Improvement of Voltage and Control of Power Flows Using Unified Power Flow Controller

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Abstract: Modern power systems having many challenges because the load on the system will not be constant and ever more over it could be always subjected to contingencies which are undesirable. Due to the development in advanced power electronics and their control schemes, flexible AC transmission system (FACTS) technology has been introduced. Modern power electronics components used in FACTS have good performance characteristics and also it provides the better solution for contingency problems such as line outage, generator outage, system blackout congestion problems etc. There several types of FACTS controllers which gives better performance and projected unified power flow controller (UPFC) have more advantage over synchronous compensator (STATCOM), Thyristor controlled series compensator (TCSC), Static series synchronous compensator (SSSC) and Static VAR compensator (SVC). The UPFC is the most versatile and dynamic complex power electronic device that has emerged to control and optimization of real and reactive power flow in electrical power transmission lines. In this work UPFC increases the transmission power transfer capacity and reduces the power congestion in the transmission lines by improving voltage and control of power flows in the system.

Keywords: Flexible AC transmission system, voltage, power flows, Unified power flow controller.

I. Introduction

The power quality issues are so much increased in the latest time. So for power quality improvement the use of FACTS devices is increased and they become much popular compare to normal devices. Facts devices used power electronics devices to improve power quality [11] and providing control on voltage, current, power flow [12], stability, etc..of given transmission line or particular power system. FACTS [10] devices can be connected to the transmission line in different configurations like series with the power system (series compensation) and shunt with the power system (shunt compensation) and in some cases it will be connected in series and shunt compensation. Presently, it is well established in the scientific community that the UPFC [5] has the ability to increase the power flow capacity and improve the stability of an electric power transmission system through the proper design of its controller. In the series compensation the FACTS devices are connected in series with the power system and they will be working as a controllable voltage source. In shunt compensation power system has been connected in shunt [3] with the FACTS devices and they will be working as a controllable current source, were UPFC are connected in a series and shunt combination. Over the past several decades, linear and nonlinear control techniques have been successfully proposed and applied in the literature for the control of UPFC based on modern and classical control theories.

In this work UPFC [8] is injected into the power system to improve voltage and control power flows [6]. Simulation has been done accordingly, finally output revels UPFC installation helps in improvement of voltage [1] and power flow control at each bus in the power system, UPFC even performs better when extra load is added to the system.

II. List of Devices Considered for the Study

The study has been carried out by introducing UPFC in 5-BUS SYSTEM.

A. **UPFC:**UPFC is the combination of STATCOM and SSSC, Impacts both active and reactive power flow in transmission line fig1.The shunt converter (STATCOM) [13] is primarily used to provide active power demand of the series converter (SSSC) through a common DC link. STATCOM [14] can also generate or absorb reactive power and thereby provide independent shunt reactive compensation for the line. SSSC provides the main function of the UPFC [4] by injecting a voltage with controllable magnitude and phase angle in series with the line via an voltage source.

