AN EFFICIENT DATA LOGGER SYSTEM FOR CONTINOUS MONITORING AND TRACEABILITY OF CARGO: APPLICATION OF GPS AND GSM TECHNOLOGY

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Abstract

Data logger is an electronic device used for storing measurement data. It can be used in wide range of embedded logging applications like cold chain traceability, medical lab and clean room, agriculture & greenhouse. The purpose of present paper is to design a low cost data logger prototype suitable for Cold Chain Logistics. In this case, the physical distance between the two regions is the critical factor to be considered. Since this process involves the transportation of goods over longer distance, probability of the freight can be damaged is higher in one of the complex transport operations involved. Generally cold chain logistics involves transportation of perishable goods, medical products like drugs, blood, vaccines which can have their properties affected by temperature changes. With the use of data loggers it is possible to monitor the parameter that may affect the quality of products. The proposed data logger is capable of measuring levels of Temperature (T), Humidity (H), and Carbon monoxide (CO). It is capable of alerting the user regarding the parameter changes using SMS, so that early precaution steps can be taken. The system also incorporates GPS module which enables the live tracking capability of the cargo at any point of time.

Keywords- Data logger, Cold Chain Logistics, SMS, GPS s

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1. INTRODUCTION

Cold Chain Logistics is a process of transportation of temperature sensitive goods along a supply chain through thermal and refrigerated packaging methods. The temperature sensitive products are perishable foods like fruits, vegetables, meat or medical products like blood, vaccines, drugs, plasma and tissues. Some of the chemical and electronic components like microchips are also temperature sensitive. All these products have their properties affected by temperature changes and hence control of temperature is essential. When these products are to be transported it is vital to first assess its characteristics. For instance, impact of humidity will be more when it is about transportation of goods by sea. There are several means in which these goods can be transported, including refrigerated cargo ships as well as air cargo. Moving these products across the supply chain without suffering any damage or temperature anomalies is the key challenge. There are various methods and technologies that have been developed to monitor temperature during the transport and storage of cold chain dependent products. Some of them are namely fixed pressure dial thermometer, thermograph, and temperature data logger etc. A fixed pressure dial thermometer is an analog device that displays the temperature within a single refrigerator at all times. Advantage of using this device is that it is not required to open the cabinet door for data reading. But a person is required to manually record all the measured data. A thermograph is an analog device that continuously records temperature over a period of time for a single or in some cases multiple refrigerator units. Again the major drawback is

the need for special recording paper, pens and ink, which can run out over time. A temperature data logger allows continuous temperature monitoring for one or more refrigerator units, maintaining a constant temperature record for each. However, these conventional methods focused only on one parameter i.e. temperature. A recent study showed that the quality of products might be changed rapidly when adequate temperature and relative humidity, carbon monoxide level. And it is essential to alert the owner/user about the anomaly occurred with respect to these environmental parameters and hence necessary actions can be taken to preserve the quality of products.

This paper proposes a hybrid data logger, to automatically monitor and predict the changes of temperature, relative humidity and CO level in the cargo environment. This data logger uses PIC microcontroller to control the hardware for recording and monitoring of general purpose measurements. It is designed with integration of various technologies such as GSM/GPRS, GPS, sensors and RTC. The overall system overview is as shown in Fig.1. The data logger continuously monitors the environmental parameters. In case of any anomaly with respect to the temperature, relative humidity, carbon monoxide value variations, this data logger will send the above information to the owner using short message services. The received data will be displayed on a user monitor i.e. PC using GUI. Also current location of the cargo will be displayed on Google Earth Map.

This paper is organized into four sections. Data logger system design along with brief description of basic functional units is presented in section II. Section III describes the working of the data logger system. Section IV concludes the paper.
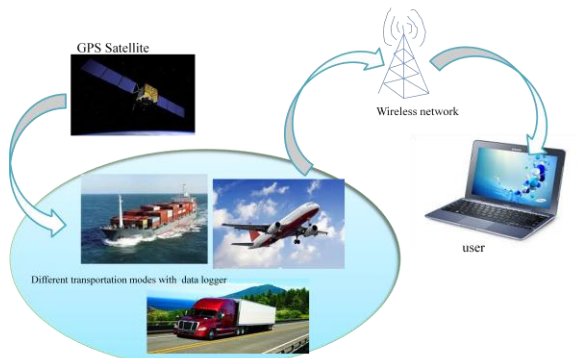

