



# PCIe400 Thermal Model

Jean-Marc NAPPA on behalf of the LAPP team



## *Simulation Passive (v6)*

- Volume Air 312x100x36.4mm
- Tamb : 38 °C

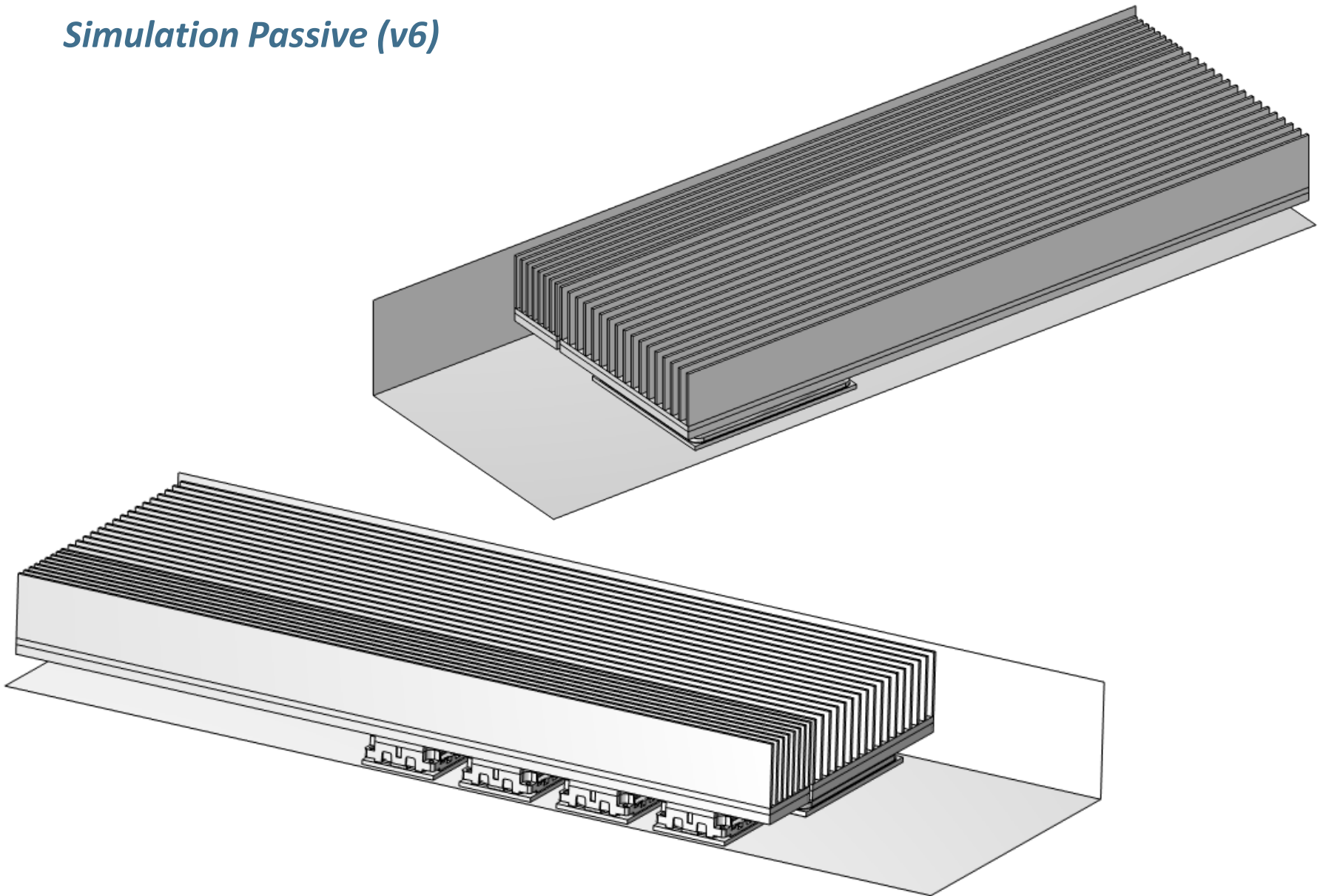
### *- FPGA Agilex*

- Dimension 56x66x4.824mm
- Heat Sink 254x70x20mm with Fins 17x1mm (Aluminum)
- Vapor Chamber 254x70x3mm with Encoche 59.7x46.6x4.7mm (Copper)
- Heat source : 156 W

### *- OBT*

- Heat Sink 254x23x18.5mm with Fins 8x1mm (Aluminum)
- Vapor Chamber 254x20x3mm (Copper)
- Heat rate LD : 3.89 W
- Heat rate TIA : 3.63 W

## *Simulation Passive (v6)*



### *Simulation Passive (v6) – FPGA*

| U0 (m/s) | T Die (degC) | T IHS (degC) | T VC (degC) | T HeatSink (degC) |
|----------|--------------|--------------|-------------|-------------------|
| 1.0000   | 89.891       | 85.859       | 84.941      | 84.318            |
| 2.0000   | 67.732       | 63.700       | 62.727      | 62.119            |
| 3.0000   | 60.172       | 56.140       | 55.121      | 54.524            |
| 5.0000   | 54.166       | 50.132       | 49.060      | 48.485            |

| U0 (m/s) | Rθ J-C (degC/W) | Rθ C-V (degC/W) | Rθ V-S (degC/W) | Rθ S-A (degC/W) | Rθ J-A (degC/W) |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1.0000   | 0.025943        | 0.0058917       | 0.0039923       | 0.29705         | 0.33288         |
| 2.0000   | 0.025945        | 0.0062387       | 0.0038997       | 0.15468         | 0.19077         |
| 3.0000   | 0.025947        | 0.0065327       | 0.0038284       | 0.10598         | 0.14228         |
| 5.0000   | 0.025958        | 0.0068749       | 0.0036846       | 0.067246        | 0.10376         |