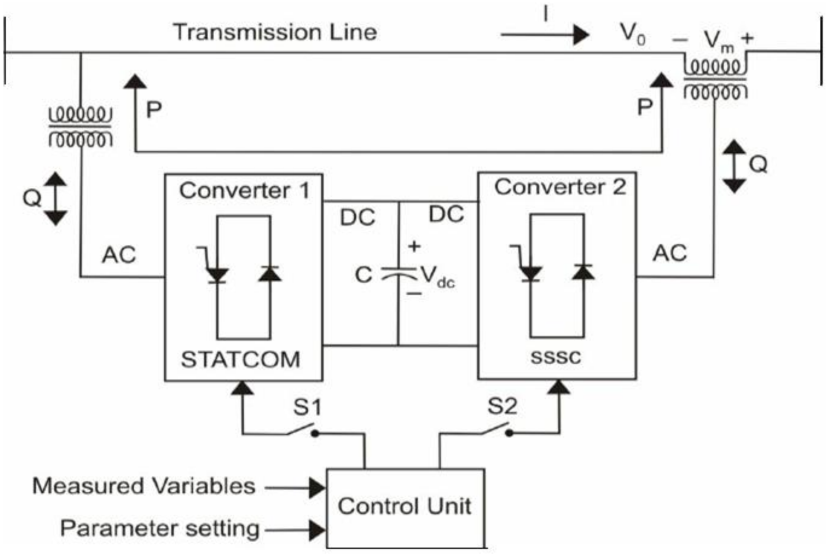

Fig 1. UPFC

III. System Considered For Simulation Study

The power system consists of 2 power plants, 2 transformers and buses. A UPFC is used to manage the power flow in a 500KV /230kV transmission systems. The system, associated with a loop arrangement, comprises of five buses (B1, B2, B3, B4, B5) joined by three transmission lines (L1, L2, L3) and two units of 500 kV/230 kV transformer banks named as Tr1 and Tr2. The plant models include a speed regulator, an excitation system as well as a power system stabilizer (PSS). In normal operation, most of the 1200MW generation capacity of power plant 2 is exported to the 500KV equivalent through three 400MVA transformers connected between buses B4 and B5.

The model of UPFC device would give two types of outcomes, Initial outcome is regarding the simulation at power flow adjustment module and second outcome is a voltage injection module. In the power control elements the series converter is at nominal 100 MVA with a peak voltage injection of 0.1 Pu. The shunt converter is also at nominal 100 MVA, Also in the adjustment elements that the shunt converter is in voltage adjustment module and that the series converter is in a power flow adjustment module. System parameters are shown in table1.

Case 1:-In case 1 UPFC is injected between transmission lines in a power system as shown in fig 2. By injecting UPFC, voltage has been improved at every bus by shunt converter were as power flow control as being done by series converter.

Case 2:-In case 2 an extra load of 200 MW is introduced in between transmission lines in power system as shown in fig 3 , in order to know whether the system performs voltage improvement and power flow control even when extra load was added.

Table 1:- System parameters

Shunt converter	500KV, 100MVA
Series converter	10%injection, 100MVA
Reference active and reactive power in UPFC	5.87MW, -0.27MW
Transformers rating	1000MVA, 230KV/500KV 800MVA, 230KV/500KV
DC link capacitor	2500e-6F

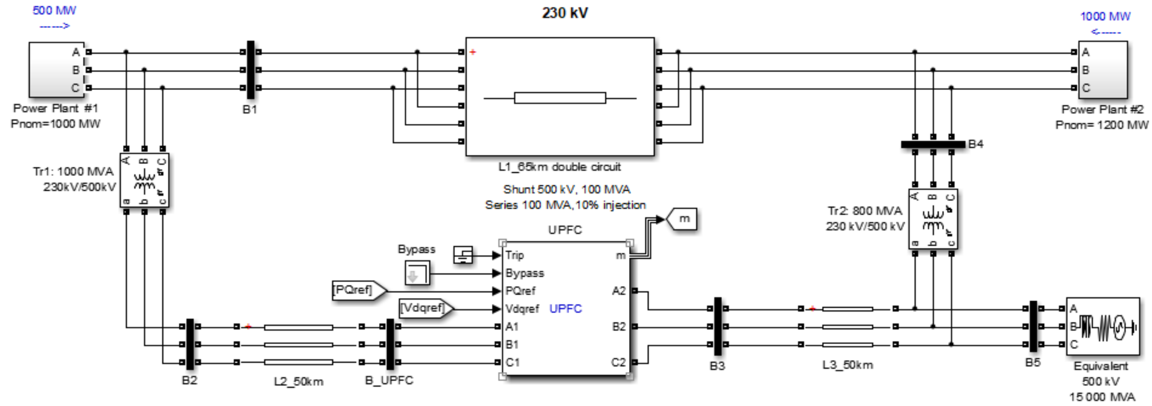

Fig 2: Simulation block diagram of the power system with a shunt UPFC device in MATLAB Simulink.

