D-STATCOM OPTIMUM POSITION AND SIZING IN A DISTRIBUTION SYSTEM USING VARIOUS APPROACHES

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Abstract

This paper provides a brief idea of the various methods used to evaluate the position and scale of D-STATCOM under different conditions in a distribution network. As we all know, most of the loads in the distribution network system are inductive, causing lagging power factor that causes power losses, voltage instability, voltage variations, load variations, security issue of the system that affects power transfer performance. Distribution Static Compensator (DSTATCOM) is a shunt connected voltage source converter that has been used to compensate for reactive electricity, reduce power loss, boost voltage profile, minimize total harmonic distortion of average voltage, average voltage variance, cost of investment reduction. D-Optimum STATCOM's Placement is a challenging job and it plays a critical role. In order to ensure adequate investment of the system in networks that will increase the voltage stability margin, minimize power loss and boost the voltage profile, the required position of DSTATCOM is of crucial importance. A lot of research is going on to optimize D-location STATCOM's and sizing in a radial distribution network. This analysis provides an idea of how the position of DSTATCOM can be calculated in a distribution network under various realistic conditions.

Keywords: *DSTATCOM, Optimal placement, Voltage stability, power loss, Distribution system.*

1. Introduction

Everyone now depends for a few days on the use of electricity, which has become part of our lives. For electrical power systems, the generation of electrical energy, transmission and distribution are very important. It is governed by either a number of entities or a single entity. Construction, layout, security of various electricity supply schemes with generation and medical records for the benefit of society. The key motive of the distribution system is to provide exceptional electricity to the customers from transmission. A key portion of the electrical power, however. With the aid of recent studies, it is proven that the energy produced is wasted as I2R losses at the distribution stage. In the distribution network, the majority of loads are inductive in nature. Because of this the problem of network power lags in the countryside. Because of this the voltage profile may be negative, electricity losses may increase and greater problems may be generated within the distribution network.

The Power delivery system takes away the high capacity of transmission circuits for electrical energy. Below this level, so many electrical loads are connected. The distribution system has a very high R/X ratio relative to the transmission system, causing high voltage drops and power losses.

Increased demand for traditional sources for a few days now, so that it can transition to distributed renewable energy sources. We get 13 percent of electrical energy lost in line losses (I2R) in the distribution sectors from the estimated data. Power loss reduction is calculated from the customer side as the most significant problem.It is important to maintain a consistent and reliable enhancement of the profile of operating voltages in the electricity grid. Using compensating equipment, power loss reduction and voltage profile enhancement can be achieved. Such as shunt and collection reactors, capacitor banks, Automatic Voltage Regulator (AVR) and Distribution Network Versatile AC Transmission (DFACTS) have also been developed for this relatively advanced device. Static Synchronous Series Compensator (SSSC) systems are DFACTS systems.The DFACTS devices are Static Synchronous Series Compensator (SSSC), Distribution Static Compensator

Traditionally, shunt capacitors are used within the distribution networks to cope with the compensation of reactive power. But the disadvantages of the shunt condenser are

Inability to produce uninterrupted reactive variable strength.

As a result, utilities have to pay higher costs for the installation of capacitors.

The related resonance has few operational concerns.

In addition, load balancing is not feasible.

In distribution companies, DSTATCOM (DFACTS) is used to overcome the above-mentioned disadvantages and to compensate for the reactive electricity needs. Recently, the financial way and productive way is using energy electronics mainly based distribution versatile AC transmission machine era to increase the electricity greatly.D-FACTS (Distribution Versatile AC Transmission System) devices are implemented to develop the overall gadget output at strategic locations of the sharing structures. Originally, the concept of FACTS devices was created for transmission systems, but similar concepts have begun to extend to delivery systems.

2. Construction of D-STATCOM

The D-STATCOM Constructional Knowledge and Theory is as follows. It is connected to the main distribution line in the shunt for voltage sag and swell compensation. It is composed of the following elements:

a. Voltage source converter (VSC)

b. Injection transformer

c. Control unit.

d. Energy storage device.

3. Principle of operation of D-STATCOM

The It is a voltage source converter (VSC) connected to the distribution system in shunt by a coupling transformer by means of a linked tie reactance to compensate for the load current and maintain a fixed voltage profile. The VSC converts the dc voltage to a range of three-phase AC output voltages in the storage system via the injection transformer reactance, these voltages are coupled with the ac system and they are in phase with the line voltage.The phase and magnitude adjustment of the D-STATCOM output voltages enables the active and reactive power exchanges between the DSTATCOM and the AC system to be effectively controlled. This form of configuration enables the system to absorb or produce active and reactive power that is controllable. If the load voltage/line voltage is greater than the desired load voltage, reactive current or power is absorbed by D-STATCOM; if on the other hand, the load voltage amplitude is lower than the desired load voltage, reactive current or power is supplied to increase the load voltage.

