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Integration of Wireless Sensor Network with Virtual Instrumentation in a Hazardous Environmental

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ABSTRACT: This paper proposes a hazardous environment monitoring and control for monitoring information concerning safety and security, utilizing Wireless Sensor Network (WSN) technology with virtual instrumentation (Lab VIEW) , a system architecture and concept implementation are described, in the context of a industrial safety monitoring scenario. Data acquisition is performed via the deployed wireless sensor network with focus on five main parameters: temperature, fire, smoke gas leakage and radiation. The data logging, monitoring and control functions are realized through virtual instrumentation software (Lab VIEW). This also enables an easy-to-use user interface and the accessibility of data through standards-based web server technologies.

KEYWORDS: wireless sensor networks; virtual instrumentation; safety monitoring; Lab VIEW

I. Introduction

The environmental care has become one of the biggest concerns for almost every country in the last few years. Even though the industrial accident level has been increasing without any control in the last decades, the current situation in the industry towards more hazardous environment. Recently, the modern industries are demanding sophisticated instrumentation for monitoring and control of environmental risk parameters of the hazardous area .Human safety and property losses are the essential to maintain the equilibrium between industry and environments.

Five factors compose the basis factors of a risk accident: the fire, Smoke, gas leakage, radiation and high temperature source, environmental elements and combustible material. A industrial accident usually occurs as the result of their combined effects Therefore, the moisture content of combustible materials is a major point of assessment and predicts whether a fire will take place. In this paper propose, combining the virtual monitoring technology with hazardous risk management together, a wireless multi-sensory monitoring system of hazardous site environment. Zigbee wireless sensor network architecture is adopted and based on virtual instrument technology, Virtual instrumentation environment, offers an intuitive way for engineers and scientists to quickly deploy applications for measurement and control in the form of Lab VIEW graphical programming language is used for program function design.

A virtual instrument consists of two parts. The block diagram implements the program logic by wiring together standardized library functions and control structures or user-defined routines. The front panel is the user interface which consists of standard elements such as: buttons, graphs, indicators assembled to provide an intuitive view of the program scope .The function of real-time remote-distance hazardous parameters information display, data analysis, limiting value alarm, trend monitoring and data storage is realized in this system.

II. LITERATURE SURVEY

In recent years, keeping pace with most of the industrialized accident that occur in hazardous environment due to which the consequences may be very serious and generally cause damage to life, property and environment .Hazardous environmental safety and security can be most important for moral, legal, and financial reasons.

Wireless monitoring and control for hazardous accident of a real-time system for possible implementation in industries for wireless monitoring applications, such as hazardous environments. [1] The deployment of a distributed point source monitoring system based on wireless sensor networks in an industrial site where dangerous substances are produced, used, and stored is described. Seven essential features, fundamental prerequisites for our estimating emissions method, were identified. [2] The purpose of this research is design considerations for environmental monitoring platforms for the detection of hazardous materials using System-on-a-Chip (SoC) design. Design

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considerations focus on improving key areas such as: (1) sampling methodology; (2) context awareness; and (3) sensor placement.[3] this paper proposes an agricultural environment monitoring server system for monitoring information concerning an outdoors agricultural production environment utilizing Wireless Sensor Network (WSN) technology. [4] This paper surveys the needs associated with environmental monitoring and long term environmental stewardship. Emerging sensor technologies are reviewed to identify compatible technologies for various environmental monitoring applications. [5] Automatic process control in many of the industries calls for measurement of temperature using virtual instrumentation (VI). Hence it is important to make students aware of VI and its use for temperature measurement.

III. MAIN PARAMETERS OF HAZARDOUS AREA

Five factors compose the basis factors of a risk accident: the fire, smoke, gas leakage, radiation and high temperature source, environmental elements and combustible material. An industrial accident usually occurs as the result of their combined effects Therefore; the moisture content of combustible materials is a major point of assessment and predicts whether a fire will take place.

