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EMI suppression in heat sinks

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ABSTRACT

Heat sinks are designed to dissipate heat; however, their shapes often lend themselves to radiating electromagnetic energy, which leads to unwanted electromagnetic interference (EMI). This disclosure describes heat sinks that minimize electromagnetic interference at particular design frequencies.

KEYWORDS

- Heat sinks
- Electromagnetic interference (EMI)
- EMI suppression
- Resonant frequencies

BACKGROUND

Heat sinks are designed to dissipate heat; however, their shapes often lend themselves to radiating electromagnetic energy at particular (resonant) frequencies, which leads to unwanted electromagnetic interference (EMI). Effectively, the heat sink acts as an antenna, absorbing electromagnetic energy from the equipment it is attached to and re-radiating it.

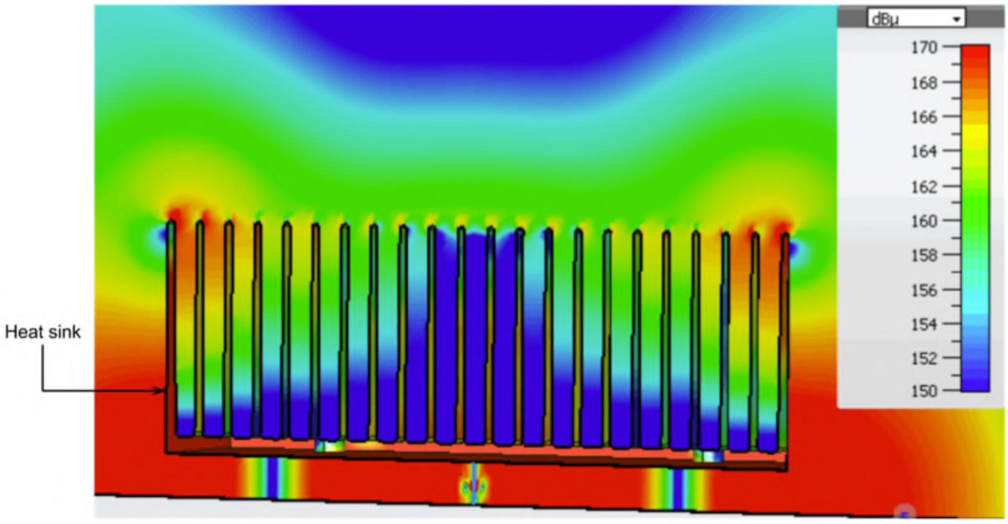


Fig. 1: Example of unintentional electromagnetic radiation around a heat sink. Colors indicate radiation intensity, with red being the most intense and blue being the least intense

Fig. 1 illustrates the pattern of unintentional radiation around a heat sink at the dominant EMI frequency. The high field intensity (red or green) around the heat sink is widespread in nearly all directions. Depending on the heat sink geometry and the electromagnetic spectrum generated by the package underneath the heat sink, heat-sink radiation can dominate the total radiated emissions. In this context, the heat sink can be for a power supply, a switch, a CPU, or any component that dissipates large amounts of heat. The radiation from the heat sink can couple to other parts of the system, e.g., power or I/O cables, cable harnesses, flex PCBs, etc., and bypass surface mounted filters designed to reduce the EMI.

Traditionally, EMI from heat sinks is reduced by grounding the heat sinks to the PCB or by shielding the package under the heat sink. Neither technique is easy from a design or implementation standpoint. For example, at frequencies greater than 1 GHz, grounding the heat sink at a few discrete locations is ineffective and may actually increase unintentional radiation. Shielding the package under the heat sink increases the cost, size, and complexity of the package, additionally requiring more package ground connections. Using a conductive gasket to continuously ground the heat sink to the PCB is a somewhat more effective way to suppress EMI. However, this solution requires a dedicated ground area under the heat sink and can complicate routing to the package under the heat sink.

DESCRIPTION

This disclosure describes heat sink geometries that suppress EMI at frequencies of interest, obviating both EMI shields and ground connections from the heat sink to the PCB. The reduction in EMI is achieved without significant loss in thermal performance.

The techniques suppress EMI by changing the geometry of the base of the heat sink. At high frequencies, the base of the heat sink serves as a three-dimensional transmission line (waveguide). By shaping the heat-sink base geometry, certain distributed inductances and capacitances to ground develop that serve to suppress electromagnetic propagation.

