

Using Neural Network to Control STATCOM for Improving Transient Stability

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ABSTRACT

FACTS technology has considerable applications in power systems, such as; improving the steady state performance, damping the power system oscillations, controlling the power flow, and etc. STATCOM is one of the most important FACTS devices used in the parallel compensation, enhancing transient stability and etc. Since three phase fault is widespread in power systems, in this paper STATCOM is used to improve the transient stability of power system when three phase fault occurred. Neural Network has been used for adjusting the gain of the supplementary controller of STATCOM. The simulation performed in MATLAB / Simulink software. Simulation results showed when STATCOM combines with proposed Neural Network based supplementary controller; the transient stability of power system improves.

KEYWORDS: FACTS, STATCOM, Artificial Neural Network (ANN), Power Oscillation Damping.

1. INTRODUCTION

The Stability is main Characteristics and requirements of the dynamical systems. Common phenomenon and stability in a power network divided into two categories, namely the turbulence intensity and duration that remain in the system. The first division including: steady state, dynamic and transient stability. Steady state stability is stability of power system under very little disturbances, transient stability is stability of power system under large disturbances and dynamic stability is stability of power system under disturbance that is resolved via plant controller like voltage and frequency Controllers. In the

second division, the phenomenon of the power grid is divided according to time duration remained in the network. There are many control systems in a power system that their aim is to supply necessary power to consumers in the desired Frequency and voltage. Another role of control systems eliminates the rapid transient Fluctuations and create stability in the system when it deals with disturbances. This control system can be divided into two categories: Control systems in a plant and control systems in transmission lines. The control system of transmission lines helps to maintain the voltage, frequency level and control of amount active power and reactive power [1]. One of the technologies

that makes optimum use of lines and systems and maintains power system stability is FACTS technology. This technology was introduced in 1986 by the Institute EPRI [2]. STATCOM is one of the FACTS devices which operate in parallel with the system. STATCOM is used for voltage control by compensating an appropriate amount of reactive power in the early years but in recent years it has been considered to reduce the power grid fluctuations. This is done by using appropriate controller. Some previous studies showed that using an additional control system is an effective method to reduce fluctuations. Some of them have been used in a simple PI controller. Other researchers have used fuzzy logic for improving the performance of the controller. The fuzzy logic calculates the appropriate gain [3-4]. In this paper, to achieve greater and faster oscillation damping, the amount gain of additional controller is calculated by the neural network. With this controller, the STATCOM is able to reduce oscillations quickly when the three-phase to ground fault occurs in the system. Simulation is done in MATLAB, for three cases: I-system without STATCOM, II-system with STATCOM without additional controller, III- system with STATCOM with additional controller. Simulation results showed that the system with STATCOM with additional controller that its gain was calculated by the neural network has a faster and better damping.

2. TRANSIENT STABILITY

In a power system, transient stability is the ability of a system to maintain stability, and oscillation damping after a severe disturbance. Disturbances in power systems such as the removal of equipment, changes in load and short circuit lead

to increase the generator rotor angle. So system response is affected by the non-linear relationship between power and load angle. The relationship between power and angle in a power system can be expressed as follows:

$$P = \frac{V_s V_e}{X} \sin(\delta) \quad (1)$$

Where V_s is Terminal voltage of the transmitter, V_e Terminal voltage of the receiver, X is Line impedance, **Error! Bookmark not defined.** is angle between the voltage of the transmitter and the voltage of the receiver or load angle. According to equation (1), the curve of power-angle load is similar to Fig. 1:

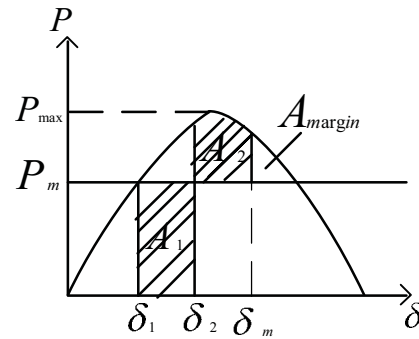


Fig.1. Power-angle load without compensator

According to this curve (fig. 1), when the fault occurs in a synchronous machine, Electromagnetic torque is suddenly reduced and the amount transferred power can be significantly reduced, while the mechanical power remains constant. So the rotor is accelerated and load angle increases from δ_1 to δ_2 . Generator absorbs energy accelerators that it is shown with the area A_1 . After eliminating the fault in point related to the angle δ_2 , transferred power increased from Mechanical power and generator begins to decrease the acceleration. In this case angle δ

increased more Due to the kinetic energy stored in the machine and it reaches to the maximum angle δ_m and established balance between Energy accelerators and energy reducing Acceleration. Energy reducing Acceleration is shown with the area A_2 . The area between the curve of power and line of Mechanical power named Transient stability margin that shown with A_{margin} [5]. Parallel compensation instruments such as STATCOM With appropriate control in the connection point can Support the voltage. The result showed increased Ability of the transfer system after the fault. Therefore it increases the transient stability. With parallel compensation Maximum power will be equal below:

$$P_{max} = \frac{2V_s V_e}{X} \quad (2)$$

Fig. 2 shows the power - angle curve in the presence a STATCOM.

