The need for high-current power interconnect solutions in increasingly smaller spaces continues to rise rapidly. As demand grows for more power in smaller packages, solving the power equation on new architectures and system platforms can pose electrical and mechanical design challenges for OEM system and power engineers charged with specifying interconnect components that ensure both signal and power integrity.

Unlike signal connectors, which continue to get smaller at higher transmission speeds, power connectors require a specific amount of conductive material to carry specific amounts of current or amperage. There are no special secrets to design that will allow smaller power contacts to carry more current! While progress is being made in perfecting low interference interfaces, as power needs increase so does the amount of space needed for higher ampacity interconnects.

In this article, we will look at key factors design engineers need to evaluate in the early stages of the design process. And, we will discuss how connector innovations and sound power integrity engineering principles can not only drive smarter design, but also help to ensure that the interconnect solutions specified will deliver optimal electrical performance, as well as safety and long-term reliability.

Key Elements to Consider

Even though new system designs often require more power to travel across a limited amount of space, several factors still affect the density of a design and how much power it can actually handle. A clear understanding of each of these elements is critical to successfully designing power integrity and safety into the system — and will help streamline the overall design process. These key factors include:

**Balancing Space and Power.** First, it is necessary to determine how much space is required for a power interconnect versus how much available space has been allotted in the finished product design. While saving space is a high priority for most OEMs, the height, width and length of the connector, and particularly its copper content, will directly affect the achievable current density. System architects always want to get more power in the same space, which can pose a challenge for connector manufacturers.

However, leading global connector manufacturers continue to develop new and innovative designs that use higher conductivity materials and utilize space more creatively to improve power delivery and electrical performance without expanding space requirements. For example, in some cases, a lower profile connector may be preferable to maximize air flow for cooling. In other cases, a taller connector offering improved contact performance may be the right solution to properly handle the amount of current generated in less card edge space. What’s important is striking the optimal balance of power and its resultant thermal effects in the PCB with the spatial design requirements to ensure the end product’s safety and performance.

**Thermal Management.** Thermal issues caused by contact or constriction resistance and inefficient air flow are always a concern and should be carefully considered early on. The PCB copper content is one element of this. Too little copper can restrict current flow causing constriction resistance. Appropriate copper trace sizes decreases bulk resistance, allowing for cooler temperatures and less loss. Otherwise that heat could be “sunk” to the connector interface, increasing reliability concerns. Power supply manufacturers are very creative in supplementing PCB structures with features to alleviate thermal and constriction concerns.

In addition, as systems are packaged into smaller boxes with more components, it is critical to ensure proper management of air flow around connectors which are positioned at the intersection point (such as between a power supply and server) and can block the free flow of air. Ample air flow around and through the connector helps cool the power contact, allowing for more current and/or an increased margin of safety. At the same time, connectors are sometimes located at key points and block airflow. Cooling connectors is not high on the list of priorities for designers when considering air flow.

With operational safety in mind, the designer needs to consider the entire system and its power architecture to understand what potential may exist—from end to end—for constriction areas and voltage drops that affect thermal and electrical performance. Typically, a maximum 30mV drop defines the threshold of thermal stability for a power contact. Once this threshold is crossed, the probability of thermal instability increases significantly.
POWER INTEGRITY ENGINEERING IN INTERCONNECT DESIGN: KEY FACTORS TO ENSURING SAFETY, PERFORMANCE AND RELIABILITY

World class producers of innovative connector designs are working with their customers to develop improved power interconnect solutions for safe operation and reliable performance in smaller spaces at higher temperatures over long product life. New designs incorporate new alloys and molding resins, plating, improved contact technology – all to increase current density without sacrificing safety and reliability.

Risk Mitigation. Connector manufacturers have traditionally based current ratings on their products’ electrical performance on testing under ideal circumstances. These published ratings, while accurate for what they measure, rarely tell the whole story because they fail to take into account the various conditions and interactions that will affect the environment in which the connector actually will be operating.

As a result, a common practice among OEMs has been to derate the connectors in order to build in a thermal safety margin over product ratings published in the connector manufacturers’ literature. Many use a simple approach, testing a smaller circuit count along with a longer one and charting a range of T rise versus current showing lower current carrying capability as the circuit count increases. Some customers assign another arbitrary percentage, so if a connector supplier submitted a product rated at say 100 amps, the user would automatically derate it by 30 percent to ensure a built-in safety margin against the possibility of overheating.

Today’s leading connector providers understand this and will work closely with OEMs and their design team to match their connector selection to the specific application, based on scientific testing and performance analysis under real-world application conditions.

To provide accurate ratings, top manufacturers conduct extensive testing and predictive modeling, such as Joule Heating FEA (finite element analysis) and CFD software (Computational Fluid Dynamics) with inputs pertaining to the connector and PCB geometry and material properties, current, contact resistances (actual test data) and air flow. In this way, they can estimate the performance of each of their interconnect products and provide reliable counsel to customers as to which of their products would be the best match for the application requirements. It is not practical to simulate and or test every possible environment but these models and analyses can help guide designers to smarter choices in a shorter amount of time. This is important in the fast paced design cycles required in the electronics industry.

Power Integrity Planning Yields Better Results

In today’s competitive and trend-driven technology market – in which compact size, transmission speed, signal and power integrity are paramount – the benefits of proactive power integrity engineering simply cannot be overstated. Increasing demand for computing power is driving the demand for more raw power. Meanwhile, product design cycles continue to shrink, giving power engineers less time to make critical decisions.

As we have seen, gaining a clear understanding of all the requirements early in the design phase, before specifying interconnect components, can help ensure the right decisions and avoid costly missteps. Most important, high quality power integrity engineering enables OEMs and their product designers to maximize the performance, reliability and safety of their products, resulting in higher sales and customer satisfaction.

About the Author:

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