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THE PLACEMENT OF DG USING TLBO OPTIMIZATION TECHNIQUE IMPROVES POWER QUALITY IN THE POWER DISTRIBUTION SYSTEM

Dr. Basanagouda Patil
Associate Professor Department of E & E Engineering, A.G.M Rural College of Engineering &Technology Varur, Hubli- 581207 Karnataka, India

Dr. Ganesh K
Senior Assistant Professor, Dept of Electronics & Communication Engineering, Alvas Institute of Engineering and Technology, Moodbidre-574225 Karnataka, India,

Tanveer Ahamed Khatib
Assistant Professor Department of E&C Engineering, A.G.M Rural college of Engineering and Technology Varur, Hubli-581207 Karnataka, India

***Abstract* –**The distribution system is more susceptible to power losses than other components of the power system. Reduced power losses and higher bus voltages are the outcomes of optimal distributed generation (DG) integration into the distribution system. The TLBO algorithm was developed in this research with the main objectives of reducing power loss and improving the system voltage profile in order to determine the appropriate DG sizes and placements in the distribution network. An IEEE-14 distribution bus system is used in this work as a case study. The appropriate position and size of the DG are chosen using the voltage stability index. The system's overall performance is assessed after the installation of the DG of the ideal size in the appropriate location, along with enhancements to the voltage profile, voltage balance index, and real power loss reduction. Matlab codes are produced for the TLBO algorithm and the redesigned electrical power system. Results show that the suggested TLBO algorithm is successful in determining the optimal size and location of the needed DG unit.

Keywords- Radial Distribution System-RDS, Power Quality, Power Loss, Voltage Profile, Reconfiguration, Reconstruction

I INTRODUCTION

Electricity distribution systems play a critical role in delivering power from generation sources to end-users, ensuring the reliability and efficiency of electricity supply. Radial distribution systems are one of the most common configurations for distributing electricity, particularly in residential and small commercial areas. However, these systems are susceptible to power losses, which can result in decreased efficiency and increased operational costs. This introduction provides an overview of the importance of power loss minimization in radial distribution systems and the strategies employed to achieve this goal.

The Significance of Power Loss Minimization: Radial distribution systems consist of a hierarchical network of transformers, feeders, and distribution lines, with power flowing from a central substation to individual customers. The primary objective of such systems is to deliver electrical energy reliably and economically. Power losses in these systems occur primarily due to resistive losses in conductors and transformers. These losses manifest as heat and reduce the

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amount of usable electrical energy at the end-user's point.

The significance of minimizing power losses in radial distribution systems includes:

Efficiency Improvement: Reducing power losses improves the overall efficiency of the distribution system, ensuring that a greater percentage of generated electricity reaches consumers.

Cost Reduction: Lower losses mean reduced energy wastage, leading to cost savings for both utility companies and customers.

Environmental Impact: Decreased energy losses contribute to a smaller carbon footprint and align with sustainability goals.

Voltage Quality: Minimizing losses helps maintain voltage levels within acceptable limits, ensuring that customers receive reliable and stable power.

Factors Contributing to Power Losses: Power losses in radial distribution systems can be attributed to various factors, including:

Resistance: The primary contributor to losses is the resistance in distribution lines and transformers, leading to I2R losses where "I" represents current and "R" represents resistance.

Voltage Drop: Voltage drop along distribution lines can result in losses and affect the quality of power supplied to consumers.

Unbalanced Loads: Inefficient load balancing can lead to uneven distribution of power, causing additional losses in some sections of the network.

Reactive Power: Poor power factor, where the system has excessive reactive power compared to active power, can lead to increased losses.

Strategies for Power Loss Minimization:

To mitigate power losses in radial distribution systems, several strategies can be employed:

Voltage Regulation: Maintain optimal voltage levels to minimize resistive losses.

Load Balancing: Ensure loads are evenly distributed among feeders and phases.

Efficient Transformers: Use energy-efficient transformers with low core and copper losses.

Capacitor Banks: Install capacitor banks to improve power factor and reduce reactive power losses.

Smart Grid Technologies: Implement real-time monitoring and control systems for better load management and fault detection.

Distribution Automation: Use automated switchgear and reclose systems for fault isolation and quicker fault resolution.

