

Transient Stability Analysis of Power System With UPFC Using PSAT

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Abstract—UPFC is a versatile FACTS controller that can regulate the Power Flow through the Line by controlling its Series and shunt parameters. In shunt it is having STATCOM and in series SSSC are employed can independently control the Line Power Flow. Two Converters improves the flexibility and provide additional degree of freedom in Power System. With the application of UPFC, Transient stability of the system can be Improved. This Paper shows that how Transient Stability of the Inter Area system is Improved. The Mathematical Model of Transient Stability is also given in this Paper.

Keywords—Power system, FACTS, Transient stability, Inter area power system.

I. INTRODUCTION

In recent years, energy, environment, deregulation of power utilities have delayed the construction of both generation facilities and new transmission lines. FACTS devices are available, which can help Power Engineers to deal with problems like Large Signal Stability and economic Factors that gives strong incentives to raise the Stability limit of the System, depending upon the diverse conditions. Facts devices can provide fast control of Active and Reactive power through Power system. Among the converter based FACTS devices Static Synchronous Compensator (STATCOM) and Unified Power Flow Controller (UPFC) are the popular FACTS devices. They play an important role, not only in increasing the amount of energy transported over the lines, but also in oscillatory and transient-stability enhancement, system reliability, and controllability over the power flow. Considering the practical application of the UPFC in power systems, it is of importance and interest to investigate the benefits as well as model of these devices for power system Transient Analysis. Unified Power Flow Controller (UPFC) is a power electronic based device that has capability of controlling the power flow through the line by controlling appropriate its series and shunt parameter. It has been reported that UPFC can improve transient stability of a system.

II. PRINCIPLE OF UPFC

One FACTS controller in particular, the Unified Power Flow Controller (UPFC), is capable of concurrently or selectively controlling transmission line power flows, voltage magnitudes and phase angles in a power system. Here in fig.1 given below UPFC is shown with both PWM and Phase Control strategy.

The Unified Power Flow Controller (UPFC) concept was proposed by Gyugi in 1991. UPFC is an electrical device for providing fast-acting reactive power compensation on high-voltage electricity transmission networks. The UPFC is a combination of a Static Synchronous Compensator (STATCOM) and a Static Synchronous Series Compensator (SSSC) coupled via a common DC voltage link. The UPFC is made out of two voltage-source converters (VSC) with semiconductor devices having turn-off capability, sharing a common dc capacitor and connected to a power system through coupling transformers.

The basic UPFC structure is depicted in Figure shown above. This figure represents control strategies (pulse-width modulation (PWM) and phase control). The reactive power is generated/absorbed independently by each converter and does not flow through the dc link. There are two basic control strategies that can be utilized to control the switching of the semiconductor switches in the converters, i.e., PWM and phase controls.

GTO switches operate adequately at the “low” switching frequencies required in phase control, but present high losses at the “high” switching frequencies needed for PWM control.

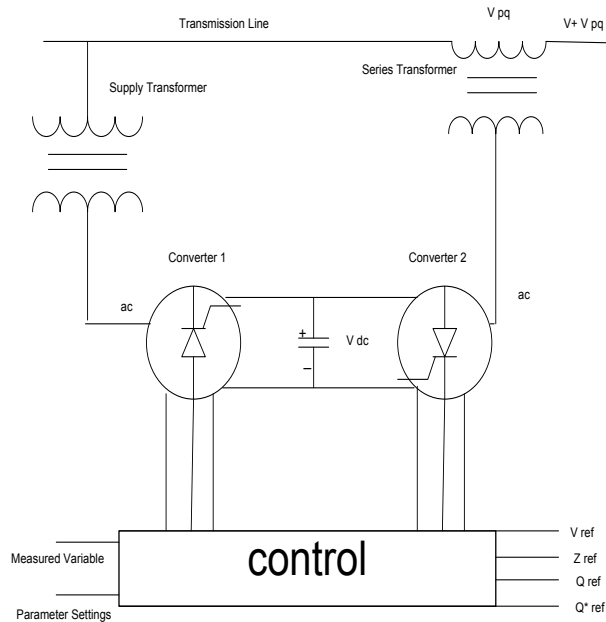


Figure 1.UPFC is shown with both PWM and Phase Control strategy.

