Power Distribution Solutions

METHODE ELECTRONICS, INC.
Network Bus Products

Technology Leadership...Global Manufacturing...Enabling Solutions
Welcome to Network Bus Products

With over 45 years of experience in bus bar design and manufacturing, Methode Network Bus Products is the global leader with plants in the United States and China along with sales and technical support worldwide. We are a leading supplier of bus-bar solutions. Products include powder coated and laminated bus bars, custom power distribution assemblies, and braided flexible cables.

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Methode Network Bus Products - China

Methode Network Bus Products has a full bus bar production and design facility in Shanghai, China. This dedicated facility has full production capabilities from fabrication through final test. We also have in-house, state-of-the-art powder coating capabilities. Design engineers are on staff to assist with product development using the latest design techniques and CAD tools.

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Cableco Technologies - a Methode Company

Cableco Technologies offers power distribution cabling solutions from its west coast design center in San Jose, California, and its manufacturing facility in Reynosa, Mexico.

Cableco Technologies Corporation
1750 Junction Avenue • San Jose, CA 95112
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### Markets & Applications

#### Telecommunications
- Cellular base stations
- Switching systems
- Routers
- Back planes

#### Computers
- Servers
- Mainframes
- Supercomputers
- Mass memory storage

#### Power Conversion
- Power supplies
- UPS systems
- Inverters

#### Industrial
- Motor drives
- Motor controls
- Fabrication machinery
- Test equipment
- Elevator systems
- Switch gear

#### Transportation
- Locomotives
- Hybrid vehicles
- Electric vehicles
- Earthmovers
- Light rail systems

#### Aerospace and Space
- Satellite systems
- Aircraft
- Space stations
- Missile systems

#### Military
- Submarines
- Communication systems
- Ground vehicles
- Radar systems

#### Medical and Diagnostic Equipment
- MRI
- CAT Scan

### Major Customers

#### Customers
- Alcatel
- BAE Systems
- Boeing
- Bombardier
- Cisco Systems
- Emerson
- GE Healthcare
- General Electric Company
- Goodrich
- Hamilton Sunstrand
- Hewlett Packard
- IBM
- L3 Communications
- Liebert
- Lockheed Martin
- Nortel
- Northrop Grumman
- Otis Elevator
- Raytheon Systems
- Rockwell Automation
- Sanmina
- Siemens
- Solectron
- Square D
- Sun Microsystems
- TDI
- Teradyne
- Tyco
- United Technologies

### Quality Policy

We are committed to continually improve our products and services through a defined program which is designed to meet the requirements of national and international standards along with our customers’ expectations. It is our charter to meet or exceed specified and implied contract requirements with the object to achieve 100% customer satisfaction.

We strive to be the best of the best in the products we provide our worldwide customers. We view each contributor in the quality chain as our customer whether he/she is a supplier, office worker, engineer, technician, shop floor specialist or manager. Each employee has a key role in determining our reputation, allowing us to prosper as a business while providing our shareholders a reasonable return on investment.

☑ RoHS Compliant

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**OUR COMMITMENT to the highest quality in design and manufacturing is demonstrated by the wide acceptance of Methode interconnect buses and cabling systems in space vehicles. Astronaut Rich Clifford, involved in the final assembly of the International Space Station utilizing Methode distribution buses, meets with employees of Methode Network Bus.**
Network Bus Capabilities

Capabilities

- Systems Engineering Design and Assembly
- CAD/CAM 3D Modeling
- CNC Machinery
  - A) Machining
  - B) Turning
  - C) Fabrication
- Powder Coating
  - A) Thermoset
  - B) Thermoplastic
- Laminated Assembly
- Prototype Manufacture
- Inspection Scanning Equipment
- Complete Test Capabilities to Meet Standards
  - A) Electrical
  - B) Mechanical
  - C) Environmental
  - D) Safety

Lamination presses provide high levels of heat and pressure to produce multi-layer bus bars.

All bushings are fabricated in-house to reduce costs and improve cycle time.

Our automated powder coating lines provide a means of electrical insulation for virtually any shape of bus bar.

Multiple computer controlled machining centers provide ample capacity and precision machining capabilities.
Laminated bus bars may be tested in-house for partial discharge conditions.

Our staff of design and application engineers utilize the latest CAD systems to streamline the design process.

State-of-the-art Coordinate Measurement Machine provides precise measurements for tight tolerance applications.

