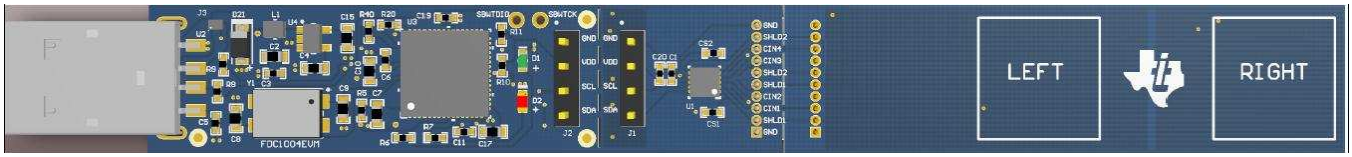
FDC1004EVM User's Guide



The FDC1004EVM evaluation kit is a plug and play system to test and evaluate the FDC1004, 4-Channel capacitive to digital converter. The EVM is a breakable PCB which consists of 3 sections. The first section is a USB to I2C converter based on MSP430F5528 micro-controller, the second section contains the FDC1004 and the third section is a touchless sensor (to demonstrate the sensitivity of the FDC1004) . The third section can be removed and replace with customized sensors to evaluate the capabilities of the FDC1004 in various applications. The FDC1004EVM can be used with the Sensing Solutions EVM GUI. The software is able to configure the FDC1004's registers, graph the measured values, and export the data in CSV format.

The EVM contains one FDC1004 (See Table 1).

Table 1. Ordering

DEVICE	IC	Package
U1	FDC1004DSC	SON 10pin

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1 Setup

This section provides a general description about FDC1004EVM, its I/O connectors and how to properly setup the evaluation module.

1.1 FDC1004EVM

The FDC1004EVM is divided in three sections:

1. USB to I2C section: this has the purpose to interface the communication of FDC1004 to a USB port.
2. FDC1004 section: this section embeds FDC1004 capacitive to digital converter.
3. Sensor section: this section contains a capacitive sensor that can be used for both human proximity and simple gesture recognitions..

The EVM has precut lines on the borders of each section that allow for a flexible and specific system design. As an example of the flexibility of this design, the sensor can be replaced with a customer sensor, or the MCU section can be separated to allow for a remote placement of the FDC1004.

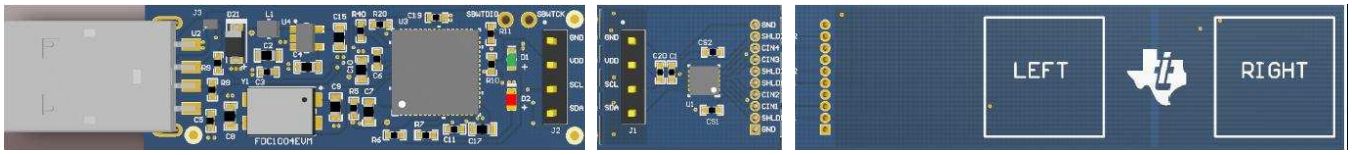

Figure 1. FDC1004EVM : Sections

1.2 Input/Output Connector Description

J1, J2: 4x1 Header: the I/O ports of sections between the USBtoI2C and the FDC1004 sections. This provides the I2C communication channel and the power connections between these two sections should the EVM be separated into sections. A simple 4 wire cable can be used to interface the sections.

Table 2. J1, J2 Pin Out

Pin	Pin	Description
J1.1	J2.1	GND
J1.2	J2.2	VDD
J1.3	J2.3	SCL
J1.4	J2.4	SDA

J3: USB interface to connect the EVM to a PC; it also provides power to the EVM.

J4: 10x1 Headers. This is not populated by default. It provides an easy method to change sensors or to remotely place the sensor away from the FDC1004. This connector with its counterpart, J5, allows the communication of the two modules through a 10-wire cable.

Table 3. J4 Pin Out

Pin	Description
J4.1	GND
J4.2	SHLD1
J4.3	CIN1
J4.4	CIN2
J4.5	SHLD1
J4.6	SHLD2
J4.7	CIN3
J4.8	CIN4
J4.9	SHLD2

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Table 3. J4 Pin Out (continued)

J4.10	GND

J5: 10x1 Header, for the electrical connection between the FDC1004 and the sensor section.

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Table 4. J5 Pin Out

Pin	Description
J5.1	GND
J5.2	SHLD1
J5.3	CIN1
J5.4	Not Connected
J5.5	SHLD1
J5.6	SHLD2
J5.7	Not Connected
J5.8	CIN4
J5.9	SHLD2
J5.10	GND

1.3 HW Setup

The power supply of FDC1004 is provided by the LDO (U4), which is sourced from the USB 5.0V. The I2C communication with FDC1004 is fully managed by the MSP430F5528IRGC microcontroller (U3). The FDC1004 has a fixed I2C address.

2 Sensing Solutions EVM GUI

The Sensing Solutions EVM GUI provides direct device register access, user-friendly configuration, and data streaming.

2.1 System Requirements

The host machine is required for device configuration and data streaming. The following steps are necessary to prepare the EVM for the GUI:

- The GUI and EVM driver must be installed on a host computer
- - The EVM must be connected to a full speed USB port (USB 1.0 or above)

The Sensing Solutions EVM GUI supports the following operating systems (both 32-bit and 64-bit):

- Windows XP
- Windows 7
- Windows 8 and 8.1
- Windows 10

2.2 Installation Instructions

The Sensing Solutions GUI and EVM driver installer is packaged in a zip file. Follow these steps to install the software:

1. Download the software ZIP file from the EVM tool page
2. Extract the downloaded ZIP file
3. Run the included executable
4. If prompted by the User Account Control about making changes to the computer, click "Yes"

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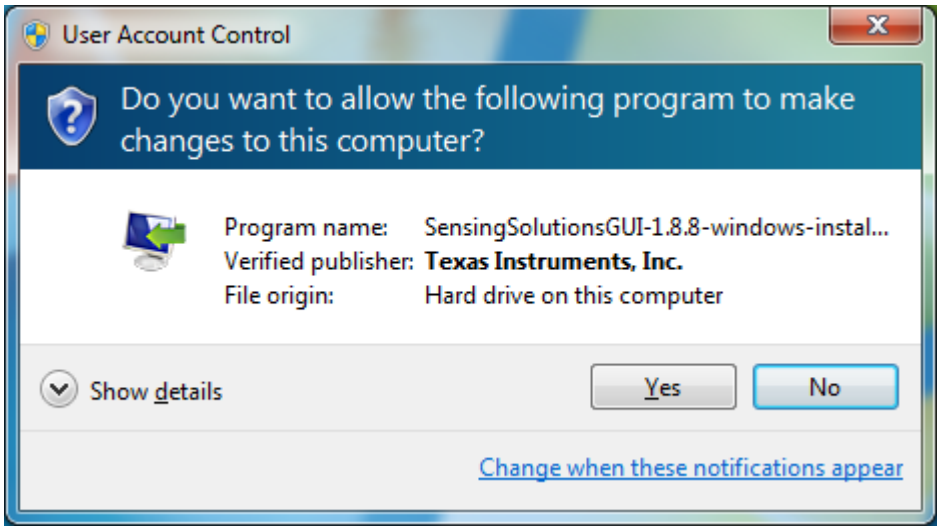

Figure 2. User Account Control Prompt

5. After the setup wizard starts, click "Next"

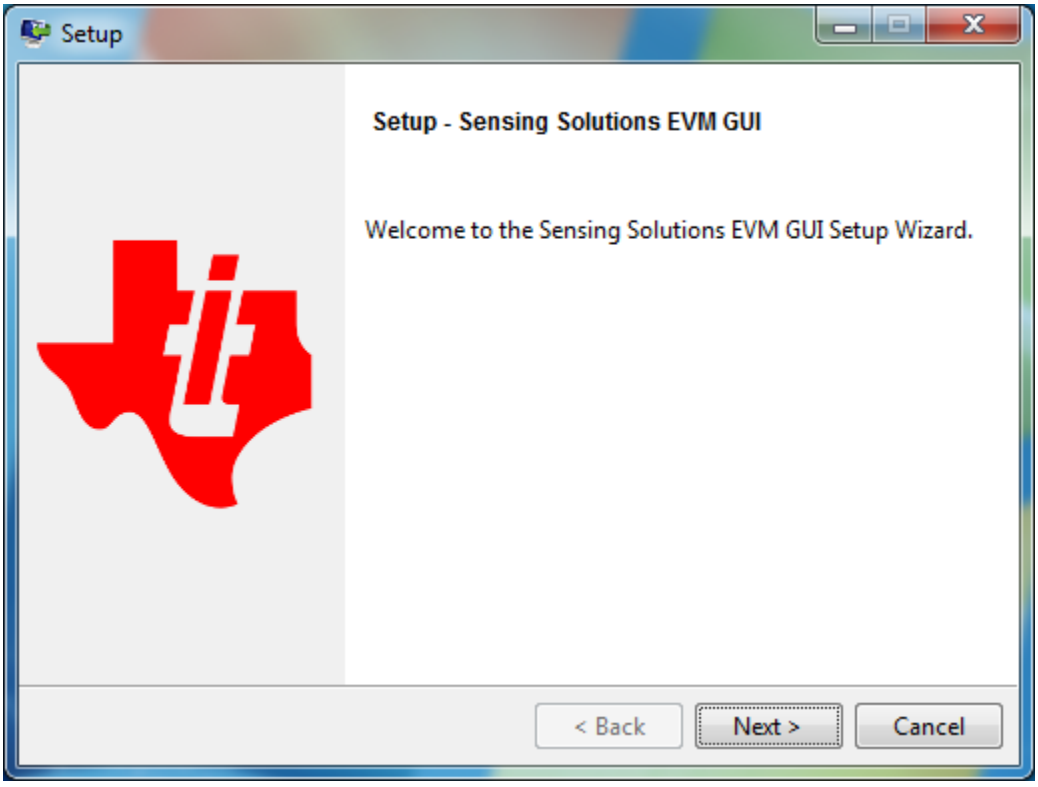

Figure 3. Software Installer Wizard

6. Read the license agreement, select "I accept the agreement", and click "Next"

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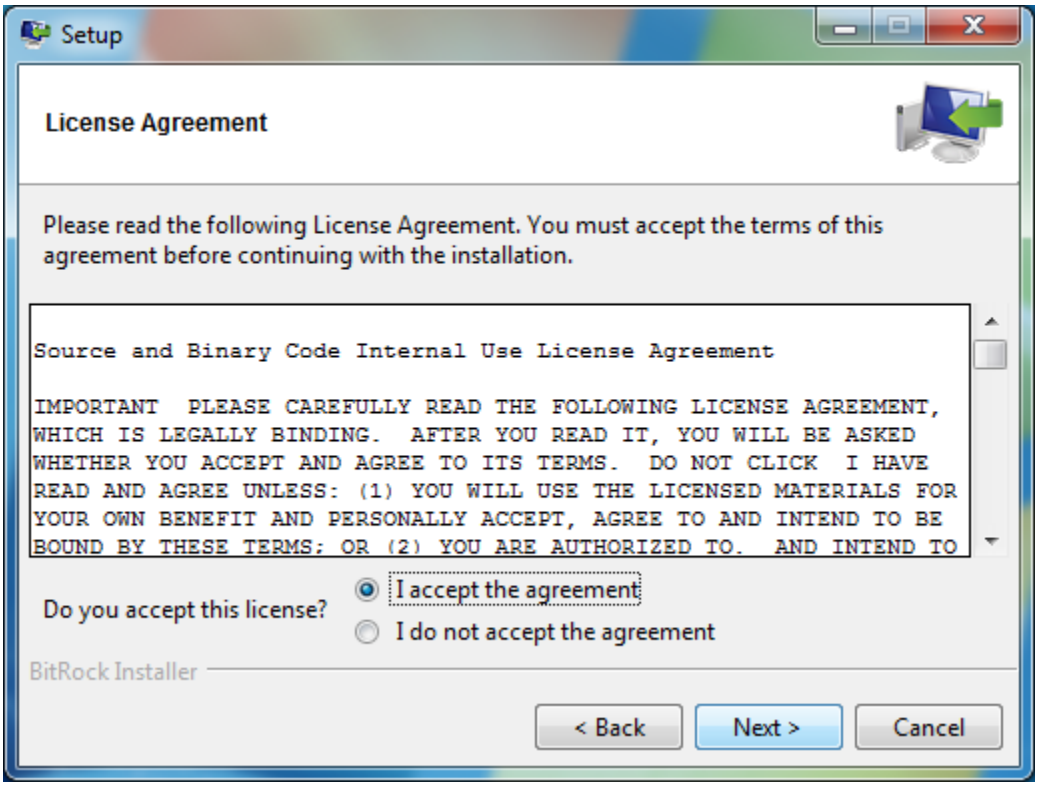

Figure 4. Software Installer License Agreement

7. Use the preselected installation directory and click "Next"

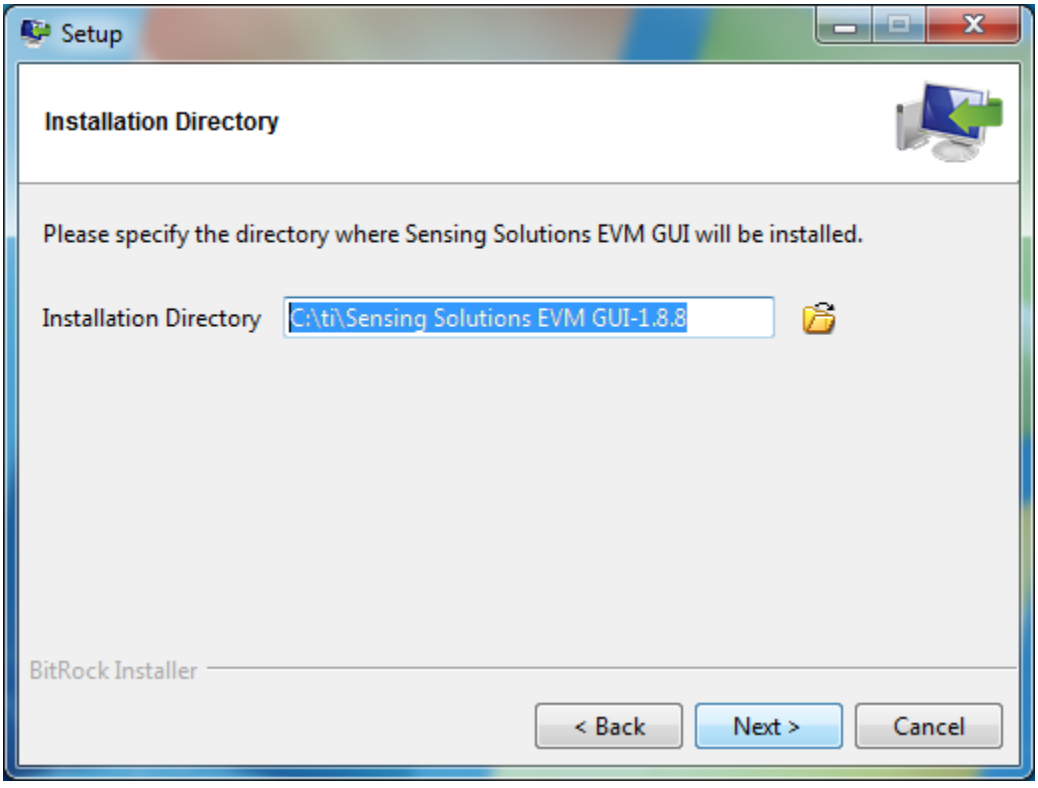

Figure 5. Software Installation Directory

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8. Start the installation by clicking "Next"

