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Optimal sizing of distributed generation using a genetic algorithm approach for IEEE 33 bus system

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Abstract

The electric power system consists of three main components, namely the generation, transmission, and distribution systems. The main problem that often occurs in distribution systems is voltage drops and power losses. So an effort is needed to overcome these two problems, one of which is by installing a small-scale generator or commonly called distributed generation (DG) in the electricity distribution system. To get optimal results, we need a method that can solve problems that are optimization in nature. In this final project Genetic Algorithm (GA) is a method used to solve a value search in the optimization problem of determining DG capacity. From the results of capacity optimization, the most optimal results are obtained in scenario 3 with the number of DG 3 and a power factor of 0.95, the optimal capacity results for DG are 1057.52 kW, 1203.01 kW, and 1159.37 kW respectively. To produce a total power loss value of 54.495 kW.

Keywords

Optimal sizing, Distributed generation, Genetic algorithm, IEEE-33 bus, Wind turbine

Introduction

The electric power system consists of three main components, namely the generation, transmission, and distribution systems. The electric power distribution system is part of the electrical power that supplies power from the substation to the consumer. The main problem that often occurs from the distribution system is voltage drops and power losses, the occurrence of voltage drops can have an impact on the damage to existing electrical equipment for consumers, and power losses will cause the inefficiency of a network in the electric power system. So an effort is needed to overcome these two problems, one of which is by installing a small-scale generator or commonly called distributed generation (DG) in the electricity distribution system.

Distributed generation (DG) is a small-scale electric energy generation technology that produces electrical power in a place that is closer to consumers than the power plant center [1][2]. Distributed generation can function to improve the voltage profile, reduce

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power losses, increase system security to increase the reliability of a distribution system. In its installation, it is necessary to pay attention to the optimal DG capacity because it can affect increasing the voltage profile, reducing power losses, and increasing the capacity of the electrical distribution system [3][4][5].

To get optimal results, we need a method that can solve problems that are optimization in nature. In this final project, a Genetic Algorithm (GA) is a method used to solve a value search in the optimization problem of determining DG capacity. The genetic algorithm (GA) is different from other heuristic algorithms.

In general, the heuristic method looks for the optimum solution by gradually arranging a combination based on the selection criteria and the certain iteration termination. The solution obtained is only one solution. On the other hand, the Genetic Algorithm (GA) creates a genetic code from the combination in question, which is better known as the term gene (genotype), which is further refined by iterations that resemble natural processes in inheriting genetic traits. Genetic algorithm (GA) does not require special criteria found in other heuristic algorithms in filtering solution quality or reducing computation time and can produce several alternative solutions that have the same objective function value [6].

