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# Design and Implementation of DC to DC Converter for Mobile Phone Charging Based on Microcontroller

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**ABSTRACT**

The increasing demand for portable and energy-efficient electronic devices has driven innovation in smartphone charging technology. Continuous smartphone operation requires an efficient power source, especially when AC power is unavailable. This study presents the design and implementation of a microcontroller-based DC-to-DC Buck Converter for smartphone charging using a 12V DC input. The system employs a MOSFET as a switching device controlled by PWM signals generated by an ATMega16 microcontroller. By adjusting the PWM duty cycle, the microcontroller regulates the output voltage to meet different smartphone charging requirements.The converter steps down the 12V DC input to a lower, stable voltage suitable for mobile phone charging while maintaining high efficiency. Essential circuit components, including the microcontroller, MOSFET, inductor, and capacitor, are arranged to ensure smooth voltage conversion with minimal ripple. Experimental results confirm that the designed converter effectively produces adjustable voltage levels compatible with various smartphones.Overall, this system demonstrates a reliable and energy-efficient solution for DC-powered smartphone charging, offering flexibility for use in portable and off-grid conditions.

## 1. INTRODUCTION

In recent years, the continuous growth of digital technology has significantly increased the demand for portable and energy-efficient electronic devices. Smartphones, which serve as essential tools for communication, entertainment, and work, now integrate a wide range of advanced features that require higher power consumption. As a result, maintaining efficient battery charging systems has become an important aspect of smartphone design and usability[1]. Most conventional chargers depend on alternating current (AC) from the main power grid, which restricts their functionality in mobile or outdoor situations where direct current (DC) sources, such as car batteries or renewable energy systems, are more accessible.

To address this limitation, a charging device capable of operating directly from a DC power source is required. Such a system should be efficient, reliable, and adaptable to different smartphone voltage requirements. A DC-to-DC step-down converter, commonly known as a Buck Converter, provides a suitable solution by converting a higher DC input voltage into a lower, regulated output voltage. The use of a microcontroller in this system enables precise control through Pulse Width Modulation (PWM), which adjusts the switching activity of the MOSFET to maintain a stable output voltage.

This paper presents the design and implementation of a microcontroller-based Buck Converter for smartphone charging using a 12V DC input. The proposed system enhances flexibility, energy efficiency, and safety during the charging process. Moreover, it demonstrates the potential of DC-powered charging devices as practical alternatives in environments where AC power is limited or

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unavailable, contributing to the development of more versatile and sustainable portable energy solutions.

## 2. THEORITICAL BACKGROUND

### *2.1. DC Chopper (Buck Converter)*

A DC chopper is a power electronic circuit that transforms a fixed DC input into a variable DC output. Among its types, the Buck Converter is commonly used to reduce voltage levels efficiently[2]. It operates by switching the input voltage on and off at high speed, producing an average output that depends on the duty cycle. By adjusting this duty cycle, the converter can regulate the output voltage as required. Because of its simplicity, compactness, and high efficiency, the Buck Converter is widely applied in portable devices and battery charging systems[3].

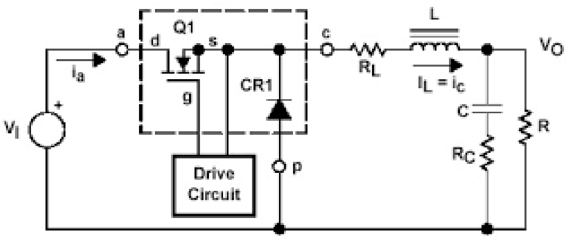


*Figure 1. DC Chopper (Buck Converter)*

### *2.2. MOSFET (Metal Oxide Semiconductor Field Effect Transistor)*

The MOSFET acts as a key switching element in the converter, rapidly turning the current flow on and off. This high-speed switching produces a pulsating signal that is filtered to obtain a stable DC voltage. The output characteristics are determined by the switching frequency and duty cycle[4]. Due to its fast operation, low power loss, and ease of control, the MOSFET is an ideal component for DC converter applications.

