HDC1000 Low Power, High Accuracy Digital Humidity Sensor with Temperature Sensor

1 Features

- Relative Humidity (RH) Operating Range 0% to 100%
- 14 Bit Measurement Resolution
- Relative Humidity Accuracy ±3%
- Temperature Range
  - Operating -20°C to 85°C
  - Functional -40°C to 125°C
- Temperature Accuracy ±0.2°C
- 200nA Sleep Mode Current
- Average Supply Current:
  - 820 nA @ 1sps, 11 bit RH Measurement
  - 1.2 µA @ 1sps, 11 bit RH and Temperature Measurement
- Supply Voltage 3 V to 5 V
- Tiny 2 mm x 1.6 mm Device Footprint
- I2C Interface

2 Applications

- HVAC
- Smart Thermostats and Room Monitors
- White Goods
- Printers
- Handheld Meters
- Medical Devices
- Cargo Shipping
- Automotive Windshield Defog
- Wearable Devices
- Mobile Devices

3 Description

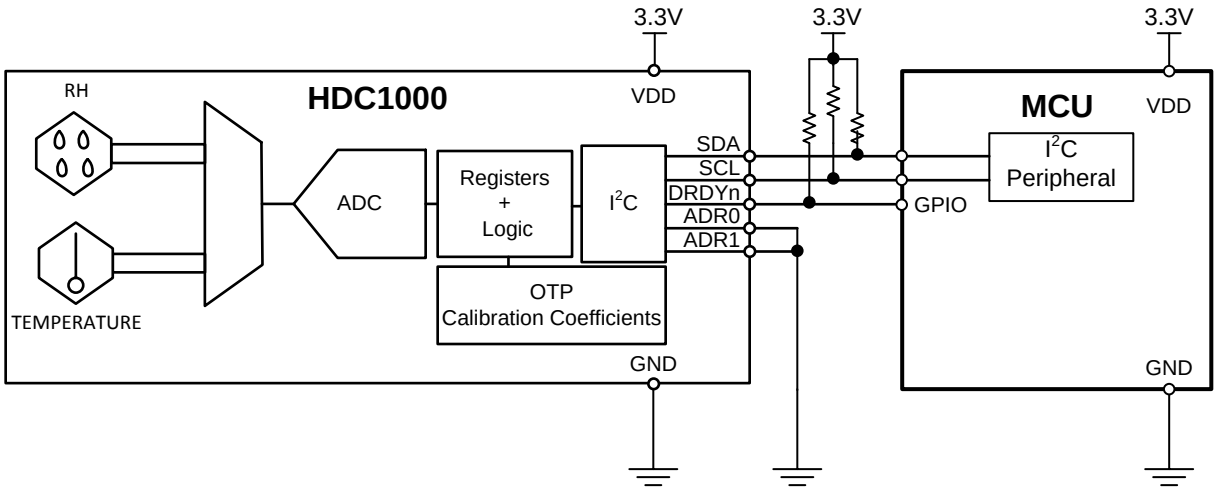
The HDC1000 is a digital humidity sensor with integrated temperature sensor that provides excellent measurement accuracy at very low power. The device measures humidity based on a novel capacitive sensor. The humidity and temperature sensors are factory calibrated. The innovative WLCSP (Wafer Level Chip Scale Package) simplifies board design with the use of an ultra-compact package. The sensing element of the HDC1000 is placed on the bottom part of the device, which makes the HDC1000 more robust against dirt, dust, and other environmental contaminants. The HDC1000 is functional within the full -40°C to +125°C temperature range.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
HDC1000	DSBGA (8-bump)	2.04 mm x 1.59 mm

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

4 Typical Application



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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5 Revision History

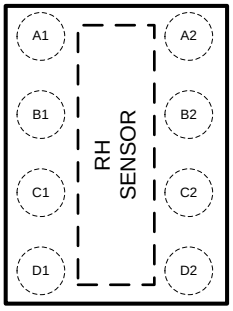
Changes from Original (JULY 2014) to Revision A **Page**

- Changed Datasheet's title ... 1
- Changed description ... 1
- Changed package description ... 3
- Added heater consumption ... 5
- Changed overview ... 9
- Added heater description ... 9
- Added heater bit ... 15
- Added application note ... 17
- Changed application information ... 17
- Changed recovery from soldering ... 19

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6 Pin Configuration and Functions

WLCSP (DSBGA)
8 Pin
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 connect to GND
DRDYn	D2	O	Data ready, active low, open-drain; requires a pull-up resistor to VDD. If not used tie to GND or no connect.

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

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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	

(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 Handling Ratings

			MIN	MAX	UNIT
T_{STG}	Storage Temperature(1)		-65	150	°C
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins (2)	-1000	1000	V
		Charged device model (CDM), per JEDEC specification –500 500 JESD22-C101, all pins (3)	-250	250	

(1) For long term storage, it is recommended to stay within 10%RH-80%RH and +5°C to 60°C. Storage beyond this range may result in a temporary RH offset shift.
(2) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(3) 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	Ambient Operating Temperature	-40		125	°C

7.4 Thermal Information

THERMAL METRIC(1)		HDC1000 DSBGA 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-Ambient Thermal Resistance	98.0	°C/W

(1) For more information about traditional and new thermal metrics, see the: *IC Package Thermal Metrics* application report, SPRA953.

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7.5 Electrical Characteristics

The electrical ratings specified in this section apply to all specifications in this document, unless otherwise noted. T_A = 30°C, V_{DD} = 3V.

