

TKperf Test Report

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1 Setup Information

Tested Device:

- Western Digital CL SN720 NVMe SSD 256GB
- Firmware Version: 10103122

Used command line:

- `/usr/local/bin/tkperf ssd WDC_CL_SN720 /dev/nvme0n1 -rt 30 -nj 2 -iod 16 -rfb -i nvme -dsc WDC_CL_SN720.dsc`

Performance System:

- TKperf Version: 2.2
- Fio Version: fio-3.1
- Date of test run: 2019-12-12
- Number of jobs: 2
- Number of outstanding IOs (iodepth): 16

Operating System:

- Kernel Version: 4.15.0-72-generic
- `BOOT_IMAGE=/vmlinuz-4.15.0-72-generic root=/dev/mapper/ubuntu--vg-ubuntu--lv ro noibrs noibpb nopti nospectre_v2 nospectre_v1 l1tf=off nospec_store_bypass_disable no_stf_barrier mds=off mitigations=off`
- Description: Ubuntu 18.04.3 LTS

Notes:

- Motherboard: Supermicro X11DPi-N
- BIOS Version: 3.1
- CPU: Intel Xeon Gold 5120T, CPUID 0x50654, Microcode Revision=0x2000064

2 General Information

- *workloads*: The percentage of read operations in the random mixed workload. In the plots the term "100/00" means 100% read and 0% write, "95/5" 95% read and 5% write, and so on.
- *block sizes*: The block size of Fio to be used for IO operations.
- *measurement window*: Those rounds, where the dependence variable became stable.
- *dependence variable*: A specific type of test variable to determine the steady state.

2.1 Steady State

The Steady State is to determine if a test has reached a steady performance level. Each test has a different dependence variable to check if the state has already been reached. To check for the steady state the performance values of a test measurement window are taken (the last 5 rounds). The steady state is reached if:

- The maximum data excursion is less than 20% of the average in the measurement window.
- The slope of the linear best fit line is less than 10% of the average in the measurement window

If these two conditions are met the steady state has been reached for the specific dependence variable. Therefore the test can be stopped and the performance values of the measurement window can be taken for the measurement plots. If the steady state has not been reached after a maximum number of rounds the test can be stopped as well. The numbers for these two variables are:

- Measurement Window: 4
- Max. number of rounds: 25

3 IOPS

The IOPS test consists of looping over the following parameters:

```
Make Secure Erase
Workload Ind. Preconditioning
While not Steady State
  For workloads [100, 95, 65, 50, 35, 5, 0]
    For block sizes ['1024k', '128k', '64k', '32k', '16k', '8k', '4k', '512k']
```

Each combination of workload and block size is carried out for 60 seconds using direct IO. The average number of read and write IOPS is measured and summed up, therefore 56 values are the result of the two loops. After these loops are finished one test round has been carried out. To detect the steady state the IOPS of 4k random write are taken.

- Dependent Variable: 4k block size, random write

3.1 Steady State Information

Steady State has been reached:

- True

Steady State has been reached in rounds :

- deque([18, 19, 20, 21, 22])

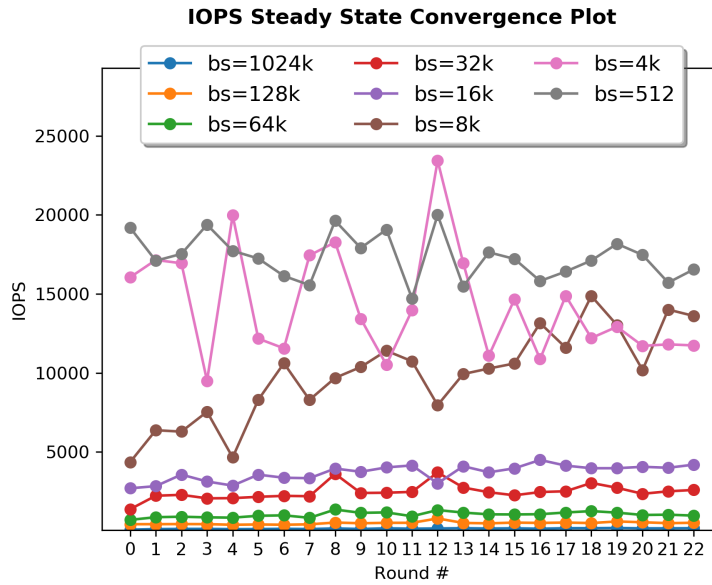
Values in stdy measurement window:

