STUDY OF THE IMPACT OF THE TOPOLOGY OF THE SHUNT ACTIVE FILTER ON THE NEUTRAL CURRENT

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ABSTRACT

The shunt active filter is a new solution to improve the power quality. It is able to compensate the current disturbances as well as the reactive power. This paper shows the impact of the neutral current compensation on the two different topologies, according to the obtained results, the configuration with four arms is more preferment than the classical topology which uses the inverter with three arms.

Keywords: *Unbalanced electric, neutral current, active filter, compensation*

1. INTRODUCTION

The three phase's network, with four wires for electrical energy distribution, is generally used to supply residential, offices…. Most of the applications connected to four wires system are single-phases dispositive that consume a current containing many harmonics.

In addition, the use of single-phases loads cause many other undesirable effects, such as unbalanced phase current causing the presence of a neutral current flowing through the fourth wire system. Shunt active filters provide an effective solution to improve the power quality.

2. DESCRIPTION OF TOPOLOGIES

The shunt active filter with four wires has the objective to delete the harmonic component of the current, compensate the neutral current, balance the source current and the correct of the power factor:

- The shunt active filter with four wires of three arms is based on conventional converter with three arms an six controllable switches, whom the neutral wire is directly connected to the middle of the DC connection (Fig.1) [1].
- The shunt active filter with four wires of four arms is based on conventional inverter with four arms and height controllable switches; thereby the neutral wire is connected through a connection filter in the fourth arm of the converter [2].

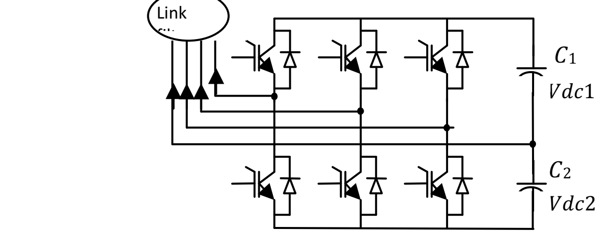


Fig. 1 S.A.F. with three arms

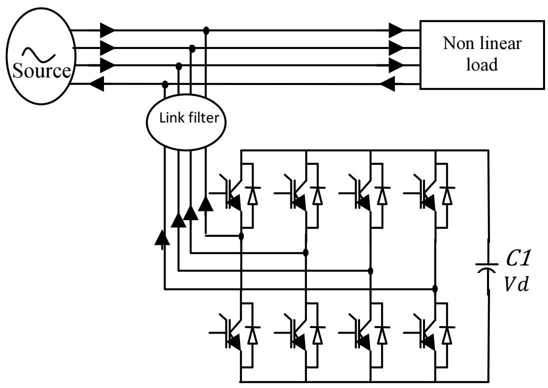


Fig. 2 S.A.F. with four arms

3. UNBALANCED SYSTEM

In this particular case, the converter is designed not to a balanced load but to an unbalanced one [3].

3.1. Definition of unbalance

There are different approaches to define the unbalanced loads. One of these approaches is based on the difference between the largest amplitude and the smallest one, of the three phases.

$$UnBal\ \% = 100 \times \frac{Max\ Amplitude - Low\ Amplitude}{\sum three\ amplitudes} \quad (1)$$

where: *UnBal %* – the unbalance in a three phase system

Another approach is based on the definition of a sequential representation. According to IEC defines the unbalance in a three phase system as the ratio between the RMS values of the negative sequence or the zero sequence vis-a-vis to the positive sequence.

$$UnBal\ \% = 100 \times \frac{Negative\ sequence\ component}{Positive\ sequence\ component} \quad (2)$$

And

$$UnBal\ \% = 100 \times \frac{Zero\ sequence\ component}{Positive\ sequence\ component} \quad (3)$$

3.2. Creation of the neutral connexion

In a three-phases balanced system with three arms, the sum of the three phase currents equal to zero and also for the voltage. For the unbalanced load system, the voltage of the neutral line will become unbalanced [1].

3.2.1. Passive methods with transformer Δ/Y

Transformer Δ/Y is designed to trap the zero sequence. The first part (Δ windings) are connected with the inverter while the second part (Y windings) are connected to the load. Zero-sequence current caused by the load is trapped in the (Δ) windings. Another way to provide passive connection is to use a neutral transformer zigzag, which also balances the load to a certain extent.

