# AN EFFECTIVE CONTROLLER DESIGN FOR BLDC MOTOR DRIVE WITH GIANT TREVALLY OPTIMIZER

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**Abstract**
In this project, an effective controller design for the BLDC motor drive is proposed using nature inspired Giant Trevally Optimizer (GTO). The PI controller is developed for the speed control of BLDC motor using Giant Trevally Optimizer. The gain settings of a PI controller are improved using GTO, with Integral square Error (ISE) as the objective function. The dynamic characteristics of the BLDC motor are observed by the developed model using MATLAB/simulink environment.

The suggested controller's performance is evaluated under a variety of load and set speed settings, and it is compared to other known optimization approaches such as PSO and DE. Based on the simulation results, it is clear that the suggested controller performs better under all of the drive's operating conditions.

**Keywords**— Giant Trevally Optimizer(GTO), Brushless DC motor, torque control, speed estimations.

## Introduction:

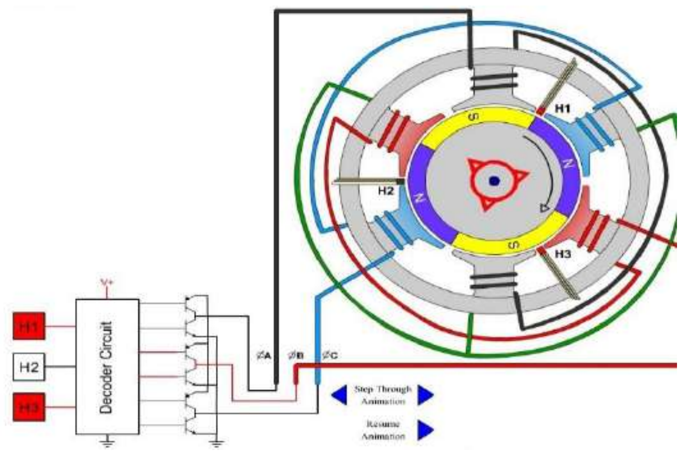
The electricity industry is one of the largest and most complex industries in the world. An electric power system is a network of electrical components used to supply, transmit and use electric power. Power system engineers are concerned with every step in the process of generation, transmission and distribution and efficient utilization of electrical energy. Since an engineer is always concerned with the cost, hence, it is important for all power engineers to understand the economy within which the generation, transmission, distribution, supply of electrical power, and its pricing policies are directed towards producing maximum benefits in consuming electrical energy in efficient and effective ways.

## I. Modelling of BLDC Motor

The BLDC motor is a self-synchronous rotating motor and in construction point of view similar to the permanent magnet synchronous motor. It has better speed versus torque characteristics and better dynamic response. Straight forward structure and lower cost than other motors are the most attracting features of BLDC motor. The applications which require less space and weight, BLDC motor is the best choice. Maintaining the Integrity of the Specifications.

In BLDC motor, a permanent magnet produces the main flux whereas in dc motor, DC current through the field coil of the stator produces field flux. The other constructional differences are: hall effect sensors are used in place of commutator and brushes. The rotor position of the BLDC motor is sensed by hall sensors and give position signal to the electronic commutation controller. Hence, the power state of windings is controlled without a mechanical commutator. This continuous commutating is to drive the rotor to move. The back emf influences the torque and speed of the BLDC motor.

Consider the figure below in which motor stator is excited based on different switching states. With the switching of windings as High and Low signals, corresponding winding energized as North and South poles. The permanent magnet rotor with North and South poles align with stator poles causing motor to rotate.




Observe that motor produces torque because of the development of attraction forces (when North-South or South-North alignment) and repulsion forces (when North-North or South-South alignment). By this way motor moves in a clockwise direction.

Here, one might get a question that how we know which stator coil should be energized and when to do. This is because; the motor continuous rotation depends on the switching sequence around the coils. As discussed above that Hall sensors give shaft position feedback to the electronic controller unit.

Based on this signal from sensor, the controller decides particular coils to energize. Hall-effect sensors generate Low and High level signals whenever rotor poles pass near to it. These signals determine the position of the shaft.

BLDC motors in general, will have rotor with permanent magnets and trapezoidal Electromotive force (EMF). A three-phase inverter is usually used to drive BLDC motors, which necessitates the use of a rotor position sensor element for beginning and a correct commutation sequence for the supply to run the inverter module. A six-step commutation mechanism is used by the three-phase inverter to drive the BLDC motor. Positional sensors must be used for appropriate commutation sequence and commencing hall-effect. In each phase, there will be a 120° second break between conducting. In accordance with Fig.1, the conducting sequence will be 5–6, 1–6, 1–2, 3–2, 3–4, and 5–4.

