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Power Quality Analysis of Transmission Line By Using UPFC

Hafsa shaikh,Anila Tassawer,Nawab Zahid
Department of Electrical engineering, Mehran University of Engineering and Technology,jamshoro ,sindh
Corresponding author e-mail: (hafsariazuddin125@gmail.com)
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***Abstract:* This paper will present the importance of presence of UPFC in transmission system for the enhancement of power quality of existing transmission network. In FACTS controllers UPFC is dynamic and versatile controller that can control various transmission parameters such as series impedance, shunt impedance, line voltages, current, active and reactive power. The basic structure of UPFC consist of two voltage source converters one converter is connected parallel to the transmission line while other one converter is connected in series with transmission line. In this paper we will develop the Simulink model of open loop based UPFC and close loop based UPFC and then the results are compared. The Simulink model for UPFC is developed by using inverter and converter circuits with the help of IGBT's. At receiving end real and reactive power is varied by varying control angle of converter. The simulation results are present to validate the model.**

***Index Terms*—UPFC, PI controller, power Quality, Transmission Line, compensation.**

I. INTRODUCTION

Transmission system is a system which transfer electrical energy from generating station to the consumer end which is complex and requires careful design and an additional device for proper operation and controlling of power quality of transmission line [1].

The voltages increase at the receiving side at lightly loaded condition and decreases at heavily loaded condition due to increase of current. If the load is increasing continuously on network, then it will result in shortage of reactive power. The traditional way to compensate reactive power is the use of fixed capacitor or mechanical switches but they are slow and create a delay that can damaged the system's equipment. The power electronic based equipment like FACTS (flexible AC transmission system) devices has been inserted in transmission system to improve the power quality and voltage stability of system [3]. They can efficiently control the active and reactive power and have fast switching action and enhanced the voltage stability and power quality of system. The categories of FACTS that can be inserted in transmission line are shunt like SVC (static var Compensator), STATCOMs and series compensator like SSSC and series-shunt compensator like UPFC [2]. Unified Power Flow Controller (UPFC) belongs to 2nd generation of FACTS family which consists of two voltage source converter (VSCs) and it is most versatile device and can control all the parameters of transmission line. It can control both active and reactive power. The UPFC can enhance the power quality, increase the utilization capacity of transmission line and can mitigate the power system oscillations.

II. METHODLOGY

The UPFC consists of series controller which is known as static synchronous series compensator (SSSC) connected in series with the transmission line through series transformer and a shunt controller which is known as static synchronous compensator (STATCOM) connected in parallel with the transmission line through a shunt transformer. These two voltage source converters (VSCs) are connected back-to-back through a common dc link capacitor. The main function of converter 1 is to supply or absorb active power demanded by converter 2 through common dc link and it is also independently controlling the reactive power of the bus. The converter 2 inject the voltage with adjustable magnitude $0<V_{pq}<V_{pqmax}$ and phase angle that can be vary from 0 to 360.The real and reactive power can quickly be change by changing the magnitude and phase angle of injected voltage.[4]

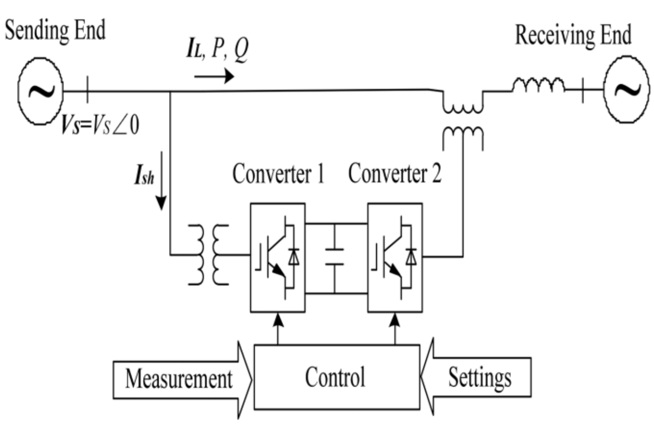

Fig. 1. UPFC installed in power system

The above discussion does not contain the closed loop strategy of UPFC. The controller is design for both series converter and shunt converter separately. controllers are design to control the shunt current of the bus in which shunt converter is connected and the voltage magnitude and phase angle of series injected voltage. The shunt branch act as controllable current source and the series branch acts as controllable voltage source.

