2006-394: LABVIEW GRAPHICAL PROGRAMMING IN AN INTRODUCTORY ENGINEERING PHYSICS COURSE

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LabVIEW graphical programming in an introductory engineering physics course

Abstract

LabVIEW graphical programming is used at the introductory engineering physics level to expand the student mindset in an early stage. The virtual instrumentation and computational capabilities are incorporated into the laboratory exercises. The virtual instrumentation serves as a practical equipment simulation tool, especially for those with expensive equipment such as the E/M ratio and fiber optics laboratory exercises. The computational capabilities serves as a powerful numerical simulation tool for assessing uncertainties where closed form mathematical expressions are not available. A few selected LabVIEW programming designs are presented as illustration with additional emphasis on preparing the students for continuing to the upper division courses and for conducting undergraduate research. The role of LabVIEW parallel programming is contrasted with other text oriented languages such as Visual Basic in simple examples such as the virtual instrumentation of light switches. While the LabVIEW data acquisition feature is not taught in this introductory course, its deployment as a software interface certainly streamlines the data collection procedure for the students and adds remote control capability. Furthermore, our campus has student clubs such as the Robotics Club. LabVIEW can serve as an integral part of this kind of extracurricular activity that combines mechanical, electrical and optical engineering principles. Due to the low cost of purchasing a student version, LabVIEW is cost effective in a teaching environment.

I. Introduction

One of the major utilities of an introductory course is to provide for the prerequisite for advancement to advanced courses. The use of LabVIEW in the engineering curriculum for data acquisition and virtual instrument has been well documented [1, 2, 3, 4]. Computation and programming for a lecture setting was also reported [5]. Various independent projects using LabVIEW were well documented in many publications [6, 7, 8, 9, 10, 11, 12]. It is accepted that the use of LabVIEW is invaluable in general but is limited to hands-on intensive situations[13]. Our experience in using LabVIEW in our laser engineering technology program is consistent [14]: LabVIEW's virtual instrumentation and internet remote access features are not effective for hands-on intensive lab exercises.

The teaching of introductory engineering physics lab exercises can be enhanced with LabVIEW. The virtual instrumentation and computational capabilities are incorporated into the laboratory exercises. The virtual instrumentation serves as a practical equipment simulation tool especially for those with expensive equipment such as the E/E ratio and fiber optics laboratory exercises [15]. The very same idea of supplementing expensive lab equipment with virtual instrumentation was reported earlier in the simulation of fire alarm and power station exercises [7, 8]. The computational capabilities serves as a powerful numerical simulation tool for assessing uncertainties where closed form mathematical expressions are not available. In a typical exercise, a student is asked to infer some parameter values from the collected data. Using a simulation to match the collected data is a typical methodology for solving inverse problems. In addition, if engineering physics can act as a universal donor [16], the use of LabVIEW in an introductory engineering physics course provides a proper mindset orientation for graphical parallel programming.

