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Research Article

VOLTAGE SAG COMPENSATION USING UNIFIED POWER FLOWER CONTROLLER IN MV POWER SYSTEM USING FUZZY CONTROLLER

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ABSTRACT
Voltage sags is the most important power quality problems faced by many industries and utilities. It contributes more than 80% of power quality (PQ) problems that exist in power systems. Voltage sag can cause loss of production in automated process, since voltage sag can trip a motor or cause its controller to malfunction. To compensate the voltage sag in a power distribution system, appropriate devices need to be installed at suitable locations. This paper aims to present an approach to mitigate voltage sag in transmission lines and avoid it to propagate into distribution system. So in this paper the voltage sag compensation based application of a FACTS device in transmission and sub transmission lines is presented and focused. In this paper a UPFC as a suitable FACTS device in transmission level of power system based fuzzy controller is simulated and discussed.

INTODUCTION
Electric problems always occur regardless of time and place. This may cause an impact to the electric supply thus may affect the manufacturing industry and impede the economic development in a country. The major electric problems that always occur in power systems are the power quality problems that have been discussed by the electrical engineers around the world, since problems have become a major issue due to the rapid development of sophisticated and sensitive equipment in the manufacturing and production industries. The increased concern for power quality has resulted in measuring power quality variations, studying the characteristics of power disturbances and providing solutions to the power quality problems (Sambugari and Vanurrappa, 2011).
In distribution systems, the power quality problems can reduce the power supplied to the customers from its nominal value. Voltage sag, harmonic, transient, overvoltage and under voltage are major impacts to a distribution system. The utility and the users are responsible in polluting the supply network due to operating of large loads.
There are many solutions in mitigating the power quality problems at a distribution system such as using surge arresters, active power filters, isolation transformer, uninterruptible power supply and static VAR compensator. Mienski *et al.*, (2004) proposed a new D-STATCOM control algorithm which enables separate control of positive and negative sequence currents and decoupled control of d- and q-axes current components. A series connected converter based mitigation device, the dynamic voltage restorer (DVR) proposed by (Woodley *et al.*, 1999) is the most economical and technically advanced mitigation device proposed to protect sensitive loads from voltage sags.
Voltage sag is one of the most severe power quality disturbances to be dealt with by the industrial sector, as it can cause severe process disruptions and result in substantial economic loss. One of the main factors which limit capabilities of dynamic voltage restorer (DVR) in compensating long-duration voltage sags is the amount of stored energy within the restorer. In order to overcome this limitation, inter-line dynamic voltage restorer (IDVR) has been proposed where two DVRs each compensating a transmission line by series voltage injection, connected with common dc-link (Wijekoon *et al.*, 2003). When one DVR compensates voltage sag, the other DVR of the IDVR replenish the de-link energy storage. This IDVR works efficiently when the lines under consideration are connected with two different grid substations, as it is reasonable to assume that voltage sag in one line would have lesser impact on the other line. But in

case when the lines are connected with same grid substation and feeding two different sensitive loads in an industrial park, voltage sag in one line affects the voltage profile of other lines. Under the above circumstances, long duration voltages sags cannot be mitigated by IDVR due to insufficient energy storage in dc-link. This paper proposes a voltage sag compensator based on unified power flow controller (UPFC), which comprises of two voltage-sourced converter modules sharing a common delink. Some authors have investigated the voltage mitigation process using UPFC (Abhishek, *et al.*, 2014). One voltage-sourced converter module connected in series with the lines, which compensates voltage sag and a second shunt converter module maintains bus voltage and replenish the common dc-link energy storage. The control strategy for power flow control of shunt converter and sag compensation control of series converters are discussed in detail. Adjustable earner PWM is used for generating switching pulses. The simulation model of UPFC is developed in this paper. The salient advantages of the proposed method are compensating long duration deeper voltage sags.

