Mapping of Temporary Disturbance and Testing Partial Discharge To Minimize Disturbance and Improving System Reliability In Lampur Feeder

E M Siregar\textsuperscript{1}, T H Budianto\textsuperscript{2}, R Kurniawan\textsuperscript{2} and M Y Puriza\textsuperscript{2}

\textsuperscript{1}PT PLN (Persero) UIW Kepulauan Bangka Belitung – UP3 Bangka, Indonesia
\textsuperscript{2}Department of Electrical Engineering, Universitas Bangka Belitung, Indonesia

E-mail: vancoenregar@gmail.com

Abstract. Of the total disturbances that occur in Lampur feeder, most of disturbance are caused by temporary disturbance whose source of disturbance is unknown/not found. Only relying on sense of sight to find the source of disturbance results in a disturbance occurring repeatedly without a solution to resolve the disturbance and inefficient in the process of finding the location of the disturbance. With middle voltage air feeder inspection management, the location of the source of the disturbance can be found. Disturbance point search process with inspection management consists of mapping medium voltage air feeder using distribution software and detailed search in the field with ultrasonic tools. The results of this inspection management can reduce temporarily disturbance and also reduce energy not sale (ENS) on Lampur feeder.

1. Introduction
Disturbance in middle voltage air feeder divided into 2 (two), when viewed from the character of the disturbance. The first is a permanent disturbance where the source of the disturbance must be removed first and then can recover the electricity supply. Usually this permanent disturbance is the source of the disturbance in plain view, making it easier for the supply recovery process due to disturbance. The second is a temporary disturbance where the source of the disturbance is not detected, but the recovery of supplies tends to be possible. Especially temporary disturbances are very difficult to find the cause because the source of the disturbance is invisible.

To make it easier to determine the location of the source of disturbance, it is necessary to do an inspection management of the physical condition of feeders which consists of mapping middle voltage air feeder with distribution software and middle voltage air feeder inspection using ultrasonic tools used to detect partial discharge in the material. With this inspection management, it is expected that searching for the source of the disturbance will be better because inspections are carried out with detailed initial mapping with distribution software and inspection up to certain points in the field with ultrasonic tools. With this inspection management expected reduce temporarily disturbance about 30\% and also reduce energy not sale (ENS) on Lampur feeder.

2. Mapping Lampur Feeder
To make a mapping model, several tools are needed namely distribution software and ultrasonic tool. Beside that some data is also needed, among others detailed physical data, single line diagram, historical disturbance data of Lampur feeder.

2.1. Data of Lampur feeder
Lampur feeder configuration made according to detailed physical dataand single line diagram. Some of detailed physical data of Lampur feeder shown in Table 1.
Table 1. Detailed physical data of Lampur feeder.

| Origin      | Aim          | Type of Conductor | Length (meter) |
|-------------|--------------|-------------------|----------------|
| GI Kampak   | Initial pole | XPLE 240          | 54             |
| Initial pole| Jointing SKTM| A3C 150           | 1985           |
| Jointing SKTM| Branching 1  | A3C 150           | 1944           |

Single line diagram of Lampur feeder shown in Figure 1.

Figure 1. Single Line Diagram of Lampur Feeder

2.2. Input data to distribution software

Lampur feeder physical data, type of conductor, length conductor, substation location, and type of load and load substation inputted to the distribution software to find out the short circuit level. For accuracy of calculations, parameters that must be in accordance with real conditions in the field include:

- Power Grid and Line

![Power grid editor](image1)

![Line editor](image2)

Figure 2. (a) Power grid editor; (b) line editor

- Substation and Load

Short circuit level can be known to use the "short circuit" feature in the distribution software. It easier to find the location of disturbance by comparing the result of short circuit analysis with disturbance historical data. Some of Lampur feeder disturbance historical data shown in Table 2:


Figure 3. (a) Substation Editor; (b) Load Editor

Table 2. Disturbance Historical of Lampur Feeder

| Date            | Time | Disturbance Current Value (A) | Disturbance Location |
|-----------------|------|------------------------------|----------------------|
|                 |      | R   | S   | T   |                   |
| 04/05/2017      | 13.51| 112 | 114 | 320 | unknown           |
| 06/15/2017      | 05.30| 86  | 307 | 95  | unknown           |
| 12/11/2017      | 11.37| 60  | 281 | 64  | unknown           |

2.3. Searching for Disturbance Location

The estimated location of disturbance is known by comparing short circuit result dan disturbance historical of Lampur feeder. Detailed disturbance location search is done by using ultrasonic tool to detect partial discharges that occur.

