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Low Cost Data Acquisition System for Students

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***Abstract*— Today the engineering education in India is increasing, so the demand of quality projects and quality research at the students level is also increasing. To make good hardware projects most of the time we need to acquire real time data. This acquisition is done through the dedicated device which is called Data Acquisition Device. In India there are very less no. of companies which are making the Data Acquisition Devices and the available devices are very costly for the students. Hence, there is need to provide students a cost effective or low cost device which can suite according to their proposed work. In this paper we have designed and implemented a prototype of Data Acquisition Device (DAQ) using AVR microcontroller. The software for the DAQ device has been mode on MATLAB and LabView and the device has been tested for different tasks and under different conditions.**

Keywords- Data Acquisition Device; MATLAB; LabView; AVR microcontroller

I. INTRODUCTION

In the present scenario, there is lot of scope of technical education and many students are also going towards engineering field. As hardware equipment require a lot of investment but due to lack of investment colleges are not able to provide practical oriented education or quality education to their students which in turns reduce their knowledge about hardware. This situation creates a big question mark on the employability of the students as core companies think that students don't know anything about the hardware on which they work and they have to train them before giving them any project and only on training they have to invest a lot. Hence there is a big difference between the knowledge of students and the requirements of the company. This difference arises due to the high cost of hardware equipments which can be used by colleges to train the students.

Like any other hardware devices data acquisition device is also important at college and as well as industry level. DAQ devices[2-3] are used to send the information from real world to the computer. DAQ device converts the analog signal and send it to the computer for the data manipulation. DAQ device interfaced with good software can show the variation of the analog quantity with varying parameters. Software can also be used for implementing any algorithm and this algorithm together with the suitable hardware device can be used to implement sophisticated applications. Hence this can be used for teaching the basic science concepts by showing practically the variation of any quantity like current variation with voltage, LDR response, strain gauge response etc. and it can also be used in various small students' projects like monitoring and controlling some physical quantity and an associated process with that physical parameter. There are lot of DAQ devices available in the market from different vendors like National Instruments, Dr DAQ etc. but the cost of these devices varies starting from 15,000 INR to 3,00,000 INR [1], which can not be afforded by the students.

The goal of this paper is to provide the basic idea of making of data acquisition device which can be interfaced easily with the well-known softwares like Matlab, LabView, and Visual Basic etc. The proposed DAQ device is very useful for the application where input signal does not vary rapidly, like temperature monitoring, level monitoring etc. Hence this device can easily be used by the college students for their projects and it also provide a good platform for the students on which they can see their theory concepts converting into practical one.

In this paper we have designed and made a data acquisition device (DAQ) using the AVR atmega 8 microcontroller. This device sends the digitized information to the computer via serial communication using RS232 protocol. The software for the data acquisition is made on Matlab and LabView. We have tested this device for various applications like temperature monitoring, level monitoring, LDR response monitoring etc. under different conditions. The repeatability of the hardware is also tested and it shows very good results.

II. ARCHITECTURE OF DAQ DEVICE

Data Acquisition Device mainly consists of sample and hold circuit, digital to analog converter, USART module and a RS232 connector. Description of every block is given below. The block diagram of the architecture of DAQ device is shown in the figure 1. Explanation of each block in the block diagram is given below.

A. Sample and Hold Circuit

The main function of sample and hold circuit is to sample the incoming signal. The sampling frequency of the circuit should be such so that it follows the nyquist criteria of the sampling theorem.

B. Analog to Digital Converter

Analog to Digital converter is used to convert the analog voltage into digital sequence. Analog to Digital converter took the instantaneous voltage value from the sample and hold circuit and converts it to the appropriate digital sequence depending the reference voltage.

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Successive approximation type A/D converter is widely used in the A/D converter.