However, recent advances in high voltage IGBT technology have led to the development of the Integrated Gate Commutated Thyristor (IGCT), which is basically an optimum combination of thyristor and GTO technology at low cost, low complexity, and high efficiency. It can handle higher switching frequencies with relatively low losses, allowing for the practical implementation of PWM control methodologies.

III. PSAT SIMULATION MODEL

SYSTEM (1) UNDER STUDY

In this Model there are 11 Buses, Bus No. 3 is kept as Slack bus which maintain its voltage at 1 p.u. and Bus 1,2 & 4 are Generator (PV) Buses. Fault is simulated at Bus 8 at 1sec. and Fault clearing time at 1.05 sec.

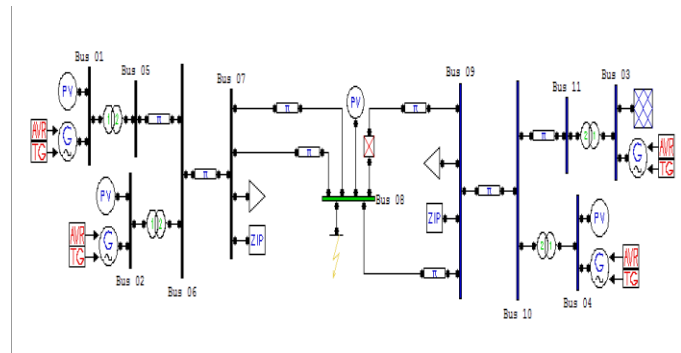


Figure 2 11 Bus test System Without FACTS devices

The all four Generators has been modeled with Power Rating of 900MVA and 20KV at 60HZ frequency. All buses connected to each other by π - Section of transmission line.

The automatic voltage regulator used is type 3 in PSAT tool of MATLAB with the range of +100KV to -100KV and having the gain of 200p.u. for maintaining the voltage level as near to 1p.u. Turbine Governor is used of type 2 and having the ref. speed of 1 p.u. and the droop is kept 0.02p.u. with max. torque and min. torque limit at 1.2 and 0.3p.u.

Generators are connected to the system via transformers maintaining the system voltage at 230KV and 100MVA. Load is also connected to the Bus7 and Bus8.

In this Model, Voltage profile at all 11 buses and Rotor angle are studied without any FACTS devices.

SYSTEM (II) UNDER STUDY

The all the parameters of Generators, Slack bus, Transformers and Load are kept same as were in above given Model. UPFC is employed in between Bus8 where fault is simulated and Bus9 POD controller for maintaining the voltage at faulty bus. The Voltage profile of all the buses and Rotor angle are studied at different Fault clearing time with UPFC and there results are compared with the results of 11Bus test system without any FACTS device.

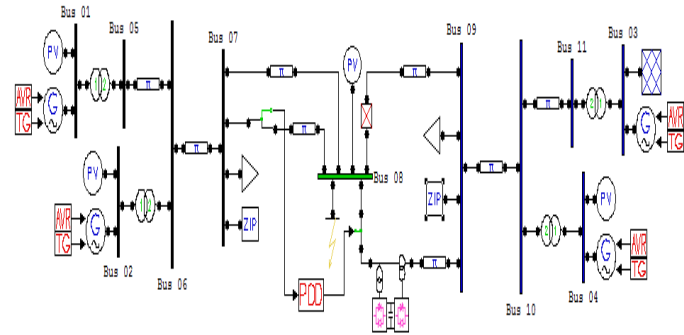


Figure 3 11Bus test System With United Power Flow Controller

IV. SIMULATION RESULTS

Fig 4 – 14 show the simulation results of rotor angle, voltage at different buses and angular frequencies in PSAT

ROTOR ANGLE

The graphs shows the Generator rotor angles w.r.t. time in case with and without UPFC.

