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Planning a Protection Coordination System Against Over Current Relays and Ground Fault Relays Using the Neural Network Method

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ABSTRACT PT PAMA PERSADA is one of the power plants located in Barunang, Kalimantan, which has 2 feeders. In one of the feeders there is often a disturbance for protection coordination. The disturbance can hamper the performance of the PT PAMA PERSADA company. This disturbance turned out to occur in the coordination of overcurrent relay type protection and ground fault relay. Therefore, it is targeted to find the location of the problem and fix it. So, it is necessary to analyze the coordination evaluation of relay settings using the Electrical Transient Analysis Program (ETAP) 19.0.1 software on the electrical system. The disturbance that occurred was on feeder 2 which was divided into KM30 and Parilahung substations. This disturbance occurs because the trip coordination relay works simultaneously. From the results of the ETAP simulation, the power value is 4.164 KW, the reactive power is 780.3 KVAR, the apparent power is 4.237 KVA, and the cos phi value used is 0.9. Meanwhile, the protection coordination settings meet the IEEE 60255 standard with a grading time of 0.2 - 0.6 seconds. After being successfully simulated with Electrical Transient Analysis Program (ETAP) 19.0.1 software, it is continued with Matlab software which is used as an optimization of relay settings and the use of the working effects of the NN (Neural Network) method. thus, the final value that comes out according to the MSE (Main Square Error) value reaches 0.33452.

INDEX TERM Neural Network, overcurrent, ground fault, Main Square Eror, setting relay.

I. INTRODUCTION

PT PAMA PERSADA is a steam power plant located in Central Kalimantan, Barunang, which has a capacity of 2x15 megawatts (MW). PT PAMA PERSADA identifies the effects of disturbances on the power supply by utilizing the recreational Electrical Transitory Examination Program (ETAP) program to determine the proximity of postoperative disturbances. Disturbances that often occur in the power supply at PT PAMA PERSADA, are found on active 1 and active 2 which are separated into feeder 1 and feeder 2 (KM30 and Parilahung substations). This interference effect occurs because the hand-off coordination trips work at the same time. In this way, the company administration requires an assessment of the introduced transfer arrangement. So that the unwavering quality level of the electrical vitality carrier framework is more dependable. The guarantee transfer components to be assessed are Over Current Hand-off and Ground Blame Hand-off on feeder 2.

Due to non-optimal protection coordination, it can increase the possibility of equipment damage, power outage and can even cause an explosion if the fault occurs in a potentially flammable area [1]. Therefore, this protection system uses an adaptive that can coordinate the relay settings automatically following the changing conditions of the scattered generator status.

Referring to the description of related research as a basis, this research was conducted as a research development in the form of settings in the coordination of Over Current Relay (OCR) and Ground Fault Relay (GFR) protection at PT PAMA PERSADA. The hope of this research is to optimize the performance of Over Current Relay (OCR) and Ground Fault (GFR) relay coordination settings at PT PAMA PERSADA. This protection coordination can be applied to relays by utilizing the Neural Network method under certain conditions, namely in the settings. Which will only appear in the form of a graph of the Neural Network method itself [3].

II. MATERIALS AND METHOD

A. MATERIAL

1. System Protection

Electrical power system protection is electrical safety in the electric power system, in the event of an electrical disturbance or overload. Where one way to limit equipment damage, by limiting the continuity of the distribution of electricity can run well [2]. The disturbance that occurs is a short circuit that will cause a large enough current. A large current if not removed immediately will damage the equipment in its path, to release the disturbed area, a protection system is needed [4].

FIGURE 1. Relay schematic protection [23].

2. Instrument Protection

Some of the protection instruments used are load break switch, busbar, current transformer, and circuit breaker (FIGURE 1). Load break switch is a three-phase circuit breaker which can usually be used at feeder substations or electrically controlled cubicles under normal conditions without any disturbance [7]. The busbar installation is usually installed on the split-circuit panel, based on the PUIL 2000 standard, with the following conditions: red for the R phase, yellow for the S phase, black for the T phase and blue for the Neutral wire [11]. The busbar size is used the following equation: circuit breaker: [10]

$$ln = \frac{P}{\sqrt{3}.V.cos\emptyset\,\eta} \quad (1)$$

Then, next instrument protection is current transformer. Current transformer is an electrical equipment used to transfer electrical power from a circuit and to reduce the current [18]. And the last instrument protection is Circuit breaker (CB). Circuit breaker is a three-phase low-voltage automatic key protector as a breaker with control and relay. The grid protector is mounted on the transformer or the vault wall [17] (FIGURE 2).

