Xilinx Answer 34944

QDMA Performance Report

**Important Note:** This downloadable PDF of an Answer Record is provided to enhance its usability and readability. It is important to note that Answer Records are Web-based content that are frequently updated as new information becomes available. You are reminded to visit the Xilinx Technical Support Website and review (Xilinx Answer 34944) for the latest version of this Answer.

# Revision History

The following table shows the revision history for this document.

|  |  |  |
| --- | --- | --- |
| **Date** | **Version** | **Description** |
| 28-Feb-2023 | 1.0 | CMP5 QDMA 2023.1 performance report |
| 2-May-2023 | 2.0 | CPM5 Performance Improvement with software optimizations |

# Overview

Xilinx QDMA (Queue Direct Memory Access) Subsystem for PCI Express® (PCIe®) is a high-performance DMA for use with the PCI Express® 3.x Integrated Block(s) which can work with AXI Memory Mapped or Streaming interfaces and uses multiple queues optimized for both high bandwidth and high packet count data transfers. (Please refer [Versal ACAP CPM DMA and Bridge Mode for PCI Express v2.1 - PG347](https://docs.xilinx.com/v/u/2.1-English/pg347-cpm-dma-bridge) for additional details).

Xilinx provides two reference drivers for QDMA IP

* Linux Kernel driver (Linux Driver)
* DPDK Poll Mode driver (DPDK Driver)

This performance report provides the measurement of the DMA bandwidth of the CPM5 QDMA IP using the reference DPDK driver. This report provides the measured DMA bandwidth with different DMA configurations that can be extrapolated to the target application.

The reference designs are targeted at PCIe Gen 3 x16 design and PCIe Gen 5 x8 design on Xilinx Versal XCVP1202 device on VPK120 board only. The reference design can be ported to other Xilinx cards too.

The performance report for QDMA5.0 soft IP is available at [Xilinx Answer 71453](https://support.xilinx.com/s/article/71453?language=en_US)

***Note****: The QDMA DPDK Driver and Linux Driver are hosted* *at* <https://github.com/Xilinx/dma_ip_drivers/>*,under directory QDMA.*

## Audience

The pre-requisite for understanding this document is that the user has gone through the following:

* [Xilinx Answer 70928](https://www.xilinx.com/support/answers/70928.html)
* [Versal ACAP CPM DMA and Bridge Mode for PCI Express v2.1 - PG347](https://docs.xilinx.com/v/u/2.1-English/pg347-cpm-dma-bridge), and
* [DPDK driver User guide](https://xilinx.github.io/dma_ip_drivers/master/QDMA/DPDK/html/index.html)

## System Overview

The system overview is presented in the

Packet Generator + Capture

Host

Memory

C2H

H2C

C2H

H2C

C2H

H2C

C2H

H2C

QDMA Driver

Sysfs

nl

Char dev

dma-perf application

dmactl application

Hardware

Kernel

Application

igb\_uio driver

DPDK testpmd application

DPDK Environment

Xilinx QDMA DPDK PMD

dpdk-pktgen application

DPDK Driver

Linux Driver

PCIe

QDMA Subsystem

Figure 1: System Diagram

## Hardware

Xilinx provides sample reference designs for Streaming (ST) mode and Memory Mapped (MM) mode.

ST performance reference design consists of an AXI Stream-only packet generator in the C2H direction and performance / latency measurement tools in both C2H and H2C directions. The reference design will generate a known data pattern (timestamp) and send a user-specified packet length on the C2H direction when there is an available descriptor. This data pattern can be looped back into the H2C direction by the application and measured for performance and latency. Please refer the Example Design section in [Versal ACAP CPM DMA and Bridge Mode for PCI Express v2.1 - PG347](https://docs.xilinx.com/v/u/2.1-English/pg347-cpm-dma-bridge) on how to configure the packet generator and read the data collected by the measurement counters through the AXI Lite Master BAR (BAR# 2).

For details regarding register maps and the limitations of the design, please refer to the Reference Design RTL.

## Software

### DPDK Poll Mode Driver

The Xilinx reference QDMA DPDK 2023.1.1 driver is based on DPDK v22.11. The DPDK driver is tested by binding the PCIe functions with igb\_uio kernel driver.

The dpdk-pktgen application is used to perform uni-directional performance measurement and the testpmd application is used for the Bi-directional forwarding performance measurement.

## Generating Reference Design

The Reference Design bitfile used in this Performance report is available for immediate download into a VPK120 design. For users who are using a different card, the Reference Design can be generated by following the steps under Design Flow Steps section in [Versal ACAP CPM DMA and Bridge Mode for PCI Express v2.1 - PG347](https://docs.xilinx.com/v/u/2.1-English/pg347-cpm-dma-bridge)

# Measurement

For DPDK driver performance analysis, below performance measurements are taken with dpdk-pktgen and testpmd DPDK applications on PF-0 for this report.

* ST Mode DMA Performance of PF-0 on Host (i.e. Run DPDK performance application on the PF-0 in the Host):
  + C2H only DMA performance using dpdk-pktgen application
  + H2C only DMA performance using dpdk-pktgen application
  + Bi-directional (forwarding) DMA performance using testpmd application

## DMA Overheads

The PCIe bandwidth utilization is higher than DMA bandwidth as this number excludes PCIe protocol overheads. In addition to PCIe overhead, DMA will have its own overhead to communicate with the driver as listed below.

* CIDX update by driver affects C2H and forwarding performance
* PIDX update by driver affects H2C and forwarding performance
* 16B H2C descriptor affects H2C and forwarding performance
* 8B C2H descriptor affects C2H and forwarding performance
* C2H completion can be 8B or 16B or 32B or 64B sent for every packet to pass the meta-data.
* Status descriptor writes affect both C2H and H2C performance
* Memory controller overhead in Memory-mapped mode.

When possible, QDMA reduces various TLP overheads by coalescing reads and writes. QDMA is highly customizable, the overheads can be reduced by customizing the solution to be specific to an application.

## DMA Bandwidth Performance Measurement

The packets per second (PPS) numbers reported by the application are noted and the DMA bandwidth performance is calculated as below:

* ***DMA Bandwidth Performance = PPS \* DMA Packet size in bytes \* 8***

For NIC use case the performance can be extrapolated as follows:

* ***Ethernet Performance = PPS \* (DMA Packet size in bytes + Preamble bytes + Inter-frame gap bytes + FCS) \* 8***

Every Ethernet packet includes Preamble of 8 bytes, Inter-frame Gap of 12 bytes, FCS of 4 bytes and the DMA packet size can be 4 bytes less than the network packet size as the FCS 4 bytes can be stripped off by the MAC and as a result are not DMA’ed.

