# Real Time Monitoring and Control of Inventory Storage Conditions for Grains

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#### Abstract

**Objectives**: The aim is to design and monitor the system for better performance, clear structure and scalability. **Methods**: PIC16F877A, ZigBee wireless communication and sensor technology were used in this project. ZigBee is used to transfer data. The collected data is transmitted to user, real-time behaviour and to make perfect decisions. The sensors convert the physical parameters into electrical signals and the input is given to the processor. Then checking of temperature along with humidity values against predefined threshold value is carried out. If the temperature increases the fan is switched ON. Heater is switched ON if the humidity increases. When the values again reach their normal value again the fan and heater are switched OFF. The data are transmitted to the control room using ZigBee architecture. A database is maintained for further reference. For accurate monitoring it is important to know the behavior of each grain under different climatic conditions. A database is made for minimum and maximum storage conditions for grains. Temperature ranges are specified in Celsius and Relative Humidity is specified in gm/cm<sup>3</sup>. **Findings:** Grains can be stored in different atmospheric conditions with real time monitoring. Different conditions such as temperature and humidity are monitored and controlled for various type of grains. This system not only saves the wastage of grains but also reduces human resources to monitor them physically in warehouse.

Keywords: Humidity, PIC16F877A, Temperature, ZigBee

## 1. Introduction

Grain production has been increasing steadily due to advancement in the production technology. But improper infrastructure facilities along with unfavorable conditions of environmental result in losses of food grains in storage<sup>1,2</sup>. Environmental factors that greatly influence the storage of food grains are temperature, moisture content, humidity, as well as light. Food storage loss is due to time, storage purpose, type of storage, preventive insecticide treatments as well as storage practices. Insect pests, mould growth, rodents, rats, fungi, microorganisms results in both qualitative and quantitative losses during storage. The major disadvantage of using large temperature cables in traditional warehouse monitoring systems results in delay of grains. The sacks also get soaked easily during rainy seasons. An integrated system has been proposed to monitor and control the temperature, moisture content as well as the humidity remotely<sup>3.4</sup>. To automate the granary PIC16F877A and ZigBee is used. This helps to improve the duration of storage and reduces labour intensity. The sensors acquire the values from atmospheric conditions, the signals are then converted to digital form using analog to digital convertor. The digital values are processed, compared against threshold limits. A database is maintained for each value processed. It can be communicated to the server in control room using wireless transmission process which improves the flexibility as well as scalability of warehouse management<sup>5</sup>.

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# 2. Existing System

#### 2.1 Grain Aeration

Aeration is done mechanically using fans in order to reduce the commodity temperature in an acceptable practice. For low humidity environment this system is suitable.

### 2.2 Refrigerated Storage

The bulk grains are treated with cooled air to dry as part of insect or pest control instead of untreated air at ambient temperatures. In tropical climates, the refrigerated storage system and dehumidified air method provide better solution to the practicability of aeration for safe commercial storage<sup>6</sup>.

## 3. Proposed System

The Figure 1 exposes the block diagram of the proposed method. It consists of PIC16F877A along with temperature sensor as well as humidity sensors in warehouse. The quality of grain storage is documented in the host computers database server. The terminals are usually incorporated to host computers through high-speed network. The proposed terminals receive and execute commands from clients placed in control room remotely which provide several advantages over accessibility over more traditional solutions. For example, the humidity as well as temperature of the grain can easily be monitored and analyzed remotely. Also the administrators can operate device and allowing for remote configurability of granary temperature and humidity through remote access.



Figure 1. Block diagram.

### 3.1 PIC16F877A

A CMOS FLASH-based 8-bit microcontroller is a PIC16F877A. The specifications of PIC16F877A are EEPROM data memory with 256 bytes, 2 channels of 10-bit Analog-to-Digital converter, comparators of 2, and capture/compare/PWM functions of 2. The configuration of synchronous serial port can be as either 2-wire Inter-Integrated Circuit ( $I^2C^{\infty}$ ) bus or a Universal Asynchronous Receiver Transmitter (USART) or 3-wire Serial Peripheral Interface (SPI<sup> $\infty$ </sup>). These features make it effective for usage in industrial and automotive appliances in addition to consumer applications.

#### 3.1.1 DHT11 Humidity Sensor and Temperature Sensor

To sense the temperature and humidity, the value of measured analog signal DHT11 Temperature and Humidity Sensor shown in Figure 2 (referred from DHT11 Datasheet) is used. Its accurate digital-signalacquisition makes it highly reliable and stable for long term.



