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Research paper

A Novel Hybrid Particle Swarm- Multiverse Optimization based Voltage Stability Improvement in IEEE 57 Bus System

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Abstract

The major role of power system is voltage stability. It is required to plan properly and smooth operation and control. It presents a new approach of voltage stability improvement in IEEE 57 bus system using hybrid algorithm. The hybrid algorithm (PSO-MVO) is combination of PSO which is used for exploitation and MVO used for exploration. It is used in an uncertain environment. The FACTS device as STATCOM is connected in IEEE 57 test system to check for event of voltage stability improvement through power system analysis tool (PSAT) software. Once the ability of system goes through sudden loading, its stability gets affected. It desires compensation to boost voltage from disturbances. The varied operative condition while not used STATCOM in the system, used with STATCOM tuned by PSO-MVO algorithm are measured judge the performance of the projected system. The hybrid PSO-MVO technique is implemented in this paper to solve the proposed problem. The simulation results are obtained by PSAT software for 57 IEEE bus systems. The hybrid algorithm validates its effectiveness compare to individual PSO and MVO algorithm.

Keywords: *STATCOM; voltage stability;PSAT; PSO-MVO Algorithm.*

1. Introduction

The modern power industries are growing rapidly from many years. It is required to flow of power in smoothly to fulfill the stain of the consumers. The most functions of those industries unit to provide the electricity to consumers at affordable value with prime quality and reliability. So it's troublesome to control the system firmly. If these systems operate adequately and firmly, then the systems stability is maintained [1] [2]. It is to retain the system stability, it's necessary to preserve the voltage in any respect buses that is closed to value in any respect the days. The power of an influence system is maintained in an appropriate vary relating to as voltage stability [3] [4]. If the voltage moves out an excessive amount from their reset value, it's referred to as voltage collapse. In facility new technologies has established. It is called as flexible AC transmission system (FACTS). The FACTS is fashionable devices that are employed in several aspect like power quality, power stability etc. the idea of this paper, the voltage stability of a multi machine system is analyzed by applying FACTS device called as STATCOM. It is tuned the STATCOM parameter value using hybrid algorithm. The ability of the system is improved [5] [6]. The foremost advantage of the facts device is their fast response to the system's ability recovery. Many authors have solved using intelligent techniques and it is implemented for voltage stability assessment. Recently differential evolutionary algorithm has been implemented. The differential evolutionary has realized new approach for optimization problem. It's successfully applied in many artificial networks with real optimization problems [7]-[13].

In this paper is highlighted new hybrid PSO-MVO algorithm is novel approach to implement and to solve problem. It is to improve the voltage stability.

2. Problem Formulation in IEEE 57 Bus

A. Objective Function

The basic concept is an objective value of reactive power control. The voltage control is identified based on selection of optimal place which minimize the objective function. The objective is to minimize the fitness value.

Fitness = max (λ) ------------------------- (1)

Where λ is loading parameter.

B. Equality Constraints

The equality constraints are used for power flow in all buses in the system.

i) The power balance equation is

$$P_i - V_i \sum_{j=1}^{N} V_j \left[G_{i,j} \cos\delta_{i,j} + B_{i,j} \sin\delta_{i,j} \right] = 0; i = 1, 2 -- (N-1) \quad (2)$$

ii) The reactive power equation is

$$Q_i - V_i \sum_{j=1}^{N} V_j \left[G_{i,j} \cos\delta_{i,j} + B_{i,j} \sin\delta_{i,j} \right] = 0; i = 1, 2 -- N \quad (3)$$

C. Inequality Constraints

The inequality constraints are

$$P_{g,i}^{\min} \prec P_{g,i} \prec P_{g,i}^{\max}, i = 1, 2 - - N_{generator} \quad (4)$$

$$Q_{g,i}^{\min} \prec Q_{g,i} \prec Q_{g,i}^{\max}, i = 1, 2 - - N_{generator} \quad (5)$$

$$V_{g,i}^{\min} \prec V_{g,i} \prec V_{g,i}, i = 1, 2 - - N_{load} \quad (6)$$

3. Test Analysis IEEE 57 Bus System

The proposed hybrid has been tested on standard IEEE 57 bus test system using PSAT software. The performance of the STATCOM has evaluated in this system. It is seven generators and forty two loads are connected. The random parameter values are selected and found that bus 31 is very weak bus. It is shown in table 1. First it is analyzed without STATCOM in this system then with STATCOM tuned by hybrid algorithm. The 57 bus system is shown in figure 1.

