The Effect of Feeding Point on Electromagnetic Emission Due to Heat Sink

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Abstract— As like physical dimensions of heat sink, determining the exact location of source feeding point is quite critical step of design. Location of feeding point divides heat sinks into particular dimensions, and each one has different resonance frequency and radiation pattern. Varying radiation pattern refers to varying electromagnetic emission level. In order to control unintended electromagnetic emissions due to heat sinks, proper location of feeding point must be determined. During the investigation, heat sinks are fed through the base surface of heat sinks. Data were obtained by simulation in the frequency range of 30 MHz and 1 GHz. Dimensions of base surface of heat sink are 10 cm × 13 cm, and 4 five different feed points have been taken into account for electromagnetic emission. Near to 11 dB improvement was observed at some frequency intervals.

1. INTRODUCTION

In parallel with the development of modern technology, the power requirements of electronic devices have increased. In this context, power supplies with complex circuit structure have emerged. Switch Mode Power Supplies (SMPS) are the best examples of such power supplies because they are widely used. Located inside; MOSFET, BJT, Diode etc.. The switching speeds of the switching elements increase in parallel with the development of the technology. And this switching that occur at high speeds create heat. This heat must be removed in order for the switching elements and the integrated circuit to function properly and efficiently. Metallic heat sinks with high thermal conductivity, and/or fans are used to remove the exposed heat. In this study, metallic heat sinks were studied and examined individually. The increase of the switching speeds brings not only thermal problems but also some harmonic components in terms of electromagnetic radiation. These harmonic components are induced on the heat sink, causing the heat sink to behave like an antenna. The studies in the literature are mainly aimed at the prevention of these radiations by examining the radiation emitted by the heat sinks around them [1–4]. Various filter designs for the specified frequency range have been reduced to reduce the intensity of radiation [2]. It has been investigated for the different numbers of grounding by indicating that the radiation will be reduced by connecting the heat sink to the ground [3]. The idea that if a resistance is added between the heat sink and the ground, radiated emission would be reduced is proposed [4].

In line with this idea, it is tried to determine the most suitable resistance value by adding different resistance values between ground and heat sink. It has been stated that using the microwave absorber materials can eliminate the radiation [5, 6]. The effect of reducing the radiation is observed when covered the section between the refrigerant and the circuit with different absorber materials [6].

The connection of the heat sinks to the integrated circuit and the position of the heat sinks relative to the switching elements will show different radiation behaviour. The heat sinks are generally connected to the desired device to be cooled by the base having a flat structure. The harmonic components produced by the switching elements can be induced on different points of the heat sink. The points at which the harmonic components are induced are called feeding points. In this study, a heat sink with 11 fins of 13 cm × 10 cm × 15 mm × 8.4 cm (base length × base width × base thickness × fin depth) was selected in the transverse fin structure. In the base of the heat sink effects on the radiation were investigated by simulating 4 different feeding points.

In Section 2 operating wavelength and electromagnetic relation is investigated, in Section 3 simulation results are proposed, and in the last section discussions are given combined with suitable comments.

2. RADIATION OF HEAT SINKS

The change in physical dimensions of heat sinks has an important role in determining their behaviour in terms of electromagnetic emission, since it becomes comparable with operating wavelength. Resonance is expected to occur when any dimension of any metallic structures present on electronic units corresponds to a value between λ and $\lambda/20$ wavelengths, and heat sinks are good examples for those [7]. These kinds of emissions are not limited with metallic structures but they are also due to apertures present on any metallic enclosures [8, 9].

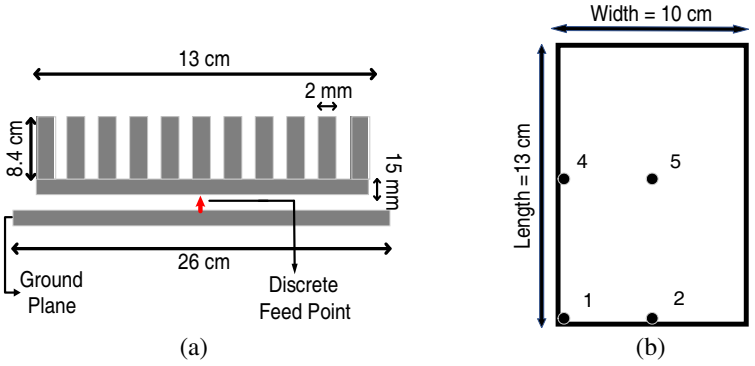


Figure 1. (a) Modelling of heat sink as a monopole antenna. (b) Different feeding points.

