Greenhouse gas monitoring and control using wireless sensor network

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Abstract : Certain Greenhouse gases present in the atmosphere causes a serious threat to earth, since it will leads to global warming, ozone depletion etc. The emission of such green house gases should be monitored and controlled. A wireless environment monitoring system with a capability to monitor greenhouse gases such as CO, CO_2, SO_x, NO_x, and O_2 with environmental parameter is developed in the existing system. But there is no provision for the controlling unit. In the proposed work, a circuit for both the monitoring and controlling of the major greenhouse gases such as CO_2, SO_2 is designed. So that the overall system involves three processes namely, sensing the outlet gas, monitoring the process and controlling the concentration level of the gas. The Electrostatic precipitation method is used as a controlling mechanism, which can collect particles sized 0.1 to 10 microns very efficiently. The developed module is designed and implemented using LabVIEW software.

***IndexTerms* - Greenhouse gases, wireless sensor network, electrostatic precipitation method, LabVIEW.**

I. INTRODUCTION

Greenhouse gases are the gases present in an atmosphere that absorbs and emits radiation within the thermal infrared range. The primary greenhouse gases in earth atmosphere are carbon dioxide, methane, nitrous oxide, water vapor and ozone. Greenhouse gases greatly affects the temperature of the earth, thereby it is found to be, without these gases, earth's surface would be average about 33ºC colder, which is about 59ºF below the present average of 14ºC. Since the beginning of the industrial revolution, extensive clearing of native forests and the burning of fossil fuels has contributed to a 40% increase in atmospheric concentration of carbon dioxide, from 280 to 392.6 parts per million in 2012 and now has reached 400 ppm in the northern hemisphere. This increase has occurred due to the uptake of a large portion of the emissions by various natural sinks involved in the carbon cycle. Under on-going greenhouse gas emissions, available earth system models project that the earth's surface temperature could exceed historical analogues as early as 2047 affecting most ecosystems on the earth and the livelihoods of over 3 billion people worldwide. Greenhouse gases also trigger ocean bio-geochemical changes with broad ramifications in marine systems. The World Resources Institute (WRI) is now actively working through the Measurement and Performance Tracking (MAPT) project to enhance the measurement of greenhouse gas (GHG) emissions in developing countries and to track the performance towards low carbon development goals, where it is needed. GHG measurement and performance tracking is the process through which GHG emissions and emission reductions are measured and the progress towards mitigation goals is evaluated regularly. Such systems can support both the domestic policymaking and international reporting requirements.

The objective of this paper is to acquire multiple data from the physical world with the help of different transducers and embedded unit and store it in the computer for further analysis and control. A Greenhouse is taken as a case study for data acquisition and data logging. Different physical parameters of greenhouse such as multiple gases are acquired using different sensors and embedded unit and subsequently LabVIEW is used for display and analysis of data.

II. SYSTEM DESCRIPTION

2.1Microcontroller

The Microcontroller PIC (16F877) manages the operation of each module. Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed technology that is used in PIC 16F877, so that the data can be retained even when the power is switched off. Easy Programming and Erasing are the other features of PIC 16F877.

2.2 Sensor unit

The sensing unit is the main component of a wireless sensor node that differentiates it from any other embedded system with communication capabilities. A gas sensor is a device that transforms the concentration of the gas into an electric signal [2]. Generally, five technologies are used for monitoring the concentration of gases such as catalytic bead, infrared, photo ionization, solid state, and electrochemical. Detailed information on these technologies and gas sensors, such as, advantages, disadvantages, usage, and life time are found in [15] and [16]. Electrochemical gas sensors are gas detectors that measure the concentration of a target gas by oxidizing or reducing the target gas at an electrode and measuring the resulting current. It may also noted that the electrochemical sensor have low cost, low power consumptions, single gas detection property with high accuracy, good selectivity, no effect of the environmental parameter fluctuations, excellent repeatability, and miniature as compared to solid-state, photo ionization, catalytic bead, and infra red.

In the gas sensor the supply voltage is given to input terminal. The gas sensor output terminals are connected to non inverting input terminal of the non inverting amplifier. The Non inverting amplifier amplifies the voltage level and it will be given to the PIC microcontroller.

