Simulation Analysis of a Series Active Filter Employed for Power Quality Enhancement of an Electrical Vehicle

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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 project assists the energy management and power quality issues related to electronic 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. While protecting sensitive loads from voltage disturbances, sags, and swells initiated by the power system, ridded of the series transformer, the configuration is advantageous for an industrial implementation. This type of hybrid topology allowing the harmonic isolation and compensation of voltage distortions could absorb or inject the auxiliary power to the grid. The control scheme represented will particularly addresses about the power factor issues

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 vehicles battery charging units have detrimental effects on power distribution system harmonic voltage levels On the other hand, the growth of harmonics fed from nonlinear loads like electric vehicle propulsion battery chargers, 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 failure of the electrical equipment. Such phenomenon effectively reduces system efficiency and should properly been addressed.

A solution is to reduce the pollution of power electronics based loads directly at their source. Although several attempts are made for specific case study a generic solution is to be explored. There exist two types of active power devices to overcome described power quality issues. The first category are series active filters including hybrid type ones. They were developed to eliminate current harmonics produced by non-linear load from the power system. Series active filters are less scattered than shunt type of active filters. The advantage of series active filter compared to shunt type is the inferior rating of the compensator versus load nominal rating. However, the complexity of the configuration and necessity of an isolation series transformer had decelerated their industrial application in distribution system. The second category was developed in concern of addressing voltage issues on sensitive loads. Commonly known as Dynamic voltage restorer (DVR), they have a similar configuration as of Series active filter. These two categories are different from each other in their control principle. This difference relies on purpose of their application in the system.

Hybrid series active filter (HSeAF) was proposed to address above aforementioned issues with only one combination. Hypothetically, they are capable to compensate current harmonics, ensuring a power factor correction, and eliminating voltage distortions at the PCC. These properties make it an appropriate candidate for power quality investments.. In this a single-phase transformerless-HSeAF is proposed and capable of cleanup the grid side connection bus bar from current harmonics generated by a non-linear load

Electric vehicle (EV) battery charging presents a potential problem to power distribution systems in the form of excessive harmonic currents which, in turn, cause high voltage distortion levels. Thus, it is important to develop a model to characterize the possible impact of EV battery charging on distribution harmonic voltages, and to detail the critical penetration levels.

The typical concept of EV includes urban driving only, where the full battery charge is sufficient for medium-range routes of 50–100 miles. Recharging is accomplished by plugging the car into charge spots placed at different city locations throughout the day and at driver’s home during the night. Recently, a paradigm shift toward closing the gap between EV and conventional vehicles has occurred, forcing the infrastructure to support EV intercity driving as well. When out of charge, the EV battery can be replaced at a BSS, allowing nearly uninterrupted long range driving. The replacement process takes 2–4 min, similar to the duration of conventional refueling process. In order to reduce the disturbances produced by these electrical vehicles different techniques are used

2. LITERATURE REVIEW

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. 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. Next generation container cranes, already in the bidding process, will require average power demands of 1500 to 2000 kW – almost double the total average demand three years ago. The rapid increase in power demand levels, an increase in container crane population, SCR converter crane drive retrofits and the large AC and DC drives needed to power and control these cranes will increase awareness of the power quality issue in the very near future

Common causes of sags include starting large loads (such as one might see when they first start up a large air conditioning unit) and remote fault clearing performed by utility equipment. Similarly, the starting of large motors inside an industrial facility can result in significant voltage drop (sag). A motor can draw six times its normal running current or more, while starting. Creating a large and sudden electrical load such as this will likely cause a significant voltage drop to the rest of the circuit it resides on. If you could imagine someone turning on all the water in your house while you're in the shower. The water would probably run cold and the water pressure would drop. Of course, to solve this problem you might have a second water heater that is dedicated to the shower. The same holds true for circuits with large start-up loads that create a large inrush current draw.

While it may be the most effective solution adding a dedicated circuit for large start- up loads may not always be practical or economical, especially if a whole facility has a myriad of large start-up loads. Other solutions to large starting loads include alternative power starting sources that do not load the rest of the electrical infrastructure at motor start- up such as, reduced-voltage starters, with either autotransformers or star-delta configurations. A solid-state type of soft starter is also available and is effective at reducing the voltage sag at motor start-up. Most recently, adjustable speed drives (ASDs), which vary the speed of a motor in accordance with the load (along with other uses), have been used to control the industrial process more efficiently and economically and as an additional benefit, addresses the problem of large motor starting

