SMART BOILER EXPLOSION AND RECTIFICATION SYSTEM

ECE3003 (MICROCONTROLLER AND ITS APPLICATIONS)
J-COMPONENT REPORT
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Slot:C2

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ABSTRACT

Steam boilers are used in many industry sectors, such as the food industry, textile mill, paper factory, sugar mill, oil field, power plants and other industries. Boiler explosion is a very widespread problem that can be easily averted by just keeping a log of boiler data and understanding its behavioural trends in real time systems. Since these data are not accessible nor is properly recorded, every year lots of avoidable boiler explosions still occur. This project devises a strategy to solve this issue by tracking all the vital readings from a boiler and documenting it. Over a period of time, boiler operating logs help distinguish operating trends that can allow problems to be diagnosed, and boiler system maintenance to be scheduled, before an emergency shutdown is necessary. For instance, a steady rise in stack temperature, at the same boiler load, indicates dirty boiler firesides or waterside scale build-up. In either case, remedial action can be taken before it is necessary to shut the unit down for cleaning. This data will be collected by using an 8051 microcontroller and then accordingly a servo motor is rotated so that the right amount of substances are sent into the boiler.

INTRODUCTION

Every year there are several boiler explosion cases, and we designed a project that can solve this avertable accident. The project is focussed on getting various data required from the boiler and using that to analyse the possible threat, then accordingly the solution will be deployed. One of the classic mechanisms would be, when the temperature rises, our circuit will make the valve sending in fuel reduce the amount sent. Hence the temperature will reduce.

This problem is avertable, because of the fact that there is no timely monitoring and alerting the concerned worker or people responsible for the control of the boiler. So, we have devised a strategy to solve this issue by tracking all the vital readings from a boiler and documenting it. Over a period of time, boiler operating logs help distinguish operating trends that can allow problems to be diagnosed, and boiler system maintenance to be scheduled, before an emergency shutdown is necessary. This problem is not only restricted to boiler plants, but any industrial application where there is a need for controlling the amount of input substance into a chamber and monitoring necessary parameters. So on a larger scale the same application could be taken and applied on to several other industrial applications that have similar functionality.

THEORY

The overall project incorporates the mixture of sensor integration, LCD integration and serial communication which has been used in the case of the proteus simulation virtual terminal. The sensors used are temperature sensor, PIR sensor, servo motor which is an actuator. The entire theoretical portion can be divided into the portions used in the making of this project.

Serial Communication

It is a communication method that uses a particular transmission and receiving line for transferring of data from microcontroller to the sensor and vice- versa. The entire data is sent continuously in one bit interval. The 8051 microcontroller has a register named Timer Mode (TMOD) which is an 8 bit, bit addressable register that is used to specify if the register is acting as a timer or counter. The TMOD has four modes namely:

M1	M2	Mode
0	0	Mode 0- 13 bit
0	1	Mode 1- 16 bit
1	0	Mode 2- 8 bit auto reload
1	1	Mode 3- Split Mode

Table I: Modes and meaning in TMOD register

In order to set the microcontroller into serial communication mode, Timer 1 Mode 2 is used which enables the user to set the baud rate of communication. Baud rate is the rate at which information is transferred in a communication channel. In order

to set the value of TMOD in Timer 1 Mode 2, value of 20H is passed to it which in terms of bit values stand as follows in the TMOD structure

GC	T/C	M1	M0	GC	T/C	M1	M0
0	0	1	0	0	0	0	0

Table II: TMOD for setting baud rate in Serial Communication

The Serial Communication protocol also includes two other registers namely Serial Control (SCON) and Serial Buffer (SBUF). SCON is an 8 bit, bit addressable register used to control the activity and set the mode. In order to use serial communication, SCON is set to 50H.

SM0	SM1	SM2	REN	TB8	RB8	TI	RI
0	1	0	1	0	0	0	0

Table III: SCON for setting Serial Communication by setting value of 50H.

The SBUF carries the data that is to be transferred from the sender to the receiver. Apart from the data, the start and stop bit are added at the sender side which are then received at the receiver side which leaves only the data that has been transferred.

Sensor Integration

Sensor is a device which is in contact with the physical environment and measures certain readings in order to quantize the parameters the sensor records. The sensors can be of two types:

a. Digital Sensor
b. Analog Sensor

Digital sensors transmit data digitally i.e in bits which are either 0 or 1. The digital sensors do not require analog to digital converters. Analog sensor produces output in terms of voltage readings which require ADCs for sampling the voltage levels and converting them into digital bits format.

