IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 3, Issue 9, September 2016

Solar Energy Power System Stabilizer Design Using H∞ Robust Technique Based On Enhance ABC Optimal Power System

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Abstract: Solar energy has become a chief source of energy with the advancements in PV cell efficiency and reduction in cell cost, grid-connected photovoltaic systems does not require bulk and lossy battery bank. High voltage Distributed generation and on-site supply of PV system minimizes distribution losses, and mitigates environment pollution. In this, the robust solar power system stabilizer (RPSS) is designed using enhanced ABC for designing the controllers for dynamical systems in electrical engineering. Comparisons are also made between the Conventional power system stabilizer (CPSS), PSS with H∞ optimization and PSS with PSO optimization. Experimental results show that compare to other techniques, enhanced ABC is more effective to produce desired response.

Keywords: RPSS, CPSS, H∞, PSO, Enhanced ABC.

I. INTRODUCTION

The extension of interconnected power systems is constantly increasing because of the continuously growth in electric power demand. Due to the rising electrical power system demand and necessitate to power systems operate close to their stability limit, present power systems can reach the stressed conditions more simply than the past. In this situations occurrence of any disturbance may lead to instability or weakly damped oscillations [1]. Low-frequency oscillations in a power system is the source of many undesirable effects such as constraining the power transfer on the transmission lines, initiating and propagating pressure in the mechanical shaft, endangering the system's security, and decrease the whole operating efficiency of a power system[2,3]. These oscillations may sustain and grow to cause system partition if no adequate damping is available [4, 5].

In the preceding decades, power system stabilizers (PSSs) have been used by utilities in real power systems as they have prove to be the most cost-effective electromechanical damping control [6]. Numerous researchers have posed techniques for designing PSSs to increase the damping of electromechanical oscillations of power systems and increase power systems stability. The most significant aspects for designing such a controller are the proper selection of stabilizer's feedback signals, the optimal parameter setting and the proper selection of controller's location [7].

Now a days, renewable energy sources particularly wind and solar energy gaining momentum and increasing its share in world energy demand. Moreover, photovoltaic systems are eco-friendly noise free source of electricity. Distributed PV generation necessarily to meet challenges related with power quality and system security problems not only on the distribution network but also on the transmission grid.

Solar energy has become a very potential energy source. Grid-connected photovoltaic (PV) system does not necessitate bulk and lossy battery and reduces transmission losses. Since Conventional sources of energy are rapidly depleting and the cost of energy is rising, photovoltaic energy becomes a promise alternative source. Among its advantages are that it is abundant, pollution free, distributed throughout the earth and clean and noise-free source of electricity.

In this, a solar based power system stabilizer in deregulated environment is proposed. The proposed enhanced ABC optimization technique is compared with conventional PSS and PSS with H∞ optimization technique and PSS with PSO optimization technique.

II.LITERATURE OF REVIEW

Many prior works have investigated diverse aspects of PV systems, including the energy production and economics [8]–[10]. The most extensively addressed technical problem regarding PV systems is the so-called maximum power-point tracking (MPPT).

Reference [11] reviews 19 different MPPT methods introduced since 1968. The benefit of the reported works encompasses both large-scale and distributed PV systems. Another broadly addressed topic is that of power converter configurations and aggregation schemes for PV systems.

References [12]–[15] offer comprehensive surveys on different single-phase and three-phase converter circuits for photovoltaic applications. Now a days, with the consideration of PV systems as DG units, research works also gives to report as the integration of islanding recognition schemes into single-phase PV systems [16]–

[19]. In addition, a reasonable amount of the technical literature has mainly dealt with the integration of PV systems into distribution networks. The greater part of this body of the literature review has focused on single-phase PV systems, with an prominence on their harmonic interactions with the distribution networks [20]–[22] and on their impact on the power quality (PQ) [23]–[25].

Research has also dealt with transformer overload and feeder overvoltage problems. However, only a few prior works have investigated the control and stability aspects of Photovoltaic systems. Dynamic stability of single-phase, distributed PV systems is analyzed in [26] and [27].

Reference [26] has conducted an eigen value study for a two-stage configuration, including the model of the dc cable between the two stages considered. Yet, the distribution line and loads are not modeled. Reference [27] has studied the impact of grid impedance changes on the closed-loop stability of a single-phase PV system. In addition, a control design methodology to guarantee the provision of adequate damping has been presented.

