

## Technical Note

# SPI Communication with the Honeywell HumidIcon™ Digital Humidity/Temperature Sensors

### 1.0 Introduction

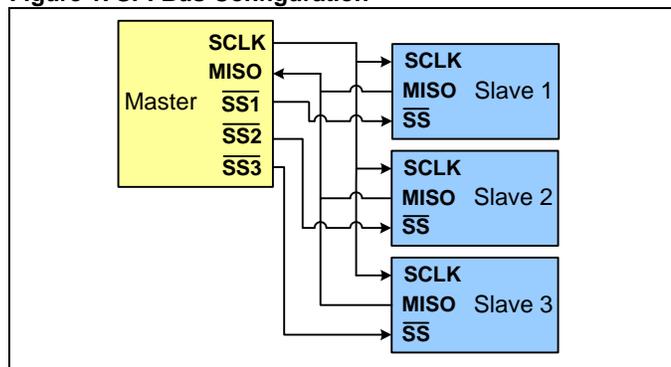
The Serial Peripheral Interface (SPI) is a simple bus system for synchronous serial communication between one Master and one or more Slaves. It operates in either full-duplex mode or half-duplex mode, allowing simultaneous communication in both directions, or in one direction only. The Master device initiates an information transfer on the bus and generates clock and control signals. Slave devices are controlled by the Master through individual Slave select lines and are active only when selected.

Honeywell HumidIcon™ digital humidity sensors with SPI output operate in half-duplex mode only, with data transfer from the Slave to the Master. Three data lines are required for data transmission:

- Slave Select (SS)
- Signal Clock (SCLK)
- Master-In-Slave Out (MISO)

All three of these bus lines are unidirectional. SS and SCLK are controlled by the Master while MISO is controlled by the Slave (see Figure 1).

**Figure 1. SPI Bus Configuration**



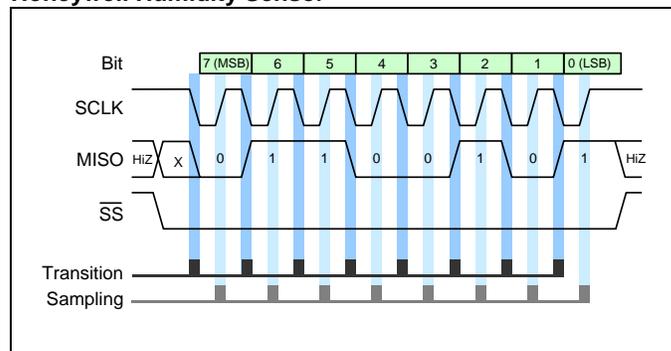
### 2.0 Data Transfer with SPI Output Humidity Sensors

Honeywell's digital output humidity sensors are designed to work as Slaves and will therefore only respond when the SS line is asserted. Once the SS line is asserted, the sensor will begin sending data once a clock is received. By default, Honeywell digital humidity sensors are configured to change data on the MISO line with the falling edge of SCLK. This means the Master device should sample MISO on the rising (opposite edge) of SCLK.

Honeywell digital humidity sensors can handle high and low SCLK polarity without configuration change. Please contact Honeywell Customer Service with questions regarding SCLK polarity and sampling MISO.

Figure 2 shows an example of a 1 byte data transfer from the Slave to the Master. In this example, the data 101 (01100101 binary, or 65 hex) would be read.

**Figure 2. Example of a 1 Byte SPI Data Transfer with a Honeywell Humidity Sensor**



Once the clocking begins, Honeywell digital humidity sensors are 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 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 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 2.5 for details of the status bits.

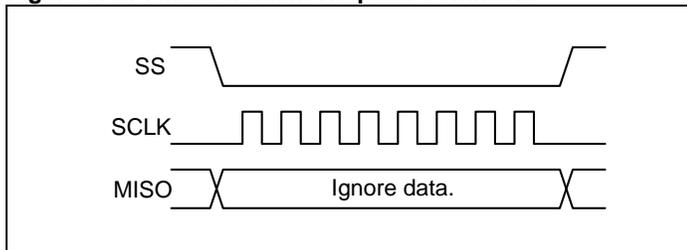
# SPI Communication with the Honeywell HumidCon™ Digital Humidity/Temperature Sensors

## 2.2 Humidity and Temperature Measurement Request

To wake up the humidity sensor and complete a measurement cycle, an MR command is used. The complete measurement cycle performs a humidity measurement and a temperature measurement and stores the results. As shown in Figure 3, an MR command is a read of eight or more bits, ignoring the data that is returned.

A DF (Data Fetch) command must be completed before sending another measurement request command to start a new measurement cycle.

**Figure 3. SPI Measurement Request Command**

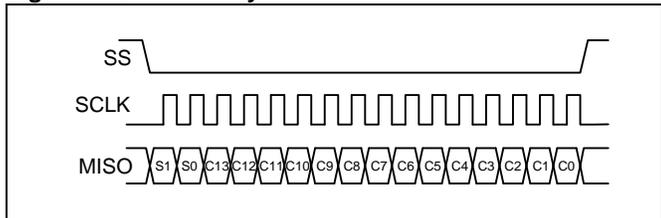


## 2.3 Humidity Data Fetch

To receive a compensated humidity reading, the Master generates the necessary clock signal after activating the sensor with the Slave select line. The sensor will transmit up to four bytes of data: the first two bytes contain the compensated humidity output, and the second two bytes contain the compensated temperature output.

If only the compensated humidity value is required, the Master can terminate communication by stopping the clock and deactivating the slave select line after the second byte. An example of the communication is shown in Figure 4.

