MODELING AND SIMULATION OF A NEURAL NETWORK BASED GENERALIZED INTERLINE POWER FLOW CONTROLLER

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ABSTRACT:

A Generalized Interline Power Flow Controller (GIPFC) is an emerging FACTS based controller that provides better stability, better controllability and enhanced power flow between the interconnected transmission lines by exchanging the real and reactive power flow between interconnected transmission lines. To maintain the desired power flow in all the transmission lines of the interconnected system, a shunt converter and a number of series converters are used. A neural network controller is used to control the shunt converter and a number of series converters to maintain the desired power flow in the interconnected transmission lines. The system was simulated using MATLAB/Simulink.

Keywords: Interline Power Flow Controller, FACTS, Neural Network controller.

INTRODUCTION:

A Generalized Interline Power Flow Controller (GIPFC) consists of one shunt and number of series connected converters fed from a common dc link capacitor providing shunt and series compensation respectively. With this scheme the net power difference at the dc terminal is supplied or absorbed by the shunt converter, and ultimately exchanged with the ac system at the shunt bus. This arrangement can be economically attractive because the shunt converter has to be rated only for the maximum real power difference anticipated for the whole system.

In this paper, a neural network controller for controlling the shunt and number of series converters of the GIPFC is proposed.

1. INTRODUCTION TO GIPFC:

The concept of GIPFC used for a 3 bus interconnected system is shown in Fig.1. The V_s bus is the sending end port 1. The V_{R1} and V_{R2} are receiving end ports 2 and 3. There are three converters, one is a shunt converter and the other two are series converters. The loads are connected to the ports 1 and 3 respectively.

A control strategy for the generalized IPFC, modeling it using MATLAB/*Simulink* is developed. The control strategy is used to analyze the series voltage injection and shunt current injection for generalized IPFC control of interconnected transmission systems. In a GIPFC control strategy, steady state objectives (i.e. real and reactive power flows) are readily achieved by setting the references of the controllers.

To simplify the design procedure we carry out the design for the series and shunt branches separately. In each case, a simple equivalent circuit represents the external system. The design is validated when the various subsystems are integrated.

The design tasks are:
I. Series injected voltage control
1. Power flow control by using series voltage injection in the respective load lines.
2. The voltage control in the respective ports by using series voltage injection.

II.Shunt converter voltage control
1. Closed loop current (real and reactive) control by shunt current injection.
2. Voltage control in the respective port by using reactive current injection.
3. DC side capacitor voltage regulation using active current injection.

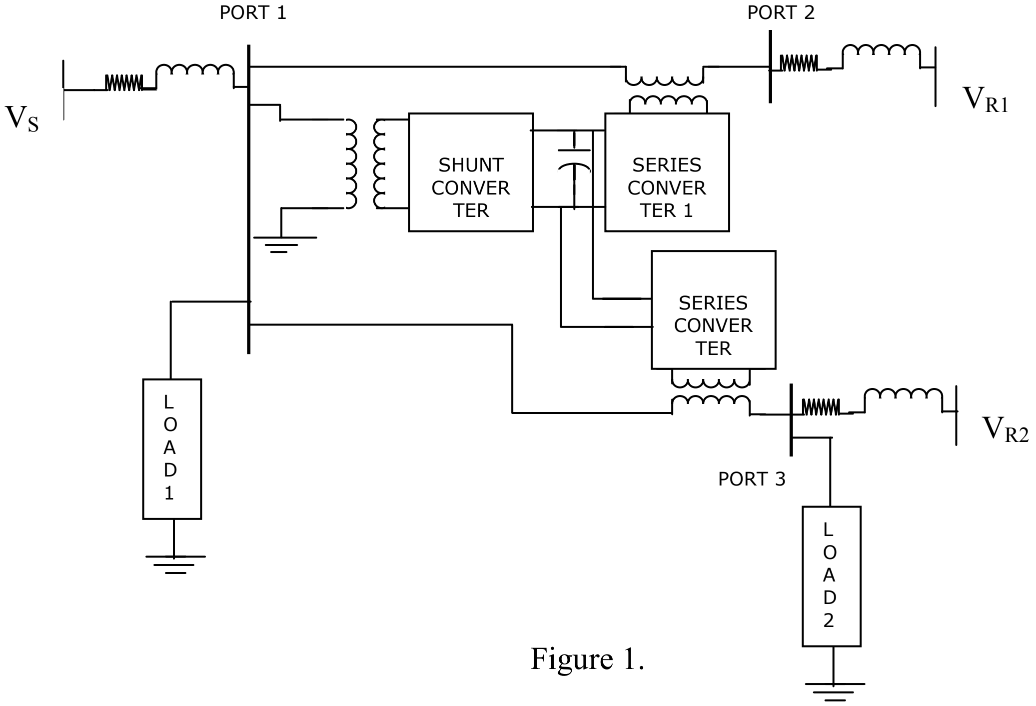


Figure 1.

