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Original Article

A New Approach for Converting Radial Distribution in to Loop Distribution System with Regulating Voltage and Line Loss Minimization using UPFC

Ch .S Ganga Bhavani and B.Lavanya

Ch .S Ganga Bhavani and B.Lavanya

From
[1]M. Tech, Scholar , [2] Asst. Prof. HITS
Engineering college, Denduluru

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ABSTRACT

The Ability to control power flow in an electric power system without generation rescheduling or topology changes can improve the power system performance using controllable components, the line flows can be changed in such a way that thermal limits are not exceed, losses are minimized, stability margins are increased and contractual requirements are fulfilled without violating the economic generation dispatch. Flexible AC Transmission systems (FACTS) technology is the ultimate tool for getting the most out of existing equipment via faster control action and new capabilities. Voltage regulation and line loss minimization in distribution networks are challenging problems, particularly when it is not economic to upgrade the entire feeder system. This project presents a new method for achieving line loss minimization and all nodes voltage regulation in the loop distribution systems, simultaneously, by using unified power flow controller (UPFC), one of the most important FACTS devices. First, the line loss minimum conditions in the loop system are presented. Then, load voltage regulation is applied under line loss minimum conditions. Reference voltage of the controlled node is determined based on the assumption that this voltage can subsequently improve all node voltages to be within the permissible range. Also, the proposed control scheme of the UPFC series converter, to regulate all node voltages under line loss minimization, is presented. The effectiveness of the proposed control scheme has been performed in MATLAB/SIMULINK environment.

Keywords:
Line loss minimization, loop distribution system, series compensation, unified power flow controller (UPFC), voltage regulation, fuzzy controller.

Introduction

The electric power system is considered to be composed of three functional blocks-generation, transmission and distribution. For a reliable power system, the generation unit must produce adequate power to meet customer's demand, transmission systems must transport bulk power over long distances without overloading or jeopardizing system stability and distribution systems must deliver electric power to each customer's premises from bulk power systems. Distribution system locates the end of power system and is connected to the customer directly, so the power quality mainly depends on distribution system. The reason behind this is that the electrical distribution network failures account for about 90% of the average customer interruptions. In the earlier days, the major focus for power system reliability was on generation and transmission only as these more capital cost is involved in these. In addition their insufficiency can cause widespread catastrophic consequences for both society and its environment. But now a day's distribution systems have begun to receive more attention for reliability assessment.

Initially for the improvement of power quality or reliability of the system FACTS devices like static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), interline power flow controller

(IPFC), and unified power flow controller (UPFC) etc are introduced. These FACTS devices are designed for the transmission system. But now a day's more attention is on the distribution system for the improvement of power quality, these devices are modified as custom power devices. The custom power devices which are used in distribution system for power quality improvement are distribution static synchronous compensator (DSTATCOM), dynamic voltage restorer (DVR), active filter (AF), unified power quality conditioner (UPQC) etc.

Power Quality in electric networks is one of today's most concerned areas of electric power system. The power quality has serious economic implications for consumers, utilities and electrical equipment manufacturers. The impact of power quality problems is increasingly felt by customers-industrial, commercial and even residential. Some of the main power quality problems are sag, swell, transients, harmonics, and flickers etc.

The interest in the practice of Power Quality Devices (PQDs) arises from the need of growing power levels to meet everyday growing sensitivity of customer needs and expectations. One of those devices is unified power flow controller (UPFC), which is the most efficient and effective modern custom power device used in power distribution networks.

There are many control strategies reported in the literature to determine the reference values of the voltage and the current of three-phase four-wire UPFC, the most common are the p-q-r theory, modified single-phase p-q theory, synchronous reference frame (SRF) theory, symmetrical component transformation, and unit vector template (UVT) technique, one cycle control (OCC) (without reference calculation). The following present a brief review of the work undertaken so far.

N.G. Hingorani, presents the concept of custom power is now becoming familiar. The term describes the value-added power that electric utilities and other service providers will offer their customers in the future. The enhanced level of reliability of this power, in terms of reduced interruptions and less variation, will stem from an integrated solution to present problems, of which a prominent feature will be the application of power electronic controllers to utility distribution systems and/or at the supply end of many industrial and commercial customers and industrial parks.

Yash Pal, A. Swarup, . Presents a comprehensive review of compensating custom power devices mainly DSTATCOM (distribution static compensator), DVR (dynamic voltage restorer) and UPFC (unified power flow controller). It is aimed at providing a broad viewpoint on the status of compensating devices in electric power distribution system to researchers and application engineers dealing with power quality problems.

Kesler, E. Ozdemir, et al. Presents synchronous reference frame controlling method for series Active Power Filter (APF) and the concept of instantaneous reactive power theory is applied for shunt APF for the generation of reference voltages and currents. These reference voltages are compared with actual load voltages by means of sinusoidal PWM and for the comparison of reference source currents with actual source currents, hysteresis PWM is implemented. The sine and hysteresis PWM techniques gives gate signals to IGBTs of 3-leg VSC.

Vinod Khadkikar, presents the concept of realization of 3-phase, 4- wire system from 3-phase, 3-wire in 2009. The 3-phase, 4- wire system can be realized by providing the neutral conductor along with the three power lines from generation station or by utilization a delta-star transformer at distribution level.

Metin Kesler, Engin Ozdemir . Presents the 3-phase, 4-wire system which can be realized by providing the neutral conductor by means of the split phase capacitor topology which injects the compensator current and finally source neutral current is approximately going to zero was implemented by in 2010.

