# REVIEW ON POWER QUALITY IMPROVEMENTS IN DG USING DSTATCOM AND DVR

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## Abstract

*Power quality impacts equipment manufacturers, customers, and electricity suppliers in recent times. Power quality refers to variations in frequency, current, and voltage in a power system. The electromagnetic ion [EMI] phenomena that characterize current and voltage at a certain time and place in the power system. Manufacturing and process unit technology is used in so many industries today. A power supply device of higher quality and reliability is required for this technology. Power supply efficiency is highly sensitive to industries such as semiconductors, manufacturing, and computer equipment. There are many types of network disturbances associated with PQ, including voltage, harmonic distortion, impulse transients, sags and swells, interruptions, and flicker. More often than any other phenomenon of power quality, voltage swells and sags occur. Voltage sags/swells are the most unfavorable PQ issue in the power distribution system. This paper examines how power quality (PQ) occurs in distribution devices.*

*Key words:, Custom power, Power Quality (PQ), Dynamic Voltage Restorer (DVR), Distribution Static Compensator (DSTATCOM)*

## 1.0 INTRODUCTION

Power Loss is a major issue concerning distribution systems as it is operated at low voltage and high current compared to a transmission network. This in turn, causes raise in the active power loss and voltage profile is lowered to a major extent in the distribution feeder. The biggest challenge around the world to many distribution companies is to reduce these losses. So, power loss minimization is considered to be the most essential step to be taken for economic operation and energy cost reduction. During the last few years, distributed generation (DG) technologies are attracting utilities and regulators as the most flexible grid assets. DG resources have made their major way through the distribution systems due to factors such as environmental concerns, liberalization of electricity and congestion of transmission and distribution lines. A general definition for DG suggested in as "Distributed generation is an electric power source connected directly to the distribution network or on the customer side of the meter". DG's modularity, compact size, and low investment cost make it a valuable resource in the development of power distribution networks. The distribution system's operating characteristics and the DG's characteristics determine the extent to which these DGs contributes positively or negatively to the system. Positive impacts are generally called 'system support benefits', as major system upgrade is possible, lowers the total energy loss and increases the quality of the supply and reliability. Though there are positive impacts, certain technical challenges with the addition of active DG units are of higher prominence in the conventional systems. Thus, the DG units should be placed properly and optimally sized in an effective manner without causing degradation of reliability, system operation and power quality.

### 1.1 Distribution Network Congestion

Congestion of the distribution system is an issue that can take different forms such as a sudden increase in the load demand and an outage of transmission lines and generators. In order to solve this issue, several methods are used such as Distribution Network Reconfiguration (DNR) and Optimal Placement and sizing of Distributed Generators (DGs). Network Reconfiguration is a method that deals with the uncertainty of loads by opening a few sectionalizing switches and closing a few tie switches. Optimal Penetration of DGs has many advantages including improvement in the voltage profile, security, reliability, and minimization of transmission losses by installing DGs in proximity to the user. Several algorithms have been proposed for distributed generation placement and sizing in distribution networks to minimize real power loss and improve the voltage stability of the power system. However, very few of these algorithms have used network reconfiguration in parallel with the DG location and size for the maximum system loss reduction.

### 1.2 Advantages Of Distributed Generation

The basic merits of Distributed Generation are given below:

- Reduces the cost as there is no use of long transmission line.
- Reduces the complexity.
- Environment friendly.
- Easy to maintain and easy to operate as it consists of simple construction.
- Better power quality and reliability.
- The factor of high peak load shortage gets eliminated.
- Improves the efficiency of providing electric power.