2. MODELING OF GENERALIZED INTERLINE POWER FLOW CONTROLLER:

The two transmission lines, the loads at ports 1 and 3, the shunt and series converters are modeled as separate blocks in MATLAB/Simulink using the mathematical model describing each block. Vector representation of the three phase variables (d-q reference frame) is used while modeling. A Neural Network controller does the control of the shunt and series converters, which draws necessary shunt currents from port 1 and injects series voltages in ports 2, 3 in order to maintain the desired load powers.

3.NEURAL NETWORK CONTROLLER:

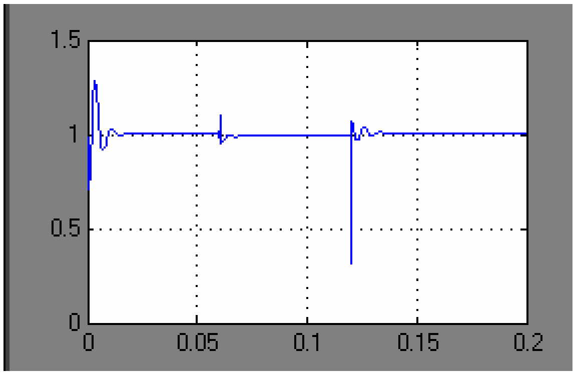
The neural controller needs a model of the plant being controlled, but because the power system is a nonlinear and nonstationary process, a continually variable model is needed. The “plant” indicates the generators, its controllers, the transmission lines, the converters with DC link and the load. The plant is first controlled using PI controllers. The required port 1 voltage and the capacitor voltage set the real and reactive current reference for the shunt converter. The required real power flow and the required voltage at the respective ports set the real and reactive current reference for the series converters.

The network structure consists of four layers. The input layer consists of six neurons, which are the above said reference values for the converters and the two intermediate hidden layers consists of five neurons each. The output layer consists of six neurons, which are the respective real and reactive current references for the three converters. The training values are obtained from the system controlled by PI controller. The system is trained and tested. Supervised learning algorithm is used and the network used is a feed forward back propagation network. The matlab provides with the number of training functions, but the one used is 'trainlm' function. The transfer functions used for the layers of neural network are 'logsig' and 'purelin'. The coding is written in 'm file' of matlab and a model of the neural network is obtained using the code 'gensim'. The obtained neural network model is used in the system to control a shunt converter and a number of series converters.

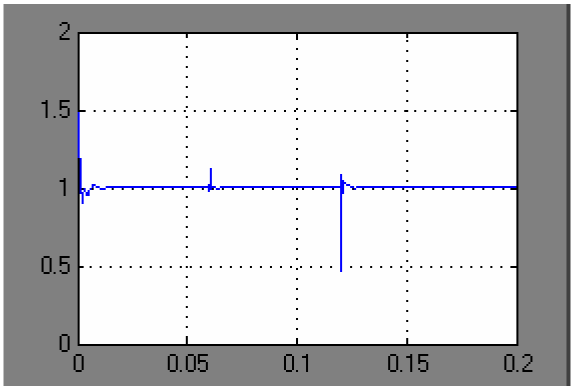
4. RESULTS OBTAINED FROM MATLAB SIMULINK:

$V_s = 1\angle 0$, with load 1 set at 2 p.u and load 2 set at 1.5 p.u , both with lagging power factors 0.8. The load 1 is ON at 0.06 sec and load 2 is ON at 0.12 sec. The port 2 draws a power of 3p.u

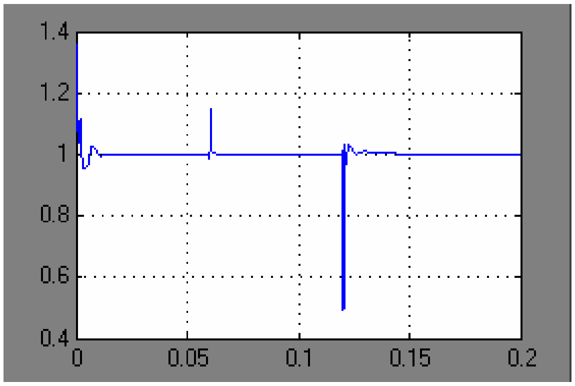
The rms value of port 1 voltage:



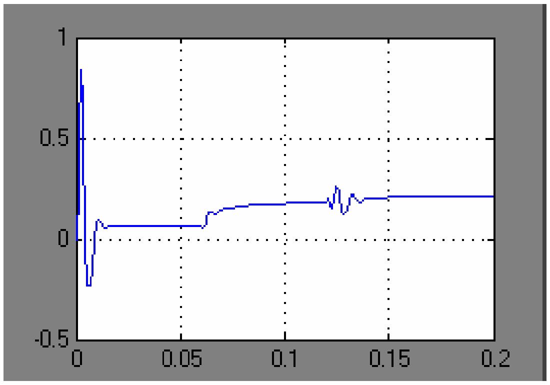
The rms value of port 2 voltage:



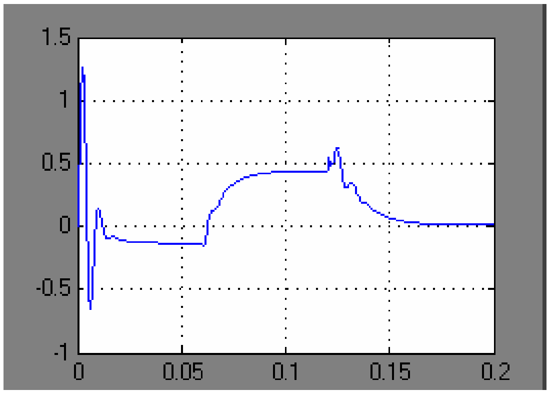
The rms value of port 3 voltage:



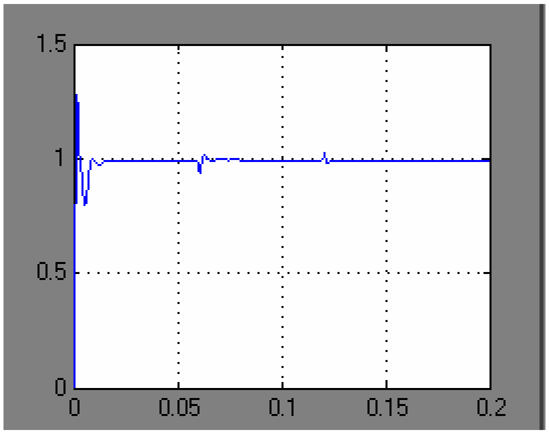
The d- axis shunt current:



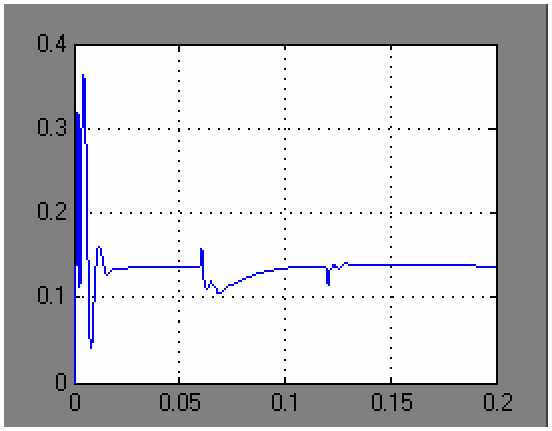
The q-axis shunt current:



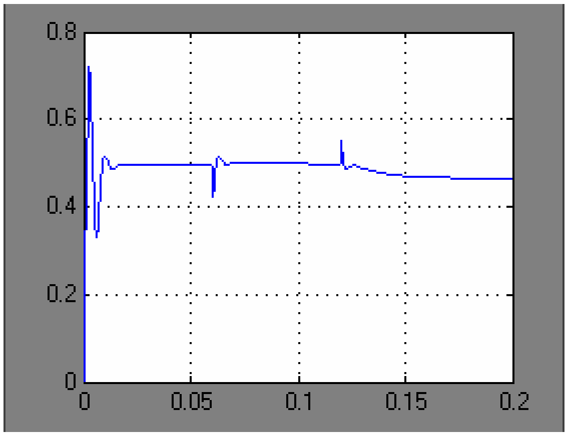
The d-axis series injected current at port 2:



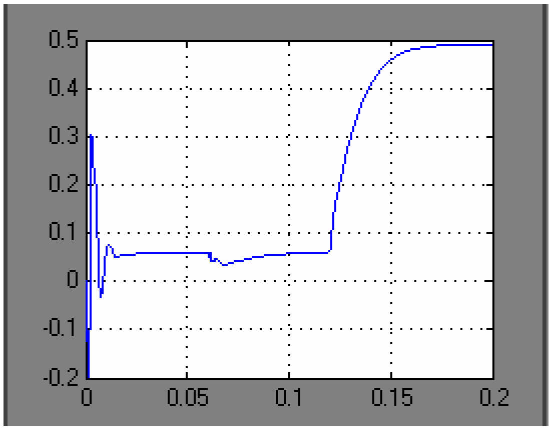
The q-axis series injected current at port 2:



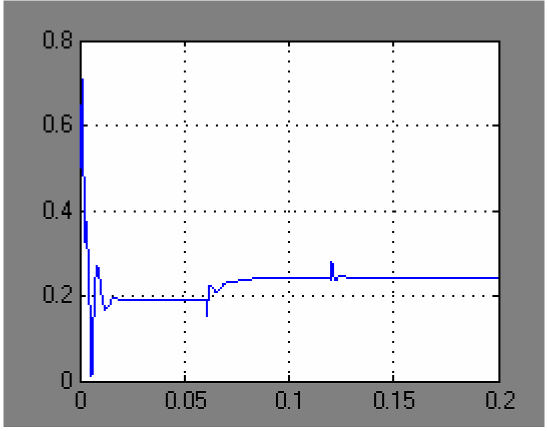
The d-axis series injected current at port 3:



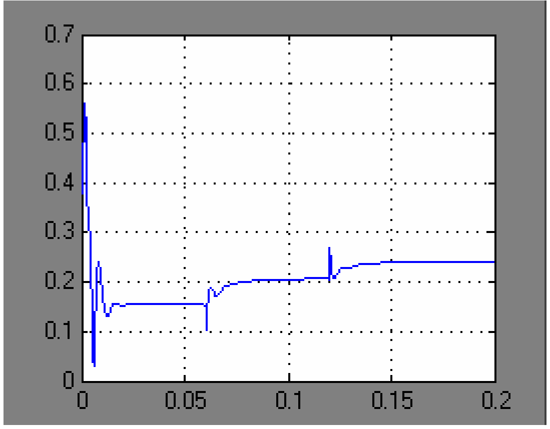
The q-axis series injected current at port 3:



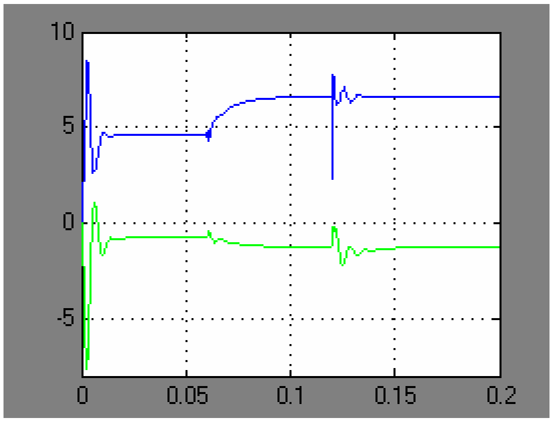
The rms value of series injected voltage at port 2:



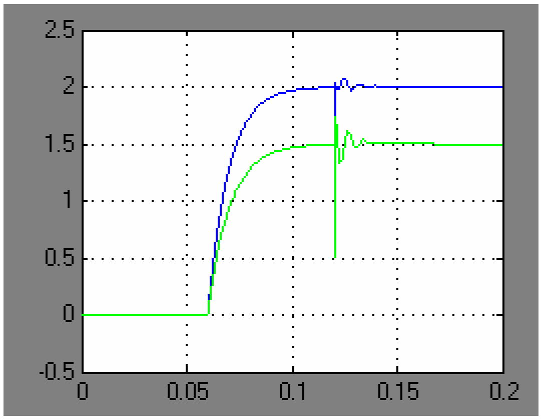
The rms value of series injected voltage at port 3:



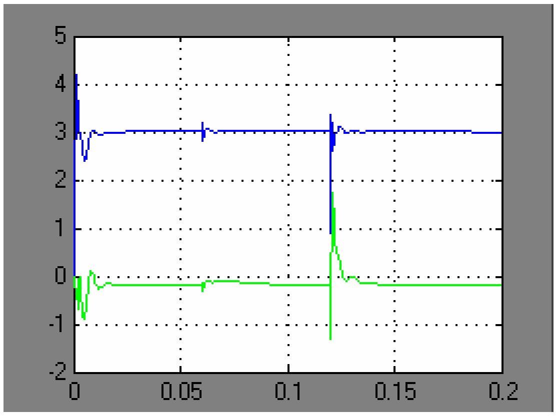
The active and reactive powers at port 1:



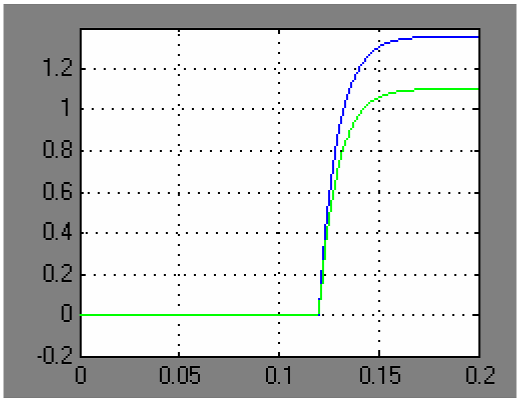
The active and reactive powers at load 1:



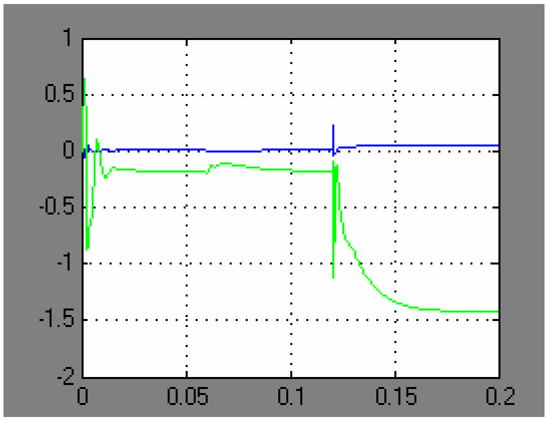
The active and reactive powers at port 2:



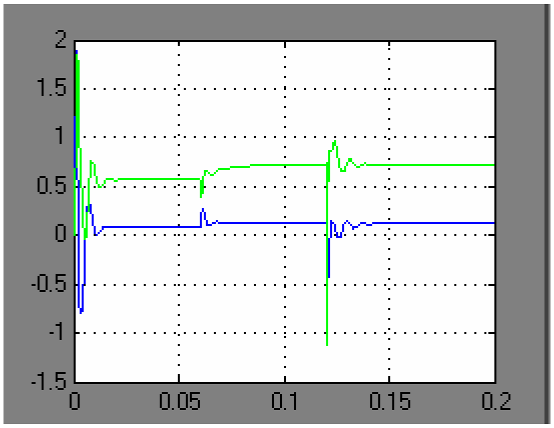
The active and reactive powers at load 2:



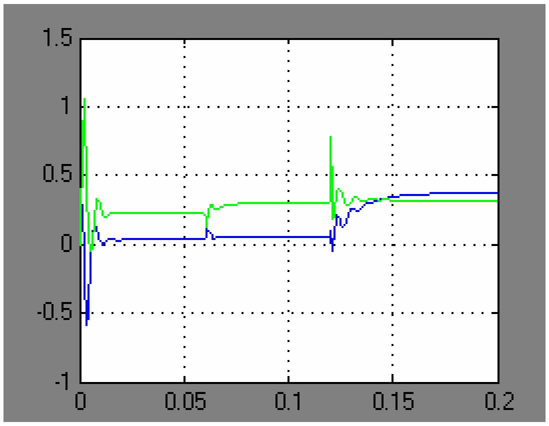
The active and reactive powers at port 3:



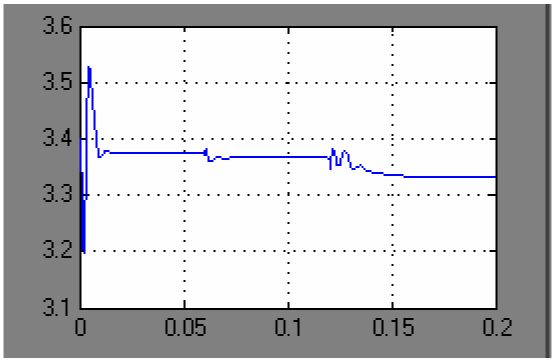
The active and reactive powers injected by the series converter 1:



The active and reactive powers injected by the series converter 2:



The DC link Capacitor Voltage in p.u:



CONCLUSION:

A neural network controller, controlling the shunt and series converters of the generalized interline power flow controller is presented in this paper. A model system consisting of three buses was modeled and its performance was studied using MATLAB/Simulink. Simulation studies show that a neural controller provides fast, precise and simultaneous control over a number of parameters like bus voltages, real and reactive power.

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