Analysis of Voltage Profile Improvements and Transmission Losses by Using UPFC and UPQC under Three Phase Fault Condition

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Abstract- *This paper is about to study of voltage profile and transmission losses under three phase fault condition and improves sag voltage by using two different FACTS devices. The flexible ac transmission system is one of important system used to mitigate any type of voltage and current fluctuation. The unified power flow controller & unified power quality conditioner are used to analyze the voltage profile and transmission losses under three phase fault condition in IEEE 9 bus system.*

Keywords- Unified power flow controller, Unified power quality conditioner, three phase fault, MATLAB

I. INTRODUCTION

Modern power system consists of wide range of electrical, electronic and power electronic equipment in commercial and industrial applications. The quality of the Electrical power is affected by many factors like harmonic0contamination due to0non-linear loads and as the load increases; power utilities are looking foriways to maximize the utilization of their existing transmission system.

Voltages in every bus get reduce due to faults hence it has to be return to their original rating by allocating reactive power in system by using compensating devices. The voltage profile of the System can be improved by adding FACTS devices like Unifiedipower flow controller and unified power quality conditioner under healthy condition, a power system is in balanced state. All the equipments carry normal load voltage and current. Due to the faults the stability is not constant in power system. Faults may occur due to internal or external effects. Fault occurs in between phase to phase or phase to ground. Due to faults the high current will flow in the system hence to give uninterrupted supply to consumers it requires to add protective and compensating devices in the circuit [1].

Power quality and power electronics are linked irrevocably together as gives advance technologies in each area. From last 20 years the energy system is using power electronics devices to improve power quality. It is simple and convenient way to improve power iquality by using FACTS devices. The power electronics devices are used in all applications like industrial, commercial, houses, military etc.

The FACTS devices can be add in series, shunt or shunt-series configurations in transmission line and it controls the operations of all parameter in steady state and dynamic behavior in fault conditions.

II. FACTS CONTROLLERS

Developing technology needs uninterruptable energy supply and sender should supply power in profitable margin. The operation of the power system in every step like generation, transmission and distribution should give profit to sender.

The modern technologies gives reliable, secure and profitable operable of power system with existing system.iFor this achievement FACTS controller plays major role. FACTS devices can gives controllable operation of power system with minimum investment, infrastructure and it takes less time to insert in existing system.

The FACTS controller technology can controls series impedance, shunt impendence, voltage, current and phase angle and it can upgrade existing transmission system, substation and all equipments in power system. By this technique power system can controls voltage and current even in fault conditions [2].

The speeds of mechanical switches are low. With help of mechanical switches grid operator is not able to meet the steady state condition in system. As compared to static electronic devices the mechanical switches wear out quickly and life of power system get reduced. The maintenance of mechanical switches complex as compared to electronic devices.

Advantages of using facts devices in transmission system are:

- It increases transmission capacity and reliability of system.
- It increases the Transient and dynamic grid stability.
- It increases quality of energy system.
- Fact devices can increases the better utilization of existing system.
- Increases the security and stability of transmission line.
- Speed of controlliabity is high as compared to mechanical devices

FACTS devices have more advantages as compared to mechanical switches. Hence now a day's power system engineers are using more FACTS devices. These devices providing better and uninterrupted supply with less investment. FACTS devices can connect in series or parallel, its depends on structure and connections.

This research helps to analyze the effects of unified power flow controller and unified power quality conditioner on voltage profile improvement and transmission losses.

III. UNIFIED POWER FLOW CONTROLLER

The figure.1 shows UPFC construction. It consist of two voltage source converters. Those are VSC1 & VSC2 which are connected backito back. The DC storage capacitor provides the dc link to both VSC

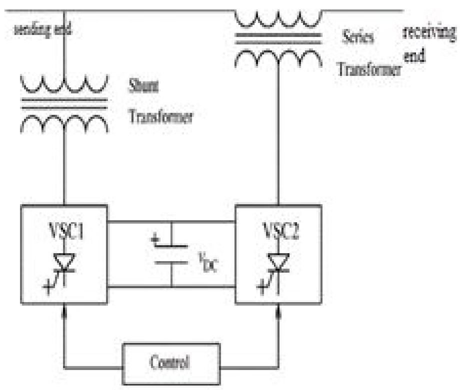

Fig.1 UPFC construction

This arrangement is act like ac to ac converter. The real power can flow freely in either directions in between two ac converters and both converters can absorb or generate reactive power.

