iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.78443

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

DC Motor Step Up and Step Down Chopper

Mr. Ketan Khobragade[1], Mr. Sarthak Rohankar[2], Ms. Shamma Patil[3], Mr. Ayush Nagpure[4], Ms. Laxmi Meshram[5]
Tulsiramji Gaikwad-Patil, College of Engineering & Technology, Nagpur, Maharashtra, India

Abstract: ***A DC motor step-up and step-down chopper is a power electronic device used to control the voltage supplied to a DC motor by converting a fixed DC input into a variable DC output. Choppers operate by rapidly switching the input voltage ON and OFF using semiconductor devices such as transistors, MOSFETs, or IGBTs. In a step-down chopper (buck chopper), the output voltage is lower than the input voltage and is commonly used for controlling the speed of DC motors in applications like electric vehicles, industrial drives, and battery-powered systems. In contrast, a step-up chopper (boost chopper) increases the output voltage higher than the input voltage, which is useful when higher voltage is required from a lower voltage source. By controlling the duty cycle of the switching device, the average output voltage and motor speed can be precisely regulated. This method provides high efficiency, better speed control, reduced power loss, and improved performance compared to conventional control methods. Therefore, DC motor step-up and step-down choppers play an important role in modern power electronics and motor control applications.***

I. INTRODUCTION

DC motors are widely used in many industrial and commercial applications such as electric vehicles, cranes, conveyors, and machine tools because of their simple control and high starting torque. To control the speed and performance of a DC motor efficiently, power electronic devices called choppers are commonly used. A chopper is a DC-to-DC converter that converts a fixed DC input voltage into a variable DC output voltage by rapidly switching the supply on and off. This switching operation allows precise control of the average voltage applied to the motor, which directly controls its speed. There are mainly two types of choppers used for DC motor control: step-down choppers and step-up choppers. A step-down chopper, also known as a buck chopper, reduces the input voltage to a lower output voltage and is mainly used when the motor requires a lower voltage than the supply. On the other hand, a step-up chopper, also called a boost chopper, increases the input voltage to a higher output voltage when the motor requires higher voltage than the available supply. By adjusting the duty cycle of the switching device, the output voltage and motor speed can be controlled smoothly and efficiently.

II. LITERATURE SURVEY

A literature survey on DC motor speed control using step-up (boost) and step-down (buck) choppers reveals that these power electronic converters are essential for adjusting armature voltage to control motor speed, often replacing traditional methods due to higher efficiency and reduced size. Modern research focuses heavily on improving efficiency using Pulse Width Modulation (PWM) and advanced controllers (PID, Fuzzy Logic, SMC) to handle non-linearities and loadMany researchers have studied the use of chopper circuits for controlling the speed and performance of DC motors. DC motors are widely used in adjustable speed drives, and chopper-based control techniques are considered one of the most efficient methods for regulating the voltage supplied to the motor. Several studies have focused on modeling and designing DC motor speed control systems using chopper circuits. Researchers have developed mathematical models of DC motors and chopper converters to analyze their performance. By using simulation tools such as MATLAB/Simulink, they demonstrated that chopper-controlled systems provide smooth and accurate speed control by adjusting the duty cycle of the switching device. Other studies analyzed different types of DC choppers such as single-quadrant, two-quadrant, and four-quadrant converters for DC motor control. These converters allow better control of motor voltage, current, and direction of operation. Simulation results show that chopper-based drives offer improved efficiency, flexibility, and dynamic performance compared with conventional control techniques. Many researchers have studied the use of chopper circuits for controlling the speed and performance of DC motors. DC motors are widely used in adjustable speed drives, and chopper-based control techniques are considered one of the most efficient methods for regulating the voltage supplied to the motor.

From the literature survey, the following gaps were identified:

Most studies focus on converter design and control, but fewer integrate real-time display systems for monitoring voltage, current, and motor speed.

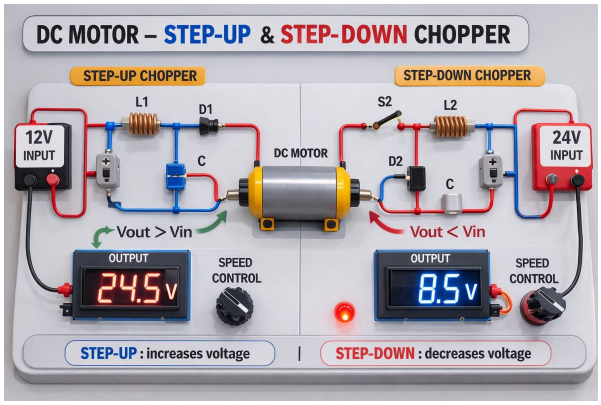
Limited work is done on combined step-up and step-down chopper systems for educational demonstration.

