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Resducational Kit The Development Of An Electronic Quiz Board That Test Engineering Students Knowledge on Resistors Concept in Electrical Circuit

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*Abstract***:** *The concept of basic electrical circuit has been covered in most engineering field especially electrical and electronic engineering via Fundamental of Electrical Circuit subject. One of the topic is to test student knowledge on calculation on the combinatorial resistors connection which can be either in series, parallels or combination of both. This can be done by theoretical calculation or hands-on assembling the circuit. This educational kit attempts to bridge the gap between theory and real-time hands-on for the circuit connection. The kit will give questions by providing the desired resistors output while the students need to do the connection base on the available resistors values in order to obtain the desired output resistor. The educational kit will deliverer the answer once the connection is successfully constructed. The kit is developed using Arduino Uno Microcontroller with other components such as LCD, LED, keypad, buzzer and resistors. This paper explains the procedure required in developing the prototype and testing being done to verify the functionality of the proposed kit.*

*Index Terms***:** *Educational kit, learning tool, teaching aid, quiz board, resistor, electrical circuit*

I. INTRODUCTION

The Fundamental of Electrical Circuit subject has been a mandatory subject need to be taken by not only electrical and electronic engineering but also other engineering fields, such as Mechanical Engineering and Chemical Engineering. One of the topics in this subject is related to the resistance calculation and design combinatorial resistors connection which can be either in series, parallels or combination of both. This can be done by theoretical calculation or hands-on assembling the circuit. As most of the engineering subject given more time to the theoretical execution where an average of three hours lectures a week and one hour per week for tutorial, the average time for hands-on during laboratory session is roughly an hour per week. Thus, the student might excel in theoretical design and calculation but fail to translate that during the laboratory session. Increasing additional contact time for laboratory session leads to other difficulties such as additional resources required (teaching engineer, laboratory equipment, laboratory room). The proposed kit attempts to bridge the gap where without additional resources mentioned earlier, the kit itself able to provide question and automatically check the student answer without any supervision. There are increasing trend in academic publication related to unsupervised educational kit, R. F. Mustapa et al. proposed an electronic board game of the famous Mastermind board game as the output of the Conceive Design Implement Operate (CDIO) program implemented in Universiti Teknologi MARA Cawangan Johor Kampus Pasir Gudang [1]. M. H. A. H. A. M. Faseh et al. proposed a cheaper version of the electronic board kit which powered by Arduino that simulates Programmable Logic Controller's (PLC) Mneumonic Code which targeted to secondary school students [2]. A. Anuar et al. proposed an electronic board that able to check the functionality of the commonly used Arduino's components [3]. R. Rifin et al. proposed the development an Android-based app for examination purposed [4]. M. F. Z. M. Zakaria proposed the development of an electronic educational quiz board that test student knowledge on a topic of Control Principles [5]. M. R. Yaacob et al. proposed an educational kit that test student knowledge of C Programming by using Flowchart block [6]. M. I. Z. M. Zabidi proposed an educational kit that test secondary school student knowledge on Mathematics topic related to transformation [7]. K. A. Kadiran et al. has proposed an educational kit that use water level as application in order to test student knowledge in Control Principles subject [8].

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Meanwhile, A. F. Hafizan et al. proposed the development an electronic-based of Congkak board game in order to encourage younger generation to play the traditional board game [9]. M. A. Hairuddin et al. on the other hand has proposed Computer Assisted E-Laboratory using LabView and Internet-of-Things Platform as Teaching Aids in the Industrial Instrumentation Course [10]. I. A. Rozani et al. proposed E-Othello: The Development of an Electronic-Hardware version of Traditional Othello Board Game [11]. M. A. Husaini et al. proposed Rabbit and Carrot Electronic Board Game: The Development of an Educational Kit that Test Student Knowledge in Flowchart Concept [12]. Lastly, M. I. Z. M. Zabidi et al. also has proposed A Brief Review of Educational Kit Publications from Year 2002 to 2016 [13]. Based on the literature review mentioned, there is no attempt to develop an educational kit related to Electrical Circuit Fundamental subject. As mentioned earlier, the kit will ask questions by providing the desired output resistor and the students need to do connection of the available resistors values on the board in order to obtain the desired output resistor given by the question. The educational kit will provide feedback whether the answer given by the students is correct or otherwise.

