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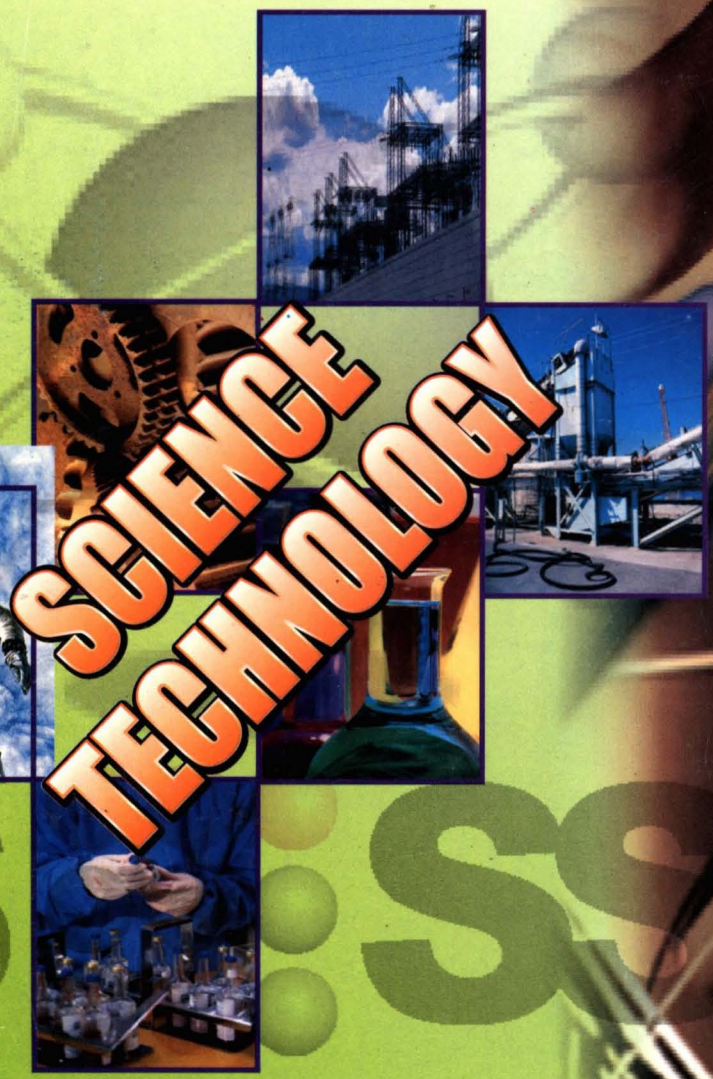

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The Centralized Hazardous Gas Detector System Using Microcontroller

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ABSTRACT

A new approach to centralized hazardous gas detectors using a low cost embedded microcontroller system is presented. Particularly emphasized is the innovation of an auto RS232 to RS485 converter using PIC16F877. Supported devices that included embedded system, external devices and problem related with multi drop communication were briefly discussed. The operation of the system is monitored using Graphical User Interface (GUI) developed based on QBasic environment. The complete prototype system was developed and the performance is reported in this paper.

Keywords: *Microcontroller; PIC; Gas detector; QBasic*

Introduction

The dramatic growth in industrial development especially in oil, chemical and gas industry has led to the emergence of an incredible rise in living standards. Nevertheless, this has caused pollution problems which have deteriorated the atmospheric environment.

To prevent or minimize the damage caused by various factors of pollution, monitoring and controlling system are imperative. Until now, air pollution has been analyzed with analytic instrument which provides a higher precision. However, they are time-consuming, expensive, and can seldom be used in real-time in the field.

These issues have fuelled a rapid growth in development of semiconductor gas sensors that are reliable, compact and cost effective and applications are compatible for environmental, industrial and domestic needs. Meanwhile, many applications for measuring hazardous pollution do not require an exhaustive analysis of the gas, but only an alarming level on the detection and safety of human. In addition, most of sensor systems available in the market are portable and decentralized (Ortmeyer and Pillay 2001; Lammel et al. 2002). As such, a centralized for detecting hazardous detectors based on an alarm level on detection and safety of human is embarked. This technique was adapted with the application of microcontroller in which has offered some advantages (Mustafa Burunkaya and Inan Gueler 2000).