Proposes a control strategy for a single-stage, three-phase, photovoltaic (PV) system that is connected to a distribution network. The control strategy depends on an inner current-control loop and an outer DC-link voltage regulator. The current-control method decouples the solar power system dynamics from the network and the loads. The DC-link voltage-control system enables control and maximization of the real power output. Appropriate feed forward actions are proposed for the current-control loop to make its dynamics independent of those of the remaining of the system. Further, a feed forward compensation mechanism is proposed for the DC-link voltage-control loop, to create the PV system dynamics resistant to the PV array nonlinear characteristic. This, in turn, allows the design and optimization of the PV system controllers for a broad range of operating conditions [28].The focus is a detailed examination of energy production, together with a discussion of the capacity value of photovoltaic (PV) systems. Data are offered on the customer demand reduction potential of roof-mounted residential PV systems. It is revealed that these systems can give, on average, 63% of their normalized capacity (1.8 kW) during 6-h peak load periods. The output range is 34% to 80% during these periods. Reverse energy flow from residential PV systems has been analyzed. The data point out nonzero reverse energy flow for almost all participants in summer, and high amounts for one group of participants. The profitable and institutional PV systems usually operate in a more hostile electrical environment. In result, they have required more attention to sustain operating status and metering accuracy [29].

The numerous techniques for maximum power point tracking of photovoltaic (PV) arrays are discussed. The techniques are taken from the previous literature to the initial methods. It is shown that at least 19 distinct methods have been introduced in the literature, with numerous variations on implementation. This work should serve as a suitable reference for future work in PV power generation [30].

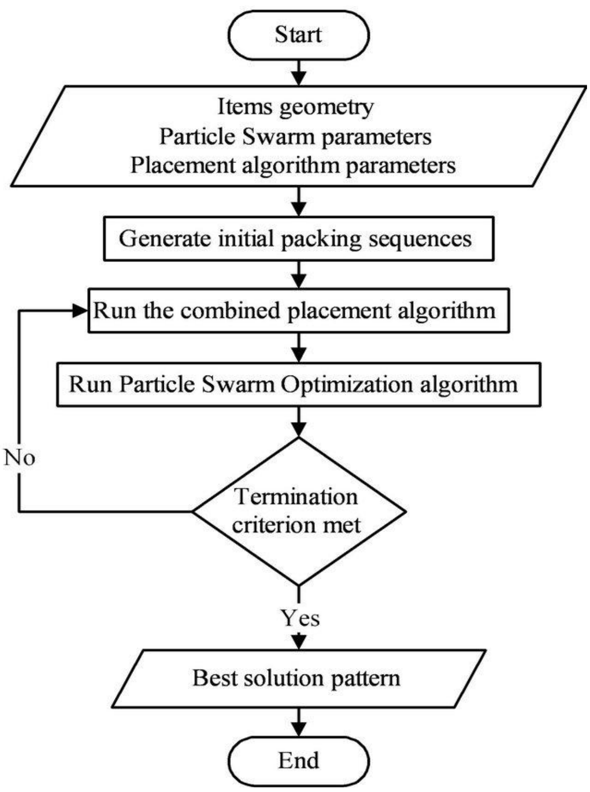
III. H∞ ROBUST DESIGN TECHNIQUE BASED ON ENHANCE ABC OPTIMAL POWER SYSTEM STABILIZER

a) H∞

H_∞ methods are used in control theory to synthesize controllers attaining stabilization with definite performance. To use H_∞ techniques, a control designer expresses the control problem as a mathematical optimization problem and then identify the controller that resolves this optimization. H_∞ techniques have the benefit over classical control techniques in that they are voluntarily applicable to problems involving multivariate systems with cross-coupling between channels. But non-linear constraints such as saturation are generally not well-handled.

b) PARTICLE SWARM OPTIMIZATION

Particle swarm optimization is a population based optimization technique developed by Dr. Kennedy and Dr. Eberhart in 1995, inspired by social behavior of bird flocking or fish schooling. Particle swarm optimization (PSO) is an optimization method that optimizes an issue by iteratively trying to increase a candi date solution with consider to a given measure of quality. PSO optimizes a issue by having a population of candidate solutions (dubbed particles), and moving these particles around in the search-space along with simple



Flow chart for Particle Swarm Optimization algorithm

mathematical formulae over the particle's velocity and position. Each particle's movement is influenced by its local well known position but, is also guided to the best known positions in the search-space, which are updated as improved positions are originate by other particles. This is probable to move the swarm toward the best solutions.

c) ARTIFICIAL BEE COLONY (ABC)