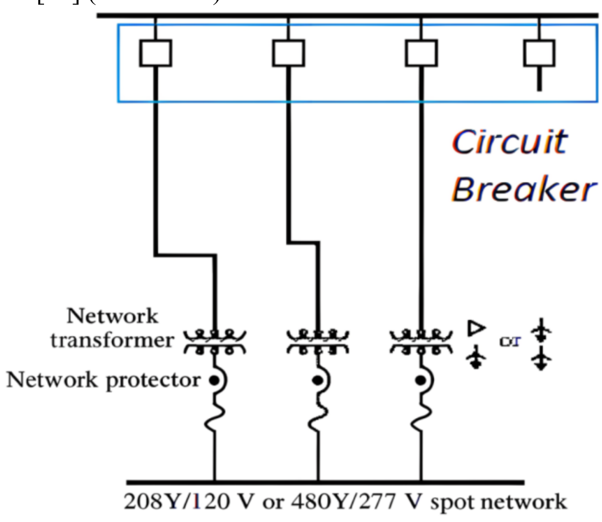

FIGURE 2. Circuit Breaker [20].

3. Curve Protection Coordination

Protection coordination system is the main system in production control. Where in this system the type of relay that works as follows [8].

Overcurrent relay is a relay that works against overcurrent. The relay will work if the current flowing exceeds the setting value (I set). It has the working principle of an overcurrent relay that works by analyzing the input in the form of a current which then the results of the current passing will be compared with the setting value, if the current value read by the relay exceeds the setting value, the relay will send a trip command to the CB (Circuit Breaker) as power breaker after the time delay applied to the setting [19]. This overcurrent relay will protect the electrical installation against interference between phases. And the overcurrent relay will work if it meets the following conditions: [14]

$$\text{If} > \text{Ip (trip)} \quad (2)$$
$$\text{If} < \text{Ip (block)} \quad (3)$$

Where when Ip is the working current used as a parameter for the maximum current value and If is the fault current stated on the transformer secondary winding. Overcurrent relays function to secure equipment parts of the electric power system, such as generators, utilities, transformers, motors [22].

The inverse curve has the following types of operations based on IEC Standard 60255: [13]

Curve Standar Inverse

$$\text{T (s)} = \frac{0{,}14}{\left(\frac{\text{Isc Max Saluran}}{\text{I Pickup}}\right)^{0{,}02} - 1} \text{ x } \mathbf{TMS} \quad (4)$$

Curve Very Invers

$$T\ (s) = \frac{13{,}5}{\left(\frac{Isc\ Max\ Saluran}{I\ Pickup}\right) - 1}\ x\ \boldsymbol{TMS} \quad (5)$$

Curve Extremely Inverse

$$\text{T (s)} = \frac{80}{\left(\frac{\text{Isc Max Saluran}}{\text{I Pickup}}\right)^{2} - 1}\ x\ \mathbf{TMS} \quad (6)$$

Curve Long Inverse

$$T\ (s) = \frac{120}{\left(\frac{Isc\ Max\ Saluran}{I\ Pickup}\right) - 1}\ x\ \boldsymbol{TMS} \quad (7)$$

Instantaneous is the next of curve protection coordination. This current relay will give a command to the PMT when a short circuit occurs and the current value of the disturbance exceeds its setting (Is), then the time period for the relay starts from pick up until the relay works for a certain time and does not depend on the amount of current that works on the relay [21].

Then, Definite Time. Relays on overcurrent use certain time characteristics, namely when the response period by the relay to the value of the pick-up current until the relay is complete does not depend on the amount of current that passes through the relay. The relay in this state will work based on a predetermined delay time and does not depend on the difference in the magnitude of the current [25] (FIGURE 3).

