International Journal on Emerging Technologies **10**(4): 57-61(2019)
ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

LVRT Capability Improvements with Hybrid Grey Wolf Optimizer–PSO Algorithm

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(Received 26 June 2019, Revised 30 September 2019, Accepted 09 October 2019)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The extending consolidation of wind imperativeness, there is a general example to coordinate the show of wind power plants with the objective that they can add to the quality and enduring nature of the power structure. The basic requirements of active power control and reactive power compensation, the two of which influence wind power plants action, are revolved around. Along these lines, present-day WECSs are required and planned to the Low Voltage Ride Through (LVRT) limit in the line issue condition. The purpose of the paper is to chart some noticeable approaches to manage the LVRT capacity redesign in the line defect condition. With LVRT capability, the system has to inject the reactive power instead of absorbing, by reducing the active power with which helps in improving system stability. Along with the system should get connected to the system to support the LVRT characteristics as per grid code requirement which is the challenging task presented in paper. The challenge is proved through dc link voltage and active and reactive power performance characteristics. The preliminary outcomes demonstrate the ampleness and common sense of the Grey Wolf Optimizer (GWO)-Particle Swarm Optimisation (PSO). Integral-squared error are limited by using GWO and GWO with PSO controllers to control the main objective of PMSG issue of LVRT. The efficiency of the proposed flexible controller during dynamics is differentiated with that of GWO controller. The additional feature of swarm intelligence improves the performance of GWO tend to improve the LVRT capability during the consideration of severe grid dynamics.

Keywords: LVRT, PMSG, hybrid GWO-PSO, active and reactive power, DC link voltage.

Abbreviations: LVRT, Low Voltage Ride Through; GWO, Grey Wolf Optimizer; PSO, Particle Swarm Optimization; WECS, Wind Energy Conversion System.

I. INTRODUCTION

Permanent Magnet Synchronous Generator (PMSG) based Wind Energy Conversion System (WECS) is coordinated with the electrical framework over the repeat converter [1]. The national administrative systems are liable to constant changes and corrections, bringing a few troubles up in their immediate correlation and the extraction of worldwide ends [2]. Wind vitality demonstrated to be spotless without CO_2 outflow. The steadiness and unwavering quality of the entire power framework can be impacted by the expanding entrance level of wind control [3]. Wind vitality is a characteristic skilled wellspring of environmentally friendly power vitality. In any case, wind power endures from multiple points of view. One of the serious issues is the line deficiency for the WECS. Therefore, the WECS is required and intended to the Low Voltage Ride Through (LVRT) ability in the framework flaw condition [4].

The expanding interest for vitality has required the mix of sustainable power source assets, for example, wind and sun powered vitality into the power framework. Regular PI controller with disconnected tuning by PSO calculation dependent on the Integral Time Absolute Error (ITAE) record, PI controllers with online self-tuning by PSO calculation dependent on the blunder and PI controllers with online self-tuning by PSO calculation dependent on the ITAE list [5].

Fuzzy based fractional order PI controller was planned with a PSO to acknowledge MPPT of WECS. An Artificial Neural Network (ANN) based Reinforcement Learning (RL) was utilized for PMSG to accomplish MPPT, which empowers the WECS to act as a smart operator with memory to gain from its own understanding, in this way improving the learning effectiveness [6]. The settled circle control structure, the external circle voltage controller ensures following the presentation of air conditioning voltage reference and the internal current circle guarantees quick powerful remuneration for framework aggravations [7].

The examination demonstrates how the converter flows can surpass as far as possible because of the poor conduct of standard PI-based controllers [8]. PI controller experiences two disadvantages. (1) It is definitely not an extremely basic errand to ideally tune it in situations where we are managing profoundly non-direct frameworks which may encounter a few activities focuses. (2) Its fixed non-versatile structure makes it to not be a decent decision for controlling non-straight frameworks [9]. One of the fundamental difficulties for PMSG-based WECS is the LVRT satisfaction, as requested by network association necessities of various nations [10]. The FRT investigation is performed in the light of ongoing breeze ranch framework codes referenced before. The association of the paper is given as pursues [11].

