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Effect of Using Ground Wire to Lightning Surge Interference at 20 KV Medium Voltage Distribution System Based on Genetics Algorithm

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Abstract

The research was carried out on Sempidi feeder in Kapal area electric power house to analyze influence of using the ground wire to lightning surge interference at 20 kV SUTM distribution system. Based on the research is showed that amount of interference in Sempidi feeder because lightning attack before and after using ground wire, have interference decrement as 85,71%, and also decrement of turned off time duration as 38 minutes 34 seconds. And using genetics algorithm to determine protection angle at SUTM is used 41° and 29°. That's mean the angle has been matched with the toleration of protection angle. From those results, it needs to using protection to lightning surge such as a ground wire.

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1. Introduction

Bali is the most tourism destination in Indonesia, so very important to have a good reliability in the distribution system. To distribute electric power PT PLN of Bali distribution using feeder 20 kV with 3 phase 3 lines in Bali.[4], [7], [8].

From data found that in November till March, Indonesia area especially Bali will get rainy season. Sometimes every rain also followed by lightning, and it risks the feeder will be attacked by a lightning surge. Although has been using protection tools, distribution system can be disturbed. One of the problems is Arrester no strong and its grounding not good either so that lightning surge can enter to the system. The effects are so bad for the system like

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the lines are broken, electric will be cut off, until the distribution transformer damaged. To decrease these effects caused by the lightning surge, PT. PLN of Bali Distribution modified the air line of medium voltage 20 kV from system with 3 phase 3 lines to be 3 phase 4 lines. By using the ground wire in the feeder, where the ground wire located in the highest point of the feeder as line protection to lighting surge.

Problems

These research problems are:

a) Why must be using the ground wire in the feeder?
b) What is the goal using the ground wire in the feeder?
c) How many angles of safety to a lightning surge in the feeder?
d) How the methods of grounding system in the feeder?

The Goals of Research

The goals of this research are:

a) To know why in the feeder need to use ground wire
b) To understand the goal using ground wire in the feeder
c) To determine angle of safety to lightning surge in the feeder by using genetics algorithm
d) To know method of grounding system in the feeder

2. Materials and Methods

In accumulation data to finishing this research is using some methods of research, such as the study of reference, observation, and some experiments.

Recloser

Recloser is a tool to make a narrow area of the electric network that got a disturbance. The location of recloser is based on the distance between recloser and another circuit breaker then determine a count of consumers there.

Instruments of research

Processing cumulated data with formulas of singel bar grounding electrodes such as:

$$R = \frac{\rho}{2\pi L}\left(\ln \frac{4L}{d} - 1\right) \quad \text{..... (1)}$$

where :

R = resistance of electrode grounding [Ω]
ρ = resistance of ground [Ω.m]
L = length of bar [m]
d = diameter of elektrode [m]

To know the angle safety to lightning surge is using the formula:

$$tg\,\alpha = \frac{A}{t} \quad \text{..... (2)}$$

where :

tg α = angle of safety to lightning surge (°)
t = high / distance of location grounding wire from travelers (cm)
A = distance of line to center of ground wire (cm)

Genetics Algorithm

Methods that used to simulate optimation distribution system to increase the reliability of the system is genetics algorithm (GA). Optimation is an activity to get the best result with the qualifications. The result is the minimize of work and the maximize of advantage.

Genetics algorithm describes process regenerative from parents to next generation until got the optimum result. The illustration of the four steps that consists of a cycle like a figure below.

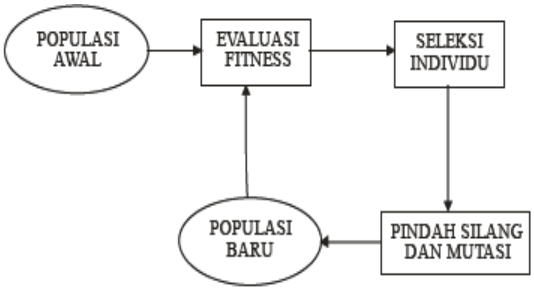

Figure 1. Cycle of genetics algorithm

Process in GA only using string and part of the strange exchange. Process GA generally consists of 3 main components.
They are:

a) Selection proces,
b) Cross over, and
c) Mutation process

3. Results and Discussions

Data used in this research is:

a) Data of the feeder
b) Data of lightning surge in the feeder
c) Data of disturbance in the feeder
d) Data of grounding in the feeder

3.1 Data of the feeder in Sempidi GI Kapal

Data behave in the feeder Sempidi consist of the length of network medium voltage (JTM), low voltage (JTR), conector medium voltage, and capacity of district house (GD) such as table 1 below.

