

Simulation And Experimental Model of UPFC Used for Power Quality Improvement of Transmission Line

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Abstract — In this research, the significance of UPFC for improving the power quality of the transmission network will be discussed. UPFC is a dynamic and adaptable controller used in FACTS controllers that can regulate a number of transmission parameters, including series and shunt impedances, line voltages, current, active, and reactive power. The fundamental design of a UPFC consists of two voltage source converters, one of which is linked in parallel to the transmission line and the other in series. In this study, we will create Simulink and laboratory models of UPFC, and then compare their outcomes. Inverter and converter circuits were designed by using IGBTs.

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

I. INTRODUCTION

A transmission system is one that transfers electrical energy from a generating station to the consumer end. It is complicated, necessitating careful design as well as extra devices for proper functioning and controlling the transmission line's power quality. [1].

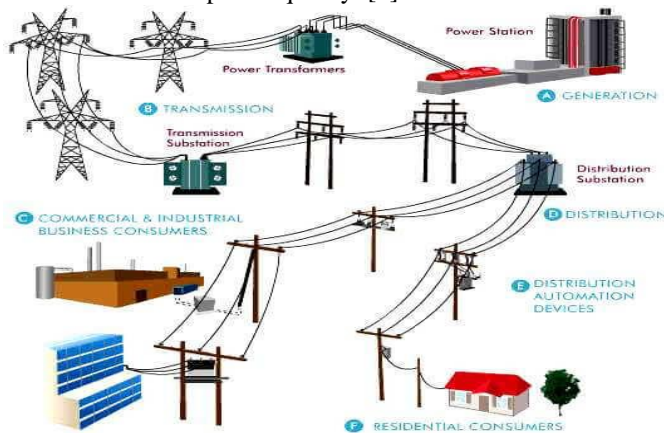


Fig 1 Electric power system

Reactive power will be in short supply if the demand on the network is continuously rising. The use of mechanical switches or fixed capacitors is the conventional method for compensating reactive power, however these methods are slow and cause delays that can harm the system's equipment.

To enhance the power quality and voltage stability of the transmission system, power electronic-based devices such FACTS (flexible AC transmission system) devices have been added. [3]. They feature quick switching actions, are effective in controlling both active and reactive power, and improve system power quality and voltage stability. Shunt FACTS like the SVC (static var Compensator), STATCOMs, series FACTS like the SSSC, and series-shunt FACTS like the UPFC can all be introduced into transmission lines. [2]. It consists of two voltage source converter (VSCs) and it is most versatile device and can control all the parameters of transmission line . Both active and reactive power can be managed by it. The UPFC can improve power quality, boost transmission line usage capacity, and reduce oscillations in the power system.

II. METHODOLOGY

A shunt controller known as a static synchronous compensator (STATCOM) is connected in parallel with the transmission line through a shunt transformer, and a series controller known as a static synchronous series compensator (SSSC) is connected in series with the transmission line through a series transformer. A common dc link capacitor connects these two voltage source converters (VSCs) back-to-back as shown in fig: 2. The major job of converter 1 is to supply or absorb the active power needed by converter 2 through a shared dc link. It also controls the reactive power of the bus separately. By adjusting the voltage's magnitude and phase angle, converter 2 injects a variable magnitude voltage. [4]

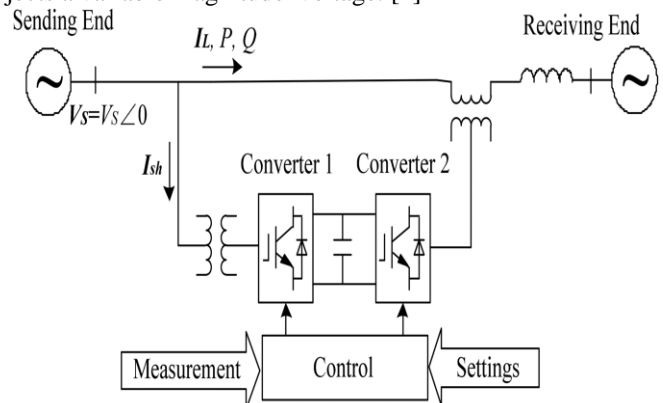


Fig. 2 UPFC installed in power system

The shunt converter acts as variable current source and the series converter acts as variable voltage source and compensate the voltage of the transmission line.

