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MODELING TO IMPROVE THE PERFORMANCE OF REVERSE POWER RELAY IN GENERATOR

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Abstract -- *The generator is the primary component in electricity generation and requires a protection system from internal and external interference that occurs. This study considers how to improve the performance of relays in power plants. A model of a generator that is executed in a fault condition to reset the protective equipment, namely Reverse Power Relay (RPR). The study is intended to model the state of internal and external fault on the generator by applying a working principle of RPR. The model is designed to anticipate the actual fault in the generator. The simulation results obtained output such as; active power, current and time delay relay. The RPR reset of the generator system is applied to the generator in Riau Power. The RPR is installed on the generator is -612 kW, equivalent to 30%, the relay delay time is 0.2 seconds. Based on standardization, the return of power reaches a maximum of -12.66 MW, which is captured 50% with a maximum replacement of 30 seconds. Results of the RPR simulation have been validated with the IEEE standard at a time delay that corresponds to the percentage of reverse power settings installed at 6% and a time delay of 0.6%. Finally, to maximize the protection system on the generator, adjust 50% to 95% of the installed settings. It can be said that the system is able to increase generator protection and minimize the impact of internal or external fault.*

Keywords: *Fault; Generator; Modeling; Protective; Reverse Power Relay*

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INTRODUCTION

Maintenance of electrical power plants can be carried out on a regular basis by optimizing the performance of the protection system on the internal and external fault generator [1]. In this case, the protection of the generator is necessary, because the generator is an essential item for the electrical power system. The protection system is developed using the protection of the system generator [2]. There are types of faults that have occurred, such as overcurrent, overvoltage or less voltage, overfrequents or undercurrent, more heat, and reverse power [3, 4, 5].

Fitriyani et al. have conducted a study focusing on protection relays used in generators and power transformers. They analyze the relay settings installed on the generator and transformer. The analysis method used ETAP 12.6 simulation, which is to condition the system in an abnormal state with electrical fault such as; two phases and phase to ground. The simulation results can be concluded that the adjustment of relay power back to the generator is in line with standardization [6] [7].

The same thing is done by [8], a case study that has been carried out in Tanjung Jati B PLTU related to protection systems in generators and power transformers [8]. Then also, [9] has researched the PT PetroChina International Jabung Ltd. Power Plant and Jabung Betara Complex Development Project. The simulation results obtained concluded that the adjustment of the relay installed in the generator using a Reverse Power Relay was reasonable to use [9].

Generator protection is an essential thing to do because of the nature of the generator as the principal component in the power plant. If there is a fault in the generator, it will cause a significant constraint to the generation process, which will create a negative impact on the delivery of electrical power to consumers. The most common faults include; down frequency fault, reverse power, and forward power. Therefore, it is essential to evaluate and maximize the performance of Reverse Power Relays (RPR) by adjusting the relays [10, 11, 12].

Distributed Generation (DG) into the utility grid has led to a renewed emphasis on looking into power system control and protection issues about DG units. They focus on the loss of mains (LOM) detection and protection for DG. Commonly used methods of detection fail to effectively detect the failure of the mains scenario when the local area network load and generation are closely matched. The proposed way of detection and protection is highly efficient when the demand and supply are similar. For this reason, it can be used together with the present techniques to provide a complete solution to LOM protection [13].

The Reverse Power Relay serves to detect the active return power coming into the generator at the power plant. The dynamic power flow on the generator will make the generator change into a motor. This influence is due to the low mechanical input of the prime mover [14] [15].

Figure 1 shows the scheme of the Reverse Power Relay employed to secure the generator system. It consists of output power and reverses power that occurs in the generator. If there is a significant phase difference between current and voltage, the relay sends a trip signal to the Circuit Breaker (CB) to protect the generator.

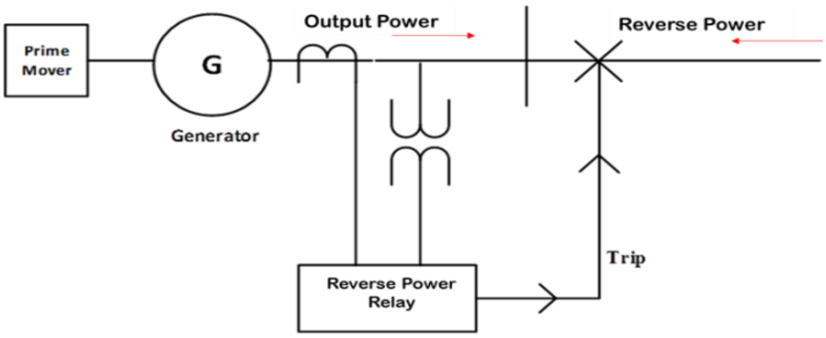

Figure 1. Reverse Power Relay Scheme

METHOD

Reverse power is a mechanical fault generated by a working failure of the prime mover of the generator. Under normal conditions, the generator supplies power to the electric power system, when there is reverse power the generator receives an electrical power supply from the system so that the generator will switch function as a motor. Preventing failure due to the generator must be equipped with a highly sensitive Reverse Power Relay [16].

