SG2300X
Thermal and Mechanical Design Guide

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Revision History

Revision	Revision Date	Author	Comments
1.0	2022-09-26	Sam Du, Echo Lei, Emily Duan	Initial Release
1.1	2022-12-27	Sam Du	Update Package size

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Catalogue

1. SG2300X Thermal Design Information

1.1 Temperature Specifications

Table 1-1 SG2300X Thermal Temperature Spec.

Parameter	Minimum	Typical	Maximum	Unit
Absolute Minimum and Maximum Temperature (Tj)	TBD	-	125	℃
Recommended operating temperature range(Tj)	TBD	-	85	℃

Notes：

1. The chip junction temperature cannot be greater than the “absolute junction temperature” specified in Table 1-1 under any condition. If the junction temperature exceeds this value, the chip may be damaged physically
2. The chip junction temperature must be within the recommended operating temperature range at normal working mode
3. The chip junction temperature is proportional to the chip power consumption, so it’s necessary to control the chip junction temperature within a reasonable range to match the power supply specifications

1.2 Thermal Resistance Parameters

The main description and heat transfer path are as follows:

Tj: the junction temperature

Ta: the ambient or environment temperature

Tc: the compound surface temperature

Tb: the surface temperature of PCB bottom

P: total input power

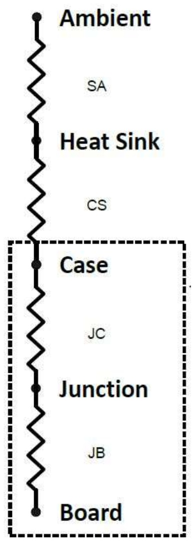
Junction-to-ambient thermal resistance, Theta Ja ϴ ja=(Tj-Ta)/P	
Junction-to-Case thermal resistance, Theta Jc ϴ jc=(Tj-Tc)/P	
Junction-to-Board thermal resistance, Theta Jb ϴ jb=(Tj-Tb)/P	

Table 1-2 SG2300X Thermal Resistance

SG2300X	Rjc(℃/W)	Rjb(℃/W)	Rja(℃/W)
	0.15	6.47	19.44

Notes:

Thermal resistance is given based on JEDEC JESD51 series standards. The system designer and environment may be different from JEDEC JESD51 series standards when applied, and analysis should be made according to the application conditions:

1. RJA，please refer to JESD 51-2
2. RJB, please refer to JESD 51-8
3. RJC, please refer to：

(1) MIL-STD 883 1012.1

(2) SEMI G30-88

2. SG2300X Package Thermal Design

2.1 Package Information

SG2300X is FCBGA package, the package size is 21mm x 21mm and Ball pitch is 0.4mm, the total number of Balls is 2441. See the figure below for details:

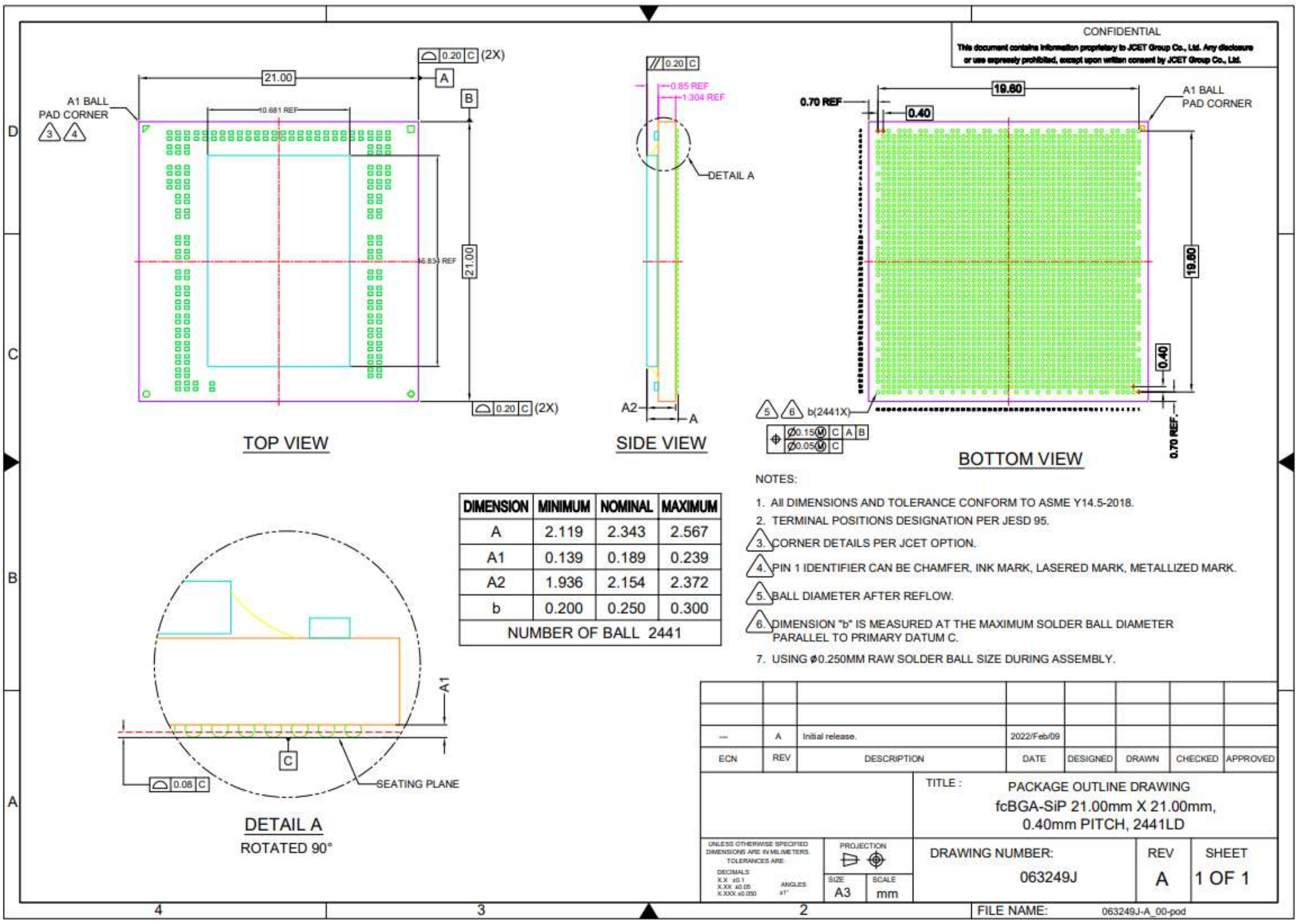


Fig.2-1 Package Outline Drawing of SG2300X

2.2 Package Assembly

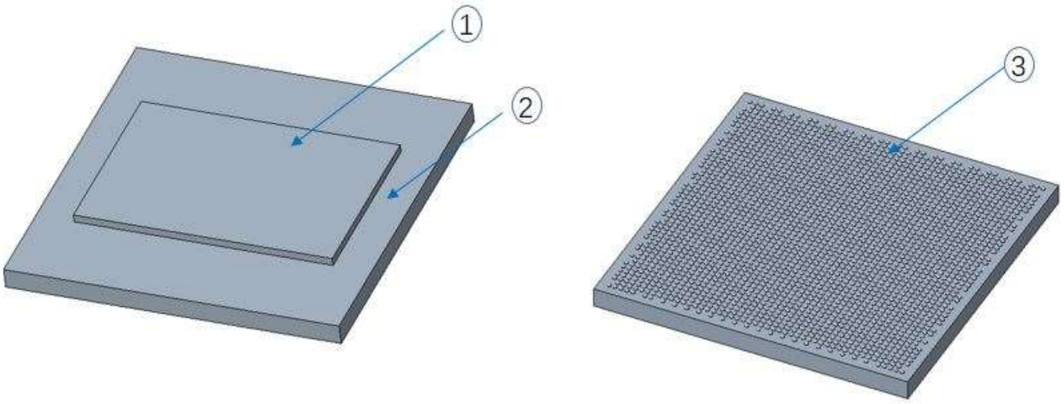


Fig.2-2 Assembly Diagram

The package illustrations below include the following features:

1. Processor Die
2. Package Substrate + bump
3. Solder Balls

2.3 Processor Materials

Table 2-1 Key Components and Materials Information

Component	Material
Die	Silicon
Substrate	ABF-GX92
Solder Balls	SAC305

3. SG2300X Thermal Design Guide

3.1 Thermal Design Guide

SG2300X's power consumption is high, thermal design suggestions are as below：

1. It's recommended to design a heat-sink for the chip separately
2. Active cooling is preferred to improve cooling capability and reduce chip temperature
3. If passive cooling is necessary, sufficient cooling capacity is required to meet the chip spec requirements, and surface treatment technology (such as spraying or anodic oxidation) is required for the fins to increase thermal radiation

3.2 Thermal Interface Material Selection Suggestion

3.2.1 Why Use Thermal Interface Material(TIM)

Usually, the chip surface and the heat-sink surface are always convex and concave, or even twisted. When the two surfaces contact, the contact only occurs at the highest point, and the low point forms a gap filled with air. The thermal conductivity of air is very small, resulting in a very large contact thermal resistance of the contact surface. The use of TIM can eliminate the low air voids, and the thermal conductivity of TIM is usually more than 10 times that of air, so as to reduce the contact thermal resistance of the interface and improve the thermal conduction ability.

