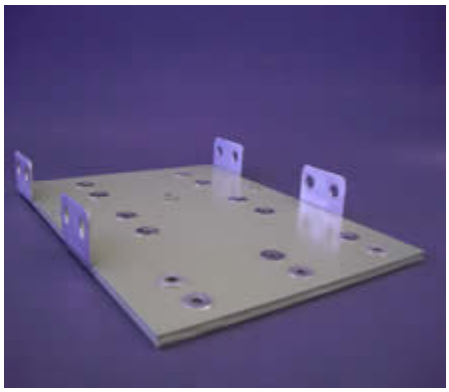
# *STRONG*BAR Multi-layer Bus Bar Assemblies


Custom Electronics launched the ***STRONG*BAR** products division in response to the growing world-wide demand for power distribution technology. This new division specializes in the manufacturing of custom designed multilayer bus bars for use in military systems, industrial/commercial drives and renewable energy applications.

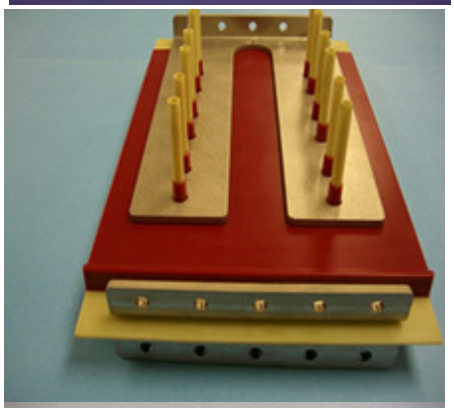


## Multi-Layer Bus Bars:

A multi-layer bus bar consists of two or more planer conductors insulated from one another by a dielectric material. The conductors are formed to accommodate component installation and typically routed to promote magnetic flux cancellation; thus, reducing parasitic circuit inductance. Through the use of adhesives or other assembly techniques, this component stack is held together, forming a convenient single part.

Within the power electronics industry, multi-layer bus bars serve as the functional equivalent of the Printed Circuit Board (PCB), neatly connecting components together to form a complete, typically, high performance circuit. Multi-layer bus bars have been around for years and most power electronics engineers clearly understand their many advantages:

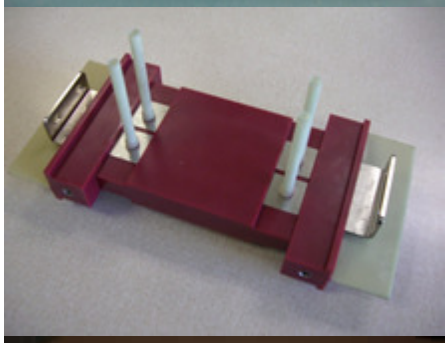
- Lower inductance
- Simplified assembly
- Reduced system EMI
- Structural support
- Reduced system cost
- Higher system reliability
- …the list goes on



Multi-Layer Bus Bars are, indisputably, the most attractive and widely accepted high performance power interconnect technology available.

Using only the best materials and proprietary construction techniques, we pledge to manufacture the most reliable multi-layer bus bars you can find anywhere!

Consider ***STRONG*BAR** for any design, military or commercial, where quality and reliability are of paramount importance.



## Services

- Customer design assistance and teamed co-design
- Manufacturing to customer's specifications
- Prototype and short run manufacturing
- Institution of dedicated line for high volume applications
- Electrical and environmental testing
- Component Installation and sub-system assembly

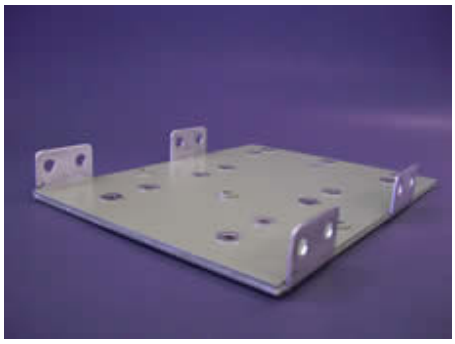
## Construction Options

- Laminated, Powder Coated & Vacuum Molded Assembly
- Formed Copper, Commercial, Military and Custom Connectors and Bushings
- Custom Molded Creep Barriers and Connector Shrouds

The sky is the limit with STRONGBAR!

