

Design and construction of a multi input boost converter

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ABSTRACT

This study designs and implements a Multi Input Boost Converter (MIBC) to improve the efficiency and stability of renewable energy systems. The device combines two DC voltage sources, such as solar panels and wind turbines, into a higher and more stable output voltage. The system is controlled by an Arduino Mega 2560 programmed via MATLAB Simulink to generate Pulse Width Modulation (PWM) signals, which are amplified by an IR2110 gate driver before activating the MOSFET. Two 12 V DC inputs are processed through the boost converter circuit to produce voltages of up to 24 V DC. An ACS712 current sensor and a voltage sensor are used as feedback for real-time duty cycle adjustment. The research process includes block diagram design, circuit construction, hardware assembly, and microcontroller programming. Testing on 50 Ω and 110 Ω loads shows that the MIBC can efficiently combine two power sources, maintain voltage stability, and minimize power losses. This design enhances the reliability and flexibility of hybrid power generation systems and has the potential to serve as a reference for developing multi-input power conversion in small to medium-scale renewable energy applications.

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1. INTRODUCTION

The development of renewable energy technology is advancing rapidly in line with the increasing demand for environmentally friendly and sustainable energy sources [1],[2]. Energy sources such as solar panels and wind turbines have become strategic options to reduce dependence on depleting fossil fuels [3],[4]. However, one of the main challenges in their utilization is the unstable nature of their output, which is influenced by external factors such as sunlight intensity and wind speed [5]. This instability can potentially reduce the efficiency of power generation systems if not properly managed [6],[7].

To address this issue, power conversion technology capable of optimizing energy from multiple sources simultaneously is required [8]. One effective solution is the use of a Multi Input Boost Converter (MIBC), a DC–DC conversion circuit that can step up low input voltage from multiple sources into a higher and more stable output voltage [9]. With its multi-input design, the system can utilize more than one energy source simultaneously, thereby reducing the risk of supply failure due to fluctuations in a single source [10],[11]. The advantage of MIBC lies in its flexibility to integrate various renewable energy sources into a single coordinated conversion system [12]. With the support of a microcontroller-based control algorithm, operating parameters can be automatically adjusted to maximize conversion efficiency [13]. This approach not only improves the reliability of energy supply but also contributes to the efficient utilization of available resources [14].

In this study, the MIBC was designed using an Arduino Mega 2560 programmed via MATLAB Simulink to generate a pulse width modulation (PWM) signal [15]. This signal is amplified through an IR2110 gate driver before activating the MOSFET in the converter circuit [16]. The system is also equipped

with an ACS712 current sensor and a voltage sensor to provide real-time feedback, enabling automatic duty cycle adjustment to maintain stable output voltage and current [17].

The design and implementation of the MIBC are expected to serve as a technical solution for optimizing hybrid power plants based on renewable energy [18]. With the ability to combine and regulate two DC power sources simultaneously, this system offers improved efficiency, reliability, and flexibility. The research findings are anticipated to serve as a reference for developing multi-input power conversion technology in small- to medium-scale renewable energy applications [19].

2. METHOD

This study aims to design and implement a Multi Input Boost Converter capable of combining two DC power sources into a single output with higher and more stable voltage. The block diagram of the Multi Input Boost Converter design using Arduino, as developed in this final project, is shown in Figure 1. The functions of each block in the Multi Input Boost Converter design are as follows : 1) PC with MATLAB is using to runs Matlab Simulink to model, simulate, and program the Arduino, 2) Arduino Mega 2560 as the microcontroller processes sensor data and generates PWM signals to control the MIBC. 3) 220 VAC Power Supply to provides electricity from the mains, stepped down to 12 V AC. 4) 12 VDC & 5 VDC Power Supply, where supplies 12 V DC for the gate drive and 5 V DC for the Arduino. 5) DC1 & DC2 12 V Power Supply for provides two separate 12 V DC sources as MIBC inputs. 6) Multi Input Boost Converter for steps up the voltage and combines two DC power sources into a single stable output. 7) Gate Drive for amplifies the PWM signal from the Arduino before it drives the MOSFET. 8) Current Sensor for measures the MIBC output current as feedback for duty cycle control. 9) Voltage Sensor for measures the MIBC output voltage through a voltage divider and Load with 50 Ω and 110 Ω resistors as test loads for the MIBC output.