While the radiation of the heat sinks is investigating, they are modelled as monopole antennas because this way gives us an easier analysis [7]. As shown in Figure 1(a), the discrete feed point is positioned in the ground plane in the lower part of the heat sink and this way it is simulated as monopole antenna. For the discrete feeding, the starting point is formed by contacting the end point of the ground plane with the heatsink. The discrete feed point determined in the ground plane shows different radiation behaviour for different positions. Figure 1(b) shows four different feed points selected at the bottom of the heat sink to examine these radiation behaviours.

3. SIMULATION RESULTS

The simulations of the heatsinks were analyzed in CST Microwave Studio. SK613 heatsink model designed by Fischer Elektronik was selected. Heatsink measurements were taken as 13 cm × 10 cm × 15 mm × 8.4 cm from the heatsink datasheet and used for simulation. In the frequency range of 30 MHz to 1 GHz, a 1 watt input signal was applied to the 4 different feed points in the heatsink base shown in Figure 1(b) with the discrete port. The applied input signal was selected as Gaussian. In order to observe the effect of feed points on the radiation, separate simulations were performed in Figure 2.

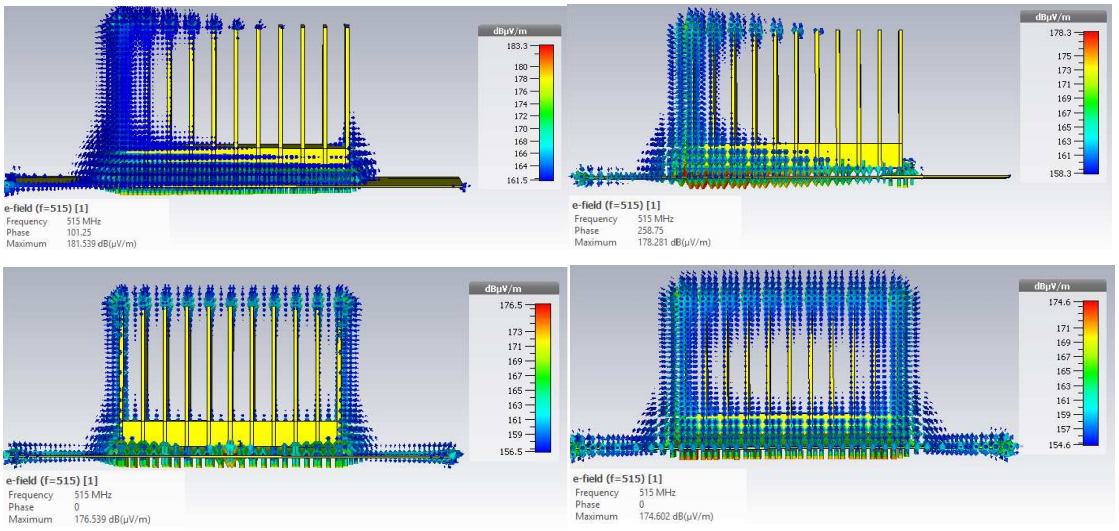


Figure 2. *E*-Field lines induced by the heatsink at the feed points 1, 2, 4, 5 respectively from the top left.

The stimulation of the heatsinks with four different feed points resulted in different E-Field induction in each case. Figure 2 shows the visualization of these inductions in the simulation environment. In far field area irradiation, each feed point has different radiation patterns. The radiation patterns obtained in Figure 3 were shown.

