SIMCOM Module
Thermal Design Guide

Module

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GENERAL NOTES

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Version History

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2021-11-26	V1.00	First Release	Wang yaling

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1 Introduction

This document mainly introduces the thermal design part of the Module design, for reference only.

1.1 Why Need Thermal Design?

Proper thermal design significantly extends the high performance operating time without taking the risk of device failure which affects user experience adversely.

■ The module's internal electronic circuits will generate more and more heat, due to the increasing demand of high-speed communication and embedded applications.

■ Complex workspaces, which is more and more common to see, require modules to have high heat dissipation performance.

■ Heat accumulation of modules gives rise to the risk of damage on devices.
May cause burning sensations on skin/result in high surface temperature.
Some ICs may not work properly.

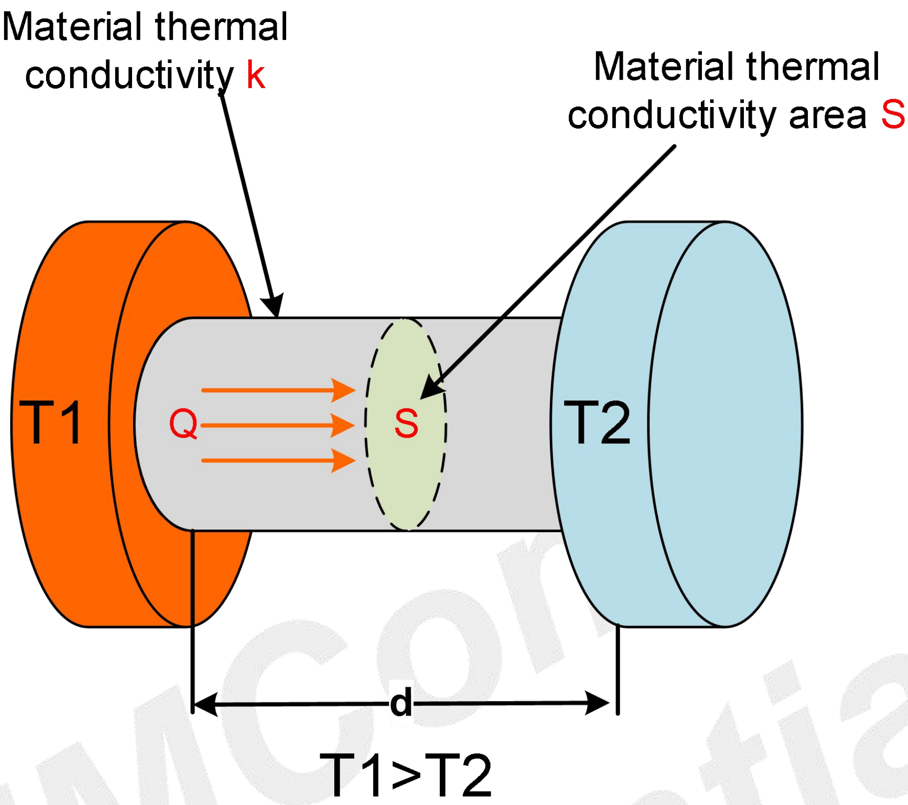
■ Users may undergo limited device performance due to thermal mitigation algorithms.

■ The module will disconnect from network automatically if the device temperature is higher than the absolute maximum temperature.

■ The module offers high performance when the internal baseband (BB) chip stays below 105℃. If the peak temperature of the BB chip reaches or exceeds 105℃, the module will not be able to provide high-performance as usual (may offer decreased RF output power, limited data rate, etc.). Therefore, the modules are recommended to optimize thermal design so as to keep the peak temperature of BB chip lower than 105℃.

1.2 Basic concept of thermal design

1.2.1 Thermal calculation formula



$$\frac{Q}{t} = \frac{k*S*(T1-T2)}{d}$$

Figure 1: Thermal calculation formula

Table 1: Thermal calculation formula description

Item	Description	Unit
Q/t	Heat transfer rate（传热率）	W
k	Thermal conductivity(导热系数)	W/m*k
S	Heat conducation area（导热面积）	m^2
T1-T2	T1-T2 Surface temperature difference（表面温差）	K
d	Heat conduction length（导热长度）	m

It can be seen from the formula that Heat transfer rate is directly proportional to the thermal conductivity of the thermally conductive material and the thermally conductive area, and inversely proportional to the thermally conductive distance.

- Materials with higher thermal conductivity (k) transfer heat better.
- Housing/enclosures with larger surface area (S) dissipate heat better.
- The smaller distance between the cooling system and heat source is preferred.

1.2.2 Thermal conductivity of common materials

Table 2: Materials thermal conductivity

Materials	Thermal conductivity	
Graphite (石墨)	k > 370 W/m*K	
Pure Copper（铜）	k = 400 W/m*K	
Pure Aluminum（铝）	k = 236 W/m*K	
Magnesium（镁）	k = 156 W/m*K	
Plastic(塑料)	k = 0.2 W/m*K	
Air（空气）	k = 0.024 W/m*K	

1.2.3 Thermal contact resistance

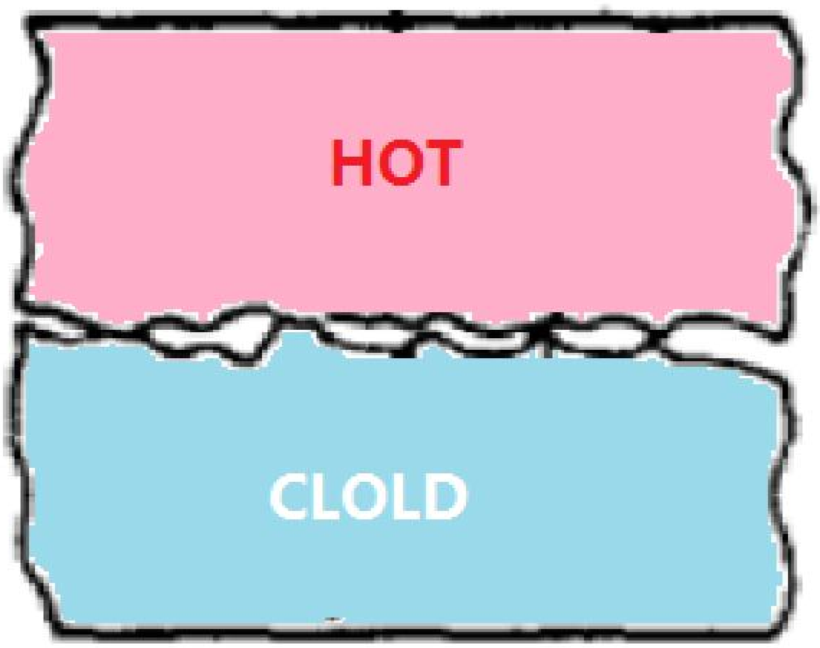


Figure 2: Thermal contact resistance

When the two-phase solid surface is in contact, it is limited by the material processing technology. The actual contact is only some discrete parts of the area. The gap between the non-contact interface is full of air, and the difference from the ideal complete contact is very large. There is actually a lot of thermal contact resistance. The method to reduce the contact thermal resistance is to increase the contact pressure and the interface material (thermal conductive silica gel, etc.) to fill the gap between the interfaces

