

EVALUATION DONGLE KIT FOR THE Si7013, Si7020, AND Si7021 TEMPERATURE AND HUMIDITY SENSORS

1. Introduction

The Si7013, Si7020 and Si7021 are a family of relative humidity and temperature sensors in 3 mm x 3 mm QFN packages. They are all register compatible. The Si7020 and Si7021 are available in a six-pin package. The Si7013 has support for an additional analog input (typically for an external thermistor) and is in a 10-pin package. It is compatible with the Si7020 and Si7021 registers, with added registers for configuring the voltage measurements and for addition control of the heater. Access to the sensor output is via a standard I²C digital interface.

2. Evaluation Kit Description

This document describes the operation of the Silicon Laboratories Si7013USB-DONGLE Rev 1.0 evaluation kit. The Si7013 evaluation kit and accompanying graphical user interface software allow the user quick and easy access to the features and functions of the Si7013, Si7020 and Si7021 sensor as well as enabling the evaluation of the sensor's performance. The evaluation kit includes the following:

- Si7013USB-DONGLE evaluation board consisting of one Si7013 sensor as well as USB interface and circuitry for evaluation of the Si7013 with thermistor or other analog input
- Si7013- EB “postage stamp” size evaluation board for the Si7013 including circuitry for evaluation with a thermistor or other analog input
- Si7020-EB “postage stamp” size evaluation board for the Si7020.
- Si7021-EB “postage stamp” size evaluation board for the Si7021
- 3-foot flat cable to connect the “postage stamp” boards to the USB dongle
- USB extender cable
- Windows graphical user interface software for complete control of the Si7013, Si7020 or Si7021 sensors (Windows XP, VISTA, or 7 required)

Using the Si7013 USB-dongle, the windows GUI will also support “postage stamp” size boards for the Si7005 first generation temperature and humidity sensor in a 4x4 mm package (Si7005-EB) as well as the Si7015 pin compatible upgrade of this part (Si7015-EB).

The windows GUI will also support the older version Si7005USB-dongle although not all features of the newer parts can be evaluated in this case.



Figure 1. Si7013USB-DONGLE

Si7013USB-DONGLE



Figure 2. Si7013-EB and Si7021-EB

3. Software Setup

It is important that the software be installed before connecting the USB dongle to the PC; this ensures that the software drivers are correctly installed. To set up the software, run the file, setup.exe, from the supplied software installation disk. The Si7013 demo platform was developed based on National Instruments LabView™ platform. To install it, you must accept the National Instruments end-user license agreement shown in Figure 3.



Figure 3. National Instruments Software License Agreement

Continue through the following screens, which track the Graphical User Interface installation.

