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A Real-Time Data Acquisition System for Monitoring Sensor Data

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Abstract— A low-cost data acquisition system, for use in sensing applications, is presented here. The system uses Arduino UNO board to implement data acquisition strategy and to interface analog sensor data from signal processing unit, to PC for further processing. A fiber optic loop serves as a sensor for the system. Python programming is used to process the incoming digital data and provide the required graphical-interface. The graphical data provided by the system is stored separately in a spreadsheet, which can be later used for processing and analyzing. The results obtained by the system are linear and stable.

Keywords— Data Acquisition (DAQ) System, Arduino UNO, Universal Serial Bus (USB), Python programming

I. Introduction

In today's world, data acquisition system (DAQ) serves as the bridge between analog and digital environments. DAQs are widely used in a research laboratory for testing and measurements by scientist and engineers, for automation in various areas of industry and so on. Typically, DAQs are systems well-suited for measuring current and voltage signals. The data from the physical world are acquired by sensors or transducers for processing. However, the output signals from these sensors or transducers are needed to be conditioned before it can be acquired by a digital environment for further processing [1]. In view of the wide variety of signals and parameters that can be sampled and stored, DAQ involves many techniques and skills. There are many different components to a DAQ including sensors, communication links, signal processors, computers, databases, data acquisition software, etc. All these components have to operate together to make a successful DAQ [2]. In the literature, DAQs based on various architecture are discussed. To mention a few, a simple embedded system based DAQ is discussed in [3] and a web-based DAQ system was reported in [4]. Another one, based on Arduino application in [5] describes a DAQ as a general acquisition system to study the principal characteristics of low-frequency applications for environmental studies. Also in [6], an Arduino based low-cost data-logger system is designed for monitoring PV

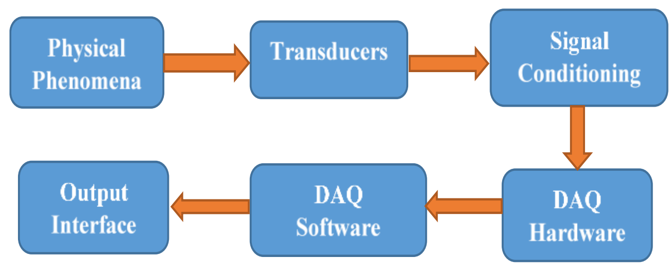


Figure 1: Block Diagram of a DAQ System

system. The one in [7] describes the same type for coastal applications and in [8] for automobile application. DAQs are application specific. Different type of DAQs require different customization. The present work focusses on a real-time DAQ for monitoring continuous data from a sensor, using Arduino and python programming. Figure 1 shows the basic block diagram of a DAQ with its elemental blocks. The rest of the paper is organised as such: the proposed system is described in Section II, followed by experimental details in Section III. Finally, the results and discussion are described in Section IV with the conclusion in Section V.

II. The Proposed Method

The proposed method is described by a block diagram shown in figure 2. It mainly consists of a sensing unit, followed by a signal processing unit (SPU). The output of the SPU is then converted to digital form for further processing, by an Arduino UNO Development Board (AUDB). The output from AUDB is sent to PC through serial port for real-time monitoring and display. The different stages of the proposed system are briefly discussed below:

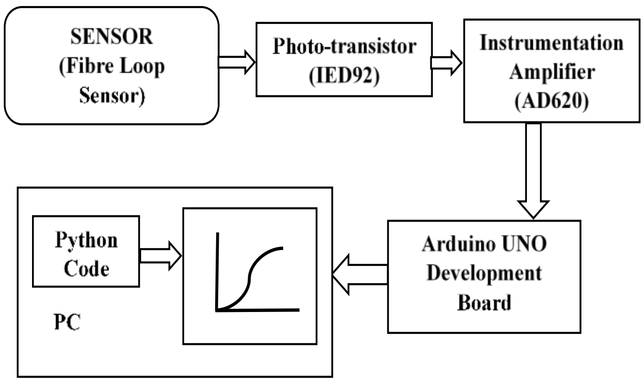


Fig 2: Block Diagram of a the proposed DAQ System

A. Sensing

A fiber loop is used as a sensor to measure volume of liquid collected in a beaker attached to it. A plastic fiber optic red LED (IFE91A) is used to illuminate the fiber. IFE91A is a high output medium speed infrared LED in a ‘connector-less’ package suitable for optical fiber applications. The sensing system is so arranged that when the beaker is empty, the fiber loop is stable and it corresponds to maximum output voltage at the detector end. When the beaker is gradually filled with liquid drops, the weight of the liquid and beaker changes the shape of the fiber loop from circular to elliptical, and the output voltage starts dropping. The change in the output voltage is measured by a photo-transistor (IFD92) compatible for fiber optic applications.

B. Signal Processing Unit (SPU)

The output from the photo-transistor is applied to a signal conditioning circuit for further processing. The signal conditioning unit consists mainly of an Instrumentation Amplifier (IA) AD620. It is a low cost, high accuracy IA that requires only one resistor to set the gain of the output from around 1 to 10,000. It has two inputs: one inverting and the other non-inverting. The IA amplifies the differential input voltage applied to those pins. In the proposed system, a value of 560Ω is used between the gain pins and hence it amplifies the detected output of the phototransistor by a gain of around 89 and then sends it to the AUDB. A ±15V supply is used to power the circuit.