# Test Environment

The test setup is as outlined in Figure 1. Table 1 lists the AMD system settings used for the Gen3x16 performance measurement.

|  |  |
| --- | --- |
| Item | Description |
| CPU | AMD EPYC 7763 64-Core Processor |
| Vendor | AuthenticAMD |
| No of Sockets | 2 |
| No of logical Cores | 256 |
| Threads Per Core | 2 |
| RAM | 512GB (16 x 32GB, Fully populated DIMMS) |
| DUT | Xilinx Versal XCVP1202 device based VPK120 board |
| Performance design | CPM5 bitstream |
| PCIe Setting | MPS=512, MRRS=512, Extended Tag Enabled, Relaxed Ordering Enabled |
| Additional settings (Recommended) | Fully populated memory channels  Use the CPU slot on which PCIe slot is used |
| Other Setting (Recommended) | Tx queue depth = 2048, Rx queue depth = 2048, Packet buffer size = 4096, Burst size = 256 |
| Operating System | Ubuntu 22.04.1 LTS, Kernel 5.15.0-58-generic |
| BIOS version | v2.21.1278 |
|  | |
| *DPDK driver specific settings:* | |
| Boot Setting | default\_hugepagesz=1GB hugepagesz=1G hugepages=36 iommu=pt amd\_iommu=on pci=realloc |
| DPDK Version | 22.11 |
| Performance setting | isolcpus=1-16  Disable iptables/ip6tables service  Disable irqbalance service  Disable cpuspeed service  Disable numa balancing service  Point scaling-governor to performance |

Table 1: Performance System Settings for Gen3x16 AMD setup

*There could be some variation in performance with other AMD setups based on system settings.*

Table 2 lists the Intel system settings used for the Gen3x16 performance measurement.

|  |  |
| --- | --- |
| Item | Description |
| CPU | Intel(R) Xeon(R) Platinum 8168 CPU @ 2.70GHz |
| Vendor | GenuineIntel |
| No of Sockets | 1 |
| Number of Physical Cores | 24 |
| Threads Per Core | 2 |
| No of logical Cores | 48 |
| RAM | 128GB (4 x 32GB) |
| DUT | Xilinx Versal XCVP1202 device based VPK120 board |
| PCIe Setting | MPS=512, MRRS=512, Extended Tag Enabled, Relaxed Ordering Enabled |
| Additional settings (Recommended) | Fully populated memory channels  Use the CPU slot on which PCIe slot is used |
| Other Setting (Recommended) | Tx queue depth = 2048, Rx queue depth = 2048, Packet buffer size = 4096, Burst size = 256 |
| Operating System | Ubuntu 18.04.5 LTS, Kernel 4.15.0-194-generic |
| Linux Driver Specifc Settings | |
| Boot Setting | "intel\_idle.max\_cstate=0 processor.max\_cstate=0 intel\_pstate=disable rcu\_nocb\_poll audit=0 pci=realloc  nosoftlockup iommu=pt intel\_iommu=on" |
| BIOS Version | 2.1 |
| BIOS Settings | ACS, IOMMU, ARI enabled. Power Technology is set to Custom, Power Performance Tuning – OS controls EPB |
| VM Settings for Linux VF Performance | VM RAM = 32G, Number of cores for VM = 32 |
| *DPDK driver specific settings:* | |
| Boot Setting | default\_hugepagesz=1GB hugepagesz=1G hugepages=36 iommu=pt intel\_iommu=on pci=realloc transparent\_hugepages=never isolcpus=1-16 rcu\_nocbs=1-16 nohz=on nohz\_full=1-16 numa\_balancing=disable  nmi\_watchdog=1 audit=0 nosoftlockup hpet=disable tsc=reliable selinux=0 |
| DPDK Version | 22.11 |
| Performance setting | Disable iptables/ip6tables service  Disable irqbalance service  Disable cpuspeed service  Disable numa balancing service  Point scaling-governor to performance |

Table 2: Performance System Settings for Gen3x16 Intel Setup

*There could be some variation in performance with other Intel setups based on system settings.*

Table 3 lists the AMD system settings used for the Gen5x8 performance measurement.

|  |  |
| --- | --- |
| Item | Description |
| CPU | AMD EPYC 9654 96-Core Emb Processor |
| Vendor | AuthenticAMD |
| No of Sockets | 2 |
| No of logical Cores | 384 |
| Threads Per Core | 2 |
| RAM | 384GB (24 x 16GB) |
| DUT | Xilinx Versal XCVP1202 device based VPK120 board |
| Performance design | CPM5 bitstream |
| PCIe Setting | MPS=512, MRRS=4096, Extended Tag Enabled, Relaxed Ordering Enabled |
| Additional settings (Recommended) | Fully populated memory channels  Use the CPU slot on which PCIe slot is used |
| Other Setting (Recommended) | Tx queue depth = 2048, Rx queue depth = 2048, Packet buffer size = 4096, Burst size = 256 |
| Operating System | Ubuntu 22.04.1 LTS, Kernel 5.15.0-50-generic |
| BIOS Version | v2.11.0.17b |
|  | |
| *DPDK driver specific settings:* | |
| Boot Setting | hugepagesz=1GB hugepages=100 default\_hugepagesz=1GB iommu=pt amd\_iommu=on pci=realloc numa=on isolcpus=1-95,193-287 nohz\_full=1-95,193-287 rcu\_nocbs=1-95,193-287 nohz=on rcu\_nocb\_poll numa\_balancing=disable transparent\_hugepage=never nosoftlockup irqaffinity=0,192" |
| DPDK Version | 22.11 |
| Performance setting | isolcpus=1-16  Disable iptables/ip6tables service  Disable irqbalance service  Disable cpuspeed service  Disable numa balancing service  Point scaling-governor to performance |

Table 3: Performance System Settings for Gen5x8 AMD setup

*There could be some variation in performance with other AMD setups based on system settings.*

Following are the additional DPDK Performance tuning settings that could be used.

##### PCIe MRRS

Performance System Settings listed in Table 1 uses PCIe MRRS (Max Read Request) of 512, with which all performance data has been collected. However, depending on the system in use (motherboard, PCIe root ports and its capability, etc.), system specific tuning might be needed. For example, if line-rate is not observed for packet size 4K on a system then, PCIe MRRS could be tuned to 2048.

##### CPU isolation and additional kernel settings

If the system in use runs additional apps then, it is always good to set aside CPU cores for dpdk workload.

