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Impact of Available Transfer Capability Enhancement in a Three Area System Using UPFC.

D.V.S.B.Chaitanya[1], N.Bharath Kumar[2] And Mahaboob Shareef Syed[3]
[1, 2,3]*Assistant Professor, School of Electrical Engineering, Vignan University, Vadlamudi.*

Abstract
The paper deals with the study of ATC enhancement between the areas to show the impact of ATC enhancement during the power imbalances which will be going to effect the voltage profile of the system. The case study has been done on a Modified IEEE 30 bus system divided into 3 areas using PSAT (Power System Analysis Tool Box) Software. ATC calculations have been carried out from the load flow study obtained from PSAT which reduces the complexity in ATC calculations. Here we have gone for some static analysis to determine the best location of UPFC between the areas and gone for some power imbalances in the system due to generator outages to show the impact of ATC enhancement on voltage profile.
Key words: Available transfer capability (ATC), Total transfer capability (TTC), Capacity benefit margin (CBM), Transmission Reliability Margin (TRM), Existing Transmission Commitments (ETC), FACTS, UPFC.

I. INTRODUCTION

Deregulation of power systems not only bring cheaper electricity and better service to the consumers but also brings new technical challenges to power industries. In a open transmission access there is a need to quantify the transmission transfer capability which leads to the concept of Available Transfer Capability (ATC).Major traditional ways to enhance the ATC are rescheduling active power generations, adjusting terminal voltage of generators and changing taps of on load tap changers. Construction of new transmission lines is always been an option but it is subjected to environmental restrictions and social problems too. Thus effective utilization of the existing transmission systems with the help of new technologies so called Flexible AC Transmission Systems (FACTS) devices[3]. Here we are using Unified Power Flow Controller (UPFC) for ATC enhancement in between the areas, Since UPFC is a multifunctional FACTS device which has the capability to control all the three parameters that dictate power flow overpower transmission line.This paper investigates the impact of ATC enhancement on the voltage profile of the system whenever there is an power imbalance takes place due to generator outages. The case study have been implemented on a modified IEEE 30 Bus [6] system divided into three areas using PSAT(Power System Analysis Tool box) [2,5].According to North America Electric Reliability Corporation (NERC) [1],ATC is a measure of transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses.ATC is defined mathematically as the Total Transfer Capability(TTC) less the Transmission Reliability Margin(TRM),less the sum of Existing Transmission Commitments(ETC) and Capacity Benefit Margin(CBM),that is

ATC=TTC-TRM-ETC-CBM **(1)**

II. UNIFIED POWER FLOW CONTROLLER

The main features of UPFC are it mainly consists of two inverters, one connected in series with the line through a series injection transformer and another connected in shunt with the line through a shunt coupling transformer. The series inverter is used to inject a controllable voltage in series with the line, to obtain the desired power flow over the line. In general series inverter exchange both real and reactive power, a voltage source inverter is capable of generating required reactive power at its ac terminals but is incapable of handling real power exchange unless there is power source connected at its dc terminals. Thus the shunt connected inverter performs its primary function by delivering exactly right amount of real power required by series inverter, it also performs its secondary function of generating required reactive power for regulation of the real ac bus voltage. Thus UPFC offers the unique capability of independently regulating the real and reactive power flows on the transmission lines, while also regulating the local bus voltge. The following cases have been considered to show the impact of ATC enhancement in between the areas.

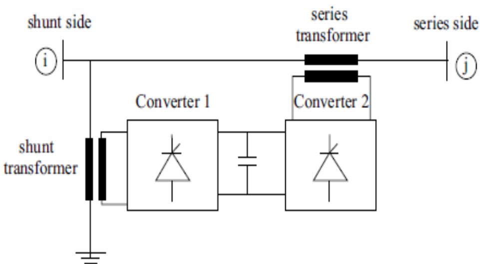

Fig.2.Basic Circuit Arrangement of UPFC.

