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APPLICATION OF BACKPROPAGATION NEURAL NETWORK FOR FAULT LOCATION IN TRANSMISSION LINE 150 kV

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ABSTRACT

This paper discusses the implementation of backpropagation neural network to locate fault in transmission line 150 kV between substations to substation. Distance relay is one of the good protective and safety device that often used on transmission line 150 kV. Then backpropagation neural network is a computational model that uses the training process that can be used to solve the problem of work limitations of distance protection relays. The backpropagation neural network does not have limitations cause of the impedance range setting. If the output gives the wrong result, so the correct of the weights not only can be minimized and but also the response of error, the backpropagation neural network is expected to be closer to the correct value. In the end, backpropagation neural network modeling is expected to detect the fault location and identify operational output current circuit breaker while it was tripped.The performance tested by interconnected system 150 kV of Riau Region.

KEYWORDS: Backpropagation Neural Network, Distance Relay, Impedance, Transmission Line, Zone

INTRODUCTION

In electrical power system has been applied to fault detection, fault location,and fault diagnosis. This paper proposes fault location in transmission line 150 kV. Protective devices usage is distance relay and circuit breaker. In this research developed modeling of one line diagram which used ETAP software to produce part of parameters as input from Matlab. The method usage in this paper presents backpropagation neural network that it is generated by matlab. Several author was described their ideas in fault location by using different parameters. In [3], they investigated the construction of fuzzy logic for alarm processing and fault location in electrical power systems. The among Fuzzy associations system components: relays and circuit breakers have been established with the aid of human experts through their experience and knowledge on protection devices operation for faults involving different system component. In other researcher [1] and [5] distance relaying scheme is based on fuzzy neural network.This paper explained the classifier uses normalize peaks of voltage and current waveforms as input where as fault location. The among fuzzy relations alarm patterns and possibly faulted system components are established and employed as training sets for artificial neural networks. That methodology has tested using the seven bus systems real Brazilian system. The artificial neural network have been successfully apply to many power systems [2], [4] dan [6]. With the information provided by scada used to detection fault sections. The neural classifiers are trained off line using several different training alarm patterns. They are employed for producing real time classifications; this is in order to obtain final diagnoses from the classification results.

In this paper, protection devices is to detect system disturbances distance relay and circuit breaker. When interference happened in source area, the power system will respond and trip for fault location. Additionally, scheme of distance relays are mainly used for transmission line protection which is the interconnected networks. It is usually consists of three zones: the main protection zone for detecting and eliminating fault in 100% of the transmission line, it must operate without any time delay. The first zone backup protection for protecting about 80% of transmission line, serve as an instantaneous backup protection for the main protection zone. thus, the second zone is usually backup protection that set to 120%-150% of the length of the line, serves as backup protection for adjacent transmission lines. A breaker failure protection scheme can also be employed. Whenever a breaker failure is detected, a tripping command is sent to remote breakers without anytime delay [2]. It can be showed in Figure 1.

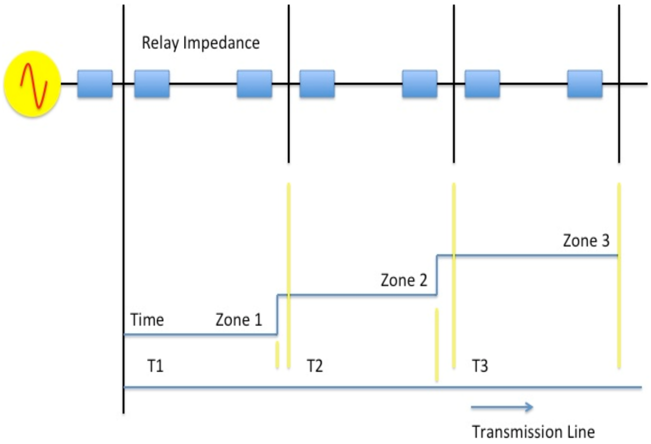

Figure 1: Setting of Time for each Distance Relay

While the transmission line disturbed, the distance relay can show the decrease from impedance of transmission line, then distance relay will get respond. Distance relays can be measure the voltage on relay points and noise current visible from relay, by dividing the amount of voltage and current, the impedance to the point of occurrence interference can be determined. Distance relay will work while is comparing impedance interference to make measure impedance setting on the distance relay. In this moment the value is less interference impedance rather than setting the impedance distance relay and thus distance relay will work. Otherwise, if the value of impedance is greater disruption or equal to the impedance setting distance relay, it will know the distance relay will not work.

