LDC2114 Evaluation Module for Inductive Touch Applications

User's Guide

Literature Number: SNOU144
December 2016

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LDC2114 Evaluation Module for Inductive Touch Inductance to Digital Converter

1 Overview

The LDC2114 EVM demonstrates the use of inductive sensing technology to sense and measure the presence or position of conductive target objects, and to detect the press of an inductive touch button. The LDC is controlled by an MSP430, which interfaces to a host computer.

The LDC2112 is the two-channel version of the LDC2114. The LDC2112 does not have a dedicated EVM. Instead, the four-channel LDC2114 EVM should be used to evaluate the technology and performance.

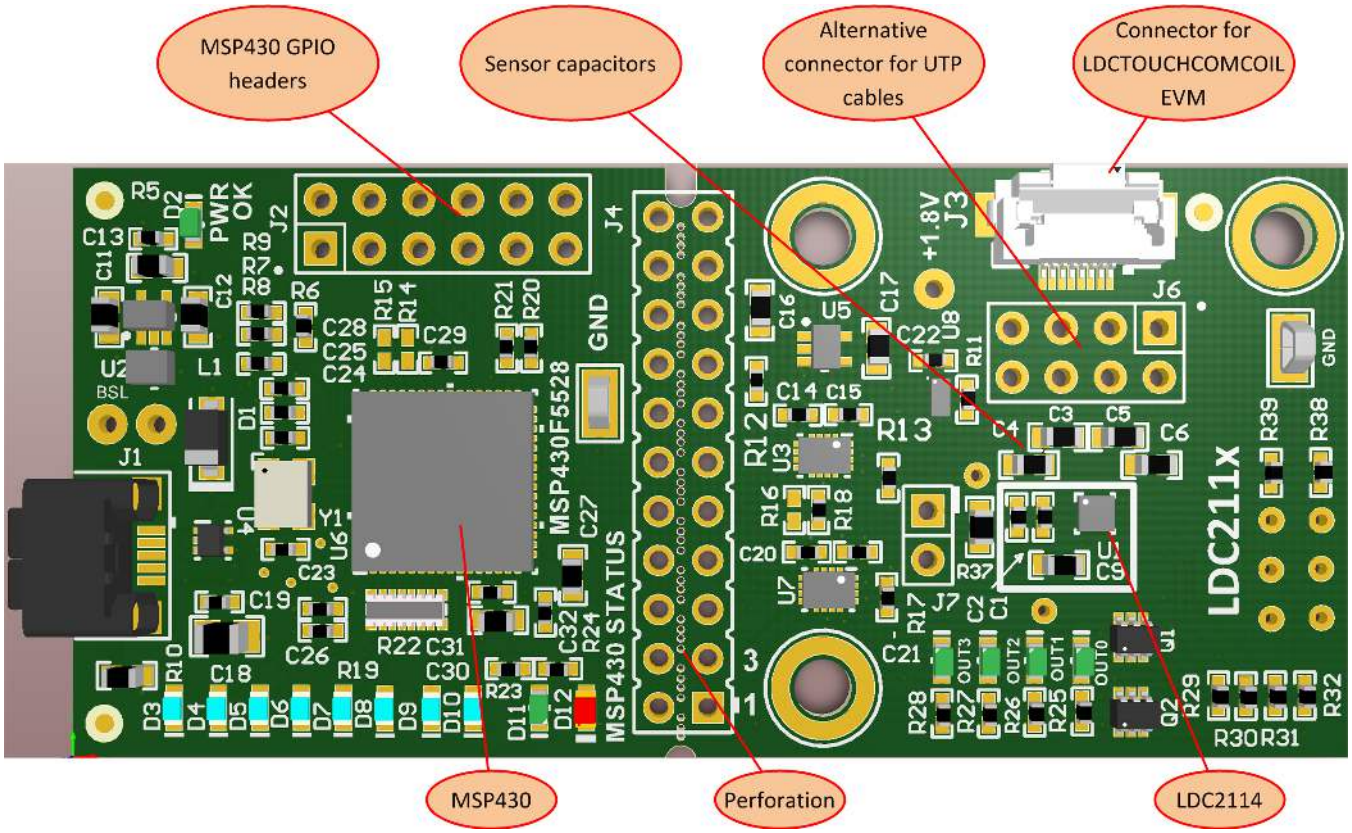

Figure 1. LDC2114 Evaluation Module

PCB perforations allow removal of the microcontroller, so that a different microcontroller can be connected.

This user guide covers the following EVMs:

Table 1. List of Evaluation modules

EVM name	EVM revision	Device under test
LDC2114EVM	A	LDC2114 WCSP

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2 Compatible Sensor EVM

The EVM does not include any example sensors, but can easily be connected to sensors by using either the ZIF connector or soldering wires to the header pins on the PCB. The LDC2114 EVM is compatible with the LDCCOILEVM, which is available on the TI estore and contains 19 different sensor designs. Connect sensors from the LDCCOILEVM with unshielded twisted pair wires to J6 of the LDC2114 EVM.

NOTE: Schematics, Layout, and Coil characteristics of the LDCCOILEVM are described in the LDCCOILEVM user guide.

Table 2 shows the connection options for each coil type.

Table 2. Connection options

LDCTOUCHCOMCOILEVM coil type	Connect to
A	J3 ZIF connector using flat ribbon cable
B	J3 ZIF connector using flat ribbon cable
C	J3 ZIF connector using flat ribbon cable
D	J3 ZIF connector using flat ribbon cable
E	J6 2.54mm header using unshielded twisted pair wires

NOTE: When connecting the coil board to the EVM, it is recommended to attach the assembly to a static object using tape or screws. This will prevent the cables from moving and potentially changing the output code reading or reporting false triggers.

3 Main EVM elements

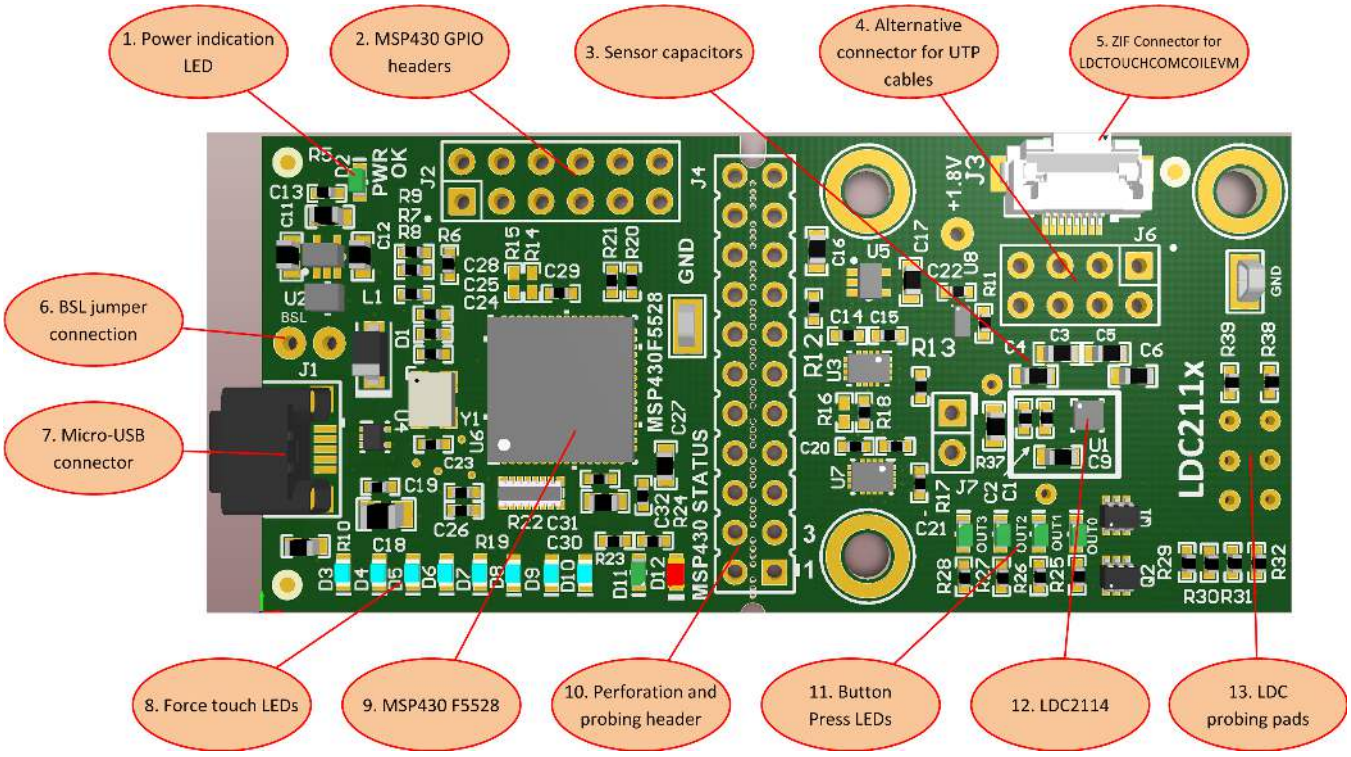

Figure 2. Main EVM elements

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The EVM has the following features, as shown in Figure 2:

1. Power indication LED: this LED shows that the PCB is powered through the USB cable
2. MSP430 GPIO headers: This is a multi-purpose GPIO header which facilitates connection with a second I2C interface, JTAG, UART, and three additional GPIOs. It also contains 5V, 3.3V, and GND rails. These pins could be used for example to connect a haptics driver or an audio amplifier. Note that functionality pof these pins is not implemented in the default EVM firmware.
3. Sensor capacitors: These are the sensor capacitors of the LDC2114. Replace them with suitable values if appropriate.
4. Alternative connection for UTP cables: Custom sensors can be connected to these header connections. Unshielded twisted pair (UTP) wires are the preferred wire choice for the sensor.
5. ZIF connector for LDCTOUCHCOMCOILEVM: Sensors of this PCB can be connected easily by connecting the supplied flat ribbon cable.
6. BSL jumper connection: If firmware upgrade is unsuccessful, put the MSP430 into bootstrap loader mode by shorting these two pins while powering up the EVM.
7. Micro-USB connector: connect to the PC using a micro-USB cable
8. Force touch LEDs: these eight LEDs show the intensity of the button press. They default firmware chooses the channel with the strongest button push to indicate intensity.
9. MSP430 F5528: This microcontroller is used to configure the LDC2114, facilitate data streaming to the GUI, and to show the intensity of the button press.
10. Perforation and probing header: These pads can be used for probing any signals between the MSP430 and the LDC2114. It can be populated with a standard 2x11 pin 2.54mm header for ease of access. It is also possible to break the LDC along the perforation and attach a different microcontroller to these pins. The signals of the header are: [1-2]: OUT3, [3-4]: OUT2, [5-6]: OUT1, [7-8]: OUT0, [9-10]: INTB, [11-12]: LPWRB, [13-14]: SDA, [15-16]: SCL, [17-18]: GND, [19-20]: +3.3V, [21-22]: GND. Note that the signals on this header are referenced to the Microcontroller VIO voltage (3.3V).
11. Button Press LEDs: These LEDs indicate which button has been pressed. Note that the MAXWIN function is not enabled by default, so multiple buttons can be pressed simultaneously, and therefore multiple LEDs may light up.
12. LDC2114: The LDC2114 Inductive Touch Inductance-to-Digital Converter for Consumer and Low-Power Applications
13. LDC probing pads: These probing points use the level-shifted (1.8V referenced) signals of SDA, SCL, OUT0, OUT1, OUT2, and OUT3

4 Sensing Solutions EVM GUI

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

4.1 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

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4.2 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 latest version of the Sensing Solutions EVM GUI from EVM tool page.

NOTE: The minimum Sensing Solutions GUI revision for this EVM is 1.9.1. The latest GUI can be downloaded here.

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.*

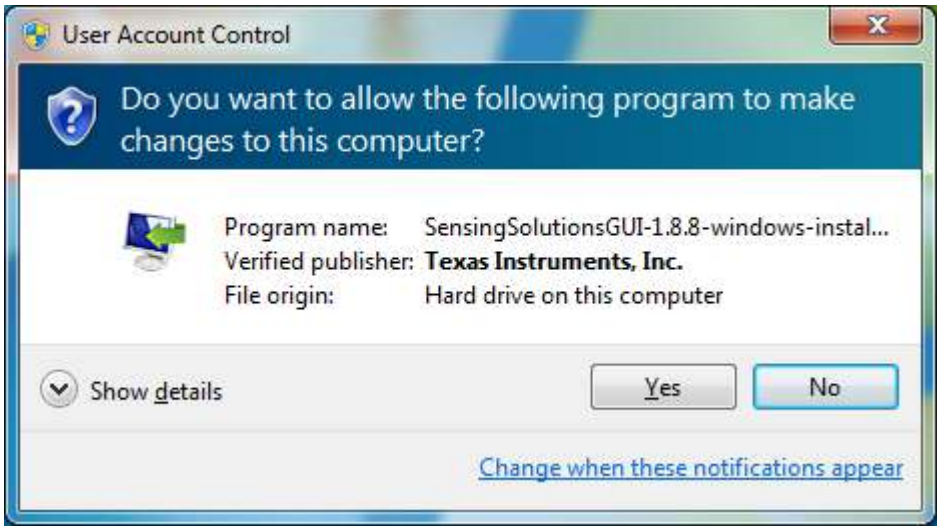

Figure 3. User Account Control Prompt

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

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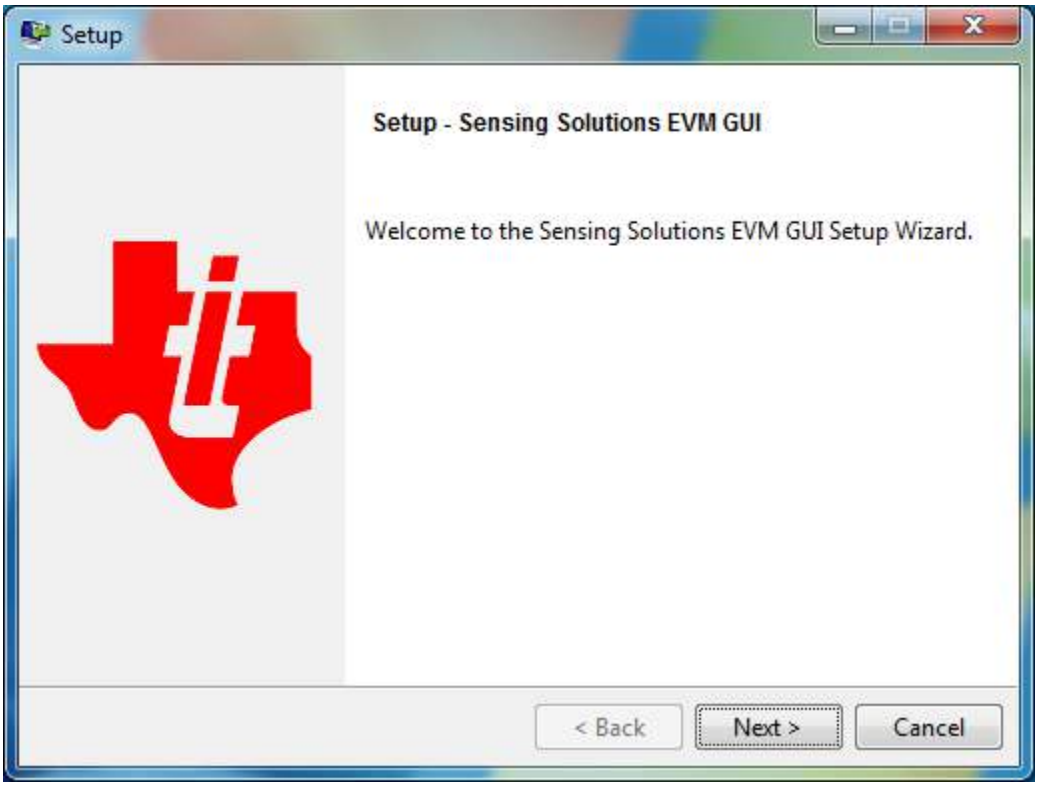

