User's Guide

HDC3 Silicon

ABSTRACT

This document is to familiarize the user with the HDC3 family of devices by providing storage and handling guidelines, software configuration examples, and pseudo code. The HDC devices are integrated humidity and temperature sensors. The devices measures humidity through a capacitive polymer dielectric that has the capability to calibrate and restore humidity accuracy to meet product specifications. The HDC3 features a 2.5-mm × 2.5-mm WSON open-cavity package where the sensor is exposed directly to ambient air. On the HDC3021, the sensing element is protected during the assembly by factory-installed PI (Polyimide) tape. The HDC3022 sensing element is protected by a hydrophobic PTFE filter and is ideal for outdoor environments or anywhere condensation is expected. The HDC3021-Q1 is an AEC-Q100 qualified automotive grade humidity sensor. All of these HDC3 family devices are NIST traceable, factory calibrated and software-compatible with each other.

Table of Contents

Trademarks

All trademarks are the property of their respective owners.

Copyright © 2022 Texas Instruments Incorporated

1 HDC302x Devices

1.1 HDC3020 in WSON

The HDC3020 is the standard WSON device in the HDC3020 family. It does not have additional protection over the relative humidity (RH) sensor window and the sensor is centered. The device is available in a 2.5-mm × 2.5-mm WSON package. When using the HDC3020, take care to ensure all the requirements are followed.

Figure 1-1. HDC3020 in WSON Package

1.2 HDC3021 in WSON

The HDC3021 is pin-to-pin compatible with the HDC3020. Unlike the HDC3020, the sensor opening is protected by a factory-installed polyimide cover tape. The tape protects the humidity sensor element from pollutants that can be produced as part of the manufacturing process, such as surface mount technology (SMT) assembly, printed circuit board (PCB) wash, and conformal coating. The tape must be removed after the final stages of assembly for accurate measurement of relative humidity in the ambient environment.

Figure 1-2. HDC3021 in a WSON Package

1.3 HDC3022 in WSON

The HDC3022 is identical to the HDC3021, but instead of the removable assembly tape, this device features an IP67 rated hydrophobic protective PTFE membrane over the sensing element. This filter is intended to be left for the lifetime of the device, and protects with 99.99% filtration efficiency for particles down to 100 nm in size. The PTFE filter protects the device from dust, debris and condensation. The filter further protects the device during PCB wash and water submergences when the device is operational.

Figure 1-3. HDC3022 in a WSON Package

Copyright © 2022 Texas Instruments Incorporated

2 Storage and Handling Guidelines

2.1 Exposure to Contaminants

Humidity sensors are not standard ICs and therefore must not be exposed to articles or volatile chemicals such as solvents or other inorganic compounds. The opening in the package allows the sensor to sense the relative humidity in the air, but also exposes the polymer to the environment, making it susceptible to pollutants. Typical ambient conditions do not present a significant risk for chemical exposure but manufacturing and storage environments are a known source of volatile contamination. During assembly, a Kapton tape can be placed over the sensor opening to ensure that the device is not exposed to harmful chemicals. The HDC3021 is great for applications where the chance for chemical exposure is high since it comes with a factory installed kapton cover. The tape can be removed after this process, but the device is still susceptible to contamination.

Exposure to a range of chemicals must be avoided or minimized. Exposure of the following chemicals is known to cause drift of the humidity output readings which may be irreversible:

- Solvents such as:
  - Toluene: C_7H_8
  - Acetone: $(CH_3)_2CO$
  - Ethanol: C_2H_6O
  - Methanol: CH_3OH
  - Isopropyl Alcohol: C_3H_8O
  - Di-isopropyl Ether: $C_6H_{14}O$
  - Ethylene Glycol: $(CH_2OH)_2$
  - Ethyl Acetate: $C_4H_8O_2$
  - Butyl Acetate: $C_6H_{12}O_2$
  - Methyl Ethyl Ketone: $CH_3C(O)CH_2CH_{3\backslash}$
- Acids such as:
  - Hydrochloric Acid: HCl
  - Sulfuric Acid: H_2SO_4
  - Nitric Acid: HNO_3
- Other chemicals, including:
  - Ketenes
  - Ammonia: NH_3
  - Hydrogen Peroxide: H_2O_2
  - Ozone: O_3
  - Formaldehyde: CH_2O

Such chemicals are an integral part of epoxies, glues, adhesives, or reaction byproducts that outgas during baking and curing processes.

The sense layer must not have direct contact with cleaning agents such as a PCB wash after soldering. Applying cleaning agents to the sense layer may lead to drift of the RH output or even complete breakdown of the sensor. Avoid strong blasts from aerosol dusters and use only low-pressure, oil-free air dusting.

If it is necessary to expose the HDC to contaminants, concentration and exposure time must be reduced as much as feasible. Good ventilation (fresh air supply) aids in lowering the concentration of volatile chemicals, particularly solvents.

Copyright © 2022 Texas Instruments Incorporated

2.2 Chemical Analysis

The exposed layer of the HDC3020 can sense small changes in moisture content in the air. If the volatile compound is absorbed by the sense layer, it may degrade the sensor and lead to incorrect measurements. The below section describes the effect of some volatile chemicals that have been exposed to the HDC3020. The purpose of this section is to determine the chemical effects on RH accuracy of the HDC3020 sensors. The devices were exposed to volatile organic compounds (VOCs) that are common in commercial, industrial, and residential cleaning products.

The list of chemicals can be divided into two subsections categorized based on the level of exposure: Saturation and recovery testing and long-term exposure testing. These two subsections have different test procedures, methods of application and exposure quantities.

These sections go over some of the results that were observed during testing. The devices were measured against a chilled mirror and swept at 30°C. An average of the error between 10% to 90% RH was measured and graphed in the following sections. The exposure quantity was minimum and the chemical concentrations were below industry standards, therefore the devices did not exhibit significant change in humidity measurement. However, during manufacturing and assembly processes, the humidity sensors should not be exposed to the chemicals outlined in the above section. Any significant exposure can damage the polymer and it will be difficult to recover the sensor back to operating conditions. If the device will be assembled where chemical exposure is high, then a HDC3021 can be the right solution. Another option is to consider the HDC3022 which comes with a permanent Polytetrafluoroethylene (PTFE) filter that can block particles up to 100 nm.

If salt contamination occurs and the RH error is greater at higher humidities, then the sensor can be washed with deionized (DI) water.

Copyright © 2022 Texas Instruments Incorporated

2.2.1 Saturation and Recovery Tests

The chemicals in this list were exposed to the sensor only for a short period of time. Two conditions were evaluated for each chemical: a 30-second exposure and eight 30-second exposures over a period of 24 hours.

Table 2-1 shows the chemicals in this list. The device operated at 3.3 V at 30°C and an average humidity error was calculated.

Table 2-1. List of Chemicals for the Short-Term Exposure Test

CHEMICAL	CONCENTRATION	OBSERVABLE DAMAGE	NUMBER OF HDC3020 UNITS
Isopropyl alcohol	65.7% m/m	None	4 per exposure rating
Hydrogen Peroxide	7.35% m/m	None	
Sodium Hypochlorite	4.5% m/m	Copper traces corroded	
Iodophors	74 ppm m/m	None	
Flux - Microcare Universal Contact Cleaner	100%	None	

30-Second exposure: Five drops of each chemical was dropped directly on the sensor opening. After 30 seconds, the sensor was turned over to get rid of excess solution. After a minute of exposure, the device was cleaned to prevent further exposure.

Overall, Figure 2-1 shows there is not much change between the pre- and post tests for these chemicals other than a small negative gain.

