X2Y® Heatsink EMI Reduction Solution

Summary

Many OEM's have EMI problems caused by fast switching gates of IC devices. For end products sold to consumers, products must meet FCC Class B regulations for radiated emissions. As IC fabrication densities and processing speed increase according to Moore's Law, electromagnetic radiation has become increasingly more difficult to control.

This application note is a suggested solution for reducing EMI noise from heatsinks attached to microprocessors and other packaged devices using X2Y® components.

The Problem

Before looking at the X2Y® solution, let's take a closer looks at the issues involved.

Issue #1

"Motherboards with fast processors will generate high frequency E and H fields from currents and voltages present in the component silicon and signal traces"[1]. TThese fields are generated when a time element (switching rate) is involved in conjunction with the parasitic inductance of conductors such as wires, traces or planes, which carry current in a system (di/dt).

Issue #2

A typical heatsink design involves an insulating material that is used to bond the heatsink structure to the device package. If the microprocessor and the heatsink have different voltage potentials (dv/dt), the insulating material acts like a dielectric which combines to form a capacitor (Figure 1). "Parasitic" coupling (Cp) between the heatsink and device package allows current propagation (di/dt) which results in the heatsink becoming a radiating antenna.

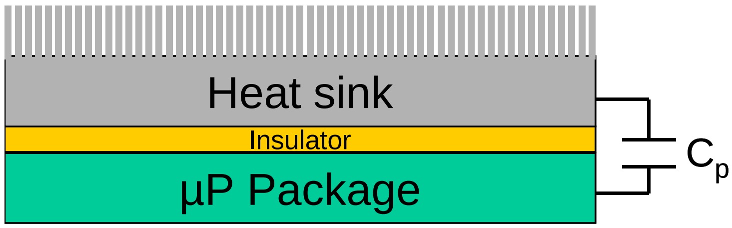

Figure 1. *Heatsink is shown with parasitic coupling*.

Current EMI Reduction Solutions

There are a variety of ways to reduce the radiated emissions. One technique involves *total containment* of the emissions by an encapsulating structure such as a Faraday cage[2]. With this technique, electromagnetic interference (EMI) is contained within the cage structure and cannot escape to the outside world (*left* Figure 2).

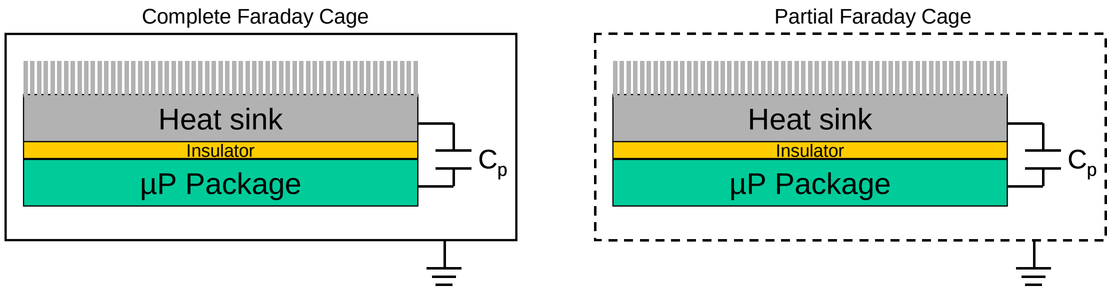

Figure 2. *A Faraday cage can be used to contain radiated emissions*.

A ‘complete’ Faraday cage is optimal but not always practical due to design limitations and cost. In some instances a complete cage is not necessary to meet compliance. The solution is often a combination of mechanical structures that form a ‘quasi-Faraday cage’ (*right* Figure 2). An example of this would be: *the heatsink+ the board ground layer + a grounding frame = Faraday cage*.

Another solution is to *decouple* the microprocessor from the heatsink with capacitance. Decoupling is “an element that is a loss-less path for direct current and infinite impedance for alternating current. This element allows devices to be powered with no loss and prevents any noise from moving from one load to the next”[3]. This technique requires a large numbers of capacitors (bulk, high frequency ceramics) that are placed in parallel to the switching IC (µP) to provide enough local energy supply to mitigate the di/dt transients. This reduces the magnitude of the changing voltage waveform and the corresponding current through the “parasitic” capacitance.

