![Texas Instruments logo]

Sharp$^®$ LCD BoosterPack (430BOOST-SHARP96) for the LaunchPad

The Sharp® Memory LCD BoosterPack plug-in module is based on the LS013B4DN04 display from Sharp Electronics and features capacitive touch sliders. MCU LaunchPad™ evaluation kit developers can use this BoosterPack to display sensor readings, time, and other information using the display's 96x96 pixels and can also provide touch-based input.

Figure 1. 430BOOST-SHARP96 Sharp LCD BoosterPack

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1   Getting Started

1.1   Key Features

- Sharp LS013B4DN04 Memory LCD
  - 1.3-inch screen of 96 x 96 pixels
  - Ultra-low-power consumption
  - Provides excellent viewing angles and high-contrast images or text
  - Display is controlled serially using SPI
- Two capacitive touch sliders (three-element sliders)
- DC/DC 3-V to 5-V converter available to support 5-V Sharp displays
- Software enabled by TI's software libraries
  - Graphics Library support and examples available
  - Capacitive Touch Library support and examples available
- Fully open-source hardware and software available for download

1.2   Kit Contents

- 1x 430BOOST-SHARP96 BoosterPack
- 1x Quick Start Guide

1.3   First Steps - Out of Box Experience

A good method to get familiar with the EVM is by using available example code online. The examples demonstrate the key features of the BoosterPack.

3. Choose a LaunchPad that fits your needs–see Section 3

2. Download example code

1. Plug the BoosterPack into the LaunchPad

Launch!

1.4   Next Steps - Looking Into the Provided Code

After the EVM features have been explored, the fun can begin. It's time to set up an IDE and start digging into the code examples.

Section 3 describes the example projects available to make it easy to dig into the software. Section 4.2 explains the required steps for IDE installation.

1.5   FCC/IC Regulatory Compliance

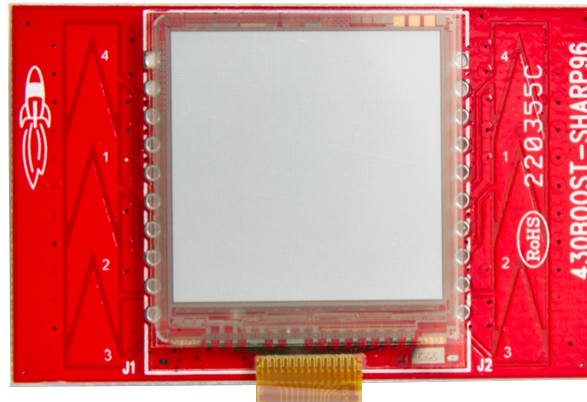| FCC Part 15 Class B Compliant |
| --- |
| IC ICES-003 Class B Compliant |

2   Hardware

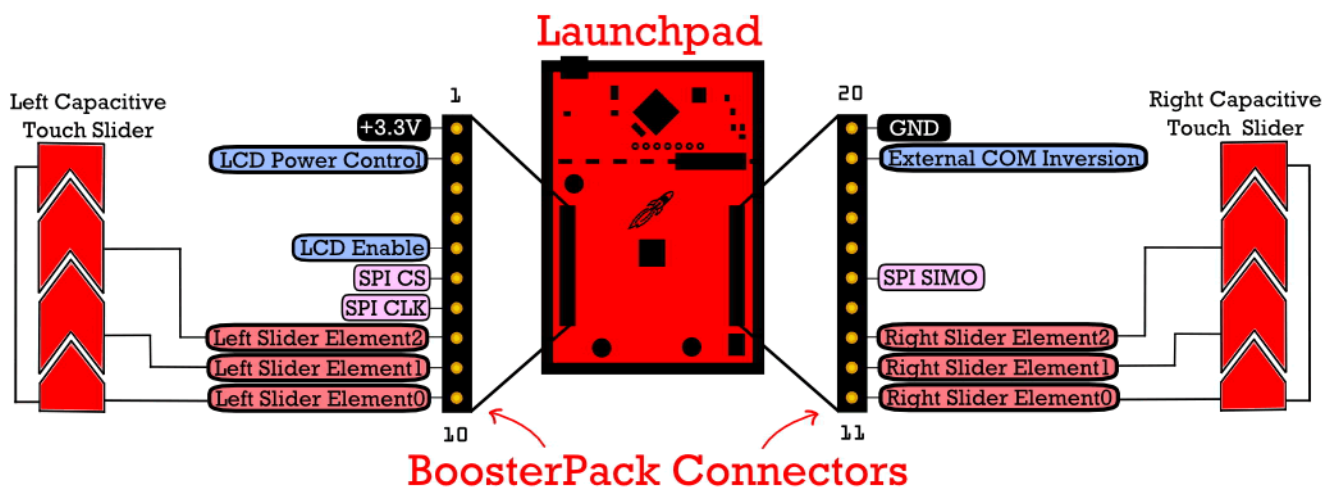
Figure 2. EVM Top View

Figure 3. BoosterPack Default Pinout

2.1   Hardware Features

2.1.1   Ultra-Low-Power LCD

The Sharp Microelectronics LS013B4DN04 1.35-inch PNLC Memory LCD is loaded with features that deliver a display capable of smooth-moving graphics with 50% reflectance and low power use of 10 µW. The LCD is visible in a 0.5-lux environment without requiring a light source.