3.2.2. Passive methods with division of the link condenser

In this topology, the division of the DC link capacity where the neutral point is connected in the midway between the two capacitors (Fig. 1), there are two problems with this approach:

- The neutral point will be fixed in the middle of the DC link, which will cause a misuse of continuous voltage.
- Huge increase in capacity is required to maintain the ripple voltage at a reasonable level.

3.2.3. Active method

The active method consists in connecting the neutral connection of the load at the midpoint of the fourth arm, the PWM control converter with four arms can handle the neutral current caused by unbalanced load (Fig. 2), the advantages of this method are :

- The possibility of using a high voltage of the DC link.
- No bulky transformers.
- Capacitor used in this method, is a smaller capacity therefore, the cost is low.

4. CONTROL CIRCUIT

The application of the synchronous reference frame (Synchronous Reference Frame, SRF) is based on the extraction of the current harmonic of the load, injecting in the opposite sense to obtain sinusoidal source current and finally injecting inverse current into the fourth arm to achieve a zero neutral current (Fig. 3).

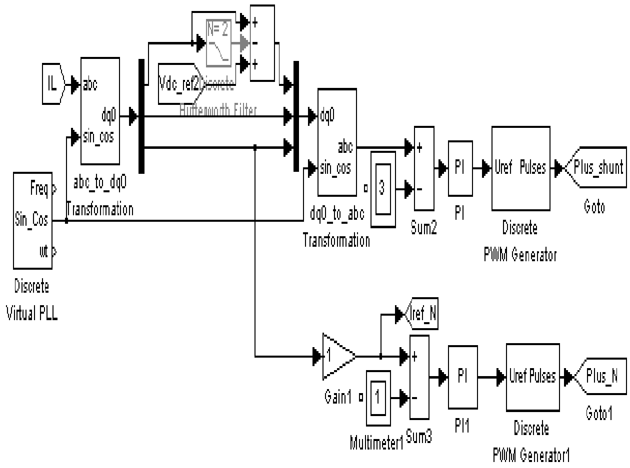


Fig. 3 Control circuit of S.A.F

4.1. Study Shunt active filter

For the determination of the parameters of the PI controller to adjust the control loops shunt were used methods of imposed phase for the determination of controller parameters DC bus, using the pole placement method [4],[5].

The control scheme represented as follows [6].

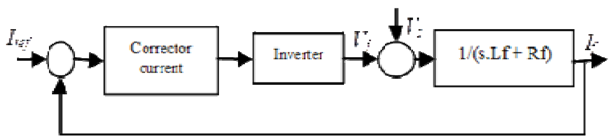


Fig. 4 Control Loop shunt filter

Following a gap between V_{dc} and $V_{dcréf}$ as shown in Figure 5, the power output of the controller is added to the active power fluctuation and gives rise to a fundamental active current and voltage correcting [7].

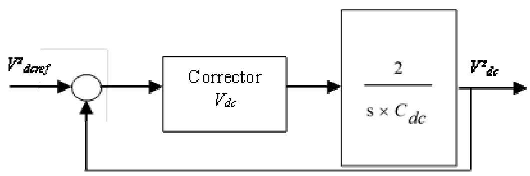


Fig. 5 Control loop of the DC bus of the inverter

5. RESULTS

In this study we present a comparison between a shunt active filter with three arms connected to the neutral wire which are connected to the midpoint of the two capacitors (Fig. 6.) , and another shunt active filter with four arms which is connected to the fourth arm (Fig. 7.).The SAF model parameters are shown in the following Table 1.

Table 1 SAF parameters

Supply phase voltage *U*	220 V
Supply frequency *fs*	50 Hz
Sample time *Ts*	9.9 µs
Filter inductor L_f	2.2 mH
Dc link capacitor C_f	8.7 mF
Dc link voltage	735.6 V
Active power of the nonlinear load	8 KW
Reactive power of the nonlinear load	500 Var
Active power unbalanced load	16KW, 80KW and 8KW
Reactive power unbalanced load	500Var, 150Var and 500Var

The shunt active filter with three arms is represented in the fig. 6.