2 Thermal Design

2.1 Structure Design

1.Select walls with thinner thickness because of smaller thermal resistance.

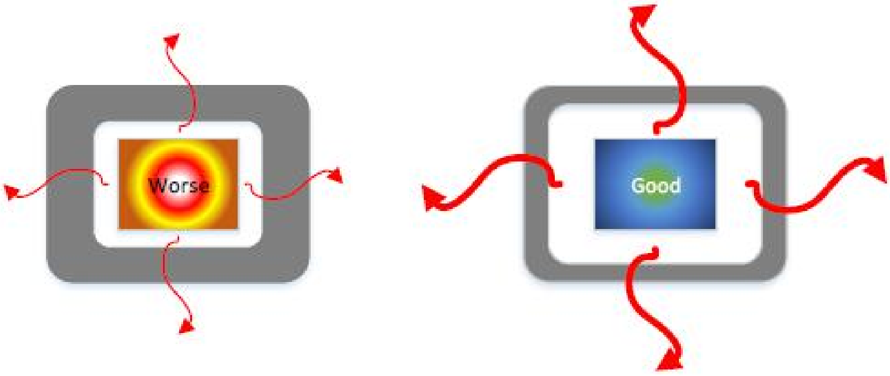


Figure 3: Comparison of Housing thickness

2.Try to expand the internal space as much as possible for better convection.

Figure 4: Comparison of Housing space

3. Reserve enough space to add a heat sink on the top of the module as well as the opposite side of the PCB area where the module is mounted.

4.If the internal space is small, it is recommended to add a Thermal silica with high thermal conductivity between the module and the housing/enclosure.

5. Do not install any battery or other components that may generate heat both at the top and bottom of the module.

2.2 Heat Sink Design

■ If the housing/enclosure is made up of aluminum alloy, it is recommended to integrate the heat sink with the housing/enclosure.

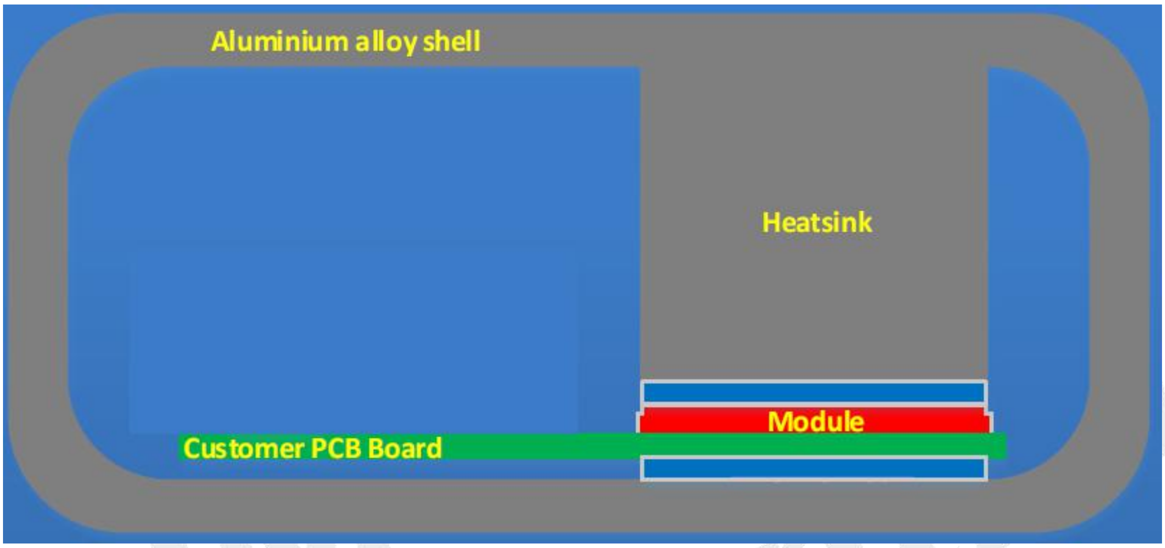


Figure 5:Module Thermal silica place position

■ If the housing/enclosure is made up of plastic, it is recommended to design an independent heat sink whose heat dissipation surface should be outside the housing/enclosure.

