

Integration of LabVIEW for Novel Interactive Learning Courseware on Digital Electronics

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Abstract

Digital electronics involves communication between systems or instruments in digital form. Digital electronics is an important field in physics and engineering, and included in the syllabus in almost all higher learning institutions. The main objective of this study is to develop an interactive learning courseware for Digital Electronics with the integration of LabVIEW applications in order to facilitate the learning process of Digital Electronics. The novel developed courseware mainly covers the basics of digital electronics. The integration of LabVIEW enables students to get hands on real time experiences as in a real laboratory. These virtual laboratories can be accessible anytime and anywhere. Students can interact with the courseware which makes the learning process more dynamic.

1. Introduction

It is without a doubt that Digital Electronics stands as a basic fundamentals for students in the physics and engineering courses. The knowledge of digital electronics is prior to learn higher level languages and communication system in machines. Therefore, these fundamentals must be made to be easily understandable by students from different background, other than physics, instrumentations or engineering. Today, there are common needs to adapt these fundamentals for the students with different backgrounds [1]. As the ever evolving world of technologies, electronics have replaced and taken over our daily life routine. Basic digital electronics knowledge might then develop into an even greater idea for innovations.

In order to strengthen the fundamental of the subject, an effective method must be used to conduct the learning and teaching process. Using interactive multimedia orientated teaching material is one of the methods that have been proven to be successful [2]. Each type of teaching aids can lead to different results which are significantly higher than normal teaching methods. Normal teaching methods such as reading from text books and verbal methods may not be sufficient for the student to get the full comprehension on the related subjects. Students need to have hands on leaning experience in order for them to get the full latch of understanding on the topic. Interactive learning aid is one of the alternatives.

Previous research shows that computer aided learning in higher education are still in progress [3]. There are still rooms for improvement and upgrade especially on the content of the courseware. For digital electronics, most courseware revolves around lab experiment, yet there is still a specific courseware on teaching the basics. Furthermore, for practical exercise on digital electronics, the main problem is the equipment availability and the expensive instruments involved. The difficulties by the traditional laboratories are the lack of equipment needed as well as the proper instrument for various lab exercises [4]. Hence in this study, we propose the integration of LabVIEW in our novel interactive learning

courseware on the subject Digital Electronics. Virtual laboratories, such as LabVIEW, enable the students and the educators to interact with real laboratory equipment from anywhere, provided they have a working electronic bench. In addition to such easily accessible features, a virtual laboratory is believed to have the potential to be tailored into specific design based on the needs. The range and variety of experiments are vast and there are rooms for mistakes, without damaging the real time instruments which are expensive.

2. LabVIEW method

LabVIEW enables the real-time simulation, such as simulation of the logic gates. The simulation is an excellent addition to the courseware as the user can interact with the courseware directly. LabVIEW program is called a virtual instrument (Vi). A setup of virtual instruments can make up a simple laboratory exercises. The lab exercise is chosen base on the topic and also the complexity of the circuit itself. Figure 1 shows the block diagram window where the visual programming takes place. In the block diagram, the components are dragged on and connected via connecting wires which can be acquired from the tools palette. There are colour codes that represent different function, e.g. blue wires and diagram box represents the integer data type, pink boxes represent strings. Components or instruments can be added into the block diagram by right clicking and choose the desired instrument. These instruments or components are virtual representative of an actual instrument.