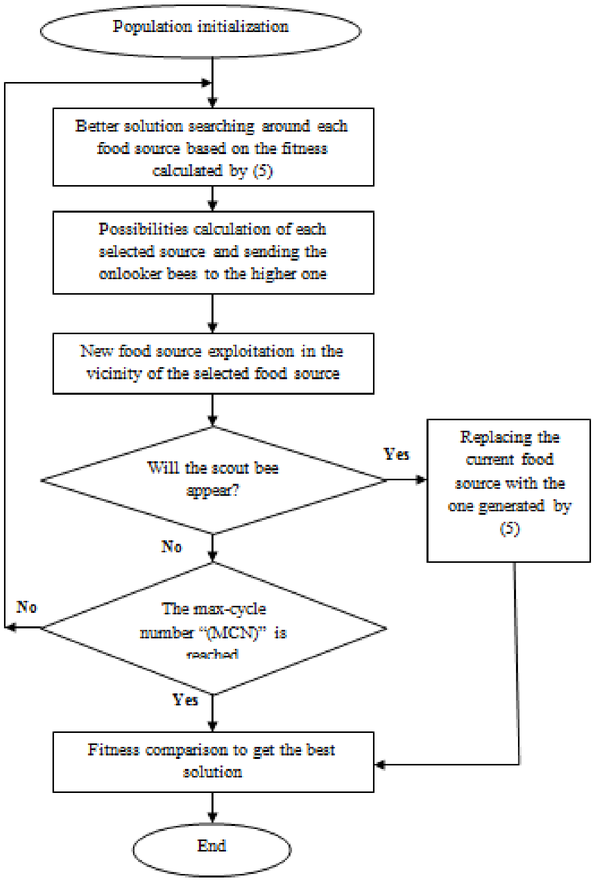
Artificial bee colony (ABC) algorithm is a newly proposed optimization technique which simulates the intellectual foraging behavior of honey bees. A group of honey bees is called swarm which can effectively accomplish tasks through social cooperation. In the ABC algorithm, it consists of three types of bees which are employed bees, onlooker bees, and scout bees. The employed bees look for food around the food source in their memory; in the meantime they share the information of these food sources to the onlooker bees. These bees tend to choose good food sources from those found by the employed bees. The food source that has superior quality will have a large chance to be chosen by the onlooker bees than the one of inferior quality. The scout bees are translated from some employed bees, which abandon their food sources and search new ones.

d) ENHANCED ARTIFICIAL BEE COLONY ALGORITHM

Artificial bee colony algorithm (ABC) is an optimization algorithm based on the intellectual foraging behavior of honey bee swarm, identified by Karaboga in 2005.

In ABC, the colony of artificial bees consists of three groups of bees: employed bees related with specific food sources, onlooker bees inspecting the dance of employed bees within the hive to prefer a food source, and scout bees searching for food sources randomly. Both onlookers and scouts are called as unemployed bees. Initially, all food source positions are found by scout bees. After that, the nectar of food sources are exploited by employed bees and onlooker bees, and this continual exploitation will finally cause them to become exhausted. Then, the employed bee which was exploiting the exhausted food source becomes a scout bee in search of additional food sources once again. In other words, the employed bee whose food source has been exhausted is a scout bee. In ABC, the position of a food source represents a possible way to the problem and the nectar quantity of a food source corresponds to the quality of the associated solution. The number of employed bees is equivalent to the number of food sources since each employed bee is associated with one and only one food source.

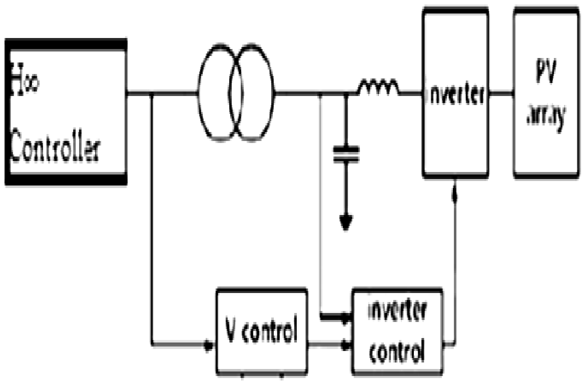
The major steps of the algorithm are as below:
Step 1: Initialize Population
Step 2: repeat
Step 3: Place the employed bees on their food sources
Step 4: Place the onlooker bees on the food sources depending on their nectar amounts
Step 5: Send the scouts to the search area for finding new food sources
Step 6: Memorize the best food source found so far
Step 7: until requirements are met



Flow chart for Artificial Bee Colony algorithm

IV.MODELLING OF SOLAR POWER SYSTEM

At distribution level, technical studies include steady-state analysis such as voltage control and protection coordination. Power flow study is generally used to observe equipment loading, system losses, voltage drop/rise, transfer capability and conductor ampacity ratings. Short circuit study and protection coordination is used to find out the parameter used in protection settings.



