BACKPLANE DESIGN CONSIDERATIONS FOR HIGH SPEED SPACEWIRE NETWORKS

Session: Missions and Applications

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Abstract

- SpaceWire is quickly becoming the preferred protocol for over the backplane mission applications
- SpaceWire has the advantage of being simple, with readily available flight quality physical layer devices, IP cores and test equipment.
- However, the SpaceWire standard does not address specific guidelines for implementing SpaceWire over a backplane
- This paper discusses NASA's Goddard Space Flight Center's implementation of high speed SpaceWire over backplane on James Webb Space Telescope and other missions.

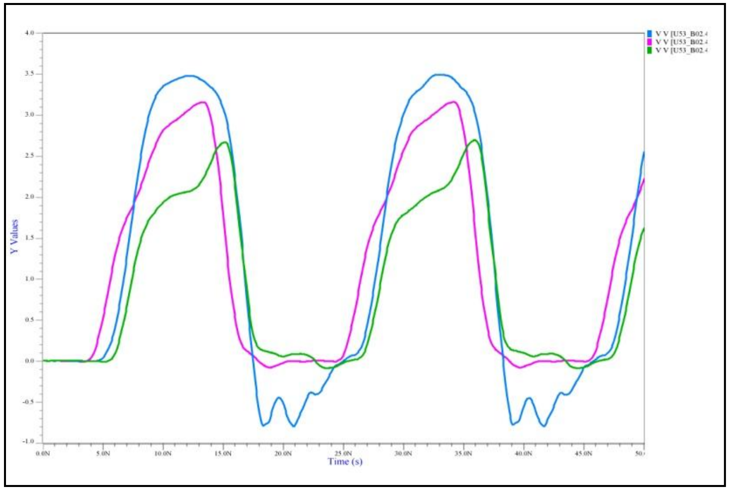
Overview

The topics covered by this paper include the following:

- **Connector selection**
  - Issues to consider include choosing a connector that is suited for high reliability applications and has the appropriate characteristics for high speed signal propagation
- **Impedance control**
  - Specifying a stackup and routing constraints to meet differential impedance requirements
- **Signal integrity and crosstalk**
  - Impacts to the design, methods of mitigating problems, analysis tool options
- **Power integrity**
  - Methods of mitigating power distribution problems, analyzing return current flow, analysis tool options
- **Test and accessibility**
  - Ways of providing probing access, verifying margins, interfacing to available validation and test equipment

Connector Selection

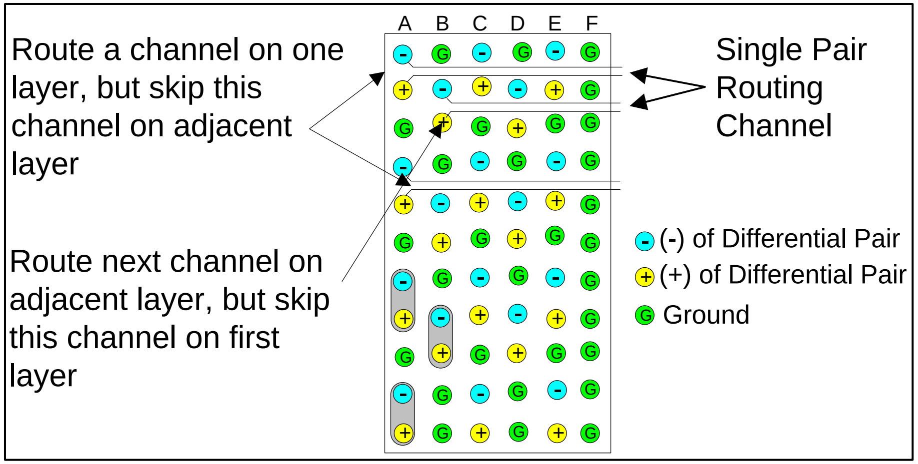
- **SpaceWire standard specifies a 9-pin MDM**
  - Not intended for or suitable in a backplane application
- **Need high speed, rugged connector suitable for mounting to a Printed Circuit Board (PCB)**
- **Connector data for high speed propagation signal quality should be reviewed before selecting a connector**
- **For the JWST ICDH application, Hypertronics CPCI connectors were used, with excellent high speed characteristics up-to 1 GHz edge rates**
- **Not all connectors are suitable for high speed signaling**



