SpaceWire Margins Tester

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SpW performance degrading factors:

• **Evolutional:**
  – Higher speeds
  – Longer distances
  – Lower Bit Error Rate (BER) levels requirements

• **Physical media losses:**
  – Smaller wire cross-section (to save weight)
  – Cable/connector parameters deviations and imperfections

• **Interface hardware:**
  – Parameters variations from different IC manufacturers

• **External media susceptibility:**
  – Common Mode Voltage (CMV) noise
  – Electro Magnetic Interference (EMI)

Needed: verification tools to assess SpW margins!!
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Parts to be tested:

- **FPGA / ASIC**
  - *Digital simulation*
    - Standard design procedure
- **Transmitter**
  - *No testing except maximum drive current*
    - Fixed and specified by manufacturer
- **Receiver**
  - *Most likely to fail (induce errors) due to various operational conditions*
    - Marginal operation conditions needs to be established

Required: define marginal receiver operation conditions
Parameters to be simulated:

- **Skew/Jitter:**
  - Between Data and Strobe
  - Within each D/S pair

- **Received signal span:**
  - Guaranteed minimum Peak-to-Peak (P2P) voltage span at receiver end

- **Common mode voltage:**
  - Received signal bias

Goal: simulate marginal receiver “eye” at desired BER or FER (Frame Error Rate)
Parameter simulation diagrams:

- **D/S skew**
  - Red: fixed positive D / negative S skew
  - Blue: fixed negative D / positive S skew

- **LVDS bias**
  - +1.2V

- **“Eye” span**
  - Span

**Major SpW physical layer parameters can be simulated**
Suggested Tester types:

• **Coarse** (no effects on protocol or communication speed):
  – *Pass through mode*:
    • Inserted between known good SpW transmitter (Auxiliary Tester) and Device Under Test (DUT) receiver for full duplex peer-to-peer SpW operation
  – *Loop back mode*:
    • Connected to DUT as Slave and loops marginalized signal back to DUT
  – *Error detection*:
    • DUT SpaceWire dropouts monitoring

• **Precise** (simulates protocol and communication speeds):
  – *Master mode*:
    • Connected to DUT and works as Master
    • Emulates SpW protocol with simultaneous signal marginalization
  – *Error detection*:
    • Works as simple BER tester, assuming that DUT can report errors back to it
    • Dropouts monitoring as in Coarse tester

Proposed: create 1 Coarse tester by Q4 2008; start on Precise tester in Q1 2009
Coarse tester diagram (Pass mode):

- Aux. SpW Tester
- Mode switch
- Skew injector
- Span injector
- Bias injector
- Front buttons
- Micro controller
- Front display
- Optional isolated USB 2.0
- TX
- RX

Full duplex communication between Master and DUT
Coarse tester diagram (Loop mode):

Tester is used as “bend pipe” for DUT
Coarse tester parameters for both Pass and Loop modes:

- **D and S Skew injection:**
  - **Simulation range**
    - 0 to ±30 nS (speed dependent) from “0” nominal with D leading and S trailing, or vs. vs.; max of 61 steps
  - **Internal differential pair skew injection:**
    - None
  - **Step resolution**
    - 1 nS with ± 0.5 nS accuracy

- **Span injection:**
  - **Simulation range**
    - 180–720 mV peak-to-peak at 100 Ohm termination
  - **Step resolution**
    - 20 mV with ± 10 mV accuracy in 28 steps

- **Bias injection:**
  - **Simulation range**
    - ± 1.2 V from +1.2 V LVDS nominal
  - **Step resolution**
    - 200 mV with ± 10 mV accuracy in 13 steps

- **Other parameters:**
  - **Operating speed**
    - 10 to 200 Mbps (with potential to 310 Mbps) in 20 (31) steps of 10 Mbps each
  - **Number of stored test profiles**
    - up to 8
  - **Protocol dropouts detection**
    - Up to 99999 over 99999 seconds (27+ hours)
  - **Pin 3 (Transmit Ground) short to chassis detection and warning**
  - **Dimensions (DxWxH):**
    - 160mm x 160mm x 86mm
  - **Optional communications port**
    - Isolated USB 2.0

