REMOTELY ACCESSIBLE PCBASED DAQ SYSTEMS

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ABSTRACT

PC-based data acquisition (DAQ) systems are irreplaceable in terms of capacity and flexibility for data processing. Data acquisition systems serving IoT are a recent development trend. It is necessary to develop a remotely accessible PC-based DAQ system. In this paper, we present a PC-based DAQ system that can be accessed remotely via the internet. The system consists of several sensors connected to a microcontroller. A two-sided application is developed to set up data access, namely, a local application on the DAQ PC and a web-based application in Google Drive (GD) that can interact with applications on the PC.

1. INTRODUCTION

In instrumentation and control, the need for data acquisition (DAQ) is continuously increasing. The data obtained from a microcontroller is sent to a PC as the main data processor to increase the capability of an existing system. In the need for remote data access has become important in the presentation of data, both for acquisition and for managing results by the control system when system management must be carried out remotely. One should address how a local PC-based DAQ system can be accessed remotely.

The first DAQ systems were bulky and expensive, and required significant programming and setup expertise. National Instruments Corp. (NI) with their product devices (GPIB DAQ cards, DAQ boards, and Lab VIEW) first offered such a service. MATLAB offered its Data Acquisition Toolbox with featured apps, which was the first solution to this problem.

A low-cost, small, and lightweight DAQ system can be created using microcontrollers or a mini-PC. A low-cost DAQ system was developed for effective fault diagnosis in fused deposition modeling (FDM)-based 3D printing products. An Arduino microcontroller is used to collect real-time multi sensor signals using vibration, current, and sound sensors. Osinowo developed a weather monitoring system based on Arduino Mega 2560. For data analysis, the data is stored in Excel format and can be copied directly from an additional micro SD card. An ac field measurement DAQ system uses a programmable logic device field-programmable gate array (FPGA) and an A/D converter, and realizes serial data communication using PC-developed software based on the Java+ MySQL database platform. This system improves DAQ and processing efficiency. Research results have been of great significance for the detection and evaluation of surface defects.

A PC-based DAQ system is one of the main elements in the data retrieval and recording process. A PC has a very important role in supporting complex analyses such as that based on genetic algorithms to ensure high accuracy. DAQ solutions and the escalating demand for DAQ systems across the food and beverage sector to improve product quality have created a positive outlook for the market.

The involvement of IoT leads to flexibility and low costs. Owing to the high demand for and constant development of information and communication technology, there is a need to build improved low-cost sensor systems that rely on new concepts such as IoT or Web of Things

(WoT).

The essence of the remote access DAQ system is the implementation of Web-accessible software built a DAQ system by implementing a Web access application to facilitate users through the internet. A versatile and configurable DAQ system for measuring engine parameters, which used instrumentation software package integration, Lab VIEW, and the MySQL relational database, was presented by He and Xia. This system is supported by database engineering, the internet, a real-time operating system, a network communication module, a DAQ module, a graphical monitoring module, and a data management module integrated into the system.

2. Design approach of the DAQ system

A simplified functional diagram of the DAQ system is shown below in **Fig.2.1**. Here, a local web server PC directly acquires digitized sensor data from a DAQ circuit with a web application.

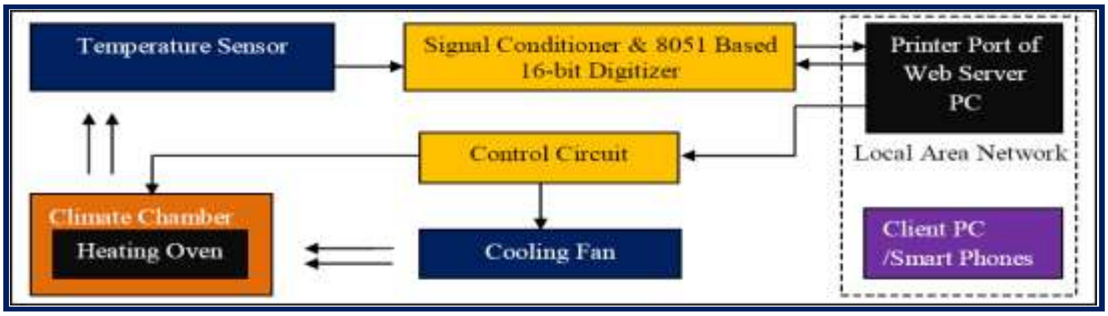

Fig.2.1: Functional block diagram of the DAQ system for temperature monitoring and control

The web application runs as a website of a server PC in LAN. The web application allows authenticated user to perform monitoring and control of temperature of a climate chamber via LAN. The DAQ system has been designed and implemented in the following ways:

a. A climate chamber is designed and its internal temperature is controlled by a heating oven, which is kept inside the chamber. A commercially available thermistor is used as transducer for detecting temperature variation of climate chamber from room temperature to 70°C.