VSC1 is connected in series through series transformer at sending terminal and VSC2 is connected in parallel through shunt transformer at receiving end. Both VSC are coupled via DC link.

This DC link provides path to exchange the active power between two VSC.UPFC can send controllable voltage means the magnitude and phase angle of voltage can be controlled by using VSC's through the transformer. The injected voltage from VSC2 is synchronous ac voltage. The line current which flows through vsc can exchange real and reactive power between these converters and in ac system. The converters can generate the reactive power internally at terminal of the dc link. The exchanged real power at ac terminal will convert into DC power and It will appear at dc terminal as real power demand. The VSC1 can absorb or supply real power as per requirement of VSC2.The common DC link can exchange real power by injecting series voltage. The power demand of VSC2 at dc link will be converted to ac by using VSC1 and it is connected to tramsmission line through shunt connected transformer and VSC1 can also absorb or generate reactive power if it is essential hence it can compensate shunt reactance independently for transmission line. Thus VSC1 can operate almost near to unity power factor[7].

UNIFIED POWER QUALITY CONDITIONER

Series active power flow:-It is connected in series at transmission line and connected to transmission line through series transformer. Problems created due to unbalanced voltage and distortion of voltage will be solved by using series APF.

It injects compensating voltage to load hence system can get perfect balanced and regulated voltage. The pulse width modulation technique is used control the series inverter.

Shunt active power filter: -In transmission line the shunt APF is connected in parallel. The distortion and harmonics produced by current will be compensate by shunt APF.

The harmonics in current are produced due to unbalanced load current. Hence to get balanced and sinusoidal current the shunt APF is used. For balancing the source current hysteresis band PWM techniques is used. This technique will make output current follows the reference and current will be in the fixed hysteresis band.

Series Transformer: Series transformer is used to inject balanced, sinusoidal and regulated voltage from series APF to transmission line. The turns ratio of transformer should suitable such that voltage inject from transformer will be completely balanced and sinusoidal. And it prevents current flowing in series inverter

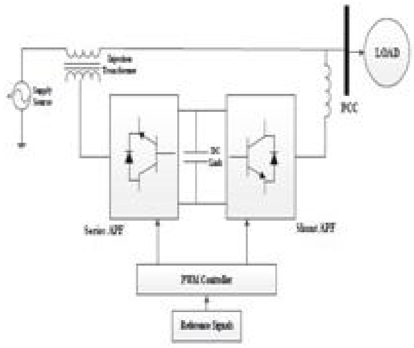

Fig.2 UPQC construction

Low Pass Filter: At output of series inverter the low pass filter is connected. The low pass filter is used to remove high frequency voltage component which are produced due to switching of voltage source inverter.

High pass filter: High pass filter is used to absorb the ripples produced due to current switching. It is connected at output of shunt inverter.

DC link capacitor: The DC link capacitor is used make link in between two voltage source inverters. These two inviters are connected back to back at the dc capacitor. This capacitor will provide the dc voltage for operation of two inverters. It will also provide extra real power in case of transient period to match source and load power. At steady state condition the power at will be equal to load demand but small portion of energy will be consumed by the active filter. The output of dc capacitor voltage will be equal to reference voltage but due to some disturbance in power system output may slightly differ from reference value[7].

THREE PHASE FAULT:

Three phase faults are symmetrical faults. It occurs phase to phase. All the phases are shorted and in phase to ground fault all 3 phases are earthed. But all are in balanced condition hence it is called as symmetrical fault.

The currents are displayed by 120 degree and current in all three phases are same. The three phase faults occurs only 5% of total fault in power system.The below figure showing LLL fault in transmission line[3].