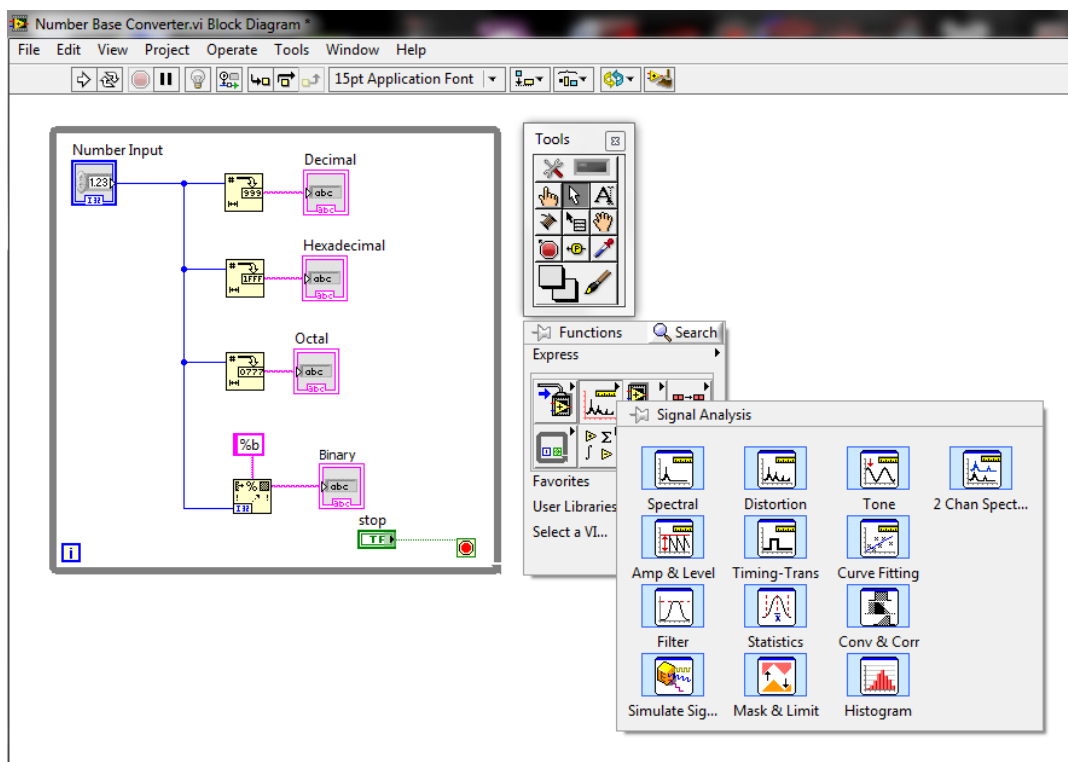


Figure 1. LabVIEW Block Diagram Window

In order to use LabVIEW in the courseware, the Vi must be saved into a standalone application. A standalone application is the application that does not require parent program to run. In this case, the standalone application of LabVIEW in the form of .exe files can be run without installing LabVIEW on

the target computer. To produce a standalone application, we must create a new project for the particular Vi. The option can be found under the tab “File” > “New project”. To build an application, the option can be found under the tab of “Build Specification” as shown in Fig. 2. However, LabVIEW Runtime Engine is necessary for the target computer. The runtime engine contains the entire database and the library needed for the components in LabVIEW to work. The installation of the runtime engine can be done by attaching the installer along with the courseware's package. Hence, the user can install the runtime engine first before using the courseware.

