Low Cost Link Synchronization for Crystal-less System

William Lo

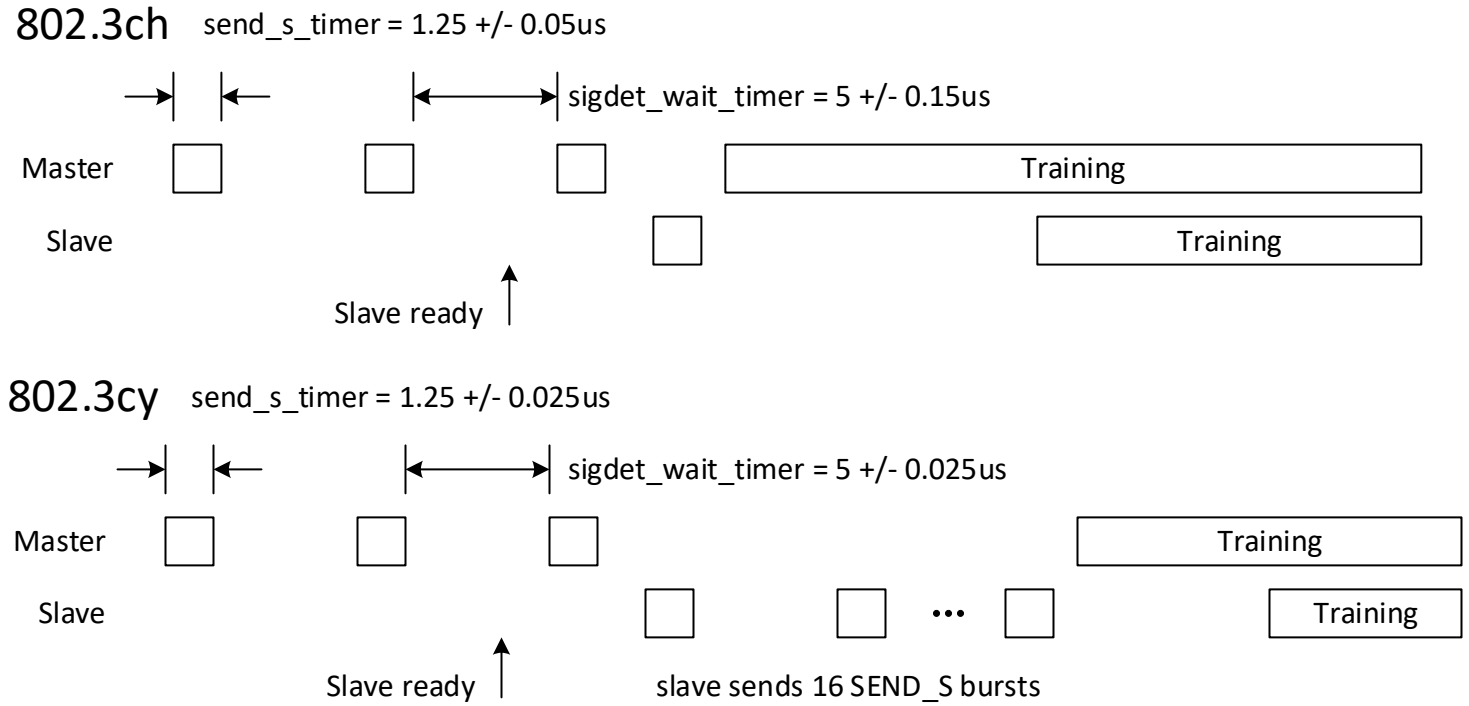
May 1, 2025

Why an Alternate Version of Link Sync

- Previous proposal leveraged 802.3ch/cy link sync mechanism
  - https://www.ieee802.org/3/dm/public/0325/Lo_01_0325.pdf
  - Possibly requires use of matched filters for reliable detection
  - Requires clock frequency offset to be relatively close
- Alternate version
  - Crystal-less system friendly
  - Eliminate need for tight frequency offset between master and slave devices during link sync
  - Simplify sync pulse detection mechanism
  - Potentially decrease silicon needed for link sync

Link Sync Sequence 802.3ch and 802.3cy

- Highly reliable PRBS sequence detection in presence of noise with matched filter implementation
- Frequency offset between devices needs to be < 2%

