International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

The Best Location for the Statcom to Achieve Voltage Stability with GA

Balu krishna

ABSTRACT

Improving voltage stability is an essential part of any power system. Voltage stability may be classified as either transient or steady state, depending on the loading type and environmental factors. Stability in steady states has been considered in this study. This demonstrates the development of voltage stability, which in turn improves system performance, reduces losses, and makes the system more secure. This study employs Static Synchronous Controller (STATCOM) devices, which are adaptable, dependable, and give the required features, out of the different options for boosting stability. This article compares the outcomes before and after STATCOM was applied to the system network, focusing on the best location of STATCOM. First, with or without STATCOM, the magnitude and phase angle of the voltage at each node in the IEEE 14 bus system are determined using the Newton Raphson (NR) technique. Optimal site selection for the STATCOM is accomplished in the second step by use of a Genetic Algorithm (GA). The losses were reduced once the STATCOM was placed. We put the suggested approach through its paces using an IEEE 14 bus system in MATLAB.

Keyword: The following are examples of such algorithms: STATCOM, FACTS, NR, and Genetic Algorithm.

1. INTRODUCTION

Approach and resources are very domain dependent when it comes to voltage stability. Voltage stability in the power system network is critically dependent on power consumption. An issue arises in a system when the demand for power rises and the reactive power is insufficient. As a result, the system's performance degrades, leading to blackouts caused by overvoltage, losses, insecurity, voltage instability, collapse, and deregulation. The inability to provide enough reactive power to the system in the face of abrupt changes in power demand is the primary issue in this study. As a result, our system is becoming unregulated and prone to blackouts due to the rising losses and the difficulty in keeping the voltage at each bus within the system's limitations and security. The issue of blackouts may be prevented by enhancing voltage stability, which might lead to the network running smoothly. Attempts to address voltage instability have been made since the 1920s, but thus far, none of these methods have been successful. Thus, the latest approach, the FACTS (Flexible AC Transmission System), was used.

FACTS are brand new devices that were developed to improve voltage stability and are based on power electronics. Its primary concerns are with the network's voltage, power, cost, security, and loss characteristics [3]. In order to address this issue, this article employs STATCOM type FACTS devices. The best placement of FACTS devices is determined using GA.

2. VOLTAGE STABILITY ENHANCEMENT

Nowadays the increasing population is causing the problem in power system by increasing the power demand continuously. As the increase in power demand beyond its given limit causes the insufficient supply or too much absorption of reactive power in the system. The incapability of the system to maintain reactive power is causing the problem of voltage instability. The common form of voltage instability is the continuous decline in the bus voltages, increase in losses and system becomes vulnerable [1].

Voltage stability is basically the capability of the system to maintain the bus voltages within its limit under normal condition and after being subjected to the disturbances.

2.1 Causes of Voltage Instability

- Increment of load is the reason for the voltage at the buses to decline.
- Reduction of power generation
- Outage of apparatus and lines
- Voltage control mechanism failure.
- System supply or absorbs insufficient reactive power.

2.2 Methods to Enhance Voltage Stability

- Excitation of the generators is improved.
- Regional grids can be connected by using HVDC.

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

- Synchronous condensers can be used.
- Lines are compensated.
- Inertia of generating unit is improved.

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

3. FLEXIBLE AC TRANSMISSION SYSTEM (FACTS)

4. Voltage stability in power system networks was once achieved using equipment such as phase shifting transformers, tap changing transformers, etc. Reliability, efficiency, and speed of reaction are all compromised by the complexity of these approaches [3]. Therefore, the FACTS system is a controller that improves the controllability and power system capabilities of ac transmission systems via the application of power electronics. Instead of being individual controllers, FACTS are a group of controllers.
   The FACTS controllers are categorized as follows:

:

1. Series Controllers
2. Shunt Controllers
3. Series-Shunt Controllers

3.1 Series Controllers

It is used for injecting the voltage in series with the line. It supplies reactive power when the injected voltage gets in phase quadrature else it deals with the real power. It is used for long distance lines. Series Controllers implies the fractional neutralization of the transmission line reactance by a capacitor bank installed in series with line.
Series Controllers are of three types:

1. Thyristor Controlled Series Controller (TCSC)
2. Static Synchronous Series Controller (SSSC)
3. Thyristor Switched Series Controller (TSSC)

3.2 Shunt Controllers

It is used for injecting the current in the line. It supplies reactive power when the injected currents gets in phase quadrature with the line voltage else it deals with the real power.
Shunt Controllers are of two categories:

1. Static Synchronous Controller (STATCOM)
2. Static VAR Controller (SVC)

3.2.1 Static Synchronous Controller

A static synchronous generator operated as a shunt connected static VAR controller whose capacitive or inductive output current can be controlled independent of the ac system voltage [6]. It is based on voltage source or the current source converter. Voltage source converter is preferable by considering cost as the important. STATCOM is also used as the active filter for reducing or absorbing the harmonics.

