Embedded DAQ System Design for Temperature and Humidity Measurement

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ABSTRACT

In this work, we have proposed a cost effective DAQ (Data Acquisition) system design useful for local industries by using user friendly LABVIEW (Laboratory Virtual Instrumentation Electronic Workbench). The proposed system can measure and control different industrial parameters which can be presented in graphical icon format. The system design is proposed for 8-channels, whereas tested and recorded for two parameters i.e. temperature and RH (Relative Humidity). Both parameters are set as per upper and lower limits and controlled using relays. Embedded system is developed using standard microcontroller to acquire and process the analog data and plug-in for further processing using serial interface with PC using LABVIEW. The designed system is capable of monitoring and recording the corresponding linkage between temperature and humidity in industrial unit's and indicates the abnormalities within the process and control those abnormalities through relays.

Key Words: **DAQ, LABVIEW, Industrial Automation, Embedded Design.**

1. INTRODUCTION

DAQ system instruments are widely used to collect the information, store or examine some events. These instruments play very important role in the industrial field and can be found in small to large scale in most of the current industries like sugar mills, oil refineries, cement factories, gas fields, pharmaceutical companies and many more [1].

The DAQ instruments are used to measure, record and control diverse parameters like: pressure, temperature, velocity, and flow by using actuators, solenoid valves, conveyor belts etc. [2]. Important aspect of DAQ instruments includes data analysis flexibility, real time data display, current and future trend indications etc. With the help of easily available hardware modules and software codes, required characteristics of DAQ instrument can be easily achieved [3].

In this perspective, most of the industries rely on PLC (Programmable Logic Controller) and DCS (Distributed Control System) as an efficient DAQ systems for effective recording and monitoring of the industrial process control

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[4]. These DAQ systems would become simpler to use, accurate, and flexible with the use of electronic tools. These electronic tools can be counted from simple recorders to complicated personal computers. Currently in industries, where sensors are used to measure temperature, flow, pressure and other parameters, DAQ products plays vital role a system. Nowadays, data acquisition system in industries has been replaced by computer control that is a process of sampling the signals which measure physical conditions that are analog in nature and converting them into a form of digital numerical values that can be manipulated by computer. These systems require hardware tools and software design to manage and collect multiple parameters either in analog or digital form. The Nationals Instruments are the giant producers of DAQ devices that facilitate from small to large scale industries [5-6]. The general block diagram of data acquisition system which contains the set of sensors, signal conditioning, hardware circuitry, recording mechanism and output display is shown in Fig 1. Every set of block is linked another set to perform specific tasks.

DAQ cards have analog and digital inputs in a form of either voltage or current signals 4-20mA as the standard input of the card.

The hardware card of data acquisition system has flexibility of being installed to the personal computer either through USB, serial, parallel port or PCI port. In case of any additional sensor to be connected, the signal conditioning circuit is incorporated to convert signal into voltage or in current. Signal conditioning circuit is normally connected with sensor for the case when the sensor output is not compatible with DAQ card. The signal conditioning circuit offers diverse functions like linearization, attenuation, amplification, filtration, isolation, and excitation [1]. Upper limits and lower limits ranges can be set for input parameters and output signal in order to have notification of any abnormality. For the purpose of monitoring of input parameters and output of the generated signal, special types of software can be used.

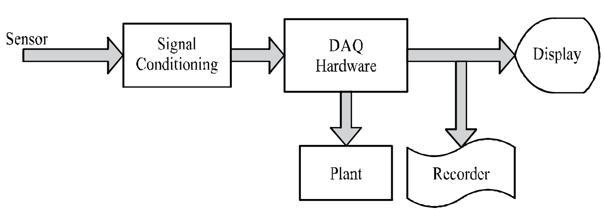

FIG. 1. GENERAL BLOCK DIAGRAM OF DAQ

In Cai, et. al. [7] have designed a DAQ system with a single digital temperature sensor having maximum range of 125^{o}C. In the proposed system, we are having all analog inputs that can measure many other parameters for example pressure, velocity, flow etc.

