International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 2, February - 2014

ZigBee Based Data Acquisition System to Monitor Heater Temperature using LabVIEW

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***Abstract*—The past several years have witnessed a rapid development in the data acquisition systems. Wired telemetric DAQ systems are developed and continuously improved for noise free, high speed and reliable operation. However, there are many wireless monitoring and control applications for industrial and home environments which require longer battery life, lower data rates and less complexity than those from existing standards. What the market need is a globally defined standard that meets the requirement for reliability, security, low power and low cost.**

We have designed a wireless data acquisition system using ZigBee and LabVIEW. Zigbee is a transreceiver module compatible with IEEE 802.15.4 protocol. With this module we are transmitting temperature from process using pic microcontroller interfaced to Zigbee transmitter. At the computer side, we have interfaced Zigbee receiver to another pic microcontroller. Microcontroller is sending data to NI6008 DAQ card. Received data is processed and displayed in LabVIEW 8.51. Labview is platform and development environment for a visual programming language from National Instruments.

Keywords—*DAQ – Data acquisition, NI- National Instruments*

I. INTRODUCTION

The wireless data acquisition system is quite useful for several applications such as home automation, climate sensors communication, collection of data in small area in research field & industrial control etc[3]. Zigbee module is a very small in size battery operated module. It is reliable, easy to deploy, secure, low cost and globally accepted wireless transreciever[1]. Zigbee alliance is responsible for Zigbee standards and IEEE is for IEEE 802.15.4. ZigBee module products are available with several types of interfaces (USB and Serial) and they work at low power consumption [9]. The control software for the module is bundled in the product or is available for free download through the Internet [2]. Their configurations such as baud rate and others are easy to control. LabVIEW, as a programming language, is a powerful tool that can be used to help achieve various goals. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphically-based programming language developed by National Instruments. Its graphical nature makes it ideal for test and measurement (T&M), automation, instrument control, data acquisition, and data analysis applications [5]. It gives driver support for various National Instruments DAQ cards[6].

In this paper a simple Wireless Data acquisition system based on Zigbee and LabVIEW is presented.

II. HARDWARE

The wireless data acquisition system mainly consists of two sections transmitter and receiver.

In transmitter section the temperature is sensed by temperature sensor LM35. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. This analog temperature is converted into digital using PIC microcontroller. P16F877A has 8 channel, 10-bit resolution A/D converter. Converted temperature is fed to Zigbee module. Zigbee has UART input, so we used universal synchronous asynchronous receiver transmitter (USART) of P16F877A. Zigbee operate on 2.4GHZ carrier frequency. With the help of Zigbee data is transmitted. The transmitter section is shown in fig.1.

In receiver section, Zigbee receiver module receives data and serially transfers that to P16F877A. For acquiring data we used DAQ card (NI6008), manufactured by National Instrument Corporation and is interfaced to P16F877A. This card has sampling rate of 10KS/s, having 8 analog inputs, two analog outputs, 12 digital I/O's and one counter input. LabVIEW 8.51 is used to read transimitted data from DAQ card and after processing that is displayed on thermometer and waveform chart present on front panel of it. The receiver section of the system is as shown in fig. 2.

