Layout Considerations for Accurately Measuring Ambient Temperature

Introduction

Measuring ambient temperature with a surface mount device can be challenging due to the heat transfer from other power-hungry electronic components that can influence the temperature reading of the sensor.

To accurately measure ambient temperature, it is important to follow good layout techniques, such as understanding the dominant thermal path, isolating the sensor package, and placing the device away from interfering heat sources. Figure 1 shows a simple thermostat design using these techniques.

The passive air flow from the self-heating of the system draws external air over temperature sensor A. The sensor is placed at the intake vent away from the main heat source—the CPU—and is thermally isolated for a more accurate measurement.

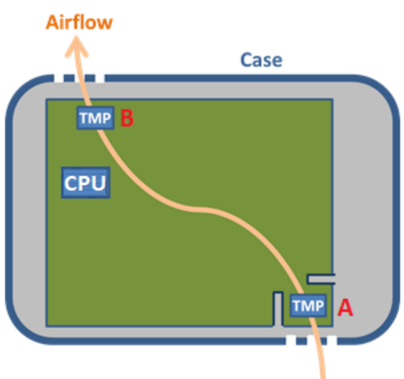

Figure 1. Temperature Sensor Thermostat Design

Heat Radiation and PCB Layouts

It is important to know which components radiate the most heat first so that routing traces near the heat sources can be avoided. Figure 2 shows a thermal image captured with the FloTHERM thermal analysis tool that shows the temperature distribution through the air from the heat source.

If components are placed within an enclosure, the heat distribution may be more condensed. Remember that the temperature sensor should be placed away from the heat source to avoid erroneous temperature readings in both open-air setups and enclosures.

Table 1 lists the recommended distances to place the sensor for various heat source temperatures.

Table 1. Recommended Distance Away From Heat Source

HEAT SOURCE TEMPERATURE	AMBIENT TEMPERATURE	RECOMMENDED DISTANCE
40 °C	20 °C	7.62 mm
60 °C	20 °C	15.24 mm
100 °C	20 °C	38.1 mm

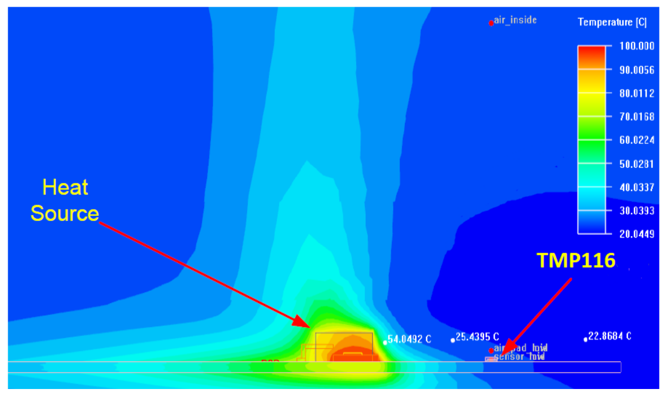

Figure 2. Heat Radiated Across Test Board

If the sensor is close to the heat source, it is good practice to create an isolation island and maximize the air gap between the sensor and heat source. The bigger the air gap, the better the ambient temperature measurement. When the sensor is further away, however, the gap does not provide additional shielding. The gap may improve the thermal response time of the sensor, though.

Figure 3 shows a 0.8-mm wide cutout with a temperature reading of about 38.5°C, and Figure 4 shows a 1.8-mm wide cutout with a temperature reading of about 35.5°C. These images show how a larger isolation gap affects the ambient temperature reading.