The remainder of this paper proceeds as follows. In Section 2, proposed hardware design is discussed, followed by proposed hardware implementation in Section 3. In Section 4, simulation results and observation are discussed that are followed by conclusion in Section 5.

2. PROPOSED HARDWARE DESIGN

The proposed system design was carried out in two steps namely hardware and software. In the following section, both design and implementation aspects are discussed in detail.

2.1 Proposed Hardware Design and Implementation

Proposed hardware design is shown in Fig. 2. This design is based on 89S52 microcontroller, which belongs to the family of 8051 series of microcontrollers. 89S52 microcontroller contains all the basic accessories of personal computer, like I/Os, RAM, ROM, CPU, UART, widely known as a "system on chip" controller.

Conversion block shown in the model is responsible to convert the analog signal into digital form. The digital signal is then processed by microcontroller. In our proposed model, analog to digital converter channel have the flexibility of 8 analog inputs to monitor 8 diverse parameters. For the measurement and monitoring of temperature and RH, two parameters are used in the implementation phase, while rest are being as optional. ADC (Analog to Ditital Converter) and Microcontroller are linked to collect the data and control the devices. In order to have adjustable control on device turn ON and turn OFF mechanism, relays have been incorporated. The upper and lower limit of Temperature and Humidity can be set and adjusted as per set point. Two wire serial ports is used for interfacing, however USB can also be used.

It is noticeable that (Fig. 2) with only 3 serial port wires, the interface between computer and hardware is made and 8 bit parallel output data have been proposed. Serial communication packets were formed to transmit and receive the data through microcontroller. Serial packets are converted into specially generated codes through computer program codes. Finally any device can be turned on/off according to the specified codes.

Corresponding flow chart of the proposed hardware design is given in Fig. 3. The hardware contains 8