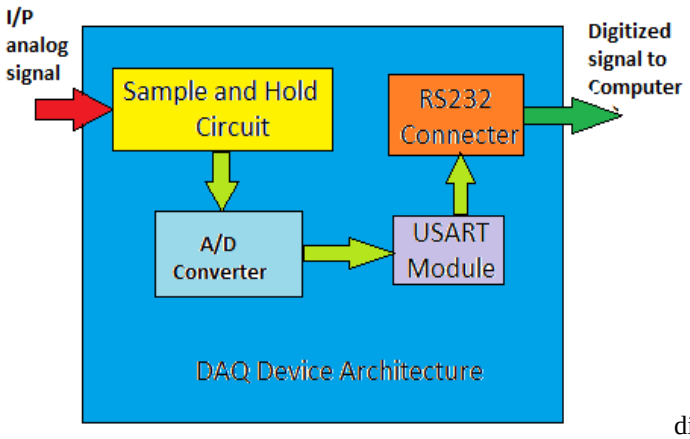

Fig.1: Architecture of DAQ Device

C. *USART*

USART stands for universal synchronous asynchronous receiver transmitter. It is inbuilt unit under the microcontroller and it is used to transfer the signal serially to the computer. It took the digital sequence from the A/D converter and according the baud rate specification it transfers the data to the computer.

D. *RS232 Connector*

RS232 is a protocol which is used to transfer the data serially between two devices. RS232 connector is used to connect the RS232 cable to the computer serial port. Output of the microcontroller USART module connects to the MAX232 IC and output of this IC goes to the RS232 connector. MAX232 IC is used to make the microcontroller output compatible to the computer input.

When we connect the RS232 cable to the computer port, operating system of the computer assigns a port no. to that port. This port no. is further used in the program to identify from which port serial data is coming.

The Baud rate of the DAQ device and the computer should be same otherwise wrong data will be read by the computer. The implemented DAQ device works on 4800 baud rate. The same baud rate should be provided in the software.

III. DAQ Device Hardware

We made this DAQ hardware on the AVR microcontroller platform. We use the atmega 8 [4] microcontroller of the AVR microcontroller series. Technical specifications of the AVR microcontroller are given below:

- Operating Voltages
  - 2.7 - 5.5V (ATmega8L)
  - 4.5 - 5.5V (ATmega8)
- Speed Grades
  - 0 - 8 MHz (ATmega8L)
  - 0 - 16 MHz (ATmega8)
- Power Consumption at 4 Mhz, 3V, 25°C
  - Active: 3.6 mA
  - Idle Mode: 1.0 mA
  - Power-down Mode: 0.5 µA
- Peripheral Features
  - 6-channel ADC in PDIP package. Six Channels 10-bit Accuracy
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
- High Endurance Non-volatile Memory segments
  - 8K Bytes of In-System Self-programmable Flash program memory
  - 512 Bytes EEPROM
  - 1K Byte Internal SRAM

AVR microcontroller comes with on chip analog to digital converter and on chip USART module. The baud rate of the USART can be configured by program. For storing the embedded program it has 8K Bytes of on chip flash program memory. Hence this microcontroller is a complete system in itself. We have to just program it according to our requirement. The following figure shows the prototype hardware which is made by us.

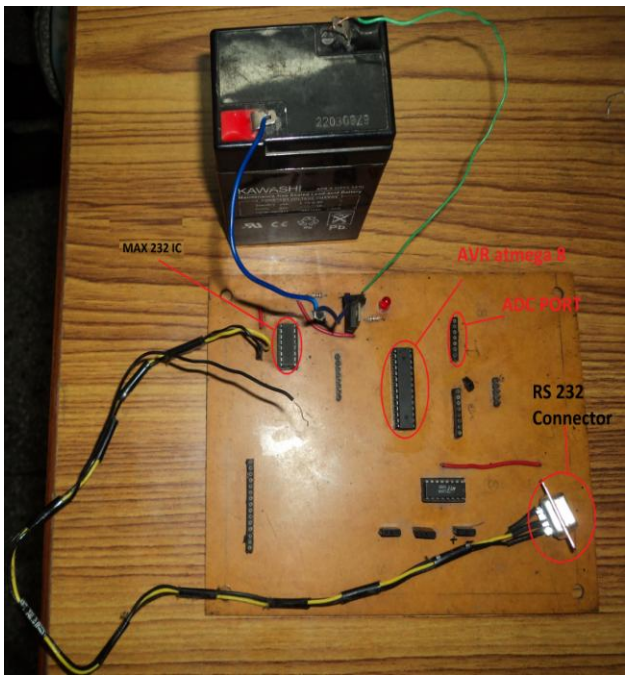

Fig. 2: DAQ Device hardware

Apart from atmega 8 microcontroller IC there is one more IC that is MAX232 [5]. Output of the microcontroller is very low in voltage range. This IC boosts up the microcontroller signal level so that it becomes compatible to the computer.

