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An Analysis Of Reliability Protection Systems At PLTU PT. Indah Pontjan

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ABSTRACT

In this research, the aim is to analyze the reliability of the protection system at the Steam Power Plant (PLTU) at PT. Indah Pontjan. The protection system is a crucial component in PLTU operations, which functions to protect equipment and systems from interference and ensure operational safety. In this research, the reliability evaluation method is used to assess the effectiveness of the existing protection system. Analysis is carried out through operational data collection, protection system inspection, and simulation of various disturbance scenarios. The research results show that the reliability of the protection system at PLTU PT. Indah Pontjan already meets industry standards, but there are still several areas that require improvement. Some important findings include the detection of discrepancies in protection coordination, the need for improved protection devices, and the importance of further training for system operators. Recommendations are provided to strengthen the protection system, including the addition of modern protection devices, increased routine maintenance, and implementation of regular training programs. By increasing the reliability of the protection system, it is hoped that PLTU PT. Indah Pontjan can operate more safely and efficiently, reducing the risk of equipment damage and minimizing operational downtime. This research makes an important contribution to the development of a more reliable and effective protection system for the steam power generation industry.

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INTRODUCTION

Protection coordination has become a common problem and must be overcome in order to maintain continuity and increase the reliability of an electrical system, so it must be designed so that protection relays can operate to detect disturbances and prevent damage caused by disturbances. Protection is something that is very necessary and very important in the electric power system because it can prevent large production losses due to equipment outages or equipment damage caused by interference or overload. Continuity of power supply in an industry is very necessary to ensure that the production process continues, so good protection coordination is needed. When the CB closest to the fault point fails, the CB backup fault current flowing in the electric power system causes the protection relay to operate and moves the circuit breaker and the power flow that is interrupted will immediately work according to the predetermined time. It is hoped that when a disturbance occurs, the circuit breaker (CB) located closest to the point of disturbance can work first.

The Paiton steam power plant (PLTU) is a power plant built by the Indonesian government as a supplier of electricity for Java-Bali. PLTU Paiton is a very vital and important generating complex. If damage or disruption occurs, it is possible that parts of Java will experience rolling blackouts or blackouts or loss of Java-Bali electricity if it is not protected by reliable and appropriate security. Therefore, it is necessary to coordinate protection such as phase overcurrent relays and safe and reliable ground fault relays in the electrical system.

In the industrial world, the sustainability and reliability of electrical energy supply is a critical factor that influences a company's operational performance. One source of electrical energy that is commonly used is Steam Power Plants (PLTU). PT. Indah Pontjan as a company that relies on electrical energy supplies from PLTU needs to maintain the reliability of its electrical power system so that it can carry out operations efficiently and without interruption. Reliability analysis is an important aspect in evaluating the PLTU electric power system at PT. Indah Pontjan. Several factors that can influence the reliability of a PLTU's electric power system include:

a. Operational conditions of PLTU machines and equipment.
b. Periodic care and maintenance carried out.
c. Technical problems and equipment accidents.
d. Reliability of regulation and control systems.

Therefore, reliability analysis is a very relevant step to be implemented in evaluating PLTU electrical power systems. This aims to identify potential risks of failure and take the necessary precautions so that the electrical energy supply can run smoothly and efficiently. By conducting reliability analysis, PT. Indah Pontjan can increase operational efficiency, reduce the risk of downtime, and increase customer or consumer satisfaction who rely on the company's electrical energy supply. In addition, high power system reliability can also help achieve sustainability and environmental performance goals by reducing the negative impact of operational disruptions and unplanned power outages.

Coordination of protection in the electric power system plays an important role in protecting equipment from damage due to disturbances. When a disturbance occurs in the electric power system, the protection system must be able to isolate the fault current so that damage to equipment does not occur and service continuity is maintained. There are many problems related to protection, from short circuit problems to problems with system grounding. Because protection must be set to sense interference as quickly as possible and isolate interference as quickly as possible, sometimes protection problems become quite complex problems. There are many types of relays for protection, one of which is the overcurrent relay and the ground fault relay.

Protection relays in an industry are a very important part because they can prevent losses in an industry caused by equipment outages or unnecessary equipment damage caused by interference or overload. The fault current flowing in the system will later cause the protection relay to operate and actuate the power breaker so that the power flow will be interrupted. This is what can sometimes cause losses in an industry.