Distribution networks are typically of two types, radial or loop. It is well understood that radial distribution systems are more desirable than loop systems, and distribution engineers have preferred them because they use simple and inexpensive protection schemes. Also, when a fault occurs in the radial network, the faulted part can be isolated fast from the system to avoid the influence of the fault. However, there is high possibility of unbalanced power flow among feeders due to the different loads, which in turn causes high power loss and high voltage drop. In heavy loaded feeders, the voltage at the far end point may be beyond the allowed voltage limit. In order to operate distribution system effectively, loop system configuration has been proposed to balance the power flow, to reduce the power loss, and to regulate the load voltages. However, short-circuit current will increase, and fault location detecting method in loop systems has not yet been established [2]. Recent research in distribution systems has been focused on voltage regulation and line loss minimization. Some of them proposed reconfiguring radial distribution system to loop 1 using the existing infrastructure. In [3], the reliable operation of loop distribution systemwas achieved by installing a high-speed protective relay to prevent fault expansion. In [4] and [5], backto- back (BTB) loop power flow controller and loop balancer controller are installed to connect the adjacent feeders to perform loop system. In [5] and [6], a looping wire is used to reconfigure two radial feeders to loop system, and the BTB converter is used to overcome problem of increase/decrease voltages.In addition, many papers considering loss reduction and voltage regulation in distribution systems, using FACTSdevices, have been published [8]–[14]. Most of them used STATCOM, shunt active filter, series-shunt power converter, and BTB converter to regulate and balance load voltages and to reduce line loss by reactive power injection. However, these literatures did not consider load voltage regulation and line loss minimization simultaneously. In [15], the authors have proposed the line loss minimum conditions in loop distribution systems, and experimentally achieved them by using unified power flow controller (UPFC). Also, in [16], the authors have proposed a new control technique for UPFC to regulate load voltage to be equal in magnitude to source voltage under line loss minimization. However, these methods cannot guarantee all node voltages to be within the permissible voltage limit. In this project, the authors wish to deal with the UPFC as a centralized control device with the aim of attaining a better service quality, in terms of all nodes voltage regulation and power loss minimization in loop distribution system, simultaneously. Whenever the voltage profile violates voltage restriction, the control strategy is determined to keep voltage level along the feeders within a prespecified range, ±5% of the nominal voltage. Proposed a new control technique for UPFC to regulate load voltage to be equal in magnitude to source voltage under line loss minimization. However, these methods cannot guarantee all node voltages to be within the permissible voltage limit. In this project, the authors wish to deal with the UPFC as a centralized control device with the aim of attaining a better service quality, in terms of all nodes voltage regulation and power loss minimization in loop distribution system, simultaneously. . The proposed control scheme of the UPFC is presented. All nodes voltage regulation and line loss minimization in loop system are experimentally investigated by using laboratory prototype in a 200-V, 6-kVA system.

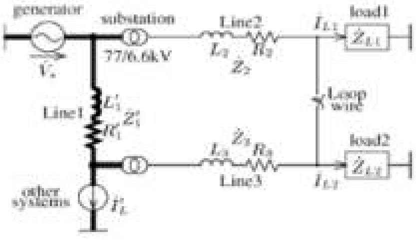


Fig. 1. Model of loop distribution system.

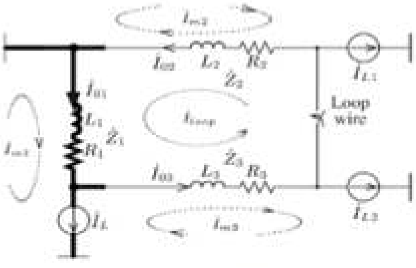


Fig. 2. Approximate model of loop distribution system.

II. LINE LOSS MINIMUM CONDITIONS [14]

Mesh analysis is another general procedure for analyzing circuits, using mesh currents as the circuit variables. Using mesh currents instead of element currents as circuit variables reduces the number of equations that must be solved simultaneously. Recall that a loop is a closed path with no node passed more than once. A mesh is a loop that does not contain any other loop within it.Nodal analysis applies KCL to ?nd unknown voltages in a given circuit, while mesh analysis applies KVL to find unknown currents. Mesh analysis is not quite as general as nodal analysis because it is only applicable to a circuit that is planar.

The load currents İL1 and İL2 , and the other systems current İL are assumed to be constant .Also, the line currents I?0i (i=1, 2, 3, and 4) flow in each line in the same direction (counter clockwise).According to the line currents and the system parameters, the total line loss Pl in the loop system can be formulated as follows

$$
\begin{aligned}
P_l &= \sum_{i=1}^{3} R_i |\dot{I}_{0i}|^2 \\
&= R_{\text{loop}} \left| \dot{I}_{01} - \frac{R_2\dot{I}_{L1} + R_2\dot{I}_{L2} + (R_2 + R_3)\dot{I}_L}{R_{\text{loop}}} \right|^2 \\
&\quad - \frac{|R_2\dot{I}_{L1} + R_2\dot{I}_{L2} + (R_2 + R_3)\dot{I}_L|^2}{R_{\text{loop}}} \\
&\quad + R_2|\dot{I}_{L1} + \dot{I}_{L2} + \dot{I}_L|^2 + R_3|\dot{I}_L|^2
\end{aligned}
$$

where

$$R_{\text{loop}} = \sum_{i=1}^{3} R_i.$$

Since the second, third, and fourth parts in (1) are constants, because the currents İL1, İL2 and İL are assumed to be constants, the first part is the only part that can be used to obtain the line loss minimum conditions. These conditions can be obtained by equating the first part in (1) with zero. In this case, the total line loss Pl min in loop system can be formulated as follows

$$P_{l\min} = \sum_{i=1}^{3} R_i \left|\dot{I}_{mi}\right|^2 \qquad (3)$$

where I?mi (i = 1, 2, and 3) is the line current that flows in the loop lines in case of line loss minimization. The loss minimum line currents can be formulated as follows:

$$
\left.
\begin{aligned}
\dot{I}_{m1} &= \frac{R_2\dot{I}_{L1} + R_2\dot{I}_{L2} + (R_2 + R_3)\dot{I}_L}{R_{\text{loop}}} \\
\dot{I}_{m2} &= -\frac{(R_1 + R_3)\dot{I}_{L1} + (R_1 + R_3)\dot{I}_{L2} + R_1\dot{I}_L}{R_{\text{loop}}} \\
\dot{I}_{m3} &= \frac{R_2\dot{I}_{L1} + R_2\dot{I}_{L2} - R_1\dot{I}_L}{R_{\text{loop}}}
\end{aligned}
\right\}. \qquad (4)
$$

The difference between the currents I?0i and I?mi is defined as the loop current I?loop that circulates in loop system in the same direction, and can be formulated as follows:

$$\dot{I}_{\text{loop}} = \dot{I}_{0i} - \dot{I}_{mi} = -\frac{\sum_{i=1}^{3} j\omega L_i I_{0i}}{R_{\text{loop}}}. \qquad (5)$$

The line loss minimum conditions in loop systems can be realized by eliminating the loop current I?loop from the system, which can be achieved if any of the following conditions is realized [14]:

$$\frac{R_1}{L_1} = \frac{R_2}{L_2} = \frac{R_3}{L_3} \qquad (6)$$

$$\sum_{i=1}^{3} j\omega L_i \dot{I}_{0i} = 0. \qquad (7)$$

III. VOLTAGE REGULATION UNDER LINE LOSS MINIMUM CONDITIONS

Load voltage regulation problems in distribution systems arecommonly solved by using STATCOM, which has the abilityto control voltage magnitude by compensating reactive power. However, STATCOM cannot control the line loss in loop distribution systems. On the other hand, series compensators, such as UPFC, have the ability to regulate load voltage and to minimize line loss simultaneously in the loop distribution system. The main object of this paper is to minimize the total line loss and to regulate the load voltages in loop distribution system, simultaneously. The line loss minimum conditions can be achieved if the loop current is eliminated from the loop system. Under this condition, the load voltages can be controlled in order to keep it within the permissible voltage range, ±5%of the nominal source voltage. Fig. 3 shows a simple model ofthe loop distribution system that is used to simplify the idea ofvoltage regulation under line loss minimum condition.

