

ENHANCING POWER SYSTEM STABILITY USING NEURO-FUZZY BASED UPFC

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Abstract -Rapid development of high power semiconductor devices with fast control features have given birth to several Flexible AC Transmission Systems (FACTS) controllers for improving power system performances. One of the advanced FACTS Controllers is Unified Power Flow Controller (UPFC), which can control power flows, both real and reactive in Transmission line. This project presents performance analysis of UPFC based on Matrix converter. So far the standard practice of realizing the UPFC has been confined to connecting two inverters back to back with a DC link capacitor in between. This capacitor brings with it several disadvantages which affects the overall reliability of the UPFC. The Matrix Converter (MC) topology comes without any such bulky reactive element except for lighter components as filters. This project examines the effectiveness of MC as UPFC and simulation results shows a comparable performance with the traditional back to back constructs. The complete digital simulation of the proposed scheme of UPFC incorporated into the power system is performed in the MATLAB/Simulink environment and the results are presented.

Index Terms - Controller, neural network, power system, transient stability, unified power flow controller (UPFC).

I. INTRODUCTION

In recent years, due to economics and environment problems, build of new power plant and transmission line become more difficult. Hence, it is advisable to enhance the power transfer capability of the existing transmission lines up to thermal limit instead of constructing new one. The main aim of FACTS devices is rapid compensation and enhancement of flexibility of power line parameter.

Some of the main FACTS controllers are static var compensator (SVC), thyristor control series capacitor (TCSC), static synchronous compensator (STATCOM) and static synchronous series compensator (SSSC). But, due to configuration, these controllers are not able to control the active and reactive power, separately. Among the various FACTS controllers, the unified power flow controller (UPFC) is the most versatile device capable of providing simultaneous control of voltage magnitude, phase angle and line power flow.

The UPFC is combination of STATCOM and SSSC which are connected back to back via a common dc link. There is a large dc capacitor in the dc link that connects two voltage source inverter (VSI) to each other. The main role

of dc capacitor is the control of power exchange between series and shunt terminals of UPFC.

The cost and physical size of UPFC depends on rating of this dc link capacitor bank, considerably. Also, this capacitor has shorter life when compared to an ac capacitor of same rating, which limits the life and reliability of VSI's, too.

To overcome these limitations, a matrix converter (MC) is employed in UPFC whereby the classical AC/DC and DC/AC converter structure with dc link capacitor is replaced by a matrix converter. The matrix converter has several advantages such as bidirectional power flow, less number of switches, reduced THD etc., Also matrix converters are more reliable and potentially have much longer life, because of the absence of the DC link capacitor.

The indirect space vector modulation (ISVM) technique is used to control the matrix converter present in the UPFC.

This feature of the matrix converter with ISVM algorithm motivated to use it in UPFC since the STATCOM controls the input current displacement angle and the SSSC controls the magnitude and angle of the series injected voltage.

II. SYSTEM MODEL OF PROPOSED UPFC

Fig. 1. show the common configuration of three-phase matrix converter as an ac/ac converter.

The usual UPFC configuration is replaced by a matrix converter that is placed in shunt combination with transmission line as shown in Fig. 2.

The SMIB power system is used for verifying the performance of proposed configuration of UPFC as shown in Fig. 3. The feeding network has been represented by it's Theremin's equivalent circuit on bus B1.

The UPFC has been placed between B1 and B2 buses along transmission line (Fig.3). The STATCOM side of the UPFC is connected in shunt with the transmission line using a step-down the transmission line current transformer.