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
POWER CONSUMPTION						
I_{DD}	Supply Current	RH measurement, bit 12 of 0x02 register = 0 (1)		180	220	µA
		Temperature measurement, bit 12 of 0x02 register = 0 (1)		155	185	µA
		Sleep Mode		110	200	nA
		Average @ 1 measurement/second, RH (11 bit), bit 12 of 0x02 register = 0 (1)(2)		730		nA
		Average @ 1 measurement/second, Temp (11 bit), bit 12 of 0x02 register = 0 (1)(2)		580		nA
		Average @ 1 measurement/second, RH (11bit) +temperature (11 bit), bit 12 of 0x02 register = 1 (1)(2)		1.2		µA
		Startup (average on Start-up time)		300		µA
I_{HEAT}	Heater Current (3)	Peak current		7.6		mA
		Average @ 1 measurement/second, RH (11bit) +temperature (11 bit), bit 12 of 0x02 register = 1 (1)(2)		57		µA
RELATIVE HUMIDITY SENSOR						
RH_{ACC}	Accuracy			±3		%RH
RH_{REP}	Repeatability (3)	0%RH		±0.1		%RH
RH_{HYS}	Hysteresis (4)			±1		%RH
RH_{RT}	Response Time (5)	t_{63}% (6)		15		s
RH_{CT}	Conversion Time (3)	8 bit resolution		2.50		ms
		11 bit resolution		3.85		ms
		14 bit resolution		6.50		ms
RH_{HOR}	Operating Range (7)	Non-condensing	0		100	%RH
RH_{LTD}	Long Term Drift			±0.5		%RH/yr
TEMPERATURE SENSOR						
$TEMP_{ACC}$	Accuracy (3)	5°C < T_A < 60°C		±0.2	±0.4	°C
$TEMP_{REP}$	Repeatability (3)			±0.1		°C
$TEMP_{CT}$	Conversion Time (3)	11 bit accuracy		3.65		ms
		14 bit accuracy		6.35		ms
$TEMP_{OR}$	Operating Range		-40		125	°C

(1) I^2C read/write communication and pull-up resistors current through SCL, SDA and DRDYn not included.
(2) Average current consumption while conversion is in progress.
(3) This parameter is specified by design and/or characterization and it is not tested in production.
(4) The hysteresis value is the difference of measured values of a given sensor at a certain measuring point accruing from a dry environment to a humid environment after a dwell time.
(5) Actual response times will vary dependent on system thermal mass and air-flow.
(6) Time for the RH output to change by 63% of the total RH change after a step change in environmental humidity.
(7) Recommended humidity operating range is 10% to 80% RH. Prolonged operation outside these ranges may result in a measurement shift. The measurement shift will decrease after operating the sensor in the recommended operating range.

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7.6 I2C Interface Electrical Characteristics

At T_A=30°C, V_{DD}=3V (unless otherwise noted)

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
I2C INTERFACE VOLTAGE LEVEL						
VIH	Input High Voltage		0.7xV_{DD}			V
VIL	Input Low Voltage				0.3xV_{DD}	V
VOL	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.

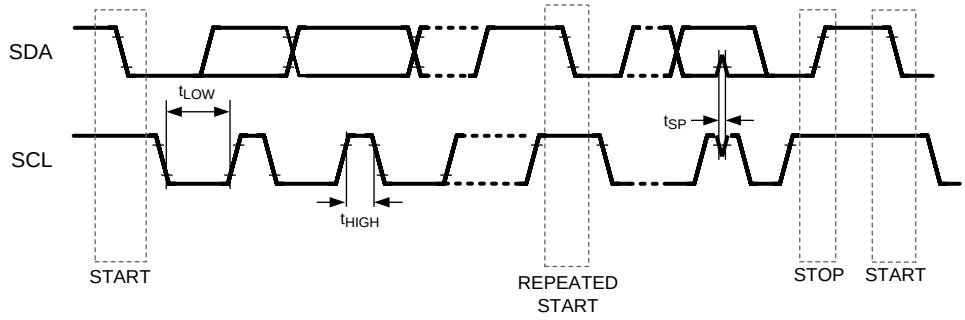


Figure 1. I2C Timing

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7.8 Typical Characteristics

Unless otherwise noted. T_A = 30°C, V_{DD} = 3V.

