LIGHT WEIGHT AND MASS SAVING SOLUTIONS FOR SPACE WIRING

M.Jakob, Axon‘ Kabel GmbH, Hertichstr.43, 71229 Leonberg, Germany

abstract

Reducing the mass of all components, parts and equipment is a continuous target in the space industry. Axon’ with its development and manufacturing solutions in all fields of electrical interconnect, has been exploring and developing various solutions to meet this requirement:

Axalu® aluminium cables
Silver plated aluminium braid
Low Mass Spacewire cables to ESCC3902/003
Busbar Power Distribution Systems
New high temperature wires for mass savings (under evaluation)
Miniature connectors acc. to ESCC 3401 086

1. AXALU® CABLES

Axalu® hook-up cables have been developed for satellite data transmission and battery power distribution. The product range consists of silver plated aluminium conductors and shielding wires made of the same material.
For the shielding application Axalu® has a second advantage for use in shields with exposure to cosmic radiation (x-rays), due to its low atomic mass.
The Axalu® range of cables is insulated as standard in extruded crosslinked ETFE, although other materials are available.
The voltage rating of this family is 600VAC, while the operating temperature ranges from -100°C to +150°C.
Axalu® wires have proven space heritage over the past 4 years within various TAS satellites: Telecommunication satellites since ArabSat2/Spacebus 2000, 3000 (and following Spacebus 4000 platforms).

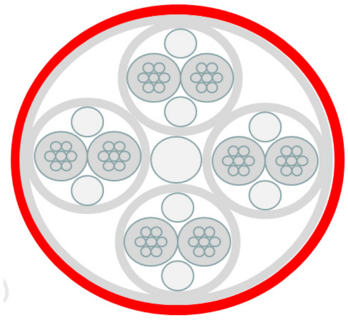
2. SILVER PLATED ALUMINIUM BRAID

Silver plated Aluminium braid, called AXOTRESS® by Axon’, are designed for manual shielding over a small length of assembly branches on a harness. For space applications the products are plated with a silver thickness of 2µm. The advantages compared to plated copper material are the mass saving factor of up to 60% and less effect to cosmic radiation due to its low atomic mass. Braids are available as single or double layer version, and also as optimized version for an accurate transfer impedance (mΩ/m).

PICTURE 1. Double layer AXOTRESS®

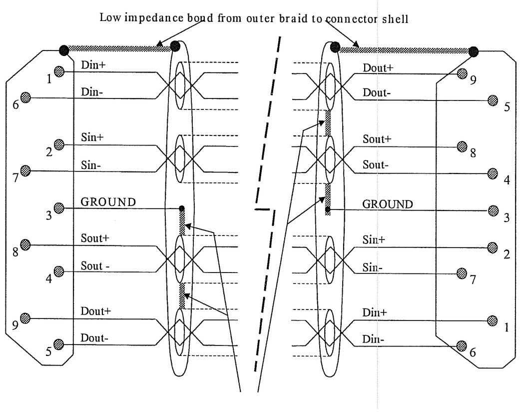
3. LOW MASS SPACEWIRE

In response to an ESA request to develop a low mass variant for the existing SpaceWire cable Axon’ developed a new product in 2013 and prepared an update of the standardisation. This low mass 28AWG SpaceWire cable is built according to ESCC 3902/003 variant 03 requirements and consists of 4 shielded twisted pairs covered by an overall shield and outer jacket. The shields of this cable are made using silver plated aluminium . The 19 stranded copper conductor is designed to improve flexibility and enables easier installation (routing) due to the smaller bend radius of the overall cable. The primary insulation is of an aleveolar PTFE (or aPTFE) construction, where the material is not solid but has a number of air gaps in a lattice-like structure. This has the twin advantages of improving the dielectric constant whilst also reducing weight. For improved radiation resistance the outer jacket is made of lightweight Polyimide tape. With these significant changes AXON’ is able to offer a solution which saves almost 50% of the mass of the existing SpaceWire link!



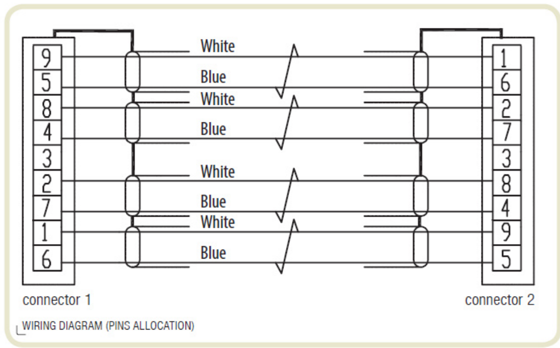
PICTURE 2. Variant 03 (C-OA-TPA-A-2819) Low Mass SpW cable (Outer shield in contact with inner pair shields, all shields in silver plated aluminium)

