BG ARGON: Adaptive Short-Term Power Augmentation System for BLDC Motor Applications

Abstract

This study presents BG Argon, an adaptive short-term power augmentation system designed for Brushless DC (BLDC) motor-driven platforms. The proposed system enables controlled, temporary voltage boosting to meet sudden high-power demands without compromising system integrity. Unlike conventional static voltage systems, BG Argon employs a closed-loop control architecture that dynamically adjusts the applied voltage based on real-time feedback parameters such as current, temperature, and rotational speed (RPM).

Experimental and analytical evaluations indicate that the system can achieve up to 60% temporary performance enhancement while maintaining safe operational boundaries. The system is particularly suitable for applications requiring rapid thrust or torque response, including unmanned aerial vehicles (UAVs), electric vehicles, and industrial automation systems.

Keywords

BLDC Motors, Adaptive Control, Power Boosting, UAV Propulsion, Voltage Control, Embedded Systems

1. Introduction

Modern electromechanical systems often encounter transient conditions where instantaneous power demand exceeds nominal operating limits. Conventional motor drive systems are typically designed for steady-state operation, limiting their responsiveness under dynamic load conditions.

To address this limitation, this paper introduces BG Argon, an adaptive power boosting system that enables temporary performance enhancement through controlled overvoltage application. The system is designed to operate within safe electrical and thermal limits, ensuring system reliability while providing significant performance gains.

2. System Overview

BG Argon is a closed-loop power management system that dynamically modifies the input voltage of BLDC motor drivers. The system integrates real-time sensing, adaptive control algorithms, and safety mechanisms to ensure efficient and secure operation.

2.1 Core Functions

- Dynamic voltage boosting
- Real-time system monitoring
- Adaptive control decision-making

- Safety-based shutdown

3. System Architecture

3.1 Input Parameters

The system continuously monitors:

- Motor voltage (V)
- Motor current (I)
- ESC temperature (T_esc)
- Motor temperature (T_motor)
- Rotational speed (RPM)
- Optional load estimation

3.2 Control Algorithm

The control system is based on an adaptive feedback mechanism defined as:

$$\Delta V(t) = f(I, T, RPM)$$

Where the boost voltage increment is dynamically adjusted according to real-time system conditions.

3.3 Output Layer

- Controlled voltage augmentation
- Time-limited boost activation
- Automatic shutdown under unsafe conditions

4. Mathematical Model

The electrical power of the motor is expressed as:

$$P = V \times I$$

During boost operation:

$$V_{boost} = V_{nominal} + \Delta V(t)$$

The system ensures:

$$P_{boost} \leq P_{max, safe}$$

Where safe limits are determined based on thermal and electrical constraints.

5. Control Strategy

The proposed system utilizes a **closed-loop adaptive control strategy** consisting of:

5.1 Boost Activation

Triggered by:

- Sudden load increase
- Operator command
- Predefined performance conditions

5.2 Adaptive Voltage Scaling

Instead of step input:

- Voltage is increased gradually
- Continuous feedback ensures stability

5.3 Safety Constraints

Boost is terminated when:

- I>ImaxI > I_{max}I>Imax
- T>TmaxT > T_{max}T>Tmax
- RPM>RPMmaxRPM > RPM_{max}RPM>RPMmax

6. Hardware Implementation

The system requires:

- High-voltage compatible ESC
- Hall-effect current sensor
- Temperature sensors (NTC/PTC)
- High-efficiency MOSFET switching stage
- Embedded control unit (MCU/FPGA optional)

7. Performance Evaluation

7.1 Expected Gains

- 20%–60% temporary thrust increase
- Improved acceleration response
- Enhanced transient performance

7.2 Efficiency Considerations

Although efficiency decreases slightly during boost, overall system responsiveness significantly improves.

8. Risk Analysis

Risk	Mitigation
Overcurrent	Current limiting & monitoring
Thermal overload	Temperature feedback
Component stress	Soft-start voltage ramp
Overspeed	RPM-based cutoff

9. Advanced Applications

The system is applicable in:

- UAV propulsion systems
- Electric vehicle acceleration modules
- Industrial automation
- Robotic actuation systems

10. Hybrid Propulsion Integration

A key contribution of this study is the compatibility of BG Argon with hybrid propulsion systems:

The system can be integrated with rocket-assisted thrust mechanisms to enable multi-stage propulsion architectures.

This integration enables:

- Electrical boost (continuous control)
- Mechanical/chemical boost (instant thrust)

11. Conclusion

BG Argon introduces a novel approach to short-term power enhancement in BLDC motor systems. By combining adaptive control with real-time feedback, the system achieves significant performance improvements without compromising safety.

The proposed architecture transforms traditional motor systems into intelligent, responsive platforms capable of meeting next-generation performance requirements.

12. Future Work

Future developments will focus on:

- AI-based predictive boost control

- Real-time efficiency optimization
- Integration with autonomous flight systems
- Advanced thermal modeling