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Power Quality Improvement By Mitigating Voltage Sag and Unbalance By Using Multi-level UPQC

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***Abstract* - This paper presents on the utilization of UPQC with cascaded Multi-Level Inverter to improve the power quality in distribution systems. UPQC(Unified Power Quality Conditioner) is a series-parallel element and a custom power device of the FACTS family. SPWM technique is used for pulse generation to control MLI.Using of Transformers and Filters are not necessary,when a multilevel UPQC is used.power Quality problems like Voltage sag and Unbalance have been mitigated by adopting UPQC. The Effectual results exhibit the proposed method.**

***Index Terms* - UPQC, Multilevel Inverter,Voltage sag, Custom Power, Power Conditioner.**

I. INTRODUCTION

Power Quality (PQ) related issues is of most concern nowadays. Increasingly the development of nonlinear loads is deteriorating power quality. These loads are simultaneously the major causes of power quality problems. Due to their non-linearity, all these loads cause disturbances in the voltage waveform. Nowadays concern about voltage sag is far more than that of other power quality problems. Due to their non-linearity, all these loads cause disturbances in the voltage waveform. Along with technological advance, the organization of the worldwide economy has evolved towards globalization and the profit margins of many activities tend to decrease. The increased sensitivity of the vast majority of processes (industrial, services and even residential) to PQ problems turns the availability of electric power with quality a crucial factor for competitiveness in every activity sector. The most critical areas are the continuous process industry and the information technology services. When a disturbance occurs, huge financial losses may happen, with the consequent loss of productivity and competitiveness. Although many efforts have been taken by utilities, some consumers require a level of PQ higher than the level provided by modern electric networks. This implies that some measures must be taken in order to achieve higher levels of Power Quality. Custom power devices, such as Dynamic Voltage Restorer (DVR),Distribution Static Compensator (DSTATCOM), and Unified Power Quality Conditioner (UPQC) have been introduced in recent years for power quality improvement in electricity distribution. Advances in manufacturing of power semiconductor devices have led to better characteristics such as higher voltage and current ratings as well as increased switching frequency. Besides, the implementation of multilevel inverters has made high power and high voltage power quality conditioners much feasible. In this paper, A UPQC employing cascaded H-bridge multi-level inverter is studied. This technique compensates voltage sag and unbalance. To minimize, THD, phase shifted multi-carrier based strategy (SPWM) is used to control the multi-level inverter. It is shown that by cascading a few numbers of H-bridge inverters, UPQC can be directly connected to the distribution grid without any step-down and a series injection transformer. The results show that using a multilevel UPQC prevents of using filters and transformer extra to compensating voltage sag, unbalance and obtaining unity power factor. In addition, minimization of THD is another advantage of the method. The operation of the proposed UPQC was verified through simulations with MATLAB/ Simulink software.

II. MULTILEVEL INVERTER

A multilevel inverter is a power electronic device which is capable of providing desired alternating voltage level at the output using multiple lower level DC voltages as an input. Mostly a two-level inverter is used in order to generate the AC voltage from DC voltage. There are several topologies of multilevel inverters available. The difference lies in the mechanism of switching and the source of input voltage to the multilevel inverters. Three most commonly used multilevel inverter topologies are:

1. Cascaded H-bridge multilevel inverters
2. Diode Clamped multilevel inverters
3. Flying Capacitor multilevel inverters

It is generally accepted that the performance of an inverter, with any switching strategies, can be related to the harmonic contents of its output voltage. Due to the great demand for medium-voltage high-power inverters, the cascade inverter has drawn tremendous interest ever since. The structure of separated dc sources is well suited for various renewable energy sources such as fuel cell, photovoltaic, biomass, etc. This multi-level inverter is made of several full-bridge inverters. The AC output of each of the different levels of full-bridge inverters are connected in series such that the synthesized voltage waveform is sum of the inverter outputs. The distance between each level is the same and equal to Vdc. Each full-bridge inverter product a three level waveform +Vdc, 0,-Vdc. so the number of levels is: N=2k+ 1,Where k is the number of dc sources.A so-called phase-shift sinusoidal pulse width modulation (PS_SPWM) switching scheme is proposed to operate the switches in the system. f Figures and obtained by simulation with MATLAB. A number of K-cascaded cells in one phase with their carriers shifted by an angle ɵ= (360^{O} / k) and using the same control voltage produce a load voltage with the smallest distortion. This result has been obtained for the multilevel inverter in a seven-level and nine-level configurations. The smallest distortion is obtained when the carriers are shifted by an angle of ɵ = 360/3=120.