This inspection machine rapidly scans bus bars and compares the results to CAD files to ensure that the product meets specifications.
Features & Benefits

*Methode Power Distribution Systems include Planar Bus, Laminar Bus, Epoxy Coated Power Bus, Omega Flexbus Braided Cables,* and sub-assemblies based on these products. These components add value to many areas of power packaging. Among the features and benefits are:

**Ease of Installation**
- Error proofed - You’re one step closer to 6-sigma with power distribution components that eliminate system damage from wiring installation errors while reducing labor and increasing quality.
- Lower assembly costs - Significantly reduces installation time.
- Lower field service costs - Eases access to field repairable items.

**Lower Total Costs**
- Methode Power Distribution Systems can lower your total costs through:
  - Error-free installation.
  - Lower field service costs.
  - Lower trouble-shooting costs.
  - Reduction of overall components (and associated reliability and procurement costs of those components).
  - Faster installation times.
  - In applications with numerous inputs and outputs, Methode Power Distribution Systems cost less than a wire harness, as proven in multiple previous applications.

**Improved Electrical Performance**
- Predictable performance - Consistent product means consistent performance.
- Low voltage drop.
- Low inductance - Great for demanding IGBT applications. Reduces chance of damage to components due to voltage spikes.
- Reduced system electronic noise and EMI/RFI radiation.

**Structural Member**
- Provides stable platform – Use as base for additional components including connectors, capacitors, diodes, resistors, inductors, IGBTs, fuses and circuit breakers.

**Thermal Management**
- A bus bar often runs cooler than cabling. Greater power density can usually be achieved with less temperature rise.

**Simplicity in Design**
- Improved Reliability - Simple design reduces overall component count and number of interconnections in your system.

**Compact**
- Carries current in space-saving low-profile designs. Great where space is at a premium and thermal management is a concern.

**Neat, Attractive Appearance**
- The simplicity of Methode Power Distribution Systems is aesthetically pleasing.

**Specialty Insulation Systems**
- Wide range of standard insulation films, adhesives, and coatings are available. If your application requires something unique, Methode’s expertise in composite materials can engineer a solution.

**Meets the Standards**
- Engineered solutions can meet various agency standards including UL, CSA and NEBS telecommunications requirements.
- Powder coating approved for UL 746A.

**Omega Flexbus Braided Cable**
- Braided cable provides a flexible means of termination to ensure proper alignment.
Challenges & Solutions

Mainframe Computer Challenge/Solution

The Challenge
Designers from a major computer company had a requirement to distribute power to several different locations for a large computer system. They desired a cost-effective solution that offered high reliability, space savings, fast installation and ease of serviceability. A wiring approach was deemed to be inadequate primarily because of reliability concerns. Because of the many wires, crimped connections, heat shrink tubing over exposed wiring and tie wraps, there were many opportunities for failure.

The Solution
A Methode laminated bus bar was selected as the preferred solution. The design included 8 conductive layers, Mylar/Tedlar insulation, silk-screened terminal identification, self clinching hardware, tin plated terminals and epoxy insulation edge filled. This simpler approach minimized the opportunities for error as compared to a wired design. The customer also concluded that the total installed cost of the bus bar system was less than the wiring alternative. They were especially pleased with the fast installation of the bus bar and the ease of serviceability.

Telecommunications Challenge/Solution

The Challenge
A leading manufacturer of power distribution systems for the telecommunications industry previously used discrete wires in their fuse panel applications. A need for higher current carrying capacity from major telecommunications companies arose. Specifically, a system with a rating of 20 Amperes instead of the previous 15 Amperes would give them a competitive advantage. With the wiring approach, a rating of 20 Amperes could not be achieved as the system ran too hot which damaged other components.

The Solution
A Methode bus bar system provided the solution. The design included discrete single conductors with laminated polyester insulation that were formed to the required shapes. In order to reduce the customer’s cycle time, Methode supplied a subassembly that included the bus bars, fuse holders, mounting brackets, pc boards and terminal blocks. A rating of 20 Amperes was achieved as the bus bars ran much cooler and met the temperature rise specification. With this new design, the customer could offer their customers this innovative product with superior power density.
Telecommunications

High power connections for blind mate applications.

A higher current rating is obtained with cooler running bus bars.

Bus bar designed to mate with pluggable circuit breakers.

Bus bars mount to backplanes for router applications.
A modular mainframe computer utilizes pluggable bus bars for ease of installation.

A mainframe computer application requires a multi-layer laminated bus bar providing mechanical support for capacitors and connectors. With sharp forming angles required, epoxy powder coating provides the best insulation solution.