The developed Simulink model of the solar power system is shown in the following figure.

IARJSET

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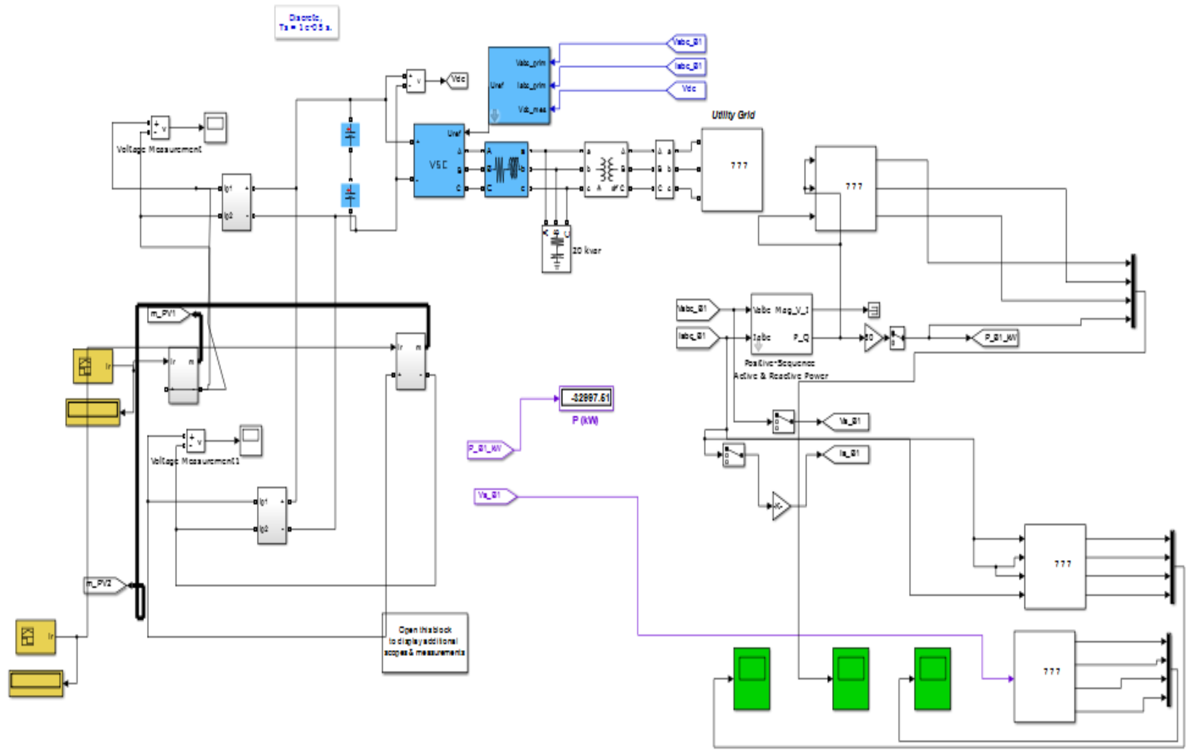

Fig.3 Simulink model of with (RPSS) and (CPSS) control for the PSS

In a steady state study, a PV inverter may be modeled as a conventional power source generally with constant power factor or reactive power.

Solar power is the conversion of sunlight into electricity, either using PV directly or indirectly by concentrated solar power (CSP). Concentrated solar power systems utilize mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaics transfer light into an electric current using the photovoltaic effect.

The power system stabilizer (PSS) is a control device offers a maximum power transfer and optimal power system stability. PSS has been generally used to damp electromechanical oscillations that take place in power systems due to disturbances.

Boost converter is a DC-to-DC power converter with an output voltage larger than its input voltage. It is a class of switched-mode power supply (SMPS) having at least two semiconductors and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors are generally added to the output of the converter to reduce output voltage ripple.

A controller is a device, historically using mechanical, hydraulic, pneumatic or electronic techniques frequently in combination, but recently in the form of a microprocessor or computer, which monitors and physically changes the operating conditions of a given system.

