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A Review on Power Quality Improvement by Artificial Neural Network Using Dstatcom in Industry

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Abstract: *We know the concepts of reactive power & its problem's in power system of ship. There is some conventional method used to solve this problem but this method has constraints, different type of FACTS controller & various controls technique are also used. To over-come this problem a new adaptive control technique based on (Artificial Immune System) AIS for a DSTATCOM in an Industry power system is introduce in this paper. DSTATCOM is a shunt compensator which improves the power quality during pulse load launching. An control technique of DSTATCOM plays a most important role. This paper present control strategy was made more advance by replacing the PI controller with ANN (Artificial Neural Networks) so that the response time of the system become faster then that of PI controller.*

Keywords: DSTATCOM, Artificial Neural Network, VSC

I. INTRODUCTION

All electrical navy ship consist integrated network power system, which consist of propulsion loads, pulse loads (like aircraft launcher, rail gun, missile launcher etc.), different sensors, some emergency load etc. All loads are constant load except pulse load. Pulse load is load which affects the power system of ship. It is short time load which consume high amount of energy for very small time. It is very difficult to survive in battle condition, so to improve the survivability battle conditions of ship, a static compensator namely DSTATCOM (distribution static compensator) are used to improve or say to reduced the impact of fluctuation in power system and keep it at desire level. It is VSI (voltage source inverter) based shunt device. It improve the power system of ship by canceling a poor power factor, suppress the harmonic content in load side current (load current) regulate the voltage etc. It also compensates the reactive power. It inject the current in system during fluctuation and store energy during over current. It inject the current in system very effectively with the help of some power electronic device. An control technique of DSTATCOM plays a most important role. PI based controller are conventionally used in DSTATCOM. It is very difficult task to tuned PI controller with non-linear system. To over-come such difficulty a CI (Computational Technique) are used. An application of CI technique in design of control strategy for DSTATCOM is explain in this paper. PI controller is replaced by Neural Network with back propagation. CI technique require some prior knowledge of the system behavior & its is an offline technique, but an ANN has a potential of online system identification & control it. Quick changes in the system are identified and react on it without having any prior knowledge. It is inspired by theoretical immunology and observed immune functions. The performance of the designed measure method will be tested trough a simulation platform designed in Matlab/Simulink through the analysis of some practical cases.

II. DSTATCOM AND ITS CONTROL STRUCTURE

Two AC sources namely (V_{bus}, V_{vsc}) have a same frequency are together by link inductor X_L in synchronous link shown in (Fig.1), active power flows from the leading bus to the lagging one and reactive power flows from the source with higher voltage magnitude to the one with lower voltage magnitude. If exchange of reactive power is zero means the output voltage is equal to the AC system voltage. The real and reactive power transfer between the system and

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STATCOM are given by following equations

$$S = 3\frac{V_{vsc}V_{bus}}{X_L}\sin\delta - f3\left(\frac{V_{vsc}V_{bus}}{X_L}\cos\delta - \frac{V^2{}_{bus}}{X_L}\right)$$

$$P = \frac{V_{bus}V_{vsc}}{X_L}\sin\delta$$

$$S = 3\frac{V_{vsc}V_{bus}}{X_L}\cos\delta - \frac{V^2{}_{bus}}{X_L}$$

where 'δ' is the angle difference between system bus voltage and STATCOM output voltage. The complex power developed in the STATCOM controller to support the load voltage is given as

$$S_{sh} = V_{bus}\,\dot{i}^{*}$$

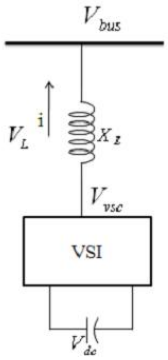

Figure 1: Static Synchronous Compensator

The terminal voltage Vbus is equal to the sum of inverter voltage Vbus and the voltage across the coupling transformer reactance VL in both capacitive and inductive modes. The transition capacitive to inductive mode occurs by changing the angle δ from zero to a positive value. The active power is transferred from DC capacitor to AC terminals and causes the DC link voltage to drop. The transition from inductive to capacitive mode occurs by changing the angle from zero to negative value. The active power is transferred from the AC terminals to DC capacitor and causes the DC link voltage to rise.

