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Developing and qualification high speed digital harness for Telecom space flight

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Outline

Digital capabilities of telecommunication satellites are increasing significantly with the onset of flexible payload requirements. A lot of time and expertise is invested in the processors, converters and electronic hardware needed to accommodate an ever more demanding market. But the requirement to connect together the various units whilst ensuring no loss in digital integrity is overlooked at the system designers peril. This paper covers some of the aspects addressed by the payload team working with connector and cable manufacturers to meet the processor design teams requirements in a telecom satellite, particularly the qualification needed to address the real project needs.

When dealing with a distributed digital processor scenario the interlinking harness needs to support the digital high speed traffic in a manner that ensures minimal loss of signal integrity, for many years this could be supported with simple twisted pair digital cabling but with high speed signals in the Giga hertz improvements need to be made in many aspects.

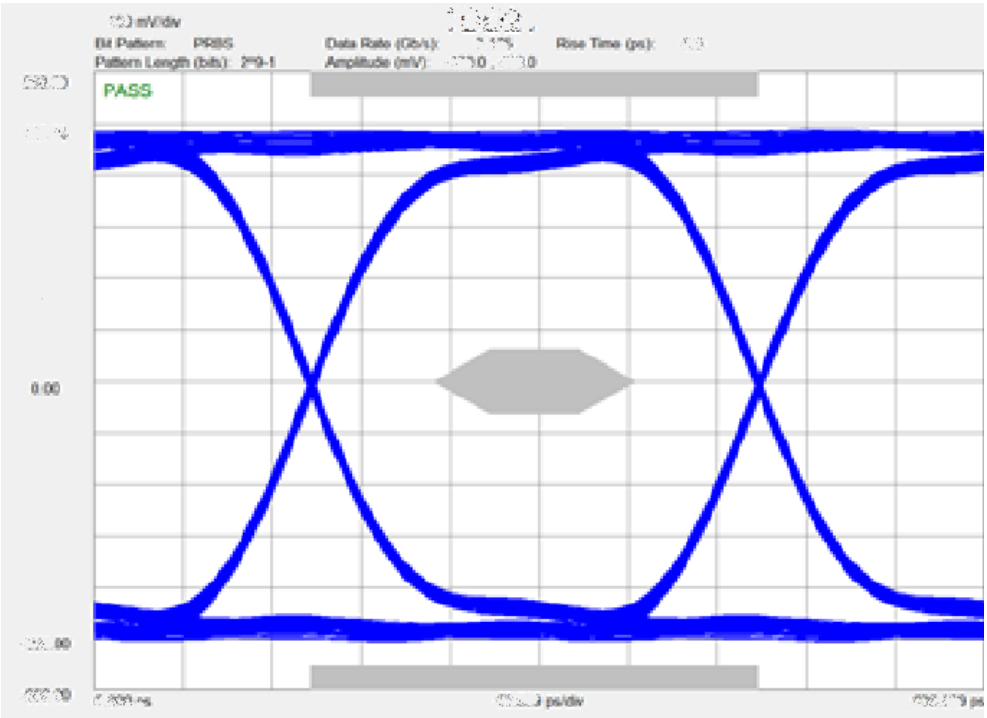
The team assembled by ADS included the processor design, system architects, connector and cable designers and harness specialists. With the common goal to fulfil the processor design team requirements it actually meant a great deal of communication and co-engineering to ensure the final payload solution worked successfully and would do so for the lifetime of the payload.

To be clear each member of the team brings unique skills and experience, managing the team successfully ensures the payload application works. The specification created by the processor team addresses their needs, signal integrity, speed, skew etc, but does not always address the real life scenario the payload team deals with, the Airbus equipment specialist brings expertise supporting the connector and cable manufacturers to create products addressing multiple payload criteria.

Present

As the digital speeds required of connectivity increases then the previous experience of twisted pair cables with off the shelf connectors becomes less feasible. We see the digital signals speeds increasing significantly and in many ways these harnesses could be aligned with RF connectivity, the factors influencing the high speed digital signal being loss of amplitude-insertion loss, poor match-return loss, skew of signal-phase delay, although measuring just the RF S parameters gives the most relevant data manipulation of this data is required to present in a form the digital world can easily assess. Each of these factors is directly related to the cable, connectors and assembly of the linking cables.