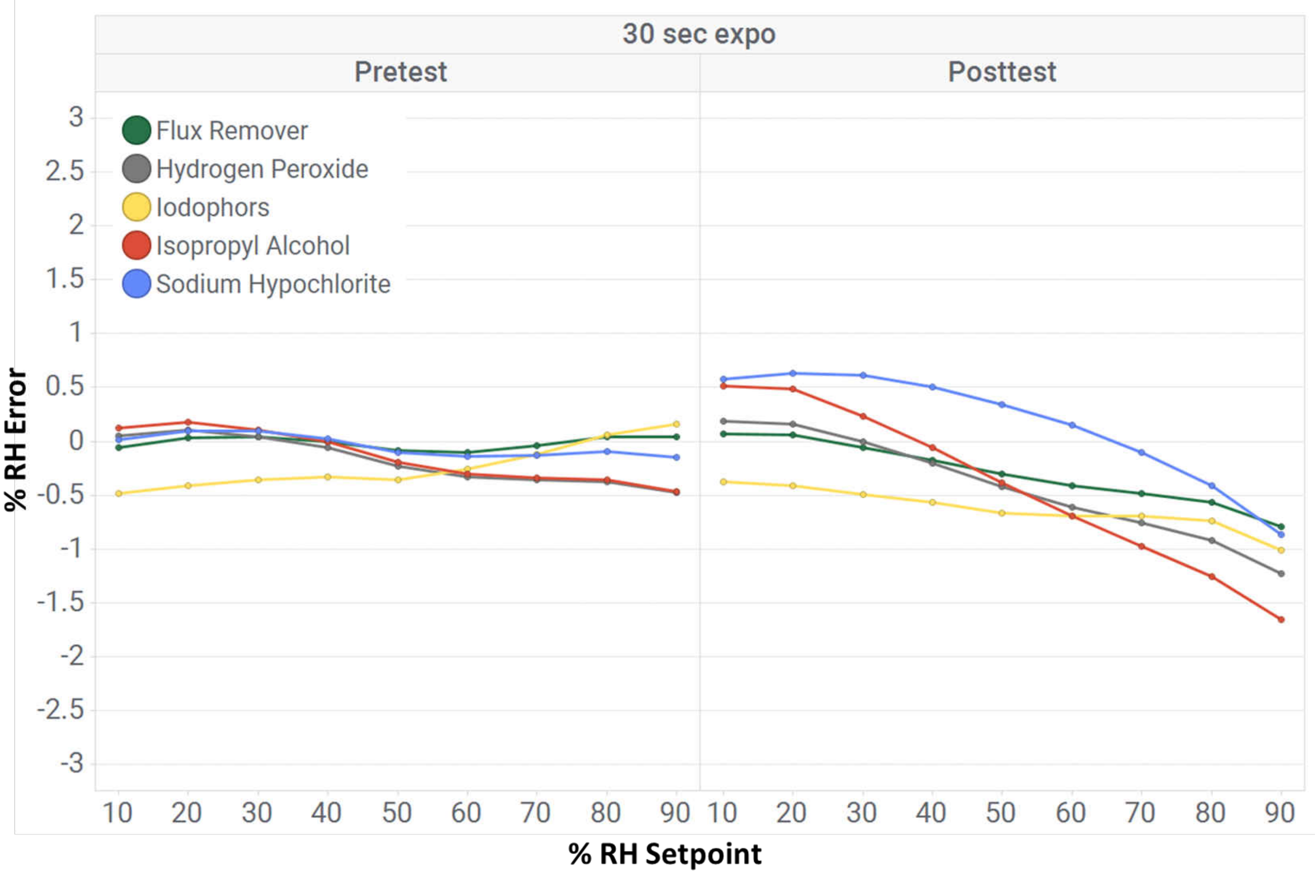


Figure 2-1. Short-Term Exposure: One-Time Exposure

Copyright © 2022 Texas Instruments Incorporated

Multiple 30-second exposures: Four HDC3020 devices followed a similar procedure as the 30-second test. The procedure was performed seven more times.

Overall, most of the chemicals did not have any major shift other than a negative gain.

However, exposure to Sodium Hypochlorite resulted in some corrosion on the copper traces on the board and some of the pins. To clean the PCB, the opening was protected using a kapton cover and it was cleaned using a horsehair brush and DI water. A humidity sweep shows that the devices had a very large negative gain shift, especially at higher humidity setpoints.

Exposure to Isopropyl Alcohol also resulted in some negative gain shift at lower humidity setpoints. Any further exposure would result to severe gain shifts.

Figure 2-2 shows the sweeps for this exposure.

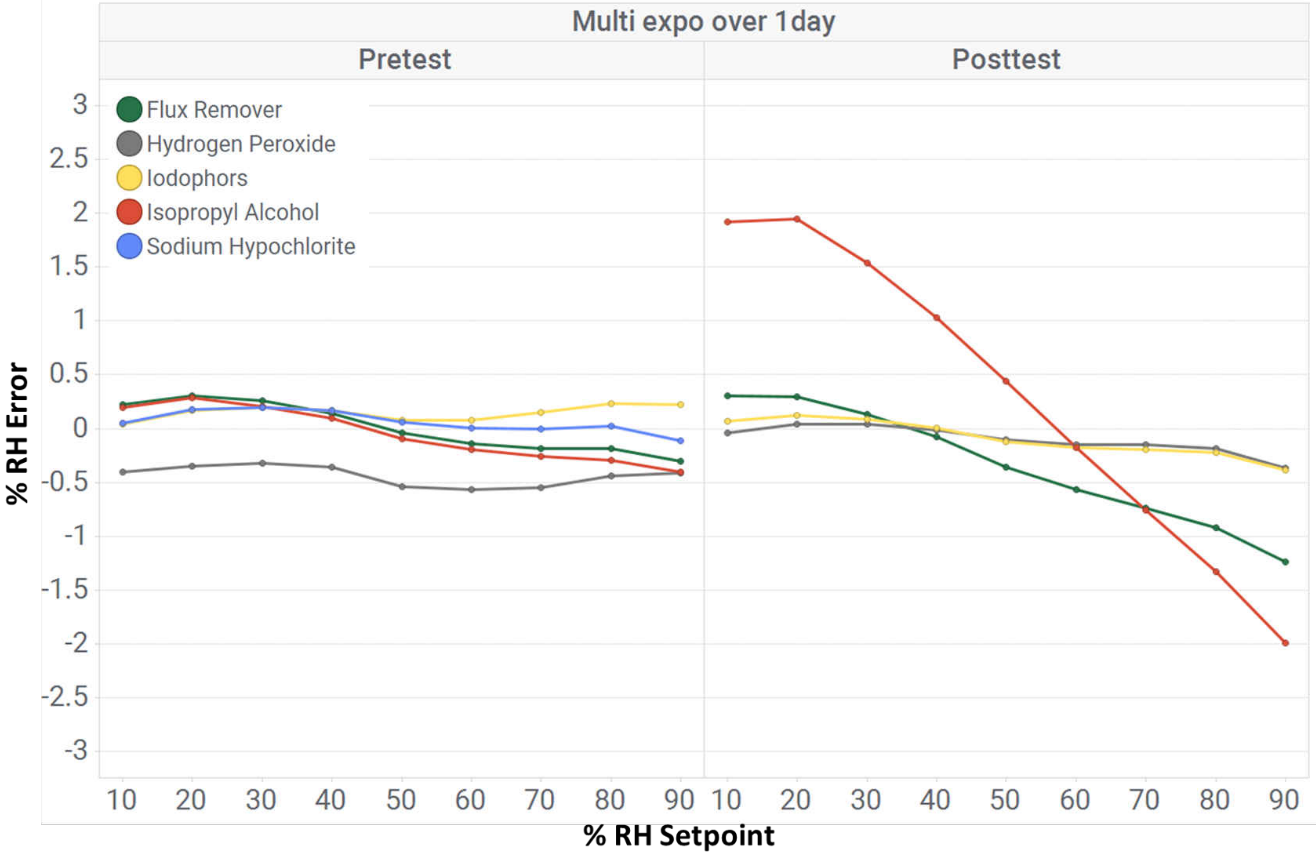


Figure 2-2. Short-Term Exposure: Multiple Exposures

Copyright © 2022 Texas Instruments Incorporated

2.2.2 Long-Term Exposure

Four samples per chemical were submitted for a long-term exposure test. These devices were exposed to gaseous forms in a sealed chamber for 21 days. Table 2-2 shows the chemicals in this test.

Table 2-2. List of Chemicals for the Long-Term Exposure Test

CHEMICAL	CONCENTRATION (ppm)	OBSERVABLE DAMAGE
Toluene	298 – 322	None
Xylene	108 – 131	None
Butyl Acetate	200 – 220	None
Formaldehyde	3 – 5	None
Sulfur Dioxide	5	None
Ethanol	862 – 1003	None
Methanol	195 – 260	None
Ammonia	34 – 35	None
Cigarette Smoke	Saturated	Staining and coating

For the devices exposed to cigarette smoke, smoke from a cigarette was blown into a chamber until it was saturated and the devices were not visible. Half a cigarette was used each time to saturate the chamber and the smoke inside the chamber was refreshed every day.

For the rest of the chemicals, the chemicals were administered using a syringe. The gases were refreshed every seven days by the chemist to ensure the concentration of the gases remained high.

Overall, most of the chemicals had an increased negative gain, but there were no significant offset changes on these parts. Figure 2-3 and Figure 2-4 show the results for these sweeps.