In this work, a centralized hazardous detector system is implemented and constructed with the application of solid state sensor. However, sensor from other type of materials can also be alternatively applied when they can produce output voltage and current.

Principle and Operation of the Proposed System

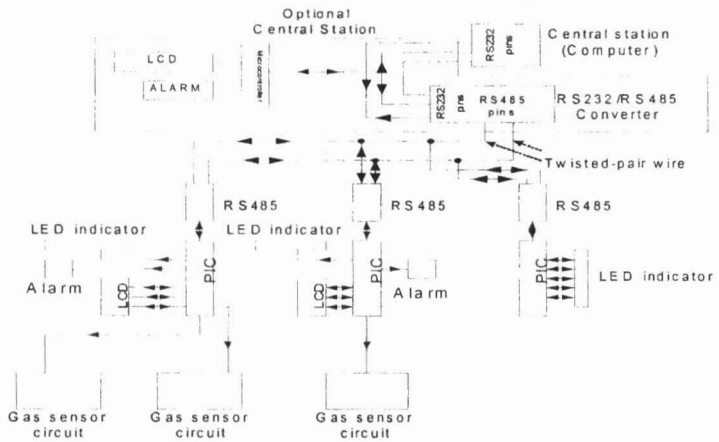

Fig. 1: The Block Diagram of the Proposed Centralized Hazardous Gas Detector System

The overall block diagram of the centralized detectors system for controlling data from slave devices is shown in Figure 1.The proposed system utilizes a concept of master/slave communication that can be seen in Figure 2. In this system, one master device will control the others slave devices which have had identification address to be called.

When all of slave devices receiving the same data, they have extracted the address from master and compared to their identification address.

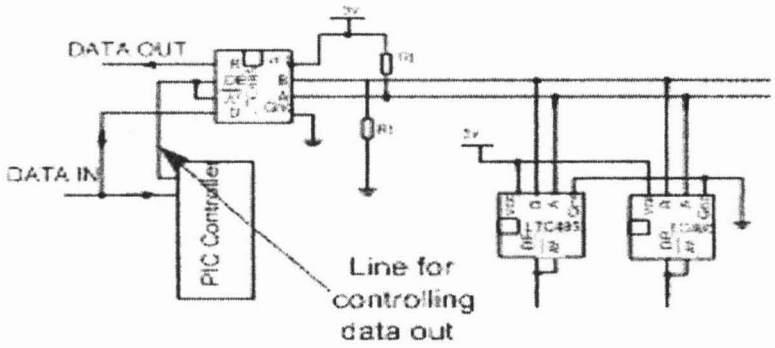

Fig. 2: Data from PC is Controlled

Slave devices with matching address, on the other hand, will send back the address to the master devices for confirmation of a successful transfer. Similarly, the rest of slave devices will receive the same data respectively without transmitting data back and immediately returning to the receiving mode.

Table 1: Pin to be Enabled in Transmitting Mode

LTC485 Transmitting

INPUTS			LINE CONDITION	OUTPUTS	
$\overline{RE}$	DE	DI		B	A
X	1	1	No Fault	0	1
X	1	0	No Fault	1	0
X	0	X	X	Z	Z
X	1	X	Fault	Z	Z

Table 2: Pin to be Enabled in Receiving Mode

LTC485 Receiving

INPUTS			OUTPUTS
$\overline{RE}$	DE	A – B	R
0	0	≥0.2V	1
0	0	≤–0.2V	0
0	0	Inputs Open	1
1	0	X	Z

Since data is commenced via two lines, organizing of sending and receiving mode pins is important to prevent interference data on the line. Direction of data (receiving and sending) is determined by the state of input pins of line interface RS-485 as listed in table 1 and 2 (National Semiconductor). For receiving mode, pins RE and DE are connected to ground position. In contrast, transmitting mode, pin DE is connected to power supply. However, the direction of data is previously to be initiated in receiving mode.

As such, an auto for handshaking line driver by the application of microcontroller is used. The protocol for controlling data is programmed into a block of a subroutine to create a suitable delay as illustrated in Figure 3.

