

SINGLE PHASE UNIFIED POWER FLOW CONTROLLER WITHOUT DC LINK

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Abstract : The main focus of this paper is Flexible AC Transmission System (FACTS) Device known as the Unified Power Flow Controller (UPFC). We know that UPFC has unique capability to control simultaneously real and reactive power flows on a transmission line as well as to regulate voltage at the bus where it is connected, this class of FACTS device creates a tremendous quality impact on power system stability [2]. These features become even more significant knowing that the UPFC can allow loading of the transmission lines close to their thermal limits, forcing the power to flow through the desired paths. The most cost-effective way to estimate the effect the UPFC has on a specific power system operation is to simulate that system together with the UPFC by using one of the existing simulations packages. Specifically, the objective of this paper is to develop a single phase UPFC model that can be incorporated into existing MATLAB [3,9]. As it is known that UPFC has two parts one is in shunt and other is in series with the transmission line, but in conventional UPFC these two parts are connected and designed to install in one corner of power grid. An attempt, in this paper had made to separate or extend the series part and shunt part of UPFC. This gives the possibility to installed series and shunt part of UPFC at different required locations. Finally the responses of two modified DC link UPFC is compared.

Index Terms—FACTS (Flexible AC Transmission System), UPFC (Unified Power Flow Controller), VSC (Voltage Source Converter), STATCOM (Static Synchronous Compensator), SSSC (Static Synchronous Series Compensator).

I. INTRODUCTION

In this world of ever expanding consumers the design of a particular device is to be done with utmost care. It is well known that with the help of present over head (OH) transmission line it will become impossible to laying a new transmission line for increase in consumers to supply them their electric needs. So to supply the electric need of every consumer after 10-20 years we have done to lay a new transmission line as these so called FACTS devices are available in the market. Unified power flow Controller (UPFC) is the most versatile converters among the Flexible

AC Transmission System (FACTS) devices[2]. It comprises of two voltage source converters (VSC), one is connected with parallel with transmission line to insert a reactive power in the transmission line and other is connected with series with the transmission line to insert active power in the transmission line, by this way this converter will compensate the reactive power and active power all together or independently. As the exchange of active and reactive power is taking place in between the shunt and series part, the location of series and shunt part is of most important.

The power system stability, efficiency and disturbance problems in power system are undefined in the grid. To improve the power system stability efficiency, the shunt part of Unified Power Flow Controller UPFC should be located in the place from where it can decrease the effect of voltage changes and the series part should be located in the place where its parameter changes effect the variation of active and reactive power the most. As to fulfill the above requirement here, the actual function of single phase UPFC with modified DC link between the Series and Shunt parts of conventional UPFC is presented in the paper.

For simulation in MATLAB 7.0 [9] Version is used to obtain the actual wave form of the injected voltage to the shunt part of Unified Power Flow Controller (UPFC), output active and reactive power wave form and the line current wave form.

The DC link of Conventional UPFC has been modified with first totally eliminated this DC link whose responses are observed and then DC link has been modified with lengthened the DC link as in field and one extra transmission line need to be lay. Finally the combined responses are compared for simplicity here in the paper. Various observations are made only on a single phase Unified Power Flow Controller (UPFC) [5].

The main problem we are facing here in transmitting power with eliminated DC link is the present of harmonics which required harmonics filters at both the end. The main problem was in power exchange between series and shunt part of UPFC [5]. Here the problem is solved by simply lengthening the DC connector between the series and shunt part and other part is grounded to overcome the problem of harmonics. Ignoring the cost involved in laying one extra line, this approach can be used to improve the system

stability condition using UPFC with lengthening DC link, and where we can install the UPFC in our required location.

The systematic diagram is:-

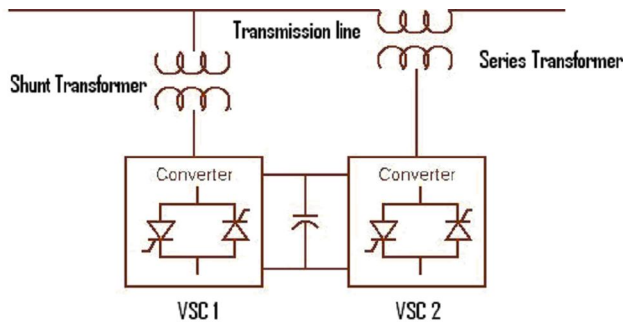


Fig: 1 Unified Power Flow Converters

II. PROPOSED TOPOLOGY

To improve the power system stability efficiency, the shunt part of Unified Power Flow Controller (UPFC) should be located in the place from where it can decrease the effect of voltage changes and the series part should be located in the place where its parameter changes the effect of the variation of active and reactive power the most.