RESEARCH METHOD

This simulation is based on real conditions in the field area with the mutually interconnected transmission system. The power supplied from two sources generated by using power grid model swing generator two units with capacity 26.6 MVA (TL Lembu) and generator three unit with capacity 45 MVA (Kt Panjang). Then interconnected to other substation transmission around Riau Region.

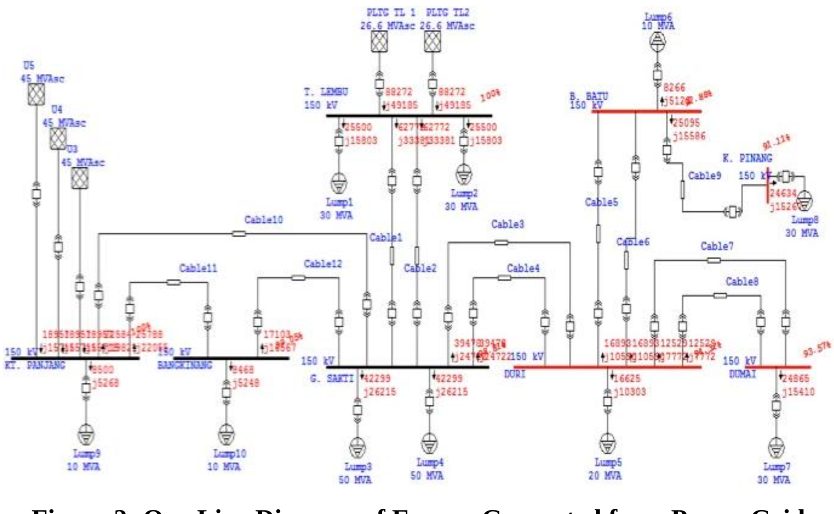

Figure 2: One Line Diagram of Energy Generated from Power Grid

Electrical power system in Riau region is an over head line transmission with nominal voltage of 150 kV. Fitted with a line length of a particular type ACSR conductor. The ETAP (Electrical Transient Analyzer Program) software experiments based on real system conditions with the values of the input variables, then obtained output values based on the simulation results run load flow analysis. It can show in table 1.

Table 1: Branch Connection

SUBSTATION	R	X	Z
TL Lembu to G Sakti	1.38	0.96	1.68
TL Lembu to G Sakti	1.38	13.53	1.68
G sakti to Duri	7.85	5.44	9.54
G Sakti to Duri	7.85	76.85	9.54
Duri to B batu	4.75	5.27	7.10
Duri to B Batu	4.75	72.17	7.10
Dumai to Duri	3.96	2.74	4.81
Dumai to Duri	3.96	2.74	4.81
Kt Pinang to B Batu	4.56	3.16	5.55
Kt Panjang to G Sakti	2.66	2.95	3.98
Kt Panjang to Bangkinang	1.88	2.09	2.81
Bangkinang to G Sakti	0.67	0.75	1.01

