Protection System Coordination On 20 kV Distribution Network In Makassar City

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Abstract - This study is a quantitative study that aims to a) describe the coordination of protection systems under abnormal conditions in the distribution network and b) to determine the selectiveity of protection systems in isolating equipment in abnormal conditions of distribution networks. Data *setting existing rele* protection system obtained in PT. PLN (Persero) UP2D Makassar, the data is then processed, simulated, and analyzed using the ETAP 19.0.1 program. The series analyzed in this study is the distribution network PLN ULP Karebosi Paotere refiner with a channel length of 8,234 km, where sktm channel 0.844 km and SUTM 7,390 km, consisting of 33 distribution substations. The results showed that the flow of short circuit disruption on Hatta buses was: 3-Phase by 3,887 kA, *Line-to-Ground* by 3,550 kA, *Line-to-Line* by 3,357 kA, and *Line-to-Line-to-Ground* by 3,831 kA. To achieve reliability and coordination of protection system equipment *resetting rele* on *recloser* Sabutung Set OCR 250 kA, TMS-TD OCR 0.08 s, *moment* OCR 3x, Sect. Paotere bridge OCR 200 kA, TMS-TD OCR 0.07 s, *moment* OCR *Block*, Sect. Hatta OCR 180 kA, TMS-TD OCR 0.05 s, *moment* OCR *Block*.

Keywords: Short Circuit Flow, Coordination, *Recloser*, *Sectionalizer*, *Existing Rele Setting*, *Resetting*, ETAP 19.0.1

I. INTRODUCTION

Along with the increasing economic growth and the increasingly rapid rate of development in the city of Makassar which requires a large enough electrical energy, it is hoped that the system will remain reliable and continuously of good quality. Therefore, the distribution of electrical energy to consumers is endeavored to remain stable, sustainable and must always be maintained in order to meet the demand for electrical energy consumption. [1]. Makassar City is one of the largest metropolitan cities in eastern Indonesia with a population of more than 1.5 million people (SP2020) and is a large industrial area which certainly requires large and increasing electrical energy, in carrying out its activities and life. With a population of this size, PT. PLN (Persero) as a state-owned company engaged in electricity services in Indonesia will certainly try to meet the public's need for quality electricity in the city of Makassar and maintain reliability in distributing it to consumers.

The protection system is a complete arrangement of protective equipment, including the main equipment and other equipment needed to carry out the protection function from interference caused by the protection of the electrical equipment. The protection system in the electric power distribution network needs to support continuity and minimize blackout areas. The protection system is part of ensuring that the distribution network can be considered safe. Protection systems are also used to protect critical equipment and areas so they can be protected from tampering [2]. The main function of protection or protection equipment is to release or separate the disturbed equipment from the overall system in order to minimize the damage that can occur and maintain as much as possible the continuity of the electricity supply. Safety equipment must do it in the shortest possible time so it needs to be fully implemented automatically.

System reliability is needed in electricity distribution which has a reliable protection system to reduce the occurrence of power outages for consumers which harm the residents who use it [3]. With such a large population and the many industries in Makassar City that need electricity to produce goods. So to maintain the reliability of the electricity distribution system, a protection system and network maneuvers are carried out in an effort to reduce blackout areas, when there is a disturbance in the system and the widespread impact of the disturbance that occurs in an area.

The problem is that the operation of the electric power system often experiences interruptions which can result in disruption of the distribution of electricity to consumers. These disturbances will become a barrier for a system that is currently operating, even this can damage electrical equipment including devices and components used [4]. The distribution network is the part of the electric power system that is closest to the consumer. In terms of physical volume, the distribution network is generally longer than the transmission network and the number of disturbances is also the highest compared to the number of disturbances on the transmission line.

In general for a fault on the rail by ignoring the pre-disturbance currents, namely:

$$I_f = \frac{V}{Z} \qquad (1)$$

Description :

I_f = Fault current flowing (A)

V = Source voltage (V)

Z = Network impedance, the equivalent value of all impedances in the network (Ω)

The successful functioning of a protection system requires coordination between the various protection devices used, both those that work automatically and manual protection equipment. The fault current in the network is calculated as part of the coordination analysis [5]. To determine the working time value of a protective equipment with other protective equipment, it is necessary to calculate the coordination between the protective equipment. so that each safeguard has an important role in overcoming interference according to its function [6].

