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Controlling of PV fed BLDC Motor using Lion Optimization Algorithm

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ABSTRACT

This study deals with a buck-boost converter controlled solar photovoltaic array fed water pumping in order to achieve the maximum efficiency of an SPV array and the soft starting of a permanent magnet brushless DC (BLDC) motor. The current sensors normally used for speed control of BLDC motor are completely eliminated. The speed of BLDC motor is controlled through the variable DC-link voltage of a voltage-source inverter (VSI). This project deals with the operation of the interleaved DC-DC converter in solar PV array fed water pumping system as an intermediate DC-DC converter between the solar PV array and soft starting of BLDC motor. The intermediate converter with semiconductor switches has the features of reducing ripple current in its output and provide endless region for maximum power tracking (MPPT). In this project, Brushless DC motor speed has been controlled using the Lion Optimization technique to tune the parameters of PI controller. The system is supplied from a Solar PV Array along with the MPPT technique to fetch its maximum efficiency from the solar array.

1. INTRODUCTION

A BLDC Motor or Electronically Commutated Motor (ECM) are synchronous motor which are supplied by Direct Current (DC) through Inverter or Switching Power Supply producing AC through which each phase of the motor can be driven. Brushless motor are similar to permanent magnet synchronous motor in terms of construction but it can also be transformed into a switched reluctance motor. BLDC motors find numerous applications in the field of industrial engineering, consumer appliances, electric vehicles, motion control system, positioning and actuation system's aero modeling and many more [1]. BLDC motor has number of advantages over other motors which include high power-to-weight ratio, better speed, electronically controllable, reliable operation and require less maintenance [2].

Brushless motors typically have rotating permanent magnets and a fixed armature, which eliminates the challenges associated with supplying current to the moving armature. The brush/commutators unit of the brushed DC motor is replaced by an electronic controller, which continuously shifts the phase to the windings to keep the motor moving. Instead of the brush/commutators scheme, the controller uses a solid-state circuit to conduct similar timed power distribution [2]. In the no-load and low-load regions of the motor's performance curve, the increased efficiency is greatest. Brushless motors and high-quality brushed motors are comparable in efficiency under high mechanical loads. Environments and requirements in which brushless-type DC motors are used include maintenance-free operation, high speeds, and operation where sparking is hazardous (i.e. explosive environments) or could affect electronically sensitive equipment.

The brushless dc (BLDC) motor sensorless control system for an automotive fuel pump is developed by Chun et al (2014). It is recommended that sensorless techniques based on a hysteresis comparator and a potential start-up method with a high starting torque be used. The hysteresis comparator compensates for back EMF phase delay caused by a low-pass filter (LPF) while also preventing numerous output transitions caused by noise or ripple in the terminal voltages.

Il-oun Lee et al. (2012) proposed an interleaved buck converter (IBC) with low switching losses and increased step down conversion ratio, which is also appropriate for applications with high input voltage and low operational duty cycles. It indicates that before or after turn-on, the voltage across all switches is half of the input voltage, and that when the operating duty is less than 50%, the capacitive discharge and switching losses are also decreased.

2. MODELLING OF BRUSHLESS DC MOTOR

One of the types of permanent magnet synchronous motors is BLDC motors. Brushless DC motors, for example, do not experience the "slide" that is commonly noticed in induction motors since they have a permanent magnet rotor. Magnetism that is permanent Mechanical commutators and brushes are commonly used in DC motors to complete the commutation process. However, instead of mechanical commutators and brushes, BLDC motors use Hall Effect sensors. Brushless DC motors' stators are coils, and their rotors are permanent magnets [3]. Initially, the magnetic field is created by the stator winding of a brushless DC motor, and the rotor begins to rotate as a result of this field. And the Hall effects presents in this type of drive is used for sensing the position of rotor as in the form of commutating signals. The schematic diagram for the brushless dc motor is as shown in figure 1.