Below additional kernel command-line parameters could be added to GRUB boot settings:

isolcpus=1-<n> nohz\_full=1-<n> rcu\_nocbs=1-<n>

where:

isolcpus isolates cpus 1 to <n> from kernel scheduling so that they are set aside for dedicated tasks like dpdk.

nohz\_full will put cpus 1 to <n> in adaptive-ticks mode so as not to interrupt them with scheduling-clock interrupts.

rcu\_nocbs will fence off cpus 1 to <n> from random interruptions of softirq RCU callbacks.

Now, use from these CPUs 1 to <n> in DPDK testpmd, pktgen command-lines to make sure that the DPDK apps use these dedicated CPUs.

##### Disable CPU power savings from kernel command-line

Sometimes, disabling CPU power savings from BIOS alone may not always make the CPU(s) run on full horse-power. As an additional confirmation, disable power savings from kernel command-line too

processor.max\_cstate=0 intel\_idle.max\_cstate=0 intel\_pstate=disable

Above will disable power savings on CPUs and disable intel\_idle as well as intel\_pstate cpu frequency scaling driver. Further, always double-confirm from 'cat /proc/cpuinfo | grep -i Mhz' output that all the intended CPUs are operating at max speed.

##### NOTE:

1. Above tuning parameters may not always be needed. And one should be thoroughly aware about the system in use, and the kind of apps/workload running on the system before applying any of these parameters.

2. Some parameters are specific to Intel x86-64 and may not work for ARM, PPC or AMD based systems. Always consult respective CPU’s manual and related Linux parameters for the same.

3. These parameters were NOT used for the performance numbers published in this guide.

## lspci output

Figure 2 depicts sample lspci output of the PCIe function under test.

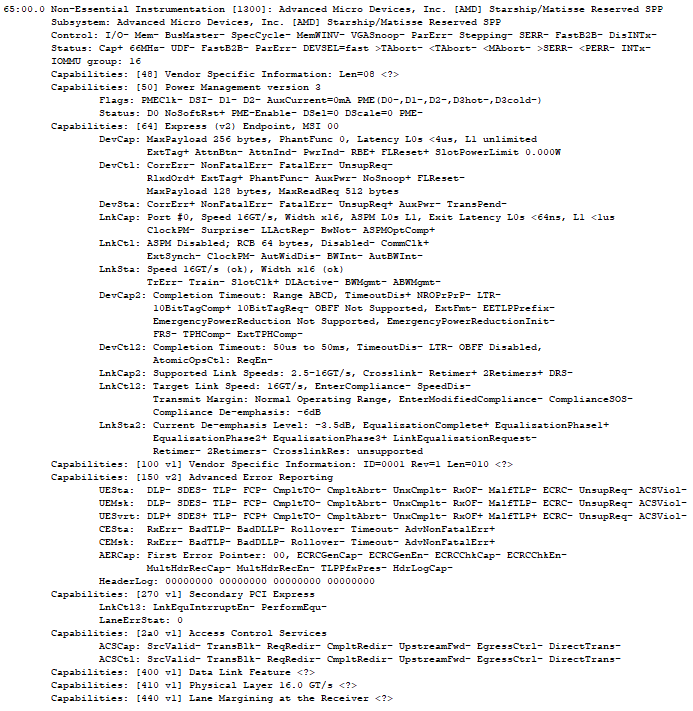


Figure 2: lspci output of the PCIe function being tested

## QDMA Settings

The QDMA IP is highly configurable. This section lists only a subset of the available settings limited to the tests carried out in this report.

|  |  |
| --- | --- |
| Configuration Option | Description |
| Number of Queues | The QDMA IP supports up to 2048 queues. The number of queues for a given test are specified when starting the software application.  ***Benchmarking is done for 1, 2, 4 and 8 queues***  ***Forwarding performance on Gen5x8 Setup: Benchmarking is done for 1, 2, 4, 8, 16, 32, 64, 128 and 190*** |
| Packet Size | Tests accept a range of packet sizes along with a packet size increment.  ***Benchmarking is done with packet size in the range of 64B to 4KB for streaming queue performance and 64B to 32KB for memory mapped queue performance*** |
| Completion Descriptor size | Completion queue descriptors can be configured to 8-byte, 16-byte, 32-byte or 64-byte.  ***Benchmarking is done with 16B descriptor format.*** |
| Descriptor Prefetch | Prefetch causes descriptors to be opportunistically prefetched so that descriptors are available before the packet is received.  ***Benchmarking is done with prefetch enabled***. |
| Prefetch Cache depth | Prefetch cache depth is selectable from Vivado when building the design. Supported values are 8, 16, 32, 64. The Prefetch cache can support that many active queues at any given time.  ***Benchmarking is done with prefetch cache depth set to 64.*** |
| Completion Coalesce Buffer depth | Completion coalesce buffer depth is selectable from Vivado when building the design. Supported values are 8, 16, 32.  ***Benchmarking is done with completion coalesce buffer depth set to 32.*** |

Table 4: QDMA Settings

# Performance Benchmark Results

## DPDK Driver

This section provides the performance results captured using DPDK driver in streaming mode using the customized bitstream provided in release package.

QDMA currently has a limitation that the packet buffers be aligned to 256 bytes boundary for optimal DMA performance. Since the mbuf data pointers in DPDK need not be aligned to 256 bytes boundary, the higher packet size performance for DPDK reported below is slightly lower than that reported for Linux driver. This alignment limitation in QDMA IP will be fixed in future IP releases.

### Streaming Mode C2H and H2C performance test

Below dpdk-pktgen command-lines were used for performance measurement.

* The ‘-9’ option is the extension added by Xilinx to enable dpdk-pktgen to support packet sizes beyond 1518 bytes.
* The dpdk-pktgen application was also modified to disable the packet classification.

The ‘-a’ EAL option is specified to enable or disable prefetch and to change the completion descriptor length.

In the table below, 3b:00.0 represents PCIe function in “bus:device.function” format.

|  |  |
| --- | --- |
| # of queues | dpdk-pktgen command line |
| 1 | ./build/app/pktgen -l 0-2 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 -- -P -m "[1:2].0" -9 |
| 2 | ./build/app/pktgen -l 0-4 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 -- -P -m "[1-2:3-4].0" -9 |
| 4 | ./build/app/pktgen -l 0-8 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 -- -P -m "[1-4:5-8].0" -9 |
| 8 | ./build/app/pktgen -l 0-16 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 -- -P -m "[1-8:9-16].0" -9 |
| 16 | ./build/app/pktgen -l 0-32 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 -- -P -m "[1-16:17-32].0" -9 |

Table 5: Command-line for dpdk-pktgen application

For H2C performance tests the C2H traffic is disabled and H2C packets are generated using dpdk-pktgen application. The EAL option (-a) is ***not*** required to be specified in the command lines.