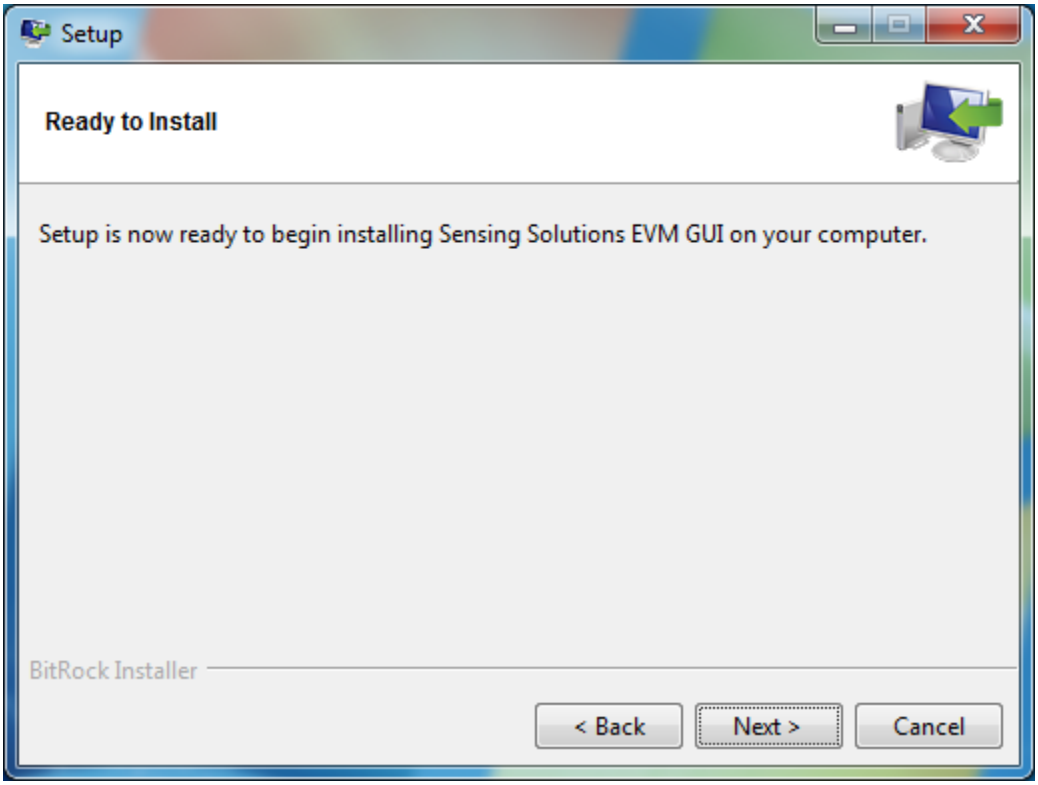

Figure 6. Software Installer Ready

9. Wait for the installation to complete

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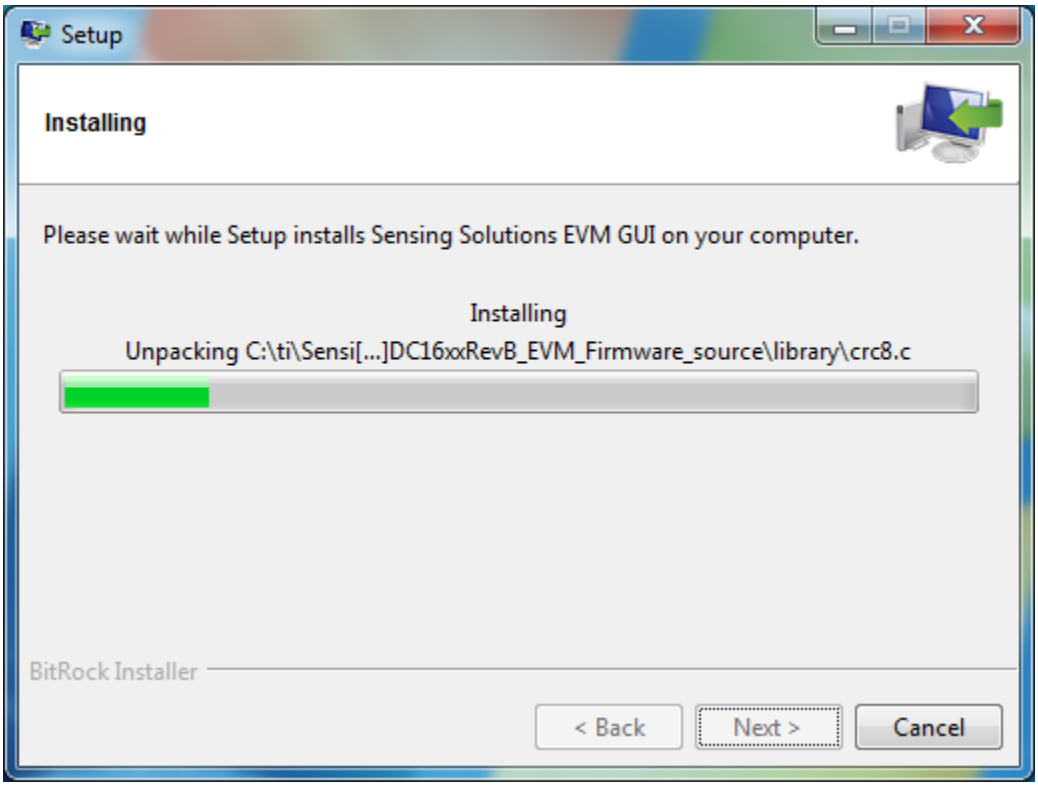

Figure 7. Software Installer In Progress

10. When the "Device Driver Installation Wizard" appears, click "Next" to install the EVM driver

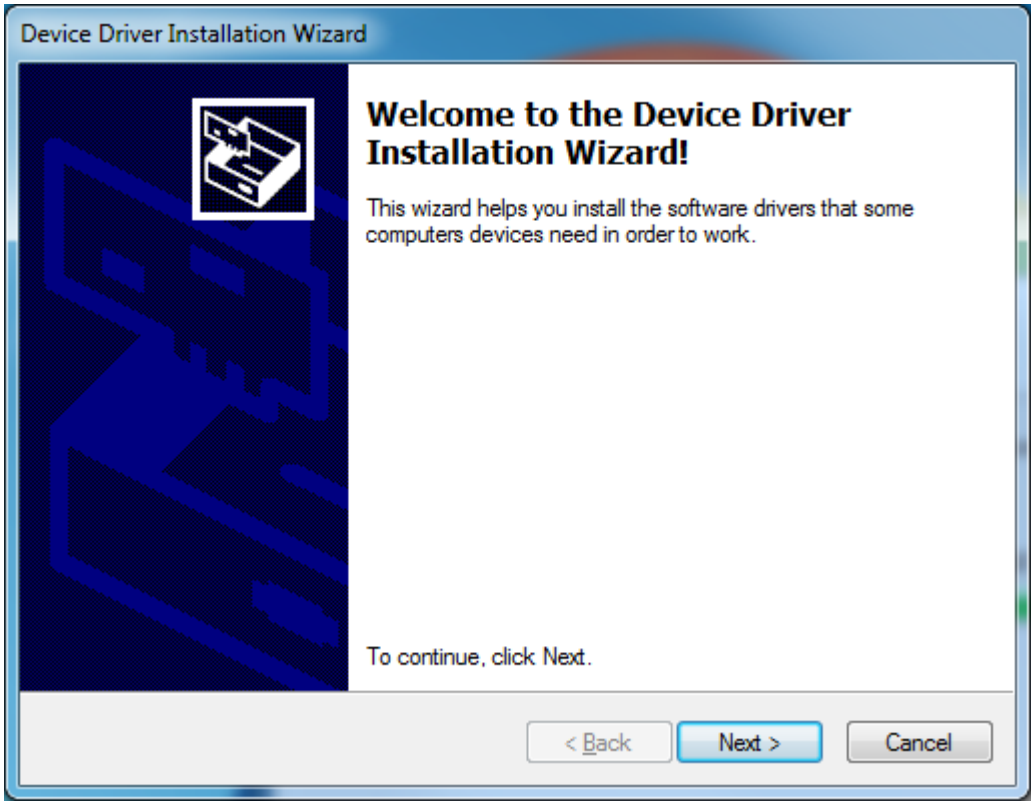

Figure 8. Device Driver Installer Wizard

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11. Wait for the driver installation to complete

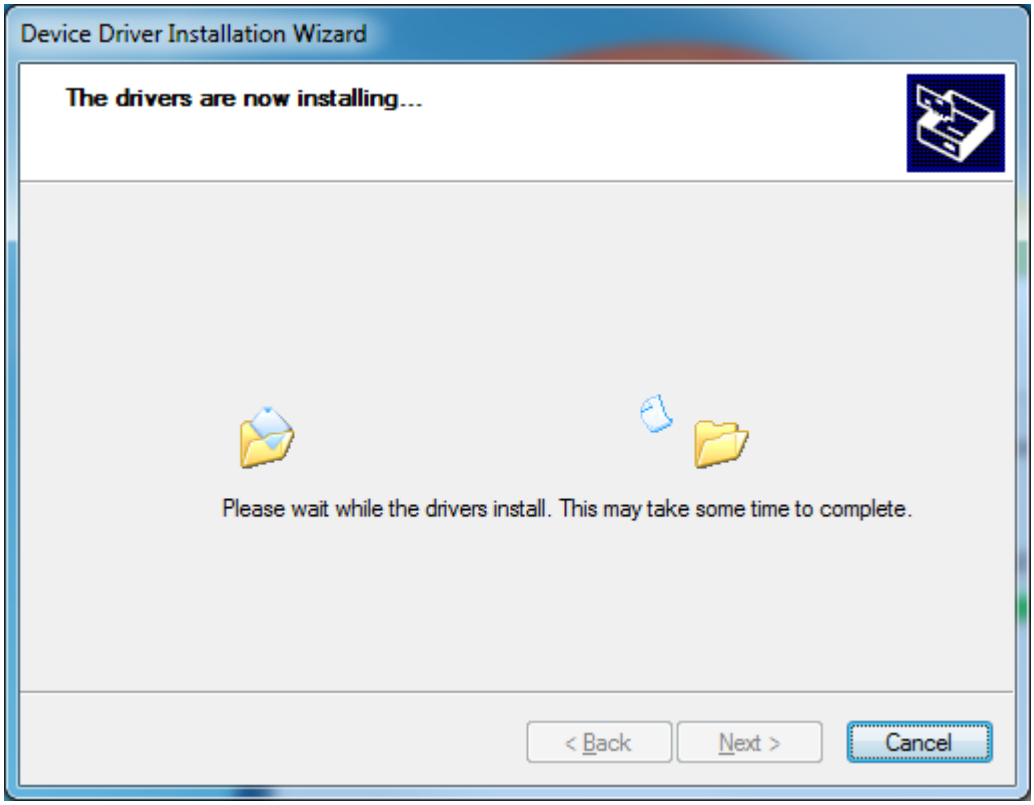

Figure 9. Device Driver Installer In Progress

12. After the driver installation is completed, click "Finish"

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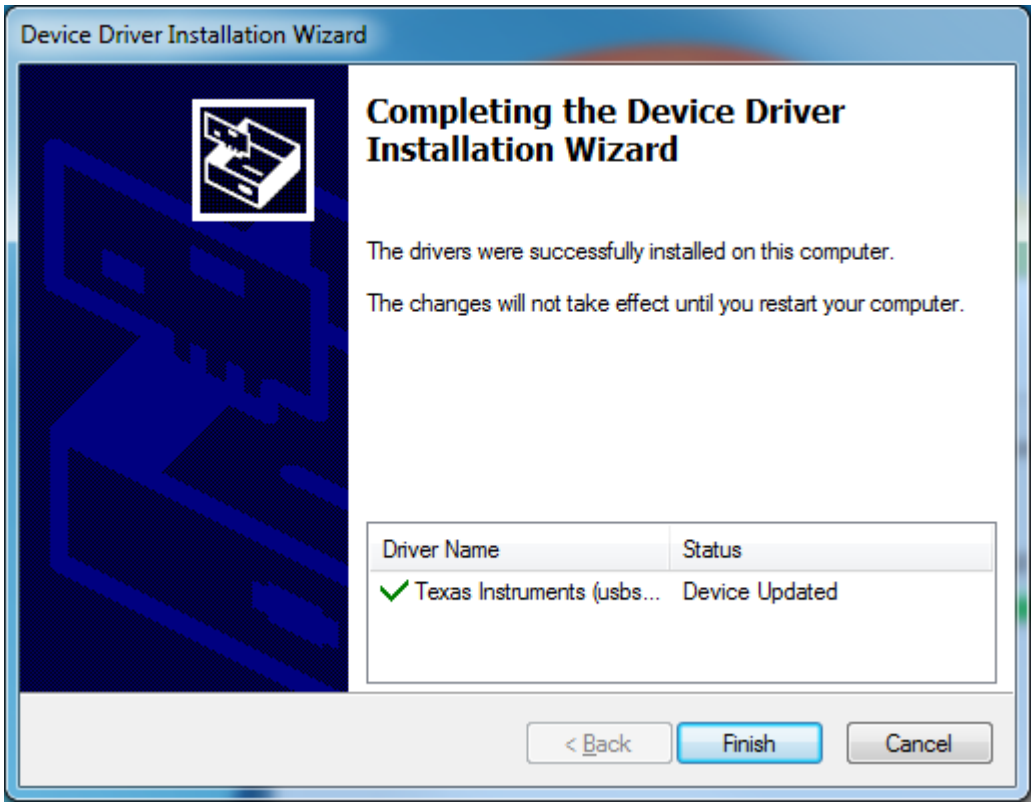

Figure 10. Device Driver Installer Completed

13. Click "Finish" to complete the installation

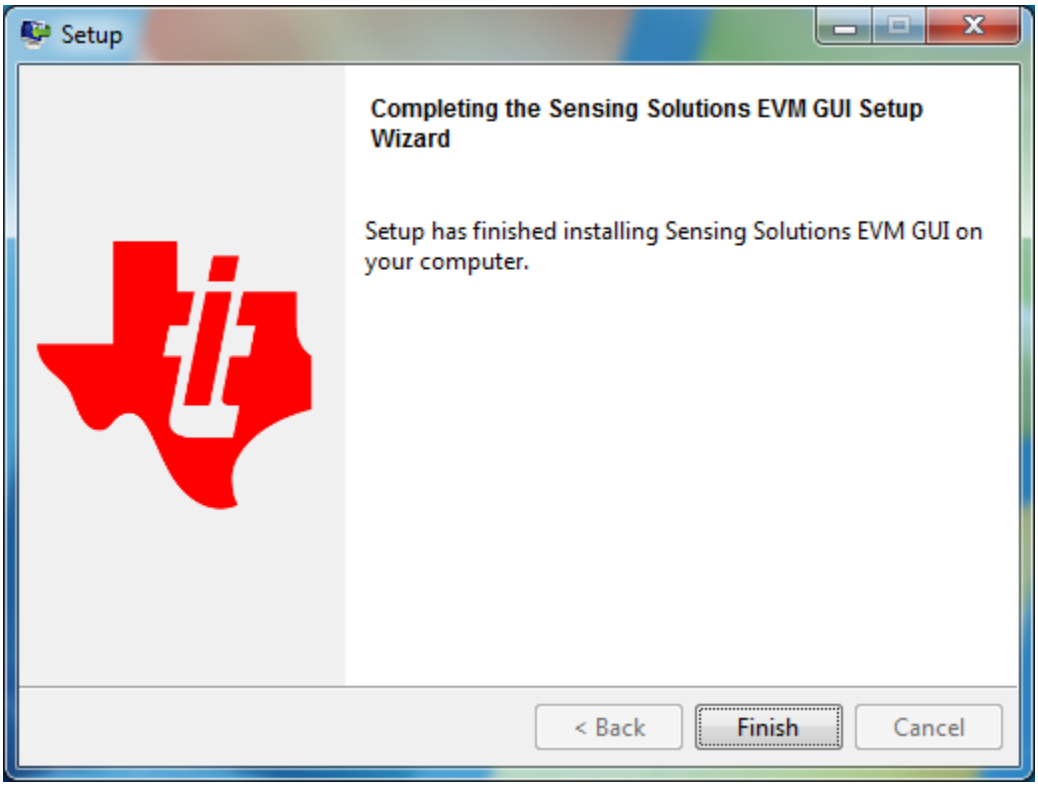

Figure 11. Software Installer Completed

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2.3 Starting the GUI

Follow these steps to start the GUI:

1. Select the Windows start menu
2. Select "All programs"
3. Select "Texas Instruments"
4. Select "Sensing Solutions EVM GUI"
5. Click "Sensing Solutions EVM GUI"
6. Splash screen will appear for at least two seconds

