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***Abstract*—The electrical systems, the addition of loads can result in fewer stability limits, if there is interference, it can cause black out. In this study analyzing early warning, by observing the limits of stability in the event of a disturbance before black out in the South Sulawesi electricity system. This study observed an early warning system consisting of 44 buses and 15 generators using a Voltage stability margin (VSM) in the event of a disruption. From the training data about each disruption from various buses that occur then learning to use Extreme Learning (ELM) engines is used to detect early warnings during transient conditions. From the ELM simulation results can work quickly 0.0001 and 0.0024 and the error value is low so that it can be known before a blackout occurs.**

***Keywords*—early warning, transient stability, ELM, south sulawesi**

I. Introduction

The increase in load can lead to a narrowing of the stability area. In the power system stability and control is a major problem, it has been scrutinized by experts since 1920 by [1]. Until now, the stability problem that was connected directly to the rotor angle (transient and steady state) became the focus of the research. System stability improvement using PSS has been investigated by [2] increased transient stability by regulating the moment of inertia [3] improvements using DG have been reviewed by [4]. System stability conditions are affected by operating patterns and load patterns. Because interference can cause stability to become a major problem on the generator side, stability appears in accordance with mechanical and electrical rotor angle fluctuations so that the use of new technologies and controls is needed, to improve operation under oscillation conditions.

Research on voltage collapse and early warning conditions has been carried out [5, 6] and on [7] discuss about Steady state load shedding to mitigate blackout in power systems using an improved harmony search algorithm. Metaheuristic method has also been applied to predict blackout [8] in this study using fuzzy method to find out blackout. Another approach has been taken [9] that is, using scenario dynamics initiated by internal and seismic event in boiling water reactor. Voltage stability and oscillation Analysis and control of major blackout events have been discussed [10]. Research using ELM has also been applied to the Java-Bali 500 kV Interconnection Power System [11, 12]. However, at present the system of South Sulawesi has installed wind turbines so that research is needed on early detection of the system, whether wind turbines affect stability which can lead to blackout. This study presents the ELM application to train the stability of the South Sulawesi system when disruption, which can lead to blackout. To provide information on the state of stability of the system at the level of stability of the interconnected generator. ELM is able to provide an early warning so that blackout does not occur when the condition is disturbed.

II. Power System Model

A. Stability System

The state of a power system to restore a power equal to or greater than the power of interference to maintain a balanced state is called stability, from supply and demand. The power from the generator is produced to keep the engine in sync with the others enough to supply the load to overcome the need for load surges [11, 12]. Disturbances that occur in large or small systems in the power system have an impact on synchronous operation. For example, a sudden increase or decrease in load, or a consequence of loss of generation, becomes one type of interference that has a significant effect on the system. Another type of potential disturbance is the transmission network disconnection, overload, or short circuit. With good control, it is expected that system stability will lead to steady conditions in a short time after the disturbance has been overcome.

B. Voltege Stabiity Margine

The VSM stabilities system is divided into VSM (P) and VSM (Q). VSM (P) states that the index is stable at active power loads and VSM (Q) for the freedom index in reactive load (Q). For this system condition, critical conditions and Q are active and reactive power at critical stress points. The critical voltage on the side of the generator in the system is the value of the voltage at the point of collapse or fall caused by far from the voltage or performance of the conductor. The

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system will discuss the collapse voltage from zero, where the VSM critical voltage value is zero. Equation (1) to determine VSM.

$$VSM = \frac{V_{initial} - V_{critical}}{V_{critical}} \quad (1)$$

C. Generator, exciter, and governor Modeling

In this study the excitation model representation in the South Sulawesi system in the generator generation system, Fig. 1 and Fig. 2.

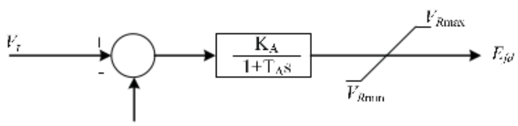

Fig. 1. Exciter diagram block

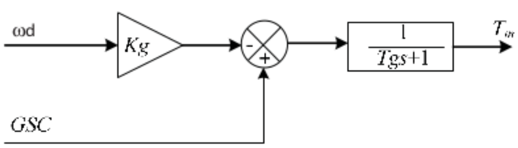

Fig. 2. Governor Modeling

D. Determine Steady State and Transient Stability

Several methods have been developed in analyzing the electric power system, to determine the conditions of transient and steady state stability. The first method is the same criteria as Equal Area Criterion or (EAC). This method is directly to determine the time of crinites on a Critical Clearing Time (CCT) machine, so that to determine the condition of multi-machine or large-scale systems, this system cannot be used. The second method is, continuation power flow (CPF) is used to determine loading parameters that are connected to the bus voltage. The CPF method is used to reformulate the load flow power fluid on the load parameter. To determine it can be expressed through the following (2).

$$F(\theta, V) = \Lambda k \quad (2)$$

Where:

- λ is load parameter
- θ is vector of bus voltage angle
- V is vector of bus voltage
- K is vector which describes the percentage change in load on each bus

Third, the load flow is used to determine the total load on each bus, but when the load flow is added the load flow method does not converge so that the system conditions cannot be ascertained. This method uses the Newton Raphson method which is an upgraded Gauss-Seidel. The basis used in the calculation is the admittance matrix (Y_{bus}) in the three methods. In this study, will implement the Transient Stability Analysis in the South Sulawesi system in real time or not real time using the ELM method.