### Streaming Mode Forwarding performance test

The testpmd application is executed with the below command-line options for different queue configurations.

|  |  |
| --- | --- |
| # of queues | testpmd command line |
| 1 | ./build/app/dpdk-testpmd -l 1-17 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=1 --rxq=1 --txq=1 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 2 | ./build/app/dpdk-testpmd -l 1-17 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=2 --rxq=2 --txq=2 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 4 | ./build/app/dpdk-testpmd -l 1-17 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=4 --rxq=4 --txq=4 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 8 | ./build/app/dpdk-testpmd -l 1-17 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=8 --rxq=8 --txq=8 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 16 | ./build/app/dpdk-testpmd -l 1-17 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=16 --rxq=16 --txq=16 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 32 | ./build/app/dpdk-testpmd -l 1-33 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=32 --rxq=32 --txq=32 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 64 | ./build/app/dpdk-testpmd -l 1-65 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=64 --rxq=64 --txq=64 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 128 | ./build/app/dpdk-testpmd -l 1-129 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=128 --rxq=128 --txq=128 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |
| 190 | ./build/app/dpdk-testpmd -l 1-191 --socket-mem=4096 -n 4 -a 3b:00.0,desc\_prefetch=1,cmpt\_desc\_len=16 --log-level=3 -- --burst=256 -i --nb-cores=190 --rxq=190 --txq=190 --forward-mode=io --rxd=2048 --txd=2048 --mbcache=512 --enable-drop-en --port-numa-config=0,0 --no-rmv-interrupt --no-mlockall --no-lsc-interrupt --rss-udp |

