

HDC1010 Low Power, High Accuracy Digital Humidity Sensor with Temperature Sensor

1 Features

- Relative Humidity Accuracy $\pm 2\%$ (typical)
- Temperature Accuracy $\pm 0.2^\circ\text{C}$ (typical)
- Excellent Stability at High Humidity
- 14 Bit Measurement Resolution
- 100 nA Sleep Mode Current
- Average Supply Current:
 - 710 nA @ 1 sps, 11 bit RH Measurement
 - 1.3 μA @ 1 sps, 11 bit RH and Temperature Measurement
- Supply Voltage 2.7 V to 5.5 V
- Tiny 2 mm x 1.6 mm Device Footprint
- I²C Interface

2 Applications

- HVAC
- IoT Smart Thermostats and Room Monitors
- Refrigerators
- Printers
- White Goods
- Medical Devices
- Wireless Sensor (TIDA: [00374](#), [00484](#), [00524](#))

4 Typical Application

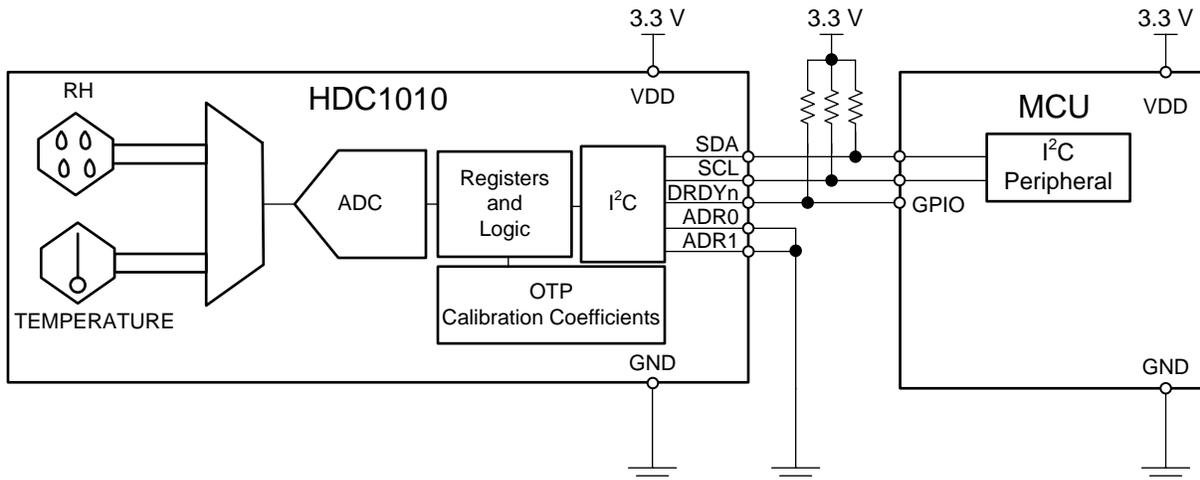
3 Description

The HDC1010 is a digital humidity sensor with integrated temperature sensor that provides excellent measurement accuracy at very low power. The HDC1010 operates over a wide supply range, and is a low cost, low power alternative to competitive solutions in a wide range of common applications. The innovative WLCSP (Wafer Level Chip Scale Package) simplifies board design with the use of an ultra-compact package. The sensing element of the HDC1010 is placed on the bottom part of the device, which makes the HDC1010 more robust against dirt, dust, and other environmental contaminants. The humidity and temperature sensors are factory calibrated and the calibration data is stored in the on-chip non-volatile memory.

Device Information (1)

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|-------------|----------------|-------------------|
| HDC1010 | DSBGA (8-bump) | 2.04 mm x 1.59 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.



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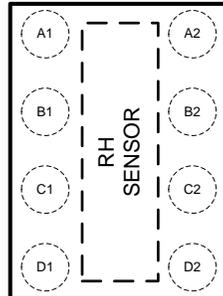
5 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Original (May 2016) to Revision A | Page |
|---|-------------|
| • Changed Product Preview to Production Data | 1 |

6 Pin Configuration and Functions

**WLCSP (DSBGA)
8 Pin YPA
Top View**



Pin Functions

| PIN | | I/O TYPE ⁽¹⁾ | DESCRIPTION |
|-------------------|-----|-------------------------|---|
| NAME | NO. | | |
| SCL | A1 | I | Serial clock line for I2C, open-drain; requires a pull-up resistor to VDD |
| VDD | B1 | P | Supply Voltage |
| ADR0 | C1 | I | Address select pin – hardwired to GND or VDD |
| ADR1 | D1 | I | Address select pin – hardwired to GND or VDD |
| SDA | A2 | I/O | Serial data line for I2C, open-drain; requires a pull-up resistor to VDD |
| GND | B2 | G | Ground |
| DNC | C2 | - | Do not connect, or, may be connected to GND. |
| DRDY _n | D2 | O | Data ready, active low, open-drain. Requires a pull-up resistor to VDD. If not used tie to GND. |

(1) P=Power, G=Ground, I=Input, O=Output

7 Specifications

7.1 Absolute Maximum Ratings⁽¹⁾

| | | MIN | MAX | UNIT |
|---------------------|------------------|------|---------|------|
| Input Voltage | VDD | -0.3 | 6 | V |
| | SCL | -0.3 | 6 | |
| | SDA | -0.3 | 6 | |
| | DRDYn | -0.3 | 6 | |
| | ADR0 | -0.3 | VDD+0.3 | |
| | ADR1 | -0.3 | VDD+0.3 | |
| Storage Temperature | T _{STG} | -65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

| | | | VALUE | UNIT |
|--------------------|-------------------------|---|-------|------|
| V _(ESD) | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins ⁽¹⁾ | ±1000 | V |
| | | Charged device model (CDM), per JEDEC specification –500 500 JESD22-C101, all pins ⁽²⁾ | ±250 | |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

over operating range (unless otherwise noted)

| | | MIN | NOM | MAX | UNIT |
|---|----------------------------------|-----|-----|-----|------|
| V _{DD} | Supply Voltage | 2.7 | 3 | 5.5 | V |
| T _A , Temperature Sensor | Ambient Operating Temperature | -40 | | 125 | °C |
| T _A , Humidity Sensor ⁽¹⁾ | Ambient Operating Temperature | -20 | | 70 | °C |
| T _A , Humidity sensor ⁽¹⁾ | Functional Operating Temperature | -20 | | 85 | °C |

(1) See [Figure 2](#)

7.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | HDC1010 | UNIT |
|-------------------------------|--|------------|------|
| | | DSBGA -YPA | |
| | | 8 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 98.0 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 0.8 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 17.8 | °C/W |
| ψ _{JT} | Junction-to-top characterization parameter | 3.7 | °C/W |
| ψ _{JB} | Junction-to-board characterization parameter | 17.8 | °C/W |

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

7.5 Electrical Characteristics⁽¹⁾

The electrical ratings specified in this section apply to all specifications in this document, unless otherwise noted. $T_A = 30^\circ\text{C}$, $V_{DD} = 3\text{V}$, and $\text{RH} = 40\%$.

| PARAMETER | | TEST CONDITION ⁽²⁾ | MIN ⁽³⁾ | TYP ⁽⁴⁾ | MAX ⁽³⁾ | UNIT |
|---------------------------------|---------------------------------|---|--------------------|--------------------|--------------------|------------------|
| POWER CONSUMPTION | | | | | | |
| I_{DD} | Supply Current | RH measurement, bit 12 of 0x02 register = 0 ⁽⁵⁾ | | 190 | 220 | μA |
| | | Temperature measurement, bit 12 of 0x02 register = 0 ⁽⁵⁾ | | 160 | 185 | μA |
| | | Sleep Mode | | 100 | 200 | nA |
| | | Average @ 1 measurement/second, RH (11 bit), bit 12 of 0x02 register = 0 ⁽⁵⁾⁽⁶⁾ | | 710 | | nA |
| | | Average @ 1 measurement/second, Temp (11 bit), bit 12 of 0x02 register = 0 ⁽⁵⁾⁽⁶⁾ | | 590 | | nA |
| | | Average @ 1 measurement/second, RH (11bit) +temperature (11 bit), bit 12 of 0x02 register = 1 ⁽⁵⁾⁽⁶⁾ | | 1.3 | | μA |
| | | Startup (average on Start-up time) | | 300 | | μA |
| I_{HEAT} | Heater Current ⁽⁷⁾ | Peak current | | 7.2 | | mA |
| | | Average @ 1 measurement/second, RH (11bit) +temperature (11 bit), bit 12 of 0x02 register = 1 ⁽⁵⁾⁽⁶⁾ | | 50 | | μA |
| RELATIVE HUMIDITY SENSOR | | | | | | |
| RH_{ACC} | Accuracy | Refer to Figure 2 in Typical Characteristics section. | | ± 2 | | %RH |
| RH_{REP} | Repeatability ⁽⁷⁾ | 14 bit resolution. | | ± 0.1 | | %RH |
| RH_{HYS} | Hysteresis ⁽⁸⁾ | $10\% \leq \text{RH} \leq 70\%$ | | ± 1 | | %RH |
| RH_{RT} | Response Time ⁽⁹⁾ | $t_{63\%}$ ⁽¹⁰⁾ | | 15 | | s |
| RH_{CT} | Conversion Time ⁽⁷⁾ | 8 bit resolution | | 2.50 | | ms |
| | | 11 bit resolution | | 3.85 | | ms |
| | | 14 bit resolution | | 6.50 | | ms |
| RH_{HOR} | Operating Range ⁽¹¹⁾ | Non-condensing | 0 | | 100 | %RH |
| RH_{LTD} | Long Term Drift ⁽¹²⁾ | | | ± 0.25 | | %RH/yr |
| TEMPERATURE SENSOR | | | | | | |
| TEMP_{ACC} | Accuracy ⁽⁷⁾ | $5^\circ\text{C} < T_A < 60^\circ\text{C}$ | | ± 0.2 | ± 0.4 | $^\circ\text{C}$ |
| TEMP_{REP} | Repeatability ⁽⁷⁾ | 14 bit accuracy | | ± 0.1 | | $^\circ\text{C}$ |
| TEMP_{CT} | Conversion Time ⁽⁷⁾ | 11 bit accuracy | | 3.65 | | ms |
| | | 14 bit accuracy | | 6.35 | | ms |

