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ASSESSMENT OF VOLTAGE FLUCTUATION AND REACTIVE POWER CONTROL WITH SVC USING PSO

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ABSTRACT—*Smart grid novel growth in the arena of power, this is a new scheme and apparatus for producing and distributing electricity. Smart grids are very important part of the electrical circuit. Distribution Management System (DMS) used by the utilities for the state Estimation (SE). Basic application distribution control system, evaluation (SE) and the control reactive power). There SE principally used to monitor and to control the entire distributed network. In the distribution network has a problem voltage profile. It is controlled by distributed generators (DG), which are located in diverse positions in the system to maintain the voltage within certain limits. Validation through the implementation on the IEEE 14-bus radial transmission system indicated that PSO is reasonable to achieve the task. MATLAB software is used for results simulation.*

Key Words—FACTS device, state Estimation, Particle Swarm Optimization, Static VAR Compensator.

I. INTRODUCTION

Smart grid increases productivity, uniformity, earning, and the protection of the electrical system with automated monitoring and exchange of information between endpoints. Smart Grid development is ongoing and is expected to be bright, unwavering, flexible, diverse and fully governable. Smart Grid also compresses the power outages and moderate load shedding. Smart grid reduces the power loss, maintenance and carbon emissions. However, it is difficult to implement smart grid, because so many problems in the development and integration, such as the combination of advanced energy sources has problems two-directional flow of energy in the current network is unidirectional. There is so much failure in the existing system, such as lack of communication and disabled bidirectional energy flow is literate strategy nets expansion pack monitoring and control. Smart grid has so many applications, as shown in Figure 1.

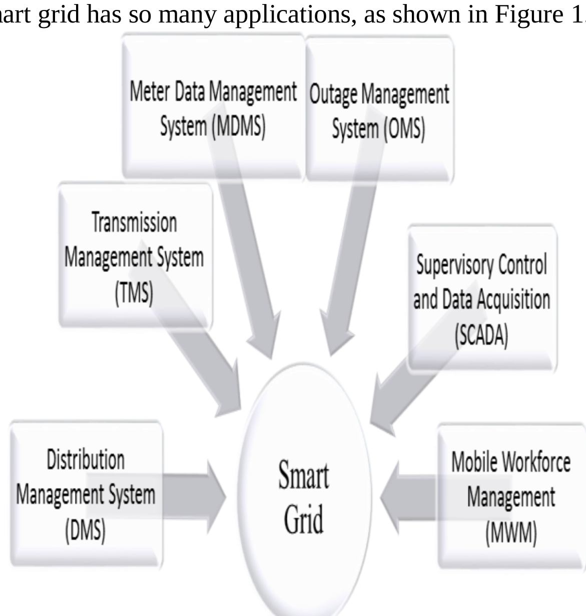

Figure 1: Application of Smart Grid

Distribution Management System is a set of applications considered to control and monitor the whole distribution system competently & accurately. This serves as a result support system to help dispatch and field operations staff to monitor and manage power distribution network, getting better the reliability and excellence of service in relationships of immersion downtime, reduce downtime, keeping adequate frequency measured in hertz and voltage levels are key transferable in the DMS.[1]

In the modern system of **distribution management (DMS)** assessment (SE) are necessary for the observing and management of the whole distribution system. For that efficient system operating point can be determined, and then the consumer receives all the necessary amenities. In distribution networks have dimensional constraints in linear currents and power injection at the feeder. The boundaries cause problems in monitoring the complete distribution network in accordance with the requirement of information from all nodes in the system. In this study distribution control system will be based on these measurements, as shown in Figure 2.

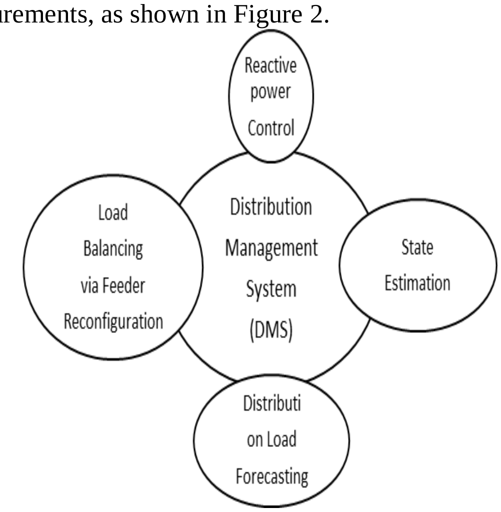

Figure 2: Distribution Management System

In this research, PSO algorithm is proposed to optimize the voltage in order to minimize the voltage fluctuation in the system. The SVC is chosen as the device for compensation and modeled as a reactive power added to system bus. A computer simulation were done in the IEEE 14-bus radial transmission system. The effect of population size on loss reduction is also investigated.