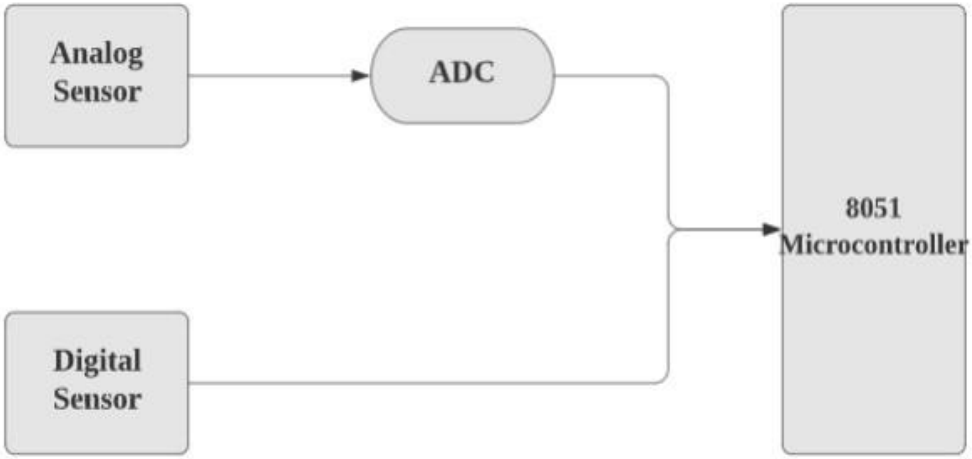

Figure I: Sensor Integration Overview

LCD Integration

Liquid Crystal Display (LCD) is a display system which uses crystal and consumes less power compared to that of the LED. For our case we are using a 16x2 display LCD. It means that 16 characters can be printed in a line and contains two lines of display. Therefore our LCD can print 32 characters overall.

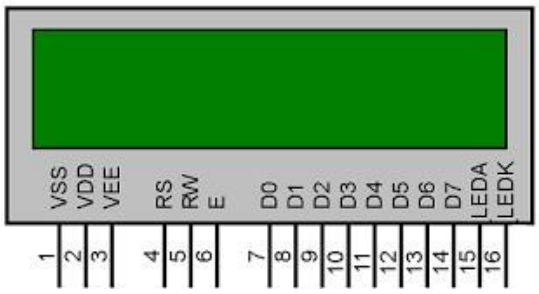

Figure II: 16x2 LCD Pinout

The Vss pin is connected to the ground and the Vcc in the input voltage required in order to switch the LCD on which is 5V. RS stands for Register Select, when it is 0, it stands for command register where the MCU gives the command to the LCD. If the register select is 1, MCU sends the data that is to be displayed to the LCD.

RW is the read and write pin of the LCD. When the value is 0, it enables the read activity of the LCD where the data is written to the LCD or in other terms, MCU sends the data to the LCD. When the value is 1, it activates the write mode in which the LCD displays the contents and the value is read by the user displayed on the LCD.

The pin E is toggled in order to display the data. Initially it is set to 1 but when it turns to 0, the LCD displays the data and again the normal condition of 1 is set when the displaying process is completed.

Pin D0 to D7 are the data pins which are connected to the microcontroller which sends the data in bits format starting from the LSB to the MSB.

ADC Connection

ADC stands for Analog to Digital Converter which we have used in the case of pressure sensors. Analog sensors provide output in the form of voltage readings which are sent to the ADC. Based on the readings of the voltages, the ADC does sampling of those levels and the data is quantized which is in turn converted into digital bits of the data. The ADC can be of two types namely serial which contains one output line and serial which contains multiple output lines. ADCs are available for various resolution sizes where the step size can be given by Vin/2.

For our project we have used ADC0804 which contains one input line and 8 output lines. The output lines have been connected to the Port 1 of the microcontroller. It is a 5V and 8 bit resolution type. Since it is a 5V input ADC, 2.5V has been provided at pin 9. Vin+ refers to the input voltage that is basically the data voltage provided by the pressure sensor. Vcc is the voltage required in order to switch the ADC on which is 5V in the case of ADC 0804. The pin diagram has been provided in the

figure below for better understanding and the rest of the connection can be seen in the software simulation figure provided below. The description of the important pins have also been added.

PIN-1 – CS (chip select) Make this pin ground(0) low to activate the ADC0804.

PIN-2 – RD (Read) Make this pin high(1) and after some time low(0). This will bring data from internal registers to the output pins after conversion (analog to digital converted value).

PIN-3 – WR (Write) Make this pin low(0) to high(10) to start conversion of data(analog to digital)

PIN-4 – Clock IN (CLK IN) Connect external clock to this pin.

PIN-5 – Interrupt (INTR) This pin automatically goes low when conversion is done by

ADC0804 or when the digital equivalent of analog input is ready..

PIN-6 – Vin (+) connects input analog sensor pin/input voltage to this pin.

PIN-7 – Vin (-) ground this pin.

PIN-8 – Analog Ground (AGND) ground this pin.

PIN-9 – $V_{ref}/2$ sets the reference voltage for analog input.

PIN-10 – Digital Ground (DGND) ground this pin

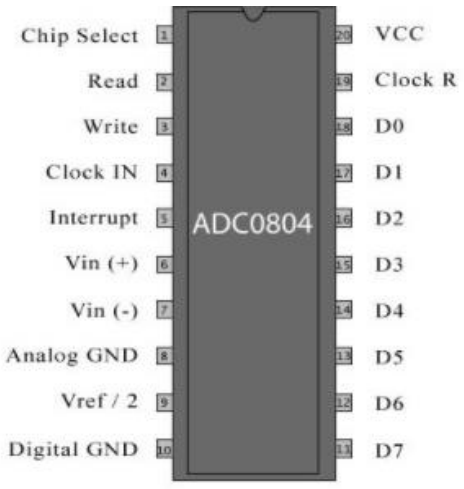

Figure III: ADC 0804

WORKING

Our project is mainly focused on getting sensor values of temperature and humidity and using those values , we control the servo motors. The servo motors are responsible for controlling the valve that opens and closes the fuel or any stored liquid based component being sent into the boiler. This can give an overall control over the hazard regulations of the boiler. The overall Simulation was done in Proteus, we connected all the sensors to the microcontroller, except the Pressure sensor the rest were digital sensors, therefore an analog to digital converter was connected to the pressure sensor so that the values are stored in the microcontroller. The real time values of the sensors are tracked and displayed in small intervals in the LCD display placed in the circuit. Overall the servo motors are made to rotate according to the amount of value difference shown in the sensors. If it goes above or below certain values, the servo motors are rotated in respective directions.

