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Control Design and Comparison of Unified Power Flow Controller for Various Control Strategies

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Abstract: Unified Power Flow Controller (UPFC) is the most widely used Flexible ac Transmission system (FACTS) device to control the power flow and to optimize the system stability in the transmission line. This paper is basically used to verify the UPFC system in order to improve its performance in power system for various control strategies by using MATLAB software. The parameters of the as length of the transmission lines has been changed to a different dimension and the result is compared with an existing model.

Index Terms: FACTS, UPFC, STATCOM, control strategy.

I. INTRODUCTION

Unified Power Flow Controller (UPFC) is the universal and most flexible FACTS (Flexible ac Transmission System). It is used to control the power flow in the transmission systems by controlling the impedance, voltage magnitude and phase angle. This device can allow the path of power as we desire. UPFC consist of two Voltage Supply Inverters, one series converter and one shunt converter. This device is actually a combination of two FACTs device which are STATCOM (Static Synchronous Compensator) and SSSC (Static Series Synchronous Compensator). SSSC is used to add controlled voltage magnitude and phase angle in series with the line, while shunt converter STATCOM is used to provide reactive power to the ac system, besides that, it will provide the dc power required for both inverter [1].

The reactive power can be compensated either by improving the receiving voltage or by reducing the line reactance [2].UPFC should be installed to control the voltage, as well as to control the active and reactive power flow through the transmission line. However, the right transmission line to be injected by UPFC and the effect of injection will only know by doing the analysis using MATLAB. Thus, this paper presents the active and reactive power control through a transmission line by placing the UPFC using computer simulation. MATLAB program are used to model and to verify the performance of UPFC in order to increase the ability of the system.

II. PROBLEM STATEMENT

Unified Power Flow Controller (UPFC) is the most widely used Flexible ac Transmission system (FACTS) device to control the power flow and to optimize the system stability in the transmission line**.** It should be installed to control the voltage, as well as to control the active and reactive power flow through the transmission line.

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II. OBJECTIVES

The objectives of this paper are to:

i. analyze the steady-state analysis of the system before and after UPFC applied.
ii. model UPFC and determine the most efficient line to be injected.
iii. simulate the network using MATLAB.

The scopes of this work are:

i. analyze and compare the performance before and after applied.

III. UNIFIED POWER FLOW CONVERTER

The cost of losing synchronous through a transient instability is extremely high in modern power systems. Consequently, utility engineers often perform a large number of stability studies in order to avoid this problem. A unified power flow controller (UPFC) is the most promising device in the FACTS concept. It has the ability to adjust the three control parameters such as the bus voltage, transmission line reactance, and phase angle between two buses, either simultaneously or independently. A UPFC performs this through the control of the in-phase voltage, quadrature voltage, and shunt compensation.

UPFC can control the three control parameters either individually or in appropriate combinations at its series-connected output while maintaining reactive power support at its shunt-connected input. The mechanism of the three control methods of a UPFC in enhancing power system damping. It was shown that a significant reduction in the transient swing can be obtained by using a simple proportional feedback of machine rotor angle deviation. It is generally accepted that the addition of a supplementary controller to the UPFC can significantly enhance power system damping [3].

The main function of the UPFC is to control the flow of real and reactive power by injecting of a voltage in series with the transmission line. Both the magnitude and the phase angle of the volt age can be varied independently. Real and reactive power flow control can allow for the power flow in prescribed routes, loading of transmission lines closer to their thermal limits and can be utilized for improving transient and small signal stability of the power system. The schematic of the UPFC is shown in Figure 1.

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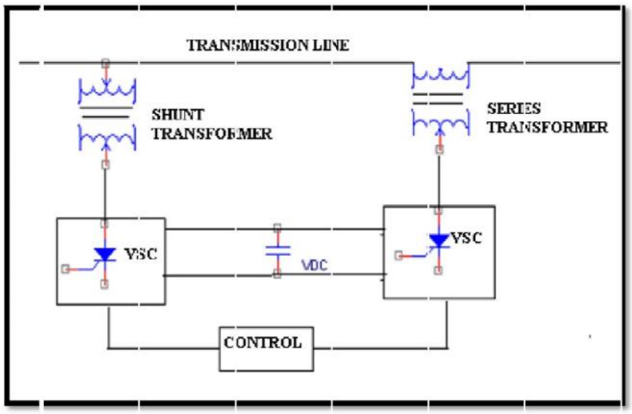