III. SIMULATION RESULTS OF LINE MODEL WITHOUT UPFC

To observe the performance of the UPFC connected to the transmission line under abnormal conditions, a single-phase AC transmission line of 230 volts was built in the matlab/simulink environment. The 230V transmission voltages from the grid station or power station were utilized. Due to safety concerns, a low voltage transmission line was built. The information gathered for transmission line modelling is displayed below.

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

It consists of 24V of supply, RL branch, RL load, circuit breakers, and a meter for measuring current, voltage, active power, and reactive power on the transmission line. The circuit breaker trips at t=0.3sec and connect the extra load in the system as shown in fig: 3.

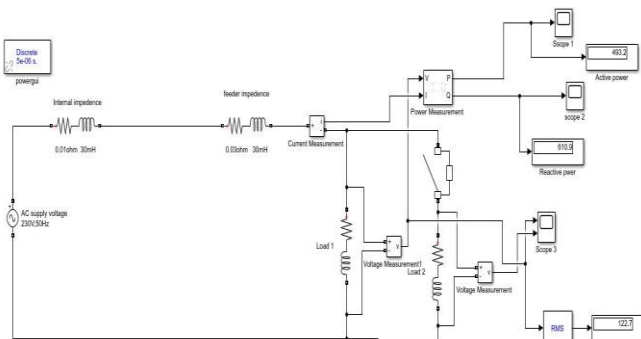


Fig: 3 line model without UPFC

Under sag condition:

The effects of transmission lines without unified power flow controllers are as follows . When an inductive load ,load 2 is added at t = 0.3sec to the transmission line, it becomes strongly loaded and the voltage across the load lowers, causing voltage sag as shown in fig:4. This is caused by an increase in transmission line losses and a decline in power factor.

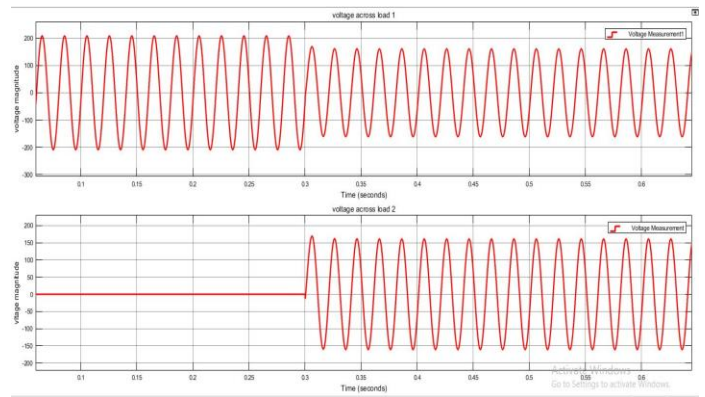


Fig: 4. voltage across load 1 and 2 under sag condition

The active and reactive power waveform is shown in fig:5.

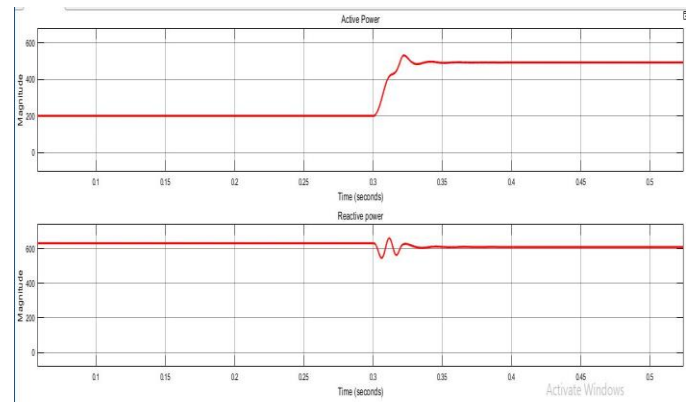


Fig: 5. Active and Reactive power

Under swell condition:

In a situation similar to the one described above, both loads were initially connected, but after 0.3 seconds, load 2 disconnected from the transmission line, causing the line to become lightly loaded. So-called voltage swell refers to the increase in voltages across the load as shown in fig: 6.

