Power Quality Improvement by Using Modular Multilevel Cascade Converter Based UPQC

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Abstract

The widespread use of non-linear loads is leading to a variety of undesirable phenomena in the operation of power systems. The harmonic components in current and voltage waveforms are the most important among these. Conventionally, passive filters have been used to eliminate line current harmonics. However, they introduce resonance in the power system and tend to be bulky. So, active power line conditioners have become more popular than passive filters as it compensates the harmonics and reactive power simultaneously. This paper presents the power quality improvement by using multilevel cascade converter based UPQC. total circuit is implemented using MATLAB software.

INTRODUCTION

Nowadays the end users and electric utilities are focusing on the electric power quality. The power quality issues are not new, but the electric utilities are becoming aware of these quality problems [1]. The main reason for focusing on the quality of electric power is increase in use of electronic loads, which are nonlinear in nature. Mostly, the electronic equipments used are microprocessor based and they are much sensitive to the electric power quality. The various issues of power quality like voltage swell, sag, interruptions, harmonic current and voltage harmonics are becoming a challenge to the utilities [2]. The current harmonics results into several problems like, Increase in losses of the power system, overheating of conductor, burden of reactive power, malfunctioning of relays, poor power factor. The reason for focusing on the quality of electric power is the economic value. The automatic impacts on quality of electric power on the utilities, customers and suppliers are explained in [1]-[3]. Hence for maintaining the quality of power is always a great task. For mitigating the voltage and current harmonic, voltage swell and voltage sag the active power filter (APF) is one solution. The extensive survey is collected on active power filter in [4].

Voltage sag from grid affects on the sensitive load. For protection of such sensitive loads, the custom power devices are taken into consideration. Custom power improves the reliability and quality of power, which is delivered to the customers. The improvement in power quality results in low unbalanced supply voltage, harmonic distortion is low, Reduction in flicker of supply voltage, voltage sag and swell are reduced. Dynamic voltage restorer (DVR), Distribution static compensator (D-STATCOM), Unified power quality conditioner (UPQC) The main function of DVR is to increase the quality of power. Whereas the D-STATCOM compensates the harmonic and unbalance in current of loads which are nonlinear. The UPQC is the combination of DVR and D-STATCOM. The explanations of custom power devices are given below.

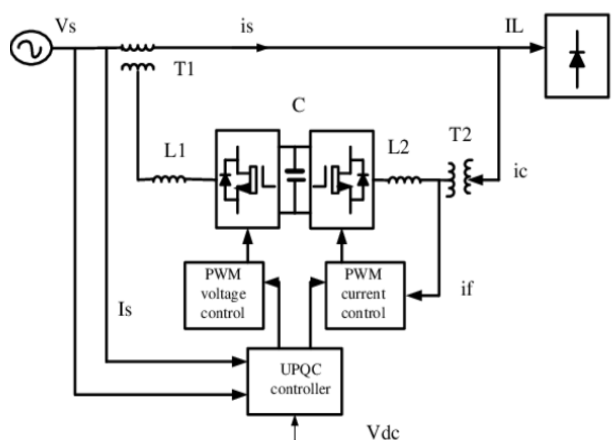
Dynamic Voltage Restorer (DVR) DVR is the custom power device which is power electronic converter based used for improving quality. According to survey [5], [6] the DVR is the device which is an economical and suitable solution for compensating the sag in voltage. Along with the sag in voltage compensation, a DVR is used to mitigate load voltage harmonics. The [6] presents one of the control strategies for mitigating the selective voltage harmonics. The power quality problems related to power are eliminated by use of DVR. the series connection of Dynamic voltage Restorer (DVR) to the distribution line. For correcting load voltage, DVR injects the voltage in phase and magnitude by using a coupling transformer. DVR consists of VSI, i.e. voltage source inverter, storage device, coupling transformer, LC filter, series connected coupling transformer. Mostly for storing the energy, capacitor DC link is used. The main important role of DVR is a reduction of voltage sag, which causes damage of sensitive load.

The variation in voltage like, voltage sag, swell, flicker in voltage is minimized by using the static compensator (STATCOM). The STATCOM used in the distribution side is called as DSTATCOM [7], [8]. By use of the coupling transformer the DSTATCOM is connected in parallel to the line as shown in Fig. 3. The main function of DSTATCOM is to eliminate all the load harmonics, which are given to the supply The DSTATCOM connected in parallel to the load act as a current source. DSTATCOM has the capacity to absorb as well as inject the reactive power very vastly. The main functions of DSTATCOM are compensation of reactive power, mitigating harmonic, and improving power factor.