Copyright © 2022 Texas Instruments Incorporated

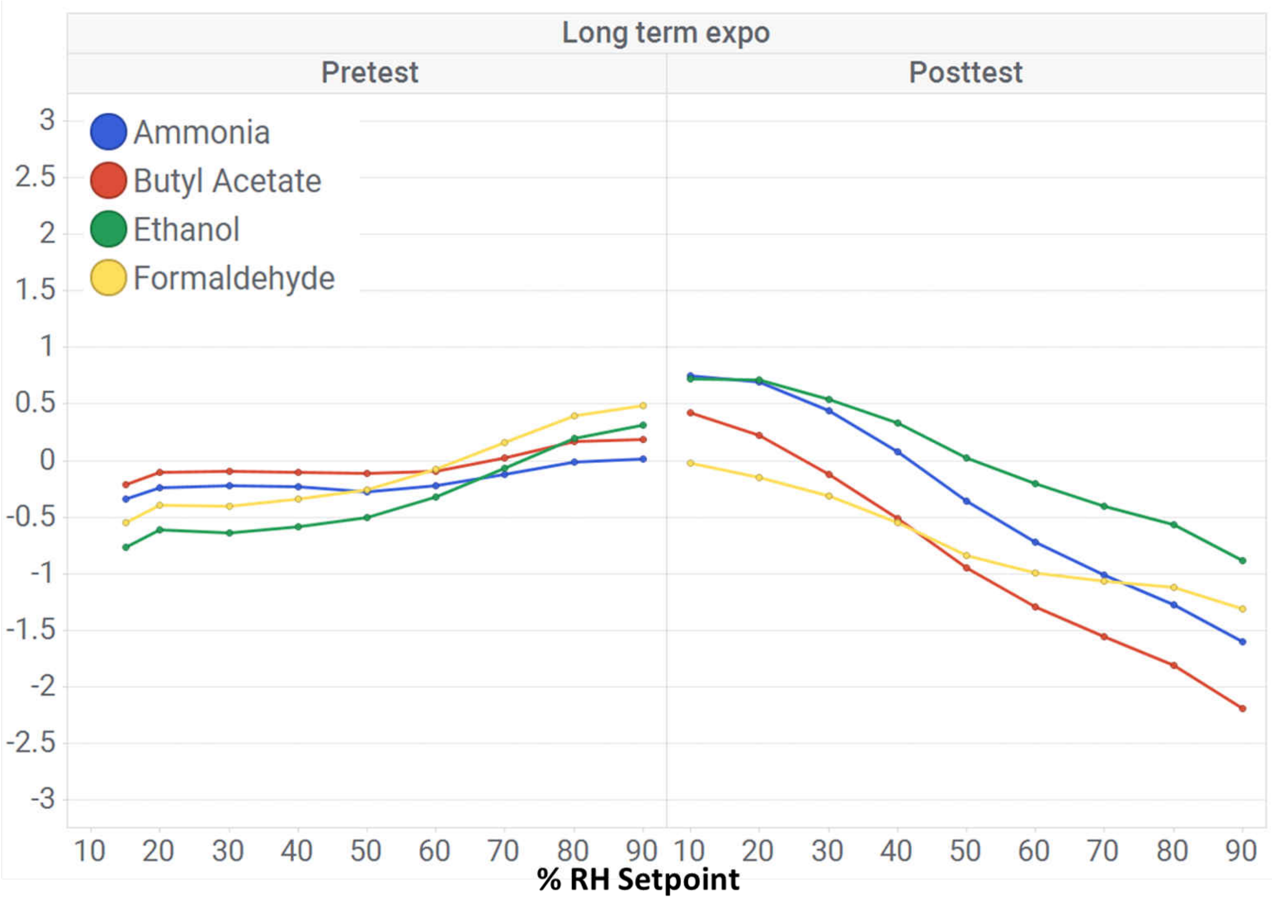


Figure 2-3. Long-Term Exposure Results

Copyright © 2022 Texas Instruments Incorporated

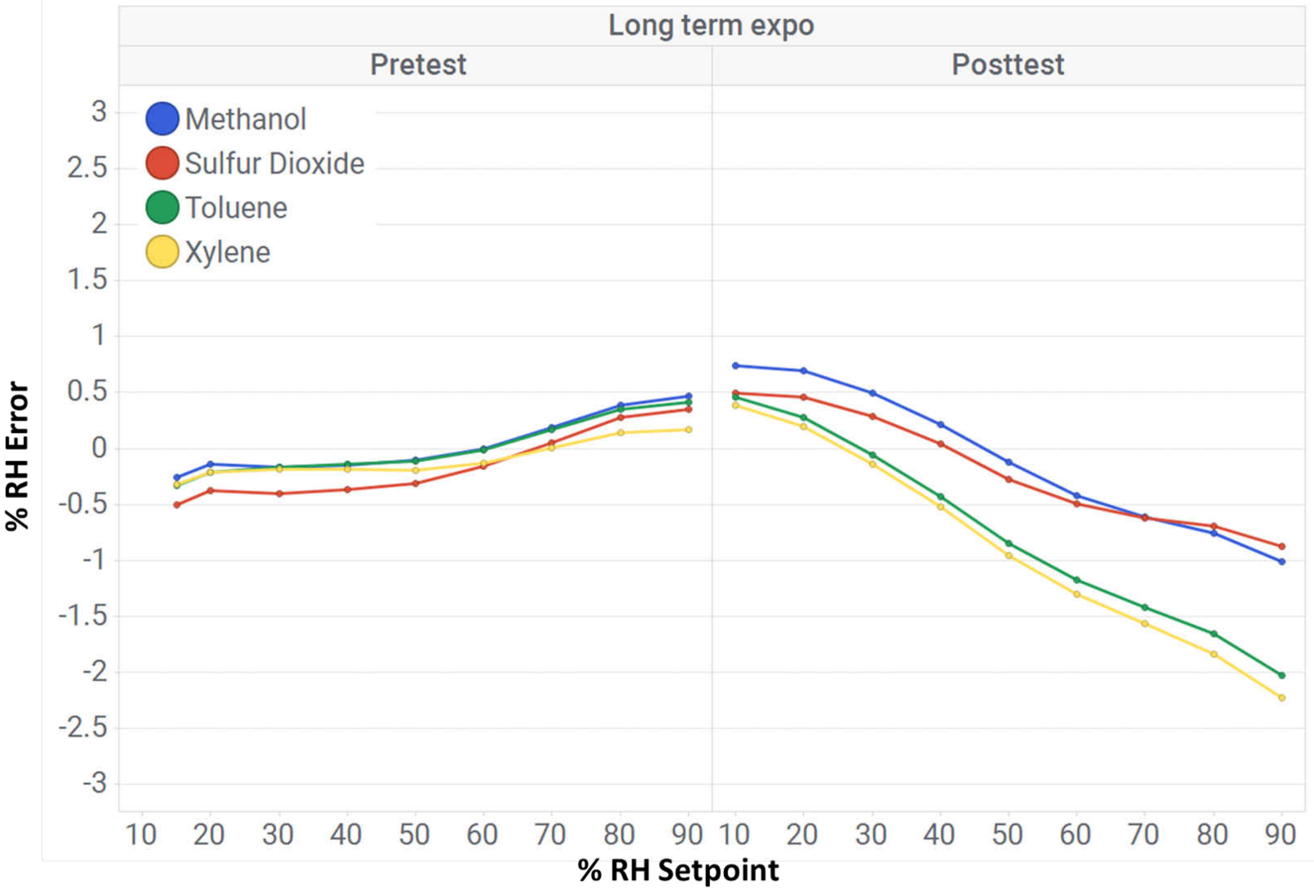


Figure 2-4. Long-Term Exposure Results

Figure 2-5 shows that exposure to cigarette smoke resulted in a huge negative gain and the RH error of these parts varied from 25% to –50% between 10% to 90% RH setpoints. The boards also had severe discoloration and visible residue on the sensor opening. The sensor was cleaned using air, but the device performance did not recover.