1. Here we have gone for generator outage in area 3 at bus no 11, under such conditions if there is increase of load in this area say 30%, since due to fixed MVA rating of the interconnecting lines between the areas there will be an power imbalance and it is going to effect the voltage profile in area3 and it also effects the voltage profile of remaining buses in area1 &2. After keeping the UPFC in between the areas depending upon the static analysis, we are going to determine what is the impact of ATC enhancement on the voltage profile during the power imbalance due to generator outages.
2. Here we have gone for generator outage in area 2 at bus no 8, under such conditions if there is increase of load in this area say 30%, since due to fixed MVA rating of the interconnecting lines between the areas there will be an power imbalance and it is going to effect the voltage profile in area2 and it also effects the voltage profile of remaining buses in area1 &3. After keeping the UPFC in between the areas depending upon the static analysis, we are going to determine what is the impact of ATC enhancement on the voltage profile during the power imbalance due to generator outages.
3. Here we have gone for generator outage in area 1 at bus no 2, under such conditions if there is increase of load in this area say 30%, since due to fixed MVA rating of the interconnecting lines between the areas there will be an power imbalance and it is going to effect the voltage profile in area1 and it also effects the voltage profile of remaining buses in area2 & 3. After keeping the UPFC in between the areas depending upon the static analysis, we are going to determine what is the impact of ATC enhancement on the voltage profile during the power imbalance due to generator outages.

III. CASE STUDY

Figure shows the modified IEEE 30 bus system into three areas using PSAT (Power System Analysis Tool Box), here we have taken two generators in each area. Whenever there is generator outages takes place in particular area there will be deficient of power in that particular area so it has to take the power from the remaining areas through interconnecting lines under these conditions if the total load in that area increases by 30% due to fixed MVA rating of the interconnecting lines between the areas they are not in a position to transmit the additional power more than their rated values due to which there will be an power imbalance in that area which leads to voltage drop in voltage at all the buses in that area which is undesirable. If that power imbalance is within the limits that will be balanced by the slack bus but in some situations if the slack bus is not in a position to balance this imbalance in power in such a situations we have to use the FACTS devices to balance this imbalance in power. Whenever there is an enhancement of ATC in between the areas this additional power can be used in the area where there is an deficient of power instead of going for new generations in that area. Here we have gone for static analysis[4] to determine the best allocation of UPFC in between the areas, based on which interconnecting line is having the highest ATC enhancement that can be taken as the best line. After keeping the UPFC in between the areas depending upon the static analysis, what is the impact of ATC enhancement on the voltage profile during the power imbalance we are going to study.

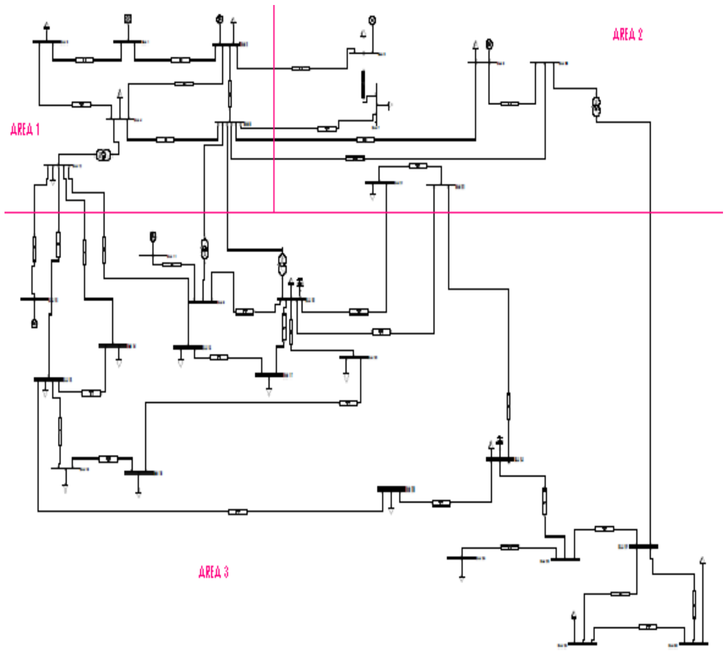

Fig. 3. A modified IEEE 30-bus Test System into 3 Areas using PSAT .

TABLE I
FOR FIXED COMPENSATION OF UPFC BETWEEN AREA 1 & 2.