Differences in Signal Quality Depending on Connector Type

Connector Routing Considerations

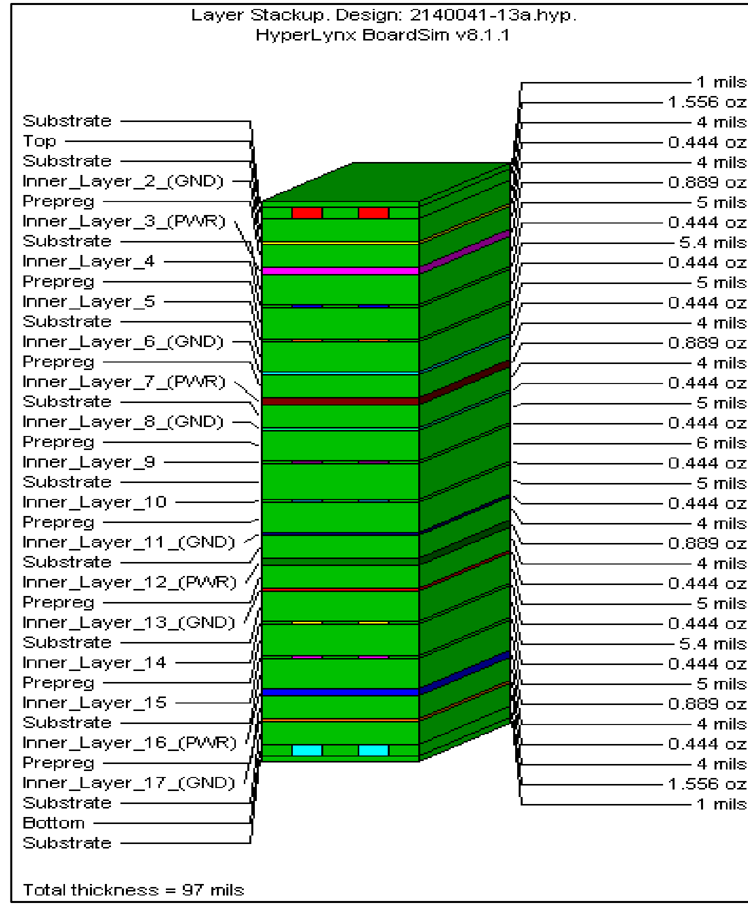
- **Differential signaling signal integrity issues must be considered when specifying a connector pinout**
- **Adjacent pins should be selected, with ground pins in between**
- **The connector grid may only allow for a single pair to be routed through**
- **Pad and anti pad sizes need to be considered to minimize noise and EMI**



Connector Arrangement of a typical high density BP connector

Impedance Control

- SpaceWire over backplanes must provide 100-Ohm differential impedance
- Unlike cabling, this impedance must be met via PCB traces, across daughter cards and backplane traces
- Connector discontinuities must be considered and accounted for
- The stackup of the PCB must be specified early in the design phase to meet the impedance requirements
- Routing topology and parameters must be defined for all cards plugging into the backplane as well as the backplane to meet impedance as well
- Trade-offs may be needed to determine whether edge coupled or broadside coupled PCB traces are best for the application