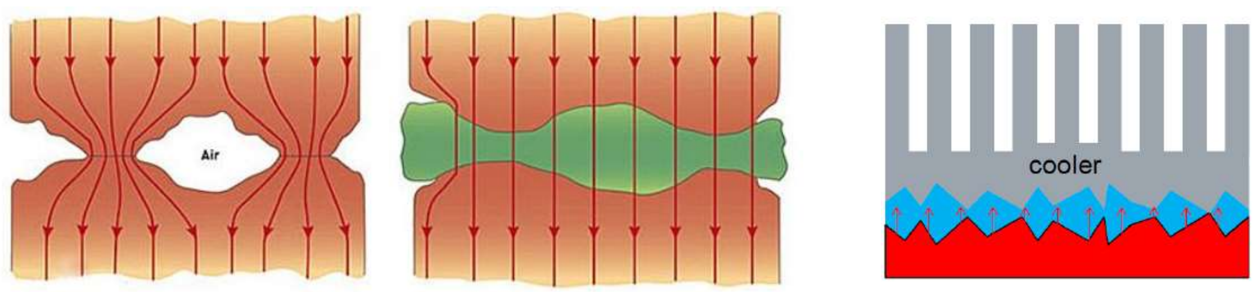


Fig.3-1 Gap between Chip and Heat-sink Surface

3.2.2 TIM Selection Suggestion between SG2300X and Heat-sink

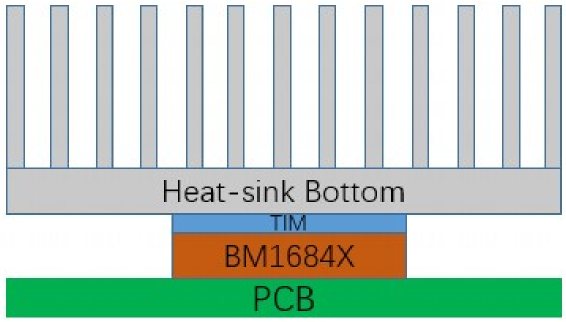


Fig.3-2 TIM Position

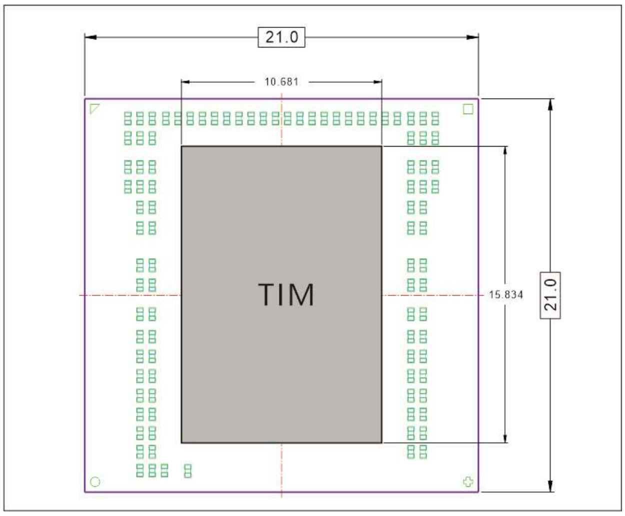


Fig.3-3 TIM Smear/Paste Area

Notes:

1. Considering SG2300X power consumption, in order to reduce the influence of thermal resistance, it's recommended to choose thermal grease (thickness: 0.1-0.15mm, thermal conductivity greater than 3W/m.k) or phase change materials as TIM
2. If the gap pad is chosen as TIM, it's recommended that the thickness of the gap pad is not greater than 0.5mm, and the thermal conductivity is above 5W/m.k
3. When choosing other TIM, it's necessary to design accordingly according to actual system requirements

3.3 Active Cooling Design Suggestion

3.3.1 Heat-sink with Fan

The follow design comes with its own fan in the middle of the aluminum profile, the air duct direction can be up and down, or the frameless fan can be chosen and the air flow is blown around, in order to increase the thermal convection capacity.