Figure 4. Software Installer Wizard

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

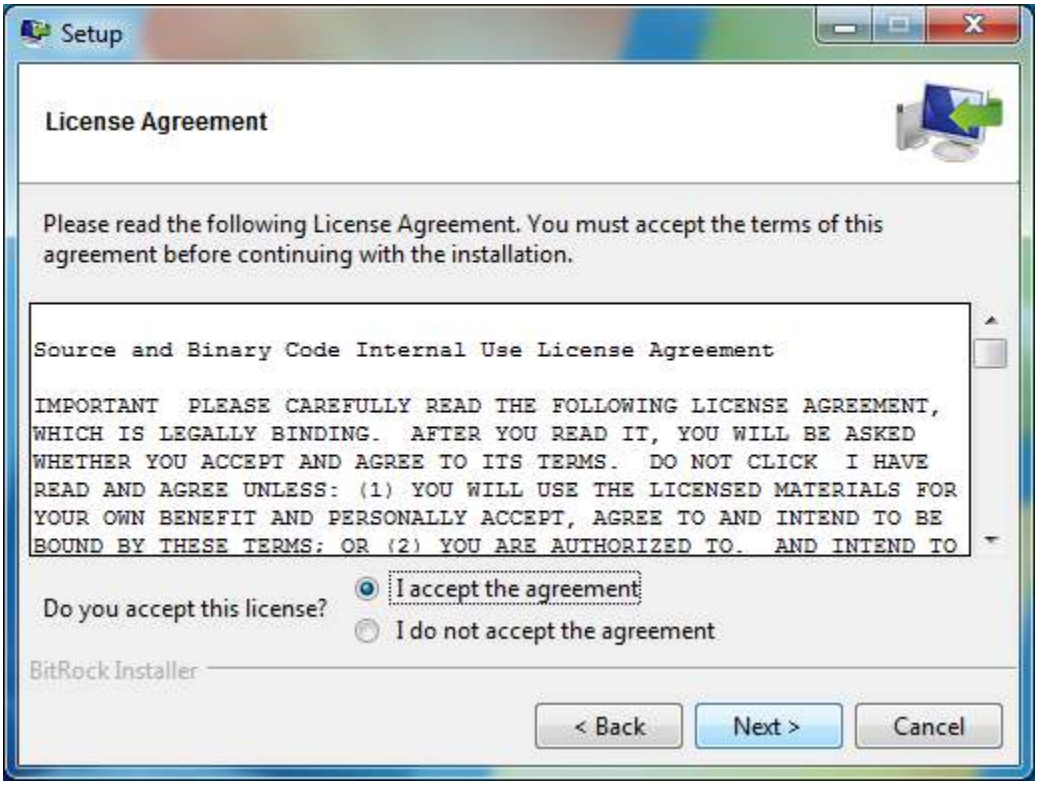

Figure 5. Software Installer License Agreement

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

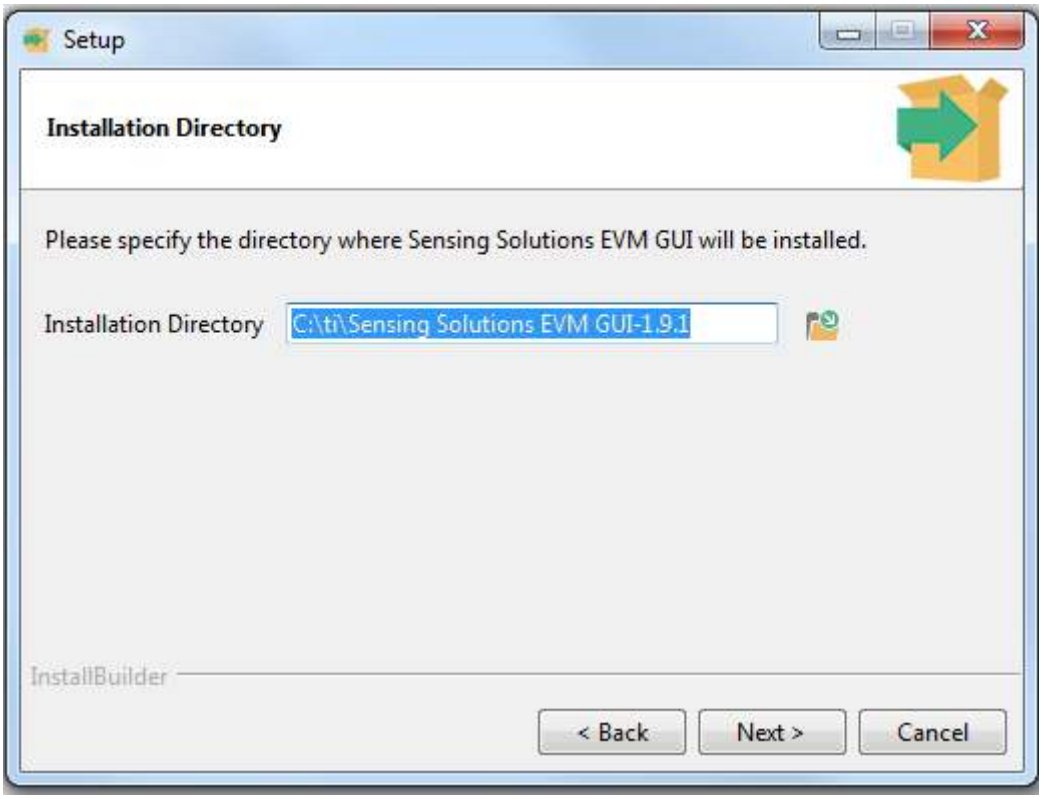

Figure 6. Software Installation Directory

8. Start the installation by clicking *Next*.

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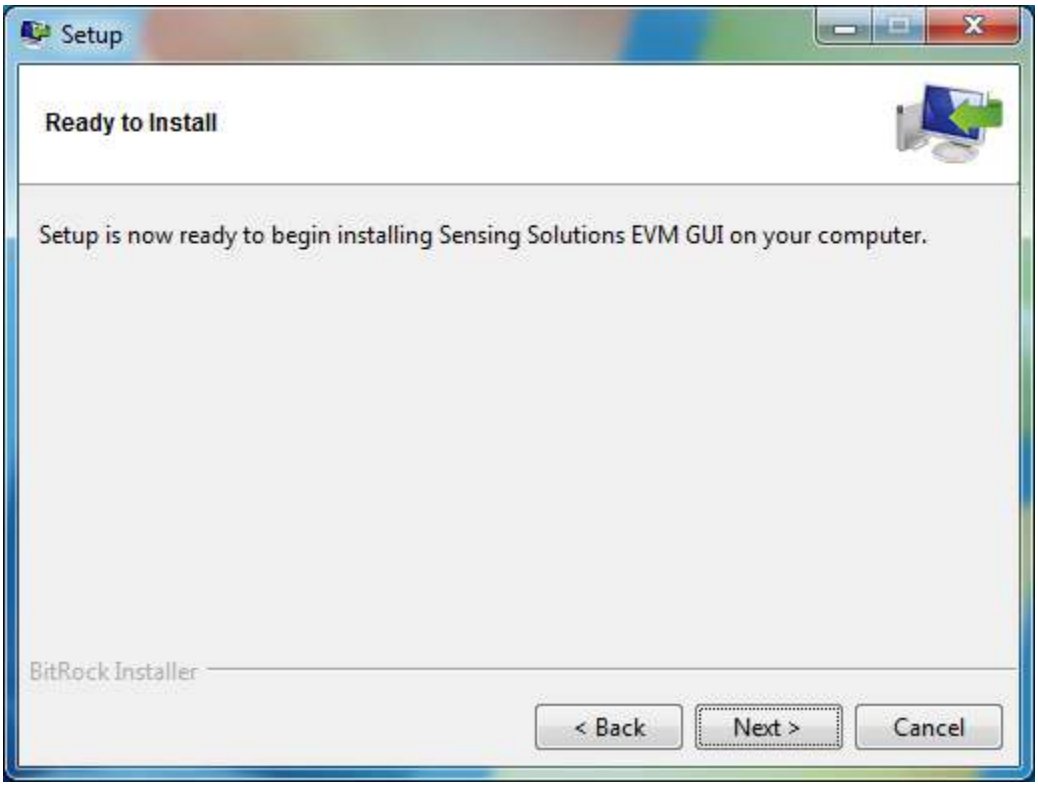

Figure 7. Software Installer Ready

9. Wait for the installation to complete.

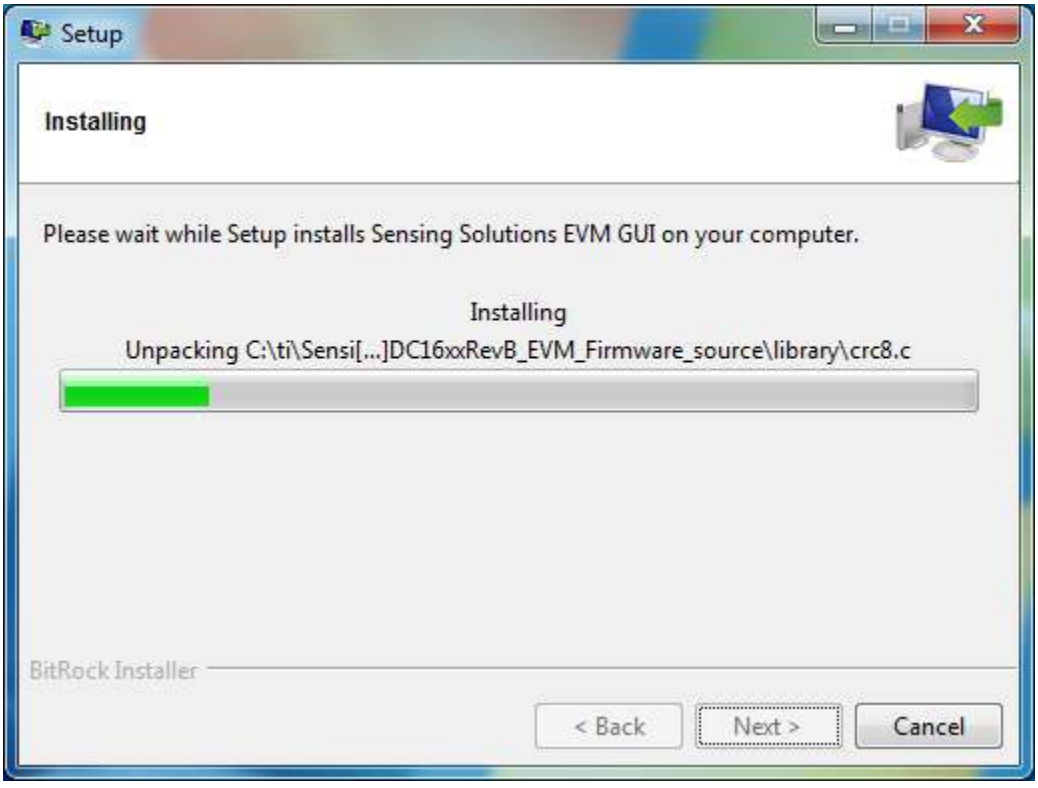

Figure 8. Software Installer in Progress

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

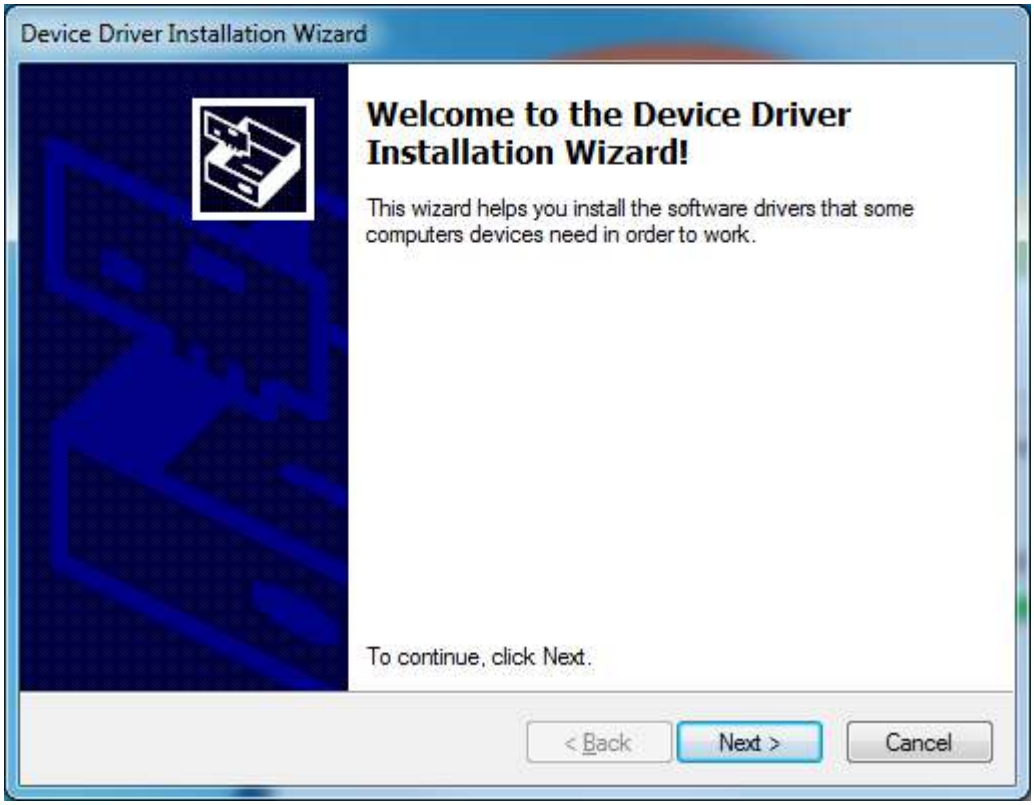

Figure 9. Device Driver Installer Wizard

11. Wait for the driver installation to complete.

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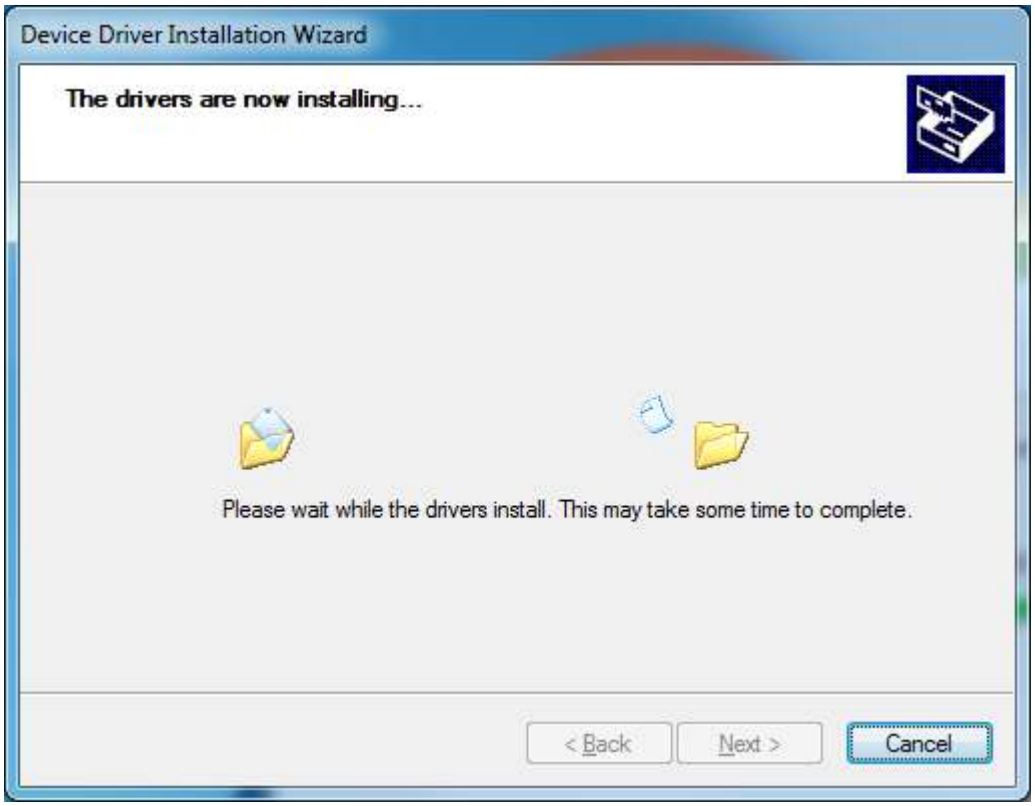

Figure 10. Device Driver Installer in Progress

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

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Figure 11. Device Driver Installer Completed

13. Click *Finish* to complete the installation.

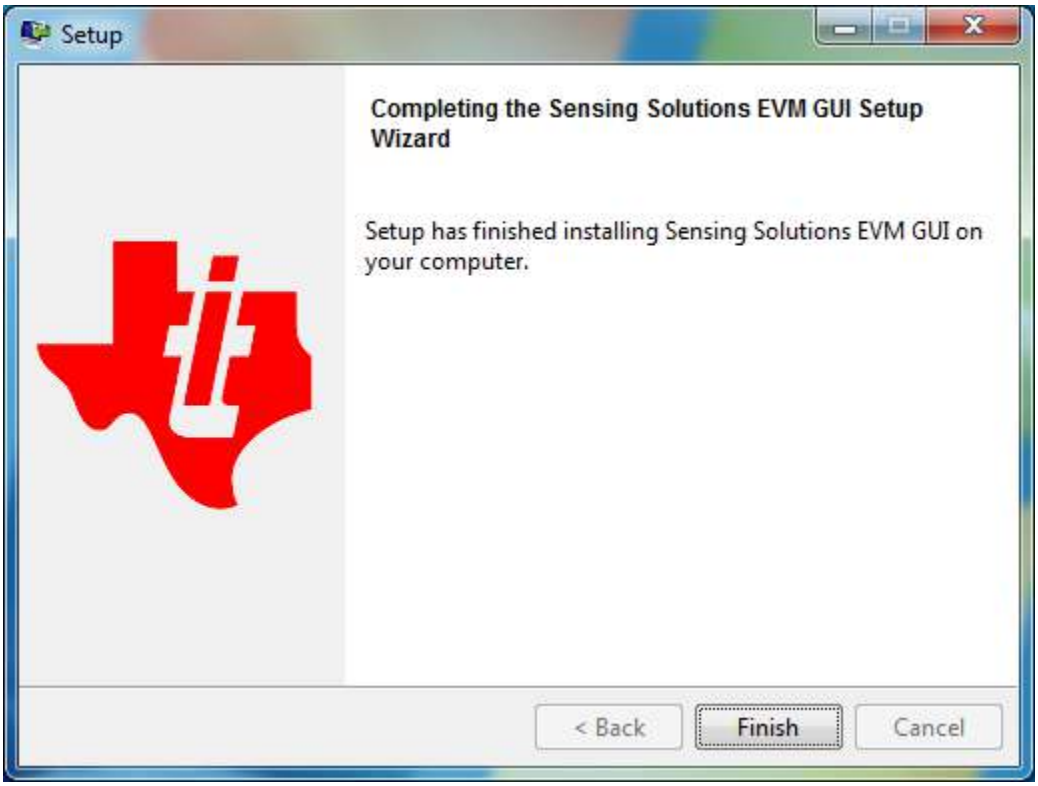

Figure 12. Software Installer Completed

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4.3 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 GU*.
5. Click *Sensing Solutions EVM GU*.
6. The splash screen will appear for at least two seconds.

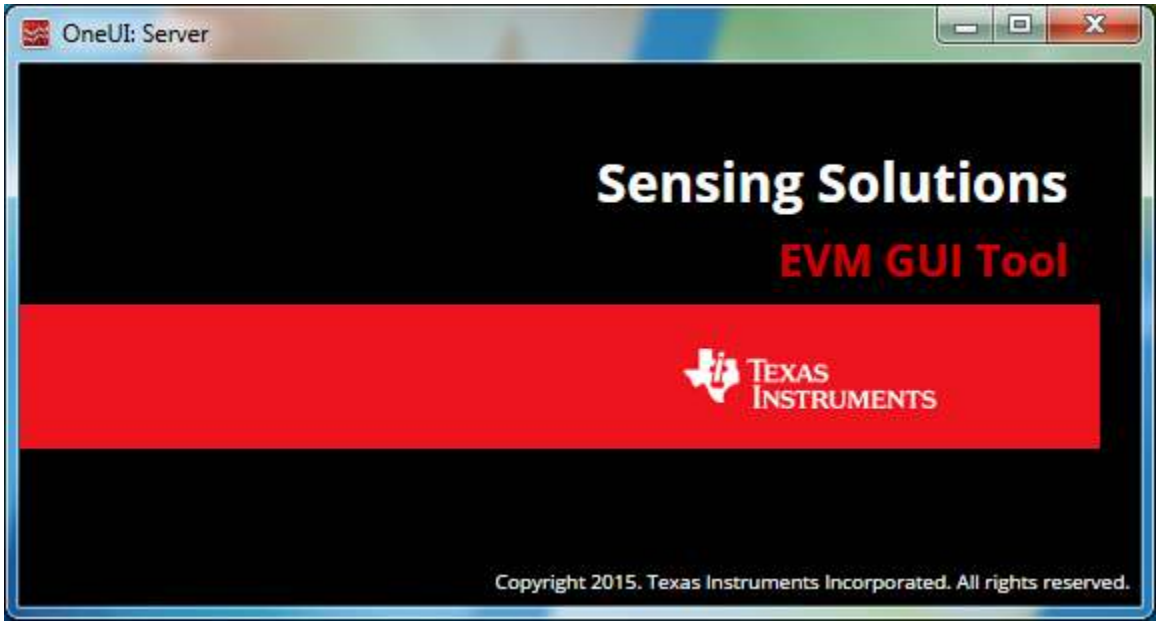

Figure 13. Splash Screen

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

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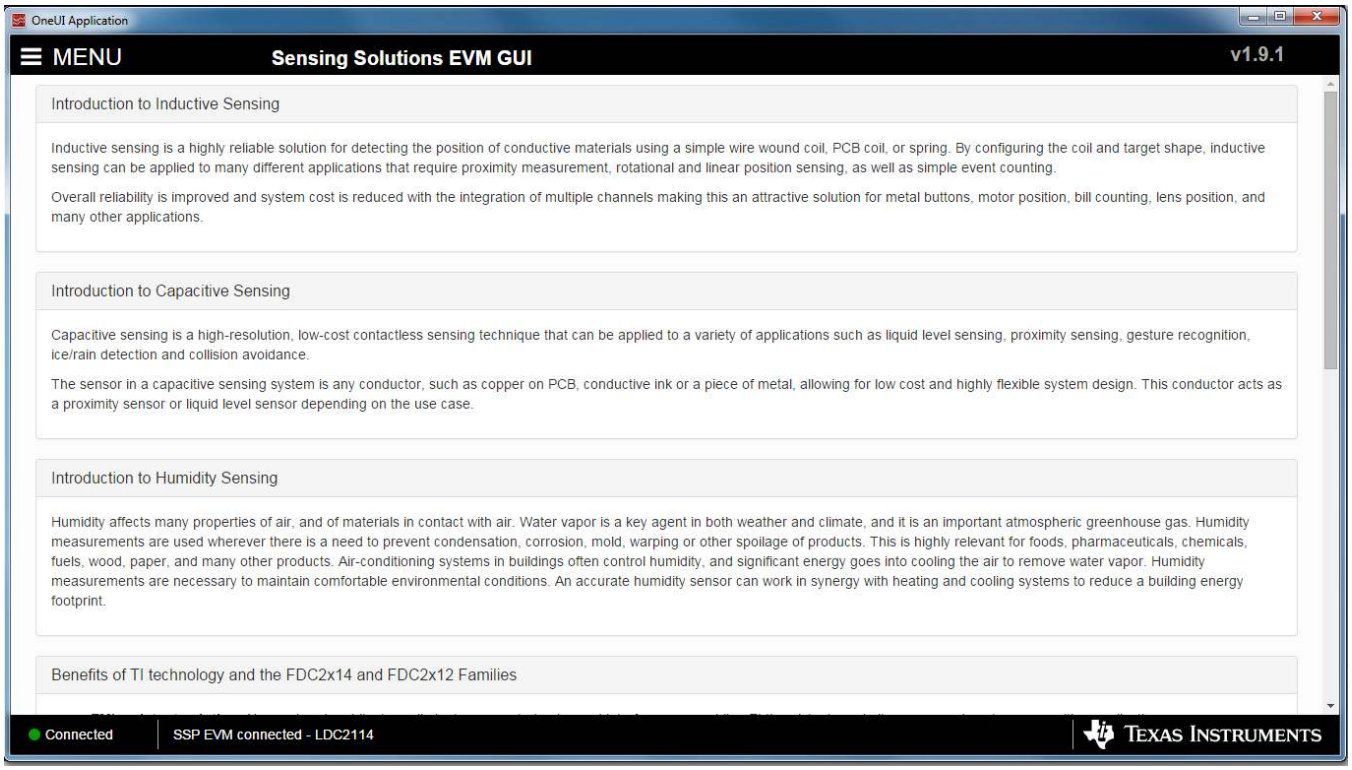