PROPOSED SYSTEM CONFIGURATION

Many researchers [9]-[11] have studied one of the ways for improving the quality of power by using a unified power quality conditioner (UPQC). The use of a separate shunt and series active power filter may not be economical. Hence, the Moran [12] introduced one of the devices combining both shunt and series active filter. After that Akagi and Fujita [13] developed the concept of UPQC. After this, many of the researchers used this concept of UPQC.

Fig 1 Proposed system block diagram



The various components used in UPQC are as follows:

1. Series inverter - The inverters connected in series to the supply known as the series active filter. This inverter behaves as a voltage source line which eliminates a voltage interruption.

2. Shunt inverter - The inverter connected in shunt to the supply line is known as shunt active filter. It eliminates the current related

harmonics also minimize the reactive current in the load circuit.

3. DC link - The capacitor or inductor can be used as common DC link. As shown in fig. 4 the capacitor is used as DC link, which supplies the DC voltage.

4. LC filter - The output of the series active filter produces high switching ripples. The LC filter minimizes the ripples in a system. The LC filter acts as the low-pass filter.

5. Lsh Filter - The Lsh filter act as a high-pass filter. The ripples during switching mode are minimized by Lsh filter.

6. Injection transformer - The series injection transformer connected to series convertor.

Fig 2 Proposed circuit with out UPQC

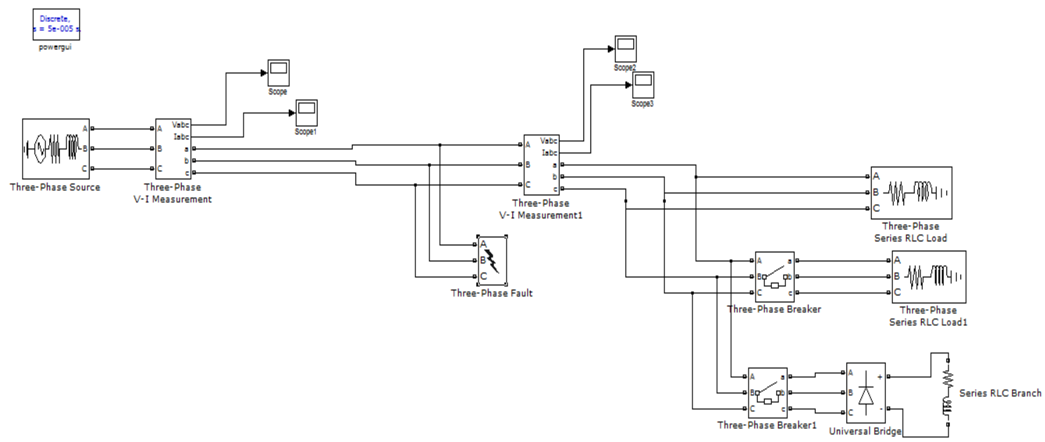


Fig 3 Output voltage without UPQC

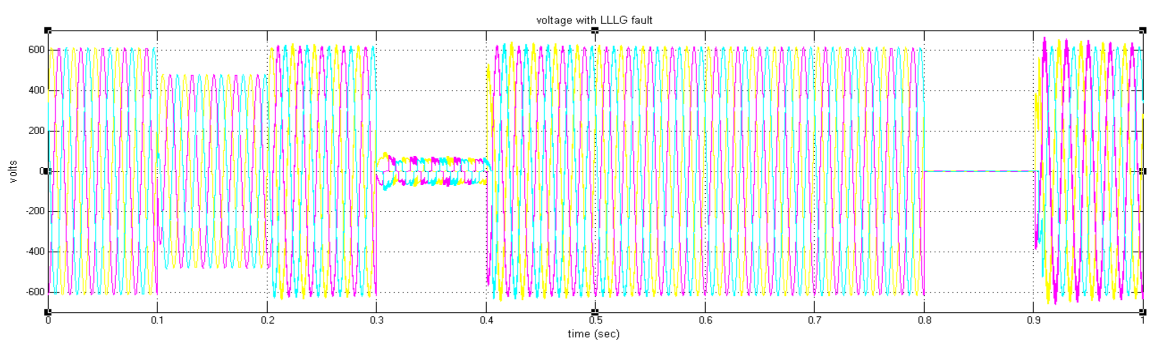
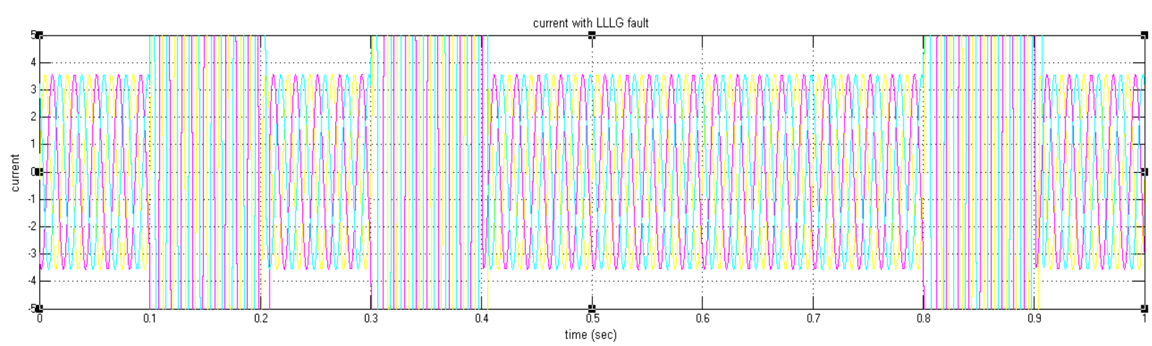