- (1) Electrical Characteristics Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
- (2) Register values are represented as either binary (b is the prefix to the digits), or hexadecimal (0x is the prefix to the digits). Decimal values have no prefix.
- (3) Limits are ensured by testing, design, or statistical analysis at 30°C . Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
- (4) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.
- (5) I²C read/write communication and pull-up resistors current through SCL and SDA not included.
- (6) Average current consumption while conversion is in progress.
- (7) This parameter is specified by design and/or characterization and it is not tested in production.
- (8) The hysteresis value is the difference between an RH measurement in a rising and falling RH environment, at a specific RH point.
- (9) Actual response times will vary dependent on system thermal mass and air-flow.
- (10) Time for the RH output to change by 63% of the total RH change after a step change in environmental humidity.
- (11) Recommended humidity operating range is 10% to 70% RH. Prolonged operation outside this range may result in a measurement offset. The measurement offset will decrease after operating the sensor in this recommended operating range.
- (12) Drift due to aging effects at typical conditions (30°C and 20% to 50% RH). This value may be impacted by dust, vaporized solvents, out-gassing tapes, adhesives, packaging materials, etc.

Electrical Characteristics⁽¹⁾ (continued)

The electrical ratings specified in this section apply to all specifications in this document, unless otherwise noted. $T_A = 30^\circ\text{C}$, $V_{DD} = 3\text{V}$, and $\text{RH} = 40\%$.

| PARAMETER | TEST CONDITION ⁽²⁾ | MIN ⁽³⁾ | TYP ⁽⁴⁾ | MAX ⁽³⁾ | UNIT |
|--------------------|-------------------------------|--------------------|--------------------|--------------------|------|
| TEMP _{OR} | Operating Range | -40 | | 125 | °C |

7.6 I2C Interface Electrical Characteristics

At $T_A=30^\circ\text{C}$, $V_{DD}=3\text{V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITION | MIN | TYP | MAX | UNIT |
|------------------------------------|---------------------------------------|---------------------|-----|---------------------|------|
| I2C INTERFACE VOLTAGE LEVEL | | | | | |
| V _{IH} | Input High Voltage | 0.7xV _{DD} | | | V |
| V _{IL} | Input Low Voltage | | | 0.3xV _{DD} | V |
| V _{OL} | Output Low Voltage | Sink current 3mA | | 0.4 | V |
| HYS | Hysteresis ⁽¹⁾ | 0.1xV _{DD} | | | V |
| CIN | Input Capacitance on all digital pins | | 0.5 | | pF |

(1) This parameter is specified by design and/or characterization and it is not tested in production.

7.7 I2C Interface Timing Requirements

| PARAMETER | TEST CONDITION | MIN | TYP | MAX | UNIT |
|------------------------------------|--|--|-----|-----|------|
| I2C INTERFACE VOLTAGE LEVEL | | | | | |
| f _{SCL} | Clock Frequency | 10 | | 400 | kHz |
| t _{LOW} | Clock Low Time | 1.3 | | | µs |
| t _{HIGH} | Clock High Time | 0.6 | | | µs |
| t _{SP} | Pulse width of spikes that must be suppressed by the input filter ⁽¹⁾ | | | 50 | ns |
| t _{START} | Device Start-up time | From V _{DD} ≥ 2.7 V to ready for a conversion ⁽¹⁾⁽²⁾ | 10 | 15 | ms |

(1) This parameter is specified by design and/or characterization and it is not tested in production.

(2) Within this interval it is not possible to communicate to the device.

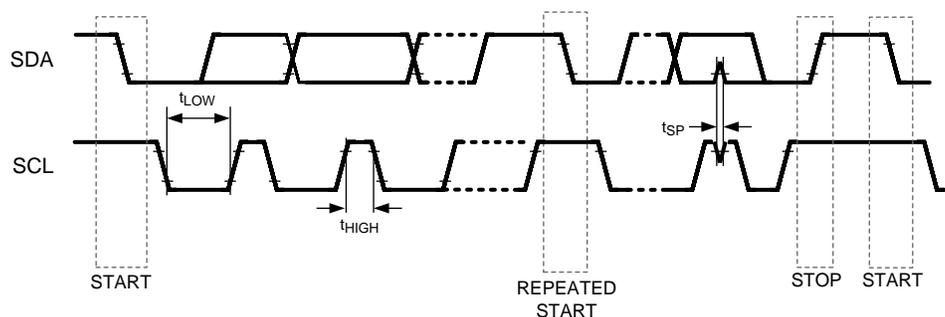


Figure 1. I2C Timing

7.8 Typical Characteristics

Unless otherwise noted. $T_A = 30^\circ\text{C}$, $V_{DD} = 3\text{V}$.