III. SIMULATION RESULTS OF LINE MODEL WITHOUT UPFC

A single phase two bus system is shown in fig: 2.1. The line voltage is 230Vrms and the line is represented by the RL circuit, the shunt branches for small and medium transmission line can be neglected. The sag is produced at t= 0.3sec when the extra load is added to the system. Due to this small disturbance an oscillatory instability occurs in the power system which is counter by the damping torque and after few milliseconds the system become stable. when load increases, the current flowing through the transmission line will increase which will increase the line losses and the power quality decrease.

Collected data of subjected feeder

Single phase source	230Vrms
Source impedance	0.001ohm,30mH
System frequency	50Hz
Line impedance	0.03ohm,30mH
Load 1	3kW
Load 2	4kW

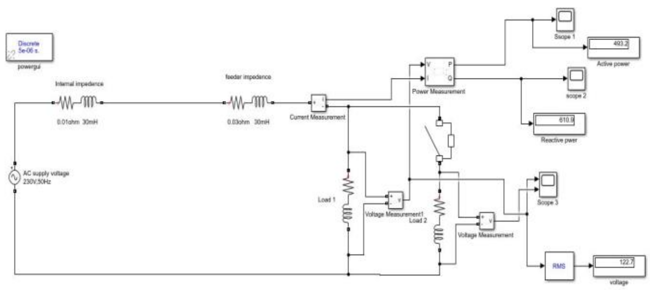

Fig. 2.1. line model without UPFC

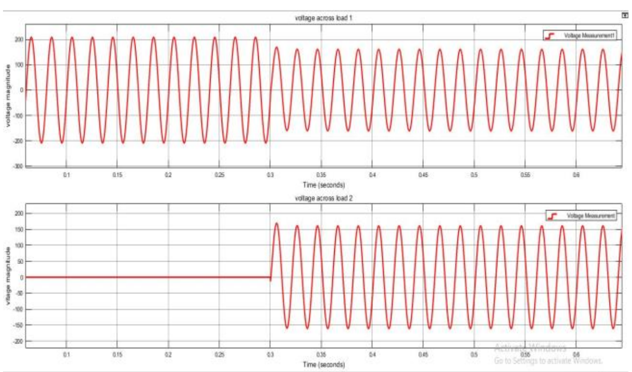

Fig. 2.1(a). voltage across load 1 and 2 under sag condition

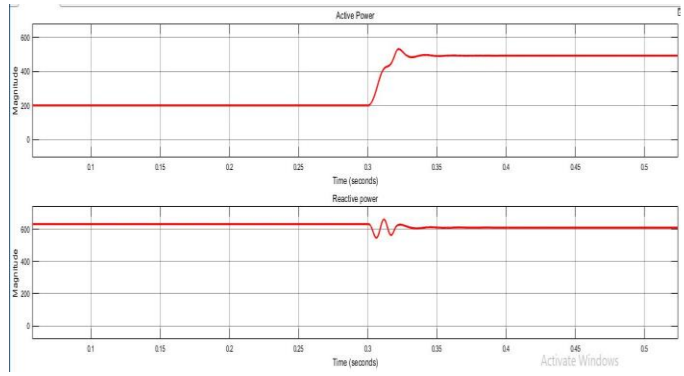

Fig. 2.1(b). Active and Reactive power

AT t=0.3sec circuit breaker opens, extra load is removed from the system and the swell is produced. Under swell condition the voltages increase due to sudden release of extra load, and it effect on the power quality of the transmission line.

