MVH4000A Series

High Performance Analog Relative Humidity & Temperature Sensor

GENERAL DESCRIPTION

[Patents protected & patents pending]

MEMS Vision's relative humidity (RH) and temperature (T) sensors are built by combining the company's revolutionary MoSiC® technology with its extensive ASIC design experience. This combination enables high levels of performance, such as fast RH measurement response time and high accuracy.

The technology also offers a very robust proprietary sensor-level protection, ensuring excellent stability against aging and harsh environmental conditions such as shock and volatile chemicals.

The highly miniaturized smart sensors are fully calibrated and provide analog relative humidity and temperature outputs that are ratiometric with supply voltage. This sensor type supports systems operating in high noise environments where sensors with digital outputs cannot be used.

The micro-Watt levels of power consumption of these sensors make them the ideal choice for portable and remote applications.

MEMS Vision's combined RH/T sensors offer the industry's most competitive performance-to-price value, for a wide range of applications and end users.

FEATURES

- **Fast RH response time**
  Typical 4 seconds time constant
- **High accuracy**
  Relative humidity (MVH4001A): Typical: ±1.5% RH
  Temperature (MVH4001A): Typical: 0.2°C
- **10% to 90% ratiometric analog output voltage**
- **Fully calibrated analog relative humidity output with temperature compensation**
- **Very low power consumption**
  92 µA avg. current (3.3V supply)
- **Small form factor for use in compact systems**
  2.5 x 2.5 x 0.9 mm DFN-style LGA package

USER BENEFITS

- **Long Term Stability and Reliability:**
  Proprietary sensing structures and protection technology, robust biasing circuitry, and self-diagnosis algorithms ensure accurate and repeatable measurements.
- **Analog Output:**
- Supports systems operating in high-noise environments where digital outputs are susceptible to errors.
- **Fully Calibrated System:**
  Built-in digital calibration ensures high accuracy measurements and linear behavior under varying sensing environments.

APPLICATIONS

The MVH4000A series is ideal for use in environmental sensing for consumer electronics, automotive, industrial, agricultural, and other sectors. Some application examples include:

- OEM products
- Instrumentation
- Medical equipment
- White goods
- Battery-powered systems
- Drying
- Meteorology
- Refrigeration equipment
- Smartphones and tablets
- HVAC systems
- Building automation
- Data logging

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1 Pin Configuration

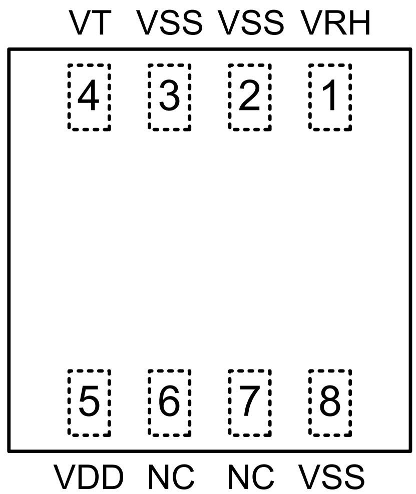


Fig. 1: Diagram of pin configuration (top view).

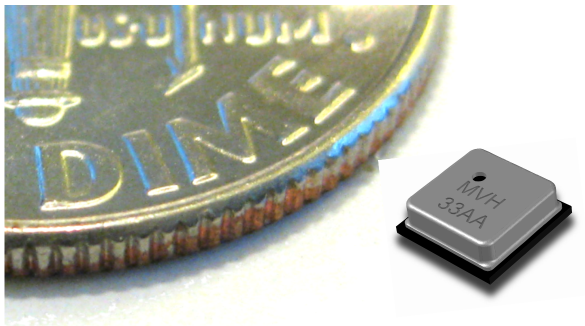


Fig. 2: DFN-style LGA package.

2 Pin Assignment and Application Circuit

Table 1: Pin Assignment.

Pin	Name	Function
1	VRH	Analog RH output voltage[1]
2	VSS	Connect to ground
3	VSS	Connect to ground
4	VT	Analog temperature output voltage[1]
5	VDD	Positive supply
6	NC	No connect
7	NC	No connect
8	VSS	Negative supply or ground

[1] Requires a capacitor

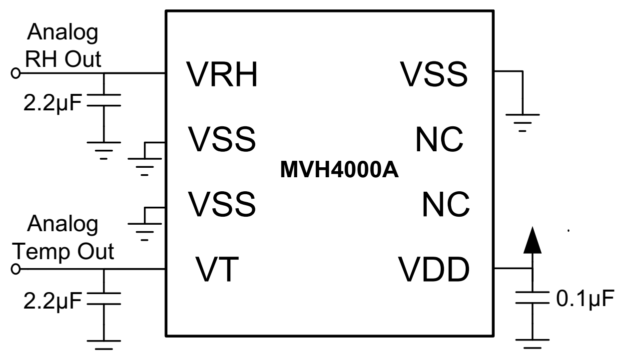


Fig. 3: Application Circuit.

