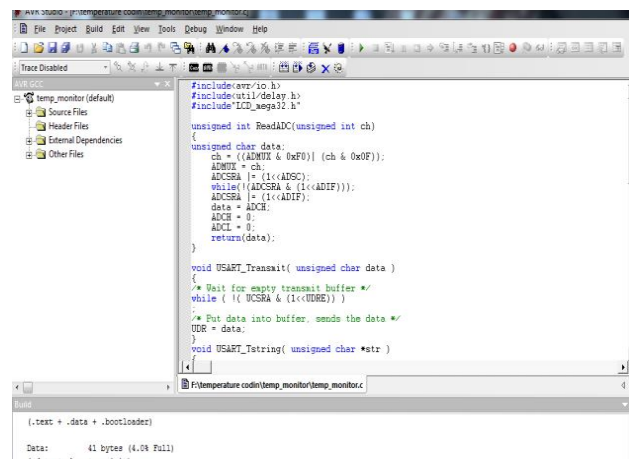

Fig - 4.2: AVR Studio with embedded coding

4.1.1 Interfacing Serial Bluetooth Modem with Microcontroller

Serial USART provides full-duplex communication between the transmitter and receiver. Atmega16 is equipped with independent hardware for serial USART communication. Pin-14 (RXD) and Pin-15 (TXD) provides receive and transmit interface to the microcontroller [8-10]. The

Receiver pin (RX) of Bluetooth module is connected to the transmitter pin (TXD) of the microcontroller. So, that the data transmitted from the controller received by Serial HC05 Bluetooth module and received by PC through USB dongle connected to USB port of computer and displayed in HyperTerminal software.

The following steps are to be implemented for connecting Bluetooth device with PC: i) the software for the Bluetooth (BlueSoleil Space) should be installed on PC; USB Dongle which is connected to the USB port of PC's (if you don't have Bluetooth device in your pc); ii) After installation, Power ON the Serial Bluetooth Modem and also turn ON the Bluetooth on your computer.iii) Right-click on the Bluetooth Icon and you should see the below given option. Click on "Add a Device". iv) Once you click that option your computer initiates a Bluetooth connection and starts searching for any nearby Bluetooth enable devices; the Device name (Linvor), which is a serial Bluetooth device name in HC -05 is found, right click on the device name and choose the option pairing; Enter the code "1234" and click next. As soon as you click "Next", you could see notifications at your right hand corner saying "Device drivers are installed". v) If everything goes well, it shows a message as connecting Bluetooth device on specified COM port number, and it establishes Bluetooth port ongoing communication on specified port. vi)The Windows HyperTerminal private edition is used to set on the COM port, which is same as Bluetooth device connected with serial port communication and having the following parameters: 8 data bits, 1 stop bit, no parity, hardware protocol, and 9600 kbps.
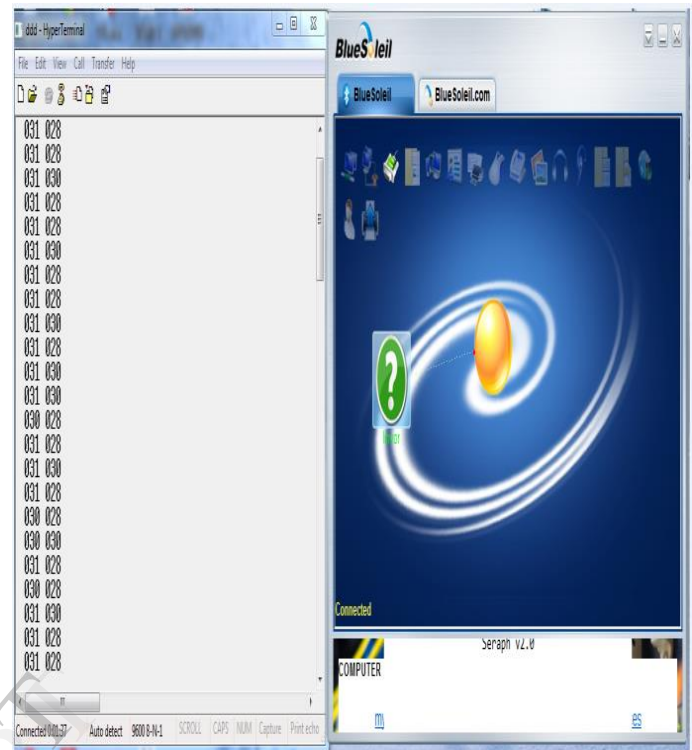

