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Article

Multi Chip Modules (MCM), Miniaturization meets Reliability and Optimum Performance

Author: Robert Costa, C&D Technologies Power Electronics Division

Multi-Chip Modules (MCMs) are often times referred to as Hybrids or Chip and Wire Technology. This technology enables customers to reduce their board size compared to building a discrete solution that may require hundreds of components. In parallel, an MCM solution provides increased reliability and optimum circuit performance.

In addition to these functional advantages, further benefits for MCM users include reduced product assembly times with lower defect rates, as well as greatly reduced procurement and inventory management overheads.

Perhaps even more importantly, buying a MCM will shorten the design cycle time of the final product, which will translate into huge savings and enable the design engineer to spend more time on improving the performance of the end product.

Introduction

Where complete integration into a System on Chip (SoC) is not possible for practical or economic reasons, MCM technology often enables a convenient, low-footprint solution. The alternative for designers is to seek a discrete solution comprising two or more monolithic ICs and their associated external components.

At first sight, the discrete solution may appear to offer a lower cost. But engineers need to look beyond the bill of materials to understand the true value in a MCM. Many of the costs associated with bringing up a discrete system are not obvious at the outset. In extreme cases, or where system integration presents particularly difficult challenges such as analog signal management issues, designers may pay the ultimate price – non-delivery of the end product.

This presentation examines important factors that contribute to the overall cost of designing a system, showing how MCM technology absorbs many of these to deliver a more cost-effective solution than many engineers realize.

High-Performance Multi-Chip Module

There are many solutions and manifestations of Multi-Chip Module technology, but fundamentally a MCM combines two or more bare die or maybe chip-scale packages on a single substrate, as well as additional passive or active components as necessary to meet the MCM functional requirements. Alongside chip capacitors or resistors, these may also include magnetics or other specialist devices. The substrate supports the interconnections between devices, and may be a small laminated PCB or a ceramic material such as a Low-Temperature Co-fired Ceramic (LTCC). Automatic pick and place equipment is typically used to place the components on the substrate. A variety of mounting technologies may be used, including wire bonding, flip-chip or TAB bonding.

MCM technology enables a miniaturized solution by using components in die form, eliminating most of the package overheads associated with a discrete solution. The dice can be closely spaced on the substrate, allowing a higher component count within a small footprint.

Reliability is also improved over a discrete solution comprising individually packaged ICs and their supporting components. The removal of IC packaging eliminates many of the joins and structures used to connect various pads on the die to the device pins, thereby removing many potential points of failure. The process variability of surface mount assembly is also eliminated. MCM assembly processes are proven to be robust and reliable, and typically include thick film on ceramic substrates, die-attach, wire bond and seam sealing processes. In addition, military screening may be performed to further qualify the products.

Reliability at the board level is also improved, because one MCM replaces multiple discrete, passive and active components that otherwise are used individually as separate parts. It is also important to note that significant costs are associated with designing separate discrete passive and active components onto a PC board as individual parts. For instance, costs are incurred in procuring and managing components, dealing with lot-to-lot variability, and additional design complexity. The effects of assembly overheads including the time to build each unit and the extra challenges of optimizing production equipment, including feeder scheduling and line balancing, must also be added the overall cost of a discrete solution.

With an MCM there is only one component to procure, as opposed to hundreds. Lot-to-lot variability is eliminated, since the system is fully tested and trimmed before delivery. The assembly process is also simplified, with one component to mount instead of hundreds. Moreover, the MCM solution eliminates many of the logistical issues associated with acquiring and managing large numbers of individual components. These include managing vendors, goods-in issues including inspection and put-away, correct storage and ensuring adequate inventory, managing lead-times, and dealing with obsolescence of individual components.

There are also valuable performance advantages. Eliminating package overheads not only leads to footprint savings and greater reliability but also eliminates parasitic effects including lead-frame resistance and inductance for each included die. Close spacing of dice also reduces the signal path lengths for inter-IC connections. As a result, an MCM solution achieves better signal to noise ratio than a functional equivalent implemented using discrete components, Upon completion of assembly, the MCM is also actively laser trimmed to further optimize noise performance.

Package-free assembly and close die spacings also give MCM integrators greater freedom to optimize the layout of the system. This, too, delivers a powerful performance boost compared to a discrete solution, but also solves some of the most serious challenges facing designers of high-performance systems. Consider the design of a high-speed, specialist data acquisition system. Managing the layout to optimize signal path lengths can present engineers with a multitude of parameters to manage simultaneously, and there are substantial issues with grounding that must be dealt with. Often, the black-artistry of the analog engineer is the only effective tool to establish a route through the maze. With an MCM solution, these come already solved. Hence, MCM technology delivers perhaps its most significant advantage in specialist applications by providing an insurance against the costs of failure.

Now this talk of project failure may sound excessive. But it can, and does, happen. Stepping back from the abyss, however, it is certainly true that a complex analog design is not a trivial undertaking. It does require specialist-engineering skills that can be expensive, and it does take time to complete and fine-tune. Alternatively, if a specialist contractor has to be consulted, the overall cost of the project can quickly dwarf the extra purchase-price associated with an MCM. The MCM, on the other hand, represents a turnkey solution that, importantly, comes with guarantees and technical support from the supplier.

As an example, consider the engineering costs involved in developing and proving a high-speed A-to-D converter, compared to using an off the shelf MCM solution such as C&D Technologies' ADS-939; a 16-bit, sampling ADC designed for operation up to 10Mhz. The major analog design challenges such as grounding issues are dealt with internally to the package, as well as the most sensitive system layout decisions. For the customer engineer, the remaining board layout challenges are relatively easily solved. The ADS-939 is delivered as a 40-pin ceramic TDIP component of nominal footprint 2.1" x 1.1", thereby also delivering the advantages of small-size, high-reliability ease-of-assembly and easy procurement that have already been discussed.

The MCM solution effectively shortens the time to market by eliminating a large part of the data acquisition design, and also frees engineers' time to focus effort and expertise at the higher levels of the product to create truly differentiating features.

This is the point at which the arguments surrounding MCM shift from discussing the costs added to the project, and instead center on the value added to the product and to the customer's business.

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