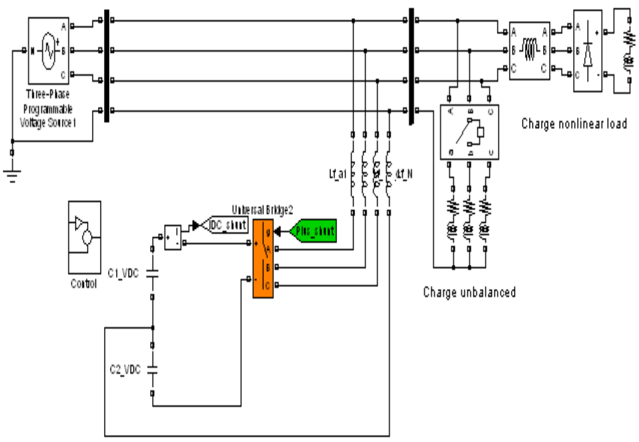


Fig. 6 Simulation model of SAF with three arms

And the Shunt active filter with four arms is represented in the fig. 7.

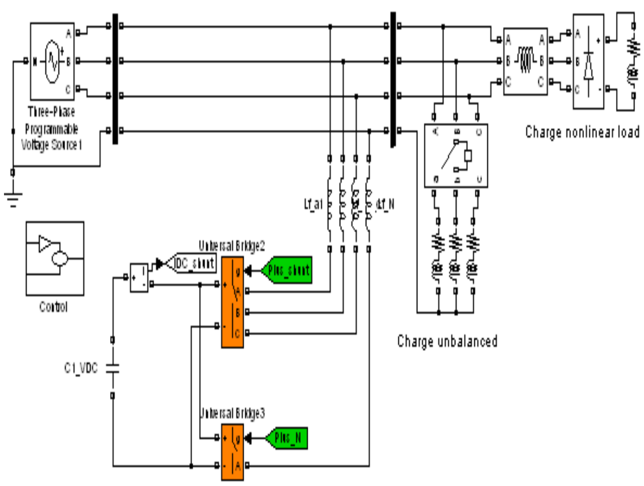
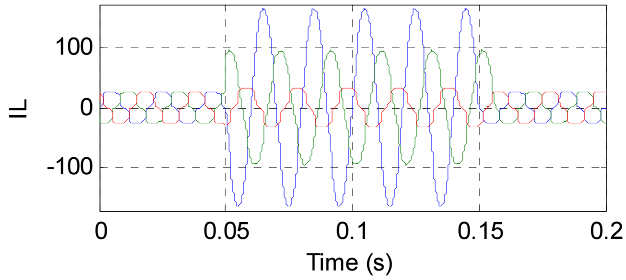


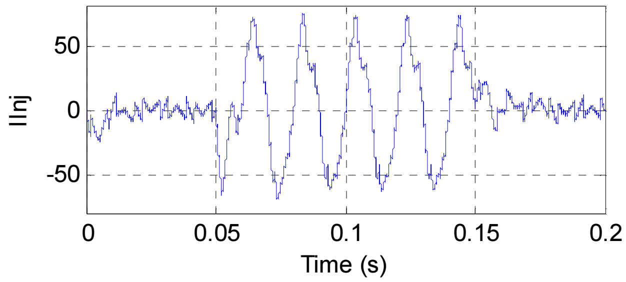
Fig. 7 Simulation model of S.AF with four arms