Table 6: Command-line for testpmd application

### QDMA Performance metrics on Gen3x16 AMD System

#### PF Performance

##### ST C2H Performance

Figure 3: DPDK Driver – CPM5 PF ST C2H performance in Gbps

Figure 4: DPDK Driver – CPM5 PF ST C2H performance in Mpps

##### ST H2C Performance

Figure 5: DPDK Driver – CPM5 PF ST H2C Performance in Gbps

Figure 6: DPDK Driver – CPM5 PF ST H2C Performance in Mpps

##### ST Forwarding Performance

Figure 7: DPDK Driver – CPM5 PF Forwarding performance in Gbps

Figure 8: DPDK Driver – CPM5 PF Forwarding performance in Mpps

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Packet Size (Bytes) | 8 queues | | 4 queues | | 2 queues | | 1 queue | |
| **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** |
| 64 | 77.62 | 39.74 | 92.09 | 47.15 | 71.43 | 36.57 | 35.72 | 18.29 |
| 128 | 65.24 | 66.81 | 65.04 | 66.60 | 62.50 | 64.00 | 31.25 | 32.00 |
| 192 | 48.39 | 74.32 | 48.35 | 74.27 | 48.34 | 74.25 | 27.78 | 42.67 |
| 256 | 38.51 | 78.86 | 38.16 | 78.15 | 38.54 | 78.93 | 25.00 | 51.20 |
| 320 | 31.19 | 79.85 | 31.19 | 79.85 | 31.19 | 79.85 | 22.73 | 58.18 |
| 384 | 27.45 | 84.33 | 27.07 | 83.17 | 27.26 | 83.74 | 20.83 | 64.00 |
| 448 | 24.10 | 86.37 | 23.59 | 84.54 | 23.62 | 84.66 | 19.23 | 68.92 |
| 512 | 21.22 | 86.92 | 21.16 | 86.69 | 21.13 | 86.53 | 17.86 | 73.15 |
| 576 | 18.83 | 86.76 | 18.90 | 87.08 | 18.86 | 86.89 | 16.67 | 76.80 |
| 640 | 16.98 | 86.92 | 16.90 | 86.53 | 16.79 | 85.95 | 15.63 | 80.00 |
| 704 | 15.48 | 87.20 | 15.24 | 85.84 | 15.11 | 85.12 | 14.71 | 82.82 |
| 768 | 14.23 | 87.41 | 13.88 | 85.27 | 13.83 | 84.95 | 13.89 | 85.34 |
| 832 | 13.07 | 86.99 | 12.89 | 85.77 | 12.81 | 85.28 | 13.16 | 87.58 |
| 896 | 12.13 | 86.97 | 11.95 | 85.68 | 11.84 | 84.89 | 12.50 | 89.60 |
| 960 | 11.64 | 89.42 | 11.44 | 87.84 | 11.31 | 86.85 | 11.91 | 91.43 |
| 1024 | 11.20 | 91.76 | 11.01 | 90.16 | 10.86 | 88.93 | 11.36 | 93.09 |
| 1088 | 10.73 | 93.40 | 10.73 | 93.42 | 10.73 | 93.41 | 10.74 | 93.52 |
| 1152 | 10.18 | 93.81 | 10.18 | 93.82 | 10.14 | 93.43 | 10.19 | 93.93 |
| 1216 | 9.68 | 94.19 | 9.68 | 94.19 | 9.68 | 94.21 | 9.69 | 94.28 |
| 1280 | 9.23 | 94.55 | 9.23 | 94.55 | 9.24 | 94.58 | 9.24 | 94.62 |
| 1344 | 8.82 | 94.85 | 8.82 | 94.85 | 8.82 | 94.86 | 8.83 | 94.89 |
| 1408 | 8.45 | 95.13 | 8.45 | 95.13 | 8.45 | 95.15 | 8.45 | 95.19 |
| 1472 | 8.10 | 95.40 | 8.10 | 95.40 | 8.10 | 95.42 | 8.11 | 95.45 |
| 1536 | 7.79 | 95.67 | 7.79 | 95.66 | 7.79 | 95.69 | 7.79 | 95.69 |
| 1600 | 7.49 | 95.89 | 7.49 | 95.90 | 7.49 | 95.91 | 7.49 | 95.91 |
| 1664 | 7.22 | 96.12 | 7.22 | 96.11 | 7.22 | 96.13 | 7.22 | 96.14 |
| 1728 | 6.97 | 96.33 | 6.97 | 96.32 | 6.97 | 96.33 | 6.97 | 96.34 |
| 1792 | 6.73 | 96.50 | 6.73 | 96.50 | 6.73 | 96.52 | 6.73 | 96.52 |
| 1856 | 6.51 | 96.68 | 6.51 | 96.68 | 6.51 | 96.68 | 6.51 | 96.68 |
| 1920 | 6.31 | 96.86 | 6.31 | 96.85 | 6.31 | 96.87 | 6.31 | 96.86 |
| 1984 | 6.11 | 97.01 | 6.11 | 97.00 | 6.11 | 97.01 | 6.11 | 97.01 |
| 2048 | 5.93 | 97.14 | 5.93 | 97.14 | 5.93 | 97.15 | 5.93 | 97.15 |
| 2112 | 5.61 | 94.84 | 5.62 | 94.89 | 5.62 | 94.96 | 5.64 | 95.22 |
| 2176 | 5.45 | 94.95 | 5.46 | 94.99 | 5.46 | 95.06 | 5.47 | 95.29 |
| 2240 | 5.31 | 95.15 | 5.31 | 95.20 | 5.32 | 95.27 | 5.33 | 95.46 |
| 2304 | 5.17 | 95.34 | 5.17 | 95.38 | 5.18 | 95.46 | 5.19 | 95.63 |
| 2368 | 5.04 | 95.49 | 5.04 | 95.54 | 5.05 | 95.61 | 5.06 | 95.79 |
| 2432 | 4.92 | 95.65 | 4.92 | 95.69 | 4.92 | 95.76 | 4.93 | 95.94 |
| 2496 | 4.80 | 95.82 | 4.80 | 95.87 | 4.80 | 95.93 | 4.81 | 96.10 |
| 2560 | 4.69 | 95.97 | 4.69 | 96.01 | 4.69 | 96.07 | 4.70 | 96.25 |
| 2624 | 4.58 | 96.10 | 4.58 | 96.15 | 4.58 | 96.22 | 4.59 | 96.37 |
| 2688 | 4.47 | 96.23 | 4.48 | 96.26 | 4.48 | 96.32 | 4.49 | 96.50 |
| 2752 | 4.38 | 96.37 | 4.38 | 96.42 | 4.38 | 96.48 | 4.39 | 96.63 |
| 2816 | 4.28 | 96.50 | 4.29 | 96.54 | 4.29 | 96.60 | 4.29 | 96.75 |
| 2880 | 4.19 | 96.61 | 4.19 | 96.65 | 4.20 | 96.71 | 4.20 | 96.85 |
| 2944 | 4.11 | 96.73 | 4.11 | 96.76 | 4.11 | 96.81 | 4.12 | 96.96 |
| 3008 | 4.02 | 96.83 | 4.03 | 96.87 | 4.03 | 96.92 | 4.03 | 97.06 |
| 3072 | 3.94 | 96.93 | 3.95 | 96.97 | 3.95 | 97.03 | 3.95 | 97.16 |
| 3136 | 3.87 | 97.03 | 3.87 | 97.06 | 3.87 | 97.12 | 3.88 | 97.25 |
| 3200 | 3.79 | 97.13 | 3.80 | 97.15 | 3.80 | 97.21 | 3.80 | 97.35 |
| 3264 | 3.72 | 97.22 | 3.72 | 97.26 | 3.73 | 97.31 | 3.73 | 97.44 |
| 3328 | 3.66 | 97.32 | 3.66 | 97.35 | 3.66 | 97.40 | 3.66 | 97.52 |
| 3392 | 3.59 | 97.40 | 3.59 | 97.43 | 3.59 | 97.49 | 3.60 | 97.60 |
| 3456 | 3.53 | 97.48 | 3.53 | 97.51 | 3.53 | 97.56 | 3.53 | 97.68 |
| 3520 | 3.46 | 97.56 | 3.47 | 97.60 | 3.47 | 97.65 | 3.47 | 97.75 |
| 3584 | 3.41 | 97.65 | 3.41 | 97.68 | 3.41 | 97.73 | 3.41 | 97.82 |
| 3648 | 3.35 | 97.72 | 3.35 | 97.75 | 3.35 | 97.80 | 3.35 | 97.88 |
| 3712 | 3.29 | 97.80 | 3.29 | 97.82 | 3.30 | 97.87 | 3.30 | 97.96 |
| 3776 | 3.24 | 97.86 | 3.24 | 97.89 | 3.24 | 97.94 | 3.24 | 98.02 |
| 3840 | 3.19 | 97.93 | 3.19 | 97.96 | 3.19 | 98.01 | 3.19 | 98.09 |
| 3904 | 3.14 | 98.00 | 3.14 | 98.03 | 3.14 | 98.07 | 3.14 | 98.15 |
| 3968 | 3.09 | 98.07 | 3.09 | 98.09 | 3.09 | 98.13 | 3.09 | 98.22 |
| 4032 | 3.04 | 98.12 | 3.04 | 98.15 | 3.04 | 98.19 | 3.05 | 98.27 |
| 4096 | 3.00 | 98.18 | 3.00 | 98.21 | 3.00 | 98.25 | 3.00 | 98.33 |