IV. Software for The DAQ Device

We need a software/program on the computer side to read and display the data. Any computer language like C, C++, and Visual basic etc. can be used for this purpose, but the problem with these languages is they don't provide enough flexibility to the programmer as well as to the user. Students will also be not able to use the data given by the DAQ device for further application. There are also some

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power full tools like Matlab and LabView which provide good user interface and flexibility for the programmer. Moreover further algorithms can be implemented with the help of these softwares too. Hence keeping in mind the requirements of the students we implemented the software/program for reading and displaying the data on the computer coming serially from the DAQ device is made on LabView and Matlab on each.

A. *LabView Program*

LabView is famous for it's easy to use graphical interface and it's well performance ability to work in real time. Displaying the data in LabView is also very easy. The read data from the DAQ device also remain available to the user and can be used for further manipulation or in other algorithm. The following figure shows the front panel made for the data acquisition device.

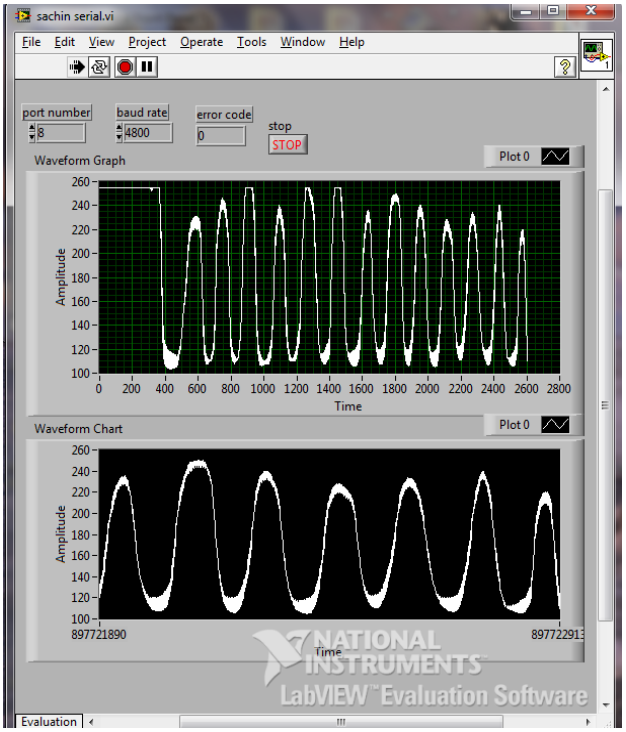

Fig. 3: Front Panel of the DAQ device program in LabView

The waveform showed in this figure is the response of the LDR circuit. When light fall on it, resistance will decrease so the voltage drop across it will also drop. When the light falling on the LDR decrease the resistance of the LDR [6] will increase so the voltage drop across LDR will also increase. This type of waveform as shown in the figure arise due to rapidly decreasing and increasing the light falling on the LDR.

There are two type of plots in the figure, 1st plot (in green) is called graph and it plots the accumulated previous data against the no. of samples. The 2nd plot (black) is called chart and it plots the instantaneous value of the input on running time base. From the figure it is evident that the response of labview is quite good and it provide the best platform for the real time applications.

In figure, above the graph there are three control buttons named as: Port number, Baud rate, Error Code. Controls, port number and baud rate are used to configure the serial port of the computer. We have made the hardware on 4800 baud rate so it should be same every time when we use this hardware. Port no. depends upon the no. provided by the operating system at the time of connecting the RS232 [7] port to the computer serial port. In our case it was port 8. Error code occur when there is misconfiguration in assigning the port no. or in other cases like serial communication driver of labview is not installed. Stop button is used to stop acquiring the signal.