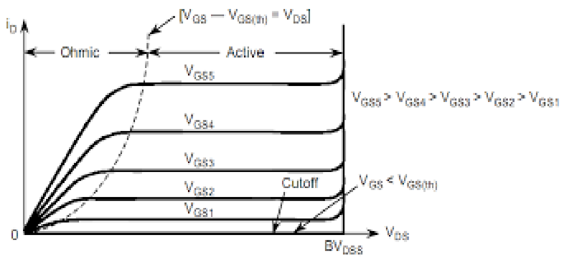


*Figure 2. MOSFET Characteristic Curve*

### *2.3. PWM (Pulse Modulation Width)*

Pulse Width Modulation (PWM) is a control method that adjusts the output voltage by varying the width of the ON pulse while maintaining a constant frequency[5]. A longer ON time (higher duty cycle) increases the output voltage, whereas a shorter ON time decreases it. PWM enables precise and efficient voltage control, making it essential for managing the MOSFET's operation in DC converters.

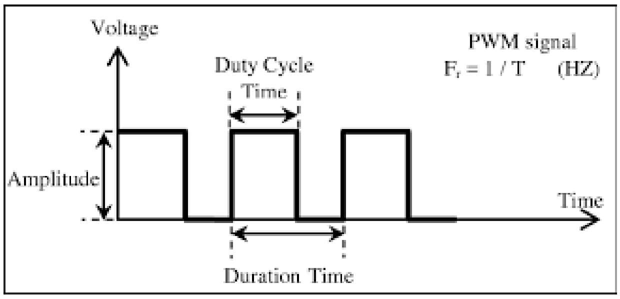


*Figure 3. PWM Waveform*

### *2.4. ATMega16*

The ATMega16 is an 8-bit AVR microcontroller designed for control and automation systems. It includes timers and PWM generators that can be used to control switching devices such as MOSFET[6]. In this work, the ATMega16 produces PWM signals to regulate the output voltage of the Buck Converter[7]. Its programmable design allows for flexible control and potential enhancements, such as feedback systems and protection features[8].

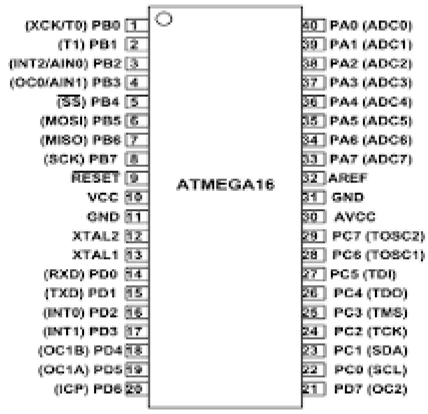


*Figure 4. ATMega16 Pin Configuration*

## 3. SYSTEM DESIGN

### *3.1. System Block Diagram*

The system is designed to perform DC-to-DC voltage conversion for smartphone charging using a 12V DC source. It applies a Buck Converter topology controlled by an ATMega16 microcontroller to achieve stable and efficient voltage regulation[9]. The main components include the power supply (12V battery), control unit (microcontroller), driver circuit (TLP250), power converter (Buck Converter), and load (smartphone). The microcontroller generates PWM signals that drive the MOSFET through the driver circuit, allowing the converter to step down the input voltage to a suitable output level. This configuration enables efficient, flexible, and reliable operation under varying input and load conditions. The



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complete arrangement is shown in the system block diagram.

