*Product Overview*

# *NIST Traceability for Temperature and Humidity Sensors*

As sensing measurement requirements become more stringent across multiple industries, the need for quality assurance and regulatory compliance grow. Critical applications such as cold chain, medical devices, and test and measurement equipment drive the need for enhanced quality assurance and traceability. NIST traceability offers several advantages, including increased confidence in measurement accuracy, improved quality control, global consistency, and comparability of results. This document reviews NIST traceability in relation to TI's portfolio of temperature and humidity sensors.

The sensors highlighted in this product overview are verified with a NIST traceable test setup, using calibrated equipment for production and development. During production, the sensor accuracy of each device is tested and calibrated to conform to the respective data sheet specification limits. Per ISO 9001 procedures and TI's quality assurance program, there is a scheduled and documented equipment calibration procedure. These procedures provide for measurement traceability to national standards. Figure 1 provides an overview of TI's NIST traceable temperature and humidity sensors, highlighting advancements in size, accuracy, and tiers of traceability (further explained within this document). Table 2 and Table 3 list the key specifications to facilitate device comparison and selection.

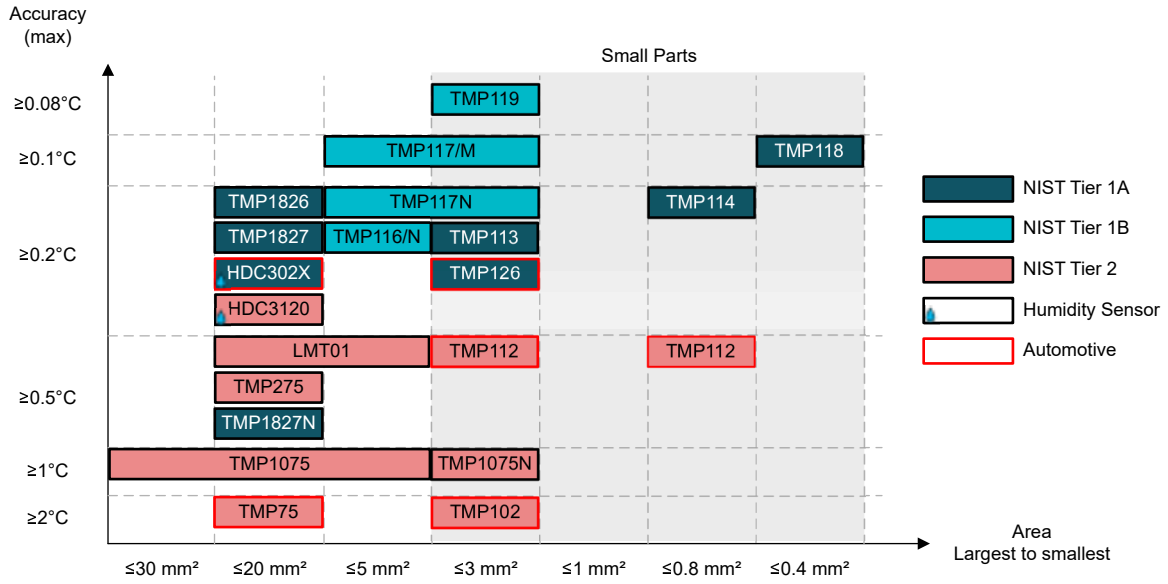


**Figure 1. Overview of NIST Traceable Temperature and Humidity Sensors**

### What is NIST Traceability?

The National Institute of Standards and Technology (NIST) is an agency of the U.S. Department of Commerce. NIST functions as the National Metrology Institute (NMI) for the U.S. and is recognized for measurement traceability through international approval. NIST is responsible for maintaining national measurement standards and calibration procedures. NIST maintains that the U.S. national standards are accurate realizations of the units of the International System of Units (SI), which is the international standard for measurement. NIST provides calibrations, reference materials, laboratory accreditation services and more to help manufacturers

meet standards and establish traceability to SI. There are two main measurement standards that are relevant in the context of this document:

1. Temperature, which is measured in kelvins, one of the seven SI base units.
2. Relative humidity, which is unitless. NIST provides SI traceability of humidity standards through a CIPM Mutual Recognition Arrangement (MRA).

