Wireless Performance Monitoring of Chemical Inventory

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***Abstract*—The expansion of wireless communication explores new possibilities of making monitoring through a graphical programming language-LabVIEW. As rapid advancement, in the areas of sensor network design, information technologies and wireless networking has paved way for Wireless Sensor Network; potential to interface the physical world with computing provide practical usefulness in unprecedented manner. The main contribution of this paper is the implementation and assessment of a sensor node deployed in an inventory which especially monitors critical health parameter for chemicals.**

***Index Terms*— Beaglebone Black ; LabVIEW; Wireless Sensor Network; Xbee-Pro**

I. INTRODUCTION

The emerging field of wireless sensor networks (WSN) combines sensing, computation and communication. Wireless sensor networks are widely used in environmental monitoring applications. Implementation of the idea placed in this paper is to gather precise real time information via wireless sensor nodes which are deployed on various chemical containers where its parametric health conditions are monitored effectively. On regular basis, each node is assembled with various kinds of sensors, computation unit, storage device and communication modules. The miniaturization of computing and sensing technologies enables the development as well as expansion of low power and inexpensive sensors, actuators and controllers. The expansion of wireless communication explores new possibilities of making monitoring through LabVIEW faster as well as reliable. XBEE-PRO which is a IEEE 802.14.5 standard enhances network security and minimizes power consumption.For establishing wireless nodes, star topology is used in order to measure the parametric health conditions of chemical containers various suitable sensors are deployed which measures temperature, pressure, flammability and gas. LabVIEW's novelty leverages the integration of the interfaced sensors with Beaglebone Black (BBB). The data that is collected at the monitoring station by XBEE-PRO is gathered from differently placed nodes and all these data is stored as a database. Further, the parametric health values of chemical containers are displayed on LabVIEW's monitor screen, thus providing an effective approach to modularity and accuracy.

The comparison of different nodes available off the shelf with regards to the node presented in this paper has been given in Table. I. The comparison among the processor, range, frequency of operation, data range, operating system and power consumption are shown.

TABLE I
COMPARISON OF AVAILABLE WIRELESS NODES

	MicaZ	WiSense mote	IMote -2	EagleB
Processor	ATmega 128	MSP 430	Intel PXA271 XScale	ARM Cortex-A8
Max Range(outdoor)	Upto 70m	Upto 30m	Upto 30m	Upto 100m
Frequency of Operation	2.4Ghz	2.4Ghz	2.4Ghz	2.4Ghz
Max Data Rate(in Kbps)	250	250	250	250
Operating System	Tiny OS	Tiny OS	Tiny OS	Debian
Input Voltage	2.8V	3.8V	5V	5V

In the last few years, the problem of collecting data from WSN was quite intensive as in [3] a hybrid RFID and WSN were designed for efficient data collection. In [2] the concept of wireless sensor data acquisition (WSDA) has been preferred by deploying MICA2 motes that integrates different legacy sensors usually found in an oilfield that aids receiving and transmission (ReT) module, conditioning and digitizing (CoD), a management and control (MaC) module. Arithmetic mean filtering in [4] has been used to process the data while monitoring a remote system based on GPRS which is used in oil well. For the monitory process [4] has used a robust

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SCADA system. Temperature measuring techniques, mathematical calculations, and programming has been performed in LabVIEW instead of LabWindows as [6] designing VI's methodologies were taken into account. Power consumption is an important factor of interest as utilization of WSN has incremented the requirements of energy saving like [5] the solution used to reduce data transmission is a model-driven data acquisition. The evaluation of the algorithms in [5] with regard to temperature patterns vary accordingly. In the concept of [1] a prototype remote node was installed to monitor water level using sensors to calibrate level, contamination, temperature etc. and a XBEE that regulates control of water-based tank in wide areas.

The main contributions of the present paper are as follows:-

- The comprehensive simulation in LabVIEW as designing and implementation of programs in VI's provides an unprecedented integration of all controls and operations building of a WSN node.
- The goal was to study different sensors as in [6] and further interfacing the various sensors with the processor. BMP180 outputs a digital value to the processor via I2C protocol for calculating the uncompensated data of temperature and pressure. MQ2 is used as a gas sensor which provides both digital and analog outputs to the processor.
- Using AM335x Sitara 1GHz ARM Cortex-A8 BBB as a processor makes it different from other nodes. LINX by LabVIEW Maker hub provides a common embedded platform as an I\O interfaces with other LabVIEW VI's makes it an expedient framework.
- XBEE-PRO operates at a 2.4GHz frequency is used as actual wireless module makes operation quick and robust. Thus providing a line of site range for 10-100 meters.