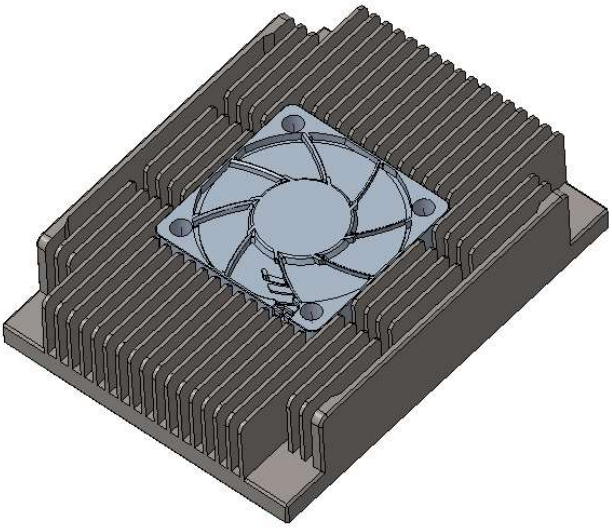


Fig.3-4 Active Cooling Heat-sink

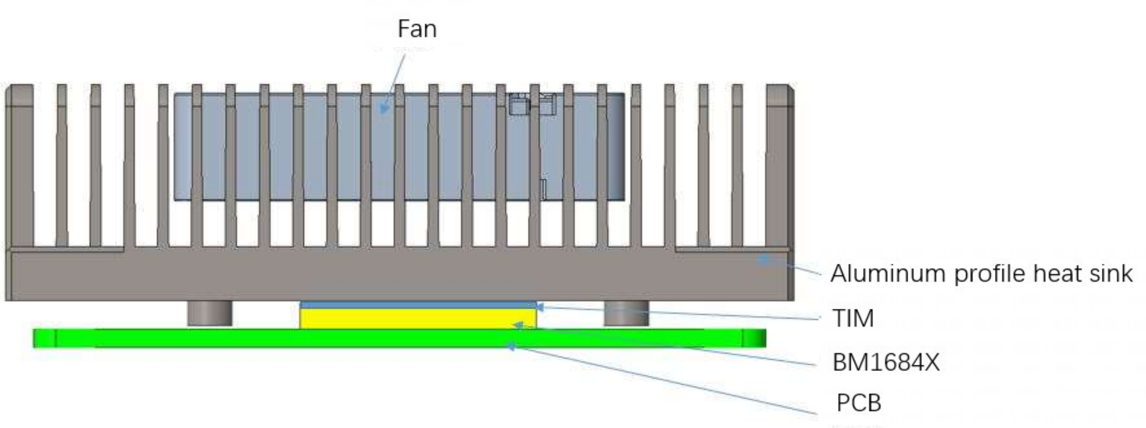


Fig.3-5 Side View of Active Cooling Heat-sink

Notes:

1. Users can design different active cooling based on actual situation
2. Heat-sink reference size: 90(L)*70(W)*25(H)mm, Material: Al6063
3. Fan performance: recommended maximum air flow＞10cfm and size ＞ 40mm
4. The TIM used for this thermal evaluation is thermal grease (thickness: 0.1mm, thermal conductivity: 4W/m.k)

3.3.2 Heat-sink without Fan, it need Chassis Fan for Cooling

If there is only a heat-sink (without a fan) on the SG2300X, it’s necessary to use the Chassis fans to assist in cooling. In this case, the system must provide a certain air flow and pressure to ensure that the chip temperature is controlled within the specifications. The recommended parameters are as follows：

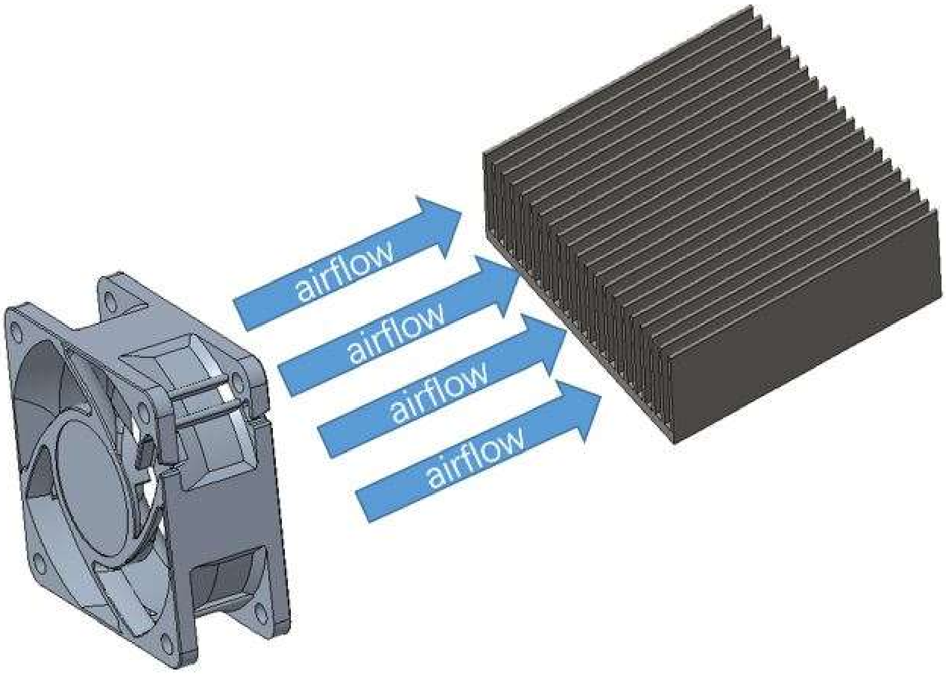


Fig.3-6 Heat-sink without Fan

Notes：

1. The TIM used for this thermal evaluation is thermal grease (thickness: 0.1mm, thermal conductivity: 4W/m.k)
2. Heat-sink reference size: 60(L)*60(W)*25(H)mm
3. Material: Al6063
4. Fan: Axial or Blower fan