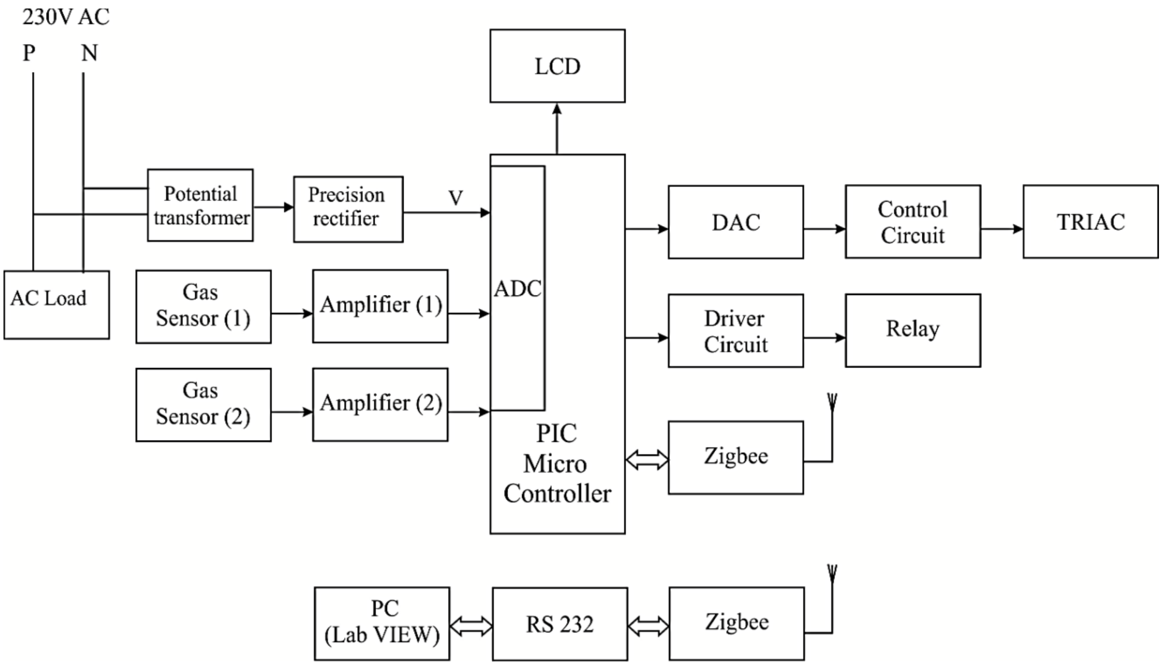

Figure.1 Block diagram of monitoring and controlling unit

2.3The precision rectifier

The precision rectifier is a circuit behaving like an ideal diode or a rectifier. The full wave rectifier is the combination of half wave precision rectifier and summing amplifier. When the input voltage is negative, there is a negative voltage on the diode, too, so it works like an open circuit, there is no current in the load and the output voltage is zero. When the input is positive, it is amplified by the operational amplifier and it turns the diode on, so it works like a closed circuit, there is a current in the load and because of the feedback, the output voltage is equal to the input.

2.4TRIAC control circuit

This circuit is designed to monitor the supply voltage. The supply voltage that has to monitor is step down by the potential transformer. Usually the 0-6V potential transformer is used. The step down voltage is rectified by the precision rectifier. In this case, when the input is greater than zero, D2 is ON and D1 is OFF, so the output is zero. When the input is less than zero, D2 is OFF and D1 is ON, and the output is like the input with an amplification of $-R_2 / R_1$. The full-wave rectifier operates by producing an inverted half-wave-rectified signal and then adding that signal at double amplitude to the original signal in the summing amplifier. The result is a reversal of the selected polarity of the input signal. Then the output of the rectified voltage is adjusted to 0-5v with the help of variable resistor VR1. Then given to ripples are filtered by the C1 capacitor. After the filtration, the corresponding DC voltage is given to ADC or other related circuit. The LM1458 is the general purpose dual operational amplifier with sharing common supply. U1A delivered the saw tooth wave output which is given to non inverting input terminal of comparator. The comparator is constructed by the U1B. The 12V square wave signal is given to inverting input terminal. The 12V square wave signal is generated by the comparator U5 which is constructed by LM741 operational amplifier. The U1B comparator compares the input saw tooth wave and square wave signal and outputs the +12V to -12V square pulse. The -12V square pulse is rectified by D3 diode.