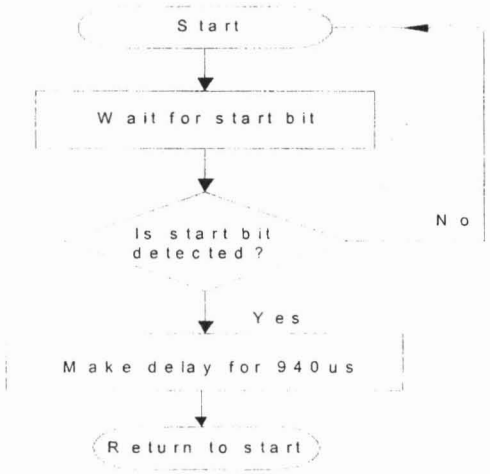

Fig. 3: The Proposed Technique for Auto Changing of Data Direction in RS-485 Converter

Meanwhile, only a frame of data begins with a start bit, follow with data bit and ended with one stop bit is transmitted as shown in Figure 4. The rest of data on the other hand, is blocked or filtered. This method will avoid interference of data in sharing line by provide a necessary time for line interface RS-485 returning back to receiving mode.

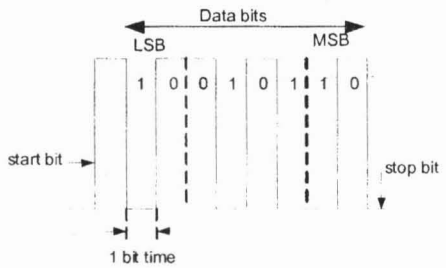

Fig. 4: Serial Data is Framed by a Start Bit and a Stop Bit.

A bit time is determined by a baud rate to represents a bit of data which are calculated using equation (1). The bit time is controlled by the selected baud rate. A higher baud rate will produce a smaller bit time and vice versa. Furthermore, the baud rate of each microcontroller is previously initialized with equality of baud rate GUI system.

$$\text{Bit time} = \frac{1}{Baudrate} \qquad \ldots [1]$$

Since communication is asynchronous, the process of sending and receiving byte of data is sequential. Although this method is slower than parallel communication, it is simpler and can be used over longer distances. Serial communication is completed using three transmission lines: ground, transmit, and receive. Therefore, RS232/485 port is transmitted data on transmitting line and received data on receiving line. The important serial characteristics are baud rate, data bits, stop bits, and parity. To communicate between microcontroller and a serial port on computer, these parameters should be matched.

An integral part for observing data from responded slave of microcontroller is played by GUI environment as depicted in Figure 5. The American Standard Code (ASCII) is used to transmit information interchange data which presents the address of microcontroller and action from gas sensors. This process is done by a Universal Asynchronous Receiver Transmitter (USART) at PC stage which is interfaced with RS-232 port. RS-232 port is sequentially sent and received bytes of information one bit at a time to and from RS-232 to RS-485 converter (master device).

