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Performance Analysis and Improvement of powerTransmission line Network Using Unified Power Flow Controller

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Abstract— **The Power generation is achieved by increasing rural electrification are used by minimizing the transmission line losses. The Power Flow by used on the recently developed of the power system network UPFC of the latest technology facts devices used of the Transmission line. It is used to compensating the active and reactive power control to the power flow with the increasing the stability of the transmission line to control the flow of power in the transmission line as well as to improve the quality of Active and Reactive power. Power system network it is used of the without UPFC and with UPFC different buses line Matlab/Simulink.**

Keywords— **Facts devices, without UPFC, With UPFC, Active and Reactive power.**

I. INTRODUCTION

Interconnected power systems, which today are very complex, there is a great need to improve utilization, while still maintaining reliability and security. While, some transmission lines are charged up to the limit load, the others may have been overloaded, which have an effect on the values of voltage and reduce system stability and security. For this reason, it is very important to control the power flows along transmission lines to meet transfer of power needs. In the late 1980s, the Electric Power Research Institute (EPRI), introduced a new approach to solve the problem of designing and operating power systems; the proposed concept is known as Flexible AC Transmission Systems (FACTS). The main objectives of FACTS are to enhance the UPFC. Transfer the capability, facilitate the power flow control and improve the security and stability of the power system [1].

$$P_{ij} = \frac{V_i V_j}{X_{ij}} \sin \delta_{ij} \qquad (1)$$

Where, Vi and δi are the ith bus voltage magnitude and angle Vj and δj are the jth bus voltage magnitude and angle, xij is the line reactance .thus from the equation (1). Power in the transmission line is a function of transmission line impedance, the magnitude of sending end and receiving end voltage and the phase angle between voltages. Control the active and reactive power flow in the transmission line is possible by controlling one or a combination of the power flow arrangements. The bus voltage, line impedance and phase angle in the power system can be regulated rapidly and flexibly with FACTS technology, such as Static Var Compensator (SVC), Static Synchronous Compensator

(STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC).

The Unified Power Flow Controller (UPFC) is a second generation FACTS device, which enables independent control of active and reactive power besides improving reliability and quality of the supply. It is the most sophisticated power flow controller currently, and probably the most expensive. The UPFC is able to control, simultaneously or selectively all the parameters affecting power flow in the transmission line (voltage, impedance, and phase angle). The UPFC, consists of a series and a shunt converter connected by a common dc link capacitor, can simultaneously perform the function of transmission line active/reactive power flow control in addition to UPFC bus voltage/shunt reactive power control . The UPFC was devised for the real-time control and dynamic compensation of ac transmission systems, providing multifunctional flexibility required to solve many of the problems facing the power industry. Under the traditional power transmission concepts, the UPFC is able to control, all parameters affecting in power flow in transmission line, simultaneously or selectively. Otherwise, the UPFC can independently control both the active and reactive power flow in the line unlike all other controllers [2].

II. FACT CONTROLLERS

The basic principles of the following FACTS controllers, which are used in the single machine infinite bus system under study, are discussed briefly calculation and dynamic simulation. FACTS technology is used extensively to enhance the controllability and the capability of power transfer in the AC systems. FACTS involve conversion or switching power electronics wide-range megawatts relatively.

2.1Unified Power Controller (UPFC)

Gyugyi proposed UPFC concept in 1991(Gyugyi et al. 1992). The UPFC was devised for the real time control and the dynamic compensation of AC transmission systems, providing the required multifunctional flexibility in order to solve many of the problems facing the delivery industry. Within the framework of traditional power transmission concepts, UPFC is able to control simultaneously or selectively all the parameters affecting the power flow in the transmission line (i.e., voltage, impedance and phase angle) and this unique capability is signified by the adjective unified in its name. The UPFC is a combination of STATCOM and a SSSC, which are coupled via a common DC link. This link allows a bi-directional flow of real power flow between the shunt output terminals of the STATCOM and the series input terminals of the SSSC. This real power is controlled to provide concurrent real and reactive series compensation without an external electric energy source. The active power for the series converter is obtained from the line via the shunt converter STATCOM. It is also used for voltage phase and amplitude to control its reactive power. This is a complete controller for controlling the active and reactive power through the line, as well as line voltage controller. The details circuit of UPFC is shown in Figure 1.Additional storage, such as capacitor or DC voltage source connected to the dc link via an electronic interface, would provide the means of enhancing the effectiveness of UPFC.[12]-[13].