The applied current defines the functioning of a BLDC motor, and it must be synced with the back electromotive force voltage signal. The resulting currents are rectangular in shape, and the motor's switching consists of six distinct steps controlled by a switching block with six steps control mechanism. The converters switch the current depending on the rotor position, which may be determined with position sensors or without them.

## II. GIANT TREVALLY OPTIMIZER ALGORITHM(GTO):

**Introduction:**

The giant trevally (Caranx ignobilis) is a large marine predator in the jack family. It is also called the giant kingfish. They are abundant in the Indian and Pacific oceans, such as in areas around Australia and New Zealand. They are also found off the East Africa and around the Hawaiian Islands.

Giant trevally is usually silver with some dark spots. It can be recognized by its sharp head, strong tail scutes, and numerous additional anatomical details. Their height can reach up to 170 cm and 80 kg of weight. Their daily diet consists of fish, cephalopods, crustaceans, and seabirds.

Literature investigated the movement of giant trevallies within their ecosystems and between habitats as the search space expands. Some data suggests that adult giant trevallies make daily and seasonal movements of up to 9 kilometers within their roaming range . Juveniles can migrate up to 70 kilometers from their home atolls and reefs.

In most of its habitats, the giant trevally is a top predator and uses intelligent ways to hunt. The giant trevally is known to hunt alone and in groups (schools). According to grouped (schooled) predators are most effective at capturing schooled prey. The most effective member of a group or school at capturing prey is the leader, or first predator.

During the dry season, over half a million terns crowd onto one of the remote atolls in the Indian Ocean. It was reported that about fifty giant trevallies come from neighboring reefs, attracted by this abundance of potential prey, where the juvenile terns start learning to fly. After specifying the hunting area, the giant trevally starts to stalk (chase) its prey, then jumps out of the water and attacks the prey (seabird).

These novel hunting strategies of foraging moving patterns, choosing the appropriate area in terms of quantity of food, and jumping out of water to attack and catch the prey were the main inspiration in the design of the GTO

In this GTO algorithm, the unique strategies of giant trevally when hunting seabirds are mathematically modeled and are divided into three main steps.

- In the first step, the foraging movement patterns of giant trevallies are simulated.
- In the second step, the giant trevallies choose the appropriate area in terms of food where they can hunt for prey.
- In the last step, the trevally starts to chase the seabird (prey). When the prey is close enough to the trevally, the trevally jumps out of the water and attacks the prey in the air or even snatches the prey from the water surface.

**Steps in GTO algorithm:**

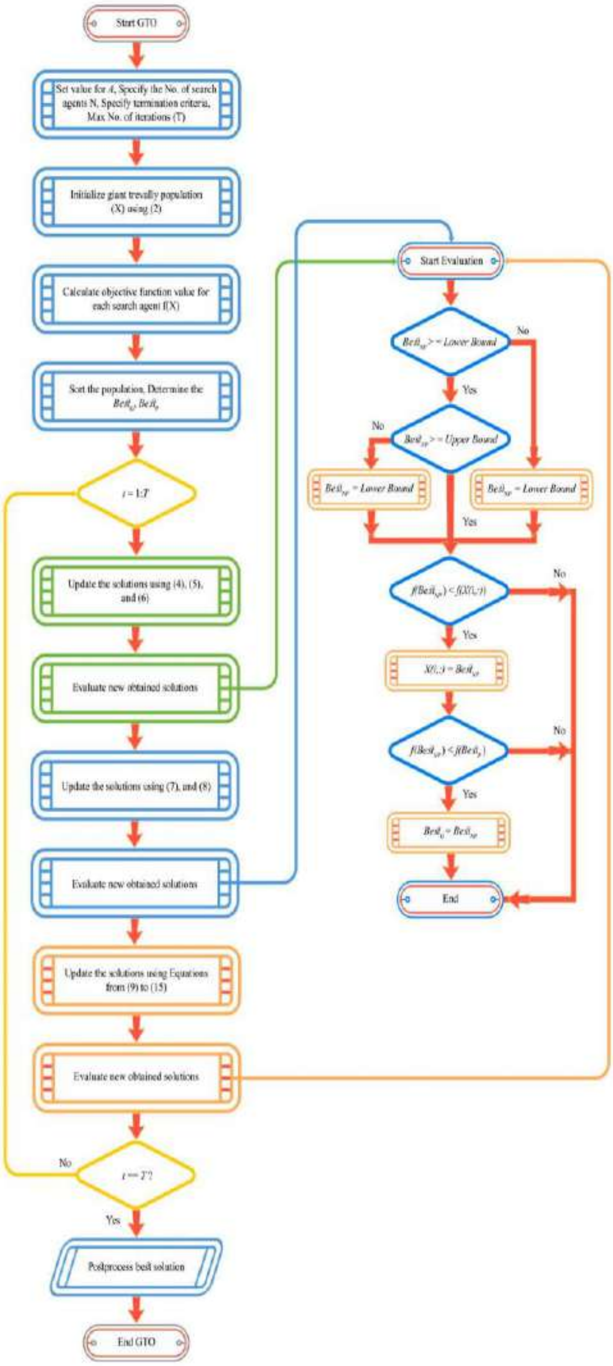
- Step 1: Initialization of GTO parameters
- Step 2: initial generation of GTO population.
- Step 3: Start the number of generations
- Step 4:Position update in Extensive search
- Step 5: Position update in Choosing area
- Step 6: Position update in Attacking
- Step 7:Trevallies with best fitness values are selected.
- Step 8: Stopping criteria.

