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Design and Development of an Electric Power Mirror Simulator on Vehicles

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Abstract

The electric power mirror is one of the essential components in modern vehicles. Understanding how the electric power mirror works is crucial, as it facilitates troubleshooting and repair when the system malfunctions. The development of an electric power mirror simulator aims to help users directly understand the components, working principles, and electrical circuits involved, through an interactive simulator board. This simulator was created using an experimental method involving the design, frame construction, material collection, and testing processes. The test results show that the electric power mirror simulator functions properly and is suitable for use as an educational tool, The average voltage flowing in the circuit is 11.4 volts, and the electric current is 1.48 amperes.

Keywords*:* Electric Power Mirror, Simulator, Learning media

Abstrak

Electric Power Mirror *merupakan salah satu komponen pada kendaraan modern. Pada saat ini mempelajari cara kerja* Electric Power Mirror *sangat penting karena dapat mempermudah dalam proses perbaikan jika fitur ini tidak berfungsi sebagaimana mestinya. Pembuatan simulator* Electric Power Mirror *bertujuan untuk memudahkan seseorang memahami komponen- komponen, cara kerja dan jalur kelistrikan pada* Electric Power Mirror *secara langsung melalui papan simulator. Dalam pembuatan simulator ini menggunakan metode eksperimen dengan cara perancangan, pembuatan rangka dan pengumpulan bahan-bahan yang diperlukan dan pengujian. Hasil pengujian menunjukan bahwa simulator* Electric Power Mirror *berfungsi dengan baik dan layak untuk dijadikan media pembelajaran dengan tegangan rata-rata yang mengalir dalam rangkaian adalah 11,4 volt, dan arus listriknya 1,48 ampere.*

Kata-kata Kunci*: Electric Power Mirror, Simulator,* Media Pembelajaran

1. Introduction

Simulator-based automotive learning media is currently essential, as the automotive field is continuously experiencing technological advancements [1]. The development of learning media through simulators makes it easier for learners to study systems in the automotive field, particularly electrical systems [2], learning media simulator can improve a student to become a professional in the automotive field [3], Learning media simulator can also increase students' enthusiasm for learning [4]. With the presence of a simulator, learners can engage in hands-on learning by observing and assembling the electrical system directly on the simulator board. This allows the knowledge gained from books or other sources to be compared and applied more easily through direct practice on the simulator [5].

Several individuals have successfully developed automotive simulator tools, including Aris et al., who created a learning media simulator for the automotive starter system, which proved effective in supporting the learning process for understanding the starter system [6], Priya et al. developed a learning media simulator for a 5-speed manual automotive transmission, which has been proven to enhance students' understanding of the transmission system [7], Suryani et al. developed a simulator prototype of a three-phase induction motor, while Sidiq Supriyanto created a prototype of an Electronic Fuel Injection (EFI) system [8], Dwi Jatmoko et al. developed a learning media for the battery charging system [9], Nurcholis created a simulator learning media about the car charging system which has proven to be an effective learning media [10], Bambang created a catalytic converter learning media simulator, which has been proven to make it easier to learn about catalytic converters [11], Meiyaldi created a learning media simulator about automotive lighters and it was proven to be able to improve the quality of student learning [12]. Raducan developed a prototype device for monitoring the power mirror using a camera [13], And Bin Xu developed a power mirror prototype using a microprocessor [14]. Based on these simulators, it can be confirmed that they help learners to study various systems in the automotive field [15].

As a further contribution, this study aims to develop a learning media simulator for the electric power mirror, considering that this feature has become a standard in modern vehicles. The simulator is designed to facilitate learners in understanding the working principles of the power mirror system through hands-on practice and visualization on the simulator board.

2. Method

An experimental method was employed in this study, consisting of four main stages: (1) simulator design, (2) tools and materials procurement, (3) simulator construction, and (4) performance testing of the power mirror simulator.

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A. Research Flow

he research flow presented in **Figure 1** illustrates the process flow and methodology of the study.

