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Improvement of Midle Voltage Network Protection System at Kualanamu International Airport

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Abstract

The electricity grid protection system at Kualanamu International Airport is urgently needed. The purpose of protection in addition to maintaining the reliability and stability of the electric power system also functions to detect disturbances, prevent damage to equipment (equipment & networks), protect humans and minimize outages in the event of a system disturbance. flight safety operations, services to passengers, operations, and equipment work at Kualanamu Airport. Safety or protection settings are based on the characteristics of the protection installed in the distribution system, which greatly affects working time, from the protection security area if there is a failure in the main protection. determine the setting of the overcurrent relay against overcurrent disturbances that may occur due to short circuit faults. To simplify the calculation of the disturbance analysis, it is simulated using the Electric Transient and Analysis Program (ETAP) Power Station12.6 software. The relay protection that is used and set is the overcurrent relay at the Kualanamu Airport Medium Voltage Network Sub Station. This relay functions to protect fault currents against ground-phase, ground-phase, ground-phase, and 3-phase. The protection relay setting refers to the provisions in force at PLN, namely for the interruption time of the 20 kV network disturbance at the substation from the time of a disturbance to the extinction of the electric arc by the opening of the power circuit breaker (PMT) the feeder is: less than or equal to 400 milliseconds and for ground-phase short circuit faults NGR12 maximum disconnection time of 500 milliseconds, NGR40 maximum disconnection time of 1000 milliseconds.

Keywords
protection relay; SCADA; ETAP; OCR; GFR.

I. Introduction

Kualanamu International Airport – Deli Serdang is the second largest airport in Indonesia after Soekarno Hatta International Airport. Along with this, the reliability of the electrical system is needed to ensure the continuity and quality of the entire electrical system in supporting airport services and flight security. Aviation navigation equipment at Kualanamu Airport such as radar, instrument landing system, Glade path, Localizer, PAPI and others cannot be interrupted by the Ministerial Regulation 2 Transportation Number: PM 83 of 2017 concerning Civil Aviation Safety Regulation Part 139 (Civil Aviation Safety Regulation Part139) concerning Airports (Aerodrome) has stipulated that every construction and operation of an airport (Aerodrome) must comply with technical and operational

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standards of civil aviation and the ability of an electric power system to serve consumers is highly dependent on the protection system used.

Therefore, in designing an electric power system, it is necessary to consider the disturbance conditions that may occur in the system, through fault analysis. Electrical power system protection is a protection system installed on electrical equipment, such as generators, transformers, networks, and others, against abnormal conditions of the system's operation itself. These abnormal conditions can include, among others; short circuits, overvoltage, overload, low system frequency, synchronous, and others. Disturbances in the distribution system can cause damage to important equipment in the distribution of electricity, namely: transformers, conductors, insulation, and connecting equipment. The presence of damage means that it disrupts the continuity and reliability of the electrical system. In the distribution system, errors in relay work between the incoming and outgoing or feeder sides often occur, which are mostly caused by short circuit faults. Therefore, for distribution system security, it is necessary to obtain an appropriate relay setting value (sensitive and selective).

Electrical energy comes from two sources, namely renewable energy and non-renewable energy. Included in renewable energy is solar power, ocean wave energy, wind energy but requires research for its development in Indonesia. The types of non-renewable energy are hydroelectric power plants, wind power plants, diesel power plants, gas power plants, and nuclear power plants. The use of non-renewable energy must be considered in quantity because it will greatly disrupt these energy forces in the future if used excessively. (Suwarno, et al. 2021)

In the medium voltage network of Kuala Namu Airport, there has been a case of a power breaker trip (PMT). From the results of the field survey, the possibility that caused this to happen was due to flashover or due to inaccurate short-circuit current analysis during the initial setting. On this occasion the author will discuss one of the causes of the problem, namely reanalyzing the short-circuit current in the medium-voltage network to re-setting the relay, which is more precise (selective and sensitive) using the ETAP12.6 application. Meanwhile, the short-circuit analysis carried out is only a 3-phase fault for re-setting the relay in each cubicle.