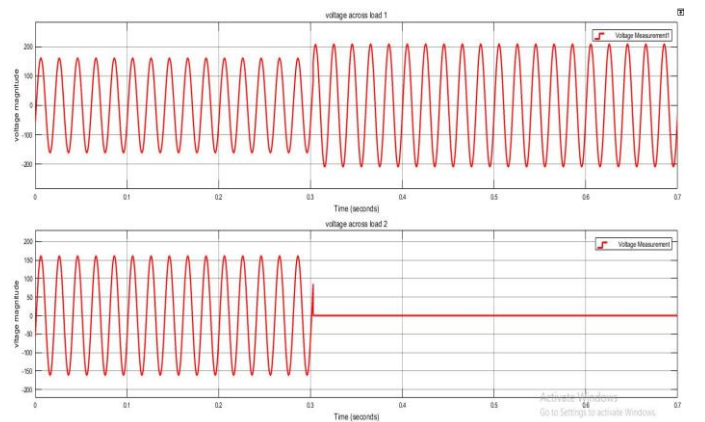


Fig: 6 Voltages under swell condition

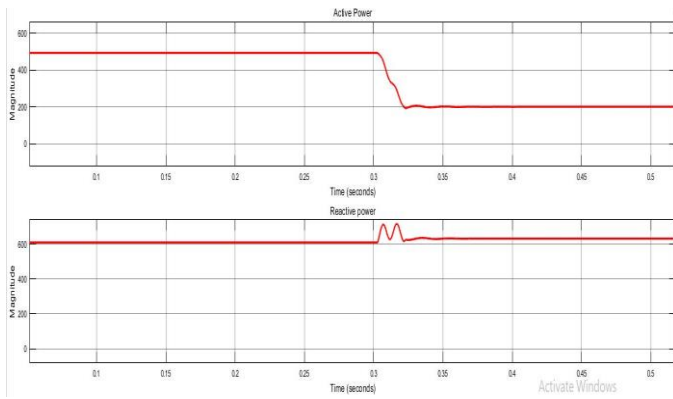


Fig. 7. Active and Reactive Power

IV. SIMULATION RESULTS OF LINE MODEL WITH UPFC

The UPFC was built utilizing two voltage source converters that use IGBTs and are interconnected by a 220uf dc link capacitor. The transistors (IGBT) are triggered by a pulse generator, as illustrated in fig: 8 . For the pure sinusoidal wave, the RL filter is utilized at the inverter's output.

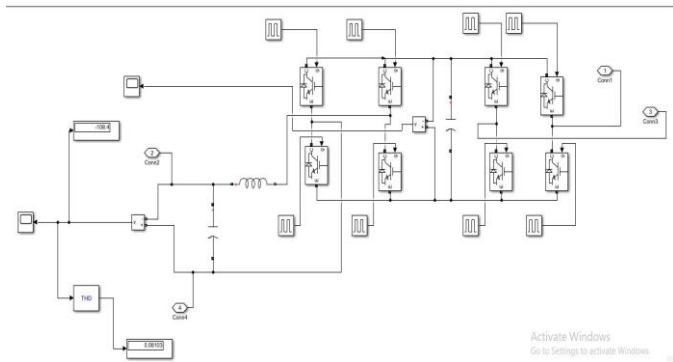


Fig. 8 Rectifier-inverter circuit

When voltage sag and swell occur on a transmission line owing to load changes, the UPFC is linked to an ac transmission line and compensates the line voltages by injecting the voltage through a series transformer with controlled magnitude and phase angle as shown in fig: 9

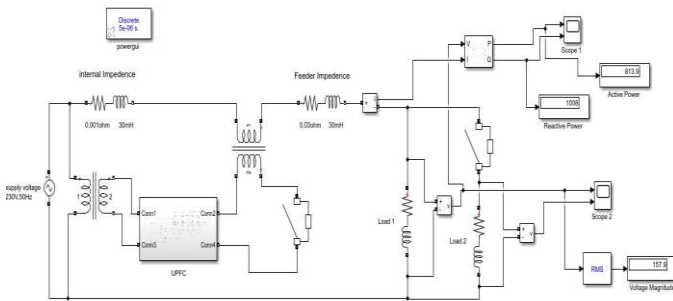


Fig. 9 line model with UPFC

Under sag condition:

When the system is connected to the unified power flow controller (UPFC), which compensates the voltage. The voltage sag appears at 0.3 seconds when the transmission line becomes excessively loaded, the UPFC activates and connects to the system at 0.4 seconds, injecting voltage into the transmission line with adjustable magnitude and phase angle.

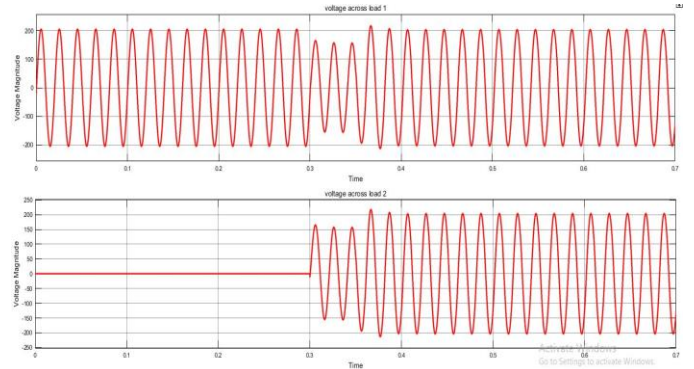


Fig: 10. voltage across load 1 and 2 under sag

The active and reactive power were also increase which enhanced the transfer capability of transmission line.

