CHAPTER-II

LITERATURE SURVEY
2.0. LITERATURE SURVEY

A very long time is required to regain HVDC systems stability after the occurrence of a fault. In a HVDC system, as soon as a fault takes place, the current and voltage values stray away from their feasible range. Under such conditions generally PI controllers are used to sustain current and voltage at the normal steady state value. Several PI controllers are offered in literature since years. A short survey of those controllers from the available literature is reviewed in the subsequent few paragraphs.

S. Lefebvre [1] presented the advantages of adaptive tuning of current regulators in a HVDC converter system depending upon the system requirements. It is shown that the converter SCR or the net commutation resistance offered by the converter is the major parameter which effects tuning. A basic HVDC system is linearised around an operating point and the controller takes care that Eigen values and zeros of the system are maintained at predefined locations for every set of variation of system parameters. Estimation of this parameter variation is done by subjecting the system to a small noise signal. Estimation and controls are done at different bandwidths to improve robustness of the controller.
John Reeve [2] in his paper tried to incorporate gain scheduling adaptive control into the fast regulator loops in the control of dc transmission systems to improve the performance of the system under large interruptions, low Effective Short Circuit Ratio’s and faults that lower the operating SCR of the system further. 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 under large ac disturbances. These variables are presumed for every case to enhance the stability of the system under large interruptions based on the result given by the contingency indicators.

John Reeve [3] amalgamated the theoretical aspect of auto tuning with gain scheduling. Two points are basically addressed. 1) whether auto tuning provides sufficient advantages over fixed gains i.e. conventional controller gain scheduling or the combination of two controls can be applied to increase the robustness of the two controllers for large disturbances. It was shown that for particular applications involving continuous or contingent low short circuit ratio, auto tuning alone may not be reliable in response to certain disturbances. It has to be combined with gain scheduling.

P.K. Dash et al [4] introduced a practical control strategy for a HVDC system based upon the principle of feedback linearization. A neural estimation algorithm has been used to track the linearised control parameters which are functions of rectifier side dc voltage,
inverter side dc voltage, dc link reactance and equivalent resistance. The dc link is subject to various transient conditions to prove the performance of the controller. A better error tracking law can still improvise the working of the controller for dynamic stability.

A. Routary et al [5] replaced the rectifier side current regulator with a fuzzy self tuning controller. The controller gain which takes care of \( K_p \) and \( K_i \), proportional plus integral controller constants is adjusted through fuzzy interface. The linearised values of current error and its derivative are the two inputs used to generate the ordered value of firing angle for the rectifier end. On a similar lines ordered value of extinction angle at the inverter end is generated and the performance of the system is observed under transient conditions and proved the superiority of self tuning the PI controller parameters using Fuzzy logic.

Chi-Hshing Lin [6] has debated the distinctness between two frequently occurring faults in an HVDC link. He made a comparison between the misfire fault in the rectifier valve and inverter valve. A dynamic simulation results found out the difference between the two resultant phenomena. A misfire fault in the rectifier valve generates a significant torsional torque in a turbine generator adjoining the inverter station whenever the natural torsional modes are interrupted by the power variation, which in turn affects the rectifier side system frequency. On the contrary, a misfire fault in an inverter valve tries to cause commutation failure in converters, resulting in HVDC link
failure. This, immediately affects the rectifier and inverter sides of the generator.

Vinod Kumar [7] have presented a HVDC transmission system, which operates with speed and accuracy in a weak ac system. They carried out an analysis of the control strategy and working of this system, which has been controlled by employing fuzzy logic. The system showed the capability of feeding an ac system whose inverter side SCR value was very low even under large oscillatory margin of ac power. The performance of the HVDC link was validated and optimized by employing an FLC. Their implementation will guide a specific user to design his own model for a basic HVDC system build. A DQ-type of phase-locked-loop has been developed to generate firing pulses in synchronization with harmonic free supply voltage signal. The HVDC system employing a fuzzy logic based control system operated steadily and recovered very soon from short circuit faults, and it’s obvious merits have been proved from PSCAD/EMTDC based simulations.

Mohammed Kathir [8] have made an attempt to investigate the effect of short circuit ratio which is an indication of AC system strength on commutation failures in the converter acting as an inverter in a basic HVDC transmission system. Also an attempt was made to find out the role played by the DC controls to restore the system from different ac faults and their intensities. The results proved that SCR at the inverter and the severity of fault both effect the process of commutation. The part played by VDCL control on DC link
from fault recovery was very significant. A single phase-to-ground fault has been imposed on the model for analysis.

In the above paragraphs literature available on the conventional strategies adopted to improve the system performance under pre-fault and post fault conditions is presented and the drawbacks of the controllers is briefly discussed. PI controller parameters variation has an imperative role to play in perpetuating current and voltage of a HVDC system within steady state limits. Hence, in this thesis an attempt has been made to self tune the PI controllers parameters by an hybrid technique. The controller variables are self tuned by utilizing a hybrid methodology which is a blend of fuzzy logic and neural networks.