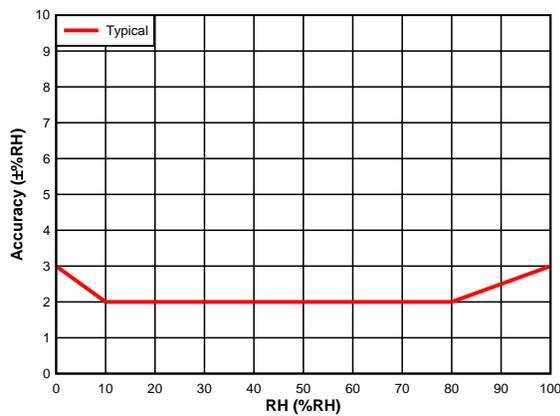


Figure 2. RH Accuracy vs. RH

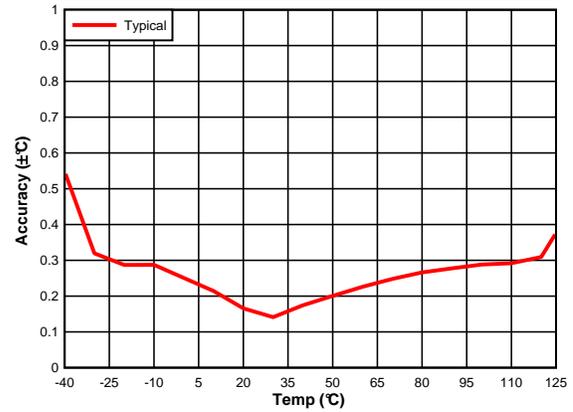


Figure 3. Temperature Accuracy vs. Temperature

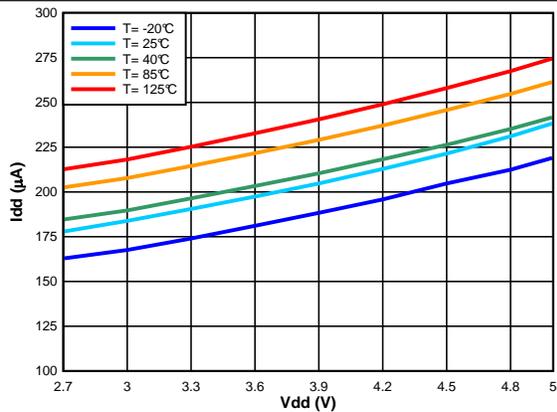


Figure 4. Supply Current vs. Supply Voltage, RH Measurement

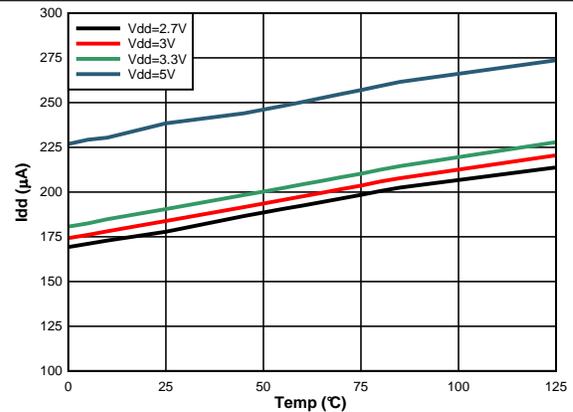


Figure 5. Supply Current vs. Temperature, RH Measurement

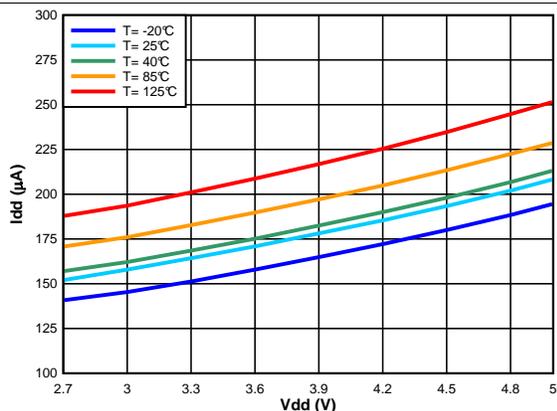


Figure 6. Supply Current vs. Supply Voltage, Temp Measurement

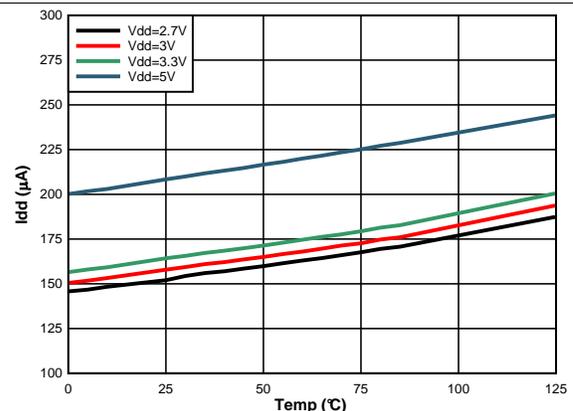
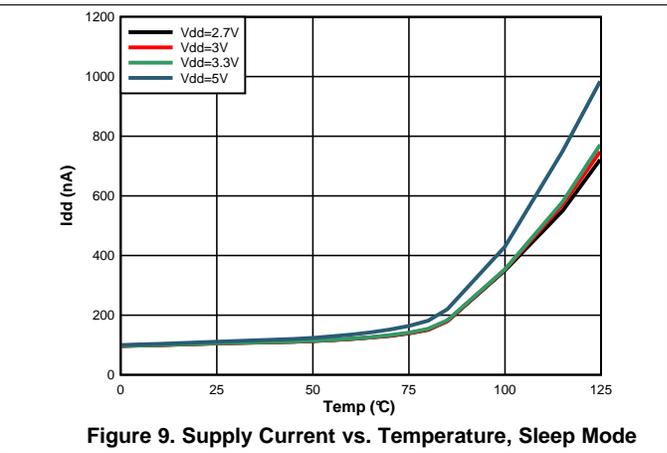
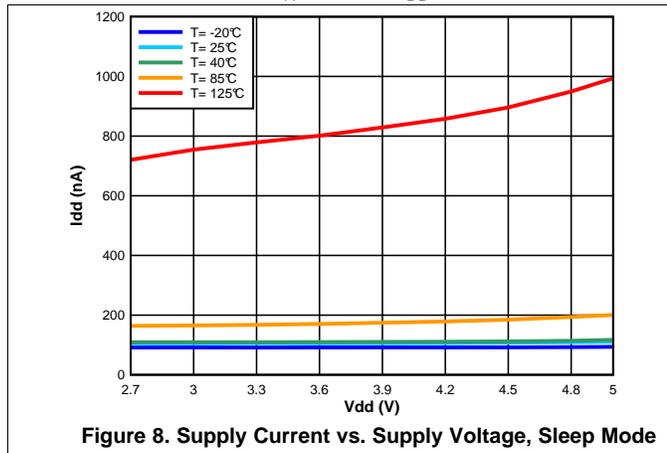


Figure 7. Supply Current vs. Temperature, Temp Measurement

Typical Characteristics (continued)

Unless otherwise noted. $T_A = 30^\circ\text{C}$, $V_{DD} = 3\text{V}$.

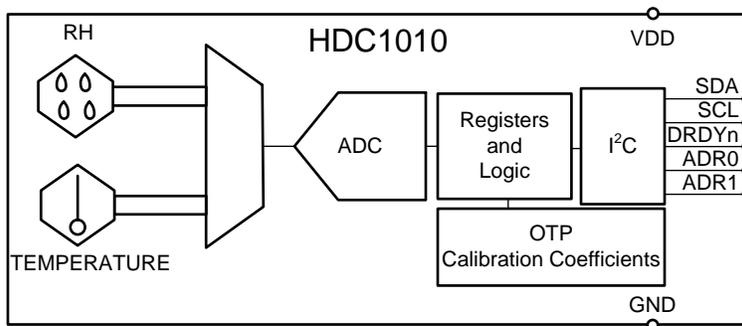


8 Detailed Description

8.1 Overview

The HDC1010 is a digital humidity sensor with integrated temperature sensor that provides excellent measurement accuracy at very low power. The sensing element of the HDC1010 is placed on the bottom part of the device, which makes the HDC1010 more robust against dirt, dust, and other environmental contaminants. Measurement results can be read out through the I2C compatible interface. Resolution is based on the measurement time and can be 8, 11, or 14 bits for humidity; 11 or 14 bits for temperature.

8.2 Functional Block Diagram



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8.3 Feature Description

8.3.1 Power Consumption

One of the key features of the HDC1010 is its low power consumption, which makes the device suitable in battery or power harvesting applications. In these applications the HDC1010 spends most of the time in sleep mode: with a typical 100nA of current consumption in sleep mode, the averaged current consumption is minimal. Its low consumption in measurement mode minimizes any self-heating.

8.3.2 Voltage Supply Monitoring

The HDC1010 monitors the supply voltage level and indicates when the voltage supply of the HDC1010 is less than 2.8V. This information is useful in battery-powered systems in order to inform the user to replace the battery. This is reported in the BTST field (register address 0x02:bit[11]) which is updated after power-on reset (POR) and after each measurement request.

8.3.3 Heater

The heater is an integrated resistive element that can be used to test the sensor or to drive condensation off the sensor. The heater can be activated using HEAT, bit 13 in Configuration Register. The heater helps in reducing the accumulated offset after long exposure at high humidity conditions.

Once enabled the heater is turned on only in the measurement mode. To have a reasonable increase of the temperature it is suggested to increase the measurement data rate.

8.4 Device Functional Modes

The HDC1010 has two modes of operation: sleep mode and measurement mode. After power up, the HDC1010 is in sleep mode. In this mode, the HDC1010 waits for I2C input including commands to configure the conversion times, read the status of the battery, trigger a measurement, and read measurements. Once it receives a command to trigger a measurement, the HDC1010 moves from sleep mode to measurement mode. In measurement mode, the HDC1010 acquires the configured measurements and sets the DRDYn line low when the measurement is complete. After completing the measurement and setting DRDYn low, the HDC1010 returns to sleep mode.

8.5 Programming

8.5.1 I2C Serial Bus Address Configuration

To communicate with the HDC1010, the master must first address slave devices via a slave address byte. The slave address byte consists of seven address bits and a direction bit that indicates the intent to execute a read or write operation. The HDC1010 features two address pins to allow up to 4 devices to be addressed on a single bus. [Table 1](#) describes the pin logic levels used to properly connect up to 4 devices. The state of the ADR0 and ADR1 pins is sampled on every bus communication and should be set before any activity on the interface occurs. The address pin is read at the start of each communication event.

Table 1. HDC1010 ADDRESS

| ADR1 | ADR0 | ADDRESS (7-bit address) |
|------|------|-------------------------|
| 0 | 0 | 1000000 |
| 0 | 1 | 1000001 |
| 1 | 0 | 1000010 |
| 1 | 1 | 1000011 |

8.5.2 I2C Interface

The HDC1010 operates only as a slave device on the I2C bus interface. It is not allowed to have on the I2C bus multiple devices with the same address. Connection to the bus is made via the open-drain I/O lines, SDA, and SCL. The SDA and SCL pins feature integrated spike-suppression filters and Schmitt triggers to minimize the effects of input spikes and bus noise. After power-up, the sensor needs at most 15 ms, to be ready to start RH and temperature measurement. During this power-up time the HDC1010 is only able to provide the content of the serial number registers (0xFB to 0xFF) if requested. After the power-up the sensor is in the sleep mode until a communication or measurement is performed. All data bytes are transmitted MSB first.

8.5.2.1 Serial Bus Address

To communicate with the HDC1010, the master must first address slave devices via a slave address byte. The slave address byte consists of seven address bits, and a direction bit that indicates the intent to execute a read or write operation.

8.5.2.2 Read and Write Operations

To access a particular register on the HDC1010, write the desired register address value to the Pointer Register. The pointer value is the first byte transferred after the slave address byte with the R/W bit low. Every write operation to the HDC1010 requires a value for the pointer register (refer to [Figure 10](#)).

When reading from the HDC1010, the last value stored in the pointer by a write operation is used to determine which register is read by a read operation. To change the pointer register for a read operation, a new value must be written to the pointer. This transaction is accomplished by issuing the slave address byte with the R/W bit low, followed by the pointer byte. No additional data is required (refer to [Figure 11](#)).

The master can then generate a START condition and send the slave address byte with the R/W bit high to initiate the read command. Note that register bytes are sent MSB first, followed by the LSB. A write operation in a read-only register such as (DEVICE ID, MANUFACTURER ID, SERIAL ID) returns a NACK after each data byte; read/write operation to unused address returns a NACK after the pointer; a read/write operation with incorrect I2C address returns a NACK after the I2C address.