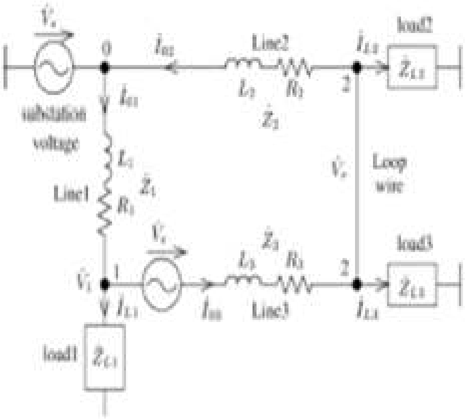


Fig. 3. Model of loop distribution system with series voltage source.

In this model, ?Vs ,?V1 , and ?Vr are assumed to be source voltage, load 1voltage, and (loads 2 and 3) voltage, respectively. The series voltage source ?Vc is assumed to be a controlled series voltage that is used to regulate the load voltages. The controlled series voltage Vc is inserted to the loop system by the UPFC series converter. Therefore, the voltage Vc is assumed to be controlled in both voltage magnitude and phase angle.

A. Before Installing the Controlled Series Voltage ?Vc

Fig. 4(a) shows the phasor diagram of the line currents and node voltages in the loop system shown in Fig. 3. The permissible voltage range is defined by the lower and upper voltage limits. It is cleared that the node 2 voltage ?Vr is less than the lower voltage limit and lags behind the source voltage ?Vs by the angle θ. Therefore, series compensation can be used to control node 2 voltage in order to regulate all node voltages to be within the permissible voltage limit.

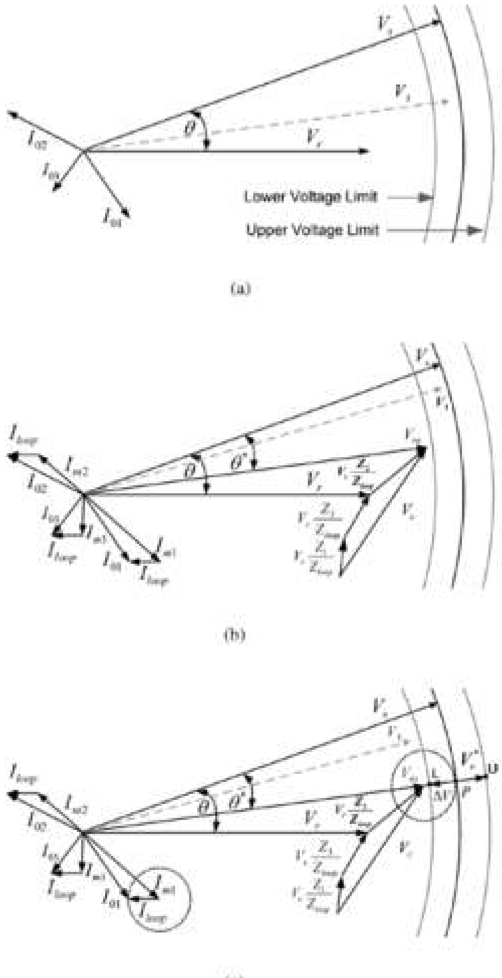
B. After Installing the Controlled Series Voltage ?Vc

Installing a series voltage source in a loop distribution system affects the power flow and hence changes all the node voltages. Based on the superposition theorem, the change in node 1 and node 2 voltages due to the installation of the controlled series voltage ?Vc in the loop system shown in Fig. 3 can be formulated as follows:

$$\left.\begin{aligned}\Delta\dot{V}_1 &= -\dot{V}_c\frac{\dot{Z}_1}{\dot{Z}_{\text{loop}}}\\ \Delta\dot{V}_r &= \dot{V}_c\frac{\dot{Z}_2}{\dot{Z}_{\text{loop}}}\end{aligned}\right\}\qquad(8)$$

where ?Vc is the series injected voltage, and ?Z loop is the summation of the loop impedances. Fig. 4(b) and (c) shows the phasor diagrams of all line currents and node voltages after installing the controlled series voltage ?Vc . The phasor diagrams are drawn based on the change in each node voltage due to the installation of ?Vc. The value of the controlled series voltage ?Vc is determined according to its function in the loop distribution system, and the change in each node voltage can be calculated based on (8).

Since the controlled series voltage ?Vc realize its function by controlling the node 2 voltage, the phasor lines, representing the change in each node voltage, are drawn to show the overall change related to node 2 voltage. Also, the line currents I?0i and their components (I?mi and I?loop) are drawn in the phasor diagrams based on (4) and (5). The focus of the phasor diagrams, shown in Fig. 4(b) and (c), is the relation between the change in the node 2 voltage and the loop current. In the system shown in Fig. 3, if the controlled series voltage ?V c is installed to achieve loss minimum condition, node 2 voltage changes to be Vra , which is still less than the lower voltage limit and lags behind source voltage ?Vs by the angle θ*, as shown in Fig. 4(b). In this case, node 2 voltage can be formulated as follows



(a)

(b)

(c)

Fig. 4. Phasor diagram of the loop distribution system. (a) Before installing $\dot{V}_c$. (b) After installing $\dot{V}_c$ to achieve line loss minimization. (c) After installing $\dot{V}_c$ to achieve voltage regulation under line loss minimization.

$$\dot{V}_{ra} = \dot{V}_r + \dot{V}_c \frac{\dot{Z}_2}{\dot{Z}_{\text{loop}}} \qquad (9)$$

where ?Vr is the load voltage before installing ?Vc , and ?Vra is the load voltage after installing ?Vc .Inserting a controlled series voltage in loop system to achieve line loss minimization affects all voltages in the system. However, Fig. 4(b) shows that this method cannot guarantee all node voltages to be within the permissible voltage range. Fig. 4(c) shows the phasor diagram of the distribution system, shown in Fig. 3, with the effect of using ?Vc to achieve load voltage regulation under line loss minimum condition. Based on the loop current, total power loss shown in (1) can be formulated as follows

$$P_l = \sum_{i=1}^{3} R_i|\dot{I}_{0i}|^2 = \sum_{i=1}^{3} R_i|\dot{I}_{mi}|^2 + R_{\text{loop}}|\dot{I}_{\text{loop}}|^2. \qquad (10)$$

Equation (10) shows that any circle centered by the current *I?mi* , due to the change in loop current, has constant power loss. The change in loop current will change the node 2 voltage by ΔV , as shown in Fig. 4(c). The resultant node 2 voltage can be formulated as follows:

$$\left.\begin{aligned} \dot{V}_r^* &= \dot{V}_{ra} + \Delta\dot{V} \\ \Delta\dot{V} &= \dot{Z}_2\dot{I}_{\text{loop}} \end{aligned}\right\}. \qquad (11)$$

