E1.S Thermal Study

Microsoft Azure Team

Abstract

SSD Density vs Thermal Capabilities

- Use three 25mm thickness E1.S SSDs as the spatial boundary
  - Three SSDs consider device cross-heating and limited surrounding air boundary layer development.
- Increase SSD quantity within 25mm spatial boundary as SSD thickness decreases.
- Calculate server width SSD power.

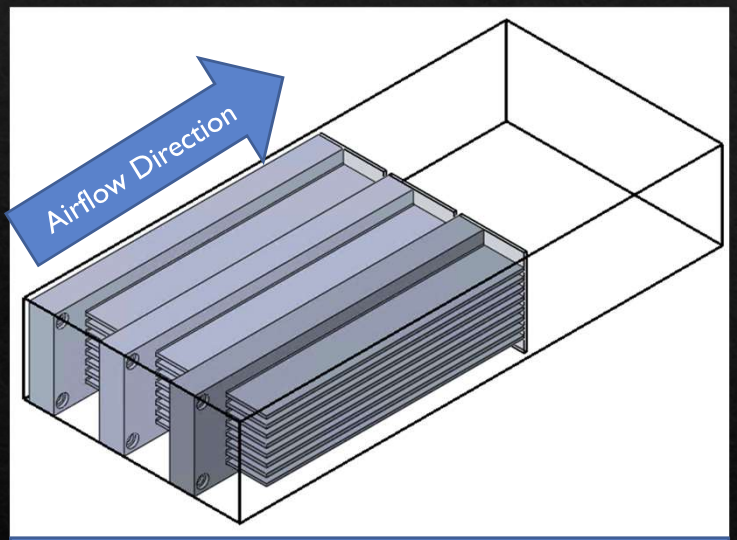
Thermal specification compliance

- Establish constant airflow velocity for simulation domain.
  - Characterized to 20W for the center 9.5mm SSD device
- Maintain constant 2mm SSD gap (pitch will vary).
- All simulations assume 35C inlet temperature
- Record & scale total & individual power, temperature, & through card airflow of the SSDs inside the domain

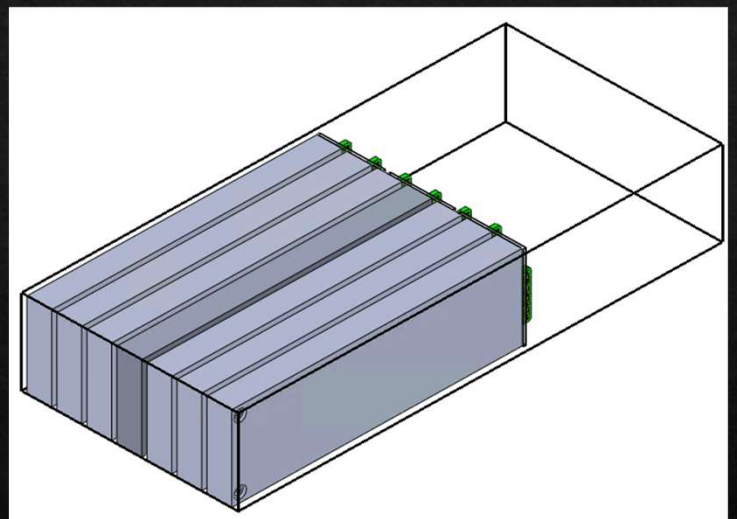
Supplier expectations

- Provide through-card airflow and pressure requirements for most thermally constrained SSD.
  - (Need to decide if this is the best approach vs. center SSD (sees nominal airflow).

