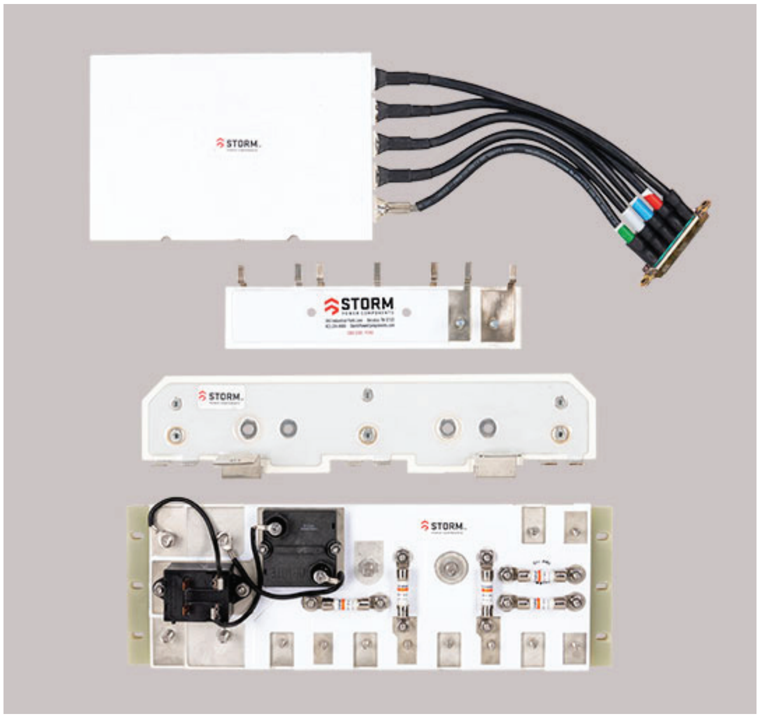
STORM
POWER COMPONENTS

Applications Note

Thermal Management for Laminated Busbars
Overview of Challenges and Mitigation Methods

Thermal management of laminated busbars is essential to ensure the safe and efficient operation of electrical systems, particularly in high-power applications. Laminated busbars are used to distribute electrical power within various devices and systems, and they can generate heat due to the electrical current passing through them.



What is a Laminated Busbar

Laminated busbars consist of multiple layers of conductive metal (copper or aluminum) separated by paper-thin layers of dielectric material, all of which are then heated and compressed into an integrated component. This provides a number of performance advantages over single layer bus bar and cable conductors, including:

- **Reliability** - by eliminating points of failure
- **Low Inductance** - with mutual cancellation between multiple layers
- **Decrease Electrical Noise** - with lower inductance, distributive capacitance and improved EMI
- **Clean Power** - with integration of advanced IGBT that require low inductance
- **Space savings** - small busbar form factor enables efficient use of cabinet space and improves airflow

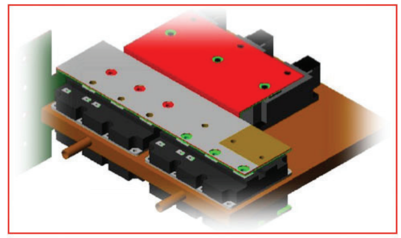
Thermal Management Challenges

Although the more efficient use of space and improved airflow with laminated busbars helps reduce heat in the cabinet, it is also important to design the laminated busbars to minimize thermal issues as well.
Some key focus areas include:

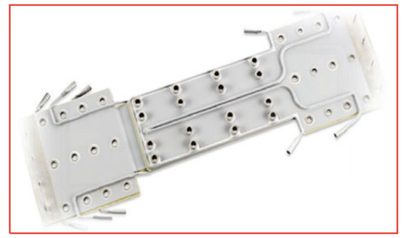
- **Heat Generation:** The primary challenge is managing the heat generated during the flow of electrical current through the busbars. This heat can lead to temperature rise and potentially damage the components or insulation.
- **Temperature Non-uniformity:** Laminated busbars often have complex geometries, and it can be challenging to ensure uniform temperature distribution across the entire structure.
- **High Current Density:** In high-power applications, laminated busbars may carry extremely high current densities, leading to significant heat generation.
- **Limited Space:** In many applications, there is limited space available for thermal management solutions.

Thermal Mitigation Methods

Material Selection: Choose materials with high thermal conductivity for the laminated busbars. Copper and aluminum are commonly used due to their good thermal conductivity properties. Materials need to be adequate for normal load conditions.



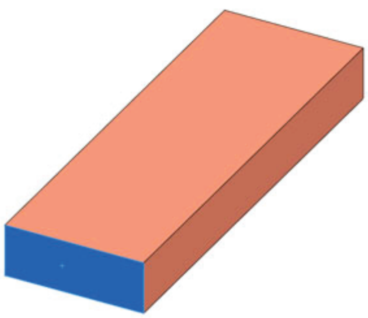
Cooling Techniques: Air cooling can be optimized with design for natural convection and/or adding fans. Laminated busbars also can be designed to accommodate liquid cooling systems if needed by circulating water or other phase change materials (PCMs).



