WATTSYS®
Power distribution system
As vital components for electrical power distribution in telecommunication satellites and land-based weapon systems, the bus and battery bars developed by AXON ensure reliable distribution of constant energy.

**BUS & BATTERY BARS**

Bus and battery bars are used to distribute energy in the different parts of a satellite (see drawing):

- between the different components of the batteries (e.g. cells, bypass, shunt, connectors.) (1),
- between the solar array slip ring and the power system regulator (PSR/PCU) (2),
- between the batteries and the power system regulator (3),
- between the power supply regulator system and the different devices in the satellite (e.g. computer, power emitter, navigation system, propulsion.) (4),
- between battery pack groups (5).

AXON’s bus and battery bars are composed of silver plated pure aluminium or high conductivity aluminium alloy. They are characterised by their flat shape.

Their main advantages:
- high electrical conductivity of pure aluminium and aluminium alloy,
- mass reduction compared to a copper solution,
- improved heat dissipation in comparison with a circular power cable bundle,
- significant improvement in voltage drop throughout the power distribution chain.

Numerous satellites of the EUROSTAR 3000 platform have been equipped with AXON’s bus and battery bars and have been in orbit for more than 10 years: e.g. ASTRA, ARABSAT, INTELSAT, SKYNET.
The construction of the bars can be single or multi-layer. Depending on the application, different types of bars can be studied for specific applications. Below is a description of the main shapes qualified by AXON®. Other shapes can be studied for specific applications.

**Flat cables:** Monolayer inter cell battery bars.

**Type U:** Multilayer bar for the link between the solar arrays and the power system regulator.

**Type E:** Monolayer bar for the link between the batteries and the power system regulator.

**Type I:** Monolayer bar for the link between the power system regulator and the different satellite devices.
## MAIN CHARACTERISTICS

### Type of bar (indicative values)
These bars shapes and sections are not frozen and can be matched to customer needs.

<table>
<thead>
<tr>
<th>Type of bar</th>
<th>RESISTANCE MAX (mΩ/m)</th>
<th>MAXIMUM DERATED CURRENT (A)</th>
<th>RATED VOLTAGE (VDC)</th>
<th>MAX. NON OPERATING TEMP. (°C)</th>
<th>SECTION (mm²)</th>
<th>ΘT° MAX (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus bar Type U (0v shape) 31mm x 18mm (9 layers)</td>
<td>0.201</td>
<td>200</td>
<td>100</td>
<td>120</td>
<td>184</td>
<td>105</td>
</tr>
<tr>
<td>U (Layer) 0.8mm x 23mm (each internal layer)</td>
<td>1.52</td>
<td>22</td>
<td>100</td>
<td>120</td>
<td>18.4</td>
<td>105</td>
</tr>
<tr>
<td>Bus bar Type E (0v shape) 28 x 24.8mm</td>
<td>0.17</td>
<td>300</td>
<td>100</td>
<td>120</td>
<td>224</td>
<td>85</td>
</tr>
<tr>
<td>Bus bar Type I version 8mm x 23mm (each internal layer of E shape bars)</td>
<td>0.186</td>
<td>200</td>
<td>100</td>
<td>120</td>
<td>184</td>
<td>85</td>
</tr>
<tr>
<td>Bus bar Type I version 3mm x 23mm (free I shape)</td>
<td>0.406</td>
<td>80</td>
<td>100</td>
<td>120</td>
<td>69</td>
<td>105</td>
</tr>
<tr>
<td>Flat cables (battery bars) 3mm x 40mm</td>
<td>0.233</td>
<td>300</td>
<td>100</td>
<td>180**</td>
<td>120</td>
<td>150*</td>
</tr>
<tr>
<td>Flat cables (battery bars) 4mm x 40mm</td>
<td>0.175</td>
<td>400</td>
<td>100</td>
<td>180**</td>
<td>160</td>
<td>150*</td>
</tr>
<tr>
<td>Flat cables (battery bars) 5mm x 40mm</td>
<td>0.160</td>
<td>500</td>
<td>100</td>
<td>180**</td>
<td>200</td>
<td>150</td>
</tr>
</tbody>
</table>

*: 110°C if a connector is bounded by soft soldering.
**: Without connectors.
For other bar shapes please contact us.

### Type of connection (indicative values)

<table>
<thead>
<tr>
<th>Type of Connection</th>
<th>MAX. CONTACT RESISTANCE (mΩ/m)</th>
<th>MAXIMUM DERATED CURRENT (A)</th>
<th>RATED VOLTAGE (VDC)</th>
<th>ΘT° MAX (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMC (AXON® Micro Modular Connectors), Inline variant.</td>
<td>≤ 2.5</td>
<td>40* per contact</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>MMC (AXON® Micro Modular Connectors), PCB variant.</td>
<td>≤ 2.5</td>
<td>25* per contact</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>Bolted interface (4 screws M4) e.g. flat cable (battery bar) terminations</td>
<td>≤ 0.02</td>
<td>400*</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Space approved power D-Sub connector xWx</td>
<td>≤ 2.5 per contact</td>
<td>40* per contact</td>
<td>300</td>
<td>125</td>
</tr>
<tr>
<td>Space approved standard D-Sub connector</td>
<td>≤ 5 per contact</td>
<td>7.5* per contact</td>
<td>300</td>
<td>125</td>
</tr>
</tbody>
</table>

