MODELING AND SIMULATION OF UPFC FOR POWER QUALITY IMPROVEMENT

By

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ABSTRACT

This paper deals with digital simulation of power system using UPFC to improve the power quality. The UPFC is also capable of improving transient stability in a power system. It is the most complex power electronic system for controlling the power flow in an electrical power system. The real and reactive powers can be easily controlled in a power system with a UPFC. The circuit model is developed for UPFC using rectifier and inverter models. The control angle is varied to vary the real and reactive powers at the receiving end. The Matlab simulation results are presented to validate the model.

Keywords : UPFC, Power Quality, Statcom, Compensation and matlab simulink.

INTRODUCTION

The power-transfer capability of long transmission lines are usually limited by large signals ability. Economic factors, such as the high cost of long lines and revenue from the delivery of additional power, give strong incentives to explore all economically and technically feasible means of raising the stability limit. On the other hand, the development of effective ways to use transmission systems at their maximum thermal capability has caught much research attention in recent years. Fast progression in the field of power electronics has already started to influence the power industry. This is one direct outcome of the concept of flexible ac transmission systems (FACTS) aspects, which has become feasible due to the improvement realized in power-electronic devices. In principle, the FACTS devices could provide fast control of active and reactive power through a transmission line. The Unified Power-Flow Controller (UPFC) is a member of the FACTS family with very attractive features. This device can independently control many parameter, so it is the combination of the properties of a static synchronous compensator (STATCOM) and Static Synchronous Series Compensator (SSSC) [1].

These devices offer an alternative mean to mitigate power system oscillations. Thus, an important question is the selection of the input signals and the adopted control strategy for these devices in order to damp power oscillations in an effective and robust manner. Much research in this domain has been realized [2]-[4]. This research shows that UPFC is an effective device for this aim.

The UPFC parameters can be controlled in order to achieve the maximal desired effect in solving first swing stability problem. This problem appears for bulky power systems with long transmission lines.

Various methods to reference identification of the series part, in order to improve the transient stability of the system based on: "optimal parameters"[2], "state variables"[3], and also "injection model" were studied. Finally, a new identification method based on "state variables" was proposed[4].

This paper is organized as follows. After this introduction, the principle and operation and of a UPFC connected to a network are presented. In section II, the control strategy for UPFC is introduced. Simulation results are presented in section III. Section IV describes the conclusion.

1. UPFC System

A simplified scheme of a UPFC connected to an infinite bus via a transmission line is shown in Figure.1.

UPFC consists of a parallel and series branches, each one containing a transformer, power-electric converter with

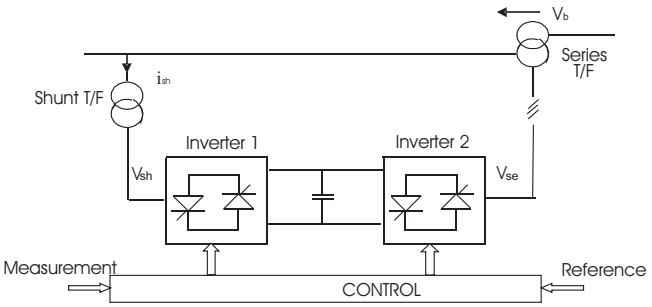

Figure 1. UPFC Installed in Transmission Line

turn-off capable semiconductor devices and DC circuit. Inverter 2 is connected in series with the transmission line by series transformer. The real and reactive power in the transmission line can be quickly regulated by changing the magnitude (V_b) and phase angle (δ_b) of the injected voltage produced by inverter 2. The basic function of inverter 1 is to supply the real power demanded by inverter 2 through the common DC link. Inverter 1 can also generate or absorb controllable power [5],[6].

Literature [1] to [10] does not deal with the matlab simulation of UPFC using shunt and series sources. An attempt is made in the present work to model and simulate UPFC using matlab.

2. Simulation Results

Two bus system without compensation circuit is shown in Figure 2a. Sag is produced when an additional load is added. Voltage across loads 1 and 2 are shown in Figure 2b. The real power and reactive power waveforms are shown in Figures 2c and 2d respectively.