An elective perspective to tackle these challenges is proposed in this investigation utilizing the Taguchi strategy keeping the structure explores in the base number to accelerate the tuning procedure [12]. Where every vector control plan contains four PI controllers [13]. In complex drive structures, likewise, the parameter of postponement, happening in controllers and power converters isn't consistent.

Likewise, in the conditions of field debilitating, the parameter of electromagnetic torque to engine current proportion may change. Subsequently, there is a solid interest for the structure of controllers that are heartless (or have constrained affectability) to changes in the parameters recorded above [14]. The above mentioned all the control techniques are not much effective in grid dynamic operations, to overcome these difficulties we proposed a metaheuristic algorithms with hybridization to achieve the objective of LVRT capability enhancements literally.

PSO is an amazing asset for displaying as it can get familiar with the direct and non-straight connection between the factors [15]. The PSO calculation is one of the advanced heuristic calculations and has been found to strong in taking care of consistent nonlinear streamlining issues [16]. PSO is utilized in this paper to decide the required controller gains since it combines to a palatable arrangement in a productive way [17]. The controller tuning guarantees a decreased affectability as for the parametric varieties of the procedure [18]. The streamlining issues are understood by the change of the PSO proposed for tuning GWO for demonstrated to be a productive developmental nature-propelled improvement calculation in the ideal tuning of the parameters of GWO-PSO controllers. To improve the vigour of the control framework, a PSO-GWO controller for the PMSG framework is proposed [19-22].

II. SYSTEM MODELLING

The wind energy collected by the turbine blades was transformed to mechanic energy by the wind turbine. The model proposed here is illustrated by Fig. 1, which contains the wind model, an aerodynamic part and a mechanical model of PMSG model, DC interface capacitor, MSC, GSC, inductive and capacitive (LC) channel.

The mathematical expression for the wind turbine power output and the turbine torque is expressed as follows:

$$P_W = \frac{1}{2} \delta\pi R_0^2 V_W^3 C_P (\lambda \beta) \quad (1)$$

$$T_W = \frac{1}{2} \delta\pi R_0^3 V_W^2 C_P (\lambda \beta)/\lambda \quad (2)$$

where, δ = air density

R_0 = radius of the turbine

V_w = winds speed

C_p = power coefficient

λ = tip speed ratio

W_w = rotational speed of the turbine

β = pitch angle

III. GWO ALGORITHM

The evolutionary algorithm is based on the wolves hunting nature. In this hunting process of a group grey wolves involved with leader wolf is named as alpha (α), supporting one is named as beta (β) and remaining members of group are named as delta (δ) and omega (ω).

The method of chasing the nourishment by the dark wolves is searching for the sustenance, encompassing the sustenance, chasing, and assaulting the nourishment. The number juggling model of encompassing the nourishment is composed as pursues.

$$\bar{d} = |\bar{c} \ldots \bar{x}_{pi} - \bar{x}_i \quad (3)$$

$$\bar{x}_{i+1} = \bar{x}_{pi} - \bar{a} \ldots \bar{d} \quad (4)$$

where, x_t = place of grey wolf; x_{pt} = food place; d = distance; a and c = vectors

$$\bar{a} = 2 - 2 * t / \max_{itr} \quad (5)$$

$$\bar{a} = 2\bar{a}.\bar{r}_1 - \bar{a} \quad (6)$$

$$\bar{c} = 2.\bar{r}_2 \quad (7)$$

where, r_1 and r_2 are random numbers between [0, 1].