Fig.1. Data logger system overview

2. SYSTEM DESIGN

The proposed data logger is basically designed to record environmental parameters such as temperature, relative humidity and CO level. It is compact, battery powered device, equipped with microcontroller, different sensors, GSM and GPS module. The system architecture of proposed system is as shown in Fig.2.
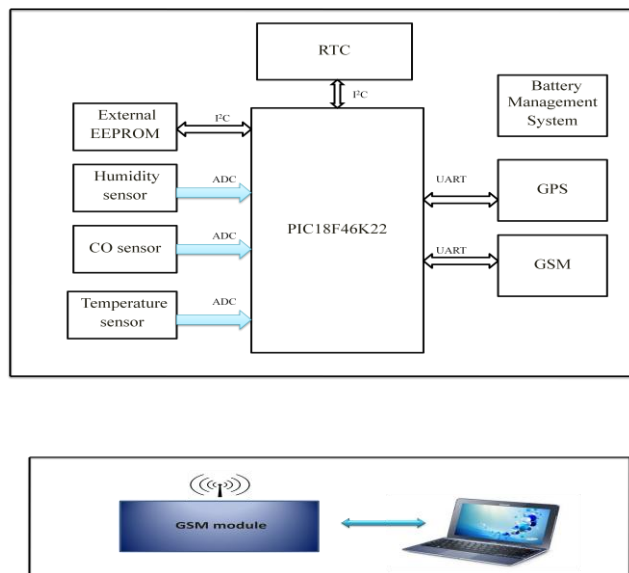

Fig.2.Proposed data logger system functional Block diagram

2.1 PIC Microcontroller

Microchip's 8-bit PIC18F46K22 microcontroller is the heart of the overall system. This family offers the advantages of all PIC18 microcontrollers namely, high computational performance at an economical price with the addition of high endurance, flash program memory. On top of these features, the PIC18(L)F2x/4xK22 family introduces design enhancements that make these microcontrollers a logical choice for many high performance, power sensitive

applications. It is fully equipped with a number of peripheral interfaces such as I2C, SPI, EUSART, analog to digital converter (ADC) and digital to analog converter (DAC).

2.2 Sensor Modules

The different sensors used are LM35 temperature sensor, HSM20G relative humidity sensor and MQ-7. The LM35 sensor is calibrated directly in °C and rated for full -55°C to +150°C range. Every 10mV change in the analog output voltage causes 1°C rise in temperature value. The operating range of humidity sensor is 0 to 95% RH. MQ-7 is a gas sensor with high sensitivity to CO. when compared to other temperature sensors LM35 is selected since it is more accurate than a thermocouple and it puts out higher voltage than a thermocouple, minimizing the possibility that the voltage needs to be boosted. It uses very little power and does not heat up. MQ-7 sensor is highly stable and has got long life. Hence these selected sensors are best suited for our application. Some of the features of these sensors are given in Table 1.

Table.1. Specifications of sensors used

Sl. No.	Sensor Name	Measure ment range	Measureme nt Accuracy	Respons e time(app x)
1	LM35 Precision Centigrade Temperatur e sensor	-55°C to +150° C	0.5° C	2sec
2	HSM20G Relative Humidity Sensor	0 to 95%RH	±5%RH	15sec
3	MQ-7 Gas Sensor(CO sensitive)	20 to 2000ppm	Highly accurate	30sec

2.3 RTC

The DS1307 real time clock operates as a slave device on a I^2C bus. Access is obtained by implementing a START condition and providing a device identification code followed by a register address. Subsequent registers can be accessed sequentially until a STOP condition is executed. It counts seconds, minutes, hours, date, month, day, weak and year with leap year compensation valid up to 2100.

2.4 GSM /GPRS Module

The system communication part consists of GSM/GPRS capable SIM 900 modem which gets connected to the GSM network using SIM card. SIM 900 is a quad band GSM/GPRS engine that works on frequencies 850, 900, 1800, 1900MHz. This quad band GSM modem can be used for basic services almost anywhere in the world. This technology is used to send SMS with the existing GSM network to preconfigured owners mobile number and to

further log the same data to a web server with a database to handle the information.

2.5 Global Positioning System

The GPS is a space based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed lone of sight to three or more GPS satellites. GPS receivers are able to identify their locations when three GPS satellites triangulate and measure the distance to the receiver and compare the measurements. A fourth satellite measures the time to receiver. The information from all four satellites is compiled to determine the location. The sophistication of a GPS receiver impacts the reliability and accuracy of the GPS data receiver.