Parasitics inductance inherent to standard capacitor structures and interconnects used to make the connection between the power source and load, combine to reduce decoupling effectiveness and limit this technique.

X2Y® Heatsink Solution

EMI problems with heatsinks are similar to EMI problems with DC motors. Figure 3 illustrates the comparison and outlines circuit similarities.

DC Motor Circuit

- **Active switching device (motor)**
- **Parasitic capacitance from windings to motor housing**
- **Ground plane is represented by motor housing**
- **Motor housing can either float or be grounded**
- **Full or partially enclosed**

Heatsink/µP circuit

- **Active switching device (microprocessor)**
- **Parasitic capacitance from package to heat sink**
- **Ground plane is represented by heatsink**
- **Heatsink can either float or be grounded**
- **Full or partially enclosed**

DC Motor | Heatsink/µP

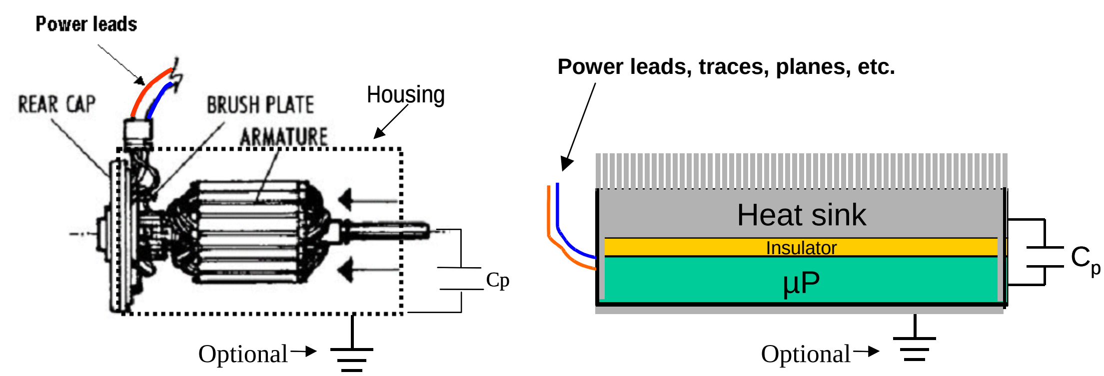

Figure 3. *DC motors and heatsink applications generate EMI for similar reasons.*

X2Y® is currently solving problems for the automotive industry by reducing EMI in DC motors to meet the industry's stringent, self-imposed EMC regulations. The X2Y® circuit is used to reduce the RF noise from DC motors so that EMI does not affect the other electronic circuitry in automobiles.

How Does X2Y® Reduce EMI?

The internal structure of X2Y® reduces the parasitics associated with standard capacitors. X2Y® eliminates the DC motor noise by canceling the opposing voltage waveforms present on the power leads. If noise is already present on the leads, opposing noise currents cancel within the component. This cancellation promotes fast switching within the X2Y® component structure. The combination of fast switching, cancellation, and reduced parasitics significantly reduces the need for capacitance and results in broadband frequency decoupling performance with a single X2Y® component.

An important feature of this cancellation process for both applications is no requirement to be grounded. The reason that grounding is not necessary is similar to reasons outlined by Ott[4]; a nearby conducting plane (in this case, the motor housing or heatsink, Figure 4) will have an equivalent image of the differential and common mode currents that flows in opposition. A proper low impedance attachment of the X2Y®component will provide broadband cancellation of these currents and significantly reduces the radiated emissions. Therefore the X2Y®solution provides the flexibility to either float or ground the heatsink. This would be an ideal benefit in situations where grounding the heatsink is not possible.