## 2.0 LITERATURE REVIEW

**Askar Bagherinasab et al [1]** In this work, a modern algorithm by hybrid genetic algorithm and ant colony 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. As part of the cost-benefit analysis, three DSTATCOMs are strategically placed in the 30-bus IEEE model. D-STATCOMs are distributed according to ant colony optimization. **D.K. Tanti et al [2]** In In their study, an Artificial Neural Network (ANN) based approach for optimal placement of Distribution Static Compensator (DSTATCOM) and Dynamic Voltage Restorer (DVR) in a power system network has been considered to mitigate voltage sag under faults. Voltage sag under different type of short circuits has been estimated using MATLAB/SIMULINK software. **Mohit Bajaj et al [3]** In their study presents a modified id-iq based control algorithm for time varying active and reactive power control and load harmonics compensation by DSTATCOM under load fluctuations. The proposed scheme of control algorithm has been introduced for enhancing steady-state performances in addition to useful elimination of power quality disturbances. Employing a preexisting D-STATCOM to attain these added control purposes can advantage system handling operators to maximize complete response of the system. **P. K. Kaushal [4]** To overcome the problem of voltage profile and Power losses in radial distribution system (RDS) is a task that must be solved through different optimization technique. IEEE33 bus system is taking for sensitivity analysis some buses sensitivity is drastic changed so need of real power support it is calculated by LSO. **Rakesh Choudhary et al [5]** In their study presents real and reactive power loss of IEEE-33 bus radial distribution system using local search optimization for dg placement at optimum location. It describes active power loss, reactive power loss and voltage profile of radial distribution system as well as distributed generation. **Zaenab muslimin et al [6]** The electrical energy demand continues to increase along with the rapid development of technology and population growth. Fulfilling the electricity supply is a challenge for the operation of the electric power system since the construction of distribution and transmission infrastructures require large costs and such long-time process. **Bindeshwar Singh [7]** In their study presents the enhancement of voltage profile using distributed generation (DG) incorporated with distribution static synchronous compensator (D-STATCOM) with different load models (DLMs) such as constant power, constant current, constant impedance, composite and reference load modelsin distribution power networks by using genetic algorithm (GA) from minimization of total real power loss of the system. **Chandan Kumar et al [8]** The proposed control scheme combines two methods of DSTATCOM operation to improve its performance. Considering power factor and voltage magnitude as degree of freedom, the DSTATCOM provides features such as mitigation of voltage and current harmonics, balancing of source currents, improvement of power factor, voltage regulation during voltage sag and swell, reduction in inverter losses, and control of load power to achieve energy conservation. The performance of proposed DSTATCOM control is better as compared to its conventional operation at any time of operation. PSCAD simulation and experimental results validate the performances. **Eklas Hossain et al [9]** In their study discusses the power quality issues for distributed generation systems based on renewable energy sources, such as solar and wind energy. A thorough discussion about the power quality issues is conducted here. In their study starts with the power quality issues, followed by discussions of basic standards. A comprehensive study of power quality in power systems, including the systems with dc and renewable sources is done. **Pooja Sharma [10]** In this research work, the power flow problem, also called as the load flow problem, has been dealt with. The load flow solution gives the complex voltages at all the buses and the complex power flows in the lines. To obtain power flow solution, the most popular Newton-Raphson method is used. The method has been used to obtain power flow solutions and is tested on IEEE 57- bus distribution system. **Susanta and Roy [11]** developed chemical reaction optimization for optimal location of STATCOM, in order to solve optimal reaction power dispatch problems. STATCOM can minimize transmission losses and voltage deviations and improves voltage profile, voltage stability of the system. This CRO method is more efficient than PSO and DE. **Rezaee Jaordehi [12]** developed Brainstorm optimization algorithm for optimal placement of FACTS devices, it is heuristic algorithm, which is inspired from Brainstorming process in human being. SVC and TCSC devices are used for voltage profile enhancement, over load minimization and loss reduction. Compare to enhancement GA, PSO and DE, this BSOA provides better voltage profile and less power losses.