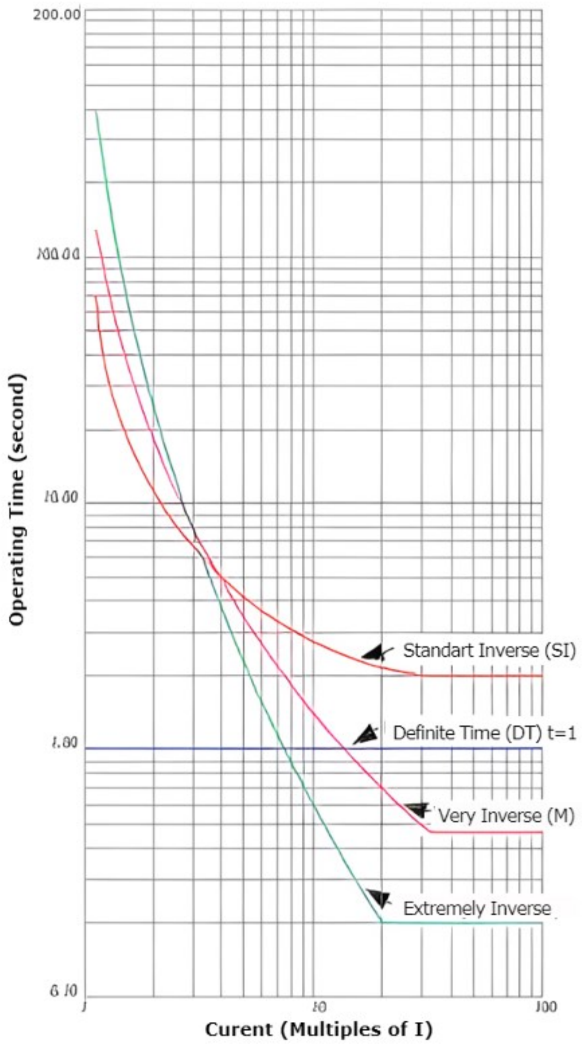

FIGURE 3. Characteristic Curve 60255 [13].

4. Electric Transient and Analysis Program (ETAP)

In designing and analyzing an electric power system, an application software is needed to represent real conditions before a system is realized. ETAP (Electric Transient and Analysis Program) 19.0.0 is an application software used to simulate electric power systems [24]. ETAP is able to work offline for electric power simulation, and online for real-time data management or used to control the system in real time. The features contained in it also vary, including features used to analyze electric power generation, transmission systems and electric power distribution systems [15]. The analysis of the electric power system that can be carried out by ETAP includes: Power flow analysis, short circuit analysis, arc flash analysis, motor starting, protection coordination, transient stability analysis, etc [9].

The power flow study is a calculation of voltage, current, active and reactive power found at network points in normal operational conditions, while the objectives are as follows: knowing the voltages on each bus in the system, both magnitude and phase angle of the voltage, knowing active and reactive power flowing in an existing line in a system, knowing the condition of all equipment, whether it meets the specified limits for delivering the desired electrical power, obtaining the initial conditions for the new system design, and obtaining the initial conditions for the study [16]. Further studies such as short circuit studies, stability and economic loading (FIGURE 4).

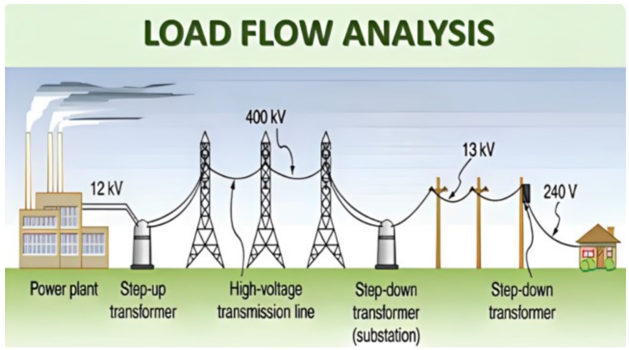

FIGURE 4. Load Flow Analys [16].

ANN (Artificial Neural Network) is a nervous system in the human brain. The working process of the human brain is composed of billions of neurons where each neuron will be connected to tens of thousands of other neurons: A neuron consists of 3 main components, namely: Dendrites, an input signal channel whose connection strength to the cell nucleus is influenced by a weight. Cell Body (Cell Body), is where the computational process of weighted input signals to produce output signals that will be sent to neurons. The axon is the part that sends the output signal to other neurons that are connected to the neuron [12] (FIGURE 5).