IV. SYSTEM OVERVIEW

The system comprises of a base station and a Wireless sensor node. A PC attached with a RF module gateway coordinator serves as a base station. Temperature, Fire, Smoke, radiation and gas leakage sensors with associated signal conditioners attached to AT mega 18 microcontroller serves as a wireless sensor node. Fig. 1 shows the block diagram of the system.

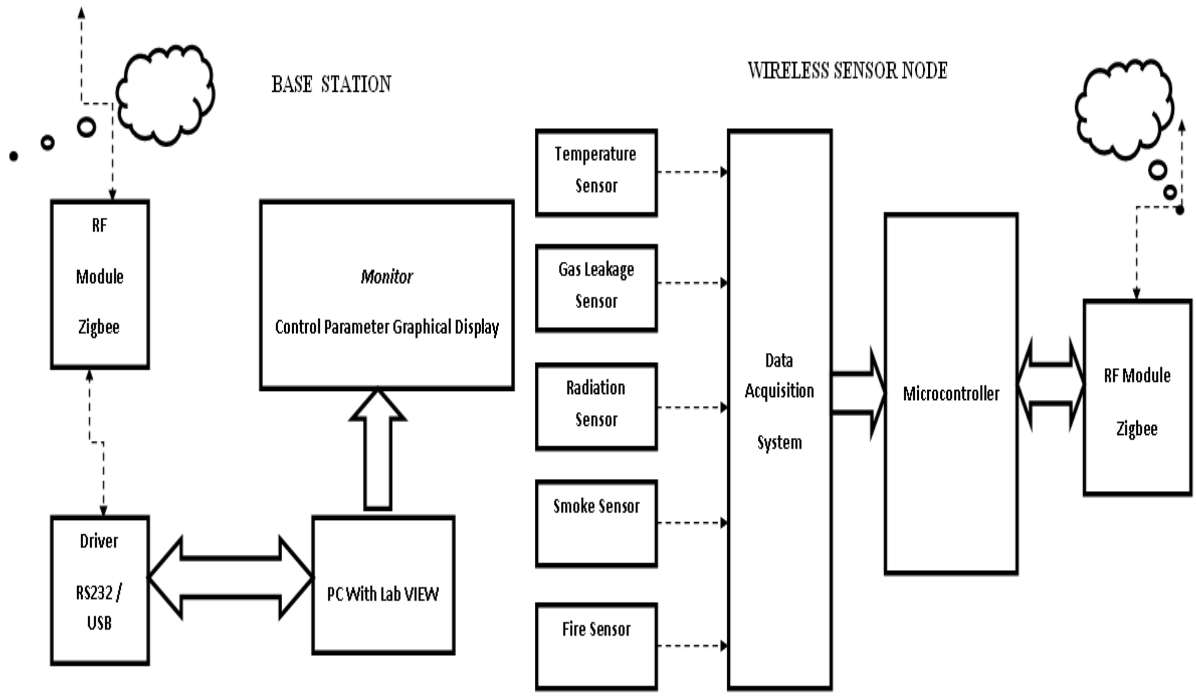

Fig 1: System Block Diagram

The WSN devices use the Zigbee (IEEE 802.15.4) wireless communication protocol and operates in ISM band, 2.4 GHz frequency. WSN devices can communicate up to 300 m in open space and support data communication rate up to 250 kbps. The RF Module with Zigbee gateway can collect measurement data from up to 36 measurement nodes in a network and transfer data to a host PC through 10/100 Mbps Ethernet port.

The wireless sensor node has following measurement are:

A. ***Temperature Sensor :***

The wireless measurement node uses pt-100 RTD temperature sensor module .The module provides outputs in the range of 0–1 V for temperature 0 to 100°C and sensitivity of 10 mV/°C in temperature measurement.