- Reflective panel of white and black with aspect ratio of 1:1
- 1.3-inch screen has 96x96 resolution (9216 pixels stripe array)
- Display control by serial data signal communication (SPI)
- Typical power consumption 6 µW (static mode, depends on update rate)

2.1.2   Capacitive Touch Sliders

Two capacitive touch sliders are featured to enable user input. Each slider consists of three elements, one of which is on both the top and bottom of the slider. See Figure 3 for slider element connections.

The capacitive touch sliders are bare PCB elements without any material overlay. This reduces overall performance but is still sufficient for menus and other user interaction with the Sharp display. For improved performance, an overlay can be used on the sliders, although this requires recalibration of the MSP430G2 LaunchPad capacitive touch example (see Section 3.2.2).

Note that when using the capacitive touch sliders, the LaunchPad + 430BOOST-SHARP96 BoosterPack should be held carefully. It is possible for the user to hold the LaunchPad in a way that touches the capacitive touch slider pins directly; for example, hands touching through-hole pins on the bottom of the LaunchPad. If this occurs, the readings of the sliders will be incorrect and unexpected behavior could occur. It is best to set the LaunchPad + BoosterPack flat on a surface instead of holding it to prevent this.

2.1.3 Customizable Power Section

The power section is designed to work out of the box in most use cases; however, some special cases might require a different power supply wiring.

Through-hole pins are provided for BoosterPack headers and the power system. A set of 0-Ω resistors allow routing in predefined scenarios.

The default setting uses a GPIO pin to power the BoosterPack at LaunchPad GPIO voltage. This allows removing power from the BoosterPack entirely via software on the LaunchPad. It is often beneficial to control the power of the LCD directly, and although the LCD is ultra-low power, completely powering it down can extend battery life.

By modifying the 0-Ω resistors the setup can be changed to connect to VCC all the time. This frees up one pin on the BoosterPack header.

Additionally, there is a 3-V to 5-V DC/DC converter on board. In the default configuration this DC/DC converter is completely disconnected. Using 0-Ω resistors or solder bridges the converter can be enabled and the output used to power the display. This can be useful to interface other Sharp displays that come with the same connector but require 5 V.
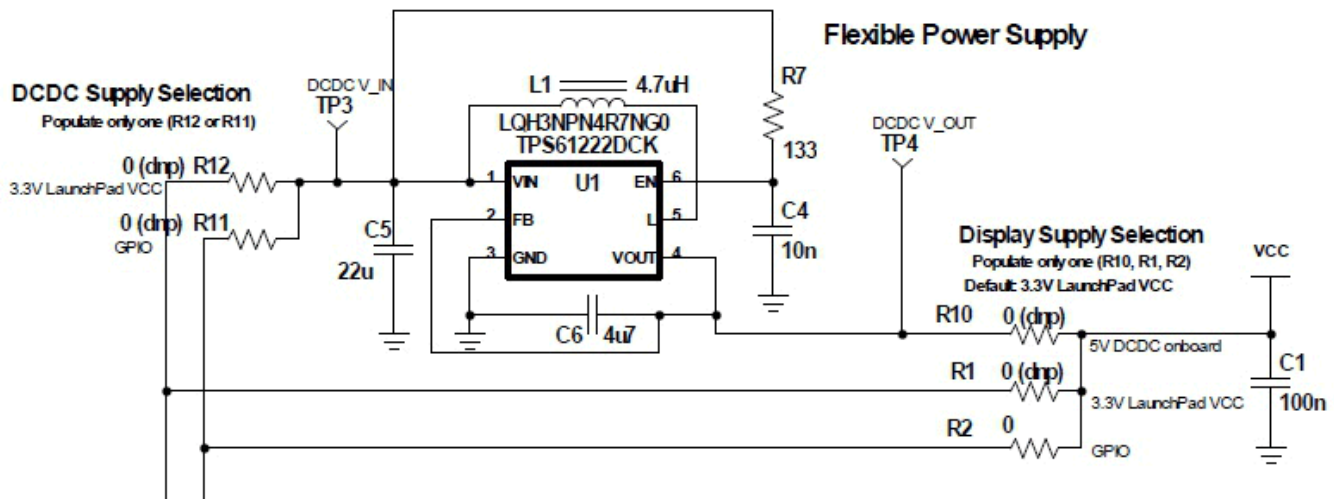
Figure 4. LCD Power Selection

To change to 5-V power for the LCD, use the following procedure:
- Add in 0-Ω (or solder bridge) R11 or R12 to source 3.3 V to DC-DC converter
  - Populate only R11 or R12, not both
  - R12 supplies 3.3V V_{cc} from the BoosterPack header to V_{in} (DC-DC always on)
  - R11 supplies GPIO (Pin 2) from the BoosterPack header to V_{in} (control V_{in} on or off)
- Remove R2, which is the 3.3-V I/O supply to the LCD
- Add a 0-Ω (or solder bridge) R10 to select 5-V output

2.1.4 Fully Customizable Wiring

The BoosterPack wiring is fully user configurable to match special setups. All BoosterPack headers are brought to through-hole pins. From there the signals are connected through 0-Ω resistors to the display header by another set of through-hole pins. This is the default wiring that should work in most cases.

To allow for special use cases, especially when stacking multiple BoosterPacks, the 0-Ω resistors can be removed with a soldering iron. Custom connections can then be made from using the through-hole pins for easy soldering.

2.2 Schematic and Layout

All design documents are available for download in PDF and native design format from http://www.ti.com/lit/zip/slac643.

