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ANNbased SVM Based HVDC Light Transmission System

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ABSTRACT:

Currently, converter control is one of the major fields of present day research works in the area of HVDC Light transmission systems. In this paper, ANN and fuzzy logic controllers are utilized for controlling both the converters of the HVDC Light transmission systems. The space vector pulse width modulation (SVPWM) concept is also used for better DC bus utilization and harmonic reduction. The proposed controller changes the PI gains automatically for different operating conditions. The performance of the proposed controller is compared and validated with the fixed gain conventional PI controller. The simulations are carried out in the MATLAB/SIMULINK environment. The results reveal that the ANN controller is reducing power fluctuations at both the converters. It also improves the dynamic performance of the test power system markedly when tested for different ac fault conditions.

Introduction:

High-Voltage direct current (HVDC) transmission is an economic way for long distance power delivery and/or interconnection of asynchronous systems with different frequency [1]. With the development of modern power system, HVDC system plays much more important role in power grids due to their huge capacity and capability of long distance transmission. Towards 2015, there will be 7 HVDC transmission systems constructed in the China South PowerGrids (the CSGs) [2]. Conventional HVDC transmission system is based on line-commutated thyristor rectifier [3]. With the advent of high-voltage and high power gate-turn-off thyristor (GTO), insulated-gate controlled transistor (IGBT) and more recently, insulated-gate controlled thyristor (IGCT), high power solid-state switches have symmetrical turn-on and turn-off capabilities. They have given the birth to a new generation of HVDC stations, HVDC Light, which is also called as voltage-source-converter (VSC) HVDC [4]. Unlike conventional HVDC scheme that employs line commutated current source converters with thyristors, HVDC Light is a new technology utilizing forced-commutated voltage source converters [5].

HVDC light can control both active and reactive power independently without commutation failures in the inverter side. It doesn't require reactive power compensators resulting much smaller equipment size. HVDC light can be applied to the voltage support in the receiver systems [6], interconnection between asynchronous power systems [7], grid connection of large wind farm [8] or offshore wind farm [9] and subsea power transmission [10]. So far, there are 12 HVDC Light projects for different purposes already in operations world wide. HVDC systems are responding and can be controlled within tens of milli-seconds. HVDC systems can also improve the stability, especially transient stability of power system [11]. The appearance of the HVDC Light, which has more advantages than conventional HVDC systems, can bring a new approach for the AC/DC hybrid transmission systems and multi-infeed HVDC transmission system. If the receiver system is weak, voltage stability and commutation failure may

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become serious problems in conventinal HVDC system [12]. By pulse wide modulation (PWM) control, HVDC Light realizes independent control of active and reactive power control, and dose not need reactive compensation in both rectifier and inverter side.

HVDC converter stations

An HVDC converter station is normally built up of one or two 12-pulse converters as described above, depending on the system being mono- or bipolar. In some cases each pole of a bipolar system consists of two converters in series to increase the voltage and power rating of the transmission. It is not common to connect converters directly in parallel in one pole. The poles are normally as independent as possible to improve the reliability of the system, and each pole is equipped with a DC reactor and DC filters. Additionally the converter station consists of some jointly used equipment.

This can be the connection to the earth electrode, which normally is situated

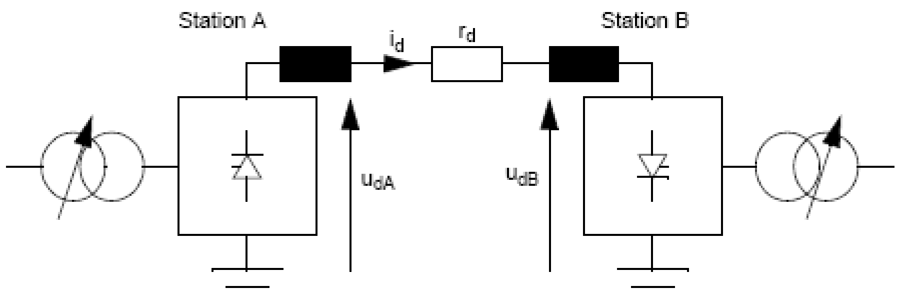

Figure 1: 12-Pulse HVDC Transmission System

In this case, converters are controlled through SVPWM scheme, where the modulation ratio m=sqrt(3)Vref / Vdc and 0> m >1. SVPWM is a new concept for power system applications, and is based on the space vector representation of the voltages on the two phase coordinates. The overall control structure of both the converter stations is identical and controlled parameters are:

• Active power (P) and Reactive power (Q) in station 1.

• DC voltage (Vdc) and Reactive power (Q) in station 2.

