Intelligent System for Monitoring and Controlling Grain Condition Based on ARM 7 Processor

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Abstract— **Agriculture is the backbone of any nation's economy and there is a dependency between agricultural growth and economic prosperity. As India is an Agriculture country where 70% of the population depends on farming, the storage of grains plays a crucial role in national economy. Due to the seasonality of grain production, the storage of grain is the top priority task for restoring and reusing. In the process of grain storage, temperature, humidity and carbon dioxide concentration (CO_2) are major ecological factors that can influence directly on the quality of the Grain. Hence, there is a necessity to monitor the vital parameters continuously during storage and communicate the status to the manger in real time which becomes a challenging. The traditional methods are limited to simple manual temperature and humidity testing which are relatively backward since grain situation analysis are made without any effective means of processing and regulation hence there is a need for smart grain management system with automation which can also avoid hidden security risks. The Real-time monitoring of the grain storage system is designed based on ARM7 and using GSM/GPRS module as lower level Control unit which improves the level of grains storage and reduce the grain losses during storage procedure and also reduce man power and labour intensity. The Experimental results shows that grain condition intelligent monitoring system designed in this paper has several good features such as realtime online detection, easy acquisition and good site stability.**

***Keywords*— ARM7 development board; Temperature sensor; Humidity sensor; CO_2 sensor; Wireless Sensor Networks; NeoWay GPRS modem; Buzzer;**

I. INTRODUCTION

In many countries Grains are the main source of food and many staple food products are prepared from them, so every human life depend on Grains food products for survival in one or the other way. Hence cultivation and storage of grains plays a crucial role in national economy and overall development of the society. Economies of developed and developing nations depend directly or indirectly on storage of cultivated grains since they are related to the several hundreds of millions of people. The aim of grain storage facility is mainly to provide safe storage condition and to maintain quality of stored product. Grain loss occurs by adverse environmental conditions and from the activities of insects and micro-organisms. Temperature and moisture content of the stored grain environment are the most important factors that can influence stored-product mold growth, insect activity and subsequent production of mycotoxins in storage facility. Maintaining optimum temperature, relative humidity and proper moisture content in the storage facility are the challenges faced in Grain acquisition. Seasonal and daily climate fluctuations influence quality of Grain to the greater extent results in mold growth, insect activities. The optimum temperature range for mold growth inside the depot is around 25-30°C, and temperatures above 15°C (Celsius) are ideal for insect growth and reproduction. Insect metabolic activity in dry commodities below 15% moisture content can result in heating up to 42°C (Mills 1989). A major contributor to the spoilage of grain is growth of variety of mold species, including several that produce mycotoxins. Mycotoxins are natural chemicals produced by fungi that are detrimental to the health of grain. These activities release CO_2 in Grain depot so CO_2 concentration can be effectively used to monitor early detection of spoilage during storage.

Now we are still using our old methods to store various cultivated crops, traditional methods of grain condition monitoring and controlling is limited to simple manual temperature and humidity testing and grain situation analysis without any effective means of processing and regulation. Usually these are carried out by means of ventilation, drying and circulative fumigation which are relatively backward and results in wastage a lot of manpower and resources hence it not only brings great inconvenience to the grain storage management but also hidden security risks. The advancement in technology allows us to develop real-time monitoring system of remote locations, which makes it easier to control and monitor conditions from any place at any time. The Real-time monitoring of the grain storage system is designed based on ARM7, which helps us to improve the level of grains storage and reduce the grain losses during storage procedure and also reduce man power and labour intensity. The objective is to design a granary monitoring system by combining Embedded and IoT technology. The GPRS modems are used to complete acquisition and transmission of environment parameters over the network to achieve the system's remote control and using ARM7 to achieve precise control of the Granary environment as system data controller.

It greatly improves the flexibility and scalability of the warehouse management which sends available data to grain depot manager and each and every minute condition of grain will be monitored.