Fig. 1.Schematic of UPFC

The UPFC consists of two branches. The series branch consists of a voltage source converter which injects a voltage in series through a transformer. Since the series branch of the UPFC can inject a voltage with variable magnitude and phase angle it can exchange real power with the transmission line. The energy storing capacity of this dc capacitor is generally small. Therefore, active power drawn by the shunt converter should be equal to the active power generated by the series converter. The reactive power in the shunt or series converter can be chosen independently, giving greater flexibility to the power flow control. The coupling transformer is used to connect the device to the system. Figure 2 shows the schematic diagram of the three phase UPFC connected to the transmission line.

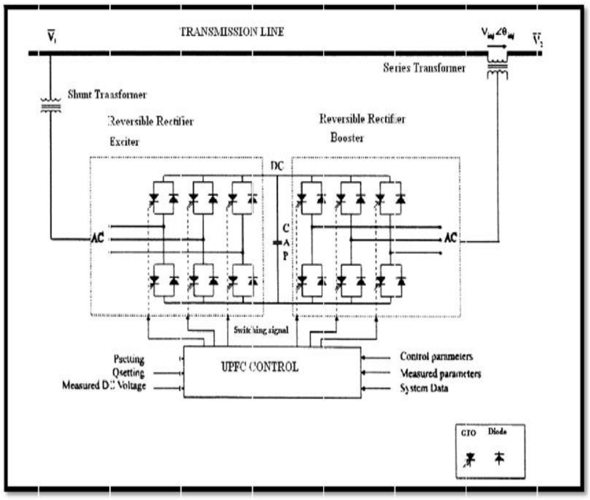

Fig.2. Schematic diagram of the three phase UPFC connected to the transmission line.

However the UPFC as a compensator cannot supply or absorb real power in steady state (except for the power drawn to compensate f or the losses) unless it has a power source at its DC terminals. Thus the shunt branch is required to compensate (from the system) for any real power drawn/ supplied by the series branch and the losses. If the power balance is not maintained, the capacitor cannot remain at a constant voltage. In addition to maintaining the real power balance, the shunt branch can independently exchange reactive power with the system. The main advantage of the power electronics based FACTS controllers over mechanical controllers is their speed. Therefore the capabilities of the UPFC need to be exploited not only for steady state load flow control but also to improve stability.

