APPLICATION OF ARTIFICIAL TECHNIQUE IN POWER SYSTEM STABILITY ENHANCEMENT: STATE OF ART

Sita Singh[#], Nitesh Tatwal[*],

[#]*Electrical & Electronics department, Oriental University*
Opposite Revati Range Gate no. 1, Sanwer Road, Jakhya,Indore,MP,India 453555

[*]*Electrical & Electronics department, Oriental University*
Opposite Revati Range Gate no. 1, Sanwer Road, Jakhya,Indore,MP,India 453555

[#]sitasigh200711@gmail.com

*niteshtatwal@oriental.ac.in

Abstract— **Manual calculation, technical analysis and conclusions initially adopted the power system design, operation and control. As the system grew it became more complex due to the technical advancements, variety and dynamic requirements. This special study gives a review of the Artificial Intelligence (Both Artificial Neural Network and Fuzzy systems) basic principles and the concepts, along with the application of these tools in power system areas. This paper also focuses on application of different artificial technique in power system stability improvements.**

Keywords— **Power system stability, FACTS, Neuro-Fuzzy controller, voltage stability, ANN, Fuzzy logic**

I. INTRODUCTION

HVDC power transmission system offers several advantages, one of which is rapid control of the transmitted power. Consequently, they have a considerable impact on the stability of the associated AC power systems. Moreover, HVDC link effectively uses frequency control and improves the stability of the system using fast load-flow control. The significance of AC-DC power transmission systems in the improvement of stability has been a subject to much research. An HVDC transmission link is vastly controllable. It is probable to take benefit of this unique characteristic of the HVDC link to augment the transient stability of the ac systems. In the past, numerous investigations have been carried out to improve transient stability of power system, ranging from theoretical studies to advanced control devices [1-4].

A proper design of the HVDC controls is essential to ensure satisfactory performance of overall AC/DC system [5-6]. The control strategy, traditionally employed for a two-terminal HVDC transmission system is the current margin method, where the rectifier is in current control, and the inverter is in constant extinction angle (CEA) control [4]. Both ends of the dc system rely on PI controllers to provide fast robust control. The conventional methods often require a precise mathematical model of the controlled system. Because of fixed gains (Kp, Ki, Kd) these controllers perform well over a limited operating range as for power systems in practice, there exists parameter uncertainty in plant modelling and large variations in environmental conditions. Therefore HVDC systems are prone to repetitive commutation failure when connected to a weak AC systems and also when subjected to faults and disturbances. This leads to considerable research in the field of effective control of HVDC systems using adaptive, optimal, intelligent controllers such as neural network, fuzzy logic, neuro – fuzzy controllers etc.

Artificial neural networks and fuzzy logic systems are successfully implemented for improvement of transient stability of power system [7]. The salient features of both techniques are combined to form a hybrid controller i.e. Neuro – fuzzy controller. Self-learning capability of neural network is combined with inference system of fuzzy logic to form self-organizing neuro – fuzzy controller. Thus in this paper, the feasibility of employing a neuro – fuzzy controller for an HVDC transmission system is explored.

II. RELATED WORKS

Rani et al. [11] have proposed a genetic algorithm based technique to identify the best location for fixing FACTS devices for improving the Available Transfer Capability (ATC) of power transactions between source and sink areas in the deregulated power system. Here, two types of FACTS have been simulated: Thyristor Controlled Series Compensator (TCSC) and Unified Power Flow Controller (UPFC) for improving the ATC of the interconnected power system. A Repeated Power Flow with FACTS devices including ATC has been employed to compute the best possible ATC value within real and reactive power generation limits, voltage limits, and line thermal limits. Venkaiah et al. [12] have proposed a Static Security based ATC computation for real-time applications by means of three artificial intelligent techniques: Back Propagation Algorithm (BPA), Radial Basis Function (RBF) Neural Network, and Adaptive Neuro Fuzzy Inference System (ANFIS). These three diverse intelligent techniques have been tested on IEEE 24-bus Reliability Test System (RTS) and 75-bus Practical System for the base case and critical line outage cases for various transactions.

Umapathy et al. [13] have presented an application of probabilistic distribution based interval arithmetic approach to compute the ATC in a power network in terms of confidence intervals. The interval arithmetic approach allows integration of the uncertainty in the input parameters and offers strict bounds for the solution. Here, the deviation of the real power load has been represented as a Gaussian distribution function. Moreover, the proposed technique has been tested and validated on IEEE 14 bus test system.

