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ANALYSIS OF STATIC AND DYNAMIC STABILITY OF POWER SYSTEM USING UPFC BY PARTICLE SWARM OPTIMIZATION

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ABSTRACT

The objective of this paper is to reduce power loss and to improve the voltage profile in transmission system. The proposed particle swarm optimization algorithm has been used for optimal sizing of Unified power flow controller (UPFC) and foreven more seriousproblem of voltage stability. Voltage Phasor method is used and loss minimization including UPFC is formulated as an optimization problem that is by using PSO exact real and reactive power loss is minimized. There are many new power-electronics-based devices which are used to solve the difficult problems. Unified Power Flow Controller (UPFC) is the most powerful device of these devices.

Index Terms: Flexible AC Transmission System (FACTS), UPFC, SIMULINK, PSO, Voltagestability

I INTRODUCTION

Flexible AC Transmission System (FACTS) device concept was described by N. G. Hingorani in 1988s. The FACTS devices give more flexible control for secure and economic operation of the power system [1]. The UPFC is used for the real-time control and dynamic compensation of Transmission system, which provides multifunctional flexibility required to solve problems while the power is being delivered. Within the framework of conventional power transmission concepts, the Unified Power Flow Controller is able to control simultaneously all the parameters affecting power flow in the transmission line (i.e., voltage, impedance, and phase angle), and this exclusiveability is signified by the adjective "unified" in its name. It can autonomously control both the real and reactive power flow in the line. It provides the suppleness at the same time management all the transmission parameters of systems.Basically,the UPFC consists of two voltage source convertersconnected back-to-back. The series converter is connected through a series transformer, and shunt converter is connected through a shunt transformer. These two converters are coupled by means of common dc link that is provided by a dc storage capacitor [2]-[5].

Particle swarm optimization technique is used to find the best of viable solution to an optimization problem. We consider a global optimum of an n-dimensional function. In the PSO algorithm, all particles are initiated randomly and evaluated to compute fitness, together with finding the personal best (best value of each particle) and global best (best value of particle in the entire swarm) .After that a loop starts to find most favourable solution. First the particle's velocity is updated by the personal and global bestsin the loop, and then each particle's position is updated by its current velocity [6]- [9].

II PARTICLE SWARM OPTIMIZATION TECHNIQUE

Particle Swarm Optimization (PSO) is a stochastic global optimization approach, and its main strength lies in its simplicity and fast convergence rates [11, 12, 13]. PSO is flexible enough to control the balance between the global and local investigation of the search space. This unique feature of PSO overcomes the early convergence problem and improves the search capability. Also, the solution quality doesn't depend on the initial populationunlike the other methods. The PSO algorithm ensures the convergence to the optimal solutionstarting anywhere in the search space. The following is a brief introduction to PSO [21].

PSO is similar to the evolutionary computation techniques, in which, a population of possible solutions to the optimal problem under consideration is used to explore the search space. Each potential solution is also assigned a randomized velocity, and the possible solutions, called particles, correspond to individuals. Each particle in PSO flies in the D-dimensional problem space with a velocity dynamically adjusted according to the flying experiences of its own and other particles[10]. The location of the i[th] particle is represented as = $x_{i1} + x_{i2} \dots \dots . x$…,

where, X_{iD}.[I_d], d $\in [1,$..

and ı are the lower and upper bounds for dth dimension, respectively. The best previous position (which gives the best fitness value) of the ithparticle is recorded and represented as $P_i = [P_{i1} + P_{i2} + \cdots P_i$which is also calledPbest. The index of the best particle among all the particles in the population is represented by the symbol g. The location Pg is also denoted asgbest. The velocity of the i[th]particle is represented as =[$V_{i1} + V_{i2} \dots \dots \dots$]and is clamped to a maximum velocity $V_{max} = [V_{\max 1} + V_{max2} \dots \dots \dots V_{ma}$]which is specified by the user. The particle swarm optimization concept is, at each time step, to regulate the velocity and location of each particle toward its Pbestand gbestlocations according to the equation (3) and (4), respectively.

$$v_{id}^{n+1} = wv_{id}^{n} + C_1 r_1^n (P_{id}^n - X_{id}^n) + C_2 r_2^n (P_{gd}^n + X_i^n \text{…………….(3)}$$

$$X_{in}^{n+1} = X_{id}^{n} + V_{id}^{n} \text{……………………………………………..(4)}$$

Where:

$C_1\ and$are two positive constants, called cognitive and social parameters respectively;

m is the size of the swarm;

d is the number of members in a particle;

$r_1\ and$are random numbers which are uniformly distributed in the range [0,1];

n is the pointer of iterations (generations); and w is the inertia weight, which provides a balance between global and local explorations, thus requiring less iteration on average to find a sufficiently optimal solution, and it is specified

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by equation (5):

w= $w_{max} - \frac{w_{max} - w_{n}}{iter_{max}}$ iter …………………… (5)

Where: w_{m} is the initial weight; w_{n} is the final weight; iteris the current iteration number; and $iter_{m}$ is the maximum iteration number (generations).

Using above equation a certain velocity that gradually gets close to $P_{best}\, and\, g_{be}$ can be calculated, which can further used to calculate the position with the following equation:

$X_{id}(t+1) = X_{id}(t) + V_{id}(t+$ (6)

$X_{id}(t+1)$: $current\ position\ of\ particle\ i\ at\ iteration$+1

$X_{id}(t)$: $current\ position\ of\ particle\ i\ at\ iteration\ t$

$V_{id}(t+1)$; $modified\ velocity\ of\ particle\ i$

In this work, the implemented PSO technique can be described as follows:

Step I: initialize related parameters, such as the size of swarm, the maximum number of iteration, the number of variables to be optimized, the load factor, and the power flow data.

Step II: P_{best} is set to each initial searching point. The best values among the P_{best} are set to g_{best}

Step III: New Velocities are calculated using equation(16)

Step IV: If $v_{id}(t+1) < V_{dm}$

Then, $V_{id}(t+1) = V_{dmin}\, and if\, V_{id}(t+1)) < V_{dm}$

then $V_{id}(t+1) = V_{dn}$

Step V:New searching points are calculated using equation (6)

Step VI: check the capacity limits constraints.

If $P_{id}(t+1) > P_{dm}$

Then $P_{id}(t+1) = P_{dmax}\, and if\, P_{id}(t+1) < P_{dn}$

Then $P_{id}(t+1) = P_{dm}$

Step VII:Evaluate the fitness values for new searching point .If evaluated value of each agent is better than previous P_{best} then set to P_{best}. If the best P_{best} is better than G_{best} then set to G_{best}.

Step VIII: if the maximum iteration is reached, stop the processes otherwise go to step III.