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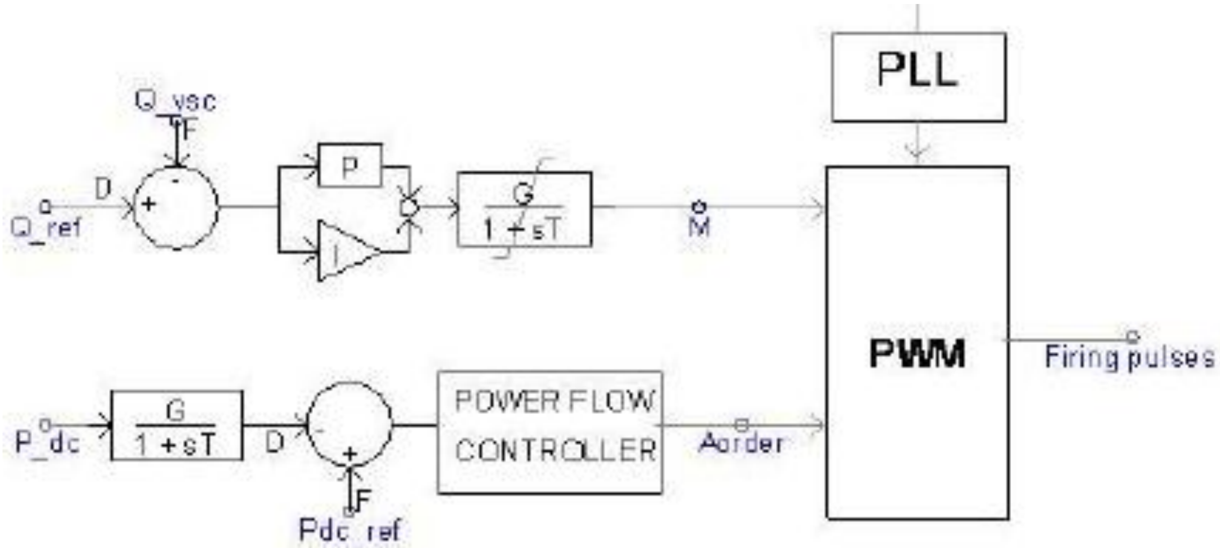

Figure 2: HVDC Control Diagram for Rectifier Converter System

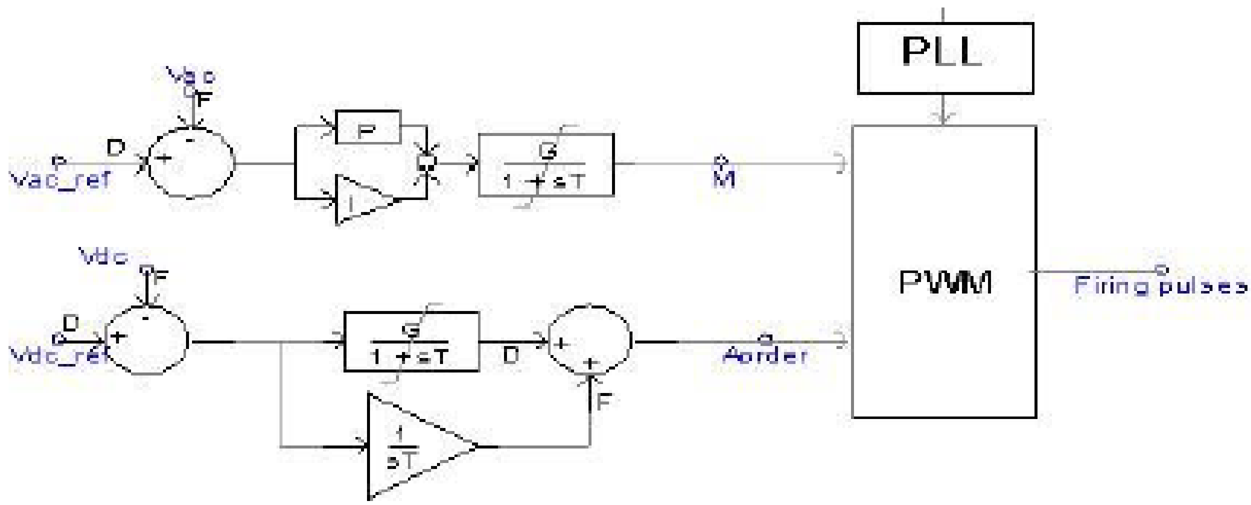

Figure 3: HVDC Control Diagram for Inverter Converter System

In PQ control mode, the function of the converter is to regulate active and reactive powers as required. Similarly, in DC voltage and reactive power control mode the converter will maintain the DC voltage as constant and also keep the desired reactive power.

Artificial Neural Networks

Figure 4 shows the basic architecture of artificial neural network, in which a hidden layer is indicated by circle, an adaptive node is represented by square. In this structure hidden layers are presented in between input and output layer, these nodes are functioning as membership functions and the rules obtained based on the if-then statements is eliminated. For simplicity, we considering the examined ANN have two inputs and one output. In this network, each neuron and each element of the input vector p are connected with weight matrix W.