5.1. S.A.F with three arms

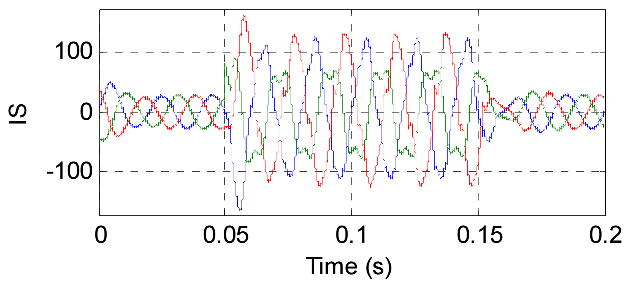
a) Load current



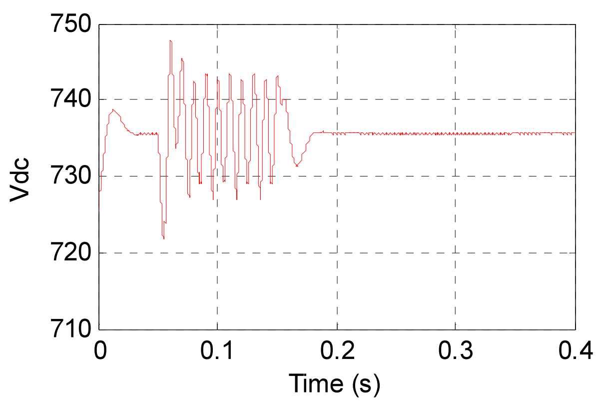
b) Injected current



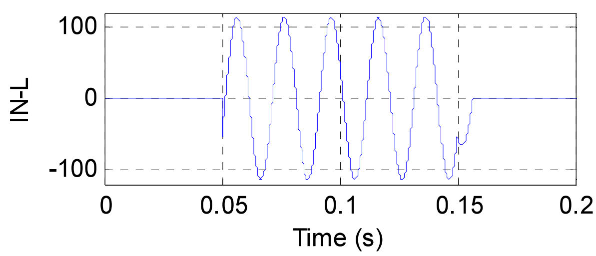
c) Source current



d) Dc bus V_{dc}



e) Neutral current of the load



f) Neutral current of the source

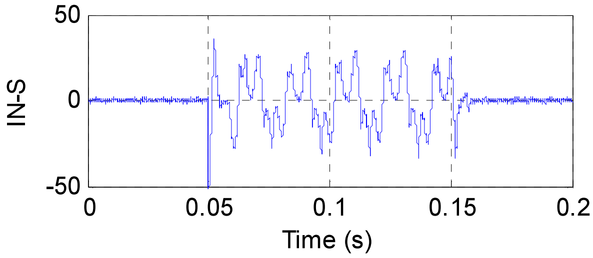
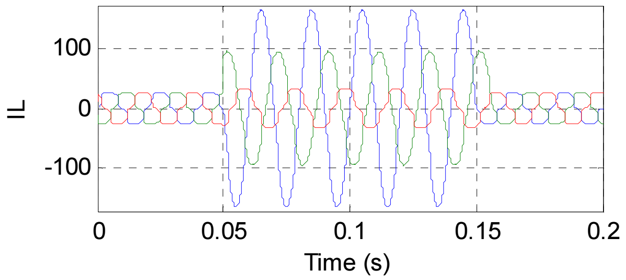


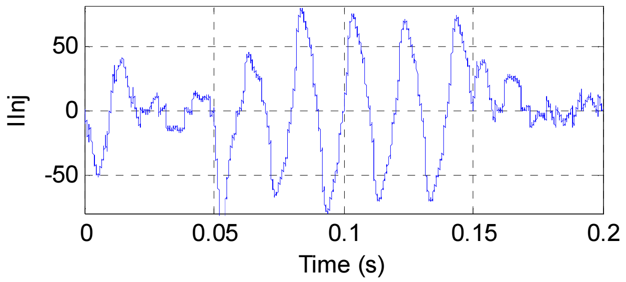
Fig. 8 Simulation results of S.A.F with three arms