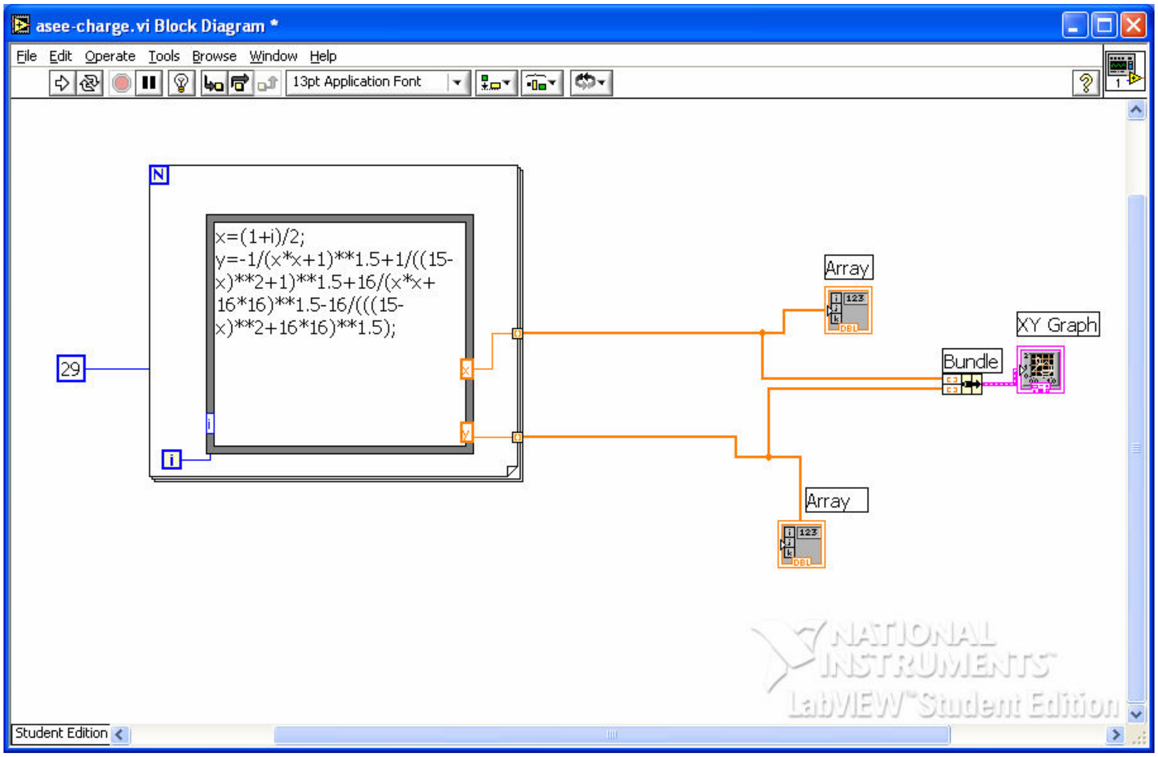
Four LabVIEW programming designs are presented as illustration in this paper. The selection criteria include the utility of preparing the students for continuation to the upper division courses and conducting undergraduate research in an integrated setting such as robotics and bio-physics. The LabVIEW features used are those available in the student version so that the programs are ready for the students to use and to do further modification. The role of LabVIEW parallel programming is contrasted to other text oriented language such as Visual Basic in simple examples such as the virtual instrumentation of light switches. This contrast is helpful to those students who already learned programming in their high schools.

