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RECLOSER PLACEMENT OPTIMIZATION IN THE PDP-03 RADIAL NETWORK DISTRIBUTION SYSTEM USING ANT COLONY OPTIMIZATION (ACO)

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Abstract

The increasing demand for electricity demanded that the power distribution system has a good reliability. To improve the reliability of electric power systems, PT. PLN Area Semarang use Recloser on the electricity network. Nowadays, the determination of recloser position is very important in reliability of electrical power system. Reliability index used in distribution systems are SAIFI and SAIDI. The value of SAIFI and SAIDI can be calculated from the outage time and the failure rate occurred in one year. Reliability can be concluded better if SAIFI and SAIDI smaller. This research aims to determine the optimal placement of recloser location on the electrical network in feeder PDP 03 Pudak Payung substation. The method used for the recloser location placement is Ant Colony Optimization (ACO) using Matlab Software R2014a. From simulation result, it can be concluded that the reliability value before and after placement recloser changed. SAIFI and SAIDI before recloser placement is 1.0172 times/year and 2.5435 hours/year. Optimal placement location for 1 recloser is at a location 4 with a value of SAIFI and SAIDI is 0.3361 times/year and 1.0456 hours/year. While for 2 reclosers is at a location 2 and 7 with a value of SAIFI and SAIDI is 0.26755 times/year and 0.86069 hours/year.

Keywords— Reliability. SAIFI, SAIDI, recloser, ant colony optimization

PRELIMINARY

System reliability is the opportunity for a component or system to fulfill the required function within a certain period. The increasing demand for electric power requires an electric power distribution system that has a good level of reliability. In the distribution system, the quality of reliability can be seen from the duration of blackouts and how often blackouts occur in one unit of time, for example in one year. With a standard level of reliability, users can enjoy electricity in a sustainable manner [1]. The level of reliability of the distribution network is generally measured by two parameters, namely: Standard Average Interruption Duration Index (SAIDI) and Standard Average Interruption Frequency Index (SAIFI). The higher the SAIDI and SAIFI numbers indicate the lower the level of reliability and level of service to customers. One method to increase the reliability of the distribution network based on the reliability index is to add a sectionalizer or recloser.

The function of the recloser is as a tool to reduce the area of the electrical network that is affected by interference. The installation of reclosers so far has only been based on a safe distance between a recloser and other breaker components and has not considered many customers in protected areas. Based on other research, many linear methods such as Simplex and non-linear methods such as GA [2], PSO [3] & Simulated Annealing are used for cases of recloser placement. Optimization of recloser placement in this paper is carried out using Ant Colony Optimization (ACO). ACO is used for some combinatorial problems & complex problems where there are many variables. Ant Colony is included in the Swarm Intelligence group, which is one of the paradigm developments used to solve optimization problems [5]. The results obtained using ACO, although not optimal, are close to optimal. Ant-based techniques were first used by Dorigo et al. [1996], using ACO to solve the Traveling Salesman Problem [6]. The goal of this method is to find a good acceptable solution, not to find the best solution. Recloser placement simulation in this study used the Ant Colony Optimization method with the help of Matlab R2014a software to solve the optimal solution.

RESEARCH METHODS

2.1. Data collection

The data needed in this study were obtained from PT. PLN (Persero) Semarang Area and PT. PLN (Persero) UPJ South Semarang. These data include single line diagram data for the Pudak Payung Sulang PDP-03 Substation, data regarding line length, recap of blackout data in 2020, distribution transformer capacity, loading data, and the load of each distribution transformer.

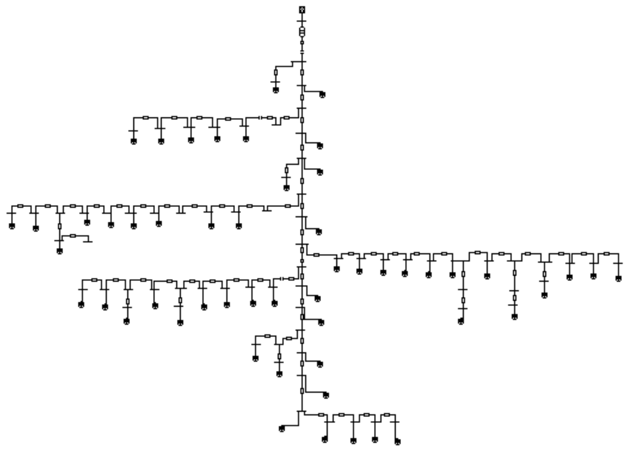

Figure 1. PDP-03 feeder network

2.2. Data processing

Calculation of Reliability Index Before and After Placement of Recloser)