For the above reasons, normally in a power system network, shunt and series devices should be located at different places. However, because of the power exchange, the shunt and series parts of the UPFC have to be at the same location. The paper presents a new method of power transmission through existing power line but at different frequency, which gives freedom to separate the series and shunt part of the Unified Power Flow Controller (UPFC). The single phase power system is with UPFC is constructed in MATLAB simulation and the comparison have been made [3,9].

The basic components of the UPFC are two voltage source inverters (VSI's) sharing a common dc storage capacitor, and connected to the system through coupling transformers [8]. One VSI is connected in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer.

A basic UPFC functional scheme is shown in Fig.1. The series part is controlled to inject a symmetrical three phase voltage system, V_{se} , of controllable magnitude and phase angle in series with the line to control active and reactive power flows on the transmission line. So, this shunt and series parts will exchange active (P) and reactive power (Q) with the line.

The reactive power is electronically provided by the series inverter, and the active power is transmitted to the dc terminals. 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 V_{dc} constant. So, the net real power absorbed from the line by the UPFC is equal only to the losses of the two inverters and their transformers.

Block Diagram is:-

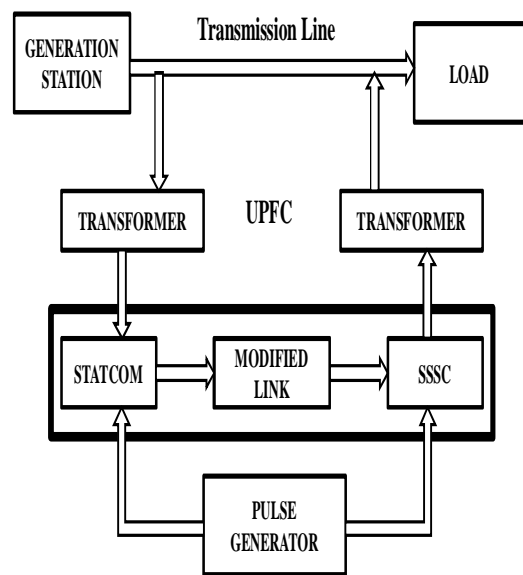


Fig: 2 Block Diagram of Modified UPFC

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 that generates or absorbs reactive power to regulate the voltage magnitude at the connection point. Instead, the series inverter is operating as SSSC that generates or absorbs reactive power to regulate the current flow, and hence the power flows on the transmission line[1]

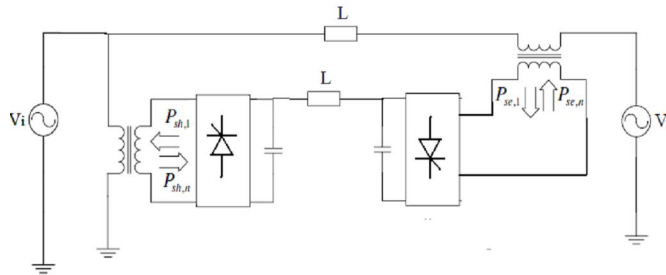


Fig: 3 Schematic Diagram of separated UPFC

In above figure shows that the single line diagram of extended UPFC with line impedance L , here the a DC line is extended to the distribution side with only a single line. The two condensers are used to balanced instantaneous difference in the fundamental power. The shunt part and Series part of UPFC can be separated to desired location. V_i and V_j represents the two terminal voltages on two bus bar, this UPFC is installed in between the two section of bus bar (i & j).

In this mode of operation, the series voltage injected by the SSSC is a two dimensional quantity with both quadrature and in phase components relative to the line current, and it is therefore able to independently control both the real and reactive power flow down the transmission line. Depending on the desired real and reactive power, these components of series injected voltage are automatically and continuously adjusted to respond to any system change[1].

The UPFC is seen by the transmission line as a high impedance power source or sink. It is in this mode that the UPFC yields best advantage over conventional compensating devices as it provides simultaneous, real-time control over all basic power system parameters.

The transmission line voltage is maintained at a certain reference level by regulating the shunt reactive current injected by the STATCOM. This thesis considers the detailed modeling of a STATCOM as a part of a larger UPFC model but does not consider the performance of a standalone STATCOM in ac transmission systems.

A STATCOM is comparable to a Synchronous Condenser (or Compensator) which can supply variable reactive power and regulate the voltage of the bus where it is connected. The STATCOM exchange reactive power with the grid. The exchange of reactive power between the converter and the grid can be varied by the amplitude of the three-phase STATCOM voltage.