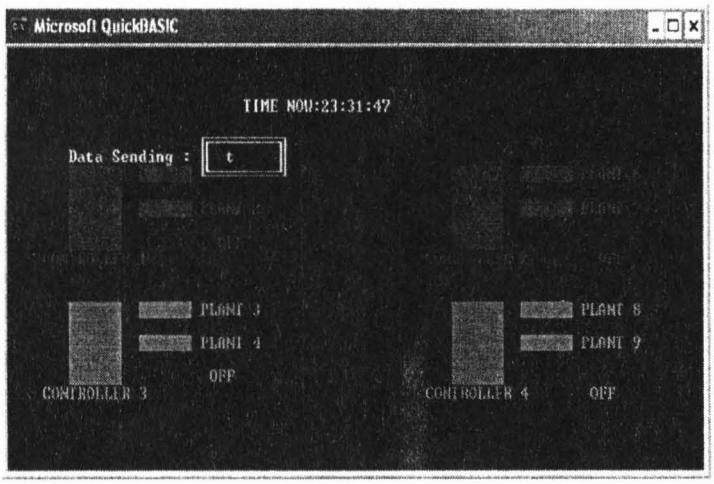

Fig. 5: Graphical User Interface for Sending and Receiving Data

An embedded Analog Digital Converter (ADC) in microcontroller converts physical signal to digital form which has been eliminated the used of external ADC. The converted signal is mapped into an N bit digital code which is temporarily stored in special purpose register (SPR) and lastly stored in a general purpose registers (GPR). Furthermore, the converted data can be viewed in PORTB which is represented in terms of binary number, and has been measured with digital multi-meter to get a voltage value. The lit LED and unlit LED are represented as binary one and zero respectively. Hence, the threshold value can be determined through this process. The value in specific GPR is compared with setting value through the process of subtraction. Here, a Z flag is used to determine the process of subtraction. A complete subtraction will jump the process to the desired output i.e. activate Alarm, transmission data, and displaying result through LCD. Uncompleted subtraction on the other hand, will return back to the early process continuously. This reaction can be summarized in a flowchart as shown in Figure 6.

At microcontroller stage, serial communication is controlled by an embedded USART which has been eliminated the used of external USART. This is the advantages of using microcontroller since the part of the system can be minimized as well as to reducing the cost. The basic principles of operation are the same whether they are implemented in hardware or software. Hence data is sent and received sequentially one bit at a time begins with a start bit and ending with stop bits. The microcontroller can be directly connected to RS-485 without previously converted to RS-232 level as PC stage required. In consequences, the system using microcontrollers become simplified and systematic.

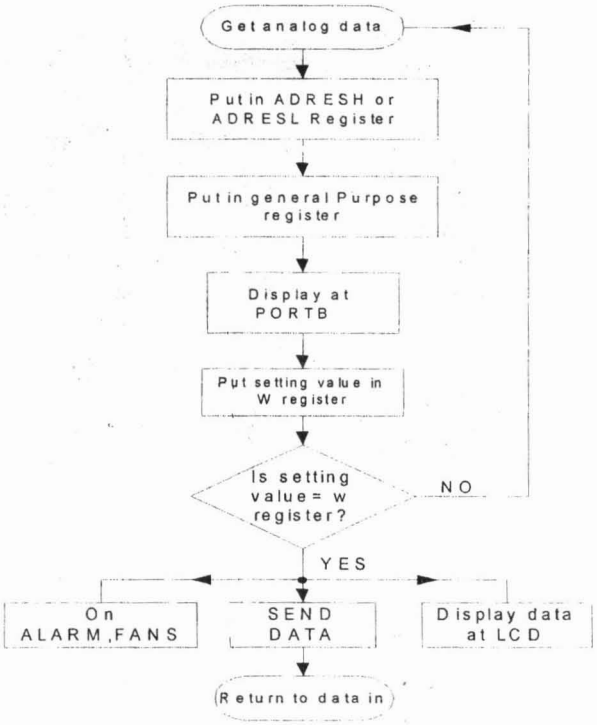

Fig. 6: Analog and Digital Converter Process

Besides other things, resistor and cable tolerances can affect a mismatch between these two impedances and can ultimately caused loss of data. Nevertheless, the cable used is categorized as a simple wire rather than a transmission line. As a result, the length of cable and data rate used is totally outside the characteristic of line transmission. Hence, problem of line transmission is beyond this analysis. However, circuit for multi-drop system is designed with parallel termination in order the twisted-pair line is matched with the line characteristic impedance specified by the manufacture. This value describes the intrinsic impedance of the transmission line and is not a function of the line length. Match impedance will produce higher data quality and can eliminate the effect of resonant.

Experimental Result and Discussion

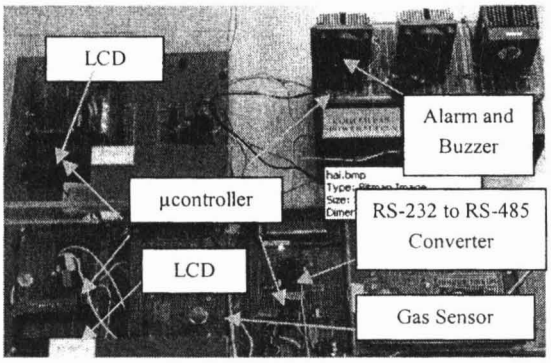

Fig. 7: Centralized Hazardous Gas Detector System

Commercial gas sensors (NAP11A) manufactured by Nemoto & Co. Ltd were used for detecting Carbon monoxide (CO) gas (Nemoto Gas Sensor). The functionality and performance of the centralized system were tested by using multiple carbon monoxide gas sensors. The CO gas sensor circuit was designed to be able to produce an analog voltage in output sensor circuit when the target input is detected or the input variable (potentiometer) of circuit is varied. From the experiment done, it has shown that, the sensor circuit was responded with gases taken from