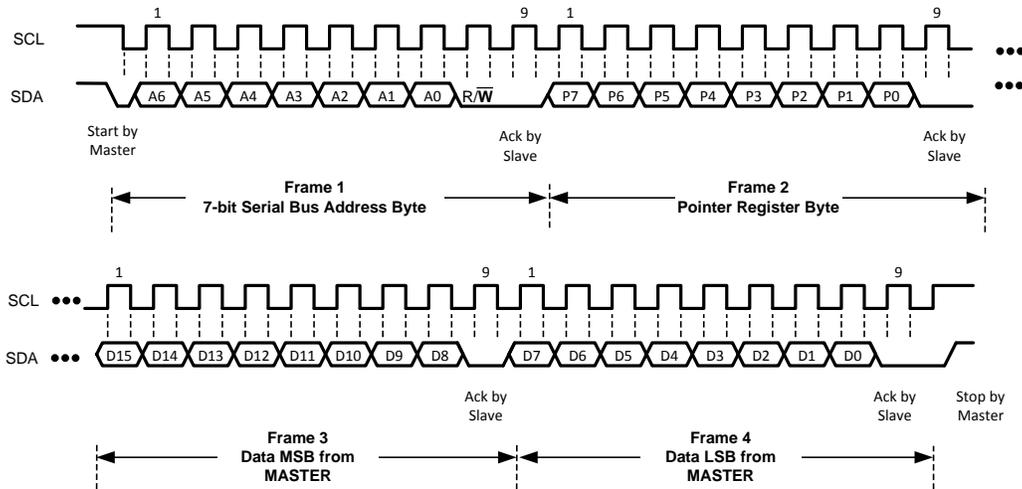


Figure 10. Writing Frame (Configuration Register)

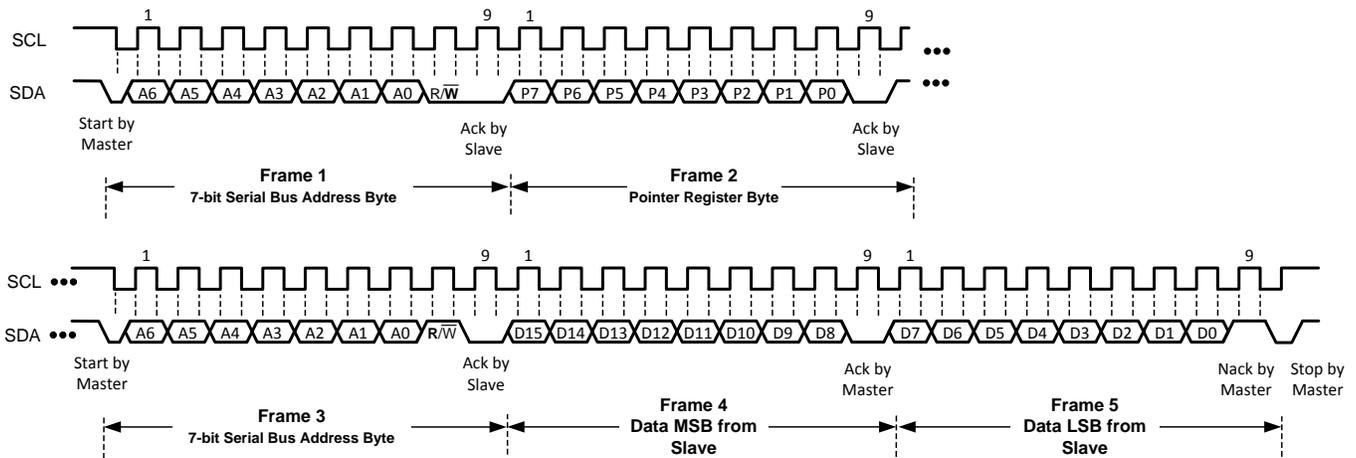


Figure 11. Reading Frame (Configuration Register)

8.5.2.3 Device Measurement Configuration

By default the HDC1010 will first perform a temperature measurement followed by a humidity measurement. On power-up, the HDC1010 enters a low power sleep mode and is not actively measuring. Use the following steps to perform a measurement of both temperature and humidity and then retrieve the results:

1. Configure the acquisition parameters in register address 0x02:
 - (a) Set the acquisition mode to measure both temperature and humidity by setting Bit[12] to 1.
 - (b) Set the desired temperature measurement resolution:
 - Set Bit[10] to 0 for 14 bit resolution.
 - Set Bit[10] to 1 for 11 bit resolution.
 - (c) Set the desired humidity measurement resolution:
 - Set Bit[9:8] to 00 for 14 bit resolution.
 - Set Bit[9:8] to 01 for 11 bit resolution.
 - Set Bit[9:8] to 10 for 8 bit resolution.
2. Trigger the measurements by executing a pointer write transaction with the address pointer set to 0x00. Refer to [Figure 12](#).

3. Wait for the measurements to complete, based on the conversion time (refer to [Electrical Characteristics^{\(1\)}](#) for the conversion time). Alternatively, wait for the assertion of DRDYn.
4. Read the output data:

Read the temperature data from register address 0x00, followed by the humidity data from register address 0x01 in a single transaction as shown in [Figure 14](#). A read operation will return a NACK if the contents of the registers have not been updated as shown in [Figure 13](#).

To perform another acquisition with the same measurement configuration simply repeat steps 2 through 4.

If only a humidity or temperature measurement is desired, the following steps will perform a measurement and retrieve the result:

1. Configure the acquisition parameters in register address 0x02:
 - (a) Set the acquisition mode to independently measure temperature or humidity by setting Bit[12] to 0.
 - (b) For a temperature measurement, set the desired temperature measurement resolution:
 - Set Bit[10] to 0 for 14 bit resolution.
 - Set Bit[10] to 1 for 11 bit resolution.
 - (c) For a humidity measurement, set the desired humidity measurement resolution:
 - Set Bit[9:8] to 00 for 14 bit resolution.
 - Set Bit[9:8] to 01 for 11 bit resolution.
 - Set Bit[9:8] to 10 for 8 bit resolution.
2. Trigger the measurement by executing a pointer write transaction. Refer to [Figure 12](#)
 - Set the address pointer to 0x00 for a temperature measurement.
 - Set the address pointer to 0x01 for a humidity measurement.
3. Wait for the measurement to complete, based on the conversion time (refer to [Electrical Characteristics^{\(1\)}](#) for the conversion time). Alternatively, wait for the assertion of DRDYn.
4. Read the output data:

Retrieve the completed measurement result from register address 0x00 or 0x01, as appropriate, as shown in [Figure 10](#). A read operation will return a NACK if the measurement result is not yet available, as shown in [Figure 13](#).

To perform another acquisition with the same measurement configuration repeat steps 2 through 4.

It is possible to read the output registers (addresses 0x00 and 0x01) during an Temperature or Relative Humidity measurement without affecting any ongoing measurement. Note that a write to address 0x00 or 0x01 while a measurement is ongoing will abort the ongoing measurement. If the newest acquired measurement is not read, DRDYn stays low until the next measurement is triggered.

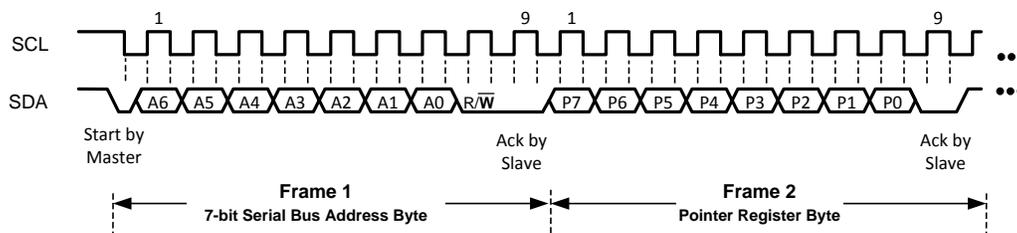


Figure 12. Trigger Humidity/Temperature Measurement

(1) Electrical Characteristics Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.

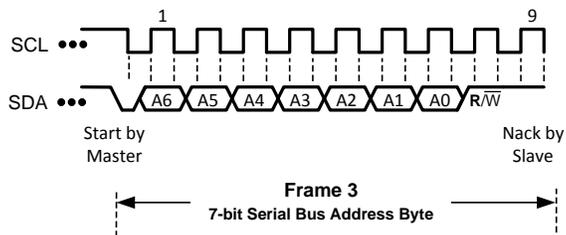


Figure 13. Read Humidity/Temperature Measurement (Data Not Ready)

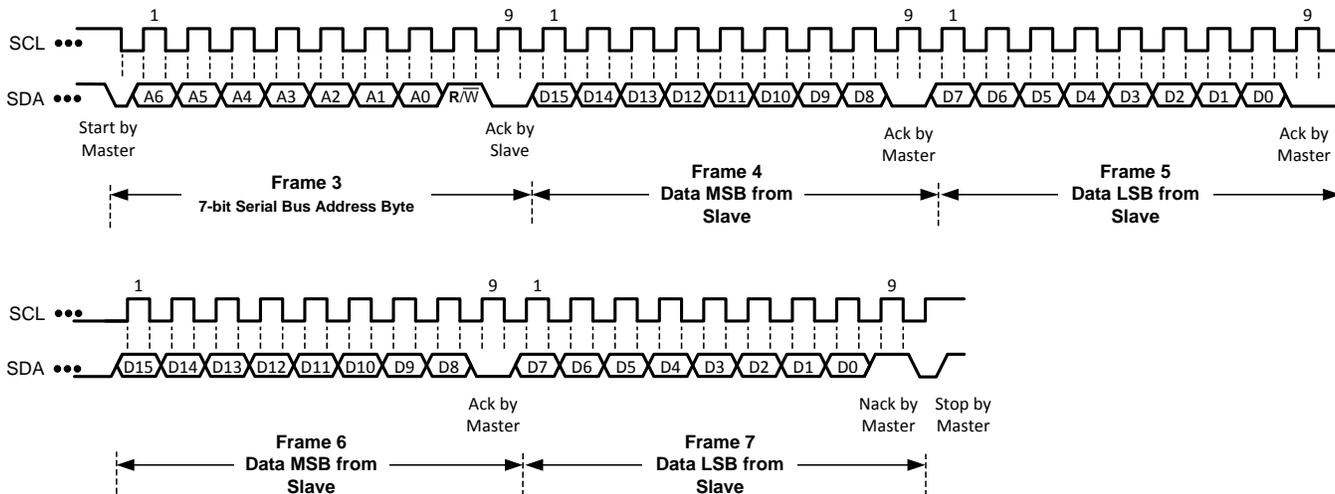


Figure 14. Read Humidity and Temperature Measurement (Data Ready)

8.6 Register Map

The HDC1010 contains data registers that hold configuration information, temperature and humidity measurement results, and status information.

