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On-Line Monitoring Of Co2 Storage, Leakage By Using Wireless Sensor Networks

1.**LONKOJU RAKESH,2.M. SHYAM SUNDAR**

1PG Scholar, Department of ECE, SVS INSTITUTE OF TECHNOLOGY (Approved by AICTE, New Delhi & Affiliated to JNTU, Hyderabad & ISO 9001:2008 certified) BHEEMARAM(V), HASANPARHY(M),WARANGAL (Dt). T.S. India -506015.

Email id: lonkojurakesh567@gmail.com

2.Associate Professor, Department of ECE, SVS INSTITUTE OF TECHNOLOGY (Approved by AICTE, New Delhi & Affiliated to JNTU, Hyderabad & ISO 9001:2008 certified) BHEEMARAM(V), HASANPARHY(M),WARANGAL (Dt). T.S. India -506015.

Email id: shyam.ecehod@gmail.com

ABSTRACT: A remote online carbon dioxide (CO2) concentration monitoring system is developed, based on the technologies of wireless sensor networks, in allusion to the gas leakage monitoring requirement for CO2 capture and storage. The remote online CO2monitoring system consists of monitoring equipment, a data center server, and the clients. The monitoring equipment is composed of a central processing unit (CPU), air environment sensors array, global positioning system (GPS) receiver module, secure digital memory card (SD) storage module, liquid crystal display (LCD) module, and general packet radio service (GPRS) wireless transmission module. The sensors array of CO2,temperature, humidity, and light intensity are used to collect data and the GPS receiver module is adopted to collect location and time information. The CPU automatically stores the collected data in the SD card data storage module and displays them on the LCD display module in real-time. Afterwards, the GPRS module continuously wirelessly transmits the collected information to the data center server. The online monitoring Web GIS clients are developed using a PHP programming language, which runs on the Apache web server. MySQL is utilized as the database because of its speed and reliability, and the stunning cross browser web maps are created, optimized, and deployed with the Open Layers JavaScript web-mapping library. Finally, an experiment executed in Xuzhou city, Jiangsu province, China is introduced to demonstrate the implementation and application

INTRODUCTION Atmospheric concentrations of the key greenhouse gas(ghg) carbon dioxide (co2) well above pre-industrial levels constitute the main cause for the predicted rise at average

surface temperature on earth and the corresponding change of the global climate system . co2 capture and Storage (CCS) is on the one hand an effective way to realize effective greenhouse gas storage, and on the other to improve oil and gas production . Many countries such as the United States, Japan, and Canada are in search of effective approaches for CO2 storage in either geological formations or ocean. In China, the first demonstrative industrial project of CO2 storage has come into operation in Shenhua mine area. However, once CO2 leaks from the storage reservoir, all the efforts human beings have made to fight global warming would be go down the drain. Therefore, what is in needed after the geological CO2 storage is long-term terrain monitoring of the greenhouse gas leakage, which is absolutely crucial to help ensure that geologic sequestration of CO2 is safe. For this reason, the development of remote online monitoring system is of great significance to geological CO2 storage and leakage warning. Recent advances in information and communication technologies have resulted in the development of more efficient, low cost and multi-functional sensors. These microsensors can be deployed in wireless sensor networks (WSN) to monitor and collect air environmental information such as CO2 concentration, temperature, humidity, light intensity, air pressure, wind power, wind direction, etc. The information is then wirelessly transmitted to data center server where they are integrated and analyzed for evaluating of geological CO2 storage and leakage. Deploying sensor networks allows inaccessible areas to be covered by minimizing the sensing costs compared with the use of separate sensors to completely cover the same area. The remainder of this paper isas follows. SectionII presents the backgrounds of CCS leakage monitoring based on WSN and their related issues. SectionIII describes the hardware infrastructure of CO2 leakage monitoring equipment and different sensors and modules selected. SectionIV demonstrates the firmware flow of CO2 remote online monitoring system .In sectionV, the implementation and application example is presented. Finally, sectionVI is the conclusion of the paper and new avenues for the future works are put forward in this part.

