

## Technical Note

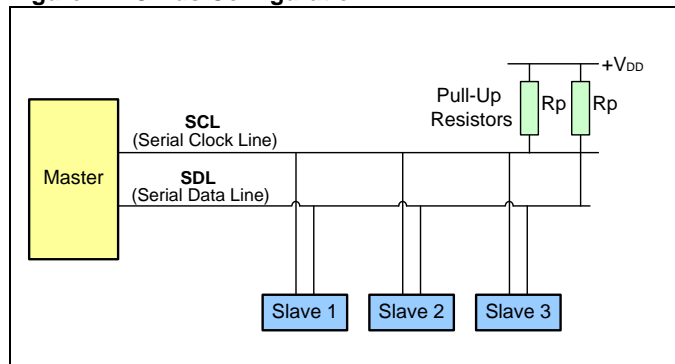
# I<sup>2</sup>C Communication with the Honeywell HumidIcon™ Digital Humidity/Temperature Sensors

### 1.0 Introduction

The I<sup>2</sup>C bus is a simple, serial 8-bit oriented computer bus for efficient Inter-IC (I<sup>2</sup>C) control. It provides good support for communication between different ICs across short circuit-board distances, such as interfacing microcontrollers with various low speed peripheral devices.

Each device connected to the bus is software addressable by a unique address and a simple Master/Slave relationship exists at all times. The output stages of the devices connected to the bus are designed around open collector architecture. Because of this, pull-up resistors to +V<sub>DD</sub> must be provided on the bus (see Figure 1).

**Figure 1. I<sup>2</sup>C Bus Configuration**



Both SDA and SCL are bidirectional lines, and it is important to system performance to match the capacitive loads on both lines to ensure reliable edge transitions at 400 kHz clock speeds.

When the bus is free, both lines are pulled up to +V<sub>DD</sub>. **Data on the I<sup>2</sup>C-bus can be transferred at a rate up to 100 kbit/s** in the standard-mode, or up to 400 kbit/s in the fast-mode.

### 2.0 Data Transfer with I<sup>2</sup>C Output Humidity Sensors

The sensor is designed to work as a Slave and will therefore only respond to requests from a Master device.

Following the address and read bit from the Master, the sensor is designed to output up to four bytes of data, depending on the sensor options and the needs of the application. In all cases, the first two data bytes are the compensated humidity output, along with sensor status bits. The third and fourth bytes are for optional compensated temperature output.

### 2.1 Sensor Address

Each sensor is referenced on the bus by a seven bit slave address. The default address is 0x27. Other available addresses are: I<sup>2</sup>C Slave addresses from 0x00 to 0x7F. Please contact Honeywell Customer Service with questions regarding custom Slave addresses.

### 2.2 Making a Measurement Request

By default, the digital output humidity sensor performs humidity measurement and temperature measurement conversions whenever it receives a Measurement Request (MR) command; **otherwise, the digital output humidity sensor is always powered down**. The results are stored after each measurement in output registers to be read using a Data Fetch (DF) command.

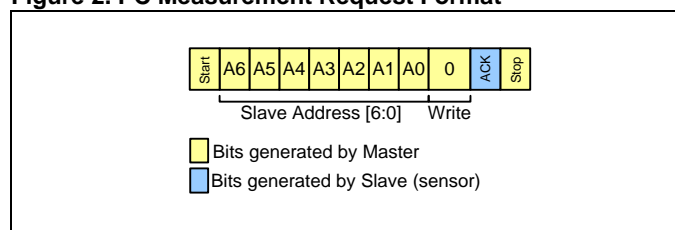
**Detecting whether data is ready to be fetched can be handled by testing the status bits in the fetched data.** Refer to Section 2.6 for details of the status bits.

### 2.3 Humidity and Temperature Measurement Request

To wake up the sensor and complete a measurement cycle, a Measurement Request (MR) command is used. The complete measurement cycle performs a humidity measurement and a temperature measurement and stores the results.

As shown in Figure 2, a Measurement Request command consists of the Slave address **plus the WRITE bit (0)**. **Once the sensor responds with an acknowledge (ACK), the Master generates a stop condition.**

**Figure 2. I<sup>2</sup>C Measurement Request Format**



Another measurement request may be sent to start a new measurement cycle without fetching the previous data, but the first Measurement request command must be completed first.