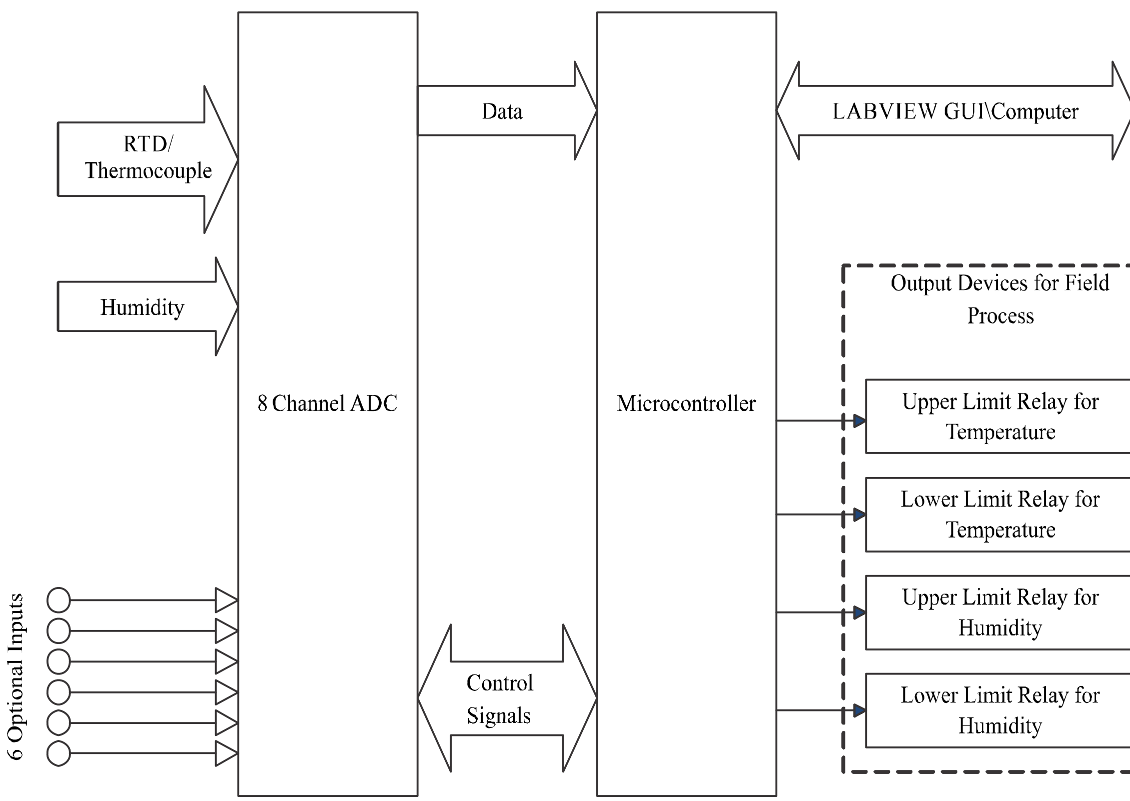

FIG. 2. HARDWARE BLOCK DIAGRAM

channels ADC along with a microcontroller that is capable to measure 8 different parameters. Microcontroller performs channel selection step by step in sequence of one through eight. At the start of the system, microcontroller will send the control signal for selection of channel (may be any from 1-8) so that data from selected channel (for example 1) sensor will be received. Once the complete data from corresponding channel is received the interrupt signal will be generated by ADC to update microcontroller for further processing. Binary format of data is converted into 3 digit decimal numbers so that data can be easily taken to computer in form of ASCII (American Standard Code for Information Interchange) codes. However, this data is saved temporary in RAM of microcontroller till other channels detect the data from ADC. We have considered three digits so that data goes from 000-999 (three digit) however, these digits can be increased to 4 or more or even decreased.

Similarly, another channel can be selected by microcontroller and the data will be converted into 3 digit format and stored into memory. Finally all the digits are sent to LABVIEW software where these 6 digit data will be divided into two sections of 3 digits for separate channels.