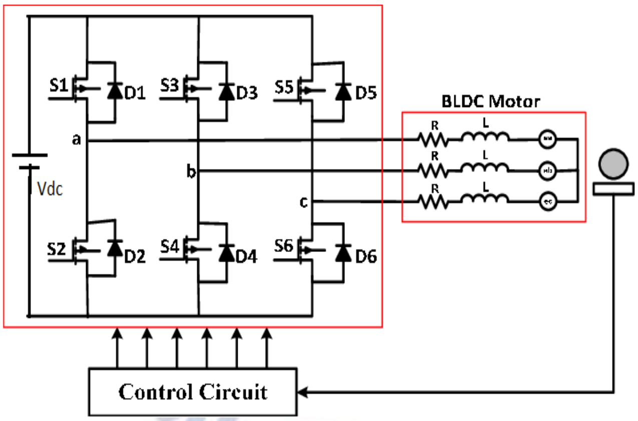

Figure 1: Basic schematic diagram for BLDC

Sensorless Control Methods of BLDC

To maintain synchronisation, a BLDC motor drive typically employs one or more positioning sensors.Due to sensor wiring and motor implementation, such a design results in a greater driving cost. Furthermore, sensors cannot be employed in applications where the rotor is enclosed in a closed housing and the number of electrical entry is limited, such as in a compressor, or in applications where the motor is submerged in a liquid, such as some pumps.Therefore, for cost and technical reasons, the BLDC sensorless drive is an essential capability of a brushless motor controller.

Since the neutral point of the BLDC motor is not offered, it is difficult to construct the equation for one phase. Therefore, the unknown input observer is considered by the following line-to-line equation:

Since the neutral point of the BLDC motor is not offered, it is difficult to construct the equation for one phase. Therefore, the unknown input observer is considered by the following line-to-line equation:

$$i'_{ab} = \frac{2R}{2L} i_{ab} + \frac{1}{2L} v_{ab} - \frac{1}{2L} e_{ab}$$

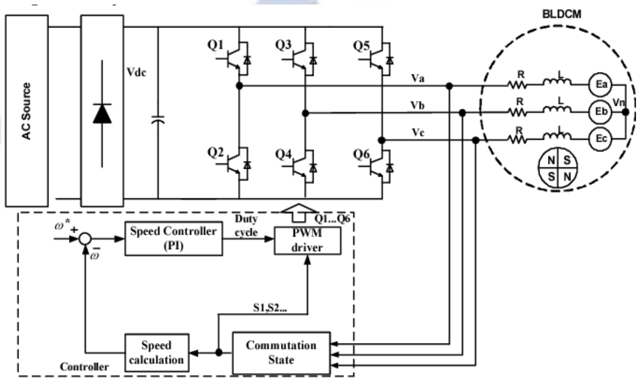

Figure 2: Sensorless Control Method of BLDC

Analysis of PSO Technique:

The convergence criteria in the standard PSO algorithm aim to find the optimal solution or the success of the maximum number of iterations.. Therefore, the proposed PSO algorithm will reinitialize and tune the better parameters of Kp and Ki whenever the following conditions are satisfied:

$$|v(i+1) < \Delta v|$$
$$(pi(k+1) - pi(k) / pi(k) > \Delta p)$$

Where pi (k+1) is the new parameters, pi (k) is the previous parameters. From above equations, stand for the agent's convergence detection and abrupt alteration of insolation, correspondingly. There are two matters associated with ΔV choice:

1) lesser values lead to better MPPT firmness but a poor tracking reaction, and 2) superior values result in a faster tracking reaction at the cost of greater oscillations. Therefore, a balanced rate must be selected. Nevertheless, when the ΔP is great, the subsequent constraint might not be fulfilled due to lesser variations in real power; therefore, the agents' rate of initialization is minor.