II. RELATED WORK

The Design of Granary Environmental Monitoring and Control System Based on ARM Controller and ZIGBEE: An application developed in the monitoring system incorporates a host PC, information administration and remote monitoring system based on Lab Windows and ZigBee sensor system. Sensor system outlined considering temperature, humidity and Light are principle variables impacting condition of the Grain. ZigBee WSN's[2] has some significance in complex systems such as it offers low-power operation, robustness and high security and scalability. The author likewise depicts framework of the design [4], hardware and software components, this paper additionally covers performance of the transmission separation of ZigBee remote hub in grain and the hub lifetime estimation. The system contains various observations regarding to environment such as temperature, humidity and moisture along with other factors can be of importance. A normal way to compute these factors in storage environment meant individuals manually taking dimensions and inspecting them at different times.

III. GRAIN SYSTEM DESCRIPTION AND WORKING PRINCIPLE

The general model proposed for grain storage framework comprised of two parts, one is the host PC which assembles Grain environment ie Sensor data, it procedure and forecast of grain circumstance, the other one lower level control terminal in the silo/depot with grain information obtaining. The principle reason for the framework is to get information from various sensors and transmits these informations over Wireless Network.

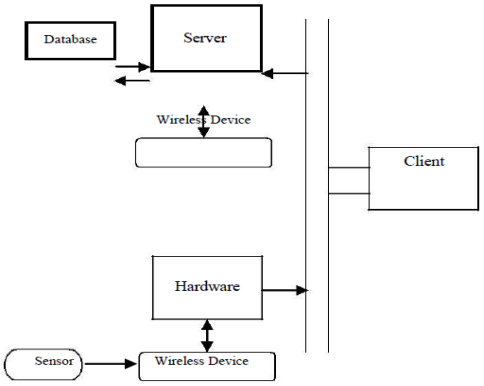

Fig 1: Overview of Grain System

The sensors collect the information from environment, the collected signals through the analog to digital conversions. These conversions are sent to micro controller unit. This micro controller unit is connected to LCD to display the values of temperature, humidity and CO_2 values and using GSM/GPRS to achieve the system's remote control. It greatly improves the flexibility and scalability of the warehouse management which sends available data to grain depot manager (Database management) in time and filters invalid data on the spot.

The architecture of proposed grain monitoring system is consisting of Hardware as well as Software components.

The hardware part include sensors, controller and GPRS module are connected properly inside remote grain acquisition depots and controlling action can be performed using software application running on host PC which is situated in administrator room. Three environmental monitoring sensors are used they are HSM20G humidity sensor, LM35 temperature sensor and MQ9 series CO_2 concentration detector Sensor. These three monitoring sensors are connected to ARM-7 LPC2148 series micro-controller. These sensors are analog in nature they sense signals and produces output voltage proportional to corresponding signal measured. The output voltage is processes using controller and data acquisition model. The signals are amplified if signals are week and digitized using Analog to Digital converters. It Acquire the real time data from granary process the signal and then given to the ARM controller in digital form.

The software part contains an application running on host PC computer monitoring above parameters, placed inside the monitoring room. The database is created to store the measured valves in the cloud. The ARM7 controller sends the data received and processed from granary environment over the above model to host computer using GSM/GPRS module. The collection of Real-time data samples from different sensor and transmit it over the GSM/GPRS module is the main objective.

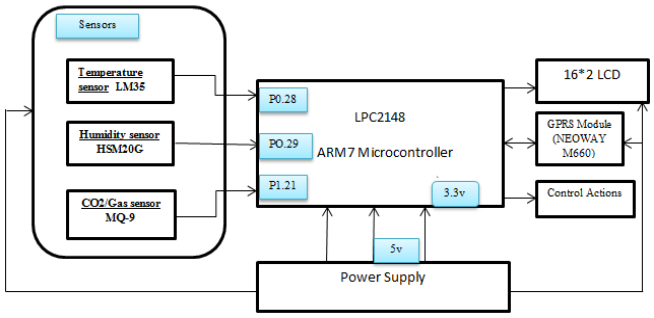

Fig 2: Grain Monitoring System Architecture

A) ARM7 LPC2148 TDMI

The ARM7 LPC2148 microcontroller series development boards are widely used now adays and they are easily available in the market. LPC2148 series controllers are based on either 16bit or 32bit ARM7TDMI (16bit Thumb