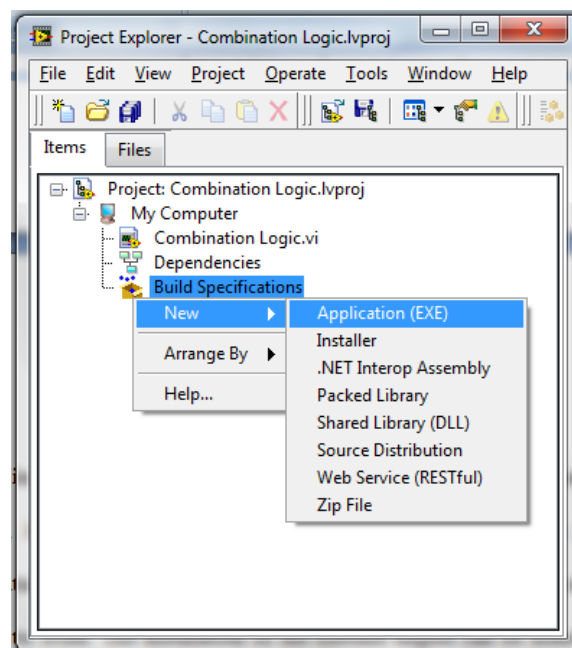


Figure 2. Building LabVIEW standalone application

3. The courseware

This courseware covers four basic topics of digital electronics, i.e. numbering systems, logic gates, boolean algebra and combinational logic. A brief introduction at the beginning of the courseware and quizzes at the end of every topic are also included. The courseware is developed based on the needs of making learning more dynamic and effective. It is useful for students in higher learning institute, with or without prior knowledge on digital electronics. The explanation and examples are easy to understand for the users. The courseware is interactive, which means that there are interactions between the user and the courseware. Users can navigate through the topics easily at their own will. The courseware graphical appearances are interesting and eye-catching.

Figure 3 shows the welcoming screen once the user starts the application. A LabVIEW runtime installer is attached via the button as in the Figure 3. The user need to first install the runtime engine in order to use the LabVIEW exercises later on in the courseware. Upon pressing the button, a window will pop up with instructions to install the runtime engine. The runtime engine will take a few minutes to install depending on the speed of the user's computer.

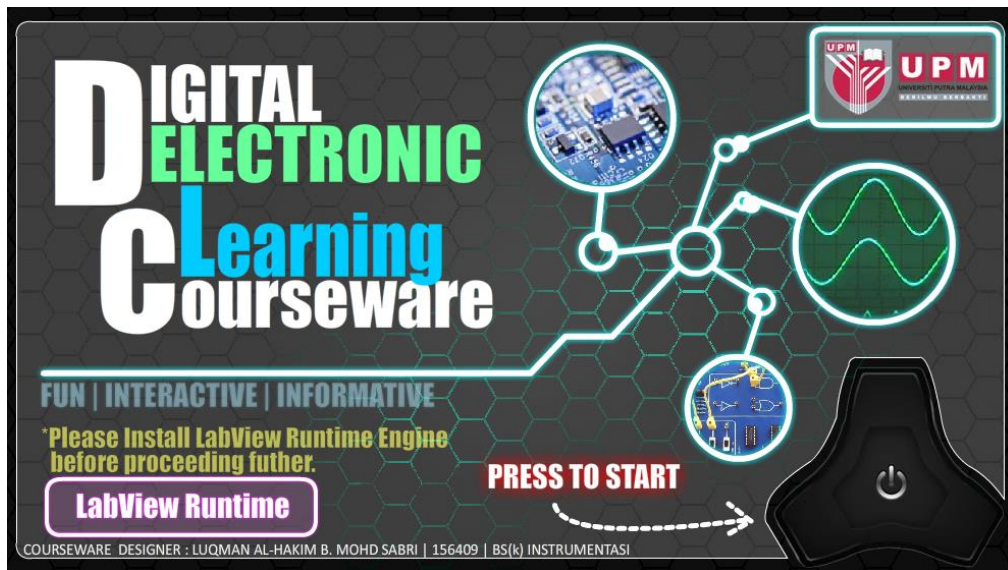


Figure 3. Welcome page of the courseware

After the LabVIEW runtime engine has been installed, the user can proceed by pressing the start button. Users will then be directed to the home screen as shown in Figure 4. The home screen contains side menus for the users to choose from. The side menu buttons are interactive and will automatically provide its description when the mouse cursor hovers on the buttons. Upon clicking the button, the user will be directed to the desired topic. User can always return to this home screen via the home screen button that is located on every pages of the courseware.

