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The selection of UPFC entering signal in order to enhance the Dynamic Stability

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***Abstract*— In this article we are going to analyze the selection of UPFC entering signal in order to enhance the dynamic stability, and also to analyze the position of UPFC tools in the network which are effective for improving their efficiency especially in the discussion of system stability and system instability. A lot of studies for replacement of the UPFC have been down which were directed at a special aim. The suitable position and place of this plants in the network should be determined. Then the setting of the control parameters are improved. The best place of installing UPFC for voltage control is near the final BUS of the receiver, and the best place for STATCOM for voltage control in the middle of the transmission line where we can control the BUS of line voltage. The method of the of UPFC place-finding has been scrutinized by means of the analysis of the remaining amount. The controller UPFC is able to control all the parameters that have effects on the power flux in the line.**

***Index Terms*— STATCOM, UPFC devices, FACTS, damper controller, oscillation damping.**

I. INTRODUCTION

The stability of power system has been discussed since 1920 BC as an important issue in order to ensure the performance of the system. The damping of the electro mechanic oscillations between synchronous generators are essential.

The stability of the short signal shows the ability of the system for keeping synchronous state caused by little disturbances. The damping of the electro mechanic oscillations between synchronous generators are essential for stability of the system performance. UPFC was offered for FACTS devices, which possesses multi- purpose controllers, and those major function is to control the power. In order to analyze the stability we need to provide the system formulas:

$$\bar{v}_s = (v_p + v_q)e^{jQ} = r\bar{v}_k e^{jy} \quad (1)$$

$$\bar{i}_{SH} = (i_p + i_q)e^{j\theta_k} \quad (2)$$

The series voltage source and parallel current source are defined by means of formulas (1) and (2) respectively. All the parameters that are effective for active and reactance power flux, including line impedance, voltage ranges in the line terminals and the phase angle, are controlled independently by means of the monolithic controller of power flux.

II. DESCRIPTION AND FUNCTION OF THE CONTROLLER OF POWER FLUX

The monolithic controller of the power flux is composed of two voltage source transformers which are attached to each other back to back by means of DC BUS. In the figure (1) the UPFC structure is shown.

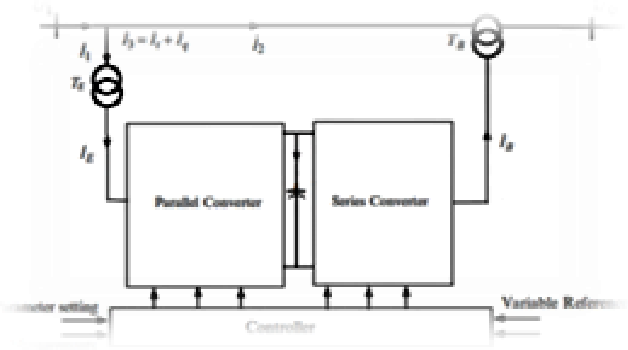

Fig.1: UPFC structure

The main function of the parallel transformer is to feed or attract the demand of the active power which is essential for series transformers that is appeared in the DC link. in figure 1 two transformers are fed by means of the common DC capacitive link. The series transformer has the main function of UPFC which is the injection of voltage series with a controllable range and phase angle.

The parallel transformer can produce and attract controllable reactance power. It can perform parallel compensation independently. It is clear that there can be no reactance power flux from the connective DC in UPFC.

The series transformers has the main function of UPFC which entails the injection of the voltage series with a controllable range and phase angle. The passing of current from this transformer leads to treading active and reactance power between transformer and the connective line.

III. THE CONTROL SYSTEM OF POWER FLUX CONTROLLER

The control design of UPFC includes real and reactance power flux control and model that is most used is a design based on controllability [2], so we can control active and reactance power independently. Four parameters torque angle, reactance line, sender BUS voltage and receiver BUS voltage can affect active and reactance power.

UPFC control BUS has been explained in reference[3. In this reference UPFC can be controlled by means of changing in amounts of active and reactance power reference by output

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controller. We can use controllability design for both series and control for UPFC control system (3,4). Another control design is to use PI controller for parallel.

IV. UPFC WORKS MODELS

The unlimited capacity of series voltage injection along with reactance power trade or independent control capacity, which is presented by orbiting structure of two back to back, provides several functional or controlling method for UPFC orbiting structure permits the general separation of two so that the parallel compensation of reactance STATCOM is down independently and also the series reactance compensation (SSSC) is down without any real power trade (7).

