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Research Article

ANALYSING THE EFFECT OF USSC CONNECTION TO DISTRIBUTION SYSTEM ON VOLTAGE FLICKER

***Montazeri M.[1], Abasi Garavand S.[1] and Azadbakht B.[2]**
[1]*Department of Electrical Engineering, College of Engineering, Borujerd Branch, Islamic Azad University, Borujerd, Iran*
[2]*Department of Medical Radiation Engineering, College of Engineering, Borujerd Branch, Islamic Azad University, Borujerd, Iran*
**Author for Correspondence*

ABSTRACT
One of power quality disturbances is voltage flicker. Fluctuating voltage is caused by loads that exhibit continuous, rapid variations in load current. Electric arc furnace is the main generator of fluctuating voltage which affects the performance of other sensitive loads connected with the system. Heavy industries like steel mills connected at the local grid in a power system consume a large amount of power, which fluctuates with the voltage. This paper deals with flicker mitigation especially in distribution system due to induction motor starting. In this research a series-shunt based compensation using USSC is presented, simulated and discussed.

***Keywords**: USSC Connection, Voltage Flicker*

INTRODUCTION
Many researches have focused on the voltage flicker mitigation. In (Marei and Salama, 2006) a control strategy based on implementation of symmetrical components estimation techniques to compensate voltage flicker and other types of voltage disturbances such as sag, swell and unbalance voltage by DVR is presented. The DVR is employed to balance and regulate the load terminal voltages by compensating both negative and the zero sequence components. In (Sanjay, 2010) the induction motor voltage flicker analysis and its mitigation using SVC is studied. The successful compensation of voltage flicker by SVC is observed in (Sanjay, 2010) .The proposed control of the SVC is based on measuring the reactive component of the load current and deciding the firing angle in such a way that the SVC injects or absorbs the amount of reactive power required for compensation. From researches it is found that SVC not only can improve power quality of nearby system, but also increase EAF productivity and leads to additional economic benefits. However, it cannot catch up the fast-varying flicker (1Hz-20Hz) very well with the inherent limit of relatively low bandwidth and hence it has a limited flicker mitigation capability (Schauder, 1999). Also it leads undesired problems such as injecting a large amount of harmonics (Kolluri *et al.*, 1997). In (Czarkowski *et al.*, 2002) a 6-Pulse converter based STATCOM was used to mitigate the voltage flicker. The concept of instantaneous reactive power components is used in the controlling system which is nothing but 'dqo' components. Due to observation of some harmonic in results of 6-Pulse converter based STATCOM, in (Raghava *et al.*, 2012) a novel 12-pulse converter based STATCOM is presented to simultaneously minimize the load harmonics and mitigate the propagation of voltage flicker in to the system. One of the main advantages of series compensators such as DVR over the parallel active compensator such as STATCOM and SVC are that it can maintain the output voltage waveform to be sinusoidal and also it balance the three phase voltages. However, due to the inherent drawbacks of series circuits, the series compensator is less popular in the industrial applications, namely it must handle high load currents, which increases their current rating compared with the parallel active power filters. As a result, the hybrid compensator is suitable for high-power applications. Today's for mitigating voltage flicker Unified Power Flow Controller (UPFC) has been widely used. In (Elnady *et al.*, 2002) the UPFC with series active compensation capability is proposed to variations of the arc resistance and suppress voltage flicker at the source. In similar research by (Justin Sunil *et al.*, 2012) a robust control strategy is presented for UPFC for mitigating voltage flicker Using fuzzy bang-bang control.

Using Fuzzy Logic Control (FLC) based on bang-bang control; the UPFC will contribute to the mitigation of flicker without deteriorating the effect of the other compensating devices. The FLC design is based on Lyapunov function analysis and is simulated on a power system model with arc furnace load. Unified power flow controller is most used in MV power system and is less used in distribution system. In recent years the engineers suggest the unified series shunt controller (USSC) to compensate various phenomena of power qualities in distribution level of power system. Therefore this paper deals with the performance analysis of USSC on the voltage flicker mitigation.