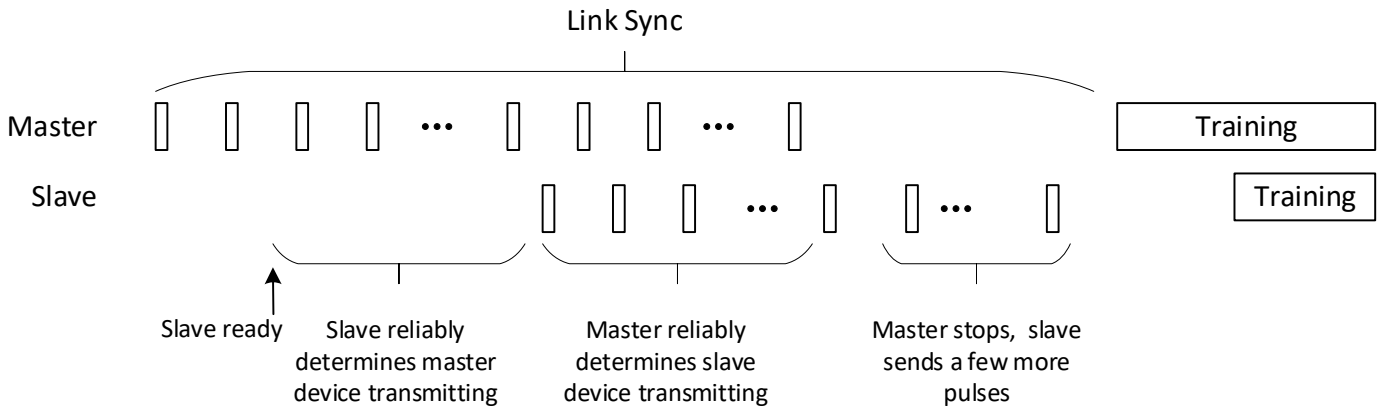


- SEND_S - 703.125 MHz PAM2
- PRBS sequence period 255 symbols

ALTERNATE PROPOSAL

Use Simple Pulses to Indicate Presence

- Detect the presence/absence of short pulses and don't try to match filter it
- Master periodically sends pulses
- Slave responds with pulses once it determines master sending
- Slave pulse offset from master's pulse
- Master keeps sending until it determines slave is sending
- Slave stops sending when it determines master stops sending
- No need to react right away. Can wait several pulse intervals to increase certainty.

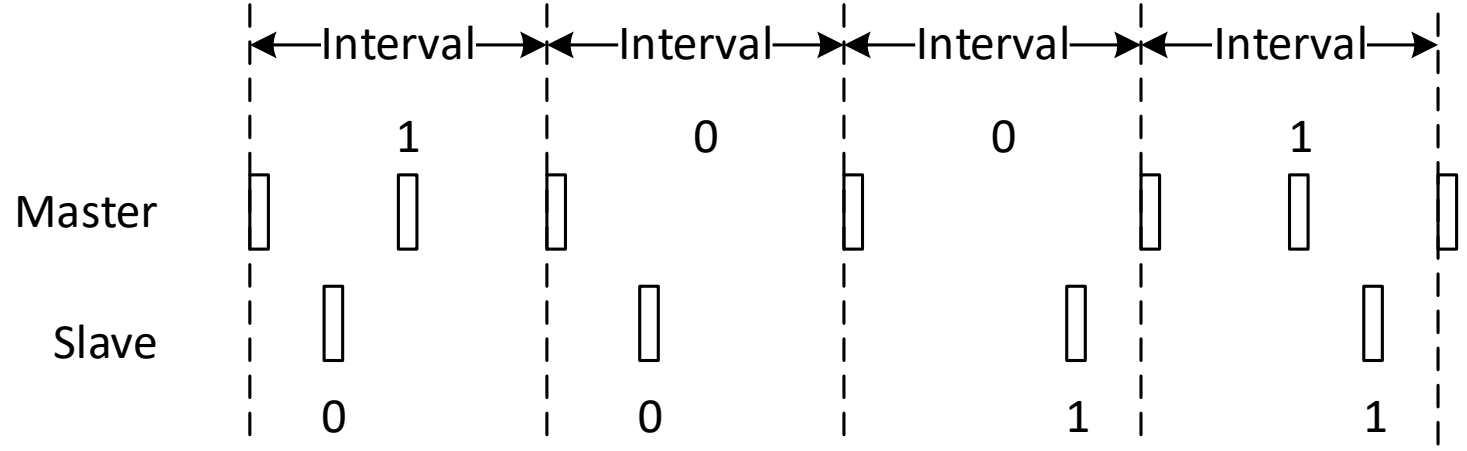


Slave Frequency Offset

- Slave can rough estimate its frequency offset by counting number of clock cycles that elapses between master's pulses.
- Slave can adjust PLL to get frequency closer to the master's frequency, or
- Don't adjust PLL and use the counts to estimate the required offsets