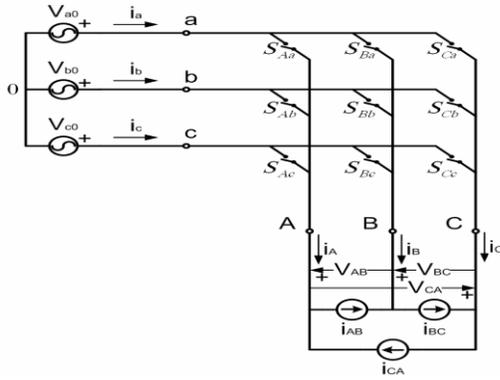


Fig. 1. Three-phase matrix converter

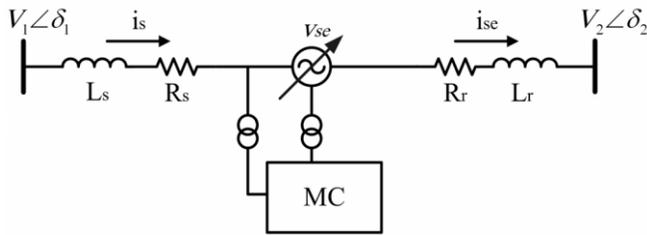


Fig. 2. Matrix converter placed as UPFC in the system

As a result, it plays the role of an inductance or capacitance in series. A small phase difference existed from 90° between injected voltage and line current to supply the required losses in the coupling transformer and matrix converter.

The input voltage equations for Matrix converter is, as follows:

$$\begin{aligned} V_a &= V_m \cos \theta_{av} = V_m \cos (\omega t) \\ V_b &= V_m \cos \theta_{bv} = V_m \cos (\omega t - (2\pi/3)) \\ V_c &= V_m \cos \theta_{cv} = V_m \cos (\omega t + (2\pi/3)) \end{aligned}$$

The line side current in the shunt side is described as,

$$\begin{aligned} I_a &= I_m \cos \theta_{av} = I_m \cos (\omega t - \psi_{in}) \\ I_b &= I_m \cos \theta_{bv} = I_m \cos (\omega t - (2\pi/3) - \psi_{in}) \\ I_c &= I_m \cos \theta_{cv} = I_m \cos (\omega t + (2\pi/3) - \psi_{in}) \end{aligned}$$

The sampling rate has to be set much higher than both input and output frequencies, and the duration of each sample is controlled in such a way that the average value of the output waveform within each sample period tracks the desired output waveform. As consequence of the input ± output direct connection, at any instant, the output voltages have to fit within the enveloping curve of the input voltage system. The output voltage injected into the transmission line:

$$\begin{aligned} V_u &= V_o \cos \theta_{ou} = V_o \cos (\omega t + \phi_o + \psi_{out}) \\ V_v &= V_o \cos \theta_{ov} = V_o \cos (\theta_{ou} - (2\pi/3)) \\ V_w &= V_o \cos \theta_{ow} = V_o \cos (\theta_{ou} + (2\pi/3)) \end{aligned}$$

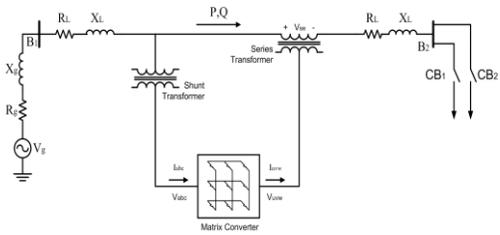


Fig. 3. Power system with the proposed scheme of UPFC

In this technique, the matrix converter is separated into two parts, aVSI and a voltage source rectifier (VSR), which linked to each other via fictitious dc link

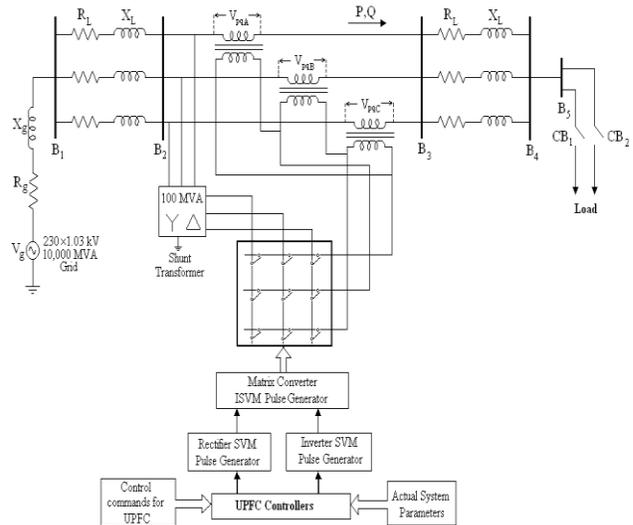


Fig 4. Proposed scheme of UPFC with Matrix Converter

III. CONTROL SCHEMES

The control of input bus voltage hasn't been attempted in this work. However, the input displacement factor of the matrix converter has been maintained close to unity. The controller is designed in a way that the UPFC operates in the automatic power flow control mode.

