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Application of UPFC to compensate THD in Power System

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Abstract:- This paper mitigate the harmonics, current balancing and investigate THD in distribution system. When the UPFC in power system is connected to distribution system to maintain the stability of a system in power quality issues like variation of voltage, current and harmonics at source side and load side will be penetrated into the distribution system. The simulation is carried out in MATLAB SIMULINK and the results shows the results confirm the feasibility of proposed system.

Keywords:- Unified power flow controller (UPFC), Total harmonics distortion (THD), Flexible AC Transmission Systems (FACTS)

I. INTRODUCTION

A Power quality problem is an occurrence manifested as a non standard voltage, current or frequency that results in a failure or a mis-operation of end user equipments. Utility distribution networks, sensitive industrial loads and critical commercial operations suffer from various types of outages and service interruptions which can cost significant financial losses. With the restructuring of power systems and with shifting trend towards distributed and dispersed generation, the issue of power quality is going to take newer dimensions [6]. At present, a wide range of very flexible controllers, which capitalize on newly available power electronics components, are emerging for custom power applications. Among these, the UPFC and the dynamic voltage restorer are most effective devices, both of them based on the VSC principle. UPFC injects a current and voltage into the system to correct the power quality issues. Comprehensive results are presented to assess the performance of each device as a potential custom power solution [3]. The FACTS (Flexible AC Transmission Systems) technology is a new research area in power engineering. It introduces the modern power electronic technology into traditional ac power systems and significantly enhances power system controllability and transfer limit. In this paper, the unified power flow controller (UPFC) with control will be used to improve power system dynamic behavior after a system disturbance [1].

II. BASIC CONFIGURATION AND OPERATION OF UPFC:

Flexible AC Transmission Systems

The FACTS initiative [1,3] was originally launched in the 1980s to solve the emerging problems faced due to restrictions on transmission line construction, and to facilitate growing power export/import and wheeling transactions among utilities. The two basic objectives behind the development of FACTS technology are to increase the power transfer capability of transmission systems, and to keep the power flowing over designated routes, therefore significantly increasing the utilization of existing (and new) transmission assets. This plays a major role in facilitating contractual power flow in electricity markets with minimal requirements for new transmission lines.

Injecting a series voltage phasor, with a desirable voltage magnitude and phase angle in a line, can provide a powerful means of precisely controlling the active and reactive. power flows, by which, system stability can be improved, system reliability can be enhanced while operating and transmission investment cost can be reduced. It is possible to vary the impedance of a specific transmission line to force power flow along a desired "contract path" in the emerging power systems, to regulate the unwanted loop power flows and parallel power flows in the interconnected system. Dynamic reactive power compensation and damping power system oscillations can also be achieved using FACTS controllers. In general, FACTS controllers can be divided into four categories based on their connection in the network as follows;

a) Series Controllers.

b) Shunt Controllers.

c) Combined Series-Series Controllers.

d) Combined Series-Shunt Controllers.

III. BASIC CONFIGURATION AND OPERATION OF UPFC:

a. Basic Configuration:

UPFC is a combination of a shunt compensator and series compensation. It acts as a shunt compensating and a phase shifting device simultaneously under proper control can manage the capacitor i.e., the dc voltage source, to be charged (or discharged) to the required voltage level [2]. In this way, or by PWM controller, the amplitude of the output voltage of the inverter can be controlled for the purpose of reactive power generation or absorption.

