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BLDC Motor Speed Controller with ATS-tuned PID Controller

Satyanarayana Addala[1], Lavanya Nandyala[2] and Chandini Palakoti[3]
[1-3]Department of EEE, SCET Narsapuram, India
Email: addalasatyam@gmail.com, palakotichandini@gmail.com, palakotichandini@gmail.com

***Abstract*— The present research reveals an Adaptive Tabu Searching Algorithm (ATSA) that was created particularly for discovering the best speed controller design for commercial brushed DC (BLDC) motors. Because they are efficient and easy to control, BLDC motors are used in a multitude of different ways. Even if things are changing and unpredictable, it's still challenging to acquire the optimum outcomes with BLDC motor speed control. Many factories utilize brushless DC (BLDC) motors as they are very efficient, dependable, and can alter speed very accurately. This work offers utilizing the Tabu method for an adaptive search to improve the settings of a PID (proportional integral derivative) controller that controls the speed of a BLDC motor.**

The suggested solution is meant to get around the issues that arise with regular PID tuning methods. By automatically adjusting the controller settings to provide the greatest performance in a variety of situations. We use both simulations and experiments in the actual world to show that the ATSA is a good way to optimize BLDC motor speed controllers for a wide range of circumstances and issues. The results suggest that the algorithm is strong and might be applied in the real world to make BLDC motors function better and use less power.

***Keywords*— BLDC MOTOR, Ziegler-Nichols, Adaptive Tabu search Algorithm, PID controller.**

I. INTRODUCTION

Brushless DC motors are now employed in most of the industrial, automotive, and consumer applications because of their efficiency, reliability and their precise speed control. However, to get the best performance out of BLDC motors, speed controllers must be designed to meet the needs of each application. The best way to build these speed controls is to find a compromise between a lot of different goals, like using less energy, making things more efficient, and making sure they work well in a variety of situations. The design challenge for a BLDC motor speed controller is multi-dimensional and non-linear, which makes it hard for traditional optimization methods to solve it well.

Now a days, meta heuristic optimization approaches had become an option for these kinds of hard optimization tasks. Tabu explore is one of these because it can explore huge solution spaces and move on to less-than-ideal solutions.

This paper presents an Adaptive Tabu Search Algorithm (ATSA) designed for the optimal design of speed controllers in commercial BLDC motors [2]. By utilizing the intrinsic flexibility and adaptability of Tabu. The proposed algorithm aims to enhance efficiency in speed controller design by tackling the drawbacks of conventional optimizationnmethods.

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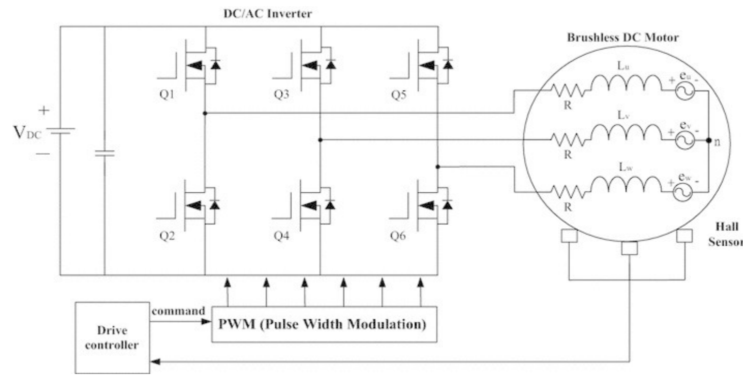

Figure 1. A driver board-equipped BLDC motor

The primary objective of this research is to develop an optimization framework that can effectively tune the parameters of the BLDC motor speed controller to achieve optimal performance such as energy efficiency, response time, and stability. In pursuit of this goal, the ATSA adapts its search strategy in response to the altering dynamics of the solution space, letting it to successfully explore promising areas while steering clear of getting stuck in local optima[3].

In the coming sections of this paper, we will talk about how to come up with the BLDC motor speed controller design problem, the main parts of the ATSA algorithm, experimental results that show how well it works, and possible directions for future research and use of the proposed method. We want to make optimization algorithms more effectively so that BLDC motor speed controls work better and faster in a wide range of real-world scenarios. The principal advantages of utilizing the ATS in the recommended design process are as follows:

The ATS algorithm serves as an effective tool for system identification when developing the optimal PID controller for a commercial BLDC motor and driver. The PID controller generated through this method can yield superior performance compared to one designed using the traditional Ziegler-Nichols approach. Throughout the design process, the ATS technique considers the control signal. As a result, the control signal for the final PID controller remains unconstrained during implementation. This leads to the anticipated high-quality speed response.; however, the typical approach will not allow for the anticipated speedy reaction. By utilizing the concept this study presents, further artificial.

