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VOLTAGE REGULATION THROUGH KY CONVERTER USING MATLAB SIMULINK

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ABSTRACT :

Voltage regulation is a critical requirement in modern electronic systems to ensure consistent and reliable power delivery. This paper presents the design and implementation of a KY converter for efficient voltage regulation in low- voltage DC-DC conversion applications. The KY converter, a hybrid topology combining the features of buck and boost converters, offers a non-pulsating output current and improved transient response. It operates in continuous conduction mode (CCM), which enhances output voltage stability and reduces ripple compared to traditional converters. The proposed system is analyzed using theoretical modeling and verified through simulation and hardware implementation. Performance metrics such as voltage ripple, load regulation, and efficiency are evaluated, demonstrating the KY converter's effectiveness in maintaining a regulated output under varying load and input conditions. This work highlights the potential of KY converters in compact, high-performance power supply applications such as embedded systems and portable electronics.

Keywords: KY Converter, Voltage Regulation, DC-DC Converter, Continuous Conduction Mode (CCM), Power, Output Voltage Stability

INTRODUCTION

In modern electronic systems, maintaining a stable voltage is critical for the proper operation of various components, especially in applications where the input voltage fluctuates due to changing power sources or varying load conditions. Voltage regulation is therefore one of the key challenges in power electronics, ensuring that sensitive devices are supplied with a constant voltage despite these fluctuations.
A highly effective solution for voltage regulation is the KY Converter, a DC-DC converter that can function as both a buck (step-down) and boost (step-up) converter. This hybrid topology allows the KY converter to adjust the output voltage according to varying input conditions, making it suitable for applications requiring flexible and efficient voltage regulation.

The primary objective of this project is to design, model, and simulate a voltage regulation system using the KY Converter in MATLAB Simulink, a widely used platform for system simulation and design. The focus is on achieving stable and reliable output voltage under varying input voltages and load conditions.

This project introduces a comprehensive solution to voltage regulation, utilizing feedback control systems to adjust the duty cycle of the converter's switching elements in real time. This ensures that the output voltage remains consistent regardless of changes in the input or load.

METHODOLOGY

Method Voltage Regulation Through KY Converter Using MATLAB Simulink
The methodology for the Voltage Regulation Through KY Converter Project involves several steps, from designing and modeling the KY converter system in MATLAB Simulink to simulating the voltage regulation process under different conditions. This process includes the selection of components, development of control algorithms, modeling of the system, and analysis of the results. Below is a detailed step-by-step methodology for the project:

1. **System Design and Requirements Definition**

The first step in the methodology is to define the system requirements for the KY converter and the voltage regulation system.
Input Voltage Range: The input voltage can fluctuate over a specified range (e.g., 12V to 24V). This range will define the operation mode of the converter (buck or boost).

Output Voltage (V_out): The desired stable output voltage needs to be specified (e.g., 5V or 12V). The system should maintain this voltage despite variations in the input voltage and load conditions.
Load Conditions: The system should be capable of regulating the output voltage for varying loads, from light (e.g., 10Ω) to heavy loads (e.g., 2Ω).
Performance Metrics: Key performance metrics such as voltage ripple, efficiency, response time, and stability need to be defined for the system.

2. **KY Converter Circuit Modeling in MATLAB Simulink**

The next step is to model the KY converter circuit in MATLAB Simulink. The key components of the converter are represented using Simulink blocks. The modeling process involves:

Inductor and Capacitor: These are modeled as inductors and capacitors in Simulink's Simscape Electrical library. They are essential for filtering and energy storage.

Switching Devices (MOSFETs/IGBTs): The MOSFET or IGBT is modeled as a controlled switch that regulates energy flow based on the control signal (PWM). These blocks allow switching at high frequencies for efficient energy conversion.

Diodes: Used to provide unidirectional current flow when the switch is off.

Block connections in Simulink will include the input voltage source, the converter circuit, and the output load. The system will include the following components:

DC Voltage Source: Represents the varying input voltage (which can be either constant or variable).

KY Converter Circuit: The core of the system, consisting of inductors, capacitors, MOSFETs, diodes, and control circuitry.

Load: A variable load is simulated to test the converter's ability to regulate output voltage under dynamic load conditions.

3.

4. **Control System Design for Voltage Regulation**

The control system is crucial for maintaining a stable output voltage under varying input voltages and load conditions. The control strategy will be based on a closed-loop feedback system.

Control Strategy Selection:

PID Control: A PID controller (Proportional-Integral-Derivative) is designed to regulate the output voltage by adjusting the duty cycle of the switching signal.

The PID controller adjusts the switching element (MOSFET) based on the error between the reference (desired output voltage) and the actual output voltage.

Proportional (P): Controls the error proportional to the difference between the desired and actual output. Integral (I): Corrects accumulated error over time.

Derivative (D): Predicts future error to prevent oscillations.

PWM Generation: The PWM generator creates the switching signal for the MOSFET based on the control signal from the PID controller. The duty cycle of the PWM signal is continuously adjusted to ensure the output voltage remains stable.

Simulation of the Control Loop:

The PID controller is connected to a feedback loop, where it continuously compares the actual output voltage to the desired reference voltage.