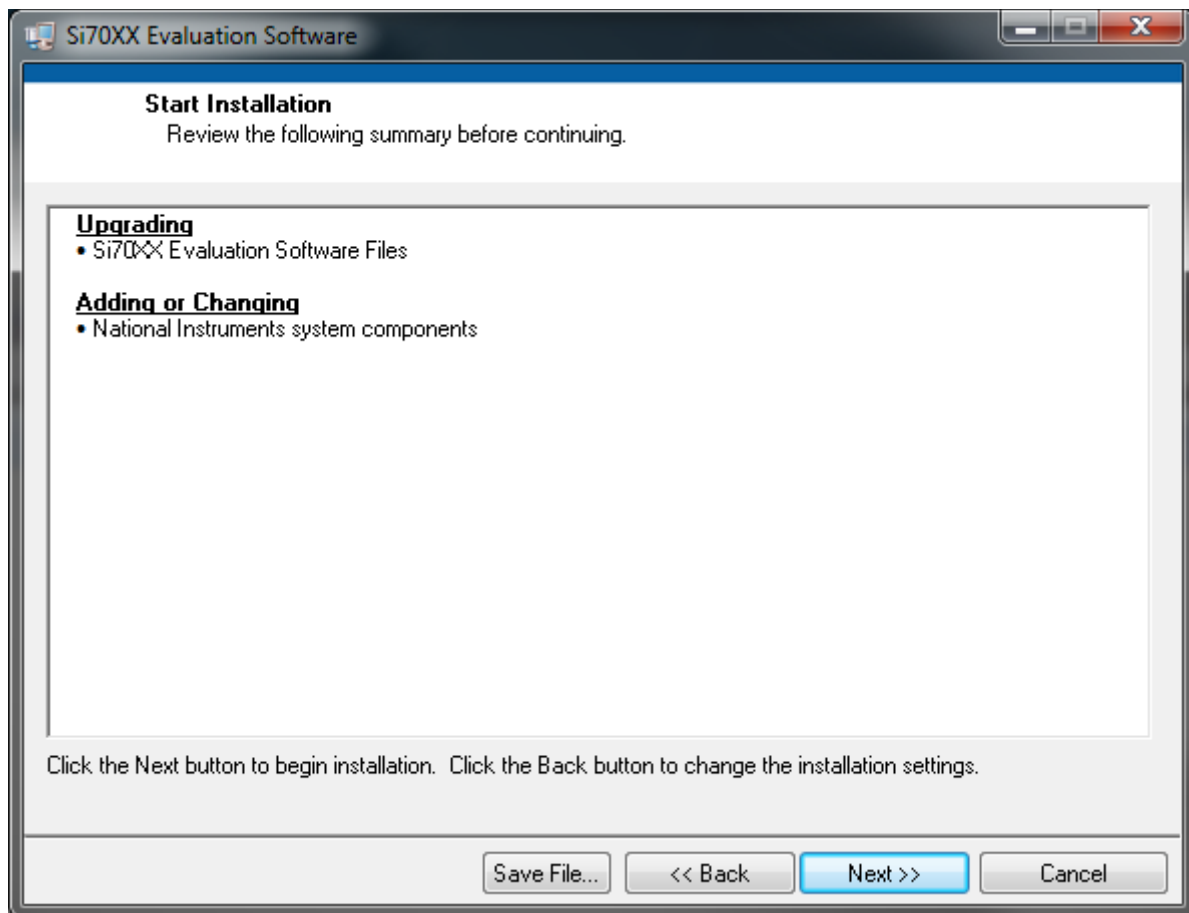


Figure 4. Start Installation Screen

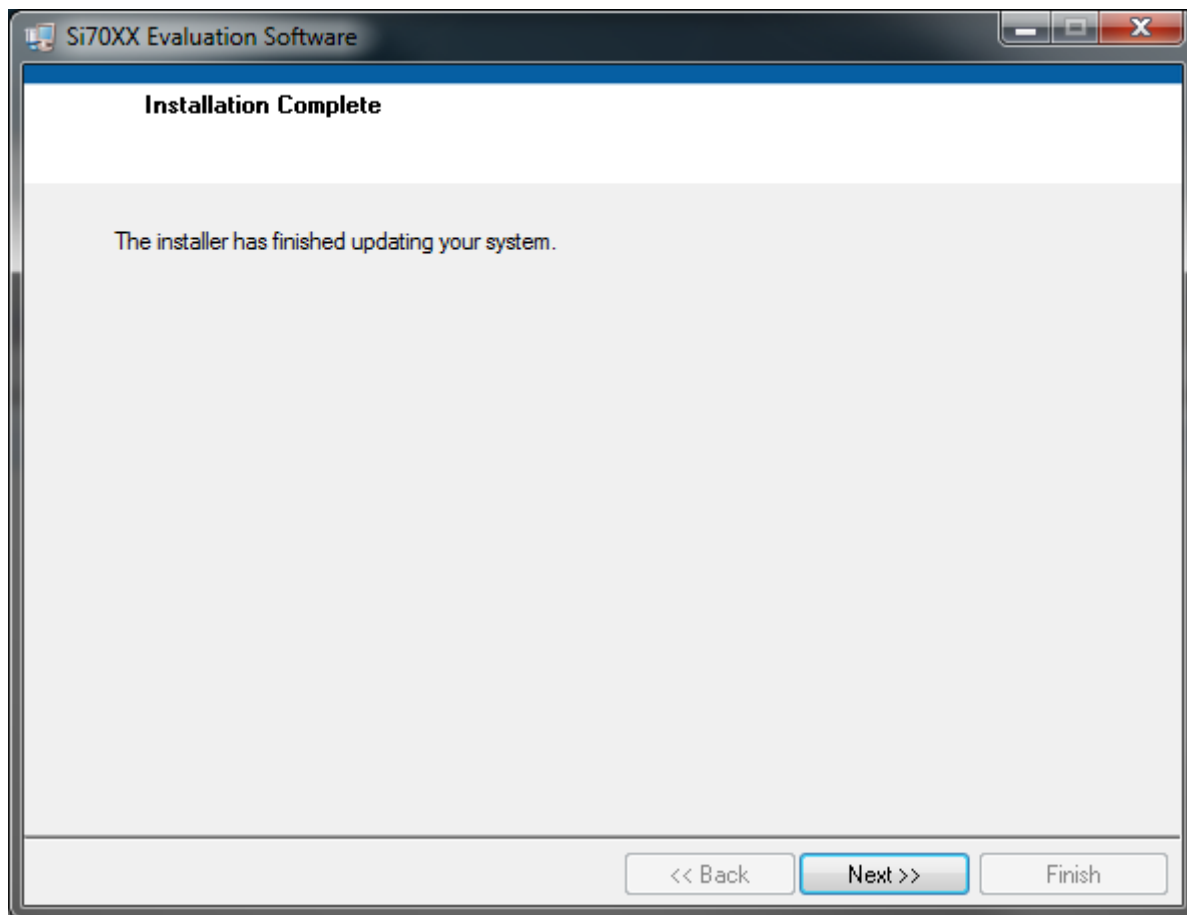


Figure 5. Installer Update Screen

After this screen, you will see the installer for the Si7013 device drivers.

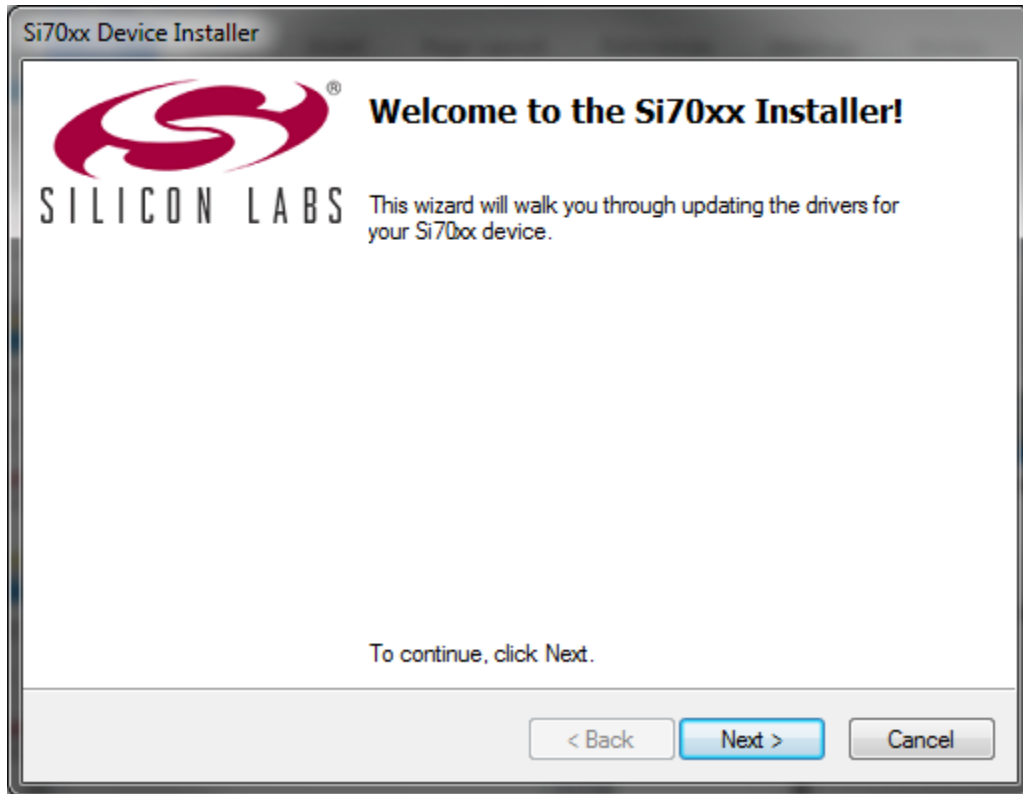


Figure 6. Device Drivers Installer Screen

4. Hardware Setup and Software Operation

Once the GUI installation is complete, connect the Si7013 USB dongle to your PC. Your PC should automatically recognize the USB dongle and use the newly-installed driver. Next, find the icon for the Si7013 GUI, which should be easily found under recently-installed programs from the start menu, under Programs → Silicon Laboratories → Si700x Evaluation Software or at

C:\program files\Silicon Laboratories\Si700x\.

With all the hardware plugged in and once your PC identifies the USB dongle, launch the GUI.

The GUI itself is simple to use. Figure 7 shows a screen shot of the GUI.

