STATCOM'S IDEAL PLACEMENT AND SIZE IN THE IEEE 30 BUS SYSTEM UTILIZING PSO

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ABSTRACT

To reduce the amount of voltage deviation, we determine in this work where STATCOM should be placed in the IEEE 30 bus. Particle swarm optimization (PSO) is an evolutionary computational method that we utilize to determine where STATCOM should be placed. To determine the voltage value at each and every bus, we employ the Newton-Raphson approach. The objective function used to calculate voltage deviation is minimized to determine the voltage deviation's lowest possible value. The best placement of one STATCOM in the IEEE 30 bus is initially determined by simply minimizing the value of the objective function, and the best placement of two STATCOM in the same bus is then determined by employing the particle swarm optimization technique.

KEYWORDS: *Newton-Raphson-method, particle swarm optimization technique (PSO), FACTS, STATCOM*

1. INTRODUCTION

In electrical power systems, reactive power compensation is a crucial issue. By using FACTS devices, we can manage the reactive power flow to the power network and, in turn, the volatility and stability of the system voltage [1]. Voltage collapse issues in power networks have been a constant source of worry ever since several significant blackouts around the globe have been directly linked to this voltage collapse issue. Maximum load ability points are another name for the collapse points. The new reactive compensation equipment’s can significantly alter the power flow regulation and static stability limits of the power system [2].

The Newton-Raphson method is a strong technique for solving nonlinear algebraic problems is the Raphson method. It works more quickly and will converge in many situations, but it demands a lot of computer RAM.

2. LITERATURE REVIEW

In this section we will disused about the various technique of reactive power compensation. reactive power compensation is a crucial issue. By using FACTS devices, we can manage the reactive power flow to the power network. The STATCOM (Static Synchronous Compensator) is a shunt-connected reactive compensation device that can produce and absorb reactive power, and whose output can be adjusted to retain control of particular electric power system parameters. The best place for STATCOM can be found using population-based stochastic optimization method known as particle swarm optimization (PSO) when two STATCOM is connected then it is very difficult to find optimal location without using of PSO. So, we get the optimal location of STATCOM by using PSO. By using this algorithm, we find an optimum bus location of (12 ,24) in which the first STATCOM is connected to the BUS NO. 12 and the second STATCOM is connected to the BUS NO. 24. On this optimal location we found the minimum value of objective function which is .1682. This indicate that if we increase the no. of STATCOM then it is possible to find the lesser value of objective function and minimum size of STATCOM. Here we will discuss the best place for STATCOM .and their minimum objective function.

3. STATCOM

The STATCOM (Static Synchronous Compensator) is a shunt-connected reactive compensation device that can produce and absorb reactive power, and whose output can be adjusted to retain control of particular electric power system parameters [3],[4]. Normally, STATCOM is made up of a voltage source inverter and a dc-link capacitor. It often connects to a system via a transformer. The transformer serves the dual purposes of increasing STATCOM voltage and preventing short circuit of the dc-link capacitor through leakage reactance. Therefore, an interface reactor is needed to operate as the transformer leakage reactance when employing multilayer STATCOM, where the STATCOM voltage can be constructed from a number of dc-links to that of the system voltage. Basically, STATCOM can be modeled as a synchronous generator that absorbs/injects reactive power but does not generate any real power rather absorbed real power to cater for its internal and interface losses. ZSTATCOM represents the impedance of the STATCOM. The imaginary part represents the transformer leakage reactance/interface reactor and the real part forms the ohmic losses of the STATCOM. Assuming multilevel Inverter STATCOM, in this model, the ohmic resistance is excluded from the admittance matrix. This is due to the fact that, various switching techniques can be employed [6][7]. Fundamental frequency switching (FFS) and PWM are the two main switching strategies, and their switching losses differ. Based on the reactive power specified at the STATCOM bus, the true power losses of the STATCOM are calculated prior to the load flow. Four attributes were added by the bus, matching the number of system buses.
Both the STATCOM bus and the bus to which it is attached continue to be load buses. The STATCOM reactive power has the same sign as the load when the power factor is lagging but the opposite sign when the power factor is leading.