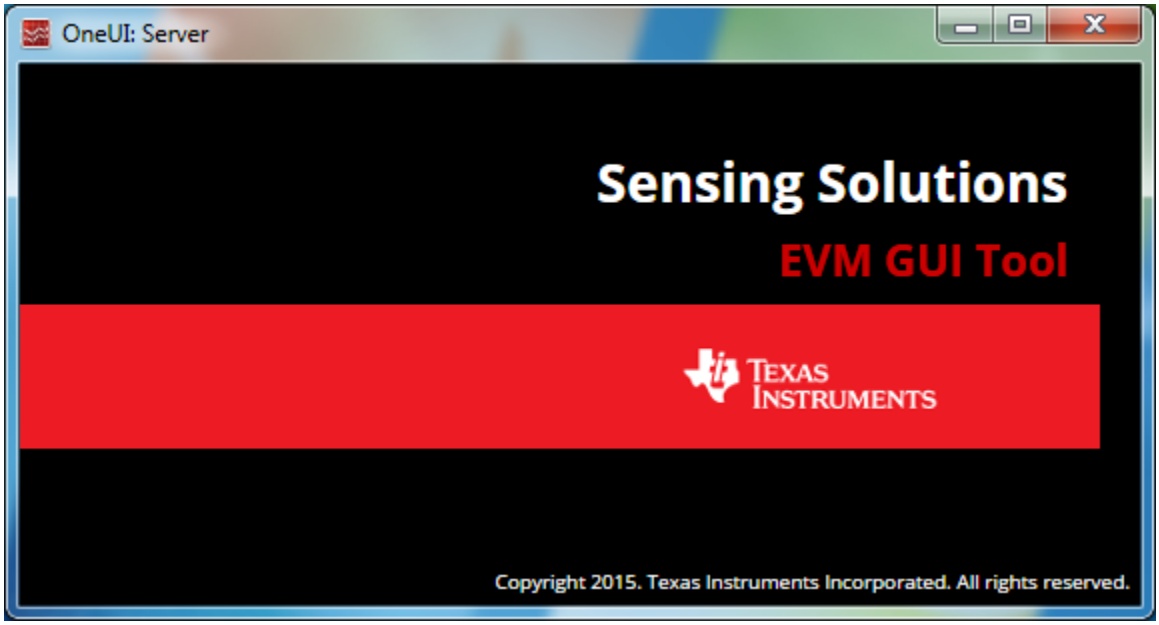

Figure 12. Splash Screen

7. After the splash screen is displayed the main window will open

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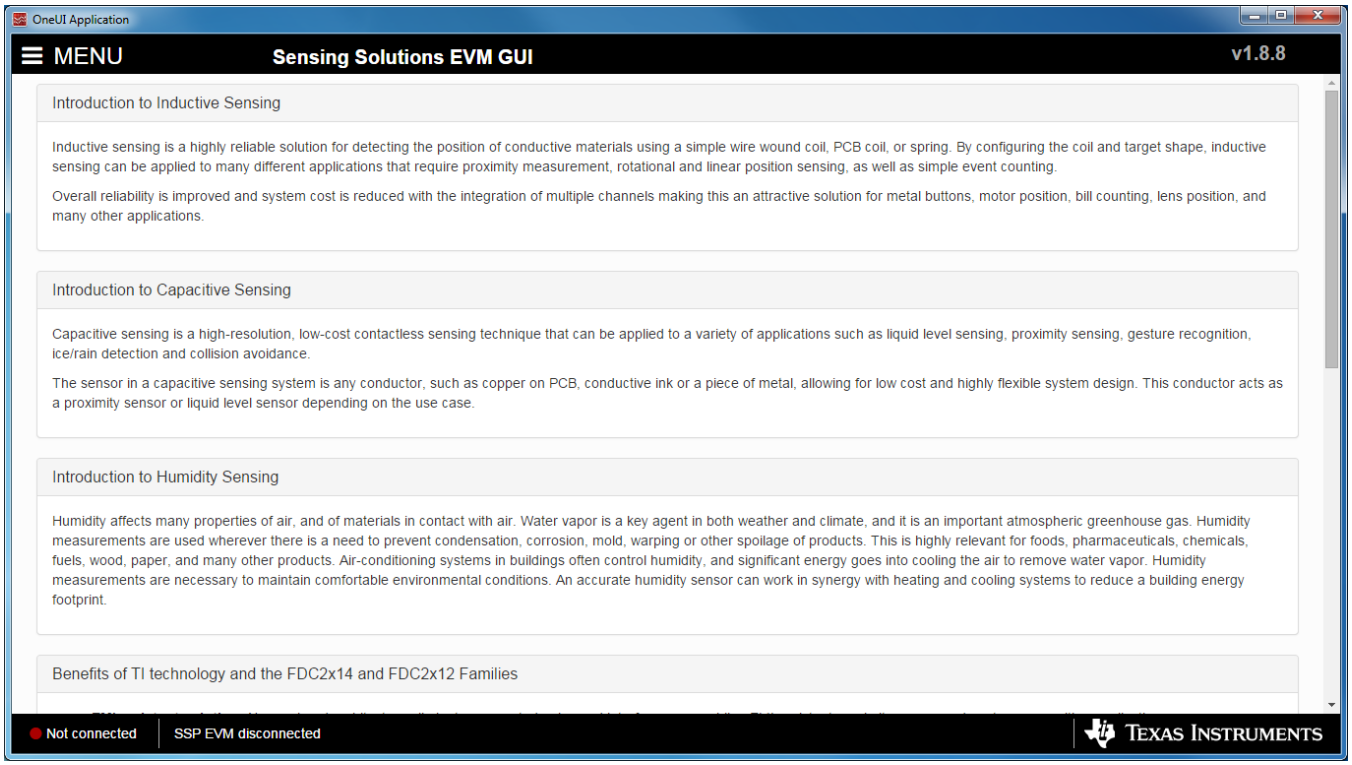

Figure 13. Introduction Page

2.4 Navigating the GUI

To navigate to different pages of the GUI follow these steps:

1. Click “Menu” in the upper left corner

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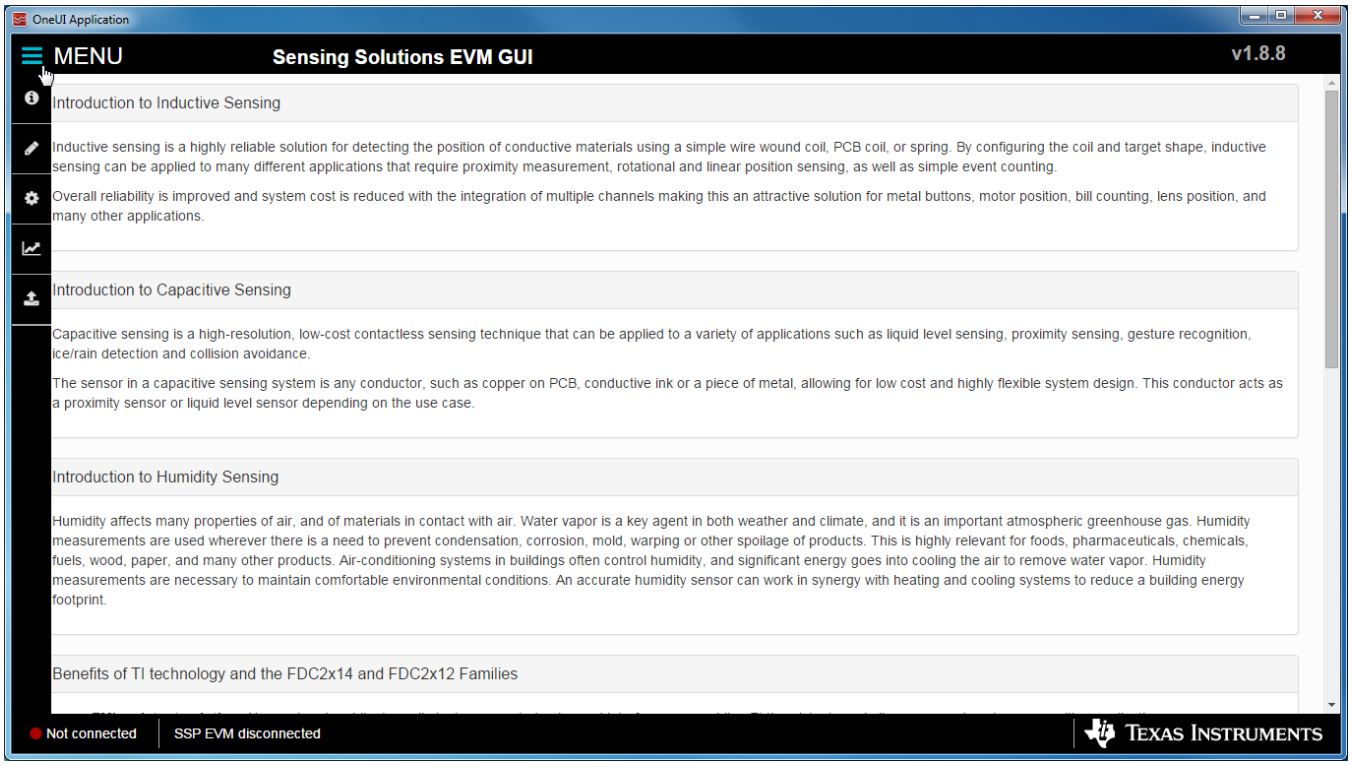

Figure 14. Mouse Hovered Over Menu Button

2. Select the desired page from the menu shown on the left

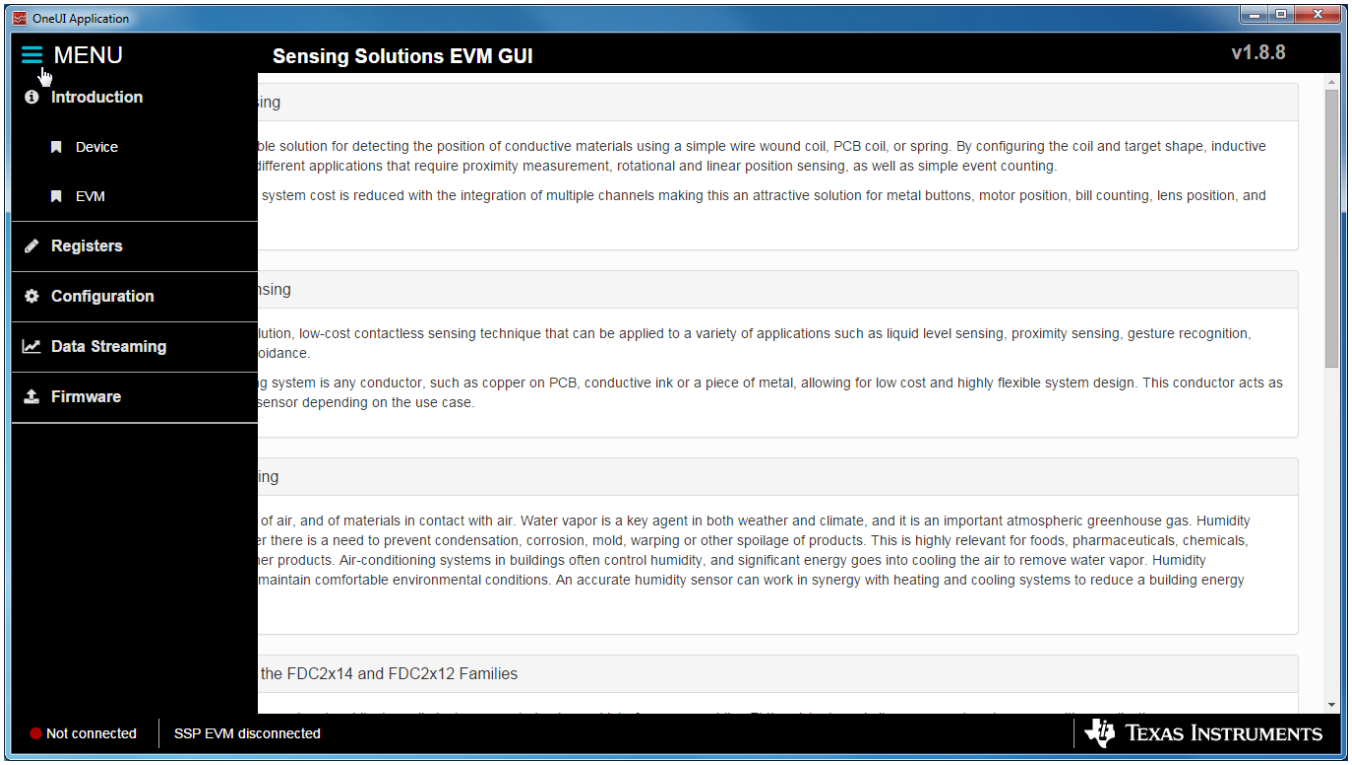

Figure 15. Menu Display After Clicking Button

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2.5 Connecting the EVM

Follow these steps to connect the EVM to the GUI:

1. Attach the EVM to the computer via USB
2. The GUI always shows the connection status on the bottom left corner of the GUI

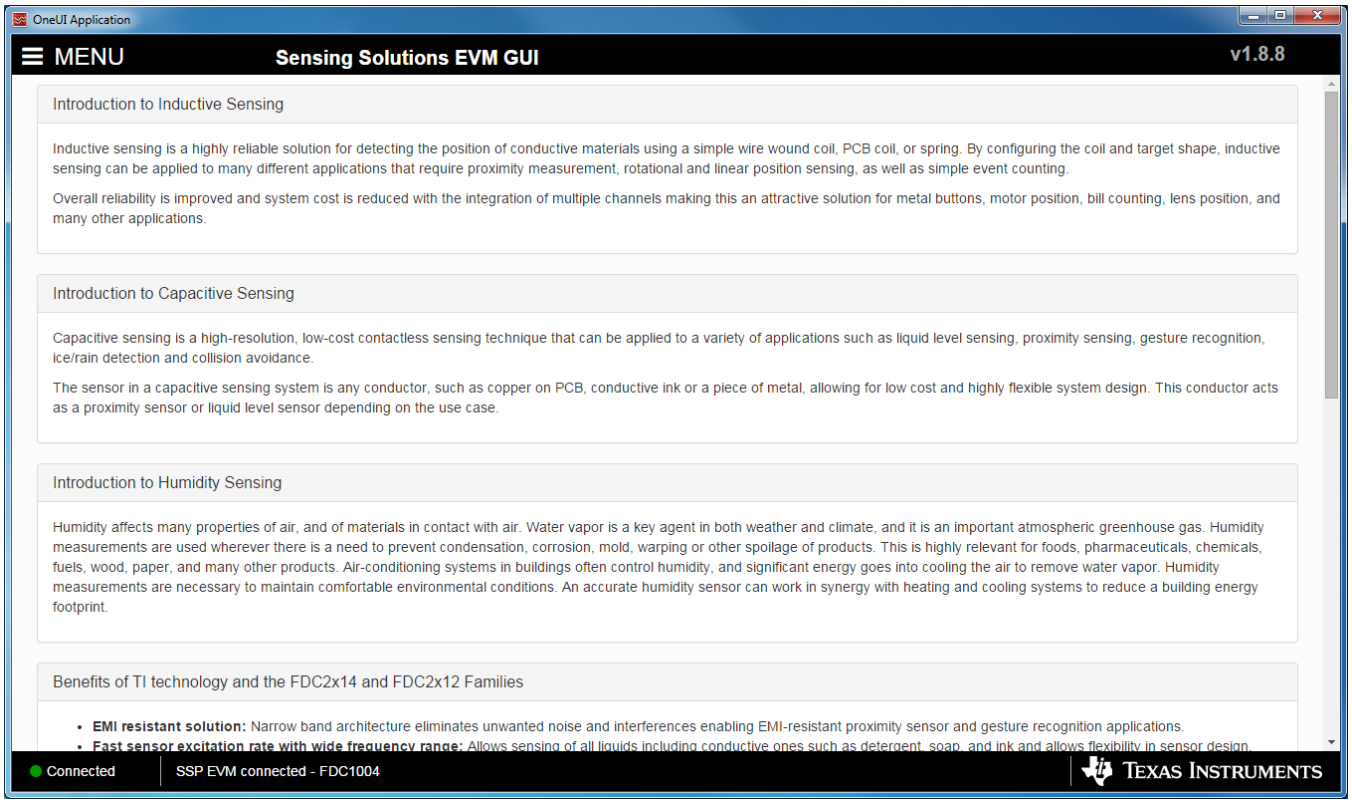

Figure 16. FDC1004 Connected to GUI

2.6 Configuring the EVM Using the Register Page

The register page allows users to control the device directly with the register values. The user may also use this page to read the currect register values on the device.

2.6.1 Automatically Update GUI Register Values Using Auto-Read

Autoread will periodically request the register values on the device. Click the dropdown box next to “Auto Read” to select the update interval.

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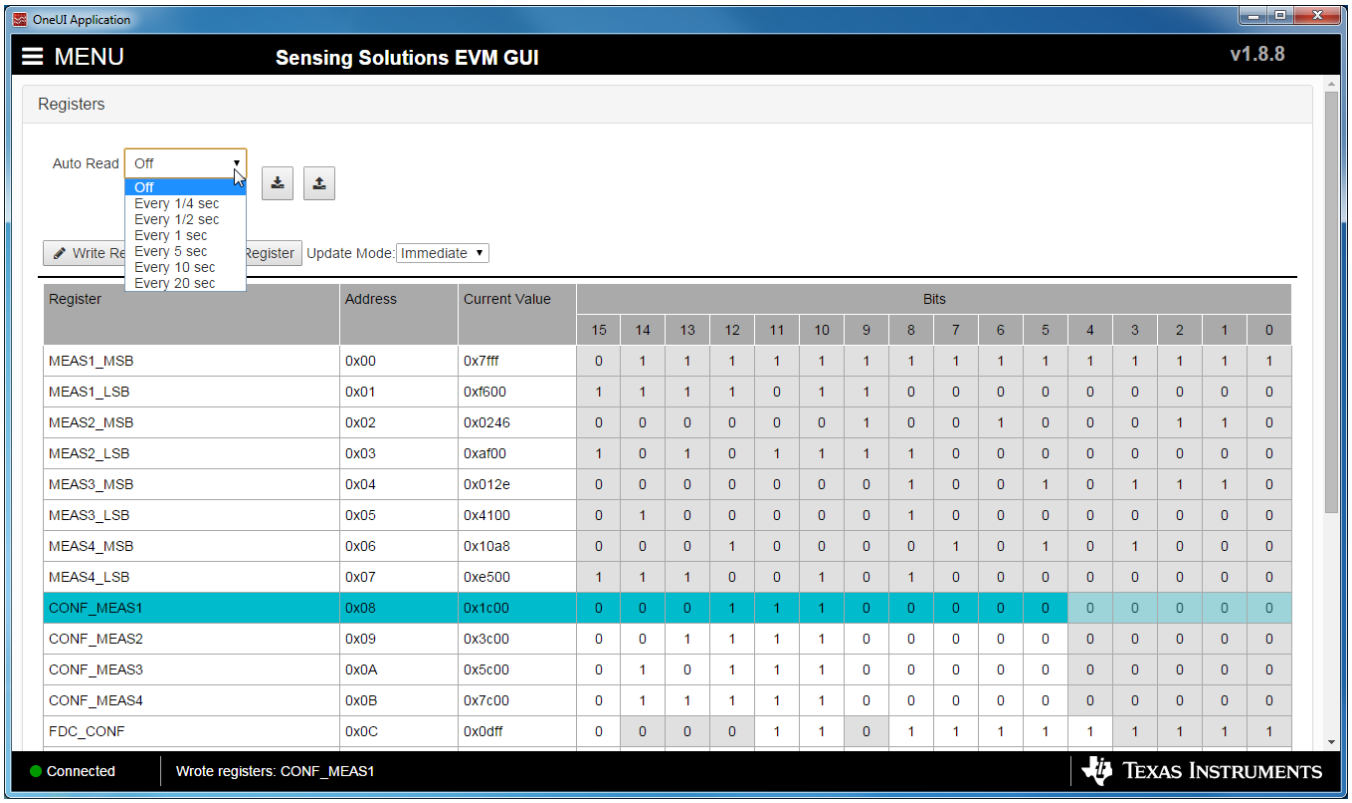

Figure 17. Selecting Auto-Read Interval on Register Page

2.6.2 Manually Update Device Register Values

There are two methods to change register values: update the entire register value or change a single bit within the register. The recommended update mode is always “Immediate” and not “Deferred”. To update register values, follow these steps.