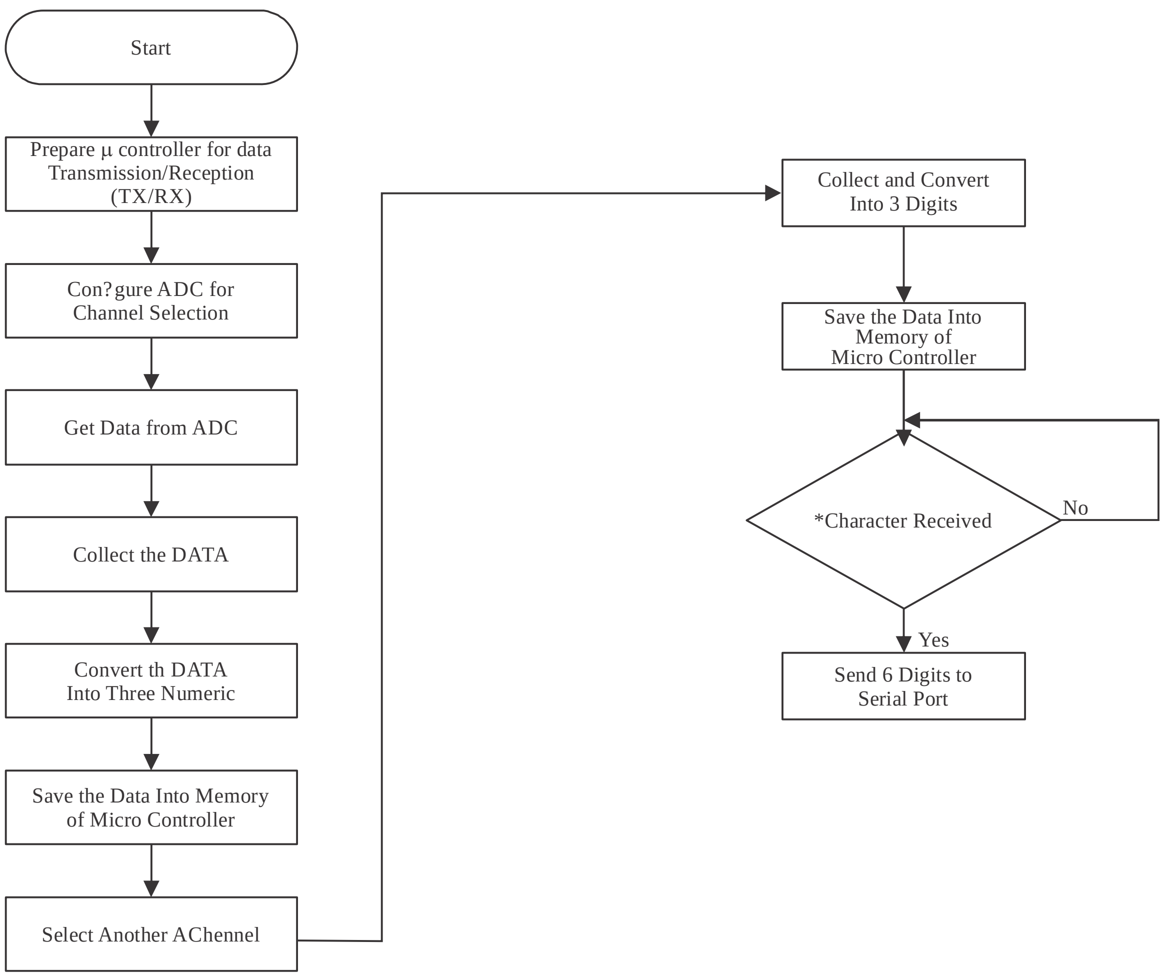

FIG. 3. FLOW CHART OF THE PROPOSED HARDWARE MODEL

The comparison of standard DAQ and proposed system is given in the Table 1. It can be seen that the proposed system offers more than one channels, and have upper and lower limits instead of only one as in contemporary DAQ systems. Other important aspects of proposed design are its simple interfaces, and cost-effective nature that is about 5 times lesser than contemporary designs.

3. PROPOSED HARDWARE IMPLEMENTATION

Many interfacing software tools are available to build a communication link between hardware and software starting from the most common one hyper terminal to MATLAB and LABView. In this work, we have adopted LABVIEW due to its simplicity, robust and user friendly nature.

LABVIEW software is flexible in nature and it has built in controls that can be customized as per application requirement to develop front and back panel GUI. Icons, symbols, knobs, buttons are used to design front panel whereas programming tools can be used to develop the back panel in LABVIEW. Various interface standards like; RS-232, RS-485 and GPIB (General Purpose Interface Bus) can be connected by using wires [6].

The proposed system was designed and developed in the LABVIEW as shown in Fig 4. In this design, various controls have been incorporated including: visa configure visa write, visa read, visa close, data splitter, string converter, comparator, and selector.

4. DESIGN SIMULATION AND RESULTS

Wet and dry bulbs are the methods to measure the humidity appropriately by employing two temperature sensors [8]. Humidity measurement formula is already built-in function in Formula block module of LABVIEW through which dry and wet bulb reading can be acquired [9]. Relative humidity table was needed for the purpose of humidity calculation of wet and dry bulb method. standard psychometric chart for measuring Humidity using dry and wet bulb method was adopted [10]. Following is given the detailed observations made so far.

TABLE 1. EXISTING DAQ STANDARDS VERSUS PROPOSED MODEL

No.	Features	PLC	Specific Controller	Proposed Design
1.	User Friendly	Yes	Yes	Yes
2.	Large number of I/Os	Yes	No	Yes
3.	PID	Yes	No	No
4.	ON/OFF Controller	Yes	Yes	Yes
5.	Set Point	Upper Lower Both	Only One	Upper Lower Both
6.	Universal Inputs	Yes	Available in Some Versions	Yes
7.	Total Inputs	Application Specific	1	2
8.	Upgrading Features	Requires DAQ Cards	No Upgrading	Up to 8 Analog without Changing Hardware
9.	Computer Interface	Yes, Special Software	No	Any Interfacing Software can be Used, can be Built with Visual Basic, C Language and even with MATLAB
10.	Cost	More than 500$	$50	Component Cost Approximately $10

4.1 Experimental Results Analysis

Using dry and wet bulb temperature in the ranges of temperature (18-29^{o}C) and relative humidities (55-78%), we have obtained observations for the proposed method using formula block in LABView. Using relative error formula (Equation (1)) we have calculated error percentage between the proposed method and the Psychometric chart.

