Dynamic behavior with comparative study of the parallel active filter commande

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ABSTRACT

The aim of this article relates to the comparison between two strategies for identifying harmonic currents, namely the instantaneous active and reactive power method and the instantaneous currents method, faced with a dynamic non-linear load. This work particularly concerns the study by digital simulation of a parallel active filter intended to filter the harmonic currents generated by a non-linear load and to compensate for reactive energy. Our study focuses on the identification of harmonics and inverter control. The step of identifying harmonic currents is fundamental in the filtering process.

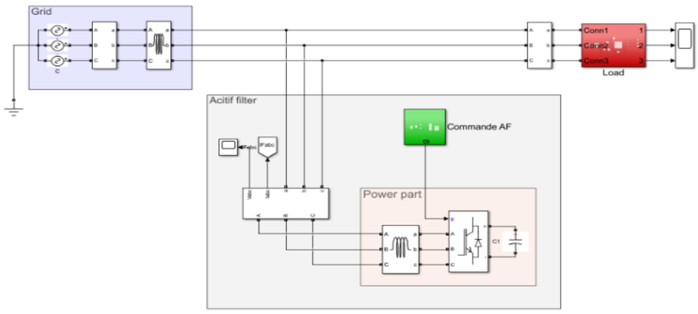
Two identification techniques have been studied and validated namely, the method of instantaneous active and reactive powers **"pq"**, it is an identification method based on the detection of the source current **"dq"** and the method of identification of the powers. instantaneous real and imaginary was chosen to generate the reference currents. The latter offers the advantage of choosing the disturbance to be compensated with precision, speed and ease of implantation. The modeling and simulation of the network assembly, pollutant load and parallel active filter were presented. The validation of the two proposed methods was carried out by numerical simulation. Several simulation cases accompanied by a temporal analysis and a spectral analysis were carried out from the model of the network assembly, parallel active filter and pollutant load. The simulation results for the two proposed methods show that the parallel active filter effectively extract the harmonics from the electrical network, generated by the non-linear load.

I. Introduction

The use of power electronics-based systems, especially static converters, during the last decades has resulted in a significant deterioration in the quality of electrical power [1-3]. This electrical equipment is considered to be so-called deforming loads. So-called deforming charges. These non-linear loads, such as diode and thyristor rectifiers, absorb non-sinusoidal currents, even if they are supplied by a sinusoidal voltage and therefore introduce harmonic pollution into the currents and voltages of electrical distribution networks. . These harmonics are the cause of these distortions. In fact, this phenomenon deserves to be taken seriously given the many anomalies it can cause, and which can even start fires. Several solutions have been proposed to resolve the problem of harmonic pollution in electrical distribution networks. The approach consists of installing so-called conditioning systems whose objective is to counter harmonic disturbances. One of these conditioning systems is active power filtering (AF) [4-6]. A comparative study between two active filter control strategies, including harmonic current identification algorithms, namely the instantaneous active and reactive power method pq, and the dq method, as well as the DC voltage regulation loop and the phase locked loop. The comparative study between these command and control strategies is carried out by simulation tests under different conditions such as: the variation of the non-linear dynamic load, composed of a diode bridge rectifier associated with a DC motor, and the variation of the DC bus reference voltage, in order to evaluate the performance of these control strategies.graduate students and beginning researchers.

II. Filtering system

The parallel active filter has more advantages than other topologies [7-9]. Among these advantages, the reduction in volume compared to the active series filter which requires the presence of a transformer, it is possible to connect several FAs in parallel in order to increase the range of power to be compensated and its capacity to eliminate the current harmonics generated by the non-linear load [10-12]. They are mostly found in the industrial and domestic fields. The DPF is structured in two parts, the power part and the control part consisting of a voltage regulation system (figure 1).



Figur.1 General structure of a parallel active filter

- Power part: Contains the storage element, inverter and the output filter.
- Control part: Contains the various control elements, block for identifying disturbances, regulating the DC and regulating the injected current, and finally the inverter control block.