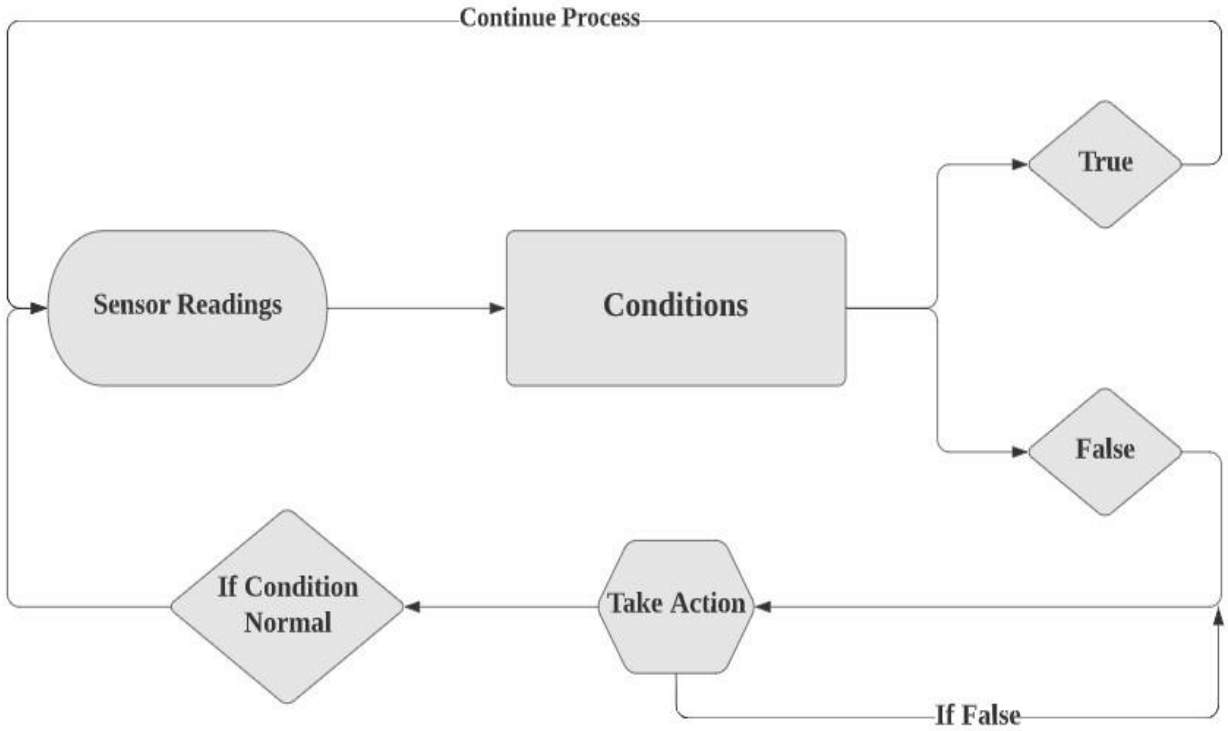

Figure IV: Algorithm Structure of the System

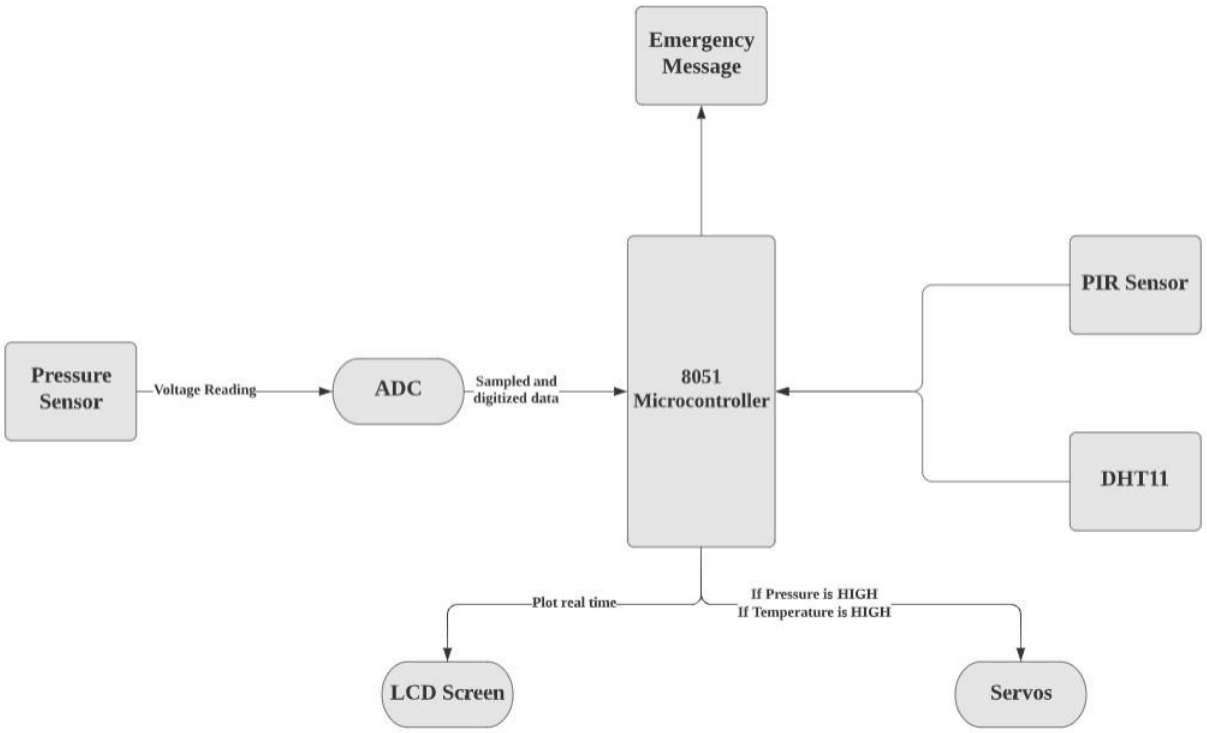

Figure V: Project Block Diagram

Presently, we use distributed control systems in the industries, using a panel control unit to control and monitor the temperature and flow parameters. Manual assistance at all times when the plant is in operation is the limitation of this system. The person who is present inside the plant during an emergency also is in risk of his/her life in case of any emergency. Hence, we propose a model so that the operating person can remotely control and monitor the boiler feed water in a power plant. Boiler parameters such as water level, pressure and temperature are monitored using water level sensor, pressure sensor and temperature sensor respectively. The real time information of these parameters will be sent to the programmed decision making microcontroller unit which