INDUSTRY MONITORING AND CONTROL USING CAN BUS PROTOCOL

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ABSTRACT

Now a days, in many countries energy efficiency improvements sometimes make buildings relatively airtight, reducing stale air exhaust and air exchange with the outside. It can result in poor indoor air quality which may lead to occupant health and structure durability problems. Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems at homes, industries and in air conditioned cabins. In this research we will focus on application of CAN (Controller Area Network)in forming a smart sensor network The nodes are physically distributed where the serial common bus communication network CAN provides a robust means of interconnecting the nodes in the network. This paper proposes the Atmel CANary based sensor node and moor control nod for monitoring and control of all parameters. The system output is a prototype of Industry automation system which is evaluated through hardware tests.

Keywords: Accelerometer, CAN, CO Sensor, LPG Sensor, Pressure Sensor, Temperature Sensor, PIC Microcontroller

I INTRODUCTION

CAN (controller area network) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer [3].

CAN bus is a message-based protocol, designed specifically for automotive applications but now also used in other areas such as industrial automation and medical equipment. CAN bus was originally invented in 1983 by Robert Bosch GmbH. The protocol was officially released in 1986 at the Society of Automotive Engineers (SAE) congress in Detroit, Michigan. Previously, sensor networks consisted of small number of sensor nodes that were wired to a central processing station. However, nowadays, the focus is more on wireless, distributed, sensing nodes.

A typical smart sensor network is made up of nodes that have different functions. Some nodes will only transmit data, some will receive data, and some may have multiple functions [1].

A typical smart sensor node is made up of both digital and analog components, which allow the sensor data to be captured, transformed, analyzed, and transmitted to other nodes in the system. There are various methods for communication between these distributed nodes like RF(Radio Frequency, Bluetooth and other various wireless method. But by Applying the CAN protocol to a smart sensor network is a natural progression from existing sensor networks. It will prove itself efficient and economic media for communication. The CAN bus provides an ideal platform for interconnecting nodes and allows each node to communicate with any other node. A networked system which requires fast and robust communication and where data should maintain high integrity, Controller Area Network protocol (CAN) can be used for the communication between nodes, as CAN protocol was optimized for systems that need to transmit and receive relatively small amounts of information reliably to any or all other nodes on the network. The CAN protocol is robust and uses sophisticated error checking and handling, which allows errors and failures to occur without shutting the entire system down which is useful in the motor control node[1].

The error containment also allows sensor nodes to be added to or removed from the system while the network is in operation. The objective of this paper is to design a CAN based networked industry monitor and control using two sensor nodes and a motor control node with display[1].

II PROPOSED SYSTEM DESIGN

2.1 System Design

The schematic of proposed system is shown in fig.1with two sensors nodes and a motor control node with display. The sensors continuously takes the reading which shows the presence of voltaic organic compound and other gaseous air contaminants for a particular time and sends the data out on the bus.