3 Functional Description

The MVH4000A series are digital sensors at their core. They accurately measure relative humidity and temperature, and then convert the results to analog output signals.

An analog-to-digital converter (ADC) with a configurable resolution is interfaced with an analog multiplexer to allow for the measurement of both relative humidity and temperature. High precision biasing and clock generation ensures stable operation over a wide temperature range. The sensor can be used to measure the ambient relative humidity and temperature in real-time, and produces an analog output signal for both measurement types simultaneously.

Calibration data and compensation logic are integrated within the system, such that the chip does not require any user calibration, and is readily compensated for accurate operation over a wide range of temperature and humidity levels.

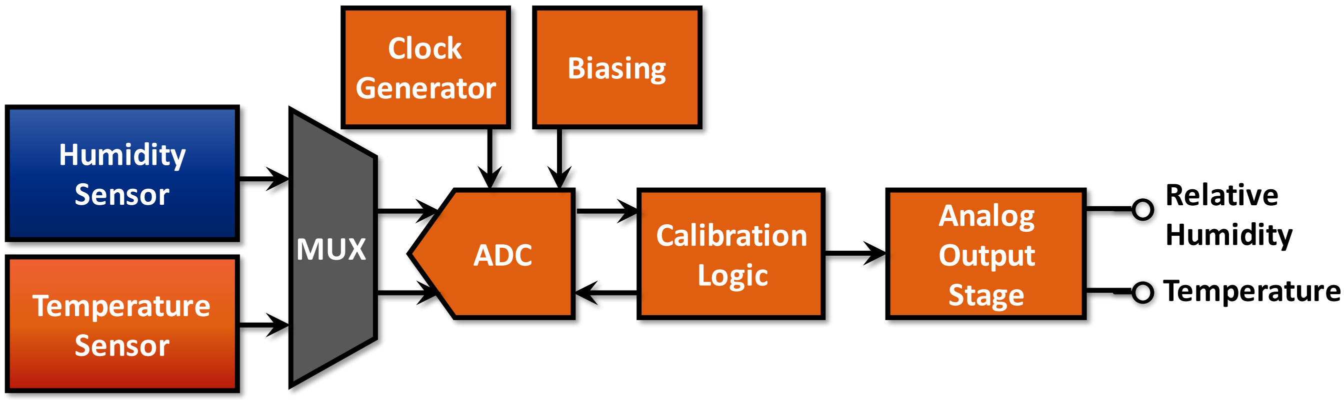


Fig. 4: MVH4000A series functional diagram.

4 Chip Performance Summary

Table 2: MVH4000A Series Specifications.

At T_A = +25°C, V_{DD} = +1.71 V to +3.6 V unless otherwise noted.

PARAMETER		CONDITION	MIN	TYP	MAX	UNITS
RELATIVE HUMIDITY SENSOR						
Range			0		100	%RH
Accuracy Tolerance[2]	MVH4001A	10% to 90% RH		±1.5	±1.8	%RH
	MVH4002A			±2.0	±2.3	
	MVH4003A	20% to 80% RH		±2.5	±3.5	
	MVH4004A			±3.5	±4.5	
Resolution				0.04	0.05	%RH
Hysteresis					±1.0	%RH
Non-Linearity from Response Curve	MVH4001A	10% to 90% RH		±0.15	±0.25	%RH
	MVH4002A			±0.15	±0.25	
	MVH4003A	20% to 80% RH		±0.15	±0.25	
	MVH4004A			±0.15	±0.25	
Long-term Stability				0.1	0.25	%RH/yr
Response Time Constant[3] (τ_H)		20% to 80% RH Still air	3.0	4.0	6.0	sec.
TEMPERATURE SENSOR						
Range			-40		105	°C
Accuracy Tolerance[4]	MVH4001A	-10°C to 80°C		±0.2	±0.3	°C
	MVH4002A			±0.2	±0.3	
	MVH4003A	0°C to 70°C		±0.25	±0.35	
	MVH4004A			±0.3	±0.5	
Resolution		8 bits	0.01	0.015	0.025	°C
Response Time Constant[5] (τ_T)				> 2		sec.
Long-term Stability					0.03	°C/yr
Supply Voltage Dependency				0.03	0.1	°C/V

Table 2 (cont'd): MVH4000A Series Specifications

PARAMETER		CONDITION	MIN	TYP	MAX	UNITS
CHIP TEMPERATURE RANGE						
Operating Range			-40		105	°C
Recommended Storage Range			0		60	°C
Storage Range			-40		125	°C
MEASUREMENT TIME						
Humidity and Temperature Measurement				1.7	2.3	ms
POWER SUPPLY						
Operating Supply Voltage	V_{DD}		1.71	3.3	3.6	V
SUPPLY CURRENT						
Average Current	I_Q	VDD = 1.8V		82	95	µA
		VDD = 3.3V		92	110	

