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A NOVEL STRATEGY FOR IDEAL DISTRIBUTION STATIC SYNCHRONOUS COMPENSATOR PLACEMENT AND SIZING

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ABSTRACT

This research presents a new scheduling strategy for optimizing the placement and sizing of Distribution Static Compensators in radial distribution networks to reduce power loss. The voltage stability index is employed in the suggested method to find the best location for distribution static synchronous compensator installations. The bat algorithm is used to determine the ideal size of distribution static synchronous compensator. Comprehensive simulation results from different situations show that the proposed method outperforms other existing algorithms in terms of voltage stability and loss reduction in distribution networks. The suggested algorithm has been validated using MATLAB simulation on conventional IEEE 33-bus radial distribution systems.

Keywords: single machine, Static var compensator, Practical swarm optimization, Multi objective function, bat algorit \

1.INTRODUCTION

The importance of distribution networks in the quality and planning of power systems has been a major focus of research in recent years. Poor regulation of the power system can lead to power quality issues, including voltage fluctuations, voltage sag, and voltage instability. As the demand increases, power transfer across the distribution network increases, which is limited by the line temperature, voltage, and stability. Research has proposed a variety of strategies to address voltage system stability issues and reduce distribution system losses.

Distribution static synchronous compensators have good low-voltage operational characteristics due to the ability to maintain the reactive current constant [1-3]. Optimization is process in which we try to find the best solution among available alternatives. In the distributed generation allocation (distribution static synchronous compensator) problem, the distribution static synchronous compensator locations need to be optimized to provide the most technically sound, efficient and economical distribution system. The two most common methods of keeping distribution system voltages within an acceptable range are series voltage regulators and shunt capacitors. [4-6]. Distribution static synchronous compensator has many advantages over conventional reactive power compensators, including low power loss, low harmonic output, excellent tunability.

According to the literature review, the proper location and sizing of distribution static synchronous compensator have a significant impact on the radial distribution system. Only a few researches researched the distribution static synchronous compensator allocation area. Various researchers have implemented various optimization techniques to discover the ideal location of the distribution static synchronous compensator, such as differential evolution [7], immune algorithm [8], and particle swarm optimization algorithm [9]. A differential evolution approach distribution static synchronous compensator allocation in radial distribution systems with reconfigurations is provided in [7]. Many studies have been conducted on efficient STATCOM allocation in transmission systems utilizing various optimization approaches like particle swarm optimization (PSO) and genetic algorithm (GA) [10-12].

The authors of the previous study were able to locate distribution static synchronous compensator deployment in radial distribution networks with satisfactory results. Be that as it may, these calculations have various weaknesses concerning computational time in settling distribution static synchronous compensator, and each researcher have focused exclusively on three burden levels (low, medium, and top), with no thought for load variety in spiral appropriation frameworks. Every distinction in load steps influences the best size of distribution static synchronous compensator, causing vulnerability in the dispersion framework.

The authors' objective in this paper was to make a quick and compelling enhancement procedure for deciding the best area and size of single and numerous distribution static synchronous compensators for the reduction of power losses. Distribution static synchronous compensator's location was resolved by utilizing the voltage stability indices. The bat algorithm was utilized to ascertain the size of distribution static synchronous compensator.

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2.METHODOLOGY

2.1 Load Flow Analysis:

Because of the high resistance rate (r/x), classic load flow studies similar as Newton-Raphson, Gauss-Siedal, and fast decoupled load flow techniques aren't suited for determining voltages and line flows in radial distribution systems. For the distribution system load flow result, a direct approach was espoused [13]. Power flow analysis is crucial during the planning stages of new networks or additions to existing ones, such as the inclusion of new generation sites, satisfying rising load demand, and identifying new transmission locations.

2.2 VSI

There are multitudinous indicators used to assess the position of security in the power system. In this part, a new steady-state voltage stability indicator is employed to determine the node with the loftiest imminence of voltage collapse [14,15]. The node with the minutest voltage stability index value has a lesser probability of installing distribution static synchronous compensator. As a result, the voltage stability index should be maximized to avoid voltage collapse.

2.3 Bat Algorithm

Nature-inspired algorithms have surfaced as the most important algorithms for problematic power system optimization challenges in recent times. Yang [16] suggested a new nature-inspired meta-heuristic algorithm named 'bat algorithm' based on the echolocation actions of natural bat in relating their prey. Bat are fascinating creatures since they're the only mammals with bodies and superior echolocation to find their prey. In general, it emits a sound signal called echolocation to identify objects around them detect their route indeed in complete darkness.

3.RESULTS

Using MATLAB simulation, a typical IEEE 33-bus RDS is used to show the effectiveness of the proposed method. The direct load flow analysis is used to determine the losses and bus voltage for each system. The proposed optimization technique is used to determine the best position and size for distribution static synchronous compensator.

33 bus system:

This paper discusses a bus test radial distribution system. Four separate case studies have been examined in order to demonstrate the capability of the recommended methodology. Table 1 compares the simulation outcomes of the suggested algorithm and alternative optimization strategies.

