The Role of Component Packaging in System Electromagnetic Compatibility

Todd Hubing
University of Missouri-Rolla
Rolla, MO 65401

Abstract

Increases in the speed and density of electronic systems do not necessarily result in tougher electromagnetic compatibility problems. In fact, recent advances in packaging technology can help designers to meet electromagnetic compatibility requirements. However, working with new technologies requires us to re-evaluate existing EMC design models and guidelines. Understanding the system-level impact of component-level packaging changes, is a prerequisite for meeting stringent electromagnetic compatibility requirements in a timely and cost-effective manner.

Electromagnetic Compatibility

High speed electronic systems generate electromagnetic fields that are capable of interfering with licensed radio transmitters and with the proper operation of other electronic systems. Natural electromagnetic phenomena such as lightning and electrostatic discharge can also interfere with or damage electronic systems. As systems grow in complexity and speed, the developers of electronic products are finding it necessary to devote much more attention to EMC concerns early in the design cycle.

Numerical electromagnetic modeling tools are playing an important role in the effort to anticipate EMC problems before they occur, but these tools are rarely used to model specific products. Instead, numerical models help EMC engineers to understand the behavior of more generalized structures. These models help to evaluate the impact that basic technology changes will have on EMC.

Impact of Changes in Technology

The electronic circuits in products being developed today look much different than the circuits in products sold just a few years ago. More function is being packed into a smaller space, power consumption per gate is dropping, and clock speeds are increasing. Programmable logic and custom VLSI components have become standard tools of the trade. Pin-in-hole components, two-sided boards, and discrete logic devices are becoming less commonplace.

What effect have these changes had on circuit or system electromagnetic compatibility? A quick overview of some of the more significant aspects of modern high-speed circuit designs and their impact on system electromagnetic compatibility is provided in the table on the following page.

In general, the benefits of each technology change in the table outweighs the drawbacks. Thus today it is possible to design complex systems that meet EMC requirements, are more reliable, and cost less than similar systems developed a few years ago. However each technology change has resulted in a new set of EMC concerns and new EMC design rules. For example, the multiple power and ground pins in VLSI components with ball-grid arrays permit these devices to draw current from the power bus much faster than traditional decoupling capacitors can replace it. Changes in the way components are connected to the power bus must be accompanied by changes in the way the bus is decoupled. Guidelines concerning the selection, placement, size, and value of components as well as changes in the placement, orientation, and width of traces depend on the packaging technologies used on the board.

0-7803-2411-0/94/$4.00 ©1994 IEEE

Trends

Traditionally, the most difficult radiated emission problems have occurred in the 30 MHz - 500 MHz frequency range. This is the range of frequencies where external cable and product enclosure resonances usually occur. As clock speeds continue to climb, problems at frequencies where individual circuits and boards resonate are becoming more common.

Signal integrity concerns are causing most high speed circuit designers to be more careful about how their designs are implemented. Microstrip circuits, guard traces, and striplines are widely used. The importance of a solid, non-gapped, ground plane is being recognized. Designers have begun to realize that the radio frequency behavior of their circuits can not be left to chance.

In the past, radiated emissions and signal integrity were often considered to be separate, independent issues. Signal integrity was addressed by the circuit designer, based on a knowledge of circuit and transmission line theory and guided by component manufacturers specifications. Radiated emissions were addressed by the EMC engineer guided largely by experience, design guidelines, and a few limited modeling tools. Current changes in circuit technology are forcing radiated emissions and signal integrity to be considered simultaneously, often by the same people using the same tools.

Technology	Positive Impact	Negative Impact
Surface Mount Technology	More compact circuits, less parasitic inductance and capacitance, less efficient radiation source	Higher component density, crosstalk between traces
Faster Components	Signal integrity concerns have forced designers to use better RF design techniques.	Most radiation and crosstalk quantities (for a given geometry) scale directly with frequency.
Multilayer Boards	Microstrip and stripline circuits are possible, presence of a reference ground plane makes it easier to control crosstalk and radiation.	Low-impedance power bus can make it easier to couple noise between circuits.
VLSI Components and MCM's	More function contained in a small space, less chance of coupling noise to the outside world	Boards are more complex and dense. Tight pin spacing can create coupling problems for external signals.
Pin Grid Arrays, Ball Grid Arrays	More function contained on a single chip, multiple ground pins	Multiple power pins allow components to draw power more efficiently and effective decoupling is more difficult to achieve.
Logic with Controlled Risetimes	Lower amplitude upper harmonics	Limited application
High-Capacitance Boards	Improved decoupling	Higher amplitude signal harmonics, expensive