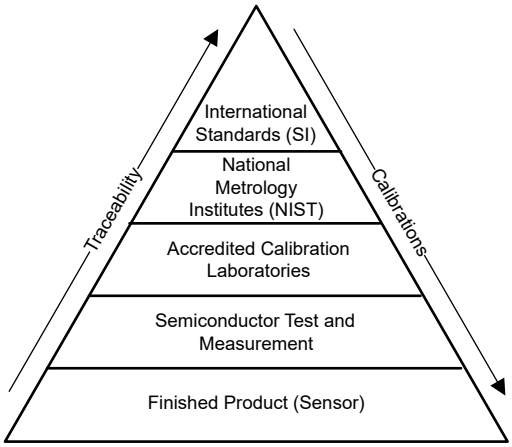


**Figure 2. Traceability Pyramid**

Metrological traceability is defined as the *property of a measurement result whereby the result can be related to a stated reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty*. The definition for metrological traceability comes from the *International Vocabulary of Metrology*. By extension, NIST traceability means that measurement results are traceable through NIST to the SI or to another internationally recognized reference standard through a chain of calibrations. To claim traceability, the entire measurement process must be documented. This includes the chain of calibrations used to establish the connection to a specified reference, where the calibrated instrument is one of the links in the chain. Note that under this definition, traceability is not the property of an instrument, calibration report, or laboratory; traceability is the property of a measurement. NIST traceable devices or similar statements can be used as shorthand to mean *devices whose specifications, measurement results, or other indications are traceable to NIST*.

The NIST Quality System for Measurement Services is based on the ISO/IEC 17025, which is the international standard for testing and calibration laboratories and maintains the accuracy and reliability of such laboratory results. TI routinely sends measurement equipment used for production and development to an ISO/IEC 17025 accredited laboratory. Figure 3 illustrates the steps taken to verify that TI's products are always verified with a NIST traceable setup. At each step in the timeline, measurement uncertainties are documented, maintaining complete metrological traceability and accurate sensor performance. The final measurement uncertainty is reflected in the sensor accuracy as specified in the device data sheet.

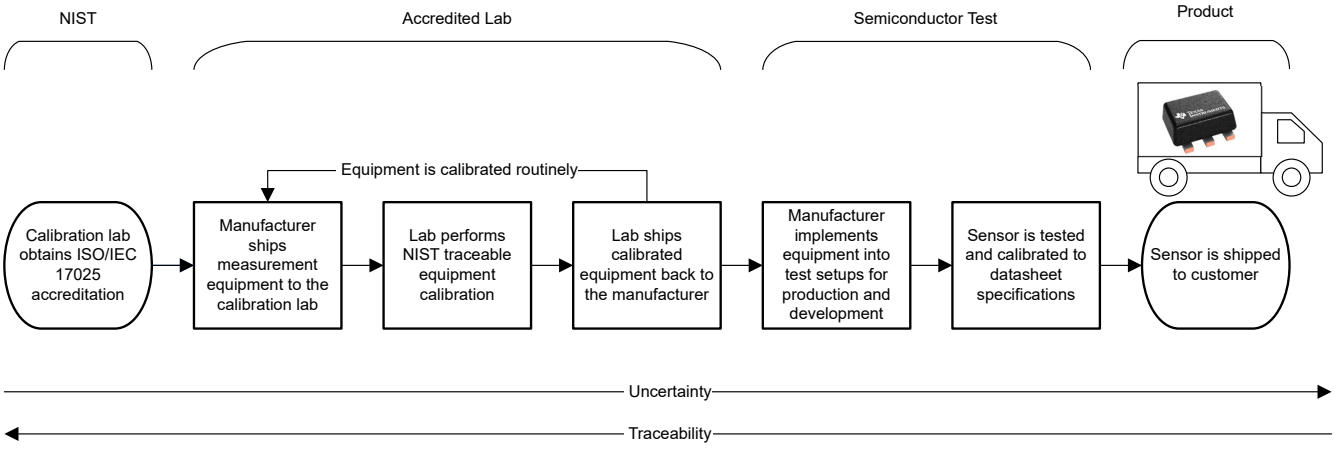


**Figure 3. The Chain of Calibrations**

### Levels of Traceability in TI's Sensor Portfolio

There are two main tiers of NIST traceability within TI's sensor portfolio, as outlined in Table 1 below.

