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AVR Microcontroller Based Data Acquisition System for Laboratory Experiments

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ABSTRACT

Data acquisition and control system based on AVR microcontroller (Atmega16), for laboratory experiments is presented. This makes use of the built in ADC of the microcontroller and thus the resolution is 10 bits i.e. one part in 1024. In a typical setup the measuring system, under program control keeps on monitoring the voltage or current analogue inputs and makes the digital equivalent available on the selected ports. The controlling program on a PC read this input at pre-decided time intervals. The controlling program reads these values and process accordingly. Microcontroller programs are also developed and tested successfully. The data acquisition system was successfully used to monitor voltage and current during the experiment of growth of fractals. This data acquisition system is also used for other application such as to monitor changes in optical density of chemical solutions to demonstrate its application in Nephlometry. This data acquisition system can be easily be implemented on any real time measuring system in experimentation.

Key Words: Fractal Growth, Data Acquisition system, optical density, Microcontroller.

INTRODUCTION

The research in the field of Microsystems is progressively directed towards smart electronic interfacing [1,2, 3] , which provides the ability of performing complex operations. Specially designed interfacing electronics for specific applications improve the performances of the microsystem and provide a user-friendly environment for the control and the communication with it. Data acquisition system[4 to 7] is extensively employed in a number of automatic test and measuring equipments. They are used to collect the required data from any peripheral input devices, such as meters, sensors and etc. via controlling Program [8]. The measured data could be stored in the PC in a file for further processing if needed. The data i.e. the parameters measured can be shown numerically whereas their relationship can be displayed graphically as a curve on the screen [9].

A microcontroller (Atmega16)-based data acquisition and control system designed, fabricated and tested [10, 11] is presented. The system makes use of printer port in SPP mode for input and output of digital data. The data transfer to the controlling computer was in nibble mode and for 10 bits of data three nibbles are used. The system was redesigned and constructed eliminating finer bugs in the earlier work based on ADC 0809[].

The present data acquisition system makes use of a 10 bit fast ADC available in AVR microcontroller Atmega16. The ATmega16 has 16K bytes of Flash Program, 512 bytes EEPROM and 1K byte SRAM. Three Timer/Counters, Internal and External Interrupts and many more additional resources.

Atmega16 supports 8 input analogue channels for ADC with 10 bit resolution. The data acquisition system presented makes use of two analogue inputs out of which one can be used for sensing the voltage and the other can be used for sensing the current so that the electric resistance of the electrodeposition cell can be found. The system can easily be adopted for additional analogue inputs.

The microcontroller based data acquisition and control unit with two analogue inputs and keeps on sampling voltage and current by monitoring the two analogue inputs I0 and I1. The converted data is sent to Port C and Port D. Port C and D are read by the computer using printer port in SPP mode for ease and convenience keeping in view downward compatibility. The selection of I0 or I1 i.e. voltage or current reading is implemented using a controlling signal via D2 bit of the printer port connected to pin 4 of the D type shell connector of the printer port. This pin is sensed by the micro controller via Port B bit 0. Thus making this pin high or low, the desired input I0 or I1 can be selected through the controlling program.

Details of circuit design and construction are presented and few typical results from the testing of the data acquisition system with the electro deposition system and an optical density measurement are also presented and discussed.

Features of Atmega16

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega16 provides the following features: 16K bytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 512 bytes EEPROM, 1K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the USART, Two-wire interface, A/D Converter, SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next External Interrupt or Hardware Reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping.

The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run. The device is manufactured using Atmel's high density nonvolatile memory technology. The On chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega16 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega16 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger / simulators, in-circuit emulators, and evaluation kits.

