

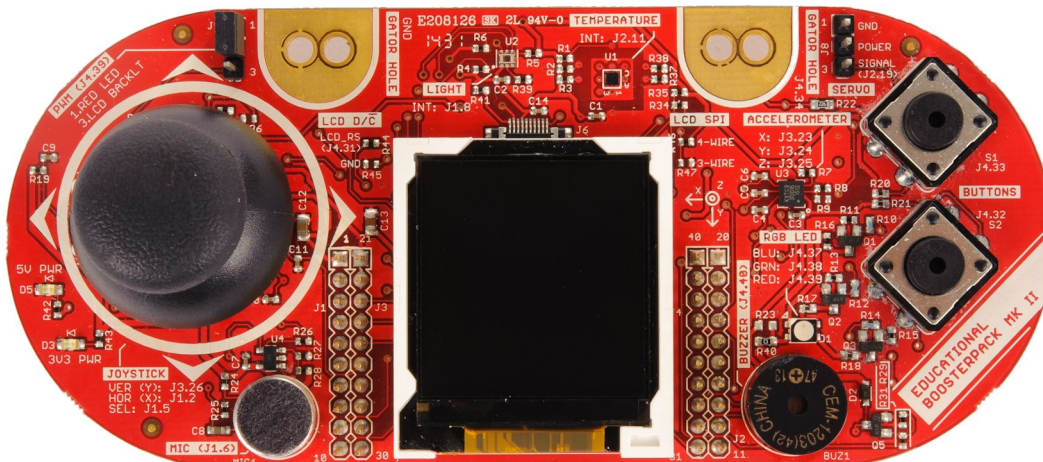
## **BOOSTXL-EDUMKII Educational BoosterPack™ Plug-in Module Mark II**

---

---

The **BOOSTXL-EDUMKII** BoosterPack™ (see [Figure 1](#)) kit is an easy-to-use plug-in module that offers a high level of integration for developers to quickly add to LaunchPad™ development kit designs. Various analog and digital inputs and outputs are at your disposal including an analog joystick, environmental and motion sensors, RGB LED, microphone, buzzer, color LCD display, and more.

This BoosterPack plug-in module was developed with Energia in mind. Energia is an open-source community-developed coding environment, which is supported by a robust framework of intuitive APIs and easy-to-use software libraries for rapid firmware development. TI recommends Energia v12 or later. Learn more about Energia at [www.energia.nu](http://www.energia.nu).



**Figure 1. BOOSTXL-EDUMKII BoosterPack Plug-in Module**

## Contents

|   |                            |    |
|---|----------------------------|----|
| 1 | Getting Started .....      | 3  |
| 2 | Hardware.....              | 4  |
| 3 | Software Examples .....    | 9  |
| 4 | Additional Resources ..... | 15 |
| 5 | Schematics.....            | 16 |

## List of Figures

|    |  |    |
|----|--|----|
| 1  | BOOSTXL-EDUMKII BoosterPack Plug-in Module .....           | 1  |
| 2  | BOOSTXL-EDUMKII Overview .....                             | 4  |
| 3  | BoosterPack Plug-in Module Pinout.....                     | 5  |
| 4  | 3-Axis Analog Accelerometer.....                           | 10 |
| 5  | 2-Axis Analog Joystick With Digital Input .....            | 11 |
| 6  | OPT3001 Ambient Light Sensor .....                         | 12 |
| 7  | TMP006 Infrared Contactless Temperature Sensor .....       | 13 |
| 8  | Microphone.....  | 14 |
| 9  | TI Drivers Software Examples in TI Resource Explorer ..... | 15 |
| 10 | Schematics (1 of 2) .....                                  | 17 |
| 11 | Schematics (2 of 2) .....                                  | 18 |

## List of Tables

|    |   |    |
|----|---|----|
| 1  | OPT3001 Pinout .....                              | 5  |
| 2  | TMP006 Pinout.....                                | 6  |
| 3  | Servo Motor Connector Pinout.....                 | 6  |
| 4  | 3-Axis Accelerometer Pinout .....                 | 6  |
| 5  | RGB LED Pinout.....                               | 7  |
| 6  | Piezo Buzzer Pinout.....                          | 7  |
| 7  | Color LCD Pinout .....                            | 7  |
| 8  | RGB LED Pinout.....                               | 8  |
| 9  | Joystick Pinout .....                             | 8  |
| 10 | User Pushbuttons Pinout .....                     | 8  |
| 11 | Hardware Change Log.....                          | 9  |
| 12 | Software Examples .....                           | 9  |
| 13 | IDE Minimum Requirements for MSP-EXP432P401R..... | 9  |
| 14 | Source File and Folders .....                     | 10 |
| 15 | Source File and Folders .....                     | 11 |
| 16 | Source File and Folders .....                     | 12 |
| 17 | Source File and Folders .....                     | 13 |
| 18 | Source File and Folders .....                     | 14 |

## Trademarks

BoosterPack, LaunchPad, SimpleLink, MSP432, Code Composer Studio, E2E are trademarks of Texas Instruments.

Keil,  $\mu$ Vision are registered trademarks of ARM Limited.

*Bluetooth* is a registered trademark of Bluetooth SIG.

IAR Embedded Workbench is a registered trademark of IAR Systems.

Wi-Fi is a registered trademark of Wi-Fi Alliance.

All other trademarks are the property of their respective owners.

## 1 Getting Started

### 1.1 Introduction

The BOOSTXL-EDUMKII BoosterPack plug-in module is an easy-to-use plug-in module that offers a high level of integration for developers to quickly add to LaunchPad development kit designs. Various analog and digital inputs and outputs are at your disposal including an analog joystick, environmental and motion sensors, RGB LED, microphone, buzzer, color LCD display, and more.

This BoosterPack plug-in module was developed with Energia in mind. Energia is an open source, community developed coding environment, which is supported by a robust framework of intuitive APIs and easy-to-use software libraries for rapid firmware development. TI recommends Energia v12 or later. Learn more about Energia at [www.energia.nu](http://www.energia.nu).