**Figure 4. SPI Humidity Data Fetch Format**

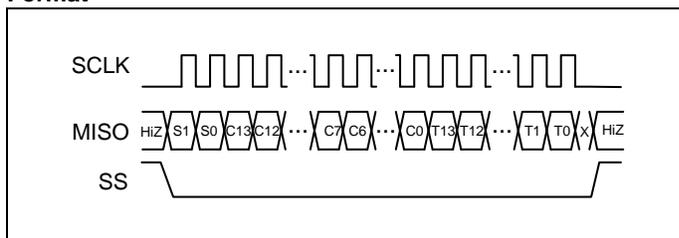


## 2.4 Humidity and Temperature Data Fetch

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 can be read, as shown in Figure 5.

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.

**Figure 5. SPI Humidity and Temperature Data Fetch Format**



Packet = [ {S(1:0),C(13:8)}, {C(7:0)}, {T(13:6)},{T(5:0),xx} ]

Where:

- S(1:0) = Status bits of packet
- C(13:8) = Upper six bits of 14-bit humidity data
- C(7:0) = Lower eight bits of 14-bit humidity data
- T(13:6) = Corrected temperature data
- T(5:0),xx = Remaining bits of corrected temperature data for full 14-bit resolution
- HiZ = High impedance

## 2.5 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).

**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

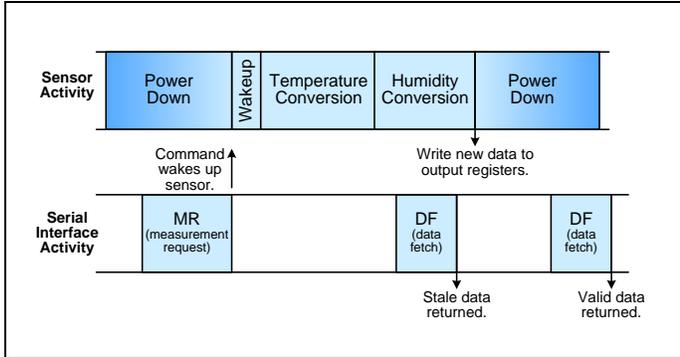
When the status bits read “01”, “stale” data is indicated. This means that the data in the output buffer of the sensor has already been fetched by the Master, and has not yet been updated with the new data from the current measurement cycle. This can happen when the Master polls the data quicker than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

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## 3.0 Measurement Cycle

Figure 6 shows the measurement cycle for the humidity sensor. The measurement cycle time is typically 36.65 ms for temperature and humidity readings. It is recommended that the user wait until the measurement cycle has completed rather than polling for data to reduce current consumption and noise.

**Figure 6. Measurement Cycle for Humidity and Temperature Measurement**



## 4.0 Calculation of the Humidity Value from the Digital Output

For Honeywell humidity sensors, the output of the device is simply a 14 bit number representing between 0 %RH and 100 %RH (see Equation 1):

$$0 \%RH = 0 \text{ counts}$$

$$100 \%RH = 2^{14} - 2 \text{ counts}$$

## 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 Honeywell Humidity 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):

$$-40 \text{ }^\circ\text{C} = 0 \text{ counts}$$

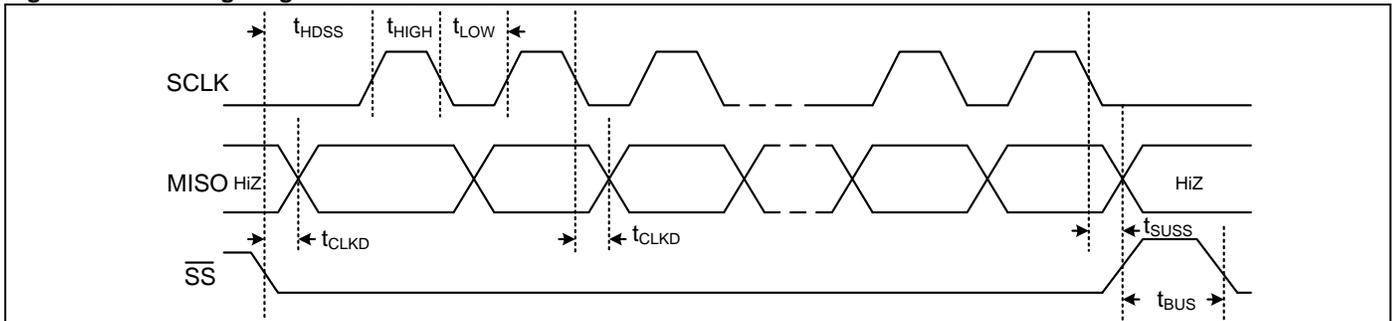
$$125 \text{ }^\circ\text{C} = 2^{14} - 2 \text{ counts}$$

## 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 7.)

**Figure 7. SPI Timing Diagram and Parameters**



Characteristic	Abbr.	Min.	Typ.	Max.	Unit
SCLK clock frequency	f <sub>SCL</sub>	50	–	800	kHz
SS drop to first clock edge	t <sub>HDSS</sub>	2.5	–	–	µs
Minimum SCLK clock low width	t <sub>LOW</sub>	0.6	–	–	µs
Minimum SCLK clock high width	t <sub>HIGH</sub>	0.6	–	–	µs
Clock edge to data transition	t <sub>CLKD</sub>	0	–	0.5	µs
Rise of SS relative to last clock edge	t <sub>SUSS</sub>	0.1	–	–	µs
Bus free time between rise and fall of SS	t <sub>BUS</sub>	2	–	–	µs

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