Copyright © 2022 Texas Instruments Incorporated

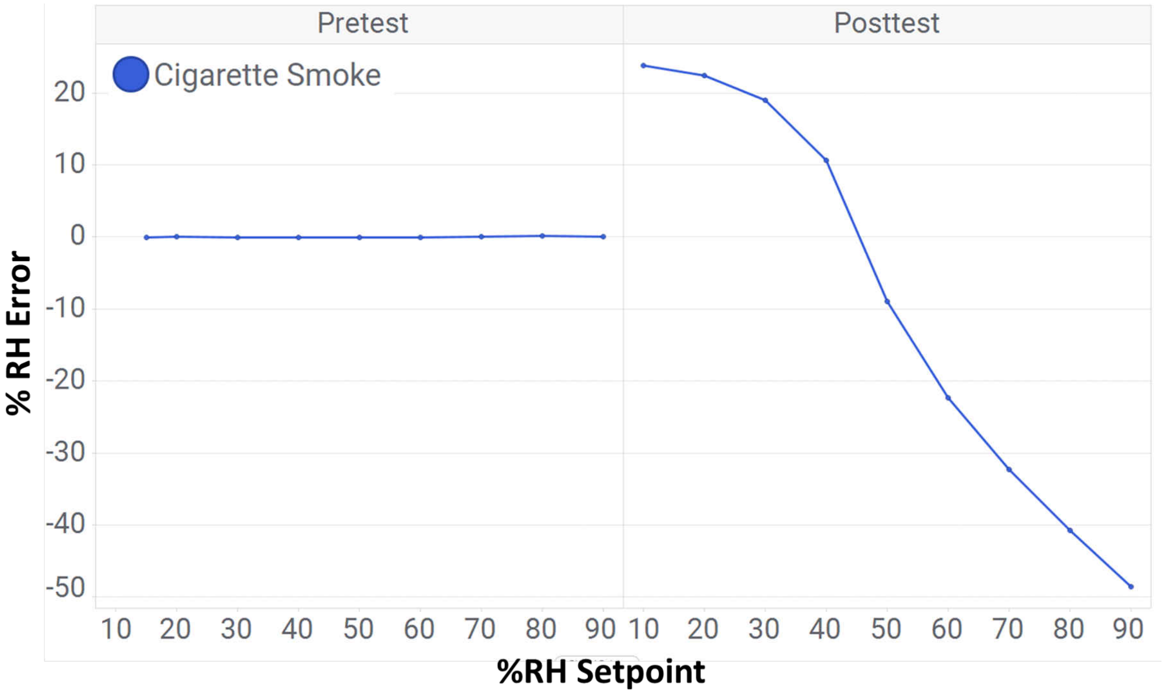


Figure 2-5. Long-Term Exposure To Cigarettes

Copyright © 2022 Texas Instruments Incorporated

2.3 Packaging and Storing

TI's humidity sensors are shipped in sealed anti-static tape and reel cavities. The sensors can be stored in a humidity and temperature-controlled environment after being removed from the tape and reel cavity prior to assembly. Storage temperature and humidity limitations are defined by the moisture sensitivity level (MSL) of the sensor. Refer to the application note *MSL Ratings and Reflow Profiles* for more details.

Do not store the humidity sensors within anti-static polyethylene bags or packing materials (pink foam/wrap), as these materials emit gases that can affect the sensor. TI recommends metallized, anti-static sealable bags for storage. Do not use adhesives or tape inside the storage container as outgassing can degrade the polymer as well.

2.3.1 Assembly

The HDC must be added in the last assembly step. In case the PCB passes through multiple solder cycles (as is the case for PCBs that have components on the top and bottom side), adding the HDC last reduces the risk of damage to the sensing polymer from contaminants or excessive heat. Contaminants such as those listed in *Exposure to Contaminants* must be avoided or minimized. Maximum assembly temperatures and exposure times must not be exceeded.

Note

It is important that no-clean solder paste is used and no board wash is applied once the sensor is assembled onto the PCB. To ensure proper device performance, these instructions should be communicated to board manufacturers before assembly.

2.3.2 Application in Extreme Environment

Some applications require the usage of the HDC in harsh environments. Ensure that the exposure of the sensor to the maximum limit of temperature and humidity operating conditions meets the data sheet guidelines. Limiting exposure to volatile organic compounds at high concentration and long exposure time is critical. Usage in harsh environments must be carefully tested and qualified.

Exposure to any aqueous solutions is highly discouraged. In the event some aqueous exposure cannot be avoided, TI recommends to use the HDC3022 and follow the guidelines below:

- Exposure to acids or bases may affect humidity output accuracy readings
- Bases are less damaging than acidic solutions. All acids must be considered damaging to the sensor. Etching substances such as H_2O_2 or NH_3 at high concentrations can be damaging to the sensor.
- Corrosive solutions at very low concentrations are not damaging to the sensor itself. However, take care to ensure that the solder contacts are not damaged.

Copyright © 2022 Texas Instruments Incorporated

3 Programming the HDC3020

The Functional Modes

The HDC3 has two modes of operation: sleep and measurement mode. After power up, the HDC3 enters sleep mode. In this mode, the device waits for I^{2}C instruction to set the programmable low power mode, trigger a measurement/conversion, or read/write valid data. When a measurement is triggered, the device wakes from sleep mode to enter measurement mode. In measurement mode, the HDC3 coverts temperature or humidity values from integrated sensors through an internal ADC.

Two different types of ADC conversions (measurement modes) are available in the HDC devices: Trigger-on Demand and Auto Measurement mode.

3.1 Trigger-On Demand

In this mode, I^{2}C commands triggers each measurement conversion. After device power up, the device is placed in sleep mode waiting for an input.

To configure the device to collect both the humidity and temperature data in a single acquisition mode, select TRIGGER ON DEMAND (MSB HEX CODE 24) in the command table along with the appropriate low power mode selection. The device will exit from sleep mode and perform a single measurement. Figure 3-1 shows the Trigger-on Demand mode.

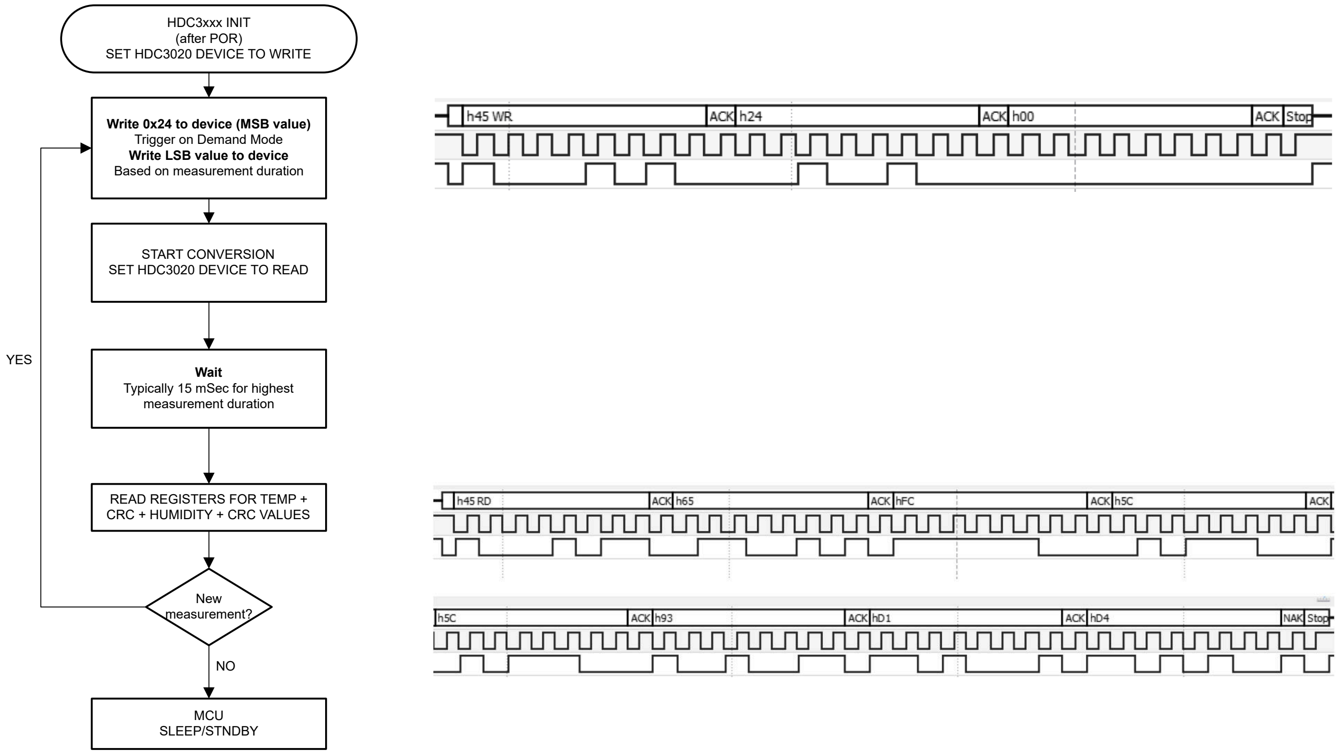


Figure 3-1. Flowchart for Trigger-On Demand Mode

Copyright © 2022 Texas Instruments Incorporated

3.2 Auto Measurement

Auto Measurement mode is a continuous operation mode. The user can select the measurement frequency between 10 samples a second to 1 sample every 2 seconds.