Domain Spatial Boundary Condition



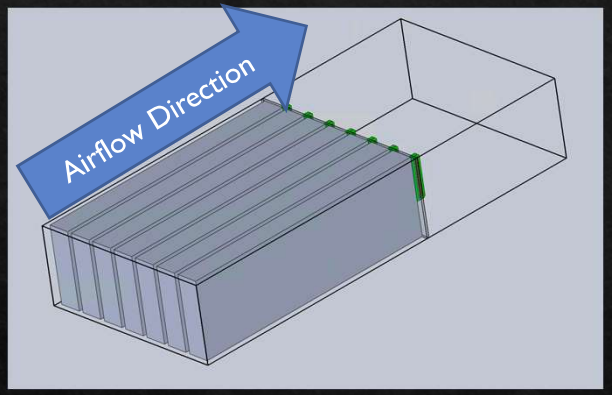
25mm spatial boundary



Fitting 9.5mm SSDs into 25mm spatial boundary

- Maintain 2mm gap between side (vertical orientation) and top (horizontal orientation) surfaces of SSD's.
- Goal is to establish an SSD device ratio when compared to a 25mm device.
  - Example: 25mm vs. 9mm has a 3:7 ratio.

Airflow Characterization for SSD Drives

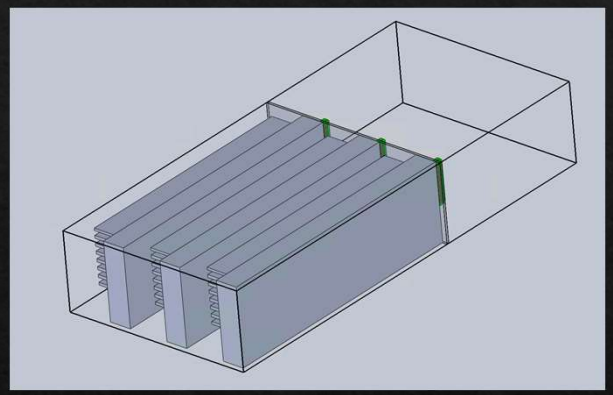


9.5mm device set target airflow constraint due to high airflow impedance and least surface heat dissipation area.

Name	Type	Paramet...	Calc	Value	Unit	%
IND_VIS-1	Vol	Solid Temp	Ave	76.477	°C	✓
L351-1	Vol	Solid Temp	Ave	76.403	°C	✓
L352-1	Vol	Solid Temp	Ave	75.798	°C	✓
L354-1	Vol	Solid Temp	Ave	76.818	°C	✓
L355-1	Vol	Solid Temp	Ave	75.810	°C	✓
L356-1	Vol	Solid Temp	Ave	76.865	°C	✓
L357-1	Vol	Solid Temp	Ave	77.697	°C	✓
L401-1	Vol	Solid Temp	Ave	75.616	°C	✓
NAND-1	Vol	Solid Temp	Ave	75.225	°C	✓
NAND-2	Vol	Solid Temp	Ave	75.196	°C	✓
NAND-3	Vol	Solid Temp	Ave	77.670	°C	✓
NAND-4	Vol	Solid Temp	Ave	79.344	°C	✓
NAND-5	Vol	Solid Temp	Ave	78.037	°C	✓
NAND-6	Vol	Solid Temp	Ave	78.177	°C	✓
NAND-7	Vol	Solid Temp	Ave	75.759	°C	✓
NAND-8	Vol	Solid Temp	Ave	75.828	°C	✓
PMIC-1	Vol	Solid Temp	Ave	75.524	°C	✓
Q354-1	Vol	Solid Temp	Ave	75.352	°C	✓
Q355-1	Vol	Solid Temp	Ave	75.656	°C	✓
QFN-1	Vol	Solid Temp	Ave	77.393	°C	✓

Update Default Iterations: 139

Inlet air velocity established by coolest SSD in domain at 20W of power. Bottom-side NAND established as temp limiting device.



Applied inlet velocity to varying SSD device thicknesses and reported through-card airflow as the active cooling requirement.

