Development of an Eight-Channel Data Acquisition System and Control for Industrial Application

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ABSTRACT--- ***The subject of this paper is the Development of an Eight Channel Data Acquisition System using off-the-shelf components for Industrial Application. The system is typically configured to acquire data like voltage, current, temperature, pressure, flow etc, in an industrial environment. To achieve the objective the LPT1 of a PC served to connect the various sensors through the interface circuit that was designed and constructed. Visual C++ was used in developing the program that controls the system. The system offers great economic advantage as the cost is just about 28% of the commercially available data acquisition cards. The accuracy of the system for acquisition was found to be high when used to measure signals from transducers.***

1. INTRODUCTION

Computers are tools for the processing of information. However before processing can start, the data upon which the computer will act needs to be collected. This requires firstly, acquisition of required information from its source. Secondly, the information is converted into the particular form that is suitable for the form of analysis that is to be carried out. The two-step process is referred to as data collection. Data acquisition is a restricted form of data collection. The distinguishing features are two:

- First, the information to be acquired is contained in physical variables like temperature, flow and pressure.
- Secondly, the physical variables are functions of time. Numerous manufacturers market equipment that plays well-defined functions as part of the data acquisition process.

Traditional industrial data acquisition monitoring systems are poor in flexibility and versatility [1]. Also the cost of such data acquisition system is high .Several attempts have been made to design data acquisition systems that are flexible, versatile and have low cost The use of PC for data acquisition offers standard interfacing, low cost and flexible system [2]. Data acquisition is widely used in industries in order to achieve production efficiency and improvement of quality of product. [3]

Several industries around the world have data acquisition systems installed. In the developing world, Nigeria as example, you have data acquisition systems installed with special purpose computers, mini-computers in some cases – some of these computers have since become unserviceable, without parts to ensure their operation. Such industries are faced with a lot of investment made on sensors that are dispersed across the industry an investment that could go down the drain without a system that can utilize the sensors. Solving the problem could mean changing the old mini computer system with a personal computer and designing an interface that connects the multi-channels from the sensors to a personal computer system (PC).

Physical quantities like temperature, humidity, pressure, flow, voltage, current, are all in analogue form. There is a need to interface the physical world to the digital world of the computer. An interface circuit has to be designed. Software has to be developed using a language like C++ that will control the process of the acquisition

2. METHODOLOGY

A basic data acquisition system requires sensors/transducers for capturing the data like voltage, current, temperature, humidity, flow, pressure, etc which exist in analogue form. An analogue to Digital converter is then used to convert the data into digital form before being transported into the computer for processing. A block diagram of the system is shown in Fig.1.