1) The Operational Control Of Parallel

The parallel works in such a way that pulls a controlled current ish from the line. One parameter of this current ish p is determined automatically with necessary equilibrium of real power in series. Another parameter of ish q is reactance and can be regulated in any arbitrary reference level (inductive or phase) in the range. But the situation of compensation control of reactance in is very similar to the methods that are used for STATCOM and static compensator of reactance power.

2) The Operational Control Of Series

The series controls the amount and angle of voltage vector vpq that is injected in the line in the form of series. This voltage injection always directly or indirectly affects power Flux in the line. But vpq depends on the situation of selected function for UPFC in order to control power flux.

V. THE FUNCTION OF UPFC IN POWER SYSTEM

In the power system we can use UPFC as a power flux control in the system. In the reference [8] the power flux control was modeled by UPFC based on voltage source model. UPFC can be used as a device for controlling the optimum load distribution [9].

In the reference [10] by use of the UPFC capability in controlling power flux and genetic algorithm, the expence function and damages were reduced.

UPFC can help the system stability including transient and dynamic stability.

VI. THE DAMPING REGULATIONS OF POWER OSCILLATION FOR UPFC

The problem of electro mechanic oscillations is the issue of short-time phase stability for power system (14).The aim of this part is to present a method for regulating damping oscillations of power system for UPFC by using control theoretical concepts in the stability of power system (16,15).

One of the main issues in effective and efficient design of POD is to select the suitable input signal. In order to improve damping and to prevent from delay in the connection with communicative systems, We only use locational signals as an input signal to POD. But today, because of the developments in communicative devices and decrease in delays caused from communicative devices, this problem was declined to some extent (17).

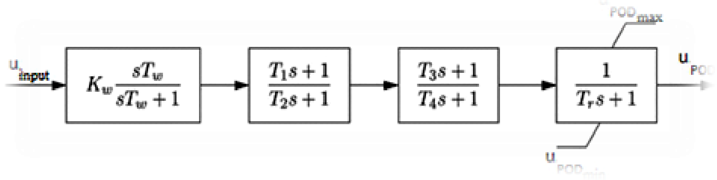

Fig 2: depiction of diagram of POD controller

VII. PARALLER AND SERIES COMPENSATION INDEPENTILY

UPFC orbiting structure provides the facilities for parallel and series convertors separately, by means of cut off in common connector terminals DC. In this way the parallel of an STATCOM works independently and the series convertors work as an independent SSSC. Of course in the independent situation, non of the convertors can attract or produce real power, in such a way that the function is possible in the domain of reactance power. Structure provides the facilities for parallel and series convertors separately, by means of cut off in common connector terminals DC. In this way the parallel of an STATCOM works independently and the series convertors works as an independent SSSC. Of course in the independent situation, non of the convertors can attract or produce real power, in such a way that the function is possible in the domain of reactance power.

VIII. UPFC LOCATION-FINDING IN POWER SYSTEM IN ORDER TO EXPAND DYNAMIC STABILITY FACTS

Locating- finding such as UPFC in power system take place for various reasons. Some of these reasons include distribution of optimum load[9]. Management of electricity market [9, 11], removing permanent and transient problems of power system [12] and etc. one of the aims of locating-finding in UPFC in power system is to improve dynamic stability.

IX. THE STUDIED SYSTEM

The studied system in this article is a 9 BUS and 3 machine and 11 BUS and 4 machine system. The simulation of this network was done by means of PSAT software and was depicted in figure 2 [17]. This network has three generators and the first BUS was considered as the reference BUS.

X. MONOLITHIC CONTROLLER OF POWER OF FLUX [UPFC]

Monolithic controller of power flux is the last achievement that provided the recent developments of power electronic industry in high levels of power and also control technologies. UPFC was introduced in 1992 AD by Gayugi [18]. In figure 1 UPFC structure was shown.

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Table (1): placing UPFC in each line and calculating the normalized remainder

State Line	Base	Cutline 7_8	Cut line 8_9	Average
9 - 8	0.4833	0.3935	0.8591	0.5786
7 - 8	0.5034	0.9556	0.4623	0.6404
6 - 7	1	1	1	1
9 - 10	0.8663	0.7344	0.7167	0.7725

Table (2): the normalized remainder by installing UPFC in line 6-7, near BUS 6 and near BUS 7.