Table 2. Register Map

| Pointer | Name | Reset value | Description |
|---------|-----------------|------------------|--|
| 0x00 | Temperature | 0x0000 | Temperature measurement output |
| 0x01 | Humidity | 0x0000 | Relative Humidity measurement output |
| 0x02 | Configuration | 0x1000 | HDC1010 configuration and status |
| 0xFB | Serial ID | device dependent | First 2 bytes of the serial ID of the part |
| 0xFC | Serial ID | device dependent | Mid 2 bytes of the serial ID of the part |
| 0xFD | Serial ID | device dependent | Last byte bit of the serial ID of the part |
| 0xFE | Manufacturer ID | 0x5449 | ID of Texas Instruments |
| 0xFF | Device ID | 0x1000 | ID of HDC1010 device |

Registers from 0x03 to 0xFA are reserved and should not be written.

The HDC1010 has an 8-bit pointer used to address a given data register. The pointer identifies which of the data registers should respond to a read or write command on the two-wire bus. This register is set with every write command. A write command must be issued to set the proper value in the pointer before executing a read command. The power-on reset (POR) value of the pointer is 0x00, which selects a temperature measurement.

8.6.1 Temperature Register

The temperature register is a 16-bit result register in binary format (the 2 LSBs D1 and D0 are always 0). The result of the acquisition is always a 14 bit value. The accuracy of the result is related to the selected conversion time (refer to [Electrical Characteristics^{\(1\)}](#)). The temperature can be calculated from the output data with:

$$\text{Temperature}(\text{°C}) = \left(\frac{\text{TEMPERATURE}[15:00]}{2^{16}} \right) * 165\text{°C} - 40\text{°C}$$

Table 3. Temperature Register Description (0x00)

| Name | Registers | Description |
|-------------|-----------|--|
| TEMPERATURE | [15:02] | Temperature Temperature measurement (read only) |
| | [01:00] | Reserved Reserved, always 0 (read only) |

- (1) Electrical Characteristics Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.

8.6.2 Humidity Register

The humidity register is a 16-bit result register in binary format (the 2 LSBs D1 and D0 are always 0). The result of the acquisition is always a 14 bit value, while the accuracy is related to the selected conversion time (refer to [Electrical Characteristics^{\(1\)}](#)). The humidity can be calculated from the output data with:

$$\text{Relative Humidity}(\% \text{ RH}) = \left(\frac{\text{HUMIDITY}[15:00]}{2^{16}} \right) * 100\% \text{ RH}$$

Table 4. Humidity Register Description (0x01)

| Name | Registers | Description |
|----------|-----------|--|
| HUMIDITY | [15:02] | Relative Humidity Relative Humidity measurement (read only) |
| | [01:00] | Reserved Reserved, always 0 (read only) |

- (1) Electrical Characteristics Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.

8.6.3 Configuration Register

This register configures device functionality and returns status.

Table 5. Configuration Register Description (0x02)

| NAME | REGISTERS | | DESCRIPTION | |
|----------|-----------|------------------------------------|-------------|---|
| RST | [15] | Software reset bit | 0 | Normal Operation, this bit self clears |
| | | | 1 | Software Reset |
| Reserved | [14] | Reserved | 0 | Reserved, must be 0 |
| HEAT | [13] | Heater | 0 | Heater Disabled |
| | | | 1 | Heater Enabled |
| MODE | [12] | Mode of acquisition | 0 | Temperature or Humidity is acquired. |
| | | | 1 | Temperature and Humidity are acquired in sequence, Temperature first. |
| BTST | [11] | Battery Status | 0 | Battery voltage > 2.8V (read only) |
| | | | 1 | Battery voltage < 2.8V (read only) |
| TRES | [10] | Temperature Measurement Resolution | 0 | 14 bit |
| | | | 1 | 11 bit |
| HRES | [9:8] | Humidity Measurement Resolution | 00 | 14 bit |
| | | | 01 | 11 bit |
| | | | 10 | 8 bit |
| Reserved | [7:0] | Reserved | 0 | Reserved, must be 0 |

8.6.4 Serial Number Registers

These registers contain a 40bit unique serial number for each individual HDC1010.

Table 6. Serial Number Register Description (0xFB)

| Name | Registers | Description | |
|------------------|-----------|----------------|---|
| SERIAL ID[40:25] | [15:0] | Serial Id bits | Device Serial Number bits from 40 to 25 (read only) |

Table 7. Serial Number Register Description (0xFC)

| Name | Registers | Description | |
|-----------------|-----------|----------------|--|
| SERIAL ID[24:9] | [15:0] | Serial Id bits | Device Serial Number bits from 24 to 9 (read only) |

Table 8. Serial Number Register Description (0xFD)

| Name | Registers | Description | |
|----------------|-----------|----------------|---|
| SERIAL ID[8:0] | [15:7] | Serial Id bits | Device Serial Number bits from 8 to 0 (read only) |
| | [6:0] | Reserved | Reserved, always 0 (read only) |

8.6.5 Manufacturer ID Register

This register contains a factory-programmable identification value that identifies this device as being manufactured by Texas Instruments. This register distinguishes this device from other devices that are on the same I2C bus. The manufacturer ID reads 0x5449.

Table 9. Manufacturer ID Register Description (0xFE)

| Name | Registers | Description | |
|-----------------|-----------|-----------------|---|
| MANUFACTURER ID | [15:0] | Manufacturer ID | 0x5449 Texas instruments ID (read only) |

HDC1010

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8.6.6 Device Register ID

This register contains a factory-programmable identification value that identifies this device as a HDC1010. This register distinguishes this device from other devices that are on the same I2C bus. The Device ID for the HDC1010 is 0x1000.

Table 10. Device ID Register Description (0xFF)

| Name | Registers | | | Description |
|-----------|-----------|-----------|--------|-------------------------------|
| DEVICE ID | [15:0] | Device ID | 0x1000 | HDC1010 Device ID (read only) |

9 Application and Implementation

NOTE

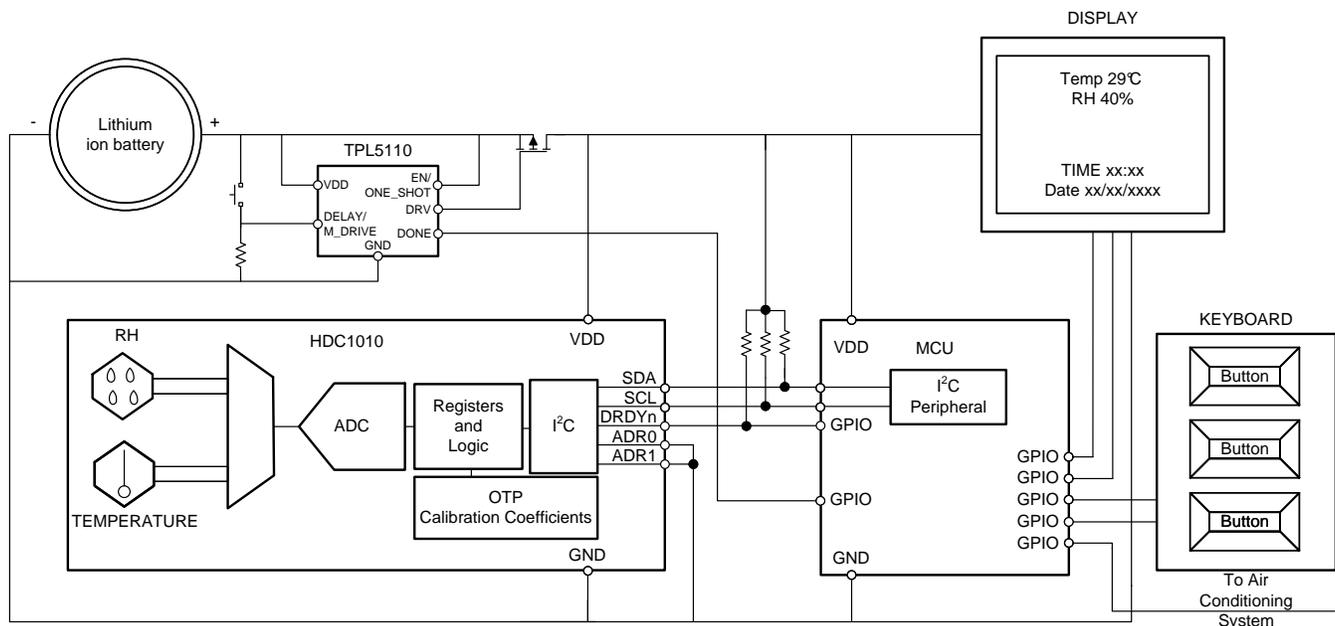
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

An HVAC system thermostat control is based on environmental sensors and a micro-controller. The micro-controller acquires data from humidity sensors and temperature sensors and controls the heating/cooling system. The collected data are then showed on a display that can be easily controlled by the micro controller. Based on data from the humidity and temperature sensor, the heating/cooling system then maintains the environment at customer-defined preferred conditions.