Unified Series Shunt Compensator

The Unified Series Shunt Compensator is a combination of series and shunt voltage source inverters as shown in Fig.1. The basic components of the USSC are two 12-pulse voltage source inverters composed of forced commutated power semiconductor switches, typically Gate Turn Off (GTO) thruster valves. One voltage source inverter is connected in series with the line through a set of series injection transformers, while the other is connected in shunt with the line through a set of shunt transformers. The dc terminals of the two inverters are connected together and their common dc voltage is supported by a capacitor bank (Asha *et al.*, 2010). The USSC is almost similar to the UPFC, but the only differences are that the UPFC inverters are in shunt series connection and used in transmission systems whereas the USSC inverters are in series-shunt connection and used in distribution systems (Hannan *et al.*, 2009).

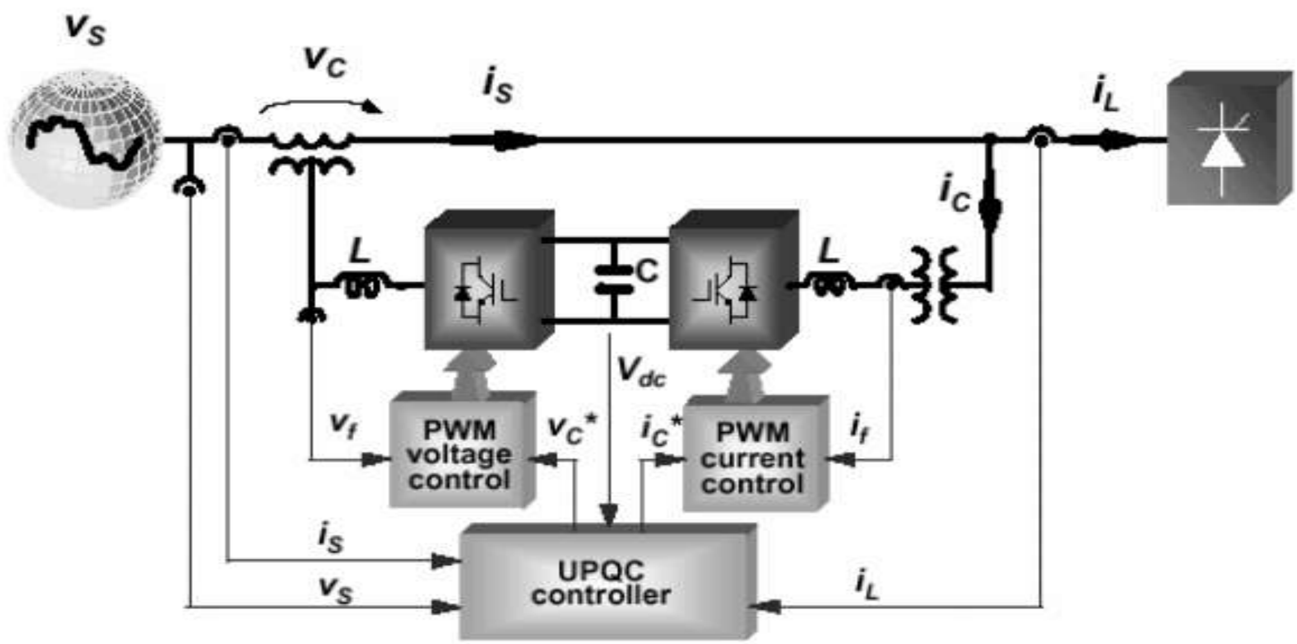

Figure 1: General configuration of Unified Series Shunt Compensator-USSC

Voltage Flicker Concept

The relationship between power quality and distribution system has been a subject of interest forseveral years. The concept of power quality describes the quality of the supplier voltage in relation to the transient breaks, falling voltage, harmonics and voltage flicker (Sun *et al.*, 2002). As shown in Figure 2 voltage flicker is the disturbance of lightning induced by voltage fluctuations. Very small variations are enough to induce lightning disturbance for human eye for a standard 230V, 60W coiled-coil filament lamp.