Method

System method

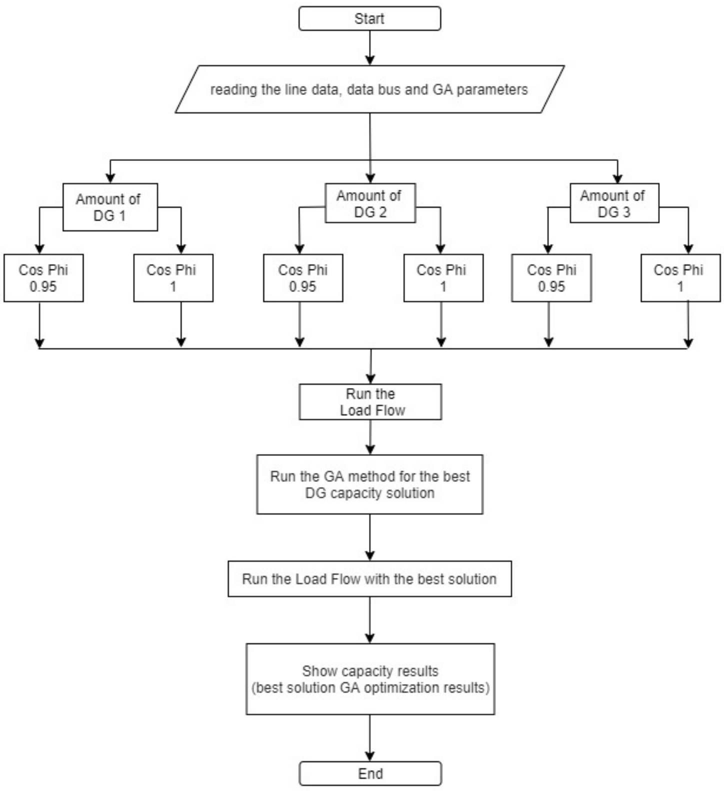

Figure 1. Flowchart system method

In this research using a flowchart shown in Figure 1, what I did was to simulate to find the optimum value to reduce power losses on a distribution network by installing Distributed Generation. Where in running this simulation there are several steps, namely: reading the data line, the data bus on the IEEE 33 bus distribution system, and the Genetic Algorithm parameters. In this simulation, I used three scenarios with different amounts of DG and also used different power factors for each scenario. The next step is to find the initial load flow value to find out the initial power losses value before DG is installed. After knowing the value of the power losses that can be obtained, it is continued by running the Genetic Algorithm Method by taking into account the parameter values used, the parameter values I use here, namely, the number of generations of 100, the number of population 500, the crossover probability value of 0.9 and the probability value mutase 0.2. carried out 15 times running optimization repeatedly, aiming to get the optimal value, because the characteristics of the Genetic algorithm are looking for optimal values instead of looking for maximum or minimum values, then each running simulation may have different results, but if the value obtained is optimal then the value which is obtained in every running simulation will not be different.

Genetic algorithm steps

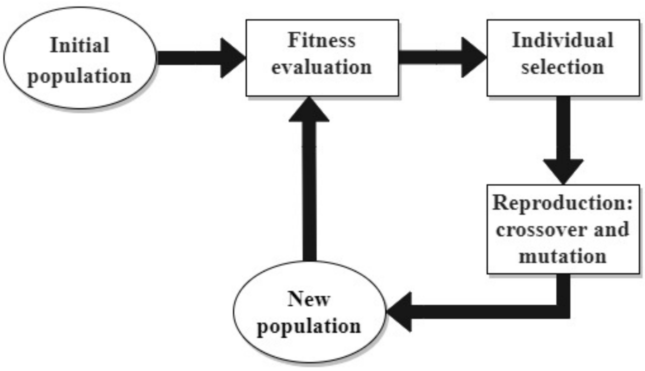

Figure 2. Genetic algorithm cycle David Goldberg [7]

1. Start, Parents, or generate the initial population that is used to do it randomly so that the initial solution is obtained. The population itself consists of several chromosomes that represent the desired solution.
2. The new population, Creates a new population by repeating the steps below until a new population is formed.
   a. Selection, Select two chromosomal parents from the population including the previous best.
   b. Crossover, With a crossover probability, crossing the parents is done to form new offspring. If no crossover is formed, the offspring formed is purely a copy of the parent. In this research, using a crossover probability value of 0.9.
   c. Mutation, With a probability of mutation, the newly formed offspring is mutated at each locus (position on the chromosome). This research using a mutase probability value of 0.2.

   d. Accepting, Place the new offspring on the new population.
3. Evaluation Solution, In each generation, the chromosomes will go through an evaluation process using a measuring instrument called fitness. The value of this fitness is obtained from the fitness function that has been previously defined. Where in this final project the fitness function is a function to minimize the value of active power losses. The fitness value of a chromosome describes the quality of the chromosomes in the population. This process will evaluate each population by calculating the fitness value of each chromosome and evaluating it until the stop criteria are met. If the stopping criteria are not met, a new generation will be formed by repeating step 2.

Discussion

In this research, it is divided into 3 (three) optimization scenarios, namely:

1. Scenario 1 with the amount of DG = 1
2. Scenario 2 with the amount of DG = 2
3. Scenario 3 with the amount of DG = 3

In these three scenarios, optimization was carried out 15 (fifteen) times to see the difference in the results given. The number of generations or iterations given is 100, the population is 500, with a crossover probability value of 0.9 and a mutation probability of 0.2

Optimization simulation for distributed generation capacity using the Genetic Algorithm method

In finding the optimal capacity of the DG on the IEEE 33 bus system, a Genetic Algorithm method is used. In the process, this search is carried out by randomly combining the best solution choices in a group to get the next best solution generation (fitness). This generation will represent improvements in the original population. By repeating this process, this algorithm is expected to simulate an evolutionary process. In the end, you will find the most appropriate solutions. With the DG capacity constraint ranging from, 10 - 3.72 MW adjusts the power flow value in the IEEE 33-bus system [8].

