FDC2114 and FDC2214 EVM User’s Guide

User's Guide

Literature Number: SNOU138
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FDC2114 and FDC2214 EVM User's Guide

1 Overview

The FDC2114/2214 EVM demonstrates the use of capacitive sensing technology to sense and measure the presence or position of target objects. The EVM contains two example LC tank sensors that are connected to the FDC2114/2214 input channels. The latter is controlled by an MSP430, which interfaces to a host computer.

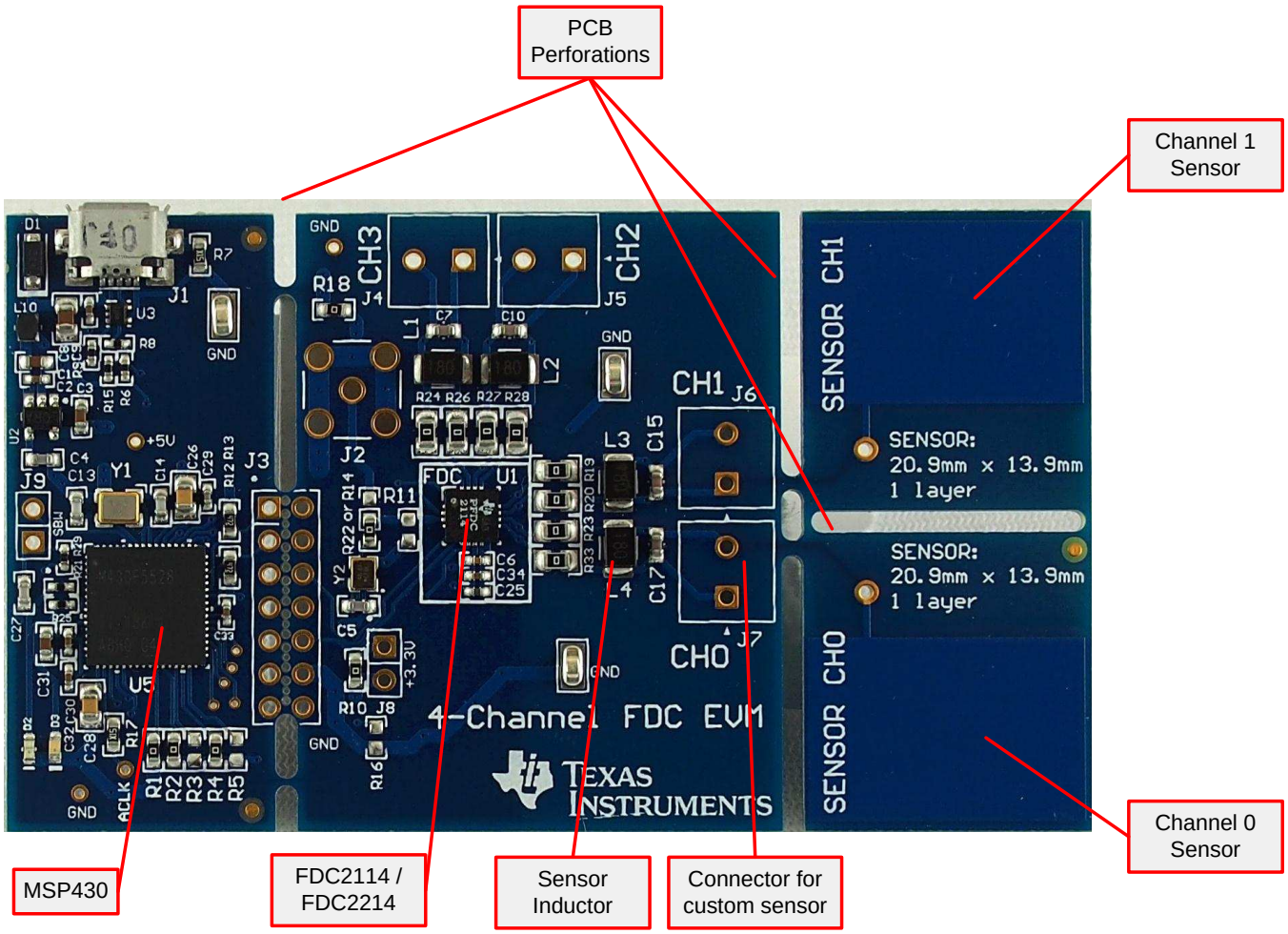

Figure 1. FDC2114/2214 Evaluation Module

The FDC2114/2214EVM includes two example PCB sensors. Each sensor consists of a single-layer capacitor plate, a 33pF 1% COG/NP0 capacitor, and a 18µH connected in parallel to form an LC tank.

PCB perforations allow separation of the sensor coils or the microcontroller, so that custom sensors or a different microcontroller can be connected.

2 Software Setup

2.1 System Requirements

The Sensing Solutions GUI supports:

- 64-bit Windows 7
- 64-bit Windows XP

The current GUI does not support 32-bit Windows operating systems. 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 the host.
- The EVM must be connected to a high speed USB port (USB 2.0 or above).

2.2 Sensing Solutions GUI and EVM Driver Installation

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. Follow all directions from the installer

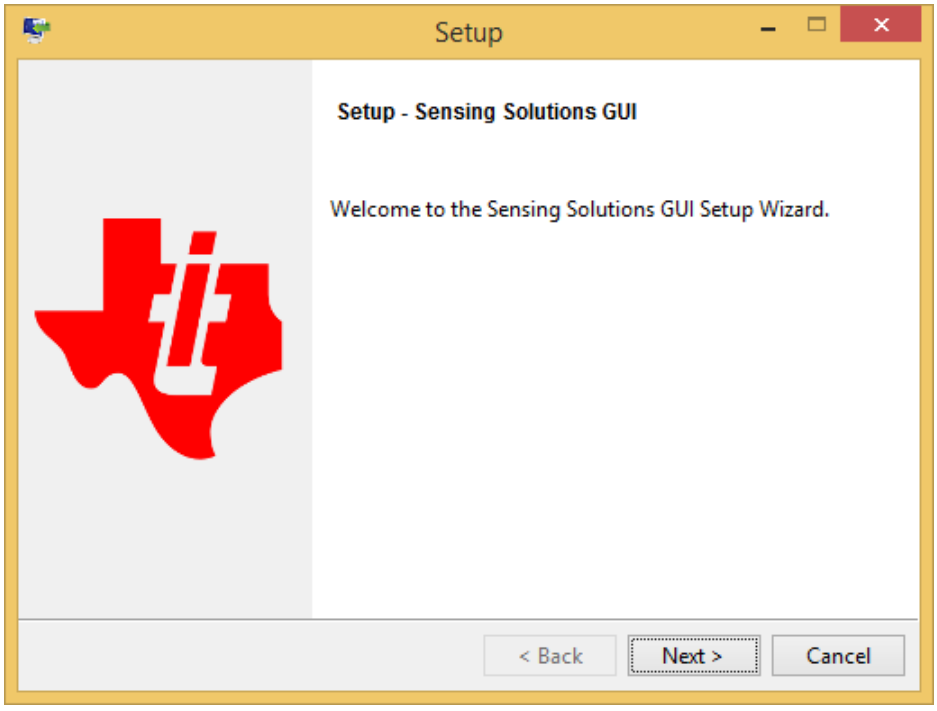

Figure 2. GUI Installer Welcome Page

5. Read the license agreement and if you still wish to install the software, select “I accept the agreement” and click “Next” as shown in Figure 3

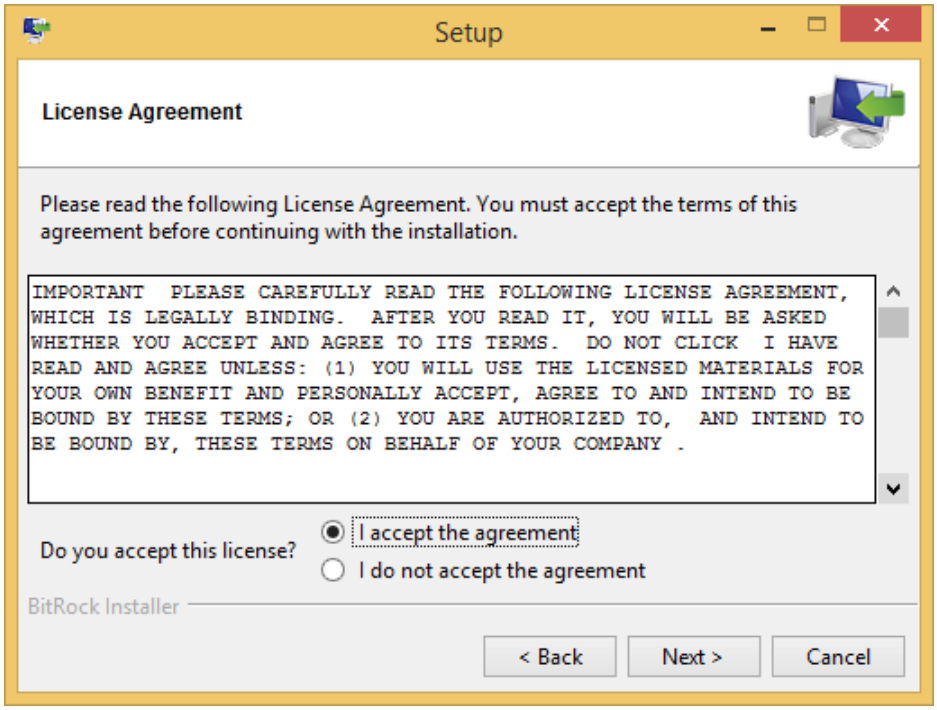

Figure 3. GUI Installer License Agreement

6. Select the installation directory. If the user installing the software is not a system administrator a directory not with “Program Files” should be chosen instead of the default.

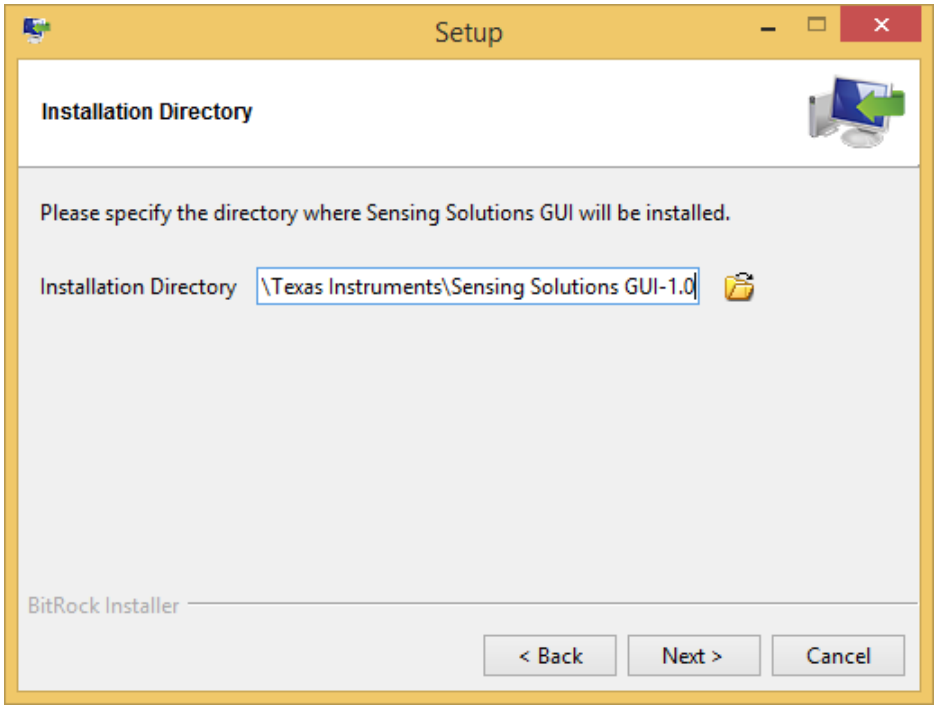

Figure 4. GUI Installer Installation Directory

7. Wait for all files to install

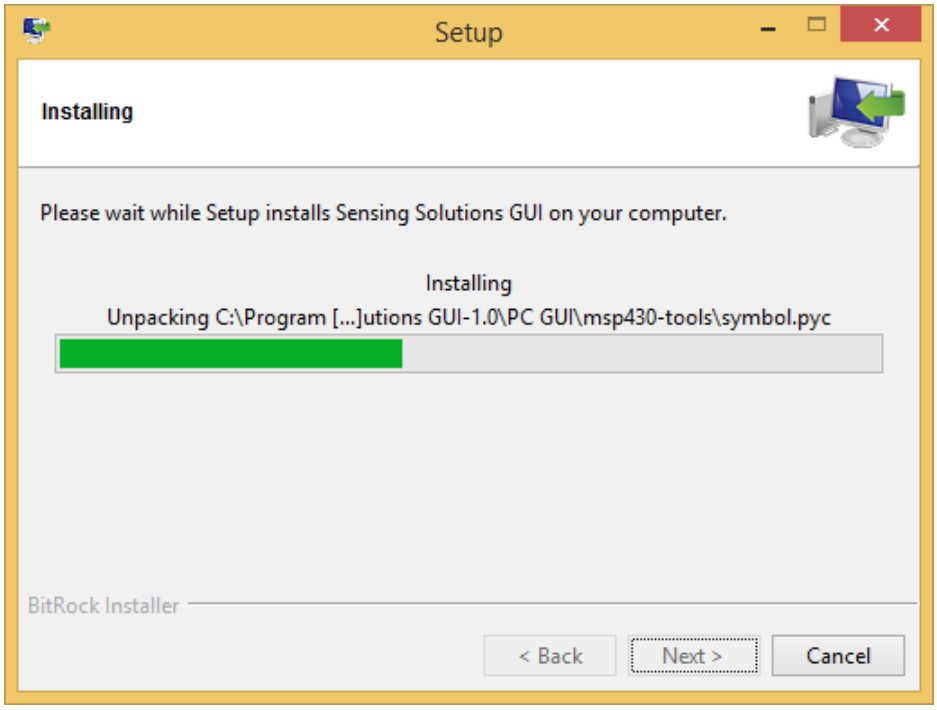

Figure 5. GUI Installer Copying Files

8. After the files have copied a device driver installer will start. If prompted about an unsigned driver, choose to install the driver anyways. If running Windows 8 or 8.1, the PC must be started in a “Safe” mode to install the unsigned driver.

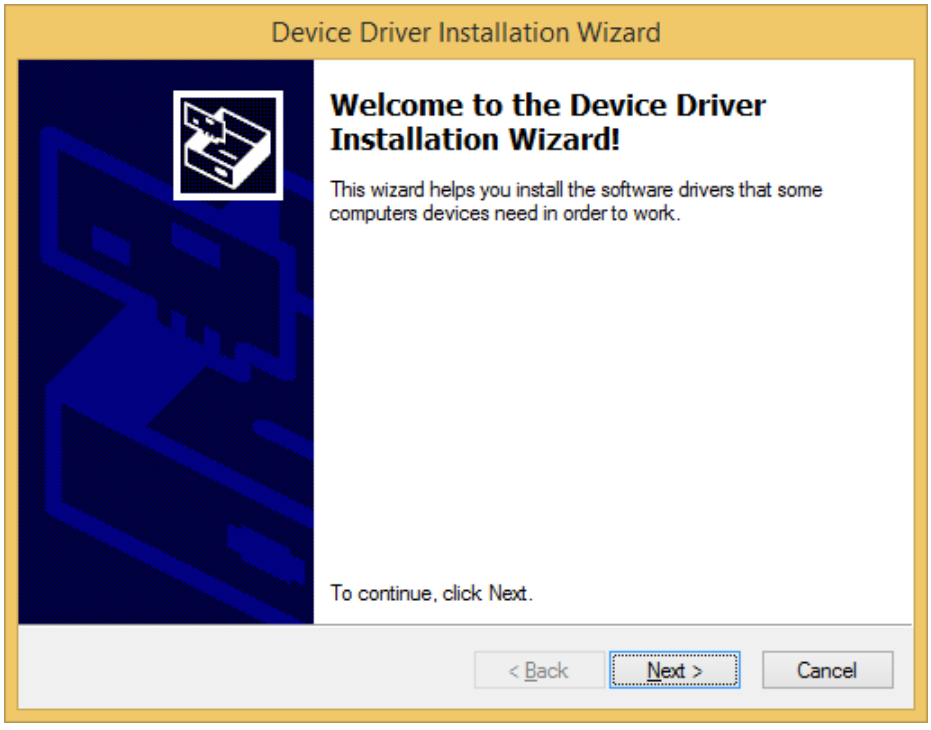

Figure 6. EVM Driver Installer Welcome Page

9. Wait for the driver to install

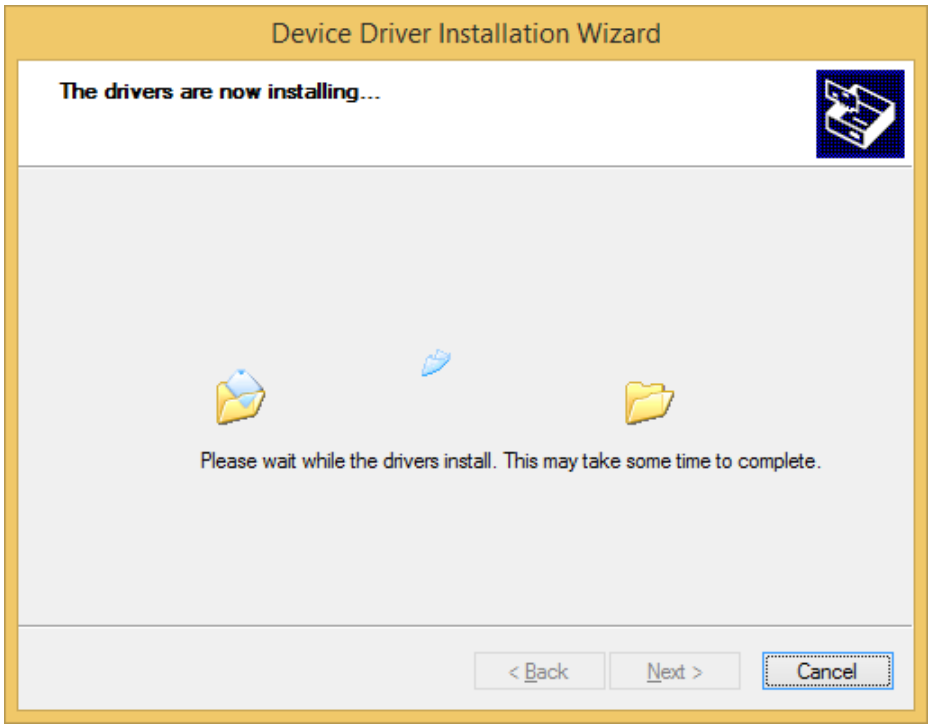

Figure 7. EVM Driver Installer In Progress

10. Click “Finish” after the driver has been installed

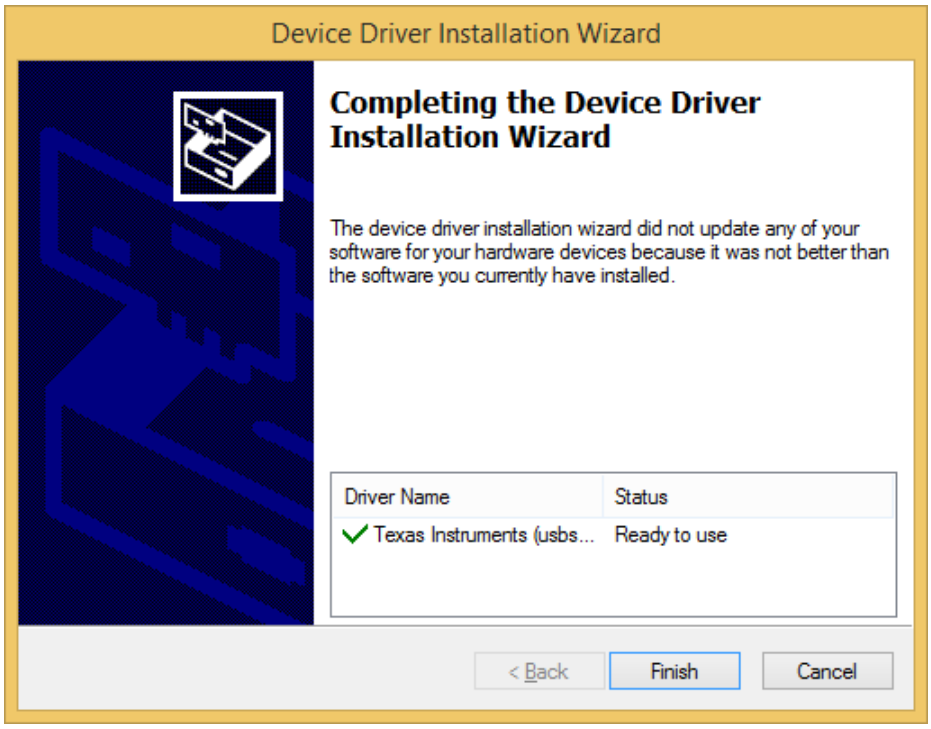

Figure 8. EVM Driver Installer Complete

11. Click “Finish” to complete the software installation

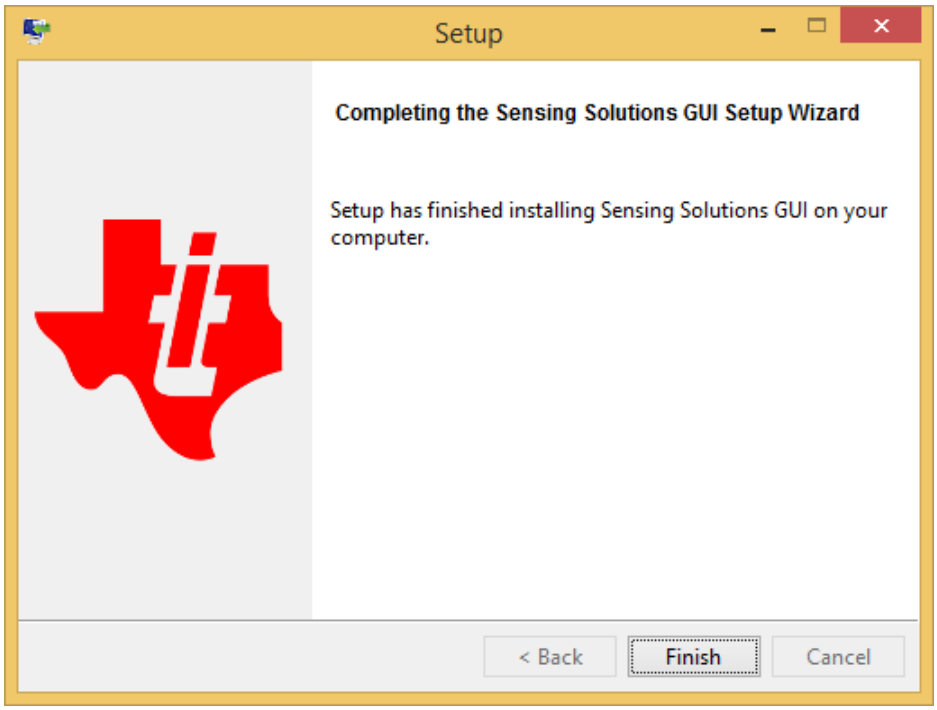

Figure 9. GUI Installer Complete

3 GUI Operation

The section describes how to use the GUI

3.1 Starting the GUI

Follow these steps to start the GUI:

1. Select the windows start menu
2. Select “All programs”
3. Select the “Texas Instruments” folder
4. Select the Sensing Solutions GUI
5. Click “Sensing Solutions GUI”
6. Splash screen will appear for at least two seconds.
   - Slower PC’s may show a blank splash screen without any texts for up to 20 seconds

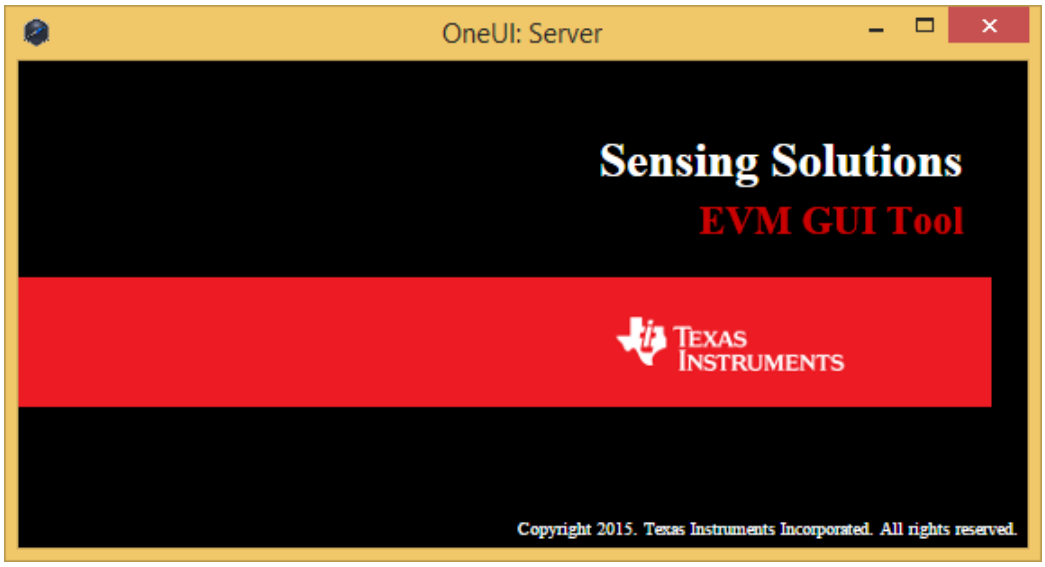

Figure 10. GUI Splash Screen

7. After the splash screen is displayed the main window will open. Note: Only one instance of the GUI may be open at a time!

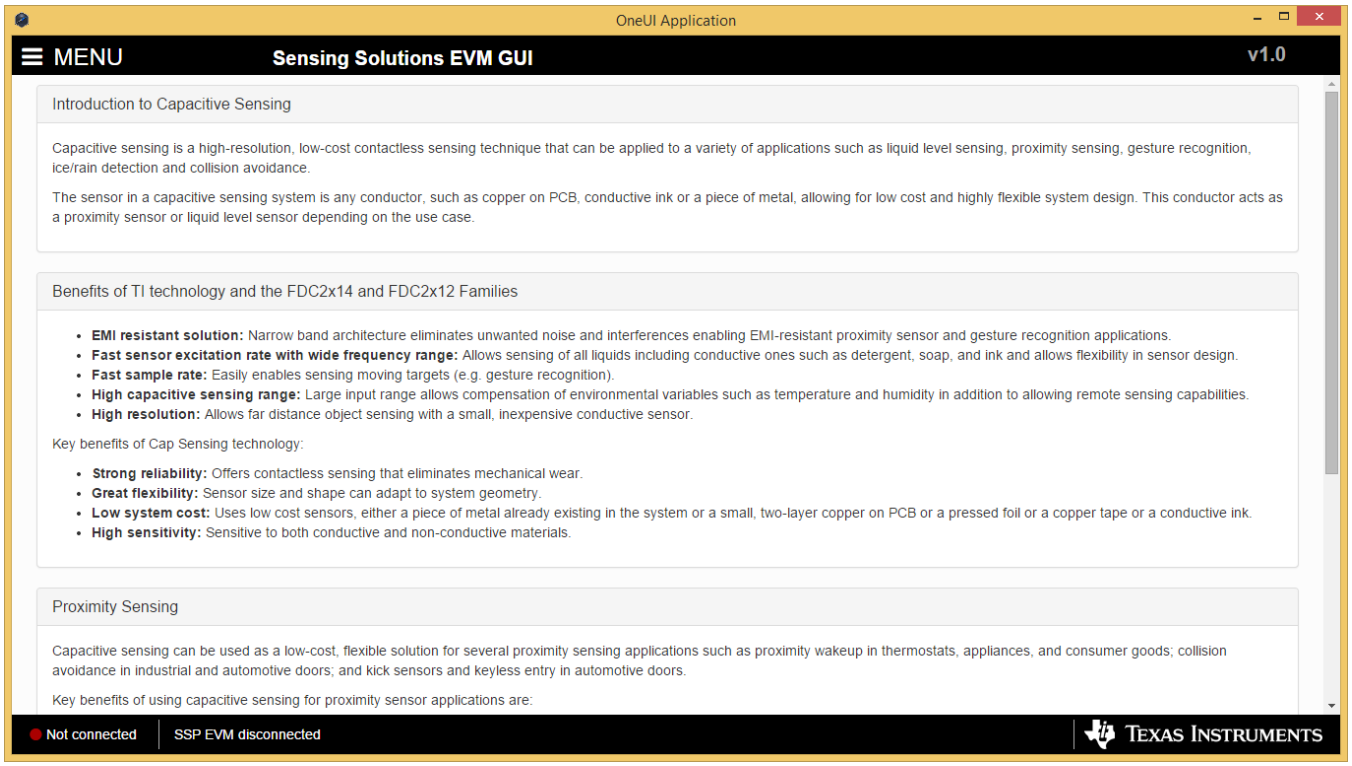

Figure 11. GUI Introduction Page

3.2 Connecting the EVM

Follow these steps to connect the EVM to the GUI:

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

- The initial release of this GUI does not support multiple GUI instances or multiple devices. To control multiple EVMs, virtual machines may be used or multiple PC's are required. Future releases will support multiple EVMs from a single instance of the GUI.