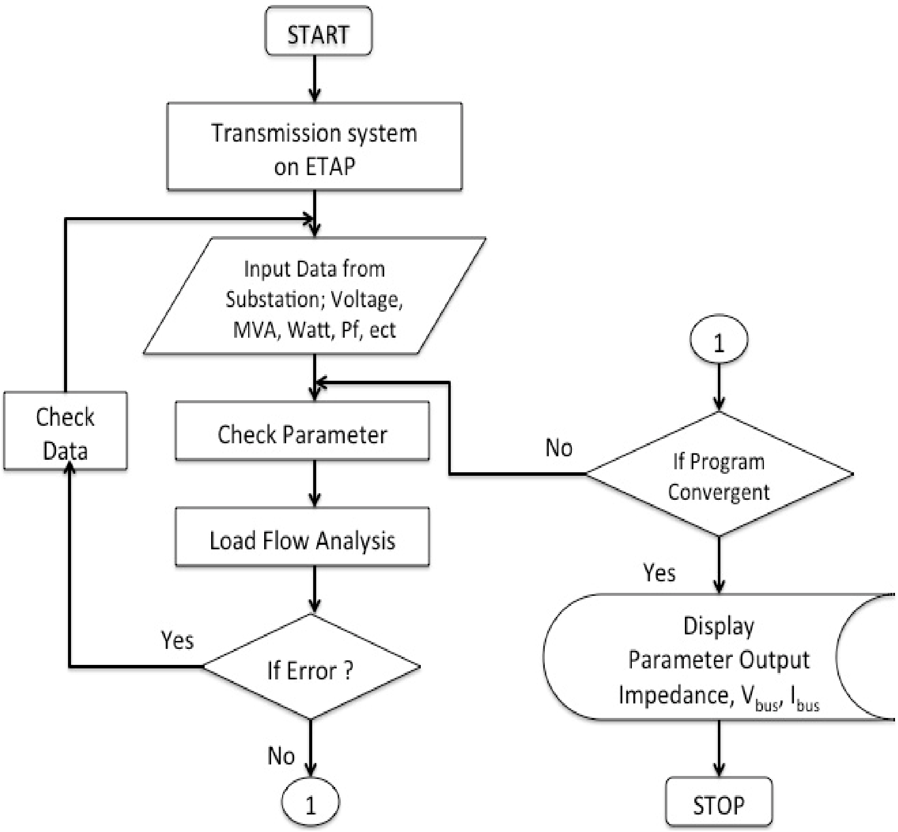

Figure 3: Flowchart Simulation of ETAP

The simulation and result under normal conditions that previously have been done. Modeling setting a disturbance between the bus Garuda Sakti and bus Duri in accordance the conditions of real disruptions has happened in the field on the 27th of September 2011. Distubance occured at a fault location line length is 22.4 Km long line between bus Garuda Sakti to bus Duri.

Table 2: The Simulation Result Current Conditions Disorder in ETAP

SUBSTATION		VOLTAGE (kV)	LOADFLOW	
From	To		Voltage (kV)	Current (A)
TL. Lembu	G Sakti	150	150	273
	G Sakti	150	150	273
G Sakti	TL Lembu	150	148.22	273
	TL Lembu	150	148.22	273
	Duri	150	148.22	181
	Duri	150	148.22	181
	K Panjang	150	148.22	112
	Bangkinang	150	148.22	107
Duri	G Sakti	150	141.479	181
	G Sakti	150	141.479	181
	B Batu	150	141.479	81
	B Batu	150	141.479	81
	Dumai	150	141.479	60
	Dumai	150	141.479	60
B Batu	Duri	150	139.315	81
	Duri	150	139.315	81
	Kt Pinang	150	139.315	112
Dumai	Duri	150	140.352	60
	Duri	150	140.352	60
Kt Pinang	B Batu	150	136.672	122
Kt Panjang	G Sakti	150	150	112
	Bangkinang	150	150	145
Bangkinang	G Sakti	150	107	107
	Kt Panjang	150	145	145

Backpropagation Neural Network Modeling

Backpropagation Neural Network (BNN) can be used to solve problems in this research to determine the zone of disturbance in an electric power system thus can make the right decision by given input pattern in testing. BNN is one model of feed forward neural network using supervised training which is based on the algorithm error back propagation training rule based on error correction. The process of error back propagation consists of two stages that are: feed forward and feed backward. Every neuron in each has the function of activation. Each neuron in the input using the identify activation function. Each neuron in the hidden layer using a non linear activation function, continuous activation functions used derivative. Each neuron output use the same activation function is linear activation function. The activation functions must have a derivative usage in the algorithm method for BNN which using derivative of the activation in each to improve weights of neural network. Hidden layer is using the linear activation function; BNN can solve the problem because the composition of linear functions is linear.

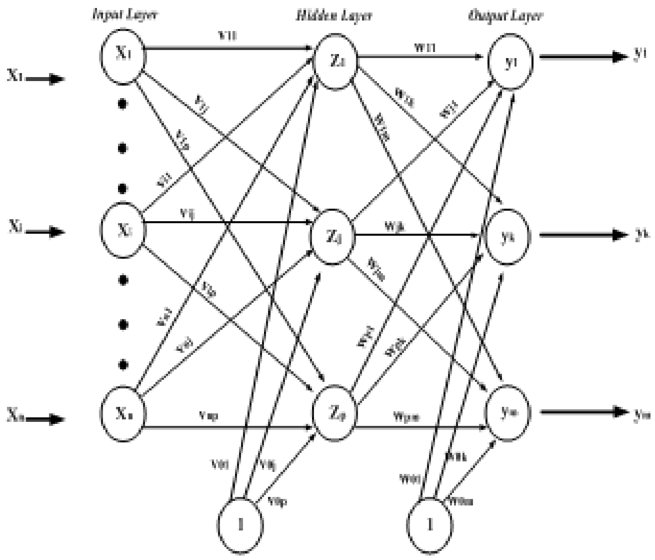

Figure 4: The Architecture Back Propagation Neural Network

Procedure of Backpropagation Neural Network Application

Stage 1: Initialized weights.