This paper is structured as follows. Section II describes the flow of the system model for monitoring applications and Section III contains the simulations and LabVIEW block diagram of all the parametric health conditions. In Section IV the front panel results have been displayed. In Section V, graph that plots the calibrated values has been presented. Further; Section VI concludes the paper.

II. SYSTEM MODEL

In a chemical inventory during certain hazards it is difficult to monitor the parameters through wires and analog devices. To overcome this shortcoming WSN was designed, that intricate real time monitoring system. Enabling the monitory of chemical parameters in oil reservoirs unlike[4] this paper proposes the readers designing of VI's that incorporates algorithms like [5] for measurement of data units of the deployed sensors hence using XBEE-PRO enhances the node's reliability. Furthermore, the proposed application is required to store large amount of incoming database, [3] which leads into a large scale management. Therefore a data monitoring station is required where all the incoming data is stored and displayed of the end user.

A. Block Diagram

The system model as shown in Fig.1 contains three spatial wireless nodes which are responsible for sensing various health parameters of containers, and a Data Monitoring Station. The star topology has been used for building up this architecture. The receiver side system has Data Monitoring Station (DMS) which consists of a receiving XBEE PRO Module and a PC with LabVIEW. Thus, all the nodes send their data wirelessly to the central station, which will collect the data and it, is shown on the LabVIEW Front Panel. The similar data can be logged into a file for later analysis.

B. A Typical Node

Sensor nodes sense and measure the continual analog signal that is digitized by an analog-to-digital converter and eventually is sent to controllers for further processing. Sensor nodes are of very small size, consume extremely low energy, are operated in high volumetric densities, and can be autonomous and adaptive to the environment.

A Typical node presented in this paper consists of a sensor array, a wireless module and a processor as shown in Fig.2.

Recently, the techniques that waive off the manual requirement have received an immense attention as it diminishes the complexity involved in monitoring of nodes.

When the processor BBB acquires the data from the sensors [6] that is Temperature, Pressure, Flammability and Gas it sends the respective calibrated information further to the wireless module i.e. XBEE-PRO S1 which transmits this information to data monitoring station. The data monitoring station comprises of wireless module and a display module. It is thus a competent [3] way to store the gathered data received by the other two nodes deployed on the chemical containers. The data is then transmitted by wireless nodes and is finally received by the station. It then displays the status of all the parametric health conditions effectively on LabVIEW's front panel which has been programmed in a graphical manner to solve modularity and reproducibility problems with ease.

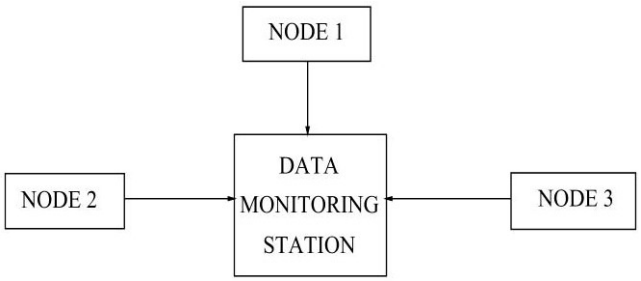
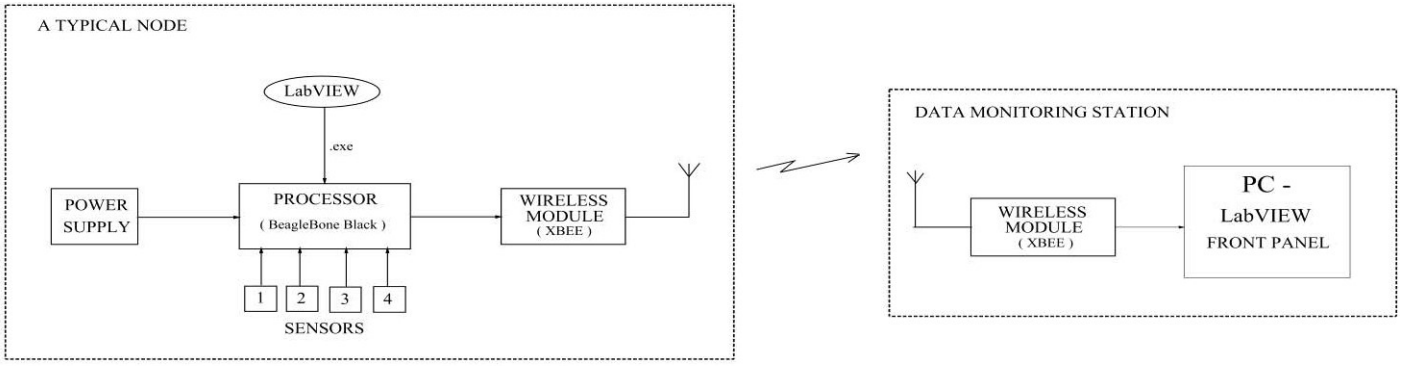