The quality of current harmonic compensation strongly depends on the performance of the chosen identification method [13]. Indeed, a control system, even a very efficient one, will not be able on its own to perform satisfactory filtering if the harmonic currents are poorly identified. For this reason, many identification methods have been developed in the literature [14,15].

II.1. Instantaneous power method

This temporal method was used in order to avoid the difficulties due to the high number of computations during the implementation of the frequency methods [16,17]. Introduced by H. Agaki, this method is based on the principle of making the transition from three-phase systems consisting of phase-to-neutral voltages and line currents to a two-phase system in the orthogonal (αβ) plane using the Concordia transformation. In order to calculate instantaneous active and reactive power. Its principle is illustrated by the synoptic diagram shown in figure 2.

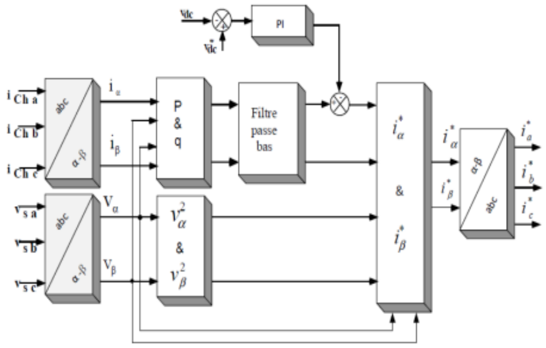


Figure.2 Principle of the p-q method

II.2. Instantaneous current method

This method is based on the Park transform. The currents are transformed in a rotating frame, being synchronized with the network voltages and rotating at the same frequency; thus, the currents are composed of a DC component, linked to the fundamental, and an AC component, linked to the harmonics, which can be separated using a high pass filter or a low pass filter. This method makes a passage of the currents of the load towards currents in a two-phase reference mark (d-q) [18,19].