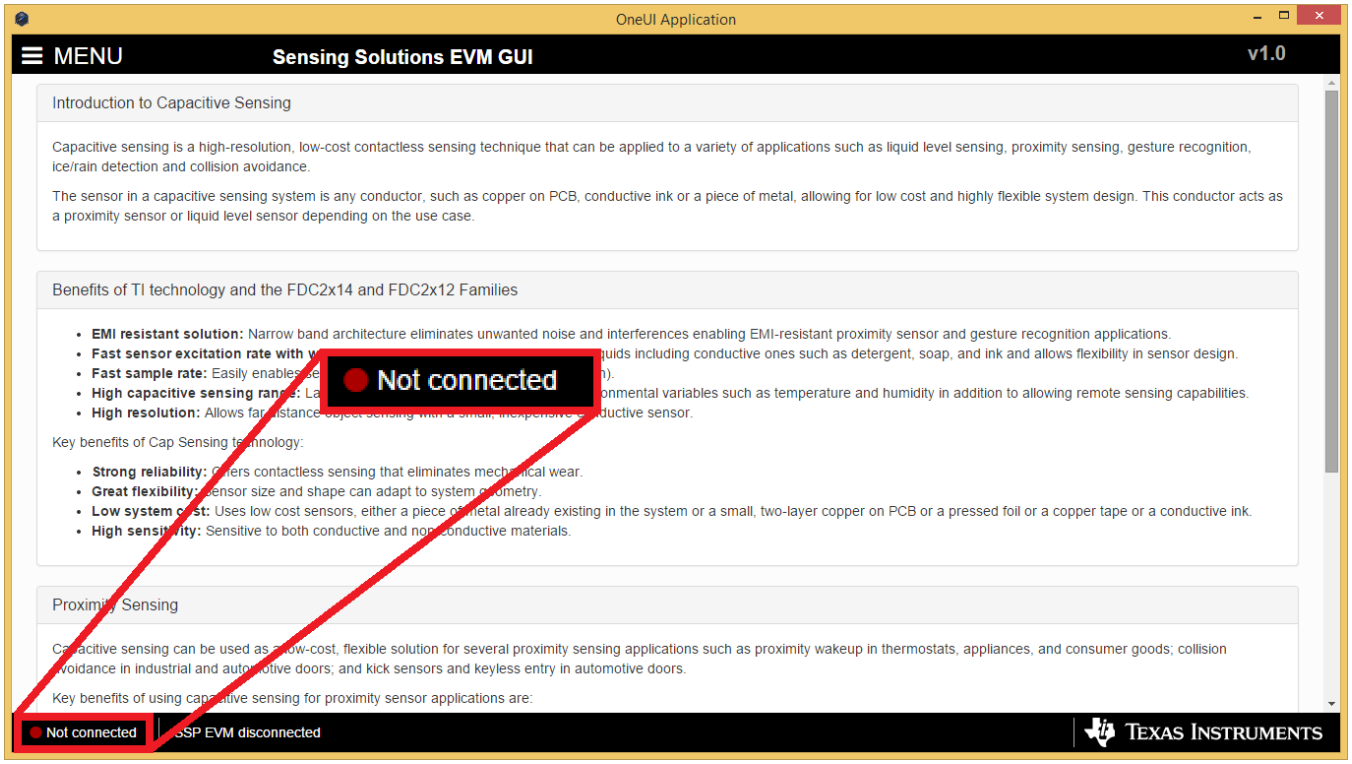

Figure 12. GUI Disconnected From EVM

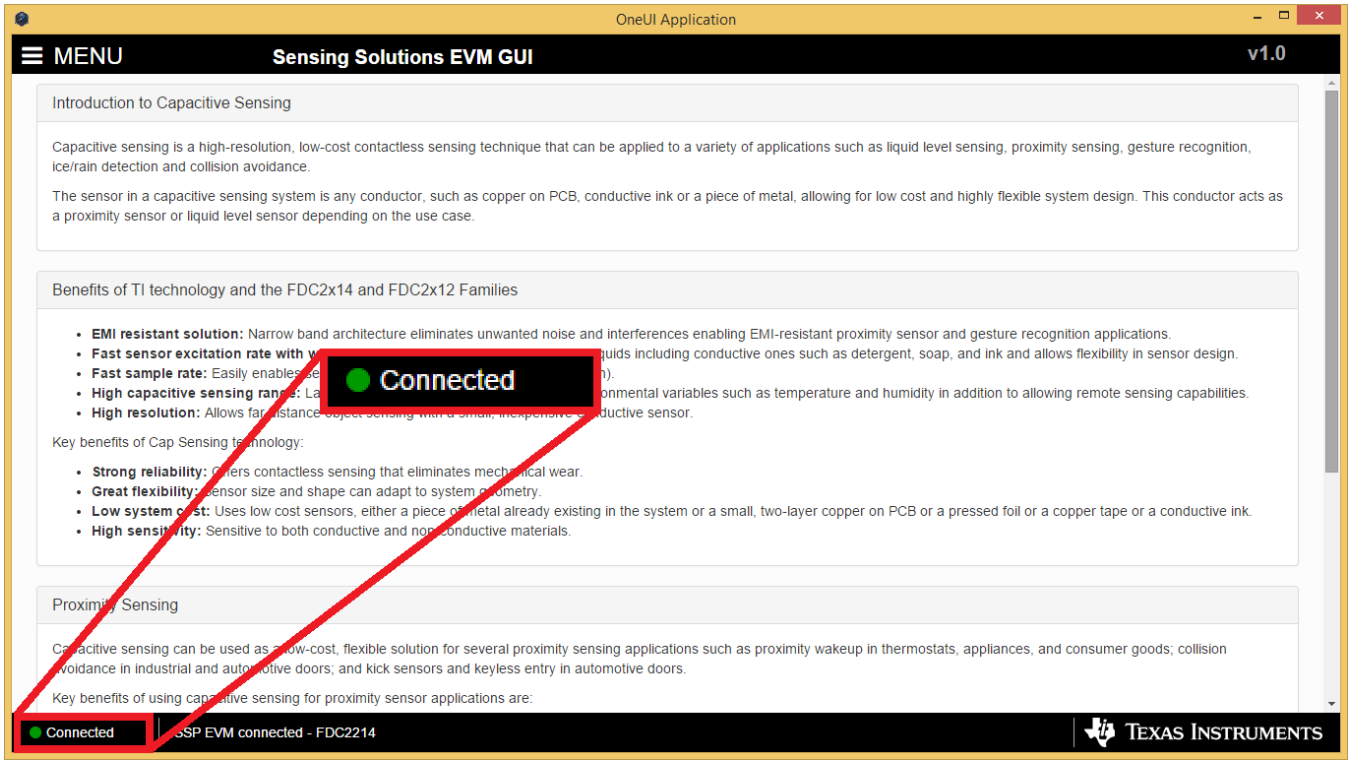

Figure 13. GUI Connected from EVM

3.3 Navigating the GUI

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

1. Click “Menu” in the upper left corner

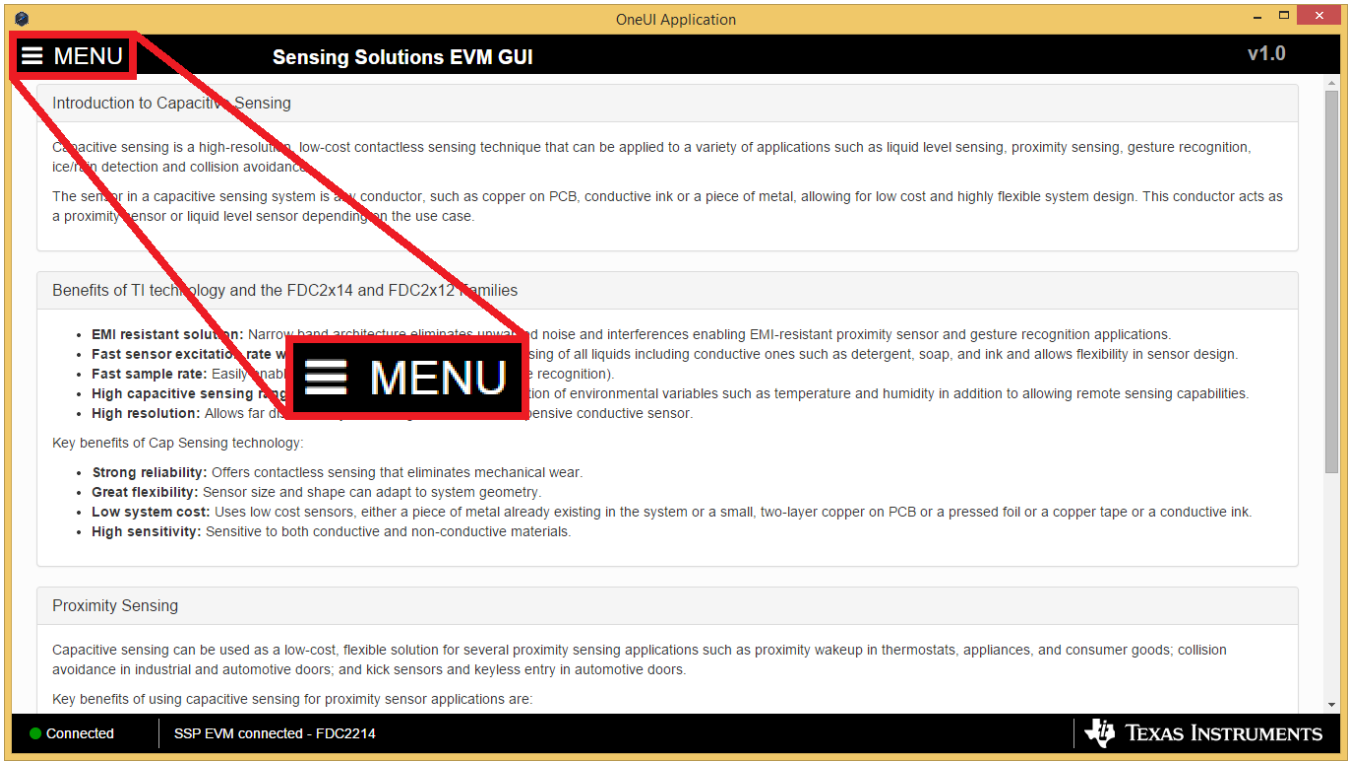

Figure 14. GUI Menu Button

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

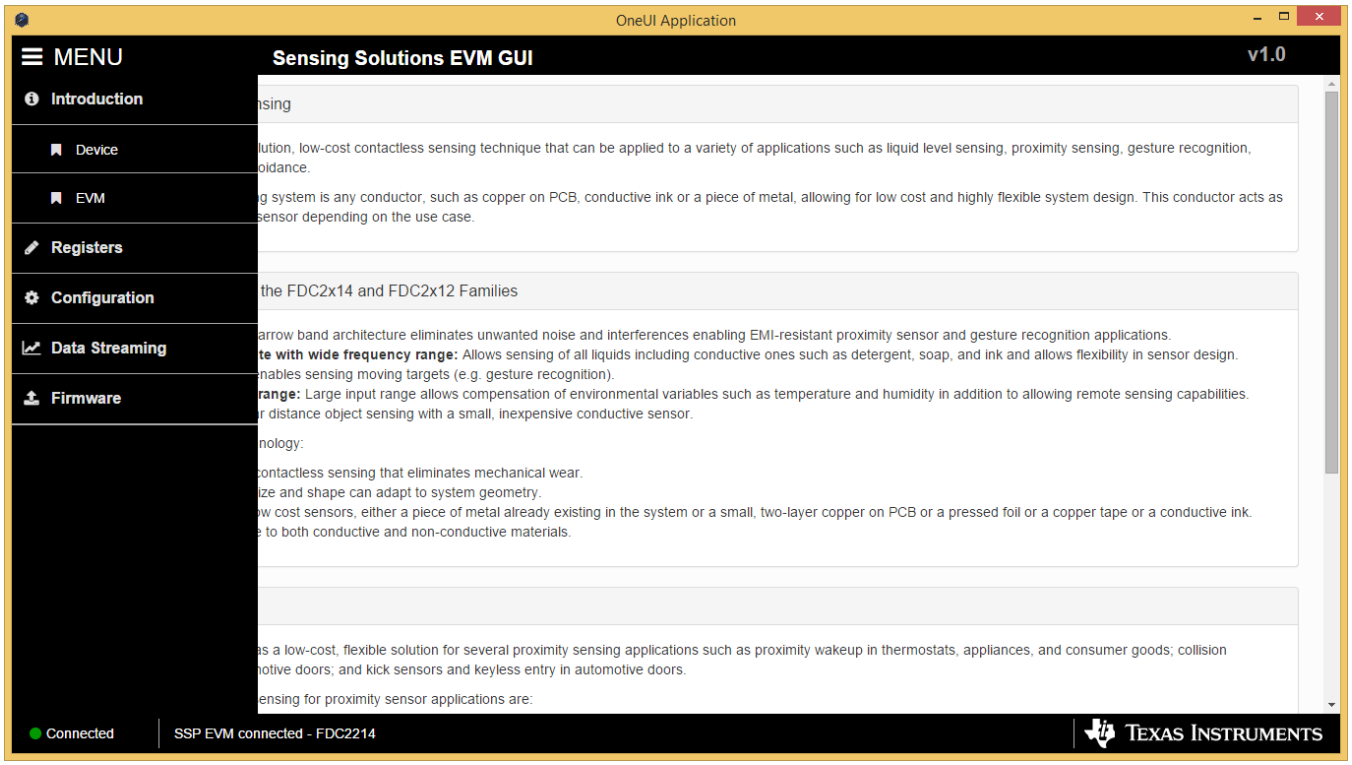

Figure 15. GUI Navigation Menu

3.4 Configuring the Device Using 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.

3.4.1 Automatically Updating 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.

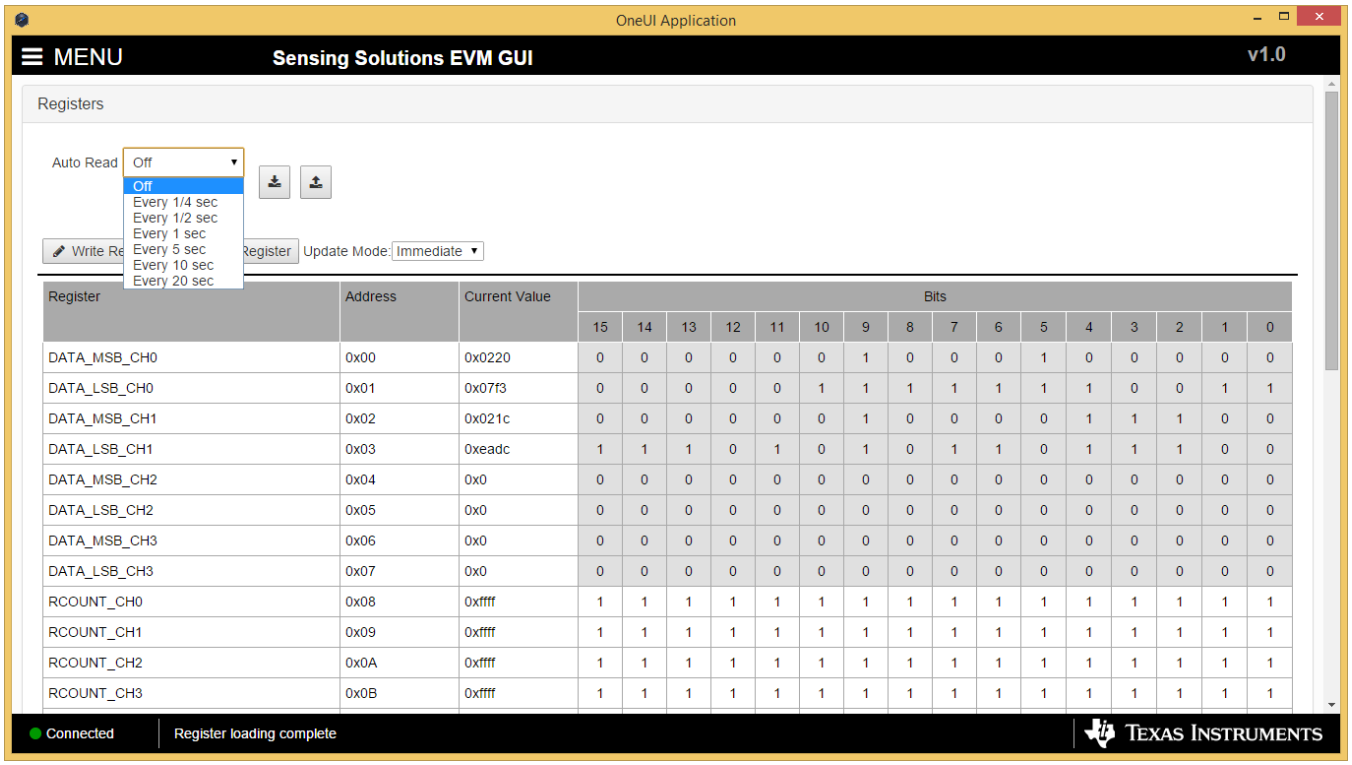

Figure 16. Selecting Auto-Read Interval on Register Page

3.4.2 Manually Updating 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

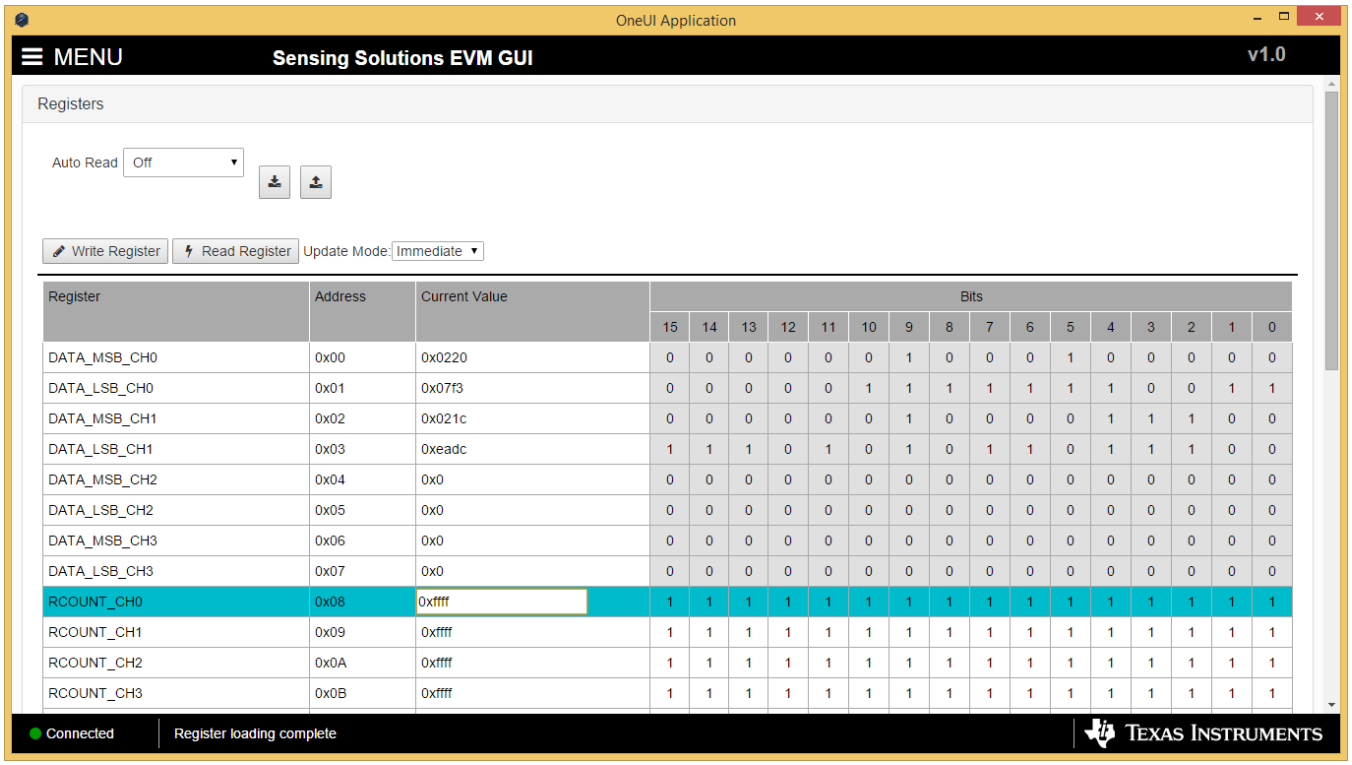

Figure 17. Selecting a Register's Current Value for Editing on Register Page

2. Type the new value in hexadecimal 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

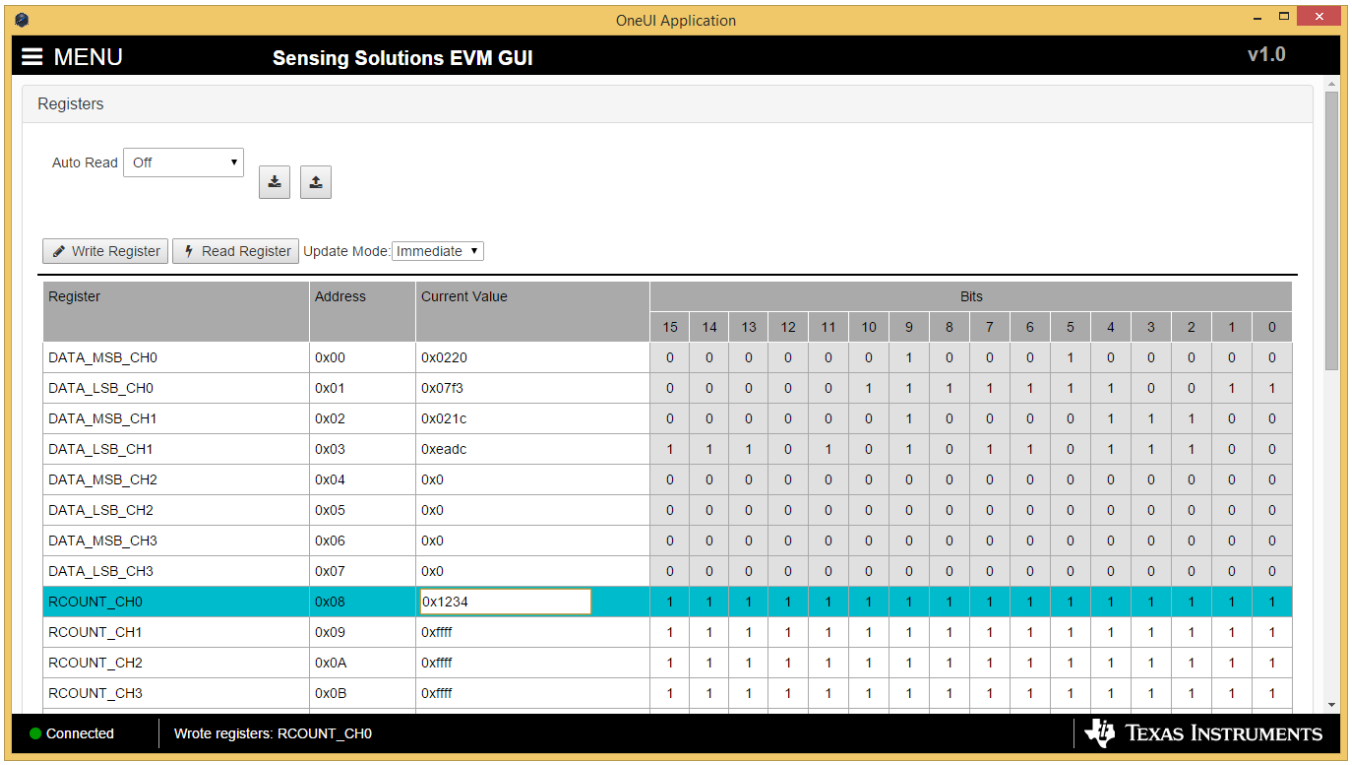

Figure 18. Entering New Value for Register on Register Page

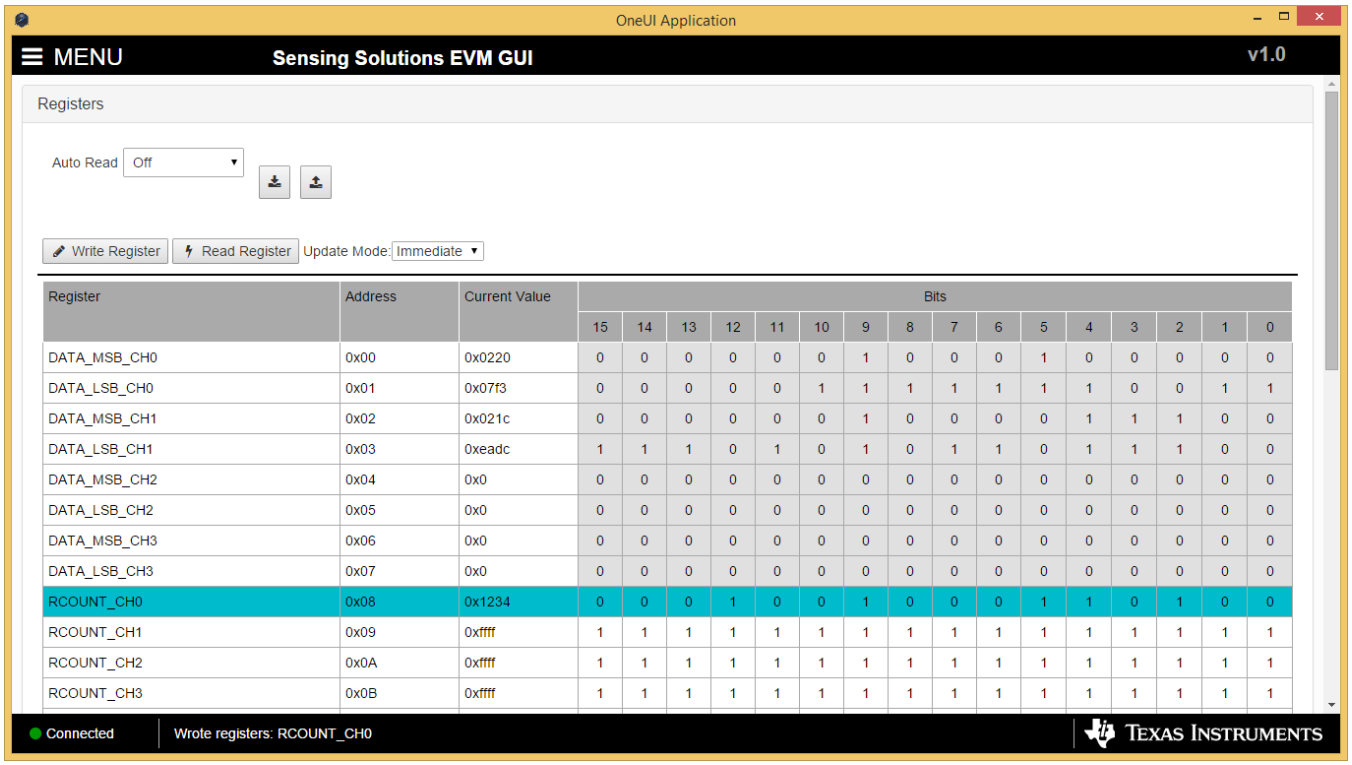

Figure 19. Register Value Updated After Changing Value on Register Page

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

1. Hover the mouse over the desired bit to change

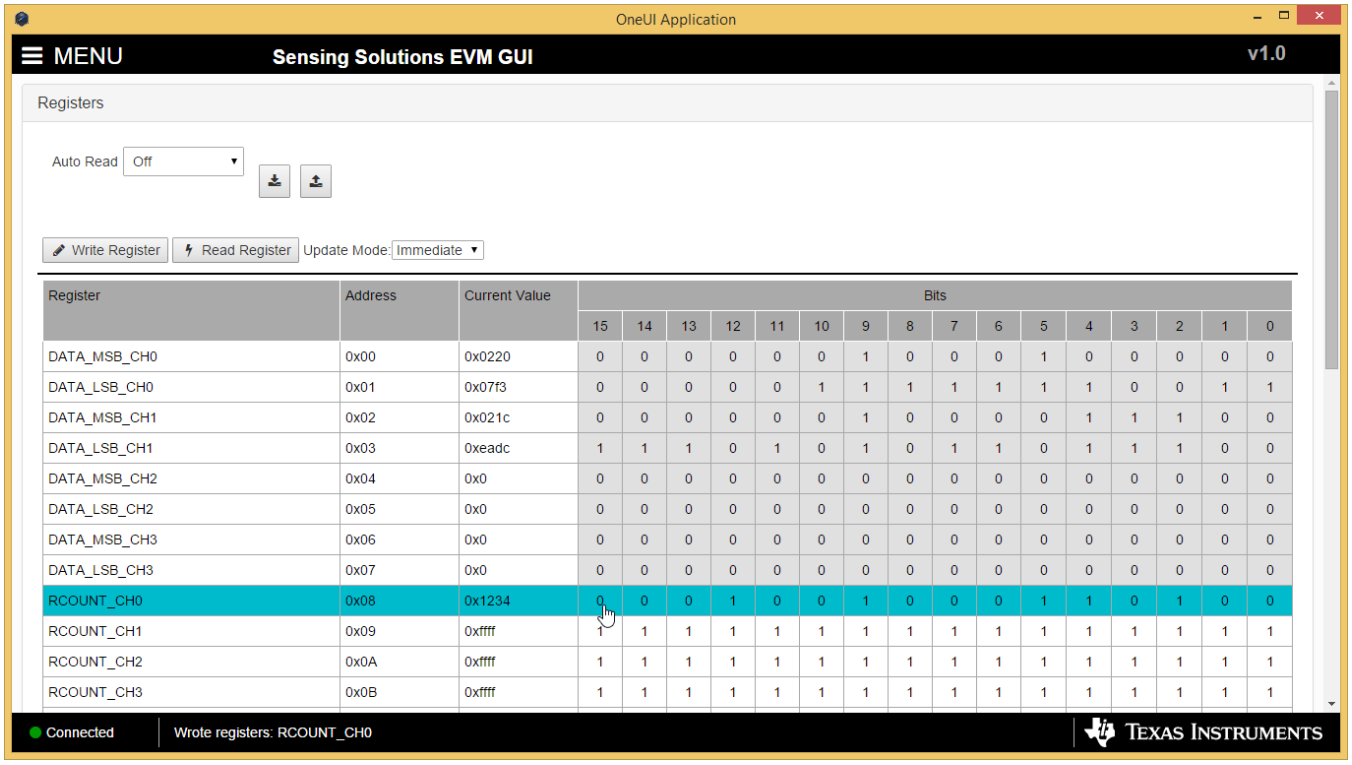

Figure 20. Hovering Mouse Over Register Bit Value on Register Page

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

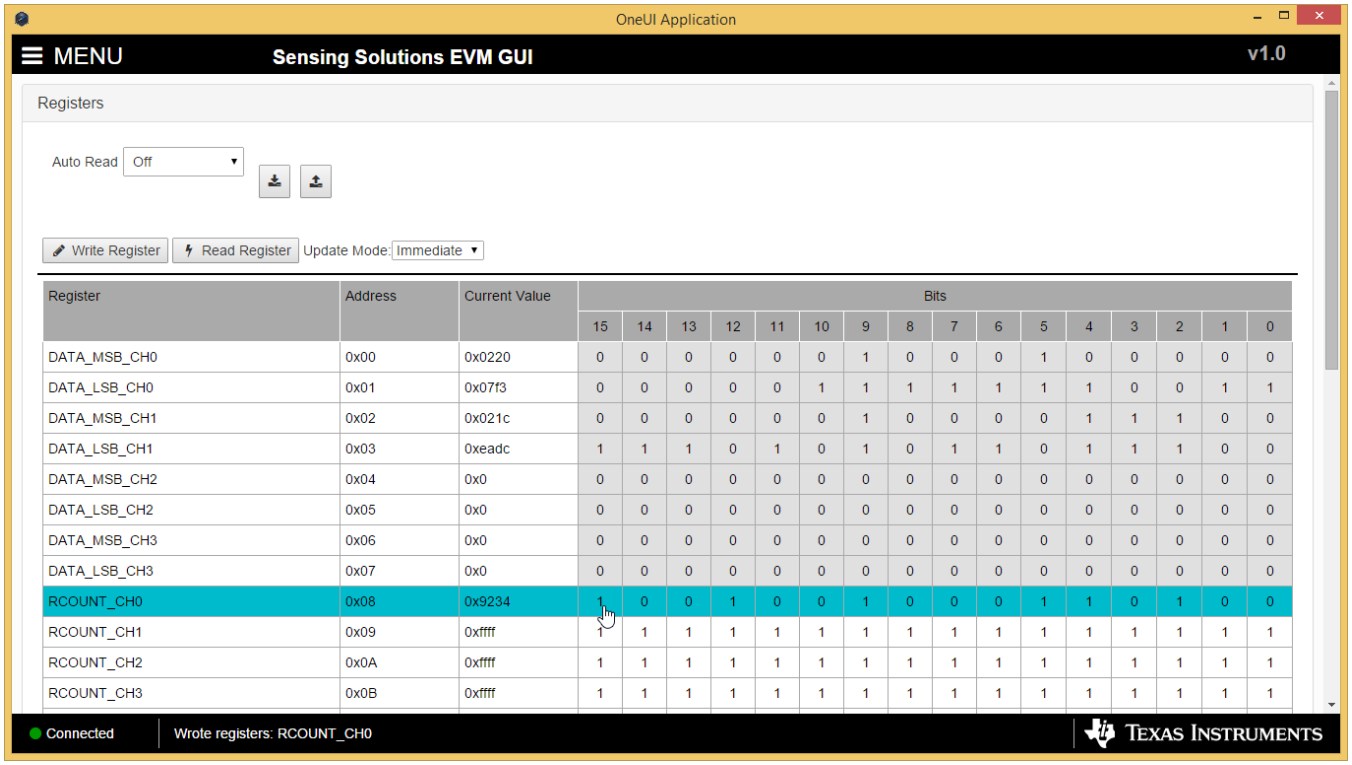

Figure 21. Toggling Register Bit Value on Register Page

3.4.3 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

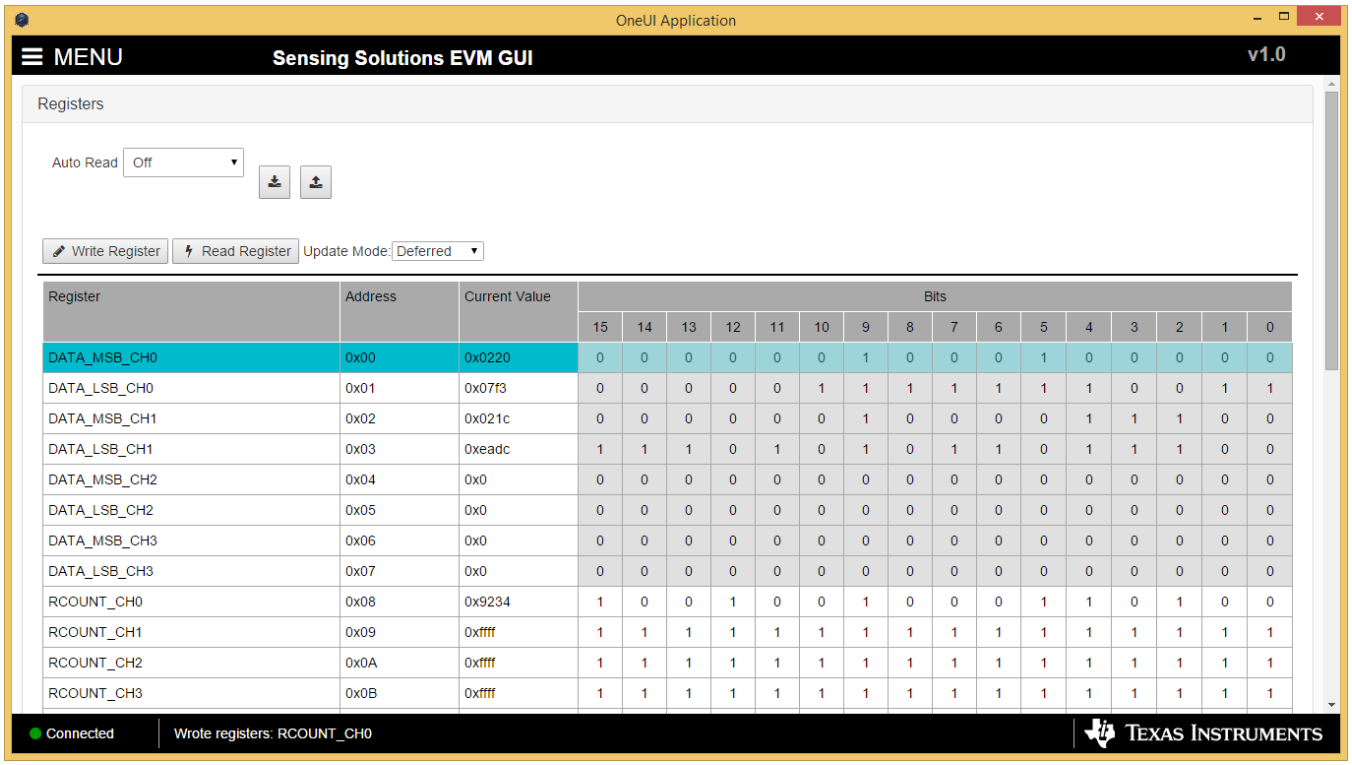

Figure 22. Selecting a Register on Register Page

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

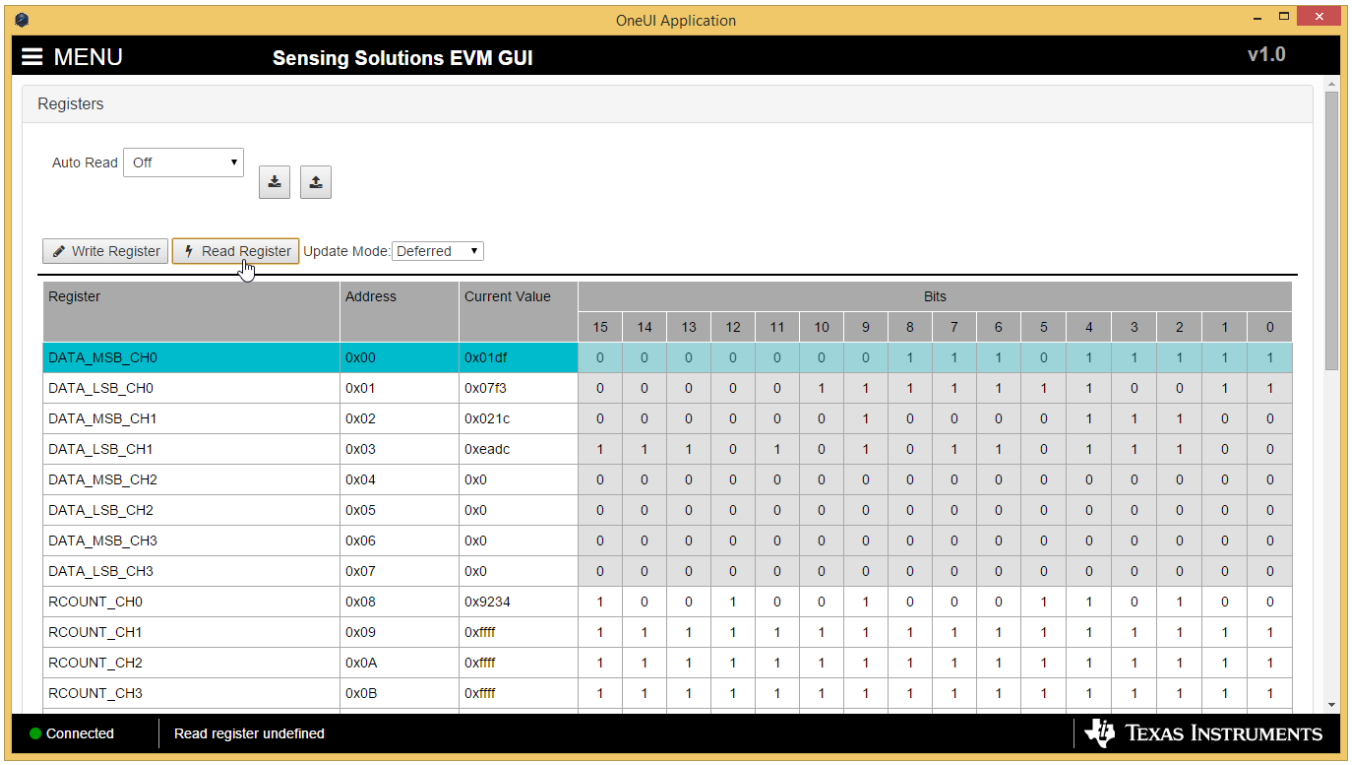