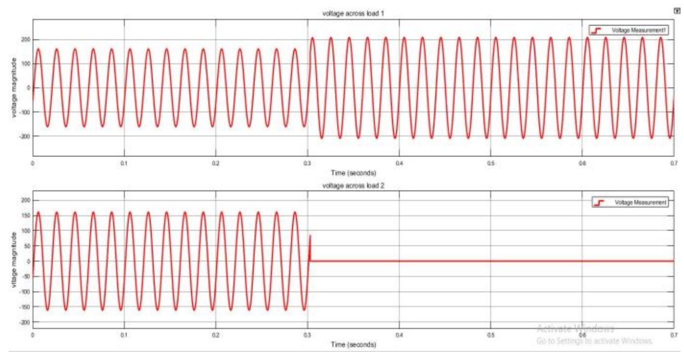

Fig. 2.2(a) Voltages under swell condition

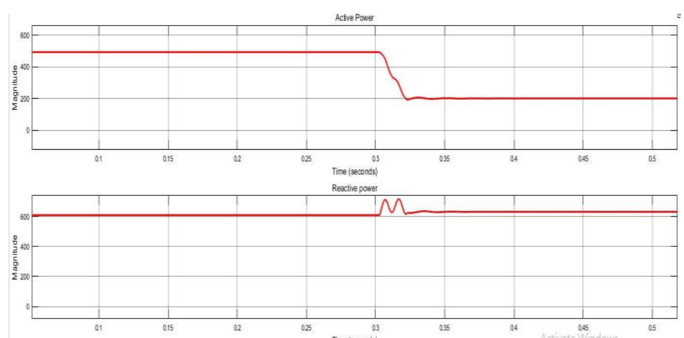

Fig. 2.2(b). Active and Reactive Power

IV. SIMULATION RESULTS OF LINE MODEL WITH UPFC- (OPEN LOOP SYSTEM)

Now the compensated line model is shown in fig 2.2. The UPFC is connected with open loop system .The shunt converter is always in ON condition whereas the series converter is ON at t=0.4sec and inject the voltage with controllable magnitude and phase angle and compensate the voltage regulation and increase the power quality and power transfer capability of power system.

(1)

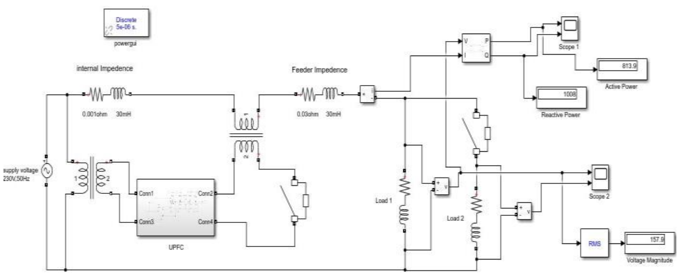

Fig. 2.3. line model with UPFC

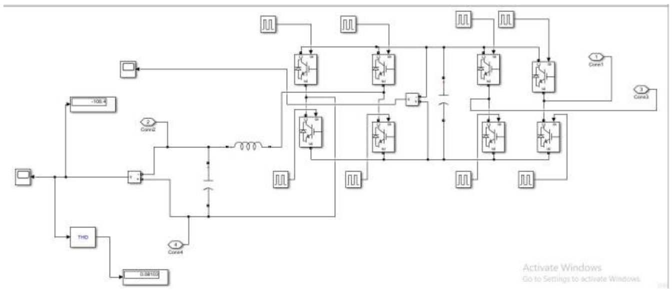

Fig.2.3(a) Rectifier- inverter circuit

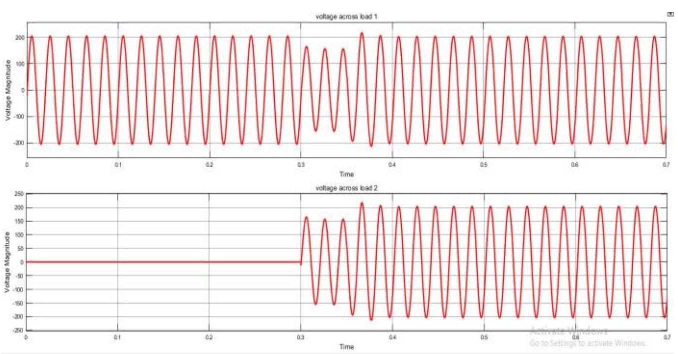

Fig. 2.3 (b). voltage across load 1 and 2 under sag

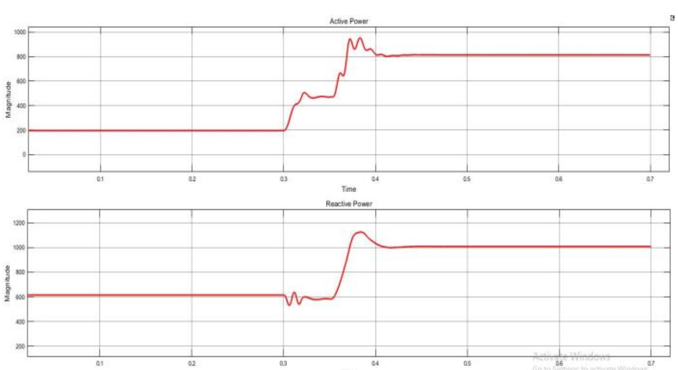

Fig. 2.3 (c). Active and Power under sag condition

Swell compensation at t=0.4sec is shown in fig.2.4, 2.4(a),2.4(b).