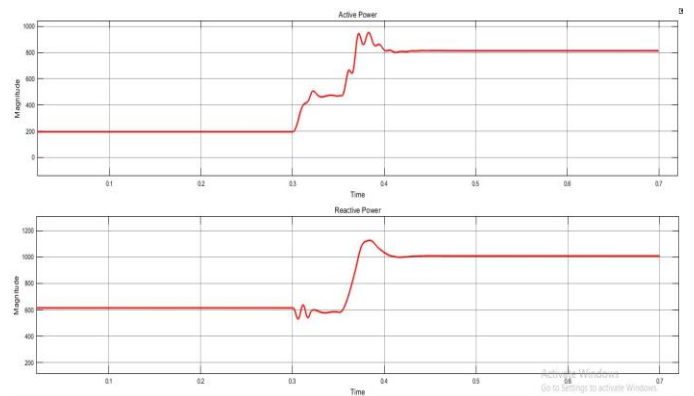


Fig: 11. Active and Reactive power under sag condition

Under swell condition:

The voltages across the load increase when the transmission line becomes lightly loaded at 0.3 seconds, and at 0.4 seconds, the UPFC comes in to keep the voltages at the rated amount.

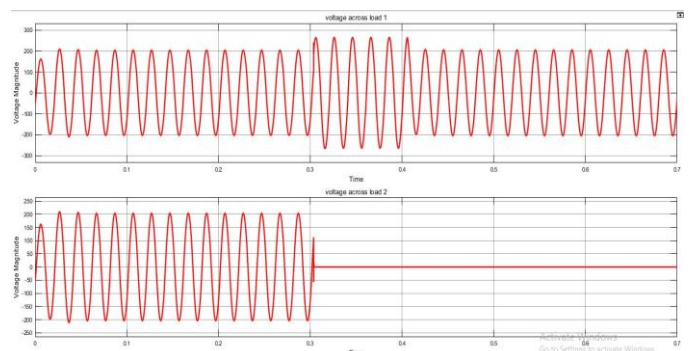


Fig: 12. voltage across load 1 and 2 under swell

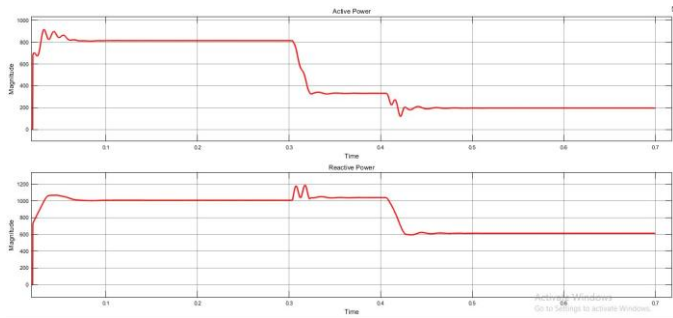


Fig: 13 Active and Reactive power under swell condition

V. HARDWARE IMPLEMENTATION AND RESULTS

Introduction:

This laboratory model of UPFC was created to compare the results of simulation with the hardware performance of the proposed model of UPFC in order to verify the working suggested model of UPFC that is displayed above in MATLAB/Simulink environment. The laboratory's experimental results suggest how well UPFC performs in real time. The hardware model's Block diagram is displayed below in fig: 14.

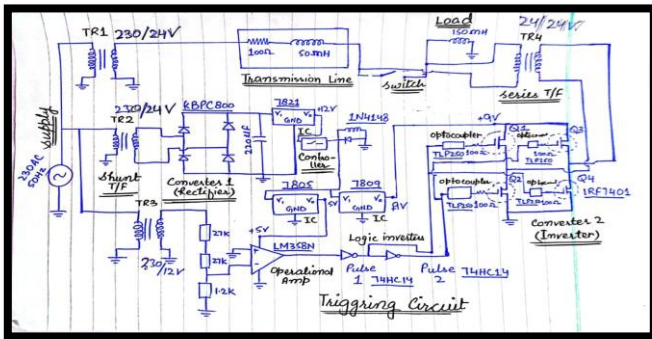


Fig: 14 block diagram of the proposed model

Experimental setup:

The laboratory model of UPFC consists of power circuit and control circuit. the control circuit is used to generate the pulses for IGBTs and the output of inverter is controlled by the controller. The power circuit consist of series and shunt transformers, supply of 24V and the inverter rectifier circuit coupled through dc link capacitors. The experimental setup is shown in fig: 15.

