

Disk streaming solutions with libads

Streaming ADQ35 Data to RAID Drive

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Changelog

Location	Description
Revision	2025-12-15
	Initial revision

1 Introduction

This application note describes a high-throughput data streaming solution using Teledyne SP Devices' ADQ35 digitizers in combination with RAID arrays of NVMe SSDs. The goal is to achieve sustained write speeds of at least **25 GB/s** directly to storage without intermediate file system overhead, leveraging libaio, Teledyne SP Devices' proprietary NVMe streaming library.

To illustrate the versatility of this approach, we demonstrate two implementations with different properties:

- A high-performance disk configuration that, at higher cost, enables recordings totaling **75 TB** at full speed.
- A cost-effective disk configuration using standard drives, supporting high-speed recording of up to **4 TB** of data at full speed.

These complementary solutions highlight the trade-off between maximum performance and economical scalability. This document outlines the architecture, performance considerations, and best practices for implementing these solutions.

1.1 System Configuration

- Two ADQ35 digitizers, each operating at 2 channels 5 GSPS with 10-bit samples, resulting in 12.5 GB/s per digitizer and a combined throughput of 25 GB/s.

1.1.1 Option 1: Enterprise-Grade RAID

Component	Specification
Configuration	5 × Kioxia CD8 15.3 TB
Total Capacity	75 TB (15 TB × 5)
Aggregate Write Speed	30 GB/s (6 GB/s × 5)
Endurance	140,000 TBW (28,000 TBW per drive)
Use Case	Long-duration, high-speed acquisition, with long service life

1.1.2 Option 2: Cost-Efficient RAID

Component	Specification
Configuration	2 × Kingston Fury Renegade G5 2 TB
Total Capacity	4 (2 TB × 2)
Aggregate Write Speed	Up to 25 GB/s (12.5 GB/s × 2)
Endurance	4,000 TBW total (2,000 TBW per drive)
Limitation	Performance drops after 1.3 TB due to SLC exhaustion
Use Case	Short-duration, high-speed acquisitions at lower cost

1.2 Key Advantages of libads

The libads library provides a highly efficient and integrated solution for data acquisition and storage:

- Writes raw data blocks directly to disk sectors, bypassing the operating system's file system for maximum efficiency.
- Supports export to file for streamlined data handling and archiving.
- Handles multiple datasets per acquisition, with support for up to 32k datasets.
- Offers optional real-time GPU Processing support for accelerated analysis workflows.
- Fully compatible with all ADQ3 series digitizers, ensuring broad hardware support.
- Highly integrated with the digitizer API.

By bypassing the file system, full control is given to the user, reducing overhead and enabling direct, optimized data placement. A dedicated readout and export to file mechanism is provided by libads.

1.3 Definitions and Abbreviations

Table 3 lists the definitions and abbreviations used in this document.

Table 3: Definitions and abbreviations used in this document.

Item	Description
ADQ35	High-speed digitizer from Teledyne SP Devices
GSPS	Giga Samples Per Second
GB/s	Gigabytes per second
libads	Teledyne SP Devices' NVMe streaming library
RAID	Redundant Array of Independent Disks
RAID-0	Striped disk array for maximum throughput without redundancy
mdadm	Linux utility for managing software RAID arrays
SLC	Single level cell
TBW	Terabytes Written

1.4 System Specification

The following hardware and software configuration was used for the measurements and implementation described in this document.

Table 4: Hardware and software configuration used for disk streaming tests.

Component	Specification
System	Teledyne DPS7-PCIe
Motherboard	ASRock GENOAD8X-2T/BCM
CPU	AMD EPYC 9135 16-Core Processor
RAM	4 × M5R0-AGS2ACVP, 16 GB × 4 DDR5
Storage	Option 1: 5 × Kioxia CD8 15.3TB, PCIe Gen4; Option 2: 2 × Kingston Fury Renegade G5 2TB
Disk Adapter	Option 1: 2 × Delock 90169 U.2 Adapter; Option 2: 1 × ASUS Hyper M.2 x16 Gen5 Adapter
RAID	Software RAID-0 using mdadm
Digitizers	2 × Teledyne SP Devices ADQ35, 10 GSPS, 10-bit compression
OS	Ubuntu 24.04 LTS
Software	2025.1 TSPD SDK and libads library



Figure 1: Overview of the Teledyne DPS7-PCIe system used for disk streaming tests, digitizers, and RAID storage.

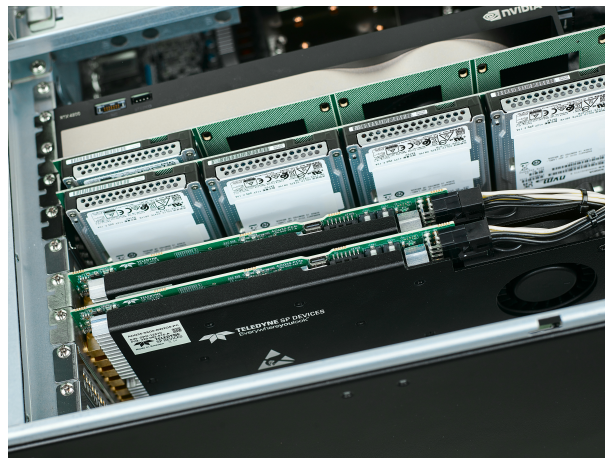


Figure 2: Teledyne ADQ35 digitizers and Kioxia CD8 drives inside the DPS7-PCIe system.

The SSD adapters were selected based on form factor compatibility: Kingston drives use the M.2 PCIe Gen5 interface, while Kioxia drives use the U.2 PCIe Gen4 interface.

2 Installation and Setup

To enable disk streaming using libads, we followed these steps:

Table 5: Procedure for installing libads and running the streaming example.

