Technical Note

I²C Communication with Honeywell Digital Airflow Sensors

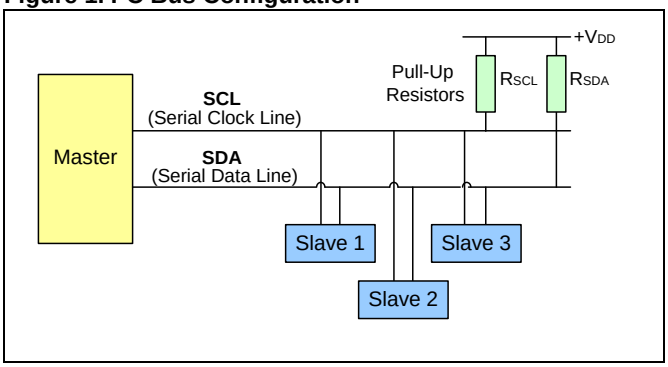
1.0 Introduction

The I²C bus is a simple, serial 8-bit oriented computer bus for efficient I²C (Inter-IC) 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. For detailed specifications of the I²C protocol, see **I²C Bus Specification Version 2.1 January 2000.** Source: NXP Semiconductor at http://www.nxp.com/acrobat_download/literature/9398/39340011.pdf. (Note: this link is controlled by NXP Semiconductor and is subject to change by them.)

Each device connected to the bus is software addressable by a unique address and a simple master/slave relationship that exists at all times. The output stages of devices connected to the bus are designed around an open collector architecture. Because of this, pull-up resistors to +V_{DD} must be provided on the bus.

Both SCL and SDA are bidirectional lines, and it is important to system performance to match the capacitive loads on both lines. In addition, in accordance with the I²C specification, the maximum allowable capacitance on either line is 400 pF to ensure reliable edge transitions at 400 kHz clock speeds (see Figure 1). When the bus is free, both lines are pulled up to +V_{DD}. Data on the I²C-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.

Figure 1. I²C Bus Configuration



2.0 Sensor Address

Each I²C digital sensor is referenced on the bus by a 7-bit slave address. The I²C default address is 0x49; however, the address is selectable according to the Nomenclature and Order Guide in the Honeywell Zephyr™ Digital Airflow Sensors: HAF Series-High Accuracy product data sheet.

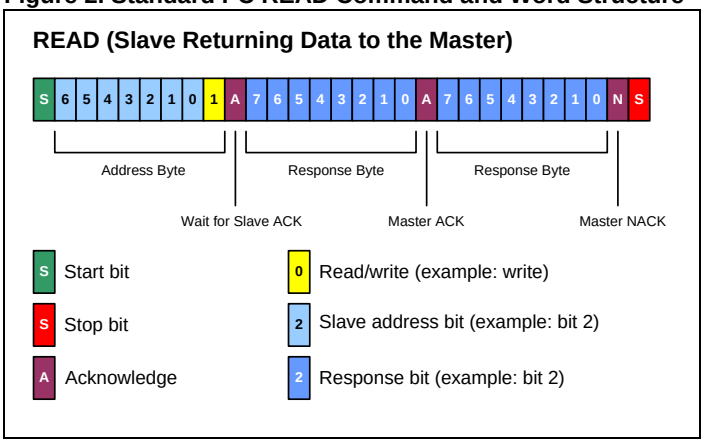
(Other custom values are available. Please contact Honeywell Customer Service if there are questions regarding custom slave addresses.)

3.0 Digital Flow Reading

Honeywell's digital output airflow sensors are designed to work as slaves and will therefore only respond to requests from a master device. The sensors operate as a slave-only and the READ command structure is shown in Figure 2.

The sensors report the 0x00 or "data not ready" status until after a start-up time. The first two consecutive READ commands that respond with non-zero valid data will provide the contents of two 16-bit registers with serial number information.

Figure 2. Standard I²C READ Command and Word Structure



The sensor is asynchronous at start-up and will wait to supply the sequential serial number values on the first two READ commands.

After the serial number registers are read in succession, the sensor will then begin repeating 14-bit calibrated flow sensor output values updated every 1 ms (I²C 16-bit word including two leading zero bits = '00' specifying calibrated flow data packet). Table 1 shows the initial start-up sequence and subsequent data transfers of the sensor after power is applied.

Table 1. Start-up Sequence

Data	I²C Transfer 1	I²C Transfer 2	I²C Transfer 3	I²C Transfer 4
Received by airflow sensor	slave address with read bit	slave address with read bit	slave address with read bit	slave address with read bit
Command	I²C read op	I²C read op	I²C read op	I²C read op
Transmitted by airflow sensor	0x0000	Data [15:0]	Data[15:0]	{00, Data[13:0]}
Response	diagnostic low	customer Reg0	customer Reg1	corrected flow
Comment	data not ready	data ready, send serial number register 0 once	send serial number register 1 once	start sending flow for successive reads

Note: The leading 2-bits of each word of the 14-bit sensor output data are '00'.

