

## Enhancement of Power Quality in Transmission Line Using Flexible Ac Transmission System Device U.P.F.C (Unified Power Flow Controller)

B. Divya Lakshmi<sup>1</sup>, M. Manoj Gupta<sup>2</sup>, G.Manoj Kumar<sup>3</sup>, G. Jyothsna<sup>4</sup>, A. Parvathi<sup>5</sup>

<sup>1</sup>Assistant Professor Lendi Institute of Engineering

<sup>2, 3, 4, 5</sup>Lendi Institute of Engineering

### Abstract

Present scenario states that power demand has been increased in a rapid and random manner. Hence power generated is unable to meet the power demand so power scarcity exists. There is an approximate loss of (20 - 40)% of power generated during its transmission. Hence there is a need for enhancing the power quality in transmission lines. In order to improve the power quality our paper make use of FACTS DEVICES. FACTS devices can be added to power transmission and distribution systems at appropriate locations to improve system performance. The real and reactive powers can be easily controlled in a power system with FACTS devices. Flexible AC Transmission System creates a tremendous quality impact on power system stability. This paper describes the basic principle of operation of UPFC, its advantages and to compare its performance with the various FACTS equipment available. The objective of this paper is to keep the power system to remain in voltage stable condition when it experiences a load change and contingency, also deals with the simulation of various FACTS controllers using simulation program with MATLAB/SIMULINK

### I. INTRODUCTION

Now, more than ever, advanced technologies are paramount for the reliable and secure operation of power systems. The promising concept of the Flexible AC Transmission System (FACTS) makes it possible to achieve fast and reliable power system control by means of power electronic devices. The emergence of the FACTS devices offers great opportunities to the operation and control of modern power systems. Better, faster, cheaper and more reliable utilization of electrical energy is an important subject that electric power companies are concerned about. Harmonics and reactive power flowing to the supply system, transients caused by less reliable electrical supply systems. In order to cope with these kinds of problems and increase usable power transmission capacity, FACTS (Flexible AC Transmission Systems) devices were developed and introduced to the market.

FACTS devices can only regulate either the active power flow or reactive power flow of a single transmission line. A breakthrough is made by the availability of the UPFC, which is one of the most versatile FACTS devices and is capable to control the active and reactive power flows in the transmission line at the same time.

Power Flow is one of the major problems in a transmission system. When a fault occurs in a

transmission system there is said to be a drop in the voltage. The UPFC is capable of enhancing transient stability in a power system. It is the most complex power electronic system for controlling the power flow in an electrical power system.

The UPFC in its general form can provide simultaneous, real-time control of all basic power system parameters (transmission voltage, impedance and phase angle) and dynamic compensation of ac system. The Unified Power Flow Controller (UPFC) is a relatively new and more versatile device in the FACTS family, because of its simultaneous control ability of active and reactive power, and its effective damping capability for transient swings.

Many studies were made before in order to achieve the suitable and optimal representation of the UPFC model with the Newton-Raphson load-flow algorithm. The drawback of these represented models is mainly for its difficulty and heavy computation burden. In this paper, control of both real and reactive power flow of transmission line is achieved through a suggested UPFC model.

Within this paper, which is on the trace of our previous works, the impact of the Unified Power Flow Controller (UPFC) on power flow regulation is analyzed. The proposed models accurately represent behavior of the controllers, and are adequate for transient and steady state analysis of power systems.

In recent years, MATLAB has become more and more popular in all engineering fields for its flexibility and the well support from its toolboxes. The real power and reactive power in the load is measured using the Active & Reactive Power measurement block.

## II. OPERATING PRINCIPLE OF UPFC

The basic components of the UPFC are two voltage source inverters (VSIs) sharing a common dc storage capacitor, 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 a series transformer. A basic UPFC functional scheme is shown in fig.1.

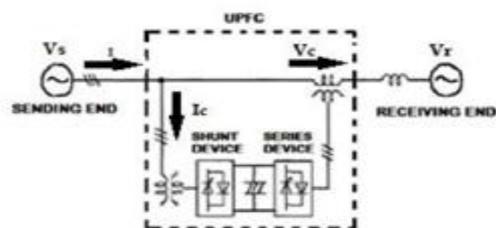


Fig.1 Basic functional scheme of UPFC

### A. Basic Transmission Line

The voltage measurement block is used to measure the source voltage. The current measurement block is used to measure the instantaneous current flowing in the transmission line. Fig.2 represents the source impedance and the line impedance of  $(6+j0.023) \Omega$ , and the load impedance of  $(2+j0.02) \Omega$  respectively. Scope displays the signals generated during a simulation. In, scope is used to view both the line current and source voltage.