To configure the device to collect both the humidity and temperature data in continuous mode, select the desired Auto Measurement mode and low power mode duration from the command table. To obtain the temperature and humidity values, the user can issue commands 0x0E & 0x00. After each measurement, the device will update register 0x0E and re-enters sleep mode. Figure 3-2 shows this transaction.

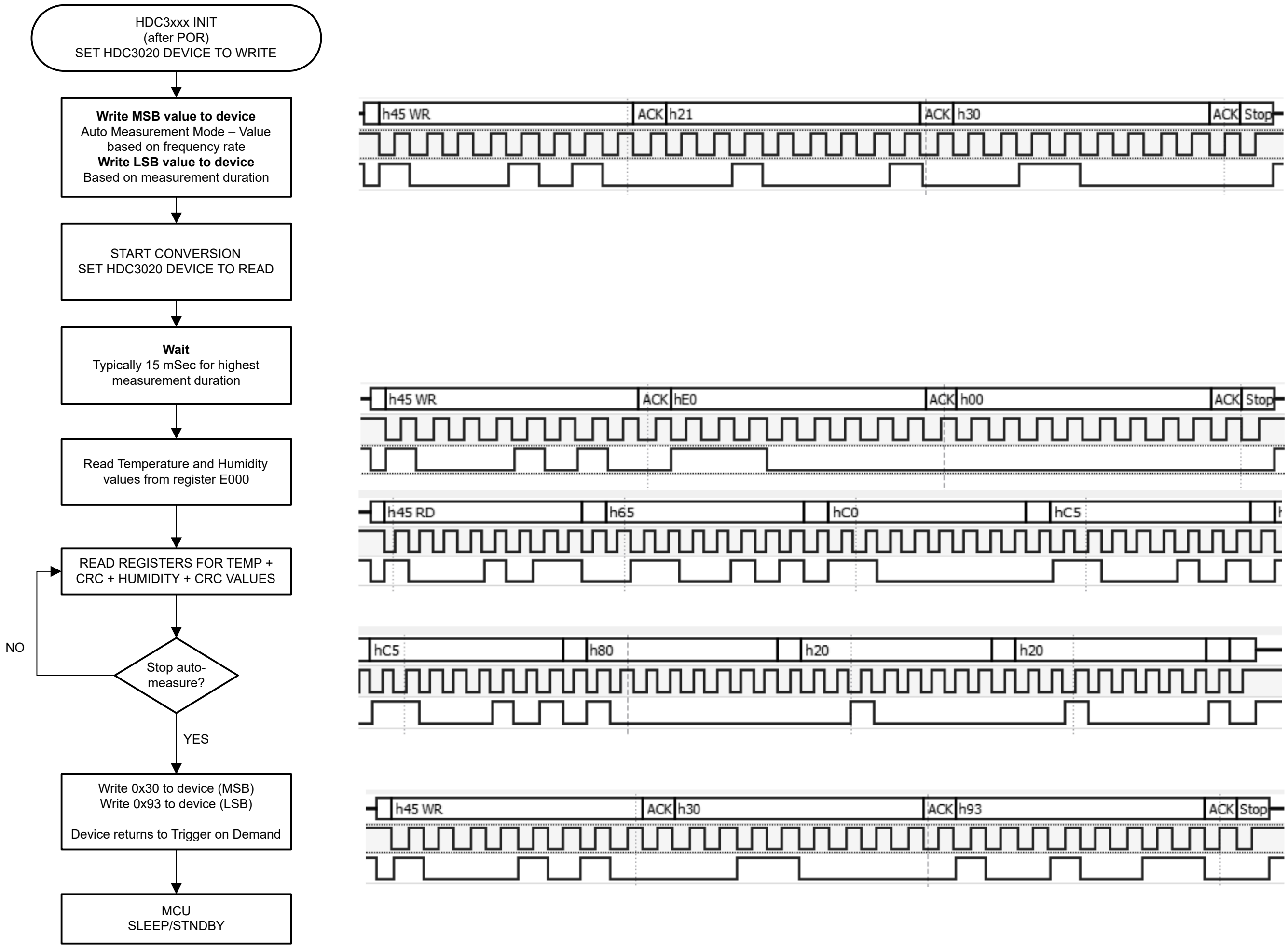


Figure 3-2. Flowchart for Auto Measurement Mode

Copyright © 2022 Texas Instruments Incorporated

3.3 Programming the CRC

The Cyclical Redundancy Check (CRC) computation module can be used for message transfer and safety system checks. The 8-bit CRC checksum transmitted after each data word is generated by a CRC algorithm. The CRC covers the contents of 2 bytes of transmitted data. To calculate the checksum, only these two previously transmitted data bytes are used.

Table 3-1. HDC3x CRC Properties

PROPERTY	VALUE
Name	CRC-8 / NRSC-5
Width	8 bit
Protected Data	Read and/or write Data
Polynomial	0x31 ($x^8 + x^5 + x^4 + 1$)
Initialization	0xFF
Example	CRC of 0xABAB is 0x72

3.3.1 CRC C Code

The following code snippet describes how to generate an 8-bit CRC code in C for the HDC3x devices.

```
#include <stdio.h>
unsigned char crcHDC3 (unsigned char msg[], int msglen) {
    unsigned char crc = 0xFF;
    for (int byte = 0; byte < msglen; byte++) {
        crc ^= msg[byte];
        for (int bit = 0; bit < 8; bit++) {
            if (crc & 0x80)
                crc = (crc << 1) ^ 0x31;
            else
                crc = (crc << 1);
        }
    }
    return crc;
}
void main(int argc, char *argv[]) {
    unsigned char msg[20];
    int msglen = (argc > 1) ? (argc - 1) : 2;
    msg[0] = 0xAB;
    msg[1] = 0xCD;
    for (int i = 1; i < argc; i++) {
        sscanf(argv[i], "%X", &msg[i-1]);
    }
    printf("crc" 0x%X\n", crcHDC3(msg, msglen));
}
```

Copyright © 2022 Texas Instruments Incorporated

3.4 Condensation Removal

Certain environments can force the temperature to drop below the dew point. During such an event, condensation can occur on the device. The sensor opening will be blocked and this can impact accurate sensor readings. In such situations, the integrated heater on the HDC3020 can be beneficial to remove any condensation and can continue reading error free measurements.

Note

The HDC3020 should only be used in a non-condensing environment. The recommended humidity operating range is 10 to 90% RH (non-condensing) over –20°C to 70°C. Prolonged operation beyond these ranges may shift the sensor reading with a slow recovery time. Excess condensation could degrade sensor performance and might make it harder to recover.

The HDC3 comes with a configurable heater to allow customers to use the heater based on their application and the amount of power needed to evaporate the condensation. The highest power (lowest resistance) offered on this device is 35.92 Ω and the lowest power (highest resistance) is 1996 Ω. This setting can be configured as needed but the recommended resistances are outlined in Table 3-2.

The recommended operating condition for the heater can be set between 2.7 V to 5.5 V. The condensation removal is layout-dependent as some layouts would need more power or more time to evaporate the moisture. The recommended layout can be found in the *Layout Example* section of the data sheet. Users can configure a setting between 25% and 100% and characterize a setting based on the layout and application. Users must note that they need to calculate and write the CRC to the device based on the heater configuration.

Calculating the dew point (DP) from the temperature and humidity measurements can be important when it comes to this feature. If the temperature drops below the DP, the device can be placed in an environment where the temperature gets above the DP and the heater can be enabled. The user can also leverage the ALERT output, which is triggered when the part crosses preset temp and %RH levels. The timing of this process can take a couple of minutes, sometimes even five minutes until the device can read the temperature and humidity accurately. When the %RH reading goes to zero % (or near it), the heater can be subsequently turned off to allow the device to cool down. Cooling of the device can take several minutes, but the temperature measurement will continue to run to ensure the device goes back to normal operating condition before restarting the device for normal service.

Refer to the flowchart in Figure 3-3 to configure and enable the heater.

