Application Report

SNAA312–August 2018

Programming the HDC20X0 Devices

ABSTRACT

The purpose of this document is to familiarize the user with the HDC20X0 devices by providing programming configuration examples, and pseudo code. The HDC devices are integrated humidity and temperature sensors that provide excellent measurement accuracy (RH accuracy typ. 2% RH, Temperature accuracy typ. 0.2°C) with very low power consumption. The device measures humidity through a capacitive polymer dielectric. This sensing element is placed on the bottom of the HDC2010, and the top of the HDC2080 device. The HDC2010 features a WLCSP (Wafer Level Chip Scale Package), while the HDC2010 features a WSON package. The humidity and temperature sensors are factory calibrated with calibration data stored in it's internal non-volatile memory.

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1 Device Functional Modes

The HDC20X0 has two modes of operation: sleep and measurement mode. After power up, the HDC20X0 enters sleep mode. In this mode, the HDC20X0 waits for I2C instruction to set programmable conversion times, trigger a measurement/conversion, or read/write valid data. When a measurement is triggered, the HDC20X0 wakes from sleep mode to enter measurement mode. In measurement mode, the HDC20X0 converts temperature or humidity values from integrated sensors through an internal ADC and stores the information in their respective data registers [0x00 - 0x03]. The DRDY/INT pin can be monitored to verify if data is ready after measurement conversion. The DRDY/INT pin polarity and interrupt mode is set according to the configuration of the Interrupt Enable and DRDY/INT Configuration registers . After completing the conversion, the HDC20X0 returns to sleep mode.

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

In Trigger on Demand mode an I2C command triggers the measurement conversion. After the measurement is converted, the device remains in sleep mode until a new trigger is written.

Auto Mode is a continuous operation, adjusting the RESET and DRDY/INT Configuration Register enables the user to select from 7 different conversion frequencies (from 5Hz to 1/120Hz). In auto mode, the HDC20X0 wakes from sleep to measurement mode based on the selected sample rate.

2 Single Acquisition

2.1 Startup Sequence

After power up, the HDC20X0 is in sleep mode waiting for I2C input commands. To configure the device to collect both the humidity and temperature data in single acquisition mode, select TRIGGER ON DEMAND in CONFIG register (0x0E), select the desired Temperature and Humidity resolutions and the Temperature + Humidity measurement configuration in MEASUR_CONFIG register (0x0F).

2.2 Reading Procedure

To initiate a single measurement, the bit MEAS_TRIG is set to '1' in the MEASUR_CONFIG register. The device will exit from sleep mode and perform a single measurement. After the conversion, the device will update the respective measurement register and will return to sleep mode. The register can be accessed through a pointer mechanism. When reading from the HDC20X0, the current pointer location is used to determine which register to read -- the pointer location points to the last written register address. To change the address 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 set to '0', followed by the pointer byte.

The pointer auto increments, therefore it is possible to read all 4 bytes of information related to Temperature and humidity in a single transaction, this is shown in Figure 1:

2.3 Example Flowchart For A Single Acquisition Configuration

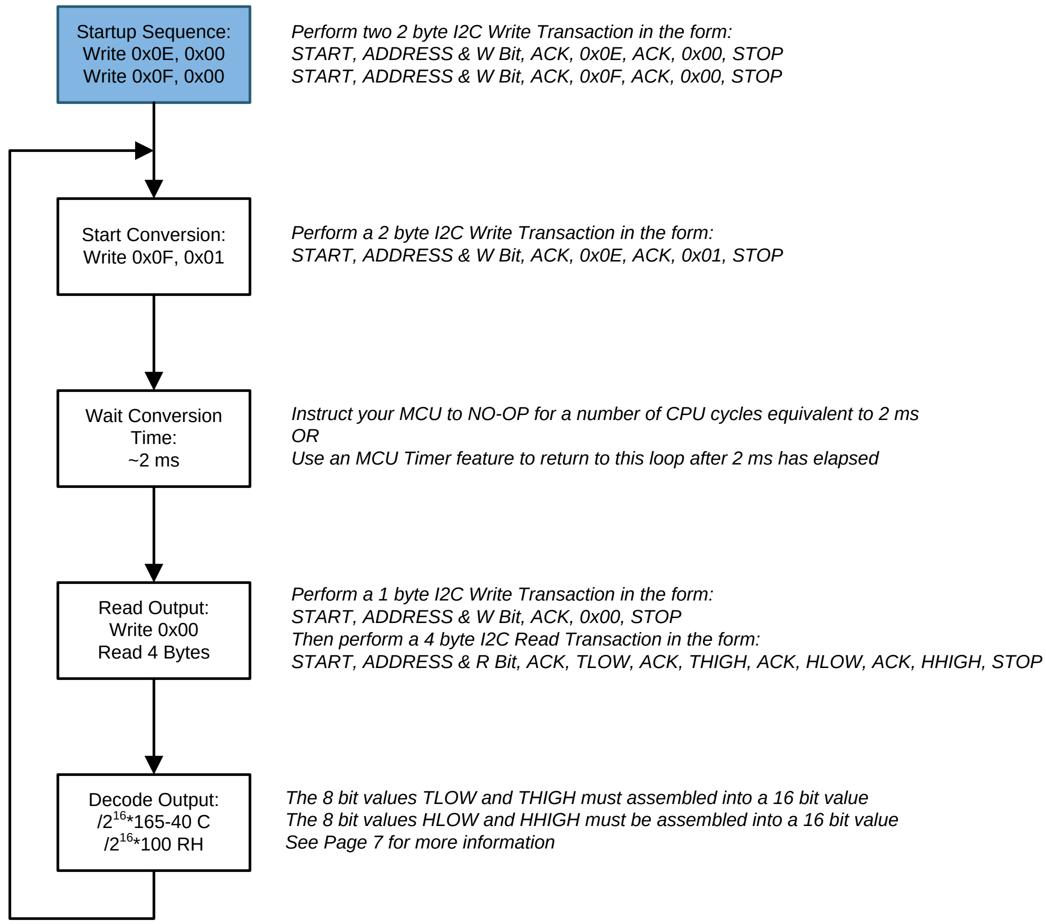

Figure 1. Single Acquisition Configuration

3 Continuous Acquisition

3.1 Startup Sequence

After power up, the HDC20X0 is in sleep mode waiting for I2C input commands. To configure the device to collect both the humidity and temperature data in continuous mode, select the desired Auto Measurement Mode (AMM) in CONFIG register (0x0E), and select the Temperature and Humidity resolutions and the Temperature + Humidity measurement configuration in MEASUR_CONFIG register (0x0F).

3.2 Reading Procedure

To trigger the start of the measurements, the bit MEAS_TRIG is set to '1' in MEASUR_CONFIG register (0x0F). The device will exit from sleep mode and will start to periodically convert the measurements based on the selected sample rate in the CONFIG register (0x0E). After each conversion, the device will update the measurement related registers and re-enter sleep mode. The register can be accessed through a pointer mechanism. When reading from the HDC20X0, the current pointer location is used to determine which register to read -- the pointer location points to the last written register address. To change the address 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 set to '0', followed by the pointer byte.