Designed for a mainframe computer cabinet requiring several connectors for fast installation and service, includes nine conductive layers to distribute power to several output circuits.

Bus bars provide multiple high power connections.

Fuse receptacle mates to bus bar for server application.

Pluggable high power bus bar for low voltage computer systems.
Meets demanding automotive environmental requirements for electric vehicles.

The battery interface center (BIC) for an electric vehicle is a unique power distribution system completely designed and manufactured in our facility. It was fully tested to meet automotive requirements.

Electric and hybrid vehicle applications utilize bus bars to distribute power efficiently.

Designed and manufactured to meet the stringent shock and vibration requirements of locomotive applications.

Powder coated bus bar provides power distribution in a hybrid automobile.
This motor drive inverter assembly includes bus bars, capacitors and IGBT power semiconductor modules. Powder coated epoxy insulation is used for its high dielectric strength, flammability rating and cost effectiveness.
A semi-flexible surface mount bus bar was required to ensure proper connections. The solution included a three-layer product with Kapton insulation that provided the necessary flexibility.

Meets NASA standards for use in space applications.

Distributes power in an aircraft radar system.

Used in the International Space Station, this bus bar includes multiple methods of connection.

Radar array bus bar for aircraft.
Ideal for missile systems because of high reliability.

A military application required circuit protection for several discrete circuits. To save space, fuse clips, fuses and protective Lexan covers were mounted directly to the bus bar. Terminal designations were screen printed on the outer insulation layer to provide terminal identification.

Power distribution for military vehicle.

High current and pluggable bus bar used in tight submarine quarters.
Omega Flexbus Braided Cable Bus Systems

The Omega Flexbus™ from Network Bus Products is the perfect solution for rugged grounding or high current electrical applications. Utilizing Methode's patented solidification process, terminations are free of “crimping.” This means a stronger, lighter, higher current-carrying bus bar delivered finished and ready for easy installation. Omega Flexbus is ideal for use in a wide range of OEM applications where a low-inductance, durable, flexible conductor is required.

Omega Flexbus products use Methode’s proprietary solidification process which transforms the individual conductors of the stranded cable into one conductive mass that can be machined, drilled, brazed, soldered or sonic bonded to create a termination stronger than the actual cable itself. These terminations also provide higher moisture resistance and higher current-carrying capacity than crimped-on terminals.

Methode’s solidification technology also makes it possible for the company to produce braided cables with solid areas located virtually anywhere in the middle of the cable. In addition, this bonding process allows smaller cables to be attached to a large, main cable, to create spine cables with excellent mechanical strength and electrical characteristics.

Standard or Custom Product Choices
Omega Flexbus braided cable products may be ordered off-the-shelf, or customized with your choice of conductor gauge, length, terminations and insulation material. Network Bus offers engineering support and a complete range of design services.

Insulation Options
A Shrink Tubing
- MIL-I-23053 black polyolefin, UL VW-1.
- 600V/125°C rating.
- Sizes up to 2” in stock.
- Other colors or sizes available for custom orders.

B Expandable Tubing
- Silicone rubber expandable fiberglass tubing UL VW-1.
- 600V/200°C rating.
- Available in 1/8” to 2-1/2” in black or white standard.

C Expandable Sleeving
- Polyester monofilament.
- Fingertrap design has tensile strength of 100,000 psi.
- Clear or black available in sizes from 1/8” to up to 4” expanded.

Termination and Connector Options
Termination options include: silver brazing, soldering, sonic bonding, or attachment with fastener. These processes are applicable to a variety of industrial, electrical, or custom connectors which suit the applications.
Product Markets and Applications

**Computer**
- Grounding straps and pluggable terminals

**Telecommunications**
- Grounding straps for outdoor boxes
- Communications tower grounding

**Appliance**
- Outdoor electric tools
- Welding equipment
- Indoor home/industrial

**Motor Controls and Drives**
- High current grounding and power distribution

**Machine Tools**
- Vibration intensive grounding and power distribution
- Flexible connections to cycling or reciprocating parts

**Defense**
- Durable, high reliability flexible grounding and power transmission

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**Omega Flexbus™ Features**
- Various size and length selection
- Lugless solid terminals – no moisture retention
- Durable nickel plated construction
- Braided material offers better durability in flexing applications
- Can be integrated into larger bus bar components
- Quick connect – easy installation – low applied cost
- Single component design – less weight
- High current and voltage capacity
- Available with insulation sleeving and termination holes

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**Standard Products Matrix**
Standard product configurations are available for quick delivery. If a standard product won’t fit your application, give Network Bus a call. Our engineering team is experienced in developing unique, cost-effective solutions to grounding, bonding or connecting challenges.