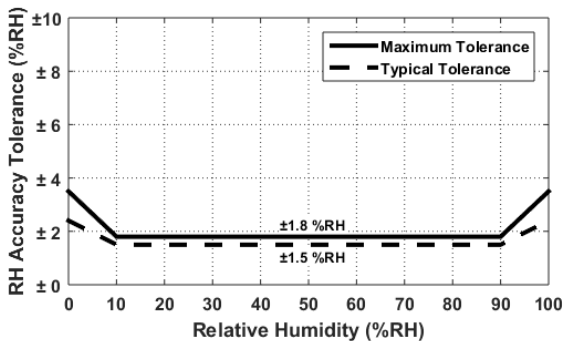
[2]For monotonic increases in the range of 10% to 90% RH after the sensor has been stabilized at 50% RH. See Fig. 5 and Fig. 6 for more details.
[3]From initial value to 63% of the total variation.
[4]See Fig. 5 for more details.
[5]Response time depends on system thermal mass (e.g., PCB dimensions and thickness) and airflow.

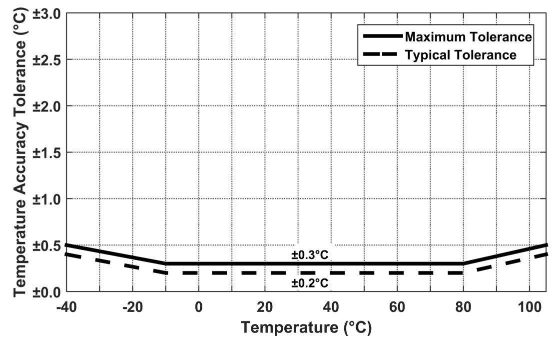
5 Relative Humidity and Temperature Tolerances

5.1 Accuracy Tolerances

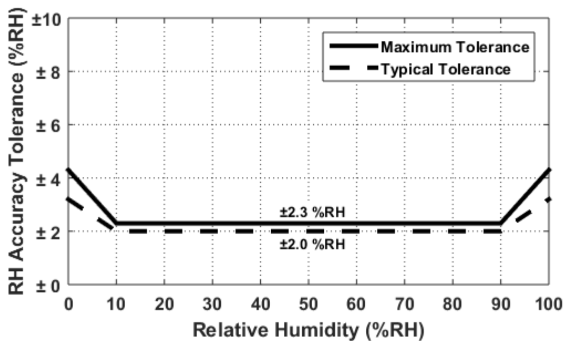
The typical and maximum relative humidity and temperature accuracy tolerances for the MVH4000A series sensors are shown in Fig. 5.