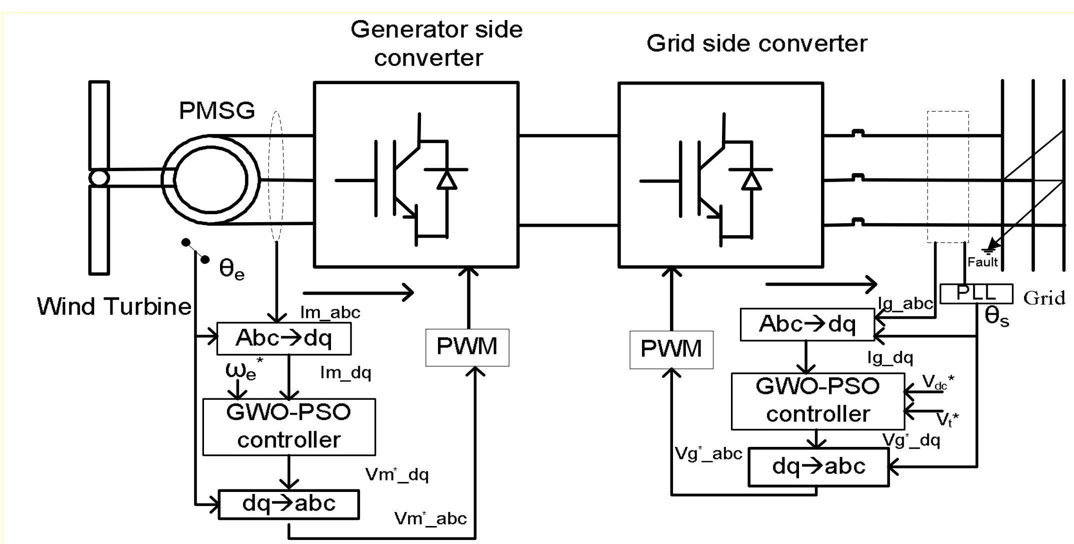


Fig. 1. PMSG based wind turbine.

IV. PSO TUNED GWO

PSO is a nature-motivated and worldwide improvement calculation, created by Kennedy and Eberhard [6]. It is roused by the social conduct of winged creature and fish swarms.

The basic steps involved in hybrid evaluation process is,

(a) Introduce the populace and structure the arrangement space.
(b) Perform GWO.
(c) Create least qualities for all people.
(d) Pass these people to the PSO as beginning stages.
(e) PSO Gives the updated position back to GWO.
(f) Keep running till halting criteria is met.

The looking through begins from a gathering of starting in the issue space so as to expand the likelihood of finding the ideal answer for the issue. The population is designed by NP individual's particles, being every molecule a conceivable answer for the issue. The following position of every molecule is administered by this following condition which relies upon the last position in addition to a refreshed speed, represented in Fig. 2.

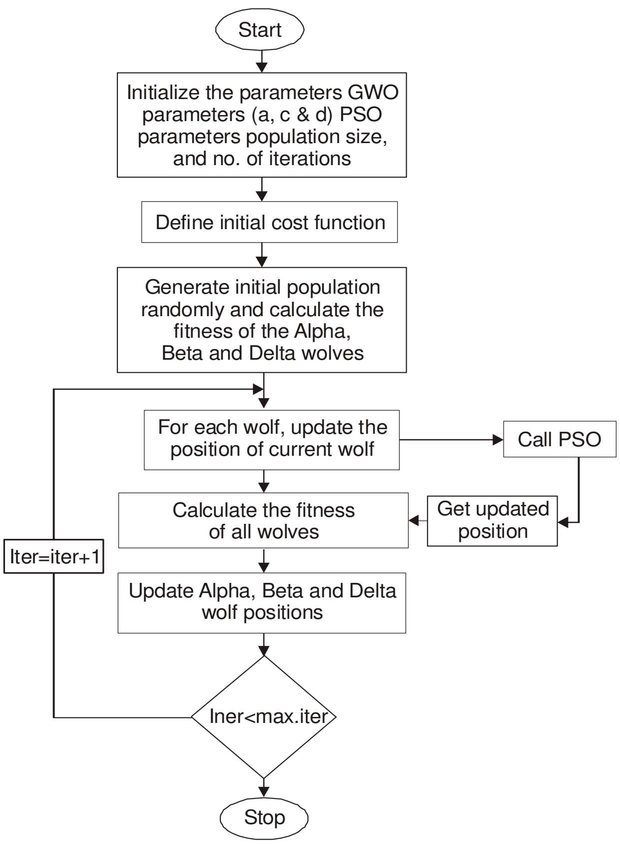


Fig. 2. Flowchart for GWO-PSO algorithm.

