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LOW COST DATA ACQUISITION SYSTEM FOR TIME RELATIVELY SLOW PHYSICAL EVENTS

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ABSTRACT

Computer interface can be used to make reliable time measurements. This study involves in building a low cost computer based data acquisition (DAQ) system to collect data for time relatively small physical events that can be used in the laboratories. The printer port available in a normal computer has been used to interface computer and the instruments. The results obtained through the interface for all experiments described in this article, shows the accuracy of the instrument with the time measurements of three decimal places for event rates of around 14 Hz. Further, the article describes that the same locally built low cost DAQ system could be used to acquire data not only for one specific experiment but also for similar experiment which involves in time measurements having small physical events.

Key words: Data acquisition system, Interrupt, Computer based laboratory

INTRODUCTION

From the beginning of human life, historical evidence revealed that human has used several tools and has been modified time to time according to his need and for the advancement of his lifestyle. Now he is helpless without them. The computer is an enhanced tool used by human for the last sixty years to do his work efficiently and more conveniently. The computer was originally invented for the purpose of scientific application such as for research in science. However, at present, the application areas are broadening in the field of commercial, engineering application, education, and other including personal usage.

In education, computer has wide variety of uses such as Computer Aided Instruction (CAI), Data acquisition (DAQ) and Automation. CAI mainly concerns the schedule events through computers. DAQ involves in using computers as an intelligent laboratory instruments for the purpose of measurements, recording and analyzing data. Automation is a communication technology to handle the different patterns of work required [1].

This study involves in building a low cost DAQ system that can be used in laboratories for the continuous data acquisition of time relatively small physical events. Furthermore, the same device could be used to acquire data not only for one specific experiment but also for similar experiment described in this paper.

MATERIALS AND METHODS

The computer based DAQ system for an experiment, requires connection from a computer to equipments, through an interface. In this study, the printer port available in a normal computer has been used for interfacing. It should be noted that the interfacing does not involve in any modification on internal circuit of the computer. However, an electronic module proposed by R.O. Ocaya [2], has been built with suitable modification to communicate between the computer and the instruments. This will be discussed below.

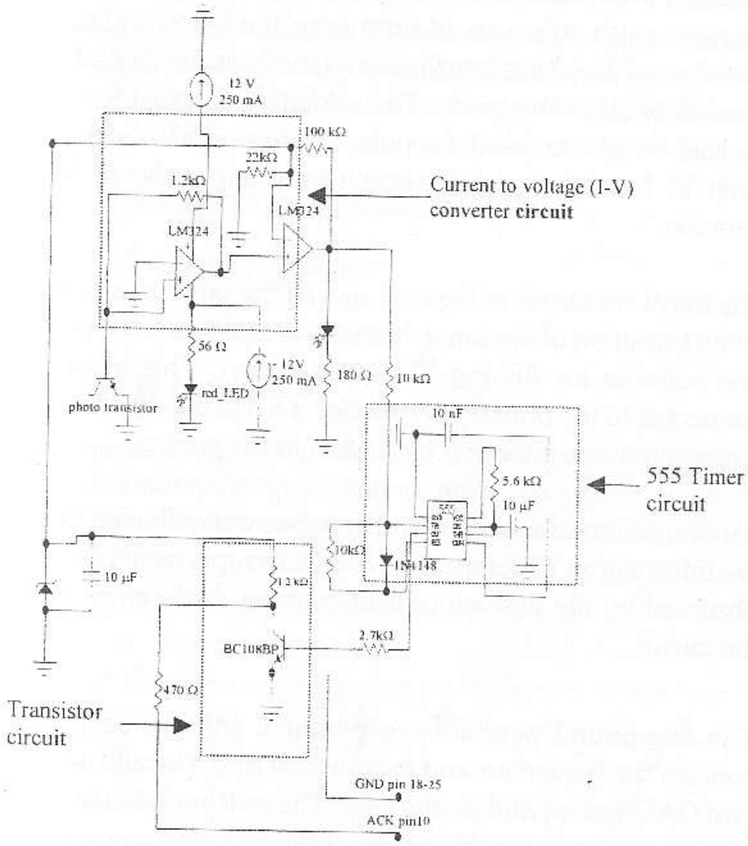

Figure 1: Complete schematic diagram of the Schmitt trigger circuit

Figure1 shows the electronic circuit of the interface called the Schmitt trigger circuit. It works as follows. A beam of light is emitted by the emitter and falls on a photodiode sensor. If a moving object is allowed to move between the emitter and the sensor, then it will blocks the light momentarily while it crossing the light beam. This produces a brief change in the current through the photodiode called the current pulse. The current to voltage (I-V) converter circuit in the Schmitt trigger circuit transforms this current pulses in to a brief voltage pulses. However, this out put still isn't suitable to accept by the computer because it consists of several close spurious pulses. These spurious extra pulses could arise from the light conditions at the edges of the object that fluctuate rapidly as the object begins to cross or leave the beam. The solution employed for this in the said circuit is to stretch the pulse width using 555 monostable timer IC having a negative-going transition pulse of 50 ms duration.