The selection of protection relays must consider the following: Maximum protection, minimum equipment costs, reliable protection, fast operation, simple design, high sensitivity to disturbances, and insensitivity to normal load currents. Generally, high-speed relays (eg, breaker operating time 1 cycle to 3 cycles). If the fault is not isolated after some delay time, backup protection will work by tripping the main circuit breaker or by tripping the circuit breaker in an adjacent zone.

Literature Review

Disturbance

In the electrical system there are several disturbances that can cause overcurrent. The disturbances that often occur in electric power systems are overload disturbances and short circuit faults. This disturbance occurs because the current flowing exceeds the permitted nominal current (I in). When this disturbance occurs, the current flows in excess of the capacity of the electrical equipment (transformer, generator, motor, etc.) and the safety installed. If this disturbance is allowed to continue, it can damage the electrical equipment that carries the current. A short circuit will result in overcurrent in the disturbed phase and will also result in an increase in voltage in the uninterrupted phase. This is very dangerous considering that the current caused by a short circuit is very large.

Short circuit faults can be classified into two groups, namely symmetrical short circuit faults and unsymmetrical (asymmetrical) short circuit faults. The faults included in the symmetric short circuit are three-phase short circuit faults, while the other faults are asymmetric short circuit faults. Most of the disturbances that occur in electric power systems are asymmetric disturbances. This asymmetrical fault occurs as a result of a single phase short circuit to ground fault, a two phase short circuit fault, or a two phase short circuit to ground fault.

Over Current Relay

To overcome overcurrent disturbances, one of the ways we can use an overcurrent relay. An overcurrent relay is a relay that operates when the current flowing exceeds the permitted limit. The relay will work if the following conditions are met : If > IP relay works (trip) If < IP does not work (block)

Where IP is the working current expressed according to the secondary winding of the current transformer (CT). And If is the fault current which is also expressed in the CT secondary winding. This overcurrent relay protects almost all parts of the electric power system, for example the transmission network, transformers, generators and motors. Current relay or overcurrent relay can be a specific time overcurrent relay, inverse time overcurrent relay, instant time overcurrent relay.

Setting the safety relay using certain time characteristics set on the relay is only based on the working time of the safety relay without looking at the magnitude of the fault current. In other words, all current levels that exceed the pickup set point will be disconnected at the same time.

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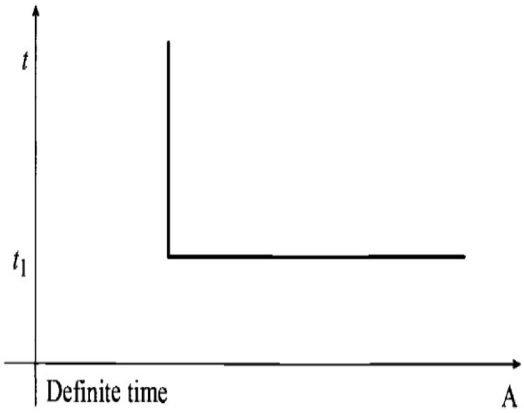

Figure 1. Specific time overcurrent relay characteristics

The inverse time overcurrent relay has the characteristic that the greater the fault current, the faster the relay will operate. On the other hand, if the fault current is small, the relay operation delay time will be longer. The working characteristics of the inverse time overcurrent relay are described in the current-time curve or what is usually called the time-current characteristic (TCC). In the IEEE std 242-2001 standard there are several characteristics of inverse curves, namely long time inverse, very inverse, short time inverse and extreme inverse. Its use can also be combined with an instantaneous overcurrent relay which will be explained further later.

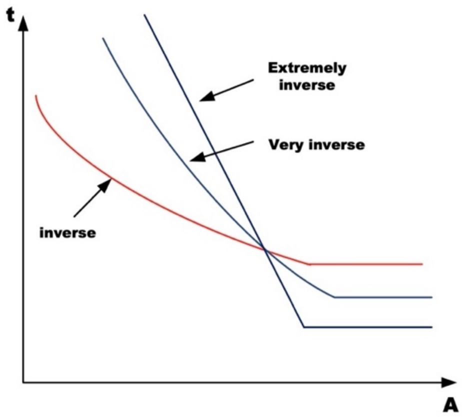

Figure 2. Characteristics of standard inverse, very inverse and extremely inverse

Protection

Protection System Disturbances at power generating centers can occur at any time, for this reason a protection system is needed, which functions in addition to securing equipment at the generating center as well as to localize the impact of the disturbance. The fault detection tool is a relay, which then gives a command to the trip coil to open the power breaker (PMT). The main requirements for the protection system are sensitivity, reliability, selectivity, speed.