Figure 14. Introduction Page

4.4 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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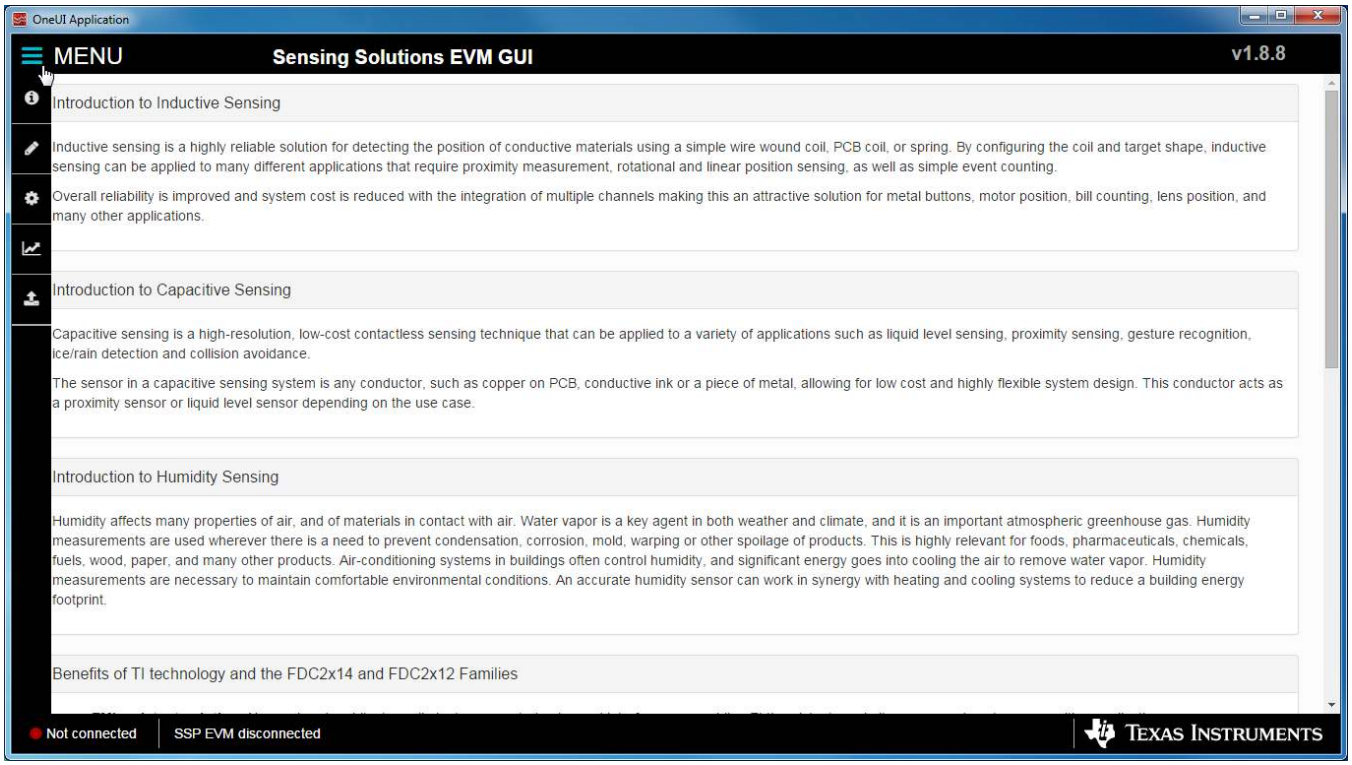

Figure 15. Mouse Hovered Over Menu Button

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

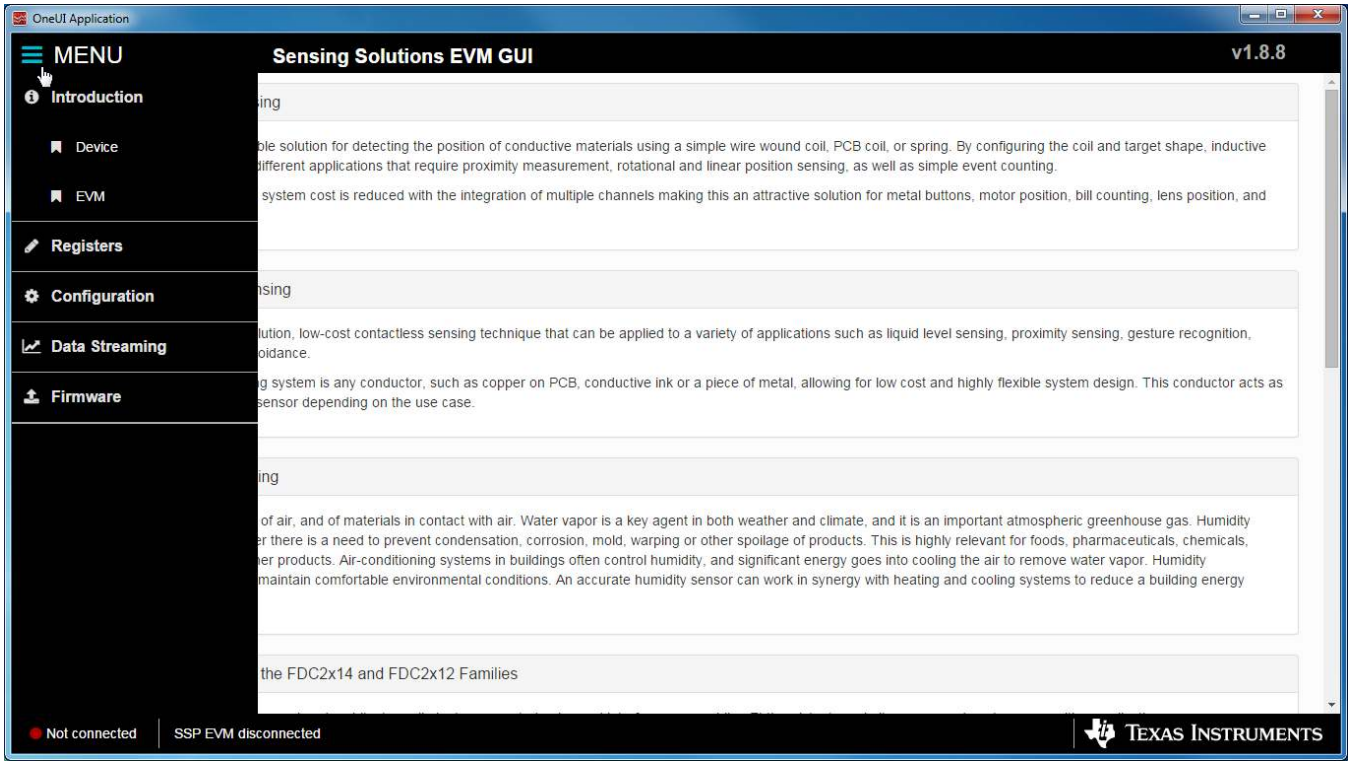

Figure 16. Menu Display After Clicking Button

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4.5 Connecting the EVM

Follow these steps to connect the EVM to the GUI:

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

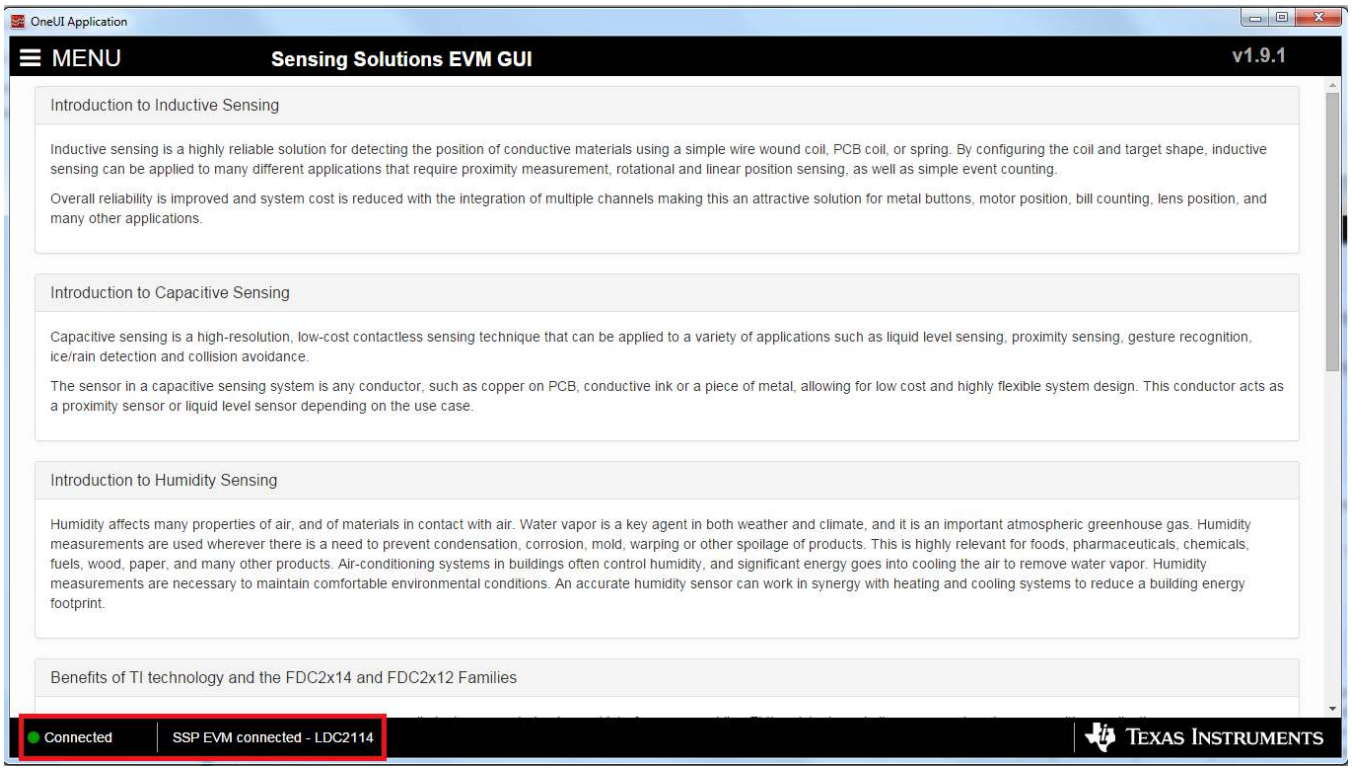

Figure 17. EVM Connected to GUI

4.6 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 current register values on the device.

4.6.1 Automatically Update GUI Register Values Using Auto Read

Auto read will periodically request the register values on the device. Click the drop down box next to *Auto Read* to select the update interval.

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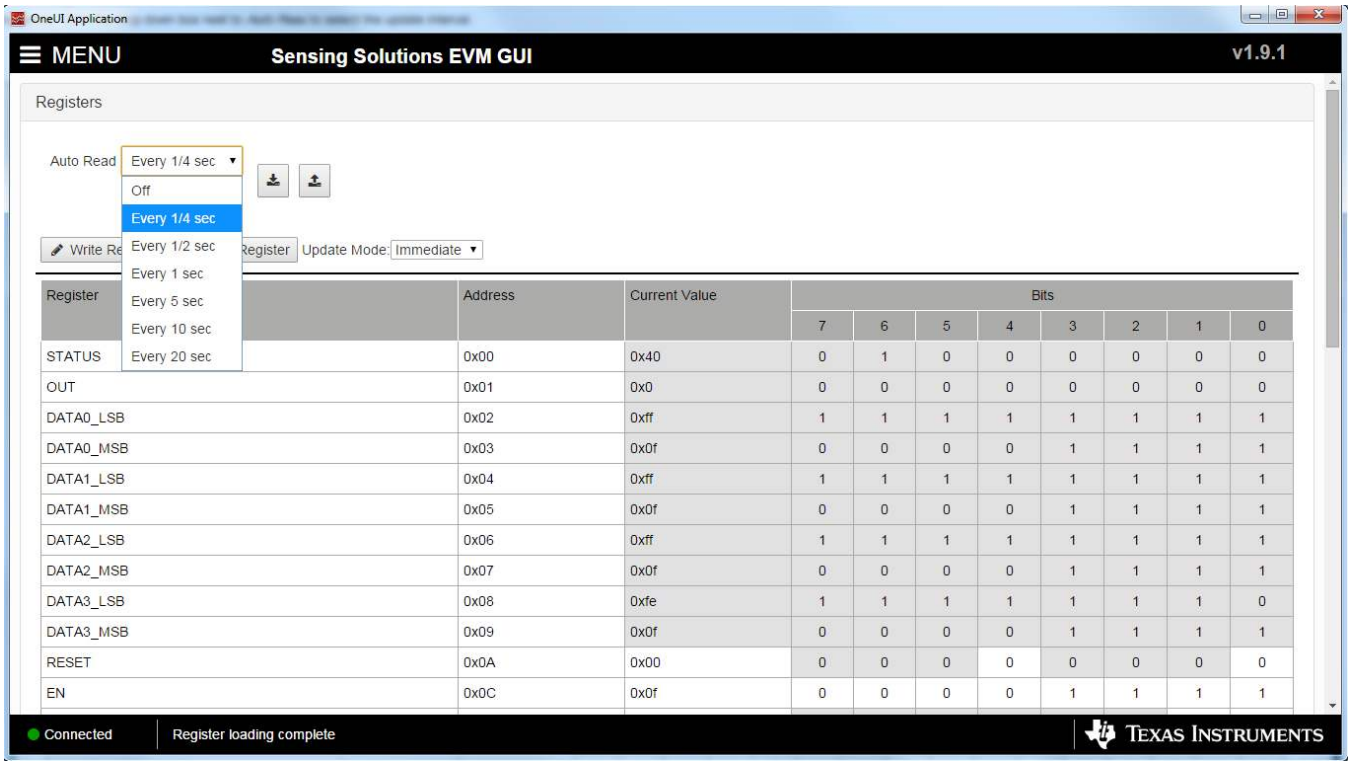

Figure 18. Selecting Auto Read Interval on Register Page

4.6.2 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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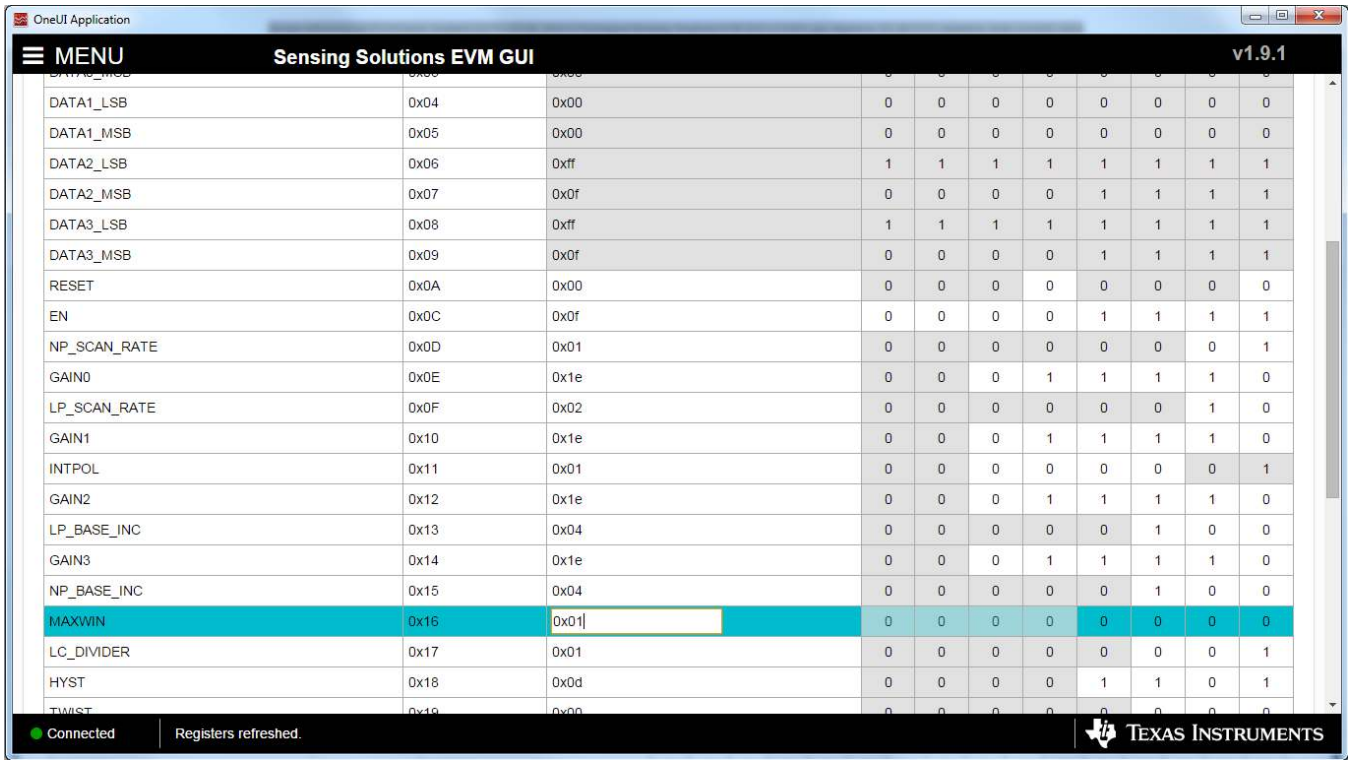

Figure 19. Selecting a Register's Current Value for Editing on Register Page

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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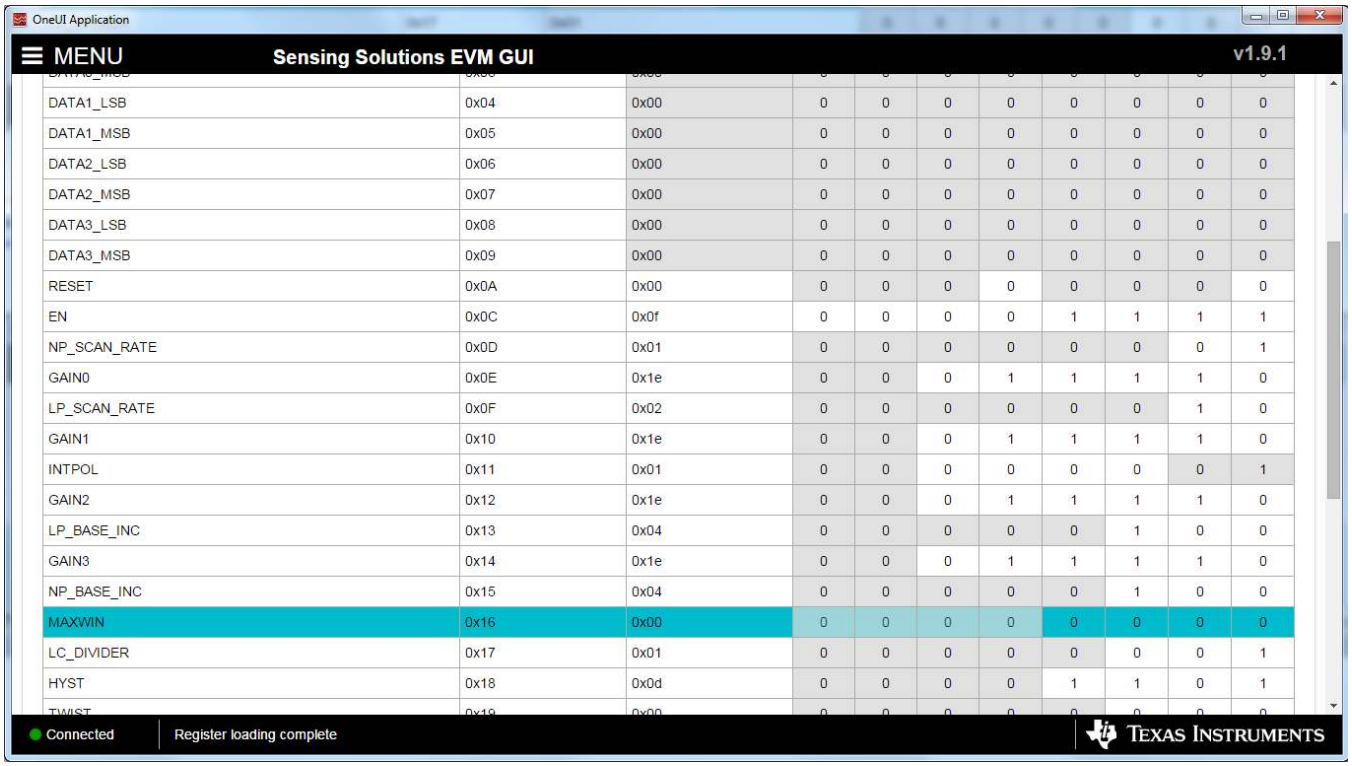

