Nested Virtualization Benchmarks

Disk benchmark tests

fio simple write test

```
fio --name=sequential_write --rw=write --bs=1M --size=10G --filename=/root/testfile --direct=1
```

fio random read job file

```
[global]
ioengine=libaio
direct=1
group_reporting
runtime=60
time_based

[random_read_job]
rw=randread
bs=4k
iodepth=64
filename=/root/testfile
size=10G
```

fio sequential read job file

```
[global]
ioengine=libaio
direct=1
group_reporting
runtime=60
time_based
```

```
[random_read_job]
rw=read
bs=4k
iodepth=64
filename=/root/testfile
size=10G
```

BASH code to generate lots of different commands

```
for fio_sync in 0 1; do
    for fio_bs in 4KB 16KB 1MB; do
        for fio_rw in read write randwrite randread; do
            echo "fio --name=${fio_rw}_${fio_bs}_${fio_sync} --size=16g --bs=$fio_bs --
rw=$fio_rw --ioengine=libaio --sync=$fio_sync --iodepth=32 --numjobs=1 --direct=1 --
end_fsync=1 --gtod_reduce=1 --time_based --runtime=60"
        done
    done
done
```

Hardware: DELL Latitude 5520 (Laptop)

CPU: 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
Disk: 2 x 256GB
Filesystem: ZFS Raid-1 Mirror

PVE benchmark

```
# Disk information
root@pve:~# smartctl -a /dev/nvme0n1
Model Number:                       Micron 2450 NVMe 256GB
Temperature:                        43 Celsius
Percentage Used:                    15%

root@pve:~# smartctl -a /dev/nvme1n1
Model Number:                       PC SN520 NVMe WDC 256GB
Temperature:                        45 Celsius
```

```
Percentage Used:                    28%



# CPU Information
root@pve:~# cat /proc/cpuinfo | grep "model name"
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
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model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz



# Benchmark - write
root@pve:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --filename=testfile --
direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=60.1MiB/s][w=60 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1838716: Mon Aug 11 13:47:12 2025
  write: IOPS=64, BW=64.1MiB/s (67.2MB/s)(10.0GiB/159737msec); 0 zone resets
    clat (usec): min=1521, max=2857.4k, avg=15554.55, stdev=30350.48
     lat (usec): min=1564, max=2857.4k, avg=15595.47, stdev=30349.98
    clat percentiles (msec):
     |  1.00th=[    3],  5.00th=[    3], 10.00th=[    3], 20.00th=[   15],
     | 30.00th=[   15], 40.00th=[   16], 50.00th=[   17], 60.00th=[   17],
     | 70.00th=[   18], 80.00th=[   18], 90.00th=[   20], 95.00th=[   22],
     | 99.00th=[   32], 99.50th=[   37], 99.90th=[  110], 99.95th=[  226],
     | 99.99th=[  760]
   bw (  KiB/s): min= 4096, max=448512, per=100.00%, avg=66923.14, stdev=44636.99, samples=313
   iops        : min=    4, max=  438, avg=65.35, stdev=43.59, samples=313
  lat (msec)   : 2=0.50%, 4=12.31%, 10=1.23%, 20=77.88%, 50=7.84%
  lat (msec)   : 100=0.13%, 250=0.07%, 500=0.02%, 1000=0.01%, >=2000=0.01%
```

```
  cpu          : usr=0.34%, sys=13.49%, ctx=11028, majf=5, minf=10
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=64.1MiB/s (67.2MB/s), 64.1MiB/s-64.1MiB/s (67.2MB/s-67.2MB/s), io=10.0GiB
(10.7GB), run=159737-159737msec




# Benchmark - read
root@pve:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=10.3MiB/s][r=2626 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1841119: Mon Aug 11 13:54:44 2025
  read: IOPS=2638, BW=10.3MiB/s (10.8MB/s)(618MiB/60001msec)
    slat (usec): min=167, max=6793, avg=377.03, stdev=155.55
    clat (nsec): min=1728, max=36276k, avg=23873354.46, stdev=1833473.80
     lat (usec): min=458, max=36588, avg=24250.38, stdev=1850.88
    clat percentiles (usec):
     |  1.00th=[20579],  5.00th=[21627], 10.00th=[21890], 20.00th=[22414],
     | 30.00th=[22938], 40.00th=[23200], 50.00th=[23725], 60.00th=[23987],
     | 70.00th=[24511], 80.00th=[25035], 90.00th=[26084], 95.00th=[27132],
     | 99.00th=[29754], 99.50th=[31065], 99.90th=[33162], 99.95th=[33817],
     | 99.99th=[34866]
   bw (  KiB/s): min= 7944, max=11024, per=100.00%, avg=10553.40, stdev=363.11, samples=120
   iops        : min= 1986, max= 2756, avg=2638.35, stdev=90.78, samples=120
  lat (usec)   : 2=0.01%, 500=0.01%, 750=0.01%
  lat (msec)   : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.65%, 50=99.33%
  cpu          : usr=0.64%, sys=6.66%, ctx=158463, majf=0, minf=72
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=158301,0,0,0 short=0,0,0,0 dropped=0,0,0,0
```

```
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=10.3MiB/s (10.8MB/s), 10.3MiB/s-10.3MiB/s (10.8MB/s-10.8MB/s), io=618MiB (648MB),
run=60001-60001msec
```

Nested VM Benchmark

Ubuntu 24.04

```
root@nested-vm-l2:~$ cat /proc/cpuinfo | grep "model name"
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz

root@nested-vm-l2:~$ fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][97.1%][w=178MiB/s][w=177 IOPS][eta 00m:08s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1820: Mon Aug 11 18:43:38 2025
  write: IOPS=37, BW=37.9MiB/s (39.8MB/s)(10.0GiB/269886msec); 0 zone resets
    clat (nsec): min=0, max=44001M, avg=26294437.47, stdev=800866646.25
     lat (nsec): min=0, max=44001M, avg=26331483.73, stdev=800866317.34
    clat percentiles (usec):
     |  1.00th=[    1270],  5.00th=[    1385], 10.00th=[    1434],
     | 20.00th=[    1516], 30.00th=[    1582], 40.00th=[    1647],
     | 50.00th=[    1745], 60.00th=[    1860], 70.00th=[    2057],
     | 80.00th=[    2606], 90.00th=[    4293], 95.00th=[    5997],
     | 99.00th=[   11600], 99.50th=[   13960], 99.90th=[  826278],
     | 99.95th=[17112761], 99.99th=[17112761]
   bw (  KiB/s): min= 2043, max=610304, per=100.00%, avg=332192.42, stdev=168523.35,
samples=62
   iops        : min=    1, max=  596, avg=324.08, stdev=164.57, samples=62
  lat (nsec)   : 2=0.26%
  lat (usec)   : 20=0.01%, 100=0.01%, 500=0.03%, 750=0.03%, 1000=0.02%
  lat (msec)   : 2=67.67%, 4=20.74%, 10=9.56%, 20=1.42%, 50=0.10%
  lat (msec)   : 100=0.04%, 250=0.01%, 1000=0.01%, >=2000=0.10%
```

```
  cpu          : usr=0.23%, sys=1.18%, ctx=10245, majf=0, minf=16
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=37.9MiB/s (39.8MB/s), 37.9MiB/s-37.9MiB/s (39.8MB/s-39.8MB/s), io=10.0GiB
(10.7GB), run=269886-269886msec

Disk stats (read/write):
  sda: ios=3017/10737, sectors=75792/21008312, merge=253/833, ticks=3237/526767,
in_queue=686667, util=96.37%




# Benchmark - read
root@nested-vm-l2:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
random_read_job: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [r(1)][100.0%][r=20.0MiB/s][r=5112 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=3300: Mon Aug 11 19:02:19 2025
  read: IOPS=4748, BW=18.5MiB/s (19.4MB/s)(1113MiB/60004msec)
    slat (nsec): min=0, max=13840k, avg=116055.33, stdev=350395.40
    clat (usec): min=2917, max=48588, avg=13307.65, stdev=5035.71
     lat (usec): min=2958, max=48739, avg=13423.70, stdev=5063.84
    clat percentiles (usec):
     |  1.00th=[ 5735],  5.00th=[ 6980], 10.00th=[ 7832], 20.00th=[ 8848],
     | 30.00th=[ 9896], 40.00th=[10945], 50.00th=[12125], 60.00th=[13566],
     | 70.00th=[15533], 80.00th=[17695], 90.00th=[20317], 95.00th=[22938],
     | 99.00th=[27657], 99.50th=[29754], 99.90th=[33817], 99.95th=[35390],
     | 99.99th=[39584]
   bw (  KiB/s): min=12645, max=34142, per=100.00%, avg=19000.53, stdev=4050.47, samples=119
   iops        : min= 3161, max= 8535, avg=4749.84, stdev=1012.64, samples=119
  lat (msec)   : 4=0.01%, 10=30.78%, 20=58.31%, 50=10.90%
  cpu          : usr=3.98%, sys=90.23%, ctx=2410, majf=0, minf=74
```

```
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=284908,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=18.5MiB/s (19.4MB/s), 18.5MiB/s-18.5MiB/s (19.4MB/s-19.4MB/s), io=1113MiB
(1167MB), run=60004-60004msec

Disk stats (read/write):
  sda: ios=283830/8, sectors=2270640/72, merge=0/1, ticks=1580398/232, in_queue=1580794,
util=49.28%
```