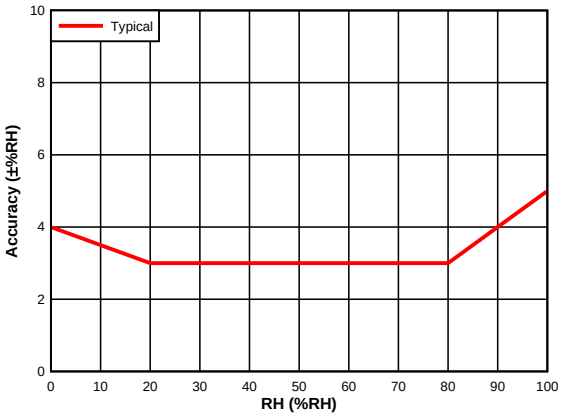


Figure 2. RH Accuracy vs. RH

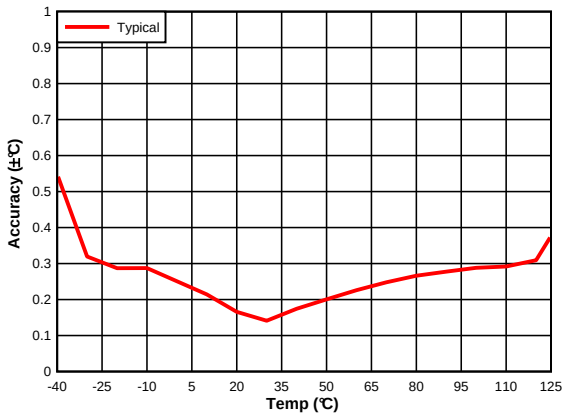


Figure 3. Temperature Accuracy vs. Temperature

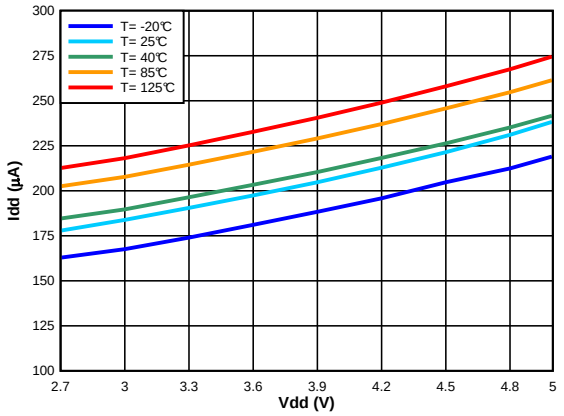


Figure 4. Supply Current vs. Supply Voltage, RH Measurement

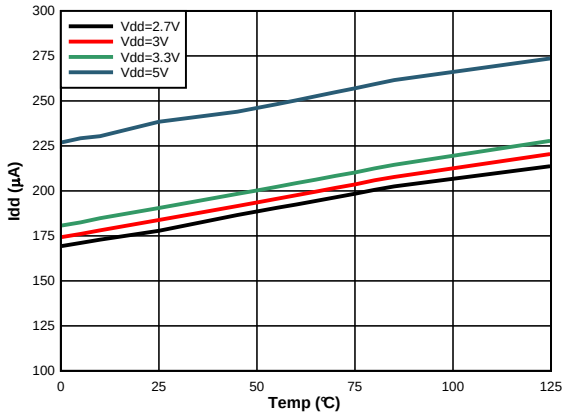


Figure 5. Supply Current vs. Temperature, RH Measurement

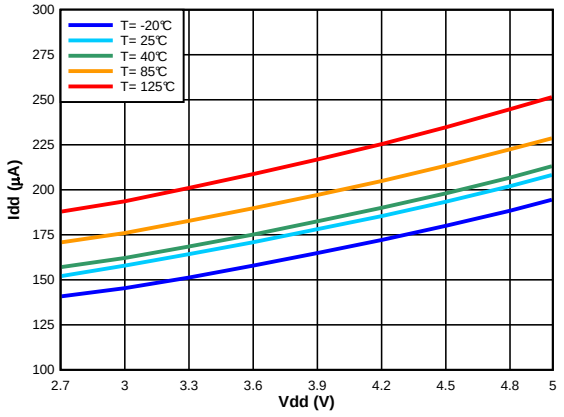


Figure 6. Supply Current vs. Supply Voltage, Temp Measurement

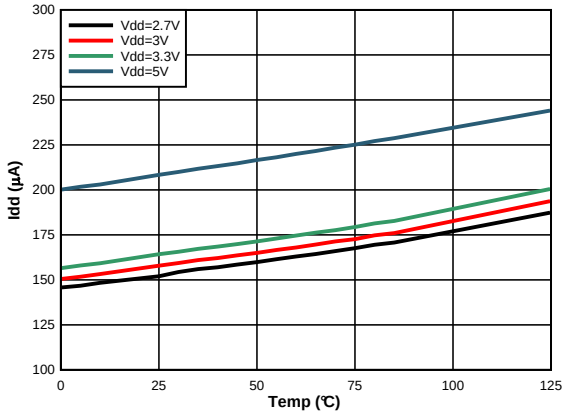


Figure 7. Supply Current vs. Temperature, Temp Measurement

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Typical Characteristics (continued)

Unless otherwise noted. T_A = 30°C, V_{DD} = 3V.

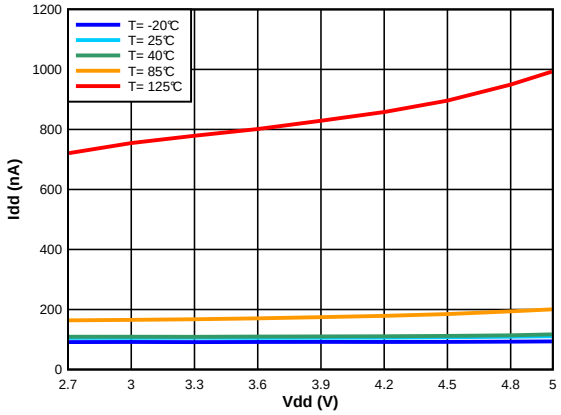


Figure 8. Supply Current vs. Supply Voltage, Sleep Mode

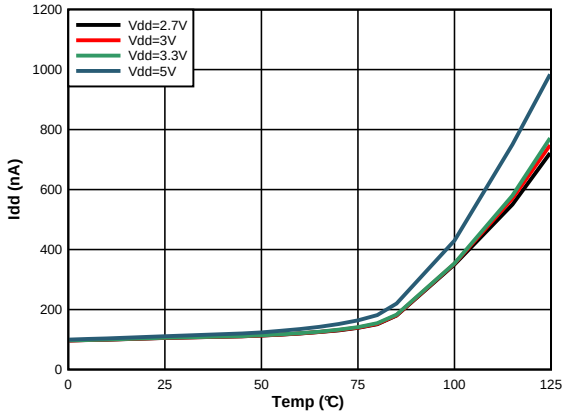


Figure 9. Supply Current vs. Temperature, Sleep Mode

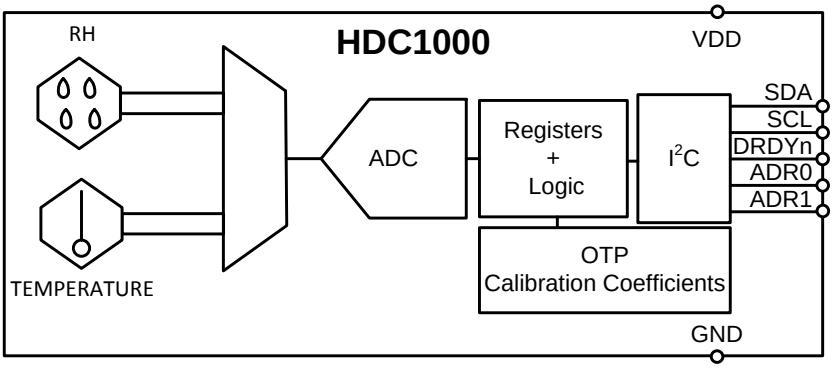
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8 Detailed Description

8.1 Overview

The HDC1000 is a digital humidity sensor with integrated temperature sensor that provides excellent measurement accuracy at very low power and long term. The sensing element of the HDC1000 is placed on the bottom part of the device, which makes the HDC1000 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



8.3 Feature Description

8.3.1 Power Consumption

One of the key features of the HDC1000 is its low power consumption, which makes the device suitable in battery or power harvesting applications. In these applications the HDC1000 spends most of the time in sleep mode: with a typical 110nA of current consumption in sleep mode, the averaged current consumption is minimal. Moreover its low consumption in measurement mode minimizes any self-heating.

