S800BASE-T
Standby Mode

June, 2003
When a physical layer “LINK” is established, opposite ends are synchronized in a master / slave relationship

- Necessary for proper cancellation of Near End Crosstalk (NEXT) and Far End Crosstalk (FEXT)
- Link start-up is based on values derived from auto-negotiation
- Link start-up time is significant
  - 1000BASE-T devices are allowed 750ms after completion of autonegotiation to establish link

**IDLE pattern is very similar to data**

- All four pairs transmit and all four pairs receive simultaneously
- IDLE pattern is a 3 level subset of the PAM5 coding on each of 4 pairs at 125MHz on each line
- IDLE pattern consumes as much transmit power as data
- Cessation of IDLE results in link drop
  - Followed by restart of auto-negotiation
  - Several seconds to re-establish link

No 1000BASE-T equivalent to “Standby” mode
S800BASE-T Standby Options

• Option 1: Preserve end-to-end timing synchronized
  — Keep enough TX/RX circuitry on to keep PLL’s synch’d
  — Significant power reduction from normal idle, but not the lowest possible
    • Likely <100mW
  — Relatively quick time to RESTORE from Standby to normal operation (~10ms)

• Option 2: Lowest power, drop synchronization
  — Power off all Rx circuitry except a simple signal detect
  — Reduce TX to a low frequency “link pulse” equivalent
  — Potentially <50mW of power
  — RESTORE time may be perceptible (~ second)
Option 1: Standby Mode Basic Functions

- **Initiation**
  - Command from local node
    - E.g., local node 1394b PHY layer receives a standby packet and instructs S800BASE-T sublayer to enter standby
    - Standby Initiation Signal on the wire
      - Unique PAM5 Constellation symbols, currently unused

- **Standby**
  - Lower power mode
  - Some form of “link” must be maintained
    - Timing information and adaptive filter states maintained to bring up full operation quickly
    - Auto-negotiation parameters maintained
    - Ability to detect a cable disconnect

- **Restore**
  - Resume previous S800BASE-T operation
    - No repeat of auto-negotiation
**Standby Mode: Proposed Method**

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**Auto-Negotiation**

**Proposed Method**

**S800BASE-T Normal Operation**

**Standby Mode:**

- No Data Traffic; Enable STANDBY

**Local Node Instructs Local PHY To Enter STANDBY**

- Local PHY Sends Unique PAM5 Code Group To Link Partner to Initiate STANDBY

**Both PHYs Enter STANDBY, Begin Transmitting 3 level STANDBY signal to Maintain STANDBY mode**

- Each PHY Powers Down Unneeded Circuitry

**Local Node Has Data to Transmit**

- Local Node Signals Local PHY to RESTORE

**On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY**

**Local PHY Stops Transmitting 3 level STANDBY signal, and begins sending PAM5 IDLE**

**On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY**

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Standby Mode: Proposed Method

Auto-Negotiation

S800BASE-T Normal Operation

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Local Node Signals Local PHY to RESTORE

Local Node Has Data to Transmit

Each PHY Powers Down Unneeded Circuitry

Both PHYs Enter STANDBY, Begin Transmitting 3 level STANDBY signal to Maintain STANDBY mode

On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY

Local Node Has Data to Transmit
Local PHY Sends Unique PAM5 Code Group To Link Partner to Initiate STANDBY

• 1000BASE-T PAM5 Constellation code space includes ~500 symbols defined for data, IDLE, and ~100 “unused” symbols

• Propose assigning a sequence of one or more unused symbols to have the meaning “STANDBY INITIATION”

• On receipt of STANDBY INITIATION symbol (from the UTP wire), the link partner will enter STANDBY mode
Standby Mode: Proposed Method

Auto-Negotiation → S800BASE-T Normal Operation → No Data Traffic; Enable STANDBY → Local Node Instructs Local PHY To Enter STANDBY

On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY

Local PHY Sends Unique PAM5 Code Group To Link Partner to Initiate STANDBY

Local PHY Stops Transmitting 3 level STANDBY signal, and begins sending PAM5 IDLE

Both PHYs Enter STANDBY, Begin Transmitting 3 level STANDBY signal to Maintain STANDBY mode

Local Node Signals Local PHY to RESTORE

Local Node Has Data to Transmit

Each PHY Powers Down Unneeded Circuitry
STANDBY MODE

Both PHYS Enter STANDBY, Begin Transmitting 3 level STANDBY signal to Maintain STANDBY mode

• Each PHY powers down critical circuitry
  – 3 of 4 Transmitters are powered off
  – 3 of 4 Receivers are powered off almost completely
    • NEXT / FEXT cancellers, adaptive filters, ADCs are powered off
      – Pads and signal detect functions remain powered
  – Code is changed from PAM5 constellation to a single pair, 3 level code:
    • STANDBY SIGNAL similar to IDLE code, but on 1 pair instead of 4
    • Allows phases of each channel’s phase recovery circuit to remain locked
      – Power reduced by >80%, to <100mW (implementation specific)
• STANDBY SIGNAL allows:
  – Detection of physical disconnect
    • e.g., cable pulled out of connector, link partner loses power
  – Synchronization to allow quick restore to S800BASE-T IDLE /data
Standby Mode: Proposed Method