Stage 2: There are no specific criteria for determining the value that the algorithm stops.

Feed Forward

Stage 3: Each neuron input $(x_i, i = 1, \dots, n)$ receives signals x_i and sends value is the value of all these neuron in the next.

Stage 4: Each hidden neuron receives input $(z_j, j = 1, \dots p)$ in the form of the result of multiplying the value of each signal with the weight on the line connected to the hidden layer;

$$z_{in_j} = v_{0j} + \sum_{i=1}^{n} x_i v_{ij} \quad (1)$$

Use the activation function to compute its output signal;

$$z_j = f\left(z_{in_j}\right) = \frac{1}{1+e^{-z\_in_j}} \quad (2)$$

Stage 5: Each neuron output; $(y_k, k = 1, \dots, m)$ accept input in the form of the theoretical value of the output of each hidden layer with a weight on the line connected to the output layer;

$$y_{in_k} = w_{0k} + \sum_{j=1}^{p} z_j w_{jk} \quad (3)$$

Use the activation function is to calculate the output signal;

$$y_k = f\left(y_{in_k}\right) = \frac{1}{1+e^{-y\_in_k}} \quad (4)$$

Backpropagation of Error

Stage 6: Calculate the output factor of error in each output layer by layer; $(y_k, k = 1, \dots, m)$

$$\partial_k = (t_k - y_k) f'\left(y_{in_k}\right) = (t_k - y_k) y_k (1 - y_k) \quad (5)$$

∂_k : error units that will be used in the changing weight layer.

Calculate of the spart weight change jk which will be used later to change the weight w_{jk} rate perception α

$(z_j = j = 1, \dots, p)$ To update the hidden layer bias to the output layer;

$$\Delta w_{0k} = \alpha \partial_k \quad (6)$$

Stage 7: Calculate the hidden layer based on the error factor in each hidden layer; $(z_j = j = 1, \dots, p)$ assumed ∂ input;

$$\partial_{net_j} = \sum_{k=1}^{m} \partial_k w_{jk} \quad (7)$$

The factor ∂ hidden layer;

$$\partial_j = \partial_{in_j} f'\left(z_{in_j}\right) = \partial\_in_j z_j \,(1 - z_j) \quad (8)$$

Calculate of the spart weight change; v_{ij}

$$\Delta V_{ij} = \alpha \partial_j X_i \ , j = 1,2, \dots , n \tag{9}$$

Which will be used later to change the weight; $j = 1,2, \dots , p$ and $i = 1,2, \dots , n$

To update the weights with the input layer hidden layer;

$$\Delta V_{0j} = \alpha \partial_j \tag{10}$$

Renewed Weight and Bias

Stage 8: Each neuron output $(y_k, k = 1, \dots , m)$ update the weights and bias $(j = 1, \dots , p)$;

$$w_{jk}(new) = w_{jk}(old) + \Delta w_{jk} \tag{11}$$

Every neuron hidden; $(z_j, j = 1, \dots , p)$ to update the hidden layer bias$(i = 1, \dots , n)$;

$$v_{ij}(new) = V_{ij}(old) + \Delta v_{ij} \tag{12}$$

Stage 9: Test the value that has been determined to quit.

After learned the process, the network above can be used for the testing process. In this case only the feed forward measures are used to determine the output results of the network.

Table 3: Description of Notation

Description of Notation is used;	
δ_k	The correction of error from the output layer to hidden layer
δ_j	The correction of error from the hidden layer to input layer
α	Learning rate
x_i	Input unit i
v_{0j}	Bias for neuron hidden j
z_j	Neuron hidden j
w_{0k}	Bias for neuron output k
y_k	Neuron output k
t_k	Target BNN

The results of the simulation modeling using ETAP software go on if returned as input to matlab programming. Rated output at normal conditions in the system was produced the previous ETAP simulation, highly attention for a new input values in Matlab simulations. The value is in the form of bus voltage magnitude value, the current in the line length and impedance as the target output value, which used for the training of neural network method.

In different to the training process, the current state of the system modeling interference occurs, the value of the results simulation ETAP for a new input values in programming Matlab then simulation to be used for the testing process, the form of input noise current of each line length and voltage disturbances respective bus. In the process of testing, the target values for the impedance settings are used constant as the value on the training process, so that it can detect the location or zone of disturbance in the system and can be known protective equipment decisions that work in the location of the disorder. The data can be seen in table 4.