This research method is to have the opportunity to design generator modeling and RPR using Matlab/Simulink software. The fault simulation on the generator adopts generator data installed in the power generation system. Power Generation system data are required for modeling via software such as; generators, relay settings, power transformers, and other supporting data. RPR provides an opportunity to detect the active return power that enters the generator. Furthermore, the active power flow to the generator becomes a function as a motor. Figure 2 shows a single line diagram of a gas power plant in Riau Power (case study). This gas power plant has a capacity of 29.6 MVA, also a power transformer with a capacity of 30 MVA at a voltage of 11 kV / 20 kV. Single line diagram and parameters have been modeled in this study using software using Matlab/Simulink [17].

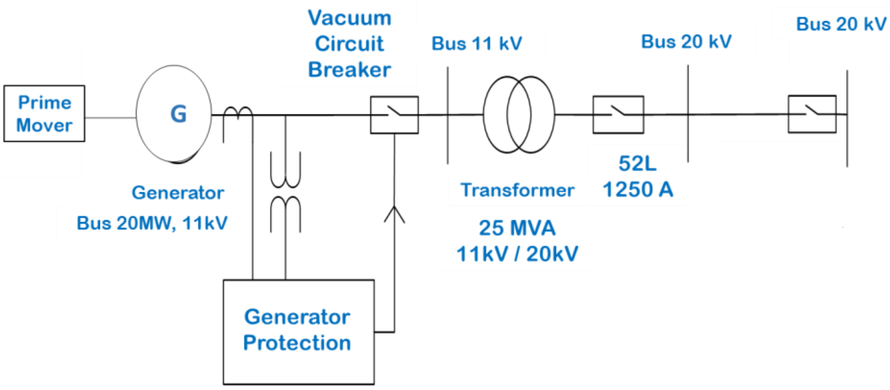

Figure 2. Single line diagram of Gas Power Plant at Riau Power

Generators at PT Riau Power's PLTG has been reset RPR several times since it began operating. This adjustment is adapted to the condition of the generator and power system. Installed RPR sends signals to the alarm, CB generator, and excitation. Table 1 shows that's the fixed RPR setting is a reverse power value of 3% of the output power or around -612 kW for trip orders to CB and excitation, as well as 2% (-408 kW) for notification of alarm faults. The setting of the RPR on the generator in the Riau Power (PLTG). The reverse power and set of Reverse Power Relay can be calculated as follows [18, 19, 20].

$$\text{Reverse Power} = \frac{\text{S x \%Reverse Power}}{\text{CT Ratio x PT Ratio}} \quad (1)$$

$$\text{Reverse Power Setting} = \text{S x \%Reverse Power x PF} \quad (2)$$

Table 1. Setting the RPR installed on PT Riau Power's PLTG

Relay	Code	Setting Relay	Indicator
Reverse Power	32 G	Alarm 2% rated = -408 kW delay time: 0.5 second	Alarm
		Trip 3% rated = -612 kW delay time: 0.2 second	52 G and excitation

