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Effect of the auxiliary power supply of active circuits on the performance of Active EMI Filter

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Abstract

Compared to passive EMI filter, active EMI filter (AEF) used active circuits to process noise and provide a corresponding compensation noise. These active circuits required an auxiliary power supply, which can affect the proper functioning of the AEF. In the literature, the study and design of AEF have been the subject of several research. However, the issue of the power supply of AEF has not been presented and resolved. This paper gives an experimental study of the influence of the auxiliary power supply of active circuits on the performances of AEF. A functional prototype of common mode AEF for a Boost power converter that comply to the DO160 standard up to 1 MHz has been realized.

Introduction

Switched-Mode Power Supply (SMPS) are sources of electromagnetic interferences (conducted and radiated) due to the high gradients of voltages and currents. In conducted emission, a passive EMI filter comprised differential-mode (DM) and common-mode (CM) filters is widely used to ensure EMC conformity including aeronautic conformity (DO160 standard) in the 'RF' range (150 kHz – 30 MHz). The design and analysis of such passive filters are available in the literature [1]. Passive filters are quite expensive and bulky, and may represent up to 30% of the cost, weight, and volume of a power converter. In addition, the effectiveness of passive filter is limited because of imperfections and limitations in high frequencies of the passive components (inductors and capacitors). Therefore, using active components appears to be a promising alternative to reduce the size, weight, and cost of power converters. A volume reduction greater than 40% has been reported in [2] by using hybrid filter (active plus passive filter). In the literature, two main families of AEF exist: the feedback and the feedforward topologies. A comparative analysis of these two topologies was made in [3] and it was concluded that the feedback topologies is more easily controllable than the feedforward. Indeed, for efficient filtering, the feedforward gain must be equal to one: this condition is hard to achieve due to the non-linearity and parasitic elements of the passive components used for the detection and injection in the AEF. Four feedback topologies are available depending on the sensing (Voltage, using RC filter, or Current, using a current transformer) and the cancelling (Voltage or Current injection) methods. These four possible combinations are given in Fig.1. In this figure, the Common Mode generation of the converter is represented using a Norton equivalent circuit. The principle of linear active filtering consists in detecting an output quantity (voltage or current) at the terminals of the LISN (Line Impedance Stabilization Network) and comparing it to a zero reference (ground). The error is processed in an analog- (Op amp) way to obtain the necessary gain to reject noises. Noise processing used active components, which required extra power consumption. The auxiliary power supply can be an external power supply [4] or associated power supply powering by the power converter [2].

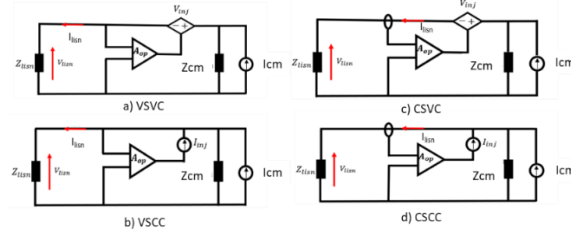
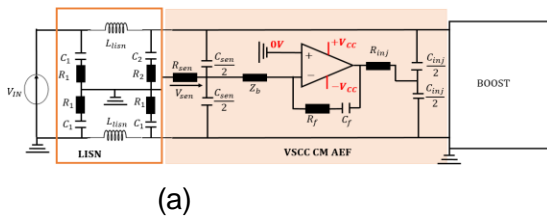


Fig.1: Four active filter topologies. (a) Voltage sensing-voltage cancellation (VSVC). (b) Voltage sensing-current cancellation (VSCC). (c) Current sensing-voltage cancellation (CSVC). (d) Current sensing-current cancellation (CSCC)

Using an external power supply will greatly increase the size of the filter and be impractical for embedded system. An associated power supply can be a linear power supply or a small SMPS connected to the input or output of the converter to supply the Op amp. However, using linear power supply can cause additional losses of the active filter. On the other hand, using a small SMPS can generate extra EMI noise, which can be injected during the compensation by the active EMI filter. Also as the auxiliary power supply is powered from the power conductors of the converter, it can therefore impact the differential mode. Hence, effort has to be put into the realization of the power supply for the active filter section and investigations on the reliability have to be done. As current injection topologies provide better attenuation than voltage injection for common mode filtering [3] and taking into account its simplicity and lightness, a voltage sensing-current cancellation common mode topology (VSCC) has been chosen in this paper for a boost power converter (14V/42V - 115 kHz – 27W) to show the influence of power supply of active circuits on the performances of AEF. A Traco power TMR 1-1223SM is used to supply active circuits.

I. Common mode VSCC active EMI filter

Fig. 2a shows the circuit model of the voltage sense current-compensation (VSCC) CM AEF. Both sensing and compensation are made by RC circuits. The detail design methods of this AEF topology have already been well detailed in [7].