Visualization through LCD or digital display can improve understanding and monitoring of motor parameters.

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III. METHODOLOGY

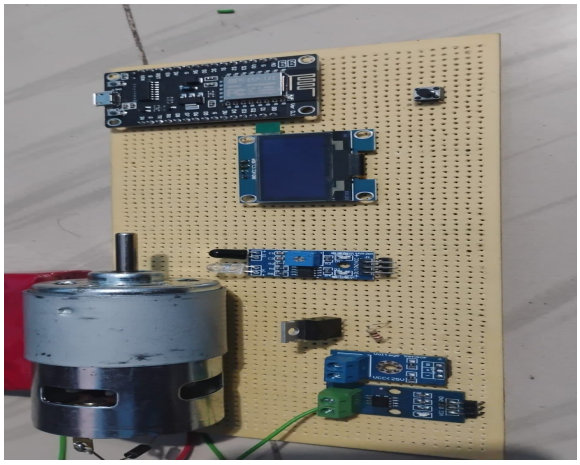


The methodology of a DC motor step-up and step-down chopper with display involves controlling the motor speed by varying the average DC voltage supplied through high-frequency switching. In the step-up (boost) chopper mode, a low input voltage is applied to the circuit, and when the semiconductor switch turns ON, energy is stored in the inductor. When the switch turns OFF, the stored energy is released through the diode and capacitor, thereby increasing the output voltage supplied to the DC motor, resulting in higher speed operation. In the step-down (buck) chopper mode, a higher input voltage is provided, and the switch controls the duration for which the supply is directly connected to the motor. During the OFF period, the free-wheeling diode maintains continuous current flow, reducing the average output voltage and enabling smooth low-speed control. The duty cycle of the switching signal is adjusted using a speed control knob or potentiometer, which regulates the motor speed according to load requirements.

This is the set up for the chopper based single phase Separately excited dc motor drive. A fixed dc voltage is applied across the field winding of the motor to produce a rated field current. The variable dc voltage at the output of the chopper is applied is applied across the armature winding of a separately excited dc motor. A variable armature voltage is derived from the chopper that can be of the required class, in order To implement the armature voltage control. The methodology of a DC motor step-up and step-down chopper system involves the design and implementation of a DC-DC converter to control the voltage applied to the DC motor for speed regulation. The system mainly consists of a DC power supply, chopper circuit, switching device, control circuit, and the DC motor load.

First, a DC input supply is provided to the chopper circuit. The chopper uses a high-speed semiconductor switching device such as a MOSFET, IGBT, or transistor to convert the constant DC input into a controlled DC output. The switching device rapidly turns ON and OFF, and this switching action controls the average output voltage supplied to the motor.

IV. RESULT AND DECISION



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The results of the DC motor step-up and step-down chopper system show that the motor speed can be effectively controlled by varying the duty cycle of the chopper circuit. When the step-down (buck) chopper is used, the output voltage applied to the DC motor is lower than the input voltage, which allows the motor speed to be reduced smoothly. As the duty cycle increases, the average output voltage increases and the motor speed also increases proportionally. When the duty cycle decreases, the output voltage decreases, resulting in a lower motor speed.

In the step-up (boost) chopper operation, the output voltage becomes higher than the input voltage due to the energy stored in the inductor and released during the switching process. This increase in voltage allows the DC motor to operate at higher speeds even when the input supply voltage is low. The system provides efficient voltage conversion and better speed regulation compared to conventional methods.

The overall results indicate that the chopper-controlled DC motor system provides high efficiency, fast response, and smooth speed control. Power losses are reduced due to the use of high-speed switching devices, and the performance of the DC motor drive system is improved. Therefore, the step-up and step-down chopper method is suitable for applications such as electric vehicles, industrial drives, robotics, and battery-powered systems where efficient and flexible motor speed control

V. CONCLUSION

In conclusion, the DC motor step-up and step-down chopper is an efficient power electronic technique used for controlling the speed and performance of DC motors. By using high-speed switching devices, the chopper converts a fixed DC input voltage into a variable DC output voltage. The step-down (buck) chopper reduces the input voltage to control the motor speed at lower levels, while the step-up (boost) chopper increases the voltage when higher motor speed is required.