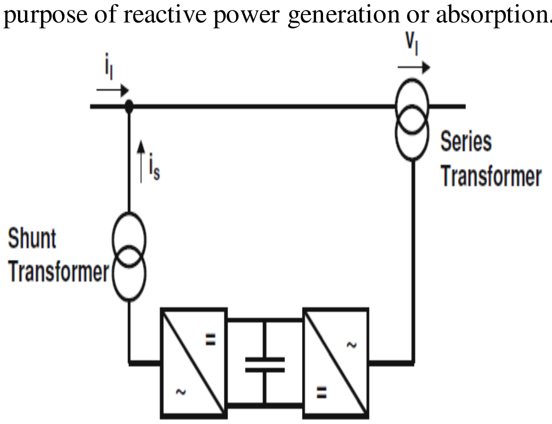

Fig. 1 Principle configuration of an UPFC

The UPFC consists of a shunt and a series transformer, which are connected via two voltage source converters with a common DC-capacitor. The DC-circuit allows the active power exchange between shunt and series transformer to control the phase shift of the series voltage. This setup, as shown in Figure1,provides the full controllability for voltage and power flow. The series converter needs to be protected with a Thyristor bridge. Due to the high efforts for the Voltage Source Converters and the protection, an UPFC is getting quite expensive, which limits the practical applications where the voltage and power flow control is required simultaneously [3]

b. Operating Principle Of Upfc:

The basic components of the UPFC are two voltage source inverters (VSIs) sharing a common dc storage capacitor, and connected to the power system through coupling transformers. One VSI is connected to in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer. A basic UPFC functional scheme is shown in fig.2.

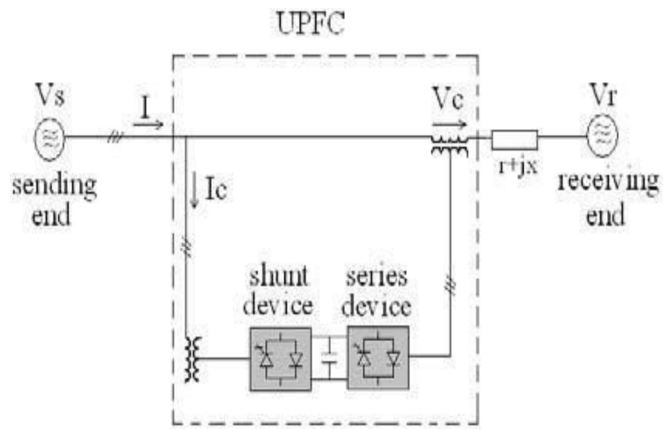

Fig. 2 Basic Operation of UPFC

IV. MODEL OF UPFC

Equivalent model of UPFC is shown in Fig 3. In the Equivalent model of UPFC a voltage source is connected in series with the transmission line for representing series converter and a current source is connected in shunt for representing shunt converter. The waveforms of Active and reactive power is shown in figures 4.1, 4.2, 4.3.
From the waveforms obtained through simulation of equivalent model of UPFC, the results are shown in fig 4.1, 4.2, 4.3 [1]. From the observations, that the Active and reactive power of the power system can be control by controlling the phase angle of series injected voltage.

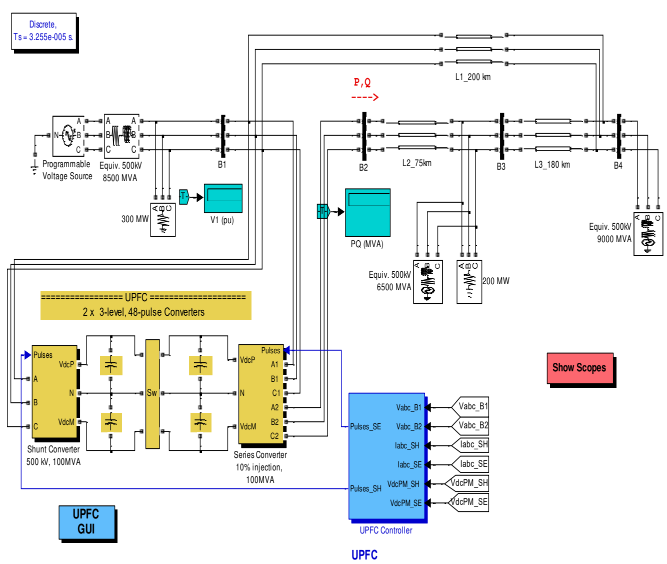

Fig. 3 Equivalent model of UPFC

Model Description

A Unified Power Flow Controller (UPFC) is used to control the power flow in a 500 kV transmission system. The UPFC located at the left end of the 75-km line L2, between the 500 kV buses B1 and B2, is used to control the active and reactive powers flowing through bus B2 while controlling voltage at bus B1. It consists of two 100-MVA, three-level, 48-pulse

GTO-based converters, one connected in shunt at bus B1 and one connected in series between buses B1 and B2. The shunt and series converters can exchange power through a DC bus. The series converter can inject a maximum of 10% of nominal line-to-ground voltage (28.87 kV) in series with line L2.