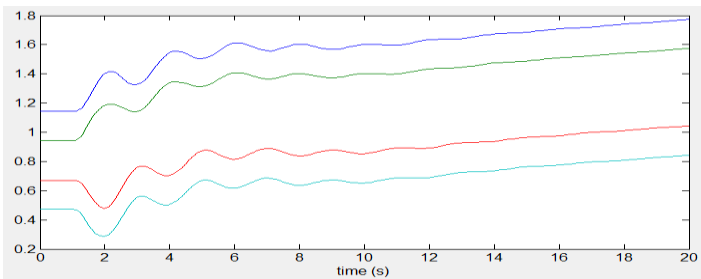


Figure 4 Rotor angle 1,2,3& 4 without UPFC.

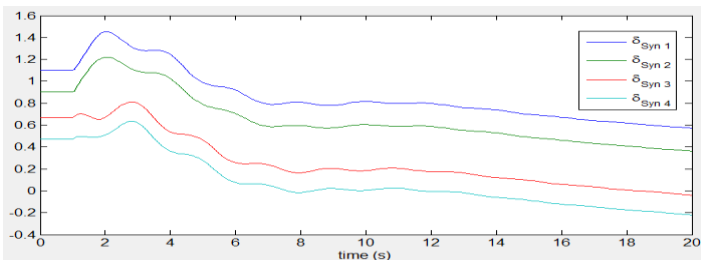


Figure 5 Rotor angle 1,2,3& 4 with UPFC at fault clearing time a 1.05sec..

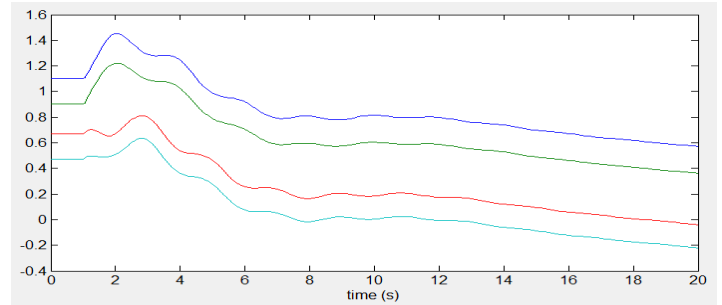


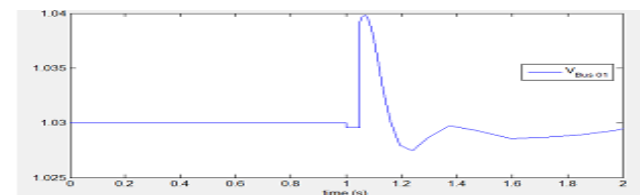
Figure 6 Rotor angle 1,2,3& 4 with UPFC at fault clearing time at 1.2sec.

Without using the UPFC the Rotor Angle are increasing and go out of synchronism but with the UPFC they remain in synchronism at time 1.05sec. and 1.2 sec. both.

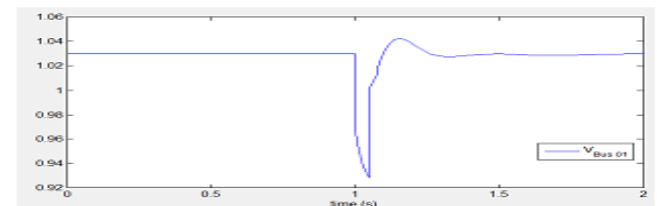
VOLTAGE PROFILE

The graph shows the voltages at various buses with and without UPFC at different fault clearing time.