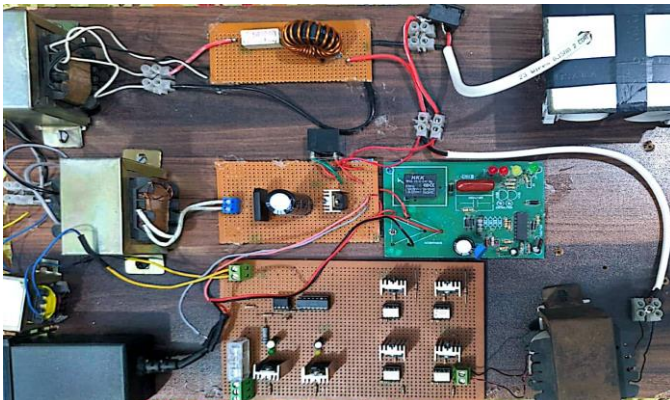


Fig 15: Experimental setup

Results:

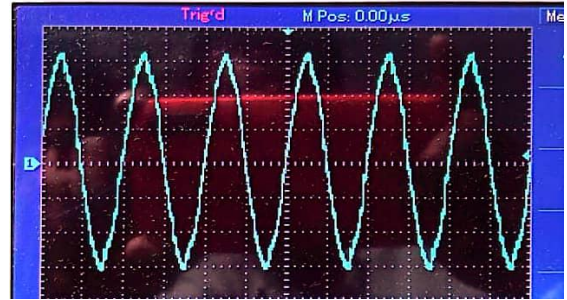


fig:16a AC input voltage waveform



Fig:16b AC input voltage

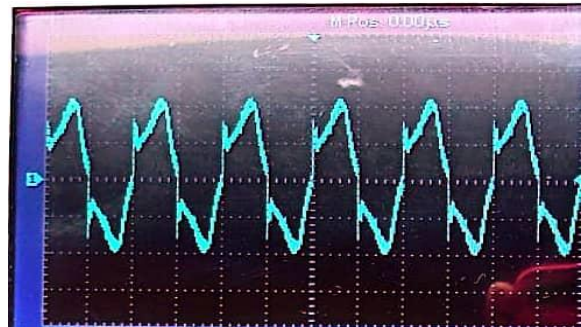


Fig:17a load voltage waveform of heavily loaded transmission line



Fig:17b voltage across heavily loaded transmission line

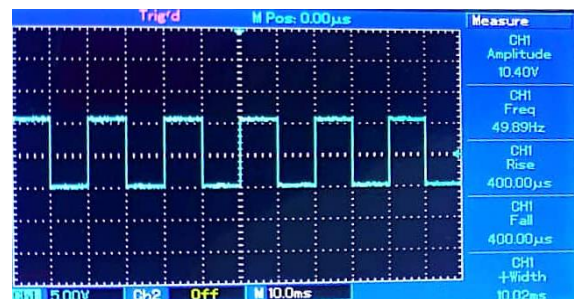


Fig:18 driving pulses for inverter

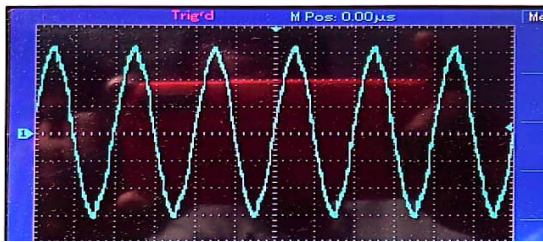


Fig:19a load voltage waveform after compensation



Fig:19b load voltage after compensation

VI. CONCLUSION

Simulink's Matlab environment is used in simulation studies to simulate a model of a single-phase connected UPFC system. The control and effectiveness of UPFC, which was utilized to enhance network quality, are presented in this paper. Investigating Voltage Compensation via UPFC. Increases in real and reactive power. Results from simulations show how successful UPFC is as a solution. When UPFC is implemented, the transmission line's active and reactive power improve. The system's capacity to control both reactive and active power requires minimal maintenance. It is clear that the experimental studies confirm those from the simulation.

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