II. MATERIAL AND METHODS

In electric power system node voltages significantly depend on the load changes and changes in the network topology. The voltage may drop significantly, and even when the network is operating at high loads collapse. This may cause the relay energized and other voltage-sensitive controls, leading to extensive load shedding and thus negatively affecting the consumers and the company's revenues. Conversely, when the level of the system load is low then surge may happen due to the effect Ferranti. Capacitive excessive compensation and over-excitation of synchronous machines can also occur. Over excitation phenomena of synchronous machine also appeared due to the Ferranti effect.

Accordingly, in order to compensate for the effect of heavy loads and reactive load is constantly changing facts (Flexible AC Transmission system) device widely used at the present time of day. These devices are constructed on the basis of Thyristor Controlled Reactor (TCR) and Voltage Source Inverters (VSI), such as; Static VAR Compensator (SVC), thyristor controlled Phase Shifter Transformer (TCPST) and Unified power flow controller (UPFC) etc.

Static VAR compensator (SVC) is a shunt type FACTS device defined as a parallel connected static var generated or absorber whose output is adjusted to exchange capacitive or inductive current so as to sustain or control specific measurements of the power system usually the bus voltage in volts. An electrical equipment for quick action of reactive power at high voltage electrical transmission system. SVC are component of the transmission Facts device family, such as voltage regulation and stabilization of the system. Here the term "static" discusses to the fact that the SVC has no moving component (except the on and off switches which do not move in a normal mode SVC). Before the discovery of SVC the power factor correction was to keep bulky rotating machineries such as synchronous condensers. The SVC is a mechanized impedance device which is deliberate to get the system closer to the power factor. When reactive load on the power system is capacitive (leading) then SVC will use reactors (generally in the form of a thyristor-controlled reactors) consume VARs from the network which will reduce the system voltage While inductive (lagging) conditions the capacitor banks automatically switches, therefore provided that a higher voltage system.

In this research, a standard power system IEEE-14 bus is organized. Modeling tool implemented in MATLAB / SIMULINK tool. It consists of three generator buses usually the bus number 1 is deliberated as the slack bus. SVC is the main selling shunt FACTS controller for voltage control in power systems. A slight variation of load can affect the voltage profile of the system. Thus, the dynamic characteristics of the SVC control voltage with varying load are analyzed.

To evaluate the state estimation, consider the following assumptions have a distinctive results. [5]

1) The position of the switches and insulators known.

2) Distributed generation values and connected load on each node are identified.

3) In the substation current and voltage values are known.

4) The output power and power factor will be given if the distributive generation and loads are stable.

The purpose of assessment of the state is to provide the most accurate state of the network, considering the redundant measurements. In fact, however, the accuracy of the assessment of the state has ever known, since the measurement without errors is unknown. In this framework, to maximize the precision of the state estimation is done by reducing the state of ambiguity.

The weighted least-squares (WLS) is the main problem to solve tactic SE. WLS is a statistical relationship between the measurements and state variables. Mathematically, this relationship can be expressed as follows:

$$\min f(x) = \sum_{i=1}^{n} w_{i\,(z_i - h(x))^2}$$

Where

w_i = weight related with each measurement variable i.

z_i = vector on behalf of the measured values.

h_i = equation of state measurements.

X = state variables with the variable loads and DG.

N = number of measurements.

H (X) may be one of the following forms:

a. The branch current

b. power injection to the bus.

c. Load at the bus

d. Node voltage value

For voltage measurement the state estimation has number of iterations to evaluate the sum of voltage. Each iteration has internal block shown in figure 3.