The formulation of the problem from this research are How is the relay protection time setting for the medium voltage network at Kualanamu Airport and how does the relay protection work for the medium voltage network at Kualanamu Airport.

II. Review of Literature

2.1 History and Introduction of ETAP

Electric Transient and Analysis Program (ETAP) is software that supports the electric power system. This device can work offline for electric power simulation, online for real-time data management, or used to control the system in real-time. The features contained in it also vary, including features that are used to analyze electric power generation, transmission systems, and electric power distribution systems. Types of application programs in electric power systems include PSS/E, EDSA, MATLAB, MATHCAD, ETAP, DIGSILENT, etc. ETAP was created and developed to improve the security quality of nuclear facilities in the United States which was further developed to become a real-time energy management monitoring system, simulation, control, and optimization of the electric power system (Awaluddin, 2007). ETAP can be used to create electric power system projects in the form of single-line diagrams and grounding system paths for various forms of analysis, including power flow, short circuit, motor starting, transient stability, releprotection coordination, and system harmonization. Electric power system projects have individual circuit elements which can be edited directly from single line diagrams and/or grounding system paths. For ease of analysis, calculation results can be displayed on a one-line diagram.

2.2 ETAP Program Concept

ETAP Power Station allows working directly with a single line diagram image display. The program is designed according to three main concepts:

1. Virtual Reality OperationThe existing operating system in the program is very similar to the operating system in real conditions. For example, when opening or closing a circuit breaker, placing an element in the system, changing the operating state of a motor, and de-energizing an element and sub-element of the system are shown in the single line diagram in gray.
2. Total Data Integration ETAP Power Station combines electrical system information, logic systems, mechanical systems, and physical data from an element that is entered in the same database system. For example, an element of a cable, not only contains electrical data and its physical dimensions but also provides information through the raceways that the cable passes. Thus, the data for one cable can be used for load flow analysis and short-circuit analysis - which requires electrical parameters and connection parameters - as well as calculating the ampacity derating of a cable that requires physical routing data.Simplicity in Data Entry ETAP Power Station has detailed data for each element used. By using a data editor, you can speed up the data entry process for an element.

2.3 Types of ETAP Analysis

Electrical power analysis that can be done using ETAP: Load Flow Analysis, Short Circuit Analysis, Optimal Capacitor Placement, Harmonic Analysis, Protection Analysis, Reliability Analysis, Transient Stability Analysis, Motor Starting Analysis, Optimal Power Flow, Arc Flash Analysis, etc. ETAP Power Station provides library facilities that will facilitate the design of an electrical system. This library can be edited or added with equipment information if needed. Load Flow Analysis in ETAP software can calculate the voltage in each branch, the current flow in the electric power system, and the power flow flowing in the electric power system. The power flow calculation method in ETA software is three, namely Newton Raphson, Fast Decouple, and Gauss-Seidel. Short Circuit Analysis on ETAP Power Station analyzes short circuit faults of three phases, one phase to ground, between phases, and two phases to ground in an electric power system.

2.4 Purpose of the Protection System

To identify and detect disturbances, to separate the disturbing parts of the installation from other parts that are still normal, to protect humans and at the same time to secure the installation from greater damage or loss, as well as to provide information/signs that a disturbance has occurred, which is generally followed by opening the Power Circuit Breaker (PMT). Power breaker (PMT) to separate/connect one part of the installation with another part of the installation, both the installation in normal conditions and a disturbed state. The boundary of the parts of the installation may consist of one or more Power Breakers (PMT).

Some things that need to be considered in working using ETAP include

1. One Line Diagram Is a simplified notation for a three-phase electric power system
2. Library is information about all equipment that will be used in the electrical system. Electrical and mechanical data from detailed/complete equipment can simplify and improve the simulation/analysis results.
3. The standard used is the IEC standard, the frequency value used is 50 Hz, the ANSI standard, the frequency value used is 60 Hz.

