

## An Active Device For Power Quality Improvement Of Single Phase Electrified Transportation

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### Abstract:

A transformerless hybrid series active filter is proposed to enhance the power quality in single-phase systems with critical loads. This paper assists the energy management and power quality issues related to electric transportation and focuses on improving electric vehicle load connection to the grid. The control strategy is designed to prevent current harmonic distortions of nonlinear loads to flow into the utility and corrects the power factor of this later. While protecting sensitive loads from voltage disturbances, sags, and swells initiated by the power system, riddled of the series transformer, the configuration is advantageous for an industrial implementation. This polyvalent hybrid topology allowing the harmonic isolation and compensation of voltage distortions could absorb or inject the auxiliary power to the grid. Aside from practical analysis, this paper also investigates on the influence of gains and delays in the real-time controller stability.

**Keywords:** Sags, Controller, Riddled, Distortions.

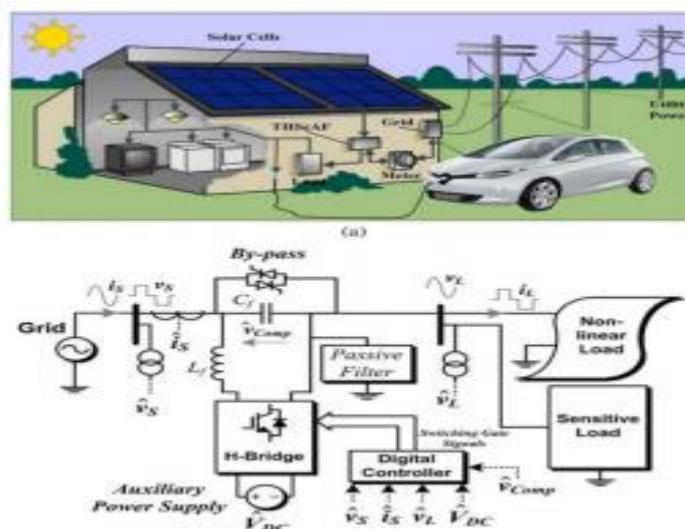
### 1. INTRODUCTION

The forecast of future Smart Grids associated with electric vehicle charging stations has created a serious concern on all aspects of power quality of the power system, while widespread electric vehicle battery charging units. which indeed have detrimental impacts on the power system and affect plant equipment, should be considered in the development of modern grids. Likewise, the increased rms and peak value of the distorted current waveforms increase heating and losses and cause the failure of the electrical. Moreover, to protect the point of common coupling (PCC) from voltage distortions, using a dynamic voltage restorer (DVR) function is advised. A solution is to reduce the pollution of power electronics-based loads directly at their source. Although several attempts are made for a specific case study, a generic solution is to be explored. There exist two types of active power devices to overcome the described power quality issues. The first category are series active filters (SeAFs), including hybrid-type ones. They were developed to eliminate current harmonics produced by nonlinear load from the power system. SeAFs are less scattered than the shunt type of active filters. However, the complexity of the configuration and necessity of an isolation series transformer had decelerated their industrial application in the distribution system. The second category was developed in concern of addressing voltage issues on sensitive loads. Commonly known as DVR, they have a similar configuration as the SeAF. These two categories are different from each other in their control principle. This difference relies on the purpose of their application in the system. The advantage of the proposed configuration is that nonlinear harmonic voltage and current producing loads could be effectively compensated. The transformerless hybrid series active filter (THSeAF) is an alternative option to conventional power transferring converters in distributed generation systems with high penetration of renewable energy

sources, where each phase can be controlled separately and could be operated independently of other phases. This paper shows that the separation of a three-phase converter into single-phase Hbridge converters has allowed the elimination of the costly isolation transformer and promotes industrial application for filtering purposes. The setup has shown great ability to perform requested compensating tasks for the correction of current and voltage distortions, PF correction, and voltage restoration on the load terminal.