Load Shedding: Implement load shedding during peak demand periods to reduce losses.

Renewable Integration: Integrate distributed generation sources to reduce dependence on the central grid.

In conclusion, minimizing power losses in radial distribution systems is crucial for ensuring efficient and reliable electricity delivery. By adopting various strategies and technologies, utilities and operators can enhance the overall performance of these systems, reduce energy

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waste, and meet the growing demands for cleaner and more sustainable energy distribution.

Due to competition, restructuring of power systems, changes in management and ownership of the electrical sector, and other factors, it is anticipated that the significance of DG- distributed generating units would increase significantly in the future. The goal is to maximize the benefits of the DG while ensuring the stability and reliability of the distribution system. Here are some key factors to consider when deciding where to place a DG in a radial distribution system:

Load Centers: DGs are typically placed near load centers or areas with high electricity demand. This minimizes transmission and distribution losses and enhances voltage stability in those areas. Load centers can be residential, commercial, or industrial zones.

Voltage Profile: Evaluate the voltage characteristic of the distribution system. DG placement should help maintain voltage levels within acceptable limits. If a particular section of the network experiences voltage drop issues, placing a DGthere can help boost local voltage levels.

Feeder Length and Loading: Analyze the length of the distribution feeders and their loading conditions. Feeder segments with longer lengths and higher loading may benefitmore from DG installations to alleviate voltage drop and reduce losses.

Renewable Resource Availability: If the DG is a renewable energy source, such as solar panels or wind turbines, it should be placed in areas with favorable renewable resource availability. This ensures efficient generation and contributesto the integration of clean energy into the grid.

System Reliability: Consider the reliability of the distribution system. Placing DG units strategically at locations prone to frequent outages can enhance overall system reliability by providing backup power during emergencies.

Protection and Coordination: Ensure that protective devices (e.g., circuit breakers and relays) are appropriately coordinated with the DG's connection to prevent unwanted islanding (when a section of the system operates independently of the main grid) and protect against faults.

Control and Communication Infrastructure: Adequate control and communication infrastructure should be in place to monitor and control DG units remotely. This includes data communication for real-time monitoring and control.

Grid Impact Assessment: Conduct a grid impactassessment to analyze how the addition of the DG will affectthe distribution network's operation, voltage levels, and fault characteristics. Make necessary adjustments to accommodatethe DG.

Regulatory and Compliance Requirements: Ensure compliance with local regulations, codes, and standards governing DG installations, including safety and interconnection requirements.

Cost-Benefit Analysis: Perform a cost-benefit analysis to evaluate the economic viability of installing DG at a specific location. Consider factors such as fuel costs, maintenance, and potential revenue from excess generation.

The placement of DGs in a radial distribution system should be a well-planned process that takes into account technical, economic, and regulatory considerations to optimize the benefits of distributed generation while maintaining the reliability and stability of the distribution

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network. Additionally, advanced modeling and simulation tools can aid in the selection of optimal DG locations and sizing.

II LITERATURE SURVEY

D.B. Prakash, C et.al.,[1] In this study, The Particle SwarmOptimisation (PSO) technique is used in this paper to handle the placement of many Distributed Generators (DGs) in a distribution system and reduce power losses. It goes into great detail on how the PSO algorithm is used to choose where the DGs should be placed in the distribution system.

G. Swetha.et.al [2], this paper describes the many reconfiguration circumstances when DG is placed. The grid reconfiguration problem has been approached by numerous academics in a number of ways. In order to offer clear direction for future study, this paper conducts a thorough review of network reconfiguration. be associated with enhancing distribution networks' power quality through rebuilding and reconfiguration. The writers probably describe methods, tactics, or strategies for boosting power quality inside distribution networks, which can be essential for making sure that consumers receive an efficient and stable supply of electricity.

Sunil Kumar, A.V.et.al.,[3]. This study gives a complete assessment of different procedures and strategies utilized for control coordination among Adaptable Exchanging Current Transmission Framework (Realities) regulators in power frameworks with various machines. The analysts are certain that finding significant hotspots for Realities regulator coordination will be made more straightforward for scholastics with the guide of this overview study. Current realities (Adaptable Substituting Current Transmission Frameworks) regulators utilized in this paper's power quality upgrade frameworks and advancement approaches are entirelyevaluated. Power frameworks use Realities regulators to further develop control, solidness, and power quality.