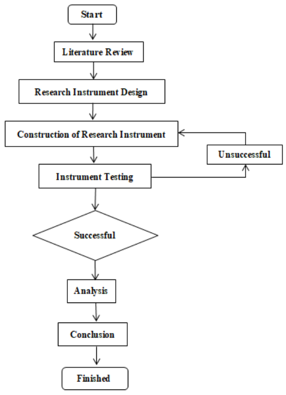

Figure 1. Flowchart of the Research Process and Methodology

The research process begins with a literature review of several previous studies, followed by designing the research tool based on the principles of the system to be simulated. Next, components and materials needed are identified and collected. Then, the electric power mirror simulator is constructed and assembled. Afterward, testing is conducted on the simulator to determine whether the tool functions according to the design objectives. Data from the testing are collected, and finally, conclusions are drawn based on the results of the study.

B. Design of the frame and panel board for the electric mirror simulator

The design of the frame and panel board for the electric mirror simulator, as illustrated in Figure 2, was developed using CorelDRAW software. The layout design dimensions of the power mirror simulator board are 90 cm (length), 33 cm (width), and 67 cm (height). These specifications ensure structural integrity to securely support the power mirror and provide sufficient rigidity to withstand operational vibrations during power mirror movement.

Figure 2. Power Mirror Frame Design Drafting

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C. Construction of the Power Mirror Simulator Frame

Following the completion of the power mirror simulator frame design using CorelDRAW software, the subsequent step involved the physical fabrication of the simulator frame utilizing hollow steel, as depicted in Figure 3. Hollow steel was selected based on its advantageous properties of being lightweight yet possessing high structural strength, thereby providing an efficient and durable material choice for the construction of the power mirror simulator frame.

Figure 3. Steel Measurement and Cutting Process for Simulator Frame Construction

D. Welding Process of the Frame

After the steel material has been measured and cut, the next step is to join the pieces using arc welding, as shown in **Figure 4.** This process ensures strong and neat weld joints.

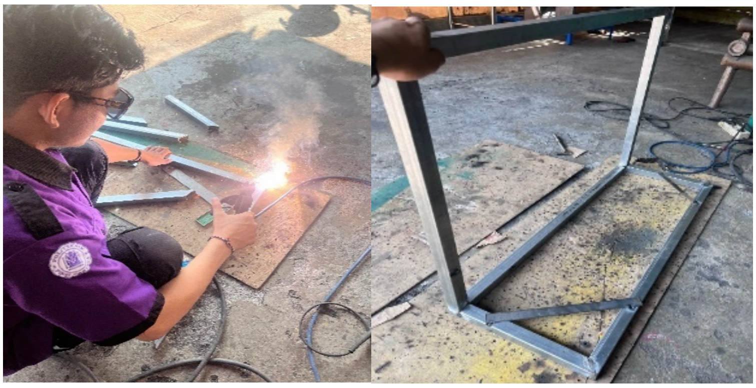

Figure 4. Welding Process of the Simulator Frame

E. Cleaning Process of Welding Slag

After the welding process, the cut and welded surfaces remain rough and uneven. Therefore, a surface finishing process is necessary to smooth the frame. This is done using a grinding tool, as shown in **Figure 5**, to ensure an even surface. Smoothing the frame also helps prevent hand injuries during handling and avoids damaging the acrylic during installation.

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Figure 5. Welding Slag Removal Process

F. Simulator Frame Painting Process

The final step in the frame fabrication process is painting. Besides enhancing aesthetics, painting protects the frame from corrosion, which can reduce the lifespan of the steel used. Before painting begins, the frame surface must be cleaned of dirt and rust using a grinder and sandpaper. Uneven surfaces or welding marks require putty application. The painting process, shown in **Figure 6**, involves applying a primer coat followed by a top coat. Painting is carried out using a spray gun.