Fig 4 Output current waveform



Hybrid filter is a filter topology which combines the advantages of the passive and active filters. For this reason, it is considered as the best solution to eliminate the harmonic currents from the grid. The principal reason for the use of hybrid filters is the development of the power semiconductors like MOSFETs and IGBTs. Over more, from an economical point of view, the hybrid power filters allow reducing the cost of APF.

Hybrid power filters can be classified according to the number of elements used in the topology, the treated system (single phase, three phase three legs or four legs) and the used inverter type (current source inverter or voltage source inverter).

When the input current into the electrical equipment does not follow the impressed voltage across the equipment, then the equipment is said to have a nonlinear relationship between the input voltage and input current. All equipment's that employ some sort of rectification are examples of nonlinear loads. Nonlinear loads generate voltage and current harmonics that can have adverse effects on equipment designed for operation as linear loads. Transformers that bring power into an industrial environment are subject to higher heating losses due to harmonic generating sources (nonlinear loads) to which they are connected.

The concept of using active power filters to mitigate harmonic problems and to compensate reactive power was proposed more than two decades ago. It has proven its ability to control the grid current and to ameliorate the power quality. The theories and applications of active power filters have become more popular and have attracted great attention. Without the drawbacks of passive harmonic filters, such as component aging and resonant problems, the active power filter appears to be a viable solution for reactive power compensation as well as for eliminating harmonic currents. As we mentioned earlier, the SAPF is connected in parallel with the non-linear load to behave as another controlled non-linear load. The system of the non-linear load and the SAPF will be seen by the grid as a linear load connected to the PCC. In the case of compensation of reactive power this load will be resistive. Otherwise it will be either inductive or capacitive linear load.

A high current is observed under LLLG fault condition to the circuit with PI controller. This increases the system loses and effects the quality of power supply.

The above graph clearly describes the THD of the system with PI controller. It is observed a total harmonic distortion of 6.02%.