Equation (11) shows that changing the loop current to draw a circle around its center I?mi causes the node 2 voltage to draw a similar circle around its center ?Vra that also has constant power loss. In case of line loss minimization, the loop current is zero and hence the radius of both circles is zero. As the loop current increases, the radius of these circles and hence total line loss increase, too. The tangential point, point (P), between the circle centered by ?Vra and the circle of source voltage loci, represents the point, at which node 2 voltage equals in magnitude to source voltage under loss minimum condition. In general, controlling node 2 voltage to be lag behind Vs by the angle θ*, means controlling the voltage under line loss minimum condition [15]. However, controlling the node 2 voltage to be equal in magnitude to source voltage under line loss minimum condition cannot guarantee all node voltages to be within the permissible voltage range. According to (8), the change in node 2 voltage causes an opposite change in the node 1 voltage, that may cause the node 1 voltage to be less than the lower voltage limit. In this project, the reference magnitude of node 2 voltage is controlled to be in-between points L and U, as shown in Fig. 4(c), in order to achieve all node voltages within the permissible voltage range under line loss minimum condition. The reference magnitude will start at point (p), then changes toward point (L) or (U) according to the voltage at node 1 in order to realize all node voltages in between the permissible voltage limit.

IV. PROPOSED CONTROL SCHEME

The proposed control scheme has been developed to meet the following objectives, simultaneously: 1) minimize total power loss in loop distribution systems; and 2) regulate all node voltages to be within permissible voltage range. Fig. 5 shows the loop distribution system model controlled by the UPFC. In this model, the UPFC series converter is represented by series voltage source connected at line 2, whereas the shunt converter is disregarded because its current is not as large as the distribution line current. The distribution system model has three nodes that their voltages can be controlled by the UPFC. Fig. 6 shows the control flow chart of the UPFC series converter. First, the reference voltage of the UPFC series converter is calculated based on the line loss minimum condition. If any node voltage is outside the permissible voltage limit, UPFC will control the node 2 voltage to be equal in magnitude to the source voltage under line loss minimization. In this case, if the voltage at nodes 1 or 3 is still out of the limit, node 2 voltage magnitude will be controlled in order to keep them within the limit. In all cases, the reference angle of node 2 voltage is θ* to control the node voltages under loss minimization. Fig. 7 shows the proposed control block diagram of the UPFC series converter to achieve all nodes voltage regulation under line loss minimization by controlling node 2 voltage. The difference between reference and actual node 2 voltage is controlled the reference current of the UPFC line (line 2), which is used to calculate the reference voltage of UPFC series converter Vc . The parameters in control block diagram are transformed from three-phase axis to the p–q axes using Park–Clarke transformation[18]. Also, the control technique used in this paper does not require any data about the loads because in practical distribution systems, loads are continuously varying.

In order to achieve line loss minimization in the loop system,

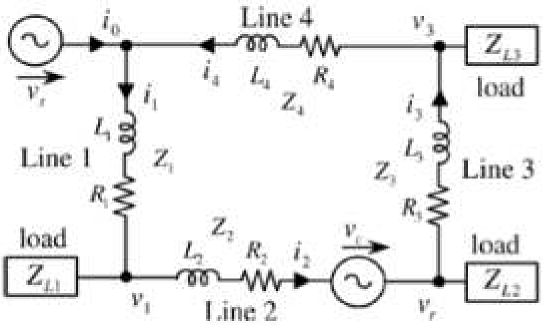
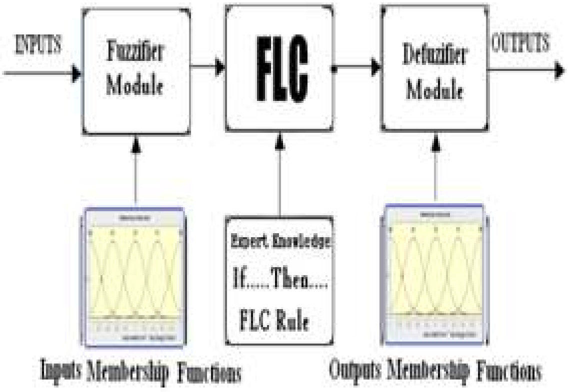


Fig. 5. Model of the system in case study.

V. FUZZZY CONTROLLER

Fuzzy control provides a formal methodology for representing, manipulating, and implementing a human's heuristic knowledge about how to control a system. When controlling any non linear process human operators usually encounter complex patterns of qualitative changing conditions, which are difficult to interpret accurately, the magnitude of the change is usually described as fast, big slow, high etc. to represent such inexact variable information, and non mathematical approach called "fuzzy set theory" was developed by Zadeh [7]. Fuzzy set theory involves very complicated theorems, but most of the theorems do not relate to the development of fuzzy control algorithms.



A fuzzy algorithm consists of situation and action pairs. Conditional rules expressed in IF and THEN statements are generally used. For example, the control rule might be: if the output is lower than the requirement and the output is dropping moderately then the input to the system shall be increased greatly. Such a rule has to be converted into a more generally statement for application to fuzzy algorithms. To achieve this the following terms are defined: error equals the set point minus the process output, error change equals the error from the process output minus the error from last output: and control input applied to the process. In addition, it is necessary to quantize the qualitative statements and the following linguistic sets are assigned

1. Large Positive (LP)
2. Medium Positive (MP)
3. Small Positive (SP)
4. Zero (ZZ)
5. Small Negative (SN)
6. Medium Negative (MN)
7. Large Negative (LN)

Thus the statement of the example control will be: if the error is large positive and the error change is small positive then the input to the system is large positive.

I. Fuzzy Rules

COE E	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PB	NS	ZE
PS	NM	NS	ZE	PS	PM	PM	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

VI. SIMULATION RESULTS

The simulation results are observed as follows.

Case(I): Vs=1, Load 2 PU with lagging power factor 0.625, initially shunt control is OFF, then shunt control is ON at T=0.04 sec,Pref=o, Load switch is ON at T=0.08 sec, at T=0.025 sec load is OFF and subsequently shunt control is OFF.

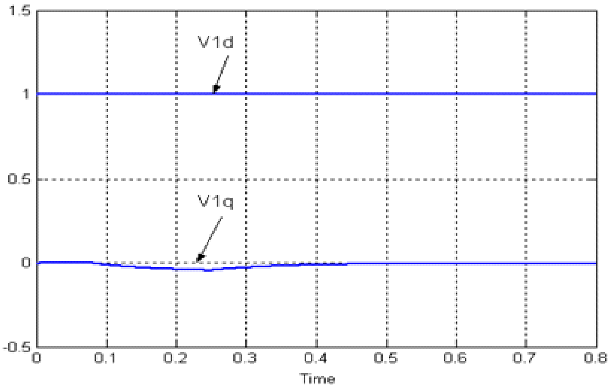
By analyzing of the below results for a step change in load at t =0.08 sec, sudden change in Q-component of the voltage is observed. At that time shunt converter RMS voltage rise to injected reactive power in to the bus. Reactive power shown is negative implies shunt converter is delivering lagging reactive power to the bus to keep the bus voltage constant.