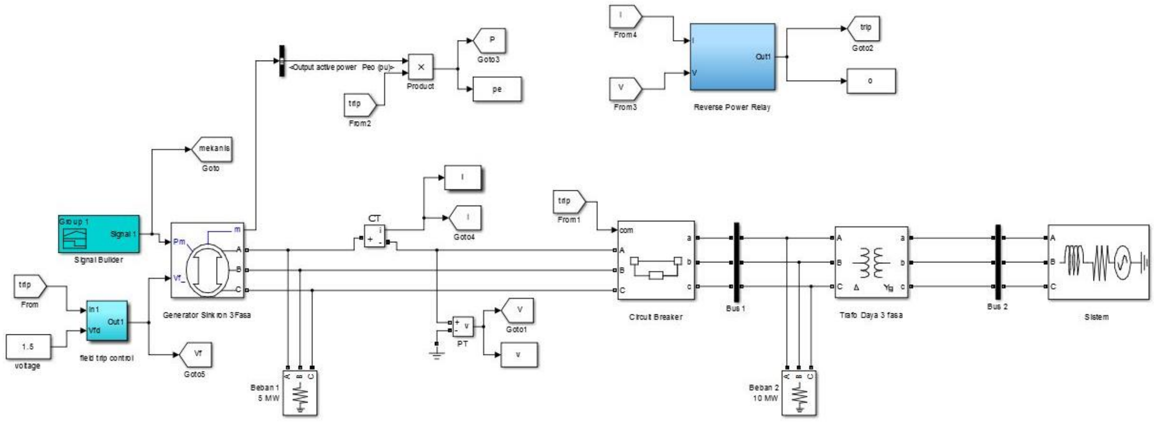

Figure 3. Modeling of a power generation system via MATLAB/Simulink

Figure 3 presented the modeling of a generating system that is synchronized using Matlab / Simulink, which is adjusted to the Riau Power system data. RPR is modeled based on the working principle to identify the direction of the electric current during the reverse power conditions that occur in the generator. The purpose of this modeling is to overcome the possibility of internal and external fault that occurs in the generator. Therefore, the model can be used as a guideline for resetting the RPR.

In this element, the Current Transformer (CT) and Potential Transformer (PT) output signals are converted to square wave values ± 1. Then, two signals are combined to get an output value of '1' during overlap and significance of '-1' for non-overlapping intervals. The upper limit of the integrator is configured on '0.01' on switch 3 so that under normal load flow, the integration value is always less than 0. However, the output return power is inclined to drop until it reaches the specified return power value. Any value can be selected depending on the amount of return power that will be determined.

The time delay element is the part that serves to send a working signal to the CB by setting the delay time after a reverse power occurs. The output of the directional element is the input of the delay time element. The input value can be a value of 0 when the condition is reasonable or is valued at 1 when the power is reversed. Furthermore, this output is integrated, and the integral value generated is comparable to the predetermined "T" threshold value. The "T" value is set for the duration of the relay delay when a power return occurs. During normal conditions, the integration input is "0" so that the integrator's output value will also be "0" which is less than the "T" value. Therefore, the output value of the delay time element will be "1". On the other hand, when the power is reversed, the integration input will be "1" and exactly "T" seconds after the output value of the integrator operator will exceed the "T" value set; consequently the output value of the delay time element will be "0". In the case, a moment or a transient condition that occurs is calculated if the duration is less than the value of the time "T" seconds and immediately after the temporary condition is dropped.

RESULT AND DISCUSSION

The system on the generator at the PLTG PT Riau Power consists of 29.6 MVA three-phase generators, 11 kV phase voltage with a power factor of 0.85, and a frequency of 50 Hz. As for the 30 MVA power transformer, the primary side voltage is 11 kV, and the secondary side voltage is 20 kV and is related to the Teluk Lembu Substation and power system network. The data specification at PT Riau Power (PLTG). It knows to power is 29.8 MVA, the power factor is 0.85. The amount of reverse power value is a maximum of 50%.

Figure 4 shows the simulation results based on the RPR settings installed on the generator, which is operated at 0.675 pu active power rating by adjusting the mechanical input from the generator. The fault starts when the main drive causes a decrease in automatic information resulting in generator output power instability. As a result, the time of seconds to 41.6 is a total failure in the main drive so that the reverse power appears. At 41.99 seconds, the relay begins to read the reverse power, which is equal to -1.38821 MW. The generator is operated as an active power rating of 0.65 pu by adjusting the mechanical input from the generator.

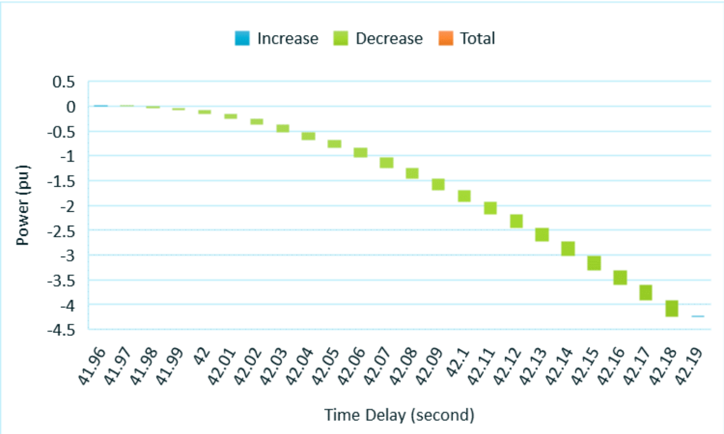

Figure 4. Simulation Result of Reverse Power Fault

The fault occurs in the prime mover, causing the effect of decreasing mechanical input power and un-stable generator output power. Fault occur at 41.6 seconds on the prime mover, giving rise to reverse power. 41.92 seconds begin reading the return of -0.05378 pu. Reverse power causes the generator output current to be un-stable. The mechanical input decreases, causing the output current to be smaller, and then when a total failure occurs, the current from the system flows towards the generator. The RPR, relay relays are carried out following several fault scenarios. This setting is developed by resetting the RPR delay to the settings installed on the generator. The simulation results of reverse power to each fault scenario is shown in Figure 5.

