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OPTIMIZATION THE REGULATION PARAMETERS OF A SYNCHRONOUS GENERATOR BY USING ARTIFICIAL NEURAL NETWORKS (ANN)

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ABSTRACT

Disturbances in electrical power system cause imbalances in electromechanical and mechanical torque of all machines. These imbalances result in oscillations between synchronous generators. In order to damp these oscillations, the stability analysis has been performed on a one machine system by using some regulator gain coefficients, which should eventually improve the recovery time after a system failure. The boundaries of the coefficients are initially defined and only some coefficients among all the calculated parameters are selected for test purposes. By measuring and recording the regulator terminal voltage continuously, some regulator parameters has been determined which finally help in optimizing the system stability by using Artificial Neural Networks.

Keywords:*Optimization, ANN, Power system*

1. INTRODUCTION

During the last century the demand in electrical energy has increased constantly proportional to the growing industry and world population. The major drawback of an AC power system may be defined as the difficulty in maintaining a reliable power plant, which should give fast response to a failure within the distribution system. In order to compensate the increasing demand the numbers of power utilities are also improving constantly, which lead problems such as system management and control. The stability of a power system, which can be described as the capability of a power plant in returning to its original working conditions after a power failure, is one of the major problems observed in power engineering. A system can only be stable if it has an equilibrium point among its own mechanical input and electrical output properties [1,2]. This equilibrium can diminish if it is exposed to a harming effect, such as a short circuit, spontaneous charge flow etc. As a result of this phenomenon oscillations in voltage and frequency can occur. Unfortunately the mechanical regulators of synchronous generators are not sensitive to rapid changes; hence they do not provide full control on the stability of the system under external or internal effects. Stability problems are mostly solved by using exciter and automatic regulators, which mainly control and adjust the exciting current of stator windings in synchronous generators according to

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various input signals. In this research artificial neural network methods are mainly employed in determining or estimating the optimum UOR parameters, which in fact can dramatically improve the recovery time [2,6].

2. PROCEDURE

A short circuit has occurred between Ambarlı Power Station and Ikitelli in one machine energy system (bus number: 2) whose electrical data and stability regions of regulator parameters are already known (Figure 1). The defective region has been shed from the system within 0.2 seconds. The stability of the energy system has been restored approximately in 4 seconds. By using some randomly selected parameters produced by EISA, 10 different regulator performances (Table 1) has been proposed to analyse the stability of the system [3]. The definite values of the parameters; the feed-back gain coefficient and the feed-forward time constant are initially known, although only the regions of the main time constant and the main gain coefficient are given. Artificial neural networks (ANN) are trained by using the terminal voltage values calculated by analysis results.

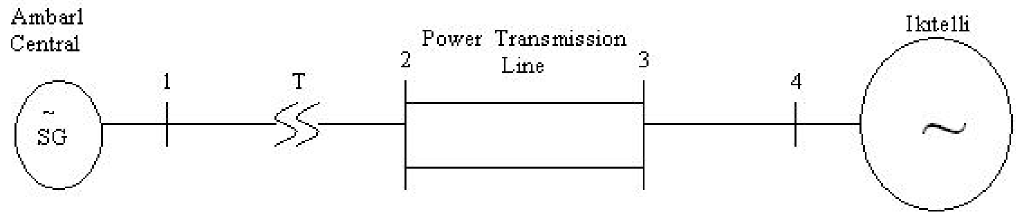

Figure1. One machine energy system chosen between Ambarli Central and Ikitelli

<u>Ambarlı Central [4]</u>

Synchronous Generator Base(güç bazı) MVA S_T=100 MVA
Synchronous Generator Rated MVA S_G=133,7 MVA
Power Factor $Cos\varphi_0$=0,95
Active Power $P_0= S_G * Cos\varphi_{0=}$127,02 MW
Reactive Power $\theta_0= S_G * Sin\varphi_{0=}$41,78 MVAR
Nominal Voltage (Rated kV)U_G=13,8 kV