Figure 2: Multisensory

B. **Smoke Sensor :**

The wireless photoelectric smoke detector MCT-426 that is compatible with wireless security systems. Designed for a wide range of residential and commercial applications, Achieving superior smoke detection sensitivity levels, the MCT-426 provides early warning of developing fire. When smoke is detected, MCT-426 issues both sound and transmitted alarms. To ensure secure communication, transmissions use a Power Code 24-bit ID command code, which is selected from 16 million possible combinations and is therefore unique and virtually impossible to accidentally reproduce. A smart anti-collision algorithm prevents signal jamming by simultaneous transmissions from multiple devices.

C. **Fire Sensors:**

Flame sensors Danfoss LD/LDS sensors are used to detect the flame in yellow flame oil burners. The LD/LDS sensors are based on the photo resistance principle and convert light from the flame into a photo current. The flame's characteristics and the location of the sensor influence the size of the photo current created in LD/LDS. For this reason, LD/LDS is available in three different levels of sensitivity

D. **Gas Leakage Sensor :**

NDIR technology, a type of IR spectroscopy, is based on the principle that gas molecules absorb IR light and absorption of a certain gas occurs at a specific wavelength. Typically, a thermopile with a built-in filter is used to detect the amount of a specific gas. For instance, since CO2 has a strong absorbance at a wavelength of 4.26 µm, a band-pass filter is used to remove all light outside of this wavelength. Figure below shows the basic NDIR gas sensor working principle.

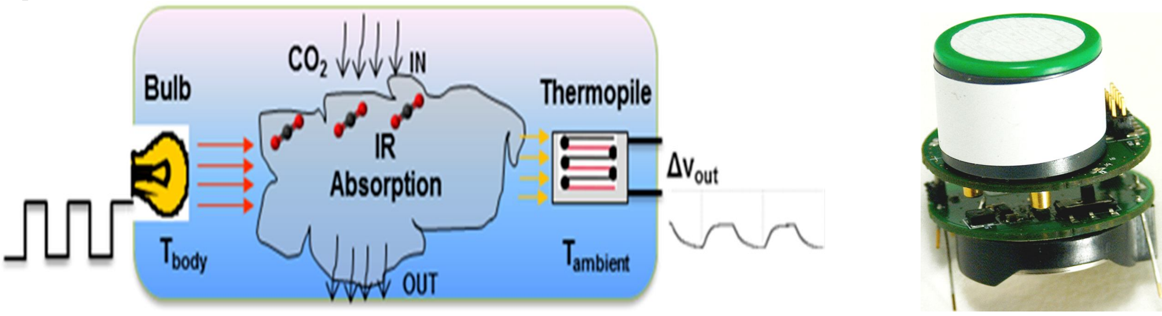

Figure 3: NDIR Gas Sensor Principle

The use of the LMP91051 NDIR AFE and MSP430F55XX microcontroller to make accurate CO2 NDIR gas measurements is examined. Performance, power, speed, and size are compared against the traditional discrete op amp system.

E. **Radiation Sensor :**

The idea is simple; each node acts as an autonomous and wireless Geiger counter. It measures the number of counts per minute detected by the Geiger tube and sends this value using Zigbee and GPRS protocols to the control point. The system is powered with high-load internal batteries what ensures a lifetime of years. With this technology radiation measurements can be known in real time without compromising the life of the security corps members as they do not

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have to be inside the security perimeter in order to activate the Geiger counters. The information is extracted automatically and sent wirelessly to the Gateway of the network.

Figure 4: Radiation Module

If a radiation leakage occurs in a place where there is not a previously installed radiation sensor network, an emergency deployment can be done in just a couple of hours. Security corps just needs to spread the sensor nodes on the ground at certain places. Sensor nodes will take the power from special high load internal batteries which will ensure the control network to be working for months. Each of these points will send the information by using a Zigbee connection through the GPRS network or sending alarms when the values are over a certain threshold.

F. **Wireless and Autonomous Geiger Counter :**

The idea of this technology is double, on the one hand this technology allows to monitor as a prevention procedure the surroundings of a hazardous area along with the closest cities autonomously without the need of human intervention, and on the other hand it let us quickly deploy emergency control points when a radioactive leakage happens.