The wiring and screen bonding schedule for the current SpaceWire cable is not optimized, but rather was adopted at the time, partially due to the constraints imposed by a combination of the construction of the cable (where all the inner screens are isolated from the outer screen) and the 9 way Micro-D connector (which does not have enough contacts to terminate all 8 wires and all 4 inner screens). We therefore have the existing standard wherein two of the inner screens are short circuited together and terminated to pin 3 at one end, and the other two inner screens are similarly terminated to pin 3 at the other end, meaning that no inner screen is continuously connected from one end to the other. This was considered acceptable under previous EMI guidelines, but it is generally accepted today that shield bonding at both ends is far better. The outer screens are terminated to the shell of the connector (or backshell) but there is no specific requirement for a 360° shield termination.



PICTURE 3. Existing SpaceWire wiring schedule

Assuming, for backward compatibility reasons, we wish to retain the 9 way Micro-D connector for some time to come, we can now substantially improve this wiring schedule with the new (ESA endorsed twisted pair) cable construction. As all the inner screens are now directly in contact with the outer screen, there is no need to terminate any screens to pin 3 of the Micro-D, which will now become redundant. We can remove any screen termination to pin 3, thus avoiding the transfer of any EMI interference directly into the electronics. We can then simply terminate the outer screen to the body of the connector or backshell, thus effectively terminating all screens together in one step. For EMC purposes, it is highly recommended to employ a backshell at the rear of the Micro-D connector, with a cable entry funnel optimized to be only slightly larger than the inner bundle of four pairs, and then to terminate the overall shield over this funnel with some recognized form of 360° screen termination, such as a EMC band clamp. This simplified, but improved, wiring schedule will now resemble Fig. 4.

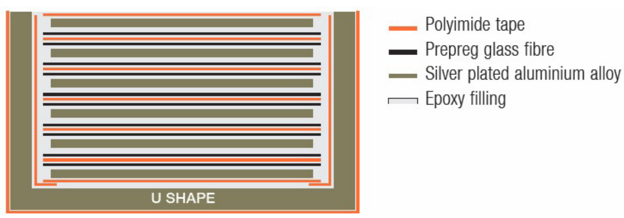


PICTURE 4. Proposed Low Mass SpaceWire Wiring Schedule

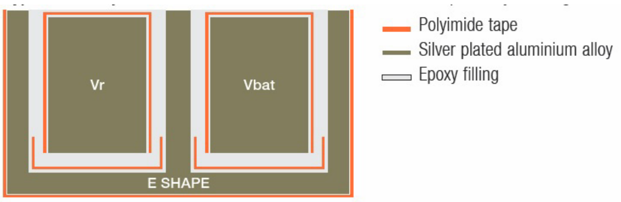
Therefore, taking all of this into account, the team of AXON' and its partners are currently working with ESA and Star Dundee to feed all of these conclusions into the latest draft of the ECSS-ST-50-12 assembly standard and the ESCC 3902/003 cable standard updates. The screen termination method has been reviewed in depth. The inner and overall shields are terminated together to the connector shell at both ends.

4. BUSBAR POWER DISTRIBUTION SYSTEM

Busbars are special designed profile bars which transport or distribute electrical energy among different parts of a satellite, e.g. between different components of a battery, between the solar array slip ring and the power system regulator, between the batteries and the power system regulator, between the power system regulator system and the different devices in the satellite (such as computer, power emitter, navigation system etc). Axon's busbars are composed of silver plated pure aluminium or high conductivity aluminium alloy.They are characterized by their flat shape. Their main advantages are 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, and a reduced voltage drop of the electrical power distribution chain. Types of busbars available are e.g. Type U (in a U-shape):

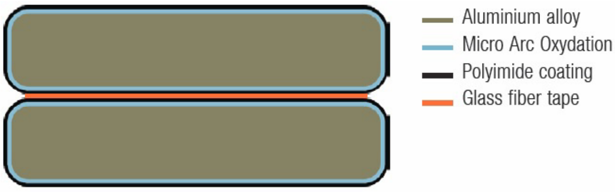


PICTURE 5. Multilayer bar (Type U) for the link between the solar arrays and the power system regulator.



PICTURE 6. Monolayer bar (Type E) for the link between the batteries and the power system regulator.

PICTURE 7. Monolayer bar (Type I) for the link between the power system regulator and the different satellite devices.

