International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 02
February 2017

# Fuzzy Control Based Power Quality Improvement of Electrified Transportation

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## Abstract

*An electrical device such as transformer less hybrid series active filter is used to improve the power quality in single-phase systems with crucial loads. In this paper we are mostly going through energy management as well as power quality problems in the electric transportation. We also think about improving electric load connection to the grid. To overcome the drawbacks of the current harmonic distortions we implemented control strategy. This implementation is very crucial to avoid damages in sensitive loads from voltage disturbances, sags and swells due to the power system which is considerations in industrial implementation. This implementation on polyvalent hybrid topology will give permission to harmonic isolations as well as the compensation can absorb auxiliary power to grid. We are getting gains and delays for real time controller stability. This implementation is based on 2-kVA laboratory prototype and shows effectiveness of proposed implemented topology.*

*Index Terms* — Hybrid series active filter, current harmonics, power quality, electric vehicle, real-time control.

## 1. INTRODUCTION

The forecast of future sensible Grids related to electrical vehicle charging stations has created a significant concern on all aspects of power quality of the ability system, whereas widespread electrical vehicle battery charging units [1], [2] have damaging effects on power distribution system harmonic voltage levels [3]. On the opposite hand, the expansion of harmonics fed from nonlinear masses like electrical vehicle propulsion battery chargers [4], [5], that so have damaging impacts on the ability system and have an effect on plant instrumentation, ought to be thought-about within the development of recent grids. Likewise, the accrued RMS and peak price of the distorted current waveforms increase heating and losses and cause the failure of the electrical instrumentation. Such development effectively reduces system potency and may have properly been addressed [6], [7]. Moreover, to guard the purpose of common coupling (PCC) from voltage distortions, employing a dynamic voltage trained worker (DVR) operate is suggested. An answer is to scale back the pollution of power electronics-based masses directly at their supply. Though many tries are created for a particular case study, a generic answer is to be explored. There exist 2 varieties of active power devices to beat the delineated power quality problems. the primary class are series active filters (SeAFs), as well as hybrid-type ones. They were developed to eliminate current harmonics

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e-ISSN: 2348-795X
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created by nonlinear load from the ability system. SeAFs are less scattered than the shunt variety of active filters [8], [9]. The advantage of the SeAF compared to the shunt kind is that the inferior rating of the compensator versus the load nominal rating [10]. Advantage of the planned configuration is that non-linear harmonic voltage and current manufacturing hundreds may well be effectively paid. The THSeAF is an alternate choice to standard power transferring converters in distributed generation systems with high penetration of renewable energy sources.

To evaluate the configuration and therefore the management approach, some eventualities area unit simulated. Experimental results performed in laboratory area unit incontestable to validate simulations with the help of MATLAB simulink. The paper is summarized with a conclusion and appendix wherever more mathematical developments area unit incontestable.

## 2. PROPOSED ARCHITECTURE

### A. System Configuration

The transformer less hybrid series active filter shown in Fig.1 consists of associate H-bridge convertor connected asynchronous between the supply and therefore the load. A shunt passive condenser ensures an occasional resistance path for current harmonics. A DC auxiliary supply can be connected to inject power throughout voltage sags. The DC link energy storage system is delineated in [19]. The system is enforced for a rated power of 2200 VA. to make sure a quick transient response with adequate stability margins over a large vary of operation, the controller is enforced on a dSPACE/dsp1103. The system parameters square measure known in **Table I.**