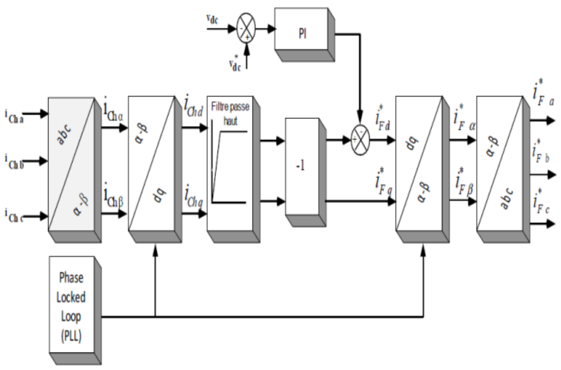


Figure.3 Principle of the d-q method

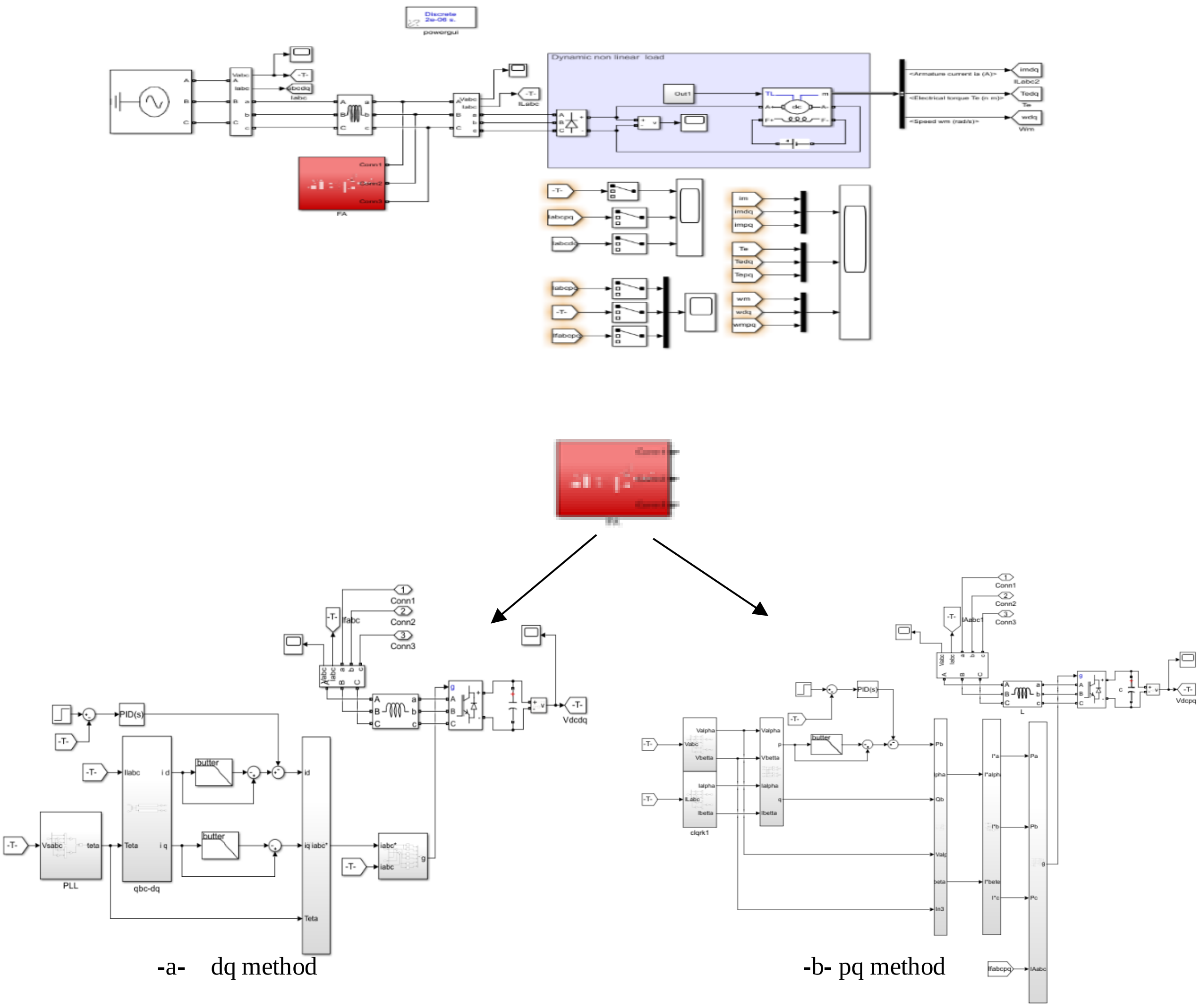
One of the most remarkable characteristics of this algorithm is that the reference currents are obtained directly from the currents of the polluting load, without taking into account the voltages of the network. The generation of the currents will not be affected either by the distortions or by the imbalances present in the voltages of the source. Thus, reinforcing the robustness and performance of the compensation; which is an important advantage.

III. Study system

The study system, shown in Fig. 4, comprises a three-phase electrical network, a non-linear dynamic load and a parallel active filter with a voltage structure. Regarding the active filter (AF) identification method, two control techniques were used, namely the so-called dq technique (figure.4.a) and the so-called pq technique (figure.4.b), for the identification of harmonics created by nonlinear dynamic load. The parameters of each element constituting the system are shown in Table 1.

Tab.1 System settings

Power supply	Three-phase: V_{max} =$220\sqrt{2}$ V, f = 50 Hz, Line inductance: $L_l = 2 \times 10^{-3}H$
Polluting load (Rectifier-DC motor)	Rectifier: three-arm diode bridge Motor DC: 10 HP, 500v, 1750 RPM, Field 300v
Parallel Active Filter	Thyristor voltage inverter Output inductance : $L_f = 2 \times 10^{-3}H$ Capacitive at the input of the inverter: $C_{dc} = 1500 \times 10^{-6}F$



