New Efficient Filter Design for a Heat Sink

J. Kulanayagam, J. H. Hagmann, K. F. Hoffmann and S. Dickmann

Helmut-Schmidt-University / University of the Federal Armed Forces Hamburg
Holstenhofweg 85, 22043 Hamburg (Germany)
Phone: +49 40 6541 2587, Fax number: +49 40 6541 2018
E-mail: **Kulanayagam@hsu-hh.de, Johannes.Hagmann@hsu-hh.de, Klaus.Hoffmann@hsu-hh.de, Stefan.Dickmann@hsu-hh.de**

Abstract. The heat sink design of a Switching Mode Power Supply influences the EMC of the supply. The capacitive coupling between electronic power device and the heat sink are responsible for common-mode currents in the system. These currents create EMC problems. This paper proposes a new filter design to avoid heat sink radiation. Experimental results validate the proposed filter.

Keywords

Switching Mode Power Supply, MOSFET, Heat Sink, Radiated Emission, Ferrite Core.

1. Introduction

Heat sinks are one of the main EMI sources in Switching Mode Power Supply (SMPS) due to capacitive coupling. Therefore, their shape and dimensions play a big role for the electromagnetic field radiation. Heat sinks should be well designed to ensure compliance with the EMC standards.

The heat sink current depends prevalently on a parasitic capacitance and the drain-source voltage variation. The decrease in commutation time and the increase of the insulation voltage of the power electronic components lead to an increase of the time derivative of the voltage. In consequence, the heat sink generates wide-band interference spectra [1, 2, 3].

The first part of this paper investigates the main concepts of common-mode EMI sources generated by SMPS. The second part concerns filter modelling to reduce EMI radiated emission of ungrounded heat sinks. The third part deals with an experimental setup for measuring the input impedance and the heat sink radiation.

2. EMI Sources and Electromagnetic Radiation

Power electronic semiconductors are generally mounted on heat sinks to drain the produced heat. A parasitic capacitance exists between the case of the semiconductor and the heat sink. The insulating thermal compound is the dielectric for this capacitor. It is shown as isolator 1 in Fig. 1.

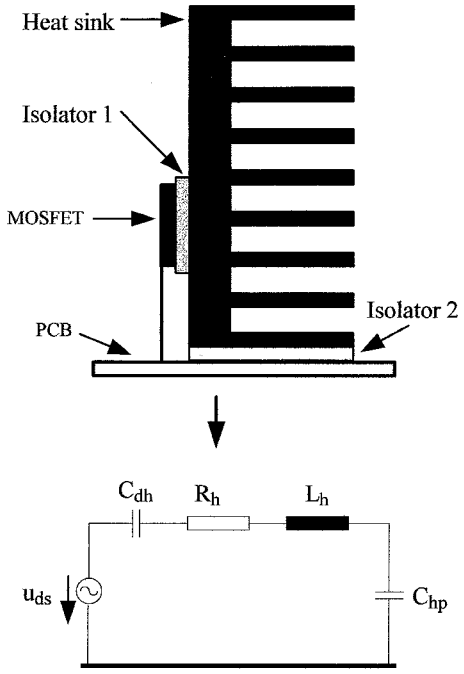

Figure 1 Schematic representation of parasitic capacitance and equivalent circuit

The typical common-mode current paths are described in [4]. If the heat sink is grounded, the common-mode currents to the SMPS increase [5]. In other words, the conducted EMI raises. If the heat sink is not grounded, the common-mode currents to the SMPS decrease, but the heat sink can become a highly efficient antenna emission when EMI resonant phenomena occur. The common-mode current paths are shown in Fig. 2.

The current path i_c via C_{hg} and ground represents the common-mode current and the current path i_h via C_{hp} and the PCB is the heat sink current. The common-mode current i_c produces conducted EMI, while i_h generates radiated EMI via the heat sink as an antenna. These currents can be calculated according to the following equation as a first approach for low frequencies

$$i_h(t) + i_c(t) = C_{dh} \cdot \frac{\mathrm{d}u_{ds}(t)}{\mathrm{d}t}. \qquad (1)$$