Power Scaling Methodology

Total SSD Power		Percent to Scale	Simulation SoC temp	Specification limit	Simulation power	Scaled power	Count	Total SoC Power	Simulation Nand temp	Specification limit	Simulation power
21.52	Device1	1.30	90	100	4.5	5.83573487	1	5.84	69.7	80	1.2
22.21	Device2	1.34		100	4.5	6.044776119	1	6.04	68.5	80	1.2
24.52	Device3	1.50		100	4.5	6.75	1	6.75	65	80	1.2
21.69	Device4	1.31		100	4.5	5.886627907	1	5.89	69.4	80	1.2
18.38	Device5	1.08		100	4.5	4.879518072	1	4.88	76.5	80	1.2
0.00	Device6	0.00		100	4.5	0	1	0.00	79.6	80	1.2
0.00	Device7	0.00		100	4.5	0	1	0.00	85.9	80	1.2
108.31											
6.2775 m/s	15mm										
2.71			SoC								
Total SSD Power		Percent to Scale	Simulation SoC temp	Specification limit	Simulation power	Scaled power	Count	Total SoC Power	Simulation Nand temp	Specification limit	Simulation power
24.38	Device1	1.49	90	100	4.5	6.705298013	1	6.71	65.2	80	1.2
25.29	Device2	1.55		100	4.5	6.982758621	1	6.98	64	80	1.2
24.82	Device3	1.52		100	4.5	6.841216216	1	6.84	64.6	80	1.2
25.29	Device4	1.55		100	4.5	6.982758621	1	6.98	64	80	1.2
20.57	Device5	1.23		100	4.5	5.547945205	1	5.55	71.5	80	1.2
0.00	Device6	0.00		100	4.5	0	1	0.00	0	80	1.2
0.00	Device7	0.00		100	4.5	0	1	0.00	0	80	1.2
120.35											

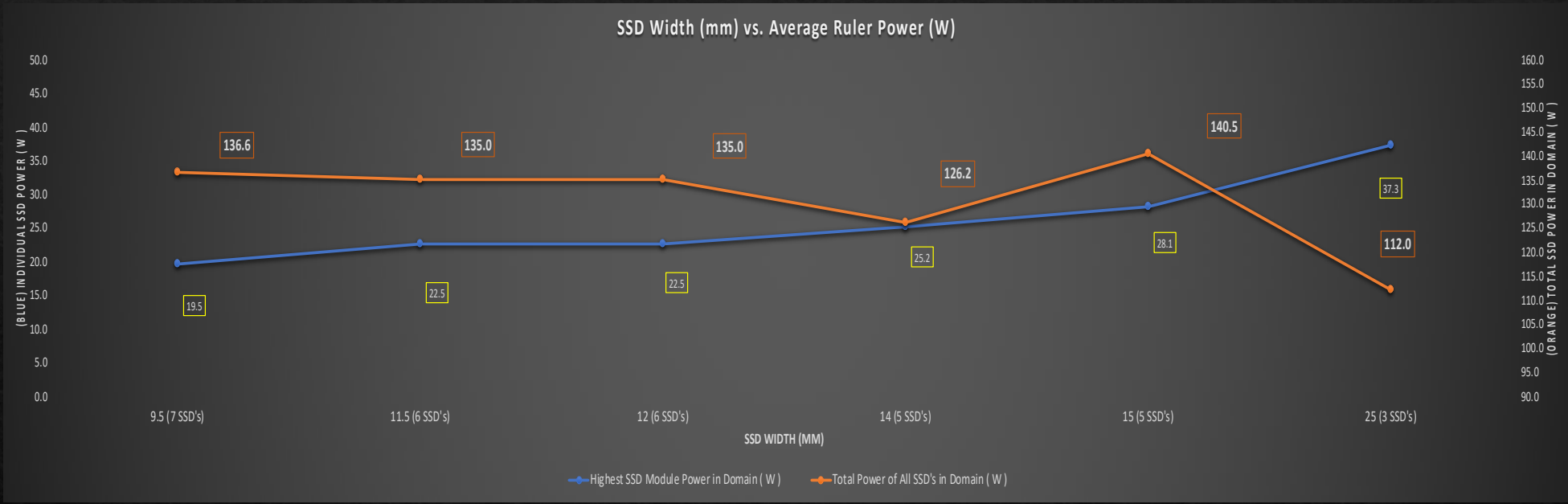
* Power is scaled to component with the least thermal margin. In this case that is the NAND.

