

Humidity Sensor Performance Characteristics

Application Sheet

GENERAL INFORMATION

When designing the best humidity probe for a specific application, the process is a series of choices to meet customer application requirements while considering key parameters. Selecting the best humidity sensor is a critical part of the process. The following is a discussion of the key performance parameters that should be considered and how they are derived in the Honeywell product sheets.

Note that for the purposes of this application sheet:

V_{OUT} = the dc output voltage from the humidity sensor, at 0%RH (unless otherwise stated).

Accuracy (Specified at 25 °C [77 °F] and 5 Vdc supply.)

This is based on the specific calibration curves for any individual sensor. Honeywell specifies this parameter using the linear Best Fit Straight Line (BFSL) and the non-linear 2nd order curve.

An “offset” parameter is derived. This parameter is the point on the V_{OUT} axis where the line with a slope derived from the average of the rising and falling slopes for that device will intersect at 0% RH (Relative Humidity). This is generated using a 9 point characterization for the product documentation.

- **Example 1: ±2% RH (BFSL)**

If a specific sensor has an output voltage of 0.789 V at 0%RH, an average slope of 0.03165 V/%RH and intersect at 0.762, then its BFSL accuracy error is given by $(0.789 - 0.762) / 0.03165 = 0.85\%$ RH. This sensor should always output 0.762 ±0.063 or a range of 0.699 V to 0.825 V. “±0.063 V” is equivalent to ±2% RH (average slope times ±2% RH).

- **Example 2: ±3.5 %RH (BFSL) over the full range**

The accuracy error is calculated at each of the nine %RH points. The accuracy error is the voltage difference between the actual output voltage and theoretical output voltage converted to a %RH. The theoretical output voltage is calculated by dividing the reference %RH by the average slope and adding the theoretical intersect. A given sensor should output the theoretical voltage ± a voltage equivalent to 3.5% RH at each of the nine points.

DATA PRINTOUT

- **Channel, wafer, MRP:** Factory references.
- **Calculated values at 5 V:** The values shown are the BFSL theoretical values using five point characterization. “Linear output for 3.5% RH accuracy at 25 °C.”
- **Zero offset:** An “offset” parameter is derived. This parameter is the point on the V_{OUT} axis where the line with slope “slope” will intersect at 0% RH for the individual device.
- **Slope:** The average of the rising and falling slopes for that device, generated using a 5 point characterization.
- **RH:** The BFSL voltage to RH conversion algorithm with an example shown using the parameters in the data print out.
- **Ratiometric response for 0% to 100% RH, V_{OUT} :** The output voltage at given RH at different supply voltages may be estimated using this formula for this individual device.

DRIVE LIMITS

- **Push/Pull Symmetric**

No specific definition is given here. It is available upon request.

- **Source and Sink Maximum Current**

This is defined over the range of RH range (0% to 95%/0.8 V to 3.9 V). The current values published take into account the effect of temperature on the drive capability.

The source and sink currents are dependent on the size of the output stage transistors and their V_T values. Equations for the source and sink currents are available upon request. The equation’s parameters (K_p , K_n , V_{bias} , V_{tn} and V_{tp}) are temperature dependent.

For an example with typical values of $V_{tn}=1.7$, $V_{tp}=1.2$, $V_{DD}=5$ V and $V_{bias}=2.6$ V (V_t dependent), the maximum source current is about 50 μ A. Therefore, for correct operation, the recommended minimum load value is 76 kOhm (3.8 V/50 μ A).

The sink current ranges from 4 μ A to 20 μ A for the 100% to 0% humidity range.

- **Turn On (Time)**

No specific definition is given, available on request.

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HYSTERESIS (Based on the BFSL Accuracy Method)

This is the difference between the two voltages to %RH conversions at each of the four duplicated points in the nine point characterization. The voltage to RH conversion is done using the BFSL calibration data. Hysteresis is recorded in absolute %RH terms.

This is specified over the full range, unless otherwise stated. The value taken is the largest %RH figure for an individual sensor over each of the four characterization points.

INTERCHANGEABILITY

This defines the range of voltages for any population of sensors at this RH point. Note that this is compared to the baseline output for Honeywell's RHIC (Relative Humidity Integrated Circuit) chip which is 0.8 V to 3.9 V (0% to 100% RH) with an excitation voltage of 5 Vdc.

• Example 1: ±5% at 0% RH

The baseline slope*, 0.031 V/%RH times ±5% RH is ±0.155 V. This means that the output voltage for this device is 0.8 V ±0.155 V, or a range of 0.645 V to 0.955 V. When exposed to an RH of 0%, the output of the entire population of sensors will fall within this range.

*baseline slope = (3.9 V - 0.8 V)/100% RH = 0.031 V/%RH.

• Example 2: ±5% at 0% RH to 59% RH and ±8% at 60% RH to 100%RH

This defines the range of voltages for any population of sensors at all RH points over the humidity range of interest.

Note that the interchangeability can increase with increasing RH since the RHIC (Relative Humidity Integrated Circuit) die is actively trimmed only at 0% RH. Trimming at other RH values is impractical.

LINEARITY

• BFSL Method

This is equivalent to Honeywell's definition of BFSL accuracy. The voltage deviation from the BFSL value and the measured output voltage value, converted to RH.

• Least Squares BFSL Method

This method uses the slope of the BFSL. The maximum deviation of any point from this line is calculated as a percentage. It is the maximum sensor output voltage at the relevant RH data point minus the slope times the %RH value all divided by slope times the full scale output voltage.

RELATIVE HUMIDITY

Relative humidity is defined as the ratio between actual partial water vapor pressure and the saturation water pressure above water.