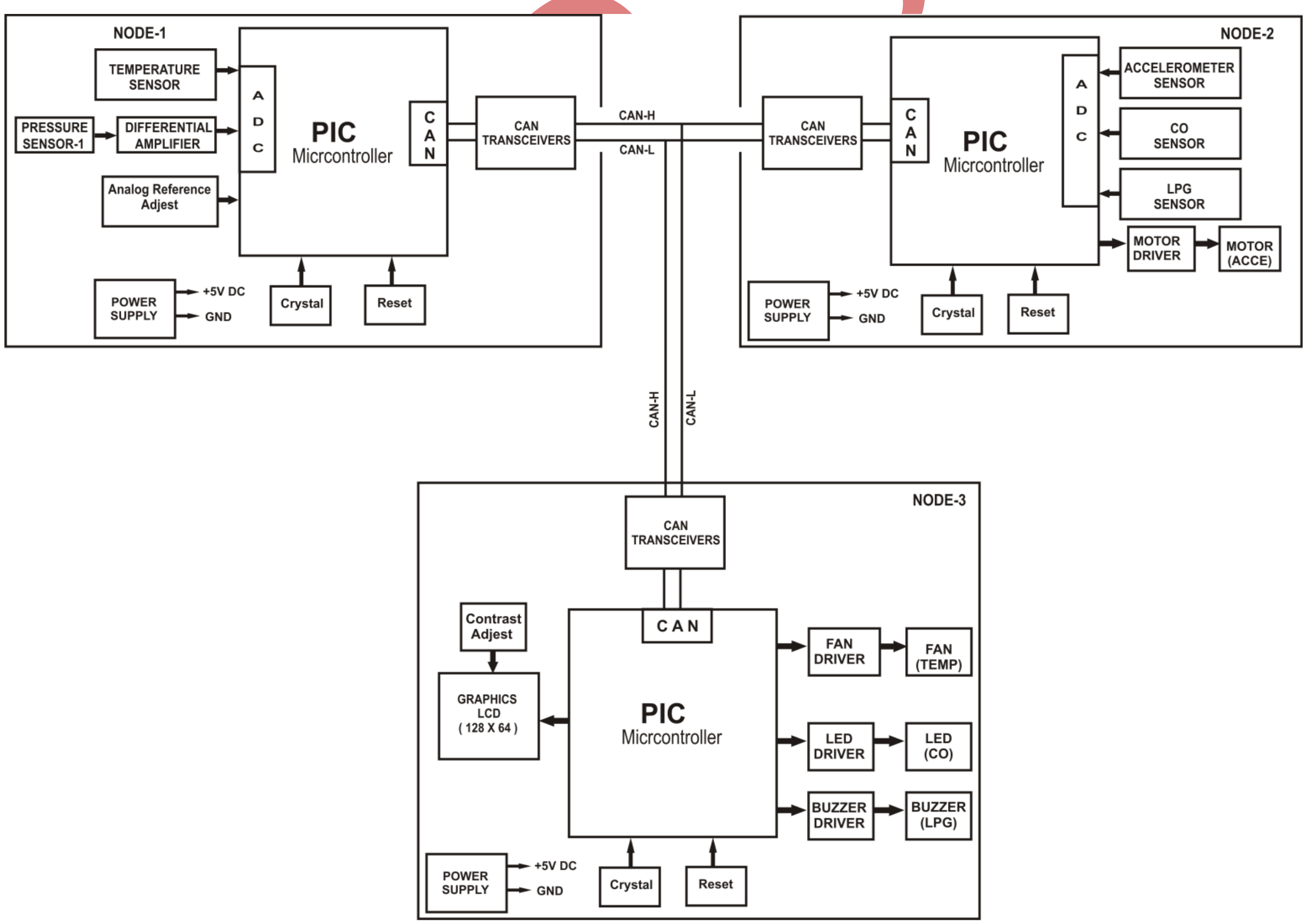


Fig.1 Block Diagram of proposed system using CAN Protocol

The inbuilt CAN controller fulfills communication function prescribed by the CAN protocol. The CAN transceiver connect the CAN controller to the CAN bus. It converts the standard logic signals from CAN controller to the physical levels used on the physical CAN bus[4]. Through the CAN bus interface the sensor data is transmitted to the third node where the concentrations of the gaseous air contaminants can be easily be monitored and controlled. If the concentration of the gases increases the sensor output will increase and the same data is received at the motor control node where the data limit is set. If the received data exceeds the predefined limit, the alarm will turn on. When accelerometer reading is above the set limit motor stops rotating. If temperature sensor o/p is above the set limit fan will be on, for exceed output of CO sensor LED is on As the fan expels the contaminated air out of the cabin the sensor output will decrease. When the sensor output is less than the predefined limit the fan will stop. The received all sensor data is also continuously displayed at this node. The CAN bus is a differential two wire interface which is terminated at the two ends with 120Q resistors to minimize reflected waves occurring from mismatched impedances. The two lines of the CAN bus is CAN _ H line and CAN L line.

