Preliminary design of an Android-based Voltage Divider Calculator to support extracurricular program in elementary school

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Abstract. In this era of 4.0, elementary school student education has been involved in simple robotic learning, such as line follower, line follower, and other robotics, mostly there is a voltage divider circuit. A voltage divider circuit is a form of many resistor configurations. The circuit is straightforward: it is constructed by a DC source (for example, Battery, Power Supply) as the input voltage (Vin), and at least two resistors (named as R1 & R2) are connected in series, where the middle point is connected - the series resistor becomes the output. Although this is a relatively simple circuit, for elementary school students, finding the output voltage (Vout) and finding the right combination of R1 & R2 to get the expected Vout takes a long time. Calculation difficulties arise because the values of R1 & R2 cannot be selected arbitrarily; it must follow commercially available resistors. A user-friendly, attractive, and simple calculation tool is needed to facilitate finding these variables. Based on literature studies, there has not been found in any paper that explicitly discusses the Android-based Voltage Divider Calculator. We also found no results for finding the applications mentioned on the sites of commercial Application providers (such as Playstore, Appstore, and so on). This paper is a preliminary study in designing an Android-based Voltage Divider Calculator Application. This paper only presents the analysis and design steps. It is hoped that this application can later be used as a complementary tool in the elementary school level electronics extracurricular program because most of the electronic material taught to elementary school students contains the introduction of resistors and mathematical expressions of resistor configuration accompany their application.

1. Introduction

Technology is the primary key in education at various levels nowadays, bringing excellent progress; this is due to the aspects of effectiveness, efficiency, and attractiveness offered by digital technology-based learning, making learning activities easier [1–3]. The rapid development of technology has its euphoria in which one of the them is learning media development. The media often used by educators and schools is Android-based applications (App) [4,5], as evidenced by the vast number of android users globally. Teaching with the help of Android App will serve many benefits [6], mostly related to understanding theory and calculations in the formal education or extracurricular programs. Adopting digital system-
based learning makes it easy for users, especially educators and students at all levels ranging from elementary, junior high, high school, and college.

There are subjects related to a mathematical analysis in Indonesia 2013 curriculum, i.e., mathematics, physics, engineering, Etc. Besides, technological advances have created many new extracurriculars, for example, at the elementary school level related to the electronic environment: robotics, basic electronic components (e.g., resistor as voltage dividers), a simple power supply, blinking LED, and others. The learning approach distinguishes the Indonesia 2013 Curriculum (K13) and the Indonesia Education Unit Level Curriculum (KTSP) and previously [7–9]. The 2013 Curriculum (K13) has used a scientific approach; this will change the perspective of students, especially in elementary schools, in learning to observe, ask, present, conclude, and be creative [10]. Viewing the changes in the existing learning methods, educators play an essential role in creating an exciting and enjoyable learning atmosphere. Being a professional teacher does not lie in developing knowledge, but in his ability as an educator to create an exciting and meaningful learning process, namely by creating the learning innovations, for example, by using new learning media.

This paper is focused on making the initial design of a User Interface (UI) calculator to calculate the voltage divider using resistors. The voltage divider is used as a divider for the input voltage into several output voltages according to other components’ needs in the circuit [11]. There is a need for tools in an extracurricular program related to electronics (e.g., robotics or calculating the voltage divider circuit for assembly purposes) in the elementary school. The purpose of making the initial design of this divider voltage calculator is to make a real application that can help educators provide primary education to elementary school students, especially in electronics or robotics extracurricular activities regarding circuits widely used in electronic devices, namely voltage dividers. As time goes by, the rapid advancement of technology allows primary electronic education to be studied and included in the pedagogic curriculum for elementary school, both aimed at educators and students. The output obtained from the App is the educators can efficiently transfer knowledge to their students regarding the basic circuit. Our App offers several features that can be utilized by the elementary student schools (especially for 4th to 6th Grade of elementary level, about 10 – 14 years old child).