3.3 Series-Shunt Controllers

It is the combination of both Shunt and Series type Controllers. So, it shows the characteristic of both types of controllers and it is used for both power flow and voltage profiles, reduce the losses, and makes the system more reliable, flexible, and secure. The type of series- shunt controller is Unified Power Flow Control (UPFC).

3.4 Featurers of STATCOM

- STATCOM functions as shunt connected synchronous voltage source.
- STATCOM provides better performance.
- STATCOM provides faster response than Static Var Controller (SVC).
- Superior functional characteristics
- STATCOM has no delay allied with the thyristor firing.
- Greater flexibility
- Low system voltage supports full capacitive output current.
- At low voltages STATCOM breeds more reactive power because, capacitive power generated α system voltage. Hence in STATCOM capacitive power generated varies linearly with system voltage.

3.5 Advantages of FACTS

- Reduces the losses
- Voltage fluctuation is controlled with the help of STATCOM.
- Power carrying capacity of the line is improved.
- Transient stability is ameliorated.
- Improves quality of supply
- Superior use of the existent transmission system

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

- Diminishes the reactive power flow

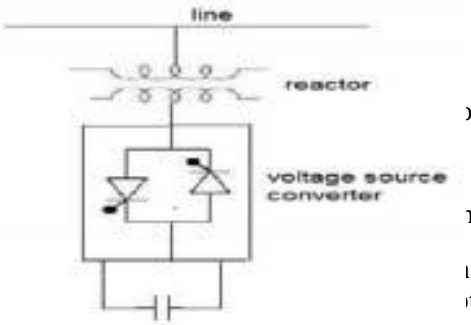
4. PROBLEM FORMULATION

In the First stage, the voltage and Phase angle at each bus in both the systems are identified, and the first bus in both the systems are considered to be the slack bus with its values as 1∠0 p.u and other may be the load bus or the generator bus. The voltage magnitude and phase angles are calculated using load flow analysis [5] i.e. NR method. Now FACTS devices are optimally placed in the system using GA technique.

4.1 Newton Raphson Method (NR)

NR method is used for solving the nonlinear algebraic equations. It provides fast response and sure convergence as compared to Gauss Seidel method.

Power flow equations [2]:



m

points. oint is exchanged between parents.

ΔQ_i^r =(

Here if an the

toleran nd Q1 and the solution is

Step 3: tained, calculate the Jacob

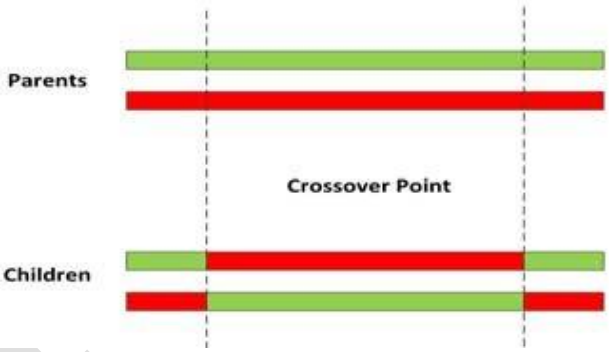
Step 4: correction of voltage magnitude and phase angles.

Step 5: Next update the voltage magnitude and phase angles.

$$|V|^{(r+1)} = |V|^r + \Delta|V|^r$$

$$\delta^{(r+1)} = \delta^r + \Delta\delta^r$$

Again go to step 2 and continue the process unless the convergence is obt



4.2 Genetic Algorithm (GA)

In 1960 I. Rechenberg introduced the idea of evolutionary computing in his work Evolutionary strategies. GA's are computerized search and optimization algorithms based on mechanics of natural genetics and natural selection.