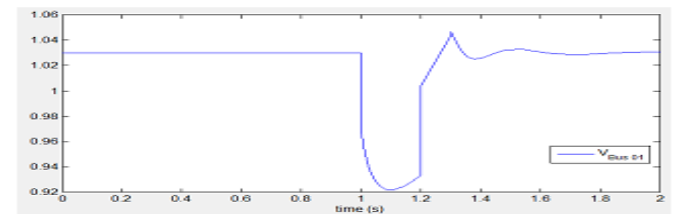
Voltage at Bus 1



V1 without UPFC



V1 with UPFC at fault clearance time 1.05



V1 with UPFC at fault clearance time 1.2

Figure 7 Voltage at Bus 1

As shown in the fig.7 voltage profile of Bus1 at different fault clearing time with and without UPFC. With FACTS Device (UPFC) the voltage is settling down at 1.2 sec without any oscillatory behavior, whereas without UPFC it takes more than 2 sec due to the oscillations after the major disturbance settles at 1.2 sec. Bus 1 is a PV bus.

Voltage at Bus 2

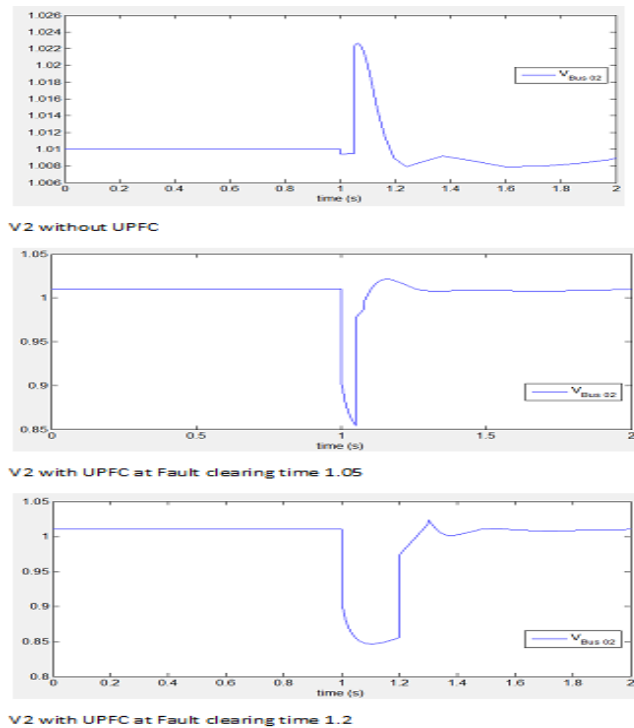


Figure 8 Voltage profile at bus 2

Voltage profile of Bus2 is again a PV bus and showing voltage rise after fault clearance time without UPFC and take more time to settle down but with UPFC it follows the normal profile and settles down quickly.

Bus 3 is a Slack bus so Voltage profile will be same with and without FACTS device.