Most LVDS and SpW parameters are being covered
SpaceWire Margins Tester

Coarse tester preliminary front panel appearance:

Stand alone portable unit
Coarse tester preliminary back panel appearance:

Optional USB port control
Coarse tester parameters control:

- Horizontal encoder wheel:
  - Selects between Profile, Mbps, Skew, Span, Bias fields
- Vertical encoder wheel:
  - Selects between available values assigned to the above fields
- Scan button:
  - Momentary press:
    - Toggle Scan option for each individual field (Skew, Span, Bias)
  - 1 sec press:
    - Toggle Scan option for all 3 fields at a time regardless of currently selected field
- Drop button:
  - Momentary press:
    - Start / Stop Drops counter and Timer
  - 1 sec press:
    - Reset Drops counter and Timer
- Mode button:
  - Switches between Loop and Pass modes
- USB port:
  - Provides isolated ground communications with host computer
    - Transmission
      - Immediate report on any wheels / buttons changes
      - Immediate report on any changes of Drop counter with 1 ms quantization
    - Reception
      - New setup data and functions

Simple interface
Precise tester diagram:

Tester will provide more comprehensive and automated DUT simulation
Precise tester preliminary parameters:

- **D and S Skew injection:**
  - *Simulation range*
    - ±50 nS (speed dependent) from nominal
  - *Internal differential pair skew injection:*
    - ±1 nS
  - *Step resolution*
    - 0.2 nS ± 0.05 nS

- **Span injection:**
  - *Simulation range*
    - 180–720 mV peak-to-peak at 100 Ohm termination
  - *Step resolution*
    - 20 mV ± 10 mV

- **Bias injection:**
  - *Simulation range*
    - ±1.2 V from +1.2 V LVDS nominal
  - *Step resolution*
    - 100 mV ± 10 mV

- **Other parameters:**
  - *Maximum operating speed*
    - 400 Mbps (TBR)
  - *Number of stored test profiles*
    - No limitations

Major requirement: DUT suppose to have a way to report errors back to tester
Precise tester error reporting locations diagram:

DUT might provide several locations for error reporting readbacks
Error reporting locations comparison:

- **Location #1 (on LVDS level such as in Aeroflex’s PHY01 chip):**
  - **Advantages**
    - Very simple implementation
  - **Disadvantages**
    - Span and bias are corrected by LVDS receiver, skew is not corrected and is looped back exactly the same
    - BER is very poor and very imprecise

- **Location #2 (after SpW decoder and message processor with minimum core modifications):**
  - **Advantages**
    - Simple implementation (just a loopback connection)
    - No special error registers
  - **Disadvantages**
    - BER accountability is poor: possibility that only TX dropouts could be counted

- **Location #2 (after SpW decoder and message processor with medium core modifications):**
  - **Advantages**
    - More complex implementation (loopback connection and protocol error registers to be reported on top of looped data)
    - Excellent BER accountability
  - **Disadvantages**
    - Special codes in protocol: trying to differentiate error registers data in looped back data stream
    - High speed TX transmission: may induce more noise in RX data

- **Location #3 (after a special built-in error processor):**
  - **Advantages**
    - Excellent BER accountability
    - Possible low speed TX rate: only received errors are transmitted back
    - Possibility of implementation of standard BER PRN sequences
  - **Disadvantages**
    - New built-in function in SpW core

Different error reporting locations will yield different BER validity results
Suggested requirements to DUT for better testing:

- **Built-in received errors counter:**
  - General received error counter
  - Optional differentiation of error types

- **Communication with DUT:**
  - High speed receive rate from Tester to DUT
  - Preferable: fixed 10 Mbps error count transmit rate from DUT to Tester
  - Less preferable: injection of error results into back data stream

- **Error testing protocol:**
  - Preferable: standard PRBS (PRN) from $2^7 - 1$ to $2^{15} - 1$ (only 1 is required)
  - Less preferable: standard SpW with new error codes

- **Error display:**
  - “Coarse” tester: counting SpW TX dropouts so it can be converted to BER
  - “Precise” tester: standard BER format fashion on remote test computer

Added complexity enhances timing simulation and BER measurements