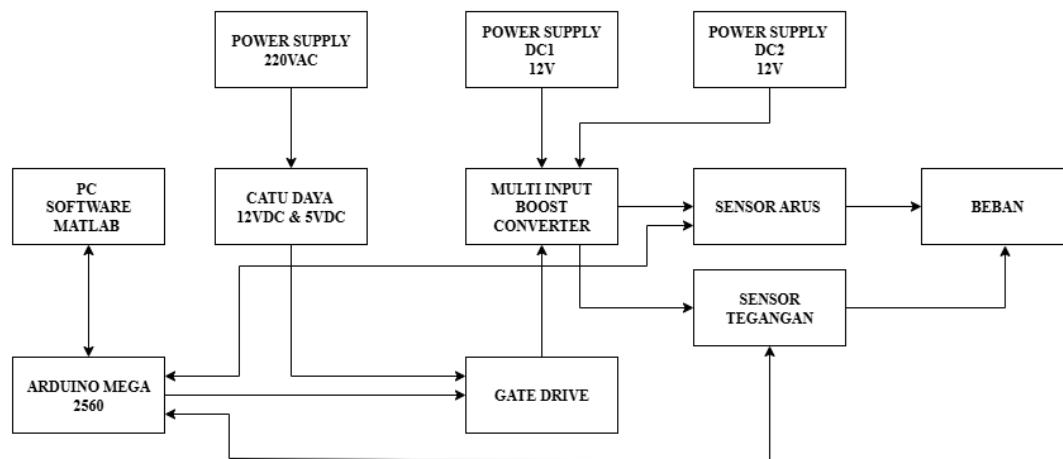


Figure 1. Diagram block of MIBC

This Multi-Input Boost Converter system integrates various components centrally controlled through MATLAB Simulink and an Arduino Mega 2560 microcontroller. The modeling, simulation, and control logic design are carried out on a computer, after which the program is compiled and uploaded to the Arduino for execution. The main power source comes from the 220 VAC mains supply, which is stepped down using a transformer and then converted into 12 VDC for the gate drive and 5 VDC for the Arduino. Additionally, two 12 VDC power supplies are used as inputs to the MIBC circuit to combine energy from both sources and boost the output voltage.

The Arduino generates PWM signals that are amplified through the gate drive before activating the MOSFETs in the MIBC circuit. This converter combines two DC inputs and steps up their voltage to produce a higher, stable output, which is then delivered to 50 Ω and 110 Ω resistor loads. The system is equipped with an ACS712 current sensor and a voltage sensor based on a voltage divider for feedback, enabling real-time PWM duty cycle adjustment to maintain stable output voltage and current according to load requirements. Through this process, the system was realized in physical form and tested directly to determine its functional performance. In this study, the device was designed to ensure that all components could be efficiently integrated into a unified system, thereby facilitating both fabrication and further testing. The design of the device is shown in Figure 2.