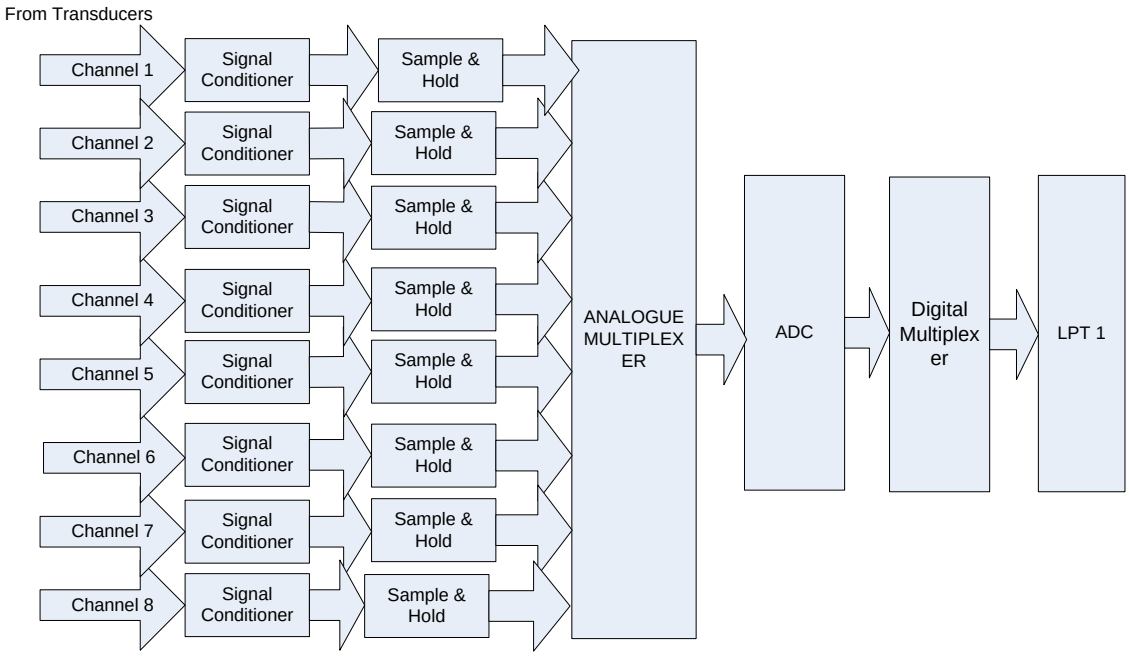

Figure 1. Block Diagram of Eight Channel Data Acquisition System

On each channel, there is a Transducer/sensor, signal conditioners and a Sample& Hold. All the channels then serve as input into an Analogue Multiplexer, which is used in selecting the channel whose value is to be sent to the computer for processing. The hardware part of this project provides an electronic platform for transferring data between a PC and the Transducers through a PC's parallel port, while the software provides a means of controlling the data flow between a PC and the interfacing circuit. The GUI provides the user with a tool for adjusting various data acquisition parameters as well as monitoring the signal waveform, which is being transferred.

3. HARDWARE

The hardware system provides an interface between a PC and the physical systems to be measured though a PC's parallel port. The circuit diagram for the hardware system is shown in Fig. 2. The circuit uses a printer port to interface an eight-channel Multiplexer, and 8-bit ADC to a PC. The circuit cuts the cost of addressing and decoder circuitry and saves one expansion slot for interfacing compared with add-on card type of data acquisition systems.[5]

The parallel port was chosen as the interfacing port, as this can provide a means of transferring data in a parallel manner and hence facilitate relatively high speed data transfer compared with data acquisition systems that use the serial port. The hardware part of the developed system can be divided into three components: digital data, analog data, and control signals.

Signal Conditioners

Signal conditioners that consist of voltage followers for impedance matching, voltage amplifiers and low frequency filters are designed and configured on each of the channels.

Sample & Hold - LF398 [7]

The choice of Sample-and-hold is made based on the acquisition time. In this paper a sample-and-hold circuit is used for the purpose of sampling and holding fast changing variables while the signal is read and converted to digital by the ADC. LF398 IC is a monolithic sample –and-hold circuit which utilizes high voltage ion-implant technology to obtain ultra high DC accuracy with fast changing acquisition of signal and low droop rate. The value of the hold capacitor is chosen to be 1nF

