Hi3798M V100 STB Thermal Design

User Guide

Issue 02

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Trademarks and Permissions

Notice

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About This Document

Purpose

This document describes the set-top box (STB) thermal design for Hi3798M V100, providing guidance and references for customers.

Related Version

The following table lists the product version related to this document.

Product Name	Version
Hi3798M	V1XX

Intended Audience

This document is intended for:

- Technical support personnel
- Software development engineers

Change History

Changes between document issues are cumulative. Therefore, the latest document issue contains all changes made in previous issues.

Issue 02 (2015-05-11)

This issue is the second official release, which incorporates the following change:

Descriptions of the QFP package are added.

Issue 01 (2015-04-21)

This issue is the first official release, which incorporates the following change:

The table1-6 is modified.

Issue 00B01 (2014-12-16)

This issue is the first draft release.

Contents

Figures

Tables

1 Hi3798M V100 STB Thermal Design

1.1 Thermal Resistance Parameters

Table 1-1 to Table 1-4 describe the package thermal resistance.

CAUTION

The thermal resistance is provided in compliance with the JEDEC JESD51-2 standard. The actual system design and environment may be different.

Table 1-1 Thermal resistance parameters for the 4-layer PCB in BGA package

Parameter	Symbol	Min	Typ	Max	Unit
Rated ambient temperature	T_A	−20	-	70	ºC
Junction temperature	T_{JMAX}	-	-	125	ºC
Junction-to-ambient thermal resistance	θ_{JA}	-	23	-	ºC/W
Junction-to-board thermal resistance	θ_{JB}	-	9.62	-	ºC/W
Junction-to-case thermal resistance	θ_{JC}	-	5.53	-	ºC/W
Junction-to-top center of case thermal resistance	Ψ_{JT}	-	-	-	ºC/W

Table 1-2 Thermal resistance parameters for the 2-layer PCB in BGA package

Parameter	Symbol	Min	Typ	Max	Unit
Rated ambient temperature	T_A	−20	-	70	ºC
Junction temperature	T_{JMAX}	-	-	125	ºC

Parameter	Symbol	Min	Typ	Max	Unit
Junction-to-ambient thermal resistance	θ_{JA}	-	34.4	-	ºC/W
Junction-to-board thermal resistance	θ_{JB}	-	15.2	-	ºC/W
Junction-to-case thermal resistance	θ_{JC}	-	6.7	-	ºC/W
Junction-to-top center of case thermal resistance	Ψ_{JT}	-	-	-	ºC/W

Table 1-3 Thermal resistance parameters for the 4-layer PCB in QFP package

Parameter	Symbol	Min	Typ	Max	Unit
Rated ambient temperature	T_A	–20	-	70	ºC
Rated temperature	T_{JMAX}	-	-	125	ºC
Junction-to-ambient thermal resistance	θ_{JA}	-	25	-	ºC/W
Junction-to-board thermal resistance	θ_{JB}	-	9	-	ºC/W
Junction-to-case thermal resistance	θ_{JC}	-	6.5	-	ºC/W
Junction-to-top center of case thermal resistance	Ψ_{JT}	-	-	-	ºC/W

Table 1-4 Thermal resistance parameters for the 2-layer PCB in QFP package

Parameter	Symbol	Min	Typ	Max	Unit
Rated ambient temperature	T_A	–20	-	70	ºC
Rated temperature	T_{JMAX}	-	-	125	ºC
Junction-to-ambient thermal resistance	θ_{JA}	-	27	-	ºC/W
Junction-to-board thermal resistance	θ_{JB}	-	9.9	-	ºC/W
Junction-to-case thermal resistance	θ_{JC}	-	6.5	-	ºC/W
Junction-to-top center of case thermal resistance	Ψ_{JT}	-	-	-	ºC/W

The thermal resistance in the table is the reference values assuming that no heat sinks are installed on a multi-layer PCB. The actual temperature varies according to the design, size, thickness, material, and other physical factors of the PCB.

Table 1-5 describes the operating environment parameters.

Table 1-5 Recommended operating environment parameters

Parameter	Symbol	Min	Typ	Max	Unit
Ambient Temperature	T_A	0	25	55	ºC
Temperature after long-term operation	T_{JMAX}	-	-	125	ºC

1.2 Chip Heat Dissipation Design Reference

External heat sinks are required for heat dissipation of Hi3798M V100. This section describes how to select heat sinks.

Classification of Common Heat Sinks

Heat sink materials include aluminum alloy, copper alloy, aluminum-copper alloy, and ceramics.

Heat sink technologies include aluminum extrusion, cutting, bonding, casting, and mechanical lamination.