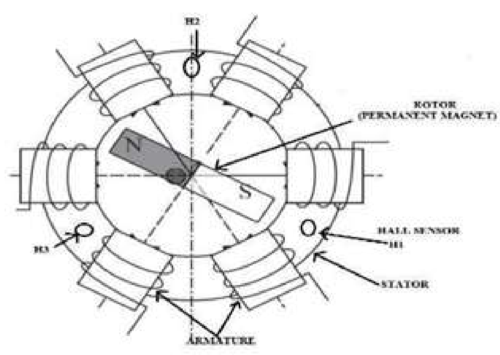

Figure 2. Structure of BLDC Motor

II. LITERATURE REVIEW

This study uses the adaptive Tabu Search (ATS) technique to construct the controller. The input-output relationship is illustrated by a black-box model that is developed in the first step to identify the system using the ATS. In the second stage, the ATS is again used to construct the PID controller after acquiring the black-box transfer function. A two-step approach that makes use of the ATS may yield considerably faster output performance in comparison to the conventional design methods. The standard conventional design method used in this study for comparison is the Ziegler- Nichols method. When utilizing this method to create a PID controller, a transfer function is not needed.

Testing may be used to determine the Ziegler-Nichols approach's open-loop response. A BLDC motor's design is shown in Figure 1. Results from experiments and simulations show that the suggested design approach, whose utilizes the benefits of the ATS algorithm, yields better and quicker outcomes than the Ziegler-Nichols technique. The best supervisors were created using a variety of artificial intelligence techniques, according to assessments of the literature.
The control signal limitations, which may saturate once the optimal controller gains are attained, hasn't caused concerns, however. Therefore, when the ATS is utilized for the design process in this study, the control signal from the PID controller may be detected, but the Ziegler-Nichols approach does not allow for the consideration of control signals. Therefore, PID controller design using the suggested ATS technique may ensure that the ultimate PID controller can be implemented with actual devices, even while the Ziegler-N approach is unable to detect the control signal.Ziegler-Nichols is therefore unable to offer the type of good reaction that was expected.
The principal advantages of utilizing the ATS in the recommended design process are as follows:
The ATS algorithm is a helpful tool for system identification when building the best PID controller for an industrial BLDC motor and driver. In contrast to a controller constructed using the traditional Ziegler-Nichols approach, the resultant PID controller may have a superior response.
The control signal is considered at each stage of the design procedure using the ATS approach. As a result, the control signal of the final PID controller's output is unconstrained during implementation. As anticipated, the speed response would be good.; however, the typical approach will not allow for the anticipated speedy reaction.
The concept in this study can also be utilized to develop an artificial intelligence using other artificial intelligence methods, such as the particle swarm and genetic algorithm

III. SYSTEM CONFIGURATION

As seen in Fig. 1, A BLDC motor powered by a commercial driver board is the system being examined. It is possible to convert a brushed direct current motor to a BLDC motor due to the similarities in their internal structures. Magnetic induction is produced by three sets of coils. Unlike synchronous three-phase AC motors, this motor does not require a brush. The power converter circuit therefore becomes need for a BLDC motor. Fig. 2 displays the BLDC motor's structural configuration. Fig. 2 illustrates the three basic elements of a BLDC motor. The AC/DC converter's initial component, a stationary portion called a "stator," is linked to it via an armature winding. A "rotor" is a rotating part, also referred to as a permanent magnet. The BLDC functions on the fundamental principle of force. Similar to an AC motor operating in synchronous mode, the permanent magnet (rotor) & the electromagnet (stator) interact through attraction and repulsion.

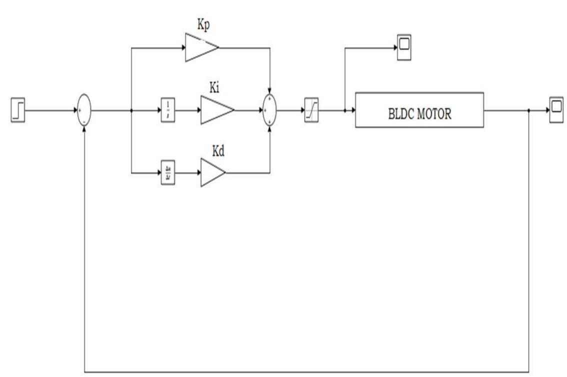

Figure 3. Block diagram of BLDC motor

In this work, we aim to actuator for the open-loop speed control of the BLDC. Fig. 3 contribute to the advancement of optimization techniques for enhancing shows the commercial driver board utilized in this investigation.