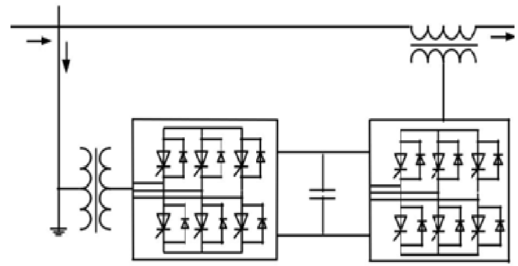

Fig.1 configuration of UPFC

2.2Static Synchronous Series Compensators (SSSC)

The VSC based series compensator is known as Static Synchronous Series Compensator (SSSC). It was proposed by Gyugyi in 1989. SSSC represents an alternative like synchronous voltage source in the series line compensation. It is operated as series compensator without an external electric energy source, and its output voltage is controllable and is in quadrature with the line current. It is implemented by thyristors-based VSC and used to provide the controllable series compensation, seen in Figure 2.When SSSC is operated with an appropriate dc power supply at its input terminals, this compensator is used in generators and solid-state switching converters. When SSSC is coupled with an energy storage capacitor, it can be used only to generate or absorb the reactive power from the system. The SSSC is connected to the three-phase transmission line with series VSC through a coupling transformer.

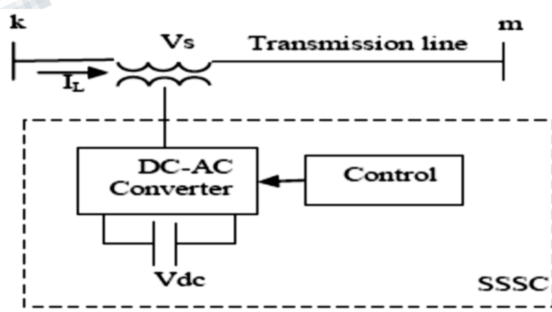

Fig. 2 Basic Scheme of SSSC

The battery storage or capacitance can also be connected with the series controller to inject the series voltage with variable angle in the line. Without an extra energy source, SSSC can inject only variable voltage, which is 90 ^{o} leading or lagging the current.

2.3Static Synchronous Compensator (STATCOM)

A static synchronous compensator (STATCOM) is a shunt-connected reactive power compensation device that is capable of generating or absorbing reactive power whose output can be varied to control specific parameters of an electric power system. In general, it is a solid-state switching converter, capable of generating or absorbing independently controllable real and reactive power at its output terminals when it is fed from an energy source or energy. Storage device is coupled at STATCOM input terminals. STATCOM system is comprised of three main parts: a voltage source converter, a coupling reactor or a step-up transformer, and a controller. The STATCOM is connected to the power networks at a point of common coupling. All Figure a simple Figure3 of STATCOM based on a VSC. The reactive power exchange between the converter and the AC system can be controlled by varying the amplitude of the three-phase output voltage of the converter. That is, if the amplitude of the output voltage is increased above that of the utility bus voltage, then the current flows through the reactance from the converter to the AC system and the converter generates capacitive reactive power for the AC system. If the amplitude of the output voltage is decreased below the utility bus voltage, then the current flows from the AC system to the converter, and the converter absorbs inductive reactive power from the AC system. If the output voltage is equal to the AC system voltage, the reactive power exchange is zero required voltages and currents are measured and fed into the controller in order to be compared with the references. The feedback control is used as outputs by switching signals to drive the main semiconductor switches of the power converter accordingly. The magnitude and phase of the VSC output voltage is controlled by the turn-on/turn-off of semiconductor switches in the VSC.

Similarly, the real power exchange between the converter and the AC system can be controlled by adjusting the phase shift between the converter output voltage and the AC system voltage. That is, the converter can supply real power to the AC system from its dc energy storage if the converter output voltage is made to lead the AC system voltage. On the other hand, it can absorb real power from the AC system for dc energy if its voltage lags the AC system voltage.[6]-[7].

