Development of Arduino-based logic gate training kit

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Abstract. In this work, we develop a compact, robust, and portable Arduino-based logic gate training kit. It was designed for an electronic engineering undergraduate university course in order to learn a fundamental concept of logic gates operation regarding to six logic gates; AND, NAND, OR, NOR, XOR, and XNOR. An ATmega 2560 Arduino board was used to develop the training kit. It consists of two 3.7V batteries as a power supply, 2-input or 3-input selectors, and input pin connectors to connect the desired logic input. Therefore, the training kit can be used to explore the output of the 2-input or 3-input basic logic functions. The output of each logic function can be detected by the LED light (Green = high output, Orange = low output). Moreover, students can directly observe the output of the logic gate through the LED when they select the desired input logic 1 or 0. A size of the logic gate training kit is 19 × 16.5 cm which can be used easily in the typical classroom. Students are asked to predict the basic logic gates operation on the activity sheet before doing the experiment with the kit. After that students have to explain he operation of the basic logic gates. This provides the active learning environment to the students.

1. Introduction

In many universities, logic gate concept is one of the fundamental concept in digital electronics course for undergraduate Physics, computer science, and Engineering students. This course consists of the theoretical contents that are linked to the practical understanding of how computers operate physically.

Generally, students were taught the operation of logic gate by lecture before doing experiment. The separation between the lecture class and the laboratory class made students difficult to grasp completely the ideas. Moreover, it may cause the lack of knowledge between the lecture and practice. As Rickel [1] introduced the “learning by doing” method as students retain 25% of what they hear and 45% of what they hear and see, but students can get 70% of learning if they do what they hear and see.

Many teaching apparatuses for laboratory have been used in several years ago such as traditional laboratory using breadboard circuit or commercial fixed laboratory apparatus [2-4], microcontroller based real-time logic emulator [5] and FPGA based digital logic emulator [6], and other web-based learning in this concept [7-10]. However, there were some inconveniences such as 1) most commercial fixed laboratory apparatus and web-based learning modules were not only expensive to build in the laboratory but also take more area 2) for IC based laboratory, students need to map between the IC’s pins and the pins of logic gate. In order to fulfil these gaps, we present the compact and effective

apparatus, for lecturer to demonstrate or let student hands-on the logic gate operation, to help students to learn the operation of logic gate.

2. The development of Arduino-based Logic Gate Training Kit

An Arduino platform was selected to develop the logic gate training kit because it is an open-source electronics prototyping platform based on flexible, easy-to-use hardware with reasonable price and the associated software has free access for all users [11]. An Arduino ATmega 2560 was chosen because of its abundance of digital inputs and output pins that enough for demonstrate the operation of 2-input and 3-input of AND, NAND, OR, NOR, XOR, and XNOR logic gates. The schematic diagram of the training kit is shown in figure 1.

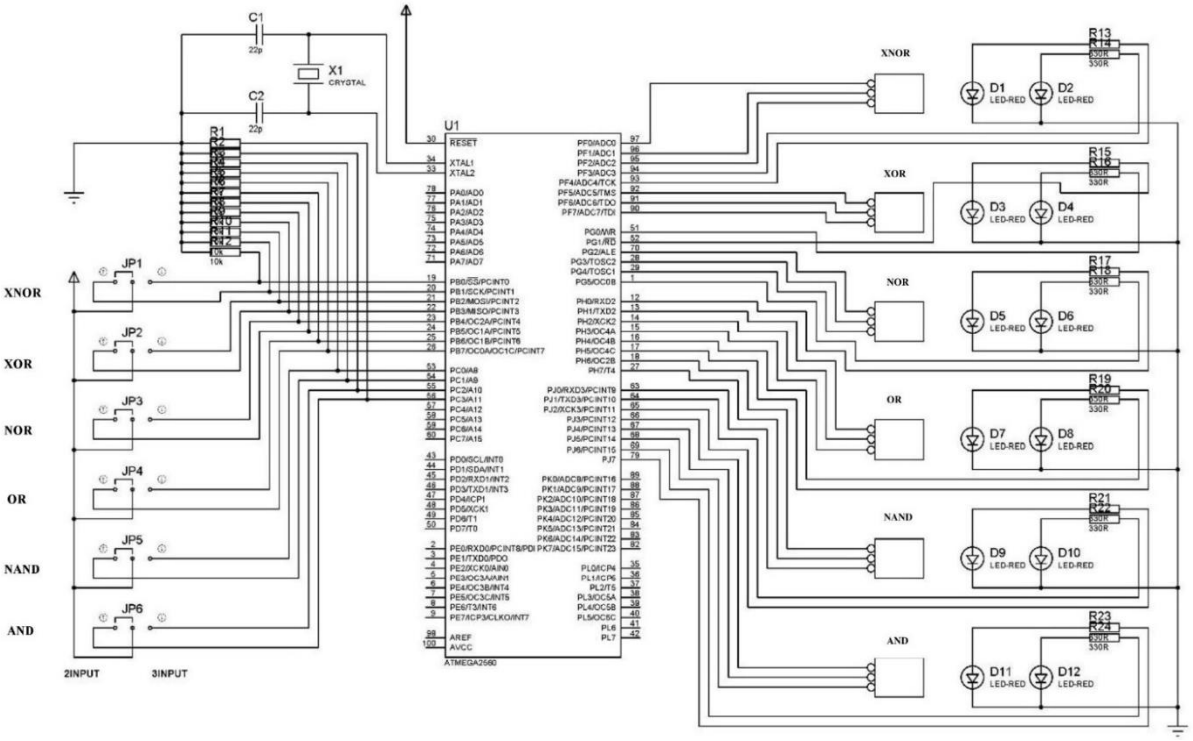

Figure 1. The schematic layout of logic gate training kit.

