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Compensated Power through Unified Power Flow Controller

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***Abstract— R*ecent time compensated power play a important role in the electrical transmission of power, UPFC FACTs device is better for electrical power compensation. FACTs devices are based on power electronics components and the UPFC model is control through multilevel inverter. Pulse width modulation technique used for switching and control the inverter in UPFC system. The multilevel inverter technology has got recently as a very important in the area of electrical power transmission for controlling of power at high frequency and voltage. This paper presents the simulation model of five level inverter for controlling the UPFC system in the transmission line also present the compensated power through it with the comparison of without UPFC transmission line.**

Keywords: UPFC, Compensated Power, MLI, PWM, MATLAB and simulink.

I. INTRODUCTION

Unified power flow controller (UPFC) has been the most versatile Flexible AC Transmission System **(FACTS)** device due to its ability to control real and reactive power transmission lines while controlling the voltage of the **bus** to which it is connected. UPFC being a multi-variable power system controller it is necessary to analyze its effect on power system operation [1]. Fixed series capacitors help in increasing stability limits in an interconnected power system. With transmission open access, each transmission system owning utility will increase their transmission capacity to attract more utilities to use its transrnission facilities. Many existing power systems have already made the use of series compensation to increase their transmission capacity [2].

Control of power flow by series compensation means that by changing the amount of impedance in the circuit, the current in individual transmission lines are varied thereby varying the power flow in it. In essence, it controls only the magnitude of the current in a transmission line. Hence the reactive power demand at the end points of the line is determined by the transmitted real power in the same way **as** if the line **was** uncompensated but had lower line impedance [3].

Phase angle compensation is a method of controlling power flow and has been used in many existing systems. Phase shifters by themselves do not cause SSR. Phase shifters have the advantage of initiating sub-synchronous resonance modes (**SSR)** caused by series capacitors. A phase shifter by no means increases the maximum amount of real power transfer, but can improve transient stability. The operation of a phase shifier is such that, it represents a small inductance in sense with the line which leads to increased reactive power consumption in the line **as** compared with the uncompensated line.

Advances made in the field of solid state devices have made it possible to combine the functionality of series, shunt and phase angle compensation into one device. Such a device has been named the unified power flow controller (UPFC). It **has** the ability to control real and reactive power flow in a transmission line, while simultaneously regulating the voltage of the bus to which it is connected. UPFC does not cause SSR**.** By using a UPFC many distributed FACTS devices could be eliminated in the transmission line, thereby reducing capital costs. Also, the problem of unwanted interactions between the FACTS devices could be reduced to **a** little issuer extent, if not completely. As seen from the industry point of view, the unified approach of controlling power flow promises simplified design, reduction in equipment size and installation labor, and improvements in system performance [2].

The UPFC, which was proposed by L. Gyugyi in 1991 [4], [6], [7], is one of the most complex FACTS devices in a power system today. It is primarily used for independent control of real and reactive power in transmission lines for a flexible, reliable and economic operation and loading of power system. Until recently all four parameters that affect real and reactive power flow on the line, i.e. the line impedance, voltage magnitudes at the terminals of the line or power angle, were controlled separately using either mechanical or other FACTS devices such as a Static Var Compensator (SVC), a Thyristor Controlled Series Capacitor (TCSC), a phase shifter, etc.

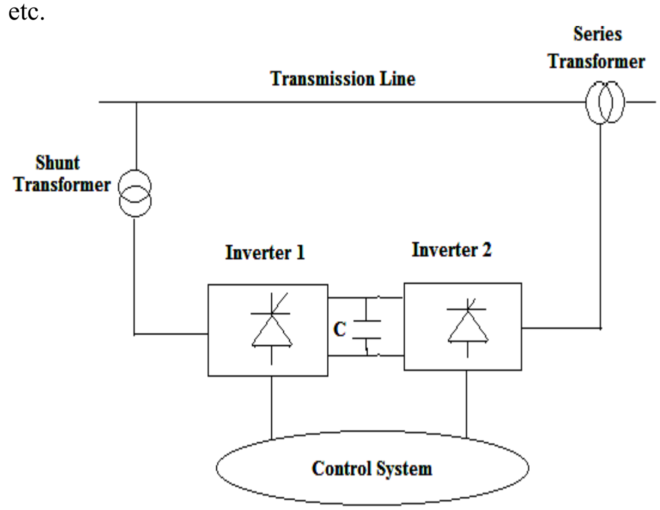

Figure 1: The basic diagram of UPFC

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However, the UPFC allows simultaneous or independent control of these parameters with transfer from one control scheme to another in real time. Also, the UPFC can be used for voltage support, transient stability improvement and damping of low frequency power system oscillations. Because of its attractive features, modeling and controlling an UPFC have come into intensive investigation in the recent years.