9.2 Typical Application

In a battery-powered HVAC system thermostat, one of the key parameters in the selection of components is the power consumption. The HDC1010, with its 1.3 μ A of current consumption (average consumption over 1s for RH and Temperature measurements) in conjunction with an MSP430 represents an excellent choice for the low power consumption, which extends the battery life. A system block diagram of a battery powered HVAC or Thermostat is shown in [Figure 15](#).



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Figure 15. Typical Application Schematic HVAC

9.2.1 Design Requirements

In order to correctly sense the ambient temperature and humidity, the HDC1010 should be positioned away from heat sources on the PCB. Generally, it should not be close to the LCD and battery. Moreover, to minimize any self-heating of the HDC1010 it is recommended to acquire at a maximum sample rate of 1sps (RH + Temp). In home systems, humidity and the temperature monitoring rates of less than 1sps (even 0.5sps or 0.2sps) can be still effective.

Typical Application (continued)

9.2.2 Detailed Design Procedure

When a circuit board layout is created from the schematic shown in [Figure 15](#) a small circuit board is possible. The accuracy of a RH and temperature measurement depends on the sensor accuracy and the setup of the sensing system. The HDC1010 samples relative humidity and temperature in its immediate environment, it is therefore important that the local conditions at the sensor match the monitored environment. Use one or more openings in the physical cover of the thermostat to obtain a good airflow even in static conditions. Refer to the layout below ([Figure 20](#)) for a PCB layout which minimizes the thermal mass of the PCB in the region of the HDC1010, which can improve measurement response time and accuracy.

9.2.3 Application Curve

The data showed below have been acquired with the HDC1010EVM. A humidity chamber was used to control the environment.

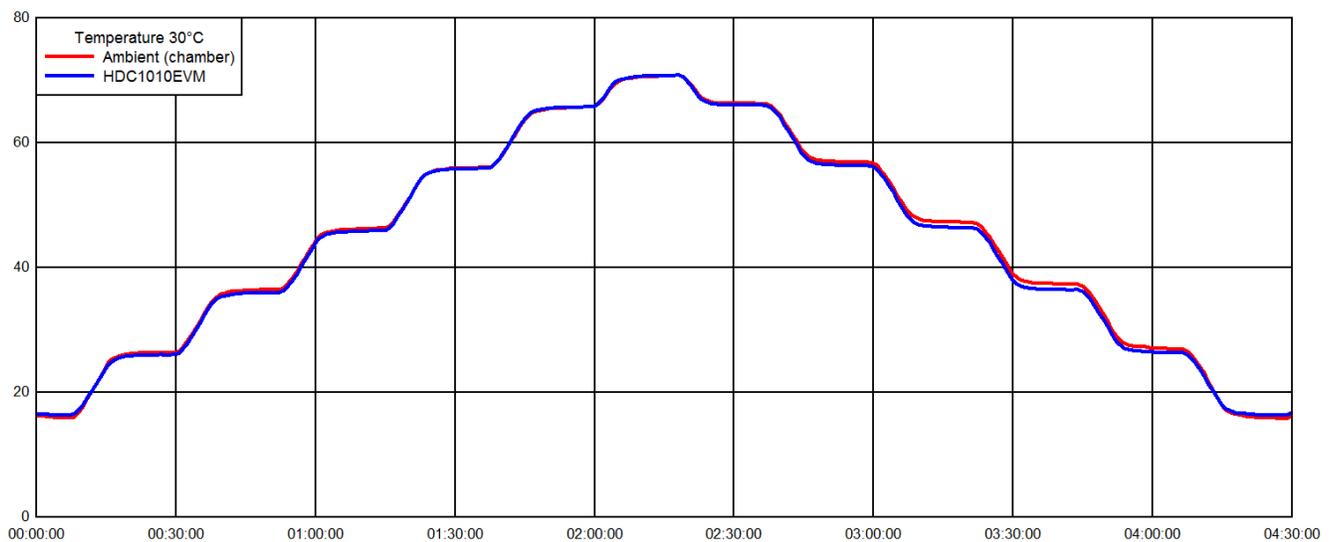


Figure 16. RH vs. Time

9.3 Do's and Don'ts

9.3.1 Soldering

For soldering HDC1010 use the standard soldering profile IPC/JEDEC J-STD-020 with peak temperatures at 260 °C. Refer to the document [SNVA009](#) for more details on the DSBGA package. In the document refer to DSBGA package with bump size 0.5mm pitch and 0.32mm diameter.

When soldering the HDC1010 it is mandatory to use no-clean solder paste and no board wash shall be applied. The HDC1010 should be limited to a single IR reflow and no rework is recommended.

9.3.2 Chemical Exposure and Sensor Protection

The humidity sensor is not a standard IC and therefore should not be exposed to particulates or volatile chemicals such as solvents or other organic compounds. If any type of protective coating must be applied to the circuit board, the sensor must be protected during the coating process.

9.3.3 High Temperature and Humidity Exposure

Long exposure outside the recommended operating conditions may temporarily offset the RH output. [Table 11](#) shows the RH offset values that can be expected for exposure to 85°C and 85% RH for duration between 12 and 500 hours (continuos).

Table 11. Induced RH Offset Due to Extended Exposure to High Humidity and High Temperature (85°C/85% RH)

| 85°C/85% RH Duration (hours) | 12 | 24 | 168 | 500 |
|------------------------------|----|----|-----|-----|
| RH Offset (%) | 3 | 6 | 12 | 15 |

When the sensor is exposed to less severe conditions, [Figure 17](#) shows the typical RH offset at other combinations of temperature and RH.

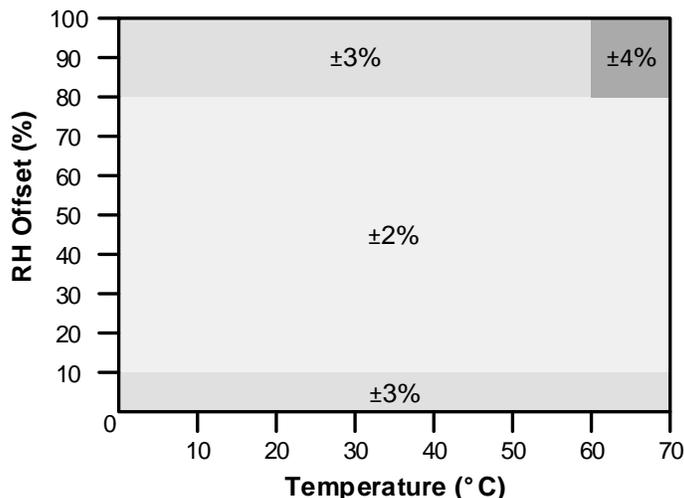


Figure 17. Relative Humidity Accuracy vs Temperature

10 Power Supply Recommendations

The HDC1010 require a voltage supply within 2.7V and 5.5V. A multilayer ceramic bypass X7R capacitor of 0.1µF between VDD and GND pin is recommended.

11 Layout

11.1 Layout Guidelines

The Relative Humidity sensor element is located on the bottom side of the package. It is positioned between the two rows of bumps

It is recommended to not route any traces below the sensor element. Moreover the external components, such as pull-up resistors and bypass capacitors need to be placed next to the 2 rows of bumps or on the bottom side of the PCB in order to guarantee a good air flow.

It is recommended to isolate the sensor from the rest of the PCB by eliminating copper layers below the device (GND, V_{DD}) and creating a slot into the PCB around the sensor to enhance thermal isolation.

11.1.1 Surface Mount

Two types of PCB land patterns are used for surface mount packages:

1. Non-solder mask defined (NSMD)
2. Solder mask defined (SMD)

Pros and cons of NSMD and SMD:

1. The NSMD configuration is preferred due to its tighter control of the copper etch process and a reduction in the stress concentration points on the PCB side compared to SMD configuration.
2. A copper layer thickness of less than 1 oz. is recommended to achieve higher solder joint stand-off. A 1 oz. (30 micron) or greater copper thickness causes a lower effective solder joint stand-off, which may

Layout Guidelines (continued)

compromise solder joint reliability.

- For the NSMD pad geometry, the trace width at the connection to the land pad should not exceed 2/3 of the pad diameter.