5.2. 2. S.A.F with four arms

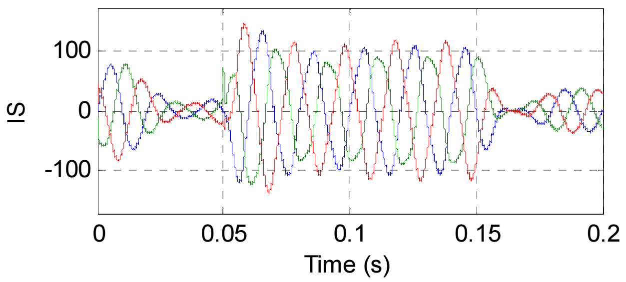
a) Load current



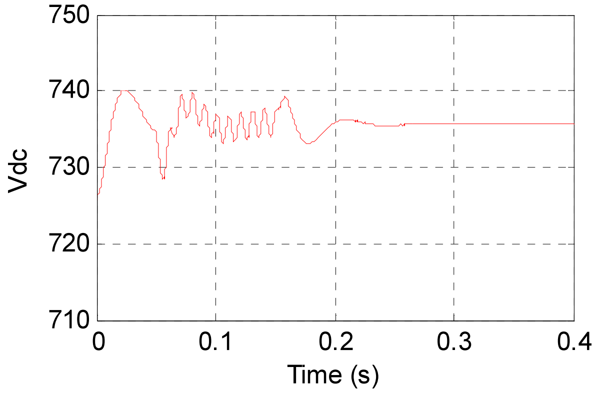
b) Injected current



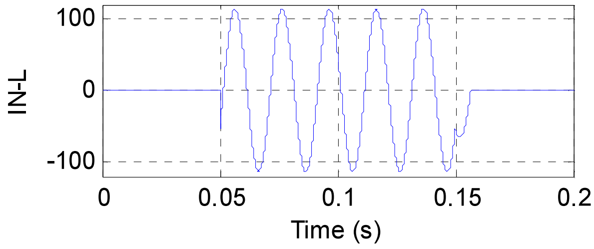
c) Source current



d) Dc bus V_{dc}



e) Neutral current of the load



f) Neutral current of the source

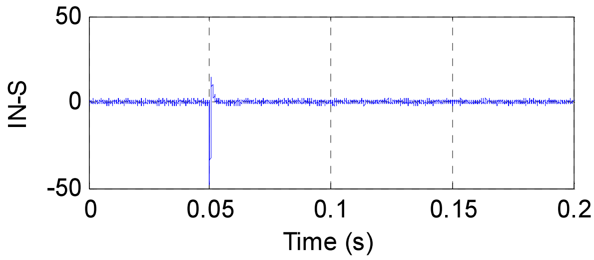


Fig. 9 Simulation results of S.A.F with four arms

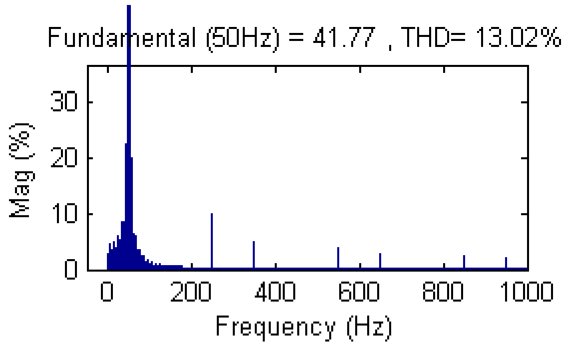


Fig. 10 THD of load current

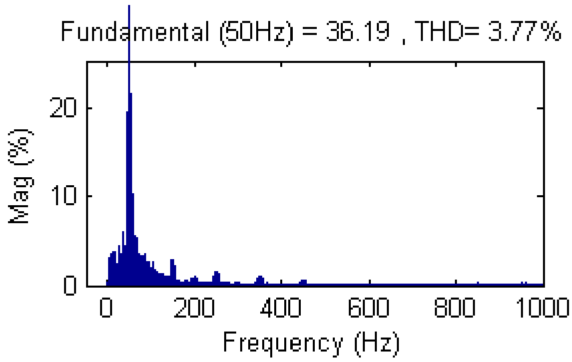


Fig. 11 THD of current source (S.A.F with tree arms)

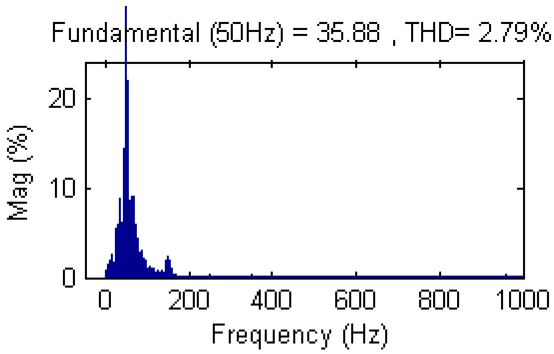


Fig. 12 THD of current source (S.A.F with four arms)

For the simulation, the three-phase voltages at the coupling point are assumed sinusoidal and balanced. The nonlinear load is constituted by a three-phase rectifier diode bridge feeding a load (R, L), as there are three single-phase auxiliary loads for generating the current unbalance for a time definite (0.05s to 0.15s) (Fig. 6, Fig.7).

Figure 10 (a) shows current source by S.A.F with three arms is poorly compensated the phenomenon of unbalanced, Figure 8 (f) shows the three-arm S.A.F the neutral current decreases from 110A to 40A. Figure 9 (f) shows S.A.F with four arms that the neutral current decreases from 110A to 1.5A.

Figures 8 (d) and 9 (d) shows the lure of the DC bus voltage *Vdc*.

The topology of S.A.F with tree arms reduced the THD of current source from 13.02% to 3.77% (Fig. 11), while the THD of current source is measured by a four arms S.A.F is corrected to 2.79% (Fig. 12).

6. CONCLUSIONS

The work presented here, is a part of the researches for new solutions to improve the quality of the electrical energy into the grid.

The obtained results show that the shunt active filter simulation with four arms are better than the three arms . When the neutral conductor is connected to the fourth arm ,this gives us, suitable results compared to the neutral wire which is connected to the midpoint of the two condensers.

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BIOGRAPHIES

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