Manchester Coding Option for SpaceWire:
Providing Choices for System Level Design

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Acronyms

DC = Direct Current
DS = Data Strobe
FPGA = Field Programmable Gate Array
Gbps = Giga bits per second
Mbps = Mega bits per second
NRE = Non-Recurring Engineering
QoS = Quality of Service
SpaceWire-RT = SpaceWire-Real Time
WG = Working Group
Outline

• Introduction – goals, constraints and use cases
• Original SpaceWire Data Strobe coding
• Manchester coding option
• Manchester implementation considerations
• Use cases
• Preserve design heritage
• SpaceWire working group solutions
• Summary
Introduction

• Presentation proposes an optional line code scheme for SpaceWire to meet following goals:
  – electrically isolate SpaceWire interface
  – further reduce cable mass and bend radius and
  – define common physical layer specification for different protocols

• Constrain data rate to 10 Mbps for low complexity implementation
  – no clock multiplier logic – phase lock loop or delay lock loop
  – target design to typically used rad tolerant Field Programmable Gate Array (FPGA)

• Use cases include command and control and moderate rate data applications and common physical layer interface for DC to multi-gigabit per second protocols
Original SpaceWire Data Strobe Coding

• Data Strobe is a clock and data coding scheme which requires two signals to transmit information and has an unbalanced voltage density over time

• Advantages
  – easy to decode
  – supports variable data rate easily

• Disadvantages
  – difficult to electrically isolate reliably
  – requires double the number of wires than other options
Manchester Coding Option

- Manchester is a phase coding scheme and utilizes one signal to transmit with clock and data encoded on the same signal and has a balanced voltage density over time

- Advantages
  - can be electrically isolated
  - requires half the number of wires compared with other clock and data schemes

- Disadvantages
  - More difficult to decode than other clock and data schemes
    - requires oversampling of received waveform
    - need to extract the clock from signal
  - Requires at least twice the sampling frequency than clock and data schemes
Manchester Implementation Considerations

- SpaceWire is a well layered protocol, which lends to making changes in the coding scheme straightforward.
- SpaceWire “Signal Layer” defines the coding scheme and may be changed from Data Strobe to Manchester without a change to upper layers (character, exchange, packet and network level).
- Implementation is simplified by setting the data rate at the start-up rate of 10 MHz.
- For the 10 MHz data rate, there is no need for clock multiplication circuitry, which simplifies the implementation so that typical radiation tolerant FPGAs can be used.
- Straightforward implementation exists for oversampling at 4 to 8 times data rate (i.e., 40 to 80 MHz oscillator).
Use Cases

• Primary use cases for the SpaceWire Manchester code option would be for those applications that require less than 10 Mbps of bandwidth and/or desire/require an electrically isolated interface
  – command and control applications
  – moderate data rate generating instruments
• Tight space for cabling and/or common physical layer to support different protocols for different data rate applications
  – Use same physical layer for SpaceWire (if Manchester used) and multi-gigabit per second protocols (e.g., RapidIO, Gigabit Ethernet, SpaceFiber, etc.)
  – “SpaceAGE Bus” (NASA intra-box interface specification)
    • defines one communication physical layer to support different data rate applications (0 to 4 Gbps)
    • cabling harness used instead of backplane to interconnect cards (short distances require small bend radius)
Preserve Design Heritage

- SpaceWire has been used on many missions and significant Non-Recurring Engineering (NRE) has been expended on the development and maintenance of SpaceWire designs, including fixing “bugs” as well as improving performance.
- SpaceWire standard needs revising based upon lessons learned from various uses on missions from different agencies - revisions in the areas of: electrical isolation, cable mass, and Quality of Service (QoS), etc.
- Important to leverage existing SpaceWire design investments while choosing solutions to solve concerns so as to preserve investment.
SpaceWire Working Group Solutions

- SpaceWire Working Group (WG) has proposed solutions for the electrical isolation of SpaceWire and reduction of cable mass
  - new protocol called SpaceWire-Real Time (SpaceWire-RT) based upon the SpaceWire WG’s multi-Gigabit per second protocol called SpaceFiber, which uses 8b/10b DC balanced line code that is half the number of wires of the original SpaceWire
  - also removes some of the shields in the existing cable
- SpaceWire-RT is a new standard that does not leverage existing SpaceWire design heritage, i.e., requires new design effort
- SpaceWire-RT is more complex than the original SpaceWire design and will require higher resource utilization in typical radiation tolerant FPGAs leaving less room for user defined logic
Summary

• Improvements to SpaceWire are needed based upon user responses
• This presentation addresses two improvements that may be implemented by change to SpaceWire line code scheme
  – electrical isolation
  – cable mass and bend radius
• Change SpaceWire line code from Data Strobe (DS) to Manchester scheme enables:
  – a DC balanced signal, which can be electrically isolated
  – reduces number of wires by factor of 2 for reduced cable mass and bend radius
• Use cases include:
  – command and control and moderate rate instrument applications
  – common communication physical layer for intra-box cabling applications
• Improvements can be implemented so that SpaceWire heritage designs may be significantly leveraged in order to recoup existing investments in SpaceWire