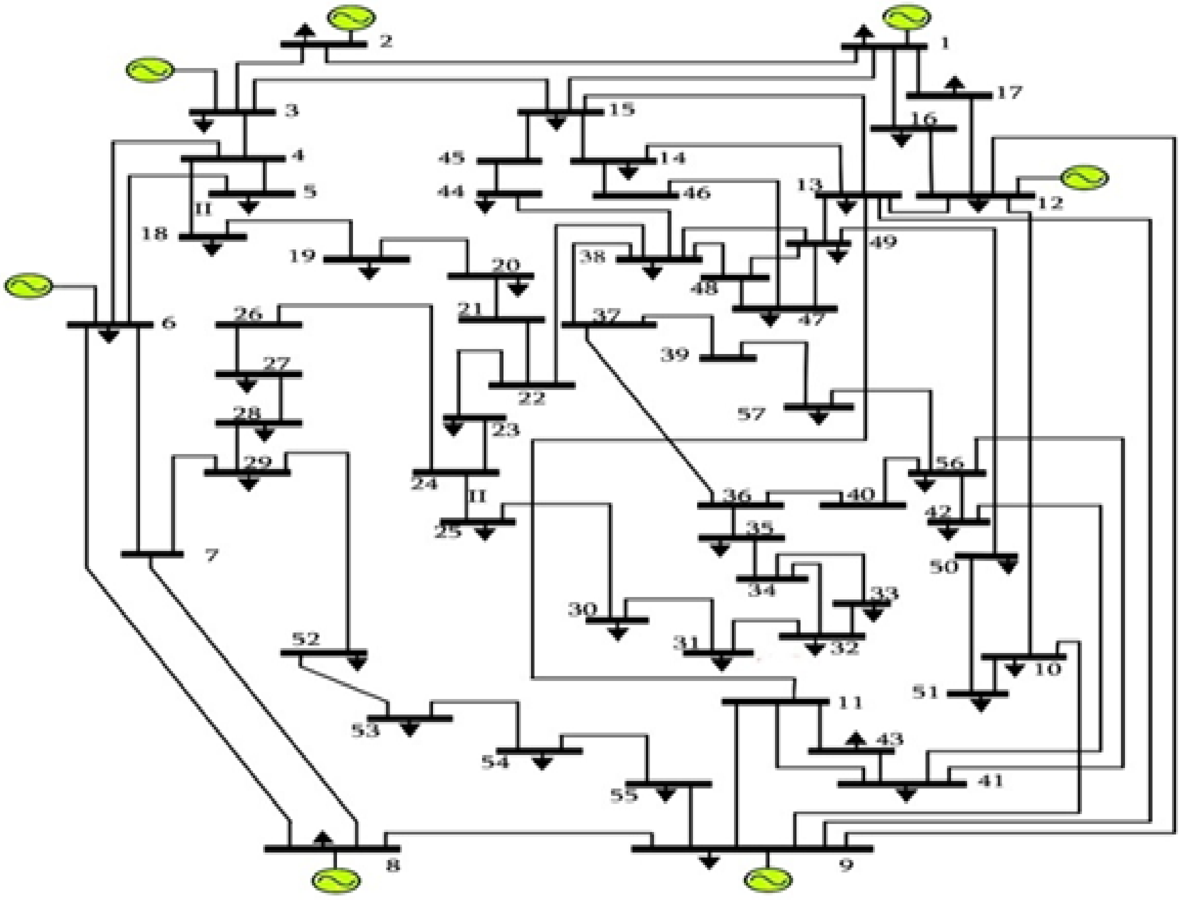

Fig. 1: 57 bus system

4. Hybrid PSO-MVO Algorithm

Step 1: to initialize the PSO and STATCOM parameter values
Step 2: compute the fitness value
Step 3: to determine G_{best} from the P_{best} value.
Step 4: updated modify velocity and position value
Step 5: verify the solution whether it is feasible or not
Step 6: if the solution is feasible then verify the iteration calculation
Step 7: if iteration achieves the maximum, stop the procedure
Step 8: if iteration does not reach the maximum value, then continue the process from step2-7.
Step 9: to obtain the optimal value of PSO and it uses the boundary value of MVO algorithm
Step 10: ti initialize the STATCOM parameter values using MVO
Step 11: to create a set of random universes using roulette wheel selection method