- deque([12207, 12920, 11712, 11806, 11740])

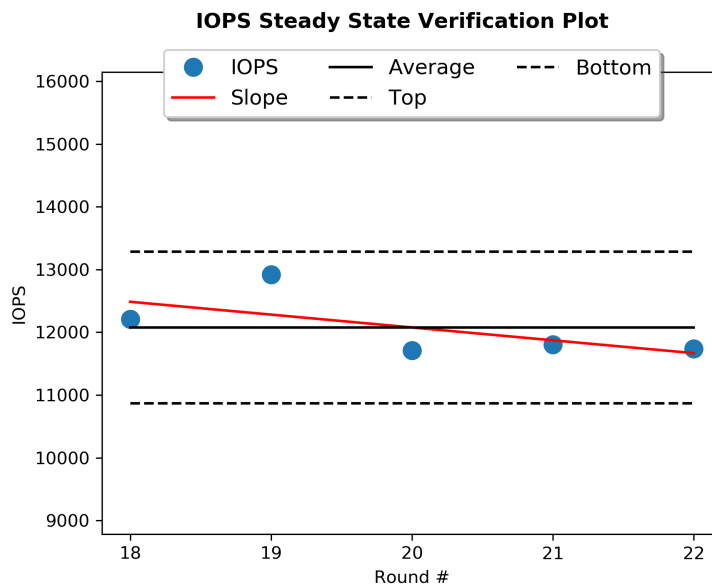
Average in stdy measurement window:

- 12077

3.2 Measurement Plots

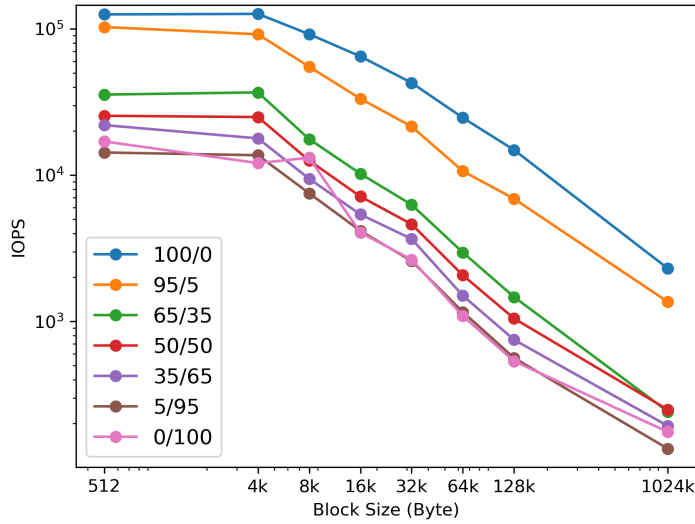


The Steady State Convergence Plot shows the reached IOPS for all block sizes of random writes over all rounds.



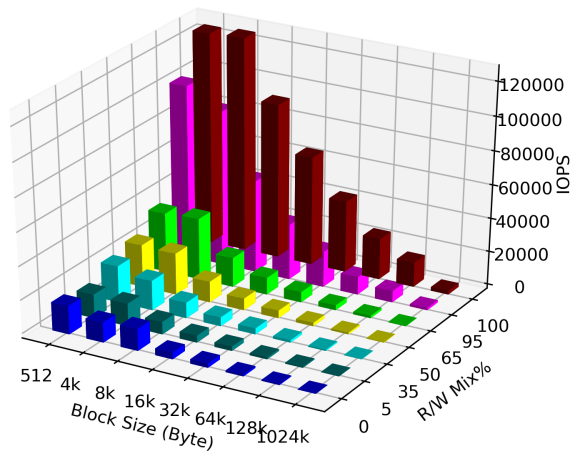
The Steady State Verification Plot shows the measured IOPS of 4k random writes, the 20% average window and the slope of the linear best fit line in the measurement window.