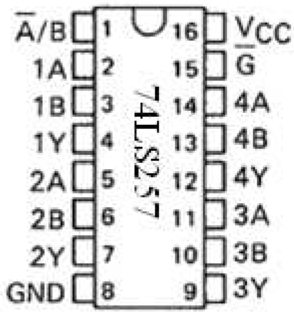
Data Acquisition System Design Considerations:

The data acquisition system was designed basically to monitor two analogue inputs under program control. In view of the downward compatibility, the printer port was used in SPP mode and the data acquisition wad implemented in nibble mode. To improve the precession of the voltage and current measurements, suitable sensing approach was adopted and 10 bit ADC was selected. This was found sufficient as the 10 bit ADC allows for a resolution of 1 part in 1024 which is sufficient for the present application and higher resolutions are not desired.

To reduce the burden on the computer, the data acquisition was constructed using a microcontroller Atmega16 from Atmel Corporation. This microcontroller has a built in Analogue to digital converter with 10 bit resolution and good capabilities. It has 8 analogue input channels so that 8 analogue inputs can be monitored, however in the present application we needed only two analogue inputs and thus used I0 and I1 connected to pin 40 and 39 or Port A i.e. PA0 and PA1.

The micro controller was programmed to keep watching the controlling input pin PB0 of port B, if the pin is low, the input I0 is read, converted and put on Port C and D, else it reads the input I1 and puts the converted data on the respective ports. All the 8 bits of port C are used where as from port D only two bits are used and the remaining bits are not used and hence discarded in the controlling program. The microcontroller continuously monitors the inputs and makes the digitally converted data available on the port C and port D.

For reading in the data by computer, additional circuitry is needed on the data acquisition system for multiplexing. For this purpose we used 74LS257 multiplexer that has tristated outputs.



Pin Digram 74LS257

As two 8 bit ports i.e. Port C and D are to be read, we needed two 74LS257 ICs and two control inputs to decide which nibble of what input are to be read. To this effect we used D0 and D1 bits of the output port connected to pin 2 and 3 of the 26 pin D type shell connector of the printer port. Bit D0 was used for chip select, as the chip select input of the 74LS257 is active low; we used hex inverter 74LS04 to select port D. When the bit D0 is low, port C is selected and when it is high, port D is selected. Bit D1 of printer port (pin 2) is used to select the nibbles, when this pin is low nibble A is selected and when this pin is high upper nibble is selected. The four outputs of the 74LS257 are joined together as on single 4 bit bus as the outputs are tristated and only one chip at a time is selected. Circuit diagram of the data acquisition system with multiplexing part is shown in Fig. 1below.

The 4 bit bus from the 74LS257, the three control signals coming from printer port of controlling computer and its ground connection i.e. 8 pins are brought on a single 8 pin header and a cable was constructed to connect to the 26 pin D type printer port connector on one side and 8 pin header on the other side.

The micro controller based data acquisition system was constructed on a standard AVR board fitted with minimum required system, IC bases, crystal etc and ISP port for in system programming. The circuit was carefully constructed using necessary decoupling and taking care of stray pickups as shown in fig 1 below. The full details of experimental set-up are described elsewhere [12].

A program was developed to implement the controls discussed above in C++ that is supported by AVR GCC using AVR Studio from Atmel Corporation. The program was debugged and assembled. The AVR studio on assembling the program generates a hex file containing the microcontroller code. This code is then downloaded in to the microcontroller using a programmer, we used a USB based ISP programmer for AVR from Extreme Electronics. The programmer is easy to use however has few tricky things to be implemented in order to make it work.

After downloading the program into the microcontroller, it starts running, at times, logical flaws remain and the program needs revision and necessary corrections. It took several repetitions to make it run the way it was expected to. Once the hex code is downloaded to the microcontroller, it functions independently and when connected to the computer, allows for the data transfer via printer port using appropriate controlling program.

We used Visual Basic for the controlling program. A user friendly program was written and tested in visual basic to monitor both the inputs from the microcontroller board. Visual basic does not have instructions to directly access the ports on the computer, to this effect an additional file input32.dll is needed that provides with the instructions for accessing the ports using Visual Basic. The program was successfully tested and the results obtained were found to be in agreement with what is expected. Initially to test the functioning of both the microcontroller board and the VB program on PC, we used two potentiometers at the two analogue inputs of the microcontroller board. The variations of the inputs were found to be in agreement with expected ones. A screenshot showing the variation of the two inputs of the data acquisition system is shown in Fig.3.