Si7013USB-DONGLE

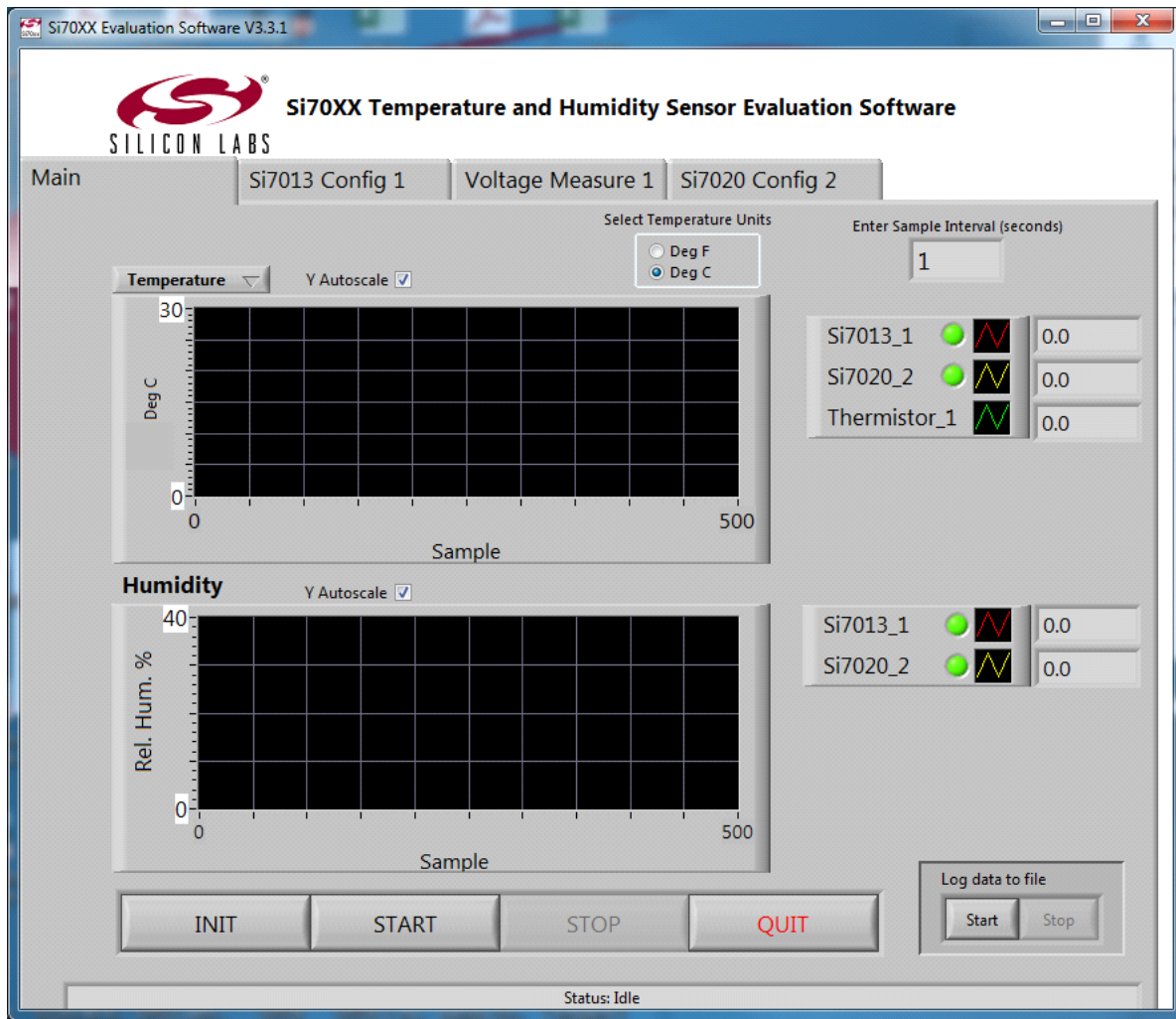


Figure 7. GUI Screen

Note: This is the GUI screen when an additional Si7013-EB is plugged in giving 2 humidity sensors and 4 temperature sensors (2 Si7013 temperature sensors and 2 thermistors). The appearance will change according to the number of sensors detected.

The USB dongle contains one Si7013 relative humidity and temperature sensor and can also support one additional sensor at connector J2. Si7005, Si7013, Si7015, Si7020 and Si7021 sensor evaluation boards are all supported.

When the GUI is started, it will recognize the sensors that are connected. The INIT button should be pressed if the hardware wasn't connected or was changed after the GUI was started.

Select temperature units by clicking on the "Select Temperature Units" button, the button will toggle between "Deg C" and "Deg F" indicating the selection of either degrees Celsius or degrees Fahrenheit.

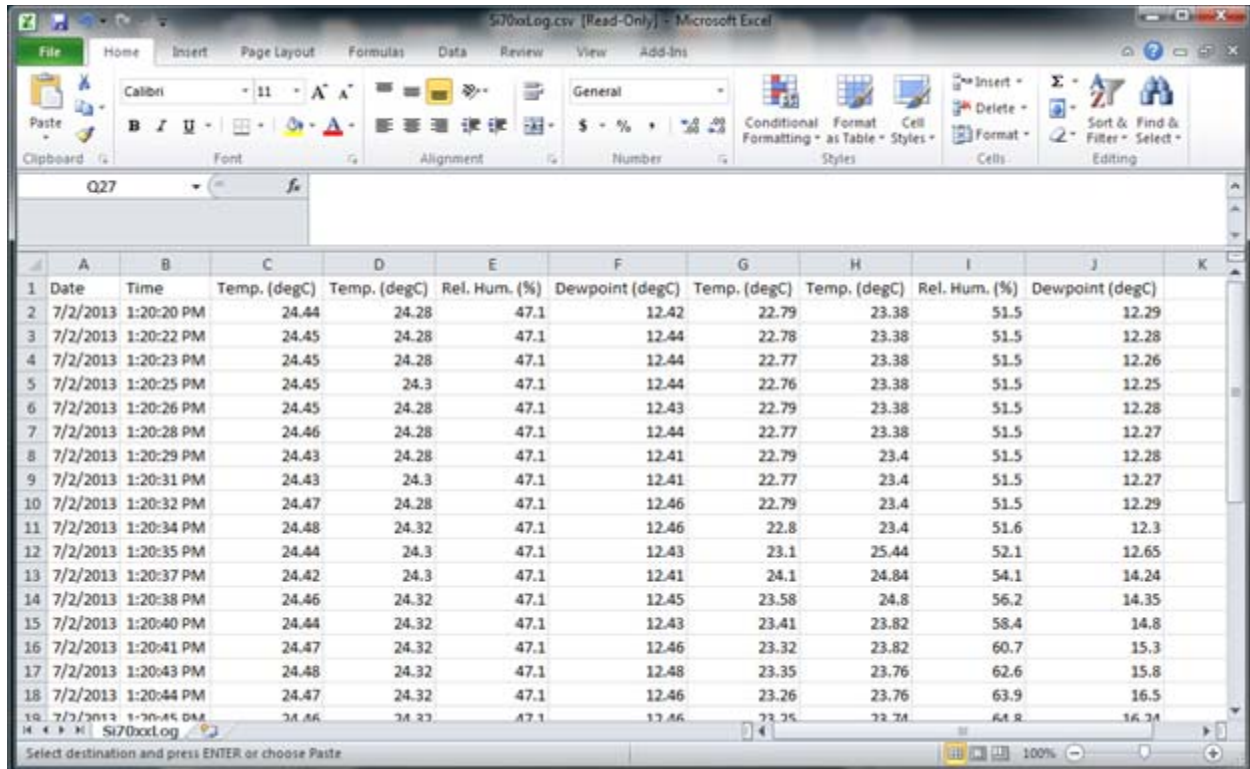
In the "Enter Sample Interval (seconds)" number box, the time interval between samples can be entered as any value greater than 0.2 seconds in increments of 0.1 seconds. Depending on the number of devices connected, sample times less than 1 second might not be possible. In this case, the window will turn red and the sample time will be as short as possible.

The upper chart by default displays temperature; this can be changed to dew point by clicking on the selection box located directly under the Silicon Labs logo. The temperature and dew point should always be logged regardless of setting.

The default Y-axis range on each chart auto-ranges. If desired, the auto-ranging can be turned off and the upper and lower limits for the charts can be set by clicking on the appropriate box. The same configuration changes can be made to the X-axis.

If a log of the data is desired, click “START” inside the “Log Data to File” box to begin collecting data. If “Create Log File?” is enabled, a dialog box will appear requesting a file name and save location. The time base of the log file can be chosen to be absolute date and time or relative time in seconds. To stop data collection, click “STOP”. To exit the GUI click “QUIT”.