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III THE ALGORITHM

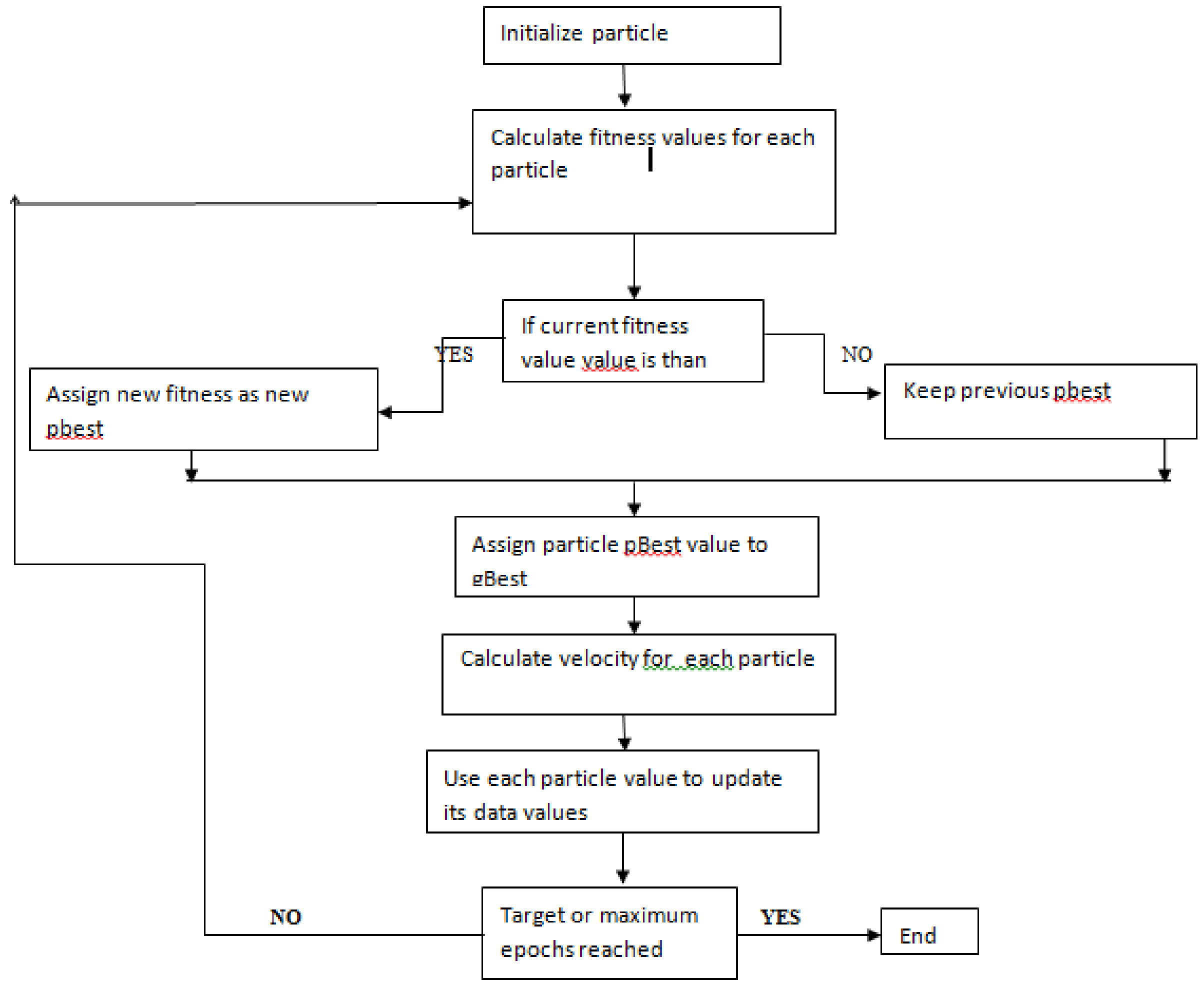

Figure 2. Flow diagram illustrating the particle swarm optimization algorithm.

IV CONTROL OF POWER FLOW USING UPFC

It delivers the flexibility to the transmission constraints of systems, The UPFC is used that consists of two voltage, the first series converter connected through a series transformer, and shunt converter connected over a shunt transformer. These converters are coupled by common dc link.Steady state and dynamic performance of a UPFC used to reveal power congestion in a transmission system. Power data parameters that the series converter is rated 100MVA with a maximum voltage injection 1.0pu. The shunt converter is also rated 100MVA.

To control parameters that the shunt converter is in voltage regulation mode & the series converter is in power flow control mode.. To control parameters of the shunt converter is in voltage regulation mode & the series converter provide power flow control mode PSO technique is to find the best of feasible solution to a optimization problem. Consider the global optimal of an n-dimensional function. The PSO is all particles initiated randomly and evaluated to calculate fitness together with finding the pbest (best value of each particle) and gbest (best value of particle in the entire swarm) After that a loop starts to find an optimum solution. In the loop, first the particles' velocity is updated by the personal and global bests, and then each particle's position is updated by the current velocity.