4. Electrical power analysis that can be carried out using ETAP: Load Flow Analysis, Short Circuit Analysis, Optimal Capacitor Placement, Harmonic Analysis, Protection Analysis, Reliability Analysis, Transient Stability Analysis.

2.5 Security Area

The safety area is divided into sections that are restricted to power breaker (PMT) as shown in Figure 2.1 and Figure 2.2, where each section has a safety relay and has a safety area. The local backup security is located in the same place as the main security, while the remote backup security is located in the upstream section. Of course, there is an overlap between the main safety area and the reserve area, both local reserves, and remote reserves. This means that disturbances that occur in the main security area will be detected by both the main security and local backup security or remote backup security. To avoid the release of two sections at once (the main safety area section by the main safety relay and the upstream section by the remote backup safety relay), the remote backup safety relay is given a time delay.

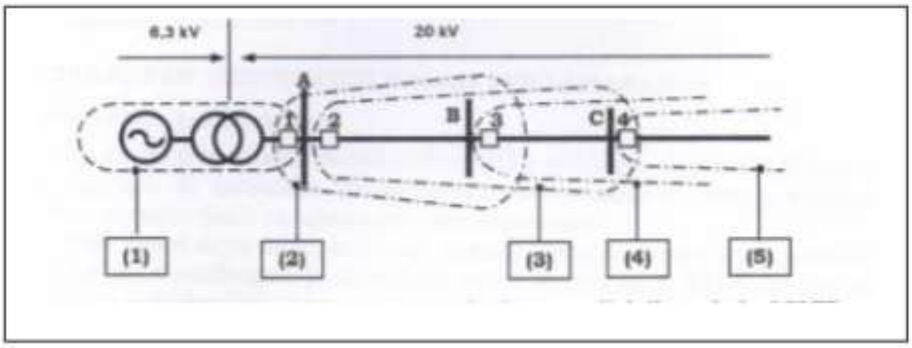

Figure 1. *Safety Area for Radial System supplied*

Description of the picture 2.1 :(1)Overall DifferentialRele, Gen-Transformer main protection,(2)OverCurrent Local backup protection Rele Gen-Transformer remote backup safety bus A,(3)Over CurrentRele 20 KV side power transformer Bus A main safety, line remote backup protection AB,(4)Over Currentrele at B, Main Protection for BC channel remote backup protection channel C – network end,(5)Over currentrele at C, main safety for channel C end of network.Figure 2.2Safety Area for Radial System supplied from SubstationSource: Wahyudi SN & Pribadi. K, 2000 Power breaker failure (PMT) can occur to detect fault currents that should have been open but failed, due to weak batteries, tripping circuit breaks, mechanical disturbances in the Power Circuit Breaker (PMT), this requires a safety reserve. as described above.Main security and backup protectio.

Electrical power transmission protection is protection that is installed on electrical equipment in an electric power transmission so that the process of distributing electricity from the power plant (power plant) to the electricity distribution channel (substation distribution) can be distributed safely to consumers using electricity. Electric power transmission protection is applied to electric power transmission so that in the event of a disturbance the equipment related to electric power transmission is not damaged. This also includes when maintenance is carried out under-voltage conditions. If the protection works well, then workers can perform maintenance of electric power transmission in high voltage conditions. If during the maintenance there is a disturbance, then the installed safeguards must work to secure the system and the people who are doing the maintenance.

2.6 Types of Disturbance

1. Overload disturbance this disturbance is not pure, but if it is allowed to continue it can damage electrical equipment that is fed by the current. Because the current flows exceed the capacity of the electrical equipment and the installed safety exceeds the capacity of the equipment so that when the load exceeds the safety, it does not trip. For example, the capacity of the conductor is 300 A and the safety is set to 350 A but the load reaches 320 A, so that the safety does not trip and the conductor will burn out.
2. Short circuit faults, can occur between phases (3 phases or 2 phases) or 1 phase to ground and can be temporary or permanent.