Fig. 1. Block Diagram



Sensors :-

1. TEMPERATURE (BMP180)
2. PRESSURE (BMP180)
3. FLAME
4. GAS (MQ-2)

Fig. 2. A Typical Node

III. SIMULATION

Simulations have been performed in LabVIEW and several VI's have been designed for adequate functioning of various parameters used in acquisition and monitory process.

A. Flow chart for temperature and pressure measurement

BMP180 measurements are calibrated according to an algorithm. When the microcontroller sends a start sequence, to start a pressure and temperature measurement the conversions that take place are shown.

In Fig.3 the shown algorithm depicts the flow of temperature and pressure. After the reading is calibrated from EEPROM of BMP180 to measure the respective factors, then an uncompensated value is read in order to calculate further true values of temperature and pressure. The algorithm is programmed in LabVIEW where a reference value has been considered. If the temperature rises than that data unit, an LED glows in the front panel of LabVIEW monitor screen.

In Fig.4 and Fig.5 respectively, simulation has been done to check the calculation to get desired temperature value from raw value received by the sensor. In the similar manner, the required calibrated data for the sensor and the raw value of the pressure from the sensor is given to the simulation block diagram where output is checked.

B. Data Acquiring and Transmitting

In Fig 6 In the first part processor is programmed to acquire the data from various sensors used then a comma separated string is made which consists of all the parametric values which are acquired and then the string is given to the transmitting side XBEE- PRO module which will transmit it to the data monitoring station.

C. Reception

In Fig.7 the XBEE-PRO is connected to the USB explorer is interfaced using the NI VISA pallet. The transmitted string is received by this receiving side XBEE-PRO using the VISA read block. The string is then separated out as their corresponding parametric values.