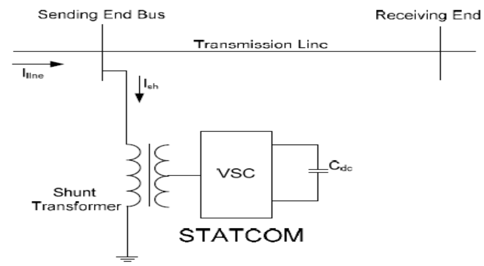

Fig.3. Basic scheme of STACOM

III. PERFORMANCE ANALYSIS OF THE POWER SYSTEM NETWORK WITHOUT UPFC

A load flow study is conducted for the 3-bus power system network and power system parameters are voltage, currents, active and reactive power determined the given point of the electric network under normal condition. The system is analysed of the existing power system network for the system planning and future expansion.

3.1Problem formulation

It is Analysis of the load flow required the transmission line parameter to be known. The resistance of the line is given by and their inductance (L) and capacitance (c) Parameter can be calculated. The Three phase Transmission line are equally spaced and the line inductance and the line Inductance equation.

$$L = 2\times10^{-7}\ln\frac{D}{GMR}$$

L is the inductance in Henry per meter.
D is the spacing between the lines in meters GMR is the Geometric Means Radius of the Conductor in meter. The capacitance to Neutral of a given line (2) .The effect of the capacitance between and Neutral conductor is neglected.

$$C = \frac{2\pi\times8.85\times10^{-12}}{\ln\frac{D}{GMR}}$$

C is the capacitance between the line and the and the neutral in farads per meter. The power system is represented by admittance bus in equation. The admittance of simplify the hurdle with power flow study

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of the admittance between the buses of the power system network.

$$Y_{bus} = \begin{bmatrix} Y_{11} & -Y_{12} & \cdots & -Y_{1n} \\ -Y_{21} & Y_{22} & \cdots & -Y_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ -Y_{n1} & -Y_{n2} & \cdots & Y_{nn} \end{bmatrix}$$

n is the number of buses in the power system network

Y_{11}, Y_{22} and Y_{nn} are called the self admittances Admittance is the inverse of impedances. The line impedances basics to be calculated are obtained using equation.

$$Z = \left(R + j2\pi fL\right).l\left(\Omega\right) \qquad (2)$$

Where

Z is the impedance of the line in Ohms

R is the resistance in Ohm

L is the inductance of the line in Henry per meter

l is the length of line in Meter

The Gauss-Seidal method is used to solve the power flow problem .

$$V_i = \frac{1}{Y_{ii}} \cdot \left[\frac{P_i - jQ_i}{V_i^*} - \sum_{k=1}^{n} (Y_{ik}.V_k) \right] (k \neq i) \qquad (3)$$

(1.6)

$$P_i - jQ_i = V_i^* \cdot \left[Y_{ii}.V_k + \sum_{k=1}^{n} (Y_{ik}.V_k) \right] (k \neq i) \qquad (4)$$

The power flow in each line calculated using equation (3&4)

$$P_s = \frac{|A|}{|B|} |V_s|^2 \cos(\beta - \alpha) - \frac{|V_R||V_S|}{|B|} \cos(\beta + \delta) \qquad (5)$$

$$Q_S = \frac{|A|}{|B|} |V_s|^2 \, Sin(\beta - \alpha) - \frac{|V_R||V_S|}{|B|} Sin(\beta + \alpha) \qquad (6)$$

$$P_R = \frac{|V_R||V_S|}{|B|} \cos(\beta - \alpha) - \frac{|A|}{|B|} |V_R|^2 \cos(\beta - \alpha) \qquad (7)$$

$$Q_R = \frac{|V_R||V_S|}{|B|} Sin(\beta - \delta) - \frac{|A|}{|B|} |V_R|^2 \, Sin(\beta - \alpha) \qquad (10)$$

P_s And Q_s are Real and Reactive Power at the Sending End Line

P_R and Q_R are the real and reactive powers at the receiving end line.

V_S and V_R are the sending end voltage and receiving end voltage line.

δ is the phase angle between the sending end and receiving end voltage.

$A = |A| \angle \alpha$ and $B = |B| \angle \beta$ a part of ABCD Parameter of two transmission line. A and B are calculated.

$$A = \cosh(\sqrt{Z.Y})$$

$$B = \sqrt{\frac{Z}{Y}}.Sinh(\sqrt{Z.Y})$$

Y is the total shunt admittance of the transmission line.