will turn ON/Off corresponding parameter relays and its associated switching units depending upon the real time information received from the various parameter relays, if the operating conditions are well within the preset limits then no control command will be sent to the relay via the decision making microcontroller or else if there is any

violation in the operating conditions then microcontroller will send the control signal to the associated relay to turn ON/OFF depending on the real time information. The real time information can be visualized on the LCD display and the same information can be sent to the mobile-phone registered number in the form of SMS via GSM

SOFTWARE IMPLEMENTATION

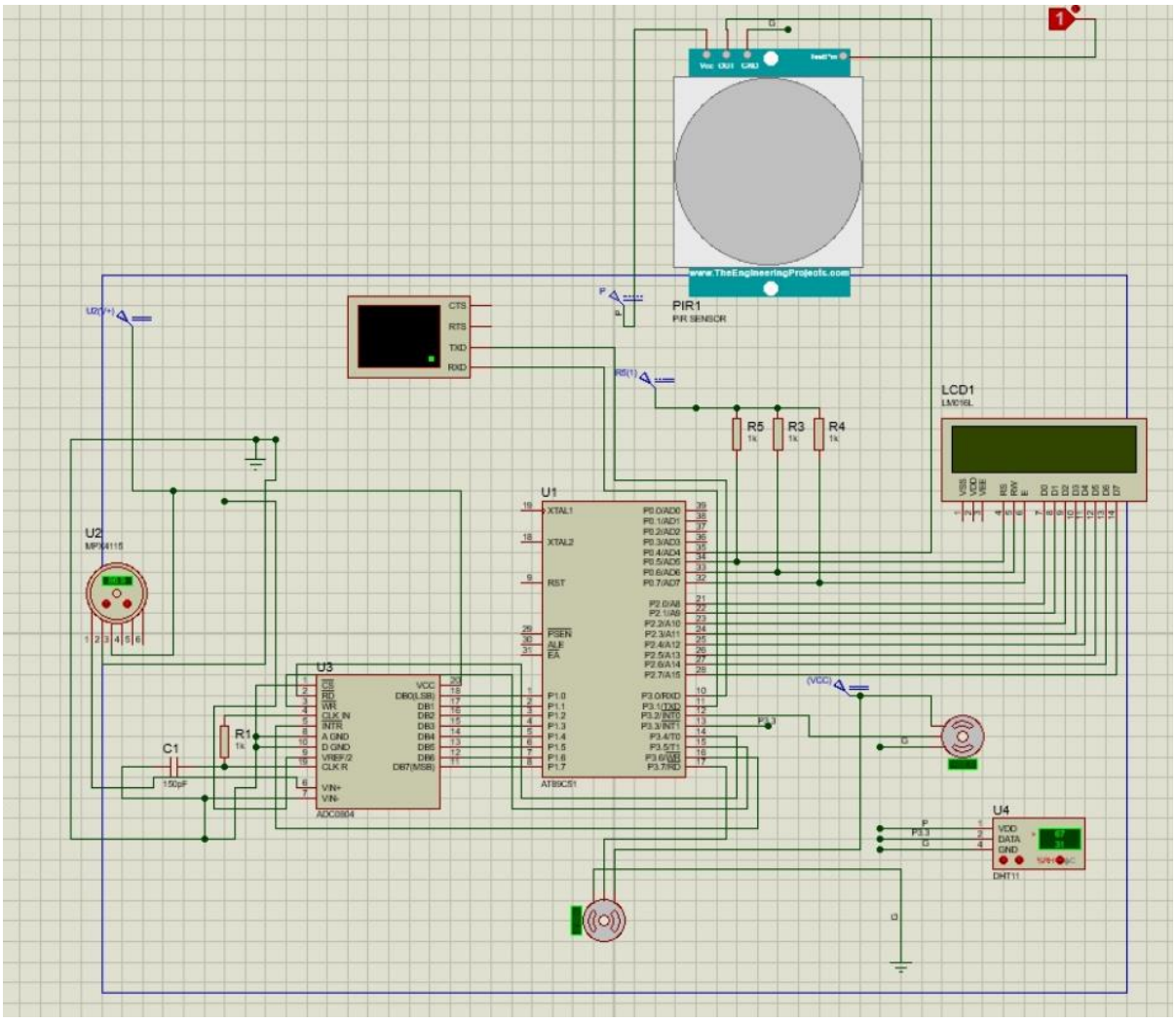

Figure VI: Proteus Circuit Diagram

In this system transmitter section mainly consists of three sensor networks which senses various boiler parameters. Temperature sensor, PIR sensor and pressure

