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PIC Microcontroller Based Boiler Monitoring and Controlling System for Power Plant Industry

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***Abstract-* In most of the process control industries different parameters need to be monitored and controlled simultaneously. Hence there is a need for implementation of separate circuits to measure these different parameters. But it is very difficult to implement such high complexity circuits. Hence there is a need to reduce this complexity. This led to the use of multichannel process monitoring in a single window. This paper is concern about to implement monitoring and controlling of four different parameters such as Temperature, pressure, Smoke and gas leakage using PIC microcontroller through controller area network (CAN) protocol inside a plant. The programming language used for developing the software to the microcontroller is Embedded C. The KEIL cross compiler is used to edit, compile and debug this program. JET Flash programmer is used for burning the developed code on Keil in to the microcontroller Chip.**

Keywords: CAN, fire and temperature control, gas leakage, pressure control

I. INTRODUCTION

Now a day the automation field gets a wide growth in the world wide. So every process control industries, different parameters need to be monitored and controlled simultaneously. So in order to achieve this CAN protocol can be chosen. CAN is a message-based protocol, designed specifically for automotive applications but now also used in other areas such as industrial automation and medical equipment. Development of the CAN-bus started originally in 1983 at Robert Bosch GmbH. The protocol was released in 1986 at Society of Automotive Engineers (SAE) congress in Detroit, Michigan. The communication can be achieved between various devices using CAN protocol. The CAN bus can be used to connect the control unit, transmitting and receiving unit. The multi-master node CAN is able to send and receive messages but not simultaneously. The message consists primarily of an id which represents the priority of the message. The data is transmitted serially on to the bus. This signal pattern is encoded in NRZ form and sensed by the node. Whenever the bus is free the most dominating message will be executed first and the lower priority will sense these and will back-off. Bit rate is up to 1MB/S are possible at network length below 40m and decreases with increase in network distance. Carrier senses multiple access protocol with collision detection and arbitration on message priority mechanism is used in the CAN. Error control mechanism such as CRC is used to ensure sensor data integrity.

The main objective of this paper is to build low cost industrial automation and control using embedded design. Four critical process parameters such as temperature, pressure, gas leakage and smoke have to be controlled automatically when abnormal condition is reached.

II.PROPOSED SYSTEM DESIGN

The fig 1. shows the proposed system. Entire system is divided into two nodes such as processing node and control node. Four sensors - Temperature sensors, Pressure sensors, Smoke sensors and gas sensors are employed to sense their respective physical parameters from the process and convert them it into equivalent voltage levels. These analog outputs are given to an ADC (Analog to digital) unit for digital conversion. This conversion is done by a PIC microcontroller which has ADC inbuilt in it. External CAN controller and CAN transceiver modules are interfaced with PIC microcontroller which is used as both transmitter and receiver. PIC microcontroller is used because it is a versatile device which is very flexible and hence reduces the hardware assembly. Its inbuilt memory feature is easily adaptable to various situations. Its inbuilt memory feature is easily adaptable to various situations.

