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ENHANCED CURRENT QUALITY SYSTEM DURING ELECTRIC TRANSPORATION

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ABSTARCT

A transformer less 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, ridded 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. The simulations and experimental results presented in this paper were carried out on a 2-kVA laboratory prototype demonstrating the effectiveness of the proposed topology.

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 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 the failure of the electrical equipment. Such phenomenon effectively reduces system efficiency and should have properly been addressed .

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 The advantage of the SeAF compared to the shunt type is the inferior rating of the compensator versus the load nominal rating .

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 hybrid series active filter (HSeAF) was proposed to address the aforementioned issues with only one combination. 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 transformer less HSeAF is proposed and capable of cleaning up the grid-side connection bus bar from current harmonics generated by a nonlinear load . With a smaller rating up to 10%, it could easily replace the shunt active filter .

Furthermore, it could restore a sinusoidal voltage at the load PCC. The advantage of the proposed configuration is that nonlinear harmonic voltage and current producing loads could be effectively compensated. The transformer less 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 H bridge 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 .

This paper is organized as follows. The system architecture is introduced in the following section. Then, the operation principle of the proposed configuration is explained. The third section is dedicated to the modeling and analysis of the control algorithm implemented in this work.

The dc voltage regulation and its considerations are briefly explained, and the voltage and current harmonic detection method is explicitly described.

To evaluate the configuration and the control approach,

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some scenarios are simulated. Experimental results performed in the laboratory are demonstrated to validate simulations. This paper is summarized with a conclusion and appendix where further mathematical developments are demonstrated.

1.POWER QUALITY

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.

2 POWER QUALITY PROBLEMS

Any power problem that results in failure or disoperation of customer equipment, manifests itself as an economic burden to the user, or produces negative impacts on the environment.

When applied to the container crane industry, the power issues which degrade power quality include:

- Power Factor.
- Harmonic Distortion.
- Voltage Transients.
- Voltage Sags or Dips.
- Voltage Swells.

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 fazed 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. 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 has been our experience that end users often do not associate power quality problems with Container cranes, either because they are totally unaware of such issues or there was no economic

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Consequence if power quality was not addressed. Before the advent of solid-state power supplies, Power factor was reasonable, and harmonic current injection was minimal. Not until the crane Population multiplied, power demands per crane increased, and static power conversion became the way of life, did power quality issues begin to emerge.

Even as harmonic distortion and power Factor issues surfaced, no one was really prepared. Even today, crane builders and electrical drive System vendors avoid the issue during competitive bidding for new cranes. Rather than focus on Awareness and understanding of the potential issues, the power quality issue is intentionally or Unintentionally ignored. Power quality problem solutions are available. Although the solutions are not free, in most cases, they do represent a good return on investment. However, if power quality is not specified, it most likely will not be delivered.

3.THE BENEFITS OF POWER QUALITY

Power quality in the container terminal environment impacts the economics of the terminal operation, affects reliability of the terminal equipment, and affects other consumers served by the same utility service. Each of these concerns is explored in the following paragraphs.

ECONOMIC IMPACT

The economic impact of power quality is the foremost incentive to container terminal operators. Economic impact can be significant and manifest itself in several ways:

A. POWER FACTOR PENALTIES

Many 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.

4.TOTALHARMONIC DISTORTION

Harmonic problems are almost always introduced by the consumers' equipment and installation practices. Harmonic distortion is caused by the high use of non-linear load equipment such as computer power supplies, electronic ballasts, compact fluorescent lamps and variable speed drives etc, which create high current flow with harmonic frequency components.

The limiting rating for most electrical circuit elements is determined by the amount of heat that can be dissipated to avoid overheating of bus bars, circuit breakers, neutral conductors, transformer windings or generator alternators.

DEFINITION

THD is defined as the RMS value of the waveform remaining when the fundamental is removed. A perfect sine wave is 100%, the fundamental is the system frequency of 50 or 60Hz. Harmonic distortion is caused by the introduction of waveforms at frequencies in multiples of the fundamental ie: 3rd harmonic is 3x the fundamental frequency / 150Hz. Total harmonic distortion is a measurement of the sum value of the waveform that is distorted.

V.SIMULATION RESULTS:

Fig : Model File:

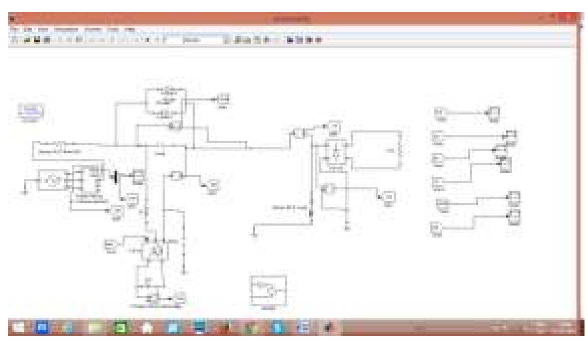

Fig: SIimulation Wave forms

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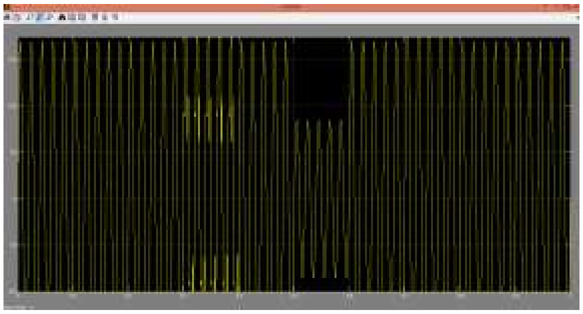