4. PARTICLE SWARM OPTIMIZATION TECHNIQUE

The best place for STATCOM can be found using a variety of evolutionary techniques, including the generic algorithm (GA), evolutionary programming, and particle swarm optimization (PSO). In 1995, Drs. Eberhart, Kennedy, and Shi invented the population-based stochastic optimization method known as particle swarm optimization (PSO), which was motivated by the social behavior of fish schools and flocks of birds. An optimization method called particle swarm adaptation mimics how human societies might process knowledge. The PSO is a powerful global optimizer for problems involving continuous variables. The algorithm simulates a population of individuals exploring a problem area; as individuals succeed, so do their peers' searches. The algorithm has implications for cognition, particularly the way that it represents schematic knowledge. Perhaps more obvious are its ties to artificial life (A-life) in general, and to bird flocking, fish schooling, and swarming theory in particular. It is also related, however, to evolutionary computation, and has ties to both genetic algorithms and evolutionary programming. These relationships are briefly reviewed in the paper.
Kennedy and Eberhart's suggested fundamental algorithm Individual particle positions have been updated as follows:

x_k^i - Particle position

v_k^i - Particle velocity

p_k^i - Best "remembered" individual particle p

p_k^g - Best "remembered" swarm position

c_1, c_2 - Cognitive and social parameters

r_1, r_2 - Random numbers between 0 and 1

Position of individual particles updated as follows:

$$x_{k+1}^i = x_k^i + v_{k+1}^i$$

with the velocity calculated as follows:

$$v_{k+1}^i = v_k^i + c_1 r_1 \left(p_k^i - x_k^i \right) + c_2 r_2 \left(p_k^g - x_k^i \right)$$

5. BUS SYSTEM

For our research work we have taken the IEEE-30 bus system. the line data, bus data is taken from the reference as shown in fig-1

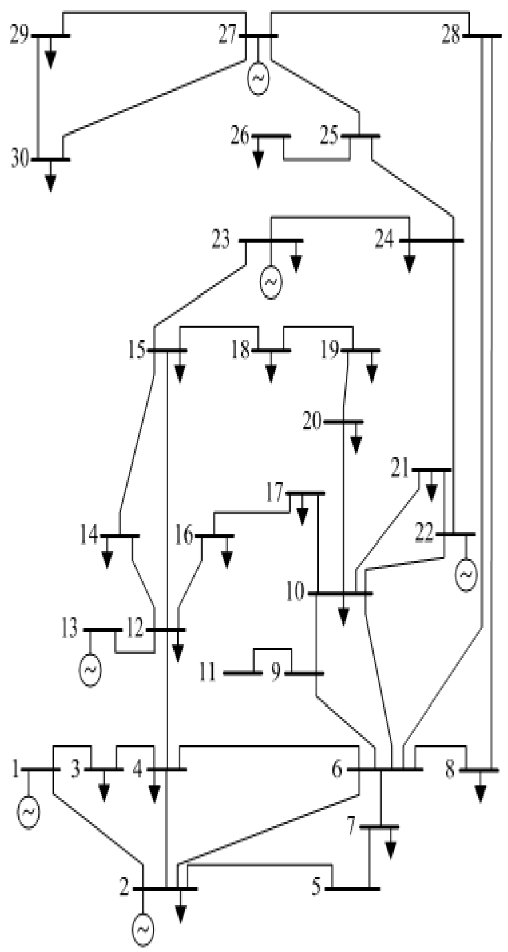


Fig-1 Single line diagram of the IEEE 30-bus test system

Table -1 contains the line information for the IEEE 30 bus system. We use these data to determine the IEEE 30 test bus system's YBUS, which is then used in the Newton-Raphson load flow analysis.
As we see from the standard IEEE30 bus data the bus system has
a)1 slack bus
b)5 generator or PV buses
c)24 load or PQ buses
by using the load data and bus data we calculate the voltage at each bus by Newton Raphson load flow method. The result is given in following **Table-1**.

Table-1.

