

## **Better Design Practices and Connector Technologies for Midplane Power Engineering**

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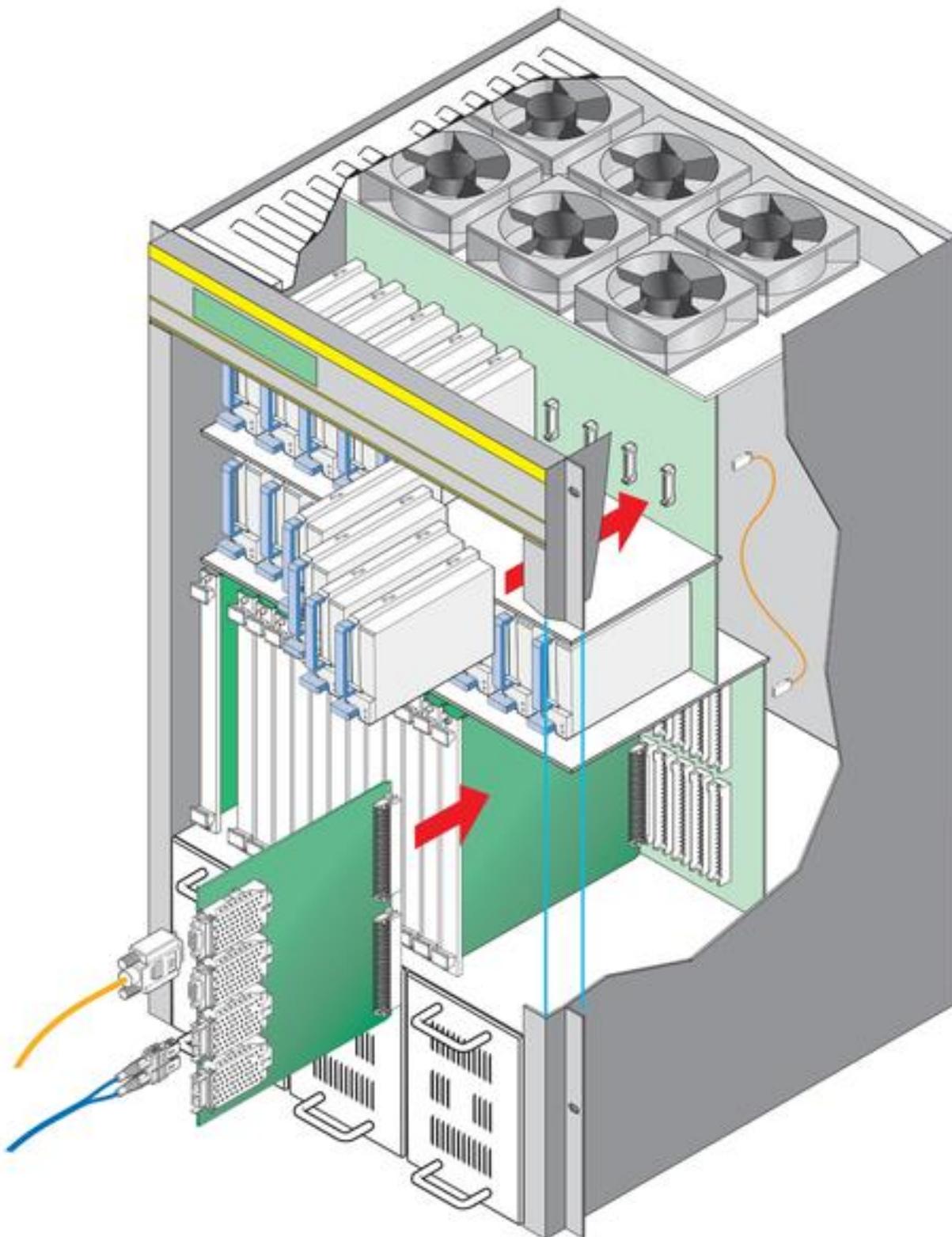


Midplane power engineering requires better design practices and connector technologies

Upticks in computing power in a range of industries—consumer goods and appliances, data/communications devices, medical and diagnostic equipment, servers and other networking systems—in addition to shorter product design cycles and more compact designs have compounded the need for better design practices and innovative customized midplane solutions.