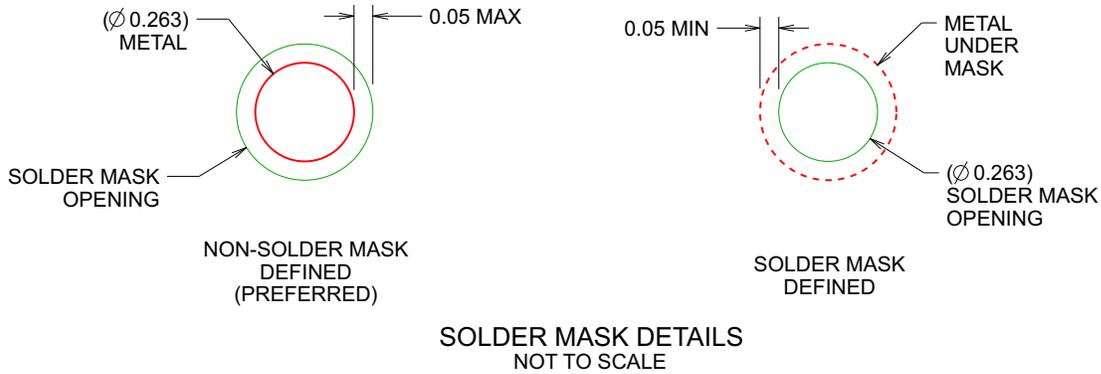


Figure 18. Solder Mask

11.1.2 Stencil Printing Process

- Use laser cutting followed by electro-polishing for stencil fabrication
- If possible, offset apertures from land pads to maximize separation and minimize possibility of bridging for DSBGA packages
- Use Type 3 (25 to 45 micron particle size range) or finer solder paste for printing

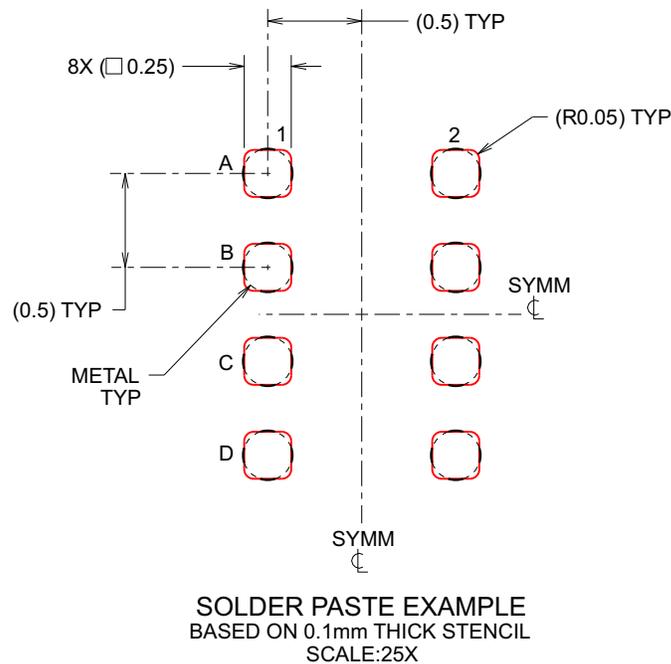


Figure 19. Solder Paste

11.2 Layout Example

The only component next to the device is the supply bypass capacitor. Since the relative humidity is dependent on the temperature, the HDC1010 should be positioned away from hot points present on the board such as battery, display or micro-controller. Slots around the device can be used to reduce the thermal mass, for a quicker response to environmental changes.

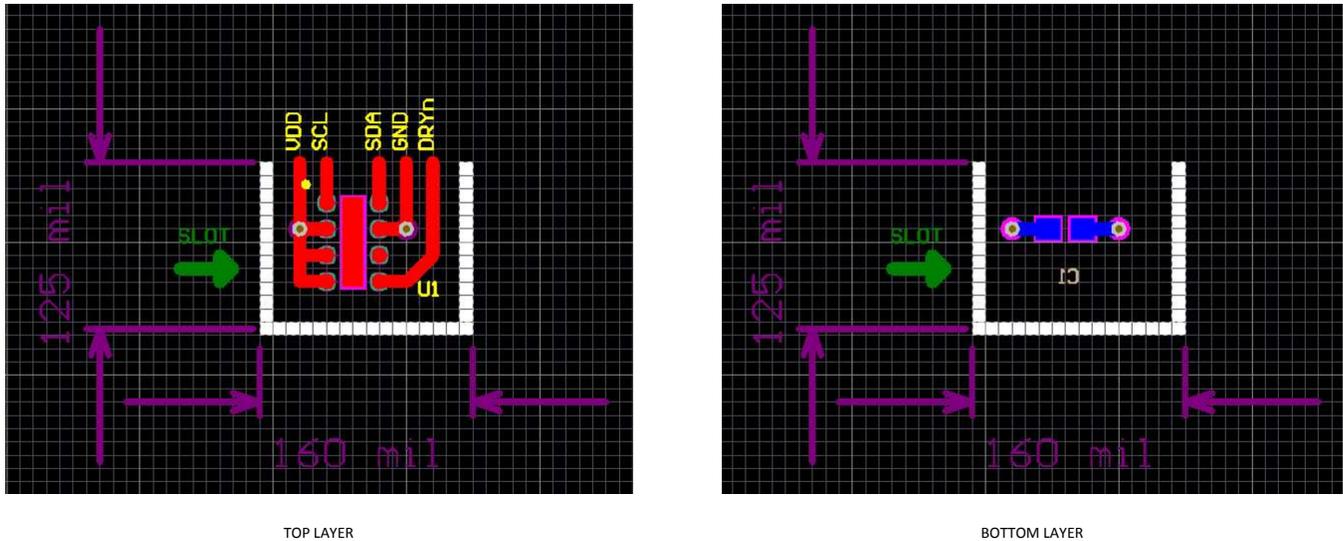


Figure 20. Layout

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

Wireless Sensor Humidity & Temp Sensor Node for Star Networks Enabling 10+ Year Coin Cell Battery Life Ref Design [TIDA-00374](#)

Humidity & Temp Sensor Node for Sub-1GHz Star Networks Enabling 10+ Year Coin Cell Battery Life [TIDA-00484](#)

Ultralow Power Multi-sensor Data Logger with NFC Interface Reference Design [TIDA-00524](#)

HDC1010 Texas Instruments Humidity Sensors, [SNAA216](#)

12.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.4 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

12.5 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| HDC1010YPAR | ACTIVE | DSBGA | YPA | 8 | 3000 | RoHS & Green | SAC405 SNAGCU | Level-1-260C-UNLIM | -40 to 85 | 3N | Samples |
| HDC1010YPAT | ACTIVE | DSBGA | YPA | 8 | 250 | RoHS & Green | SAC405 SNAGCU | Level-1-260C-UNLIM | -40 to 85 | 3N | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

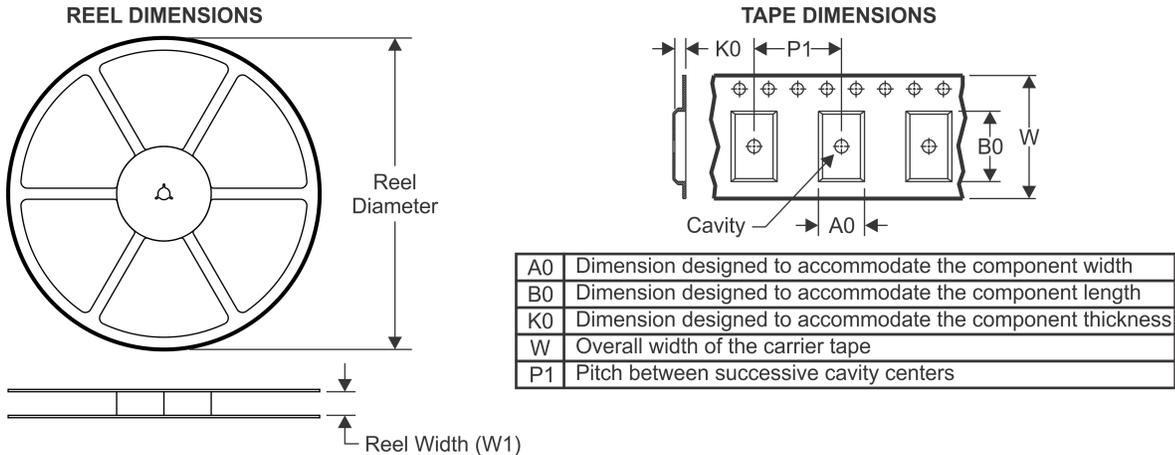
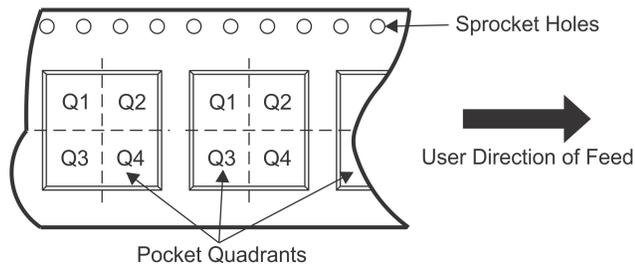
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