### 1.2 Key Features

- TI OPT3001 light sensor
- TI TMP006 temperature sensor
- Servo motor connector
- 3-axis accelerometer
- RGB multicolor LED
- Piezo buzzer
- Color 128x128 TFT LCD display
- Microphone
- 2-axis joystick with pushbutton
- User push buttons
- 40-pin BoosterPack plug-in module standard for use with any LaunchPad development kit

### 1.3 What's Included

#### 1.3.1 Kit Contents

- 1 x BOOSTXL-EDUMKII BoosterPack plug-in module
- 1 x Quick Start Guide

#### 1.3.2 Software Examples

- SimpleLink™ [MSP-EXP432P401R LaunchPad development kit](#) + BOOSTXL-EDUMKII demos (see [Section 3](#))
  - BOOSTXL-EDUMKII\_Accelerometer\_MSP432P401R
  - BOOSTXL-EDUMKII\_JoyStick\_MSP432P401R
  - BOOSTXL-EDUMKII\_LightSensor\_MSP432P401R
  - BOOSTXL-EDUMKII\_Temperature\_MSP432P401R
  - BOOSTXL-EDUMKII\_MicrophoneFFT\_MSP432P401R

### 1.4 Next Steps: Looking Into the Provided Code

After the EVM features have been explored, the fun can begin. It's time to open an integrated development environment (IDE) and start looking at the code examples. [Section 3](#) describes the example projects available to make it easy to understand the provided software. For more information on where to find and download an IDE, see [Section 4](#).

## 2 Hardware

Figure 2 is an overview of the BOOSTXL-EDUMKII hardware.

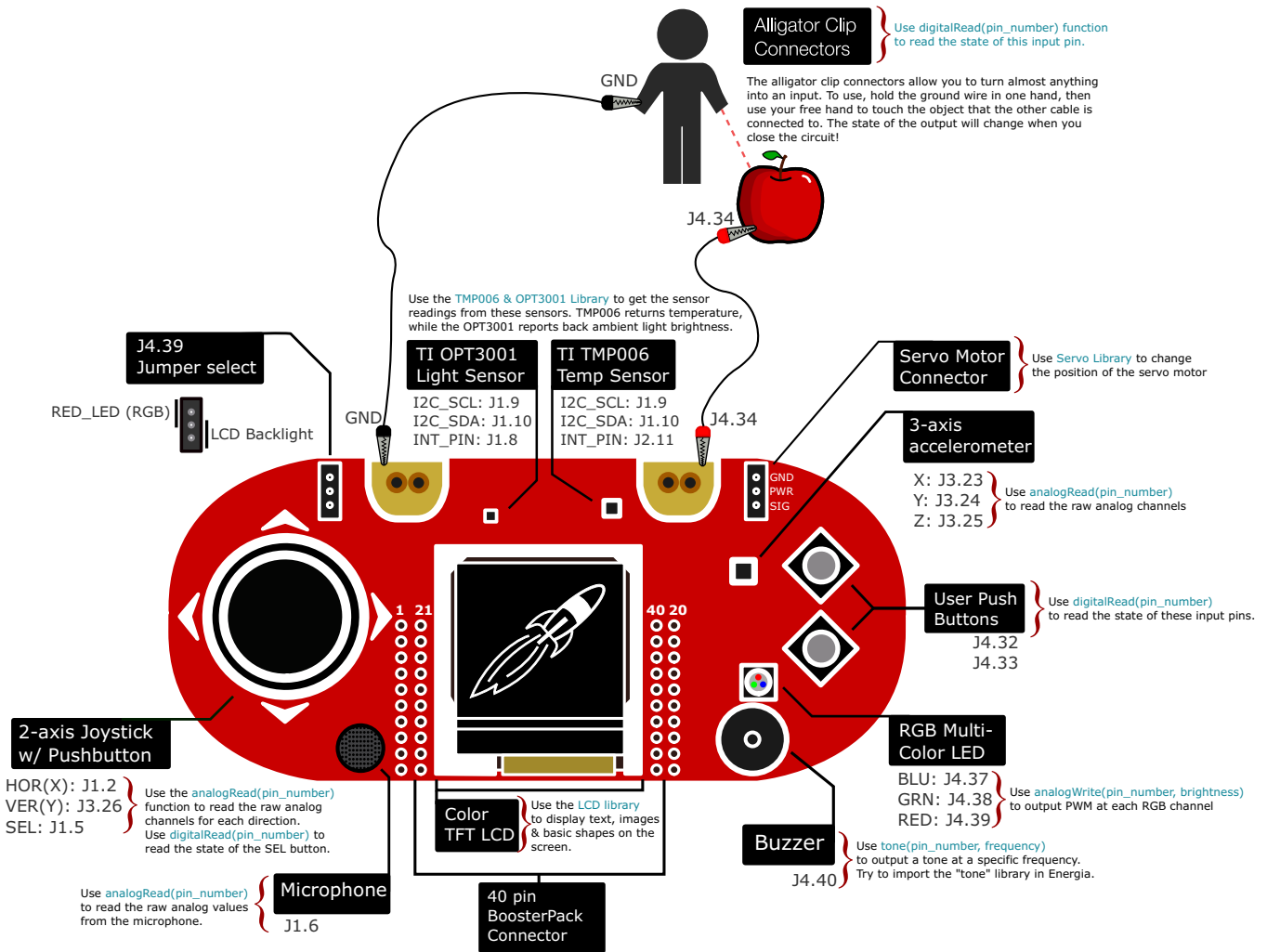


Figure 2. BOOSTXL-EDUMKII Overview

## 2.1 Hardware Features

### 2.1.1 BoosterPack Plug-in Module Pinout

The Educational BoosterPack plug-in module MKII adheres to the 40-pin LaunchPad development kit and BoosterPack plug-in module pinout standard (see Figure 3). A standard was created to aid compatibility between LaunchPad development kits and BoosterPack plug-in modules across the TI ecosystem.