2.2 CAN 2.0 Protocol Specifications

CAN is a serial bus protocol especially suited for networking intelligent devices as well as sensors and actuators within a system or subsystem CAN (Controller Area Network) was originally developed for automotive applications in the early 1980's [3]. It is an asynchronous serial communication protocol which efficiently supports distributed real-time control with a very high level of security. CAN 2.0 is a broadcast digital bus designed to operate at speeds from 20kb/s to IMb/s [3], [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 [4].

CAN is a serial bus system with multi-master capabilities, that is, all CAN nodes are able to transmit data and several CAN nodes can request the bus simultaneously. It covers the lowest two layers of the ISO/OSI reference model which includes the data link and physical layer. The Datalink layer recognizes and understands the format of messages [5]. CAN protocol define messages as frames. Embedded in the data frames are arbitration fields, control fields, data fields, cyclic redundancy check sum (CRC) fields, a 2 bit acknowledge field, and an end of frame. The arbitration field prioritizes messages on the bus. For a standard data frame, the arbitration field consists of 11 bit identifier and for extended data frame 29 bit identifier [6], [7]

The physical layer specifies the physical and electrical characteristics of the bus. Most CAN systems implement the physical layer of the protocol by using some ki□d of transceiver which connects the CAN Hand CAN L pms to the CAN bus with a differential signal of 0-3 V. ISO 11898- 2 is the most used physical layer standard for CAN networks in which data rate is defined up to 1 Mbitls with a theoretically possible bus length of 40 m at 1 Mbitls. The high-speed standard specifies a two-wire differential b□s with a maximum of 30 nodes [7]. The bus level IS determined by a potential difference between the CAN H and CAN L wires. The CAN bus line can have one of two logical states: recessive and dominant. Typically, the voltage level corresponding to recessive (logical 1) is 2.5 V and the levels corresponding to dominant (logical 0) are 3.5 V for CAN Hand 1.5 V for CAN L. The voltage level on the CAN bus is recessive when the-bus is idle.

The CAN protocol handles bus accesses according to the concept called Carrier Sense Multiple Access with Arbitration on message priority. If two or more bus nodes start their transmission at the same time after having found the bus to be idle, collision of messages are avoided by bitwise arbitration. Each node sends the bits of its message identifier and monitors the bus level. When a dominant bit is being sent, the resulting bus state according to wired-AND principle is also dominant. Otherwise, if a recessive bit is being sent, the resulting bus state depends on what other nodes are sending in the same time [6], [7]. The recessive bus state means that there is no collision, the dominant state means that at least one node is sending dominant bit. When the node receives a dominant bit during sending a recessive one, it loses the arbitration and withdraws from the transmission. It means that messages with lower ID values higher priority. Nodes that lose arbitration automatically try to repeat their transmission once the bus return to the idle state.

III HARDWARE APPROACH

There are total three nodes among which node one and two are sensing modules which are connected to various sensor while node three is control module. Which is connected to controller equipment's.

3.1Microcontroller Module

IN this system we will use PIC 18F4680 IC.It is 8 bit microcontroller with inbuilt 10 bit ADC and Can controller. The signals from the sensors are given to the Microcontroller. It is used to digitize the received signal. It also compares the signal with preset values. It also checks the output of the sensor and compares with set values and gives corresponding output to the driver. The output of the Microcontroller is given to the CAN Transreceiver IC MCP 2551.

3.2 CAN Transceiver Module

IC MCP2551 is CAN transceiver. 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 1 Mb/s. Shown in fig 2.