Step 12: to calculate the inflation rate i.e fitness value of the universe
Step 13: select the universe value as per inflation rate
Step 14: to update position of the universes
Step 15: if if the convergence criterion is reached then get the results
Step 16: if the convergence criterion is not reached then continue the process from step 2-6

5. Proposed Flow Chart in 57 Bus

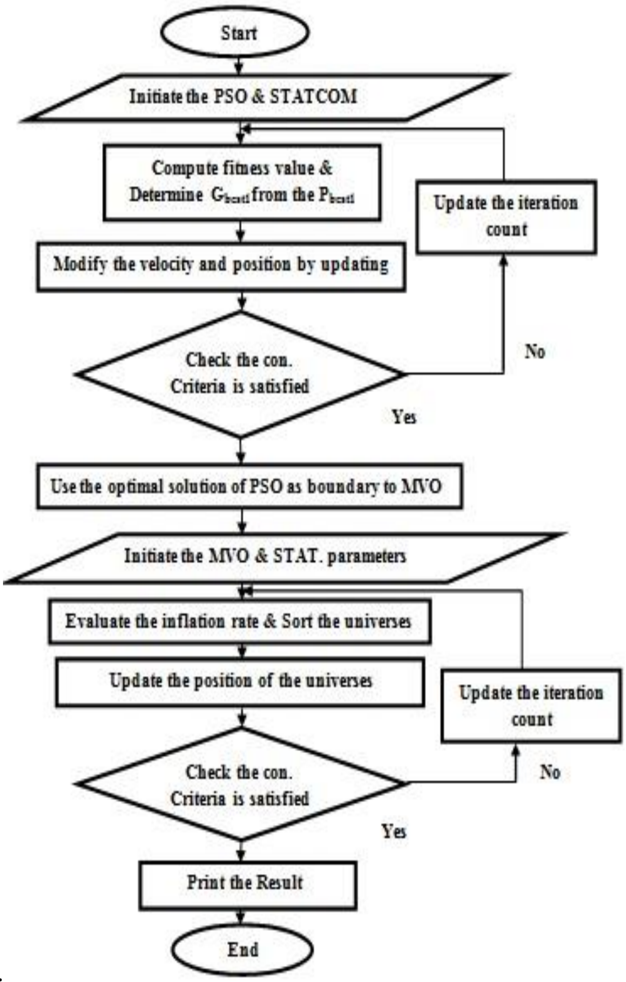

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Fig. 2: Proposed flow chart using hybrid system

6. Hybrid PSO-MVO Algorithm in 57 Bus System

The hybrid PSO-MVO is combination algorithm. It is separated of PSO and MVO. The hybrid algorithm merges the best strength of both PSO in exploitation and MVO is in exploration towards the optimum solution [9] [10]. When it is replaced P_{best} value of PSO with universe value of MVO as shown in flow chart. The hybrid equation in this system can be written as

$$V_{i,j}^{t+1} = V_{i,j}^{t} w + C_1 R_1 (universes^{t} - X^{t}) + C_2 R_2 (b_{best}^{t} - X^{t}) \quad (7)$$

7. Simulation Result and Discussion

Here the voltage magnitude profile is shown in figure 3. In this figure at bus 31 is severely affected due to fault. The value is 0.39 p.u without STATCOM. It is shown in figure 3.