The transistor circuit in Figure 1 inverts the pulse to a positive-going transition of the same duration and converts the pulse to one suitable for driving TTL printer port. This inverter is connected to the printer port through a 470Ω resister that offers a measure of over current protection to the port.

For one oscillation, two interrupts pulses were allowed to send the information to computer. These interrupts were physically observed by the flashing of light-emitting diode employed in the circuit.

The compound pendulum experiment [3] was selected to confirm the behaviour and its accuracy of the locally built low cost DAQ system and its modules. The outcomes of the results were compared with the results obtained using commercially available DAQ (PASCO interface) system and with the standard method practice at the laboratory. Further, two other experiments namely the Katter's pendulum and the Spiral springs were tested using the same locally built DAQ system without any alteration to the modules. These experimental results were also compared with the results obtained by the standard method practice at the laboratory and with the commercially available DAQ (PASCO interface) system.

RESULTS

The results of the following experiments were computed and analysed using the locally built low cost DAQ system and standard packages called Macrocal Origin and Microsoft Excel respectively.

1. Compound pendulum
2. Katter's pendulum
3. Spiral springs

Compound pendulum

The Figure2 shows the variation observed in average period computed using the time taken to make 25 oscillations verses distance in a typical compound pendulum experiment [3].

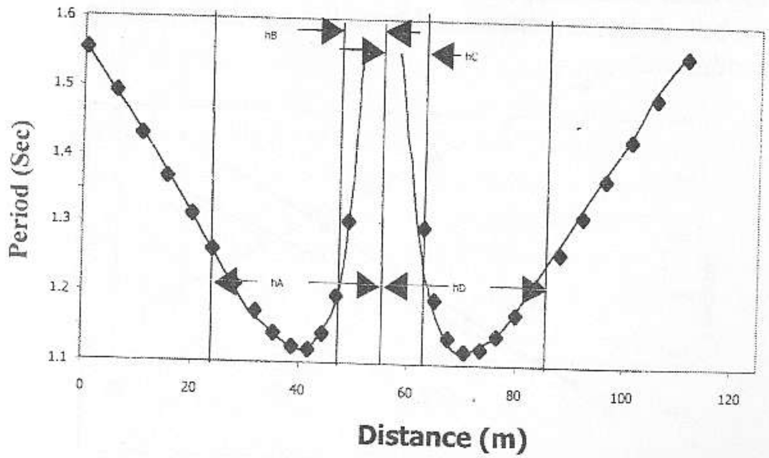

Figure 2: Period Versus Distance

The result shown in the Figure2 is of the form of parabolic and it reflects the equation on period T as a quadratic equation on h described in the standard empirical form given by [3]

$$T = 2\pi\sqrt{\frac{K^2 + h^2}{gh}},$$

where h is the distance between centre of gravity and the rotating axis, K is the radius of gyration and g is the gravitational acceleration.

If we draw a horizontal line on this graph for a particular value of T, it gives two values for h as a solution. Using these two solutions for h, the gravitational constant was estimated giving a value as $9.7950 \pm 0.0001 ms^{-2}$.

Katter's pendulum

The Figure 3 shows the variation observed in average period computed using the time taken to make 25 oscillations verses bop distance in a typical kater's pendulum experiment. Where the bob distance is measured from the oscillating centre of the pendulum.

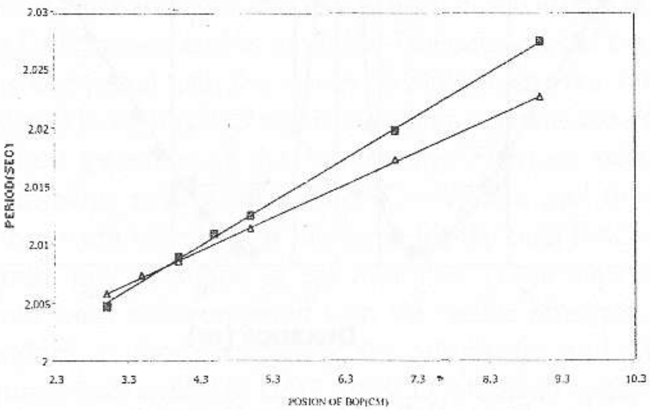

Figure 3: Period VS Bob Position

In Figure3, the rectangular (□) points represents the data when the large bob placed on top of the pendulum, the triangular (□) points in Figure2 represents the data when the small bob placed on top of the pendulum. The both data reflects the fact that the average period varies with the distance linearly. Further, it could be seen in the Figure3 that these two linear variations cross each other at some points. Hence, it shows that there is a common/equal period for these two different oscillations. Using these two results and the standard Keter's pendulum empirical equation[3], the gravitational acceleration was estimated as $9.7800 \pm 0.00001\ ms^{-2}$.