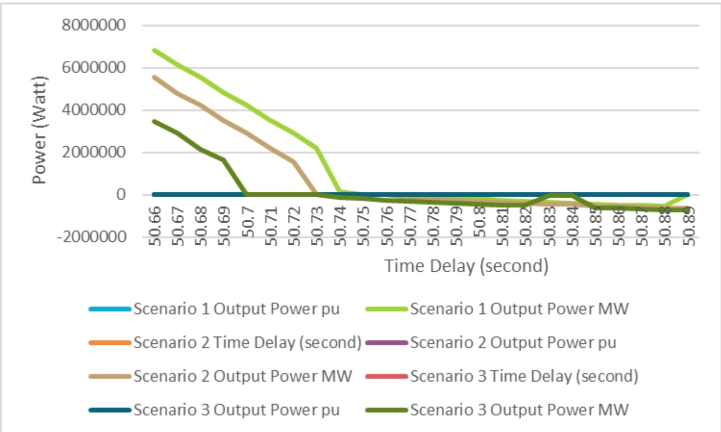

Figure 5. The Simulation Results of Reverse Power to Each Fault Scenario

Scenario 1

The generator is operated as an active power rating of 0.675 pu by adjusting the mechanical input from the generator. The fault starts at the main drivers causing a decrease in mechanical input so that there is instability in the output power of the generator. This can be observed at 50.4 seconds when there is a total failure of the principal drive so that the reverse power appears at 50.79 seconds. The relay began to read the reverse power of -1.42007 MW.

Scenario 2

The generator is operated as an active power rating of 0.675 pu by adjusting the mechanical input from the generator. The fault starting at the main drive causes a decrease in mechanical input resulting in generator output power instability. As a result, 61 seconds in total failure occur in the main drive so that the reverse power appears at 61.39 seconds, and the relay began to read the reverse power of -1.42691 MW.

Scenario 3

The generator is operated as an active power rating of 0.675 pu by adjusting the mechanical input from the generator. The fault starting at the main drive causes a decrease in automatic information resulting in generator output power instability. As a result, 65 seconds of total failure occurs in the main drive so that the reverse power appears at 6.39 seconds; the relay begins to read the reverse power of -1.47068 MW.

RPR set up a generator at the PT PLTG Riau Power is 0.2 seconds. In comparison, the results of the modeling simulation after resetting the RPR delay are 0.1 seconds, 0.13 seconds, 0.16 seconds, 0.18 seconds, and 0.19 seconds. The percentage change in relay settings becomes 50%, 65%, 80%, 90% and 95%. In RPR delay time settings in the system are according to the IEEE C32.102-2006 standard. The result is that adjustments according to maximum standardization are for 30 seconds, while those installed in the modeling system are 0.03 pu or equivalent to 3%. For adjustment, the delay time is 0.2 seconds at a percentage of 0.6% compared to adjustments acting in conformity with the IEEE standard earlier, which is for 30 seconds.

In this research, a model for system 1 has also been developed to compare with the results of previous research. Based on the results of research conducted by M Aman [4], which the delay setting of the RPR that has been tested is for 7 seconds. Meanwhile, system simulation results set out in the present study for the time delay of RPR are 2 seconds. Then, the result of the percentage change in the RPR delay time setting was 28.9%.

CONCLUSION

RPR can protect the generator from the effects of reverse power caused by the operation fault of the main drive to the power plant. The fault that occurs is caused by instability and decreasing the output power of the generator, causing the generator to change the function. With the help of RPR, it can read the change in the direction of the generator output by resetting the RPR to the generator. The maximum return value that has been set according to the IEEE standard is -12.66 MW which is equivalent to 50%. The simulation results obtained a large percentage of turning power of 6%, this value falls within the IEEE standard range. The RPR delay time setting has been set for 0.2 seconds (IEEE is 30 seconds). The delay time is 0.2 seconds equivalent to a percentage of 0.6%. Then the RPR settings installed on the generator are required to comply with the IEEE C37.102-2006 standard. RPR adjustment can speed up the relay delay time with the 50% to 95% adjustment percentage of the installed settings. The evaluation results obtained it can increase generator protection and minimize the impact of internal or external fault.

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