Per Unit Values of Reactances $X = \frac{X_{real}}{S_T}$

Transient Reaktance X'_d=0,13838 pu
Synchronous Reantance X_d=0,9723 pu
Doğru Eksen Subtransient Reactance X''_d=0,10098
Dikey Eksen Subtransient Reactance X''_q=0,0972
Potier Reactance X_l=0,1533
T_{d0}=6,5 sn
T_y=29,968

<u>Electrical Parametres of Transformer [4]</u>

Power Base S_T=120 MVA
Voltage Ratio 13,8 kV/161 kV
Reactance X_T=0,1811 pu

Power Transmission Line [4]

Voltage U_H=154 kV
Reactance X_H=0,01264 pu

Transient Stability Limits of Regulator Parameters [4]

Gain Constant K_A=25~175
Time Constant T_A=0,2~0,05
K_F=0,108
T_F=0,35

Table 1

K_A	25	30	35	40	45	50	55	70	80	90
T_A	0,12	0,12	0,16	0,18	0,2	0,16	0,2	0,05	0,08	0,1

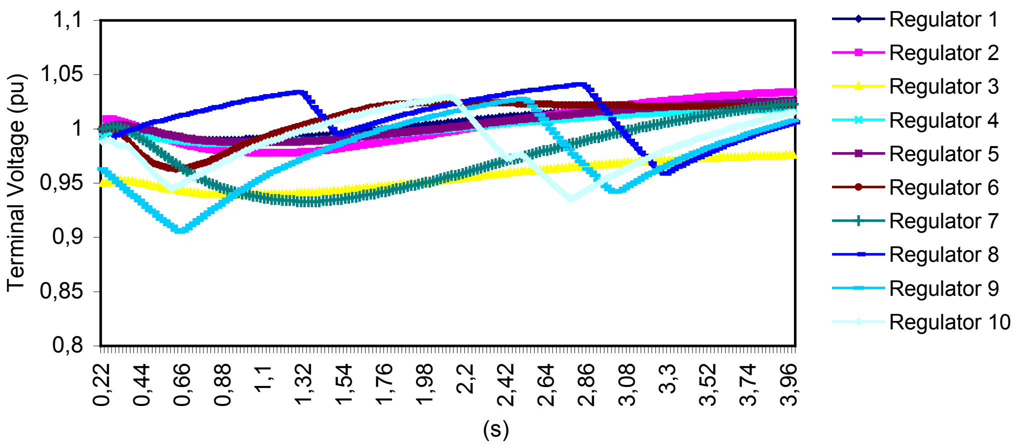

Figure 2. Transient Stability of the Power System Depends on Different Regulator Parameters

3. NEURAL NETWORKS

Artificial neural networks (ANN) which consist of simplified neurons connected to each other are models of nervous system. Although each neuron has a simple function alone, they can solve complex problems when they are used together. Artificial neural networks are adaptive systems, which have learning capabilities. ANNs adapt and organize themselves to the changing conditions, improve a function and make the calculation by learning. ANNs can produce the correct response even though missing or corrupted data is given as input values [8].

A neuron can be seen in Figure 3. x_1, x_2,….. x_n are inputs, w_1, w_2, ……., w_n are synaptic weight coefficients , t is desired output and y is output.

A neural network model can be seen in Figure 4. Each neuron has many inputs and only one output. This output is the input for the other neurons so this system is formed parallel.