Figure 23. Reading the Current Device Register Value on Register Page

3.4.4 Saving Device Configuration

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

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

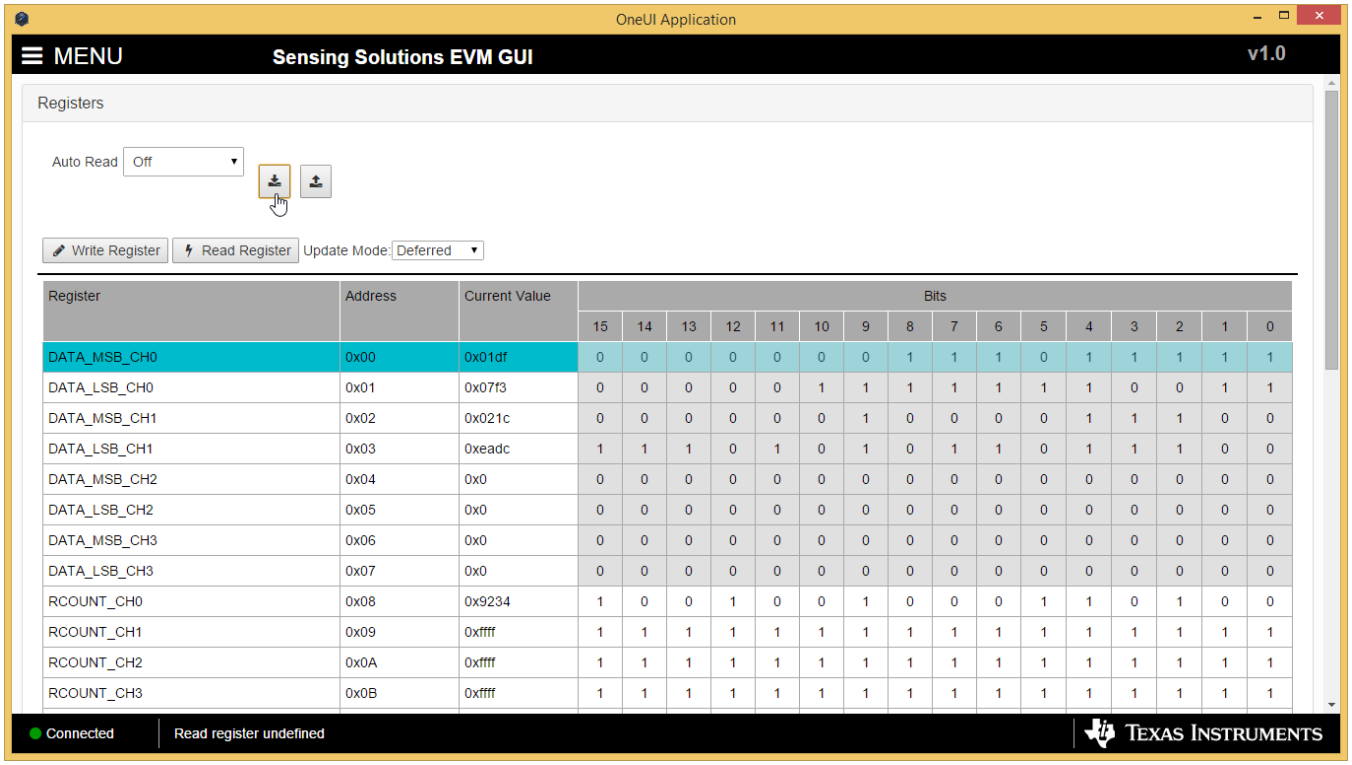

Figure 24. Save Register Values to File on Register Page

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

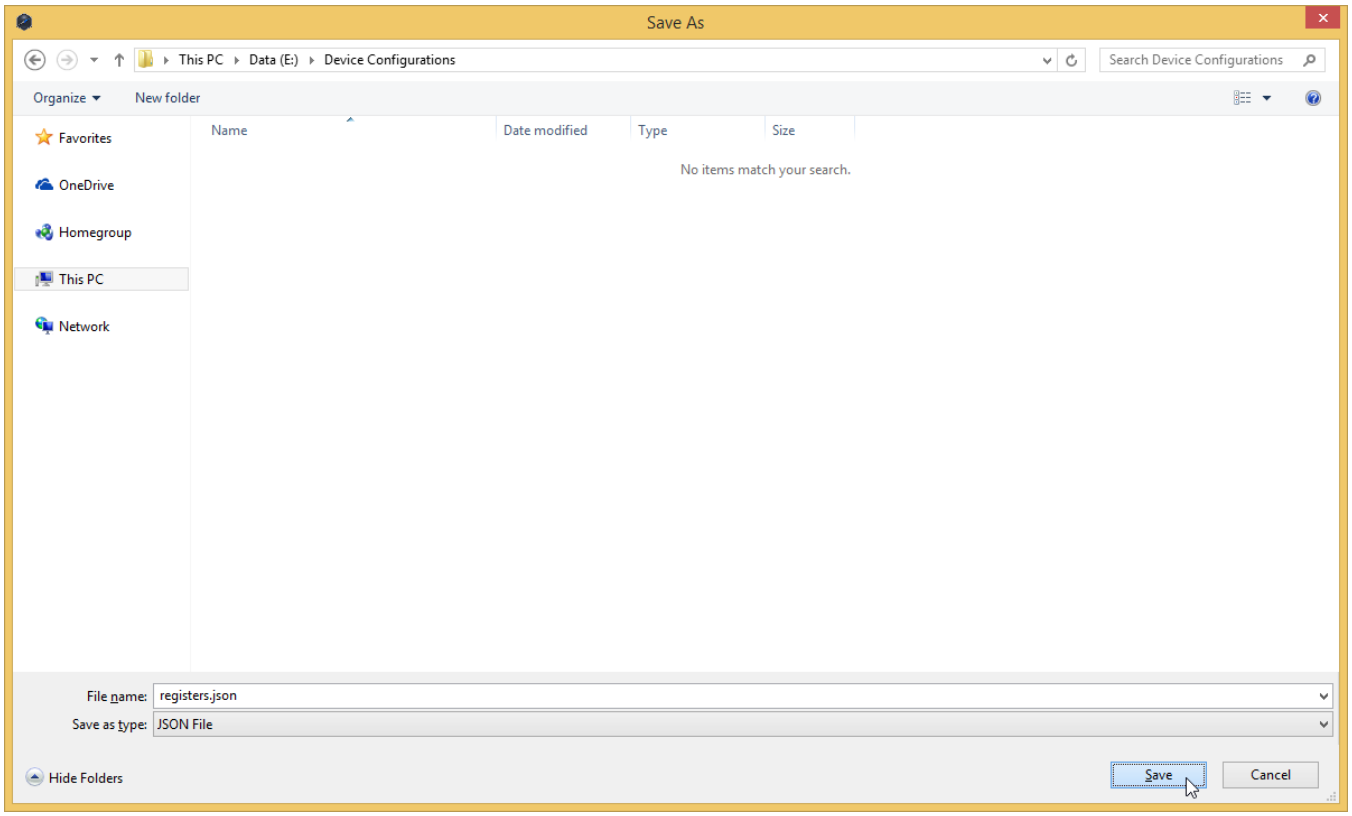

Figure 25. Choosing a JSON File Name to Save Register Values

3.4.5 Loading Previously Saved Device Configuration

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

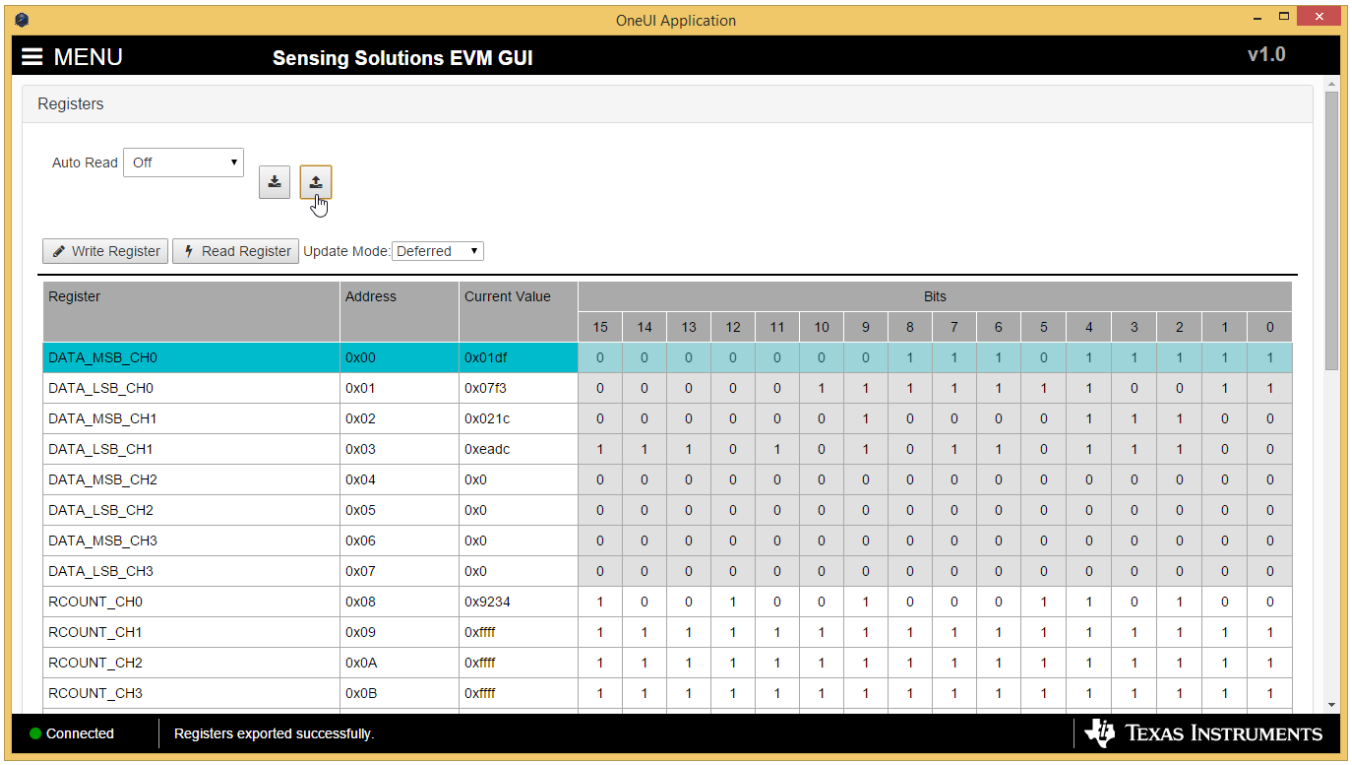

Figure 26. Loading Previously Saved Register Values from File on Register Page

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

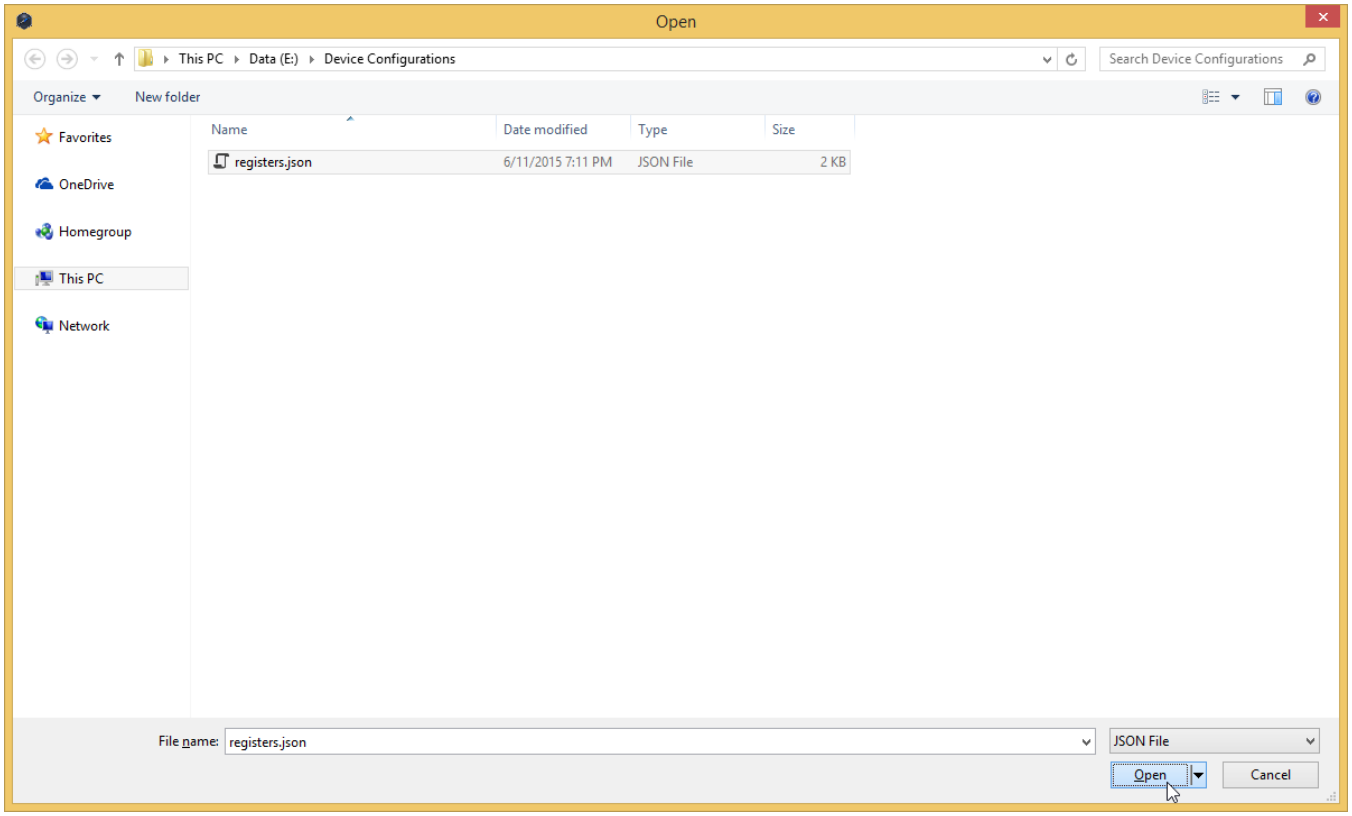

Figure 27. Selecting Previously Save Register Value JSON File

3.5 Configuring the Device Using 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.

3.5.1 Enabling and Disabling Channel Measurements

The FDC211x and FDC221x devices take measurements in two different modes: repeated single channel measurement and measuring single channels sequentially. When the device repeatedly measures a single channel any channel can be selected for measurement. To measure a single channel follow these steps.

1. Select “Repeat single channel measurement” in the “Measurement Settings”

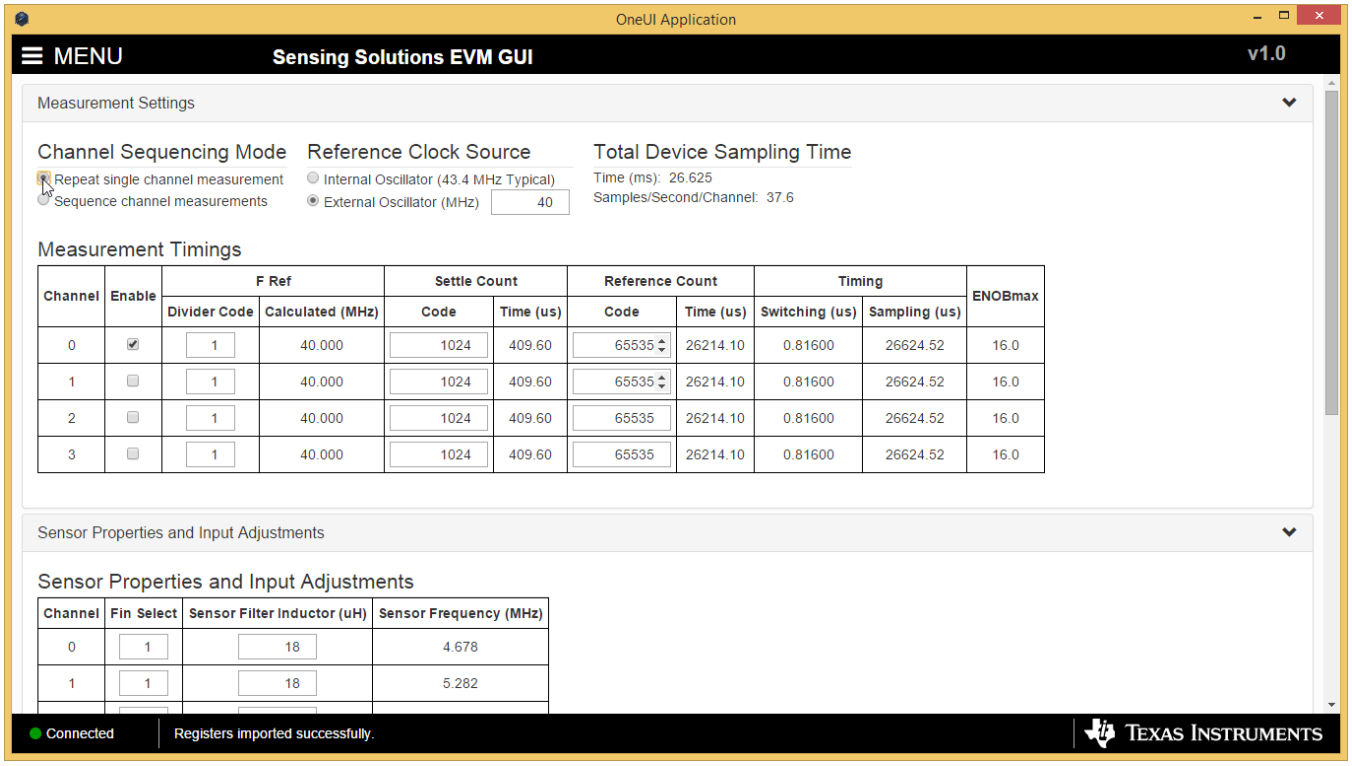

Figure 28. Configuring Device to Repeatedly Measure a Single Channel

2. Choose which channel to measure by clicking the enable check-box of the desired channel (any channel may be selected)

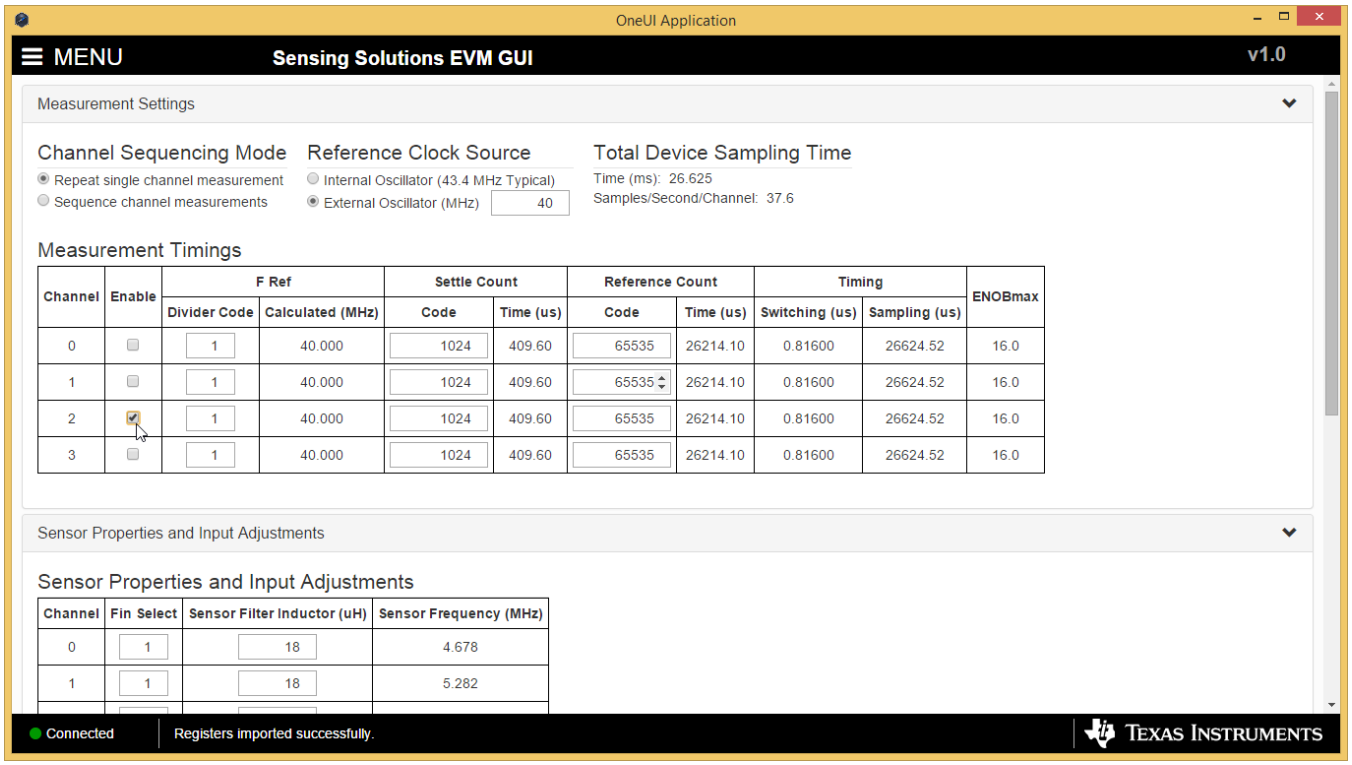

Figure 29. Selecting Channel 3 for Single Channel Measurements

If measuring more than one channel, they are always measured sequentially from channel 0 to the highest selected channel. To measure multiple channels follow these steps.