This pair of converters can be operated in three modes:

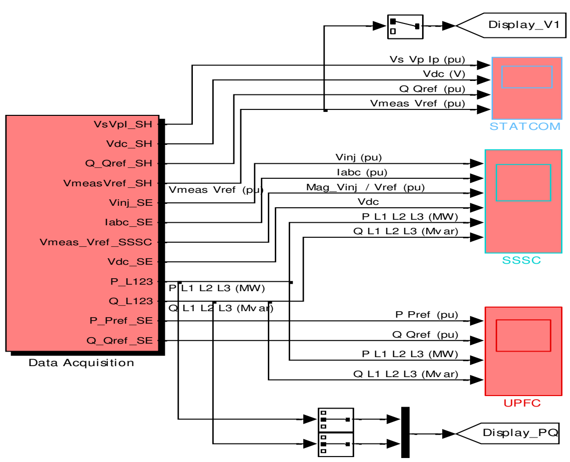

Fig. 4 Pair of converters of UPFC in three modes

Unified Power Flow Controller (UPFC) mode, when the shunt and series converters are interconnected through the DC bus. When the disconnect switches between the DC buses of the shunt and series converter are opened, two additional modes are available:Shunt converter operating as a Static Synchronous Compensator (STATCOM) controlling voltage at bus B1Series converter operating as a Static Synchronous Series Capacitor (SSSC) controlling injected voltage, while keeping injected voltage in qudrature with current.

The mode of operation as well as the reference voltage and reference power values can be changed by means of the “UPFC GUI” block.

When the two converters are operated in UPFC mode, the shunt converter operates as a STATCOM. It controls the bus B1 voltage by controlling the absorbed or generated reactive power while also allowing active power transfer to the series converter through the DC bus. The reactive power variation is obtained by varying the DC bus voltage. The four three-level shunt converters operate at a constant conduction angle (Sigma= 180-7.5 = 172.5 degrees), thus generating a quasi-sinusoidal 48-step voltage waveform. The first significant harmonics are the 47th and the 49th.

When operating in UPFC mode, the magnitude of the series injected voltage is varied by varying the Sigma conduction angle, therefore generating higher harmonic contents than the shunt converter. As illustrated in this demo, when the series converter operates in SSSC mode it generates a “true” 48-pulse waveform.

The natural power flow through bus B2 when zero voltage is generated by the series converter (zero voltage on converter side of the four converter transformers) is P=+870 MW and Q=-70 Mvar. In UPFC mode, both the magnitude and phase angle and the series injected voltage can be varied, thus allowing control of P and Q. The UPFC controllable region is obtained by keeping the injected voltage to its maximum value (0.1 pu) and varying its phase angle from zero to 360 degrees. To see the resulting P-Q trajectory, double click the “Show UPFC Controllable Region”. Any point located inside the PQ elliptic region can be obtained in UPFC mode.

Demonstration

1. Power control in UPFC mode

Open the UPFC GUI block menu. The GUI allows you to choose the operation mode (UPFC, STATCOM or SSSC) as well as the Pref/Qref reference powers and/or Vref reference voltage settings . Also, in order to observe the dynamic response of the control system, the GUI allows you to specify a step change of any reference value at a specific time.

