Implementation of Sensor Network for Indoor Air Quality Monitoring using CAN Interface

Minu A Pillai  
Department of ICE  
National Institute of Technology  
Tiruchirappalli, India  
e-mail: minuapillai@yahoo.com

Sridevi Veerasingam  
Department of ICE  
National Institute of Technology  
Tiruchirappalli, India  
e-mail: sridevi@nitt.edu

Yaswanth Sai D  
Department of ICE  
National Institute of Technology  
Tiruchirappalli, India  
e-mail: yaswanthsai@gmail.com

Abstract—Indoor air quality (IAQ) is a key factor for ensuring the safety, health and comfort of the people. Since physical variables describing IAQ, such as the concentration of volatile organic compounds (VOCs), concentrations of gaseous air contaminants and that of other toxic gases need to be closely monitored, concept of distributed monitoring and control network needs to be implemented.

In this paper, a framework of sensor network for monitoring IAQ is explained where sensors are physically distributed and the serial common bus communication network CAN is used to exchange system information. CAN (Controller Area Network) is a high integrity serial bus protocol that is designed to operate at high speeds ranging from 20kbit/s to 1Mbit/s which provide an efficient, reliable and very economical link between sensor nodes and display node. This paper proposes Atmel CANary based sensor nodes and display node for the monitoring of indoor air quality. The communication between the sensor nodes and the display node through the CAN bus is evaluated through hardware tests.

Keywords—Indoor Air Quality, Sensor Network, Controller Area Network.

I. INTRODUCTION

Indoor air quality (IAQ) is a steadily increasing health concern since people spend approximately 90% of their time indoors. Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems at homes, crowded subways, in chemical industries and closed cabins like AC railway cabins. Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the home.

With a networked system with distributed sensor nodes and display nodes indoor air quality can be continuously monitored [7], [8]. Due to the unprecedented growth of wireless technology the term sensor network implies wireless sensor network which uses wireless protocol for the communication between nodes in the network. Vast majority of conventional wireless protocol emphasize bit rate over versatility and reliability, which is unsuitable for control and monitoring applications. For this reason, even if wireless technology is used at testing control level, real time control applications using wireless communication techniques are still very few [7]. A wired communication protocol is a good option in this case.

In the networked system a large number of short data has to be transmitted and received between nodes and also data should maintain high integrity. In order to meet these specifications Controller Area Network (CAN) protocol can be used for the communication between nodes [1], [2]. CAN protocol support bus topology which will provide high network flexibility [5], [6]. Failure of one of the nodes does not affect the function of the rest of the nodes in the network.

The objective of this paper is to design a networked indoor air quality monitoring system with two sensor nodes and a display node. The paper is organized into VI sections including this introduction. Section II gives the architecture of the proposed system which also gives the CAN protocol specifications. Section III gives the detailed description of hardware design of CAN nodes. Section IV explains the software used in the design of the CAN nodes. Simulation and real time results are shown in section V. Finally conclusions and future works are presented in section VI.

II. ARCHITECTURE OF THE PROPOSED SYSTEM

A. Can based sensor network for indoor air quality monitoring

The schematic of proposed system is shown in Fig.1. The sensor node continuously detects the presence of volatile organic compounds and other gaseous air contaminants. The sensor data is scaled to that level which the inbuilt ADC of the microcontroller can accept. The inbuilt CAN controller fulfills communication functions prescribed by the CAN protocol. The CAN transceiver connects the CAN controller to the CAN bus. The transceiver converts the transmit bit signal received from the CAN controller into a signal that is sent to the bus. It also adapts signal levels from the bus to levels that the CAN controller supports. Through the CAN bus interface the sensor data is transmitted to a display node were the concentrations of the gaseous air contaminants can be easily be monitored. The CAN bus is a two wire differential line bus which is terminated at the two ends with 120Ω resistors. The two lines of the CAN bus is CAN_H line and CAN_L line.
B. CAN 2.0 protocol specifications

CAN is an asynchronous serial communication protocol which efficiently supports distributed real-time control with a very high level of security. It is a two wire, half duplex high speed network system developed in the mid 1980s by Bosch GmbH, to provide a cost-effective communication bus for automotive applications. CAN 2.0 is a broadcast digital bus designed to operate at speeds from 20kb/s to 1Mb/s [5], [6]. CAN 2.0 is an attractive solution for embedded control systems because of its low cost, light protocol management, the deterministic resolution of the contention, and the built-in features for error detection and retransmission [3].

The CAN protocol includes the data link and physical layers of the basic OSI reference model. The Datalink layer recognises and understands the format of messages. This layer constructs the messages to be sent to the Physical Layer, and decodes messages received from the Physical Layer based on the CAN protocol specification [4]. In CAN controllers the data link layer is implemented in hardware. The physical layer specifies the physical and electrical characteristics of the bus. The physical layer is implemented in hardware. ISO 11898-2 is the most used physical layer standard for CAN networks in which data rate is defined up to 1 Mbit/s with a theoretically possible bus length of 40 m at 1 Mbit/s. The high-speed standard specifies a two-wire differential bus with a maximum of 30 nodes [6]. The CAN bus normally consists of two wires (CAN_High and CAN_Low) which is terminated at the two ends with 120Ω resistors to minimized reflected waves that occur from mismatched impedances. The bus level is determined by a potential difference between the CAN_High and CAN_Low wires.