Table 4: Input Current Normal and Disturbance Conditions Disorders Matlab Simulation

Normal Condition					Disturbance Condition			
From Substation	VOLTAGE (kV)	To Substation	CURRENT (A)	IMPEDANCE	From Substation	VOLTAGE (kV)	To Substation	CURRENT (A)
*Tl Lembu	150	G Sakti	273	549.45	*Tl Lembu	5.06	G Sakti	0
	150	G Sakti	273	549.45		5.06	G Sakti	0
G Sakti	148.22	T Lembu	273	542.93	G Sakti	1.98	Tl Lembu	0
	148.22	T Lembu	273	542.93		1.98	Tl Lembu	0
	148.22	Duri	181	818.89		1.98	Shadow	620
	148.22	Duri	181	818.89		1.98	Duri	0
	148.22	Kt Panjang	115	1288.87		1.98	Kt Panjang	0
	148.22	Bangkinang	92	1611.08		1.98	Bangkinang	0
Duri	141.48	G Sakti	181	781.75	Duri	4.41	Shadow	66
	141.48	G Sakti	181	781.75		4.41	G Sakti	0
	141.48	B Batu	81	1746.65		4.41	B Batu	0
	141.48	B Batu	81	1746.65		4.41	B Batu	0
	141.48	Dumai	60	2357.98		4.41	Dumai	0
	141.48	Dumai	60	2357.98		4.41	Dumai	0
B Batu	139.32	Duri	81	1719.93	B Batu	1.97	Duri	0
	139.32	Duri	81	1719.93		1.97	Duri	0
	139.32	Kt Pinang	122	1141.92		1.97	Kt Pinang	0
Dumai	140.35	Duri	60	2339.2	Dumai	1.97	Duri	0
	140.35	Duri	60	2339.2		1.97	Duri	0
Kt Pinang	136.672	B Batu	122	1120.26	Kt Pinang	1.97	B batu	0
*Kt Panjang	150	G Sakti	115	1304.34	*Kt Panjang	8.12	G Sakti	0
	150	Bangkinang	130	1153.84		8.12	Bangkinang	0
Bangkinang	148.58	G sakti	92	1615.02	Bangkinang	5.39	G Sakti	0
	148.58	Kt Panjang	130	1142.93		5.39	Kt Panjang	0

In different the training process, the occurs current state of the system modeling interference, the results of value simulation ETAP in table 2 and table 3 reused for a new input values in programming Matlab simulation to be used for the testing process, the form of input noise current of each line length and voltage disturbances every bus.

In the process of testing the target values for the impedance settings are used constant as the value on the training process, it can be detected the location or zone of disturbance in the system and it will respond of protective equipment decisions when the location disturbance is work.

RESULTS AND DISCUSSIONS

The process of training and testing of the method in modeling the Back propagation Neural Network, by using the value of learning rate and hidden layer are determined by reference to the source, the result was obtained the back propagation method can detect the output of the work process in the form of output protection method that CB was connected electric power systems, where it done modeling interference testing in one of the long line between lines of Garuda Sakti Bus and Bus Duri, back propagation neural network modeling output CB detect the location or zone disrupted the zone 1 and zone 2.

The simulation of modeling methods BPNN and table 6 and table 7, it can be seen in the current system interference with reading protection equipment installed CB respective bus systems in substations, the BNN will be able to detect the location or zone of disturbance. BNN on the distance relay will detect first the location of the disruption that occurred in zone 1, because of the zone 1 is the primary protection zone along 80% of the line. Then if the interference cannot be secured along the zone 1, the BNN in the distance relay will detect the fault location occurred in zone 2.

The results of the modeling using BNN can be seen modeling method and detect the location or zone of disturbance more accurate. Almost as long as line system is the main zone of protection in other words, BNN can handle and overcome the problem of detecting interference in electrical power system line transmission.