## 2. RELATED WORK

The contemporary container crane industry, like many other industry segments, is often enamored by the bells and whistles, colorful diagnostic displays, high speed performance, and levels of automation that can be achieved. Although these features and their indirectly related computer based enhancements are key issues to an efficient terminal operation, we must not forget the foundation upon which we are building.



**Fig.1.System Structure**

Power quality is the mortar which bonds the Foundation blocks. Power quality also affects terminal operating economics, crane reliability, our environment, and initial investment in power distribution systems to support new crane installations. To quote the utility company newsletter which accompanied the last monthly issue of my home utility billing: ‘Using electricity wisely is a good environmental and business practice which saves you money, reduces emissions from generating plants, and conserves our natural resources.’ As we are all aware, container crane performance requirements continue to increase at an astounding rate. The AC and DC variable speed drives utilized on board container cranes are significant contributors to total harmonic current and voltage distortion. Whereas SCR phase control creates the desirable average power factor, DC SCR drives operate at less than this. In addition, line notching occurs when SCR’s commutate, creating transient peak recovery voltages that can be 3 to 4 times the nominal line voltage depending upon the system impedance and the size of the drives. The frequency and severity of these power system disturbances varies with the speed of the drive. Harmonic current injection by AC and DC drives will be highest when the drives are operating at slow speeds. Power factor will be lowest when DC drives are operating at slow speeds or during initial acceleration

and deceleration periods, increasing to its maximum value when the SCR's are phased on to produce rated or base speed.

### 3. PROPOSED SYSTEM

The THSeAF reacts instantly to this variation and does not interfere its operation functionality. Meanwhile, it is normal to observe a slight transient voltage variation depending on the momentum of the load disengagement or connection. Moreover, to protect the point of common coupling (PCC) from voltage distortions, using a dynamic voltage restorer (DVR) function is advised. A solution is to reduce the pollution of power electronics-based loads directly at their source. Although several attempts are made for a specific case study, a generic solution is to be explored. There exist two types of active power devices to overcome the described power quality issues. The first category are series active filters (SeAFs), including hybrid-type ones. They were developed to eliminate current harmonics produced by nonlinear load from the power. However, the complexity of the configuration and necessity of an isolation series transformer had decelerated their industrial application in the distribution system. The second category was developed in concern of addressing voltage issues on sensitive loads. Commonly known as DVR, they have a similar configuration as the SeAF. These two categories are different from each other in their control principle. This difference relies on the purpose of their application in the system. The advantage of the proposed configuration is that nonlinear harmonic voltage and current producing loads could be effectively compensated. The transformerless hybrid series active filter (THSeAF) is an alternative option to conventional power transferring converters in distributed generation systems with high penetration of renewable energy sources. The existing method describes a forecast of future Smart Grids associated with electric vehicle charging stations has created a serious concern on all aspects of power quality of the power system, while widespread electric vehicle battery charging units have detrimental effects on power distribution system harmonic voltage levels. Moreover, to protect the point of common coupling (PCC) from voltage distortions, using a dynamic voltage restorer (DVR) function is advised. A solution is to reduce the pollution of power electronics-based loads directly at their source. Although several attempts are made for a specific case study, a generic solution is to be explored. Hypothetically, they are capable to compensate current harmonics, ensuring a power factor (PF) correction and eliminating voltage distortions at the PCC. These properties make it an appropriate candidate for power quality investments. The three-phase SeAFs are well documented whereas limited research works reported the single-phase applications of SeAFs in the literature. In this paper, a single-phase transformerless HSeAF is proposed and capable of cleaning up the grid-side connection bus bar from current harmonics generated by a nonlinear load.

### 4. ANALYSIS

In this paper, a transformer-less HSeAF for power quality improvement was developed and tested. The paper highlighted the fact that, with the ever increase of nonlinear loads and higher exigency of the consumer for a reliable supply, concrete actions should be taken into consideration for future smart grids in order to smoothly integrate electric car battery chargers to the grid. The key novelty of the proposed solution is that the proposed configuration could improve the power quality of the system in a more general way by compensating a wide range of harmonics current, even though it can be seen that the THSeAF regulates and improves the PCC voltage. Connected to a renewable auxiliary source, the topology is able to counteract actively to the power flow in the system. This essential capability is required to ensure a consistent supply for critical loads. Behaving as high-harmonic impedance, Power factor will be lowest when DC drives are operating at slow speeds or during initial acceleration and

deceleration periods, increasing to its maximum value when the SCR's are phased on to produce rated or base speed. Above base speed, the power factor essentially remains constant. Unfortunately, container cranes can spend considerable time at low speeds as the operator attempts to spot and land containers.