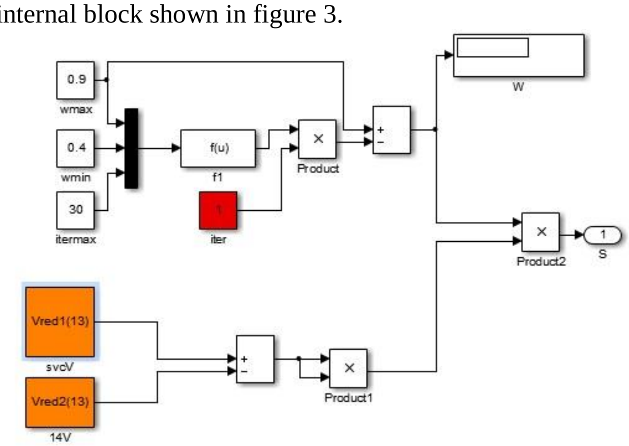

Figure 3: Internal block for SE

III. PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization (PSO) is a biologically motivated computational technique and optimization method introduced in 1995 by Eberhart and Kennedy on the foundation of social behavior of birds clustering and schooling fish [11]. The number of major changes have been developed in connection with the increase of the rate of convergence and the quality of the solution found in the PSO. Whereas, the basic Particle Swarm Optimization (PSO) is more suitable for processing of static, a simple optimization problem. Modification of PSO is intended to solve the basic problem of peacekeeping operations. The application may show a modified or variant PSO, who were not and which one modified or variant PSO, be developed.

The theory of particle swarm optimization (PSO) is rising quickly. PSO has been used in many applications numerous problems. PSO technique imitates the behavior of the animal societies that have no front-runner in the cluster or swarm, such as bird clustering and schooling fish. As a rule, a herd of animals that do not have leaders will find food at random, do one of the members of the group that is closest to the position of the power source. Flocks attain their finest conditions at the same time through the communication between members who have already a better position. An animal that has the best condition will let know him that his cluster and others will move all together in this place. This will happen until better conditions or food source found. PSO technique is the process to get the optimal values of following the effort of the animal society. Particle swarm consists of a cluster of particles, where the particles are a latent solution.

Speed of individual particle can be modified by the expression as given [9]

$$V_i^{k+1} = w \times v + c_1 \times rand_1 \times (P_{best\,i} - s_i^k) + c_2 \times rand_2 \times (G_{best\,i} - s_i^k)$$

Where

V_i^{k+1} = velocity (speed) of particle i at iterations

w= weight function

The weight function is founded by the expression as [9]

$$w = w_{max} - \frac{w_{max} - w_{min}}{iter_{max}} \times iter$$

Where

w_{max}= initial weight equal to 0.9

w_{max} = initial weight equal to 0.4

$iter_{max}$ = maximum iteration number

iter = current iteration number

c_1 & c_2 = weight coefficient both equal to 2.

$rand_1$ & $rand_2$= random number between 0 and 1.

s_i^k= current position of particle i at iteration k.

$P_{best\,i}$= best position of particle i-th up to the current iteration.

$G_{best\,i}$= best overall position found by the particle up to the current iteration.

PSO algorithm implemented in a Simulink as displayed in figure 4.

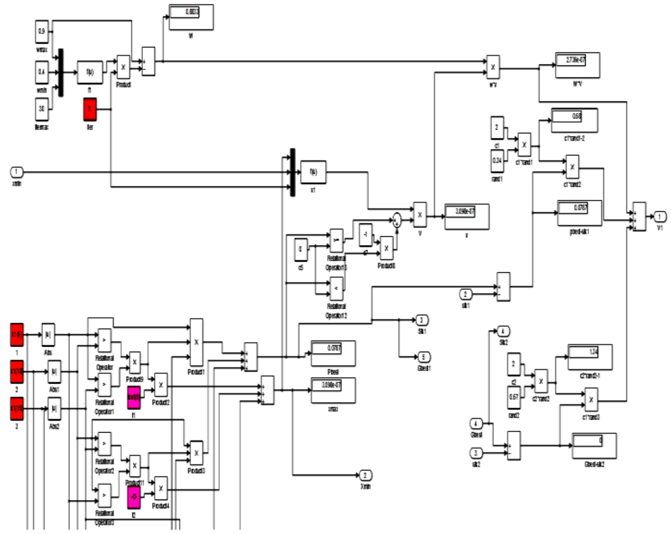

Figure 4: PSO Implementation

IV. RESULTS AND DISSCUSSION

In order to recognize the efficiency of the recommended PSO technique, the IEEE 14-bus radial transmission system was tested to find the convergence of voltage. The line data and bus data of IEEE 14-bus radial transmission system are given in appendix 19. The parameters of the PSO are listed in table 1.