Copyright © 2022 Texas Instruments Incorporated

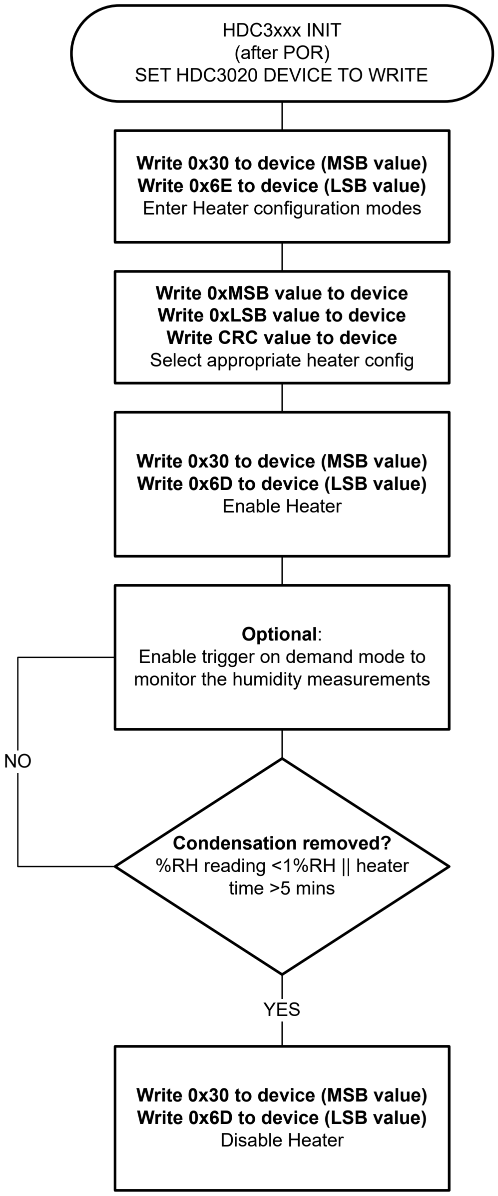


Figure 3-3. Flowchart for Condensation Removal

The integrated heater evaporates moisture that forms on top of the humidity sensor, but does not remove any contaminants. Any contaminant residue, if present, may impact the accuracy of the humidity sensor and can cause drift. If the device experiences drift due to contamination or precipitation, refer to the *Offset Error Correction* section.

Copyright © 2022 Texas Instruments Incorporated

3.5 Offset Error Correction

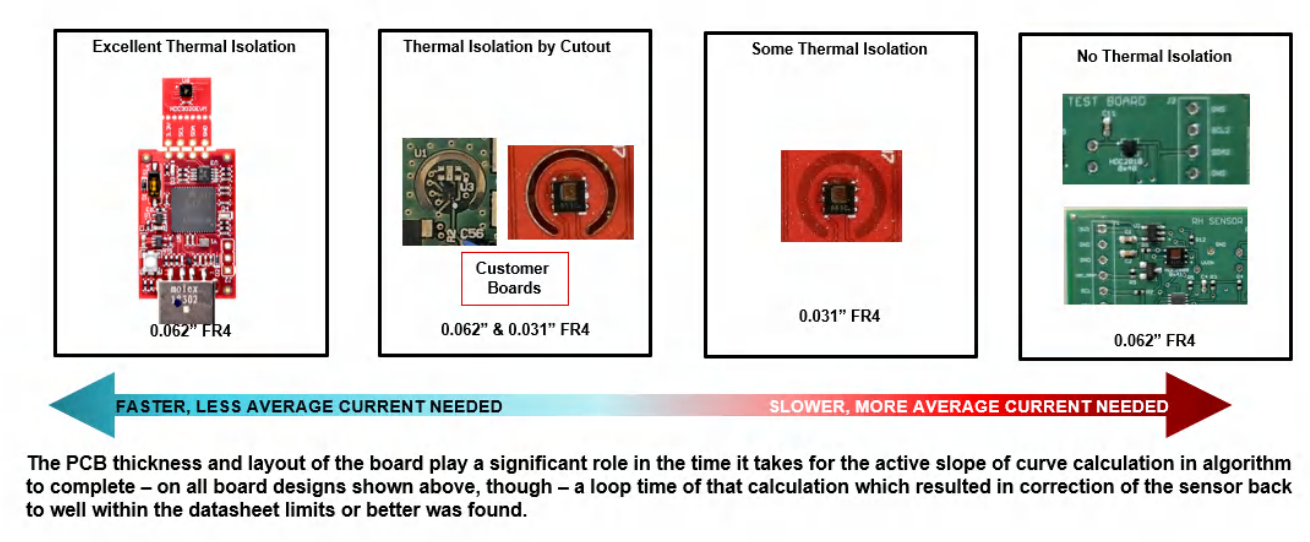
The Offset Error Correction Algorithm calibrates the device and corrects any observed sensor drift that may be encountered due to device mishandling or exposure to contaminants. There are cases where the devices have been permanently shifted as a result of accelerated aging test exposure, chemical exposure, or device mishandling. Heating the humidity sensor to a high temperature for a long period of time (to bake it) can remove the drift from prolonged exposure to extreme conditions and/or harsh contaminants, but this is not practical after the sensor is in the field for many applications. Devices that exhibit this shift can be expensive to replace and would also consume a lot of time for technicians to replace the system module. Many polymer-based sensors are susceptible to these shifts and finding a solution to correct this kind of error is greatly desired. This algorithm can reduce cost and potentially improve the life of your product.

This section will cover the electrical, mechanical design and the recommended layout required to correct the humidity offset that is observed on the HDC3020. The offset error correction algorithm calibrates the device and corrects any observed sensor drift that may be encountered due to device mishandling or exposure to contaminants.

This feature should be operated using the Trigger-on Demand mode. When the algorithm is done running, the user can continue to run the device in any other mode of their choosing. This feature can work well for devices that exhibits a positive humidity shift.

This technique uses the built-in heater to eliminate the drift. The triggering of the firmware routine could be accomplished any number of ways, from a cloud-connected handset application, button press, triggered periodically, or just on a power-on reset (POR). The exact method implemented is at the discretion of the developer and also based on the application. In the below examples, a software interrupt was used to trigger the execution of the calibration routine. The algorithm can be run as many times as the users would prefer. However, TI recommends to run the algorithm once a year or whenever it is suspected that the device was contaminated by some chemical.

The unit(s) under testing must have their heater switched on and observed for highest temperature that can be achieved. In this effort, the different packages and layouts each have their own impact on the heater performance. Figure 3-4 describes the different layout considerations that can be implemented on the HDC devices. The EVM and the layout with the cutout would require lower current to execute the offset error correction algorithm. However, the layout that has little to no thermal isolation would require a lot more current to execute this command. The device has a recommended 125°C maximum temperature, but certain layouts cannot support this temperature rise. The first step is to see how hot the parts can get on a given layout (if not starting with a cutout), and then change the layout (if possible) to get best results.



The PCB thickness and layout of the board play a significant role in the time it takes for the active slope of curve calculation in algorithm to complete – on all board designs shown above, though – a loop time of that calculation which resulted in correction of the sensor back to well within the datasheet limits or better was found.

Figure 3-4. Thermal Isolation Examples

Copyright © 2022 Texas Instruments Incorporated

The HDC3020s heater power setting is also customizable. Users can choose their power setting based on their operating voltage, layout, and overall application, and this can help users reduce their power consumption. Table 3-2 shows some common power settings that were tested along with their approximated power consumptions. If a user plans to modify the heater configuration, a thorough power analysis must be generated along with a look up table.

Table 3-2. Recommended Heater Configurations

HEATER POWER SETTING	HEATER HEX CODE	CRC	TYPICAL HEATER RESISTANCE (Ω)	TYPICAL CURRENT AT 3.3VDC (A)	TYPICAL POWER AT 3.3VDC (W)	TYPICAL CURRENT AT 5VDC (A)	TYPICAL POWER AT 5VDC (W)
25%	0x009F	0x96	150.35	21.95 mA	72.43 mW	33.26 mA	166.29 mW
50%	0x03FF	0x00	71.04911037	46.45 mA	153.27 mW	70.38 mA	351.87 mW
100%	0x3FFF	0x06	35.92	91.89 mA	303.22 mW	139.22 mA	696.1 mW

A characterization table or a look up table (LUT) should be used to apply the correct humidity offset for these devices. TI provides a LUT for two suggested layouts, and one of the recommended layouts can be found in the data sheet. The other suggested layout can be found at the end of this section. The tables were characterized using a Temperature and Humidity chamber (ex: TE1007H) and a high-accuracy temperature and humidity reference (ex: chilled mirror), and the test records the temperature rise from initial conditions until the device reaches the humidity offset. Table 3-2 in the next section records the values between 10% to 45%RH and between 15°C and 30°C.

Figure 3-5 describes the steps required to use the LUT. The humidity value obtained after running this algorithm is the offset that must be subtracted from the device to correct the error. You can apply this offset to the device using the offset register. Refer to the data sheet for more information.