Auto-Negotiation → S800BASE-T Normal Operation → No Data Traffic; Enable STANDBY → Local Node Instructs Local PHY To Enter STANDBY

On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY

Local PHY Sends Unique PAM5 Code Group To Link Partner to Initiate STANDBY

Both PHYS Enter STANDBY, Begin Transmitting 3 level STANDBY signal to Maintain STANDBY mode

Each PHY Powers Down Unneeded Circuitry

Local Node Has Data to Transmit → Local Node Signals Local PHY to RESTORE → Local PHY Stops Transmitting 3 level STANDBY signal, and begins sending PAM5 IDLE

On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY
RESTORE

- Local Node Has Data to Transmit
- Local Node Signals Local PHY to RESTORE
- Local PHY Stops Transmitting 3 level STANDBY signal, and begins sending PAM5 IDLE
- On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY

- PHY PLLs aligned by STANDBY SIGNAL to allow quick return to S800BASE-T IDLE
  - Receive pairs Signal Detect function will sense activity on pairs 2, 3, 4, and power up full receive functions
- All parameters from initial auto-negotiation are preserved
- ~10ms to transition from STANDBY to IDLE, and be ready for data transmission and reception
Option 2: Standby Mode Basic Functions

• Initiation
  – Command from local node
    • E.g., local node 1394b PHY layer receives a standby packet and instructs S800BASE-T sublayer to enter standby
    – Standby Initiation Signal on the wire
      • Simple link pulses: 100ns pulse, ~16ms spacing
        – Low frequency

• Standby
  – Lower power mode
  – Some form of “link” must be maintained
    • Timing information lost, adaptive filter states lost
    • Auto-negotiation parameters maintained
    • Ability to detect a cable disconnect

• Restore
  – Resume previous S800BASE-T operation
  – No repeat of auto-negotiation
  – Must re-synch clocks
Standby Mode: Proposed Method 2

Auto-Negotiation → S800BASE-T Normal Operation → No Data Traffic; Enable STANDBY → Local Node Instructs Local PHY To Enter STANDBY

On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY → Local PHY Sends Unique PAM5 Code Group To Link Partner to Initiate STANDBY

Local PHY Stops Link Pulses, and begins sending PAM5 IDLE → Both PHYS Enter STANDBY, Begin Transmitting Link Pulse to Maintain STANDBY mode

Local Node Signals Local PHY to RESTORE → Local Node Has Data to Transmit → Each PHY Powers Down Unneeded Circuitry

On Receipt of PAM5 IDLE, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY → Local Node Has Data to Transmit → Each PHY Powers Down Unneeded Circuitry

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STANDBY MODE Option 2

Both PHYs Enter STANDBY, Begin Transmitting Link Pulses to Maintain STANDBY mode

• Each PHY powers down critical circuitry
  – 3 of 4 Transmitters are powered off
  – 4 of 4 Receivers are powered off almost completely
    • NEXT / FEXT cancellers, adaptive filters, ADCs are powered off
      – Pads and signal detect functions remain powered
    – Code is changed from PAM5 constellation to a single pair, 2 level low frequency code:
      • STANDBY SIGNAL similar to 10BASE-T IDLE code, on 1 pair
        – 100ns pulses, ~16ms spacing
      • Clocks lose synchronization
        – Power reduced by >90%, to <100mW (implementation specific)
  • STANDBY SIGNAL allows:
    – Detection of physical disconnect
      • e.g., cable pulled out of connector, link partner loses power
RESTORE

- Local Node Has Data to Transmit
- Local Node Signals Local PHY to RESTORE
- Local PHY Stops Transmitting 3 level STANDBY signal, and begins sending normal link pulses

- On Receipt of NLPs, Link Partner Exits STANDBY Mode, RESTORES state prior to entering STANDBY

- Receive pairs Signal Detect function will sense activity on pairs 2, 3, 4, and power up full receive functions
- All parameters from initial auto-negotiation are preserved
- 750ms to transition from STANDBY to IDLE, and be ready for data transmission and reception

Note: 1000BASE-T link start-up assumes some coordination based on the conclusion of autonegotiation. When exiting Standby, some additional synchronization handshake may be necessary
**S800BASE-T Standby Options**

- **Option 1: Preserve end-to-end timing synchronization**
  - Keep enough TX/RX circuitry on to keep PLL’s synch’d
  - Significant power reduction from normal idle, but not the lowest possible
  - Relatively quick time to RESTORE from Standby to normal operation (~10ms)

- **Option 2: Lowest power, drop synchronization**
  - Power off all Rx circuitry except a simple signal detect
  - Reduce TX to a low frequency “link pulse” equivalent
  - Potentially <50mW of power
  - RESTORE time may be perceptible (~ second)

- **Trade-offs:**

  Power consumption of Standby
  
  **vs.**

  Time required to exit Standby and Restore data transmission