motorbike exhaust by producing an increased voltage at its output sensor circuit. To minimize respond time reading from sensors circuit, a pre-set value at microcontroller is set to a minimum value. This can overcome the respond time optimization to active the output microcontroller when the sensor signal is reached the preset value. At this point, slave microcontroller is sending one ASCII character to RS-232 to RS-485 converter (master device) as shown in Figure 8.

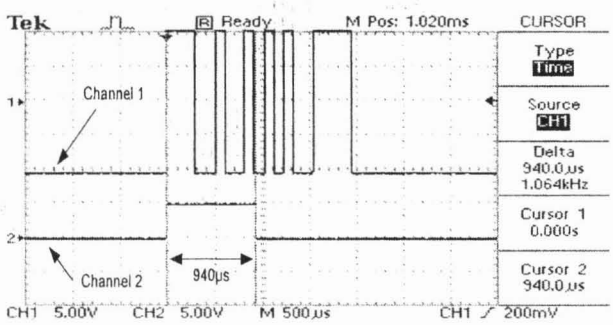

Fig. 8: Microcontroller is Activated when Signal Reached Threshold Value

However, data at RS-232 to RS-485 converter is firstly converted in the form of RS-232 level in order data can be read by USART at PC port. Channel 1 is the ASCII character in TTL form from microcontroller. Channel 2 is the equal ASCII character from microcontroller which has been converted into RS232 form at master device (RS232 to RS485 converter)

The data-flow mode is controlled by enable lines of an RS485 in master device. Microcontroller which is connected with the enable lines of an RS-485 in master device controls the handshaking mode automatically by using software delay. The purpose of software delay is to allow a frame of data to be transmitted successfully during transmitting mode when the start bit of data frame is detected by the microcontroller. PC sends data in term of a frame of data (start bit, 8 data bits and one stop bit) using 9600 baud rate. Thus, the width for a frame of data to be sent is around 940µs. After enabling lines for the period of delay, microcontroller then changes the mode of transmission back to receiving mode. Thus, the delay of 940µs is created as shown in channel 2 of Figure 9.

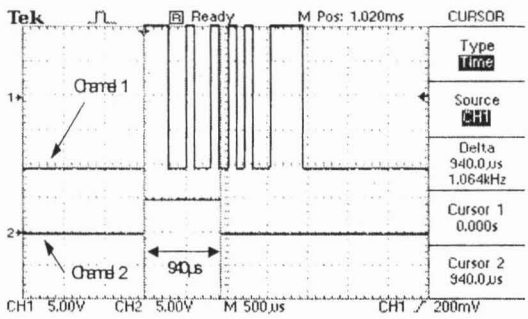

Fig. 9: Data from PC is Filtered using Delay Technique.

In master/slave communication, the RS232 to RS485 converter is acted as a master device for sending and receiving data to every slave unit microcontroller. Master device sends the same ASCII character to every slave unit as shown in channel 1 of Figure 10. All slave unit microcontrollers receive ASCII character data. They compare the ASCII character received with their own unique ASCII character address. Slave unit microcontroller with matching address sends its address via master device to PC as shown in channel 2 of Figure 10.