*: See parameter derating information.
**: Please contact us for more information.
Other connector types are possible on request.
Flexible links and braid
Example of wires used for flexible links (indicative values)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance (mΩ/m)</td>
<td>6.03</td>
</tr>
<tr>
<td>Maximum current per conductor (A)</td>
<td>23</td>
</tr>
<tr>
<td>Rated voltage (Volts)</td>
<td>600</td>
</tr>
<tr>
<td>@T°C Max (°C)</td>
<td>200</td>
</tr>
<tr>
<td>Section (mm²)</td>
<td>3.2</td>
</tr>
<tr>
<td>Parameter derating information (allowable current)</td>
<td></td>
</tr>
</tbody>
</table>

| ESA wire AWG12* ESCC 3901 001 31 (QPL) | 14.3 |
| ESA wire AWG16* ESCC 3901 001 29 (QPL) | 3.2 |
|ESA wire AWG20* ESCC 3901 002 59 (QPL) | 0.3 |
|Power isolated copper braid P/N: P540409 | 0.3 |

* refer to AXON’s ESA qualified ESCC cables for more information. Other sections available on request.

GENERAL CHARACTERISTICS (ALL TYPE OF BARS)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low outgassing materials</td>
<td>TML (Total Mass Loss) &lt;1% CVCM (Collected Volatile Condensable Material) &lt;0.1%</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-35°C to +85°C (for flat cables: -35°C to +150°C)</td>
</tr>
<tr>
<td>Qualification temperature</td>
<td>-40°C to +110°C</td>
</tr>
<tr>
<td>Insulation resistance between bars</td>
<td>&gt; 1000 MΩ under 500 Vdc</td>
</tr>
<tr>
<td>Maximum capacitance between bars</td>
<td>4 nF/m</td>
</tr>
<tr>
<td>Emissivity of bar surface</td>
<td>&gt; 0.65</td>
</tr>
</tbody>
</table>

For all types of bars a double electrical insulation is effected between two conductors with different types of insulating materials: - Silicone + epoxy, - Epoxy + polyimide tape,.....

in order to guarantee an excellent insulation.

Heat resistance of bars is optimised:
› Flat bar shapes (surface increased = better heat dissipation)
› Outer surface insulation (thermal radiation improved)
› Low insulation thickness (thermal conduction improved)
FIXING OF THE BARS IN THE SPACECRAFT

In order to install the bus bars onto the spacecraft walls, both rigid aluminium fixtures and flexible fixtures made of high performance thermoplastic polymers or aluminium assemblies are used. These significantly help to reduce the mechanical impact of vibration, shock and temperature. To mount the bar AXON’ recommends one rigid and several flexible fixtures placed every 200 mm (7.9”). Flexible fixturing allows the bar to flex with the spacecraft movement, taking into account its thermo-elastic behaviour. Rigid support ensures complete fastening of the bar to the mechanical structure.

Installation of fixtures and bars are carried out according to the applicable customer specification.

EXAMPLE OF FIXTURING FOR "I"-SHAPE BAR

EXAMPLE OF FIXTURING FOR "E"-SHAPE BAR
BAR INTERCONNECTION

The bar can be connected via many different connectors and wires with different gauge sizes. The interconnection of Wattsys® bar is carried out with dismountable flexible or rigid links:

Dismountable flexible links:
› Wire bundles (e.g. ECSS wires) soldered to the bars,
› Flexible copper power braids.

Dismountable rigid terminations:
› Contacts welded onto the bars (compatible with standard connectors),
› Bolted connections (low contact resistance),
› AXON® power connectors (low size).
› AXON® Micro Modular Connectors (MMC).

The fixations of the bars (mechanical parts: e.g., screws, washers, machined parts) have been designed to allow for either:
- a very tight mechanical connection of the bar (rigid fixation: no movement), or
- a flexible mechanical connection allowing for thermo elasticity (flexible fixation).

MANUFACTURING

Production of AXON’s bus and battery bars is carried out under cleanroom conditions
› Cleanliness level: Class ISO 8 = Class 100 000 according to FED STD 209E.
› For soldering and crimping processes the operators are qualified according to ECSS-Q-ST-70-08 & ECSS-Q-ST-70-26.

The length and routing of the bars can be verified on a 3D mock-up.

QUALIFICATIONS

Various tests are carried out either in AXON’s in-house test laboratory or in specialised test facilities outside the company.

AXON® has been approved by the CNES (French space agency) for manual wire crimping and welding according to PID CNES-PID-05-AXON (refer to CNES N° ASF 13-42).

Thermal tests:
› 1000 hours at 120°C,
› 100 thermal cycles at -30/+120°C with on/off current cycles,
› 2000 thermal cycles at -20/+90°C with on/off current cycles.

Vibration tests:
› Launcher spectrum in X,Y & Z axes,
› Vibrations on satellite qualification model.
Thermal Vacuum:

› Vacuum thermal cycles at -40/+110°C with on/off current cycles.

Mechanical test:

› Mounting/dismounting (for MCP & Bolted interfaces).

Non destructive investigations:

› Ultrasound cartography: to evaluate uniformity of layer pasting,
› Tomography (X-ray cartography): to verify the position of layers inside the shape.

Destructive investigations:

› Scanning Electronic Microscope (SEM):
   - to verify wires & contact soldering,
   - to verify layer pasting & positioning,
› Differential Scanning Calorimetry polymer analyser: to verify the curing of adhesives.

SERVICE

AXON’ provides after-sales service for the whole assembly and can assist on-site to help with integration and updating of the bars. Various installation documents can be supplied on request.

GUARANTY

AXON’ bus and battery bars are guaranteed for 15 years use in orbit in addition to 5 years of storage.