### Pinout Diagram for your BoosterPack

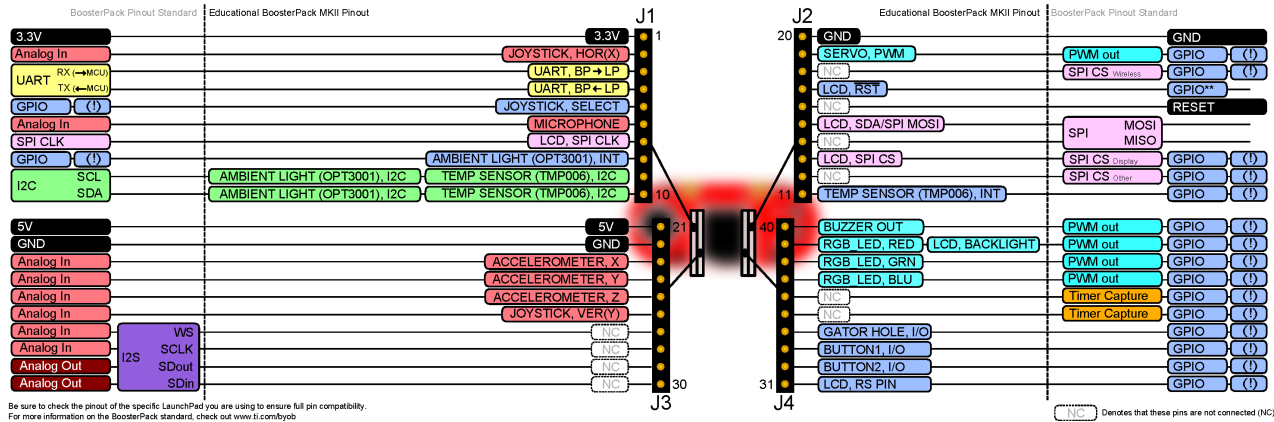


Figure 3. BoosterPack Plug-in Module Pinout

The 40-pin standard is compatible with the 20-pin standard that is used by other LaunchPad development kits like the [MSP-EXP430G2](#). This allows for 20-pin LaunchPad development kits to be used with 40-pin BoosterPack plug-in modules with some limited functionality.

The BOOSTXL-EDUMKII supports BoosterPack plug-in module stacking with its male and female BoosterPack plug-in module headers. See how many BoosterPack plug-in modules you can stack onto your LaunchPad development kit to add more functionality like wireless and battery power.

More information about compatibility can also be found at <http://www.ti.com/launchpad>.

### 2.1.2 TI OPT3001 Light Sensor

The OPT3001 is a digital ambient light sensor (ALS) that measures the intensity of light as visible by the human eye. Covering the sensor with your finger or shining a flashlight on it will change the output of the OPT3001. The digital output is reported over an I<sup>2</sup>C- and SMBus-compatible, two-wire serial interface. The reference designator for the OPT3001 is U2.

More information on the OPT3001 light sensor can be found at <http://www.ti.com/product/opt3001>.

Table 1. OPT3001 Pinout

| BoosterPack Plug-in Module Header Connection | Pin Function         |
|--|----------------------|
| J1.8   | OPT3001 interrupt    |
| J1.9 <sup>(1)</sup>                          | I <sup>2</sup> C SCL |
| J1.10 <sup>(1)</sup>                         | I <sup>2</sup> C SDA |

<sup>(1)</sup> Pin is multiplexed with the I<sup>2</sup>C communication lines of the TMP006.

### 2.1.3 TI TMP006 Temperature Sensor

The TMP006 is a digital infrared (IR) thermopile contactless temperature sensor that measures the temperature of an object without being in direct contact. Placing your hand over the sensor increases the sensor output. The digital output is reported over an I<sup>2</sup>C- and SMBus-compatible two-wire serial interface. The reference designator for the TMP006 is U1.

More information on the TMP006 temperature sensor can be found at <http://www.ti.com/product/tmp006>.

**Table 2. TMP006 Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function         |
|--|----------------------|
| J1.9 <sup>(1)</sup>                          | I <sup>2</sup> C SCL |
| J1.10 <sup>(1)</sup>                         | I <sup>2</sup> C SDA |
| J2.11  | TMP006 Interrupt     |

<sup>(1)</sup> Pin is multiplexed with the I<sup>2</sup>C communication lines of the OPT3001.

### 2.1.4 Servo Motor Connector

The servo motor connector is a 3-pin header for the user to connect an external servo to be controlled. Users can connect a servo and control it through the application code. The reference designator for the servo motor connector is J8.

**Table 3. Servo Motor Connector Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function |
|--|--------------|
| J2.19  | Servo Signal |

---

**NOTE:** This kit does not include a servo motor and the user must provide one.

---

### 2.1.5 3-Axis Accelerometer

The Kionix KXTC9-2050 is a 3-axis analog accelerometer that measures g-forces. Moving the board along the axes will change the analog signal generated by the accelerometer. The reference designator for the accelerometer is U3.

More information on the 3-axis accelerometer can be found at <http://www.kionix.com/product/KXTC9-2050>.

**Table 4. 3-Axis Accelerometer Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function         |
|--|----------------------|
| J3.23  | Accelerometer X-axis |
| J3.24  | Accelerometer Y-axis |
| J3.25  | Accelerometer Z-axis |

### 2.1.6 RGB Multicolor LED

The Cree CLV1A-FKB RGB multicolor LED light output can make any color by mixing red, green, and blue. Each color channel can be individually modified by pulse width modulation (PWM) to achieve the desired color. The reference designator for the RGB LED is D1.

More information on the RGB multicolor LED can be found at <http://www.cree.com/LED-Components-and-Modules/Products/High-Brightness/SMD-Color/SMD-Full-Color>.