Table 7: DPDK Driver – CPM5 PF Forwarding performance test results

### QDMA Performance metrics on Gen3x16 Intel System

#### PF Performance

##### ST C2H Performance

Figure 9: DPDK Driver – CPM5 PF ST C2H performance in Gbps

Figure 10: DPDK Driver – CPM5 PF ST C2H performance in Mpps

##### ST H2C Performance

Figure 11: DPDK Driver – CPM5 PF ST H2C Performance in Gbps

**Figure 12: DPDK Driver – CPM5 PF ST H2C Performance in Mpps**

##### ST Forwarding Performance

Figure 13: DPDK Driver – CPM5 PF Forwarding performance in Gbps

Figure 14: DPDK Driver – CPM5 PF Forwarding performance in Mpps

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Packet Size (Bytes) | 8 queues | | 4 queues | | 2 queues | | 1 queue | |
| **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** |
| 64 | 94.87 | 48.57 | 95.09 | 48.69 | 71.43 | 36.57 | 35.71 | 18.29 |
| 128 | 64.61 | 66.16 | 64.45 | 66.00 | 62.50 | 64.00 | 31.25 | 32.00 |
| 192 | 48.32 | 74.22 | 48.30 | 74.18 | 48.61 | 74.67 | 27.78 | 42.67 |
| 256 | 38.79 | 79.45 | 38.76 | 79.39 | 38.76 | 79.38 | 25.00 | 51.20 |
| 320 | 31.25 | 80.00 | 31.25 | 80.00 | 31.25 | 80.00 | 22.73 | 58.18 |
| 384 | 27.69 | 85.08 | 27.70 | 85.08 | 27.78 | 85.33 | 20.83 | 64.00 |
| 448 | 24.29 | 87.04 | 24.28 | 87.01 | 24.27 | 86.99 | 19.23 | 68.92 |
| 512 | 21.45 | 87.84 | 21.44 | 87.81 | 21.52 | 88.14 | 17.86 | 73.14 |
| 576 | 19.32 | 89.03 | 19.32 | 89.03 | 19.30 | 88.91 | 16.67 | 76.80 |
| 640 | 17.53 | 89.75 | 17.52 | 89.73 | 17.51 | 89.67 | 15.62 | 80.00 |
| 704 | 16.07 | 90.50 | 16.06 | 90.47 | 16.04 | 90.34 | 14.71 | 82.82 |
| 768 | 14.82 | 91.08 | 14.82 | 91.05 | 14.78 | 90.83 | 13.89 | 85.33 |
| 832 | 13.74 | 91.44 | 13.74 | 91.44 | 13.73 | 91.41 | 13.16 | 87.58 |
| 896 | 12.86 | 92.17 | 12.86 | 92.16 | 12.85 | 92.12 | 12.50 | 89.60 |
| 960 | 12.08 | 92.75 | 12.07 | 92.72 | 12.07 | 92.71 | 11.90 | 91.43 |
| 1024 | 11.38 | 93.20 | 11.38 | 93.19 | 11.37 | 93.15 | 11.36 | 93.09 |
| 1088 | 10.76 | 93.64 | 10.76 | 93.64 | 10.76 | 93.62 | 10.75 | 93.53 |
| 1152 | 10.20 | 94.04 | 10.20 | 94.04 | 10.21 | 94.06 | 10.20 | 94.01 |
| 1216 | 9.71 | 94.43 | 9.71 | 94.41 | 9.70 | 94.41 | 9.71 | 94.41 |
| 1280 | 9.26 | 94.86 | 9.26 | 94.85 | 9.26 | 94.83 | 9.26 | 94.78 |
| 1344 | 8.85 | 95.16 | 8.85 | 95.15 | 8.85 | 95.14 | 8.83 | 94.97 |
| 1408 | 8.47 | 95.39 | 8.47 | 95.38 | 8.47 | 95.39 | 8.47 | 95.40 |
| 1472 | 8.12 | 95.67 | 8.12 | 95.66 | 8.12 | 95.65 | 8.13 | 95.68 |
| 1536 | 7.81 | 95.95 | 7.81 | 95.95 | 7.81 | 95.93 | 7.81 | 95.97 |
| 1600 | 7.51 | 96.19 | 7.51 | 96.19 | 7.51 | 96.18 | 7.51 | 96.17 |
| 1664 | 7.24 | 96.42 | 7.24 | 96.41 | 7.24 | 96.43 | 7.24 | 96.44 |
| 1728 | 6.99 | 96.62 | 6.99 | 96.61 | 6.99 | 96.61 | 6.99 | 96.63 |
| 1792 | 6.75 | 96.77 | 6.75 | 96.77 | 6.75 | 96.76 | 6.75 | 96.79 |
| 1856 | 6.52 | 96.86 | 6.53 | 97.03 | 6.52 | 96.86 | 6.52 | 96.86 |
| 1920 | 6.32 | 97.13 | 6.32 | 97.13 | 6.32 | 97.14 | 6.32 | 97.12 |
| 1984 | 6.13 | 97.30 | 6.13 | 97.29 | 6.13 | 97.28 | 6.13 | 97.28 |
| 2048 | 5.95 | 97.43 | 5.95 | 97.42 | 5.95 | 97.41 | 5.95 | 97.42 |
| 2112 | 5.64 | 95.31 | 5.64 | 95.31 | 5.64 | 95.27 | 5.63 | 95.08 |
| 2176 | 5.50 | 95.72 | 5.50 | 95.70 | 5.50 | 95.68 | 5.48 | 95.42 |
| 2240 | 5.37 | 96.21 | 5.37 | 96.18 | 5.37 | 96.18 | 5.35 | 95.85 |
| 2304 | 5.24 | 96.64 | 5.24 | 96.63 | 5.24 | 96.63 | 5.22 | 96.28 |
| 2368 | 5.07 | 96.05 | 5.07 | 96.05 | 5.07 | 96.01 | 5.05 | 95.74 |
| 2432 | 4.95 | 96.21 | 4.94 | 96.20 | 4.94 | 96.18 | 4.93 | 95.88 |
| 2496 | 4.83 | 96.37 | 4.83 | 96.35 | 4.82 | 96.34 | 4.81 | 96.03 |
| 2560 | 4.71 | 96.49 | 4.71 | 96.49 | 4.71 | 96.46 | 4.70 | 96.18 |
| 2624 | 4.60 | 96.62 | 4.60 | 96.62 | 4.60 | 96.60 | 4.59 | 96.32 |
| 2688 | 4.50 | 96.75 | 4.50 | 96.74 | 4.50 | 96.71 | 4.49 | 96.46 |
| 2752 | 4.40 | 96.90 | 4.40 | 96.88 | 4.40 | 96.88 | 4.39 | 96.60 |
| 2816 | 4.31 | 97.00 | 4.31 | 96.99 | 4.30 | 96.97 | 4.29 | 96.74 |
| 2880 | 4.21 | 97.10 | 4.21 | 97.09 | 4.21 | 97.07 | 4.20 | 96.86 |
| 2944 | 4.13 | 97.21 | 4.13 | 97.20 | 4.13 | 97.17 | 4.12 | 96.98 |
| 3008 | 4.04 | 97.32 | 4.04 | 97.29 | 4.04 | 97.28 | 4.03 | 97.08 |
| 3072 | 3.96 | 97.40 | 3.96 | 97.39 | 3.96 | 97.37 | 3.95 | 97.19 |
| 3136 | 3.89 | 97.49 | 3.89 | 97.48 | 3.88 | 97.46 | 3.88 | 97.30 |
| 3200 | 3.81 | 97.59 | 3.81 | 97.58 | 3.81 | 97.57 | 3.80 | 97.40 |
| 3264 | 3.74 | 97.69 | 3.74 | 97.67 | 3.74 | 97.66 | 3.73 | 97.48 |
| 3328 | 3.67 | 97.78 | 3.67 | 97.77 | 3.67 | 97.75 | 3.67 | 97.59 |
| 3392 | 3.61 | 97.85 | 3.61 | 97.85 | 3.61 | 97.83 | 3.60 | 97.67 |
| 3456 | 3.54 | 97.93 | 3.54 | 97.92 | 3.54 | 97.90 | 3.54 | 97.75 |
| 3520 | 3.48 | 98.01 | 3.48 | 97.99 | 3.48 | 97.99 | 3.47 | 97.82 |
| 3584 | 3.42 | 98.08 | 3.42 | 98.08 | 3.42 | 98.06 | 3.41 | 97.90 |
| 3648 | 3.36 | 98.15 | 3.36 | 98.14 | 3.36 | 98.12 | 3.36 | 97.97 |
| 3712 | 3.31 | 98.23 | 3.31 | 98.22 | 3.31 | 98.20 | 3.30 | 98.05 |
| 3776 | 3.25 | 98.29 | 3.25 | 98.27 | 3.25 | 98.27 | 3.25 | 98.10 |
| 3840 | 3.20 | 98.35 | 3.20 | 98.34 | 3.20 | 98.33 | 3.20 | 98.18 |
| 3904 | 3.15 | 98.40 | 3.15 | 98.40 | 3.15 | 98.38 | 3.15 | 98.24 |
| 3968 | 3.10 | 98.48 | 3.10 | 98.47 | 3.10 | 98.45 | 3.10 | 98.31 |
| 4032 | 3.05 | 98.54 | 3.05 | 98.52 | 3.05 | 98.52 | 3.05 | 98.36 |
| 4096 | 3.01 | 98.59 | 3.01 | 98.58 | 3.01 | 98.57 | 3.00 | 98.42 |