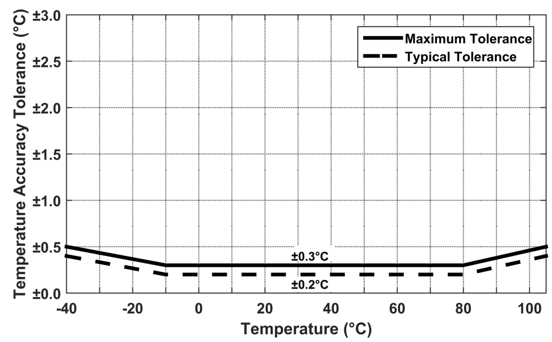
MVH4001A



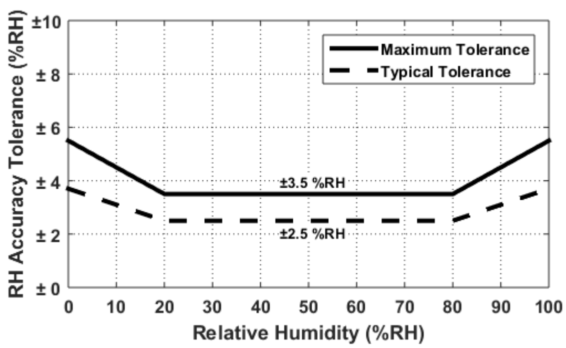


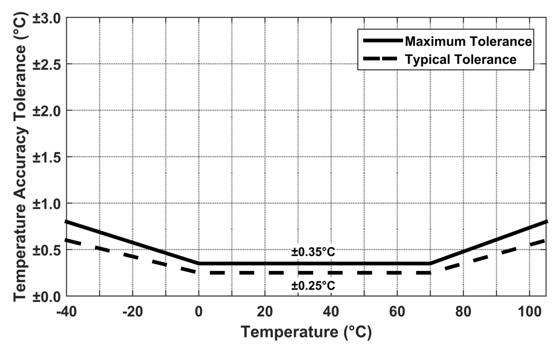
MVH4002A



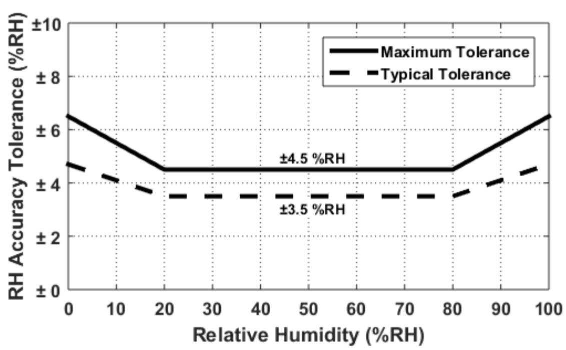


MVH4003A





MVH4004A



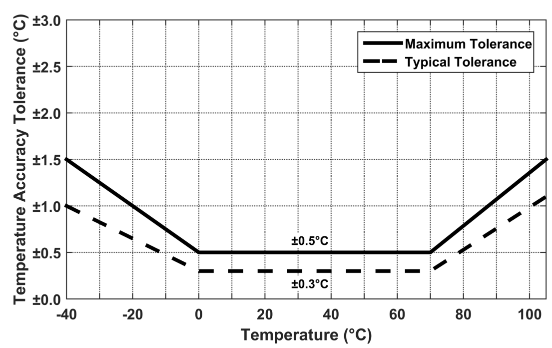


Fig. 5: Relative humidity and temperature tolerances (RH tolerances given at T_A = +25°C).

The typical relative humidity accuracy across temperature is shown in Fig. 6.