### *Key considerations in solving the midplane power equation*

While power delivery conveys bulk power into a unit, distribution disseminates the power throughout the unit. Power connectors for distribution applications are typically rated to carry 50A or greater, whereas midplane power connectors are located on the power distribution side and typically rated for 20A or less, but may range from a single amp or two, on up to 50A.



There are several factors a design engineer should evaluate in the early stages of specifying midplane power connections. In addition to a clear understanding of the application, there are a number of relevant questions to ask and answer when selecting a midplane power connector:

- \* What amperage (amp/A) per circuit is required?
- \* What are the voltage requirements?
- \* What is the spacing and configuration on the board?
- \* What box space is available?

- \* Are there any height restrictions?
- \* What are the respective requirements within these given parameters?
- \* What options or features can improve the design and functionality?

Foremost among the design considerations are amp requirements specific to the application needs. The amperage requirement for midplane power connectors can vary widely application to application. A computer monitor, for example, may only require 30A within the unit, compared with a power supply which may be a couple of hundred amps. In addition to application parameters and power needs, space availability is another important consideration in selecting the right midplane connector.

### *Strategies for balancing space savings and available power*

Industry demand is on the rise for smaller and thinner high performance midplane power connectors. System architects and electrical engineers always want to get more power in the same space, which can pose a challenge for connector manufacturers. Unlike signal connectors, which continue to get smaller at higher transmission speeds, midplane power connectors require a specific amount of conductive material to carry specific amounts of current or amperage. As power needs rise, so does the space needed for higher ampacity interconnects.

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. In order to balance space and power, it is necessary to determine how much space is required for a midplane power interconnect versus how much available space has been allotted in the finished product design. In addition to space savings being a high priority, the height, width and length of the connector, and its copper content, will all directly affect the achievable current density.

As a space and energy saving strategy, the electrical engineer needs to carefully evaluate and strategically split power. When it comes to a midplane power connector, the first thing you have to understand is how much power is needed on the connector. In addition to identifying the total bulk power and discrete application specifications, the power distribution equation needs to consider the number of circuits the power will be broken into. For example, a bulk power supply of 30 A may require routing to six circuits, essentially splitting the total power into 5 amps per circuit via a blade-style design. Instead of relying on a single power source area, a crimp and box system allows the reduction of the bulk power into smaller units that deliver power to multiple points within the application.

The selection of a single row or dual row connector generally comes down to spacing and envelope size. Gauging the board and box envelope helps determine whether the space available is vertical or horizontal, which may dictate whether a single or dual row connector would be appropriate. 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. In some design

configurations it may be advisable to place a latch on its side in order to fit a certain height envelope. As box footprints shrink, some applications are transitioning from 6m-m connectors to 4.2-mm pitch midplane power connectors.

## *Design strategies for balancing energy savings and thermal management*

Accurate power connector sizing translates into optimal energy savings. However, connector sizing should be conservative, respecting safety parameters and balanced energy consumption. In order to match connector selection to an application, it pays to have a solid understanding of the design relationship between the midplane power connector, PCB and the environment.

Thermal issues can result from contact or constriction resistance and inefficient air flow. PCB copper content is one element to consider. Too little copper can restrict current flow causing constriction resistance. Appropriate copper trace size decreases bulk resistance, allowing for cooler temperatures and less current loss.

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 potentially block the free flow of air. Although connector cooling is not always a high priority for designers considering air flow, connectors located at key points can impede or block airflow. Ample air flow around and through the connector helps cool the power contact, allowing for more current and an increased margin of safety.

## *Rate, don't derate midplane connector current*

In the process of scaling down to a smaller pitch to accommodate smaller envelopes, design engineers must still respect the laws of physics. Improperly rated midplane electric connectors can cause peripheral electromagnetic interference (EMI) affecting data signals and transmission in the box, in addition to more serious safety issues. Carrying more amperage on a circuit than what it's rated for can cause overheating and other thermal issues.

Midplane connectors and other power products should perform well within the threshold. A connector should require no more than normal force to maintain stability over time, with redundant contact points to minimize power loss. While resistance in signal contacts may be acceptable at levels up to 10 milliohms, power connector requirements usually are more stringent. Typically, a maximum 30-mV drop defines the threshold of thermal stability for a power contact. Once crossed, the probability of thermal instability increases significantly.