3.3 Temperature Sensor

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in oC) .The LM35 - An Integrated Circuit Temperature Sensor. They use the fact as temperature increases, and the voltage across a diode increases at a known rate. (Technically, this is actually the voltage drop between the base and emitter - the Vbe - of a transistor. By precisely amplifying the voltage change, it is asy to generate an analog signal that is directly proportional to temperature. You can measure temperature more accurately than a using a thermistor. Shown in fig 3.

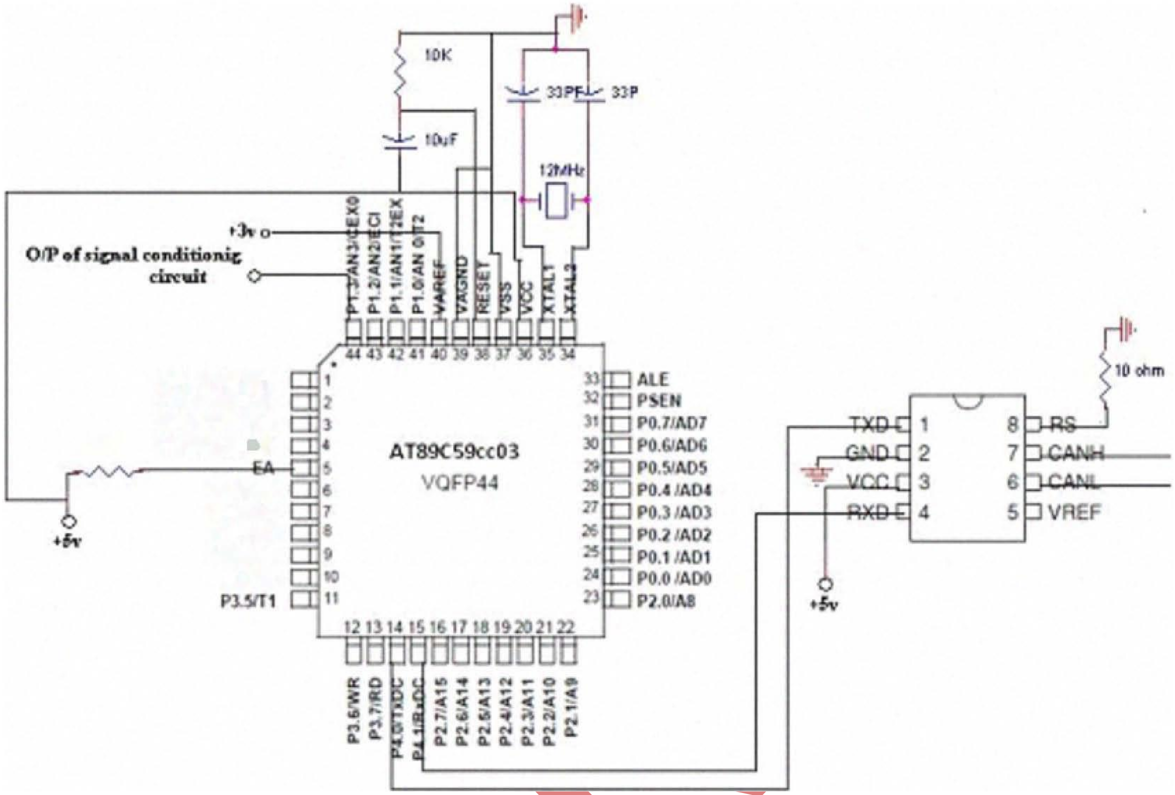


Fig.2. Microcontroller and CAN Transceiver connection

Fig.3 Temperature Sensor

Fig,4. CO Sensor

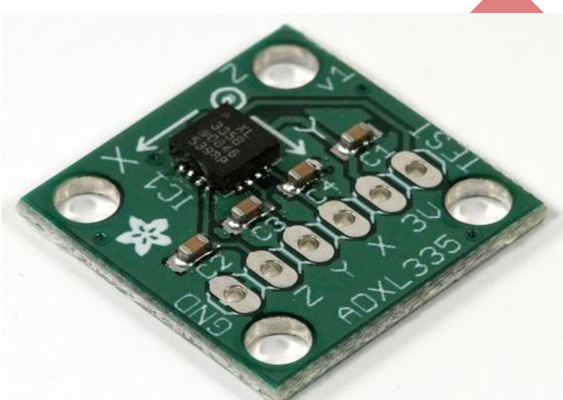
3.4 CO Sensor

This Carbon Monoxide (CO) gas sensor detects the concentrations of CO in the air and outputs its reading as an analog voltage. The sensor can measure concentrations of 10 to 10,000 ppm. The sensor can operate at temperatures from -10 to 50°C and consumes less than 150 mA at 5 V. The sensor's simple analog voltage interface requires only one analog input pin from microcontroller. Connecting five volts across the heating (H) pins keeps the sensor hot enough to function correctly. Shown in fig 4.

3.5Accelerometer

The ADXL335 is a small, thin, low power, complete 3-axis accel-erometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.The ADXL335 is available in a small, low profile, 4 mm × 4 mm × 1.45. Shown in fig 5.



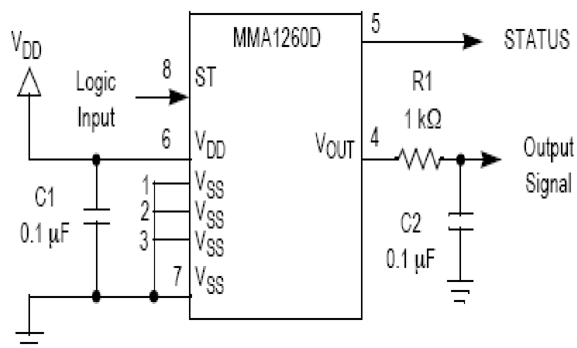


Fig.5Accelerometer **Fig.6 Electrical connections of accelerometer**

3.5 LPG Gas Sensor - MQ-6

This is a simple-to-use liquefied petroleum gas (LPG) sensor, suitable for sensing LPG (composed of mostly propane and butane) concentrations in the air. The MQ-6 can detect gas concentrations anywhere from 200 to 10000ppm.This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. 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 ADC.

Fig.7 LPG sensor

