Short Term Mobility Program - 2010

Research activity report

Electromagnetic Interference (EMI) issues in power drive systems with matrix converter

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Introduction

The research activity has been carried out under the supervision of prof. Pericle Zanchetta and with the collaboration of Dr. Lee Empringham and Dr. Liliana De Lillo in the period: October 31st 2010 to December 8th 2010.

The study has been developed in the field of Electromagnetic Emission (EMI) in matrix converters. In particular, the converter under study is a 100kW hybrid Si-SiC based matrix converter for aerospace application, designed and set up at Nottingham University.

In order to respect International Standards limits on EMI towards the power supply, two EMI filters, at the input and output of the matrix converter, have been designed to attenuate the conducted disturbances generated by the matrix converter. At the same time, devices designed for aerospace application require characteristics of lightness and compactness.

In order to study the effectiveness of the designed filters in reducing EMI and, possibly, to improve the design in terms of lightness and compactness, it is necessary to develop high frequency (HF) models of the filters.

During the research activity, carried out at Nottingham University, a HF model of the input EMI filter has been developed.

The high frequency parasitic parameters of the filter components have been measured with the HP 4194A Impedance/Gain-Phase Analyzer in the Laboratories of The Power Electronics, Machines and Control (PEMC) Group of the Department of Electrical and Electronic engineering at Nottingham University. The developed model has been implemented using Saber simulator.

HF model of the input EMI filter

A differential mode (DM) input EMI filter has been designed to mitigate the DM disturbances generated by the matrix converter. The electrical scheme of the filter is shown in Figure 1.

The capacitor is a feed-through device of 4.7 μF. A feed-through capacitor is a three terminal device, designed to mount through a metal chassis. The conductor carrying the operating current is connected concentrically to one electrode and it is run centrally through the capacitor. The other electrode is contacted concentrically to the capacitor case.

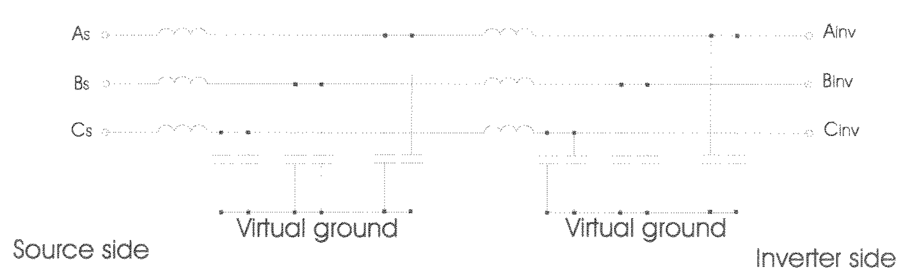

Figure 1 Electrical scheme of the Differential Model input EMI filter for matrix converter.

Figure 2 shows the developed HF circuit model of the feed-through capacitor. The parameters of the capacitor circuit model are shown in Table 1.

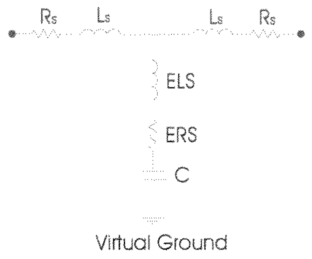

Fig. 2 – High Frequency circuit model of the feed-through capacitor.

Table 1 – Parameters of the capacitor HF model

Parameter	**Value**
C	4.701 μF
ERS	1.4 mΩ
ESL	161 pH
R_s	2.81 mΩ
L_s	1.25 nH

The inductor of the EMI filter is a Fe-based nanocrystalline magnetic material bead inductor.

In a bead inductor, the Fe-based nanocrystalline material is formed around the wire, the current flows along the wire and generates magnetic flux in the circumferential direction. This flux passes through the bead material producing an internal inductance. Bead inductors have a very small stray capacitance, and moreover, at high frequencies, this type of inductor works as a resistor, like the measurements, reported in figure 3, show.