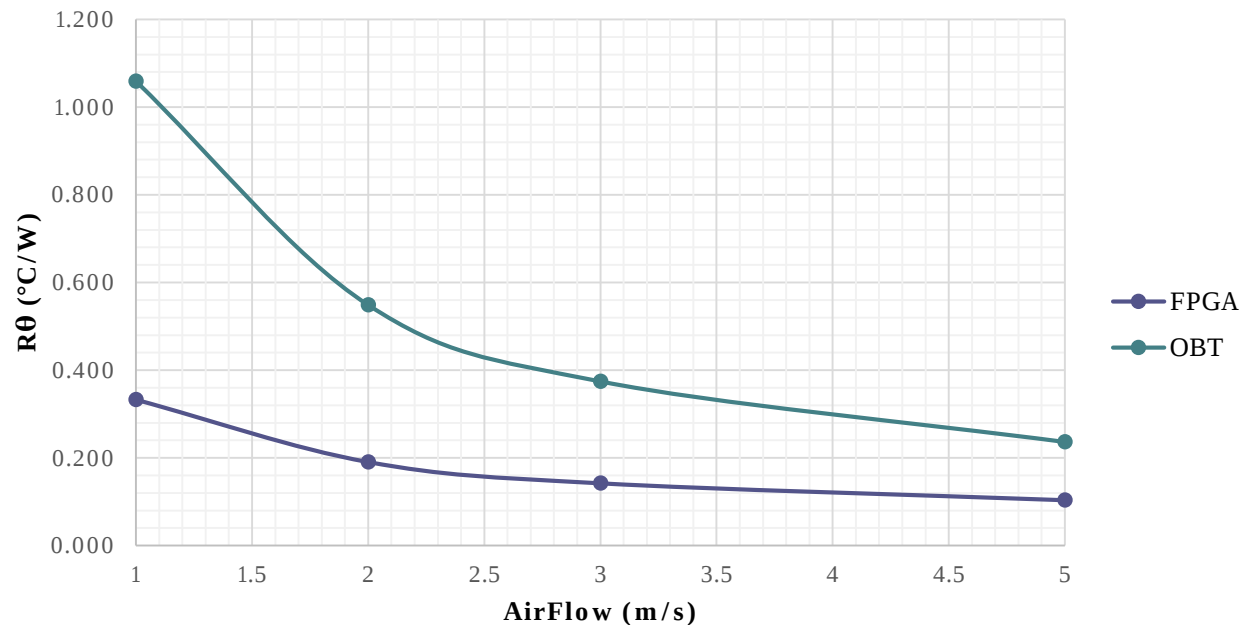
## Simulation Passive (v6) – OBT

| U0 (m/s) | T1 Die (degC) | T1 Case (degC) | T1 ZAdapter (degC) | T2 Die (degC)     | T2 Case (degC) | T2 ZAdapter (degC) |
|----------|---------------|----------------|--------------------|-------------------|----------------|--------------------|
| 1.0000   | 79.873        | 70.494         | 69.643             | 79.760            | 70.401         | 69.615             |
| 2.0000   | 64.568        | 55.190         | 54.336             | 64.426            | 55.074         | 54.297             |
| 3.0000   | 59.349        | 49.978         | 49.126             | 59.180            | 49.845         | 49.078             |
| 5.0000   | 55.207        | 45.855         | 45.003             | 54.995            | 45.697         | 49.950             |
| U0 (m/s) | T3 Die (degC) | T3 Case (degC) | T3 ZAdapter (degC) | T4 Die (degC)     | T4 Case (degC) | T4 ZAdapter (degC) |
| 1.0000   | 79.760        | 70.375         | 69.603             | 79.688            | 70.336         | 69.586             |
| 2.0000   | 64.427        | 55.039         | 54.272             | 64.323            | 54.967         | 54.231             |
| 3.0000   | 59.183        | 49.804         | 49.045             | 59.058            | 49.708         | 48.987             |
| 5.0000   | 55.008        | 45.652         | 44.891             | 54.858            | 45.532         | 44.912             |
| U0 (m/s) |               | T VC (degC)    |                    | T HeatSink (degC) |                |                    |
| 1.0000   |               | 69.308         |                    | 69.052            |                |                    |
| 2.0000   |               | 53.947         |                    | 53.701            |                |                    |
| 3.0000   |               | 48.701         |                    | 48.458            |                |                    |
| 5.0000   |               | 44.551         |                    | 44.313            |                |                    |