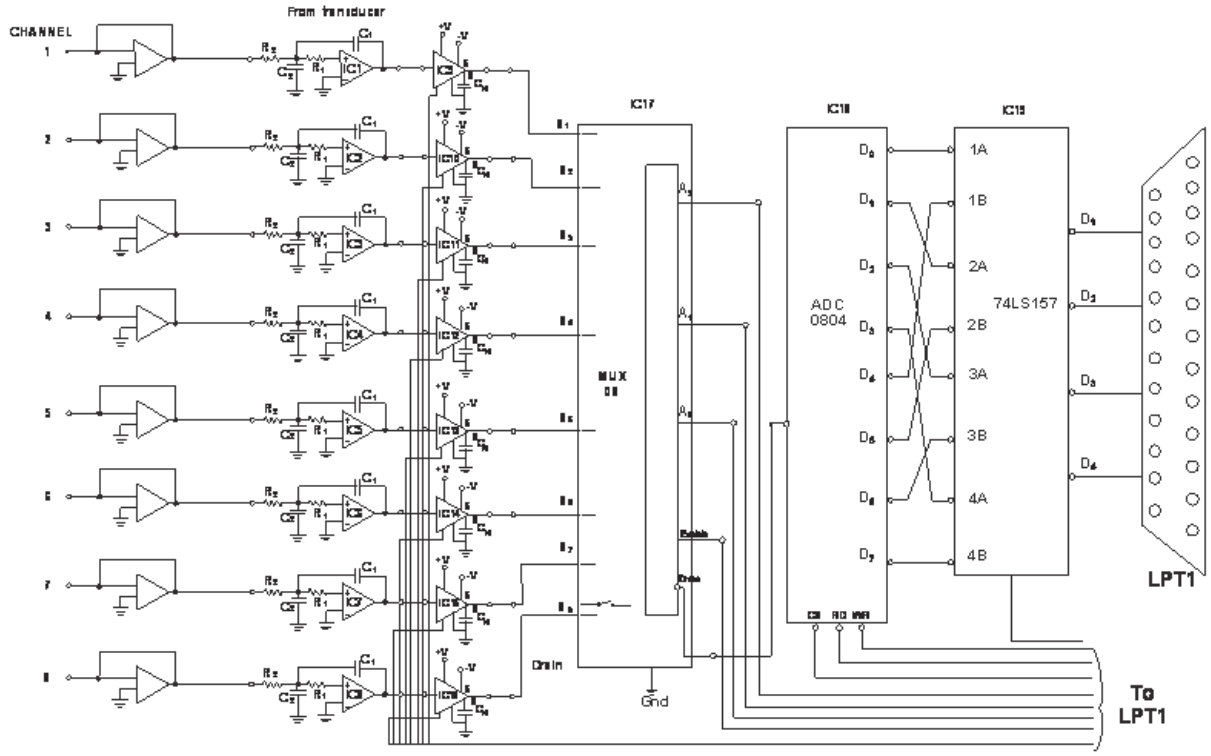

Figure 2: Circuit Diagram of Data Acquisition System

Analogue Multiplexer - MUX 08 [8]

The main features sought for the Multiplexer are: low resistance for the analogue switches, a low leakage current, a short settling time and a satisfactory isolation in the open state. These criteria led to choosing JFET devices. Multiplexer MUX08 which is an eight input multiplexer, suits these criteria. Each input is selected by decoding three address bits A0, A1, and A2 according to the truth table in Table 1

Table 1 MUX-08 LOGIC STATE

A2	A1	A0	En	CHANNEL (ON)
X	X	X	L	NONE
L	L	L	H	1
L	L	H	H	2
L	H	L	H	3
L	H	H	H	4
H	L	L	H	5
H	L	H	H	6
H	H	L	H	7
H	H	H	H	8

Analogue to Digital Converter - ADC0804 [9]

ADC0804: 8- bit ADC is used to convert an analog output from an experiment to the digital while transferring this from an experiment to a PC. The conversion depends upon the read signal, which is being altered from one of the control lines of the parallel port to initiate the conversion process. The ADC selected is an ADC0804 IC. ADC0804 is a CMOS 8-bit successive approximation A/D Converter that uses a Differential Potentiometric Ladder similar to the 256R products. The digital control inputs (CS, RD and WR) meet standard TTL logic voltage levels. These inputs are active low to allow an easy interface to the parallel port of the PC. The digital outputs of the ADC go into a 74LS157 IC which serves as a digital multiplexer to enable the digital output to be passed to the parallel port in nibbles instead of byte.

4. SOFTWARE

For the sensors to be used for taking readings from the physical world, a data acquisition program must be loaded into the computer. The flow chart used in developing the program is shown in Fig. 3. To keep track of all these data

transfers between a PC and an engineering system, there are some control signals that need to be provided in a timely manner. The control signals are produced internal to a PC in co-ordination with a user's request through the GUI

The common functions of a data acquisition program are as follows:

i. Take readings from the sensors at regular time intervals ranging from a few microseconds to hours or even days. The GUI has provision for setting the interval.

ii. The acquired data is presented in a suitable form of display on the screen.

iii. Thee acquired data can be printed on paper using a printer connected to the computer.

iv. The acquired data can be stored on a computer for future use.