III.MULTILEVEL UPQC

The unified power-quality conditioner (UPQC) has been widely studied by many researchers as an ultimate device to improve power quality. It is a type of hybrid APF and is the only versatile device which can mitigate several power quality problems related with voltage and current simultaneously therefore is multi functioning devices that compensate various voltage disturbances of the power supply, to correct voltage fluctuations and to prevent harmonic load current from entering the power system.

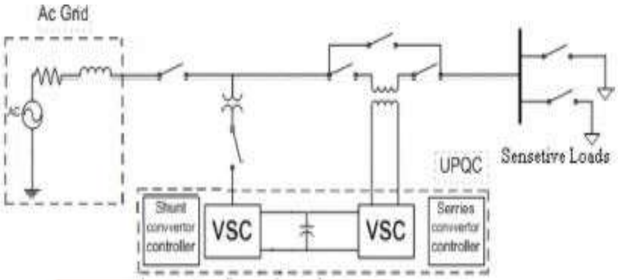


Fig 1. Common configuration of UPQC

The key components of this system are as follows.

1)Two inverters —one connected across the load which acts as a shunt APF and other connected in series with the line as that of series APF.2)A common dc link that can be formed by using a capacitor or an inductor. In Fig. 1, the dc link is realized using a capacitor which interconnects the two inverters and also maintains a constant self-supporting dc bus voltage across it. 3)Series injection transformer that is used to connect the series inverter in the network. A suitable turn ratio is often considered to reduce the voltage and current rating of series inverter. In principle, UPQC is an integration of shunt and series APFs with a common self-supporting dc bus. The shunt inverter in UPQC is controlled in a current control mode such that it delivers a current which is equal to the set value of the reference current as governed by the UPQC control algorithm. Additionally, the shunt inverter plays an important role in achieving required performance from a UPQC system by maintaining the dc bus voltage at a set reference value. In order to cancel the harmonics generated by a nonlinear load, the shunt inverter should inject a current. Similarly, the series inverter of UPQC is controlled in a voltage control mode such that it generates a voltage and injects in series with line to achieve a sinusoidal, free from distortion and at the desired magnitude voltage at the load terminal. In the case of a voltage sag condition, actual source voltage will represent the difference between the reference load voltage and reduced supply voltage, i.e., the injected voltage by the series inverter to maintain voltage at the load terminal at reference value. The proposed UPQC can be directly connected to the distribution system without series and shunt injection transformer, which struggle with core saturation and voltage drop. In order to validate the proposed system, computer simulation using the MATLAB Power System is carried out.