When the load is switched on at T=0.08 sec reactive power flow in the line (Q2) increases. The series converter voltage changes accordingly to supply the reactive power. In the above plots the real power consumed by the shunt converter is not equal to the real power at port 1; we have to subtract the real power dissipated in the resistance in the shunt converter path from the shunt real power.

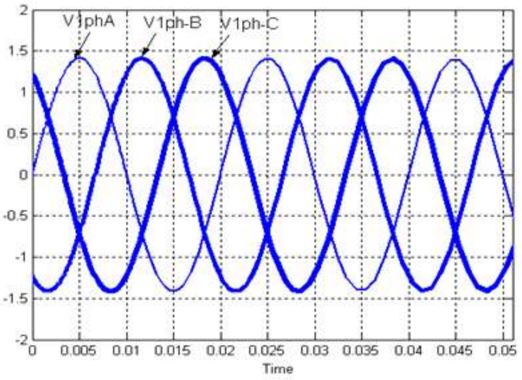
The rise and fall times observed when sudden load change occurred at T=0.08 sec and T=0.25 sec in port1 rise time and fall time are given by Tr=0.025 sec, Tf=0.002. the load powers given the figure is that of reference commanded powers and are different from the actual power drawn from the bus by considering the time period of 1ms. This accounts for the higher time which is being observed here. The parameters of the controller at different locations are tuned to get satisfactory a gain sudden change in load occurs.

Initially there is no power flow from sending end to receiving end because load angle is zero. When load changes at the port1, voltage angle changes with respect to the receiving end, so there is a real power flow from port2 to receiving end from sending end to the port1.

The rise and fall times observed in real power flow when load suddenly switched on are Tr =0.004 sec and Tf =0.0001 the rise and fall times observed when load suddenly switched off at T =0.25 sec are Tr =0.0001sec.sec.



(A)



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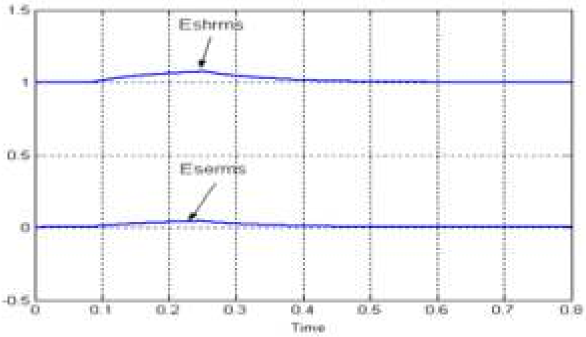
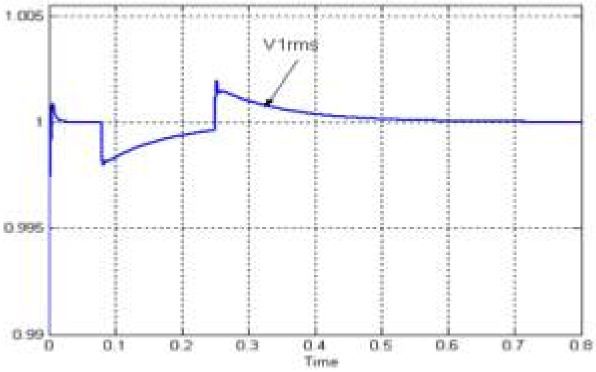
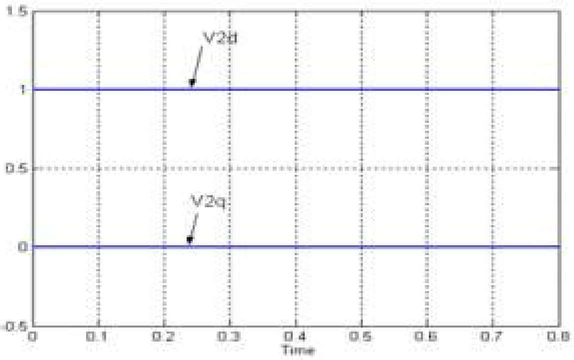


(C)

Fig: 5.2 Simulation results for Case-(I) are (A) V1d, V1q (B) V1rms (C) Eshrms, Eserms.



(A)



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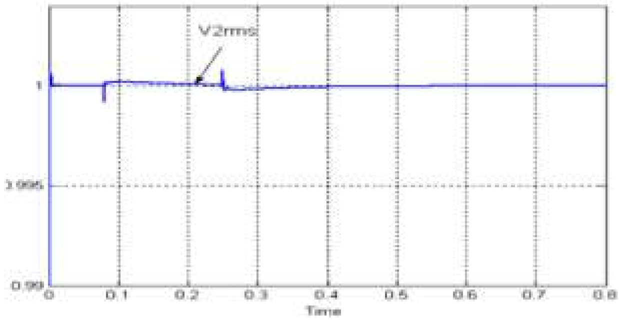
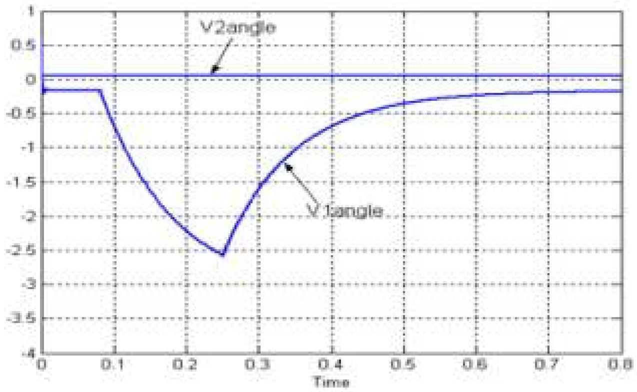
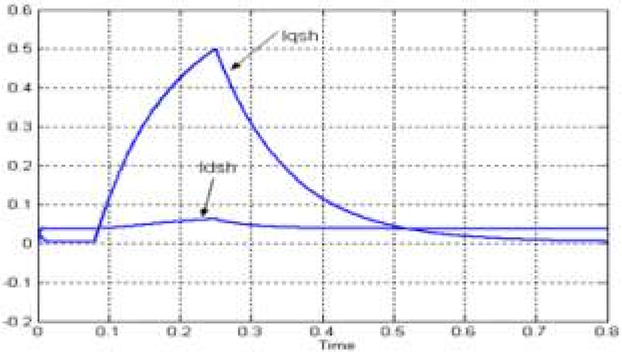


(C)