sensor are used in this model. Sensors analog output are connected to ADC (Analog to Digital Converter) to convert analog information to digital form, then this digital information is processed using PIC 8051 microcontroller. PIC 8051 microcontroller does the controlling section. Whole sensor's data are stored in the processor memory and sent to the database then to the display device. It indicates the workers through a buzzer in the workplace and through an alarming system in the user system by GSM receiver in remote places which have connectivity to the 8051 microcontroller if any of the sensor's data exceeds or below its threshold level. The connected servos are used to turn ON/OFF the fuel and water tank valves according to the situation. Hence we can automatically control the environment of the boiler.

HARDWARE IMPLEMENTATION

A specific set of parameters are the basic reason for boiler explosion, such as temperature, humidity, water conditions. These parameters have short or long term effects on the overall wellbeing of the boiler. We use these parameters to determine and control changes in order to reverse the negative effects. The amount of fuel or other liquid chemicals sent in the boiler is controlled depending on the parameter values.

The following are the hardware components used in the project -

8051 Microcontroller Development Board -

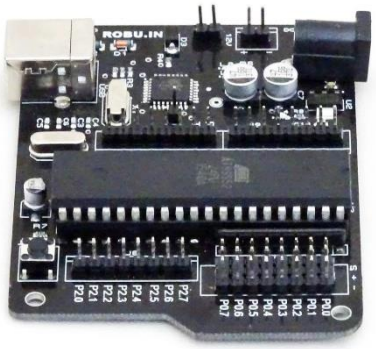

Figure VII: Aryabhatta 8051 Development Board with on board chip

The 8051 microcontroller was designed by Intel in 1981. It is an 8-bit microcontroller. It is built with a 40 pins microcontroller with 4kb of ROM storage and 128 bytes of RAM storage, 2 16-bit timers. It consists of four parallel 8-bit ports, which are programmable as well as addressable as per the requirement. An on-chip crystal oscillator is integrated in the microcontroller having a crystal frequency of 12 MHz. The development board helps in connecting the 8051 chip with the computer and enables the transferring of the hex file in order to enable the microcontroller to perform its task.

DHT11 Temperature and Humidity Sensor-

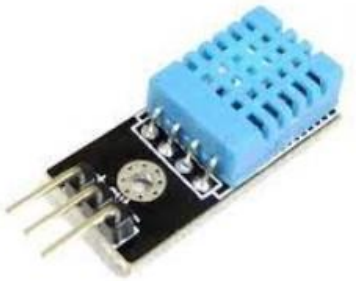

Figure VIII: DHT11 sensor

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed).

PIR sensor -

Figure IX: PIR Sensor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications.

PIR sensors detect general movement, but do not give information on who or what moved. For that purpose, an imaging IR sensor is required.

SG90 Servo motor -

Figure X : Servo Motor

A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servo motors are not a specific class of motor, although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system.

LCD display-

Figure XI : LCD Display

The LCD Display is used in order to display the real time values of the important environment parameters present inside the boiler.

Pressure sensor:

Figure XII : Pressure sensor

A pressure sensor is a device for pressure measurement 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.

Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively be called **pressure transducers**, **pressure transmitters**, **pressure senders**, **pressure indicators**, **piezometers** and **manometers**, among other names.

RESULTS AND DISCUSSIONS

From both the simulation and the hardware implementation we could cover the objectives of the project. Even though the simulations provided trustworthy results, hardware implementations verifies all the simulation data and outputs. Simulations were conducted using Proteus software as shown in the figure given down below. Normal pressure indicates that the pressure inside the boiler is under safe limits. A lot of boiler explosion cases have been seen due to extreme pressure build up inside the boilers due to the steam produced by the fluids of the container. If the pressure exceeds the safe range which has been applied inside the code, an alarm of high pressure will be displayed