Hardware: HPE

PVE - Mirrored 15K SAS

```
# CPU
root@btr-pve-c9ne1:~# grep "model name" /proc/cpuinfo
model name      : Intel(R) Xeon(R) CPU E5-2687W v4 @ 3.00GHz
# 2 Sockets, 24 Cores per socket, 48 total cores

# DISK: ZFS Mirrored HP EH0300JDYTH 15k SAS




# Benchmark - write

root@pve-hpe:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=100MiB/s][w=100 IOPS][eta 00m:00s]
```

```
sequential_write: (groupid=0, jobs=1): err= 0: pid=1156898: Mon Aug 11 14:02:36 2025
  write: IOPS=93, BW=93.5MiB/s (98.0MB/s)(10.0GiB/109530msec); 0 zone resets
    clat (usec): min=8364, max=80908, avg=10618.01, stdev=3390.34
     lat (usec): min=8507, max=80994, avg=10691.62, stdev=3390.64
    clat percentiles (usec):
     |  1.00th=[ 8717],  5.00th=[ 8848], 10.00th=[ 8848], 20.00th=[ 8979],
     | 30.00th=[ 9110], 40.00th=[ 9503], 50.00th=[10028], 60.00th=[10552],
     | 70.00th=[11076], 80.00th=[11469], 90.00th=[11863], 95.00th=[13042],
     | 99.00th=[25035], 99.50th=[32113], 99.90th=[53216], 99.95th=[57934],
     | 99.99th=[80217]
   bw (  KiB/s): min=51200, max=104448, per=100.00%, avg=95758.09, stdev=11129.23, samples=218
   iops        : min=   50, max=  102, avg=93.51, stdev=10.87, samples=218
  lat (msec)   : 10=50.61%, 20=47.46%, 50=1.81%, 100=0.13%
  cpu          : usr=0.74%, sys=65.95%, ctx=10420, majf=5, minf=8
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=93.5MiB/s (98.0MB/s), 93.5MiB/s-93.5MiB/s (98.0MB/s-98.0MB/s), io=10.0GiB
(10.7GB), run=109530-109530msec



# Benchmark - read

root@pve-hpe:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=820KiB/s][r=205 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1159109: Mon Aug 11 14:09:42 2025
  read: IOPS=217, BW=871KiB/s (892kB/s)(51.0MiB/60001msec)
    slat (usec): min=462, max=40890, avg=4580.11, stdev=1975.13
    clat (usec): min=13, max=531922, avg=288716.77, stdev=40807.24
     lat (msec): min=6, max=535, avg=293.30, stdev=41.16
    clat percentiles (msec):
```

```
     |  1.00th=[  251],  5.00th=[  262], 10.00th=[  266], 20.00th=[  271],
     | 30.00th=[  271], 40.00th=[  275], 50.00th=[  279], 60.00th=[  284],
     | 70.00th=[  288], 80.00th=[  292], 90.00th=[  313], 95.00th=[  393],
     | 99.00th=[  460], 99.50th=[  481], 99.90th=[  527], 99.95th=[  531],
     | 99.99th=[  531]
   bw (  KiB/s): min=  376, max= 1112, per=99.92%, avg=870.73, stdev=99.13, samples=120
   iops        : min=   94, max=  278, avg=217.68, stdev=24.78, samples=120
  lat (usec)   : 20=0.01%
  lat (msec)   : 10=0.01%, 20=0.02%, 50=0.05%, 100=0.09%, 250=0.54%
  lat (msec)   : 500=98.97%, 750=0.32%
  cpu          : usr=0.33%, sys=3.76%, ctx=13070, majf=0, minf=408
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.2%, >=64=99.5%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=13061,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=871KiB/s (892kB/s), 871KiB/s-871KiB/s (892kB/s-892kB/s), io=51.0MiB (53.5MB),
run=60001-60001msec
```

PVE - RAIDz3: 10 x 7200 rpm (MM1000GBKAL)

```
root@pve:/z-7200-SATA-Rz3# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=37.0MiB/s][w=37 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1546695: Tue Aug 12 10:18:08 2025
  write: IOPS=54, BW=55.0MiB/s (57.6MB/s)(10.0GiB/186319msec); 0 zone resets
    clat (msec): min=9, max=206, avg=18.11, stdev=10.06
     lat (msec): min=9, max=206, avg=18.19, stdev=10.06
    clat percentiles (msec):
     |  1.00th=[   14],  5.00th=[   15], 10.00th=[   16], 20.00th=[   16],
     | 30.00th=[   17], 40.00th=[   17], 50.00th=[   17], 60.00th=[   17],
     | 70.00th=[   17], 80.00th=[   18], 90.00th=[   18], 95.00th=[   21],
```

```
     | 99.00th=[   77], 99.50th=[   93], 99.90th=[  127], 99.95th=[  134],
     | 99.99th=[  159]
   bw (  KiB/s): min=12288, max=67584, per=100.00%, avg=56300.17, stdev=11089.88, samples=372
   iops        : min=   12, max=   66, avg=54.98, stdev=10.83, samples=372
  lat (msec)   : 10=0.03%, 20=94.98%, 50=2.80%, 100=1.90%, 250=0.28%
  cpu          : usr=0.47%, sys=46.47%, ctx=11448, majf=0, minf=9
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=55.0MiB/s (57.6MB/s), 55.0MiB/s-55.0MiB/s (57.6MB/s-57.6MB/s), io=10.0GiB
(10.7GB), run=186319-186319msec



root@pve:/z-7200-SATA-Rz3# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=436KiB/s][r=109 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1578323: Tue Aug 12 10:46:14 2025
  read: IOPS=105, BW=421KiB/s (431kB/s)(24.7MiB/60008msec)
    slat (usec): min=519, max=100246, avg=9492.20, stdev=4271.24
    clat (usec): min=14, max=1314.5k, avg=595573.00, stdev=91957.69
     lat (msec): min=8, max=1323, avg=605.07, stdev=92.62
    clat percentiles (msec):
     |  1.00th=[  550],  5.00th=[  558], 10.00th=[  567], 20.00th=[  567],
     | 30.00th=[  575], 40.00th=[  575], 50.00th=[  575], 60.00th=[  584],
     | 70.00th=[  584], 80.00th=[  592], 90.00th=[  617], 95.00th=[  793],
     | 99.00th=[  927], 99.50th=[ 1301], 99.90th=[ 1318], 99.95th=[ 1318],
     | 99.99th=[ 1318]
   bw (  KiB/s): min=  112, max=  944, per=100.00%, avg=424.40, stdev=73.04, samples=119
   iops        : min=   28, max=  236, avg=106.10, stdev=18.26, samples=119
  lat (usec)   : 20=0.02%
  lat (msec)   : 10=0.02%, 20=0.02%, 50=0.05%, 100=0.08%, 250=0.27%
  lat (msec)   : 500=0.44%, 750=92.46%, 1000=5.69%, 2000=0.97%
```

```
  cpu          : usr=0.16%, sys=2.54%, ctx=6315, majf=0, minf=82
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.3%, 32=0.5%, >=64=99.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=6313,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=421KiB/s (431kB/s), 421KiB/s-421KiB/s (431kB/s-431kB/s), io=24.7MiB (25.9MB),
run=60008-60008msec
```