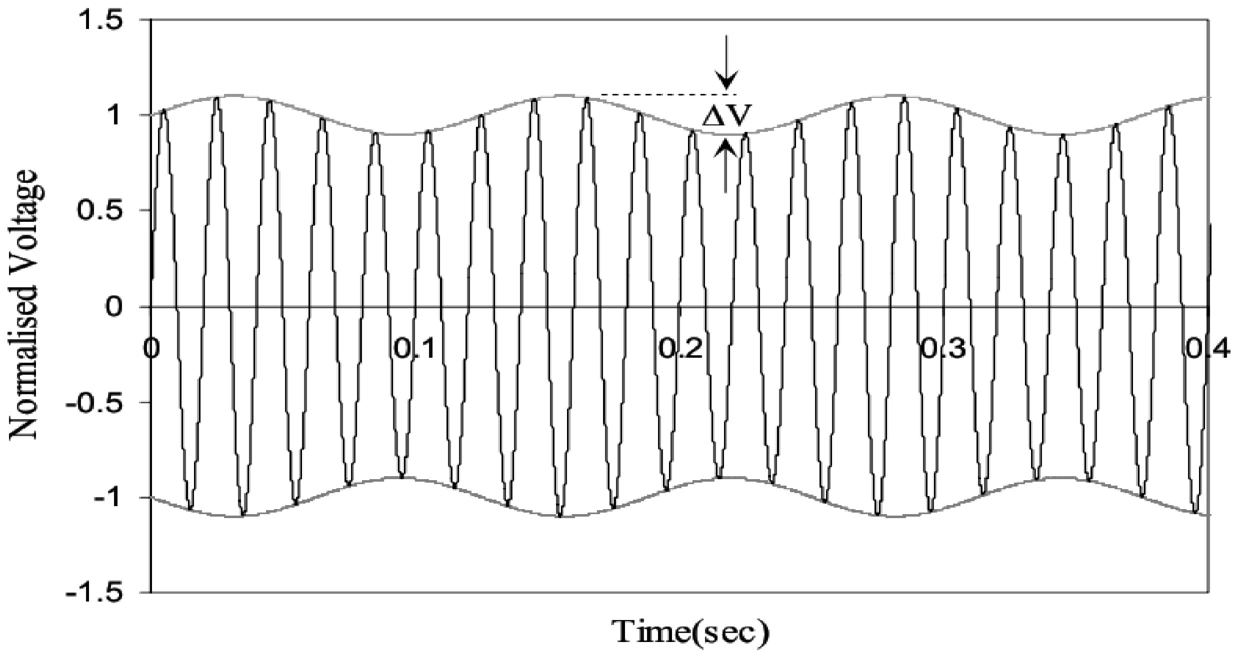

Figure 2: The voltage flicker wave

The disturbance becomes perceptible for voltage variation frequency of 10 Hz and relative magnitude of 0.26%. Huge non-linear industrial loads such as the electrical arc furnaces (Collantes-Bellido and Gomez, 1997; Tang *et al.*, 1997), pumps, welding machines, rolling mills and others are known as flicker generators. In this respect, the quality of supplied voltage is significantly reduced in an electrical power system and the oscillation of supplied voltage appears to be a major problem. Electric arc furnace, the main generator of voltage flicker, behaves in the form of a constant reactance and a variable resistance. The transformer reactance system is modeled as a lumped reactance, a furnace reactance (included connection cables and busses) and a variable resistance (Zouiti *et al.*, 1998) which models the arc. Connecting this type of load to the network produces voltage variation at the common point of supply to other consumers. The relative voltage drop is expressed by flowing equation:

$$d = \frac{\Delta U}{U_n} = \frac{R..\Delta P_L + X.\Delta Q_L}{U_n^2} \quad (1)$$

Where ***ΔP*** and ***ΔQ*** are the variation in active and reactive power; ***Un*** is the nominal voltage and ***R*** and***X*** are short circuit resistance and reactance. Since ***R*** is usually very small in comparison to ***X***, ***ΔU*** is proportional to ***Q*** (reactive power). Therefore, voltage flicker mitigation depends on reactive power control (M. Zouiti and *et al.*, 1998).