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a. Sensitivity.
b. Reliability
c. Selectivity
d. Speed

Generator protection relays are measuring equipment that can detect electrical quantities that are related to disturbances or abnormalities in a power system, which then separates the disturbed part (trips) or simply gives an alarm signal. The basic electrical quantities that change during fault conditions are voltage, current, phase angle (direction), frequency and others. In general, observations on generators can be divided into two large parts, namely: PMB, however, can sound an alarm if there is a disturbance or something abnormal in the power system.

The working principle of differential protection is to compare two magnitudes of current and phase between two points at the boundaries of the safety area. So in this case, current is used as the measuring quantity, if there is no disturbance in the equipment being secured or the disturbance is outside the secured area, then the current value and phase flow in the CT 1 and CT 2 current transformers are the same or have a ratio of current values and angular deviations. certain phase, so the relay will not work. However, if a disturbance occurs in the equipment being secured, there will be a difference in current or a change in the current ratio as well as a change in phase angle which will cause the differential relay to work. The way to compare I1 and I2 is by comparing the value and phase angle of the secondary current. The safety limits of differential protection are limited by the current transformers CT 1 and CT 2.

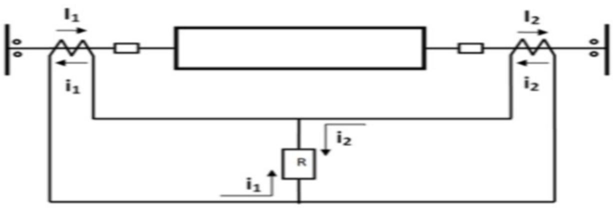

Figure 3. Differential Protection under normal circumstances

In normal conditions or the fault is outside the safety area, the current flowing in the relay is I1 = I2 where: I1 = secondary current flowing in the current transformer CT 1I2 = secondary current flowing in the current transformer CT 2 By assuming an ideal situation and selecting a current transformer CT 1 and CT 2 are the same or in accordance with the transformation of the power transformer, so while working in normal conditions (no interference) or there is interference outside the safety area, the secondary currents i1 and i2 will have the same value but with opposite vector directions, so that from the above relationship is obtained

METHOD

Electric steam power plant(PLTU) PT. Indah Pontjan Units 1 and 2, they have 2 generating units with the same auxiliary load capacity. However, in the operation of the equipment,

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only a few important pieces of equipment are operated to support the electricity generation process because some of the equipment has the same function and channels so it is sufficient to use only one unit. The generator is spread over two units, namely one generator in unit 1 and one in unit 2. The total installed capacity of unit 1 is 22 MW and unit 2 is the same as unit 1, namely 402.5 MW. Overall table of generating units in Power Plant Steam(PLTU) Pontjan Units 1 and 2 are shown in table 1.

Table 1. Generating Capacity Data at PLTU PT. Indah Pontjan Units 1 and 2

Power Plants	No.	unit ID	Voltage (KV)	Capacity (MW)
Unit 1	1.	Gen-1	27.5	22
			Total	22
Unit 2	1	Gen-2	18.75	15
			Total	15

*Summary*of the total amount of generation, loading and demand fromElectric steam power plant (PLTU) PT. Indah Pontjann Units 1 and 2 can be seen in Table 2 below:

Table 2. Total Amount of Generation, Loading, and Demand

	MW	Mvar	MVA	%PF
Source (swing bus)	59,350	30,700	66,820	88.82 Lag
Total Demand	59,350	30,700	66,820	88.82 Lag
Total Motor Load	56,898	25,133	62.202	91.47 Lag
Total Static Load	2,200	1,364	2,589	85.00 Lag

In the distribution system electric steam power plant(PLTU) PT. Indah Pontjan Units 1 and 2 are supported by several transformers before entering the load to reduce the voltage. Table 3 is the Transformer data.

Table 3. Transformer Capacity Data

No	ID	MVA	kV	%Z	Connection
4	AT-1A	10	10/3	4	delta/wye
5	AT-1B	10	10/3	4	delta/wye
6	GT-1	470	500/18	7	wye/delta
7	UAT-1A	33.4	10/18	4.5	delta/wye
8	UAT-1B	33.4	10/18	4.5	delta/wye
9	TRF-ASH HDG 1A41B	1.3	10/0.4	4	delta/wye
10	TRF-ASH HDG 2A41B10	1.3	10/0.4	4	delta/wye
11	TRF BOILERS 1B41A	2	10/0.4	5.75	delta/wye
12	TRF BOILER 2A41B10	2	10/0.4	5.75	delta/wye

Table 3.3Transformer Capacity Data (continued)

No	ID	MVA	kV	%Z	Connection
14	TRF-PRECIP 2A51B10	2	10/0.4	5.75	delta/wye
15	TRF-TURBINE 1A31A	2	10/0.4	5.75	delta/wye
16	TRF-TURBINE 1B31A	2	10/0.4	5.75	delta/wye

Data from the buses in the PLTU PT. Indah Pontjan electrical system can be seen in Table 4.

