Modeling and Simulation Five Level Inverter based UPFC System

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ABSTRACT
This paper deals with digital simulation of power system using five level inverter based UPFC to improve the power quality. The UPFC is 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 circuits. The control angle of the converters 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

1. 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, since it has the combined 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 purpose.

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.

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 sections III. Section IV describes the conclusion.

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

Using ABCD Parameters

Real Power P_r =

$$\frac{Es\,Er}{B}\cos(\beta-\alpha)-\frac{AEr^2}{B}\cos(\beta-\alpha)$$

Reactive Power Q_r =

$$\frac{ErEs}{B}\sin(\beta-\alpha)-\frac{AEr}{B}\sin(\beta-\alpha)$$

Where $A = 1L0^0$

$B = X\,L90^0$

$C = 0$

$D = 1L0^0$

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

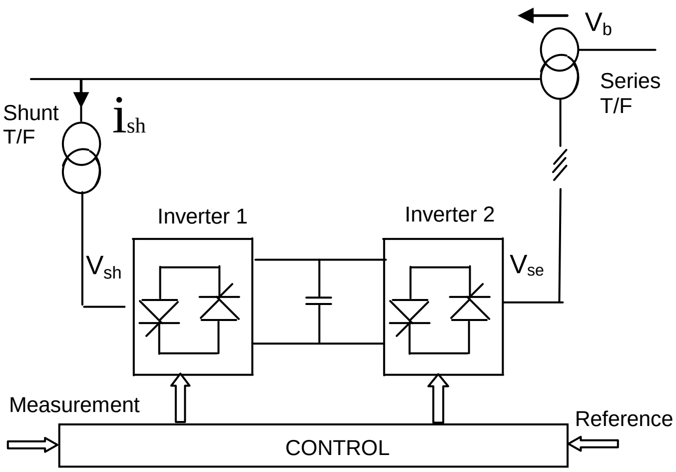

Fig1. UPFC Installed in Transmission Line

The above literature does not deal with UPFC system employing five level inverter. The author is unaware of the use of five level inverter for the application of UPFC. In the present work, five level inverter is proposed in the UPFC system.

III. SIMULATION RESULTS

Five level inverter is shown in Fig 2a. Triggering pulses for the devices are shown in Fig 2c. The inverter output voltage is shown in Fig 2c.

Two bus system without compensation circuit is shown in Fig 3a. Sag is produced when an additional load is added. Voltage across loads 1 and 2 are shown in Fig 3b. The real power and reactive power waveforms are shown in Figures 3c and 3d respectively.

Fig 4 shows the line model with UPFC. The UPFC circuit model is shown in Fig 5a. Voltage across loads 1 and 2 are shown in Fig 5b. The RMS voltage is shown in Fig 5c. Real and Reactive powers are shown in Figs 5d and 5e respectively. From the above figures, it can be seen that the sag is mitigated using statcom.