1. Double-click the current value of the register that needs to be changed. The text will turn into an editable text box

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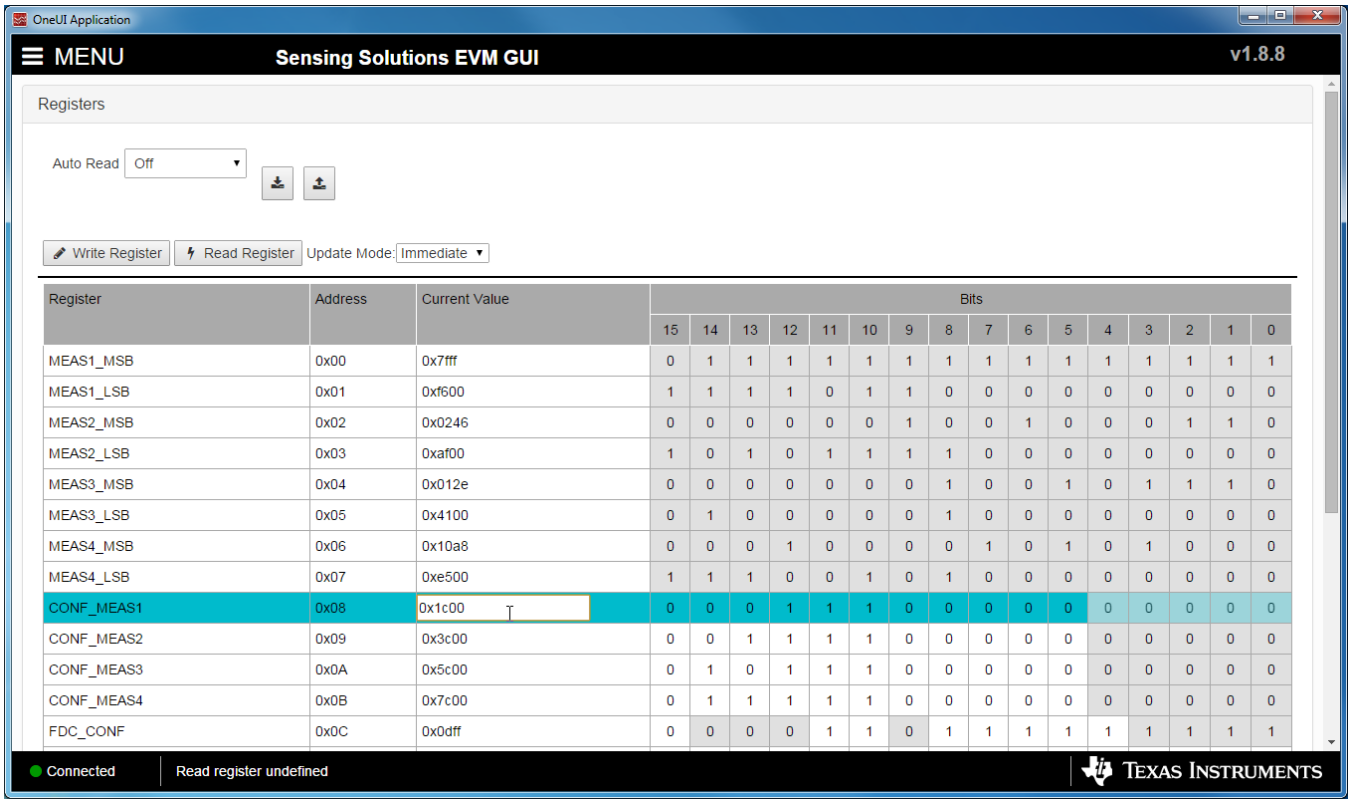

Figure 18. Selecting a Register's Current Value for Editting on Register Page

2. Type the new hexadecimal value into the box and click enter. The text box changes to normal text and the GUI will send a command to the EVM to update the device register

To change individual bit values rather that entire register values follow these steps.

1. Hover the mouse over the desired bit to change

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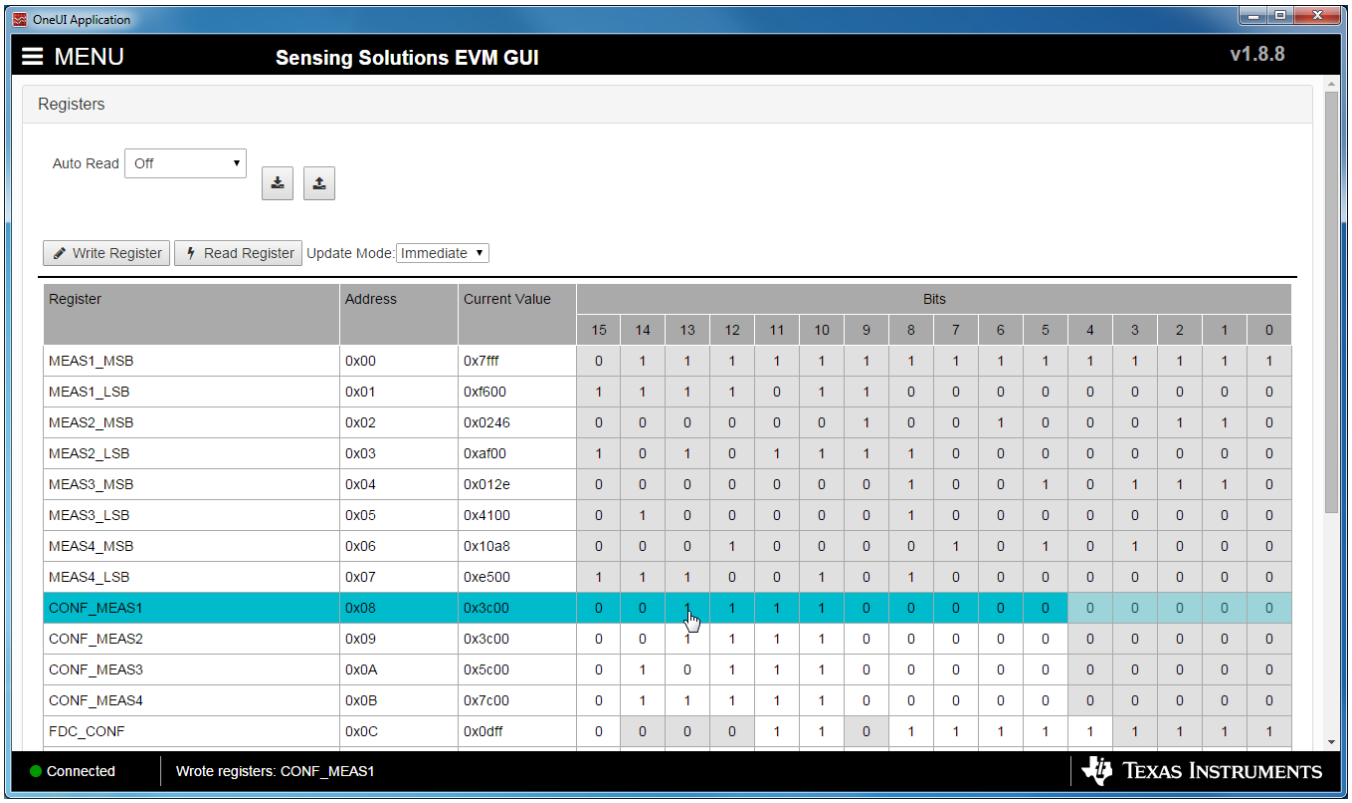

Register	Address	Current Value	Bits															
			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MEAS1_MSB	0x00	0x7fff	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MEAS1_LSB	0x01	0xf600	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0
MEAS2_MSB	0x02	0x0246	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0
MEAS2_LSB	0x03	0xaf00	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MEAS3_MSB	0x04	0x012e	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0
MEAS3_LSB	0x05	0x4100	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MEAS4_MSB	0x06	0x10a8	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0
MEAS4_LSB	0x07	0xe500	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0
CONF_MEAS1	0x08	0x3c00	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS2	0x09	0x3c00	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS3	0x0A	0x5c00	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS4	0x0B	0x7c00	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
FDC_CONF	0x0C	0x0dff	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1

Figure 19. Hovering Mouse Over Register Bit Value on Register Page

2. Double-click the bit to toggle its value and the register's current value will update automatically

2.6.3 Reading Register Values without Auto-Read

To read register values follow these steps.

1. Select the register to update by clicking any column of the register row in the table

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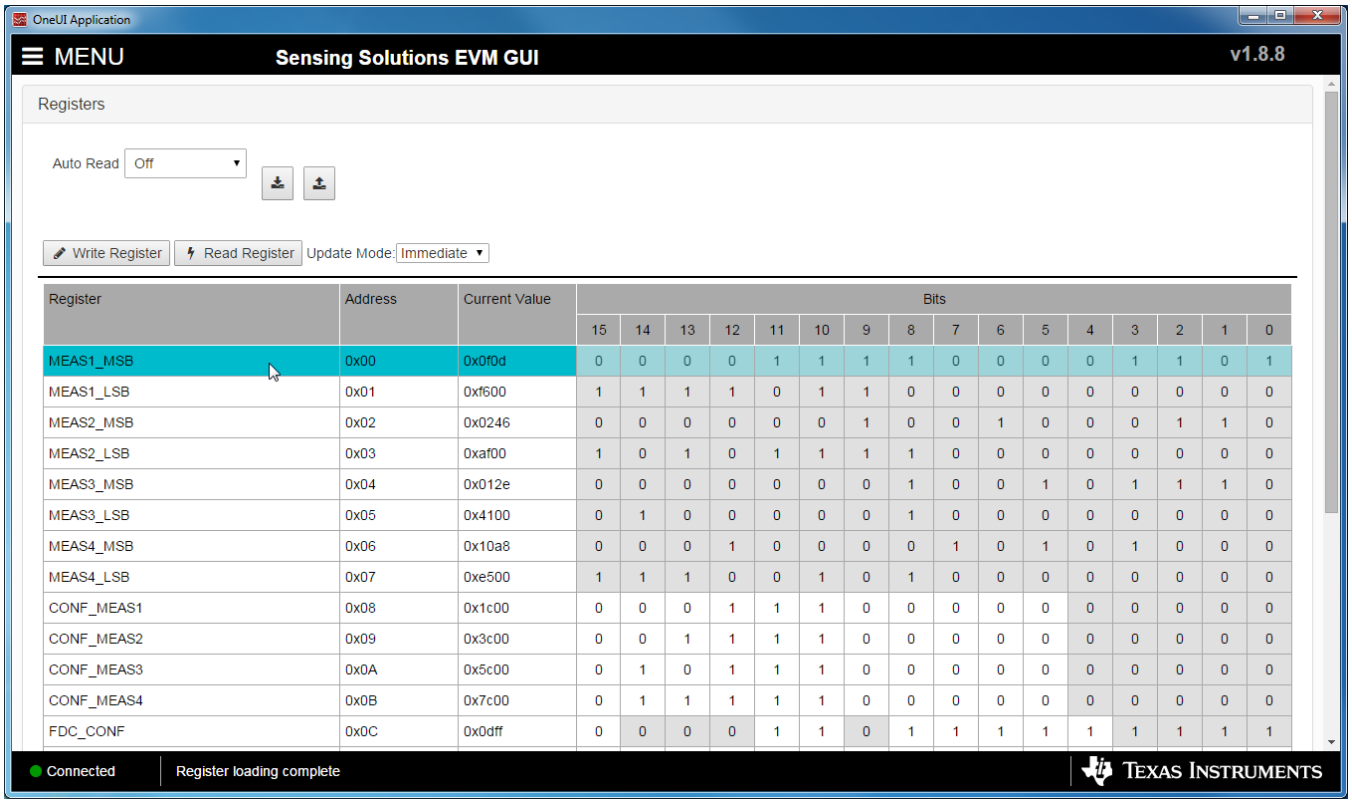

Register	Address	Current Value	Bits															
			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MEAS1_MSB	0x00	0x0f0d	0	0	0	0	1	1	1	1	0	0	0	0	1	1	0	1
MEAS1_LSB	0x01	0xf600	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0
MEAS2_MSB	0x02	0x0246	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0
MEAS2_LSB	0x03	0xaf00	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MEAS3_MSB	0x04	0x012e	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0
MEAS3_LSB	0x05	0x4100	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MEAS4_MSB	0x06	0x10a8	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0
MEAS4_LSB	0x07	0xe500	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0
CONF_MEAS1	0x08	0x1c00	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS2	0x09	0x3c00	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS3	0x0A	0x5c00	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS4	0x0B	0x7c00	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
FDC_CONF	0x0C	0x0dff	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1

Figure 20. Selecting a Register on Register Page

2. Click the “Read Register” button to update the selected register’s current value and bit values in the table

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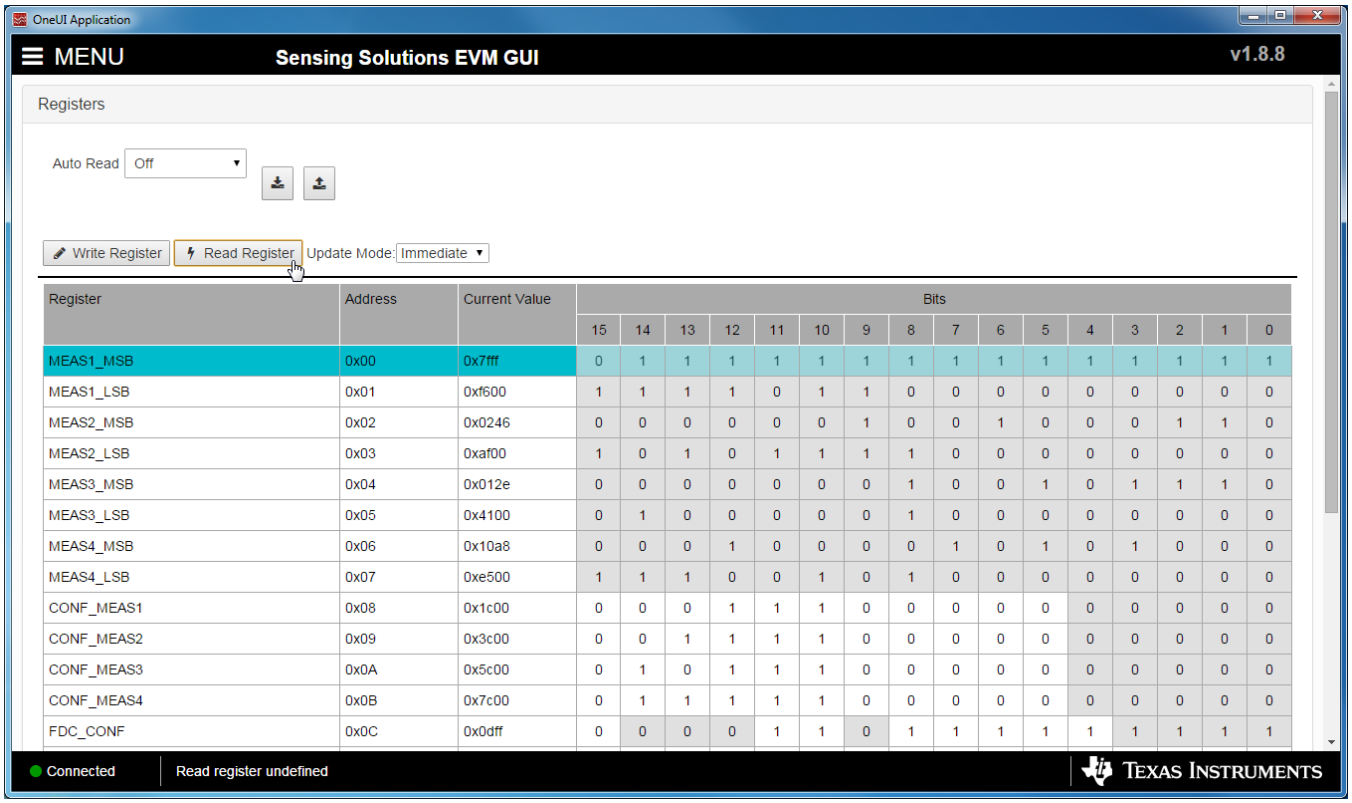

Figure 21. Reading the Current Device Register Value on Register Page

2.6.4 Saving Device Configurations

To save the current register settings of the device follow these steps.