In the use of FCO fuser type protection equipment has weaknesses, namely its use is limited to small power distribution, and it is not equipped with an arc damper that occurs in the event of a short circuit fault and cannot be used again after protecting. To be more efficient, recloser protection equipment is used which can close again and overcome arcing. The recloser is able to protect against short circuit fault currents and is even able to recognize very small short circuit fault currents, for this reason it is necessary to pay attention to the coordination between the protection equipment installed in the network system.

Coordination of protection, namely the linkage or connection of protective devices with each other, for example the first protective device cannot overcome disturbances, the second protective device will work to overcome disturbances in the system.

ETAP is commonly used to make electric power system projects in the form of one-line diagrams and grounding system paths for various forms of analysis, namely power flow, short circuit, motor starting, trancient stability, coordination of protective relays and harmonic systems. Electrical power system projects have individual circuit elements which can be edited directly from a one-line or grounding system line diagram. For convenience, the results of analysis calculations can be displayed on a one-line diagram. ETAP power station allows to work directly with a single line diagram image display [7]. ETAP 19.0.1 software certainly has a better appearance than the previous version. ETAP 19.0.1 can perform a graphical depiction of a single line diagram and conduct several analyzes namely load flow, short circuit, motor starting, harmonics, transient stability, protective device coordination, and cable derating.

Taking into account the above, in this study a study of coordination of protection systems will be carried out to improve the quality of feeder service in the primary distribution channel of PT. PLN ULP Karebosi in Makassar City. This coordination was analyzed using the Electric Transient and Analysis Program (ETAP) 19.0.1 software. ETAP is software that supports electric power systems to determine maximum current and voltage values.

II. RESEARCH METHOD

1. Types of research

   This research is a quantitative research. The data used is data in the form of numbers obtained from PLN UP2D Makassar regarding information on protection or safety equipment used in the 20 kV primary distribution system at PT. PLN ULP Karebosi, Makassar.

2. Research design

   Research design is a framework or plan for conducting a study that will be used as a guide in collecting and analyzing data. The research design is as follows:

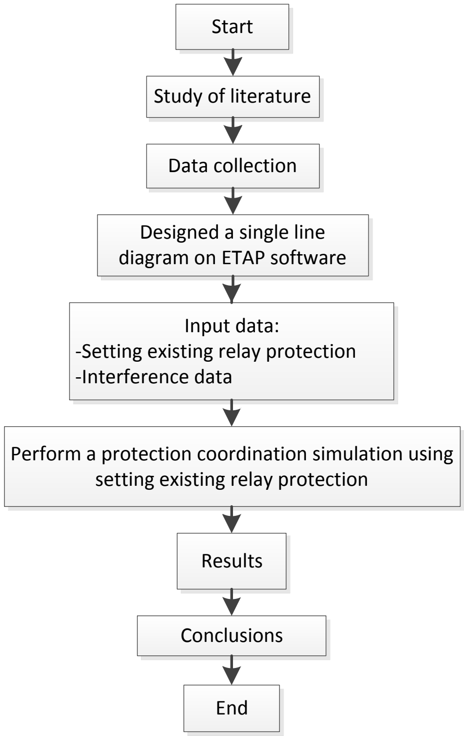

Fig 1. Research design

III. RESULTS AND DISCUSSION

PT. PLN (Persero) ULP Karebosi is one of the electricity company units under the North Makassar Area PLN. PT. PLN (Persero) ULP Karebosi with a line length of 181.118 km and consisting of 33 feeders, namely Achmad Yani feeder, Akademis, Akkarena, Andalas, Barawaja, Bawakaraeng, BMA, Bulusalaka, Caraka, Indofood 1, Indofood 2, Indofood 3, Losari, Mattoangin, Mesjid Raya, New Port 1, New Port 2, Nipah 1, Nipah 2, Panampu, Paotere, Pelamonia, Pelindo, POLDA, Rantemario, Reformasi, Rujab, Sudirman, Sungai Tangka, Sunu, Teuku Umar, TPM, Urip.

Table 1. Paotere feeder substation

Transformer Capacity (kA)	Amount
50	1
160	13
200	6
250	5
400	4
630	3
1000	1

1. Interference monitoring data

The disturbances that occurred in the paotere feeder can be seen from the disturbance monitoring report data for the last two years obtained from PLN UP2D Makassar.