II. THE HARDWARE SYSTEM

1. Micro controller This section forms the control unit of the whole project. This section basically consists of a

Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

2. ARM7TDMI ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

3. Liquid-crystal display (LCD) It is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7- segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

III. DESIGN OF PROPOSED HARDWARE SYSTEM

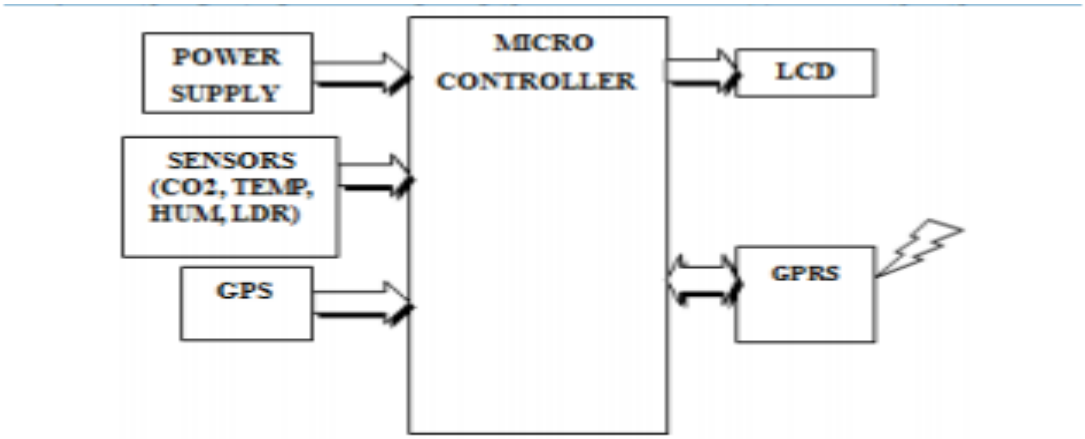
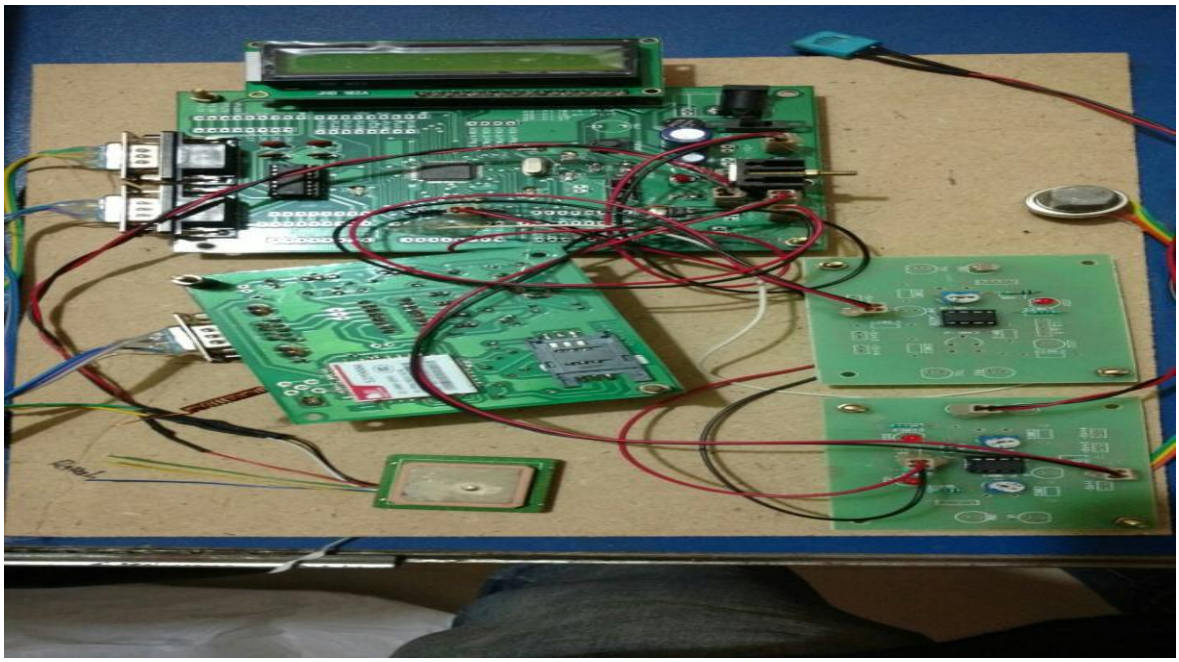


Fig.1.Block diagram.