If an Si7005 or Si7015 evaluation board is connected, the GUI automatically adjusts for the temperature and non-linearity effect of the RH sensor. (this is not required for Si7013 or Si7021 as this is done internally to the part). The data logged to file is saved in comma separated value (csv) format, which can be easily opened in a spreadsheet application such as Microsoft Excel, as shown in Figure 8.



	A	B	C	D	E	F	G	H	I	J	K
1	Date	Time	Temp. (degC)	Temp. (degC)	Rel. Hum. (%)	Dewpoint (degC)	Temp. (degC)	Temp. (degC)	Rel. Hum. (%)	Dewpoint (degC)	
2	7/2/2013	1:20:20 PM	24.44	24.28	47.1	12.42	22.79	23.38	51.5	12.29	
3	7/2/2013	1:20:22 PM	24.45	24.28	47.1	12.44	22.78	23.38	51.5	12.28	
4	7/2/2013	1:20:23 PM	24.45	24.28	47.1	12.44	22.77	23.38	51.5	12.26	
5	7/2/2013	1:20:25 PM	24.45	24.3	47.1	12.44	22.76	23.38	51.5	12.25	
6	7/2/2013	1:20:26 PM	24.45	24.28	47.1	12.43	22.79	23.38	51.5	12.28	
7	7/2/2013	1:20:28 PM	24.46	24.28	47.1	12.44	22.77	23.38	51.5	12.27	
8	7/2/2013	1:20:29 PM	24.43	24.28	47.1	12.41	22.79	23.4	51.5	12.28	
9	7/2/2013	1:20:31 PM	24.43	24.3	47.1	12.41	22.77	23.4	51.5	12.27	
10	7/2/2013	1:20:32 PM	24.47	24.28	47.1	12.46	22.79	23.4	51.5	12.29	
11	7/2/2013	1:20:34 PM	24.48	24.32	47.1	12.46	22.8	23.4	51.6	12.3	
12	7/2/2013	1:20:35 PM	24.44	24.3	47.1	12.43	23.1	25.44	52.1	12.65	
13	7/2/2013	1:20:37 PM	24.42	24.3	47.1	12.41	24.1	24.84	54.1	14.24	
14	7/2/2013	1:20:38 PM	24.46	24.32	47.1	12.45	23.58	24.8	56.2	14.35	
15	7/2/2013	1:20:40 PM	24.44	24.32	47.1	12.43	23.41	23.82	58.4	14.8	
16	7/2/2013	1:20:41 PM	24.47	24.32	47.1	12.46	23.32	23.82	60.7	15.3	
17	7/2/2013	1:20:43 PM	24.48	24.32	47.1	12.48	23.35	23.76	62.6	15.8	
18	7/2/2013	1:20:44 PM	24.47	24.32	47.1	12.46	23.26	23.76	63.9	16.5	
19	7/2/2013	1:20:46 PM	24.46	24.32	47.1	12.46	23.25	23.74	64.2	16.34	

Figure 8. Logged Data Displayed in Excel with Absolute Date and Time Base

Si7013USB-DONGLE

4.1. Configuration Screen

The configuration screen displays the configuration settings for the device that is connected.

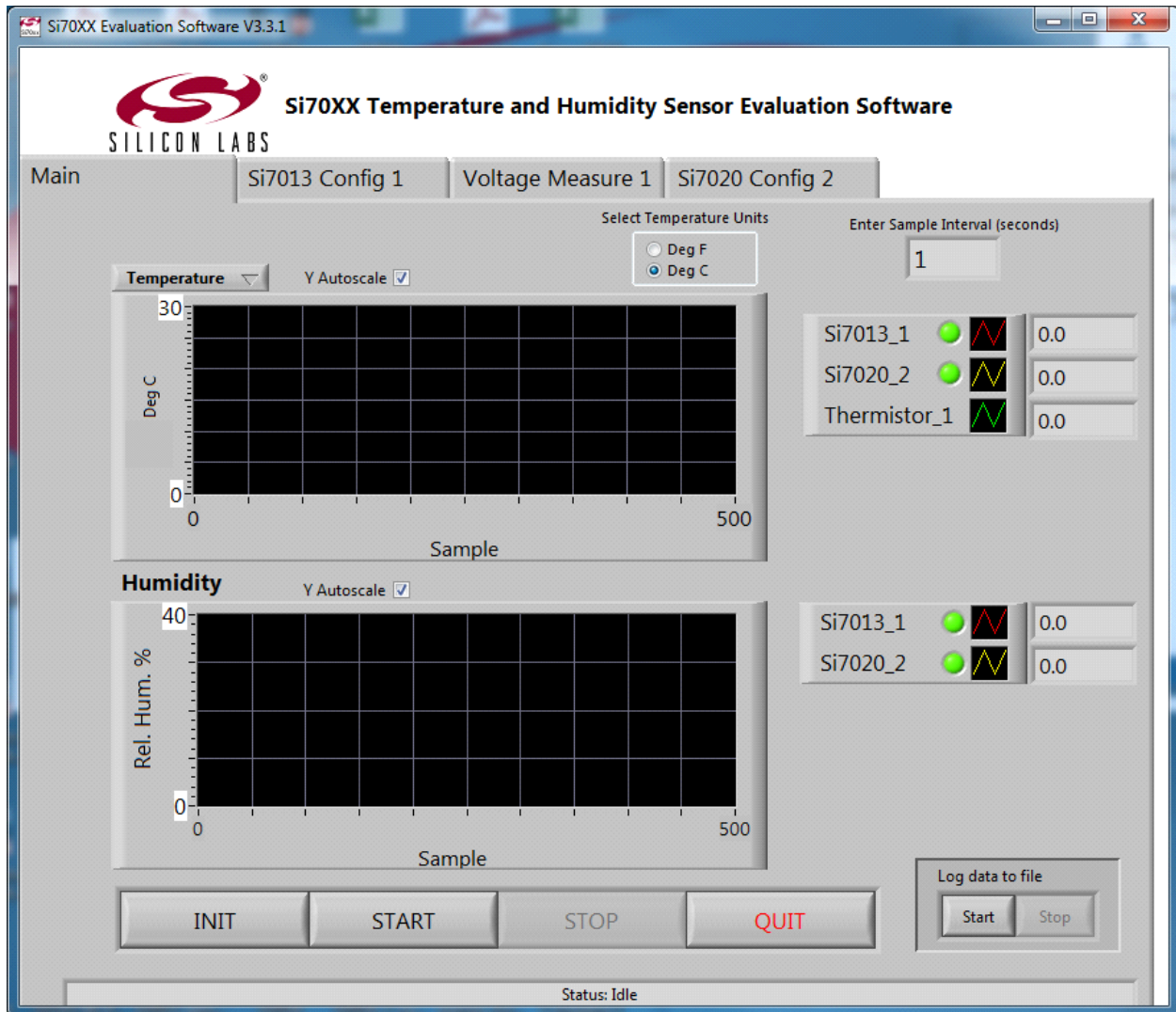


Figure 9. Configuration Screen

For Si7013, this includes:

- The device ID information (an 8-byte identification that is unique to each device)
- Configuration and enable settings for the on-chip heater. While the on-chip heater can go as high as 94 mA, the GUI only supports 39 mA maximum to avoid drawing too much power from the USB port.
- Conversion speed settings for the RH and temperature sensor
- Control of the voltage conversion settings (Si7013 user register 2)

An option to disable the Si7013 on the USB dongle is included for the case where the device connected to J2 is of more interest.