3.7 Motor Control and the Alarm Module

This module consists of an exhaust fan controlled by+5V brushless DC motor and a motor driver ULN2803 which is connected to the microcontroller. If the received sensor data is higher than the predefined limit the motor starts and the exhaust fan will start rotating continuously. At the same time alarm will turn on when LPG sensor data is higher than the predefined limit. As the voltage from the microcontroller is not sufficient to run the motor, the motor driver ULN2803 is used which supplies sufficient voltage to the motor to run. The alarm unit mainly consists of a buzzer. The triggering of the alarm unit is directly controlled by the microcontroller. As the fan rotates it expels out the contaminated air out and fresh air will replace it. As the concentration of gas decreases the sensor output decreases and when it becomes less than the limit the fan will stop.

3.8 Display Module

LED display is used to display the received data in hexvalues. 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.

IV. SOFTWARE IMPLEMENTATION

MPLAB IDE is used to develop the application software. The program is written in C language and simulated using MPLAB IDE to generate the hex file. This hex file is then downloaded into the microcontroller for it to function as programmed. As the functions related to CAN are readily available in MPLAB IDE the compilation and there after development process is easy.

V. EVALUATION

When the The sensor data is transmitted and received as either standard or extended format based on the CAN standard being used. Here the data is transmitted as CAN standard format with II-bit identifier. This is used to verify CAN data and estimate the CAN timing. The transmission speed of CAN is set to 1 Mb/s. The identifier set for sensor 1 node is 123 and for sensor 2 nodes is 214. As CAN arbitration is based on wired AND mechanism the sensor I node will transmit the data first as it has the lowest identifier number which has got highest priority.

