# Optimal Placement of D-STATCOM by Genetic Algorithm to Losses Reduction

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***Abstract*- In this paper, an optimization algorithm by genetic algorithm is designed to placement and then simulated to determine the amount of reactive power by D-STATCOM. Also this method will be able to minimize the power system losses that contain power loss in transmission lines. Furthermore, in this design a IEEE 30-bus model depicted and three D-STATCOM are located in this system according to Economic Considerations. Also, a genetic algorithm to minimizing the total network losses is applied for every output simulation of D-STATCOM that is used to produce or absorb of reactive power. Finally, the result of this simulation presents both the losses reduction and voltage improvement, that it verifies this algorithm performance.**

## Introduction

Lately, Improving of power quality has been considered for power distribution companies and both low and medium voltage costumers [1-4]. There are many reasons for more attention to power quality of power distribution companies such as connect networks together to form larger networks because of fault element in the network, increasing harmonics in power systems, customers' increasing awareness of power quality issues, increased sensitivity of electrical devices against disturbances of distribution networks [5-7]. Because of the rise of unbalanced loading on each phase, biased faults always take place in the distribution system which beginnings unstable voltage and current with negative component [8]. The distribution sector as the main link between the people and the power industry role more evaluation and judgment than other power parts and that's why the increasing quality of the electricity distribution is essential. In addition, determine the optimum capacitor placement in the distribution system is used to minimize the energy losses with improving the voltage profile of the system and then enhancement of the power factors of a distribution system [9-13]. Many potential applications such as heuristics and linear non-linear optimization techniques have been explored to solve the power quality problem [14].

## Principle of D-STATCOM

The D-STATCOM has been applied as a favourable device to provide an important role in the distribution system such as voltage sag mitigation, voltage stabilization, flicker suppression, power factor correction, and harmonic control [14-16]. It is notable that D-STATCOM is one of the important devices that are able to solve the power quality problems at the distribution network [17-18]. D-STATCOM has been used to solve the unbalanced faults in the system as a certain controller [18]. D-STATCOM is an unbiased three-phase voltage or current through an ability shunt device so that can control the magnitude and the phase angle [17]. Distribution Static synchronous compensator (D-STATCOM) includes a voltage source inverter like a controller, a DC energy storage and Gate Turn off (GTO) thristor which causes a balanced set of current or three phases sinusoidal voltage at the basic frequency. There is an efficient control of both active and reactive power which use as connecting device between the D-STATCOM and the AC system. Absorb or produce controllable active and reactive power can be applied by D-STATCOM construction [2].

Generally, the core of a D-STATCOM made of a three-phase inverter which on one side is connected to the network through the transformer and from the other side end to a capacitor which is its DC power. In addition, the input signals include voltage of bus (V), output current of convertor (I) and a reference voltage (dc). The real power is determined by reference voltage which is absorbed by the AC system to provide its internal losses.

## Basic Concepts of Genetic Algorithm

In this paper Genetic Algorithm (GA) is used to Placement and determine the D-STATCOM as an optimal system [19]. Also, GA is an effective method in bulky and extended places that has coded variables so that led to the optimal solution [20]. The advantage of coded variables is that the code is the ability to transform a continuous space to a discrete space [21]. We use the GA method optimization in population or a set of points in a certain moment while the old method optimized has been applied for only point. This means that the large number of projects can be processed at a same time by GA and also it is notable that, GA method is based on directed randomness. In order to use of GA many concepts such as defined the objective function or cost function, definition and implementation of genetic space and definition and implementation of GA operators.

**Placement of D-STATCOM in network**

Simulation results on a 30 bus of the IEEE are investigated that is one of the famous systems of power quality. After simulation of 30 bus of IEEE, Placement Optimizer of D-STATCOM is designed and then determine of D-STATCOM reactive power is calculated by using a combination of GA and ACA.

Determine the required number of D-STATCOM, placement and also the amount of reactive power generated or absorbed by the D-STATCOM is very significant stage to D-STATCOM designing. Due to economic considerations especially in power systems three similar D-STATCOM is installed. Because, the system has 30 buses, so, 30 choices are for the location of each D-STATCOM. Generally, one of bus uses to reference bus, and therefore, different modes for 3 D-STATCOM installed at 29 buses is as follows.

$$s = \frac{(n-1)!}{r!(n-1-r)!}$$

(1)

Where (n) is total of bus and (r) is the number of D-STATCOM. Also, in order to obtain possible states(s) for three number of installed D-STATCOM in the system, we can write.

$$s = \frac{(30-1)!}{3!(30-1-3)!} = 3654$$

(2)

Thus, 3654 non-repetitive mode is available for the installation of D-STATCOM in the power system and also, finds an optimal point in all cases is focused by the combination of AG and GA.

