SpaceWire Router ASIC

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SpW-10X Architecture

SpW-10X

- SpW Port 1
- SpW Port 2
- SpW Port 3
- SpW Port 4
- SpW Port 5
- SpW Port 6
- SpW Port 7
- SpW Port 8

Routing Switch

Parallel Port 9
Parallel Port 10
Time-Code Interface
Configuration Port 0
Routing Table
SpaceWire Ports

- SpaceWire compliant
- Data Signalling Rate
  - 200 Mbits/s maximum
  - Selectable 2 – 200 Mbits/s
- Each SpaceWire port can run at a different speed
- LVDS drivers and receivers on chip
  - Avoids size, mass, cost of external LVDS chips
- Receiver auto-start mode
- Power control
  - Each SpaceWire port can be completely disabled
    - including clock tree
  - LVDS can be tri-stated with auto-enable
  - Links can be held disconnected until there is data to send
Parallel Ports

- Parallel ports to support connection to
  - Processors
  - Simple logic
- 8-bit data + control/data flag
- FIFO type interface
- Operate at speed of SpaceWire links
  - i.e. 200 Mbits/s
Routing Switch

- Switches packet being received to Appropriate output port
- SpaceWire and Parallel ports treated the same
- Non-blocking
  - If the required output port is not being used already
  - Guaranteed to be able to forward packet
  - Rapid packet switching times
  - Low latency
- 3.2 Gbits/s maximum throughput
- Worm-hole routing
Configuration Port

- Used to configure router device
  - Routing tables
  - Link speeds
  - Power states
  - Etc

- Used to read router status

- RMAP Remote Memory Access Protocol

- Used for reading and writing configuration port registers

- Router can be configured over
  - Any SpaceWire port
  - Any Parallel port
Time-Code Port

- Sends and receives time-codes

- Tick-in
  - Internal time-counter incremented and time-code sent
  - Or
  - Value on the time-code input port is sent as a time-code

- Tick-out
  - Indicates valid time-code received
  - Value of time-code on time-code output port
Status/Configuration Interface

- On power up holds some configuration information
- Thereafter provides status according to four address lines
- 0-10: Port status
  - 0: Configuration port
  - 1-8: SpaceWire port
  - 9-10: Parallel port
- 11: Network discovery
  - Return port
  - This is a router
- 12: Router control
  - Enables and timeouts
- 13: Error active
- 14: Time-code
- 15: General purpose
  - Contents of general purpose register
  - Settable by configuration command
Router ASIC Performance

- **ASIC**
  - Implementation in Atmel MH1RT gate array
  - Max gate count 519 kgates (typical)
  - 0.35 µm CMOS process

- **Radiation tolerance**
  - 100 krad
  - SEU free cells to 100 MeV
  - Used for all critical memory cells
  - Latch-up immunity to 80 MeV/mg/cm²

- **Performance**
  - SpaceWire interface baud-rate 200 Mbits/s
  - LVDS drivers/receivers integrated on-chip

- **Power**
  - 5 W power with all links at maximum data rate
  - Single 3.3 V supply voltage

- **Package**
  - 196 pin ceramic Quad Flat Pack 25 mil pin spacing
## ESA SpaceWire Router Performance

**SpaceWire Router Latency and Jitter Measurements (Bit rate = 200Mbits/s)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching Latency</td>
<td>$T_{\text{SWITCH}}$</td>
<td>133.3</td>
<td>ns, max</td>
</tr>
<tr>
<td>Router Latency – SpaceWire to SpaceWire port</td>
<td>$T_{\text{SSDATA}}$</td>
<td>546.6</td>
<td>ns, max</td>
</tr>
<tr>
<td>Router Latency – SpaceWire to External port</td>
<td>$T_{\text{SEDATA}}$</td>
<td>316.6</td>
<td>ns, max</td>
</tr>
<tr>
<td>Router Latency – External to SpaceWire port</td>
<td>$T_{\text{ESDATA}}$</td>
<td>363.3</td>
<td>ns, max</td>
</tr>
<tr>
<td>Router Latency – External to External port</td>
<td>$T_{\text{EEDATA}}$</td>
<td>166.6</td>
<td>ns, max</td>
</tr>
<tr>
<td>Time-code Latency – SpaceWire to SpaceWire port</td>
<td>$T_{\text{SSTC}}$</td>
<td>409.3</td>
<td>ns, max</td>
</tr>
<tr>
<td>Time-code Latency – SpaceWire to External port</td>
<td>$T_{\text{SETC}}$</td>
<td>316.6</td>
<td>ns, max</td>
</tr>
<tr>
<td>Time-code Latency – External to SpaceWire port</td>
<td>$T_{\text{ESTC}}$</td>
<td>359.9</td>
<td>ns, max</td>
</tr>
<tr>
<td>Time-code Jitter</td>
<td>$T_{\text{TCJIT}}$</td>
<td>116.6</td>
<td>ns, max</td>
</tr>
</tbody>
</table>

[1] Note all figures are worst case

Above figures derived from simulation
Applications – Standalone Router

Router – Instrument 1
  High Rate

Router – Instrument 2

Router – Instrument 3

Router – Instrument 4

Router – Instrument 5

Router – Memory

Router – Processor
Applications – Embedded Router

- **Instrument 1**
  - High Rate

- **Instrument 2**

- **Instrument 3**

- **Instrument 4**

- **Instrument 5**

- **Router**

- **Memory**

- **Processor**

- **Prime**

- **Router**

- **Memory**

- **Processor**

- **Redundant**
Applications – Node Interface

High Rate Instrument → Instrument Control FPGA → Router
Applications – Node Interface

- Memory Banks
- Memory Control FPGA
- Router
Applications – Node Interface

- Processor
- I/O Control FPGA
- Memory
- Router
Router Prototype Implementations
Router Prototype Implementations
Router Prototype Implementations

EADS ASTRIUM
SPACE WIRE ROUTER  SN: 03

GND +5V

EX_DATA_1  TIMECODE UF  EX_DATA_0

RESET  TIME  CTR-RST

LINK 4  LINK 3  LINK 0  LINK 1  LINK 7  LINK 2  LINK 6  LINK 5
Router Prototype Implementations
Router Prototype Implementations
SpW-10X Development System

- Boxed
- 6U Rack Mount
Team

- **University of Dundee**
  - Design and Testing

- **Austrian Aerospace**
  - Independent VHDL Test Bench
  - Transfer to ASIC technology

- **Astrium GmbH**
  - Functional Testing

- **Atmel**
  - ASIC Manufacture

- **STAR-Dundee**
  - Support and Test Equipment
Conclusions

- ESA router has extensive capabilities
- Suitable for a wide range of applications
- Independently tested
- Extensively validated
- Full range of support services available
  - Evaluation boards
  - 6U and boxed
- Prototypes due November 2007
- Atmel AT7910E