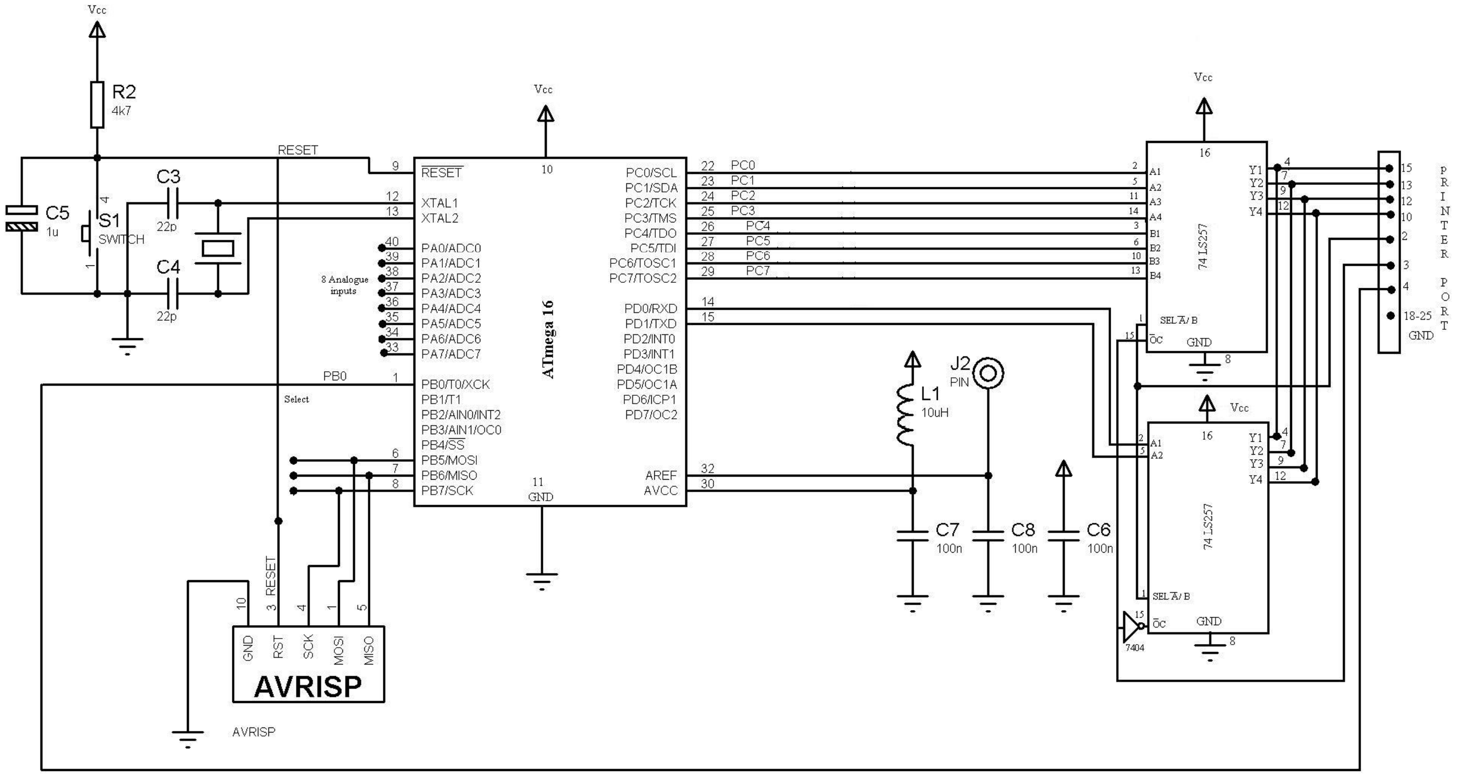


Fig 1 Circuit Diagram of 10 bit Microcontroller Based Data acquisition System

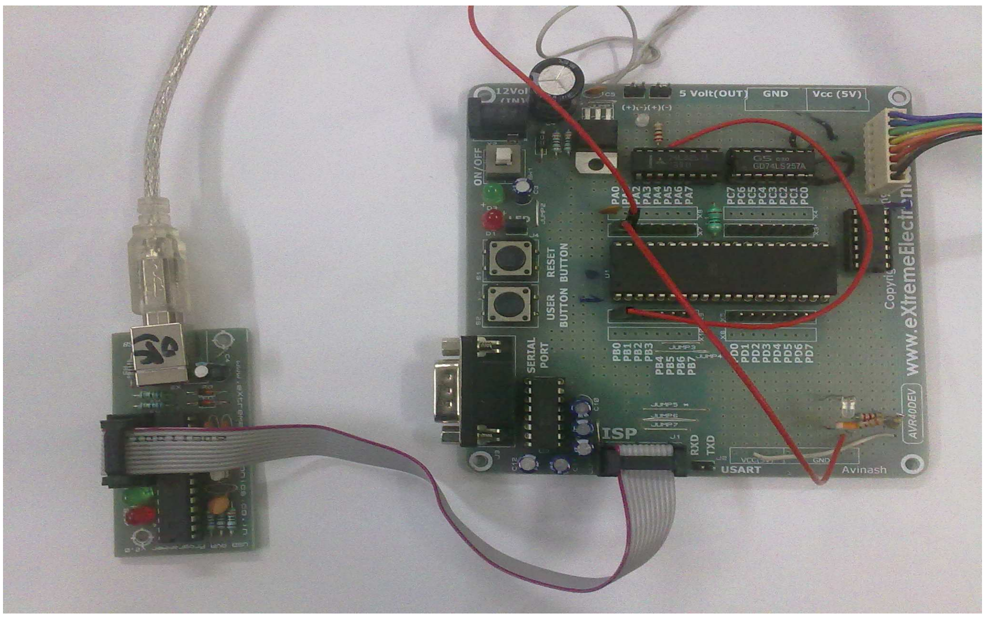


Fig.2 Shows assembled Data Acquisition System along with the AVR ISP programmer.

The changes in the two inputs are arbitrary just by changing the input potentiometers. We also checked the input values using standard meters and compared the same with those measured with the data acquisition system and the values were found to be in excellent agreement.

After having tested the data acquisition system and the controlling program, the system was used to monitor the voltage and current during a fractal growth experiment using electrodeposition [13 to 17]. The voltage across the cell and the current through the cell changes with time and thus the resistance of the electrodeposition cell also change.

A typical plot of change in voltage, current and resistance of the cell is shown in Fig. 4a, b, c.