$x(i) = x(i) + \Delta x(i)_k;\ i = 1{:}\ n_p$ (8)

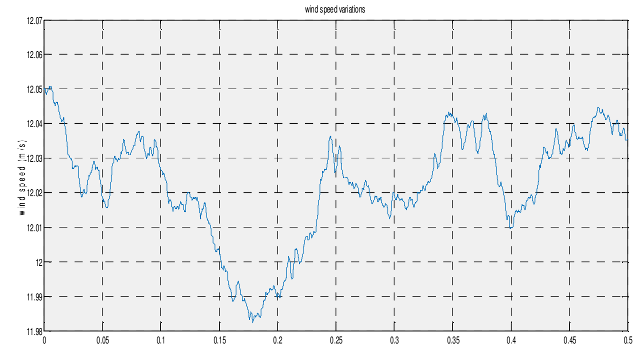
The speed term has two attributes: investigate different districts of the hunt space and permits getting away from nearby optima. The outflow of the refreshed speed is

$\Delta x(i)_{k+1} = \omega \Delta x(i)_k + \rho_i(x_{pbest}(i) - x(i)) + \rho_2(x_{gbest} - x(i))$ (9)

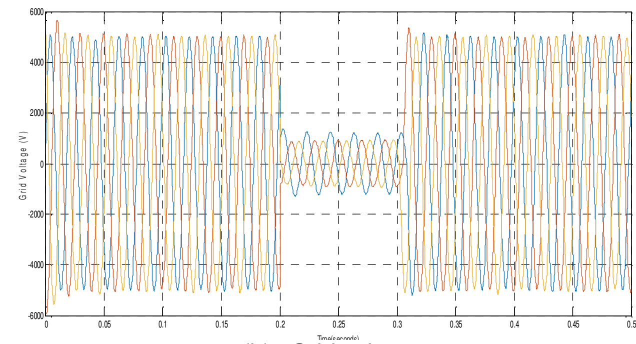
where $\Delta x(i)_{k+1}$ is the velocity of the succeeding particle which depend on the prior particle velocity multiplied by the inertia weight ω, the trust coefficients ρ_1 and ρ_2 determined by those expressions and $x_{p\ best}$, $x_{g\ best}$ are the local and global best position respectively.

V. RESULTS AND DISCUSSION

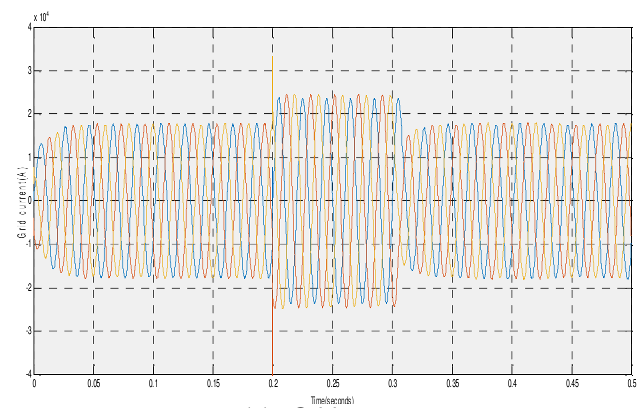
The LVRT capability is tested on 1.5 MW generator with variable wind speed 12m/s as shown in Fig. 3(a) has the dc link voltage as VDC 1500v with dc link capacitor C=15000 μf, carrier frequency fc is 10kH and number of poles P is 8 with 3 phase fault from 1.2s to 0.3s of 0.1s duration were considered in this paper.



