# MAX5861 Thermal Model Considerations

***Rev 0; 7/15***

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***Maxim Integrated 160 Rio Robles, San Jose, CA 95134 USA 1-408-601-1000***

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# 1 Thermal Considerations

The MAX5861 are high-performance, highly integrated devices housed in compact 12mm x 18mm LFBGA (low-profile fine-pitch ball grid array) packages. It is very important that the thermal system is designed properly to allow for adequate cooling. The junction temperatures of the integrated circuits in these devices must be kept in a safe operating range. There are two circuits in the package: the digital up-converter (DUC) and the digital-to-analog converter (DAC). This guide describes a method to measure the internal junction temperatures of both circuits.

The thermal system design must meet both of the following conditions for safe operation:

- The junction temperature of the DUC ($T_{JDUC}$) must be kept below 110°C.
- The junction temperature of the DAC ($T_{JDAC}$) must be kept below 110°C.

Depending on the system application, meeting these two conditions may require well-designed heatsinks and/or cooling fans. The power for both the DUC and the DAC are specified in the MAX5861 data sheet.

# 2 Package Thermal Model

In order to do a thorough thermal analysis, one needs to understand the package construction and its material composition. See **Table 1** for the package construction and material composition and **Table 2** for the substrate construction and material composition.

**Table 1. Package Construction and Materials**

| Package Description | |
|---|---|
| Package type | SBSMFC LFBGA |
| Ball counts | 308 |
| Package size | 18 x 12 x 1.3mm$^3$ |
| Ball pitch | 0.8mm |
| Die size of DUC | 8.406 × 7.792 × 0.35mm$^3$ |
| Die size of DAC | 5.536 × 5.536 × 0.35mm$^3$ |
| Bump count of DUC | 1347 |
| Bump count of DAC | 406 |
| Bump diameter | 0.085mm |
| Mold thickness | 0.54mm |
| Substrate layers | 2+2+2 layer |
| Substrate thickness | 0.35mm |
| Standoff | 0.41mm |

The location of the DUC and DAC die can also impact the thermal considerations. **Figure 1** indicates the location of the DUC and DAC die within the MAX5861 package.

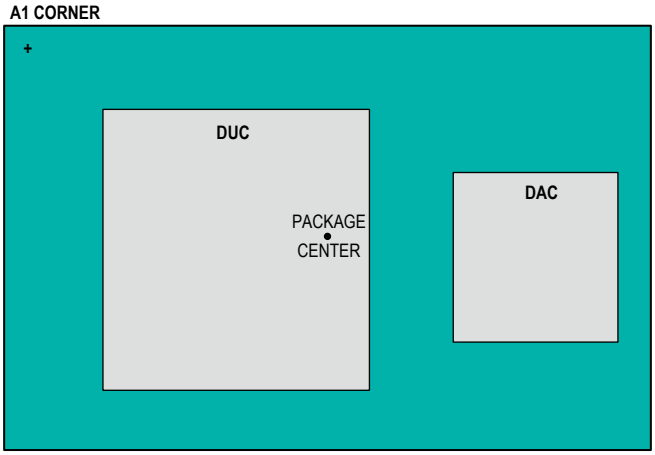


*Figure 1. MAX5861 die location – substrate top view.*

**Table 2. Substrate (PCB) Construction and Materials**

| Customize 3s3p PCB (6-layer) | |
|---|---|
| PCB dimensions | 167 x 282 x 2.69mm$^3$ |
| Core thickness | 0.06mm |
| Prepreg thickness | 0.17mm |
| Top/bottom thickness | 0.05mm |
| Inner plane thickness | 0.035mm |
| Solder mask thickness | 0.02mm |
| Top Cu coverage | 54.1% |
| L2 Cu coverage | 83.8% |
| L3 Cu coverage | 62.8% |
| L4 Cu coverage | 77.2% |
| L5 Cu coverage | 84% |
| Bottom Cu coverage | 67.4% |

The thermal properties of the package and substrate component materials are listed in **Table 3**.