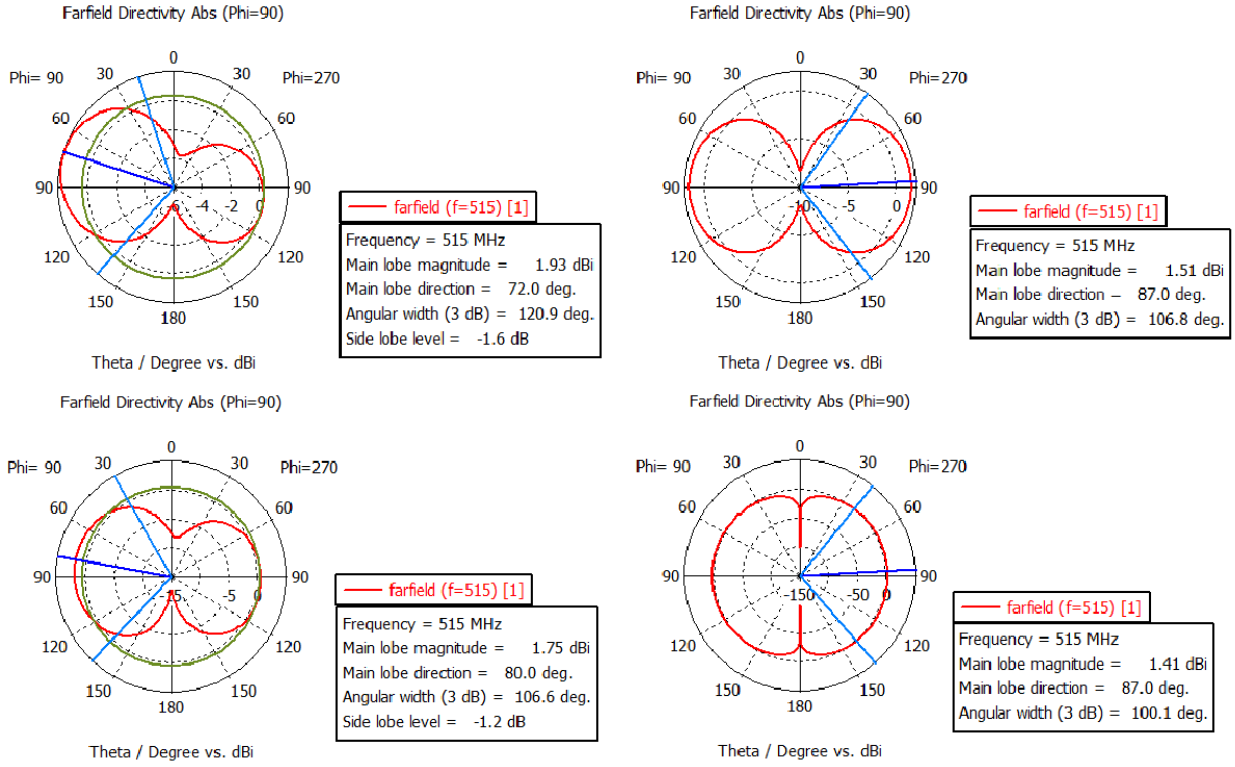


Figure 3. Phi = 90° constant, radiation patterns of feed points 1, 2, 4, 5 respectively from the top left.

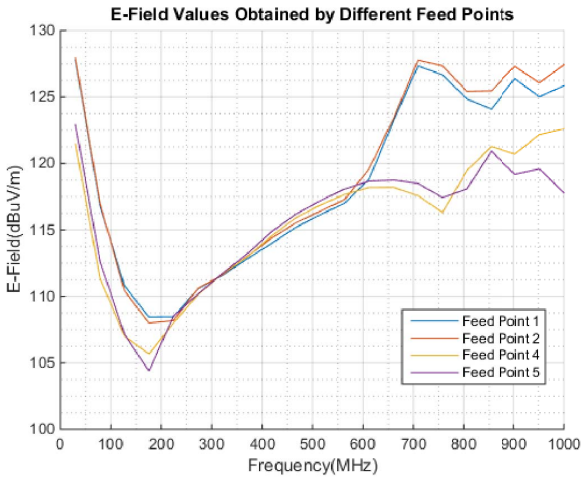


Figure 4. E-field effect of 5 different feed points in far field.

If the graph of Figure 2 is examined, it is observed that the feed points 1 and 2 at 30 MHz are the same but they have more than 7.5 and 10 dBuV radiate respectively according to the feed points 5 and 4 respectively. Between 30 MHz and 230 MHz frequencies, the highest radiation values were found to be 1 and 2 feed points. The radiation values of all the feed points in the 230 MHz to 600 MHz range remained approximately the same. Considering the feed points shown in Figure 1(b) in the 600 to 1000 MHz range, it was concluded that the feeding point 5 had less radiation in the range of 2.5 dBuV to 11 dBuV compared to the other feed points. In the frequency range of 600 MHz

to 750 MHz, the radiation effect of the feed point 4 was interpreted by means of the data in the graph, which was 1 dBuV better than the feed point 5, as well as this situation did not persist when the frequency of 1000 MHz was advanced. Generally speaking, the worst behavior in terms of radiation in the 30 MHz to 1 GHz range indicated the number 2 feed point.

4. CONCLUSIONS

The heatsink was simulated for 4 different feed points in the frequency range of 30 MHz to 1 GHz. The results obtained from these simulations were compared on the same graph and compared with each other. In the frequency range 230 MHz to 600 MHz, the radiation behavior of all the feed points is approximately the same. In the 600 MHz to 1000 MHz range, the feed points of the number 5 was found to be less than 2.5 dBuV to 11 dBuV compared to other feed points. If it is generally observed in the frequency range of 30 MHz to 1 GHz, it is concluded that the feed point 2 has the worst radiation values compared to the other feed points.

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