Learn more about CEI's Design and Manufacturing Capabilities
Learn more about Bus Bar Design Considerations
If you have an existing design to manufacture or wish to begin the design process click the request a quotation/design link below.

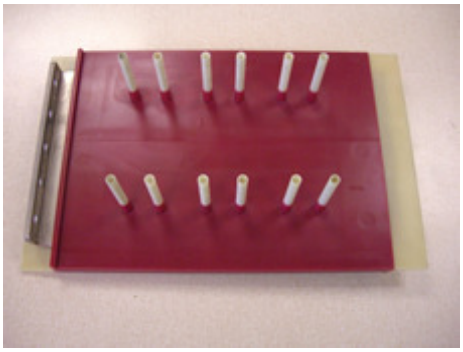
# Multi-layer Bus Bar Design Considerations



Generally speaking, a multi-layer bus bar consists of multiple, usually planer, conductors insulated from one another with an appropriate dielectric material. The conductors are typically formed to accommodate component installation and arranged to promote satisfactory circuit performance.

That said, multi-layer bus bars can be relatively simple or very complex depending on the number of conductors, required withstand voltage rating, current rating, component terminals and any other stipulation incurred by the specific application.

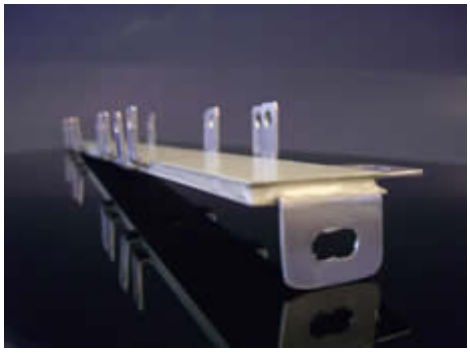
**1. Conductor Element Design**
When designing your conductor elements you must carefully consider your current handling requirement(s) and electrical layout



**Current handling**

As a general rule 0.000375 $in^2$. of copper cross section per 1 ampere is recommended for sufficient current handling. The table below lists the recommended minimum conductor widths required for three common copper sheet thicknesses (1/8", 1/16" & 1/32") when applied to a broad range of currents.

| Rated Current (Amperes) | Recommended Copper Conductor Cross Section inches2 | Minimum Recommended Conductor Width | | |
|---|---|---|---|---|
| | | Thickness 0.125" | Thickness 0.0625" | Thickness 0.0312" |
| 10 A | .00375 $in^2$ | N/A | N/A | 0.120 in |
| 20 A | .00750 $in^2$ | N/A | 0.120 in | 0.240 in |
| 50 A | .01875 $in^2$ | 0.150 in | 0.300 in | 0.600 in |
| 100 A | .0375 $in^2$ | 0.300 in | 0.600 in | 1.200 in |
| 200 A | .075 $in^2$ | 0.600 in | 1.200 in | 2.400 in |
| 300 A | .1125 $in^2$ | 0.900 in | 1.800 in | 3.600 in |
| 400 A | .150 $in^2$ | 1.200 in | 2.400 in | 4.800 in |
| 500 A | .1875 $in^2$ | 1.500 in | 3.000 in | 6.000 in |



It is recommended that the bus bar designer make their conductor elements as wide (assuming > the minimum cross section) as practical. Doing so will help reduce the overall inductance of the bus assembly. For high speed switching applications, bus inductance is considered to be highly undesirable and will result in excessive "over-shoot voltage" which will, to some level, compromise system efficiency and can potentially damage semiconductors.

The approximate inductance (L=nano Henries) of a 2 conductor bus bar assembly can be estimated using the following formula:

L=32 d lC/wC

where:

32 = 32pico Henries/mil
d = Distance between conductors
lC = Conductor Length
wc = Conductor Width

This formula assumes the 2 conductor's geometries match exactly and that the supply and return current paths are routed so that they directly oppose each other.

**2. Layout**
When laying out a bus bar assembly, aside from mechanical fit (size) and making the appropriate electrical connections, both of which are application specific, the designer, typically, has three other layout dependent characteristics to take into consideration. Each being as important as the other and more or less difficult to achieve depending on the application. These are:

- Optimize inductance (typically the lowest possible)
- Promote satisfactory current distribution (particularly important when paralleling components)
- Maintain proper strike and surface creep distances between

polarities

**Optimizing Inductance:**
As mentioned in the previous section, in order to achieve optimal (low) inductance, circuit paths must be routed so that equal amounts of current passing through one plane are directly opposed by the other plane. In essence, the two planes should be identical mirror images of one another. In practice, this is typically impossible to achieve due to the necessity of offset component mounting holes or other mechanical obstacles; however, one should attempt to mirror the planes as closely as possible.