B. *Matlab Program*

Matlab also provide the serial communication interface and it is widely used tool in academics and in research institutes. Matlab is used mainly for simulation purpose and it provides much ease in writing the algorithms. It is a text based development tool and various complex algorithms can be written with much ease. Disadvantage of the Matlab is, it appears to be slow for the real time application, and hence generally Matlab is not used for the real time applications. The following program written in Matlab used to configure the serial port and to display the data.

```
s=serial('COM9');
set(s,'BaudRate',4800);
fopen(s);
k1=0;
for i=1:1000
   a=fread(s,1);
   d=a;
for j=1:8
e(j)=rem(d,2);
d=fix(d/2);
end
f=4.5*(e(8)/2+e(7)/4+e(6)/8+e(5)/16+e(4)/32+e(3)/64+e(2)/128+e(1)/25
6);
   pause(.00001);
     k1(i)=f;
  end
plot(k1);
```

In this program initially we have configured the serial port by making it's baud rate 4800. After reading the digital data from the serial port we have converted that data into its analog equivalent voltage value.

Fig. 4 shows the output of the program. Plot shows the values of the voltages given by the DAQ device serially to the computer. From the figure is also clear that in Matlab we can easily convert our digital data into its corresponding analog value.

In this program too, the read data is available in the array k1, or its instantaneous value can be taken by doing the minor modification in the program. This read data can be used further for any other algorithm or for the decision purpose depending upon the nature of the application. Matlab data acquisition tool box can also be used for this purpose [8].

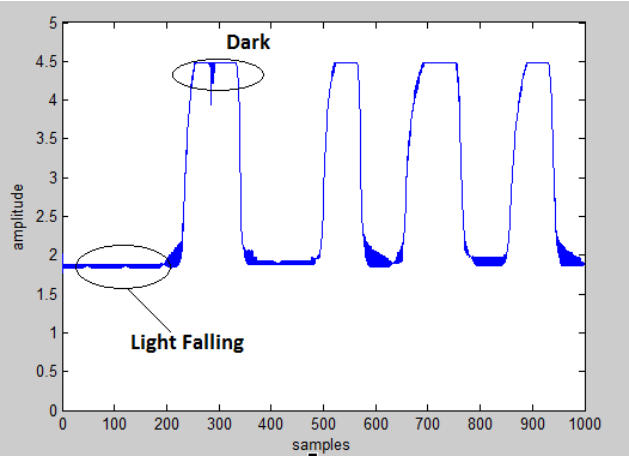

Fig. 4: Matlab response for the same LDR application

V. Cost of The DAQ device

This is the important point that what will be the estimated cost of the proposed prototype of the DAQ device. The total cost of this prototype is given in the following table.

TABLE 1. Component Price

S.No.	Component Name	Quantity	Cost (INR)
1.	AVR microcontroller	1	100
2.	MAX232IC	1	50
3.	RS232 cable	1	150
4.	RS232 Connector	1	25
5.	PCB	1	500
6.	Other electronics	-	200

Total cost of the prototype is 1025 (INR) which is very less and it can be afforded by the students for their projects. After adding various costs and charges it can be available to the students for just 1500 (INR). This can create a revolution for the students who wish to go for hardware cum software projects.

VI. Results

The results of the output of Matlab and Labview have been shown in Fig. 3 and Fig. 4. These show that the device worked satisfactory. We acquired the data for long time and it gives the same results. The repeatability of the hardware is also very good. We tested this hardware for the various other projects like temperature and level monitoring. This hardware gives the same level of satisfactory response for other projects.

VII. Conclusion

A low cost data acquisition device has been implemented and tested under various conditions and for various types of tasks. Response of the device has been checked for different application and it gives satisfactory response for all type of applications. This device can be used for the applications where input signal is not varying rapidly and very precise accuracy is not required. Future works include developing a same low cost device for very precise and fast varying signal applications so that it can also be applied in biomedical engineering [9].

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