**Genetic Algorithms to Placement and Determination of D-STATCOM**

Due to important designing of active loads in each bus of D-STATCOM, the active and reactive power of each system is determined as follows.

p= [40.0000 -2.4000 -7.6000 -94.2000 0 -22.8000 -30.0000 0 -5.8000 0 -11.2000 40.0000 -6.2000 -8.2000 -3.5000 -9.0000 -3.2000]

-9.5000 -2.2000 -17.5000 40.0000 40.0000 -8.7000 0 -3.5000 40.0000 0 -2.4000 -10.6000] (MW)

Q= [5.3000 -1.2000 -1.6000 -19.0000 0 -10.9000 -30.0000 0 -2.0000 0 -7.5000 25.0000 -1.6000 -2.5000 -1.8000 -5.8000 -0.9000 -3.4000 -0.7000 -11.2000 15.0000 8.4000 -6.7000 0 -2.3000 30.0000 0 -0.9000 -1.9000] (MVAR)

As can be seen, the values of active and reactive power at the reference bus (bus 1) is unidentified so, these unidentified powers can be solved by the Newton –Raphson method.

There is not compensation by first bus in the range of 2 to 30, so, cost function can be defined as.

$$F_1 = 1000e^{(-1000[round(x(1)-x(2))])} + 1000e^{(-1000[round(x(1)-x(3)])} + 1000e^{(-1000[round(x(2)-x(3)]}$$

(3)

Where x (1), x (2) and x (3) are location of D-STATCOM respectively and also, If the selected location will be repeated, $F_1$=0.

The following equation is used to placement x (4) and x (6) in the range of 2 to 30.

$$F_2 = 1000e^{1000(X(1)-31)} + 1000e^{1000(X(2)-31)} + 1000e^{1000(X(1)-31)} + 1000e^{1000(1-x(1))} + 1000e^{1000(1-x(2))} + 1000e^{1000(1-x(3))}$$

(4)

Where x (4), x (5) and x (6), respectively, represent the reactive power generated or absorbed by each of the D-STATCOM. Also $F_3$ is applied in the range -50MW to +50MW to calculate the amount of reactive power generated or absorbed by each of the D-STATCOM as follows.

$$F_3 = e^{1000(X(1)-50)} + e^{1000(x(2)-50)} + e^{1000(x(3)-50)} + e^{1000(-50-x(1))} + e^{1000(-50-x(2))} + e^{1000(-50-x(3))} \quad (5)$$

After determining the amount and placement of each D-STATCOM in its bus by GA and then loss of the entire network is calculated by Newton-Rawson Method will be calculated, subsequently, cost function to minimize is defined by the genetic algorithm, so, we can write.

$$F_t = F_1 + F_2 + F_3$$

The following values are selected to minimize $F_t$ by the GA.

Population size = 40, Mutation function = Gaussian, Mutation scale = 1and Mutation shrink = 1

The simulation results in is shown as below.

**Table. 1**. Simulation results of the GA

| | Number of bus | Reactive power output |
|---|---|---|
| D-STATCOM.1 | 4 | .313825. |
| D-STATCOM.2 | 5 | 23.5348 |
| D-STATCOM.3 | 10 | 32.4501 |

Total system losses with and without the D-STATCOM that is included the power losses in total transmission lines are shown in Table (2).

**Table.2**system losses

| | |
|---|---|
| Losses Without D- STATCOM | (MW) 5.1685 |
| Losses with D-STATCOM | 3.6441 (MW) |

The voltage range of each bus in the system without D-STATCOM and with D-STATCOM is shown in figure (2) as:

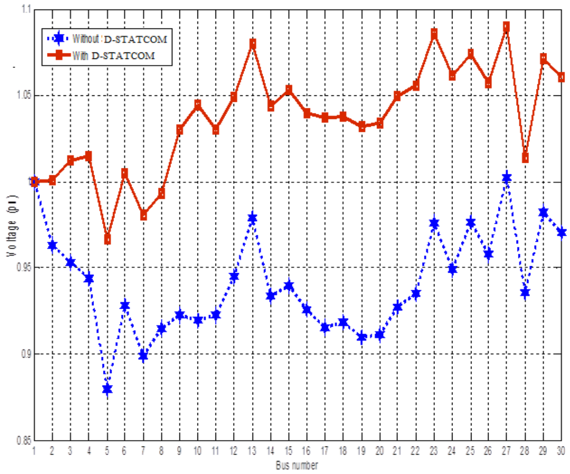


**Fig.2**.Profile voltage in 30-bus system with and without D-STATCOM

As shown in figure (2) existing of three D-STATCOM in the system not only reduces losses, but also improves the voltage profile and increasing the voltage of all bus in power system.

## Conclusion

Recently, improving of power quality has been considered for compensation of reactive power and harmonics because to solve the problem of optimum reconfiguration in distribution systems, an optimal manner has been needed. This paper presents a new approach for optimal manner of distribution systems which GA is utilized for determining the amount of reactive power generated or absorbed by each D-STATCOM. Installation and utilization of the D-STATCOM in distribution networks leads to especially significant for network qualities such as reducing of ohmic losses in transmission lines, improve voltage profiles and system efficiency. Finally, maintenance costs of the D-STATCOM in distribution networks and power systems are negligible so that the energy savings and economizing will be significant.

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