Real Time Monitoring of Geological CO_2 Storage Region using Arduino

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Abstract-- Carbon Capture and Storage (CCS) is the process of capturing waste carbon dioxide (CO_2) from large point sources such as fossil fuel power plants, and transporting it to a storage site and depositing it where it will not enter the atmosphere. The main purpose for storing CO_2 is to prevent the release of large quantities of CO_2 (Greenhouse Gas) into the atmosphere. In order to prevent CO_2 leakage from the storage region to monitoring the CO_2 stored region is required. To reduce the amount of greenhouse gas emissions entering Earth's atmosphere, real time monitoring system is essentially needed. For this reason, the development of real time monitoring system is of great significance to geological CO_2 storage and leakage warning. The effective application of monitoring technologies should ensure the safety of CCS with respect to both human health and the environment, and will contribute greatly to the development of relevant technical approaches for monitoring and verification. The main aim of the project is to monitor the CO_2 storage region using Arduino. CO_2 sensor and temperature sensor are used to sense CO_2 leakage and temperature of the surrounding in the storage region. After this the person who monitors the CO_2 storage region can get leakage warning information using GSM technology.

Keywords--Arduino UNO R3; CO_2 Sensor; Temperature sensor: GSM module.

1. INTRODUCTION

CO_2 Capture and Storage (CCS) is an effective way to realize effective greenhouse gas storage.Many countries such as the United States, Japan, and Canada are in search of effective approaches for CO_2 storage in either geological formations or ocean[1]. In China, the first demonstrative industrial project of CO_2 storage has come into operation in Shenmue mine area. Geologic sequestration of CO_2 is safe[1]. It can reduce severe damage and recovery cost. It also supports the flexible sampling interval change depending on the pollution conditions of the context model[2]. For developing sensor network applications, various kinds of technologies including sensing, communication and computing are required[6]. CO_2 is an excellent solvent and dissolves into the oil, simultaneously reducing its viscosity and increasing its volume[5]. The reduced viscosity makes the oil flow more easily and the swelling of the CO_2- rich oil enhances reservoir pressure[5]. Due to present concerns about global climate change related to GHG emissions, efforts are underway to assess CO_2 sinks, both terrestrial and geologic, as a form of carbon management to offset emissions from fossil fuel combustion and other human activities.

Monitoring may be required to ensure that natural resources, such as groundwater and ecosystems, are protected and that the local population is not exposed to unsafe concentrations of CO_2[3]. The Sleipner project is a commercial CO_2 injection project and proved that CO_2 capture and storage is a technically feasible and effective method for greenhouse mitigation. It further demonstrates that CO_2 storage is both safe and has a low environmental impact[4]. The main aim of the project is to monitor the CO_2 storage region using Arduino. CO_2 sensor and temperature sensor are used to sense CO_2 leakage and temperature of the surrounding in the storage region.

2. PROPOSEDMETHOD

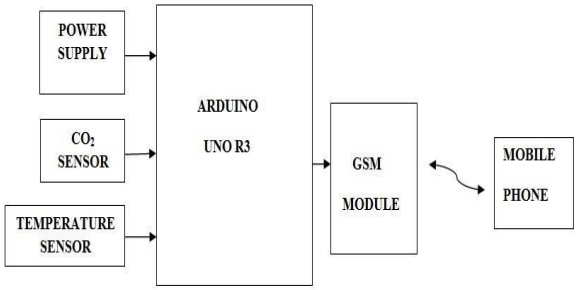

Fig.1. Block Diagram

A. Introduction on Arduino

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on, based on Processing.

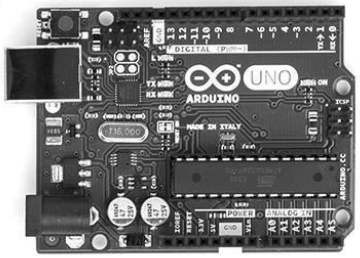

Fig.2. Arduino Uno

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

1) Why Arduino

Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50

Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.

Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

2) Controller

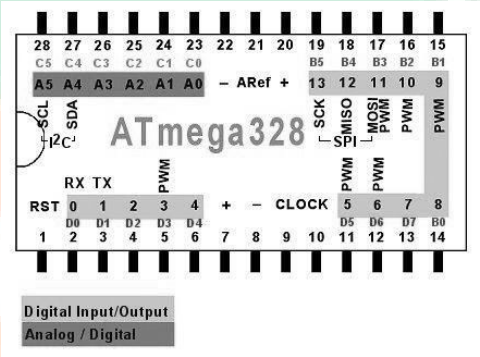

Fig.3. ATmega328 Controller

TABLE.1 ATmega328 CONTROLLER SPECIFICATION

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital

input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC- to-DC adapter or battery to get started.. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

3) Types of Thermistors

A thermistor is a temperature sensor constructed of semiconductor material that exhibits a large modification in resistance in proportion to a tiny low modification in temperature. Thermistors are inexpensive, rugged, reliable and responds quickly. Because of these qualities thermistors are used to measure simple temperature measurements, but not for high temperatures. Thermistor is easy to use, cheap, durable and respond predictably to a change in temperature. Thermistors are mostly used in digital thermometers and home appliances such as refrigerator, ovens, and so on. Stability, sensitivity and time constant are the final properties of thermistor that create these thermistors sturdy, portable, cost-efficient, sensitive and best to measure single-point temperature. Thermistors are available in different shapes like rod, disc, bead, washer, etc. This article gives an overview of thermistor working principle and applications.

Thermistor Elements

Thermistor elements are the simplest form of thermistor, it is commonly used when space is very limited. OMEGA offers a wide variety of thermistor elements which vary not only in form factor, but also in their resistance Vs temperature characteristics. Since thermistors are non-linear, the device used to read the temperature must linearize the reading.

Thermistor Probes

The standalone thermistor element is comparatively delicate and cannot be located in a ruuged environment. OMEGA offers thermistor probes that are thermistor elements fixed in metal tubes. Thermistor probes are much more suitable for industrial enviraonments than thermistor elements.

Applications of thermistors

- A Thermistor is used to measure the temperature.
- The thermistor is used as an electrical circuit component
- For temperature compensation
- Circuit protection
- Voltage regulation
- Time delay, and Volume control.
- Thermistors are used in an automotive applications
- Instrumentation and Communication
- Consumer electronics

4) GSM MODULE

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone.

When a GSM modem is connected to a computer, this allows the computer to use the GSM modem to communicate over the mobile network. While these GSM modems are most frequently used to provide mobile

internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

A. RhydoLabz GSM/GPRS TTL UART Modem

Fig.5. GSM module

GSM/GPRS TTL UART Modem is built with Dual Band GSM/GPRS engine- SIM900A, works on frequencies 900/ 1800 MHz .The Modem is coming with selectable interfacing voltage, which allows you to connect 5V & 3V3 microcontroller directly without any level conversion chips. The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with Internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface. Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and Internet etc… through simple AT commands.

5) CO_2 SENSOR

With broad measurement range, high sensitivity, fast response time, good selectivity and strong anti-interference ability, S-100 miniature CO_2 sensor module is selected. This sensor adopts Non-dispersive infrared (NDIR) spectroscopic analysis technology, and is widely used in many fields such as air quality monitoring. It's performance and accuracy could well meet the needs of geological CO_2 monitoring.