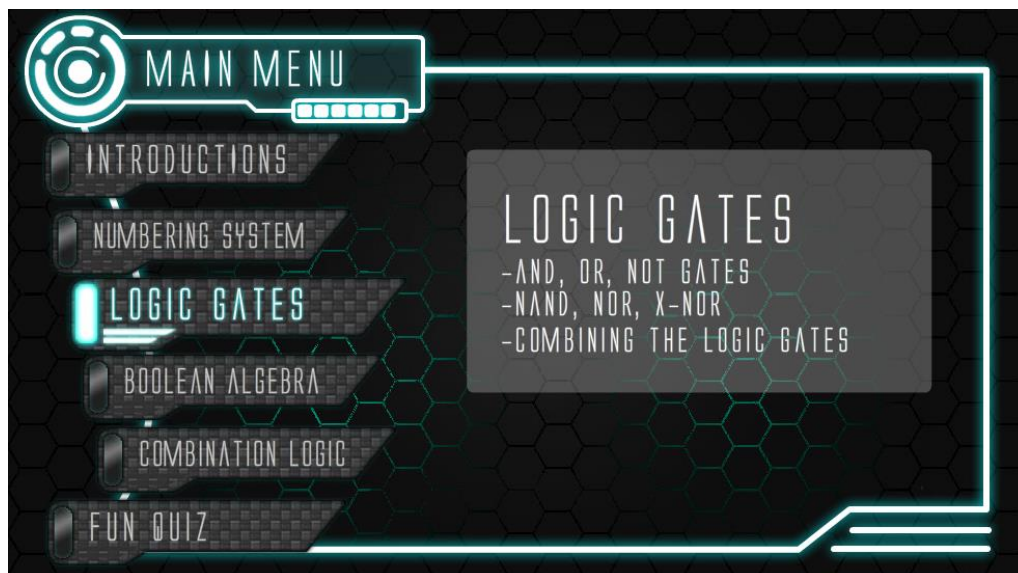


Figure 4. Home screen of the courseware

3.1. Integration of LabVIEW in Numbering System

On of the topics in the courseware is the numbering system. This topic includes four basic numbering systems namely Binary, Octal, Decimal and Hexadecimal. Figure 5 shows the numbering system selection menu with step-by-step instruction on converting the numbers to different bases.

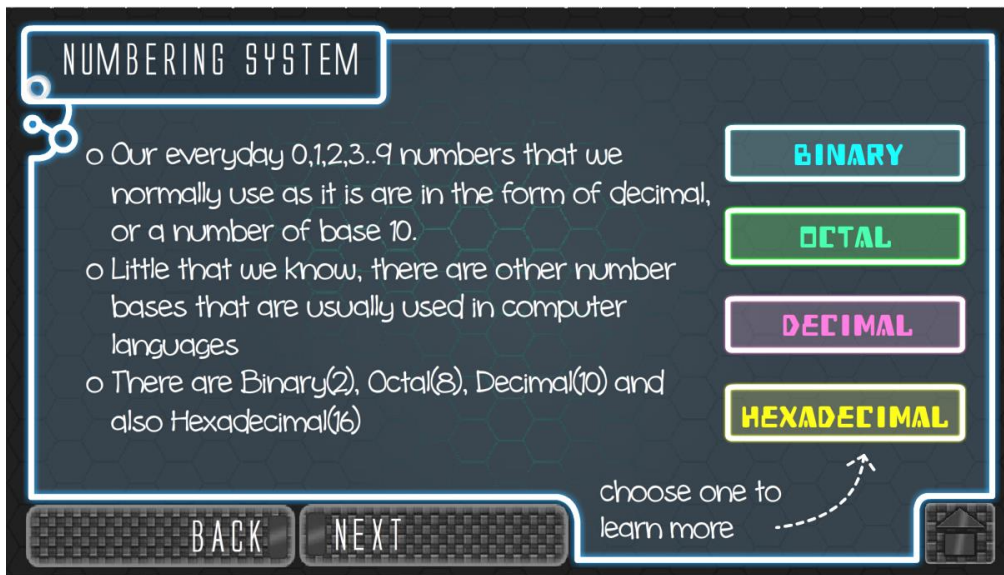


Figure 5. Numbering system menu

A LabVIEW element has been included in this topic. The LabVIEW application is used as a number base converter. It works like a calculator, where user can put in any number in the input box, and the number will be converted to all binary, octal, decimal and hexadecimal numbers. As shown in Figure 6, the number input can be any numbers and it will convert to other base numbers instantaneously. The program can be run and stopped with the buttons provided in the graphical user interface.