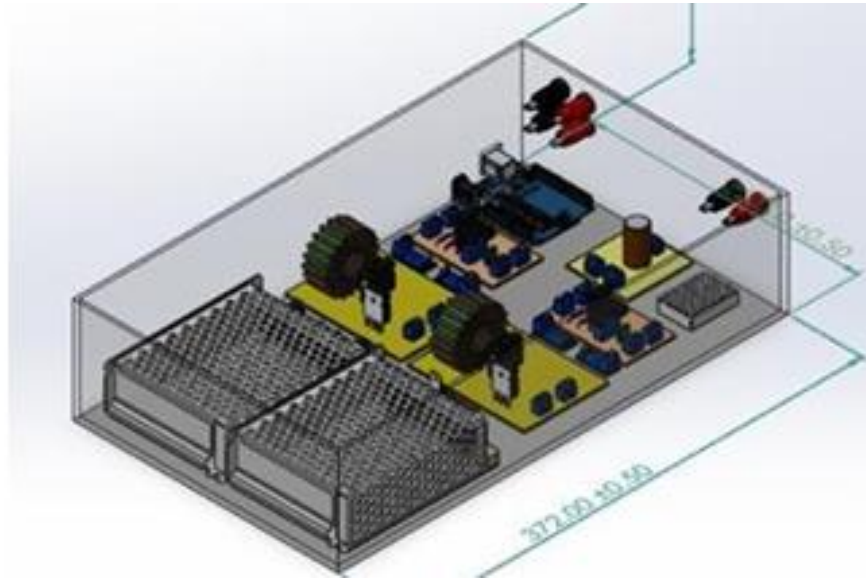


Figure 2. Device Design

The circuit shown in Figure 3 is an Arduino Mega 2560-based power control system designed to regulate the output voltage of a multi-input Boost Converter. Power from the supply circuit feeds the entire system, including the Arduino and the power conversion block. The Arduino receives input from the voltage sensor as feedback to adjust the PWM signal that controls the MOSFET through the Gate Driver. The Gate Driver amplifies the PWM signal to drive the MOSFET, enabling the inductor's energy control process to boost the output voltage. The combination of the voltage sensor, Arduino, and Gate Driver allows for efficient closed-loop control that is responsive to changes in both load and input.

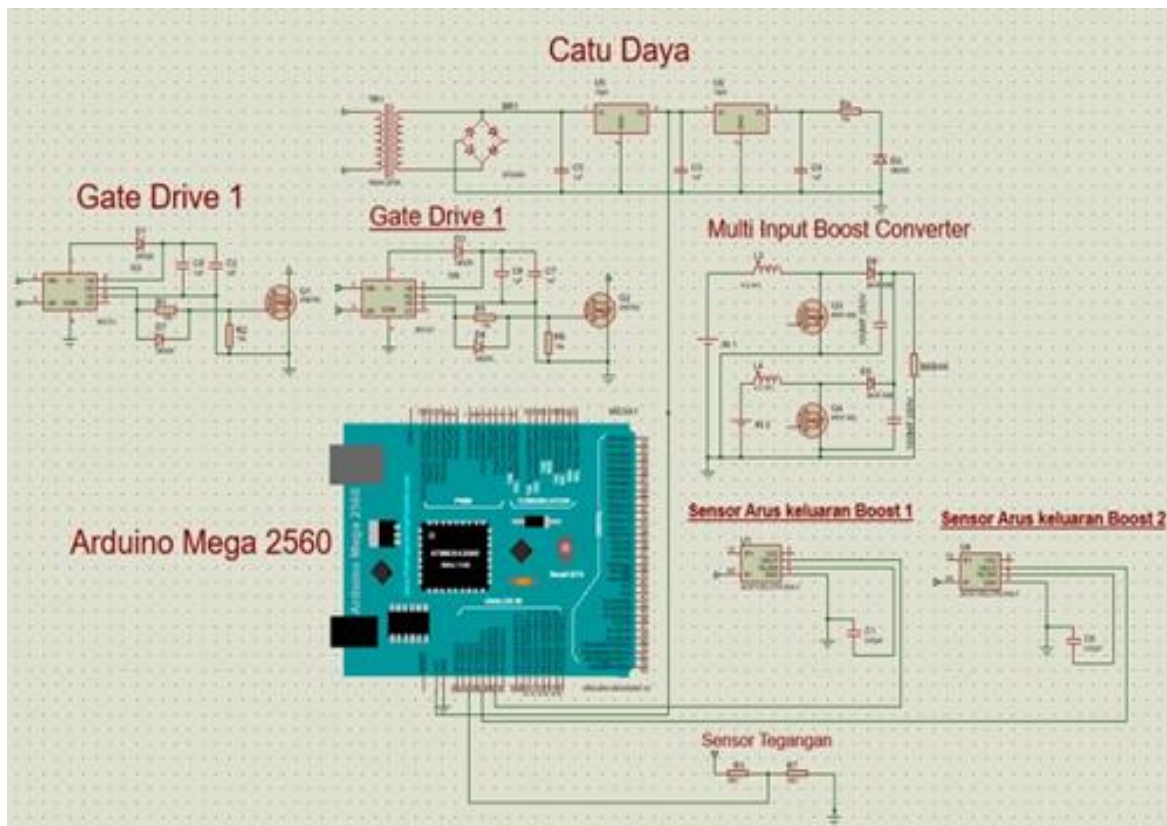


Figure 3. Overall Multi Input Boost Circuit

The flowchart in this final project illustrates the program's logic or sequence of instructions in a visual format. It clearly shows the algorithm control flow, outlining the stages of activity implementation from start to finish. The flowchart for this final project is shown in Figure 4.