An application of complex valued neural network for ATC calculations with and without contingencies have been introduced by Chary et al.. Here, a 9 bus test system has been used to evaluate the performance. The objective function is to increase the load on certain source and sink nodes. Also, the voltage limits of the buses and the line losses have been well considered in this proposed technique.

A unified optimization approach has been proposed by Jayashree et al. For computing Available Transfer Capability (ATC) and performing Congestion Management (CM) in a deregulated power system handling both pool and bilateral transactions. Here, a power injection model has been employed for Unified Power Flow Controller (UPFC), DC load flow model for power network, and repeated linear programming method for optimization. DC model impose the line operating limits in MW. A computer package has been developed and the efficacy of the proposed unified technique has been validated on 4 bus and an IEEE 30 bus systems.

III. Power System Voltage Stability

At any instant of time, operating condition of a power system should be stable, satisfying various operational criteria, and it must also be secure in the occurrence of any credible contingency. Present day power systems are being operated closer to their stability limits due to economic and environmental constraints. Maintaining a stable and secure operation of a power system is therefore a very important and challenging issue. Voltage instability has been given much attention by power system researchers and planners in recent years, and has emerged as one of the major sources of power system insecurity. Voltage instability phenomena are the ones in which the receiving end voltage decreases well below its normal value and does not come back even after setting restoring mechanisms such as VAR compensators, or continues to oscillate for lack of damping against the disturbances. Voltage collapse is the process by which the voltage falls to a low, unacceptable value as a result of an avalanche of events accompanying voltage instability [1].

A. Tools for voltage stability analysis

Different methods exist in the literature for carrying out a steady state voltage stability analysis. The conventional methods can be broadly classified into the following types.

1. P-V curve method.

2. V-Q curve method and reactive power reserve.

3. Methods based on singularity of power flow Jacobian matrix at the point of voltage collapse.

4. Continuation power flow method.

IV. APPLICATION OF ARTIFICIAL NEURAL NETWORKS IN POWER SYSTEMS

The ANNs can play a richly significant potential role in electric power systems. As a branch of Artificial Intelligence, ANNs take exploratory one step further. They can match stored examples for a new one, forming an understanding to provide better answers.

On the field of AI, ANN computing shows great potential in solving difficult data interpreting tasks. Load forecasting is perhaps the most important SCADA task and also one of the most popular areas for ANN implementation. The accessibility of historical load data on the utility databases makes this area highly suitable for ANN implementation. ANN schemes using perception networks and self-organizing feature maps have been successful in short-term as well as long-term load forecasting with impressive accuracy. ANN’s has recently invaded fault diagnosis, which has been a long-established region for ES (expert system) implementation. Though, at present the implementation of ES outnumbers the ANN implementations. The descriptive behaviour of ESs and their more powerful user interface make them a better choice. However, still there are some areas, which necessitate a fast response, and are still used for ANN implementation.

A. Voltage Stability Assessment

ANNs have been recently proposed as an alternative method for solving certain traditional problems in power systems where conventional techniques have not achieved the desired speed, accuracy and efficiency. L index has been popularly used for assessing voltage stability margin. Investigations are being carried out on the impact of information encompassed in input vector and target output vector, on the learning time and test performance of Multi Layer Perceptron (MLP) based ANN model.

In the ANN model for each loading condition various combination of control variables are generated by running many iterations of LP based reactive power optimization algorithm. Settings of control variable influences the ANN input feature vectors differently. Only active power injection of slack bus and reactive power injection of all generator buses vary in input vectors of ANN2 for a given loading condition while variation in input vectors of ANN-1 is observed in most of the critical line flows.

V. APPLICATI0N OF FUZZY LOGIC IN THE POWER SYSTEM

The most active area of the fuzzy system research in the power systems has been stability assessment and enhancement. The stable performances of the synchronous machines under all anticipated conditions of system transients are essential for ensuring overall system stability.

Application of the fuzzy set theory in transient stability evaluation was first reported by Soulfis et al [SMP 89]. The system operating states, classified as belonging to one of the six possible states were represented using the fuzzy membership values in fuzzy Pattern recognition (PR) systems. The developed method is applicable for any power system irrespective of its size, configuration or loading condition [AV 89]. An application of Fuzzy set theory for design of stabilizer to improve the dynamic performance of a multimachine power system was first proposed by Hsu and Cheng [HC 90]. This stabilizer used a fuzzy relation matrix to produce the output based on the fuzzy inputs, speed deviation and acceleration. Only local measurements from each machine were used for this stabilizer, resulting in a simple design. Hassan et al reported another successful application of a fuzzy logic stabilizer for improving the stability of synchronous machines. [MOG 91]. The practical implementation and experimental results of this stabilizer using a digital signal processor were reported in [HM 93].

