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Design of a Single Microcontroller based 29-Channel Data Logging System

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Abstract

Development of Data Logger is changing rapidly with the advancement of electronics. Data, collected from the process, is affected by speed matching problem, circuit complexity, and by limitations of the application software. The number of channels in a low cost data logger for a small system varies from one to eight. This paper describes an inexpensive, easy-to-build, microcontroller-based, data logging system with a single microcontroller that may be used in different field applications. In the present paper, a system is described, which has been developed to increase the number of channels keeping the cost as low as possible or constant, with simple electronic devices. This data logger is capable to update 29 channels data within one second. This system also records the data in a database and plots the variation of data in the form of a graph, like a real time system. All the data acquired by the system basically comes through different channels and is logged into the database. Finally the application software is typically used to store the data in the database with date and time until the system is stopped.

Key words

Data logger, microcontroller, analog to digital converter, analog multiplexer, interfacing device, timer, port connection.

1. Introduction

Supervisory control and data acquisition systems are used to monitor and control physical parameters of a process plant or a centralized machine. The basic purpose of data logging is to measure physical phenomenon such as temperature, pressure, flow etc. Data logging system uses a combination of hardware and application software with the help of computer for storing and displaying the data. The system incorporates sensors, signals, actuators, signal conditioning, data acquisition devices, and application software. Data acquisition and logging system shares a common goal of acquiring, analyzing, and presenting information.

Different processes of data collection for medical applications have been described (JI. Weihong et al 2005, GI. McCracken et al, 2002 and K. Kim et al, 2007). Some multi-channel optical sensors containing a few channels can be used as a data control system (K. Kanukurthy et al, 2007) and wireless stand-alone system (P. O. Bobbie et al 2006 and T. Landolsi et al, 2007). Microcontroller-based data logging device can be used to collect and save data for educational purposes (D. Ibrahim, 2010) and G.K. Lott et al, 2009). A scalable data logging system was presented for micrometeorological and to remote a sensing application (M. Bhen et al, 2007) which is based upon an open source operating system via network interface. A 4-channel energy efficient data logging system with the help of graphical user interface was developed for indoor environment (A. Kumar et al. 2010). It has a huge potential in terms of energy saving. An integrated wireless supervisory control and data acquisition system has been designed for monitoring and accessing the performance of remotely situated device parameter (A. Goel et al. 2009), where the infrastructure exists on mobile network. Moreover, a data logger for renewable energy was improved (J. Srinonchat, 2009) which is capable of storing data in every 5 seconds. A noble type Z8 Encore microcontroller based embedded data logging system has been designed (N. Islam et al, 2006). This entire data logger was made by some complex instructions and number of channels is limited up to sixteen. A PIC 16C73A microcontroller based data logging system containing 16 digital input channels was proposed (R. R. Dedrick et al 1999). In general, a data logger contains 22 channels using parallel port programming method has been designed (S. Saha et al, 2006). Parallel port programming method is more complex than serial port programming. In this case, design cost is high.

In this paper, an accurate measurement of data for a real time system containing more number of channels compared to other data collecting processes has been described using a simple AT89C51 microcontroller. Here system design is much simpler and programming part is easy to understand. Simple data capturing method is used to decrease the number of channels.

Here the number of channels is increased by using three analog multiplexers, hence using more multiplexers, number of channels can be increased in this system. A particular channel contains a particular type of hex code which is used for channel selection programming. Proper channel selection is controlled by selecting line of analog multiplexers and ADC. The selected line of analog multiplexers is controlled by a special type of programming in the microcontroller. To collect a large real time data using a simple microcontroller AT89C51, this system is highly useful. Moreover, AT89C51 microcontroller-based system describes the same operation of acquiring the analogue data and sending it to a remote terminal for monitoring. Also the ADC converter converts the sensor output voltage into digital voltage, which comes from different channels of analog multiplexer and is supplied to the microcontroller. The microcontroller is used to acquire real-time data from the ADC and control the overall data logging system. The data from AT89C51microcontroller is sent to the PC via serial port. Different hardware and software systems have different program control techniques. So data representation of the overall system is done in a particular format.

2. Method of Approach

Various types of process parameter such as temperature, pressure, level etc… are taken from sensors in terms of analog voltage 0-5V DC. AT89C51 microcontroller has four input and four output ports to transmit or receive data from other devices and systems. Port 0 and Port 1 of AT89C51 microcontroller is used as select lines, shown in the Fig. 1 that is connected with multiplexer 1, multiplexer 2, multiplexer 3 and 0808 ADC. Microcontroller receives digital data from ADC through Port 2. Here, 0808 ADC is used to convert the analog voltage signal into a digital value and it is transferred into microcontroller through Port 2.