Fig.8 shows the output at LCD. We can also transmit this information to PC for documentation of all sensor data .It will always show temperature , pressure CO percentage ,LPG amount and accelerometer reading.

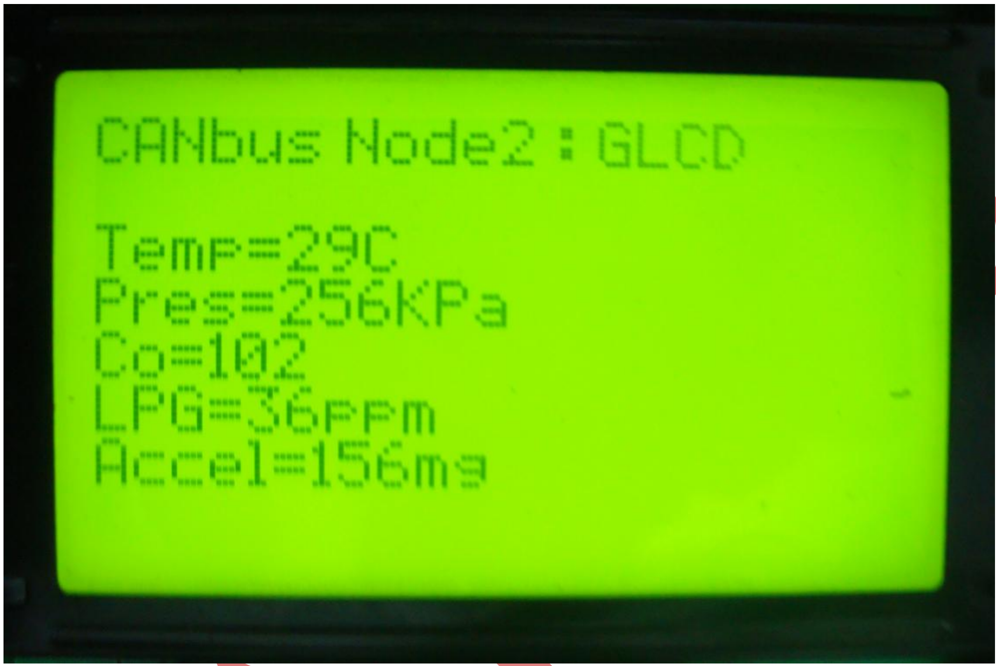


Fig.8 Output at LCD

VI. CONCLUSION

CAN based industry and home automation have been designed with transmitter nodes and receiver node. The transmitter nodes are designed as sensor nodes and the receiver node as the control node with display, which accepts messages from the sensor nodes and uses the information to detect the leakage LPG, CO quantity in air etc. The small size of the CAN transceiver IC and the micro controller with integrated CAN solution reduces the size and cost of the node considerably. With the use of high speed CAN transceiver the data is transmitted and received in faster rates with high level of integrity. The processing time associated is also small. Industry monitoring is an important class of sensor network applications with enormous potential benefits for the industrials.

CAN based smart sensor network for industry monitoring and control has been designed with two transmitter nodes and one receiver node. The transmitter nodes are designed as sensor nodes and the receiver node as the motor control node with display which accepts messages from the sensor nodes and uses the information to switch on and off the fan, there by controlling the concentration of air contaminant gases. CAN communication between the two sensor nodes and the motor control node has been implemented through the CAN physical layer standard ISO 11898-2, which defines CAN bus as two wire differential bus.

Because the protocol is message based, any node can send a message to any other node. This gives tremendous flexibility to the system designer. 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 the data is transmitted and received in faster rates with high level of integrity. The processing time associated is also small.

This paper presents the design and the implementation of a Wireless Sensor Network that monitors the air temperature, CO value and LPG percentage ,pressure in industry field.Five commercial sensors have been successfully integrated to measure these air key variables in company field. The sensor data is wirelessly transmitted to a LCD that logs the field data within seconds.

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