Overview

This presentation examines the following power interconnect trends that have emerged or that are in the process of emerging in conjunction with specific IBM power applications with comments on the drivers responsible and the resultant benefits:

- Improved Thermal Considerations
- More Power in Reduced/Confined Spaces
- A New Low Inductance Interconnect Proposal
- Environmental Challenges
Improved Thermal Considerations – Airflow Impedance

- Packaging shift to coplanar power card to system board orientation

- Connector profile off the board surface is having an increasingly important impact on the airflow particularly in systems where the power supply cooling is an integral part of the system thermal management

- Alternate connector construction can reduce the impedance effect by utilizing a coplanar mating scheme with a net height reduction of 66% vs conventional power connectors or 50% vs a right angle card edge style connector
Improved Thermal Considerations – Airflow Impedance

- Coplanar card edge style connectors require double sided soldering to terminate the contacts to the PCB traces

- An alternate connector construction was utilized to ‘offset’ the solder tail or compliant press fit terminations

- The exposed surface of the upper power contact takes advantage of the nearby airflow thus improving the connector current rating
Improved Thermal Considerations – Airflow

• Additional benefit of having a coplanar power connector orientation is the cooling effect the airflow has on the performance of the connector.

• In this HV2 example with 5 power positions, airflow of 200LFM results in a 50% reduction of the temperature rise at the mating interface.

• Has the effect of boosting the current rating by 10A to 15A per power position depending on airflow speed.
Improved Thermal Consideration – Maximizing Layout & Heat Sink Area

- Reduction of the connector height from 15mm to 7 mm provided increased layout space for the VRM designers enabling additional heat sink area to assist in the thermal management of the module.

- In addition to the space saving associated with the lower connector height, this optimized connector utilized contacts designed specifically for high current handling (25A per position) as opposed to ganging several signal contacts together to perform a power function.
Improved Thermal Consideration – Maximizing Layout & Heat Sink Area

Moac, 12v, 200 amp out, looking at connector, air is from right to left at 500LFM

Live image

This is looking at the back side of Board (inductor side). SP01-SP05 is looking through the plastic at the connector.

VRM with 6 power segments of 12V 200A output and return. ∆T at connector contacts is 28.3°C (23°C amb.). Data supplied courtesy of Artesyn Technologies.

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Improved Thermal Consideration – Maximizing Layout & Heat Sink Area

Moac, 12v, 240 amp out, looking at connector, air is from right to left at 500LFM

Live Image
ThermoVision A20M image from 11/3/2003 2:19:42.129 PM

This is looking at the back side of Board (inductor side).
SP01-SP05 is looking through the plastic at the connector.

Analysis

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VRM with 6 power segments of 12V 240A output and return. ΔT at connector contacts is 38.5°C (23 °C amb.).
Data supplied courtesy of Artesyn Technologies.
More Power in Reduced/Confined Spaces

- HV2 Power Supply Connector
  - Retro-fit of existing PSU to provide increased output in same basic form factor
  - Requires 5 separate 12V power outputs + 3 lower current outputs
  - Shared rear panel (45mm X 78mm) space with new signal fan
  - Requires blind mate alignment (2 mm gatherability)
More Power in Reduced/Confined Spaces

- HV2 Power Connector Construction
  - Non hazardous 12V outputs compressed - 2 mm pitch
  - Dual contact power blades @ P1, P3 & P5 handles 5 +12V outputs & 3.3VCS output. P2 & P4 provide GND return path
  - Cost effective ribbon cable terminated header & socket integrated into top portion of array
  - Upper most signal row reserved for Power Supply testing function
More Power in Reduced/Confined Spaces

- Integrated AC Input & DC Output
  - Applications with limited connector access area may consider this design alternative
  - AC input voltage is wired as a feed-thru termination – keeping AC lines of system board and allowing discrete internal PSU routing
  - DC output and signal contacts are handled in conventional PCB to PCB power connector configurations
Low Inductance Power Connector Proposal

- Controlling the Droop in Operating Voltage is Key

Source: "Package-Level Interconnect Design for Optimum Electrical Performance," Intel website
Low Inductance Power Connector Proposal - Simplified Power Delivery Model

\[ V_{\text{droop}} = L \frac{di}{dt} + IR_{\text{AC}} \]

- **Capacitance is only a limited bandage. Inductance is the Key.**

Source: INCEP (based on Intel ITS 2001 slew rate data)
Low Inductance Power Connector Proposal - Power Delivery Trends

Embedded Designs

AMD Desktop MotherBoard VR

Voltage Regulation Modules

Intel Itanium PowerPod

Segmented Power & Signal

Intel Desktop MotherBoard VR

VRM

PowerPod

Modular & On MB

Modular & Off MB

tyco | Electronics
Characterization of High Performance, Low Inductance Power Connector

Power interconnection devices between VRM and CPU/ASIC planes with optimized topology
The Card Edge Power Connector Approach

- Very high power density (more than 100A/inch²)
- Loop inductance of 1 nH
- Low profile for optimized component placing
Low Inductance Power Connector Proposal – Using Inter-digitated Planes

To achieve lowest resistance possible...

- Small gap between power and return
- Short path length
- High cross-section area

As the gap between power and return paths decreases, the electromagnetic coupling increases enabling the magnetic field cancellation to become effective, and lower the loop inductance.
Low Inductance Power Connector Proposal

- Lower inductance – 130 pH range
- Better utilization of PCB real estate
- Low profile to achieve short path length & lower resistance
- More contact fingers reduce loop inductance
Environmental Challenges

• Tyco Electronics is an industry leader in developing RoHS Compliant solutions and is well positioned to support our customer’s conversion to RoHS compliance.

• Tyco Electronics has and continues to conduct product/process testing to ensure adequate product performance in a lead free environment.

• Power connectors have had to deal with a much less obvious issue related to hexavalent chromium (Cr6+) content:
  – The larger current carrying style contacts used in the panel mount power cable harnesses utilize a silver plated finish to ensure reliable robust connection.
  – The tarnish inhibitor applied to the silver plated surfaces with the most common tarnish inhibitors containing the hexavalent chromium.
  – Recent internal evaluations have identified an alternative which has been tested and proven to meet Tyco Electronics specification requirements.
Environmental Challenges

Internal Tarnish Inhibitor Analysis; Replacement of Hexavalent Chromium

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Conclusion

Recent advancements in the power interconnect area have fostered increased power circuit density, higher current ratings and resolution of constrained space limitations. The collaborative dialogue that exists within the IBM design community is a key element in driving these advancements and achieving improved performance objectives. Tyco Electronics looks forward to continuing this role and providing future advancements to keep pace with IBM’s needs.