ISSN: 0972-2750
Vol-13 Issue-04 No.10: 2023

Choosing Area

Attacking

**Steps in GTO algorithm:**



The proposed GTO algorithm mimics the behaviour of giant trevallies during hunting seabirds. Consequently, the optimization procedures of the proposed GTO algorithm are represented in three steps: extensive search using Levy flight, choosing area step to determine the hunting area, and chasing and attacking the prey by jumping out of the water. Hence, the exploration phase of the GTO is represented in the first two steps, and the third one represents the exploitation phase of the GTO. The giant trevally when hunting in the nature is shown in Fig Above.

1) **STEP 1: EXTENSIVE SEARCH** If we consider the nature of giant trevallies and, as mentioned earlier, giant trevallies can travel long distances for their daily diet. Hence, in this step, foraging movement patterns of giant trevallies are simulated using (4):

$$X(t+1) = BestP \times R + ((Maximm - Minimum) \times R + Minimum) \times Levy(Dim) \quad (4)$$

where X(t + 1) is the next-iteration giant trevally position vector, BestP indicates the current search space chosen by giant trevallies based on the best position determined during their last search, R is a random number that takes a value between 0 and 1. Levy(Dim) is the Levy flight, which is a special class of non-Gaussian stochastic process whose step sizes are determined by the so-called Levy distribution [41]. The ability of the algorithm to perform a global search is aided by the occasional large steps it takes. Furthermore, the main advantages of using Levy flight are the avoidance of local optima and the improvement of the convergence rate. It is worth mentioning that numerous studies have shown that the behavior of Levy flight is exhibited by a wide variety of animals, including marine predators. Levy(Dim) be calculated using following equation

$$Levy(Dim) = step \times \frac{u \times \alpha}{|v|^{1/\beta}}$$

σ is calculated by using the following equation

$$\sigma = \left( \frac{T(1+\beta) \times \sin e\left(\frac{\pi\beta}{2}\right)}{T\left(\frac{1+\beta}{2}\right) \times \beta \times 2\left(\frac{\beta-1}{2}\right)} \right)$$

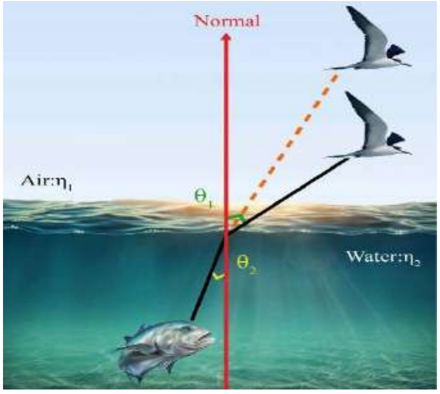
**2) STEP 2: CHOOSING AREA** In the choosing area step, giant trevallies identify and select the best area in terms of the amount of food (seabirds) within the selected search space where they can hunt for prey. The below equation simulates this behavior mathematically.

$$X(t+1) = Best_P \times A \times R + Mean\_Info - Xi(t) \times R$$

The Mean_Info which refers to the mean, indicates that these giant trevallies have used up all the available information from the previous points and can be calculated using the following equation

$$\text{Mean info} = \frac{1}{N} \sum_{i=1}^{N} X_i(t)$$

**3) STEP 3: ATTACKING** In the previous step and after specifying the best area for hunting. In this step, which represents the exploitation (intensification) phase of the GTO, the trevally starts to chase the bird (prey). Here, and finally, the trevally attacks the bird when it gets close enough to the bird by making an acrobatic jump out of the water and catching the bird.