II. Examples and Discussion

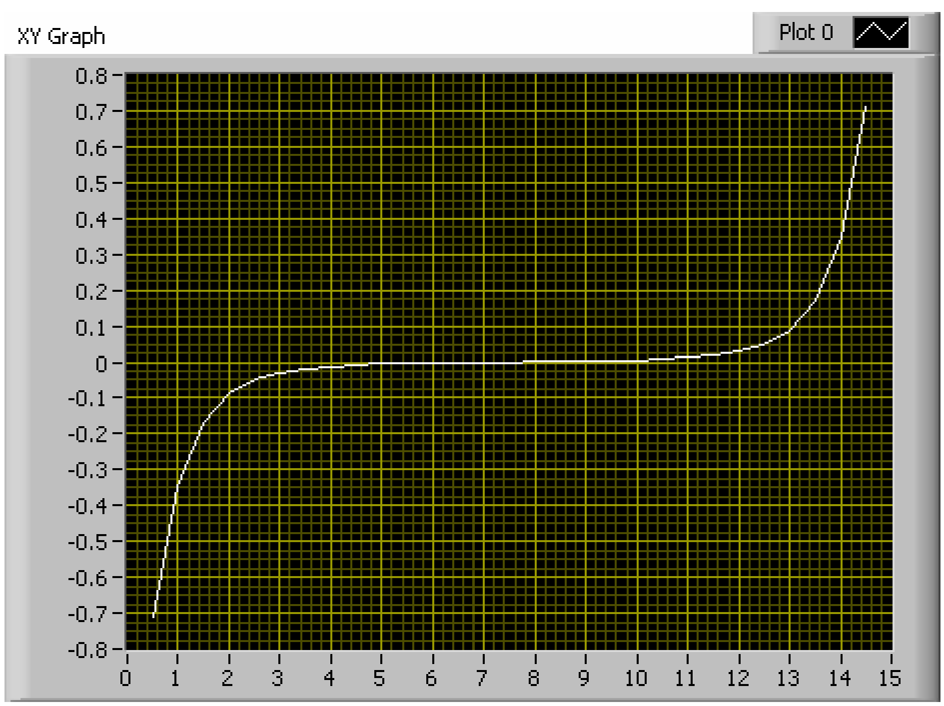
II-A Numerical simulation

The fundamental gravitational and electrical force-distance relationship in introductory engineering physics is quite difficult to demonstrate. The standard use of a torsion balance to demonstrate the gravitational force requires an extremely stable environment. In the case of electrical force, the high voltage involved may pose a safety issue. The essence is not for the students to re-discover the laws of physics, but rather to learn how to verify and discover the relationships. Therefore we developed a laboratory exercise using permanent magnets and a balance. The idea is rather simple. A 15-cm bar magnet sits horizontally on a balance and another 15-cm vertical bar magnet is moved across, changing the balance reading. The vertical bar magnet is 1 cm above the horizontal bar magnet. The experimental procedure is straight forward. The difficulty is that the uncertainty is not directly obtainable from a formula.

LabVIEW simulation can be used to calculate the expected result. There are four poles. Using the inverse square law, the balance reading (total vertical force) versus distance can be calculated easily in LabVIEW. The experimental result can be compared to the simulated result to assess the uncertainty. A log-log plot can be used to compute the power law index. The graphical block diagram is displayed below.



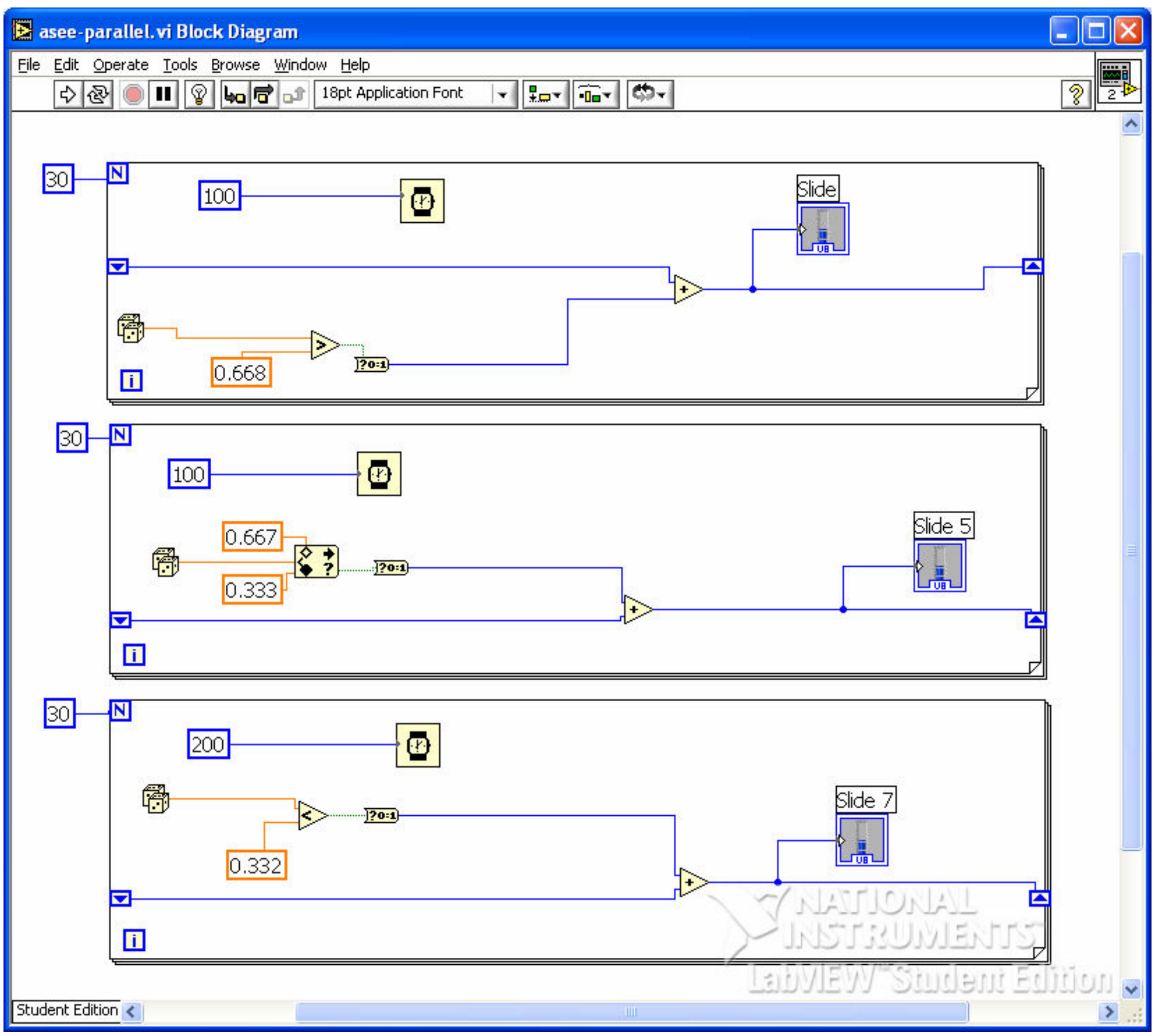
The front plot display is displayed below.



