Programmable Low Cost Embedded Controller for Controlled Atmosphere Storage Applications

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1. **Abstract**- Indian agricultural scientists have immensely contributed to innovation in agriculture in the disciplines of nutrition, breeding, genetic engineering, disease control, weed and pest eradication. This has made India self-sufficient in food grain production. The population of India has touched one billion and the need of hour is more food grain production. This can be achieved by introducing state of the art electronic technologies in agriculture production and processing. It is an universal fact, that losses are one of the main contributor for depleting the yield of any process. Agriculture is not an exception. The loss starts from harvesting, storage, distribution and consumption. Among these, losses during storage of food grains amounts to 10%. In India, the losses without storage amounts to some thousands of Crores/year. Food storage also serves to protect against such occurrences such as food shortages, natural disasters, unemployment, strikes, civil unrest, breakdown of food production and distribution etc. .During the last few decades, there has been an explosive growth in the market for the fresh fruit and vegetable products with prolonged shelf life. The main driving force for this market growth is the increasing consumer demand for fresh, healthy, convenient and additive fresh product items. However, fresh prepared produce items are highly perishable and prone to the major spoilage mechanisms of enzymatic disclosation, moisture loss and microbial growth. In order to meet these challenges, Government of India Planning Commission has funded CSIR to develop appropriate technologies for food storage. Under this funding CEERI, Pilani (India) developed an Industrial Personal Computer (PC) based control system for controlling the process operations of Controlled atmosphere storage (CAS) house and it was sucessefully tested at CSIO Chandigarh. This is a multi-Institutional project involving CSIO Chandigarh, CFTRI Mysore and CEERI Pilani. Main objective of the project was to increase the shelf-life of the fruits under store and maintaining the quality. Initial aim was to quickly develop the system in-order to prove and demonstrate the controlled atmosphere technology to users. Now, the participating Institutions are concentrating on cost reduction of the system. The advantages of the embedded system are well documented. CEERI has taken up the task of developing an embedded controller as a replacement to the present PC based controller. The present paper dwells initially on the features of the PC based controller and then on the salient features of the embedded controller. The Embedded system uses powerful RISC processor PIC18F452. The system utilizes four programmable keys for configuring the system. Mass storage is achieved by interfacing Multi-Media Card by implementing FAT16.

I. PC Based Controller for CAS system

Basically the whole system Fig1.(block diagram of PC Based CAS System) consists of a Controlled Atmosphere (CA) chamber along with refrigeration unit and humidifier, CO2 scrubber for absorbing excess CO2, Ethylene scrubber for absorbing excess Ethylene, Nitrogen generator for maintaining Oxygen, Sampling chamber for sensing various gas parameters, manual controller for manual control and a centralized controller along with solenoid Valve panel. Fig.2 shows the CA chamber along with centralized controller and manual controller.Fig3. shows the Auto/Manual controller Fig.4 shows the sensing chamber where-in the sensors of Oxygen, Carbon dioxide and Ethylene are fitted on the sensing chamber. Air from CA chamber will be pumped in by means of a suction pump and after passing through the sensing chamber reenters the CA chamber. Fig.5 shows the solenoid valve panel. An individual valve serves each Gas and each valve can receive commands from manual controller as well as central controller. Valve on/off position is indicated by a bright LED.

