ADT7320/ADT7420 Digital Temperature Sensors
Frequently Asked Questions

Why should I use a digital temperature sensor over other technologies?

Digital sensors are fully integrated and calibrated temperature measurement solutions and offer many advantages over analog type sensor technologies such as thermistors and resistance temperature detectors (RTDs).

- High performance
  - High accuracy. Accuracy to 0.2°C (maximum) with all errors included in the sensor specifications.
  - High stability, repeatability, and reliability. Drift and repeatability are included within the sensor specifications.
  - Fast thermal response. Thermal response is dependent on how the sensor is used. For example, mounting the sensor on a large PCB limits the thermal response because the PCB acts as a heat sink.
  - Traceability. Sensors are traceable to national standards such as those from the National Institute of Standards and Technology (NIST).
- Low cost
  - No additional signal processing or additional components.
  - No user calibration. Because the devices are precalibrated, all errors involved in measuring and digitizing the temperature value are included in the sensor's accuracy specifications. In contrast, an analog-based sensing element's specified error, including temperature drift and noise, must be added to that of any ADC, amplifier, reference, wiring, or other component that is used in conjunction with the sensor. Calibration costs can be expensive and, in many cases, exceed the cost of the sensor element itself.
- Easy implementation
  - No complex calibration.
  - Standard SPI (ADT7320) and I^2C (ADT7420) digital interfaces.
  - No self-heating or lead wire resistance concerns. The sensors are very robust and do not suffer from moisture ingress issues, unlike other sensors.
- Low power
  - Low software overhead; no linearization.
  - No additional components required.
  - Multiple low power modes, including a 2 μA shutdown mode.

Table 1 compares digital ICs against RTD- and thermistor-based solutions.

Note that the digital temperature sensors are not typically used as thermocouple replacements because thermocouples have a much wider temperature range. However, digital temperature sensors are very popular for providing the reference temperature for thermocouples, which is called cold junction compensation and is described in more detail in the following technical article: "Two Ways to Measure Temperature Using Thermocouples Feature Simplicity, Accuracy, and Flexibility." *Analog Dialogue.* Volume 44, October 2010 at *www.analog.com/dialogue/thermocouples.*

In summary, digital temperature sensors provide easy, reliable, and cost effective high performance temperature measurement.

How is the high accuracy of the temperature sensors achieved?

The latest sensor cores are based on a silicon band gap principle, which is the same principle used by all temperature sensing ICs in the industry today. In fact, ADI is one of the pioneers of this technique and released the industry classic, AD590, in 1978. Based on knowledge gained since the development of the AD590, ADI has optimized the temperature core and, coupled with leading precision sigma-delta ADC technology, has achieved high levels of accuracy. In addition to optimizing the design, ADI has developed a test capability that enables reliable testing of the sensors to high accuracy specifications.

The architecture diagram in Figure 1 highlights the band gap-based temperature sensor core and the high precision sigma-delta modulator that are used to convert the voltage from the band gap to a digital value.

What is the response time of these sensors?

Thermal response is a function of the thermal mass of the sensor but is heavily influenced by the mass of the object on which the IC is mounted. For example, a large PCB acts as a large heat sink and slows the thermal response. For best thermal response, it is recommended to mount the sensor on as small a PCB as possible, such as a flex PCB that provides the best thermal response. ADI has achieved thermal responses of <2 seconds (including all signal processing) using the ADT7320/ADT7420 and a flex PCB. Look for additional details in a forthcoming application note.

Do these sensors need to be calibrated?

No user calibration is required with these sensors because ADI precalibrates the devices using our high accuracy test solution. Because the devices are precalibrated, all errors involved in measuring and digitizing the temperature value are included in the sensor's accuracy specifications.

What are the repeatability and drift performance of the sensors?

Repeatability is the ability to obtain consistent results when measuring a part with the same measuring instrument. For the ADT7320/ADT7420, the repeatability performance is typically ±0.015°C.

Drift indicates how often a measurement needs recalibration. Drift includes solder heat resistance and lifetime test performed per Jedec Standard JESD22-A108. The ADT7320/ADT7420 typically drifts 0.0073°C over its operating lifetime.

How do I use a sensor for point temperature measurement?

For applications where the sensor must measure the surface temperature of an object (such as a metal plate), it is recommended to mount the sensor on a thin flex PCB and thermally glue the sensor to the object being measured. It is also recommended to thermally insulate all parts of the sensor not in contact with the object being measured. For more information on the best solution for your application, please contact ADI.

What does NIST traceability mean?

NIST is the abbreviation of the U.S. Commerce Department's National Institute of Standards and Technology (see the NIST web site at *www.nist.gov/index.html).* Traceability is the establishment of an unbroken chain of comparisons to stated references, which basically indicates that the absolute temperature reported by the sensor is traceable to a standard reference.

Are evaluation board and samples available?

An evaluation board is available for the ADT7320 and ADT7420. The board (model EVAL-ADT7X20EBZ) is available for purchase from the ADT7420 product page at *www.analog.com/ADT7420.*

Samples are also available at *www.analog.com/samples_purchase.*

What other resources are available?

