A NUMERICAL APPROACH TO IDENTIFY THE FAULT LOCATION ON 22 KV DAKLAK DISTRIBUTION GRID

MỘT PHƯƠNG PHÁP XÁC ĐỊNH ĐIỂM SỰ CỐ TRÊN LƯỚI ĐIỆN PHÂN PHỐI – ÁP DỤNG TÍNH TOÁN LƯỚI 22KV DAKLAK

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ABSTRACT

The rapid detection of accident zone, as short-circuit, is very important in improving the stability and power quality of the system, particularly in grids with difficult geographical conditions. This article introduces a method which could quickly delineate short-circuit fault location by establishing the corresponding matrix between nodes on grid and short circuit current value. A 22kV Daklak distribution grid – E471 line is studied. A big data of input as load, source, season coefficient, utilization coefficient and all four types of short circuit have been considered and calculated in detail. The modeling results will be compared to the value of measurement to valid the studied method.

Keywords**:** *Short-circuit current; fault location; simulation; measurement; distribution grid.*

TÓM TẮT

Để nâng cao tính ổn định và chất lượng cung cấp điện, việc phát hiện nhanh chóng vị trí điểm bất thường trên lưới điện qua đó có thể khắc phục sự cố kịp thời, giữ một vai trò vô cùng quan trọng. Việc xác định nhanh chóng vị trí điểm sự cố này càng có ý nghĩa đối với lưới điện ở những vùng có điều kiện địa hình phức tạp. Bài báo giới thiệu một phương pháp giúp khoanh vùng nhanh vị trí điểm sự cố bằng cách thiết lập mối liên hệ tương ứng giữa vị trí các nút trên lưới và giá trị dòng ngắn mạch. Phương pháp nghiên cứu sẽ được áp dụng tính toán trên lưới phân phối thực tế 22kV Daklak – DZ E471. Khối lượng lớn các dữ liệu đầu vào như phụ tải, nguồn, hệ số mùa, cũng như cả bốn trường hợp ngắn mạch đều được xem xét và tính toán chi tiết. Kết quả mô phỏng được so sánh với kết quả đo đạc thu thập trực tiếp tại địa phương để xác thực mô hình.

Từ khóa: *Dòng ngắn mạch; khoanh vùng sự cố; mô phỏng; đo lường; lưới phân phối.*

1. INTRODUCTION

The rapid detection of short circuit location on grid plays an essential role in improving the reliability of power system. Particularly, with grids in difficult geographical areas or grid that have not been invested with modern system and reclosers, the earlier delineation is, the quicker it helps grids' operators to repair and close the power supply and to reduce the household's time-consuming.

This article describes a method to quickly localize short-circuit issue on the grid by establishing a correlation matrix between the node position in line and the short-circuit current value. For the 100kV grid, when there is a problem in defining the location, it is possible to handle this issue due to the distance relay in spite of erroneous. For the 22kV grid, since there is only common usage of over-current protection relay, it is difficult to identify the problem area. This article would like to propose a method to partition the short-circuit incident area on 22kV grid in order to quickly help identifying and isolating trouble spots to minimize the time of losing power of load. The fault location methods in the distribution systems, have composed in three categories: the impedance-based methods, the travelling wave methods and the intelligent-based methods [1-5]. There are different requirements for each technique to be applied effectively.

Different types of short-circuit, including Three-Line (LLL), Line to Line (LL), Double Line to Ground (LLG) and Single Line to Ground (SLG), with the different coefficients of season and variations in load, are considered. A case study of a local medium-voltage grid is calculated and compared to measurement.