Two bus system with UPFC is shown in Figure 3a. UPFC is represented as a subsystem. The details of subsystem are shown in Figure 3b. Voltage across loads 1 and 2 are shown in Figure 3c. Real and reactive powers are shown in Figures 3d and 3e respectively. UPFC using voltage and current sources are shown in Figure 4a. Converter 1 is represented as a shunt current source and converter 2 is

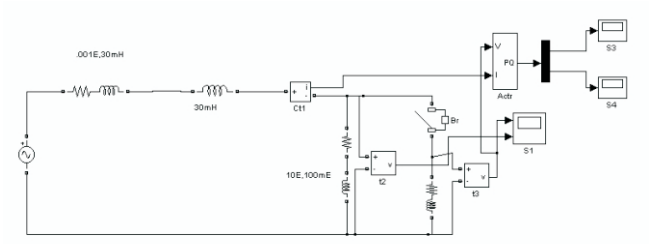

Figure 2a. Line model without compensation

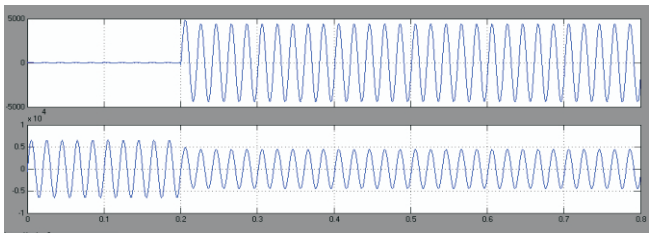

Figure 2b. Voltage across Load -2 and Load -1

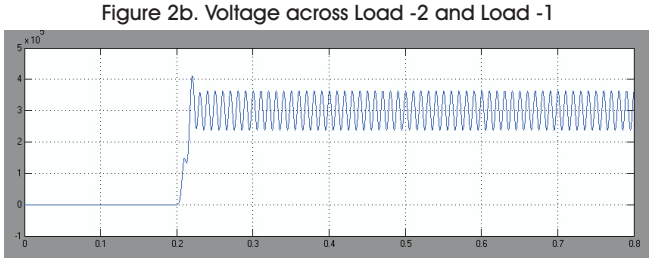

Figure 2c. Real power

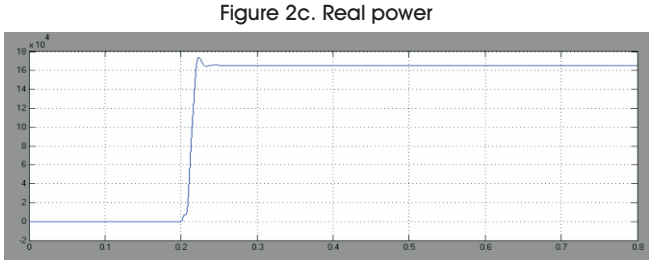

Figure 2d. Reactive power

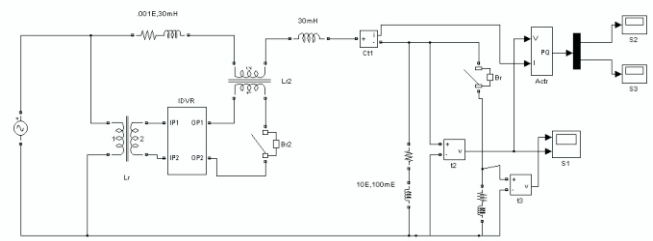

Figure 3a. Two bus system with UPFC

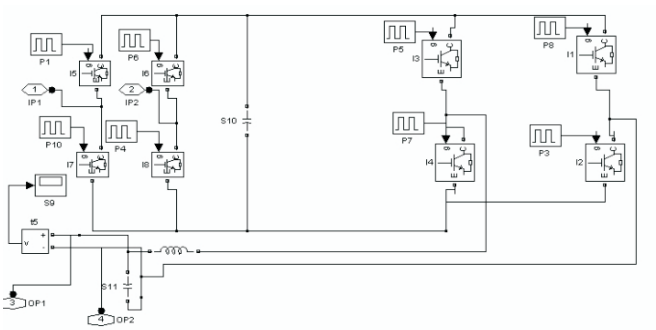

Figure 3b. Rectifier Inverter system

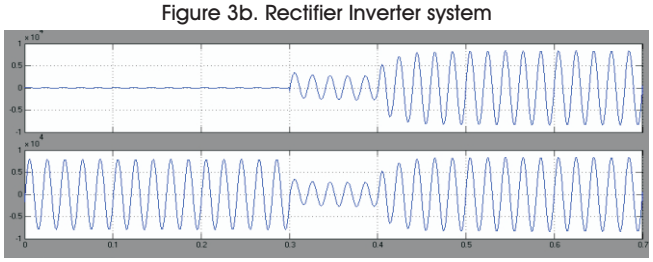

Figure 3c. Voltage across Load 2 and Load 1

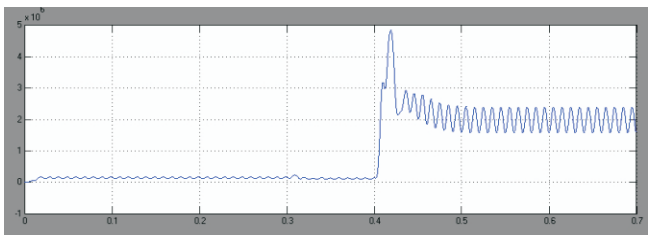

Figure 3d. Real power

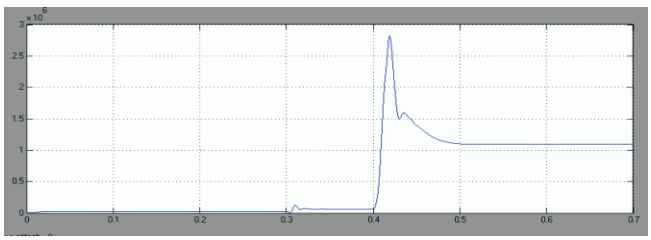

Figure 3e. Reactive power

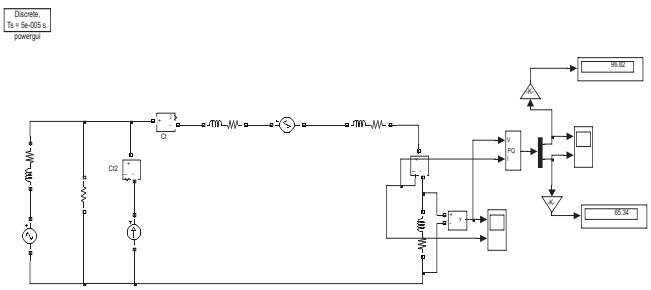

Figure 4a. UPFC circuit model using shunt and series sources

represented as a series voltage source. Load voltage and current waveforms are shown in Figure 4b. Real and reactive powers are shown in Figure 4c. Variation of powers with the variation in the angle is given in Table 1. The real and reactive powers increase with the increase in the angle of voltage injection.

