As servers, routers, and switching equipment shrink, managing the demand for more power in smaller packages is becoming an even bigger challenge for OEMs. 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. While progress is being made in perfecting low resistance interfaces, as power needs increase, so does the amount of space needed for higher power interconnects. Power Integrity engineering can help solve these challenges. With broad experience in power integrity engineering, connector manufacturers are well qualified to solve many of the problems common to these complex designs, including system safety, reliability, and airflow.

**THE SOLUTION**

**Power Integrity Engineering Factors**

Even though 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. Variables include the amount of space that is actually available (height, width, and length), the thickness and number of copper layers in the printed circuit board; and how the airflow amount; and flow pattern influence the interconnect temperature rise. Understanding each of these elements very early in the design phase is necessary to successfully design power integrity into the system and speed the design process.

**Space**

While saving space and costs are top priorities for OEMs, it is crucial to determine how much space is required for a power interconnect versus how much has been allotted. The available height and length for the connector directly affects achievable current density. For instance, an OEM might specify there is 3.5 inches on a card edge to place a power connector and needs to deliver 600 amps though this distance. While a lower profile power connector may be preferable for maximizing airflow, a taller connector may be required to handle the amount of current.

**PCB Construction**

The number of layers, the thickness of layers (often referred to as number of ounces, e.g., a one ounce copper layer is roughly .0015 inch thick), copper and trace widths all impact current density. Designing trace sizes can be compared to choosing the appropriate wire gauge in a power harness. When considering the entire power architecture, understanding constriction points end-to-end is a key factor for understanding resistance and voltage drops, as well as for managing temperature rise.

**Contact Design**

Bulk resistance and contact resistance are the two critical factors in a power interconnect. Bulk resistance refers to the amount of contact material and its resistive properties. Contact resistance is that resistance between the mating contacts at the point of interface. When designing power recepta-

Lower height connectors such as these help manage airflow in dense pack power supplies.
cle contacts, design engineers must understand the relationship between the material conductivity and spring force characteristics. The higher percentage of copper in an alloy (for example, standard phosphor bronze is 47 percent) the more conductive it is. The trade off with higher percentage copper content is in long term stress relaxation and the resulting loss in normal force and increased contact resistance.

Ensuring adequate normal force over time is the primary goal when designing a power contact. The contact design must provide multiple points of contact for redundancy as well as appropriate plating. Because contact fretting and corrosion must be avoided at all costs, gold and silver are preferred for contacts used in high power interconnects.

More companies are using press-fit or compliant-pin technology to assemble components to printed circuit boards. This provides another challenge because, generally, engineers will not accept more than six amps per board hole or via. The thin copper plating of via walls can become a weak point over time. Therefore, designing an interconnect with more current-carrying capability to the PCB requires more space. For example, a 150 amp power module needs at least 25 individual compliant pins to adequately distribute the current from the interconnect to the PCB to meet the six amp maximum requirement.

Airflow and Thermal Requirements
Thermal issues, often influenced by the system airflow, are another important element that must be considered early in the design process. Directing airflow is critical as systems are packaged into smaller boxes with more components. Since power connectors are at the connection point (like between a power supply and server) they are often in the path of air and can block the flow. Minimizing the connector height is crucial in blade servers where low profile blades are attractive to businesses trying to maximize computing power in the smallest amount of space. Airflow around a connector also helps cool the power contact, lowering the temperature rise and allowing for more current or a bigger safety margin.

Rating Connector Performance
Power connectors are typically rated at performance levels with a 30° temperature rise benchmark. However, there are caveats to this rating method. First, how and where thermocouples are attached to the interconnect can have profound influence on measuring temperatures. The hottest spot in a well-designed interconnect is at the point of contact between the two connecting contacts, often called the plug side contact and the receptacle side contact, or just the plug and receptacle. Placing a thermocouple in close proximity to this point can be challenging.

Understanding contact stability over time is as important as understanding the T-rise. Some system architects are comfortable using a connector at currents that generate over a 30° T-rise as long as the contact interface is proven to be stable over time. Measuring contact resistance often expressed in milli-ohms or voltage drop, is one way to do this. The change in resistance or $\Delta R$ can be used to predict interconnect performance. An excellent explanation of how to do this is available in a paper titled “Voltage Drop Stability as a Method of Rating Power Contacts”, by Dr. Robert Malucci and Frank Ruffino.

**THE CONCLUSION**

**Tools for Power Integrity Engineering**
Connector manufacturers can provide analyses and tests to help support design engineers’ efforts to provide the required power (current) at manageable temperatures. Thermal models correlated with actual testing can identify hot spots that require additional airflow. Voltage drop information can often be a critical factor, so providing resistance measurements is a useful tool. Providing a reliable prediction on the interconnect’s current-carrying capability is also very important. The system designer must know precisely what the connector can handle. This is a major responsibility because the designer must ensure the system runs at all times without compromising safety.

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This chart illustrates the effect of mutual heating in relation to power connectors with 2 or 4 or 8 power blades.