Typical applications of controllers are to hold settings for temperature, pressure, flow or speed.

V. SIMULATION RESULTS

An optimization method is examined here for PID gains setting. Response of power, voltage and current was observed. Comparison of the robust optimization technique enhanced ABC with the conventional PSS, PSS with H∞ technique and PSS with PSO show that optimization technique can attain excellent robustness, while the design process used in much simpler.

In this solar PSS design, the robustness of PSS should be evaluated in different loading conditions and different operating conditions. The change of operating conditions corresponds to the variation of transmission line parameters and the active and reactive powers.

The quantitative results of the comparison of the static and dynamic performances with CPSS and solar PSS (RPSS) of the different parameters are shown respectively in table I and II. The proposed Table I and Table II clearly shows the value of the proposed method in comparison with CPSS. Comparing the results of the system it can be directly identify very large developments of static and dynamic performances of the system with the RPSS in compare with the application of the CPSS.

Simulation results demonstrate the good damping performance of the robust designed solar PSS with enhanced ABC. Results show that enhanced ABC, an optimization method is more effectual to damp out oscillations.

1. Under-exited mode x=0.5 , y=0.85 , z=0.1802

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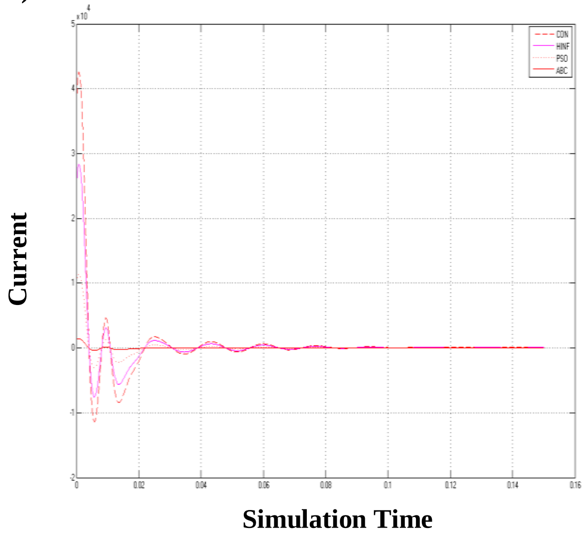
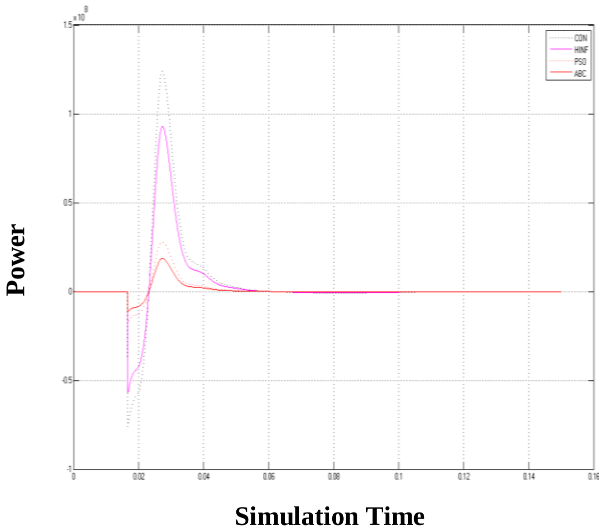
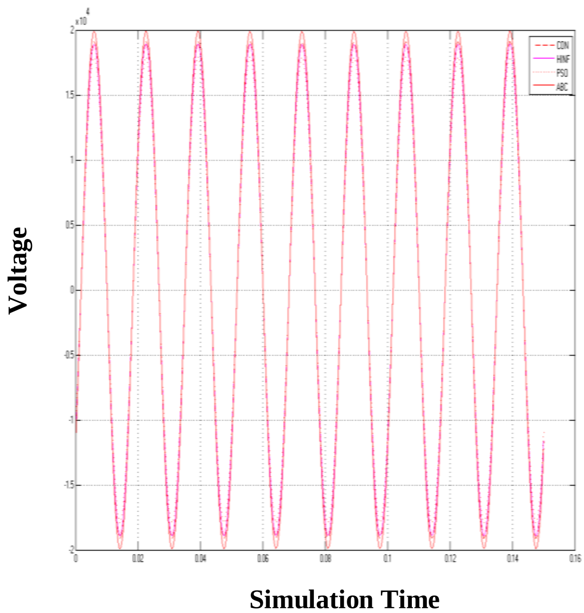
a) Current