C. Arduino UNO Development Board (AUDB)

Arduino is a microcontroller (µC) based board which serves as a physical computing platform. It uses ATmega328 and has its own development environment to create software for the board. It has fourteen (14) digital input/output pins, out of which six (6) can be used as pulse width modulation (PWM) outputs and a pair of serial transmission pins. In addition to this, it also has six (6) analog inputs, marked as A0 to A5 in the board. Each analog inputs offers a resolution of 10 bits giving a resolution of 4.88 mV for operating voltage of 5V. A 16 MHz crystal oscillator supplies the desired frequency to the controller. Besides these, it also consists of a power jack, an In Circuit Serial Programming (ICSP) header, and a reset button. It is powered via a USB port or with an

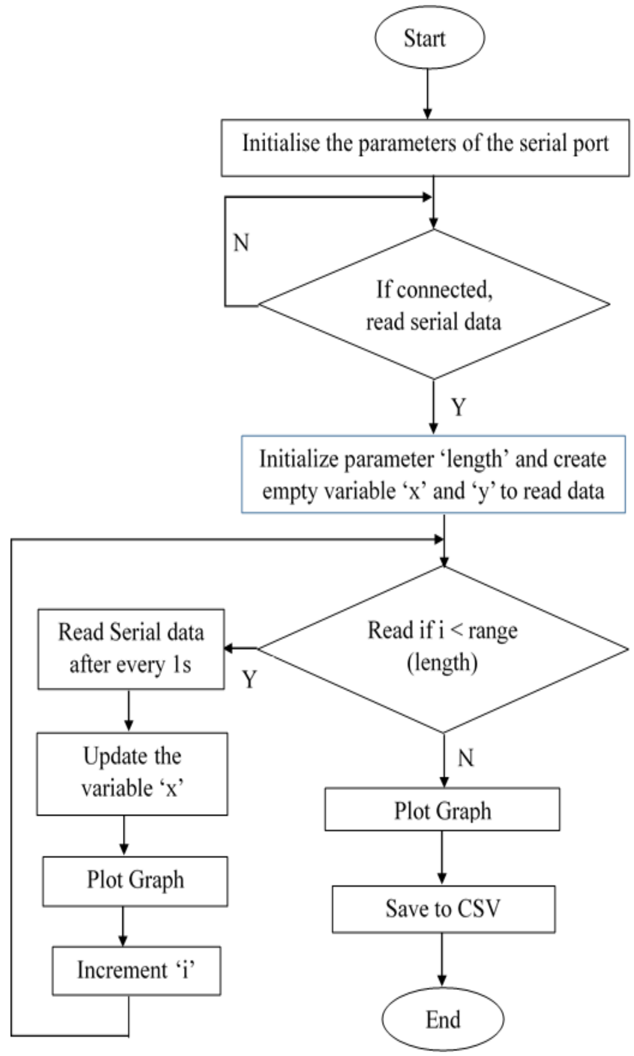


Figure 3: Flow Chart of the DAQ program

external power supply of 5V. It provides good reliability and durability even when it is used in hostile environments [9]. For the proposed system, A0 is used for the analog input in the voltage range of 0 to 5V.

D. PC Interface

The digital output from AUDB is transferred to PC through the USB port. In order to monitor and display the incoming serial data on PC, a python code is run on the PC. Python is a general purpose, interactive, interpreted, object-oriented and high-level programming language that offers easy handling of complex data structures [10]. Figure 3 shows the flowchart of the application program to control the DAQ.

III. EXPERIMENTAL DETAILS

The experimentation of the proposed DAQ is carried out on a fibre-loop sensing system for measuring volume of liquid sample collected on a beaker. Five different liquid concentration of water and glycerol, along with pure water are taken as samples. A table for the liquid samples along with its concentration and density is shown in Table 1 and a snapshot of the experimental setup is shown in figure 4. At a time, a particular liquid of a definite concentration is allowed to fall in drops for a fixed time interval to a plastic lightweight container hanged from the optical fibre loop. As the liquid fills up the container, the fibre loop deforms to an elliptical shape depending on the weight of liquid. This results to change in output voltage of the photo-transistor. As we know that the IA amplifies the differential input voltage, the sensor output is applied to the inverting terminal of the IA and a constant reference voltage is applied to the non-inverting terminal of the IA. Therefore, when the output of the photo-transistor drops gradually with time, an increasing output voltage is obtained at the final stage. This continuous change in the output voltage is recorded by the DAQ and displayed on the PC screen. The value recorded by the DAQ is also saved in CSV file separately by the algorithm so that it can further use for post-processing. For each sample, 3 sets of readings are taken to verify the precision of the proposed DAQ. Again each sample is monitored for five different time intervals of 60s, 90s, 120, 150s and 180s.