Table 1 Disruption contribution data for 2019-2020

year	Origin of disturbance			The nature of the disturbance	
	Medium voltage network equipment	Nature	Unclear	Perm anent	Temporary
2019	22	15	26	3	17
2020	16	7	9	8	4

Based on table 2, it shows that the dominant network equipment contributed to causing disturbances in the distribution network 22 times in 2019 and 16 times in 2020.

Based on table 3 shows the Sabutung recloser which often protects when there is a disturbance in the distribution network. The protection system equipment coordinated once throughout 2019. The protection system that works when coordinating is the Sabutung recloser, where the disturbance point is located on the Sabutung bus.

Table 2. Data lockout of Paotere feeder protection system equipment

year	Keypoint LBS/Rec.				Coordination
	Rec. Sabutung	Paotere	Lanal	Hatta	
2019	34	27	6	6	1
2020	24	7	5	11	0

Based on table 4, it shows that the largest number of disturbances in 2019-2020 was on the Hatta bus. Based on disturbance data, the Hatta bus is the bus that most frequently experiences disturbances in the distribution network

Table 3. Data interference on the bus

year	ID					
	Sabu tung	Jem Paot ere	Lana l	Hatta	Pel. Timur	Seo karno
2019	2	7	12	16	1	5
2020	1	3	2	11	3	6

2. Simulation of Coordination of Protection System Using ETAP 19.0.1

In the protection system coordination simulation using ETAP 19.0.1 software. The disturbance point was carried out on the Hatta bus because disturbances often occur on this bus based on the disturbance data obtained from research data. In this simulation, a coordination simulation will be carried out using the setting existing rele protection and resetting rele protection data on ETAP 19.0.1.Peralatan proteksi yang dianalisa yaitu peralatan yang mampu berfungsi SCADA (Supervisory Control And Data Acquisition) pada penyulang paotere yaitu Recloser Sabutung, LBS Jembatan Paotere , dan LBS Hatta

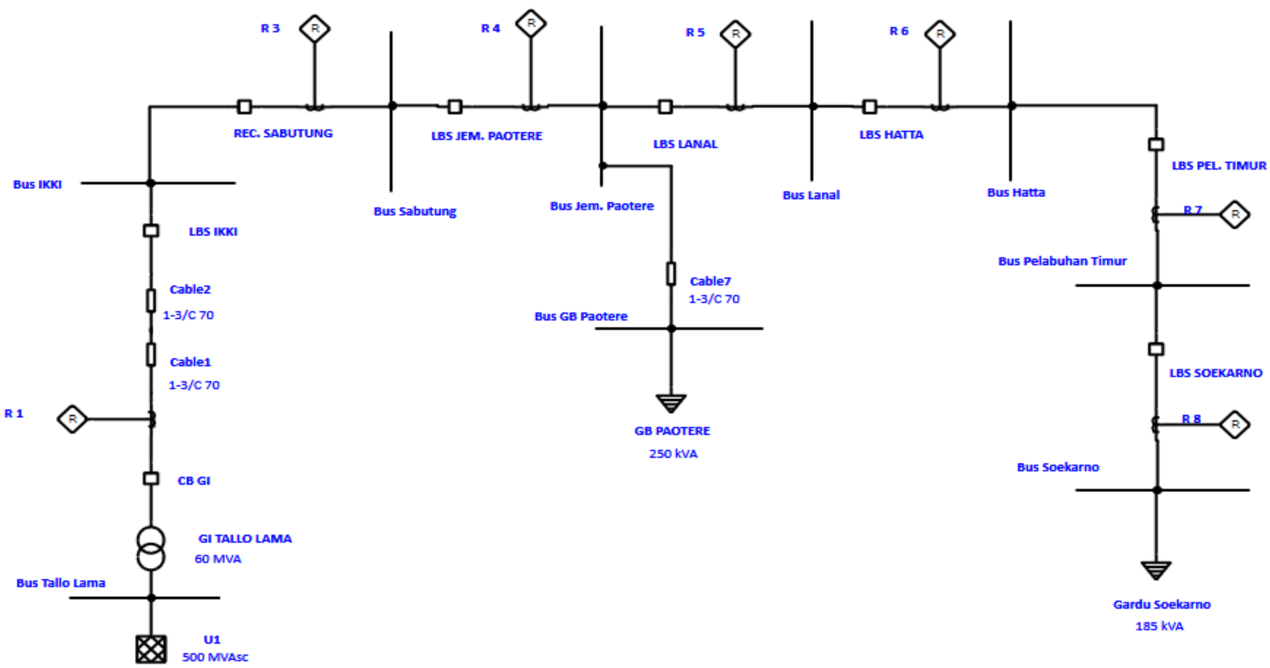

Figure 2. Single line diagram of a paotere feeder with ETAP 19.0.1

a. Setting Existing Rele Protection System

The simulation being analyzed is setting existing rele of the Paotere feeder protection system using ETAP 19.0.1. Setting existing rele protection system on paotere feeders can be seen in the following table.