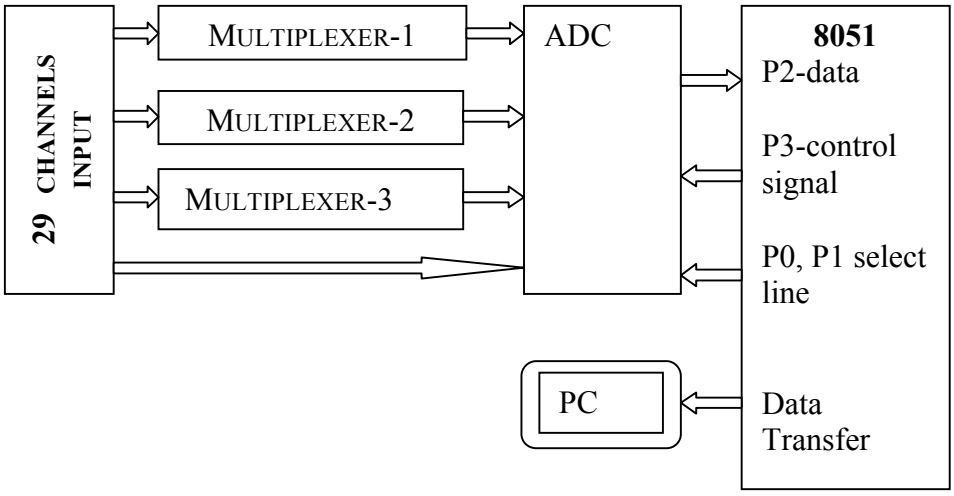

Fig. 1. Block diagram of data logger

Proper control signal like Start, End of Conversion, Output Enable, External Clock data are transmitted from ADC to microcontroller. In AT89C51 microcontroller, the data transfer is made possible through serial data buffer register. The data is transmitted through MAX232 along with the serial port.

The data is collected from the database and Visual Basic Software window is used to represent the variable data in the label box with some command button. At first the data is taken from serial port and can be checked by hyper terminal and button terminal of PC using Microsoft operating system. It is done by setting proper speed between the hardware circuit and communication terminal of the PC. Further the data is transferred to label box of the displays i.e. Visual Basic. This data can be updated with time by using a proper programming loop, but the label box data is in form of characters. By using proper commands like Val function in Visual Basic Software, the data can be transferred to an integer value. Without connecting any sensor, the system output was seeing to be zero taking scale factors zero or blank. Every sensor has some conversion or scale factor so when the conversion factor or scale factor in the scale factor box was selected then the system shown exact value of input parameter. The parameter data can also be found in the database for printing or any analytical purpose.

3. Microcontroller Configuration

The working principle of the microcontroller is illustrated step by step with the help of flowchart, Fig. 2. The special functions register i.e. the timer mode control register is bit addressable. It has two timers with 4-bit register each. Hence, the serial communication speed can be adjusted by setting the timer mode control register in mode 2 and loading the appropriate value in TH1 and TL1 register. Practical value of crystal oscillator frequency was 11.052 MHz. Serial Port Control Register band rate is f/12 due to multiprocessor mode. Then value of

$$TH1 = 256 - \frac{2^0 * 11.0592 * 10^6}{32 * 12 * 1200} = E8 \qquad (1)$$

Communication band rate is 1200. To control data communication, Serial Port Control Register should be configured and serial interrupt also enabled.