**Table: Power Quality Using Dg & Facts in IEEE 33 & 57 Bus System**

| REFERENCE | STUDY | METHODS | CONCLUSION |
|---|---|---|---|
| Sujata Huddar (2014) | In their study distributed generation source placement for minimizing loss is proposed. | The most popular DG placement methods such as Optimal Power Flow using NR method and Evolutionary Computational Method including Genetic Algorithm | That's why the most of researchers have been divided the problem into limited parts along with imposed constraints and then they were tried to propose their solutions. |
| Ghassan Abdullah Salman (2018) | Review of optimal siting and sizing techniques for distributed generation in the distribution system | Multi-objective problems, however, require a study of different optimization methods in order to find the optimal solution | The DG in the distribution system reduces the losses, voltage profile improvement, system reliability, and economic benefit to the system |
| P. Lokender Reddy (2019) | The study covers a comparison between the proposed approaches and shows the importance of installing the right amount of DG in the best suited location. | The objective function consists of both power losses and investment costs and the methods are tested on the IEEE 69-bus system. | In some cases, they become even larger than the ones in the base case. Furthermore, the voltage profiles are also degraded if the optimal solution is not implemented |
| A.D. Rana, J.B. Darji (2014) | This paper presents a new method for | The proposed method utilizes gravitational search algorithm | the optimal sizing of the DG was performed with |

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|---|---|---|---|
| | determining optimal sizing and suitable placement for distributed generation (DG) in distribution system. | (GSA) in the optimization process and its performance is compared with other optimization techniques | the GSA technique. The multi-objective function was to minimise the total power loss and THDv |
| Mohammad Farhadi (2018) | This paper offers a composite survey on various optimization techniques and objectives, aiming at optimal siting and sizing | The scope of this paper covers analytical/numerical, heuristic/meta heuristic, and other relevant optimization techniques. | Hybrid techniques are used for future research work in planning, operation and optimal placement, for enhancing the performance of power networks |
| | of DG units | | |
| Dr. A. Lakshmi Devi (2012) | In this study, a loss sensitivity factor, based on the equivalent current injection, is formulated for the distribution systems | the conventional techniques developed for the transmission systems generally fail on the determination of optimum size and location of distributed generations. I | impedance or Jacobian matrix with only one power flow for radial systems. The method is easy to be implemented and faster for given accuracy |
| Gopiya Naik (2018) | To determine optimal location and size of DG so as to minimize real/active power loss in the distribution network | The proposed method is applicable for sizing and siting of single DG unit at a time. | However, in case of load power factor DG, it is better as compared to the case with unity power factor DG. |

| | | | |
|---|---|---|---|
| Alan (2012) | Optimal placement and sizing of DG in distribution network is an optimization problem with continuous and discrete variables. | The SFLA is a meta-heuristic search method inspired from the mimetic evolution of a group of frogs when seeking for food | Test results indicate that SFLA method can obtain better results than the simple heuristic search method on the 33-bus radial distribution systems |
| Kola Sampangi (2018) | to improve system overall efficiency with minimum power loss, maximum system security, voltage stability, and reliability | This technique offers efficient and reliable global optimum solutions for complex multi-objective problems. | Meta-heuristic and hybrid techniques are well suitable for extensively large systems. They process with high accuracy and splendid convergence features |

**2.1 Literature findings**

In the formulation of the DG allocation problem, the objective function may have a variety of forms. To control excessive losses and feeder overloading result from non-optimal integration of DGs and D-STATCOMs deployed in non-optimal locations with non-optimal ratings. For nonlinear optimization problem, simple algorithm to reconfigure a fault Current voltage for all buses, and new technique is based on multiple objectives are needed. Some of them still need to require the vast research in keeping DG and compensatory with DVR and D-STATCOM. The research need to continue for finding of optimal location on the power failures, the areas of improvements are as follows.

1. Reduction or minimization of power losses in a distribution system.
2. Reduction of the economic cost of the system.
3. Improvement of the voltage profile and voltage stability margins or any combination of two or more functions, such as the simultaneous minimization of power losses and total harmonic voltage distortion (THD -V)
4. Simultaneous minimization of losses and maximization of the voltage deviation
5. Simultaneous voltage profile improvement, losses and (THD -V) reduction
6. Simultaneous minimization of DG investment cost and total operation cost of the system.
7. Simultaneous reduction of active and reactive power losses, reduction of

purchased energy from transmission line and improvement of voltage profile.