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**FLAT CABLE PART NUMBERS**

<table>
<thead>
<tr>
<th>X</th>
<th>WIDTH</th>
<th>H</th>
<th>Y</th>
</tr>
</thead>
</table>

---

**Example:** **F1 - 200 - 08 - S - ET**
1 AWG/200 AMPERE CABLE, 8" LONG, STANDARD HOLES, INSULATED WITH EXPANDABLE TUBING.

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**Approximate Dimensions**

<table>
<thead>
<tr>
<th>STANDARD PART NUMBER</th>
<th>AWG SIZE</th>
<th>AMPERE RATING</th>
<th>X in (mm)</th>
<th>Y in (mm)</th>
<th>H in (mm)</th>
<th>T in (mm)</th>
<th>WIDTH in (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1 - 200</td>
<td>1</td>
<td>200</td>
<td>.95 (24.1)</td>
<td>.95 (24.1)</td>
<td>.33 (8.4)</td>
<td>.09 (2.3)</td>
<td>1.00 (25.4)</td>
</tr>
<tr>
<td>F3 - 140</td>
<td>3</td>
<td>140</td>
<td>.95 (24.1)</td>
<td>.95 (24.1)</td>
<td>.33 (8.4)</td>
<td>.08 (2.0)</td>
<td>1.00 (25.4)</td>
</tr>
<tr>
<td>F4 - 100</td>
<td>4</td>
<td>100</td>
<td>.57 (14.5)</td>
<td>.57 (14.5)</td>
<td>.20 (5.1)</td>
<td>.06 (1.5)</td>
<td>.62 (15.7)</td>
</tr>
<tr>
<td>F7 - 70</td>
<td>7</td>
<td>70</td>
<td>.50 (12.7)</td>
<td>.50 (12.7)</td>
<td>.20 (5.1)</td>
<td>.05 (1.3)</td>
<td>.53 (13.5)</td>
</tr>
<tr>
<td>F9 - 40</td>
<td>9</td>
<td>40</td>
<td>.57 (14.5)</td>
<td>.57 (14.5)</td>
<td>.20 (5.1)</td>
<td>.03 (7.1)</td>
<td>.62 (15.7)</td>
</tr>
<tr>
<td>F12 - 20</td>
<td>12</td>
<td>20</td>
<td>.38 (9.6)</td>
<td>.38 (9.6)</td>
<td>.14 (3.6)</td>
<td>.015 (4.1)</td>
<td>.38 (9.6)</td>
</tr>
</tbody>
</table>

H = Hole Diameter; T = Thickness
Capacitance
The capacitance for a bus bar can be designed to achieve specific results. The construction of the bus bar can be manipulated so as to perform as required by the system. The dielectric constant of the insulator you choose will have the greatest effect on capacitance, without having to physically change the bus structure. The capacitance can be altered without affecting the inductance within the system, assuming you will still meet your dielectric breakdown voltage requirement as shown in this formula:

\[ C = \frac{0.225 \times b \times E_r}{a} \]

\[ C = \text{pF} \]
\[ c = \text{Conductor Length} \]
\[ b = \text{Conductor Width} \]
\[ E_r = \text{Dielectric Constant} \]
\[ a = \text{Dielectric Thickness} \]

Inductance
Inductance is always present whenever there is voltage passing through a conductor. How you manage that inductance makes the difference. A laminated bus structure can effectively control the inductance generated in power distribution systems by maintaining a consistent distance between conductors. This enables the designer to accurately calculate what inductance will be generated in the system. Generally, the physical length of the bus bar will be determined by the system. Where the components to be powered are located will have a direct result on the bus bar configuration. The greatest effect on reducing the inductance, with little affect on the overall assembly, is by reducing the distance that the conductors are separated by. The conductors should also be designed to be as wide as is allowed by the system or practical as shown in this formula:

\[ L = \frac{3.19 \times a}{b} \]

\[ L = \text{nH} \]
\[ c = \text{Conductor Length} \]
\[ a = \text{Dielectric Thickness} \]
\[ b = \text{Conductor Width} \]

Current
The current (amperage) rating is based upon the cross-sectional area of the conductor. This directly reflects the temperature rise at given amperage. A general rule of thumb for determining the current carrying capacity is:

\[ I = \frac{(W)(T)}{0.00036} \]

\[ I = \text{Amperage} \]
\[ W = \text{Width of conductor} \]
\[ T = \text{Thickness of conductor} \]
\[ 0.00036 = 360 \text{ sq. mils per amp} \]