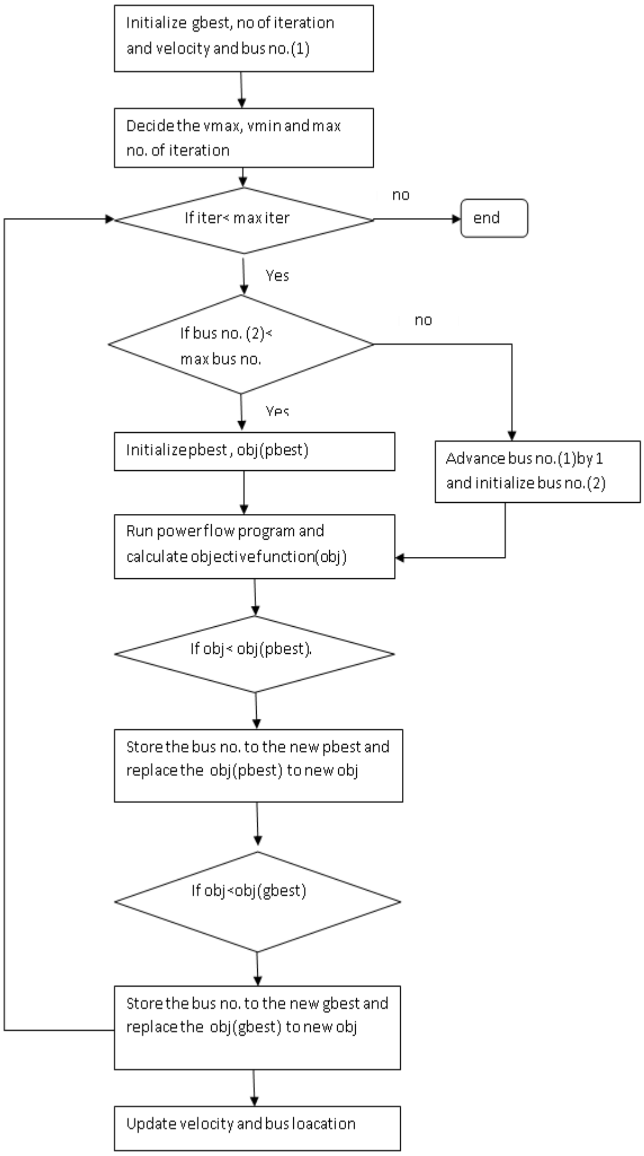
Bus no.	Voltage at bus
1	1.060
2	1.043
3	1.019
4	1.010
5	1.010
6	1.009
7	1.002
8	1.010
9	1.039
10	1.021
11	1.082
12	1.049
13	1.071
14	1.032
15	1.025
16	1.030
17	1.018
18	1.011
19	1.006
20	1.009
21	1.008
22	1.012
23	1.008
24	0.999
25	1.003
26	0.985
27	1.014
28	1.007
29	0.994
30	0.982

OBJECTIVE FUNCTION- objective function (J) is an RMS value of voltage deviation. It is given by

$$j = \sqrt{\sum_{i=1}^{30} \left(V_i - 1\right)^2}$$

Our main goal is to reduce the objective function since a smaller objective function translates into better stability and lower voltage variation. The IEEE 30 bus's objective function without STATCOM is.1636.

6. ALGORITHM OF PSO



7. PSO PARAMETER

By using the hit and trail method, we determine the next PSO parameter.

a) inertia weight- we can take inertia weight in three manners

I. Constant inertia weight- the inertia weight can be taken constant throughout the process but it seems somewhat unconvincing because as the particle reach near the final solution the impact

of pbest and gbest should be increase to avoid to trap in local minima.

II. Linearly decreasing inertia weight –we can tan take inertia weight as linearly decreasing but it has also problem to trap in local minima.

Randomly decrease inertia weight- in our thesis we take inertia weight as randomly decreasing inertia weight as it has not any problem to trap in local minima.
So, for our study we take inertia weight as a function which decrease randomly from .9 to .1.
It is given by following:

$$w_i = 0.9 - 0.8 * \frac{iter - 1}{\max\_iter - 1}$$

b) No. of of particle- we have taken 5 particles with the random initial STACOM position.

c) Acceleration constant- there are two accelerations constant we use.

