Design and Development of an Embedded System Based on Wireless Instrumentation Technique to control Environmental Parameters of a Storage Chamber

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Abstract: The main objective is to design a monitoring system for storage atmosphere. Controlled storage atmosphere means constant monitoring of storage environment and adjust accordingly to maintain the atmospheric parameter such as temperature, relative humidity etc. Several actuators are used for controlling the above parameters. The design and implementation of this process has been done using PIC 16F877A microcontroller, Zigbee & LABVIEW software. The project provides details about sensing, data acquisition, and controlling the storage atmosphere accordingly.

Keywords: PIC 16F877A, Zigbee, LabVIEW, Sensor, Actuator etc.

I. INTRODUCTION

The most important factors affecting food items are moisture, temperatures, insects, rodents, storing type of storage bin, uses of pesticides and fumigants general conditions of location of storage etc. More the temperature variation more will be natural convection with in food in bulk, resulting moisture movement with further growth of modules, fungi, insects. Different system exits in monitoring and control of environment parameters of storage. Several control algorithms have been developed and well established in different environmental parameters control. Storage chamber using wired and wireless platforms are in use these days. Wired control systems have some drawbacks as it is having high costs, difficult installations, and copper theft. Wireless communication technology is play vital role in automation and control overcoming the wired communication drawbacks. Rahali et al [1] developed system of a data acquisition and greenhouse control system based on GSM. Nishantkumar D. Gajipara et al [2] developed model of SCADA for real time system with LabVIEW and microcontroller. Hariprabha et al [3] developed model on monitoring and control of food storage depots using wireless sensor networks. P.V. Mane Deshmukh et al [4] proposed model on microcontroller PIC 18F4550 based wireless sensor node to monitor industrial environmental parameters. M.Sudhagar et al [5] had done implementation of WSN based transport information system through Zigbee protocol. Tanmoy Maity et al [6] proposed model on wireless surveillance and safety system for mine workers based on Zigbee. Yubin Zhao et al [7] worked on monitor and control system design of grain depot temperature based on wireless communication technology. Afshan Mulla et al [8] proposed method for GSM based interactive voice response system for wireless load control and monitoring. Ismail Sultan, et al [9] developed a wireless control and monitoring system for wave energy converters. Zigbee based wireless sensor network in water irrigation control monitoring system is developed by Zulhani Rasin et al [10]. This paper focuses on controlling these two parameters in such a way that environmental parameter remain almost constant throughout the storage period. The project Wireless Embedded Instrumentation (WEI) system is designed. It consists of wireless data transfer, embedded control and instrumentation using LabVIEW software. Technology used for data transfer is Zigbee which is best for the particular application among its wireless technologies. The paper is organized in the following way. Detailed methodology along with the development of WEI system is given in Section II. Results are discussed in Section III and finally the paper is concluded in the next section.

II. METHODOLOGY

A Wireless Embedded Instrumentation (WEI) system is designed to monitor and control temperature, relative humidity. Several actuators are used for controlling the above parameters. If the value of temperature or humidity is out of specified range then corresponding actuator will operate. Here, an air-conditioner and a heater are used for controlling the temperature whereas a humidifier and a dehumidifier are used for humidity control. The proposed model, sensor reading are collected with the help of PIC microcontroller’s kit1 and kit2 then will send the values through Zigbee end devices to Zigbee coordinator of main microcontroller kit. The main microcontroller kit will display reading on the graphical LCD and will send the signal to required actuator through relay card and further will send sensor values to the microcontroller kit 3. The microcontroller kit3 will send these values to PC.

WEI system part detail:
There are 6 parts which further consists of 4 microcontroller kit (PIC 16F877A) µC Kit1, µC kit2, µC kit3, Main µC kit and other hardware components.

Part 1: It consists of temperature sensor, sensor card, µC kit1 and Zigbee router/end device.

Part 2: It consists of RH sensor, sensor card, µC kit2 and Zigbee router/end device.

Part 3: It consists of Zigbee coordinator, main µC kit, relay card and LCD.

Part 4: It contains the relays for operating heavy actuator such as heater and AC etc.

Part 5: It consists of µC kit3 and RS 232 card.

Part 6: In this PC with LabVIEW software part is there.

**Block diagram of WEI system:**

![Block diagram of WEI system](image)

**Fig. 1: Block diagram of WEI system**

T - Temperature sensor  
RH - Relative humidity  
SC - Sensor card  
GLCD - Graphical LCD  
ZGB ED1 - Zigbee end device  
ZGB C - Zigbee coordinator  
µC Kit(1,2,3.main) - PIC 16F877A kit  
R(1-4) - Relay

**WEI system flow chart:**
Details of working of WEI system:

**Part 1:** Temperature sensor senses the temperature and gives its output to μC kit1 through sensor card. After receiving that temperature value, μC kit1 send it through Zigbee end device to the Zigbee coordinator which is connected to main μC kit of the part 3.

