



# Enhancement of Power Flow on 500KV Interconnected Power System using UPFC

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**Abstract:** Presently continuous demand in electric power system network has caused system to be heavily loaded leading to voltage instability. The control of power and the usable capacity enhancement of existing as well as new and upgraded line can be effectively done by Flexible Alternating Current Transmission System (FACTS) technology. FACTS technology opens new opportunities for controlling power flow and enhancing the usable capacity of present, as well as new lines. The Unified Power Flow Controller (UPFC) is the most promising FACTS device for power flow control. This project describes the performance of UPFC for effective control of active and reactive power flow on a 500 KV interconnected lines for the purpose of compensation as well as enhancement of power transmission capability of transmission line. To evaluate the performance of UPFC, simulation was carried out in MATLAB/SIMULINK environment. The simulation results reveal that UPFC device has an excellent capability to enhance real and reactive power flow.

Index Terms – Power Flow, STATCOM, SSSC, UPFC, MATLAB.

## 1.Introduction

The technology of power system utilities around the world has rapidly evolved with considerable changes in the technology along with improvements in power system structures and operation. The continuing expansions and growth in the technology, demand a more optimal and beneficial operation of a power system with respect to generation, transmission and distribution system . In the present scenario, most of the power systems in the developing countries with large interconnected networks share the generation reserves to increase the reliability of the power system.

However, the growing complexities of large interconnected networks had fluctuations in reliability of power supply, which resulted in lack of system stability, difficult to manage the power flow and security problems that resulted large number blackouts in different parts of the world. The reasons behind the above fault sequence. In order to overcome these consequences and to provide the desired power flow along with system stability and reliability, installations of new transmission lines are needed However , installation of new transmission lines with the large interconnected power system are limited to some of the factors like economic cost, environment related matters . These complexities in installing the transmission lines in a power system challenges the power engineers to research on the ways to increase the power flow with the existing transmission line .

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the system stability and reliability will also become better. This technology of power electronic devices is termed as Flexible Alternating Current Transmission Systems (FACTS) technology provides the ability to increase the Alternating Current Transmission System (FACTS) is an application of a power electronics device to control the power flow and Controllability and the transmission system operation in terms of power flow, stability limits with advanced control technologies in the existing power systems will become good FACTS technology is not a single power electronic device.