(1)

where Y_n is expected value and X_n is measured value.

A series of results were obtained in LABVIEW by varying the temperature level of dry and wet bulb as shown in Table 2. The relative humidity obtained for second

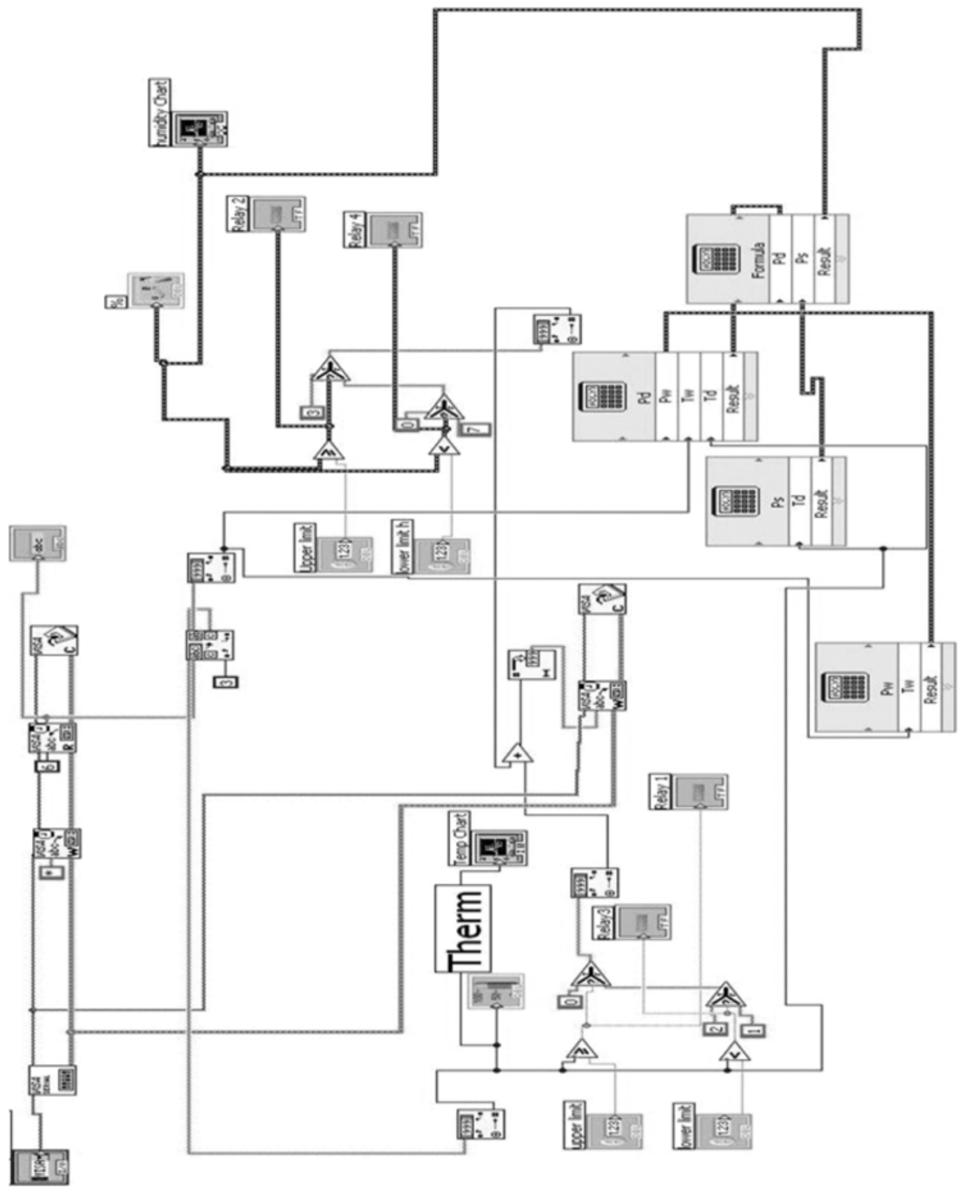

FIG. 4. LABVIEW PROGRAMMING BLOCK

TABLE 2. WET AND DRY HUMIDITY COMPARATIVE RESULTS USING PROPOSED SYSTEM

Observation No.	Dry Bulb Temperature	Wet Bulb Temperature	Proposed Model Results (RH %)	Psychometric Chart Results (RH %)
1.	24	19	61.8	62
2.	24	18	55.6	55
3.	29	24	63.53	66
4.	28	25	76.5	78
5.	27	24	76.3	78
6.	27	23	69.3	71

observation was 61.82%, at dry and wet bulb temperatures of 24 and 19^{o}C that has relative error of 0.322% than Psychometric chart. Similarly, it can be seen that as dry and wet bulb temperature increases it impacts upon the relative humidity and relative error. However, this marginal error is acceptable for the proposed data acquisition system.

5. CONCLUSIONS

In this work, we have proposed a robust and cost-effective system design that can suit local industries for data acquisition and signal processing. This inexpensive system is designed for Industries, having 8-channels facility (i.e. Analog I/Os) to measure and record the processes of industries. This work has considered two important parameters to measure Temperature and RH as being mostly measured parameters in industries.

This system can be improved by incorporating more recent microcontroller with built-in features like AVR or ARM based Microcontroller. Such devices may reduce the overall system size at the expense of limited available conversion I/O (for example ADCs) etc.

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REFERENCES