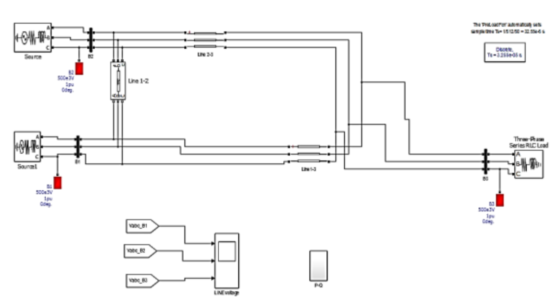
3.2 Simulation model of the Power Transmission network

The single line diagram of Matlab Simpower system environments as the load flow problem solved using the base of 500KV and 100MVA.

The Gauss-seidal load flow result for the considered power system is given Table I.

TableI Load Flow Result of the power system for the network without UPFC circuit.

Load Flow Results						
Bus No.	V (pu)	V Phase angle in degree	Generation		Load	
			Real Power in MW	Reactive Power in Mvar	Real Power in MW	Reactive Power in Mvar
B1	1.02	0.00	467.2	-158.8	-	-
B2	1.00	-2.813	149.4	-53.6	-	-
B3	0.87	-15.91	-	-	609	177



3.3 Simulation Model of the P-Q measurement without UPFC

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The P-Q measurement of the three phase V-I measurement in used of the mean discrete (frequency=50 Hz Ts=5e-6).

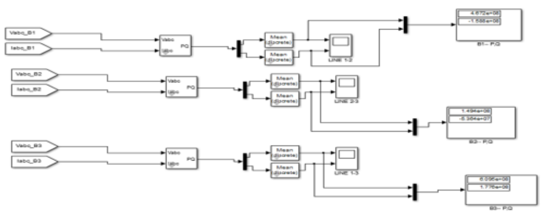

Fig5 Load flow result of the power system network without UPFC.

IV. IMPROVEMENT OF POWER TRANSMISSION LINE SYSTEM NETWORK USING UPFC

The UPFC is embedded in the power framework scheme to enhance the process of obtainable force framework organize. In the present of the UPFC is used to through the transmission line. The paper presents the operation of power analysis in the power transmission line with UPFC.

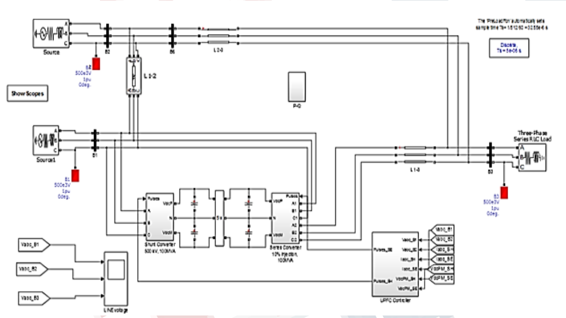

Fig6 power transmission line network with UPFC

Table II. Load flow results of the power Transmission network with UPFC circuit.

Bus NO.	Load flow Result					
	V(pu)	V Phase angle	Generation		Load	
			Real Power MW	Reactive Power Mvar	Real Power MW	Reactive Power Mvar
B1	1.02	0.00	469	-119.2	-	-
B2	1.02	1.15 X10^{-6}	143	406	-	-
B3	0.1	0.00	-	-	618	218.9