Table 3-1 Minimum CFM Requirements per Inlet Air Temperature

Heat-sink inlet temperature/ °C	Minimum airflow rate/CFM	Minimum pressure drop /inch H2O
70	15	0.27
60	8.5	0.15
50	4.3	0.09
40	3	0.07
35	2.3	0.06
<30	1.8	0.05

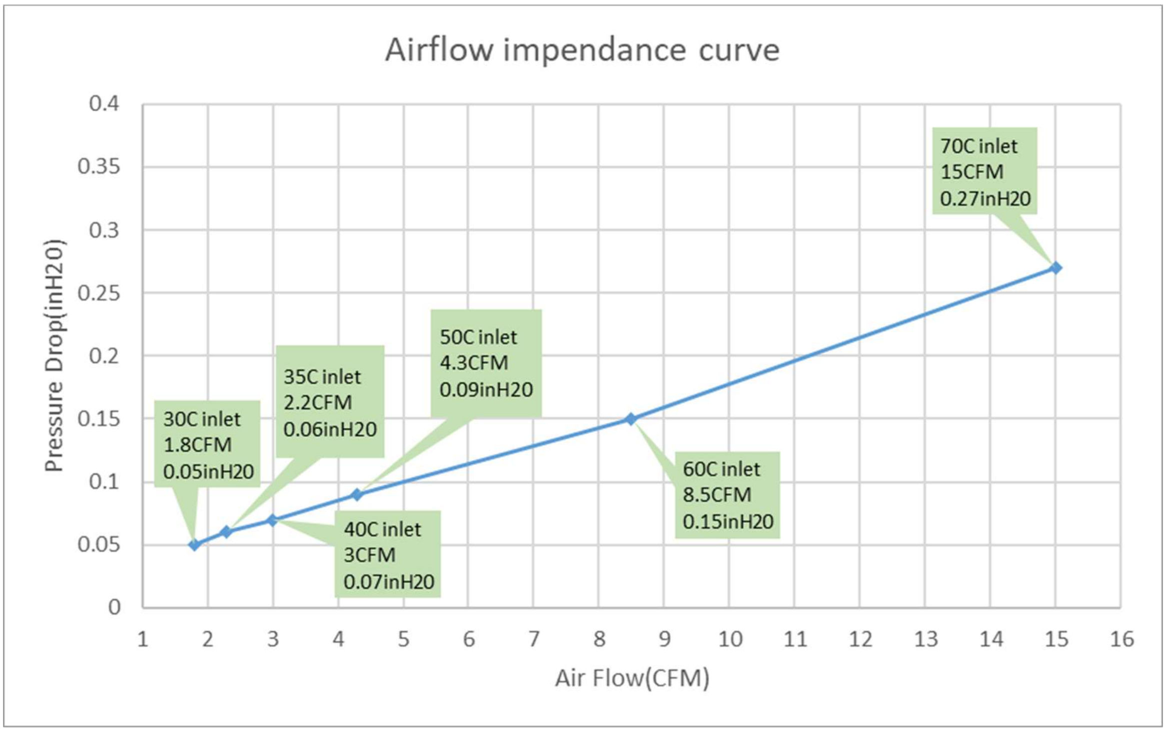


Fig.3-7 Pressure Drop vs. Airflow

Notes:

1. The heat-sink inlet temperature is the average value.
2. The minimum airflow is assumed to be fully ducted airflow through the product's heatsink
3. The required air flow is the minimum value, the airflow rate must meet or exceed this value regardless of the heatsink inlet temperature or the system's operating mode, the system airflow needs to be determined based on actual evaluation

3.4 Passive Cooling Design Suggestion

When the SG2300X is used in a passive cooling environment, with the increase of temperature, the power consumption of the chip will also increase, and better thermal design are needed to control the chip temperature to the specification range, the reference design is as follows：

