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Manipulation of BLDC Motor Speed Using PID Controller

Mrityunjay Kar [1], Tuleshwar[2], Bhupeshwar ku. Rana[3], Pinky Kunjam[4], Uma Rathore[5]

[1]B. Tech scholar,[2]B. tech scholar,[3]Btech scholar,[4]Btech scholar,[5]Assistan Professor
Department of Electrical Engineering **GEC** BILASPUR
CSVTU University BHILAI **C.G.**, INDIA
mrityunjaykar4@gmail.com tuleshkwd14@gmail.com manoftomorow351@gmail.com pinkykunjam601@gmail.com rathoruma93@gmail.com

ABSTRACT-

Currently, green technology is a global precedence, and electricity, being clean energy, plays a very vital part in the furtherance of this technology. Electric motors are essential factors in exercising electricity as they convert electrical energy into mechanical energy. Brushless Direct Current (BLDC) motors have gained considerable fashion ability in colorful diligence due to their low conservation, compact size, and effectiveness. These motors have the potential to substitute the conventional systems, rendering diligence more flexible and efficient. For achieving the best performance, BLDC motors carry a control system that can adjust their speed as well as necking precisely. This paper presents the design of a BLDC motor control system using a Commensurable-Integral-Secondary (PID) regulator, implemented in MATLAB/ SIMULINK. It is known that the PID algorithm effectively enhances the speed control for similar motors.

1. INTRODUCTION: -

A PID (Proportional-Integral-Derivative) controller is one of the most common techniques for speed control of Brushless DC (BLDC) motors, which are popular due to their efficiency and reliability. The PID controller adjusts the input voltage of the motor by comparing the desired speed or setpoint with the actual speed or feedback. Proportional (P): This term produces an output proportional to the error, hence providing a quick correction for large errors.

• Integral (I): This is a term dealing with accumulated past errors and helps remove long-term discrepancies and steady-state errors.

• Derivative (D): The derivative predicts future errors by analysing the rate of change of the error; hence, it reduces overshoot and stabilizes the system.

• The speed of the BLDC motor does not fluctuate; thus, regardless of the load, its operation is stable. A right and appropriate tuning of PID parameters (Kpa, Ki, Kid) is essential in providing an optimal performance. Tuning will ensure smooth working without any oscillation and gives speedy changes in speed control and provides very efficient control over speed to achieve desired performance in PID.

2. COMPONENTS—

The main components for BLDC motor speed control by a PID controller include

2.1 BLDC Motor:

The motor whose speed needs to be controlled.

2.2 PID Controller:

Compares the desired speed (setpoint) with the actual speed (feedback) and adjusts the motor's input to minimize the error. It uses three terms:

Proportional (P): Reacts to the current error.

Integral (I): Addresses accumulated past errors.

Derivative (D): Predicts future errors.

2.3 Speed Sensor:

Measures the actual motor speed and sends feedback to the PID controller. This can be an encoder or tachometer.

2.4 Motor Driver:

Receives the control signal from the PID controller and adjusts the motor's voltage/current to control its speed.

2.5 Setpoint Input:

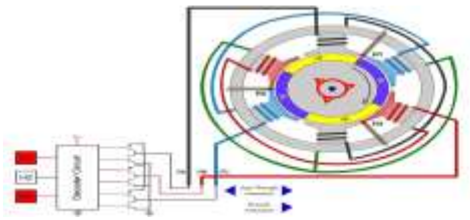
The desired speed input for the system.

2.6 Feedback Loop:

This is a continuous loop in which real-time data provided by the sensor goes to the PID controller to maintain the desired speed.

BLOCK DIAGRAM-
Manipulating speed of BLDC motor by PID controller :-

Circuit Diagram:-



3. Working: -

3.1. Desired Speed (Setpoint):

The desired motor speed is given as a setpoint by the user or control system.

3.2. Actual Speed Measurement:

A speed sensor such as encoder or tachometer continuously monitors the actual speed of the motor and provides it to the PID controller for feedback.

3.3. Error Calculation:

The error is computed by subtracting the actual speed by the desired speed or the setpoint using the PID controller.

3.4. PID Calculation:

Proportional (P): Controller will multiply error by proportional gain, Kp; motor input varies by error.

Integral (I): Sum the accumulated past errors multiplied by an integral gain, Ki; controls for steady-state error.

- Derivative (D): The rate of change of the error is calculated and multiplied by a derivative gain (Kd) to predict and prevent future errors, improving stability.

3.5. Control Signal Generation:

The PID controller combines the three terms (P, I, D) to generate a control signal.

3.6. Motor Driver Adjustment:

The control signal is transmitted to the motor driver, which alters the motor's voltage or current to adjust the speed.