Fig 6 Simulation circuit with ML-UPQC

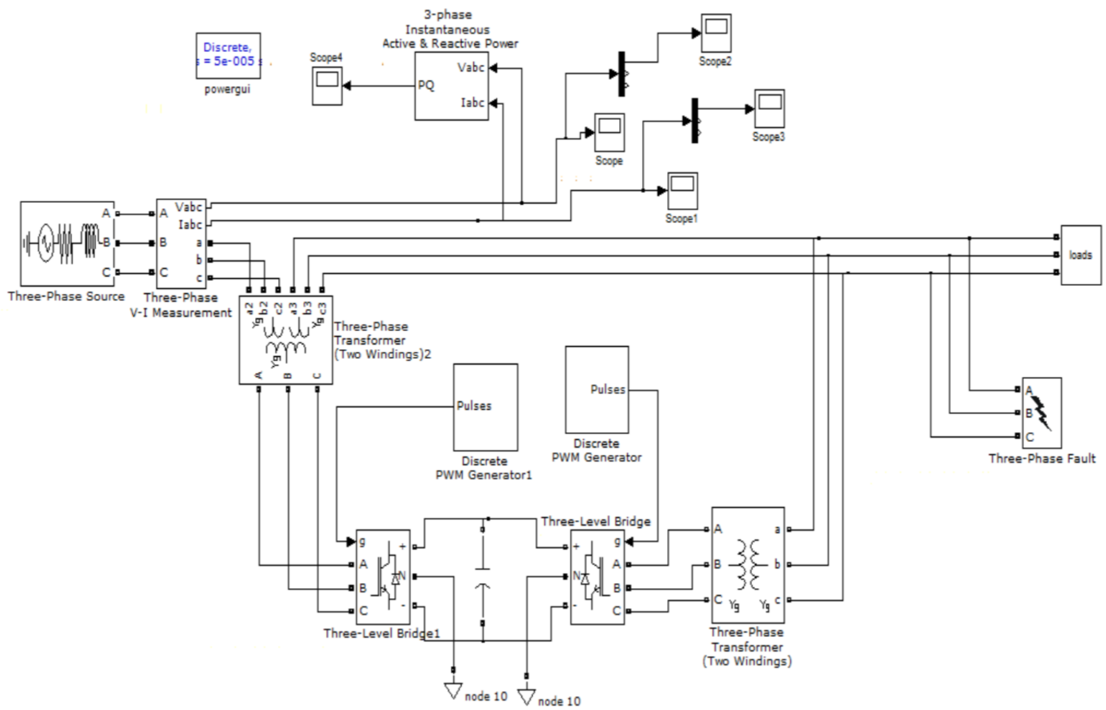
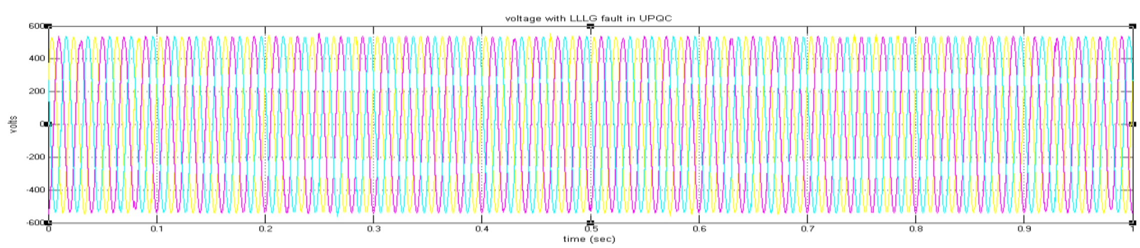
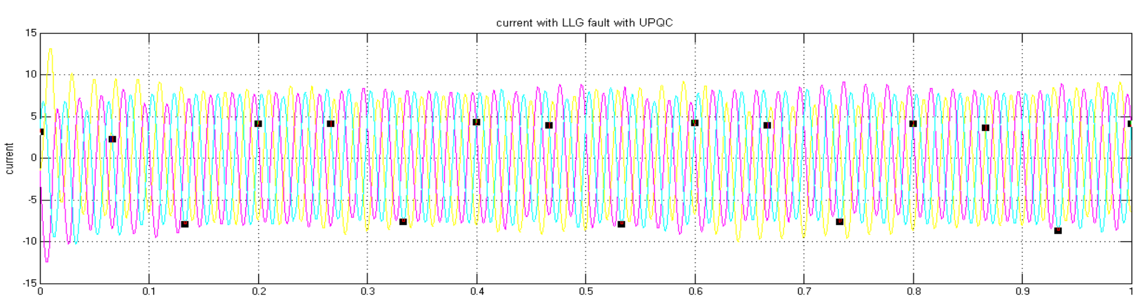


Fig 7 Output voltage waveform



The system with UPQC has generated a stabilized output voltage waveform without any distortions maintained during the LLLG fault condition.

Fig 8 Output current waveform



The current waveform is still have some distortions under LLLG fault condition with UPQC Controller. This effects the system parameters.