III. Research Methods

This research was conducted at PT Angkasa Pura II (Persero) Kualanamu International Airport - Deliserdang, North Sumatra. Where the implementation time of this research starts from January 2021 to February 2021. And also the data collection used in this study is a case study of the Kualanamu-Deliserdang International Airport Electrical System, wherein the research that will be studied, the Kualanamu International Airport Medium Voltage network protection system using software tap(Electrical Transient Analyzer Program) 12.6.

In this study, several methods were used to obtain the necessary data as a guide in writing this research report. These methods are 1. Literature study. By reading theories related to the topic of the Final Project which consists of reference books either owned by the author or from the library and also from articles, journals, internet services, and others. -other. 2. Data collection. Data collection is in the form of data collection to be processed in this study. In this study what is needed, among others, is a description of the protection settings and single line diagrams on the electrical power system of Kualanamu Deli Serdang Airport. 3. Design. Designing the SEPAM protection relay settings using the ETAP12.6 application through preliminary calculations. 4. Interference testing. Carrying out trial simulation of disturbances to relay settings using the ETAP12.6 application that has been designed. 5. Implementation and analysis. Implementing the ETAP12.6 application offline analyzing the existing protection relay settings.

This research data is primary data obtained from Kualanamu-Deliserdang International Airport, especially data related to research. especially data related to research in the form of the following data:

1. Data on the electrical system network of Kualanamu-Deliserdang International Airport (Single Line Diagram).
2. Data on electrical equipment of Kualanamu-Deliserdang International Airport (Generators, Transformers, loads, and other supporting data). Kualanamu-Deliserdang with PLN. Data on generating units, transformers, line lengths, and loads from PLN Kualanamau.

An electric power system is presented in a single line diagram in ETAP, then the next step is to enter data on the equipment. The data needed is data on generators, buses, transmissions, transformers, safety, and loads on the system. a. Generator Data – Generator Data required for generators: □ Generator ID □ Generator type (steam generator, diesel, turbo, hydro, hydro w/o damping) □Operating mode(swing, voltage control, PF control, and Mar control) □Voltage rating □ % V and angle for swing operating mode 50□%V, MW loading and Wvar limits (Qmax and Qmin) for Voltage Control operation mode MW and Mar loading for Mvar control operation mode ETAP12.6 program generator data display.

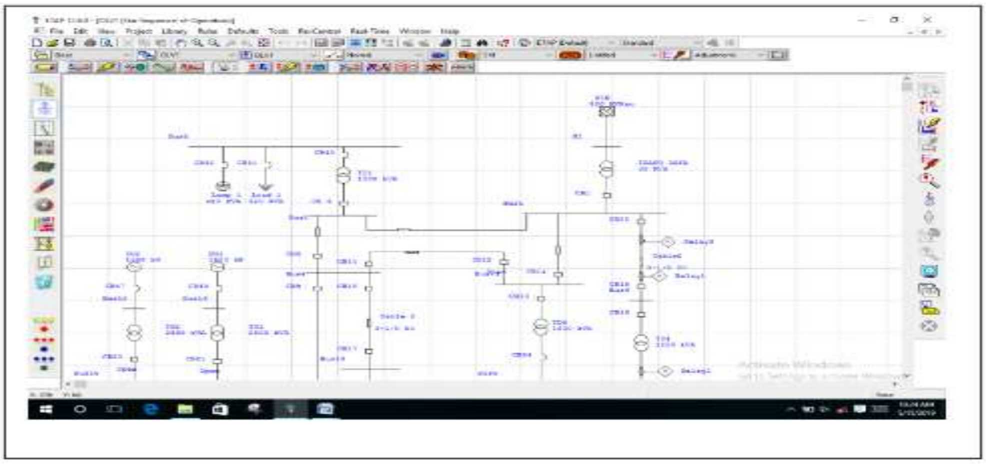

Figure 2. *Single Line Etap*

The process of analyzing the protection coordination system using ETAP12.6 is as follows:

1. Create a single line diagram of the system;
2. Enter data for generators, transformers, buses, cables, and load relays into the program after a single line diagram is created;
3. Run a power flow analysis by selecting the Load Flow Analysis icon on the toolbar to determine the current flowing;
4. Click Star-Protective Device Coordination and then specify the type of fault to be tested (3 phase fault, 1 phase to ground fault, phase to phase fault, or 2 phase to ground fault);
5. Single line the diagram will display a flashing animation that shows the working sequence of the protection device.