TABLE I
CONFIGURATION PARAMETERS

| Symbol | Definition | Value |
|---|---|---|
| $v_s$ | Line phase-to-neutral voltage | 120 Vrms |
| $f$ | System frequency | 60 Hz |
| $R_{non\text{-}linear\ load}$ | Load resistance | 11.5 Ω |
| $L_{non\text{-}linear\ load}$ | Load inductance | 20 mH |
| $P_L$ | Linear load power | 1 kVA |
| $PF$ | Linear load power factor | 46 % |
| $Lf$ | Switching ripple filter inductance | 5 mH |
| $Cf$ | Switching ripple filter capacitance | 2 μF |
| $T_S$ | dSPACE Synchronous sampling time | 40 μs |
| $f_{PWM}$ | PWM frequency | 5 kHz |
| $G$ | Control gain for current harmonics | 8 Ω |
| $V_{DCref}$* | VSI DC bus voltage of the THSeAF | 70 V |
| $PI_0$ | Proportional gain ($K_p$), Integral gain ($K_i$) | 0.025(4*), 10 (10*) |

* Adopted value for the experimental setup

Even if the quantity of switches has augmented, the transformer less configuration is less expensive than the other series compensators, that usually use a electrical device to inject the compensation voltage to the ability grid. The optimized passive filter consists of a fifth, 7th, and High-pass filters. The passive filter ought to be adjusted for the system upon load and government laws.

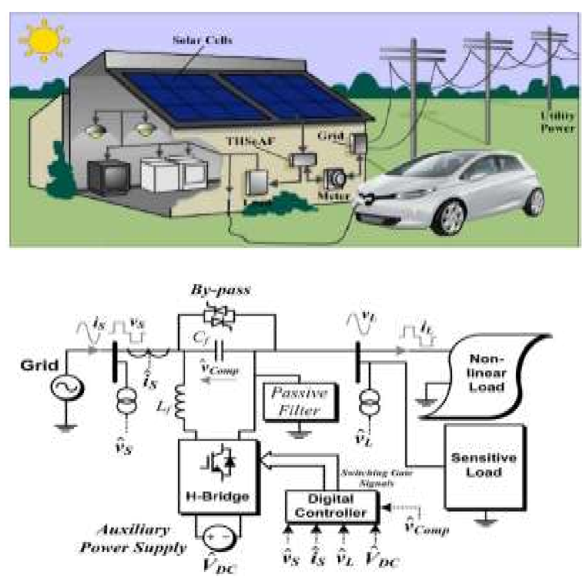


Fig. 1. a) Schematic of a single-phase smart load with the compensator installation, b) Electrical diagram of the THSeAF in a single-phase utility.

### B. Operation Principle

The series active filter represents a controlled voltage supply (VSI). So as to stop current harmonics iLh to drift into the supply, this series supply ought to gift low resistivity for the basic part and high resistivity for all harmonics as shown in Fig. 3.

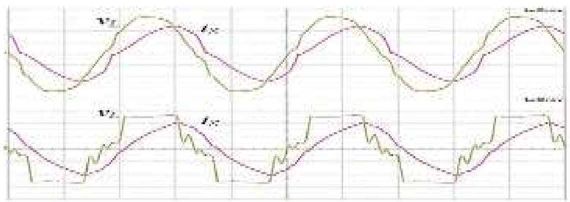

Fig. 2. Terminal voltage and current waveforms of the 2kVA single-phase system without compensator. a) Regular operation, b) Grid's voltage distortion (scales: 50 V/div for channel 1 and 10 A/div for channel 2).The behavior of the series active filter (SeAF) for a current management approach is evaluated from the phasor's equivalent circuit shown in Fig. 3. The non-linear load may well be sculptured by a resistance representing the active power consumed and a current supply generating current harmonics. Consequently, the resistance ZL represents the non-linear load and also the inductive load.