PVE - draid3:6d:10c:1s-0: 10 x 10k SAS (EG1200JEMDA)

```
root@pve:/# cd z-10K-SAS-dRAID3/
root@pve:/z-10K-SAS-dRAID3# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=98.0MiB/s][w=98 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1550993: Tue Aug 12 10:20:41 2025
  write: IOPS=90, BW=90.8MiB/s (95.2MB/s)(10.0GiB/112818msec); 0 zone resets
    clat (usec): min=7765, max=67166, avg=10939.46, stdev=3638.62
     lat (usec): min=7858, max=67210, avg=11012.52, stdev=3639.09
    clat percentiles (usec):
     |  1.00th=[ 8160],  5.00th=[ 8356], 10.00th=[ 8455], 20.00th=[ 8979],
     | 30.00th=[ 9503], 40.00th=[10028], 50.00th=[10552], 60.00th=[10945],
     | 70.00th=[11469], 80.00th=[11863], 90.00th=[12125], 95.00th=[12387],
     | 99.00th=[28705], 99.50th=[36439], 99.90th=[49021], 99.95th=[56361],
     | 99.99th=[64226]
   bw (  KiB/s): min=45056, max=112640, per=100.00%, avg=93088.43, stdev=12260.36, samples=225
   iops        : min=   44, max=  110, avg=90.91, stdev=11.97, samples=225
  lat (msec)   : 10=39.64%, 20=57.95%, 50=2.31%, 100=0.10%
  cpu          : usr=0.76%, sys=65.33%, ctx=10540, majf=0, minf=7
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
```

```
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=90.8MiB/s (95.2MB/s), 90.8MiB/s-90.8MiB/s (95.2MB/s-95.2MB/s), io=10.0GiB
(10.7GB), run=112818-112818msec



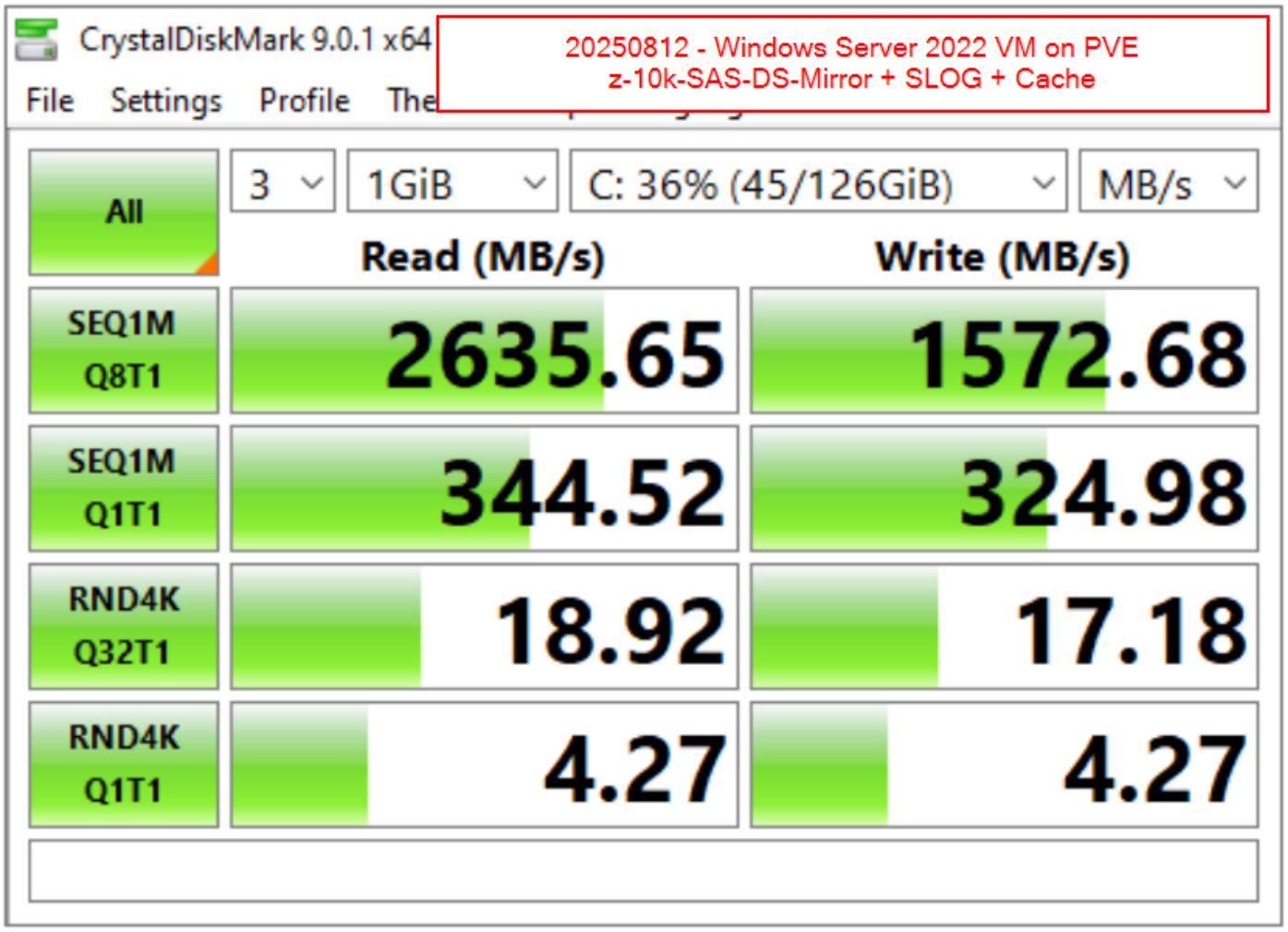
root@pve:/z-10K-SAS-dRAID3# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
random_read_job: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [r(1)][100.0%][r=576KiB/s][r=144 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1580837: Tue Aug 12 10:48:22 2025
  read: IOPS=163, BW=655KiB/s (671kB/s)(38.4MiB/60004msec)
    slat (usec): min=13, max=39844, avg=6090.61, stdev=2135.90
    clat (usec): min=12, max=523484, avg=383170.17, stdev=33200.56
     lat (msec): min=6, max=529, avg=389.26, stdev=33.38
    clat percentiles (msec):
     |  1.00th=[  338],  5.00th=[  355], 10.00th=[  363], 20.00th=[  368],
     | 30.00th=[  372], 40.00th=[  376], 50.00th=[  380], 60.00th=[  384],
     | 70.00th=[  388], 80.00th=[  393], 90.00th=[  401], 95.00th=[  409],
     | 99.00th=[  510], 99.50th=[  514], 99.90th=[  523], 99.95th=[  523],
     | 99.99th=[  523]
   bw (  KiB/s): min=  112, max= 1104, per=99.95%, avg=655.40, stdev=75.42, samples=120
   iops        : min=   28, max=  276, avg=163.85, stdev=18.85, samples=120
  lat (usec)   : 20=0.01%
  lat (msec)   : 10=0.01%, 20=0.01%, 50=0.05%, 100=0.08%, 250=0.23%
  lat (msec)   : 500=97.36%, 750=2.25%
  cpu          : usr=0.22%, sys=3.94%, ctx=9518, majf=0, minf=256
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.2%, 32=0.3%, >=64=99.4%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=9831,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

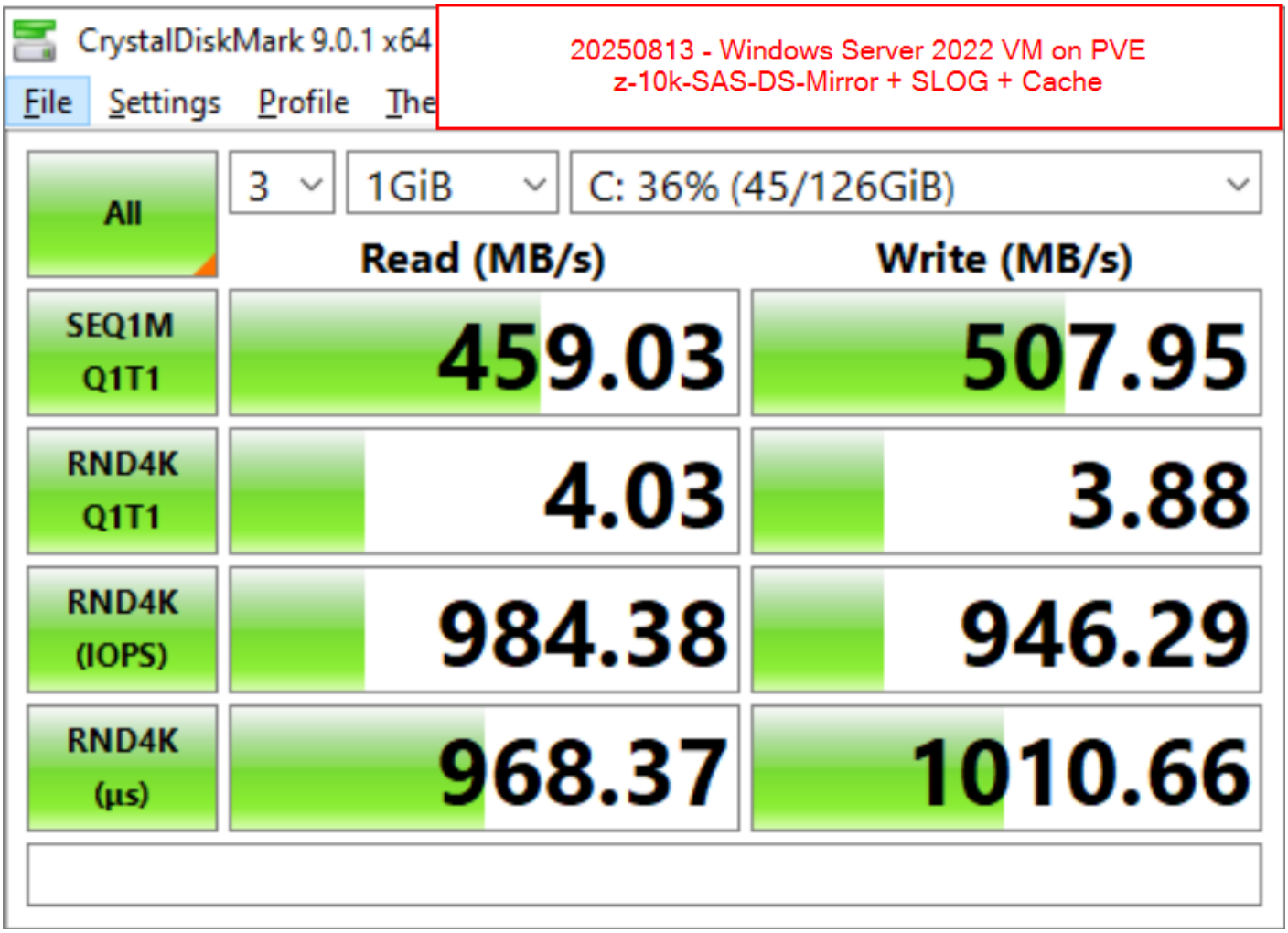
Run status group 0 (all jobs):
   READ: bw=655KiB/s (671kB/s), 655KiB/s-655KiB/s (671kB/s-671kB/s), io=38.4MiB (40.3MB),
```