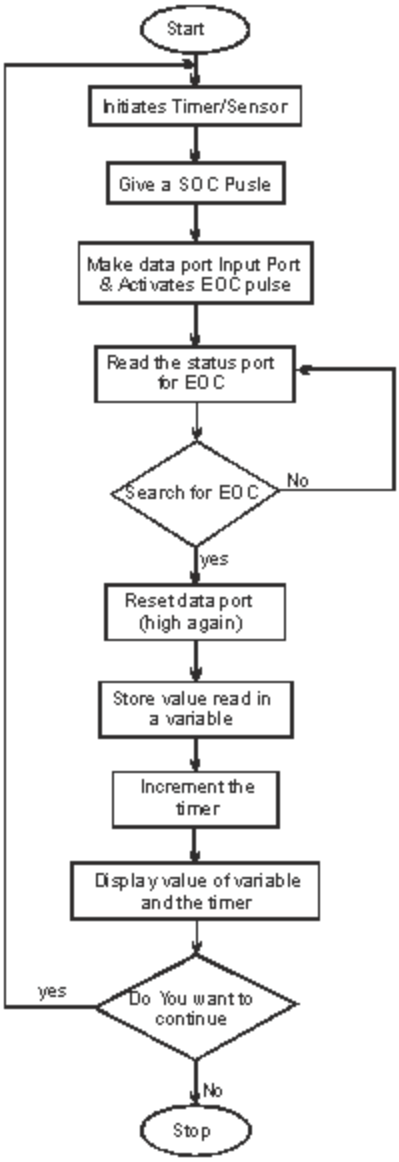

Figure 3: Flow Chart for Data Acquisition

The design uses three of the eight signals (pins 2-4) of LPT1 from the Data status register as control signals for channel selection, on the Multiplexer MUX 04, handshaking, and data transfer to the ADC0804. These signals are programmable by means of a bit position in the control word of the respective port. A falling edge at the RD and CS pins of the ADC0804 initiates a conversion, and the read operation latches the multiplexer address inputs, A0 through A2, for the channel selection. The Visual C program works satisfactorily and can scan the entire channels one after the other and display the converted data on the screen.

5. PRINCIPLE OF MEASUREMENT AND CALIBRATION

Several data in industries are dissimilar. Data like voltage, current, flow, pressure, temperature, humidity have to be measured as parameters for the safeguard of the machines and the quality of the product produced. The form in which these data are is analogue, it is therefore necessary to translate them to digital. However the signals have to first be converted to electrical signal.

Transducers are used to convert the signals to electrical form. The signals are conditioned to the range of 0-5V. To calibrate the points for the correct output, some follow mathematical function while on others the corresponding output from the transducer has to be looked up. The program therefore has the option of a look up table from the computer and in other cases the value is calculated from a mathematical formula. Fig. 4 shows the graph of the Temperature versus Resistance for a TH1 thermistor which is a temperature transducer. From the graph it can be seen that it is fairly linear, therefore a straight line equation is used to convert temperature to resistance value and ultimately to temperature values. For the cases where it is not linear, the equation of a curve may follow; otherwise we create a look-up table that tells the particular value from the transducer

Table 2. Measured Temperature and Resistance values on TH1 Thermistor

TEMPERATURE ^{0}C	RESISTANCE KΩ
5	6.68
10	5.68
15	3.94
20	3.40
25	2.94
30	2.46
35	2.11
40	1.80
45	1.49
50	1.25
55	1.06
60	0.92
65	0.80
70	0.69
75	0.60
80	0.52
85	0.46
90	0.40
95	0.35
100	0.30