IV. SIMULATION RESULTS

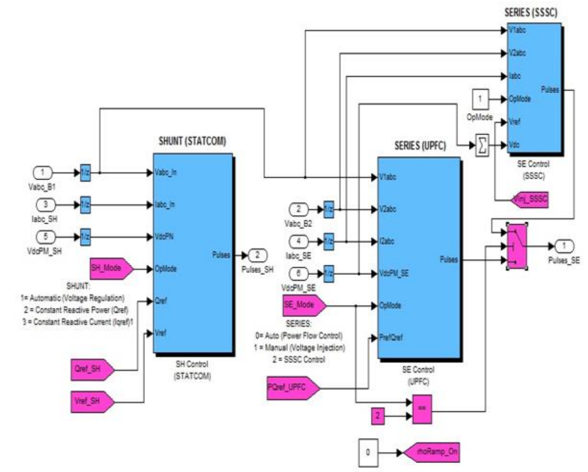

Fig.3. Simulink model of Shunt STATCOM

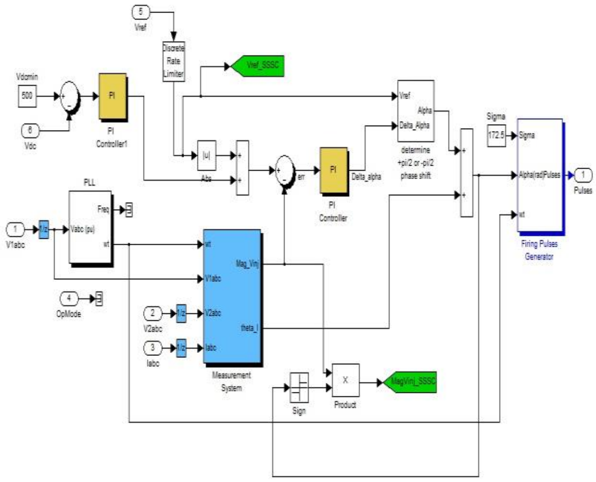

Fig.4. Simulink model of SSSC controller

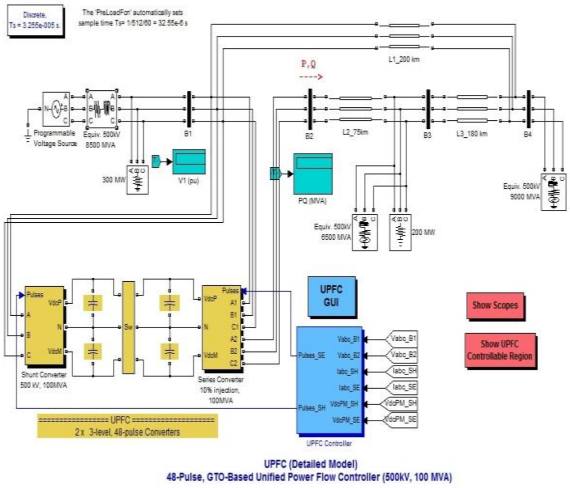

Fig.5. Simulink model of UPFC

V. COMPARISON OF SCOPE BETWEEN EXISTING AND NEW MODEL

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Values of existing model	Values of new model
Equivalent voltage-500kv	Equivalent voltage-600kv
Length L1-200km	Length L1-300km
Length L2-75km	Length L2-80km
Length L3-180km	Length L3-200km