3. PROPOSED SYSTEM WORKING

The advancement in the technology enabling the faster rates of communication and better parameter sensing devices allows both convenience and the fidelity while transmitting information from one side to another. The proposed device will be packed along with the product. Initially depending upon the type of product the owner will set upper and lower threshold values of three parameters i.e. temperature, relative humidity, carbon monoxide. Once initialized, the device will continuously measure these parameter values and compare it with the threshold value. If in case any of these three parameter values goes above or below the threshold value, an SMS alert will be sent to the owner/user. With the GPS module incorporated into the system, user is capable of tracking the location of the vehicle. Hence owner will be able to take a quick action to preserve the quality of the products. Overall system working can be understood from the flow diagram shown below.

The salient features of this project are:
- Modularity and flexibility by the use of controllers and peripherals
- Continuous monitoring system which monitors environmental parameters like temperature, humidity, and carbon monoxide
- Low cost device
- Efficient means of communication with the user of existing mobile network
- Automatic SMS sending and Call initialization
- Live tracking of the cargo at any point of time
- Robust and reliable

The success of industries based on the cold chain logistics depend on how to ship a product with temperature control adapted to a shipping circumstances. Different products require the maintenance of different environmental conditions to ensure their integrity throughout the transport chain. For instance food product require temperature to be maintained in the range 0 to -1°C, medical products like vaccines, blood require 2 to 8°C. Hence function of data logger is for continuous monitoring of the cargo environment and to alert the owner bout the same. And, we know that per day millions of tons of temperature sensitive items are

produced, transported, stored and distributed over the world. Since for all these products a controlled environment is required, our data logger will help in monitoring this environment.
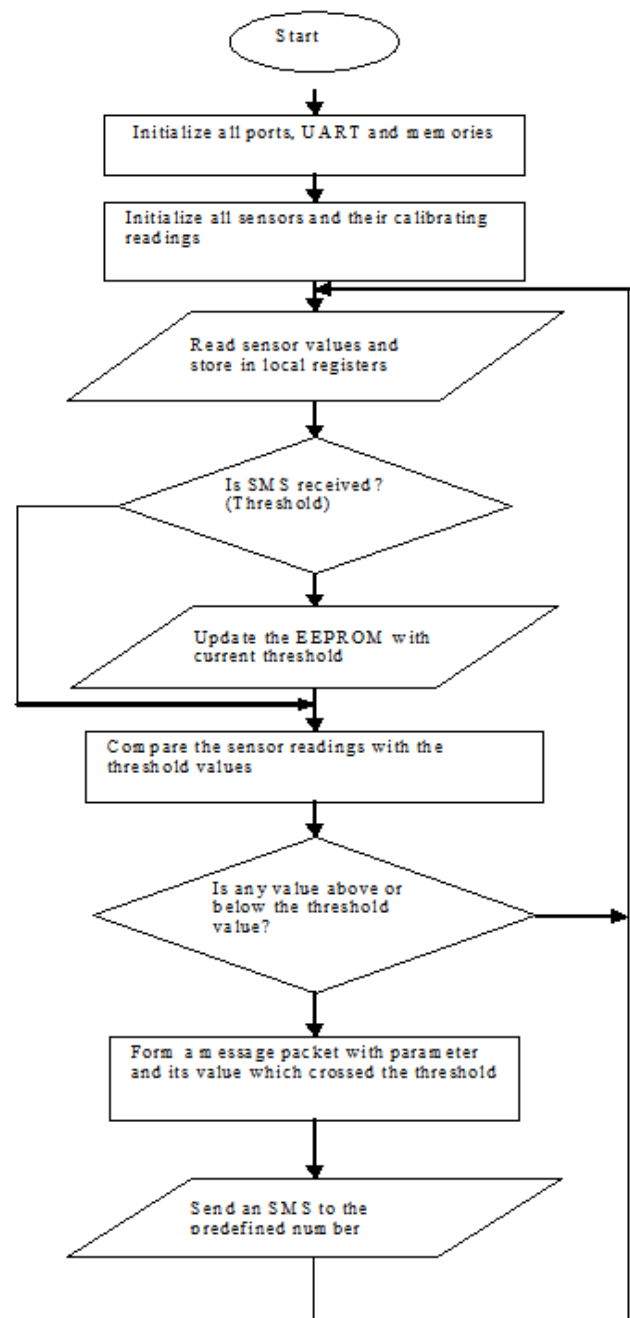
General Flow Diagram

4. CONCLUSIONS

The small portable data loggers will play an important role in cold chin logistics. The proposed hybrid data logger will monitor three important environmental parameters like temperature, relative humidity and carbon monoxide. Also it is capable of sending SMS to the predefined number in case of emergencies. With GPS module incorporated, the owner will be able to track the cargo at any point of time.

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