2. Methods

2.1. Mathematical expression
Resistors can be configured as voltage dividers. This circuit is formed by two resistors connected in series and a DC voltage source (Figure 1a). A pin is taken between the two resistors as the output (V_{out}). This circuit functions to divide the DC input voltage into an output voltage smaller than the source voltage [11]. Figure 1(b) illustrates the real setting of voltage divider circuit containing battery, 1st and 2nd Resistor (R_1 & R_2), and Voltage meter.

![Figure 1. Voltage divider circuit in (a) a basic configuration; (b) real setting.](image)

The voltage divider circuit formula can be stated in Equation (1), where V_{in} is the DC source’s voltage.
\[ V_{\text{out}} = \frac{R_2}{R_1 + R_2} \cdot V_{\text{in}} \]  

(1)

With Equation (1), the output voltage of the two resistors and the known input voltage can be found. If the values of \( R_1 \) and \( R_2 \) are unknown while the expected input and output voltages are known, deriving the formula is required. Three methods can be used to find the value of pair \( R_1 \) and \( R_2 \). It can be found by Equations (2), (3), and (4).

\[ If \, R_2 = 1000 \, \Omega, \, then \, R_1 = \frac{(V_{\text{in}} - V_{\text{out}}) \cdot R_2}{V_{\text{out}}} \]  

(2)

\[ If \, R_2 = \left(\frac{V_{\text{out}}}{V_{\text{in}}}\right) \cdot 1000 \, \Omega, \, then \, R_1 = 1000 \, \Omega - R_2 \]  

(3)

\[ If \, R_1 = 1000 \, \Omega, \, then \, R_2 = \left(\frac{V_{\text{out}} \cdot R_1}{V_{\text{in}} - V_{\text{out}}}\right) \]  

(4)

2.2. UI design

To create a UI and Voltage Divider Calculator’s prototype, it requires individual specifications to support the App’s design as defined in Table 1 and Table 2. UI is essential in an App which functioned to connect the application system with the user [12,13]. A prototype is developed as an initial design that can be run on the Android OS [14]. The specifications described in Table 1 and Table 2 refer to the recommended minimum limits for using supporting software; for example, the Android Studio requires a minimum of 4 GB RAM with a minimum storage space of 2 GB or more is recommended. The software requirements are taken from the recording results after successfully developing an App. Android studio is the critical software in developing our App; it is a software-based on Java and Kotlin. Photoshop software is used to design an attractive interface decoration [15]. Therefore, this App’s appearance is beautiful and full-color to make users feel enjoyed.

**Table 1. Software requirements.**

| No | Software | Description |
|----|----------|-------------|
| 1  | OS       | Windows 10/8/7 |
| 2  | Editor Software | Adobe Photoshop, Circuit Wizard, Mocplus, Android Studio |
| 3  | Support File | Microsoft Visual C++ 2012, Java(TM), SE Development kit 12.0.2/Android SDK, Net Framework 4.0 |
| 4  | Text Editor | Notepad++ |

**Table 2. Hardware requirements.**

| No | Hardware | Description |
|----|----------|-------------|
| 1  | Processor | Intel or AMD Processor with 64-bit Support, 2 GHz or Faster Processor |
| 2  | RAM And Disk Space | Minimum 2GB, recommended 8GB, & 4 GB or more |
| 3  | Graphics Card | R5 M320 1Gb or more, nVidia Geforce GTX 1050 |

3. Results and discussion

This paper focuses on making the initial application stage, namely the user interface design stage, and the implementation of five technical and visual menu discussions. There are menus in our Apps: 1) Find \( V_{\text{out}} \) menu; 2) Find \( R_1 \) & \( R_2 \); 3) Settings; 4) Home, and 5) Theory. First, we create an overview of the prototype system (section 3.1), then we design the dashboard and theory as in section 3.3. Later, we design the application menu as explained in section 3.5. In the 1.0 version, our App uses Bahasa because it is targeted for domestic use. These menus will be explained in the sections 3.1 to section 3.3.
3.1. **UI design, algorithm, and use case of the voltage divider calculator**