8.3.2 Voltage Supply Monitoring

The HDC1000 monitors the supply voltage level and indicates when the voltage supply of the HDC1000 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 TRES field (register address 0x00:bit[11]) which is updated after 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 HDC1000 has two modes of operation: sleep mode and measurement mode. After power up, the HDC1000 is in sleep mode. In this mode, the HDC1000 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 HDC1000 moves from sleep mode to measurement mode. In measurement mode, the HDC1000 acquires the configured measurements and sets the DRDYn line low when the measurement is complete. After completing the measurement and setting DRDYn low, the HDC1000 returns to sleep mode.

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8.5 Programming

8.5.1 I2C Serial Bus Address Configuration

To communicate with the HDC1000, 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 HDC1000 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. HDC1000 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 HDC1000 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 HDC1000 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 HDC1000, 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

Access a particular register on the HDC1000 by writing the appropriate 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 HDC1000 requires a value for the pointer register (refer to Figure 10).

When reading from the HDC1000, 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.

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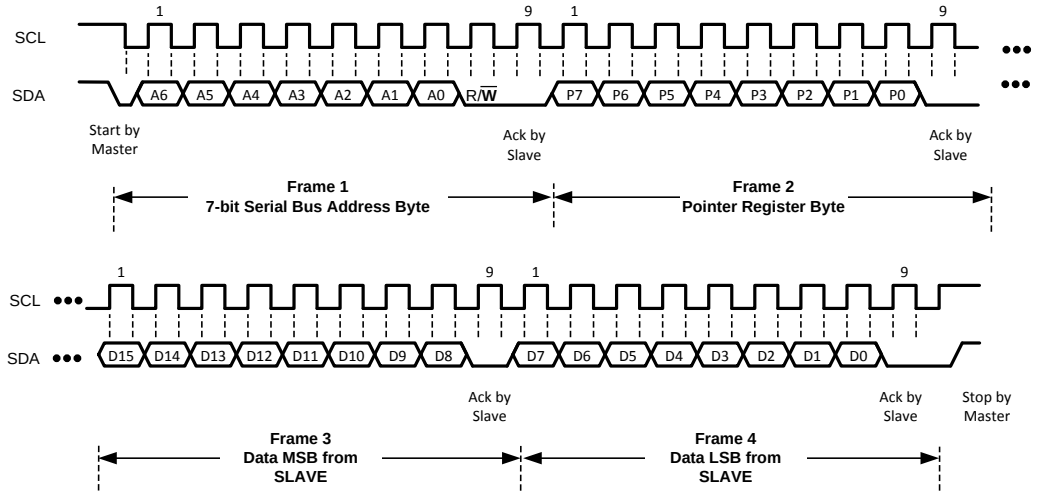


Figure 10. Writing Frame (Configuration Register)

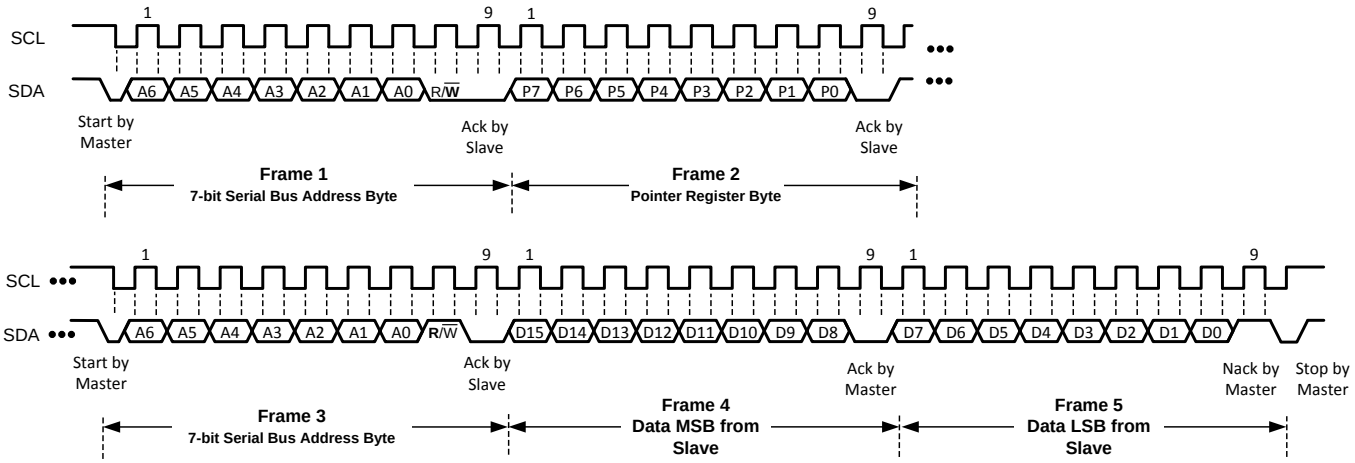


Figure 11. Reading Frame (Configuration Register)

8.5.2.3 Device Measurement Configuration

By default the HDC1000 will first perform a temperature measurement followed by a humidity measurement. On power-up, the HDC1000 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* for the conversion time). Alternatively, wait for the assertion of DRDYn.

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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* 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.