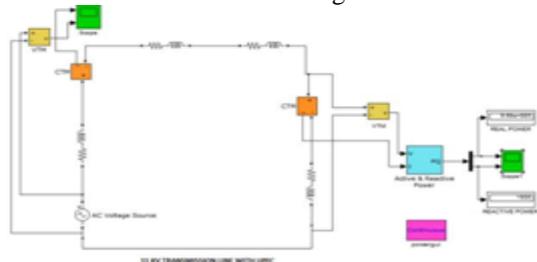


Fig. 2 Basic 11 KV transmission line without compensation

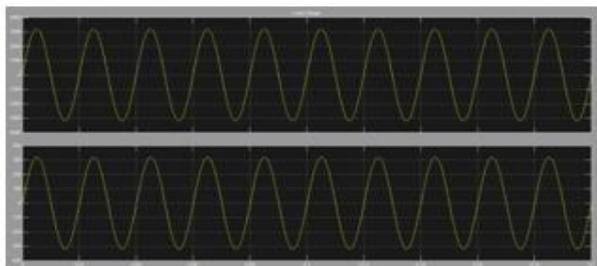


Fig.3 Load Voltage & current Waveforms

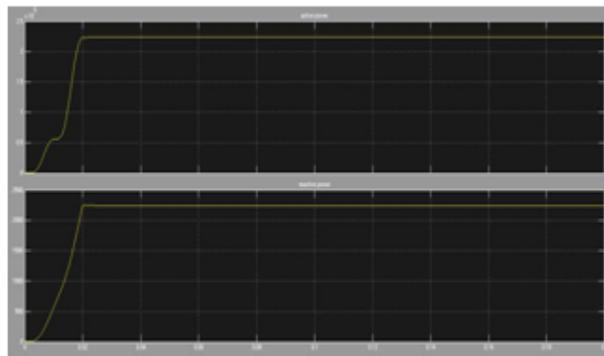


Fig. 4 Active Power & reactive Powers

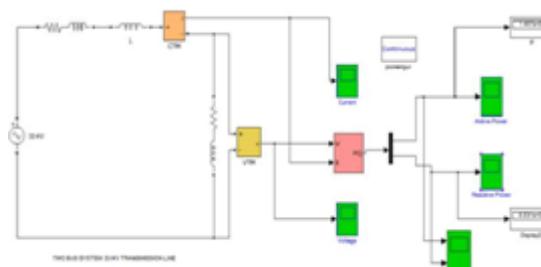


Fig. 5 Basic 33 KV transmission line without compensation

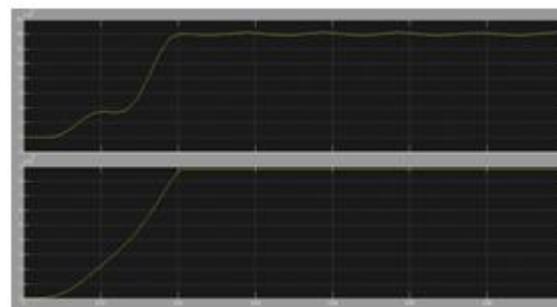


Fig. 6 Active Power & reactive Powers

## III. SIMULATION RESULTS

### A. Fixed Capacitor Thyristor-Controlled Reactor

The Fixed Capacitor Thyristor-Controlled Reactor (FC-TCR) is a var generator arrangement using a fixed (permanently connected) capacitance with a thyristor controlled reactor as shown in Fig.7. The model of FC-TCR with line voltage 11KV shown in Fig 8. Current through the reactor using the current measurement block .the line impedance of  $(5+j0.023) \Omega$  is represented by resistance and inductance of source side.