ADI has a number of additional resources available to assist with the incorporation of these sensors into an application. These include

- Circuits from the Lab™, which are tested circuit designs that address common design challenges and have been engineered for quick and easy system integration. Look for information about thermocouple cold junction in a forthcoming Circuits from the Lab.
- Cold junction compensation technical article available at *www.analog.com/dialogue/thermocouples.*
- Accuracy demonstration video available at *www.analog.com/video/digtempsensors.*
- Temperature sensing selection guide available at *www.analog.com/digtempsensors_brochure.*

For the latest list of available resources, see the ADT7320 and ADT7420 product pages at *www.analog.com/ADT7320* and *www.analog.com/ADT7420.*

What are the best practices for layout?

For PCB temperature measurement, use a common GND plane between the ADT7320/ADT7420 and the heat source. Ensure that both the GND pin and paddle are connected to the heat source GND plane. Keep the ADT7320/ADT7420 and heat source as close as possible to each other on the PCB.

For ambient temperature measurement, use a hash GND plane. Reduce the GND plane area to increase thermal resistance. Keep the ADT7320/ADT7420 as far away from the heat source as possible. Use a separate GND plane for the ADT7320/ADT7420, and keep connections to the main GND plane as low as possible. Use narrow GND connections to increase thermal resistance. Use a solid GND plane under the main heat source and expose the green solder mask. This provides the minimum thermal resistance for the main heat source to dissipate heat.

What is the MTTF?

MTTF refers to mean time to failure, which is the mean time it takes for a first failure to occur under specified operating conditions. It is calculated by dividing the total number of device operating hours by the number of failures. Details of the ADT7320/ADT7420 MTTF can be obtained at *www.analog.com/reliabilitydata.*

Does ADI offer other packaging options? Does ADI offer through-hole packaging?

ADI is currently evaluating a number of alternative packaging options as part of its temperature sensing roadmap. Please contact ADI for more information.

Other Questions/Feedback

ADI values feedback on our temperature sensing solutions. Please send feedback to ADI via *temp_sense_feedback@analog.com.*

Table 1.

NTC Thermistor	PT100 RTD (Thin Film)	Digital IC ADT7320/ADT7420
Accuracy[1]		
±0.1°C from 0°C to 70°C, ±0.3°C from 0°C to 100°C; excludes data conversion, signal conditioning, self-heating, noise, drift, and so on	±0.27°C from 0°C to 100°C (DIN Class 1/3 B); excludes data conversion, signal conditioning, self-heating, lead wire resistance, noise, and so on	±0.2°C from –10°C to +85°C, ±0.25°C from –20°C to +105°C
Linearity		
Poor	Medium to high	High
Thermal Response		
Medium to fast	Slow	Medium to fast
Long Term Stability/Reliability		
Low	Medium to high	High
System Cost		
High for low tolerance (±0.1/0.2°C)	High	Low
Calibration Required		
Yes	Yes	No
Extra Components Required		
Yes	Yes	No

[1] For thermistors and RTDs, actual tolerances degrade in the assembled system.

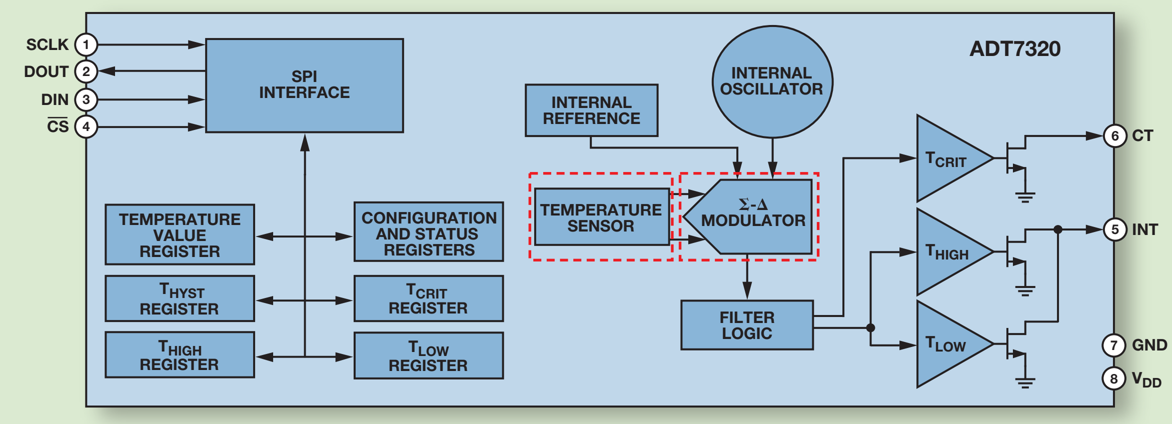

Figure 1. ADT7320 Architecture Diagram

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I²C refers to a communications protocol originally developed by Philips Semiconductors (now NXP semiconductors).

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