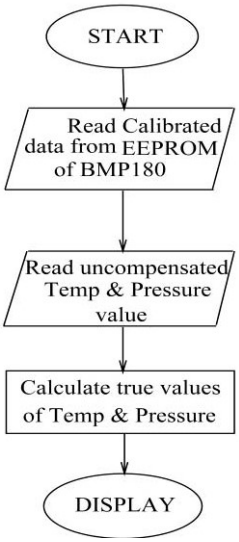


Fig. 3. Flow chart of Temperature and Pressure

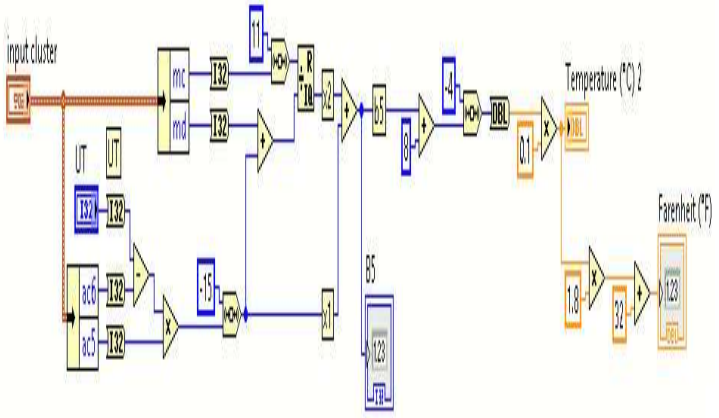


Fig. 4. Temperature value simulation

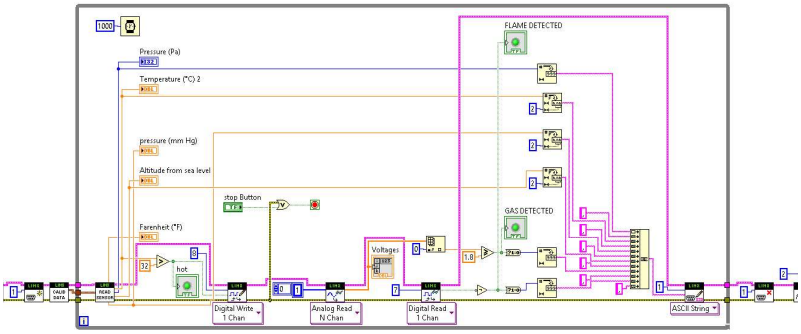


Fig. 5. Pressure value simulation

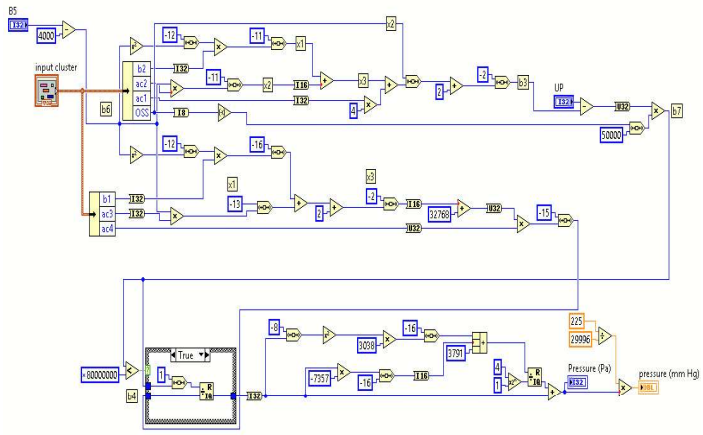


Fig. 6. LabVIEW Block Diagram (Transmitter side)

IV. RESULTS

A. *Front Panel Results*

In Fig.8 the parametric values gathered by all the sensors after successful reception are shown on the LabVIEW's front panel. When the Gas or Flame will be detected respective Gas and Flame detection LED's will glow. A reference value has been set in the system for Temperature and Pressure, if the value reaches above the specified values, the respective LED's will glow representing that the Temperature or Pressure has reached to its maximum value and the appropriate action should be taken.

B. *Final Hardware*

Fig.9 represents the hardware demonstration of a typical node, which contains a wireless node which sends data wirelessly to the DMS using XBEE-PRO.

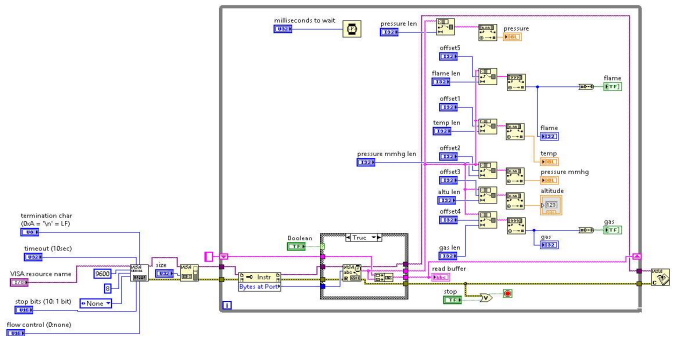


Fig. 7. LabVIEW Block Diagram (Receiver side)