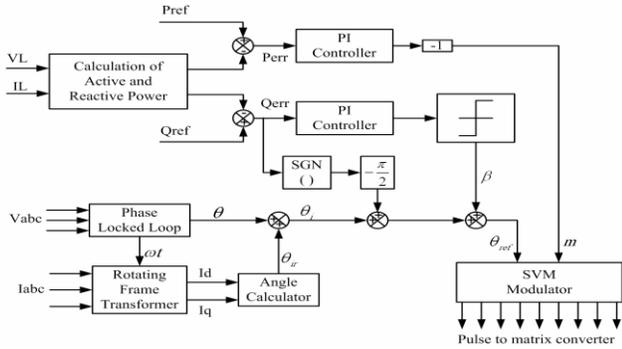


Fig. 5. Control block diagram of proposed UPFC

IV. SIMULATION RESULT

The UPFC is operated by using the automatic power flow control mode. In this mode, the UPFC can directly control the active and reactive power separately by controlling the amplitude and phase angle of the series injected voltage.

As shown in this figure, the voltage and current are almost in phase and this means that input power factor is near to unity.

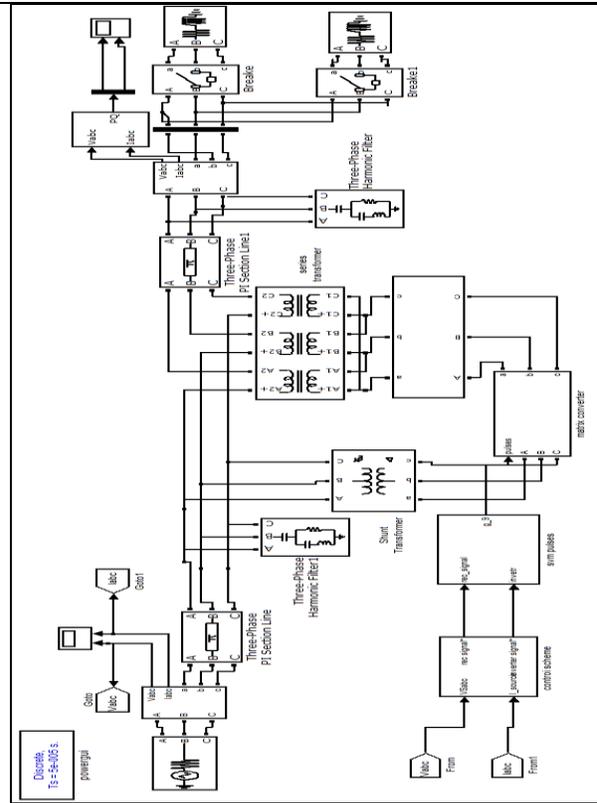


Fig 6. Simulated block diagram

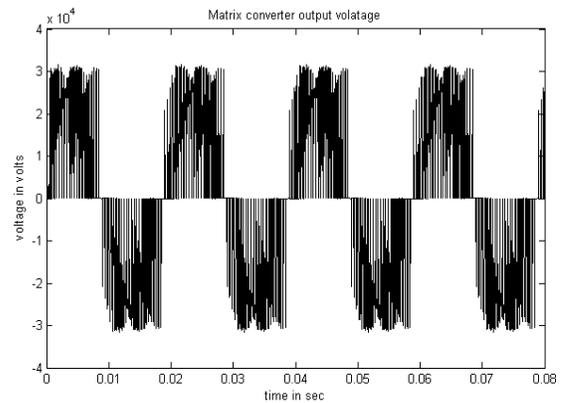


Fig 7 . Matrix converter output voltage

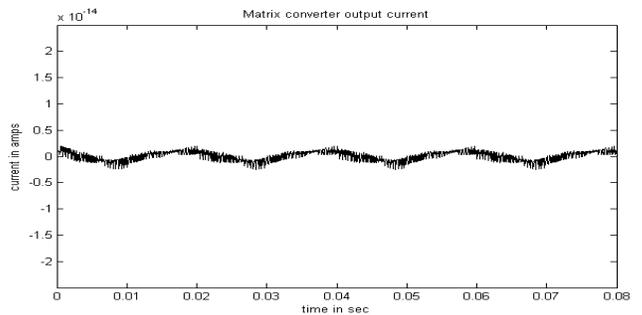


Fig 8 . Matrix converter output current

1. Line Voltage And Current Without UPFC

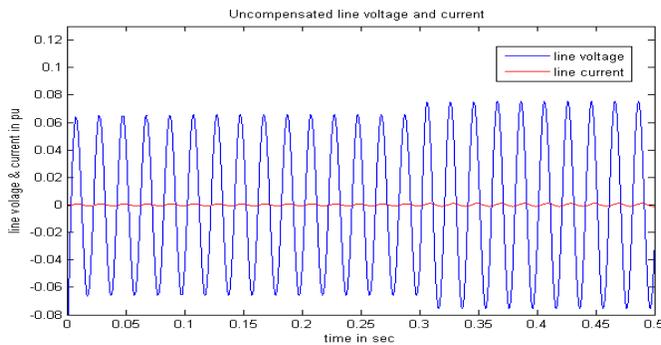


Fig 9 . Line voltage and current without UPFC

2. Line Voltage And Current With UPFC

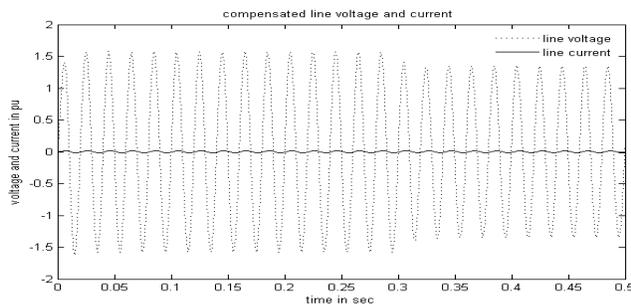


Fig 10. Line voltage and current with UPFC

3. Real And Reactive Power With UPFC

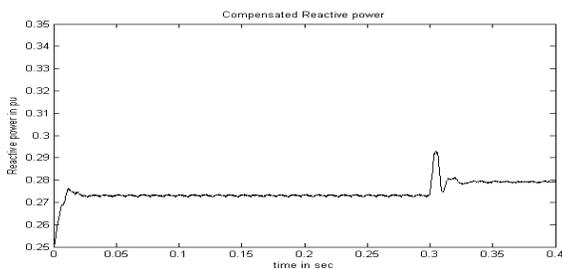


Fig 11. Real power with UPFC

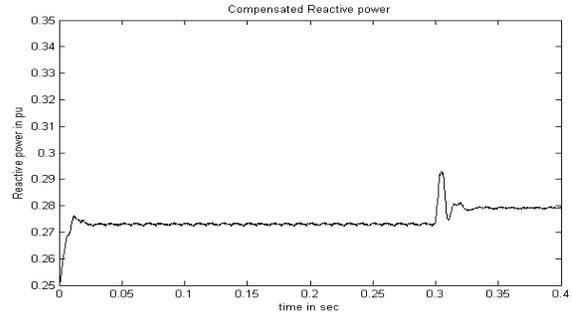


Fig 12..Reactive power with UPFC

V. CONCLUSION

The contribution of this project is to propose a novel structure of UPFC to be connected into the transmission line. The cost and space occupied by the dc link capacitor in the existing UPFC structure are quite large which leads to a complex design of UPFC. But the proposed scheme of UPFC with matrix converter allows a compact design due to the lack of dc link capacitor. The dynamic performance of the proposed system is analyzed with MATLAB/Simulink assuming that the UPFC is connected with the 230kV transmission line. In this scheme the shunt converter provides good voltage regulation and the series converter controls the magnitude and angle of the injected voltage so as to maintain the real and reactive power flow over the transmission line to follow the set reference values in spite of variations in the load and the operating conditions.

The main advantage of a UPFC based on a matrix converter is functional flexibility dependent on control algorithms. The proposed UPFC is able to control the full range of power flow and the power coefficient as is a conventional power flow controller. A UPFC based on a matrix converter is not suitable for application where supply voltages are asymmetrical because the converter does not store energy.

VI. REFERENCES

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