TABLE I. CONCENTRATION AND DENSITY OF LIQUID SAMPLES

Liquid Samples	Concentration (in mL)		Density (in g/mL)
	Water	*Glycerine*	
S1	100	0	0.996
S2	85	15	1.039
S3	75	25	1.069
S4	50	50	1.138
S5	30	70	1.189
S6	10	90	1.235

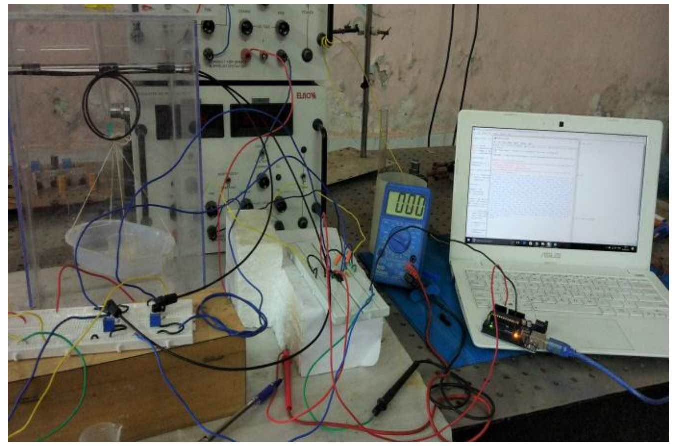
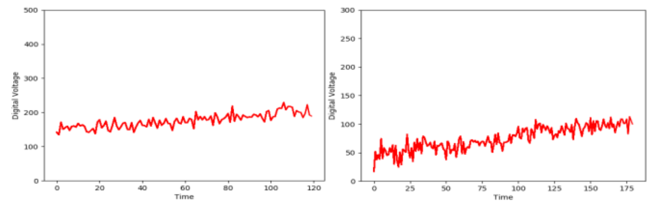
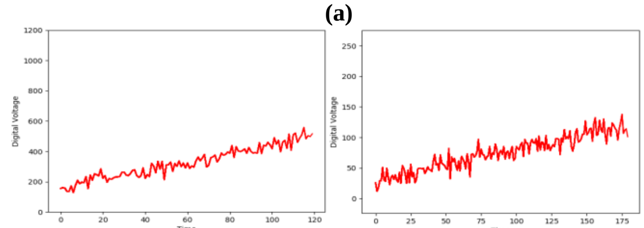


Figure 4: Experimental setup of the proposed system



(a)



(b)

Figure 5 (a) & (b): Recorded raw output real-time data of the DAQ system for two samples of liquids for two different time intervals of 120s and 180s.

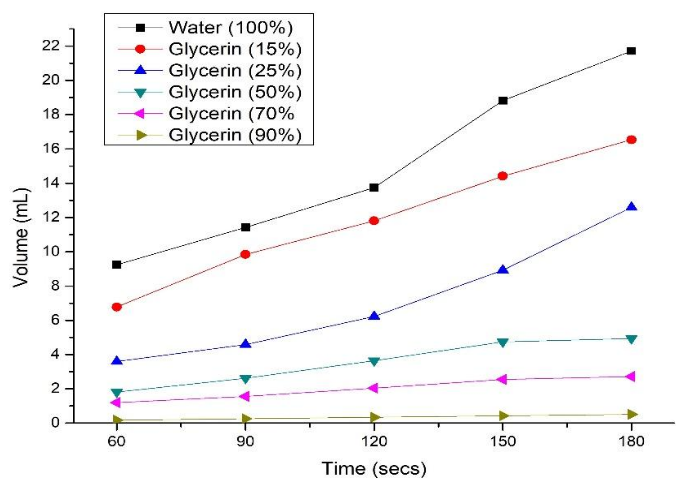


Figure 6: The overall smoothed curves for the observed readings for different types of liquid at different time intervals.

IV. RESULTS AND DISCUSSION

The DAQ generates a series of curves for all the liquid samples for different time interval. Figure 5 (a) shows the recorded raw output data of the proposed DAQ for two different time intervals of 120s and 180s for sample S3. Figure 5 (b) shows the recorded raw output data of the proposed DAQ for the same time intervals of 120s and 180s for sample S4. In this way, a series of data and curves has been generated for all the samples for five different time intervals. Then the raw data, as recorded by the python programming platform as csv files, is post-processed to get a family of smoothed curves on a single plot for all the liquid samples as shown in figure 6. It is observed from the curves that with an increase in weight of the liquid in the beaker, the deflection of the fibre optic loop is more. As a result, the output voltage obtained at the detector is increasing with time for an increased volume of liquid. It can be also noticed that the slope of the curve is decreasing with increase in liquid density of the samples.

V. CONCLUSION AND FUTURE SCOPE

A DAQ based on Arduino Platform with python programming is reported here. The data loggers available in the market, are too costly and limited to only monitor the data. Here the operation involves two steps, data monitoring as well as data storing. This concept is implemented through python programming by using Arduino development board and sensor circuits. The DAQ developed, also serves the purpose of real-time plotting of collected data. The designed system is much cost effective compared to existing products. This will also reduce errors in measurements as because in many occasion human intervention leads to errors. The designed system consumes very less power, so this is also power efficient. The calibration part of the system is yet to be carried out.

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Authors Profile

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