3. Result and Discussion

The estimated point of disturbance source obtained from the results of analysis (short circuit level) with distribution software shown the Table 3.

Table 3. Short Circuit Level of Lampur Feeder.

| I-hs (kA) | GI PKP | REC TERU | KERETAK | PENAGAN | SP KATIS | END FEEDER |
|-----------|--------|----------|---------|---------|----------|------------|
| 3PH       | 7.94   | 1.7      | 1.37    | 2.08    | 1.51     | 0.836      |
| L-G       | 0.316  | 0.238    | 0.205   | 0.252   | 0.216    | 0.174      |
| L-L       | 6.88   | 1.47     | 1.19    | 1.8     | 1.31     | 0.724      |
| L-L-G     | 6.87   | 1.51     | 1.21    | 1.83    | 1.34     | 0.748      |

In this study the suspected cause a temporary disturbance is an insulator that experiences a partial discharge event. This condition is due to the indication that other causes such as trees and animals are relatively small because the work of felling trees approaching the tissue on routine Lampur is done and automatic animals will not approach the feeder. In accordance with PLN 520 SK-DIR in 2014 that material that experiences partial discharge will be one of its characteristics to produce sound and testing can be carried out by the aquatic method. The isolator that experienced a partial discharge event was tested by ultrasonic tool. The way to operate this tool is to direct the mic to the suspected component in Lampur feeder section where the source point of the disturbance has been evaluated to
be the main cause of the temporary disturbance. With comparing short circuit level and disturbance historical data, the estimated location of disturbance can be divided into 4 location based on the amount of fault current.

3.1. Disturbance Locations With Short Circuit Current 280 - 350 amperes (Approximate Location Around Reclosers And Beginning Of Each Branch)

From this location, there are 2 points suspected of causing the disturbance, shown in figures below:

Figure 4. In this test there was partial discharge on phase R insulator on pole 129-R183 with the acoustic method. Ultrasonic devices obtained results of 23.25 dB at ambient temperatures around 27.8 °C and humidity 77% with ultrasonic instrument settings frequency 40kHz, sensitivity 116 dB, the test mode is "real time", the volume is 70% and the offset is 0.

Figure 5. In this test there is partial discharge on phase S insulator on pole 129-R197 with acoustic method. Ultrasonic devices obtained results of 21.39 dB at ambient temperatures around 27.8 °C and humidity 77% with ultrasonic instrument settings frequency 40kHz, sensitivity 116 dB, the test mode is "real time", the volume is 70% and the offset is 0.

3.2. Disturbance Locations With Short Circuit Current 250 - 280 amperes (Approximate Location Around Beginning Of Each Branch)

From this location, there are 1 point suspected of causing the disturbance, shown in figure below:

Figure 6. In this test there is partial discharge on phase T insulator on pole 129-R325 with acoustic method. Ultrasonic devices obtained results of 21.27 dB at ambient temperatures around 27.7 °C and humidity of 77.4% with ultrasonic instrument settings frequency 40kHz, sensitivity 116 dB, the test mode is "real time", the volume is 70% and the offset is 0.
3.3. Disturbance Locations With Short Circuit Current 200 - 250 Ampere (Approximate Location Around Mid of Each Branch)
From this location, there are 1 points suspected of causing the disturbance, shown in figure below:

Figure 7. In this test there was partial discharge on phase S insulator on pole 129-R295-L206 with aquatic method. Ultrasonic devices obtained results of 15.37 dB at ambient temperatures around 27.7 °C and humidity of 77.6% with ultrasonic instrument settings frequency 40kHz, sensitivity 116 dB, "real time" test mode, volume 70% and offset of 0.