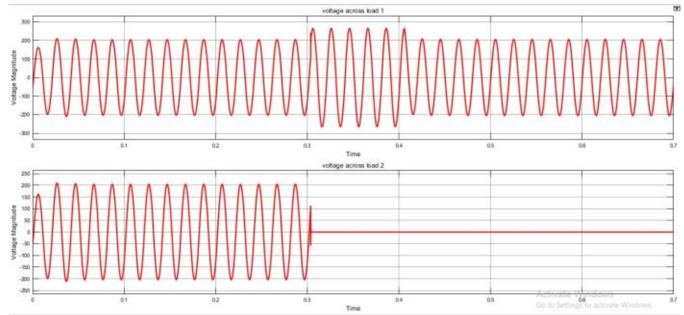

Fig. 2.4 (a). voltage across load 1 and 2 under swell

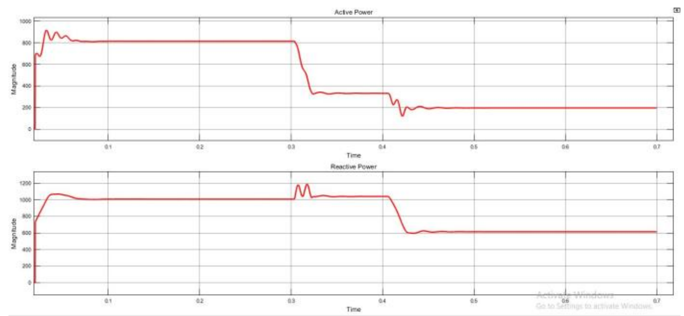

Fig. 2.4 (b). Active and Reactive power under swell condition

V.SIMULATION RESULTS OF LINE MODEL WITH UPFC- (CLOSED LOOP SYSTEM)

The compensated line model of closed loop based UPFC is shown in fig 2.3. Here PID controller is design to control the generated pulses of back-to-back connected voltage source converter (VSCs) circuit.