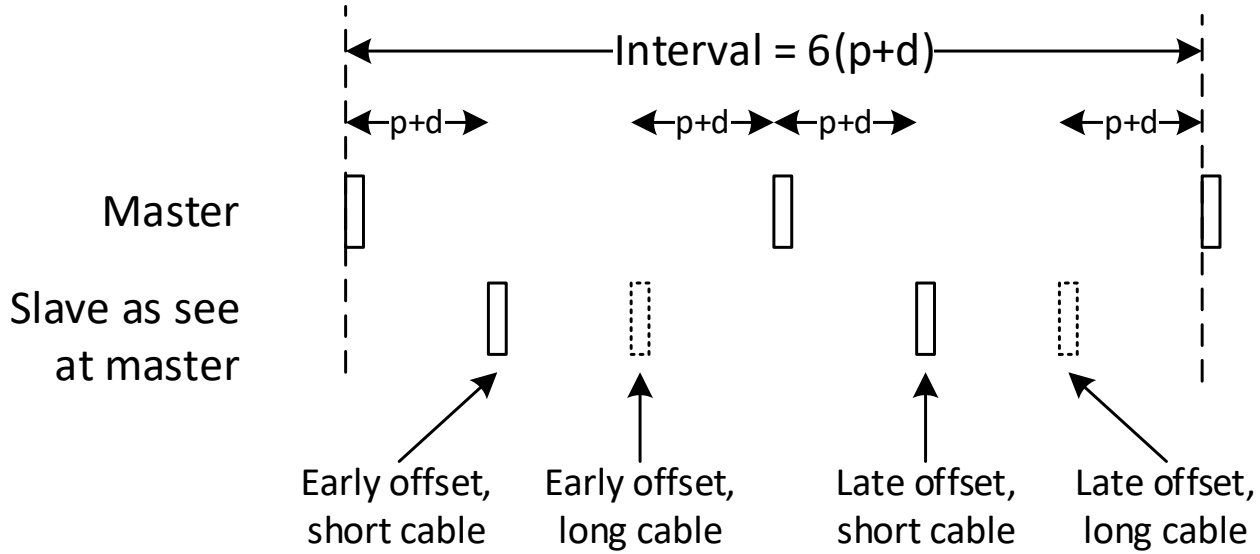
Making things more robust

- Introduce pseudo random sequence over each interval
  - Master – Send 1 pulse if 0, send 2 pulses if 1
  - Slave – Send early offset pulse if 0, send late offset pulse if 1
- Receiver locks to sequence and see if it proceeds correctly
- More intervals matching, more certainty



Taking propagation delay into account

- Slave offsets are delayed when viewed at the master's receiver depending on cable length
- Let p = width of pulse, d = round trip delay
- Minimal interval is 4p+6d
- Use 6p+6d to simplify



Proposed Pulse Properties

- Upstream and Downstream transmitter uses DME pulses
- DME pulses sent at the rate to 117.1875 MHz in either direction
- Each DME pulse is 4 symbols long (34ns)
- Simple for downstream transmitter to send DME
  - Integer number of downstream symbol

Proposed Interval Properties

- The interval is 192 DME symbols (6 x 32 symbols = 1.6384 us)
- Master sending 0 – pulse at 0 to 3
- Master sending 1 – pulses at 0 to 3, 96 to 99
- Slave sending 0 – Offset at 32 to 35
- Slave sending 1 – Offset at 128 to 131
- Windows to look for slave pulses at master 24 to 71 and 120 to 167

Proposed Pseudo Random Sequence

- Upstream - $x^8 + x^4 + x^3 + x^2 + 1$
- Downstream - $x^8 + x^6 + x^5 + x^4 + 1$

THANK YOU