Figure 20. Hovering Mouse Over Register Bit Value on Register Page

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

4.6.3 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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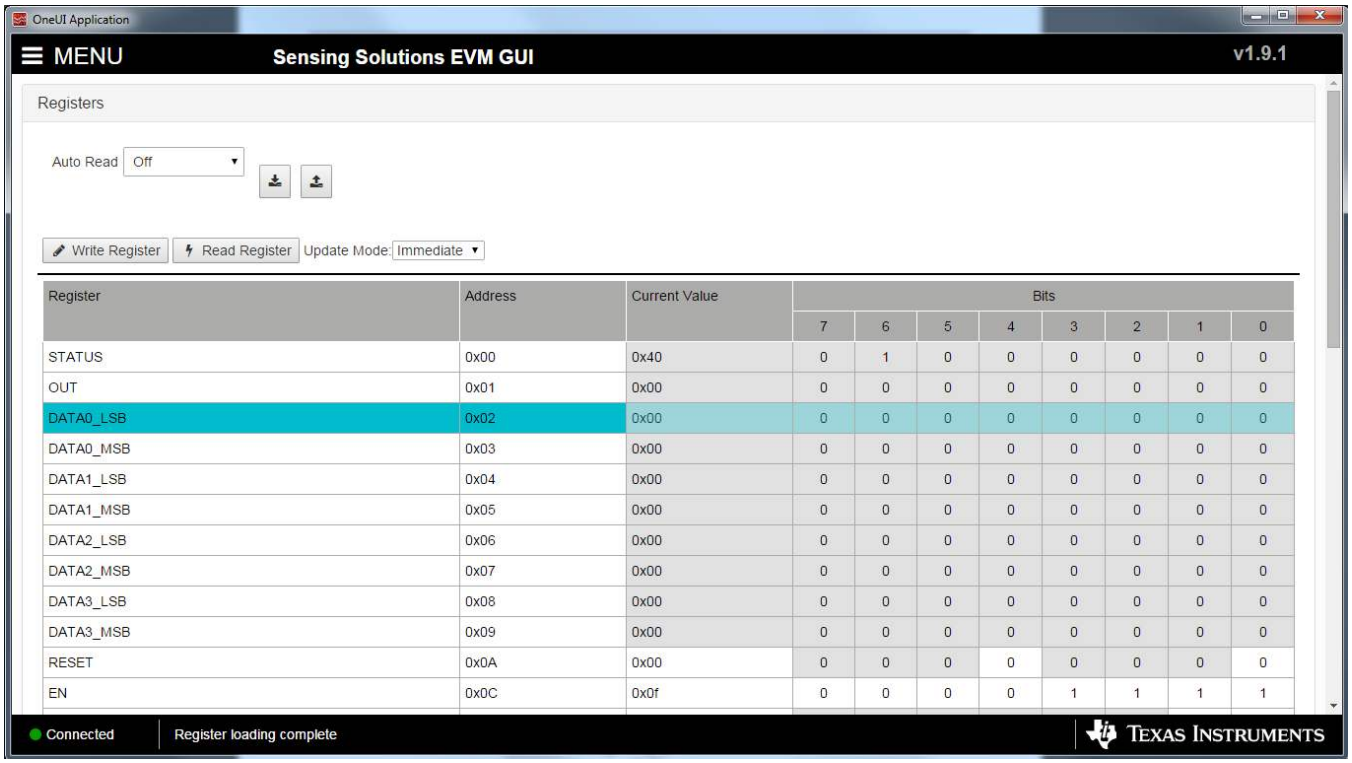

Figure 21. Selecting a Register on Register Page

2. Click the *Read Register* button to update the selected register's current value and bit values in the table.

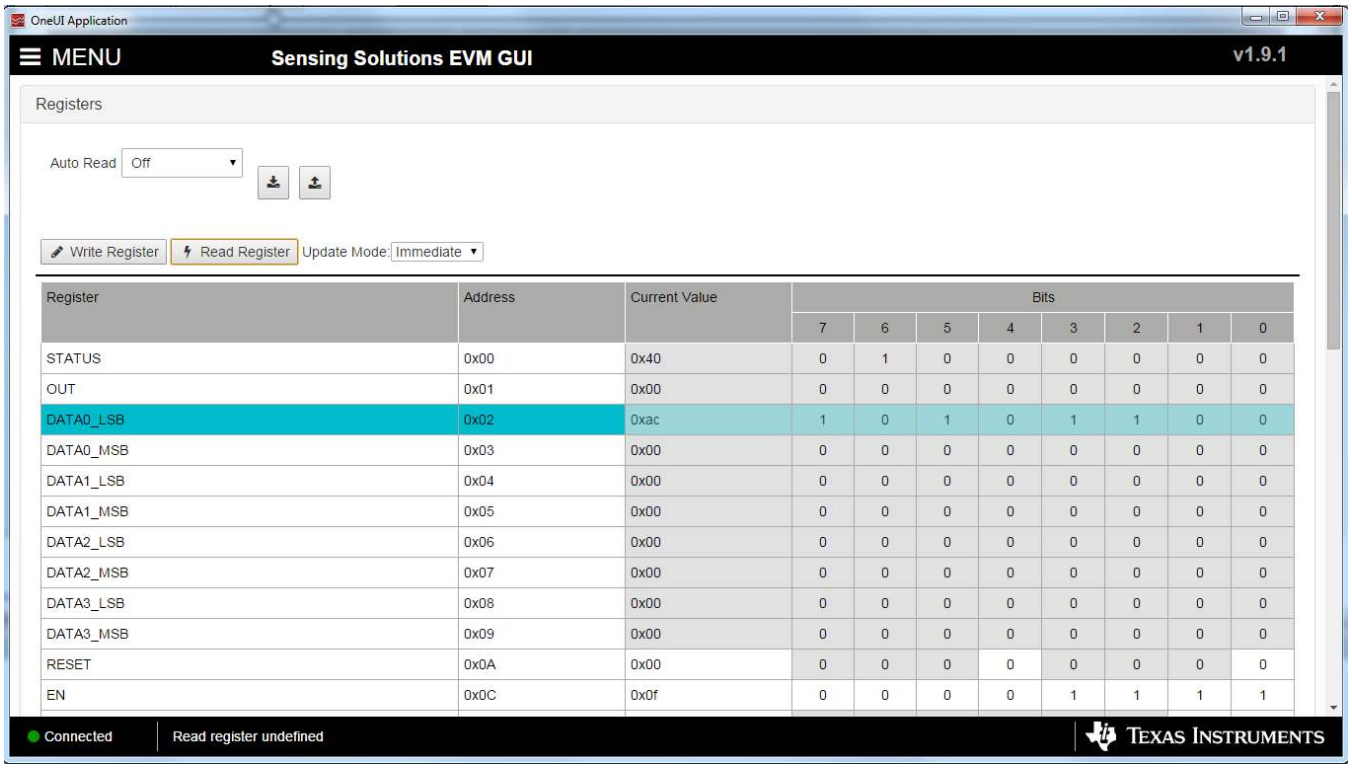

Figure 22. Reading the Current Device Register Value on Register Page

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4.6.4 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 drop down.

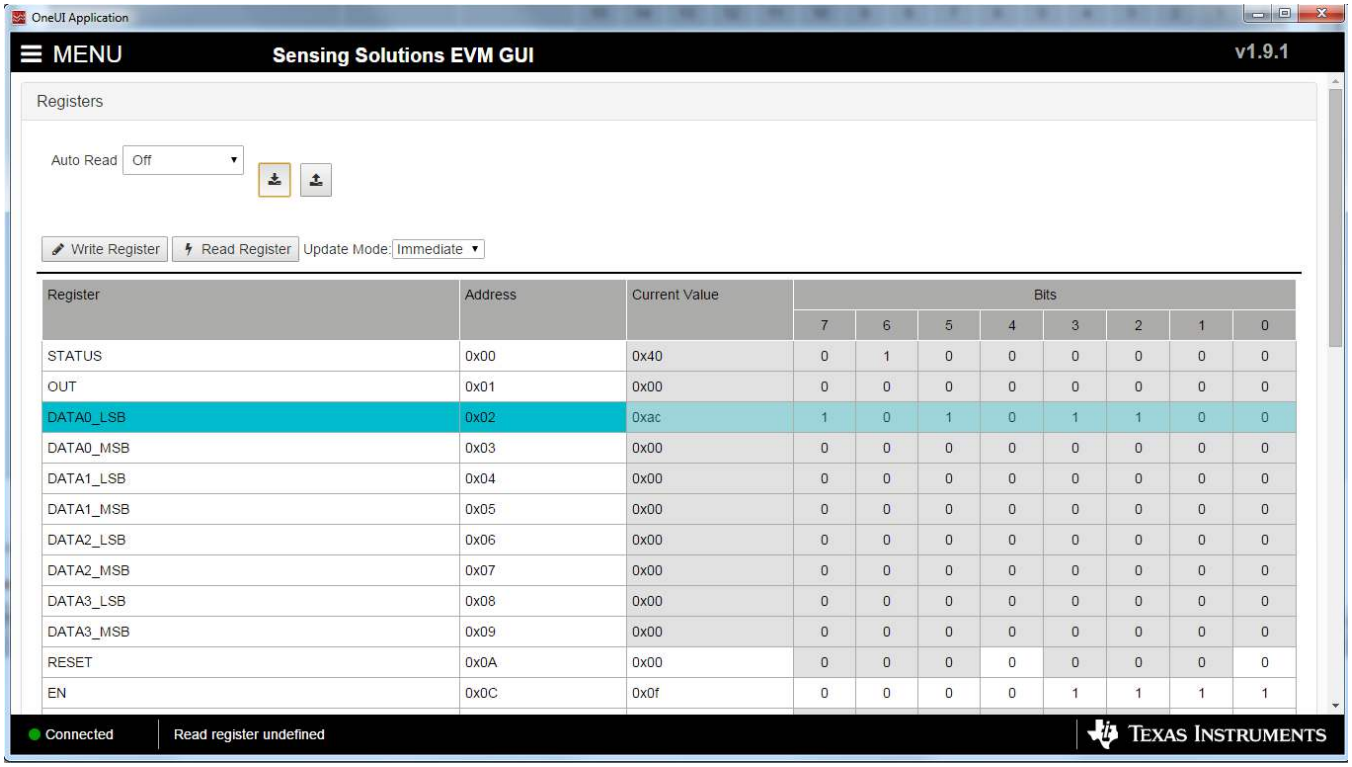

Figure 23. Save Register Values to File on Register Page

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

4.6.5 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 drop down.

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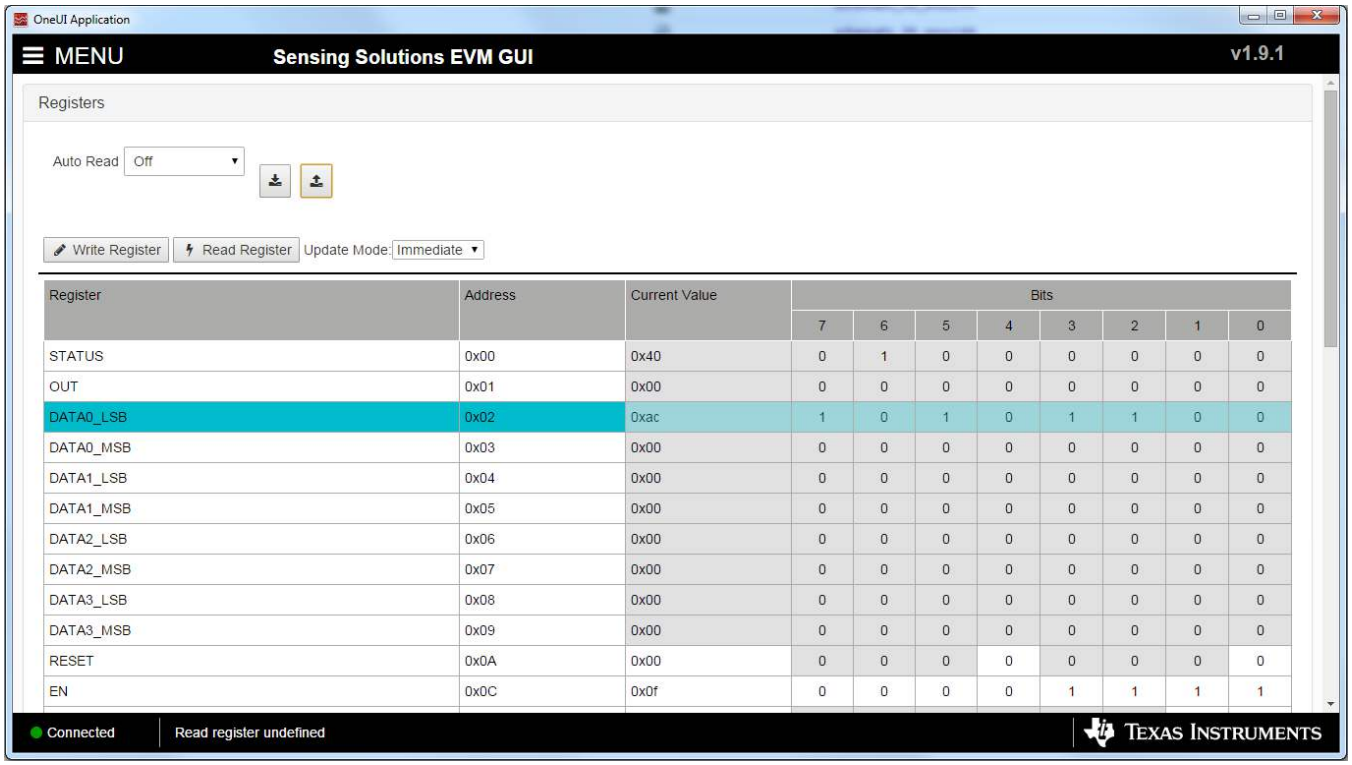

Figure 24. Loading Previously Saved Register Values from File on Register Page

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

4.7 Configuring the EVM Using the Configuration Page

The Sensing Solutions GUI is capable to configure the device in a more intuitive way than through 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.

4.7.1 Changing registers through the Configuration Pane

The device configuration must only be changed while STATE_RESET=b1. This mode can be entered while selecting the appropriate option in the *Reset Mode* section of the *Global Buttons Settings*. After changing the configuration, the *Reset Mode* must be changed back to *Active processing*, as shown in Figure 25.

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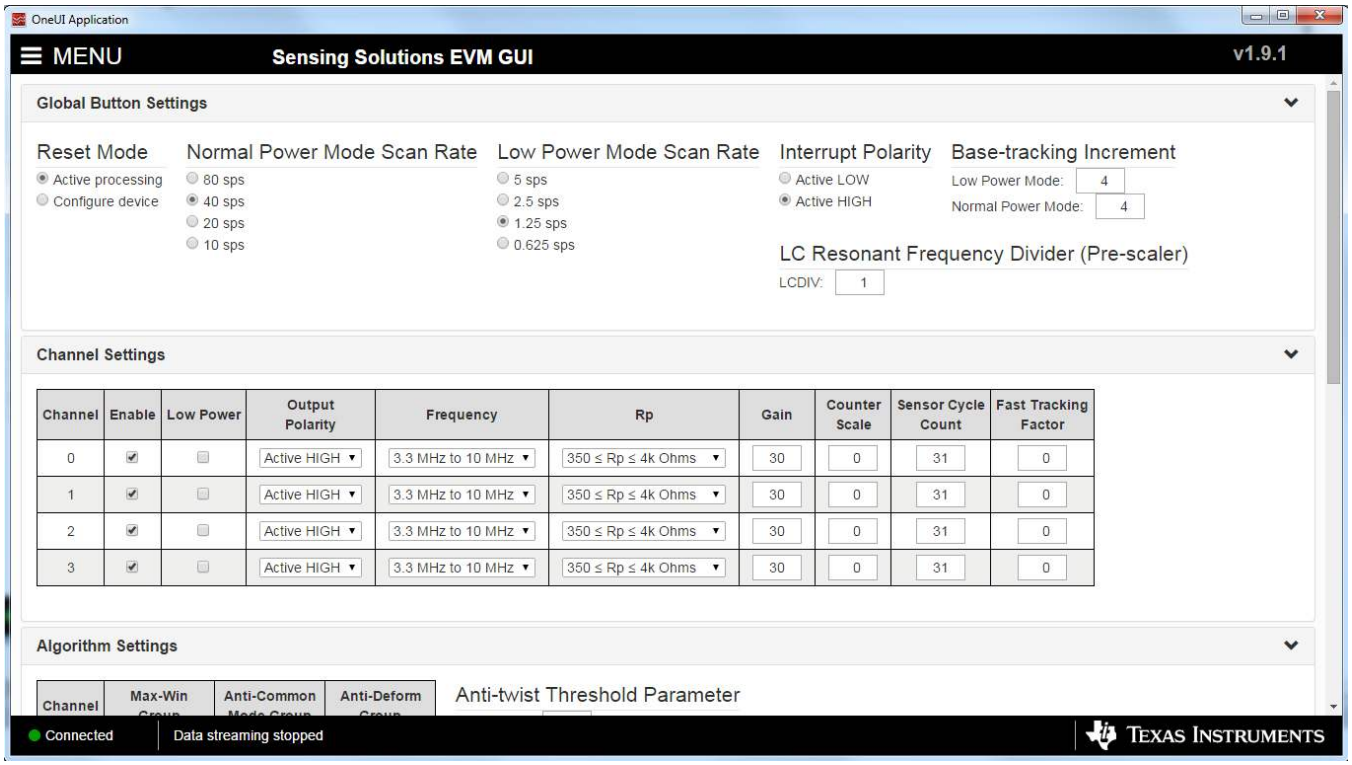

Figure 25. Global Button Settings, Channel Settings on Configuration Page

4.7.2 Selecting the Mode of Operation and Scan Rate

Each channel on the LDC2114 can be configured to operate either in *Normal power mode* or in *Low power mode*. The *Global Button Settings* menu contains *Normal Power Mode Scan Rate* and *Low Power Mode Scan Rate* selections, in which the desired scan rate chan be chosen for each mode of operation.

Channels can be assigned to either the *Normal Power Mode* or the *Low Power Mode* by toggling the *Low Power* button in the Channel Settings table for each channel individually.

4.7.3 Interrupt polarity

The LDC interrupt pin polarity can be chosen in the 'Interrupt Polarity' option of the 'Global Buttons Settings' section.

4.7.4 Base-tracking Increment

The LDC incorporates a baseline tracking algorithm to automatically compensate for any slow change in the sensor output caused by environmental variations, such as temperature drift. The baseline tracking is configured independently for Normal Power Mode and Low Power Mode. The increment for this feature is configured in the *Base-tracking Increment* option.

4.7.5 LC Resonant Frequency Divider (Pre-scaler)

The LCDIV field sets the oscillation frequency divider. This field should be set as described in section *Programmable button sampling window* of the LDC2114 datasheet.

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4.7.6 Channel Settings

In the *Channel Settings* section, each channel can be configured independently. Each channel has its own enable bit and its own output pin with configurable polarity. The remaining parameters (*Frequency*, R_P, *Gain*, *Counter Scale*, *Sensor Cycle Count*, and *Fast Tracking Factor*) should be configured according to the characteristics of the attached sensor.

4.7.7 Algorithm Settings

The LDC has four additional algorithms, which can be enabled in the *Algorithms Settings* section, as shown in Figure 26.

1. The *Max-Win* algorithm enables the system to select the button pressed with maximum force when multiple buttons are pressed at the same time. This feature must be enabled for each applicable channel individually.
2. The *Anti-Common Mode* algorithm eliminates false detection when a user presses the panel in certain positions, which could cause a common-mode change to two or more buttons. This feature must be enabled for each applicable channel individually.
3. The *Anti-Deform* algorithm filters changes due to metal deformation in the vicinity of one or more buttons. Such metal deformation can be accidentally caused by pressing a neighboring button that does not have sufficient mechanical isolation. This feature must be enabled for each applicable channel individually.
4. The *Anti-twist* algorithm reduces the likelihood of false detection when the case is twisted, which could cause unintended mechanical activation of the buttons, or an opposite reaction in two adjacent buttons. The anti-twist function can be enabled by configuring the *ANTITWST* setting to a value larger than 0.

4.7.8 Calculator

The *Calculator* does not write any registers and is used for information purposes only. It calculates the time of the sampling window for each channel based on its configured register settings.