A mathematical model of STATCOM has to be developed so that control systems can be designed. The development of mathematical model is based on the following assumptions:

1. All switches are ideal
2. The AC source voltages to which inverter is connected are balanced;
3. The total losses in each phase can be represented by a lumped resistor, R;
4. The harmonic content caused by switching action can be neglected;
5. The capacitor voltages are equal; and
6. As the capacitances are equal capacitor currents are equal.

2.1 Control Approaches for STATCOM

STATCOM performance is based on accurately and quickly compensated error signals. For this various control methods are used to improved STATCOM performance. Some direct & indirect method like PI, fuzzy-logic controllers etc are used. But conventional controller like PI controller requires precise linear mathematical models, which is difficult to develop and fails to perform satisfactorily under parameter variations nonlinearity load disturbance. So in recent year effort has been taken to develop new, unconventional control techniques which will replace conventional

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control techniques. In this technique functional relationship between the inputs and outputs of an intelligent controller is directly specified from training set.

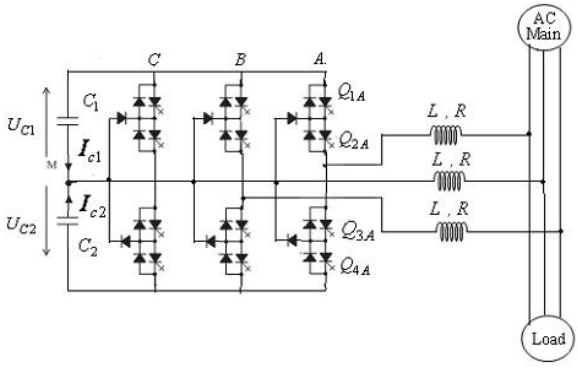

Figure 2: Three-Level NPC STATCOM

An Artificial neural networks is based on this directly specified technique. It is a computational model or mathematical model which is inspired by structure and functional aspects of biological neural network. It consist a group of artificial neurons & it changes its structure based on internal or external information which flows in network. Modern neural networks are non-linear statistical data modeling tools.

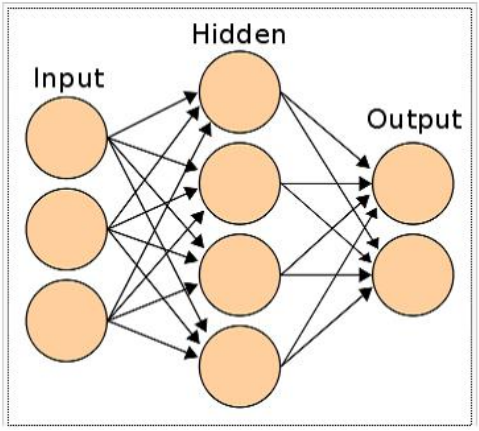

Figure 3: Artificial Neuron

It is divided or consist of three layers namely Input, Hidden & Output layers. Input layers of ANN sense the changes in system and compute it, if there is any change it generate an output signal. It resembles the brain in two respects;

1. Knowledge is acquired by the network from its environment through a learning process.
2. Interneuron connection strengths, known as synaptic weights, are used to store the acquired knowledge.

ANN is a basically;

1. Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.
2. Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
3. Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.

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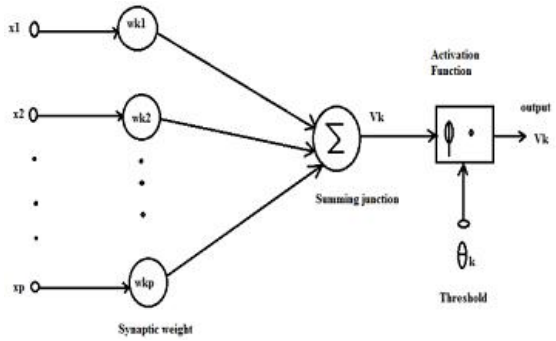

Figure 4: Mathematical model of an ANN

$$v_k = \sum_{j=1}^{p} w_{kj} * x_j$$

Output yk is given as

$$y_k = \varphi(v_k + \theta_k)$$

Artificial neuron is characterized by

1. Network architecture
2. Training or learning(determining weight on the connections)
3. Activation function

2.2 Design of Neural Network

Using back propagation algorithm, in each training set, the weights are modified to reduce MSE (mean squared error) between the networks prediction & actual target value. These modification are made in the reverse direction, from the output layer, through each hidden layer down to the first hidden layer, till the terminating condition is reached. The steps in the algorithm are:

- Initialize the weights
- Propagate the inputs forward
- Back propagate the error
- Terminating condition