1. Select “Sequence channel measurements” in the “Measurement Settings”

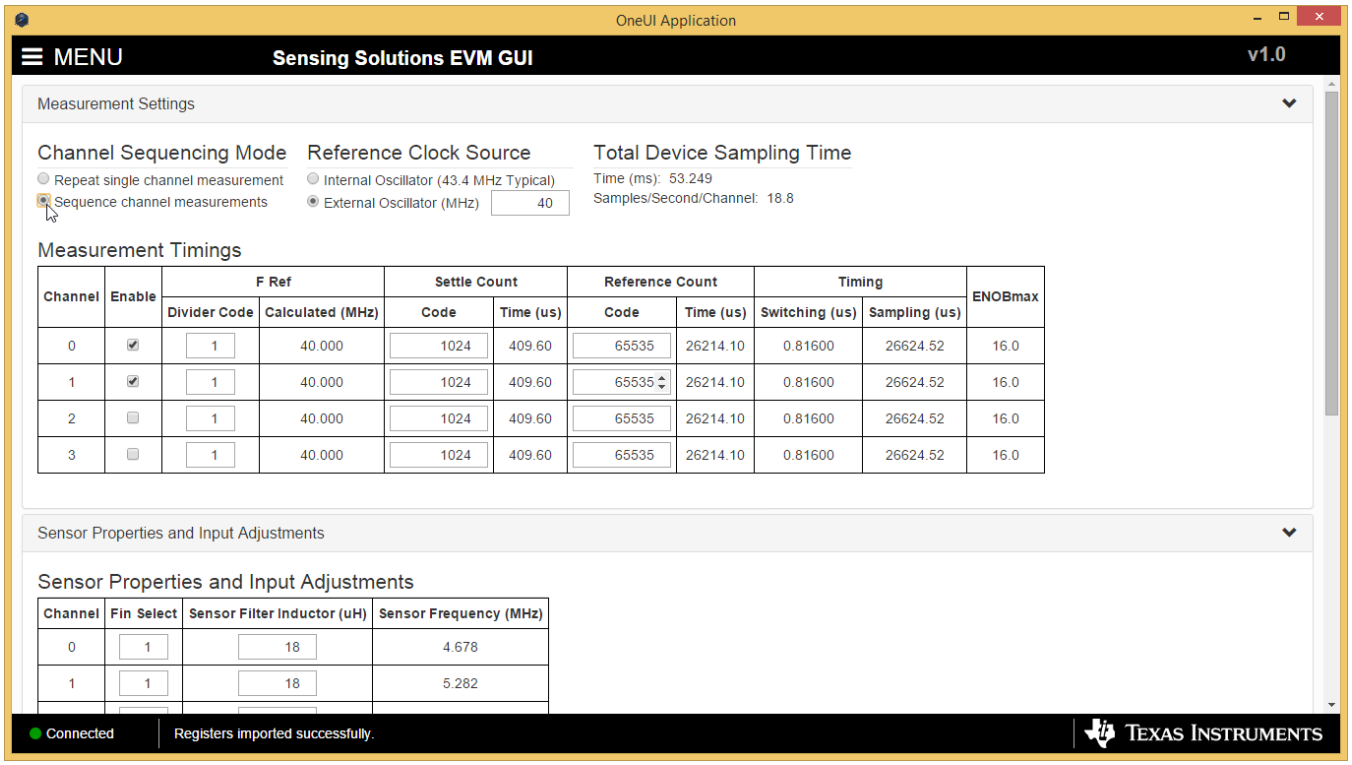

Figure 30. Configuring Device to Sequentially Measure Multiple Channels

2. Choose which channels to measure by clicking the highest channel desired
   Channel 0 and 1 will always be enabled in this mode

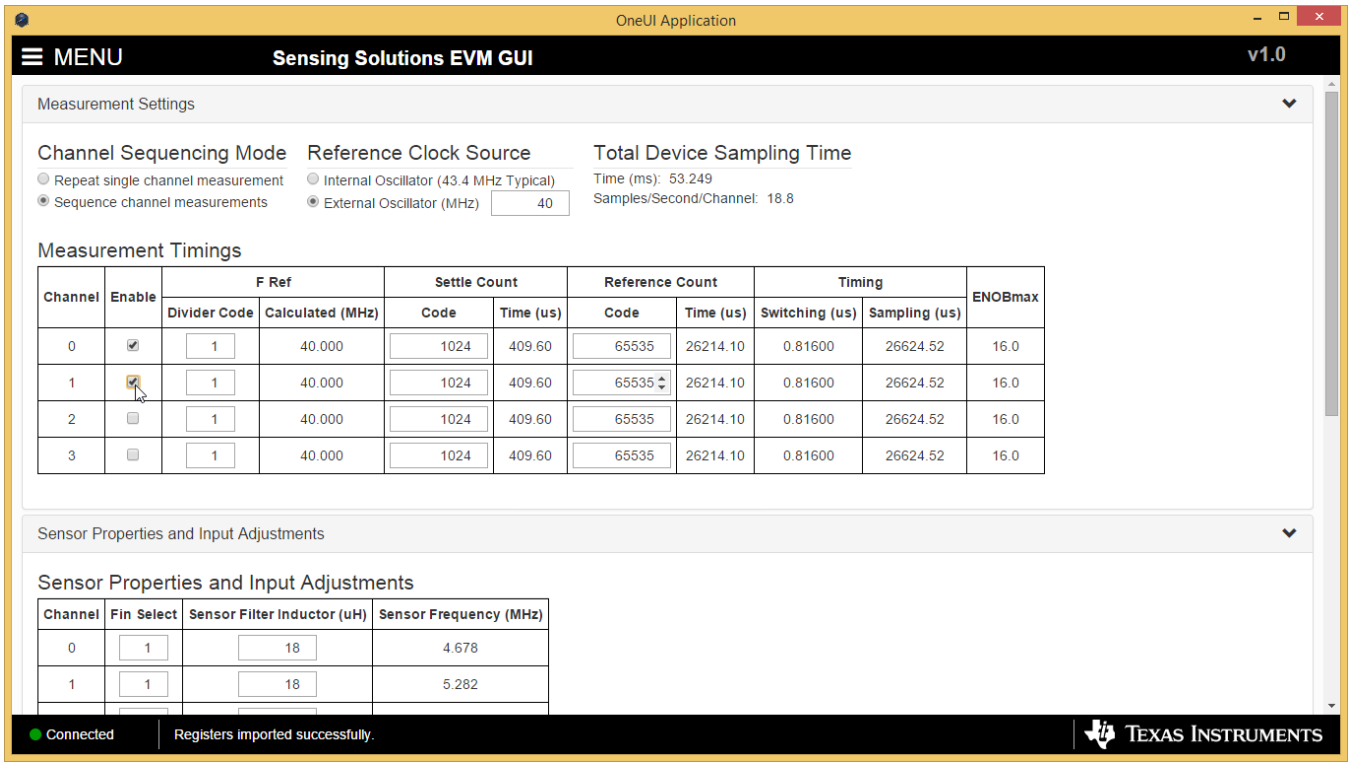

Figure 31. Selecting Channels 1 and 2 for Sequential Channel Measurements

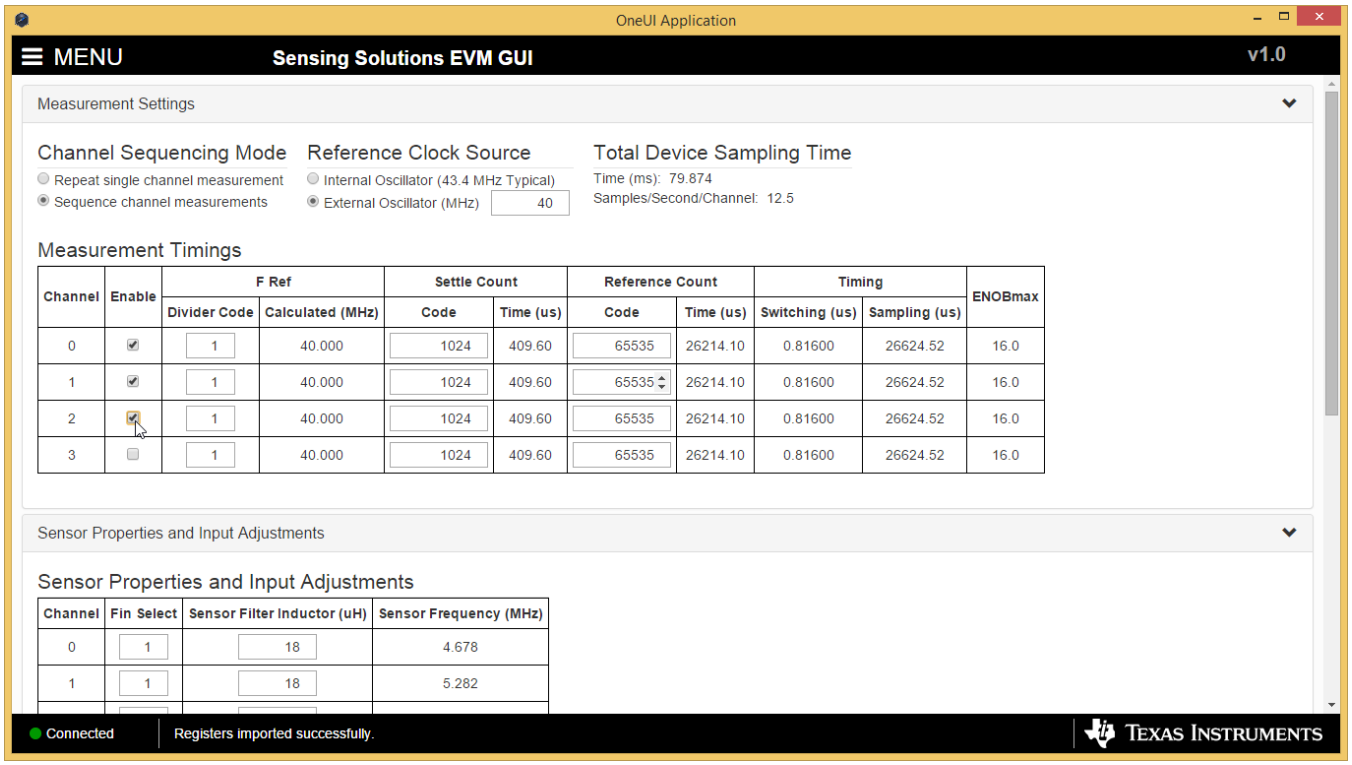

Figure 32. Selecting Channels 1, 2, and 3 for Sequential Channel Measurements

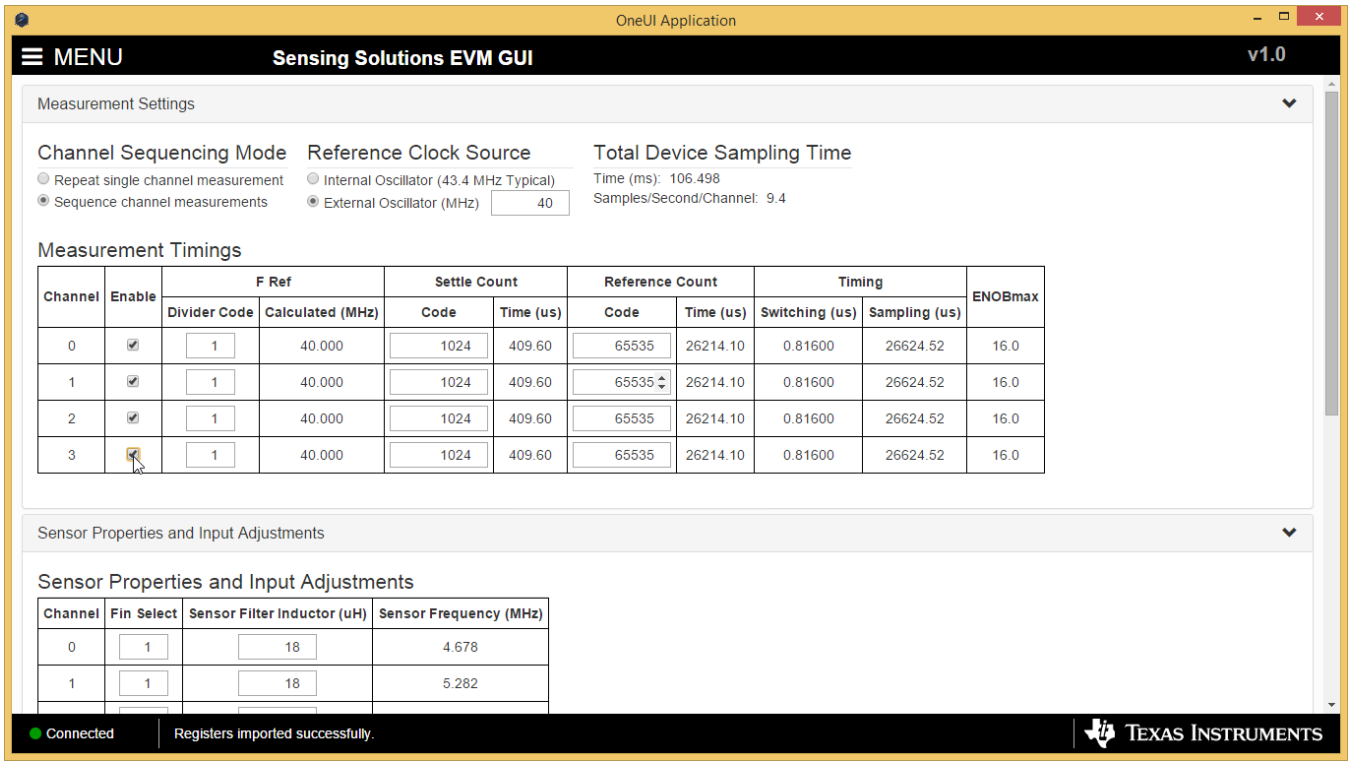

Figure 33. Selecting All Channels for Sequential Channel Measurements

3.5.2 Selecting the Clocking Source

While the device contains an internal oscillator which requires fewer components in a system, it is recommended to use an external oscillator for precision applications. The EVM includes a 40MHz oscillator on-board, but an external off board signal can be used.

To choose the oscillator source select one of the options in the “Reference Clock Source” section of the “Measurement Settings”. If using an external oscillator, enter the oscillation frequency so that the GUI correctly displays data measurements of frequency and capacitance.

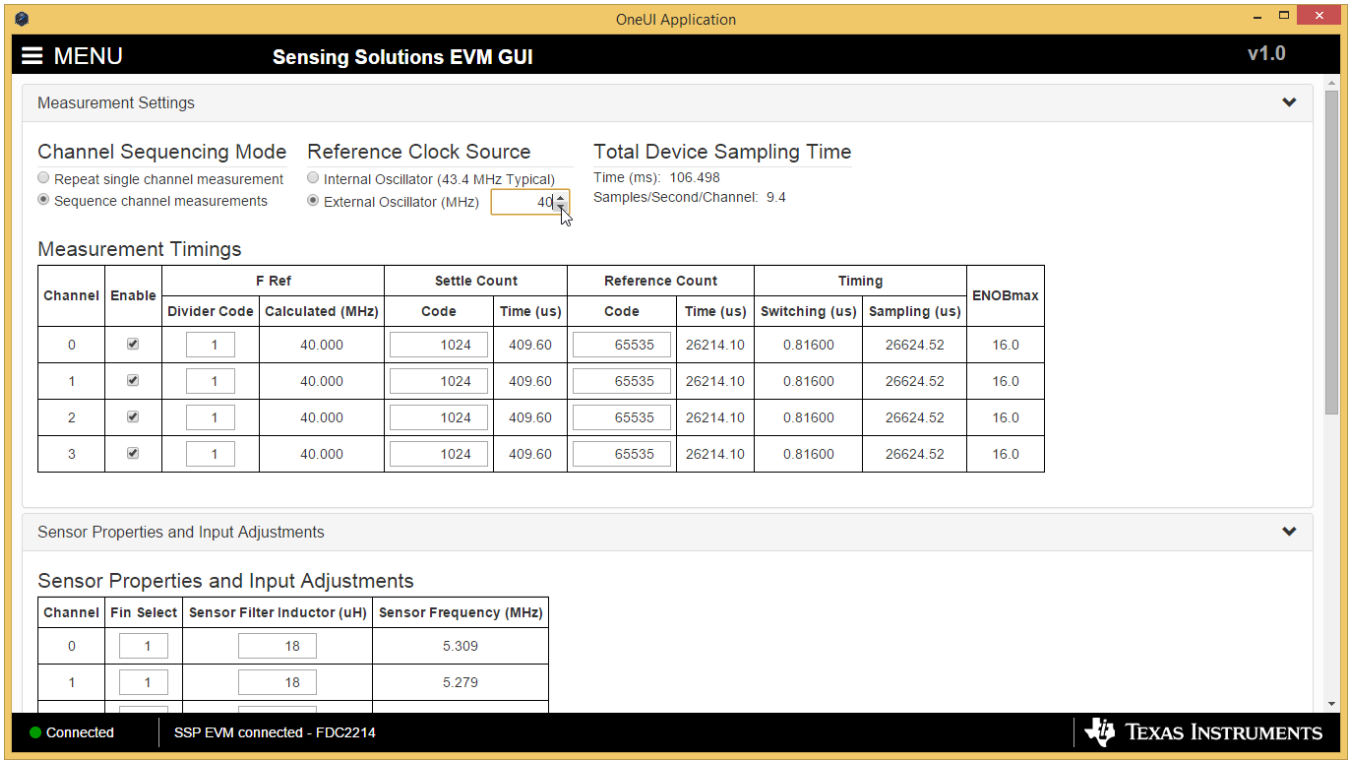

Figure 34. Selecting the External Oscillator and Entering its Frequency

3.5.3 Setting the Measurement Timings

Determining the best timing settings for the device is largely dependent on the application and sensor design, but in general the following items should be considered

- Each channel should have the maximum reference frequency possible. Most applications should have the channel Fref dividers set to one.
- Settle count needs to be long enough, but increasing it arbitrary holds no value and only decreases the sampling rate. Reference the datasheet for calculating the optimal settle count.
- Reference count has the largest effect on the accuracy of a measurement. Increasing the reference count leads to a more accurate measurement, but at the cost of decreased sampling rate. The effective number of bits for each channel is calculated in the table for each channel based on the reference count.

3.5.4 Using a Different Sensor

When using a different sensor, several parameters could be changed. The sensor’s resonant frequency could be vastly different or a different sensor inductor could be used. If the resonant frequency of the sensor is less than 8.75MHz the F_{in} select should be set to one. If the sensor frequency is greater than 8.75 MHz, F_{in} select should be two. The sensor filter inductor for each channel should be updated to reflect to actual component value on the sensor.

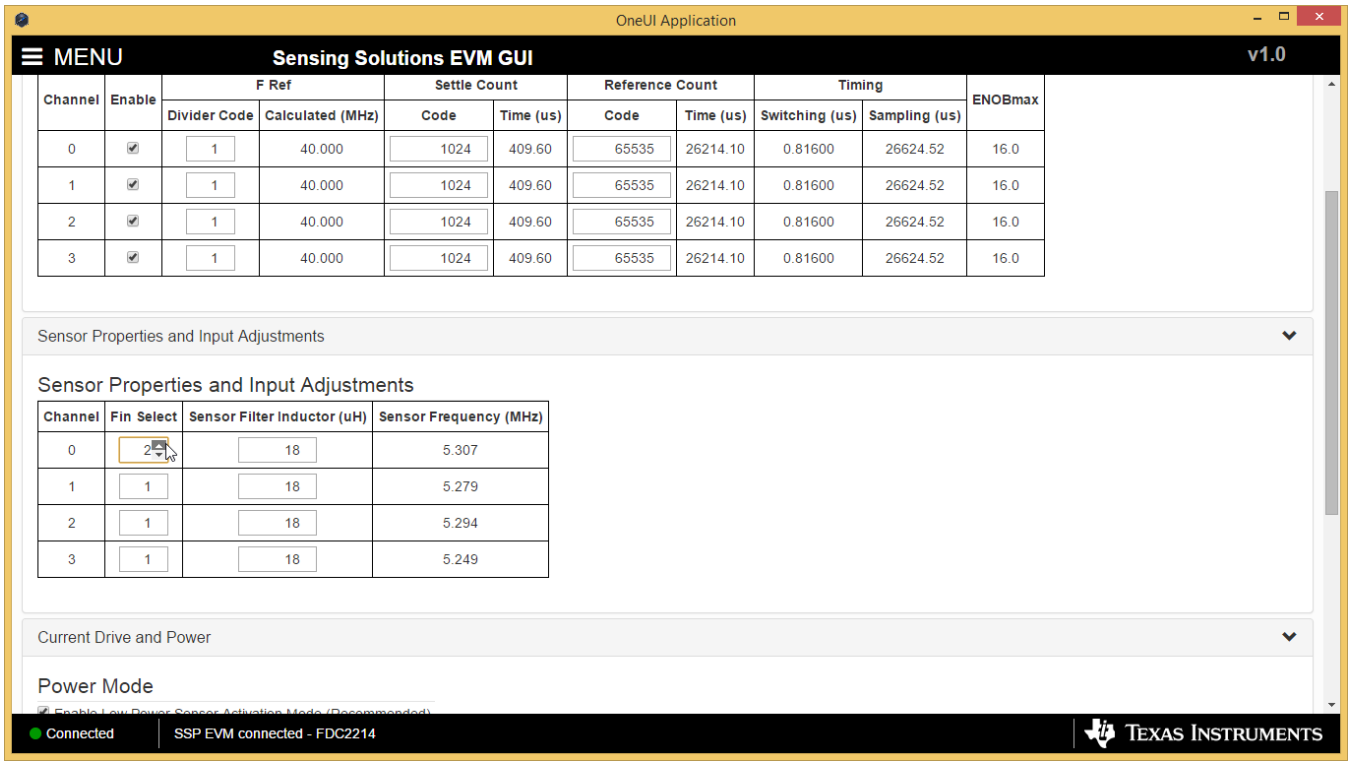

Figure 35. Selecting F_{in} for Channel Measurements

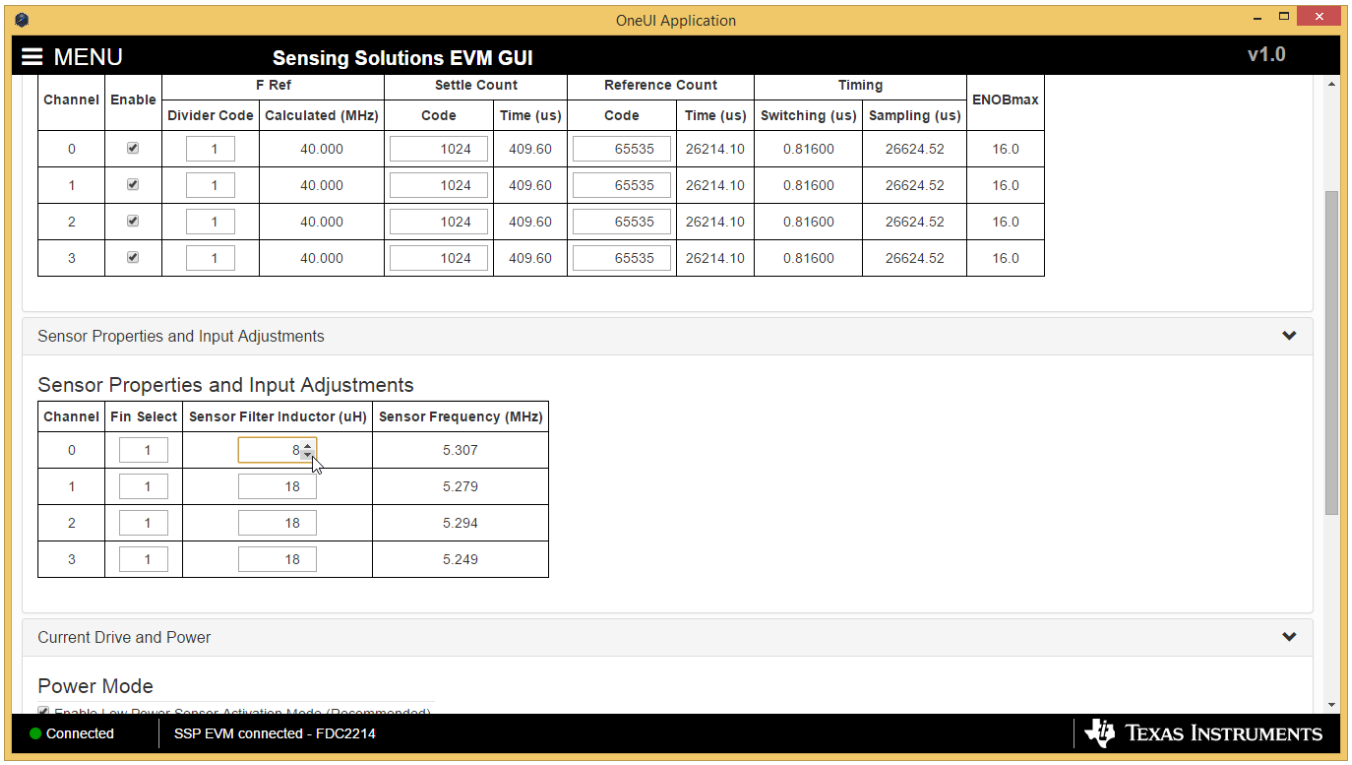

Figure 36. Entering the Sensor Inductor Values for Calculating Capacitance Measurements

While the FDC2214 doesn't support any gain or offset adjustments, the FDC2114 device has a limited measurement resolution and so a gain or offset may need to be set. The code offset may be set in the “Sensor Properties and Input Adjustments” table and the input gain is globally set for all channels. Please reference the device datasheet for more information to correctly set these values.

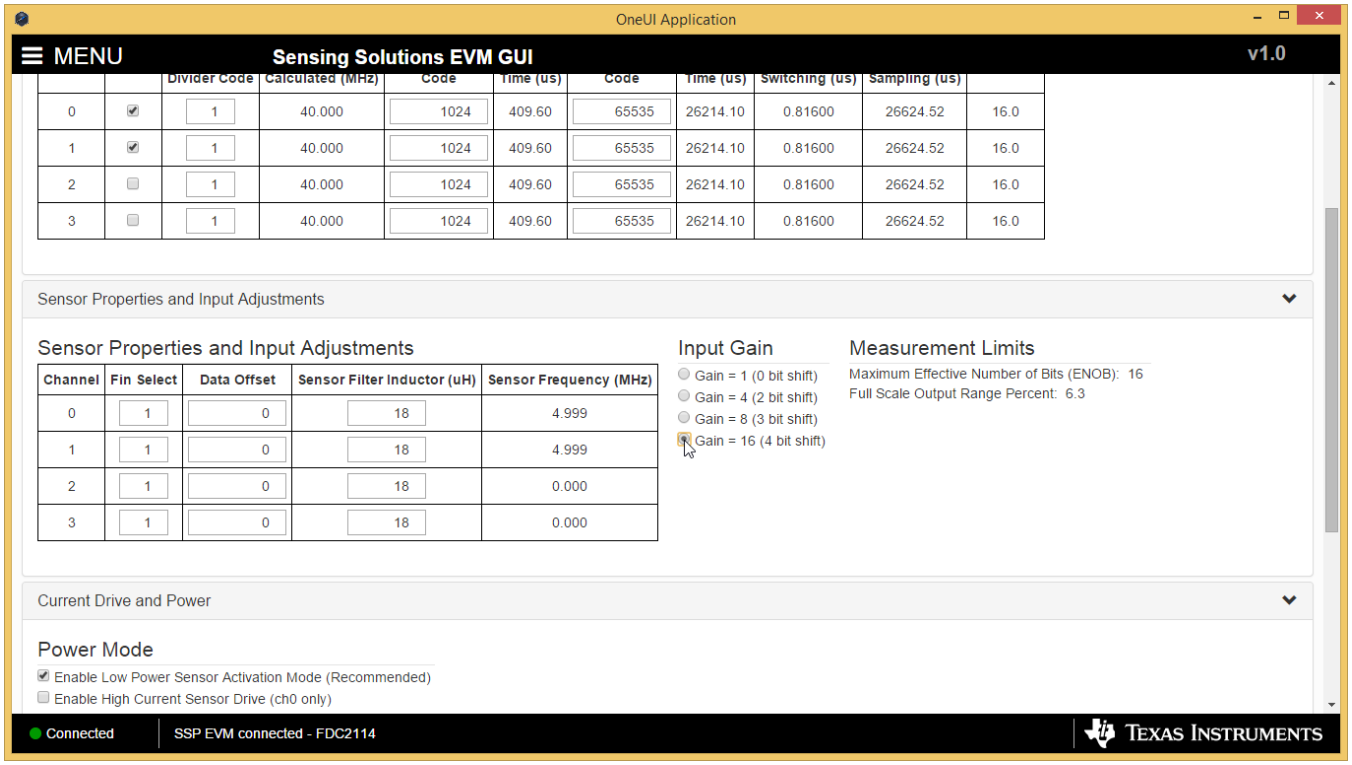

Figure 37. Updating Input Measurement Gain for FDC2114

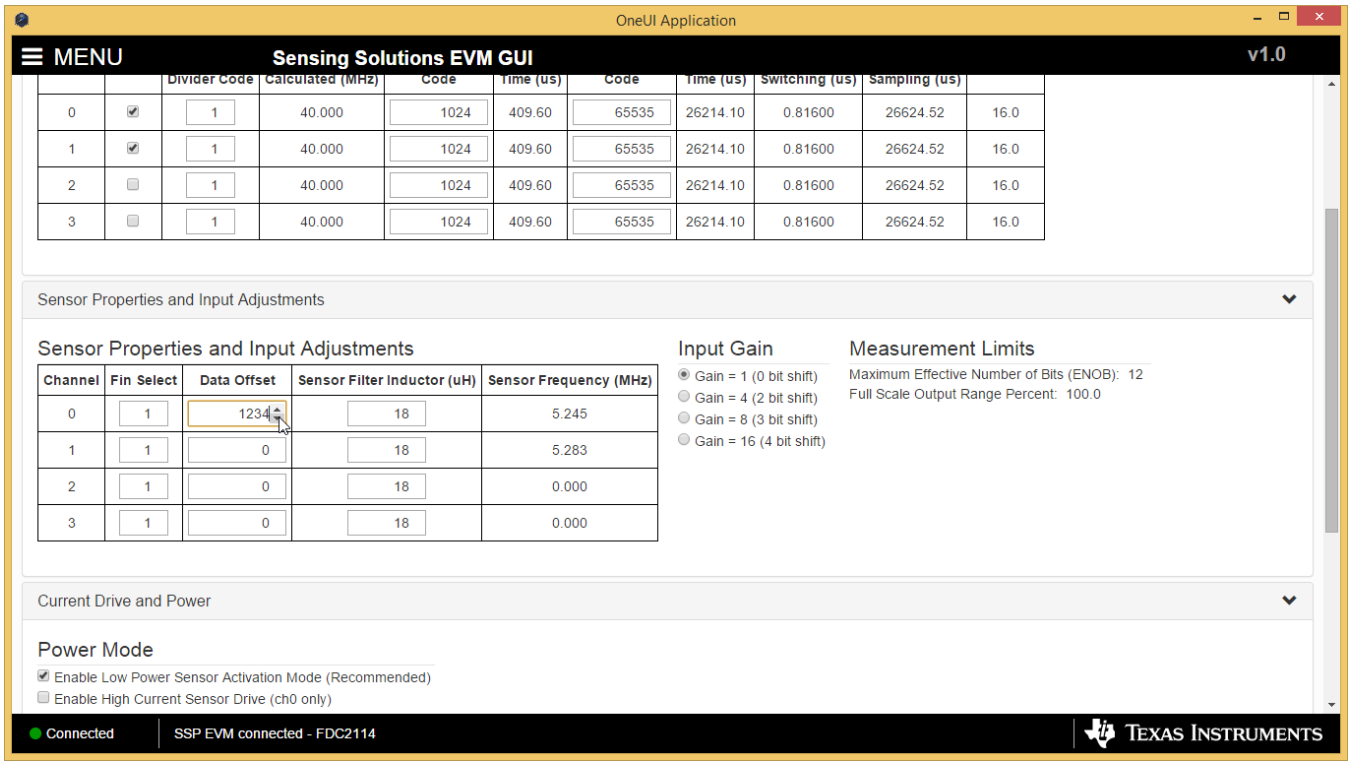

Figure 38. Updating Input Measurement Offset for FDC2114

3.5.5 Setting the Power Mode and Sensor Initialization Currents

Most applications do not need maximum channel initialization currents and the low power sensor activation mode should be enabled. When low power sensor activation mode is enabled, the IDRIVE code determines how much current the device supplies to the sensor. To determine the optimal current drive setting, move the system target to its furthest distance from the sensor and click the “Detect iDriveInit with Auto-Amplitude Correction” button. This will take a measurement to determine an appropriate current setting. After the setting has been measured, the code value of I_{drive} must be adjusted.

