Optimal Network Reconfiguration using Binary Firefly Algorithm in The Medium Voltage Distribution Network of Medan City

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Abstract. The distribution system is one of the important parts in the electric power system because it is directly connected to the customer, therefore the quality of the power in the distribution system must be maintained, but because the characteristics of the distribution system are far from the power plant causing the distribution system to have large feeder losses and voltage drops below standard, therefore the feeder loss and voltage drop must be corrected so that the quality of the power supplied to consumers is maintained. In this paper will use the feeder reconfiguration method to minimize feeder losses and increase the voltage drop. The benefit of feeder reconfiguration is to obtain the most optimal feeder reconfiguration with the best voltage level and the smallest feeder power loss. This method has been tested on the NR7 84 bus 20 kilo volt distribution system in Medan. The results of the analysis using the proposed method obtained a decrease in power loss from 33.21 kW to 24.49 kW or reduced 26.25% with an open switch 84, 9, 10, 17, 19, 26, 29, 75, 34 , 39, 43, 95, 96, 97.

Keywords: feeder reconfiguration, firefly algorithm, power loss

1 Introduction

The distribution system is one of the important parts in the electric power system because it is directly connected to the customer. The power quality in the distribution power system must be good and maintained. the quality of power in the distribution system must remain in good condition so that continuity of service can be maintained [1]. Feeder losses on distribution systems can be affected by channel length and loading [2]. Network losses can be minimized in several ways, including the addition of distributed generators (DG), increasing channel capacity, ne reconfiguration, installing capacitors and so on.

Feeder reconfiguration is resetting the feeder configuration by replace the state of the open or closed scalar (sectionalizing or tie switch) [3]. Grid reconfiguration can improve power quality by reducing power losses, improving reliability, voltage stability and loading balance. The main purpose of feeder reconfiguration is to minimize feeder losses [4]. In addition to feeder reconfiguration, capacitor installation can also minimize feeder losses. This paper used feeder reconfiguration to minimize feeder losses using firefly algorithm, This scheme was tested on the 20kV distribution system in Medan, optimal feeder configuration is expected to result in optimal loss.[5][6].

2 Research Method

Firefly algorithm is one of the metaheuristic algorithms inspired by the life behavior of firefly in attracting the attention of other firefly and their prey [7][8]. The firefly algorithm was first introduced by Dr xin from the university of cambridge in 2007, because in the

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reconfiguration of the distribution feeder the output data is in binary form so that additional functions are needed in the distribution feeder reconfiguration process, this function is known as the sigmoid function. the sigmoid function is explained in equation (1)

$$S(x_i) = \frac{1}{1+exp\,(-x_i)} \qquad (1)$$

$$x_i = \{1, if\ S(x_i) > r\ 0, - \} \qquad (2)$$

Because the attractiveness of fireflies is proportional to the intensity of light seen by other firefly around them. so that equation (3) can be formulated as the relationship between attractiveness β and distance r. β_0 is the value of the initial attraction at a distance of r=0, and γ is the coefficient used to control for the decrease in light intensity. Equation (4) describes the distance between two fireflies i and j represented by Xi and Xj. Xik is the kth component of the spatial coordinate Xi of firefly i and the parameter d in equation (4) represents the number of dimensions. Equation (5) explains the displacement of firefly i which is attracted to firefly j which has a brighter light intensity.

$$\beta(r) = \beta_0 * e(-\gamma r^m), \qquad (m\ \geq 1) \qquad (3)$$

$$r_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \qquad (4)$$

$$x_i new = x_i + \beta_0 * e\left(-\gamma r_{ij}^2\right) * \left(x_i - x_j\right) + \propto * \left(rand - \tfrac{1}{2}\right) \qquad (5)$$

The first formula fragment Xit in equation (5) describes the position of the firefly i before moving, the second formula fragment $\beta_0 * e\left(-\gamma r_{ij}^2\right) * \left(x_i - x_j\right)$ in equation (5) describes the attractiveness of the firefly, and the third part of the formula $\propto * \left(rand - \frac{1}{2}\right)$ in the equation (5) is the random movement of fireflies. rand is a random number between 0 and 1, β_0 values varies from 0 to 1, γ values varies from 0.1 to 10. The γ parameter describes the variation in attractiveness and affects the convergence speed of the firefly algorithm.