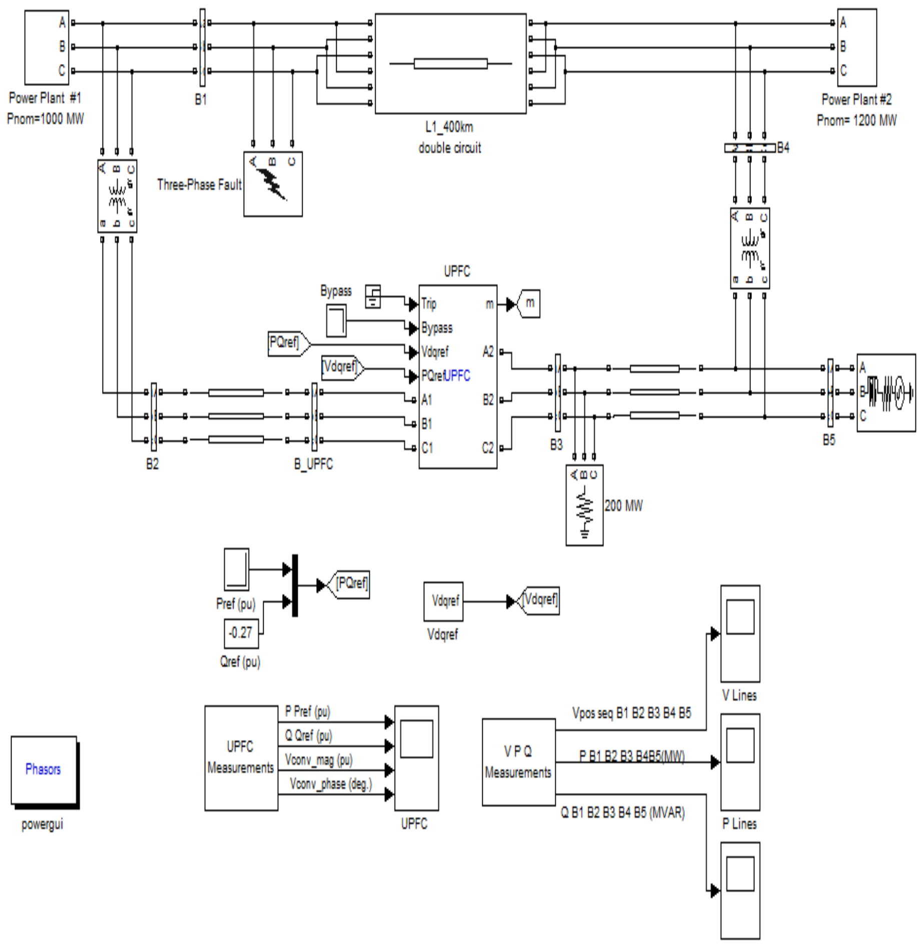

Fig. 3 SIMULINK model of the UPFC controlling power of 500/230 KV Power System

4.1 Mathematical model

The UPFC consists of two voltage source converters, as illustrated in Fig. 1. The two back-to-back converters, labeled as "Shunt Converter" and "Series Converter" in the figure are designed to be driven from a common DC link

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voltage supported by a DC storage capacitor. In normal operations, the phase angle of the series voltage can be chosen independently of the line current between 0 and 2π, and its magnitude can be varied between zero and a pre-specified maximum value.

Therefore the real power can freely flow in either direction between the AC terminals of the two converters and each converter can also generate or absorb reactive power independently at its own AC output terminals to affect system voltages. In the UPFC system, Series Converter, the series branch, operated as a SSSC, is used to perform the main control functions of a UPFC. It generates voltage, VCR, at the system frequency controlled by a proper switching control technique. During the operation the voltage, VCR, is added to the AC system terminal voltage, V_k, by the series connected injection series transformer, T_{se}. The transmission line current flows through this voltage source resulting in reactive and active power exchange between it and the ac system. The reactive power exchanged at the ac terminal is generated internally by the converter. The active power exchanged at the ac terminal is converted into dc power which appears at the dc link as a positive or negative active power demand.