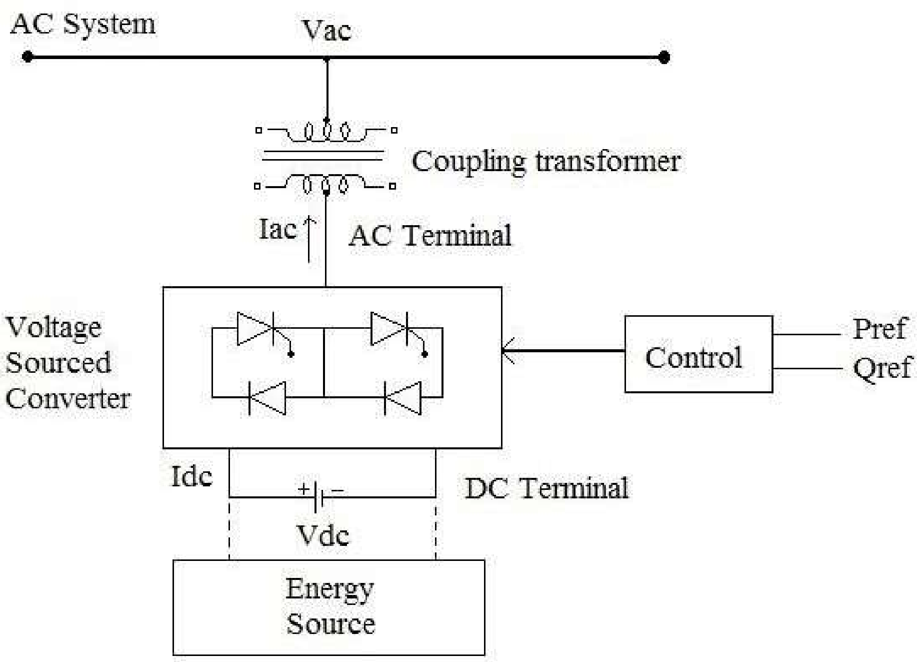

Fig.1: Block diagram of D-STATCOM

Voltage Source Converter (VSC): The VSC attached to the AC system in the shunt converts the storage device's dc voltage. There are three functions it serves:

• Generating voltage and injecting reactive power.

• Power factor correction.

• Removal of current harmonics.

Injection transformer: It is a two-winding transformer with one high-voltage side and one low-voltage side. On one side, while the low voltage side is connected to the D-STATCOM circuit, the high voltage side is connected to the distribution network in shunt. Via the injection converter, the DSTATCOM passes the current into the device. The distribution line is also separated from the D-STATCOM by the injection transformer.

Control unit: For the proper functioning of the D-STATCOM system, a controller is used. The PI controller is used in this paper to research the function of D-STATCOM under the impact of faults and dynamic load.

DC storage: The purpose of the energy storage system or dc storage is to supply the VSC with the required energy to convert the direct quantity into alternating quantities and flow through the injection transformer to the main distribution line. The most widely used energy storage systems are batteries and the battery decides the amplitude of the sag or swell of the voltage.

4. Optimal Placement of D-STATCOM and sizing

DSTATCOM's proper setting is important for optimizing its benefits. This device's optimum position enhances load ability, compensates for reactive energy, improves reliability, decreases power loss, and improves the efficiency of electricity. It affects the system and function when the unit is incorrectly mounted. The D-STATCOM is classified into three groups of common techniques for placing and sizing. They are

1) Analysis of modals
2) Analytical Techniques
3) Optimization Techniques
4) Metaheuristic methods
5) ANN based Approach

1. Analysis of Modals:

In time-domain simulation, modal analysis is nothing but a study of the properties of a system. D-STATCOM analysis may be conducted to determine a solution to a problem in a distribution network.

2. Analytical Techniques

The analytical methods create an algebraic expression and robustification and optimization can be studied. The computer is depicted in these strategies with the help of a mathematical model and calculates numerical responses without delay. The results obtained by these methods are very precise and also give less processing time. These kinds of techniques are mainly for simple and small devices in which there is less range for the amount of state variables involved. The methodological methods that are applied are the Index approach, the Power Stability Index, the Sensitivity analysis. Analytical techniques, however are not ideal for large and complex systems, as they perform adversely in recognizing computational efficiency.