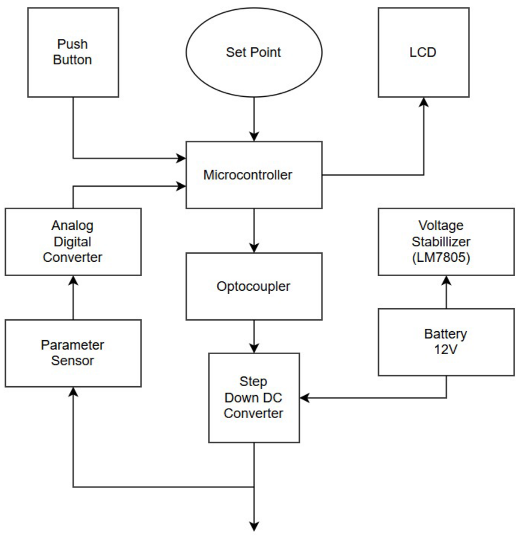


*Figure 5. System Diagram Block*

### 3.2. *Software Flowchart*

The software controls the PWM generation and output voltage adjustment through the microcontroller. It starts by initializing system parameters, setting timers and registers, then continuously adjusts the duty cycle to maintain a stable output voltage. This process ensures consistent and safe charging performance. The overall control logic is represented in the software flowchart which outlines each step of the program execution.

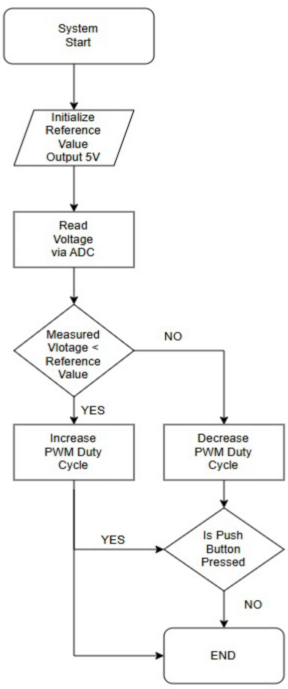


*Figure 6. Software Flowchart for PWM Control*

### 3.3. *Buck Converter Design Parameter*

The design specifications for the converter are:

Vin = 12V
Vout = 5V
Iout max = 1A
fs = 29.2 kHz

The theoretical relationship between input and output voltage
for a Buck converter is given by:

$$Vo = D \times Vin$$

The duty cycle (D) can be calculated as:

$$D = \frac{V_{out}}{V_{in}} = \frac{5}{12} = 0.4167$$

Inductor Value Calculation:

$$L = \frac{(V_{in} - V_{out}) \text{ x } V_{out}}{V_{in}\ x\ \Delta iL\ x\ fs}$$

Substituting the design value:

$$\text{L x } \frac{1}{f_s} = \frac{12}{(12-5)\ x\ 5} = \frac{1}{29.200}$$

Hence, the selected inductance is:

$$L = 100\ \mu H$$

Capacitor Value Calculation

$$V_c = V_r = 5\ V$$

With ripple current $I_c = \Delta i = 1\ A$:

$$\frac{1}{2_{\pi f_s C}} = 5$$

$$\frac{1}{2(3.14)(29.2\ x\ 10^{3)}\ C} = 5$$

$$C = \frac{1}{(6.28\ x\ 29.2\ x\ 10^3)\ x\ 5} = 1\ \mu F$$

Therefore the selected passive components are:

$$L = 100\mu H, \quad C = 1\mu F$$



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## 4. RESULTS AND ANALYSIS

### *4.1. PWM Signal Testing*

Testing of the Pulse Width Modulation (PWM) signal was conducted to verify the functionality of the control system and ensure that the generated signals met the expected switching characteristics. The microcontroller was programmed to produce PWM signals by varying the ICR register values, which determine the duty cycle of the output waveform.

Oscilloscope observations were carried out at several ICR values to analyze the pulse width and frequency. The resulting waveforms confirmed that the duty cycle increased proportionally with the ICR value, while the switching frequency remained constant. This indicates that the microcontroller successfully generated stable PWM signals suitable for controlling the MOSFET switching in the Buck Converter circuit.