Bus 4 is a PV Bus and the settling time is reduced with UPFC

Voltage at Bus3

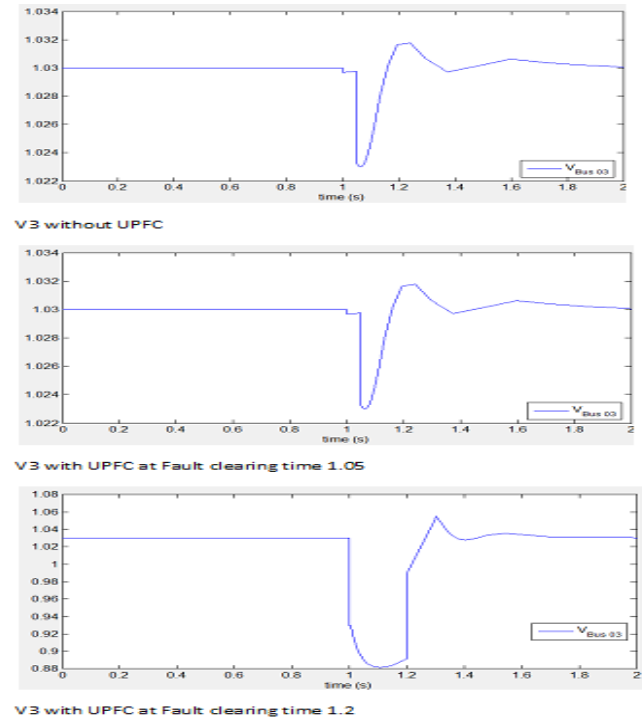


Figure 9. Voltage profile at Bus 3

Voltage at Bus4

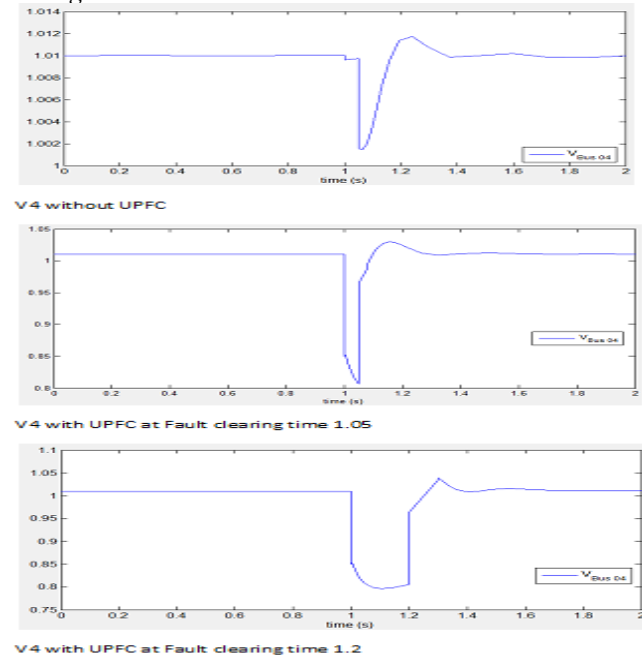


Figure 10 Voltage profile at bus 4

Voltage at Bus 11

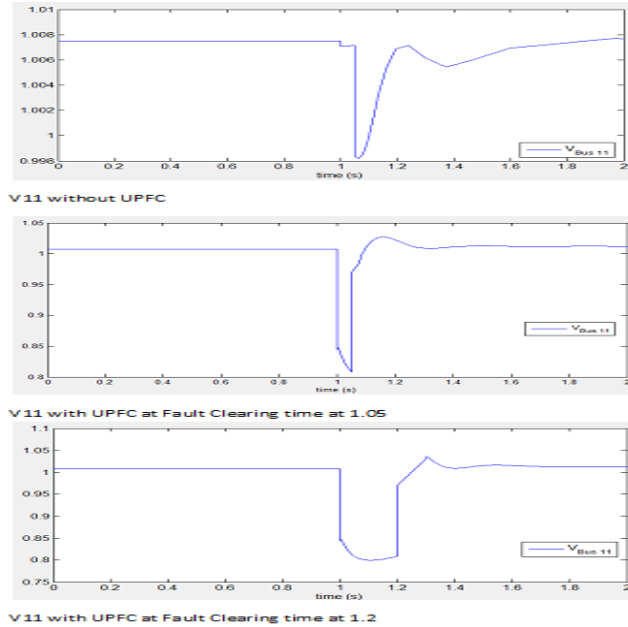


Figure 11 Voltage profile at bus 11

At Bus11 settling time is reduced and Voltage reaches to its pre fault value quickly without oscillations.

