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Power Quality Enhancement using TSA with RNN for 2 kV Grid Connected Hybrid System

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Abstract
Renewable energy becomes turns into a key supporter of our cutting-edge society, however their combination to control power grid poses critical specialized difficulties.The major power quality concerns are voltage sag, swell, fluctuations, distortion and interruption which are caused by non controllable variability of renewable energy resources.Recurrent Neural Network (RNN) with Tree Seed Algorithm (TSA) is employed as a control scheme.Distribution Static Synchronous Compensator (D-STATCOM) can be adopted for reactive power compensation and for decreasing the problems caused renewable energy sources. The proposed methodology has been tested for D-STATCOM under various conditions, simulation study can be used to develop control strategy of non conventional energy system to mitigate PQ issues. The proposed system will be implemented in MALAB/Simulink platform. In order to evaluate the effectiveness of the proposed method, this is compared with the existing methods, such as PSO-RNN and CSO-RNN technique and techniques.

Keywords: *PV-D-STATCOM, TSA (Tree Seed Algorithm), PSO (Particle Swarm Optimization), CSO (Chicken Swarm Optimization), RNN (Recurrent Neural Network).*

1. Introduction

Renewable energy systems use natural resources and provide desirable green energy. On the one hand, the discontinuous idea of renewable energy will intensify the instability of power flow [1]. However, unlike conventional energy generation, renewable energy is uneven in nature [2]. PV inverter injects reactive power components into the PV system since of its inherent nonlinearity [3]. PV is regularly combined with the output at unity power factor, which indicates the infusion of active power can affect voltages around the PV Point of Common Coupling (PCC) in view of local reverse power VC flow in the United States [4].PV sun farm ranch creates original power amid daytime and amid night term they are completely sits still. For solar plant owner, these are very expensive properties which are determined entirely unutilized among nighttime and not bringing any revenues [5]. To decrease the utilization of FACTS device, with the aim that it is conceivable to use solar inverter as STATCOM [6].

The paper is organized as follows. Design of the PV-STATCOM system and suggested control structure is afforded in section 3 and 4. To establish the efficacy of the suggested plan, the model results are introduced in Section 5. Finally, the conclusion is afforded in Section 6.

2. Recent Research Works: An Overview

A new smart PV inverter generates as STATCOM, mentioned PV-STATCOM, for voltage control has been implemented by Rajiv et al. [7]. It generates as a STATCOM with complete inverter capacity in night-terms as well as among any term of the day to render critical grid support. The power management strategy for hybrid unit has been evaluated by Jayachandran*et al.* [8]. For islanded ac

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micro-grid, this article introduces a decentralized power management strategy established on Model Predictive Control (MPC) approach. A large scale PV plant would have been associated with control frameworks and one of the impacts of those plants on the power framework stability has been analyzed by Khayyatzadeh*et al.* [9].

The PV-STATCOM innovation in extensive large scale solar power frameworks is considerably more unpredictable. Real issues required to different designs of inverters: six-pulse, multi-pulse, multilevel, and so forth and control coordination between multi inverters in a PV solar plant, with each working in PV-STATCOM mode. The RNN procedure depends on the forward and reverse path which is utilized in the control of PV Inverter. This area portrays the preparation procedure of the RNN [10]. The suggested technique is design the PV-STATCOM for maximal utilization of the day and night time. In the below section, the design technique and control structures are elaborated.

3. Proposed D-STATCOM based control

PV-D-STATCOM is utilized for compensating its DC-side voltage. Here PV and wind energy sources are utilized for generating electricity. PV is considered as a first source for power generation in this work if it is absent means wind energy is considered. At dayterm PV and wind systems produce power. The energy generated from wind and PV is given to the D-STATCOM, which acts as an inverter in this work. . The structure of this technology is illustrated in Fig. 1.