Adepoju, G.A. et.al.,[4], This study Particle Swarm Optimisation (PSO) to implement Optimal Placement and Sizing of DG (OPSDG) in the appropriation framework, bringing down the general power loss of the dispersion organization. A numerical model of the dispersion framework without and with DG was created from a solitary voltage source portrayal utilizing the Transport Infusion to Branch Current (BIBC) and Branch Current to Transport Voltage (BCBV) load stream procedures. The model was executed in MATLAB and was advanced in PSO.

Salimon, S.A et.al.,[[5] This exploration examines the effect of appropriated age (DG) infiltration level (PL) on the power misfortune and voltage profile of spiral dissemination organizations (RDNs) utilizing different sorts of DG. Different kinds of disseminated age (DG) are reproduced utilizing models that consider the genuine and receptive power they create. The voltage profiles got under different settings were decently looked at utilizing the voltage profile file (VPI), which relegates a solitary worth to portray how well the voltages fit the best voltage. Two unmistakable successful power voltage solidness measures were

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created to pick the competitor transports that would be generally delicateto DG infiltration. To explore the impacts of the DG PL on the power misfortune and voltage profile, the measures of the DG types were continuously raised on these applicant transports by 1% of the all out load interest.

P. Vijay Babu et.al.,[6] The critical commitments of the paper are as per the following: GAMS programming gives spiral and cross section appropriation network load stream arrangements. DG size and arrangement were arranged at two phases. The ideal destinations for the DG in light of Power Loss Sensitivity (PLS) and the best size for the DG were resolved utilizing the CONOPT solver of GAMS to solve non-linear programming (NLP). Two particular DG sorts havebeen utilized in the examination.

Sattianadan, D., et.al.,[7]. This paper's endeavor to diminish power misfortune is based on the organization of distributed generators (DG) in the circulation framework. The place ofthe DG is laid out utilizing the voltage stability index (VSI). After this, the size of the DG is either steadily raised orbrought down, and the power misfortune that happens as astill up in the air by running the influence stream. Following that, a genetic algorithm n is used to approve the outcomes.

Zaid, Mohammad et.al.,[8]. Utilizing the teaching learning coupled with harmony search (TLCHS) method, which consolidates the notable methods of teaching learning (TL) and harmony search (HS), the reasonable sizes and areas of DG in the distribution network have been developed. This calculation thinks about the decline in power misfortune and the improvement in framework execution..

Venkatesan, C et.al.,[9] This work proposes a hybrid enhanced grey wolf optimizer and particle swarm optimisation (EGWO-PSO) approach for the best situatingand measuring of DGs and CBs. The EGWO metaheuristic enhancement strategy was enlivened by dim wolves To find the most intelligent solution to an issue, PSO utilizes a multitude put together metaheuristic streamlining method based with respect to molecule portability. The upsides of the two methodologies — the EGWO's ability for investigation and the PSO's for double-dealing — are consolidated to deliver equal advantages. The suggested cross breed method meets rapidly and isn't restricted by neighborhood best.

Neda Hantash et.al.,[[10], An improved particle swarm optimization approach (PSO) is proposed in this examination to appropriately plan and position a DG unit in an electrical power framework, upgrade voltage profile, and lessen dynamic power misfortunes in the framework. An IEEE 34 conveyance transport framework is utilized in this paper as a contextual investigation. The use of a clever weight idleness condition upgrades the exhibition of the PSO ordinary calculation. This improvement is accomplished by controllingthe dormancy weight, which influences the molecule update speed of the calculation.