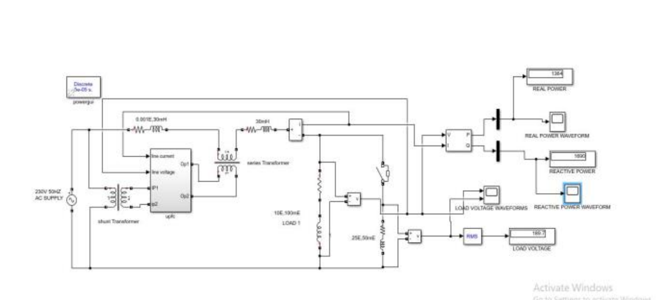

Fig. 2.5-line model with closed loop based UPFC

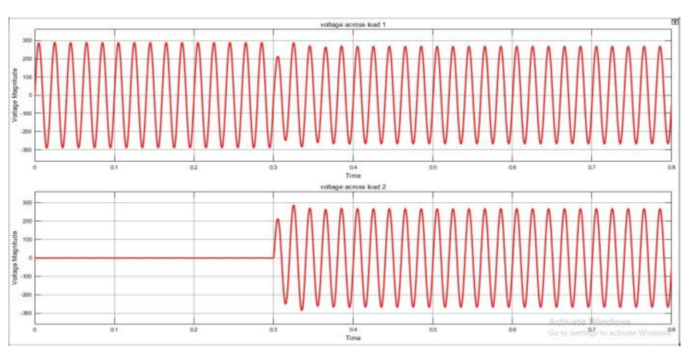

Fig. 2.5 (a). Mitigate the sag across load 1 and 2

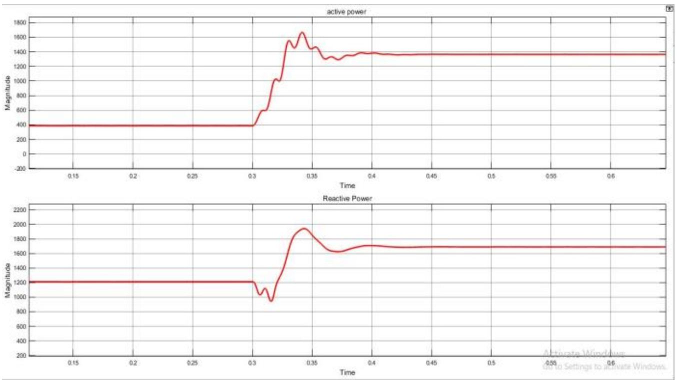

Fig. 2.5 (b). Active and Reactive power under sag condition

Mitigation of swell by closed lp UPFC when extra load is removed is shown in fig 2.6(a). with real and reactive power in 2.6(b) and 2.6(c).

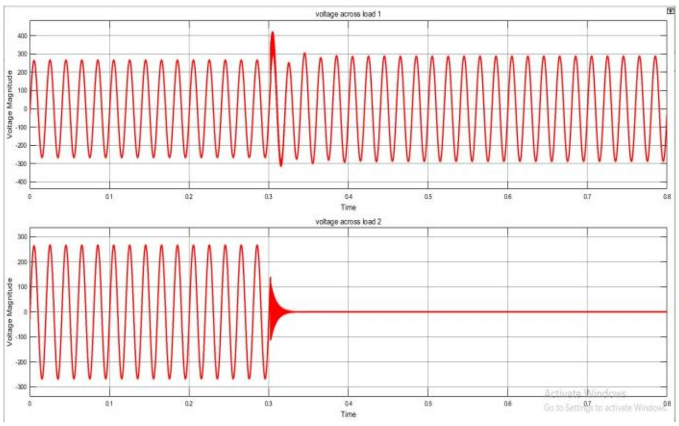

Fig. 2.6 (a). Mitigate the swell across load 1 and 2

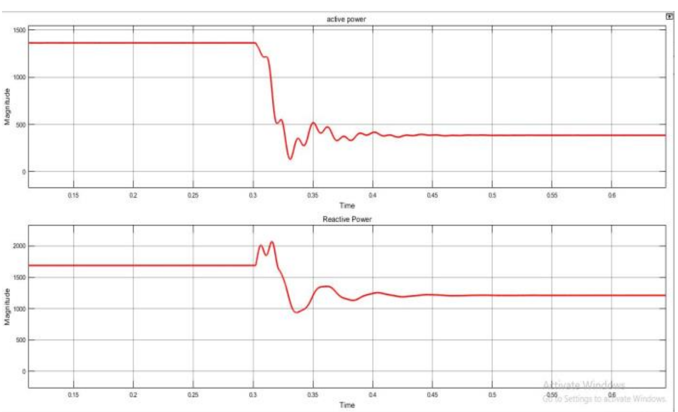

Fig. 2.6 (b). Active and Reactive power under swell condition

By closed loop based UPFC using PID controller, under swell and sag condition the UPFC compensate the voltages across loads and automatically overcome the sag and swell and enhanced the power quality and power transfer capability of power transmission system.

VI. COMPARISON BETWEEN RESULTS OF OPEN LOOP AND CLOSED LOOP BASED UPFC

S.NO	CONDITION	LOAD VOLTAGEs	ACTIVE POWER	REACTIVE POWER
1.	WITHOUT UPFC	222VRMS	493W	611VAR
2.	WITH UPFC (OPEN LOOP)	257VRMS	813W	1008VAR
3.	WITH UPFC (CLOSED LOOP)	289VRMS	1364W	1690VAR

VII. CONCLUSION

In power transmission system, our aim is to maintain the power quality and the voltage magnitude and phase angle at the receiving side f the power system. This project covers the designing of single phase UPFC which inject the voltage in series when disturbance occurs. The simulation results of open loop based UPFC shows the enhancement in the active and reactive power and compensate the voltage magnitude when sag and swell occur. After that a closed loop based UPFC is simulate whose performance are better than open lop based UPFC. It enhances more the active and reactive power and quickly compensate the voltage with better stability performance of power system.

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