STORM POWER COMPONENTS

Applications Note

Understanding Use Cases for Laminated and Flexible Busbars or Combining Both Technologies Together

Laminated and flexible busbars are types of electrical conductors used to distribute electrical power in a variety of applications. Two of the primary areas of usage are:

- **Power electronics** – such as switching inverters, motor drives and other control systems where power density, reliability and efficiency are key factors.
- **Power distribution** – such as single or multiple power feed sources that are going to single or multiple destinations.

This applications note provides a brief overview of laminated and flexible busbar characteristics and use cases, along with an exploration of when both technology approaches could be used in combination.

Laminated busbars consist of layers of conductive material, typically copper or aluminum, separated by thin dielectric film for insulating layers. The layers are then bonded together using heat and pressure to form a single, flat, and rigid conductor. The laminated structure provides excellent thermal and electrical performance and allows for custom shapes and sizes to be easily produced. Laminated busbars are commonly used in power distribution systems for EV power modules, switchgear, transformers, and other high-power equipment.

Flexible busbars, on the other hand, are made of a flexible conductive material, such as braided copper or aluminum, and are typically coated with an insulating material to protect against damage and moisture. Flexible busbars are ideal for applications where vibration or movement is present, such as in EVs, high-speed trains, wind turbines, or industrial machinery. They are also commonly used in data centers and other applications where space is limited.

Laminated Busbars

Flexible Busbar

The benefits of using laminated and flexible busbars include:

- **Improved reliability:** Due to their high-quality construction, laminated and flexible busbars offer improved reliability for consistent electrical performance and reduced risk of failures.
- **Increased efficiency:** These types of busbars are designed to provide low resistance and minimize energy losses, resulting in improved efficiency and lower operating costs.
- **Customization:** Laminated busbars can be customized to fit specific applications and equipment, while flexible busbars can be bent and routed to fit tight spaces or irregular shapes.
- **Reduced maintenance**: Because of their robust construction, laminated and flexible busbars require minimal maintenance and have a longer lifespan than other types of conductors.
- **Low inductance**: Multi-layer laminated busbars also can minimize inductance by designing adjacent layers with alternating charges to create mutual inductance cancellation, which makes them ideal for use in power applications that are highly sensitive to interference.

Use Cases for Laminated or Flexible Busbars

Laminated busbars have become the preferred technology approach for advanced power applications, such as the high-speed IGBTs that are increasingly used in electric vehicles (EVs) and other e-Mobility applications. Prior to the rise of high performance IGBTs, inductance was less of a concern because previous generation designs using discrete diodes were much less sensitive to inductance.

In addition, as IGBT designs have evolved into smaller and thinner form factors, the power connection points are more delicate, making them more sensitive to vibration damage.

For many industries, such as automotive, industrial, power utilities, and communications systems, both flexible and laminated busbars are often used in certain applications to take advantage of their distinct benefits.

For example, a laminated busbar may be used to connect a high-power switchgear, while a flexible busbar could be used to distribute power to a more compact component within the same system. Or, in an electric vehicle, laminated busbars could be used to connect the battery cells, while the flexible busbars could be used to distribute power to the motor and other components that are subject to vibration or movement.

Another example could be in a data center, where laminated busbars could be used to distribute power to high-power equipment, while flexible busbars could be used to connect servers and other equipment that are subject to frequent movement or replacement.

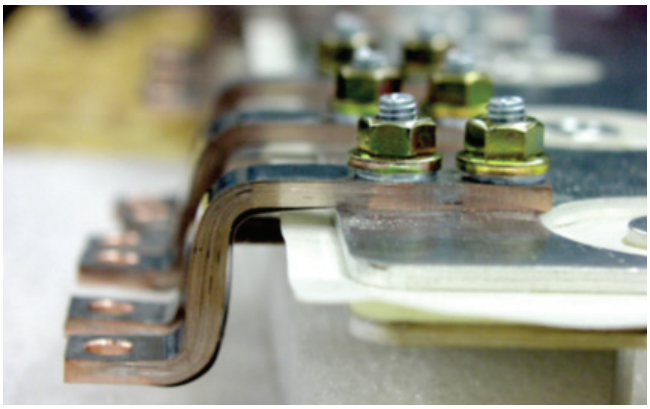
In general, the decision to use both flexible and laminated busbars in an application will depend on the specific requirements of the system, such as power distribution requirements, space constraints, and environmental factors.

Combining Both Laminated and Flexible Approaches within the Same Busbars

In some cases, an application may need to incorporate both lamination and flexibility advantages within the same hybrid busbar design. These types of busbars can be referred to as laminated flexible busbars or flexible laminated busbars.

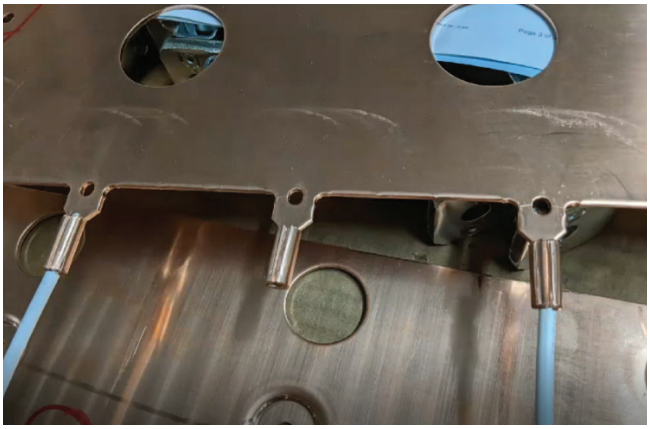
A good example of this type of hybrid design is to replace the solid connections on a laminated busbar with braided flex connectors. As shown, the flex busbars can be separately connected to each layer. This simplifies subsequent assembly steps, while also mitigating issues with vibration.

In applications using small and thin high-performance IGBTs with wideband gap technology, this flex busbar integration approach can be an excellent method for absorbing vibration and avoiding damage to delicate connection points.



Such a hybrid approach also can have many variations depending on the specific application needs, including the use of a variety of connection methods such as bolt-on, crimping, laser, or sonic welding, etc.

These connections could be a sense lines, such as for power of current sensing, or you could be making power connections. Depending on requirements, we stack the layers and provide options for insulation or non-insulated.



Other considerations include managing the length of the flex connectors to optimize the low inductance benefits from the laminated busbar. The key design objective is avoiding too much distance between the laminated busbar end points and the connection points on the IGBT or other device. As soon as the current from the laminated section is separated to support the connections, the low inductance characteristics begin to diminish.

Summary

As described above, both laminated and flexible busbar technologies have important benefits for efficiently and effectively providing robust, noise resistant, power connectivity between a variety of devices across a wide range of applications and industries.

In many cases, both busbar approaches are used for different applications within complex systems, such as electric vehicles, power grids, communications infrastructures, and more. In addition, to address the requirements of a growing set of specialized applications, laminated and flexible busbar techniques are being combined in hybrid configurations that provide the best of both worlds.