The pointer auto increments, therefore it is possible to read all 4 bytes of information related to Temperature and humidity in a single transaction, this is shown in Figure 2 and Figure 3:

3.3 Example Flowchart For Continuous Acquisition Mode: TIMER BASED

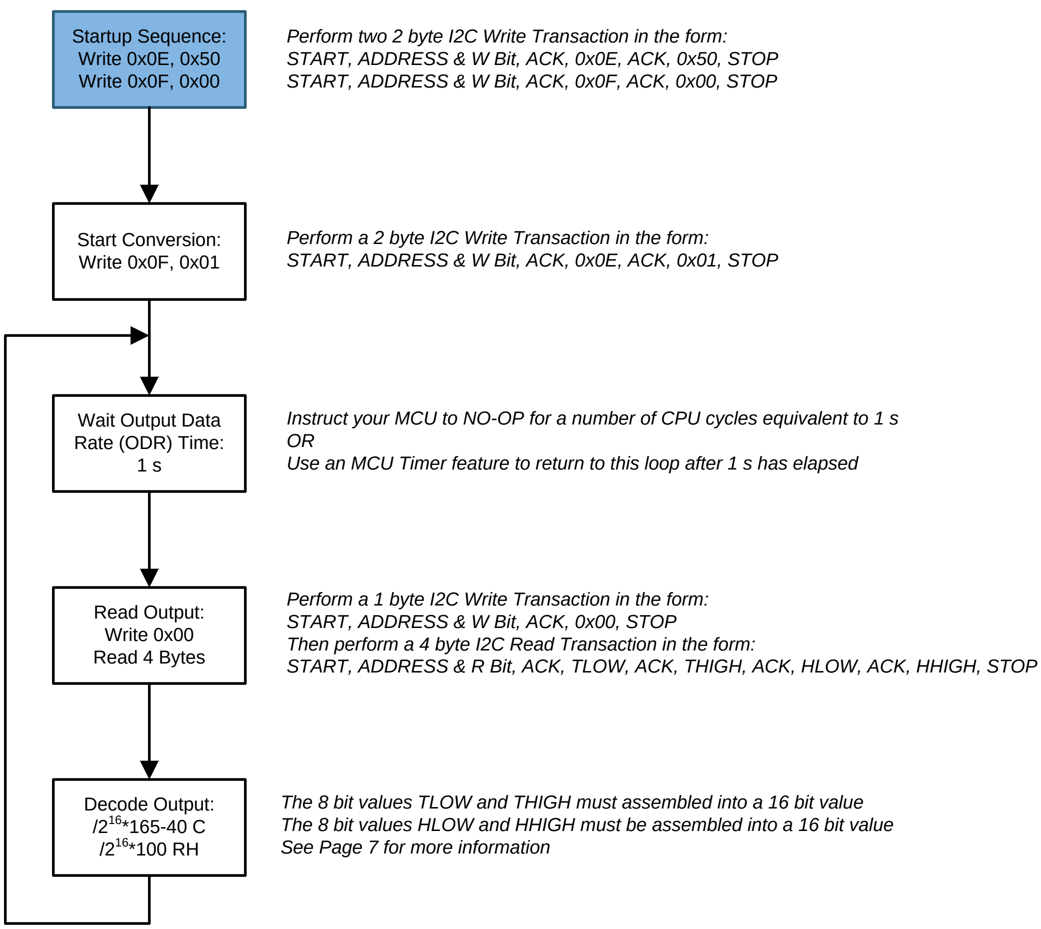

Figure 2. Continuous Acquisition Mode: TIMER BASED

3.4 Example Flowchart For Continuous Acquisition Mode: INTERRUPT BASED

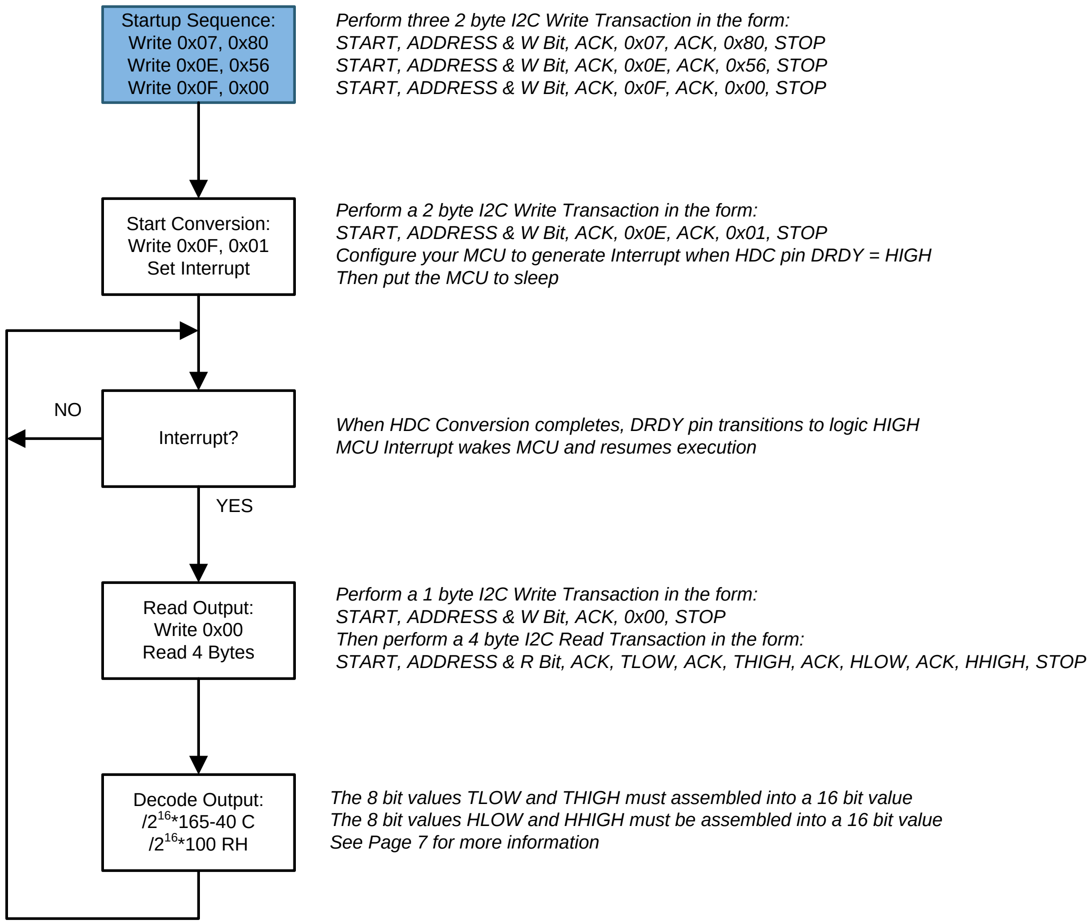

Figure 3. Continuous Acquisition Mode: INTERRUPT BASED

4 Interrupt Pin Functionality

Interrupt pin functionality is shared between Data Ready and Event Interrupt functionality. Enabling the interrupt pin for Data Ready (DRDY) can help reduce the power consumption of the system as the MCU/CPU will enter sleep when the HDC device is making temperature and humidity measurements, and awaken the MCU/CPU for communication through it's DRDY interrupt pin. To verify that data is ready after manual conversion, the DRDY/INT pin should be monitored. If monitoring this pin is not possible, it is recommended that the user program the device for auto mode and program the sampling rate of the device to perform periodic automatic conversions.

Additionally, the DRDY/INT pin can be set for interrupt capability based on input alarm thresholds for either temperature or humidity measurements.

5 Understanding The Output Data

The measured temperature and humidity data are sent to the output register: TEMP_LOW, TEMP_HIGH, RH_LOW and RH_HIGH. Temperature data are represented as 16-bit numbers, so the complete values are given by the concatenation of the low and high register:

$TEMPERATURE_{LSB}$ = TEMP_HIGH <<8 + TEMP_LOW;

$HUMIDITY_{LSB}$ = RH_HIGH <<8 + RH_LOW;

Convert the output value

$$TEMPERATURE(°C) = \left(\frac{TEMPERATURE_{LSB}}{2^{16}}\right) \times 165 - 40$$

$$HUMIDITY(\%RH) = \left(\frac{HUMIDITY_{LSB}}{2^{16}}\right) \times 100$$

Temperature Calculation Example:

1. Output registers:

TEMP_LOW = 0x5E;

TEMP_HIGH = 0x64;

Temperature value in hex:

$TEMPERATURE_{LSB}$ = 0x645E

Temperature value in decimal:

$TEMPERATURE_{LSB}$ = 25694

Temperature value in degree C:

$$TEMPERATURE(°C) = \left(\frac{25694}{2^{16}}\right) \times 165 - 40 = 24.67°C$$

2. Output registers:

TEMP_LOW = 0x3B;

TEMP_HIGH = 0x29;

Temperature value in hex:

$TEMPERATURE_{LSB}$ = 0x293B

Temperature value in decimal:

$TEMPERATURE_{LSB}$ = 10555

Temperature value in degree C:

$$TEMPERATURE(°C) = \left(\frac{10555}{2^{16}}\right) \times 165 - 40 = 13.43°C$$

Humidity Calculation Example:

Output registers:

RH_LOW = 0xDC;

RH_HIGH = 0x42;

Temperature value in hex:

$HUMIDITY_{LSB}$ = 0x42DC

Temperature value in decimal:

$HUMIDITY_{LSB}$ = 17116

Temperature value in degree C:

$$HUMIDITY(\%RH) = \left(\frac{17116}{2^{16}}\right) \times 100 = 26.11\%RH$$

6 Conclusion

In this application note, configuration examples and pseudo code were presented to familiarize the user with the different configuration options of the HDC20X0 family of devices.

The following different acquisition modes and Interrupt capability have been discussed:

1. Trigger on Demand to generate a single acquisition.
2. Auto mode to perform continuous acquisitions
3. INTERRUPT based functionality for DRDY/INT pin

Mathematical conversion of digital code to respective temperature and humidity readings have also been included for reference.

7 Appendix A

Table 1. Output Registers

Register Name	Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TEMP_LOW	0x00	TEMP7	TEMP6	TEMP5	TEMP4	TEMP3	TEMP2	Reserved	Reserved
TEMP_HIGH	0x01	TEMP15	TEMP14	TEMP13	TEMP12	TEMP11	TEMP10	TEMP9	TEMP8
RH_LOW	0x02	RH7	RH6	RH5	RH4	RH3	RH2	Reserved	Reserved
RH_HIGH	0x03	RH15	RH14	RH13	RH12	RH11	RH10	RH9	RH8

7.1 Address 0x00 Temperature LSB

Table 2. Address 0x00 Temperature LSB Register

7	6	5	4	3	2	1	0
TEMP[7:0]							

Table 3. Address 0x00 Temperature LSB Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
[7:0]	TEMPERATURE [7:0]	R	00000000	Temperature LSB

7.2 Address 0x01 Temperature MSB

Table 4. Address 0x01 Temperature MSB Register

7	6	5	4	3	2	1	0
TEMP[15:8]							

Table 5. Address 0x01 Temperature MSB Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
[15:8]	TEMPERATURE [15:8]	R	00000000	Temperature MSB

The temperature register is a 16-bit result register in binary format (the 2 LSBs D1 and D0 are reserved bits, and must be set to '0' in formula). The result of the acquisition is always a 14 bit value, while the resolution is related to one selected in Measurement Configuration register. The temperature can be calculated from the output data with:

$$\text{TEMPERATURE}(°\text{C}) = \left(\frac{\text{TEMPERATURE}[15:0]}{2^{16}}\right) \times 165 - 40 \quad (1)$$

7.3 Address 0x02 Humidity LSB

Table 6. Address 0x02 Humidity LSB Register

7	6	5	4	3	2	1	0
HUMIDITY[7:0]							

Table 7. Address 0x02 Humidity LSB Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
[7:0]	HUMIDITY [7:0]	R	00000000	Humidity LSB