Impedance
Impedance is a function of inductance and capacitance in the bus bar. When the bus bar is supplied with alternating current, the current builds up voltages that act in opposition to the flow of that current. This opposition is called reactance and it must be combined with the resistance to find the impedance. In order for a power source that has an internal impedance to transfer maximum power to a device that also has impedance, the two impedances must be matched. Impedance matching is important in any electrical or electronic system in which power transfer must be maximized. The calculation for impedance is:

\[ Z_o = \sqrt{\frac{L}{C}} \]

\[ Z_o = \text{Impedance} \]
\[ L = \text{Inductance} \]
\[ C = \text{Capacitance} \]

Voltage Drop
If power is being distributed over long distances or components require precise voltage requirements, voltage drop across the distance between the input and output connections of the bus bar can be very important. You can calculate how much voltage will be lost with the formula:

\[ V_d = \frac{[(2p)(L)(I)]}{[(W)(T)]} \]

\[ V_d = \text{Voltage Drop} \]
\[ p = \text{Conductor Resistivity (Ω in.)} \]
\[ p = 10.43 \times 10^{-7} (\text{Ω in.}) \text{ (De-Rated)} \]
\[ L = \text{Conductor Length} \]
\[ W = \text{Conductor Width} \]
\[ T = \text{Conductor Thickness} \]
\[ I = \text{Amperage} \]

Interconnections
The interconnections or terminations that are available to designers for bus bars are virtually unlimited. Everything from stock shelf items to custom manufactured connectors can be installed onto bus bars. Some of the more common options are:

- Quick disconnect
- Soldered board-style connectors
- Compliant board-style connectors
- Board-to-board connectors
- Blind mate connectors
- Lug terminations
- Clinch hardware
- Hot-pluggable connectors
- Brazed connections
Design Formulas


LAMINAR BUS BARS

\[ V_d = 2\pi R_I \]
Where: 
- \( R_c \) = Conductor resistance (\( \Omega \))
- \( I \) = Current (A)
- \( \rho \) = Conductor resistivity (\( \Omega \) in m)

\[ C = \frac{2225 \epsilon_0 \epsilon_r}{a} \] (pF)
Where: 
- \( \epsilon_0 \) = Dielectric constant
- \( \epsilon_r \) = Relative dielectric constant

INDUCTANCE

\[ L = 31.9 \frac{\epsilon_0}{\rho} \] (nH)
Assumption: conductors are non-ferromagnetic and frequency effects can be neglected.

CHARACTERISTIC IMPEDANCE

\[ Z_0 = \frac{1}{\rho} \] (\( \Omega \))
Where: \( L \) = Inductance (H)
\( C \) = Capacitance (F)
Assumption: Effective Lossless conductors and dielectric.

WIRING HARNESSES

\[ V_d = 2\pi R_I \]
Where: 
- \( R_c \) = Conductor resistance (\( \Omega \))
- \( I \) = Current (A)
- \( \rho \) = Conductor resistivity (\( \Omega \) in m)

\[ C = \frac{\epsilon_0}{\frac{0.707}{d}} \] (pF)
Assumption: Effective dielectric constant is close to 1 due to conductor spacing.

INDUCTANCE

\[ L = 20.3 \frac{\epsilon_0}{d} + \frac{\sqrt{2}}{2} - 1 \] (nH)
Assumption: Conductors are non-ferromagnetic and frequency effects can be neglected.

CHARACTERISTIC IMPEDANCE

\[ Z_0 = \sqrt{L/C} \] (\( \Omega \))
Where: \( L \) = Inductance (H)
\( C \) = Capacitance (F)
Assumption: Lossless conductors and dielectric.