instructions + JTAG Debugging unit + very fast Multipliers + built in enhanced ICE) having simple central processing unit. They are inbuilt with embedded real time emulation/debugging and tracing supports. LPC2148 series having flash memory ranges from 32kb to 512kB operating at high speed. A unique architecture of these series controllers enables execution of 32bit code at max clock speed using distinctive accelerators and 128bit wide memory space.

The development boards of these series controller are small and consume less power compared to other series controllers which makes it ideal for some applications where miniaturisation is the main constraint. The serial communication interfaces ranges from full speed USB-device, multiple UART's, SSP, SPI interfaces to I^2C buses and 8 kB-40 kB onchip static RAM. The LPC2148 series controllers are well suited for industrial control applications and in the medical fields since it has dual 10bit analog to digital converters, 10bit digital to analog converters, various 32bit timer, Pulse Width Modulation channels and fast 45 General Purpose IO pins with upto 9 level triggered or edge triggered very sensitive external interrupts ports.

B) Sensors

1) Temperature sensor

Temperature sensors LM35 is chosen since LM35 provides reliable accurate surrounding temperature directly in °C according output voltage. These sensors are analog in nature which senses surrounding temperature produces output voltage in mV proportional to surrounding temperature, so it is easy to take accurate readings by connecting to development boards. It can measure temperature ranges from -55°C to 150 °C.

2) *Humidity sensor*

HSM20G humidity sensor modules are chosen and they are configured with IC's circuitry to provide onchip signal conditioning. Absorption-based humidity sensors provide both Relative Humidity(%RH) and temperature outputs. Onchip signal processing ensures Relative Humidity output versus linear voltage. The Sensor laser trimming offering +5%RHaccuracy and attains 2%RH accuracy with calibration. Packages are chemical resistant and operating in range of -40 °C to 85 °C [-40°F to 185°F] to accommodate erratic environment.

3) *CO_2 concentration sensor or Gas sensor*

MQ series gas sensors are used to detect the CO_2 concentration level. These are Electrochemical in nature having gas detector that can measures the concentration of a targeted gas by oxidization or reduction of the targeted gas at an electrode and measuring the resulting current. Gas detectors are used widely in industrial applications to detect gas level in air. The gas sensor is designed in such a way that it detects the gas level if it exceeds the limits specified. The various gas sensor modules are used now a days to detect different types of gases on such MQ-series gas sensor detects the presence Propane (LPG), Carbon Dioxide (CO_2), Methane (CH4).

C) GSM/GPRS Module

This GSM/GPRS Modem NeoWay M660 are simple to interface serial interface. It features with voice, SMS, and Data services. GPRS data related operations can be controlled with the help of ATtension commands from the PC and also from controllers. This module contains the highly popular SIM300 module inside it which holds sim card meant for all its data, voice related operations. This module come with familiar widely used standard RS232 interface, so these modules can be easily interfaced to PC and controllers.

IV. IMPLEMENTATION

Implementation part of grain system includes Hardware implementation and software realization. Each implementation part is described in the lower section.

A. Firmware Implementation and Flowchart

The program source code is written in such a way that operations of the development board can be controlled. The PCB circuit design for the hardware used in the present work is done using Orcad design software. The software development kit Keil IDE µv3 supports ARM family controllers, with the help of this tool source code is written in C language and compiled to generate hex file. The hex code generated by the compiler is burned into ARM7 development board using flash magic programmer. Flowchart for transmitting and receiving station grain monitoring system model is shown below.

