The Impact of the Commutation on Electromagnetic Interference Generated in Static Converters

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***Abstract* — The aim of this paper is to evaluate the frequency composition generated by the commutation of static converters and the its impact on the electromagnetic interference emitted by these structures. In order to study these effects, it were implemented two static converters. The first one is a DC-DC converter using the isolated flyback topology where the ringing effect was analyzed, and the second one is a DC-AC converter using isolated push-pull topology where the commutation was analyzed considering the placement of auxiliary circuits of commutation.**

I. GENERAL INTRODUCTION

The static converters considering different kind of topologies, can operate in commutation frequencies higher than 100 kHz, and powered by few mW up to MW. These converters show separately or in groups, many kind of electromagnetic compatibility (EMC) problems, causing electromagnetic interference (EMI) in all electronic equipment connected to them or to the electrical energy supply system. On the other hand, the electromagnetic interference can affect the converters causing auto-interference. The problems due to the EMI can be minimized when designing the converters if the designer uses some EMI reduction technique. These techniques can actuate on the EMI generation and after that, on its propagation of the EMI.

II. TECHNICAL INFORMATION

A. EMI Generation

In a static converter, the EMI generation is associated to the energy involved on the commutation of semiconductors (higher dv/dt or di/dt), which can be minimized when defining the power structure, the command strategy and the component selection. The energy transference from the electrical energy supply system to the load of the converter can be controlled in many ways, however, the most usual control is the use of *Pulse Width Modulation (PWM)*. The waveform on the commutation has a frequency composition which basically depends on the period, the conduction time, the rise time and fall time of the semiconductors, as shown in Fig. 1.[2][3]

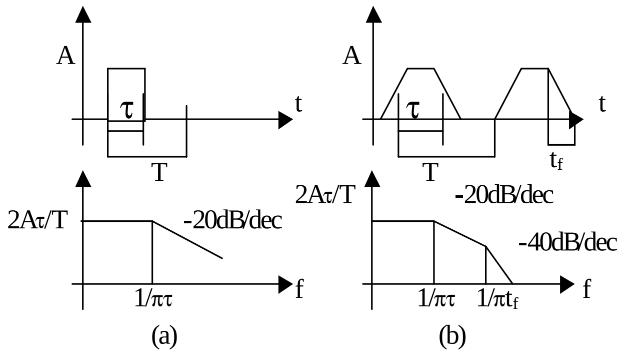

Fig. 1. PWM signal and its harmonic composition: (a) Null rise time and fall time.(b)Not null rise time and fall time.

B. EMI Propagation

There are two ways in order to reduce EMI propagation, build a high impedance path to reduce de noise energy or build a low impedance path to confine de noise signal in a specific region. In both ways its recommended to optimized the converter design (topology, layout, semiconductors, magnetic elements, snubbers, etc) as a first action. After that, filters and shielding can be also used.

III. EXPERIMENTAL RESULTS

A. Experimental Results: Fly-back topology

Fig.2, Fig.3 and Fig.4 show respectively the fly-back (24W, 28Khz) topology, the voltage on the main semiconductor and the frequency composition of this voltage. It is possible to notice the effect of the ringing (510 kHz – 18th harmonic).

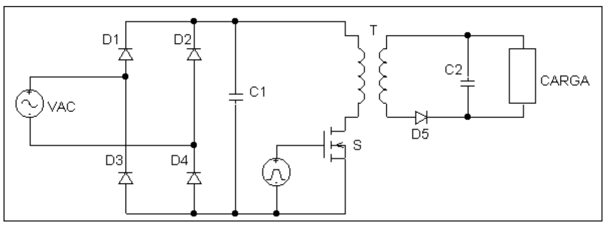

Fig. 2. Fly-back topology

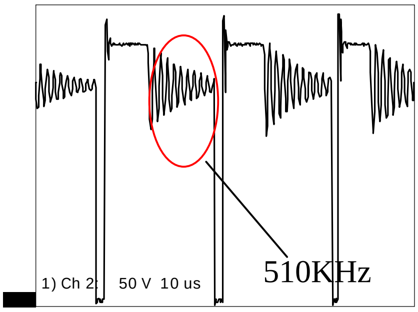

Fig. 3. Waveform of the voltage on the main semiconductor.

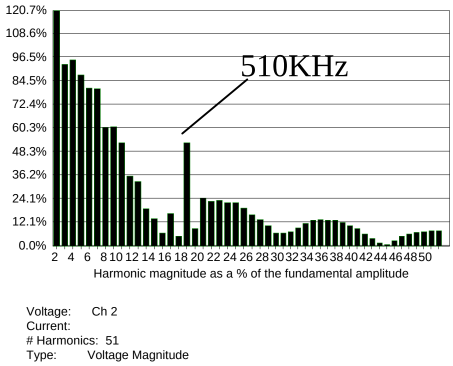

Fig. 4 Frequency composition of the voltage on the main semiconductor.