b) Power

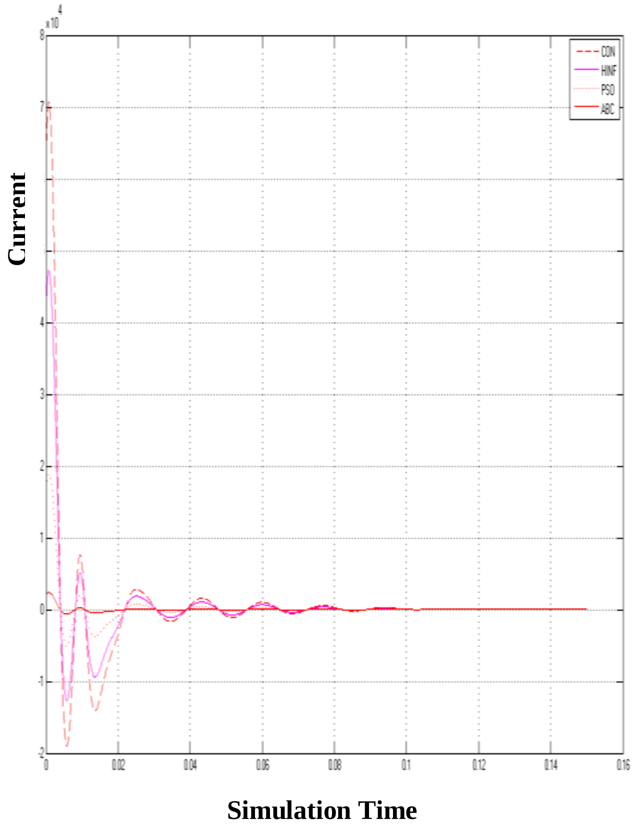


C) Voltage

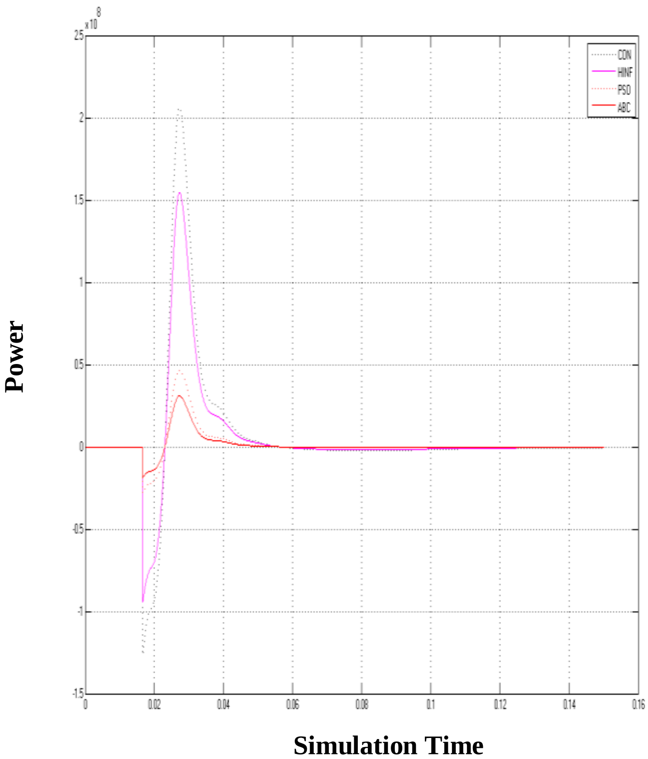


2. Nominale mode x=0.3, y=0.85, z=0.1102

a) Current