4.1 P-Q Meassurement with UPFC in different-different line

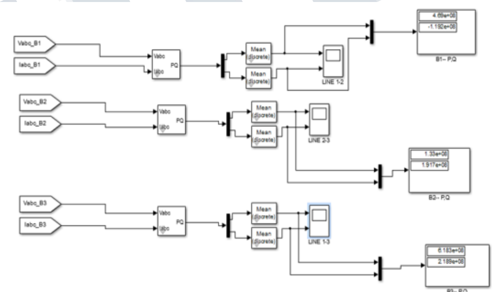

Fig7Buses B1, B2, B3 in different-different Line

4.2 Simulation Result of the line graph

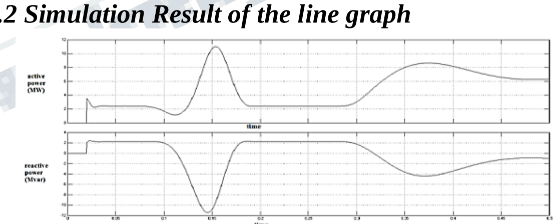

Fig8 P-Q Measurement of the Line1-2

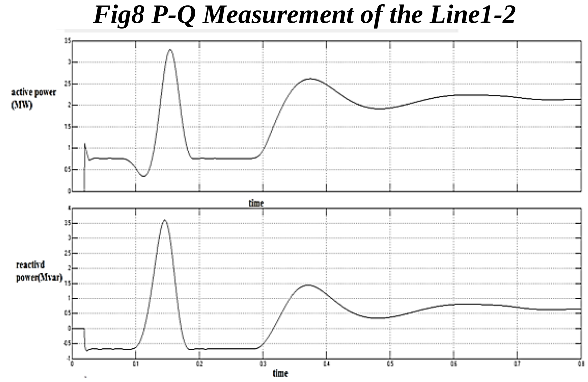

Fig 9 P-Q Measurement of the Line 2-3

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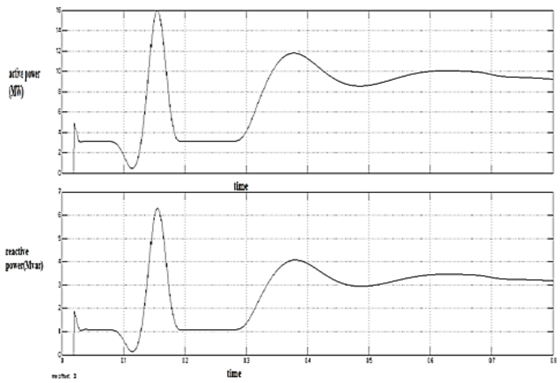