Voltage Sag

Voltage sags and swells in the low and medium voltage distribution system have been considered to be the most frequent type of power quality problems based on recent power quality researches. Their effect on sensitive loads is severe. Their effects could be ranged from the disruptions of load to influential economic losses up to millions of dollars. Several solutions have been proposed to protect sensitive loads against this kind of disturbances but the dynamic voltage restorer is considered to be the most effective solution. The advantage of this custom power device includes its dynamic response to the disturbance, lower cost and smaller size. As shown in Figure 1 the voltage sags may be occurred at any instant of time, with amplitudes ranging from 10 to 90% and a duration which lasting between a half cycle to one minute. On the other hand, voltage swell, is defined as an increase in rms voltage or current for 110% to 180% under power frequency for duration between 0.5 cycles to 1 minute. Energizing a large capacitor bank or switching off a large inductive load is a typical system event which causes swells (Sharanya *et al.*, 2012).

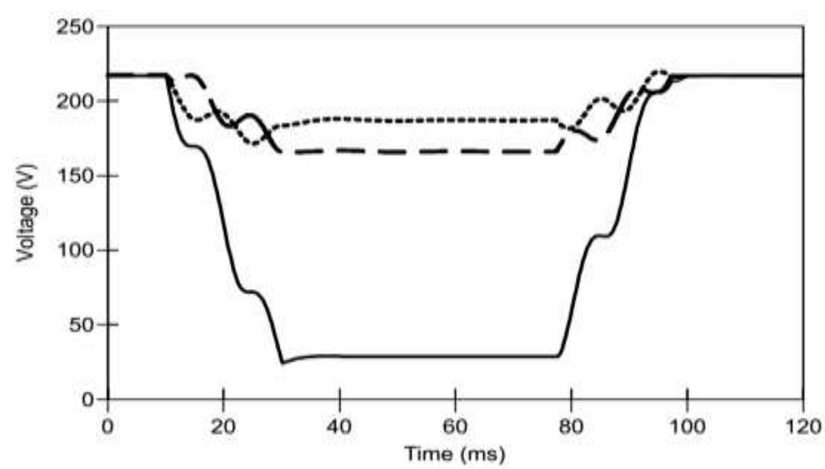

Figure 1: Volatge sag in three phase

Fuzzy Logic Controller

The performance of Fuzzy logic controller is well documented for improvements of both transient and steady state performances. The function of fuzzy logic controller is very useful since exact mathematical model of it is not required (Shilpa and Jaswal, 2014). The fuzzy logic control system (Figure 2) can be divided into four main functional blocks namely Knowledge base, Fuzzification, Inference mechanism and Defuzzification. The knowledge base is composed of data-base and rule-base. The data-base, consisting of input and output membership functions, provides information for appropriate fuzzification operations, the inference mechanism and defuzzification. The rule-base consists of a set of linguistic rules relating the fuzzy input variables to the desired control actions. Fuzzification converts a crisp input signal, the error (e), and error change (Δe) into fuzzified signals that can be identified by level of membership in the fuzzy sets. The inference mechanism uses the collection of linguistic rules to convert the input conditions to fuzzified output. Finally, the defuzzification converts the fuzzy outputs to crisp control signals, which in the system acts as the changes in the control input.

