

## In-depth Exploration of Serial Attached SCSI (SAS)

The “In-depth Exploration of Serial Attached SCSI” course provides students with a comprehensive insight into the operation of the Serial SCSI interface. The class examines the evolution of SCSI, summarizes the operation of the parallel SCSI interface and then explores in detail the operation of Serial SCSI at all architectural levels. The class concludes with a study of new application areas in which Serial SCSI will be deployed.

### Course Outline

#### **Introduction**

- Parallel SCSI Overview
  - Physical Interface
  - Protocol
  - Command Language
  - SCSI-3 Architectural Model
- Architecture
  - Architecture overview
  - Physical links and phys
  - Ports (narrow ports and wide ports)
  - SAS devices
    - Initiator devices
    - Target devices
    - Target/initiator devices
  - Expander devices
  - Domains
  - Expander device topologies
  - Connections
  - Pathways
- Names and identifiers
  - Names and identifiers overview
  - SAS addresses
  - Hashed SAS address
  - Port names
  - Port identifiers
  - Phy identifier
- State machines
- Transmit data path
- Resets
  - Reset overview
  - Hard reset
  - Loss of signal
- Expander device model
  - Expander device model overview
  - Expander ports
  - Expander connection manager (ECM)
  - Expander connection router (ECR)
  - Broadcast primitive processor
  - Expander device interface
  - Expander device interface detail
  - Expander connection manager interface
  - Expander connection router interface
  - Broadcast primitive processor interface

#### **Physical layer**

- SATA cables and connectors (informative)
- SAS cables and connectors
- Connectors
  - SAS plug connector
  - SAS internal cable receptacle connector
  - SAS backplane receptacle connector
  - SAS external cable receptacle connector
  - SAS external plug connector
- Cables
  - SAS internal cables
  - SAS external cables
- Backplanes
- READY LED pin
- Driver and receiver electrical characteristics
- General interface specification
- Eye masks
- Transmitted signal characteristics
- Received signal characteristics
- Jitter
- Jitter tolerance
- Impedance specifications
- Electrical TxRx connections

- Driver characteristics
- Receiver characteristics
- Spread spectrum clocking
- Non-tracking clock architecture

#### **Physical layer**

- Phy layer overview
- Encoding (8b10b)
- Character encoding and decoding
- Bit order
- Out of band (OOB) signals
- Phy reset sequences
- Phy reset sequence after signal cable insertion
- SAS phy (SP) state machine
  - OOB sequence states
- SAS phy dword synchronization (DWS) state machine
- Spin-up

#### **Link layer**

- Primitives overview and summary
- Primitive sequences
  - Primitive sequence overview
  - Single primitive sequence
  - Repeated primitive sequence
  - Triple primitive sequence
  - Redundant primitive sequence
- SAS primitives
  - AIP (Arbitration in progress)
  - ALIGN (ALIGN(0), ALIGN (1), ALIGN (2), and ALIGN (3))
  - BREAK
  - CHANGE
  - CLOSE
  - EOAF (End of address frame)
  - ERROR
  - HARD\_RESET
  - OPEN\_ACCEPT
  - OPEN\_REJECT
  - SOAF (Start of address frame)
- SSP primitives
  - ACK (Acknowledge)
  - CREDIT\_BLOCKED
  - DONE
  - EOF (End of frame)
  - NAK (Negative acknowledgement)
  - RRDY (Receiver ready)
  - SOF (Start of frame)
- STP primitives
  - SATA\_ERROR
  - SATA\_PMACK, SATA\_PMNAK, SATA\_PMREQ\_P, and SATA\_PMREQ\_S (Power management acknowledgements and requests)
  - SATA\_HOLD and SATA\_HOLDA (Hold and hold acknowledge)
  - SATA\_R\_RDY and SATA\_X\_RDY (Receiver ready and transmitter ready)
  - Other STP primitives
- Clock skew management
- Idle links
- CRC
  - CRC overview
  - CRC generation
  - CRC checking
- Scrambling
- Bit order of CRC and scrambler
- Address frames
  - Address frames overview
  - IDENTIFY address frame
  - OPEN address frame