A. Voltage Stability Enhancement

Fuzzy Control Approach has been effectively presented in the Voltage Stability Enhancement too. The concept is as the same in reactive power planning and control which leads to better voltage profile. G.K.Purushothama, N Udupa and D. Thukaram et al [PuUTPa] presented a new technique using fuzzy set theory for reactive power control with the purpose of improving the voltage stability of the power system. Here the voltage stability index (L index) n and the controlling variables are translated into fuzzy set of notations to formulate the relation between voltage stability level and controlling ability of controlling devices. Then a fuzzy ruled-based system is formed to select the controllers, their movement direction and the step size. The performance obtained from testing the above fuzzy controlled system was found to be encouraging. First the L index is computed for the system. This is found, from the load flow algorithm incorporating the load characteristic and the generator control characteristics. The load flow result is obtained for a given system operating characteristics or from the online state estimator. Then the L index sensitivity is computed.

VI. CONCLUSION

The concepts of the AI techniques are reviewed to understand those categories of models, which are used in Power Systems, and the future hybrid models that are useful. It gives the understanding of the strengths of the models. ANNs are mainly used for learning and pattern Recognition for depicting the reference knowledge database. It helps to analyse and gives the result, which can be substituted for any logical analysis.

As in the case of Fuzzy Logic applications it can be seen that these techniques can be blended with the conventional systems as well as with the other techniques like Neural Networks and Genetic Algorithms. The 8hybrid systems thus formed can be the most powerful systems for design, planning and control & Operation of practical problems.

REFERENCES

[1] Jing Zhang,J.Y. Wen, S.J. Cheng, and Jia Ma , “ A Novel SVC Allocation Method for Power System Voltage Stability Enhancement by Normal Forms of Diffeomorphism,” IEEE Trans . on power System, Vol.22,No.4,pp119-1825,Nov.2007.

[2] C.R.Fuerte-Esquivel and E.Acha, and H.Ambriz- Perez , “ A Thyristor Controlled Series Compensator Model for the Power Flow Solution of Practical Power Network,” IEEE Trans. Power system, Vol.15,No.1,pp 58-64, Feb-2000.

[3] M.A.Abdel Moamen, P.P.Narayana , “ Newton- Raphson TCSC Model for the Power flow Solution Of Practical Power Networks,” IEEE Power Engineering Society Summer Meeting, Vol.3,pp 1488-1493,2002.

[4] M.Saravanam, etal, “Application of PSO Technique for optimal Location of FACTS Devices
Considering System Loadability and Cost of Installation,” Power Engineering conference, Vol.2
pp.716-721 29 Nov-2Dec.2005.

[5] Y.Mansour et al. “ SVC Placement Using Critical Modes of Voltage Instability,” IEEE Trans. On power System, Vol.9,no.2, pp.757-763, May 1994.

[6] J.Kennedy and R Eberhart, “ Particle Swarm optimization,” proc. IEEE Int. Conf.Neural
Networks, Vol 4 , pp 1942-1948, 1995.

[7] Park, K. Lee, Shin, and K. Y. Lee, "A Particle Swarm Optimization for Economic Dispatch with Non smooth Cost Function," IEEE Trans. on Power Systems, Vol. 20, No.1, pp. 34-42, Feb. 2005.

[8] Kundur, Paserba, V. Ajjarapu, G. Andersson, A. Bose, C.A. Canizares, N. Hatziarg Y fiou, D. Hill, A. Stankovic, C. Taylor, T. Van Cutsem, and V. Vittal, "Definition and Classification of Power Systeln Stability," IEEE Trans. On Power Systems, Vol. 19,No.2, pp.1387-1401, May 2004.

[9] A.K. Sharma, "Optimal Number and Location of TCSC and Loadability Enhancement in Deregulated Electricity Markets Using MINLP," International Journal of Emerging Electric Power Systems, Vol. 5, Issue 1, Article 6, 2006.

[10] H Yoshida, Y. Fukuyama, "A Particle Swarm Optimization for Reactive Power and Voltage
Control Considering Voltage Security Assessment," IEEE Trans. On Power Systems, Vol. 15,No.4, pp.1232 -1239, Nov. 2001.