Recommendations for Heat Sink Materials and Technologies

The aluminum alloy heat sink is recommended because of its low cost. The following are the recommendations for heat sink technologies:

- The extruded heat sink outperforms the cast aluminum heat sink. 25–30% of the cast aluminum heat sink is aluminum, and the remaining is carbon and alloy. 70–80% of the extruded heat sink is aluminum, and the remaining is carbon and alloy. Therefore, the cast aluminum heat sink offers lower heat dissipation efficiency than the extruded heat sink.
- The black aluminum heat sink provides 3–8% higher heat dissipation efficiency than the silvery white one in natural environments, because the black outperforms the silver in thermal radiation.
- Common heat sinks are black and are processed by anodic oxidation.

To sum up, the aluminum alloy heat sink with the black surface and processed by anodic oxidation is recommended.

Heat Sink Size

The thermal resistance of the aluminum heat sink is calculated as follows:

$R = 1/hA$

where

- **A** indicates the superficial area of the heat sink.
- **h** indicates the heat dissipation coefficient that depends on the temperature difference, wind speed, and material, thickness, and density of the heat sink.

A greater heat sink superficial area means a smaller thermal resistance. The following data is inferred (assume that the heat sink is 2 mm thick):

Superficial Area (cm^2)	Thermal Resistance (°C/W)
500	2.0
250	2.9
100	4.0
50	5.2
25	6.5

The thermal resistance of the heat sink required by Hi3798M V100 is calculated as follows:

Rsa = (Tj – Ta)/Q – (Rjc + Rcs) (formula 1)

- Tj: indicates the highest junction temperature (110°C−125°C) supported by Hi3798M V100.
- Ta: indicates the maximum ambient temperature (55°C) for long-term working.
- Q: indicates the power consumption (3.5 W) of Hi3798M V100.
- Rsa: indicates the thermal resistance of the heat sink (taking the wind speed into account).
- Rcs: indicates the thermal resistance (for example, 5°C/W) of heat-conducting media such as the thermal conductive adhesive.
- Rjc: indicates the package thermal resistance of Hi3798M V100 (5.53°C/W for the 4-layer PCB and 6.7°C/W for the 2-layer PCB).

After the required thermal resistance of the heat sink is calculated by using formula 1, the superficial area of the heat sink can be obtained based on the preceding mapping between the superficial area and the thermal resistance.

Assume that the ambient environment is 55°C, the STB temperature increases by 25°C (reference value), and Hi3798M V100 uses the thermal conductive adhesive with 5°C/W thermal resistance. The heat sink size can be calculated by using formula 1 as follows:

Rsa = (115 – 55 – 25)/2 – (6.7 + 5) = 5.8°C/W (It is recommended that the junction temperature of Hi3798M V100 be lower than 115°C. Tj is set to 115. Assume that the heat dissipation power consumption is 2 W.)

Based on the preceding data, the heat sink with the superficial area of 50 cm^2 meets the heat dissipation requirement of Hi3798M V100 with 2-layer PCB design.

NOTE

The preceding specifications are for reference only. You need to select heat sinks based on the actual board design.

Recommended Thermally Conductive Materials

Table 1-6 describes recommended thermally conductive materials.

Table 1-6 Recommended thermally conductive materials

Mode of Fixing Heat Sinks	Model	Thermal Conductivity Coefficient (w/m x k)	Ambient Temperature (°C)	Colloid Type	Insulation (V/mil)	Flame Retardance	Bearing Capacity (g)
Mechanical fixing	GF2000	2	−60 to +200	Silicone rubber	500	UL9V0	None
Non-mechanical fixing	Locotite 315	0.808	None	Acrylic resin	6000	UL9V2	None

Relationship Between the Fixing Mode and Heat Sink Mass

The fixing mode of the heat sink depends on the heat sink mass. You are advised not to fix a large-mass heat sink by using the thermally conductive adhesive. Table 1-7 describes the relationship between the fixing mode and the heat sink mass. You can select the fixing mode based on the board design.

Table 1-7 Relationship between the fixing mode and heat sink mass

Fixing Mode	Mass		
	m < 85 g	85 g ≤ m < 150 g	m ≥ 150 g
Thermally conductive adhesive	√	-	-
Push-pin buckle	√	-	-
Spring and screw	-	√	√
Dedicated metal buckle (non-preferable)	√	√	√
Plastic holder (non-preferable)	√	-	-

1.3 Board Thermal Design Reference

Component Layout

Lay out components based on the product architecture and heat dissipation design:

- Evenly place the components that consume a large amount of power and produce much heat to avoid local overheating, which may affect the reliability and efficiency of components. Place Hi3798M V100 away from power supplies.

- Place components that produce much heat at the top layer.
- Place thermal-sensitive components such as the crystal and liquid electrolytic capacitor as far away from heat sources as possible.

Stack

- Increase the percentage of copper in the board to decrease thermal resistance in the horizontal direction.
- Lay complete and large-scale copper planes to facilitate heat dissipation.
- Minimize the spacing between the top layer or bottom layer and the adjacent layer.