The amount remaining with the installation of UPFC	
Near bus 7	**Near bus 6**
0.00686	**0.00822**

XI. THE RESULTS OF SIMULATION RELATED TO 11 BUS AND 4 MACHINE SYSTEM

PSAT tool box is free text software and Mr Milano provided its program. PSAT tool box has special capabilities in comparison to the other software that includes load distribution perceptual load distribution, optimum load distribution, stability of short signal and time simulation. At first the system was simulated by means of the standard information IEEE. Then by replacement of UPFC in each line (with the exception of the lines that are directly connected to the generator) was calculated instead of the usual state of the system and the states of N-1 remainder. The injected voltage and injected power by UPFC is the formula (2).

The result of the simulation was presented in table (1). As we can see in the following table, putting UPFC in the line 7-6 leads to the average maximum remainder in comparison to different states of the system.

Therefore this line is the most suitable line for installing UPFC. In order to clarify this issue that UPFC should be placed near which one of the BUSES, the remainder amount should be calculated UPFC parallel input that is ish. From the table it is clear that that the best place for installing UPFC is near BUS because putting UPFC near this BUS has more remainder in comparison to BUS7.

The results of simulation on BUS 11 system show well that by optimum placement and suitable input signal selection we can improve dynamic stability.

The numeral place of roots before and after UPFC was depicted in figure 3. It is clear that with considering numeral place of specific amounts, stability was improved. It is clear that by installing UPFC in line 6-7 and the selection of Pline signal as the input signal to UPFC controller the numeral place of the poles was commutated, with considering the numeral place of poles after installing UPFC we can see that stability of the system increased. In this article we dealt with one of the FACTS tools, named the monolithic power flux controller, that can help to improved the stability of the dynamic system.

UPFC installation and the selection of suitable signal causes that the between-the-region mode, that we had in system without UPFC, turn into regional mode and so the system damping is increased.

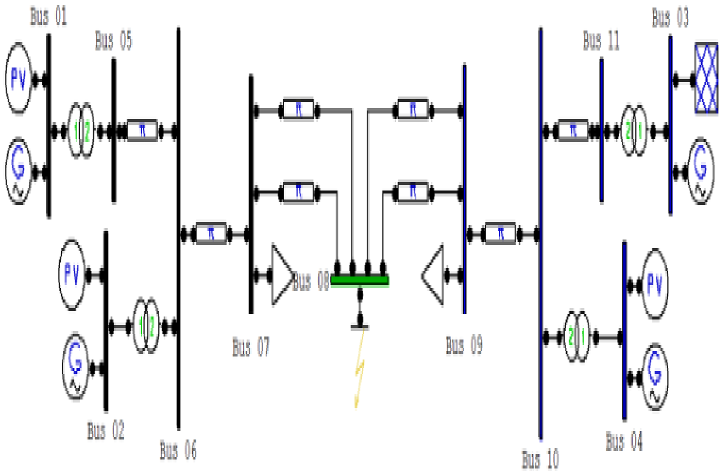

Fig 3: 11-bus system 4 car IEEE standard

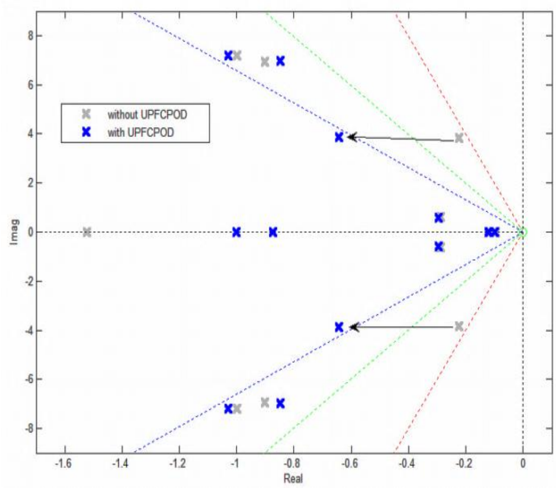

Fig 4: **Numeral place of the system special amounts before and after installing UPFC**

A comparison between UPFC replacement in another line in reference [13] UPFC was placed in 8-9 line. In this article by the method that we introduced line 6-7 was determined as the best place and IBUS 7-BUS signal as the desirable signal for UPFC. In figure (4) and (5) we compared the two systems; the results show that by placing UPFC in line 6-7, the two system oscillations a similar error was damping much faster.