Fig - 4.3: wireless Temperature Monitoring System

4.1.2 Testing of Hardware and Software

Testing phase is used to evaluate the system's function whether it meets the intended functionality. Two method of testing was carried out to make sure the hardware and software is functioning according to the objectives. The first phase is the Hardware Testing on Temperature Sensor. In order for the temperature sensor board to function, it needs to be setup. The hardware setup must be done properly. It also must follow the entire step that require for hardware connection. The proper hardware connection must be tested using HyperTerminal. If the hardware setup occurs any problems then it is checked for possible wrong configurations. The second phase is the Software Testing on Temperature Monitoring System. In this phase, the sensor is connected to the computer and runs the VB application program called temp, to display the temperature received from temperature sensor. Without the VB temp application, the user cannot display the current temperature, as well as record and compute the temperature into the database. Also temp functions to store the current temperature into the MS Access database at Remote temperature monitoring system. This is the most critical part of the system.
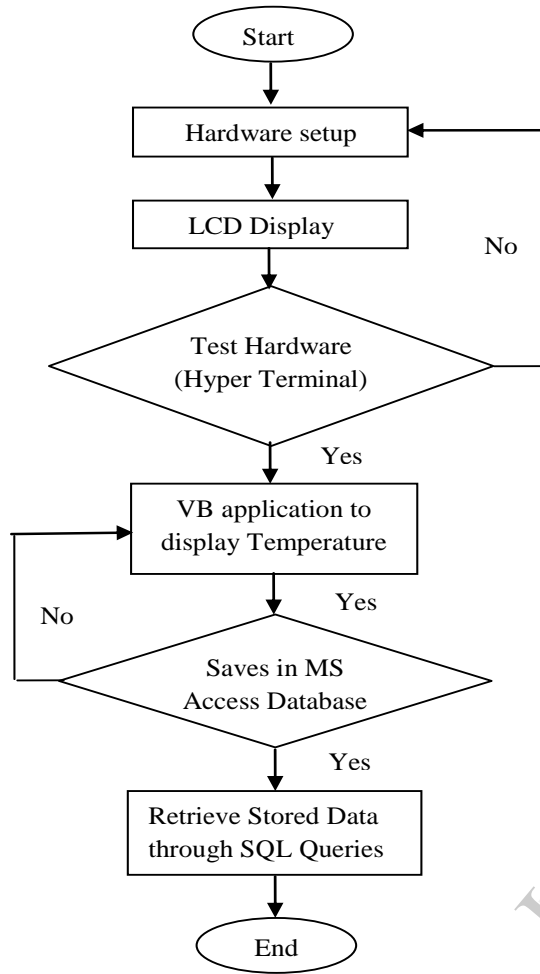
Fig - 4.4: Data Flow Development Model

5. Results And Discussion

The temperature values are also displayed in VB.NET form using serial COM port communication and the result was observed by proper COM port selection, Baud rate and other UART parameters which was selected same as in Hyperterminal software in temperature monitoring system and data was saved in MS Access Database by creation of table and retrieved easily using SQL command Queries.
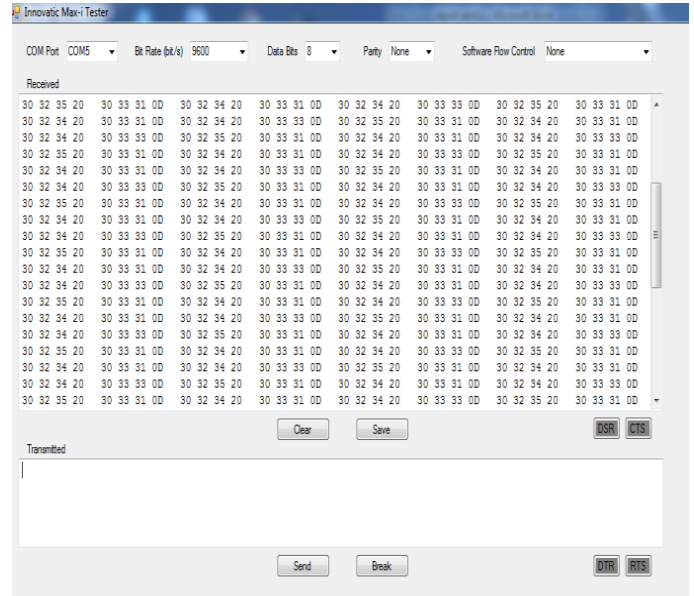