-a- dq method

-b- pq method

Figure.4 System simulation block

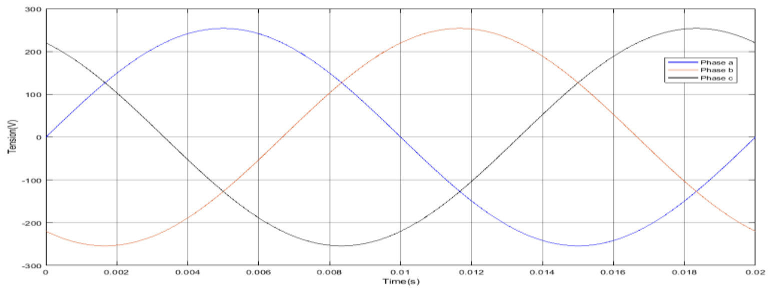


Figure.5 Source voltage

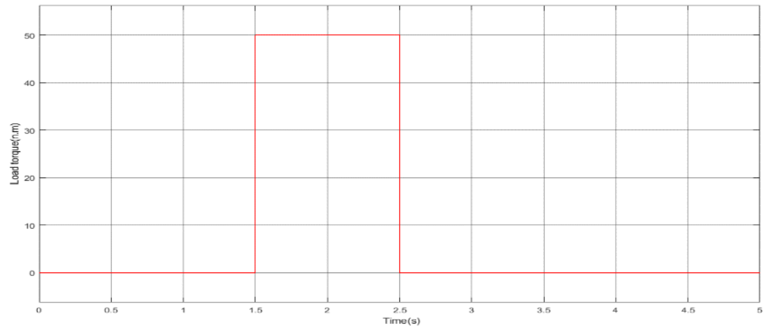
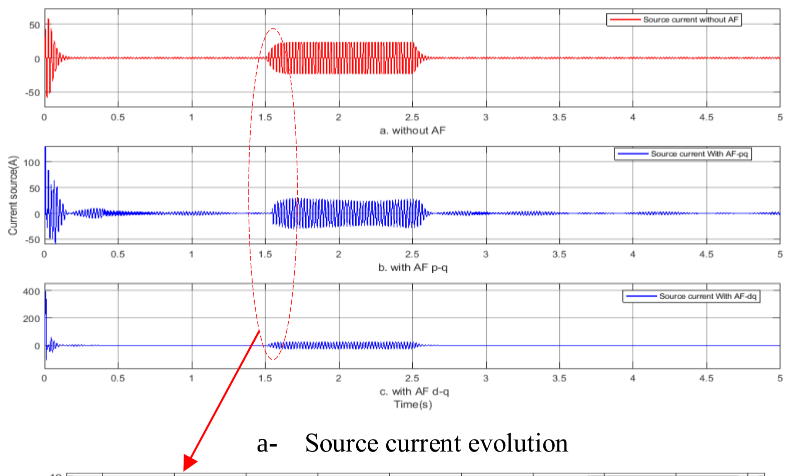
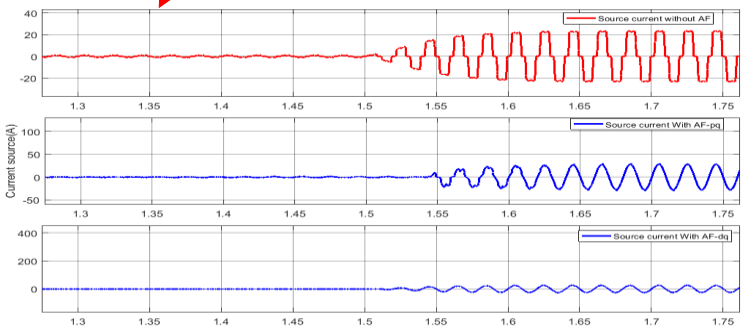