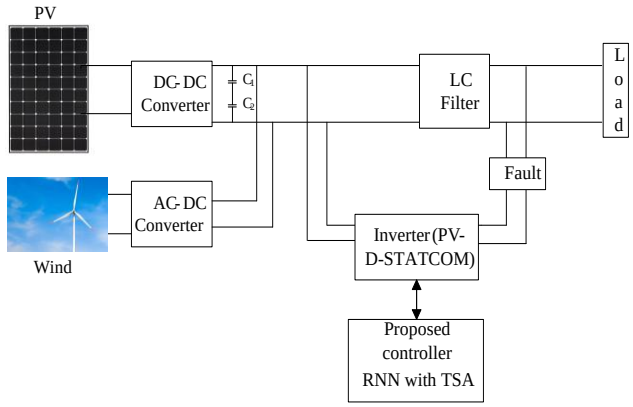

Fig.1: Proposed D-STATCOM Based Control Structure

For control of PV-D-STATCOM, a controller is proposed, based on RNN with TSA. The output from the D-STATCOM is given to the control structure and control operation takes place until the required compensation is achieved.

3.1. Objective Function

In this work, the main objective is controlling PQ issues . For reducing these issues ANN with TSA is exercised and faults are reduced efficiently. The power quality issues of the system mainly depend on the real and reactive power, voltage, harmonics and etc. So, the problem can be formulated as the objective function with the specified constraints.

$$\text{Min } \delta_{OF}(x, u) \quad (1)$$

$$\text{Subject to } p(x, u) = 0 \quad (2)$$

$$s(x, u) \leq 0 \quad (3)$$

where δ_{OF} - objective function, p - equality constraints and s - inequality constraints which effects on variables x and u .

4. Development of Adaptive Tree Seeds Algorithm with Aid of RNN Technique

In this section, the suggested method is used for enhancing the D-STATCOM performance and minimizing the harmonics of the system. For achieving the objective function, the reference current, reference voltage, regulation of dc voltage and tuning of the PID controller is performed and specified their parameters. Here, the error voltage and load side error current are taken as input parameters for the suggested algorithm. The PQ issues can be determined from the inputs. The proposed method structure is portrayed in the fig. 2 and suggested algorithm is explained as follows:

4.1. Procedure of Adaptive TSA algorithm

Step 1:

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Initialize the inputs which are considered as the trees.

$$T_i = (T_{i\,1} \ldots\ldots T_{ig} \ldots.. T_{in}) \quad (4)$$

Where, n is the search tree position, T_{ig} is the i^{th} position of the tree in the g^{th} dimension

Step 2: The fitness function of the agent is intended as follows:

$$F_i = \min (PQ_i) \quad (5)$$

Where PQ_i is the power quality issue.After that, new seeds production is calculated.

Step 3: Find the best solution by using equation (3).

$$T_{bestj} = \min \{ f(T_i)\} \quad i = 1,2,3\ldots\ldots N \quad (6)$$

Here, N is the number of trees in the population.

Step4: The random search solution for reduced the error voltage in the D-STATCOM. Update this dimension using equation (4) and (5) respectively.

$$\zeta_{ij} = T_{ij} + \vartheta_{ij} . u (T_{bestj} - T_{rj}) \quad (7)$$

$$\zeta_{ij} = T_{ij} + \vartheta_{ij} . u (T_{bestj} - T_{rj}) \quad (8)$$

Step 5: Optimize the parameters using RNNtechnique.

Step 6: Select the optimized solution which is better than the previous solution.

Step 7: Calculate the fitness function and if there is a better solution, find the best search solution. Let t=1 reaches Maxgen, the algorithm is finished.

