SpaceWire and SpaceFibre

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STAR-Dundee Ltd.
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- SpaceFibre Integrated QoS
- SpaceFibre IP cores
- SpaceFibre on RTAX and RTG4
SpaceWire
SpaceWire IP Cores

- SpaceWire IP
  - SpaceWire Interface
  - SpaceWire Router
  - SpaceWire RMAP Target
  - SpaceWire RMAP Initiator

- Running in RTAX, ProASIC and RTG4
SpaceFibre
SpaceFibre

- SpaceFibre is
  - A spacecraft on-board data link and network

- SpaceFibre runs over
  - Electrical and fibre optic cables

- SpaceFibre initially targeted at
  - Very high data rate instruments
    - Synthetic Aperture Radar
    - Multi-spectral imaging instruments

- SpaceFibre meets the needs of
  - Most spacecraft onboard network applications
  - Because of its built-in capabilities
    - Quality of Service (QoS)
    - Fault detection, isolation and recovery (FDIR)
    - Compatibility with SpaceWire
SpaceFibre Benefits

- Very high data rates
- Reduction of harness mass
- Simplification of redundancy
- Increase in reliability
- Straightforward error recovery
- Deterministic data delivery
- Long distance
- Galvanic isolation
SpaceFibre Key Features

- **High performance**
  - 2.5 Gbits/s current flight qualified technology
  - 3.125 Gbits/s soon (6.25 Gbits/s coming)
  - Multi laning of up to 16 lanes (40 Gbits/s)

- **Innovative integrated QoS**
  - Priority
  - Bandwidth reservation
  - Scheduling

- **Novel integrated FDIR support**
  - Transparent recovery from transient errors
  - Error containment in virtual channels and frames
  - "Babbling Idiot" protection

- **Low latency**
  - Broadcast codes

- **Compatible with SpaceWire at packet level**
SpaceFibre Target Applications

- SpaceFibre now targeted at
  - Most spacecraft onboard network applications
    - SAR and multi-spectral, high resolution optical
    - Any system where SpaceWire is used
      - Interfacing to existing SpaceWire equipment
    - AOCs/GNC and other control systems
    - Launchers

- Single integrated network
  - Carrying
    - Instrument data
    - Configuration and control information
    - Deterministic traffic
    - High resolution time information
    - Event signals
  - Improves reliability, mass, cost
SpaceFibre Integrated QoS
SpaceWire CODEC

Packet Interface  Time-Codes  Management

SpaceWire CODEC

Serial
SpaceFibre IP Core

- Each VC like pair of SpW FIFOs. Sends and Receives SpFi packets.
- Broadcasts short messages.
- Time distribution, synchronisation, event signalling, error handling.
- Management interface configures VCs, BC, etc.

Virtual Channel Interfaces

Broadcast

SerDes

...
SpaceFibre Quality of Service

- Integrated QoS scheme
  - Priority
    - VC with highest priority
  - Bandwidth reserved
    - VC with allocated bandwidth and recent low utilisation
  - Scheduled
    - Synchronised time-slots
      - E.g. by broadcast messages
    - VCs allocated to specific time-slots
    - In allocated time-slot, VC allowed to send

- “Integrated” because
  - All three QoS work together
  - QoS is implemented in the hardware of the SpaceFibre interface
Virtual Channels

- VC sends when
  - Source VC buffer has data to send
  - Destination VC buffer has space in buffer
  - QoS for VC results in highest precedence
- A SpW packet flowing through one VC does not block another packet flowing through another VC
QoS: Bandwidth Reserved

Precedence

Bandwidth Credit Counter

time
QoS: Bandwidth Reserved
QoS Babbling Idiot Protection

Priority 1

Priority 2

Priority 3
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### Simple Mixed QoS

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### Deterministic Data Delivery

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- **VC 1** (high priority) is highlighted in blue in time-slot 1.
- **VC 2** (high priority) is highlighted in yellow in time-slot 2.

#### Time-Slot 1:

- **Packets being transmitted**: Blue squares.
- **Packets being received**: Cyan squares and green squares.
SpaceFibre IP Cores
SpaceFibre VHDL IP Core

- Compliant to very latest version of standard specification
- Extensively tested and validated

Incorporates all capabilities
- Full QoS
- Fault detection, isolation and recovery
- Low latency broadcast messages

Available from STAR-Dundee
- Implemented in a range of FPGAs
  - Microsemi: AX, RTG4
  - Xilinx: V4, V5, Spartan 6, …
- Full and “lite” versions
  - Full has configurable number of VCs
  - Lite is designed for a simple instrument interface with 2 VCs
    - High rate data VC
    - Low rate, high priority command and control VC
Radiation Tolerant SpaceFibre ASIC
RC64 Many Core DSP Processor

- 64 fast CEVA X1643 DSP with FP extension and HW scheduler
  - 300 MHz
  - 40 GFLOPS, 384 GOPS
- Modem and Encrypt accelerators
- 4 Mbyte on-chip shared memory
- Fast I/O
  - 12x SpaceFibre,
  - SpaceWire
  - DDR3, AD/DA LVDS I/F, NVM
- Rad-Hard, for space
- Advanced technology
  - TSMC 65nm LP
  - CCGA / PBGA / COB
  - 10 Watt
- Modular
  - Payloads can employ many RC64
- Versatile
  - Designed for all space missions
  - Planned for 2020—2050
- Re-programmable in space
SpaceFibre on RTAX and RTG4
Commercial equivalent of flight proven parts
- Microsemi RTAX1000
- TLK2711-SP SerDes

Pre-programmed with STAR SpFi IP core

FMC interface for connection to development boards

2.5 Gbits/s with 32-bit interface at 62.5 MHz

20% to 25% of AX1000
SpaceFibre on RTG4

- FMC board to provide SpaceWire and SpaceFibre
- RTG4 SerDes running at 2.5 Gbits/s
- SpaceFibre interface 4% to 6% of RTG4 (2 to 8 VCs)
- SpaceWire interface 1%, RMAP Target 2% of RTG4
Demonstration RTG4 Design
Demonstration

STAR Fire
- Packet Generator
- Packet Checker

RTG4
- SpaceFibre
- SpW

RTG4
- SpaceFibre
- SpW

Brick Mk3
- USB 3.0

Command Window
**Conclusions**

- SpaceFibre designed specifically for spaceflight applications
  - Integrated QoS
  - Integrated FDIR capabilities
  - Galvanic isolation
  - Compatible with SpaceWire packet level
  - Efficient design giving very small footprint

- **Benefits**
  - Very high performance
  - Reduced harness mass
  - Interoperability with existing SpaceWire devices
  - Simplification of redundancy
  - Deterministic data delivery for control applications
  - Single integrated network

- Running on RTAX and RTG4 now
Thank You
Any questions?

For more information and to see a demonstration please visit the STAR-Dundee stand

www.star-dundee.com