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To Minimize the Losses in a Transmission Line by Using UPFC

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Abstract : **The concept of Flexible Alternating Current Transmission system (FACTS) brought radical changes in the power system operation and control. A new technique using FACTS devices linked to the improvements in a semiconductor technology opens new opportunities for controlling the power and enhancing usable capacity of the existing transmission lines. The Unified Power Flow Controller (UPFC) is the most versatile and complex power electronic equipment that has emerged for the control and optimization of power flow in electrical power transmission system. This paper presents real power, reactive power and power factor control through a transmission line by placing UPFC at the different lengths of transmission lines. When no UPFC is installed, real and reactive power losses in the transmission line can't be controlled. This research deals with simulation of transmission line using UPFC to improve the real power, reactive power and power flow control through a transmission line. In this research paper a Simulink Model is considered with UPFC model to evaluate the performance of a single and double transmission line of the transmission systems.**

Keywords: **AC transmission system, FACTS Devices, Power flow control, UPFC.**

I. INTRODUCTION

Most of the large power system blackouts, which occurred worldwide over the last twenty years, are caused by heavily stressed system with large amount of real and reactive power demand and low voltage at the buses. When the voltages at the system buses are low, the losses will be increased. This study is devoted to develop a technique for improving the voltage, minimizing the loss and hence eliminate voltage instability in a power system. Thyristor Controlled Series Capacitors (TCSC), Thyristor Controlled Phase Shifting Transformer (TCPST) and Static Var Compensator (SVC) can maintain the voltage in power system as well as, can control the active power through a transmission line. Unified Power Flow Controller (UPFC) is a versatile FACTS device which can independently or simultaneously control the active power, the reactive power, and the bus voltage to which it is connected. Following factors can be considered in the optimal installation and the optimal parameter of the UPFC, active power loss reduction, stability margin improvement, the power transmission capacity increasing and power blackout prevention. UPFC was proposed for real time control and dynamic compensation of Alternating Current transmission systems, providing the necessary functional flexibility required to solve many of the problems which are being faced by the these day industry. Many advantages in power system include UPFC such as minimization of system losses, elimination of line over loads and the low voltage profiles. Over the years, it has become clear that the maximum safe operating capacity of the transmission system is often based on voltage and angular stability rather than on its physical limitations. In the recent years ecological concerns and high installation costs have put constraints over construction of new plants and overhead lines in many of the countries, thereby forcing existing system to be used more efficiently rather than constructing new system of lines, industry has tended towards the development of technologies or devices that has increased transmission network capacity while maintaining or even improving the grid stability . Our main objective is to meet the electric load demand reliably while simultaneously satisfying the certain quality of constraints imposed on power supply. Therefore, it has become effective to the way of permitting a more efficient use of the transmission lines by controlling the power flows.

II. OPERATING PRINCIPLES OF UPFC

UPFC device has been selected in suitable location to reduce the losses i.e. to increase the active power, reduce the reactive power and improving the power factor profiles in the power system. 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. UPFC circuit is shown in Fig.1. Power flow through the transmission line depends on line reactance, bus voltage magnitudes, and the phase angle between sending and receiving end buses.