## Simulation Passive (v6) – OBT

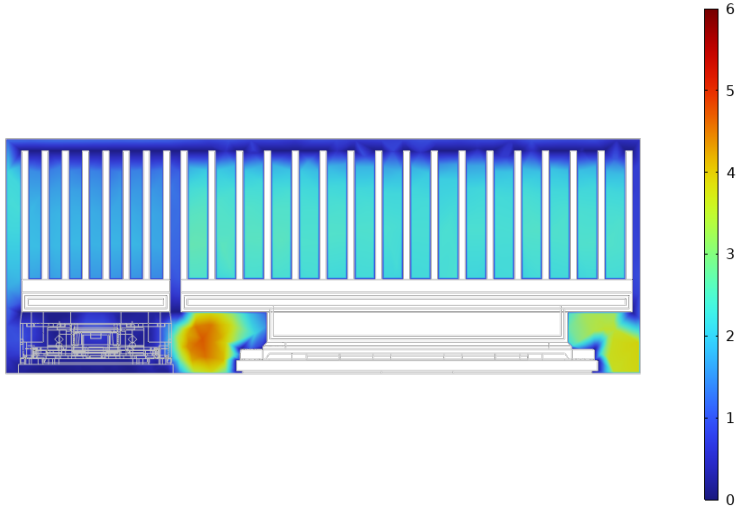
| U0 (m/s) | Rθ J-C<br>(degC/W) | Rθ C-V<br>(degC/W) | Rθ V-S<br>(degC/W) | Rθ S-A<br>(degC/W) | Rθ J-A<br>(degC/W) | Rθ C-A<br>(degC/W) |
|----------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| 1.0000   | 0.31151            | 0.018129           | 0.0084954          | 1.0323             | 1.3705             | 1.0589             |
| 2.0000   | 0.31149            | 0.018531           | 0.0081885          | 0.52196            | 0.86017            | 0.54868            |
| 3.0000   | 0.31115            | 0.018701           | 0.0080747          | 0.34766            | 0.68559            | 0.37444            |
| 5.0000   | 0.31027            | 0.018648           | 0.0079064          | 0.20987            | 0.54669            | 0.23642            |

FPGA Rθ J-A (°C/W) & OBT Rθ C-A (°C/W)