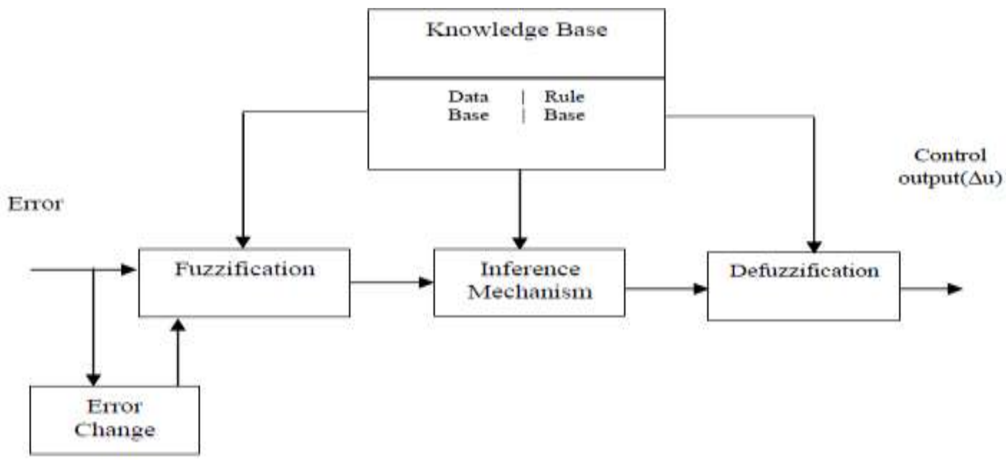

Figure 2: Functional block diagram of Fuzzy logic control

Unified Power Flow Controller (UPFC)

This FACT device is consisted of two converters which the converter-1 is to supply or absorb the real power demanded by converter-2 at the common dc link to support the real power exchange resulting from the series voltage injection. Converter-1 can generate or absorb controllable reactive power if desired, and thereby provide independent shunt reactive compensation for the line. The superior operating characteristic of UPFCConverter-2 provides the main function the UPFC by injecting a voltage V_{pq} with controllable magnitude and phase angle ρ in series with the line via an insertion transformer.

At first to investigate the effect of short cicuit as a fault in transmission network, the system without any compensator is simulated.

The voltage and current system at bus 1 is shown in Figure 3.

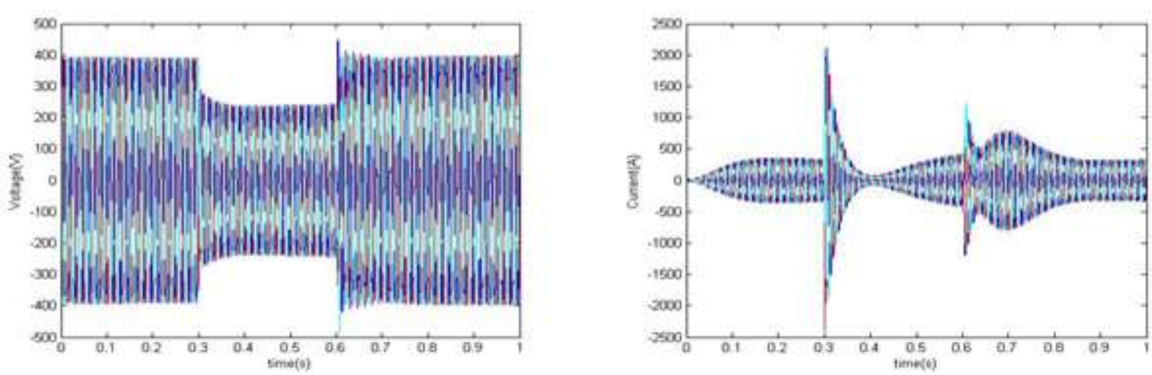

Figure 3: The voltage and current of system without UPFC

Due to fault occurred in network, the active and reactive power in bus 1 of system is changed and faced with a transient variation. This is presented in Figure 4.