V. HARDWARE IMPLEMENTATION

A. **Specifications :**

The eZ430-RF2500 is a complete wireless development tool used for the MSP430 and CC2500 that includes all the hardware and software required developing an entire wireless connectivity with the MSP430 in a convenient USB stick. The tool includes a USB-powered emulator to program and debug your application in-system and two 2.4-GHz wireless target boards featuring the highly integrated MSP430F2274 ultra-low-power MCU. Projects may be developed and instantly deployed using the included battery expansion board and AAA batteries. All the required software is included such as a complete Integrated Development Environment and SimpliciTI, a propriety low-power star network stack, enabling robust wireless networks out of the box. The eZ430-RF2500 uses the MSP430F22x4 which combines 16-MIPS performance with a 200-ksps 10-bit ADC and 2 op-amps and is paired with the CC2500 multi-channel RF transceiver designed for low-power wireless applications.

The eZ430-RF emulator interface may be used with any Spy Bi-Wire enabled MSP430, such as the F22xx and F20xx series, and is fully compatible with the eZ430-F2013 and eZ430-T2012 target boards. The emulator interface can be used to download and debug your target applications, and can transmit serial data to your PC while in or out of a debug session.

B. **Signal Conditioning :**

Signal Acquisition and Processing: The output range of the temperature sensor is very small and thus the signal needs to be amplified before processing to prevent introduction of errors. The signal chain has to handle the small signal accurately in presence of noise. TI's temperature sensor front-ends have an input multiplexer, high impedance PGA and high resolution sigma-delta modulator all integrated into a single chip. The low noise, chopper stabilized PGA provides the versatility of scaling the gain as needed in accordance with how small or large the output from the sensor is. High end products also have integrated features for system diagnostics and fault monitoring. A further level of system calibration could be implemented in the MCU.

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Traditional analog (4 - 20mA) interface remains the popular choice for industrial control and sensor applications. The other popular protocols include HART, Profibus and IO-Link. TI's IO-Link interface products have integrated regulators and diagnostic outputs. In addition, wireless options based on IEEE 802.15.4 protocols are becoming more prevalent. TI is committed to provide solutions for both traditional and emerging industrial interfaces.

C. **Power Management :**

The Field Transmitter can be powered in one of three ways. Line powered transmitters are commonly powered by voltage rails of 12V, or 24V. Loop powered transmitters are powered by the 4-20 mA loop. Such transmitters require extremely low power architectures as the entire solution has to be powered off the loop. TI provides high efficiency Step Down converters with low quiescent current and low output ripple appropriate for Line and Loop powered transmitters. Battery powered transmitters powered can be designed using TI's low power Buck and Buck-Boost converters. The DC/DC buck converters offer over 95% efficiency over a wide battery voltage range, even with input voltage down to 1.8 volts extending battery life. Special Buck-Boost converters generate a stable required output voltage and supply constant current for over- and under-input voltage conditions and support various battery configurations.

D. **Microcontroller :**

The Hercules™ Safety MCUs offer an ARM Cortex-R4F based solution and are certified suitable for use in systems that need to achieve IEC61508 SIL-3 safety levels. These MCUs also offer integrated floating point, 12 bit ADCs, motor-control-specific PWMs and encoder inputs via its flexible HET Timer co-processor. Hercules Safety MCUs can also be used to implement scalar and vector-control techniques and support a range of performance requirements.