The vertical force changes sign as the vertical scan across the horizontal magnet. There are two main goals in performing this simulation. First, we show the students that uncertainty is not always a calculation that derives from a formula and that uses directly measured quantity, but rather is an assessment process. Second, we show the student the ease of using LabVIEW to perform calculations that use a graphic display. LabVIEW combines the power of Visual Basic, in the ease of calculation, and Excel, in the ease of data plotting. Exposure to this tool exposure in introductory engineering physics is very important for shaping students' mindset for advanced courses.

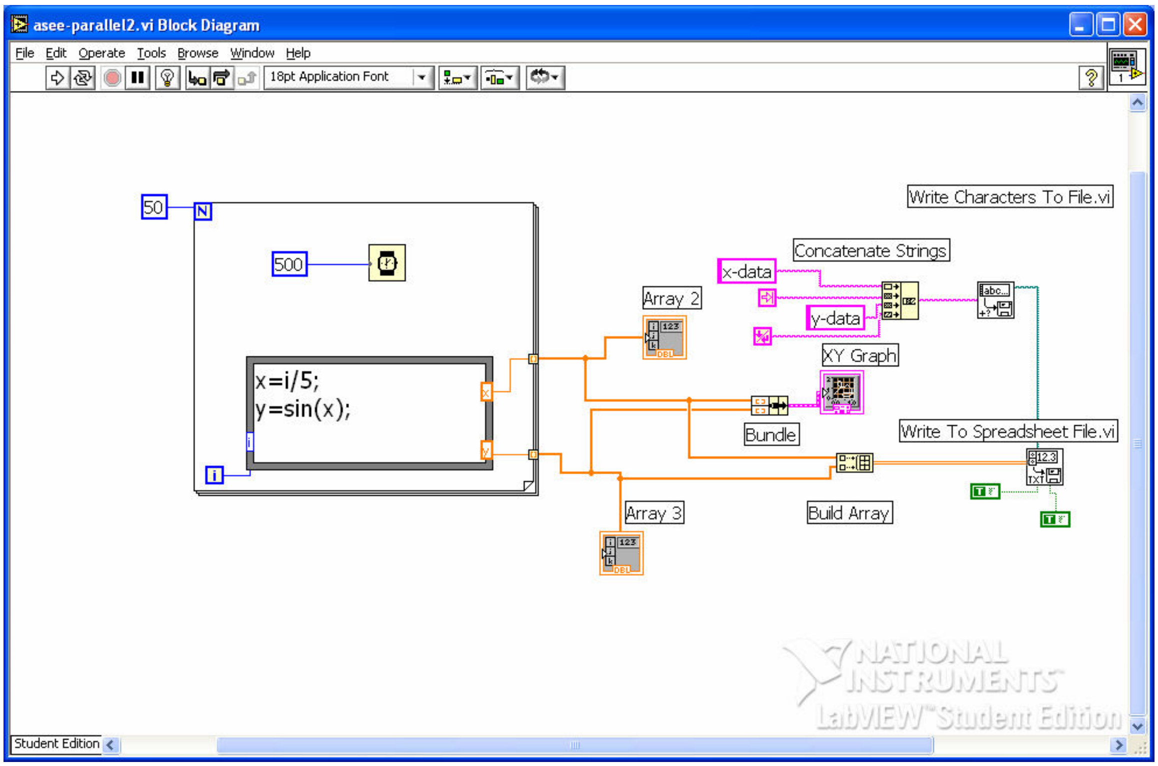
II-B Parallel programming

LabVIEW is a parallel programming language. All the diagrams are executed together and a component starts execution only when the data for it is ready. A virtual instrument for a situation with several thermal emitters is used for demonstration. Three thermal emitters are represented by three diagrams and each diagram executes independently. The graphical block diagram is displayed below.