II. UNIFIED POWER FLOW CONTROLLER

A. Constructional Details

A particular concept called Unified Power Flow Controller is unified power flow in the transmission line. It is a unique combination of shunt and series compensation and power flow optimization. STATCOM (Static Synchronous Compensator) and SSSC (Static Synchronous Series Controller) are used for shunt and series combination respectively shown in figure 1. The basic roll of the STATCOM to flow active power demanded by the SSSC and also supply or absorb reactive power. SSSC used for the supply of active power in the line. Capacitor C is a DC link that allows the flow active power between the output terminal of SSSC and output terminal of STATCOM. Shunt transformer used as a step down transformer and series transformer as a step up.

B. Working Principal of UPFC

The main operation of inverters, inverter 1 connected through the transmission line in series, with transformer and inverter 2 in shunt with the transmission line through a second transformer. The DC terminals of the inverter are connected together with dc link capacitor.

In this model of UPFC, inverter 1 convert the AC to DC and also the real power flows from the AC side to AC side (inverter operation) if the inverter 2 output voltage is controlled to increases the AC system voltage. If the converted output voltage is made to decreases the AC system voltage the real power will flow from the AC side to DC side (rectifier operation). Inverter action is carried out by the MOSFETs while the rectifier action is carried out by the diodes. Two switches on the same leg cannot be on at the same time. The magnitude of the inverter output voltage controls the reactive power exchange between the converter and the AC system [5].

If the magnitude of the converter output voltage is greater than the magnitude of the AC system voltage. If the magnitude of the converter output voltage is less than that of the AC system the converter will absorb reactive power. This all the conditions made by the fluctuation of load side when load are increases voltage level will be decreases but load are decreases the over voltage condition will be occur at receiving end. Over voltage and voltage drop can be controlled by the use of UPFC in the transmission line.

Pulse Width Modulation technique used for this UPFC controller because this technique is an old conventional technique for switching of MOFET, IGBT and also power electronics switches.

III. SIMULATION ENVIRONMENT

The transmission line model is shown in figure 2.

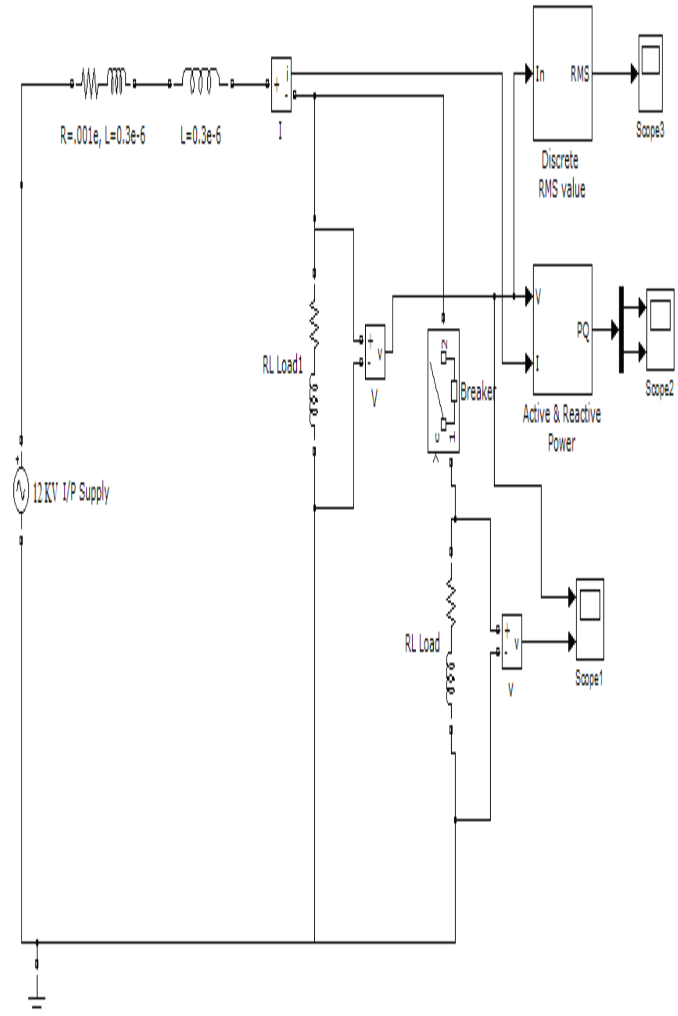

Figure 2: Single line diagram of transmission line

The line circuits model without UPFC system shown in figure 2 that this line is also called as without compensated line model. This circuit have 12 KV supply, R= $0.001*10^3\Omega$, L=$0.3*10^{3}*2$ H With two RL load, one is connected and other is disconnected from the supply through circuit breaker. The designed UPFC system will be connect in the transmission line model shown in figure 4.