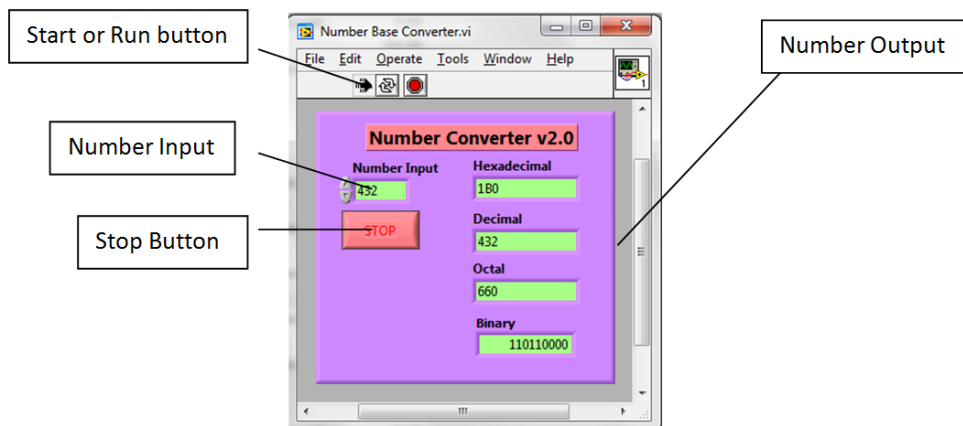


Figure 6. Number converter using LabVIEW application

3.2. Integration of LabVIEW in Logic Gates

Logic gates are the basic building blocks of a digital circuit. There are a few logic gates that are discussed in this topic, i.e. NOT gate, AND gate, OR gate, NOR gate, NAND gate and also XNOR gate. A logic gate has two or more inputs except for NOT gate, which has only one input. At any given moment, every terminal of the logic gate is in one of the two binary conditions, which is low(0) or high(1), represented by different voltage levels. The low state is approximately zero volts (0 V) whereas the high state is approximately five volts positive (+5V) depending on the circuit. In this part of the courseware, the logic gates are explained with their basic information, symbols, equation and also their truth table. User can hover over the truth table button to see the truth table. Figure 7 shows the example from the courseware for the OR logic gate.