Figure 3: Two Point Crossover

Cut and Split: - This shows change in length of child string, because each parent string is separated at different crossover point.

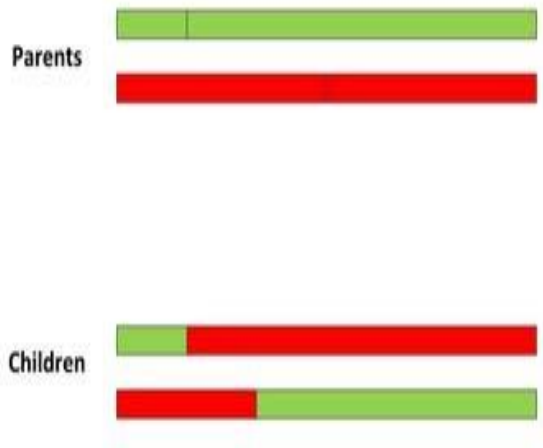


Figure 4: Cut and Split Point Crossover

1. Mutation:

It is used to maintain genetic diversity from one generation to next generation. Mutation changes one or more gene values from their initial ones in chromosome and a result obtained in mutation is totally different from the last solutions [4].

2. Fitness Function:

Due to the Fitness function result is in the form of single figure called figure of merits. After every round of testing, previous

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

worst design solutions are deleted and new ones are raised.

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

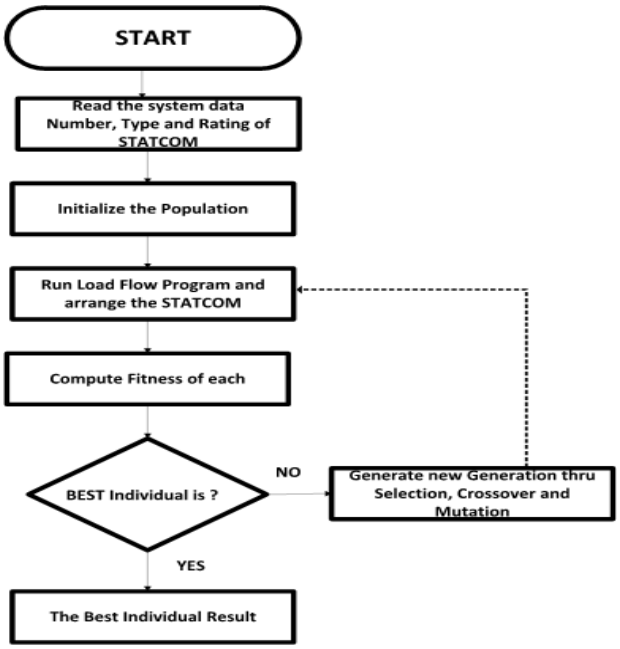
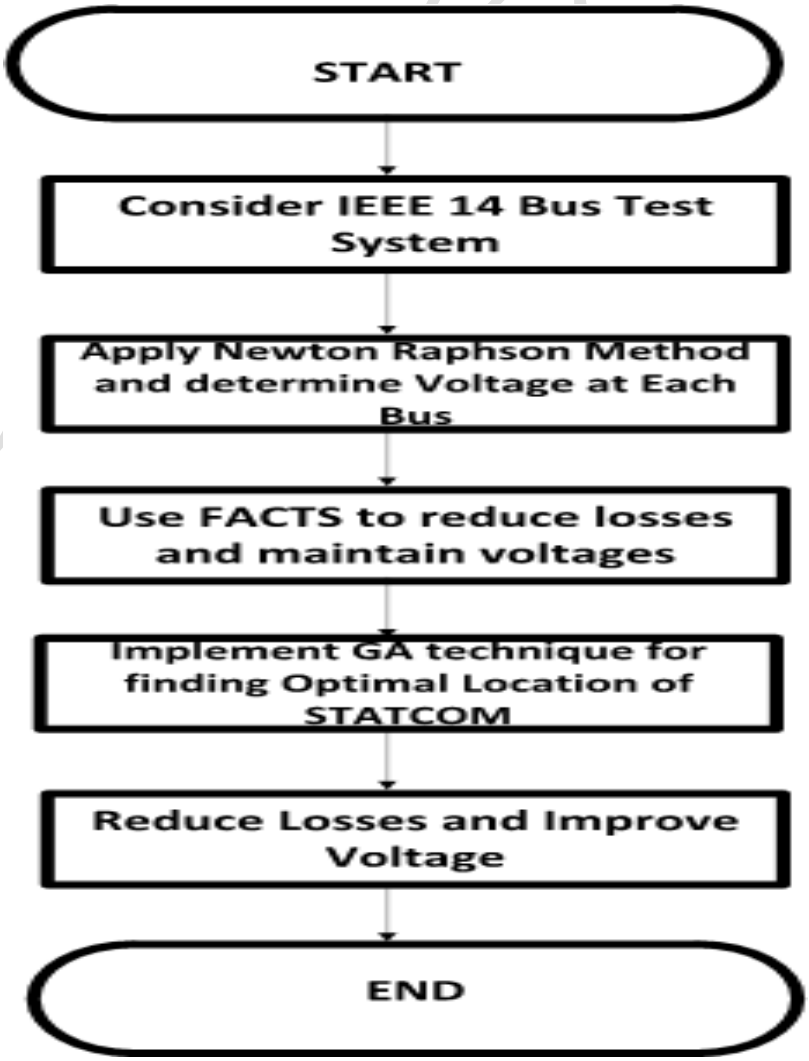


