LOW-MASS SPACEWIRE

Session: SpaceWire Components (Poster)

Short Paper

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ABSTRACT

The current cable specification given in the ECSS-E-ST-50-12C SpaceWire standard [1] is defining the detailed construction of the cable. With this, the manufacturer can produce a cable compliant to the standard which is able to transmit the signal over a length of 10 m and support a data rate of 200 Mbps. A disadvantage is that this cable may be heavier and more rigid than necessary for short connections and too lossy for distances beyond 10 m.

For the upcoming update of the SpaceWire standard, the intention is not to specify the cable construction, but rather specify physical and electrical parameters which can be verified by measurement. These could comprise parameters like Differential Impedance, Signal Skew, Return Loss, Insertion Loss, Near-end Crosstalk (NEXT), Far-end Crosstalk (FEXT) and radiated EMI. From this specification, cable manufactures will be able to design SpaceWire compliant cables optimised for a particular application.

An ESA funded activity aimed to develop a low-mass SpaceWire cable was initiated at the beginning of 2010. The activity will define the electrical and physical performance parameters of the current SpaceWire cable and use these metrics to design a new cable with lower mass properties. Following this initial definition, ESA will develop, manufacture and validate a low-mass SpaceWire cable, a cable that is mainly targeted at shorter SpW interconnections. The goal is to reduce the mass by 30% to 50%. An important part of the activity is to determine whether the current SpaceWire cable grounding and shielding scheme can be changed without affecting performance factors such as EMC/EMI, mechanical properties and data rate adversely.

In this paper, the latest results obtained during the first part of the Low-Mass SpaceWire activity will be reported. It discusses candidate cable constructions to achieve lower mass, alternative connectors for the cable assembly and the upcoming tasks leading up to activity completion.

1 EFFECTIVENESS OF INNERSHIELDS

The SpaceWire cable uses multiple shields where the outer shield is connected to the spacecraft structure through the connector backshell, and the inner shields of the transmitting pairs is grounded to pin 3 of the MDM connectors. As shown in figure 1,

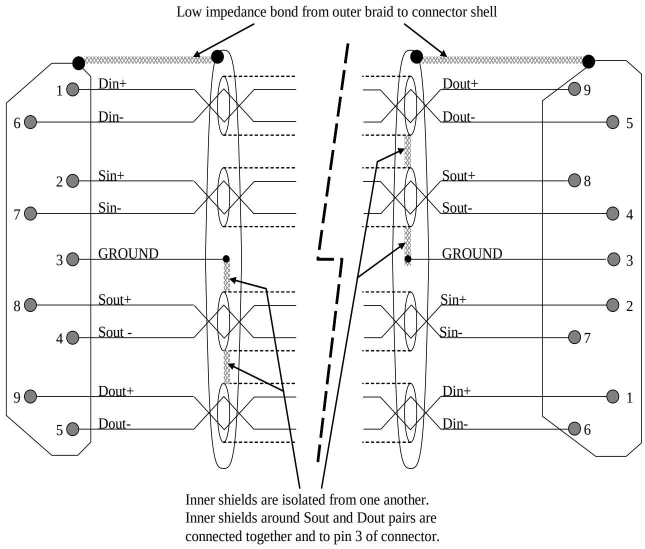

Figure 1: SpaceWire cable shield arrangement.

the inner shields are terminated at one end with the idea to avoid ground loops to occur. This type of arrangement is effective for cancelling out EMI at lower frequencies, but ineffective for higher frequency ranges. The rise and fall times of a typical LVDS signal is close to 1ns, which translates to a signal bandwidth in the range of 1-2 GHz. The notion that high frequency EMI is not effectively reduced by the inner shields, means that cross talk becomes an increasing problem both with respect to cable length and transmission rate. Tests carried out in [3] and [4] confirmed the inner shields to have little effectiveness.

2 SPACE CRAFT GROUNDING

In order to evaluate what parts of the current SpaceWire cable can be changed it is necessary to have an understanding of the typical space craft grounding practises. Although these may vary quite a bit from one mission to the other, there are commonalities which can be exploited. While diving into the complex domain of space craft grounding is out of scope in this paper, the findings in the initial phase of the Low-Mass SpaceWire activity shows that the inner shields of the SpaceWire cable could be connected on both sides without affecting its general use in a spacecraft.

3 REDUCING CABLE MASS

The previous sections highlighted the inner shields as not performing their intended function. Hence the cable construction could be adapted in a way which also reduces cable mass. Feasible solutions are to either remove the inner shields all together, while keeping the outer shield, - or removing the outer shield and grounding the inner shields at both ends to the chassis ground. To ensure good EMC performance it is important that these screens are continuous and are all 360˚ in contact with the backshell of the connector.