**Part 2:** Similarly, relative humidity sensor sense the humidity and give its output to μC kit 2 through sensor card and μC kit 2 receive it and then transmit its value to Zigbee coordinator of the main μC kit through its Zigbee end device.

**Part 3:** The Zigbee Coordinator of main μC kit tries to communicate with Zigbee end devices of μKit1 and Kit2 which are discussed in part 1 & part 2. If it does then, it collects sensor values from the Zigbee end devices. The main μC kit compare sensor values with the specified range with upper limit and lower limit set by the programmer. The main μC kit after reading the sensor output tries to maintain the environmental parameter in given range by operating respective actuator which uses following logic. According to this program, there will be two required limits, upper and lower. Sensor output is compared with the upper and lower limit and necessary action is performed. Action may be these:

i. Sensor output greater than upper limit: Actuator A will operate. Here actuator A is device which decreases the physical parameter e.g. AC for temperature.

ii. Sensor output lesser than lower limit: Actuator B will operate. Here actuator B is device which increases the physical parameter e.g. heater for temperature.

iii. Sensor output is in between upper and lower limit: No need to operate any Actuator.

This main μC kit shows the respective values on graphical LCD. Respective operation performed through relay card which is further connected to heavy actuator like heater etc. The main μC kit send these values to μKit 3.

**Part 4:** Relay card is having 4 relay further these relay are included in the circuit of heater, AC, dehumidifier, humidifier to make them work whenever main μC kit give the command. These actuators are controlled by main μC kit.

**Part 5:** μC kit 3 receives data from main μC kit and then μC kit 3 transmits the data to PC in LabVIEW through RS232 card.

**Part 6:** LabVIEW software with the help of VISA protocol receives the data from the μC kit 3 and extracts that data and check that values in the conditional SubVI and further shows its output in the front panel of LabVIEW software. The values are collected with the help of Write to measurement file icon which further gets stored at the user given location and reports can be made. In this way, real time WEI system works.

Set up picture of WEI system:
Fig. 3: WEI system set up picture

Hardware components and Software used:

The temperature sensor and relative humidity sensor are used to measure temperature and humidity in the air. The sensor card is used to interface sensor and microcontroller. PIC 16F877A microcontroller is used as controller. Wireless module Zigbee is used for sending and receiving data for WEI system. Zigbee board comes in two functioning types one as coordinator nodes and other one is router/end device nodes. Heavy actuators such as AC or heater are controlled by microcontroller with the help of relay card. On the Relay card, there are 4 relay. LCD is used to display readings. RS232 card is used to for communication between microcontroller and PC. There are two software used LabVIEW and Flow code. LabVIEW is instrumentation software used for measurement, automation and data analysis. Flow code software can make program for microcontroller and convert the program file in to hex file. Hex file can be further burn in the microcontroller.

III. RESULTS AND DISCUSSIONS

The algorithm has been implemented successfully and output data recorded in different conditions. There are two platforms on which outputs are shown; one is on the LabVIEW front panel and second on the LCD. Operations of respective actuator are shown with LED indication on relay card. On the LCD, the sensed value of temperature and humidity are shown & the actions performed are indicated by following keywords HE ON, AC ON, TR ON, HU ON, DH ON, and HR ON whose meaning are as HE ON - Heater ON HU ON - Humidifier ON AC ON - Air conditioner ON DH ON - Dehumidifier ON TR ON - Temperature is in Range HR ON - Humidity is in Range

On the Relay card, there are 4 relay. These relays are the part of the actuator which further completes the circuit of the heavy actuator (e.g. heater, AC etc.). The status of activated relay is shown by ‘ON’ and ‘OFF’ of respective LED. The sensor value is displayed on LCD and compared with set conditions & accordingly required action is performed. LabVIEW software with the help of VISA protocol receives the data coming from the µC kit 3 and extracts that data and check that values in the conditional SubVI and further shows output on the front panel. The values are collected which further get stored at the user defined location.