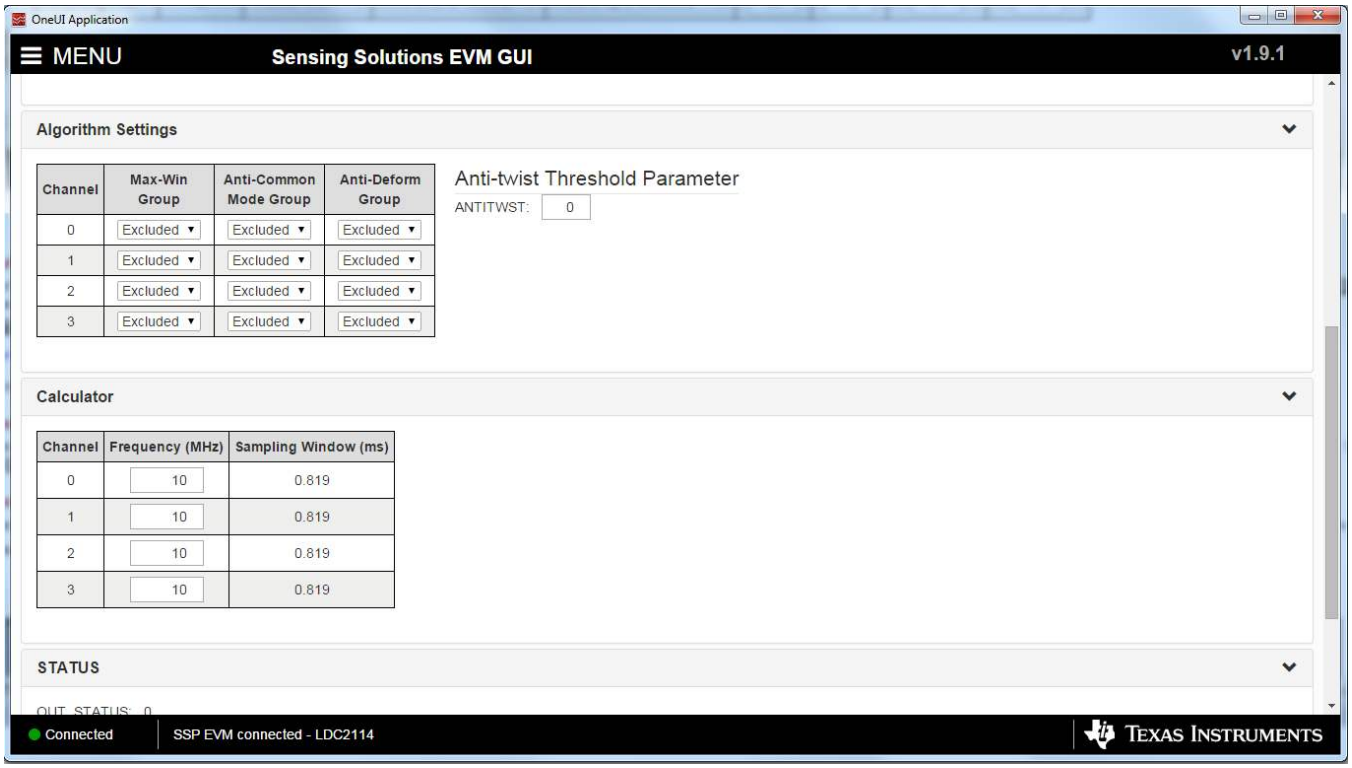

Figure 26. Algorithm Settings and Calculator on Configuration Page

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4.7.9 Status

The *Status* section, as shown in Figure 27, reports the flags in the STATUS register of the LDC2114.

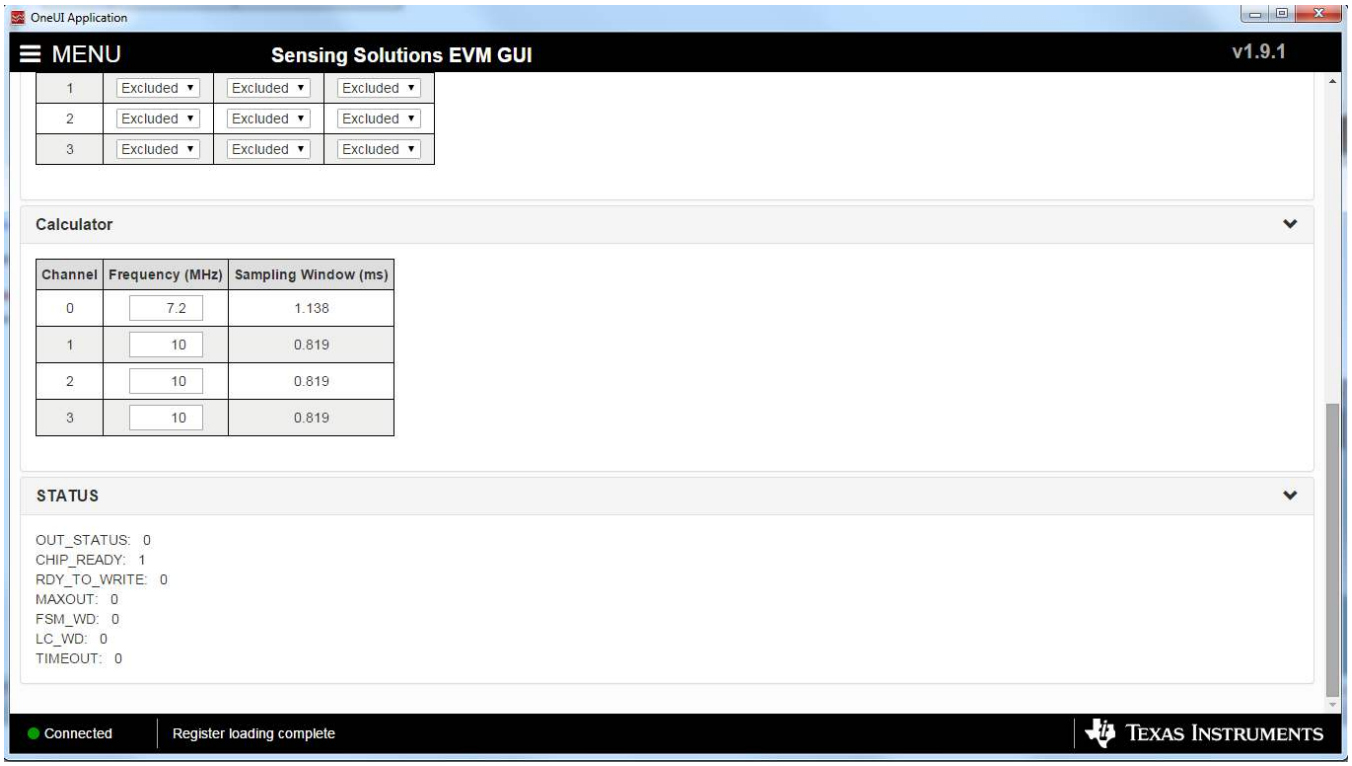

Figure 27. Device Status

4.8 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.

4.8.1 Choosing Visible Channels

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 28 shows a streaming window in which channel 0 and channel 1 are enabled, and channel 1 shows a button press.

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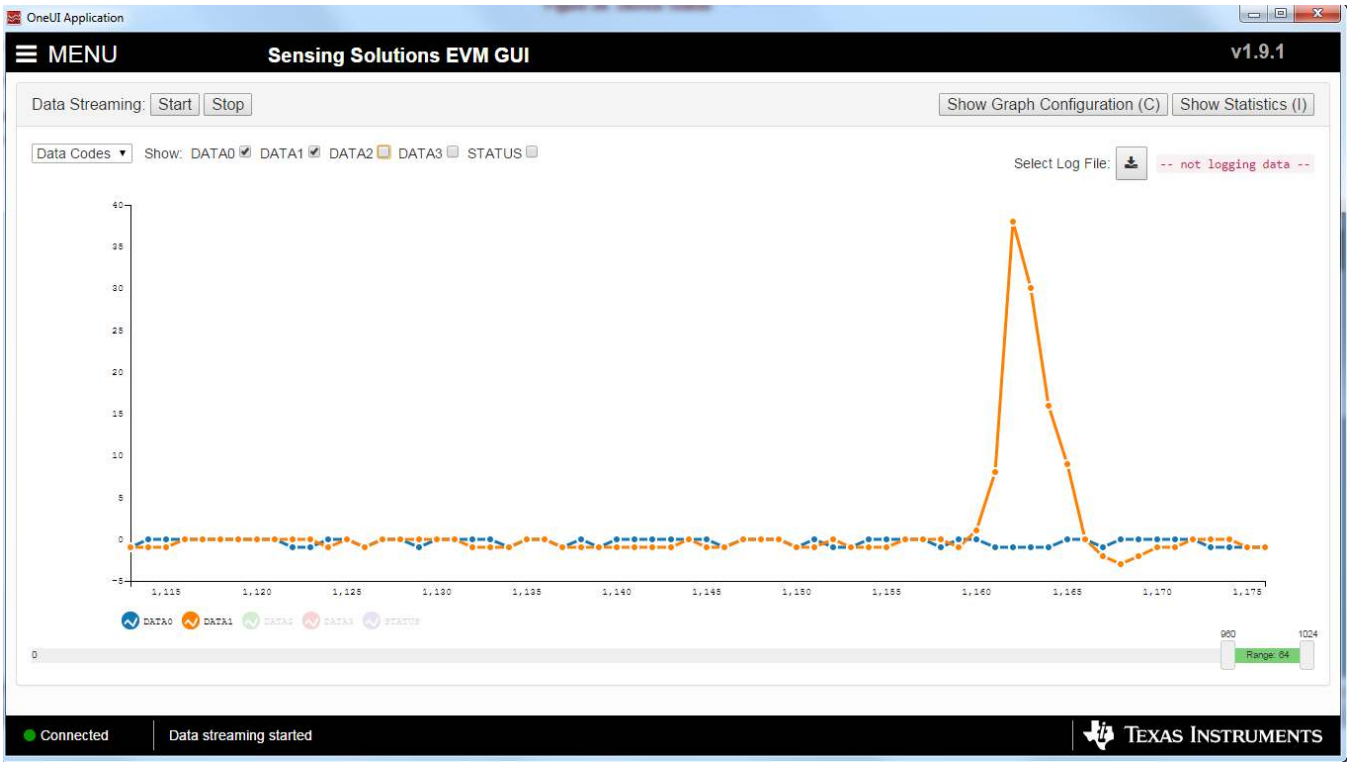

Figure 28. Select the Data Graph on Data Streaming Page

4.8.2 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 29. 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.

4.8.3 Starting and Stopping Data Streaming

To start data streaming click the *Start* button.

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Figure 30. Start Button on Data Streaming Page

To stop data streaming click the *Stop* button.

4.8.4 Data Statistics

Click the *Show Statistics* button to view the measurement statistics. Click the *Hide Statistics* button to hide the measurement statistics.

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Figure 31. Show Statistics Button on Data Streaming Page

Figure 32. Hide Statistics Button on Data Streaming Page

4.8.5 Configuring the Graph

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

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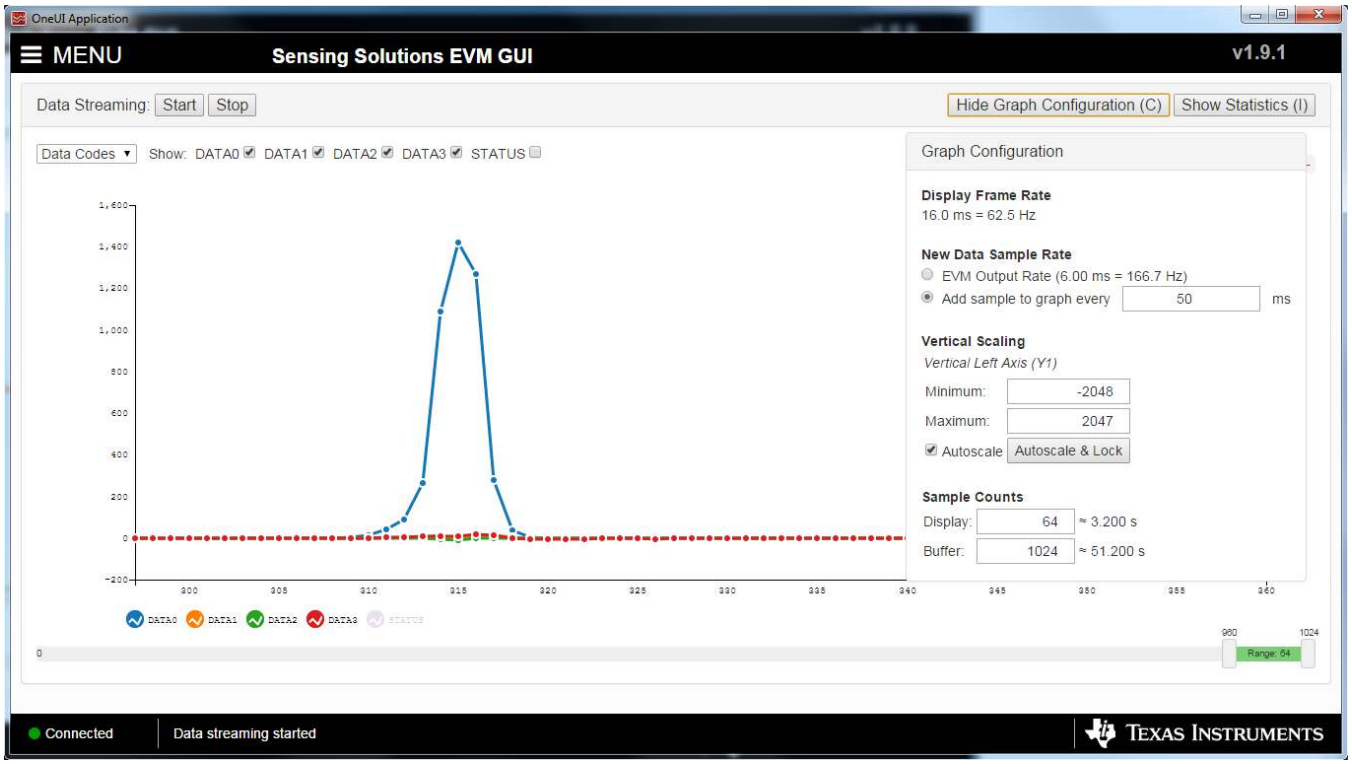

Figure 33. Show Graph Configuration Button on Data Streaming Page

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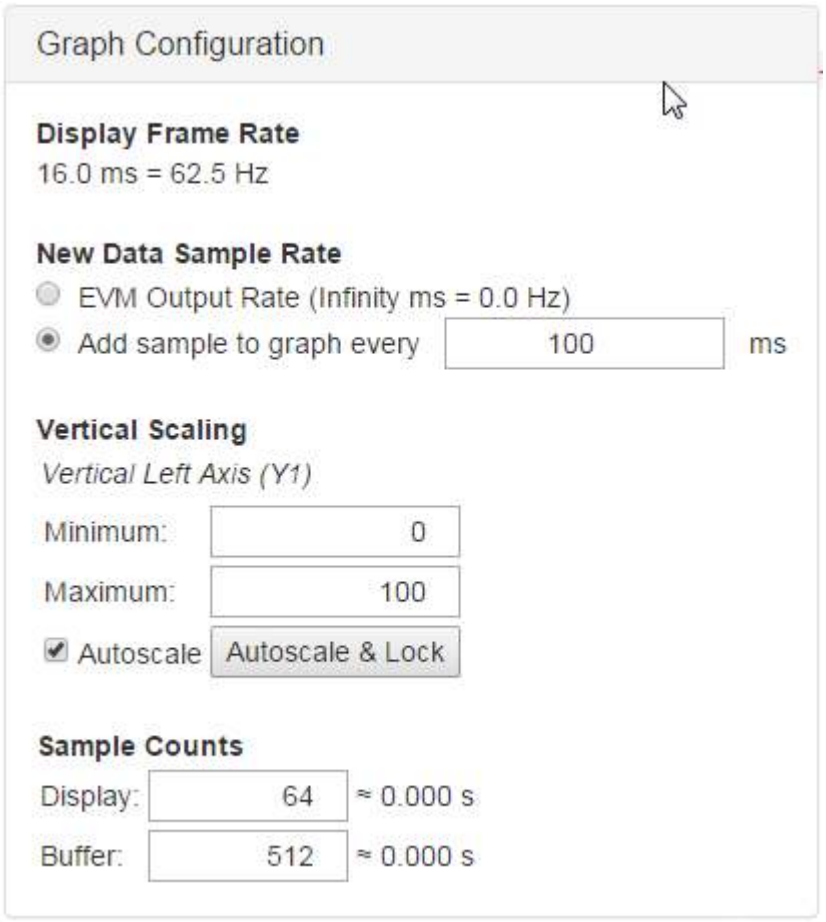

Figure 34. Graph Configuration Button on Data Streaming Page

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 *Vertical 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.

4.8.6 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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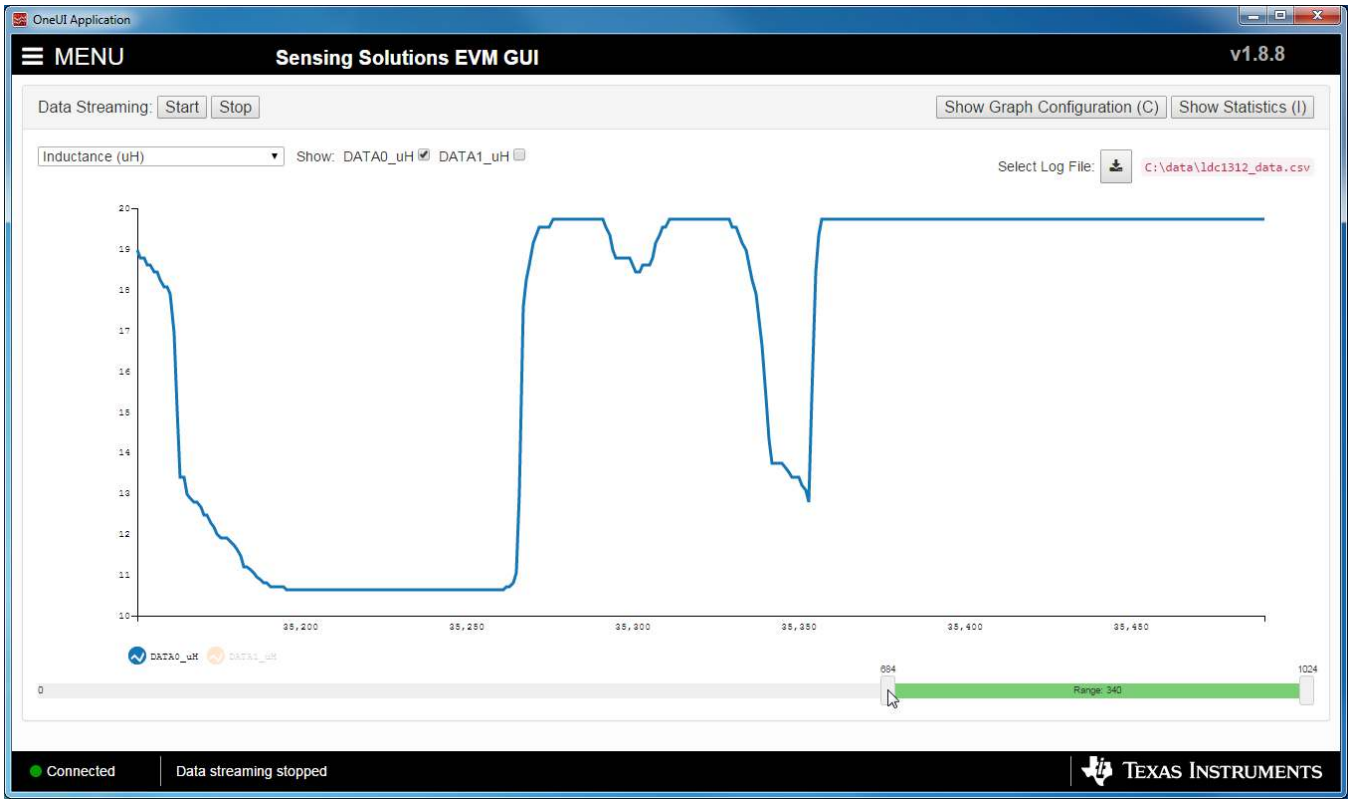