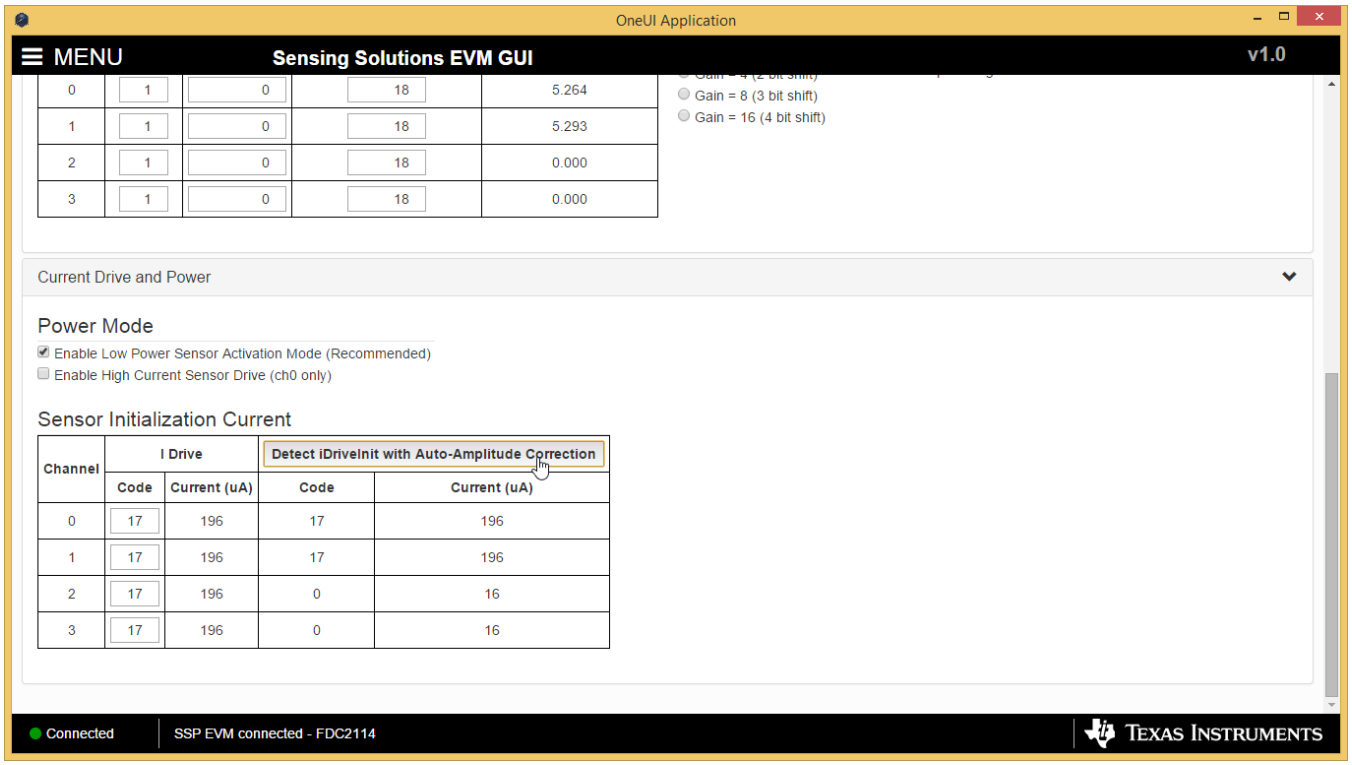

Figure 39. Detecting Optimal I_{drive} from the Configuration Page

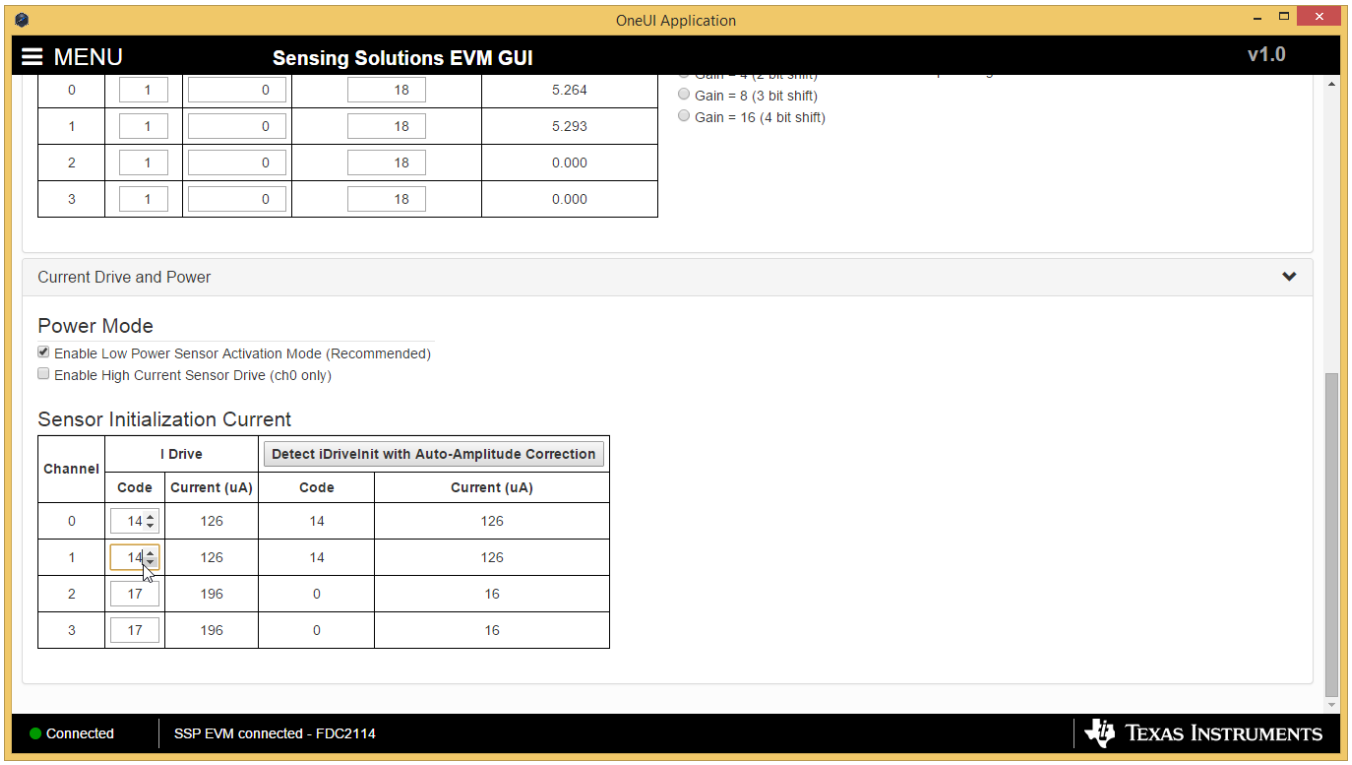

Figure 40. Updating I_{drive} Code with Recommended Value

If the low power sensor activation mode is disabled, the I_{drive} settings are ignored. If only measuring channel 0 and the sensor requires maximum drive current, enable the high current sensor drive.

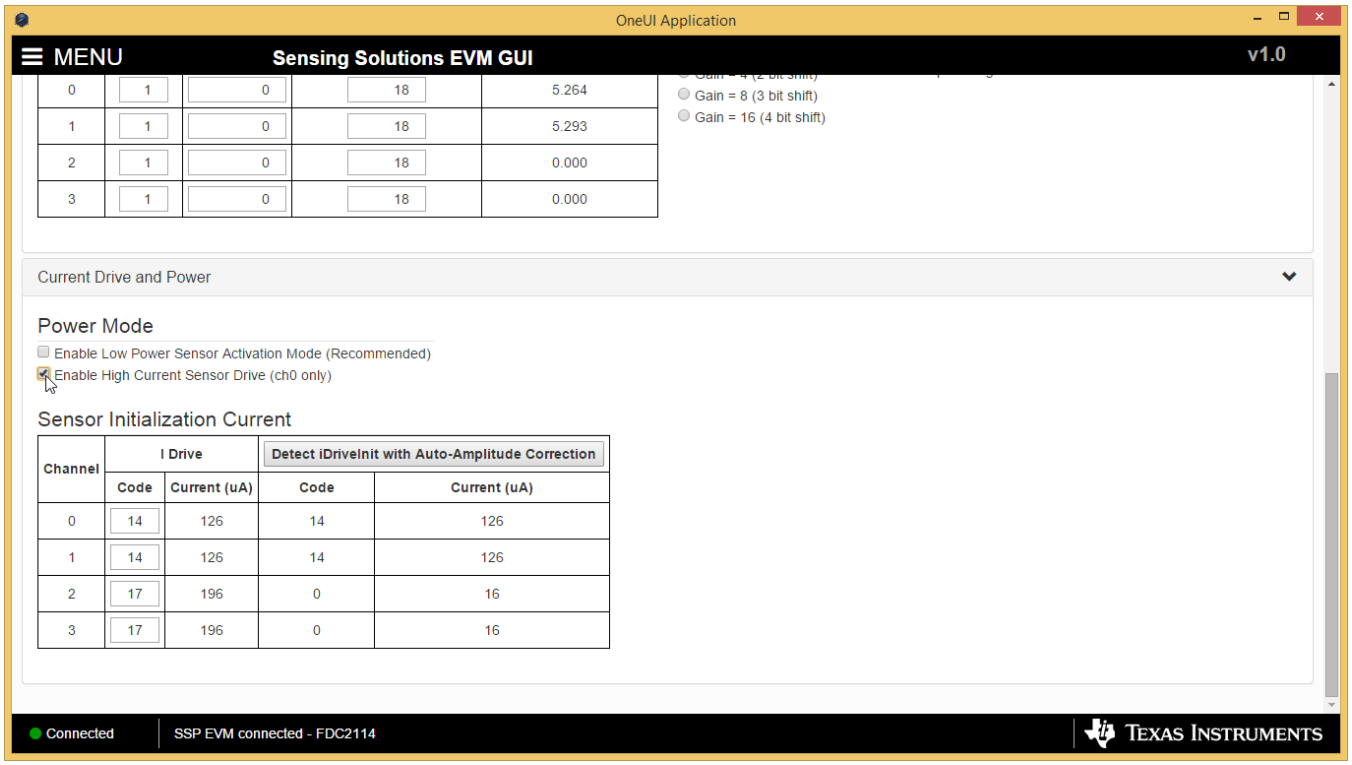

Figure 41. Selecting Maximum Current Drive for Channel 0

3.6 Streaming Measurement Data

The Sensing Solutions GUI and EVM provide a tool to capture measurement data at rates up to 500Hz. The section describes how to use the data measurement tools from the "Data Streaming" page accessible from the GUI menu.

3.6.1 Choosing Graph Units and Visible Channels

Select the drop down menu on top of the y-axis to choose the units of the graph. Available options include: Capacitance, Raw Code, and Frequency. Note that if the source oscillator frequency or the individual sensor inductor values on the Configuration page are not set accurately the capacitance and frequency measurements will be inaccurate for graphing and logging.

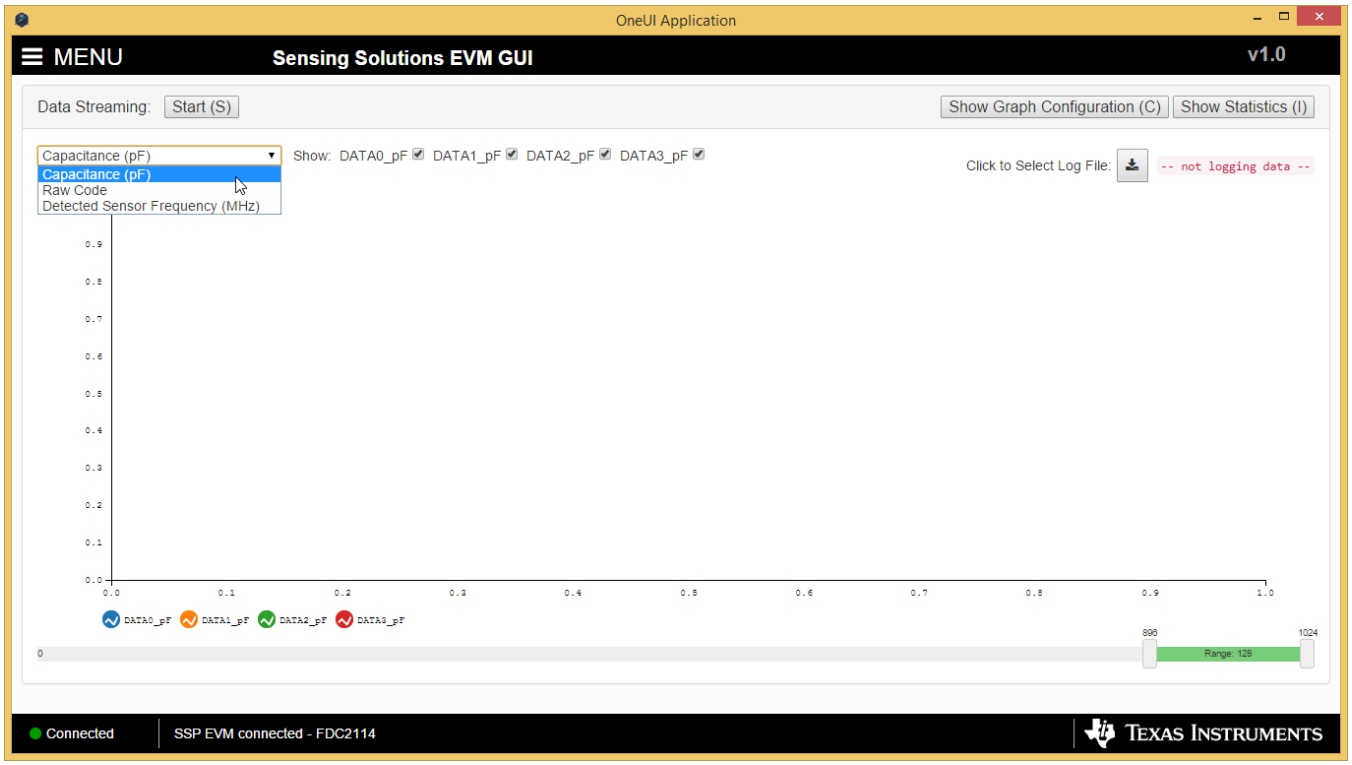

Figure 42. Selecting the Measurement Units for the Data Streaming Graph

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.

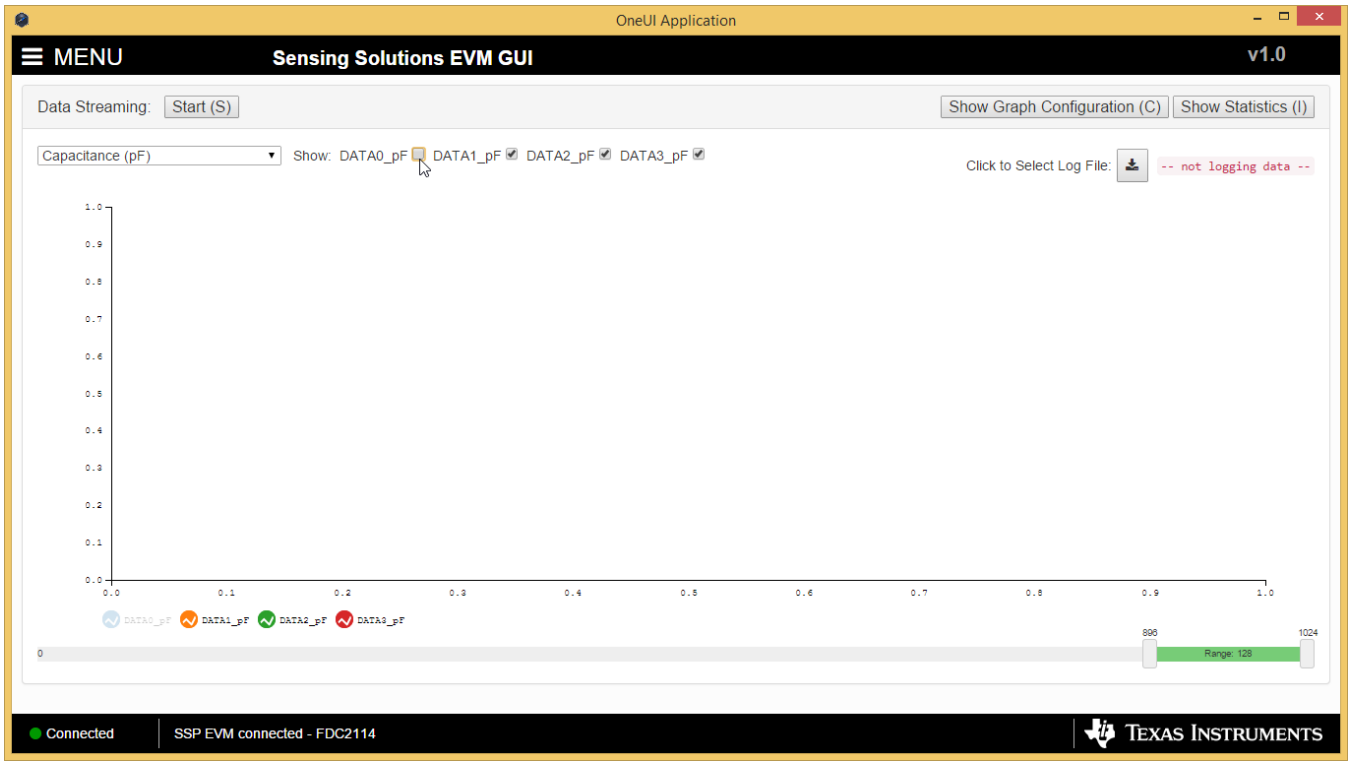

Figure 43. Hiding Channel 0 from the Data Streaming Graph

3.6.2 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"

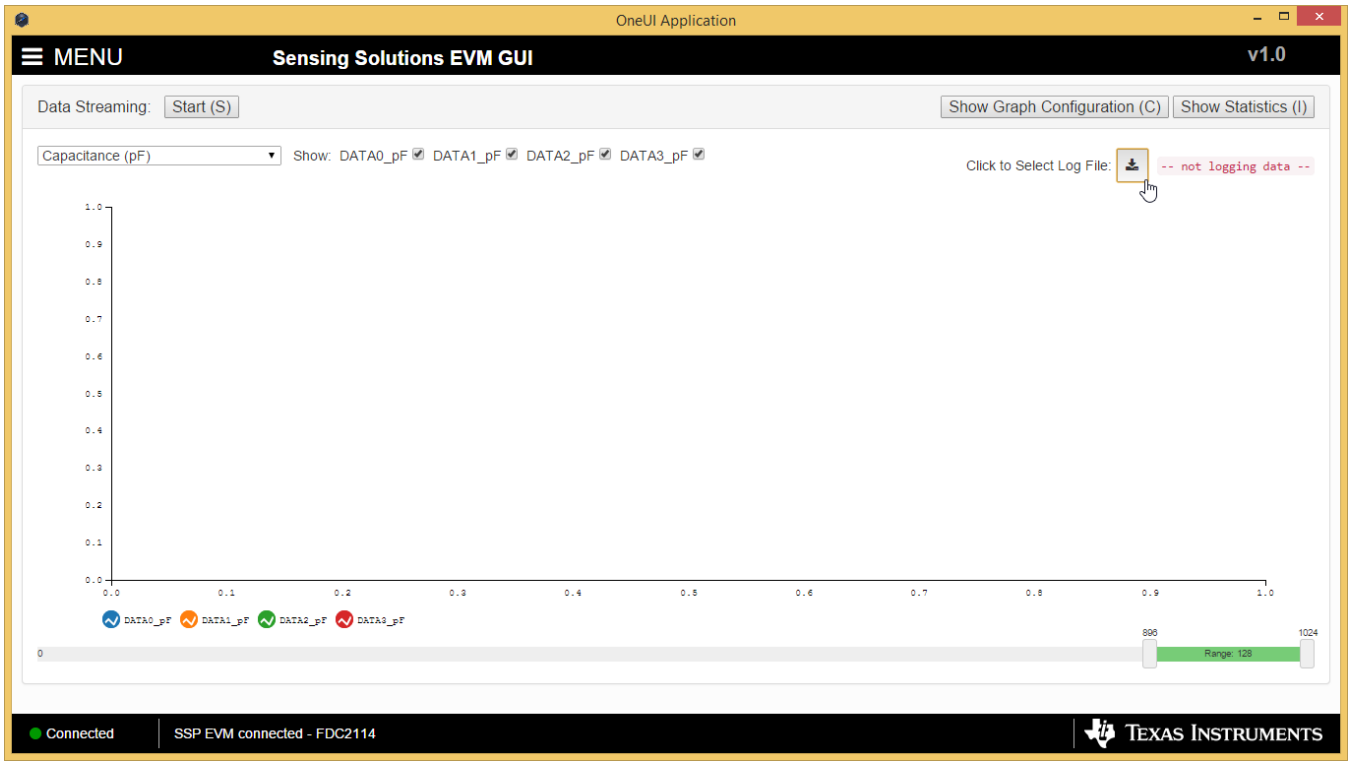

Figure 44. Select Log File Button on Data Streaming Page

2. Select a file name and directory to save the data to and then click the “Save” button

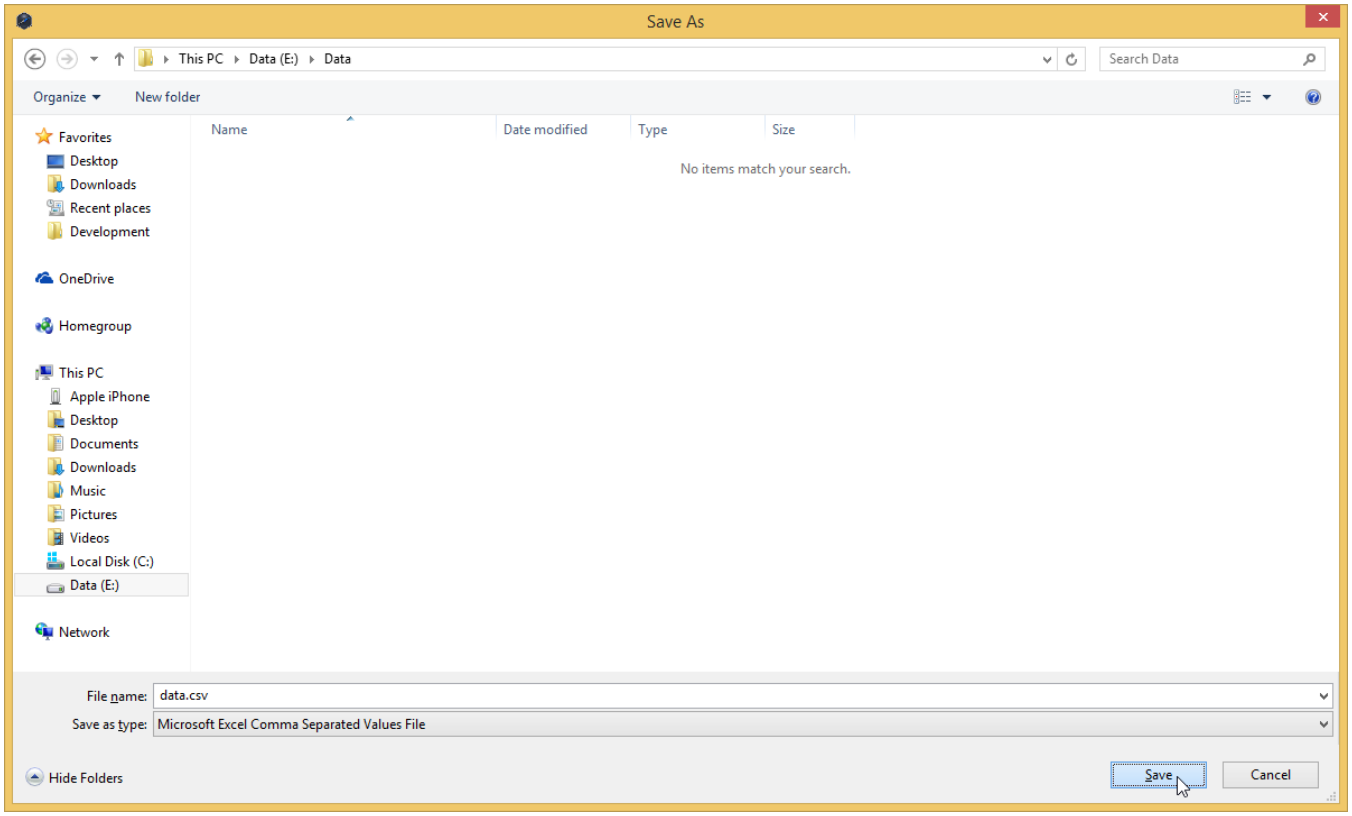

Figure 45. Selecting the Log File for Data Streaming

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

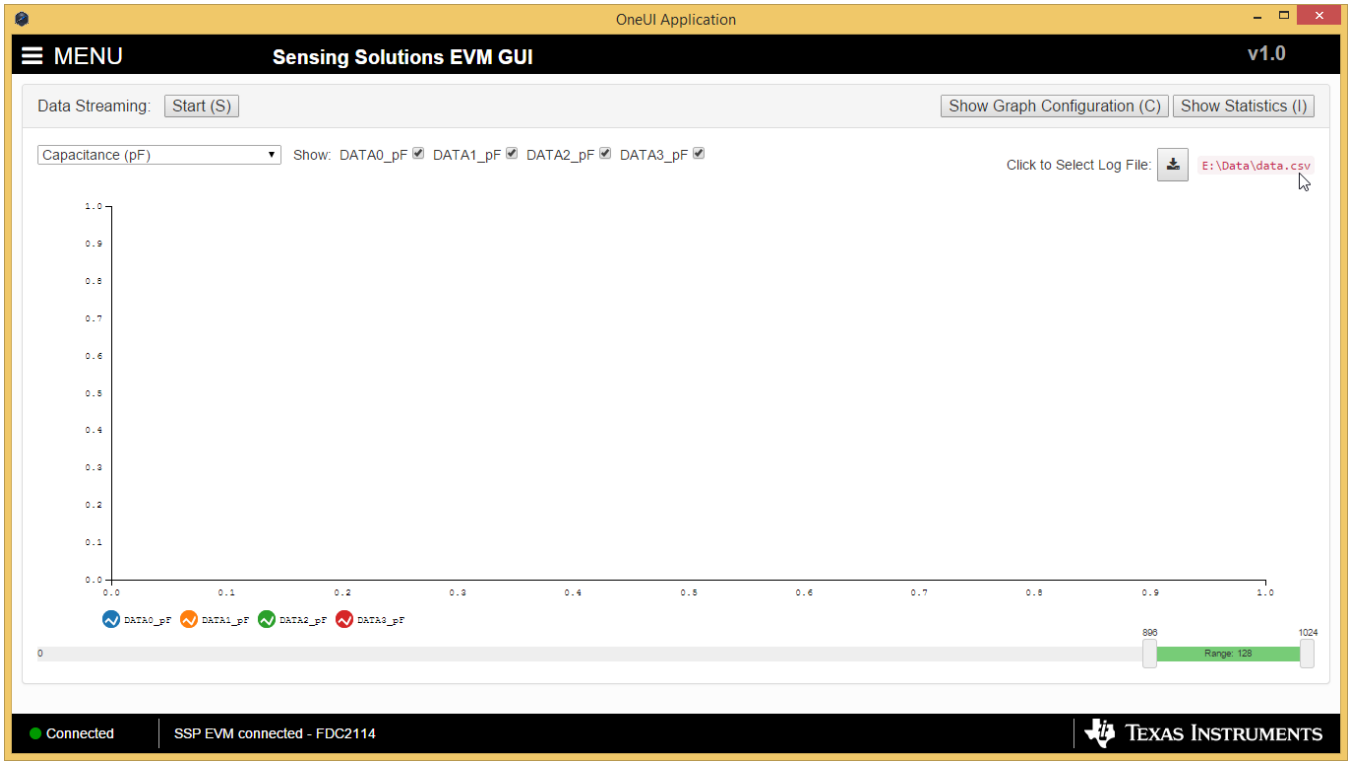

Figure 46. Selected Log File Shown on Data Streaming Page

3.6.3 Setting the Vertical Axis Scale and Sampling Rate

To set the vertical axis scale or change the sampling rate follow these steps.