RESULTS AND DISCUSSION

Simulation and Results

In this section, the simulation of proposed USCC for flicker mitigation is presented. In this simulation to simulate the flicker voltage, a programmable AC source is utilized to inject flicker to system. To investigate the flicker effects, a simple linear load in connected to system.The control system of USSC for both series and shunt converters are presented in Figure 3

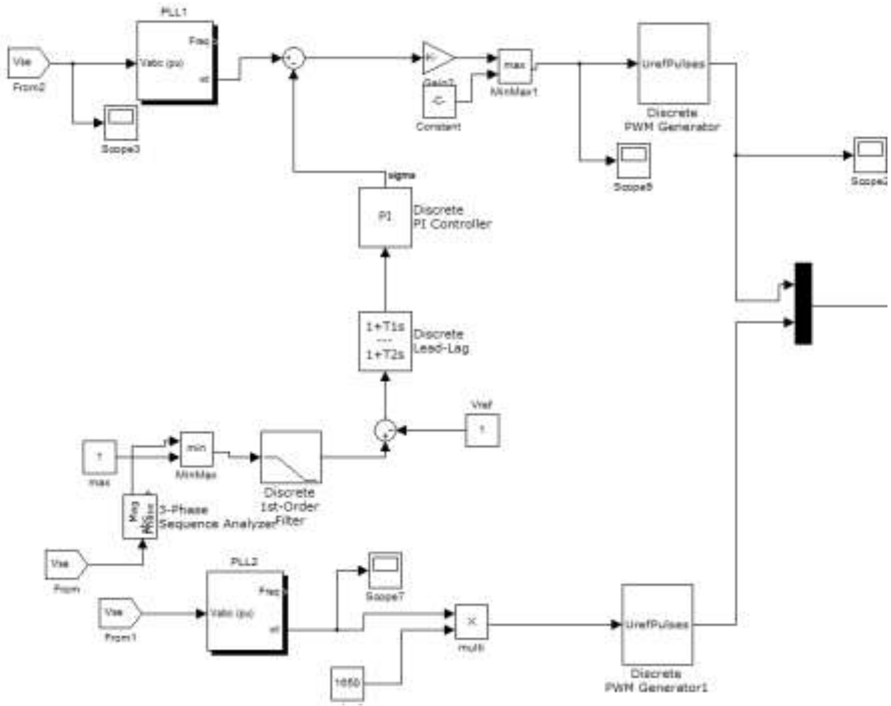

Figure 3: The controller of USSC

In Figure 4 the voltage wave of flicker distorted voltage is presented.

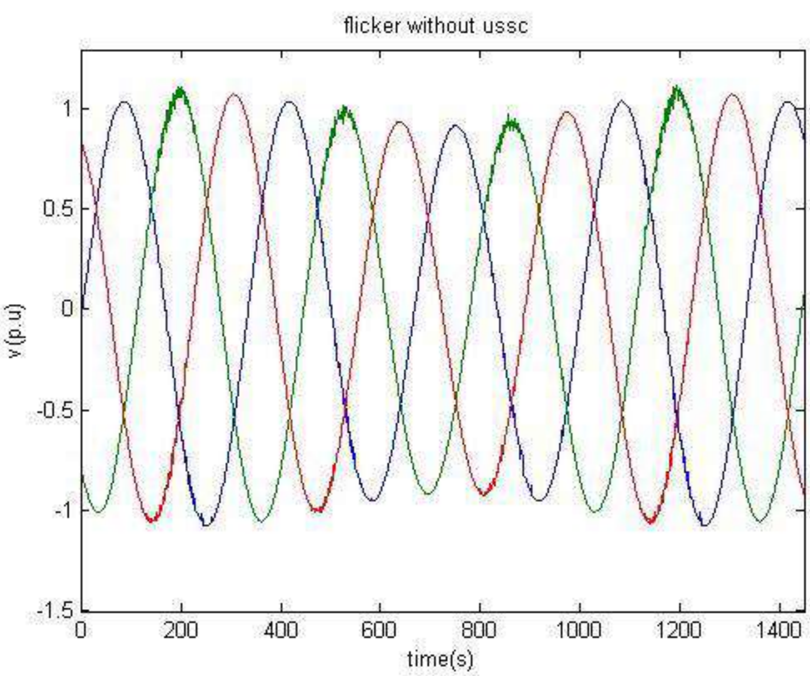

Figure 4: The flicker voltage without USSC

The load voltage due to voltage flicker in main ac source without USSC is indicated in Fig.5. As shown in this figure, the load is faced with a fluctuated voltage.