Table 5 Setting existing rele protection system on Paotere feeders

No.	Keypoint	Brand	Set OCR	TMS-TD OCR	Moment OCR
1.	Rec. Sabutung	Jongwon	250	0,03	3 X
2.	Sect. Jem. Paotere	Schneider advc	200	0,05	Block
3.	Sect. Hatta	*Schneider* advc	180	0,05	Block

Based on table 5, it shows the protection relay settings that exist in the Paotere feeder. The protection equipment in table 4 is equipment that can be controlled using the SCADA system which is controlled from the Makassar PLN UP2D office, namely the Sabutung recloser, Sect. Paotere bridge, sect. Hatta.

Based on Figure 3, it shows a simulation of interference on Paotere feeders using ETAP 19.0.1. use setting existing rele protection system. Where the disturbance point occurs on the Hatta bus with a voltage of 20 kV, based on the ETAP 19.0.1 simulation it can be seen that the protection system equipment trips sequentially. The first protective equipment is a recloser with a hose of 35.0 s, an interval of 45.0 s LBS Lanal makes a trip, an interval of 55.0 s LBS Hatta makes a trip.

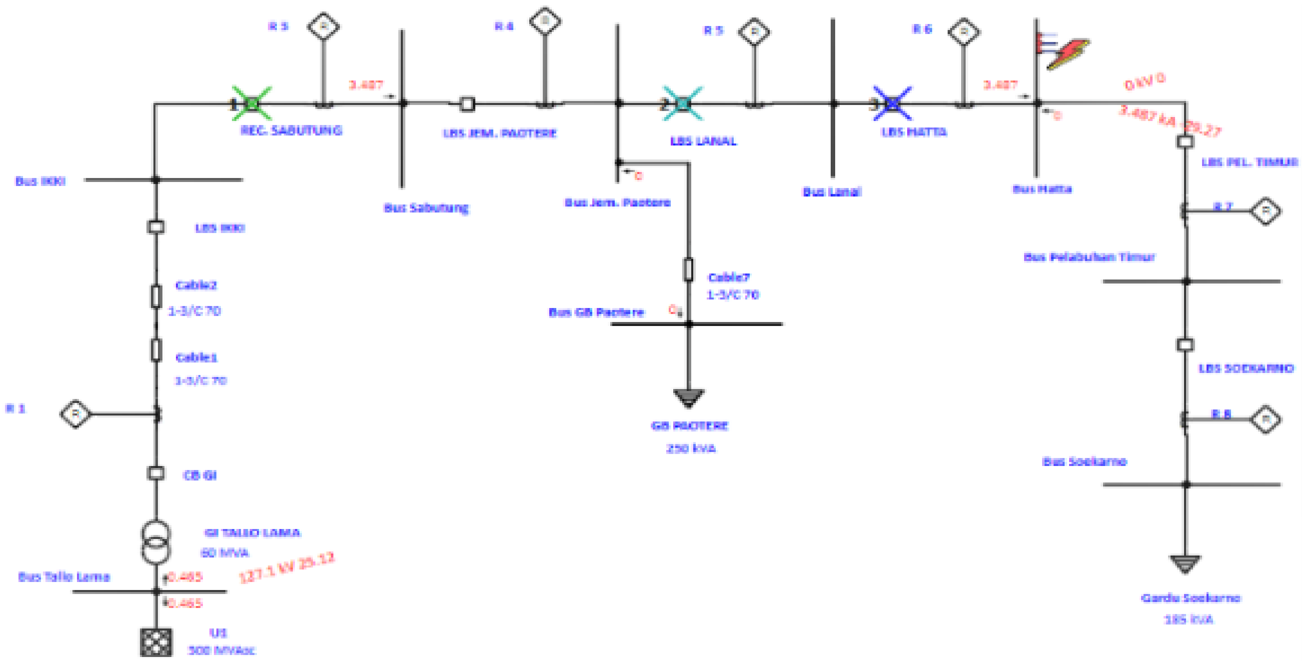

Figure 3. Simulasi koordinasi *setting existing rele* proteksi pada ETAP 19.0.1

In the simulation using data setting exsisting rele protection system from PLN. In this condition, the Hatta LBS is late in eliminating the disturbances that occur on the Hatta bus, this shows that the protection system equipment is still not maximally coordinating in eliminating the disturbances that occur.

