ABSTRACT

The Flexible AC Transmission System (FACTS) technology is used because of easy power flow control and also it increases maximum power transfer capability. FACTS controllers are also used to control the interrelated parameters such as series impedance, shunt impedance, current, voltage, phase angle and oscillations. Recent advances in the power electronic static switches have made the use of the Voltage Source Converter (VSC) feasible at both the transmission and distribution levels. As a result, Static Compensator (STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC) have been developed.

There is a lack of clear comparison of performance of different controllers for STATCOM in dSPACE environment, which is a real time simulation software and has lot of advantages over other simulation software. This research aims at covering this gap, by introducing intelligent controllers such as fuzzy, ANNC and ANFIS controllers for STATCOM which is connected to the transmission line. From these controllers, the best controller has been suggested when STATCOM is subjected to different loading conditions.

The STATCOM, is a VSC based shunt connected device, which does not employ capacitor or reactor banks to produce reactive power as the Static

VAR compensator (SVC) does, but instead uses a capacitor to maintain a constant DC voltage for the inverter operation. The control objectives of the STATCOM are to provide in-dependent reactive power support and to maintain constant DC capacitor voltage.

This is best accomplished by regulating the Pulse Width Modulation (PWM) switching commands to alter the modulation index and phase angle. One easy implemented control is PWM control. In this control, the input signals are compared against reference value of V_{dc} and are used to compute the error signals in 'K' and 'α'. A PI-based control is then used to produce the control signals.

The modelling of STATCOM is done by connecting a three phase source and RL load through a transmission line. The power flow in the system without STATCOM is first studied. The AC voltage at source is maintained at 110V (1.p.u) and the frequency is 50Hz. In order to get the sine wave output at the inverter end, a sine triangular PWM output is given to the Insulated Gate Bipolar Transistor's (IGBT) gates. The load real and reactive power are varied and the real and reactive power flow in the bus are observed.

The state space equation of the STATCOM is obtained with the help of its equivalent circuit. By defining a proper synchronous reference frame, the dynamic model of STATCOM can be simplified. The reference frame coordinate is defined in which the d-axis is always coincident with the instantaneous system voltage vector and the q-axis is in quadrature with it. Different controllers such as PI, fuzzy and Artificial Neural Network Controller (ANNC) are used in this state space modelling of STATCOM.

A STATCOM control scheme is implemented in a Digital Signal Processor (DSP) controller board and is tested on a ±1kVA, 75V laboratory setup. In the real time environment, the control law is designed in simulink and executed using the DSP Advanced Controller Engineering (dSPACE) DS1104 DSP board. Once the controller is built in simulink block-set, machine codes are achieved that runs on the DS1104'TMS320F240 DSP processor. While the experiment is running, the dSPACE DS1104 provides a mechanism that allows the user to change controller parameter online.

The real time performance analysis of STATCOM with PI controller is done by giving a load disturbance. The load current is changed from 0.5A to 1.1A and again the load current is brought back to 0.5A. The reference V_{pcc} is of 70V. In order to control V_{pcc}, its value is received in the dSPACE environment through one ADC. The command to change the phase angle 'α' so as to change the V_{pcc} is given to the polling interrupt pins of the dedicated DSP TMS320F2407 through DAC from the dSPACE. A fuzzy controller for STATCOM is designed in dSPACE environment. For the Sugeno type fuzzy controller, seven set of rules are used for the inputs error and change in error.

A two layer feed forward neural network is constructed with two neurons in the input layer and one neuron in the output layer in order to find the STATCOM's performance using ANNC. As the inputs to the controller are the error and the change in error, two neurons are used as input layer. A supervised back propagation neural network-training algorithm is used with a fixed error goal. The network is trained for an error goal of 0.0005. The output from the ANNC is used to vary the phase angle 'α'

In order to find the performance of STATCOM using Adaptive Neuro Fuzzy Inference System (ANFIS) controller, training patterns for ANFIS are extracted from the conventional PI controller. The inputs, Error (E), Change in Error (CE) and the outputs of PI controller are normalized to one and are taken as training and testing data for the ANFIS controller. The error (E), change in error (CE) and outputs (OP) are taken at every 0.1ms. To take testing data, the Error (E1), Change in Error (CE1) and Output (OP1) are taken at every 0.3ms. In the input side, 5 membership functions are used with triangular membership function and Sugeno type fuzzy inference is used. The comparison is made based on the control system parameters such as peak overshoot, steady state error and settling time.