II. METHODOLOGY

The Arduino Uno has been used as the microcontroller that accepts input from the resistors and keypad and then processed the information from the inputs and produces corresponding outputs via LCD, buzzer and LEDs. Figure 1 show the schematic diagram of the proposed educational kit which was drawn using Proteus 8 Professional. The 4X4 keypad is used to accept any input from user especially related to the difficulty level selection on the questions and to the selection option of the next process flow. The 16X2 liquid crystal display (LCD) is used to display the menu and question. There is buzzer which is used to indicates whether the answer is correct or not by producing different tones. The buzzer also used as indicator for the user when the button need to press. Three diodes are used where the green light emitting diode (LED) to indicates correct answer, red LED to indicate wrong answer, and yellow LED to indicate that the educational kit is waiting the respond from the user.
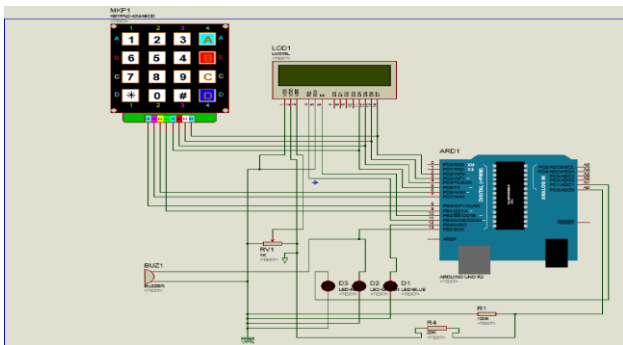
Figure 1. Schematic diagram of Resducational Kit

The trick behind the ability of the proposed kit to detect the total resistance value connected by the student is by performing a simple concept of Voltage Divider Rule (VDR)

whereby the value of resistor R1 is the total resistance due to student connection and resistor R2 is a fixed value. In this kit, the value of R2 is fix which is 100 kΩ. Once the student performs the connection of the circuit and Arduino is ready to read the resistance value, the LCD Display will show that students must press the button A in order to confirm the circuit connection. Once button A is pressed, the LCD will show the value of the resistor. The value of R1 is calculated by using the formula:

$$R_1 = (5 - V_{out}) \times R_2 \div V_{out} \qquad (1)$$

The variable Vout voltage is detected at the analogue pin assigned on Arduino Uno. To read the resistor R1 at the circuit connection, V_{out} can expressed as in (2) in which to convert the analog signal to digital signal to display at LCD, the values of the resistor that read need to multiply with 5V and divide with value 1024:

$$V_{out} = (V_{an} \times 5) / 1024 \qquad (2)$$

where V_{an} is the analogue value which has been quantized in 10-bit digital value which can have a maximum value of 1023. Notice that the resistor has a tolerance error of ±5%, therefore the reading will fluctuate with margin of at most ±5%. From the programming code, there is a buffer of ±7% to detect the resistor value to ensure it can capture correct result.

Figure 2 shows the flowchart of the program. The program will start by greeting the user and provide three level of difficulties for user to choose. Once the user selects the difficulty level by pressing the number on the keypad that corresponds to the difficulty, the white LED will turn ON to indicate that the quiz board is ready to accept user answer.
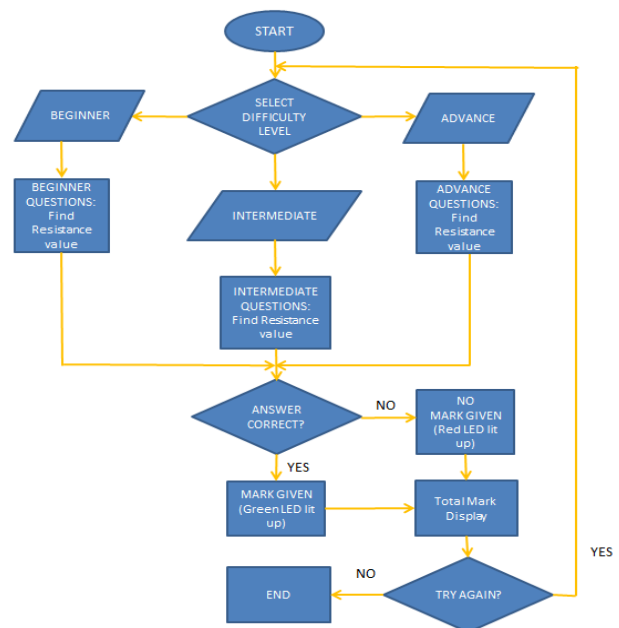
Figure 2: The flowchart of the operational