Table 1
Data of the Feeder Sempidi

Specification	Value
length JTM	47771.41 meters
length JTR	101497.04 meters
Capacity GD	15695 KVA
Sum Trafo GD	79
Sum GD	77
Sum tower TM	980
Sum tower TM with PE	104

Sum tower TR	2763
Consumers TM	10
Length connection TM	0
Total load TM	9480000 VA
Sum connection TM	10
Consumers TR	30190
Length connection TM	386230 meters
Load TR	58425040 VA
Sum connection TR	30190

Source: PLN (PERSERO) Area South Bali

3.2 Data of Lightning Surge

Next is data of sum lightning surge in the feeder Sempidi in years 2010 until 2012.

Table 2
Sum of lightning surge in the feeder Sempidi

No	Month	Year		
		2010	2011	2012
1	Jan	160	199	201
2	Feb	125	192	140
3	Mar	48	48	15
4	Apr	0	0	0
5	May	0	0	0
6	Jun	9	0	0
7	Jul	172	55	-
8	August	11	0	-
9	Sep	0	0	-
10	Oct	0	0	-
11	Nov	9	0	-
12	Dec	150	171	-
Total		684	665	356

Source: BMKG (Stasiun of Geofisika)

3.3 Data disturbance in the feeder Sempidi

Frequency blank out in the feeder Sempidi

Disturbance in the feeder Sempidi caused by lightning surge until making blank out between years 2009 until 2011 showed in table 3 below.

Table 3
Sum of Blank off in the feeder Sempidi before using ground wire caused by Lightning Surge

No	Month	Years		
		2009	2010	2011
1	Jan	0	1	2
2	Feb	1	1	1
3	Mar	2	0	1
4	Apr	0	0	0

5	May	0	0	0
6	Jun	0	0	-
7	Jul	1	2	-
8	August	1	0	-
9	Sep	0	0	-
10	Oct	0	0	-
11	Nov	1	0	-
12	Des	1	1	-
Total		7	5	4

Source: PLN (PERSERO) Area Jaringan Bali Selatan

Data of blank off after using ground wire (2011 mid till 2012 research) showed in table 4 that seem only once blank off in January 2012.

Table 4
Sum of Blank off in the feeder Sempidi after using ground wire caused by lightning surge

No	Month	Years	
		2011	2012
1	Jan	2*	1
2	Feb	1*	0
3	Mar	1*	0
4	Apr	0*	0
5	May	0*	0
6	Jun	0	0
7	Jul	0	-
8	August	0	-
9	Sep	0	-
10	Oct	0	-
11	Nov	0	-
12	Dec	0	-
Total		0	1

Note:
*: before using ground wire
Source: PLN (PERSERO) Area South Bali

Duration of Blank off in the feeder Sempidi

Data duration time blanks off caused by lightning surge also can be minimized like showed on table 5 below. After using the ground wire in the feeder only one-time blank off in the feeder area (on January 3rd, 2012) and its duration time is shorter than duration time before using ground wire.

Table 5
Duration of Blank off caused by lightning surge in the feeder Sempidi

Date	Hours_Trip	Hours-in	Duration	Note
14/02/2009	10:52:39	10:55:57	0.055	Before use
13/03/2009	6:27:34	6:29:34	0.033	Before use
29/03/2009	14:30:25	14:33:36	0.0531	Before use
30/07/2009	5:16:40	5:18:30	0.0306	Before use
02/08/2009	16:12:56	16:14:31	0.0264	Before use
14/11/2009	7:59:54	8:03:01	0.0519	Before use

30/12/2009	0:34:57	0:37:38	0.0447	Before use
12/01/2010	6:09:04	6:11:34	0.0417	Before use
28/02/2010	1:14:50	1:16:38	0.03	Before use
07/07/2010	2:59:14	3:01:34	0.0556	Before use
23/07/2010	19:10:41	19:11:31	0.0139	Before use
30/07/2010	3:14:50	3:16:38	0.03	Before use
02/12/2010	17:58:10	18:00:21	0.0364	Before use
14/12/2010	8:29:09	8:31:12	0.0342	Before use
01/01/2011	14:18:20	14:21:31	0.0531	Before use
03/01/2011	4:49:31	4:51:31	0.033	Before use
08/02/2011	15:18:20	15:21:31	0.0531	Before use
03/01/2012	6:29:34	6:31:34	0.033	After use

Source: PLN (PERSERO) Area South Bali

3.4 Data of Grounding

Next is data of bar electrode using in the feeder; its length, diameters, resistance, and count of them also determining of measure resistance in every point of grounding