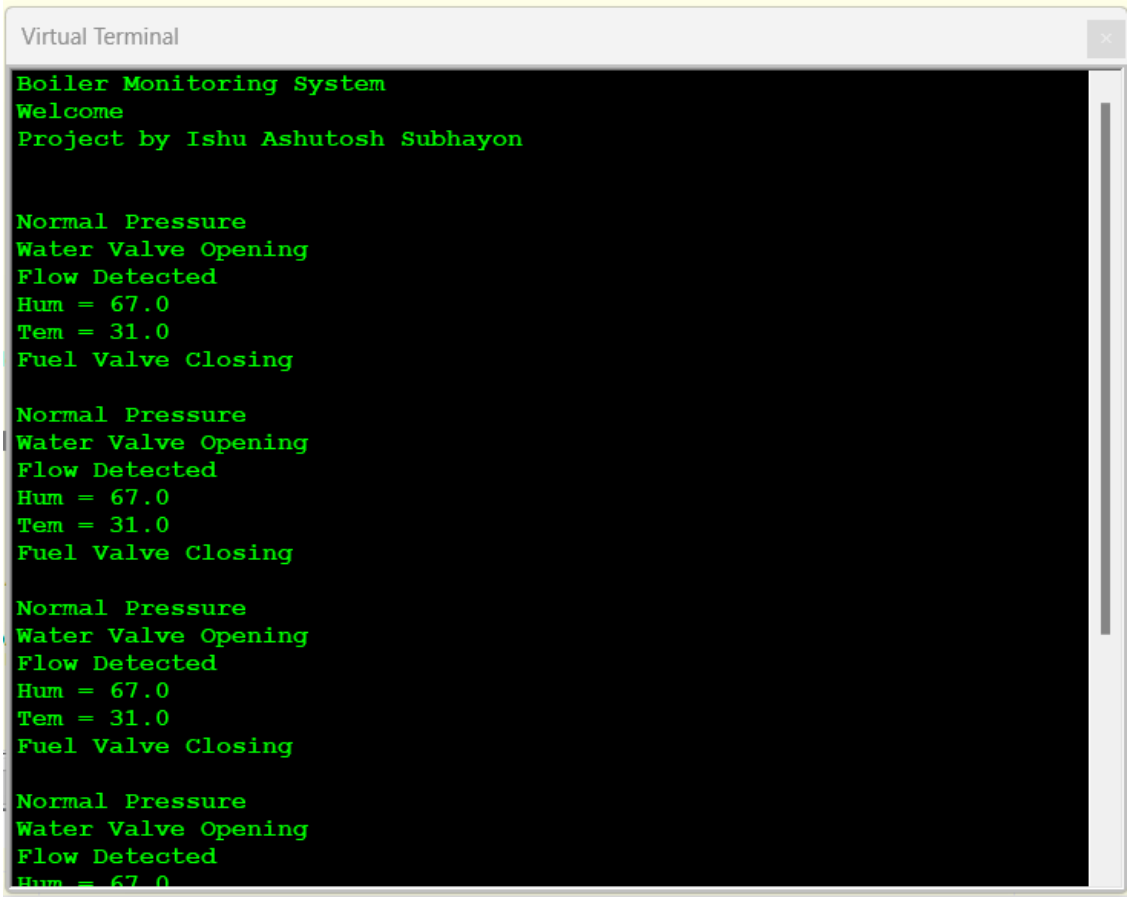

Figure XIII: Simulation Output under normal condition

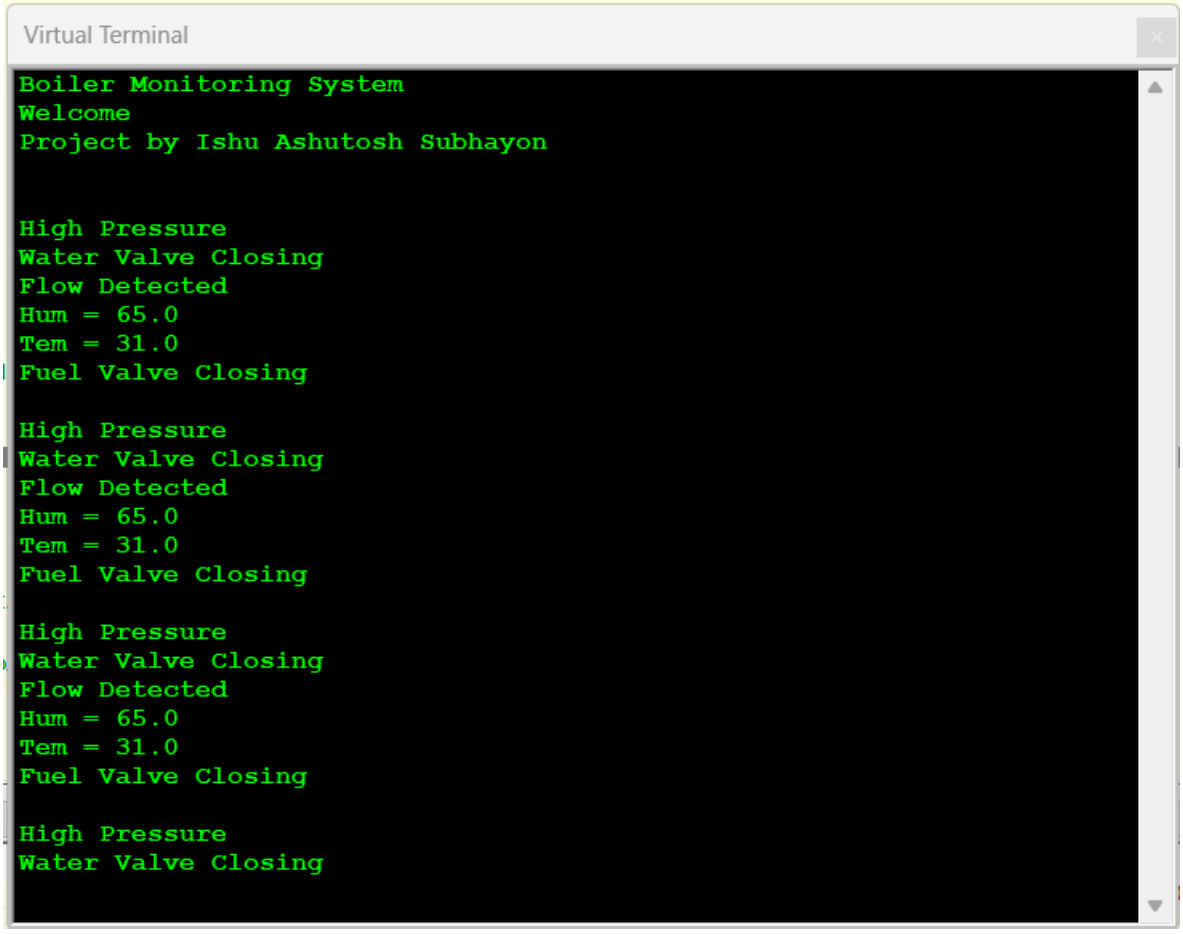

Figure XIV: Simulation Output under emergency condition

Flow Detection uses a PIR sensor which detects the movement of the fluids through pipes. This leakage can cause hazards not only to the workers but can be inflammable which will put the entire factory in danger. Therefore the PIR sensor notifies incase of any change in the fluid level or outflow of fluid even if it's not needed. The temperature and humidity sensor is very important and notifies the real time value. Sometimes the rise in temperature causes the formation of steam of the fluids present inside the boilers. Two servo motors are also connected which will be activated in case of high temperature and high pressure. It has been added for safety which will eject excess pressure and excess fluids when the temperature rises due to any situation. The virtual terminal is added to replicate the GSM module which will give real time updates and emergency messages to the head of the factory or the owner who can take any actions required in the case of any