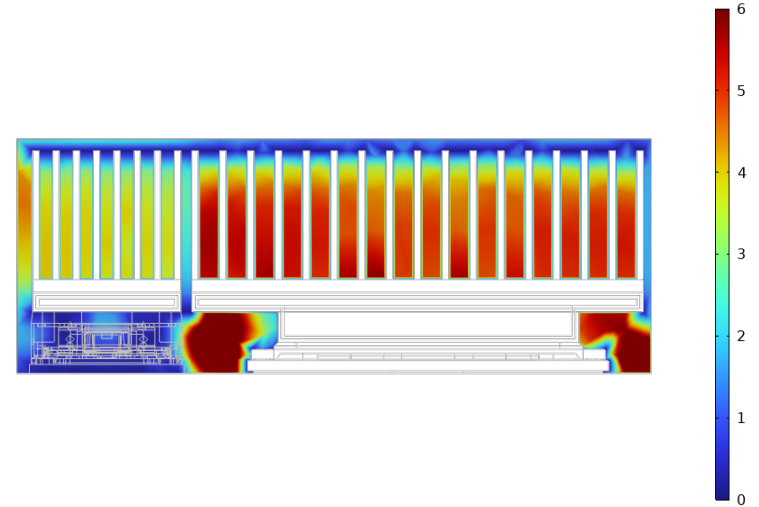


## *Simulation Passive (v6)*

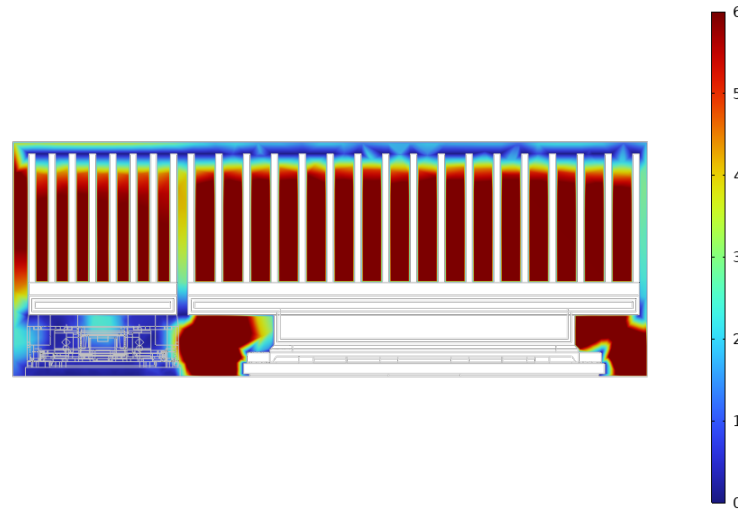
U0(1)=1 m/s



U0(2)=2 m/s



U0(3)=3 m/s



## *Simulation Active (v4)*

- Fan : RL481912
- Volume Air 312x100x36.4mm
- Tamb : 38 °C

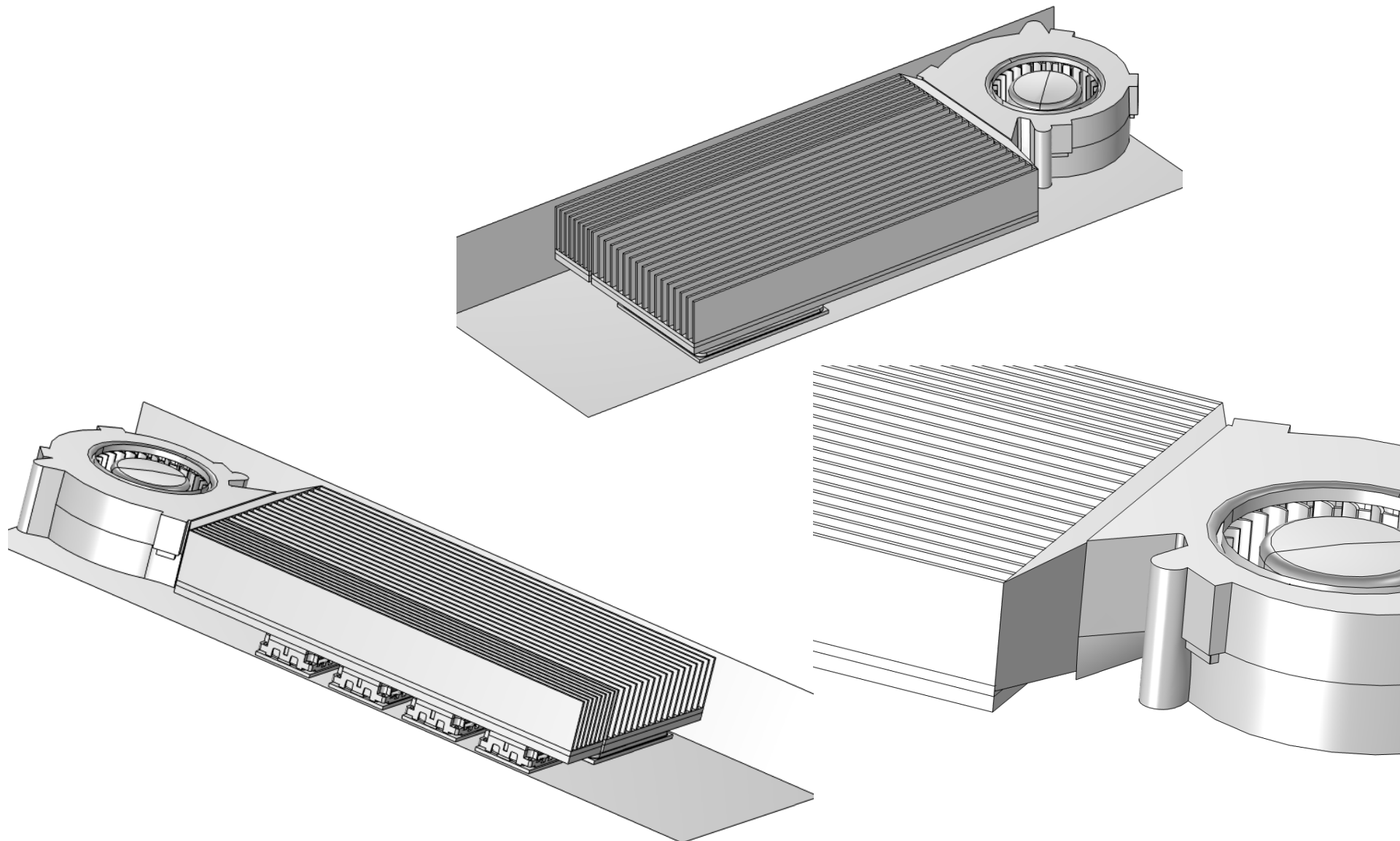
## *- FPGA Agilex*

- Dimension 56x66x4.824mm
- Heat Sink 176x70x20mm with Fins 17x1mm (Aluminum)
- Vapor Chamber 176x70x3mm with Encoche 59.7x46.6x4.7mm (Copper)
- Heat source : 156 W

## *- OBT*

- Heat Sink 176x23x18.5mm with Fins 8x1mm (Aluminum)
- Vapor Chamber 176x20x3mm (Copper)
- Heat rate LD : 3.89 W
- Heat rate TIA : 3.63 W

## *Simulation Active (v4)*



### *Simulation Active (v4) – FPGA*

| U0 (m/s) | T Die (degC) | T IHS (degC) | T VC (degC) | T HeatSink (degC) |
|----------|--------------|--------------|-------------|-------------------|
| 1.0000   | 93.901       | 89.860       | 88.984      | 88.062            |
| 2.0000   | 70.038       | 65.993       | 65.107      | 64.270            |
| 3.0000   | 61.820       | 57.772       | 56.872      | 56.078            |

| U0 (m/s) | Rθ J-C (degC/W) | Rθ C-V (degC/W) | Rθ V-S (degC/W) | Rθ S-A (degC/W) | Rθ J-A (degC/W) |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1.0000   | 0.025997        | 0.0056131       | 0.0059147       | 0.32107         | 0.35859         |
| 2.0000   | 0.026025        | 0.0056820       | 0.0053660       | 0.16848         | 0.20555         |
| 3.0000   | 0.026049        | 0.0057725       | 0.0050945       | 0.11594         | 0.15286         |