**Table 1. Traceability Tiers**

| | Tier 1A: Fully Device Traceable | Tier 1B: Device Traceable | Tier 2: Lot Traceable |
|---|---|---|---|
| NIST Traceable Measurement Results | ✓ | ✓ | ✓ |
| Requires Shipment Box Label | ✖ | ✓ | ✓ |
| Factory-Encoded Unique ID | ✓ | ✓ | ✖ |

*Lot traceable* products from Tier 2 utilize the lot code printed on the label of the original shipment box from TI. These products can be traced back to the specific assembly and test lots, production test dates, and production equipment. To maintain traceability of lot traceable products, the engineer must take note of the lot code printed on the original label. Figure 4 shows an example of the shipment box label to refer to, with the relevant lot code highlighted.


**Figure 4. Shipment Box Label**

*Device traceable* products from Tier 1 offer the highest level of traceability and have a Unique ID programmed into each individual sensor. This Unique ID can be used to trace production information and measurement results for each individual unit, such as tracing back to a specific wafer die at a given wafer X/Y coordinate. Depending on the traceability sub-tier, the Unique ID can be used alone or in conjunction with the shipment box label. Devices from Tier 1A only require the Unique ID to maintain traceability. For devices from Tier 1B, the engineer must note the lot code printed on the original shipment box label. To maintain full traceability of device traceable products, the engineer must verify that the software has the ability to read the factory-encoded Unique ID from the sensor. Additionally certain sensors, such as the TMP117, have user-programmable EEPROM that is preprogrammed during manufacturing with the Unique ID. These preprogrammed registers can be overwritten to store general-purpose data. To support traceability on devices such as TMP117, do not reprogram the relevant EEPROM registers, or note the Unique ID before overwriting the EEPROM.

Regardless of the traceability tier, NIST traceability provides quality assurance and confidence in sensor accuracy and performance by maintaining that sensors are verified with equipment that is traceable and undergoes routine, documented calibrations. Sensors from different traceability tiers are available and can be more advantageous based on the applications use-case. For example, since device-level traceability requires a programmed Unique ID using multiple digital registers, this is only available with digital sensors and not analog sensors. Fully device traceable sensors from Tier 1A offer the benefit of not requiring the engineer to retain the shipment box label information. Other unique features can be offered for specific devices, such as programmable EEPROM or authentication engines. The engineer must make an informed choice when selecting a device and consider factors such as sensor features, accuracy, communication interface, package and board size, as well as industry regulations and requirements. The last section of this document highlights the key specifications and feature differences among TI's NIST traceable temperature and humidity sensors.

### NIST Calibration Documentation

NIST calibration documentation for TI's temperature and humidity sensors is available and can be requested online here. More detailed NIST letters can be provided upon request. For additional questions and information, contact ths-nist@list.ti.com.

### Comprehensive Overview and Key Specifications

The tables below shows a comprehensive overview of TI's portfolio of NIST traceable temperature and humidity sensors, comparing key specifications and feature differences.

**Table 2. Humidity Sensors: Key Specifications Comparison**

| Device | Traceability Tier | Interface Type | Maximum Accuracy | Package | Area (mm) | Power Supply Range | Shutdown Iq (typical) | Additional Features |
|---|---|---|---|---|---|---|---|---|
| HDC3020, HDC3020-Q1 | 1A | I²C | 2%RH, 0.2°C | WSON | 2.5 × 2.5 | 1.62V to 5.5V | 0.36µA | Automotive grade available, Unique ID |
| HDC3021, HDC3021-Q1 | 1A | I²C | 2%RH, 0.2°C | WSON | 2.5 × 2.5 | 1.62V to 5.5V | 0.36µA | Automotive grade available, Unique ID, Removable tape cover |
| HDC3022, HDC3022-Q1 | 1A | I²C | 2%RH, 0.2°C | WSON | 2.5 × 2.5 | 1.62V to 5.5V | 0.36µA | Automotive grade available, Unique ID, Permanent IP67 filter |
| HDC3120 | 2 | Analog | 2%RH, 0.3°C | WSON | 2.5 × 2.5 | 1.62V to 5.5V | - | |