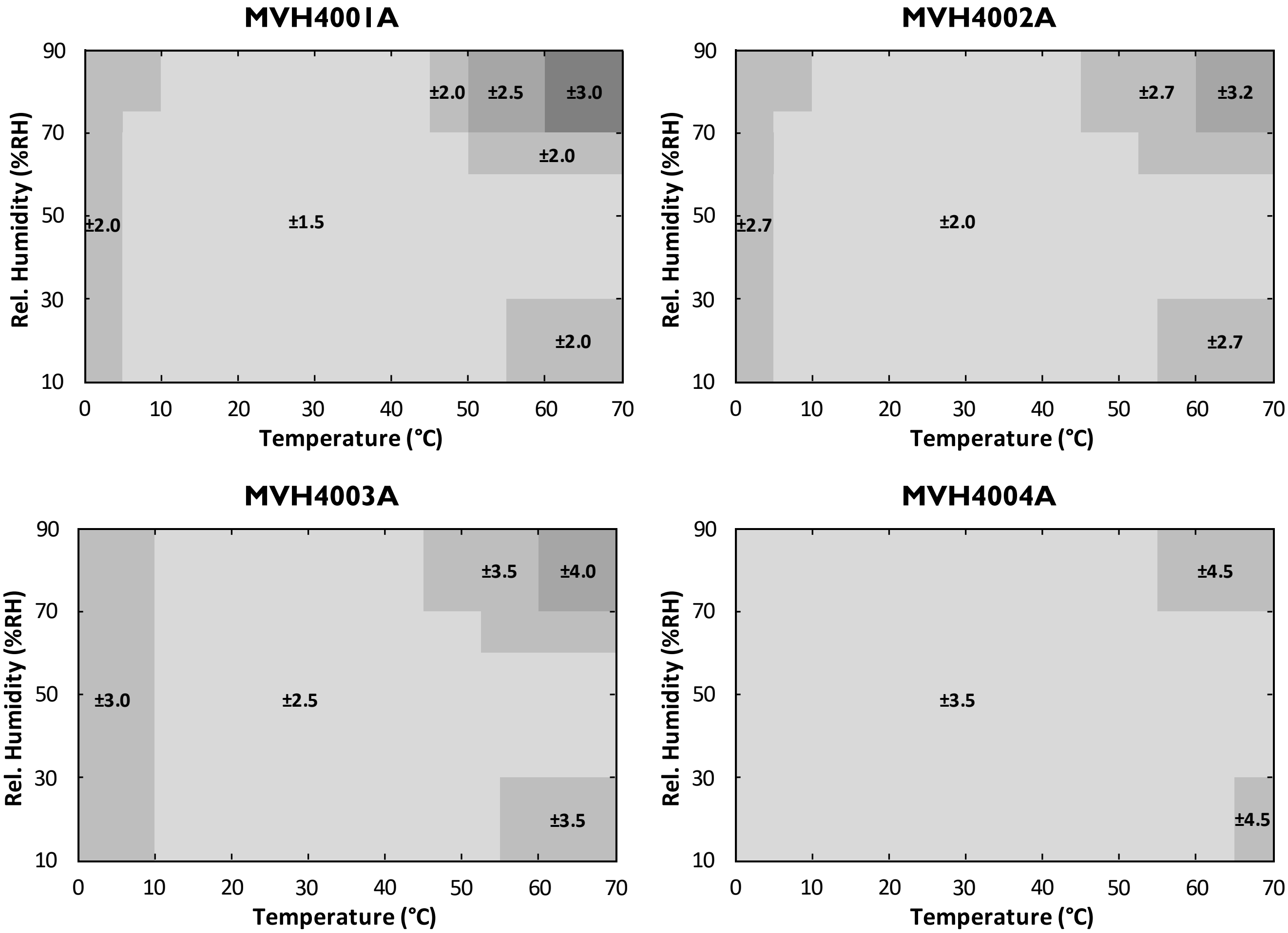


Fig. 6: Relative humidity tolerances across temperature.

5.2 Normal Operating Conditions

The sensor has been optimized to perform best in the more common temperature and humidity ranges of 10°C to 50°C and 20% RH to 80% RH (non-condensing), respectively. If operated outside of these conditions for extended periods of time, especially at high humidity levels, the sensors may exhibit an offset. In most cases, this offset is temporary and will gradually disappear once the sensor is returned to normal temperature and humidity conditions. The amount of the shift and the duration of the offset vary depending on the duration of exposure and the severity of the relative humidity and temperature conditions. The time needed for the offset to disappear can be decreased by using the procedure described in Section 8 of this datasheet.

6 User Guide

6.1 Sensor Startup

The typical startup time of the MVH4000A series sensor is 100 ms, after which temperature and relative humidity measurement data will be provided on the corresponding pins.

6.2 Applications Circuit

The MVH4000A series of sensors requires a 2.2µF ceramic capacitor connected to ground on both the VRH and VT outputs. It is also recommended to buffer the output of the relative humidity and temperature signals before processing the analog voltage. The buffer should have a low input leakage current (< 1nA) and a low input offset voltage (< 1mV) to ensure high signal integrity. Fig. 7 shows an example application circuit.

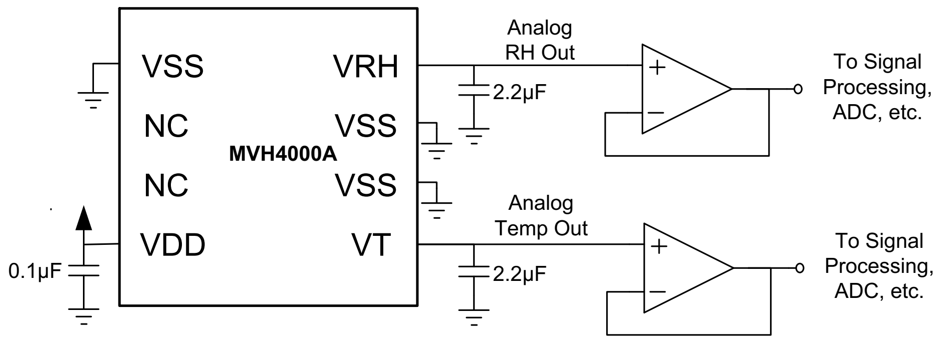


Fig. 7: Application circuit to buffer relative humidity and temperature outputs.

6.3 Conversion of the Output Signal

The voltage levels of the filtered analog output signal are ratiometric with V_{DD}. The default output range for the relative humidity and temperature is from 10% to 90%, and custom output ranges are also supported. (Please contact support@mems-vision.com for further details.)
Each MVH4000A sensor is individually calibrated, so that a standard linear fitting equation can be used to obtain the measured temperature and RH value. The equation to convert the VRH output voltage to relative humidity is given as:

$$RH = 125 * \frac{V_{RH}}{V_{DD}} - 12.5.$$

This is shown graphically in Fig. 8.

The equation to convert the VT output voltage to temperature is given as:

$$Tempearture = 181.25 * \frac{V_T}{V_{DD}} - 58.125.$$

This is shown graphically in Fig. 9.