Table 1: Parameters of PSO

Parameters	PSO
Population size	5, 10, 15
Inertial weight, w	0.9 – 0.4
Constant, C1	2
Constant, C2	2
Number of iteration performed	30
Rand1	0 to 1
Rand 2	0 to 1

The static VAR compensator installation in the system to improve the voltage fluctuation by injecting or absorbing reactive power at bus number 3.Steady state values are used for designing of the capacitor and inductor values in SVC. The impact of voltage convergence to the optimization technique performance was also monitored so that the best convergence can be identified from the simulation.

General flow chart for particle swarm optimization, managed as from initial conditions to maximum reach point of convergence. Update the values for local and global best until or unless the maximum reach point of convergence for voltage is not achieved.

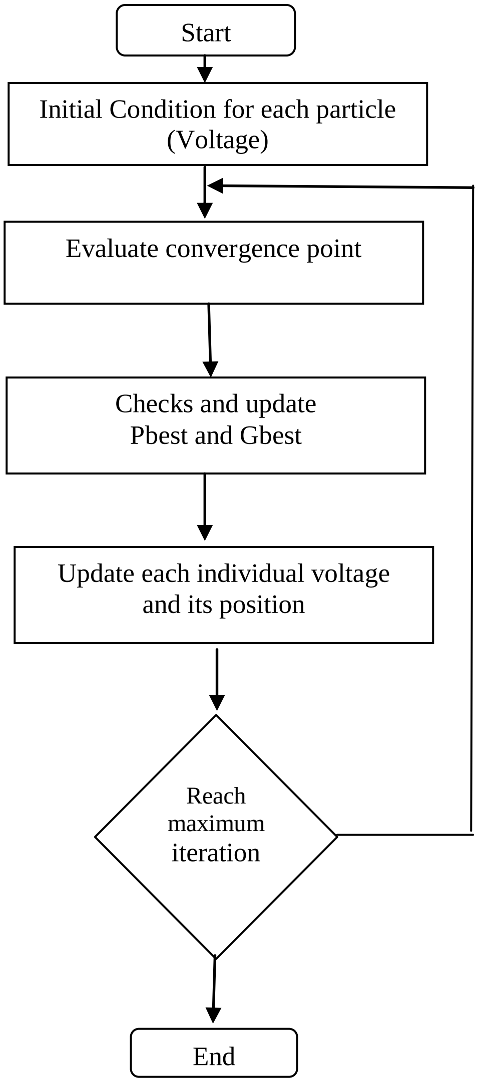

Figure 5: Flow chart for PSO

The voltage convergence using PSO for each phase was amazing. State Estimation results show the monitoring of voltage at each phase with and without FACT device. Results for state estimation are given in figure 6.

State Estimation is calculated by using the weighted least square (WLS) method. Voltages monitored by the assessment of systems with and without FACT device. In point of fact that the voltage fluctuation is calculated at each phase by state estimation respectively. Results represented that how much fluctuation in voltages at each phase.

The convergence of voltage by using optimizing technique is extraordinary. Graphically shown the results and convergence of voltage