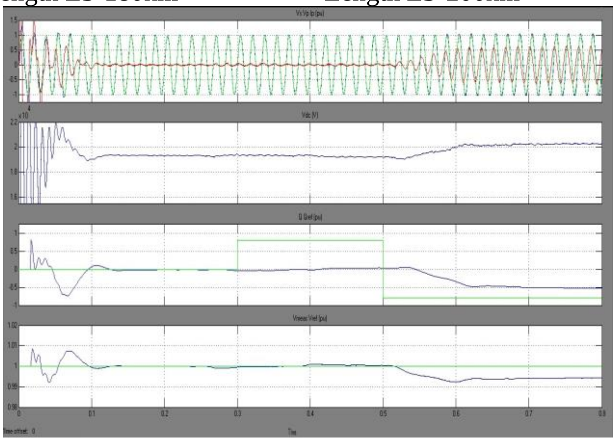

Fig.6. STATCOM based on existing model

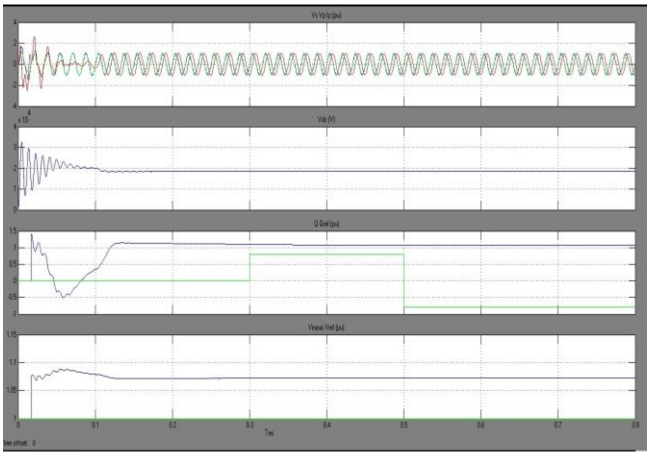

Fig.7. STATCOM based on new model

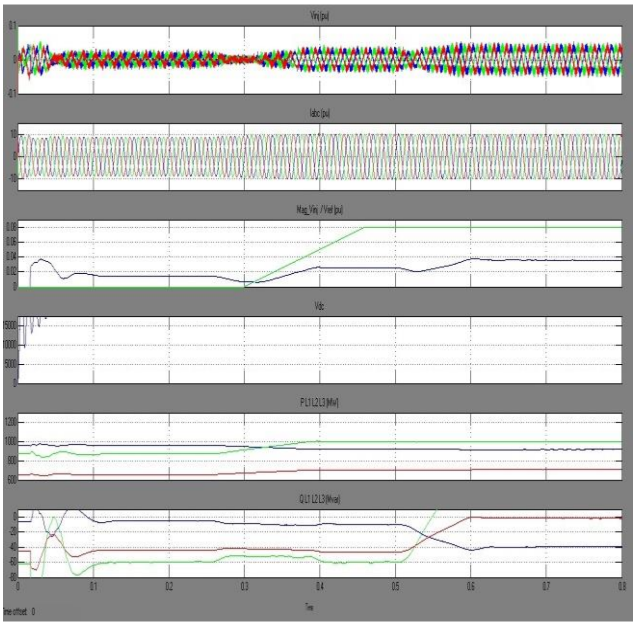

Fig.8. SSSC based on existing model

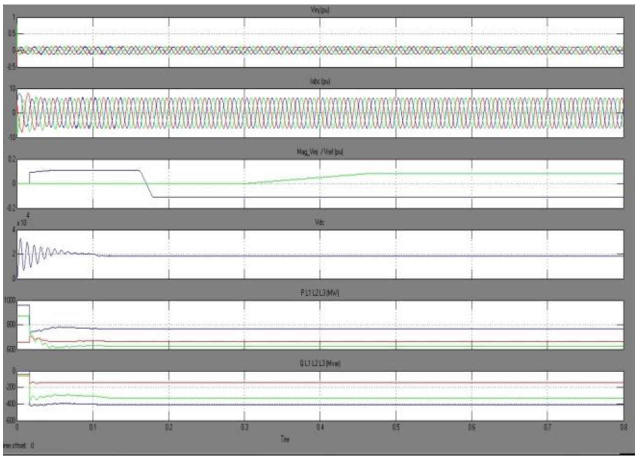

Fig.9. SSSC based on new model

VI. COMPARISON OF UPFC ON VARIOUS CONTROL STRATEGIES

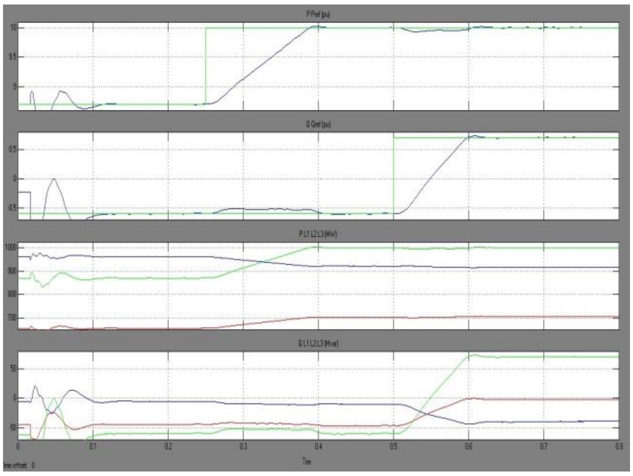

Fig.10. UPFC based on existing model

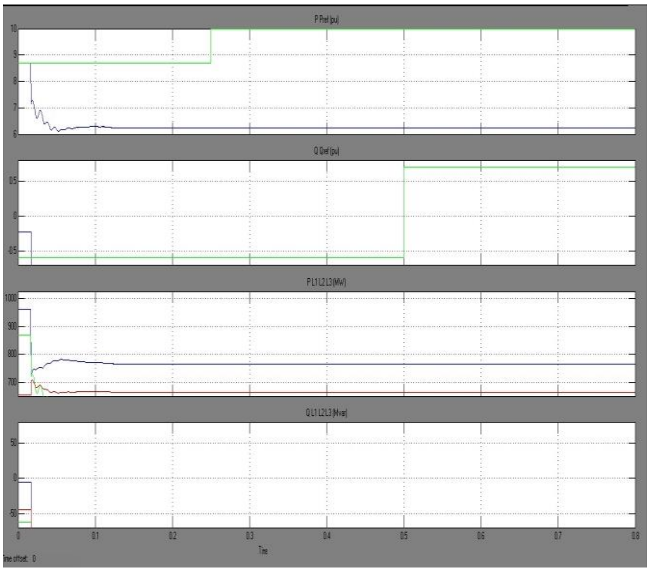

Fig.11. UPFC based on new model

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VII. CONCLUSION

In this paper we have compared the results of the new model with an existing model by changing the line 1, line 2 and line 3 values. We got better results in comparison to the existing model for UPFC. We have used STATCOM based control strategy and compared with the new model.

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