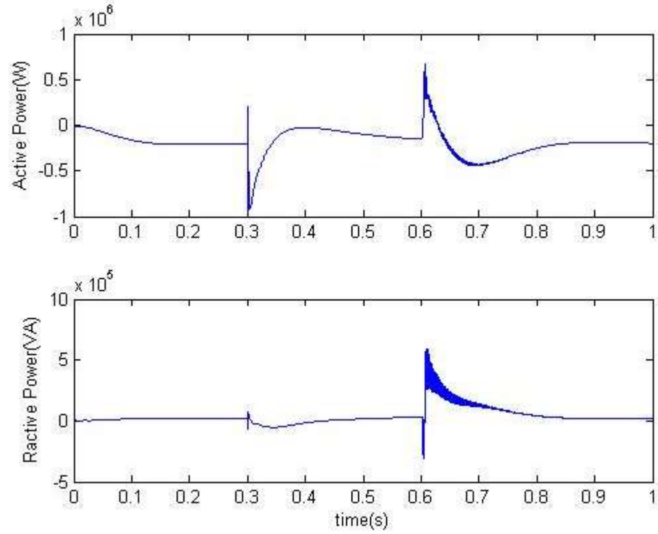

Figure 4: The active and reactive power variation without UPFC

In this section to find out the effects of UPFC on voltage sag compensation, the unified power flow controller through a fuzzy based controller is applied to transmission level of network. The UPFC configuration and its controller based fuzzy controller is shown in Figure 5.

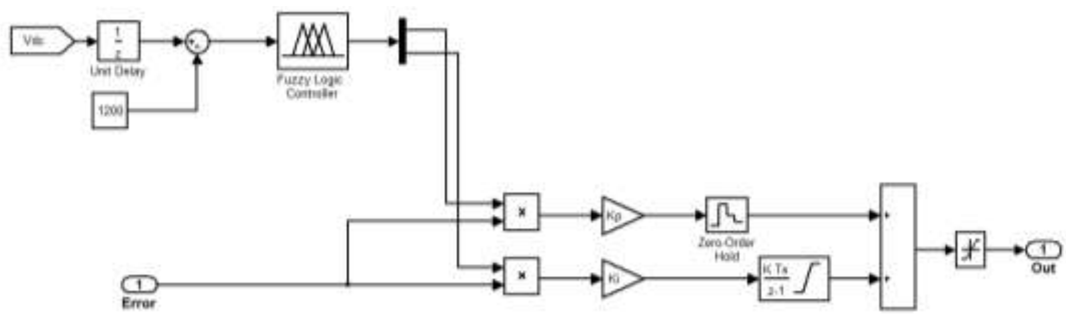

Figure 5: The fuzzy based controller of UPFC

The voltage and current at bus 6 with presence of UPFC as a compensator is obtained. As seen in this figure the voltage sag is improved. This is indicated in Figure 6 and it is seen that the suddenly increase in current due to short circuit has been removed after compensation.

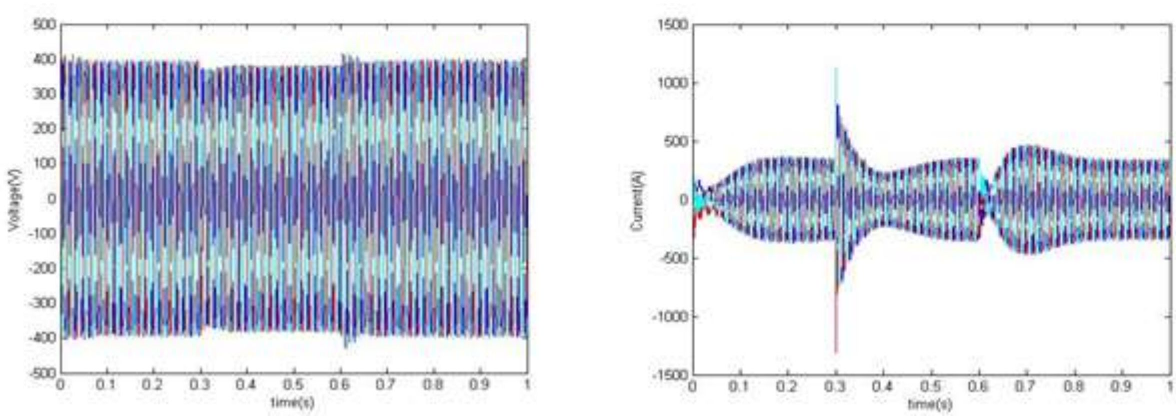

Figure 6: the voltage and current of system with UPFC

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The active and reactive current of system with UPFC compensator is improved and is presented in Figure 7.