	Base Case (MW)	Case1 (MW)	Case2 (MW)	Case3 (MW)	Case4 (MW)
ETC	180.82	246.13	390.21	878.09	454.01
ATC	1117.74	1052.43	908.35	420.47	844.55
%ATC ENHANCEMENT	---------	6.20%	23.05 %	165.83 %	32.34 %

TABLE II
FOR FIXED COMPENSATION OF UPFC BETWEEN AREA 2 & 3.

	Base Case (MW)	Case1 (MW)	Case2 (MW)	Case3 (MW)	Case4 (MW)
ETC	56.33	119.96	113.92	365.31	169.16
ATC	485.77	422.14	428.18	176.79	372.94
%ATC ENHANCEMENT	----------------	15.07%	13.44%	174.77%	30.25 %

TABLE III
FOR FIXED COMPENSATION OF UPFC BETWEEN AREA 1 & 3.

	Base Case MW	Case1 MW	Case2 MW	Case3 MW	Case4 MW	Case 5 MW	Case 6 MW
ETC	128.16	576.99	293.65	271.88	215.37	159.59	437.90
ATC	1063.12	614.29	897.63	919.4	975.91	1031.69	753.38
%ATC ENHACEANT	----------	73%	18.4 %	15.6 %	8.9 %	3.0%	41.1 %

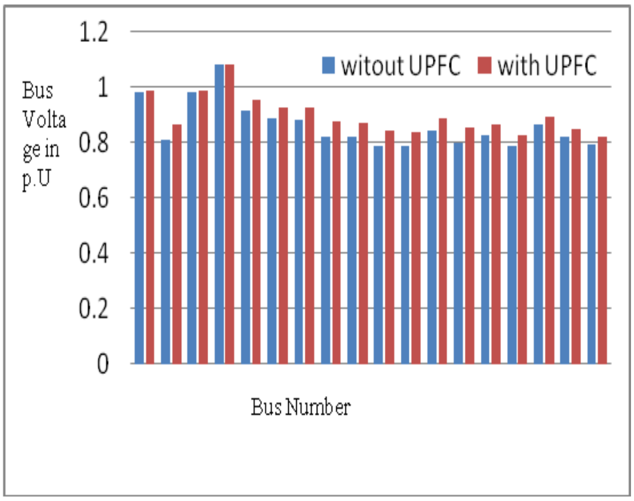

Fig.4. Bus Voltage Profile of Area 3 during generator outage at bus number 11 in area 3and with 30% increase in load of area3.

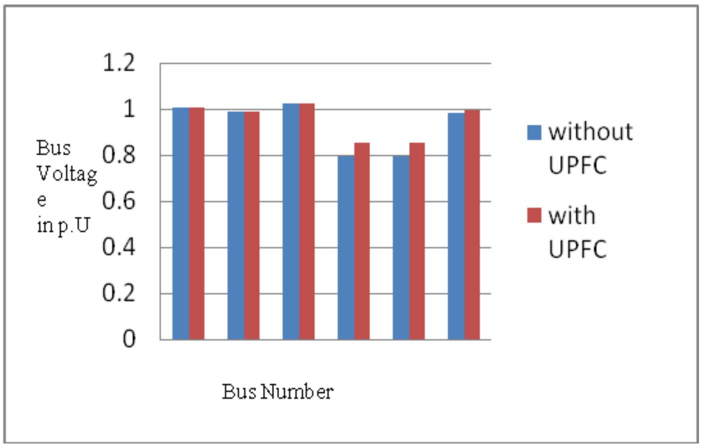

Fig.5. Bus Voltage Profile of Area 3 during generator outage at bus number 11 in area 3and with 30% increase in load of area3.

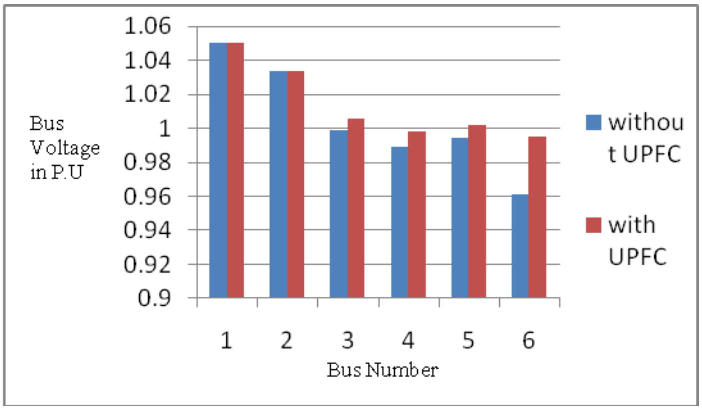

Fig.6. Bus Voltage Profile of Area 1 during generator outage at bus number 11 in area 3and with 30% increase in load of area 3.