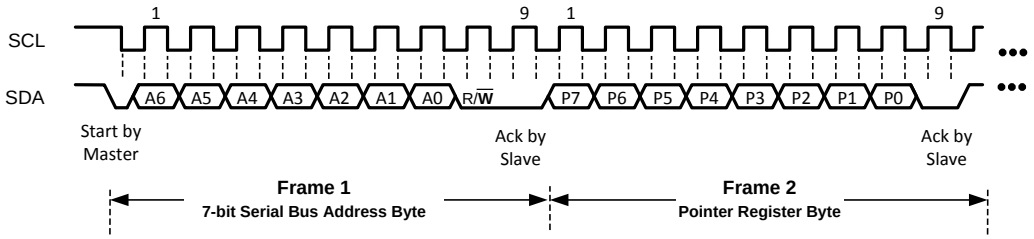


Figure 12. Trigger Humidity/Temperature Measurement

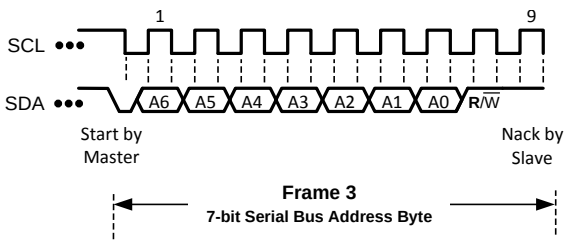


Figure 13. Read Humidity/Temperature Measurement (Data Not Ready)

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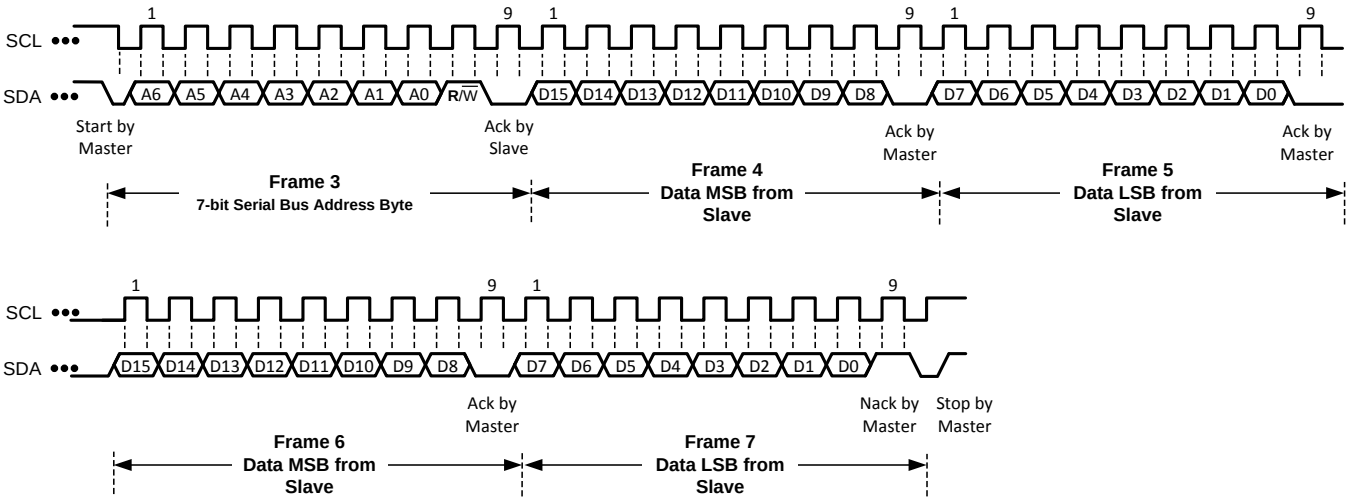


Figure 14. Read Humidity and Temperature Measurement (Data Ready)

8.6 Register Map

The HDC1000 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	HDC1000 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 HDC1000 device

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

The HDC1000 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, while the accuracy is related to the selected conversion time (refer to *Electrical Characteristics*). The temperature can be calculated from the output data with:

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

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)

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*). 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)

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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 HDC1000.

Table 6. Serial Number Register Description (0xFB)

Name	Registers		Description
SERIAL ID[39:24]	[15:0]	Serial Id bits	Device Serial Number bits from 39 to 24 (read only)

Table 7. Serial Number Register Description (0xFC)

Name	Registers		Description
SERIAL ID[23:8]	[15:0]	Serial Id bits	Device Serial Number bits from 23 to 8 (read only)

Table 8. Serial Number Register Description (0xFD)

Name	Registers		Description
SERIAL ID[7:0]	[15:7]	Serial Id bits	Device Serial Number bits from 7 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)

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8.6.6 Device Register ID

This register contains a factory-programmable identification value that identifies this device as a HDC1000. This register distinguishes this device from other devices that are on the same I2C bus. The Device ID for the HDC1000 is 0x1000.

Table 10. Device ID Register Description (0xFF)

Name	Registers			Description
DEVICE ID	[15:0]	Device ID	0x1000	HDC1000 Device ID (read only)

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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

A HVAC or Thermostat are based on environmental sensors and a micro-controller which 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 or thermostat, one of the key parameters in the selection of components is the power consumption. The HDC1000, with its 1.2µA 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.