Fig - 5.1: Temperature Display in VB.NET Form

Thus, for temperature Monitoring system the program has been written in Embedded C language and for recording system the code has been written in Visual Basic, the code has been executed successfully, which allows dynamic element visualization, database accessing, etc.,
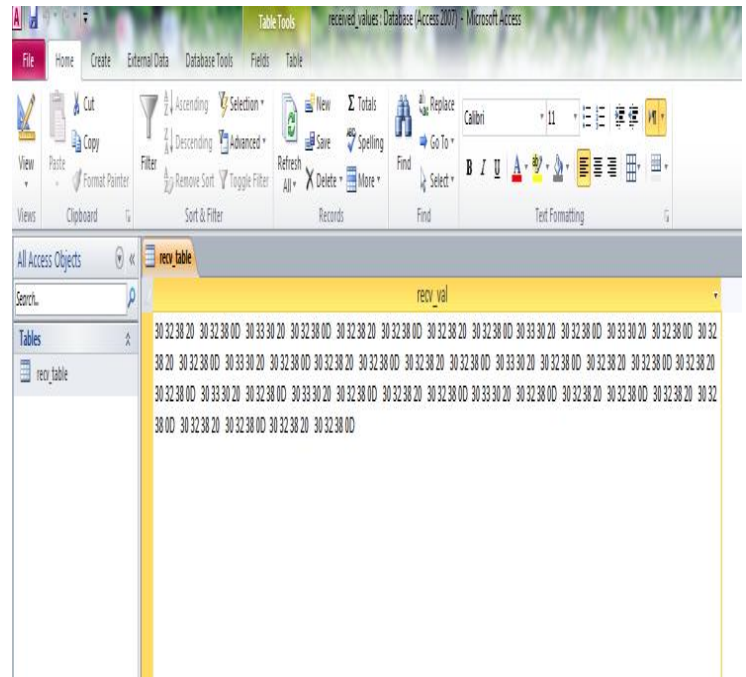

Fig -5.2: Temperature Reccording System Using MS Access Database

The test cases are carried out individually and the following are the results obtained from the testing phases. Table 1 shows the derived testing results.

Table -1: Testing results

Hardware/ Software	Expected Output	Test	Testing Output
Temperature Sensor	The temperature sensor will sense the temperatures.	passed	The temp. is sensed
Wireless Temperature Monitoring System	Temperature will be displayed in Hyper Terminal	passed	The temp. data is displayed.
VB temp application design	Data is displayed and stored in MS Access Database	passed	Data is stored and retrieved using SQL Query.

6. Conclusions

The application is easy to use and the Remote Temperature Monitoring and Recording system is a user friendly system because this system can assist to monitor temperature at certain distance. The objectives in this paper have been successfully achieved. The developed system is cost effective and requires very low power to operate. It can be used in indoors as well as outdoors. This work is considered successful because new skills and lots of knowledge have been gained throughout the development process of this system. Overall, this system is ready to be used and a lot of benefits can be obtained through the system. This system is very flexible which allows the user to monitor and compute the temperature remotely and it will increase the accuracy of the monitoring system in many industry. The demonstrative system can be extended for measuring and computing different parameters of interest, like humidity, gas concentration, light intensity etc.

7. Acknowledgement

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