Low-Cost USB-Based Data-Logger for LVDT Sensor

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Abstract

Data logging with displacement sensor has diverse functionality in scientific fields like robotics, mechanical engineering, civil engineering. Linear (LVDT) sensors are widely used in systems for measuring physical quantities like displacement, force or pressure. Signal conditioning electronics handles the output from the LVDT sensor to produce data of voltage, current proportional to the measurement position of the displacement transducer. Therefore, we can analyze the data to meet our purpose. Using the computational power of PC for analyzing large amount of discrete data is not only more error free but also time saving method. In this paper we are going to describe a developed system consists of PIC18F4550 microcontroller, signal conditioning electronics and Microsoft visual studio. The developed system facilitates a user by providing an interface between LVDT sensor and PC through USB protocol.USB protocol has now became the dominant among other PC interface protocols like serial RS232, parallel, PCI. Firmware was developed with the implementation of Microchip USB framework. C# programming language was used to develop the PC side interface.

Keywords
USB, LVDT, data logger, signal conditioning, PIC Microcontroller.

1. Introduction
In the field of science and engineering data acquisition has very important role. Data logger is the tool being used for the purpose of acquiring data. A data logger consists of three major parts. First of them are Sensors that convert physical parameters to electrical signals. The second one is Signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values. The last one is Analog-to-digital converters, which convert conditioned sensor signals to digital values. Once we get the values or data in digital form we can use the computational power of the computer to make complex analysis which cannot be done as efficiently with bare pen and paper calculation.

There is verity of data logger devices available in the commercial market [National Instruments.(2013)]. However, the price and affordability has been issues for the researcher .There are some existing problems yet to be solve like sampling rate, diverse compatibility and the cost. Many works have been done against this challenges but the tradeoff between the price and quality is always present. In our development process we always focused on the cost factor and compatibility issue for a diverse range of users.

ARM7 kernel Microprocessor S3C44B0X and a kind of Embedded Operating System µC/OS- II had been transplanted to develop a data logging system by another researchers with success [Bao,Y and Jiang.X. (2010)].

ATmega32 microcontroller based data logging system including Software-defined open source USB stack was developed [Lakkoju, N.K. et al, B.S. (2011)]. However, the implementation is far away from reach for users from developing countries like Bangladesh. In our development process we emphasized on the availability of discrete components and their prices. We made a prototype and tested our system successfully .

2. Design Architecture

We developed the system made of three different parts. We designed the circuit for the hardware which will be used to collect data from the inductive linear displacement sensor and generate a output of digital data. Signal conditioning circuit was used to filter the sensor signal to the ADC of core microcontroller. We also developed the firmware using the Microchip USB stack which is a framework for the PIC microcontroller as the core processing unit of our system. A user interface software in the PC side also been developed written it C sharp programming language.

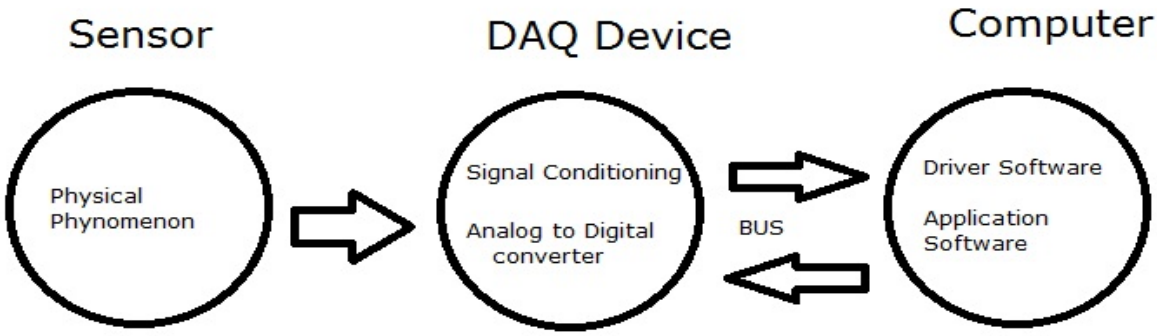

Fig.1: A schematic of the design architecture

2.1 Hardware Design

The Hardware consists of a signal conditioning unit and a microcontroller. The linear displacement of LVDT is represented as voltage from +2.5 to -2.5 volt as output from the sensor. Operational amplifier and voltage level converter IC was used to condition the signal from the sensor and convert it to 0 volt to 5 volt range accordingly. Then we need analog to digital converter to make our analog data to take digital form. After that we need to send the digital data to the bus of PC side interface. We chose PIC18F4550 microcontroller as it serves the dual purpose of analog to digital conversion and interfacing with the PC with its built in USB engine. Therefore ,the hardware construction was done by making the circuit of signal conditioning unit and microcontroller based unit.