3. Optimization Techniques

The optimization system is focused on the available set of alternatives to find the correct answer. It's miles hard to find the most suitable size and position of the compensating gadgets manually in common as the dispersal systems have numerous nodes. The literature utilizes various optimization methods. A variety of methods are known as classical techniques for optimization. Intelligent approaches are techniques that might be able to cleverly achieve reliable, efficient, ideal solutions. Meta-heuristic search methods are some of the competing techniques. In different areas, these techniques are most useful for solving complications. The following are numerous methods of optimization such as Genetic Algorithm (GA), Fuzzy Logic (FL), Cuckoo Search Algorithm (CSA), Bat Algorithm (BA), Particle Swarm Optimization (PSO), Differential Evolution Algorithm (DEA), Efficient Immune Algorithm (IA), Instantaneous Lively and Reactive Modern Problem Concept (IARCC), Differential Evolution Algorithm (DEA),The primary management algorithm, Firefly Algorithm, Instant Reactive Power Theory (IRPT) control set of rules, Bacterial Foraging Optimization Algorithm (BFOA) and many others are the single section p-q theory.

4. Metaheuristic methods

The most widely used methodologies for solving D-STATCOM allocation problems are metaheuristics. They are stochastic, population-based optimization algorithms that are generally successful in managing environments that are multimodal, multi-objective, discrete and limited.In[40], the immune algorithm (IA) was used by Taher &Afsari to identify the optimal position and setting of D-STATCOM in distribution networks in order to minimize energy loss, expense, congestion of power and improve the voltage profile. A newly defined objective feature has been added, which includes the cost of installing D-STATCOM and the cost of losing electricity. Compared to GA, in both IEEE 33 and 69-bus delivery systems, IA offers lower objective feature value at light, medium and peak load speeds.IA suffers from a premature convergence problem despite its outperformance over GA, which is a common disadvantage of metaheuristics. In 2014, in order to minimize copper losses and boost the voltage profile, Devi & Geethanjali used particle swarm optimization (PSO) to find the position and scale of distributed generation (DG) and D-STATCOM.The simulations were conducted in five separate test cases on several radial distribution systems. However a comparison of this approach with other methods was not included in this study. PSO is a metaheuristic that instead of the global optimum, is likely to converge into local optimals[7]. Jazebi et al. used the Differential Evolution Algorithm (DE) for reconfiguration and D-STATCOM allocation in 2014 to relieve losses and improve the distribution network voltage profile.The proposed approach was tested on 69 and 83 bus delivery networks where DE outperformed PSO. D-STATCOM allocation has been used in the binary gravitational search algorithm (BGSA) to increase the efficiency of the distribution system. In order to decrease the amount of sags propagated across delivery networks, D-STATCOM placement is performed. Compared with other optimization algorithms, the proposed algorithm has not been validated.In 2015, Kanwar et al. implemented an enhanced cat swarm optimization (CSO) in electric distribution networks for the simultaneous allocation of DGs and DSTATCOM to reduce copper losses and enhance the voltage profile. Cat swarm optimization is a technique of optimization focused on the intelligence of a powerful newly formed swarm that mimics cats' natural behaviour, but generally suffers from low convergence and accuracy.The improved CSO (ICSO) technique is then proposed to effectively solve the problem by changing CSOs' search behaviour. The results of the simulation show the efficiency of the proposed updated CSO with regard to traditional CSOs and PSOs. For optimum allocation of photovoltaic arrays and D-STATCOM, Tolabi et al applied fuzzy-based ant colony optimization (ACO). The goal of this research was to reduce losses, improve voltage profiles and improve the balancing of feeder loads.Fuzzy definitions have been used to deal with different targets. Concerning traditional ACO, fuzzy-based PSO and fuzzy-based GA, the results show the performance of the proposed fuzzy-ACO. The Firefly algorithm is used to assess the optimal location of D-STATCOM to boost power efficiency. The aims of the research are to alleviate harmonics and enhance the profile of voltage. Four D-STATCOM's used in solving the problem of optimum allocation of D-STATCOM.The results showed the firefly algorithm's outperformance over GA and PSO. The harmony search (HS) algorithm, inspired by the music improvisation method, was used in another research work to find the optimum position and size of D-STATCOM with an objective function to reduce copper losses[28]. The approach suggested has been tested for the IEEE 33-bus delivery network.The results of the proposed HS in reducing losses indicate its outperformance over IA. In order to solve the D-STATCOM allocation problem, Chabok and Ashouri suggested a combination of imperialist competition and Nelder-Mead algorithms. Active network power losses and an index of voltage stability were included in the objective feature. For optimal allocation of D- STATCOM's, a hybrid genetic algorithm and ant colony optimization algorithm were designed.The feeding system losses involving power losses in the transmission lines were reduced by this technique. For the IEEE 30-bus system, three D-STATCOMs were used. To reduce overall device losses, the optimal reactive power values produced or absorbed by three D-STATCOM are determined by GA. In smart quest, ACO is used to decide the best point for the network to mount three D-STATCOMs.