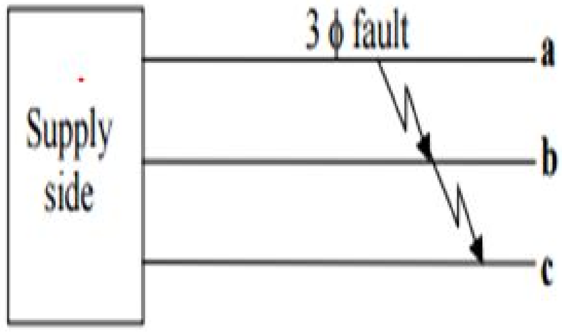

Fig.3 LLL fault

IV. PROPOSED SYSTEM

The figure shows IEEE 9 bus system. The three phase fault occurs in between 7th and 8th bus it increases the system current and reduces the voltage. The stability of system reduces hence to increase the stability of the system FACTS devices like UPFC and UPQC are connected in IEEEE 9 bus system(Between 7th and 8th bus).The results includes the voltage and current in each bus before and after faults.

FACTS devices are used to improve voltage profile of system. This paper is about analyzing the voltage profile and transmission loss by adding UPFC and UPQC.

IEEE 9 bus system:

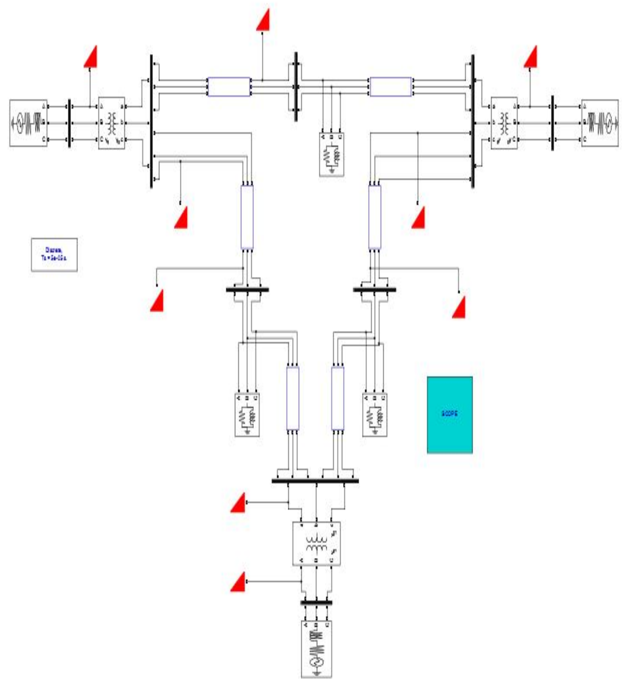

Fig.4 IEEE 9 bus system

IEEE 9 bus system with three phase fault

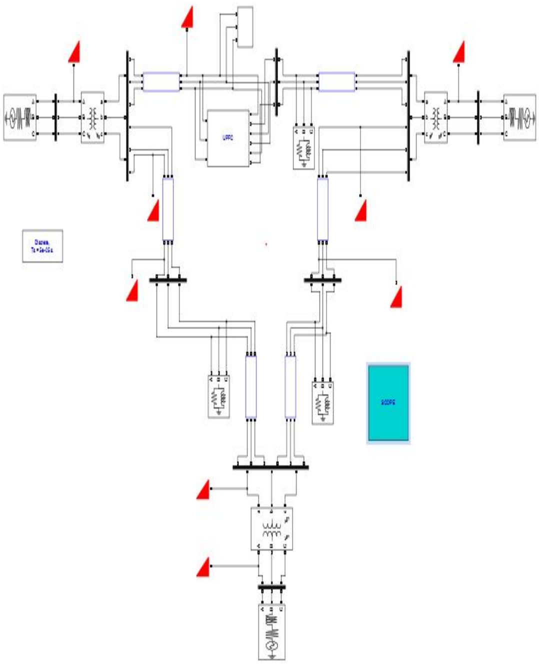

Fig.4 IEEE 9 bus system

IEEE 9 bus system with UPFC device:

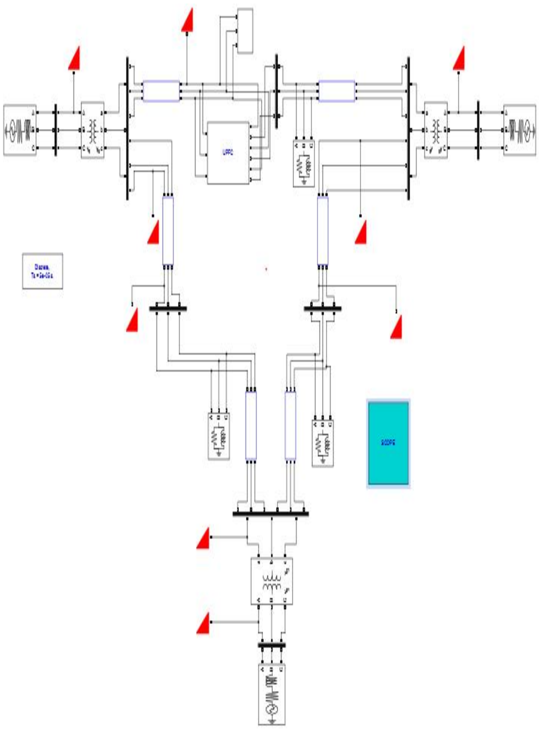

Fig.5 UPFC connected IEEE 9 bus system

IEEE 9 bus system with UPQC device:

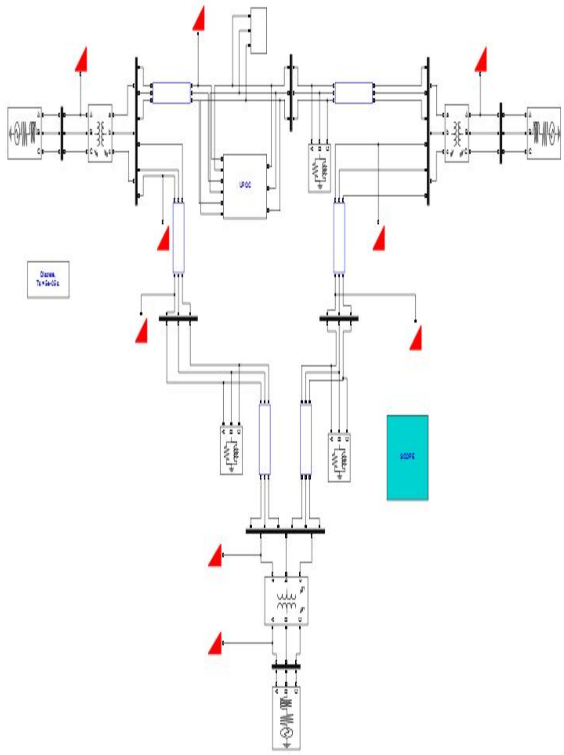

Fig.6 UPQC connected IEEE 9 bus system

Table 1: Comparisons of voltage in each bus

Bus no	Voltage in (Kv)	9 bus System Voltage (KV)	Fault Voltage (KV)	UPFC voltage (KV)	UPQC voltage (Kv)
1	16.5	13	7.45	9.8	12
2	18	14.4	8	11.65	14.4
3	13.8	11	6.15	7.2	8.8
4	230	178	98.4	130	162
5	230	175	96.4	134	168
6	230	176	96.7	117	114.5
7	230	179	97.2	142	179
8	230	176	94.6	99.5	121
9	230	178	97.3	114	140

Table 2: Comparison of current in each bus

Bus	9 Bus system current (A)	Fault system current (A)	UPFC system current in (A)	UPQC system current in (A)
1	2030	2806.66	2400	2045
2	4150	5850	4625	3733.33
3	2840	3966.66	4620	3216.66
4	101	130	76	125.2
5	149.75	18	220	326.66
6	136.2	32.85	102.3	137.66
7	167.33	442.85	172	68
8	170.23	105.5	179.2	176
9	178.3	242.5	222.5	196