Example Impedance Controlled Stackup

Signal Integrity

- **Any high speed design requires careful attention to mitigate signal integrity and crosstalk concerns**
- **SpaceWire Traces are now embedded within a PCB alongside various other signals such as**
  - Other SpaceWire links
  - Single ended Digital
  - Analog
  - Power/Ground
- **Noise can be coupled in various ways**
- **Same layer and adjacent layer crosstalk coupling are both possible**
- **Coupling is more likely to be asymmetrical**
- **Signal lengths may be harder to match due to routing topology, connector locations and other trace and components in the path**
- **Signal integrity tools should be used to analyze noise paths, crosstalk risk and other signal integrity issues**

Power Integrity

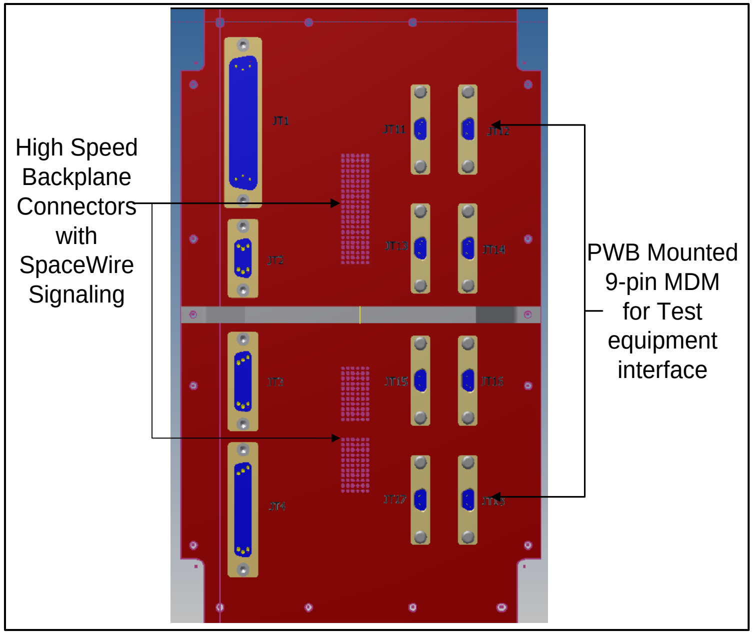
- **Power Integrity concerns must be addressed during the design cycle**
- **Proper design and routing of the power distribution network is important**
  - Typically power/ground planes
- **A backplane system does not have twisted shielded pairs, so shielding must be done by proper routing of ground and return paths**
- **Noise transients must be minimized by providing adequate decoupling**
- **Noise caused by single ended signals such as LVTTL can also cause SpaceWire failures**
- **Location of vias, split planes and all signal routing with respect to these PCB structures must be analyzed to ensure a continuous path for return currents so that unaccounted for reverse crosstalk does not cause functional failures**

Test and Accessibility

- Test access issues must be considered during the design phase
- Both backplane and daughter cards may require special probing access points for design verification
- Daughter cards may need to accommodate pads for differential probes at optimal locations for making eye pattern measurements
- Modeling should be used to determine location of test points such that signal degradation is minimized
- Cards installed in a backplane, adjacent to other cards may not be easily accessible
- Extender cards can be used, however, these can effect signal behavior and change propagation characteristics
- Any change in timing and signal quality must be well understood such that the test equipment does not change operation

Test Equipment Interface

- Standard test equipment may not easily be used with a backplane system
- Custom test equipment development may be time consuming, costly or both
- Breakout boards or open frame backplanes may be designed to interface to standard test equipment
- An open frame backplane may provide the means to convert the daughter card SpaceWire signals from the backplane interface to the standard 9-pin MDM interface
- Connector shell grounding must be considered with any design



Peripheral Card Test Access

Conclusion

- SpaceWire is a good fit for card to card interfaces where a backplane and not cabled interface exists
- Since the SpaceWire standard does not address the problems unique to this environment, designers must consider their unique application requirements more carefully
- Failure to do so may result in a degradation of performance or even mission failure

References

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- Hyperlynx SI, Hyperlynx PI and Interconnectix Synthesis, Signal and Power Integrity Tools, Mentor Graphics Inc.
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