Table 4. Busbar Data

No.	Busbars	Voltage (kV)
1	ASH HDG 1A41A	0.4
2	ASH HDG 1B41B	0.4
3	BOILER 1A41A	0.4
4	BOILER 1B41A	0.4
5	BUS LINK 500 KV 1-1	500
6	MTR1A-3KV	3
7	MTR1B-3KV	3
8	PRECIP 1A51A	0.4
9	PRECIP 1B51A	0.4
10	TURBINE 1A31A	0.4
11	TURBINE 1B31A	0.4
12	U1-AT	18
13	BUS UNIT 1A	10
14	BUS UNIT 1B	10
15	MTR-10KV-1A	10
16	MTR-10KV-1B	10

RESULT

Model of the (PLTU) Electrical System.

The electrical system of the turbin 1 and 2 Steam Power Plant (PLTU) is model in simulation software. This model contains the latest data. The initial step in this model is to create a single line diagram from the existing data at the Steam Power Plant (PLTU) turbin 1 and 2. The data entered includes generator, busbar, cable, existing relay, CB, motor, lump load data. , and grounding system.

After model the electrical system, it is necessary to carry out a power flow analysis (load flow analysis) to determine the condition of the electrical system of the turbin 1 and 2 Steam Power Plants (PLTU). After that, short circuit analysis and protection coordination

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analysis are carried out so that you can find out what the coordination settings are. whether the safety equipment is correct or not.

Typical model in a protection coordination system aims to make it easier to set protection. In setting up protection at the Steam Power Plant (PLTU) PT. Indah Pontjan 1 and 2, it is divided into several types. This typical will later become a reference for protection settings, including:

a. Typical 1: Coordination of protection of BFP A motor loads. For BFP A, the protection equipment that is coordinated is BFP A OCR and UAT1A
b. Typical 2: Protection coordination of the PA FAN A motor load. For PA FAN A the protection equipment that is coordinated is the PA FAN A OCR relay, AT-1A OCR, Relay 2, and UAT1A.
c. Typical 3: Coordination of protection from lump load TURBINE-1A31A to bus U1-AT. The coordinated protection equipment is LVCB ACB-TURBINE-1A31A, LVCB ACB-1A31A, TURBINE 1A31A OCR, and relay UAT1A.

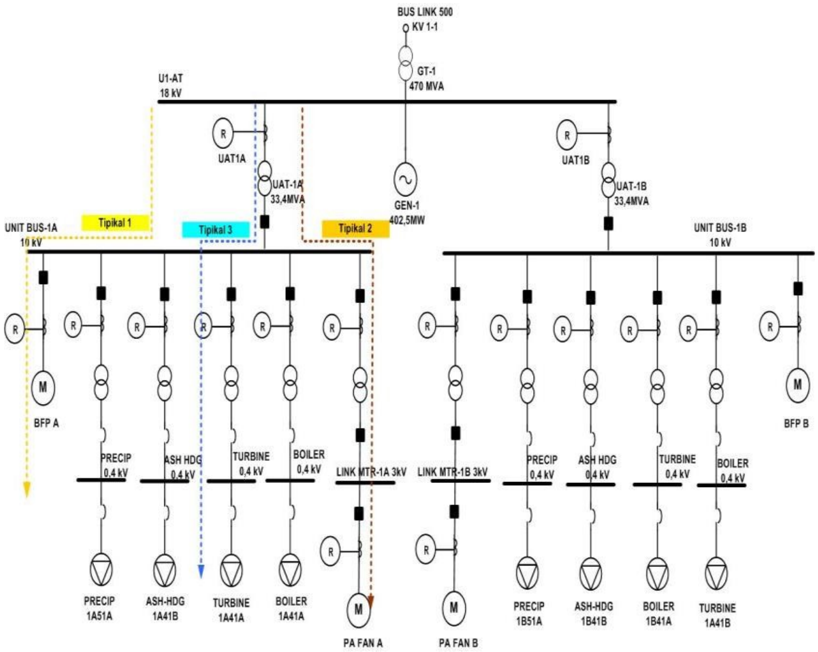

Figure 4. Single Line Diagrams

Short Circuit Fault Current Analysis

After carrying out load flow analysis, the next step is short circuit analysis using software. This analysis is used to determine the overcurrent relay setting. To calculate short circuit current, 2 parameters are used, namely maximum short circuit and minimum short circuit. The minimum short circuit is a 2 phase short circuit at 30 cycles. Meanwhile, the maximum short circuit is a 3 phase short circuit. This analysis was carried out on selected typical buses.