b) Power



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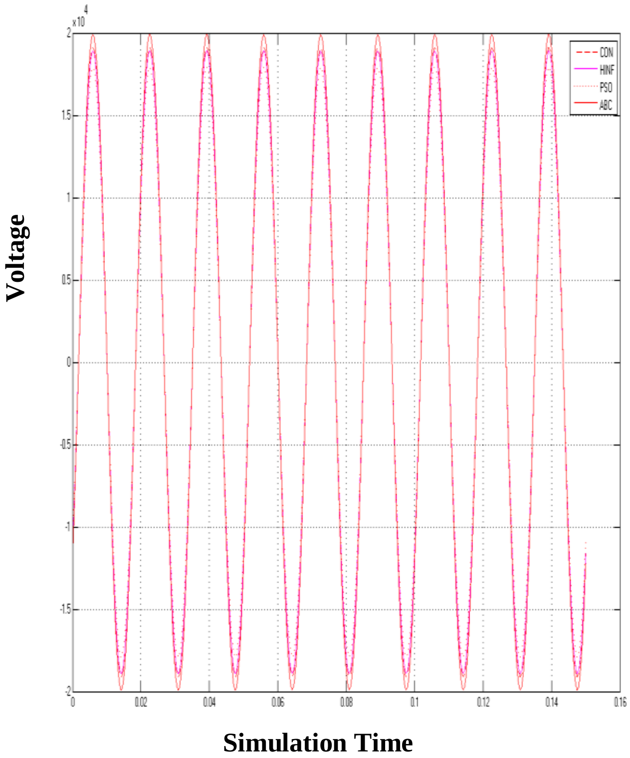
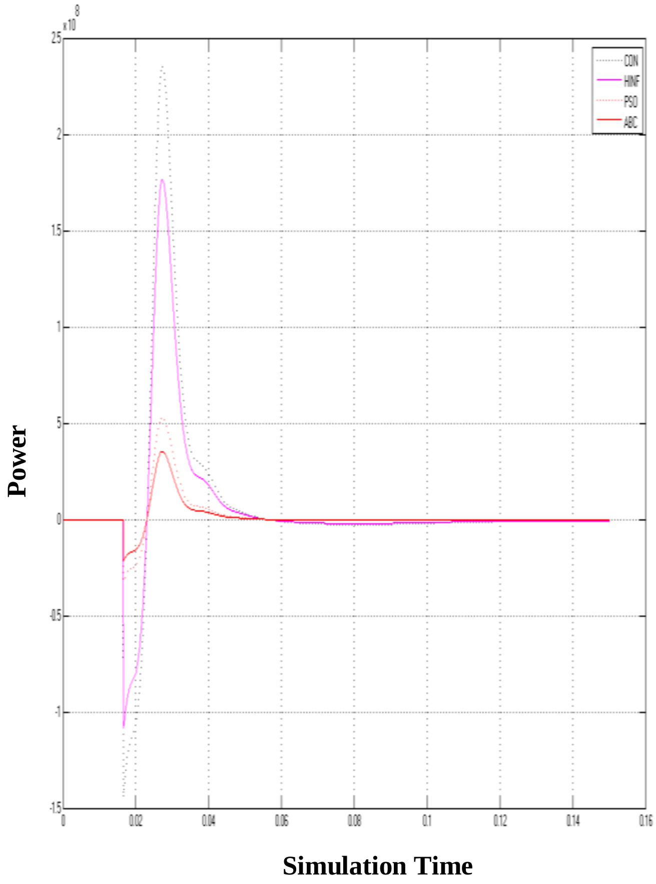
C) Voltage