Table 8: DPDK Driver – CPM5 PF Forwarding performance test results

### QDMA Performance metrics on Gen5x8 AMD System

#### PF Performance

##### ST C2H Performance

Figure 15: DPDK Driver – CPM5 PF ST C2H performance in Gbps

Figure 16: DPDK Driver – CPM5 PF ST C2H performance in Mpps

##### ST H2C Performance

Figure 17: DPDK Driver – CPM5 PF ST H2C Performance in Gbps

Figure 18: DPDK Driver – CPM5 PF ST H2C Performance in Mpps

##### ST Forwarding Performance

Figure 19: DPDK Driver – CPM5 PF Forwarding performance in Gbps

Figure 20: DPDK Driver – CPM5 PF Forwarding performance in Mpps

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Packet Size (Bytes) | 8 queues | | 4 queues | | 2 queues | | 1 queue | |
| **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** | **Packet rate (Mpps)** | **Throughput (Gbps)** |
| 64 | 77.62 | 62.10 | 92.09 | 77.00 | 71.43 | 62.77 | 35.72 | 31.36 |
| 128 | 65.24 | 109.78 | 65.04 | 131.09 | 62.50 | 109.87 | 31.25 | 54.93 |
| 192 | 48.39 | 146.41 | 48.35 | 147.64 | 48.34 | 146.49 | 27.78 | 73.25 |
| 256 | 38.51 | 154.57 | 38.16 | 156.25 | 38.54 | 154.04 | 25.00 | 87.90 |
| 320 | 31.19 | 159.75 | 31.19 | 159.50 | 31.19 | 157.57 | 22.73 | 99.88 |
| 384 | 27.45 | 162.12 | 27.07 | 161.21 | 27.26 | 160.09 | 20.83 | 109.87 |
| 448 | 24.10 | 165.78 | 23.59 | 165.69 | 23.62 | 164.91 | 19.23 | 118.32 |
| 512 | 21.22 | 138.51 | 21.16 | 167.06 | 21.13 | 162.68 | 17.86 | 125.57 |
| 576 | 18.83 | 140.95 | 18.90 | 173.42 | 18.86 | 165.71 | 16.67 | 131.84 |
| 640 | 16.98 | 150.92 | 16.90 | 176.01 | 16.79 | 166.83 | 15.63 | 137.34 |
| 704 | 15.48 | 161.65 | 15.24 | 172.03 | 15.11 | 159.68 | 14.71 | 142.18 |
| 768 | 14.23 | 157.84 | 13.88 | 168.27 | 13.83 | 152.60 | 13.89 | 146.49 |
| 832 | 13.07 | 170.04 | 12.89 | 167.61 | 12.81 | 157.94 | 13.16 | 150.35 |
| 896 | 12.13 | 161.59 | 11.95 | 168.30 | 11.84 | 162.05 | 12.50 | 153.82 |
| 960 | 11.64 | 159.11 | 11.44 | 173.17 | 11.31 | 159.47 | 11.91 | 142.84 |
| 1024 | 11.20 | 160.71 | 11.01 | 178.25 | 10.86 | 161.33 | 11.36 | 99.86 |
| 1088 | 10.73 | 168.06 | 10.73 | 181.83 | 10.73 | 168.83 | 10.74 | 100.73 |
| 1152 | 10.18 | 175.35 | 10.18 | 185.17 | 10.14 | 176.23 | 10.19 | 104.60 |
| 1216 | 9.68 | 185.06 | 9.68 | 188.33 | 9.68 | 185.93 | 9.69 | 111.11 |
| 1280 | 9.23 | 189.35 | 9.23 | 189.41 | 9.24 | 189.44 | 9.24 | 118.75 |
| 1344 | 8.82 | 190.01 | 8.82 | 190.00 | 8.82 | 190.02 | 8.83 | 126.46 |
| 1408 | 8.45 | 190.62 | 8.45 | 190.62 | 8.45 | 190.61 | 8.45 | 133.56 |
| 1472 | 8.10 | 191.13 | 8.10 | 191.16 | 8.10 | 191.15 | 8.11 | 136.52 |
| 1536 | 7.79 | 191.62 | 7.79 | 191.63 | 7.79 | 191.65 | 7.79 | 138.64 |
| 1600 | 7.49 | 192.09 | 7.49 | 192.09 | 7.49 | 192.09 | 7.49 | 140.46 |
| 1664 | 7.22 | 192.50 | 7.22 | 192.50 | 7.22 | 192.50 | 7.22 | 143.82 |
| 1728 | 6.97 | 192.88 | 6.97 | 192.92 | 6.97 | 192.90 | 6.97 | 147.93 |
| 1792 | 6.73 | 193.24 | 6.73 | 193.25 | 6.73 | 193.26 | 6.73 | 153.79 |
| 1856 | 6.51 | 193.60 | 6.51 | 193.60 | 6.51 | 193.60 | 6.51 | 158.34 |
| 1920 | 6.31 | 193.93 | 6.31 | 193.94 | 6.31 | 193.92 | 6.31 | 163.66 |
| 1984 | 6.11 | 194.22 | 6.11 | 194.25 | 6.11 | 194.23 | 6.11 | 168.19 |
| 2048 | 5.93 | 194.51 | 5.93 | 194.53 | 5.93 | 194.54 | 5.93 | 172.45 |
| 2112 | 5.61 | 190.14 | 5.62 | 189.85 | 5.62 | 190.15 | 5.64 | 185.86 |
| 2176 | 5.45 | 190.31 | 5.46 | 190.02 | 5.46 | 190.34 | 5.47 | 186.71 |
| 2240 | 5.31 | 190.64 | 5.31 | 190.43 | 5.32 | 190.71 | 5.33 | 187.52 |
| 2304 | 5.17 | 191.05 | 5.17 | 190.77 | 5.18 | 191.08 | 5.19 | 188.28 |
| 2368 | 5.04 | 191.36 | 5.04 | 191.10 | 5.05 | 191.37 | 5.06 | 189.02 |
| 2432 | 4.92 | 191.66 | 4.92 | 191.40 | 4.92 | 191.68 | 4.93 | 189.71 |
| 2496 | 4.80 | 191.93 | 4.80 | 191.74 | 4.80 | 192.00 | 4.81 | 190.38 |
| 2560 | 4.69 | 192.26 | 4.69 | 192.01 | 4.69 | 192.30 | 4.70 | 191.01 |
| 2624 | 4.58 | 192.51 | 4.58 | 192.28 | 4.58 | 192.52 | 4.59 | 191.63 |
| 2688 | 4.47 | 192.76 | 4.48 | 192.53 | 4.48 | 192.78 | 4.49 | 192.21 |