Here, if we know the angle of incidence, it is possible to predict what the angle of refraction will be, and likewise, if we know the angle of refraction, it is possible to predict the angle of incidence. The Snell's law is demonstrated below.

$$\eta_1 \sin\theta_1 = \eta_2 \sin\theta_2$$

**SIMULATION CASE STUDY:**

The performance of the GTO technique for controlling the speed of a BLDC motor was tested using a MATLAB/Simulink model with a recommended control system. In order to compare its efficiency with other algorithms, PSO was chosen due to its proven effectiveness. The simulation results shows that PSO with Non-linear descending inertia weight (NLDIW) with threshold provides the best performance among the five PSO methods studied. However, the proposed GTO technique outperforms PSO with the help of a superior algorithm design. The current, speed, and voltage waveforms obtained with both techniques are shown in Figure. The study concludes that all the considered algorithms resulted in satisfactory operating characteristics, but the proposed algorithm with the objective of error minimization resulted in the least values.

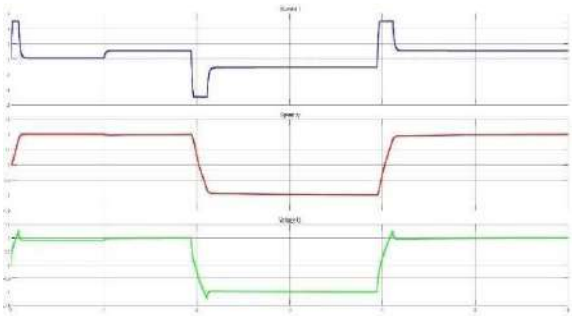


Fig: Output current, speed and voltage waveforms

**CONCLUSION:**

The paper proposes a new optimization method (GTO) for setting the parameters of a PI controller to control the speed of a BLDC motor, with the aim of achieving more accurate and reliable control under dynamic conditions. The simulation results demonstrate that the proposed method outperforms the existing PSO based technique in terms of performance. As a result, the paper presents an effective method for controlling the speed of a BLDC motor.

**References**

[1] haval tariq sadeeq and adnan mohsin abdulazeez "Giant Trevally Optimizer (GTO): A Novel Metaheuristic Algorithm for Global Optimization and Challenging Engineering Problems"

[2] ramesh devarapalli and naraharisetti jaya naga lakshmi "Application of a Novel Political Optimization in Optimal Parameter Design of PI Controller for the BLDC motor Speed Control" 2020

[3] B. Stefán, "BLDC Motor Modelling and Control A Matlab®/Simulink® Implementation," Chalmers Tekniska Högskola, Göteborg, Sverige, 2005.

[4] Trinayani Chittajallu and Ravi Srinivas Lanka "An Effective Controller Design for BLDC Motor Drive with Nature Inspired Heuristic Algorithm"

[5] H. Jigang, F. Hui, and W. Jie, "A PI controller optimized with modifieddifferential evolution algorithm for speed control of BLDC motor," Automatika, vol. 60, no. 2, pp. 135–148, Apr. 2019, doi: 10.1080/00051144.2019.1596014

[6] N. Azizi and R. K. Moghaddam, "Permanent Magnet Brushless DCMotor optimal design and determination of optimum PID controllerparameters for the purpose of speed control by using the TLBOoptimization algorithm," AmericanJournal of ResearchCommunication, vol. 1, no. 1, pp.294–313,2013.

[7] P. Salawria, R. S. Lodhi, and P. Nema, "Implementation of PSO-BasedOptimum Controller for Speed Control of BLDC Motor," InternationalJournal of Electrical, Electronics and Computer Engineering, vol. 6, no.1, pp. 104–109, 2017.

[8] Gwo-Ruey Yu and Rey-Chue Hwang, "Optimal PID speed control ofbrush less DC motors using LQR approach," in 2004 IEEE International Conference on Systems, Man and Cybernetics (IEEE Cat.No.04CH37583), Oct. 2004, vol. 1, pp. 473–478 vol.1, doi:10.1109/ICSMC.2004.1398343