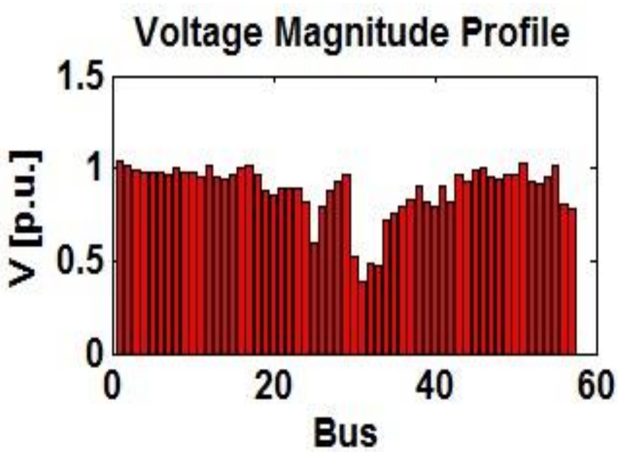

Fig. 3: voltage magnitude of the system without STATCOM

Table 1: System voltage parameter without STATCOM

BUS	V	Phase	P generator	Q generator	P Load	Q Load
	pu	rad	pu	pu	pu	pu
BUS 1	1.04	0.000	6.720	1.436	0.596	0.185
BUS 2	1.010	-0.035	0.057	0.049	0.053	0.896
BUS 3	0.985	-0.170	0.446	0.678	0.467	0.248
BUS 4	0.976	-0.208	0.000	0.000	0.000	0.000
BUS 5	0.973	-0.248	0.000	0.000	0.176	0.055
BUS6	0.980	-0.256	0.046	0.304	0.773	0.036
BUS7	0.966	-0.252	0.000	0.000	0.000	0.000
BUS8	1.005	-0.195	4.557	0.908	1.557	0.258
BUS9	0.980	-0.280	0.046	0.695	1.256	0.275
BUS10	0.971	-0.306	0.000	0.000	0.073	0.036
BUS11	0.948	-0.284	0.000	0.000	0.000	0.000
BUS12	1.015	-0.267	3.146	2.005	3.827	0.27837
BUS13	0.954	-0.261	0.000	0.000	0.226	0.038
BUS14	0.936	-0.248	0.000	0.000	0.128	0.069
BUS15	0.965	-0.191	0.000	0.000	0.277	0.088
BUS16	1.007	-0.217	0.000	0.000	0.476	0.045
BUS17	1.011	-0.126	0.000	0.000	0.443	0.096
BUS18	0.969	-0.318	0.000	0.000	0.329	0.042
BUS19	0.876	-0.374	0.000	0.000	0.079	0.021
BUS20	0.854	-0.377	0.000	0.000	0.046	0.026
BUS21	0.891	-0.353	0.000	0.000	0.000	0.000
BUS22	0.892	-0.350	0.000	0.000	0.000	0.000
BUS23	0.886	-0.352	0.000	0.000	0.120	0.059
BUS24	0.813	-0.363	0.000	0.000	0.000	0.000

BUS25	0.601	-0.722	0.000	0.000	0.109	0.025
BUS26	0.791	-0.350	0.000	0.000	0.000	0.000
BUS27	0.885	-0.337	0.000	0.000	0.116	0.021
BUS28	0.931	-0.321	0.000	0.000	0.103	0.061
BUS29	0.969	-0.309	0.000	0.000	0.216	0.041
BUS30	0.518	-0.779	0.000	0.000	0.059	0.034
BUS31	0.389	-0.908	0.000	0.000	0.115	0.067
BUS32	0.481	-0.832	0.000	0.000	0.062	0.023
BUS33	0.473	-0.836	0.000	0.000	0.061	0.035
BUS34	0.718	-0.376	0.000	0.000	0.000	0.000
BUS35	0.756	-0.375	0.000	0.000	0.117	0.068
BUS36	0.795	-0.372	0.000	0.000	0.000	0.000
BUS37	0.824	-0.367	0.000	0.000	0	0
BUS38	0.906	-0.345	0.000	0.000	0.186	0.085
BUS39	0.820	-0.369	0.000	0.000	0.000	0.000
BUS40	0.792	-0.374	0.000	0.000	0.000	0.000
BUS41	0.904	-0.418	0.000	0.000	0.086	0.046
BUS42	0.822	-0.460	0.000	0.000	0.128	0.082
BUS43	0.962	-0.326	0.000	0.000	0.066	0.025
BUS44	0.926	-0.320	0.000	0.000	0.143	0.034
BUS45	0.987	-0.253	0.000	0.000	0	0
BUS46	1.003	-0.298	0.000	0.000	0	0
BUS47	0.954	-0.337	0.000	0.000	0.354	0.154
BUS48	0.941	-0.340	0.000	0.000	0.000	0.000
BUS49	0.967	-0.348	0.000	0.000	0.2264	0.100
BUS50	0.967	-0.356	0.000	0.000	0.233	0.12I
BUS51	1.026	-0.334	0.000	0.000	0.237	0.091
BUS52	0.927	-0.347	0.000	0.000	0.095	0.037
BUS53	0.917	-0.360	0.000	0.000	0.22302	0.063
BUS54	0.954	-0.345	0.000	0.000	0.098	0.052
BUS55	1.020	-0.318	0.000	0.000	0.114	0.049
BUS56	0.807	-0.464	0.000	0.000	0.099	0.038
BUS57	0.782	-0.484	0.000	0.000	0.124	0.058

In the above table, it found that at bus 31 is affected due to fault or overloaded. So the STATCOM is used at bus31 system for improvement of voltage stability. It is shown in figure 4.