4.2. Voltage Measurement Screen

The voltage measurement screen configures the lookup table based linearization of analog measurements for Si7013. This is discussed in more detail in the Si7013 data sheet and also in AN607.

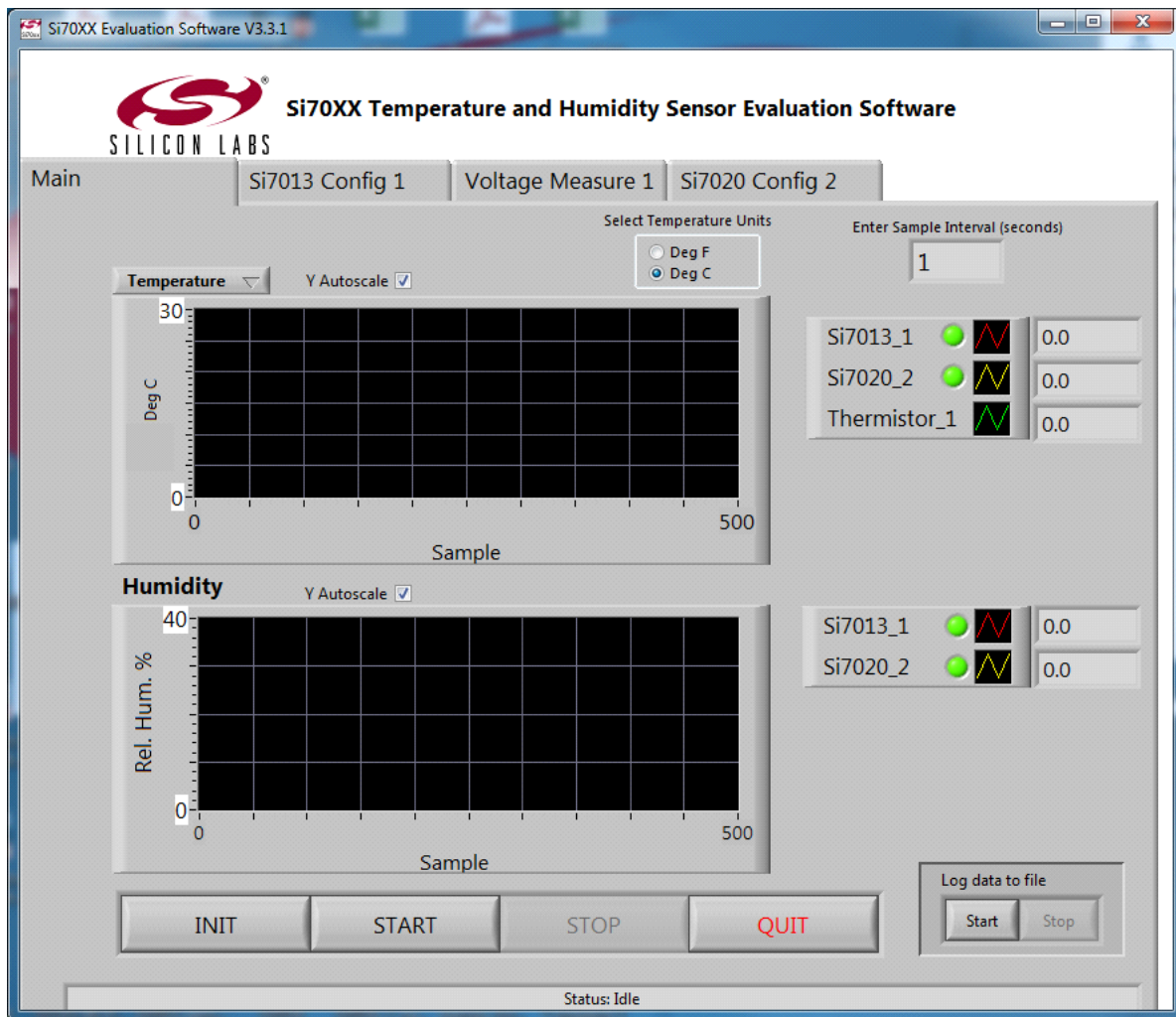


Figure 10. Voltage Measurement Screen

The graph and output window in the upper section of this page shows the measurement result. The graph can be configured as in the previous discussion of graphs on the main page.

By default, the linearization is configured to support the NCP18XH103F03RB thermistor with 24.3 k Ω bias resistors supplied on the evaluation board. The lookup table is chosen so that the linearization results in an output code that is linear with temperature and scaled in the same way as the temperature sensor internal to the Si7013.

If the linearization coefficients have not been written to the Si7013 part the lookup table entries are applied by the GUI and the resultant linearized (temperature) output can be graphed on the main page. In this case the coefficients can be modified to try different look up tables. Prior to writing the coefficients to the Si7013, the coefficients in the GUI entry boxes can be saved and later loaded. (they are saved to the file Si7013.ini in the directory where the GUI executable is located).

Clicking the Program coefficients button writes the coefficients to the part. This is a once time process. After doing the write, close the GUI and cycle power. After doing this, the internal correction can be enabled on the configuration screen (lower right) and when enabled the corrected data will be displayed on the measurement screen as well as the main screen (if enabled).

4.3. Calculation of Dew Point Value

The Si7013 measures both temperature (T) and relative humidity (RH). These two values can be used to approximate the dew point (Td).

$$T_d = \frac{b\gamma(T,RH)}{a - \gamma(T,RH)}$$

Where

$$\gamma(T,RH) = \frac{aT}{b + T} + \ln\left(\frac{RH}{100}\right)$$

$$a = 17.625$$

$$b = 243.04$$

The calculation used is based on the August-Roche-Magnus approximation for the saturation vapor pressure of water in air as a function of temperature, it is considered valid for:

$$0\text{ }^{\circ}\text{C} < T < 60\text{ }^{\circ}\text{C}$$

$$1\% < RH < 100\%$$

$$0\text{ }^{\circ}\text{C} < T_d < 50\text{ }^{\circ}\text{C}$$

5. Si7005 USB Dongle Description

The USB Dongle facilitates communication between the Si7013 and the optional postage stamp size evaluation board and a PC. This function is enabled by the Silicon Laboratories' C8051F381 microcontroller. The optional postage stamp board is connected to connector J2 by a 6 wire flat flexible cable, The pin connections for connector J2 are shown in Figure 10. A full circuit diagram of the board is shown in Figure 11.