Table 6
Data of Bar Electrode used

Length (L)	3 meters
Diameter of circle (D)	2 cm (1.5 cm diameter steel with 0.25 cm layer of cup rum)
Resistance of ground	40 Ω m (ground with watery) and 100 Ω m (ground of ricefields)
Sum of bar electrode used	24 bars

Source: PLN (PERSERO) Area South Bali

Table 7
Data of measurement resistance grounding every point

Points grounding	Resistance grounding	Points grounding	resistance grounding
1	23.24	13	12.24
2	19.64	14	10.84
3	11.68	15	11.1
4	13.17	16	15.25
5	13.65	17	15.1
6	15.35	18	17.2
7	13.12	19	17.31
8	15.21	20	15.25
9	12.08	21	18.55
10	11.05	22	16.35
11	11.21	23	14.64
12	11.21	24	18.77

3.5 The Significant and goals using ground wire in the feeder Sempidi

a. In the early planning the feeder Sempidi, PLN Bali Distribution applied network system of 3 phase 3 lines, when the lightning surge happens. But, in several last years, from data of disturbance before using ground wire, they are some disturbance caused lightning. From early data in 2009 known 7 times disturbance caused lightning, in 2010 known 5 times disturbance and from January till May 2014 known 4 times disturbance caused lightning. So that decrease reliability of continuity distributes electric to consumers.
b. Percentage of decrease some disturbance in a year before using ground wire (periods June 2010 until May 2011) and some disturbance after using ground wire (periods Jun 2011 until May 2012) can be counting with formulas:

Decrease percentage = percentage T_0 - percentage T_1
Percentage T_1 (%) = 1/7 x 100% = 14,29%
Decrease percentage = 100% - 14,29% = 85,71%

3.6 Determining Area 0f Ground wire

In planning to use ground wire, the line that chosen will be using is type AAAC, with a wide area of surface 35 mm^2 until 75 mm^2, besides that in General Qualification of Electrical Install decide in using grounding lines must be using lines type BC with wide area minimal 50 mm^2.

Because using differ lines types must determine how big diameter of AAAC for change lines type BC with area surface is 50 mm^2. In determine of the area, lines can be compared with KHA lines qualified. [1],[2],[3]

KHA lines BC with area 50 mm^2 is 250 A. From this value of KHA can determine the area of surface lines if using lines AAAC, with looking at the table of lines AAAC. Based on table AAAC to look for KHA 250A can use lines AAAC with area 70 mm^2 and KHA 255 A.

3.7 Grounding System of Ground Wire used in the feeder Sempidi

In the grounding system of ground wire that used in the feeder, Sempidi is using bar electrode, the ground wire must be grounded in every 5 GW. This grounding used with the least resistance 10,84 ohm and the biggest resistance is 23,24 ohm, it will be accepted. Better if using the best grounding system so that the protection will be better too. For determine resistance can be using this below formulas:

$$23.24 = \frac{\rho}{2x3.14x3}\left(ln\frac{4x3}{0.02} - 1\right) \quad \text{..... (3)}$$

Note:
R: value of resistance
ρ: value of relatives resistance

In determining ground resistance to every point, can be using formulas 2.3 with an example for one point of grounding is like below:

$$23.24 = \frac{\rho}{2x3.14x3}\left(ln\frac{4x3}{0.02} - 1\right)$$

$$23.24 = \frac{\rho}{18.84}\left(6.3969 - 1\right)$$

$$23.24\ x\ 18.84 = \rho\ (5.3969)$$

$$\rho = \frac{437.84}{5.3969} = 81.2\ ohm$$

A grounding system for good ground wire used in the feeder Sempidi GI Kapal can be determined by using the value of resistance type ground that has been calculated before, every grounding points as well as has maximum resistance about 5 ohms.

Table 8
Result of calculating resistance types ground in every point of grounding

point grounding	Rbt (ohm) measurement	L (meter)	*D* (meter)	P (ohm.m)
1	23.24	3	0.02	81.12835
2	19.64	3	0.02	68.56114
3	11.68	3	0.02	40.77363
4	13.17	3	0.02	45.97506
5	13.65	3	0.02	47.65069
6	15.35	3	0.02	53.58521
7	13.12	3	0.02	45.80052
8	15.21	3	0.02	53.09648
9	12.08	3	0.02	42.16999
10	11.05	3	0.02	38.57437
11	11.21	3	0.02	39.13291
12	11.21	3	0.02	39.13291
13	12.24	3	0.02	42.72853
14	10.84	3	0.02	37.84128
15	11.1	3	0.02	38.74891
16	15.25	3	0.02	53.23612
17	15.1	3	0.02	52.71248
18	17.2	3	0.02	60.04336
19	17.31	3	0.02	60.42736
20	15.25	3	0.02	53.23612
21	18.55	3	0.02	64.75606
22	16.35	3	0.02	57.0761
23	14.64	3	0.02	51.10667
24	18.77	3	0.02	65.52406

Source: result of calculating and measure

To find the value of grounding maximum about 5 ohm, can be by a change to using bar electrodes with length 6 meters and area of the surface is about 3 cm^2 and if still not yet qualified can be using parallel grounding system.