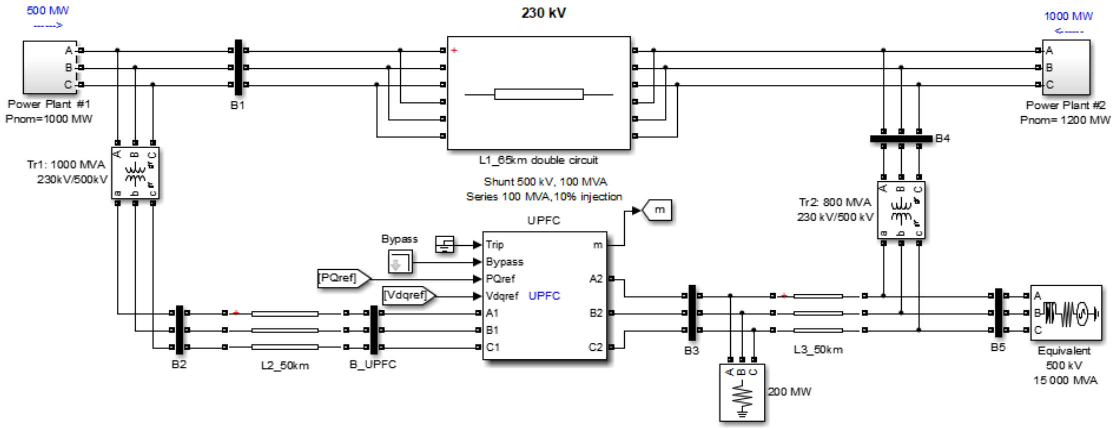

Fig 3: Simulation block diagram of the power system with a shunt UPFC device with extra load in MATLAB Simulink.

IV. Simulation Results

The simulation study of the system using UPFC has been discussed in this section. Fig 4 and 5 represent a voltage, active and reactive powers at buses when UPFC is injected into the power system. Table 2,3,4 represents the comparison of active, reactive powers and voltages of all buses in different cases. Were this comparison output revels UPFC installation helps in improvement of voltage and power flow control at each bus in the power system, UPFC even performs better when extra load is added to the system.

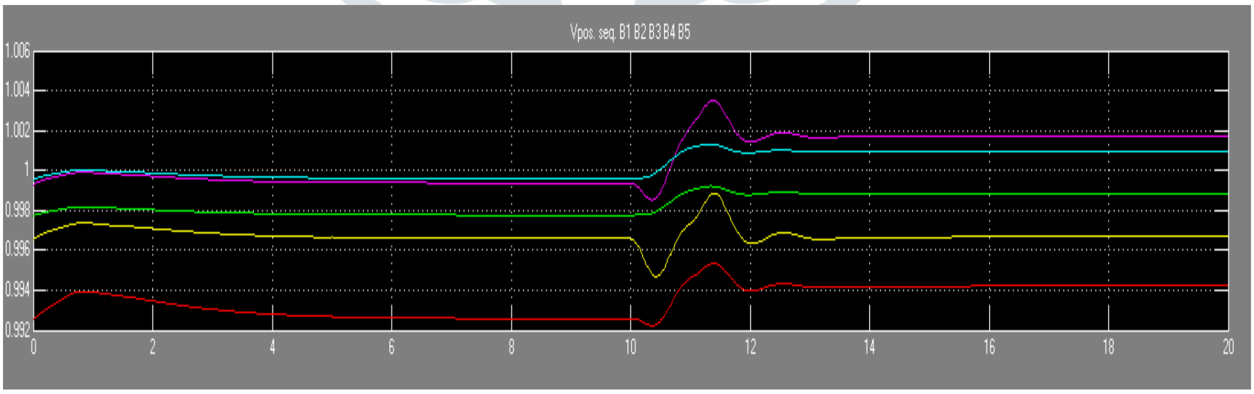

Fig 4: Voltage at buses when UPFC injected into the power system, (X-axis represents time(sec), Y-axis represents voltage(pu)).