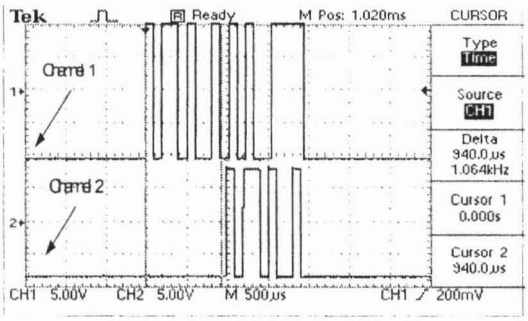

Fig. 10: Data from Slave Address of Microcontroller to RS-232 to RS-485 Converter and PC

Figure 10 shows another ASCII character address from PC to slave unit. Channel 2 shows the ASCII character address of w sends by one of slave unit to PC via master device. From Figure 10, slave unit sends address data back to master device before the whole data from PC ended. The other data from PC is blocked when the transmission mode is changed to receiving mode by microcontroller. The unchanged of previous mode will block the address data sending by slave unit to master device. As such, the mode of transmission is limit for only 940µs before changed back to receiving mode.

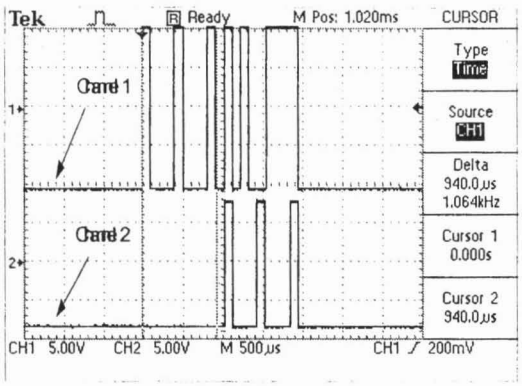

Fig. 10: A Small Letter of w Representing the Address Data of Slave Microcontroller

Using parallel termination, the resonant effect that is caused by mismatch impedance can be eliminated and thereby produces a higher quality data transfer between twisted pair lines as shown in Figure 11. The twisted pair line is transmitted data inversely proportional with each other.

The resonant effect in twisted pair wire becomes significant as the length of wire increased. Figure 12 shows the effect of increasing the length of twisted pair wire for transmitting an ASCII character to slave unit. Channel 1 and channel 2 show the ASCII code transfers from master slave to slave unit microcontroller using parallel termination. The length of twisted pair wire changes its characteristic impedance thereby produces resonant effect in transmission. However, the magnitude of resonant exits in both channels does not affect the actual data.

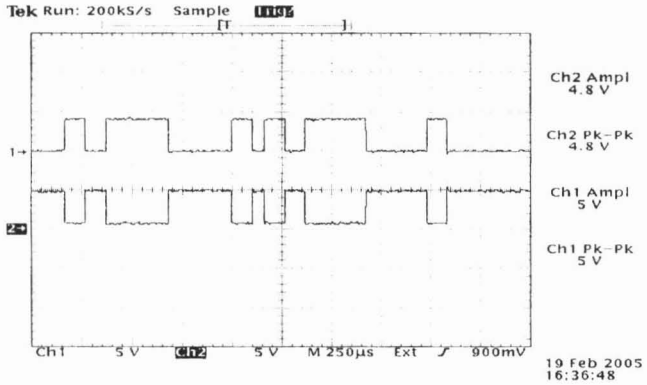

Fig. 11: Twisted-Pair Line (A and B) Signal when Address Data is injected from PC

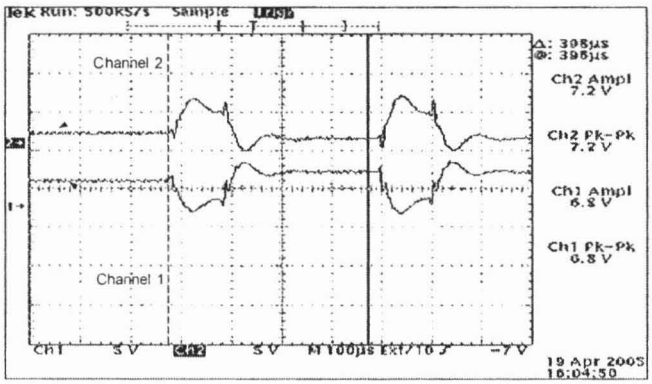

Fig. 12: 300 meter Length with Parallel Termination

Conclusion

The functionality of a complete prototype of the centralized hazardous gas detector system was demonstrated. The master device was designed for an auto switching mode and stand alone device (optional main station). The developed system has shown that the main controller (PC), optional main station and slave devices were performed excellently communicated with other and recognized the data being received or transmitted.

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