2. METHODOLOGY

The impedance-based methods are the simplest, the most generic and practical ones to implement. In this method, the apparent impedance is calculated by solving mathematical equations with respect to the measurement at a monitored node to locate a fault location. The technique which is presented in [1] uses impedance-based method to determine the fault location in distribution grid by using the line shunt admittance. However, the fault location error is high between two sections of the line. In [2], a two-stage fault location technique using both pre-fault and fault voltage and current measurement is presented. In order to improve the accuracy of estimation, the calculated impedance is also compared with a threshold in [3]. A method which is based on apparent fault impedance, can determine effectively a fault location in a distribution system with intermediate taps, lateral and with heterogeneous lines [4]. In the other approach, a new fault location method for both underground and overhead lines is presented in [5]. In this technique, based on power-flow analysis, the local voltage and current values and matched pre-fault load impedance parameters are determined. In the other approach, the apparent impedance is calculated by using phasor-components of voltage and current at the substation end [6].

The second fault location algorithms category is the travelling wave based methods. This technique is based on the measure travelling time of voltage or current reflection waveform from the fault location to the measurement point for determining fault distance. When the incident occurs, the travelling waves will be generated in the network. These waves are divided in two parts: a part travels between fault points and substation; and the second part is reflected between substation and junction of distribution grid [7]. The technique which is presented in [8] uses continuous wavelet transform or discrete wavelet transform based algorithm for fault location in a distribution network example. Although this method has given an accurate result to locate the fault, it is not economical by using a large numbers of measuring units. The reflection and transition of waves can help to calculate the several fault types. A new technique is proposed for ground fault types by using wavelet and supporting vector regression [9]. Reference [10] proposed a wavelet based technique using voltage transient waveform to calculate fault location in distribution network. This method has the advantage which is able to locate accurately the fault distance in not only balanced system, but also in case of unbalanced and larger distribution system. A fault location technique proposed in [11] using the influence of the traveling waves produced by faults to determine the integrated time-frequency wavelet decompositions of the voltage transients. In general, the accuracy of fault location using travelling wave-based methods is better than the impedance based algorithms, but measurement and communication equipment required for this technique is more expensive and more complicated.

The third fault location algorithms are the intelligent based methods. In order to determine the fault location, this technique uses the intelligence algorithms like Fuzzy Logic, Genetic Algorithm, Artificial Neutral Network. Reference [12] is presented a technique using GA with measurements of the electronic equipment to locate the fault. A method uses Radial Basis Function Neutral Network and Optimum Steepest Descent to identify the fault location in distribution line [13]. This algorithm of method needs a suitable and sufficient data for training or for developing logical set of rules.

The technique in this paper is a method in the third fault location algorithms – the intelligent based methods. The hybrid method proposed is using Multi-Layer Feed Forward Neural Network (MLFFNN) with the big data collected and back-propagation algorithm to determine the fault location. A local 50 nodes radial unbalanced distribution grid with its all component and the data input depending the season and time-frame is calculated in detail. The total power of this network is 8,2MW and voltage level is 22kV. The studied fault is all four short-circuit types – LLL, LL, LLG and SLG.

A Multi-Layer Feed Forward Neural Network [14,15] is a network consisting of multiple layers of units, and all of these are adaptive. The network consists of some input nodes, some output nodes and a set of hidden nodes. Every hidden node takes inputs each of the input nodes, and feeds into each of the output nodes.

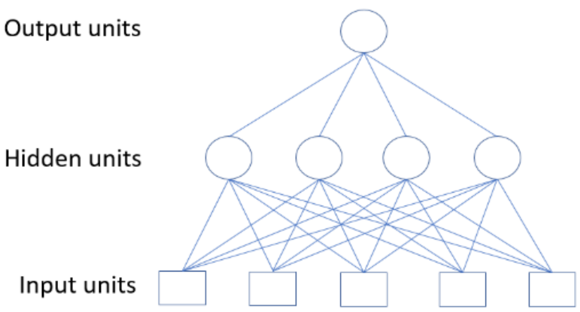

Figure 1. *Multi-Layer Feed Forward Neural Network principle*

The Figure 1 presents the principle of a Multi-Layer Feed Forward Neural Network. The input units receive the information of the outside world, usually in the form of a data file like the load of all bus depending on time-frame and season. The intermediate neurons including one or more hidden layers, allow nonlinearity in the data processing. The output layer is used to provide an answer for a given set of input values, and the short-circuit current on 50 nodes for all four fault types by using PSS/Adept software. A matrix of short-circuit current value and its location in grid were established. Based on this relation, the short-circuit location can be identified.