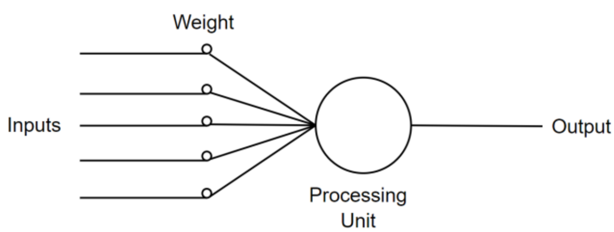

FIGURE 5. Basic NN Neuron [12].

B. METHOD

From the information in the FIGURE 6 above about load flow, it consists of input, process, and output. Where the input contains transformer data, bus data and equipment data. Meanwhile, the process contains power flow methods, by producing outputs in the form of voltage magnitude simulations, power losses, voltages, and current flows.

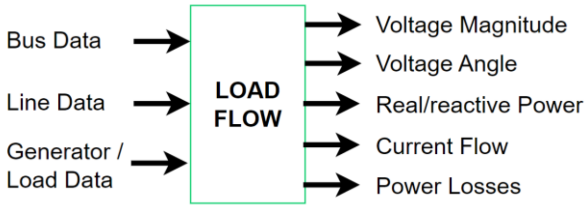

FIGURE 6. **Block Diagram Load Flow.**

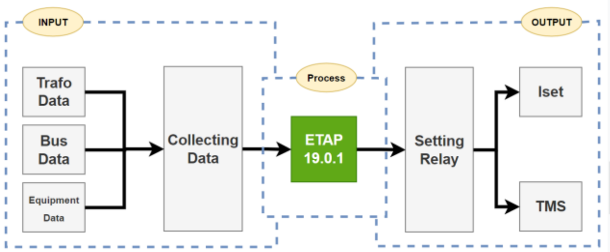

FIGURE 7. **Block Diagram Protection.**

From FIGURE 7 above, shown about protection coordination. it consists of input, process, and output. Where the input contains transformer data, bus data and equipment data, while the process contains a simulation of how the protection coordination works in the ETAP application, by producing outputs in the form of current settings, and time multi settings.

On the outgoing side, this one will calculate the Iset and Time Multi Setting (TMS) values. On the first outgoing, time value (t) used is 0.6 second. The following is a description of the known calculations on the first outgoing, load is 36A, Ihs is 2048 A, and CT is 600/5 A. Then, the current set (I set) is 43,2A and TMS is 0,36 second.

Outgoing 2 on Gardu KM 30. The calculations known is, load is 25A, I_{hs} is 840A, CT is 1000/5A, I_{set} is 30A, and TMS is 0,31 second. The known calculations on the outgoing 2 on Parilahung include, load is 0,031A, I_{hs} is 300A, CT is 1000/5A, I_{set} is 0,037A, and TMS is 0,01 second (TABLE 1).

TABLE 1
Data Analys Calculation

Outgoing 1		
	Current Set (A)	Time Multi Set. (s)
Substation KM 30	43,2	0,36

Outgoing 2		
	Current Set (A)	Time Multi Set. (s)
Substation KM 30	30	0,31
Parilahung	0,037	0,01