IOPS Measurement Plot



The Measurement Plot shows the average of IOPS in the measurement window. For every workload the IOPS of all block sizes are plotted.

IOPS 3D Measurement Plot



The Measurement 3D Plot shows the average of IOPS in the measurement window. For every workload the IOPS of all block sizes are plotted.

3.3 Measurement Window Summary Table

Average IOPS vs. Block Size and R/W Mix %

Block Size ↓	Wld. → 100/0	95/5	65/35	50/50	35/65	5/95	0/100
512	125489.0	102911.0	35511.0	25442.6	21976.6	14275.6	17001.6
4k	126545.4	91818.2	36761.6	24938.8	17826.0	13670.2	12077.0

8k	91937.8	55108.2	17630.4	12585.2	9443.2	7517.4	13137.6
16k	64824.4	33315.2	10218.0	7139.4	5381.8	4155.6	4039.8
32k	42741.4	21486.6	6270.6	4614.8	3660.8	2587.2	2646.4
64k	24647.8	10646.2	2957.2	2065.6	1498.6	1157.4	1087.2
128k	14844.0	6883.8	1467.6	1045.6	747.6	562.4	534.2
1024k	2299.6	1358.8	241.6	248.8	192.8	134.6	175.4

4 Throughput

The throughput test consists of looping over the following parameters:

```
For block sizes ['1024k', '64k', '8k', '4k', '512']
  Make Secure Erase
  While not Steady State
    Sequential read
    Sequential write
```

For each block size sequential read and write is carried out for 60 seconds using direct IO. The number of kilobytes for read and write is measured, therefore 2 values are the result of one round. To detect the steady state the throughput of 1024k sequential write is taken.

- Dependent Variable: 1024k block size, sequential write

4.1 Steady State Information

Steady State has been reached:

- True

Steady State has been reached in rounds :

- deque([1, 2, 3, 4, 5])

Values in stdy measurement window:

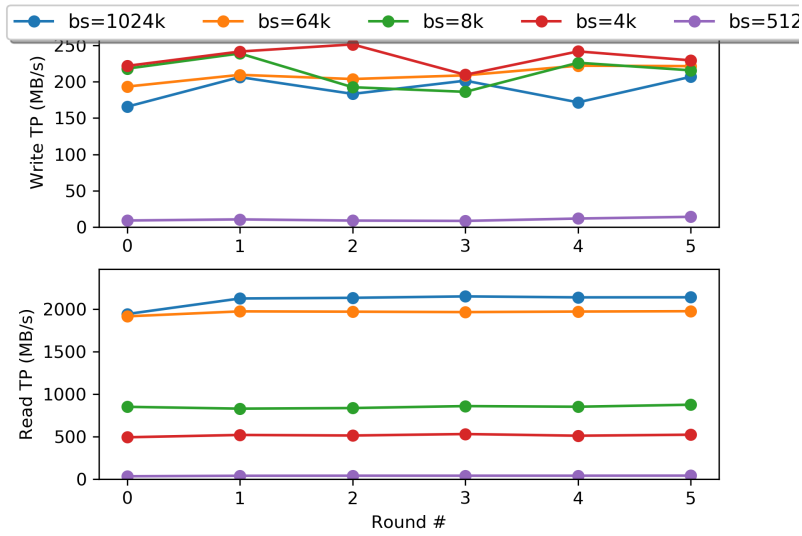
- deque([211428, 187733, 206387, 175822, 211849])

Average in stdy measurement window:

- 198643

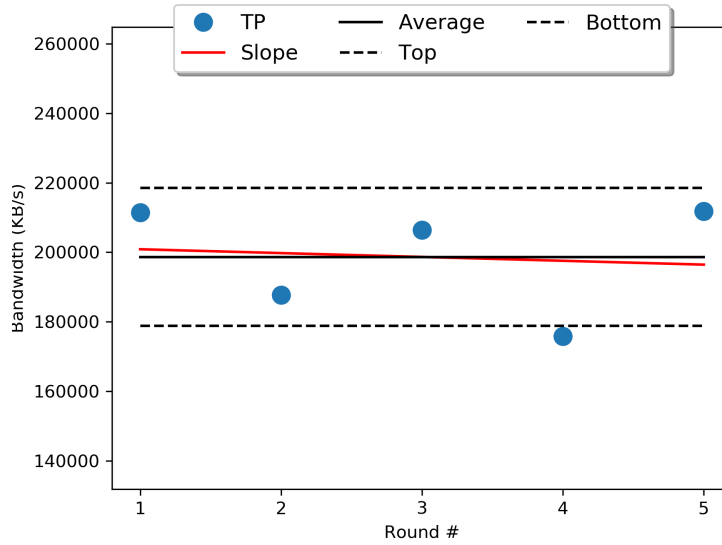
4.2 Measurement Plots

TP R/W Steady State Convergence Plot

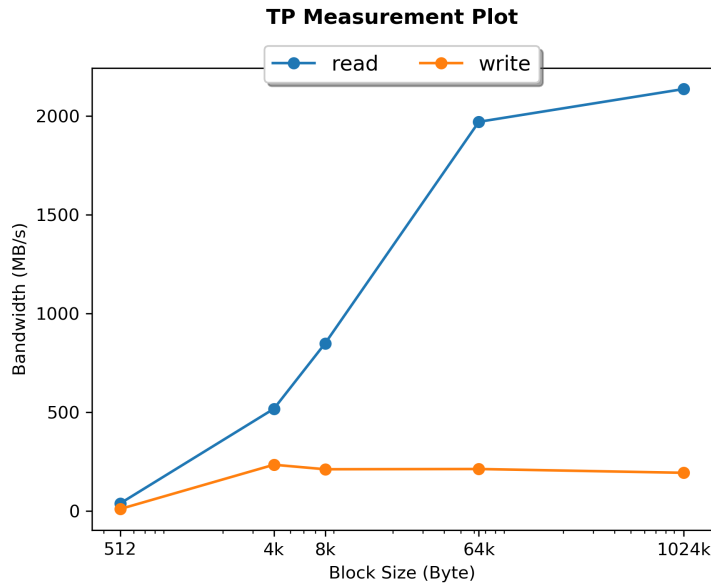


The Read/Write Steady State Convergence Plot shows the bandwidth for all block sizes of seq. reads over all rounds. On the top the write throughput is plotted, below the throughput for read.

TP Steady State Verification Plot



The Steady State Verification Plot shows the bandwidth of 1024k seq. writes, the 20% average window and the slope of the linear best fit line in the measurement window.



The Measurement Plot shows the average bandwidth of reads and writes in the measurement window. For all block sizes the seq. read and write bandwidth is plotted.

4.3 Measurement Window Summary Table

Average MB/s vs. Block Size and R/W

Block Size ↓	Read	Write
1024k	2137.501	193.988
64k	1971.361	213.219
8k	849.629	211.958
4k	518.3	234.859
512	39.044	10.687

5 Latency

The latency test consists of looping over the following parameters:

```

Make Secure Erase
Workload Ind. Preconditioning
While not Steady State
    For workloads [100, 65, 0]
        For block sizes ['8k', '4k', '512']

```

For all block sizes random read, a 65/35 read/write mixed workload and random write is carried out for 60 seconds using direct IO. For every combination the Min, Max and Mean Latency is measured. After these loops are finished one test round has been carried out. To detect the steady state the mean latency of 4k random write is taken.