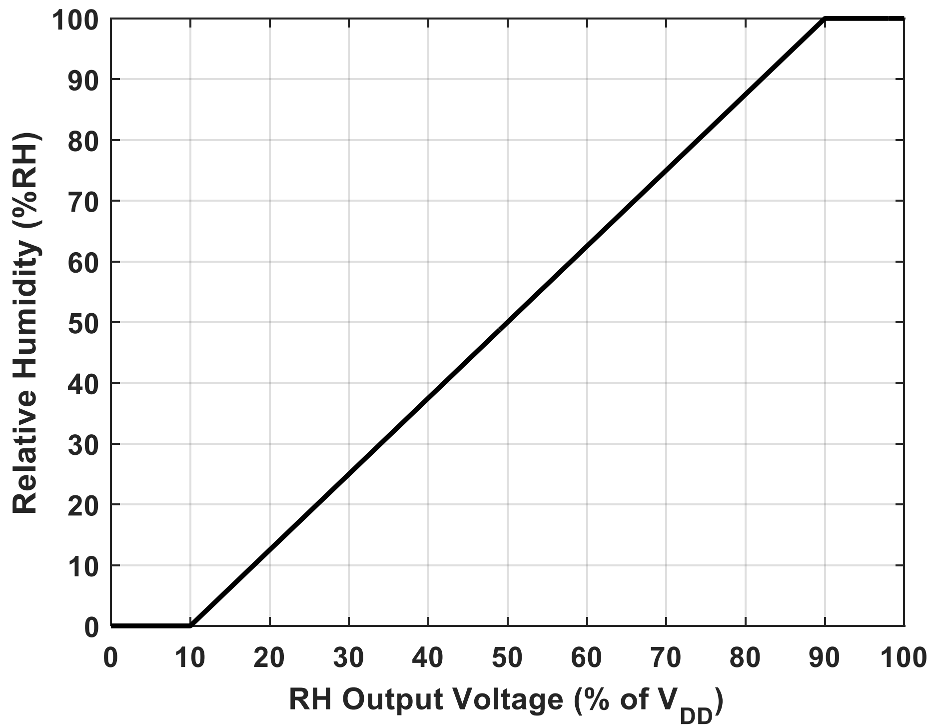


Fig. 8: Relative humidity vs. the VRH output analog voltage.

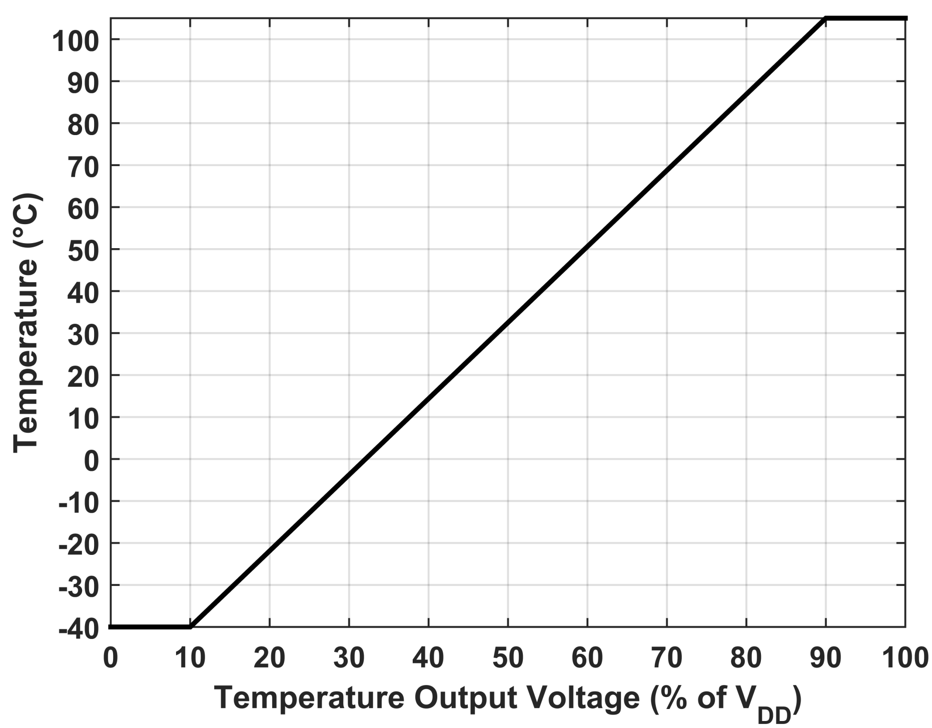


Fig. 9: Temperature vs. the VT output analog voltage.

7 Package and PCB Information

The MVH4000A series sensors are packaged in a 2.5 × 2.5 × 0.9 mm 8-pin dual-flat no-leads (DFN)-style LGA package.

7.1 Package Drawing

The mechanical drawing of the LGA package is shown in Fig. 10, and a suitable land pattern for soldering the sensor to a PCB is shown in Fig. 11.

