Prevention of Gas Poisoning of Sewage Workers using Arm Cortex-M4

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Abstract – This paper describes the ARM based safety system to overcome the gaseous hazards in sewage. In this a smart device is designed based on ARMCORTEX_M4 platform which is 32-bit microcontroller. This device measures the gas concentration, pulse rate of the person working in poisonous gaseous area. The measured quantity can be displayed on LCD screen at the same time when those parameters goes beyond the threshold level the sewage worker is been alerted instantly with a vibration sensor on the other hand the system has long-distance communication facility, tends to send a text message using GSM module, which can reduce some sort of disturbances and rejection in the communication network. A protection mask is provided to restore the supply of oxygen to the person. This system is designed for the sewage workers. We can extend the use of application in industries, oil wells etc where the poisonous gas are present in extreme level.

Keywords - gas concentration, ARM cortex M4, protective mask, pulse rate,GSM.

I. INTRODUCTION

We know that, our society depends on human being for most of the work. Amidst which the most lethal work is the work done by those who know that their work is dangerous and that the chances of death or injury is more. One of such work is sewage cleaning process. According to a 2014 story on the Zee News website the work kills 2% of those who do it in Delhi, meaning 100 deaths annually in a community of 5,000,. A January 2014 study by the non-profit Praxis India called "D own The Drain! " , on the occupational and health hazards and the perils of contracting faced by the sewerage workers of Delhi, shows that every year 100 sewerage workers die after entering drains and manholes with high temperature, slippery walls, floors and toxic gases, in Delhi[1]. These are staggering numbers and the fact that we are ignorant and totally unconcerned , So it becomes much important to monitor such areas to assure them a safety and a secured life. Here they need extreme precaution before they undergo a cleaning process. As for sewage cleaning is concerned the various factors that have to be considered are poisonous gases, pressure, temperature, depth and so on. These parameters are needed to be maintained and monitored at a desired level and whenever these parameters goes beyond certain limit they may lead to unconscious state and sometimes even to death. So, in order to maintain the desired levels of these parameters, they must be monitored and made

known to those who work there and thus preventing them from gas poisoning.

Now a day ' s message becomes an integral part of human life. So, it is clear that transfer of message is more useful for various purposes. The GSM services being deployed on various embedded processors such as Advanced RISC Machine (ARM) in real time context. Microcontroller is very practical and successful to utilize in such system, since it is 32 bit[2,3]. The ARM architecture is Reduced Instruction Set Computer (RISC), and the instruction set and related decode mechanism are much simpler than those of microprocessor of Complex Instruction Set.As a result of this simplicity in the instruction set results in fast throughput from a small and cost-effective processor. ARM based embedded system will be more functional, reliable, cost effective, compact in size and also low power consumption[3,4]. The system consists of ARM micro controller of TM4C123GXL series.

The main purpose to use this controller is its advantages. Some of the main advantages are, it consumes very low power, high speed controller and have many built in features.RTOS stands for Real-Time Operating System. Real time kernel is simple and stable. RTOS divides the complex application into number of mutually independent tasks based on its priority [5]. The difference between simple programming concept and RTOS programming is that, the response of the RTOS programming is much satisfactory than that of the simple programming concept. Real-Time gives an expected response to an event with respect to its time interval and production of the result depicts deadline for instant of the events' evolution.

Operating System (OS) is a system program that makes device user friendly and provides an interface between hardware and application programs. Synchronization, Multitasking, Event Handling, Input/ Output, interrupt and Inter-task Communication are the common features of Operating system. RTOS is therefore an operating system that supports real-time applications and embedded systems by providing logically correct result within the deadline. Such capabilities shows that, why the RTOS is superior to that of the simple programming concept and shows its deterministic timing behavior and limited resource utilization nature [5,6]. The use of this system can make anyone to monitor the parameters like gas concentration, pulse rate and depth. For this, the proposed system consisting sensors like of gas sensor, heart

beat sensor and ultrasonic sensor. The sensed data by the sensors is then being read by the microcontroller TM4C123GXL. When the sensor value exceeds the desired value, the sewage workers will be given a vibration using vibration motor instantly so as to alert them about the critical situation of the place the message is send simultaneously through GSM module to the local monitoring. This system is used to monitor the status of unwanted situation[7,8].