Spiral spring

Figure 4 shows the square of the average period taken for 25 oscillations versus square of the distance for the horizontal oscillation of the rod attached to the spiral spring in a typical spiral spring experiment[3]. Where the distance is measured horizontally from the spring to the attached mass.

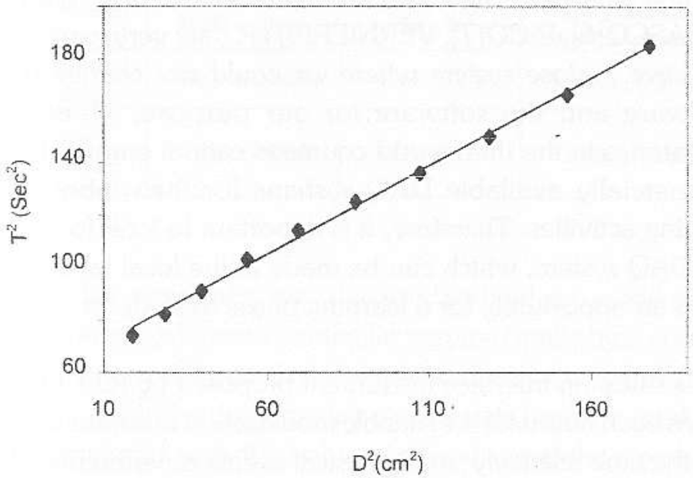

Figure 4: Time square versus Distance square

The motion of the horizontal oscillation of the attached rod to the spiral spring is given by the equation

$$T^2 = \frac{32\pi^2}{Yr} NR\left[I_0 + 2m_0 D^2\right],$$

where N is the number of turns in the spring, R is the radius of a turn of the spring, m_0 is the attached mass to the rod, r is the radius of the spring wire, Y is the young modulus of the material of the spring and I_0 is the moment of Inertia of the attached rod related to its centre. The Figure 4 shows the linear variation of the square of the period verses square of the distance obeying the above equation of motion. Hence, from the gradient, the value for Young modulus of the material was estimated giving a value as $(1.91\pm0.01)\ x10^{11}$ $Kgm^{-1}sec^{-2}$.

DISCUSSION

In present day research and teaching laboratories the computer based DAQ systems are common in use for their research and teaching activities. The commercially available DAQ systems like PASCO[6], PICO[7], VERNIER[8] etc., are very expensive and have a close system where we could not change both hardware and the software for our purpose. Teaching laboratories in the third world countries cannot employ these commercially available DAQ systems for their laboratory teaching activities. Therefore, it is important to look for a low cost DAQ system, which can be made at the local laboratory giving an opportunity for a learning phase to students.

In this study an interface instrument proposed by R.O. Ocaya [2] has been built with the suitable modification to communicate with the time relatively small physical events experiments. This instrument has been tested with the standard experiment called the compound pendulum, which has been initially proposed by R.O. Ocaya and found to be working as we expected. The

Figure 2 shows the typical behavior of the said compound pendulum. The data that we obtained from this experimental result has been analyzed and seen that the experimental value of the gravitational acceleration falls within the acceptable experimental error. The Table 1 shows the results obtained using the locally built DAQ system and the result obtained from the standard manual method using the stopwatch. Comparing these results the accuracy is much higher in the case of using the DAQ system both locally built and the commercially available system than the manual method as expected and the results are very closer to the predicted value 9.81 $msec^{-2}$. The result of the locally built DAQ system is very much closer to the commercial system.

Table 1: The value of acceleration of gravity in $msec^{-2}$ obtained in the Compound pendulum and Ketter's pendulum experiment using different DAQ systems.

Experiment	Using Local DAQ system	Using stop watch	Using commercial DAQ system (PASCO interface)
Compound pendulum	9.7950±0.0001	9.89±0.01	9.8050±0.0001
Katter's pendulum	9.7800±0.0001	9.90±0.01	9.8180±0.0001

Further, the same instrument was used without any modification to test the fairly different but similar varying small physical event experiment to estimate the Young Modulus of a material, using the typical spiral spring experiment. The data has been analyzed and compared with the value obtained using the stopwatch and the commercially available DAQ system. This is showed in Table 2.

Table 2: The value of the Young Modulus of a material obtained in the typical spiral spring experiment using different DAQ systems.

Experiment	Value of Young modulus ($Kgm^{-1}sec^{-2}$)
Using Local DAQ system	$(1.91\pm0.01)\times10^{11}$
Using stopwatch	$(1.89\pm0.01)\times10^{11}$
Using commercial DAQ system (PASCO interface)	$(2.28\pm0.01)\times10^{11}$

It is interesting to note that the value for Young Modulus obtained using locally built DAQ system is comparable with the value obtained using commercial DAQ system. Also these values are closer to the theoretical value 2.00×10^{11} $Kgm^{-1}sec^{-2}$.

The above results indicate that the instrument built locally is reliable and can be used to demonstrate or employed for experimental session to investigate the time relatively small events at the universities or even at the secondary schools laboratories.

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