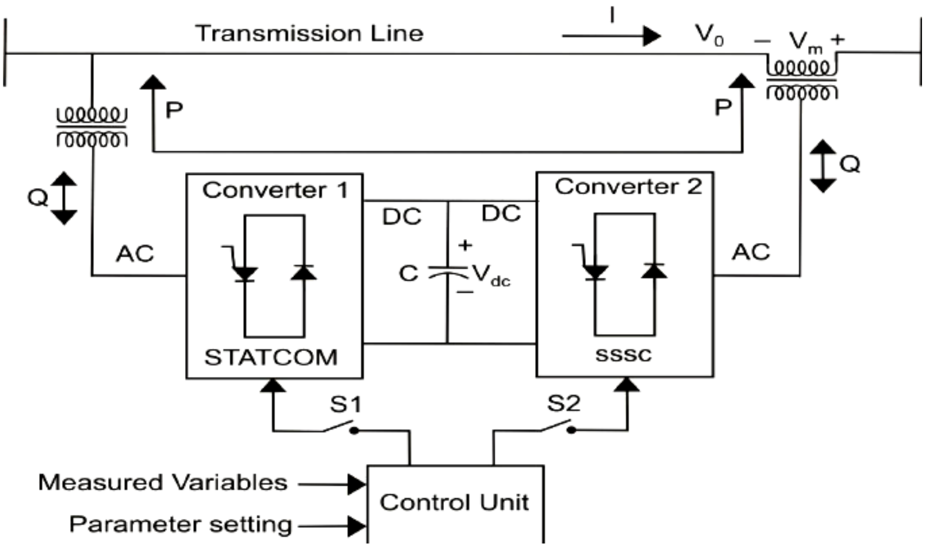

Fig. 1: UPFC schematic diagram

UPFC is capable of both supplying and absorbing the real and reactive power and it consists of two ac/dc converters. One converter is connected in series with the transmission line through a series transformer and the other converter is connected in parallel with the line through a shunt transformer. The dc side of the two converters is connected through a common capacitor, which provides dc voltage for converter operation. As the series branch of the UPFC injects a voltage of variable Magnitude and phase angle, therefore it can exchange real power with the transmission line and thus improves the power flow capability of the line as well as its transient stability limit. The shunt converter exchanges a current of controllable magnitude and power factor angle with the power system. It is normally controlled to balance the real power absorbed from or injected into the power system by the series converter. The shunt converter (STATCOM) of the bus voltage/shunt reactive power is decomposed into two components. One component is in phase and the other in quadrature with the UPFC bus voltage. The series converter (SSSC) provides simultaneous control of real and reactive power flow in the transmission line. To this, the series converter injected voltage is decomposed into two components. One component of the series injected voltage is in quadrature and the other in phase with the UPFC bus voltage. The quadrature injected components controls the transmission line real power flow. In this paper a Simulink Model is developed to evaluate the performance of a single line and double line transmission system. The aim of this technique is to control the real and reactive power flow in the transmission lines, by effectively changing the firing angle of shunt converter and modulation index of the series converter of the two leg three phase converters based on UPFC.

III. INVESTIGATION OF TRANSMISSION LINE WITH UPFC

The MATLAB Simulink Model is shown in Fig.2 represents the double Line transmission model which consists of normal circuit and compensation circuit with an UPFC device.. The real power needed by the compensation circuit is exactly equal to the real power delivered by the normal circuit which includes both line and converter switching losses. Fig 2 shows the MATLAB Simulink model of single line diagram with UPFC When the length of transmission line L1=60KM, L2= 50KM, L3=45KM