The 430BOOST-SHARP96 BoosterPack was designed in Mentor Graphics PADS schematic and layout. A free viewer is available to see both the schematic and layout files on the Mentor Graphics website at

http://www.mentor.com/pcb/downloads/pads-pcb-viewer. A time-limited version of PADS is available online from Mentor Graphics for free. This version has complete functionality until the 30-day license expires. This version can be downloaded directly from http://www.mentor.com/pcb/product-eval/pads-download-evaluation.

2.2.1 Schematic

Figure 5 shows the schematic of the 430BOOST-SHARP96 BoosterPack.
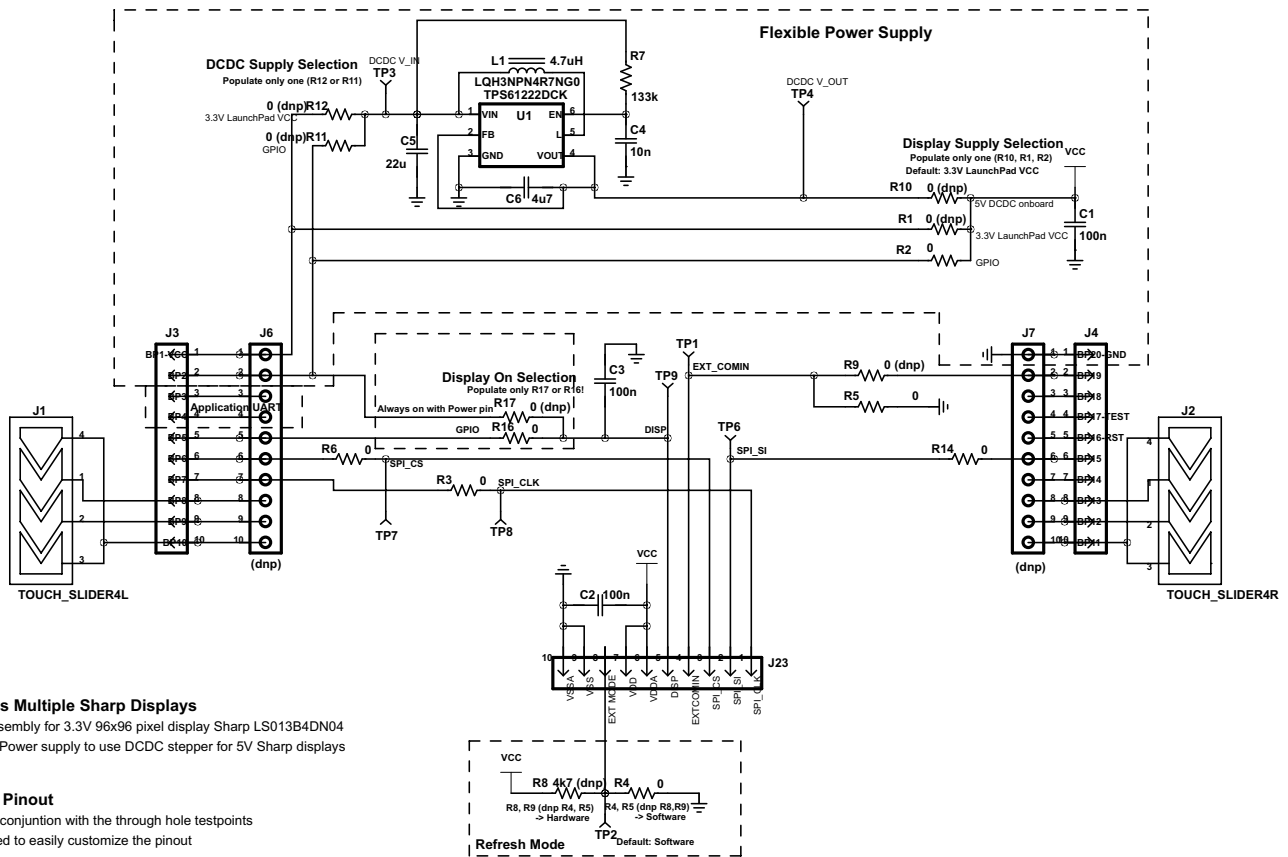
Figure 5. Schematic

2.2.2 Display Connections

Table 1. Sharp LS013B4DN04 Display Connections

Pin	Symbol	Function
1	SCLK	Serial clock signal
2	SI	Serial data input signal
3	SCS	Chip select signal
4	EXTCOMIN	External COM inversion signal input High = Enabled Low = Serial input flag enabled
5	DISP	Display on or off signal
6	VDDA	Power supply (analog)
7	VDD	Power supply (digital)
8	EXTMODE	COM inversion select terminal
9	VSS	GND (digital)
10	VSSA	GND (analog)