- Dependent Variable: 4k block size, random write mean latency

5.1 Steady State Information

Steady State has been reached:

- True

Steady State has been reached in rounds :

- deque([1, 2, 3, 4, 5])

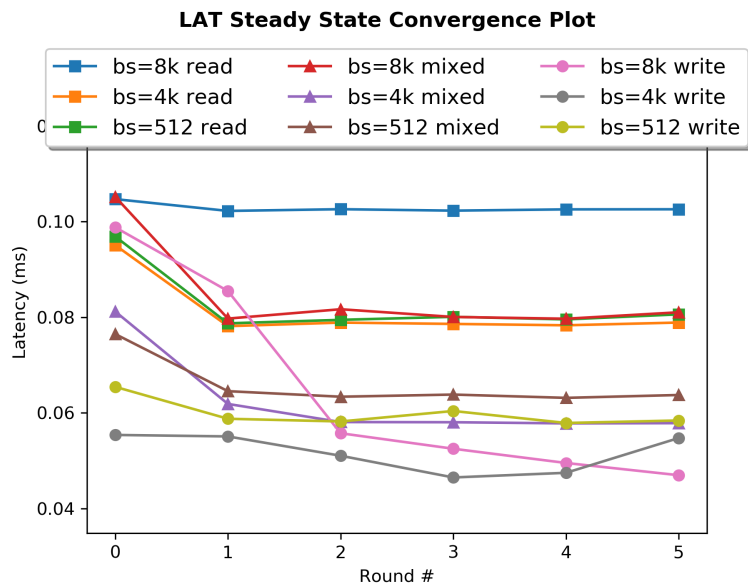
Values in stdy measurement window:

- deque([55.05859, 51.016463, 46.472058, 47.450451, 54.728707])

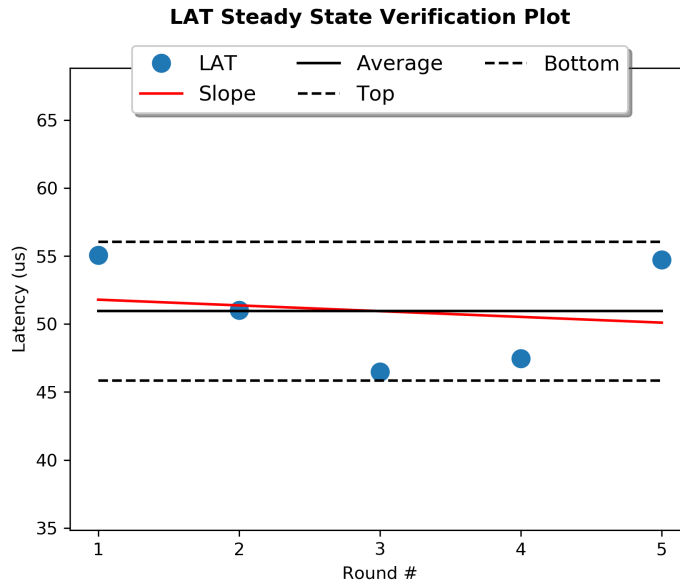
Average in stdy measurement window:

- 50.9452538

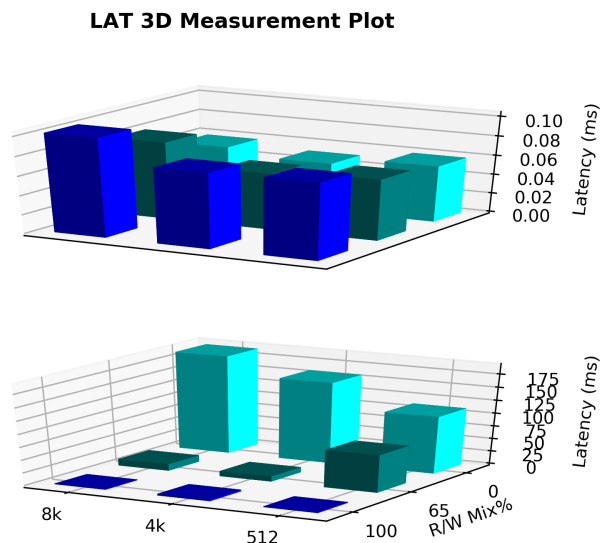
5.2 Measurement Plots



The Steady State Convergence Plot shows the mean latency for all block sizes of random read, mixed workload and write.



The Steady State Verification Plot shows the mean latency of 4k random writes, the 20% average window and the slope of the linear best fit line in the measurement window.