Utilization studies involve the deterministic small network topology with 5 nodes as shown in Fig.1. The proposed energy efficient algorithm is implemented with MATLAB. We transmitted same size of data packets through source node 1 to destination node 5. Proposed algorithm is compared between two metrics Total Transmission Energy and

VI. SOFTWARE CONTROL

The process begins with the start and the input request was sent through the computer monitored host input, then the enquiry is transmitted through the Zigbee RF control module. When the network is present the enquiry will goes to the communication or if the communication is not available it will loss the pocket and updates router and generate the report to the host computer software. If communication is available then the coordinator receives the data and broadcast to the controller. The sensor signals from the all the sensors status has received by the controller and it was recorded in the DAQ system. It the condition is true then the controller sends the information about the level of risk and the type of the risk to node collect & synthesis and sends to the data retransmission and it was transferred to the RF module Zigbee and retransmitted to the host monitor computer . If the condition is not at risk then controller normally sends the status report to the data synthesis and retransmission then it is transferred to the RF Zigbee retransmission to the host computer monitor the simulation studies involve the deterministic small network topology with 5 nodes as shown in Fig.5.

The proposed energy efficient algorithm is implemented with LabVIEW. We transmitted same size of data packets through source node 1 to destination node 5. Proposed algorithm is compared between two metrics Total Transmission Energy and Maximum Number of Hops on the basis of total number of packets transmitted, network lifetime and energy consumed by each node. We considered the simulation time as a network lifetime and network lifetime is a time when no route is available to transmit the packet. Simulation time is calculated through the central process unit time function of LabVIEW. Our results shows that the metric total transmission energy performs better than the maximum number of hops in terms of network lifetime, energy consumption and total number of packets transmitted through the network.

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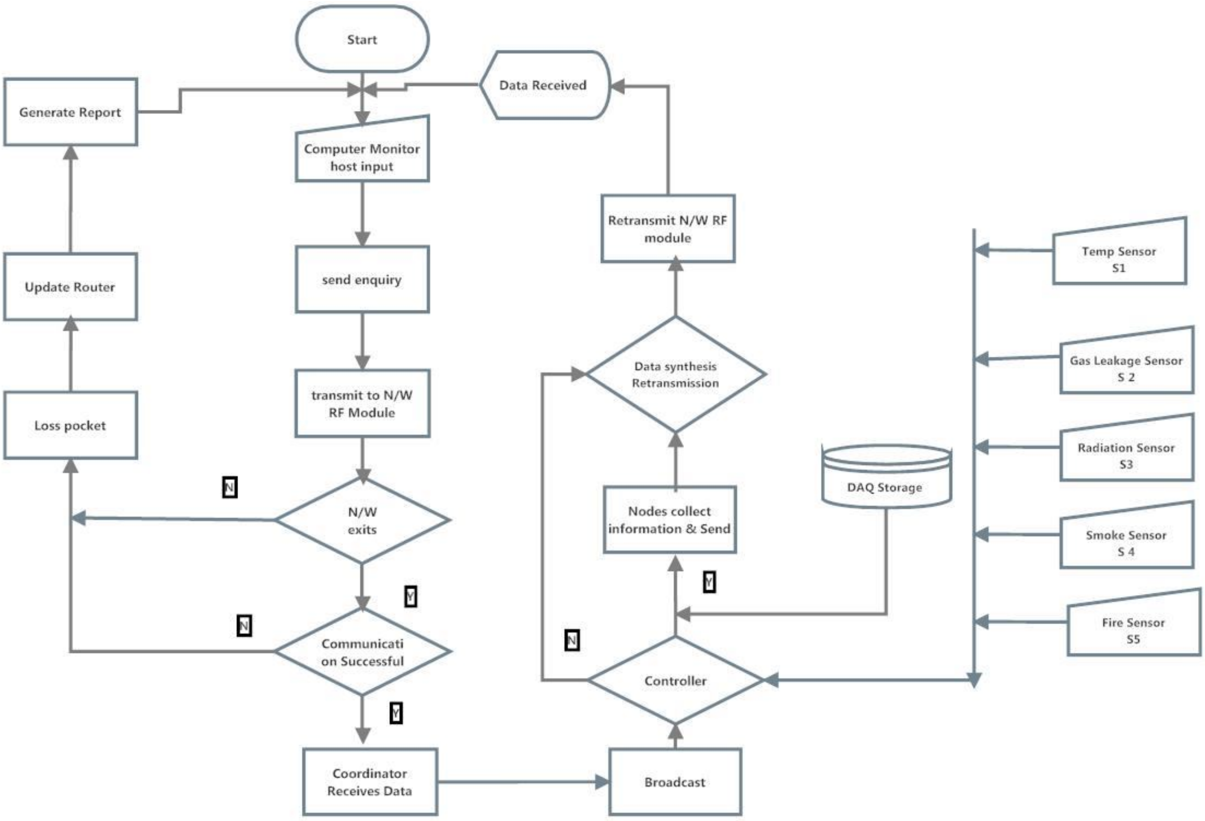

