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**Product Brief**

# SAS4016 Tri-Mode I/O Controller
## PCIe 4.0 x8, 16-port 24G SAS/SATA/NVMe IOC Solution

**High-Performance IOC Delivers Enhanced Flexibility and Reliability to Tri-Mode Environments**

## Broadcom® Storage

Broadcom now enables high-performance 24G serial-attached SCSI (SAS), PCIe 4.0 storage connectivity, and flexible system designs to support NVMe, SAS, and SATA devices with a new family of SAS4000 Tri-Mode I/O Controllers (IOCs). Broadcom offers the industry's broadest portfolio of storage solutions, backed by decades of experience and trusted by the world's leading server and storage suppliers. Broadcom provides the building blocks for storage solutions that help customers understand, prioritize, store, and protect critical data.

## Overview

The SAS4016, part of the eighth generation of SAS IOCs from Broadcom, is based on the industry-leading Fusion-MPT™ (Message Passing Technology) architecture and features Tri-Mode SerDes technology that enables seamless operation of up to 16 direct-connect NVMe, SAS, or SATA storage devices from any system design.

The SAS4016 host interface supports 16 PCI Express (PCIe) lanes and complies with the PCIe 4.0 specification, offering up to 3 million Random Read IOPS. The ROC incorporates advanced security features such as attestation and hardware secure boot. Hardware secure boot, which permits only authenticated firmware to execute, enables the controller to boot from an Internal Boot ROM (IBR) to establish the initial Root of Trust (RoT). Hardware secure boot authenticates and builds a Chain of Trust (CoT) with succeeding software using this RoT (Implicit Trust). The SAS4016 ROC also supports attestation, the next generation in security (Explicit Trust).

The introduction of PCIe devices executing NVMe command sets to the existing SAS/SATA infrastructure makes industry-standard hot-pluggable drive bays even more versatile. The 16-port Tri-Mode IOC device interface provides SAS data transfer rates of 24, 12, and 6 Gb/s per lane, SATA at 6 Gb/s data transfer rates per lane, or PCIe data transfer rates of up to 16.0 GT/s per lane and is backward compatible to 5.0/2.5 GT/s. The ROC automatically negotiates between the speeds and protocols. A T-10 End-to-End Data Protection (EEDP) model for early detection of and recovery from data corruption, and Spread Spectrum Clocking (SSC) for EMI reduction are supported. Additional features include SAS 2.1 power management and DataBolt2 technology, allowing users to take advantage of 24 Gb/s speeds while utilizing existing 12 and 6 Gb/s drives and backplanes.

## Key Features

- High-performance I/O processor
- Arm A15 processor core at 1.6 GHz, offering 32 KB L1 I/D cache
  - 2 MB shared L2 cache
  - 15 MB on-chip memory
- PCIe 4.0 Host Interface
  - Supports x8, x4, x2, x1 PCIe lanes at a transfer rate up to 16.0 GT/s per lane, full duplex
  - Lane and polarity reversal
  - Supports End-to-End CRC (ECRC) and Advanced Error Reporting (AER)
  - PCIe hot plug support
  - Supports PCIe rate negotiation
- Tri-Mode Device Interface: x16 PHY SAS4/SATA/PCIe4
  - SAS/SATA:
    - 22.5, 12, and 6 Gb/s SAS and 6 Gb/s SATA data transfer rates
    - Spread spectrum clocking
    - Supports SSP, SMP, STP, and SATA protocols
    - T10 End-to-End Data Protection (EEDP)
    - Optical cable support
    - SAS 2.1 power management
    - Supports up to 2,000 SAS/SATA devices
    - Supports DataBolt2 bandwidth aggregation technology

The SAS4016 ROC integrates 15 MB on-chip memory, more than double previous generations, and is powered by a high-performance CPU Complex Arm A15 at 1.6 GHz, featuring 32 KB L1 I/D caches and 2 MB shared L2 cache.

## Fusion-MPT Architecture Overview

Fusion-MPT architecture marks the next generation of I/O architecture designed to deliver the highest performance available today while reducing time to market, integration, and certification time. Fusion-MPT devices are high performance, cost-effective protocol controllers that represent the newest system-level integration technology in intelligent I/O processors from Broadcom.

## Applications

- Server and external storage applications
- Direct-attached SAS/SATA/NVMe IOC solutions
- SAS RAID host bus adapter (HBA)
- PCIe-attached SSDs with industry-leading device management and error recovery

## Key Features (cont.)

- PCIe:
  - Supports x16, x8, x4, x2, x1 PCIe lanes at a transfer rate up to 16.0 GT/s per lane, full duplex
  - Lane and polarity reversal
  - Supports End-to-End CRC (ECRC) and Advanced Error Reporting (AER)
  - PCIe hot plug support
  - Supports PCIe rate negotiation
  - Separate Refclk Independent SSC (SRIS)
  - Supports up to 64 PCIe devices behind PCIe switches
- HW Secure Boot and Attestation
- Advanced Power Management
  - Slumber and Partial power mode support for SAS and SATA devices
  - Programmable SAS link power down
- External memory interface support: SPI-based Flash ROM
  - Communication Interfaces
  - I$^2$C interfaces for enclosure management services
  - UART interface for debug
- SFF-8485 compliant, SGPIO
- Supports Universal Bay Management (UBM)
- JTAG support
- Package: 31 mm

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