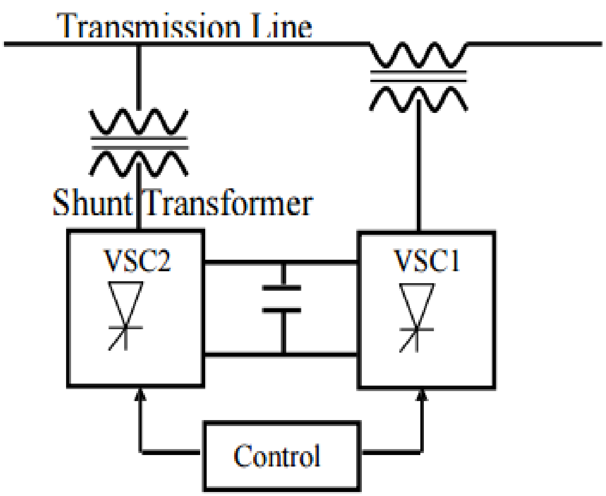


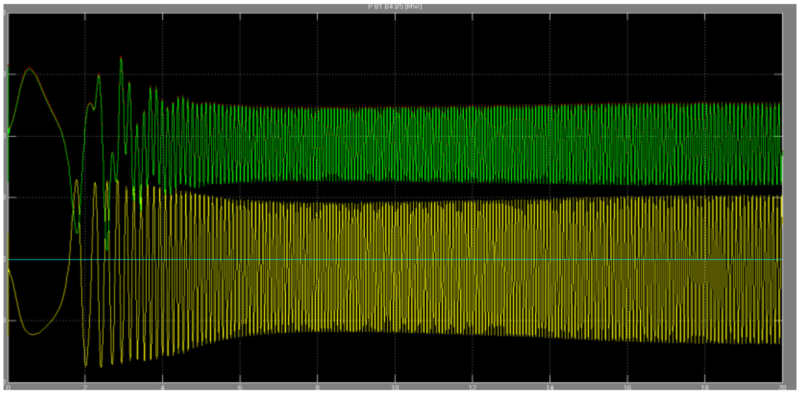
Fig. 4 The Schematic diagram of UPFC

V SIMULATION RESULTS

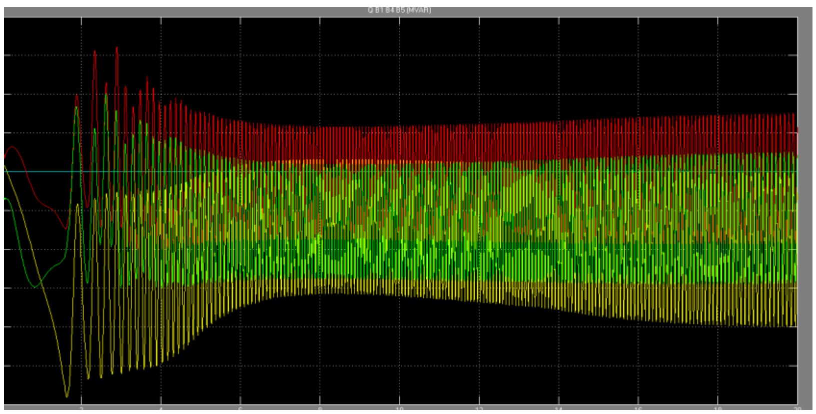
The proposed method approach is used for UPFC placement for the objectives considered, is placed on the node having maximum loss reduction and poor voltage profile which is discussed below.

5.1 When UPFC is not connected

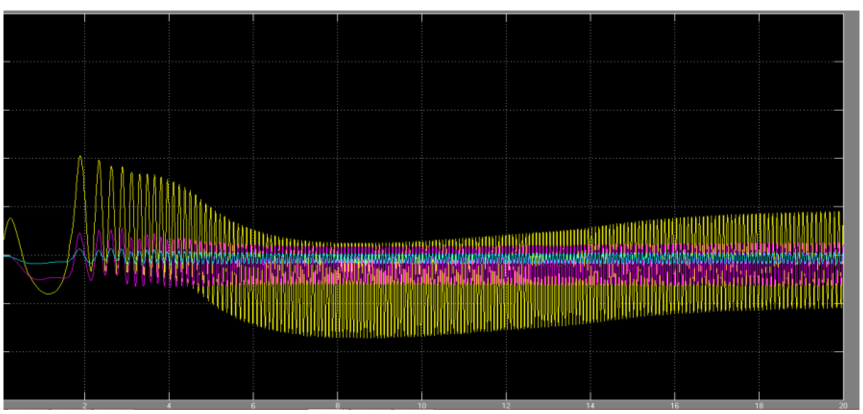
The following output shown in fig. 5 is obtained when UPFC is not connected to the system. There is variation in the system at various time periods during which Increases the load. The model has been simulated for 20 seconds.



FIG(a): Variation in power (P) when fault is occurred.



Fig(b): Variation in power (Q) when fault is occurred.