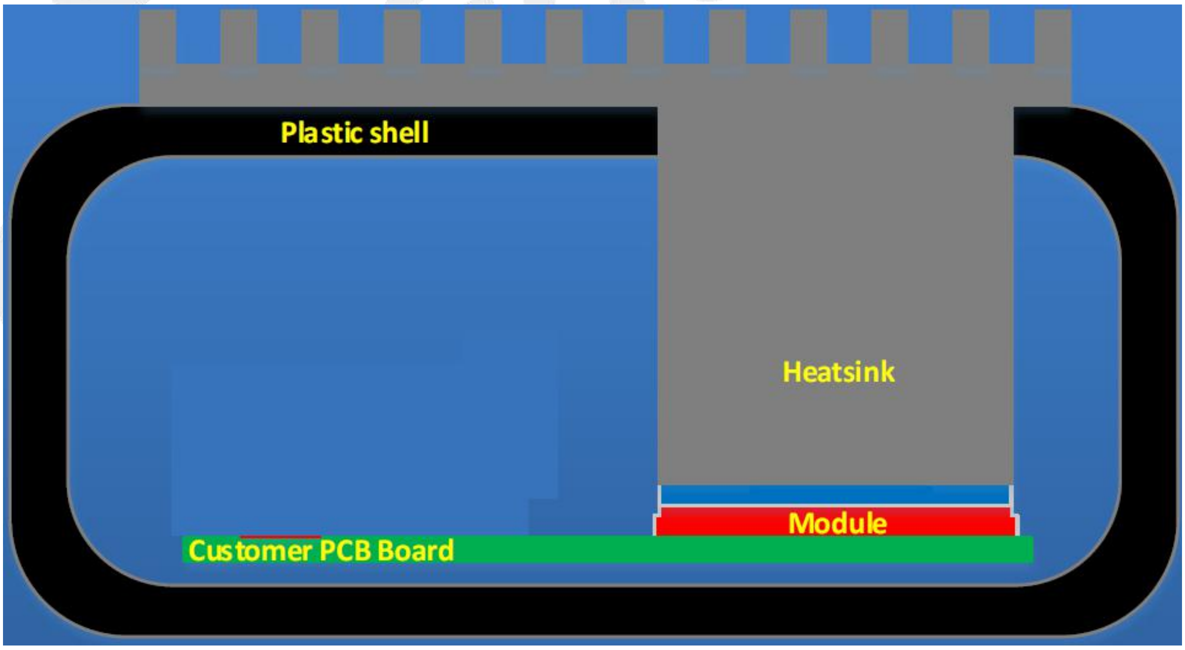


Figure 6: Module far awaly hot components

■ Increase the number of heat sink fins as many as possible.

2.3 Thermal silica Design

1.Thermal silica thickness:
The Thermal silica thickness is recommended to be 0.5mm greater than the distance between the module's top/bottom side and the heat sink (or housing/enclosure). It is recommended that the maximum thickness is less than 3mm.

2.Thermal silica position:
Cooling system on top side of the module: the Thermal silica is used between the module's shielding cover and the heatsink (or housing/enclosure).
Cooling system on bottom side of the module: the Thermal silica is used between the PCB area on opposite side of

Example:
Taking M.2 module as an example, the Thermal silica is placed between the module's bottom side and the PCB. In such case, please do not apply solder mask on the connection area so as to ensure better heat dissipation performance. The solder mask size should be almost the same as the bottom size of the module.

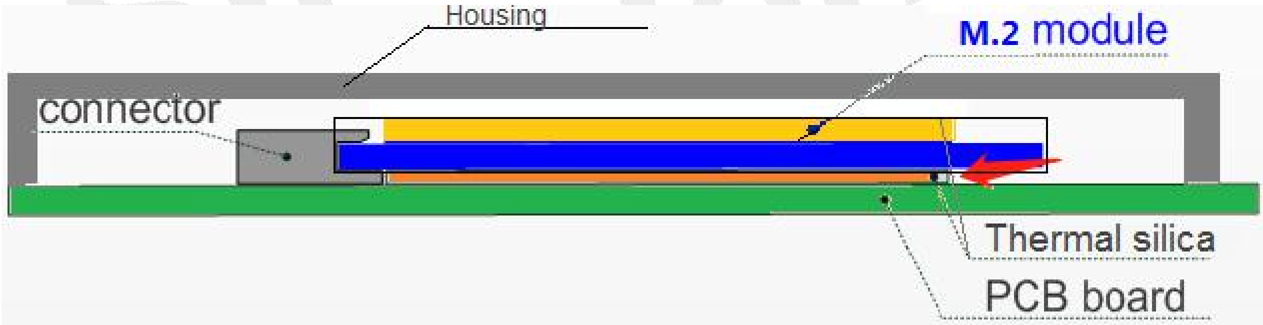


Figure 7:Module Thermal silica place position

2.4 PCB Design

1. Larger PCB size is beneficial for components placement and has the better performance for heat dissipation
2. Keep the module away from the ARM, audio amplifier, and other components that may generate heat.
3. Keep the module away from the heat sensitive elements such as the TCXO/XO.

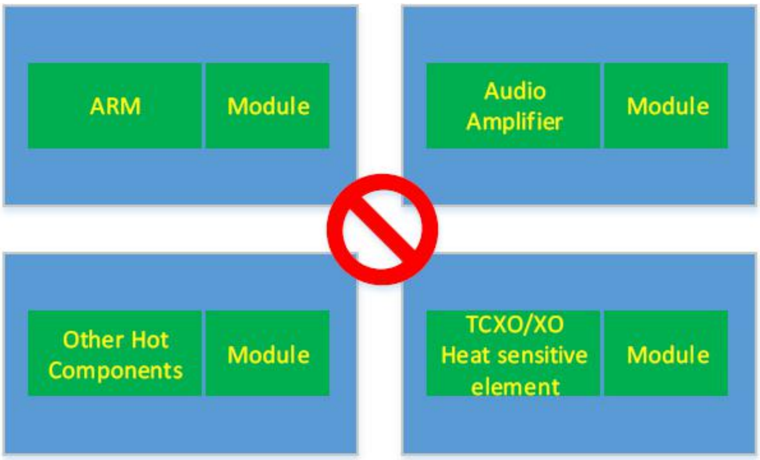


Figure 8: Module far awaly hot components

4. PCB Components place

■ Best design:

To facilitate adding of the heat sink when necessary, please do not place components on the opposite side of the PCB area where themodule is mounted, and do not place components on both the PCB top and bottom areas where the M2 module is installed.

■ Good design:

Place only some passive components with small packages, such as resistors, capacitors, and inductors, on the opposite side of the PCB area where the module is mounted, and leave a large blank area for adding the cooling system.

■ Bad design:

Placed many components with large packages and even heat sourceson the opposite side of the PCB area where the module is mounted.