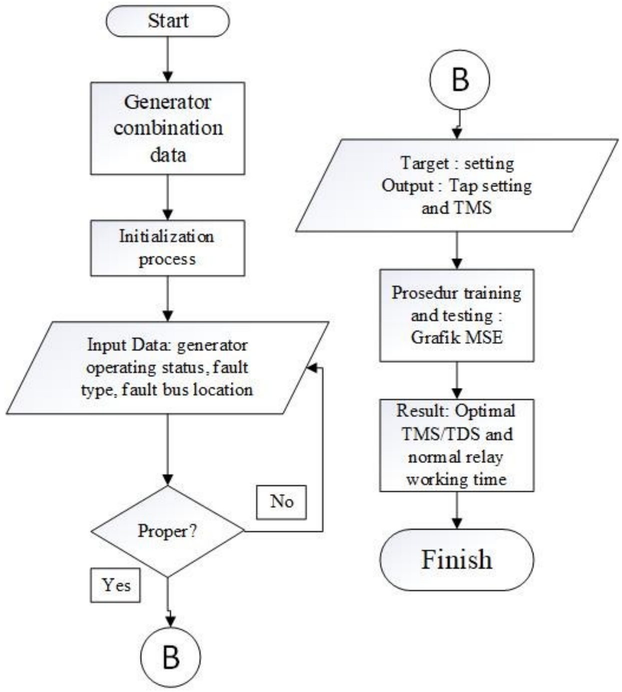

FIGURE 8. **Block diagram Protection.**

In the FIGURE 8 obtained the following description, the first one is start by opening the Matlab 2017 software. then, collect generator combination data to be entered in M-Files. After that, the entire data initialization process. The data input process, continued if it is appropriate to the next step namely the target input and output. Perform procedures and testing to generate the MSE graph as evidence of the optimization of the results of setting the relay working time.

III. RESULT

Electrical system at PT. PAMA PERSADA uses four voltage ratings, namely 150 kV, 36 kV, and 0.4 kV. The power flow test is carried out to determine the power flow between components that have been integrated, are able to issue current and voltage values and are able to determine the critical and marginal bus sections in the region. The power flow simulation will be tested under three conditions, namely at full load, medium load, and low load. There are numberings as regional markers, that number 1 is the generating area, number 2 is the Outgoing I area and number 3 is the outgoing II area. Where the load testing is located in all outgoing areas (FIGURE 9, FIGURE 10 and FIGURE 11; TABLE 2, TABLE 3, and TABLE 4).