III. Methodology:

Teaching-Learning-Based Optimization (TLBO) is a population-based optimization

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methodology inspired by the teaching and learning processes observed in a classroom. Itis used to find optimal or near-optimal solutions to various optimization problems. Here is a step-by-step methodology for implementing TLBO:

1. Problem Formulation: Define the optimization problem that you want to solve. This includes specifying the objective function to be minimized or maximized and any constraints on the decision variables.
2. Initialization: Initialize the population of candidate solutions. This population represents potential solutions to the optimization problem. The size of the population is typically determinedin advance. Randomly generate initial solutions within the feasible domain of the problem.
3. Evaluation: Evaluate the fitness of each solution in the population based on the objective function. The fitness represents how well each solution performs with respect to the optimization goal.
4. Teacher Phase: Select the best-performing individual (teacher) from the population based on their fitness. The teacher is the solution with the highest fitness (lowest objective function value). The teacher guides the learning process by providing information to the other individuals in the population.
5. Teaching: For each student (individual) in the population: Calculate the difference between the student's solution and the teacher's solution. Update the student's solution based on the teacher's knowledge. Typically, this involves adjusting the student's solution towards the teacher's solution.
6. Learner Phase: Each student evaluates its own solution's fitness in comparison to the teacher's solution.

If a student's solution is better (higher fitness) than the teacher's solution, it retains its current solution.

If a student's solution is worse (lower fitness) than the teacher's solution, it updates its solution to be more similar tothe teacher's solution. This is done to improve the student's solution.

7. Updating Population:

After the teaching and learning phases, update the population with the newly adjusted solutions obtained during the learnerphase.

8. Termination Criteria:

Determine the stopping criteria for the algorithm. Common termination conditions include a maximum number of iterations, convergence of solutions, or achieving a satisfactory solution quality.

9. Results and Analysis:

Once the termination criteria are met, analyze the finalpopulation to find the best solution obtained through TLBO. Evaluate the objective function value and check if anyconstraints are satisfied.

10. Post-Processing (Optional):

Depending on the problem, you may need to perform post- processing tasks on the obtained solution. This could involverounding or refining the solution to meet specific requirements.

11. Implementation and Parameter Tuning:

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Implement the TLBO algorithm, making sure to incorporate all the steps mentioned above. Experiment with different population sizes, learning rates, and other algorithm-specific parameters to fine-tune its performance for your specific problem.

12. Validation and Testing:

Validate the results by comparing them with known solutions (if available) or using problem-specific validation techniques.

Test the algorithm on a variety of instances of the optimization problem to assess its generalizability and robustness.

This methodology outlines the key steps involved in applying Teaching-Learning-Based Optimization to solve optimization problems. Remember that the effectiveness of TLBO can vary depending on the problem, so it may require parameter tuning and problem-specific adaptations for optimal performance.

The key idea behind TLBO is the exchange of knowledge between individuals in the population to improve the overall performance in finding an optimal solution to an optimization problem. It is often used in a wide range of optimization tasks, including mathematical optimization, engineering design, machine learning, and more.

The general formula for an optimisation problem is: Optimize

$$f1.....fN,\ x=(x1.....xd)$$

subject to

$$hj(x)=0,(j=1,2,...J)$$

$$gk(x)=0,(j=1,2,...K)$$

where f1.....fN are the objectives and hj and gk are equality and inequality constraints, respectively. Single objective optimisation is what is used when N=1. When N=2, it transforms into a multi-objective optimisation problem witha different approach for solving it than when N=1.

This leads to the introduction of a unique meta-heuristic optimization technique known as Teaching Learning Based Optimization (TLBO).

A recently created population-based algorithm is TLBO. The optimization algorithm itself is referred to as the algorithm's star. The TLBO has been used in a variety of applications across several fields. The algorithm is fairly straight forwardto understand and implement. The main thing is that it functions without a particular parameter.

The algorithm allows us to determine where DG should be placed. The ideal DG placement

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is crucial from both an economic and system computation standpoint.