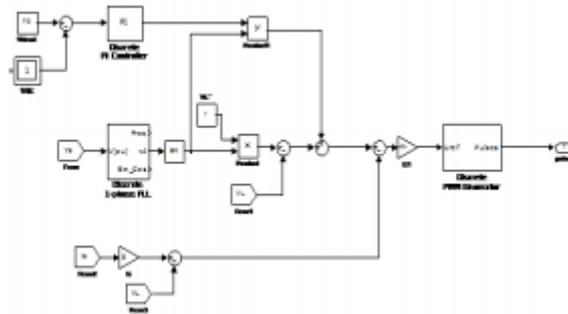


Fig.2.Simulink

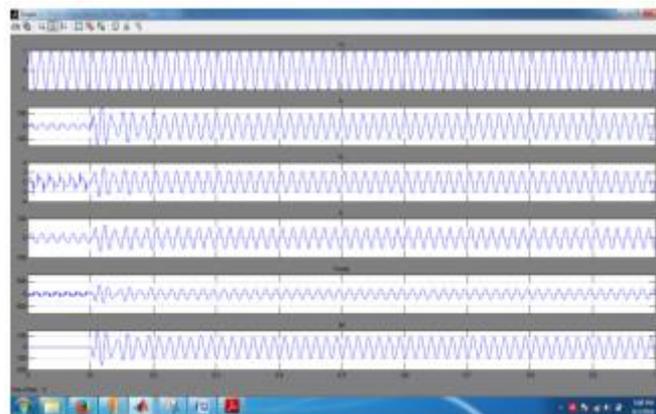


Fig.3.Output

Poor power factor places a greater kVA demand burden on the utility or engine-alternator power source. Low power factor loads can also affect the voltage stability which can ultimately result in detrimental effects on the life of sensitive electronic equipment or even intermittent malfunction. Voltage transients created by DC drive SCR line notching, AC drive voltage chopping, and high frequency harmonic voltages and currents are all significant sources of noise and disturbance to sensitive electronic equipment it cleans the power system and ensures a unity PF. The theoretical modeling of the proposed configuration was investigated. The proposed transformer-less configuration was simulated and experimentally validated. It was demonstrated that this active compensator responds properly to source voltage variations by providing a constant and distortion-free supply at load terminals. Furthermore, it eliminates source harmonic currents and improves the power quality of the grid without the usual bulky and costly series transformer. During voltage sag and swell, the auxiliary source supplies the difference of power to maintain the magnitude of the load side voltage regulated. The harmonic content and THD factor of the source utility and load PCC presented show dramatic improvements in THD, while the load draws polluted current waveforms. Furthermore, although the grid's voltage is polluted, the compensator in a hybrid approach regulates and maintains a harmonic-free load voltage.

## CONCLUSION

In this paper, a transformerless THSeAF for power quality improvement was developed and tested. The paper highlighted the fact that, with the ever increase of nonlinear loads and higher exigency of the consumer for a reliable supply, concrete actions should be taken into consideration for future smart grids in order to smoothly integrate electric car battery chargers to the grid. The key novelty of the proposed solution is that the proposed configuration could improve the power quality of the system in a more general way by compensating a wide range of harmonics current, even though it can be seen that the THSeAF regulates and improves the PCC voltage. Connected to a renewable auxiliary source, the topology is able to counteract actively to the power flow in the system. This essential capability is required to ensure a consistent supply for critical loads. Behaving as high-harmonic impedance, it cleans the power system and ensures a unity PF. The theoretical modeling of the proposed configuration was investigated.

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