DC side voltage is automatically maintained to serve as a voltage source. Mostly, STATCOM is designed based on the

VSI. The switching device of a VSI is usually a gate turn-off device paralleled by a reverse diode; this function endows the VSI advanced controllability. Various combinations of the switching devices and appropriate topology make it possible for a STATCOM to vary the AC Output voltage in both magnitude and phase. Also, the combination of STATCOM with a different storage device or power source.

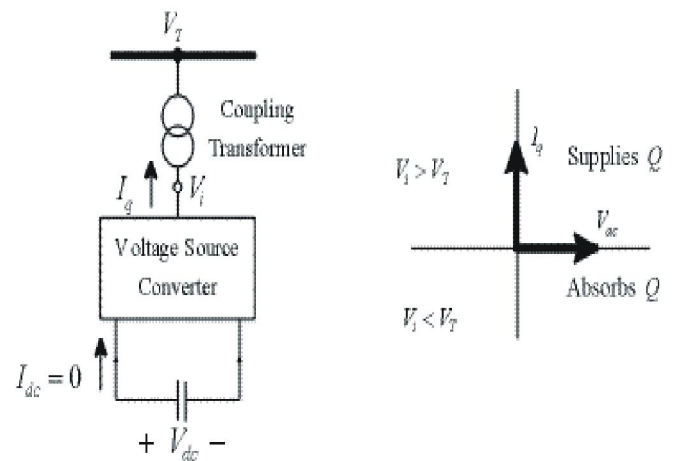


Fig: 4 Schematic Diagram of STATCOM

STATCOM the ability to control the real power output. STATCOM has much better dynamic performance than conventional reactive power compensators like SVC. The gate turn-off ability shortens the dynamic response time from several utility period cycles to a portion of a period cycle.

STATCOM is also much faster in improving the transient response than a SVC. This advantage also brings higher reliability and larger operating range. Static synchronous compensator is a regulating device used on AC transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. I_q is the converter output current and is perpendicular to the converter voltage V_i . The magnitude of the converter voltage and thus the reactive output of the converter (Q) is controllable.

It is static synchronous generator operated without an external electric energy source as a series compensator. It is independent of the line current for changing the overall reactive voltage drop. It has energy absorbing devices to increase the dynamic behavior of the system by adding real power to momentarily change in real voltage drop in the

line. SSSC can inject a voltage lagging or leading the current.

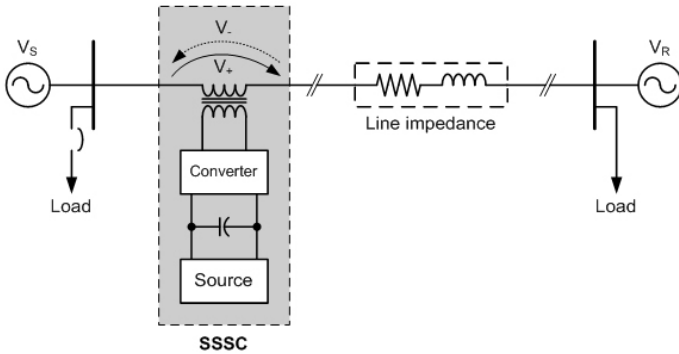


Fig: 5 Schematic Diagram of SSSC

SSSC is a solid-state controllable voltage source inverter that is connected in series with power transmission lines. With the injected voltage in quadrature with the line current and the capability of dynamically changing its reactance characteristics from capacitive to inductive, SSSC is very effective for power flow control. In addition, an auxiliary stabilizing signal can be superimposed on its power flow control function to improve power system oscillations stability. It can regulate the flow of active and reactive power by injecting controllable capacitive or inductive impedance compensation into a line at the point of connection[1]. In addition, with a suitably designed damping controller, the SSSC has an excellent performance in damping low frequency power oscillations in a power network.

III. SIMULATION RESULT

Based on the schematic diagram given above a single phase model is constructed in MATLAB[3,9]. The capacitor connected in the model is used to balance instantaneous difference in fundamental power ($V_1 I_1 \cos \phi_1$) and power at different frequency ($V_n I_n \cos \phi_n$). The UPFC is assumed to be installed in the Single phase power system with voltage source at sending end and single phase load at receiving end. The single phase model is shown in Fig 3 for simplicity in the single phase UPFC the value of capacitance is taken as inf.