Specific calculated steps are presented in the following diagram in Figure 2.

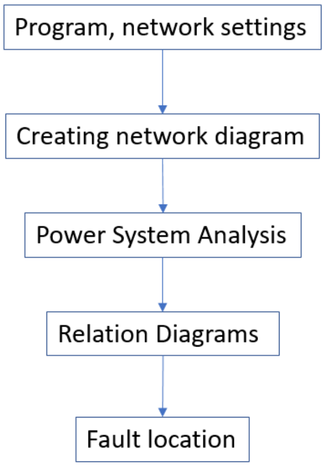

Figure 2. *Steps of calculation*

The first step is called "Program, network setting". Power consumption of every substation was collected and classified into load groups of similar characteristics. The instance can be divided into the groups of substations depending on industry, agriculture, daily-life activities, and residential areas in local area.

Next is to create Network Diagram. According to the characteristic of load and parameter of components in grid, the circuit diagram of this local network is established. The exact and detailed of data of parameters of network design in simulation of the network with its all components could determine the accuracy of calculated results of the short-circuit current. Therefore, source fluctuation, load and grid's structure are in need to be updated frequently.

After that, the Power System should be analyzed. Calculating the corresponding P and Q with capacity of every substation is

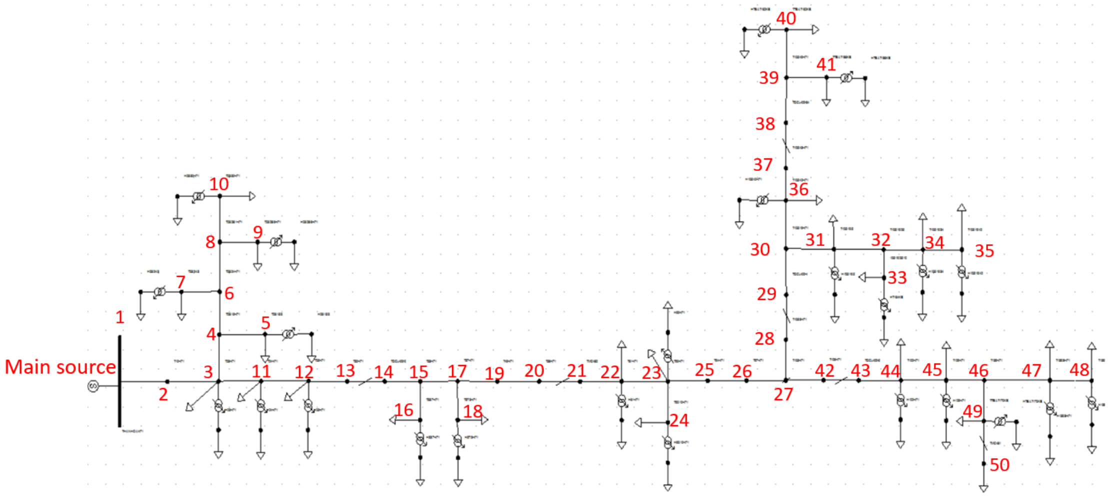

Figure 3. *Studied distribution grid - E471 22kV Daklak*

based on load group and substation type with cosφ coefficient.

The two last steps are Relation Diagrams and Fault Location. Once the load data of each substation has been completed, the issue current with different time-frames corresponding to the demand variation of the load for four fault types was determined. The relation diagram between the short-circuit current value and its location was established.

3. CASE STUDY

Based on the method presented, a local radial distribution system is simulated. The power and voltage level of the grid are in the rainy season and has an effect on the reliability of power supply.

The short-circuit incident on the local network in this study is divided into five groups of causes as follow:

Table 1. *Causes of short-circuit fault on 22kV Daklak grid*

No	Cause of fault	Percentage
1	Equipment damage	0.05
2	Impact of animal	0.50
3	Violate the safety corridor of grid	0.10
4	Lightning and Thunderstorm	0.20
5	Other causes	0.15

The impact of animal account for a very high proportion (50%), which is reasonable as this grid passes through the forest and places where there are harsh natural conditions. The Figure 4 shows a short-circuit fault on isolated porcelain in local grid which is caused by a bat.