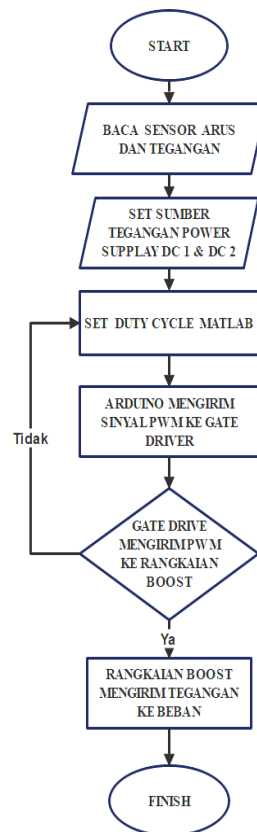


Figure 4. Flowchart of the Multi Input Boost Converter System

3. RESULTS AND DISCUSSION

The multi-input boost converter testing in this study was conducted using two variable power supplies as input sources. The purpose of the testing was to analyze the converter's performance when subjected to varying input voltages and duty cycles for each input. Figure 5 shows the experimental hardware installation.

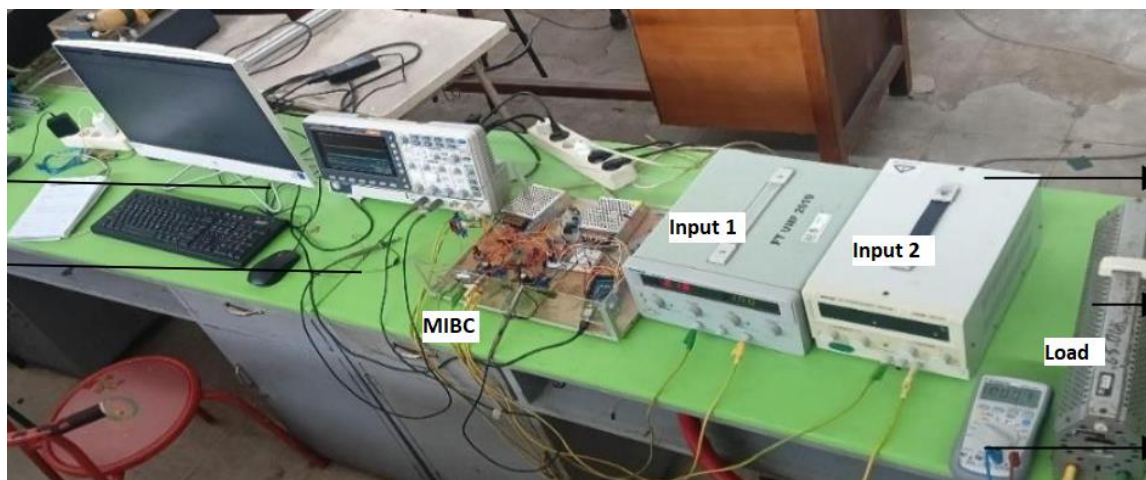


Figure 5. Hardware setup for experiment

The first experiment was conducted by integrating two converters with identical input voltages (12 V) and identical duty cycles (0.4) on both inputs, to observe output stability when both operate under the same conditions. Figure 6 shows the first experiment results.