Fig10. P-Q measurement of the line 1-3

4.2Simulation Result of SSSC, STATCOM and UPFC

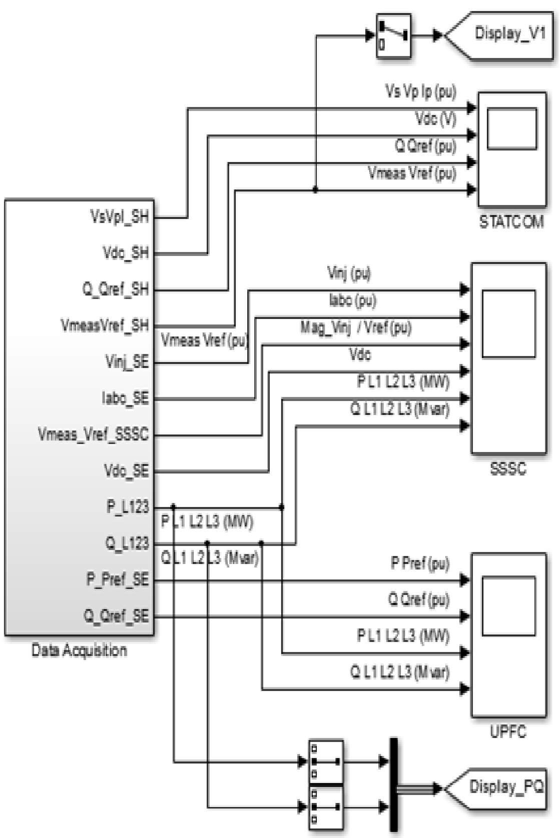

Fig11 Combination of UPFC

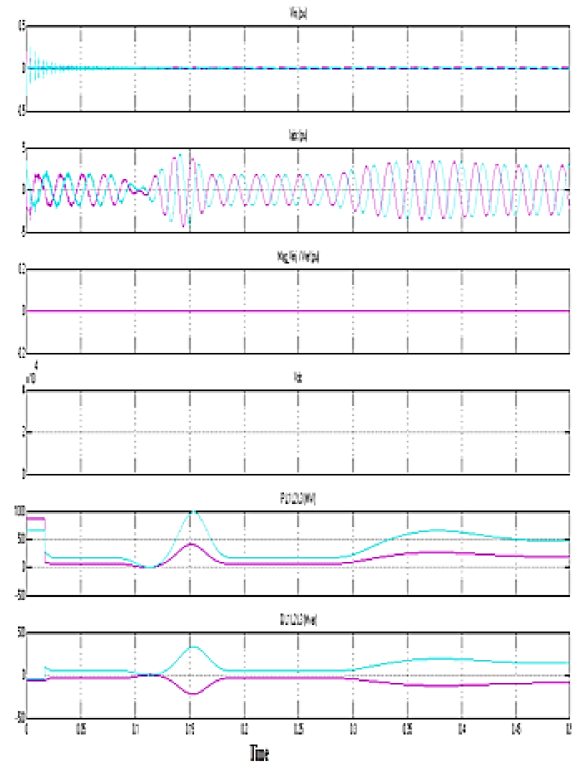

Fig12Simulation of SSSC

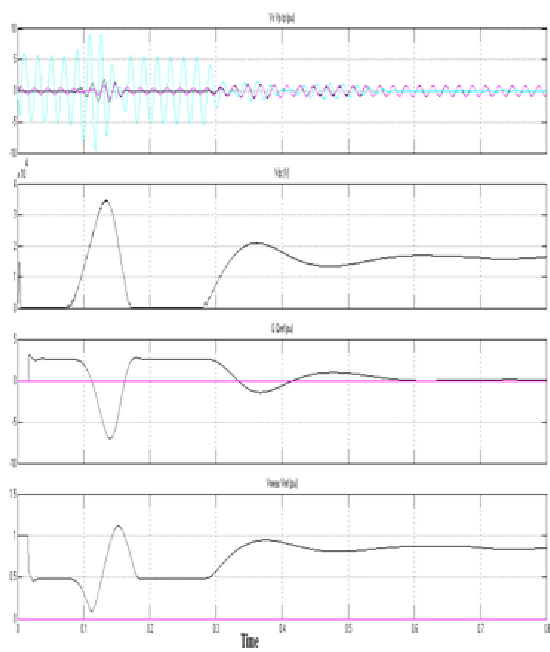

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Fig13Simulation of STATCOM

4.3Simulation model of the with UPFC result buses

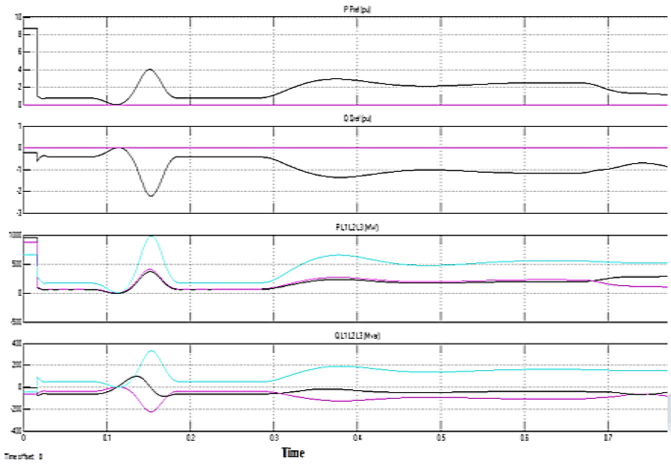

Fig14 a) Real power at bus (B3), b) Reactive power at bus (B3) c) Real power at line (B3), d) Reactive power at line (B3)

V. CONCLUSION

The performance analysis and improvement of a power system network using a Unified Power Flow Controller. The considered power system network was modelled and analysed with and without the UPFC circuit.In addition to that Gauss-Seidal method is used to determine the real and reactive power at the sending and receiving end of the line (withoutUPFC circuit).). It was proved that the hands-on power flow calculation results are close to the MATLAB Simpower system result. It is observed that without the UPFC circuit, the transmission line 2-3 was overloaded and the load bus voltage experienced and undervoltage condition. This situation motivated engineers and us to use the network which is Implemented .The simulation results show that the voltage is regulation is improved and the overload condition on the existing power system network are avoided by using the UPFC circuit. The simulation result of the power system network show that the performance of the power system network is improved the UPFC circuit.) power system with UPFC connected to a three phase three wire transmission system. The control and performance of UPFC intended for installation on a transmission line is presented. Simulation results show the effectiveness of UPFC on controlling the power angle oscillations and real and reactive power flow through the line. From the simulation results, it is inferred that there is an improvement in the real and reactive power flow through the transmission line with UPFC when compared to the system without UPFC and with SSSC.

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