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Review on Implementation of Various Soft computing Techniques for Tuning Conventional PI Controllers in an HVDC Transmission System

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ABSTRACT

The converter control has a major role to play in avoiding large variations of the DC link current and voltage to attain a reasonable performance of the HVDC system. Conventionally, the controllers used for rectifier and inverter pole current control and inverter extinction angle control are PI controller with fixed gains and can operate well over a narrow range. Many researchers have reported, the HVDC system based on the fixed gain PI controllers cause instability under various abnormal conditions. The problems due to conventional PI controllers for converter controls are inadequate to tune its gain for different operating conditions. To overcome this drawback intelligent technique have been introduced such as fuzzy, neural network, adaptive neuro fuzzy, improved particle swarm optimization, etc., for proper tuning of the controller parameters. In this paper, the literature on the implementation of various soft computing techniques for tuning conventional PI controllers in an HVDC transmission system are presented.
Keywords : HVDC transmission system, Converter control, PI controllers, Tuning, Fault Recovery and Soft computing techniques

I. INTRODUCTION

In an HVDC transmission system, after the occurrence of a fault, the current and voltage values stray away from their reasonable range. Under such conditions generally PI controllers are not enough to maintain current and voltage at the nominal steady state value. Several PI controllers are offered in literature since years. They may be either based on one soft computing technique or a hybrid combination of one or more soft computing techniques.

II. TUNING OF CONVENTIONAL PI CONTROLLERS USING SOFT COMPUTING TECHNIQUES

A brief survey of those controllers available in the literature is reviewed in the subsequent few paragraphs. Lefebvre et al. [1] offered the system requirements depended advantages of adaptive tuning of current regulators in an HVDC converter system. Estimation and controls are done at different bandwidths to improve robustness of the controller.

Reeve et al. [2][3] in his paper made an effort to improve the performance of the system under large interruptions by incorporating gain scheduling adaptive control into the fast regulator loops in the control of back-to-back DC transmission systems. DC current error signal, DC voltage error signal, AC voltage zero crossings and firing angle at the rectifier are the various scheduling variables chosen depending upon the response of the system.

Albostan et al. [4] proposed an adaptive optimal control strategy for monopolar HVDC transmission systems embedded in an AC system. Real-time measurements achieved with the AC/DC system are used for control using the nonlinear power system dynamic equations. The effectiveness of the optimal control algorithm in damping the electromechanical oscillations is illustrated with the use of a nine bus AC/DC system. Pandey et al. [5] presented the modelling of self-tuning controllers for a monopolar HVDC transmission system using a multi-rate sampling based novel discrete-time converter model. In a monopolar HVDC transmission system has been adapted to show the effectiveness of the control strategies proposed which include the modelling of the minimum variance controller. In order to evaluate the routine of self-tuning controllers, digital simulation has been used.

Routray et al. [6] have hosted a tuning method of the controller parameters for the rectifier DC current regulator and the inverter extinction angle controller of an HVDC transmission system with fuzzy logic. In order to obtain the optimal system performance during numerous fault conditions, the controller gains are decided using fuzzy logic. A comparative analysis was carried out to prove the advantages of the proposed scheme.

Sarve et al. in their paper made a fuzzy-PD controller [7] proposal for control of HVDC transmission system. The control system of HVDC with fuzzy controllers in small faults and variations with tiny amplitude, are similar to traditional control, but on large faults and variation with high amplitude, the routines are better when compared to conventional control.

Dash et al. [8] have introduced a practical control strategy for an HVDC transmission system based upon the principle of feedback linearization. A neural estimation algorithm has been used to track the linearized control parameters which are functions of rectifier side DC voltage, inverter side DC voltage, DC link reactance and equivalent resistance. The DC link was subjected to various transient conditions to prove the performance of the controller.

Multani et al. [9] presented a PI controller tuning technique based on the combination of four-layer neural network-fuzzy logic. With the aid of neural network-fuzzy logic-based PI controllers the transient performance of the HVDC transmission system controller gets improved.

Kumar et al. [10] presented a novel HVDC link in service with weak AC system, which is controlled using fuzzy logic. The system can feed a weak or very weak network under variations of the input power. With the aid of the fuzzy logic PI control of the system optimizes the efficiency of the link under several disturbances.