The transmission line parameters will be same, only have to do is to add another transmission line running parallel to existing line. The basic idea of this project is to attempt to transmit power or exchange power between the series and parallel part of UPFC through extended line.

Simulation Model for UPFC

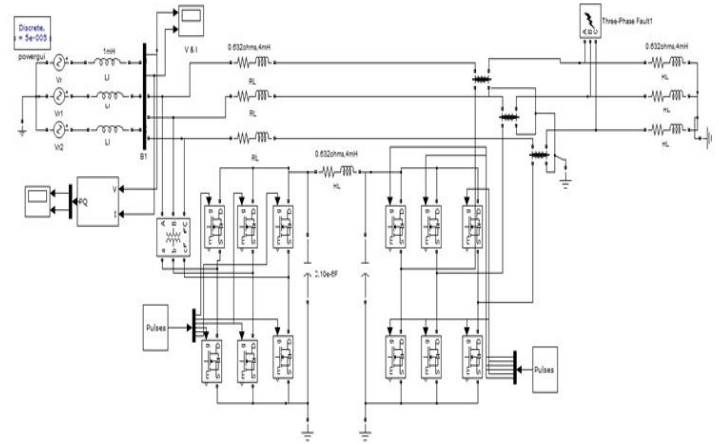


Fig: 6 Simulation Model for UPFC in MATLAB

The output graph for receiving active power, Reactive power and sending active power receiving power is shown

Line current and injected voltage Output

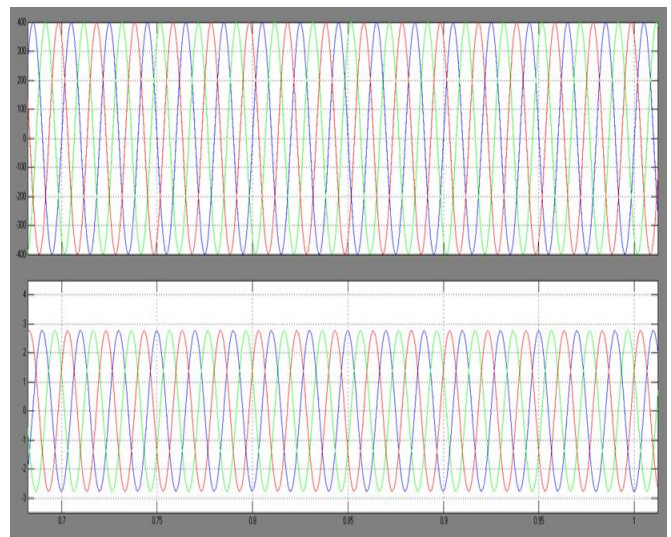


Fig: 7 Output waveform for Line current and injected voltage

Active & reactive power Output

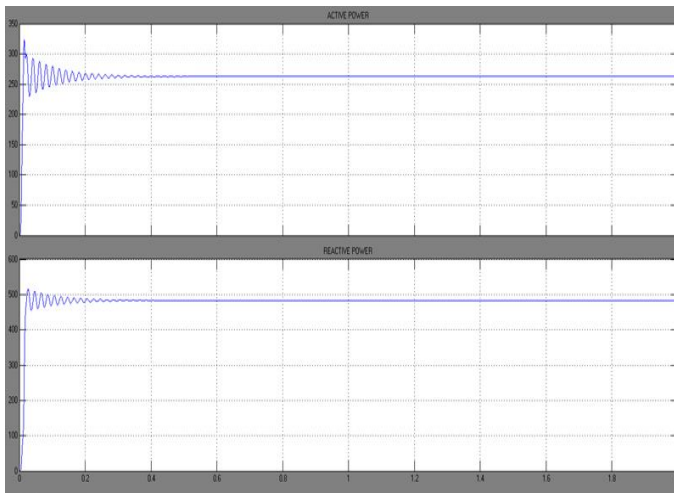


Fig: 8 Output waveform for Active & reactive power

IV. CONCLUSION

The paper presents a single phase new UPFC concept of transmitting power with modified DC link between series and shunt part of UPFC, which gives more flexibility of UPFC installation. The active power exchange between shunt and series is transmitted through a single DC transmission line. The UPFC can be install at different location with extended DC link which will reduces the effect of harmonics problems encounter in UPFC with eliminated DC link. However it reduces the power transmission capability as shown in result and additional lossless in the transmission line and transformers. But both the modified UPFC have the full function as conventional UPFC. The Separated series part of this UPFC will reduce the cost significantly and have a lot of extra benefits, such as higher reliability, convenient for installation and maintenance.

V. REFERENCES

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