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. Discrete RMS value component and active reactive power block gives the result in the scope.

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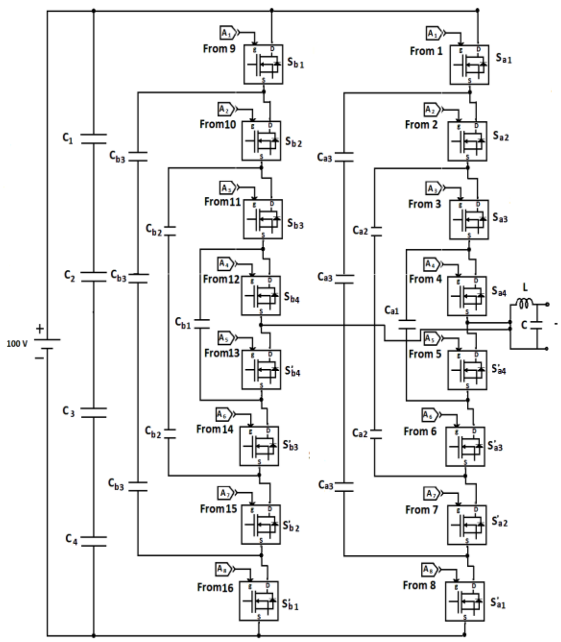

Figure 3: Simulation model of Multilevel Inverter

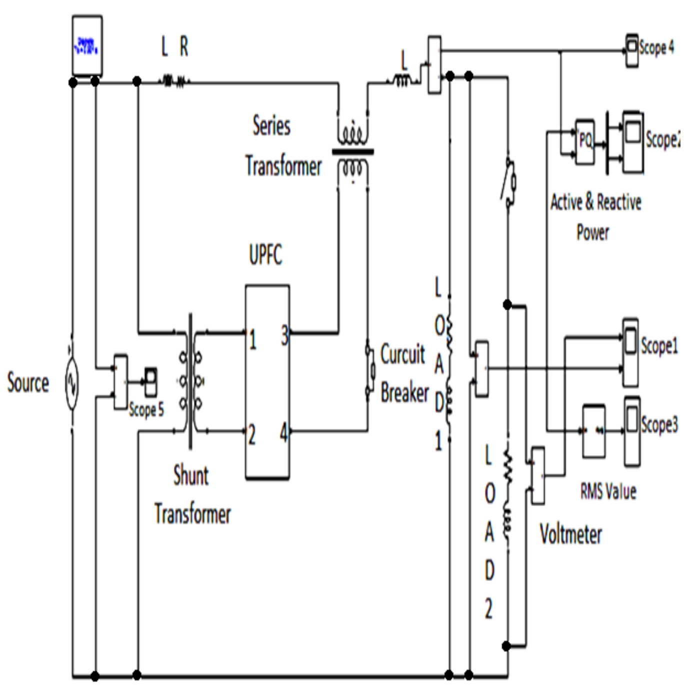

Figure 4: Line model with UPFC

Table: Comparative result analysis at different voltage level

Input in KV	Active Power (KW)		Improved in (%)	Reactive Power (KVAR)		Improved in (%)
	Without UPFC	With UPFC		Without UPFC	With UPFC	
3	40	178.8	22.36	10.12	87.50	11.57
6	170	760	22.36	40.50	350	11.57
12	680	3040	22.36	160.50	1387	11.57

It can be seen that in the above table without and with UPFC line model the value of active and reactive power from the simulation results valuable changes that's very important for improvement of reactive power compensation.

IV. CONCLUSION

In the simulation study, matlab simulink enviroment is used to simulate the model of Multi level inverter based UPFC. This paper presents the control & performance of the UPFC used for reactive power improvement. It is found that there is an improvement in the real and reactive powers in the transmission line when UPFC is introduced. The UPFC system has the advantages like reduced harmonics 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 from this effect improve the power shown by table.

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