The ringing effect depends on the topology of the structure and on the non-idealities or stray behavior of the elements of the converter circuit. Figure 5 shows the effect of the ringing on the harmonic composition of the conducted EMI signal

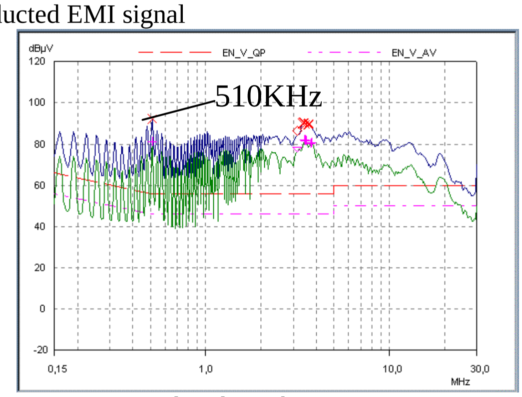

Fig. 5. – Conducted EM I harmonic composition.

B. Experimental Results: Push-Pull topology

Considering the flyback converter analysis, shown on the item *A* , it is possible to notice the influence of the layout on the generated EMI by the converter. In order to analyze the effect of the topology and the control/switching strategy it was implemented a push-pull converter (24W, 25Khz) . On the analysis of the push-pull topology it was implemented three different structures:

- Conventional Push-pull Inverter;
- Push-pull Inverter with auxiliary commutation switch;
- Push-pull Inverter with non-dissipative snubber.

Conventional Push-pull Inverter

Fig.6, Fig.7, Fig.8 and Fig.9 show respectively the conventional push-pull topology, the voltage on the main semiconductor, the frequency composition of this voltage and the harmonic composition of the conducted EMI signal considering a conventional Push-pull topology.

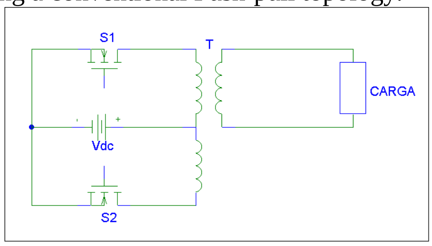

Fig. 6. Conventional push-pull topology.

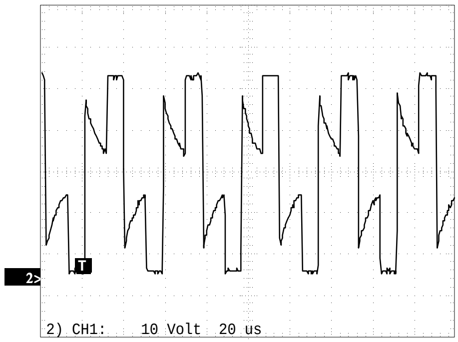

Fig. 7. Waveform of the voltage on the main semiconductor.

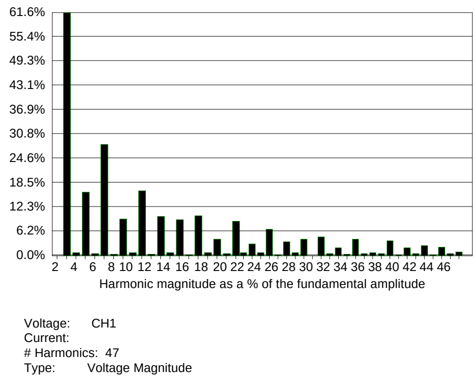

Fig.8 Frequency composition of the voltage on the main semiconductor.

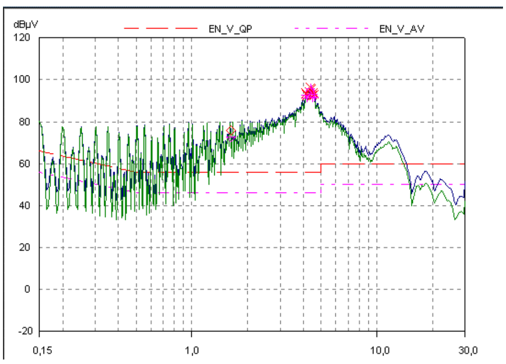

Fig. 9. – Conducted EM I harmonic composition.

Push-pull Inverter with auxiliary circuit of commutation

Fig.10, Fig.11, Fig.12 and Fig.13 show respectively the push-pull with auxiliary circuit of commutation, the voltage on the main semiconductor, the frequency composition of this voltage and the harmonic composition of the conducted EMI signal, considering a Push-pull inverter with auxiliary commutation switch circuit.

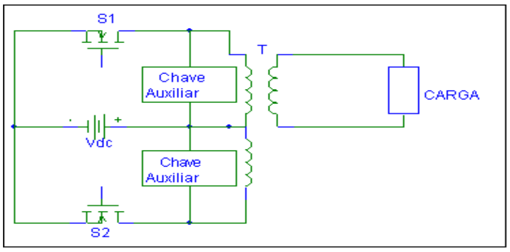

Fig.10 Push-pull with auxiliary circuit of commutation.