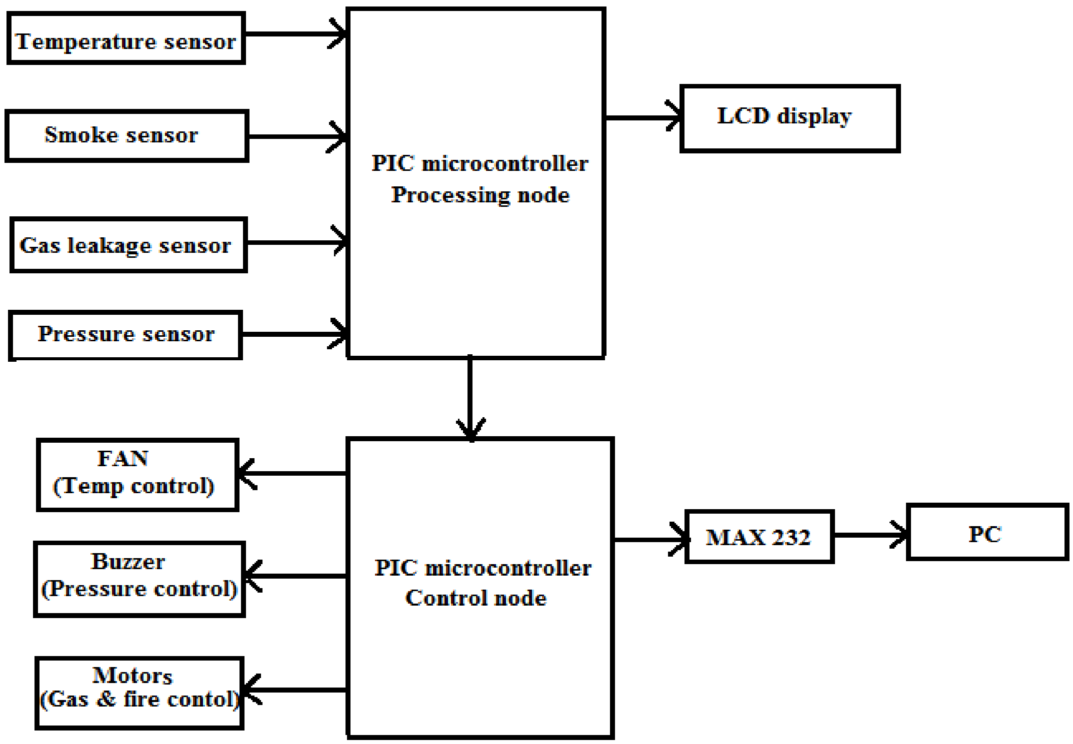

Fig 1. Block diagram of automation and control system using PIC microcontroller and CAN

The corresponding assembly language program is flashed into the PIC microcontroller memory to process the values obtained from the sensor output and take control action. Control actions are performed by means of fan on-off control for temperature control. Motors which are connected to window opening mechanism are controlled for fire & gas leakage control action. Pressure critical level is raised by alarm signal through buzzer.

Then the PIC microcontroller is interfaced with a computer using a PC interfacing unit. This interfacing unit includes MAX232 and RS-232 COM port assembly. The final output is visually displayed in the pc using visual basic software. The process is monitored to be maintained at the optimum performance with the help of LCD and front panel display.

III. HARDWARE DESIGN

A. PROCESSING ELEMENTS

a. PIC MICROCONTROLLER-PIC16F877A

The PIC16F877A is a CMOS FLASH-based 8-bit microcontroller. It features are 200 ns instruction execution, 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port, a USART, and a Parallel Slave Port.

In this paper, 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 LCD. The output of the microcontroller is given to the CAN transceiver IC MCP 2551 in order to transmit to the control node.

b. CAN TRANSCEIVER MODULE

The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The MCP2551 device provides differential transmit and receive capability for the CAN protocol controller, and is fully compatible with the ISO-11898 standard, including 24V requirements. It will operate at speeds of up to 1 Mb/s. Fig 2 shows pin diagram of CAN transceiver.

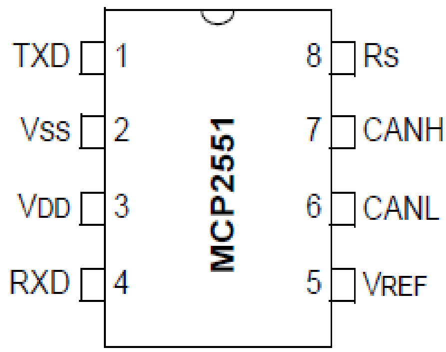

Fig 2. Pin diagram of MCP2551

c. TEMPERATURE SENSOR-LM35

The LM35 series are precision integrated circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4 at room temperature and ±3/4°C over a full -55 to +150°C temperature range. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy.

d. SMOKE SENSOR-LIGHT DEPENDENT RESISTER

Light Dependent Resistor is also called as Fire Sensor. A photo resistor or light dependent resistor or cadmium sulfide (CdS) cell is a resistor whose resistance decreases with increasing incident light intensity. It can also be referenced as a photoconductor.
A photo resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

e. GAS LEAKAGE SENSOR-MQ6

The semiconductor flammable gas sensor detects the presence of combustible gas and smoke at concentrations from 300 to 10,000 ppm. The sensor’s simple analog voltage interface requires only one analog input pin from your microcontroller. This sensor detects the concentrations of combustible gas in the air and ouputs its reading as an analog voltage. The sensor can operate at temperatures from -20 to 50°C and consumes less than 150 mA at 5 V.

f. PRESSURE SENSOR-MPX5050/MPXV5050G

A pressure sensor measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed. For the purposes of this article, such a signal is electrical.

g. LCD DISPLAY

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.