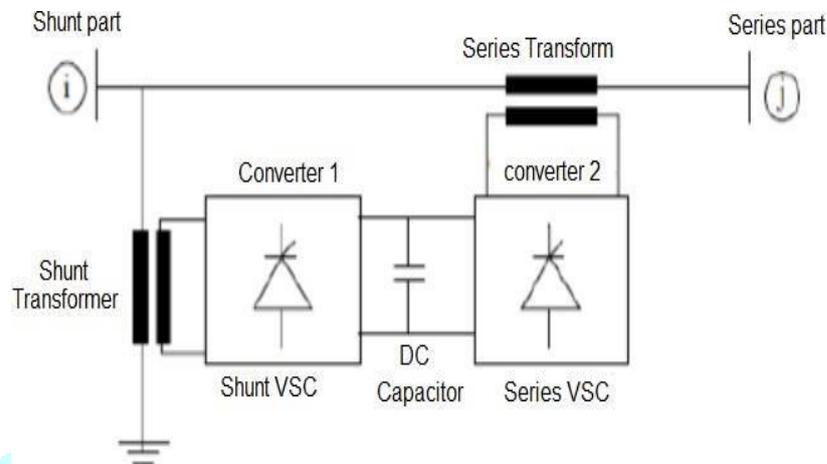


Figure 1: UPFC Basic Configuration Arrangement

## 2. Materials And Methods

The UPFC model has been designed and running in MATLAB under 48 pulses and GTO base united power movement control with 500 kV and 100 MVA. The UPFC is use to switch the flows of power in 500 kV transmissions systems which is located at the end of 75 km. Among 500 kV bus B2 and B1, the UPFC is use to monitoring the reactive and active power flows via bus B2 whilst voltage controlling at the B1 bus. This system contains three levels. two 100 MVA, 48 pulses GTO converter, one connection in shunts buses B1 and other one connection in sequence among B2 and B1. The series and shunts converters could be changed the power via DC buses and the series converter could be injected as extreme of 10% of nominals lines to grounds voltages 28.87 kV in serially within line L2. In three mode of operation, this pair of converters could be operating as UPFC mode, static synchronous compensators, and statics synchronous capacitors. The UPFC mode is used when the series and shunt converter is interconnecting via DC buses and in case of disconnected switch between DC bus of series and shunt converters are opened for further mode available. The compensators are used as shunt converter operation to control the voltage at bus B1. The capacitors convertor is used in case of series conversion that operates to control the injected voltages whilst keep injected voltages in quadrature with the currents. The reference power value, reference voltage value, and mode of operation could be change under UPFC GUI blocks. Hence, in case of 2- converter is operating in UPFC model, the converters of shunt are operating at STATCOM conditions. It used to control the voltage of B1 bus by control the generated reactive power or absorbed, while allow active power transfer to series converters via DC buses. The four 3-level shunt converter operates at constant conduction angles as 180 and 172 degrees. Therefore, generate the quasi sinusoidal 48 steps voltages waveforms. At 49<sup>th</sup> and 47<sup>th</sup>, the first harmonics are happened. In case of UPFC mode was operated, the serially inject voltage magnitude is vary through varies the conductions angles. Hence, high harmonic content is generated than the shunt converters. In addition, when the series converters operate at SSSC mode, the true 48 pulse waveforms were generated. In case of zero voltage is generating by series converter, the natural power flow via B2 bus is equal to 870 MW and in the mode of UPFC the phase angle and magnitude of series injected voltages could be vary to allow for power control.

By keeping the injection voltages to maximum values, the UPFC controllable area is obtained with varied phase angle from 0-360 degree. Figure 2 shows the UPFC model that design and running in MATLAB under 48 pulses and GTO base combined power flows control with 500 kV and 100 MVA