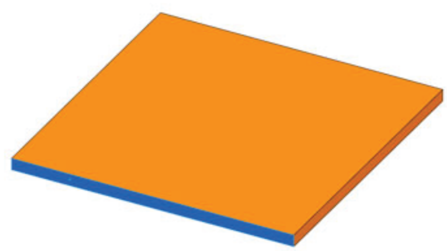
Busbars as Heat Sinks: The busbar structure can be designed to provide a heat sink for connectors, IGBTs, or other components.

Design Optimization: Optimize the busbar design to reduce heat generation. This may involve increasing the cross-sectional area to lower current density or using wider conductors. Current carrying is a trade off between temperature rise and conductor cross sectional area and shape. As shown below, a larger surface area will dissipate heat more quickly, thereby carrying more current with the same temperature rise as a conductor with less surface area.

3/8" X 1" WILL CARRY 510A @ 30DEG C TEMPERATURE RISE



1/8" X 3" WILL CARRY 710A @ 30DEG C TEMPERATURE RISE



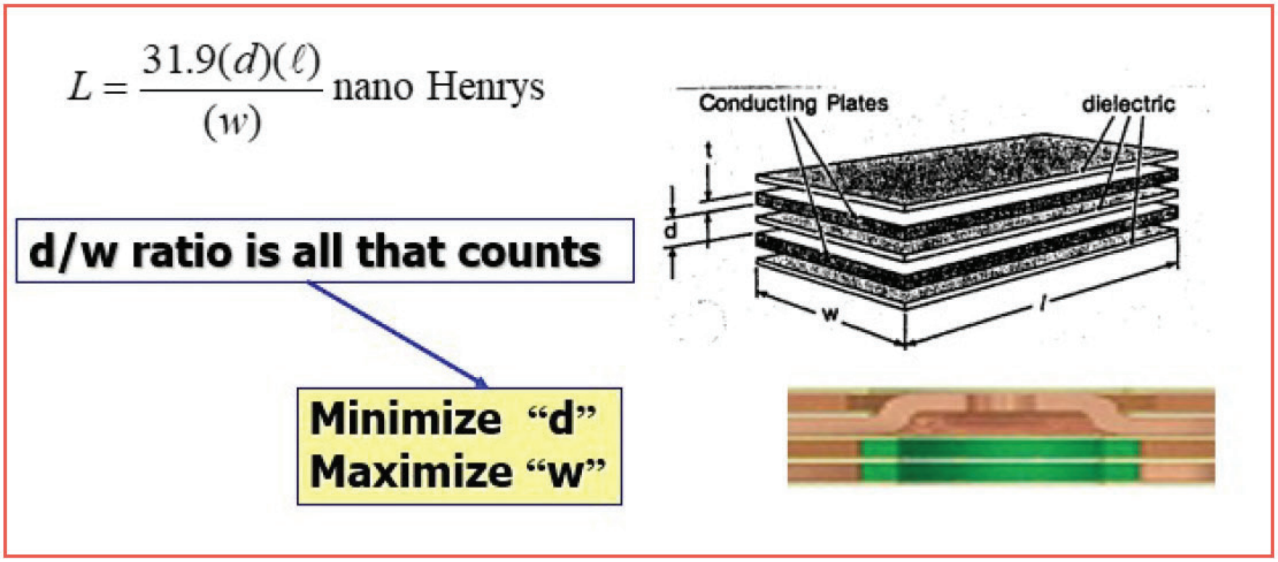
Thermal Insulation: Use thermal insulating materials or coatings to minimize heat transfer to adjacent components or surfaces.

Modeling and Simulation: Utilize computational modeling and simulation tools to analyze the thermal behavior of laminated busbars under different operating conditions to optimize design & cooling strategy.

Temperature Monitoring: Implement temperature sensors at critical points on the busbars to continuously monitor temperature levels. This allows for real-time feedback and control of cooling systems.

Optimizing for Low Inductance and Impedance

As shown below, optimizing the depth-to-width ratio by minimizing depth while maximizing width is a key design factor that provides low inductance, low impedance and delivers improved noise attenuation.



Summary

As discussed above, laminated busbars are able to reduce the overall heat in a number of ways. The first advantage is the compact nature of its construction. More efficient use of space in an operating cabinet means improved airflow.

In addition to optimizing space efficiency, laminated busbars can be designed to reduce the amount of excess heat by managing the precise amount of conductive materials needed to carry power.

For specific applications, a laminated busbar designs can include a cooling component called a "chill plate" or heatsink. This could be an aluminum layer within the laminated bus bar design with small channels which allow for coolant to be pumped directly through the bus bar.

Although bus laminations have been around for almost two decades, newer, advanced insulating materials like Kapton and Teonex work in combination with improved design and fabrication techniques to utilize electric energy more efficiently, and save time and money.

Selection of the proper busbar design and internal dielectric insulations can depend on capacitance, inductance, voltage potentials, and operating environment. We have a variety of materials in-stock and ready for production.

With over 30 years of hands-on experience with designing and optimizing busbars, the Storm Power Components team can help you achieve thermal management requirements while balancing your product's environmental, space, and cost demands.