



DESIGN AND IMPLEMENTATION OF REMOTE ENVIRONMENT MONITORING SYSTEM FOR INDUSTRY AND LANDFILL SITES USING ARM7 PROCESSOR

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Abstract

The primary causes of the climate change and global warming on the earth are the greenhouse gases, which are produced as a result of industrial processes, burning fossil fuels, Landfill sites and rice cultivation etc. The impacts of these greenhouse gases on the environment are more troublesome to the living beings.

The main theme of this project is to design a system to measure and monitor the concentration levels of different greenhouse gases at the industry and the landfill sites is the major concern. And even it is designed to monitor the leachate, a toxic liquid released at the landfill sites. The system is built around the ARM7 processor, which processes the concentration level of greenhouse gases and monitors conditions around the industry and landfill sites. The processed information is sent to the corresponding corporations for storage and interpretation of the data. And even the system is designed for open access by any end user, who wants to know the condition around these sites, by sending an SMS to the remote environment monitoring system.

Keywords: ARM7 Processor, Gas sensor array, GSM module, Real time database application, Water flow detection module.

1. INTRODUCTION:

The air quality in the environment is reducing day by day due to industrial processes and manmade activities. The environment around the industrial area is being exposed more to the green house gases leading to the hazardous effects on the living beings. So the monitoring of the air quality is the prime factor. Timely information of the pollution level at any sites is very important to take precautionary measures over it.

Globally, millions of tons of municipal solid waste are disposed in landfills sites every day.

Landfill gas is a natural by-product of decayed organic material compiled from household waste, yard waste, food waste,

etc., disposed in these landfills. This landfill gas is mainly a combination of methane (CH₄), carbon dioxide (CO₂) plus a certain amount of non-methane organic compounds (benzene C₆H₆, toluene CH₃, and chloroform CHCl₃). Landfill is considered to be the third largest emission source in the world after rice cultivation and biomass burning from manmade activities including industry. Previously, open dumps and unmanaged landfills represented a significant issue in many of the developing countries. Over the last few decades, however, many of these countries have attempted to transfer their waste disposal activities from uncontrolled systems to landfills.

The process of monitoring these landfills is to assess the chemical decomposition of

landfill gas, soil samples, ground water, and surface water within the site. One of the goals of this monitoring is to determine the impacts of the landfill site on the environment and the surrounding area. Currently, most of the landfill sites are designed with leachate collection systems to convert the landfill gas into green power. Traditional monitoring programs, such as field sampling and laboratory testing, consume both time and effort. In cases of their large spatial extent, such monitoring schemes can cost millions of dollars, and it is difficult to investigate the impacts of landfill sites on the surroundings. In this study, the use of low power, less expensive, non-dispersive infrared gas sensors made it easy to measure & monitor the concentration level of different green house gases at industry and landfill sites.

The use of high performance, low power ARM7 controller made it easy to control and fast processing of the data and the same is made available to the end user via the GPRS or GSM service. The non dispersive infrared gas sensors are being used to measure the gas concentrations because of their fast response and sensitive to the particular gases and stable operation over wide range of temperature. The database is used to store the gas concentrations at different sites.

The purpose of this study is to provide useful supplementary information for industry and landfill site monitoring and management, instead of simply replacing the current, more traditional monitoring schemes.

2. HARDWARE SYSTEM DESIGN

2.1 BLOCK DIAGRAM

The main hardware system consists of gas sensor array (CH₄, CO₂ & CO Sensors), Water-flow (leachate) detection sensor, temperature sensor, GSM modem, 16x2 LCD module, Mobile unit, Personal computer with Database application, LED/Buzzer unit and ARM7 TDMI (LPC 2129). The complete block diagram of the environment monitoring system is as shown in the figure 2.1.

2.2 ARM7 (LPC2129) MICROCONTROLLER

The LPC 2129 are based on a 32 bit ARM7 TDMI-ST7M CPU with real-time emulation and embedded trace support, together with 256 kilobytes (KB) of embedded high speed flash memory and 16 kilobytes of Static RAM. A 128-bit wide internal memory interface and unique accelerator architecture enable 32-bit code execution at maximum clock rate 60MHz with PLL.