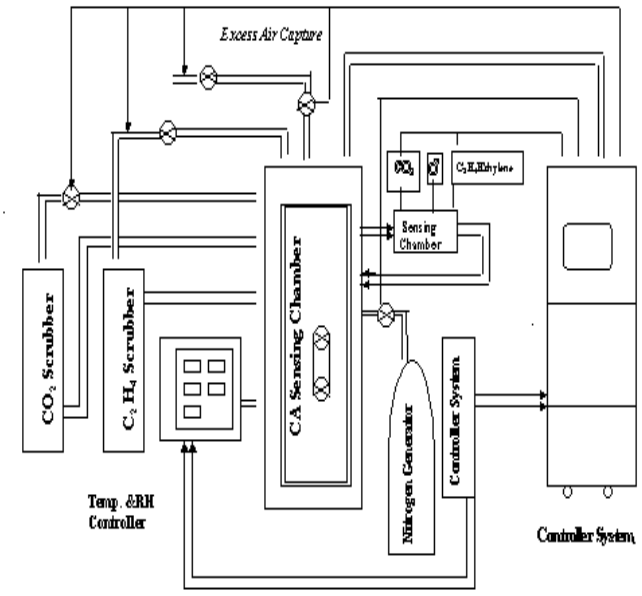


Fig1 : PC Based CAS System

Fig.2 CA chamber along with Centralized Controller and manual controller

Fig.3 Auto/Manual Controller

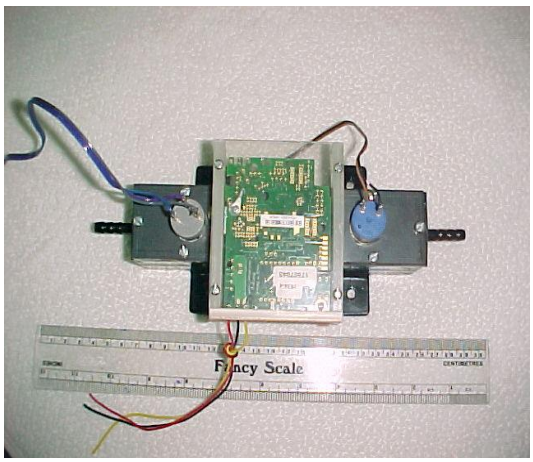


Fig.4 Sensing Chamber

Fig.5 Solenoid valve panel

The whole application software is developed using virtual instrumentation concepts. The development platform used is LabVIEW. Stand – alone traditional instruments such as oscilloscopes and waveform generators are very powerful, expensive, and designed to perform one or more specific tasks defined by the vendor. Virtual instruments, by virtue of being PC-based, inherently take advantage of the benefits from the latest technology incorporated into off-the-shelf PCs. Virtual Instrument/system is more flexible. A traditional instrument might contain an integrated circuit to perform a particular set of data processing functions; in a virtual instrument, these functions would be performed by software running on the PC processor. One can extend the set of functions easily, limited only by the power of the software used. By employing virtual instrumentation solutions, you can lower capital costs, system development costs, and system maintenance costs, while improving time to market and the quality of your own products.

Basically the application software consists of: -

- Data Acquisition
- Data Storage
- Parameter Display
- Process MIMIC Diagram
- Trend Graphing
- User Graphical Interface
- Control
- Networking

II. *MICROCONTROLLER (PIC 18F452) BASED CONTROLLED ATMOSPHERE STORAGE SYSTEM FOR MONITORING, RECORDING AND CONTROLLING OF PARAMETERS.*

An embedded system having the most of the features of a PC-based CAS controller was developed and tested. It has all the functions except that of mimic diagram. The whole system was realized around PIC 18F452. The aim of the development was to reduce cost, size and improve ruggedness. The cost and size benefits are found to be extremely useful in commercializing the developed technology**.** Fig.6 shows the block diagram of the embedded system developed for controlling the CAS. The operator's interface is realized through four programmable keys and two-line LCD display. Mass storage is realized by MMC card.

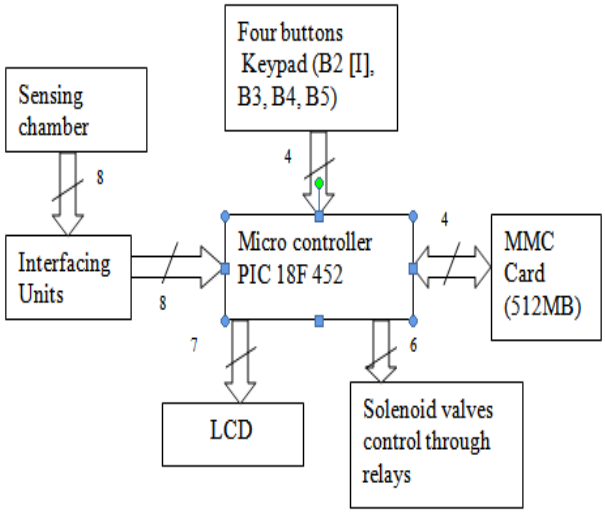


Figure 6: Block diagram of PIC based Embedded Controller for CAS system

III. *Salient features of the embedded system*

A. Four-button keypad interface

These four buttons are marked as a B0, B1, B2 and B3. B0 is external interrupt key, which is used for entering into keypad ISR. In ISR, initially B0, B1 and B2 are configured as Function, Enter and Quit key.

- Function key is used to display different functions, they are :

  I. **Set point values for all parameters:** To enter set Higher limit of all set points:

  II. **Scan rate (in minutes) Tolerance:** User has to provide tolerance for all set points. Range of tolerance is from 1 to 5.

  III. **Date and Time:** At starting point user has to provide date and time, than it will be automatically updated in software.

- Quit key is used to quit from ISR

- Enter Key is used to activate the function which is currently displayed on LCD. In function mode the Keys B0, B1, B2 and B3 are reconfigured as Increment, Decrement, Forward and Quit key.

B. Multimedia Card (MMC)

Multi Media Card (MMC) is a universal low-cost data storage and communication media. The MMC is very small, removable flash storage devices, designed specifically for storage applications that put a premium on small form factor, low-power and low-cost. The MMC card and microcontroller interface is given in the fig.7.