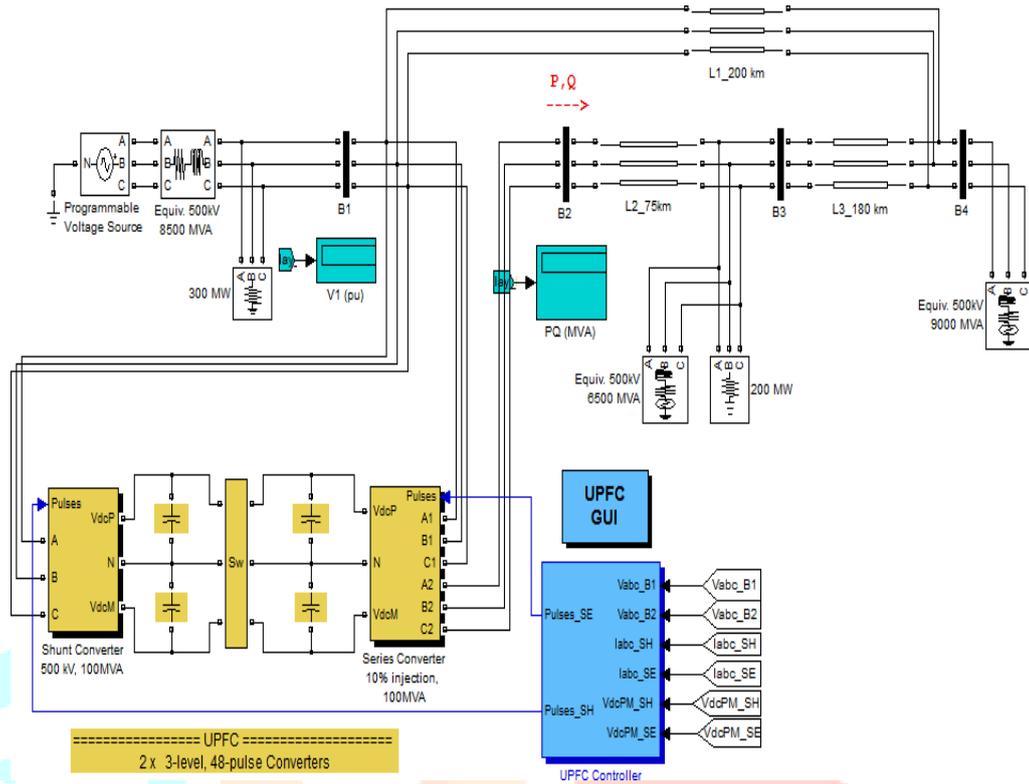


Figure 2: UPFC mode in MATLAB with 500 kV and 100 MVA

### 3. Simulation of UPFC Mode

The operation mode of SSSC, STATCOM, UPFC, reference power, reference voltage, and Q reference has been designed and running via GUI interface that allow to select any of these modes. To observe the dynamic responses of control systems, one could specify the steps changes to any references values at specific time by using GUI. Hence, the operation mode is set to UPFC and reactive/active reference of power are specified in the last two line. Initially, reference power is set to + 8.7 MW and Qref. sets to - 0.6 and PU= 100MW. Formerly, at t= 0.25 second and the reference power is changed to +10 (1000 MW). At t=0.5 second, the Q ref. is change to 0.7 and the reference voltage of shunt converters will be kept constant at V=1 during all simulation. In case of UPFC is set to powers controller modes, the change in STATCOM references sensitive power in SSSC inject voltages are unused. Then, the DC voltage bus vary in 19 kV ranges and after zooming the primary traces of SSSC scopes, one could detect the inject voltages waveform among B2 and B1.