3 Results and Discussion

In this paper using NR7 84 bus radial distribution feeder system in Medan, feeder reconfiguration using firefly algorithm to obtain an optimal distribution feeder and the least power loss. NR7 84 bus radial distribution feeder consists of 14 normally open and 83 normally close. As shown in figure 1.

In this paper, the reconfiguration was carried out in the NR7 84 bus distribution system. Reconfiguration is carried out by reorganizing the feeder of the distribution system. Reconfiguration is carried out in order to obtain a better voltage profile, minimal power loss than the initial conditions.

Network Reconfiguration is resetting the distribution network configuration by closing and opening switches on the distribution network system. In the he NR7 84 busdistribution system, there are 14 switches in the open state. In the initial condition, the open switches are switches 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97. After a network reconfiguration using the Binary Firefly Algorithm, a new combination of open switches was obtained. The combination of such open switches is switches 84, 9, 10, 17, 19, 26, 29, 75, 34 , 39, 43, 95, 96, 97.The simulation results in the he NR7 84 bus distribution system after reconfiguration are shown in Table 1 and figure 2. Table 1 describes the result of network reconfiguration of NR7 84 bus distribution system. Figure 2 shows the nominal voltage results on each bus in the NR7 84 bus distribution system after reconfiguration.

Table 1. Result of Reconfiguration of NR7 84 Bus

Reconfiguration Condition	Before Reconfiguration	After Reconfiguration
Disconect Network Switches	84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97	84, 9, 10, 17, 19, 26, 29, 75, 34 , 39, 43, 95, 96, 97
Minimum Voltage (kV)	19, 7756	19, 8818
Real Power Loss (kW)	33, 21	24, 49