IV. Result and Discussion

4.1. Intro

For the next stage after designing and making the system and tools made, the next step is to test and analyze the system and tools that have been made, so that the purpose of the design is in accordance with expectations. In circuit testing there are several parts that will be tested, namely:

a. Sensor Series consisting of LDR, LM35 and Magnetic Switch (Door Sensor). b. Driver series consisting of transistors, fans and super bright led
b. Relay Series consisting of relays, diodes, transistors, and incandescent lamps From the test section of the circuit above the following is the description:

$$t = \frac{k.\beta}{((I_f/I_{set})^{0,02} - 1)} \quad Tms$$

$$t = \frac{k\ 0,14}{((I_f/I_{set})^{0,02} - 1)} \quad Tms$$

Where:
If = Short circuit fault current (A)
Iset= Setting current entered to relay (A)
t = Relex trip time
k= time multiplier setting (TMS)
β= Standard Inverse (N)= 0.14

Table 1. Inverse Relay Characteristics

	A	β	T
Standard Invers	0.02	0.14	3.0
(N)	1.0	13.5	1.5
0.02	2.0	80.0	0.8

The following are some variations of scenarios that will be carried out in this research:

4.2. For Right Side Open Ring Non Priority Network system (RSaNPSST9 to PLN2KNG)

a. Simulation of Star-Protective Device Coordination with 3-phase interference in the cable between RSb8NP and RSa9NP
b. Simulation of Star-Protective Device Coordination with 3-phase fault on switchgear busbar20 KV SST RSb14NP.

4.3. For Left Side Open Ring Non Priority Network system (RSaNPSST8 to PLN1KNA)

a. Simulation of Star-Protective Device Coordination with 3-phase interference in the cable between RSa8NP and RSb10NP
b. Simulation of Star-Protective Device Coordination with 3-phase fault on the switchgear busbar 20 KV SST RSb17NP

4.4. Research data for the non-priority

Single-line network diagram of the Kualanamu Airport Medium Voltage Network in appendix 1.

Tables 2. PLN Feeder Data

Rated (kV)	Daya (MW)	ID	Mvar	Rating	SC Rating	X/R
150	6,069	GI Kualanamu 2	0,883	100	3384,46	0,05

Tables 3.Data of PLN Connection Substation Transformer

Type/ Sub Type	Class	Prim/Sec	Grounding			Power Rating
			Vector	Prim	Sec	
Liquid-fill	ONAN	150/20 kv	Dyn5	Not Aplicab	Resistor/40ohm	30 MVA
Liquid-fill	ONAN	150/20 kv	Dyn5	Not Aplicab	Resistor/40ohm	30 MVA

From the four working relays above, it can be seen that the average time grading between relays when a 3-phase fault occurs in 0.04125s. The time interval required for coordination between relays with a time of 0.5s is still said to be normal. With the advancement of the current protection system, the time delay can be minimized to 0.4s. This is the minimum interval that allows relays and CBS to clear faults in their protection zones, according to the State Electricity Company Standard (SPLN) that the breakdown time for short-circuit faults of phases/3 phases, must be less than or equal to 400 milliseconds or 0, 4s.

By looking at the average time interval of 0.04125s, it shows that the delay in working time between relays is still below normal. Referring to the PLN rules for the interval time between relays 0.3-0.4 seconds in Star-Protective Device Coordination Simulation with 3-phase fault on a cable between RSb8NP and RSa9NP and referring to the TMS formula, it was found that the comparison of relay working time between the calculation and simulation results is as follows with If is the closest fault current to a load of 5.019 kA (data from short circuit analysis ETAP12.6), I set is full load current2. 008 A(data from load flow analysis ETAP12.6).

