W - Weighting function,
Ci - Weighting factor,
r and uniformly distributed number b/w 0 and 1,
ik current position of agent I at iteration k,
Pbes personal best position of agent I,
gbest - global best of the group.

$$W = \frac{W_{max-}\left[\left(W_{max-}W_{min}\right)\times iter\right]}{max_{iter}} \qquad (2)$$

where,
wMax, wMin - Max. & Min. Inertia weight,
maxiter - maximum iteration number,
iter - current iteration number.

Equation (2) is normally utilized in (1)

The PSO iteration is carried out to obtain the smooth voltage profile according to the algorithm of it, as shown in fig.3. The optimization issue considered in this occasion is to curtail the cost. Target in this optimization issue is to operate as a fitness function in the problem.

B. Why PSO?

With the perspective of advancement, functioning of the PSO is wagerer with respect to Genetic Algorithm [12] & then it was found that PSO appears with its terminal parameter data in very lesser number of generations than the GA. With balancing to GA, PSO was gentle to enact and it comprises of very less variables to adapt [13]. All agents in process are kept as a fellow of society through the course of procedure. PSO is the sole algorism that will not execute the existence of the fittest. In Evolutionary Programming (EP), balance betwixt the global and local search should be managed with the strategy variable, while in PSO the poise will accomplish by the inertial weight factor (w). Apart from all, PSO came with many variants like discrete PSO, MINLP PSO, and Hybrid PSO etc. Ordinary PSO have disadvantage of the short of convergence directed to global optima.

TABLE I PSO PARAMETERS

No. of Particles	10
Max. Inertia weight	0.9
Min. Inertia weight	0.4
C1, C2	0.5, 3.5
No. of Iterations	10

IV. PROPOSED APPROACH

To examine the problem, standard IEEE 14-bus system as shown in Fig.4 is depicted. It is a one line diagram representation. System parameters related to transmission lines, transformers, synchronous generators etc is according to [14]. The placement of two of the FACTS devices is decided on Load flow analysis of this particular bus system. Normally, Real rating of the SVC and TCSC can be determined by various sizing methods [15].

Load flow analysis is required to know the total amount of real and reactive power flow in the system. It will help to find out power flow pattern through system, so one can assess the voltage stability. Result of the same is in Appendix A and B. As voltages of all networks are to be within specified limits [5], we will illustrate the voltage instability by considering various loading condition. Initially, there is a load change up to 15% has been applied at different Bus. On preliminary observations, having identified weakest Bus of the system, selection of FACTS device is possible. Accordingly SVC is placed at Bus-9 and TCSC is connected in series betwixt line 9 and 14.

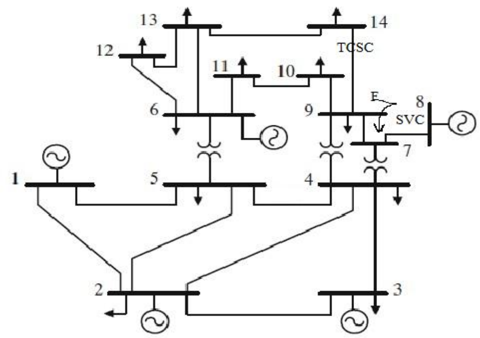

Fig. 4 IEEE-14 bus system with FACTS device

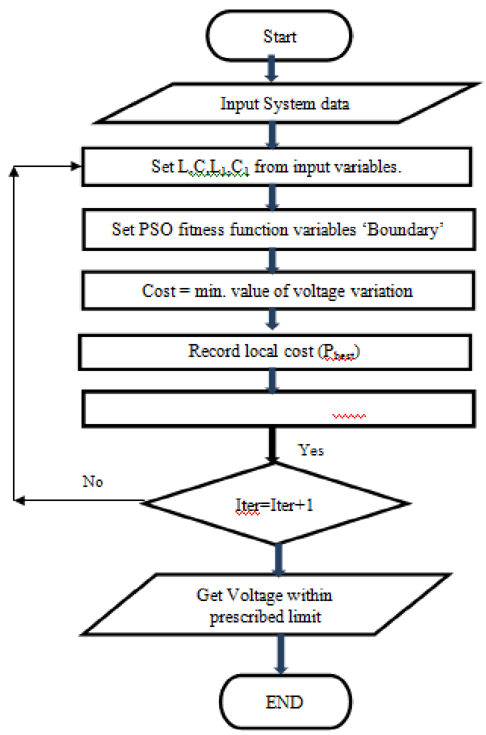

Fig. 3 Algorithm of PSO

As voltage is to be within permissible limits, we have developed a PSO algorithm. According to algorithm of fig. 3, we will initialize with Function Variables i.e. L, C, L1 and C1.Then will Set PSO Fitness Function Variables' Boundary. Generate Different Variables Combination Sets within Boundary which is equal to number of Population