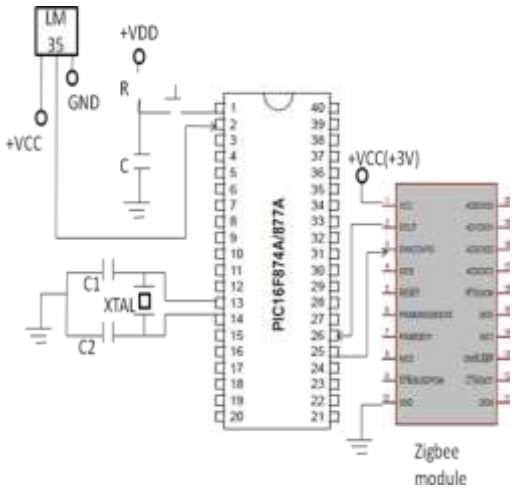


Figure 1: Transmitter System

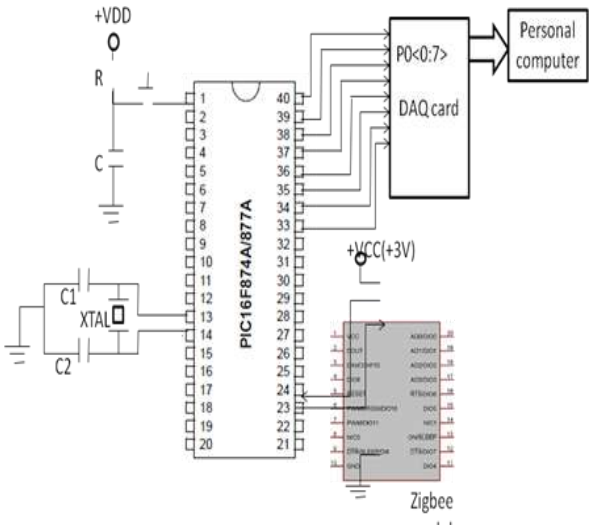


Figure 2: Receiver System

A. *What Is ZigBee?*

The ZigBee is a standard that defines a set of communication protocols for low-data-rate short-range wireless networking. ZigBee-based wireless devices operate in 868 MHz, 915 MHz, and 2.4 GHz frequency bands. The maximum data rate is 250K bits per second [4]. ZigBee is targeted mainly for battery-powered applications where low data rate, low cost, and long battery life are main requirements. In many ZigBee applications, the total time the wireless device is engaged in any type of activity is very limited; the device spends most of its time in a power-saving mode, also known as sleep mode. As a result, ZigBee enabled devices are capable of being operational for several years before their batteries need to be replaced.

The ZigBee standard is developed by the ZigBee Alliance. The ZigBee standard has adopted IEEE 802.15.4 as its Physical Layer (PHY) and Medium Access Control (MAC) protocols. Therefore, a ZigBee-compliant device is compliant with the IEEE 802.15.4 standard as well.

Figure 3: ZigBee

B. *LM 35 Precision Centigrade Temperature Sensors:*

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air.

Features:

- Calibrated directly in °Celsius (Centigrade).
- Linear + 10.0 mV/°C scale factor.
- 0.5°C accuracy guarantee (at +25°C).
- Rated for full −55° to +150°C range.
- Suitable for remote applications.
- Low cost due to wafer-level trimming.
- Operates from 4 to 30 volts.
- Less than 60 µA current drain.
- Low self-heating, 0.08°C in still air.
- Nonlinearity only ±1⁄4°C typical.
- Low impedance output, 0.1 W for 1 mA load.

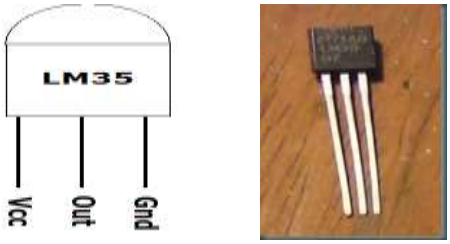


Figure 4: LM35 pin number and TO-92 Plastic Package.

C. *NI 6008 DAQ card:*

The NI USB-6008 provides connection to eight analog input (AI) channels, two analog output (AO) channels, 12 digital input/output (DIO)channels, and a 32-bit counter with a Full-Speed USB interface.

Table :1

FEATURE	NI 6008
AI resolution	12 bits differential, 11 bits single-ended
Maximum AI Sample Rate, Single Channel	10 kS/s
Maximum AI Sample Rate, Multiple Channels (Aggregate	10 kS/s
DIO Configuration	Open collector

Instrument drivers simplify instrument control and reduce test program development time by eliminating the need to learn the programming protocol for each instrument. An instrument driver is a set of software routines that control a programmable instrument. Each routine corresponds to a programmatic operation such as configuring, reading from, writing to, and riggering the instrument. Use an instrument driver for instrument control when possible. National Instruments provides thousands of instrument drivers for a wide variety of instruments.

D. LabVIEW

LabVIEW, as a programming language, is a powerful tool that can be used to help achieve these goals. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphically-based programming language developed by National Instruments[7]. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel and a connector pane.

Today, more than 50% of data acquisition customers use DAQ assistant to simplify data acquisition tasks. Figure 5. shows the front panel while figure 6. block diagram for labVIEW part.