3.4. Disturbance Locations With Short Circuit Current 160 - 200 amperes (Approximate Location Around End Of Each Branch)
From this location, there are 1 points suspected of causing the disturbance, shown in figure below:

Figure 8. In this test there is partial discharge on phase S insulator on pole 129-R295-L271 with aquatic method. Ultrasonic devices obtained results of 11.98 dB at ambient temperature around 27.7 °C and humidity 77.6% with ultrasonic instrument setting frequency 40kHz, sensitivity 116 dB, "real time" test mode, volume 70% and offset of 0

Maintenance can be carried out by replacing the insulator as a corrective/improvement follow-up from the findings in the field.

3.5. Energy Not Sale (ENS)
With the formula $P = \sqrt{3} \times V \times I \times \cos\delta$. Power can be calculated. As known the total load of Lampur feeder estimated 90 amperes. So the estimated power of Lampur feeder were 3117.6kwatt. If the minimum time of feeder disturbance was 2 minute (0.03 hour), then the energy not sale was 103.92 kwh every time Lampur feeder down. So with this numbers, the energy not sale shown in table below:

| Year | Down (Time) | ENS(kWh) |
|------|-------------|----------|
| 2017 | 143         | 14860.56 |
| 2018 | 110         | 11431.20 |
4. Conclusions
The mapping method can determine location of disturbance source so that reduce temporary disturbance. With some maintenance would eliminate the disturbance source from Lampur feeder. This condition also reduce the energy not sale at Lampur feeder. The energy not sale from 14860.56 kWh (2017) become 11431.20 kWh (2018) down about 25 percent.

Acknowledgement
We gratefully acknowledge the support from USAID through the SHERA program – Centre for Development of Sustainable Region (CDSR). In year 2017-2021 CDSR is led by Center for Energy Studies – UGM.

References
[1] Amrullah K G S A, Kurniawan R, dan Putra G B 2017 Aplikasi pemetaan prediksi lokasi gangguan hubung singkat pada saluran distribusi 20kV berbasis website pada penyulang Apel, Prosiding Seminar Nasional dan Pengabdian pada Masyarakat, Universitas Bangka Belitung, Indonesia.
[2] Avitall B 1995 Mapping and ablation electrode configuration, US Patent US5454370A. United State.
[3] Cui L 2013 Detection and analysis of partial discharges in non-uniform field, ProQuest Dissertations Publishing, Arizona State University.
[4] Dan C and Morar R 2017 Partial discharge measurements on 110kV current transformers. Setting the Control Value. Case Study IOP Conference Series: Materials Science and Engineering 200 012002.
[5] Judd M D, McArthur S D J, Mc Donald J R, and Farish O 2002 Intelligent condition monitoring and asset management. Partial discharge monitoring for power transformers IEEE Power Engineering Journal 16 297-304.
[6] Lund P D, Lindgren J, Mikkola J, and Salpakari J 2015 Review of energy system flexibility measures to enable high levels of variable renewable electricity Renewable and Sustainable Energy Reviews 45 785-807.
[7] Pregelj A, Begovic M, and Rohatgi A 2006 Recloser allocation for improved reliability of DG-enhanced distribution networks IEEE Transactions on Power Systems 21 1442-1449.
[8] Syahputra R 2014 Estimasi lokasi gangguan hubung singkat pada saluran transmisi tenaga listrik Jurnal Ilmiah Teknika Semesta 17 106-115.
[9] Velo I R Experimental Set-up for partial discharge detection (Norwegian: Department of Electrical Power Engineering, Norwegian University of Science and Technology)
[10] Zhu J, Lubkeman D L and Girgis A A 1997 Automated fault location and diagnosis on electric power distribution feeders IEEE Transactions on Power Delivery 12 801-809.