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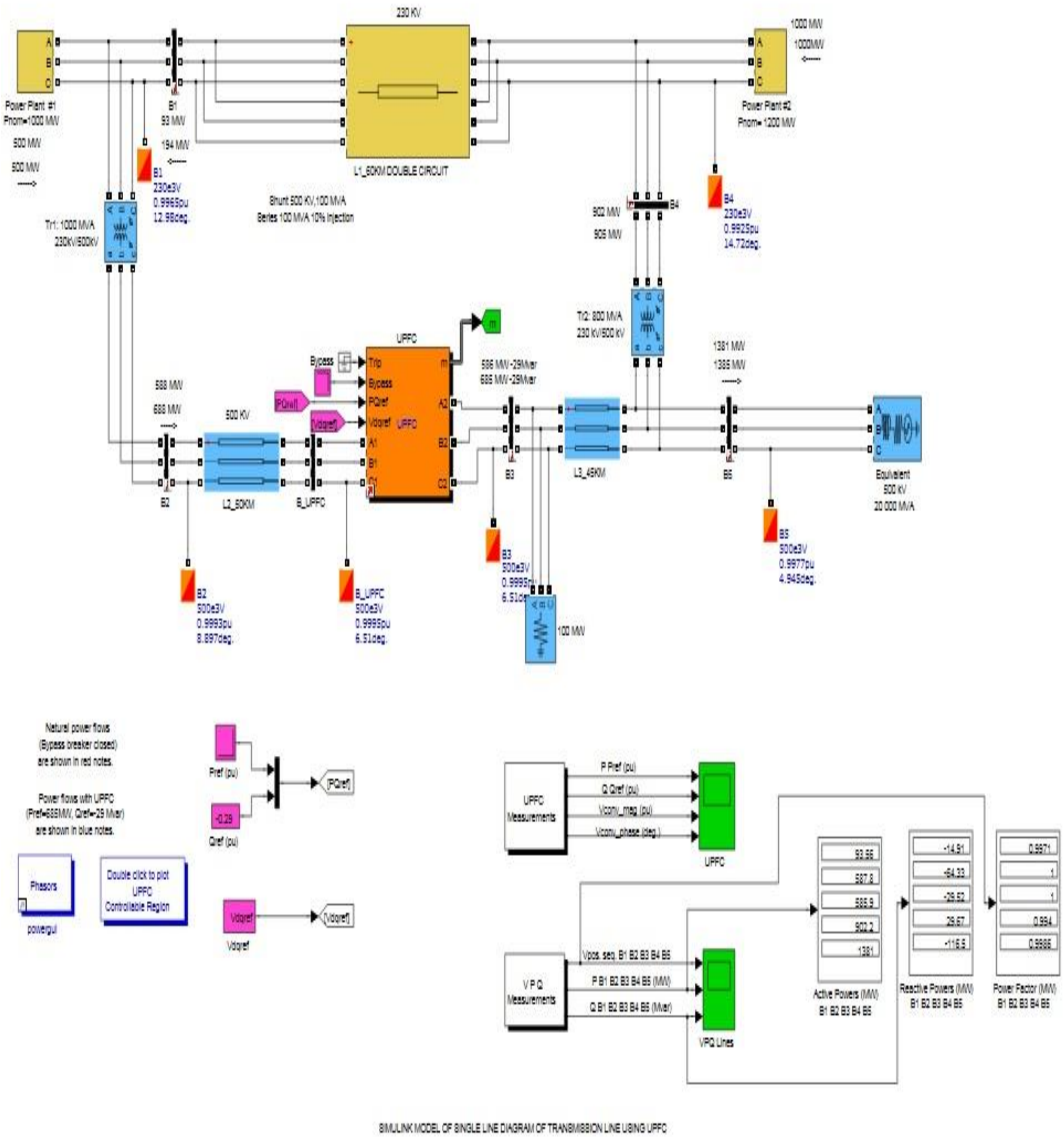

Fig. 2: MATLAB Simulink model of single line diagram at different lengths of transmission line using UPFC

A UPFC is used to control the power flow in a transmission system. The system is connected in a loop configuration, consists of five buses (B1 to B5) interconnected through transmission lines (L1, L2, L3) and two 500 kV/230 kV transformer banks Tr1 and Tr2. Two power plants located on the 230-kV system generate a total of 1500 MW which is transmitted to a 500-kV 20000-MVA equivalent and to a 100-MW load connected at bus B3. Each plant model includes a speed regulator, an excitation system as well as a power system stabilizer (PSS). In normal operation, most of the 1200-MW generation capacity of power plant #2 is exported to the 500-kV equivalent through three 400-MVA transformers connected between buses B4 and B5. The load flow shows that most of the power generated by plant #2 is transmitted through the 800-MVA transformer bank (899 MW out of 1000 MW), the rest (101 MW), circulating in the loop. Transformer Tr2 is therefore overloaded by 99 MVA. The demonstration illustrates how the UPFC can relieve this power congestion.