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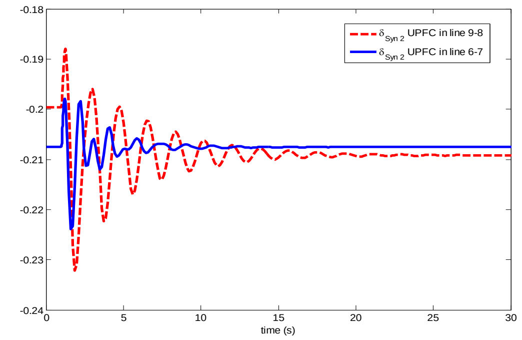

Fig 5: comparison between damping of angle oscillations of generators by replacement of UPFC in line 8-9 and 6-7

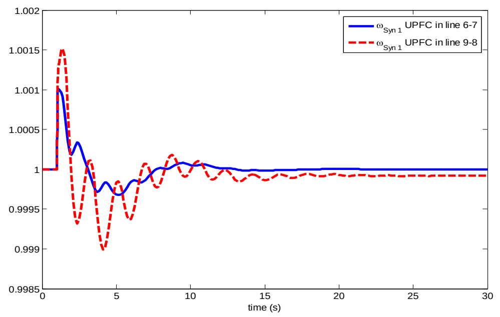

Fig 6: Comparison between damping of velocity oscilations of generator by replacement of UPFC in line 8-9 and line 6-7

XII. COMPARISON BETWEEN GENERATOR DAMPING IN THE STATE WITHOUT UPFC POD AND WITH UPFCPOD FOR SYSTEM 11 BUS 4 MACHINE

In figure 6 and 7 we can see the damping of generators angle in the state without UPFCPOD and with UPFCPOD, as we can see from the figures when the system is provided with UPFCPOD, the damping of the generator angle was improved in comparison to the state without UOFCPOD.

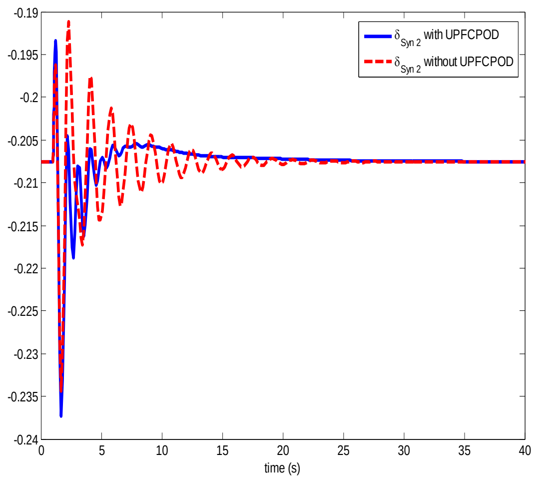

Fig 6: the damping of rotor angle oscillations of Geneator 2 (6 syn) system 11 BUS in the state without UPFC AND UPFCPOD.

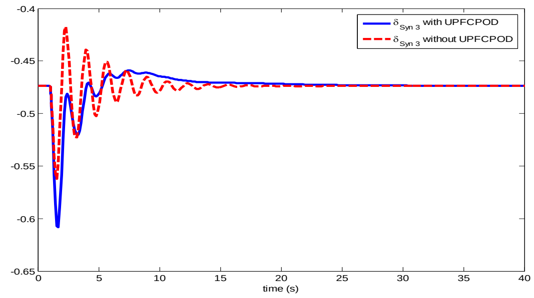

Fig (7): the damping of rotor angle oscillations of generators (8 syn3) system 11 BUS in the state Without UPFC and UPFCPOD

XIII. CONCLUSION

In this article I have introduced one of the FACTS tools, named the unified power flux controller (UPFC) that can help to improve the function of power system and can help to improve system stability. Because of the features that the tools has, it provided a lot research opportunities for improving system capabilities. By finding the best place for UPFC we can improve the dynamic stability of the power system and to help the stability of the system. In this article by simulation on system 9 BUS 11 standards IEEE and by achieving results, improvement of stability and improvement of dynamic stability was show.

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