Considering the approaches which save the most mass, we first look the implications of removing the inner shields completely. The reduction of mass will give a 35-40% decrease in mass compared to the standard SpaceWire cable. Advantages of this approach are simpler termination of the shield to the connector backshell, and using 9-MDM for connections through bulkhead is possible. The drawback is the increased cross talk between the individual pairs. For lower data rates below 100Mbps and shorter cable lengths, this may not be a significant problem. The cross talk can to some extent be reduced by the twisting scheme of the individual pairs, however excessive cable tension or bend increases susceptibility to inter pair cross talk.

A second approach is to remove the outer shield completely and terminating the inner shields 360˚at each end to chassis ground. The termination of the shields is more mechanically challenging, but cable mass is significantly reduced and the cable will be much more flexible. With this approach the inter pair crosstalk is reduced and 9-pin MDM connectors will support bulkhead connections.

3.1 MATERIAL REDUCTIONS

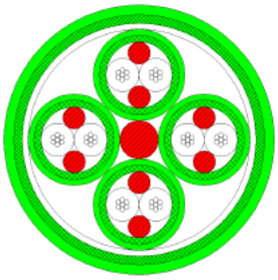

Figure 2: Suppression of fillers

Other approaches which further reduce mass is using lighter materials e.g. using silver plated aluminium instead of silver plated copper for the shields. Reducing the wire gauge is also an option which is viable for shorter cable lengths. In picture 2, the suppression of filler materials (in red) is considered to reduce mass. Adding all these options together leads to a potential mass reduction of around ~ 45 – 50 %. At present, the ongoing ESA study with Axon cable and University of Dundee has identified a range of candidates for mass reduction of the cable. Two candidate solutions will be the pre-selected for further analysis and tests. The final product will be subjected both to electrical characterisation, and mechanical stress tests which are compared to the performance of the current SpaceWire cable design.

3.2 ALTERNATIVE CABLE CONSTRUCTIONS

In the various options of different cable constructions, the well known twisted pair is usually selected. In addition, other alternative concepts based on thin coaxial cables are investigated carefully. A circular cable construction solution based on very thin coaxial cables is a promising candidate due to the inherent electrical performance. Such a design can carry very high data rates, up to several Gbit/s, with the appropriate connector for the cable assembly. It is estimated that using small conductor (AWG3401) gauge for the coax cables is estimated to give a potential weight saving in the range of 60% - 70%. A driving requirement is that such an option must be backwards compatible with 9-pin MDM connectors. The challenge is to ensure good mechanical robustness of the shield bonding towards connector.

4 ALTERNATIVE CONNECTORS

It may be attractive to also identify a small set of alternative connectors to be included in a future revision of the SpaceWire standard. These may serve applications where very high data rate is required, or where miniaturisation is needed. In the course of the Low-Mass SpaceWire (LMSPW) activity, one candidate connector that will be tested is the Nano-D connector which is most suited for application where miniaturisation is a key driver. An evaluation programme announced in ESA AO/1-6126 for this particular connector family is running in parallel to the LMSPW activity. The objective is to evaluate the family of ultra miniature Nano-D connectors with respect to the specific requirements of space applications or special space programs such as the Mars surface explorer. Connector samples manufactured as output of the parallel evaluation activity will be used in the frame of the LMSPW activity for evaluation of complete cable assemblies.

Impedance matched connectors are also under the microscope in the ongoing LMSPW activity. Previous work performed in [3], [6] have identified candidates which will be included in the assessment. Here miniaturisation may not be the driving requirement, but rather electrical performance, robustness, suitability for bulkhead connections and handling.

5 PROPOSED SPACEWIRE STANDARD REVISION

As mentioned in previous publications [5], the current SpaceWire standard contains a detailed specification of how the cable should be constructed. In the revision of the standard, it is foreseen to rather specify the electrical parameters and tolerances in order to allow for manufacturing of cables that suite a particular application rather than “one size fits all”. A proposal for standardisation will be one of the outcomes from the LMSPW.

6 CONCLUSION

In this paper, the status of the currently ongoing activity for the development of a Low-Mass SpaceWire cable has been presented. Various elements of cable construction have been discussed with emphasis on proposed cable construction changes that can significantly reduce mass. The various options will be down-selected based on simulations. The remaining candidate solutions will be manufactured and assembled in various configurations, including different connector types and cable assembly lengths. Each sample is electrically characterised, both in terms of performance and EMC/EMI properties with the current ECSS-E-ST-50-12C cable specification. In addition, a set of mechanical endurance tests will be performed to validate mechanical robustness of the cable, specifically connector/cable junction.

For shorter cable runs in the range of up to 3-5 meters, the preliminary analysis performed in the frame of the LMSPW activity show promising results in terms of reducing the cable mass significantly.

Relaxing the cable construction requirements by replacing them with electrical performance parameters will leave more freedom to use cables which are tailored to specific applications. They can be for example optimised for low-mass, link distance, mechanical handling properties or cost and still fulfil the electrical requirements to guarantee the very low bit error rate which is characteristic for SpaceWire.

7 REFERENCES

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