Sample Calculations for 100 A Systems

| a = 0.010” | \( \epsilon \) = 48” |
| C = 2225 \epsilon_0 \epsilon_r \frac{1}{a} | L = 31.9 \frac{\epsilon_0}{\rho} | Z_0 = \sqrt{L/C} |
| C = 2225 \frac{(48)}{1.00} (5) \frac{1}{0.010} | L = 31.9 \frac{(48)}{0.010} \frac{1}{1.00} | Z_0 = \sqrt{153 x 10^3} |
| C = 5,340 pF | L = 15.3 nH | Z_0 = 1.68 \Omega |

| a = 0.010” | \( \epsilon \) = 48” |
| C = \frac{\epsilon_0}{\frac{0.707}{d}} \left( \frac{(562) + \sqrt{(562)^2 + 2(204)2}}{204} \right) \frac{0.707}{d} | L = 20.3 \frac{\epsilon_0}{d} + \frac{\sqrt{2}}{2} - 1 \] (nH)
| C = 48 \frac{0.707}{d} \left( \frac{562}{204} \right) \left( \frac{562}{204} \right)^{-1} | L = 20.3 \frac{(48)}{204} \frac{(562)}{204} \left( \frac{(562)}{204} \right)^{-1} \] (nH)
| C = 17.63 pF | L = 974.4 \frac{(5.322)}{nH} | L = 1.705 nH |

Electrical Performance Comparison Chart

<table>
<thead>
<tr>
<th>CASES</th>
<th>C</th>
<th>L</th>
<th>Z_0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5,340 pF</td>
<td>15.3 nH</td>
<td>1.7\Omega</td>
</tr>
<tr>
<td>2</td>
<td>31.97 pF</td>
<td>686 nH</td>
<td>160\Omega</td>
</tr>
<tr>
<td>3</td>
<td>13.28 pF</td>
<td>2,364 nH</td>
<td>338\Omega</td>
</tr>
</tbody>
</table>

Impedance Comparison Chart
In general, a bus bar design consists of one or more flat electrical conductors laminated and electrically insulated by a thin dielectric material which is encapsulated or sealed along the edges. Input and output tabs are placed at convenient points to minimize interconnections.

To determine the proper size of copper conductors, refer to the following table for specific current and cross sectional areas needed to minimize voltage drop.

## RELATIONSHIP BETWEEN BUS BAR SIZE AND CURRENT

<table>
<thead>
<tr>
<th>Wire Gauge (AWG)</th>
<th>Circ. mils</th>
<th>Sq. mils</th>
<th>Rated Current* (amperes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>2,583</td>
<td>2,025</td>
<td>5.63</td>
</tr>
<tr>
<td>14</td>
<td>4,110</td>
<td>3,230</td>
<td>8.96</td>
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<tr>
<td>12</td>
<td>6,530</td>
<td>5,130</td>
<td>14.24</td>
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<tr>
<td>10</td>
<td>10,380</td>
<td>8,155</td>
<td>22.85</td>
</tr>
<tr>
<td>8</td>
<td>16,510</td>
<td>12,970</td>
<td>36.02</td>
</tr>
<tr>
<td>6</td>
<td>26,240</td>
<td>20,610</td>
<td>57.27</td>
</tr>
<tr>
<td>4</td>
<td>41,740</td>
<td>32,780</td>
<td>91.06</td>
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<tr>
<td>2</td>
<td>66,360</td>
<td>52,120</td>
<td>144.80</td>
</tr>
<tr>
<td>0</td>
<td>105,600</td>
<td>82,910</td>
<td>230.17</td>
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<td>00</td>
<td>133,100</td>
<td>104,500</td>
<td>290.38</td>
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<tr>
<td>000</td>
<td>167,800</td>
<td>131,800</td>
<td>366.08</td>
</tr>
<tr>
<td>0000</td>
<td>211,600</td>
<td>166,200</td>
<td>461.64</td>
</tr>
</tbody>
</table>

*Approximate values

## INSULATION MATERIALS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CONTINUOUS USE TEMPERATURE (°C)</th>
<th>DIELECTRIC BREAKDOWN ASTM D149 (KVAC, mil)</th>
<th>DIELECTRIC CONSTANT ASTM D150 (kvac, m/k)</th>
<th>FLAMMABILITY RATING</th>
<th>THERMAL CONDUCTIVITY (W/mK)</th>
<th>GENERAL CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy Powder Coating</td>
<td>130</td>
<td>10.0 KVAC (10 mil)</td>
<td>4.00</td>
<td>UL 94 V-0</td>
<td>.60 @ 50°C</td>
<td>Flame resistance</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>Approved by UL for UL 746A applications</td>
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<td>Kapton</td>
<td>400</td>
<td>13.8 KVAC (3 mil)</td>
<td>3.70</td>
<td>UL 94 VTM-0</td>
<td>.16 @ 75°C</td>
<td>High temperature rating</td>
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<td>105</td>
<td>10.0 KVAC (3 mil)</td>
<td>3.30</td>
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<td>.37 @ 75°C</td>
<td>Moisture, chemical and</td>
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<td>Cost effective</td>
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<td>Nomex</td>
<td>220</td>
<td>1.6 KVAC (3 mil)</td>
<td>1.60</td>
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<td>.11 @ 150°C</td>
<td>Flame resistant</td>
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<td>Excellent durability</td>
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<td>Tedlar (PVP)</td>
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<td>4.2 KVAC (2 mil)</td>
<td>11.0</td>
<td>UL 94 HB</td>
<td>.35 @ 60°C</td>
<td>Outstanding mechanical</td>
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Laminated Bus Bars