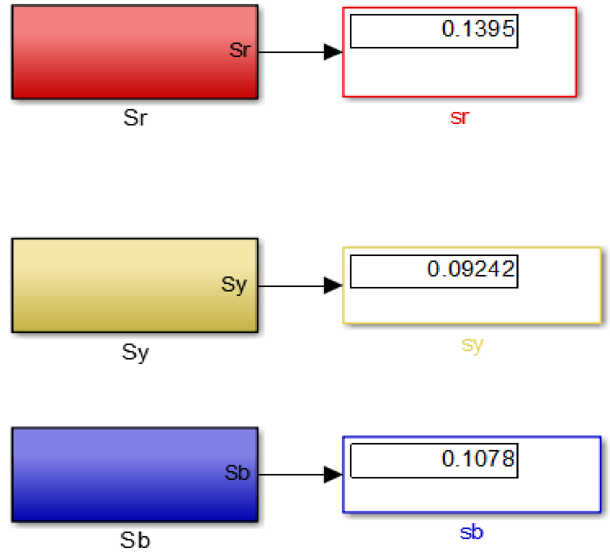

Figure 6: State Estimation results

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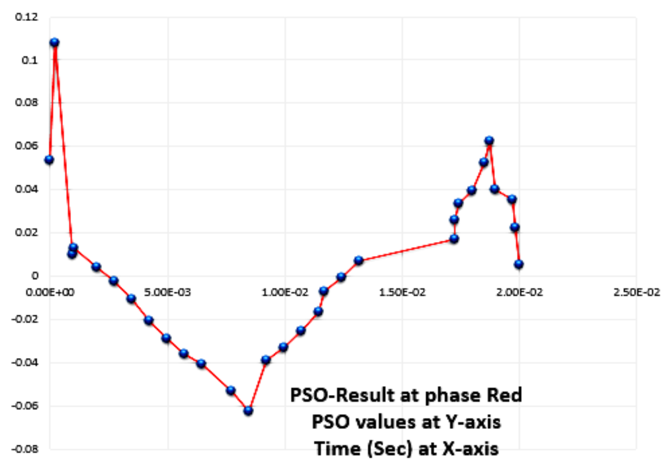
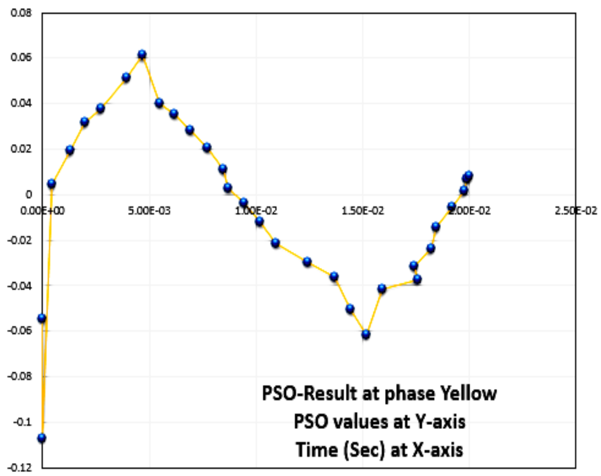


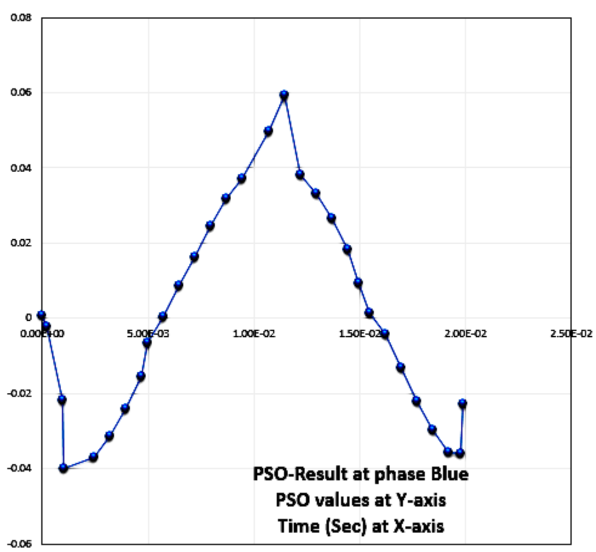
Graph 1: Convergence graph for red phase

At red phase PSO results in a graphical representation as shown in graph 1. To optimize the voltage with particle swarm optimization technique is done and above graph red phase convergence is obviously displayed. Absolutely thirty iterations are made in each phase. PSO results of red phase with respect to time for both positive and negative cycle representing the convergence level at each iteration. Every iteration has a new result with respect to time and converge the voltage to the sinusoidal wave.



Graph 2: Convergence graph for yellow phase

At yellow phase PSO outcomes in a graphical representation as shown in graph 2. To optimize the voltage with particle swarm optimization technique is done and above graph yellow phase convergence is obviously displayed. Absolutely thirty iterations are made for each phase. PSO results of the yellow phase with respect to time for both positive and negative cycle representing the convergence level at each iteration. Every iteration has a new result with respect to time and converge the voltage to the sinusoidal wave.



Graph 3: Convergence graph for blue phase

At blue phase PSO results in a graphical representation as shown in graph 3. To optimize the voltage with particle swarm optimization technique is done and above graph blue phase convergence is obviously displayed. Absolutely thirty iterations are made for each phase. PSO results of blue phase with respect to time for both positive and negative cycle representing the convergence level at each iteration. Every iteration has a new result with respect to time and converge the voltage to the sinusoidal wave.