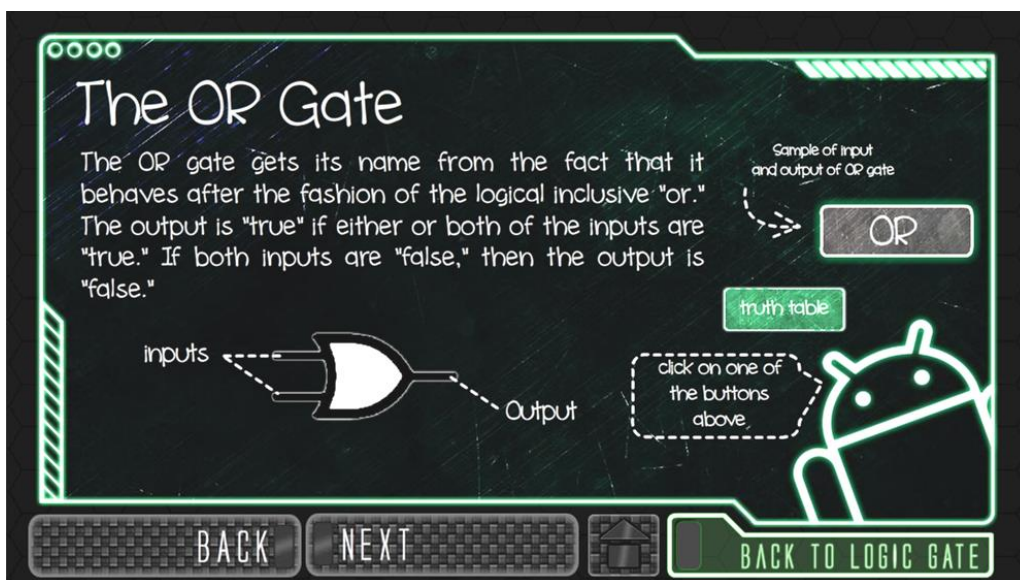


Figure 7. OR gate logic page example

A sample output application, as shown in Figure 8 was developed using LabVIEW. The application shows the output change in the form of timing diagram. In the LabVIEW application, the inputs are both A and B. The output of the logic gate is $A + B$, implying the OR function. If any of the input is 1, or HIGH, the output will be 1, since $1 + 0 = 1$. If and only if both of the outputs are 0, then the output will be 0.

The circuit for the output is constructed in the block diagram of LabVIEW, as shown in Figure 9. Both of the inputs are in the form of "Boolean Array Input". The inputs are both wired to a digital waveform converter since both of the inputs are in form of array. They need to be converted to a digital signal first before they are connected to a digital waveform graph and to the OR gate. The whole circuit is placed inside a "while loop" to keep the program looping until the user stops it manually. All of the logic gates have the sample output which follows this method in LabVIEW.