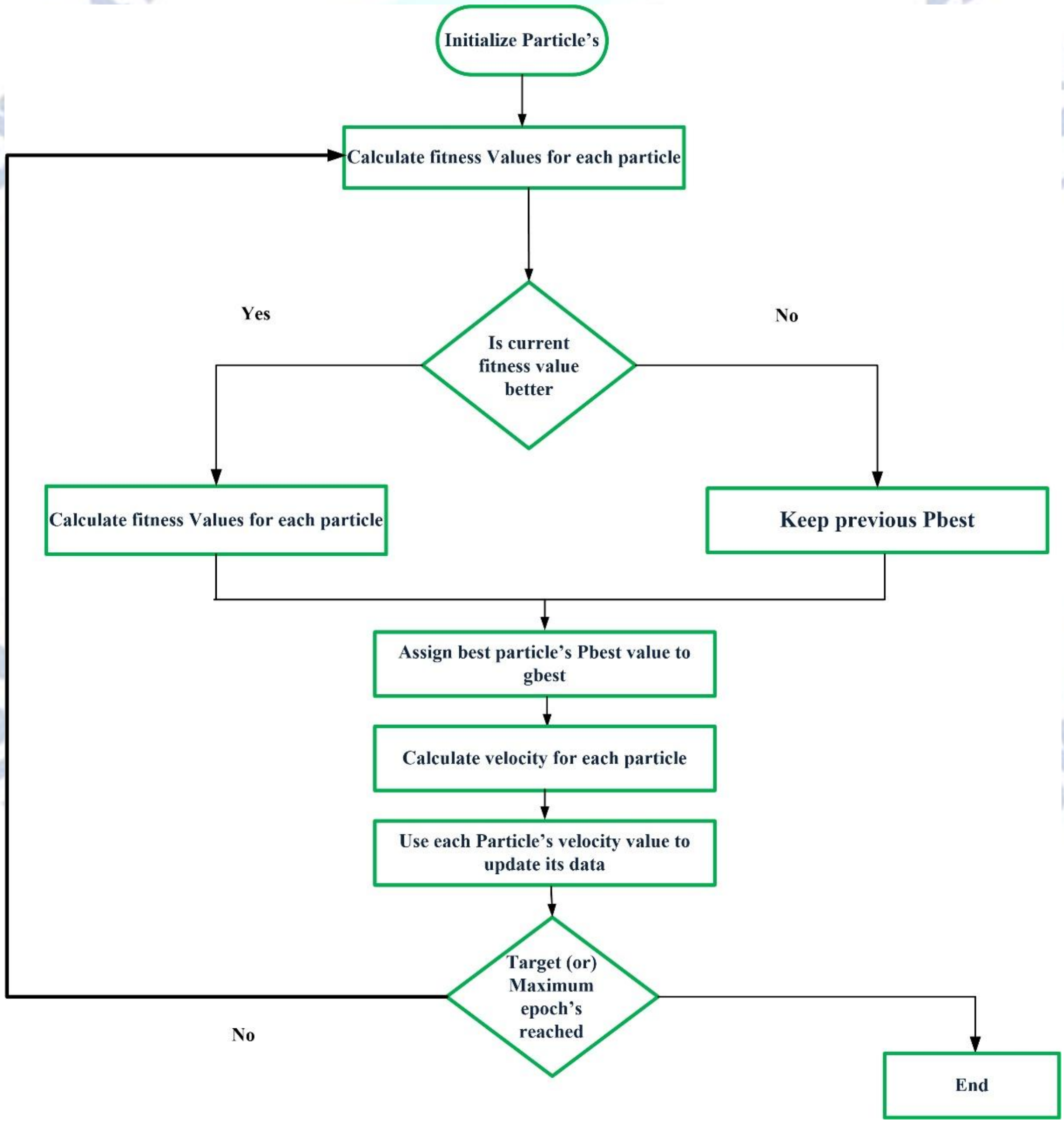

Fig.3. Algoritham for PSO Technique

3. LION OPTIMIZATION TECHNIQUE

This section describes the inspiration for the proposed meta-heuristic algorithm, and the process is explained in detail. Male cubs live in their birth to the world pride until they arrive at early adulthood, whereupon they disregard the pride to meander as itinerant lions.During their meandering, a roaming male experiences another pride, which might challenge the pioneer for strength. If the itinerant male succeeds this experience, it turns into a new pioneer of pride. In the lion's calculation, every lion speaks to an answer. A stream chart of the LOA is presented in Fig.8.This calculation continues through four essential advances:, pride age, mating, regional resistance and regional takeover.

Pride generation

In step one, 2N lions are randomly assigned to two male or female businesses.The number of lions inside the ensuing companies must be equal, lion (L_1^male, L_2^male,…,L_n^male) and lionesses(L_1^girl, L_2^female,…,L_n^girl). A lion and a lioness are then paired as a delight,; ensuing in n prides.

Mating

Crossover and mutation functions much like the ones used in genetic algorithms are used for the technology of cubs. To start with, the lion and lioness in every satisfaction crossover two times to generate four cubs ($L_{(1\text{-}4)}^{cubs}$). The resulting cubs then replica once to generate any other 4 cubs ($L_{(5\text{-eight})}^{cubs}$). The cubs were divided into male cubs (L_{male}^{cubs}) and female cubs (L_{female}^{cubs}) using k-manner clustering. We then counted the number of male and female cubs in each pride. Vulnerable cubs in large institutions are steadily killed in steps with health popularity (target function), such that the variety of male cubs is usually the same as the variety of female cubs in every pride.