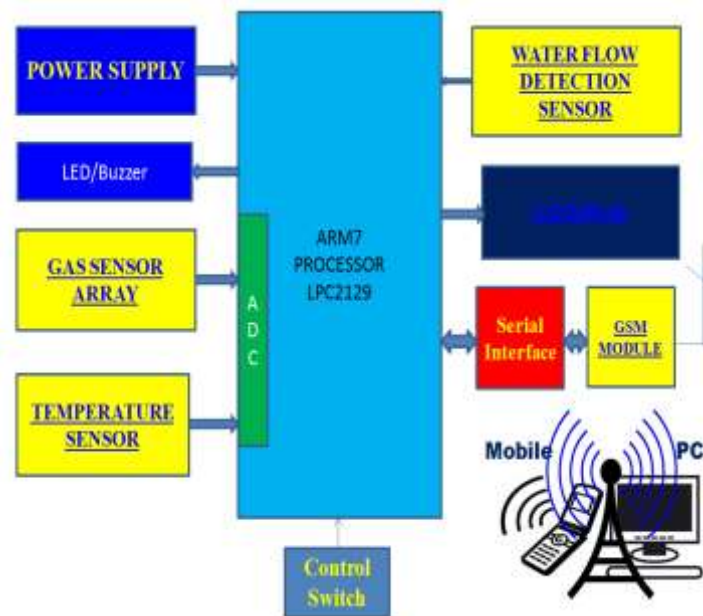


Fig. 2.1 Block diagram of the system

With their compact 64 pin packages, low power consumption, various 32-bit timers, combination of 4-channel 10-bit ADC with conversion rate of 2.44uS and 2 advanced CAN channels, 2 UART'S, SPI and up to 9 external interrupt pins, these microcontrollers are particularly suitable for high speed applications in industrial control, medical systems, and access control and point-of-sale. Number of available GPIOs goes up to 46 in 64 pin package.

The low power consumption and high performance factors of ARM7 made it

to use as heart of the controlling and processing unit in our system to monitor and coordinate all the peripherals connected to the system.

2.3 GAS SENSOR ARRAY

The gas sensor array consists of Methane gas (CH₄) sensor, Carbon Dioxide (CO₂) Sensor and Carbon Monoxide (CO) sensor. These gas sensor arrays are used to detect the CH₄, CO₂ & CO gas concentration levels which are released into the environment as a result of industrial processes & degradation of compiled waste by the bacterial breakdown at the remote sites like industry and landfills. These different sensors as discussed below,

i. Methane Gas (CH₄) Sensor



Fig 2.2 CH₄ gas sensor

The CH₄ gas sensor has wide detection scope, Fast response and high sensitivity for Methane gas and is stable in operation and has long life.

Features:

- Sensing high methane gas concentration
- Concentration range: 300-10000ppm
- Stand-alone / background sensing
- Power requirements: 5 VDC @ ~165 mA (Sense Mode) / ~5 mA (Standby)
- Interface: 1 TTL compatible input (HSW), 1 TTL compatible output (ALR)
- Operating temp range: +32°F to +158°F (0°C to +70°C)

ii. Carbon Dioxide Gas (CO₂) Sensor

In major applications non-dispersive infrared (NDIR) CO₂ sensors are used to measure the concentration levels of carbon dioxide.



Fig 2.3 CO₂ gas sensor

Features

- Good sensitivity and selectivity to CO₂ Low humidity and temperature dependency
- Long stability and reproducibility
- Concentration: 350-30000ppm
- Circuit Voltage 5.0V±0.2V AC or DC
- Normal operating temperature range: 25°C (±5°C)

iii. Carbon Monoxide Gas (CO) Sensor

Some of the industrial processes & automobiles releases enormous amount of carbon monoxide into the environment, so the CO sensor is added into our project to monitor the pollution level at different sites. Fig2.3 shows the CO sensor module.



Fig 2.4 CO gas sensor module

Features

- Sensing high carbon monoxide (CO) concentration
- Stable and long life
- circuit voltage 5V+/- 0.1V
- Detecting range:20ppm-2000ppm

2.4 WATER FLOW DETECTION SENSOR

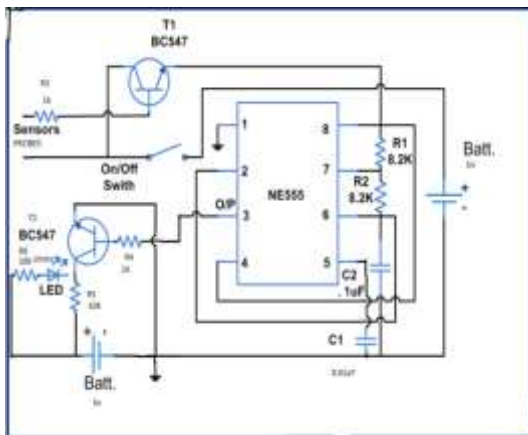


Fig 2.4 Water flow detection circuit

Especially in the Landfill sites the bacterial breakdown on the waste releases many harmful gases & apart from these gases it releases a toxic liquid called “Leachate”. So the detection and monitoring of such liquid is important & should not to allow it to mix up with the flowing streams, otherwise may cause severe diseases on the living beings who consumes such water. The water flow detection circuit is as shown in fig 2.4.