The controlling technique here used is the electrostatic precipitator technique. Electrostatic precipitator works under the electrical principle that opposites attract. In this controlling mechanism, a high voltage electrode negatively charges the airborne particles in the exhaust stream. As the exhaust gas passes through this electrified field, the particles get charged. Finally the microscopic particles are attracted to this surface where they build-up to form a dust cake.

2.5 Driver circuit

This circuit is used to drive a 12V relay using logic voltage (an input of 4V or greater will trip the relay). The circuit has its own 12V power supply making it self contained but the power supply portion can be left out if an external supply will be used. The circuit shows an output from the power supply that can be used to power other devices.

2.6 Relay

This circuit is designed to control the load. The load is turned ON and OFF through relay. The relay ON and OFF is controlled by the pair of switching transistors (BC 547). The relay is connected to the collector terminal of the Q2 transistor. A Relay is an electromagnetic switching device which consists of three pins namely Common, Normally Close (NC) and Normally Open (NO).The relay common pin is connected to supply voltage. The normally open (NO) pin connected to load. When a high pulse signal is given to base of the Q1 transistors, the transistor is conducting and shorts the collector and emitter terminal and zero signals is given to base of the Q2 transistor. So the relay is turned OFF state. When a low pulse is given to base of transistor Q1, the transistor is turned OFF. Now 12V is given to base of Q2 transistor so the transistor is conducting and relay is turned ON. Hence the common terminal and NO terminal of relay are shorted. Now the load gets the supply voltage through relay.

The following figure.2 shows the photograph of wireless sensor transmitter unit used to sense and transmit the sensed values to the receiver through zigbee.

Figure.2 Photograph of wireless sensor transmitter

The transmitted values from the transmitter unit are received at the receiver through zigbee and it is then connected to PC and the corresponding information about the process is viewed through LabVIEW software.

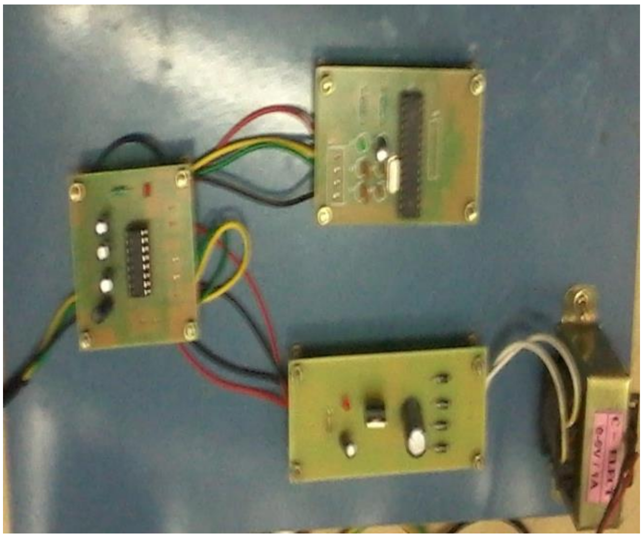

Figure.3 Photograph of wireless receiver module

III. SOFTWARE DESCRIPTION

3.1LabVIEW

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming language that uses icons instead of lines of text to create applications. It uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order of the VIs and functions, in contrast to the text-based programming languages, where instructions determine the order of program execution.

Virtual Instruments (VIs) are the LabVIEW programs that imitate physical instruments. LabVIEW is integrated fully for communication with hardware such as GPIB, VXI, PXI, RS-232, RS-485, and data acquisition control, vision, and motion control devices. LabVIEW also has built-in features for connecting the required application to the Internet using the LabVIEW web server and software standards such as TCP/IP networking and ActiveX.

LabVIEW programs are called virtual instruments or VIs, because their appearance and operation imitates the physical instruments, such as oscilloscopes and multimeters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers.

A VI contains the following three components:

•**Front panel**— serves as the user interface.
•**Block diagram**—contains the graphical source code that defines the functionality of the VI.
•**Icon and connector pane**—identifies the interface to the VI so that a VI can be used in another VI. A Virtual instrument within another virtual instrument is called a sub VI. A subVI is a subroutine in text-based programming languages.

3.2MPLAB

MPLAB IDE is an integrated development environment that provides development engineers with the flexibility to develop and debug firmware for various Microchip devices.