IV. ATS BASED BLDC MOTOR

This paper introduces an Adaptive Tabu Search Algorithm (ATSA) specifically tailored for the optimal design of speed controllers in commercial BLDC motors. By leveraging the inherent flexibility and adaptability of Tabu Search, the proposed algorithm aims to overcome the challenges associated with conventional optimization methods and provide superior performance in terms of speed controller design. The primary purpose of this study is to provide a framework for optimization that can efficiently change the BLDC motor's speed controller's settings to get the optimal performance metrics, including stability, reaction time, and energy economy.

The steps involved in the Adaptive Search using Tabu Algorithm for a PID Controller's tuning for controlling BLDC motor speed are as follows:

- Initialize: Set initial PID parameters (Kp, Ki, Kd) - Define tabu list size and maximum iterations - Set aspiration criteria
- Generate initial solution: Randomly generate PID parameter values within defined ranges
- Evaluate initial solution:Simulate BLDC motor speed control with current PID parameters - Calculate performance metrics (e.g., rise time, settling time, overshoot)
- Main loop (repeat until maximum iterations or stopping criteria met):
    - Generate neighborhood solutions:Create new PID parameter sets by slightly modifying current solution
    - Evaluate neighborhood solutions: Simulate BLDC motor performance for each new parameter set - Calculate performance metrics
    - Select best non-tabu solution: Choose solution with best performance not in tabu list - If aspiration criteria met, allow tabu solutions
    - Update current solution: Replace current solution with selected best solution
    - Update tabu list: Add new solution to tabu list - Remove oldest entry if list is full
    - Adapt search parameters:Adjust neighborhood size based on solution improvement - Modify tabu list size if needed
- Return best solution: Output optimized PID parameters for BLDC motor speed control.

V. Simulation Results

The blocks of Simulink in the MATLAB software will be used to simulate the response of the closed loop using the design and the suggested model from the preceding section. To determine the ideal PID coefficients, the response's performance throughout the ATS procedure will be calculated. To verify that the PID controller was developed using a commercial driver board. The BLDC motor's many speeds can be controlled via the ATS technique. The equivalent responses for the 5000, 10000, and 20000 rpm ranges are shown in below figures.

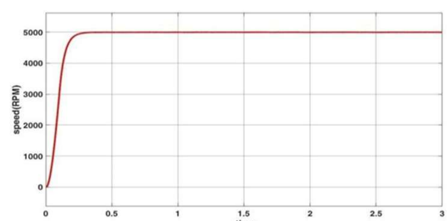

Figure 4. Speed response at 5000rpm

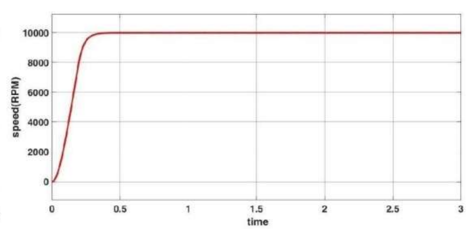

Figure 5. Speed response at 10000rpm

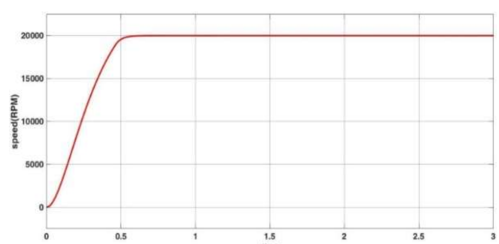

Figure 6. Speed response at 20000rpm

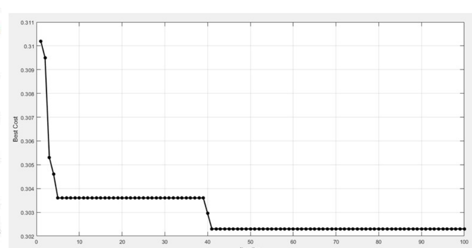

Figure 7. Convergence of PID controller with ATS.

VI. Conclusion

This study introduces a novel application of the ATS method to develop a PID controller for an BLDC motor. Both the controller design and the development of the BLDC mathematical model can be done with the ATS. Simulation and testing findings demonstrate that the PID controller created by means of the suggested ATS approch produces a better speed response for the BLDC motor than the controller planned with the traditional method. As expected, the results are good since the design technique takes into consideration the control signal constraints related with the real component specifications.

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