The three diagrams represent the working of three different energy range counters. In the above design, particles with energies larger than 0.668 units are filtered and displayed in the upper counter, and the particles with energies lower than 0.332 unit are filtered and displayed in the lower counter. The mid counter selects the particles of mid-range energy from an identical emitter. The three emitters, or diagrams, run in parallel. The shift registers are used to simulate the counters. The timings are inserted to slow down the program execution. Other distributions can be built from the uniform distribution. For example, a Gaussian distribution could be generated by adding 10 to 20 random numbers via the central limit theorem.

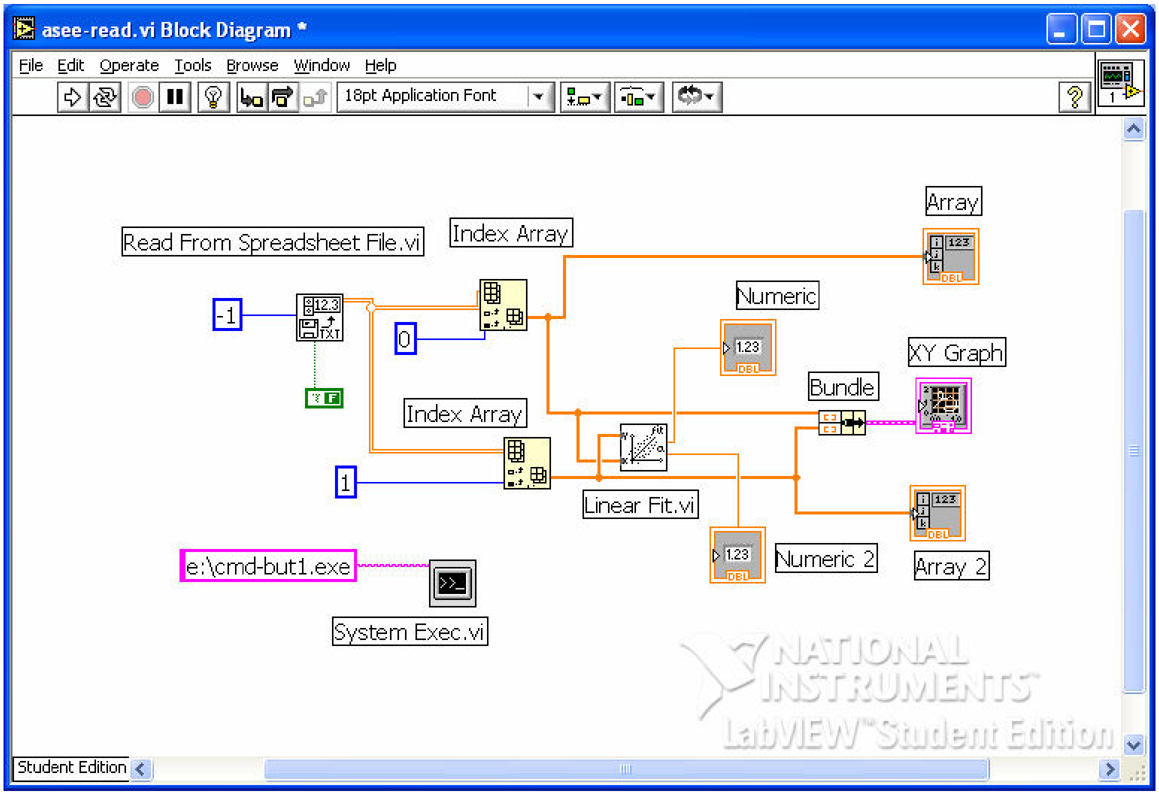
The following graphical block diagram also demonstrates the parallel programming concept. A sine wave is generated with time delay, and the data is then written into a spreadsheet.