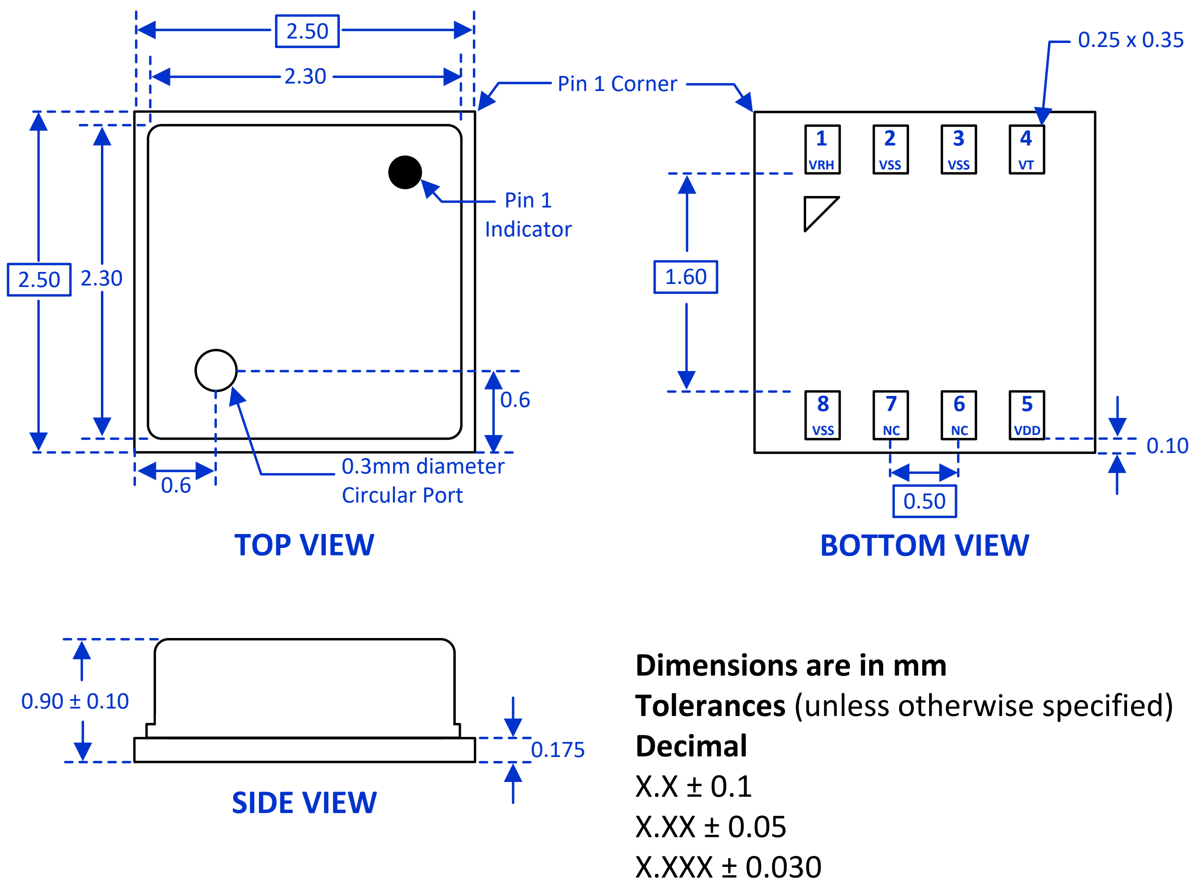


Fig. 10: LGA package drawing.

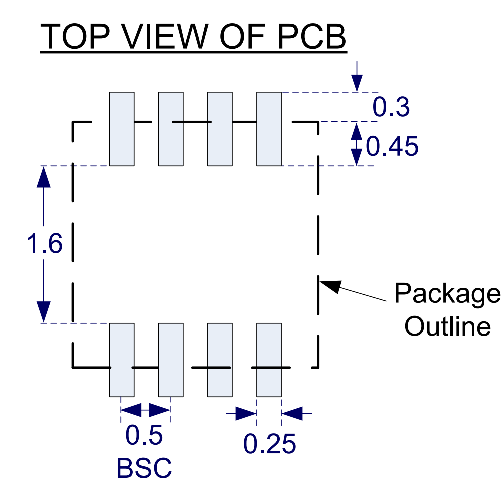


Fig. 11: LGA package land pattern (top view).

7.2 Tape and Reel Information

The MVH4000A series sensors are shipped in tape and reel packaging and enclosed in sealed anti-static bags. Standard packaging sizes are 400, 1500, and 2500 units (please contact MEMS Vision for other volumes). The tape has a 520mm leader (130 pockets) and a 410mm trailer (103 pockets). A drawing of the packaging tape is shown in Fig. 12, which also shows the sensor orientation.

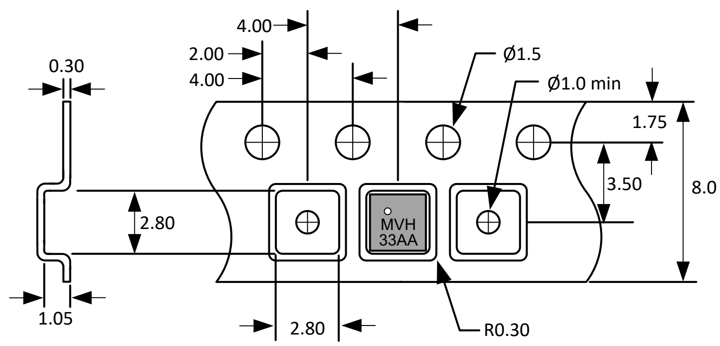


Fig. 12: Packaging tape drawing.

