Spaceborne Fiber Optic Data Bus: A Small Satellite Perspective

By
Dustin E. Rider, 2Lt, USAF
Air Force Research Laboratory, Space Vehicles Directorate, Kirtland AFB, N.M

and

Fred Orlando, VP/CTO Space Photonics Inc.
IEEE Standard 1393-1999
Spaceborne Fiber Optic Data Bus

- A Standard Approach to On-board Payload Data Handling Networks
- Joint DoD/NASA funded development
- Only network specifically designed to support realtime payload data handling for aerospace applications
- Soon to be SAE AS-1393
Redundant Ring with Cross-Strap & Bypass Links

- Multifiber Cables and Connectors
- Cross-Strapping and Node Bypass for Maximum Reliability
- Ring Can Accommodate up to 127 Nodes
- Nodes Can be Powered Down and Bypassed Through Consistent System Design
SFODB Communication Config

- Dedicated Transmit Slot Method
- Token Arbitrated Transmit Method
- Dedicated Receive Slot Method
- ATM Header Address Method
Dedicated Transmit Slot Method

- slot 1 dedicated to node 1
- slot 2 dedicated to node 2
- slot 3 dedicated to node 3

CFBIU Allocates Dedicated Network Bandwidth to Selected FBIUs
- CFBIU Assigns Slots by Number to Selected FBIUs
- Each Selected FBIU Writes into All Assigned Slots

Bandwidth Reuse Feature
- CFBIU Assigns the Same Slots to Multiple FBIUs
- Each FBIU will Overwrite Any Previous Data in the Assigned Slots
Token Arbitrated Transmit Method

- **CFBIU** Allocates Shared Network Bandwidth to Selected FBIUs
  - CFBIU Assigns Shared Slots by Number to Each FBIU
  - The Tokens are Used to Control Access to the Shared Slots

- **Token Group Feature**
  - A Token May Control a Group of Selected Slots
  - The Network Can Support Up to 4 Independent Token Groups

- Nodes share slots as follows:
  - Nodes 1, 2 & 3 share slot 1
  - Nodes 4, 5 & 6 share slots 3 & 4
Dedicated Receive Slot Method

- Node 7 receives from slots 1, 2 & 3
- Node 4 receives from slots 4, 5 & 6

CFBIU Assigns Dedicated Receive Slots to Selected FBIUs

- Each FBIU will accept all ATM cells from its assigned slots
- Empty cells can be selectively deleted
ATM Header Address Method

- CFBIU Assigns Selected Nodes a Set of ATM Cells to Accept Based on VPI or VCI Fields
  - The CFBIU Loads a Table of VPI or VCI Headers into Each FBIU
  - Each FBIU will Accept Only Valid ATM Cells with Matching VPI or VCI Fields

- node 6 assigned to receive VPI a & b
- node 7 assigned to receive VPI a, b, c & d
Notes:

1. CFBIU can be any node on any pallet.

2. All pallets can be operated and verified independently with DAVS connected across pallet connectors.

3. Active link selection and data routing will be automated.

4. Autonomous fault detection and correction processes will be implemented.

5. Multi-Subsystem Bypass Links only used for the 3rd CFBIU input in this illustration.

6. Subsystem and Multi-Subsystem Bypass Links used for both fault recovery and power management.
Plug-and-Play Spacecraft: A small Satellite Example

- Modular structure incorporates
  - Locking hinge joints allow panels to rotate about hinge line for easy access
  - Standardized mounting grid (5cm oc)
  - SPA mechanical and electrical interfaces for 48 components/payloads on interior/exterior
  - Connectors and harness recessed in panels
  - Inter-panel harness keep electrical network intact throughout assembly and I&T

- Higher performance PnP components incorporated in successive upgrades

- Payloads will be STP experiments that match bus capability

- Planned launch in Oct 2009 as co-manifest on with SIV-1 on Minotaur IV

- Spacecraft configuration to be frozen ~6 months prior to launch to complete final I&T
Hinged Joint Panel Concept for SFODB

Component and Experiment Accommodations
Hinged Joint Panel Concept for SFODB

- 1393 Capability to run panels stand alone
- Panel-to-panel bridge connectors for power and network distribution
Component and Experiment Accommodations

- SPA-U or SPA-S for payload identification
- 1393 for the high speed network
Small Satellite Advantages of SFOBD

- Simultaneous use of different Methods
- Flexible Speed (200Mbps – 1Gbps)
- Decreased Design Time
- Reduced Design Cost
- NO RFI or EMI
Conclusion

- robust, high-speed network
- compact design
- PnP Sat is just one example of the applications
- ideal for small satellites