After the required data is complete, the reliability index, voltage drop, and feeder loading are calculated. Calculation of these parameters is done by using primary data and secondary data, as well as with certain limitations in the processing.

$$SAIFI = \frac{\sum \lambda_i N_i}{\sum N} \quad (1)$$

$$SAIDI = \frac{\sum U_i N_i}{\sum N}. \quad (2)$$

Where :

λ_i = failure rate (times/year)

U_i = average blackout time (hours/year)

N_i = number of customers out

N = total number of customers

Then do the calculation of the initial conditions before placing the recloser. For the calculation of the frequency of interference:[7,8,9]

$$\lambda_{LP} = \sum_{i=K} \lambda_i \quad (3)$$

Where :
λ_i = failure rate for equipment K (failure)
K = all equipment that affects LoadPoint
For the calculation of the duration of the disturbance:

$$U_{LP} = \sum_{i=K} U_i = \sum_{i=K} \lambda_i x MTTR \quad (4)$$

Where :
MTTR = repair time (hours)

2.3. Optimization of Recloser Placement with the ACO Method

In this case, it can be done by entering the parameters from ACO so that optimization can be done. Parameters entered are iterations, number of ants, Alpha, and Rho. The objective function used in the optimization process is as follows:

$$f(x) = \frac{1}{SAIFI.SAIDI} \quad (5)$$

The parameter of the number of ants used is 5 because at the point the load used on the system is 15, so the randomization will take place well. While the Alpha parameter is obtained based on reference books, in the test set 1 and the Rho parameter is determined to be 0.1 in order to allow a more optimal recloser placement position to be obtained. This optimization is done by selecting the number of reclosers. The number of reclosers used in this optimization is 1-2 reclosers.
After optimization, new SAIFI and SAIDI values will be obtained with the location of the recloser placement.

RESULTS AND DISCUSSION

3.1. Conditions Before Recloser Placement

Conditions prior to placement of the recloser will be calculated based on real blackout data in the field, using Matlab and ETAP. Then do a comparison of the value of the reliability index.

3.2. Calculation of Initial Conditions with Matlab

From the calculation of the reliability index with Matlab, the results are obtained in table 1, as follows:

Table 1. Results of initial condition reliability index calculations with Matlab

No	Feeder	SAIFI (times/year)	SAIDI (times/year)
1	PDP-03	1,0172	2,5435

Based on IEEE Std. 1366-2000 [8] which states that the SAIFI standard is 1.45 times/year, while SAIDI is 2.30 hours/year. From the calculation results above, it can be seen that the SAIFI and SAIDI values for the PDP 03 feeders are 1.0172 times/year and 2.5435 hours/year. The SAIDI value is not in accordance with the reliability index, while the SAIFI value is in accordance with IEEE Std. 1366-2000.

3.3. Calculation of Initial Conditions with ETAP

Calculations using ETAP are the same as calculations using Matlab, namely by calculating the SAIFI and SAIDI values for each load point. In the single line diagram, the PDP-03 feeder uses 72 load points. With 16 load points on the main feeder, and the rest as load

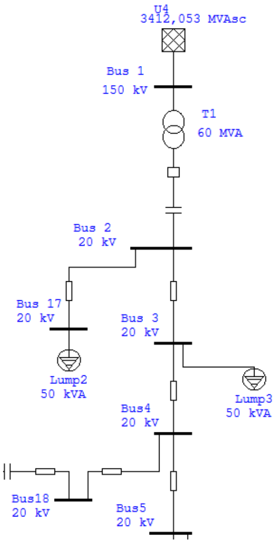

Figure 2. PDP feeder 03

Table 2. Results of initial condition reliability index calculations with ETAP

No	Feeder	SAIFI (times/year)	SAIDI (times/year)
1	PDP-03	1,0183	2,5466

From the simulation results with ETAP in Table 2, it can be seen that the SAIFI and SAIDI values for the PDP 03 feeders are 1.0183 times/year and 2.5466 hours/year.

3.4. Comparison of Real Conditions with Matlab

After calculating reliability in real conditions and Matlab, the comparison of SAIFI and SAIDI values can be seen in Table 3.