In most instances, if a satisfactory level of inductance can not be achieved with the bus bar alone, bypass capacitors can be added in close proximity of the switching devices (semiconductors) to minimize the resulting overshoot voltage (V=Ldi/dt).

If you have questions regarding optimizing inductance of a bus bar assembly or the use of bypass capacitors please contact our sales department or applicable International Sales Representative.

**Current Distribution:**
When paralleling components, proper current distribution is a paramount concern. The impact of improperly distributed current goes without saying.

In most cases, the designer's goal is to equally distribute load current among multiple like components (semiconductors, capacitors, resistors…etc). To do this, the designer must match the bus bar resistance and inductance to each of the components. The most apparent solution is by creating geometrically identical paths to each of the like components. When this isn't achievable, one may employ another technique commonly referred to as the "First-In Last-Out" method. Using this technique, the component given the lowest impedance "In" path would be assigned the highest impedance "Out" path. This approach is particularly attractive when paralleling more than two like components.

If you have questions regarding current distribution within a bus bar assembly or would like to know more about paralleling components please contact our sales department or applicable International Sales Representative.

**Strike and Surface Creep:**
Probably one the most overlooked aspects of designing a bus bar is maintaining proper strike and creep clearance between polarities. Usually this occurs in the regions where multiple terminal components are installed. For example: The terminals of an IGBT module are designed to meet strike and creep requirements associated with its rated voltage. The IGBT module designer has gone to great lengths to satisfy these requirements by using the appropriate spacing and molded elements like elevated islands, barriers or repeating barriers. The photo below demonstrates the use of these elements.

The common mistake of many laminated bus designers is to not plan for similar features on their bus bar assembly. Simply attaching this unit to a flat bus plane having no barriers between its mating terminals would spell disaster.

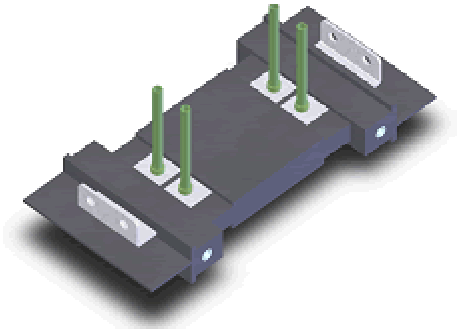
That said, not all laminated bus bar manufactures have the ability to include similar features; however, CEI has spent many years developing it's Large Scale Molding capability and can incorporate these necessary features as well as a variety of other reliability enhancing elements into your next laminated bus bar design.

If you have questions regarding creep and strike or CEI's large Scale Molding capability, please contact our sales department or applicable International Sales Representative.

# Integrated Design and Manufacturing Capabilities

Custom Electronics has been a world leading high voltage capacitor and electronic assembly manufacturer for more than 40 years. We have developed a variety of capabilities which allow us to produce some of the most reliable high voltage products available. We're confident we have the experience, know-how and equipment to meet your needs. If you have any questions or comments regarding our high voltage design and manufacturing capabilities, do not hesitate to contact our sales department or applicable Sales Representative.

**3-D CAD (Computer Aided Design):**
Custom Electronics utilizes SolidWorks solid (3-D) modeling software. The use of 3-D modeling software dramatically shortens the design cycle and reduces fabrication errors. Our engineers and designers are experts in 3-D mechanical design and welcome the opportunity to design your next product. If you wish to supply an existing solid design to have quoted for production, please use .IGES, .STEP or native SolidWorks file formats. If you have other questions regarding our solid modeling capabilities or suitable file exchange formats please contact our sales department or visit our directory for a complete listing of our Sales Representatives.



28kV Bus Bar

## 3-Dimensional Printing Service – Fused Deposition Modeling (FDM):

Most design decisions are made up-front in the design process. Typically the first 10% of the product development process affects about 80% of the products total cost. These decisions are made during the initial or prototype concept stage of the development process.