Proper PWM generation is crucial for achieving smooth and efficient voltage regulation. By accurately adjusting the duty cycle, the system can finely control the converter's output voltage, allowing compatibility with various smartphone charging requirements. These results demonstrate that the control algorithm and hardware design function as intended, providing a solid foundation for reliable converter operation.

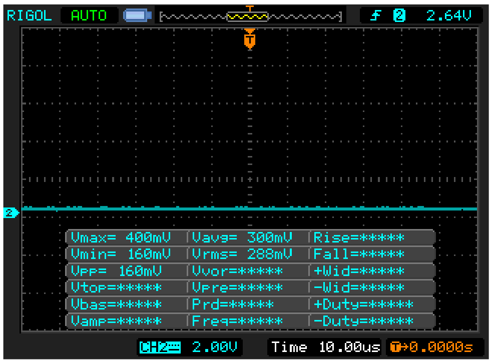


*Figure 7. PWM signal at ICR = 190*


*Figure 8. PWM signal at ICR = 90*

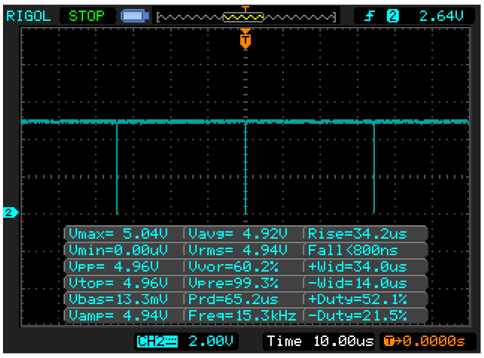


*Figure 9. PWM signal at ICR = 1*

### *4.2. Voltage Measurment Results*

Voltage measurements were conducted to evaluate the performance of the Buck Converter under different duty cycle settings. The output voltage was recorded for several PWM duty cycle variations to determine the converter's response. The experimental data showed a clear linear relationship between the duty cycle and the output voltage, consistent with the theoretical operation of a Buck Converter.

When the duty cycle was increased, the output voltage rose proportionally, confirming that the system effectively stepped down the 12V input to a lower, regulated voltage. The measured values also indicated that the converter maintained stable voltage levels with minimal ripple, demonstrating good filtering performance by the LC components.

Furthermore, the converter responded smoothly to changes in control signals, showing minimal delay and maintaining consistent performance during operation. This stability suggests that the design is capable of providing continuous charging without significant voltage fluctuation or power loss. Overall, the experimental results validate the success of the proposed system in achieving efficient DC-to-DC voltage conversion for mobile device charging applications.

| No. | Nilai ICR | Nilai Tegangan (Volt) |
|---|---|---|
| 1 | 190 | 0,3 |
| 2 | 180 | 3,44 |
| 3 | 170 | 5,38 |
| 4 | 150 | 7,11 |
| 5 | 120 | 8,08 |
| 6 | 90 | 8,3 |
| 7 | 60 | 8,49 |
| 8 | 30 | 8,65 |
| 9 | 1 | 8,8 |

*Figure 10. Voltage Measurment results of buck converter*



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## 5. RESULTS AND ANALYSIS

ATMega16 microcontroller, which generates PWM signals to control the MOSFET switching mechanism. Experimental results indicate that the system effectively steps down the 12V input to a stable and adjustable output voltage, making it suitable for charging various mobile devices. The relationship between the duty cycle and output voltage was observed to be linear, confirming that the converter performs in accordance with theoretical principles.

The prototype also demonstrated consistent performance with minimal voltage ripple and a fast response to duty cycle adjustments, validating the stability of both the control algorithm and the circuit design. Overall, the system offers a reliable, efficient, and flexible charging solution for conditions where only DC power sources are available, such as in vehicles or portable power setups.

For future improvement, it is recommended that a feedback control mechanism be integrated to automatically maintain the output voltage under varying load conditions. In addition, implementing current sensing and protection features would enhance system safety, prevent overcharging, and further improve performance reliability for wider practical applications.

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