First, a simulation of the base case system without distribution static synchronous compensator is performed. The overall power loss is thus 202.677 kw. The distribution static synchronous compensator is then positioned at the 18th bus as the ideal location and by maintaining distribution static synchronous compensator size with 487 kvar the power losses are reduced from 202.677 kw to 182.5237 kw. The second distribution static synchronous compensator is then positioned at the 17th bus as the ideal location and by maintaining distribution static synchronous compensator size with 158 kvar and 373 kvar the power losses are reduced from 182.5237 kw to 181.3614 kw. The third distribution static synchronous compensator is then positioned at 16th bus as the ideal location and by maintaining distribution static synchronous compensator size with 233 kvar, 110 kvar, and 119 kvar the power losses are reduced from 181.3614 kw to 180.8801 kw. Obviously, the combination of both vsi and bat algorithm methods reduces losses significantly compared to other methods.

Table 1 Total Power Losses of the 33-Bus System

S. No	**Distribution static synchronous compensator**	**Base case**
1	Total active power loss	202.677
2	Active power loss reduction percentage	-
3	Total system reactive power loss	135.141

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4	Reactive power loss reduction percentage	-
5	Optimal location	18
6	Distribution static synchronous compensator size (kvar)	487

Table 2 Power Loss Reduction of the 33-Bus System With Single Distribution Static Synchronous Compensator

S. No	**Distribution static synchronous compensator**	**Base case**
1	Total system active power loss	202.677
2	Active power loss reduction percentage	9.9436
3	Total system reactive power loss	123.4487

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4	Reactive power loss percentage reduction	8.6519
5	Optimal location	18
6	Distribution static synchronous compensator size (kvar)	487

Table 3 Power Loss Reduction of the 33-Bus System With Numerous Distribution Static Synchronous Compensators

S. No	**Distribution static synchronous compensator**	**Base case**
1	Total system active power loss	180.8801
2	Active power loss reduction percentage	10.7546
3	Total system reactive power loss	121.5454
4	Reactive power loss reduction percentage	10.0603
5	Optimal location	18, 17, 16

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6	Distribution static synchronous compensator size (kvar)	233, 110, 119