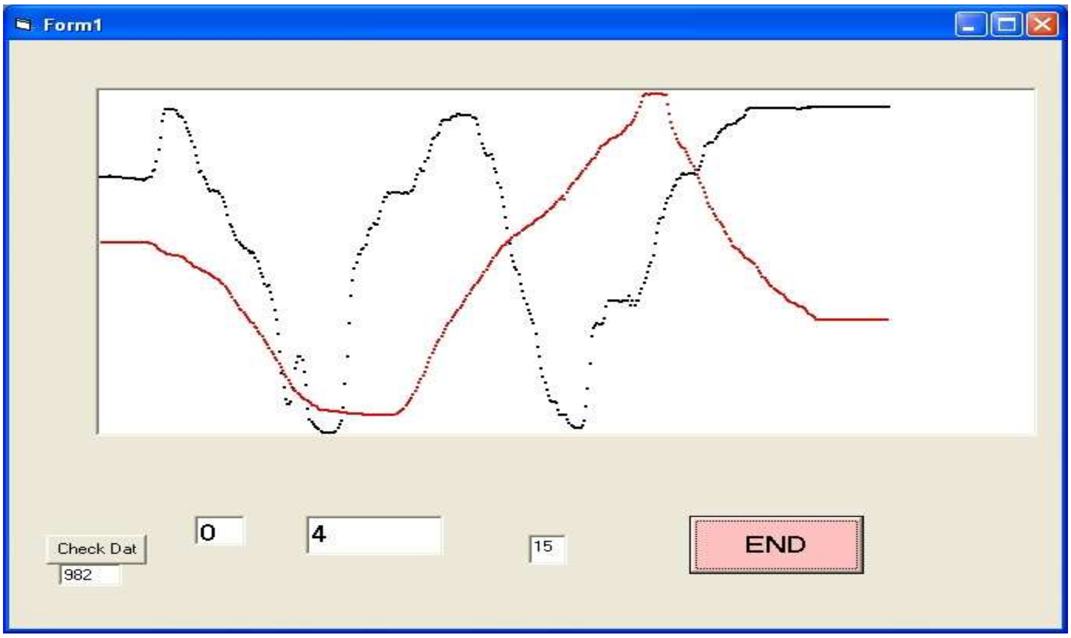


Fig.3. Shows the variation of the two inputs of the data acquisition system

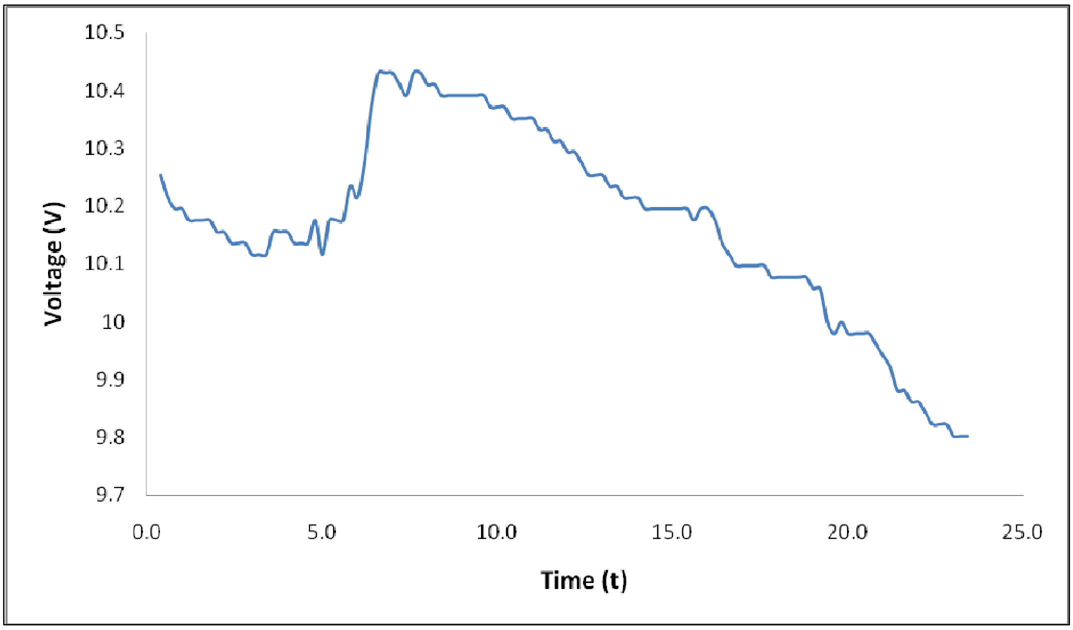


Fig 4a. Showing the plot of voltage with time in minutes.