Fig 9 THD for our proposed system configuration

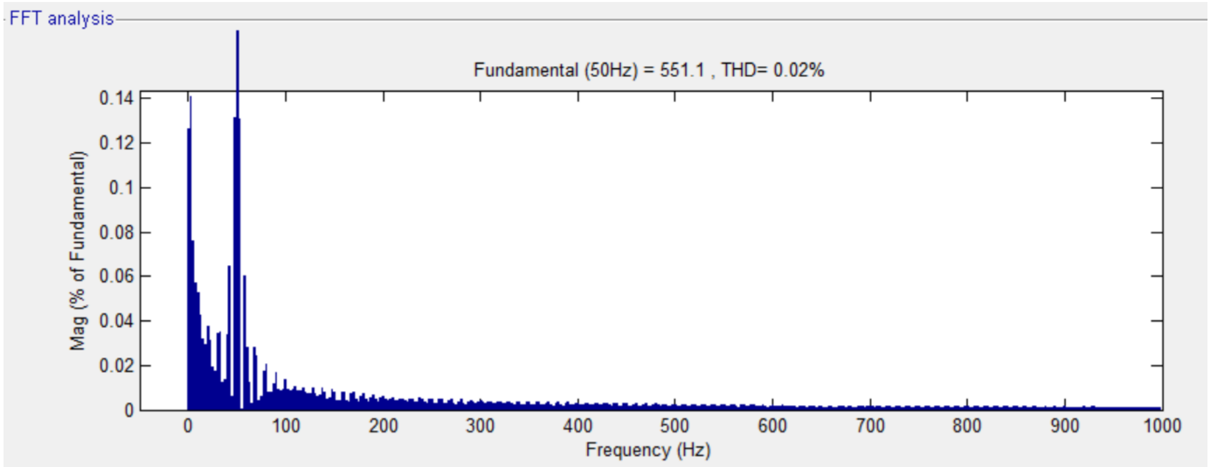
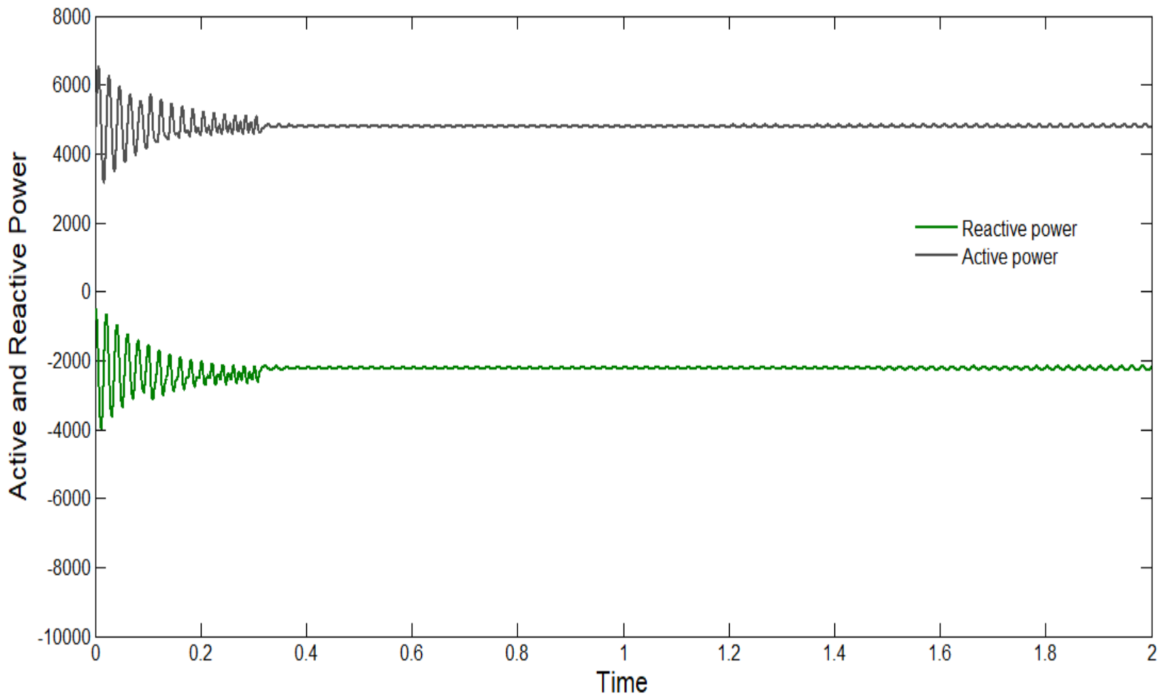


Fig 10 3-phase Instantaneous Active & Reactive Power



CONCLUSION

A noticeable trend in distribution systems is the emergence of distributed harmonic producing loads. These loads typically have comparable sizes and are distributed all over an electric network. There is a need to develop new techniques to assess harmonic distortions for systems with distributed harmonic sources. The objective of the project is to minimize the power quality problems with the implementation of power quality enhancement device ML-UPFC. This device has the capacity to improve the power quality at the point of installation. Without ML-UPFC the system voltage and currents are unbalanced undar fault condition with . When we applied ML-UPFC output voltage is balanced and still some distortions observed in current waveforms under fault conditions the THD is reduced to 0.02%.

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