The simulation of this network including transformers, distribution lines and unbalanced loads is presented in Figure 3. The number of node in grid was formatted for calculating the short-circuit current value.

In order to get the exact result, the input data needs to depend on the time-frame, the type of load and the power consumption in the network. The Figure 5 presents the variation of power consumption of load in local studied grid followed by month.

Figure 4. *Bat causes S.C fault on isolated porcelain*

Power consumption of every substation was divided into groups of loads in Table 2. The detail characteristic of input data decides the accuracy of short-circuit current calculated.

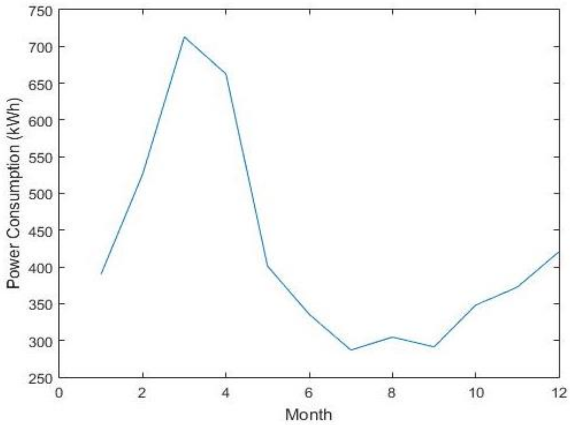

Figure 5. *Power consumption of line in year*

Table 2. *Scale factor depends of load characteristic*

Time frame	Relative duration	% (pu)	Scale Factor			
			Agri.	Industry	Hotel/Rest.	Popu.
23-05	7	0.292	0.2	0.05	0.2	0.2
06-08	3	0.125	1	0.8	0.5	0.8
09-17	9	0.375	0.8	1	1	0.5
18-22	5	0.208	0.3	0.05	0.2	1

4. RESULT AND DISCUSSIONS

All four types of short-circuit are considered in detail for plotting the relation graph in Figure 6. There is a relation between the calculated short-circuit current value and its locations. This result is realized with the data input of load during 9h00-17h00 in the dry season.

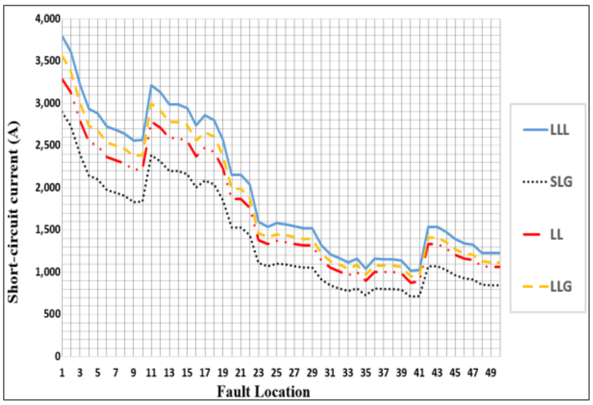

Figure 6. *Calculated short-circuit current values at 50 nodes on grid during 9h00-17h00 in the dry season*

Based on this chart, when a short-circuit occurs, the incident current value is obtained that could help the operator to quickly identify the problem location on the grid.

The LL fault current calculated in the network is presented in Figure 7. The simulation results will be compared to the data of actual incident recorded on the line.