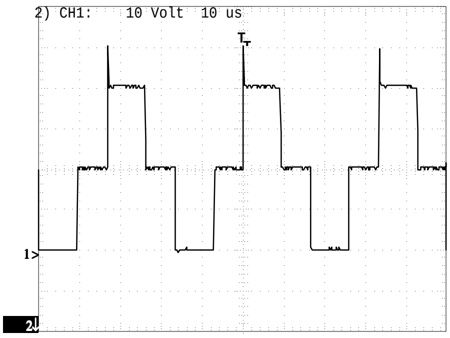

Fig. 11. Waveform of the voltage on the main semiconductor.

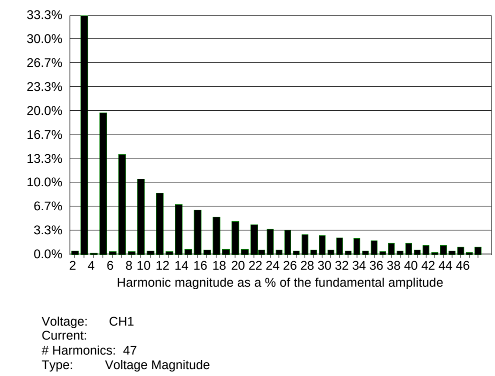

Fig.12 Frequency composition of the voltage on the main semiconductor.

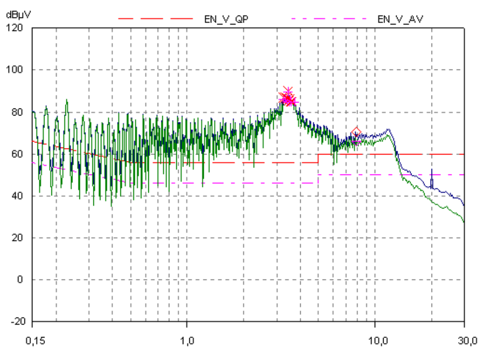

Fig. 13. – Conducted EM I harmonic composition.

Push-pull Inverter with non dissipative snubber

Fig.14, Fig.15, Fig.16 and Fig.17 show respectively the push-pull with non dissipative snubber topology, the voltage on the main semiconductor, the frequency composition of this voltage and the harmonic composition of the conducted EMI signal, considering a Push-pull inverter with non dissipative snubber.

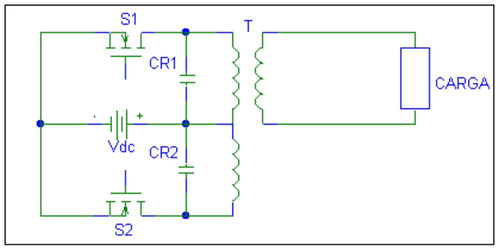

Fig. 14 Push-pull with non dissipative snubber.

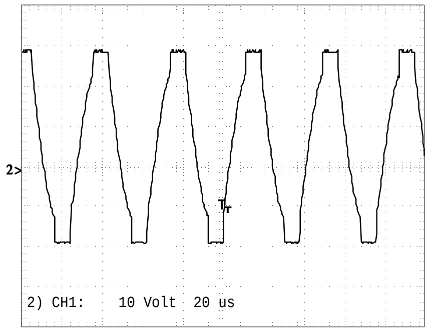

Fig. 15. Waveform of the voltage on the main semiconductor.

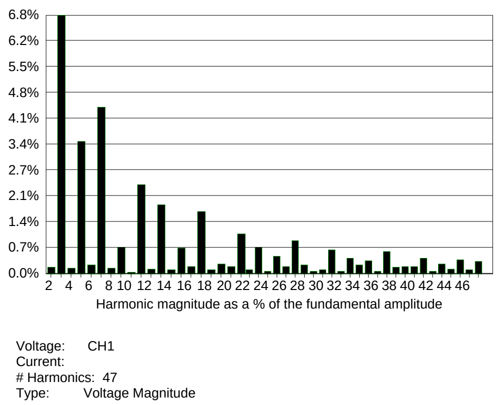

Fig.16 Frequency composition of the voltage on the main semiconductor.

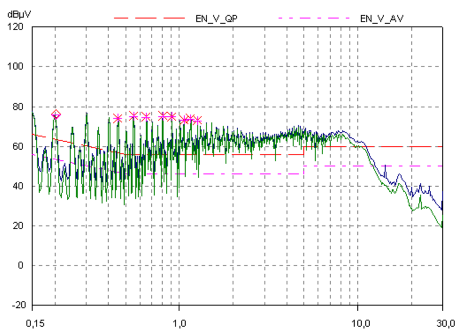

Fig. 17. – Conducted EM I harmonic composition.

IV. CONCLUSIONS

- In this paper it was characterized that there is a relation between the EMI generated in a static converter with the commutation characteristics.
- It is possible to notice that in the flyback topology there is a ringing effect on the frequency composition of the voltage on the main semiconductor and on the conducted EMI generated by the converter.
- On the push-pull topologies, it is possible to notice that there is an influence of the topology on the frequency composition of the voltage on the main semiconductor.
- Considering the obtained results, the first action to avoid EMI generation is to choose an adequate topology and commutation strategy.
- Then, it is necessary to reduce the EMI propagation by using optimized layout, filters and shielding.

V. REFERENCES

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