Because the actual partial vapor pressure cannot exceed the saturation vapor pressure, the maximum value of relative humidity is 100%.

RELIABILITY

Honeywell can supply estimates of MTTF (Mean Time to Failure) and FIT (Number of Failures per billion operating hours) to 90% confidence limits. MTBF (Mean Time Between Failures) is equal to MTTF because the product is considered non-repairable.

Tests at accelerated stress levels are normally conducted to 1000 hours. An acceleration factor is calculated using the formula:

$$Af = \left[\frac{RH_t}{RH_u} \right]^n \times \exp \left[\frac{Ea}{k} \times \left(\frac{1}{T_u} - \frac{1}{T_t} \right) \right]$$

where:

A_t = Acceleration factor

RH_u = Use environment relative humidity

RH_t = Test environment relative humidity

k = Boltzman's Constant (8.6171 x 10⁻⁵ eV)

T_u = Use environment junction temperature (in °K)

T_t = Test environment junction temperature (in °K)

If drift causes the sensor to report RH outside specification, and the drift cannot be reversed, then the product is considered to be a failed sensor. See the REVERSIBLE and STABILITY sections.

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REPEATABILITY

The standard definition is the maximum difference between output measurements for a repeated loading point(s) under identical loading and environmental conditions.

Honeywell uses a *six sigma* method called “Gauge Repeatability and Reproducibility.” The worst case repeatability is the maximum range figure read off the Gauge R and R range graph converted to a calibrated humidity. For example, if the point value is 0.013 V using the 31 mV/RH slope this is 0.42% RH.

REVERSIBLE

A characteristic assigned to a parameter to describe its behavior over time while exposed to accelerated life testing.

Tests have shown that a sensor output voltage can drift in both directions, in an apparent random manner, while remaining in specification throughout its lifetime. In time, the polyimide material retains water molecules. This causes an offset voltage that can be reduced (reversed) using an elevated temperature “drying” process.

RESPONSE TIME

This is measured in “slow moving air” (less than 5 m/s). The ratio $1/e$ is used because the voltage output changes exponentially.

The figure that Honeywell publishes is the typical maximum time for the output voltage of the sensor to rise to 63% of its final value or to fall to 37% of its final value when exposed to a step rise or fall in humidity.

STABILITY

This is the output voltage drift in time at the specified RH level converted to a %RH value.

Honeywell measures the change of the mean output voltage from a large batch of sensors at the given RH. The measurements are made over a period of up to 1000 hours of accelerated life testing. The voltage is converted to a %RH. An acceleration factor is calculated, based on Coffin-Manson relationship. For example, 168 hours of exposure to high humidity and temperature bias is equivalent to 27,000 hours at normal operating conditions. See the RELIABILITY section.

TEMPERATURE COMPENSATION

- The output voltage for an individual sensor at a given supply voltage and RH is affected by temperature. If the temperature is measured this effect can be compensated for. Algorithms are published in Fahrenheit and Centigrade to enable the sensor RH to be converted to true RH.
- **Effect at 50% RH**
Figure published is the RH temperature voltage coefficient.

TYPICAL

A value estimated to be central to a given set of data.

VOLTAGE OUTPUT (Variation with Supply Voltage)

There is a near linear relationship between the supply voltage and output voltage at a given temperature and %RH value. A conversion algorithm is published with typical values for the coefficients. Specific coefficient values can be derived on an individual sensor basis.

5 POINT CHARACTERIZATION

Used for the derivation of factory acceptance parameters and individual calibration data.

Honeywell sweeps the humidity level through the following RH values measuring the dc output voltage for the individual sensor: 0%, 53.2%, 75.3%, 93.8% and 0%. The reference RH value can be traced to an absolute $\pm 0.5\%$ RH (over the range 10% to 98% RH).

9 POINT CHARACTERIZATION

Used for the derivation of design acceptance and product documentation parameters.

Honeywell sweeps the humidity level through the following RH values measuring the dc output voltage for the individual sensor: 0%, 25%, 53.2%, 75.3%, 93.8%, 75.3%, 53.2%, 25% and 0%. The reference RH value can be traced to an absolute $\pm 0.5\%$ RH (over the range 10% to 98% RH).

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WARNING

PERSONAL INJURY

DO NOT USE these products as safety or emergency stop devices or in any other application where failure of the product could result in personal injury.

Failure to comply with these instructions could result in death or serious injury.

WARRANTY/REMEDY

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship. Honeywell's standard product warranty applies unless agreed to otherwise by Honeywell in writing; please refer to your order acknowledgement or consult your local sales office for specific warranty details. If warranted goods are returned to Honeywell during the period of coverage, Honeywell will repair or replace, at its option, without charge those items it finds defective. **The foregoing is buyer's sole remedy and is in lieu of all other warranties, expressed or implied, including those of merchantability and fitness for a particular purpose. In no event shall Honeywell be liable for consequential, special, or indirect damages.**

While we provide application assistance personally, through our literature and the Honeywell web site, it is up to the customer to determine the suitability of the product in the application.

Specifications may change without notice. The information we supply is believed to be accurate and reliable as of this printing. However, we assume no responsibility for its use.

WARNING

MISUSE OF DOCUMENTATION

- The information presented in this product sheet is for reference only. Do not use this document as a product installation guide.
- Complete installation, operation, and maintenance information is provided in the instructions supplied with each product.

Failure to comply with these instructions could result in death or serious injury.

SALES AND SERVICE

Honeywell serves its customers through a worldwide network of sales offices, representatives and distributors. For application assistance, current specifications, pricing or name of the nearest Authorized Distributor, contact your local sales office or:

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