Figure 6. Painting Process of the Simulator Frame

G. Fabrication of the Simulator Board

To create a sturdy and user-friendly panel board, transparent acrylic with a thickness of three millimeters was used. The panel board measures 76 x 90 centimeters, and the layout design was printed onto the acrylic. Before mounting the panel board onto the frame using screws, holes were drilled into the acrylic board. The hole-making process, as shown in **Figure 7**, involved the use of a handheld drill and files. These holes serve as locations for bus sockets/banana jacks, electrical components of the electric mirror system, and mounting bolts to secure the board to the frame. All holes were then finished and smoothed using sandpaper and files.

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Figure 7. Simulator Board Fabrication

H. Simulator Assembly

As illustrated in **Figure 8**, the assembly process involves installing components such as the electric headlamp, wiring, and foam connectors onto a pre-drilled acrylic board. Initially, the panel board is mounted onto the simulator frame using screws. Subsequently, components including the ignition switch, fuse, headlamp switch, mirror, and wiring harness are installed in accordance with the electrical system schematic. The assembly utilizes various tools, including 8 mm and 10 mm wrenches, screwdrivers, wire cutters, scissors, a soldering iron, heat-shrink tubing, a lighter, and a drill. The basic electric power mirror used in this study is from the Toyota All New Avanza, as it features a more modern and updated design.

Figure 8. Assembly of Electrical Components and Wiring

3. Results and Discussion

After going through several stages including frame and layout design, material selection, measurement and cutting, welding, frame finishing, painting, panel board fabrication, and the assembly of components and materials the simulator was successfully constructed, as shown in **Figure 9.**

Figure 9. Front, Side, and Rear Views of the Completed Power Mirror Simulator

Figure 10 illustrates the final form of the electric power mirror simulator. Upon completion of the construction process, a series of functional tests were conducted to evaluate the operational performance and reliability of the system.

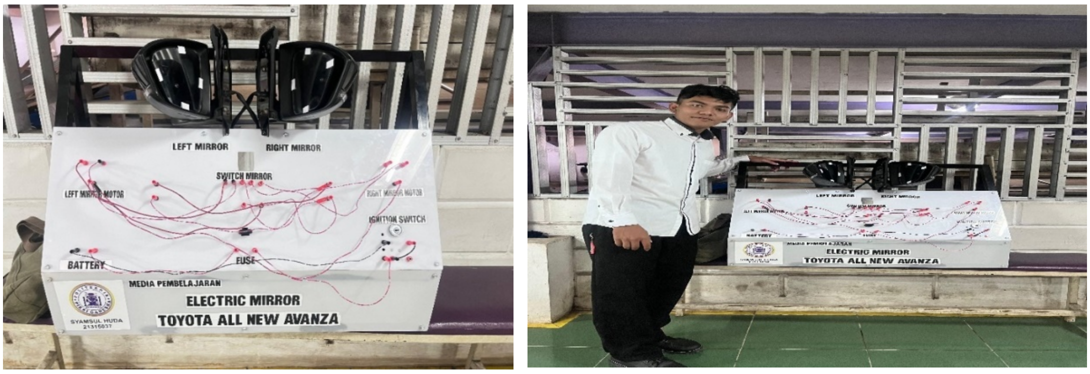

Figure 10. Final Outcome of the Electric Power Mirror Simulator Construction

A. Component Functional Testing

The component testing of the simulator aims to verify the accuracy of its operation and the functionality of the device as a simulator. The testing was conducted using a multimeter, with the selector set according to the specific inspection. Continuity tests were performed on the components of the electric power mirror system as well as between the component terminals and the ignition switch bus bar.

a) Ignition Switch Continuity Testing

Continuity testing of the ignition switch terminals, as shown in Table 1, was conducted to verify the proper functionality of the ignition switch. Based on the test results, the ignition switch was confirmed to be functioning correctly.