MPLAB SIM is a discrete-event simulator for the PIC microcontroller (MCU) families. It is integrated into MPLAB IDE integrated development environment. The MPLAB SIM debugging tool is designed to model operation of Microchip Technology's PIC microcontrollers to assist users in debugging software for these devices.

3.3Compiler-High Tech C

A program written in C, is the high level language which will be converted into PICmicro MCU machine code by using a compiler. For the use of a PICmicro MCU or Microchip development system product like MPLAB IDE, Machine code is best suited.

3.4Pic Start Plus Programmer

The PIC start plus development system from microchip technology provides the product development engineer with a highly flexible low cost microcontroller design tool set for all microchip PIC micro devices. The pic start plus development system includes PIC start plus development programmer and MPLAB IDE.

The PIC start plus programmer gives the product developer ability to program user software in to any of the supported microcontrollers. The PIC start plus software running under MPLAB provides for full interactive control over the programmer.

IV. WIRELESS COMMUNICATION

The zigbee communication is being used for the development of Wireless environment monitoring system because zigbee is a self-configuring, long battery life, low cost, high reliability communication technology. Zigbee network has distinguished applications such as smart farms, military (viginet), telemedicine services, home device control and other commercial applications. Real-world environment monitoring is one such application area that is attracting researchers around the world in response to global warming. The PIC 16F877 is already programmed for the desired process. Then this value is transmitted to the monitoring unit through Zigbee. RS 232 is a serial communication cable that is used to connect the PC with Zigbee.

V. RESULTS AND DISCUSSION

The following figure.4 shows the front panel of the developed greenhouse gas monitoring and control system which provides the necessary information about concentration of each gas, voltage applied, and the relay status along with the timing information. Whenever the gas concentration exceeds the set value, the relay is activated and the corresponding voltage is applied for the control of gases.

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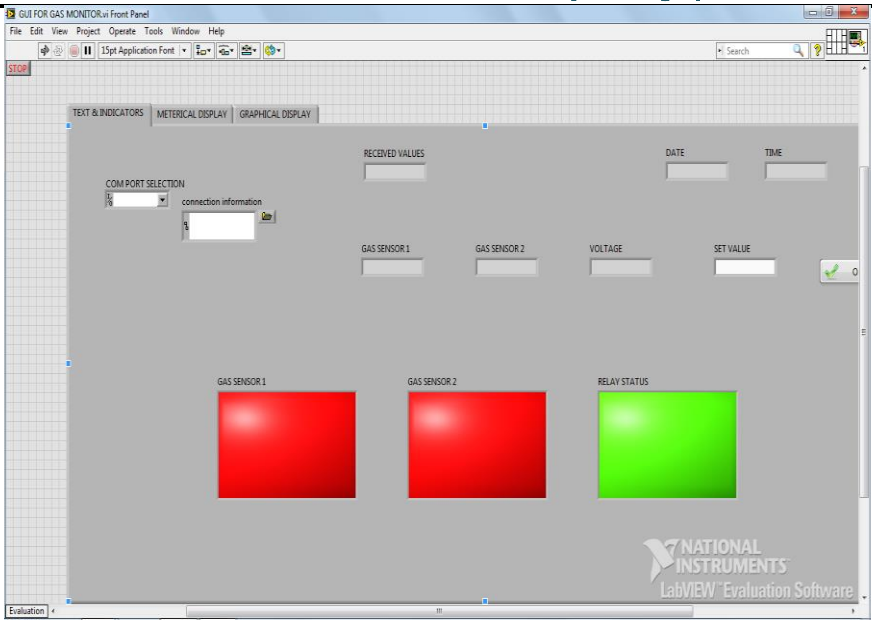

Figure.4 Front panel of gas monitoring system

The block diagram for the developed module is created in labVIEW is shown in figure.5, such a way that a database can also be created to store the necessary information.