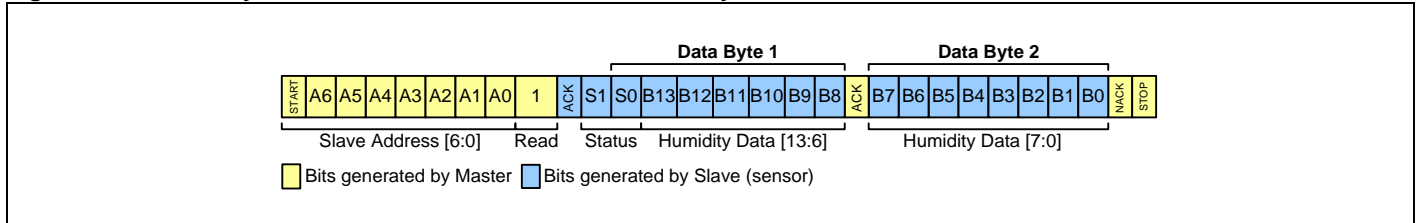
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## 2.4 Humidity Data Fetch

To read out a compensated humidity reading, the Master generates a START condition and sends the sensor Slave address followed by a read bit (shown in Figure 2). After the sensor generates an acknowledge (ACK), it will transmit up to four bytes of data – the first two bytes containing the compensated temperature output and the second two bytes containing the optional compensated temperature output.

The Master must acknowledge the receipt of each byte, and can terminate the communications by sending a Not Acknowledge (NACK) bit followed by a STOP bit after receiving both bytes of data as shown in Figure 3.

Figure 3. I<sup>2</sup>C Humidity Measurement Data Fetch Format, Two Byte Data Read



## 2.5 Humidity and Temperature Data Fetch

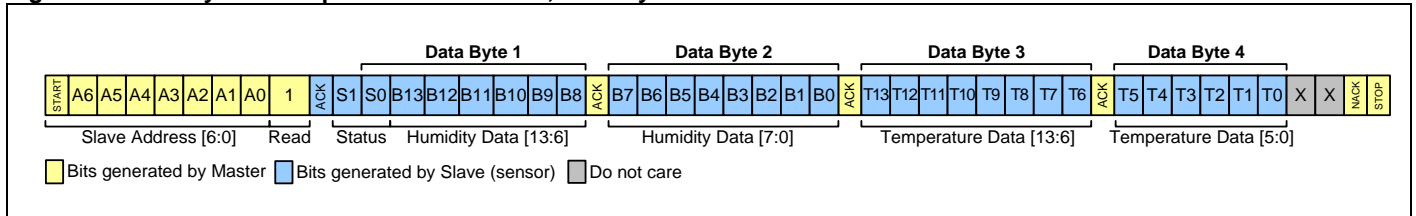
The optional corrected temperature data is read out with 14 bit resolution. By reading out the third and fourth bytes of data from the sensor, the complete 14 bit optional compensated temperature value may be read.

### NOTICE

For a sensor that does not offer the optional compensated temperature output, the sensor will still output the third and fourth bytes of data. However, the information contained in these bytes is non-corrected data, and should not be used.

When reading the full 14 bit resolution temperature output, the two least significant bits of the fourth data byte are “Do Not Care” and should be ignored (see Figure 4.)

Figure 4. Humidity and Temperature Data Fetch, Four Byte Data Read



## 2.6 Status Bits

Honeywell digital output humidity sensors offer status bits to ensure robust system operation in critical applications. The sensor status is indicated by the first two Most Significant Bits of Data Byte 1 (see Table 1).

When the status bits read “01”, “Stale” data is indicated. This means that the data in the output buffer of the sensor has already been fetched by the master, and has not yet been updated with the new data from the current measurement cycle. This can happen when the master polls the data quicker than the sensor can update the output buffer.

Table 1. Diagnostic Conditions Indicated by Status Bits

| Status Bits |    | Definition  |
|-------------|----|---|
| S1          | S0 |   |
| 0           | 0  | Normal Operation, Valid Data that has not been fetched since the last measurement cycle.  |
| 0           | 1  | Stale Data: Data that has already been fetched since the last measurement cycle, or data fetched before the first measurement has been completed. |
| 1           | 0  | Device in Command Mode <sup>1</sup>   |
| 1           | 1  | Not Used.   |

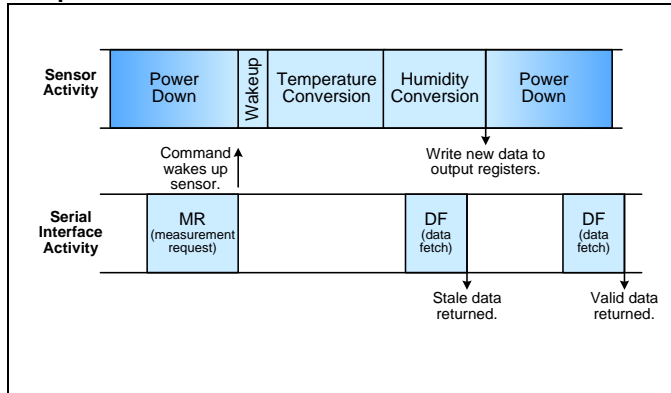
Note 1: Command Mode is used for programming the sensor. This mode should not be seen during normal operation

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## 3.0 Measurement Cycle

Figure 5 shows the measurement cycle for the humidity sensor. The measurement cycle duration is typically 36.65 ms for temperature and humidity readings.

