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 of 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