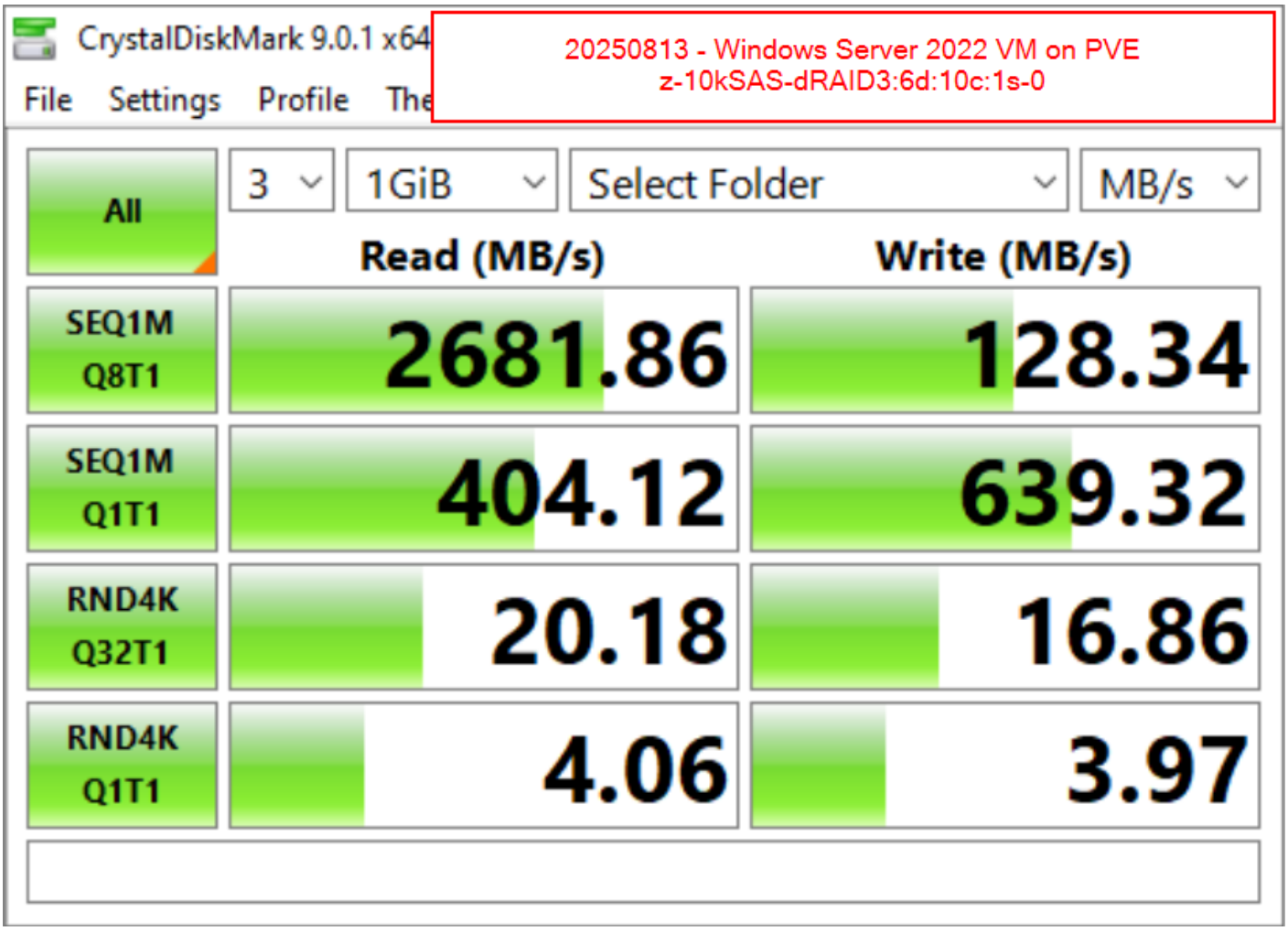
```
run=60004-60004msec
```

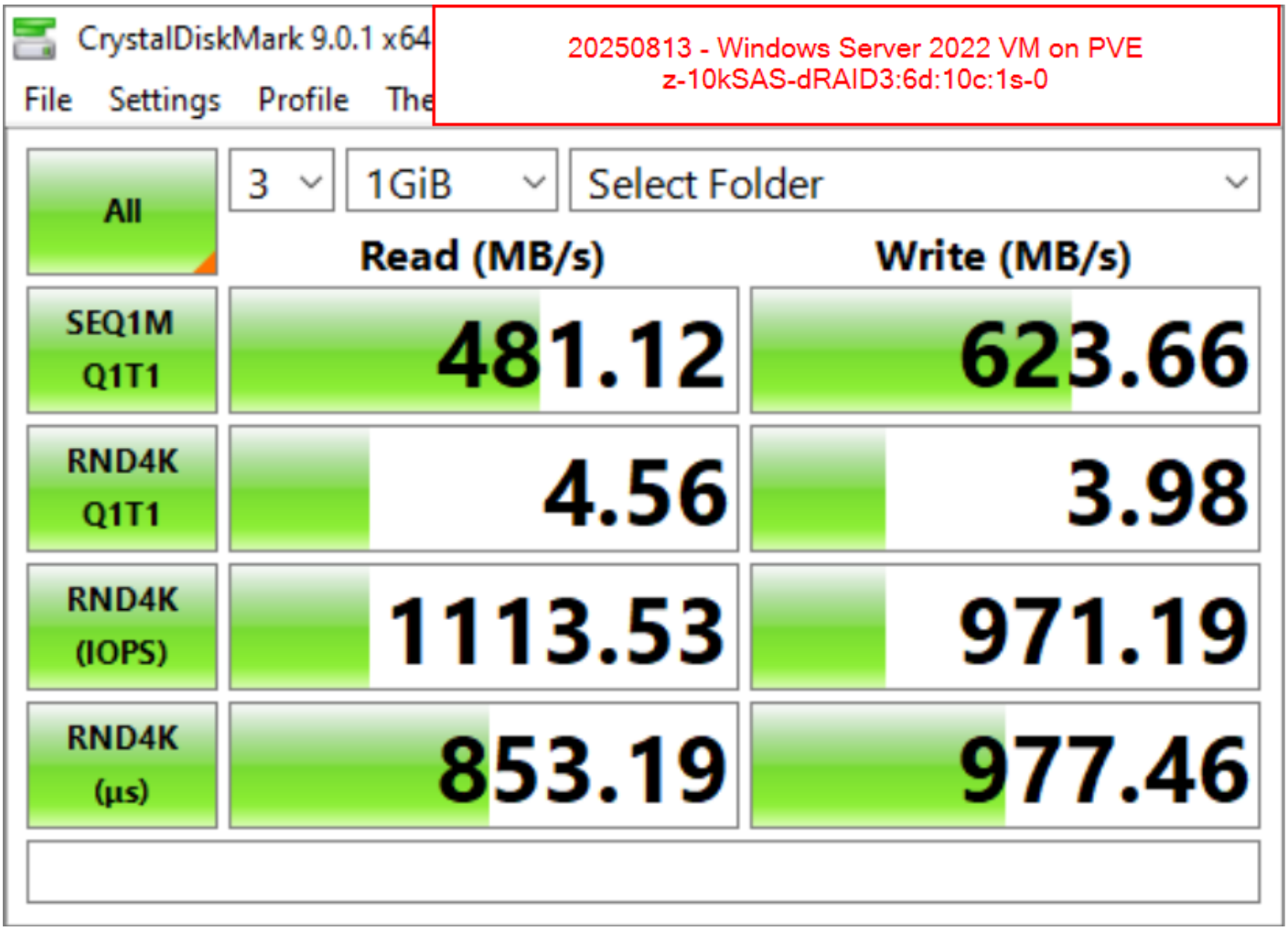
PVE - ZFS Mirror + SLOG + L2ARC (cache)

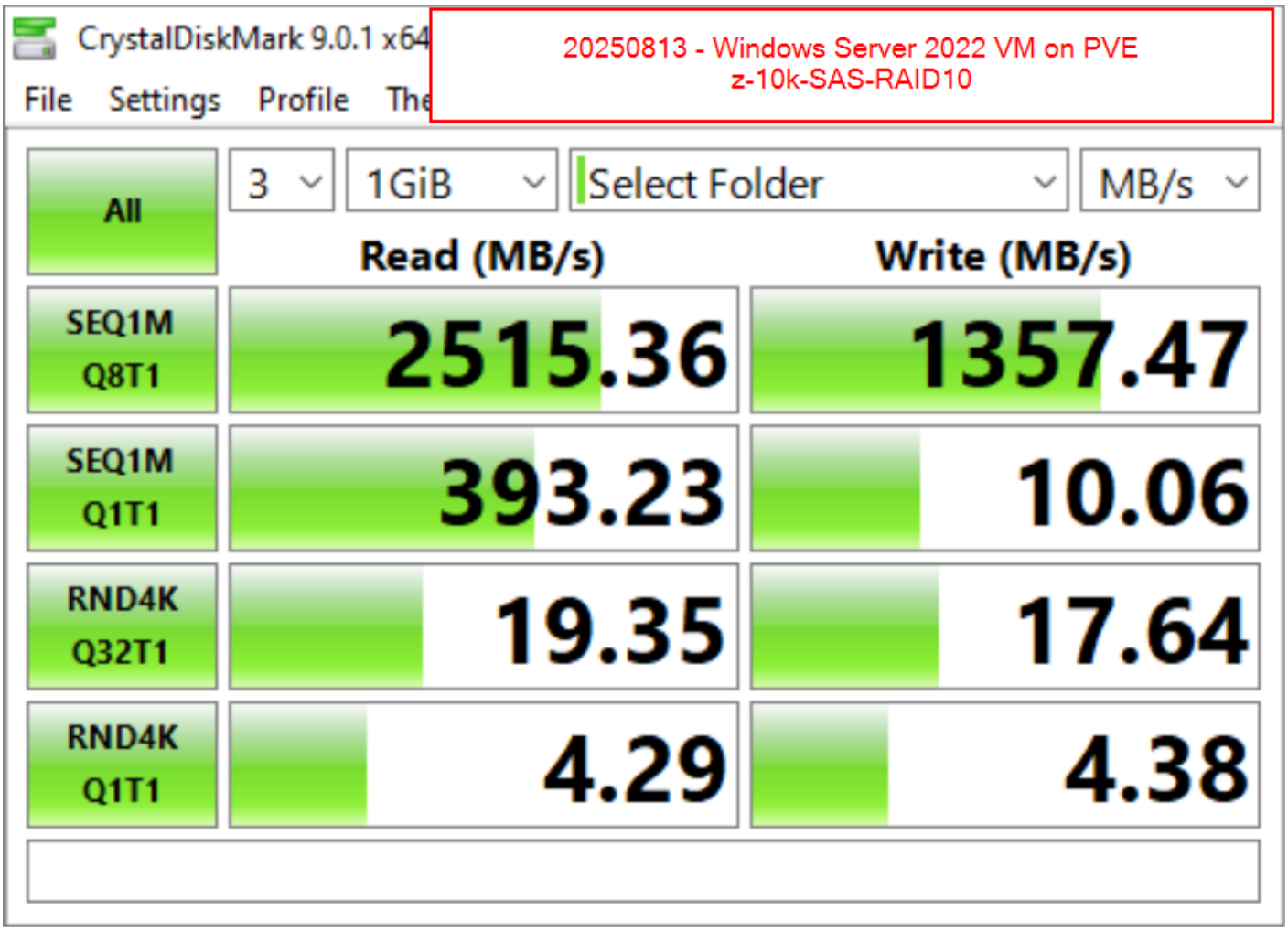
2 x 10K SAS DS EH0300JDYTH + 2 x SSD SLOG + 1 x SSD L2ARC (cache)