The development of CO2 remote real-time monitoring equipment is the core task of the whole system. The equipment can be deployed in CO2 geological storage monitoring region. It can collect CO2 concentration, temperature, humidity, light intensity and other air environmental information through sensors and get the current position (longitude, latitude and elevation) and timing (GMT) information through Global Positioning System (GPS). Each node will then transmit the data to the

monitoring station. The General Packet Radio Service (GPRS) network will send the collected data to the data center server. The system uses a compact circuitry built around LPC2148 (ARM7) microcontroller Programs are developed in Embedded C. Flash magic is used for loading programs into Microcontroller. Atmospheric concentrations of the key greenhouse gas (GHG) carbon dioxide (CO2) well above pre-industrial levels constitute the main cause for the predicted rise at average surface temperature on Earth and the corresponding change of the global climate system. CO2 Capture and Storage (CCS) is on the one hand an effective way to realize effective greenhouse gas storage, and on the other to improve oil and gas production Many countries such are in search of effective approaches for CO2 storage in either geological formations or ocean However, once CO2 leaks from the storage reservoir, all the efforts human beings have made to fight global warming would be go down the drain. Therefore, what is in needed after the geological CO2 storage is long-term terrain monitoring of the greenhouse gas leakage, which is absolutely crucial to help ensure that geologic sequestration of CO2 is safe.



IV. BOARD HARDWARE RESOURCES FEATURES

A. GSM An embedded system is a special-purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose

computer, such as a personal computer, an embedded system performs one or a few pre-defined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often mass-produced, benefiting from economies of scale.Global System for Mobile Communication (GSM) is a set of ETSI standards specifying the infrastructure for a digital cellular service. The standard is used in approx. 85 countries in the world including such locations as Europe, Japan and Australia1 . When a mobile subscriber roams into a new location area (new VLR), the VLR automatically determines that it must update the HLR with the new location information, which it does using an SS7 Location Update Request Message. The Location Update Message is routed to the HLR through the SS7 network, based on the global title translation of the IMSI that is stored within the SCCP Called Party Address portion of the message. The HLR responds with a message that informs the VLR whether the subscriber should be provided service in the new location.

B. Temperature Sensor The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in oC). The LM35 - An Integrated Circuit Temperature Sensor. You can measure temperature more accurately than a• using a thermistor. The sensor circuitry is sealed and not subject to• oxidation, etc. The LM35 generates a higher output voltage than• thermocouples and may not require that the output voltage be amplified. It has an output voltage that is proportional to the Celsius temperature. The scale factor is .01V/oC The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 oC at room temperature and +/- 0.8oC over a range of 0oC to +100oC. Another important characteristic of the LM35DZ is that it draws only 60 micro amps