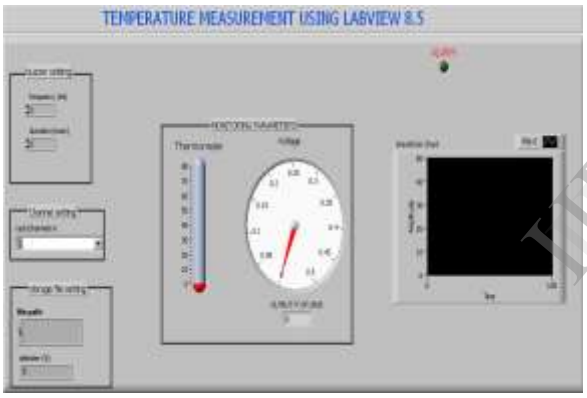


Figure 5. Front panel

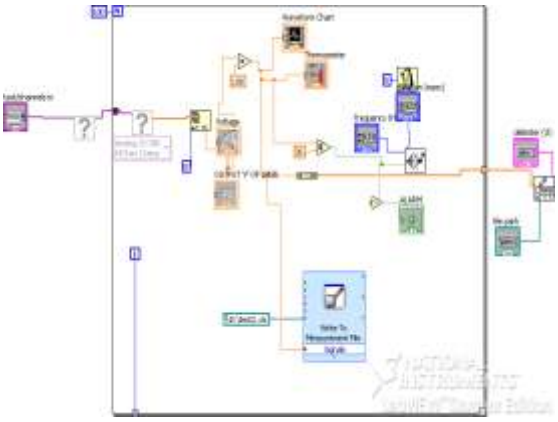


Figure 6. Block diagram

E. 16F877A PIC Microcontroller:

Figure 7. Pin out of 16F877A

PIC 16F877A is a high-performance RISC CPU. It has only 35 single word instructions. It operates on speed up to 20MHz. It has 8K x 14 word flash memory. It has three timer/counter and two capture, compare and PWM module. It includes Watch Dog timer(WDT) with its own on chip RC, synchronous serial port with SPI(master mode) and I2C(master/slave) , Universal synchronous Asynchronous receiver transmitter (USART). It has 10-bit 8 channel analog to digital converter (ADC). ADC has programmable on chip reference voltage (Vref) module and selected A/D conversion clock.

III. THE SOFTWARE

The ZigBee based data acquisition system is an embedded system. The developed embedded system is based on PIC 16F877A. MicroC pro, is employed as the IDE and firmware is developed in embedded C environment. X-XTU software is used for configuration of Zigbee module. The software winPIC800 burns the hex code into PIC 16F877A. Along with the main program the firmware comprises various subroutines developed for specific tasks. LabVIEW 8.5 is utilized for visualization of output. LabVIEW, as a programming language, is a powerful tool that can be used to help achieve goal. LabVIEW (Laboratory virtual Instrument Engineering Workbench) is graphically based programming language developed by National Instruments. Its graphical nature makes it ideal for test and measurement (T & M), automation, instrument control, data acquisition and data analysis application. This results in significant productivity improvements over conventional programming language. National Instruments focuses on products for T and M, giving them insight into developing LabVIEW. LabVIEW offers powerful features that make it easy to connect to a wide variety of hardware and other software.

With LabVIEW, the user can design custom virtual instruments by creating a graphical user interface on the computer screen through which one can:

- Operate the instrumentation program
- Control selected hardware
- Analyze acquired data
- Display results.

LabVIEW offers powerful features that make it easy to connect to a wide variety of hardware and other software. As

the system has two sections, the two separate firmwares are designed for transmitter and receiver system.

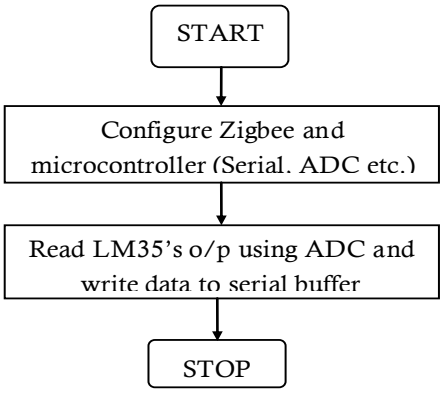


Figure 8: Flow chart for transmitter

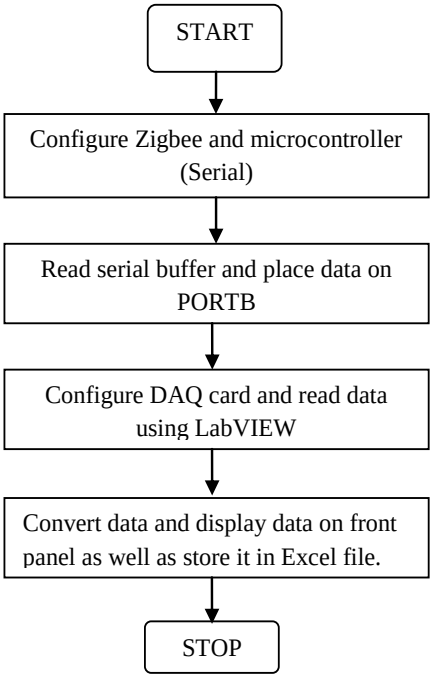


Figure 9: Flow chart for transmitter

IV. EXPERIMENTAL

Two sets of readings were taken. One set for room temperature and other is for electric sand heater. For first set a distance of 20 meters is maintained between the transmitter and receiver, and room temperature is transmitted and displayed. At the same time received temperature data is stored in excel file.