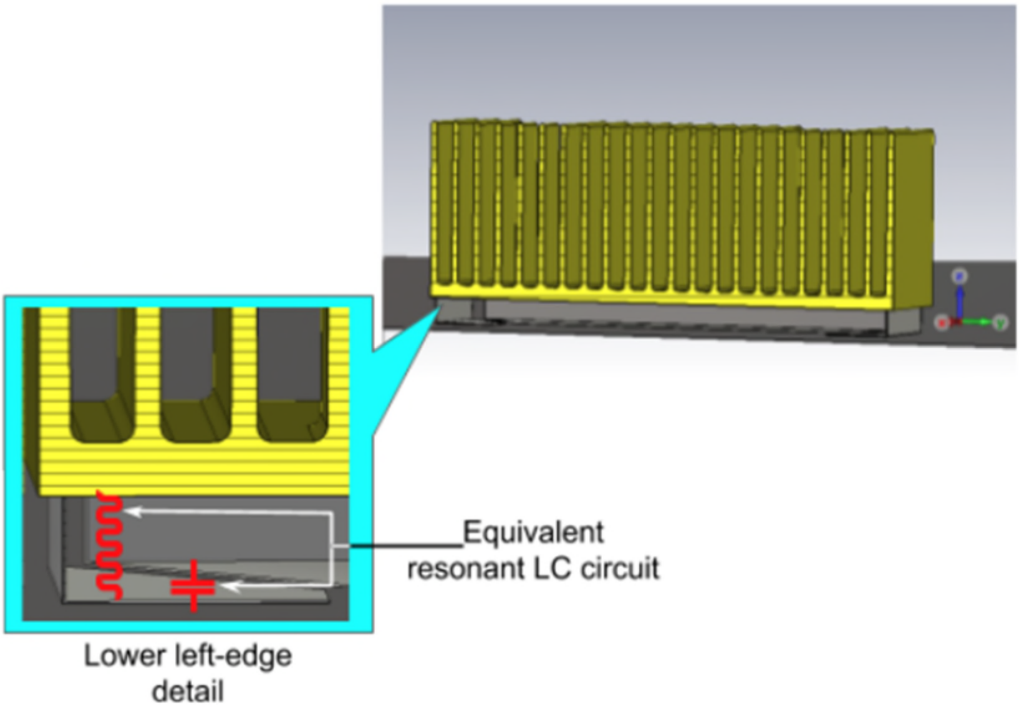


Fig. 2: Heat sink geometry that reduces EMI

Fig. 2 illustrates a heat sink geometry that reduces EMI, per techniques of this disclosure. The detail shows an L-shaped structure at the base of the heat sink, which is equivalent to a distributed, resonant LC circuit. The distributed LC circuit, which comprises a distributed inductance (L) and a distributed capacitance (C) grounds EMI at its frequencies of resonance. Effectively, EMI at particular design frequencies, e.g., those emitted by the equipment that the heat sink is attached to, is filtered out. The geometrical parameters of the L-shaped structure depend on the dominant frequencies emitted by equipment that the heat sink is attached to.

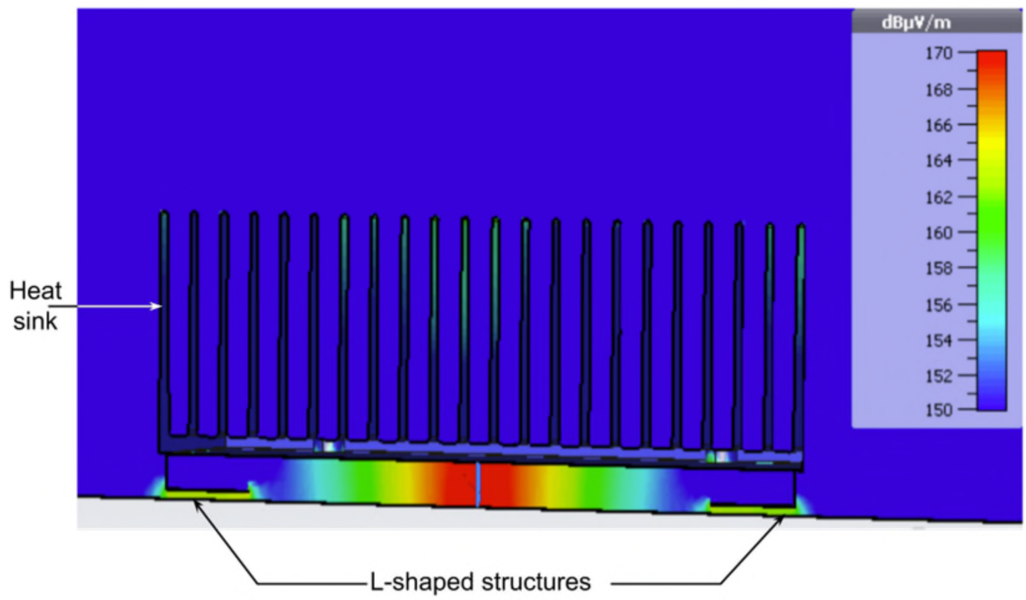
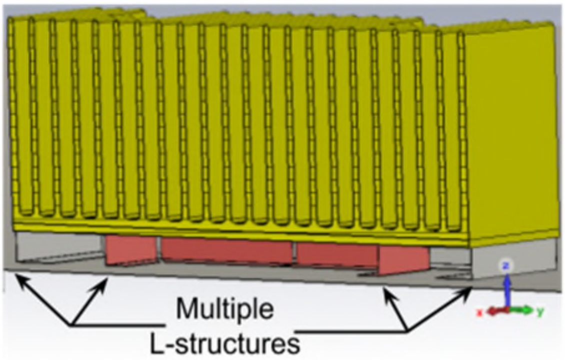
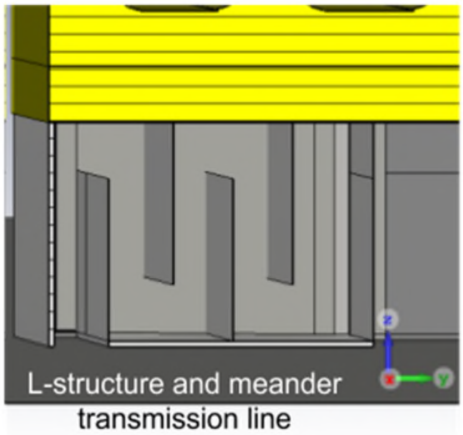