ARM Features:
 ➢ High Performance TM4C123GH6PM MCU
 ➢ 80 MHz 32-bit ARM Cortex-M4F CPU
 ➢ 256KB Flash, 32KB SRAM, 2KB EEPROM
 ➢ Two Controller Area Network (CAN) modules
 ➢ Dual 12-bit 2MSPS ADCs, motion control PWMs
 ➢ 8 UART, 6 I2C, 4 SPI
 ➢ On-board In-Circuit Debug Interface (ICDI)

II. CURRENT TECHNOLOGY

In the current scenarios, most gas poisoning incidents in drainage work occur as a result of improperly identifying the dangers of atmospheric hazards in the workspace or ignoring safety procedures so as to get the jobs done more quickly. Incidents of gas poisoning in drainage work often result in multiple deaths because in such incidents, co- workers often instinctively enter the drainage immediately in an effort to help the collapsed victim and thus also succumb to the gas poisoning. Rescue should only be performed by trained personnel with appropriate equipment and support from other rescuers. Drainage workers may be exposed to hazardous gases, fumes and vapours, resulting in serious poisoning.

However, some may arise from the work being carried out. The enclosed nature of the workspace may increase the danger, as hazardous gases can accumulate in the work area and their concentrations in air can rise rapidly.

Typical sources of hazardous gases present in drainage work include the following:

• Decomposition of organic matters in sewers, manholes and pits of the drainage system will generate methane and/ or hydrogen sulphide. Hydrogen sulphide, being very soluble in water, often dissolves in sewage and can be trapped within sediment and sludge in sewers as gas pockets. Disturbing the sewage, sediment or sludge can release the trapped or dissolved gas.

• Leaks from underground fuel tanks, gas utility pipes, connected sewer systems or contaminated land, such as landfills, may enter the work area.

Use of generators and fuel-driven tools in poorly ventilated areas may use up oxygen and generate carbon monoxide. Apart from gases, hazardous fumes or vapours can be generated from the work, e.g. welding or the use of adhesives, paints, volatile or flammable solvents, etc.
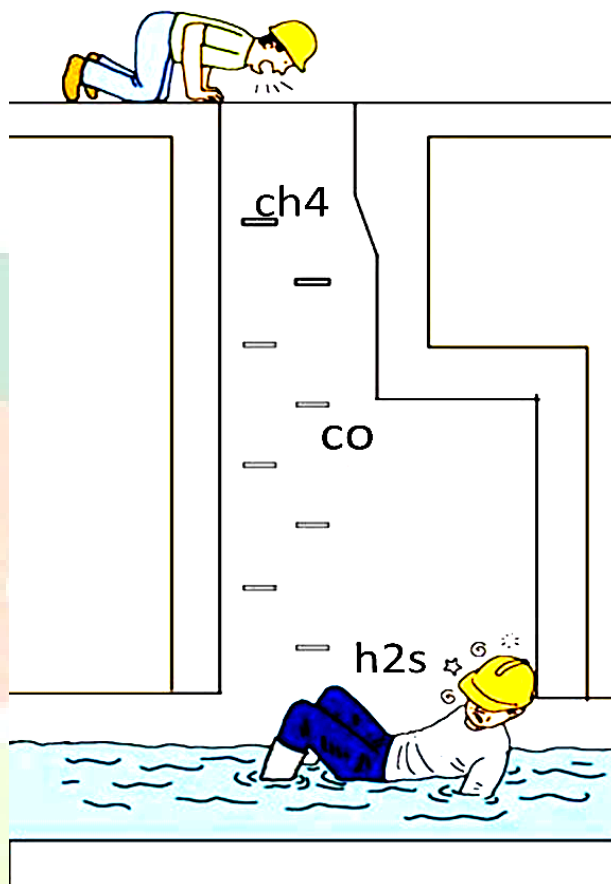