Table 1. Ignition Switch Continuity Test Results

Ignition Switch Positions	Terminal Continuity	Specifications	Result
OFF	-	-	-
IG	B-IG-ACC	Continuity confirmed	Continuity confirmed
ST	B-G-ST	Continuity confirmed	Continuity confirmed
ACC	B-ACC	Continuity confirmed	Continuity confirmed

b) Fuse Continuity Testing

Table 2 shows the results of the fuse testing, indicating that the fuse is still in good conditionbecause continuity between the input and output terminals is maintained.

Table 2. Fuse Continuity Test Results

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Fuse	**Terminal Continuity**	**Specifications**	**Hasil**
10 A	Input-output	Contnuity confirmed	Continuity confirmed

c) Operation testing of the left electric mirror for rightward movement.

Figure 11 shows the current flow in the left power mirror when moving the mirror to the right. The current originates from the battery, passes through the ignition (IG) switch and fuse, then flows to the right terminal of the mirror movement selector switch. From there, it proceeds to the HL terminal on the mirror selection switch, through the ammeter (measuring approximately 1.5 A), and into the motor that drives the left mirror, causing movement to the right. The current returns via the E terminal on the selector switch to ground. A voltmeter is installed before and after the motor, indicating a voltage of about 11.6 V across the motor circuit.

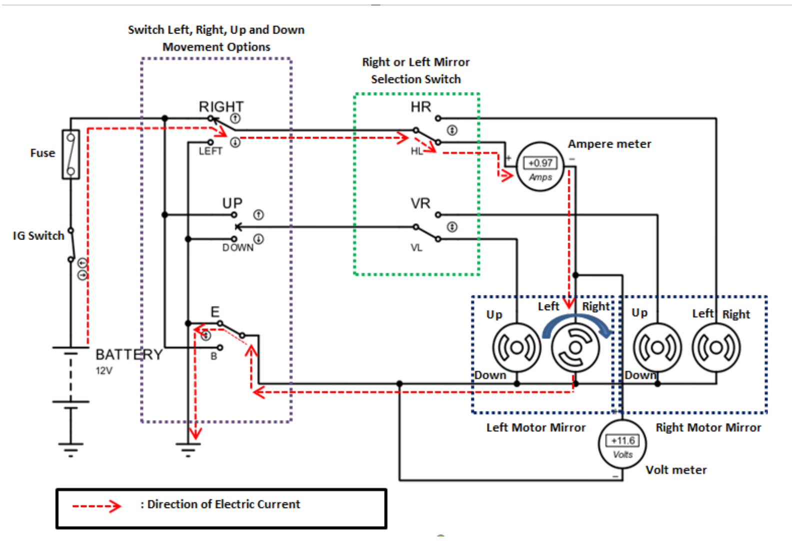

Figure 11. Current Flow in Left Power Mirror During Rightward Movement

d) Functional Testing of the Left Electric Mirror with Leftward Movement

Figure 12 shows the current flow in the left power mirror during leftward movement. Current flows from the battery through the IG switch, fuse, terminal B of the movement selector switch, and the ammeter (1.5 A), then to the motor driving the mirror leftward. The circuit continues through the HL and left terminals before reaching ground. Voltage measured across the motor is approximately 11.7 V.