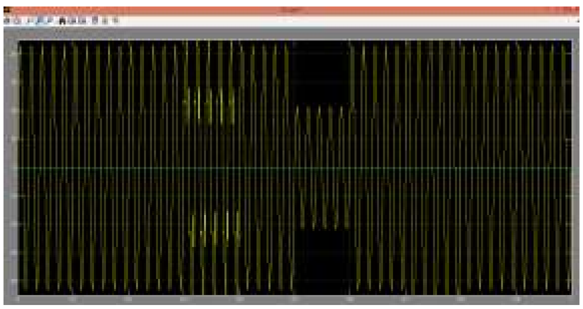

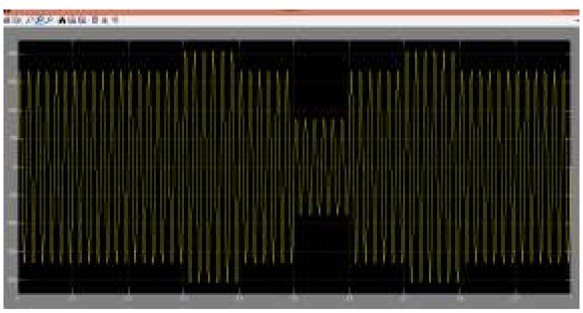

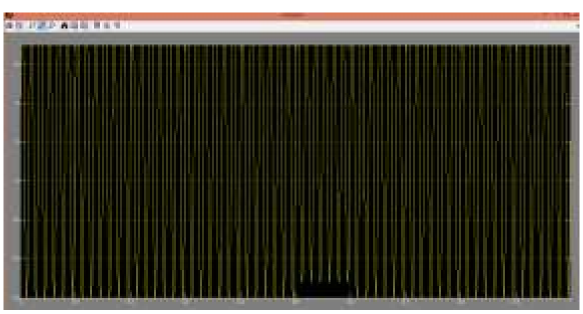

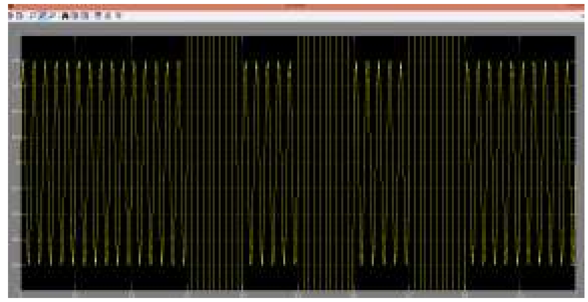

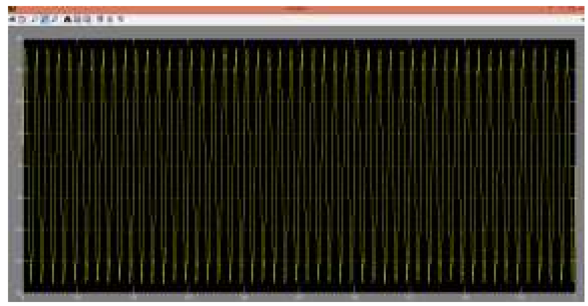

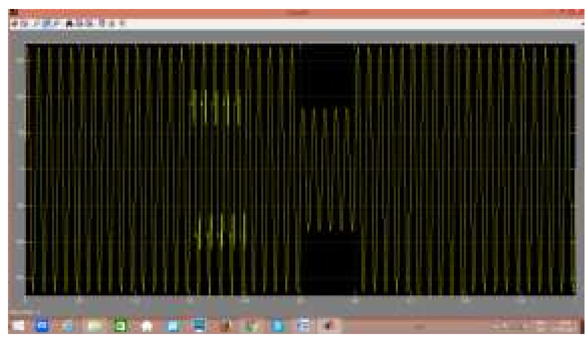

. Matlab is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include Math and computation Algorithm development Data acquisition Modeling, simulation, and prototyping Data analysis, exploration, and visualization Scientific and engineering graphics Application development, including graphical user interface building.

Matlab is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar no interactive language such as C or FORTRAN.

Simulink is a tool used to visually program a dynamic system (those governed by Differential equations) and look at results. Any logic circuit, or control system for a dynamic system can be built by using standard building blocks available in Simulink Libraries.

Various toolboxes for different techniques, such as Fuzzy Logic, Neural Networks, dsp, Statistics etc. are available with Simulink, which enhance the processing power of the tool. The main advantage is the availability of templates / building blocks, which avoid the necessity of typing code for small mathematical processes.

VI CONCLUSION

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, 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.

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