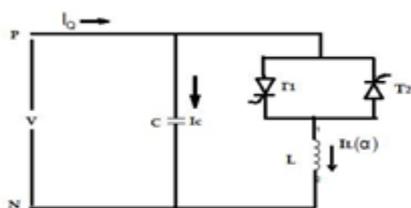


Fig. 7 Fixed Capacitor Thyristor Controlled

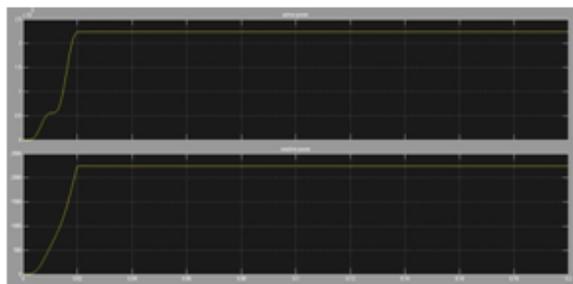


Fig. 8 Simulation Circuit of FC-TCR



Fig. 9 Active Power & reactive Powers

The value of FCTCR reactor is 100mh and apacitor C is the fixed capacitor of 200 μF. The current through FCTCR is shown in Fig.10 and behavior of Real and Reactive Power is bus voltage increases with the increase in the injected voltage. The corresponding graph is shown in fig. 16 shown in Fig. 11 also the load voltage and the load current respectively.

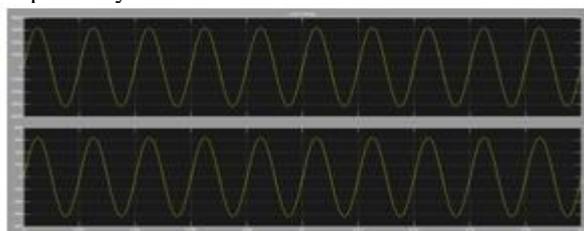


Fig. 10 Effective current through FCTCR

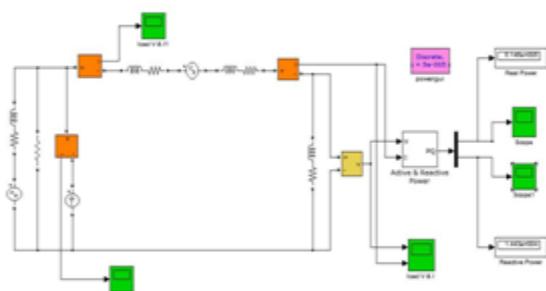


Fig.11 Load Voltage & current Waveforms

Simulation model of two bus system with UPFC shown in Fig. 12 The series convertor is represented as Voltage source (Vseries), and shunt convertor is represented as Voltage source (Vshunt). Power measurement block is connected at the load side to measure Real Power and Reactive Power.

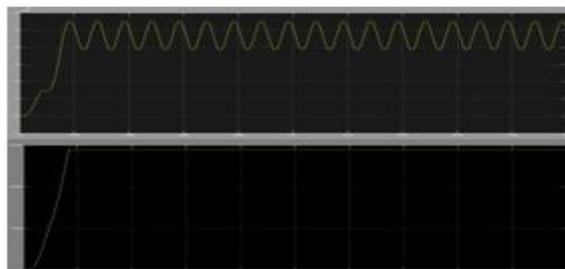


Fig. 12 Simulation Circuit of UPFC

The Variation of Real power with the variation of injected angle is given in Table1. The real power is increase with the increase in the angle of injection [5]. The corresponding graph is shown in fig. 14 The Variation of Reactive power with the variation of injected angle is given in Table2. The bus voltage increases with the increase in the injected voltage. The corresponding graph is shown in fig. 16.

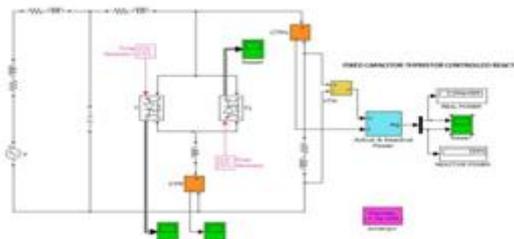


Fig. 13 Active Power & Reactive Powers

The Real power and the Reactive Powers measured in the load are 0.23MW and 1.12MVAR as shown in Fig.13. By introducing FACTS Controllers in the transmission line, the power flow can be increased [6] [7].

Table.1 Variation of Real Power & Angle of injected Voltage

S. No.	Angle of injected Voltage in series (deg)	Real Power (MW)
1	0	0.274
2	30	0.338
3	60	0.471
4	90	0.644
5	120	0.807

The reactive power can be further increased by increasing the magnitude of injected voltage. The corresponding graph is shown in fig. 16. It can be seen that the reactive power further increases with the increase in the injected voltage.