- Power scaling methodology:
  - SoC & DDR power will scale to NAND temperature limitation, because it has the least temperature margin.
  - Scaling considers that NAND can only manage limited workload throughput operations and thus the controller may not deliver more workload operations than the NAND can handle.
  - Specification will vary by SSD supplier.
  - Simulation power is the total power of each device in the CFD modeling tool.
    - The resulting temperatures are a result of the simulation power and constant inlet air velocity.
  - X.Xmm_result is the resulting temperature:

$$\text{Scaled Power} = Simulation_{Power} * \frac{(NAND_{operation_{spec}} - 35\,°C\ inlet\ temperature\ )}{\left(NAND\ X.XmmWidth\ _{result_{temperature}} - 35\,°C\ inlet\ temperature\right)}$$

Simulations Performed with Constant Airflow

Average SSD Power vs. Thickness in 83mm Domain



Power Targets

- Current generation SSDs should work within a 20W power envelope. To be forward looking, we propose to target 25-30W to enable future generations

9.5mm, 11.5mm & 12mm

- Not close to 30W but have high overall domain power.

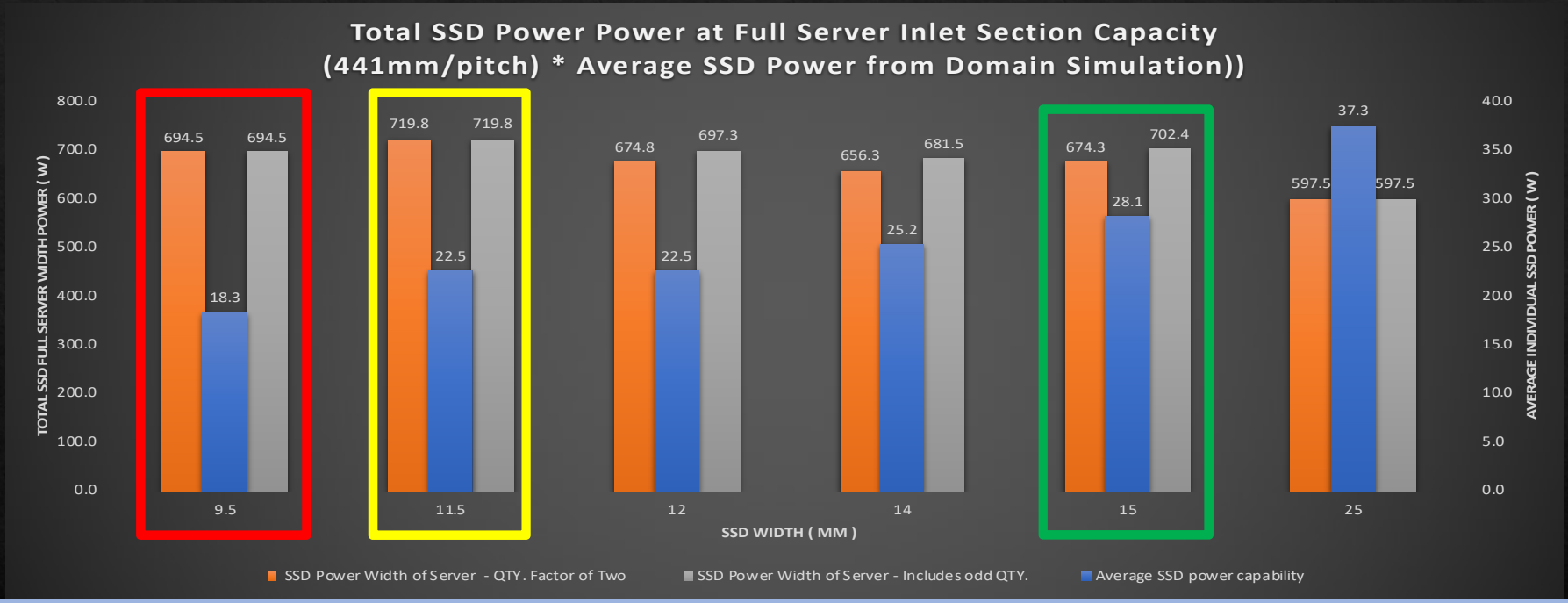
15mm

- 15mm thickness is close to 30W target and provides the highest total domain SSD power when constrained to 83mm.