III. SIMULATION MODEL

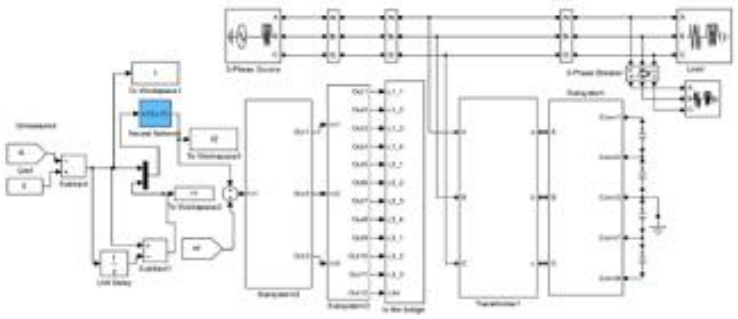

Figure 4: Matlab model of an ANN

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IV. PERFORMANCE ANALYSIS

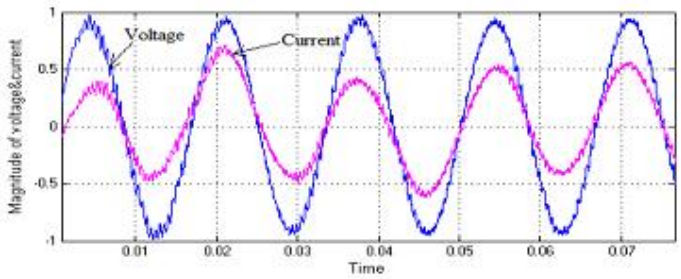

Figure 5: Phase Current and Voltage waveform when the STATCOM is ON

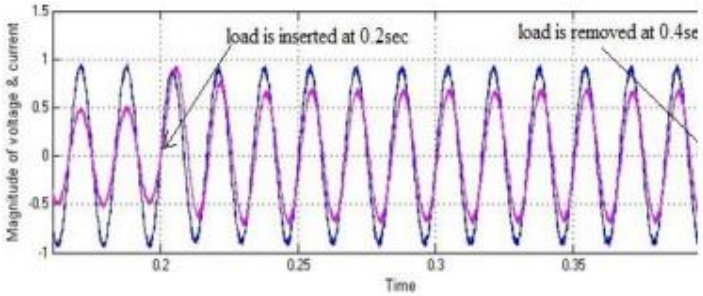

Figure 6: Phase Current and Voltage waveform when Load is Varied in the system

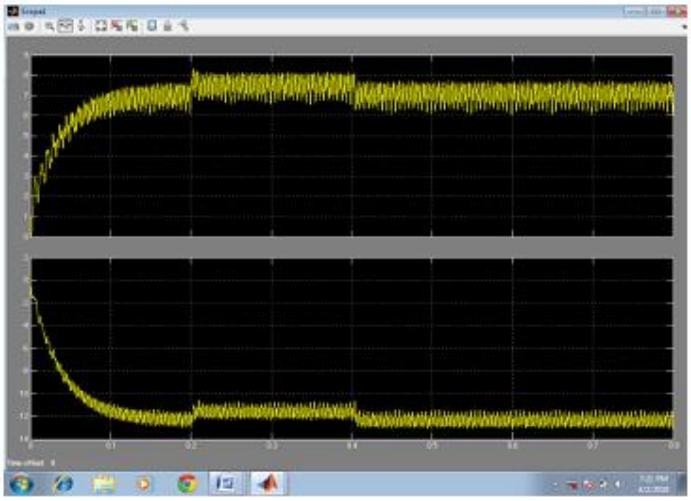

Figure 7: Active & Reactive power of compensated system

Using ANN Initially when the STATCOM is on (fig 6.5) it take around 0.02sec to bring voltage and current in phase ie. Unity power factor. So we can conclude that the response time of STATCOM used in this system is around approx 0.02sec to 0.04 sec i.e (20 milliseconds to 40 milliseconds)

V. CONCLUSION

In this paper control strategy for DSTATCOM based on ANN is represented. Innate immunity to common disturbances is achieved using a controller whose optimal parameters are determined by particle swarm optimization algorithm. For unknown, random and severe disturbances, adaptive immunity is developed based on immune feedback principles. The performance of the proposed controller is validated through both MATLAB and real-time implementations. The results show that the voltage regulation at the point of common coupling is much better with a properly tuned DSTATCOM.

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