**Table 3. Temperature Sensors: Key Specifications Comparison**

| Device | Traceability Tier | Interface Type | Maximum Accuracy | Package | Area (mm) | Power Supply Range | Shutdown Iq (typical) | Additional Features |
|---|---|---|---|---|---|---|---|---|
| TMP102, TMP102-Q1 | 2 | I²C, SMBus | 2.0°C | SOT563 | 1.6 × 1.6 | 1.4V to 3.6V | 0.15µA | Automotive grade available |
| TMP112, TMP112-Q1 | 2 | I²C, SMBus | 0.5°C | SOT563 | 1.6 × 1.6 | 1.4V to 3.6V | 0.15µA | Automotive grade available |
| | | | | X2SON | 0.8 × 0.8 | | | |
| TMP113 | 1A | I²C, SMBus | 0.3°C | DSBGA | 1.5 × 1 | 1.4V to 5.5V | 0.07µA | Unique ID |
| TMP114 | 1A | I²C, SMBus | 0.2°C | PicoStar | 0.76 × 0.76 | 1.08V to 1.98V | 0.16µA | Ultra-thin 0.15mm height, Unique ID |
| TMP116 | 1B | I²C, SMBus | 0.2°C | WSON | 2 × 2 | 1.9V to 5.5V | 0.25µA | 64-bit EEPROM, Unique ID |
| TMP116N | | | 0.3°C | | | | | |
| TMP117, TMP117M | 1B | I²C, SMBus | 0.1°C | WSON | 2 × 2 | 1.8V to 5.5V | 0.15µA | 48-bit EEPROM, Unique ID |
| | | | | DSBGA | 1.53 × 1 | | | |
| TMP117N | | | 0.2°C | WSON | 2 × 2 | | | |
| | | | | DSBGA | 1.53 × 1 | | | |
| TMP118 | 1A | I²C, SMBus | 0.1°C | PicoStar | 0.55 × 0.61 | 1.4V to 5.5V | 0.08µA | Unique ID |
| TMP119 | 1B | I²C, SMBus | 0.08°C | DSBGA | 0.95 × 1.488 | 1.8V to 5.5V | 0.15µA | Enhanced strain tolerance, Unique ID |
| TMP126, TMP126-Q1 | 1A | SPI | 0.25°C | SOT-SC70 | 2 × 1.25 | 1.62V to 5.5V | 0.35µA | Automotive grade available, CRC and slew-rate alert, Unique ID |
| TMP75, TMP75-Q1 | 2 | I²C, SMBus | 2.0°C | SOIC | 4.9 × 3.91 | 2.7V to 5.5V | 0.1µA | Automotive grade available |
| | | | | VSSOP | 3 × 3 | | | |
| TMP275 | 2 | I²C, SMBus | 0.5°C | SOIC | 4.9 × 3.91 | 2.7V to 5.5V | 0.1µA | |
| | | | | VSSOP | 3 × 3 | | | |

**Table 3. Temperature Sensors: Key Specifications Comparison (continued)**

| Device | Traceability Tier | Interface Type | Maximum Accuracy | Package | Area (mm) | Power Supply Range | Shutdown Iq (typical) | Additional Features |
|---|---|---|---|---|---|---|---|---|
| TMP1075 | 2 | $I^2C$, SMBus | 1.0°C | VSSOP | 3 × 3 | 1.7V to 5.5V | 0.37µA | |
| | | | | SOIC | 4.9 × 6 | | | |
| | | | | WSON | 2 × 2 | | | |
| TMP1075N | | | | SOT563 | 1.6 × 1.6 | 1.62V to 3.6V | 0.15µA | |
| TMP1826 | 1A | 1-Wire® | 0.2°C | WSON | 2.5 × 2.5 | 1.7V to 5.5V | 1.3µA | 2Kbit EEPROM, Unique ID |
| | | | 0.3°C | VSSOP | 3 × 4.9 | | | |
| TMP1827 | 1A | 1-Wire® | 0.2°C | WSON | 2.5 × 2.5 | 1.7V to 5.5V | 1.3µA | SHA-256 authenticator, 2Kbit EEPROM, Unique ID |
| TMP1827N | | | 0.9°C | | | | | |
| LMT01 | 2 | Pulse Count | 0.5°C | TO-92 | 4 × 3.15 | 2V to 5.5V | 0.002µA | |
| | | | | WSON | 1.7 × 2.5 | | | |

### References

1. A. Possolo, S. Bruce, and R. Watters (2021). *Metrological Traceability Frequently Asked Questions and NIST Policy*.
2. Joint Committee for Guides in Metrology (JCGM) Working Group 2 (WG2) (2006). *International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM)*. 3rd edition.

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