III. Extreme Learning Machine

Conventional methods such as fuzzy logic and the Levenberg-Marquardt (LM) method have been used for detection of electrical systems. Training and learning systems in fuzzy need a lot of time. The new learning system method uses feed-forward feed neural networks (SLFN), called extreme learning machines (ELM), Fig. 3.

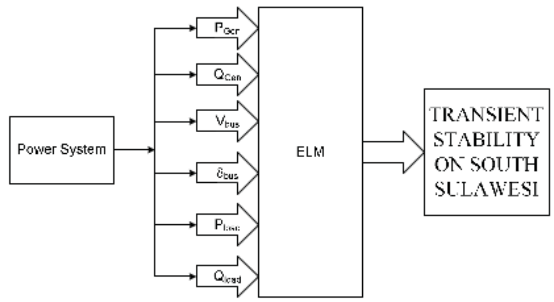

Fig. 3. Scheme of research

In ELM, the input weight and hidden bias are chosen randomly when listening. Output weights obtained using the Moore-Penrose (MP) generalization inverse. ELM has the ability in terms of speed and ease from traditional methods of algorithm-based gradient learning [11]. Fig. 3 shows the research scheme early warning condition transient stability in this study. In this paper, ELM is used to detect the network voltage of the load profile of weak buses after a disturbance occurs. First, the simulation starts with running a power flow program on the Java-Bali system. South Sulawesi. The system records the time each interruption occurs on all buses to be heard and tested.

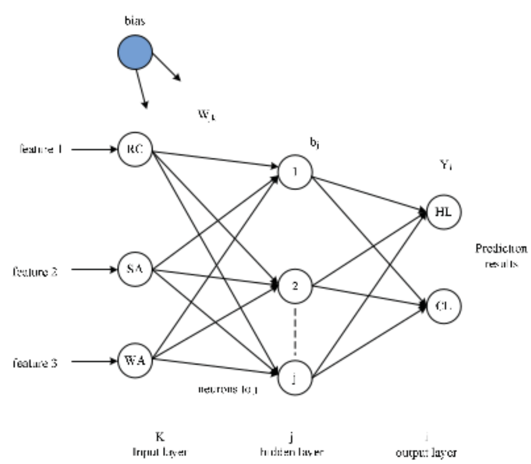

Fig. 4. 4 ELM architecture

ELM algorithm architecture consists of three layers, namely the input layer, hidden layer and output layer, can be seen in Fig. 4. In the ELM architecture, there is only one hidden layer which is characteristic of the ELM algorithm.

IV. Proposed Method

To test as a case for simulation is a South Sulawesi 150kV system as shown in Fig. 5. The generator characteristic data, line impedance and operating conditions are shown in Table I.

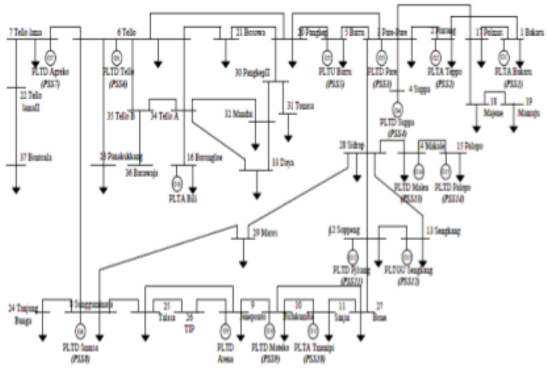

Fig. 5. Single Line Diagram of South Sulawesi Power System

V. Simulation and Result

The use of the South Sulawesi system applying the ELM method to get the bus critical value on each bus is shown in Fig. 5. In this simulation, the relationship between changes in bus load due to bus interruption has been obtained for learning. Table II, the value of Actual, the value of Elm and the error value when testing data is shown.

