

# Enhance Thermal Sensing Performance With I3C Bus



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Temperature and Humidity Sensing

As systems become more complex, there is a growing need for sensor integration. With an increasing number of target devices in a system, host controllers must consider reducing latency, implementing critical alert functions, and lowering power consumption during communication. Some of these devices, like temperature sensors play crucial roles, ranging from continuous ambient temperature monitoring to autonomous protection of critical components. To address the low latency thermal sensing challenges in complex systems like DDR5 DIMM, TI developed the **TMP139**, an I3C-based temperature sensor which features:

- Wide operating temperature range and high temperature accuracy:
  - $\pm 0.5^{\circ}\text{C}$  maximum ( $+75^{\circ}\text{C}$  to  $+95^{\circ}\text{C}$ )
  - $\pm 0.75^{\circ}\text{C}$  maximum ( $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )
- Low power consumption
  - 4.7  $\mu\text{A}$ -average quiescent current with 8-Hz conversion rate
  - 600-nA standby and shutdown current
- IO supply from 0.95 V to 1.98 V
- Two-wire serial bus interface supporting both I<sup>2</sup>C and I3C basic mode
- Up to 12.5-MHz data transfer rate in I3C basic mode
- In-Band Interrupt (IBI) for alerting host with dual temperature thresholds
- Small form factor 1.3 mm × 0.8 mm, WCSP, 6-pin package

## Performance Impact

Leveraging the I3C bus is a major step in improving communication speed versus I<sup>2</sup>C bus. Additionally, the TMP139 has a default read mode, which removes the requirement for the host to send a register address to read the temperature data. With the new bus and default read mode, customers can now see almost 85% improvement in data transfer when compared to the fastest speeds on the I<sup>2</sup>C bus. As most sensors support 400-kHz bus operation, this improvement can scale as high as 98%.

As [Table 1](#) shows, when default read mode is disabled, it takes 450  $\mu\text{s}$  to read 2 bytes of

temperature data in 100-kHz standard mode. When performing the same read in I3C mode, it takes 3.6  $\mu\text{s}$ , resulting in a 99% performance increase.

**Table 1. Performance Comparison With Default Read Mode Disabled**

I <sup>2</sup> C Bus Mode	Performance Improvement on I3C Bus
100 kHz Standard Mode	99%
400 kHz Fast Mode	97%
1 MHz Fast Mode+	92%
3.3 MHz High Speed Mode	75%

The TMP139 features a default read mode, alleviating the need for the host controller to set the register address for reading the temperature conversion result. As [Table 2](#) shows, this saves not only bus transaction time, but also results in reduced system power consumption.

**Table 2. Performance Comparison with Default Read Mode Enabled**

I <sup>2</sup> C Bus Mode	Performance Improvement on I3C Bus
100 kHz Standard Mode	99%
400 kHz Fast Mode	98%
1 MHz Fast Mode+	95%
3.3 MHz High Speed Mode	85%

## Improve Power Consumption

I3C bus interface supports push-pull mode for communication, with the host integrating an active pullup resistor. On an I<sup>2</sup>C open drain bus, current is consumed when either the host or the device is sending a logic low. Depending on the resistor value and the supply voltage on the bus, this current may range from a few 100  $\mu\text{A}$  to a few mA, impacting battery capacity on portable devices. The TMP139 with an I3C bus interface, instead limits the current to a few 10  $\mu\text{A}$ , greatly benefiting battery-powered applications.

## **In-Band Interrupt (IBI) and Target Address Reassignment**

An exciting feature of the TMP139 is support for IBI, eliminating the need for a separate IO on the host controller traditionally used for an alerts or interrupts. With the IBI support, the device can now use the Serial Data (SDA) pin to alert the host controller of a high or low temperature alert. Through IBI, the host MCU can maintain a low power state and rely on the TMP139 to wake up the I3C bus and notify the MCU to take critical action if the system becomes too hot or cold.

Lastly, an added benefit of the I3C interface in the TMP139 is the capability to reconfigure to the device to a different serial address dynamically. A dedicated pin strap allows the application to set two device addresses in hardware. Additionally, the lower 3-bits of the device address are software-configurable using SETHID Common Command Code which is transparent to I<sup>2</sup>C devices. Combining the pin strap and software configurations, the TMP139 enables 16 addresses. If the bus has a TMP139 and another device whose serial address are the same, the host controller can reconfigure the TMP139 address in software, avoiding the need to look for a different device with a non-conflicting address.

## **Summary**

The high-accuracy TMP139 temperature sensor with integrated I3C bus support, reconfigurable address, and IBI, future proofs your design for new interfaces and enhanced performance.

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