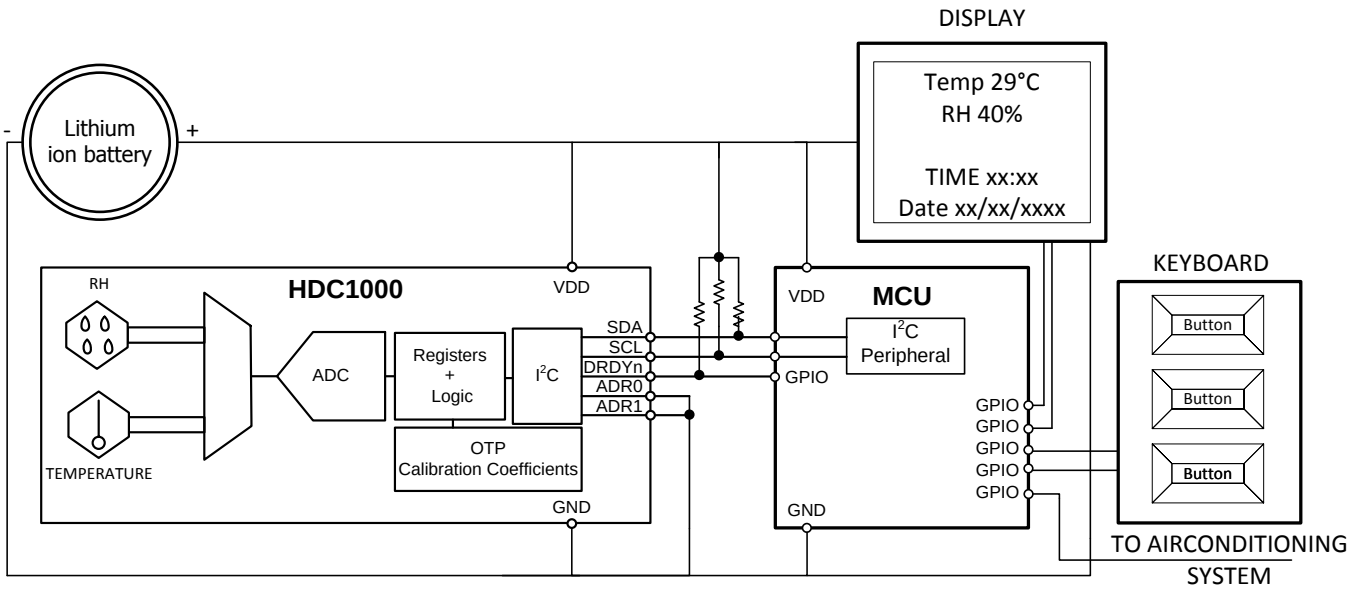


Figure 15. Typical Application Schematic HVAC

9.2.1 Design Requirements

In order to correctly sense the ambient temperature and humidity, the HDC1000 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 HDC1000 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.

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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 HDC1000 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 HVAC to obtain a good airflow even in static conditions. Refer to the layout below (Figure 19) for a PCB layout which minimizes the thermal mass of the PCB in the region of the HDC1000, which can improve measurement response time and accuracy.

9.2.3 Application Curve

The data showed below have been acquired with the HDC1000EVM. The environment conditions have been evaluated in a humidity chamber.

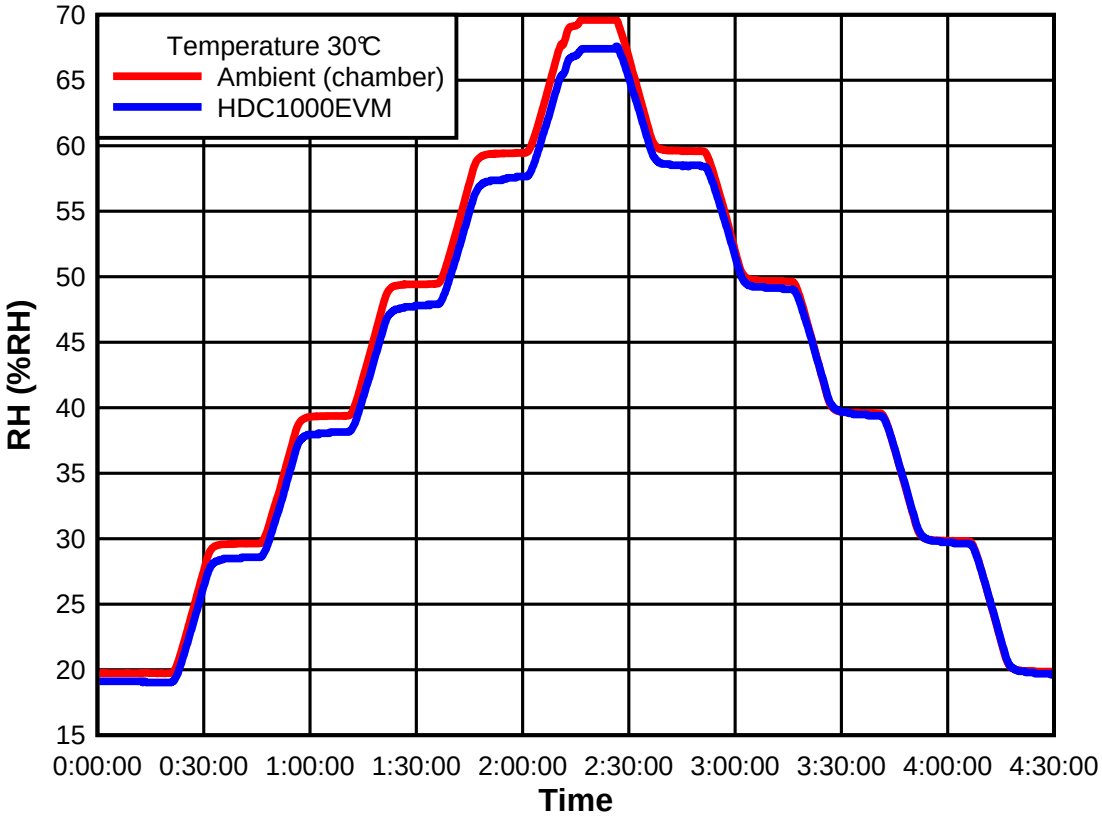


Figure 16. RH vs. Time

9.3 Do's and Don'ts

9.3.1 Soldering

For soldering HDC1000, standard reflow soldering ovens may be used. The sensor is qualified to withstand soldering profile according to 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 HDC1000 it is mandatory to use no-clean solder paste and no board wash shall be applied. The HDC1000 should be limited to a single IR reflow and no rework is recommended.

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Do's and Don'ts (continued)

9.3.2 Recovery From Soldering

After soldering, the HDC1000 may exhibit an RH offset error but will slowly recover when the humidity sensor is exposed to ambient conditions.

9.3.3 Chemical Exposure

The humidity sensor is not a standard IC and therefore should not be exposed to 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.

10 Power Supply Recommendations

The HDC1000 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.