Make sure that the operation mode is set to “UPFC (Power Flow Control)”. The reference active and reactive powers are specified in the last two lines of the GUI menu. Initially, Pref= +8.7 pu/100MVA (+870 MW) and Qref=-0.6 pu/100MVA (-60 Mvar). At t=0.25 sec Pref is changed to +10 pu (+1000MW). Then, at t=0.5 sec, Qref is changed to +0.7 pu (+70 Mvar). The reference voltage of the shunt converter (specified in the 2nd line of the GUI) will be kept constant at Vref=1 pu during the whole simulation (Step Time=0.3*100> Simulation stop time (0.8 sec). When the UPFC is in power control mode, the changes in STATCOM reference reactive power and in SSSC injected voltage as are not used.

Run the simulation for 0.8 sec. Open the “Show Scopes” subsystem. Observe on traces 1 and 2 of the UPFC scope the variations of P and Q. After a transient period lasting approximately 0.15 sec, the steady state is reached (P=+8.7 pu; Q=-0.6 pu). Then P and Q are ramped to the new settings (P=+10 pu Q=+0.7 pu). Observe on traces 3 and 4 the resulting changes in P Q on the three transmission lines. The performance of the shunt and series converters can be observed respectively on the STATCOM and SSSC scopes. If you zoom on the first trace of the STATCOM scope, you can observe the 48-step voltage waveform Vs generated on the secondary side of the shunt converter transformers (yellow trace) superimposed with the primary voltage V_p and the primary current I_p. The dc bus voltage (trace 2) varies in the 19kV-21kV range. If you zoom on the first trace of the SSSC scope, you can observe the injected voltage waveforms V_{inj} measured between buses B1 and B2.