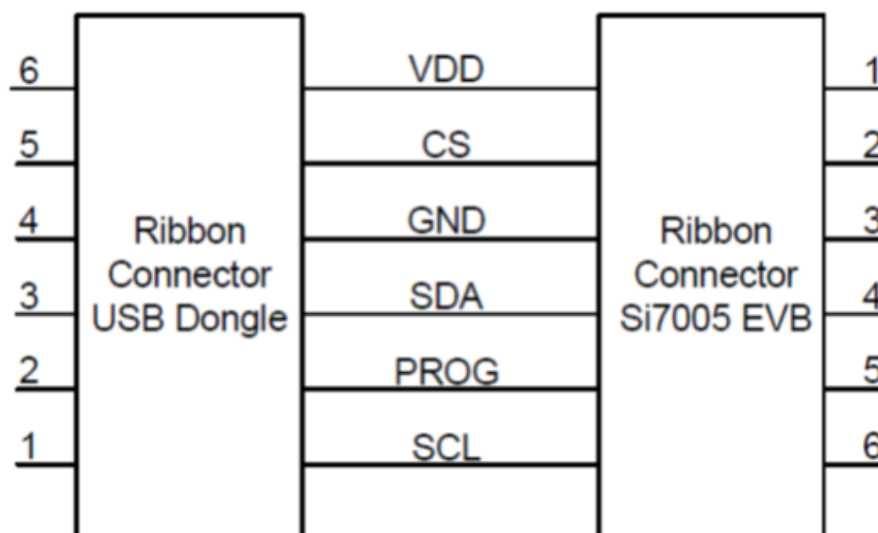


Figure 11. Ribbon Cable Pin Assignments

5.1. Si7013 USB Dongle Schematic

The Si7013 USB-DONGLE is a simple board contains a Si7013 relative humidity and temperature sensor, a C8051F381 USB microcontroller, a USB type A connector, and an auxiliary connector for connection to a second sensor. There is also support for a thermistor or other analog input. The thermistor and bias circuitry is connected by J3,J4 and J5 which are small solder bridges. To disconnect the thermistor and use the analog input directly (TP6 and TP7), simply use a soldering iron to remove the solder bridges on J3 and J4. Solder wick may aid in removing the bridge, but is usually not required.

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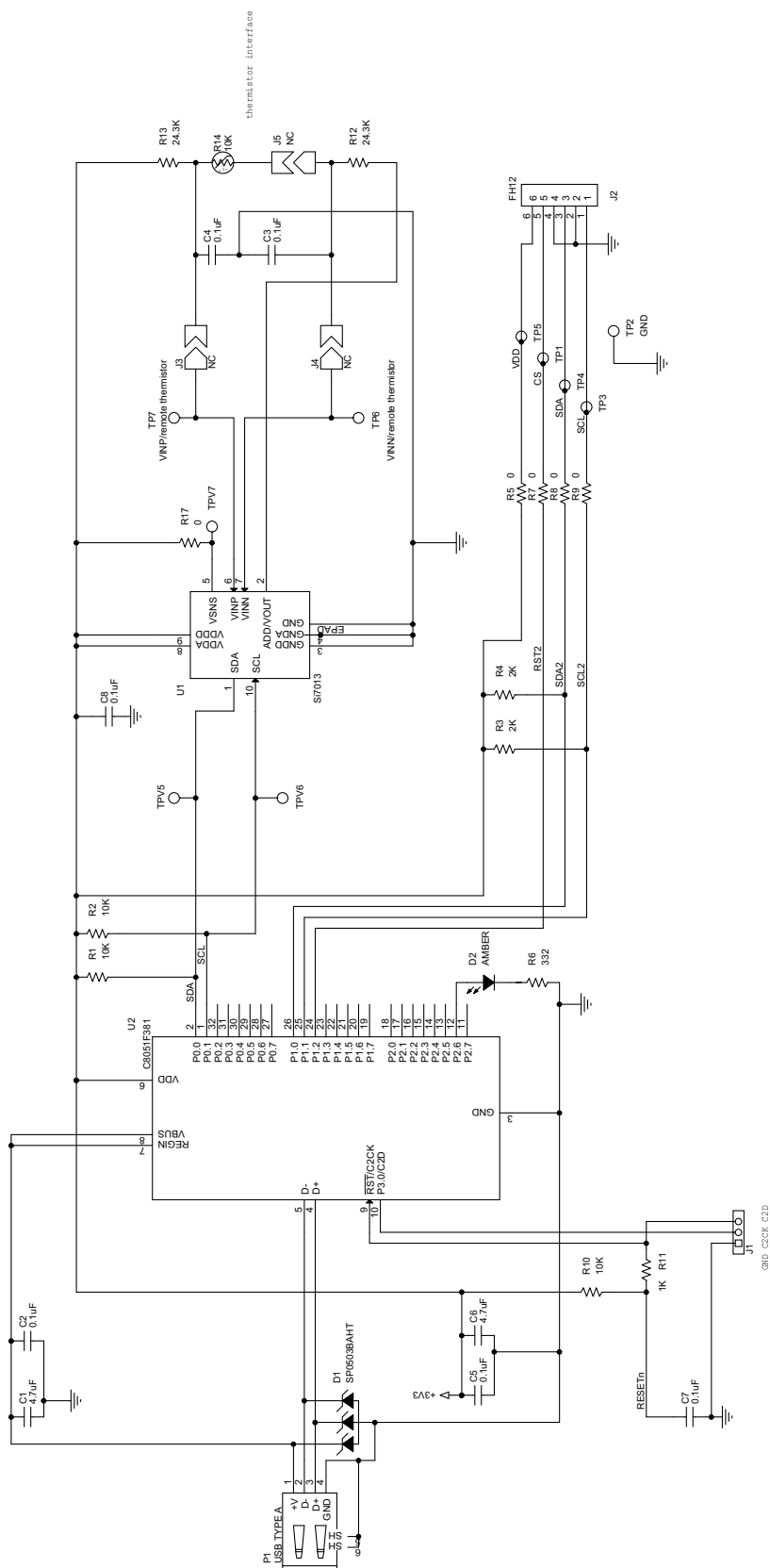
Rev. 0.4