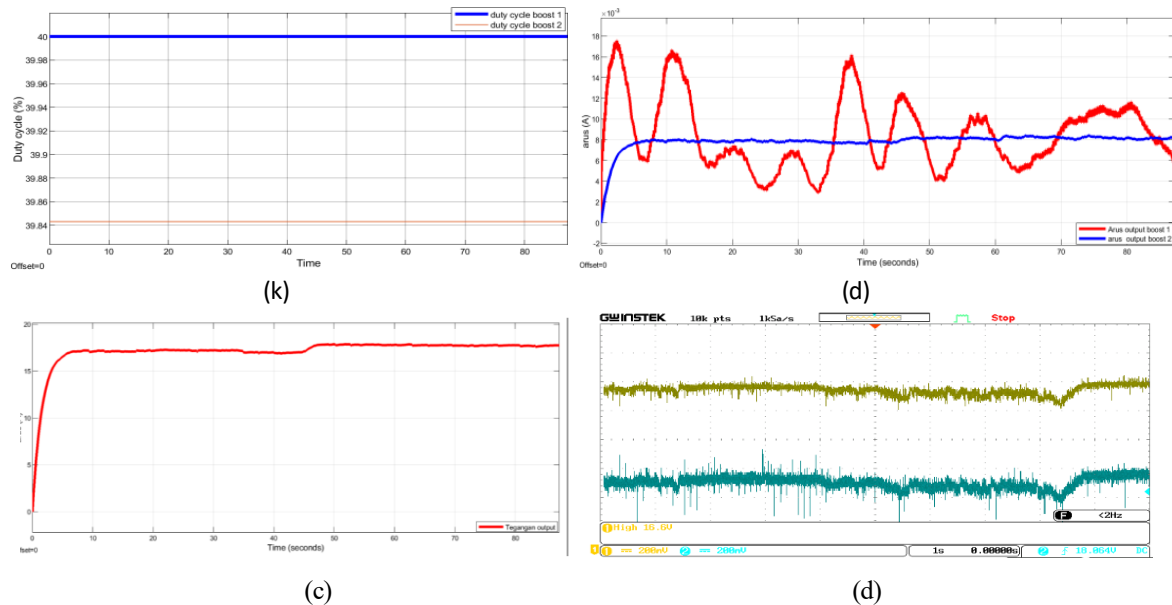


Figure 6. First experimental results. a) *Duty cycle* of Boost 1 & 2. b) *Output current* of Boost 1 & 2, c) *Overall output voltage* of the multi-input boost converter, d) *Output voltage* of Boost 1 & 2.

Testing two converters with 12 V inputs and a duty cycle of 0.4 showed a stable output of around 18 V (multimeter reading 18.35 V). However, the current was stable in only one converter, while the other experienced significant fluctuations. The second experiment is carry out by using two 12 V power supplies with different duty cycles (0.4 and 0.6) aimed to observe the effect of varying switch-on times for each input on the system's output voltage. Figure 7 shows the second experimental results.

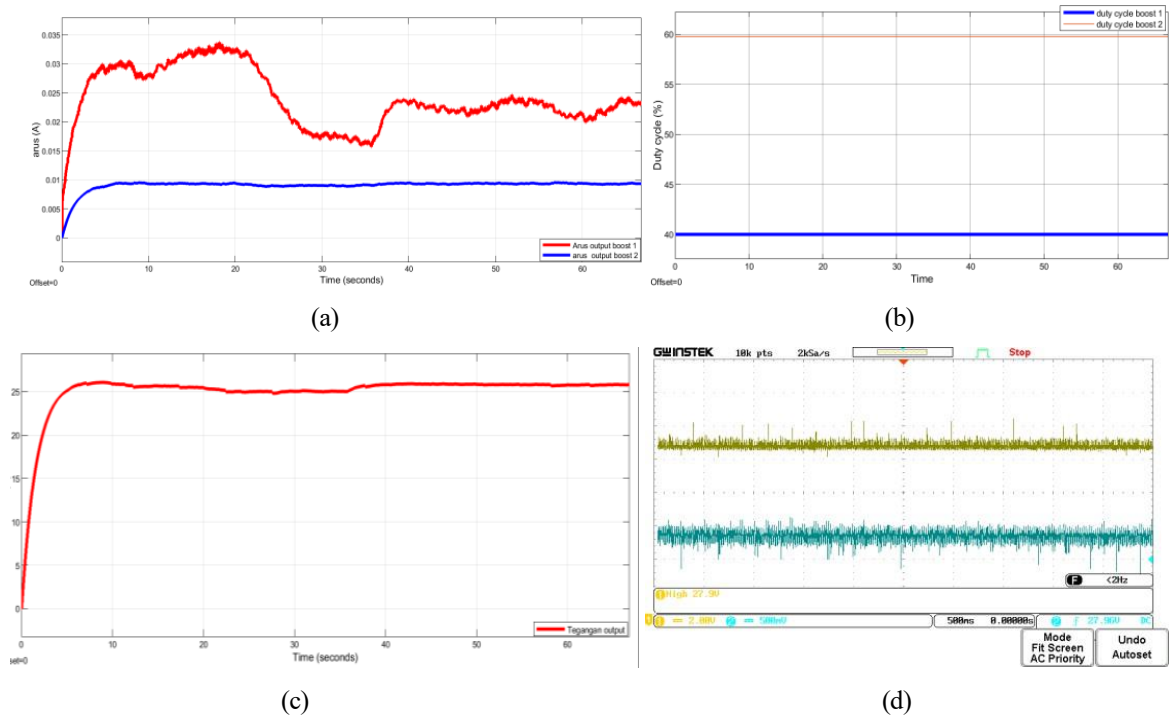


Figure 7. The second experimental results, a) *Output current* of Boost 1 & 2, b) *Duty cycle* of Boost 1 & 2.

c) Overall output voltage of the multi-input boost converter. d) Output voltage of Boost 1 & 2.