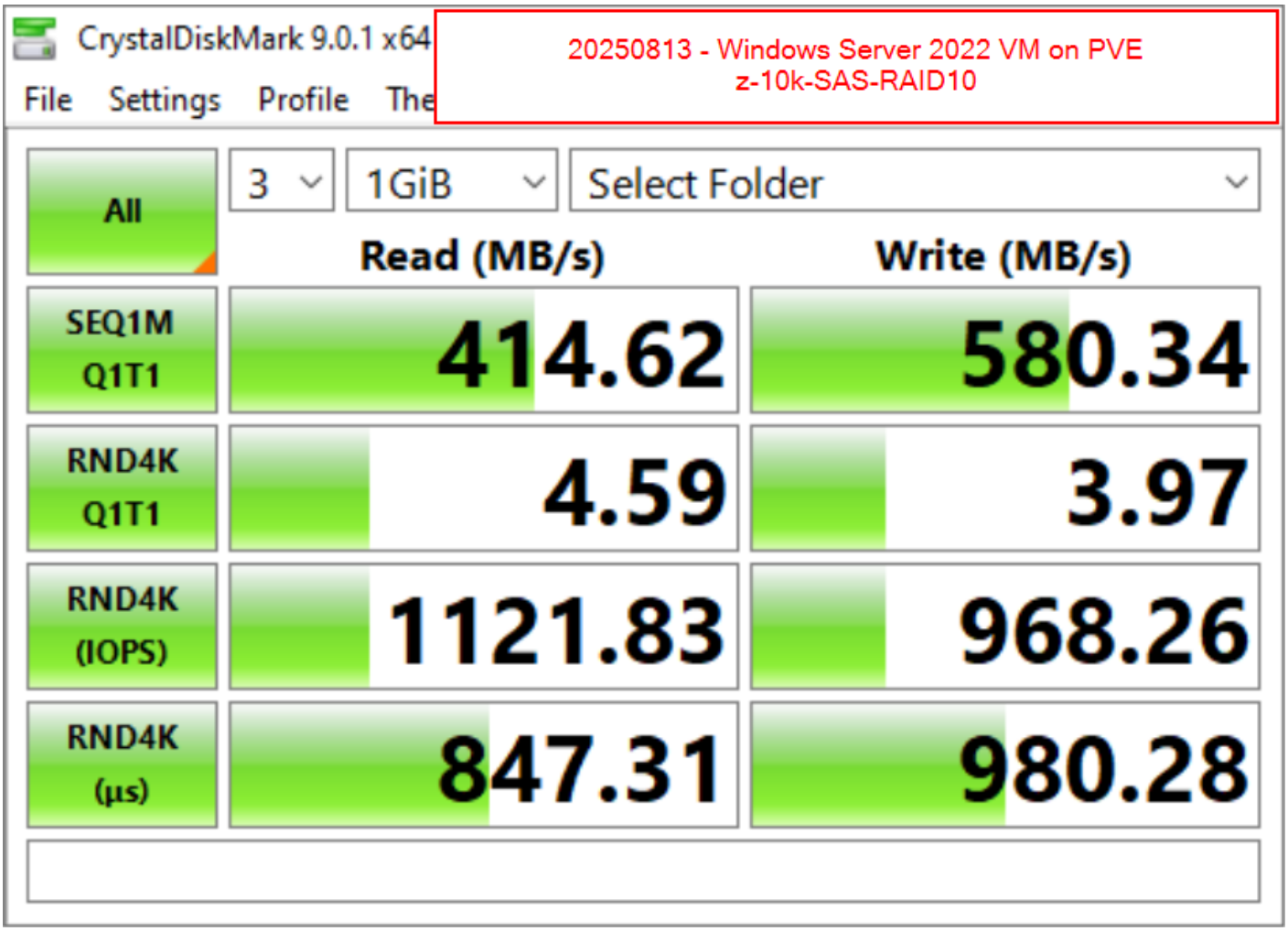



CrystalDiskMark 9.0.1 x64
File
Settings
Profile
The
20250813 - Windows Server 2022 VM on PVE
z-10k-SAS-DS-Mirror + SLOG + Cache
All
3
1GiB
C: 36% (45/126GiB)
Read (MB/s)
Write (MB/s)
SEQ1M Q1T1
459.03
507.95
RND4K Q1T1
4.03
3.88
RND4K (IOPS)
984.38
946.29
RND4K (µs)
968.37
1010.66


CrystalDiskMark 9.0.1 x64
20250813 - Windows Server 2022 VM on PVE
z-10kSAS-dRAID3:6d:10c:1s-0
File
Settings
Profile
All
3
1GiB
Select Folder
MB/s
Read (MB/s)
Write (MB/s)
SEQ1M Q8T1
2681.86
128.34
SEQ1M Q1T1
404.12
639.32
RND4K Q32T1
20.18
16.86
RND4K Q1T1
4.06
3.97


CrystalDiskMark 9.0.1 x64
File Settings Profile The
20250813 - Windows Server 2022 VM on PVE
z-10kSAS-dRAID3:6d:10c:1s-0
All
3
1GiB
Select Folder
Read (MB/s)
Write (MB/s)
SEQ1M Q1T1
481.12
623.66
RND4K Q1T1
4.56
3.98
RND4K (IOPS)
1113.53
971.19
RND4K (µs)
853.19
977.46


CrystalDiskMark 9.0.1 x64
20250813 - Windows Server 2022 VM on PVE
z-10k-SAS-RAID10
File
Settings
Profile
All
3
1GiB
Select Folder
MB/s
Read (MB/s)
Write (MB/s)
SEQ1M Q8T1
2515.36
1357.47
SEQ1M Q1T1
393.23
10.06
RND4K Q32T1
19.35
17.64
RND4K Q1T1
4.29
4.38




```
root@pve:/# cd z-10k-SAS-DS-Mirror/
root@pve:/z-10k-SAS-DS-Mirror# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [W(1)][100.0%][w=69.0MiB/s][w=69 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1553236: Tue Aug 12 10:22:50 2025
  write: IOPS=89, BW=89.3MiB/s (93.7MB/s)(10.0GiB/114626msec); 0 zone resets
    clat (msec): min=7, max=315, avg=11.11, stdev= 5.53
     lat (msec): min=8, max=315, avg=11.18, stdev= 5.53
    clat percentiles (msec):
     |  1.00th=[    9],  5.00th=[    9], 10.00th=[    9], 20.00th=[    9],
     | 30.00th=[   10], 40.00th=[   11], 50.00th=[   11], 60.00th=[   11],
     | 70.00th=[   12], 80.00th=[   12], 90.00th=[   13], 95.00th=[   14],
     | 99.00th=[   33], 99.50th=[   42], 99.90th=[   68], 99.95th=[   88],
     | 99.99th=[  116]
```

```
   bw (  KiB/s): min=14336, max=108544, per=100.00%, avg=91516.09, stdev=14694.26, samples=229
   iops        : min=   14, max=  106, avg=89.37, stdev=14.35, samples=229
  lat (msec)   : 10=39.91%, 20=57.56%, 50=2.22%, 100=0.28%, 250=0.02%
  lat (msec)   : 500=0.01%
  cpu          : usr=0.71%, sys=64.60%, ctx=10487, majf=0, minf=7
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=89.3MiB/s (93.7MB/s), 89.3MiB/s-89.3MiB/s (93.7MB/s-93.7MB/s), io=10.0GiB
(10.7GB), run=114626-114626msec



root@pve:/z-10k-SAS-DS-Mirror# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
random_read_job: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [r(1)][100.0%][r=824KiB/s][r=206 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1583195: Tue Aug 12 10:50:24 2025
  read: IOPS=203, BW=812KiB/s (832kB/s)(47.6MiB/60003msec)
    slat (usec): min=13, max=123917, avg=4911.77, stdev=3207.67
    clat (usec): min=14, max=542655, avg=309167.09, stdev=35242.70
     lat (msec): min=7, max=546, avg=314.08, stdev=35.48
    clat percentiles (msec):
     |  1.00th=[  262],  5.00th=[  279], 10.00th=[  284], 20.00th=[  292],
     | 30.00th=[  296], 40.00th=[  300], 50.00th=[  305], 60.00th=[  309],
     | 70.00th=[  313], 80.00th=[  321], 90.00th=[  334], 95.00th=[  359],
     | 99.00th=[  472], 99.50th=[  498], 99.90th=[  531], 99.95th=[  535],
     | 99.99th=[  542]
   bw (  KiB/s): min=  199, max= 1264, per=99.97%, avg=812.26, stdev=93.13, samples=120
   iops        : min=   49, max=  316, avg=203.06, stdev=23.32, samples=120
  lat (usec)   : 20=0.01%
  lat (msec)   : 10=0.01%, 20=0.01%, 50=0.06%, 100=0.07%, 250=0.27%
  lat (msec)   : 500=99.21%, 750=0.37%
```

```
  cpu          : usr=0.27%, sys=3.39%, ctx=11691, majf=0, minf=84
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.3%, >=64=99.5%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=12184,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=812KiB/s (832kB/s), 812KiB/s-812KiB/s (832kB/s-832kB/s), io=47.6MiB (49.9MB),
run=60003-60003msec
```

L1 VM - ZFS Mirrored SSD

```
# Benchmark - write

root@us-pve-101-testing:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][96.6%][eta 00m:06s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=7040: Mon Aug 11 22:41:53 2025
  write: IOPS=58, BW=59.0MiB/s (61.8MB/s)(10.0GiB/173676msec); 0 zone resets
    clat (usec): min=647, max=45665k, avg=16898.79, stdev=707938.73
     lat (usec): min=656, max=45665k, avg=16955.22, stdev=707938.94
    clat percentiles (usec):
     |  1.00th=[     988],  5.00th=[    1352], 10.00th=[    1450],
     | 20.00th=[    1582], 30.00th=[    1647], 40.00th=[    1713],
     | 50.00th=[    1762], 60.00th=[    1795], 70.00th=[    1827],
     | 80.00th=[    1860], 90.00th=[    1909], 95.00th=[    1958],
     | 99.00th=[    2278], 99.50th=[    2409], 99.90th=[    4359],
     | 99.95th=[11475616], 99.99th=[17112761]
   bw (  KiB/s): min=26677, max=819200, per=100.00%, avg=486353.63, stdev=170810.86,
samples=43
```

```
   iops        : min=   26, max=  800, avg=474.84, stdev=166.83, samples=43
  lat (usec)   : 750=0.17%, 1000=0.89%
  lat (msec)   : 2=95.51%, 4=3.31%, 10=0.06%, 750=0.01%, >=2000=0.06%
  cpu          : usr=0.51%, sys=0.95%, ctx=10241, majf=0, minf=13
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=59.0MiB/s (61.8MB/s), 59.0MiB/s-59.0MiB/s (61.8MB/s-61.8MB/s), io=10.0GiB
(10.7GB), run=173676-173676msec

Disk stats (read/write):
  sda: ios=0/10537, sectors=0/21021040, merge=0/500, ticks=0/4724709, in_queue=4862347,
util=97.87%



# Benchmark - read

root@us-pve-101-testing:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=308MiB/s][r=78.9k IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=7047: Mon Aug 11 22:43:10 2025
  read: IOPS=76.1k, BW=297MiB/s (312MB/s)(17.4GiB/60001msec)
    slat (usec): min=2, max=5361, avg= 8.95, stdev= 8.40
    clat (usec): min=115, max=8190, avg=831.02, stdev=330.81
     lat (usec): min=158, max=8199, avg=839.97, stdev=334.39
    clat percentiles (usec):
     |  1.00th=[  351],  5.00th=[  388], 10.00th=[  416], 20.00th=[  486],
     | 30.00th=[  562], 40.00th=[  619], 50.00th=[  898], 60.00th=[ 1057],
     | 70.00th=[ 1090], 80.00th=[ 1123], 90.00th=[ 1172], 95.00th=[ 1221],
     | 99.00th=[ 1663], 99.50th=[ 1745], 99.90th=[ 1876], 99.95th=[ 2008],
     | 99.99th=[ 2540]
   bw (  KiB/s): min=213812, max=539568, per=100.00%, avg=305124.23, stdev=72008.27,
```

```
samples=119
   iops        : min=53453, max=134892, avg=76281.10, stdev=18002.05, samples=119
  lat (usec)   : 250=0.01%, 500=21.93%, 750=26.28%, 1000=4.38%
  lat (msec)   : 2=47.36%, 4=0.05%, 10=0.01%
  cpu          : usr=32.95%, sys=65.00%, ctx=11406, majf=0, minf=77
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=4564316,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=297MiB/s (312MB/s), 297MiB/s-297MiB/s (312MB/s-312MB/s), io=17.4GiB (18.7GB),
run=60001-60001msec

Disk stats (read/write):
  sda: ios=4557508/19, sectors=36460064/176, merge=0/5, ticks=758830/37038, in_queue=832901,
util=68.19%
```