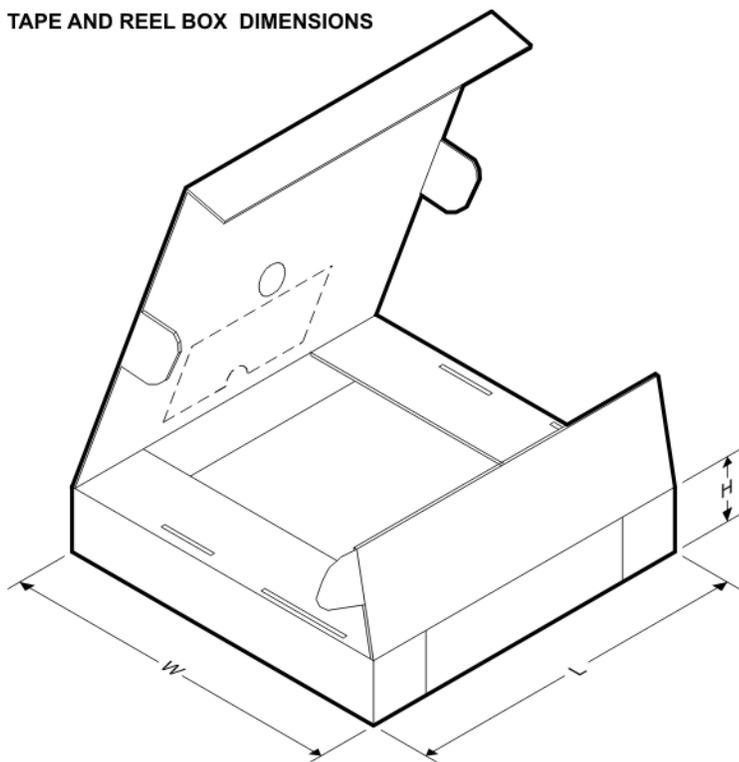
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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

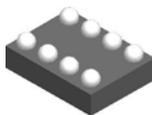
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| HDC1010YPAR | DSBGA | YPA | 8 | 3000 | 178.0 | 8.4 | 1.68 | 2.13 | 0.76 | 4.0 | 8.0 | Q1 |
| HDC1010YPAT | DSBGA | YPA | 8 | 250 | 178.0 | 8.4 | 1.68 | 2.13 | 0.76 | 4.0 | 8.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

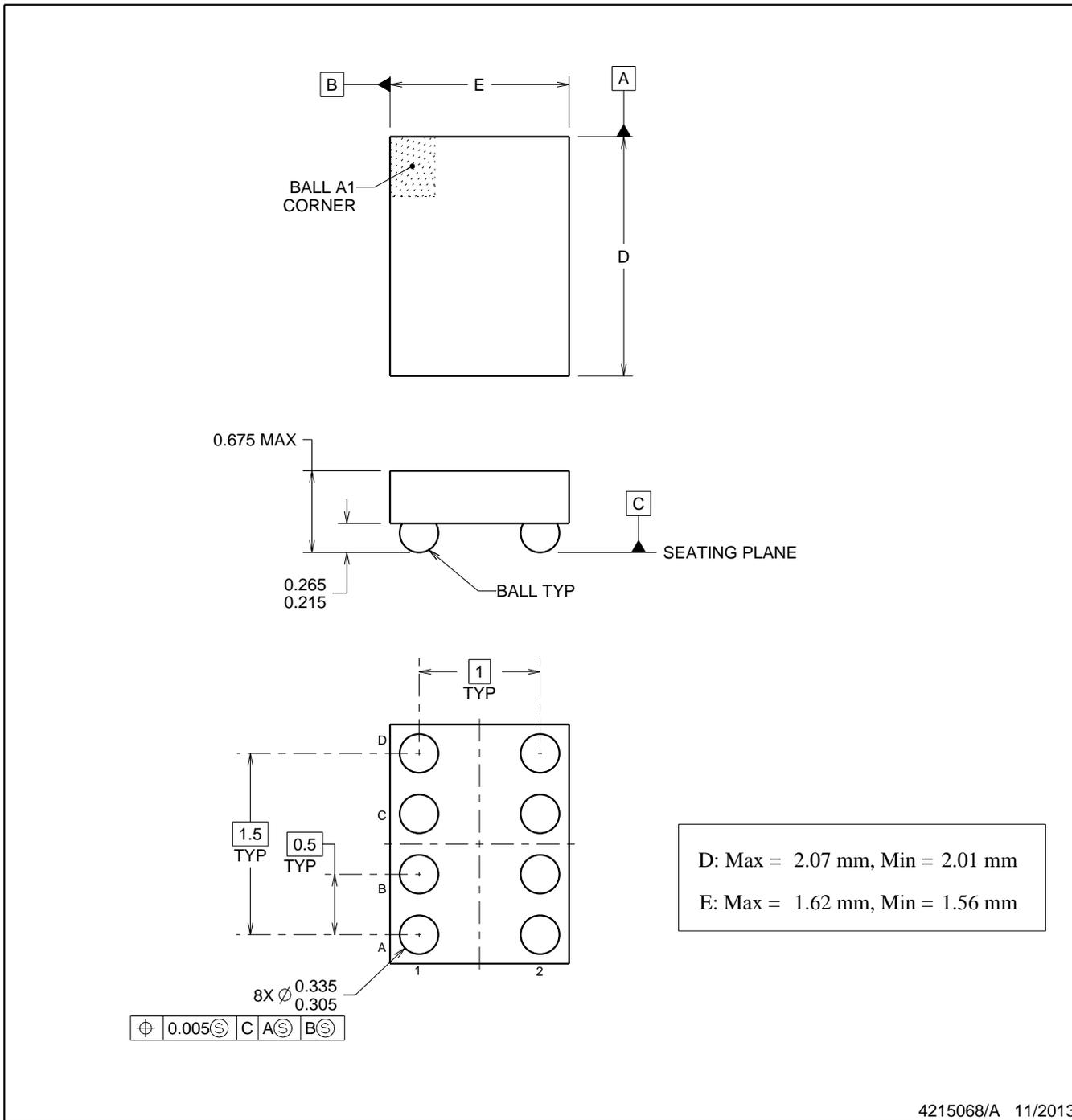
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| HDC1010YPAR | DSBGA | YPA | 8 | 3000 | 210.0 | 185.0 | 35.0 |
| HDC1010YPAT | DSBGA | YPA | 8 | 250 | 210.0 | 185.0 | 35.0 |

YPA0008



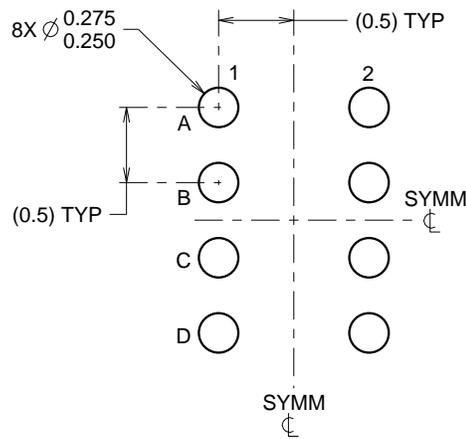
DSBGA - 0.675 mm max height

DIE SIZE BALL GRID ARRAY

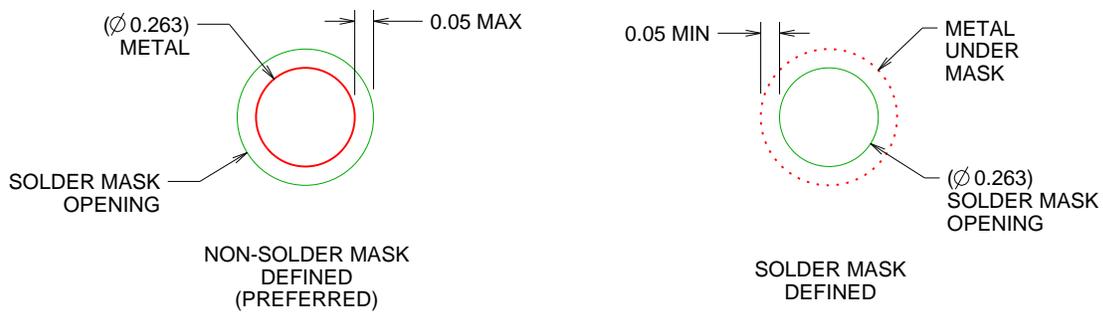


NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.



LAND PATTERN EXAMPLE
SCALE:20X

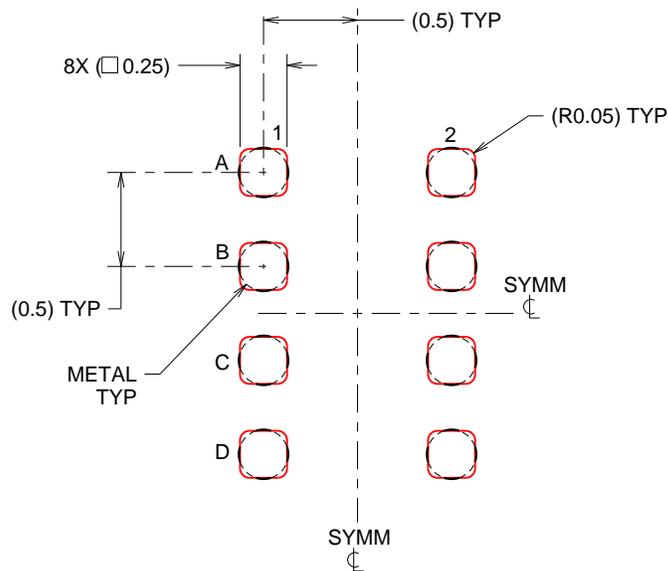


SOLDER MASK DETAILS
NOT TO SCALE

4215068/A 11/2013

NOTES: (continued)

- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SBVA017 (www.ti.com/lit/sbva017).



SOLDER PASTE EXAMPLE
 BASED ON 0.1mm THICK STENCIL
 SCALE:25X

NOTES: (continued)

- 4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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