Second set of readings are taken for electric sand heater with distance between transmitter and receiver as 30 meters. Analog thermometer and LM 35 were inserted in heating chamber of heater. In order to increase the temperature of heater an ac supply is connected to heater. This temperature rise is displayed and recorded at the receiver side.

V. RESULTS AND DISCUSSION

As shown in figure 8 and 9, the transmitted room temperature sensed by LM 35 is plotted for various time values and is stored in excel file respectively as one column. The temperature value displayed by analog thermometer at the transmitter side, same is recorded and displayed at the receiver side. Zigbee transmission and reception is with least errors and hence a good quality DAQ system was developed.

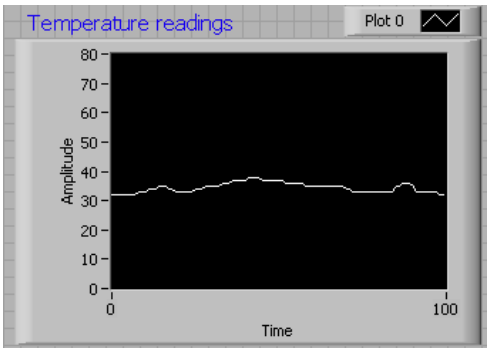
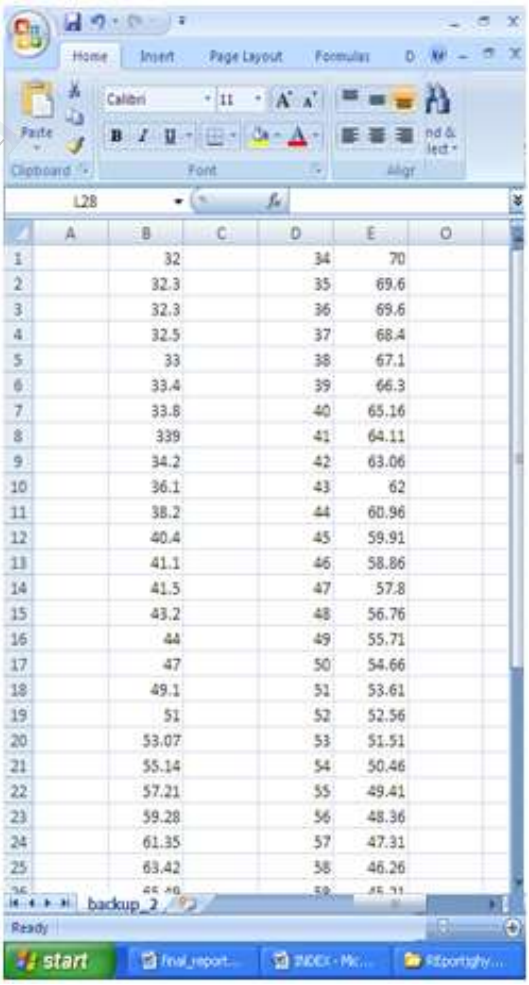


Figure 10: Graph of Temperature Vs time.



	A	B	C	D	E
1		32		34	70
2		32.3		35	69.6
3		32.3		36	69.6
4		32.5		37	68.4
5		33		38	67.1
6		33.4		39	66.3
7		33.8		40	65.16
8		339		41	64.11
9		34.2		42	63.06
10		36.1		43	62
11		38.2		44	60.96
12		40.4		45	59.91
13		41.1		46	58.86
14		41.5		47	57.8
15		43.2		48	56.76
16		44		49	55.71
17		47		50	54.66
18		49.1		51	53.61
19		51		52	52.56
20		53.07		53	51.51
21		55.14		54	50.46
22		57.21		55	49.41
23		59.28		56	48.36
24		61.35		57	47.31
25		63.42		58	46.26

Figure 11. Excel file storing temperature data.

VI. CONCLUSION

By doing this simple experimentation, a low cost moderate speed DAQ system can be easily developed. LabVIEW offers various functional blocks, so data processing and analysis is quite easy.

VII. FUTURE DEVELOPMENT

1. Now we used only one sensor (LM35), in future sensor network can be established.
2. Zigbee has 4 analog channels and in built 10 bit A/D converter with maximum 1MHz sampling frequency. So sensors can be directly interfaced with Zigbee.

VIII. REFERENCES

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