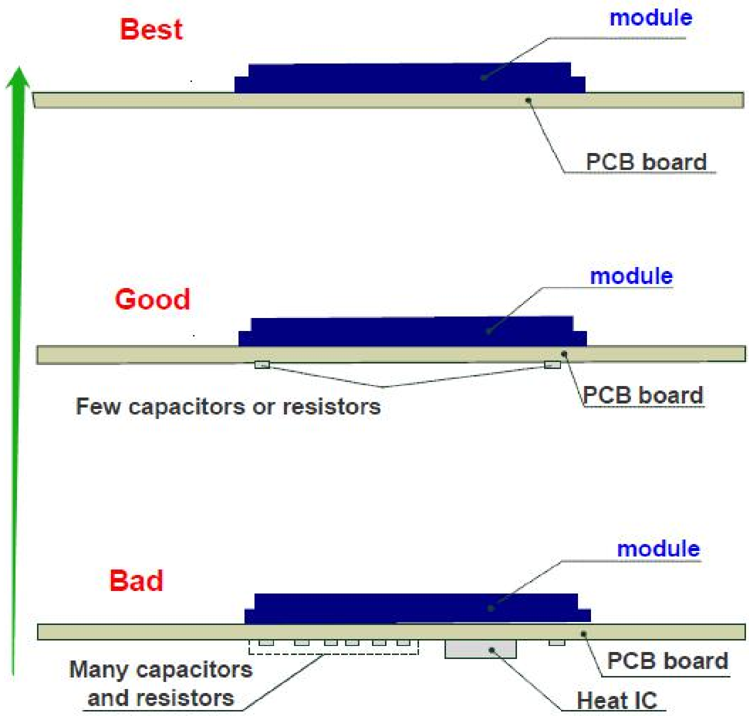


Figure 9: Comparison of components placement methods around the module

5. PCB Copper plane design:

- Add layers as many as possible and increase the copper area at each layer.
- Increase the size of the GND plane as much as possible.
- Fill empty layers with copper wherever possible.
- Increase the power supply plane using thick/wide traces as many as possible.
- Try to keep the copper plane as a whole.

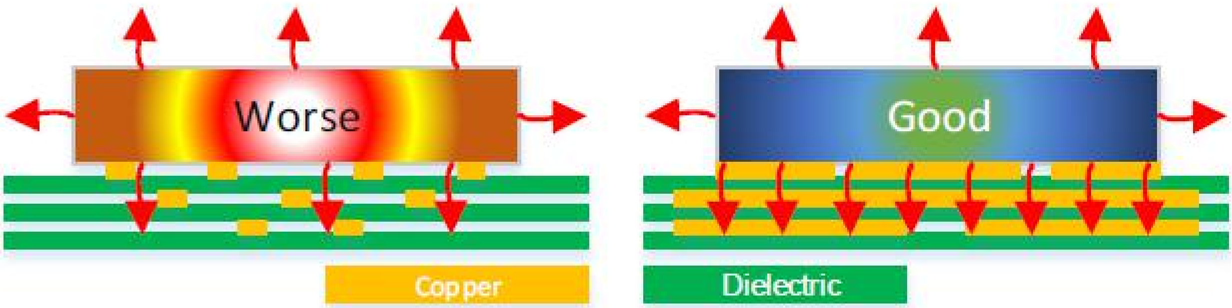


Figure 10: Comparison of PCB Copper plane design

6.PCB Vias design:

- Add adequate vias under and near the module.
- Connect the vias to a large GND plane for better heat dissipation.
- Large vias are better than small vias.
- Through holes are better than buried vias and blind vias.
- Stacked vias are better than staggered vias.

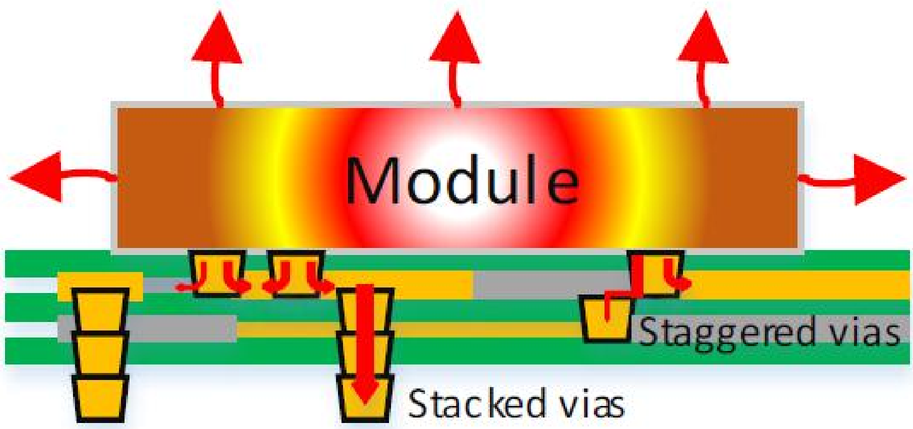


Figure 11: PCB Vias design

7. About solder mask:

Do not apply solder mask on the PCB area where the module is mounted or installed to provide better heat dissipation performance.