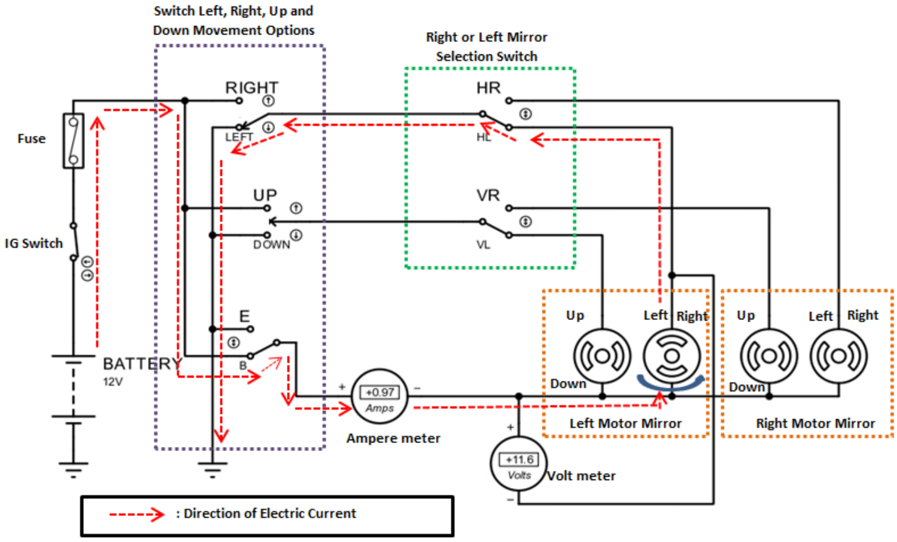

Figure 12. Current Flow in Left Power Mirror During Leftward Movement

e) Functional Testing of the Left Electric Mirror with Upward Movement

Figure 13 shows the current flow in the left power mirror during upward movement. The current flows from the battery through the IG switch, fuse, 'Up' terminal, ammeter (1.5 A), VL terminal, and into the motor, moving the mirror upward. It then exits via the E terminal to ground. Voltage measured before and after the motor is 11.7 V.

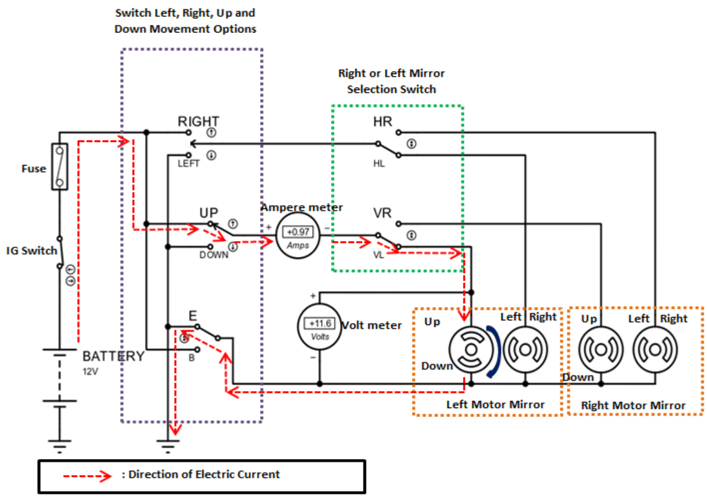

Figure 13. Current Flow in Left Power Mirror During Upward Movement

f) Functional Testing of the Left Electric Mirror with Downward Movement

Figure 14 shows the current flow in the left power mirror during downward movement. The current flows from the battery through the IG switch, fuse, terminal B, ammeter, and into

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the motor, moving the mirror downward. It then passes through terminals VL and Down before reaching ground. A voltmeter monitors voltage before and after the motor.

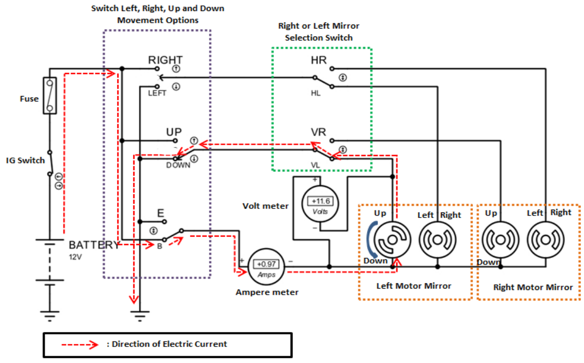

Figure 14. Current Flow in Left Power Mirror During Downward Movement

As presented in **Table 3**, the testing results of the left power mirror indicate that all directional movements—upward, downward, leftward, and rightward—functioned properly and without any significant malfunction.