IV. DISCUSSION

A. PROTECTION COORDINATION

1. Incoming

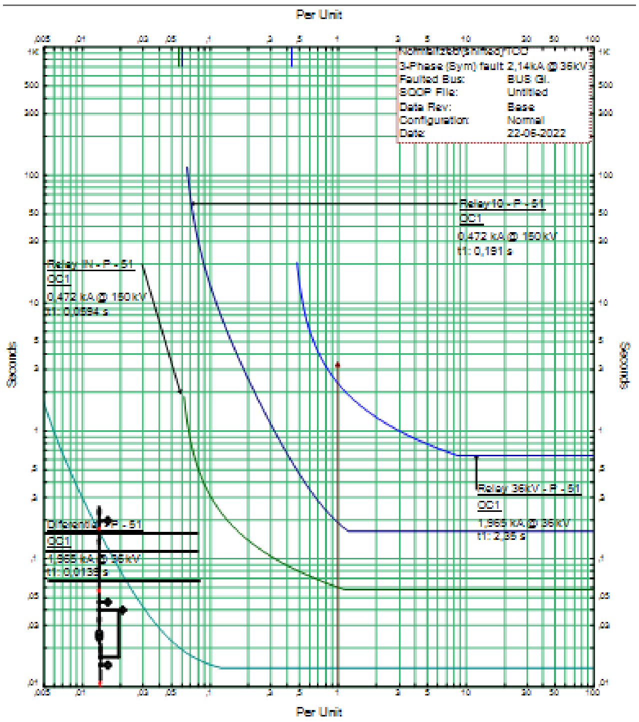

FIGURE 9. Curve Incoming

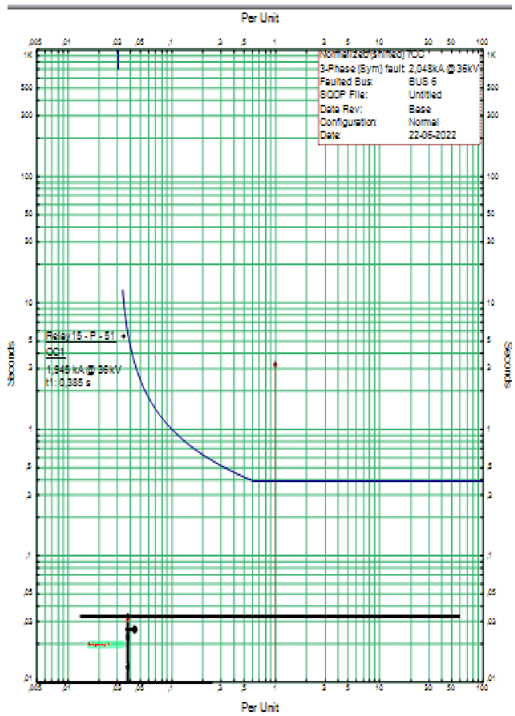

FIGURE 10. Curve Outgoing 1

TABLE 2
Existing data 150 KV

Time (ms)	ID	If (kA)	T1 (ms)	T2 (ms)	Condition
13,9	Diferential	1,965	13,9		Phase - OC1 - 51
23,9	CB 2		10,0		Tripped by Diferential Phase – OC1 – 51
59,4	Relay IN	0,472	59,4		Phase - OC1 - 51
69,4	CB2		10,0		Tripped by Relay IN Phase – OC1 – 51
191	Relay10	0,472	191		Phase - OC1 – 51
201	CB 1		10,0		Tripped by Relay10 Phase – OC1 – 51
1116	Relay 25	0,035	1116		Phase - OC1 – 51
1146	CB 3		30,0		Tripped by Relay25 Phase – OC1 – 51
1989	Relay 22	0,074	1989		Phase - OC1 – 51
2019	ARAH TOP		30,0		Tripped by Relay22 Phase – OC1 – 51
2133	Relay 15	0,104	2133		Phase - OC1 – 51
2163	OUTGOING1		30,0		Tripped by Relay15 Phase – OC1 – 51
2346	Relay 36kV	1,965	2346		Phase - OC1 – 51
2376	INCOMING		30,0		Tripped By Relay 36kV Phase – OC1 - 51

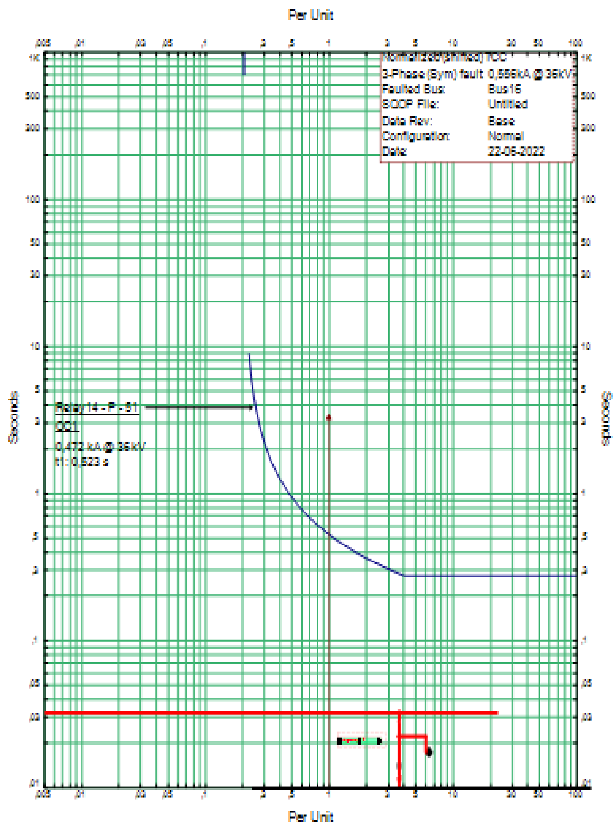

FIGURE 11. Curve Outgoing 2.

TABLE 3
Existing data 36 KV

Time (ms)	ID	If (kA)	T1 (ms)	T2 (ms)	Condition
415	OUTGOING1		30,0		Tripped by Relay 15 Phase – OC1 - 51

TABLE 4
Existing data 36 KV

Time (ms)	ID	If (kA)	T1 (ms)	T2 (ms)	Condition
23,9	OUTGOING2		30,0		Tripped by Relay14 Phase – OC1 – 51
553	CB 2		10,0		Tripped by Diferential Phase – OC1 - 51

B. NN METHOD

The information in FIGURE 12 explains that each neuron process will be different in the network configuration system used. It is influenced by the value of input and output. The input on the simple NN block diagram contains the value of the generator ON/OFF status of the bus fault, the type of fault, the location of the relay, and the short-circuit current. While the output contains the value of the Tap setting and Ipickup.

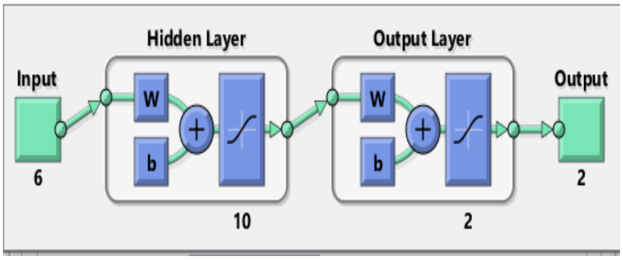

FIGURE 12. Neural Network Method.