Table 5: Process Training and Testing BNN

Input Neurons of BNN	
The number of input layer neurons	20 neurons
The number of hidden layer neurons	37 neurons
The values of neuron output layer	24 neurons
Target of error	0.001
Learning rate (α)	0.5
The number of iterations	48,370

Table 6: Simulation of Results Output Using BNN

The Zone of Protection	Fault Location (Bus)	Protective Devices Work
Zone 1	Tl Lembu 1, G Sakti 1, Tl Lembu 2, G Sakti 2, G Sakti 1, Duri 1, G Sakti 2, Duri 2, B Batu, Duri 1, B Batu 2, Duri 2, Duri 1, Dumai 1, Duri 2, Dumai 2, B Batu, Kt Pinang, Kt Panjang, G Sakti, Kt Panjang, Bangkinang	CB1, CB2, CB3, CB4, CB5, CB6, CB7, CB8, CB9, CB10, CB11, CB12, CB13, CB14, CB15, CB16, CB17, CB18, CB19, CB20, CB21, CB22
Zone 2	Bangkinang, G Sakti	CB23, CB24

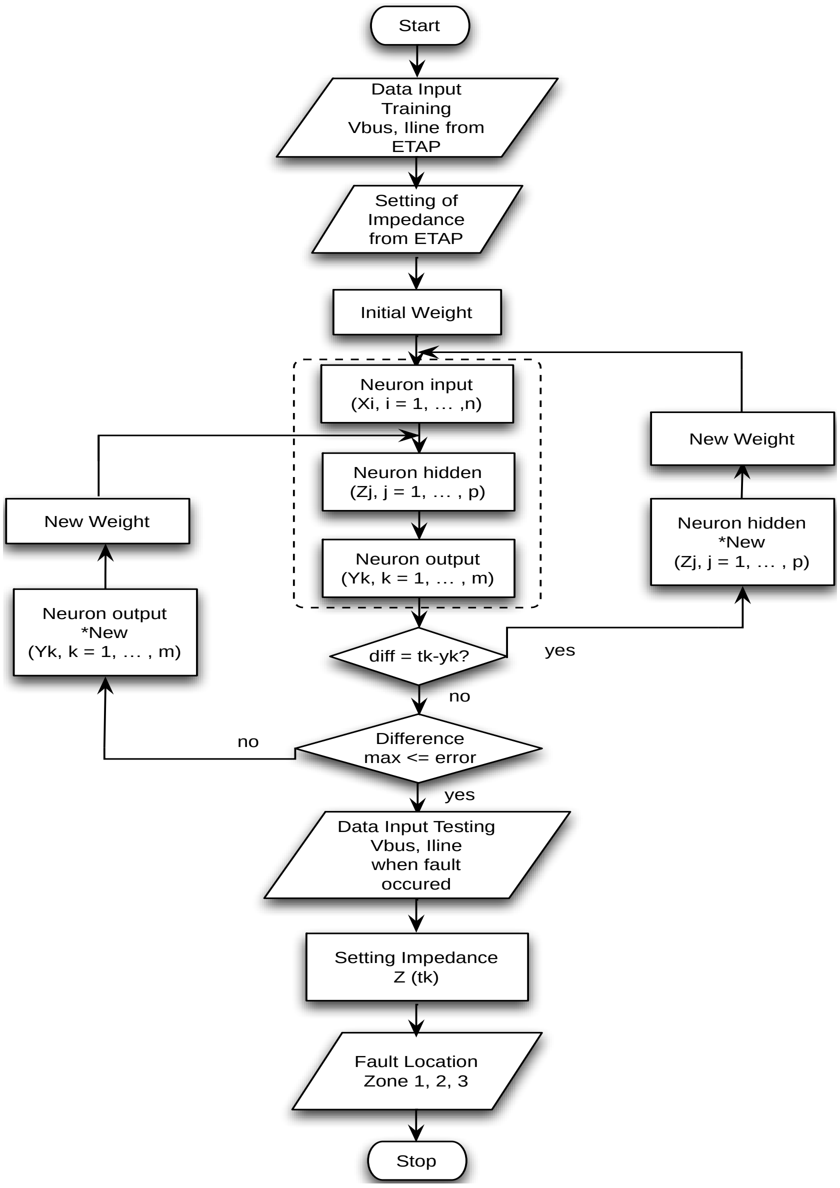

Figure 5: Flowchart BNN Generated by Simulation of Matlab

CONCLUSIONS

This paper aimed to used the application of BNN of in transmission line 150 kV. The value of the result simulation of ETAP software was gave a new input for Matlab. The prediction of the BNN on distance relays can provide information at the location or zone protection interference in the transmission system. The selection of parameters and weights for predicted applied values based on the smallest fault testing. Success in predicting affected by number of hidden layer and value of learning rate used. The input layer with one variable model will present more performance accurate test results. Modeling of disturbance in one long line transmission between bus Garuda Sakti and bus Duri in accordance with conditions of real disruptions has happened in the field. The results show that using BNN can make better predictions.

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