Copyright © 2022 Texas Instruments Incorporated

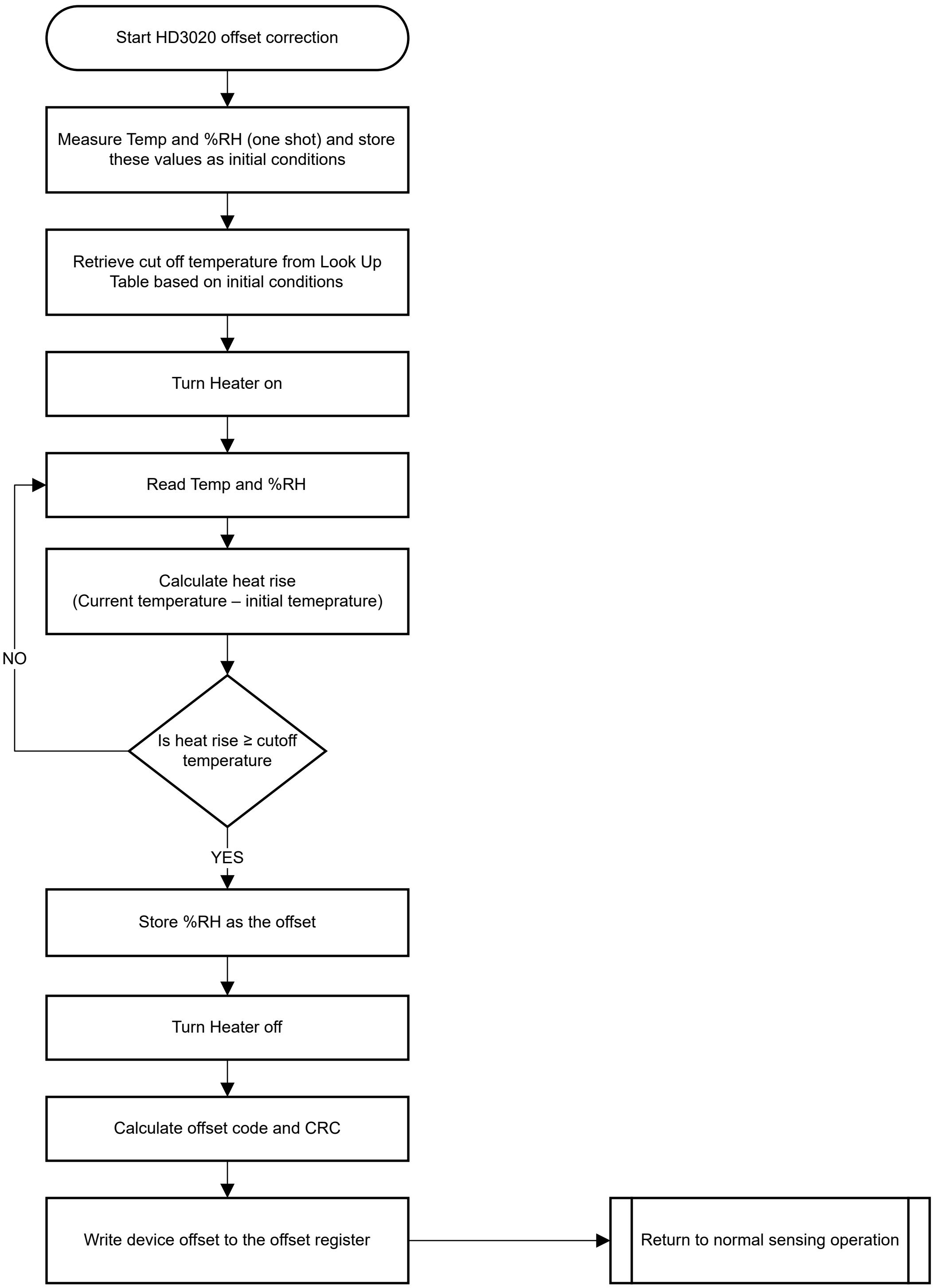
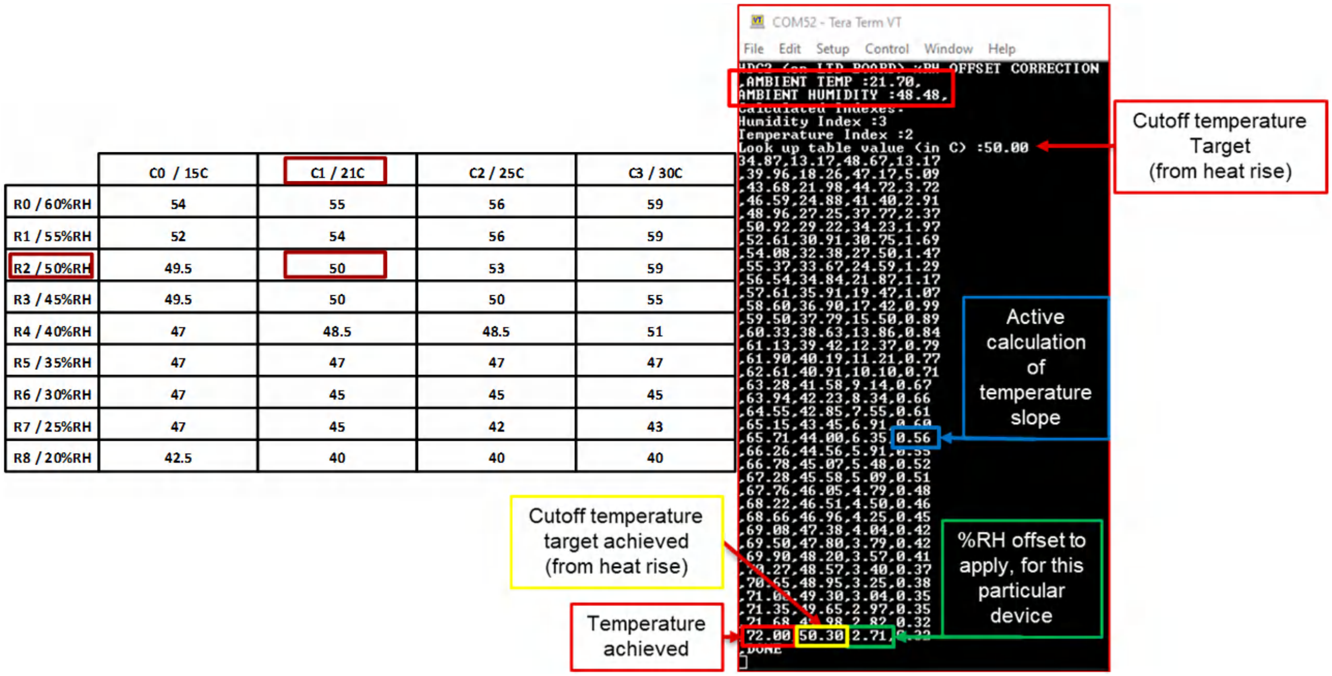


Figure 3-5. Flowchart Demonstrating the Offset Error Correction Algorithm

The algorithm can be executed at any time from normal operation, and successive approximation occurs each time you run it. When the offset is large, running drift correction more than once can help it reach a lower error. The look up table is initialized at the start of the firmware execution. After a read of the ambient conditions, the logic is used to pick out the row and column location value to use for heat rise cutoff temperature. Figure 3-6 shows a quick example of how the overall rise temperature can be selected from a LUT and what value should be subtracted from the offset register. In Figure 3-6, Rx (the first column) represents the humidity %RH set points

Copyright © 2022 Texas Instruments Incorporated

that the device measures before the heater starts. CX (The first row) represents the temperature that the device measures before the heater is run.



	C0 / 15C	C1 / 21C	C2 / 25C	C3 / 30C
R0 / 60%RH	54	55	56	59
R1 / 55%RH	52	54	56	59
R2 / 50%RH	49.5	50	53	59
R3 / 45%RH	49.5	50	50	55
R4 / 40%RH	47	48.5	48.5	51
R5 / 35%RH	47	47	47	47
R6 / 30%RH	47	45	45	45
R7 / 25%RH	47	45	42	43
R8 / 20%RH	42.5	40	40	40

```
HDC3 (on LID BOARD) %RH OFFSET CORRECTION
,AMBIENT TEMP :21.70,
AMBIENT HUMIDITY :48.48,
Calculated Indexes:
Humidity Index :3
Temperature Index :2
Look up table value (in C) :50.00
34.87,13.17,48.67,13.17
,39.96,18.26,47.17,5.09
,43.68,21.98,44.72,3.72
,46.59,24.88,41.40,2.91
,48.96,27.25,37.77,2.37
,50.92,29.22,34.23,1.97
,52.61,30.91,30.75,1.69
,54.08,32.38,27.50,1.47
,55.37,33.67,24.59,1.29
,56.54,34.84,21.87,1.17
,57.61,35.91,19.47,1.07
,58.60,36.90,17.42,0.99
,59.50,37.79,15.50,0.89
,60.33,38.63,13.86,0.84
,61.13,39.42,12.37,0.79
,61.90,40.19,11.21,0.77
,62.61,40.91,10.10,0.71
,63.28,41.58,9.14,0.67
,63.94,42.23,8.34,0.66
,64.55,42.85,7.55,0.61
,65.15,43.45,6.91,0.60
,65.71,44.00,6.35,0.56
,66.26,44.56,5.91,0.55
,66.78,45.07,5.48,0.52
,67.28,45.58,5.09,0.51
,67.76,46.05,4.79,0.48
,68.22,46.51,4.50,0.46
,68.66,46.96,4.25,0.45
,69.08,47.38,4.04,0.42
,69.50,47.80,3.79,0.42
,69.90,48.20,3.57,0.41
,70.27,48.57,3.40,0.37
,70.65,48.95,3.25,0.38
,71.00,49.30,3.04,0.35
,71.35,49.65,2.97,0.35
,71.68,49.98,2.82,0.32
,72.00,50.30,2.71,0.32
,DONE
```

Figure 3-6. Look Up Table (LUT) Example

Look up tables based on two separate layouts are described below. If your layouts have a similar thickness, similar cutouts, and the same thermal isolation, then these look up tables can be used.