Table 3. Test Results of the Left Electric Power Mirror

Type of Test	Test Results	
	Working	Inactive
Upward Movement	√	-
Downward Movement	√	-
Leftward Movement	√	-
Rightward Movement	√	-

g) Functional Testing of the Right Electric Mirror with Rightward Movement

Figure 15 shows the current flow in the right power mirror during rightward movement. Current passes from the battery through the IG switch, fuse, Right and HR terminals, then through the ammeter before reaching the motor, which moves the mirror rightward. The circuit continues to the E terminal and ground. Voltage is monitored via a voltmeter before and after the motor.

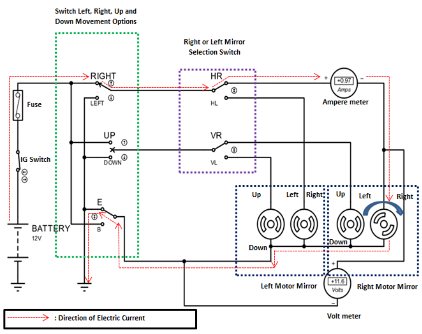

Figure 15. Current Flow in Right Electric Mirror During Rightward Movement

h) Functional Testing of the Right Electric Mirror with Leftward Movement

Figure 16 shows the current flow in the right power mirror during leftward movement. Current flows from the battery through the IG switch, fuse, and terminal B on the movement selector switch, then passes through the ammeter. It enters the motor driving the right mirror leftward, successfully moving it. The current continues through the HR terminal, then to the Left terminal, and finally to ground. A voltmeter monitors voltage before and after the motor.

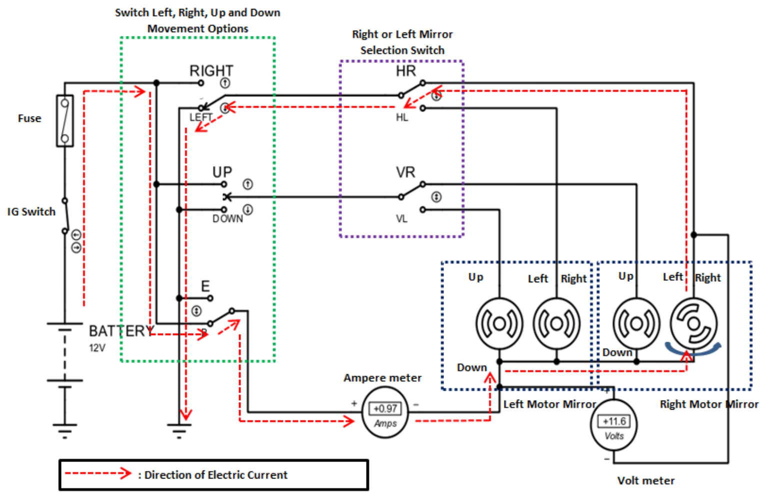

Figure 16. Current Flow in Right Electric Mirror During Leftward Movement

i) Functional Testing of the Right Electric Mirror with Upward Movement

Figure 17 shows the current flow in the right power mirror during upward movement. Current flows from the battery through the IG switch, fuse, and Up terminal on the movement selector switch, then through the VR terminal on the mirror selector switch. It passes through the ammeter before reaching the motor, which moves the right mirror upward. The current continues to the E terminal and finally to ground. Voltage is monitored via a voltmeter installed before and after the motor.