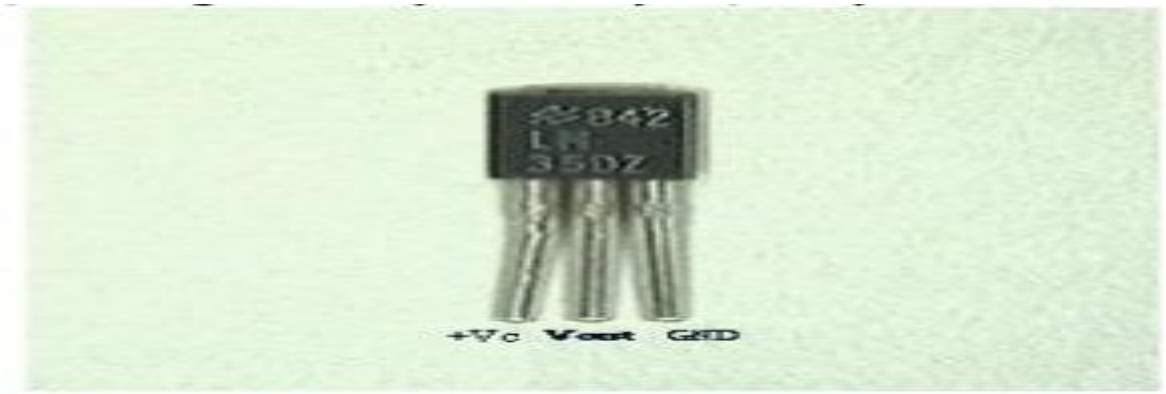


Fig2. Temparature Sensor.

from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1 oC te

C. Humidity Humidity is the amount of water vapor in the air. In daily language the term "humidity" is normally taken to mean relative humidity. Relative humidity is defined as the ratio of the partial pressure of water vapor in a parcel of air to the saturated vapor pressure of water vapor at a prescribed temperature. Humidity may also be expressed as absolute humidity and specific humidity. Relative humidity is an important metric used in forecasting weather. Humidity indicates the likelihood of precipitation, dew, or fog. High humidity makes people feel hotter outside in the summer because it reduces the effectiveness of sweating to cool the body by preventing the evaporation of perspiration from the skin. Absolute humidity is the quantity of water in a particular volume of air. The most common units are grams per cubic meter, although any mass unit and any volume unit could be used. Relative humidity is defined as the ratio of the partial pressure of water vapor in a gaseous mixture of air and water vapor to the saturated vapor pressure of water at a given temperature. Relative humidity is expressed as a percentage. Specific humidity is the ratio of water vapor to air (including water vapor and dry air) in a particular volume

D. GPS Global Positioning System (Gps) Is A Global Navigation Satellite System (Gnss) Developed By The United States Department Of Defense. It Is The Only Fully Functional Gnss In The World. It Uses A Constellation Of Between 24 And 32 Medium Earth Orbit Satellites That Transmit Precise Microwave Signals, Which Enable Gps Receivers To Determine Their Current Location, The Time, And Their Velocity. Its Official Name Is Navstar Gps. Although Navstar Is Not An Acronym A Few Backronyms Have Been Created For It.0. The Gps Satellite Constellation Is Managed By The United States Air Force 50th Space Wing. Gps Is Often Used By Civilians As A Navigation System Gps Receiver Calculates Its Position By Carefully Timing The Signals Sent By The Gps Satellites High Above The Earth. Each Satellite Continually Transmits Messages Containing The Time The Message Was Sent, Precise Orbital Information (The Ephemeris), And The General System Health And Rough Orbits Of All Gps Satellites (The Almanac). The Receiver Measures The Transit Time Of Each

Message And Computes The Distance To Each Satellite. Geometric Trilateration Is Used To Combine These Distances With The Location Of The Satellites To Determine The Receiver's Location. The Position Is Displayed, Perhaps With A Moving Map Display Or Latitude And Longitude; Elevation Information May Be Included. Many Gps Units Also Show Derived Information Such As Direction And Speed, Calculated From Position Changes.

CONCLUSION Based on the sensors of CO2, temperature, humidity and light intensity, the equipment which is suitable for the surface CO2 concentration monitoring was developed in order to realize remote real-time acquisition of multivariate information in the monitoring of CO2 geological storage. This experiment adopts self-made portable CO2 monitoring equipment, which obtains localization and time service information through GPS, and it can cache dynamic changes of real-time monitoring data into SD cards. GPRS is employed to wirelessly transmit them to the server, which ensures the continuity of data acquisition and monitoring. Apart from the sound effects, the monitoring system is simple in structure, easy to operate, convenient to carry, remote monitoring, automatic storage, real-time display and continuous wireless transmission, which provide remote realtime monitoring means for further study of quantitative analysis and dynamic simulation of the process of CO2 geological storage, leakage, diffusion and migration under complex air environment

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