In the case of digital integrity the system used is based on an EYE pattern test where the various parameters are visually interpreted to illustrate the degradation of the digital pulse, provided the measured signal exceeds the limits of the digital interpretation then the signal can be resolved. Illustrated is a typical EYE pattern results, the measured results are clear of the designated EYE pattern template.



Example EYE pattern test result

Just as in an RF system the match of the connectors is critical, this needs to balance the cable characteristics with the interfaces n and out of the processor components, similar to launching 3+ GHz RF directly onto a PCB. Previous experience at 300Mhz gave us a baseline but new thinking was required to ensure a fit for purpose solution.

Distributed processor modules has many thermal and mechanical advantages, processing near the other components of the payload system only works if we can support the required speed and signal integrity.

Connectors

The connector partner had to create a connector system capable of achieving the high digital speeds required. The connector is specifically designed for the high speed digital signal and not just an evolution of a previous design. Also taken into account needs to be the materials used, mass and assembly techniques needed. The connectors need to match the cable characteristics to ensure best signal performance. The needs for manufacture, assembly, integration and mating are also addressed at this point.

Very small geometries need to be used with high speed digital signals, these need to be maintained and replicated multiple times and support mating and demating without problems, also the materials and processes used in their manufacture must align with the payload material and process requirements.

Cable

The cable partner needed to understand both the system needs and the connector parameter in order to carefully select the cable type, construction and materials. Also how to use in harness in flight scenario. Heritage screened twisted pair type cables have been used on previous high speed digital cables, but as the speed increase the cable has to change to ensure the delay introduced does not impact performance. Not only are the cable pairs critical but also the screening. As with the connectors the cable needs to match the connector characteristics to ensure best signal performance. The needs for manufacture, assembly, integration and routing are also addressed.

Cable assembly

Every cable assembly is more than a sum of its parts, the process of attaching the connectors to the bulk cable is critical to the final result, only be working with both the cable and connector suppliers can the best performance be extracted from the bags of bits. Every connector is designed with ideal mating and matching characteristics, and the bulk cable is designed with the same goal, but in reality the variances in production and materials have to be addressed in the cable assembly.

Harness assembly

Each cable assembly provides a digital path, modern processor equipment's are made up of multiple units and many digital signal paths, so the cable assemblies have to be bundled together and routed to meet the payload accommodation requirements and without affecting the signal integrity. ADS has a lot of heritage and experience of creating harnesses for DC and RF cable assemblies but high speed digital brings its own unique problems and limitations, based on the ADS team experience and product expertise from the connector and cable partners a system of rules and criteria were developed that aimed to meet all the various aspects.