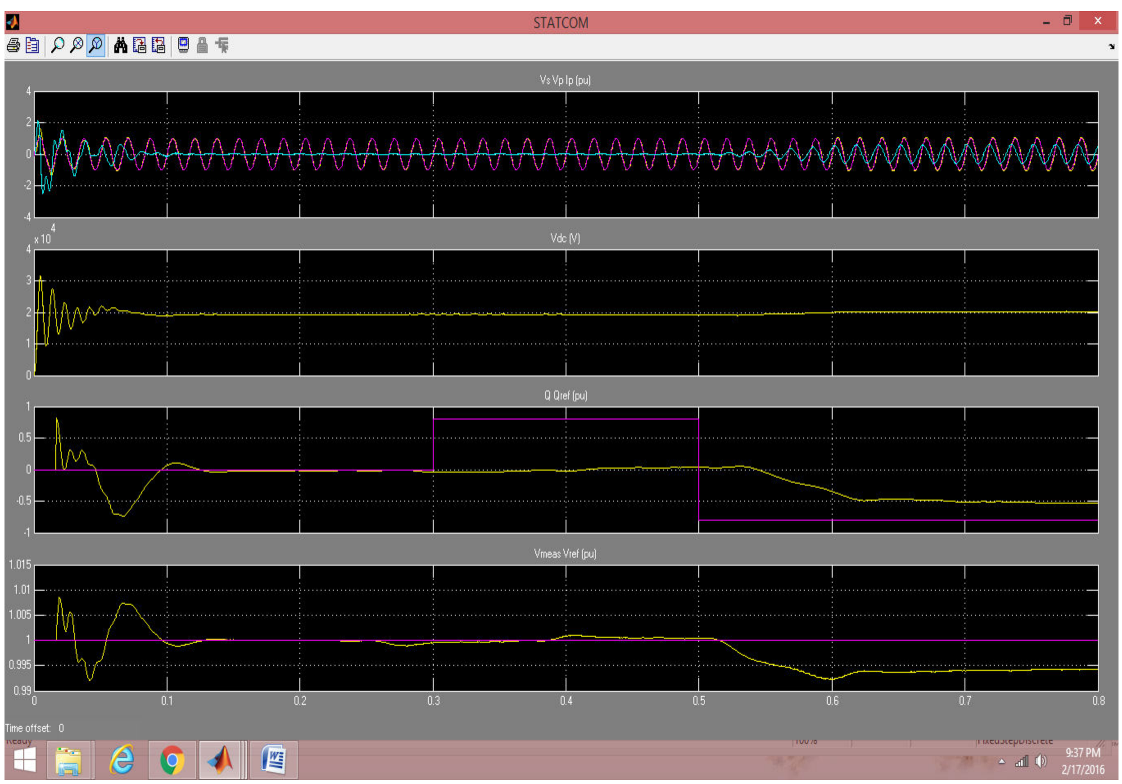

Fig 4.1 Var control in STATCOM mode

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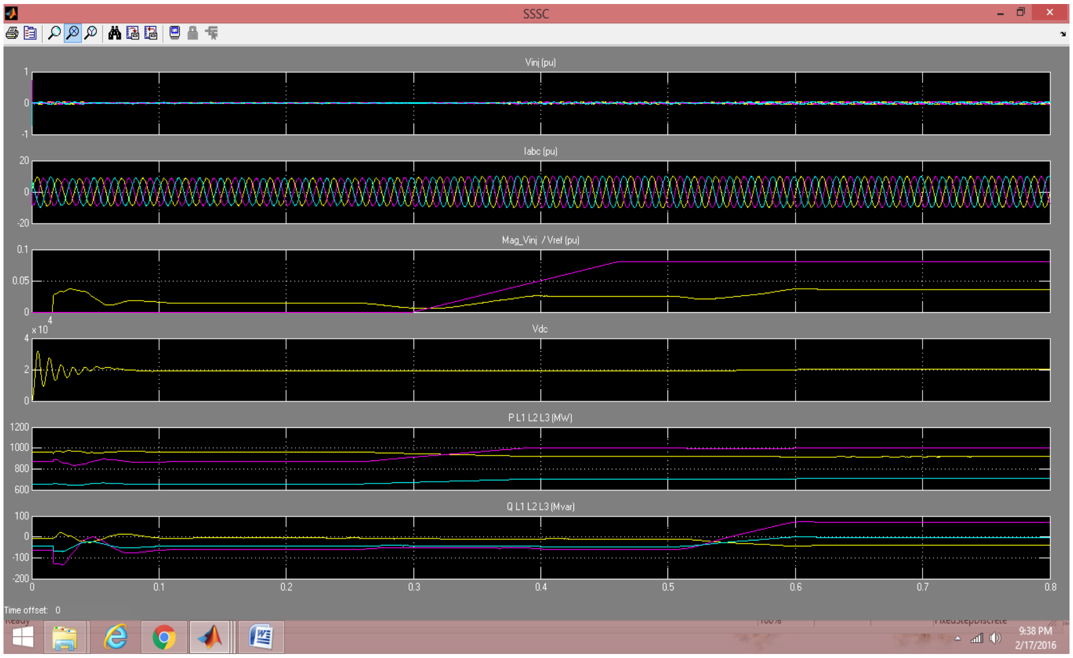