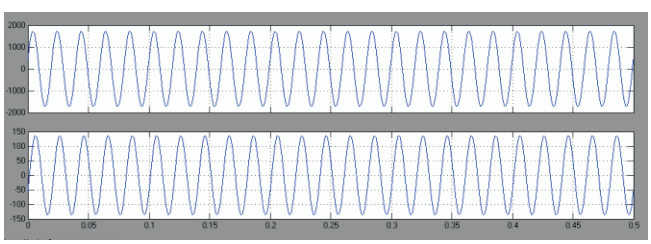

Figure 4b. Load voltage and current waveforms

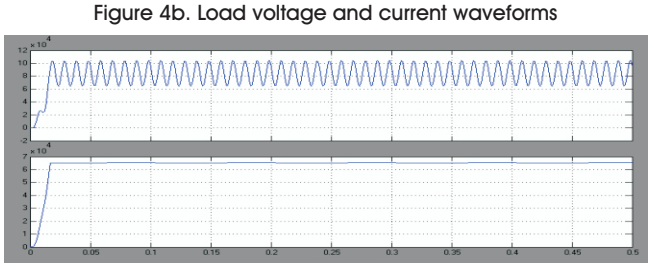

Figure 4c. Real and Reactive power

S.No	Angle Of Injected V2 Voltage (deg)	Real Power (kw)	Reactive Power(KVAR)
1	0	96.82	65.34
2	60	176.1	111.5
3	120	310.6	199.9
4	180	354.1	240.6

Table 1. Variation of power with angle of injection

Conclusion

In the simulation study, matlab simulink enviroment is used to simulate the model of UPFC connected to a 3 phase system. This paper presents the control & performance of the UPFC used for power quality improvement. Voltage compensation using UPFC is studied. The voltage compensation using UPFC system is also studied by using shunt and series source model. The real and reactive powers increase with the increase in angle of injection. Simulation results show the effectiveness of UPFC to control the real and reactive powers. It is found that there is an improvement in the real and reactive powers through the transmission line when UPFC is introduced. The UPFC system has the advantages like reduced maintanance and ability to control real and reactive powers.

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