Points of grounding 1:

$$R = \frac{82}{2x3.14x3}\left(ln\frac{4x3}{0.02} - 1\right)$$

$$R = \frac{82}{18.84}\left(6.3969 - 1\right)$$

$$R = 4.35\ (5.3969)$$

$$R = 23.48\ ohm$$

Determine the resistance of grounding in one of points of grounding by using formula before. And for example in point of grounding 1:

$$R = \frac{82}{2x3.14x6}\left(ln\frac{4x6}{0.03} - 1\right)$$

$$R = \frac{82}{37.68}\left(6.6846 - 1\right)$$

$R = 2.153\ (5.6846)$
$R = 12.24\ ohm$
$R \leq 5ohm = \frac{12.24}{5} = 2.448$

To make resistance is under 5 ohm can be reached with the result of calculating must be maximized by using 3 bars electrode. Table 9 below showed grounding system is good for the ground wire in the feeder Sempidi to protection network from lightning surge.

Table 9
The good grounding system can be used in every grounding points

Points Grounding	Rbt (ohm) Measurement	L (meter)	*d* (meter)	parallel	Rbt ohm
1	82	6	0.03	3	4.079823
2	69	6	0.03	3	3.447837
3	41	6	0.03	2	3.075667
4	46	6	0.03	2	3.468025
5	48	6	0.03	2	3.594422
6	54	6	0.03	2	4.042079
7	46	6	0.03	2	3.454859
8	53	6	0.03	2	4.005214
9	43	6	0.03	2	3.180998
10	39	6	0.03	2	2.909771
11	40	6	0.03	2	2.951903
12	40	6	0.03	2	2.951903
13	43	6	0.03	2	3.22313
14	38	6	0.03	2	2.854472
15	39	6	0.03	2	2.922937
16	54	6	0.03	2	4.015747
17	53	6	0.03	2	3.976248
18	60	6	0.03	2	4.529236
19	61	6	0.03	2	4.558202
20	54	6	0.03	2	4.015747
21	65	6	0.03	2	4.884728
22	57	6	0.03	2	4.305407
23	52	6	0.03	2	3.855117
24	66	6	0.03	2	4.94266

Source: results of calculate

3.8 Analysis Using Ground Wire

Seem from some of the lightning surge disturbance directly to phase lines 20 KV that happen in the feeder Sempidi since 2009 early until May 2011 is about 16 times. So that mean is important using the ground wire in the top of SUTM (airline of medium voltage) as protection to SUTM into directly lightning surge by determining protection shield, area surface, of using the wire, grounding system, and the constructions. [13]

A grounding system for a good ground wire used in the feeder Sempidi can be determined by using the resistance of ground that has been calculating before. To determine how big the surface of using the ground wire in this planning, can be using the comparison of BC lines with area 50 mm^2 become AAAC with are 70 mm^2. This size comes from comparison KHA both of lines type, and ground wire in location type AAAC with area 35 mm2, 50 mm2 dan 70 mm2.

3.9 Grounding of ground wire

In the grounding system has been using bar electrodes as a neutralizer of lightning surge current to the ground. In the good grounding system for using in the feeder, Sempidi is to make it parallel the bar electrodes 2 until 3 bars in every point of grounding with bar electrodes that have length 6 meters and area surface 3 cm^2. And find the value of grounding under 5 ohm. To make it qualified to the standard of using ground wire rules and standard of protection to directly lightning surge to reach the goals. The good construction is using in the feeder Sempidi is ground wire with the center axis of the tower because of this an open area.

4. Conclusion

Based on the text and analysis in this research can get conclusion below:

a) From data of disturbance in the feeder, Sempidi caused lightning surge before and after using ground wire is a decrease of disturbance about 85,71%, and also decrease the duration of blank off about 38 minutes 34 second. So that the feeder needs protection to lightning surge is ground wire.
b) As protecting of SUTM into the directly lightning surge and to increase reliability distribution system of electric power.
c) To determine the area of the surface that be using a ground wire in the planning by using comparison KHA both of types lines qualified and standard.
d) In the grounding system of the ground wire is using bars electrodes as a neutralizer of lightning surge current to the ground. Grounding measure is minimized resistance about 10.84 ohm and maximize resistance about 23.24 ohm.
e) To make the standard of ground wire construction is qualified with the rule and standard. And the construction is used center axis with the tower.

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The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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