emergency. Such systems are very important as seen after the unforgettable scenarios of Bhopal Gas Tragedy.

In terms of the hardware demonstration of the system, pressure, temperature, humidity and PIR sensor was added in order to check the conditions of the simulations and was verified. The GSM module could not be added into the demonstration since there was no stock in the market. Apart from the GSM module, all the other connections have been checked and the working picture has been added in the figure below.

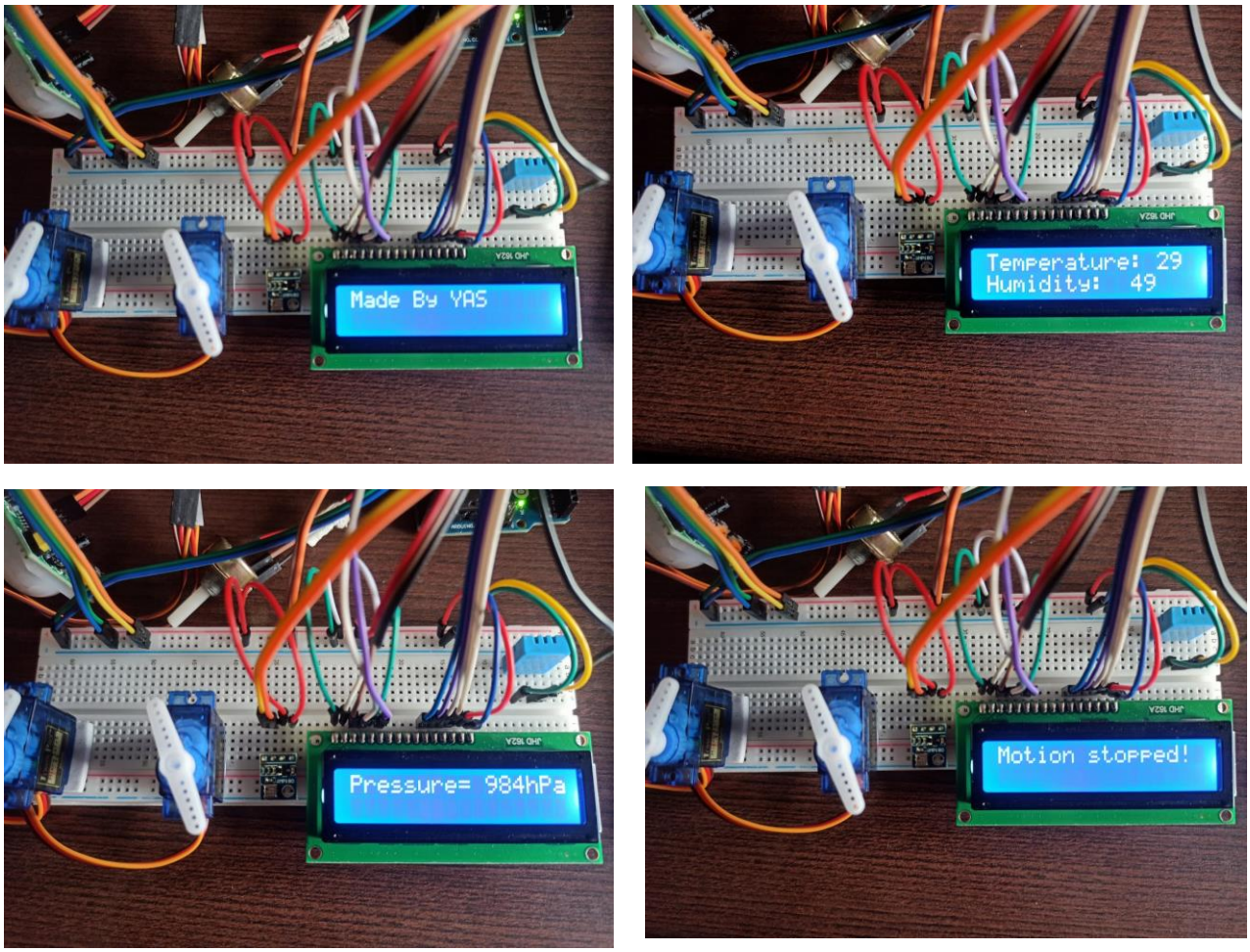

Figure XV: Hardware Demonstration of the entire system

In terms of hardware drawback, the servo is supposed to rotate when the temperature is more than the safe level which is set at 20C for demonstration

purposes. But the power required by the servo cannot be provided by the 8051 development board and therefore even though the servo vibrates, it does not rotate the required angle. An external battery needs to be added in order to provide enough power to the servo. If attached to the board, it sometimes draws more power and makes the LCD flicker and not work properly.