Figure.6 Load torque

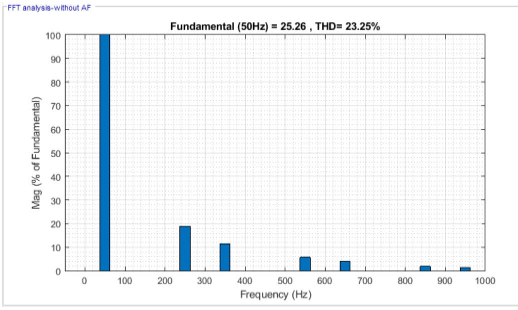


a- Source current evolution

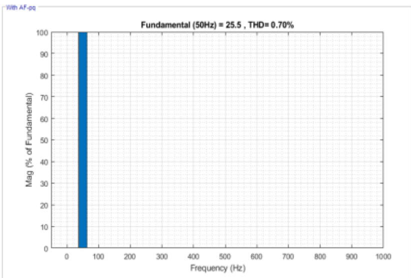


b- Zoom

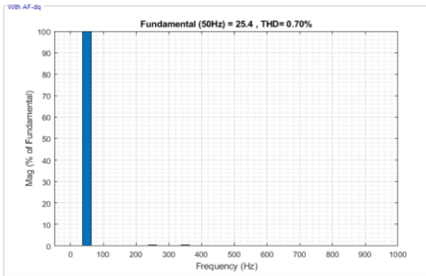
Figure.7 Source current witout and with actif filter



a. without FA



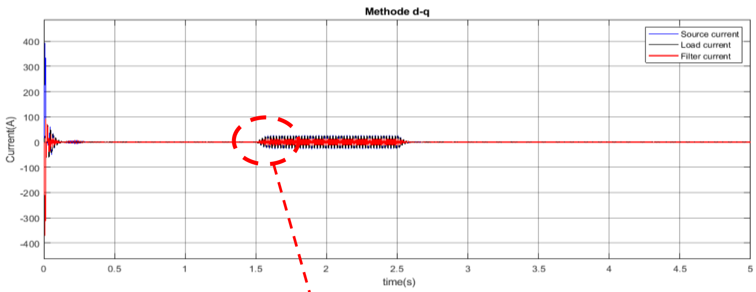
b. with FA: méthode p-q



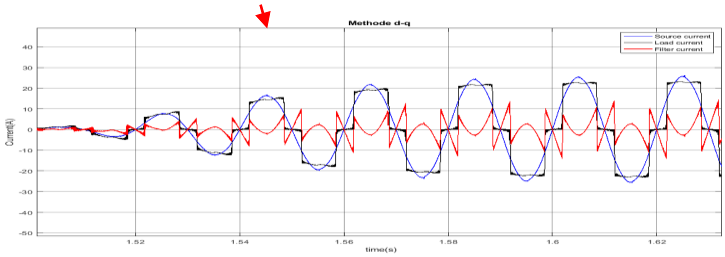
c. with FA: méthode d-q

Figure.8 THD values

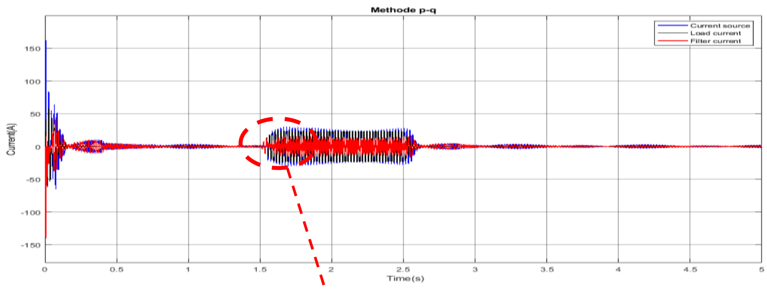
The analysis and the comparative study of the results of simulations obtained with and without active filter (Figure 7), allows to observe the effect and the impact of the AF on the improvement of the quality of the signal whatever the technique. used. Indeed, it ensures the elimination of harmonics due to the presence of a non-linear load and therefore makes the shape of the electric current closest to the sinusoidal shape and consequently reduces the rate of harmonic distortion (Figure. 8). In addition, adequate control of the inverter where the references of the harmonics to be eliminated are identified by the two identification methods used (p-q, d-q). As well as a PI controller for regulating the voltage of the DC bus at the terminals of the capacitor.