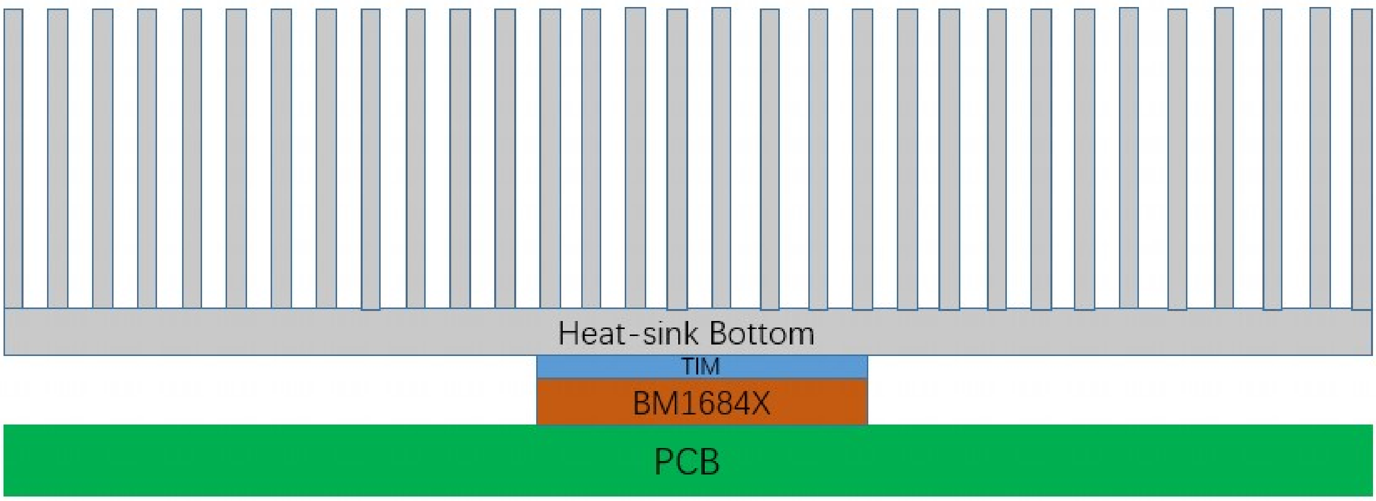


Fig.3-8 Passive Cooling Heat-sink Assembly

Taking the ambient temperature of 50 degrees as an example, the reference heat-sink design is shown in Fig.3-8 and 3-9, and the required cooling conditions are recommended as follows：

1. Heat-sink reference size:200(L)*200(W)*30(H)mm, the height of the fins is above 20mm and the gap between fins is above 4mm
2. Thermal grease (about 0.1-0.15mm thick, thermal conductivity greater than 3W/m.k) or phase change materials is recommended as TIM where the heat-sink contacts the chip
3. The surface of the heat-sink needs to be treated to increase radiation (such as anodizing, spraying graphite carbon, etc.)
4. Heatsink material：Al6063. If necessary, it’s recommended to use heat pipe or VC for the chip to cooling
5. It recommended to add high temperatures marked to to avoid burns on Product.

Notes:
1. When use passive solution, the chip temperature is high and easily reaches the maximum value. In this case, the chip performance will be impacted. Therefore, active cooling is recommended in a high temperature environment (when the environment temperature exceeds 45 degrees)