Size. In One Iteration, will Set 1st Variables Combination and will give to PSO Fitness Function. It will give us its return Cost value (which is equal to minimum value of voltage variation or voltage). Here, value of voltage is to be maintained between 0.95 pu to 1.05 pu [5]. Then Save Input Variable Combination and return Cost value. Repeat the same procedure with other Variable Combinations. After Completion of All Variable Combinations, will find better Cost. From all better Cost, will find Local Cost (Pbest). Regenerate 2nd Variables Combination Sets from last Global & local Parameters. Repeat PSO function for Remaining iteration. At Completion of each iteration will get Global cost (Gbest) (which is value of voltage within prescribed limit) from previous Global Cost and Current Local Cost. After Completion of all Iteration we get Final Global Cost.

V. RESULTS AND DISCUSSION

While investigating the problem, PSO algorism is exploited for navigation of datas of SVC and TCSC controller co-ordinately with help of eq. (1). In accordance with the present procedure, simulation is put through the multi machine system in MATLAB with toolbox. PSO [11] used here is built on searching the values of L and C of SVC and TCSC, then one can achieve desired and fine coordination. PSO taken here is available with few modification, as change in PSO range & number, difference in selection criteria technique, control technique etc, with due respect to normalize PSO. Accordingly, in PSO algorithm, initially we have to Set L, C, L1, C1 from input variables. Procedure of the same has been discussed in section 4.

To understand the behaviour of network, we have made a change in load at time from 5% to 20% at Bus-9 and Bus-14. While doing this we have observed change in voltage values, which is not in prescribed limit and network loses its stability in terms of voltage. Voltage level at Bus-9 has been reduced to 0.93 pu after 15% of change in load, which will be then 0.965 pu after application of coordination of SVC-TCSC.As a result, according to fig. (5) and (6), an enhancement in level of voltage at Bus-9 and Bus-14has been observed with the action of SVC-TCSC interaction.

Similarly, to see the effect of load change, we have changed a power factor of a load at various buses, too. At Bus-9, 10, 13 and 14, power factor of a total load has been reduced, which has given us a value of voltage, which is not acceptable. Hence with help of coordination of SVC and TCSC, achieved voltage within limit. Results are shown in table II. Similar to previous case, fig. (7) and (8) validates the result and voltage stability. The important thing here is that SVC-TSCS coordination has better result than alone TCSC or SVC. On the same note, for the reactive power flow, it encountered a small decrease too, by using coordinated control. The amount of active and reactive power can be also controlled.

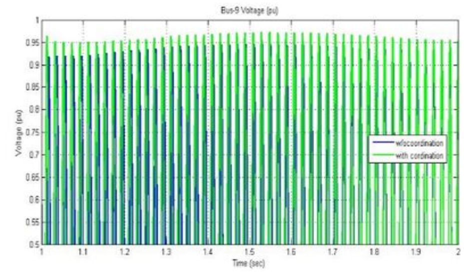
Fig. 5 Bus-9 voltage (pu)

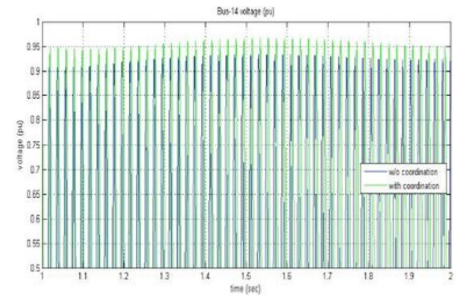
Fig. 6 Bus-14 voltage (pu)