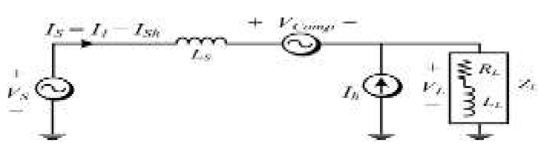

Fig.3. THSeAF equivalent circuit for current harmonics

Voltage Source proportional to the current current harmonic which flowing the frid which given by

$$V_{comp} = G.I_{sh} - V_{Lh} \qquad (1)$$

Individual eequivalent circuit given below

$$V_{source} = V_{s1} - V_{sh}, \quad V_L = V_{L1} + V_{Lh} \qquad (2)$$

Source harmonic current evaluated as given below

$$V_{sh} = -Z_s.I_{sh} + V_{comp} + V_{Lh} \qquad (3)$$

$$V_{sh} = Z_s.(I_h - I_{sh}) \qquad (4)$$

When we combined eq 3 and 4 we get following eq

$$I_{sh} = \frac{V_{sh}}{(G - Z_s)} \qquad (5)$$

TABLE II
SINGLE-PHASE COMPARISON OF THE THSEAF TO PRIOR HSEAFS

| Definition | Proposed THSeAF | [21] | [22] | [12] |
|---|---|---|---|---|
| Injection Transformer | Non | 3 per phase | 1 per phase | 1 per phase |
| # of semiconductor devices | 4 | 8 | 4 | 4 |
| # of DC link storage elements | 1+Aux. Pow. | 1 | 2 | 1+Aux. Pow. |
| AF rating to the load power | 10-30% | 10-30% | 10-30% | 10-30% |
| Size and weight, regarding the transformer, power switches, drive circuit, heat sinks, etc. | The Lowest | High | Good | Good |
| Industrial production costs | The Lowest | High | Low | Low |
| Power losses, including switching, conducting, and fixed losses | Low | Better | Low | Low |
| Reliability regarding independent operation capability | Good | Low | Good | Good |
| Harmonic correction of Current source load | Good | Good | Good | Low |
| Voltage Harmonic correction at load terminals | Good | Better | Good | Good |
| Power factor correction | Yes | Yes | Yes | No |
| Power injection to the grid | Yes | No | No | Yes |

## III. MODELING AND CONTROL OF THE SINGLE-PHASE THSEAF

### A. Average and Small-signal Modeling

Based on the average equivalent circuit of an inverter [23], the small-signal model of the proposed configuration can be obtained as of Fig. 4.Based on the typical equivalent circuit of AN electrical converter [23], the small-signal model of the projected configuration will be obtained as of Fig. 4. Hereafter, d is that the duty cycle of the higher switch throughout a shift amount, whereas v and that i denotes the typical values in an exceedingly shift amount of the voltage and current of identical leg.

The mean device output voltage and current ar expressed by (6) and (7) as follow.

$$\overline{v_0} = (2d - 1)V_{DC} \qquad (6)$$

$$\overline{\iota_{DC}} = m\overline{\iota_f} \qquad (7)$$

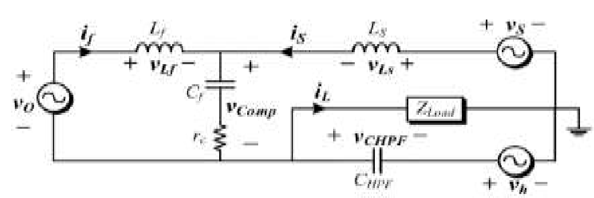

Fig. 4. Small-signal model of transformer less HSeAF in series between the Grid and the load.

When gain is large then source current became clean and that will help for the improvement of voltage distortion at grid side like this it behave as high impedance open circuit for the current harmonic when tuned at system frequency it will create a resistance for harmonic.

$$\dot{x} = Ax + B\mu \quad (8)$$

The output vector is given by,

$$y = Cx + Du \quad (9)$$

$$T_v(s) = \frac{V_{comp}}{v_0} = \frac{rc\,Cfs + 1}{LfCfs2 + rcCfs + 1} \quad (10)$$

$$T_{vm}(s) = \frac{V_{comp}}{m} = V_{DC}.T_v(s) \quad (11)$$

A DC auxiliary supply ought to use to take care of associate adequate provide on the load terminals. Throughout the sag or swell conditions, it ought to absorb or inject power to stay the voltage magnitude at the load terminals inside a given margin.