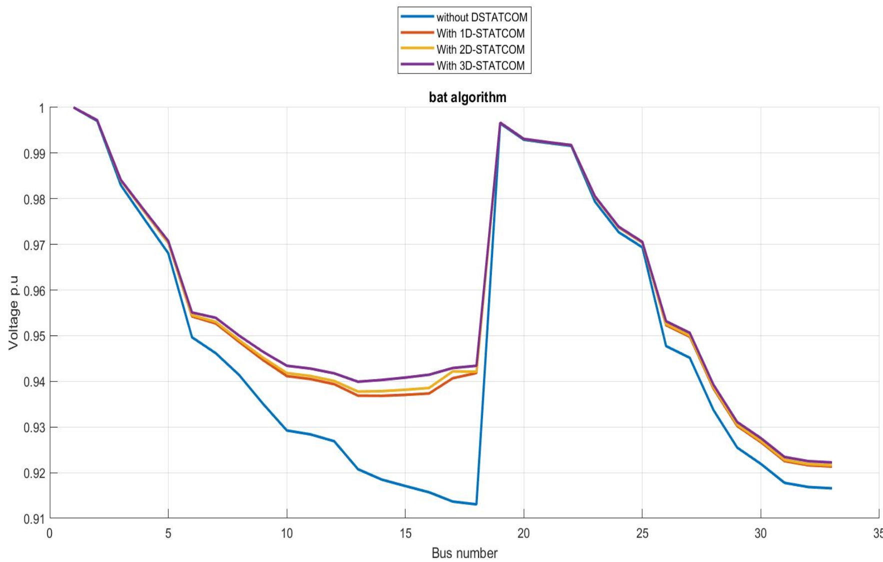

Fig 1 Active Power Losses Versus Line Number

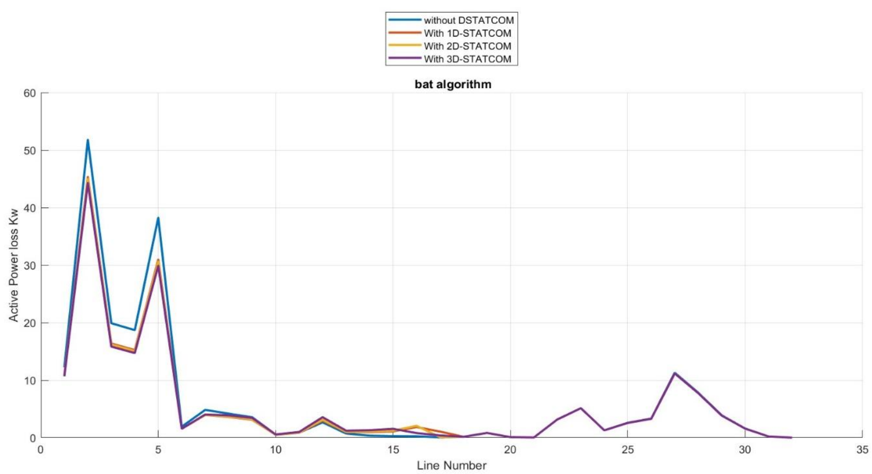

Fig 2 Active Power Losses Versus Line Number

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4. CONCLUSION

An innovative optimization method based on the combination of the Voltage Stability Index and Bat Algorithm has been put forth in this research to improve the system stability of smart distribution grids. The suggested algorithm's key benefit is that it combines the positive aspects of other optimization methods. On the power system, the suggested algorithm's efficacy has been evaluated. Additionally, in three different cases, the total outcomes were compared with various other optimization approaches. Comprehensive simulation demonstrates that when compared to alternative optimization techniques, the combination of both the Voltage Stability Index method and the Bat Algorithm significantly outperforms them in maintaining voltage stability and lowering power losses in distribution networks. This method typically offers a fast convergence.

REFERENCES

[1] S. Kamel, F. Jurado, and D. Vera, "A simple implementation of power mismatch STATCOM model into current injection Newton–Raphson power-flow method," Electrical Engineering, vol. 96, pp. 135-144, 2014.

[2] A. A. Abdou, S. Kamel, and M. Abdel-Akher, "Voltage stability assessment of distribution systems including DISTRIBUTION STATIC SYNCHRONOUS COMPENSATOR using NEPLAN," in Power Systems Conference (MEPCON), 2016 Eighteenth International Middle East, 2016, pp. 792-796.

[3] S. Kamel, M. Abdel-Akher, F. Jurado, and F. Ruiz-Rodriguez, "Modeling and analysis of voltage and power control devices in current injections load flow method," Electric Power Components and Systems, vol. 41, pp. 324-344, 2013.

[4] M. T. Bishop, J. D. Foster and D. A. Down, "The application of single-phase voltage regulators on three-phase distribution systems", Rural Electric Power Conference, the 38th Annual Conference, pp. C2/1-C2/7, April 1994.

[5] Z. Gu and D. T. Rizy, "Neural networks for combined control of capacitor banks and voltage regulators in distribution systems", IEEE Transactions on Power Delivery, Vol. 11, pp. 1921-1928, October 1996.

[6] L. A. Kojovic, "Coordination of distributed generation and step voltage regulator operations for improved distribution system voltage regulation", IEEE Power Engineering Society General Meeting, pp. 232-237, June 2006.

[7] Jazebi S, Hosseinian SH, Vahidi B. DISTRIBUTION STATIC SYNCHRONOUS COMPENSATOR allocation in distribution networks considering reconfiguration using differential evolution algorithm. Energy Convers Manage 2011; 52:2777–83.

[8] Taher Seyed Abbas, Afsari Seyed Ahmadreza. "Optimal location and sizing of DISTRIBUTION STATIC SYNCHRONOUS COMPENSATOR in distribution systems by immune algorithm." Electr Power Energy Syst 2014; 60:34–44.

[9] Devi S, Geethanjali M. "Optimal location and sizing determination of distributed generation and DISTRIBUTION STATIC SYNCHRONOUS COMPENSATOR using particle swarm optimization algorithm." Electr Power Energy Syst 2014; 62:562–70.

[10] Del Valle Y, Hernandez JC, Venayagamoorthy GK, Harley RG. "Multiple STATCOM allocation and sizing using particle swarm optimization. In: IEEE conference of the power systems and exposition"; 2006. p. 1884–91.

[11] Yorino N, El-Araby EE, Sasaki H, Harada S. "A new formulation for FACTS allocation for security enhancement against voltage collapse." IEEE Trans Power Syst 2003; 18(1):3–10.

[12] Gerbex S, Cherkaouti R, Germond A. "Optimal location of multi-type FACTS devices in a power system by means of genetic algorithms." IEEE Trans Power Syst 2001; 16(3):537–44.

[13] Teng Jen-Hao. "A direct approach for distribution system load flow solutions." IEEE Trans Power Deliv 2003;18(3):882–7.

[14] Mohamed Imran A, Kowsalya M, Kothari DP. "A novel integration technique for optimal network reconfiguration and distributed generation placement in power distribution networks." Int J Elect Power Energy Syst 2014; 63:461–72.

[15] Devabalaji KR, Ravi K, Kothari DP. "Optimal location and sizing of capacitor placement in radial distribution system using bacterial foraging optimization algorithm." Int J Electric Energy Syst 2015; 71:383–90.

[16] Yang X-S. A new meta heuristic bat-Inspired algorithm. In: Gonzalez JR et al., editors. "Nature inspired cooperative strategies for optimization" (NISCO 2010). Studies in computational intelligence. Berlin: Springer; 2010 p.65-74.

[17] S. D. Veeraganti and M. I. A, "OPTIMAL PLACEMENT AND SIZING OF DG and D-STATCOM IN A DISTRIBUTION SYSTEM: A REVIEW," 2022 International Virtual Conference on Power Engineering Computing and Control: Developments in Electric Vehicles and Energy Sector for Sustainable Future (PECCON), Chennai, India, 2022, pp. 1-13, doi: 10.1109/PECCON55017.2022.9851016.