Start from Pin A0 that it will be connected with R2 (which is with the constant value 100 kΩ). Pin A1 connected to the positive LED Red (which is a wrong answer) when the LED is active high. Pin 2 is connected to the LCD Display, Pin D7 and keypad was at Pin 8. Pin 3 was connected to the LCD Display at Pin D6 and keypad at Pin 7. While the Pin 4 was connected to the LCD Display at pin D5 and the keypad at Pin 6. Pin 5 connected to the LCD Display at pin D4 and the keypad at Pin 6. Pin 6 was connected to the keypad at pin 3. Pin 7 was connected to the keypad at Pin 2. Pin 8 connected to the keypad at Pin 1 and Pin 9 was connected to the keypad at Pin 4. For fully display, it will connect from Pin 10 to the LCD Display Pin 10. Pin 11 was connected to the LCD Display Pin RS. Pin 12 connected to the positive LED White and Pin 13 connected to the positive LED Green. Arduino Uno contains everything that need to support the microcontroller which means to simplify the connection from it to a computer with an USB cable or power it with an AC-to-DC adapter or battery to get started.

All the pins mentioned needed to be connected to the keypad. Pin 1 until 4 used to make the address of rows for the keypad button and the other 4 pins used for the column address. When the user push one of the button, the connection inside the keypad will set to active high and the signal send to the Arduino Uno and the data is displayed by the LCD Display. This is the flow program on the keypad function with an Arduino Uno and LCD. Pin D4 until pin D7 has been listed down at the connection. The Pin VSS connected to the negative supply. The Pin VDD connected to the positive supply. The Pin VO connected to the middle leg of the variable resistor. The RW connected to the negative supply.

Figure 3 and figure 4 shows the simulation runs on Proteus Pro 8.4 software. Once the code is programmed, LCD shows the starting of the program and select the difficulty level. Figure 4 shows an example LCD display result when "Easy" difficulty level is selected. Figure 5 shows the sample of the questions for the "Easy" difficulty level stage. When the user answer correctly, mark is displayed on the LCD as shown in Figure 6. However, when the questions answered is wrong, the red LED will light up and LCD will display "Incorrect" message with the total marks obtained.
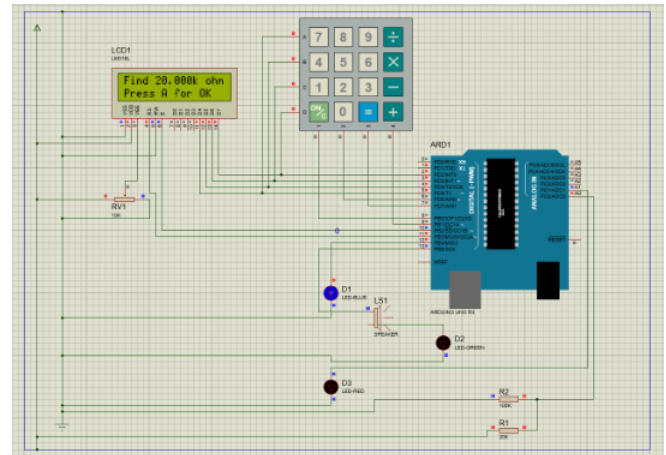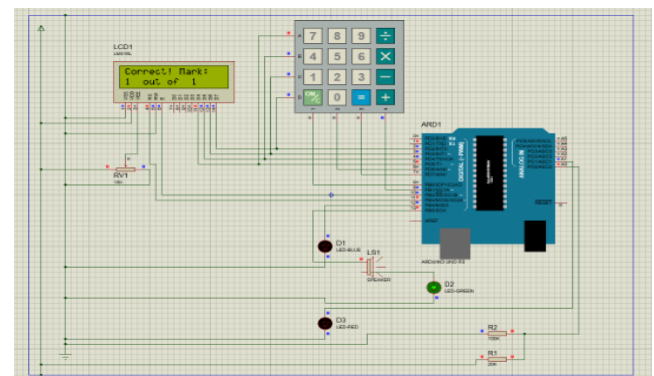