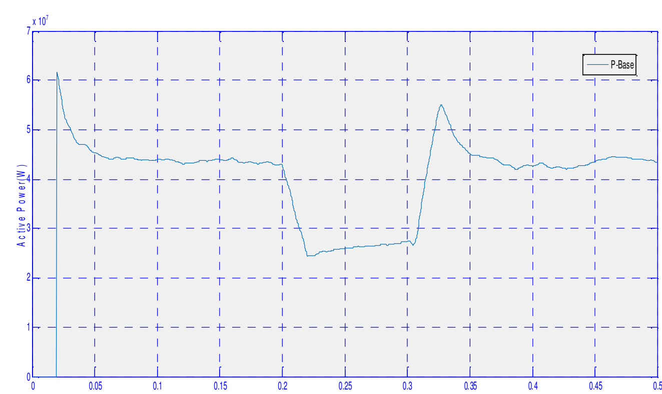
(a) Variable wind speed



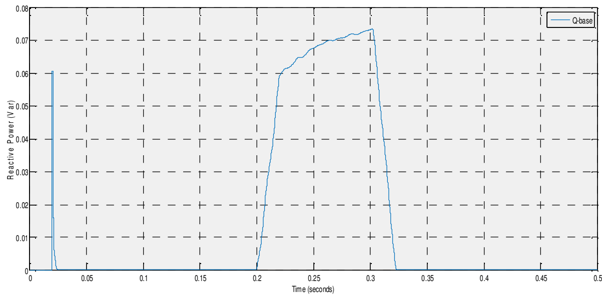
(b) Grid voltage



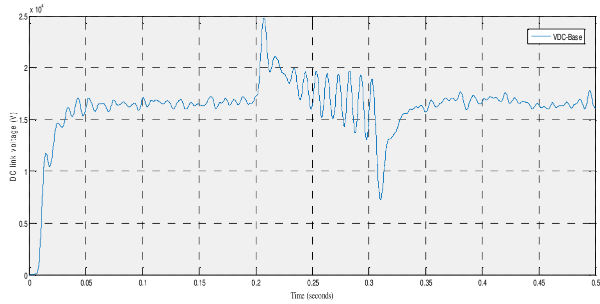
(c) Grid current



(d) Active power

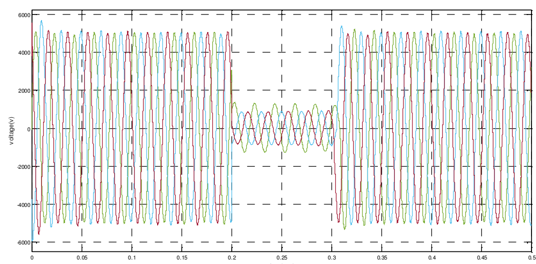


(e) Reactive power

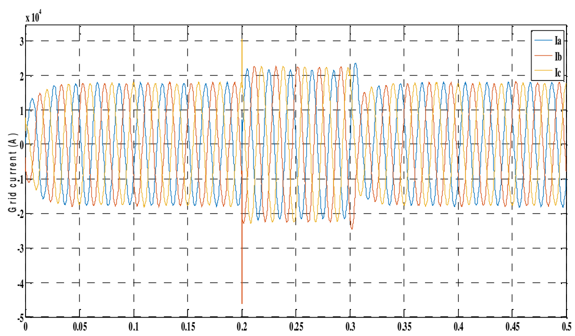


(f) DC link voltage

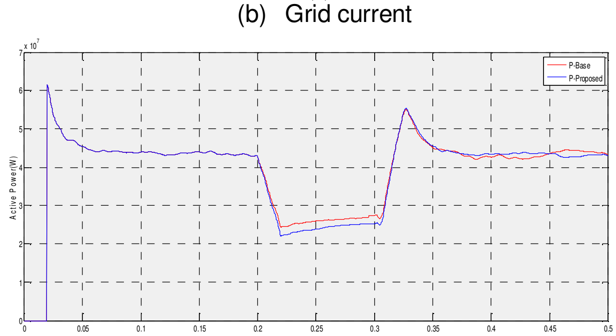
Fig. 3. Dynamic response of the system with Fault.