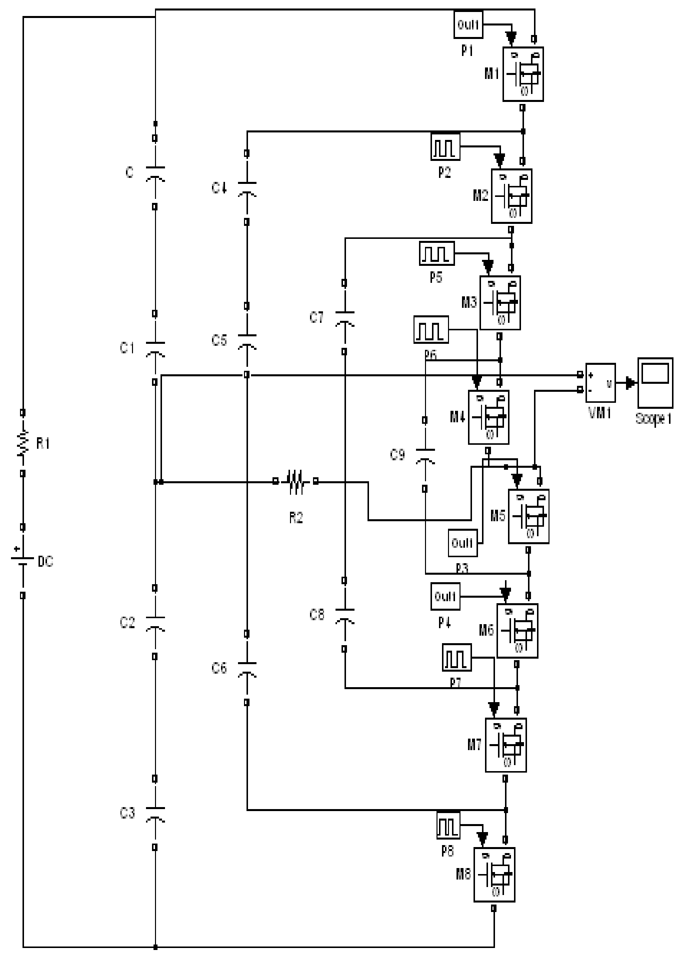

Fig 2a. Five Level inverter

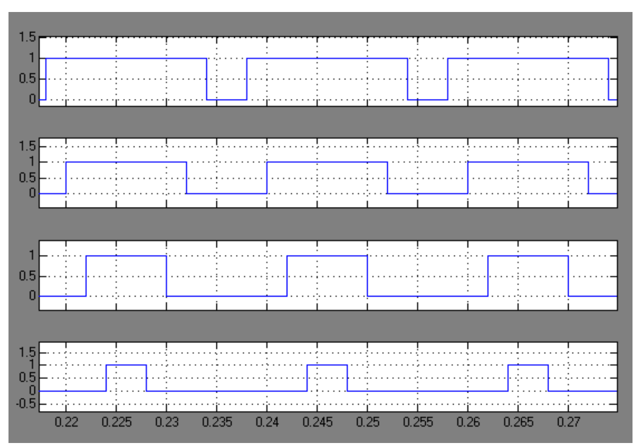

Fig 2b. Driving pulses for M1 ,M2,M3 and M4

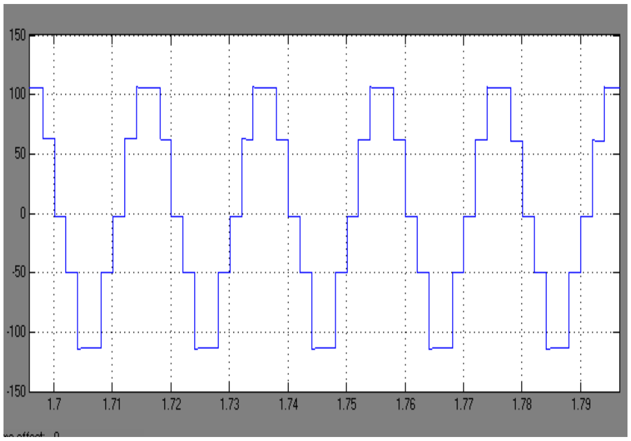

Fig 2c. Inverter output voltage

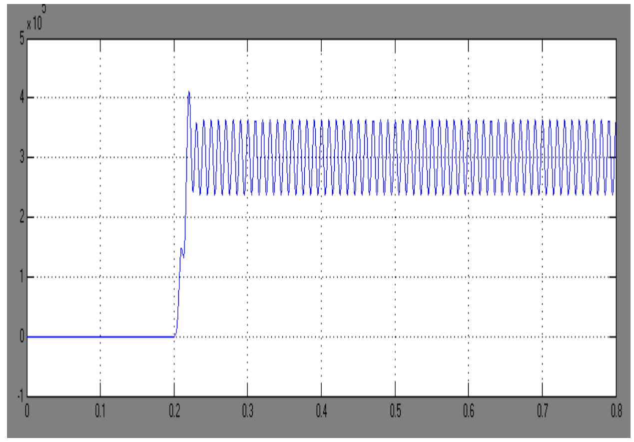

Fig 3c. Real power

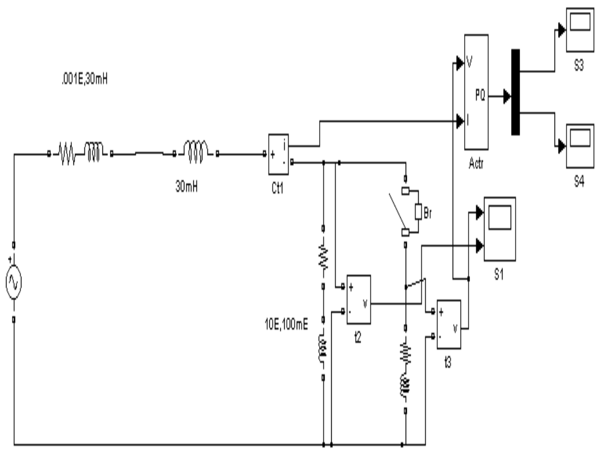

Fig 3a.Line model without compensation circuit

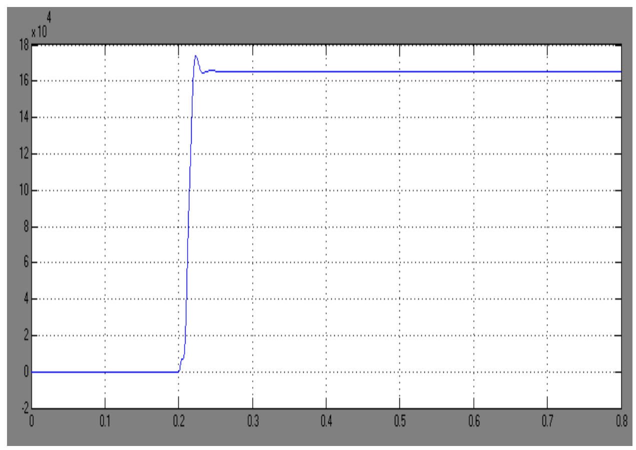

Fig 3d.Reactive power

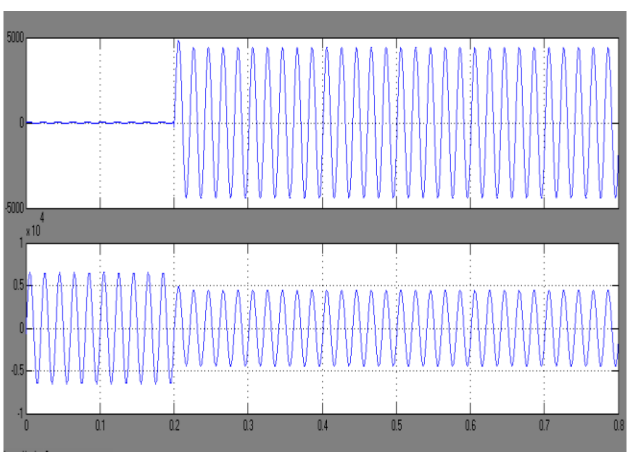