1) Flowchart

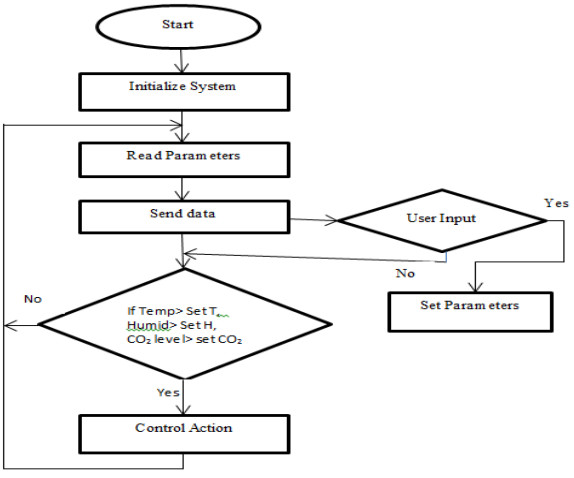

Fig 3: Flowchart for Transmitting section of Grain storage system

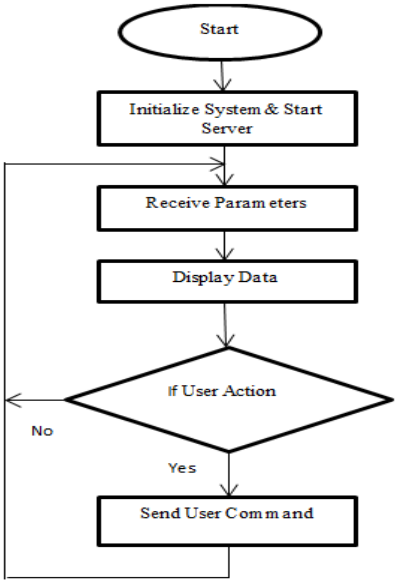

Fig 4: Flowchart for Receiving station of Grain storage system

2) Algorithm:

Step 1: Start the Data base management Server which Synchronize the connections between Remote Grain depot and Host computer.

Step 2: Temperature sensor, Humidity sensor and CO_2 sensor are connected to the Controller and they are continuously sensing the environment around the grain.

Step 3: The Sensors collect the information from environment, the collected signals through the analog to digital conversions since the signals sensed are analog in nature. Sensors also send the trigger pulse to corresponding pins of LPC2148.

Step 4: LPC2148 sends a trigger pulse to display it on LCD connected to it.

Step 5: LPC2148 sends the AT commands to GSM/GPRS module to communicate with Host computer connected to it through wireless GSM/GPRS network.

Step 6: IF any smoke/Gas detected OR Temperature goes beyond threshold OR humidity goes beyond threshold or CO_2 concentration goes beyond Threshold activates controller to take control actions.

Step 7: LPC2148 sends the AT commands to GSM/GPRS module to send alert message.

Step 8: LPC2148 sends a pulse to activate buzzer.

Step 9: Embedded Application developed in the administrator PC Stores parameter valves in the cloud and display graph for the period of monitoring which helps to take necessary action in Future.

Step 10: Stop the Server whenever monitoring is not required and collect the reports in the Dropbox.

3) Developing Client Application with the .NET Framework and MS chart

There are multiple ways to develop Windows-based applications with the .NET framework that run locally on users' computers or devices. Here in the context of our design an embedded application is created using .NET Framework and MS chart for the Grain system to monitor Grain acquisition parameters and to store these valves for future reference. The application shown in below Figure Displays Real-Time monitored parameters.MS chart Build graph based on the parameter valves received through Wireless Sensor Network (WSN). Making use of dropbox to store these valves on the cloud which helps to keep received Temperature, Humidity and CO_2 valves for future reference.

B) Hardware Implementation

Hardware implementation dealing with according to the application drawing the schematic on the plane paper, schematic of the design is tested over the breadboard using the many ICs to check whether the design meeting the objectives.Carrying out the Printed Circuit Board layout of the schematic tested on breadboard, lastly prepared the board and testing the hardware designed.