The laminated bus bar is the foundation of this system as it provides power distribution and structural support for other components. Laminated bus bars generally provide very low inductance, an important factor for IGBT applications. A choice of insulating materials is available to meet a variety of dielectric and environmental requirements.

Multiple discrete conductors, in both planar and stacked configurations, can be integrated into a single assembly. Creepage clearances between conductive surfaces can be increased with valleys and walls to assist in meeting or exceeding customer, UL or CSA requirements.

Finished assemblies are verified dimensionally and electrically 100 percent before they are shipped to the customer. Legends may be provided on the top insulation layer to ensure that components are assembled in the proper locations.

Important design features:

- Shallow or deep drawn contact surfaces can be incorporated to accommodate the planar mounting surfaces of an IGBT (Insulated Gate Bipolar Transistor) or capacitor which mounts directly to the bus bar.

- Components such as diodes, resistors and fuses can be incorporated directly into the design.

- Discrete conductors can be embedded into and isolated from the adjacent conductors.

- Dielectric film sealed together on all edges provides an excellent environmental seal.

- Packaging is optimized for compact, efficient power distribution. Virtually unlimited package sizes are possible.
Frequently Asked Questions

What are lead-times for prototypes and production orders?
Lead-times vary widely depending on the complexity of the product. Understandably, assemblies with value-added components require a longer lead-time. Generally, lead-times fall between 6 to 10 weeks with some exceptions for very simple or complex products.

Are samples available?
Samples are available for evaluation. Although a sample may not meet specific design geometry, a customer can evaluate the basic materials that will be utilized.

What must be provided to receive a quotation?
Drawings that provide electrical and mechanical details are needed to provide an accurate quotation. These may be e-mailed to save time. A written quotation is generated that provides unit pricing, NRC charges and lead-time.

Are prototypes available?
Yes. Drawings need to be submitted for quotation along with the desired quantity of prototypes.

Who do I contact with questions?
We may be contacted directly at 847-577-9545 or by email at info@methode.com. Inside sales associates and applications engineers are available to assist you. Local sales representatives can be called for customer visits.

Do you support just-in-time programs?
We regularly work with forecasts, schedule sharing and blanket orders to meet demanding customer delivery requirements.

Are you ISO 9001 certified?
We have been ISO 9001 certified for several years. The organization has a comprehensive quality system in place.

When should a customer use a bus bar instead of wiring?
When carrying high current levels, large wires with thick insulation are needed. In addition to being bulky, these wires are difficult to bend and install. In these high power density applications, bus bars are particularly attractive due to their space savings and ease of installation.

Another key factor is inductance. The flat design of bus bar conductors inherently has much lower inductance than wires. Low inductance bussing systems smooth voltage "spikes" caused in high speed switching applications that can destroy expensive components. Motor control applications that use IGBT (Insulated Gate Bipolar Transistor) power semiconductor devices are especially sensitive to voltage spikes and thus benefit from laminated bus bar technology.

Other bus bar advantages include higher reliability due to fewer components and lower total installed costs.
Can you help customers with designs?
Yes, we can utilize our years of experience to help with your design. Application engineering support is available via telephone or for in the field customer visits.

Can you share CAD files electronically?
Yes, we encourage the exchange of files electronically. We are able to work with CAD files in several common formats. Please contact us for system details.

How are bus bars tested?
Typically, our products are tested for electrical shorts at very high voltages. Products may also be subjected to various environmental and mechanical conditions. Partial discharge electrical testing is also available.

We also have access to the many test capabilities of Trace Laboratories, Inc., our Methode wholly owned subsidiary.

What is the typical amperage range for bus bars?
Bus bar applications vary widely from a few Amperes to thousands of Amperes. Most applications seem to fall into the range of 10 to 1,000 Amperes. However, more bus bars are being used in low amperage/low voltage applications because of the extremely low voltage drop of the bus bar.

What types of insulation systems are used?
We offer several different insulation options depending on the application, flammability requirements, desired geometry, environmental needs and cost objectives. We offer both film and epoxy coating insulations. More detailed information on insulation options is provided in the Design Guide section of this brochure.