Table 2: PSO results with respect to time.

Sr. No	**Results of PSO at Phase Red**		**Results of PSO at Phase Yellow**		**Results of PSO at Phase Blue**	
	Time (sec)	PSO value	Time (sec)	PSO Value	Time (sec)	PSO Value
1	3.098e-07	0.05352	1.452e-08	-0.0544	1.452e-08	0.0008531
2	0.00021	0.1077	7.516e-07	-0.1072	0.00021	-0.002349
3	0.00096	0.00987	0.00046	0.004692	0.00096	-0.02181
4	0.00102	0.01278	0.00129	0.01959	0.00101	-0.03998
5	0.00196	0.004446	0.00196	0.03162	0.00246	-0.03709
6	0.00271	-0.002558	0.00271	0.03766	0.00321	-0.03127
7	0.00346	-0.01077	0.00396	0.0513	0.00396	-0.02401
8	0.00421	-0.02042	0.00471	0.06159	0.00471	-0.01543
9	0.00496	-0.02893	0.00546	0.04015	0.00496	-0.006458
10	0.0057	-0.03565	0.0062	0.03531	0.0057	0.0005714
11	0.00645	-0.04038	0.00695	0.02856	0.00645	0.00885
12	0.0077	-0.05324	0.0077	0.02063	0.0072	0.0162
13	0.00845	-0.06219	0.00845	0.01126	0.00795	0.02465
14	0.0092	-0.03894	0.0087	0.002859	0.0087	0.03175
15	0.00995	-0.03311	0.00945	-0.00341	0.00945	0.03708
16	0.0107	-0.02545	0.0102	-0.01207	0.0107	0.04975
17	0.01145	-0.01639	0.01095	-0.02135	0.01145	0.05926
18	0.0117	-0.006893	0.0197	-0.02946	0.0122	0.03816
19	0.01245	-0.000631	0.01245	-0.03594	0.01295	0.03332
20	0.0132	0.007326	0.0137	-0.0502	0.0137	0.02663
21	0.01723	0.01723	0.01445	-0.06157	0.01445	0.01847
22	0.01728	0.02618	0.052	-0.04123	0.01495	0.009333
23	0.01745	0.03369	0.01595	-0.03727	0.01545	0.001557
24	0.01801	0.03933	0.0176	-0.03124	0.0162	-0.004284
25	0.01851	0.05269	0.01745	-0.0235	0.01695	-0.01318
26	0.01872	0.06277	0.0182	-0.01445	0.0177	-0.02199
27	0.01895	0.0404	0.01845	-0.00545	0.01845	-0.02959
28	0.0197	0.03525	0.0192	0.001561	0.0192	-0.03554
29	0.01985	0.02228	0.01975	0.007126	0.01975	-0.03579
30	0.02	0.005131	0.0199	0.008104	0.0199	-0.02279

At each phase PSO results in a tabular demonstration as shown in table 2. To optimize the voltage with particle swarm optimization algorithm is practical and in above table phases convergence is obviously presented. Absolutely thirty iterations are made for each phase and time difference between the phases are taken with the difference of five values of time. PSO results for each phase with respect to time for both positive and negative cycle representing the convergence level at each iteration. Every iteration has a new result with respect to time and converge the voltage to the sinusoidal wave.

CONCLUSION

In this article a heuristic optimization technique PSO algorithm has been implemented to optimize State Estimation and Volt-VAR Control applications of the modern DMS. Simulations have been conducted on IEEE 14-bus radial distribution test feeder with minor changes to integrate the Distributive Generators. Static VAR compensator attached at bus 3 and control the voltage fluctuation by injecting and absorbing reactive power into the system. The SVC is considering only bus 3 and injecting or absorbing reactive power only to this bus3. State estimation done according to measurement of voltage measuring the error coming from 14 bus system without a fact device and with the fact device. Particle swarm optimization algorithm is implemented in Simulink and connected to 14 bus system. The system is connected with the PSO is the last one who has Static VAR compensator and state estimation done as well at this 14 bus system. The convergence of particle (voltage) in PSO was amazing represent as above with respect to time with thirty iteration in a single cycle of each phase. At each iteration particle has a new value with respect to time and converge the particle to the sinusoidal wave.

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