Figure 35. Changing Number of Samples Displayed in Data Graph

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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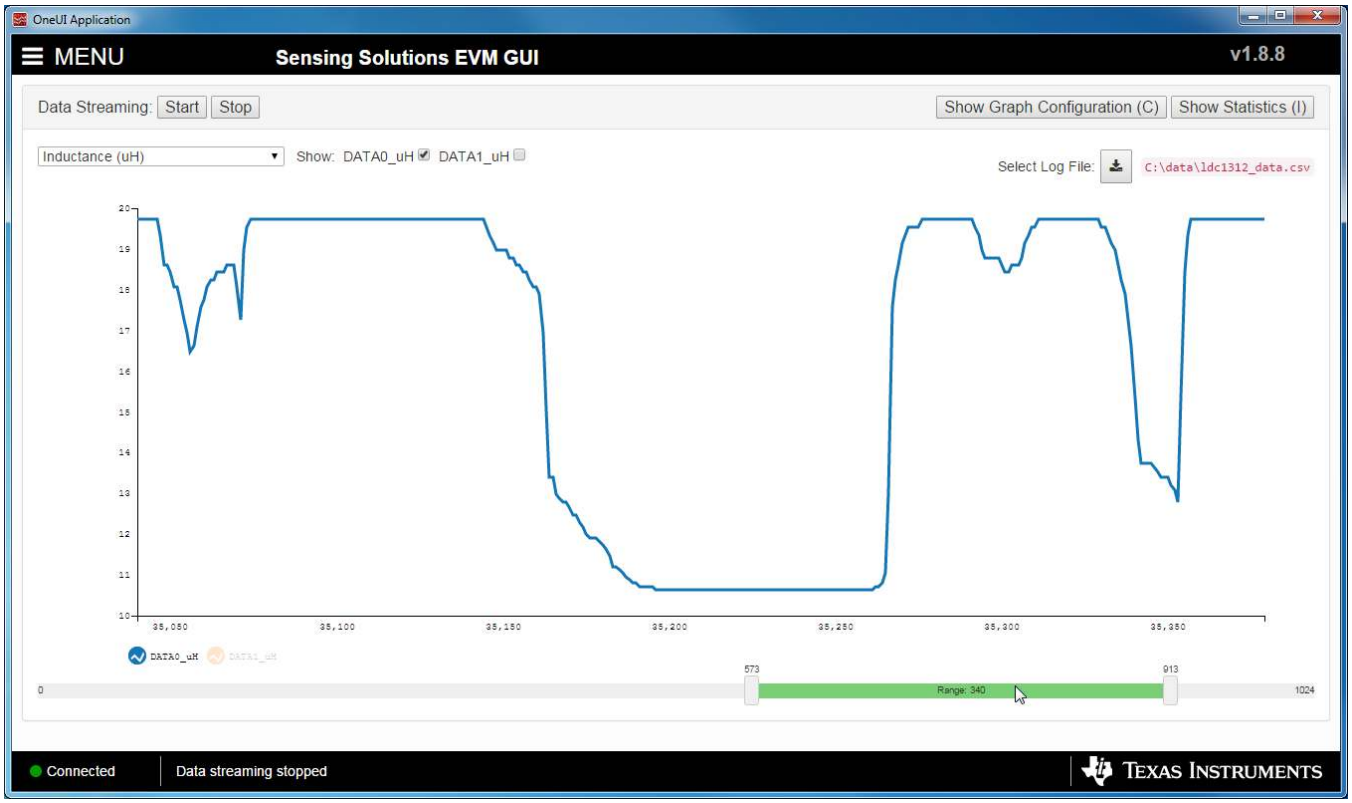

Figure 36. Displaying Previous Data Samples on the Data Streaming Page

4.9 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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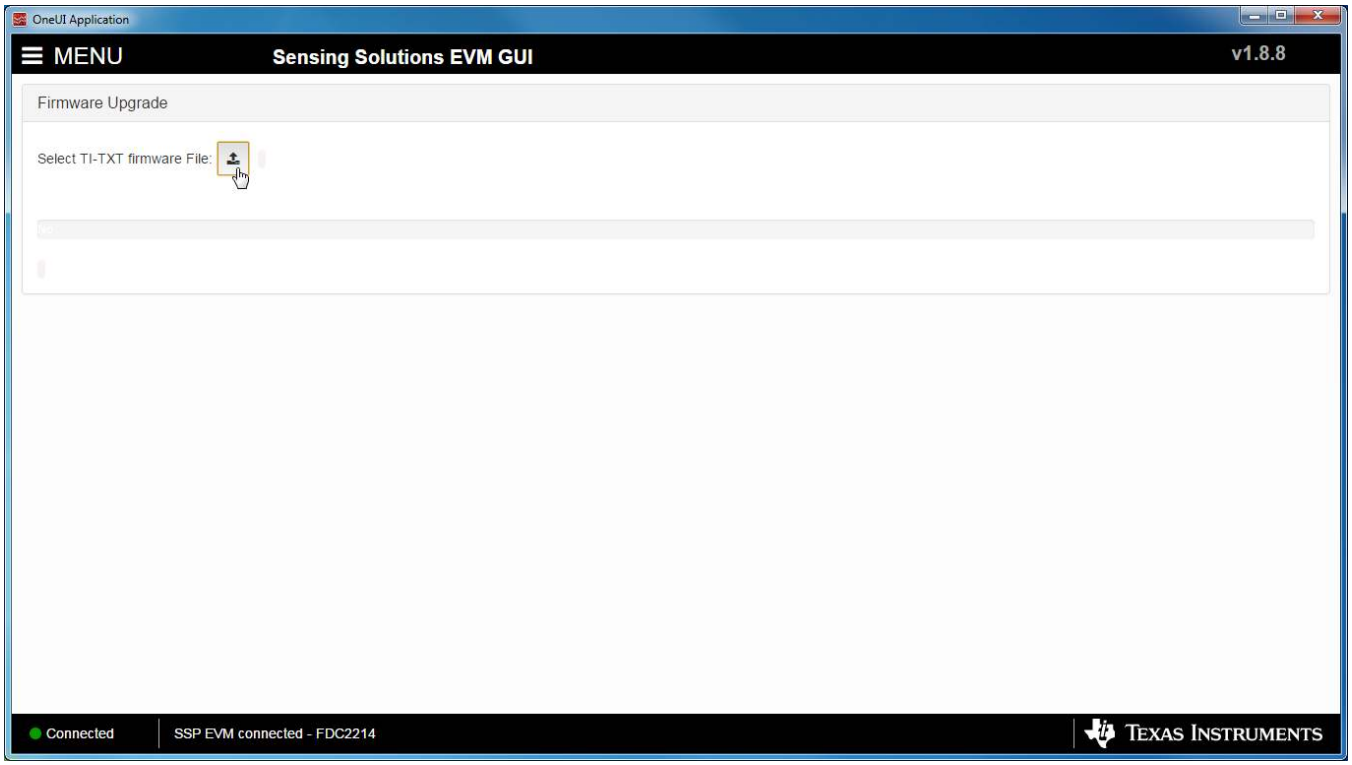

Figure 37. Select TI-TXT File Button on Firmware Upload Page

2. Select the firmware file and click *Open*.

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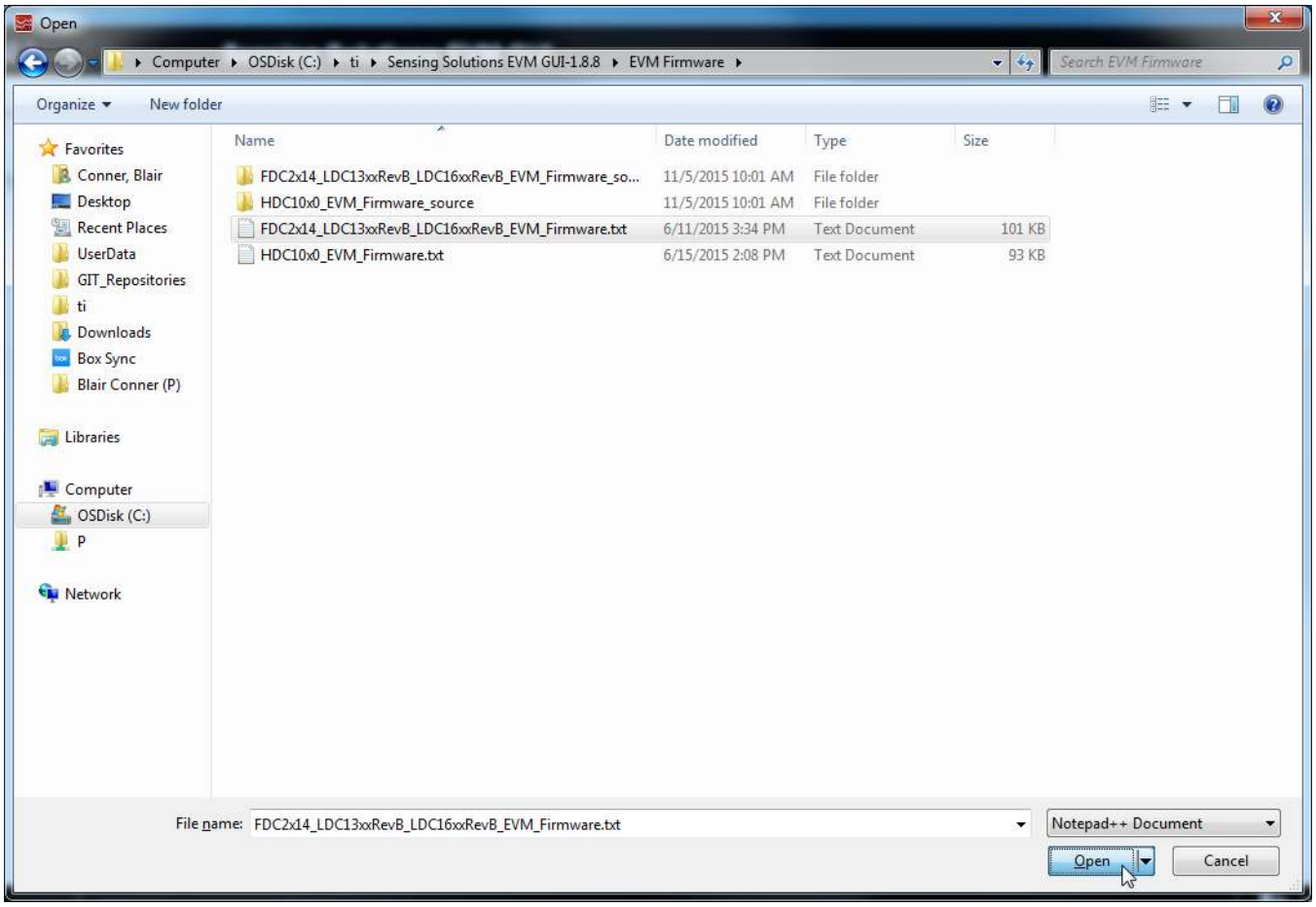

Figure 38. Selecting TI-TXT Firmware File for Upload to EVM

3. Click the *Upload Firmware* button.

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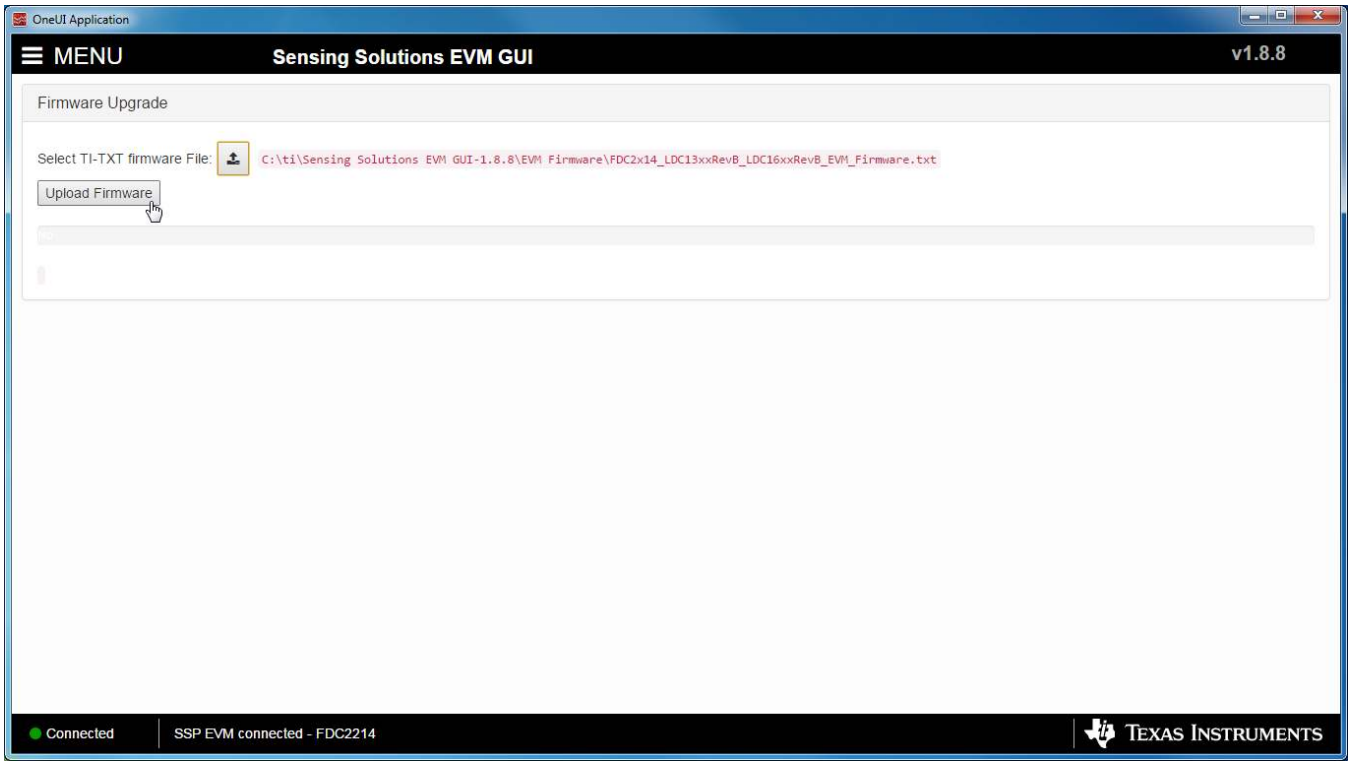

Figure 39. Upload Firmware Button on Firmware Upload Page

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.

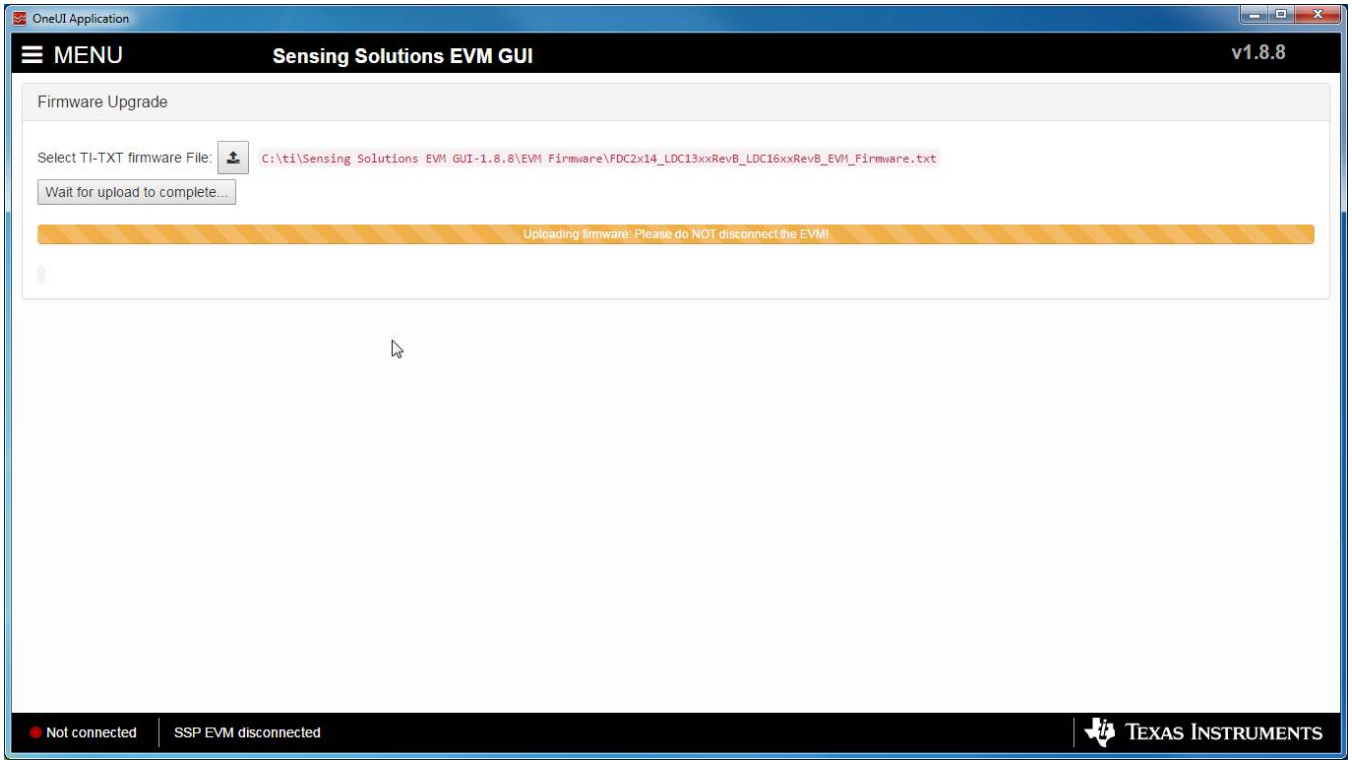

Figure 40. Firmware Upload in Progress

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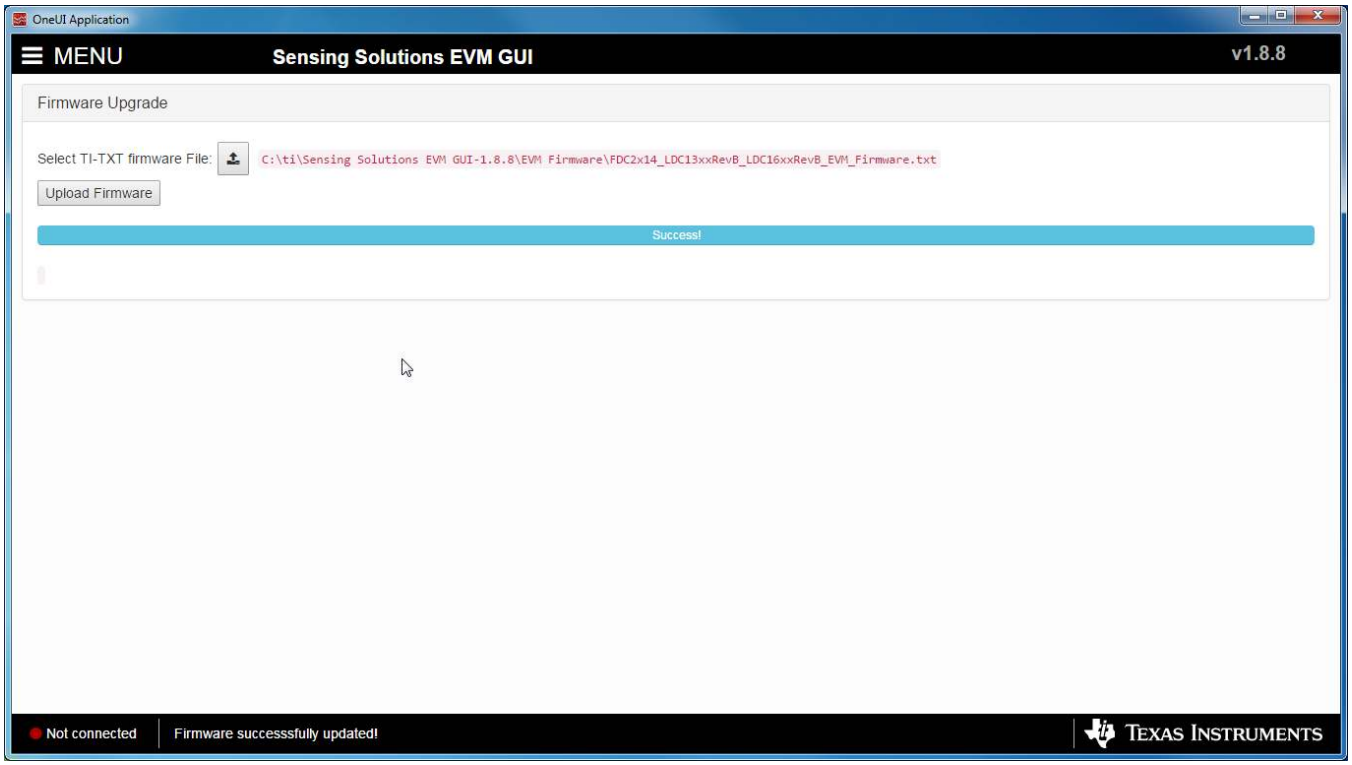

Figure 41. Firmware Upload Success

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5 LDC2114 EVM REV A Schematics and Layout

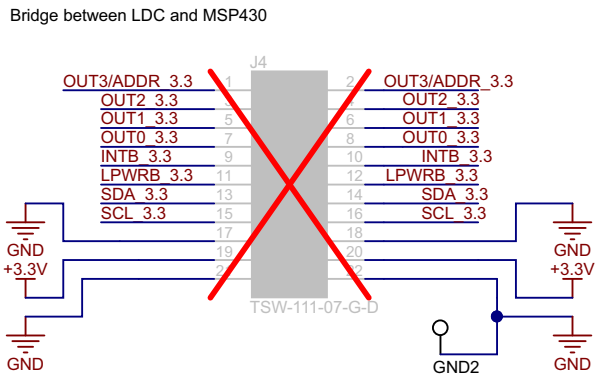

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Figure 42. Bridge between LDC and MSP430

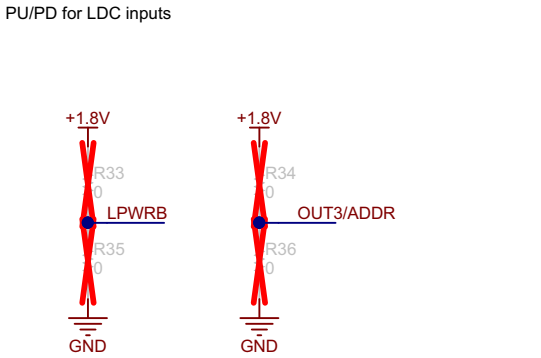

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Figure 43. PU/PD for LDC inputs