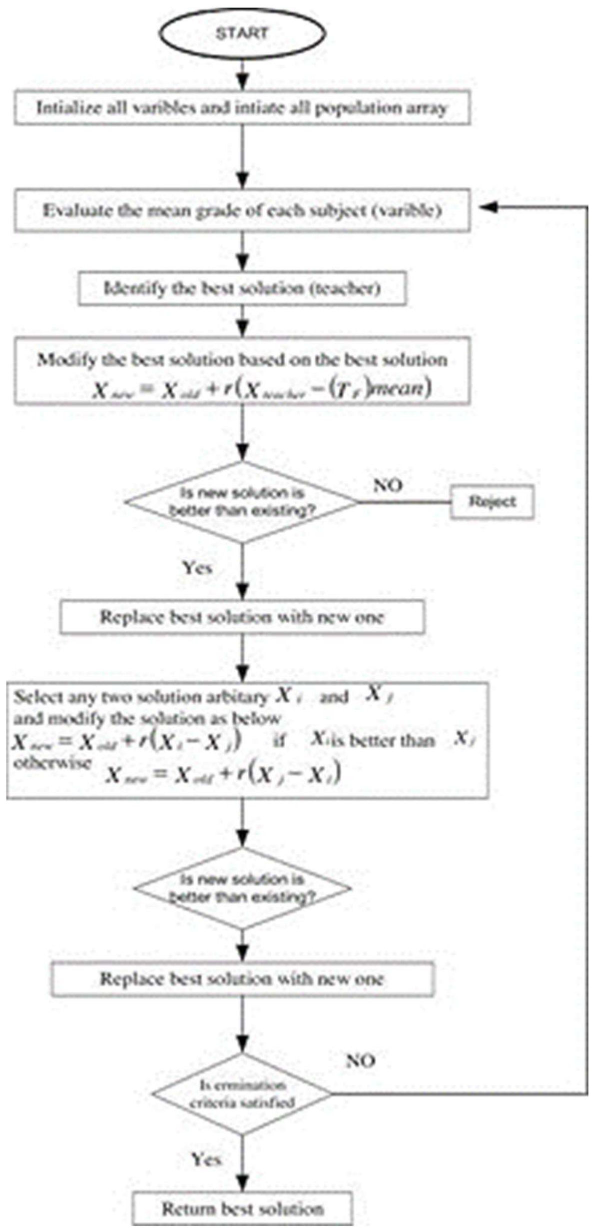

Fig.1 : The TLBO algorithm's data flow diagram

The MATLAB simulation results of voltage profile, generation, and DG are compared and summarized for the IEEE-14 bus system with and without DG.

In this paper the author has described how the DGs are used to minimize power loss in the power system and continuously maintain voltage stability. The work has undergone testing on the IEEE-14 bus system. And the results demonstrate the distinction between the two groups.

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Teaching Learning Best optimization is explained mathematically. Coding in MATLAB is used to express the algorithm.

IV. Execution of TLBO procedure for ideal DGarrangement issue

The Teaching Learning Best Optimization (TLBO) algorithm, a novel population-based strategy, was created by Rao et al. The algorithm explains the teaching-learning ability of the teacher and the students in a classroom. The methods below outline a step-by-step process for solving the best DG placement using the TLBO algorithm.

Set the populace size (NP), greatest number of iterations,number of design variables (ND) (i.e., DG), and plan variable limitations for advancement in the dispersion organization. Contingent upon the quantity of DG, make various areas for their sending. Make a scope of DG sizes inside the functioning imperatives that are scattered indiscriminately all through the dissemination organization. The functional KW ofall introduced DGs comprises of a vector that addresses an understudy's general grade as well as a likely fix for issues with DG position. Pi is equivalent to [loci,1, loci,2,..., loci,ND, PGi,1, PGi,2, PGi,ND] where PGi is the beginning size of the introduced DGs. I subs for the students, while j addresses the subjects.

Depending on the population size, the first answer is P = [P1,P2,...,Pi,...,PNP].

Run the load flow to determine how much energy is lost in thedistribution network. This study applies the forward- backward sweep method to the load flow of the chosen distribution network .The evaluation of the objective functions follows. The teacher is given the best position in theclass after sorting the students from best to worst according tothe objective value.

Run the load flow to determine how much energy is lost in thedistribution network. This study applies the forward- backward sweep method to the load flow of the chosen distribution network (Bompard et al., 2000)[12]. The evaluation of the objective functions follows. The teacher is given the best position in the class after sorting the students from best to worst according to the objective value.

Change each topic's grade point utilizing the idea of the teaching phase (i.e., the KW of installed DGs). Utilizing the learning phase idea, update the grade point (KW of installed DGs) for each topic for all students.