Step	Description
1	We installed libads using the provided Debian package: <code>sudo dpkg -i libads.deb</code>
2	We modified the <code>ads_write_drive</code> example configuration: <ul style="list-style-type: none"> • Set <code>num_disks</code> to match our RAID setup • Specified disk device paths (e.g., <code>/dev/disk/by-id/...</code>)
3	We built the streaming application with CMake and ran it.
4	We monitored console output for performance metrics and verified sustained throughput.

For ADQ35 to enumerate all 16 PCIe lanes, we configured PCIe slots for x8x8 bifurcation in BIOS. For NVMe adapters, we set slots to x4x4x4x4 bifurcation. Most server and workstation based motherboards support these configurations.

Refer to the libads User Guide for advanced configuration options.

3 Results

3.1 5 × Kioxia Enterprise RAID Solution

With five enterprise-grade Kioxia CD8 NVMe SSDs configured in RAID-0, the two ADQ35 digitizers sustained 100% duty cycle streaming at 10-bit sample compression. As a validation test, four ADC channels streamed a total of 10.4 TB, corresponding to 2.6 TB per channel, without interruption.

Explanation: The console output shows write performance at 419.44 s into the acquisition.

- **Last 1.39 s:** Data written and throughput during the most recent interval.
- **Total:** Cumulative data and sustained average speed since start.

Each stream corresponds to one digitizer channel. The aggregate line (`Tot`) indicates combined performance: ≈25 GB/s sustained throughput across four streams, confirming stable high-speed acquisition without bottlenecks.

```
***** Write status at 419.44 s *****
      |      Last  1.39 s      |      Total      |
-----|-----|-----|
Drive 0 |      |      |
Stream 0: |  8.674 GB -> 6.243 GB/s | 2621.440 GB -> 6.250 GB/s |
Stream 1: |  8.677 GB -> 6.245 GB/s | 2621.440 GB -> 6.250 GB/s |
Stream 2: |  8.706 GB -> 6.266 GB/s | 2621.440 GB -> 6.250 GB/s |
Stream 3: |  8.706 GB -> 6.266 GB/s | 2621.440 GB -> 6.250 GB/s |
  Tot:   | 34.763 GB -> 25.021 GB/s | 10485.760 GB -> 24.999 GB/s |
```

Observation:

- Aggregate sustained throughput: ≈25 GB/s
- No performance degradation over extended duration
- Ideal for long acquisitions at full speed

3.2 2 × Kingston Fury RAID Solution

With two Kingston Fury Renegade G5 SSDs in RAID-0, streaming maintained full speed until the SLC (670 GB per disk) was exhausted. After SLC depletion, write speed dropped significantly, requiring digitizer stop to prevent overflow. Test configuration: four channels streamed until performance decline:

```
***** Write status at 54.01 s *****
      |      Last 2.00 s      |      Total      |
-----|-----|-----|
Drive 0 |      |      |
Stream 0: | 12.496 GB -> 6.248 GB/s | 337.505 GB -> 6.249 GB/s |
Stream 1: | 12.494 GB -> 6.246 GB/s | 337.503 GB -> 6.249 GB/s |
Stream 2: | 12.494 GB -> 6.246 GB/s | 337.474 GB -> 6.249 GB/s |
Stream 3: | 12.494 GB -> 6.246 GB/s | 337.474 GB -> 6.249 GB/s |
  Tot:   | 49.978 GB -> 24.986 GB/s | 1349.955 GB -> 24.995 GB/s |
-----|-----|-----|
```

Observation:

- Initial aggregate throughput: 25 GB/s
- Sustained for 1.35 TB total
- Suitable for medium-duration, high-speed acquisitions
- The SLC section of the drive can be imitatively recovered by formatting the RAID array. The libads package provides a script for doing this.

4 Summary & Recommendations

This application note demonstrates two RAID-based disk streaming solutions for ADQ35 digitizers. Both approaches achieve sustained high-throughput recording, but they differ in cost, capacity, and intended use. The enterprise RAID configuration maximizes performance and reliability, while the cost-effective option provides large storage capacity at lower expense. Users should select the solution that best matches their acquisition requirements, balancing speed, duration, and budget.

4.1 Enterprise RAID (5 × Kioxia CD8)

- Sustained 25 GB/s throughput until drive is full
- Ideal for long-duration acquisitions
- High capacity (≈75 TB) for extended recording sessions
- Recommended for mission-critical or production environments

4.2 Cost-Efficient RAID (2 × Kingston Fury)

- Achieves peak 25 GB/s throughput for medium bursts (1.35 TB)
- Limited by SLC size (670 GB per disk)
- RAID can be formatted to clear SLC and restart acquisition
- Suitable for medium-duration acquisitions or budget-sensitive setups

4.3 Recommendations

- Use enterprise-grade RAID for large datasets and mission critical acquisition
- Use cost-efficient RAID for short, high-speed acquisitions where budget is a priority
- Ensure proper BIOS bifurcation settings for PCIe lanes (x8x8 for digitizers, x4x4x4x4 for disk adapters)

5 Scalability & Future Expansion

Both types of RAID-based solutions can be customized to meet specific requirements on capacity, speed, throughput, endurance, and cost by adjusting the number of drives, the drive model, and the drive carrier card.

Available solutions scale up to:

- **▶ Petabyte-scale capacity**
 - ▶ **80+ GB/s sustained write throughput**
 - ▶ **Endurance greater than 70,000 TBW per drive**

These configurations can be combined with up to six ADQ3-series digitizers, and multi-chassis solutions are available for further scaling.

Key Takeaway: The approach is modular and flexible—users can tailor the system to their needs today and expand as requirements grow, balancing performance, endurance, and cost.

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