Copyright © 2022 Texas Instruments Incorporated

3.5.1 Offset Error Correction Example With a Fingerboard

The fingerboard was designed for test and characterization purposes. The fingerboard has a dimension of 677 mils x 942 mils and an overall thickness of 62 mils. The fingerboard has two cutouts (approximately 55 mils) on either side of the DUT which makes this a good layout to verify the offset error correction algorithm. They are made with Rogers RO4350B dielectric (instead of FR4). The thermal pad is soldered down, but the thermal pad itself is not grounded, it's just a floating copper pad. However, even with these cutouts, the board itself is pretty thick which led to some heat rise challenges during this process. If a user wants to design a board similar to this, ensure that the board isn't too thick.

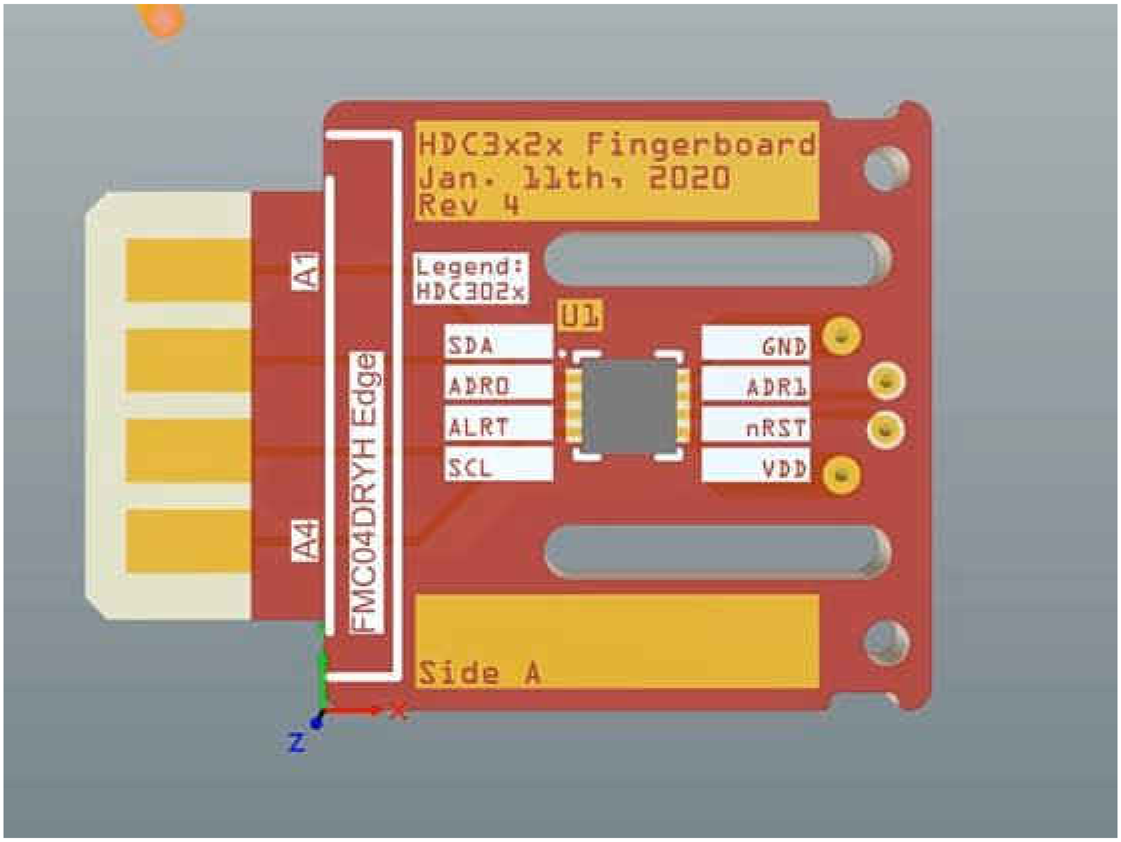


Figure 3-7. HDC3020 Fingerboard

Table 3-3 and Table 3-4 show the look up tables for the HDC3020 fingerboard. The LUT was generated using 30 HDC3020 devices and were tested between 15°C – 30°C in increments of 5°C and between 10% – 45% RH in increments of 2.5%RH. The look up tables here were generated at 3.3 V and 5 V, and both were operated at the full power setting. Al the devices were placed in the chamber and the temperature rise was calculated for each temperature and humidity set point.

Table 3-3. Look Up Table (LUT) for a Fingerboard Operated at Heater Full Power at 3.3 V

Temp [°C] %RH	15	20	25	30
10	32.99248	30.94213	31.77977	31.92152
12.5	34.57237	32.34282	33.92634	34.64464
15	36.35748	34.06128	36.43301	37.84657
17.5	38.29194	36.10141	38.93244	40.86322
20	40.32502	38.1553	41.43969	43.36861
22.5	42.32662	40.32751	43.56603	45.46563
25	44.12985	42.3089	45.44633	46.89262

Copyright © 2022 Texas Instruments Incorporated

Table 3-3. Look Up Table (LUT) for a Fingerboard Operated at Heater Full Power at 3.3 V (continued)

Temp [°C] %RH	15	20	25	30
27.5	45.68952	44.20545	46.94305	47.7198
30	47.13836	45.81257	48.01137	48.39375
32.5	48.32647	47.2488	48.72053	48.77972
35	49.34081	48.5207	49.25917	48.98883
37.5	49.90921	49.28729	49.61261	49.08352
40	50.28725	49.79383	49.83082	49.05558
42.5	50.62314	50.11981	49.91169	49.05743
45	50.7908	50.33693	49.893	49.05599

Table 3-4. Look Up Table (LUT) for Fingerboard Operated at Heater Half Power at 5 V

RH [%]/Temp [°C]	15	20	25	30
10	51.8946	50.34679	49.82128	49.10057
12.5	51.90337	50.78616	50.21534	49.50523
15	52.8088	50.78637	50.22602	49.52433
17.5	52.79793	50.7915	50.65976	50.00581
20	54.92752	50.78842	50.67655	50.46326
22.5	56.16217	50.80301	51.10399	52.07121
25	56.1347	51.28634	51.84768	52.80945
27.5	57.28141	51.27524	53.91814	54.60268
30	57.92458	52.56686	54.168	55.72237
32.5	59.45811	54.03698	55.29393	59.11533
35	61.33097	54.98721	56.11429	59.89979
37.5	58.79358	56.00296	57.56867	61.67453
40	59.39689	56.03048	60.44079	63.05386
42.5	59.8415	57.39132	60.17739	64.75773
45	60.73339	58.20351	61.19516	65.86387

Copyright © 2022 Texas Instruments Incorporated

4 References

For related documentation, see the following:

1. Texas Instruments, *HDC302x High-Accuracy, Low-Power, Digital Humidity and Temperature Sensor With Ultra-Low Drift* data sheet
2. Texas Instruments, *HDC302x-Q1 Automotive 0.5%RH Digital Relative Humidity Sensor, 0.19%RH/yr Long Term Drift, 4s Response, Offset Error Correction, 0.1°C Temperature Sensor* data sheet
3. Texas Instruments, *MSL Ratings and Reflow Profiles* application report
4. Texas Instruments, *Optimizing Placement and Routing for Humidity Sensors* application report

5 Revision History

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

Changes from Revision A (August 2022) to Revision B (August 2022)	Page
• Changed Section 2.1	3
• Changed Section 2.2	4
• Changed Section 2.2.1	5
• Changed Section 2.2.2	7

Changes from Revision * (June 2021) to Revision A (August 2022)	Page
• Added content for the HDC3021 and HDC3022 device releases	2

Copyright © 2022 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Copyright © 2022, Texas Instruments Incorporated