### *Simulation Active (v4) – OBT*

| U0 (m/s) | T1 Die (degC) | T1 Case (degC) | T1 ZAdapter (degC) | T2 Die (degC) | T2 Case (degC) | T2 ZAdapter (degC) |
|----------|---------------|----------------|--------------------|---------------|----------------|--------------------|
| 1.0000   | 79.114        | 69.757         | 68.932             | 78.869        | 69.519         | 68.862             |
| 2.0000   | 64.098        | 54.742         | 53.923             | 63.764        | 54.422         | 53.823             |
| 3.0000   | 59.070        | 49.723         | 48.912             | 58.685        | 49.367         | 48.798             |

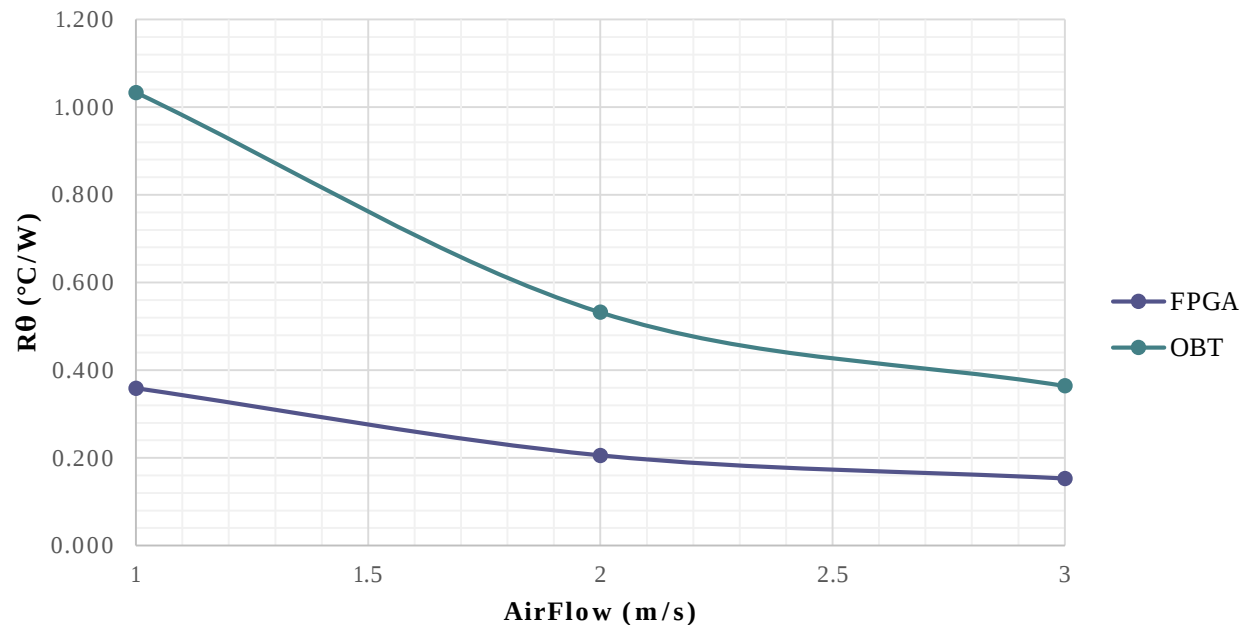
| U0 (m/s) | T3 Die (degC) | T3 Case (degC) | T3 ZAdapter (degC) | T4 Die (degC) | T4 Case (degC) | T4 ZAdapter (degC) |
|----------|---------------|----------------|--------------------|---------------|----------------|--------------------|
| 1.0000   | 78.841        | 69.502         | 68.850             | 78.758        | 69.412         | 68.848             |
| 2.0000   | 63.725        | 54.379         | 53.798             | 63.591        | 54.232         | 53.786             |
| 3.0000   | 58.651        | 49.319         | 48.767             | 58.491        | 49.149         | 48.751             |

| U0 (m/s) | T VC (degC) | T HeatSink (degC) |
|----------|-------------|-------------------|
| 1.0000   | 68.615      | 68.321            |
| 2.0000   | 53.589      | 53.368            |
| 3.0000   | 48.568      | 48.370            |

## Simulation Active (v4) – OBT

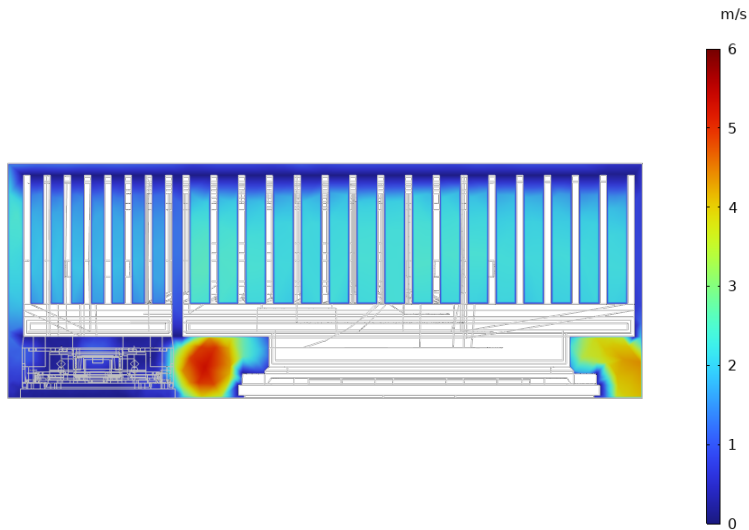
| U0 (m/s) | R $\theta$ J-C<br>(degC/W) | R $\theta$ C-V<br>(degC/W) | R $\theta$ V-S<br>(degC/W) | R $\theta$ S-A<br>(degC/W) | R $\theta$ J-A<br>(degC/W) | R $\theta$ C-A<br>(degC/W) |
|----------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1.0000   | 0.31077                    | 0.015237                   | 0.0097583                  | 1.0080                     | 1.3438                     | 1.0330                     |
| 2.0000   | 0.31084                    | 0.013606                   | 0.0073470                  | 0.51089                    | 0.84268                    | 0.53184                    |
| 3.0000   | 0.31026                    | 0.012861                   | 0.0065906                  | 0.34474                    | 0.67445                    | 0.36419                    |