Fig.4.2 Series voltage injection in SSSC mode

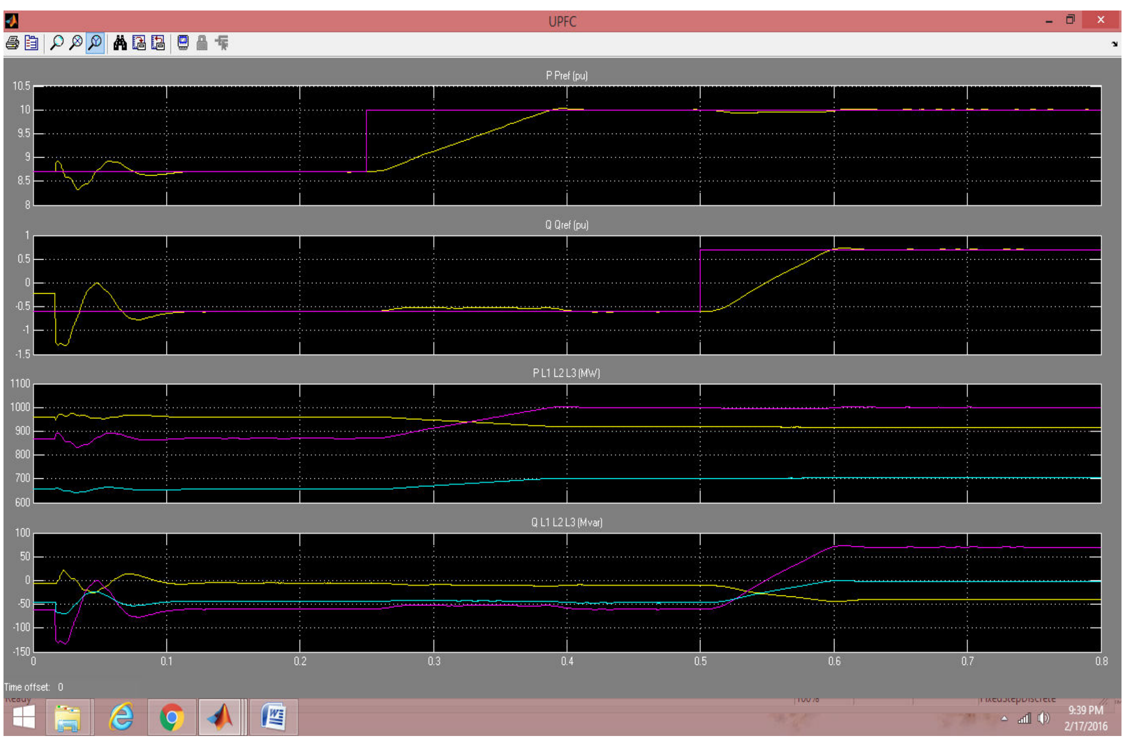

Fig 4.3 Power control in UPFC mode

V. CONCLUSION:

This paper presents a platform that can be used for FACTS controller studies. In the Simulation study, MATLAB simulink environment is used to simulate the model of UPFC. This paper presents the performance analysis of UPFC for improving the power quality in the conventional system. Simulation results show the effectiveness of the UPFC to control active and reactive powers. It has been found that there is reduction in the switching period and reduction in the value of the peak voltage during the switching period. Analysis shows that UPFC improves the power quality in the power system. The platform can be extended to study the advance controller with UPFC for improving power quality.

VI. REFERENCES:

[1] S. Muthukrishnan et al., "Performance evaluation of fuzzy logic and PI controller Based UPFC for Power quality improvement," European Journal of Scientific Research ISSN 1450-216X Vol. 88 No 2 October, 2012, pp.277- 84.

[2] S. Tara Kalyani, G. Tulasiram Das, (2008) „Simulation of real and reactive power flow with UPFC connected to a transmission line‟, Journal of Theoretical and Applied Information Technology.

[3] Khadkikar, V., Aganval, P., Chandra, A., Bany, A.O. and Nguyen, T.D. (2004) „A simple new control technique for unified power quality conditioner (UPQC)‟, 11th International Conference on Harmonics and Quality of Power, Lake Placid, NewYork, USA, Sept 12-15,pp.289– 293.

[4] R.Mihalic et al., "Improvement of transient stability using unified power flow controller‟ IEEE Trans.Power Del., vol. 11, no. 1, pp. 485-492, Jan 1996.

[5] C.D. Schaulder et al., "Operation of unified power flow controller (UPFC) under practical constraints‟, IEEE Trans.Power Del., vol.13, no.2. pp. 630-639, Apr1998.

[6] HINGORANI, N.H.: 'Flexible AC transmission systems', *IEEE Spectrum,* 1993, pp.40-45.

[7] K.R.Padiyar, "FACTS Controller in transmission and distribution"

[8] L. Gyugyi, A unified power flow control concept for flexible AC transmission systems, IEE Proc. Gener. Transm. Distrib. 139 (4) (1992) 323–331 [8]Narain G. Hingaroni and Laszlo Gyugi, Understanding Facts, Concepts and Technology of Flexible AC Transmission system, IEEE press, 2001.