**Table 5. RGB LED Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function  |
|--|---------------|
| J4.37  | Blue channel  |
| J4.38  | Green channel |
| J4.39 <sup>(1)</sup>                         | Red channel   |

<sup>(1)</sup> Pin is multiplexed with the LCD backlight pin through the jumper header J5.

### 2.1.7 Piezo Buzzer

The CUI CEM-1203(42) piezo buzzer can play various frequencies based on the user-provided PWM signal. You can even play different tones back to back to create a song. The reference designator for the piezo buzzer is BUZ1.

More information on the piezo buzzer can be found at [http://www.cui.com/product/components/buzzers/audio-transducers/magnetic/cem-1203\(42\)](http://www.cui.com/product/components/buzzers/audio-transducers/magnetic/cem-1203(42)).

**Table 6. Piezo Buzzer Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function |
|--|--------------|
| J4.40  | Buzzer input |

### 2.1.8 Color 128x128-Pixel TFT LCD Display

The Crystalfontz CFAF128128B-0145T color 128x128-pixel TFT LCD supports display updates up to 20 frames per second (FPS) while only requiring a few lines to control the TFT LCD module through the SPI interface. This module has a color depth of 262K colors and a contrast ratio of 350. The reference designator for the color LCD is LCD1.

More information on the color LCD can be found at <https://www.crystalfontz.com/product/cfaf128128b0145t-graphical-tft-128x128-lcd-display-module>.

**Table 7. Color LCD Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function        |
|--|---------------------|
| J1.7   | LCD SPI clock       |
| J2.13  | LCD SPI chip select |
| J2.15  | LCD SPI MOSI        |
| J4.31  | LCD reset pin       |
| J4.39 <sup>(1)</sup>                         | LCD backlight       |

<sup>(1)</sup> Pin is multiplexed with the RGB LED red channel pin through the jumper header J5.



### 2.1.9 Microphone

The CUI CMA-4544PF-W electret microphone uses an OPA344 operational amplifier to boost the output of the microphone. The human ear can hear frequencies between 0 and 20 kHz and the operating range of the microphone is 20 Hz to 20 kHz. The reference designator for the microphone is MIC1.

More information on the microphone can be found at

<http://www.cui.com/product/components/microphones/electret-condenser-microphone/cma-4544pf-w>.

**Table 8. RGB LED Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function      |
|--|-------------------|
| J1.6   | Microphone Output |

### 2.1.10 2-Axis Joystick With Pushbutton

The ITEAD studio IM130330001 2-axis joystick with pushbutton is simply two potentiometers, one for each axis. The select button is actuated when the joystick is pressed down. The analogRead statement reads the voltage present on the joystick axis to provide the position of the joystick to the application (for example, pushing the joystick to the left reads X = 0). The reference designator for the analog joystick is JS1.

More information on the analog joystick can be found at <http://imall.itead.cc/playstation2-analog-joystick.html>.

**Table 9. Joystick Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function      |
|--|-------------------|
| J1.2   | Horizontal X-axis |
| J1.5   | Select button     |
| J3.26  | Vertical Y-axis   |

### 2.1.11 User Pushbuttons

The user pushbuttons on the BOOSTXL-EDUMKII are connected to pullup resistors that drive the BoosterPack plug-in module pin high until the button is pressed and the pin is driven low. The reference designators for the user pushbuttons are S1 and S2.

**Table 10. User Pushbuttons Pinout**

| BoosterPack Plug-in Module Header Connection | Pin Function |
|--|--------------|
| J4.32  | S2 button    |
| J4.33  | S1 button    |

## 2.2 Power

The board was designed to be powered by the attached LaunchPad development kit, and requires both 3.3-V and 5-V power rails. Some 20-pin LaunchPad development kits like [MSP-EXP430FR4133](#) may not provide the necessary 5-V power, which will limit the functionality.



## 2.3 Design Files

### 2.3.1 Hardware

Schematics can be found in [Section 5](#). All design files including schematics, layout, bill of materials (BOM), Gerber files, and documentation are available in the BOOSTXL-EDUMKII Hardware Design Files on the [download page](#).

### 2.3.2 Software

All design files including TI-TXT object-code firmware images, software example projects, and documentation are available in the LaunchPad development kit specific software folders. To see which LaunchPad development kits feature BOOSTXL-EDUMKII examples, check the [download page](#).

### 2.3.3 Quick Start Guide

The Quick Start Guide is available from [www.ti.com](http://www.ti.com).

## 2.4 Hardware Change log

**Table 11. Hardware Change Log**

| PCB Revision | Description               |
|--------------|---------------------------|
| Rev 1.0      | Initial release           |
| Rev 1.1      | Updates for CE compliance |

## 3 Software Examples

Five software examples are included with the MSP-EXP432P401R LaunchPad development kit for the Educational BoosterPack plug-in module MKII (see [Table 12](#)). These examples can be found in the [MSP-EXP432P401R Software Examples](#), or they are more easily accessible through the [SimpleLink MSP432™ software development kit \(SDK\)](#) (see [Section 4.3](#)).

**Table 12. Software Examples**

| Demo Name                                 | LaunchPad Development Kit / BoosterPack Plug-in Module Required | Description   | More Details                |
|---|---|---|-----------------------------|
| BOOSTXL-EDUMKII_Accelerometer_MSP432P401R | MSP-EXP432P401R / BOOSTXL-EDUMKII                               | Demonstrates how to sample data from the analog accelerometer sensor using the MSP432 ADC14                 | <a href="#">Section 3.1</a> |
| BOOSTXL-EDUMKII_JoyStick_MSP432P401R      | MSP-EXP432P401R / BOOSTXL-EDUMKII                               | Demonstrates how to sample data from the analog joystick using the MSP432 ADC14                             | <a href="#">Section 3.2</a> |
| BOOSTXL-EDUMKII_LightSensor_MSP432P401R   | MSP-EXP432P401R / BOOSTXL-EDUMKII                               | Demonstrates how to communicate with the digital ambient light sensor through I <sup>2</sup> C using MSP432 | <a href="#">Section 3.3</a> |
| BOOSTXL-EDUMKII_Temperature_MSP432P401R   | MSP-EXP432P401R / BOOSTXL-EDUMKII                               | Demonstrates how to communicate with the digital temperature sensor through I <sup>2</sup> C using MSP432   | <a href="#">Section 3.4</a> |
| BOOSTXL-EDUMKII_MicrophoneFFT_MSP432P401R | MSP-EXP432P401R / BOOSTXL-EDUMKII                               | Demonstrates how to sample audio and perform FFT using the ARM CMSIS DSP Software Library                   | <a href="#">Section 3.5</a> |