Case study 1:

For temperature, Upper limit is taken as 35°C and Lower limit is taken as 25°C. Monitored sensor reading is 20°C. As the reading is less than the Lower limit, hence to increase the temperature, the heater will be switched on. For humidity, Upper & Lower Limits are set as 50%, and 40% respectively. RH (Relative humidity) sensor reading is 46% which is in between upper and lower limit, so front panel shows ‘RH IN RANGE’ on.
Case study 2:

In this Case, for temperature, Upper limit is taken as 30°C and Lower limit is taken as 20°C. Monitored sensor reading is as 32°C. As the reading is greater than the Upper limit, hence to decrease the temperature, the air conditioner will be switched on. For humidity, Upper & Lower Limits are set as 35%, and 25% respectively. RH sensor reading is 45% which is greater than upper limit so dehumidifier actuator will be in operation.
Case Study 3:

In this Case, for temperature, Upper limit is taken as 30°C and Lower limit is taken as 20°C. Monitored sensor reading is as 21°C. As the reading is between the Upper limit and lower limit, hence no actuator need to operate which is indicated by T in Range is on. For humidity, Upper & Lower Limits are set as 35%, and 25% respectively. An RH sensor reading is 45% which is greater than upper limit and so dehumidifier actuator will be operating.

Case study 4:

In this Case, for temperature, Upper limit is taken as 35°C and Lower limit is taken as 25°C. Temp sensor reading is as 29°C. As the reading is between the Upper limit and lower limit, hence no actuator need to operate which is indicated by T in Range is on. For humidity, Upper & Lower Limits are set as 55%, and 45% respectively. RH sensors reading is 42% which is less than lower limit and so humidifier actuator will be operating to increase the humidity.
Fig. 10: Humidifier LabVIEW (Front panel shows TEMPERATURE-29°C, T IN RANGE-ON & RH-42%, and HUMIDIFIER – ON)

Fig. 11: Humidifier LCD (LCD: Temp in Deg C=29°C, TR ON and Humidity value is 42%, HU ON. Relay card: Humidifier Relay –Active.)

Case study 5:

In this Case, for temperature, Upper limit is taken as 30°C and Lower limit is taken as 20°C. Temp sensor reading is as 21°C. As the reading is between the Upper limit and lower limit, hence no actuator need to operate which is indicated by T in Range is on. For humidity, Upper & Lower Limits are set as 35%, and 25% respectively. RH sensor reading is 45% which is greater than upper limit and so dehumidifier actuator will be operating.

Fig. 12: Dehumidifier LabVIEW (Front panel shows TEMPERATURE-21°C, T IN RANGE- ON & RH-45%, DEHUMIDIFIER ON).

Fig. 13: Dehumidifier LCD (LCD: Temp in Deg C =21°C, TR ON and Humidity value is 45%, DH ON. Relay card: Dehumidifier Relay –Active)
Case study 6:

In this Case, for temperature, Upper limit is taken as 35°C and Lower limit is taken as 25°C. Temp sensor reading is as 30°C. As the reading is between the Upper limit and lower limit, hence no actuator need to operate which is indicated by T in Range is on. For humidity, Upper & Lower Limits are set as 50%, and 40% respectively. RH sensor reading is as 46% which is between the Upper limit and lower limit, hence no actuator need to operate which is indicated by RH in Range is on.

**Fig.14: Humidity in Range LabVIEW (Front panel shows TEMPERATURE-30°C, T IN RANGE-ON & RH-46%, RH IN RANGE- ON)**

**Fig.15: Humidity in Range LCD (LCD: Temp in Deg C =30°C, TR ON and Humidity value is 46%, HR ON. Relay card: No relay active)**

**Block diagram of Lab VIEW software:** The data from the µC kit 3 through RS232 card LabVIEW receives with VISA protocol and then further process that data. The Fig.16 shows the VISA protocol with its parameter and then data is processed in the while loop and then VISA read protocol read that data give it to next stage of extracting the data to process. The extracting data in the form of values of temperature and relative humidity are given to a SubVI which further compare the values with the Lower limit and Upper limit set by the user. Respective values and action is displayed on front panel by the actuator indicator LEDs and these values of T and RH values given to write to the measurement file which records these parameters. Fig.17 shows the block diagram of the operation of comparing and recording the data.
IV. CONCLUSION

The Wireless Embedded Instrumentation system has been resulted in a prototype of a small system for monitoring and controlling environmental parameter (e.g. temperature and humidity). Temperature and humidity are monitored and their values send wirelessly from respective Zigbee end devices to Zigbee coordinator which is attached to the main μC kit which further shows these values on LCD and operate relay for respective conditions. The temperature and humidity values send to the LabVIEW software successfully. The system has been tested successfully with different environments to see the system operation. The relative humidity in percentage and temperature in °C were monitored continuously. In future, more number of parameter can be measured in enhancement of the system which can be further analysed. The various gas level controls using various gas sensors can be further included in the system.

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