The minimum short circuit current used is the two-phase short circuit current at 30 cycles. This minimum short circuit is used as a limit for setting the instant overcurrent relay so that when a minimum short circuit current occurs, the overcurrent relay can immediately work immediately according to the specified time delay to protect against interference. The simulation results of the minimum short circuit current at 30 cycles can be seen in table 5.

Table 5. Minimum short circuit data 30 cycles

No	Bus	Voltage(kV)	*ISC Min 30 Cycles* (kA)
1	BUS UNIT – 1A	10	27,26
2	BUS UNIT – 1B	10	27,26
3	PRECIP – 1A51A	0.4	40.88
4	ASH HDG –1A41A	0.4	38.35
5	BOILERS – 1A41A	0.4	40.88
6	TURBINE – 1A31A	0.4	40.88
7	PRECIP – 1B51A	0.4	40.88
8	ASH HDG – 1B41B	0.4	38.35
9	BOILER – 1B41A	0.4	40.88
10	TURBINE – 1B31A	0.4	40.88

The maximum short circuit current is the fault current when a 3-phase short circuit occurs. This current is used because the overcurrent relay works on 3-5 cycles. This current is used as one of the parameters in determining the instant pick up curve value in certain cases. The simulation results of the maximum short circuit current values can be seen in table 6.

Table 6. Maximum short circuit data

No	Bus	Voltage (kV)	*Isc Maximum* (kA)
1	BUS UNIT – 1A	10	33,31
2	BUS UNIT – 1B	10	33.38
3	PRECIP – 1A51A	0.4	47.93
4	ASH HDG –1A41A	0.4	44.92
5	BOILERS – 1A41A	0.4	47.93
6	TURBINE – 1A31A	0.4	47.93
7	PRECIP – 1B51A	0.4	48.05
8	ASH HDG – 1B41B	0.4	45.03
9	BOILER – 1B41A	0.4	48.05
10	TURBINE – 1B31A	0.4	48.05

Phase Fault Overcurrent Relay Coordination

Coordination of phase fault overcurrent relays is the selection of safety equipment whose aim is only to isolate systems where phase overcurrent faults occur. The disturbances can be in the form of overload and short circuit. So that good and correct protection coordination design will ensure the continuity of industrial processes.

In this coordination system, the current and time settings are regulated on the overcurrent relay (50/51). From the results of coordination, it is not expected that several

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safety equipment will work simultaneously. In calculating the overcurrent relay settings, the low set, high set and time dial values will be calculated.

After obtaining calculations on the parameters that have been determined, the next step is to plot the Time current curve on the Star-Protective Device Coordination contained in the software so that the correct coordination settings can be seen. The coordination of this relay must take into account the relays that are above or below it. The safety relay must pay attention to the motor starting current and the charging current (inrush current) in the transformer.

In typical 1, phase overcurrent coordination is carried out from the BFP A motor to UAT1A. This existing line has 2 relays, including the BFP A OCR and UAT1A relays. A typical single line diagram image 1 can be seen in figure 5.

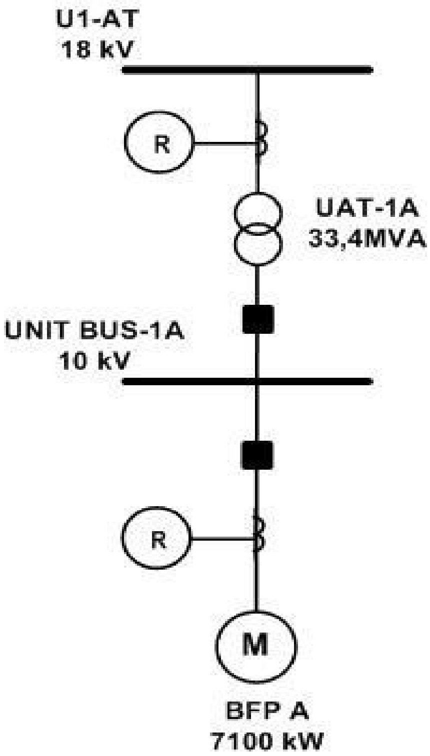

Figure 5. Single Line DiagramsTypical 1

Before carrying out coordination on typical 1, an analysis of the existing time-current curve conditions is carried out as in Figure 6.