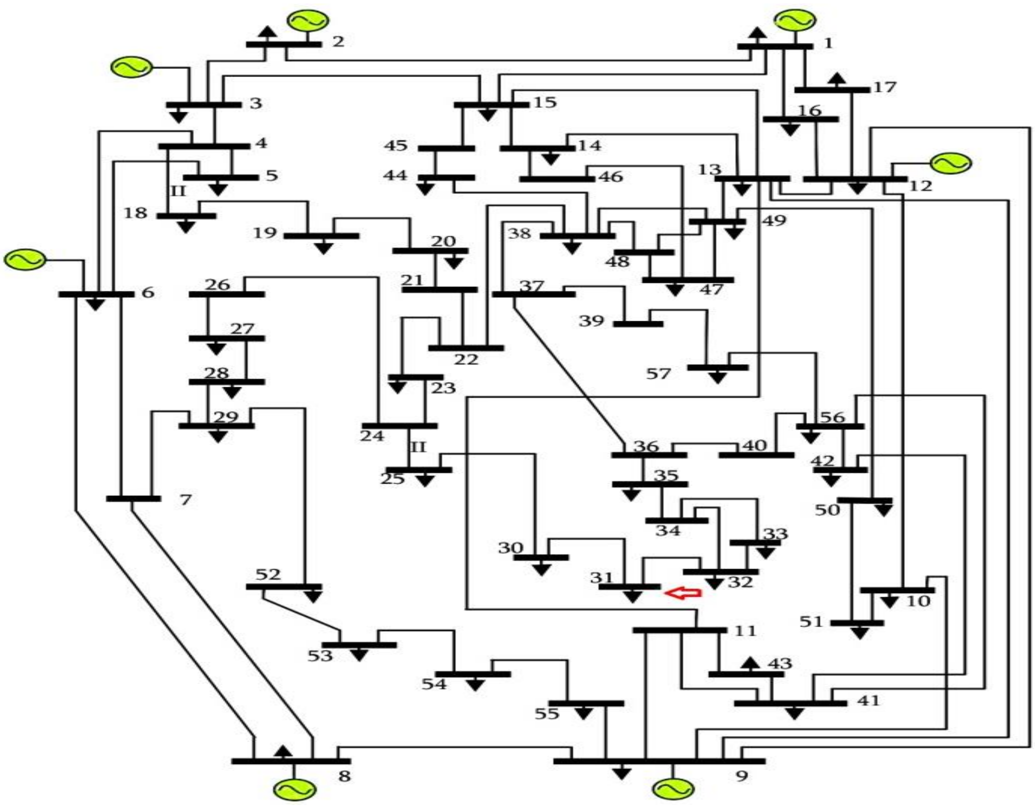

Fig. 4: 57 bus system with STATCOM tuned by hybrid algorithm

In the above figure 4 shows that the red arrow indicates the place of STATCOM. The STATCOM is tuned by PSO-MVO algorithm as shown in figure 4 and table 2.