- Identification and hard reset sequence
  - Overview
  - Initiator device specific rules
  - Fanout expander device specific rules
  - IDENTIFY and HARD\_RESET (IR) state machines
- Power management
- Near-end analog loopback test
- Domain changes
- Connections
  - Connection overview
  - Opening a connection
  - Connection request
  - Connection request responses
- Arbitration fairness
  - Arbitration and resource management in an expander device
- Expander devices and connection requests
  - All expander devices
  - Edge expander devices
  - Fanout expander devices
- Abandoning a connection request
- Breaking a connection
- Closing a connection
- SAS link layer state machine for initiator phys and target phys (SL)
- SAS link layer state machine for expander phys (XL)
- Error handling
- Rate matching
- SSP link layer
  - Opening an SSP connection
  - Full duplex
  - SSP frame transmission
  - SSP flow control
  - Interlocked frames
  - Preparing to close an SSP connection
  - SSP link layer (SSP) state machines
- STP link layer
  - STP frame transmission
  - STP flow control
  - Preparing to close an STP connection
  - STP link layer (STP) state machines
- SMP link layer
  - SMP frame transmission
  - SMP flow control
  - Preparing to close an SMP connection
  - SMP link layer (SMP) state machines

#### Transport layer

- SSP transport layer
- SSP frame format
- Information units
  - COMMAND information unit
  - TASK information unit
  - XFER\_RDY information unit
  - DATA information unit
  - RESPONSE information unit
- Frame sequences
  - COMMAND frame rules
  - TASK frame rules
  - XFER\_RDY frame rules
  - DATA frame rules
  - RESPONSE frame rules
- SSP transport layer handling of link layer errors
  - COMMAND frame
  - TASK frame
  - XFER\_RDY frame
  - DATA frame

- RESPONSE frame
- SSP transport layer error handling
  - General error handling
  - Target port error handling
  - Initiator port error handling
- SSP transport layer state machines
  - Initiator device state machines
  - Target device state machines
- STP transport layer
  - SATA tunneling
  - SATA tunneling for multiple initiator ports
  - STP transport layer (TT) state machines
- SMP transport layer
  - SMP\_REQUEST frame
  - SMP\_RESPONSE frame
  - SMP transport layer state machines
  - Initiator device state machine
  - Expander device and target device state machine

#### Application layer

- SCSI application layer
  - SCSI mode parameters
    - Disconnect-Reconnect mode page
    - BUS INACTIVITY TIME LIMIT field
    - MAXIMUM CONNECT TIME LIMIT field
    - MAXIMUM BURST SIZE field
    - FIRST BURST SIZE field
  - Protocol-Specific Port mode page
  - Protocol-Specific Logical Unit mode page
  - SCSI log parameters
    - SAS Phy Error log page
- SCSI commands
- ATA application layer
- Management application layer
  - SMP functions
    - Function overview
    - REPORT GENERAL function
    - REPORT SATA CAPABILITIES function
    - REPORT MANUFACTURER INFORMATION
    - REPORT ROUTE INFORMATION
    - DISCOVER function
    - REPORT PHY ERROR LOG function
    - REPORT PHY SATA function
    - REPORT PHY MARGIN SETTINGS function
    - CONFIGURE ROUTE INFORMATION
    - PHY CONTROL function
    - PHY MARGIN CONTROL function

#### SCSI architecture mapping

- Names and identifiers
- Protocol services
  - Protocol services overview
  - Send SCSI Command protocol service
  - SCSI Command Received protocol service
  - Send Command Complete protocol service
  - Command Complete Received protocol service
  - Send Data-In protocol service
  - Data-In Delivered protocol service
  - Receive Data-Out protocol service
  - Data-Out Received protocol service
  - Send Task Management Request protocol service
  - Task Management Request Received protocol service
  - Task Management Function Executed protocol service
  - Received Task Management Function-Executed protocol service

### **Who should attend?**

*This in-depth technical class is targeted towards engineers involved in the design, development, integration, deployment and maintenance of Serial SCSI storage devices and systems. Day 1 of the class may be taken by those requiring a broad understanding of Serial SCSI technology with less technical depth; this includes technical managers, IT managers and staff, technical writers, technical sales and marketing staff.*

**Prerequisites:** *Should be familiar with computing and storage concepts. In-depth Exploration of SCSI course will benefit the student to understand this technology.*

**Course length:** 3 days