Fig(c): Variation in voltage (V) when fault is occurred

Fig. 5 simulation results Power system

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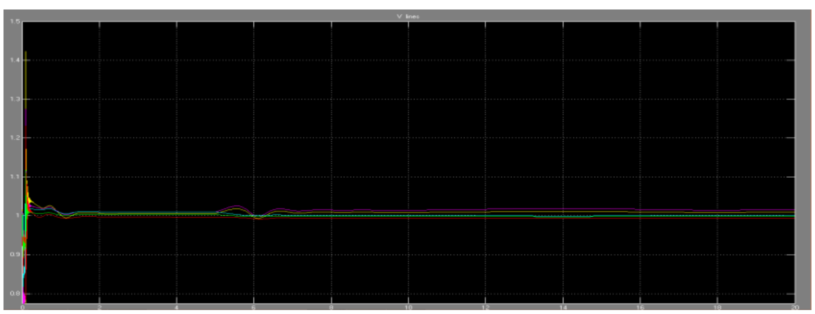
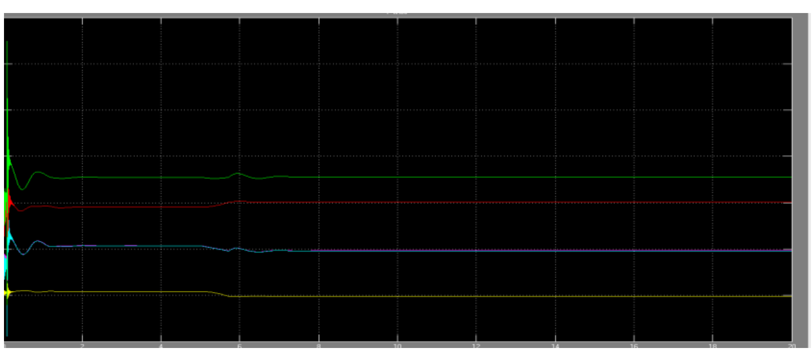
5.2 When UPFC is connected

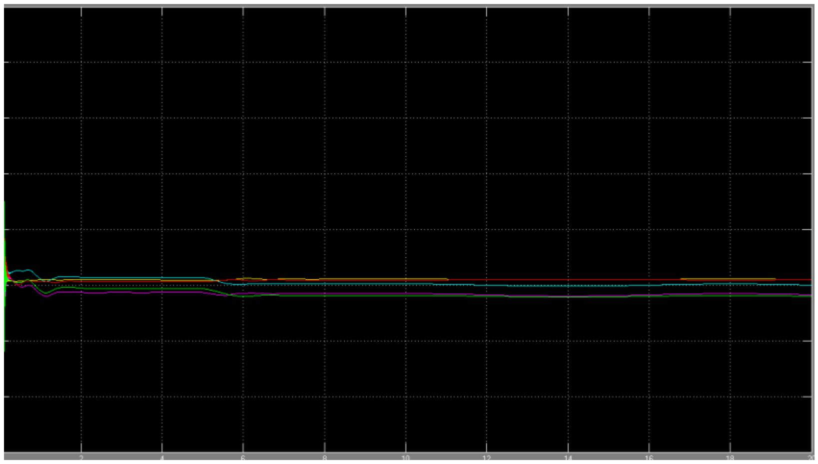
UPFC consist of two back to back converters are operated from a DC link provided by a dc storage capacitor. each converter can independently generate or absorb reactive power as its own ac output terminal. One VSC is connected to in shunt to the transmission line via a shunt transformer and other one is connected in series through a series transformer. The DC terminal of two VSCs is coupled to give a path for active power the converters. VSC exchange between provide the main function of UPFC by injecting a voltage with controllable magnitude and phase angle in series with the line via an injection transformer. This injected voltage act as a synchronous ac voltage source. The transmission line current flows through this voltage source resulting in reactive and active power exchange between it and the power system. The reactive power exchanged at the dc terminal is generated internally by the converter. The real power exchanged at the ac terminal is converted into dc power which appears at the dc link as a real power demand. And VSC1 is to supply or absorb the real power demanded by converter2 at the dc link to support real power exchange causing from the series voltage injection. This dc link power demand of VSC2 is converted back to system by VSC1 and coupled to the transmission line bus by shunt connected transformer[18]. In addition, VSC1 can generate or absorb controllable reactive power if it is required and thereby provide independent shunt reactive compensation for the line for desired output. When connecting the UPFC in power system gives the following output.



Fig(a): Waveform of Voltage(V) After Clearing Fault



Fig(a): Waveform of Real Power (P) After Clearing Fault



Fig(a): Waveform of Reactive Power (Q) After Clearing Fault

5.3 Comparison of the Results

The output obtained before connecting UPFC and after connecting UPFC system has been compared. It can be concluded that the system in which UPFC has been connected, shows less variation in its output. Hence, the stability of power system with fluctuating output improves when UPFC has been connected.

VI CONCLUSION

PSO method in this paper resulted in the power loss decrease and voltage profile enhancement in the transmission system. Various optimal locations were attained for the UPFC and a suitable location is obtained by using PSO. The results show that power loss is reduced and the voltage profile is maintained with in specified limits under different load conditions like 50%, 100%, and 160% loads. The power loss reduction obtained from existing method was 31.99% and, the power loss reduction with proposed method is 41.85%. This implies that the system stability is improved with the proposed method

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