ANGULAR FREQUENCY

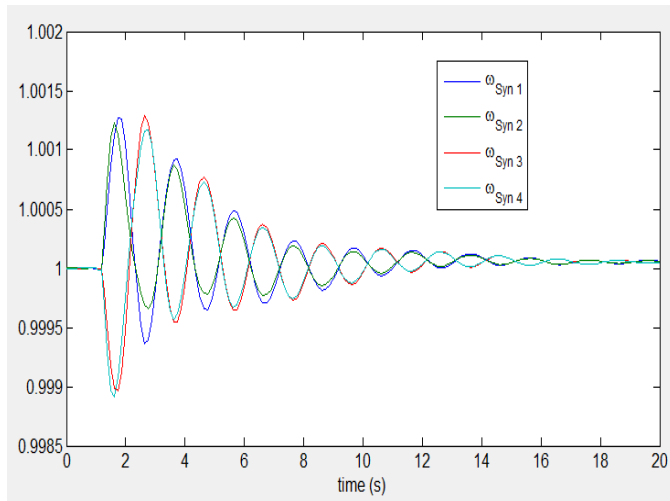


Figure 12 Angular freq at all generator Buses

Fig. 12 shows Angular freq at all generator Buses without UPFC. The peak value of remain at 1.0012

The fault is simulated at 1sec and cleared at 1.05sec.

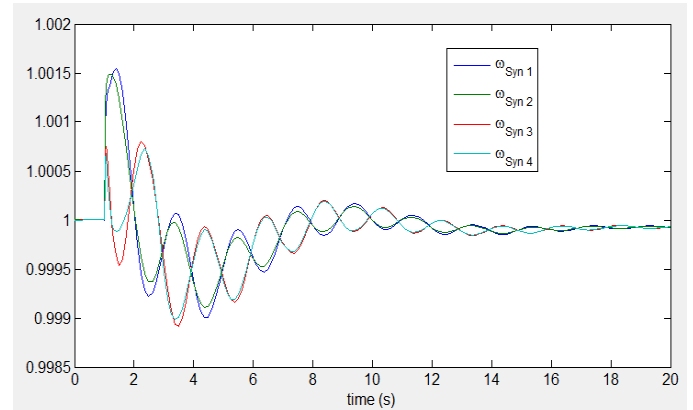


Figure 13 Angular freq with UPFC

Fig.13 shows Angular freq with UPFC at fault clearing time 1.05sec.

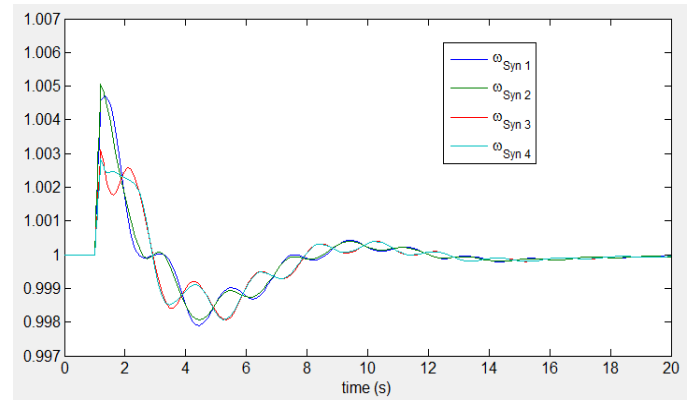


Figure 14 Angular freq with UPFC

Fig.14 shows Angular freq with UPFC at Fault clearing time 1.2sec.

With the increase in the fault clearing time the peak value of increases to 1.005.

V. CONCLUSION

This paper investigates the capability of UPFC on transient stability of a Two-area power system. The analysis of Generator Rotor angle, Voltage Profile and Angular Freq is done with and without UPFC at different fault clearing time.

Without UPFC the Rotor angle of all the buses increases and will lead the system out of synchronism whereas without UPFC they are decreasing and settling down. System will remain in synchronism.

The Buses of Area 1 i.e. Bus 1,2,5,6 and 7 and The Buses of area 2 Bus 3,4,9,10 and 11 their settling time is more than 2sec without UPFC. With the application of UPFC the settling time is reduced to 1.18 sec. for all buses.

The Angular Freq without UPFC settles to 1 p.u. value after 20sec. with UPFC Angular freq starts settling down after 15sec. at fault clearing time 1.05 sec. and 1.2 sec.

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