1. Click the button immediately right to the “Auto-Read” selection dropdown

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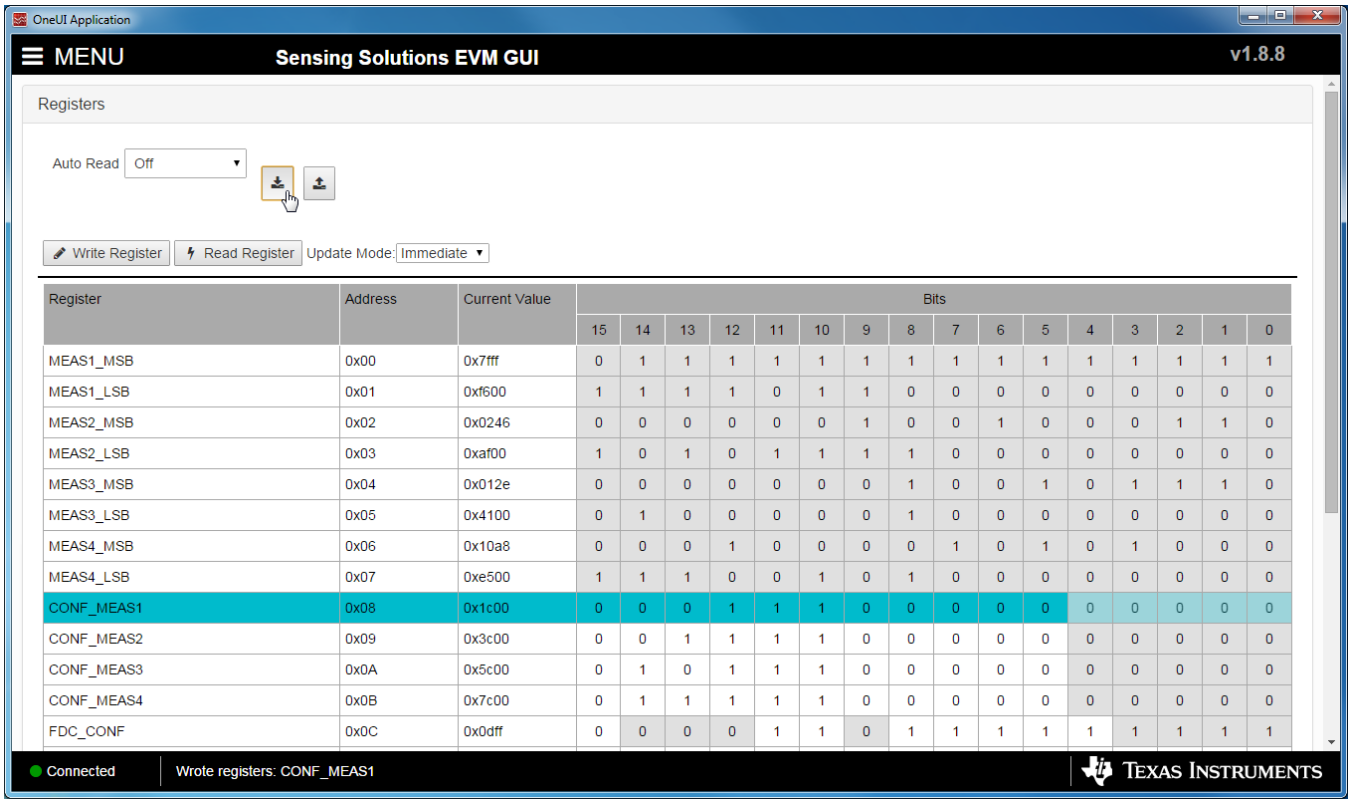

Figure 22. Save Register Values to File on Register Page

2. Choose a name for the JSON file and the directory to save it within. Then click “Save”

2.6.5 Loading Previously Saved Configurations

To load previously saved register settings from a JSON file follow these steps.

1. Click the button furthest right from the “Auto-Read” selection dropdown

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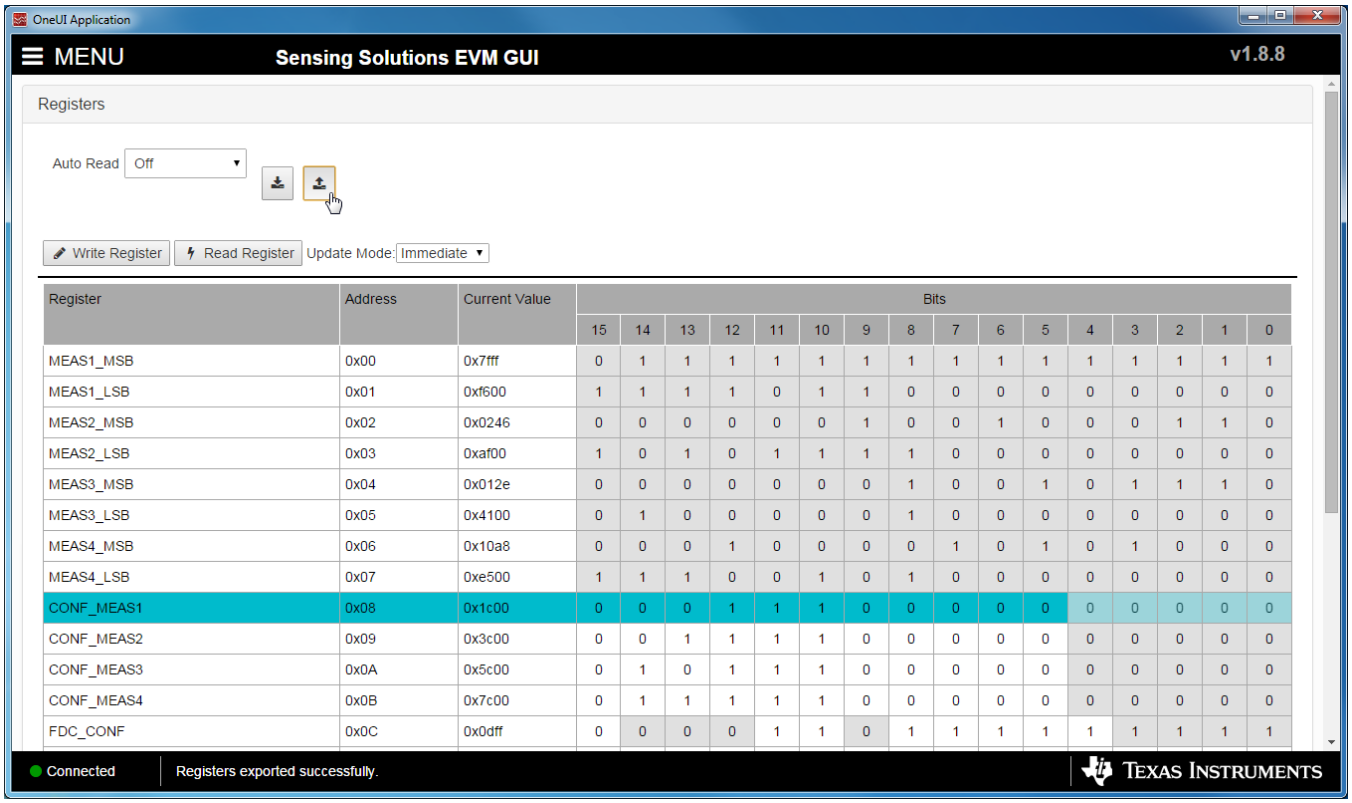

Register	Address	Current Value	Bits															
			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MEAS1_MSB	0x00	0x7fff	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MEAS1_LSB	0x01	0xf600	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0
MEAS2_MSB	0x02	0x0246	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0
MEAS2_LSB	0x03	0xaf00	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
MEAS3_MSB	0x04	0x012e	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0
MEAS3_LSB	0x05	0x4100	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MEAS4_MSB	0x06	0x10a8	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0
MEAS4_LSB	0x07	0xe500	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0
CONF_MEAS1	0x08	0x1c00	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS2	0x09	0x3c00	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS3	0x0A	0x5c00	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
CONF_MEAS4	0x0B	0x7c00	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
FDC_CONF	0x0C	0x0dff	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1

Figure 23. Loading Previously Saved Register Values from File on Register Page

2. Select the JSON file with the desired settings and click “Open”

2.7 Configuring the EVM Using the Configuration Page

The Sensing Solutions GUI is capable on configuring the device more intuitively than the direct register values. The "Configuration" page provides an easy-to-use tool for updating the device configuration and provides additional information about how the device will perform.

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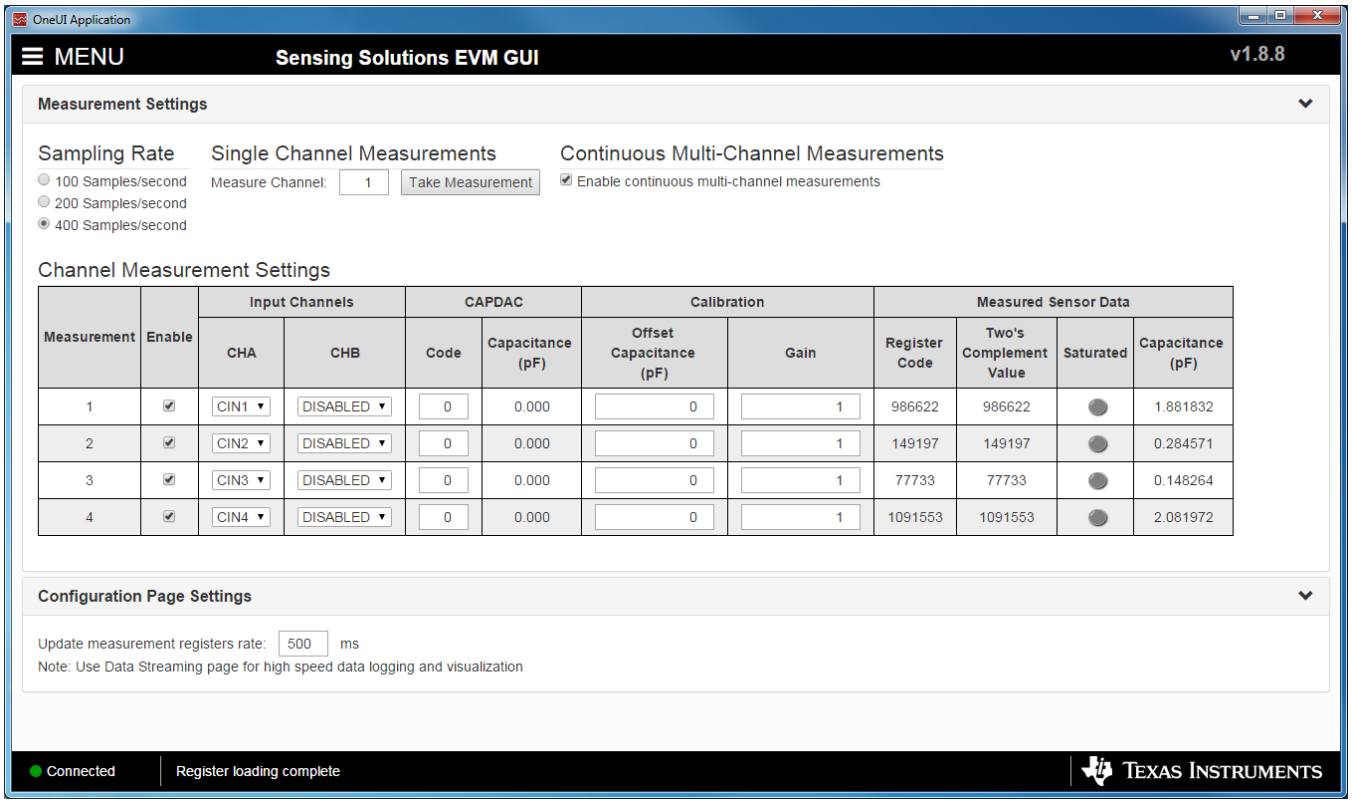

Figure 24. Configuration Page

The FDC1004 measures in a round robin mode and can make up to four measurements. If all four measurements are enabled and the sample rate is 400 samples per second new data for all four measurements would be available at a rate of 100 Hz. If a single measurement were enabled rather than all four, again with the sampling rate set to 400 samples per second, new data for the single measurement would be available at a rate of 400 Hz.

To make a single measurement only once, select the measurement channel and click "Take Measurement". This will disable the "Enable continuous multi-channel measurements" setting. Continuous measurements must be enabled for the data streaming function of the GUI and EVM.

Please reference the FDC1004 datasheet for more information regarding individual measurement settings.

2.8 Streaming Measurement Data

The Sensing Solutions GUI and EVM provide a tool to capture, display, and log measurement data. The section describes how to use the data measurement tools from the "Data Streaming" page accessible from the GUI menu.

2.8.1 Choosing the Graph and Visible Channels

Select the drop down menu on top of the y-axis to choose the graph to display.

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Figure 25. Select the Data Graph on Data Streaming Page

To select which channel measurements are displayed in the graph, check or uncheck the available channels shown next to the graph units. Selecting or not selecting the channels only affects the graph and not the data logged to a file. If a channel is not enabled in the Configuration page it will not appear on the Data Streaming page.

2.8.2 Logging Data to a File

Follow these steps to log measurement data to a file.

1. Click the button in the upper right under next to "Click to Select Log File"

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Figure 26. Select Log File Button on Data Streaming Page

2. Select a file name and directory to save the data to and then click the “Save” button
3. Whenever data streaming is running the data for all channels will be logged to this file. The selected file is shown next to the button.

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Figure 27. Selected Log File Shown on Data Streaming Page

2.8.3 Starting and Stopping Data Streaming

To start data streaming click the “Start” button.

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Figure 28. Start Button on Data Streaming Page

To stop data streaming click the “Stop” button.

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Figure 29. Stop Button on Data Streaming Page

2.8.4 Data Statistics

Click the “Show Statistics” button to view the measurement statistics.

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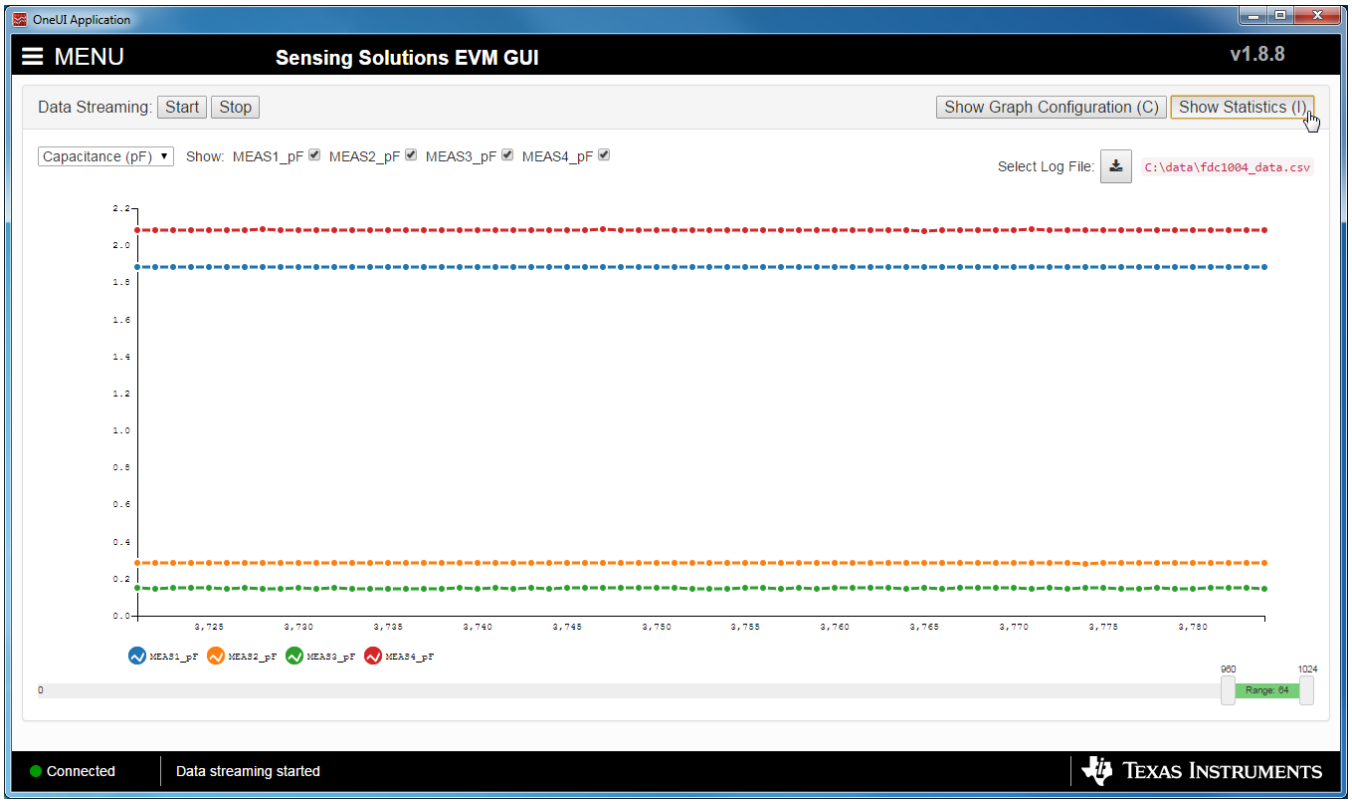

Figure 30. Show Statistics Button on Data Streaming Page

Click the “Hide Statistics” button to hide the measurement statistics.