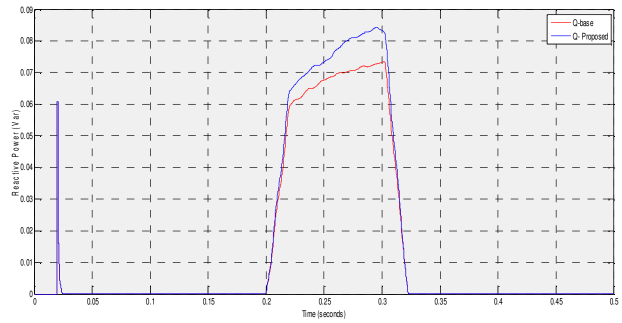
(a) Grid voltage



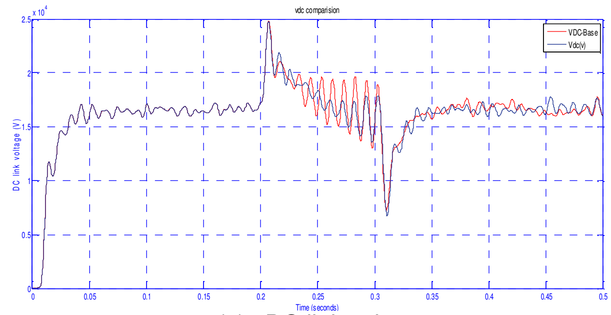
(b) Grid current



(c) Active power



(d) Reactive power and



(e) DC link voltage.

Fig. 4. Dynamic response of the system with Fault by GWO-PSO, (a) Grid voltage, (b) Grid current, (c) Active power, (d) Reactive power and (e) DC link voltage.

By the proper design of nested converters with GWO will regulates the power and DC link voltages, through which it providing LVRT capability. During the event of grid faults voltage will decreases and current will increase but during this voltage dip the system must be connected to grid and has to inject reactive power and diminishes the active power and maintain the Dc link voltage constant to support the LVRT characteristics. From the Fig. 3 (b)-(f) it is clears that requirement of LVRT is supported by the converter with GWO controller.

The proposed GWO with PSO results as shown in the Fig. 4 (a) to (e) shows the extended support towards LVRT characteristics because in increase more reactive power injection during the fault and reduces active power much more than GWO alone, more over it reduces dc link voltages towards the stable tends to conclude the GWO-PSO performance is good compared to normal GWO.

VI. CONCLUSION

In this paper, the LVRT limit, and grid penetrated PMSG based WECS are overhauled by choosing the perfect tuning of GWO parameters used in the nested converter. With this, it is comprehended that grid penetration prerequisites are reinforced in both GWO and GWO-PSO of the regards, for example, dynamic and reactive power control, DC interface voltage and LVRT to improve the security of the general power network. Despite the past compelling work of the GWO-PSO in different electrical power system improvement locales, it will, in general, be assumed that the GWO-PSO estimation is an engaged meta-heuristic computation to tune multi-target parameters in a grid associated PMSG.

VII. FUTURE SCOPE

We can improve the objective function further with hybridization of advanced metaheuristics algorithms and development of hardware setup as a future scope for validating the results.

ACKNOWLEDGMENT

I would like to pay special thankfulness, warmth, and appreciation to the Kuppam Engineering College who made my research successful and assisted me at every point to cherish my goal.

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How to cite this article: Sekhar, V. and Ravi, K. (2019). LVRT Capability Improvements with Hybrid Grey Wolf Optimizer–PSO Algorithm. *International Journal on Emerging Technologies*, **10**(4): 57–61.