2.5 Temperature Sensor

The LM35 temperature sensor is a precision IC whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

Temperature sensor plays many roles in our project like monitoring temperature around the chosen sites and to detect the fire at those sites, because at the landfill sites due to bacterial breakdown on waste it releases the highly flammable CH₄ gas, higher concentration of CH₄ may set the whole landfill into fire. And one more use of these sensors is used in calibrating some gas sensors which are highly depending on the operating temperature ranges.

GSM module is used to establish communication between a computer and a GSM-GPRS system. And even the concentration of different gases and water flow information will be sent to the respective corporations via GSM. It is being used to interact with the users directly via SMS to know the conditions at the desired sites.

3. SOFTWARE DESIGN

To make the hardware to work as per the designed application a real time software program is necessary, which makes the controller to coordinate the activities in it and monitors as well as controls the peripherals those are connected to the system.

3.1 SOFTWARE FLOW CHART

The ARM7 is the key device to control whole system activities, so the main program runs in ARM. The main program starts primarily by initializing the LCD, UART and GSM Modem, & Event Counter=0. After initializing LCD, UART manual mode or automatic mode is selected based on the control switch logic. If the control switch is at logic 1 then automatic mode is selected and it will read the concentration of gasses like methane, Carbon dioxide, Carbon monoxide levels, temperature and water flow detection then displays on LCD. Parallely it checks the gas levels of CH₄ or CO₂ or CO or temperature whether these exceeded to its normal level or not. If the gas levels and temperature is exceeded, the same will be displays on the LCD and sends the concentration levels to the Authorized mobile or respective departments. At the same time it checks whether the water flow detected or not, in case if there is presence of water flow in the

landfill sites then it displays “water flow detected” and sends the same information to the mobile number as SMS along with gas levels. In case no water flow is detected, it displays “No water-flow is detected” and sends same information to mobile as SMS. Once the defined time reaches then the gas concentration levels & water flow information will be sent to the authorized/department mobile number because it is clumsy to send the SMS every time when the main program loops back and also due to cost of message.

The software flow chart explaining the complete system design is as shown in the fig 3.1.

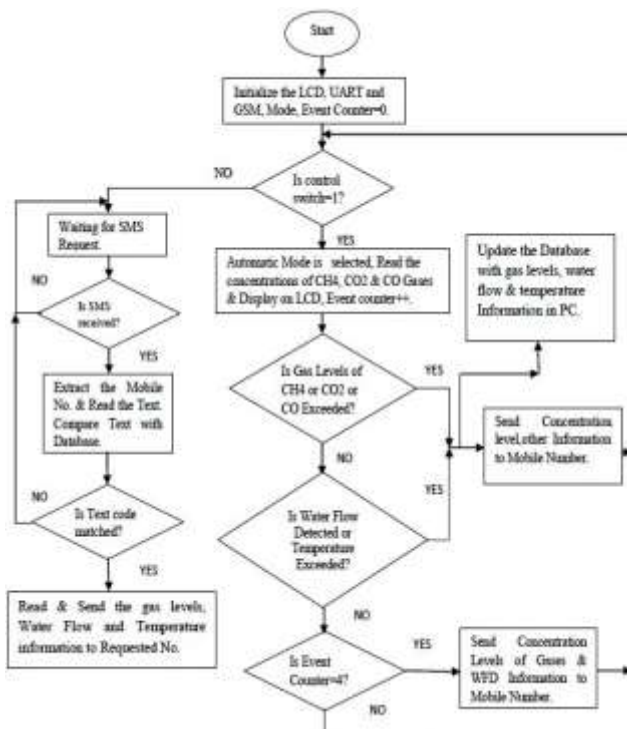


Fig 3.1 Software Flow chart

If the control switch logic is low then the manual mode is activated, then it will wait for the SMS request from any person who wants to know the condition around the

landfill site, if the SMS request is received then it will extract the mobile number and reads the text and compares the text with database. if the text is matched with the database it displays ”valid Text” on the LCD & then the system sends the gas levels, temperature and water flow detection information to the requested mobile number. If the text is not matched with database it displays “invalid Text” on LCD, and again it waits for the SMS request. Here we go for manual mode to give the information of the gases and water flow detection level to public also so that everyone can access the information about the toxic gases concentration levels at the landfill sites.