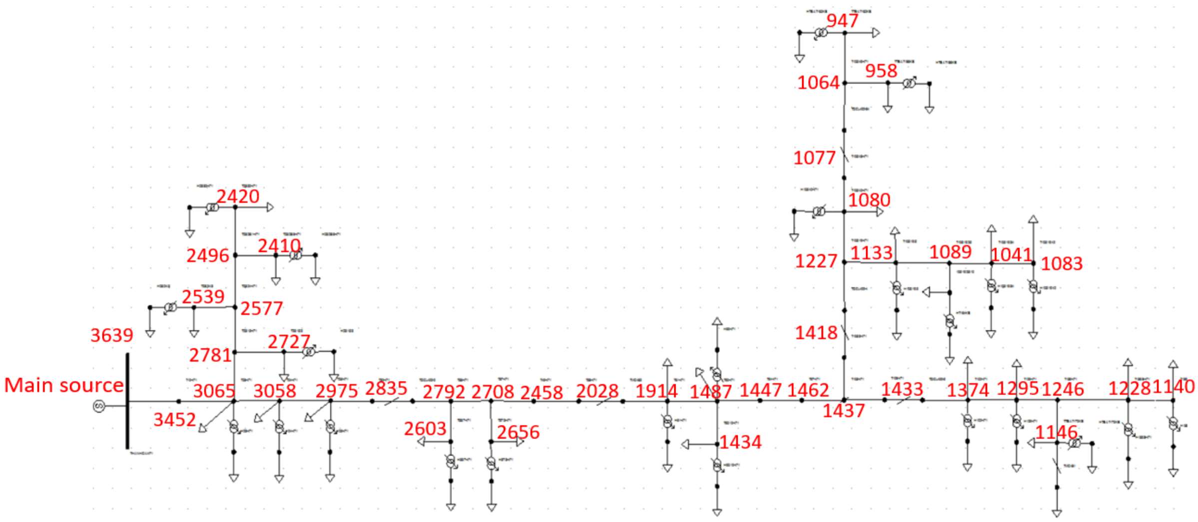

Figure 7. *LL fault current calculated in E471 22kV Daklak (A)*

No	Time of issue occurred	Types of S.C fault	Calculated current (A)	Measurement current (A)	Difference Percentage
1	10:50 on 26/03/2015	LLG	1563	1462	6.46%
2	10:50 on 23/06/2015	LL	1380	1332	3.48%
3	10:43 on 30/10/2015	LG	1010	937	7.23%
4	17:43 on 13/11/2015	LLL	4060	3879	4.46%

The figure 8 presents the comparison graph between the calculated issue fault current and the actual measured value on grid. The simulation result is close to the actual data, so the calculation model can be seen to be valid. Based on the construction network corresponding to each outgoing and interval time, from the value of the short-circuit current, the issue area could be located completely to improve the problem.

5. CONCLUSION

The finding of issue problem on grid is currently slow, affecting the reliability of the power supply, labor search and repair. In fact, there are many incidents that cannot be found or be found but it takes a long time. With the method of calculating the short-circuit and establishing short-circuit diagrams through each node, zoning and searching for the incident will be occurred quickly as follows. When the short-circuit occurs, the segment breaker at the beginning of the turning branch containing the issue point will react and record the issue current value at the circuit-breaker. At this point, the issue line recorded at the circuit breaker is seen in the above diagram of short-circuit to quickly investigate the fault location. Therefore, the method proposed in this paper could be applied for identifying quickly the fault location, especially in zones with difficult condition.

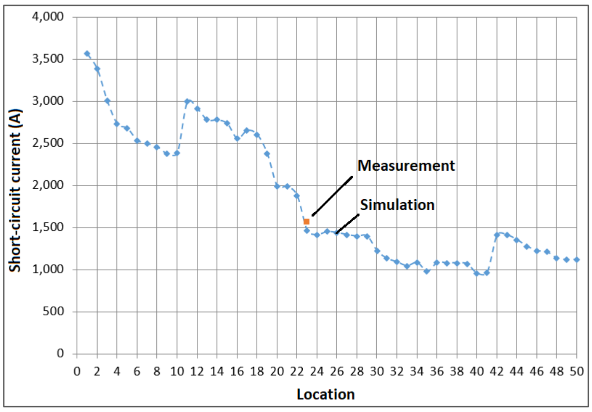

Figure 8. *Comparison chart of two-phase short-circuit currents on grid in dry season from 9h00 to 17h00*

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