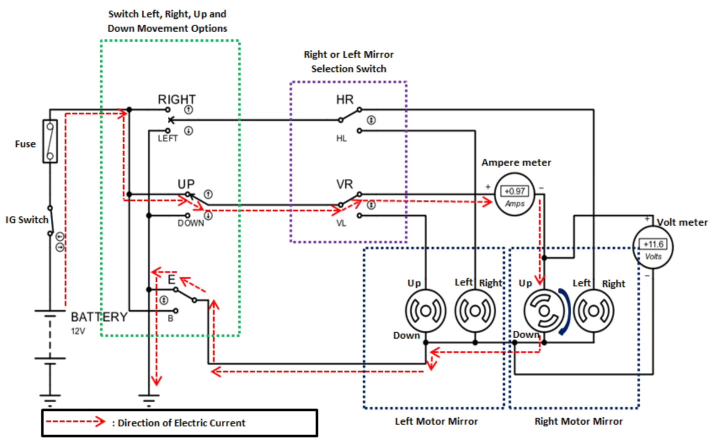

Figure 17. Current Flow in Right Electric Mirror During Upward Movement

j) Functional Testing of the Right Electric Mirror with Downward Movement

Figure 18 illustrates the current flow in the right power mirror during downward movement. The current flows from the battery through the IG switch, fuse, and terminal B on the movement selector switch, then through the ammeter. It powers the motor moving the right mirror downward. The current continues through the VR terminal, then the Down terminal, and finally to ground. Voltage is monitored by a voltmeter installed before and after the motor.

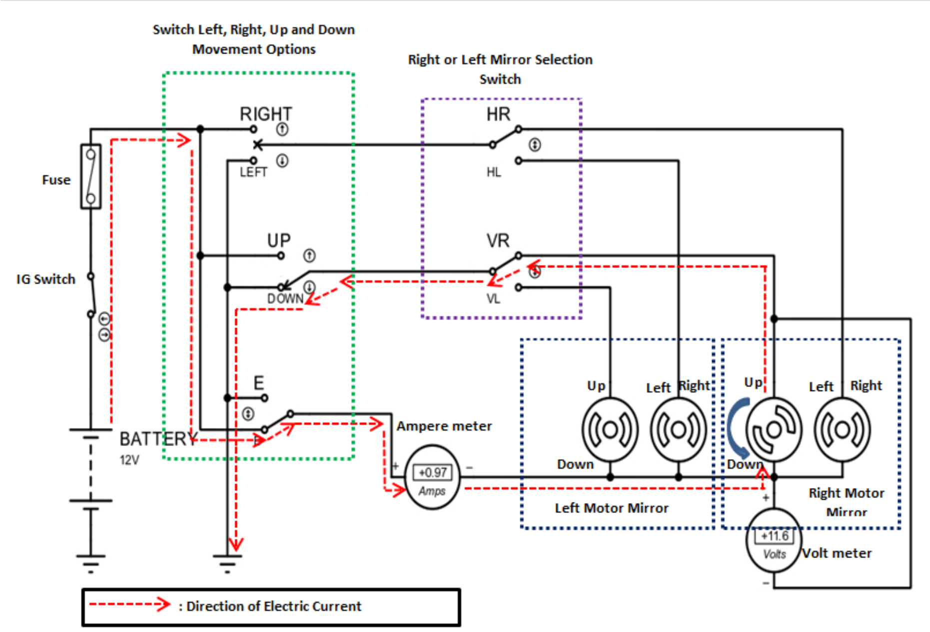

Figure 18. Current Flow in Right Electric Mirror During Downward Movement

The test results of the right power mirror, as shown in **Table 4**, indicate that the upward, downward, leftward, and rightward movements function normally and all operations perform well without significant issues.

Table 4. Test Results of the Left Electric Power Mirror

Type of Test	Test Results	
	Working	Inactive
Upward Movement	√	-
Downward Movement	√	-
Leftward Movement	√	-
Rightward Movement	√	-

k) Voltage Testing on the Electric Power Mirror

Figure 19 shows the voltage values observed in the right and left power mirror circuits when the power mirror switch is activated. Voltage was measured using a voltmeter, and data was collected based on the average voltage during switch activation in leftward, rightward, upward, and downward directions. The average voltage measured during testing was 11.4 volts.