Figure 5. Example of the question is display

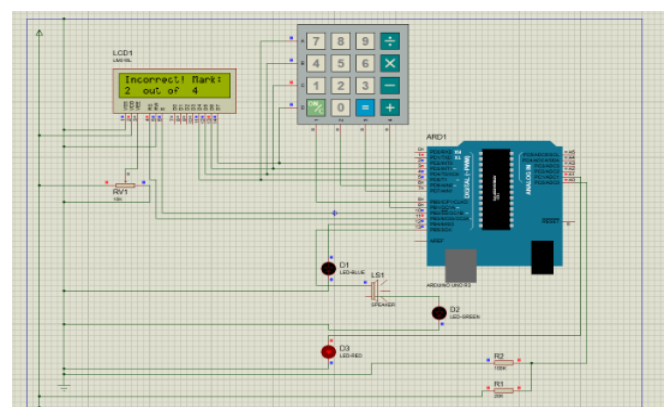**Figure 6. The correct is display and the LED green light up**

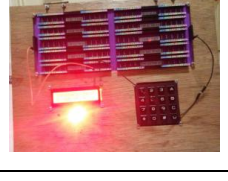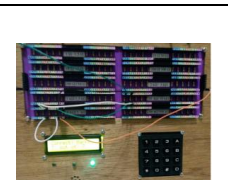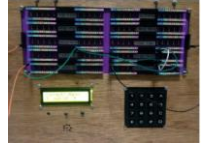**Figure 7: The incorrect answer is display and the LED red light up**

Figure 3. Selecting the difficulty

Figure 4: Example when choose 1-Easy

III. RESULT AND DISCUSSION
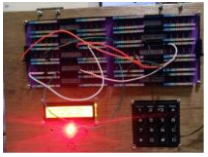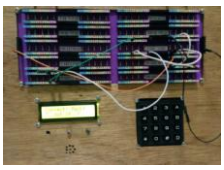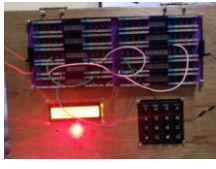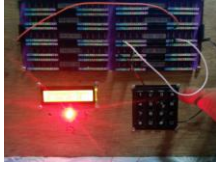
Table 1 shows the picture of the prototype hardware and the result outcome base from the input or event of the program. The table content indicates the situation and the hardware response result displayed on LCD as well as the LED result indicator. Total marks obtained also will be displayed on LCD at the end of each difficulty level.
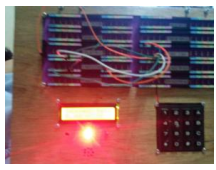
Table 1. The results from some correct and some incorrect answer.

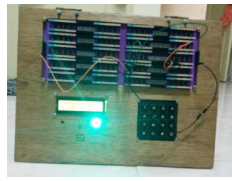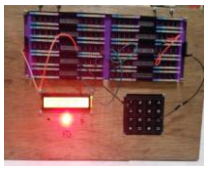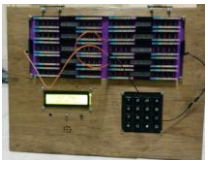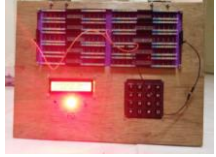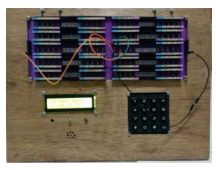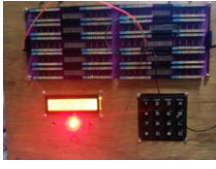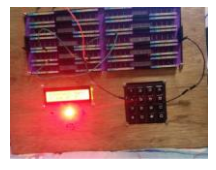| No	Scenario	Expected outcome	Result obtained
1	The user able to answer correctly. The question is find 20kΩ (Easy)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
2	The user able to answer incorrectly. The question is find 15kΩ (Easy)	The result is expected. The LCD Display show display "Incorrect"	
3	The user able to answer correctly. The question is find 21kΩ (Easy)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
4	The user able to answer incorrectly. The question is find 10kΩ (Easy)	The result is expected. The LCD Display show display "Incorrect"	
5	The user able to answer correctly. The question is find 5.454kΩ (Easy)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
6	The user able to answer incorrectly. The question is find 11.25kΩ (Easy)	The result is expected. The LCD Display show display "Incorrect"	
7	The user able to answer correctly. The question is find 27.5kΩ (Easy)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
8	The user able to answer incorrectly. The question is find 38.57kΩ (Easy)	The result is expected. The LCD Display show display "Incorrect"	
9	The user able to answer correctly. The question is find 22.21kΩ (Easy)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
10	The user able to answer incorrectly. The question is find 22.71kΩ (Easy)	The result is expected. The LCD Display show display "Incorrect"	
Total mark(s)		The result from answer all questions is expected. The LCD shows the total answer correct.	
11	The user able to answer correctly. The question is find 8.33kΩ (Medium)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
12	The user able to answer incorrectly. The question is find 13.5kΩ (Medium)	The result is expected. The LCD Display show display "Incorrect"	
13	The user able to answer correctly. The question is find 37.5kΩ (Medium)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
14	The user able to answer incorrectly. The question is find 23.5kΩ (Medium)	The result is expected. The LCD Display show display "Incorrect"	
15	The user able to answer correctly. The question is find 16.67kΩ (Medium)	The result from answer all questions is expected. The LCD shows the total answer "correct".	