Fig 5: Software functional flow diagram

VII. SIMULATION RESULTS

Monitoring ambient conditions is a fundamental feature providing valuable data for both research and production applications. Any basic or advanced experimentation, any standard or crucial step in a process demands a fine control over working conditions, thus implying the need of a proper monitoring apparatus.

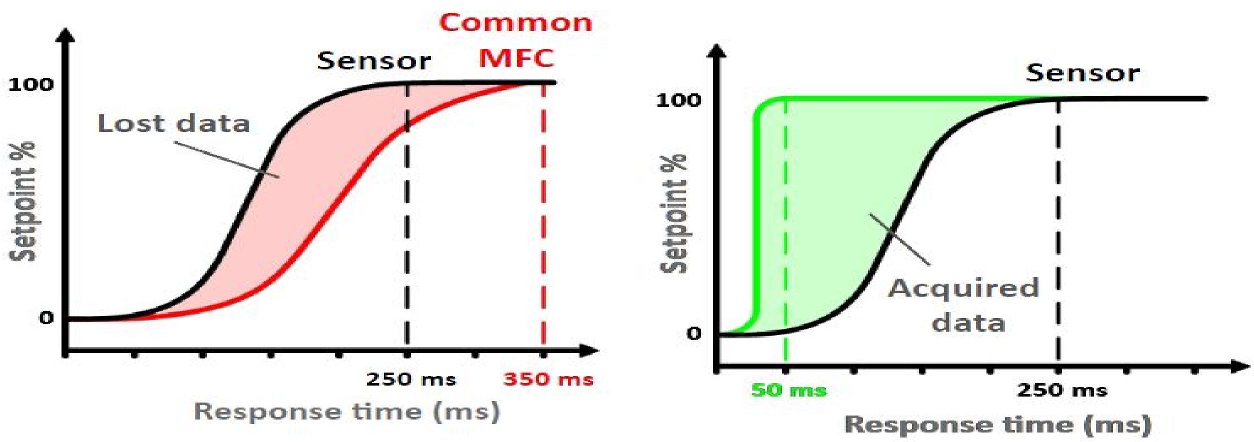

Figure 6: Performance of Multi-sensor

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Along with temperature and gas leakage, Fire & Smoke the ability to check the atmosphere composition becomes relevant since the presence, absence or simply the amount modification of the hazardous parameters can strongly affect the final result. For that reason multi-sensors are a part of the essential equipment of hazardous safety monitoring and control.

The data acquired from all sensor nodes placed in four different hazardous area are displayed on host PC by running LabVIEW GUI. The user can also acquire the data from the sensor nodes individually by operating the switches that are provided on the front panel of the LabVIEW GUI. A typical display is shown in figure 7 .