Midplane connector ratings are traditionally based on a specific product's 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 affect the environment in which a midplane power connector will be operating.

One common practice among OEMs has been to automatically derate power connectors in order to build in a thermal safety margin over product ratings published in the connector literature. Many designers use a simple approach of 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 users assign another arbitrary percentage, so if a connector supplier submitted a product rated at 100 amps, for example, the user would automatically derate it by 30 percent to ensure a built-in safety margin against the possibility of overheating.

Ideally, a designer should consider the entire system and its power architecture to understand the end-to-end potential for constriction areas and voltage drops that affect thermal and electrical performance. So, the best approach for optimal operational safety is to rate, not derate. Based on data to support current rating decisions, and a specific Amp requirement of 30 A, for example, the smallest recommended midplane connector may be 4.2-mm pitch. Again, material selection and copper content impact T rise. Light PCB copper may produce heat build-up, whereas the use of heavier copper allows for better current flow due to less resistance. In some cases, the designer may want to insert a heat sink between a connector and the PCB.

### *Midplane connector feature and options*

Some of the latest midplane power interconnects incorporate new alloys and molding resins, plating, and improved contact technologies, all intended to increase current density without sacrificing safety and reliability.

Highly challenging applications, such as when high vibration is a chief concern, may require specialty power connectors. Among midplane offerings, the Molex Sabre connector product line suits higher-current applications, which require design flexibility for wire-to-wire and wire-to-board configurations in both vertical and right-angle orientations. It uses a TPA (terminal position assurance) feature to assure that crimp terminals are fully seated in their housings and to prevent terminal back-out due to vibration. These midplane power connectors provide a current rating of 18 A per circuit at 600 V and are available in a range of wire gauges and insulation thicknesses.

Past applications were often forced to fit available midplane connector specifications, which resulted in unnecessary design challenges. It's not uncommon for midplane power requirements to call for slight variations in existing product offerings. As a result, there is increased demand—and availability—of midplane connector product customization, modifications and extensions (CME).

Designed for higher current, higher density applications requiring design flexibility in wire-to-wire, wire-to-board and board-to-board configurations, MiniFit attributes include an operating temperature of -40 to +105°C, fully isolated terminals, positive housing locks, low-engagement forces and polarized housings and receptacles. Available in single-row or dual-row, 2- to 24-circuit options and carrying 13 A per circuit 4.2 mm, MiniFit interconnects feature multiple plating and material

selections, with desirable custom options such as first-mate/last-break contacts, longer tail lengths for thicker boards and voided circuits.

Another offering for power/signal, blind-mating, wire-to-wire, wire-to-board and board-to-board and some cable assembly applications features a low profile 3-mm (.118") pitch with a maximum current rating of 5 A and is available in multiple cable lengths and circuit sizes 2 to 24. This midplane power system for compact spaces incorporates many features previously found only in large power connectors, including through-hole and SMT versions in tape and reel packaging.

Recognizing that each application is unique, it's also important to identify which connector options are desirable. For example, single row options can accommodate minimum height requirements. Midplane power connectors can be keyed to prevent mismatching or tooled for different polarizations, including hot polarization if first-mate/last-break is needed to ensure mating of ground pins first, followed by power, then signal pins. Generally it is advisable to avoid the use of passive latching connectors that are disconnected with a pull. Whether or not there's any chance of vibration, positive latching requires intentional unlatching to prevent unwanted current interruption.

### *Midplane power interconnects drive smarter designs*

Solving the power equation on new architectures and system platforms can pose electrical and mechanical design challenges for OEM system and power engineers. Sound power integrity engineering principles and midplane connector innovations can not only drive smarter designs, but help ensure that midplane interconnect solutions deliver optimal electrical performance, as well as safety and long-term reliability.

Today's system architects and designers have numerous midplane power connector products and options from which to choose. In selecting a midplane connector style the goal is to strike the optimal balance of power and resultant thermal effects in the PCB with the spatial design requirements to ensure the end product's safety and performance. It's important to work closely with the connector OEM to match the right midplane power connector to the specific application, based on scientific testing and performance analysis under real-world application conditions.

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