Figure1 : Effect of toxic gases

A. *Hydrogen sulphide (H2S)*

Hydrogen sulphide is a deadly gas with a distinctive "rotten egg" odour that can be detected at very low concentrations. At concentrations above 100 ppm, hydrogen sulphide has a paralysing effect on the sense of smell. Even at lower concentrations, hydrogen sulphide can affect the olfactory nerve and workers cannot detect the changes in concentrations. Therefore, it is very dangerous torely on the smell to detect the presence of hydrogen sulphide. A more reliable method for detecting hydrogen sulphide is by using a calibrated gas detector. An airborne concentration of hydrogen sulphide above 100 ppm is immediately dangerous to life or health and concentrations over 1,000 ppm could cause immediate collapse. As sewage is very often present in a drainage system, workers overcome by hydrogen sulphide could be easily killed by drowning.

Figure 2: Disregard the risk of sudden ingress of toxic gases as a result of the engineering work

B. Carbon monoxide (CO)

The lethal colourless and odourless gas – carbon monoxide, is given off when charcoal is burnt in poorly ventilated areas. Similarly, it is produced when gasoline/diesel generators or other fuel-driven tools are used inadequately ventilated workplaces. Exposure to carbon monoxide at concentrations over 350 ppm can cause confusion, fainting on exertion and collapse. An airborne concentration of carbon monoxide above 1,200 ppm is immediately dangerous to life or health.

C. Methane (CH4)

Methane is commonly generated when organic matter is decomposed by a variety of bacterial processes. It is a colourless, extremely flammable and explosive gas that can cause fire and explosion. The accumulation of methane in a poorly ventilated area will displace normal air and result in an oxygen deficient environment.

III. SYSTEM OVERVIEW

In this proposed system, multiple sensors like gas sensor (MQ_2), hydrogen sulphide sensor, carbon monoxide sensor, heart beat sensor and ultrasonic sensor (HC SR04) are interfaced with ARM cortex-M4 which are used for monitoring environmental parameters. The parameter includes measurement of gas concentration, distance, heart beat. Whenever the abnormalities is detected by sensors (ie, when the level of the particular gas exceeds the desired level) then the ARM processor activates the GSM module. GSM module sim900A sends the emergency message to the local monitoring unit and   immediate service is provided such as ambulance and fire service. Here protective gas mask is

provided to the workers to restore the supply of oxygen in the body. The pulse rate of the person and how much deep the worker is there is all displayed in an LCD screen. The LCD display is provided to the worker waiting outside the man hole to know the exact status of the worker gone inside. So that the immediate help is provided by the person. Here the Energia software is used to operate ARM processor. The coding are written in embedded c language.

The gas monitoring system should be conducted pre- entry and during the cleaning process done by the worker. Methane gas are present at the top layer, carbon Monoxide present at the middle and hydrogen sulphide is presented at the bottom of the manhole.