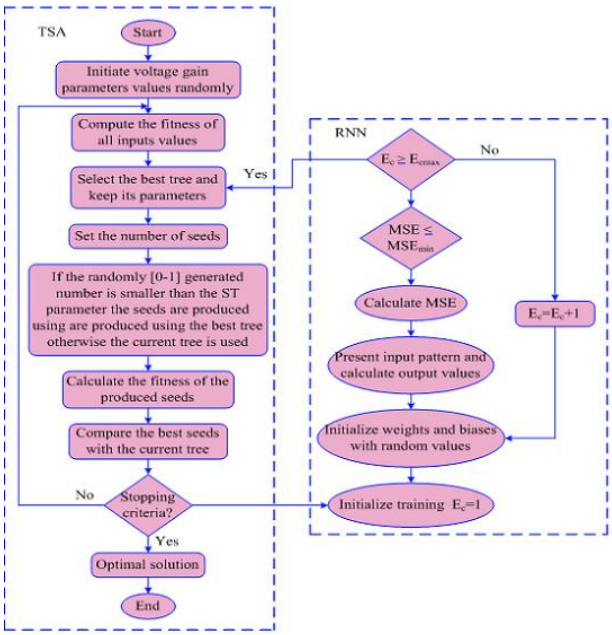

Fig.2: Structure of the proposed adaptive technique

The specified procedure is tried under the Matlab/Simulink stage and the adequacy of the proposed approach is investigated through the examination with alternate methods. After that, the detailed analysis of the execution is described in the section 5.

5. Results and Discussion

In this paper, the suggested structure is utilized to mitigate the PQ issues. The suggested system with PV-STATCOM is implemented in the MATLAB/Simulink platform and to validate the existing methods such as CSO-RNN and PSO-RNN. The fig. 3 shows the simulation model for the suggested system. Table 1 represents the implementation parameters of suggested model . fig 4 represents the comparison analysis for all PQ issues and Table 2 represents the THD comparision.

Table.1: Parameters of suggested method

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Parameters	Values
LC filter Inductance	250 e^{-6}(H)
LC filter Capacitance	1000 e^{-6}(F)
Frequency	60 (Hz)
Grid voltage	2 e^{3}(V)
Grid Power	6 e^{3}(W)
Magnetization Resistance	0.5 e^{3} (Ohm)
Magnetization Inductance	0.5 e^{3} (H)

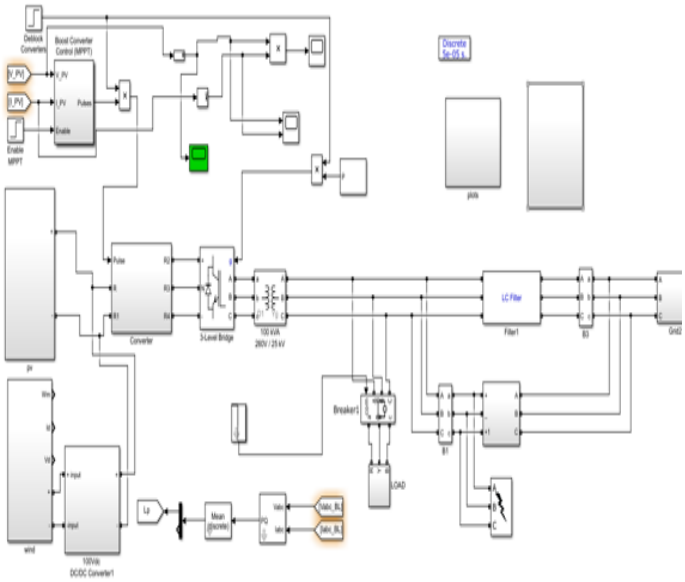
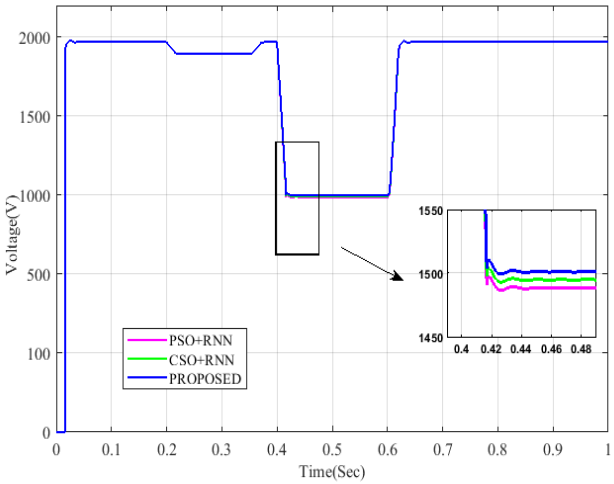
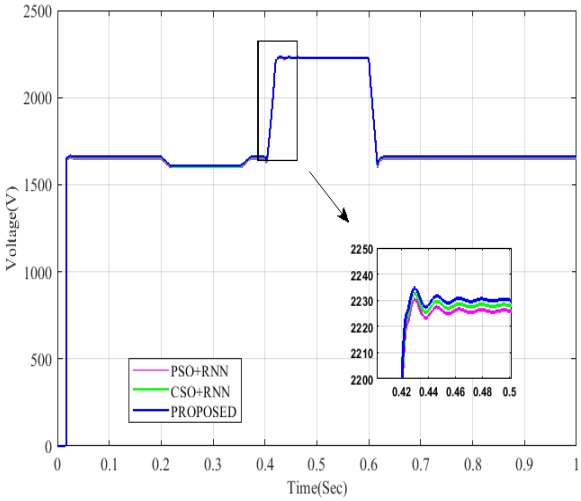