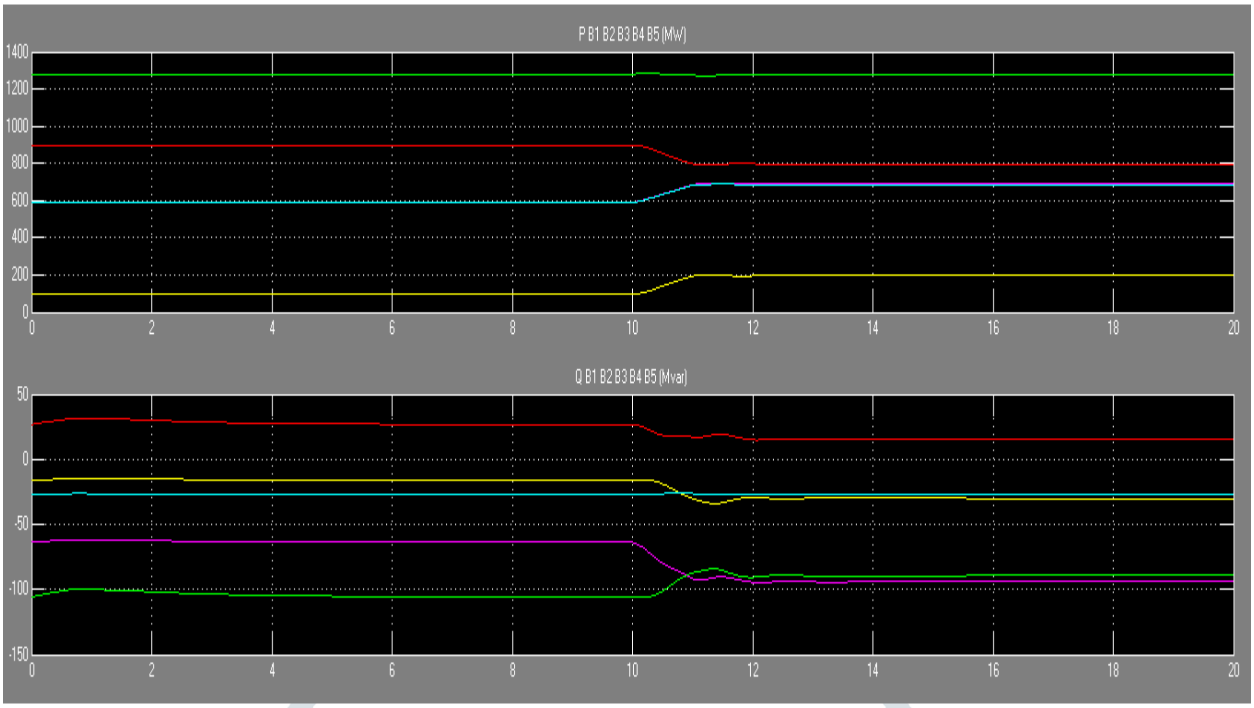

Fig 5: Active power and Reactive power at buses when UPFC injected into the power system, (X-axis represents time(sec), Y-axis represents reactive /active power(pu)).

Table 2: Comparison of active power at different cases.

Buses	Without UPFC	With UPFC	With UPFC and extra load
B1	95.2	193.5	196.6
B2	588.7	686.6	689.7
B3	586.99	683.9	687
B4	898.76	799.1	796
B5	1279.2	1476	1277

Table 3: Comparison of reactive power at different cases.

Buses	Without UPFC	With UPFC	With UPFC and extra load
B1	-16.35	-31.47	-30.06
B2	-63.3	-98.16	-94.05
B3	-27.79	-27	-27
B4	26.62	19.3	15.57
B5	-106.45	-102.9	-89.32

Table 4: Comparison of voltage at different cases.

Buses	Without UPFC	With UPFC	With UPFC and extra load
B1	0.9965	0.9971	0.9967
B2	0.9993	1.003	1.002
B3	0.9995	1.001	1.001
B4	0.9925	0.994	0.9942
B5	0.9977	0.998	0.9989

V. Conclusion

At first analysis has been done for a power system with and without installation of UPFC, after that extra load 200MW was added to the system. Comparison of active, reactive power and voltages of buses has done in different cases. This comparison output revels that UPFC installation helps in improvement of voltage and power flow control at each bus in the power system, UPFC even performs better when extra load is added to the system.

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