5. Artificial Neural Network based methods

For modelling online nonlinear systems with multiple inputs and outputs, Artificial Neural Networks (ANN) are used. In the literature, some applications of ANN-based approaches can be found, such as fault detection, voltage regulation, reactive power control and voltage disturbance detection. These methods are capable of finding the optimum position of D-STATCOM under faults in the distribution network.They are not applicable to optimum D-STATCOM sizing, however. For the optimum allocation of DVR and D-STATCOM in distribution networks, the artificial neural network (ANN) was used to mitigate the voltage sag under faults. Using a feed forward ANN, optimal DVR and D-STATCOM positions have been found. Each bus's pre-fault voltage has been considered as the output target data. For D-STATCOM placement, the bus with the greatest voltage deviation from the target value is the highest.

The authors have suggested different techniques in which DSTATCOM is tabulated for top-rated sizing. Computational time in the methods suggested is extra. Despite this the authors have had pleasant implications for the high-quality sizing and positioning of DSTATCOM for the reduction.

Table 1: Optimization Techniques and advantages

S.NO	Authors	Methodology used	Observations and Advantages
1	Jazebi, S., Hosseinian, S. H., &Vahidi, B. (2011)	Differential evolution algorithm	The differential evolution set of rules in distribution networks has evaluated its special abilities through its high computational search efficiency and right convergence homes.
2	Zaveri, T., Bhalja, B. R., & Zaveri, N. (2011)	Instantaneous active and reactive current component (IRACC)theory	The techniques are effective and strong for a wide range of load and supply circumstances. It is also efficient in reducing the supply VA score balance of supply currents and in achieving power problems.Correction under different load conditions in contrast to an uncompensated scenario.
3	Zaveri, T., Bhalja, B. R., & Zaveri, N. (2012)	Instantaneous active and reactive current component (IARCC) theory	For linear load, correction of power elements is performed. This results in a reduction of the reactive energy supplied from the source. For non-linear load, electricity source component solidarity is achieved.
4	Arya, S. R., Singh, B., Chandra, A., & Al-Haddad, K. (2012)	Single phase p-q theory based control algorithm	Suitable in time varying loads for ZVR and PFC modes of operation.
5	Masoud Farhoodnea, Azah Mohamed, Hussain Shareef,Hadiayandehroodi. (2013)	Firefly Algorithm	To boost the system's voltage profile and to minimize the THDV and the overall cost of investment. In radial distribution

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			systems, the most efficient position and optimum size of the D-STATCOM can be calculated..
6	S M Suhail Hussain, M Subbaramiah	Modelling, Load flow technique.	Effective and easy to implement.
7	Jain,A., Gupta, A.R., & Kumar, A. (2014)	Stability Index	Reduction in Active power losses and Better voltage profile.
8	Abhinav Jain ,A.R. Gupta, Ashwani Kumar (2014)	Stability Index	It provides efficient solutions for the improvement of power loss and voltage profile with benefit for the utilities.
9	Yuvaraj, T., Devabalaji, K. R., & Ravi, K. (2015)	Harmony Search Algorithm	For n number of buses it may be applied. For finding most efficient answers it is very accurate Better than the present Immune algorithm
10	Tolabi, H. B., Ali, M. H., & Rizwan, M. (2015)	Fuzzy-ACO approach	In contrast to ACO, fuzzy-GA and Fuzzy-PS, simultaneous allocation and multi-goal reconfiguration of DSTATCOM and PV with fuzzy ACO approach is observed to be better
11	Amal Amin, Salah Kamel, Juan Yu,	Power stability index and Sensitivity analysis	1) To determine the optimal position for DG and DSTATCOM, the Power Stability Index method is used and Sensitivity Analysis is used to determine the distance. 2) Minimization of power loss is achieved and the voltage profile is improved. 3) Radial systems are limited.
12	Atma Ram Gupta, Ashwani Kumar	(a) Optimal D-STATCOM placement based on the new reactive power stability index (b) Determination of bestDSTATCOM size with probabilistic ZIP load model	1) This study enables the engineer with D-STATCOM to prepare the distribution system. 2) Improved profile of voltage and reduction in losses.
13	Majid Moazzami,HosseinShahinzadeh, Gevork B. Gharehpetian, Seyed Hossein Hosseinian	Modified Shuffled Frog Leaping Algorithm(MSFLA) is applied to minimize the objective function to achieve the optimal place and size of these instruments in distribution system.	Stability of voltage and reduction of losses in the delivery networks. Improve the voltage profile and reduce the line current in distribution systems to decrease energy and power losses.

CONCLUSION

DSTATCOM is a shunt connected voltage source converter used to compensate for reactive power, reduce power loss, boost the voltage profile, minimize total harmonic distortion of the average voltage, average voltage deviation, investment cost reduction etc. A suitable position and size to place the DSTATCOM at a suitable size is very necessary to ensure that the system is sufficiently invested in networks that increase the voltage stability margin, minimize power losses and improve the voltage profile of the distribution network.

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