### 3.0 Methods of improvement

The operating conditions of a power system after connecting DG sources can change drastically as compared to the base case. The planning of DG installations should, therefore, consider several factors: what would be the best technology to be used, how many units of DG and of what capacities, where should they be installed, what connection type should be used etc. The problem of DG allocation and sizing should be approached with caution. If DG units are connected at nonoptimal locations, the system losses may increase, thus resulting in increased costs. Studies have indicated that inappropriate locations or sizes of DG may lead to greater system losses than the ones in the existing network . In DG based microgrids, the loads and generators are in the close vicinity to aid continuous power supply. However, the power electronic interfacing towards DG systems gives rise to some of the serious power quality problems, such as, the reactive power compensation and the generation of harmonics that pollutes the power distribution system. Reactive power compensation is becoming a challenging task to sustain an acceptable degree of power quality in microgrids due to tightly coupled generation and distribution. Therefore, current research is to cope up with the expanding microgrid system and mitigation of these concerned issues. Recent trends are geared towards the realization of multitasking devices to tackle several power quality problems simultaneously. Subsequently, the challenges and power quality issues faced in the microgrid are observed and succeeded by a review of compensation methods against these concerns using various control techniques, algorithms, and devices. The research work is focused on optimal reactive power dispatch scheduling, optimal reactive power pricing with the objectives of active power transmission loss minimization, bus voltage deviation minimization and L index minimization as well as development of competitive reactive power market mechanism based on uniform auction mechanism.

### 4.0 Facts Devices in Power Quality Improvement

The discussed enrichment of the quality of the voltage using FACTS in this part. A new approach has been developed to reduce voltage fluctuations. The usage of the Distribution Static Compensator was questioned The Distribution Static Compensator acts as various negative and positive series behaviors at the basic frequency. DSTATCOM is used for renovating a positive sequence voltage to its nominal value and for suppressing a negative sequence voltage at its adequate value. In terms of voltage fluctuations at the site of installation, conductance command is effectively designed to minimize voltage variation results from the renewable energy's variable sources and load changes. Low voltage microgrids would be high voltage distortion, resulting in harmonic currents. In this analysis, the harmonic current is suppressed with a resonant current control & the basic current registered the following two inferences are made about the Distribution Static Compensator site.

When the Distribution Static Compensator is near to the source, the regulation of performance is worst. The best regulation for performance is at the DSTATCOM's transmission line's end. In their work on through prominent a Distribution Static Compensator that identifies admittance of positive sequence & conductance of negative sequence for voltage regulations at positive sequence & voltage overcome at negative sequence.

- Both the negative and positive series shunt admittances were effectively regulated with respect to the deviation of the proportion of imbalanced voltage and positive sequence voltage. In the event of variations in DG or load, the voltage quality may be maintained at a sustainable stage.
- To control the basic current within the Distribution Static Compensator & also suppresses harmonic current, the proportional resonant (PR) current regulator with unique harmonic compensation is executed.

**4.1 Voltage Stability Methods:**

**A. Distribution Static Compensator (DSTATCOM):**

The static compensator device is DSTATCOM (FACTS controller, STATCOM) based on a voltage source inverter (VSI). Which is used to sustain a voltage sag of the bus at an adequate stage through the distribution system receiving or supplying reactive power. With the aid of a coupling transformer, it is linked in shunt to the distribution network. The SLD of the Distribution static compensator is exhibited in figure The DSTATCOM is composed of the voltage source inverter, energy storage unit, dc voltage, an ac filter & a coupling transformer.