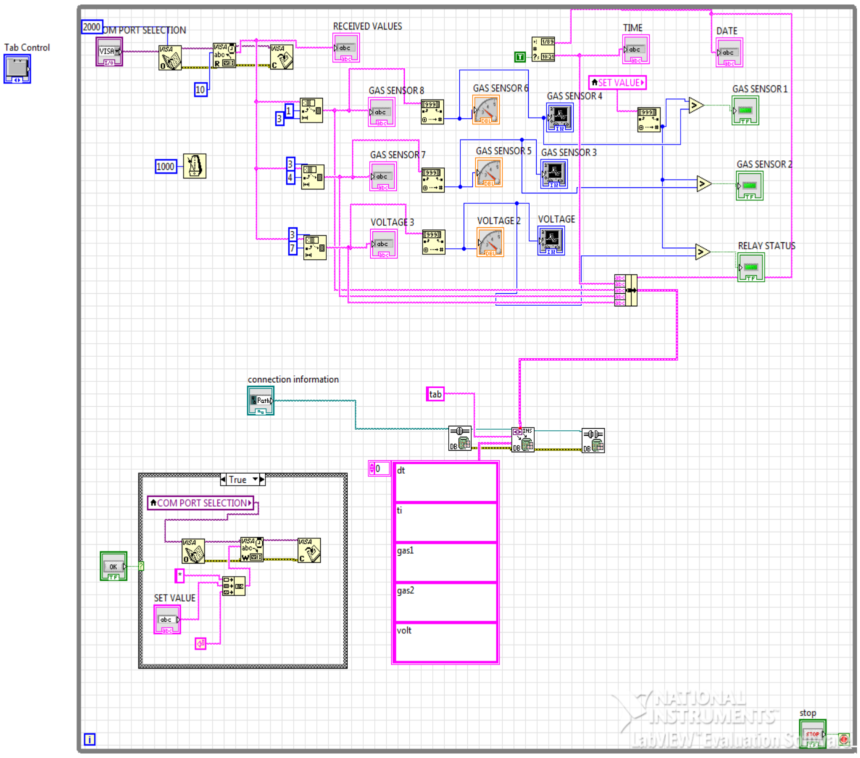

Figure.5 Block diagram of gas monitoring and control unit in LabVIEW

The following figure.6 shows the measurement of concentration of greenhouse gases and the required voltage applied to their control along with their timing information.

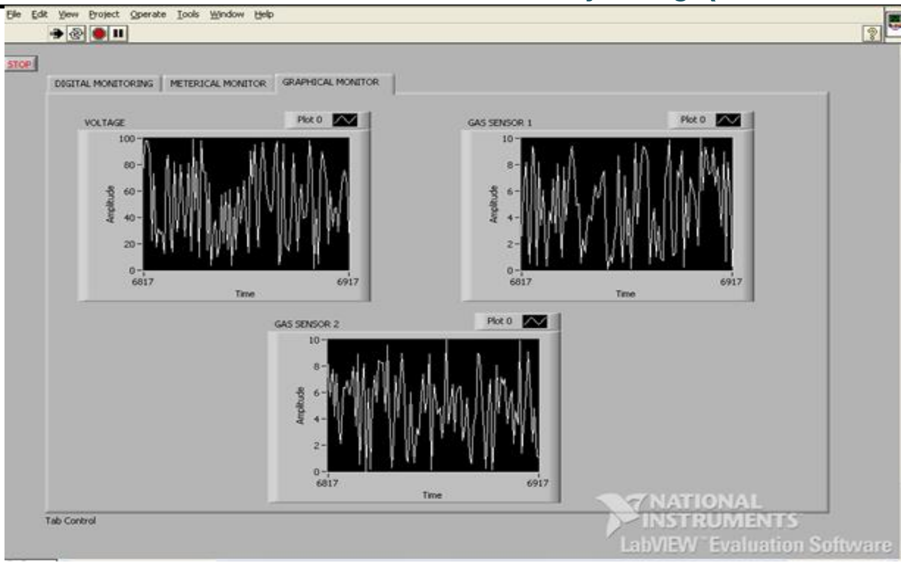

Figure.6 Measurement of concentration of greenhouse gases

VI. CONCLUSION

A Wireless Environment monitoring and control system is developed for monitoring the concentrations of greenhouse gases and to control their excessive emissions. The Zigbee is an efficient wireless protocol in terms of power consumption, scalability and it also provides a suitable data rate for controlling and monitoring purpose. The proposed method utilizes a sensor circuit, PIC microcontroller, zigbee as a wireless sensor network and other interfacing components that are integrated to perform the required task. The LabVIEW software gives the flexibility and performance of a powerful programming language without the associated difficulty and complexity. In future, the power generation circuit can also be included with the proposed system so that the power requirement with this system can be minimized.

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