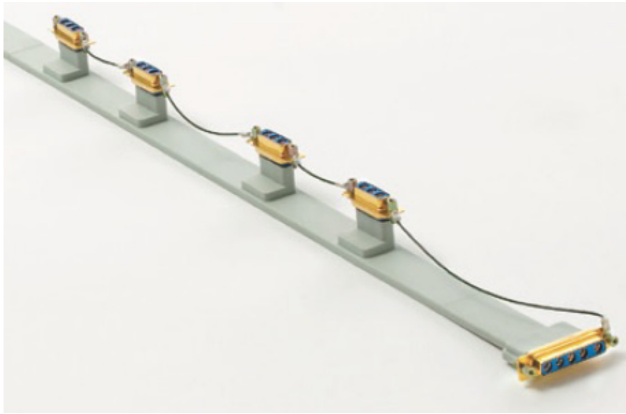


PICTURE 8. Double layer bar (Type II) for the link between high power battery parts.

Depending on the application, different types of bars can be used. The capacity of the bars varies between 22 and 400A DC at a rated voltage of 100V. The connection to/ from these bars can be made via space approved Sub-D connectors with size 8 contacts, space approved Sub-D connectors with size 20 contacts, bolted interfaces and AXON's Micro Power Connector MCP.

Interconnection of bars is carried out with dismountable flexible or rigid links. The flexible links are made of wire bundles (e.g. ECSS wires) soldered to the bars or flexible copper power braids. The rigid terminations are made with contacts welded onto the bars, bolted connection or with AXON's power connector.

PICTURE 9. Monolayer Bar Type E with flexible connection links.

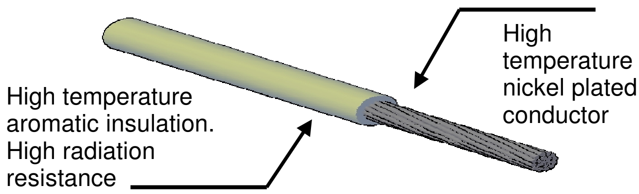


PICTURE 10. Monolayer Bar Type I with rigid connection via space approved Sub-D connectors.

5. NEW HIGH TEMPERATURE WIRES (EVALUATION)

Another approach for mass savings has been started with the development and evaluation of a new family of high temperature wires within the ESCC categories.

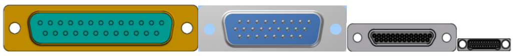
The target temperature of this family will be up to 250°C, allowing to have different results with existing derating rules. This will lead to smaller diameters of wires to be used for a given max. amperage. With such an increase of the amperage capacity the result will be a significant reduction of weight and size of harnesses.



PICTURE 11. Design of high temperature wire

6. MINIATURE CONNECTORS NANO-D

Nano-D connectors allow much higher contacts density keeping a good current rating. The data regarding the external surface of the connectors illustrates well these arguments: Surface is reduced by a factor of 2.8 between D SUB and Micro-D, by a factor 14 between D-SUB and Nano-D and by a factor of 5 between Micro-D and Nano-D. Such a connector can accommodate a very large quantity of pins. Mechanically they are robust and durable. They present low contact resistance and high current capacity. In addition, they have excellent resistance to shock and vibration. Jumpers, Pigtails, PCB connectors (CBR, BS, SMV) from 9 to 51pins are available. Customized harness can be realized.



	D SUB SD ESCC.3401.01	**D SUB HD** ESCC.3401.02	**Micro-** ESCC.3401 29 &77	**Nano-D** ESCC3401 086
Pitch	2.74	2.41	1.27	0.635
Dimensions (mm)	53.04x12.55 for a 25 ways	39.14x12.55 for a 26 ways	30.1x7.82 for a 25 ways	14.61x3.18 for a 25 ways
Surface (mm²)	665 for a 25 ways	491 for a 26 ways	234 for a 25 ways	46.5 for a 25 ways
Weight (g)	13 for a 25 ways	7.6 for a 26 ways	3.6 for a 25 ways	0.5 for a 25 ways
Wire Awg	28 to 20	26 to 22	28 to 26	30
Removable	Y	Y	N/Y	N
Screwlocks size	4-40 UNC	4-40 UNC	2-56 UNC	0-80 UNF
Work. Volt. (Vrms)	300	250	150	250 *
Rated current (A)	3 to 7.5	3 to 5	1.5 to 2.5	1 *

PICTURE 12. Migration of Space connectors to smaller sizes

Nowadays a vast majority of satellites use D subminiature connectors as they can be used for many applications. Alternatively, Micro-D and/or Nano-D connectors can be used in wired harnesses for mass and volume saving purposes. Micro-D connectors solutions are based upon ESCC3401/029 and/or Nano-D solutions based on MIL-DTL-32139 & ESCC3401/86.

PICTURE 13. Migration of PIN's from µ to Nano sizes

It is clear that reducing the size of the connectors by a ratio of 14 may cause among users a strong fear and installation problems. This technical issues have been assessed and a user guide has been issued to help installers to handle correctly the Nano-D assemblies.

PICTURE 14. NanoD assemblies