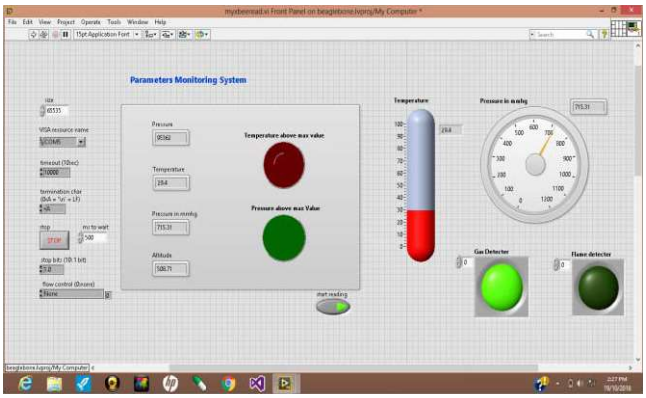


Fig. 8. LabVIEW Monitoring Front Panel

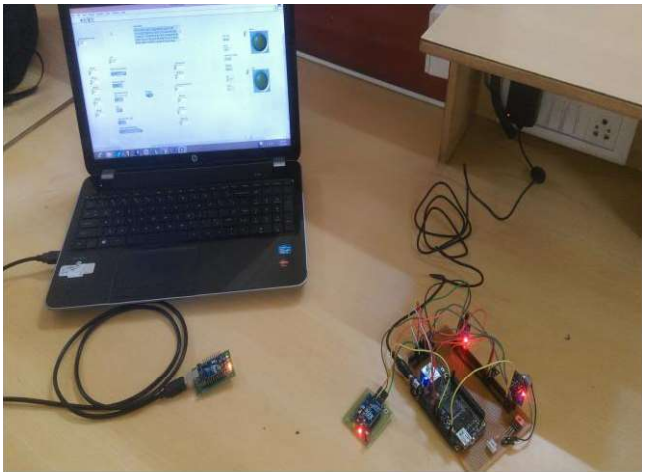


Fig. 9. Hardware

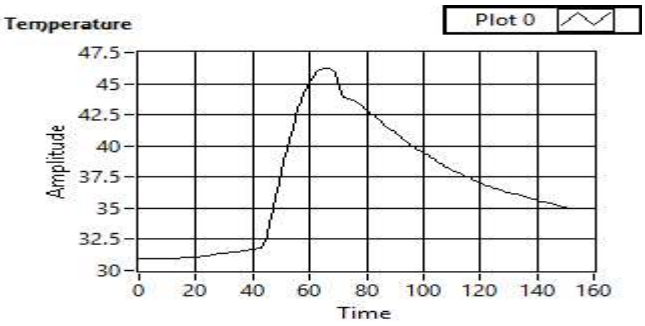


Fig. 10. Temperature Monitoring

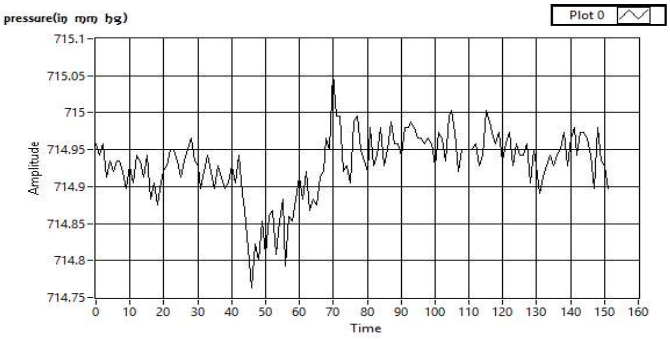


Fig. 11. Pressure Monitoring

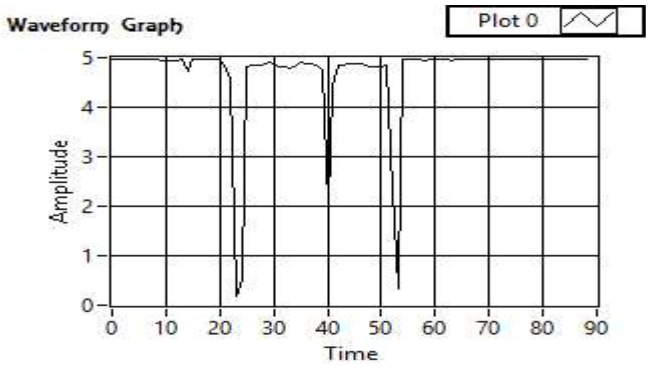


Fig. 12. Flame Monitoring

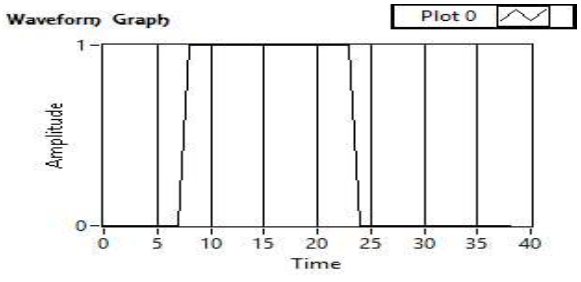


Fig. 13. Gas Monitoring

V. ANALYSIS

In Fig.10 temperature is monitored at every half millisecond, as depicted in the figure it can be observed that the temperature is varying. In the proposed system, BMP180 temperature sensor is placed in the different climatic conditions and henceforth the graph is plotted using LabVIEW.

In Fig.11 Pressure is monitored at every half millisecond, as depicted in the figure it can be observed that the pressure is varying. In the proposed system, BMP180 temperature sensor is placed in the different climatic conditions and henceforth the graph is plotted using LabVIEW.

In Fig.12 Flame is detected, a dip is plotted in the waveform graph which shows that the sensor is on for a duration of 22-25 seconds for detecting flame.

In Fig.13 Gas has been detected as portrayed in the graph when the value is changing from 0 to 1. Consequently, using MQ-2 gas sensor, as proposed in the system, gas was detected and the waveform is plotted in LabVIEW respectively.

VI. CONCLUSION

In this paper, designing of sub VI's for different parametric health conditions is discussed using LabVIEW. As rapid advancement, in the areas of sensor design, information technologies have paved way for Wireless Networking the potential to interface the physical world with the computing provides practical usefulness in a precedent manner.

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