b. The thermistor acts as temperature sensitive element in the feedback network of an electronic oscillator circuit to convert temperature variation into frequencies. The oscillator circuit is designed with a commercially available Schmitt trigger chip.

c. A commercially available cooling fan is used to cool down the climate chamber quickly. The cooling fan is driven by designing a control circuit.

d. A new16-bit digitizer circuit is designed and fabricated with an 8-bit chip to convert the output frequencies of the oscillator circuit into digital codes. This circuit acts as FDC). The FDC and temperature control circuits are interfaced to printer portof a PC that acts as a local web server PC in LAN.

e. A web application has been developed in ASP.NET AJAX technology to communicate with DAQ circuit. The web application runs as website in the webserver is configured so as to make it accessible from a remote client PCs in the LAN.

3. Hardware modules

i. Climate chamber:

A climate chamber is fabricated by using metallic enclosure. **Fig.3.1.1**. shows the snapshot of the climate chamber. A commercially available heating oven, which is normally used for vaporizing mosquito repelling liquid, is kept inside the chamber to raise temperature of the chamber up to 75˚C. Besides, a DC cooling fan rated 12V/50mA is attached to the chamber.

Fig3.1.1: Climate chamber of (20 cm × 20 cm ×10 cm) designed with metallic enclosure.

ii. Temperature sensor:

Different types of sensors such as thermistor, pyrometer, thermocouple, etc. are used for sensing temperature. In recent times, temperature sensor based on optical fiber and nano composite materials have been reported. But, in the present work, a commercially available thermistor having negative temperature coefficient is used for sensing temperature of the climate chamber. A shunting resistor RP is connected in parallel to RTH to reduce non-linearity of the thermistor, as in. The thermistor and a standard temperature sensor LM35DZ are introduced inside the climate chamber for sensing variation of temperature. However, the shunting resistor is kept in the outside of the climate chamber.

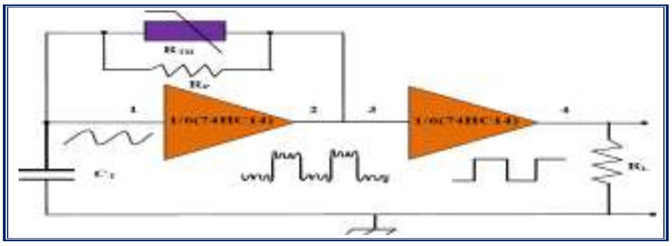

Fig.3.2.1: Oscillator circuit for converting resistance variation into frequencies.

iii. Sensor electronics and signal conditioner circuit:

The sensor electronics and signal conditioner of the DAQ system comprises of a Schmitt trigger chip (74HC14) and a feedback network. The feedback network comprises of RTH, RP and a timing capacitor (CT), as shown in Fig.3. The objective of designing this circuit is to convert temperature variation into frequency variation, as it has been reported in.

Where, REQV is the equivalent parallel resistance of RTH and RP. VT+ and VT- are upper and lower threshold voltages of the Schmitt trigger chip. From equation, it can be predicted that fo will vary non-linearly with RTH.

iv. Digitizer circuit

The sensor circuit designed and fabricated above translates temperature into frequency. As a result, two options available at the moment for digitizing the sensor output. The first option is to use combination of FVC chips with a normal ADC chip, while the other one is to directly use universal FDC chips. However, in the present work the requirements for FVC, ADC and FDC chips have been totally avoided by using a customized FDC implemented with AT89C51, as it has been reported in. Design of the FDC with AT89C51 and its interfacing to printer port is shown below in **Fig.3.4.1**.

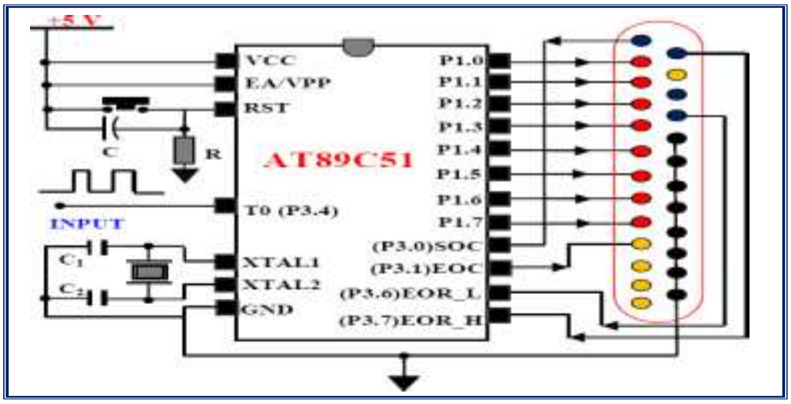

Fig.3.4.1: Schematic diagram of the FDC circuit which is interfaced to printer port of PC.