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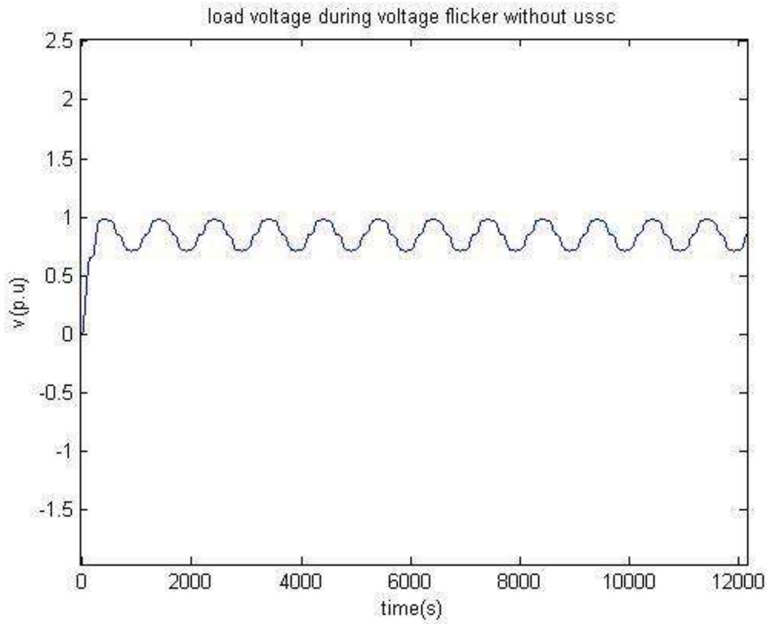

Figure 5: The voltage of load before compensation

If the voltage fluctuates within the frequency range of 8-10 Hz then this causes variation in the illumination intensity of an electric light. This variation of an electric light is called light flicker. Although observed mainly is incandescent lamps, on rare occasions fluorescent lamps also exhibit light flicker. To reduce this problem, the unified series shunt controller is implanted in system and the load voltage in presence of USSC is presented in Fig.6.

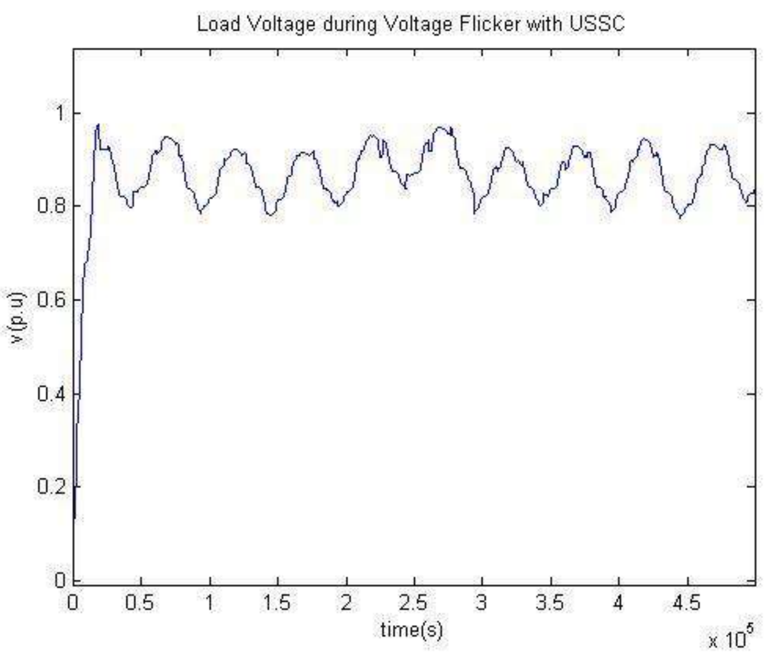

Figure 6: The load voltage after compensation using USSC

As shown in this figure the quality of load voltage with USSC is improved.

Conclusion

In this paper the voltage flicker mitigation using unified series shunt controller is presented and discussed. At first the concept of voltage flicker and its problems and effects on power system is review and analysed. At the end, the system control of flicker for USSC is presented and simulated using MATLAB/SIMULINK. To model the voltage flicker in this research, a programmable ac source is connected to system. The influence of USSC on the voltage flicker mitigation is analysed and the results of this simulation verifies the effective role of USSC in flicker mitigation.

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