I. Individual acceleration constant- this acceleration constant is used for show the impact of individual particle best position gain by particle itself on the next value of velocity of that particle. It is denoted by c_1. For our study we take c_1=2.6

II. Social acceleration constant: The social acceleration constant is used to illustrate how a particle's best location (gbest) affects the subsequent value of that particle's velocity. The symbol for it is c2. We use c2=1.4 in our investigation.

d) No of iteration- 10 iterations is sufficient while we deal with single STATCOM and when we use 2 STATCOM we need minimum 30 iterations.

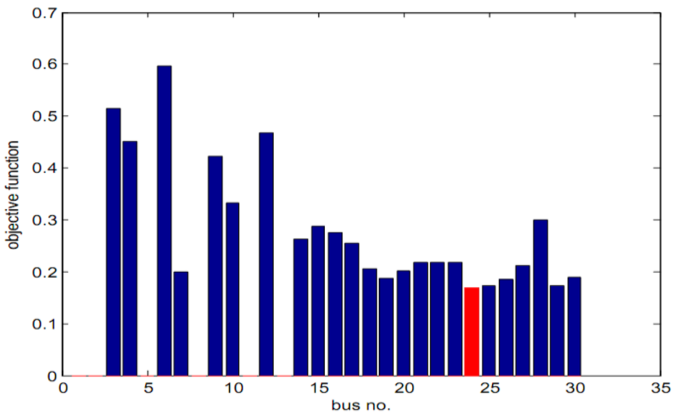


Figure 2. Objective function Vs bus no. plot of IEEE 30 bus system

8. RESULTS

For one STATCOM-

a) **Without using PSO-** without using PSO we have to calculate the objective function while apply the STATCOM on every bus one by one and then we can choose the optimal bus location with the minimum objective function. while we use only single STATCOM it is very easy to find the optimal location because we have to check only 30 buses but when we use two STATCOM at a time then it is very difficult because we have to check almost **800(30*29)** buses which is very difficult so it is easy to use PSO method.

b) In the following table the objective function corresponding to STATCOM connected bus is given as we see that when we connected the STATCOM to the **bus no. 12** then we get the minimum value of objective function which is **.1364** which is very less in comparison of other previous objective function without using the STATCOM **.1663**.

c) **by using PSO-** by using PSO we get the same result as we get without the use of PSO. We get the optimal location in only 10 iterations.

d) **2-when two STATCOM connected-** when two STATCOM is connected then it is very difficult to find optimal location without using of PSO. So, we get the optimal location of STATCOM by using PSO. By using this algorithm, we find an optimum bus location of (**12, 24**) in which the first STATCOM is connected to the **BUS NO. 12** and the second STATCOM is connected to the **BUS NO. 24**. On this optimal location we found the minimum value of objective function which is **.1682** which is very less in the comparison. As we see that when we connect the one STATCOM we found the minimum value of objective function which is **.1364** while using another STATCOM we found the minimum objective function **.1682**. This indicate that if we increase the no. of STATCOM then it is possible to find the lesser value of objective function and minimum size of STATCOM.

Table-2: Objective function of IEEE 30 bus system

STATCOM CONNECTED BUS	VOLTAGE DEVIATION	STATCOM SIZE in MVAR	OBJECTIVE FUNCTION
3	0.1570	35.863	0.5157
4	0.1575	29.425	0.4517
6	0.1507	44.613	0.5968
7	0.1632	3.5534	0.1988
9	0.1373	28.447	0.4218
10	0.1494	18.251	0.3319
12	**0.1364**	**33.179**	**0.4681**
14	0.1384	12.53	0.2637
15	0.1400	14.716	0.2871
16	0.1387	13.676	0.2755
17	0.1482	10.696	0.2551
18	0.1585	4.8035	0.2066
19	0.1605	2.6944	0.1875
20	0.1593	4.167	0.2009
21	0.1584	5.8645	0.2171
22	0.1591	5.9864	0.219
23	0.1584	5.9628	0.218
24	**0.1640**	**0.4222**	**0.1682**
25	0.1634	0.958	0.1729
26	0.1648	2.0413	0.1852
27	0.1655	4.5736	0.2112
28	0.1621	13.791	0.3
29	0.1638	0.8975	0.1727
30	0.1649	2.5149	0.1901

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