Power Quality Enhancement By Using UPFC

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***Abstract-* A prime complication of a power system engineer is energy crisis, the provocation of energy crisis is due to tremendous need of energy in distribution sector. It is probable to diminish the energy crisis issue by upgrading the power system but it's a time consuming, difficult, and expensive aspect, this problem can be vanquished by preferring Flexible AC Transmission Controllers. FACTS controllers comprises of many controllers such as SVC,SSSC,UPFC,IPFC, etc which can control the power system parameters (real and reactive power, voltage, phase angle. The most essential controller in FACTS controllers is Unified Power Flow Controller(UPFC).The Unified Power Flow Controller(UPFC) is a most versatile FACTS device for real and reactive power flow control and voltage regulation. By incorporating UPFC in our modern power system it is possible to control the power flow thereby decreasing the energy crisis to greater extent. UPFC can provide simultaneous control of real and reactive power flow by modeling the power system in MATLAB- SIMULINK, thereby improving the performance, power quality and voltage profile in the power system.**

Keywords: UPFC; SVC; SSSC; UPFC; IPFC

1. INTRODUCTION

The impact of increase in industrialization has lead to the tremendous increase in electrical energy demand in order to satisfy the demand there is the need to upgrade the electrical system by constructing new transmission lines, substations, and associated equipment but up-gradation is extremely difficult, time consuming and expensive. Hence FACTS technologies provide optimal alternative solutions. A Flexible Alternating Current Transmission System (FACTS)[2] is a system composed of static equipment used for the AC transmission of electrical energy. It is meant to enhance controllability and increase power transfer capability of the network. It is generally a power electronics-based system.

The FACTS controllers can be classified as

1. Shunt connected controllers
2. Series connected controllers
3. Combined series-series controllers
4. Combined shunt-series controllers

Depending on the power electronic devices used in the control, the FACTS controllers can be classified as

(A) Variable impedance type
(B) Voltage Source Converter (VSC) based.

The variable impedance type controllers include:

(i) Static Var Compensator (SVC), (shunt connected)
(ii)Thyristor Controlled Series Capacitor or compensator (TCSC), (series connected)
(iii) Thyristor Controlled Phase Shifting Transformer (TCPST) of Static PST (combined shunt and series)

The VSC based FACTS controllers are:

(i)Static synchronous Compensator (STATCOM) (shunt connected)
(ii) Static Synchronous Series Compensator (SSSC) (series connected)
(iii)Interline Power Flow Controller (IPFC) (combined series-series)
(iv)Unified Power Flow Controller (UPFC) (combined shunt-series)

Incorporating FACTS devices especially Unified power flow controller (UPFC) the power quality and reliability of system is improved. UPFC can provide simultaneous control of real and reactive power flow by modeling the power system in MATLAB- SIMULINK, thereby improving the performance, power quality and reliability of the power system.

2. UNIFIED POWER FLOW CONTROLLER

Unified power flow controller is an important FACTS controller device by which it is possible to control the power flow in power system transmission line.
The benefits of UPFC are as follows
A. It is possible to control and improve active and reactive power flow
B. Voltage regulation can be done.
Single line diagram of UPFC is shown in figure1. A UPFC comprises of a shunt and series converter, series converter is connected to the transmission line in series by a series transformer where as shunt converter is connected to a transmission line by shunt transformer.

2.1 OPERATION OF UPFC

The basic components of the UPFC are two voltage source inverters (VSIs) sharing a common dc storage capacitor [1] 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 series transformer.

The series inverter is controlled to inject a symmetrical three phase voltage system (Vc), of controllable magnitude and phase angle in series with the line to control active and reactive power flows on the transmission line. So, this inverter will exchange active and reactive power with the line. The reactive power is electronically provided by the series inverter, and the active power is transmitted to the dc terminals.