The result can be data errors, flickering of lights, degradation of electrical contacts, semiconductor damage in electronics and insulation degradation. Power line conditioners, UPS systems and ferro resonant "control" transformers are common solutions. Much like sags, swells may not be apparent until their results are seen. Having UPS and/or power conditioning devices that also monitor and log incoming power events will help to measure when and how often these events occur

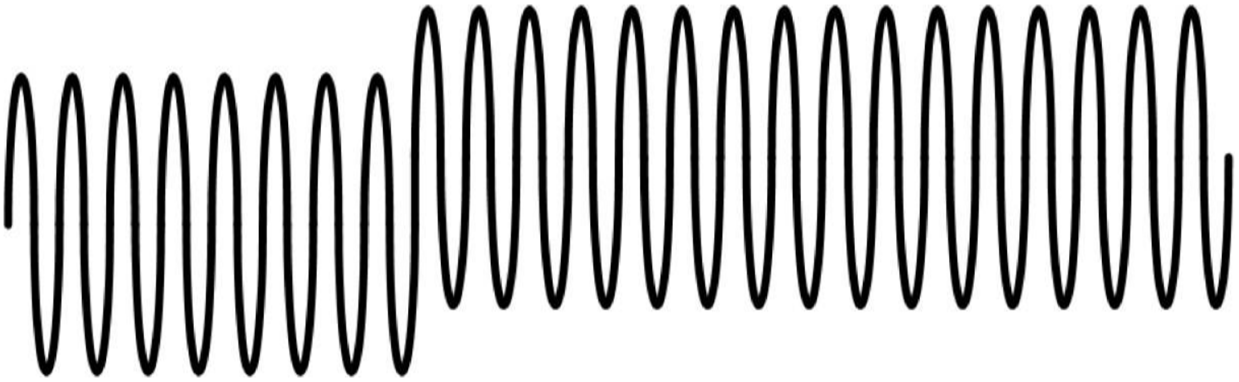

Fig.2 DC Offset Existing System

3. PROPOSED SYSTEM

Any utility companies invoke penalties for low power factor on monthly billings. There is no industry standard followed by utility companies. Methods of metering and calculating power factor penalties vary from one utility company to the next. Some utility companies actually meter kVAR usage and establish a fixed rate times the number of kVAR-hours consumed. Other utility companies monitor kVAR demands and calculate power factor. If the power factor falls below a fixed limit value over a demand period, a penalty is billed in the form of an adjustment to the peak demand charges. A number of utility companies servicing container terminal equipment do not yet invoke power factor penalties. However, their service contract with the Port may still require that a minimum power factor over a defined demand period be met.

The utility company may not continuously monitor power factor or kVAR usage and reflect them in the monthly utility billings; however, they do reserve the right to monitor the Port service at any time.

If the power factor criteria set forth in the service contract are not met, the user may be penalized, or required to take corrective actions at the user’s expense.

One utility company, which supplies power service to several east coast container terminals in the USA, does not reflect power factor penalties in their monthly billings, however, their service contract with the terminal reads as follows

Utility deregulations will most likely force utilities to enforce requirements such as the example above. Terminal operators who do not deal with penalty issues today may be faced with some rather severe penalties in the future. A sound, future terminal growth plan should include contingencies for addressing the possible economic impact of utility deregulation

Harmonic currents and low power factor created by nonlinear loads, not only result in possible power factor penalties, but also increase the power losses in the distribution system. These losses are not visible as a separate item on your monthly utility billing, but you pay for them each month. Container cranes are significant contributors to harmonic currents and low power factor. Based on the typical demands of today's high speed container cranes, correction of power factor alone on a typical state of the art quay crane can result in a reduction of system losses that converts to a 6 to 10% reduction in the monthly utility billing. For most of the larger terminals, this is a significant annual saving in the cost of operation

The power distribution system design and installation for new terminals, as well as modification of systems for terminal capacity upgrades, involves high cost, specialized, high and medium voltage equipment. Transformers, switchgear, feeder cables, cable reel trailing cables, collector bars, etc. must be sized based on the kVA demand. Thus cost of the equipment is directly related to the total kVA demand. As the relationship above indicates, kVA demand is inversely proportional to the overall power factor, i.e. a lower power factor demands higher kVA for the same kW load.