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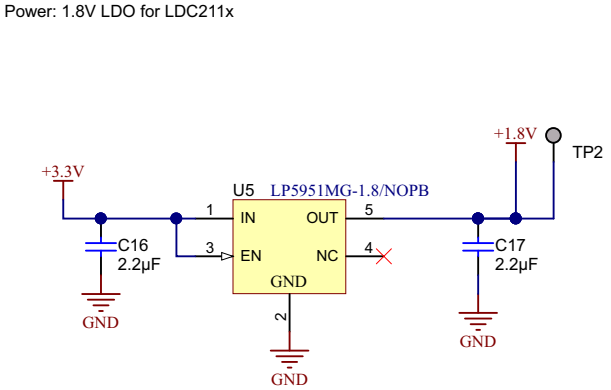

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Figure 44. Power: 1.8V LDO for LDC211x

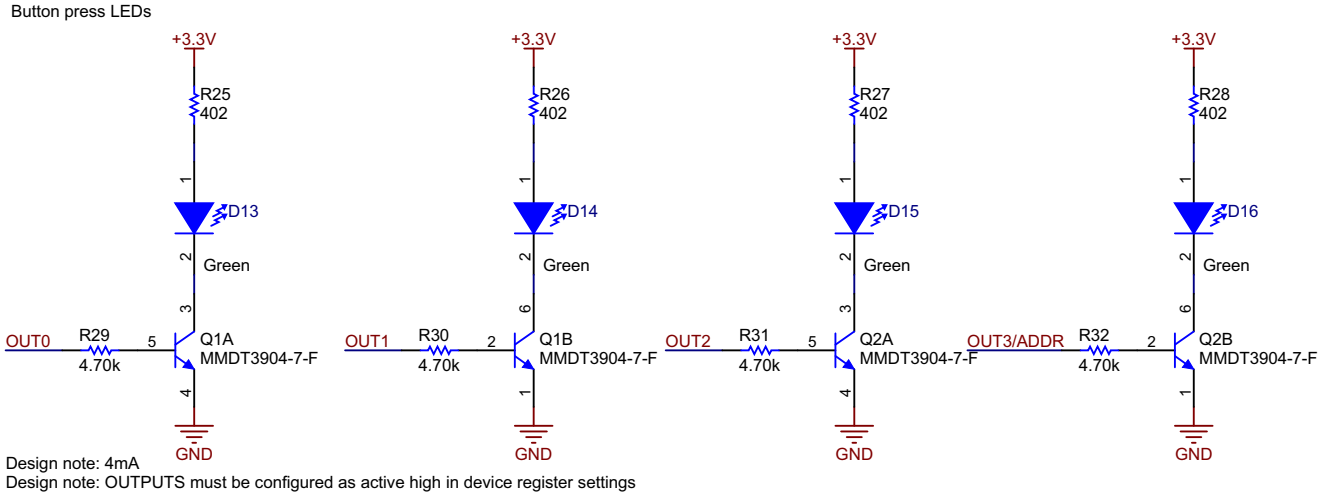

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Figure 45. Button press LEDs

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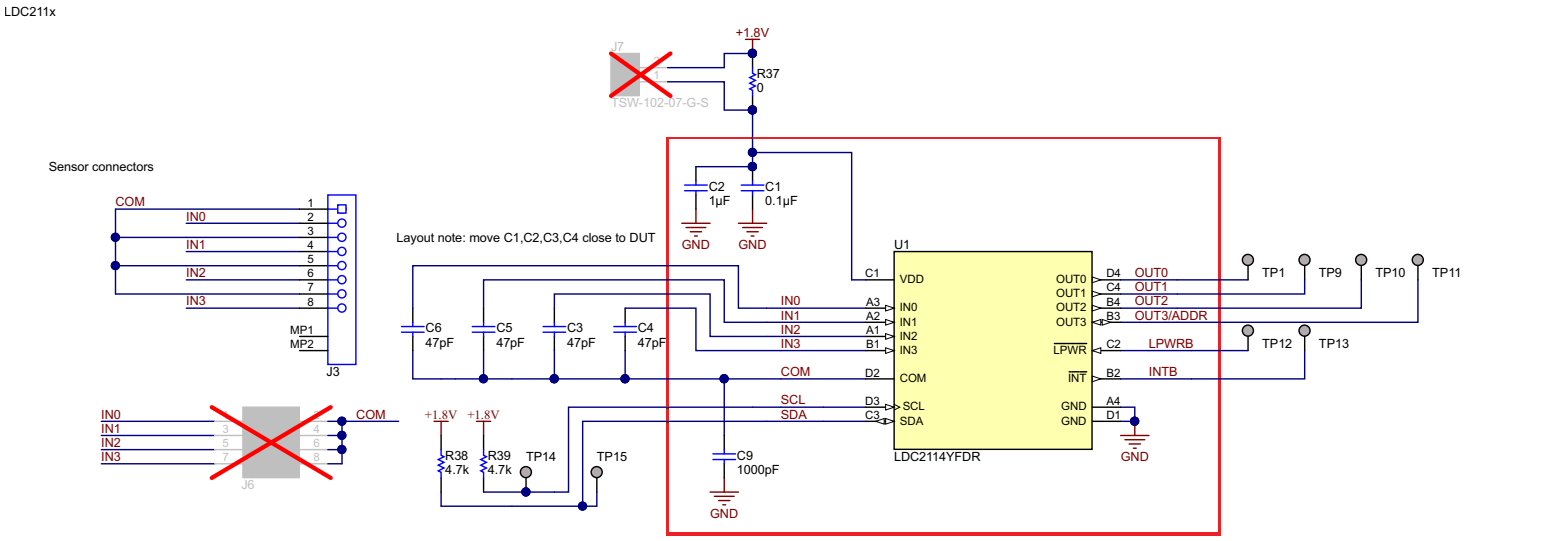

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Figure 46. LDC2114

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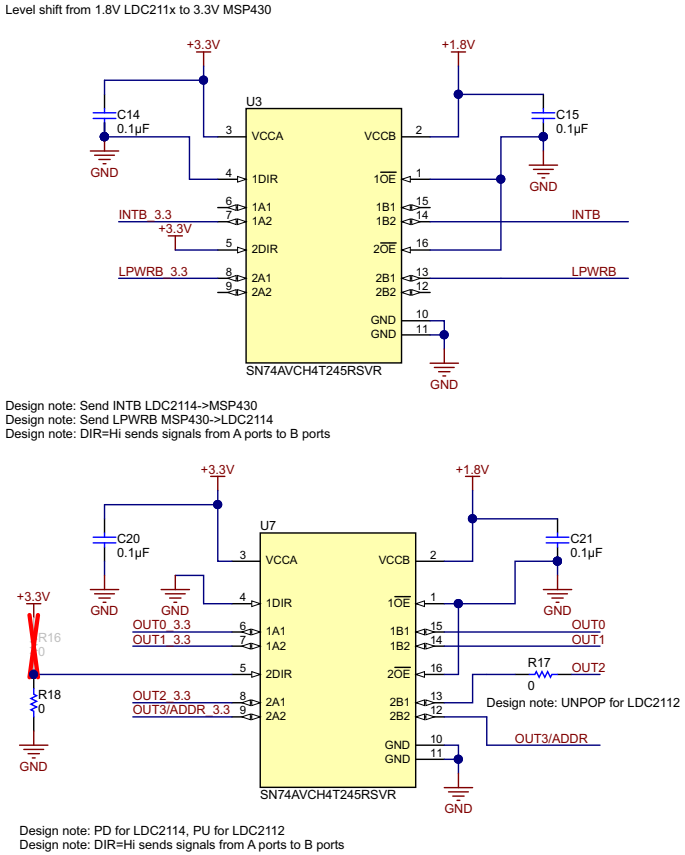

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Figure 47. Level shift from 1.8V LDC211x to 3.3V MSP430

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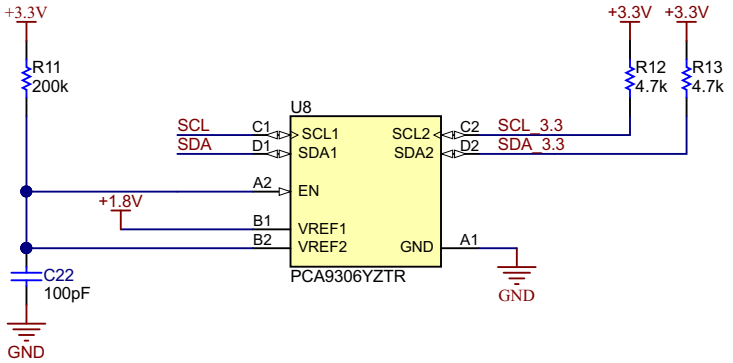
Level shift for I2C



Design note: MSP430: 3.3V, LDC211x: 1.8V
Design note: VREF2 must be 1.8V, 3.3V, or 5V if VREF1 = 1.8V

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Figure 48. Level shift for I2C

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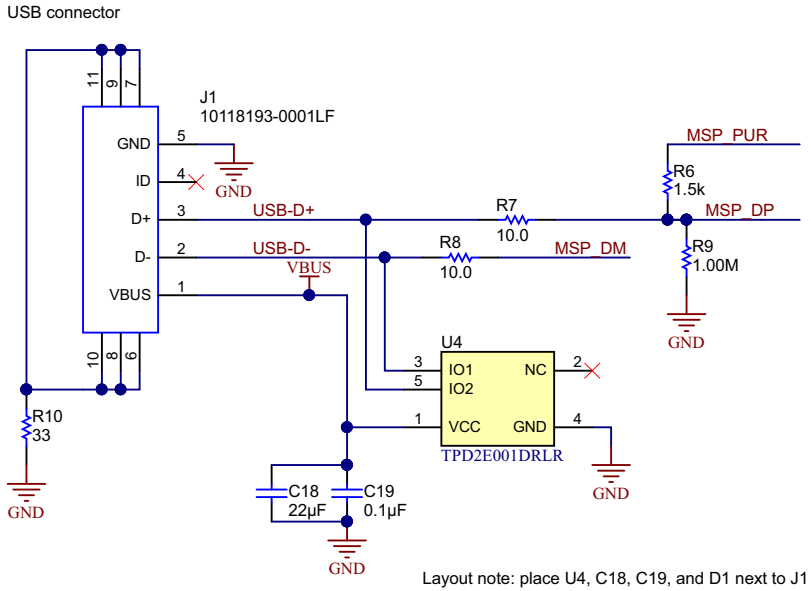

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Figure 49. USB connector

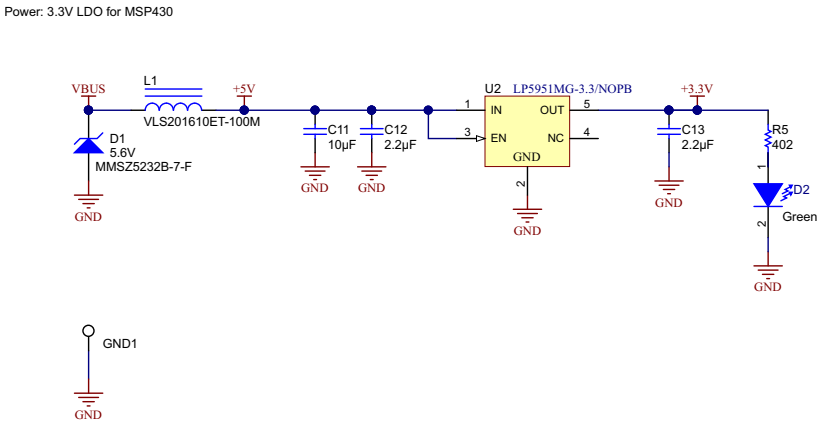

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Figure 50. Power: 3.3V LDC for MSP430

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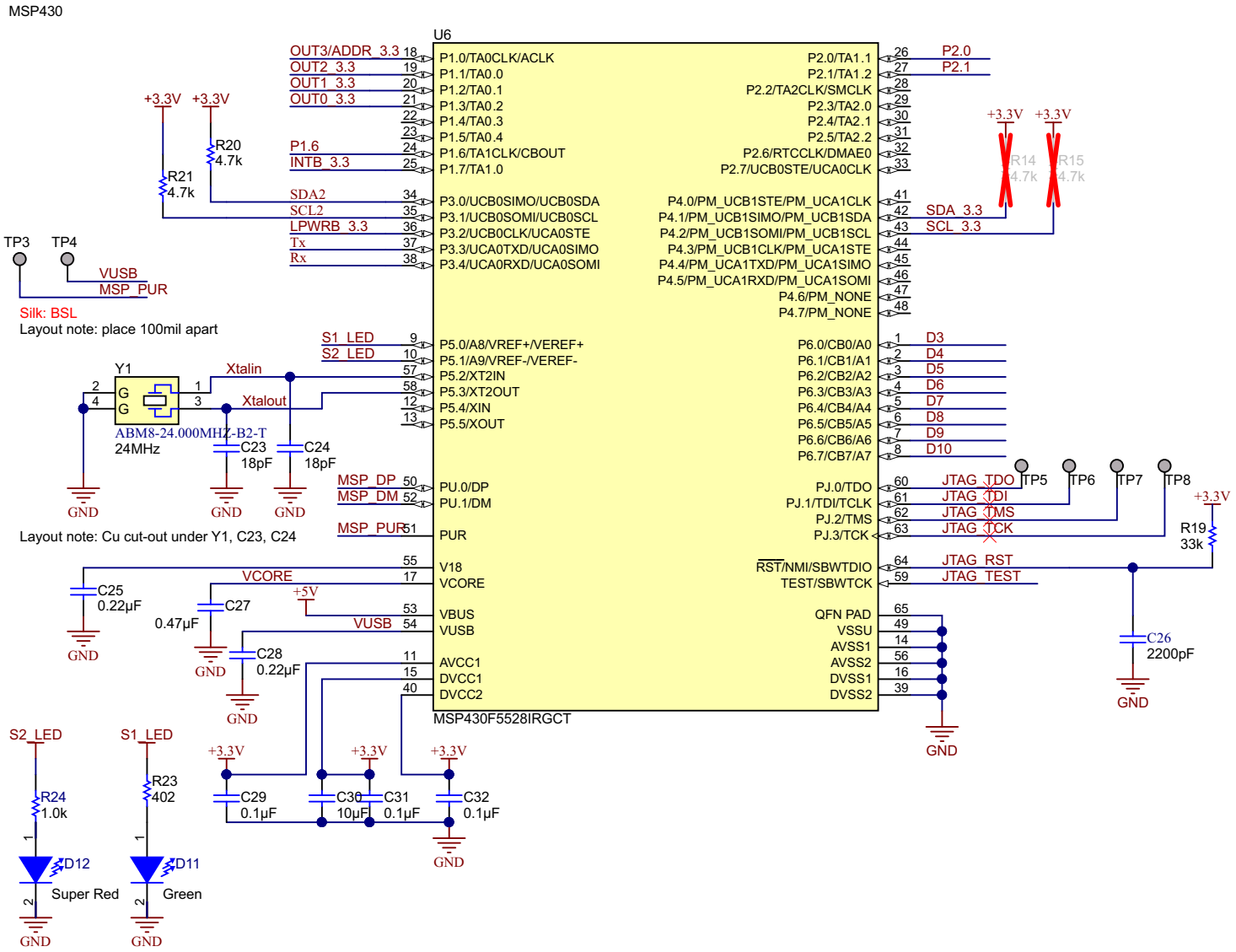

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Figure 51. MSP430

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MSP430 GPIO Breakout connector and General purpose LEDs

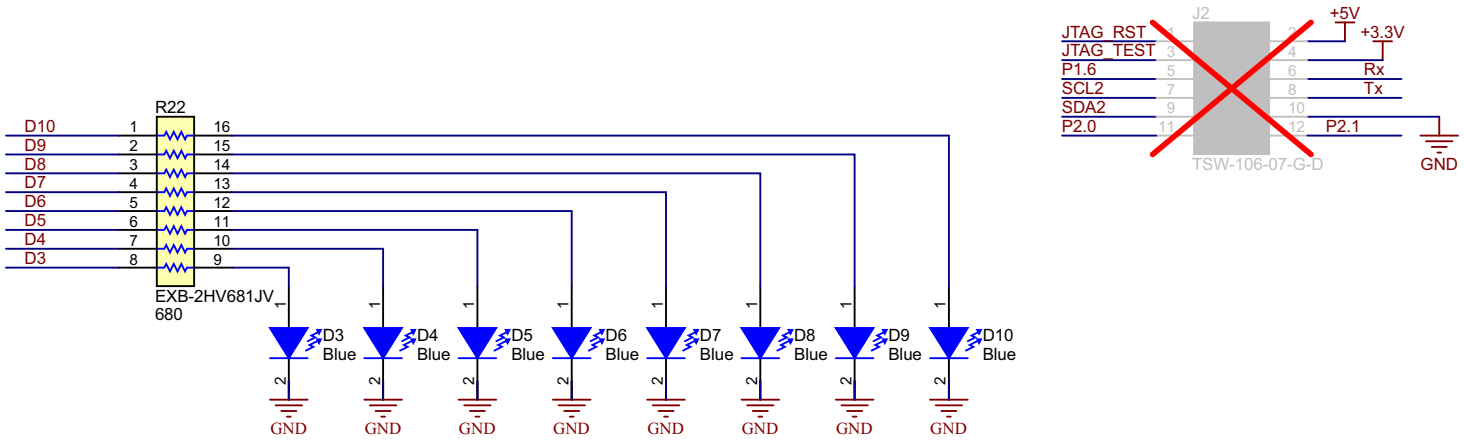

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Figure 52. MSP430 GPIO Breakout connector and General purpose LEDs

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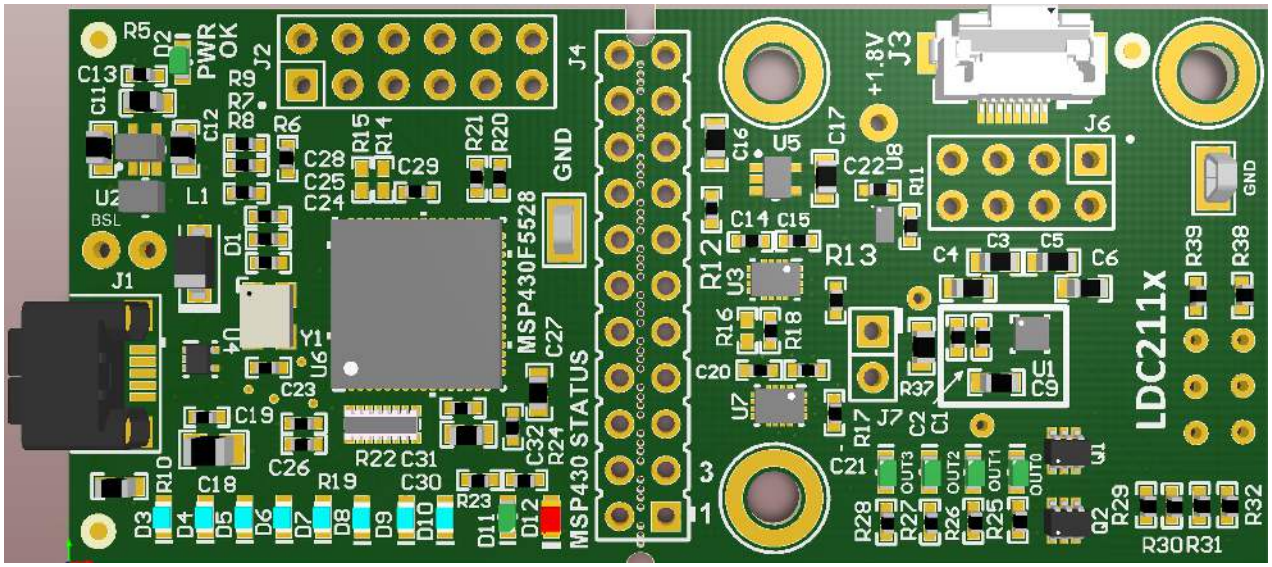