B. CONTROL ELEMENTS

a. COOLING FAN

To cool these components, fans are used to move heated air away from the components and draw cooler air over them. The exhaust fan is controlled by+5V brushless DC motor via a motor driver (ULN2803) which is connected to the microcontroller. If the received temperature sensor data is higher than the predefined limit, the exhaust fan will start rotating continuously.

b. BUZZER

A buzzer or beeper is an electronic signaling device. It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound.

In this paper, when the received pressure sensor data is higher than the predetermined value, the buzzer will raise alarm signal.

c. DC MOTOR

A direct current (DC) motor is a fairly simple electric motor that uses electricity and a magnetic field to produce torque, which turns the motor. At its most simple, a DC motor requires two magnets of opposite polarity and an electric coil, which acts as an electromagnet. This electromagnet switches the current flow as the motor turns, changing its polarity to keep the motor running. The DC motors are connected to window opening mechanism used for controlling gas and smoke level.

IV. DESIGN OF AUTOMATION AND CONTROL SYSTEM

PARAMETER PROCESSING STAGE

The temperature sensor, pressure sensor, smoke sensor and gas sensor module are connected to PIC16f877a microcontroller through pin RA0-RA3. This pins used for A/D conversion channels. LCD is connected to port D of PIC microcontroller in order to display the instantaneous values of four parameters. Control signal for LCD is obtained from PORT E. PIC is interfaced with CAN controller MCP 2515 through serial peripheral interface (SPI) which is the inbuilt feature of PIC. Pins SD0 and SD1 are used to connect CAN controller with PIC. CAN controller is connected to CAN bus through CAN transceiver (MCP2551) which acts as CAN logic converter between MCP2515 and CAN bus.