4.0 Honeywell Zephyr I²C Pull-Up Resistor Specifications

A pull-up resistance is required on both the SCL and SDA lines for proper communication.

4.1. Flow Sensors with Full Scale Less Than 1 SLPM I²C Pull-Up Resistor Restrictions

- SCL line: A resistance of 4.7 kOhm will work for any number of sensors.
- SDA line: The maximum resistance value is restricted by the number of sensors on a single bus. See Table 2 to determine the correct resistance value.

Table 2: SDA Line Pull-Up Maximum Resistor Values

Number of Airflow Sensors on a Single I²C Bus	Required Pull-up Resistance Value for SDA Line
1	4 kOhm
2	1.07 kOhm
3	0.550 kOhm
4	0.550 kOhm
5	0.383 kOhm
6	0.383 kOhm

4.2. Flow Sensors with Full Scale Greater than 20 SLPM I²C Pull-Up Resistor Restrictions

- SCL line: A resistance of 4.7 kOhm will work for any number of sensors.
- SDA line: A resistance of 4.7 kOhm will work for any number of sensors.

5.0 Parameter Specifications and Timing

Table 3 describes the minimum and maximum limits for parameters for I²C operation with the Honeywell airflow sensors. Table 4 describes I²C timing.

Table 3. Parameters for I²C Bus Communication with Honeywell Digital Airflow Sensors

Characteristic	Sym.	Condition	Min.	Typ.	Max.	Unit	Note
Input high level	V_{IH}	–	0.9	–	1	V_{DD}	1
Input low level	V_{IL}	–	0	–	0.1	V_{DD}	1
Output low level	V_{OL}	open drain, I_{OL} = -4 mA	–	–	0.1	V_{DD}	1
Pull up current	I_{OH}	pins SCL and SDA	5	–	20	µA	–
Load capacitance SDA	C_{L_SDA}	–	–	–	400	pF	–
SCL clock frequency	f_{SCL}	–	–	–	100	kHz	–
Bus free time between STOP and START condition	t_{BUF}	–	4.7	–	–	µs	–
Hold time (repeated) START condition	$t_{HD,STA}$	to first clock pulse	4.0	–	–	µs	–
Low period of SCL	t_{LOW}	–	4.7	–	–	µs	–
High period of SCL	t_{HIGH}	–	4.0	–	–	µs	–
Setup time repeated start condition	$t_{SU,STA}$	–	4.7	–	–	µs	–
Data hold time	$t_{HD,DAT}$	–	0	–	–	ns	–
Data setup time	$t_{SU,DAT}$	–	250	–	–	ns	–
Rise time of both SDA and SCL	t_R	–	–	–	300	ns	–
Fall time of both SDA and SCL	t_F	–	–	–	300	ns	–
Set up time for stop condition	$t_{SU,STO}$	–	4	–	–	µs	–
Input filter spike suppression	t_{SP}	spikes on SDA or SCL of that length are suppressed	–	–	50	ns	–

Note:

1. V_{DD} is the supply voltage.

Table 4: I²C Communications Bus Timing with Honeywell Digital Airflow Sensors

Chacteristic	Sym.	Condition	Min.	Typ.	Max.	Unit
High level	V_{IH}	–	0.7	–	–	V_{DDA}
Low level	V_{IL}	–	–	–	0.3	V_{DDA}
High level	V_{OH}	–	0.9	–	–	V_{DDA}
Low level	V_{OL}	–	–	–	0.1	V_{DDA}
Data setup time	T_{SETUP}	–	10	–	–	ns
Data hold time	T_{HOLD}	–	10	–	–	ns
Rise time	T_R	–	–	–	–	ns
Fall time	T_F	–	–	–	–	ns
Diagnostic output level	data	–	–	3FFF	–	hex
Data not ready	data	–	–	000	–	hex
Start condition hold time	$T_{SRTHOLD}$	–	1	–	–	µs
Stop condition setup time	$T_{STPSETUP}$	–	1	–	–	µs
Update rate	T_{UPDATE}	1 output selected at 100 kHz bus	–	280	–	µs
Update rate	T_{UPDATE}	4 outputs selected at 100 kHz bus	–	1120	–	µs
Update rate	T_{UPDATE}	1 output selected at 400 kHz bus	–	70	–	µs
Update rate	T_{UPDATE}	4 outputs selected at 400 kHz bus	–	280	–	µs

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

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