Kela meah et al. [11] presented a new control scheme for multi-terminal HVDC transmission systems to improve the performance during the system transients known as parallel multi-proportional integral control scheme. The performance evaluation was achieved with the help of four-terminal HVDC transmission system based on CIGRE benchmark model. The performances of the MTDC system with conventional and fuzzy logic-based PI controllers were evaluated.

Narendra Bawane et al. [12] in their paper projected computationally simple and precise HVDC transmission system control using adaptive neuro-fuzzy inference system (ANFIS). In addition, an integrated fault identifier proposed for effective and complete bridge converter.

Dash et al. [13] presented PI controller tuning method for an HVDC transmission system which is an energy function based fuzzy tuning method and verified the approach with point-to-point DC link by subjecting it to various small and large disturbances. The advantage of the adaptive fuzzy controller over the conventional fixed gain controllers is validated with the aid of computer simulations.

Sun et al. [14] detailed the commutation failure, which is a very frequent dynamic event in HVDC inverters, can deteriorate the accessibility of HVDC links and thus influence the performance of the power system and added that most commutation failures were originated by voltage reduction due to AC system faults. Additionally, an effort was made to lower the effect of commutation failure on the power system, and the solution was implemented in a fuzzy controller.

Najafi et al. designed [15] new robust nonlinear fuzzy controller for the control loops of HVDC transmission systems. For testing, a new simplified nonlinear dynamic model was developed for HVDC transmission systems that could be used. An evaluation was performed by simulation using the CIGRE benchmark HVDC model.

Nagu Bhookya et al. [16] analyzed the transient stability of multi-machine system with HVDC link by an effective neuro-fuzzy controller (NFC) to improve the fuzzy rules are used as neurons in artificial neural network (ANN) model. To illustrate the performance of NFC, transient stability analysis is carried out in a multi-machine system and results are compared with conventional controller as well as fuzzy logic controller. Mobarak et al. [17] proposed fuzzy logic controls with genetic algorithms to get an optimized and supplementary control signal to the HVDC transmission system. The employment of genetic algorithms in establishing an optimal PI-fuzzy logic controller of an HVDC transmission system is tested through digital simulation.

Treesatayapun et al. [18] conferred controller architecture for HVDC based on an adaptive network named fuzzified input perceptron (FIP). A novel FIP with simple structure is proposed with the professional knowledge to make the initial setting of FIP's parameters. Srujana et al. [19] [20] proposed two hybrid techniques to self-tune the PI controllers used in HVDC transmission systems with the combination of fuzzy-neural network and genetic algorithm-neural network. The performance of the system has been evaluated through Matlab based two terminal HVDC transmission system. Also, the superiority of the proposed approach was confirmed by comparing them with the conventional and fuzzy self-tuning techniques.

Wang et al. [21] briefly reviewed the genetic algorithm and the genetic algorithm optimized PID controller design methodology in order to improve the dynamic performance of parallel AC-DC systems. Results from simulation showed that the PID controller designed by the proposed scheme could satisfy the requirements of stability and dynamic response performance of HVDC transmission system.

Xiaofa Zhou et al. [22] presented an improved particle swarm optimization algorithm and employed it to design the optimal PI controllers in HVDC transmission system. In order to evaluate the potential of the proposal, simulation examples were implemented on the CIGRE HVDC benchmark and the results of the standard particle swarm optimization algorithm and the stable boundary law method were also given as contrasted.

Zhong xian wang et al. [23] proposed auto-tuning method for PI fuzzy logic controller inputs and outputs based on genetic algorithm optimization and applied it to the controller design of two-terminal HVDC transmission systems. The design method depends on automatically choosing the values of the gain factors associated with the input and output variables of the PI-fuzzy logic controller, while the structure of the fuzzy logic controller itself was fixed. Simulation results demonstrated the efficiency of the proposed technique, compared to the traditional methods of designing controllers.

III.CONCLUSION

In this paper, the literature on implementation of various intelligent techniques for tuning PI controllers in an HVDC transmission system were presented, which covers major developments in this field from early research to most recent. From the literature review, it is clear that, there is a vital role for proper tuning of conventional PI controllers in an HVDC transmission system.

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