### B. Voltage and Current Harmonic Detection

The outer-loop controller is employed wherever a condenser replaces the DC auxiliary supply. This management strategy is well explained within the previous section. The inner-loop management strategy is predicated on Associate in Nursing indirect management principle.

The second PI controller employed in the outer loop, was to reinforce the effectiveness of the controller once control the DC bus. Therefore a additional correct and quicker transient response was achieved while not compromising compensation behavior of the system. in keeping with the speculation, the gain G ought to be unbroken in an exceedingly appropriate level, preventing the harmonics flows into the grid. Compensating voltage for current harmonic compensation is given by the following equation as shown,

$$V_{comp_i}(t) = (-G\hat{i_s} + \hat{v_L}) - [l - Gi_{s1} + V_{L1}\,l.\sin(w_s t - \theta)] \quad (12)$$

Maintain voltage magnitude is as shown below,

$$V_{comp\_v} = \hat{v_L} - v_L^* \sin(w_s t) \quad (13)$$

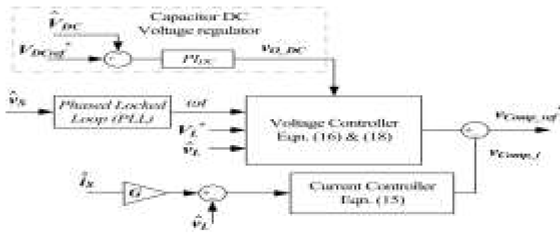

Fig. 5. Control system scheme of the active part. Source current harmonics are as shown,

$$V^*_{comp\_ref} = V_{comp\_v} - V_{comp_i} + V_{DC\_ref} \quad (14)$$

Voltage required for DC bus is as

$$V_{DC\_ref}\,(t) = V_{o\_DC}.\sin(w_s t) \quad (15)$$

According to the given detection formula, the compensated reference voltage v*comp_ref is calculated. Thereafter, the reference signal is compared with the measured output voltage and applied to a PI controller to get the corresponding gate signals as in Fig. 6.