L1 VM - ZFS Mirrored 10K SAS + SLOG + Cache

```
root@us-pve-101-testing:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [W(1)][100.0%][w=185MiB/s][w=185 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=997: Tue Aug 12 14:53:40 2025
  write: IOPS=253, BW=253MiB/s (265MB/s)(10.0GiB/40449msec); 0 zone resets
    clat (usec): min=1113, max=188603, avg=3871.65, stdev=2642.15
     lat (usec): min=1149, max=188642, avg=3943.94, stdev=2641.43
    clat percentiles (usec):
     |  1.00th=[ 1500],  5.00th=[ 1631], 10.00th=[ 1745], 20.00th=[ 1827],
     | 30.00th=[ 1942], 40.00th=[ 2311], 50.00th=[ 4817], 60.00th=[ 5211],
     | 70.00th=[ 5407], 80.00th=[ 5604], 90.00th=[ 5932], 95.00th=[ 6128],
     | 99.00th=[ 6652], 99.50th=[ 6849], 99.90th=[ 7177], 99.95th=[ 7898],
     | 99.99th=[64750]
   bw (  KiB/s): min=149504, max=610304, per=100.00%, avg=260124.17, stdev=140385.29,
```

```
samples=80
   iops        : min=  146, max=  596, avg=253.86, stdev=137.09, samples=80
  lat (msec)   : 2=32.85%, 4=15.03%, 10=52.07%, 20=0.03%, 100=0.01%
  lat (msec)   : 250=0.01%
  cpu          : usr=3.08%, sys=3.15%, ctx=10243, majf=0, minf=13
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=253MiB/s (265MB/s), 253MiB/s-253MiB/s (265MB/s-265MB/s), io=10.0GiB (10.7GB),
run=40449-40449msec

Disk stats (read/write):
  sda: ios=1/10259, sectors=8/20959881, merge=0/12, ticks=3/58119, in_queue=77002, util=93.49%



root@us-pve-101-testing:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=486MiB/s][r=124k IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1000: Tue Aug 12 14:54:52 2025
  read: IOPS=93.0k, BW=363MiB/s (381MB/s)(21.3GiB/60001msec)
    slat (usec): min=2, max=525, avg= 7.23, stdev= 7.05
    clat (usec): min=106, max=4144, avg=679.83, stdev=343.27
     lat (usec): min=166, max=4152, avg=687.06, stdev=346.99
    clat percentiles (usec):
     |  1.00th=[  355],  5.00th=[  383], 10.00th=[  400], 20.00th=[  420],
     | 30.00th=[  437], 40.00th=[  457], 50.00th=[  486], 60.00th=[  537],
     | 70.00th=[  832], 80.00th=[ 1139], 90.00th=[ 1188], 95.00th=[ 1254],
     | 99.00th=[ 1532], 99.50th=[ 1762], 99.90th=[ 1876], 99.95th=[ 1909],
     | 99.99th=[ 2089]
   bw (  KiB/s): min=211328, max=580672, per=99.82%, avg=371243.65, stdev=97421.62,
samples=119
   iops        : min=52832, max=145168, avg=92810.87, stdev=24355.37, samples=119
```

```
  lat (usec)   : 250=0.01%, 500=54.35%, 750=14.73%, 1000=2.17%
  lat (msec)   : 2=28.73%, 4=0.02%, 10=0.01%
  cpu          : usr=35.72%, sys=62.92%, ctx=11510, majf=0, minf=76
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=5578560,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=363MiB/s (381MB/s), 363MiB/s-363MiB/s (381MB/s-381MB/s), io=21.3GiB (22.8GB),
run=60001-60001msec

Disk stats (read/write):
  sda: ios=5562235/9, sectors=44497880/80, merge=0/2, ticks=1046679/49508, in_queue=1124064,
util=53.76%
```

Nested VM Benchmark - ZFS Mirrored SSD

```
# Benchmark - Write

root@us-hv-nested:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][99.1%][w=165MiB/s][w=165 IOPS][eta 00m:02s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1439: Mon Aug 11 22:26:29 2025
  write: IOPS=44, BW=44.5MiB/s (46.6MB/s)(10.0GiB/230323msec); 0 zone resets
    clat (usec): min=9, max=28370k, avg=22023.80, stdev=535433.32
     lat (usec): min=9, max=28370k, avg=22285.21, stdev=535432.32
    clat percentiles (msec):
     |  1.00th=[    4],  5.00th=[    5], 10.00th=[    6], 20.00th=[    6],
     | 30.00th=[    6], 40.00th=[    6], 50.00th=[    7], 60.00th=[    7],
```

```
     | 70.00th=[    7], 80.00th=[    8], 90.00th=[    9], 95.00th=[   10],
     | 99.00th=[   16], 99.50th=[   25], 99.90th=[ 1838], 99.95th=[14429],
     | 99.99th=[17113]
   bw (  KiB/s): min= 4079, max=176761, per=100.00%, avg=132012.25, stdev=31904.93,
samples=157
   iops        : min=    3, max=  172, avg=128.38, stdev=31.21, samples=157
  lat (usec)   : 10=0.01%, 500=0.01%
  lat (msec)   : 2=0.06%, 4=0.99%, 10=94.77%, 20=3.56%, 50=0.33%
  lat (msec)   : 100=0.06%, 250=0.08%, 500=0.01%, 750=0.01%, 2000=0.02%
  lat (msec)   : >=2000=0.10%
  cpu          : usr=0.91%, sys=8.89%, ctx=12455, majf=0, minf=16
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=44.5MiB/s (46.6MB/s), 44.5MiB/s-44.5MiB/s (46.6MB/s-46.6MB/s), io=10.0GiB
(10.7GB), run=230323-230323msec

Disk stats (read/write):
  sda: ios=111/10313, sectors=3728/20900664, merge=90/235, ticks=2312/790448, in_queue=937669,
util=89.85%
```

Benchmark - Read

```
root@us-hv-nested:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=3498KiB/s][r=874 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1454: Mon Aug 11 22:27:43 2025
  read: IOPS=1151, BW=4608KiB/s (4718kB/s)(270MiB/60009msec)
    slat (nsec): min=1200, max=30439k, avg=506941.31, stdev=1047300.59
    clat (msec): min=2, max=335, avg=54.75, stdev=34.49
```

```
     lat (msec): min=3, max=335, avg=55.26, stdev=34.75
    clat percentiles (msec):
     |  1.00th=[   15],  5.00th=[   16], 10.00th=[   17], 20.00th=[   19],
     | 30.00th=[   24], 40.00th=[   37], 50.00th=[   61], 60.00th=[   68],
     | 70.00th=[   73], 80.00th=[   80], 90.00th=[   93], 95.00th=[  111],
     | 99.00th=[  157], 99.50th=[  176], 99.90th=[  215], 99.95th=[  288],
     | 99.99th=[  326]
   bw (  KiB/s): min= 2003, max=11768, per=100.00%, avg=4613.21, stdev=1889.89, samples=118
   iops        : min=  500, max= 2942, avg=1152.94, stdev=472.50, samples=118
  lat (msec)   : 4=0.01%, 10=0.01%, 20=24.47%, 50=21.04%, 100=46.64%
  lat (msec)   : 250=7.75%, 500=0.08%
  cpu          : usr=5.15%, sys=81.55%, ctx=7548, majf=0, minf=76
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=99.9%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=69124,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=4608KiB/s (4718kB/s), 4608KiB/s-4608KiB/s (4718kB/s-4718kB/s), io=270MiB (283MB),
run=60009-60009msec

Disk stats (read/write):
  sda: ios=69121/20, sectors=552968/288, merge=0/5, ticks=583586/133, in_queue=583767,
util=67.38%
```