Qualification

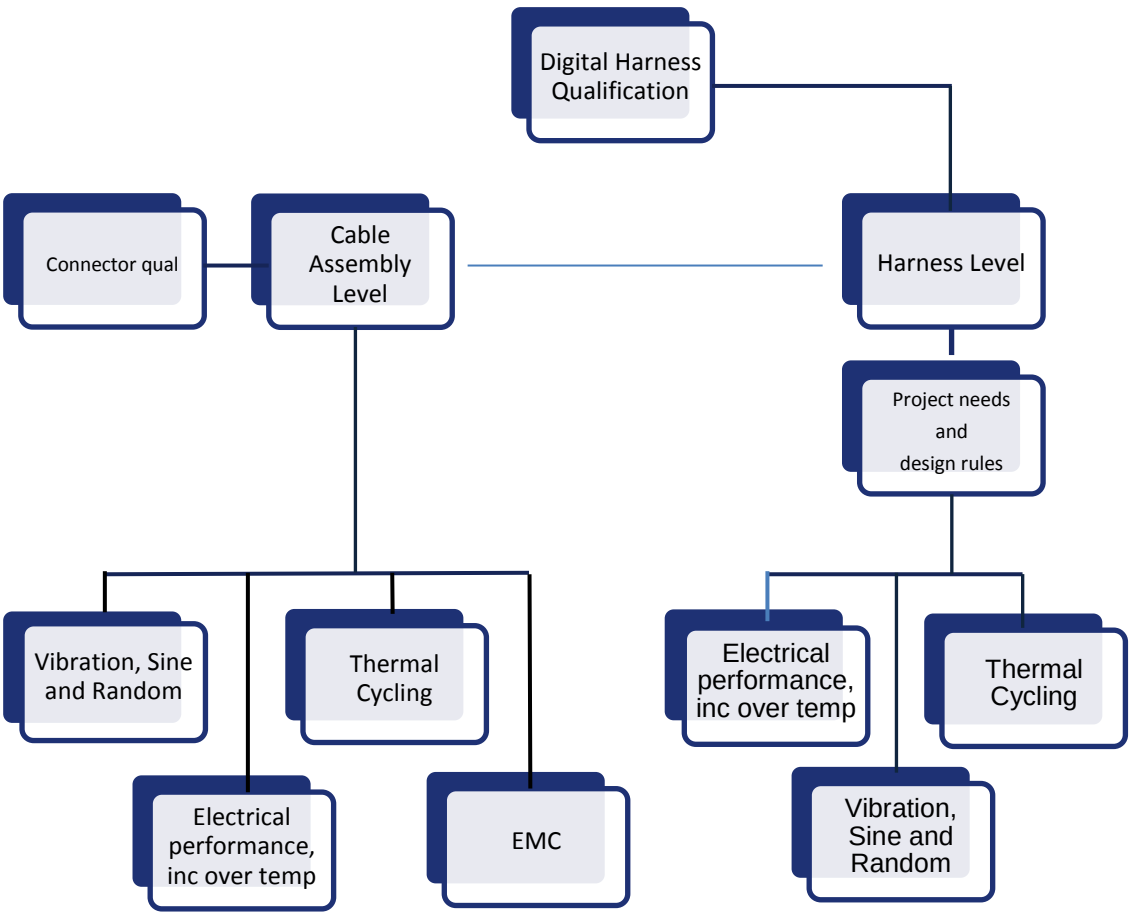
The qualification approach needed must address the actual needs for the product and its use, it is not simply a process of qualifying the connector to EEE spec then attaching to a cable also qualified to EEE spec, this creates an assembly which can have another way of qualification, finally does the harness created from multiple cable assemblies become an equipment with another set of qualification requirements.

Qualification of the connector to standard EEE requirements does not address the needs for the cables assembly, but is a useful building block that checks the mechanical and intermating requirements, aspects like pin retention, material compatibility, mating and demating forces are tested, but aspects such as electrical performance cannot be properly tested without a cable, attachment also varies with cable types. However the steps taken within the EEE development can be used later to support the harness development and qualification.

The connectors and cable combine to the cable assembly, this was then qualified to meet the payload requirements with emphasis on the environmental aspects coupled with the electrical performance. Thus addressing telecom generic needs and fulfilling the project environmental needs, the generic requirements try to envelope the various orbital location's, means of in orbit transfer and the launcher environments as much as possible.

Qualification of the complete processor harness was designed to address the influences the harness manufacture would have on the cable assemblies, each process harness will be different, depending on the number of units, layout and complexity, so the qualification verifies a set of design rules used to create the harness, provided the design rules are followed the impact on the cable assemblies should be negligible.

By which qualification of the design rules and guidelines allows us to best use the cable assemblies together as a harness in the best way for the payload application and also provides a basis for future harness application using these assemblies and design rules.



Simplified qualification flow diagram.

Summary

Only by working together could we create a digital high speed harness for current and future processor requirements for telecom satellites, only by understanding and cherry picking the best qualification routes and methods to underwrite the quality and integrity of the cables and harness to meet customer expectations.

By understanding the overall requirements for Telecom payload applications could ADS work with various different suppliers' to successfully develop a flight high speed digital harness. Where suppliers lack space flight knowledge we can advise and support, where the connector or cable manufacturer know their respective products very well they can advise ADS.

Co-engineering is much talked about term but in the case of the high speed digital harnesses currently being developed by Airbus this is a real life, real time, real world scenario that has produced great results.

Acknowledgments

I would like to extend my thanks to all the team members who worked together to make this project a success, without the support and cooperation from the processor design team within and the EEE experts Airbus, the connector designers and cable manufacturing teams we could not have created this unique digital harness for a commercial telecom satellite.