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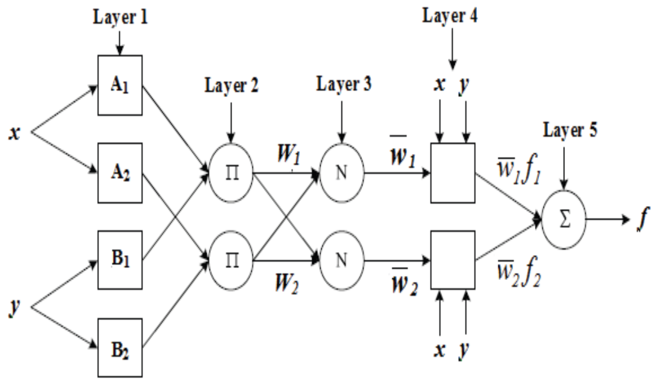

Figure 4: ANN architecture for a two-input multi-layer network

Where the two crisp inputs are x and y, the linguistic variables associated with the node function are Ai and Bi. The system has a total of five layers are shown in Figure 5.

Simulation Diagram and Results:

In this paper, conventional PI, fuzzy logic and ANN controlledSVPWM based HVDC Light transmission systems weresimulated for single phase to ground fault, three phase shortcircuit fault and the results were shown in Figure6. Here,the limiting values of the gains for all the controllers are thesame as in the conventional PI controlled system. Thedynamic performance of the test system has been studied fordifferent perturbations on an inverter AC bus.