Therefore resetting is needed to achieve coordination between reliable security devices in the distribution network.

Table 6 Short circuit current data on the Hatta bus

ID	Bus Voltage (kV)	3-P (kA)	L-L (kA)	L-G (kA)	L-L-G (kA)
Bus Hatta	20	3,877	3,550	3,357	3,831

b. Resetting Rele Protection System for Paotere Feeders

The simulation being analyzed is the resetting rele of the Paotere feeder protection system using ETAP 19.0.1. Resetting rele protection system on paotere feeders can be seen in the following table. Based on table 7, it shows the resetting rele protection system on the paotere feeder which will be simulated on ETAP 19.0.1 to analyze how the protection system coordinates when there is a disturbance on the Hatta bus.

Table 7 Resetting rele protection system on Paotere feeders

No.	Keypoint	Brand	Set OCR	TMS-TD OCR	Moment OCR
1.	Rec. Sabutung	Jongwon	250	0,08	3 X
2.	Sect. Jem. Paotere	Schneider advc	200	0,06	Block
3.	Sect. Hatta	Schneider advc	180	0,03	Block

Based on Figure 4, it shows a simulation of interference on Paotere feeders using ETAP 19.0.1. In this simulation using data resetting rele protection system. The disturbance point is located on the Hatta bus with a voltage of 20 kV, when there is a disturbance on the Hatta bus it can be seen that the protection system equipment trips sequentially. The protection equipment that protects first, namely LBS Hatta does a 55.0 s trip, at an interval of 65.0 s the LBS lanal does a trip, then at an interval of 75.0 s the LBS Paotere bridge does a trip.

In the simulations carried out using the resseting rele protection system, the LBS hatta is able to eliminate interference on the bus hatta then the next protection works sequentially. This indicates that the protection system equipment has coordinated to eliminate fault points in the distribution network.