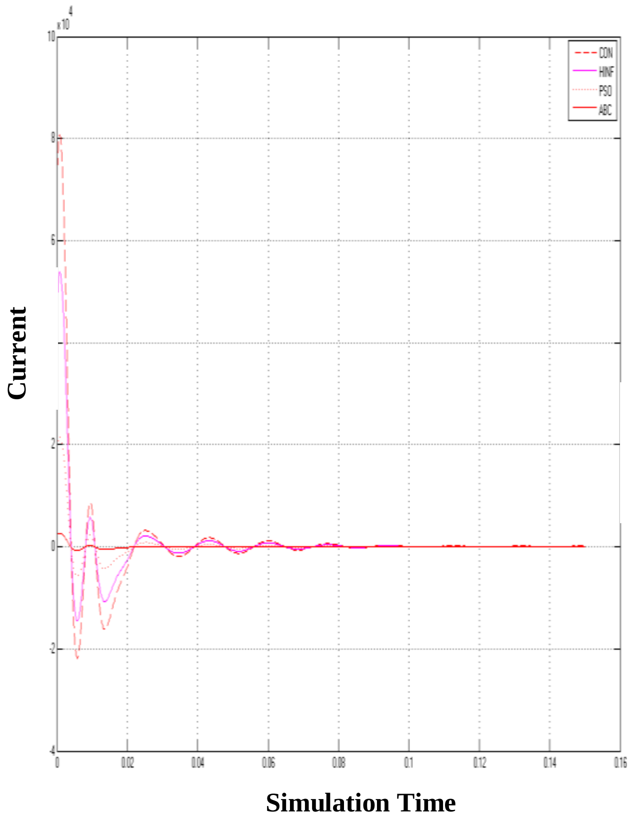


b) Power

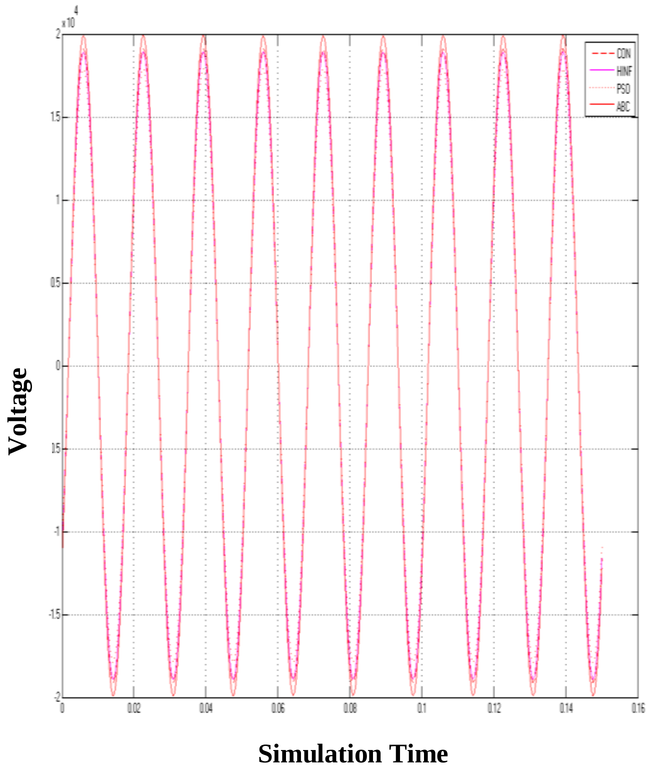


3. Over-excited mode x=0.2,y=0.85 , z=0.6760

a) Current



C) Voltage



IARJSET

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TABLE I DAMPING COEFFICIENTS ‘α’ AND STATIC ERROR ‘ξ’ OF RPSS AND CPSS IN DIFFERENT OPERATING CONDITIONS OF THE POWER SYSTEM

Reactive Power	α_{PSS}	ξ_{PSS}	$\alpha_{PSSH\infty}$	$\xi_{PSSH\infty}$	α_{PSSPSO}	ξ_{PSSPSO}	αS_{PSSABC}	ξS_{PSSABC}
-0.2033	0.6574	0.00119	0.6721	0	0.6821	0	0.7044	0
-0.2449	0.6564	0.0012	0.6843	0	0.6889	0	0.7211	0
-0.1238	0.6695	0.00112	0.6990	0	0.7014	0	0.7410	0
-0.3402	0.6671	0.00089	0.7088	0	0.7100	0	0.7484	0
-0.6840	0.6574	0.00071	0.7007	0	0.7041	0	0.7513	0

TABLE II SETTLING TIME ‘T_S’ AND PEAK TIME ‘T_P’ OF RPSS AND CPSS IN DIFFERENT OPERATING CONDITIONS OF THE POWER SYSTEM

Reactive Power	$T_{S\ PSS}$	$T_{P\ PSS}$	$T_{S\ PSSH\infty}$	$T_{P\ PSSH\infty}$	$T_{S\ SPSSPSO}$	$T_{P\ SPSSPSO}$	$T_{S\ SPSSABC}$	$T_{P\ SPSSABC}$
-0.2033	0.93	0.51	0.54	0.414	0.4	0.326	0.3	0.28
-0.2449	0.92	0.51	0.531	0.4121	0.3812	0.316	0.271	0.27
-0.1238	0.65	0.5	0.53	0.409	0.374	0.384	0.289	0.274
-0.3402	0.81	0.46	0.529	0.406	0.3356	0.342	0.297	0.249
-0.6840	0.84	0.47	0.55	0.405	0.3193	0.3874	0.2546	0.215

CONCLUSION

The increasing demand of the consumer and also the photovoltaic system is distributed system by which the transmission losses can be decreased and also transmission cost can be reduced as that cost of transmission line in the power system is major point to keep in view. The major factor that the photovoltaic system is non-polluting and not harmful to the environment. In this work, evaluation of RSCs have been utilized to validate the effectiveness and advantages of the designed PID PSS on damping improvement of the studied system under steady-state operating conditions. Results of simulation show that enhanced ABC optimized controller offers a better performance.

The method presented in this work illustrate that the efficiency, performance, reliability and robustness of the solar power system have increased. The above procedure is well suitable of solar power system in deregulated environment.

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ISSN (Online) 2393-8021
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