Figure 12. USB Dongle Circuit Schematic

5.2. Si7013 USB Dongle Board Layers

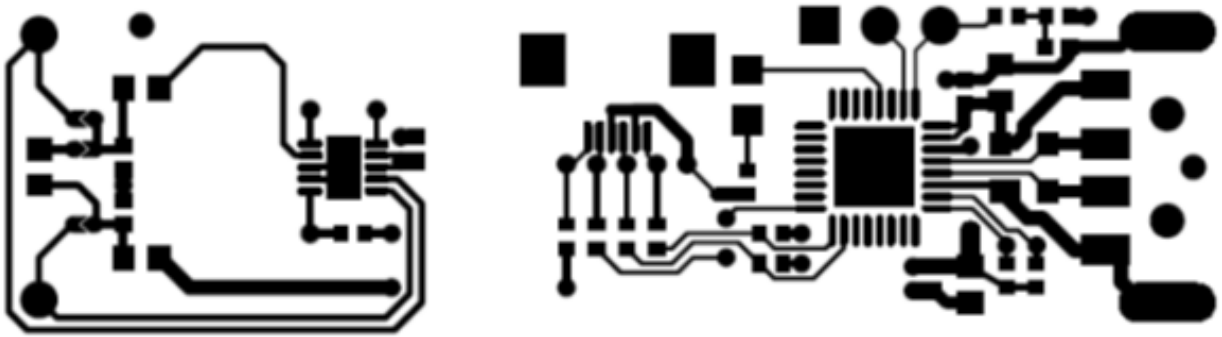


Figure 13. Si7013 Dongle Board Layout Top Layer

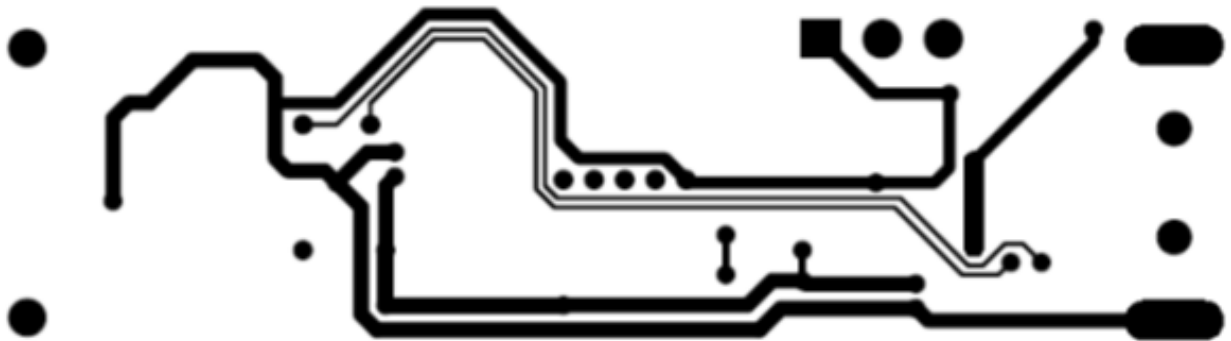


Figure 14. Si7013 Dongle Board Layout Bottom Layer

Note from Figures 11, 12, and 13, that there is no ground plane around the Si7013 and that there is a cutout in the PCB between the Si7013 and other circuitry. While these are not requirements for successful operation of the Si7013, they do (in the case of the dongle board) provide thermal isolation from heat sources, such as the host PC and MCU circuitry. There is also a second thermal cutout to provide isolation between the thermistor and Si7013.

For board firmware revisions less than 3, when using the Si7013 dongle board at the end of the USB extension cable, there will be approximately 0.8 °C of heating from the USB MCU despite the use of the thermal cutouts. This amount of heating will reduce the local humidity in the vicinity of the Si7013 by as much as 4% (the error linearly increases from zero to 4% as the ambient humidity increases from zero to 100%). For more accurate determination of the humidity, the optional “postage stamp” size evaluation boards can be used. For board revision three or greater, the heating has been reduced to about 0.1 °C and can usually be ignored.

Si7013USB-DONGLE

6. Optional “Postage Stamp” Evaluation Boards

6.1. Si7013 EB Schematic

The evaluation board is a simple board containing just the Si7013 sensor, decoupling capacitors, thermistor interface, and a ribbon connector for connection to the USB dongle board.

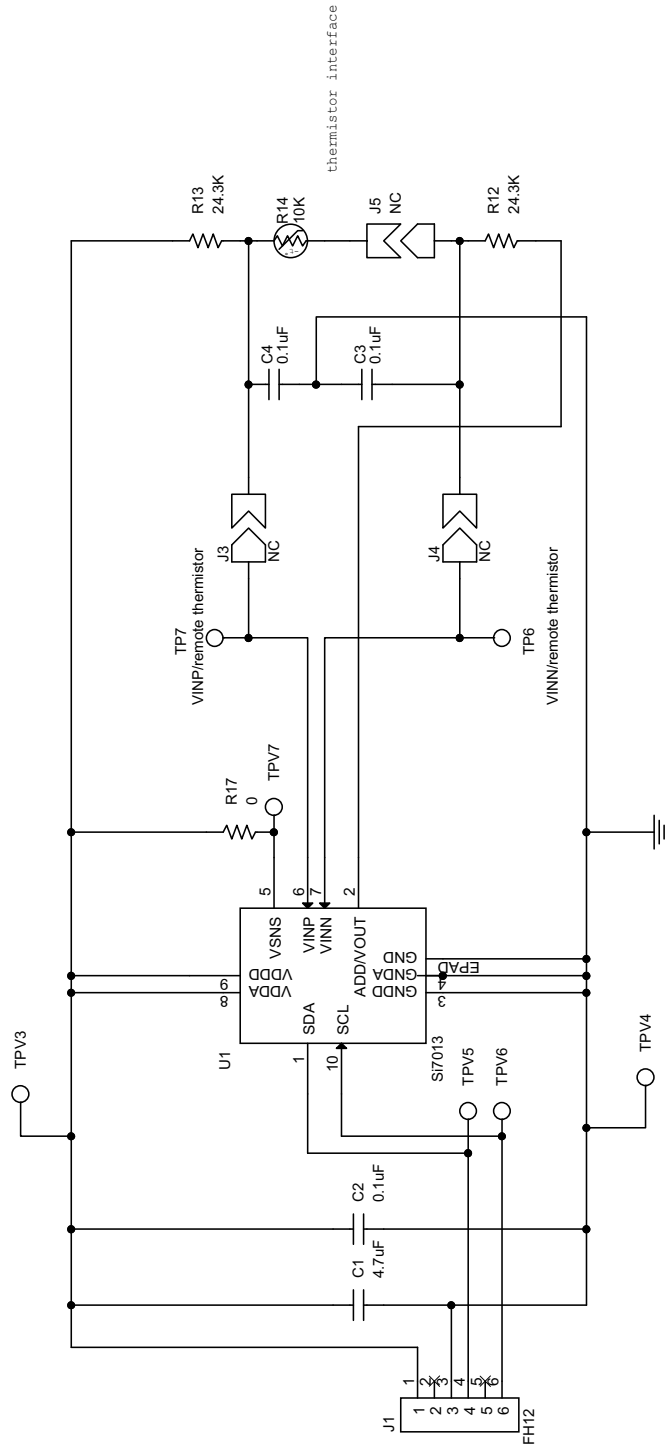


Figure 15. Si7013 EB Schematic

6.2. Si7020/21 EB Schematic

The evaluation board is a simple board containing just the Si7020 or Si7021 sensor, decoupling capacitors and a ribbon connector for connection to the USB dongle board. The populated part number is indicated by a check box on the silkscreen on the top of the PCB.