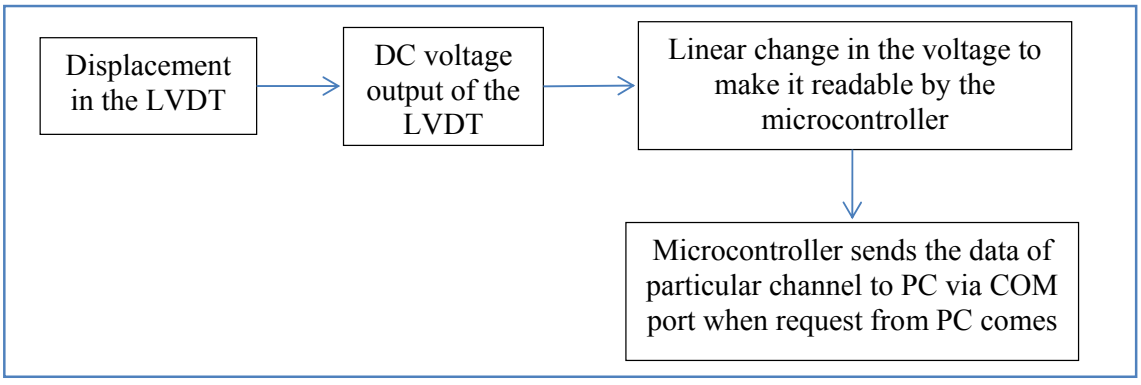

Fig. 2: A circuit diagram of the hardware

2.2 Firmware Design

The design of the firmware was done using Microchip USB stack which is a framework. The USB protocol is very complex comparing to the ancestor protocols of its own type. The development process gets more complex with the driver issue for the operating system running in the target PC. Microchips USB framework makes relief this burning facts. Using the framework it is possible to avoid writing driver software for the operating system. Operating system like Linux, Windows get updated automatically when the USB device gets attached to the PC. The firmware has two functional parts. One part is taking care of the USB communication part from the device to the computer and another part capturing analog data, converting it to digital form and then passing it to the USB bus.

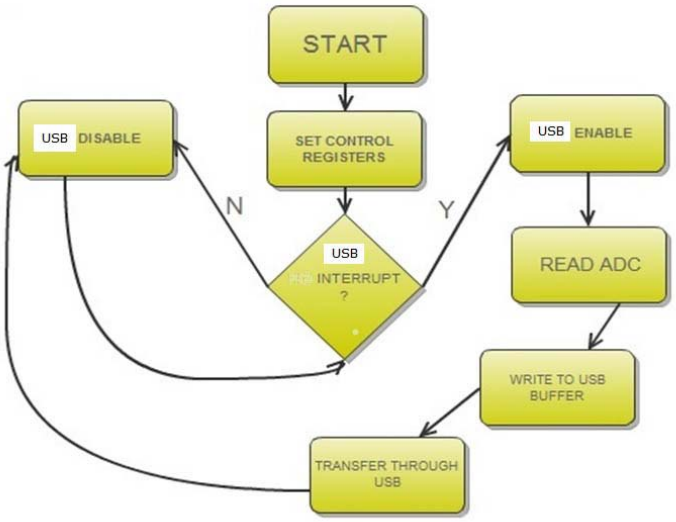

Fig. 3: A schematic of the firmware

2.3 Software Design

The software communicates with the hardware with COM port. It is password protected. When the software is first opened, it requires the proper password for opening.