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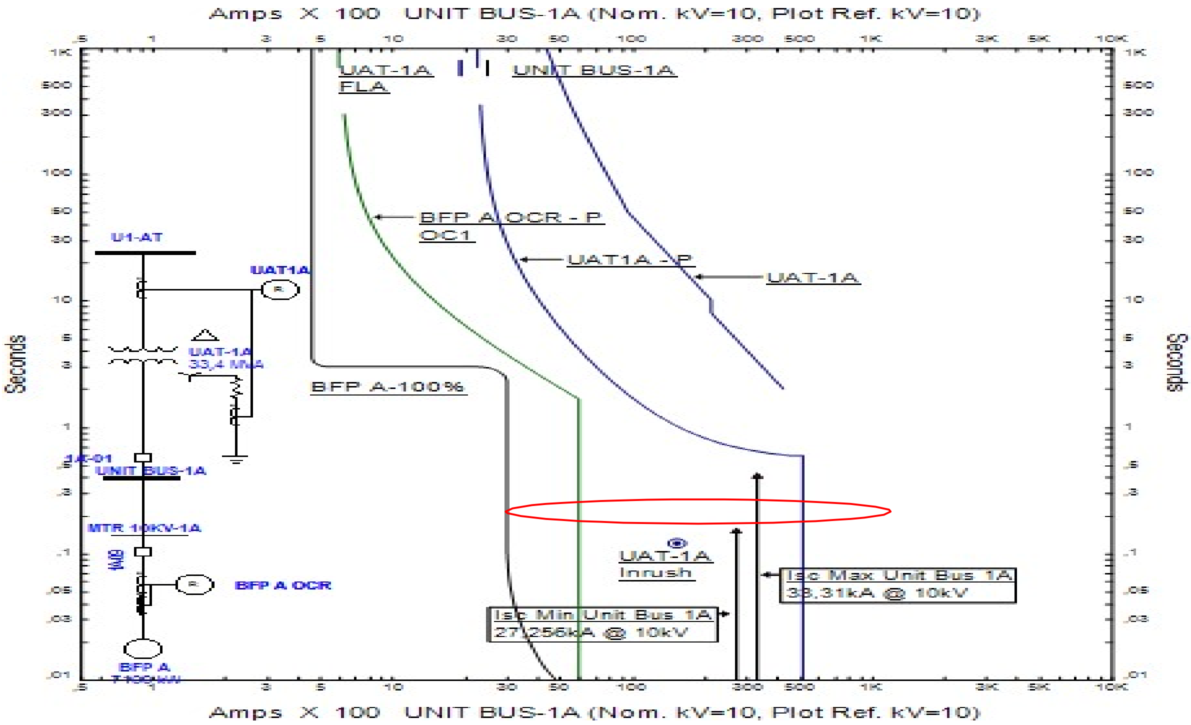

Figure 6. *Time-current curve exists*typical 1.

From the results of the typical existing safety curve plot 1 in Figure 6, we can see that there is some poor coordination, so reseeding is needed to improve the relay coordination.

CONCLUSION

Based on the results of the study and analysis of safety relay coordination at the PT. Indah Pontjan Steam Power Plant (PLTU) Units 1 and 2, several conclusions were drawn as follows: The results of the current-time curve coordination plot of the existing Steam Power Plant (PLTU) Units 1 and 2 show that there are several relay settings that are not correct and coordination is not good, especially in the pickup settings and grading time between safety relays. In the existing relay settings at PLTU , there is no grading time. The grading time used to coordinate the work of the safety relay is 0.2 seconds. This is considered appropriate because a Grading time of 0.2 – 0.4 seconds can provide sufficient time for the main safety relay to finish disconnecting the fault first. Grading time selection of 0.2 and 0.3 seconds is considered the most appropriate considering that the relay used is a digital relay. Grading time selection of 0.2 seconds is in accordance with IEEE 242 standards. The results of the coordination plot of the existing time current curve for ground fault overcurrent relays, phase to ground fault safety relays still use an inverse curve. Therefore, it is recommended to do resetting and only use the definite time curve.

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