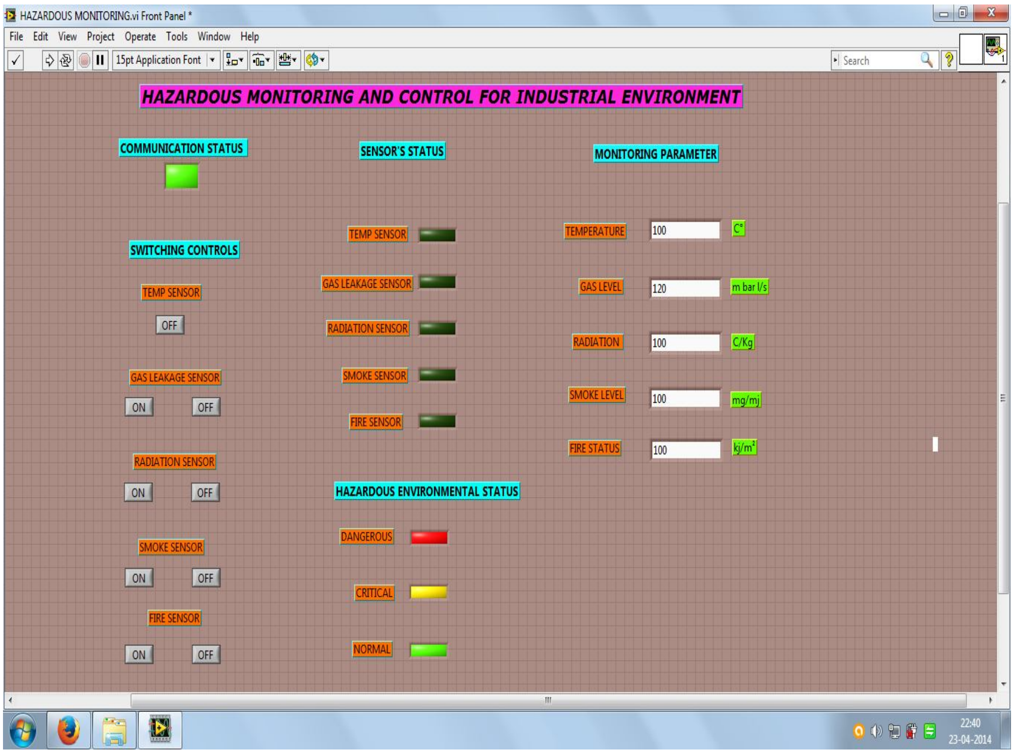

Figure 7: Experimental setup simulation using LabVIEW

The simulation studies involve the deterministic small wireless sensor network with five parameters. The proposed hazardous monitoring system is implemented with Lab VIEW. The sensor response time (RT) is especially important in many applications, since chemical and physical processes, reactions, small changes or variations often occur in a fraction of a second.

In order to check and verify them, the use of sensors wit adequate sensibility and fast RT is mandatory.

The design was successfully dissected into various modules. Each module with the exception of the database system has been implemented. The integration of the individual modules was achieved successfully. All the results were categorically measured.

VIII. CONCLUSION

This paper has described the design and implementation of a wireless sensor network for industrial hazardous safety monitoring system. Fire and radiation disasters are both prevented and minimized. However, it is difficult for managers of large industrial area standpoint; this could prevent people from safely escaping a dangerous situation. From a financial standpoint, missing, damaged, or malfunctioning can be reduced and has proven to be a trusted and increasingly applied solution in commercial settings, saving operating expenses and most importantly, human lives.

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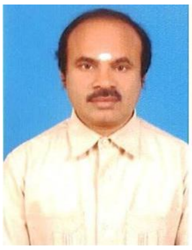
BIOGRAPHY

Suresh Kumar A is research scholar working for Ph. D. degree in Electronics. He obtained Master of Science in Applied Electronics from Bharathiar University, Coimbatore. His area of research is the development of Wireless Sensor Network for safety and security in industrial hazardous area using virtual instrumentation, He is working as Training officer at Gedee Technical Training Institute (GTTI), Coimbatore (India). He has published three national and one international research paper.



Dr. S. Muruganand received the PhD in Physics from Bharathiar University Coimbatore .He is having more than 20 years of experience in Teaching, Research and Industry. His area of research is the development of Nanoelectronics, MEMS/NEMS, Embedded systems & Automation Signal /Image processing Biomedical Instrumentation Thin films.