The study shows that controlling the duty cycle of the chopper switch allows smooth and precise regulation of the motor speed. This method improves the efficiency of the motor drive system, reduces power loss, and provides better performance compared to traditional control methods. Chopper-based DC motor drives are reliable, compact, and suitable for modern applications.

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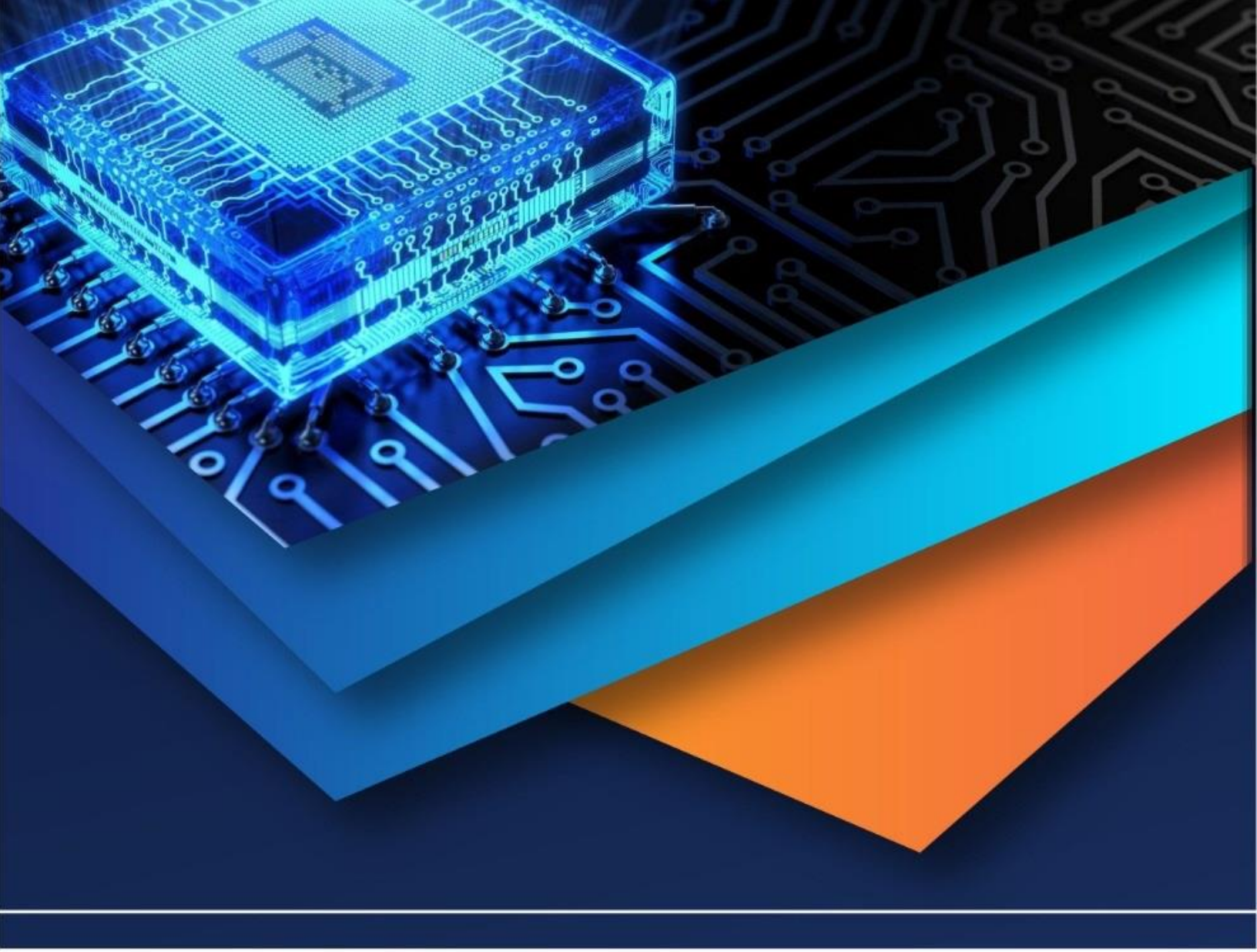
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