The above Fig.4,5,6 shows the impact of ATC enhancement in between the areas on the voltage profile of the system using UPFC. Here we have considered generator outage at bus number 11 in the area3 to create some power imbalance in the system.

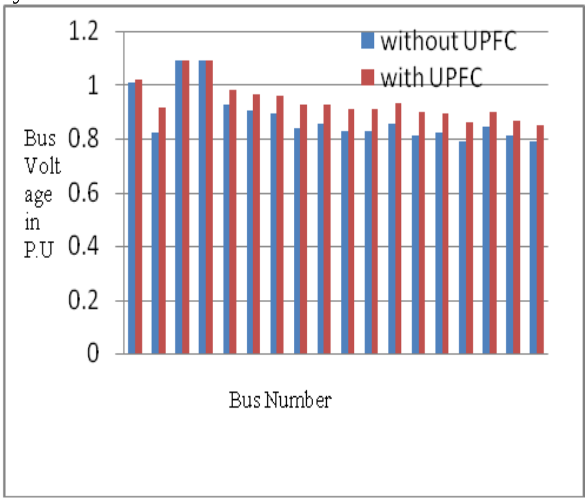

Fig.7. Bus Voltage Profile of Area 3 during generator outage at bus number 8 in area 2 and with 30% increase in load of area 2.

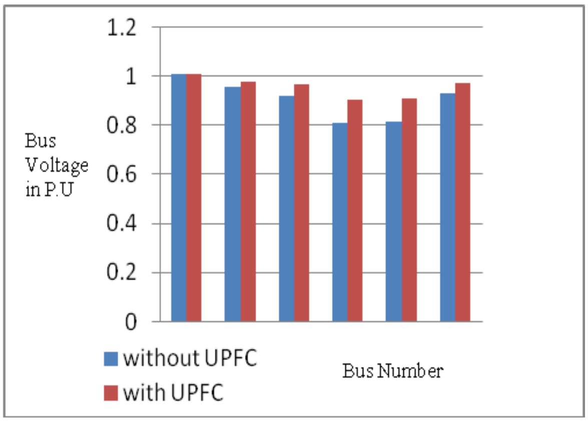

Fig.8. Bus Voltage Profile of Area 2 during generator outage at bus number 8 in area 2 and with 30% increase in load of area 2.

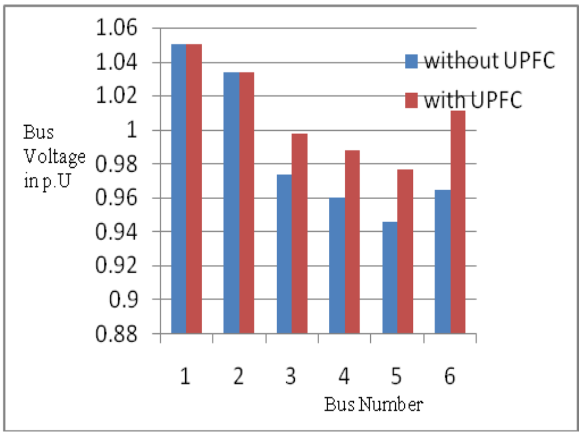

Fig.9. Bus Voltage Profile of Area 1 during generator outage at bus number 8 in area 2 and with 30% increase in load of area 2.

The above Fig.7, 8, 9 shows the impact of ATC enhancement in between the areas on the voltage profile of the system using UPFC. Here we have considered generator outage at bus number 8 in the area2 to create some power imbalance in the system.