Figure 5: Flow Chart of GA

4.3 Advantages of GA

- It can vary both the values and structure and the desired result can be obtained.
- Quick response for acceptable solution
- It deals with the large number of solution.

4.4 Algorithm



International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

5. RESULTS

The comparative result before the application of STATCOM and after optimal placement of STATCOM in the system network has been discussed. NR method is used to determine voltage magnitude and phase angle at every node of the IEEE 14 bus system with and without STATCOM. GA finds the optimal location for placing the STATCOM. After placing the STATCOM the losses got reduced.

5.1 Voltage and Phase angle of IEEE 14 bus system using NR method

The voltage and phase angle is calculated at each bus using NR method as shown in Table 1.

Table -1: Voltage and Phase angle of IEEE 14 bus system using NR method

Bus No.	Voltage (pu)	Angle (degree)
1	1.0300	0.0000
2	0.9830	-5.5790
3	0.8956	-14.0697
4	0.9125	-11.0985
5	0.9239	-9.3695
6	0.9141	-16.4834
7	0.8995	-15.0345
8	0.8995	-15.0345
9	0.8836	-17.2196
10	0.8801	-17.4841
11	0.8928	-17.1532
12	0.8956	-17.6413
13	0.8891	-17.7069
14	0.8644	-18.8546

5.2 Determine Voltage, Phase angle and Losses using GA

The voltages, phase angles and losses of the system are calculated using GA with and without STATCOM for Optimal Location of STATCOM.

Table -2: Voltage and Phase angle with and without STATCOM using GA

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

Bus No.	WITHOUT STATCOM		WITH STATCOM	
	Voltage (pu)	Angle (degree)	Voltage (pu)	Angle(degree)
1	1.0000	0.0000	1.0000	0.0000
2	0.9450	-5.3015	0.9450	-5.3005
3	1.0100	-16.1049	1.0100	-16.1026
4	0.9222	-11.7089	0.9226	-11.7099
5	0.9246	-9.7250	0.9250	-9.9713
6	0.9560	-17.3053	0.9560	-17.2908
7	0.8874	-15.3993	0.8882	-15.4023
8	0.8440	-15.3993	0.8440	-15.4023
9	0.8869	-17.4622	0.8876	-17.4645
10	**0.8904**	-17.7955	**0.8930**	-17.8125
11	**0.9186**	-17.6834	**0.9220**	-17.7391
12	0.9352	-18.3798	0.9356	-18.3655
13	0.9259	-18.3795	0.9264	-18.3673
14	0.8828	-19.2272	0.8833	-19.2212