2.3 Layout

shows the layout of the PCB.
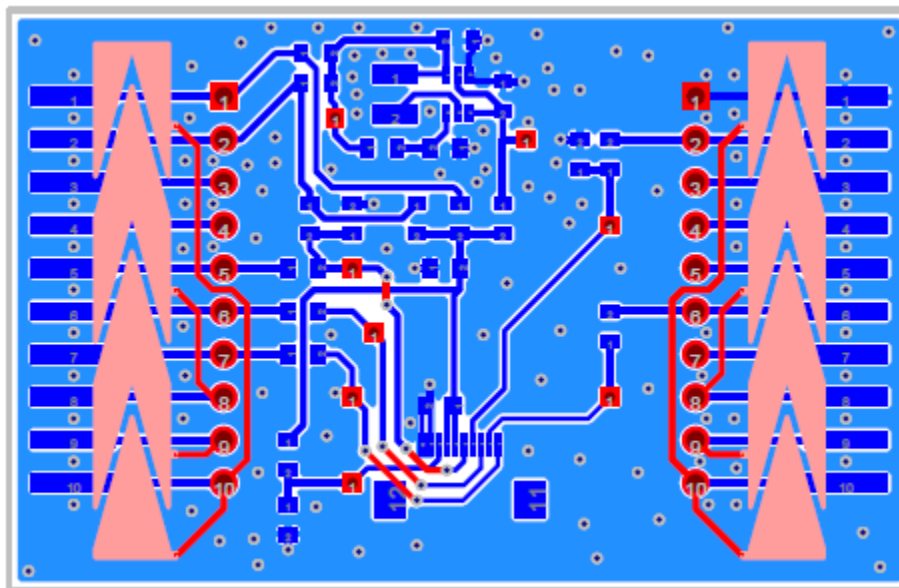
Figure 6. Layout Top and Bottom Layers

2.4 Hardware Change Log

Table 2. Hardware Change Log

PCB Revision	Description
Rev. 1.1	Initial Release

3 Example Code

This section describes the function and structure of the example code that is provided for this EVM.

3.1 *MSP430FR5969 LaunchPad - MSP-EXP430FR5969*

The MSP430FR5969 LaunchPad, or MSP-EXP430FR5969, has out-of-box code that utilizes the 430BOOST-SHARP96 LCD BoosterPack. This is the most comprehensive code example using the 430BOOST-SHARP96 LCD BoosterPack. An overview of this example code is provided here, but more details are found in the *MSP430FR5969 LaunchPad User's Guide* (SLAU535).

3.1.1 Source Code File Structure

The project is split into multiple files as shown in Table 3. This makes it easier to navigate and reuse parts of it for other projects.

Table 3. Source Files and Folders

Name	Description
Main.c	The user experience demo main function, shared ISRs, and other operations
ActivePowerMeasure.c	Main function file for Active Mode Power app
ClockApp.c	Main function file for Clock app
FR59xx_EXP.c	File for handling system init, main menu, and button operations
FRAMSpeedApp.c	Main function file for FRAM Speed app
Game.c	Main function file for SliderBall video game app
SYS.c	Functions to enter and exit LPM3.5
myTimer.c	Contains all timer-based functions and interrupts
ULPMeter.c	Main function file for Battery Free Stopwatch app
Library: CTS	Capacitive Touch Software Library CAPSENSELIBRARY
Library: Driverlib	Device driver library MSP430DRIVERLIB
Library: grlib	Graphics library MSP430-GRLIB for the Sharp LCD
Folder: Preloaded images	Images for the LCD screen

3.1.2 Navigation and Main Menu

When the User Experience demo starts, it shows a title screen on the LCD and then the main selection menu. The main menu shows all of the applications that are available in the demo. Select an application option in the menu using the left capacitive touch slider.

Note: Only the left capacitive touch slider is used for navigation.

After an application is selected, press button S2 to enter the application. To change the application or exit, press button S1 and then navigate the main menu to select a different application.

3.1.3 Clock Application

This mode provides an accurate clock using RTC in low-power mode 3 (LPM3). Immediately upon entering the Clock app, the user is expected to set the date and time details before the clock starts running. This must be done every time the application is entered, because the clock values are not maintained when running any of the other applications.

Use the slider to change the time settings, and then press button S2 to save the settings.

3.1.4   FRAM Speed Application

This mode shows the maximum write speed of FRAM on the BoosterPack display. FRAM is written in 1KB blocks. Direct Memory Access (DMA) is used to transfer data and the main clock (MCLK) is set to run at 8 MHz. This application writes data to FRAM at approximately 7300 kbps compared to typical flash write speeds at 13 kbps. This mode also shows the total number of KB written and the FRAM write endurance (%).

3.1.5   Battery-Free Application

This mode runs a stopwatch without batteries by leveraging the on-board super capacitor. When entering this mode, you are presented with two options:

Run App: In this mode, the MSP430FR5969 stays in an ultra-low-power LPM3.5 mode and consumes approximately 500 nA. The RTC is available to wake up the MCU once per minute to read the input voltage from the capacitor and store that data into FRAM. During this time, a stopwatch is continuously updated. When the MCU is asleep in LPM3.5, the display is turned off. To wake up the MCU to see the remaining charge of the capacitor and the current time on the stopwatch, press button (S2). While the MCU is awake, the stopwatch stops tracking time. Press button (S2) again to go back to LPM3.5 and start the RTC again. Ensure the supercap is being used by closing J11 to charge the capacitor, and then setting J2 to "Use" the capacitor. If an additional jumper is needed for J11, the GND jumper on J13 can be used, as this jumper is not required (GND is connected either way).

Transfer Data: In this mode, the logged voltage readings from a previous "Run App" execution are read from FRAM and sent to a PC through the backchannel UART over USB. These readings can be read using any terminal or serial monitor application on the PC.

3.1.6   Active Power Application

The active power consumption of the MSP430FR5969 is dependent on three things: the code, the data cache hit ratio, and the clock speed of the CPU. Choose the desired operating frequency of the CPU (1 MHz, 2.67 MHz, 4 MHz, or 8 MHz). Then, choose your desired cache hit ratio (50%, 66%, 75%, or 100%). Press button (S2) to enter or exit the Active Mode code operation. To measure the active mode current, remove the "Current" jumper (J9) and place an ammeter across the J9 terminals.