Figure 2. DHT11 sensor configuration.

The temperature measurement component is the NTC and humidity measurement component is of resistive type. It connects to a high-performance microcontroller of 8-bit and offering excellent quality, very fast response, anti-interference ability and effectiveness in cost.

#### 3.1.2 ZigBee

For the control, sensor networks are Wireless Personal Area Networks (WPANs) ZigBee communication which is built on IEEE 802.15.4 standard. This standard defines physical as well as Media Access Control (MAC) layers to handle many devices at low-data rates. This operating range is at 868 MHz, 902-928MHz and 2.4 GHz frequencies. The two way transmission of data between sensors along with controllers are made using data rate of  $250 \text{kbps}^{7.8}$ .

## 4. Methodology

The sensors convert the physical parameters into electrical signals and the input is given to the processor. Then checking of temperature along with humidity values against predefined threshold value is carried out. If the temperature increases fan is switched ON. Heater is switched ON if the humidity increases. When the values again reach normal, the fan and heater are switched OFF. The data are transmitted to the control room using ZigBee architecture. A database is maintained for further reference. The flow diagram of the proposed method is shown in Figure 3.



Figure 3. Flow diagram of proposed method.

## 5. Database of Relative Humidity along with Temperature for Various Grains

For accurate monitoring, it is important to know the behavior of each grain<sup>9</sup> under different climatic conditions. Table 1 provides a database of minimum and maximum storage conditions for grains. Temperature ranges are specified in Celsius and Relative Humidity is specified in gm/cm3.The values have been taken from various journal and conference papers as cited in Table 1.

Grain	Temperature	Relative humidity % (gm/ cm3)	Reference
Rice	22-32	50-75	In <sup>9</sup>
Wheat	15-37	20-45	In <sup>10</sup>
Maize	5-30	18-30	In <sup>8</sup>
Turmeric	26-32	12-18	In <sup>11</sup>
Groundnut (Unshelled)	7-35	65-80	In <sup>12</sup>
Finger Millet (Ragi)	18-27	15-20	In <sup><u>13</u></sup>
Kambu (Pearl Millet)	20-40	58-75	In <sup><u>14</u></sup>
Lentil (Thuvaramparupu)	5-25	12-21	In <sup>15</sup>
Soya Bean	20-35	10-15	In <sup>15</sup>
Sesame	25-30	55-65	In <sup>11</sup>
Brown Beans	5-25	11-23	In <sup>15</sup>

# Table 1. Temperature along with relative humidity of various grains

## 6. Software Simulation

The simulation set up of interfacing of PIC microcontroller along with temperature as well as humidity sensor is shown in Figure 4. The components are PIC16F877A, LCD (16X4), temperature, humidity sensor, motors for fan and heater load and buzzer.

# 7. Complete Hardware Setup

The complete hardware setup is designed using temperature and humidity sensors as shown in Figure 5 that uses, PIC16F877A microcontroller with motors for fan and heater load. The output is indicated in LCD display. ZigBee is used to transmit data from microcontroller to the remote server. The sensors send values to the microcontroller which is processed. If the value exceeds



Figure 4. Software simulation of grain storage.

the threshold limits either the fan or heater will be turned ON. When the conditions become normal again, the fan and heater are turned OFF. This is repeated and the values are stored in the remote server as database. The temperature as well as humidity value of maize in terms of Celsius and mm/cm3 was displayed in the Figure 6. The temperature and humidity value of Lentil was denoted in the Figure 6. Here the temperature value has exceeded the normal level. So the fan will be turned on automatically.



Figure 5. Complete hardware setup.

## 8. Conclusion

ZigBee is used to transfer data and collected data is transmitted to user, real-time behaviour and to make perfect decisions. The system saves the energy consumption and also reduces the labor intensity and material resources. Without complicated connections apply embedded technology and ZigBee wireless transceiver technology to the food storage.



Figure 6. LCD displays the temperature as well as humidity value of lentil.

## 9. Future Scope

This study deals with the disadvantages of traditional approach of grain storage and also the improvement by providing flexibility, reliability to access status grain data where controlling action minimizes grain wastage along with grain loss. Grains can be stored in different atmospheric conditions with real time monitoring. The total cost for the system is less and accurate measurement of various parameters is done. Under different conditions, temperature as well as humidity conditions are monitored for various types of grains and controlled. This system not only saves the wastage of grains but also reduces human resources to monitor them physically in warehouse.

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