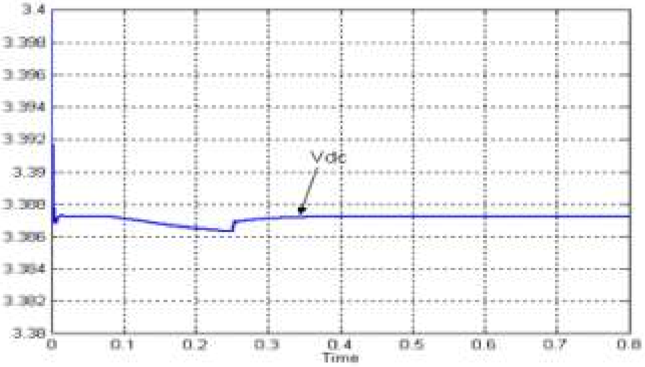
Fig: 5.3 Simulation results for Case-(I) are (A) V1rms, (B)V1d,V2d (C)V2rms



(A)

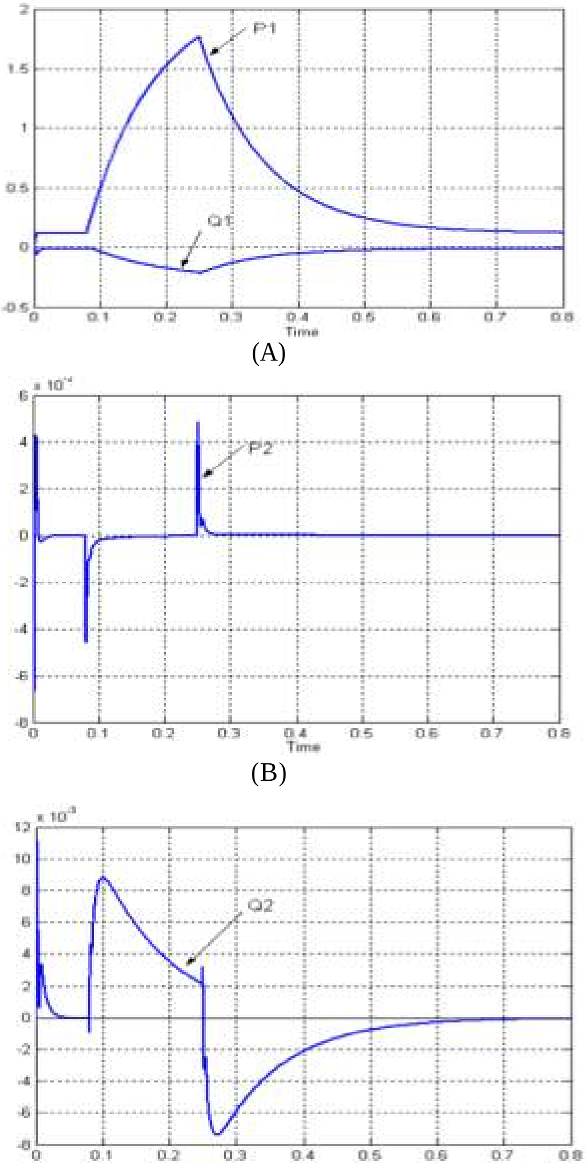


(B)



(C)

Fig: 5.4 Simulation results for Case-(II) are (A)V1angle, V2angle (B) Idsh, Iqsh (C) Vdc

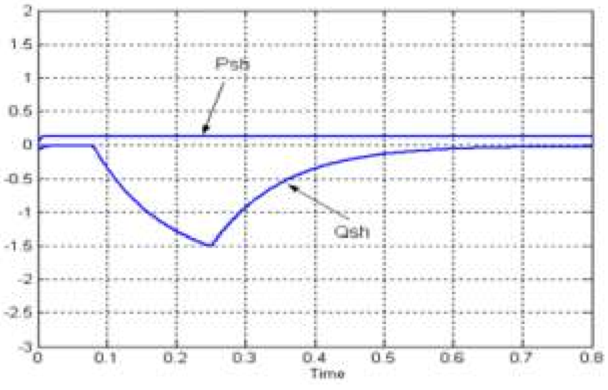


(A)

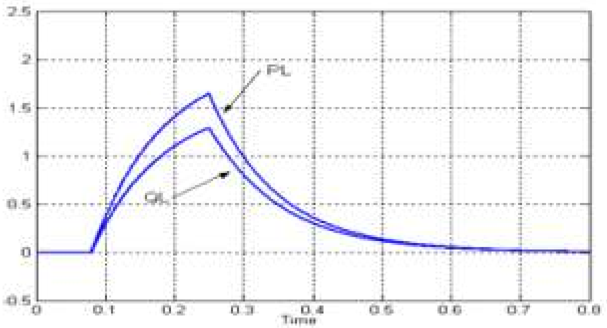
(B)

(C)

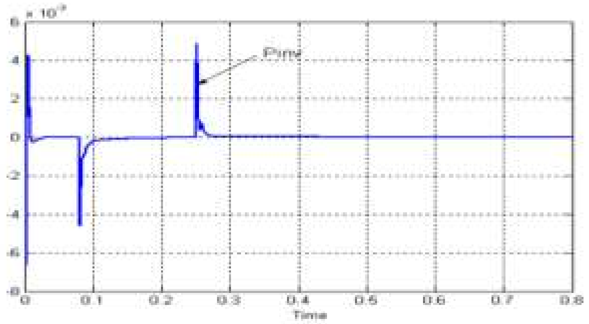
Fig: 5.5 Simulation results for Case-(I) are (A) P1, Q1 (B) P2 (C) Q2



(A)



(B)



(C)

Fig: 5.6 Simulation results for Case-(I) are (A) Psh, Qsh (B) PL,QL (C) Pinv

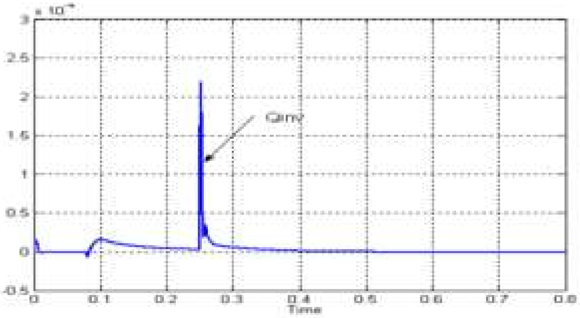
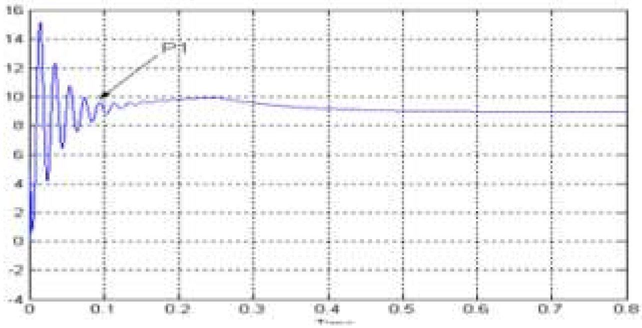