3.1.7   SliderBall Game

This mode demonstrates the capacitive touch I/O pins available on the MSP430FR5969. Two linear sliders are available on the 430BOOST-SHARP96 BoosterPack, and they control two paddles. Move the paddles to keep the ball in play! Your high scores are saved in FRAM and retained after power cycles. The scores are lost only when you reprogram the device.

3.1.8   Special Notes: Inverting the Display Color Scheme

The User Experience demo code can invert the display colors. This can be a useful feature for times when the original display color settings are difficult to read.

To invert the colors, edit the file sharp96x96.h in the grlib directory. In the 'User Configuration for the LCD Driver' section under 'Invert Display Option' use either one of the # defines NORMAL_DISPLAY or INVERT_DISPLAY as needed.

When INVERT_DISPLAY is defined, the User Experience demo displays a black background and white foreground after the demo code is downloaded onto the MSP-EXP430FR5969 board.

3.2   G2 LaunchPad - MSP-EXP430G2

3.2.1   Display grlib Demo

The grlib demo shows how to use the *MSP430 Graphics Library* MSP430-GRLIB (or "grlib") in a project with the Sharp display. This demo cycles screens without user interaction to show simple graphics primitives.

- Pixels
- Lines
- Circles
- Rectangles
- Text

The demo also introduces how to construct menu systems with grlib graphic primitives, as well as the functions to configure grlib such as initialization, color inversion, and using foreground and background colors properly.

The grlib example for the G2 Value Line LaunchPad is a special case due to the memory limitations of the Value Line devices. Typically a RAM buffer of the display contents is kept, so it can be modified and flushed back out to the display. The Sharp display requires 96x96 pixels of memory. Because each pixel requires 1 bit (1 byte = 8 pixels), the RAM buffer requires over 1KB of data. As of this writing, the largest memory G2xx device available on the MSP-EXP430G2 is the MSP430G2553, which has 512 bytes of RAM.

$$RAM\ bytes\ required = \frac{96\ pixels/row}{8\ pixels/byte} \times 96\ rows = 1152\ bytes$$

(1)

This RAM limitation led to a special implementation of the Sharp display driver in grlib. Instead of using a RAM buffer, a flash buffer is used to hold the contents of the display. The buffer resides completely in flash, where display updates are written, and then read out as the contents are flushed to the display. This implementation is not common, nor is it recommended on other devices with enough RAM. It was implemented this way only as a demonstration of grlib functionality.

The implementation of a flash buffer has drawbacks. Compared to RAM, flash is slower to write and requires more energy. Flash also has a write endurance limit. From the data sheet for the MSP430G2553 (SLAS735), flash program and erase endurance is 10 000 minimum and 100 000 typical. Keep this in mind while using this demo application; it is not designed for use with applications that repetitively update flash (for example, a game program that repeatedly updates the display) due to the endurance limits.

3.2.2   Capacitive Touch Slider Demo

The capacitive touch slider demo shows how to use the *MSP430 Capacitive Touch Software Library* (CAPSENSELIBRARY) in an application. To take full advantage of this demo, install the *MSP430 Touch Pro GUI* (MSPTOUCHPROGUI), a powerful tool for configuring capacitive touch applications. For more information on MSP430 Touch Pro GUI installation and operation, refer to the *MSP430 Touch Pro User's Guide* (SLAU486).

The capacitive touch slider demo uses the Touch Pro GUI to display the status of the on-board sliders. This includes each slider element, or electrode, as well as overall slider position. With three elements on each slider, plus the position of each slider, there are eight channels to be viewed in the GUI.

This information is transmitted by the MSP430G2553 device over the backchannel UART to the PC. It is important to configure the UART headers properly for this communication to work. The G2 LaunchPad has two configurations for its UART, software or hardware. To enable the hardware UART configuration for this demo, turn the RX and TX jumpers to be horizontal (consistent with the HW UART silkscreen configuration).
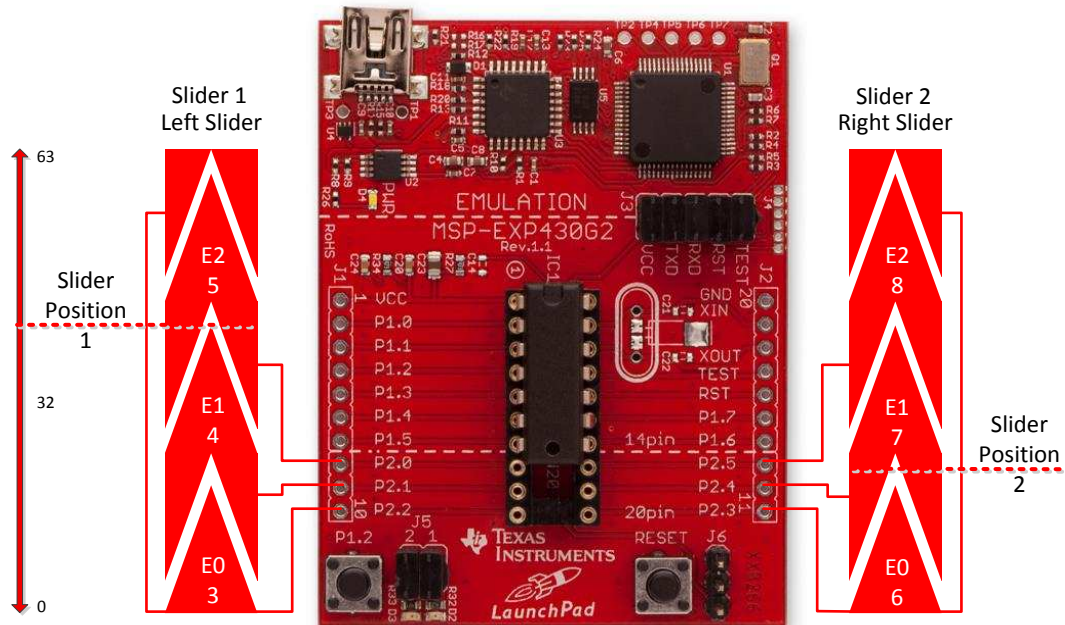
Figure 7. Slider Element Definition