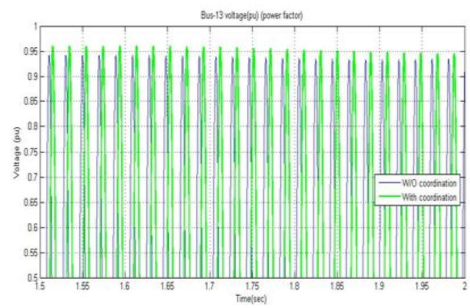
Fig. 7 Bus-13voltage (pu) (pf changed)

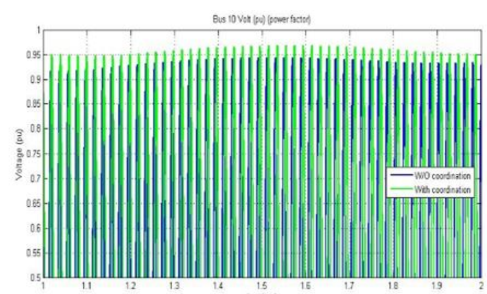
Fig. 8 Bus-10 voltage (pu) (pf changed)

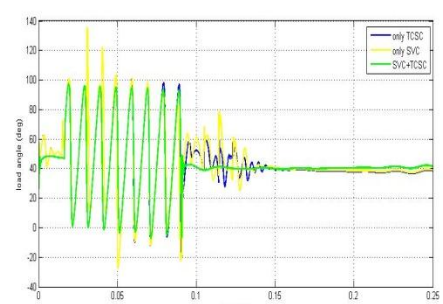

Fig. 9 Load angle at Bus-8

TABLE I VOLTAGE MAGNITUDE (PU) WHEN LOAD CHANGES

Load Changed at Bus-9	Voltage at Bus-9	Voltage at Bus-13	Voltage at Bus-14
Without FACTS	0.93	0.94	0.925
With coordination	0.965	0.961	0.96
Load Changed at Bus-14	Voltage at Bus-9	Voltage at Bus-13	Voltage at Bus-14
Without FACTS	0.941	0.94	0.93
With coordination	0.965	0.96	0.95

TABLE II VOLTAGE MAGNITUDE (PU) WHEN POWER FACTOR CHANGES

Bus No	Power Factor (original)	Power factor (load changed)	Bus Voltage (pu)	Bus Voltage (with coordination)
9	0.87	0.79	0.925	0.955
10	1.07	0.81	0.935	0.965
13	0.91	0.75	0.93	0.96
14	0.94	0.85	0.92	0.96

TABLE III LOAD FLOW DATA

Bus No	Bus Voltage (pu)
1	1.01
2	0.992
3	0.984
4	0.976
5	0.981
6	0.984
7	0.976
8	0.995
9	0.962
10	0.965
11	0.975
12	0.973
13	0.97
14	0.96

TABLE IV POWER FLOW (SIMULATION)

Bus No	P (MW) (GEN)	Q (MVAr) (GEN)	P (MW) LOAD	Q (MVAr) LOAD
1	352.16	-27.511	0	0
2	40	96.484	30.38	17.78
3	0	60.62	131.8	26.6
4	0	0	66.9	5.6
5	0	0	10.64	2.24
6	0	46.15	15.68	10.5
7	0	0	0	0
8	0	30	0	0
9	0	0	41.3	23.5
10	0	0	12.6	8.1
11	0	0	4.9	2.5
12	0	0	8.5	2.2
13	0	0	18.9	8.12
14	0	0	20.86	7

As we were interested to the evolution of Bus voltage and hence voltage stability, have also checked variation in load angle. Fig (9) shows load angle of generator at Bus-8 has been changed, when load changed at Bus-9 and gets more stable when coordination has been applied.

VI. CONCLUSION

This paper furnishes a crisp thought on outcome of coordination. Their separate donation in direction to the improvement of voltage magnitude which have experimented on a 14 bus system. The composite, SVC and TCSC has been examined, as a multi type FACTS device effect, for preservation of the voltage profile. This approach can be supported by identifying the proper location of the FACTS. The heart of the paper was SVC-TCSC combination, which have given dynamic performance under various loading condition. On the other hand, parameters like active power, reactive power (limit) and damping of oscillations can also be verified, by same coordination and with interaction of SVC & TCSC. In conclusion, appropriate coordination of FACTS devices can fruitfully refine the performance of power system.

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