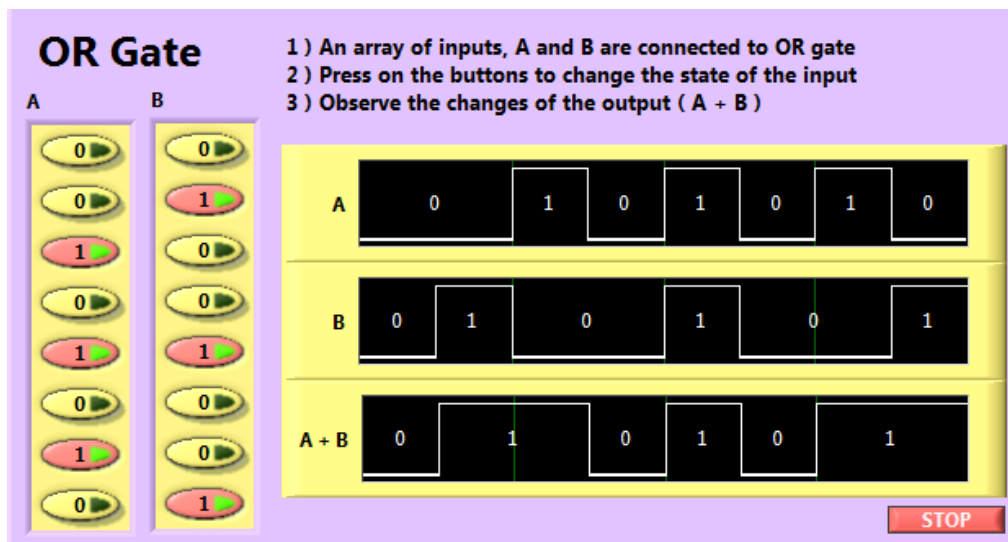


Figure 8. OR logic gate sample output in LabVIEW

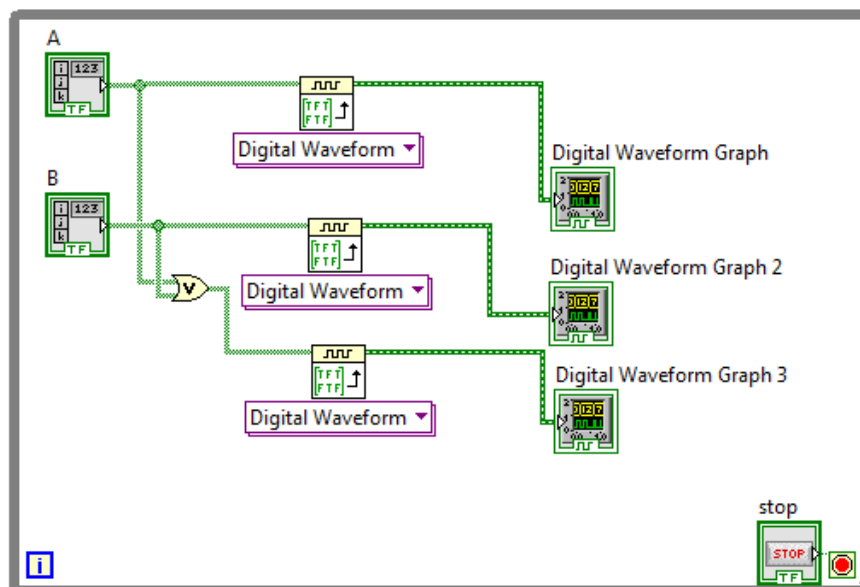


Figure 9. LabVIEW block diagram for OR gate sample output

3.3. Integration of LabVIEW in Exercises and Quizzes

LabVIEW element has also been included in the exercises and quizzes at the end of each topic. For instance, LabVIEW application has been used to develop a quiz in logic gates. Users can interactively choose and find the correct logic gate provided the inputs and output, as shown in Figure 10.

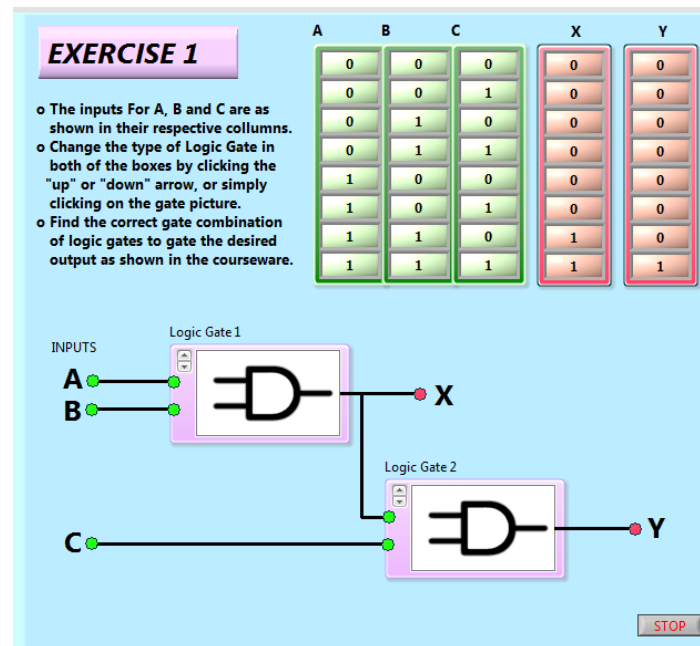


Figure 10. One of the exercises for Logic Gate using LabVIEW

4. Conclusion

This interactive courseware can be as a teaching aid: to help students understand the topics regarding digital electronics. The content of the courseware are complete with explanation, step-by-step tutorial, graphic and animation. Combination of these elements can definitely produce an efficient interactive learning courseware. The LabVIEW application that integrated in the courseware can also help users to visualize the concept, as every simulation can be studied directly. The timing diagram for logic gates can be observed in real time, which is way better than only picture or diagram in the text book.

5. Acknowledgement

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6. References

- [1] J.A. Francisco, A.D. Castro, and B. Christian, "Course on Digital Electronics Orientated Describing System in VHDL", *IEEE Transactions on Industrial Electronics*, 57, 2010, pp. 3308-3316.
- [2] R. Brown, "Thinking in Multimedia: Research-based Tips on Designing and Using Interactive Multimedia Curricula", *Extension Journal*, 39, 2001, pp. 25-29.
- [3] J.N. Coleman, D.J. Kinniment, F.P. Burns, T.J. Butler, A.M. Koelmans, "Effective of Computer-Aided Learning as a Direct Replacement for Lecturing in Degree-Level Electronics", *IEEE Transactions on Education*, 41, 1998, pp. 177-184.
- [4] S. Teyana, "Interactive Web-based Laboratories in Digital Electronics", *International Conference on Education and e-Learning Innovations*, 1, 2012, pp. 1-5.