2.5 Heat Dissipation Diagram

1.Aluminum alloy shell andrecommended cooling system design of LCC/LGA module

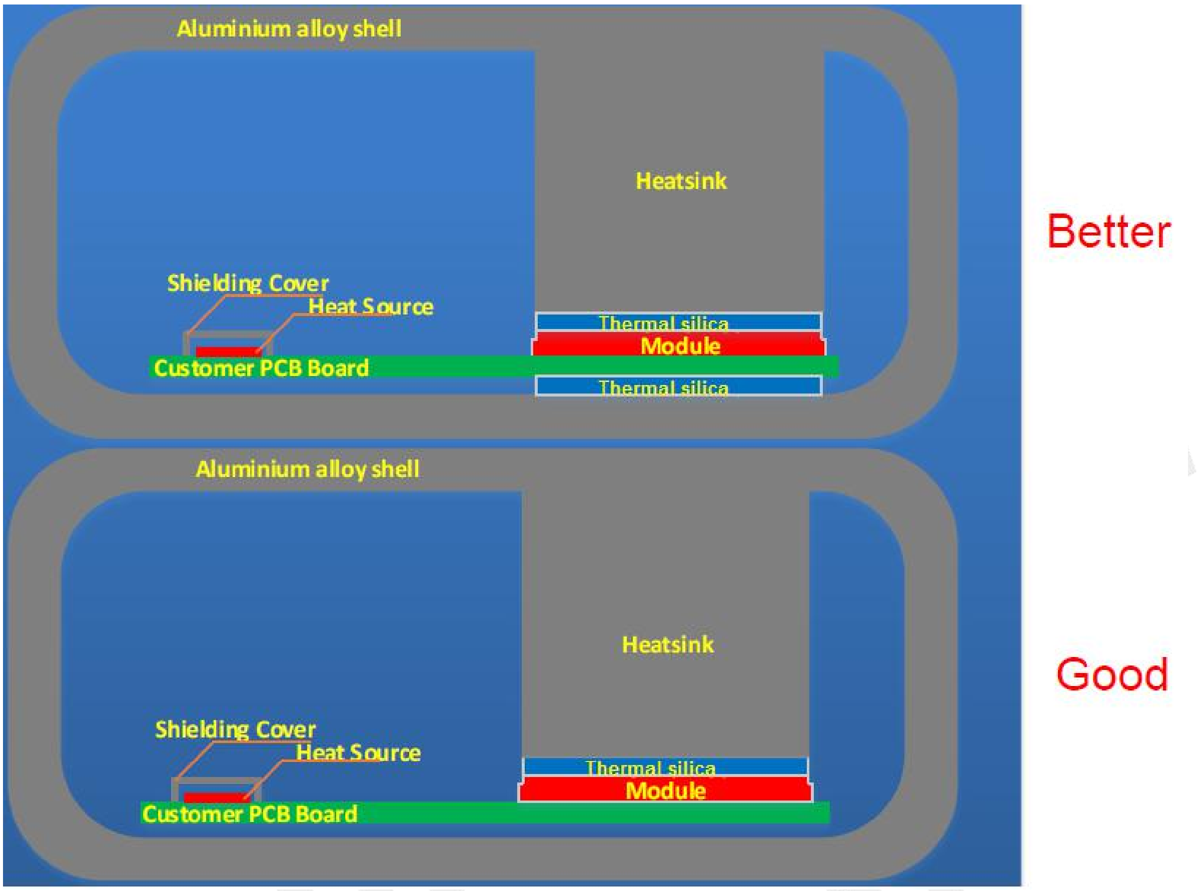


Figure 12: Aluminum alloy LCC/LGA module Comparison of Single and double-sided heat dissipation

2.Aluminum alloy shell andrecommended cooling system design of Mini PCIe-C or M.2 module

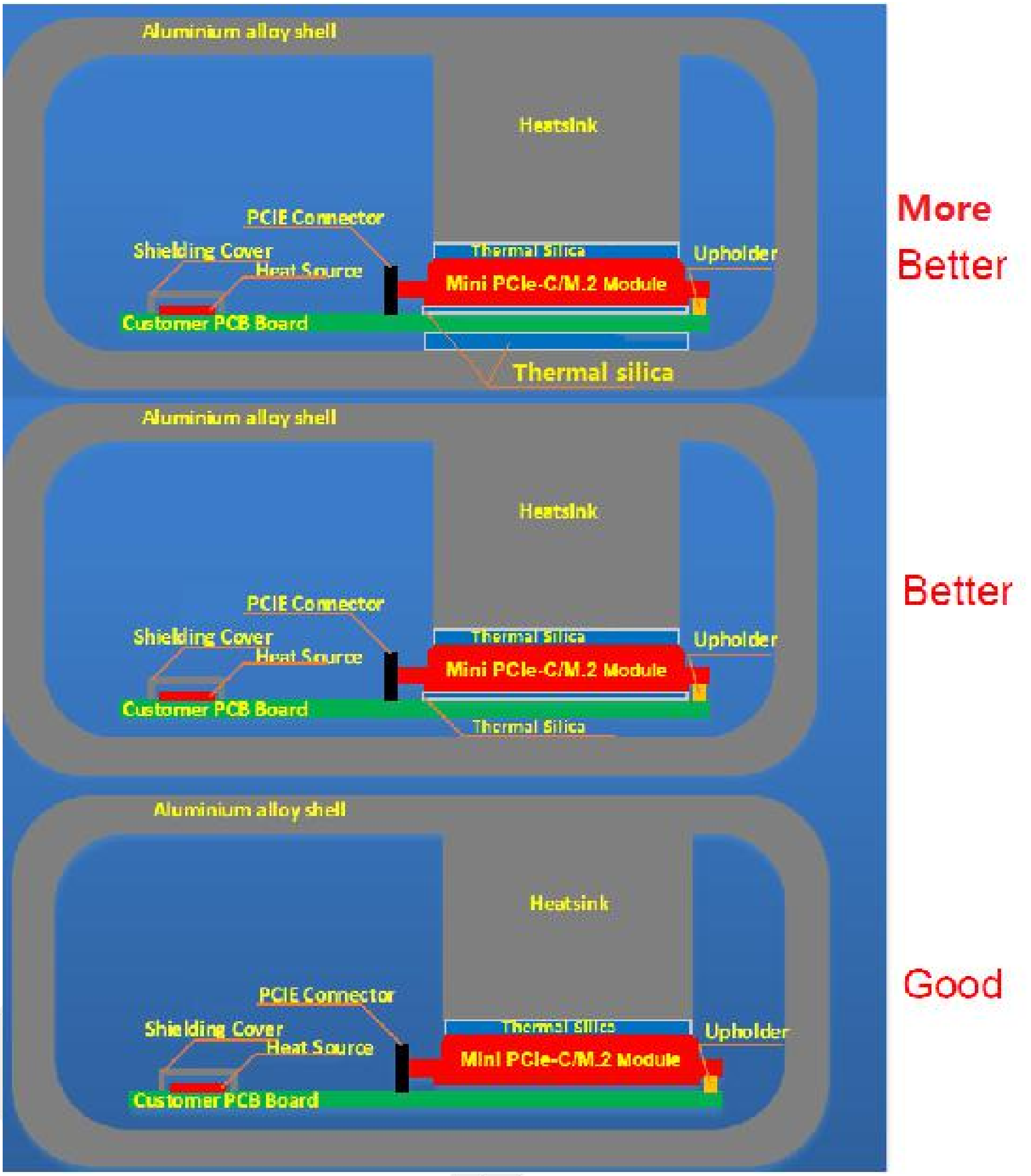


Figure 13: Aluminum alloy M.2 module Comparison of Single and double-sided heat dissipation