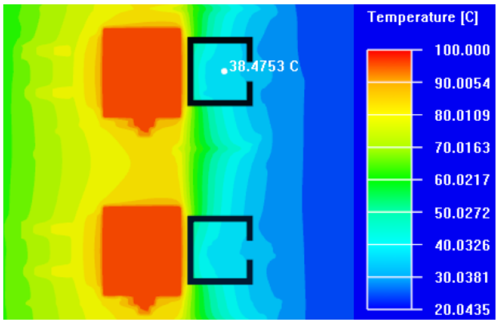

Figure 3. Thermal Air Gap With 0.8-mm Slot Width

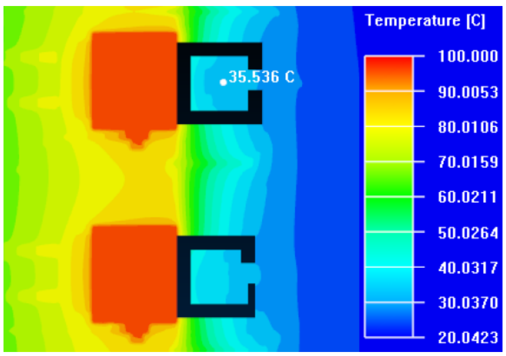

Figure 4. Thermal Air Gap With 1.8-mm Slot Width

When designing the PCB for the temperature sensor, it is important to follow good layout techniques. Figure 5 shows a PCB layout with an isolation island and contour routing, while Figure 6 shows an alternative design that incorporates perforations around the section with the temperature sensor.

On both mini-boards, the dimensions are small enough to allocate only the sensor and bypass capacitor—the smaller the thermal mass of the island, the better the thermal response. These designs greatly minimize the amount of heat transfer from other components.

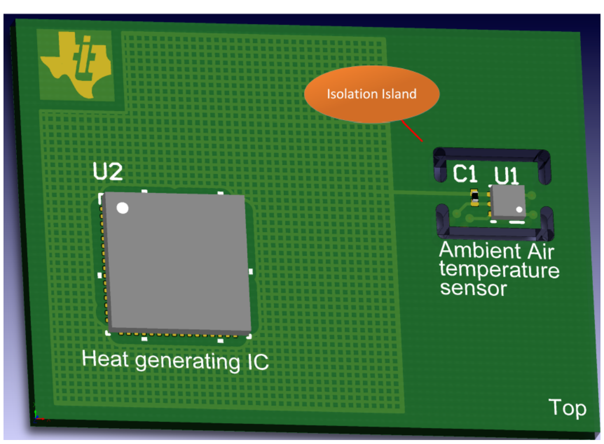

Figure 5. Isolation Island PCB Layout

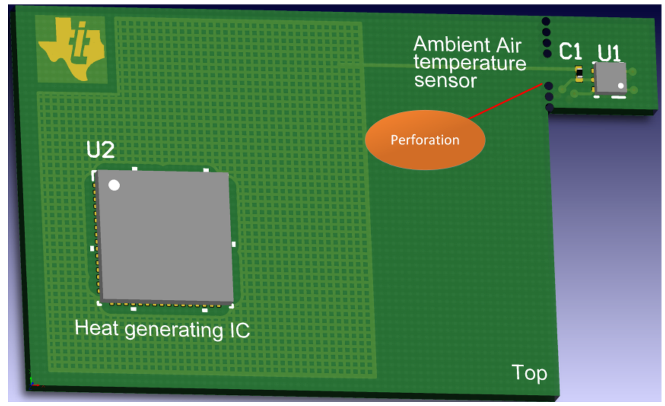

Figure 6. Perforated PCB Layout

Differential Temperature

In applications requiring more precise temperature measurement, users can consider a differential temperature design. In this type of design, additional temperature sensors are added next to hot components as shown in Figure 1, and the difference in temperature between temperature sensors A and B is measured.

A model of how the ΔT correlates to ambient temperature is required, however, and this will vary depending on the system application. This design factors in the impact of self-heating to provide a more accurate algorithm to estimate the ambient temperature.

Device Recommendations

The TMP112 and TMP116 are digital temperature sensors designed for high-accuracy, low-power applications, such as environmental monitoring and thermostat controls. The TMP112 offers an accuracy of ±0.5°C from 0°C to 65°C, whereas the TMP116 offers an accuracy of ±0.2°C from –10°C to 85°C.

Both temperature sensors are highly linear, require zero calibration, and have programmable alert functionality. The TMP112 features a compact 1.60-mm × 1.20-mm SOT563 package, while the TMP116 features a 2.00-mm × 2.00-mm WSON package.

To ensure optimal performance and device longevity, additional layout recommendations are discussed in the collateral listed in Table 2.

Table 2. Recommended Collateral

COLLATERAL	DESCRIPTION
Application Report	*TMP116 Ambient Air Temperature Measurement*
Application Report	*Precise Temperature Measurements with TMP116*
Application Report	*Temperature Sensors: PCB Guidelines for Surface Mount Devices*

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