Fig. 3: Radiation pattern around a heat sink after the appending of L-shaped EMI-suppression structures (compare with Fig. 1)

Fig. 3 illustrates the pattern of unwanted radiation around a heat sink at the dominant EMI frequency, after appending the L-shaped EMI-suppression structures described herein. Comparing with Fig. 1, it is seen that the level of unwanted radiation is significantly lower in most directions. Residual high-intensity radiation is confined to a relatively small space, colored red, between the heat sink and the equipment it is attached to.

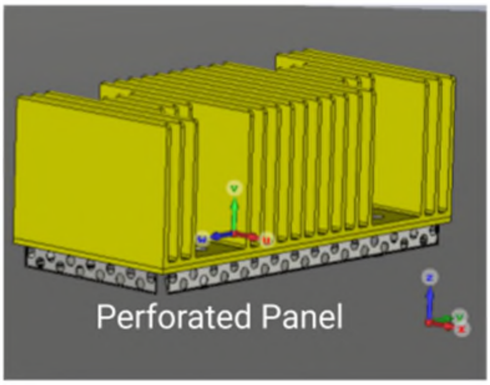


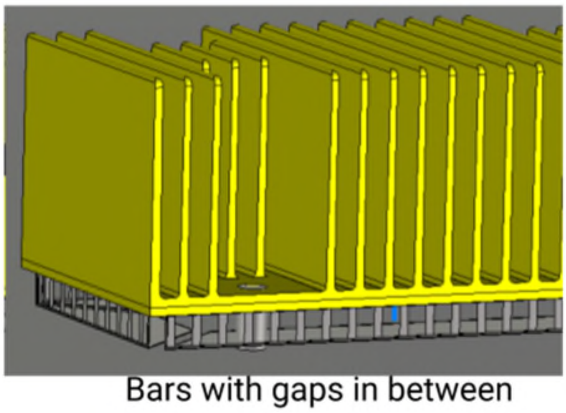


(a) (b)

Fig. 4: Examples of EMI-suppression structures (a) multiple L-structures (b) L-structure and meander transmission line

Fig. 4 illustrates other examples of EMI-structures. Fig. 4(a) illustrates multiple L-structures at the base of a heat sink, which can filter out multiple targeted frequencies. Each constituent L-structure has its geometric parameters optimized to filter out a targeted EMI frequency. Fig 4(b) illustrates an L-structure followed by a meander (or labyrinthine) transmission line, which filters out EMI at targeted frequencies that are a function of its length and baffle-spacing. The L-structure and meander transmission line has a somewhat broader frequency-suppression bandwidth.





(a) (b)

Fig. 5: EMI-suppression structures with provision for enhanced airflow

Fig. 5 illustrates EMI-suppression structures with provision for enhanced airflow, e.g., a perforated panel (Fig. 5a), and bars with in-between gaps (Fig. 5b), both at the base of the heat sink.

CONCLUSION

This disclosure describes heat sinks that not only dissipate heat efficiently but also minimize electromagnetic interference at particular design frequencies.

REFERENCES

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