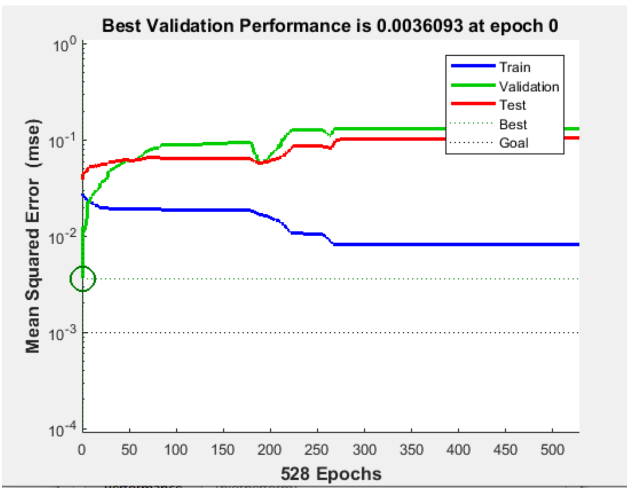

FIGURE 13. Curve Best Performance MSE.

FIGURE 13 shows the best performance values that reach up to the peak. The performance value is the smallest value that can be achieved during the training run. This is followed by the display of FIGURE 14 where the smaller the MSE value is similar between the target and the output, it means that it has reached conformity, with the conformity value reaching 0.0036093. From the results of the study, it will be obtained the value of the weight and the value of the bias used as the testing process. In fact, the weight and bias values will be included in TABLE 5.

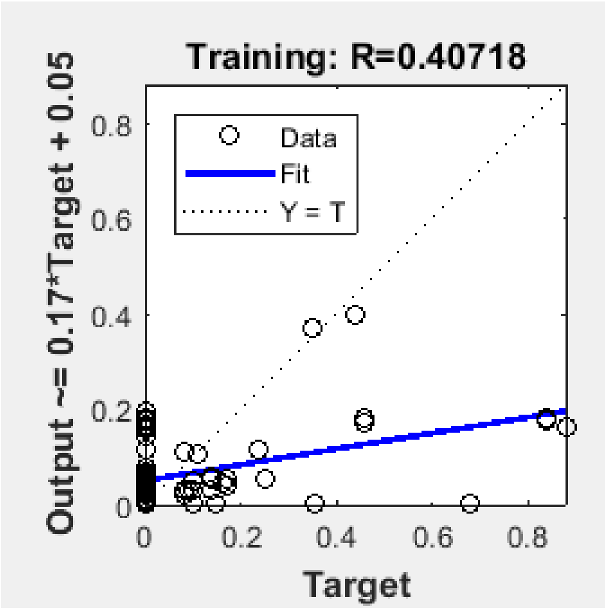

FIGURE 14. Target Suitability.

TABLE 5
Initial weight and final weight

Initial Weight				Initial Bias
Neuron	x1	x2	x3	
y1	0.52203	0.15690	-1.08398	-14579343
y2	-1.02195	0.64329	0.07114	0.95822271

V. CONCLUSION

Based on the simulation results and analysis of the coordination of Overcurrent Relay and Ground Fault Relay protection on a radial system connected to the generator using the NN method, the following conclusions can be drawn, the protection coordination simulation performed on the Electrical Transient Analysis Program (ETAP) 19.0.1 software can work according to its working principle. The location of the disturbance that dominates is at the KM 30 and Parilahung substations. The time setting used in the existing one does not meet the IEEE 60255 standard with a grading time of 0.2-0.6 second. Therefore, it is improved by selecting the resetting grading time of this final project protection coordination, which is 0.6 second. The results of the fulfillment of the curve used are in accordance with the IEEE 60255 standard in the form of an inverse standard TCC (Time Current Correlation) curve. Where the curve does not intersect with other components. The effect of the NN method system with Matlab 2017 software is used as an optimization of the settings contained in the relay with a target suitability of 0.0036093. As well as being able to display the MSE (Mean Squad Error) graph for relay operation time.

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