The developed HF model of the inductor is shown in figure 4. In figure 4, C_p is the parasitic capacitance. The simulated impedance of the HF model of the inductor is shown in Fig. 3 and the parameters values of the circuit model are reported in Table 2

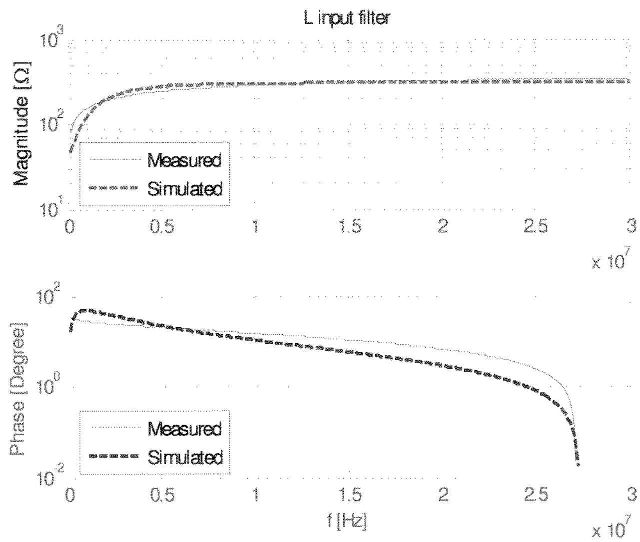

Fig. 3 – Measured and simulated HF impedance of bead inductor.

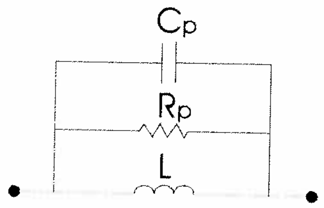

Fig. 4 – High Frequency circuit model of the nanocrystalline bead inductor.

Table 2 – Parameters of the inductor HF model

Parameter	**Value**
L	22.1940
R_p	331.271
C_p	1.5302 pF

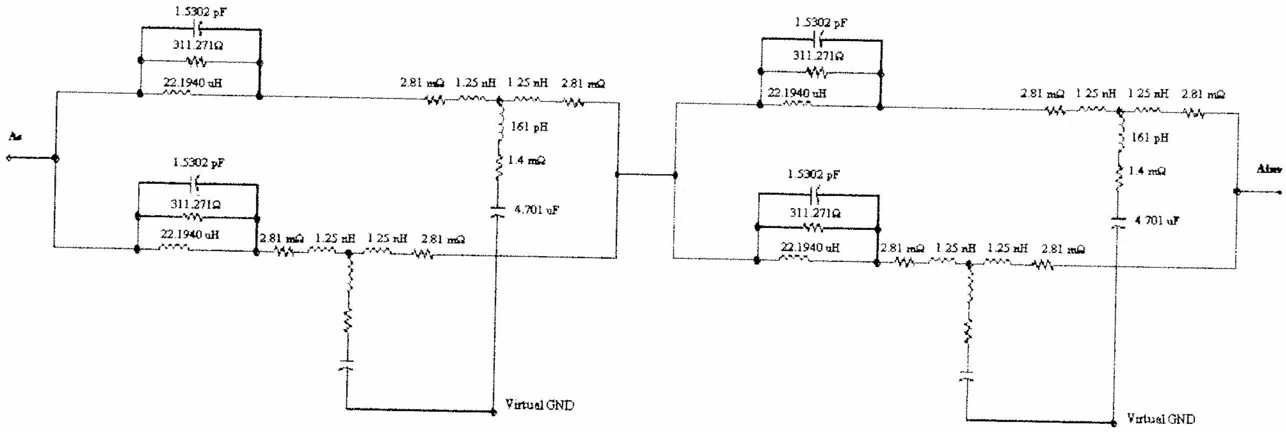

Fig. 5 –High Frequency Model of one phase of the DM Input Filter of the matrix converter.

Figure 5 shows the HF model of one phase of the DM input filter. Figure 6 shows the HF model of the EMI filter developed using Saber simulator and in figure 7 the frequency response of the filter is shown.