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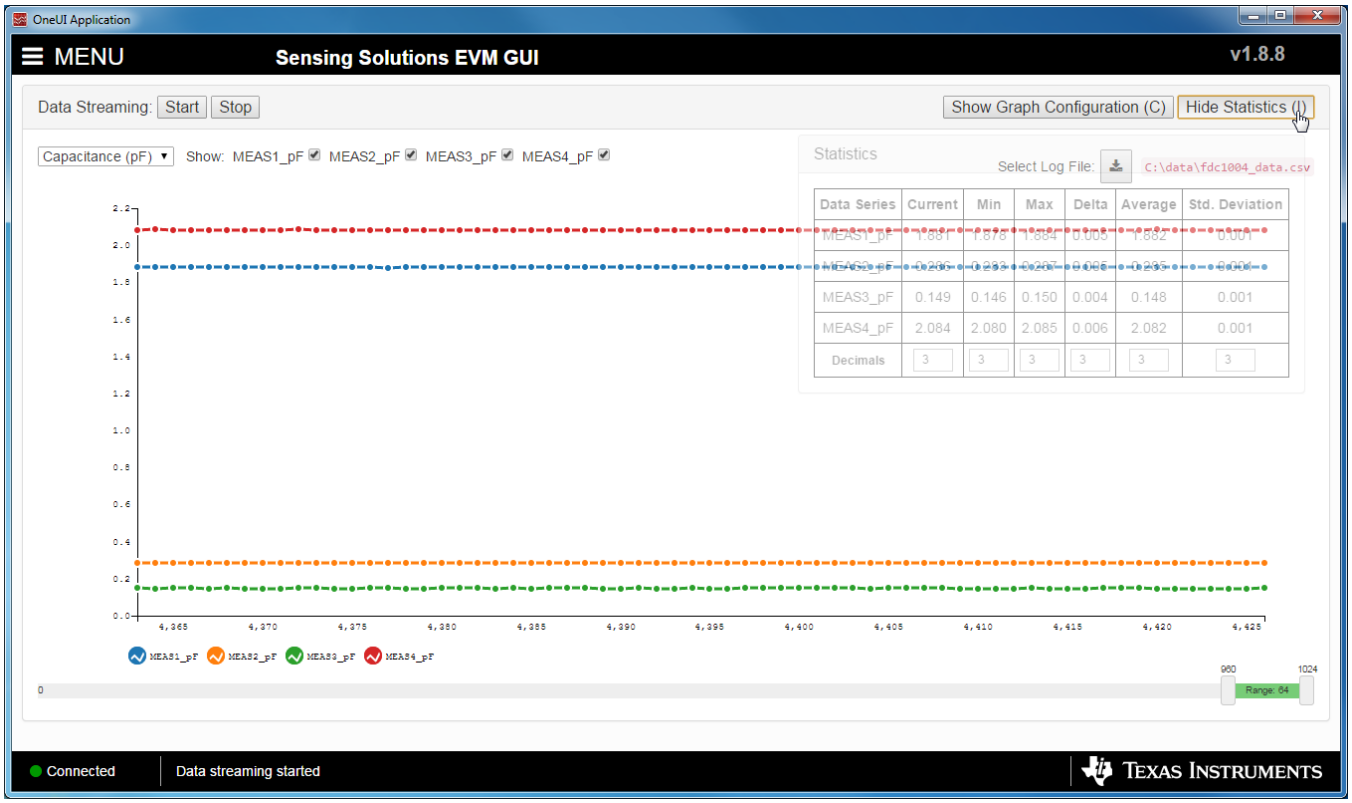

Figure 31. Hide Statistics Button on Data Streaming Page

2.8.5 Configuring the Graph

To configure the graph, click the "Show Graph Configuration" button.

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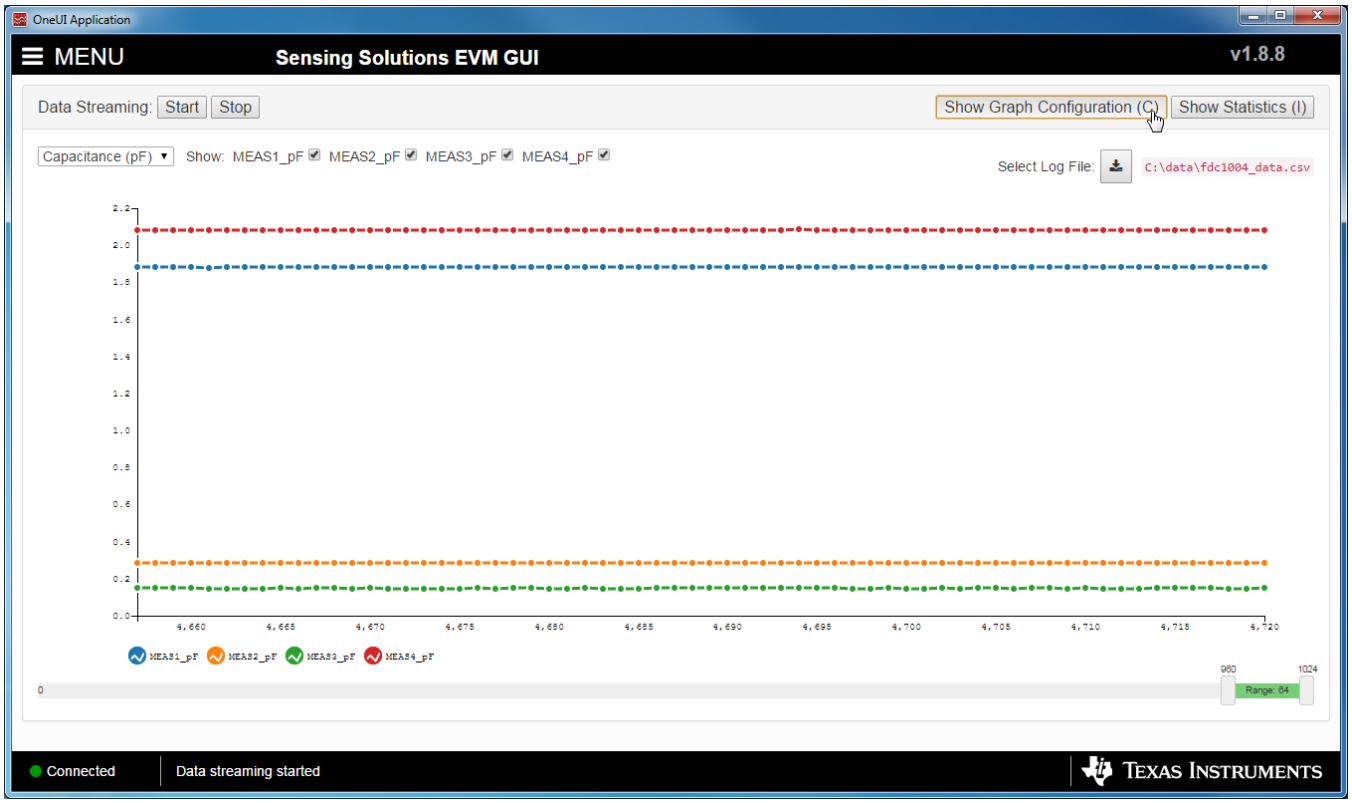

Figure 32. Show Graph Configuration Button on Data Streaming Page

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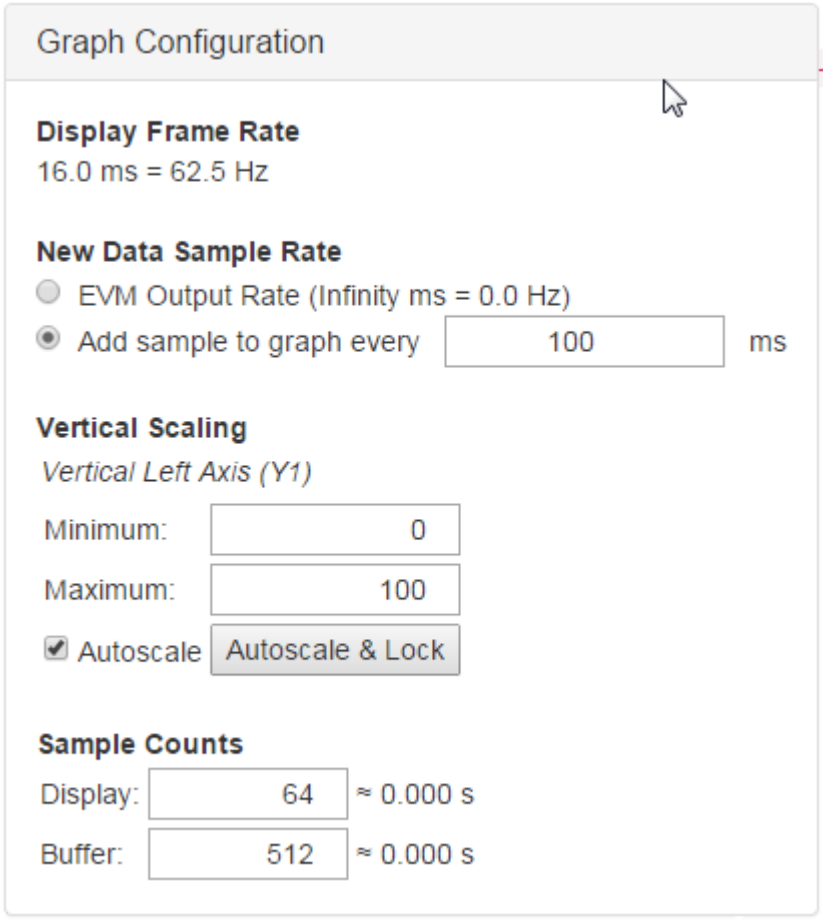

Figure 33. Graph Configuration Button on Data Streaming Page

The configuration window displays the actual frame rate of the graph, the rate at which data is added to the graph, the vertical scaling, and the sample buffer size. The display rate is the rate at which the graph updates on the computer display and is not configurable. It is automatically optimized by the GUI.

The "New Data Sample Rate" allows the user to choose when new data is added to the graph. Selecting "EVM Output Rate" will display data on the graph as fast as is available from the EVM. This should not be confused with the actual sampling rate of the device on the EVM which could be different. The "Add sample to graph every ... ms" will add a new sample to the graph at the specified rate.

The "Verical Scaling" allows the user to either manually set the minimum and maximum values of the y-axis on the graph or use auto-scaling. The "Autoscale & Lock" button scales the graph based on the data of the current display and then locks those vertical scaling settings.

The "Sample Counts" allows the user to specify the number of samples displayed on the graph and the total number of samples stored in the buffer. Please note the buffer size does not affect data logging to a file.

To hide the configuration window, click the "Hide Graph Configuration" button.

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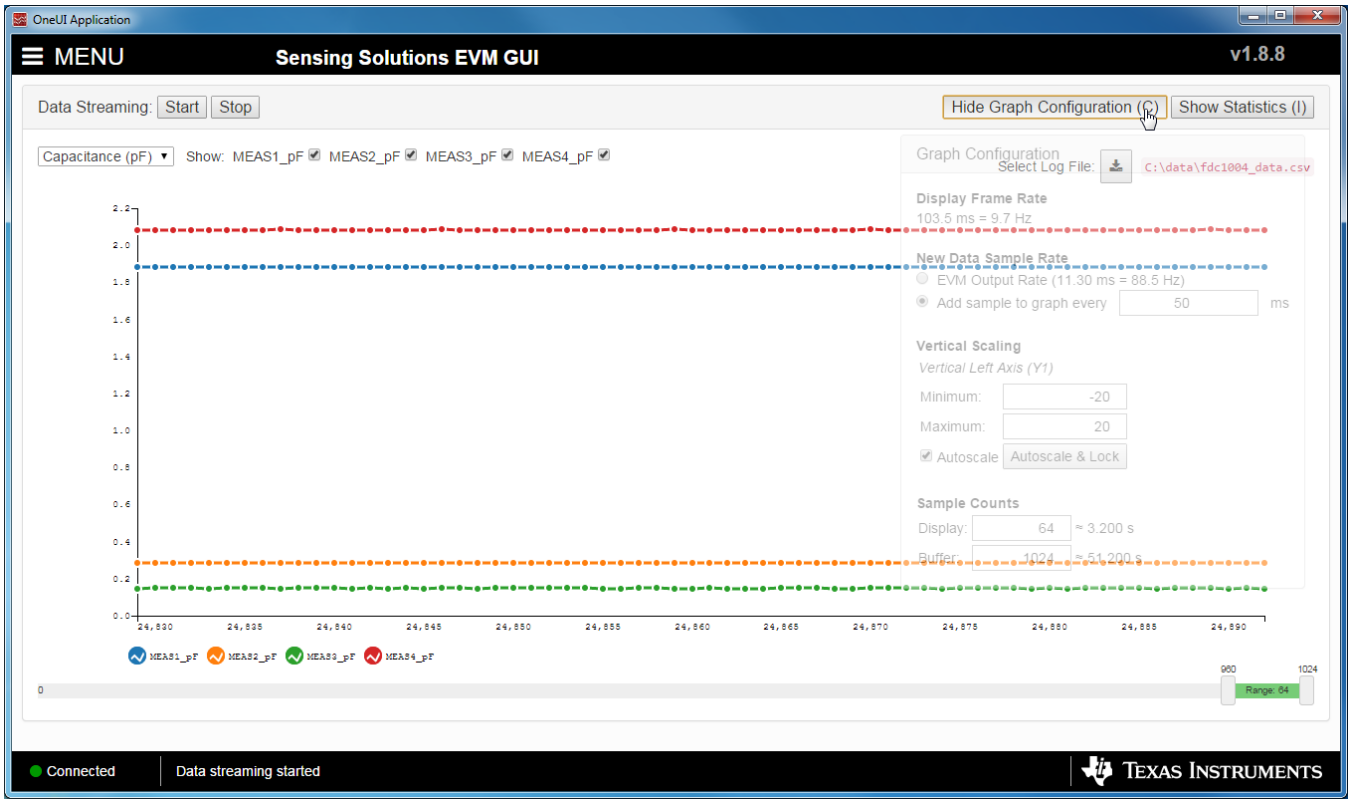

Figure 34. Hide Graph Configuration Button on Data Streaming Page

2.8.6 Navigating the Data Streaming Buffer

The Sensing Solutions EVM GUI stores a buffer of data samples and then displays a subset of those samples. The data buffer can be navigated using the horizontal slider below the graph. To show more samples on the graph, click either the slider on the left or right side of the green bar and drag it closer or further from the other slider. The number of samples displayed is shown between the left and right sliders in the green bar.