Vias

- For the connection style of vias under the Hi3798M V100, select the full connection style but not the thermal connection style to improve the board heat dissipation efficiency.
- The GND signals and 1.1 V, 1.5 V, and 3.3 V power signals of Hi3798M V100 are connected over copper sheets. When the signal overcurrent capability is ensured, more vias on copper sheets are recommended.
- Increase the size of copper planes under and around the components that produce much heat to ensure that PCB heat can be effectively dissipated. Place inductors and power chips in a distributed manner and increase the size of copper planes around them.

1.4 STB Thermal Design Reference

The design recommendations for the STB structure are as follows:

- Design the product architecture optimally to ensure that the heat produced internally can be dissipated. For example, punch holes on the cover.
- Place foot pads under the STB to ensure free air flow under the bottom cover.
- Place ballast on top of or at the bottom of the STB cover, and use the thermal conductive silicon gel in contact with the ballast to dissipate heat.
- If part of the cover is overheating, add an aluminum plate or graphite foil within the cover to balance the cover temperature and avoid partial overheating.

Temperature Rise Test

The ambient temperature should be below 26°C and the temperature rise of the cover surface cannot exceed 20°C.

Table 1-8 and Table 1-9 describe the tested temperature rise data for the 2-layer PCB in BGA package with graphite foil when an online video and a local video are played respectively. Table 1-10 and Table 1-11 describe the tested temperature rise data for the 2-layer PCB in QFP package with graphite foil when an online video and a local video are played respectively.

Table 1-8 Temperature rise for the 2-layer PCB in BGA package when an online video is being played

Heat Sink (3.5 W STB Power Consumption)	Top Surface		Bottom Surface	
	Temperature (°C)	Temperature Rise (°C)	Temperature (°C)	Temperature Rise (°C)
50 cm² heat sink without graphite foil	51	25	54	28
50 cm² heat sink with 150 x 90 graphite foil on both the internal top and bottom surfaces	38	12	42	16

Table 1-9 Temperature rise for the 2-layer PCB in BGA package when a local video is being played

Heat Sink (2.5 W STB Power Consumption)	Top Surface		Bottom Surface	
	Temperature (°C)	Temperature Rise (°C)	Temperature (°C)	Temperature Rise (°C)
50 cm² heat sink without graphite foil	45	19	46	20
50 cm² heat sink with 150 x 90 graphite foil on both the internal top and bottom surfaces	35	9	38	12

Table 1-10 Test data for the 2-layer PCB in QFP package when an online video is being played

Heat Sink (3.5 W STB Power Consumption)	Top Surface		Bottom Surface	
	Temperature (°C)	Temperature Rise (°C)		Temperature (°C)
50 cm² heat sink without graphite foil	47.71	21.71	57.95	31.95
50 cm² heat sink with 150 x 90 graphite foil on both the internal top and bottom surfaces	37.72	11.72	43.72	17.72

Table 1-11 Test data for the 2-layer PCB in QFP package when a local video is being played

Heat Sink (2.5 W STB Power Consumption)	Top Surface		Bottom Surface	
	Temperature (°C)	Temperature Rise (°C)		Temperature (°C)
50 cm² heat sink without graphite foil	46.01	20.01	55.64	29.64
50 cm² heat sink with 150 x 90 graphite foil on both the internal top and bottom surfaces	37.39	11.39	42.77	16.77

The dimensions of the 2-layer PCB are 124 mm x 80 mm x 1.6 mm (4.88 in. x 3.15 in. x 0.06 in.), and those of the cover are 160 mm x 90 mm x 25 mm (6.30 in. x 3.54 in. x 0.98 in.).

Figure 1-1 STB for the 2-layer PCB test (1)

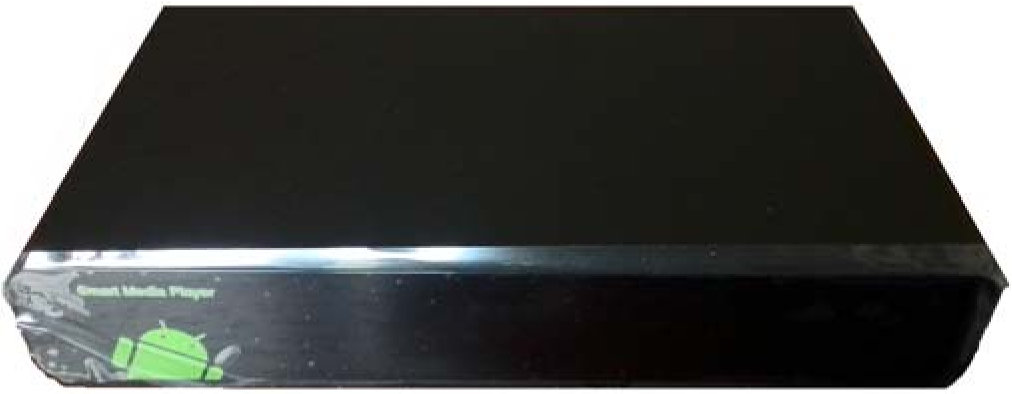

Figure 1-2 STB for the 2-layer PCB test (2)