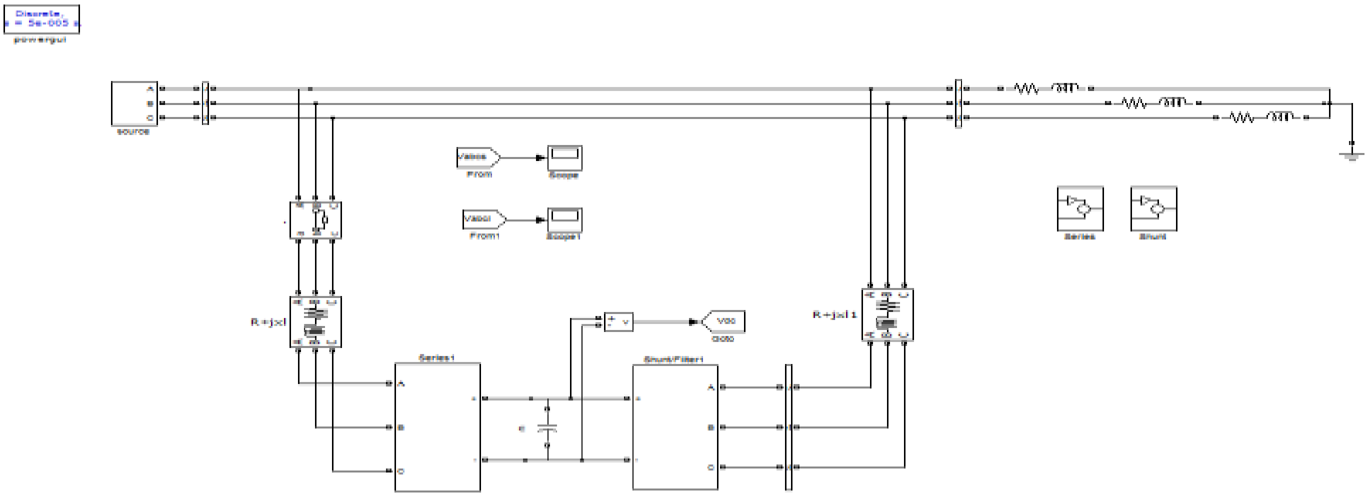
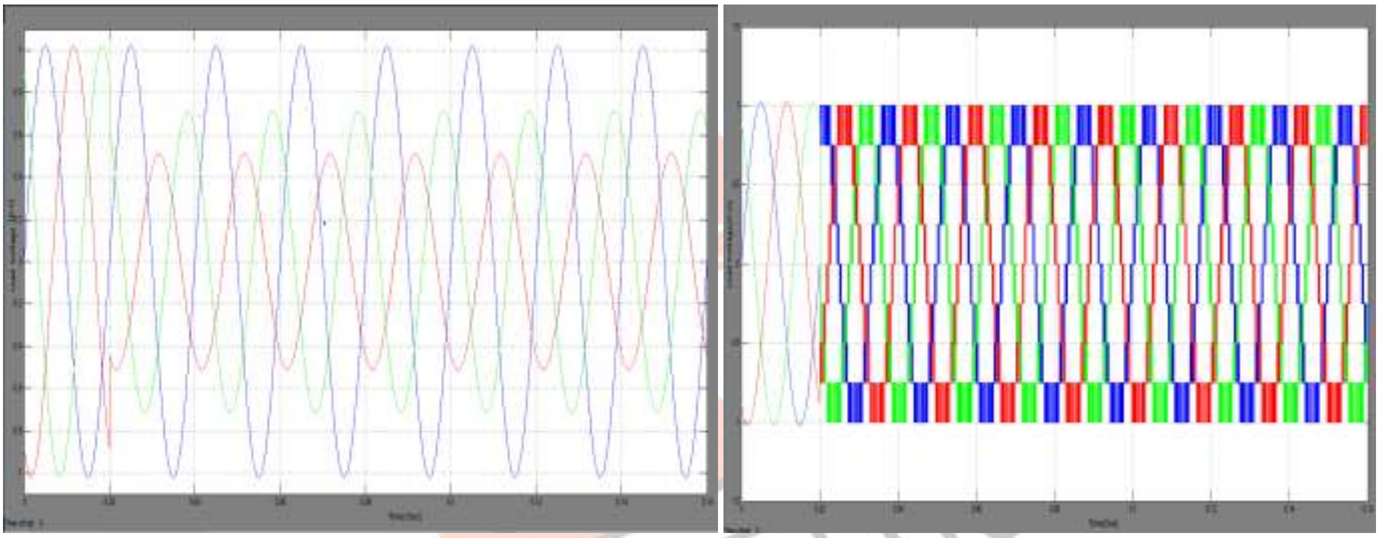


Fig 2- Simulation Block diagram of multi-level UPQC without filters



(a) **(b)**

Fig 3- Unbalance compensation(without filter) (a)unbalanced voltages (b) Compensated voltages