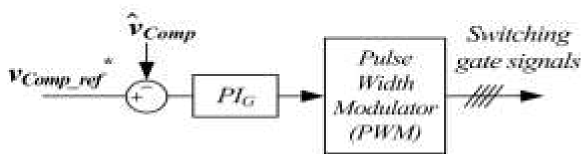


Fig.6. Block diagram of THSeAF and PI controller

4. RESULT

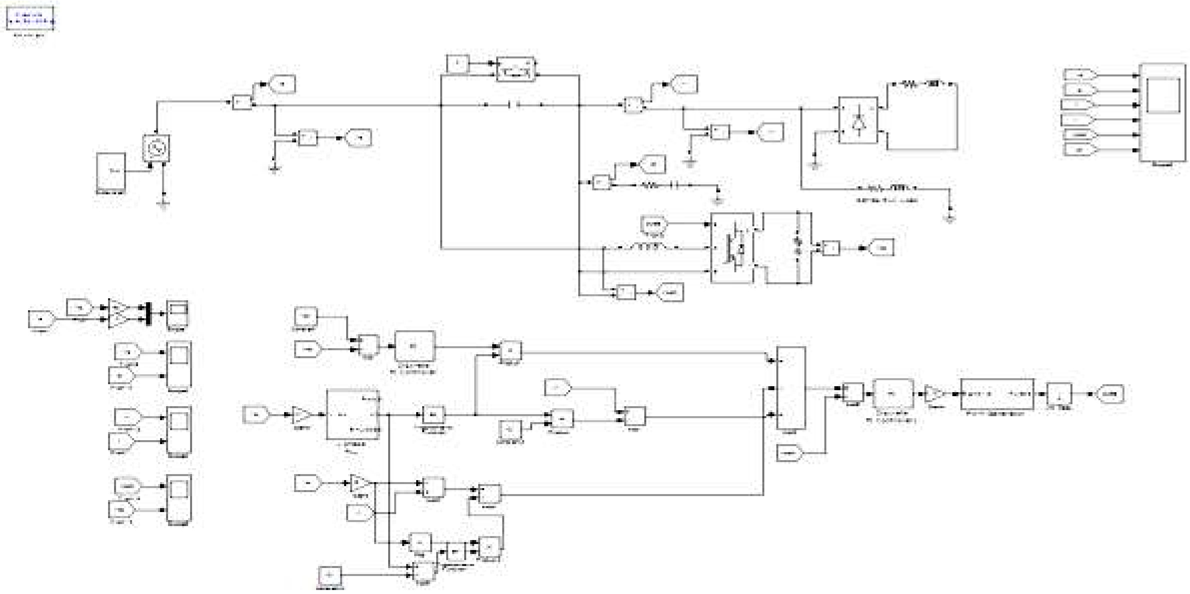

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Fig.10 System Architecture using MATLAB simulation.

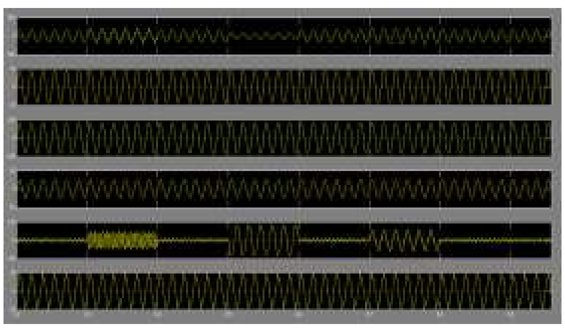

Fig.11 Simulation of the system with the THSeAF compensating current harmonics and voltage regulation. (a) Source voltage *vS*, (b) source current *iS*, (c) load voltage *vL*, (d) load current *iL*, (e) active-filter voltage *V*Comp, and (f) harmonics current of the passive filter *i*PF.

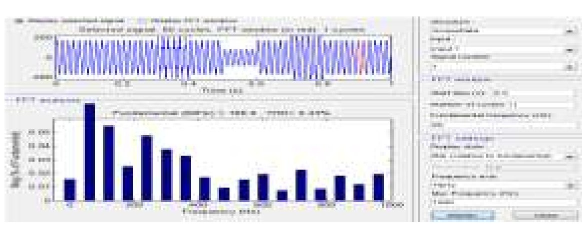

Fig.12 simulation results waveform and bar graph for Fundamental (60Hz) =169.8V and THD=0.43%

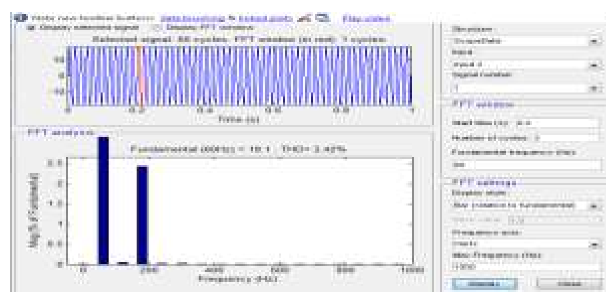

Fig.13 simulation results waveform and bar graph for Fundamental (60Hz) =18.1A and THD=2.42%

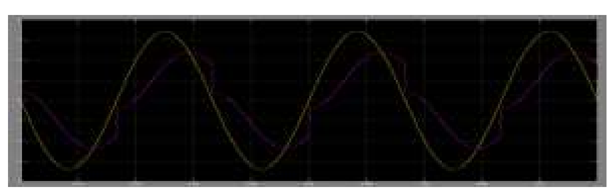

Fig.16 performance of the proposed method Waveforms with and without Filters

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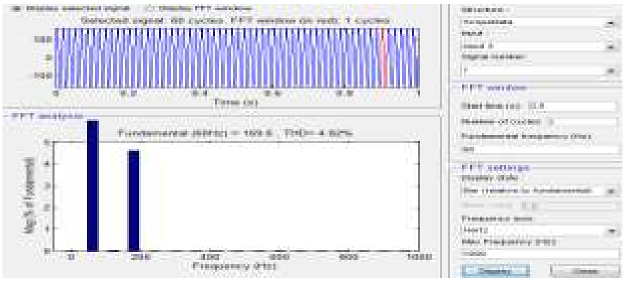