In this FDC circuit, AT89C51's internal timer-0 is programmed to act as 16-bit counter by choosing mode-1 operation of the timer, as in. **Fig.3.4.1** shows the simplified functional diagram of the internal components of AT89C51's internal timer-0 to operate as counter. The sensor output is connected to T0 pin, and this signal is sent to the counter by making C/ T =1. Signal applied to TR0 control operation of the timer. Logic states of TR0 and C/T are alterable in the firmware program of the C. The counter increments it counts value by one for every negative edge transition of the signal provided by temperature sensor circuit [85]. Thus, frequency change is translated into unique digital codes. The implemented 16-bit FDC is interfaced to a PC's printer port. The digitized outputs are made available at port 1 of the microcontroller. A firmware program developed for the AT89C51 chip performs conversion of frequency into digital codes. The FDC and PC communicate with one another asynchronously by using handshake signals. **Fig.3.4.2** shows the theoretical timing diagram of the FDC. In **Fig.3.4.3**, AT89C51 starts the conversion process after receiving a SOC signal from the PC. The PC transmits SOC signal from control bus line (Pin 1) of printer port, and it is received at P3.0 pin of AT89C51. The conversion window (TCW) and read window (TRW) are programmatically generated within the firmware of AT89C51.

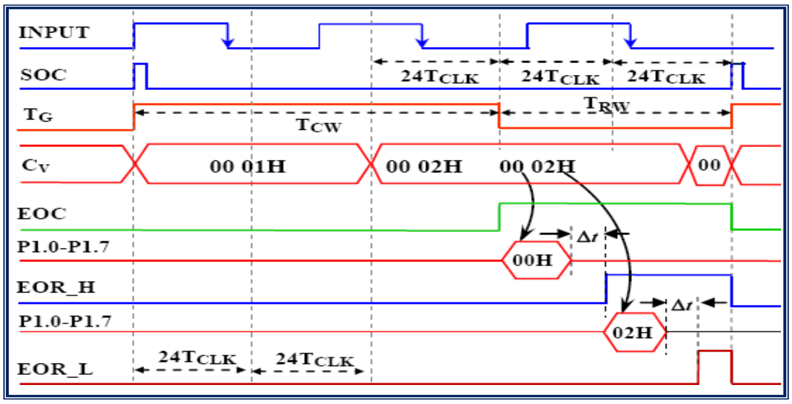

Fig.3.4.3: Conceptual timing diagram of the FD

Counting process is enabled during TCW state of the gate signal (TG), where TCW + TRW=TG (TCW is to be made very large as compared to TRW). And, counting stops during TRW, and AT89C51 EOC signal from its P3.1 pin to status bus line (Pin 10) of the PC's printer port. Then the upper byte of 16 bit digitized data is placed at port1 of AT89C51 until the byte is read by the PC via data bus line (Pin 2 - 8) of printer port. The PC's control bus line (Pin 14) sends end of reading higher byte (EOR_H) signal to P3.7 pin of AT89C51 to inform that upper byte has been read. As soon as EOR_H is received, AT89C51 places the lower byte of the digitized data again at port 1 of AT89C51 for the PC to read. The count value is zeroed after the signal so called end of reading lower byte (EOR_L) is transmitted by control bus line (Pin 17) of PC's printer port and received at P.3.6 pin of AT89C51. Then, the next conversion cycle is repeated as before with the arrival of another SOC signal. The counter needs 24 periods of crystal oscillator clock (TCLK) to increment its count value by one unit. So, both TCW and TRW are chosen large enough as compared to 24TCLK. TCW and TRW are generated by using time delay subroutines in the assembly language program (ALP) of the AT89C51. It is assumed that the counter's accumulated count (CV) is linearly proportional to frequency of signal (fIN) for a given TCW. Then, CV, fIN and TCW can be related by CV = TCW × fIN.

The relation between TCW and dynamic frequency range fD of the FDC can be written as CVMAX = (TCW × fD), where CVMAX is the maximum count of the 16-bit counter of AT89C51. Here, FDC's dynamic range indicates the difference of two frequency limits within which CV varies linearly from (0000)16 to (FFFF)16. By using the above expressions, we can write an expression for (CV ±1) in the form of (CV ±1) = TCW (fIN ± R); where, R is the resolution of the FDC, which can be defined as the smallest change of fIN that produces a unit change in the value of CV. Then, we compare the expressions for CV and (CV±1) to get a relation between R and TCW, and it is found to be R = (1/TCW). Frequency sensitivity (S) of the FDC is obtained by taking derivative of CV with respect to fIN, and it is obtained as S = TCW. From the expressions of S and R, we get S = (1/R). The above mathematical expressions indicates that transfer characteristics of the FDC will have greater slope (means larger S and better R) as TCW increases, which mean that small change in fIN will cause a significant change in CV. However, fD will decrease with the increase of TCW and vice-versa.