7.4 Address 0x03 Humidity MSB

Table 8. Address 0x03 Humidity MSB Register

7	6	5	4	3	2	1	0
HUMIDITY[15:8]							

Table 9. Address 0x03 Temperature MSB Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
[15:8]	HUMIDITY[15:8]	R	00000000	Humidity MSB

The humidity register is a 16-bit result register in binary format (the 2 LSBs D1 and D0 are reserved bits, and must be set to '0' in formula). The result of the acquisition is always a 14 bit value, while the resolution is related to one selected in Measurement Configuration register. The humidity can be calculated from the output data with:

$$\text{HUMIDITY}(\%\text{RH}) = \left(\frac{\text{HUMIDITY}[15:0]}{2^{16}}\right) \times 100 \quad (2)$$

7.5 Configuration Registers

Table 10. Configuration Registers

Register Name	Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
CONFIG	0x0E	SOFT_RES	AMM2	AMM1	AMM0	HEAT_EN	DRDY/INT_EN	INT_POL	INT_MODE
MEASUR CONFIG	0x0F	TRES1	TRES0	HRES1	HRES1	RES	MEAS_CONFIG1	MEAS_CONFIG0	MEAS_TRIG

7.6 Address 0x0E Reset and DRDY/INT Configuration Register

Table 11. Address 0x0E Reset and DRDY/INT Configuration Register

7	6	5	4	3	2	1	0
SOFT_RES	AMM[2]	AMM[1]	AMM[0]	HEAT_EN	DRDY/INT_EN	INT_POL	INT_MODE

Table 12. Address 0x0E Reset and DRDY/INT Configuration Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
7	SOFT_RES	R/W	0	0 = Normal Operation mode, this bit is self-clearing 1 = Soft Reset EEPROM value reload and registers reset
[6:4]	AMM[2:0]	R/W	000	Auto Measurement Mode (AMM) 000 = AMM disabled. Trigger on demand. 001 = 1/120Hz (1 samples every 2 minutes) 010 = 1/60Hz (1 samples every minute) 011 = 0.1Hz (1 samples every 10 seconds) 100 = 0.2 Hz (1 samples every 5 second) 101 = 1Hz (1 samples every second) 110 = 2Hz (2 samples every second) 111 = 5Hz (5 samples every second)
3	HEAT_EN	R/W	0	0 = Heater off 1 = Heater on
2	DRDY/INT_EN	R/W	0	DRDY/INT_EN pin configuration 0 = High Z 1 = Enable

Table 12. Address 0x0E Reset and DRDY/INT Configuration Field Descriptions (continued)

BIT	FIELD	TYPE	RESET	DESCRIPTION
1	INT_POL	R/W	0	Interrupt polarity 0 = Active Low 1 = Active High
0	INT_MODE		0	Interrupt mode 0 = Level sensitive 1 = Comparator mode

7.7 Address 0x0F Measurement Configuration

Table 13. Address 0x0F Measurement Configuration Register

7	6	5	4	3	2	1	0
TRES[1]	TRES[0]	HRES[1]	HRES[0]	RES	MEAS_CONF[1]	MEAS_CONF[0]	MEAS_TRIG

Table 14. Address 0x0F Measurement Configuration Field Descriptions

BIT	FIELD	TYPE	RESET	DESCRIPTION
7:6	TRES[1:0]	R/W	00	Temperature resolution 00: 14 bit 01: 11 bit 10: 8 bit 11: NA
5:4	HRES[1:0]	R/W	00	Humidity resolution 00: 14 bit 01: 11 bit 10: 8 bit 11: NA
3	RES	R/W	0	Reserved
2:1	MEAS_CONF[1:0]	R/W	00	Measurement configuration 00: Humidity + Temperature 01: Temperature only 10: Humidity Only 11: NA
0	MEAS_TRIG	R/W	0	Measurement trigger 0: no action 1: Start measurement Self-cleaning bit when measurement completed

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