A. GSM Module

GSM stands for Global System for Mobile communications; it is the most popular wireless communication medium used in the world for faithful and fast communication. GSM module allows transmission of Short message service (SMS) in TEXT mode. The proposed design uses SIM 900A. A GSM modem is a specialized type of modem which accepts a SIM card, it operated just like a mobile phone which allows the computer to communicate over the mobile network .GSM module in text mode. The Tx pin of the Microcontroller is connected to the rx pin of GSM and vice versa. it is provided with 12v power supply. It is mostly used in three digital wireless telephony technologies such as TDMA, GSM, and CDMA. It operates at either the 900 MHz or 1800 MHz frequency band.
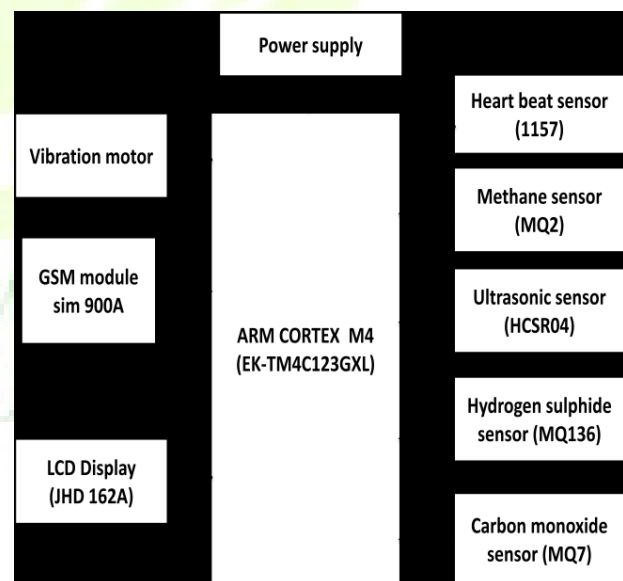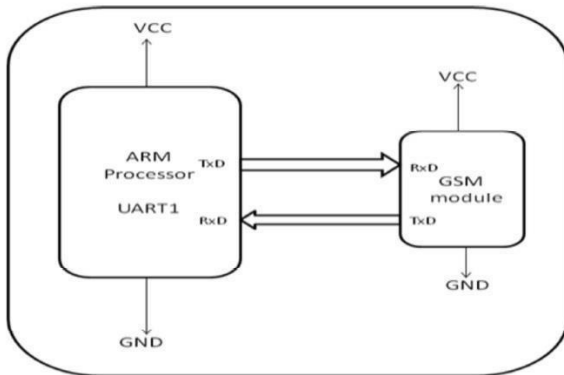
Fig 3: Block diagram of the smart device

Fig 4 Interfacing ARM cortex M4 with sim900A

B. MQ2 sensor

MQ-2 gas sensor has high sensitivity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam. Sensitive material of MQ-2 gas sensor is SnO2, which with lower conductivity in clean air. When the target **CH4** gas exist the sensor's conductivity is higher along with the gas concentration rising. Use simple electro circuit, Convert change of conductivity to correspond output signal of gas concentration. Here the pin DOUT is used for digital output, the pin AOUT is used for analog output, the pin GND is used for power ground and the pin 4 is used for power supply (2.5V-5.0V).

C. MQ136 sensor

Sensitive material of MQ136 gas sensor is SnO2, which with lower conductivity in clean air. When **H2S** gas exists, the sensors conductivity gets higher along with the gas concentration rising. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit. MQ136gas sensor has high sensitivity to H2S gas, also can monitor organic vapor including sulfur well. Here the pin DOUT is used for digital output, the pin AOUT is used for analog output, the pin GND is used for power ground and the pin 4 is used for power supply (2.5V-5.0V).

D. MQ7 sensor

Sensitive material of MQ7 gas sensor is **CO**, MQ-7 gas sensor composed by micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer , measuring electrode and heater are fixed into a crust made by plastic and stainless steel. The drive circuit is very simple; all you need to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC. This sensor has a high sensitivity and fast response time. Here the pin DOUT is for digital output, the pin AOUT is for analog output, the pin GND is for power ground and the pin VCC is for power supply (2.5-5.0V).

E. Ultrasonic sensor

Ultrasonic transmitter emitted an ultrasonic wave in one direction, and started timing when it launched. Ultrasonic spread in the air, and would return immediately when it encountered obstacles on the way. At last, the ultrasonic receiver would stop timing when it received the reflected wave. As Ultrasonic spread velocity is 340m / s in the air, based on the timer record t, we can calculate the distance (s) between the obstacle and transmitter, namely

$$S = 340t\ /2 \ \dots\dots (1)$$

which is so- called time difference distance measurement principle. The principle of ultrasonic distance measurement used the already-known air spreading velocity, measuring the time from launch to reflection when it encountered obstacle, and then calculate the distance between the transmitter and the obstacle according to the time and the velocity. Thus, the principle of ultrasonic distance measurement is the same with radar. Distance Measurement formula is expressed as

$$L = C * T \ \dots\dots (2)$$

In the formula, L is the measured distance and c is the ultrasonic spreading velocity in air, also T represents time (T is half the time value from transmitting to receiving). Here the pin VCC is used for power supply of 5V, the TRIGGER pin is used as input, the ECHO pin is used as output and the GND pin is used for power ground.