3.Plastic shell and recommended cooling system design of LCC/LGA module

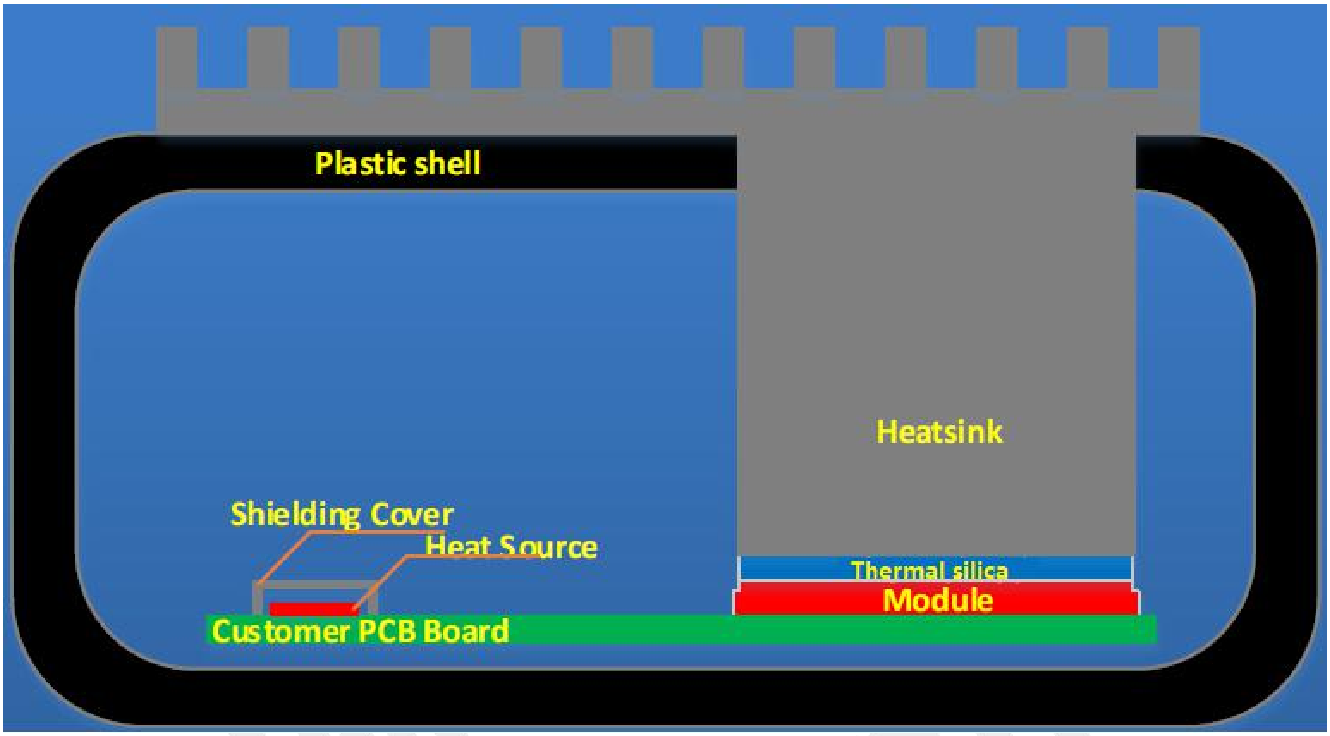


Figure 14: Plastic LCC/LGA module dissipation

4.Plastic shell and recommended cooling system design of Mini PCIe-C or M.2 module