7.3 Soldering Information

Standard reflow ovens can be used to solder the MVH4000A series sensor to the PCB. The peak temperature (T_p) for use with the JEDEC J-STD-020D standard soldering profile is 260°C. For manual soldering, the contact time must be limited to 5 seconds at up to 350°C. In either case, if solder paste is used, it is recommended to use 'no-clean' solder paste to avoid the need to wash the PCB.
Note that reflow soldering is recommended for optimal performance. The recommended lead-free (RoHS compliant) reflow soldering profile is shown in Fig. 13.

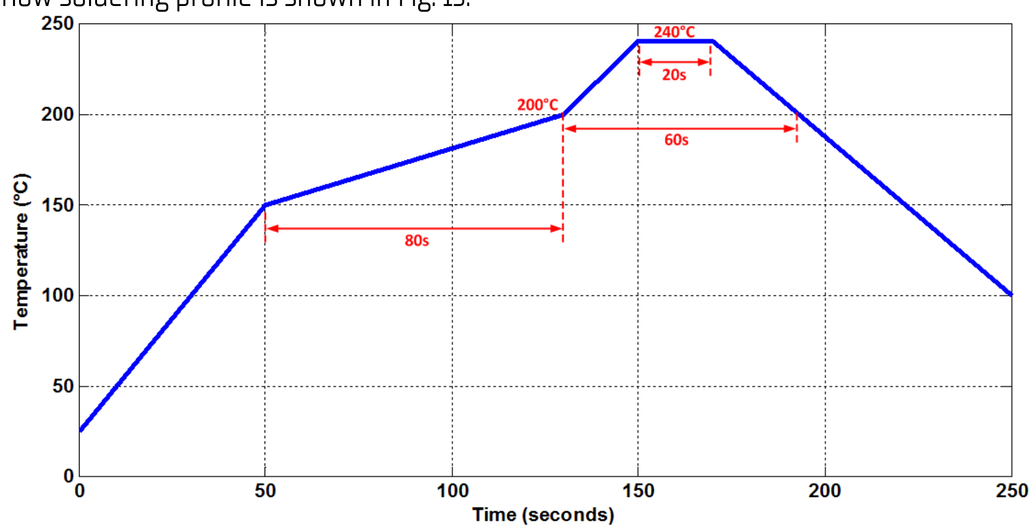


Fig. 13: Recommended lead-free soldering profile

After soldering, the humidity sensor element should be exposed to a humidity of 75% RH for at least 10 hours in order to rehydrate the element. Otherwise, there may be an initial offset in the relative humidity readings, which will slowly disappear as the sensor gets exposed to ambient conditions.

7.4 PCB Layout Considerations

When designing the PCB, undesired heat transfer paths to the MVH4000A series chip must be minimized. Excessive heat from other components on the PCB will result in inaccurate temperature and relative humidity measurements. As such, ***solid metal planes for power supplies should be avoided in the vicinity of the sensor*** since these will act as thermal conductors. To further reduce the heat transfer from other components on the board, openings can be milled into the PCB as shown in Fig. 14.

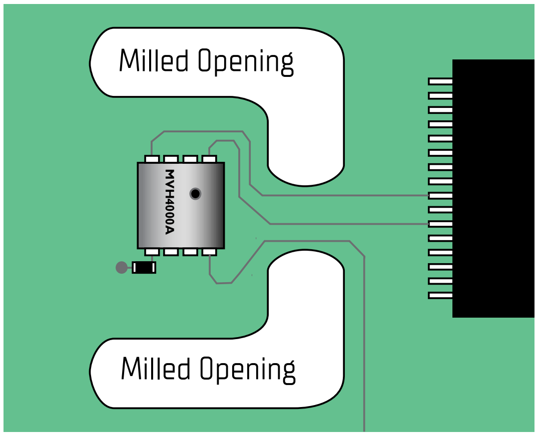


Fig. 14: Thermal isolation of sensor using milled PCB openings.

8 Storage and Handling Information

Once the sensors are removed from their original packaging, it is recommended to store them in metal-in antistatic bags. Polyethylene antistatic bags (light blue or pink in color) should be avoided as they may affect sensor accuracy.

The nominal storage conditions for the MVH4000A series chip are at temperatures in the range of 10 to 50°C and at humidity levels within the range of 20% to 60% RH. If the chip is stored outside of these ranges for extended periods of time, the relative humidity sensor readings may exhibit an offset. The sensor can be brought back to its calibration state by applying the following reconditioning procedure:

1. Baking at a temperature of 100°C with a humidity < 10% for 10 -12 hours.
2. Rehydrating the sensor at a humidity of 75% RH and a temperature between 20 to 30°C for 12 to 14 hours.

Note that the sensor may also return to its calibrated state if left at ambient conditions for a longer period of time.

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