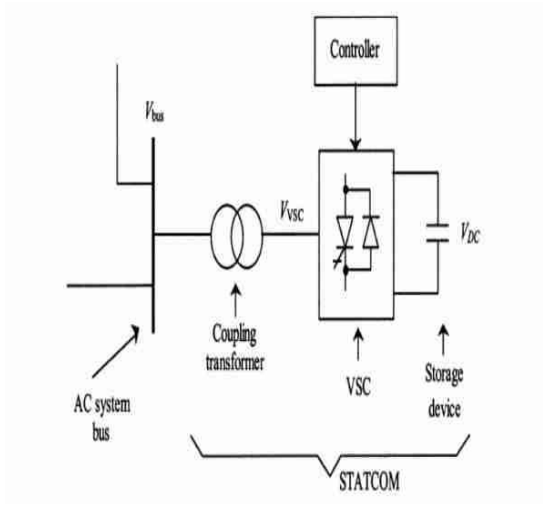


**Figure:1 Schematic diagram of DSTATCOM**

The VSI in a power circuit transfer from DC voltage to a controllable AC voltage and is connected through a coupling transformer to the AC distribution network. The Distribution Static Compensator also uses extensive renewable sources or energy storage to absorb and depend on active power. In accordance with the operating principle of DSTATCOM, the compensation required for the disturbance needs by the distribution system which continuously regulates and monitors the load currents and voltages. The angle b/w of the ac system and the voltage source inverter (VSI) voltage control the active power flow, while the difference between the amplitudes controls the reactive power flow in this scheme. Both current and voltage control modes are assisted by the DSTATCOM.

**4.2 Static Series Compensator.**

The Dynamic voltage restore is also known as a static series compensator (DVR). It is an electronic control device for highspeed switching power, also called the voltage boosters series. The custom-connected electronic device is a Dynamic

Voltage Restorer (DVR) that injects a regulated voltage dynamically into the distribution line to correct the load voltage through the coupling transformer. Figure shows the wide-ranging diagram of the DVR block.

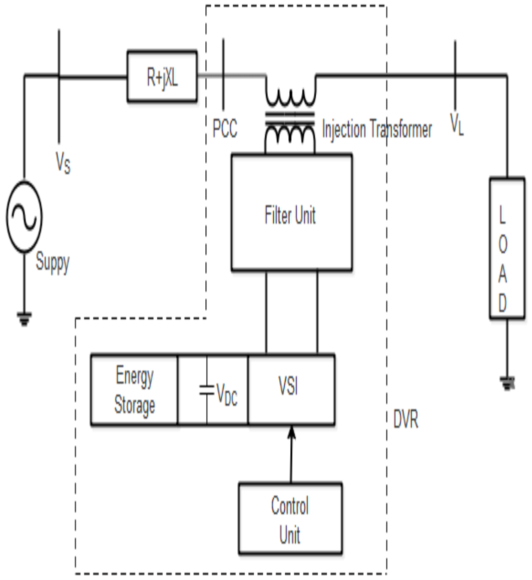


**Figure:2 Schematic diagram of DVR**

It includes a series coupling transformer, energy storage device, the voltage source inverter, the dc-dc boost converter & an ac filter. DC condensers are being used as a boost converter interface as an energy storage device. The voltage above dc capacitor is controlled through the boost converter, which is commonly used as a source of inverter voltage. The inverter method yields a voltage compensation introduced into the distribution device by a series matching transformer. voltage re-regulation is achieved by generating a reference voltage from the Dynamic Voltage Restorer (DVR) controllers, compared to the synchronized injected voltage & source voltage, to keep the load voltage to be constant. The energy storage components generate the essential voltage for synchronized injection. The AC filter eliminates effects on the coupling transformers winding & power electronics, switching losses in the generation of control signal techniques for the inverter voltage source inverter. If the supply voltage Vs(t), the injection voltage of DVR is Vi(t) & load voltage Vl(t) is interconnected serially. The load voltage is as follows

$$Vl(t)=Vi(t)+Vs(t) \qquad (1)$$

Dynamic Voltage Restorer is therefore supposed to be the controlled frequency, phase angle, and amplitude external voltage source. The purpose of the Dynamic Voltage Restorer is to keep the phase angle, amplitude & load voltage.

### 5.0 Conclusions

Despite of proposing many different research studies for DG proper placement, the systematic principle for this issue is still an unsolved problem. In practice, the main problem is the complexity of this process. Indeed, a lot of constraints should be considered simultaneously such as power loss, reliability, load factors, voltage profile (quality), operational cost, emission of greenhouse, the related capacity and so on. That's why the most of researchers have been divided the problem into limited parts along with imposed constraints and then they were tried to propose their solutions. The optimal location of DGs reduces the real and reactive power losses and improves the voltage profile, and based on that, the multi-objective performances index to find the optimal location of DG real power units and their capabilities are proposed. To protect the entire plant, loads, and feeders, these control electronics devices are used in distribution systems. The Distribution

Static Compensator (DSTATCOM) can give the best PQ in both distribution & transmission when linked in the shunt.

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