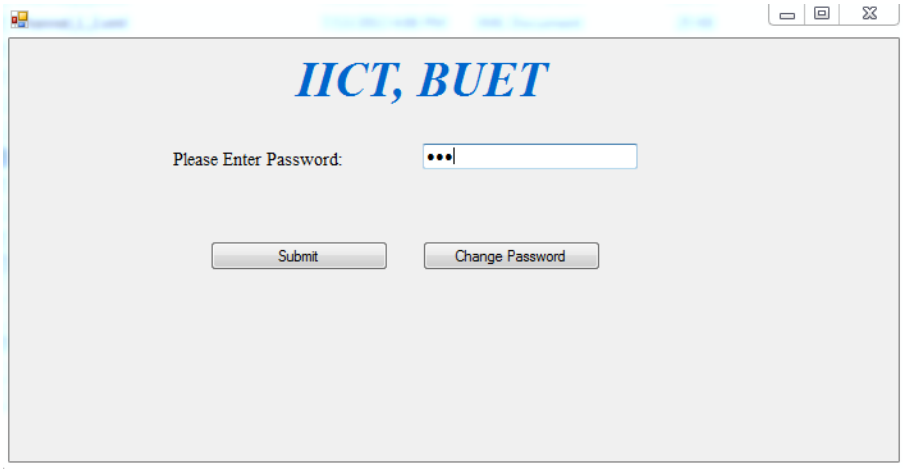

Fig. 4: The software requesting for password

After the GUI (Graphical User Interface of the software) is opened with proper password, the COM port number of the hardware connected to the PC should be entered in the proper text-box. The COM port number of the

hardware can be found from “Control Panel\Hardware and Sound\Devices and Printers” or Device Manager of the PC.

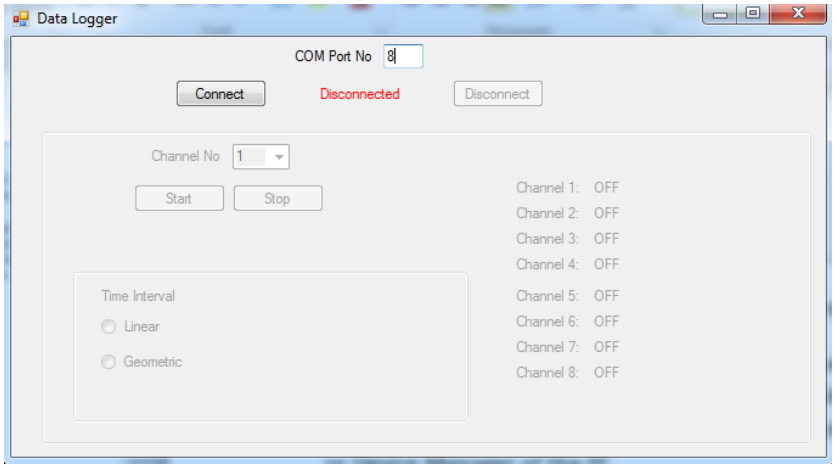

Fig. 5: Entering COM Port No.

Then the “Connect” button should be pressed to connect to the hardware. Then the channel no. of the hardware should be selected. When the channel no. is inserted, the options for time interval section come. The time interval can be either linear or geometric. For linear time interval, the software collects data after regular intervals. For geometric time interval, the time interval varies in geometric progression.

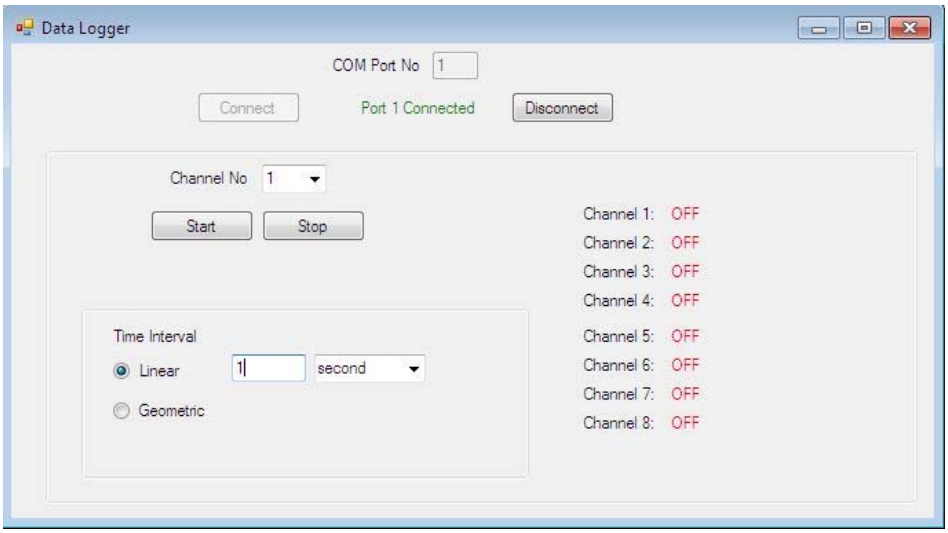

Fig. 6: Linear time interval.