Territorial defense

This case mimics the satisfaction chief protecting his function in opposition to a random interloper (L^{nomad}) earlier than the cubs in the satisfaction reach adulthood.The time required for the cubs to reach adulthood (the target function) is expressed by Eq. (3).

$$\left(L^{pride}\right)=\frac{1}{2(1+\|L^{m\_cubs}\|}\left\{F(L^m)+F\left(L^f\right)+\frac{Age_{mat}}{age(cub)+1}\sum_{c=1}^{\|L^{m\_cubs}\|}\frac{F\left(L_C^{m\_cubs}\right)+F\left(L_C^{f\_cubs}\right)}{\|L^{m\_cubs}\|}\right\} \quad (3)$$

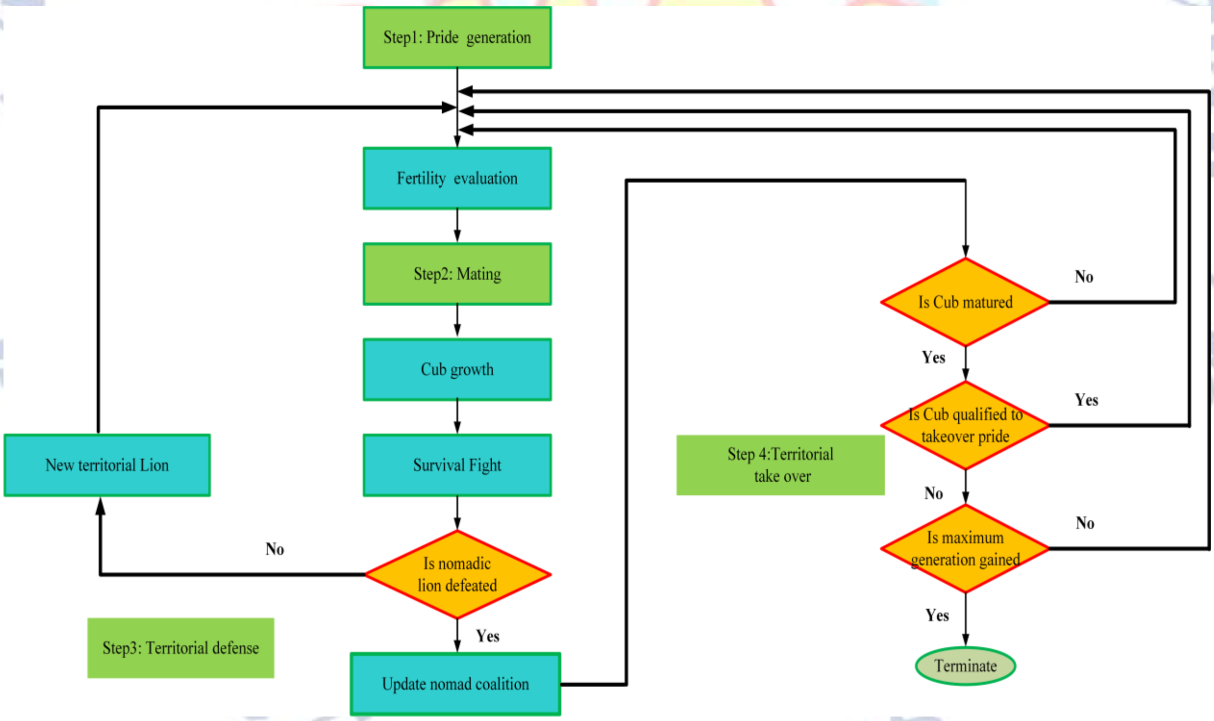

Figure 4: The flow structure of the proposed LOA based DPFC

4. SIMULATION BLOCK DIAGRAM

In this a fixed voltage source has been given to the whole system. A PSO has been used in this model to find the appropriate parameters for the PI controllers i.e., Kp and Ki , which helps in controlling the speed of the BLDC motor through a 3-ϕ inverter. With the increasing dependency on renewable sources of energy, supply from a grid or a fixed voltage source has some sort of disadvantages. A solar PV array has been connected to the system to power the whole system. Maximum efficiency from the array can be extracted using MPPT technique. A dc-dc converter has also been used to get desired output for the 3-ϕ inverter.