The determination of the boundary value used for optimization problems is very important. If the problem of function maximization or minimization is limited by several criterion functions, then the problem becomes an optimization with constrained optimization [9]. The optimal result in determining DG capacity is that if it has the lowest minimum value of losses, it can increase the voltage value on all buses and the voltage that is owned is in the constraint between 0.95-1.05 p.u.

1st Scenario

It can be shown in scenario 1 that the voltage profile value at the time before DG installation with a minimum voltage value of 0.8938 p.u, while after DG installation the voltage value becomes 0.9583 p.u, and all voltage values on each bus are within the voltage limit.

Table 1. Optimization results by installing DG scenario 1 power factor 0,95

The measured parameters	System test IEEE 33-bus
ΣPloss	88,226 kW
Vmin (p.u)	0.9583
Vmax (p.u)	0.9945
DG capacity	3138,03 kW

It can be shown in Table 1 showing the optimization results at the time of installation of DG using a power factor of 0.95 where the value of active power losses before the optimization is 283.094 kW, which has decreased in losses after optimization to 88.226 kW. From the results of capacity optimization using the GA method, it is also found that the optimal DG capacity is 3138.03 kW.

2nd Scenario

It can be shown in scenario 2 that the voltage profile value at the time before DG installation with a minimum voltage value of 0.9050 p.u, while after DG installation the voltage value becomes 0.9695 p.u, and all voltage values on each bus are within the voltage limit.

Table 2. Optimization results by installing DG scenario 2 power factor 0,95

The measured parameters	System test IEEE 33-bus
ΣPloss	74,391 kW
Vmin (p.u)	0.9694
Vmax (p.u)	0.9946
DG Capacity	2672,47 kW
	475,56 kW

It can be shown in Table 2 showing the optimization results at the time of installation of DG using a power factor of 0.95 where the value of active power losses before the optimization is 283.094 kW, which has decreased losses after optimization to 74.391 kW. From the results of capacity optimization using the GA method, it is also obtained that the optimal DG capacity is 2672.47 kW and 475.56 kW.

3rd Scenario

It can be shown in scenario 3 the voltage value, at the time before DG installation with a minimum voltage value of 0.9050 p.u, while after DG installation the voltage value becomes 0.9840 p.u, and all voltage values on each bus are within the voltage limit.

Table 3. Optimization results by installing DG scenario 3 power factor 0,95

The measured parameters	System test IEEE 33-bus
ΣPloss	54,495 kW
Vmin (p.u)	0.9840
Vmax (p.u)	0.9974
DG Capacity	1057,52 kW
	1203,01 kW
	1157,37 kW

It can be shown in Table 3 showing the optimization results at the time of installation of DG using a power factor of 0.95 where the value of active power losses before the optimization is 283.094 kW, which has decreased in losses after optimization to 54.495 kW. From the results of capacity optimization using the GA method, the optimal DG capacity is also obtained, namely 1057.52, 1203.01, and 1159.37 kW.

Comparison with other metaheuristic methods

Table 4. Comparison of multi DG optimization results

Method	Bus	Capacity	Minimum Voltage (P.U)	Presentase Lossses Drop %
GA	5	1057,52	0,9840	80,75
	24	1203,01		
	29	1159,37		
DAPSO [10]	10	681	0,9654	56,13
	18	600		
	31	719		
FPA [11]	14	759,08	0,9729	64,13
	24	1071,11		
	30	1099,91		
ACO [12]	8	1918	0,95	76,63
	14	908		
	15	504		

Conclusion

In the process, this simulation is carried out with three scenarios with a different number of DG for each scenario. In the power flow performance before DG installation, there are several critical buses with a minimum voltage value of 0.8938 p.u, after a simulation of the optimal minimum voltage optimization is in scenario 3 with a power factor of 0.95, which is 0.9840 p.u. The Genetic Algorithm method in the IEEE 33 bus distribution system is proven to be able to determine the optimal DG capacity of 1057.92 kW, 1203.01 kW, and 1159.37 kW, resulting in a total power loss value of 54.495 kW.

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