The Latency Measurement 3D Plot shows the average latency on top and the max latency below it. For the measurement window every workload including all block sizes is plotted.

5.3 Measurement Window Summary Table

Average Latency (ms) vs. Block Size and R/W Mix %

Block Size ↓	Wld. → 0/100	65/35	100/0
8k	0.058	0.08	0.102

4k	0.051	0.059	0.079
512	0.059	0.064	0.08

Max Latency (ms) vs. Block Size and R/W Mix %

Block Size ↓	Wld. → 0/100	65/35	100/0
8k	190.45	13.025	1.288
4k	157.873	10.197	3.196
512	111.916	73.752	1.557

6 Write Saturation

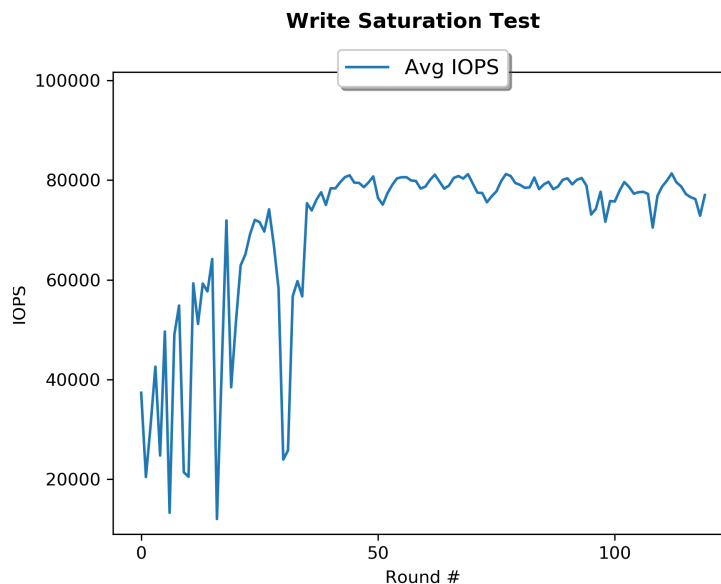
The write saturation test consists of looping over the following parameters:

```
Make Secure Erase
While not written 4x User Capacity or 24h
    Carry out random write, 4k block size for 1 minute.
```

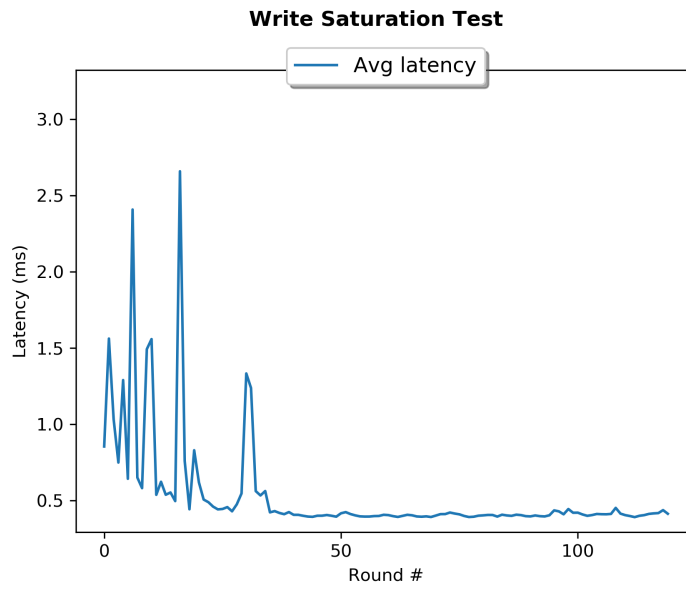
For 4k block size random write is carried out for 60 seconds using direct IO. For each round (60 second window) the write IOPS and latencies are measured. Also the total written IO is measured to check if 4x capacity has been written.

As no steady state detection is necessary there is no dependence variable.

6.1 Measurement Plots



The Write Saturation IOPS Plot shows the average IOPS of 4k random writes over all rounds.



The Write Saturation Latency Plot shows the mean latency of 4k random writes over all rounds.