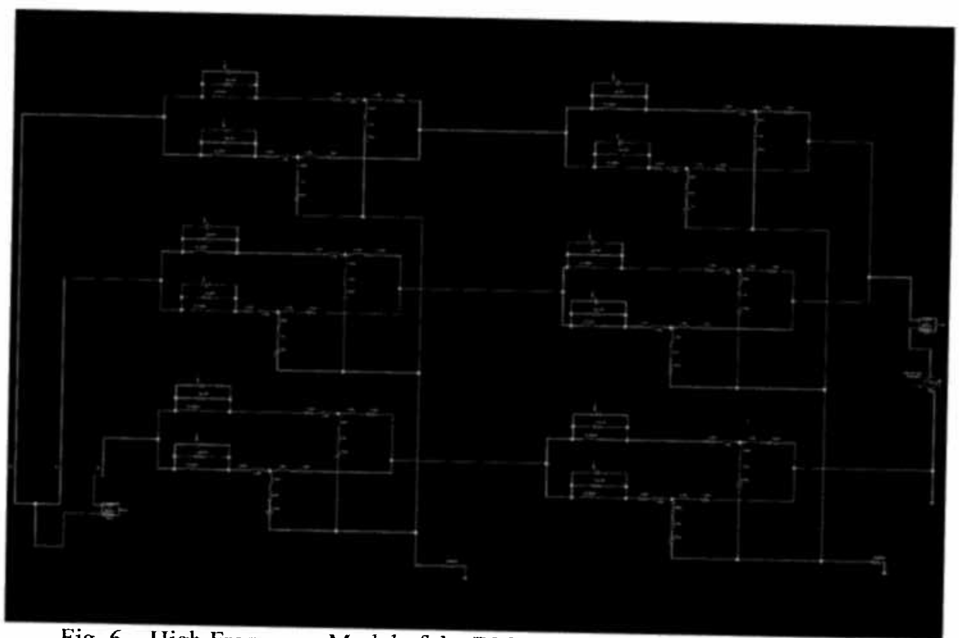

Fig. 6 – High Frequency Model of the DM Input filter using Saber Simulator.

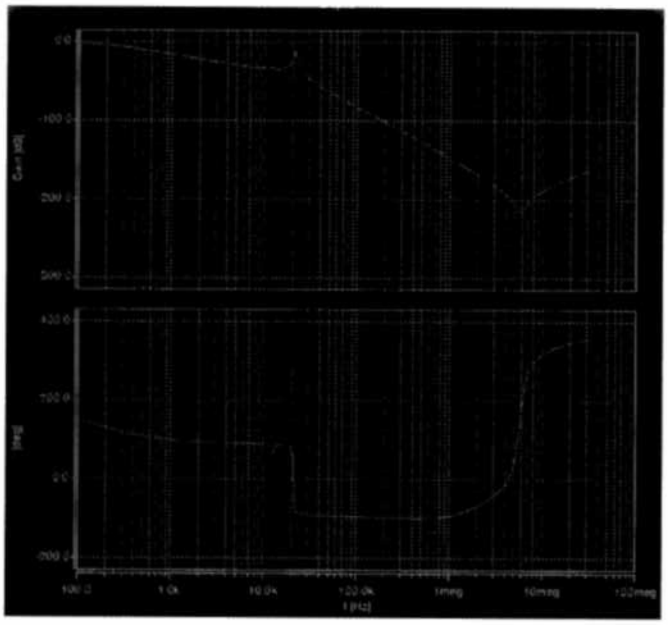

Fig. 7 – Filter frequency response: Gain [dB] (upper curve) and phase [degree] (lower curve).

Future actions

The research activity at Nottingham University, started within the Short Term Mobility program, can be continued developing the high frequency model of the output EMI filter of the matrix converter in order to obtain a complete model of the EMI filtering system of the studied matrix converter. The complete model is useful to study the combined effect of the designed input and output EMI filters and, possibly, to improve the design in terms of lightness and compactness.

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