The UI design is done by first describing the technical requirement of the algorithm. This step includes several main interactions from the available calculation menu, namely the Find $V_{out}$ & Find $R_1$ & $R_2$ menu. Each of these menus has a different calculation algorithm, as shown in Figure 2(a), Figure 2(b) and Figure 2(c). When the user opens the application in the UI flowchart, the first display that will appear is the flash logo display, followed by the dashboard app display after the flash disappears. On the dashboard, then the main menu appears in this application. The key of the Find $V_{out}$ & Find $R_1$ & $R_2$ menu is to calculate the formula used and input the value stored in the variable, then input into the formula for each menu. Figure 3 shows the use case diagram of the App.

![Flowchart](image)

**Figure 2.** Flowchart of (a) UI system of the App; (b) System to find the $V_{out}$ value; (c) System to find $R_1$ & $R_2$ values.
3.2. Dashboard and theory menus
The dashboard menu is the main menu (Home) on the Voltage Divider Calculator. This menu contains several other menus (Figure 4). The friendly design can add a sense of its impression for users. The theory menu has three submenus, namely (a) Introduction (b) Component (c) Calculation. Each of these submenus certainly has its respective functions. After designing the dashboard and the next theory, namely the stage of making UI settings, find $V_{out}$ & find $R_1$ & $R_2$ as described in section 3.5. The value of $R_1$ & $R_2$ are referred from Equation (1), (2), and (3).

The introductory submenu explains the voltage divider circuit as a basis for user knowledge; the components explain the constituent components, the calculations provide an overview of the formulas used in the calculation of this application. Users can not only look for the value of $V_{out}$, $R_1$ & $R_2$ but also can read again about the voltage divider.

![Figure 3. Use case diagram.](attachment:image.jpg)

3.3. Setting, find $V_{out}$ and find $R_1$ & $R_2$ menus
The voltage divider calculator has a choice of languages available on the settings menu, not only Bahasa Indonesia but has various languages available in the further version. In the first version (V.1.0), our App only provides Bahasa. The Find $V_{out}$ menu is one of the main features of the voltage divider calculator application, which functions as a $V_{out}$ counter for the voltage divider circuit if $V_{in}$ and the values of $R_1$ & $R_2$ are known (Equation 1). Simultaneously, the Find $R_1$ & $R_2$ menu is used to find the $R_1$ and $R_2$ values if the $V_{in}$ and $V_{out}$ are known (Equation 1, Equation 2, Equation 3). The Find $V_{out}$ menu consists

![Figure 4. (a) Dashboard of Voltage Divider App; (b) Theory menu; (c) Submenu of theory.](attachment:image.jpg)
of three parameters, i.e., $V_{in}$, $R_1$ and $R_2$ values, while the Find $R_1$ & $R_2$ menu consists of two parameters, i.e., $V_{out}$ & $V_{in}$ values. Hence, the resistor value can be determined using the formula for the resistors value available in the market. All of these menus can be seen in Figure 5.

![Figure 5](image)

Figure 5. (a) General Setting; (b) Language Setting; (c) Find $V_{out}$ menu; (d) Submenu $R_1$; (e) Submenu $R_2$; (f) Find $R_1$ & $R_2$ menu.

4. Conclusion

This voltage divider calculator application has been successfully defined and designed at the user interface design stage. Our App is mainly targeted at extracurricular activities related to electronics’ scope at the Elementary School level (mainly for 4th to 6th grade, or 10 to 14 years old child). Our App can be used by students and teachers; it can serve to facilitate the basic electronics extracurricular programs’ learning process. Our App produces a beneficial product for educators in implementing real learning through this voltage divider calculator application. The student can find $V_{out}$ and pair $R_1$-$R_2$ by using this App. In future work, we will realize our App and uploaded to the Play store.
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