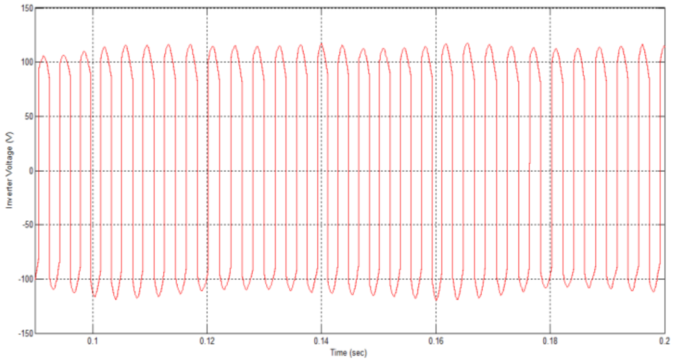

Figure 5: Inverter voltage with PSO Technique

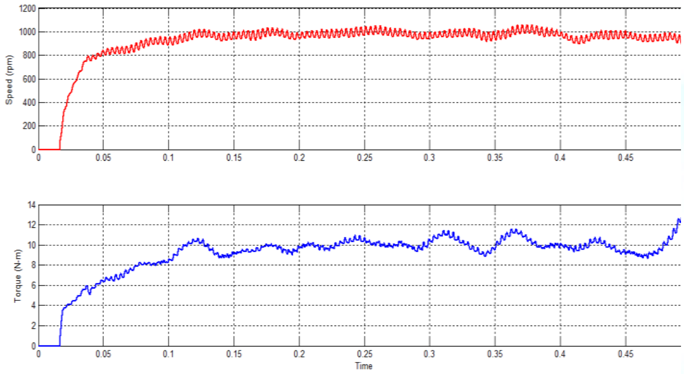

Figure 6: Speed and Torque Waveform with PSO

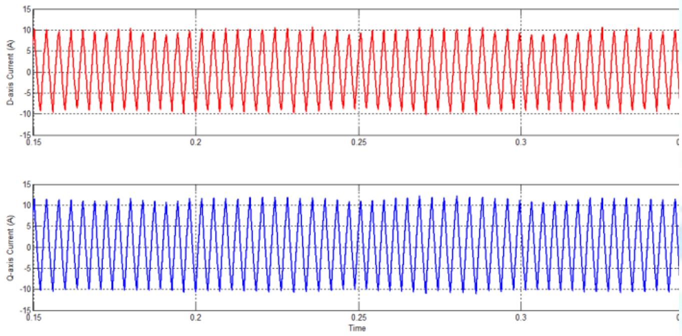

Figure 7: BLDC Stator Currents using PSO

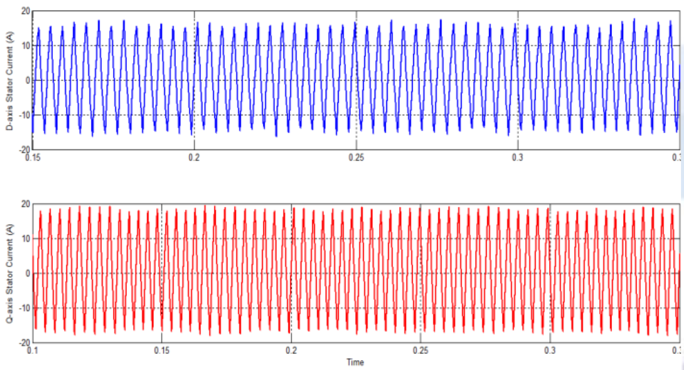

Figure 8: BLDC Stator Currents using LOA

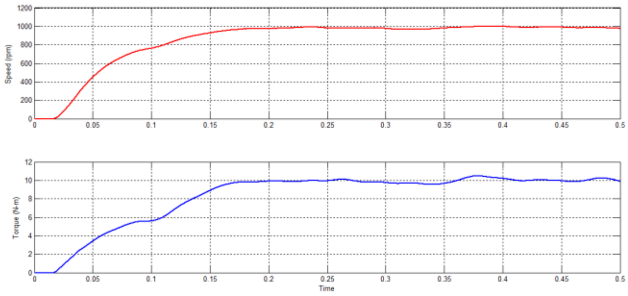

Figure 9: Speed and Torque Waveform with LOA

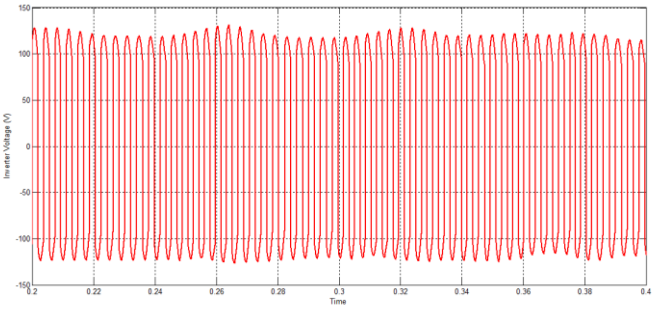

Figure 10: Inverter voltage with LOA Technique

Table 1: Comparative Analysis between PSO and LOA

Parameter	PSO	LOA
Inverter Voltage	100V	120V
Speed Distortions	15%	8%
Torque Distortions	18%	7%

5. CONCLUSION

In this paper, a comparison study of using PSO and LOA methods for the tuning of PID controller for speed control of a BLDC motor. Obtained through simulation of BLDC motor, the simulation results show that the proposed controller can perform an efficient search for the optimal gains of PID controller. By comparing between PSO method and LOA technique, it shows that LOA method can improve the dynamic performance of the system in a better way.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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