# A Review paper on Improvement of power quality in distributed generation system using optimization techniques

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***Abstract*— The integration of Distributed Generators (DGs) into power systems offers numerous benefits, including reduced electricity costs, congestion management, loss reduction, and improved voltage profiles. As DGs are expected to play a larger role in meeting future electricity demand, optimizing their placement and capacity is crucial. This paper proposes a Genetic Algorithm (GA)-based method for optimizing DG allocation in distribution systems, aiming to minimize active power loss and enhance voltage profiles.**

***Key word*—Distributed generation, genetic algorithm, voltage profile, active power loss.**

## I. INTRODUCTION

The integration of Distributed Generators (DGs) into power systems offers numerous benefits, including reduced electricity costs, improved voltage profiles, and environmental protection. DGs are expected to play a larger role in meeting future electricity demand. Optimizing DG placement and capacity is crucial to achieve these benefits.

Advantages of DGs

DGs offer several advantages, including:

1. Power loss reduction: DGs can reduce power losses in transmission and distribution systems.

2. Improved reliability: DGs can provide backup power during outages.

3. Voltage profile improvement: DGs can help maintain stable voltage levels.

4. Environmental benefits: DGs can utilize renewable energy sources, reducing pollution.

Optimization Techniques

Genetic Algorithm (GA) is a popular optimization technique used for DG allocation problems. GA can efficiently search for optimal solutions among multiple possibilities.

Problem Formulation

The optimization problem involves minimizing active power losses and improving voltage profiles. This can be achieved by strategically placing and sizing DGs in distribution systems.

Multi-Objective Optimization

One effective approach to multi-objective optimization is the Strength Pareto Evolutionary Algorithm (SPEA), which utilizes the concept of Pareto optimality. A multi-objective optimization problem can be formulated as:

Minimize $F(x) = (f1(x), f2(x), ..., fk(x))$

Subject to $x \in X$ and $F(x) \in Y$

Pareto Optimality

A solution x dominates another solution y if:

1. x is better than or equal to y in all objectives: $fi(x) \geq fi(y)$ for all i

2. x is better than y in at least one objective: $fj(x) > fj(y)$ for some j

A solution is considered Pareto optimal if it is not dominated by any other solution. The set of all Pareto optimal solutions is called the Pareto optimal set (POS), and the corresponding objective function values form the Pareto optimal front (POF).

Pareto Front

The Pareto front represents the trade-offs between different objectives, where each point on the front corresponds to a Pareto optimal solution. By analyzing the Pareto front, decision-makers can identify the best compromise solutions that balance competing objectives.

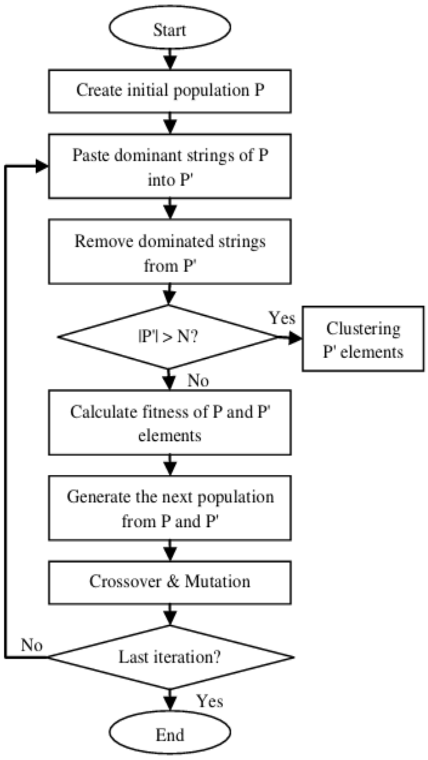


Figure 1. Strength Pareto flowchart.

## II. METHODOLOGY

This paper proposes a GA-based approach to optimize DG placement and capacity. The methodology involves:

1. GA implementation: Using GA to search for optimal DG placement and capacity.

2. Multi-objective optimization: Considering multiple objectives, such as power loss reduction and voltage profile improvement.

Improving Voltage Profile and Reducing Loss using SPEA

The Strength Pareto Evolutionary Algorithm (SPEA) can be used to optimize Distributed Generator (DG) placement and sizing in distribution systems to improve voltage profiles and reduce power losses.

Objective Functions

1. Voltage profile improvement: Minimize voltage deviations from the nominal value.

2. Power loss reduction: Minimize active power losses in the distribution system.

SPEA Application

1. DG placement and sizing optimization: Use SPEA to optimize DG placement and sizing to achieve the objective functions.

2. Pareto optimal solutions: Obtain a set of Pareto optimal solutions that balance voltage profile improvement and power loss reduction.

Benefits

1. Improved voltage stability: Enhanced voltage profiles reduce the risk of voltage instability.

2. Reduced power losses: Minimized power losses lead to energy savings and reduced strain on the distribution system.

Implementation

1. Distribution system modeling: Model the distribution system, including DGs and loads.

2. SPEA algorithm implementation: Implement the SPEA algorithm to optimize DG placement and sizing.

3. Simulation and analysis: Perform simulations and analyze the results to determine the optimal DG placement and sizing.

## III. LITERATURE REVIEW

Recent Studies

- Machine Learning-Based Approaches: Recent studies have explored the use of machine learning algorithms for power quality management and forecasting in grid-connected microgrids.

- Hybrid Renewable Energy Systems: Researchers have investigated the use of UPQC and optimized controllers to improve power quality in hybrid renewable energy systems.

These studies demonstrate the effectiveness of optimization techniques in improving power quality in distributed generation systems. By applying these techniques, power system operators can enhance the reliability and efficiency of their systems.

Optimization Techniques

- Hybrid Optimization Technique: A study by Sengolrajan Thana Singh and A. N. Sasikumar (2024) proposed a hybrid optimization technique to optimize distributed generation resources for power grid quality improvement, demonstrating its effectiveness in enhancing power quality.

- Artificial Gorilla Troops Optimization (GTO): Researchers Mohamed Sayed Hashish et al. (2023) used GTO to solve the probabilistic optimum power flow issue in a hybrid power system with photovoltaic and wind energy sources.

- Genetic Algorithm (GA): GA has been used to optimize DG placement and sizing, improving voltage profiles and reducing power losses.

- Particle Swarm Optimization (PSO): Modified PSO algorithms, such as the one proposed by Venkatesan et al. (2024), have been used to optimize power flow management and improve power quality.

Power Quality Improvement Approaches

- Unified Power Quality Conditioner (UPQC): Studies have shown that UPQC can effectively improve power quality in hybrid distributed generation systems by mitigating harmonics and voltage fluctuations.

- Distributed Generation (DG) Allocation: Optimal allocation of DG units can significantly reduce power losses and improve voltage profiles, as demonstrated by G. Srinivasan (2021) using Adaptive Genetic Particle Swarm Optimization (AGPSO).[5]

- Reactive Power Compensation: Reactive power compensation techniques, such as capacitor placement, can also improve power quality by reducing power losses and enhancing voltage stability.

## IV. CONCLUSION

The proposed approach aims to optimize DG allocation in distribution systems, reducing power losses and improving voltage profiles. The effectiveness of this approach will be demonstrated through simulation results.

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