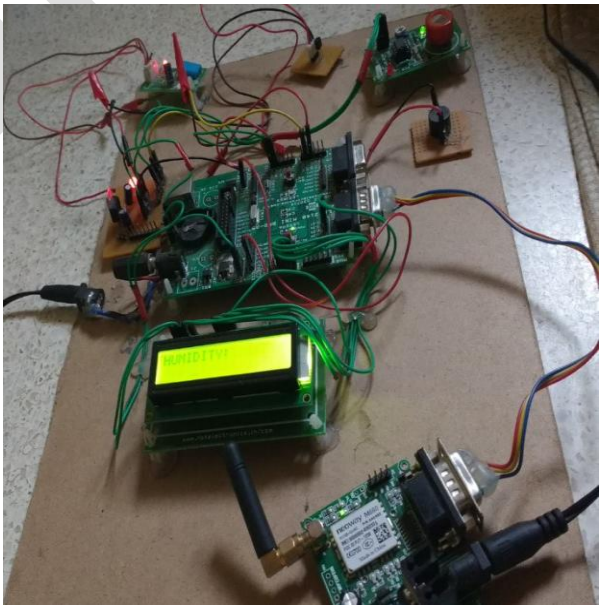

Fig 5: Grain monitoring System design Hardware

V. RESULT AND DISCUSSIONS

Grain monitoring system is designed and implementation is done on LPC2148 ARM7 development board R-4. The communication between controller and WSN's

is accurately done to avoid any interference in the design. The grain system design is done to meet all the requirement and specification as mentioned in the objective. An embedded application is created using .NET framework and MS chart for the Grain system to monitor Grain acquisition parameters and to store these valves for future reference.

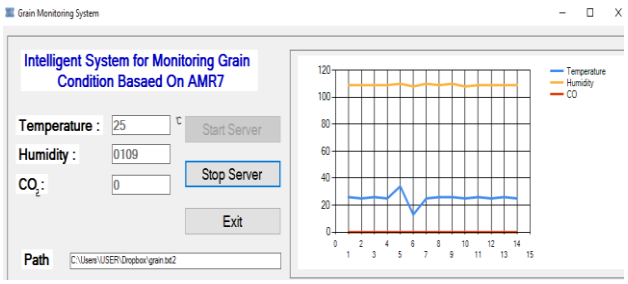

Fig 6: Client application output for Grain monitoring system

The good quality grain sample is monitored over a period of time. During the course of monitoring each sampled valves of parameters are collected. By using these valves grain quality can be predicted. The predicted results of the grain monitoring model proposed are shown in table below.

Table 1 shows result of predicted Temperature, Humidity, Gas valves of grain monitoring System

TABLE1

Temperature (Celsius)	23	>35	40
Relative Humidity (%)	45	60	72
CO_2 Concentration(1000ppm)	<50 (Less than 50)	>110	> 130
STATUS	SECURE	CRITICAL	DANGER

VI. CONCLUSION

In this Project advanced intelligent system is designed for monitoring and controlling of the Grain condition in large depots and implementation is done through ARM7 system and GPRS wireless communication module and sensor technology which provides good performance, clear structure and good scalability. The communication between controller and WSN's is accurately done to avoid any interference in the design. The grain system design is done to meet all the requirement and specification as mentioned in the objective. It is shown from the design implemented in the current work provides flexibility, scalability, portability and security/integrity of the data transmission over long networks with lower power consumption.

In this design GPRS network is used to transferring data, it can guarantee the data collected transmitted to user, real-time at environmental timely and make right decisions. The system not only save the consumption of power but also reduce the labour intensity and material resources. The WSN's wireless sensor network technology and embedded technology are applied to the rapid deployment system of event detecting emergency of granary storage in a complex system. It enhances the system flexibility, small size, low cost and good effective to use.

There are certain aspects in this work that can be investigated in future, such as Environmental factors influencing the Grain quality, we are considered only major factors Temperature, Humidity and CO_2 concentration for early detection of deterioration of Grain and Good Control actions like Reducing Temperature in the Grain depot if Temperature is High ie keeping parameters at nominal level by an Automatic system irrespective of condition.

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