| 2752 | 4.38 | 193.00 | 4.38 | 192.83 | 4.38 | 193.06 | 4.39 | 192.77 |
| 2816 | 4.28 | 193.27 | 4.29 | 193.05 | 4.29 | 193.30 | 4.29 | 193.31 |
| 2880 | 4.19 | 193.48 | 4.19 | 193.27 | 4.20 | 193.49 | 4.20 | 193.44 |
| 2944 | 4.11 | 193.72 | 4.11 | 193.50 | 4.11 | 193.73 | 4.12 | 194.18 |
| 3008 | 4.02 | 193.90 | 4.03 | 193.74 | 4.03 | 193.95 | 4.03 | 193.84 |
| 3072 | 3.94 | 194.14 | 3.95 | 193.93 | 3.95 | 194.16 | 3.95 | 194.60 |
| 3136 | 3.87 | 194.31 | 3.87 | 194.12 | 3.87 | 194.32 | 3.88 | 194.21 |
| 3200 | 3.79 | 194.51 | 3.80 | 194.32 | 3.80 | 194.52 | 3.80 | 194.92 |
| 3264 | 3.72 | 194.67 | 3.72 | 194.53 | 3.73 | 194.72 | 3.73 | 194.58 |
| 3328 | 3.66 | 194.88 | 3.66 | 194.69 | 3.66 | 194.91 | 3.66 | 195.27 |
| 3392 | 3.59 | 195.04 | 3.59 | 194.86 | 3.59 | 195.04 | 3.60 | 194.90 |
| 3456 | 3.53 | 195.21 | 3.53 | 195.03 | 3.53 | 195.22 | 3.53 | 195.55 |
| 3520 | 3.46 | 195.34 | 3.47 | 195.21 | 3.47 | 195.38 | 3.47 | 195.23 |
| 3584 | 3.41 | 195.52 | 3.41 | 195.35 | 3.41 | 195.55 | 3.41 | 195.87 |
| 3648 | 3.35 | 195.65 | 3.35 | 195.49 | 3.35 | 195.67 | 3.35 | 195.50 |
| 3712 | 3.29 | 195.81 | 3.29 | 195.64 | 3.30 | 195.82 | 3.30 | 196.12 |
| 3776 | 3.24 | 195.92 | 3.24 | 195.80 | 3.24 | 195.97 | 3.24 | 195.82 |
| 3840 | 3.19 | 196.08 | 3.19 | 195.92 | 3.19 | 196.11 | 3.19 | 196.40 |
| 3904 | 3.14 | 196.20 | 3.14 | 196.05 | 3.14 | 196.21 | 3.14 | 196.05 |
| 3968 | 3.09 | 196.34 | 3.09 | 196.19 | 3.09 | 196.36 | 3.09 | 196.62 |
| 4032 | 3.04 | 196.44 | 3.04 | 196.32 | 3.04 | 196.48 | 3.05 | 196.33 |
| 4096 | 3.00 | 196.59 | 3.00 | 196.43 | 3.00 | 196.60 | 3.00 | 196.88 |

Table 9: DPDK Driver – CPM5 PF Forwarding performance test results

## Summary

The QDMA IP provides many capabilities that allow for very high throughput and efficiency. At the same time however, there are factors that impact performance, such as packet size, DMA overhead, system latency, and settings such as MPS, MRRS, etc.

This report provides enough data to choose the number of queues needed to achieve optimal performance depending on the application.

Typically, networking applications optimize for small packet performance and so can use more queues to saturate the Ethernet interface, while compute or storage applications might optimize for 4KB performance and saturate with fewer queues. As the report suggests, more queues help achieve small packet performance, but the max number of queues cannot exceed the number of threads available for the application.

For the streaming mode this report suggests that 4 and more queues with prefetch enabled results in the high performance for different packet sizes.

For the memory mapped mode, the QDMA IP easily achieves the line rate with the typical 4K workload even with a single queue when using BRAM. If DDR is desired, more queues may be needed to obtain the best performance. This would highly depend on the memory configuration and the access pattern. For example, concurrent read and write to the same memory bank would greatly reduce the efficiency and should be avoided if possible.

The bi-directional performance should be expected to be lower than uni-directional H2C and C2H, because the PCIe RQ interface is shared.

In a multi-socket machine where NUMA is enabled, the latency for DMA reads can be prohibitively high, causing lower performance. Caution must be taken in the driver to avoid using the memory far away from the CPU core.

Based on knowledge of the application, it is possible to further reduce the DMA and TLP overheads to achieve better throughput than in the document.

# References

These documents provide supplemental material useful with this performance report.

* [Versal ACAP CPM DMA and Bridge Mode for PCI Express v2.1 - PG347](https://docs.xilinx.com/v/u/2.1-English/pg347-cpm-dma-bridge)
* [dpdk-pktgen application](http://git.dpdk.org/apps/pktgen-dpdk/tag/?h=pktgen-22.04.1)