The “write characters to file vi” executes first and the “spreadsheet file vi” waits for the x-y data as it is delayed by the timer.

II-C File I/O for image analysis and data fitting

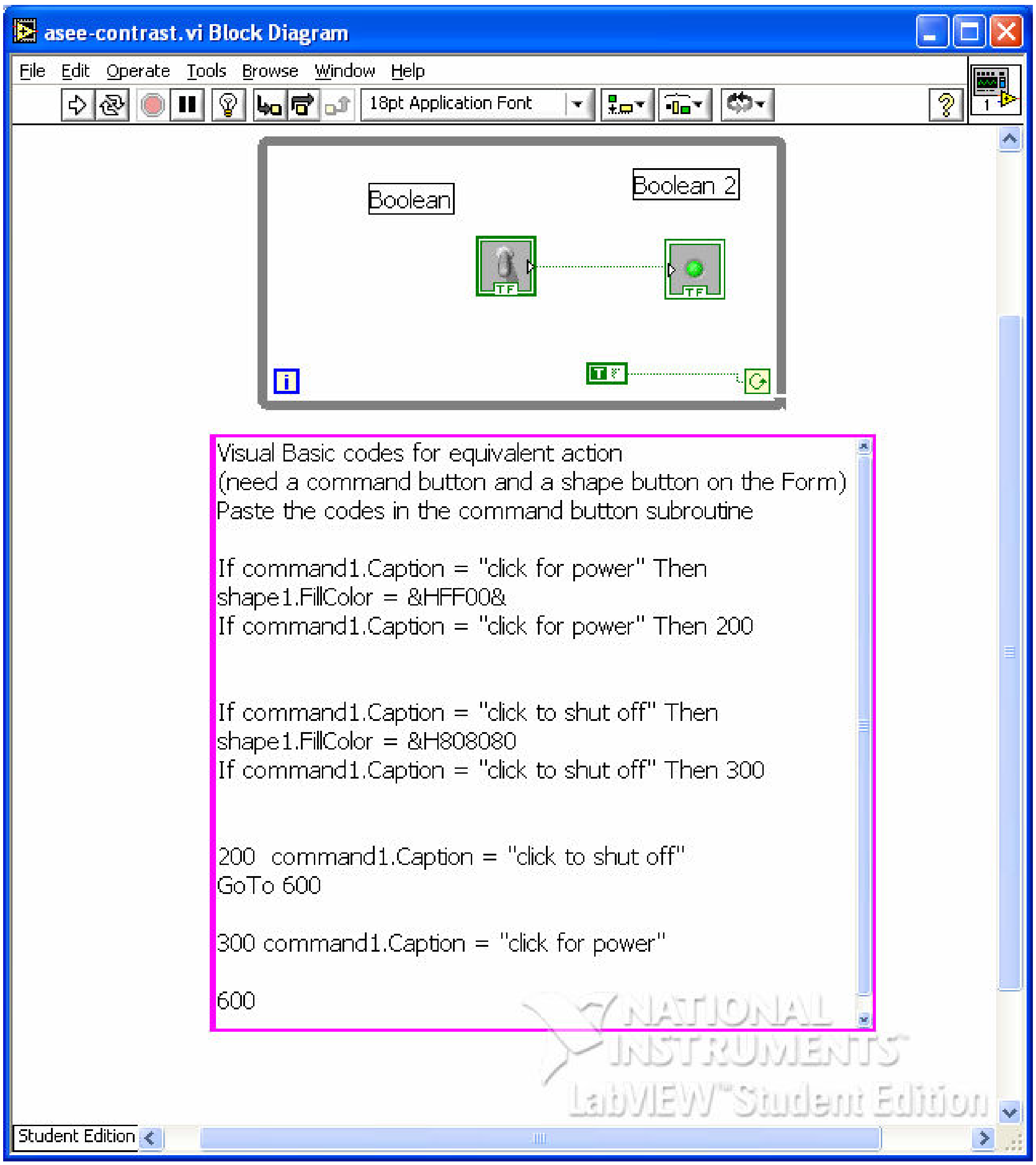
There are many instances that the data is taken by other software programs and stored in text format. A LabVIEW template for the students is very useful. We have selected a graphical block diagram to demonstrate the linear fit analysis.