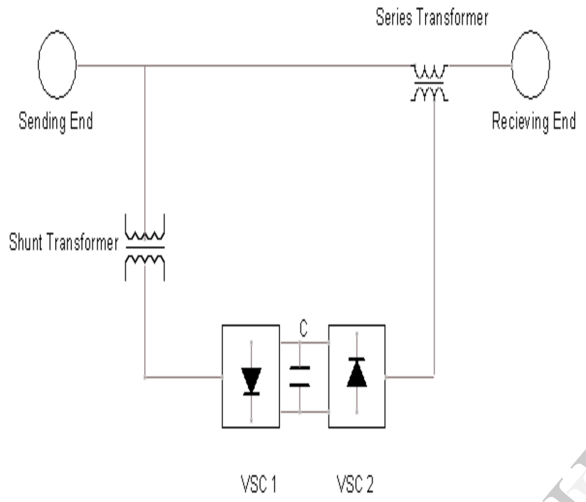

Figure 1 Unified Power Flow Controller in Transmission System

The shunt inverter is operated in such a way as to demand this dc terminal power (positive or negative) from the line keeping the voltage across the storage capacitor Vdc constant. So, the net real power absorbed from the line by the UPFC is equal only to the losses of the inverters and their transformers. The remaining capacity of the shunt inverter can be used to exchange reactive power with the line so to provide a voltage regulation at the connection point. The two VSI's can work independently of each other by separating the dc side. So in that case, the shunt inverter is operating as a STATCOM (Static Synchronous Compensators) that generates or absorbs reactive power to regulate the voltage magnitude at the connection point. Instead, the series inverter is operating as SSSC (Static Synchronous series compensators) that generates or absorbs reactive power to regulate the current flow, and hence the power flows on the transmission line.

3. MODELING OF UPFC

Modern power system can be modeled by using simulink. The figure 2 shows single line diagram of 66KV transmission network. This system is a real time system where shivansamudra is a generating station where in the power is generated and this power is transmitted to sathegala which is a load region.

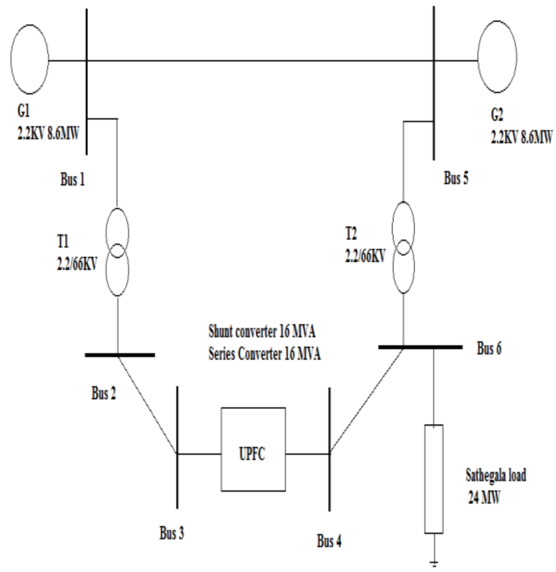

Figure 2 Shows Single Line Diagram 2.2KV/66KV Transmission System

3.1 DESCRIPTION OF SINGLE LINE DIAGRAM

A UPFC is incorporated to control the power flow in a 2.2KV/66KV transmission systems. The system, connected in a loop configuration, consists essentially of five buses (B1 to B6) interconnected through three transmission lines (L1, L2, L3) and two 2.2 kV/66 kV transformer banks Tr1 and Tr2. Two power plants located on the 2.2kV system generate a total of 17.2 MW (illustrated in figure 2) which is transmitted to a 66 kV, to a 23 MW load connected at bus B5 at Sathegala.. For the illustration purpose a contingency case is considered where Transformer T2 is tripped due to failure or for maintenance purpose resulting in power interruption to the sathegala load. By incorporating UPFC in the system this problem can be overcome. The UPFC located between the bus 3 and bus 4 will allow power flow control in the line. The power output of generator1 is combined with the UPFC power (shunt and series) converter. UPFC converters are configured to provide 15MW in order to satisfy the load. The series converter will inject voltage in 0.1 pu improving the voltage profile of the system, and provide necessary real power and reactive power to the power system.