25mm

- 25mm has the highest power density, but the lowest overall domain power.
- 25mm shows the largest increase in power density, but largest decrease in total supported SSD power in 83mm domain

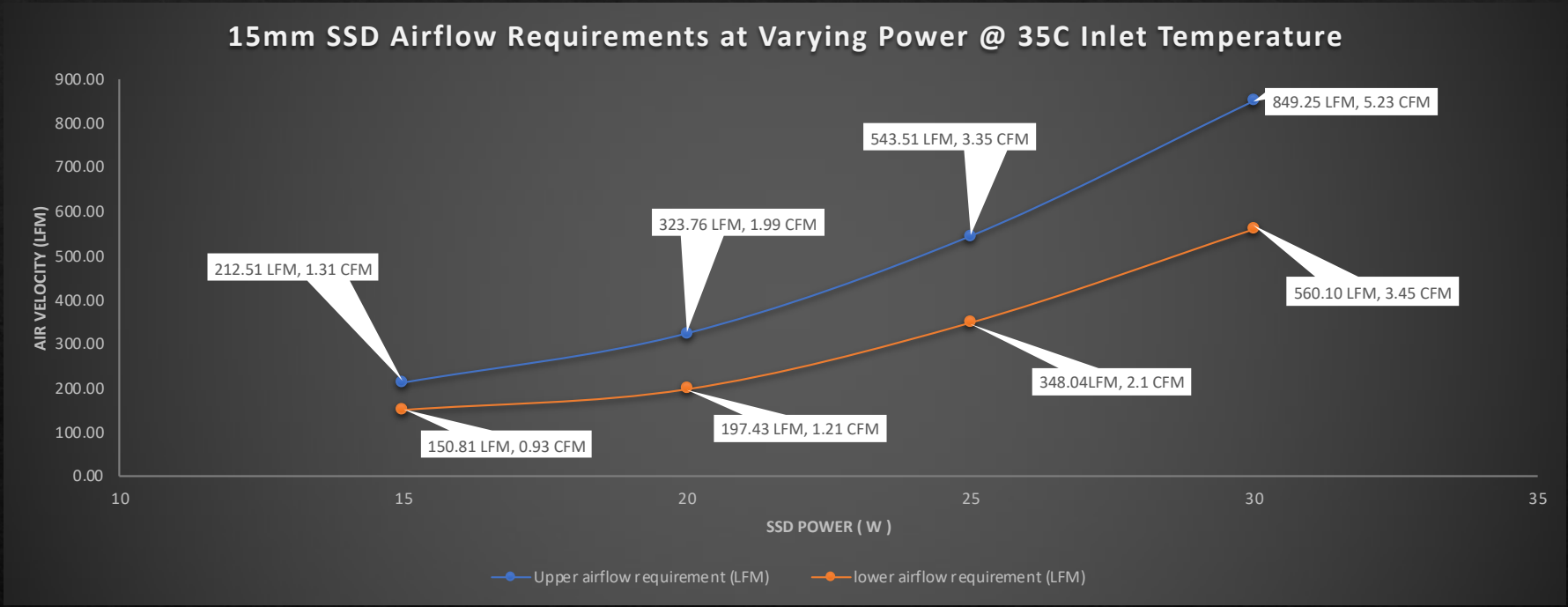
Total Power Dissipation – Full Server Width (441mm)



Note: Total designated server width considers thermal & SSD pitch. It is agnostic of other mechanical design requirements.

- 15mm SSD closest to 30W SSD power density target & has second highest full server width power dissipation
- 11.5mm has second highest but does not meet ~30W density target.
- Per the data in this document Microsoft recommends 15mm wide E1.S' when considering device airflow requirements, power density and overall server width power capacity.
- Simulations assume 4TB E1.S SSD drives at constant inlet airflow and scaled device thermal design power.

15mm Airflow Requirements



- Upper tolerance airflow requirement considers SSD's located with flat plate facing simulation edge domain.
- Lower tolerance airflow requirement reports airflow required coolest SSD in the simulation domain.

Recommendation

15mm Asymmetric appears to be the best tradeoff for density and thermal capabilities

Appendix

Single vs Dual Sided Fins for SSD Enclosures (15mm)