To use any of the software examples with the LaunchPad development kit, you must have an integrated development environment (IDE) that supports the MSP432P401R device (see [Table 13](#)). For more details on how to get started quickly, and where to download the latest Code Composer Studio, IAR, and Keil IDEs, see [Section 4](#).

**Table 13. IDE Minimum Requirements for MSP-EXP432P401R**

| Code Composer Studio™ IDE | IAR Embedded Workbench® IDE | Keil® µVision® MDK-ARM |
|---------------------------|-----------------------------|------------------------|
| v7.1.0                    | v7.80.3                     | v5                     |

### 3.1 BOOSTXL-EDUMKII\_Accelerometer\_MSP432P401R

This section describes the functionality and structure of the BOOSTXL-EDUMKII\_Accelerometer\_MSP432P401R demo that is included in the [MSP-EXP432P401R Software Examples](#) download, or more easily accessible through the [SimpleLink MSP432 SDK](#) (see [Section 4.3](#)).

#### 3.1.1 Source File Structure

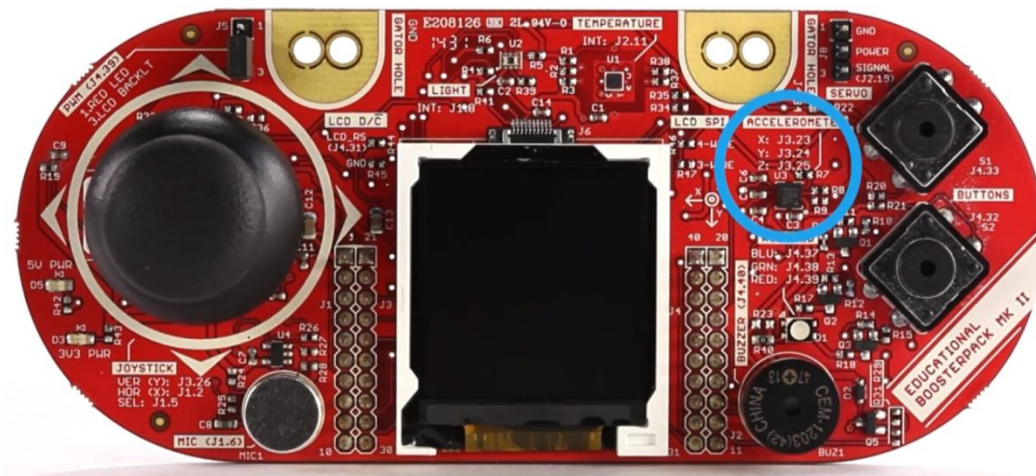
The project is split into multiple files (see [Table 14](#)). This makes it easier to navigate and reuse parts of it for other projects.

**Table 14. Source File and Folders**

| Name                 | Description   |
|----------------------|---|
| main.c               | The demo's main function, interrupt service routines, global variables, and so on |
| mcp432_startup_ccs.c | MSP432 family interrupt vector table for CGT                                      |
| Library: GrLib       | MSP Graphics Library  |
| Library: driverlib   | Device driver library (MSP432DRIVERLIB)   |
| Driver: LcdDriver    | LCD specific driver files   |

#### 3.1.2 Operation

This demo uses the MSP432 built-in ADC14 to sample from the 3-axis acceleration data output of the analog accelerometer on the Educational BoosterPack plug-in module MKII (see [Figure 4](#)). The measured 14-bit acceleration data are displayed on the BoosterPack plug-in module's colored 128x128 dot-matrix LCD. Using [MSP Graphics Library](#), the MSP432 MCU sends data to the LCD controller through SPI communication to draw texts.



**Figure 4. 3-Axis Analog Accelerometer**

The demo makes use of the acceleration data by changing the LCD orientation when the BoosterPack plug-in module is tilted in the corresponding direction.

### 3.2 BOOSTXL-EDUMKII\_JoyStick\_MSP432P401R

This section describes the functionality and structure of the BOOSTXL-EDUMKII\_JoyStick\_MSP432P401R demo that is included in the [MSP-EXP432P401R Software Examples](#) download, or more easily accessible through the [SimpleLink MSP432 SDK](#) (see [Section 4.3](#)).

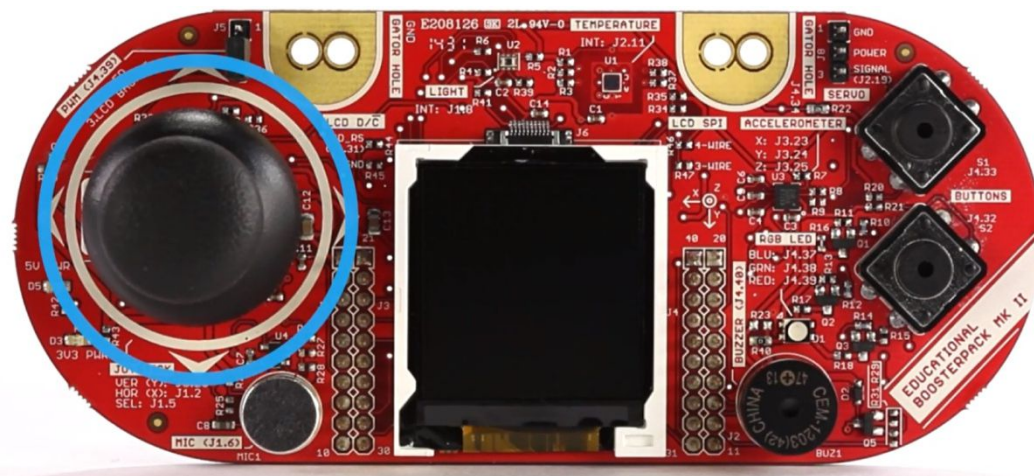
#### 3.2.1 Source File Structure

The project is divided into multiple files (see [Table 15](#)). This makes it easier to navigate and reuse parts of it for other projects.