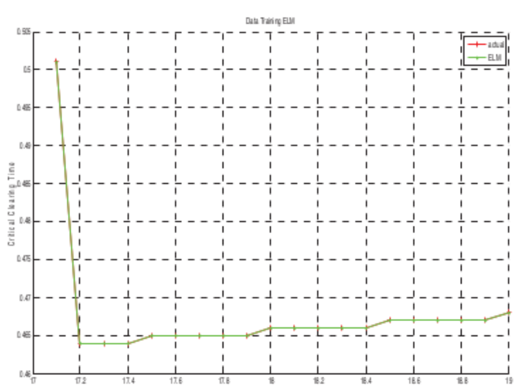

Fig. 6. Training using ELM

The South Sulawesi system data used to conduct training in measuring CCT values in the event of a disturbance can be seen in Table I. The interference data obtained from the system is trained using ELM so that the testing data can be obtained in Table II. The data that was tested contained 20 data. Error value obtained 0.0001 occurs twice, 0.0002 occurs twice, 0.0003 occurs once, 0.0005 occurs once, 0.0007 occurs once, 0.0010 occurs once, 0.0014 occurs once, 0.0018 occurs once, 0.0014 occurs once, 0.0018 occurs once, 0.0024, and for value 0.0000 occurs nine times. Fig. 6, shows the results of training using ELM.

TABLE I. DATA GENERATOR SOUTH SOUTH SULAWESI SYSTEM

MW	M_{var}	MW	M_{var}	Q_{min}	Q_{max}
3.5	0.2	63	3.1	0	0
21	4.1	0	0	0	0
23.3	3.7	0	0	0	0
9.6	4.8	0	0	0	0
24.4	6.2	14.3	0.8	0	0
18.7	4.7	0	0	0	0
0	0	31.1	8.2	0	0
26.5	10.3	0	0	0	0
0	0	60.4	4.8	0	0
10.1	2.4	0	0	0	0
22.1	8	0	0	0	0
0	0	0	0	0	0
18.9	10.6	0	0	0	0
33.1	15.4	0	0	0	0
18	5.8	0	0	0	0
63.3	18.3	21	7.9	0	0
68.3	17.7	0	0	0	0
0	-20	0	0	0	0
11.4	0	5.2	0.2	0	0
24.3	2.6	0	0	0	0
45.5	2.8	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
19.7	4.7	12.6	0	0	0
0	0	0	0	0	0
26.5	7.7	0	0	0	0
15.7	3.6	20	5.9	0	0
55.2	16.7	0	0	0	0
20.6	4.7	79	39.1	0	0
18.6	5.5	0	0	0	0
0	0	196.1	38.6	0	0
17.4	3.4	0	0	0	0
27.1	6.5	0	0	0	0
21.9	4.6	4	0.5	0	0
32.1	8.2	0	0	0	0
14.1	3.4	0	0	0	0
28.4	11.5	265.2	7.9	0	0
11.9	1.5	8.2	2.1	0	0
49.2	0	4	2	0	0
0	0	0	0	0	0
0	0	195	27.2	0	0
0	0	0	0	0	0
4.9	0.5	0	0	0	0
11	1.8	11	0	0	0

TABLE II. DATA TESTING FROM ELM

Actual	ELM	Error
0.4680	0.4680	0.0000
0.4680	0.4680	0.0000
0.4680	0.4680	0.0000
0.4680	0.4680	0.0000
0.4690	0.4690	0.0000
0.4690	0.4690	0.0000
0.4690	0.4690	0.0000
0.4690	0.4690	0.0000
0.4700	0.4700	0.0000
0.4700	0.4700	0.0001
0.4700	0.4700	0.0001
0.4700	0.4699	0.0002
0.4700	0.4699	0.0002
0.4710	0.4708	0.0003
0.4710	0.4708	0.0005
0.4710	0.4707	0.0007
0.4710	0.4705	0.0010
0.4710	0.4703	0.0014
0.4730	0.4721	0.0018
0.4720	0.4708	0.0024

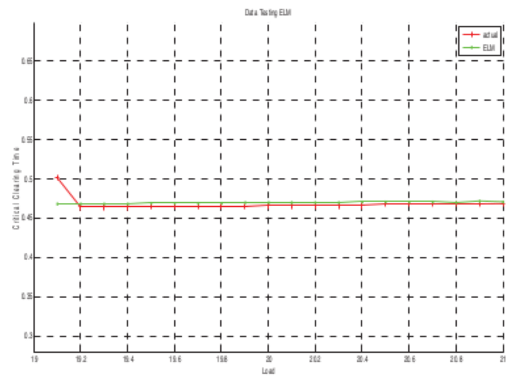

Fig. 7. Testing using ELM

VI. Conclusion

The results of the research obtained from ELM, show that this training and technique can be used with high accuracy and more accurate with the actual value of 0.4700 and the ELM value is 0.4708. ELMIS functions to listen and mentoring, so it is very appropriate to use at the decision level in the system. This shows that ELM has a small value in the output obtained from Table II testing data through some training and accuracy, it is safe that ELM is suitable for stable conditions to determine dark conditions.

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