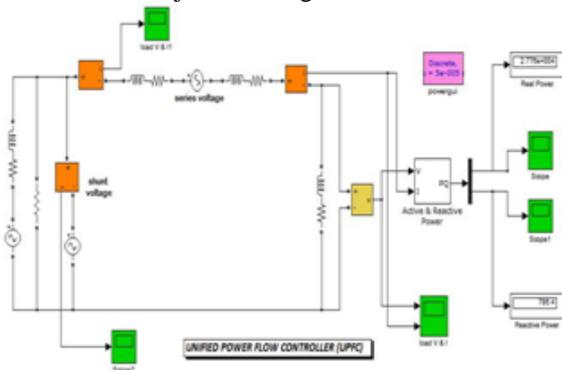


Fig. 15 Simulation Circuit of Shunt injected UPFC

Table.3 shows the variation of Real and Reactive powers by injecting a series voltage of fixed magnitude 3kV at different angles of injection from 0° to 360°[8] Table.2 shows the variation of Reactive Powers.

	Angle of injected Voltage in shunt (KV)	Reactive Power (VAR)
1	2.5	39.45
2	3	157.8
3	3.5	355.1
4	4	631.3
5	4.5	986.4
6	5	1420
7	5.5	1933

#### IV. RESULTS

Power quality enhancement is done by using upfc which enhances the real and reactive power by increasing the angle of injection. by using upfc it has wide flexibility to control real and reactive powers of the transmission line when upfc is introduced. The results are similar to the predicted results.

Table.3 Variation of Real and Reactive Powers with variation in the angle of injected voltage

S. No.	Angle of injected Voltage (Deg)	Real Power in (MW)	Reactive Power in (MVAR)
1	0	0.274	0.007
2	30	0.338	0.009
3	60	0.471	0.012
4	90	0.644	0.017
5	120	0.807	0.021
6	150	0.644	0.017
7	180	0.920	0.026
8	240	0.697	0.021
9	270	0.532	0.016
10	300	0.387	0.019
11	360	0.274	0.007

#### V. CONCLUSION

Improvement of simulation on power quality using FACTS devices in a MATLAB SIMULINK has been presented. Devices like UPFC made the improvement of power quality by injecting the voltage which avoids the major problems in transmission system. As UPFC is a fast and reliable device when compared with other FACTS devices, the results of simulation of transmission lines have been obtained using MATLAB SIMULINK. The simulation results are similar to the predicted results. Analysing the results has given an indication that UPFC are very useful when it comes to organize and maintain power system. Following conclusions are made-

- Power flow control is achieved and congestion is less.
- Transient stability is improved.
- Faster Steady State achievement.
- Improved Voltage Profile

#### REFERENCES

[1] N. G. Hingorani and L. Gyugyi "Understanding FACTS concepts and technology of flexible AC transmission systems", IEEE Press, New York, 2000.

[2] Raju Pandey and A. K. Kori August (2012) "Real and Reactive Power flow Control Using Flexible AC Transmission System connected to a Transmission line: a Power Injection Concept", Volume 1, Issue 6, ISSN: 2278 – 1323 International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) pp.

- 252 – 256.
- [3] Gyungui. L, FIEE. (2008) ‘Unified Power Flow Control concept for Flexible AC Transmission System’ IEE proceedings- C, Vol.139, No.4.
  - [4] C.D. Schaulder et al., “Operation of unified power flow controller (UPFC) under practical constraints’, IEEE Trans.Power Del., vol.13, no.2. pp.630-639, Apr1998.
  - [5] Kannan. S, Shesha Jayaram and M.M.A.Salama. (2007) ‘Real and Reactive Power Coordination for a Unified Power Flow Controller’ IEEE Transactions on Power Systems, 2007, vol.19.No.3, pp. 1454 – 1461.
  - [6] Anderson, Fouad, Power System Control and Stability, IEEE Press, 1994.
  - [7] P. Kundur, Power System Stability and Control, *McGraw- Hill Inc., 1994, pp:813-816*
  - [8] Gyugyi, Jul, 1992. “Unified power-flow control concept for flexible AC transmission system,” Proc. Inst. elect. Eng.C, vol. 139, no.4, pp. 323-331
  - [9] Sen, K.K. and A .J.F. Keri, 2003. Comparison of field results and digital simulation results of voltage sourced converter-based FACTS controller. IEEE Trans. Power Del., 18(1): 300-306.
  - [10] Padiyar. K. R and Uma Rao. K. (2008) ‘Modeling and control of Unified Power Flow Controller for transient stability’ Electrical Power & Energy Systems, pp.1 – 11.
  - [11] Gholipour, E. and S. Saadate, 2003. A new method for improving transient stability of power systems by using UPFC. Proc. European Power Electronics, Toulouse, France, September 2003.