Figure 53. LDC2114 Layout Top Layer - Overview

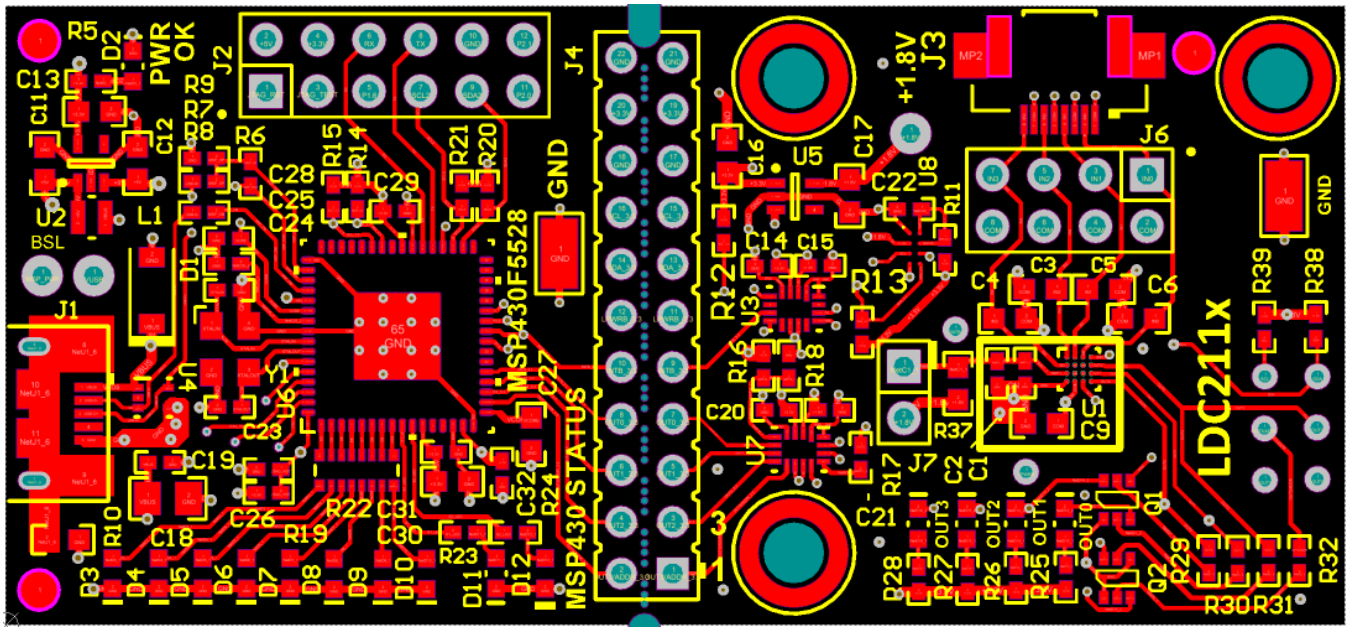

Figure 54. LDC2114 Layout Top Layer – Signals and Components

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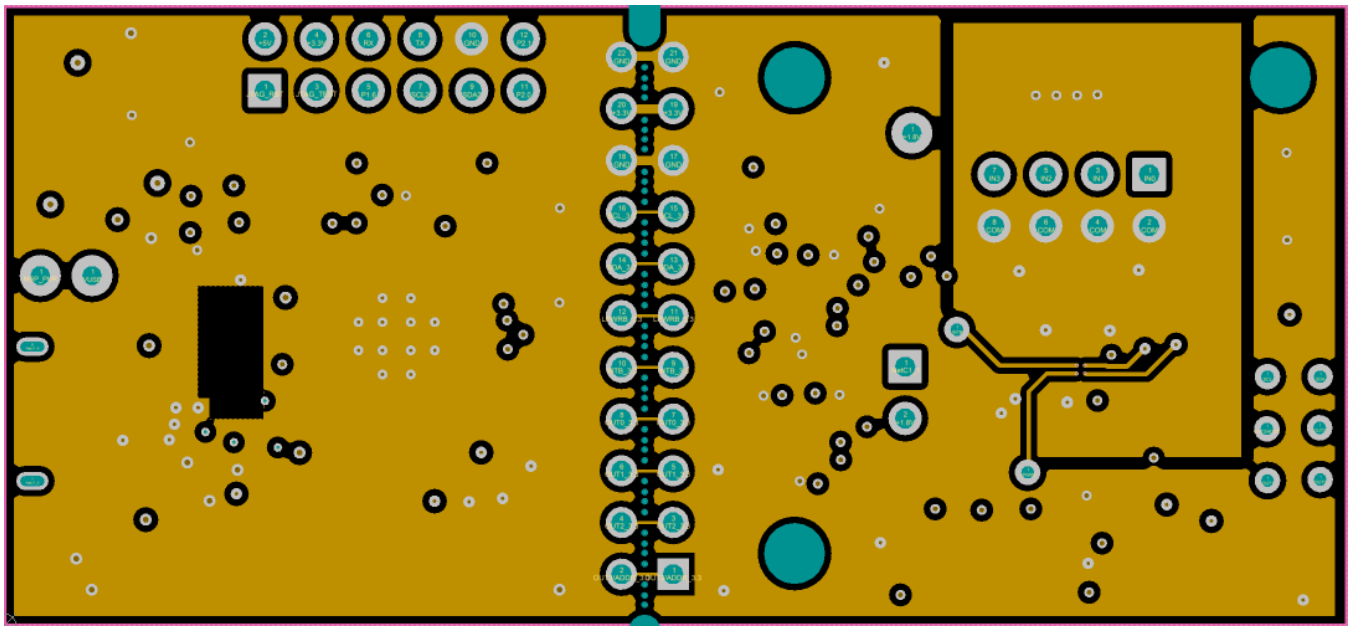

Figure 55. LDC2114 Layout MidLayer 1 – Ground Plane

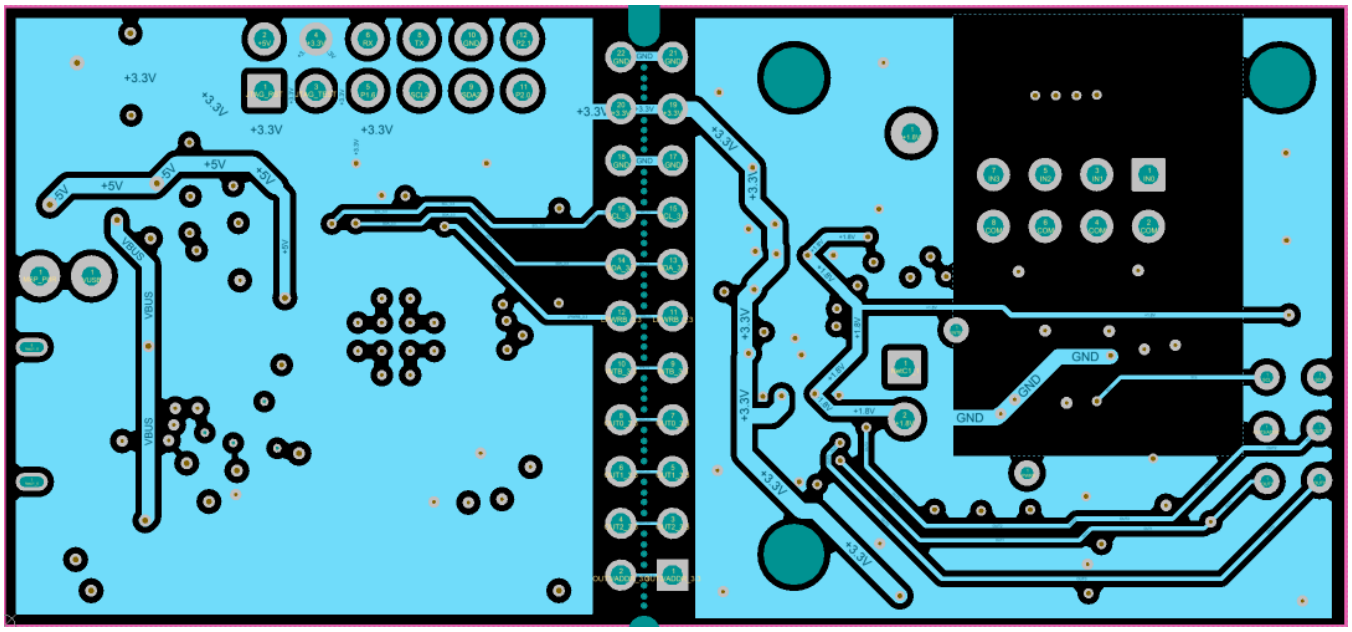

Figure 56. LDC2114 Layout MidLayer 2 – Signals and Power Plane

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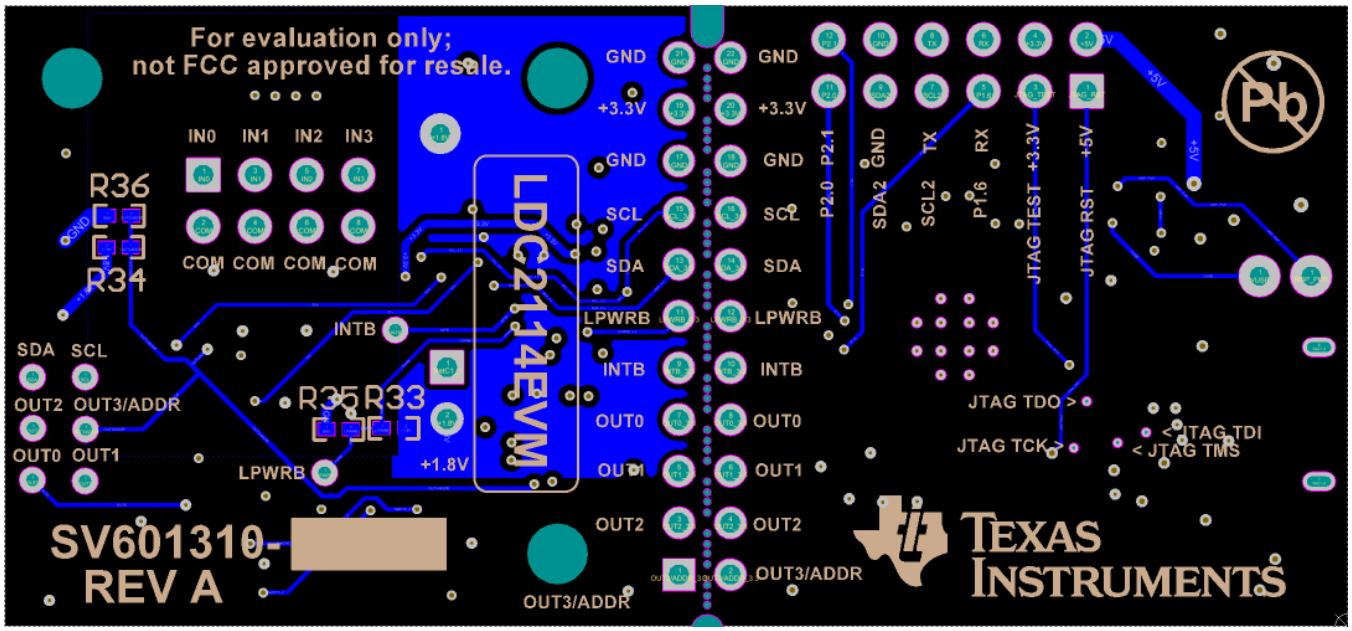

Figure 57. LDC2114 Layout Bottom Layer – Signals Plane

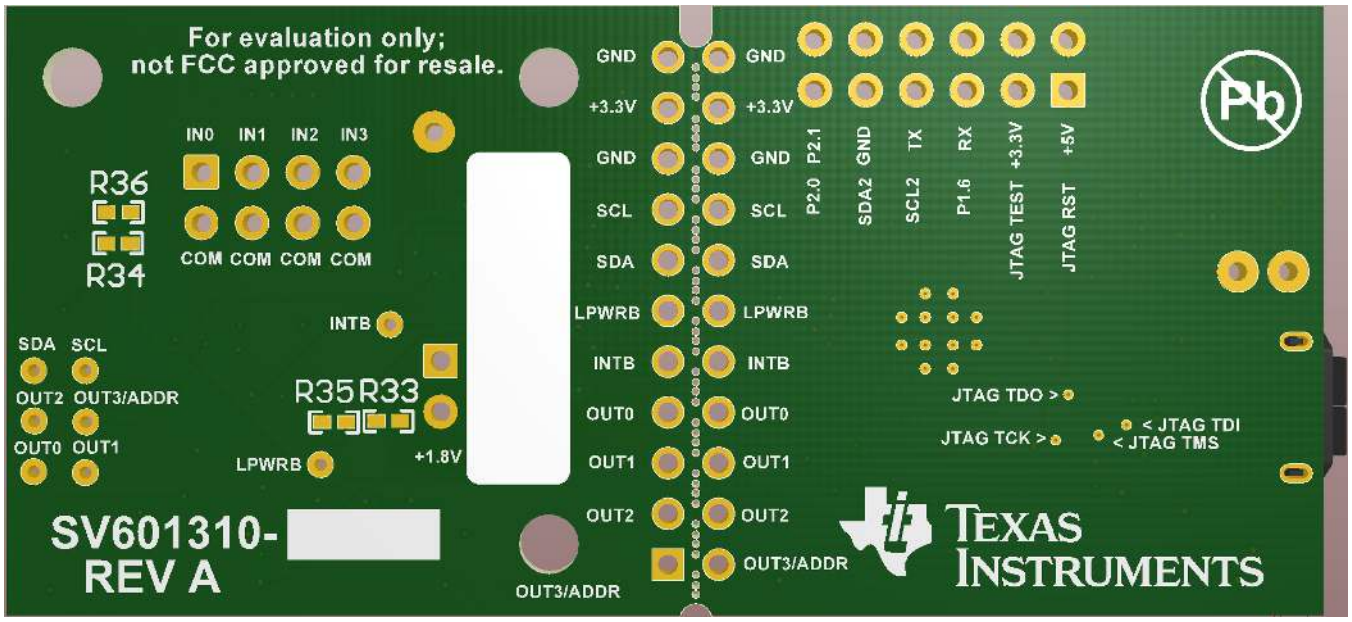

Figure 58. LDC2114 Bottom Layer - Overview

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6 LDC2114EVM REV A Bill of Materials

Table 3. BOM for LDC2114EVM rev A

DESIG-NATOR	QTY.	VALUE	DESCRIPTION	PART NUMBER	MANUFACTURER
C1, C14, C15, C19, C20, C21, C29, C31, C32	9	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0402	C1005X7R1H104K050BB	TDK
C2	1	1uF	CAP, CERM, 1 µF, 6.3 V, +/- 20%, X7R, 0402	GRM155R70J105MA12D	MuRata
C3, C4, C5, C6	4	47pF	CAP, CERM, 47 pF, 50 V, +/- 1%, C0G/NP0, 0603	GRM1885C1H470FA01J	MuRata
C9	1	1000pF	CAP, CERM, 1000 pF, 50 V, +/- 1%, C0G/NP0, 0603	GRM1885C1H102FA01J	MuRata
C11, C30	2	10uF	CAP, CERM, 10 µF, 10 V, +/- 20%, X5R, 0603	C1608X5R1A106M080AC	TDK
C12, C13, C16, C17	4	2.2uF	CAP, CERM, 2.2 µF, 10 V, +/- 10%, X5R, 0603	C0603C225K8PACTU	Kemet
C18	1	22uF	CAP, CERM, 22 µF, 10 V, +/- 20%, X5R, 0805	CL21A226MPCLRNC	Samsung Electro-Mechanics
C22	1	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0402	CC0402JRNPO9BN101	Yageo America
C23, C24	2	18pF	CAP, CERM, 18 pF, 50 V, +/- 5%, C0G/NP0, 0402	GRM1555C1H180JA01D	MuRata
C25, C28	2	0.22uF	CAP, CERM, 0.22 µF, 16 V, +/- 10%, X7R, 0402	C1005X7R1C224K050BC	TDK
C26	1	2200pF	CAP, CERM, 2200 pF, 16 V, +/- 10%, X7R, 0402	885012205027	Wurth Elektronik
C27	1	0.47uF	CAP, CERM, 0.47 µF, 10 V, +/- 10%, X7R, 0603	C0603C474K8RACTU	Kemet
D1	1	5.6V	Diode, Zener, 5.6 V, 500 mW, SOD-123	MMSZ5232B-7-F	Diodes Inc.
D2, D11, D13, D14, D15, D16	6	Green	LED, Green, SMD	LG L29K-G2J1-24-Z	OSRAM
D3, D4, D5, D6, D7, D8, D9, D10	8	Blue	LED, Blue, SMD	LB Q39G-L2N2-35-1	OSRAM
D12	1	Super Red	LED, Super Red, SMD	SML-LX0603SRW-TR	Lumex
GND1, GND2	2		Test Point, Miniature, SMT	5015	Keystone
H4	1		FFC 0.50 TYPE A 8 CKTS LGT 51	0151660075	Molex
J1	1		Connector, Receptacle, USB Micro B, R/A, SMT	10118193-0001LF	FCI
J3	1		Connector, FFC, Bottom, 0.5mm, 8 Pos, SMT	52892-0833	Molex
L1	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
Q1, Q2	2	40 V	Transistor, Dual NPN, 40 V, 0.2 A, SOT-363	MMDT3904-7-F	Diodes Inc.

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Table 3. BOM for LDC2114EVM rev A (continued)

DESIG-NATOR	QTY.	VALUE	DESCRIPTION	PART NUMBER	MANUFACTURER
R5, R23, R25, R26, R27, R28	6	402	RES, 402, 1%, 0.063 W, 0402	CRCW0402402RFKED	Vishay-Dale
R6	1	1.5k	RES, 1.5 k, 5%, 0.063 W, 0402	CRCW04021K50JNED	Vishay-Dale
R7, R8	2	10.0	RES, 10.0, 1%, 0.063 W, 0402	CRCW040210R0FKED	Vishay-Dale
R9	1	1.00Meg	RES, 1.00 M, 1%, 0.063 W, 0402	RC0402FR-071ML	Yageo America
R10	1	33	RES, 33, 5%, 0.1 W, 0603	CRCW060333R0JNEA	Vishay-Dale
R11	1	200k	RES, 200 k, 5%, 0.063 W, 0402	CRCW0402200KJNED	Vishay-Dale
R12, R13, R20, R21, R38, R39	6	4.7k	RES, 4.7 k, 5%, 0.063 W, 0402	CRCW04024K70JNED	Vishay-Dale
R17, R18	2	0	RES, 0, 5%, 0.063 W, 0402	RC0402JR-070RL	Yageo America
R19	1	33k	RES, 33 k, 5%, 0.063 W, 0402	CRCW040233K0JNED	Vishay-Dale
R22	1	680	RES, 680, 5%, 0.0625 W, Resistor Array - 8x1	EXB-2HV681JV	Panasonic
R24	1	1.0k	RES, 1.0 k, 5%, 0.063 W, 0402	CRCW04021K00JNED	Vishay-Dale
R29, R30, R31, R32	4	4.70k	RES, 4.70 k, 1%, 0.1 W, 0402	ERJ-2RKF4701X	Panasonic
R37	1	0	RES, 0, 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
U1	1		Four-channel Inductive Sensor for Touch-on-Metal Application, YFD0016ALAL	LDC2114YFDR	Texas Instruments
U2	1		Micropower, 150mA Low-Dropout CMOS Voltage Regulator, 5-pin SC-70, Pb-Free	LP5951MG-3.3/NOPB	Texas Instruments
U3, U7	2		4-Bit Dual-Supply Bus Transceiver with Configurable Voltage Translation and 3-State Outputs, RSV0016A	SN74AVCH4T245RSVR	Texas Instruments
U4	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		Micropower, 150mA Low-Dropout CMOS Voltage Regulator, 5-pin SC-70, Pb-Free	LP5951MG-1.8/NOPB	Texas Instruments
U6	1		25 MHz Mixed Signal Microcontroller with 128 KB Flash, 8192 B SRAM and 47 GPIOs, -40 to 85 degC, 64-pin QFN (RGC), Green (RoHS & no Sb/Br)	MSP430F5528IRGCT	Texas Instruments
U8	1		DUAL BIDIRECTIONAL I2C BUS AND SMBus VOLTAGE-LEVEL TRANSLATOR, YZT0008AABW	PCA9306YZTR	Texas Instruments
Y1	1		Crystal, 24.000MHz, 18pF, SMD	ABM8-24.000MHZ-B2-T	Abracon Corporation
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A
H1, H2, H3	0		ROUND STANDOFF M2 STEEL 5MM	9774050243R	Wurth Elektronik
J2	0		Header, 100mil, 6x2, Gold, TH	TSW-106-07-G-D	Samtec
J4	0		Header, 2.54 mm, 11x2, Gold, TH	TSW-111-07-G-D	Samtec
J6	0		Header, 100mil, 4x2, Gold, TH	TSW-104-07-G-D	Samtec
J7	0		Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	Samtec

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Table 3. BOM for LDC2114EVM rev A (continued)

DESIG-NATOR	QTY.	VALUE	DESCRIPTION	PART NUMBER	MANUFACTURER
R14, R15	0	4.7k	RES, 4.7 k, 5%, 0.063 W, 0402	CRCW04024K70JNED	Vishay-Dale
R16, R33, R34, R35, R36	0	0	RES, 0, 5%, 0.063 W, 0402	RC0402JR-070RL	Yageo America

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STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   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 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 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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper sytem design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, 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:*

      FCC NOTICE: 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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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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2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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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:*

   6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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8. *Limitations on Damages and Liability:*

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9. *Return Policy*. Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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