**Table 15. Source File and Folders**

| Name                 | Description   |
|----------------------|---|
| main.c               | The demo's main function, interrupt service routines, global variables, and so on |
| mcp432_startup_ccs.c | MSP432 family interrupt vector table for CGT                                      |
| Library: GrLib       | MSP Graphics Library  |
| Library: driverlib   | Device driver library (MSP432DRIVERLIB)   |
| Driver: LcdDriver    | LCD specific driver files   |

#### 3.2.2 Operation



**Figure 5. 2-Axis Analog Joystick With Digital Input**

This demo uses the MSP432 built-in ADC14 to sample from the 2-axis of the analog joystick on the Educational BoosterPack plug-in module MKII. The measured 14-bit X and Y axis data are displayed on the BoosterPack plug-in module's colored 128x128 dot-matrix LCD. Using [MSP Graphics Library](#), the MSP432 MCU sends data to the LCD controller through SPI communication to draw texts.

### 3.3 BOOSTXL-EDUMKII\_LightSensor\_MSP432P401R

This section describes the functionality and structure of the BOOSTXL-EDUMKII\_LightSensor\_MSP432P401R demo that is included in the [MSP-EXP432P401R Software Examples](#) download, or more easily accessible through the [SimpleLink MSP432 SDK](#) (see [Section 4.3](#)).

#### 3.3.1 Source File Structure

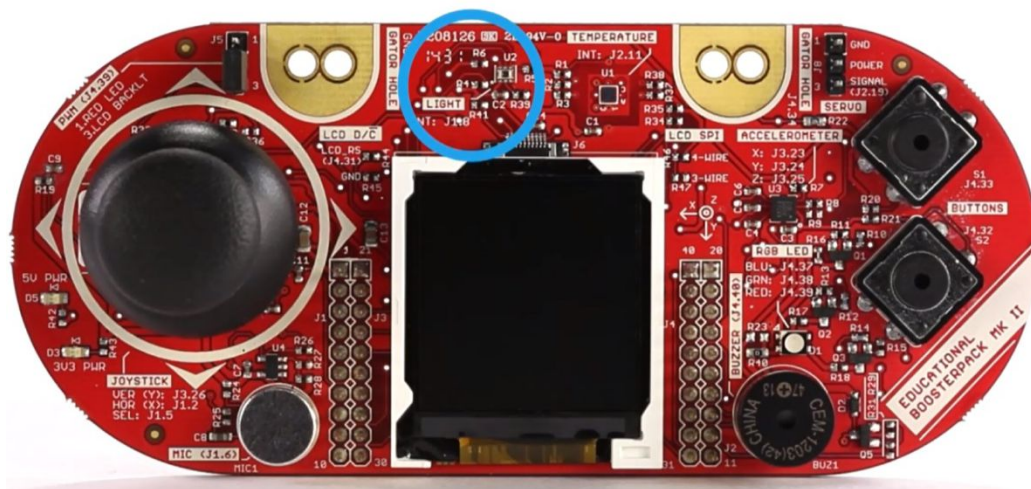
The project is split into multiple files (see [Table 16](#)). This makes it easier to navigate and reuse parts of it for other projects.

**Table 16. Source File and Folders**

| Name                  | Description   |
|-----------------------|---|
| main.c                | The demo's main function, interrupt service routines, global variables, and so on |
| mcp432_startup_ccs.c  | MSP432 family interrupt vector table for CGT                                      |
| Library: GrLib        | MSP Graphics Library  |
| Library: driverlib    | Device driver library (MSP432DRIVERLIB)   |
| Driver: LcdDriver     | LCD specific driver files   |
| Driver: HAL_I2C.c     | Generic I2C driver file   |
| Driver: HAL_OPT3001.c | OPT3001 sensor specific driver built on top of the HAL_I2C driver                 |

#### 3.3.2 Operation

This demo uses the MSP432 built-in eUSCI module in I<sup>2</sup>C mode to initialize and gather data from the digital ambient light sensor, OPT3001, on the Educational BoosterPack plug-in module MKII (see [Figure 6](#)). The measured illuminance value (Lux) is displayed on the colored 128x128 dot-matrix LCD of the BoosterPack plug-in module. Using [MSP Graphics Library](#), the MSP432 MCU sends data to the LCD controller through SPI communication to draw texts.



**Figure 6. OPT3001 Ambient Light Sensor**

The demo also controls the brightness of the LCD backlight LED by generating a Timer PWM.

---

**NOTE:** Make sure that the **J5 jumper** on the BOOSTXL-EDUMKII is connected to **3.LCD BACKLT**

---

The demo makes use of the illuminance value by brightening the LCD backlight when high illuminance value is detected, or by dimming the LCD backlight when low illuminance value is detected.



### 3.4 BOOSTXL-EDUMKII\_Temperature\_MSP432P401R

This section describes the functionality and structure of the BOOSTXL-EDUMKII\_Temperature\_MSP432P401R demo that is included in the [MSP-EXP432P401R Software Examples](#) download, or more easily accessible through the [SimpleLink MSP432 SDK](#) (see [Section 4.3](#)).