3.2 Explanation of Simulink Model

Single line diagram of the transmission network shown in figure 2 is modeled in matlab-simulink tool which is shown in the figure 3. the important keys in the model are

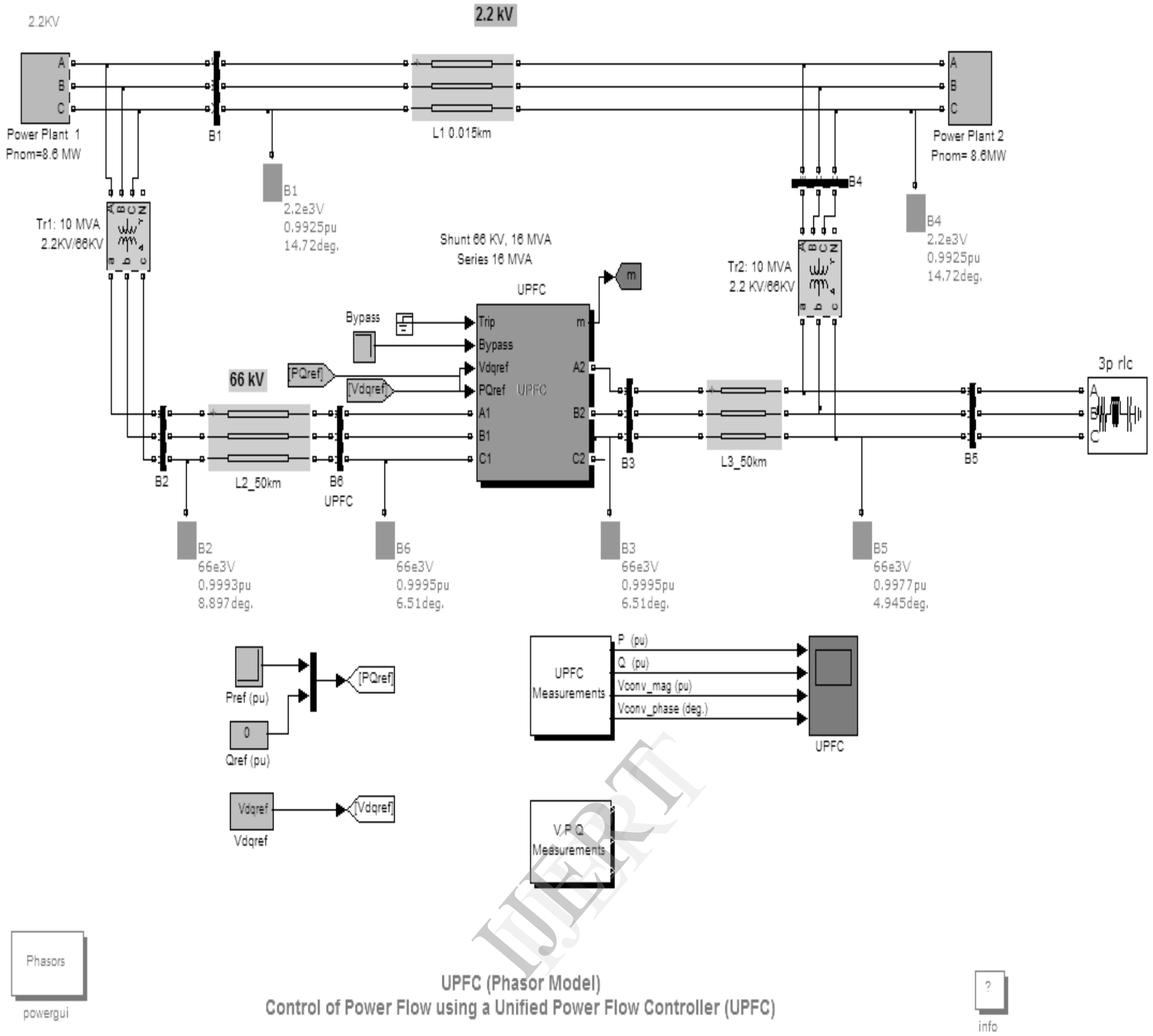

Figure 3 Shows Modeling of Single Line Diagram in Simulink

A. Use of Bypass breaker used to connect or disconnect UPFC block from system.

B. Sinks which provide UPFC simulation waveform.

C. The reference power inputs [P Qref] – Reference for power flow control

D. The reference voltage Vdref – Reference for voltage injection

4. SIMULATION RESULTS

UPFC is included in the system by selecting external control of bypass breaker. The breaker is operated at 5sec leading to the inclusion of UPFC block in the transmission network. The function or objective of UPFC is commenced from T=5sec resulting in the injection of voltage and power. The necessary simulation result waveform with inclusion of UPFC and without inclusion of UPFC is shown in figure 4 and 5.