1. Slider position 1: Shows position of finger on the left slider. After finger is lifted from slider, the last valid position is shown. Returns value 0 to 63.

2. Slider position 2: Shows position of finger on the right slider. After finger is lifted from slider, the last valid position is shown. Returns value 0 to 63.

3. E0 Left Slider: Displays the delta of timer counts between baseline (no touch) and the current touch on the E0 electrode. Note that E0 is connected on bottom and top.

4. E1 Left Slider: Displays the delta of timer counts between baseline (no touch) and the current touch on the E1 electrode.

5. E2 Left Slider: Displays the delta of timer counts between baseline (no touch) and the current touch on the E2 electrode.

6. E0 Right Slider: Displays the delta of timer counts between baseline (no touch) and the current touch on the E0 electrode. Note that E0 is connected on bottom and top.

7. E1 Right Slider: Displays the delta of timer counts between baseline (no touch) and the current touch on the E1 electrode.

8. E2 Right Slider: Displays the delta of timer counts between baseline (no touch) and the current touch on the E2 electrode.

When connecting to the Touch Pro GUI, the integrated development environment (IDE) may hold onto the COM port. If a working graph is not automatically displayed after connecting to the COM port in Touch Pro GUI, then follow this procedure:

1. Program the LaunchPad
2. Run code in IDE
3. Terminate the connection in IDE
4. Close the IDE
5. Disconnect LaunchPad from USB port
6. Check that the RX and TX jumpers on LaunchPad are set horizontally to HW UART
7. Reconnect LaunchPad to USB port
8. Open MSP430 Touch Pro GUI
9. Select the COM port in the "Select COM" pulldown menu

After COM port is connected, the signals should automatically start showing without additional user configuration. For further assistance, refer to the *MSP430 Touch Pro User's Guide* (SLAU486).

The status of the sliders can be seen using two views in Touch Pro GUI, the oscilloscope view (see Figure 8) and the bar graph view (see Figure 9). The oscilloscope view shows the slider information over time, with a scrolling window that looks like an oscilloscope.
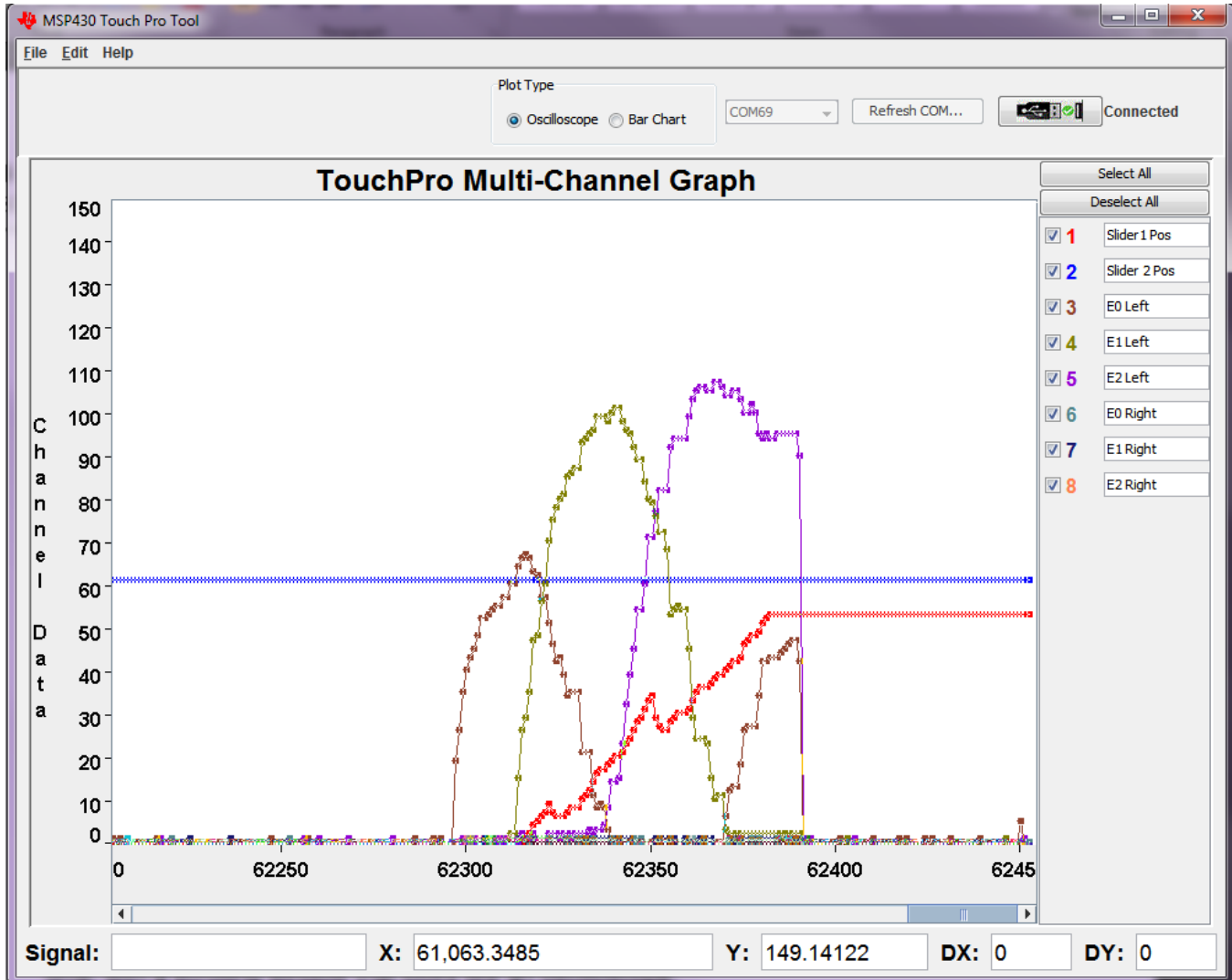