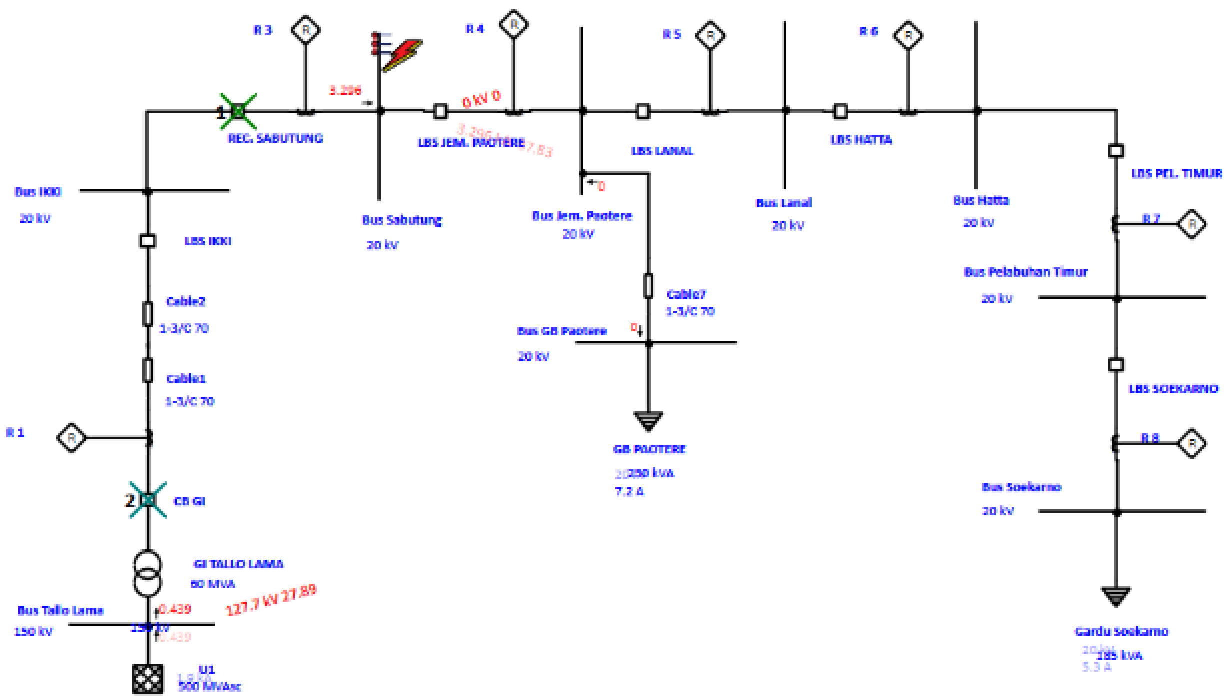

Figure 4. Simulation of resetting rele coordination on Paotere feeder protection

Table 8 Short circuit current data on the Hatta bus

ID	Teg. Bus (kV)	3-P (kA)	L-L (kA)	L-G (kA)	L-L-G (kA)
Bus Hatta	20	3,877	3,550	3,357	3,831

Based on disturbance data from PLN, the protection system for Paotere feeders has coordinated once during 2019-2010. However, when the system coordinates to protect the fault point is located on the Sabutung bus where the equipment that does the lockout, namely the Sabutung recloser with the cause of the disturbance is unclear or unknown but locks out occurs on the protection system equipment.

The protection systems whose coordination was analyzed were the sabutung recloser, the Paotere Bridge LBS, and the Hatta LBS. Each of these protection devices can work on a SCADA system and has a delay setting on the protection relay. Simulations were carried out on ETAP 19.0.1 using the setting existing rele protection system and then it was seen how the coordination was in eliminating disturbances. When the protection equipment is unable to coordinate with other protection systems, resetting will be carried out on setting existing rele so as to achieve a reliable protection system in the distribution network..

Based on ETAP 19.0.1 calculations at a bus voltage of 20 kV, the total short circuit current can be seen in tables 4.7 and 4.9. The 3-phase short circuit on the Hatta bus is 3.877 kA, the phase-to-phase short circuit current is 3.550 kA, the 1 phase to ground short circuit current is 3.357 kA, the 2 phase to ground short circuit current is 3.831 kA. While the manual calculation results obtained 3-phase short circuit of 3.524 kA, phase-to-phase short-circuit current of 3.523 kA, 1-phase-to-ground short-circuit current of 3.227 kA, 2-phase-to-ground short circuit current of 1.475 kA.

Analysis using the setting existing rele protection system in ETAP 19.0.1 at a voltage of 20 kV, can be seen in table 4.6. Where is the Sabutung recloser set OCR 250 kA, TMS-TD OCR 0.03 s, moment OCR 3X, LBS Paotere bridge set OCR 200 kA TMS-TD OCR 0.05 s, moment OCR block, LBS Hatta set OCR 180 kA TMS-TD OCR 0.05 s, moment OCR block. Based on the simulation on ETAP 19.0.1 the disturbance point on the Hatta bus where the sabutung recloser first disconnects, then the LBS of the Paotere bridge and finally the LBS of Hatta. Where this shows that LBS Hatta is slow to detect and eliminate indications of disturbances on the Hatta bus or has not been able to coordinate optimally. So it is necessary to do resetting existing rele protection system to achieve coordination and reliability on the network

Based on the simulation results using the resetting rele protection system at ETAP 19.0.1 at a voltage of 20 kV, it can be seen in table 4.8. Where is the Sabutung recloser set OCR 250 kA, TMS-TD OCR 0.08 s, moment

OCR 3X, LBS Paotere bridge set OCR 200 kA TMS-TD OCR 0.06 s, moment OCR block, LBS Hatta set OCR 180 kA TMS-TD OCR 0.03 s, moment OCR block. When there is a disturbance on the Hatta bus where the Hatta bus is able to detect indications of disturbance and make a termination first, then LBS Lanal and LBS Paotere bridge. This shows that the protection system has been able to coordinate in eliminating disturbances that occur on the network.

IV. CONCLUSION

Based on the results of the ETAP 19.0.1 simulation it can be concluded that the disturbance simulation using the setting existing rele protection system on the Paotere feeder does not coordinate to eliminate indications of disturbances that occur on the Hatta bus. The protection system on Paotere feeders can coordinate to eliminate interference with the resetting rele protection system. The protection system equipment in Paotere feeders is quite selective in securing networks and equipment in abnormal conditions of the distribution network.

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