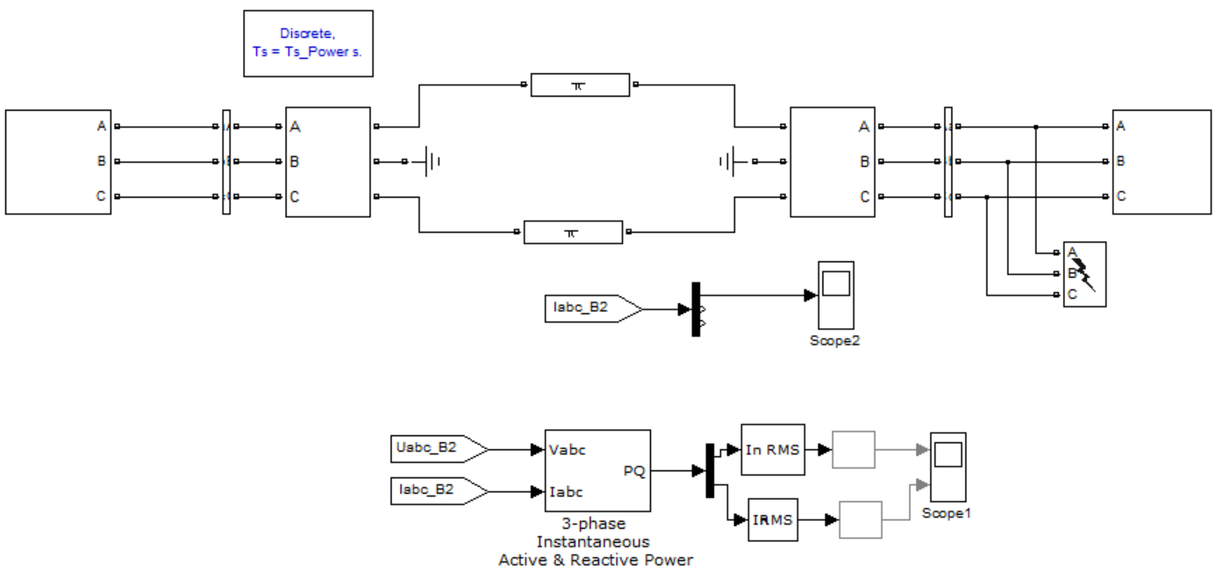

Figure 5: Simulation Diagram for Proposed HVDC System

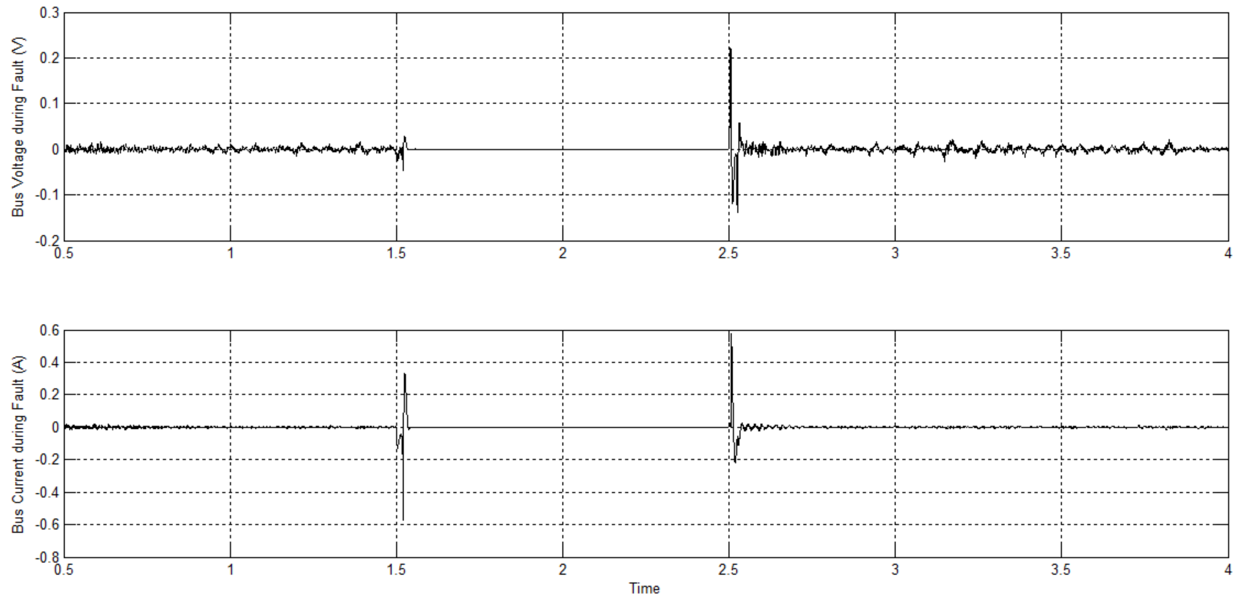

Figure 6: Simulation result for Grid Voltage and Current during Fault Condition with PI Controller

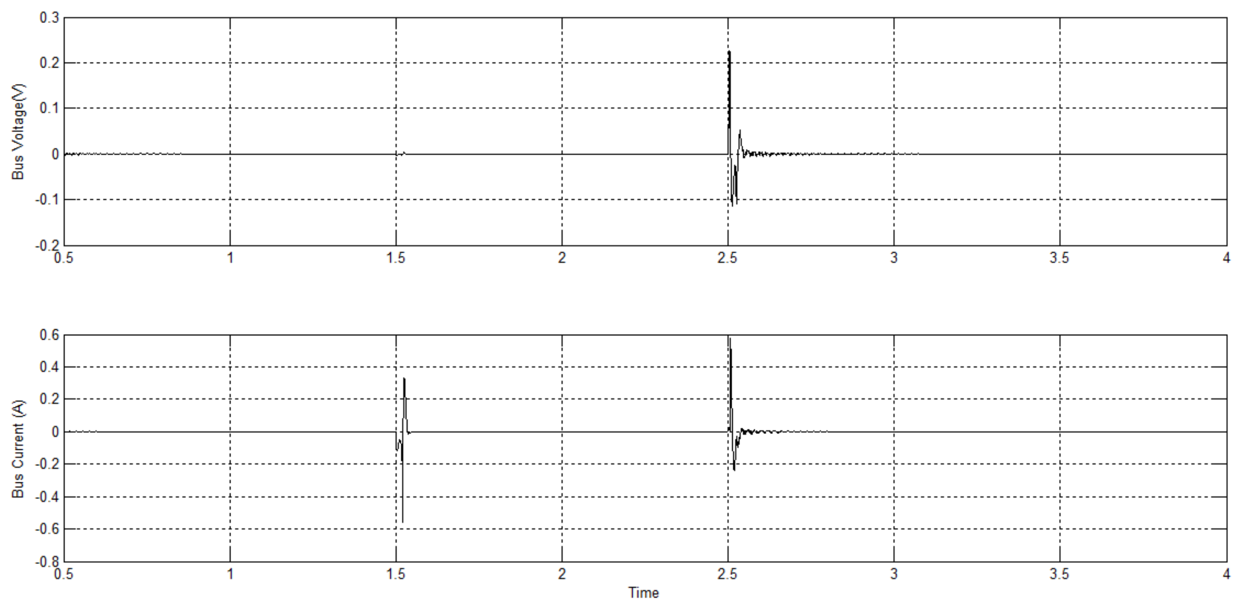

Figure 7: Simulation result for Grid Voltage and Current during Fault Condition with ANN Controller

Conclusion:

The stability improvement of two AC systems connectedthrough a SVPWM based vector controlled HVDC Lighttransmission system using an intelligent controller has beendiscussed in this paper. AnANN logic controller has beendesigned to improve the dynamic performance of the studiedsystem and simulation study has been carried out to comparethe effectiveness of the proposed controller. It is clear from thesimulation results that, the dynamic

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performance of the testpower system is better for the ANN logic controllercompared to the conventional PI controller for the AC faults atthe inverter end.

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