Examine for any updated DG's KW that exceeds the permittedoperating limitations. Any value below the minimum is assigned to the lowest limit, while any value above the maximum is given to the maximum limit. The stop criterion should be found. If you're pleased, stop iterating and publish the best answer; if not, go back to step 4 and carry out the procedure once more.

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V. System and Discussion

Single Line Diagram for IEEE-14 Bus system

The single line diagram for IEEE-14 bus system is shown below:

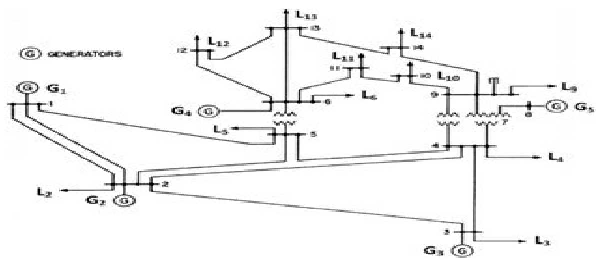

Fig 2: Single line diagram of IEEE-14 Bus system

The 14 bus system consists of 5 generating stations, 14 load points, and total of 17 lines. Three transformers are associated between the transport number 5& 6, 4 &9, and4& 8. One shunt capacitance is additionally associated at transport number 9.

VI. SIMULATION AND RESULTS

The simulation was executed using the MATLAB add-on Power System Analysis Toolbox (PSAT). The Transmission line, PV generator, PQ generator, and DG as a control block make up the toolbox.

Below is an analysis of the simulation circuits for the IEEE-14 bus systems.

Simulation and Results of IEEE-14 Bus system

Without DG, here is what the MATLAB simulation for a 14- bus system looks like:

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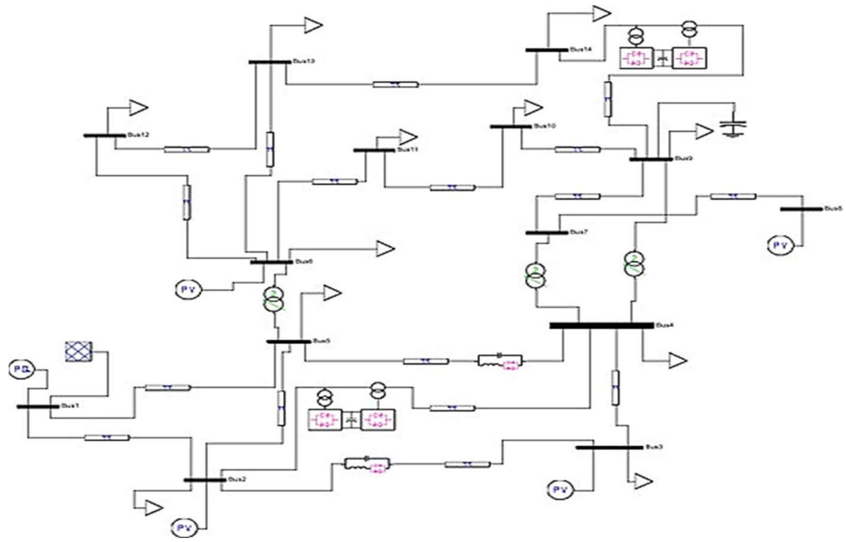

Fig 3: Simulation of IEEE-14 Bus without DG

Table 1: Total Power Loss (in p.u) of IEEE-14 bus system without DG

Total Generation	Total Load	Total Losses
Real Power = 2.7098	Real Power = 2.593	Real Power = 0.11679
Reactive Power = 0.76393	Reactive Power = 0.54644	Reactive Power = 0.21749

Simulation of IEEE-14 bus system with DG:

The location of DG was determined by comparing the existing and final solutions after running the MATLAB code for TLBO and calculating the final Xnewij value.