#### 3.4.1 Source File Structure

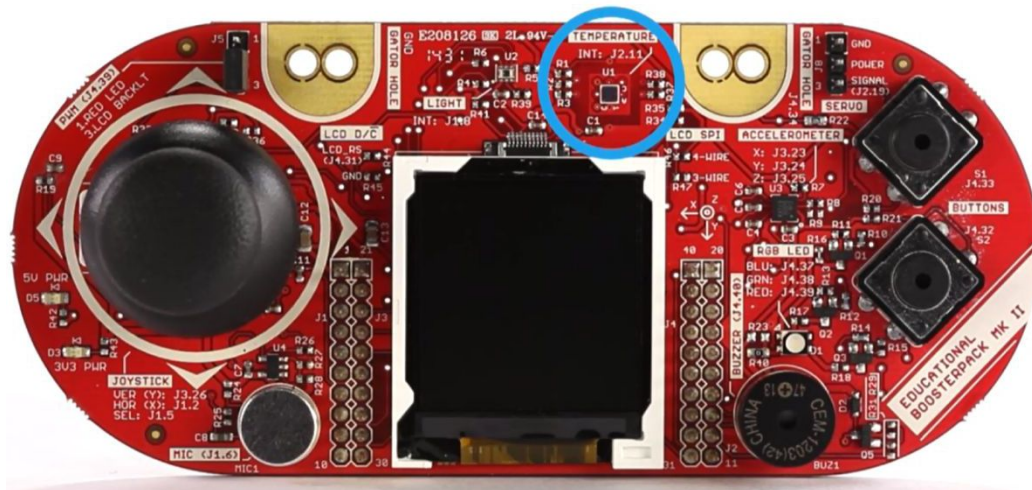
The project is split into multiple files (see [Table 17](#)). This makes it easier to navigate and reuse parts of it for other projects.

**Table 17. Source File and Folders**

| Name                 | Description   |
|----------------------|---|
| main.c               | The demo's main function, interrupt service routines, global variables, and so on |
| mcp432_startup_ccs.c | MSP432 family interrupt vector table for CGT                                      |
| Library: GrLib       | MSP Graphics Library  |
| Library: driverlib   | Device driver library (MSP432DRIVERLIB)   |
| Driver: LcdDriver    | LCD specific driver files   |
| Driver: HAL_I2C.c    | Generic I2C driver file   |
| Driver: HAL_TMP006.c | TMP006 sensor specific driver built on top of the HAL_I2C driver                  |

#### 3.4.2 Operation

This demo uses the MSP432 built-in eUSCI module in I<sup>2</sup>C mode to initialize and gather data from the digital infrared temperature sensor, TMP006, on the Educational BoosterPack plug-in module MKII (see [Figure 7](#)). The measured temperature (°F) is displayed on the colored 128x128 dot-matrix LCD of the BoosterPack plug-in module.



**Figure 7. TMP006 Infrared Contactless Temperature Sensor**

### 3.5 BOOSTXL-EDUMKII\_MicrophoneFFT\_MSP432P401R

This section describes the functionality and structure of the BOOSTXL-EDUMKII\_MicrophoneFFT\_MSP432P401R demo that is included in the [MSP-EXP432P401R Software Examples](#) download, or more easily accessible through the [SimpleLink MSP432 SDK](#) (see [Section 4.3](#)).

#### 3.5.1 Source File Structure

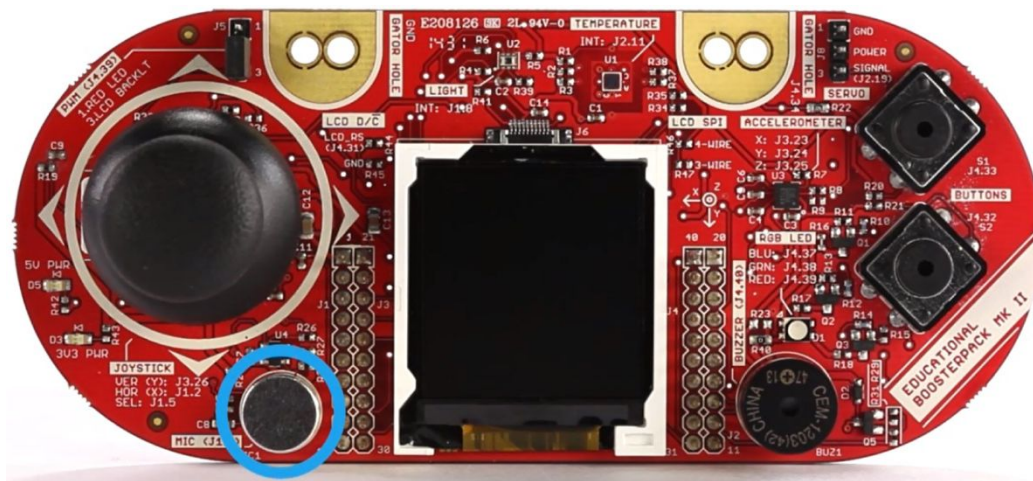
The project is split into multiple files (see [Table 18](#)). This makes it easier to navigate and reuse parts of it for other projects.

**Table 18. Source File and Folders**

| Name                  | Description   |
|-----------------------|---|
| main.c                | The demo's main function, interrupt service routines, global variables, and so on |
| mcp432_startup_ccs.c  | MSP432 Family Interrupt Vector Table for CGT                                      |
| Library: GrLib        | MSP Graphics Library  |
| Library: driverlib    | Device driver library (MSP432DRIVERLIB)   |
| Driver: LcdDriver     | LCD specific driver files   |
| Driver: HAL_I2C.c     | Generic I2C driver file   |
| Driver: HAL_OPT3001.c | OPT3001 sensor specific driver built on top of the HAL_I2C driver                 |

#### 3.5.2 Operation

This demo visualizes 512-point real FFT results calculated from audio samples gathered in real-time from the onboard microphone of the Educational BoosterPack plug-in module MKII (see [Figure 8](#)). The demo uses the real FFT function contained in the CMSIS DSP Software Library.