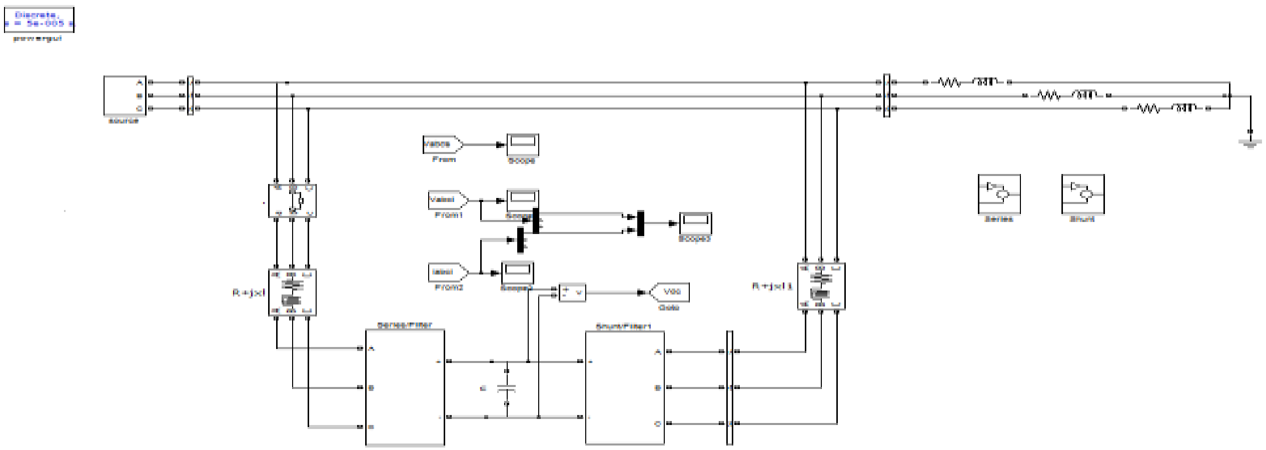
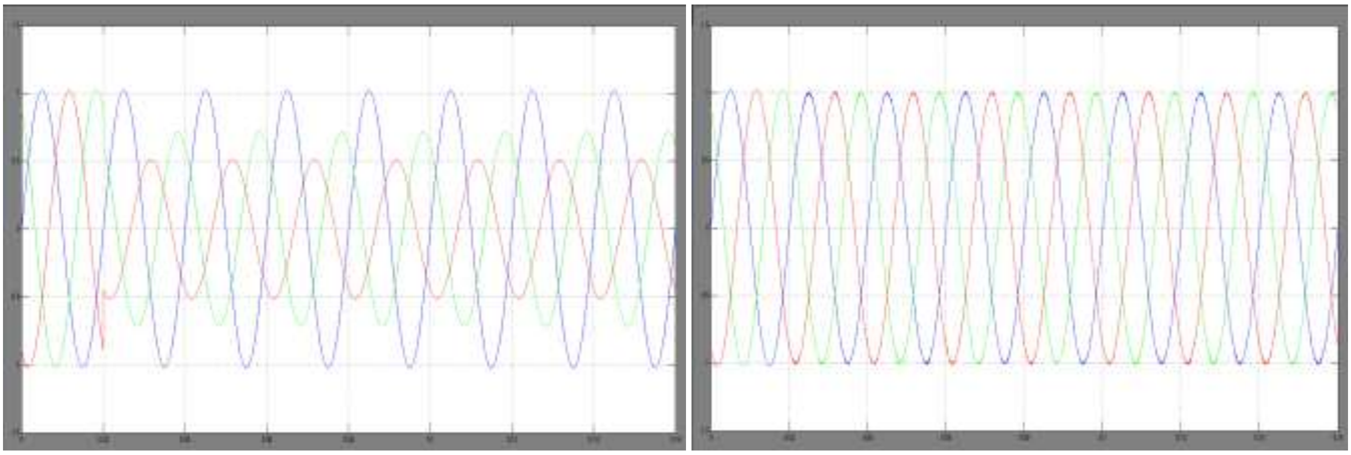


Fig 4- Simulation block diagram with filter



(a) (b)

Fig 5- Unbalance compensation(with filter) (a)unbalanced voltages (b) Compensated voltages

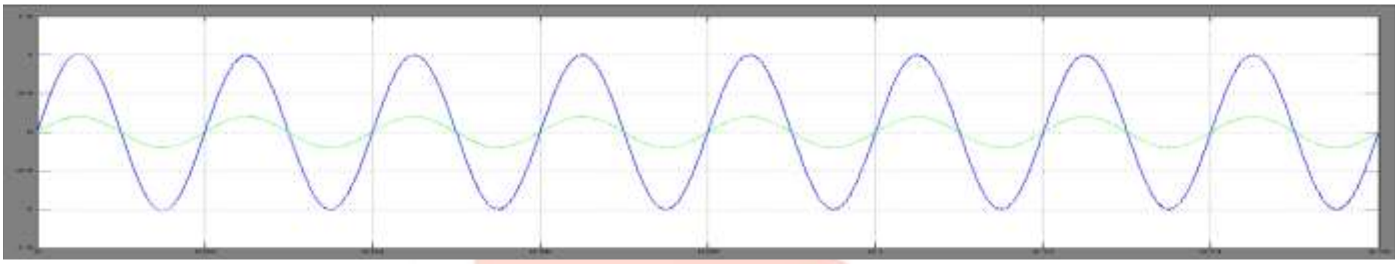


Fig 6- Power factor compensation

Similarly,the nine level inverters are designed and simulated.Harmonics reduce as the number of levels increases.This can be shown as in the THD analysis.

	Source voltage	**Load voltage**
Seven level withoutfilter	0	25.61%
Seven level with filter	0	0.63%
Nine level without filter	0	23.50%
Nine level with filter	0	0.31%

Table 1- Total Harmonic Distortion(THD) Analysis of Seven and Nine level UPQC with and without filters respectively.

IV. CONCLUSION

Power Quality problems like Voltage sag and Unbalance are objective and unavoidable. They cause additional losses. UPQC with multilevel inverter can reduce these problems like voltage sag and unbalance. This paper has used a new configuration by using a cascaded multilevel inverter with UPQC. This proposed UPQC can be directly connected to the distribution system without any injection transformer. The effectiveness of the proposed UPQC was verified by simulation of multilevel UPQC with MATLAB/Simulink.

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