No	Input	Output	Image
16	The user able to answer incorrectly. The question is find 22.5kΩ (Medium)	The result is expected. The LCD Display show display "Incorrect"	
17	The user able to answer correctly. The question is find 32.47kΩ (Medium)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
18	The user able to answer incorrectly. The question is find 35.5kΩ (Medium)	The result is expected. The LCD Display show display "Incorrect"	
19	The user able to answer correctly. The question is find 22kΩ (Medium)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
20	The user able to answer incorrectly. The question is find 47.4kΩ (Medium)	The result is expected. The LCD Display show display "Incorrect"	
Total mark(s)		The result from answer all questions is expected. The LCD shows the total answer correct.	
21	The user able to answer correctly. The question is to find 77.5kΩ (Hard)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
22	The user able to answer incorrectly. The question is to find 31.07kΩ (Hard)	The result is expected. The LCD Display show display "Incorrect"	
23	The user able to answer correctly. The question is to find 22.27kΩ (Hard)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
24	The user able to answer incorrectly. The question is to find 37.9kΩ (Hard)	The result is expected. The LCD Display show display "Incorrect"	
25	The user able to answer correctly. The question is to find 5.4kΩ (Hard)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
26	The user able to answer incorrectly. The question is to find 10.018kΩ (Hard)	The result is expected. The LCD Display show display "Incorrect"	
27	The user able to answer correctly. The question is to find 3.72kΩ (Hard)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
28	The user able to answer incorrectly. The question is to find 31.07kΩ (Hard)	The result is expected. The LCD Display show display "Incorrect"	
29	The user able to answer correctly. The question is to find 20.79kΩ (Hard)	The result from answer all questions is expected. The LCD shows the total answer "correct".	
30	The user able to answer incorrectly. The question is to find 7.78kΩ (Hard)	The result is expected. The LCD Display show display "Incorrect"	
Total mark(s)		The LCD shows the total answer correct.	

IV. CONCLUSIONS

This paper presents the development of an educational quiz board with the aim of testing student knowledge on concept of resistor connection in series and parallel.

Resducational Kit The Development Of An Electronic Quiz Board That Test Engineering Students Knowledge on Resistors Concept in Electrical Circuit

The quiz board is tested using scenario based methodology where all possibilities scenarios are tested and result obtained as expected outcome. The educational kit should be tested on field in order to better gauge the effectiveness of the educational kit.

ACKNOWLEDGMENT

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Mohd Firdaus (non-Member), Born in 1982. He is a malaysian Researcher and Engineer. He graduated from Universiti Tenaga Nasional in Bachelor of Electrical Engineering. He finished Master Degree of EEIT at University of Applied Science Rosenheim, Germany. He worked in various multinational company such as Sony, Intel and Qimonda as Electrical Test Engineer. Currently he is a full-time researcher at Universiti Teknikal Malaysia Melaka, Fakulti Teknologi Kejuruteraan. His reseach mainly focus in Energy Efficiency, Renewable Energy and Electrical Vehicle.