Figure 8. Touch Pro GUI Oscilloscope View

This oscilloscope view shows a finger sliding up the left slider from bottom to top. The first brown signal is the bottom electrode, E0, showing the touch, and the Slider 1 position slowly climbing. Then the transition from E0 to E1 occurs as the finger slides further up Slider 1. This continues until the finger is near the top of the slider. Note that after the finger is lifted, the last valid Slider 1 position continues to be shown.

The bar graph view is an instantaneous view of each element at the current time.

Figure 9. Touch Pro GUI Bar Graph View
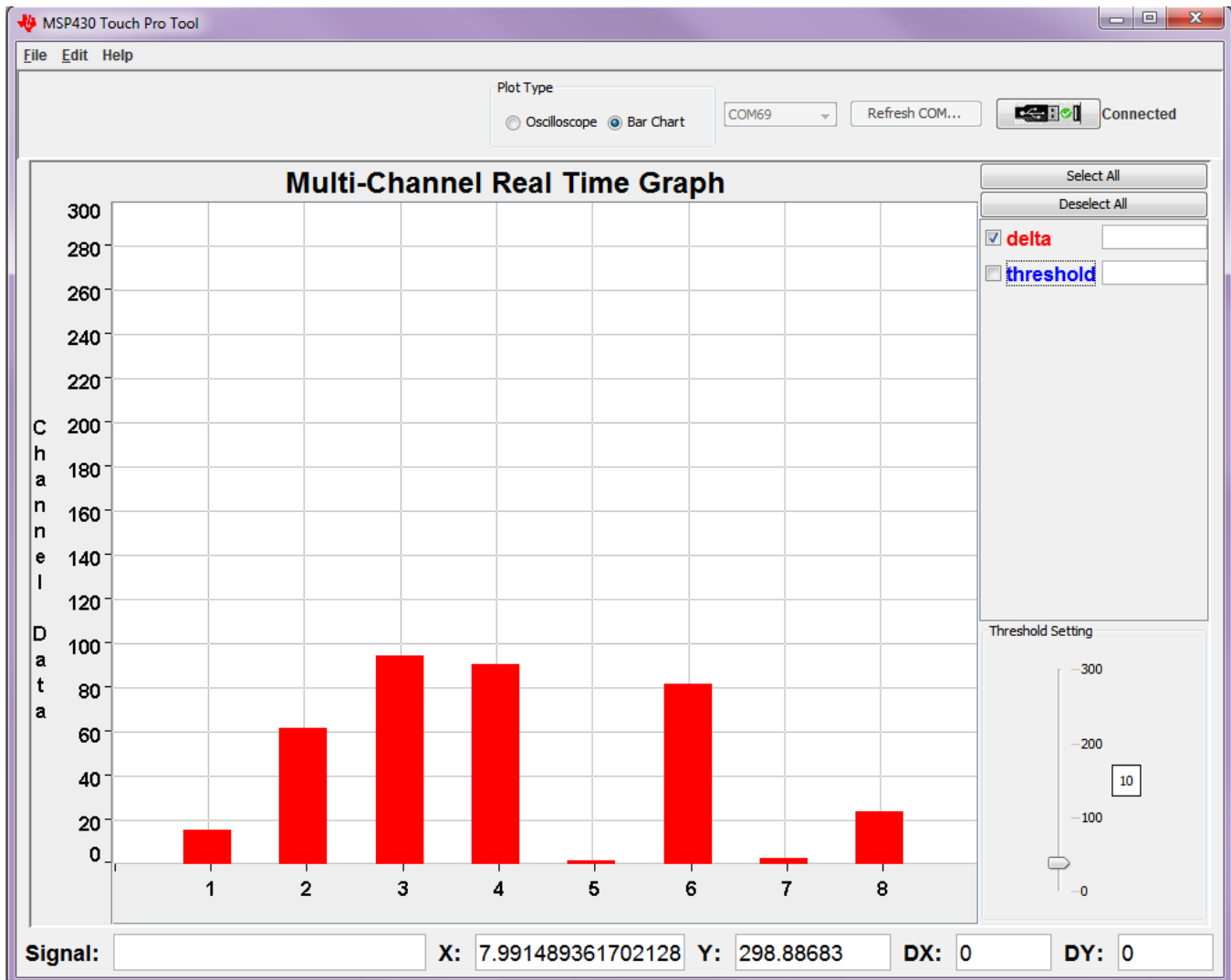
The values of 1 and 2 represent the position of the left and right sliders, respectively, from 0 to 63. The rest of the values indicate delta in timer counts during the touch and can be used to easily configure thresholds that define touch or other more complex gestures. The Touch Pro GUI makes it easy to quickly to evaluate, diagnose, and tune button, slider, and wheel designs.