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The UPFC located at the right end of line L2 is used to control the active and reactive powers at the 500-kV bus B3, as well as the voltage at bus B_UPFC. It consists of a phasor model of two 100-MVA, IGBT-based, converters (one connected in shunt and one connected in series and both interconnected through a DC bus on the DC side and to the AC power system, through coupling reactors and transformers). Parameters of the UPFC power components are given in the dialog box. The series converter can inject a maximum of 10% of nominal line-to-ground voltage (28.87 kV) in series with line L2. The blue numbers on the diagram show the power flow with the UPFC in service and controlling the B3 active and reactive powers respectively at 687 MW and -29 Mvar.

IV. RESULTS

Table 1 shows the comparison of UPFC (fact device) of a circuit. In table 1 we have included the results of the active power, reactive power and power factor values of the different lengths of transmission lines. We have observed that at various lengths of the transmission lines, we concluded that by installing the UPFC at short length we have got more active power, less reactive power loss and also very good power factor as compared to other i.e., medium and longer lengths of the transmission line.

Table 1: Comparison between the values of UPFC at different lengths of transmission line

Buses	**For L1=20*Km*, L2=15*Km*, L3=10*Km***			**For L1=30*Km*, L2=20*Km*, L3=15*Km***			**For L1=40*Km*, L2=30*Km*,L3=25*Km***		
	Real Power	**Reactive Power Loss**	**Power Factor**	**Real Power**	**Reactive Power Loss**	**Power Factor**	**Real Power**	**Reactive Power Loss**	**Power Factor**
B1	254.1	-27.95	0.9938	209.7	-26.85	0.9942	160.5	-23	0.995
B2	748	-81.21	0.9964	704.4	-74.55	0.9967	655.2	-68,33	0.9975
B3	746.9	-65.25	0.9969	703.1	-55.65	0.9972	653.7	-44.16	0.998
B4	744	19.46	0.9944	787.3	22.4	0.9942	835.9	25.43	0.994
B5	1387	-146	0.9972	1386	-141.9	0.9974	1384	-133.5	0.9978
	For L1=50*Km*, L2=40*Km*, L3=35*Km*			**For L1=60*Km*, L2=50*Km*, L3=45*Km***			**For L1=70*Km*, L2=60*Km*, L3=55*Km***		
B1	123	-18.89	0.998	93.56	-14.91	0.9971	69.81	-11.18	0.9983
B2	617.6	-65.22	0.9986	587.8	-64.33	1	563.6	-65.03	1.002
B3	615.8	-35.7	0.999	585.9	-29.52	1	561.5	-35.05	1.002
B4	873.1	27.8	0.9939	902.2	29.67	0.994	925.7	31.16	0.994
B5	1383	-125	0.9982	1381	116.5	0.9986	1380	-108	0.9991
	For L1=80*Km*, L2=70*Km*, L3=65*Km*			**For L1=100*Km*, L2=90*Km*, L3=85*Km***			**For L1=120*Km*, L2=110*Km*,L3=105*Km***		
B1	50.29	-7.729	0.9995	20.27	-1.543	1.002	-1.523	3.884	1.005
B2	543.6	-66.95	1.003	512.1	-73.33	1.007	488.2	-82.25	1.011
B3	541.3	-21.91	1.003	509.5	-18.72	1.007	485.4	-18.35	1.01
B4	944.8	32.32	0.9941	974.1	33.89	0.9944	994.9	34.61	0.9948
B5	1378	-99.51	0.995	1374	-82.82	1	1370	-66.27	1.001

Parameters of Transmission lines	
No. of phases-3	**No. of phases-6**
Resistance/length- 0.01273Ω/km Inductance/length-0.9937H/km Capacitance/length-12.74f/km	Resistance/length- 0.068Ω/km Inductance/length-1.31H/km Capacitance/length-8.85f/km