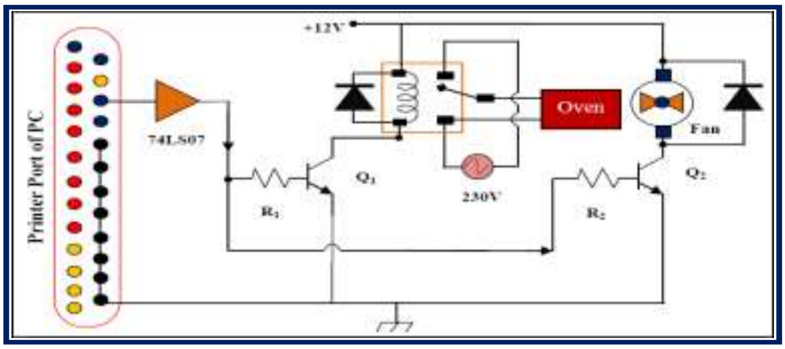

Fig.3.4.4: Schematic diagram of the oven control circuit and its interfacing to PC's printer port.

4. Web application for temperature monitoring and control

Architecture of the web application:

However, the web pages of present application are renamed as Home page-I, Log-in page-I, Unlock page-I, Recorded data page-I and DAQ system page-I. Here, DAQ system page-I has been designed for temperature monitoring and control. **Fig.4.1** shows the architecture of the web application. Similar to the web application described in, the present web application employs database operations for storing sensor data, user authentication and user log-in status. Concurrent access of DAQ system page-I is also not allowed in this web application.

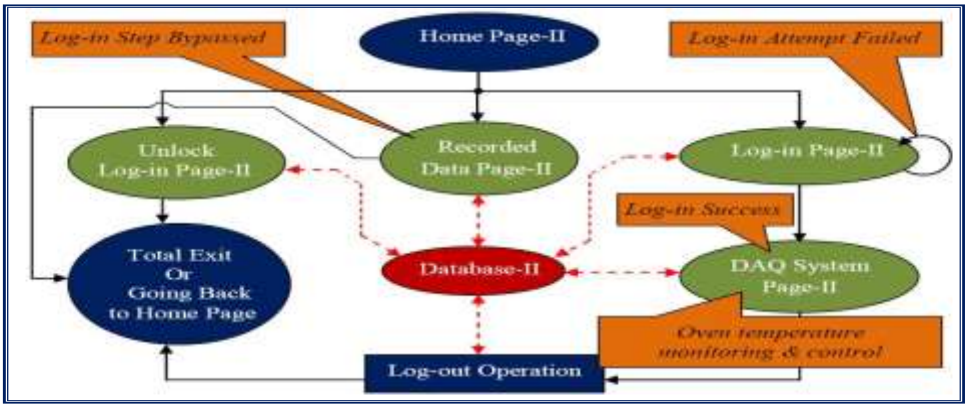

Fig.4.1: Architecture of the web application for temperature monitoring and control.

Test results

Fig.5.1 - Fig.5.3 shows three different snapshots of DAQ system page-I captured during the functional testing. In **Fig.5.1**, gradual increase of temperature is illustrated as real time chart. During the temperature increment, heating oven remains in ON state, but the cooling fan is in OFF state.

Fig.5.1: Snapshot of DAQ system page-I showing increase of temperature measured inreal time.

Fig.5.2: Snapshot of DAQ system page-I showing decrease of temperature measuredin real time.

NEW SESSION: 00
OLD SESSION: 00
THRESHOLD TEMPERATURE: 30
OVEN: ON/OFF Alternately
COOLING FAN: ON/OFF Alternately
Choose a new Session in the begining of operation

Fig.5.3: Snapshot of DAQ system page-I showing constant temperature levels measured in real time.

5. CONSULION

Fig.5.2 shows the snapshot of the web page recorded during decrement of temperature. Here, the heating oven is in OFF state, while the cooling fan remains in ON state. **Fig.5.3** shows the snapshot of the web page recorded when liquid volume is maintained at different levels during temperature decrement operation. In this snapshot, the horizontal regions of the real time plot indicate constant temperature levels while the ramp-down regions represent the decrease of temperature from an earlier level to a new level. During this operation, status of the heating oven and cooling fan remain alternately in ON/OFF states. During the time of accessing DAQ system page-I, the actual URL of the web page is kept hidden, rather the URL of log-in page-I is shown in the address bar of web browser. This is done intentionally in the program code to improve security of the DAQ system page-I. The function of LOG- OUT button has also been found to be working properly as expected.

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