Fig 3b.Voltage across Load-2 and Load-1

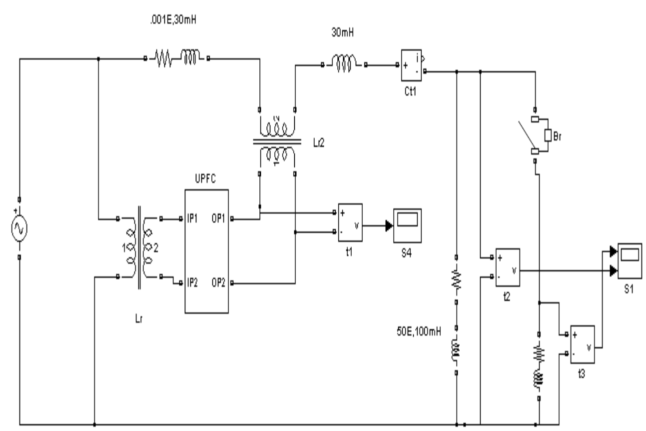

Fig 4. Line model with UPFC

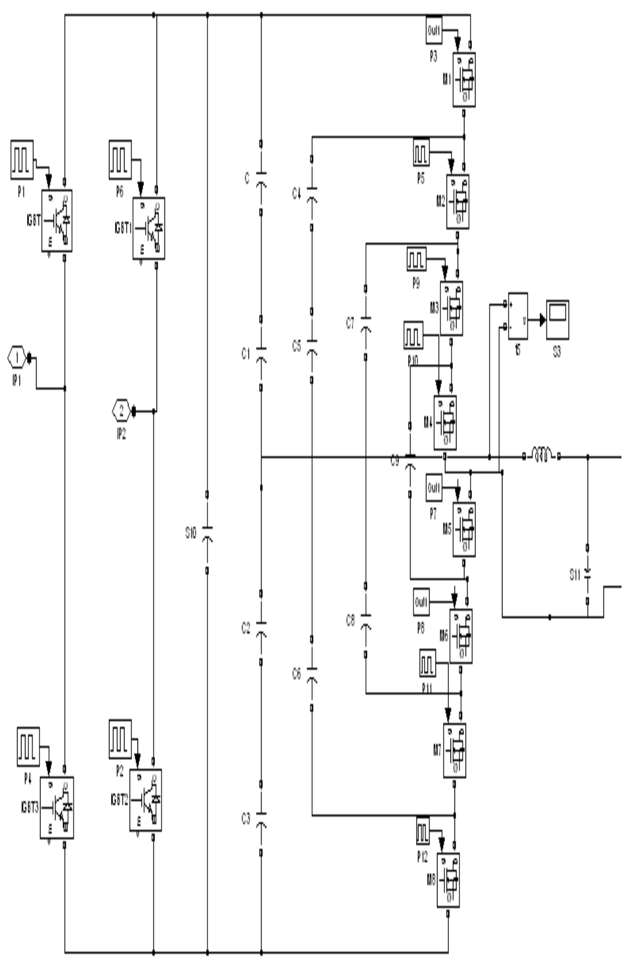

Fig 5a. Circuit model of UPFC

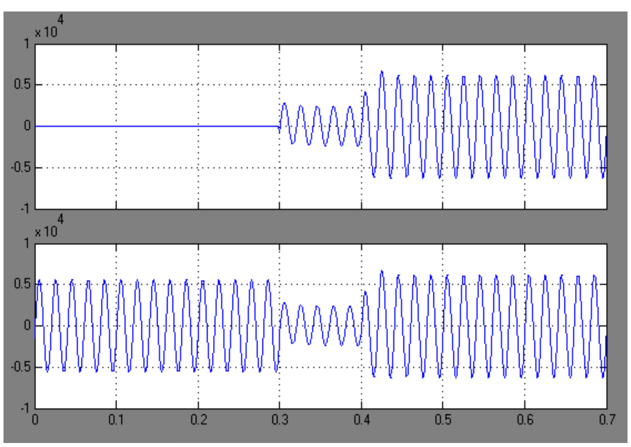

Fig 5b.Voltage across Load -2 and Load -1

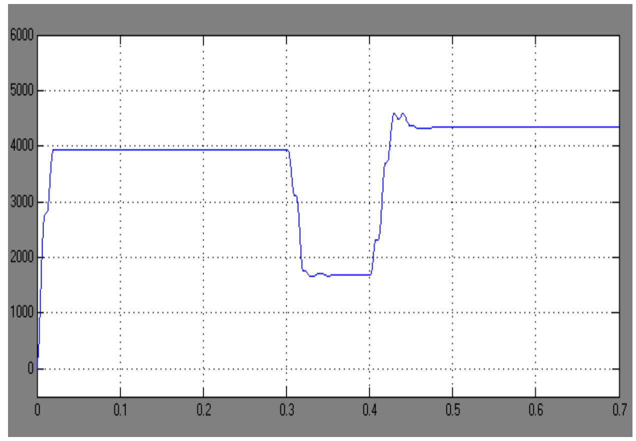

Fig 5c.RMS voltage

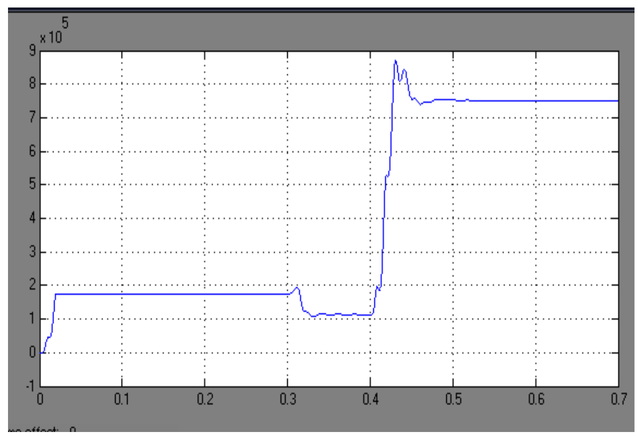

Fig 5d. Real power

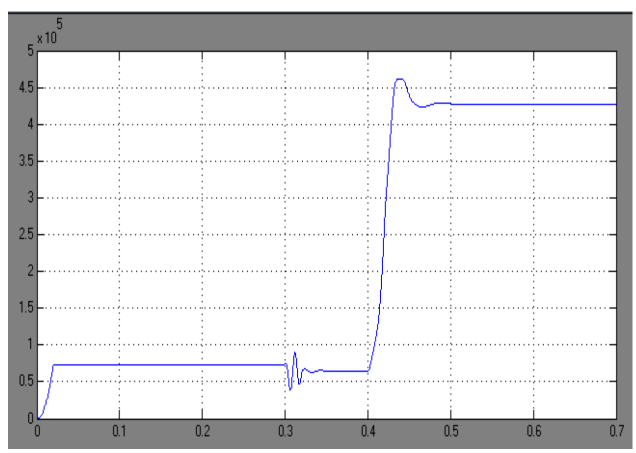

Fig 5e. Reactive power

IV. CONCLUSION

In the simulation study, matlab simulink enviroment is used to simulate the model of five level inverter based UPFC. This paper presents the control & performance of the UPFC used for power quality improvement. 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 hormonics and ability to control real and reactive powers. The heating in the transformer is reduced by using multilevel output. This is due to the reduction in the harmonics. The simulation results are inline with the predictions.

V. REFERENCES

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