Table 3. Comparison of real conditions and matlab

No	Condition	SAIFI (times/year)	SAIDI (times/year)
1	*Real*	3,88	7,03
2	Matlab	1,0172	2,5435

Based on Table 3. there are differences between real conditions and Matlab calculations. This is because when Matlab calculations use the values of λ and r, while when real conditions pay attention to the surrounding conditions such as trees, animals and others. So it has a different value.

3.5. Comparison of ETAP with Matlab

Table 4. Comparison of ETAP with Matlab

INDEKS	ETAP	Matlab	Error (%)
SAIFI (kali/tahun)	1,018	1,017	0,108

SAIDI (jam/tahun)	2,546	2,543	0,121

In Table 4 it can be seen that there is a difference between calculations using Matlab and calculations using ETAP. This difference occurs due to the rounding of numbers in calculating the number of customers in the Matlab software, because it is impossible for the number of customers to be a decimal number. Then the final calculation results obtained will be slightly different from the calculations on ETAP.

3.6. Recloser Placement Optimization with ACO

Through this test it is intended to obtain a minimum SAIFI and SAIDI value to increase the reliability of an electric power system. In this test the system parameter limits are adjusted to the SPLN [9]. Whereas the ACO parameters used are Maximum Iterations = 50, Number of Ants = 5, Alpha = 1, Rho = 0.1. The following are the system parameter values used to optimize the placement of the recloser on the PDP 03 feeder.

Table 5. System Parameters

No	Parameter	Nilai
1	Lamda SKUTM	0,07
2	MTTR SKUTM	10
3	Lamda SUTM	0,2
4	MTTR SUTM	3
5	Lamda PMT	0,004
6	MTTR PMT	10
7	Lamda Trafo	0,005
8	MTTR Trafo	10
9	Lamda Recloser	0,005
10	MTTR Recloser	10
11	Lamda FCO	0,003
12	MTTR FCO	0,25

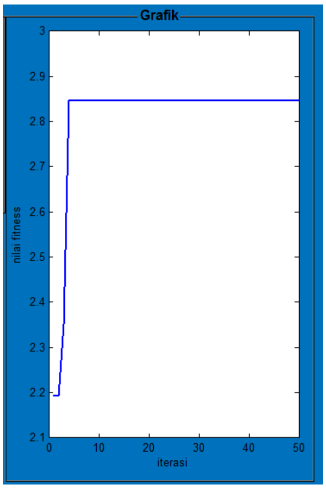

Figure 3. Graph of objective function value (1 recloser) on bus 4

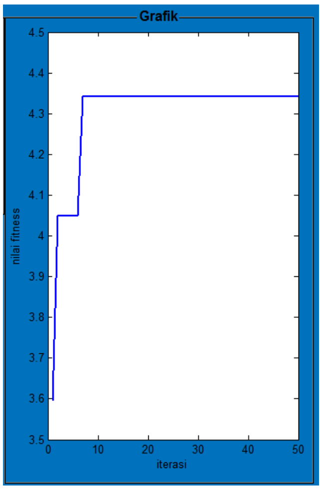

Figure 4. Graph of objective function values (2 reclosers) on buses 2 & 7

During the optimization process, a graph of the objective function value will appear. Based on Figure 4, it can be seen that in the 4th to 50th iterations the fitness value has produced a value that does not change. The number of iterations and the location conditions of the recloser needed in the test can vary because the optimization system uses ant colony optimization which generates random numbers.

Table 6. Optimization Results

No	Number of Reclosers	SAIFI (times/year)	SAIDI (times/year)	Fitness	Location
1	1	0,3361	1,0456	2,8456	4
2	2	0,2675	0,8606	4,3426	2,7

Based on the test results in Table 6, the optimal location is 4 for 1 recloser, while 2 reclosers are installed at locations 2 and 7. It can be seen that after optimization the SAIFI and SAIDI values have decreased.

CONCLUSION

From the discussion above, it was found that the SAIDI and SAIFI values before placing the recloser on the PDP03 feeder were 2.5435 times/year and 1.0172 hours/year. After optimization, optimal results were obtained with a SAIDI value of 1.0456 hours/year and a SAIFI value of 0.3361 times/year for the placement of 1 recloser located at location 4. As for the placement of 2 reclosers located at locations 2 and 7, we obtained the SAIDI value is 0.8606 hours/year and the SAIFI value is 0.2675 times/year.

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