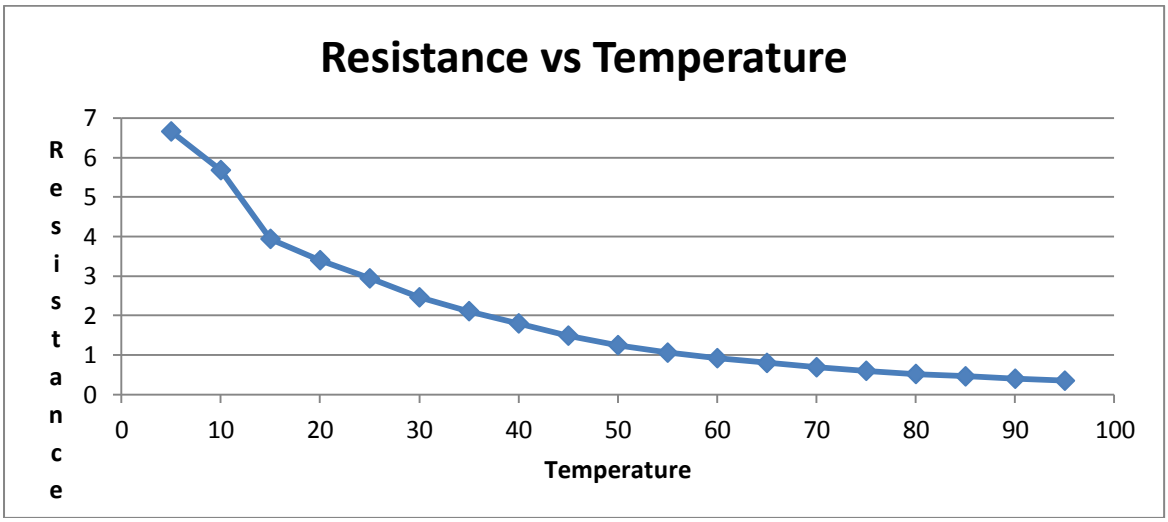

Figure 4 Graph of Resistance vs Temperature for TH1 Thermistor

6. RESULTS AND DISCUSSION

Fig. 4 shows the data acquisition values on the eight channels captured. The interval of acquisition is set. The channels had been previously calibrated for the highest signal level to correspond to 5V and the lowest to 0V, for example, in the case of temperature, 100^0C corresponds to 5V and for an 8 bit ADC it corresponds to 11111111 or a high on each of the 8 data outputs of the ADC. A reading of say 3V corresponds to (3/5)*255 which equals 153. Converting 153 to binary gives 10011001. For a temperature transducer a reading of 3V will correspond to (3/5)*100^0C = 60^0C. The GUI has been configured and tested with four of the eight channels, the acquired channels' values are displayed in millivolt.

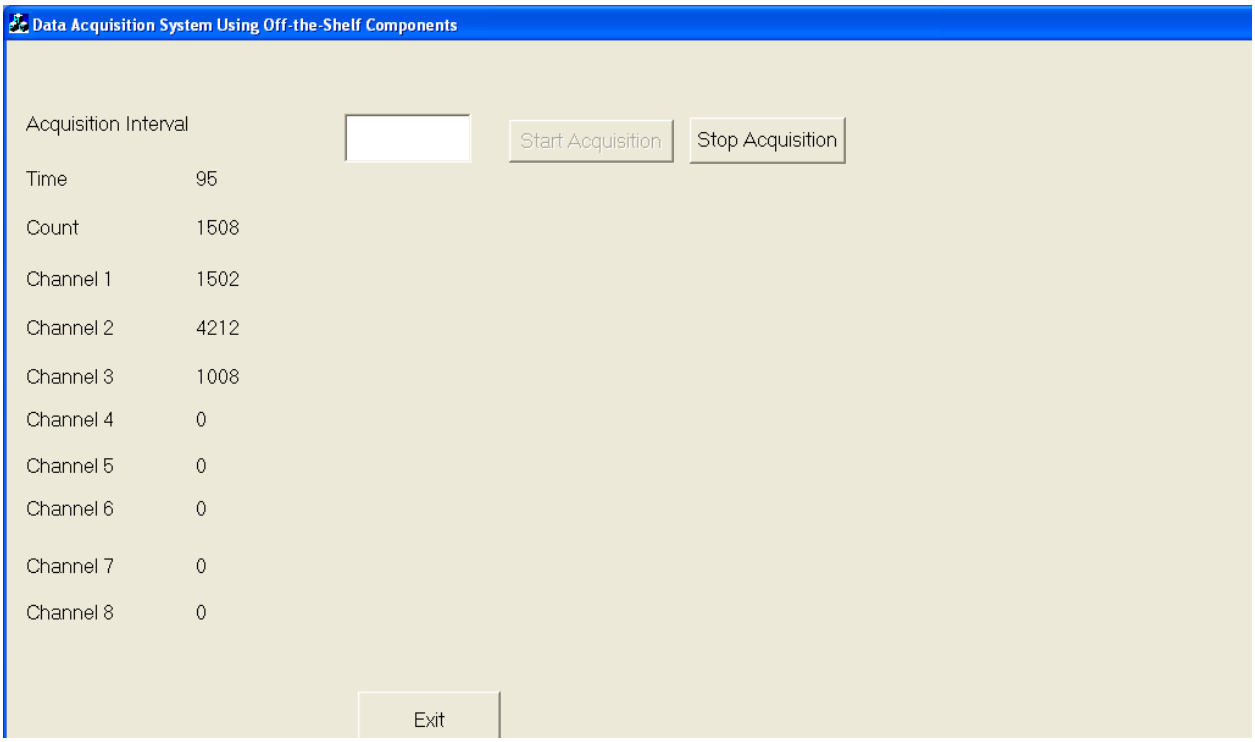

Figure 4 GUI for data acquisition

The device is capable of measuring various real time variables. The variables measured had previously been calibrated so that they maximum value corresponds to a voltage of 5V before getting to the ADC. The measured data were verified with digital meters attached during the test. The designed data acquisition system could meet the goal of providing real time data on temperature monitoring. The device can also be used in other industries, mining defense and bio-medical applications.

7. CONCLUSION

In this design work, hardware and software architecture for data acquisition system using off-the-shelf components has been designed and implemented. The developed prototype is capable to monitor temperature and it has the advantage of low cost and high accuracy. The designed system could meet the goal of providing real-time data acquisition on temperature monitoring.

8. REFERENCES

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