ESE381 Embedded Microcontroller Systems Design II

Spring 2022, K. Short revised April 15, 2022 11:47 am

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Laboratory 10: Air Quality System I - Basic Operation of SCD41 CO_2, Humidity and Temperature Sensor

To be performed the week starting April 17th.

Prerequisite Reading

(All items are posted on Blackboard.)

1 Sensirion Indoor Air Quality Brochure.
2. Product Flyer SCD4x.
3. Sensirion SCD40/41 Miniature CO2 Sensor Data Sheet.
4. Design-in Guide SCD4x CO2 Sensor.

Overview

Air quality is an important topic, particularly in the time of Covid. Systems that monitor and control air quality in smart residential and commercial environments take advantage of novel, relatively low cost, sensors. For some measurands like temperature and humidity low cost small sensors with analog and digital outputs have been available for some time. For other measurands such as CO_2 there has been a lack of small and relatively inexpensive sensors. The SCD41 from Sensirion provides a solution to that problem.

The SCD41 is a CO_2, humidity, and temperature sensor with an I2C interface. It is the first miniaturized CO_2, temperature, and humidity sensor that fits in a space of just one cubic centimeter. It uses the photoacoustic sensing principle to measure CO_2.

Design Tasks

Design Task 1: Hardware Interface of SCD41 to AVR128DB48.

Draw a schematic diagram of the interface of a SCD41 to an AVR128DB48. This device will share the I2C bus with the existing MCP23017. So, since we are continuing to use TWI0, SDA must be driven by PA2 and SCL must be driven by PA3.

Carry out a logic level and current compatibility analysis using the form that we have used in the past.

Note that in your design, the only supply voltage to be used is 3.3V from the Curiosity board.

Submit your schematic and logic level and current compatibility analysis as part of your prelab.

Design Task 2: Basic Operation of the SCD41, Function Definitions, and Reading of CO_2, Temperature, and Humidity Measured Values

The objective of this design task is to verify the basic operation of the SCD41. You must develop a set of functions that allow the AVR128DB48 to communicate with the SCD41 over the I2C bus. You must define, document, and code these functions. Choose descriptive function names. It is useful to divide these functions into two categories, functions that implement the primitive operations for the communication with the SCD41 on the I2C bus and functions that implement the subset of SCD41 commands, discussed in class, to make the basic measurements of CO_2, temperature and humidity.

Write a program using your functions to measure CO_2, temperature and humidity. Use polling to determine when a SCD41 measurement is complete using the SCD41's `get_data_ready_status` command. Display the measured values of CO_2, temperature, and humidity in a watch window in studio to verify the correct operation of the SCD41. You need not display the measured values on the LCD.

Submit your C single source file program as part of your prelab. Make sure that your program includes a program header, a header for each function, and clear comments throughout.

Design Task 3: Display Measured CO2, Temperature, and Humidity on the DOG LCD

Write a multifile program that measures CO_2, temperature, and humidity and displays these values on the DOG LCD. You can determine how you would like to arrange the display of this information on the LCD. Use one file for the main program, a second file for all of the functions associated with the LCD, and a third file for all of the functions associated with the SCD41.

Submit your C source for his multi-file program as part of your prelab. Make sure that your program includes a program header, a header for each function, and clear comments throughout.

Laboratory Activity

Laboratory Task 1: Hardware Interface of SCD41 to AVR128DB48 and Verification of Its Basic Operation.

Wire the SCD41's I2C interface to the Curiosity board's TWI0 pins. Connect the Saleae logic analyzer so you can monitor the data transfer between the AVR128DB48 and SCD41. **Caution: in your design, the only supply voltage to be used is 3.3V from the Curiosity board.**

Create a project using your program for Design Task 2. Set the compiler optimization to -Og. Build the program. Place any appropriate variables in a watch window to observe their values. Single step through the instructions in your program to verify that TWI0 is properly configured to communicate the with SCD41. Prior to single-stepping each instruction, determine what changes you expect in the values of the port registers and any variables you created.

Run your program and the Saleae logic analyzer verify that the correct transactions take place on the TWI bus. Use the Saleae logic analyzer to capture the first few transactions sent from the microcontroller to the SCD41. Submit this screen capture with your laboratory.

When your program is working correctly, have a TA verify that your program performs as required. Get the TA's signature.

Laboratory Task 2: Display Measured CO2, Temperature, and Humidity on the DOG LCD

Create a project using the program you wrote for Design Task 3. Set the compiler optimization to -Og. Build the program. Place any appropriate variables in a watch window to observe their values. Run you program using breakpoints to verify that the overall flow of control is correct.

When your program is working correctly, have a TA verify that your program performs as required. Get the TA's signature.

Leave the circuit you have constructed on your breadboard insert, it may be used in later laboratories.

Questions

1. Fill out the logic level compatibility check list (in the laboratory folder) for the AVR128DB48 and the SCD41. Make the AVR128DB48 device A. Both devices are operated with a supply voltage of 3.3V.

2. What is the maximum specified serial clock speed at which the SCD41 can be operated? What is the maximum speed and which the SCD41 can be operated in this design? Show your calculations for both.