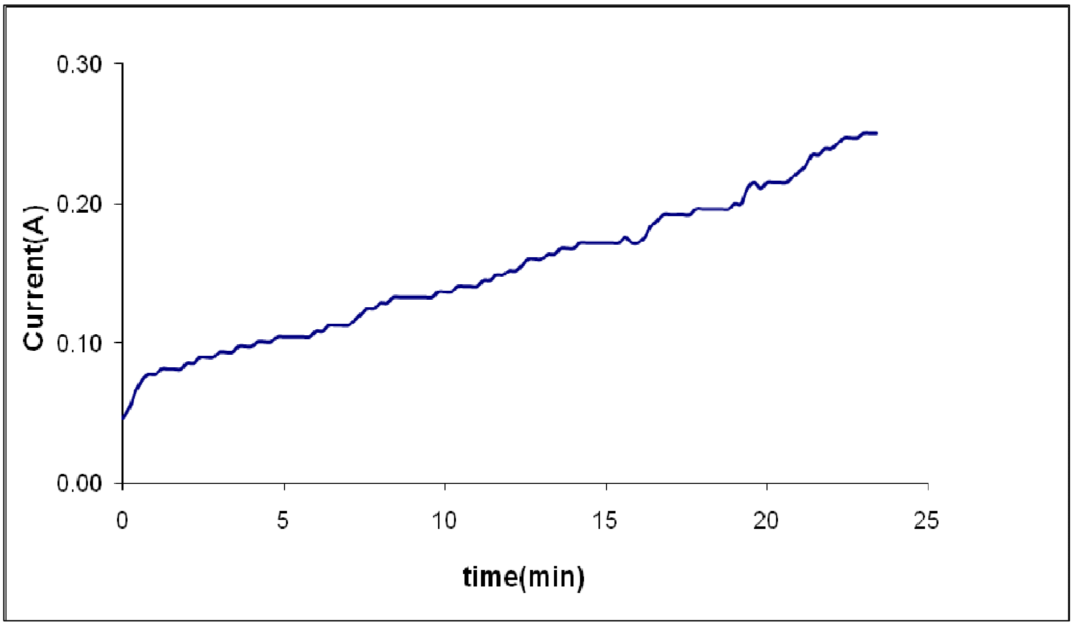


Fig .4b. Showing the plot of current with time in minutes.

The data acquisition system was tested several times in different types of cell operating conditions of fractal growth experiment using electrode position and the working of the data acquisition system was found to be satisfactory. To demonstrate the versatility of the data acquisition system, we used the data acquisition system for the measurement of optical density of chemical solution. A small rectangular glass cell was used to contain the liquid, on one side a light detector was mounted on the other side a source of light was placed. Both the source and detector were covered to avoid stray light from entering in.