1. Click the “Show Graph Configuration” button

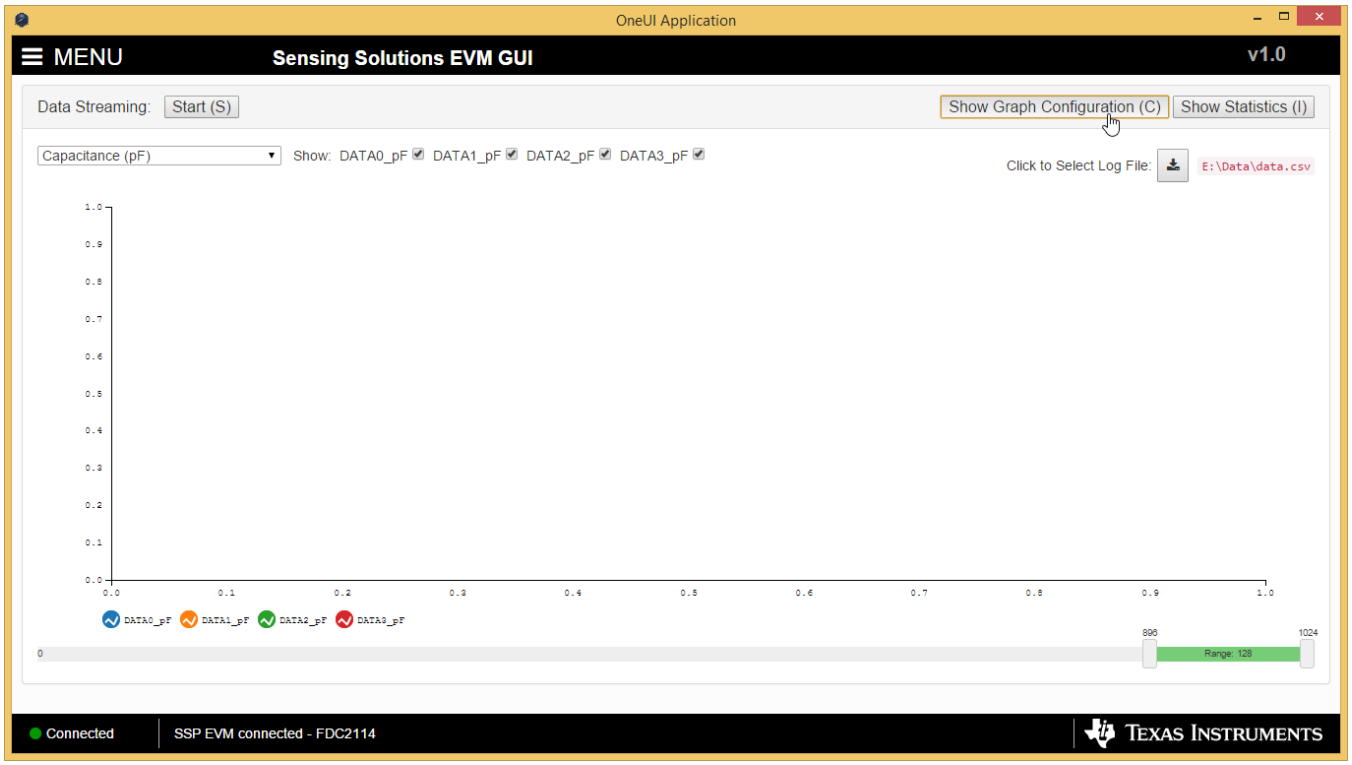

Figure 47. Show Graph Configuration Button on Data Streaming Page

2. The sampling rate can be adjusted in the “Sampling Rate” table.
   - Note that the GUI sampling rate affects only the graph and logging rate but not the actual device sampling rate

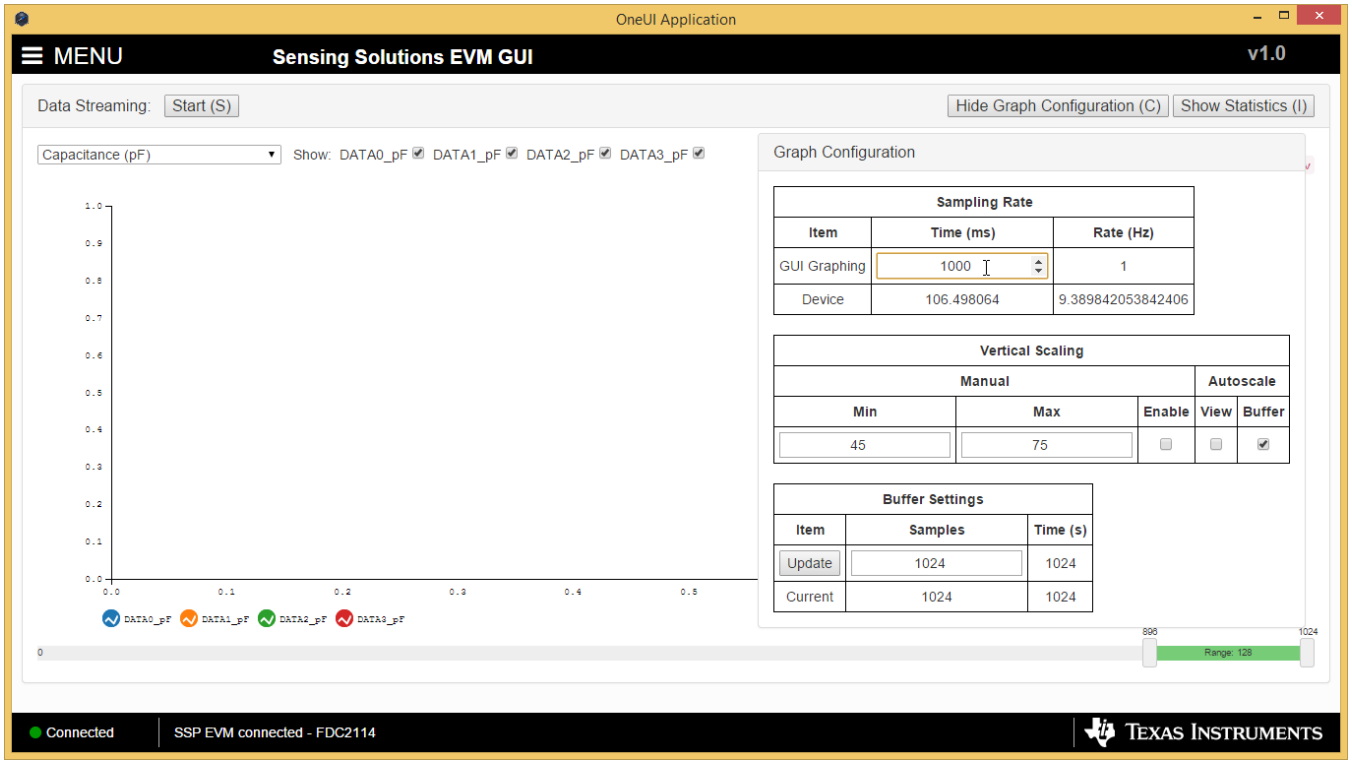

Figure 48. Setting the Data Streaming Sample Rate to 1 Second

3. The vertical scaling can be automatically updated or manually controlled by selecting either checkboxes in the “Vertical Scaling” table

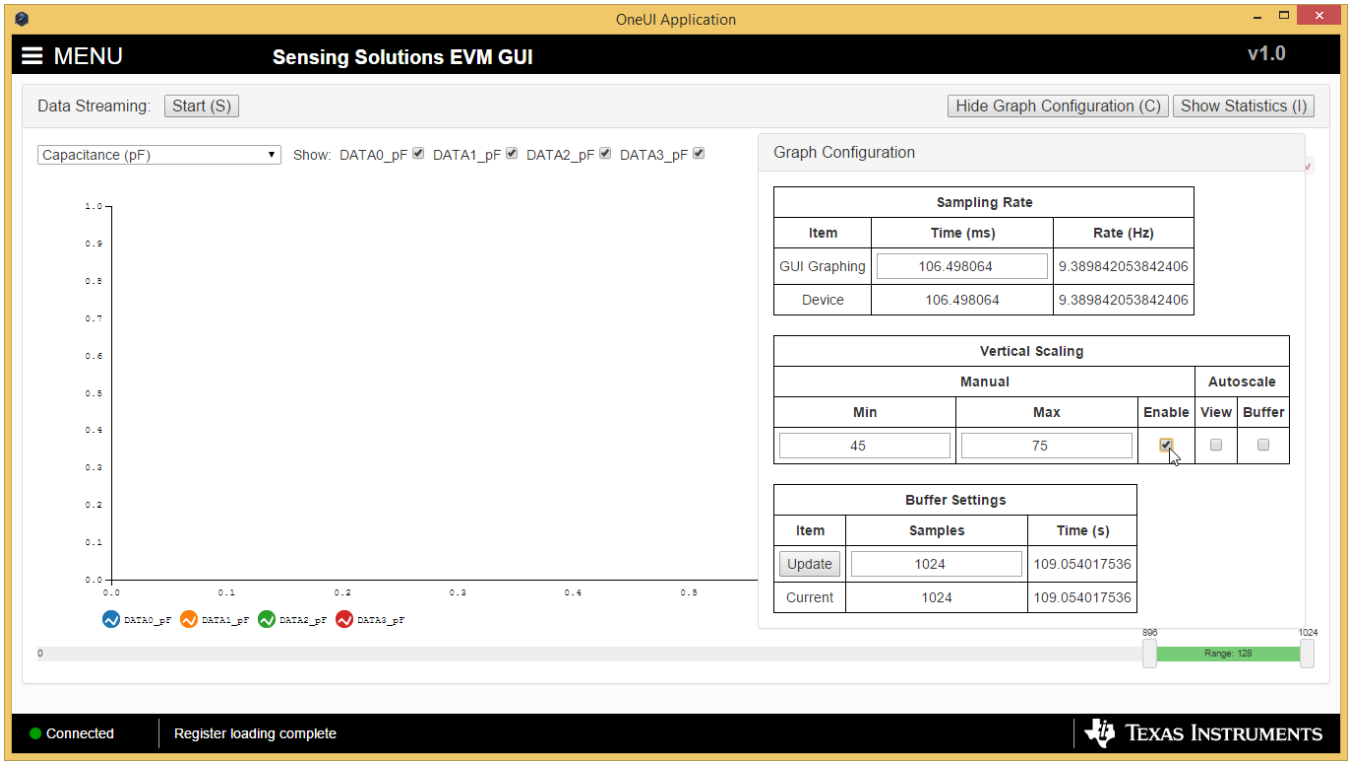

Figure 49. Manually Setting the Vertical Scale on Data Streaming Graph

3.6.4 Starting and Stopping Measurement Data Acquisition

To start data streaming click the “Start” button.

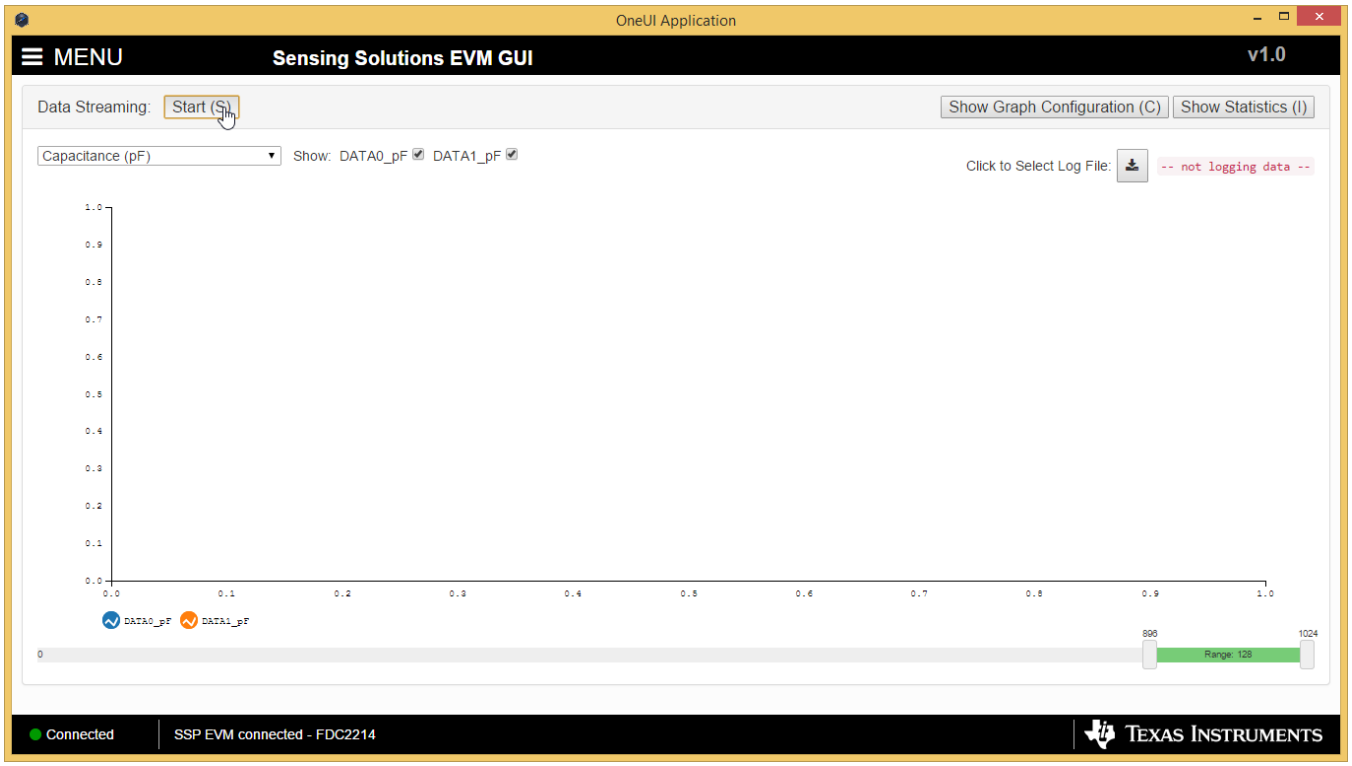

Figure 50. Starting Data Acquisition on Data Streaming Graph

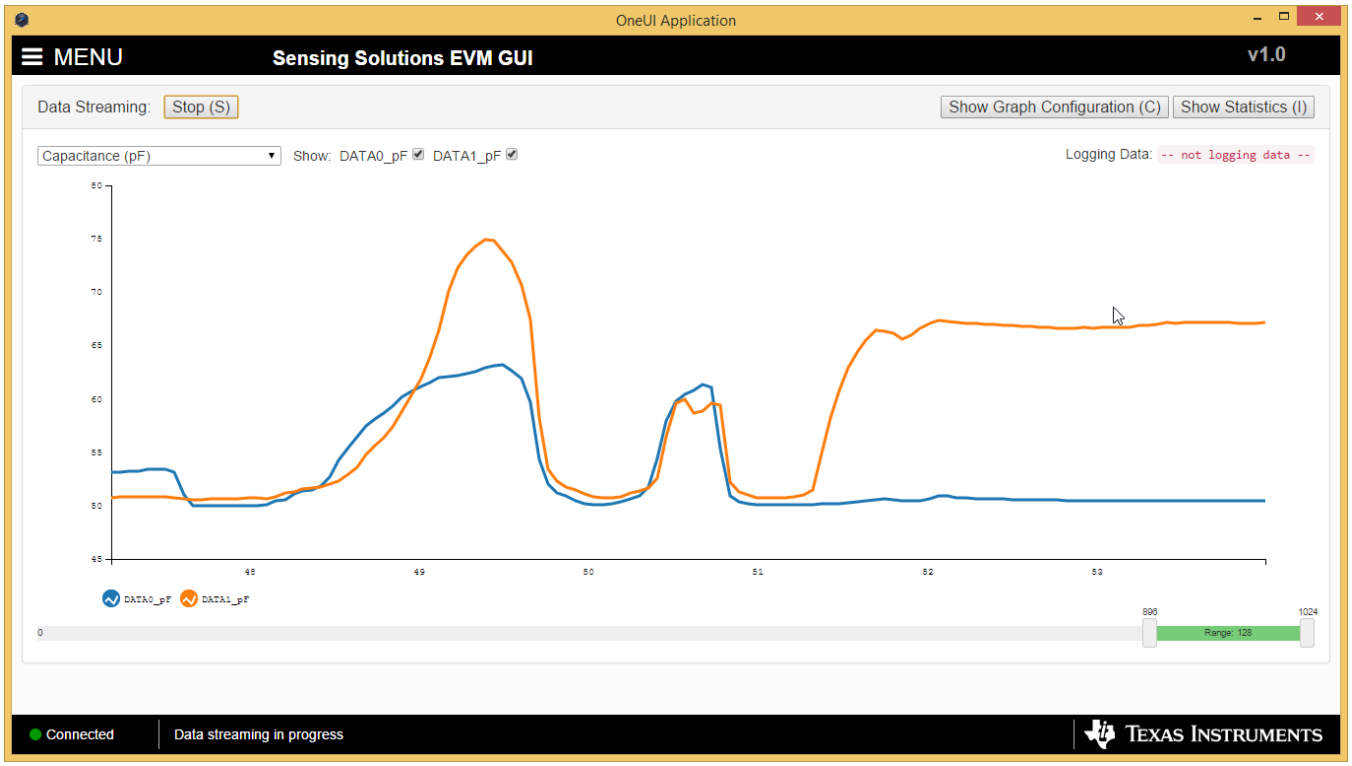

Figure 51. Data Acquisition In Progress on Data Streaming Page

To stop data streaming click the “Stop” button.

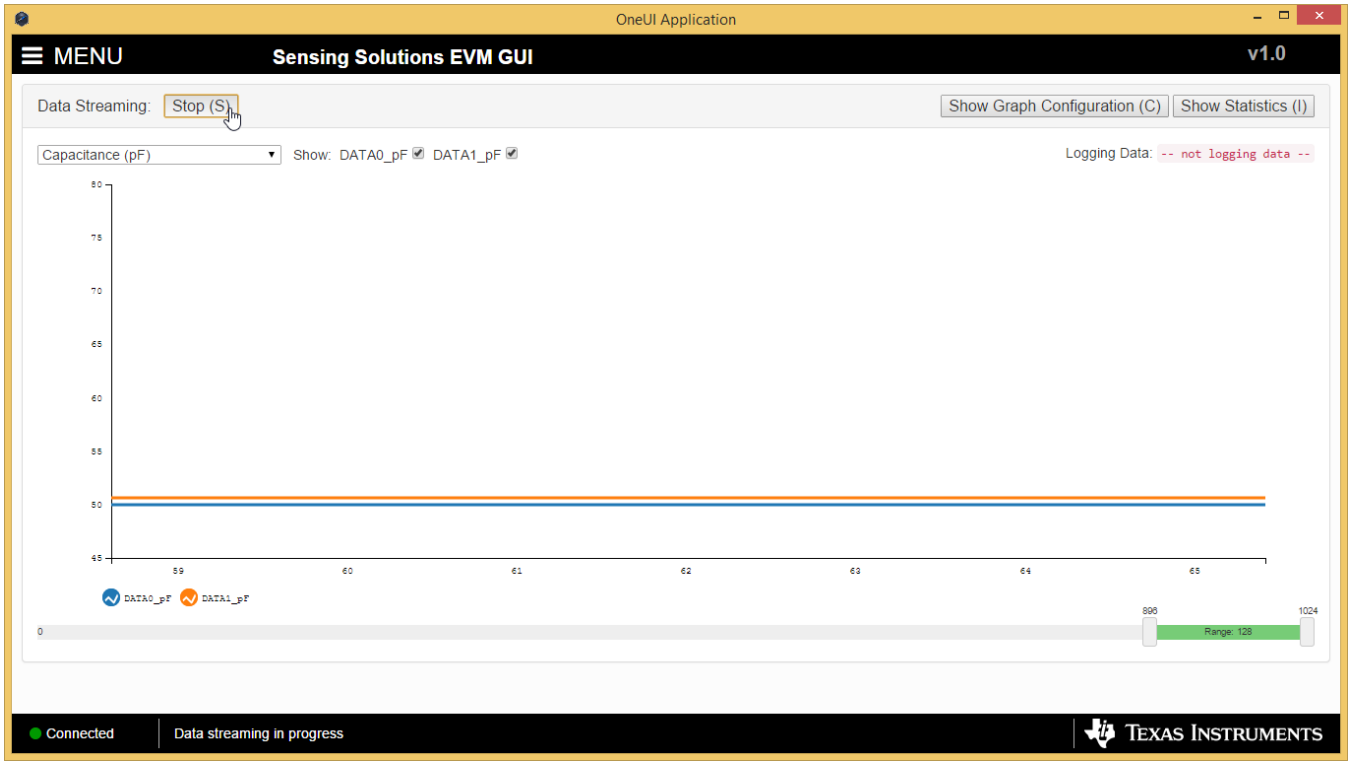

Figure 52. Stopping Data Acquisition on Data Streaming Graph

3.6.5 Displaying Measurement Data Statistics

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

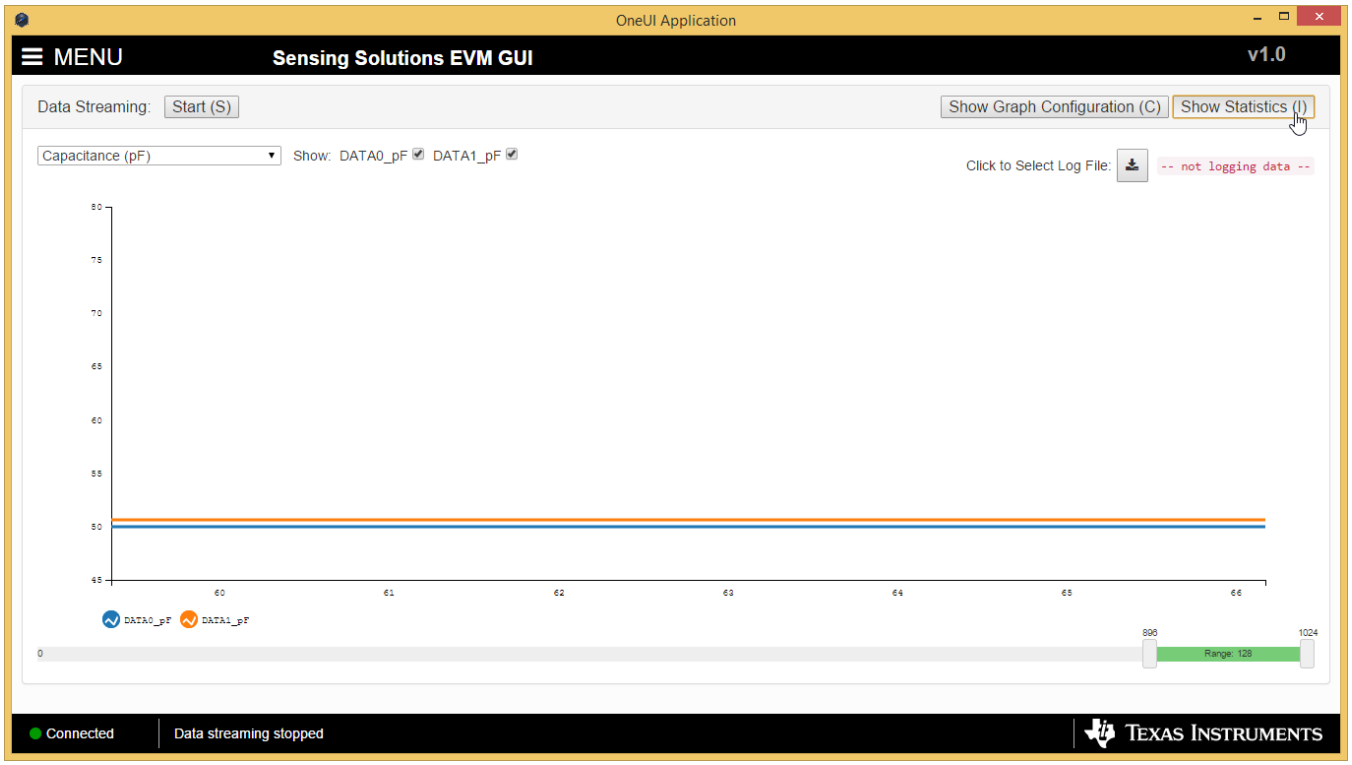

Figure 53. Show Statistics Button on Data Streaming Graph

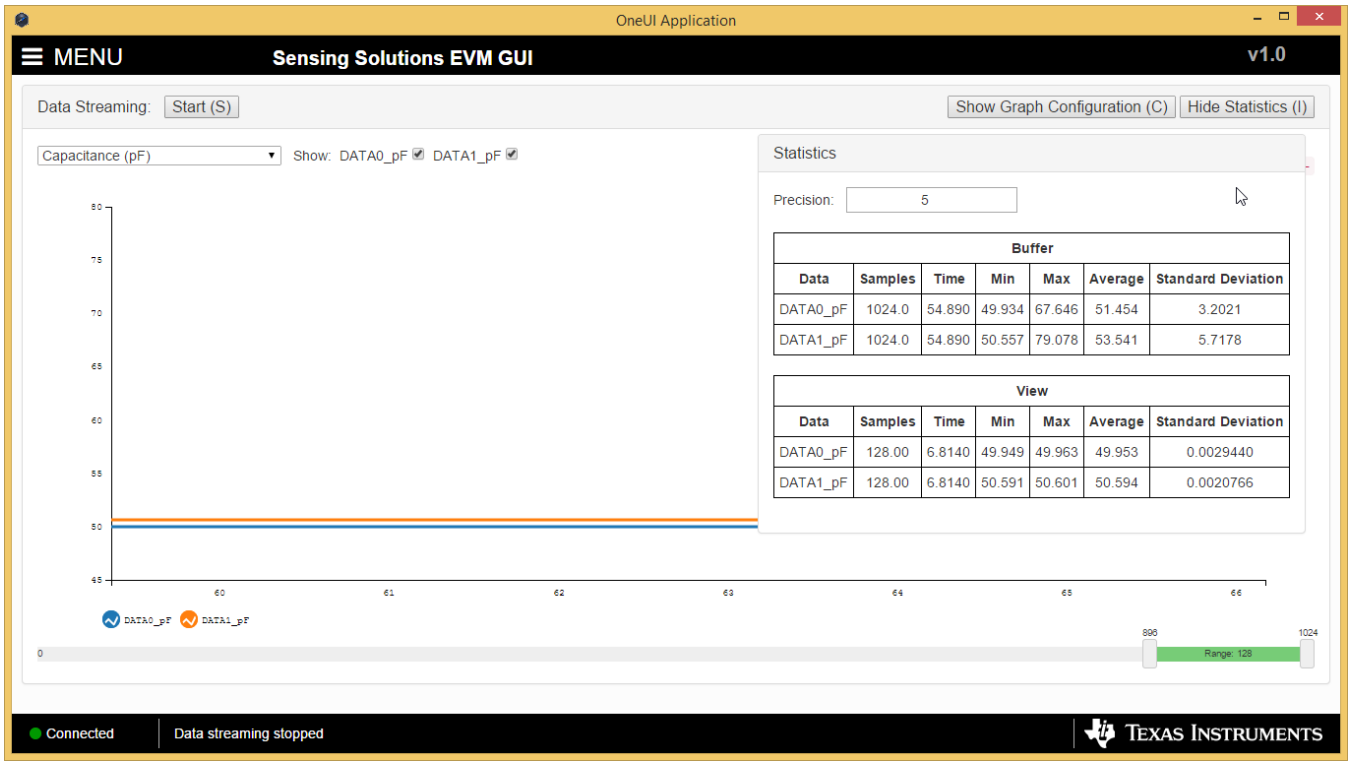

Figure 54. Data Statistics on Data Streaming Graph

3.6.6 Navigating the GUI's Data Buffer

After stopping the data stream, the number of data samples displayed can be selected by moving the dual slider under the graph.