**Figure 5. Measurement Cycle for Humidity and Temperature Measurement**



## 4.0 Calculation of the Humidity from the Digital Output

The output of the device is simply a 14 bit number representing between 0 %RH and 100 %RH (see Equation 1):

$$\begin{aligned} 0 \%RH &= 0 \text{ counts} \\ 100 \%RH &= 2^{14} - 2 \text{ counts} \end{aligned}$$

### Equation 1: Humidity Conversion Function

$$\text{Humidity (\%RH)} = \frac{\text{Humidity Output Count}}{(2^{14} - 2)} \times 100\%$$

## 5.0 Calculation of Optional Temperature from the Digital Output

For sensors with the optional compensated temperature output, the output of the device is simply a 14 bit number representing between -40 °C and 125 °C (see Equation 2):

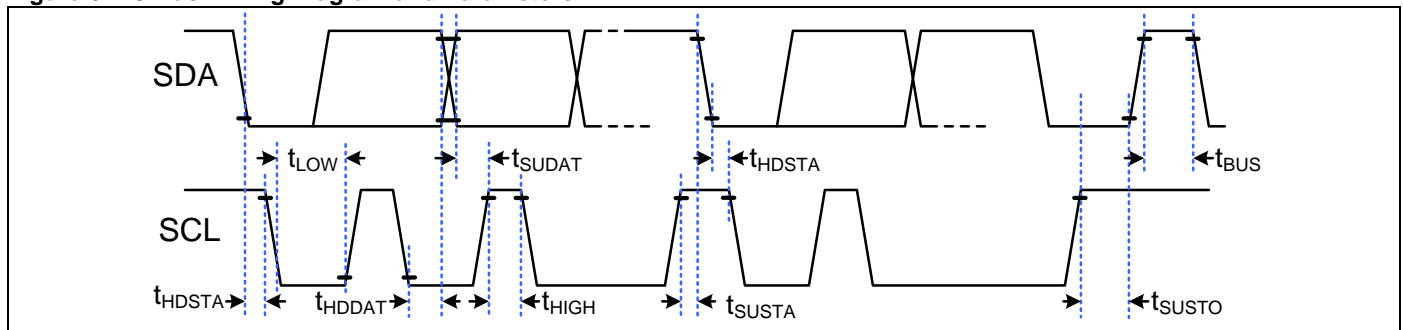
$$\begin{aligned} -40 \text{ }^\circ\text{C} &= 0 \text{ counts} \\ 125 \text{ }^\circ\text{C} &= 2^{14} - 2 \text{ counts} \end{aligned}$$

### Equation 2: Temperature Conversion Function

$$\text{Temperature (}^\circ\text{C)} = \frac{\text{Temperature Output Count}}{(2^{14} - 2)} \times 165 - 40$$

## 6.0 Timing and Level Parameters (See Figure 6.)

**Figure 6. I<sup>2</sup>C Bus Timing Diagram and Parameters**



| Characteristic                                  | Abbr.              | Min. | Typ. | Max. | Unit |
|---|--------------------|------|------|------|------|
| SCL clock frequency                             | FSCL               | 100  | –    | 400  | kHz  |
| Start condition hold time relative to SCL edge  | t <sub>HDSTA</sub> | 0.1  | –    | –    | μs   |
| Minimum SCL clock low width*                    | t <sub>LOW</sub>   | 0.6  | –    | –    | μs   |
| Minimum SCL clock high width*                   | t <sub>HIGH</sub>  | 0.6  | –    | –    | μs   |
| Start condition setup time relative to SCL edge | t <sub>SUSTA</sub> | 0.1  | –    | –    | μs   |
| Data hold time on SDA relative to SCL edge      | t <sub>HDDAT</sub> | 0    | –    | 0.5  | μs   |
| Data setup time on SDA relative to SCL edge     | t <sub>SUDAT</sub> | 0.1  | –    | –    | μs   |
| Stop condition setup time on SCL                | t <sub>SUSTO</sub> | 0.1  | –    | –    | μs   |
| Bus free time between stop and start condition  | t <sub>BUS</sub>   | 1    | –    | –    | μs   |

**Note:** Combined low and high widths must equal or exceed minimum SCL period.

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## **WARNING**

### **PERSONAL INJURY**

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

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

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

## **WARNING**

### **MISUSE OF DOCUMENTATION**

- The information presented in this technical note is for reference only. DO NOT USE this document as a product installation guide.
- Complete installation, operation, and maintenance information is provided in the instructions supplied with each product.

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

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