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

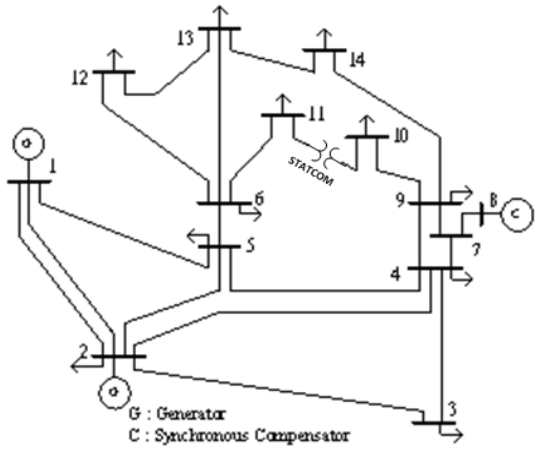


Figure 7: IEEE 14 bus system with STATCOM

In IEEE 14 bus system the Optimal Location of STATCOM has been identified by the GA hence, it can be seen that the voltage (pu) is increased from 0.9186 to 0.9220 at bus number 11 as shown in Table 2 and in Figure 7. So, the optimal placement of STATCOM is at bus number 11. The voltage profile at different scenario of IEEE 14 bus system as shown in Figure 8

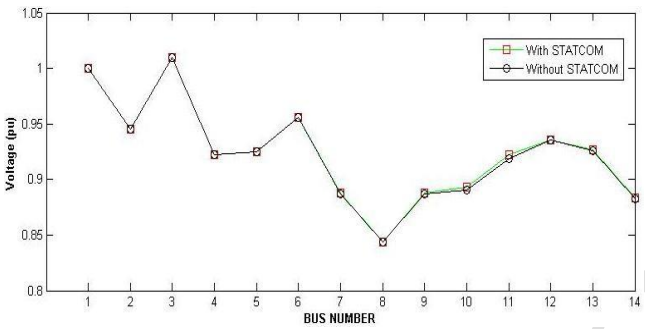


Figure 8: Voltage Profile of IEEE 14 bus system with and without STATCOM

Table -3: Losses with and without STATCOM

Losses without STATCOM in MW	Losses with STATCOM in MW
20.764	20.722

Hence it is shown in Table-3 that with the optimal placement of STATCOM in the system the voltage at buses is improved and losses are reducing hence, voltage stability is enhanced.

6. CONCLUSION

A drop in bus voltage, which in turn causes blackouts, is a hallmark of voltage instability. The magnitude of voltages and phase angles at buses were determined using load flow analysis utilizing the NR approach. The power system operators may decide on the necessary corrective activities by determining the voltages at the buses. A STATCOM is included in the system to ensure that the bus voltages are maintained. In order to determine the best spot for STATCOM, a meta-heuristic software computing method known as GA has been used. The GA's parameters, including the population size, mutation rate, and crossover rate, may also be optimized using this approach. Analyzing the optimization findings for the IEEE 14 bus test system reveals that, in addition to boosting the voltage at the buses, system losses and generating costs are reduced.

.

6.1 FUTURE WORK

Improvement in voltage stability is a wide area and there is vast research scope in this direction such as

1. The maintenance of voltage at buses can also be done under dynamic conditions by considering different contingency

ISSN: 1934--9955 www.ijise.net

Vol-11 Issue-01 Oct 2016

conditions.

2. Location of FACTS devices for voltage stability enhancement can be done by other advanced heuristic methods such as Bee Colony, Harmony Algorithm or the Gravitational Algorithm.
3. Multi- Type FACTS devices can be used for improving voltage stability and reducing losses.

REFERENCES

[1] "Modeling Issues of Grid-Integrated Wind Farms for Power System Stability Studies" (Kawady, Tamer A and Nahhas, Ahmed M). 2014, InTech.

[2] "Modern state estimation methods in power systems" by Baalbergen, Freek, Gibescu, Madeleine, and vander Sluis, Lou2009, IEEE, pages 1–6

Padhy, Narayana Prasad, and Sidhartha Panda "Enhanced power system stability through the use of PSO: optimal site and controller design of STATCOM"

Volume 345, Issue 2, pages 166–181, 2008, Elsevier

Using evolutionary algorithms, Toledo et al. [4] demonstrate fringe patterns. Jimenez and Sossa [5] also contributed to the work. 2012. toledofringe

[5] "Hybrid Harmony Search Algorithm and Interior Point Method for Economic Dispatch with Valve-Point Effect" by Sivasubramani and Ahmad, MdThe 2014 volume, issue 3, pages 253-261, of the International Journal of Emerging Electric Power Systems

[6] "Application of genetic algorithm to power system voltage stability enhancement using facts devices" by Preethi, VA, Muralidharan, S, and Rajasekar, S2011 IEEE, pp. 333–338,