4 Additional Resources

4.1 The LaunchPad Websites

More information about LaunchPads, supported BoosterPacks, and available resources can be found at:

- TI's LaunchPad portal: information about all LaunchPads from TI, for all MCUs
- The LaunchPad wiki: design resources and example projects from the community

4.2 Download CCS, IAR, or Energia

Although the files can be viewed with any text editor, more can be done with the projects if they're opened with a development environment like Code Composer Studio™ IDE (CCS), IAR Embedded Workbench® IDE, or Energia.

4.3 MSP430Ware and TI Resource Explorer

MSP430Ware is a complete collection of libraries and tools. It includes a driver library (driverlib) and the graphics library (grlib) used in the software demo. By default, MSP430Ware is included in a CCS installation. IAR users must download it separately.

MSP430Ware includes the TI Resource Explorer, for easily browsing tools. For example, all of the software examples are shown in Figure 10.
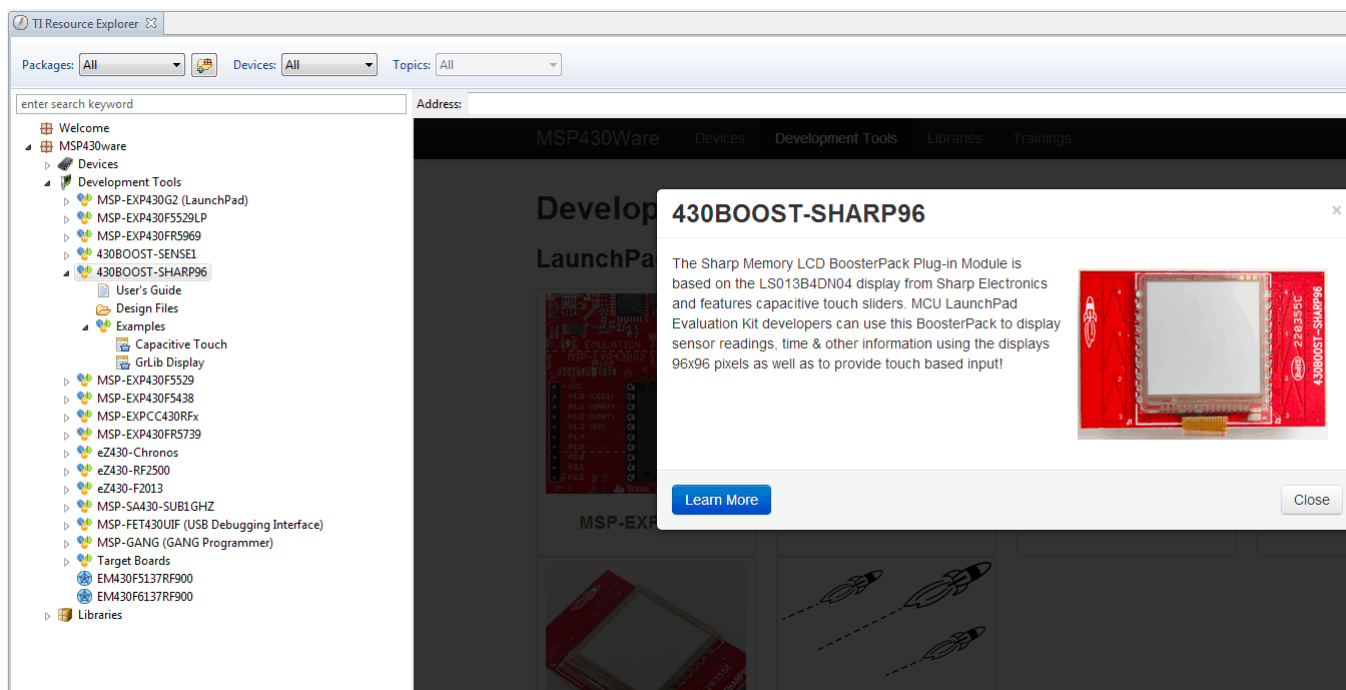

Figure 10. 430BOOST-SHARP96 Software Examples in TI Resource Explorer

Inside TI Resource Explorer, these examples and many more can be found and easily imported into CCS with one click.

4.4 The Community

4.4.1 TI E2E Community

Search the forums at http://e2e.ti.com. If you cannot find your answer, post your question to the community.

4.4.2 Community at Large

Many online communities focus on the LaunchPad – for example, http://www.43oh.com. You can find additional tools, resources, and support from these communities.

5 FAQ

Q: Why isn't this BoosterPack stackable with male and female headers?

A: This BoosterPack has a display and capacitive touch sliders; there is little room for male BoosterPack headers through the board. A display BoosterPack must be on the top of the stack for the display to be seen, so only female headers are used.

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General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

【Important Notice for Users of EVMs for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or

3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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EVALUATION BOARD/KIT/MODULE (EVM)
WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.

2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.

3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.

4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have *not* been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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