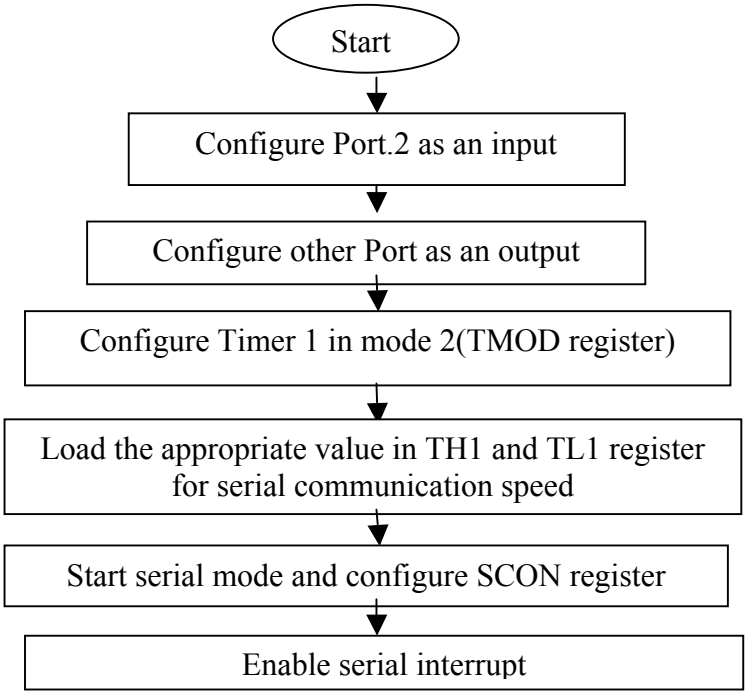

Fig. 2. Configuration flowchart

4. Control Operation

Multiplexer 1, 2 and 3 with ADC are controlled by selecting lines connected to Port 0 and Port 1 of 8051 microcontroller. Microcontroller generates some hexadecimal value to the select line to select a particular channel only. For selection of channel no. 1, Port 0 and Port 1 value is 00H and 00H. Port 1 is incremented one by one in digital form for selecting channel no. 1 [00H] to channel no. 8 [07H] without changing the value of Port 0 i.e. 00H. To select channel no. 9 to 16, the value of Port 0 will be 10H and the value of Port 1 will be incremented by one for each of these channels. Similarly for channel nos. 17 to 24, the value of Port 0 will be changed by one hexadecimal, for increasing the value of each channel i.e. 20H to 27H, keeping the value of Port 1 as 00H up to channel no. 29. Channel no. 25 to 29, the value of Port 0 is incremented to 10H for each channel i.e value changes from 30H to 70H. When the channel no. 1 is selected by using a control signal from microcontroller to ADC, then the analog voltage signal of channel no. 1 will be converted into digital voltage signal by ADC and after conversion microcontroller will read the data and store it into the accumulator as shown in the Fig. 3. This data will be kept and transmitted through Serial port data buffer register and the Microsoft communication port will capture the data into a particular format.

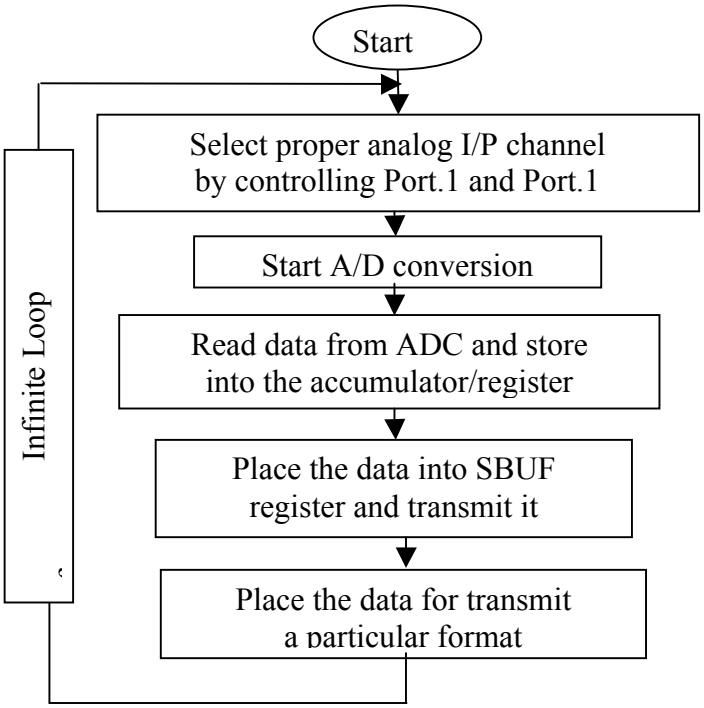

Fig. 3. Control flowchart

5. Data Display and Experimental Results

The database is designed by using some software, which contained data and time. Application software i.e Visual Basic took the date and time from PC clock. The date and time was given for checking the variation of the data per second at any instant of time. Also serial number indicated total sample of data taken from different channels over a period of time. The data is recorded in level box connected with different sensors and stored as a file of Microsoft office access software. When 29 different process parameters likes pressure, flow, Level etc. are measured by the different sensors, since different sensors have different conversion or scale factor, to observe the process parameter reading in level box, the values of scale factor in different scale factor box are selected as shown in Fig. 4. The data can be analyzed from visual basic window. Start, Stop and Delete button are designed in the same window. Data from the database can be deleted by delete command button. It can store or print the real time data, which can be taken from the sensor for future work and analysis.