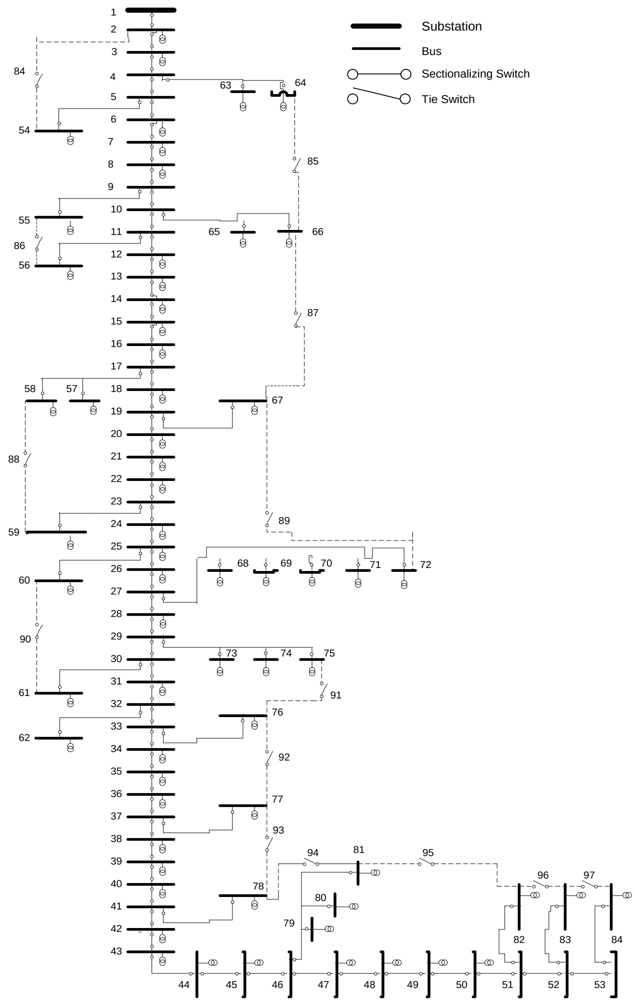

Figure 1. Initial Condition NR7 84 Bus

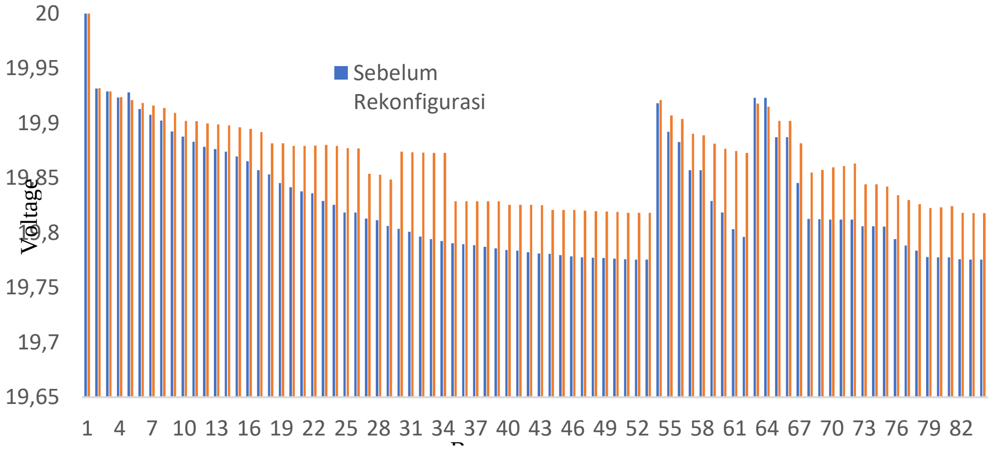

Figure 2. Voltage profile before and after reconfiguration

4 Conclusions

From the simulation results on the NR7 84 bus distribution system, several conclusions were obtained as follows, The most optimal configuration is to open the switch 84, 9, 10, 17, 19, 26, 29, 75, 34 , 39, 43, 95, 96, 97, 3. The power loss generated after reconfiguration is smaller, from 33,21 kW to 24,49 kW, and the minimum voltage after reconfiguration increases from 19, 7756 kV to 19, 818 kV

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References

[1] Saadat, Hadi, (2004), "*Power System Analysis (Second Edition)", McGraw-Hill Education (Asia)*, Singapura, hal. 189-240.

[2] Cheng T-H., dan Yang N-C, (2009), "Three-Phase Power-Flow by Direct Zbr Method for Unbalanced Radial Distribution Systems", *IET Gener.Transm.Distrib.*, Vol3, Iss.10, hal. 903-910.

[3] Civanlar, S., Grainger, J.J., Yin H., dan Lee, S.S.H., (1988), "Distribution Feeder Reconfiguration for Loss Reduction", *IEEE Trans. Power Del.*, Vol.3, No.3, hal.1217-1223.

[4] Shuaib, Y.M., Kalavathi, M.S., dan Christober, C., (2014), "Optimal Capasitor Placement in Radial Distribution System Using Gravitational Search Algorithm", *Electrical Power and Energy System*, No.64, hal 384-397.

[5] Nisa, Tyas Khairun, (2014), "Rekonfigurasi dan Penentuan Lokasi Kapasitor untuk Menurunkan Rugi-Rugi Energi pada Jaringan Distribusi Tenaga Listrik Menggunakan Metode *Simple Branch Exchange*", *Tugas Akhir Teknik Elektro ITS*, Surabaya.

[6] Isnan, Nasrullah Akbar, (2016), "Pengurangan Rugi Daya dengan Rekonfigurasi dan Penempatan Kapasitor mempertimbangkan Kontingensi Menggunakan Metode *Binary*

Interger Programmingi dan *Particle Swarm Optimization*", *Tugas Akhir Teknik Elektro ITS,* Surabaya.

[7] Laksono, Agung Try, (2015), "Rekonfigurasi dan Penentuan Lokasi Kapasitor Bank untuk meminimalkan Deviasi Tegangan Menggunakan Optimal Power Flow pada Jaringan Radial Distribusi 3 Fasa", *Tugas Akhir Teknik Elektro ITS,* Surabaya.

[8] Baran, M.E., Wu, F.F., (1989), "*Network reconfiguration in distribution systems for loss reduction and load balancing*", *IEEE Trans. Power Deliv*., 4, (2), pp. 1401–1407.