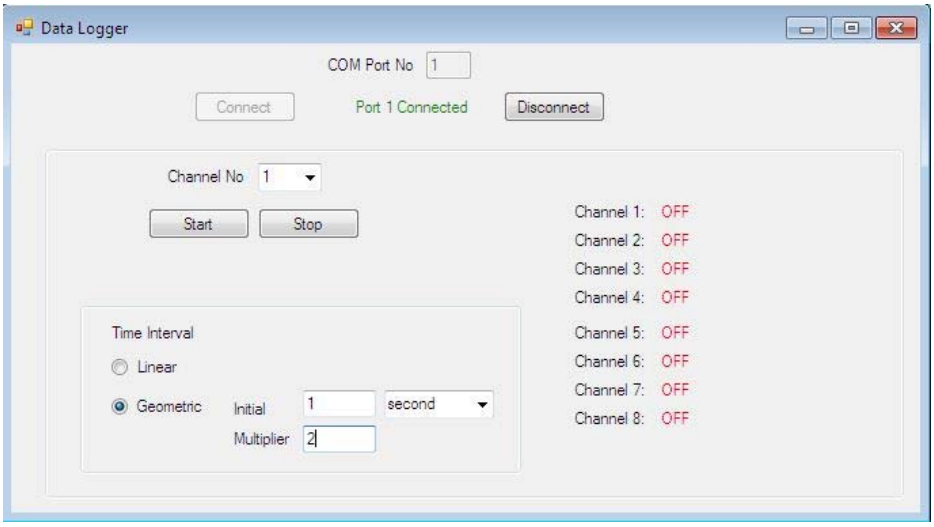

Fig. 7: Geometrically varying time interval.

Then the start button should be pressed. The data logging is started for that channel with the inserted time interval. An xml file containing logged data is produced for the respective channels for which time intervals have been inserted and start buttons are pressed. From the xml file, the data can be taken and plotted if required.

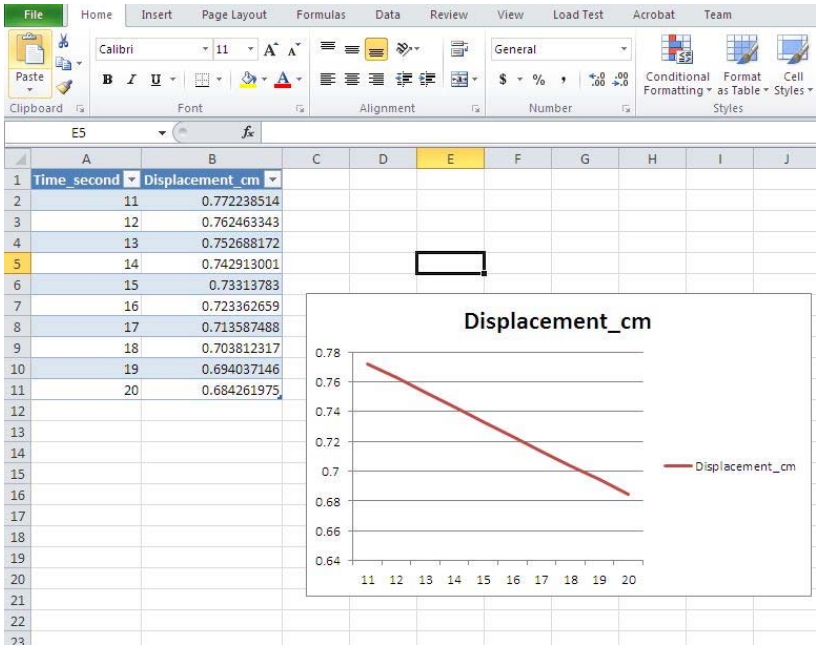

Fig. 8: Xml file opened with MS Excel.

3. Prototype

We developed prototype for checking our hypothetical concept or idea. Three number of operational amplifier IC named LM741 and two number of MAX232 IC was used to convert voltage level. Vero board, single copper wire and hand operated soldering iron was used to make our first prototype. After reconstructing several times and resolving hardware bugs we finally made our first prototype. We provided voltage supply from Lab Power supply unit and connected it to the PC. PC running on windows 7 operating system recognized the device as expected.

4. Conclusion and Future Work

The displacement sensor is useful in various fields of engineering and testing. The described device is a substantially cheap structure for the data logging of the displacement sensor. Therefore by proper finance and marketing, the device may be a potential replacement for present data-loggers of displacement sensors along with being much more cost-effective.

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Biography

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