F. Heart Beat Sensor

The heart beat sensor is designed to provide digital output of heart beat when a finger is placed on it. When the detector starts working, the top most LED will starts flashing with every heart beat. The output of the sensor is directly connected to Microcontroller directly to measure the heart beat. It function on the principle of light modulation by blood flow through the nerves of the finger every pulse. The gnd pin is connect ground, the pin VCC to 5V connect and the pin out to digital pin.

G. Vibration motor

This vibration motor is perfect indicator to alert a person when the status has changed. With a 2-3.6v operating range, these units shake crazily at 3v.Once anchored to a PCB or within a pocket, the unit vibrates softly but noticeably. With the use of this motor we can instantly alert the sewage workers about the critical situation even if their mind is somewhere focusing on their work.

IV. SOFTWARE IMPLEMENTATION

Energia software is used here for the programming of the microcontroller.It is a wonderful community driven,open-source code editor that provides a simple & friendly development environment. The compiler combines project management, make facilities, source code editing, program debugging, helping you quickly create embedded programs that work. The compiler editor and debugger are integrated in a single application that provides a seamless embedded project development environment. IDE (Integrated Development Environment) is a Windows based front end for the C Compiler and assembler.. Standard libraries are altered or enhanced to address the peculiarities of an embedded target processor.[10,11]
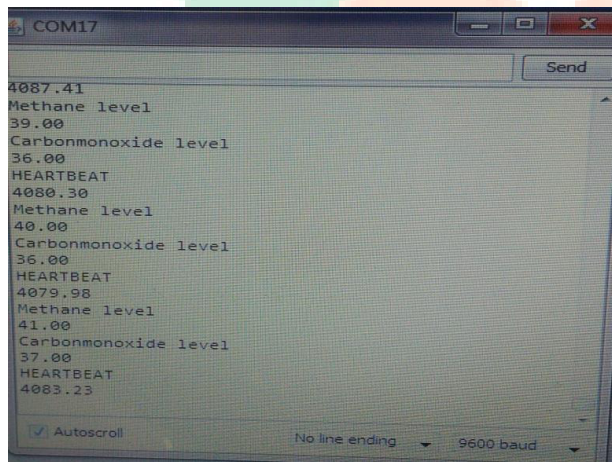

Figure 6 : Designed smart device

Figure 5: Results of ch4,carbon monoxide level, heart beat rate in serial monitor of energia

V. CONCLUSION

In this paper we have given an approach which safeguard the sewage workers from the harmful and poisoning gases, which On other hand involves intimating the life saving service thus making them to take action on behalf of the sewage workers thereby eradicating the staggered number of deaths encountered every year and thus enabling them to survive for years.
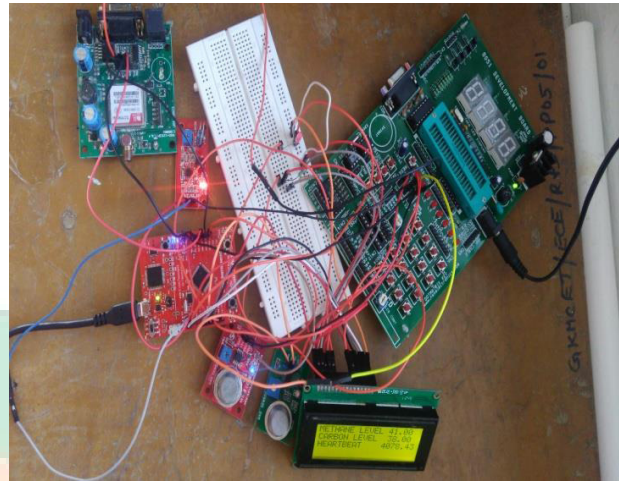
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