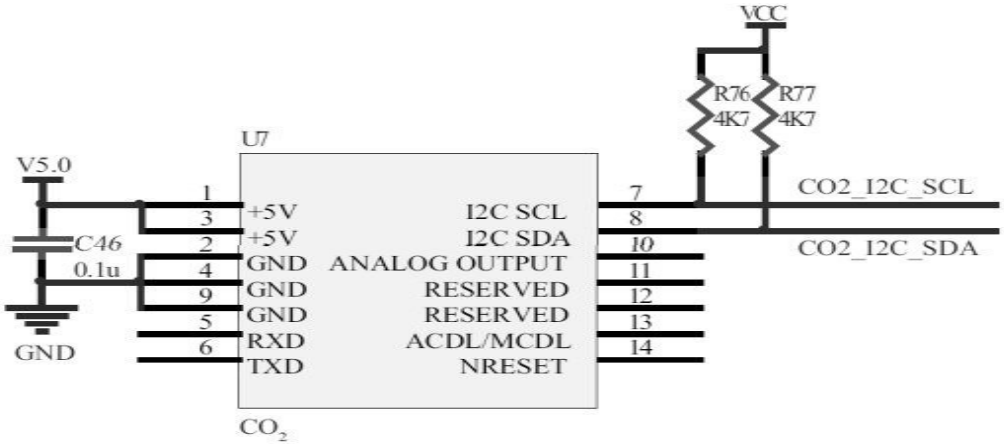

Fig.6. circuit diagram of CO_2 sensor

CO_2 gas sensors with sensitive layers based on polymer have the advantage of very low energy consumption, and can be reduced in size to fit into microelectronic-based systems. These sensors absorb ambient Infrared radiation (IR) given off by a heated surface. Carbon dioxide (CO_2) is measured in parts-per-million.

3. RESULTS AND DISCUSSION

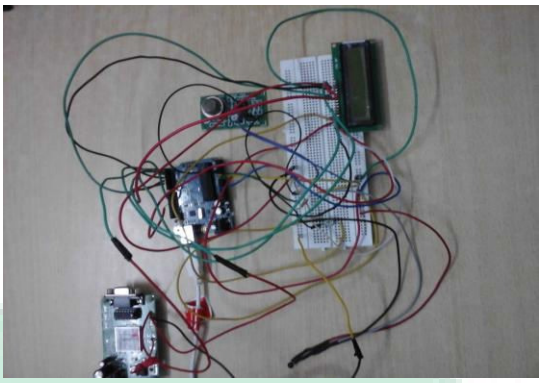

Fig.7. Physical connection

The figure.6 shows overall setup of the connection.

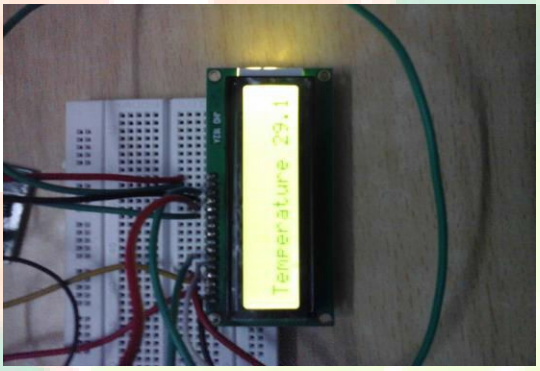

Fig.8. Display of Temperature

The figure.8 shows the temperature measurement during leakage of CO_2.

Fig.9 Display of CO_2 leakage level

The figure.9 shows the CO_2 leakage in the storage region.

From this, we measure temperature of surrounding in CO2 storage region and measure CO2 leakage level in the storage region. Leakage warning information is received using GSM technology.

4. CONCLUSION

Based on the sensors of CO_2, temperature the equipment which is suitable for the surface CO_2 concentration monitoring was developed in order to realize remote real-time acquisition of multivariate information in the monitoring of CO_2 geological storage.GSM is employed to wirelessly transmit the message to the mobile phone. The monitoring system is simple in structure, easy to operate, convenient to carry, remote monitoring, which provide remote real-time monitoring means for further study of quantitative analysis and dynamic simulation of the process of CO_2 geological storage, leakage, diffusion and migration under complex air environment.

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