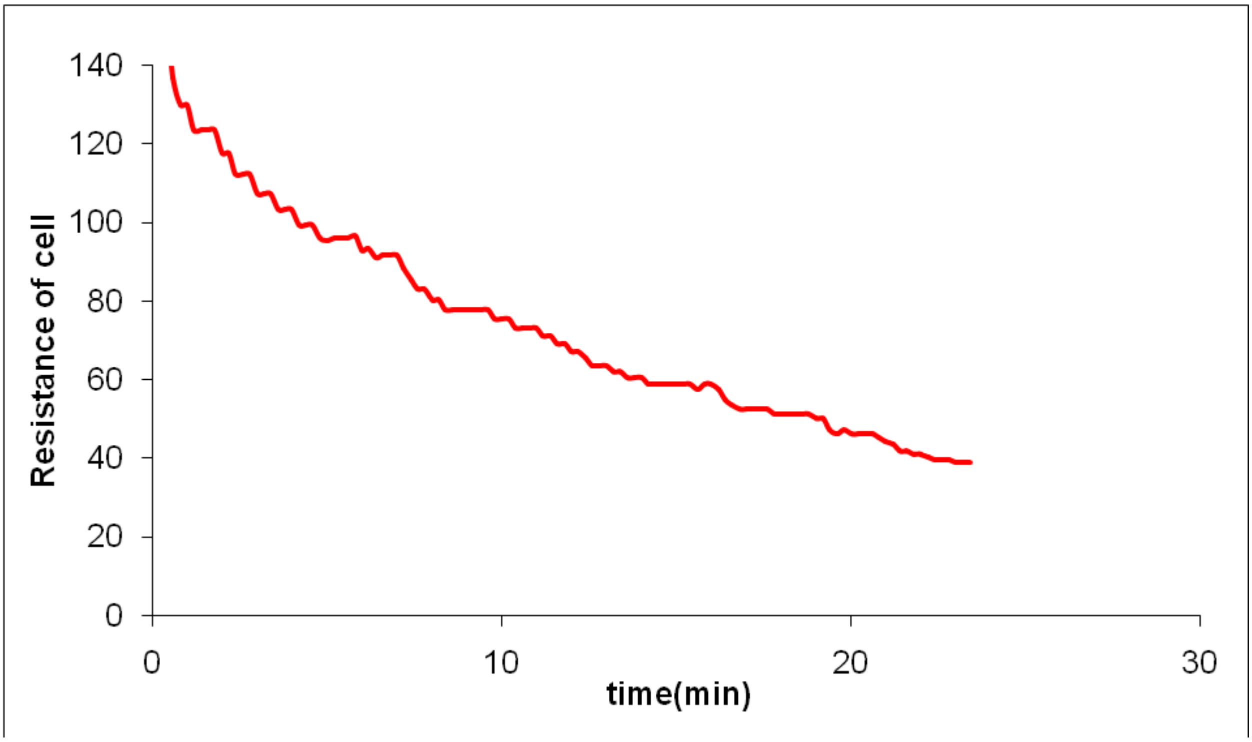


Fig .4c. Showing the plot of resistance of cell with time in minutes.

The change in optical density of the solution was clearly visible as a change in the detected signal. A typical plot of the variation of optical density of solution is shown in fig. 5, the readings are taken at in interval of 50 ms.

It is seen from the above figure that the transmitted intensity of light is low initially due to darkness of the colour of the solution. On standing, with time the colour decreases and finally it turns out to be colourless. When the solution is colourless, the transmission is maximum and thus the reading is 5V and the same continues further.

The intention of this experiment is to suggest possible use of this data acquisition system in chemistry experiments involving instruments like pH meters, conductivity meter or nephlometer. For use with a given experiment the system should first be calibrated to read the appropriate parameters, in some cases additional electronics like preamplifier may also be needed.

RESULTS AND CONCLUSION

The data acquisition system based on a AVR microcontroller Atmega16 from Atmel Corporation is designed, developed and tested. The advantage of using a microcontroller based data acquisition is that the microcontroller has built in (on chip) Analogue to Digital Converter (ADC) with 10 bit resolution (higher resolutions are also available with other microcontrollers). This allows for a measuring accuracy of one part in 1024. Additional advantage is that the measuring system, under program control keeps on monitoring the voltage or current analogue inputs and makes the digital equivalent available on the selected ports. The controlling program can read this input at pre-decided time intervals. This approach substantially reduced the burden on the processor of the controlling program as the ADC is implemented externally.