Component	Value
R_p	33k Ω
C_f	68pF
R_b	1 k Ω
R_{sen}	110
C_{zsm}	2 x 10nF
R_{inj}	6.8 Ω
C_{inj}	2x0.1 μ F
CFA	THS3121

(a)

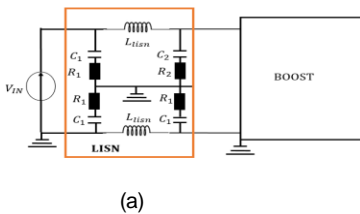
(b)

Fig.2: (a) Voltage sensing-voltage cancellation (VSVC) EMI filter. (b) Components values

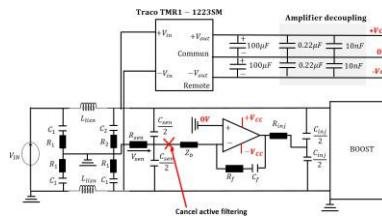
This paper just focuses on the effects of the auxiliary power supply required to supply active circuits of AEF. The design of the auxiliary power supply depends on the power consumed by the Op amp and the required voltage. To estimate the required OP-amp capacity, the voltage and current at the OP-amp output V_{OP} and I_{inj} are calculated and given in [5].

II. Effect of auxiliary power supply on the performance of VSCC CM active EMI filter

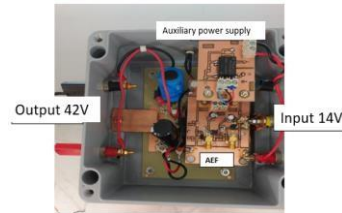
To show the influence of the power supply, the unfiltered common mode current are measured without traco, with traco powered, and compared to the DO160 standard.



(a)



(b)



(c)

Fig 3: Equivalent set up measurement of unfiltered I_{cm} (a) without traco. (b) with traco, (c) Converter + active emi filter

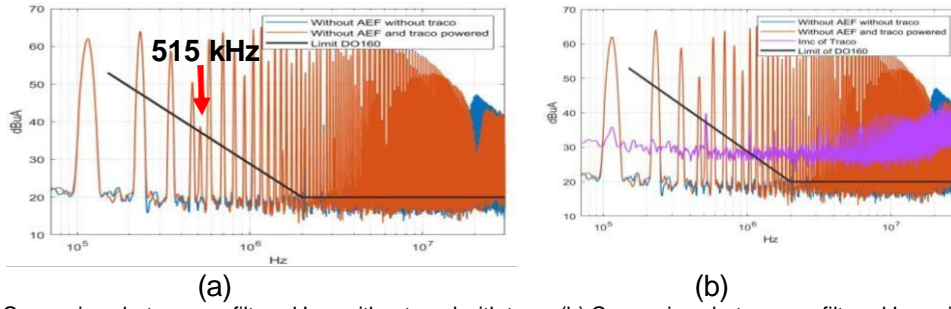


Fig.4: (a) Comparison between unfiltered I_{mc} without and with traco (b) Comparison between unfiltered I_{mc} without and with traco and the I_{mc} of the Traco

From the measurements Fig 4a, we can clearly see that a peak appears at 515 kHz in the case where the Traco is powered. This peak is not a harmonic of the switching frequency of the converter. Also this peak exceeds the limit of the standard. The measurement of the common mode current of the Traco, Fig 4b, shows clearly that the peak is due to the switching frequency of the Traco. Therefore, the auxiliary power supply affect the EMC behavior of the power converter

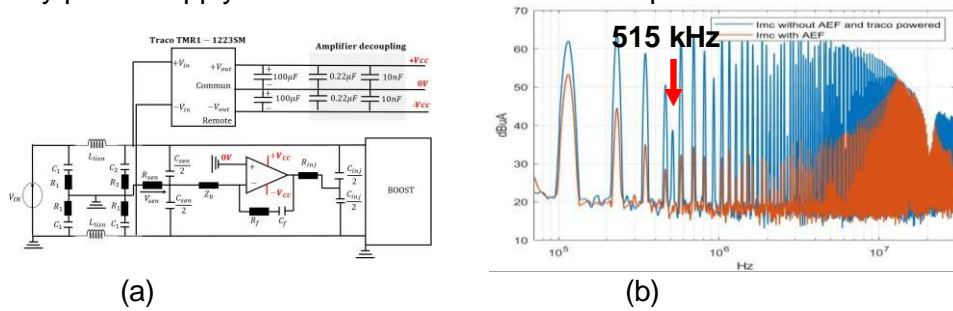


Fig.5: (a) Equivalent set up measurement of I_{mc} with AEF, (b) Comparison of I_{mc} spectrum with and without AEF

We see in Fig 6b that the AEF filters well the common mode current and the peak of 515 kHz is also filtered. This is explained by the fact that this peak is in the operating frequency range of the AEF filter. This means that if the power supply disturbed outside the operating frequency range of the active filter, the active filter would not be able to attenuate the disturbance and respect the standard.

III. Conclusion

In this paper, the effect of the auxiliary power supply of VSCC filter are experimentally discussed. The auxiliary power supply can affect the common mode EMC behavior of the power converter and can cause non-compliance with the standard after adding the EMC filter if it is not taken into account. As the auxiliary power supply is powered from the power conductors of the converter, it can therefore impact the differential mode. In the final paper the measurement of differential mode current will be made. Also as Traco power converter is more capacitive than Murata converter, a comparison of Traco TMR1-1223SM and MURATA NXJS1212 will be presented to show that whatever the nature of auxiliary power supply, it must be taken into account when designing the active filter.

IV. Reference

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