Testing two converters with 12 V inputs and different duty cycles (0.4 and 0.6) produced a stable output of around 25 V (multimeter reading 27.67 V). However, the converter with a duty cycle of 0.6 exhibited significant current fluctuations, while the other remained relatively stable, indicating an imbalance in response and load distribution. The third testing is done with different inputs (10 V and 12 V) and the same duty cycle (0.6) was conducted to assess the converter's ability to balance the output when the power sources have non-identical voltages. Figure 8 shows the experimental results.

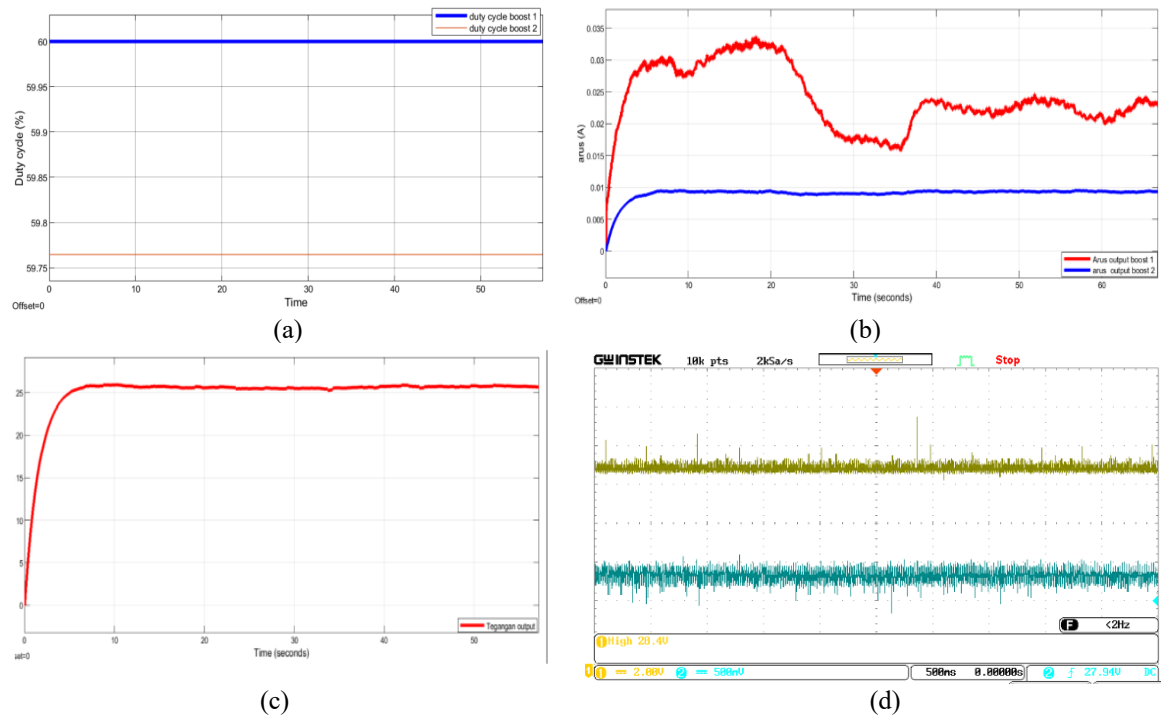


Figure 8. The third experimental results. a) Duty cycle of Boost 1 & 2. b) Overall output voltage of the multi-input boost converter. c) Output voltage of Boost 1 & 2. d) Output voltage of MIBC

Testing two converters with different inputs (10.2 V and 11.9 V) and a duty cycle of approximately 60% produced a stable output of 25–26 V (multimeter reading 27.67 V). However, the currents were unbalanced: one converter maintained a low stable current, while the other fluctuated, indicating that input differences and component characteristics affect load distribution.

4. CONCLUSION

Based on the design, testing, and analysis results, the Multi-Input Boost Converter was successfully developed using the Arduino Mega 2560 as the main controller. The circuit is capable of integrating two DC power sources and boosting the output voltage. Test results indicate that the converter operates according to its principle, producing an output voltage higher than the input voltage, with increases in voltage and current directly correlated to the increase in duty cycle.

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