Hardware: PVE: MeLE Overclock 4C

```
# sequential_write
 bw (  KiB/s): min=397312, max=444416, per=100.00%, avg=429994.67, stdev=10951.34, samples=48
 iops        : min=  388, max=  434, avg=419.92, stdev=10.69, samples=48
# random_read
 bw (  KiB/s): min=15336, max=16192, per=100.00%, avg=15984.67, stdev=114.94, samples=120
 iops        : min= 3834, max= 4048, avg=3996.17, stdev=28.74, samples=120
# sequential_read
 bw (  KiB/s): min=10184, max=24472, per=100.00%, avg=19554.20, stdev=1018.25, samples=120
 iops        : min= 2546, max= 6118, avg=4888.53, stdev=254.56, samples=120
```

```
root@pmvh2501:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=418MiB/s][w=418 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=2040323: Tue Aug 12 21:03:13 2025
  write: IOPS=419, BW=420MiB/s (440MB/s)(10.0GiB/24394msec); 0 zone resets
    clat (usec): min=1719, max=48467, avg=2336.25, stdev=896.61
     lat (usec): min=1764, max=48512, avg=2380.72, stdev=896.69
    clat percentiles (usec):
     |  1.00th=[ 2147],  5.00th=[ 2180], 10.00th=[ 2212], 20.00th=[ 2278],
     | 30.00th=[ 2278], 40.00th=[ 2311], 50.00th=[ 2311], 60.00th=[ 2311],
     | 70.00th=[ 2311], 80.00th=[ 2311], 90.00th=[ 2376], 95.00th=[ 2409],
     | 99.00th=[ 2573], 99.50th=[ 2802], 99.90th=[17957], 99.95th=[21365],
     | 99.99th=[38536]
   bw (  KiB/s): min=397312, max=444416, per=100.00%, avg=429994.67, stdev=10951.34,
samples=48
   iops        : min=  388, max=  434, avg=419.92, stdev=10.69, samples=48
  lat (msec)   : 2=0.04%, 4=99.70%, 10=0.10%, 20=0.10%, 50=0.07%
  cpu          : usr=2.16%, sys=92.04%, ctx=12136, majf=5, minf=10
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=420MiB/s (440MB/s), 420MiB/s-420MiB/s (440MB/s-440MB/s), io=10.0GiB (10.7GB),
run=24394-24394msec



root@pmvh2501:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
```

```
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=15.6MiB/s][r=3989 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=2040401: Tue Aug 12 21:04:13 2025
  read: IOPS=3996, BW=15.6MiB/s (16.4MB/s)(937MiB/60001msec)
    slat (usec): min=151, max=4918, avg=248.40, stdev=43.31
    clat (usec): min=2, max=21443, avg=15762.61, stdev=450.75
     lat (usec): min=257, max=21696, avg=16011.01, stdev=454.68
    clat percentiles (usec):
     |  1.00th=[15008],  5.00th=[15139], 10.00th=[15270], 20.00th=[15401],
     | 30.00th=[15533], 40.00th=[15664], 50.00th=[15664], 60.00th=[15795],
     | 70.00th=[15926], 80.00th=[16057], 90.00th=[16188], 95.00th=[16450],
     | 99.00th=[17433], 99.50th=[17695], 99.90th=[18220], 99.95th=[18744],
     | 99.99th=[21103]
   bw (  KiB/s): min=15336, max=16192, per=100.00%, avg=15984.67, stdev=114.94, samples=120
   iops        : min= 3834, max= 4048, avg=3996.17, stdev=28.74, samples=120
  lat (usec)   : 4=0.01%, 500=0.01%, 750=0.01%
  lat (msec)   : 2=0.01%, 4=0.01%, 10=0.01%, 20=99.96%, 50=0.02%
  cpu          : usr=0.72%, sys=9.61%, ctx=240318, majf=0, minf=72
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=239770,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=15.6MiB/s (16.4MB/s), 15.6MiB/s-15.6MiB/s (16.4MB/s-16.4MB/s), io=937MiB (982MB),
run=60001-60001msec



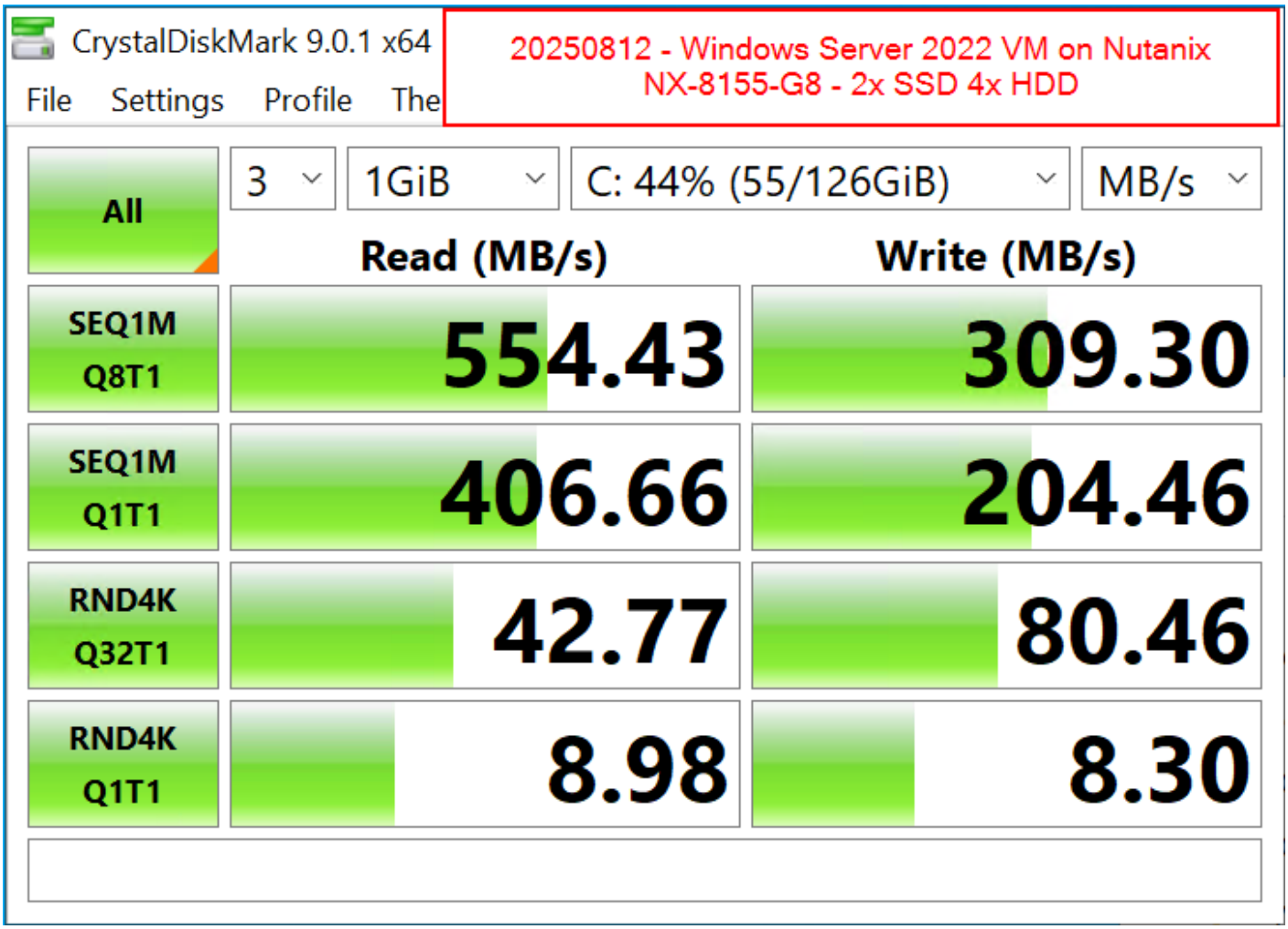
random_read_job: (g=0): rw=read, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [R(1)][100.0%][r=18.8MiB/s][r=4820 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=2041137: Tue Aug 12 21:07:41 2025
  read: IOPS=4888, BW=19.1MiB/s (20.0MB/s)(1146MiB/60001msec)
    slat (usec): min=135, max=32402, avg=202.85, stdev=82.92
    clat (usec): min=2, max=39730, avg=12873.56, stdev=959.97
     lat (usec): min=206, max=67804, avg=13076.41, stdev=978.59
```

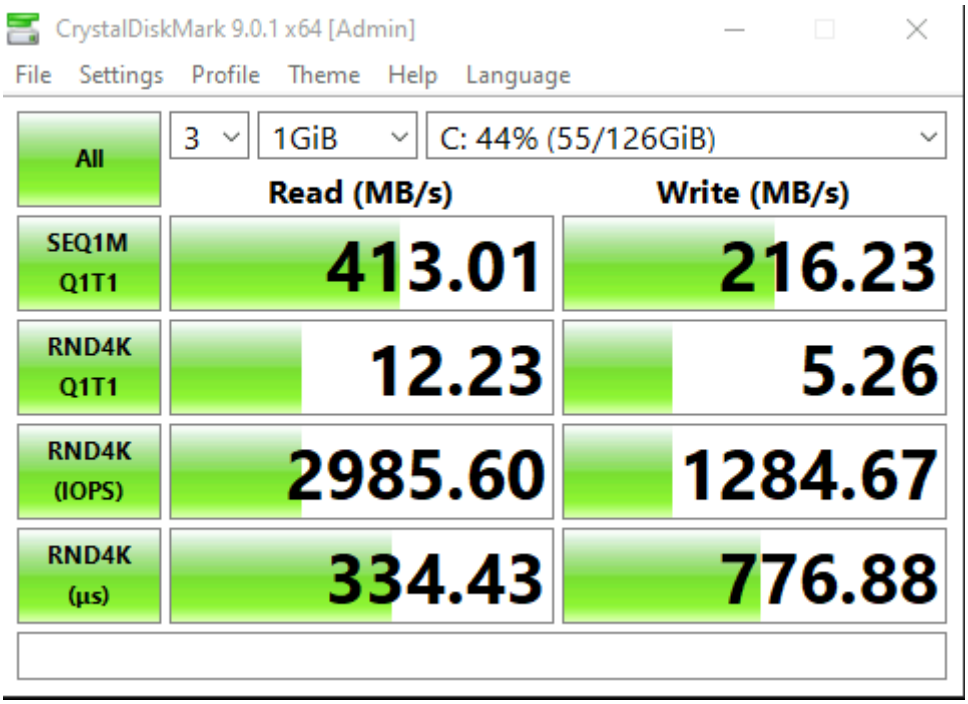
```
    clat percentiles (usec):
     |  1.00th=[10159],  5.00th=[12387], 10.00th=[12518], 20.00th=[12518],
     | 30.00th=[12649], 40.00th=[12780], 50.00th=[12780], 60.00th=[12911],
     | 70.00th=[13042], 80.00th=[13042], 90.00th=[13304], 95.00th=[13566],
     | 99.00th=[15008], 99.50th=[15795], 99.90th=[30278], 99.95th=[34866],
     | 99.99th=[38011]
   bw (  KiB/s): min=10184, max=24472, per=100.00%, avg=19554.20, stdev=1018.25, samples=120
   iops        : min= 2546, max= 6118, avg=4888.53, stdev=254.56, samples=120
  lat (usec)   : 4=0.01%, 250=0.01%, 500=0.01%, 750=0.01%, 1000=0.01%
  lat (msec)   : 2=0.01%, 4=0.01%, 10=0.87%, 20=98.95%, 50=0.17%
  cpu          : usr=0.86%, sys=11.28%, ctx=293962, majf=0, minf=71
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=293313,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

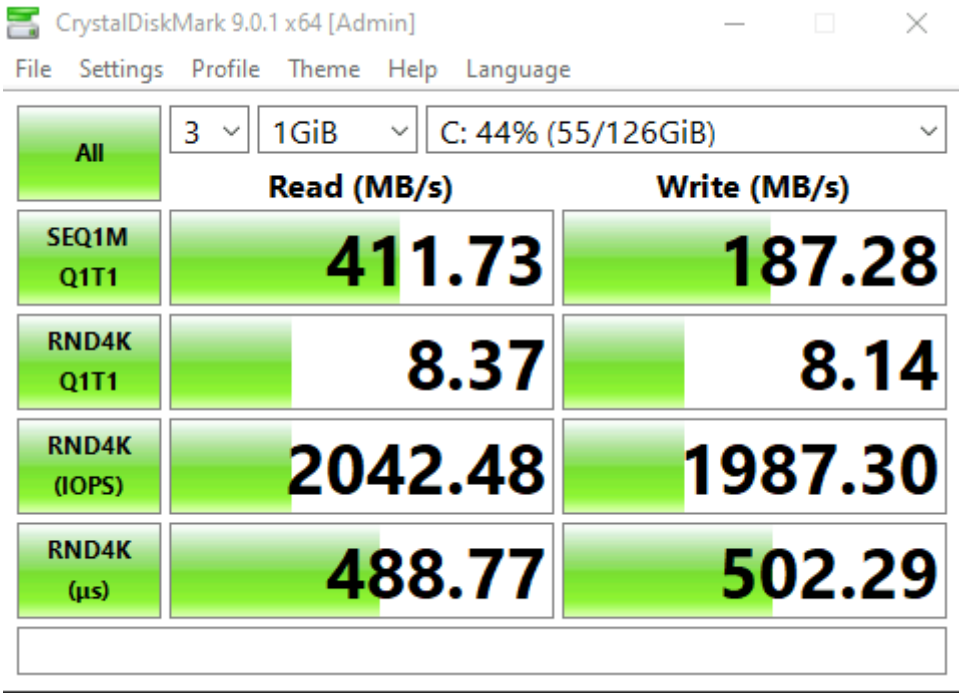
Run status group 0 (all jobs):
   READ: bw=19.1MiB/s (20.0MB/s), 19.1MiB/s-19.1MiB/s (20.0MB/s-20.0MB/s), io=1146MiB
(1201MB), run=60001-60001msec
```