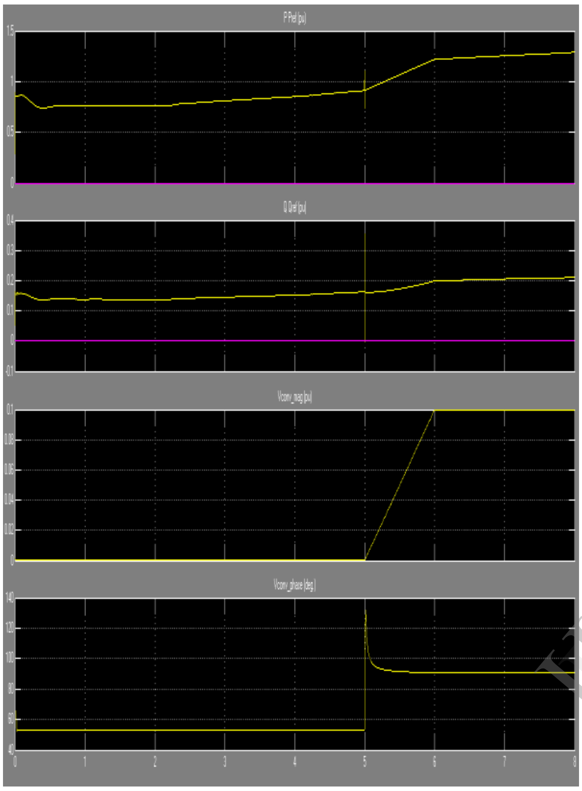

Figure 4 Shows Simulation Result of the Modeled System with UPFC

The following observations are made with UPFC block in the system

A. Active power injection is commenced as the UPFC block is included in the system.

B. The series converter injects the voltage of magnitude of 0.1pu.

C. Reactive power and voltage phase angle is also improved 0.05 pu, 40 degree respectively.

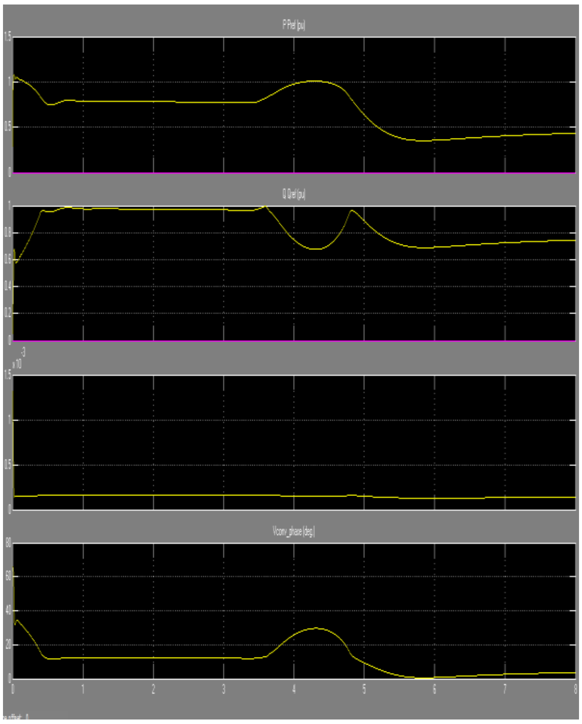

Figure 5 Shows Simulation Result of the Modeled System without UPFC

The following observations are made without UPFC block in the system

A. At t=0 to 5 sec there is power flow in the system.

B. When the UPFC block is isolated from the system with the help of bypass breaker, there is decrease in the power magnitude, voltage profile and bus angle.

5. CONCLUSION

Real and reactive power, voltage are the factors which determine the quality of power. By incorporation of UPFC in the system has lead to the control of power flow in the modern power system.

The energy demand can be satisfied, with the help of UPFC even though the generator unit or transformer unit is being tripped . The series converter in the UPFC injects the necessary voltage magnitude of 0.1 pu resulting in the improvement of voltage profile. The UPFC block in the system has provided real power and reactive power compensation, thereby enhancing the power quality in the modern power system.

6. REFERENCES

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