MMC card is interfaced in two modes

- MMC mode
- SPI mode

In the present system MMC card is operated in SPI mode . SPI mode has two advantages. First it requires only 4 I/O pins and secondly it reduces software overheads. Whole FLASH memory of card is distributed in terms of sectors of 512 bytes size, similar to IDE drives. Instructions for MMC card are of 6 bytes, which contain 4-byte sector address.

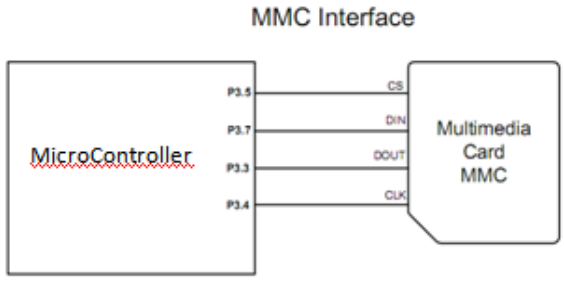


Figure7 : MMC Card Interface with Microcontroller

MMC card was formed with a primary mission of promoting worldwide adoption of storage media devices designed especially for mobile phones and digital imaging devices. Over the time this focus has shifted to a common architecture for embedded system developments.

C. FAT 16 Implementation on MMC card

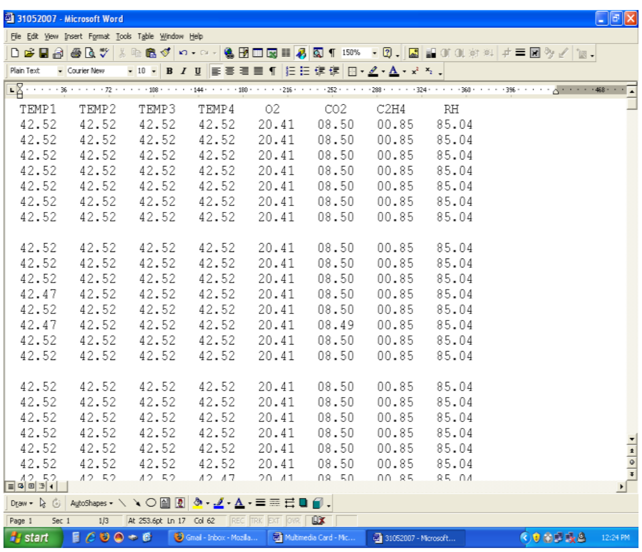
For storing sensor data, it is necessary to implement file system on MMC card. So that, data of each day, stored in a file, name of file is present date (for ex. - 25062007.txt) and will be readable on PC through card reader. Here FAT 16 file system is implemented on card through PIC micro controller in SPI mode. Before using card in system, it is mandatory to format the card by FAT 16 through window OS. By reading sector 0 of a card we get address of all sectors, which required for

creation of file on card. By reading MBR (i.e. Master Boot Record), we received the following information –

1. Bytes per sector - 512
2. Sectors per cluster - 16
3. Number of reserve sectors - 08
4. Root Directory entries - 512
5. Sectors per FAT - 248

IV. *RESULTS*

The developed Embedded system has lead to a cost-effective controller (to the tune of 10:1). The system is rugged and compact, and it can be mounted directly on the CA Chamber. Following figure (fig.8) shows the output file created with the developed embedded controller system.



TEMP1	TEMP2	TEMP3	TEMP4	O2	CO2	C2H4	RH
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.47	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.47	42.52	42.52	42.52	20.41	08.49	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.52	20.41	08.50	00.85	85.04
42.52	42.52	42.52	42.47	20.41	08.50	00.85	85.04

Figure : File created through PIC micro controller

References

[1]. K.S.N. Rao, S. Sadistap., Santosh Kumar, K.K. Pandey, Bharat Singh, Ravi Chaudhary, M.P. Kaushik, 2006. Technology Development and Demonstration of Controlled Atmosphere Storage System for Indian Scenario. Sustainability of Agri-Food Chain Conference, Spain.

[2]. K.S.N. Rao, 2006. Design of Electronic Systems for Agro Based Industry A practical approach. Proceedings of Workshop on Design of Bio-Sensors for Agro based Industry CFTRI, Mysore.

[3]. B. Singh, R.S. Shekhawat, K.S.N. Rao, 2005. Wireless sensing and monitoring of data for controlled atmosphere storage house. Proceedings of National Conference on Industrial Automation Emerging Trends, Chennai.

[4]. K.S.N. Rao, S. Sadistap, Sai Krishna, Santosh Kumar, 2005. Virtual System for Concurrent Monitoring and Control of Multiple Controlled Atmosphere Chambers. NSC – 2005, IIT Bombay.

[5]. FAT 32 File System Specification, Version 1.03, December 6, 2000 Microsoft Corporation.

[6]. Microchip PIC 18FXX2, Data Sheet.