Container cranes are one of the most significant users of power in the terminal. Since container cranes with DC, 6 pulse, SCR drives operate at relatively low power factor, the total kVA demand is significantly larger than would be the case if power factor correction equipment were supplied on board

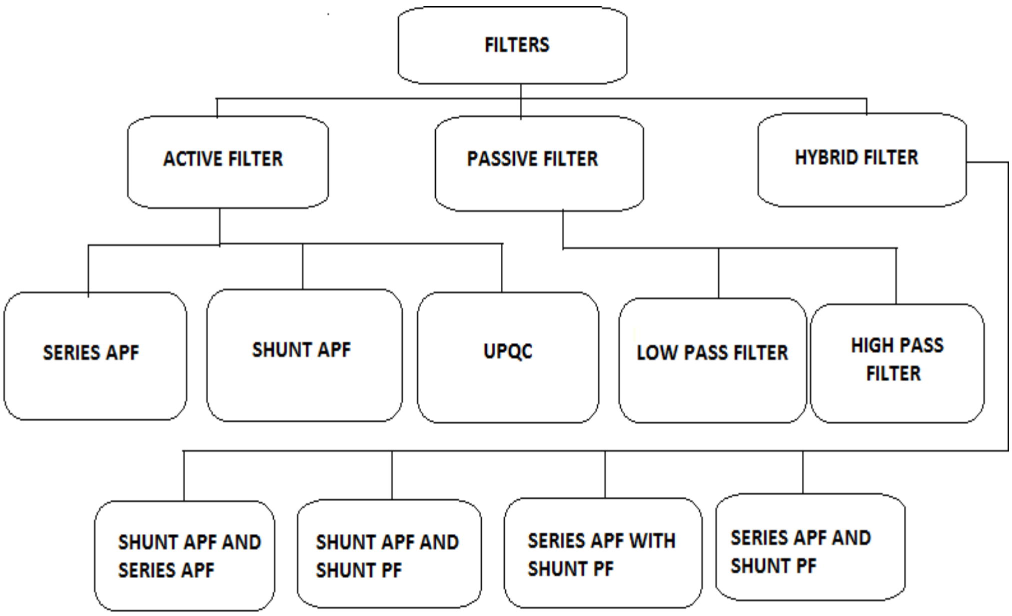

Fig.3 Proposed System

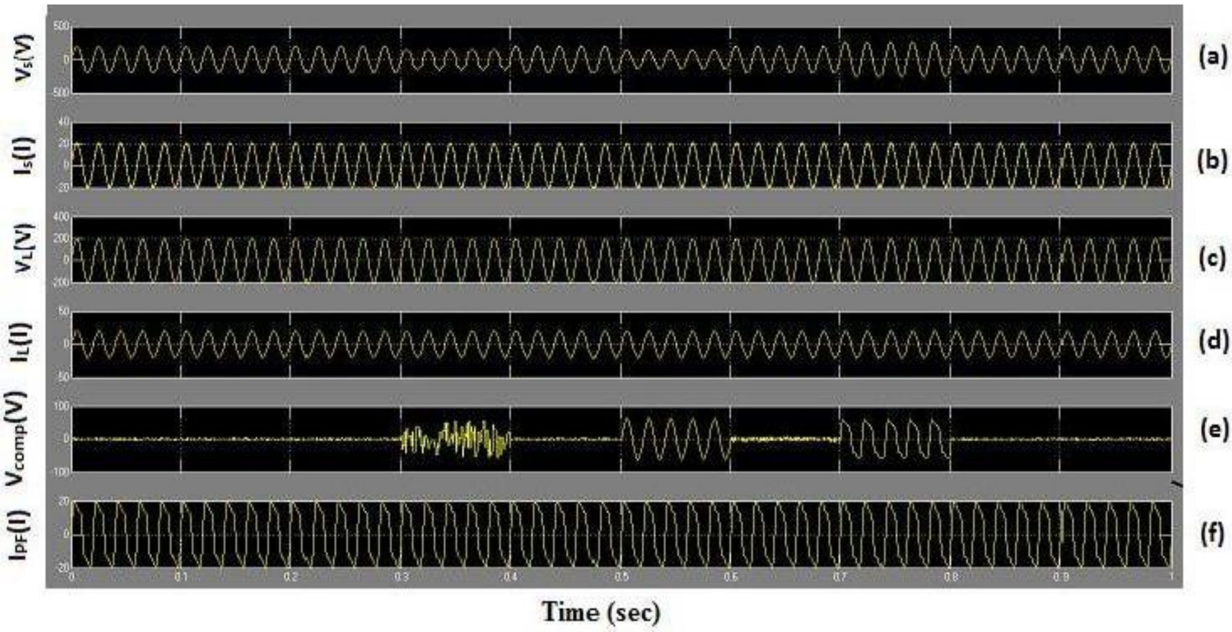

Fig.3 Proposed System output

4.CONCLUSION

A transformerless 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, it cleans the power system and ensures a unity PF. The theoretical modelling of the proposed configuration was investigated. The proposed transformerless configuration was simulated. 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

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