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The Use of Absorbers in Electronics

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Background

The trending small size of electronic devices coupled with higher data speeds, there is a merging of the increasing physical closeness among components and the shrinking wavelengths associated with higher speeds. As wavelengths shrink, they approach the physical dimensions of components and devices which results in increased "antenna effect" of noise. So, it is becoming increasingly critical to prevent coupling of noise to these objects that can radiate and/or to reduce the coupled field levels, since it is becoming more difficult to shield products in a cost efficient manner at higher frequencies.

Also, smaller wavelengths can approach the physical dimensions of many EUTs which leads to possible cavity resonance effects. The resonant frequency is the frequency where integer half-wavelengths correspond to the dimension of the enclosure. A wave is set up inside the enclosure whose nodes (i.e. zero amplitude) lie on the conductive walls of the enclosure. These structures behave as cavity resonators. A 2-inch square by ½-inch metallic enclosure resonates at a first order mode of around 12 GHz. Even weak coupling at these extremely high frequencies can induce strong oscillations than can then couple to any other points in the enclosure or can radiate. The danger of a cavity resonance is that if a noise source has a frequency component that corresponds to a resonant point, then a large field can be generated at this frequency due to the multiplication or amplification effect by the "Q-factor". One approach to reduce this phenomenon is to lower the "Q-factor" of the cavity by introducing losses (Q-dampening).

Reduce PCB Edge Fringing on PCB

When proper PCB layout design techniques such as trace routing, stack-up assignment, decoupling and bypassing, termination, are implemented, the radiation from the printed circuit board itself can be minimized. However, there are several other mechanisms of the printed circuit board assembly remaining that can still be radiation sources. These are the components themselves, cavity resonance effects of the power/signal return layers, and the edges of the printed circuit board. Edge effects can be particularly burdensome since it is the board edges that are in such close proximity to the chassis and hence these radiation fields can induce currents into the chassis frame.

There are numerous studies that discuss various approaches or techniques pertaining to reducing radiation edge effects from the printed circuit board such as proper termination. One problem with these techniques is that they can require the use of additional components and valuable PCB real estate, and often do not actually reduce the energy. Rather these common approaches allow the energy to be reflected, potentially creating additional internal resonant effects and coupling to internal vias which can result in increased radiation.

The use of microwave absorbing material applied along the edge of the printed circuit board reduces the edge radiation from the board without using additional board real estate. The absorber also reduces the possibility of board resonance problems by dissipating the energy and not reflecting the energy back into the interior of the board. This can be attached to the edge of the board using a U-channel.

Reduce PCB Trace Radiation

Placing absorber material directly on top of microstrip traces reduces the fields emanating from the top side of the traces. This can be a particularly troublesome coupling mechanism if the traces are located on the bottom side of the board laying adjacent to the bottom of the enclosure. The coupling of the field to the chassis will cause currents to flow into the chassis and set up circulating currents within it. These circulating currents can then cause radiation from any slots, seams or apertures in their path. Placing absorber with PSA on the traces reduces the field coupling to the chassis. The effect on the trace impedance is minimal since the absorber material is high impedance (> 10 kohm). It can also be conveniently placed directly on top of the trace without any additional mounting or mechanical fastening mechanisms. This approach was used on a switch box and produced about 4-6 dB reduction in radiated emissions at 6 GHz.

Reducing Cavity Resonance Effects

A six-sided conductive enclosure or cavity can support electromagnetic resonance. Its coupling is a consequence of self-resonance of various structures such as slots in the PCB, metallic enclosures, slots between the PCB and the metallic enclosure. However, small size enclosures such as a GBIC module or a board shields with a single PCB and/or containing only a few components will appear as more of a true resonant cavity since most of the volume will be empty space (i.e. air). The danger of a resonance is that if a noise source has a frequency component that corresponds to a resonant point, then a large field can be generated at this frequency due to the multiplication or amplification effect by the “Q-factor”. One approach to reduce this phenomenon is that the “Q-factor” of the cavity must be lowered by introducing losses (Q-dampening). The absorber material acts as a resistive load in the cavity. Today we see shielding more and more as a multilevel concept. Board shields will handle the lower frequencies, and an internal layer of microwave absorbing material will handle the higher frequency components. Absorbers are a viable option for handling these higher frequency resonant frequency issues. Absorbers work most efficiently at higher frequencies (i.e.>1 GHz) although work is continuing to keep reducing the low frequency end of these types of materials.

Absorbers reduce radiation or “shield” by literally absorbing the energy and converting it to heat and reducing the Q factor in a cavity. Using absorber material is convenient because it converts the electromagnetic energy, it does not have to be “grounded.” As long as the absorber material intercepts or is in the field path, then it will reduce the electromagnetic energy of the field. A secondary effect of adding absorbing material inside the cavity is that it will change the effective permittivity of the cavity depending upon the amount of material added. As the volume of material becomes a more significant percentage of the interior volume, the more effect on the combined permittivity. By changing the effective permittivity, one can cause a shift in the location of the resonant frequency. This technique was used a switch box design and resulted in about a 6 dB reduction at 8.5 GHz.

Reduce Heatsink Radiation

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Generally, the heatsink is physically and electrically larger than the high frequency chip device and so it is an efficient radiator. No matter how well the signals are routed on the printed circuit board, if the chip's currents are parasitically coupled onto the heatsink, radiated emission will occur. The fin of the heatsink acts as a monopole antenna structure with then the total fin array acting as an antenna array. Depending on overall shielding enclosure effect or heatsink resonance effect, these emissions may or may not exceed regulatory limits. The most common practice for controlling this heatsink radiated emission is to "ground" the heatsink to the PCBs reference ground.

As frequencies rise, the size of the heatsink becomes electrically larger and even of a more efficient radiator. Therefore, any grounding scheme for the heatsink must therefore also be designed to be effective at these higher frequencies. The contact between the heatsink and the reference ground of the printed circuit will have inductance and it must be low impedance. In general, the greater number of contacts used, the lower the impedance, and the more effective in reducing the radiated emissions. In general, grounding of the heatsink does not reduce the radiated emissions effectively at high frequencies above 1 GHz. Therefore, at these frequencies above 1 GHz, other approaches must be considered. To improve the grounding at higher frequencies, we must have contacts points closer than $\lambda/20$ to be effective. In other words, continuous grounding of the heatsink through an elastomeric conductive gasket to a continuous reference ground traces surrounding the heatsink. However, not only does this still require quite a bit of board real estate, but it has been shown to not reduce radiated emissions all that effectively above 10 GHz. The use of absorber material to reduce the surface currents flowing on the heatsink and hence reducing the radiating effect of the heatsink, has been shown to be effective. Using absorber reduces the potential radiated emissions by reducing the surface currents that flow on the fins of the heatsink. Studies indicate that the absorber will also reduce radiated emissions by being placed directly underneath the heatsink, between it and the printed circuit board.

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