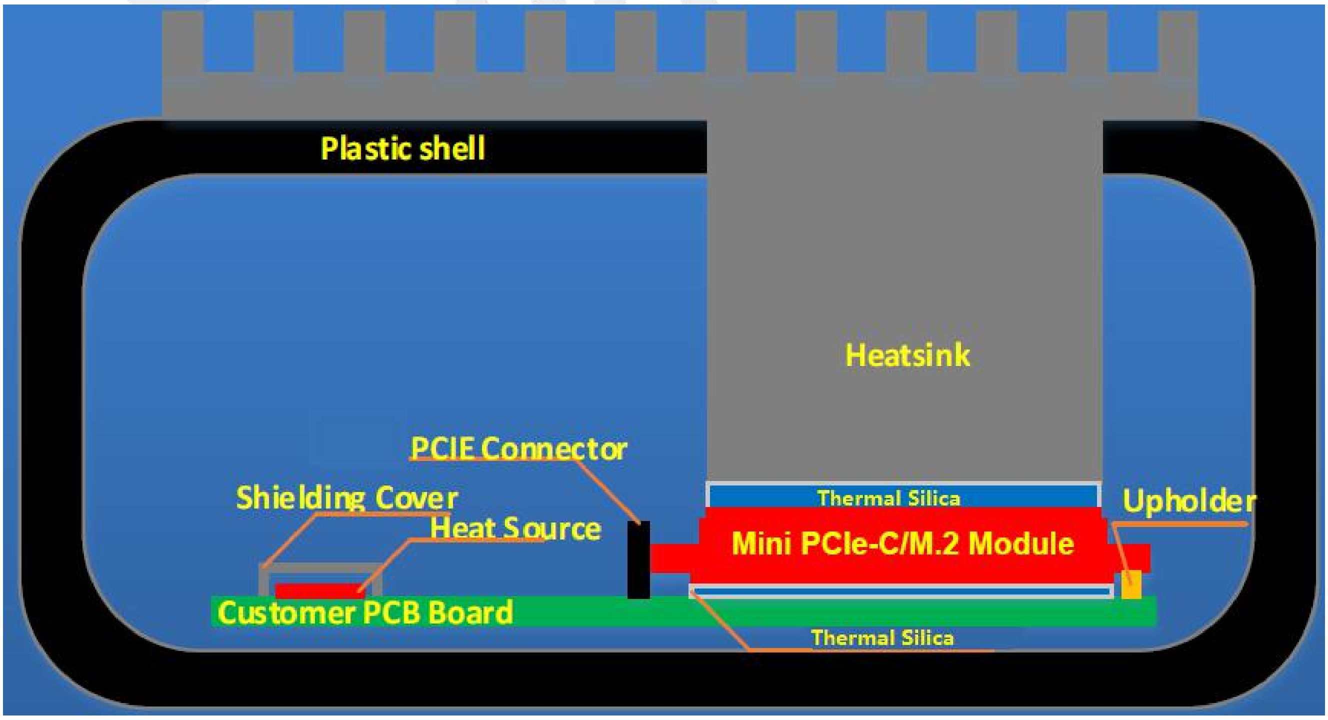


Figure 15: Plastic M.2 module Comparison of heat dissipation

3 Test

3.1 Test Environment

3.1.1 LCC/LGA module test environment

A

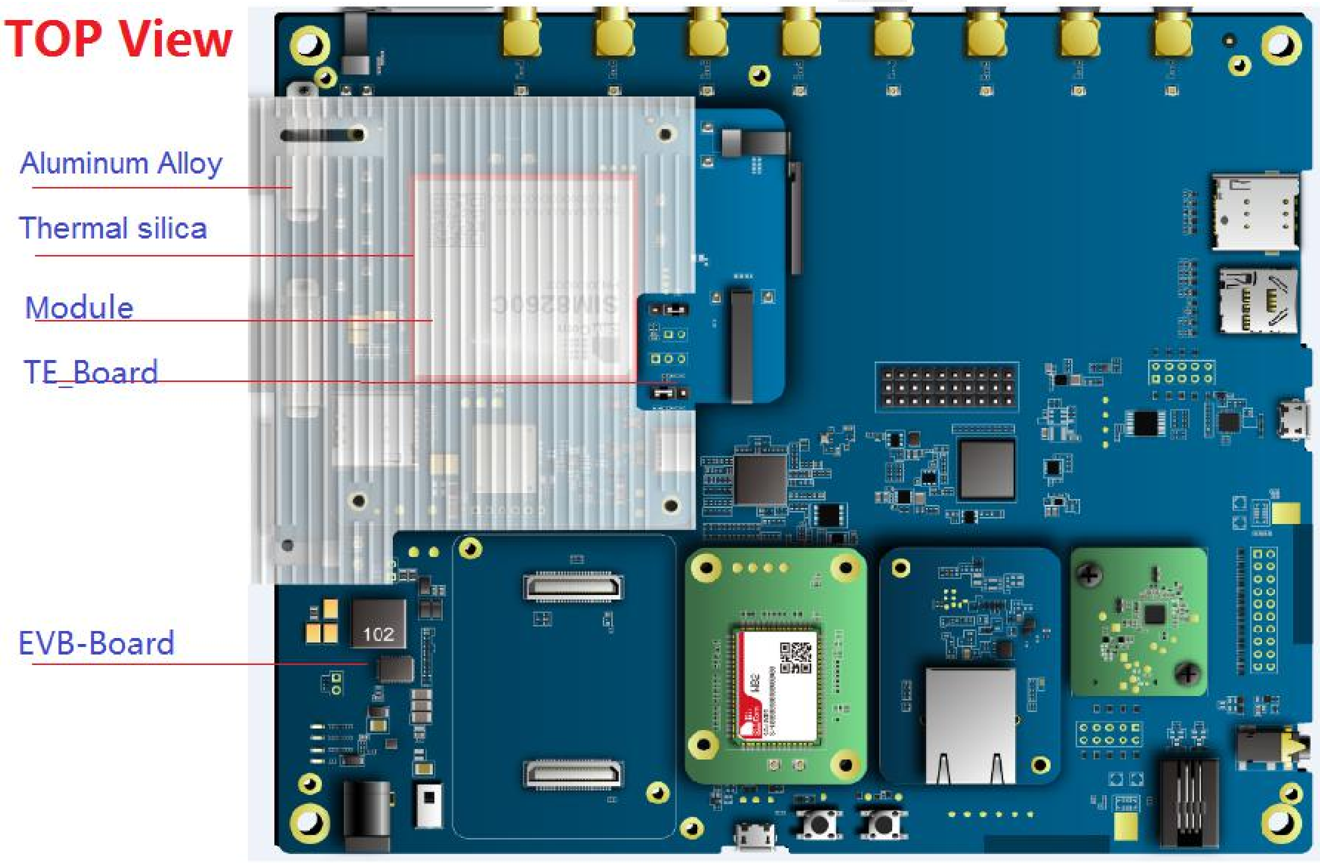


Figure 16: LCC/LGA module TOP View

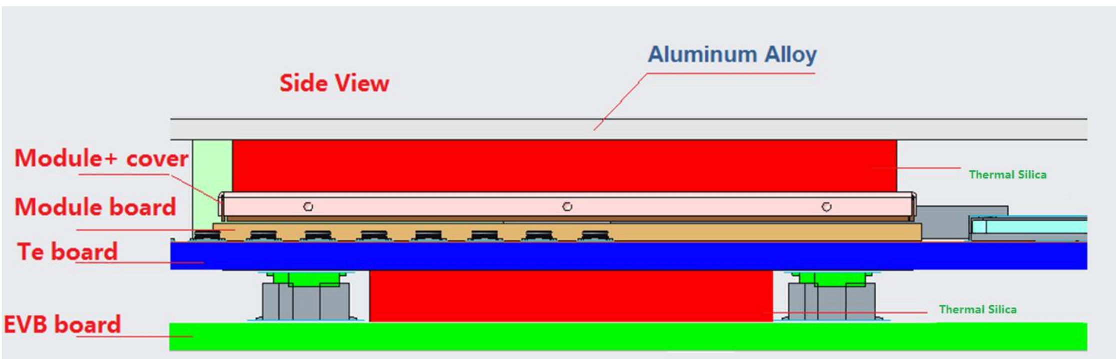


Figure 17: LCC/LGA module Side View

3.1.2 M.2 Module test environment

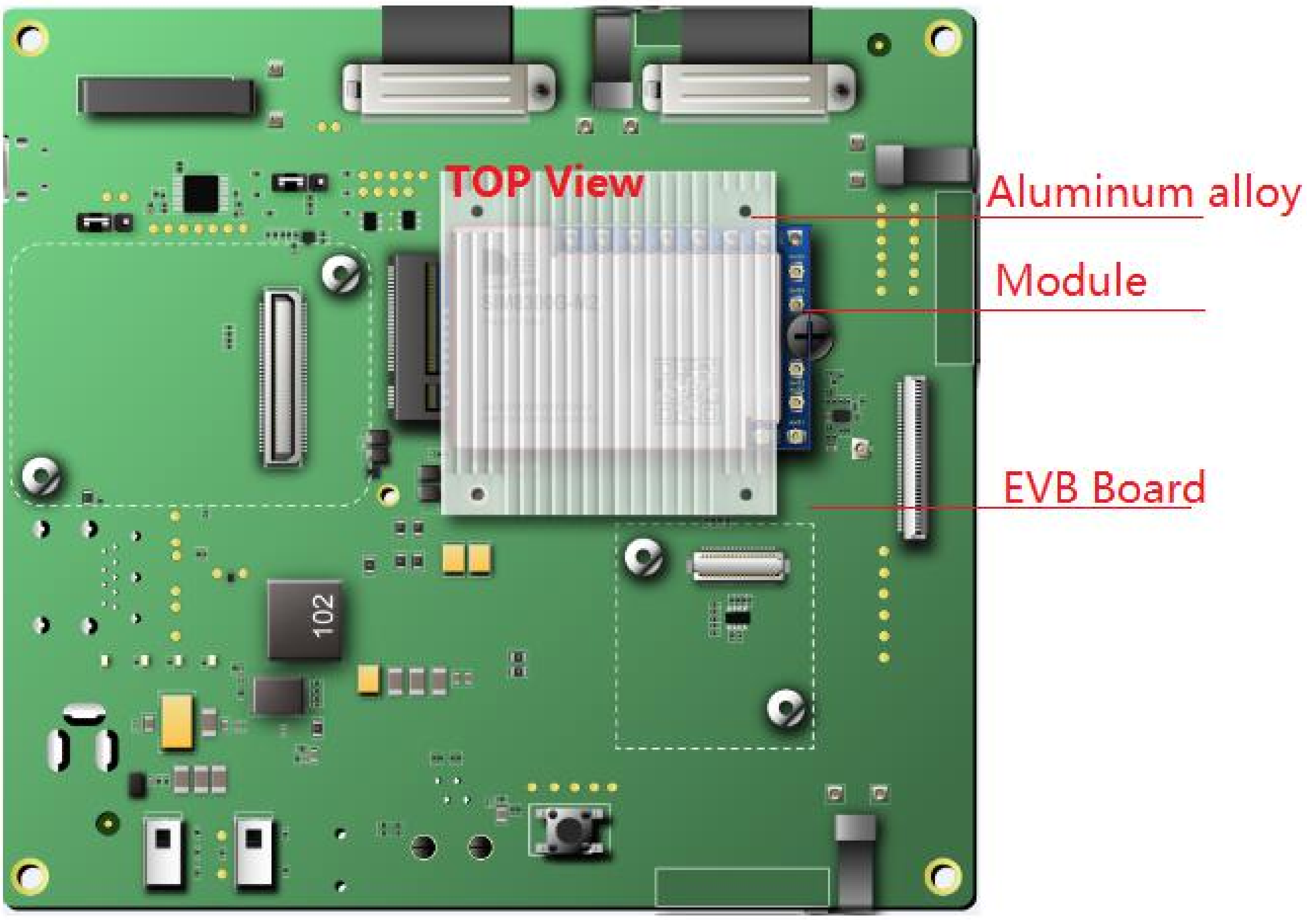


Figure 18: M.2 Module TOP View

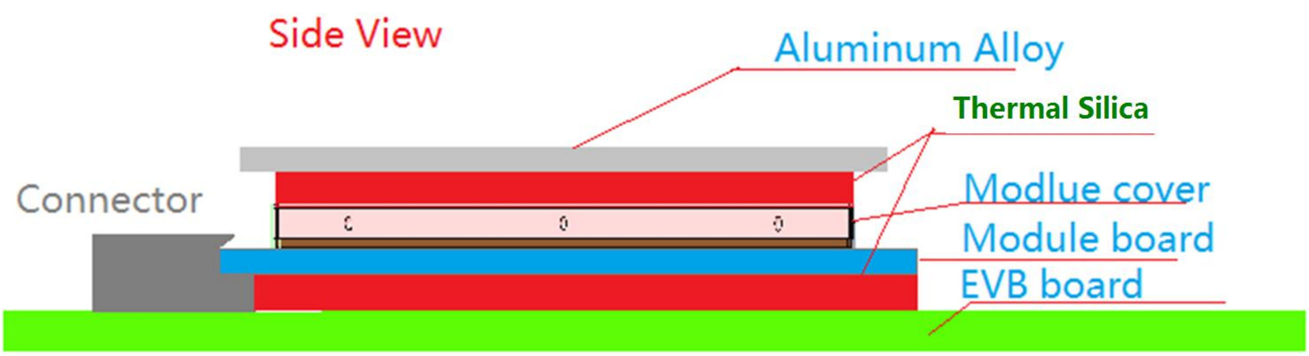


Figure 19: M.2 Module Side View

3.1.3 Thermostat test environment

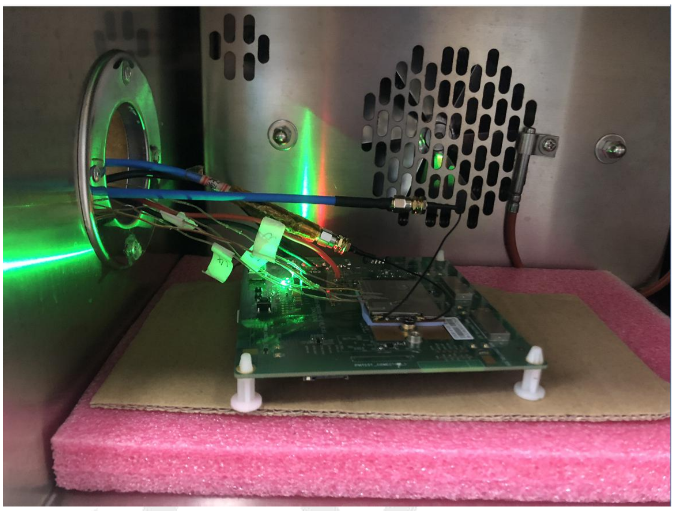


Figure 20: Thermostat environment

3.2 Test Condition

5G Module Test Condition

- Power the EVB by Programmable power supply
- Connect the antenna of the module to MT8000A through RF cable
- Set ENDC:B3+N79 ,the :B3 max power 23dB, B79 max power 23dB ,max data rate, and UDP transfer mode
- Put the module into the thermostat, open the thermostat from 47°C to 70°C (in increments of 5°C), test each temperature for 15 minutes, and record the temperature of each area of the module at this time by sending ADB or AT commands.

4G Module Test Condition

- Power the EVB by 5V DC power supply
- Connect the main antenna of the module to CMW500 through RF cable
- Set the max power, max data rate, and UDP transfer mode
- Put the module into the thermostat, open the thermostat from 47°C to 70°C (in increments of 5°C), test each temperature for 15 minutes, and record the temperature of each area of the module at this time by sending ADB or AT commands.

The test condition is to simulate the temperature rise under the maximum transmit power of the module and the uplink and downlink rate. If you need other conditions to test, please contact us.

4 Thermal simulation data

SIMCOM can provide the following data, and customers can use these data to do thermal simulation in combination with their own structural design.

Table 3: Thermal simulation data

NO.	Description
[1]	Thermal simulation model of the main heating chip of the module
[2]	Module main heating chip coordinate file
[3]	Module PCB board laminated structure