Hardware: Nutanix NX-8155-G8

2 x SSD + 4 HDD
Benchmark was run during business hours with normal production workloads occurring.


CrystalDiskMark 9.0.1 x64
20250812 - Windows Server 2022 VM on Nutanix
NX-8155-G8 - 2x SSD 4x HDD
File Settings Profile The
All
3
1GiB
C: 44% (55/126GiB)
MB/s
Read (MB/s)
Write (MB/s)
SEQ1M Q8T1
554.43
309.30
SEQ1M Q1T1
406.66
204.46
RND4K Q32T1
42.77
80.46
RND4K Q1T1
8.98
8.30


CrystalDiskMark 9.0.1 x64 [Admin]
File Settings Profile Theme Help Language
All
3
1GiB
C: 44% (55/126GiB)
Read (MB/s)
Write (MB/s)
SEQ1M Q1T1
413.01
216.23
RND4K Q1T1
12.23
5.26
RND4K (IOPS)
2985.60
1284.67
RND4K (µs)
334.43
776.88




```
root@nutanix-l1-vm:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.28
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=143MiB/s][w=143 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=129336: Tue Aug 12 10:51:08 2025
  write: IOPS=155, BW=155MiB/s (163MB/s)(10.0GiB/66001msec); 0 zone resets
    clat (usec): min=4496, max=56501, avg=6377.43, stdev=2162.18
     lat (usec): min=4542, max=56536, avg=6438.83, stdev=2164.59
    clat percentiles (usec):
     |  1.00th=[ 4686],  5.00th=[ 4752], 10.00th=[ 4817], 20.00th=[ 4948],
     | 30.00th=[ 5080], 40.00th=[ 5276], 50.00th=[ 5669], 60.00th=[ 6128],
     | 70.00th=[ 6718], 80.00th=[ 7373], 90.00th=[ 8717], 95.00th=[10290],
     | 99.00th=[14222], 99.50th=[16057], 99.90th=[21365], 99.95th=[25035],
     | 99.99th=[54789]
   bw (  KiB/s): min=120832, max=198656, per=100.00%, avg=159134.29, stdev=25598.04,
samples=131
   iops        : min=  118, max=  194, avg=155.40, stdev=25.00, samples=131
  lat (msec)   : 10=94.29%, 20=5.58%, 50=0.12%, 100=0.02%
  cpu          : usr=1.30%, sys=1.36%, ctx=10368, majf=0, minf=11
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
```

```
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=155MiB/s (163MB/s), 155MiB/s-155MiB/s (163MB/s-163MB/s), io=10.0GiB (10.7GB),
run=66001-66001msec

Disk stats (read/write):
  sda: ios=0/20672, merge=0/278, ticks=0/122765, in_queue=122764, util=99.93%



root@nutanix-l1-vm:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.28
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=43.5MiB/s][r=11.1k IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=129344: Tue Aug 12 10:53:31 2025
  read: IOPS=15.3k, BW=59.7MiB/s (62.6MB/s)(3582MiB/60009msec)
    slat (nsec): min=1483, max=352698, avg=2964.05, stdev=2532.94
    clat (usec): min=256, max=236442, avg=4184.75, stdev=4942.01
     lat (usec): min=258, max=236447, avg=4187.82, stdev=4942.20
    clat percentiles (usec):
     |  1.00th=[   537],  5.00th=[   832], 10.00th=[  1090], 20.00th=[  1467],
     | 30.00th=[  1778], 40.00th=[  2114], 50.00th=[  2606], 60.00th=[  3326],
     | 70.00th=[  4424], 80.00th=[  5997], 90.00th=[  8979], 95.00th=[ 12387],
     | 99.00th=[ 21365], 99.50th=[ 25822], 99.90th=[ 47973], 99.95th=[ 62653],
     | 99.99th=[110625]
   bw (  KiB/s): min=11144, max=151008, per=100.00%, avg=61258.53, stdev=26522.54, samples=119
   iops        : min= 2786, max=37752, avg=15314.62, stdev=6630.65, samples=119
  lat (usec)   : 500=0.72%, 750=3.00%, 1000=4.50%
  lat (msec)   : 2=28.65%, 4=29.85%, 10=25.19%, 20=6.85%, 50=1.16%
  lat (msec)   : 100=0.08%, 250=0.01%
  cpu          : usr=2.75%, sys=8.08%, ctx=475071, majf=0, minf=75
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
```

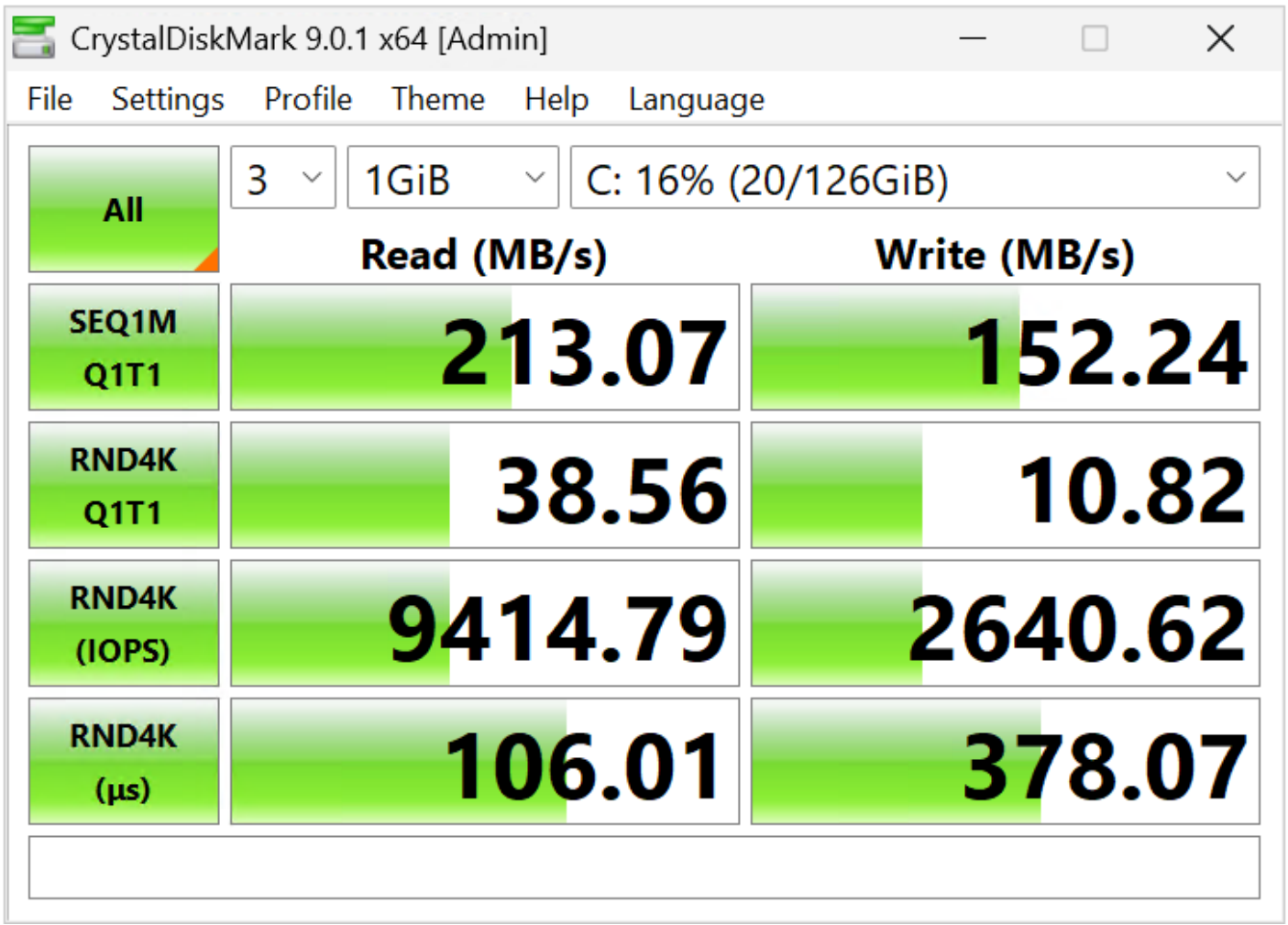
```
      complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
      issued rwts: total=916907,0,0,0 short=0,0,0,0 dropped=0,0,0,0
      latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=59.7MiB/s (62.6MB/s), 59.7MiB/s-59.7MiB/s (62.6MB/s-62.6MB/s), io=3582MiB
(3756MB), run=60009-60009msec

Disk stats (read/write):
  sda: ios=915429/91, merge=0/14, ticks=3817950/1460, in_queue=3819410, util=99.91%
```

Hardware: Azure VM

Standard D2as v6 (2 vcpus, 8 GiB memory)
Storage: Premium SSD LRS



-end

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