Fig: 5.7 Simulation results for Case-(I) are (A) Qinv

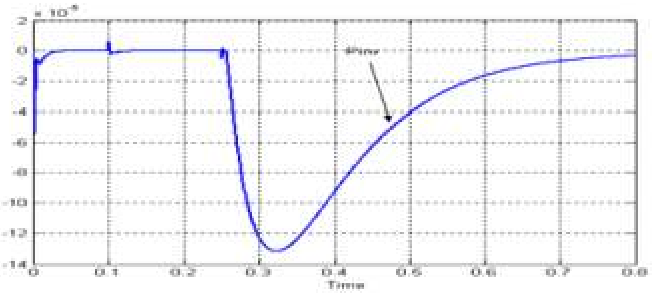
Case-2 (WITH OUT UPFC):

Vs=1, Load 2 PU with lagging power factor 0.625 without UPFC, initially Pref=o, Load switch is ON at T=0.08 sec, at T=0.025 sec load is OFF and subsequently shunt control is OFF. V1ref =1 p.u.

The simulation results are

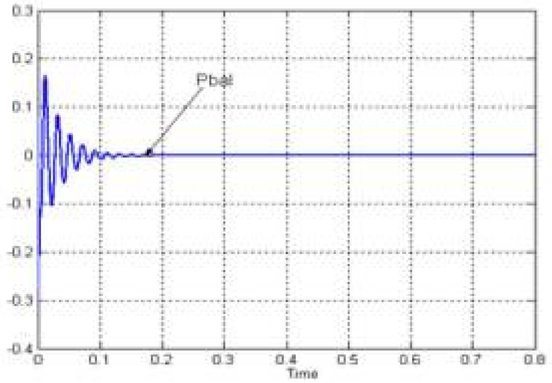


(A)

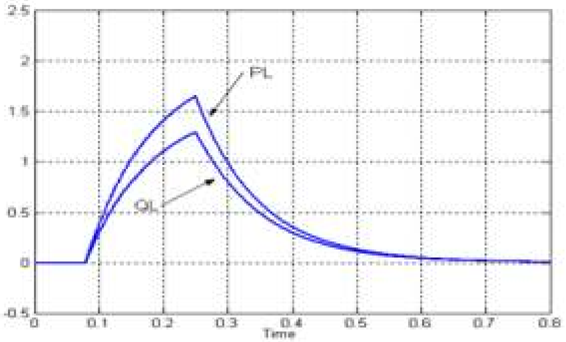


(B)

Fig: 5.19 Simulation results for Case-(IV) are (A) P1 (B) Pinv

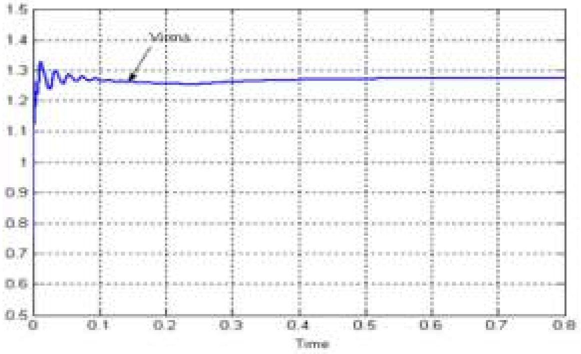


(A)

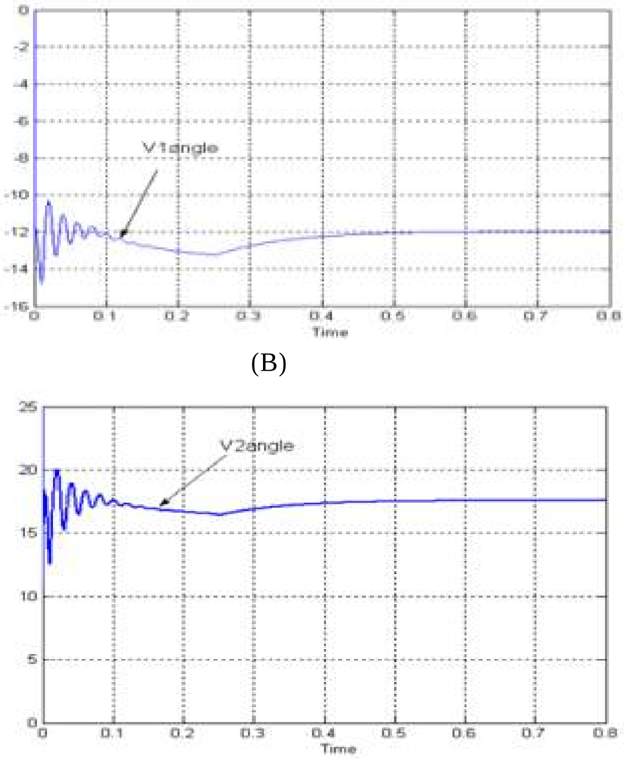


(B)

Fig: 5.20 Simulation results for Case-(IV) are (A) Pbal (B) PL, QL



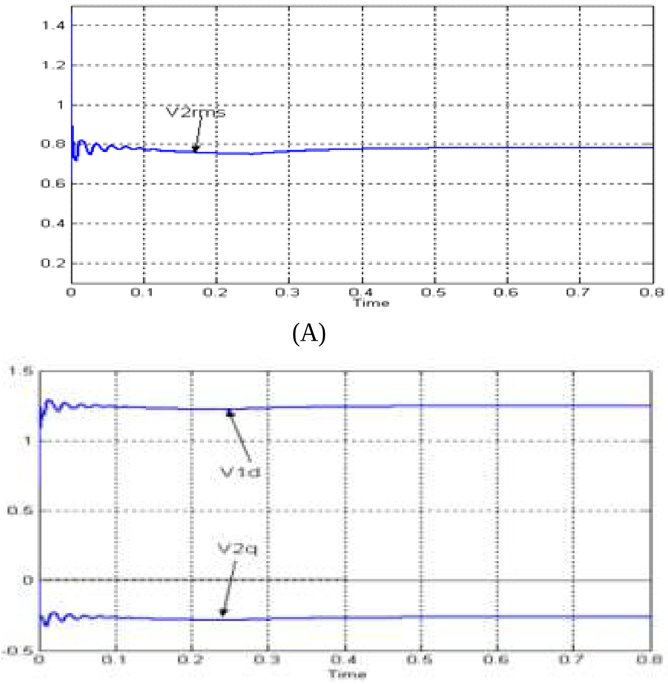
(A)



(B)