What options exist for connection to the bus bar?
Many options exist for termination to the bus bar including pluggable connectors, tabs for bolted connections, PEM studs, quick connect tabs, PCB connections, sonic welding of wires, brazed bushings, clinch hardware, etc. See our Design Guide section for further information.

How are bus bars mounted?
Mounting options include insulated holes for bolting directly to frames, press fit nuts and studs, isolated layer output tabs, nylon rivets, and tie wraps.

Why are bus bars plated?
Most bus bars are fabricated from copper base metal for conductivity and cost reasons. Bare copper will oxidize and corrode over time resulting in impaired electrical connections (higher contact resistance). We generally add tin plating to protect the copper and improve the integrity of the electrical connection.

Other plating options are available. For example, gold over nickel plating can be provided for very low voltage applications.
Definitions

Amperes
Or Amps, is the unit of measure for electrical current. A bus bar usually handles 20 to 100s of Amperes per conductor. By using several conductors laminated together, a single bus bar is able to distribute thousands of Amperes.

Capacitance
Capacitance depends on the distance between conductors. A capacitance value for a bus bar design can be calculated as shown in the Design Guide section of this brochure. In most power distribution applications, there is a need for high levels of capacitance to smooth out voltage spikes. Laminated bus bars provide a higher level of capacitance over conventional wiring approaches due to the close proximity of each conductor and the wide conductor surface areas. However, some applications require the addition of discrete capacitors to the power distribution system to achieve the necessary capacitance values.

Dielectric Strength/ Breakdown Voltage
Refers to the voltage that an insulating material can withstand before breakdown occurs. It is usually measured in Volts/mil. Typical values for bus bar insulations are 300-500 Volts/mil for 10 mil insulation.

Edge Sealing and Edge Filling
Edge sealing and edge filling are different methods of providing insulation over exposed conductors on the edges of laminated bus bars. Edge sealing refers to overlapping the outer film insulators over the exposed edges. Edge filling is applying an epoxy-based insulator over the exposed edge; this approach is used for thick, laminated bus bars or when there is insufficient space for the insulation overlap approach.

EMI/RFI
Refers to electromagnetic and radio frequency interference. The magnetic fields created when current flows through conductors can cause disruption in the operation of semiconductor and other components. Bus bars can be designed to shield high levels of EMI/RFI with their laminated structures. This factor is especially important when distributing higher frequency power such as in AC motor controllers and switching power supplies.

Hot Pluggable
Hot pluggable for power distribution applications refers to the ability to quickly change a component or module from a “live” or powered up system. Bus bars assemblies with louvered, pluggable connectors allow immediate connections to powered systems. These applications are becoming increasingly popular to avoid any system downtime.

IGBT
IGBT (Insulated Gate Bipolar Transistor) devices are power semiconductor products. They are used to switch high power loads, typically in motor control and uninterruptable power supply applications. Laminated bus bars are preferred for distributing power for IGBT applications because their low inductance helps to minimize power surges that could damage the semiconductors.

Impedance
Describes the electrical characteristics of the bus bar. Related to capacitance and inductance in that it depends on the physical design and manufacture of the bus bar conductors.

Inductance
A good inductor stores energy in the form of a magnetic field around conductors. Most designers want low inductance, especially those working with IGBTs as this “stored” energy can be a source of a voltage spike, which can damage the expensive IGBT. Low inductance can be achieved by placing flat voltage and return conductors in close proximity. See the Design Guide section of this brochure for further information.

Laminated Bus Bar
A laminated bus bar consists of multiple conductors that are separated electrically by film insulator layers with adhesive. These multiple layers are subjected to heat and pressure during the lamination process to form a single product.

Partial Discharge
Partial discharge is an electrical condition that causes insulation deterioration and can lead to breakdown of an insulation system. It can be described as an electric discharge in a gas filled void that partially bridges insulation. Methode has partial discharge test methods that effectively resolve this issue.

Power Density
High power density refers to the ability to handle high power levels in a small volume of space. By using bus bars, a power distribution design can be packaged in a smaller envelope versus using traditional wiring harnesses.

Voltage Drop
Voltage drop for bus bars usually refers to the reduction in voltage on a conductor between different locations. The voltage drop value depends on the resistivity and geometry of the conductor (see formula for voltage drop calculations in our Design Guide). Low voltage systems are especially sensitive to voltage drop. Over-designing the required conductor size helps to minimize voltage drop.

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