Typically, designers and engineers rely on 3D CAD software at this stage. But significant challenges arise using only a computer screen or color printer output to communicate the true design details to management, marketing, vendors, customers, manufacturing employees, as well as others on the design team.

Functional 3D models enable the designer and all others on the design team to make better informed design decisions, resulting in fewer design changes, better product designs, lower production costs and lower product costs.

Historically, businesses that have relied on RP parts have either used expensive, time-consuming SLA service bureaus or have utilized high-end RP systems that require dedicated operators, modified site requirements and a long learning curve. Today, companies are turning to low cost 3D Printing services that deliver fast, quality, inexpensive parts, allowing the designer to iterate designs quickly, testing for form, fit and function.

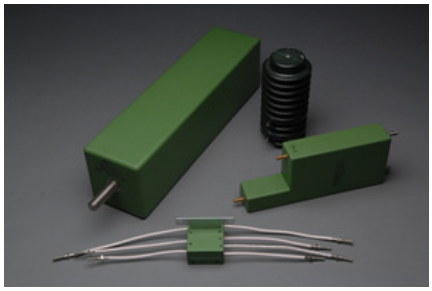
- **Build Size:** Maximum size 203 x 203 x 305 mm (8 x 8 x 12 inches)
- **Materials:** ABS plastic in white, blue, yellow, black, red or green colors

Nothing communicates design ideas faster than a three-dimensional part or model. With Custom's 3D FDM Modeling, you can bring your CAD files and design ideas to life. Test form, fit and function – and as many design iterations as you like – with functional, machinable, paintable ABS parts.

For quotes, please send .SLT files, generated from your 3-D CAD Software, to 3D@customelec.com. If you require 3-Dimensional Solid Modeling, Custom can perform this service as well. We can accept .PDF, .DXF, .DWG, and .AXP 2-D files.

**Electrical and Environmental Testing:**
CEI has continually increased its test capability to accommodate a wide variety of electrical and environmental test requirements. Our highly skilled engineers welcome the opportunity to design and build new test circuits and fixtures to suit our customer's needs. Don't hesitate to contact our sales department if your application has special test requirements not listed below.

- Partial Discharge to 20kVAC
- Dielectric Withstanding Voltage to 75kV
- Highly Accuracy Insulation Resistance/Leakage Measurement
- X-Ray
- Thermal Cycling @ Thermal Shock -65C +125C
- Cold Storage to -65C
- Temperature/Humidity up to 90% Relative Humidity
- Simulated High Altitude Testing to 70,000ft.
- ESR and SRF



**Large Scale Molded Epoxy Encapsulation:**
One of our unique strengths is the ability to mold specialized epoxy potting compounds and encapsulation materials into large scale and highly detailed shapes. With more than 120 years of combined experience, our mold engineers have developed some of the most complex molds imaginable. If you have a Bus Bar Assembly requiring dependable high voltage barriers or molded threaded inserts, this is the right technology. Please contact our sales department or visit our Sales Representative directory if you have questions concerning this unique process.

**Silicone Potting:**
Custom can also encapsulate Bus Bar Assemblies using silicone materials. These materials have advantages over other forms of encapsulation in high temperature environments. Our research technicians and engineers work together to find the proper material for every job. Custom's vast knowledge of silicone potting materials and techniques will help ensure your product is of the highest quality. For questions about our silicone potting capabilities, please contact our sales department or visit our directory for a complete listing of our Sales Representatives.

**Ink Jet Marking:**
Custom uses a computer-controlled Ink Jet Marking system to perform complex marking operations on components of all shapes and sizes. Our ink meets government requirements and is continually checked for acceptability. If you have an application that requires ink jet marking, please contact our sales department or visit our directory for a complete listing of our Sales Representatives.

Ink Jet Marking

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**Heli-coil Insertion:**
As defined by ANSI J-STD-001, almost all of Custom's high voltage assemblies are categorized as Class 3 products (High Performance Electronic Products). Custom's assemblies and modules occasionally incorporate the use of Heli-coil inserts, which are made from diamond shaped cross-section wire are screwed into tapped holes to form nominal size internal threads. These types of inserts are installed by torquing through a diametrical tang that is notched for tang removal. Heli-coil inserts meet U. S. military standards (MS33537) and insertion tools meet U. S. government standards (A-A-59158). If you have questions about this type of advanced manufacturing process, please contact our sales department or visit our directory for a complete listing of our Sales Representatives.