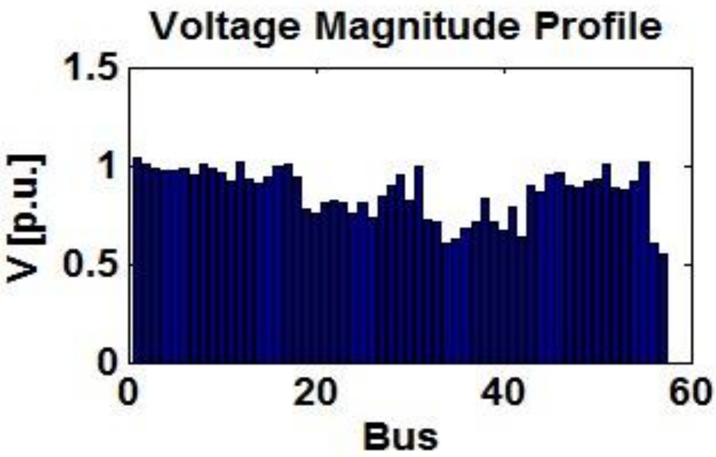

Fig. 5: Voltage profile of the system with STATCOM tuned by PSO-MVO

Table 2: System parameter with STATCOM tuned by PSO-MVO

BUS	V	Phase	P generator	Q generator	P Load	Q Load
	pu	rad	pu	pu	pu	pu
BUS 1	1.04	0	9.157	1.694	0.643	0.201
BUS 2	1.01	0.055	0.116	0.176	0.076	0.912
BUS 3	0.985	0.254	0.493	1.460	0.526	0.287
BUS 4	0.970	0.310	0	0	0	0
BUS 5	0.969	0.374	0	0	0.223	0.071
BUS6	0.98	0.391	0.093	0.573	0.796	0.052
BUS7	0.955	0.408	0	0	0	0
BUS8	1.005	0.340	4.616	1.103	1.616	0.297
BUS9	0.98	0.424	0.093	1.400	1.303	0.291
BUS10	0.958	0.439	0	0	0.096	0.052
BUS11	0.918	0.422	0	0	0	0
BUS12	1.015	0.374	3.193	2.800	3.886	0.317
BUS13	0.931	0.379	0	0	0.273	0.054
BUS14	0.905	0.360	0	0	0.151	0.085
BUS15	0.943	0.278	0	0	0.336	0.127
BUS16	0.998	0.297	0	0	0.523	0.061
BUS17	1.001	0.168	0	0	0.466	0.112
BUS18	0.937	0.460	0	0	0.388	0.087
BUS19	0.781	0.576	0	0	0.126	0.037
BUS20	0.754	0.594	0	0	0.069	0.042
BUS21	0.810	0.551	0	0	0	0
BUS22	0.816	0.548	0	0	0	0
BUS23	0.809	0.557	0	0	0.179	0.098
BUS24	0.753	0.672	0	0	0	0
BUS25	0.808	1.244	0	0	0.156	0.024
BUS26	0.729	0.647	0	0	0	0
BUS27	0.838	0.560	0	0	0.139	0.037
BUS28	0.895	0.519	0	0	0.162	0.100
BUS29	0.947	0.492	0	0	0.263	0.05
BUS30	0.820	1.416	0	0	0.082	0.050
BUS31	0.994	1.732	0	0	0.1746	-0.945
BUS32	0.723	1.422	0	0	0.109	0.039
BUS33	0.716	1.424	0	0	0.0846	0.0516
BUS34	0.597	0.731	0	0	0	0
BUS35	0.629	0.674	0	0	0.176	0.107
BUS36	0.676	0.629	0	0	0	0
BUS37	0.715	0.602	0	0	0	0
BUS38	0.833	0.530	0	0	0.233	0.101
BUS39	0.707	0.602	0	0	0	0
BUS40	0.670	0.631	0	0	0	0

BUS41	0.786	0.672	0	0	0.109	0.062
BUS42	0.630	0.771	0	0	0.187	0.121
BUS43	0.902	0.495	0	0	0.113	0.041
BUS44	0.862	0.483	0	0	0.166	0.050
BUS45	0.951	0.374	0	0	0	0
BUS46	0.960	0.435	0	0	0	0
BUS47	0.898	0.498	0	0	0.413	0.193
BUS48	0.880	0.507	0	0	0	0
BUS49	0.919	0.509	0	0	0.273	0.116
BUS50	0.924	0.513	0	0	0.256	0.137
BUS51	1.006	0.478	0	0	0.296	0.130
BUS52	0.887	0.535	0	0	0.142	0.053
BUS53	0.873	0.546	0	0	0.246	0.084
BUS54	0.917	0.521	0	0	0.157	0.091
BUS55	1.011	0.478	0	0	0.161	0.065
BUS56	0.607	0.792	0	0	0.122	0.054
BUS57	0.553	0.857	0	0	0.183	0.097

8. Conclusion

The hybrid PSO-MVO algorithm is successfully applied in IEEE 57 bus test system to solve voltage stability problem. It is intelligently applied to solve this problem. The voltage stability of the system with STATCOM device is investigated through the continuation power flow simulation. It is found that the hybrid optimization technique can be effectively utilized. It satisfies all the equality and inequality constraints value of the system. The voltage of the system is achieved from 0.39 pu value to 099 pu value.

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