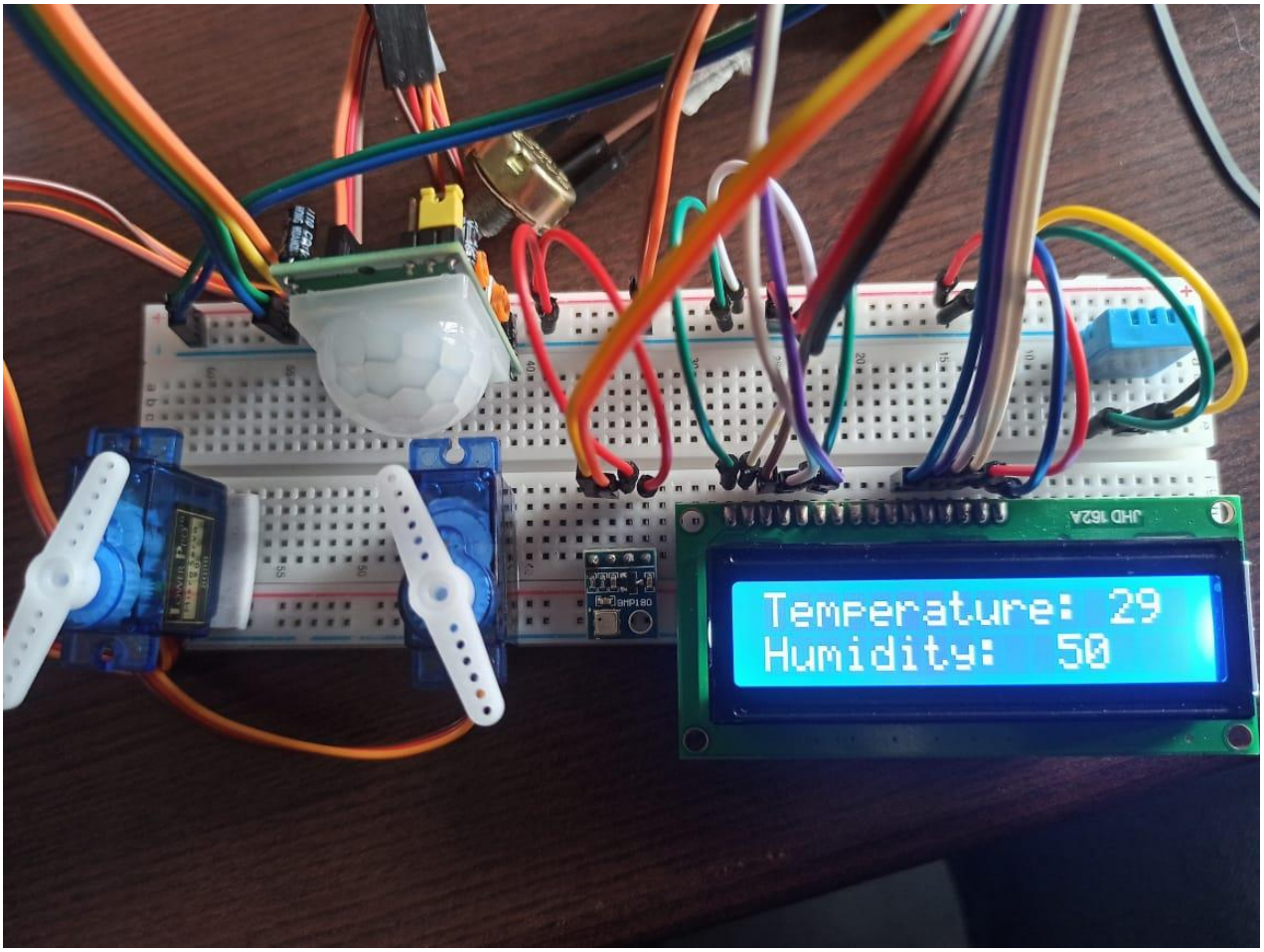

Figure XVI: Complete Hardware System

CONCLUSION

Even though our project is a miniature small scale replica of what can be done, we could use this exact same application at a larger scale and actually solve this extremely prevalent problem in the industry. The future prospects of the project range from publishing the outputs online to sending quick messages to factory workers as an alert. This problem is not only restricted to boiler plants, but any industrial application where there is a need for controlling the amount of input substance into a chamber and monitoring necessary parameters. So on a larger scale the same application could be taken and applied on to several other industrial applications that have similar functionality. By the integration of basic sensors and using them to calculate the parameter values we are reducing the costs, and also by fully rotating the servo motor without a control system application, we are further reducing the complexity and solving this problem in the most straightforward way possible.

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