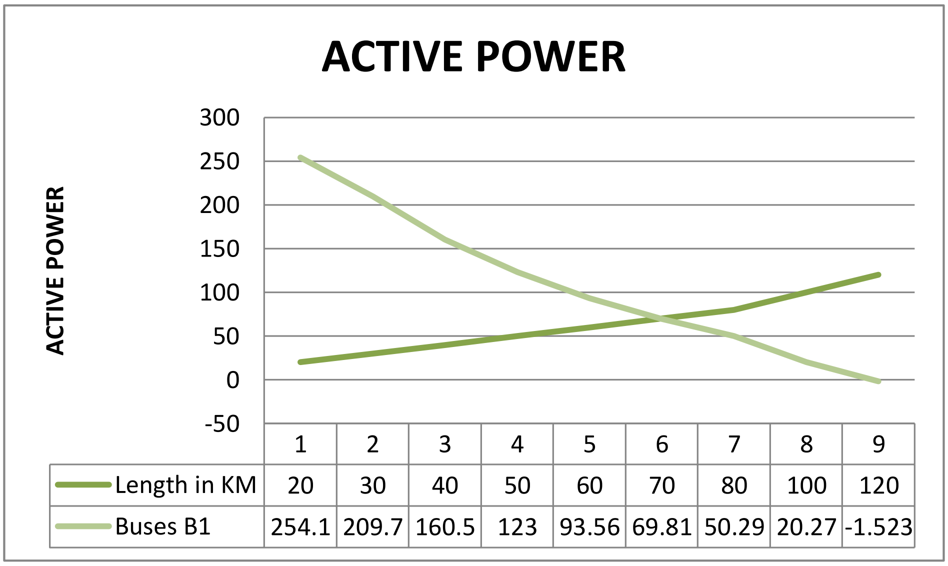

Figure 3 Active powers Comparison Plot for bus B1 for different lengths

As we see in the above Fig.3 we see that the comparison of active power for various length. We analyse from the line graph that the shorter length have more active power as compared to others.

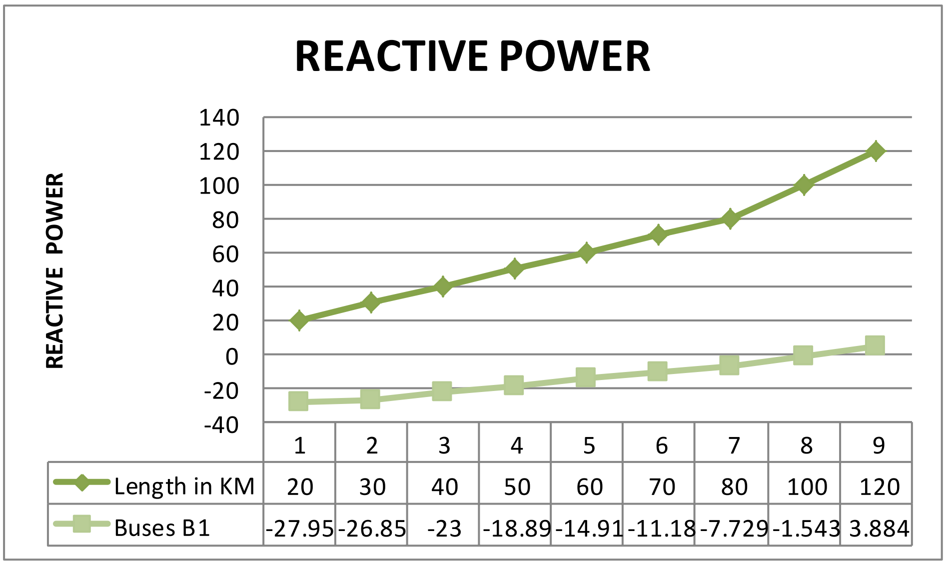

Figure 4 Reactive powers Comparison Plot for bus B1 for different lengths

As we see in the above Fig.4 we see that the comparison of reactive power for various length. We analyze from the line graph that the shorter length have less reactive power loss as compared to others.

V. CONCLUSION

In this paper various FACTs Devices has been studied and it is found that UPFC has the attributes of superior dynamic response and fast fault recovery as compared to other FACTs devices. It has been found that the performance of UPFC is higher for power system stability improvement in the transmission lines of shorter length. The UPFC system has the advantages like reduced maintenance & ability to control the active power, reactive power and power flow.

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