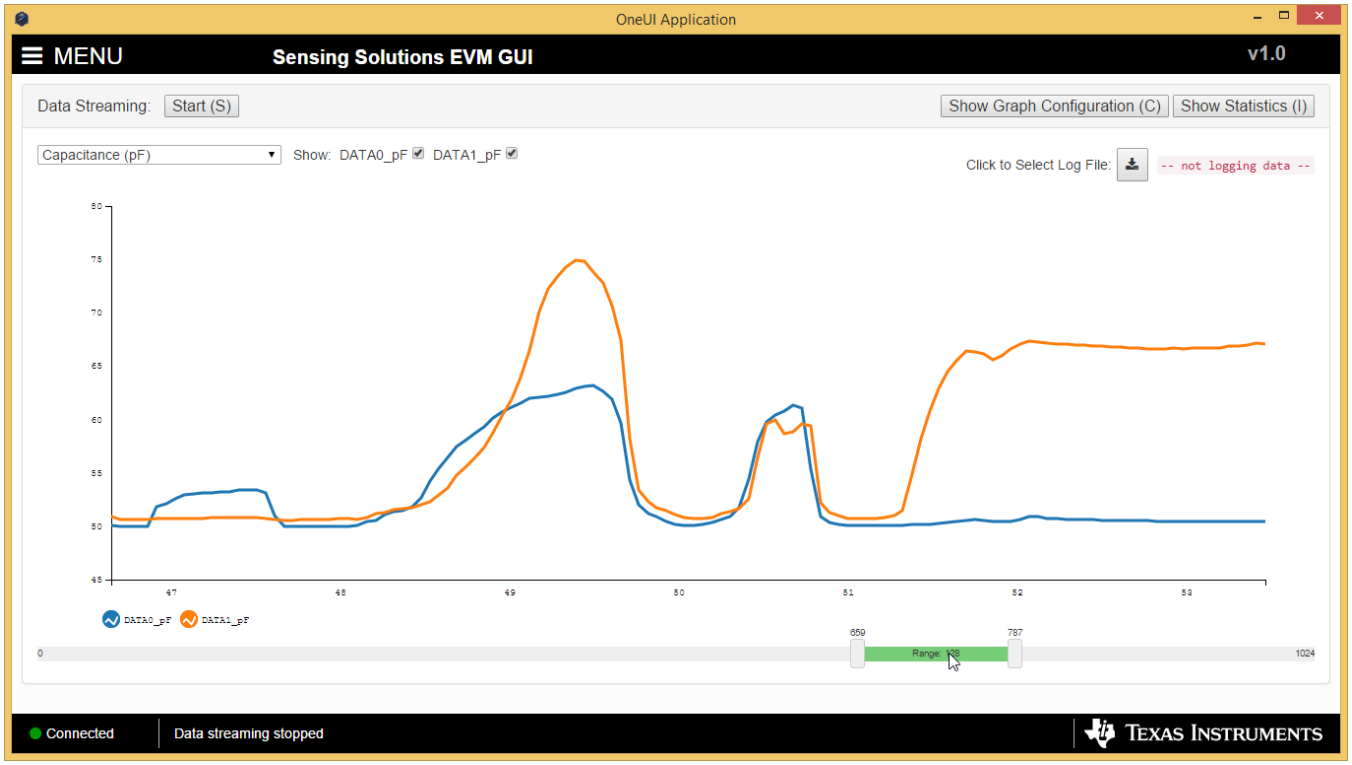

Figure 55. Moving the Data Graph Sample View

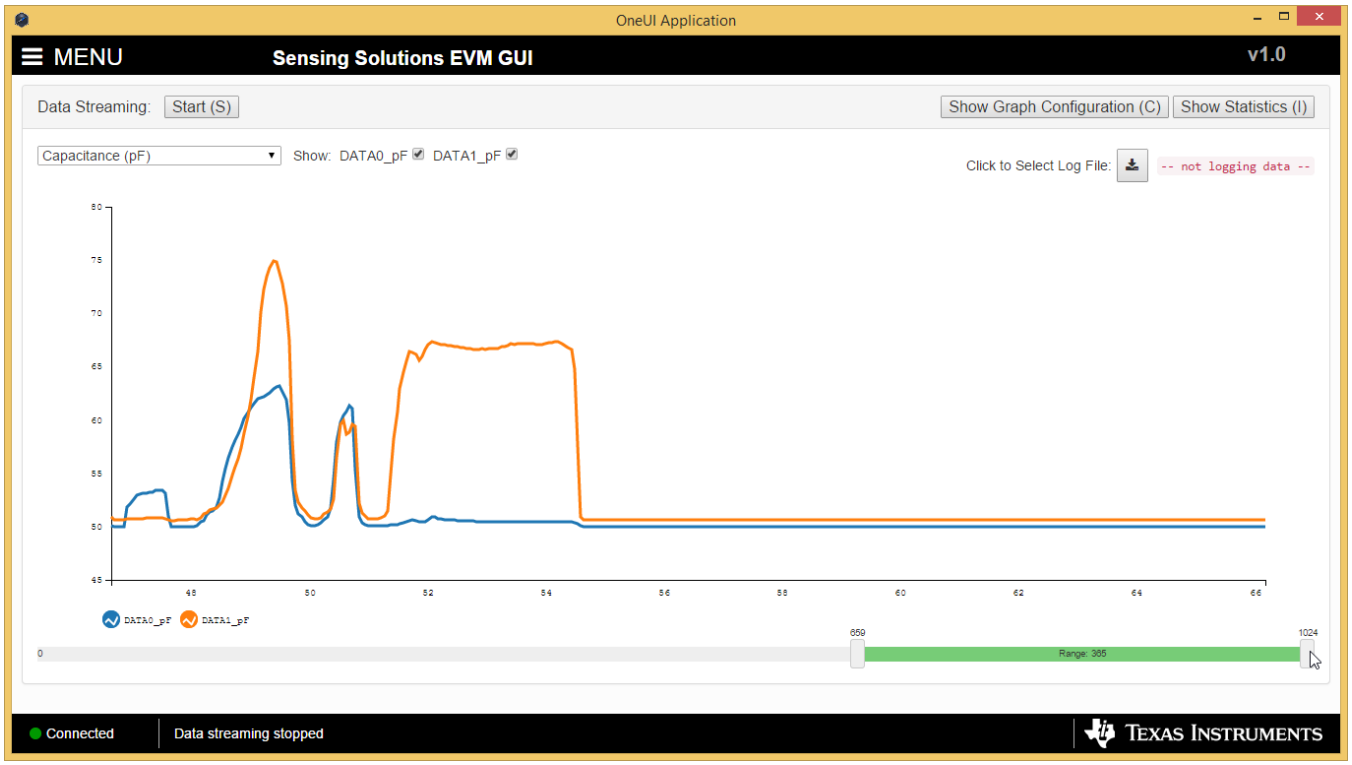

Figure 56. Changing Number of Samples Displayed in Data Graph

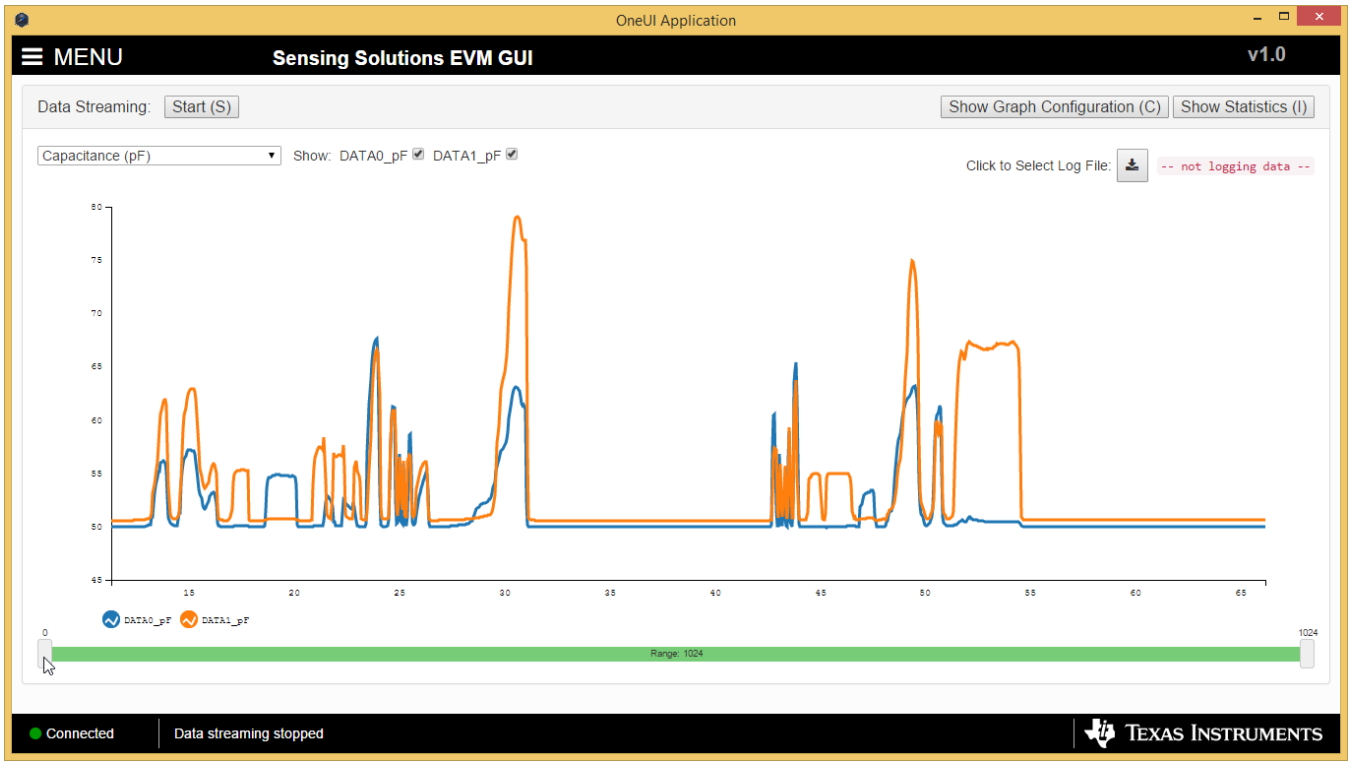

Figure 57. Viewing the Entire Buffer on Data Graph

3.7 Updating the EVM Firmware

To upload new firmware to the EVM, navigate to the "Firmware" page from the GUI menu and follow these steps.

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

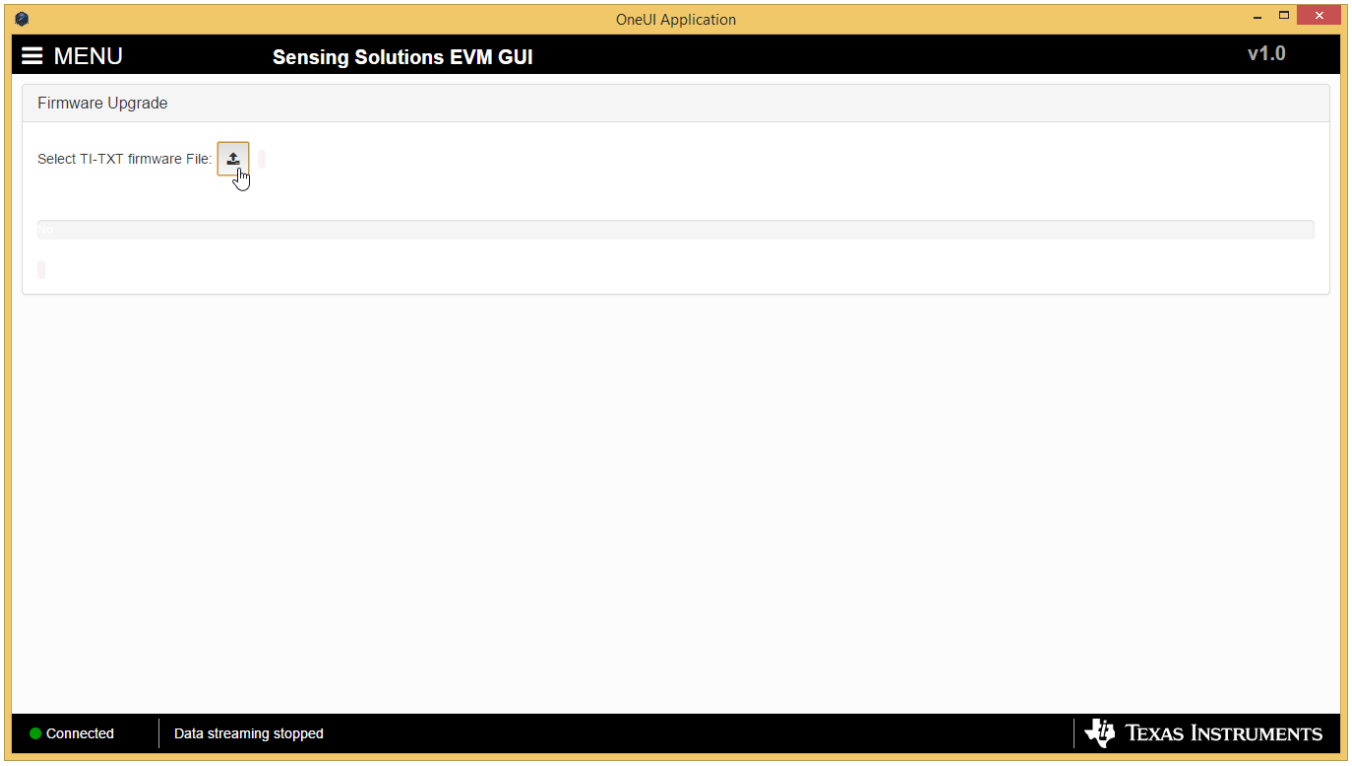

Figure 58. Select TI-TXT File Button on Firmware Upload Page

2. Select the firmware file and click “Open”

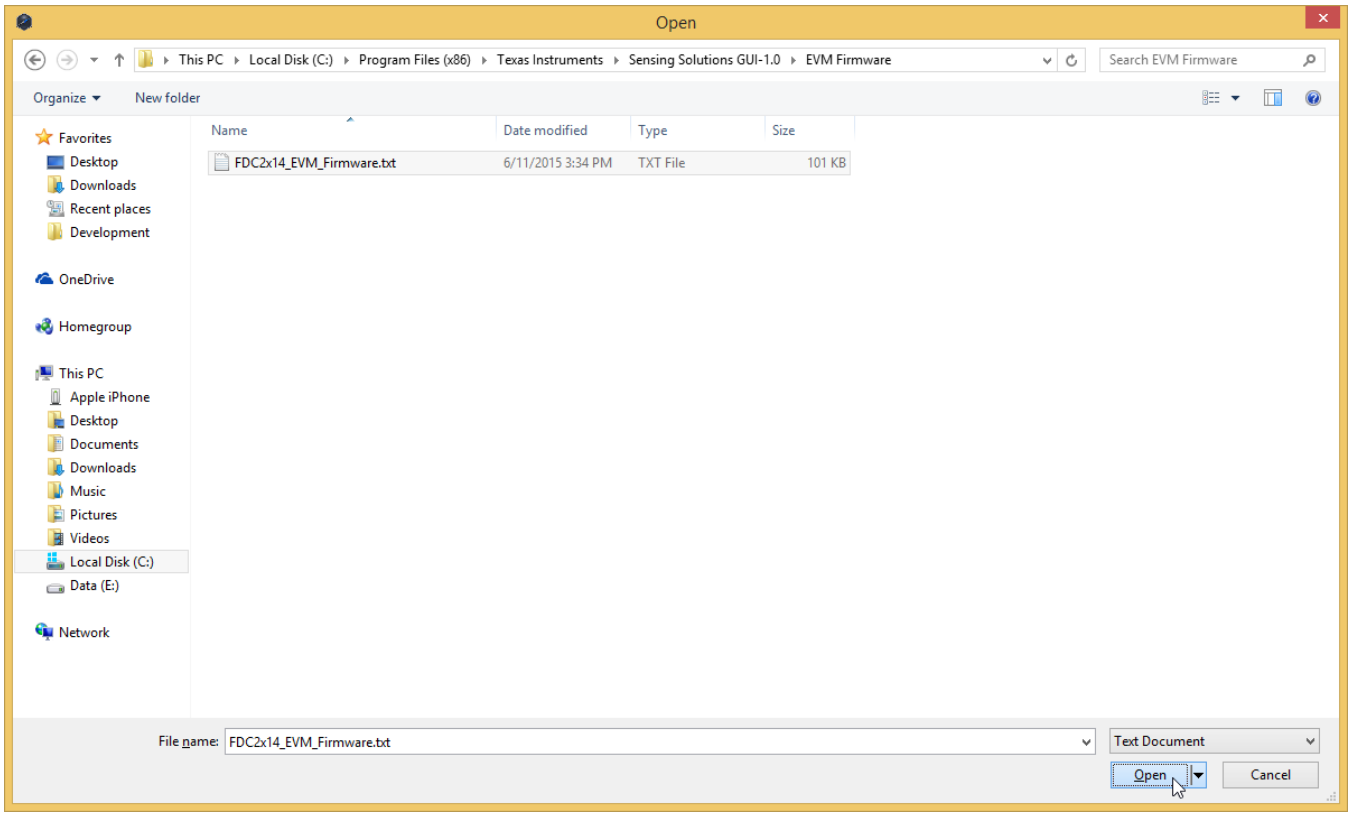

Figure 59. Selecting TI-TXT Firmware File for Upload to EVM

3. Click the “Upload Firmware” button

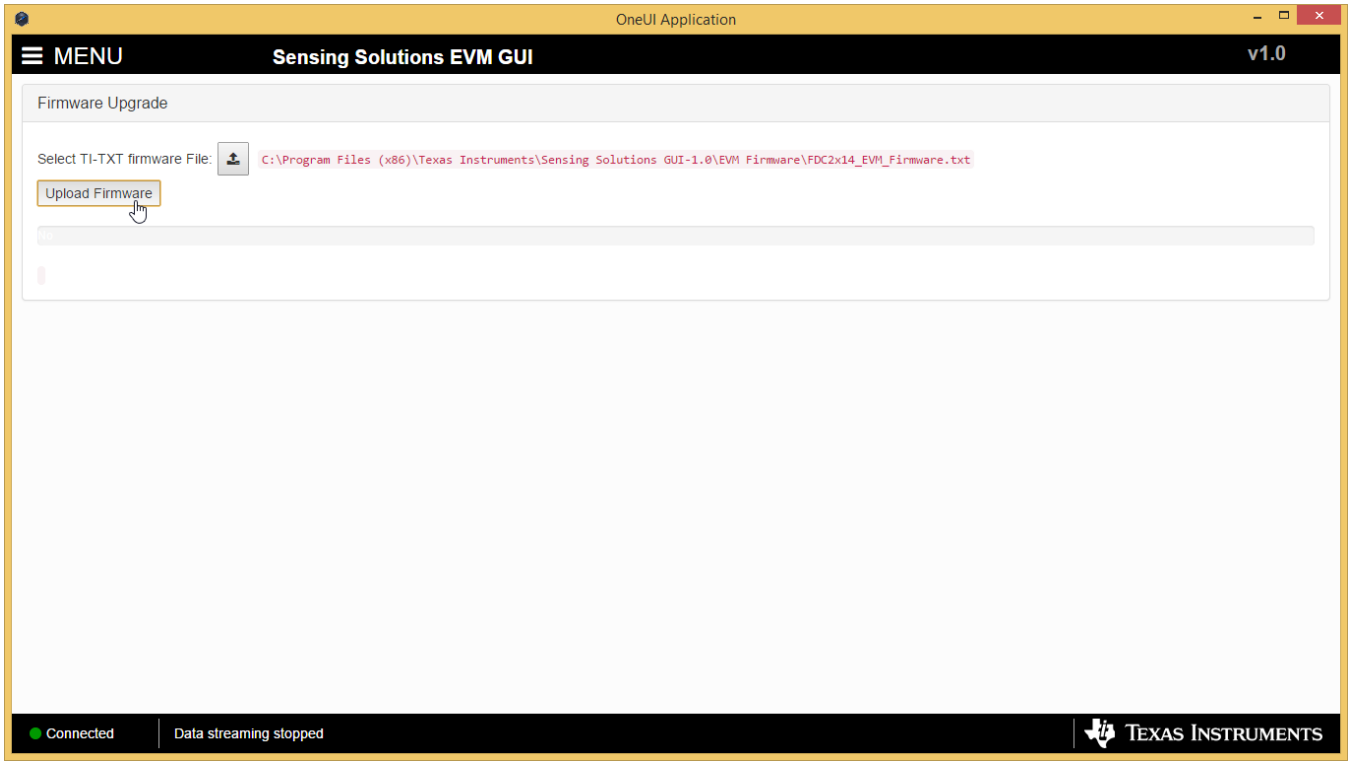

Figure 60. Upload Firmware Button on Firmware Upload Page

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.