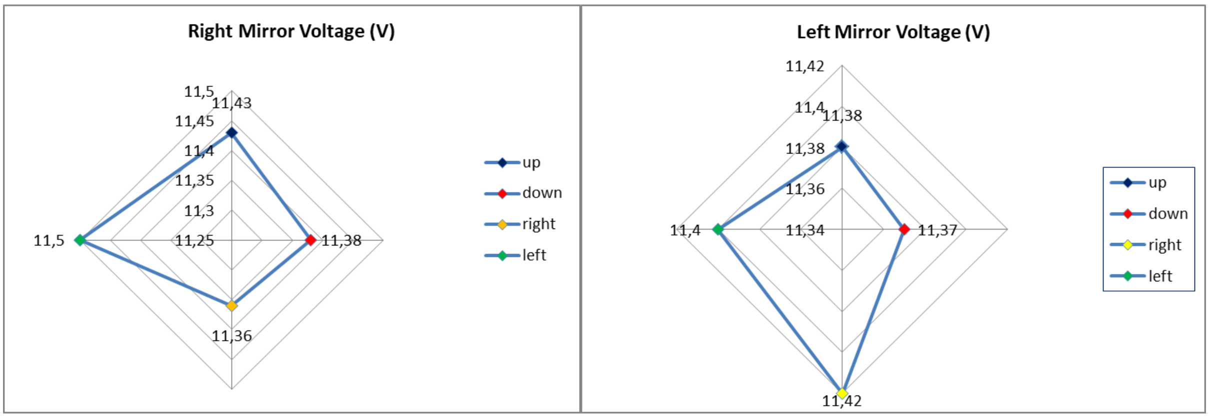

Figure 19. Voltage Graph of Left and Right Power Mirrors

l) Current Testing on the Electric Power Mirror

Figure 20 shows the electric current values in the right and left power mirror circuits when the power mirror switch is activated. Current was measured using an ammeter, with data collected based on the average current observed during leftward, rightward, upward, and downward switch activations. The average current recorded was 1.48 amperes.

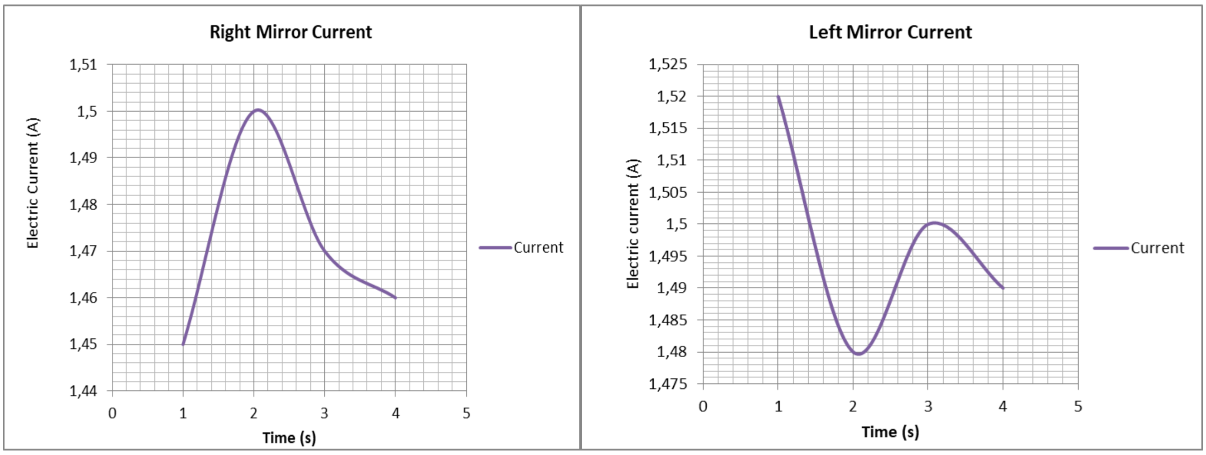

Figure 20. Current Graph of Left and Right Power Mirrors

4. Conclusion

The electric power mirror simulator has been successfully designed and developed. This simulator provides valuable support in the learning process, particularly in understanding the working principles of the electric power mirror system through hands-on practice and direct simulation on the simulator board. Based on the test results, the simulator functions as intended. Activation of the control buttons for the left and right electric power mirrors resulted in an average voltage of 11.4 volts and an average current of 1.48 amperes in the circuit. These results indicate that the simulator is capable of effectively representing the operational conditions of the electric power mirror system.

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