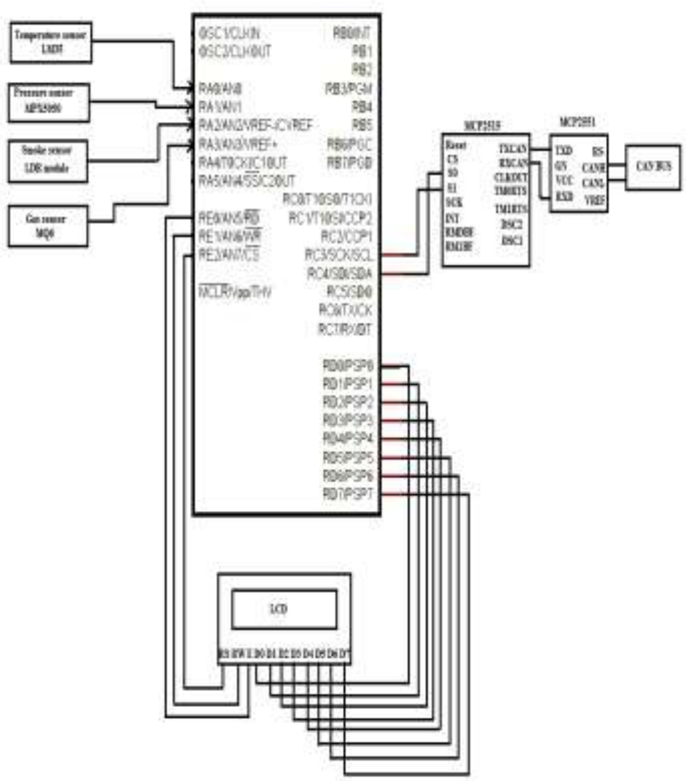

Fig 3. Circuit diagram of parameter processing node

AUTOMATION AND CONTROL SYSTEM

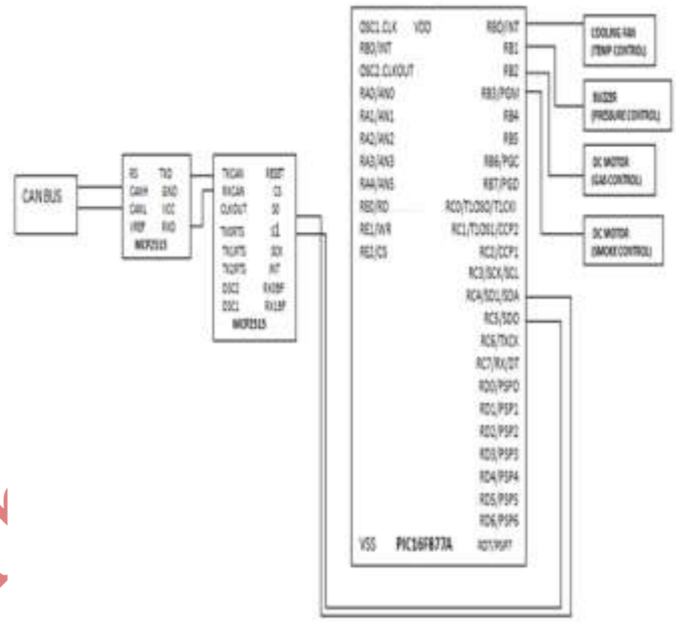

Fig 4. Circuit diagram of automation and control system

Another PIC16f877a microcontroller acts as master device which take decision upon operating final control elements such as cooling fans, DC motors and buzzers. Cooling fan is used as a corrective mechanism for temperature process. DC motors are connected to window opening mechanism used for controlling gas and smoke level. Buzzer is used for raising alarm signal whenever pressure level exceeds its safe limit. Message coming from processing unit through CAN bus is identified by CAN transceiver (MCP 2551) in the control unit. CAN controller (MCP2515) will store messages in its register and send the message to master PIC whenever it request CAN controller with unique filter ID. Based upon information obtained from CAN controller, PIC will take decision on operating control elements in order maintain normal operating condition. Fig shows the circuit diagram of control unit. Control elements are connected to PORT B of PIC. Connection to CAN controller and CAN transceiver are also showed in the diagram.

V. EXPRIMENTAL RESULT

Front panel display is generated for displaying normal and abnormal level of current process parameter and also to indicate operating conditions of control elements via cooling fan, DC motors and buzzer. Since the information is brought into personal computer (PC), it can be shared among all system in the network through local area network (LAN). Different part of the industry can monitor the process continuously and corrective action can be initiated from any part of the industry. Hence it will ensure fail safe condition of automation system.

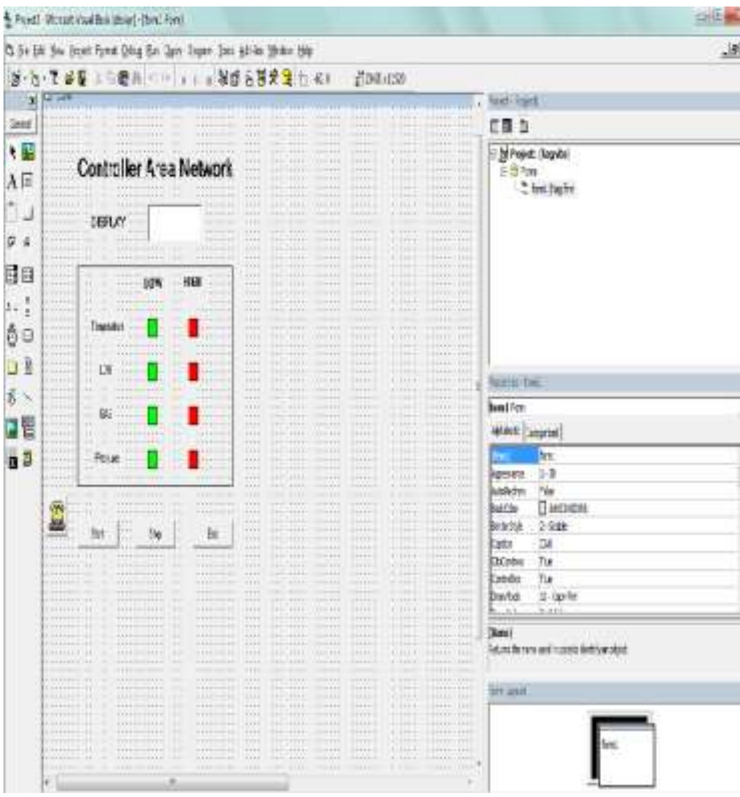

Fig 5. Front panel display of automation and control system

VI. CONCLUSION

This paper is concerned about implementation of PIC microcontroller based automation and control system for monitoring parameters of an industrial boiler. The monitoring parameters are temperature, smoke, gas and pressure level of the boiler. For monitoring the above parameters, LM35 sensor, LDR module, MQ6 sensor and MPX 5050 sensor are used. The programming of microcontroller interfacing using CAN protocol is verified using a general purpose board. The smoke, gas and pressure level of the boiler displayed through LCD are transferred from the parameter processing system to the automation and control system via CAN protocol. Normal and abnormal conditions are viewed in PC using RS232 interface. Control elements are activated and deactivated as per the program logic.

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