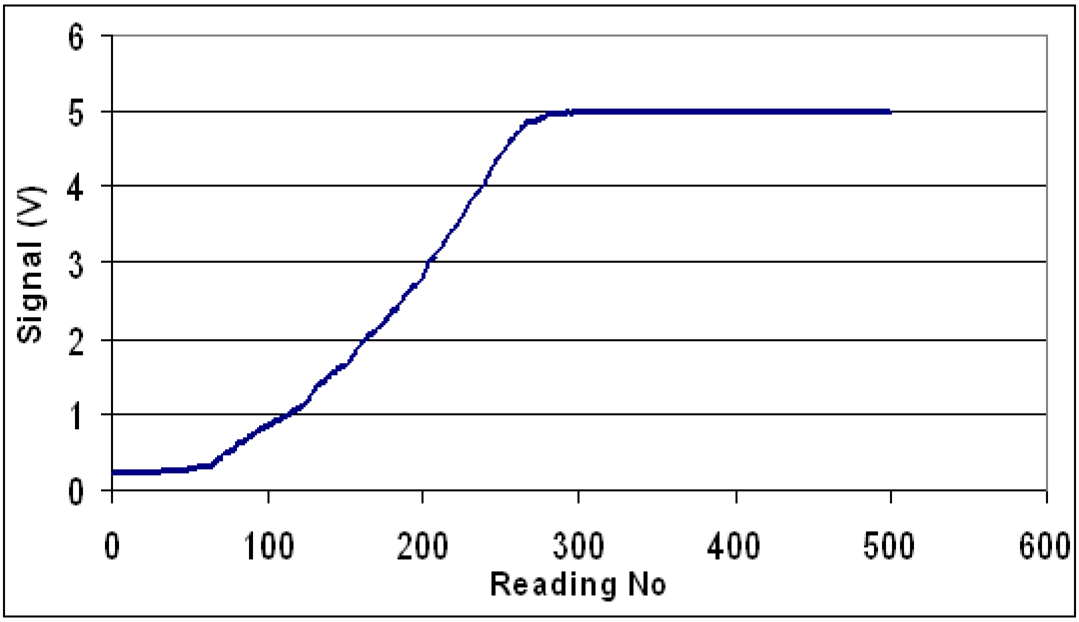


Fig.5. Showing the signal strength as a function of time (or reading number)

The system was constructed using a general purpose low cost AVR development board. Only two analogue input channels were implemented, three control signals from controlling computer were used. Details of circuit and construction are discussed. The results of testing of the data acquisition system are presented as table and plots. The performance of the data acquisition system was found to be satisfactory as per expectations. The system is flexible in design so that it can be adapted to a wide variety of experiments requiring continuous monitoring of several signals under program control.

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REFERENCES

[1] Baroncini M, Placidi P, Cardinali G C, *Scorzoni* A **2003** Sensors and Actuators A 109: 131.
[2] Zhang J and Mason A 2004 IEEE Sensors 2004 (Vienna, Austria, 24-27October **2004**).
[3] Ziad Salem, Ismail Al Kamal, Alaa Al Bashar "A Novel Design of an Industrial Data Acquisition System", Proc. of Int. Conf. on Inf. And Comm. Tech, ICTTA **2006**, : 2589.
[4] Data acquisition '*the technology interface*': *http://www.access.digex.net/~pha*.
[5] Dr R. B. '*Fundamentals of Microprocessors and Microcomputers*'Fifth edition1991 : 311.
[6] A.Peter, *The Electronic Journal for Engineering Technology: pha @eng.morgan.edu*
[7] R. F. Graf '*The encyclopedia of Electronic circuits*' (BPB Publication):(New Delhi) (First Indian Edition) **1989**.
[8] A. Sagahyroon ,T. Al-khudairi, "FPGA Based Acquisition of Sensor Data" Proc. of Int. Conf. on Ind. Tech., ICIT **2004** :1398.
[9] S. Thanee S. Somkuarnpanit and K. Saetang, "FPGA-Based Multi Protocol Data Acquisition System with High Speed USB Interface" Proceedings of the international Multi Conference of Engineers and Computer Scientists **2010** Vol II, IMCES **2010**, 17,Hong Kong
[10] V.G. Sangam , B.M. Patre, *Jl. of Instrum. Soc. of India* **2009** 39(1):30.
[11] P. Asimakopoulos, G. Kaltsas and A. G. Nassiopoulou, 'A microcontroller- based interface circuit for data acquisition and control of a micromechanical thermal flow sensor' Institute of Physics Publishing Journal of Physics: Conference Series 10 (**2005**) 301(http://iopscience.iop.org/1742-6596/10/1/074)
[12] Y. H. Shaikh, A. R. Khan, "Design and Development of Data Acquisition System for Labortary Experiment" Minor Research Project funded by UGC New Delhi Govt of India.
[13]F.Argoul, J.Huth, P. Merzeau, A. Arnrodo , H.L. Swinney, *Physica D* **1993**;62: 170.
[14]Fleury V., Chazalviel J.-N., Rosso M. and Sapoval,B ,*J. Electroanal. Chem.* **1990** ;290: 249.
[15]Microsoft internet Explorer '*Growing Rough pattern in the laboratory: Electrodeposition .htm'*
[16]Mrs. A.G Patil., S.Q.Chisty, A. R.,Khan, M.A.Basit, & S. H.Behere, '*Fractal Growth in copper sulphate solution'*, Proc. Indian Science Congress **2001**, Delhi.
[17] Y. H. Shaikh, A. R. Khan, Patange, K. B., J. M Pathan, S. H. Behere, *International Journal of Artifical Life Research*" Vol II issue I in press.