Table 3. Transmission losses in each bus

Resistance in Ohm	9 Bus system Loss (Watt)	Fault system Loss (Watt)	UPFC system Loss (Watt)	UPQC system Loss (Watt)
0	0	0	0	0
0.017	173.4	287.3	98.19	266.47
0.039	874.5	874.5	1887.6	4161.56
0	0	0	0	0
0.0119	220.7	12.84	124.53	225.83
0.0085	237.9	1666.98	251.46	39.3
0	0	0	0	0
0.032	927.3	356.16	1027.6	991.23
0.01	317.9	588.06	495.06	384.16

V. RESULTS AND DISCUSSION

This paper is about to study the performance of UPFC and UPQC in the field of Voltage profile improvements and transmission losses. Based on simulation results the graphs are plotted as shown in figure no 7 & 8.

The following observations seen from MATLAB results:

1. UPQC is found to be better than UPFC for voltage profile improvement.
2. The reduction of transmission loss is switching between UPFC and UPQC.

Further the fault current and transmission losses research has to be done because of its non constant nature.

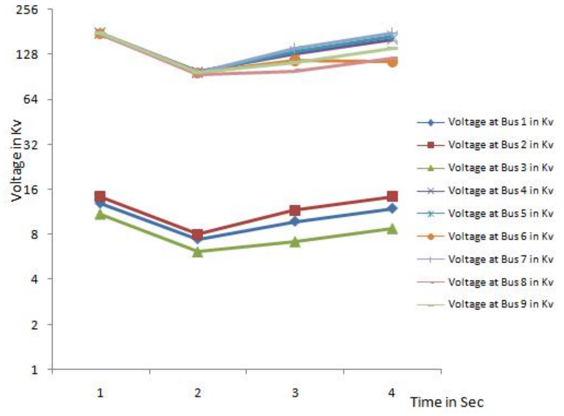

Fig.7 Voltage/Time graph of 9 bus system

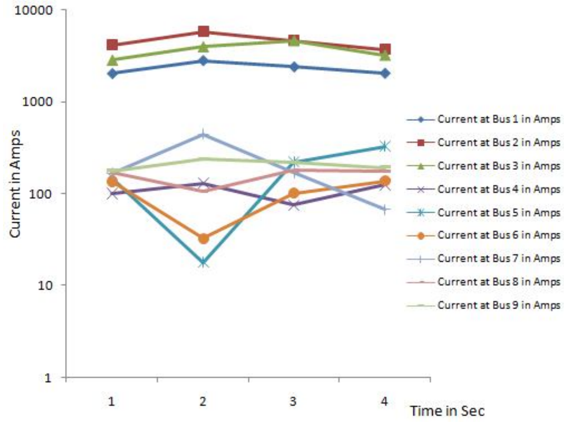

Fig.8 Current Vs Time

VI. CONCLUSION

In this paper the performance of UPFC and UPQC in terms of voltage profile and transmission losses are analyzed in IEEE 9 bus system under three phase fault condition. The comparison is done in between FACTS devices by keeping the devices between fault affected buses (Between 7th and 8th bus).Based on simulation results the Table 1 shows that UPQC is best device as compared to UPFC to improve the voltage profile and transmission losses are also analyzed as it shown in Table 3.The nature of current and transmission losses are not constant hence further research need to be carried out to understand the behavior of fault current and losses.

VII .FUTURE SCOPE

The proposed paper can be further implemented to analyze the system current at 5, 6 and 8th bus and transmission losses at UPFC and UPQC. Because the system is failed to improve the losses in three buses. It can be also be implemented on real time system which experience more frequent and complex faults. Presently three phase fault is considered to analyze the performance of UPFC and UPQC.

But the three phase fault happens only 5% of total faults in power system hence instead of LLL fault, the LG fault and LLG etc can be considered.

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