3.2 REAL TIME DATABASE APPLICATION

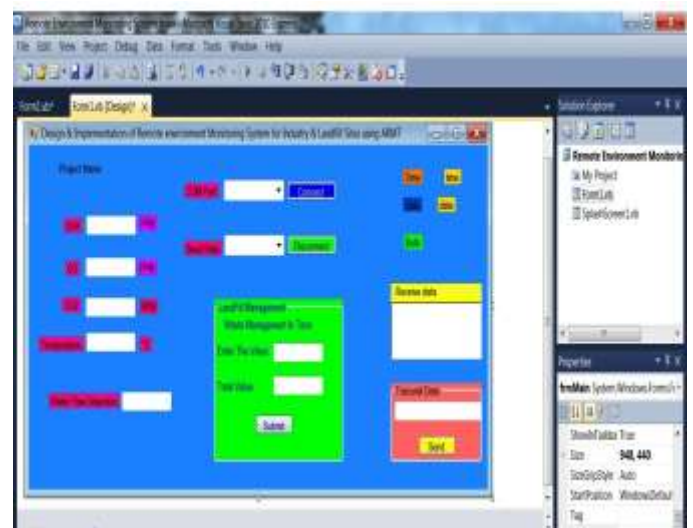


Fig 3.2 Real time Database application

Apart from displaying and sending data information regarding Gas levels, temperature and water flow detection at the remote sites, a real time database application is being created by using Visual Basic 2010, which acquires and updates the real time

data from the remote sites via the GSM/GPRS serial communication.

The real time database client application is as shown in the fig3.2.

4. RESULTS AND DISCUSSION

The environment monitoring system can be very well applied Remote sites like the Industry & landfills. The system continuously senses environmental conditions where the gasses are released from industry, landfill sites and alerts the respective departments/authorities and even common man via SMS to take certain measures. If any harmful gasses like methane, carbon monoxide, carbon dioxide released from landfills the gas sensors (methane, carbon monoxide, carbon dioxide) will sense the gasses and sensitivity will be shown on LCD display.

When the system is powered ON, ARM7 controller first it initialization of the LCD, UARTS & GSM, Then it starts the acquisition of gas concentration, temperature and water flow information from the different sensors and the same information is displayed on the LCD display.

The mode of system operation can be selected using the control switch as shown in the following figures.



Fig4.2: Automatic mode of operation

In the normal conditions the gas level, temperature and water flow detection information is as shown fig 4.3.

Fig4.3: Normal condition data display



Fig4.4: Abnormal condition data display

In case of abnormal conditions means gas level exceeding and water



flow detections the same displayed and an alert message will be sent to the respective authorities or departments.

The SMS information for different conditions are shown in the fig 4.5. If the control switch is connected to other logic then the system enters to the manual mode or user mode of operation, where any end users can access the system via "SMS ON DEMAND" request. The whole manual operation or process is as shown in the Fig 4.7.



Figure 4.5: Received SMS shows gas levels and water flow is detected info



Fig 4.7: Manual mode process for requesting users about remote area info

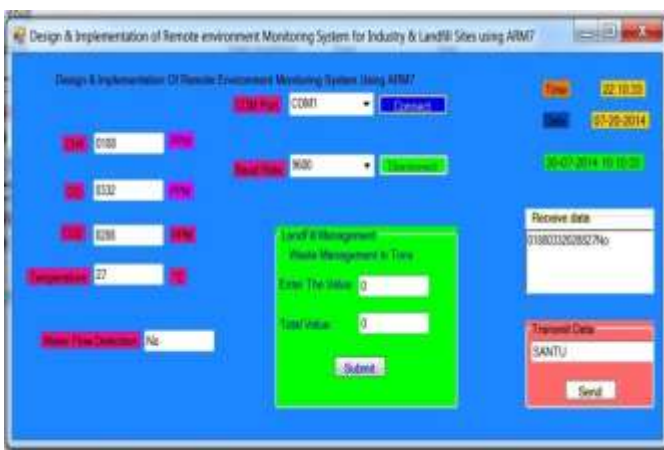


Figure 5.8 real time data base application for data storage

The real time data base application is mainly used to store the concentrations of the different gas levels, temperature and water flow information at the industry and the landfill sites for the analysis, interpretations and storage for the future use or transformation of the same to the end users. And also used for landfill waste management.

The data base software application is as shown in the below figure 6.14.

5. CONCLUSION

Hence this paper describes about the design and implementation of a system to measure and monitor the gas concentration levels and other information at the remote environments like industry and landfill sites. The system incorporates the low power, cost effective electromechanical and infrared sensors to acquire the different conditions at the mentioned sites. The system shows the satisfactory results to monitor the remote environments. A serial

communication is established to inform the gas levels, temperature and water flow detection between the system and authorized body or departments via the SMS service through the GSM/GPRS.

And even a system access facility is provided to the end users through the “SMS ON DEMAND” service.

A real time database software application is designed to update and store the data information from the different remote environments. The data information acquired at these sites can be processed in local ARM7 processor and the same is transformed and interpreted to make available to the end users.

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