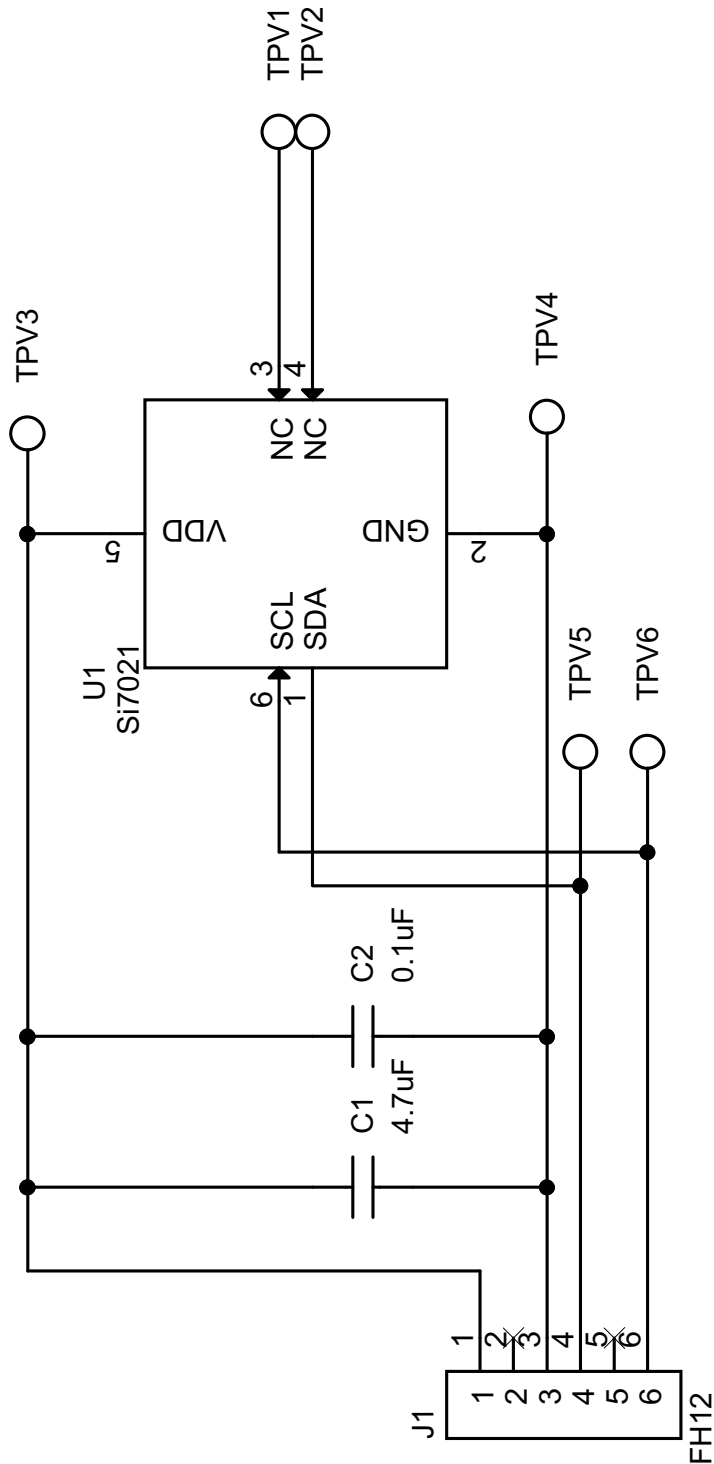


Figure 16. Si7020/21 EB Schematic

Si7013USB-DONGLE

6.3. Si7005/15 EB Schematic

The evaluation board is a simple board containing just the Si7005 or Si7015 sensor, decoupling capacitors and a ribbon connector for connection to the USB dongle board. Which part number is populated is indicated by a check box.

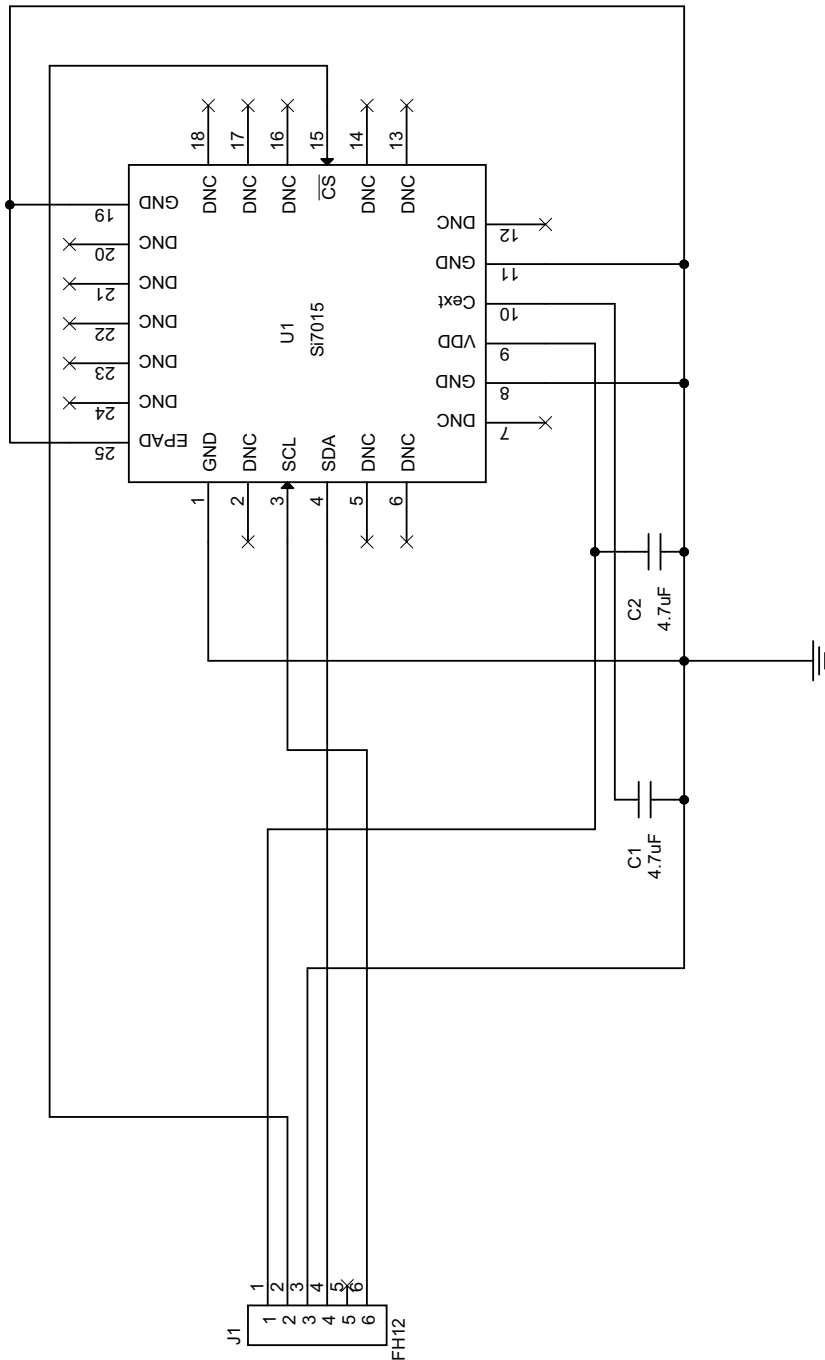


Figure 17. Si7005/15 EB Schematic

7. Additional Reference Resources

- Si7005, Si7013, Si7020, and Si7021 data sheets
- AN607: Si70xx Humidity Sensor Designer's Guide

8. GUI Revision Notes

- As explained in “5. Si7005 USB Dongle Description”, firmware Revision 3 of the USB adapter board reduces self-heating of the USB board.
- GUI Revision 3.3.0
 - Corrects a minor problem in the data logging which resulted in small output fluctuations that were not “real”
 - Adds support for disabling the device in the USB dongle.
 - Improves the timing accuracy for the sampling interval.
 - Adds support for other heater current settings for Si7020 and Si7021.
 - Allows removal of individual graphs by clicking the green radar button for that graph

DOCUMENT CHANGE LIST

Revision 0.1 to Revision 0.2

- Updated "2. Evaluation Kit Description" on page 1.
 - Added Si7020-EB "postage stamp" size evaluation board for the Si7020.

Revision 0.2 to Revision 0.4

- Updated "4. Hardware Setup and Software Operation" on page 5.
- Updated Figure 7, "GUI Screen," on page 6.
- Updated "4.1. Configuration Screen" on page 8.
- Updated Figure 9, "Configuration Screen," on page 8.
- Updated Figure 10, "Voltage Measurement Screen," on page 9.
- Updated "5.2. Si7013 USB Dongle Board Layers" on page 13.
- Added "8. GUI Revision Notes" on page 17.

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