DG-1,DG-2 = line (2-3) and line (4-13) DG-3,DG-4 = Bus No. 2 and Bus
No. 14

The MATLAB simulation depicting the IEEE-14 bus system subsequent to the addition of distributed generators (DGs) is presented below:

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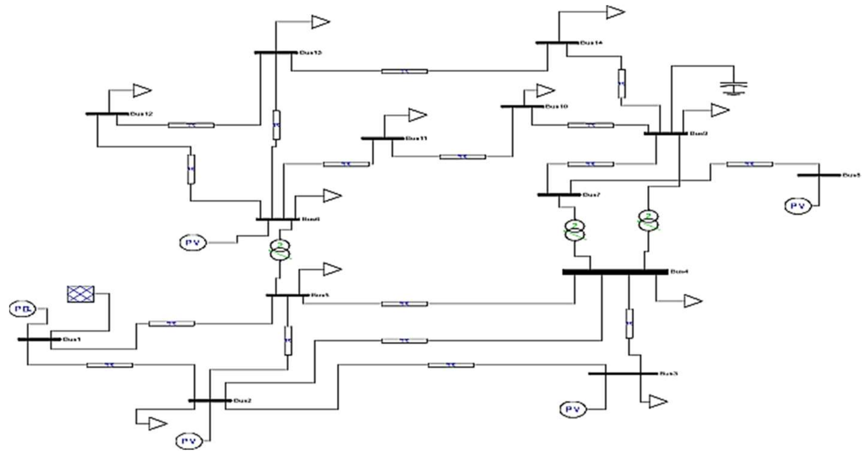


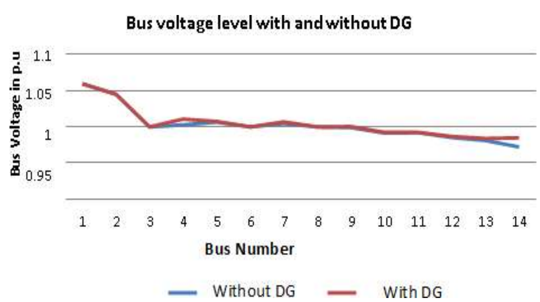
Fig 4: Simulation of IEEE-14 Bus with DG

Table 2: Total Power Loss (in p.u) of IEEE-14 bussystem with DG

Total Generation	Total Load	Total Losses
Real Power = 2.65832	Real Power = 2.5930	Real Power = 0.06532
Reactive Power = 1.02540	Reactive Power = 0.54594	Reactive Power = 0.047946

From the simulation and data above the voltage level and active power loss of IEEE-14 bus system with andwithout DG can be compared as shown below:

The voltage at Bus 2 is the same, at 1.045 p. u., with or without the addition of DGs, as illustrated in figure 5.7. However, Bus 14's voltage level has increased from 0.97181 p. u. to 0.98485 p. u. DGs also raised the other bus's voltage level. Similar to figure 5.8, figure 5.8



demonstrates thatafter DG-3 was put at line 2-3, the 21 active power loss was reduced from 0.02388 to 0 and for line 4-13, the power loss was reduced from 0.0052 to 0 p. u. Additionally, the impact of DG-4 has reduced power loss at all other lines.

Fig.5: Bus voltage level of a IEEE-14 bus system with and without DGs devices

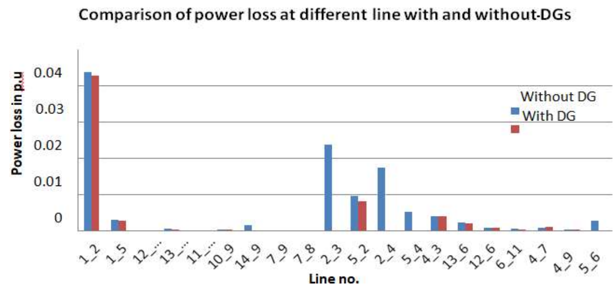


Fig 6: Simulation and Results of IEEE-14 Bus system

VII CONCLUSION

This paper looked into new placement approaches for DGs devices in order to improve system security and power quality.The TLBO algorithm is validated for placement by an experimental study conducted on standard IEEE-14 bus systems. DGs and it has demonstrated that system voltage maybe improved while minimizing line losses. Dgs has the best performance in terms of minimizing both voltage variation and line losses, according to simulation findings and data.

For the medium-sized power network utilized as an example, the data and outcomes seem promising. When consideringlarge-scale power systems, the TLBO algorithm can provide a significant computational benefit over alternative optimizationtechniques. Future study could include putting the algorithm through its paces on larger power system networks and including additional DGs.

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