Fig.14 simulation results waveform and bar graph for Fundamental (60Hz)=169.8V and THD=4.62%

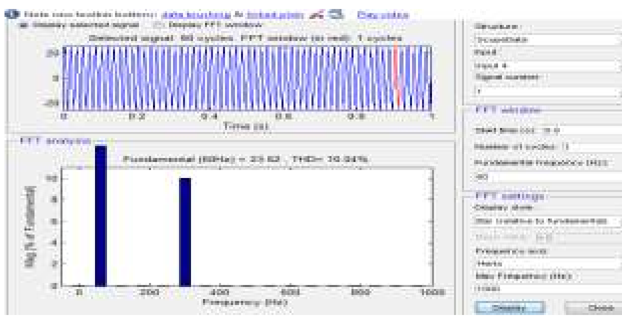

Fig.15 simulation results waveform and bar graph for Fundamental (60Hz)=23.62A and THD=10.

## 5. Conclusion

We implemented power quality improvement topology using transformer less HSeAF and by using MATLAB simulation it's tested successfully. In future, to give a reliable power supplies to users those having nonlinear loads as well as higher exigency, there should be concrete action for smoothly integration of electrical battery chargers to grids. The idea behind this implementation is improving the PCC voltage as well as regulates HSeAF that is nothing but power quality of the system is improved by the use of wide ranges of harmonic current. To get working of this topology counterlet actively in power system, the topology is used with connected to auxiliary renewable sources. The consistent power supply to the critical loads is then checked by simulations. Behaving as high-harmonic electrical resistance, it cleans the ability system and ensures a unity PF. The theoretical modeling of the planned configuration was investigated. The planned transformer less configuration was simulated and through an experiment valid. It absolutely was incontestable that this active compensator responds properly to supply voltage variations by providing a relentless and distortion-free offer at load terminals. What is more, it eliminates supply harmonic currents and improves the ability quality of the grid while not the standard large and series electrical device.

## References

[1] L. Jun-Young and C. Hyung-Jun, "6.6-kW onboard charger design using DCM PFC converter with harmonic modulation technique and two-stage dc/dc converter,"IEEE Trans. Ind. Electron., vol. 61, no. 3, pp. 1243– 1252, Mar. 2014.

[2] R. Seung-Hee, K. Dong-Hee, K. Min-Jung, K. Jong-Soo, and L. ByoungKuk, "Adjustable frequency duty-cycle hybrid control strategy for full bridge series resonant converters in electric vehicle chargers," IEEE Trans. Ind. Electron., vol. 61, no. 10, pp. 5354–5362, Oct. 2014.

[3] P. T. Staats, W. M. Grady, A. Arapostathis, and R. S. Thallam, "A statistical analysis of the effect of electric vehicle battery charging on distribution system harmonic voltages," IEEE Trans. Power Del., vol. 13, no. 2, pp. 640–646, Apr. 1998.

[4] A. Kuperman, U. Levy, J. Goren, A. Zafransky, and A. Savernin, "Battery charger for electric vehicle traction battery switch station,"IEEE Trans. Ind. Electron., vol. 60, no. 12, pp. 5391–5399, Dec. 2013.

[5] Z. Amjadi and S. S. Williamson, "Modeling, simulation, control of an advanced Luo converter for plug-in hybrid electric vehicle energy-storage system,"IEEE Trans. Veh. Technol., vol. 60, no. 1, pp. 64–75, Jan. 2011.

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