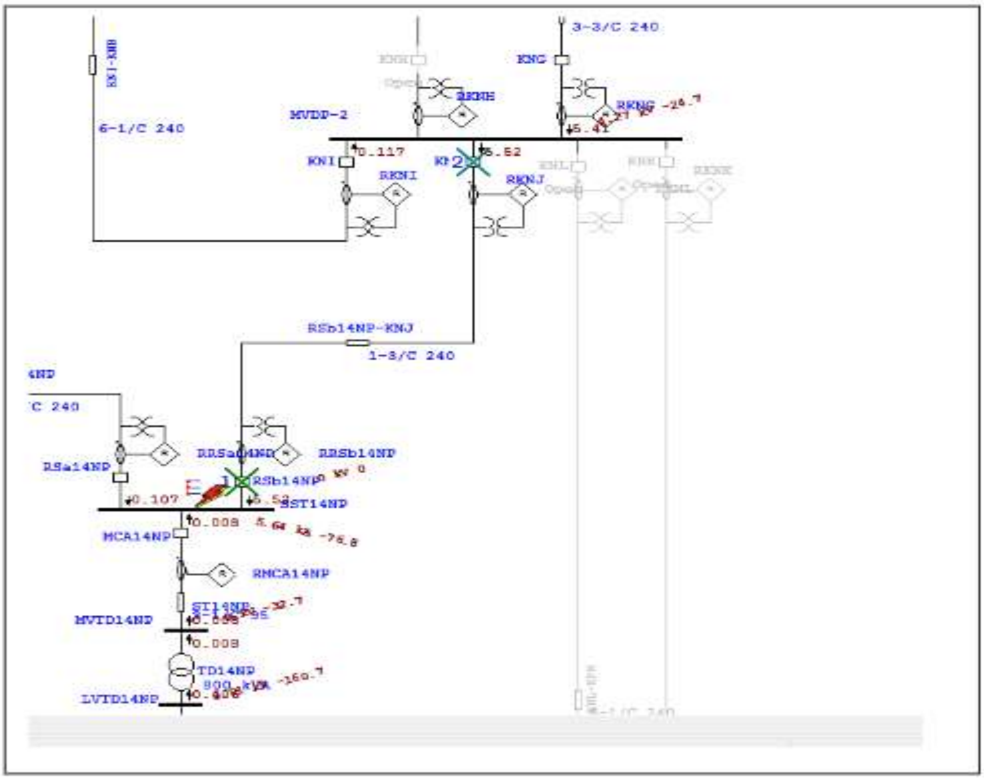

Figure 3. *Showing the Location of 3-Phase Short Circuit Faults for This Simulation*

From the three working relays above, it can be seen that the average time grading between relays when a 3-phase fault occurs is 0.0285s. The time interval required for coordination between relays with a time of 0.5s is still said to be normal. With the advancement of the current protection system, the time delay can be minimized to 0.4s. This is the minimum interval that allows relays and CBS to clear faults in their protection zones, according to the State Electricity Company Standard (SPLN) that the interruption time for short-circuit faults of phases/3 phases, must be less than or equal to 400 milliseconds or 0, 4s.

By looking at the average time interval of 0.0285s, it shows the delay in working time between relays is still below normal. Refers to the PLN rules for the interval time between relays 0.3 -0.4 seconds in Star-Protective Device Coordination Simulation with interference 3 phase on the 20 kV SST RSb14NP busbar switchgear and referring to the TMS formula, it was found that the comparison of relay working time between the calculation and the simulation results is as follows with If is the closest fault current to the load 0.313kA (data from short circuit analysis ETAP12.6), I set is the current full load 223.2A (data from load flow analysis ETAP12.6).

V. Conclusion

Based on the results of research that has been carried out using the ETAP12.6 software, it can be concluded that: 1. Based on the simulation results of Protective Device Coordination to see the coordination of the protection relay, it can be seen that: a. For 3-phase faults that occur on buses and cables located on non-priority networks, has a very short time interval and tends to be the same after a disturbance. b. The impact of 3-phase disturbances that occur on buses or cables causes blackouts in areas or parts of equipment that have not been minimized.

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