Controlling and operating the HVDC system is still an unsolved task, because of the complexities associated with maintaining the system stability whenever a fault takes place. This can be overcome by utilizing proper techniques to self tune the controllers. Therefore, effective control of the HVDC system is dependent upon efficiency of the self tuning mechanism employed by the controllers. So as a second alternative, a hybrid technique is employed to for automatic variation of the PI controller parameters. The technique is a blend of the two renowned Artificial Intelligence techniques, Artificial Neural Network and Genetic Algorithm.

Mohammed Kathir [9]. have utilized the concept of power synchronization for the control of grid connected voltage-source
converters (VSCs). This method has been expected to have more significant for VSC-HVDC when the inverter of the system has a very low SCR. The implemented procedure utilised the principle of internal synchronization operation in ac systems. By employing this type of power-synchronization control, the loss of stability due to a conventional phase-locked loop in an ac-system with low SCR connection has been prevented by the VSC. Furthermore, a VSC terminal has proved its efficiency in strengthening the voltage support to an ac system of low SCR similar to any synchronous machine. By analytical models and time simulations the control method has been proved.

Pooling operation of power systems posed severe problems particularly when dictated to exchange large chunk of power over wide spread areas. Disturbances were transmitted from one system to the other whenever fault occurred in any part of the interconnection. Power oscillations are aggravated deteriorating the systems stability resulting in abnormal increase of fault current and a huge reduction in the amount of power that is exchanged. To overcome these troubles a DC link coupled with an ac line was sought as an alternative interconnecting two areas. With that the power utilities were capable to fulfill the requirement of quality power to consumers but on the contrary operational and control phenomenon are still subjected to review. Various system based control strategies are available in literature as explained in the below lines.
Lidong Zhang[10]. have made a thorough analysis about the impact of variations of various system variables on the dynamic performance of an asynchronous power system connected via parallel ac/dc transmission lines. A model of the two area load frequency control system connected through a ac/dc link is designed by applying full state vector feedback control. Investigations carried on the asynchronous tie revealed that the dynamic response of the system was effected much because of the variation in system parameters like speed regulation, synchronization coefficient, reheat constant and integral of area control error. Frequency bias and the variations of remaining parameters could not impair the dynamic response much. Both areas were put to a load change of 1% alternately.

Zidi Sid AHMED [11]. have implemented a control technique to carry out steady-state and transient analysis of an asynchronous VSC based back-to-back HVDC link with a step by step variation of the active and reactive powers, balanced and unbalanced faults. Fast and satisfactory dynamic responses have been provided by the proposed control strategy for all the cases. It controls the through power flow and supplies reactive power in addition to providing independent dynamic voltage control at its two terminals. The reactive power supply capacity of terminals can be doubled by parallel interconnection of the two converters. Transmission lines or cables designed for higher voltage can be used to form point-to-point or
multi-terminal transmission links. Additional network advantages have been provided by increasing hierarchy in the control levels.

Hazra [12] proposed three HVDC link power modulation techniques for the improvement of transient stability in interconnected power systems. AC variables such as rotor speeds, voltage phasors, and tie-line power flows are applied as input to the controller that customises the power transfer settings through the HVDC-links. The proposed techniques are tested on the IEEE 24-Bus RTS and critical clearing times obtained for several contingencies are analyzed and showed that HVDC modulation can lead to substantial improvement in transient stability.

A number of control approaches available in literature are all system based and no sooner they will become obsolete. Therefore an attempt is made to implement a graphical-based novel control strategy for the stabilisation of an interconnected system. By considering pre-developed contingency data, a computational system for power transfer with the inclusion of HVDC links is developed. From the so developed model, a control model is developed by incorporating the variables such as rotor speeds, voltage phasors and tie-line power flows. These ac variables are segregated as control parameters and the strategy is to compute the optimal control parameters by applying Genetic Algorithm. The best power transfer settings can be found out from the calculated control parameters. These power flow settings lead us to improvise upon the transient stability as well as the power
transfer capacity of the system. Assessment of the proposed methodology is investigated by adding two HVDC links with the IEEE 24-Bus reliability test system. The results have proved that there is an improvement in the power transfer capacity of the system.

2.1 CONCLUSIONS:

This chapter summarizes the results of various investigations carried out to improve the performance of different HVDC control approaches during faults along with the drawbacks of the implemented methodologies. Different modes of ac interconnection and the merits and demerits of control strategies adopted which are available in literature so far are discussed in brief. Available Literature has shown a transition from adaptive controls to intelligent controls. So in this dissertation, hybrid controllers which utilized different artificial Intelligence techniques are implemented. So, the next chapter focuses on the application of intelligent control methods to HVDC systems.