FPGA R $\theta$  J-A (°C/W) & OBT R $\theta$  C-A (°C/W)

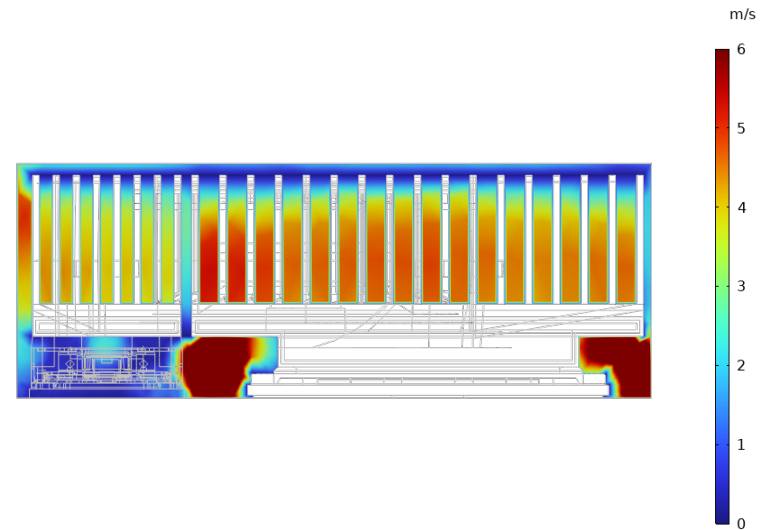


## Simulation Active (v4)

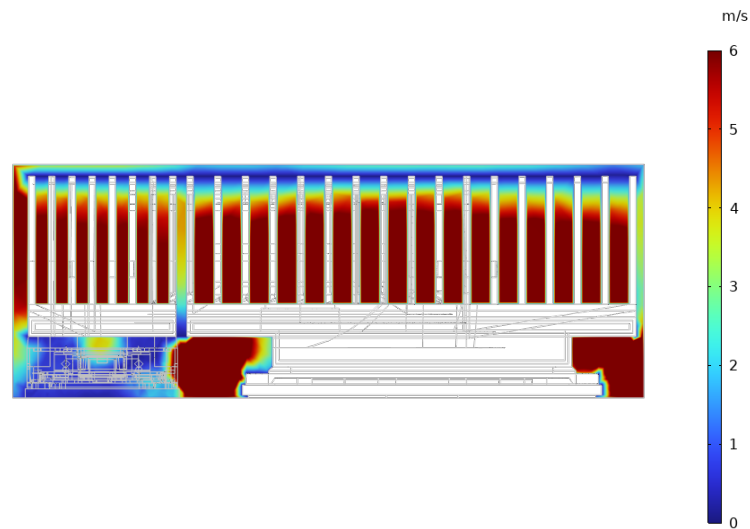
U0(1)=1 m/s



U0(2)=2 m/s



U0(3)=3 m/s



## *Simulation Active (v5)*

- Fan : RL481912
- Volume Air 312x100x36.4mm
- Tamb : 38 °C

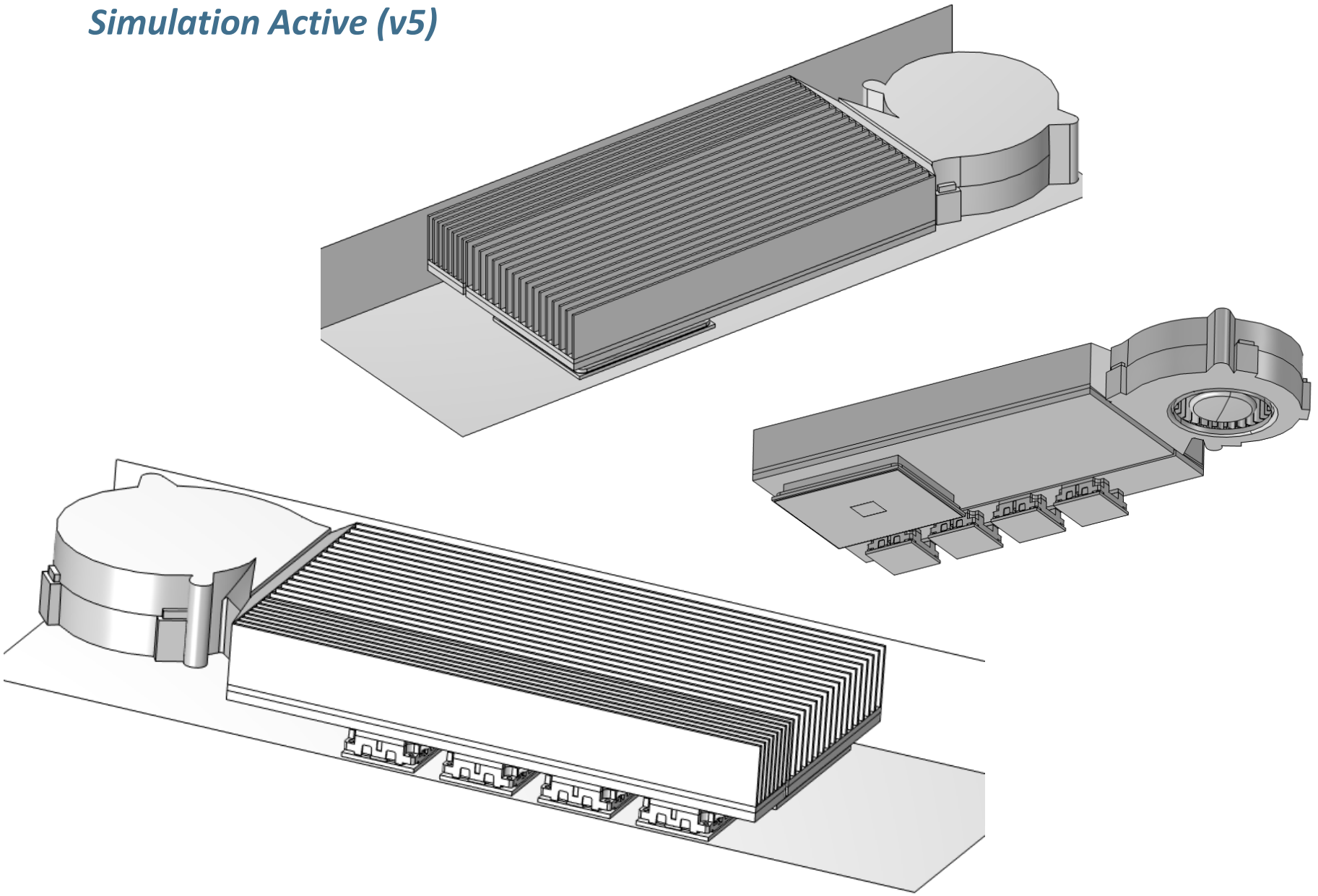
## *- FPGA Agilex*

- Dimension 56x66x4.824mm
- Heat Sink 176x70x20mm with Fins 17x1mm (Aluminum)
- Vapor Chamber 176x70x3mm with Encoche 59.7x46.6x4.7mm (Copper)
- Heat source : 156 W

## *- OBT*

- Heat Sink 176x23x18.5mm with Fins 8x1mm (Aluminum)
- Vapor Chamber 176x20x3mm (Copper)
- Heat rate LD : 3.89 W
- Heat rate TIA : 3.63 W

## *Simulation Active (v5)*



### *Simulation Active (v5) – FPGA*

| U0 (m/s) | T Die (degC) | T IHS (degC) | T VC (degC) | T HeatSink (degC) |
|----------|--------------|--------------|-------------|-------------------|
| 1.0000   | 87.098       | 83.067       | 82.141      | 80.944            |
| 2.0000   | 68.670       | 64.629       | 63.716      | 62.702            |
| 3.0000   | 61.411       | 57.365       | 56.449      | 55.513            |

| U0 (m/s) | Rθ J-C (degC/W) | Rθ C-V (degC/W) | Rθ V-S (degC/W) | Rθ S-A (degC/W) | Rθ J-A (degC/W) |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1.0000   | 0.025936        | 0.0059369       | 0.0076815       | 0.27541         | 0.31497         |
| 2.0000   | 0.026009        | 0.0058529       | 0.0065048       | 0.15842         | 0.19679         |
| 3.0000   | 0.0026041       | 0.0058766       | 0.0060042       | 0.11231         | 0.15024         |

### *Simulation Active (v5) – OBT*

| U0 (m/s) | T1 Die (degC) | T1 Case (degC) | T1 ZAdapter (degC) | T2 Die (degC) | T2 Case (degC) | T2 ZAdapter (degC) |
|----------|---------------|----------------|--------------------|---------------|----------------|--------------------|
| 1.0000   | 95.556        | 86.211         | 85.385             | 95.413        | 86.082         | 85.348             |
| 2.0000   | 67.691        | 58.335         | 57.511             | 67.423        | 58.082         | 57.431             |
| 3.0000   | 60.643        | 51.292         | 50.458             | 60.314        | 50.            | 50.333             |