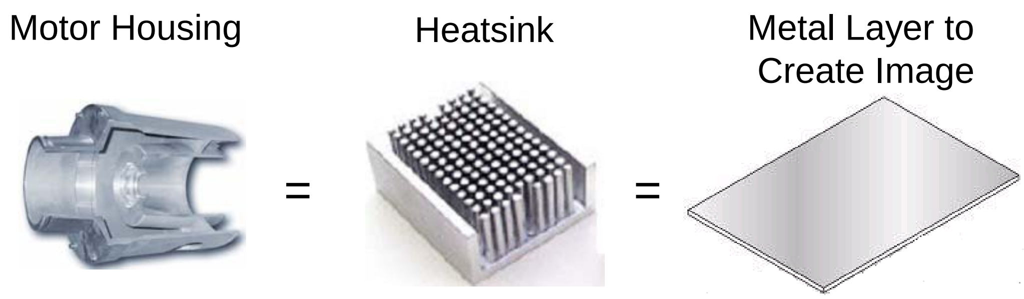

Figure 4. *Motor Housing, Heatsink, or Metal Layer are conductive and can be thought of as an Image Plane.*

X2Y® Application

The implementation of the X2Y®component in each circuit (Figure 5) would be the same. An X2Y® component attachment should have the shortest leads possible to the power and return leads. The X2Y® G1/G2 terminations would also have a low inductance connection to the heatsink/ground frame structure. Proper connection allows X2Y® to cancel noise internal to the device, rather than provide a traditional short to ground (shunt).

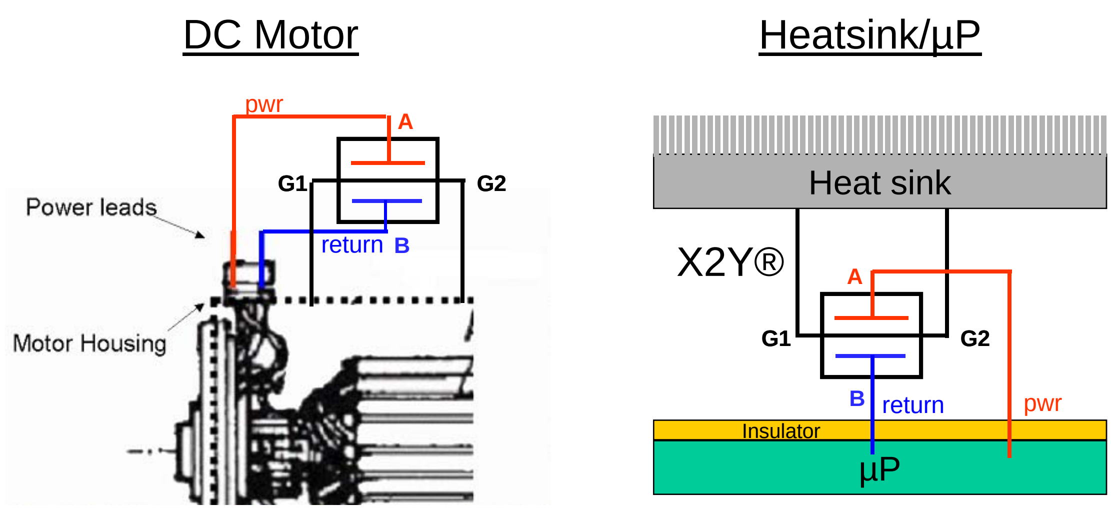

Figure 5. *X2Y® attachment concept. Note: Picture does not depict actual attachment.*

Conclusion

The use of heatsinks continues to increase as more and more active devices are used in the PCB environment. X2Y® represents a new approach to the problem of EMI reduction for EMC compliance. The X2Y® solution requires minimal overall changes to a product's design, which offers a cost effective solution.

Note: Performance results reported in this and other application notes can only be achieved with patented X2Y® components sourced from X2Y® licensed manufacturers or their authorized distribution channels.

References

[1] "Intel® Pentium® 4 Processor in the 423-pin package EMI Guideline". Hhttp://www.Intel.com/design/pentium4/guides/24923401.pdfH.

[2] "Assembly & Packaging Power, EMI and Thermal Management in One Unit". John Baliga, Associate Editor, Semiconductor International.

[3] Glencoe/McGraw-Hill's, Electronic GOTCHAS EXPOSED, http://www.glencoe.com/ps/ee/williamson/index.html.

[4] German,Robert F, Ott, Henry W., and Paul, Clayton R., "Effect of an Image Plane on Printed Circuit Board Radiation" IEEE International Symposium on Electromagnetic Compatibility, Washington, D.C., August 21-23, 1990 Hhttp://www.hottconsultants.com/pdf_files/image_plane.pdfH.

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