The kit was designed to be compact (see figure 2) to use in the typical classroom environment because the kit requires no external instruments. The 2-input or 3-input selectors were used to set the number of input for each logic gate. For the input of each logic gate, we provided both the 2-input and 3-input sections to connect with the +5V (as a high voltage level) and 0V (as a low voltage level) sections via the jumper wires. The Bi-colored LEDs were individually used for showing the basic output logic functions of each logic gate so students could see clearly and observing directly from that training kit.

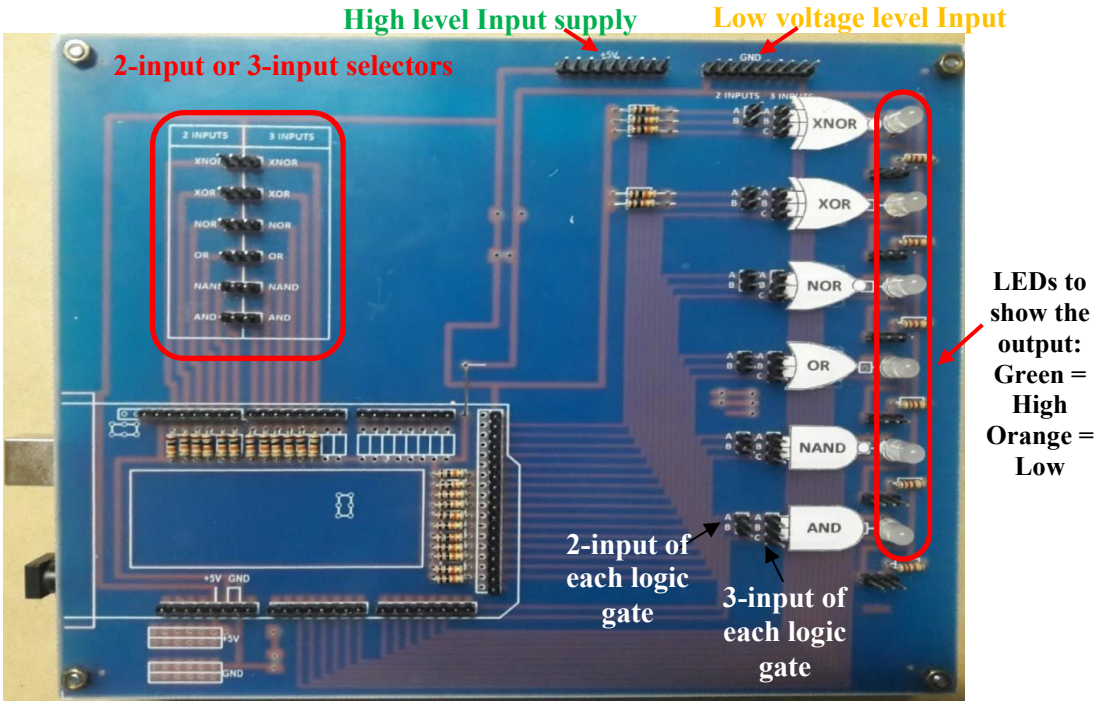

Figure 2. The portable Arduino-based logic gate training kit (Compact Set-up).

3. Implementation and Assessment

The participants of this research were 16, 2nd year undergraduate students. Instead of teaching them the truth table of the basic logic gates operation as it was done in the typical classroom, the participants were asked to make a prediction of the basic logic gates (AND, NAND, OR, NOR, XOR, XNOR) operation on the activity sheet (See figure 3) before doing the experiment with the logic gate training kit. Students then compared their prediction and observation. After that, they discussed with the group about the operation of the logic gates. This implementation took around 50 minutes to complete.

At the end, students were interviewed about the benefit of the logic gate training kit. 11 students responded that the logic gate training kit help them to learn the operation of the basic logic gates such as "I can observe by testing with output LEDs from training kit practically by myself".

The results showed that this logic gate training kit was helpful for students to learn about logic gates operation.

Student Activity Sheet 2 for the Logic Gates Operation

No.	Case	Result

2(a) 2-input NAND gate

Input 1	Input 2	Output	
		Prediction	Observation
0	0		
0	1		
1	0		
1	1		

(b) 3-input NAND gate

Input 1	Input 2	Input 3	Output	
			Prediction	Observation
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

Figure 3. Part of the basic logic gates operation activity sheet.

4. Conclusion

The Arduino-based logic gate training kit can be used by students themselves or lecturer as a demonstration tool to learn the operations of the basic logic gates; AND, NAND, OR, NOR, XOR, and XNOR. This kit has the advantages of 1) using an Arduino that allows students to see the desire basic output logic functions when the desired inputs are selected; and 2) having selectors in hardware design that gives students to know which logic gate is chosen to work.

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