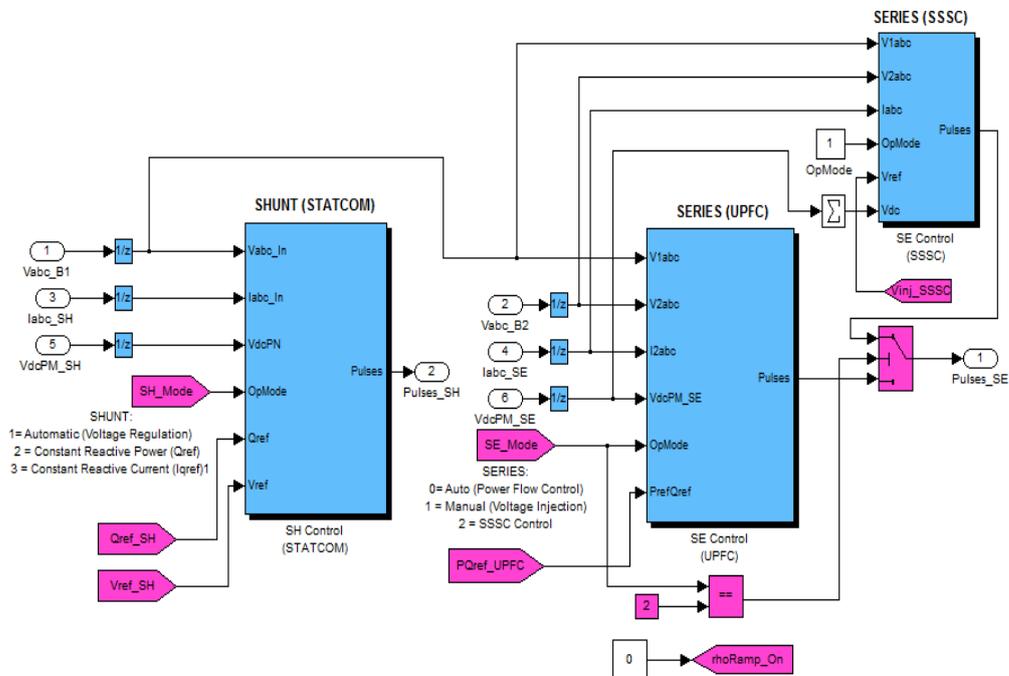


Figure 3: Controller Model of UPFC mode

#### 4.Simulation of STATCOM Modes

The operation mode is changed to the STATCOM and ensure that the reference values are set to 0.3, 0.5, - 0.8, and +0.8. The model is operated in this mode as variable sources of reactive power. First of all, the Q is sets to zeros and formerly at t= 0.3 second, the Q is increase to +0.8 and observed reactive powers at t=0.5 second and the Q is reverse to -0.8. After the model was running, the dynamic response has been observed with the trace zooming around t = 0.5 second in case of Q is changed from +0.8 to -0.8. The current flow into STATCOM mode when the Q equal to +0.8 is lagging voltages which is indicates that the model is absorbing reactives powers. In addition, when the Q is change from +0.8 to - 0.8, the phase of current is shifted with respect to the change of voltage from 90 degree lagging to 90 degree which lead with one cycle. Through varying the secondary voltage produced by shunt converter, the reactive power controlling could be obtained while keep it in phase with the B1 voltages. These changes of Vs magnitude are performing through controlling the DC buses voltages. In case of Q changed by +0.8 to -0.8, the traces voltage increased by 17.5 to 21 kV.

#### 5.Simulation of SSSC modes

The operation mode is changed to the SSSC to simulate this mode of voltage injections with ensure that this mode reference value is set to 0.0, 0.08, and 0.3 and the initial voltages are set to zero and the at t=0.3 seconds will ramp to 0.8. conflicting to the UPFC mode, the series inverter at SSCC mode operate with constant conducting angle at

172.5 degree. The injection voltage magnitude is control through varying the DC voltage that proportion to injection voltages in third traces. This will observe the injection voltage waveforms in first trace and the current flow during the SSCC in second traces. The current and voltages stay in quadrature hence the SSCC in second traces. Therefore, the SSCC operation as variable capacitors and inductances as shown in Figure 4.