Fig.3: Simulink model of proposed control technique



(a)



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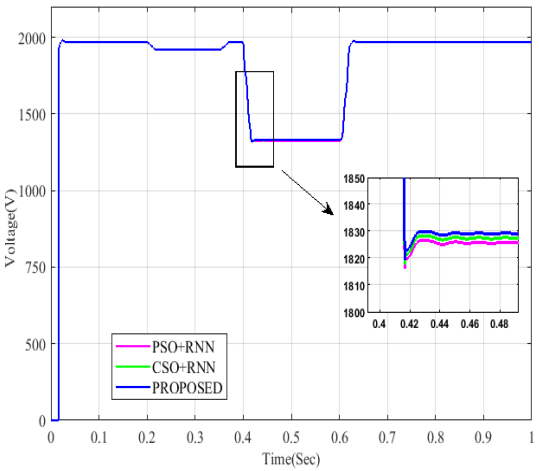
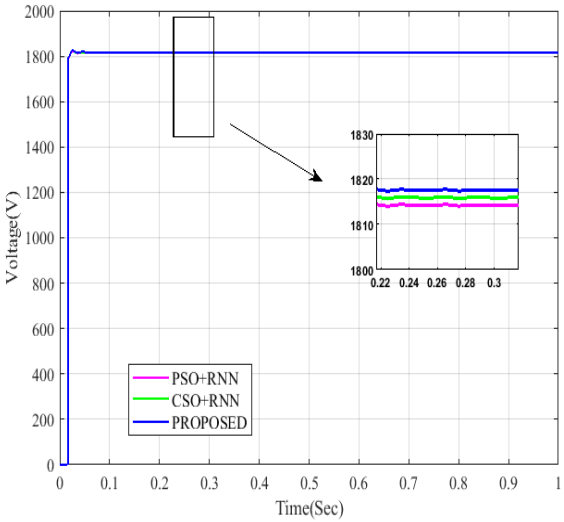


(c)



(d)

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Fig.4: Comparison Analysis of (a) Sag (b) Swell (c) Fluctuation and (d) Unbalance

Table.2: Comparison of Total Harmonic Distortion

Issues	Proposed	CSO+RNN	PSO+RNN
Sag	3.83	4.86	7.35
Swell	3.89	5.94	8.14
Fluctuation	3.67	5.55	7.75
Unbalance	2.17	4.29	7.15

6. Conclusion

This paper achieved the analysis of thePV-D-STATCOM based power quality control. Experimental results shows an improvement in the acceptable voltage value for the safe operation of the D-STATCOM at the time of voltage sag,swell,fluctuation,distortion and interruption.An effective technique is the combinations of the Recurrent Neural Network (RNN) with the Tree Seeds Algorithm (TSA), which is utilized to analyze the PQ issues in grid connected hybrid PV/WT system. The efficacy of the suggested method was compared with existing methods such as CSO-RNN and PSO-RNN. From the above investigation, it has been found that the suggested system was much effective than the existing techniques.

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