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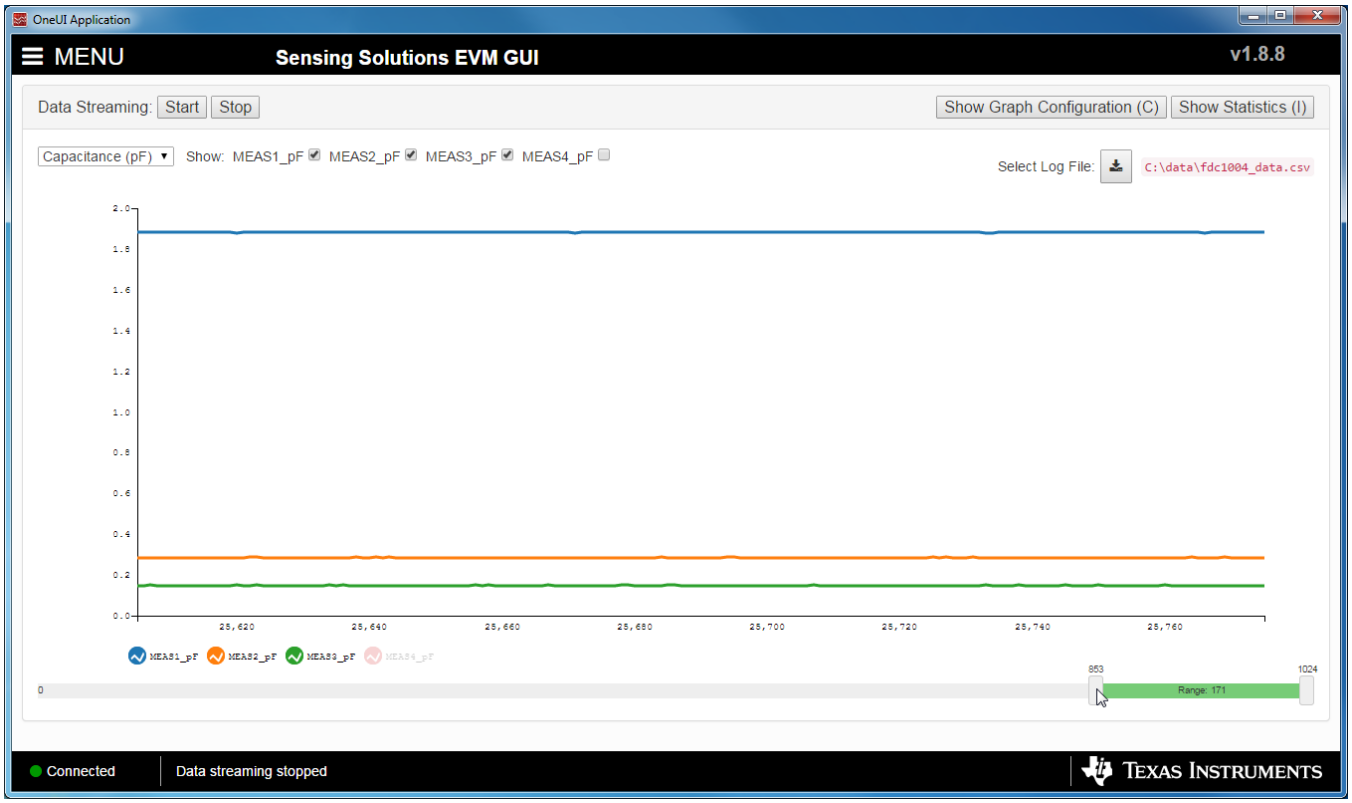

Figure 35. Changing Number of Samples Displayed in Data Graph

By clicking on the green bar and dragging the mouse left or right, previous samples in the buffer can be displayed.

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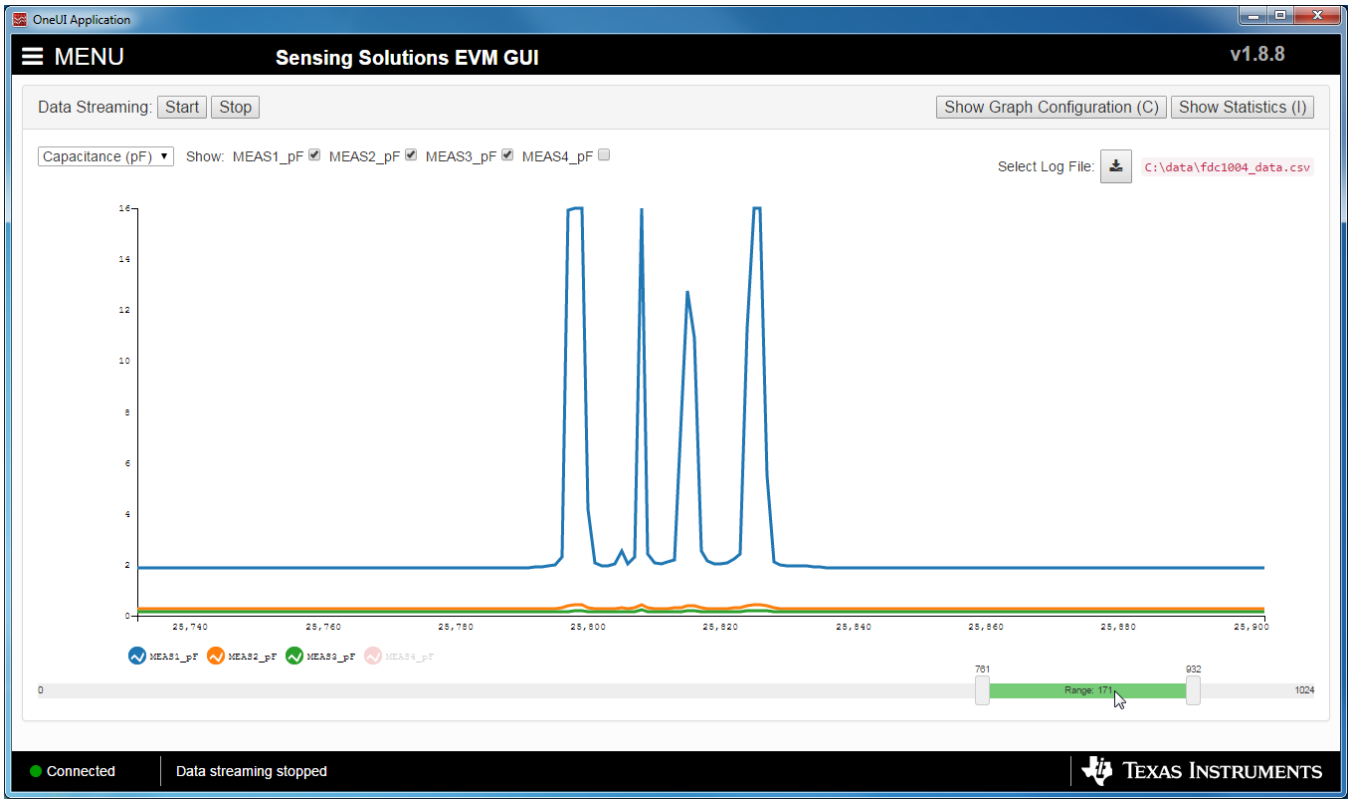

Figure 36. Displaying Previous Data Samples on the Data Streaming Page

2.9 Updating the EVM Firmware

To upload new firmware to the EVM, navigate to the "Firmware" page from the GUI menu and follow these steps. The images below show uploading the FDC2214 EVM firmware, but the steps are identical for any LDC, FDC, or HDC EVM when using their respective firmware files.

1. Click the button to select a TI-TXT firmware file

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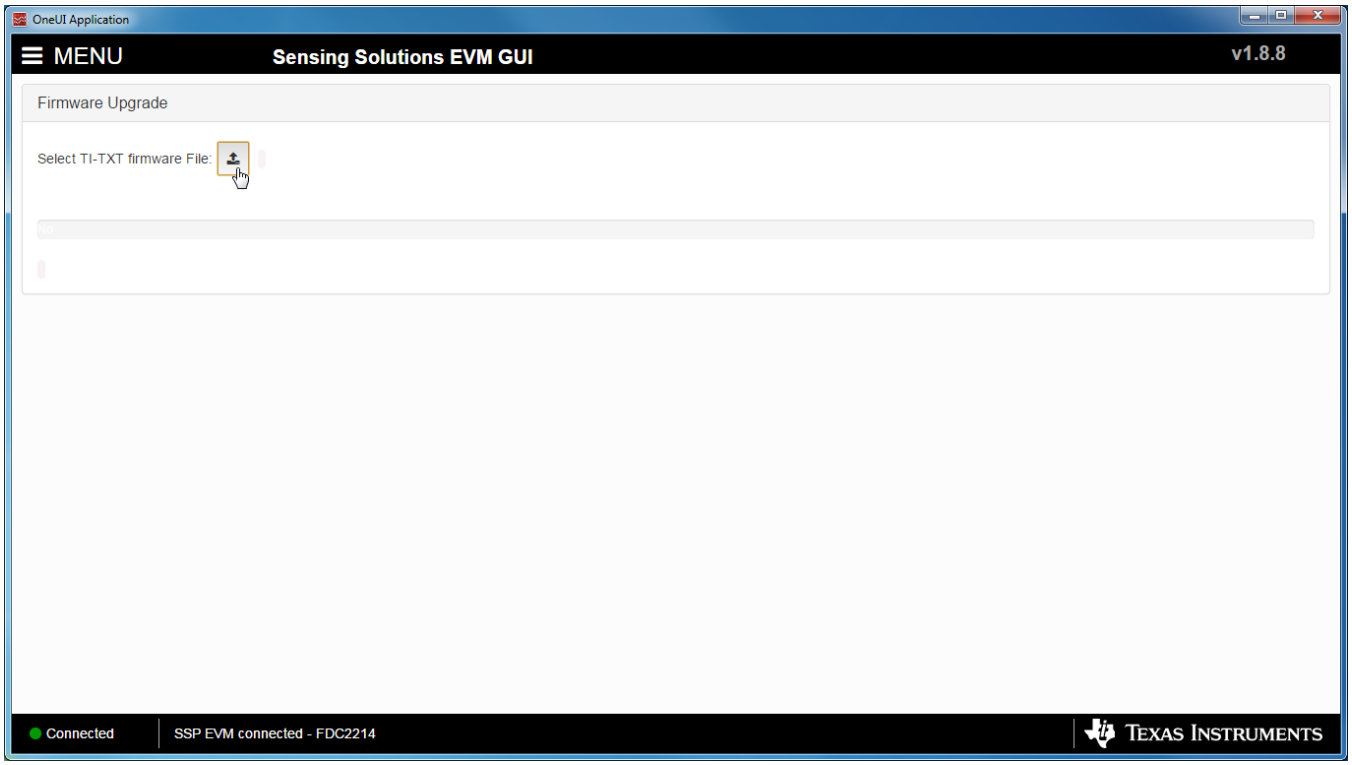

Figure 37. Select TI-TXT File Button on Firmware Upload Page

2. Select the firmware file and click “Open”

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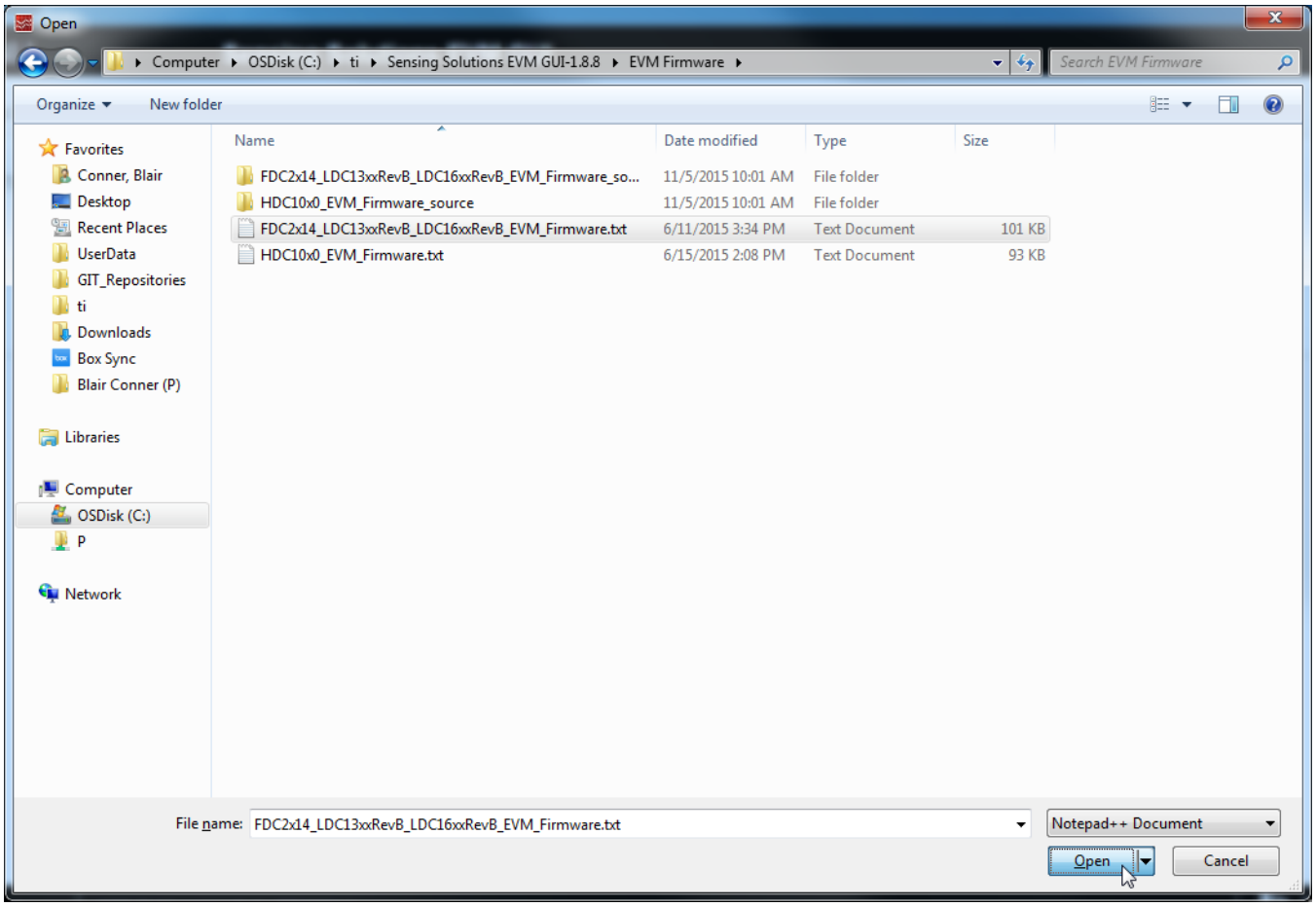

Figure 38. Selecting TI-TXT Firmware File for Upload to EVM

3. Click the “Upload Firmware” button

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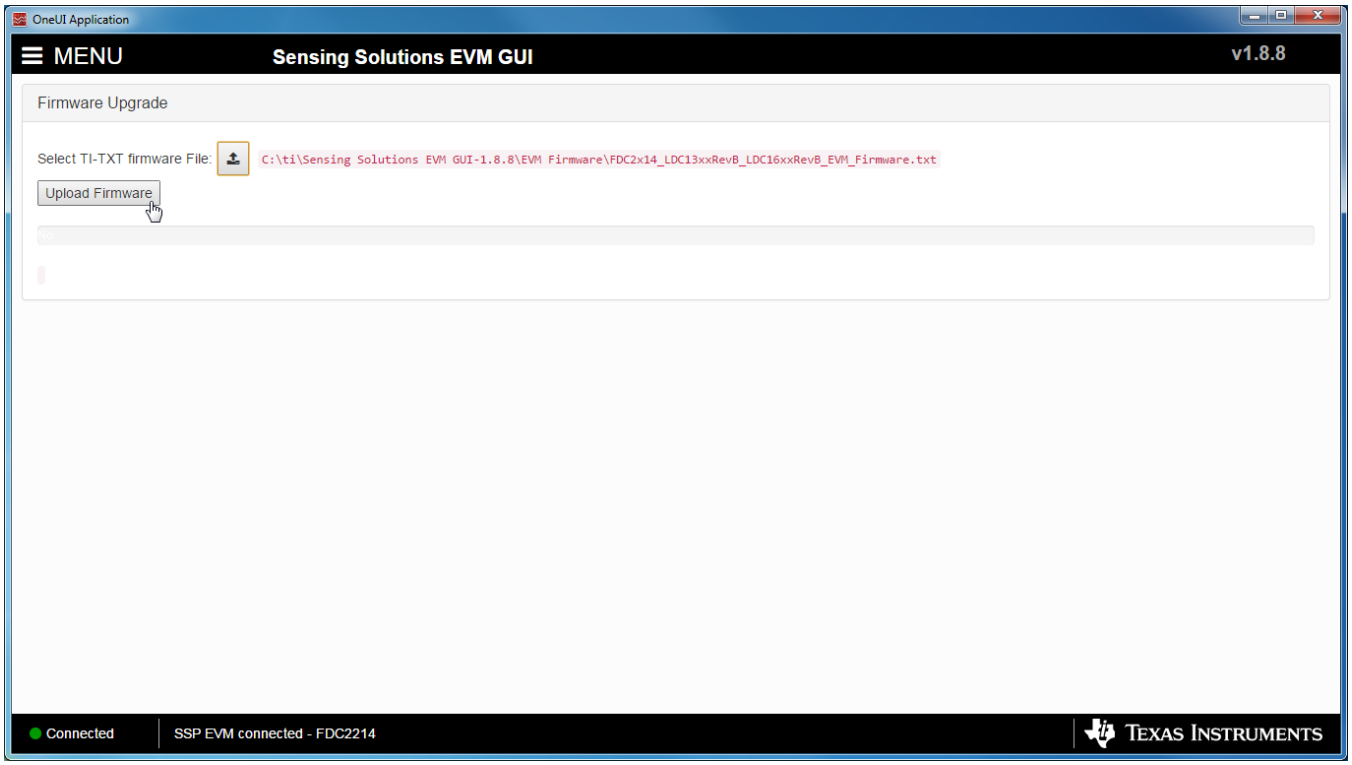

Figure 39. Upload Firmware Button on Firmware Upload Page

4. Wait for the firmware to upload. Do NOT disconnect the EVM from the PC at this time! Also note that the GUI will disconnect from the EVM. The upload process should not take more than one minute. If the upload fails or lasts longer than one minute, unplug the EVM and restart the GUI.