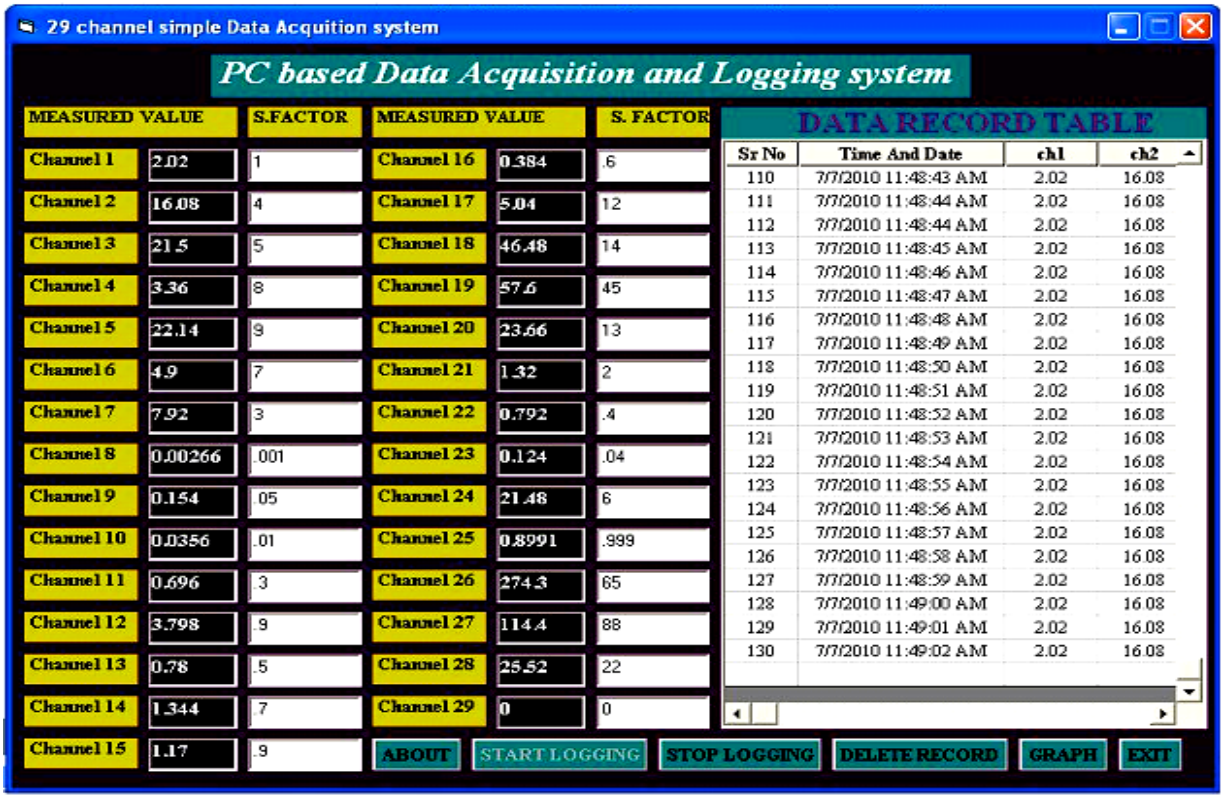

Fig. 4. Visual Basic Window

The experimental graph is represented channel no. 1 output as shown in Fig. 5. This channel is connected with LM 34 temperature sensor. Graph showing output temperature in terms of voltage with time interval of 1 second for channel no. 1. Generally voltage increases or decreases according to the change of the temperature sensor. Between 6 to 8 seconds, output voltage of the temperature sensor decreases. It indicates that process temperature is also decreasing with time.

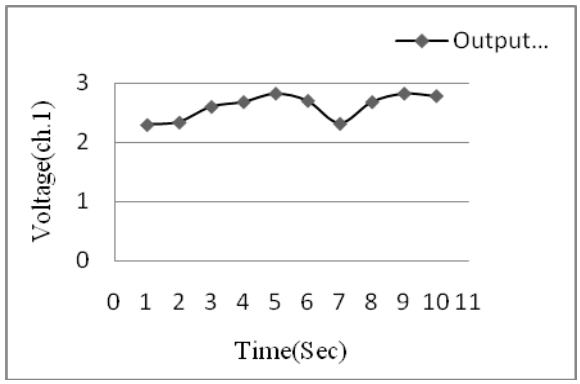

Fig. 5. Voltage versus time graph for channel no.1

6. Conclusion

In the present work, we have tried to develop data logging system with the help of Visual Basic Software. Compared to the actual value of the process parameter, it has some deviations.

The error, due to change of ADC voltage per bit, was approximately 0.019mV, which is a very small value. After changing 0.019mV voltage in the sensor output, process parameter value can be detected. But the system couldn't detect any change less than 0.019mV. This problem can be eliminated by changing the reference voltage in ADC chip. When the reference voltage is near about 2.5V, the ADC output can be changed per bit for 0.01V, but the system is affected by noise.

Visual Basic Programming Software takes data from the hardware system with a constant speed, which is equal between hardware and PC. System data transfer rate can be improved by taking 9600 baud rate. Therefore the system will take very little time, fraction of a second, to update 29 channels' data.

In AT89C51 microcontroller some pin were not connected in wiring. With the help of these pins, the channel number can be increased up to 44. To get 44 channels with a single microcontroller more multiplexers are required. Moreover, additional pins can be used as control signals enabling the PC to act as a system controller.

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