[1] Helfrick, A.D., and Cooper, W.D. "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall, 1990.

[2] Khalid, B., "Effect of Temperature and Humidity on Salt Mine Environment", Pakistan Journal of Meteorology, Volume 7, pp. 71-81, 2010.

[3] Jiannong, W., and Wei, W., "The Common Data Acquisition System Based on Arm9", IEEE 10th International Conference on Electronic Measurement & Instruments, pp. 324-327, 2011.

[4] Carlsson, H., Svensson, B., Danielsson, F., and Lennartson, B. "Methods for Reliable Simulation-Based PLC Code Verification", IEEE Transactions on Industrial Informatics, Volume 8, pp. 267-278, 2012.

[5] Gani, A., and Salami, M., "A LabVIEW Based Data Acquisition System for Vibration Monitoring and Analysis", IEEE Student Conference on Research and Development, pp. 62-65, 2002.

[6] Spanik, P., Hargas, L., Hrianka, M., and Kozehuba, I., "Application of Virtual Instrumentation LabVIEW for Power Electronic System Analysis", 12th International IEEE on Power Electronics and Motion Control Conference, pp. 1699-1702, 2006.

[7] Cai, C., and Zhang, W., "The Design on the Multi-Temperature Testing System Based on the Laview", Future BioMedical Information Engineering, IEEE International Seminar, pp. 421-424, 2008.

[8] Monteith, J., and Owen, P., "A Thermocouple Method for Measuring Relative Humidity in the Range 95-100%", Journal of Scientific Instruments, Volume 35, pp. 443, 2002.

[9] Zhang, W., and Yang, S., "Humidity Measurement in Harsh Industrial Environments", International Conference on Networking, Sensing and Control, pp. 649-652, 2010.

[10] Kumar, M., and Kar, I., "Non-Linear HVAC Computations Using Least Square Support Vector Machines", Energy Conversion and Management, Volume 50, pp. 1411-1418, 2009.