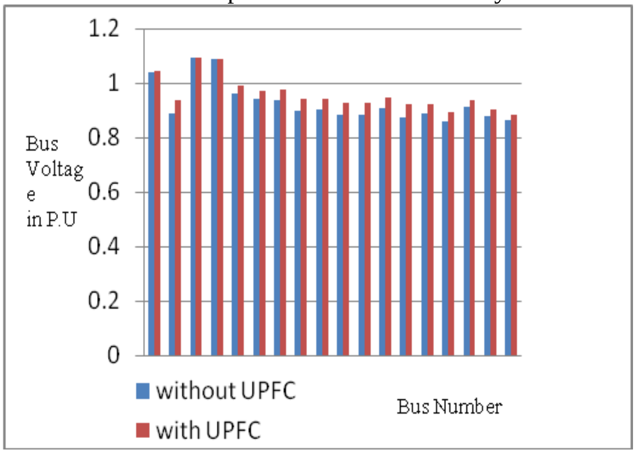

Fig.10. Bus Voltage Profile of Area 3 during generator outage at bus number 2 in area 1 and with 30% increase in load of area 1.

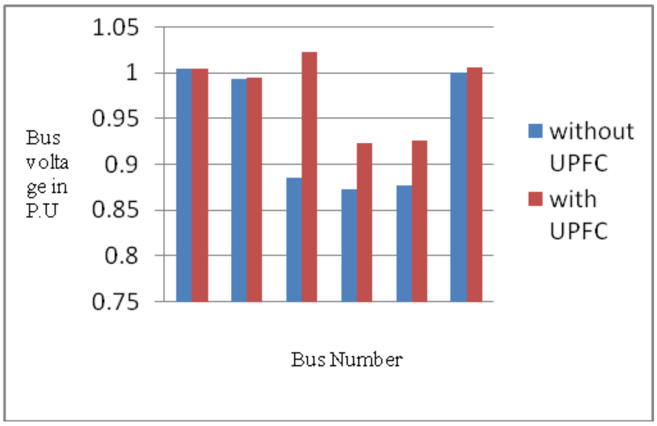

Fig.11. Bus Voltage Profile of Area 2 during generator outage at bus number 2 in area 1 and with 30% increase in load of area 1.

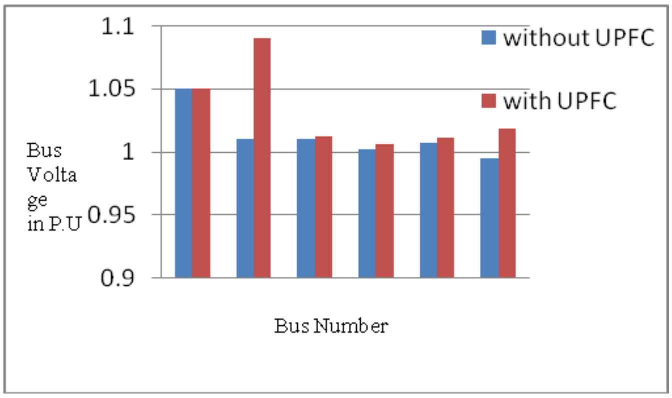

Fig.12. Bus Voltage Profile of Area 1 during generator outage at bus number 2 in area 1 and with 30% increase in load of area 1.

The above Fig.10, 11, 12 shows the impact of ATC enhancement in between the areas on the voltage profile of the system using UPFC. Here we have considered generator outage at bus number 2 in the area1 to create some power imbalance in the system.

IV. CONCLUSIONS

This paper investigates the optimal location of UPFC in between the areas depending upon which line is going to give highest ATC enhancement. Here the ATC enhancement between the areas is done usingUPFC, it can be used for some other purposes such as enhancement of transient stability, mitigations of low frequency power system oscillations and voltage regulation (reactive power). The case study has been implemented on a modified IEEE 30 bus system divided into three areas using PSAT (Power System Analysis Tool Box). The impact of ATC enhancement on the voltage profile during power imbalances due to generator outages has been studied which is shown in the Fig.4 to 12, therefore, the decision for an optimal placement of UPFC in the deregulated power system for ATC enhancement may be practical solution without going for additional generations. Thus existing network may be upgraded and up rated with new technology solutions. However, a detailed design for a good control range needs a specific care while choosing the control parameters of FACTS devices.

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