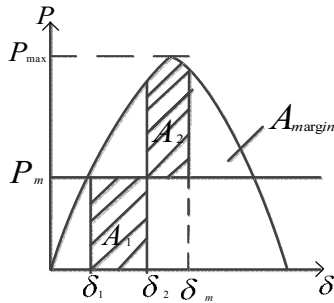


Fig.2. Curve of the power- angle

3. STATCOM

The STATCOM is based on a solid state synchronous voltage source which generates a balanced set of three sinusoidal voltages at the fundamental frequency with fast amplitude and phase angle control. The configuration of a STATCOM is shown in Fig.1. Basically it

consists of a voltage source converter (VSC), a coupling transformer and a DC capacitor. STATCOM is used for voltage support in a power system. When the voltage drop occurs in the system, it caused a rapid adjustment of the voltage at the connection point with a reactive power injection. Thus it prevents the system from instability [6].

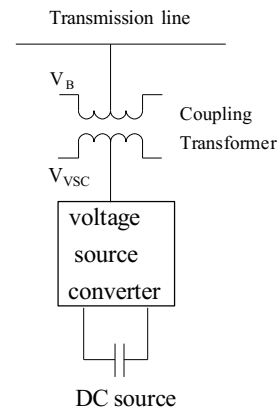


Fig.3. Structure of STATCOM

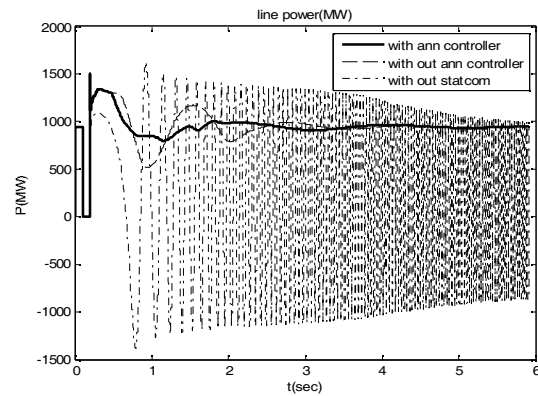
4. ARTIFICIAL NEURAL NETWORK

Nowadays with the advancement of technology and use of computer systems in Complex calculations, intelligent computer systems and artificial intelligence have a greater importance. Neural networks have been devised in accordance with the nervous system; this means that a neural network is composed of several elements called neurons. These neurons communicate with other neurons; the connections between neurons are weighted. The weight is considered as important parameters in neural network training. Generally neural networks are trained so that a particular input leads to a specific output in the output layer neural network. The multilayer PERCEPTRON network (MLP) and back propagation network

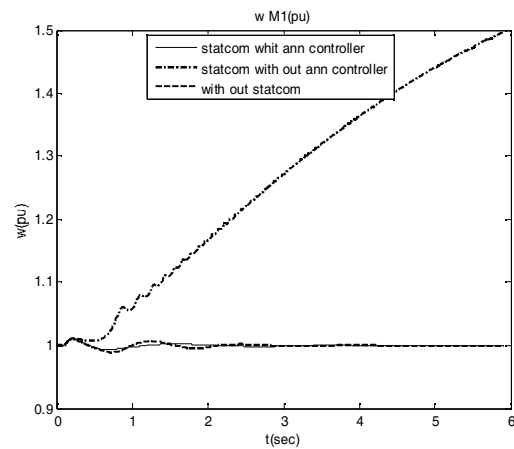
The input signal of the additional controller will be selected from error between desired and actual load angle of machine 1 (M1), also in this simulation, to adjust the weights of neural network we used the difference between the reference voltage and bus voltage of STATKAM as another input of additional controller. Neural network by adjusting the inputs calculates the desired gain for an additional controller. The controller output is added to the difference between the reference voltage and bus voltage of STATKAM input. In this way, Bus voltage of STATCOM is controlled to help damping system oscillations. In fact when the angle changes are positive, STATCOM increases voltage of connection point to grid and when the angle changes are negative, reduces it. So it causes an increase in transient stability of the system. In this paper we used three cases of simulation; case I: system without STATCOM, case II: system whit STATCOM without additional controller, case III: system whit STATCOM with additional controller. Results of system response for each control mode are shown in Fig.8. Injected Reactive power by STATCOM in tow case is shown in Fig.9. According to figures, it is clear that employing artificial neural networks to determine the gain of additional controller will increase the damping widely.

6. CONCLUSIONS

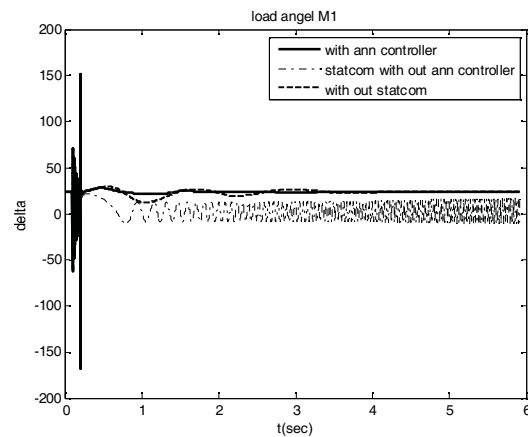
In this paper we have shown that the STATCOM has a positive effect on transient stability. Then with using an additional controller that its gain calculated with artificial neural network, we can see that ANN improved the performance of STATCOM.



(a)



(b)



(c)

Fig.8. System response: A: active power of line, B: speed deviation for generator M1, C: load angel deviation for generator M1.

Furthermore Computer simulations showed the advantage of this method to improve the STATCOM performance on transient stability of the power system.

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