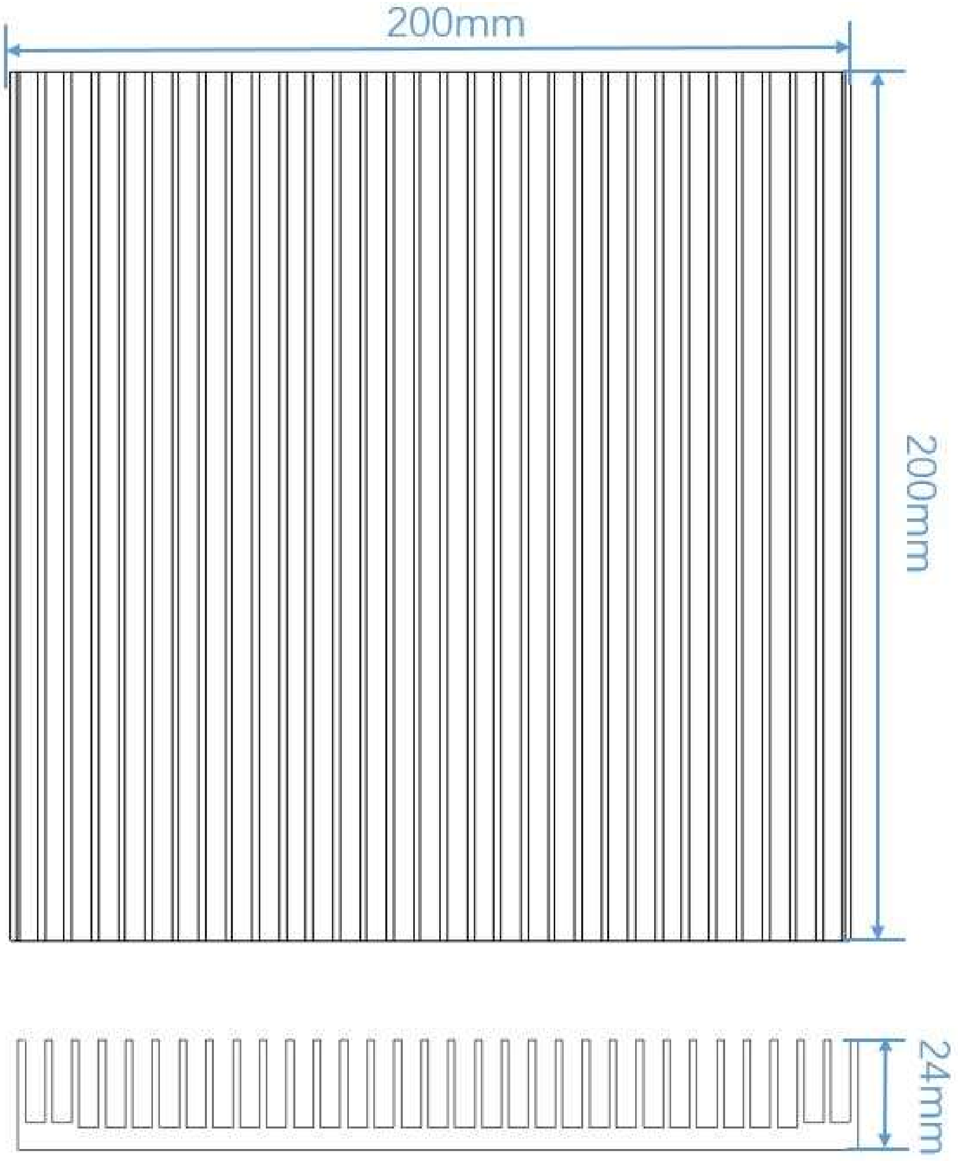


Fig.3-9 Passive Cooling Heat-sink

4. SG2300X Mechanical Design Guide

4.1 Introduction

This section provides guidelines for the design of mechanical solutions. It's necessary to comprehensively consider how to protect FCBGA solder interconnections, optimize the PCB strain and improve thermal performance during building a mechanically reliable product.

The following information provides corresponding solutions for the above three aspects:

1. Protecting FCBGA solder interconnections: to design appropriate spring forces
2. Optimizing the PCB strain: to select a robust heat-sink attachment method
3. Improving thermal performance: to reduce thermal resistance of the TIM and to increase the number of loading points

For the above solutions, design suggestions are given from screw layout, spring force and backboard, respectively.

4.2 Heat-sink Installation Suggestion

4.2.1 Rigid Mounting

Rigid fasteners are directly used to combine the heat-sink and PCB. The rigid mounting method is simple in design and low in cost. However, this method neglects tolerances of chip, heat-sink, PCB, thermal interface materials and rigid fasteners in the process of manufacturing and assembly, resulting in poor thermal performance or chip being crushed. Therefore, this method is recommended only when the requirements of thermal performance and temperature are not too high.

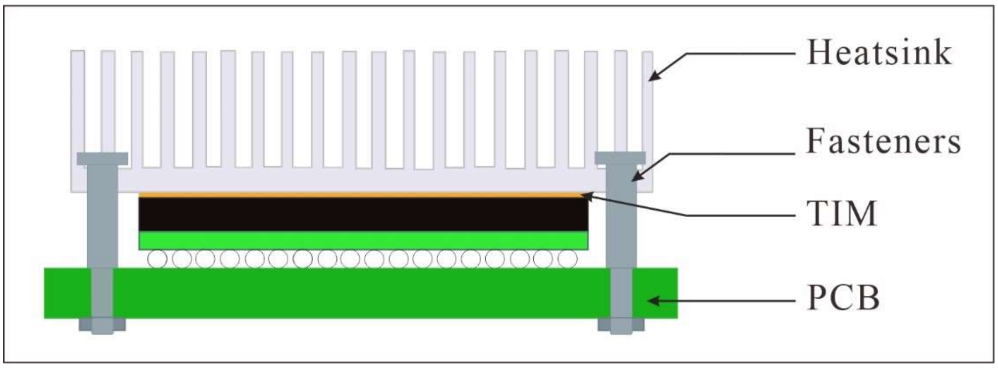


Fig.4-1 Rigid Mounting

4.2.2 Elastic Mounting

The elastic mounting method adopts appropriate elastic fasteners to maintain a certain range of contact force, which not only ensure the combination between the heat-sink and the chip are fitting, but also protect the chip from being damaged. This document recommends using spring screws, 'spring + screw', or Pushpin to assemble the heat-sink. And users can choose to place the spring on the heat-sink side or the back plate side of the PCB according to the actual situation.