III. HARDWARE IMPLEMENTATION

A. Sensing Module

In the proposed system there are two sensor nodes with two different gas sensors. The TGS 2620 is a volatile organic compound sensor and TGS 2600 is air contaminant sensor. Both of the sensors are from Figaro Group. TGS 2620 has high sensitivity to the vapours of organic solvents as well as other volatile vapours. It also has sensitivity to a variety of combustible gases such as carbon monoxide, making it a good general purpose sensor. TGS 2600 has high sensitivity to gaseous air contaminants such as hydrogen and carbon monoxide. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration.

B. Signal Conditioning Module

The output of the sensor is in the range of 0-5V. But the maximum analog input the inbuilt ADC can support is 3V. So a scaling circuit using the operational amplifier LM741 is used as the signal conditioning circuit. The gain of the op-amp and the input determines the output of the circuit.

C. Microcontroller Module

AT89C51CC03 is an 8-bit microcontroller with inbuilt 10-bit resolution ADC and CAN controller from Atmel Corporation. The proposed system uses the very thin quad flat package IC. An adapter is used as the IC cannot be programmed directly. The conditioned sensor output is given to one of the analog input channel of the ADC, which converts it into corresponding digital output. The digital output is given to the CAN message channel of the inbuilt CAN controller. The sensor data is processed by the CAN controller based on the CAN protocol version 2.0A.

D. CAN Transceiver Module

The ATA6660 is a high speed CAN transceiver from Atmel Corporation. It is especially designed for high speed CAN Controller differential mode data transmission between CAN Controllers and the physical differential bus lines. It supports a maximum transmission speed of 1Mb/s.

E. Display Module

Display unit consists of CAN transceiver which will convert the can bus signal into corresponding data and is connected to microcontroller in which inbuilt CAN controller is there. The CAN controller will decode the data. LED display is used to display the received data in hex.
values. LCD display also can be used, which will show the corresponding ASCII values of the received data. The display node can also contain a computer which continuously monitors the data coming from the sensor nodes. Fig 2 and 3 shows the snapshot of the designed sensor and display nodes respectively.

IV. SOFTWARE IMPLEMENTATION

Keil µVision 2 IDE with RTX-51 Full is used to develop the application software. The program is written in Keil C language and simulated using Keil µVision IDE. Keil µVision 2 supports RTX-51 RTOS for simultaneous execution of multiple jobs or tasks of receiving and transmitting messages in CAN network. Flowcharts for CAN transmission is shown in Fig 4 which includes initialization tasks, conversion task and send task and flowchart for CAN reception is shown in Fig 5.

![Flowchart for CAN transmission](image1)

![Flowchart for CAN reception](image2)

Fig 4. Flowchart for (a) Initialization task, (b) conversion task and (c) send task in CAN transmission

Fig 5. Flowchart for (a) Initialization task and (b) receive task in CAN reception

V. SIMULATION AND REAL TIME EXPERIMENTAL RESULTS

Fig 6 and Fig 7 shows the simulation result of CAN transmission of the ADC output in Keil µVision IDE. The transmission speed of CAN is set to 1Mb/s. The channel
selected for the transmission of first sensor data is 10 and the identifier of the first CAN data frame is set as 123. The channel selected for transmission of second sensor data is 11 and the identifier of the second CAN data frame is set as 214. The data in the CANMSG buffer which is to be transmitted are also indicated in the simulation window. Fig.8 shows the simulation window for CAN controller configuration in reception mode. Since the sensor node with lowest identifier number will have the highest priority, the first sensor data with an identifier number of 123 is received at the receiver node first.

Fig.8 shows the simulation window for CAN controller configuration in reception mode.

Three nodes have been designed, two of which are configured in transmission mode and the third one in reception mode. The transmitter nodes are designed as sensor nodes and the receiver node as the display node. Communication between the transmitter and receiver nodes has been implemented through the CAN physical layer standard ISO 11898-2, which defines CAN bus as two wire differential bus.

The small size of the CAN transceiver IC and the microcontroller with integrated CAN solution reduces the size and cost of the node considerably. With the use of high-speed CAN transceiver data is transmitted and received in faster rates with high level of integrity. The processing time associated is also small.

VI. CONCLUSION AND FUTURE SCOPE

Three nodes have been designed, two of which are configured in transmission mode and the third one in reception mode. The transmitter nodes are designed as sensor nodes and the receiver node as the display node. Communication between the transmitter and receiver nodes has been implemented through the CAN physical layer standard ISO 11898-2, which defines CAN bus as two wire differential bus.

The small size of the CAN transceiver IC and the microcontroller with integrated CAN solution reduces the size and cost of the node considerably. With the use of high-speed CAN transceiver data is transmitted and received in faster rates with high level of integrity. The processing time associated is also small.
The future scope of the work is:

- Implementation of more sensor nodes and a control node in the network.
- To implement the network for real time control of indoor air quality.

REFERENCES