Figure 61. Firmware Upload in Progress

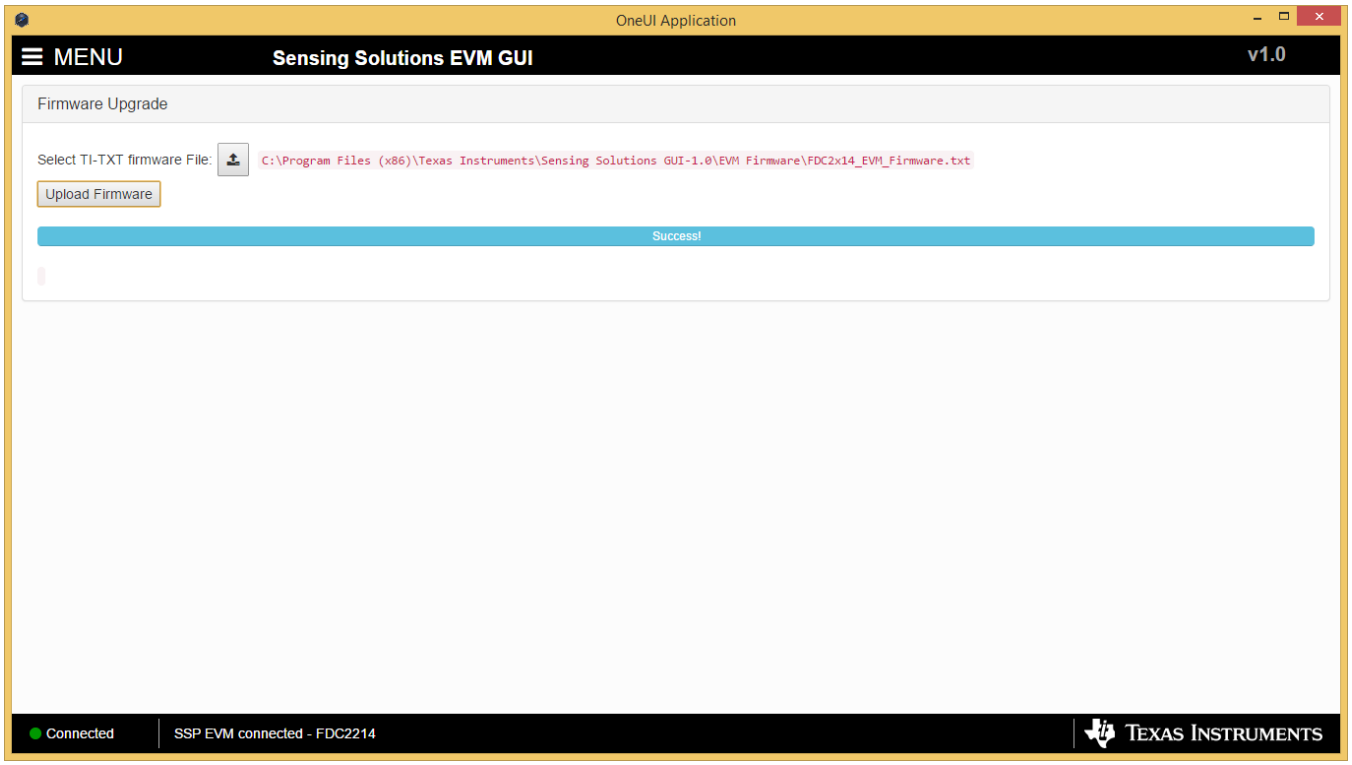

Figure 62. Firmware Upload Success

4 FDC2114/2214 EVM Schematics and Layout

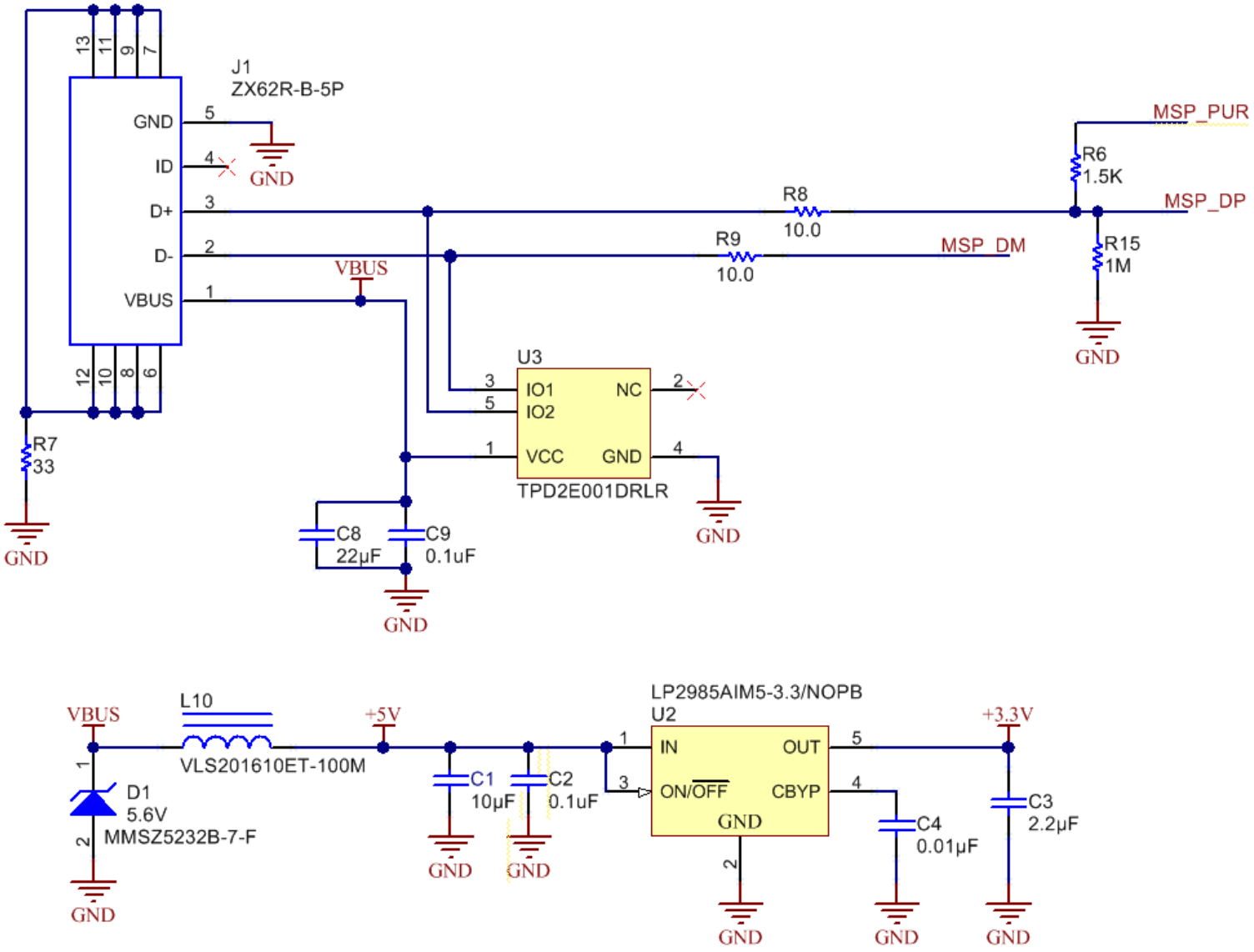

Figure 63. USB Connection and Power Circuit

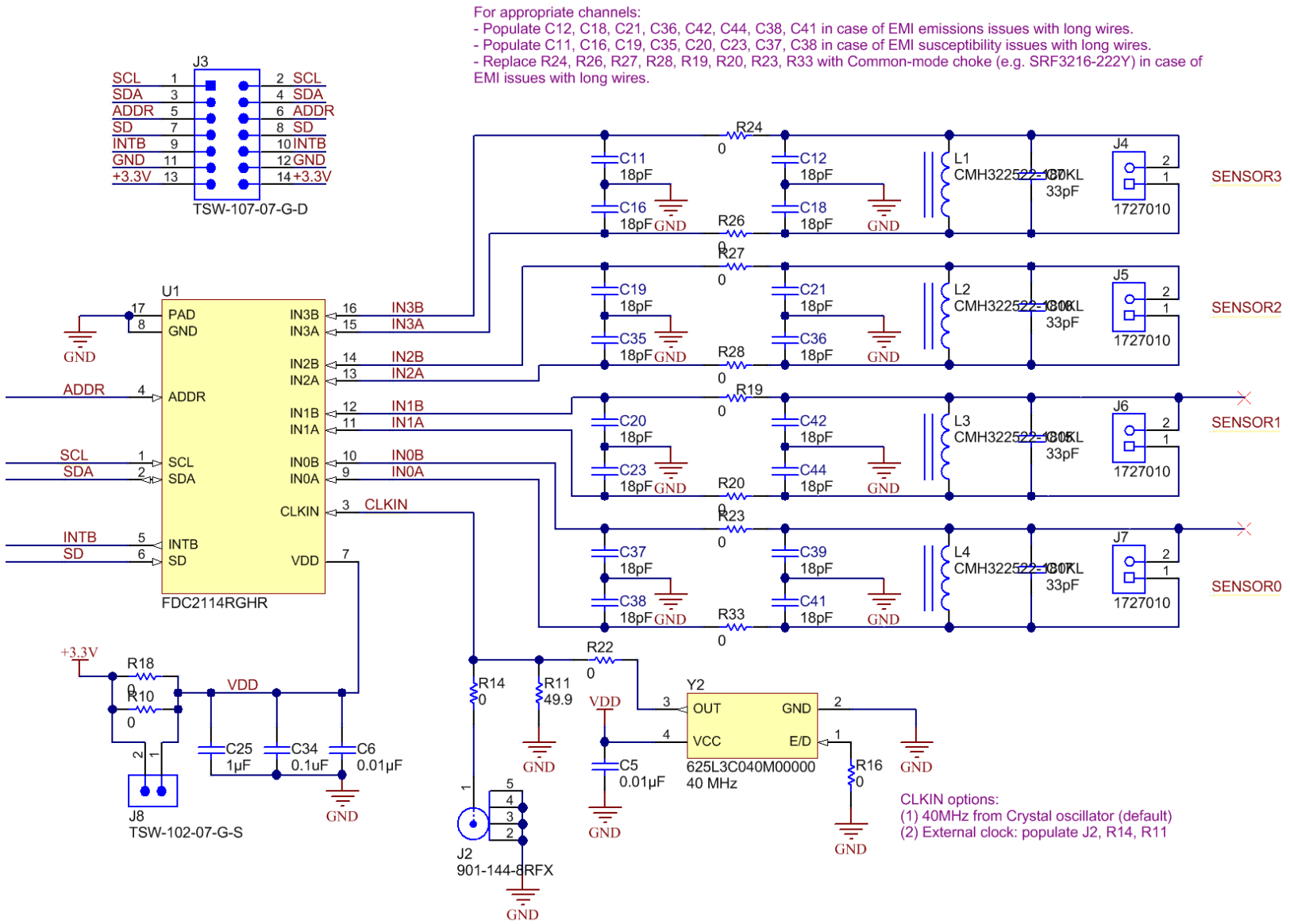

Figure 64. FDC2114/2214

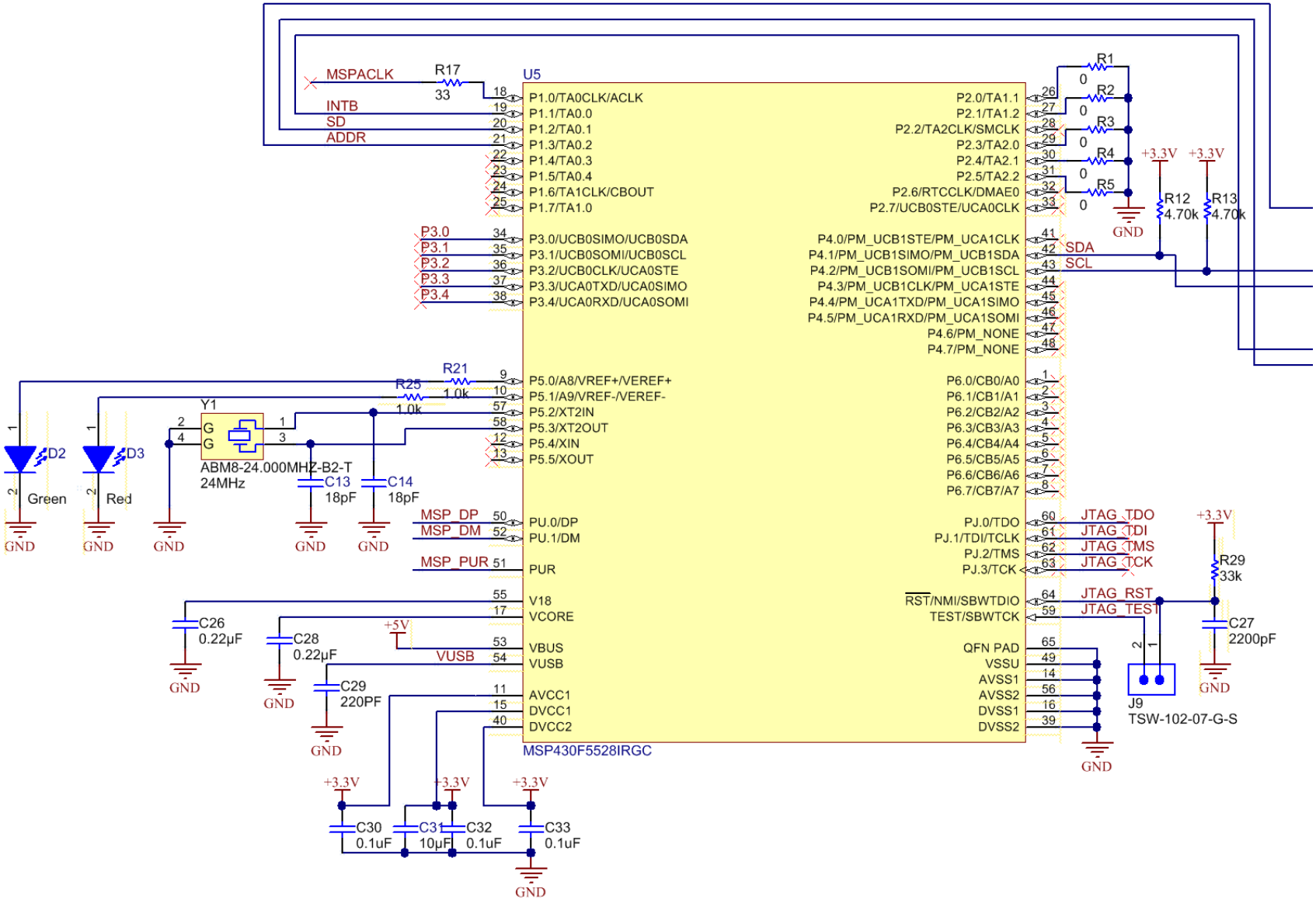

Figure 65. MSP430 Connections

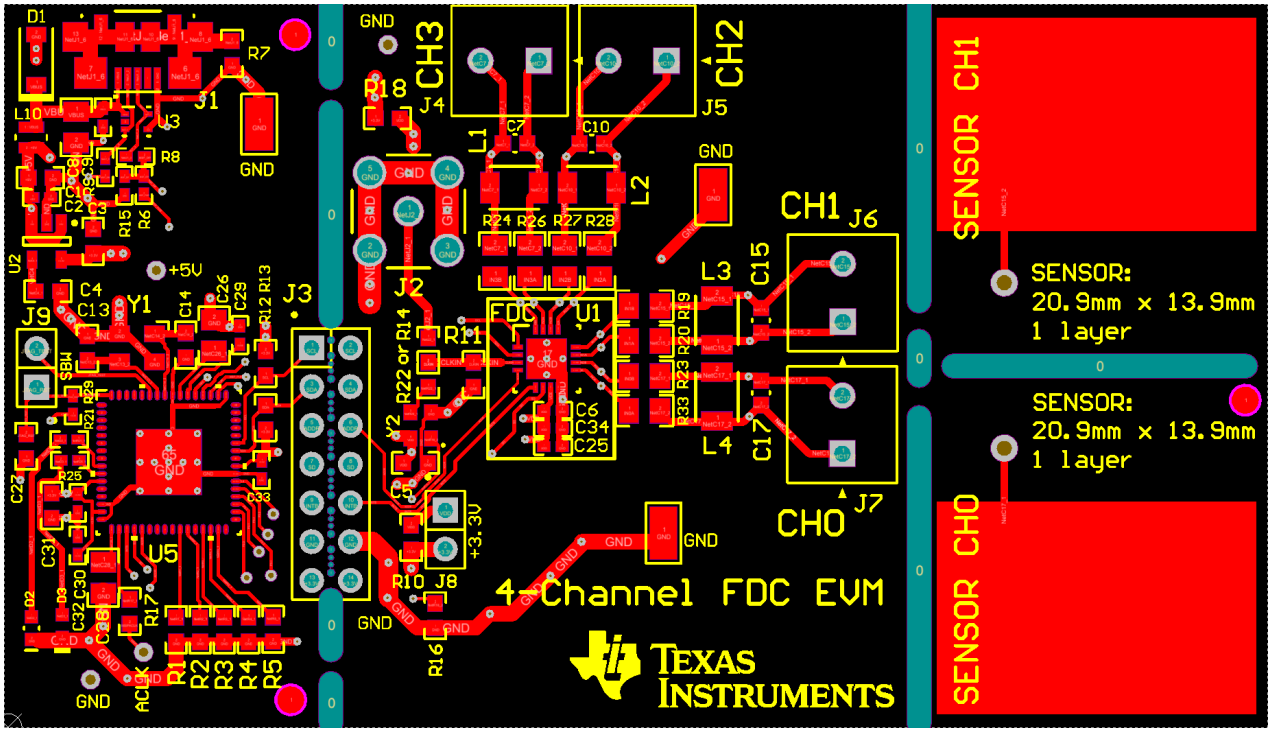

Figure 66. Layout Top Layer – Signals and Components

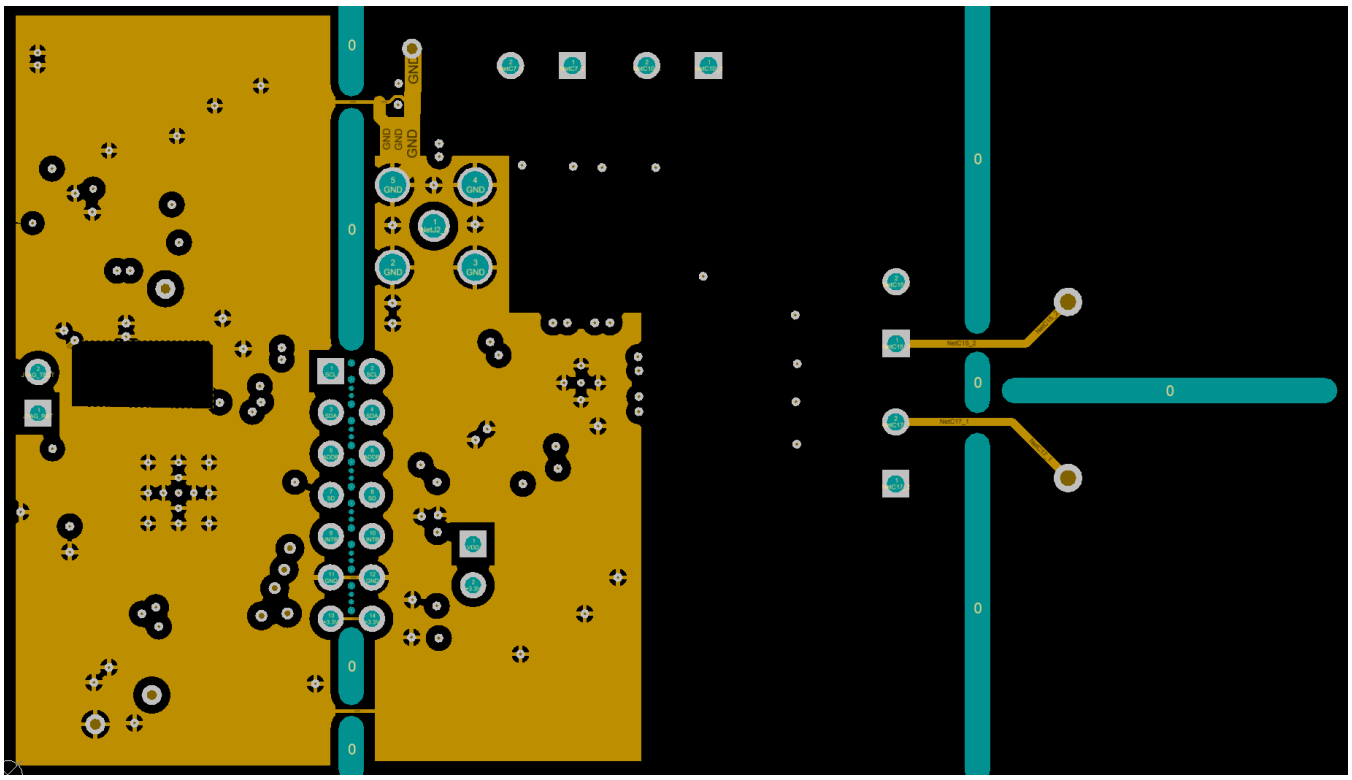

Figure 67. Layout Mid-Layer 1 – Ground Plane

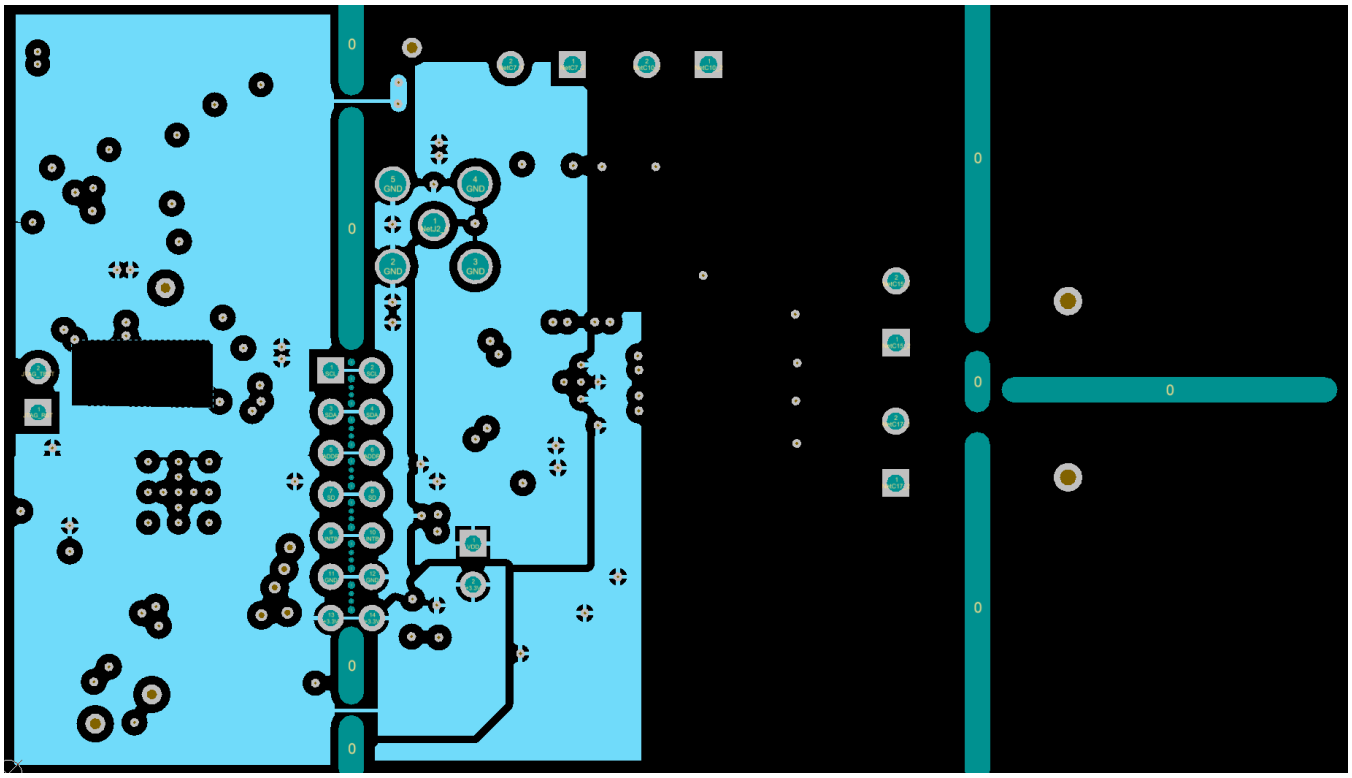

Figure 68. Mid-Layer 2 – Signals and Power Plane

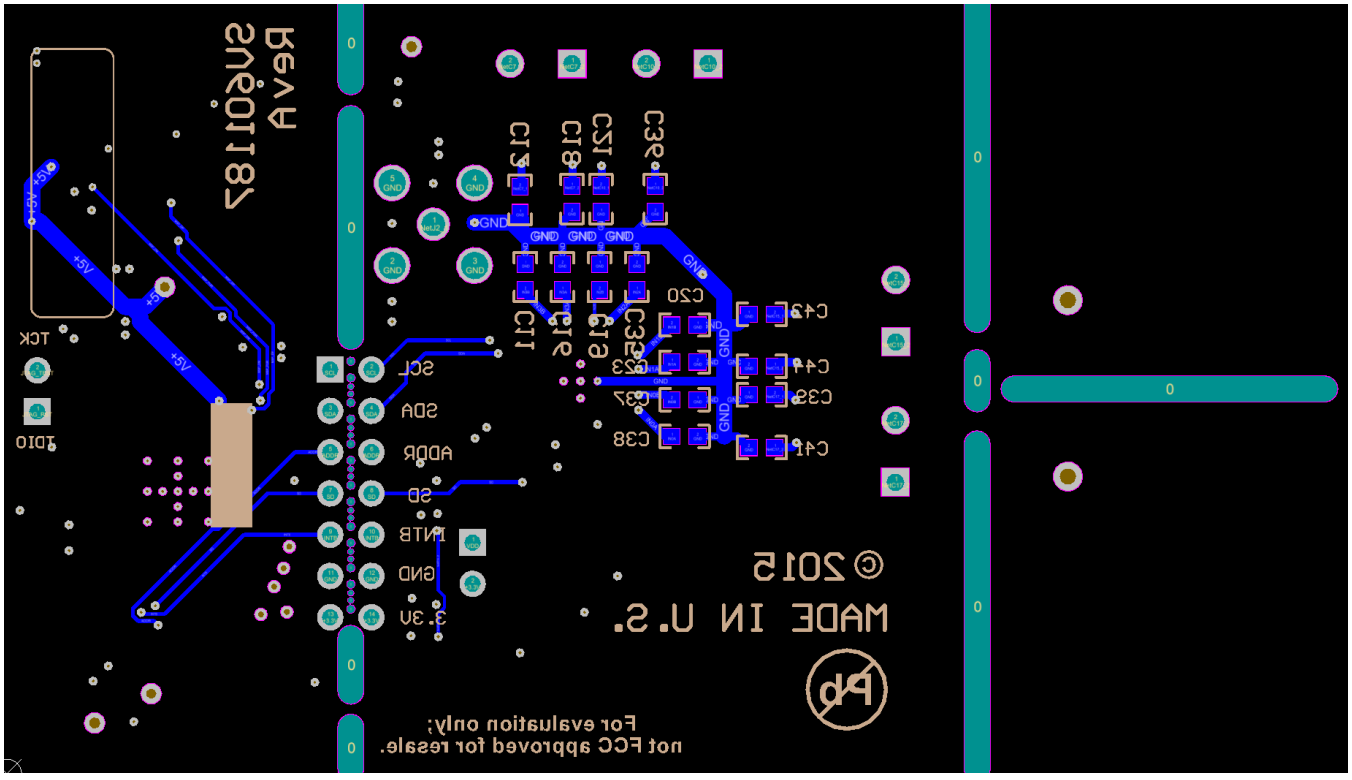

Figure 69. Layout Bottom Layer – Signals Plane

5 Bill of Materials

Table 1. BOM for FDC2114 EVM

DESIG-NATOR	QTY.	VALUE	DESCRIPTION	PART NUMBER	MANUFACTURER
!PCB1	1		Printed Circuit Board	SV601187	Any
C1, C31	2	10uF	CAP, CERM, 10uF, 10V, +/-20%, X5R, 0603	C1608X5R1A106M	TDK
C2, C9, C30, C32, C33, C34	6	0.1uF	CAP CER 0.1UF 16V 5% X7R 0402	GRM155R71C104JA88D	Murata Electronics North America
C3	1	2.2uF	CAP, CERM, 2.2uF, 10V, +/-10%, X5R, 0603	C0603C225K8PACTU	Kemet
C4, C5	2	0.01uF	CAP, CERM, 0.01uF, 25V, +/-5%, C0G/NP0, 0603	C1608C0G1E103J	TDK
C6	1	0.01uF	CAP, CERM, 0.01 µF, 16 V, +/- 10%, X7R, 0402	C1005X7R1C103K	TDK
C7, C10, C15, C17	4	33pF	CAP, CERM, 33 pF, 50 V, +/- 1%, C0G/NP0, 0603_950	CL10C330FB8NNNC	Samsung
C8	1	22uF	CAP, CERM, 22uF, 16V, +/-10%, X5R, 0805	C2012X5R1C226K125AC	TDK
C13, C14	2	18pF	CAP, CERM, 18pF, 100V, +/-5%, C0G/NP0, 0603	GRM1885C2A180JA01D	MuRata
C25	1	1uF	CAP, CERM, 1uF, 10V, +/-10%, X5R, 0402	GRM155R61A105KE15D	MuRata
C26, C28	2	0.22uF	CAP, CERM, 0.22 µF, 25 V, +/- 5%, X7R, 0805	08053C224JAT2A	AVX
C27	1	2200pF	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	C0603X222K5RACTU	Kemet
C29	1	220PF	CAP CER 220PF 50V 1% NP0 0402	C1005C0G1H221F050BA	TDK Corporation
D1	1	5.6V	Diode, Zener, 5.6V, 500mW, SOD-123	MMSZ5232B-7-F	Diodes Inc.
D2	1	Green	LED, Green, SMD	LG L29K-G2J1-24-Z	OSRAM
D3	1	Red	LED, Super Red, SMD	SML-LX0603SRW-TR	Lumex
GND1, GND2, GND3	3	SMT	Test Point, Miniature, SMT	5015	Keystone
J1	1		Connector, Receptacle, Micro-USB Type B, SMT	ZX62R-B-5P	Hirose Electric Co. Ltd.
L1, L2, L3, L4	4	18uH	Inductor, Shielded, Ferrite, 18 µH, 0.12 A, 3.3 ohm, SMD	CMH322522-180KL	Bourns
L10	1	10uH	Inductor, Shielded, Ferrite, 10 µH, 0.4 A, 1.38 ohm, SMD	VLS201610ET-100M	TDK
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
R1, R2, R4, R10, R18, R22	6	0	RES, 0 ohm, 5%, 0.1W, 0603	CRCW06030000Z0EA	Vishay-Dale
R6	1	1.5K	RES 1.5K OHM 1/16W 5% 0402 SMD	CRCW04021K50JNED	Vishay Dale
R7, R17	2	33	RES, 33 ohm, 5%, 0.1W, 0603	CRCW060333R0JNEA	Vishay-Dale
R8, R9	2	10.0	RES, 10.0, 1%, 0.063 W, 0402	CRCW040210R0FKED	Vishay-Dale

Table 1. BOM for FDC2114 EVM (continued)

DESIG-NATOR	QTY.	VALUE	DESCRIPTION	PART NUMBER	MANUFACTURER
R12, R13	2	4.70k	RES, 4.70k ohm, 1%, 0.1W, 0603	RC0603FR-074K7L	Yageo America
R15	1	1M	RES,1M ohm, 5%, 0.063W, 0402	RC0402JR-071ML	Yageo
R19, R20, R23, R24, R26, R27, R28, R33	8	0	RES, 0 ohm, 5%, 0.125W, 0805	CRCW08050000Z0EA	Vishay-Dale
R21, R25	2	1.0k	RES, 1.0k ohm, 5%, 0.063W, 0402	CRCW04021K00JNED	Vishay-Dale
R29	1	33k	RES, 33k ohm, 5%, 0.063W, 0402	CRCW040233K0JNED	Vishay-Dale
U1	1		Multi-Channel 12/28-Bit Capacitance to Digital Converter (FDC) for Capacitive Sensing, RGH0016A	FDC2114RGHR	Texas Instruments
U2	1		Micropower 150 mA Low-Noise Ultra Low-Dropout Regulator, 5-pin SOT-23, Pb-Free	LP2985AIM5-3.3/NOPB	Texas Instruments
U3	1		Low-Capacitance + / - 15 kV ESD-Protection Array for High-Speed Data Interfaces, 2 Channels, -40 to +85 degC, 5-pin SOT (DRL), Green (RoHS & no Sb/Br)	TPD2E001DRLR	Texas Instruments
U5	1		Mixed Signal MicroController, RGC0064B	MSP430F5528IRGC	Texas Instruments
Y1	1		Crystal, 24.000MHz, 18pF, SMD	ABM8-24.000MHZ-B2-T	Abracon Corportation
Y2	1		OSC, 40 MHz, 3.3 V, SMD	625L3C040M00000	CTS Electrocomponents
C11, C12, C16, C18, C19, C20, C21, C23, C35, C36, C37, C38, C39, C41, C42, C44	0	18pF	CAP, CERM, 18pF, 100V, +/-5%, C0G/NP0, 0603	GRM1885C2A180JA01D	MuRata
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A
J2	0		SMA Straight Jack, Gold, 50 Ohm, TH	901-144-8RFX	Amphenol RF
J3	0		Header, 100mil, 7x2, Gold, TH	TSW-107-07-G-D	Samtec
J4, J5, J6, J7	0	2x1	Conn Term Block, 2POS, 3.81mm, TH	1727010	Phoenix Contact
J8, J9	0		Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	TSW-102-07-G-S	Samtec, Inc.
R3, R5, R14, R16	0	0	RES, 0 ohm, 5%, 0.1W, 0603	CRCW06030000Z0EA	Vishay-Dale
R11	0	49.9	RES, 49.9, 1%, 0.1 W, 0603	CRCW060349R9FKEA	Vishay-Dale

Table 2. BOM for FDC2214 EVM

DESIG-NATOR	QTY.	VALUE	DESCRIPTION	PART NUMBER	MANUFACTURER
!PCB1	1		Printed Circuit Board	SV601187	Any
C1, C31	2	10uF	CAP, CERM, 10uF, 10V, +/-20%, X5R, 0603	C1608X5R1A106M	TDK
C2, C9, C30, C32, C33, C34	6	0.1uF	CAP CER 0.1UF 16V 5% X7R 0402	GRM155R71C104JA88D	Murata Electronics North America
C3	1	2.2uF	CAP, CERM, 2.2uF, 10V, +/-10%, X5R, 0603	C0603C225K8PACTU	Kemet
C4, C5	2	0.01uF	CAP, CERM, 0.01uF, 25V, +/-5%, C0G/NP0, 0603	C1608C0G1E103J	TDK
C6	1	0.01uF	CAP, CERM, 0.01 µF, 16 V, +/- 10%, X7R, 0402	C1005X7R1C103K	TDK
C7, C10, C15, C17	4	33pF	CAP, CERM, 33 pF, 50 V, +/- 1%, C0G/NP0, 0603_950	CL10C330FB8NNNC	Samsung
C8	1	22uF	CAP, CERM, 22uF, 16V, +/-10%, X5R, 0805	C2012X5R1C226K125AC	TDK
C13, C14	2	18pF	CAP, CERM, 18pF, 100V, +/-5%, C0G/NP0, 0603	GRM1885C2A180JA01D	MuRata
C25	1	1uF	CAP, CERM, 1uF, 10V, +/-10%, X5R, 0402	GRM155R61A105KE15D	MuRata
C26, C28	2	0.22uF	CAP, CERM, 0.22 µF, 25 V, +/- 5%, X7R, 0805	08053C224JAT2A	AVX
C27	1	2200pF	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	C0603X222K5RACTU	Kemet
C29	1	220PF	CAP CER 220PF 50V 1% NP0 0402	C1005C0G1H221F050BA	TDK Corporation
D1	1	5.6V	Diode, Zener, 5.6V, 500mW, SOD-123	MMSZ5232B-7-F	Diodes Inc.
D2	1	Green	LED, Green, SMD	LG L29K-G2J1-24-Z	OSRAM
D3	1	Red	LED, Super Red, SMD	SML-LX0603SRW-TR	Lumex
GND1, GND2, GND3	3	SMT	Test Point, Miniature, SMT	5015	Keystone
J1	1		Connector, Receptacle, Micro-USB Type B, SMT	ZX62R-B-5P	Hirose Electric Co. Ltd.
L1, L2, L3, L4	4	18uH	Inductor, Shielded, Ferrite, 18 µH, 0.12 A, 3.3 ohm, SMD	CMH322522-180KL	Bourns
L10	1	10uH	Inductor, Shielded, Ferrite, 10 µH, 0.4 A, 1.38 ohm, SMD	VLS201610ET-100M	TDK
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
R1, R2, R5, R10, R18, R22	6	0	RES, 0 ohm, 5%, 0.1W, 0603	CRCW06030000Z0EA	Vishay-Dale
R6	1	1.5K	RES 1.5K OHM 1/16W 5% 0402 SMD	CRCW04021K50JNED	Vishay Dale
R7, R17	2	33	RES, 33 ohm, 5%, 0.1W, 0603	CRCW060333R0JNEA	Vishay-Dale
R8, R9	2	10.0	RES, 10.0, 1%, 0.063 W, 0402	CRCW040210R0FKED	Vishay-Dale
R12, R13	2	4.70k	RES, 4.70k ohm, 1%, 0.1W, 0603	RC0603FR-074K7L	Yageo America
R15	1	1M	RES,1M ohm, 5%, 0.063W, 0402	RC0402JR-071ML	Yageo

Table 2. BOM for FDC2214 EVM (continued)

DESIG-NATOR	QTY.	VALUE	DESCRIPTION	PART NUMBER	MANUFACTURER
R19, R20, R23, R24, R26, R27, R28, R33	8	0	RES, 0 ohm, 5%, 0.125W, 0805	CRCW08050000Z0EA	Vishay-Dale
R21, R25	2	1.0k	RES, 1.0k ohm, 5%, 0.063W, 0402	CRCW04021K00JNED	Vishay-Dale
R29	1	33k	RES, 33k ohm, 5%, 0.063W, 0402	CRCW040233K0JNED	Vishay-Dale
U1	1		Multi-Channel 12/28-Bit Capacitance to Digital Converter (FDC) for Capacitive Sensing, RGH0016A	FDC2214RGHR	Texas Instruments
U2	1		Micropower 150 mA Low-Noise Ultra Low-Dropout Regulator, 5-pin SOT-23, Pb-Free	LP2985AIM5-3.3/NOPB	Texas Instruments
U3	1		Low-Capacitance + / - 15 kV ESD-Protection Array for High-Speed Data Interfaces, 2 Channels, -40 to +85 degC, 5-pin SOT (DRL), Green (RoHS & no Sb/Br)	TPD2E001DRLR	Texas Instruments
U5	1		Mixed Signal MicroController, RGC0064B	MSP430F5528IRGC	Texas Instruments
Y1	1		Crystal, 24.000MHz, 18pF, SMD	ABM8-24.000MHZ-B2-T	Abracon Corportation
Y2	1		OSC, 40 MHz, 3.3 V, SMD	625L3C040M00000	CTS Electrocomponents
C11, C12, C16, C18, C19, C20, C21, C23, C35, C36, C37, C38, C39, C41, C42, C44	0	18pF	CAP, CERM, 18pF, 100V, +/-5%, C0G/NP0, 0603	GRM1885C2A180JA01D	MuRata
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A
J2	0		SMA Straight Jack, Gold, 50 Ohm, TH	901-144-8RFX	Amphenol RF
J3	0		Header, 100mil, 7x2, Gold, TH	TSW-107-07-G-D	Samtec
J4, J5, J6, J7	0	2x1	Conn Term Block, 2POS, 3.81mm, TH	1727010	Phoenix Contact
J8, J9	0		Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	TSW-102-07-G-S	Samtec, Inc.
R3, R4, R14, R16	0	0	RES, 0 ohm, 5%, 0.1W, 0603	CRCW06030000Z0EA	Vishay-Dale
R11	0	49.9	RES, 49.9, 1%, 0.1 W, 0603	CRCW060349R9FKEA	Vishay-Dale

Revision History

DATE	REVISION	NOTES
June 2015	*	Initial release.

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

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7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

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