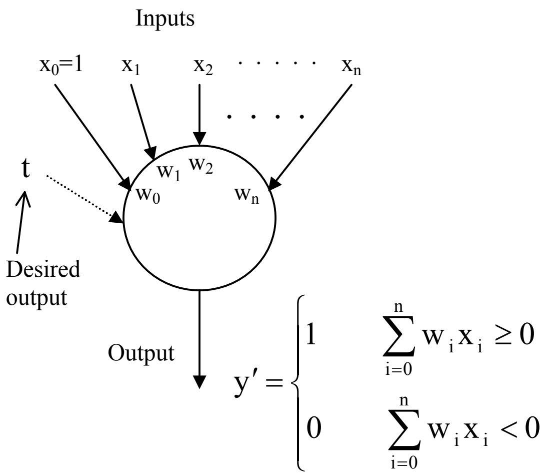

Figure 3. A Neuron Model

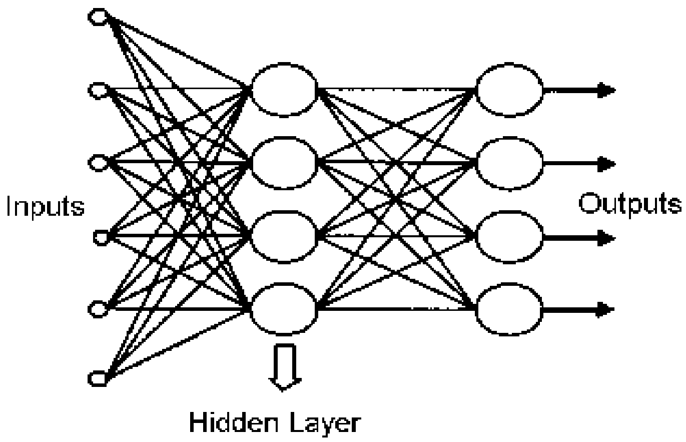

Figure 4. Artificial Neural Network Model

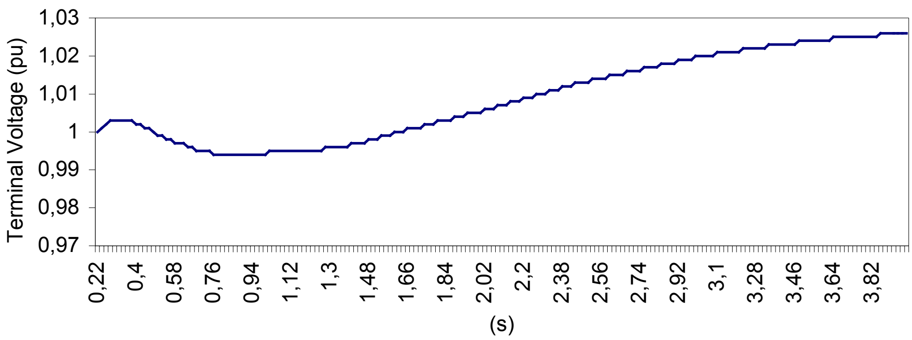

Figure 5. Transient Stability analysis for the constans K_A=42,03 and T_A=0,198

3.1. Learning with Back Propagation Algorithm

Learning in artificial neural networks is based on the calculation of the synaptic weight coefficients which are suitable for establishing an unknown nonlinear relation between the input and output parameters. In this paper back propagation algorithms used as the learning algorithm which has emerged as the most widely used and successful algorithm for the design of multiplayer feed-forward networks [8].

Initially in the learning process, an error is calculated by subtracting the output of the ANN from the desired value. After taking the square of the error, the first cycle of the training process has finished. This process repeats continiously until the calculated error remains below a predifined value.

4. CONCLUSION

The stability analysis has performed in some random selected regions among the Ambarlı power plant and Ikitelli power system. The definite values of the feed-back gain constant and feed-forward time constant are known although only the regions of main time constant and main gain coefficient are given initially. Artificial neural networks are trained by the terminal voltage values found by analysis results. The input of the algorithm is a 189x1 matrix whose entries are the desired terminal voltage of the system, 1.025 (pu), all. The optimum regulator parameters are computed by the simulation as follows:

The Result of Simulation

TT= 0,4667 0,0022

Since these are the normalised parameters, the real values are calculated as

K_A= 0,4667.90 = 42,03

T_A = 0,0022.90 = 0,198

From Figure 5, it can be seen clearly, that the calculated K_A and T_A parameters have dramatically improved and optimized the stability of the system in the convinient time interval without oscillation.

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