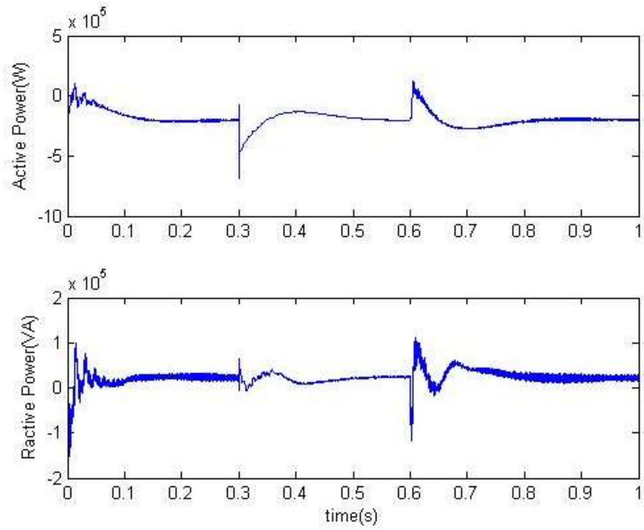

Figure 7: The active and reactive power variation with UPFC

The active and reactive power injected by UPFC is shown in Figure 8.

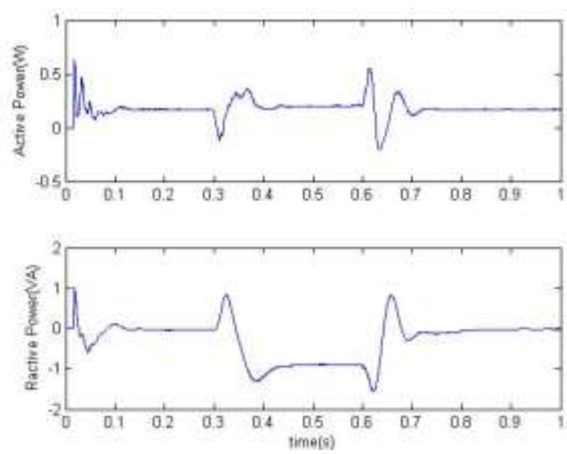

Figure 8: The injected active and reactive power by UPFC

The rms voltage before and after voltage sag compensation using UPFC is shown in Figure 9.

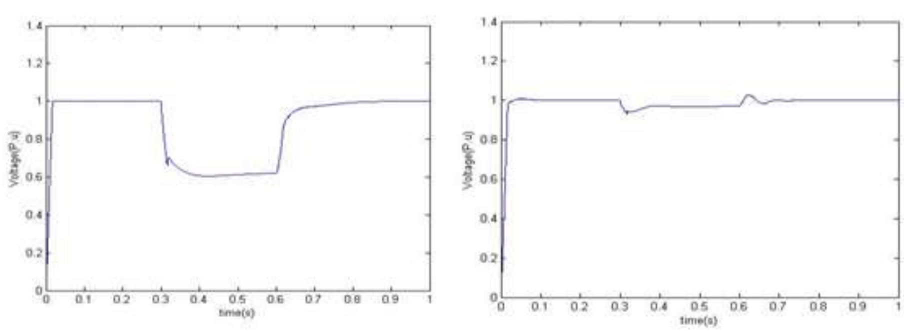

Figure 9: The rms voltage before and after sag compensation using UPFC

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CONCLUSION

This research deals with voltage sag mitigation in transmission network using unified power controller (UPFC). At first the system in absence of any compensator is simulated and the influence of a short circuit on a bus of system is investigated. In this research to mitigate the voltage sag, a fuzzy based controller using UPFC is presented and analysed. The obtained results show the more affectivity of proposed method.

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