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

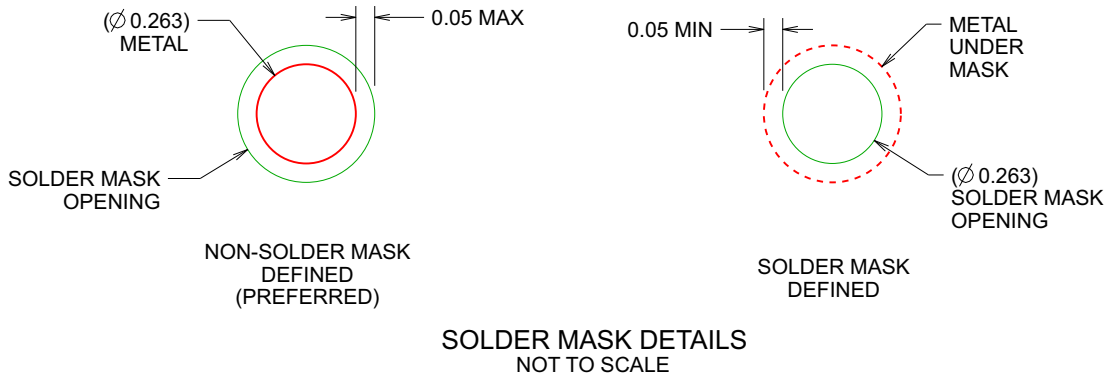


Figure 17. Solder Mask

Layout Guidelines (continued)

11.1.2 Stencil Printing Process

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

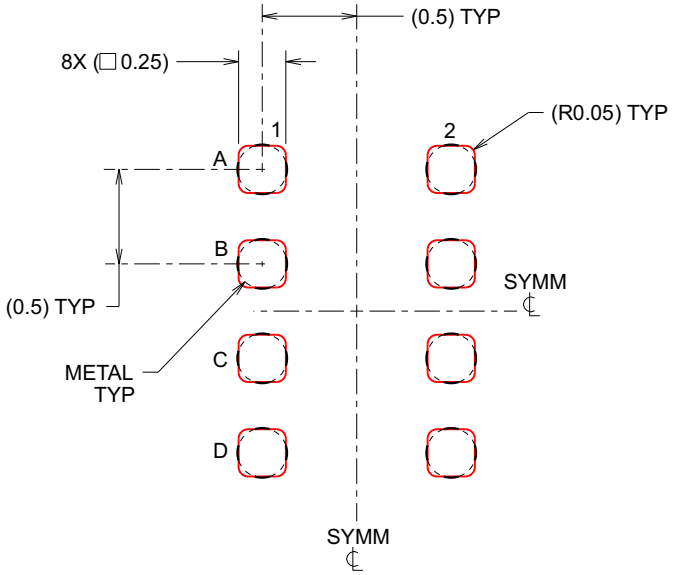


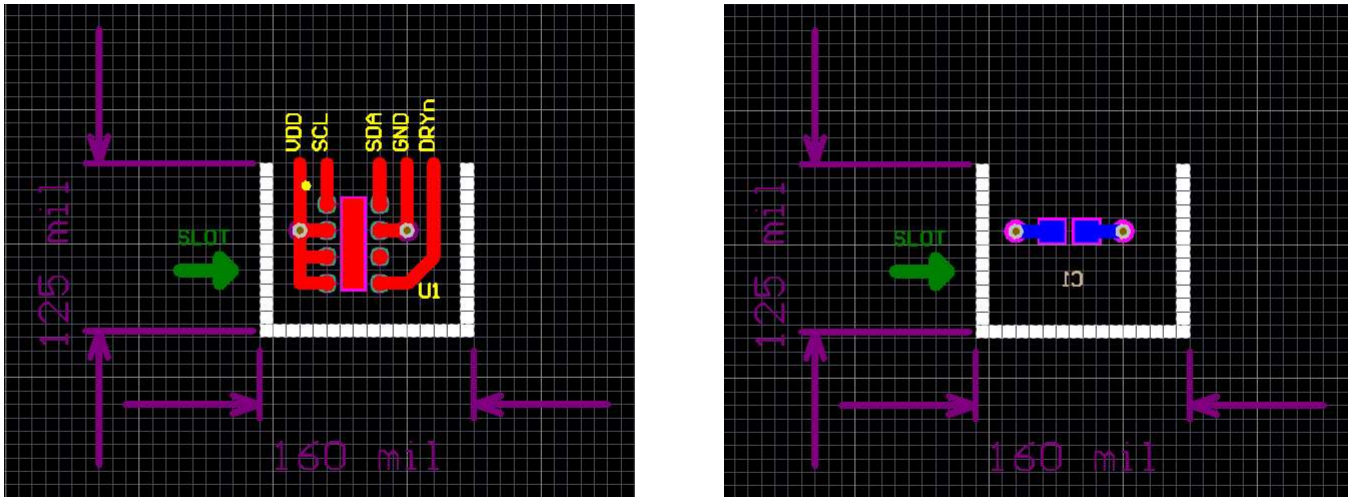
Figure 18. Solder Paste

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 HDC1000 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.

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Layout Example (continued)



TOP LAYER

BOTTOM LAYER

Figure 19. Layout

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

HDC1000 Texas Instruments Humidity Sensors, SNAA216

12.2 Trademarks

All trademarks are the property of their respective owners.

12.3 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.

12.4 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.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
HDC1000YPAR	ACTIVE	DSBGA	YPA	8	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 125	E4	Samples
HDC1000YPAT	ACTIVE	DSBGA	YPA	8	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 125	E4	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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

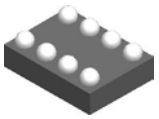
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