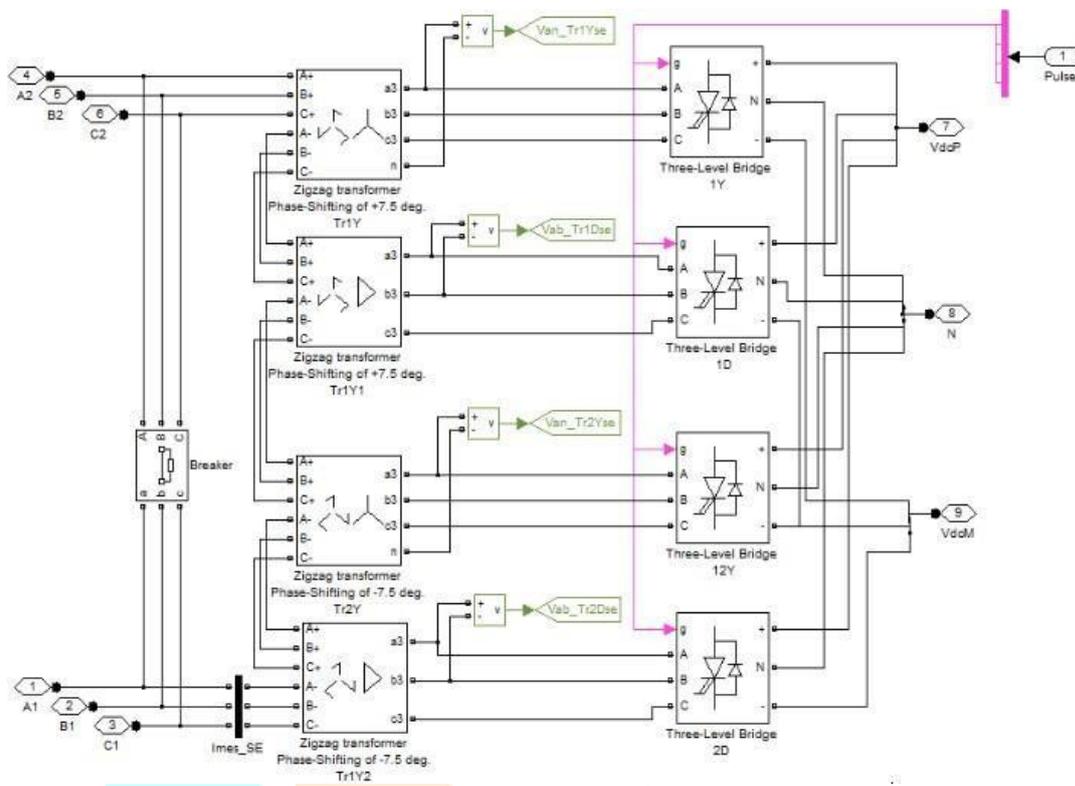


Figure 6: Series Converter 10% injection,100MVA, 48 pulse switches converters

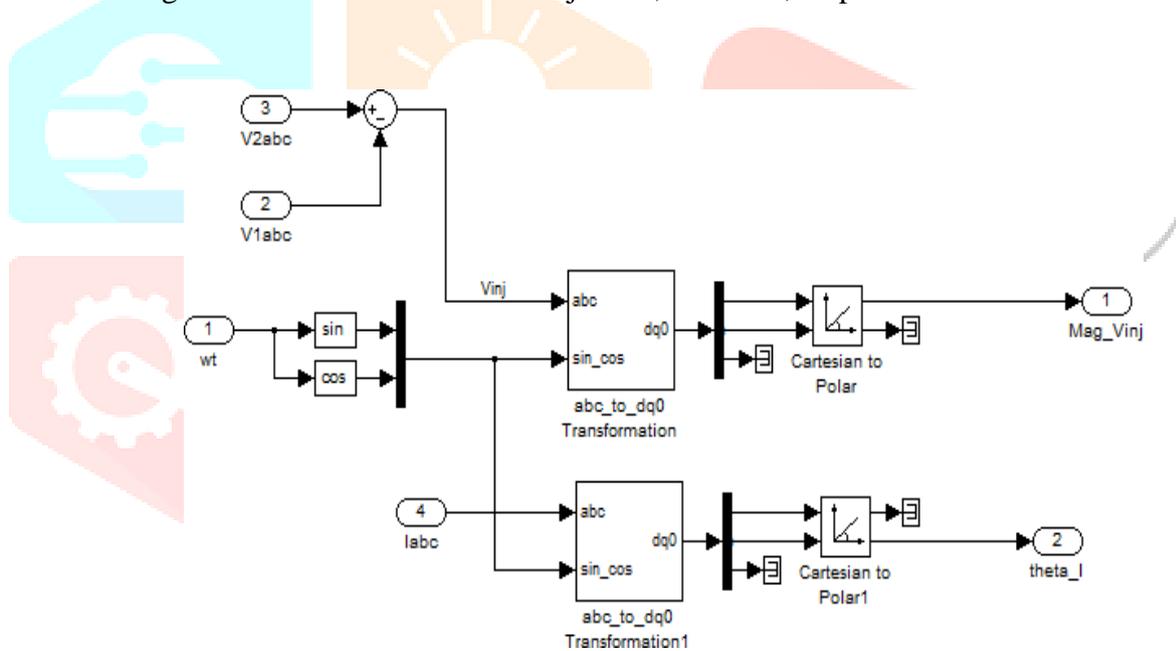


Figure 7: firing pulsed generator





Figure 9: the responses of active power in two transmission line after UPFC

The active power flows in line one increase to 1000 MW after the activation of UPFC while this power reduced in line two from 980 to 920 MW. This increasing in real power tend to decrease the congestion on the lines and make it more flexibles as illustrated in above figure. Hence, one could observe the result change in active power flows on line 2 that interconnect in the suggested model.

## 7. Conclusion

This project introduces the UPFC controller on 500 kV transmission systems to provide the possibilities of install and run this model in different conditions. To control the reactive and active power flow, the UPFC applications could be investigated and examined by using MATLAB/SIMULINK environments in this work. The interconnect lines between two power system (B1 and B2) have been simulated to control the performance of UPFC intend for installations on the transmission lines. The obtained results demonstration the efficiency of UPFC controller in reactive and active power flows during the transmission line which indicate the possible responses of controlling process is debauched than the current model. practically, prompt and therefore the UPFC is operative in treatment dynamics responses in the systems.

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