**Table 3. Thermal Properties of the Component Materials**

| Component | Material or Material Name | Thermal Conductivity (W/mK) |
|---|---|---|
| Die | Silicon | 148 at 25°C |
| | | 98.9 at 125°C |
| Bump | Sn1.8Ag | 55 |
| Underfill | UA26 | 0.5 |
| Substrate core | CCL-HL832NX | 0.53 |
| Substrate and PCB planes | Copper | 389 |
| Solder ball | SAC305 | 58.0 |
| Solder mask | AUS320 | 0.23 |
| Mold compound | G760SW | 0.92 |

This data can be used to create a package thermal model for thermal simulations. Upon request, Maxim Integrated will provide the FloTHERM® thermal model for users that have access to the FloTHERM simulator tool.

## 3 DUC Temperature Measurement

The DUC temperature ($T_{JDUC}$) is measured via a thermal diode and is described in the MAX5861 data sheet. The DUC temperature can be measured continuously in system operation. See **Figure 2** for the recommended method of measuring the DUC temperature, which uses the MAX6654 temperature sensor.

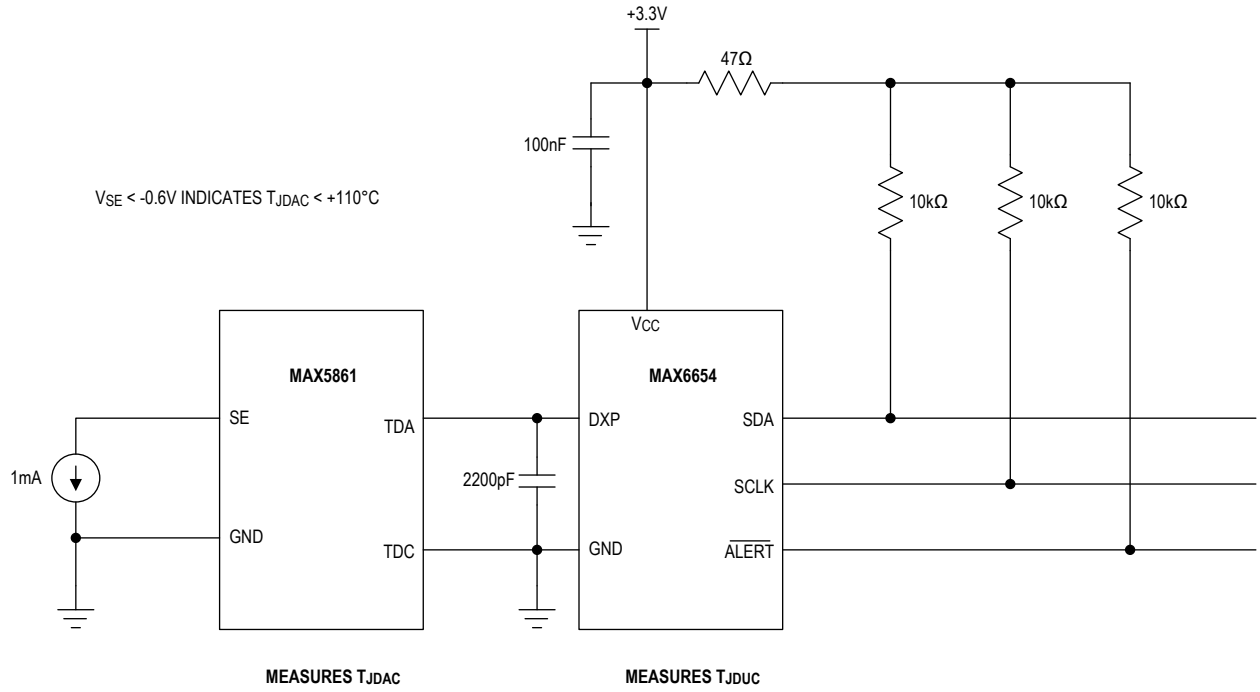


*Figure 2. The MAX5861 temperature measurement.*

## 4 DAC Temperature Measurement

The DAC temperature ($T_{JDAC}$) is measured via a second thermal diode using the MAX5861 SE pin. This circuit is shown in Figure 2. The DAC temperature measurement should only be made during the thermal system design phase to confirm compliance. The measurement should not be made during normal system operation.

The temperature of the DAC is measured pulling a 1mA current out of the SE pin. If the voltage at the SE pin is < -0.6V, the temperature of the DAC is < 110°C and the DAC is operating in the safe $T_{JDAC}$ range. To maintain a temperature within the allowable range of 0°C to 110°C, the voltage at the SE pin should be in the following range: -0.78V < SE < -0.6V.

## Trademarks

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