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

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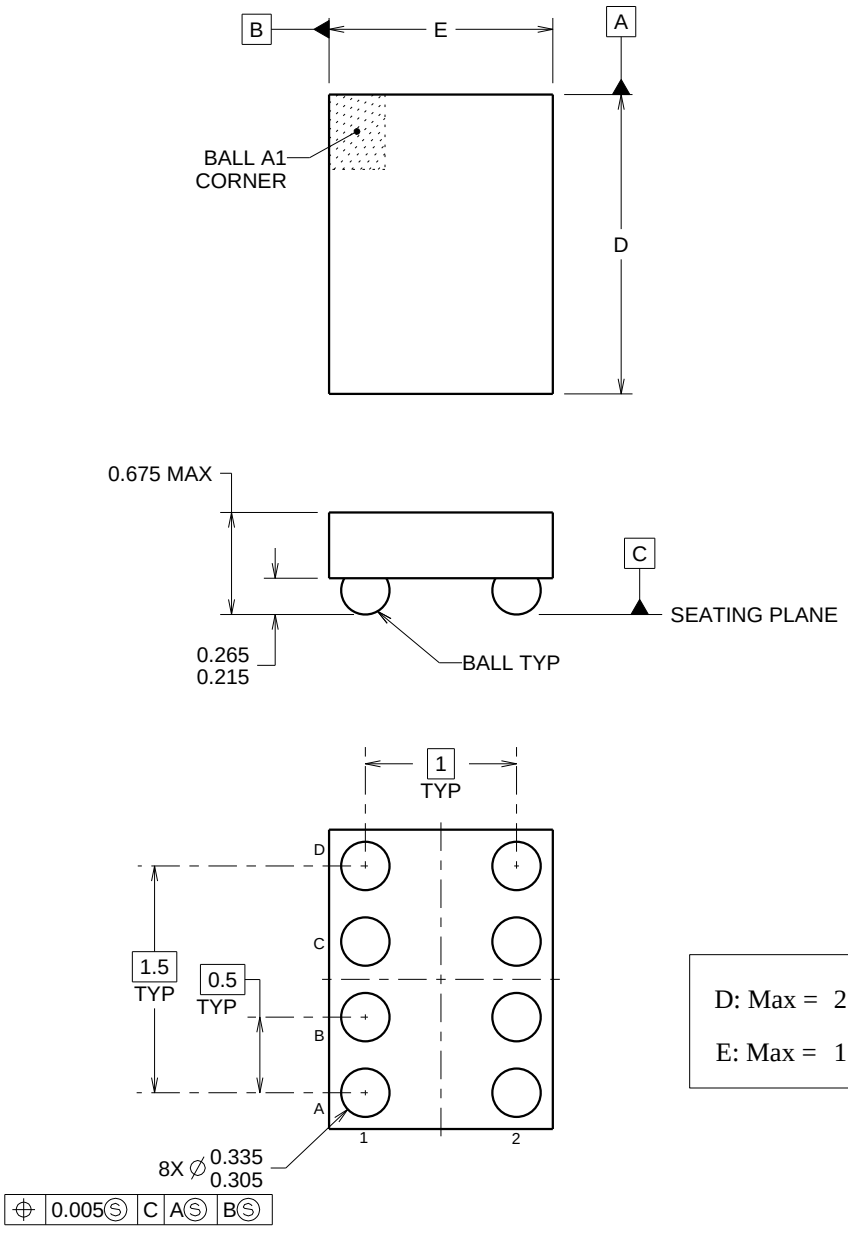
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YPA0008

DSBGA - 0.675 mm max height

DIE SIZE BALL GRID ARRAY



D: Max = 2.07 mm, Min = 2.01 mm

E: Max = 1.62 mm, Min = 1.56 mm

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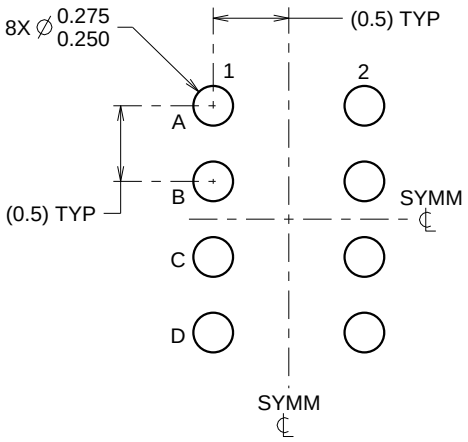
NOTES:

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.

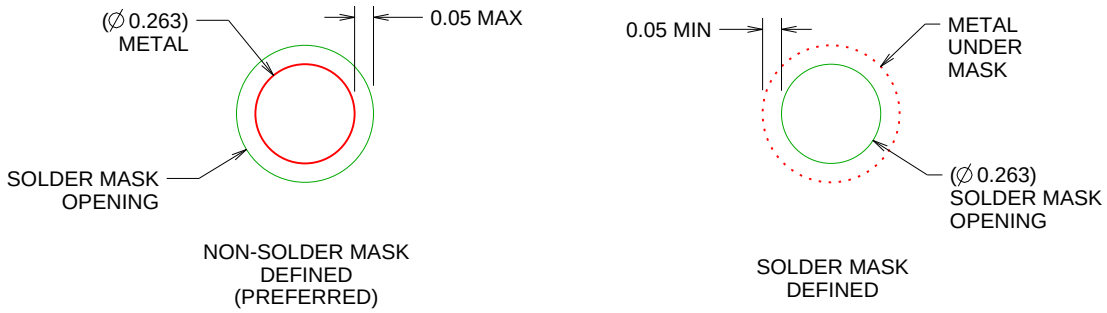
YPA0008

DSBGA - 0.675 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
SCALE:20X



SOLDER MASK DETAILS
NOT TO SCALE

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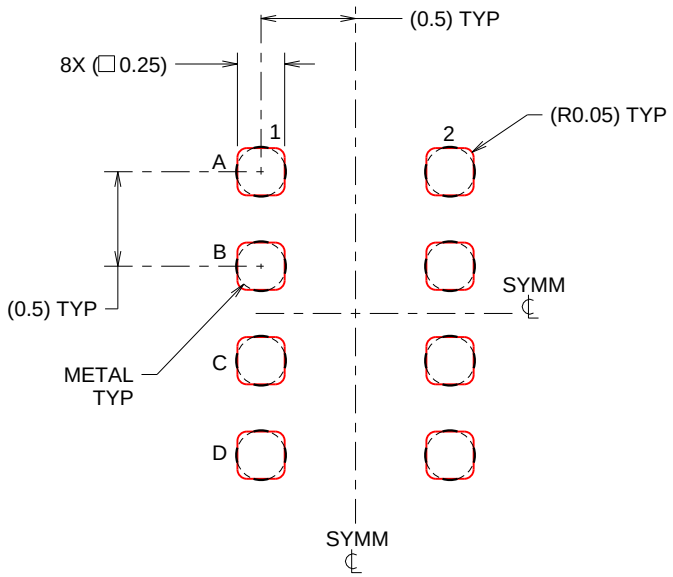
NOTES: (continued)

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

YPA0008

DSBGA - 0.675 mm max height

DIE SIZE BALL GRID ARRAY



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

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NOTES: (continued)

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

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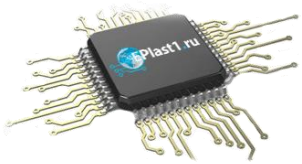
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