The “linear fit vi” can be easily replaced by another analysis vi in the LabVIEW library. For example, the “spline vi” can be used to investigate the light intensity of a diffraction image pattern. Direct comparison with the numerical calculation result discussed in the above section (II-A) is educational for the students. There is a parallel diagram in the bottom right of the graphical block diagram where LabVIEW runs an executable file. It is included to demonstrate the flexibility of LabVIEW in a teaching situation where a Windows executable file (.exe) is needed. Furthermore this template is also useful for students who conduct research using web data. For example, high level data from NASA is usually available for download in text format.

II-D Contrast with Visual Basic

Some students already learned some text oriented programming in their high schools. We found these students having some difficulties in adapting to parallel programming. Therefore we designed a LabVIEW program to explicitly contrast the programming steps. The task was chosen to be a virtual instrument to simulate a light switch action. The graphical block diagram is displayed below.



The logical steps in Visual Basic look complex as compared to the simple LabVIEW graphical block diagram. The point is that LabVIEW requires a continuous loop so the light switch is continuously functional during LabVIEW run time. Visual Basic assumes that the light switch as a command button is always accessible with a mouse click, consistent with the basic Windows design by Microsoft.

On the whole, the use of LabVIEW has positive effects for students. Our college has student clubs such as the Robotics Club. LabVIEW serves as an integral part of this kind of extracurricular activity that combines mechanical, electrical and optical engineering principles. The low cost of the student version of LabVIEW is also another encouragement. While the LabVIEW data acquisition feature is not taught in this introductory engineering physics course, its deployment as a software interface certainly streamlined the data collection procedure for the students in lab exercises (such as the oscillatory damping in a pulse RLC circuit [15]).

III. Conclusions

The usefulness of LabVIEW in an introductory engineering physics course is presented in this report. The virtual instrumentation and numerical computation capabilities enable LabVIEW to be one of the best teaching software packages for introductory courses in an engineering curriculum. The students usually had handheld calculators in their high schools. For a college setting, LabVIEW is a viable choice for the next step. The LabVIEW support from National Instruments is excellent. In addition, many examples and tutorials are on the internet. In our opinion, LabVIEW serves as a tool for life long learning in an engineering setting.

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