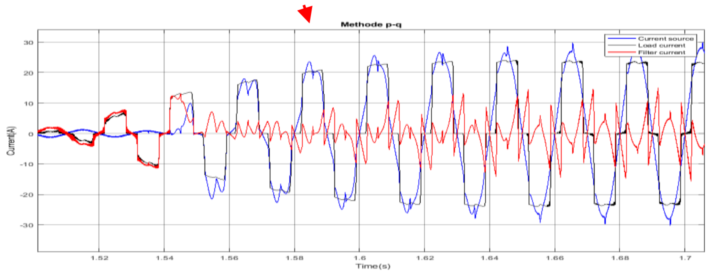
a. Source, load and filter current with the technique d-q



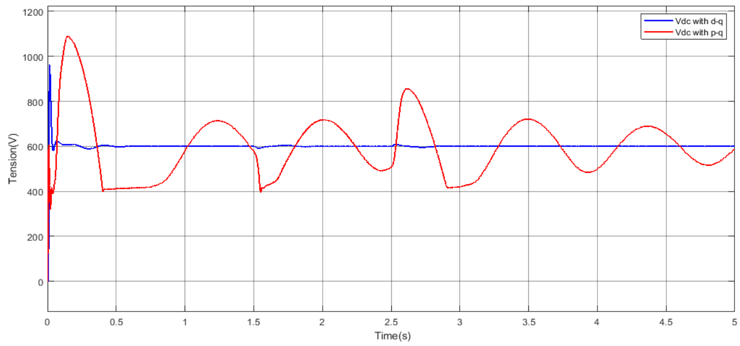
b. Zoom



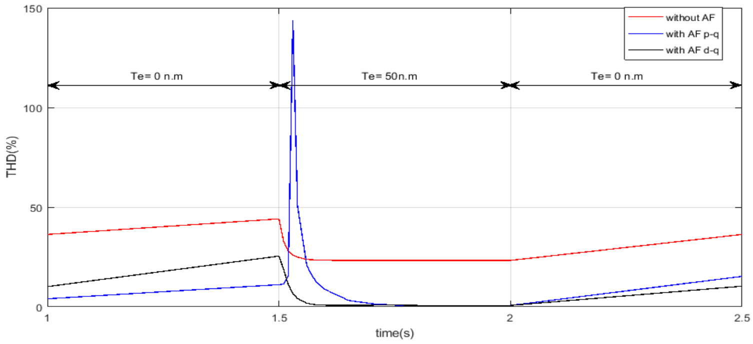
c. Source current, load current and load filter with p-q method



d. Zoom



e. Voltage across capacitor V_{dc}



f. THD evolution

Figure.9 Adaptability of the AF with the two methods (p-q, d-q)

During the variation of the polluting load (load torque at t = 1.5s), it can be seen from figure.9.e and figure.9.f, that the model of the FA with the identification method dq is more robust, stable and with a fast response time compared to the FA model with the pq method. As well, the efficiency of the FA with the d-q method for removing harmonics is better compared to the model with the p-q method (Figure9.b and Figure9.d). the results of figure 9.f, is obtained from the table.2.

Tab.2 Evolution of the THD%

THD% Evolution																
Time(s)	1	1.5	1.51	1.52	1.53	1.54	1.56	1.57	1.58	1.6	1.65	1.7	1.75	1.8	2	2.5
Without AF	36.31	44.11	32.83	28.04	25.97	24.92	23.74	23.67	23.41	23.34	23.26	23.26	23.25	23.25	23.28	36.31
With p-q method	4.03	11.12	11.41	15.69	143.93	50.72	20.92	16.10	12.7	8.65	3.24	1.56	0.84	0.66	0.7	15.28
With d-q method	10.13	25.46	18.82	11.21	6.71	4.18	1.83	1.34	1.03	0.84	0.77	0.83	0.92	0.71	0.70	10.35

III. Conclusion

The use of dynamic load (Static converter-MCC), aims to validate the adaptability and efficiency of the FA in the face of variations in the mechanical load of MCC. This adaptability is verified in view of the simulation results obtained. It can be seen from the comparison between the electrical quantities with and without AF, that the effect of AF is to improve signal quality by eliminating ripples due to harmonics created by the non-linear load. The adaptability of the FA to changes in the dynamic load is actually reflected in the effective control of the control system of the FA, which ensures that the value of the DC bus voltage across the capacitor supplying the inverter will always be reduced. is equal to the value of reference imposed, during the variations of the dynamic load.

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