3.7. Continuous Feedback:

The speed sensor constantly measures the actual speed of the motor and the PID cont roller adjusts the control signal to minimize the error to ensure that the motor speed matches the setpoint.

3.8. Optimization:

The PID controller continues to adjust in real time to maintain optimal performance even when loads or disturbances are varying, and the PID parameters (Kp, Ki, Kd) are finely tuned for stability and efficiency.

4. Future Scopes of PID Controller in BLDC Motor Speed Control:

4.1. Adaptive Tuning:

Development of automatic tuning methods for real-time optimization of PID parameters.

4.2. AI Integration:

Applying machine learning for motor behavior prediction in order to increase control efficiency.

4.3. Sensor less Control:

Enhancement of PID to make it feasible for usage in sensor less BLDC motors. Hence, decreased cost without affecting the performance

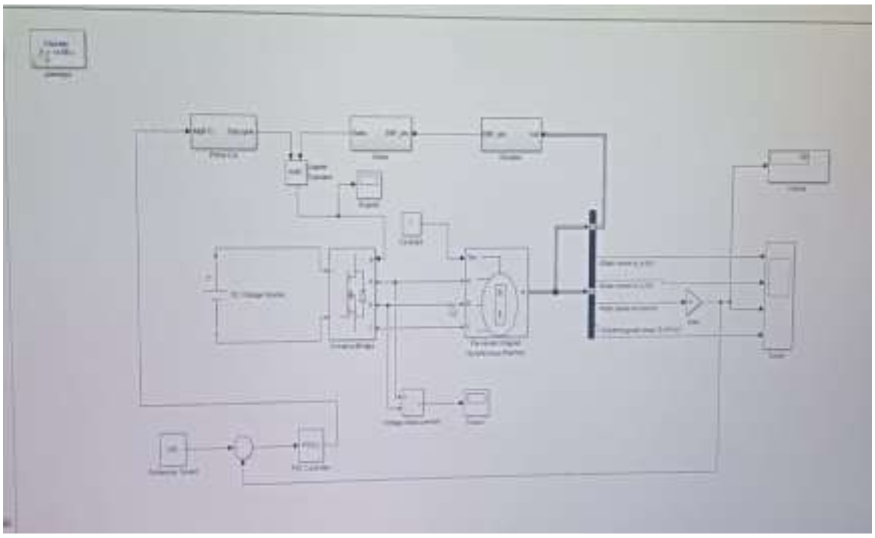
4.4. Fault Detection:

Developing fault detection and self-compensation capabilities for enhancing motor reliability and lifetime.

4.5. Multi-Motor Systems:

Applying multi-motor systems using PID control. These include robots and other electric vehicles.

5.SIMULATION MODEL: -



6. GRAPHS-

SIMULATION OUTPUT GRAPH:-
1.Stator current vs time graph:-
2.Torque vs time graph:-

7. CONCLUSION-

In conclusion, PID controllers used for BLDC motor speed control are a reliable and efficient way to maintain precise speed regulation in various applications. Through continuous adjustment of the input of the motor according to the error between the desired and actual speed, PID controllers ensure optimal performance, stability, and responsiveness. Thus, proper tuning of PID parameters is necessary to avoid overshoot or slow response.

As technology advances, the developments in adaptive tuning, AI integration, sensor less control, and energy-efficient strategies promise further improvements in the capabilities of PID controllers. These advancements will make speed control systems more intelligent, robust, and economical, thus suitable for complex and demanding applications like robotics, electric vehicles, and industrial automation. All in all, the PID controller is one of the basic methods for motor speed control and has tremendous scope for innovation soon.

FINAL OUTPUT SIGNAL; -

$U(t) = Kp\, e(t) + Ki \int e(t)dt + Kd\, de(t)/dt$

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9. Applications of PID Controller in BLDC Motor Speed Control:

9.1 Electric Cars: Controls the speed of motors to ensure smooth acceleration and optimal performance.

9.2 Robots: Controls the motor with great precision to achieve perfect movement.

9.3 Aerial Drones: Controls flight and hover by regulating the motor speeds.

9.4 Industrial Automation: Controls motor speed in conveyors, fans, and pumps for constant performance.

9.5 Home Appliances: Used in devices such as washing machines and HVAC systems for speed regulation.

9.6 Electric Power Tools: Controls the speed of tools such as drills and grinders.

9.7 HVAC Systems: Optimizes fan speeds for better energy efficiency and comfort.

9.8 Medical Equipment: Maintains precise motor speeds in devices like ventilators and surgical robots.

9.9 CNC Machines: Controls motor speed for accurate machining and positioning.

9.10 Renewable Energy: Manages turbine speed in wind and hydro power generation systems.

These applications show the versatility and importance of PID controllers in ensuring accurate and stable motor speed control across various industries.

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