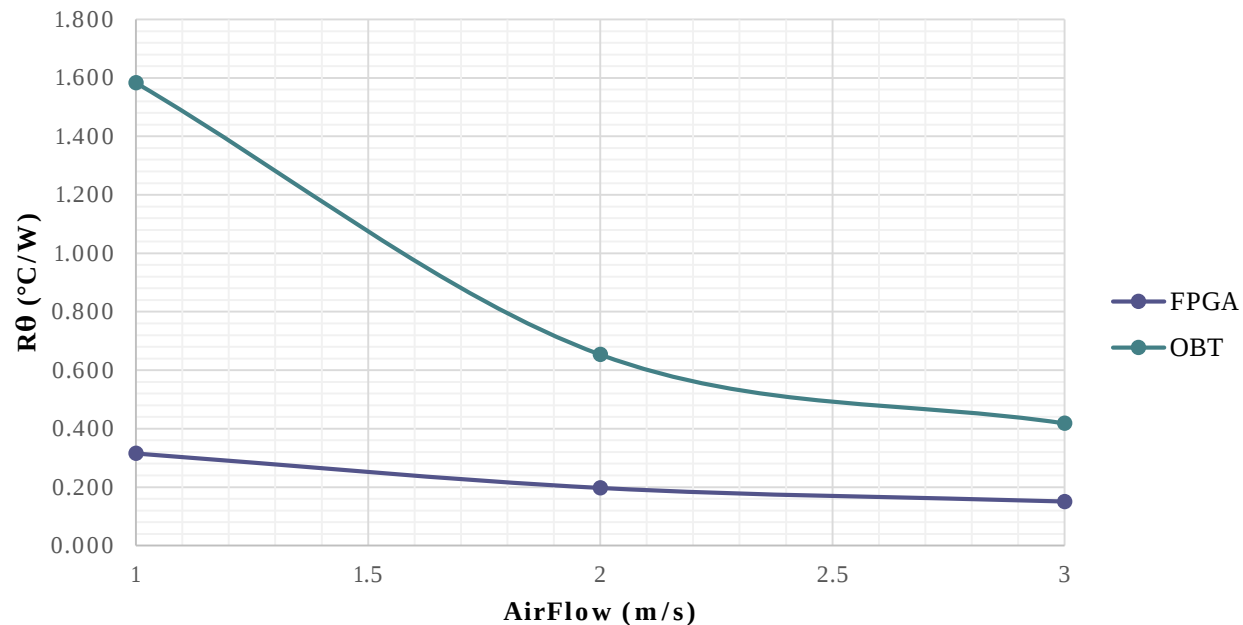
| U0 (m/s) | T3 Die (degC) | T3 Case (degC) | T3 ZAdapter (degC) | T4 Die (degC) | T4 Case (degC) | T4 ZAdapter (degC) |
|----------|---------------|----------------|--------------------|---------------|----------------|--------------------|
| 1.0000   | 95.555        | 86.222         | 85.387             | 95.415        | 86.074         | 85.366             |
| 2.0000   | 67.488        | 58.145         | 57.441             | 67.365        | 58.007         | 57.433             |
| 3.0000   | 60.348        | 51.011         | 50.327             | 60.245        | 50.896         | 50.312             |

| U0 (m/s) | T VC (degC) | T HeatSink (degC) |
|----------|-------------|-------------------|
| 1.0000   | 85.077      | 84.700            |
| 2.0000   | 57.181      | 56.856            |
| 3.0000   | 50.124      | 49.822            |

## Simulation Active (v5) – OBT

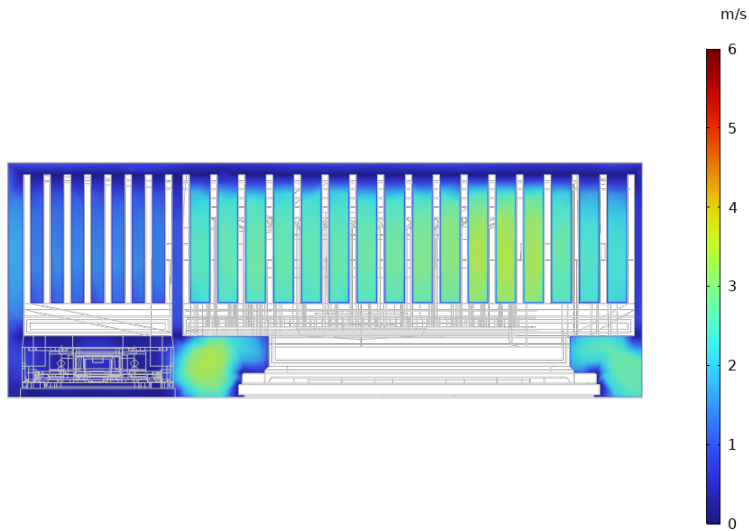
| U0 (m/s) | R $\theta$ J-C<br>(degC/W) | R $\theta$ C-V<br>(degC/W) | R $\theta$ V-S<br>(degC/W) | R $\theta$ S-A<br>(degC/W) | R $\theta$ J-A<br>(degC/W) | R $\theta$ C-A<br>(degC/W) |
|----------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1.0000   | 0.31045                    | 0.017718                   | 0.012525                   | 1.5525                     | 1.8932                     | 1.5828                     |
| 2.0000   | 0.31082                    | 0.015728                   | 0.010817                   | 0.62686                    | 0.96423                    | 0.65341                    |
| 3.0000   | 0.31046                    | 0.014996                   | 0.010055                   | 0.39301                    | 0.72853                    | 0.41807                    |

FPGA R $\theta$  J-A (°C/W) & OBT R $\theta$  C-A (°C/W)



## *Simulation Active (v5)*

U0(1)=1 m/s



U0(2)=2 m/s