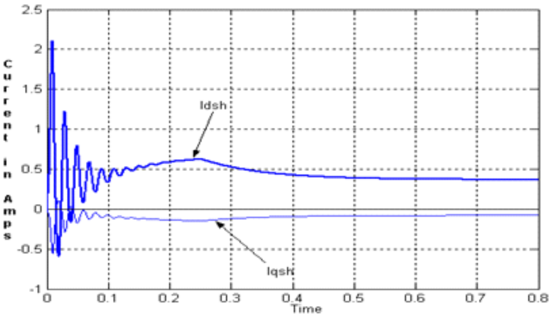
(C)

Fig: 5.21 Simulation results for Case-(IV) are (A) V1rms (B) V1angle (C) V2angle



(A)

(B)



(C)

Fig: 5.22 Simulation results for Case-(IV) are (A) V2rms (B) V1d, V1q (C)Idsh,Iqsh

VII. CONCLUSION

- In this thesis, a control strategy is proposed and tested for the UPFC, which is verified for 3 different cases.
- In all the cases, performance of the system is analyzed through MATLAB / SIMULINK 7.0.1
- Control system driving functions were tuned to attain satisfactory comparison of performance.
- A MATLAB / Simulink model is simulated in this work for design and validation of control strategy of UPFC, and which is located at a load substation while considering the parameters in to account. Control algorithm is implemented in space vector domain (d-q Co-ordinates).
- The developed SIMULINK model is used to arrive at satisfactory control levels and attains enough gain settings in various parts of the UPFC controller.
- Better controlling action was performed by the fuzzy controller.
- Detailed simulation of UPFC system with bus voltage, UPFC second part voltage and line power flow control was carried out using the developed SIMULINK model various cases involving load switching, step change in voltage reference and power flow references.
- SUB cycle rises and fall times are achievable for voltage control and power control using the developed UPFC control strategy. This was verified by detailed simulation.
- For step change in load, rise and fall times observed in port 1 volatges are Tr=0.025sec, Tf=0.02 sec; chance in port 1 voltage (1-0.975-1).
- For step change in load, rise and fall times observed in port 1 volatges are Tr=0.0005 sec, Tf=0.001 sec; chance in port 1 voltage (3-3.6-2.88-3).
- For step change in sending end voltage (1-1.05) the rise and fall times observed in port 1 volatges are Tr=0.015sec, Tf=0.003 sec, chance in port 1 voltage(1-1.06-1).
- Here Real power flow control is obtained by reactive voltage injection and indirect power flow control is obtained by control of voltage at the two ports of the UPFC.
- The controllers are designed independently and use locally available measurements.
- By modulating the active power, it is possible to bring a vast improvement in transient stability and damping.

As seen the UPFC greatly improves system damping, actually, it practically prevents power oscillation. And can be seen that also improves significantly the damping of the voltage swings.

From the waveforms, we can conclude that the UPFC can respond rapidly i.e. of the order of a cycle to a pulse change in power reference and the capability of the UPFC to regulate both the power and voltages at both ports.

VIII. REFERENCES

1]Mahmoud A. Sayed, Member, IEEE, and Takaharu Takeshita, Member, IEEE All Nodes Voltage Regulation and Line Loss Minimization in Loop Distribution Systems Using UPFC .IEEE transaction on vol 26 june 2011.
2]Sanbao Zheng and yoke Lin Tan "Dynamic Character Study of UPFC Based on Detailed Simulation Model" IEEE Power Conference 2000.
3]C.Schauder and H.Metha, "Vector Analysis and control of a advanced static VAR Compensation", IEE Proc-C Vol. 140, No.4, July 1993, PP299-306.
4]Padiyar.K.R, Kulakarni.A.M, "Control Design and Simulation of Unified Power Flow Controller" IEEE Trans. On Power Delivery Vol 13, No.4, Oct 1998, PP 1348-1354.

5]L.Gyugyi, C.D.Schauder, S.IWilliams, T.R.Rictman, D.R.Torgerson, and A.Edris, “The Unified Power Flow Controller; A New Approach to Power Transmission Control; IEEE Trans, On Power Delivery, Vol 10 No.2 April 1995; PP 1085-1097.

6]N.G Hingorani, “High power Electronics and Flexible AC Transmission System” IEEE Power Engineering Review, July 1998.

7]A.Edris “FACTS Technology Development: An Update” IEEE Power engineering review, March 2000.

8]K.R.Padiyar,K.Uma Rao “Modeling and Control of Unified Power Flow Controller For Transient Stability”, Electrical Power and Energy Systems 21 (1999).

9]L.Gyugi, “A Unified Power Control Concept for Flexible AC Transmission Systems.” IEE Procedings-C,Vol 139,No.4, July 1992,pp323-332.

10]R.Mihalie, P.Zunko, and D.Povh; “Improvement of Transient using Unified Power Flow Comtroller”, IEEE Trans; 1994.

11]N.G.Hingorani and L.Gyugyi, “Understanding FACTS”, IEEE Press, New York, 2001.

12]Roy Billinton , Mahmud Fotuhi, sheriff Omar Faried, and Saleh Aboreshaid,” Impact Of Unified Power Flow Controller on Power System Reliability”, IEEE Trans on Power Systems, Vol.15, No.1, February 2000.

13]H.Fujita,S.Tominaga,H.Akagi, “Analysis and Design of a DC Voltage Controlled Static VAR Compensator Using Quda-Service Voltage Source Inverter”, IEEE Trans, On Industry Application, Vol 32, No.41, PP970-978, 1996.

14]Menniti, A.Pinnareli, “Modelling of Unified Power flow Controller into Power Systems using P-Spice”, IEEE Trans Power System ,2000

15]N.Mohan ,T.M.Undeland and W.P Robbins, “Power Electronics-Converters, Applications and Design”, 2nd Edition,John Wiley& Sons, New York.

16]SIMULINK-Dynamic System Simulation For MATLAB,Using SIMULINK Version 2, The Math work,Inc, 1997.

17]C.Schauder and H.Mehta, “Vector Analysis and Control of a Advanced Static VAR Compensator”, IEE Proc-C Vol.140, No.4, July1993, PP.299-306.

18]Y.H.Song andA.T.Johns,“Flexible AC Transmission Systems(FACTS) ,”IEEE Press, New york

19]M.L.Kothari, and N.Tambey; “Unified Power Flow Controller (UPFC) Based Damping Controllers for Damping Low Frequency Oscillations in Power System” IE(I) Journal-EL, Vol.84, June 2003, PP 35-41.

20]I.Papic, P.Zunko, D.Povh, M.Wienhold, “Basic Control of Unified Power Flow Controller” IEEE transactions on Power System, Vol.12, No.4, Nov 1997.

Ch .S Ganga Bhavani

M. Tech, Scholar HITS Engineering college, Denduluru

B. Lavanya,

Asst. Prof. HITS Engineering college, Denduluru