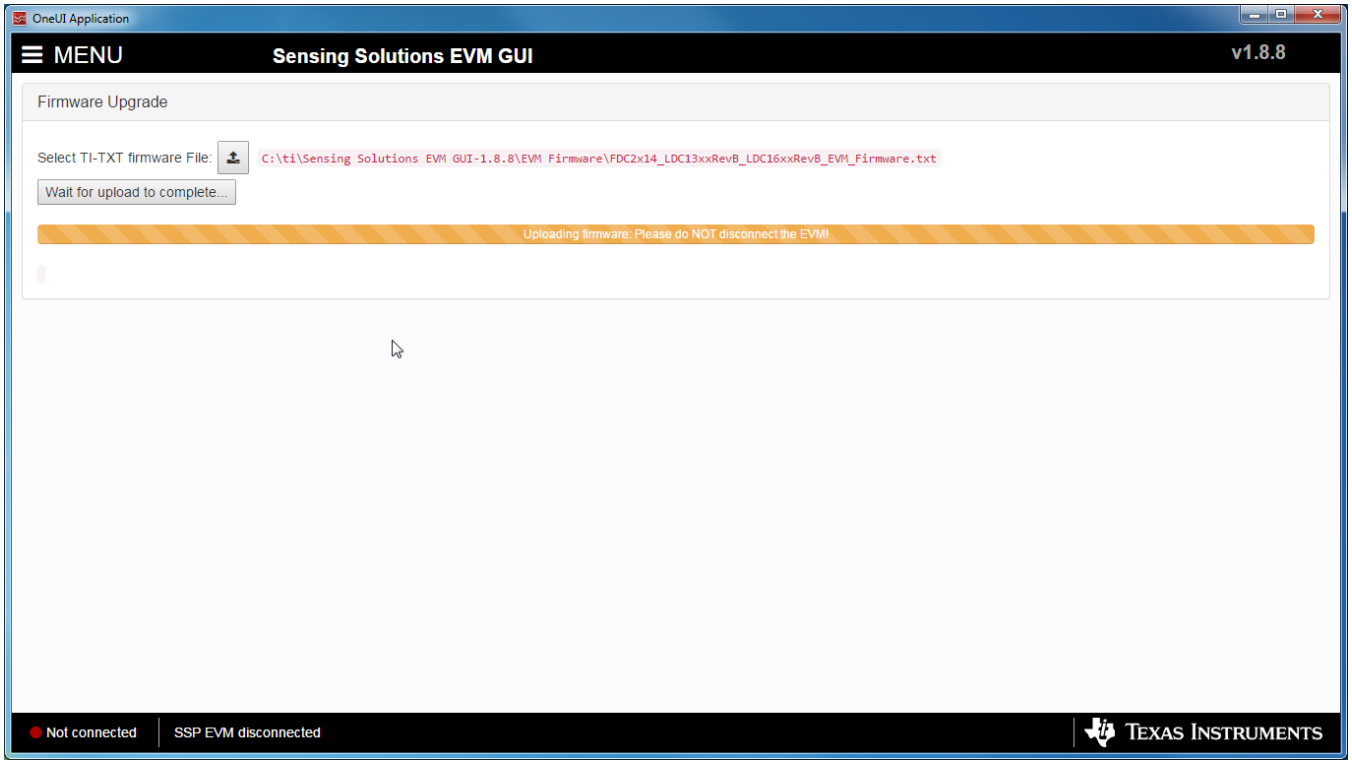

Figure 40. Firmware Upload in Progress

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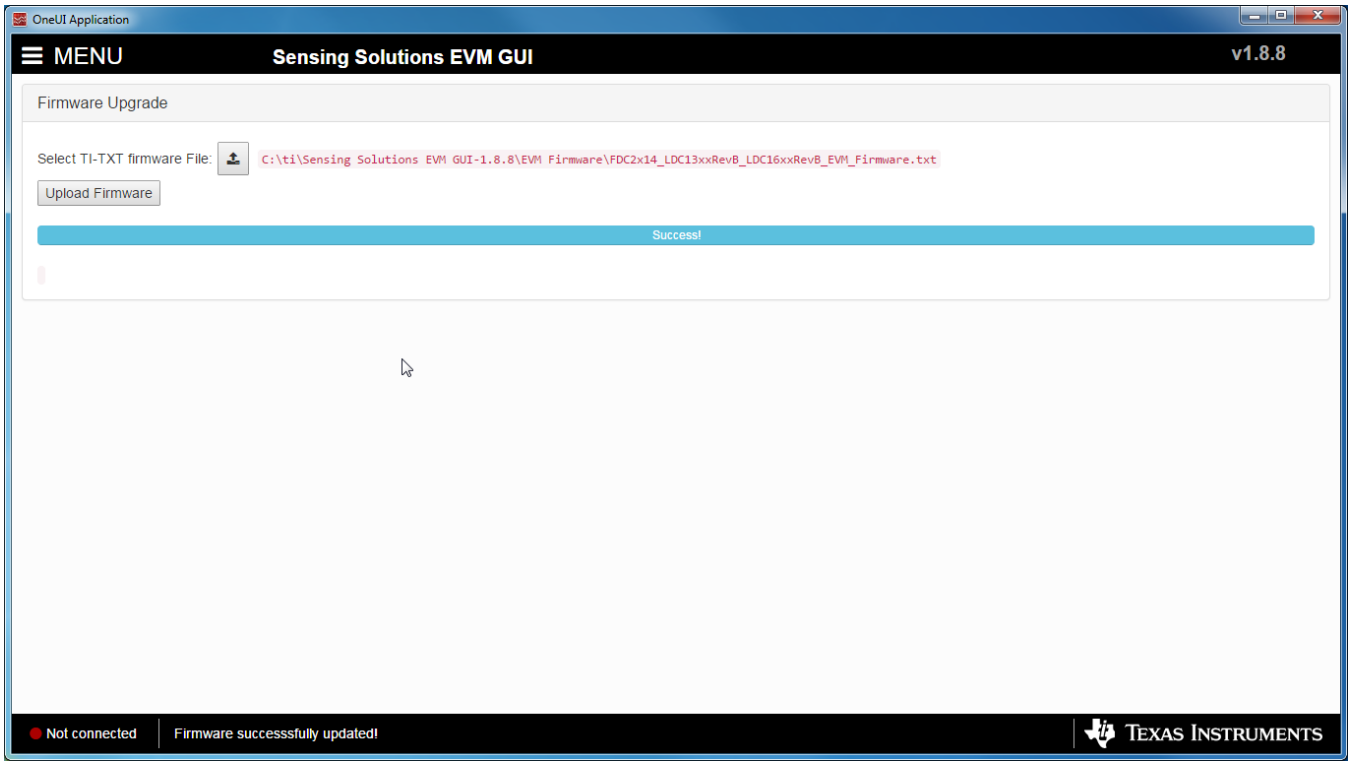

Figure 41. Firmware Upload Success

3 Board Layout

Figure 42 and Figure 43 show the board layout of the FDC1004EVM.

Sensor layout has been designed to demonstrate the possible trade-off between sensor sensitivity and protection from interferences. SHLD1 surrounds "LEFT" sensor and it has a bigger area than SHLD2 that surrounds "RIGHT" sensor. As a consequence, the "LEFT" sensor is better shielded from interferences but at the cost of lower sensitivity.

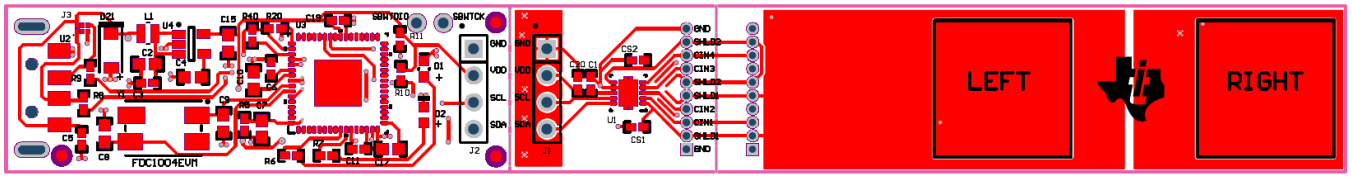

Figure 42. Top Layer Routing

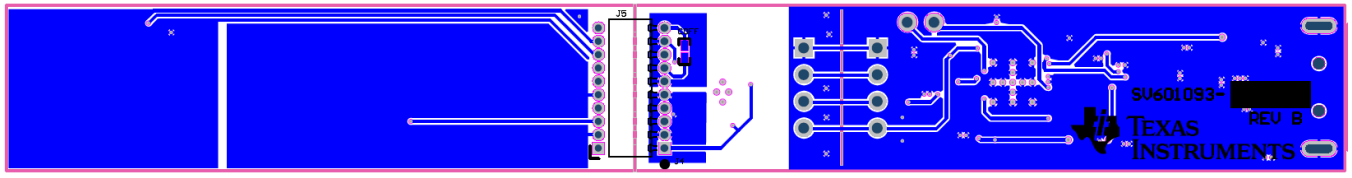

Figure 43. Bottom Layer Routing

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4 Schematic

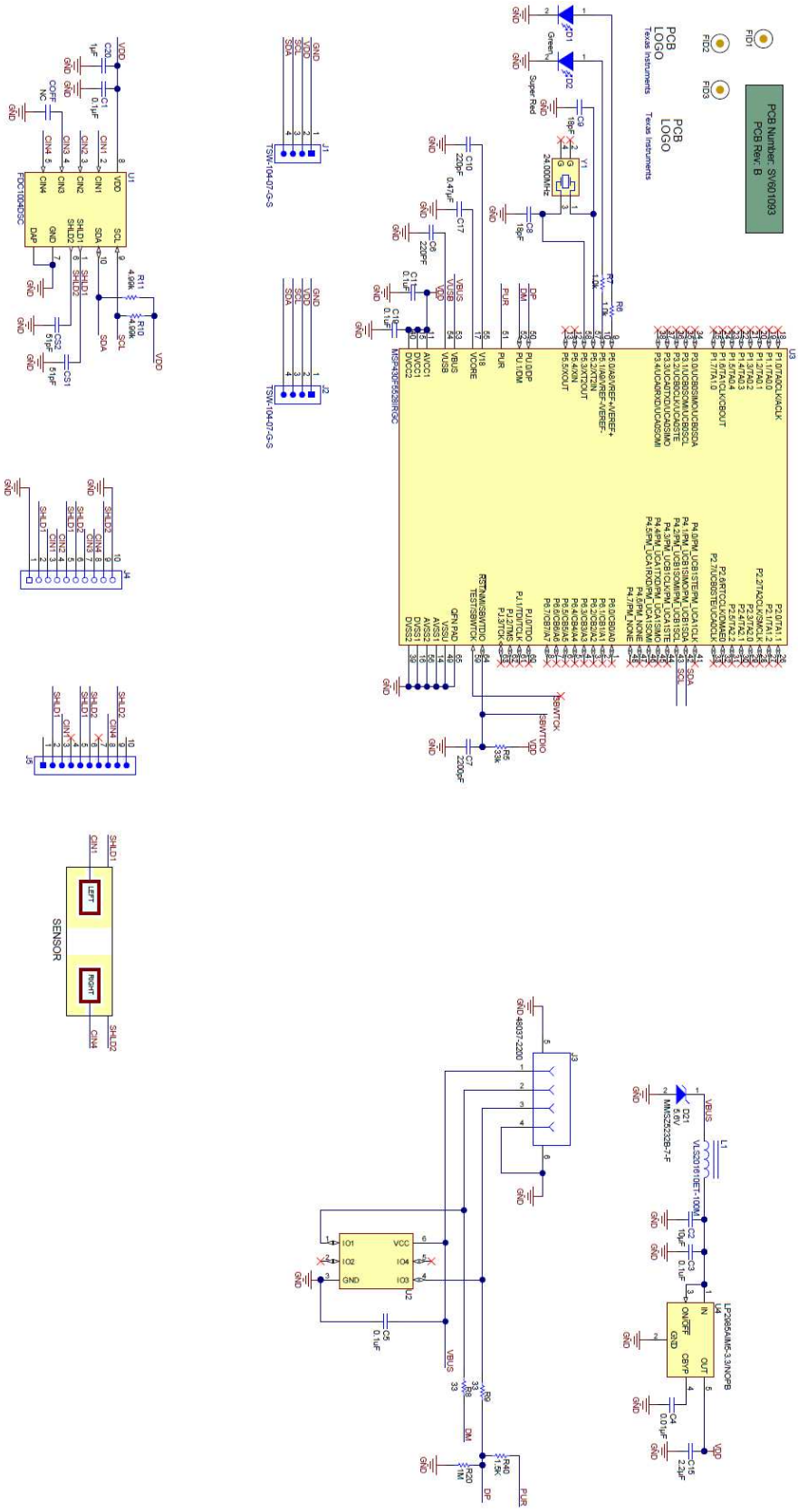

Figure 44. FDC1004EVM Schematic

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Table 5. Bill of Materials

Qty	Designator	Description	Footprint	Manufacturer Part Number
1	C1	CAP, CERM, 0.1uF, 6.3V, +/-10%, X5R, 0402	402	C1005X5R0J104K050BA
1	C2	CAP CER 10UF 10V 10% X5R 0603	603	C1608X5R1A106K080AC
4	C3, C5, C11, C19	CAP CER 0.1UF 16V 5% X7R 0402	402	0402YC132KAT2A
1	C4	CAP, CERM, 0.01uF, 25V, +/-5%, C0G/NP0, 0603	603	C1608C0G1E103J080AA
1	C6	CAP CER 220PF 50V 1% NP0 0402	402	0402YC132KAT2A
1	C7	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	603	C0603X222K5RACTU
2	C8, C9	CAP CER 18PF 100V 5% NP0 0603	603	GRM1885C2A300JA01D
1	C10	CAP, CERM, 220pF, 50V, +/-1%, C0G/NP0, 0603	603	06035A221FAT2A
1	C15	CAP, CERM, 2.2uF, 10V, +/-10%, X5R, 0603	603	C0603C225K8PACTU
1	C17	CAP, CERM, 0.47uF, 10V, +/-10%, X7R, 0603	603	C0603C474K8RACTU
1	C20	CAP, CERM, 1uF, 6.3V, +/-20%, X5R, 0402	402	C1005X5R0J105M050BB
2	CS1, CS2	CAP, CERM, 51pF, 50V, +/-5%, C0G/NP0, 0402	402	GRM1555C1H510JA01D
1	D1	LED SMARTLED GREEN 570NM 0603	603	LG L29K-G2J1-24-Z
1	D2	LED 660NM SUPER RED DIFF 0603SMD	603	SML-LX0603SRW-TR
1	D21	Diode, Zener, 5.6V, 500mW, SOD-123	SOD-123	MMSZ5232B-7-F
2	J1, J2	Header, TH, 100mil, 4x1, Gold plated, 230 mil above insulator	TSW-104-07-G-S	TSW-104-07-G-S
1	J3	Connector, USB Type A, 4POS R/A, SMD	CONN_USB_0480372200	480372200
1	J4	Receptacle, 50mil 10x1, R/A, TH	CONN_851-43-010-20-001000	851-43-010-20-001000
1	L1	INDUCTOR POWER 10UH .45A SMD	VLS201610E	VLS201610ET-100M
1	R5	RES, 33k ohm, 5%, 0.063W, 0402	402	CRCW040233K0JNED
2	R6, R7	RES 1K OHM 1/10W 5% 0402 SMD	402	CRCW040233R0JNED
2	R8, R9	RES, 33 ohm, 5%, 0.063W, 0402	402	CRCW040233R0JNED
2	R10, R11	RES, 4.99k ohm, 1%, 0.063W, 0402	402	CRCW04024K99FKED
1	R20	RES,1M ohm, 5%, 0.063W, 0402	402	RC0402JR-071ML
1	R40	RES 1.5K OHM 1/16W 5% 0402 SMD	402	CRCW04021K50JNED
1	U1	4-Channel Capacitance-to-Digital Converter for Capacitive Sensing Solutions, DSC0010B	DSC0010B	FDC1004DSC
1	U2	4-CHANNEL ESD-PROTECTION ARRAY FOR HIGH-SPEED DATA INTERFACES, DRY006A	DRY0006A	TPD4E004DRY
1	U3	Mixed Signal MicroController, RGC0064B	RGC0064B	MSP430F5528IRGCT
1	U4	Micropower 150 mA Low-Noise Ultra Low-Dropout Regulator, 5-pin SOT-23, Pb-Free	MF05A_N	LP2985AIM5-3.3/NOPB
1	Y1	CRYSTAL 24.000MHZ 18PF SMD	ABMM	ABMM-24.000MHZ-B2-T

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from B Revision (August 2014) to C Revision	Page
• Changed Sensing Solutions EVM GUI section	5
• Changed Updated Part Number	41

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Changes from A Revision (August 2014) to B Revision	Page
• Added Description of the sensor	39

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Changes from Original (August 2014) to A Revision	Page
• Changed photo of board	1

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