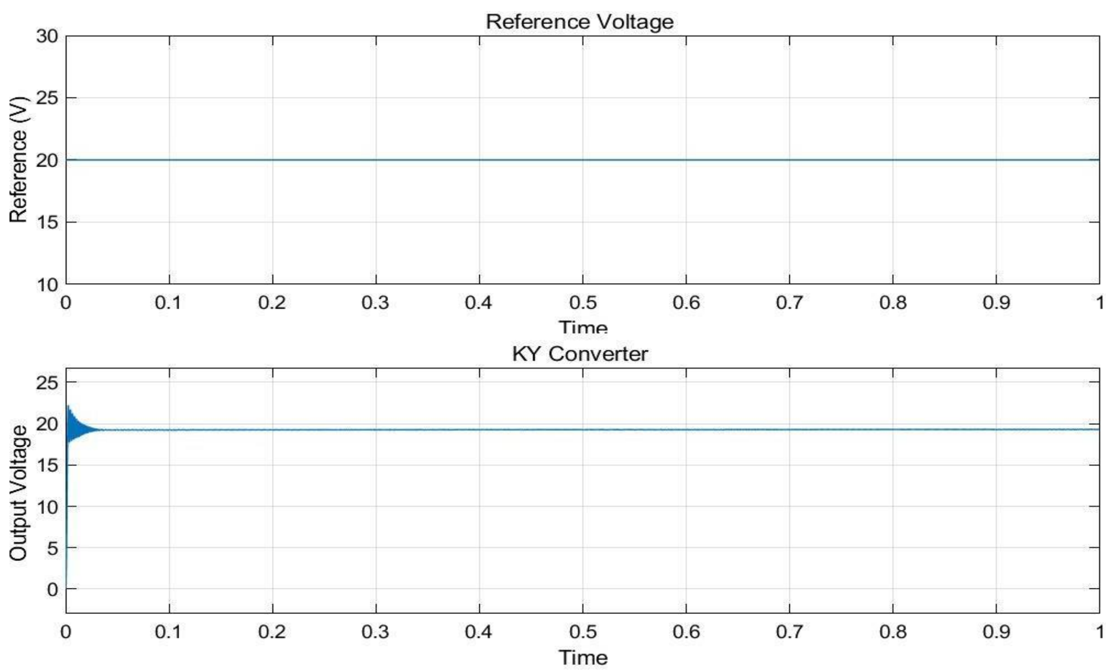
The output voltage sensor provides the feedback to the controller, and the PWM generator adjusts the duty cycle of the MOSFET accordingly.

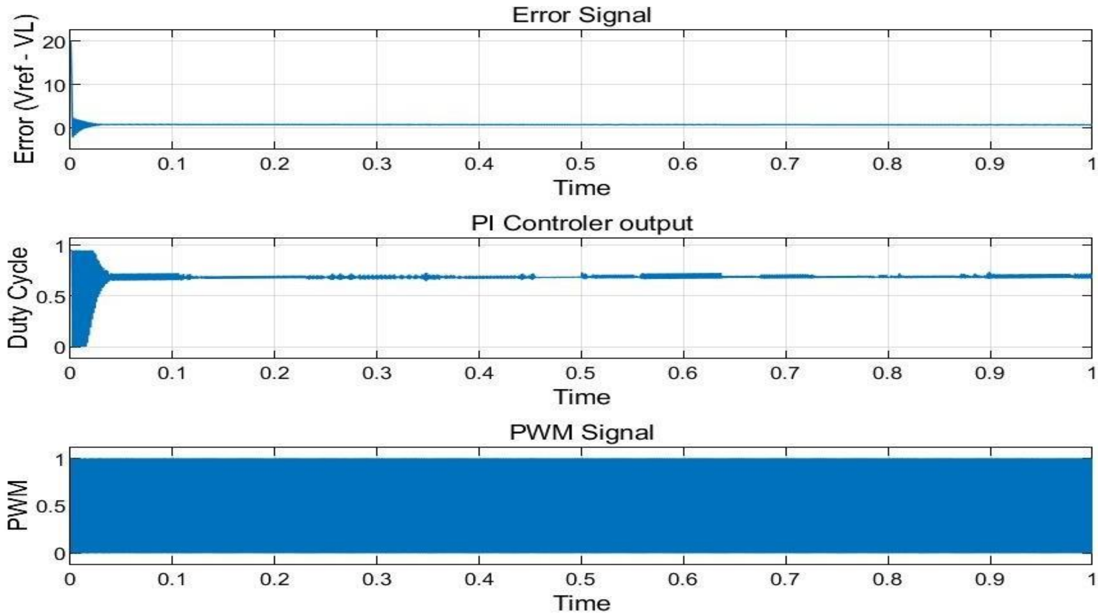
RESULTS

The KY converter successfully regulated the output voltage with minimal ripple and maintained stability under varying load conditions.

Simulation and hardware results showed high efficiency, averaging around 88–92%.

The output remained constant despite input fluctuations, demonstrating excellent line and load regulation. This confirms the KY converter's suitability for low-voltage, high-efficiency power supply applications.





VI. CONCLUSION

The implementation of the KY converter for voltage regulation has proven to be effective in achieving a stable and efficient DC output. Unlike conventional buck or boost converters, the KY converter operates in continuous conduction mode (CCM), offering low output voltage ripple and a non-pulsating output current. The simulation and hardware results confirm that the converter maintains consistent voltage levels even under varying input and load conditions, making it highly reliable for sensitive electronic applications.

Overall, the KY converter demonstrates a compact and efficient solution for low-voltage power supply systems, especially where output stability and efficiency are crucial. Its ability to combine the benefits of buck and boost operations while reducing current stress on components enhances its performance and lifespan. Future work can focus on improving control strategies, integrating digital feedback, and expanding its application in renewable energy systems, IoT devices, and battery-powered electronics.

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