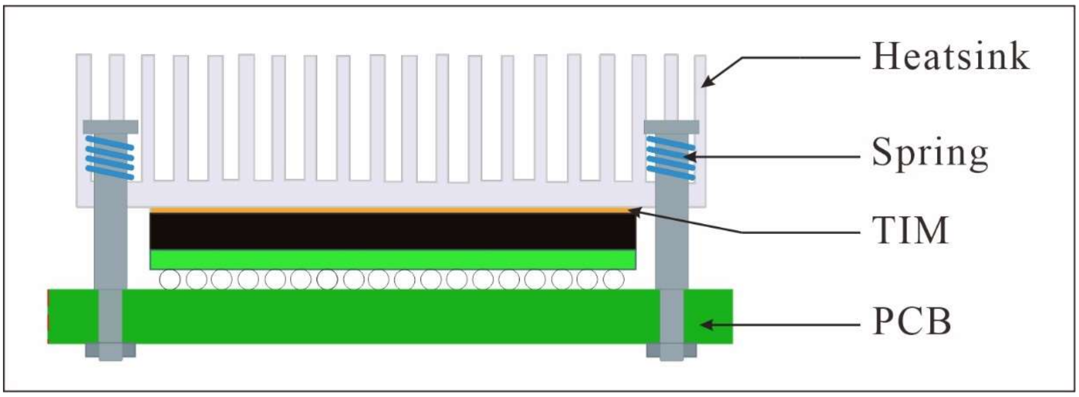


Fig.4-2 Elastic mounting

To ensure that the screws provide a uniform load, it is recommended to arrange four spring screws to assemble the heat-sink to uniform thermal interface materials and uniform stress on the FCBGA solder ball. To meet the stress requirements of the SG2300X, the distance between the screw hole wall and the BGA pin edge should be greater than 6mm. (d⩾6mm).

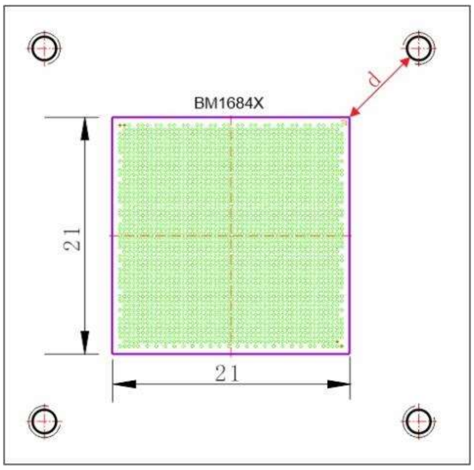


Fig.4-3 Screw Layout

To guarantee that the SG2300X neither overload nor underload, it is necessary to design the appropriate range of single spring force. The spring force is related to the screw distance, and Table 4-1 lists the maximum single spring force recommended in this document. The recommended total spring force is greater than 20 times the gravity of the heat-sink. The recommended value of spring force in table 4-1 is given based on four screws and 1.6mm PCB thickness. Users can redesign according to the actual screw layout and PCB thickness.

Table 4-1 The Maximum Single Spring Force

	Operating temperature below 85 degrees	Operating temperature above 85 degrees
L/mm	maximum single spring force /N	maximum single spring force /N
30	≤39.6	≤24.41
31	≤33.3	
32	≤26.7	
33	≤21.0	
34	≤16.3	
35	≤12.9	
36	≤11.0	
37	≤10	
38	≤10	
39	≤10	
40	≤8.6	

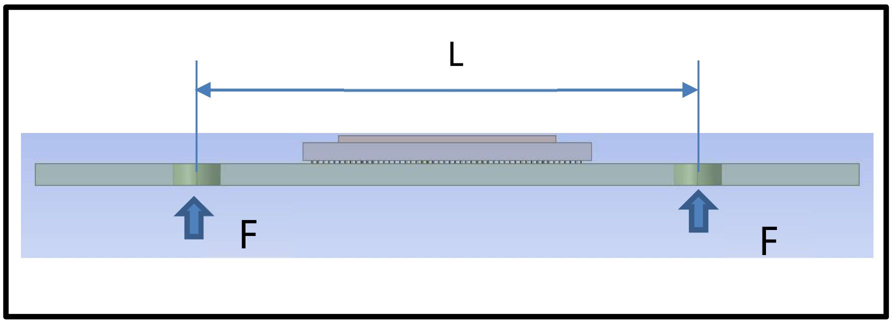


Fig.4-4 Single Spring Force and Screw Spacing

If the thickness of the PCB is less than 1.6mm, it is recommended installing an additional ring back plate on the back of PCB to optimize the PCB strain.

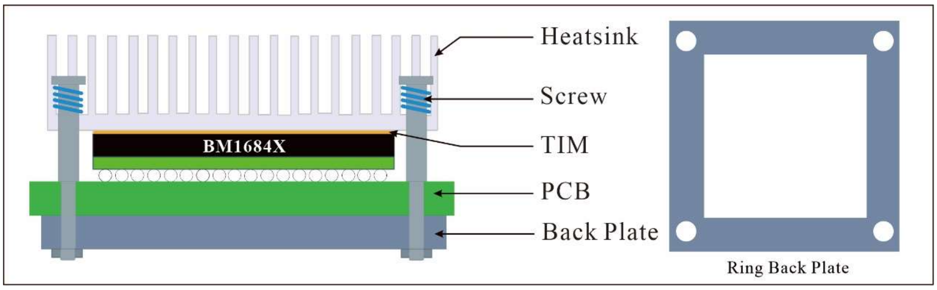


Fig.4-5 The Heat-sink on the Back Plate

5. SG2300X Thermal Design Support

Sophgo Inc. Can Provide below support:

1. SG2300X thermal simulation model (simulation software Flotherm)
2. SG2300X thermal design suggestions

Attentions:

1. Thermal simulation software and version: Flotherm12.0 or later
2. Provide model type: PDML
3. This document is SG2300X thermal and mechanical design guide, not for other purposes