**Figure 8. Microphone**

The program begins by using the MSP432 built-in ADC14 module to sample audio signal at 8 KHz from the microphone on the Educational BoosterPack plug-in module MKII. To achieve seamless data processing, the MSP432 built-in DMA module is set up in Ping-Pong mode to alternate between two data buffers. This allows the ADC14 module to continue gathering audio data into one buffer, while the MSP432 runs the FFT algorithm on the other buffer.

When the DMA module completes data transfers from ADC14 results to one of the 512 length data buffers, an interrupt is triggered to wake the MSP432 from LPM0 sleep mode to initiate the 512-point real FFT calculation. The resulting frequency bin data is displayed in a bar graph on the BoosterPack plug-in module's colored 128x128 dot-matrix LCD using [MSP Graphics Library](#).

Try generating a pure tone ranging from 1 Hz to 4000 Hz and see if the demo shows the correct frequency.

### 3.5.3 CMSIS DSP Software Library in MSP432

This demo uses a pre-built CMSIS DSP Software Library file. However, a separate project, **dsplib-mbsp432**, is included in the [MSP-EXP432P401R Software Examples](#) download, showing how to compile the ARM [CMSIS DSP Software Library](#) with a MSP432 device in Code Composer Studio IDE.

It opens up access to the suite of signal processing functions in the CMSIS DSP Software Library for MSP432 MCUs inside the Code Composer Studio development environment.

## 4 Additional Resources

### 4.1 TI LaunchPad Development Kit Portal

More information about LaunchPad development kits, supported BoosterPack plug-in modules, and available resources can be found at:

- [TI's LaunchPad portal](#): information about all LaunchPad development kits from TI, for all MCUs

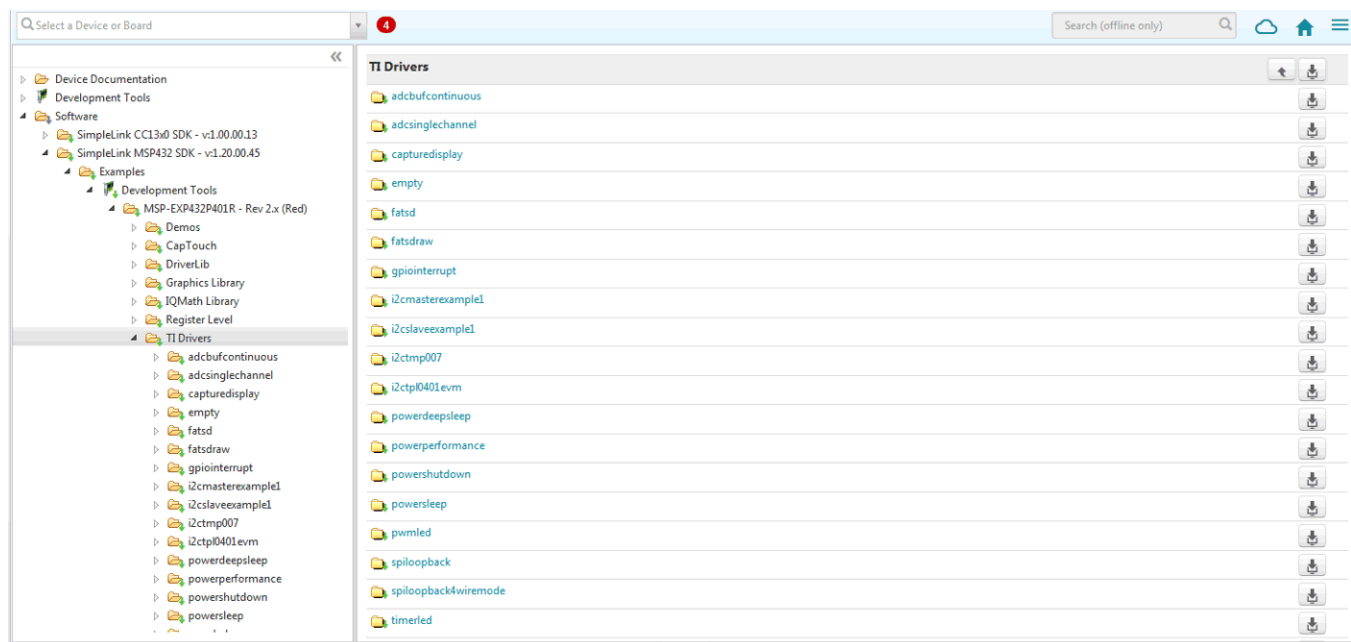
### 4.2 Download Code Composer Studio IDE, IAR, or Energia

Although the files can be viewed with any text editor, more can be done with the projects if they are opened with a [development environment](#) like Code Composer Studio IDE, IAR, or Energia.

### 4.3 SimpleLink MSP432 SDK and TI Resource Explorer

The MSP432 device is part of the SimpleLink microcontroller (MCU) platform, which consists of Wi-Fi®, Bluetooth® low energy, Sub-1 GHz, and host MCUs. All share a common, easy-to-use development environment with a single core software development kit (SDK) and rich tool set. A one-time integration of the SimpleLink platform lets you add any combination of devices from the portfolio into your design. The ultimate goal of the SimpleLink platform is to achieve 100 percent code reuse when your design requirements change. For more information, visit [www.ti.com/simplelink](http://www.ti.com/simplelink).

The SimpleLink MSP432 SDK is included in the TI Resource Explorer for easily browsing tools, documents, examples, and more (see [Figure 9](#)).



**Figure 9. TI Drivers Software Examples in TI Resource Explorer**

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



## 4.4 The Community

### 4.4.1 TI E2E™ Community

Search the TI E2E™ community 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 development kit and BoosterPack plug-in module ecosystem – for example, <http://www.43oh.com>. You can find additional tools, resources, and support from these communities.

## 5 Schematics

[Figure 10](#) and [Figure 11](#) show the schematics. All hardware design files can be found on the [download page](#).

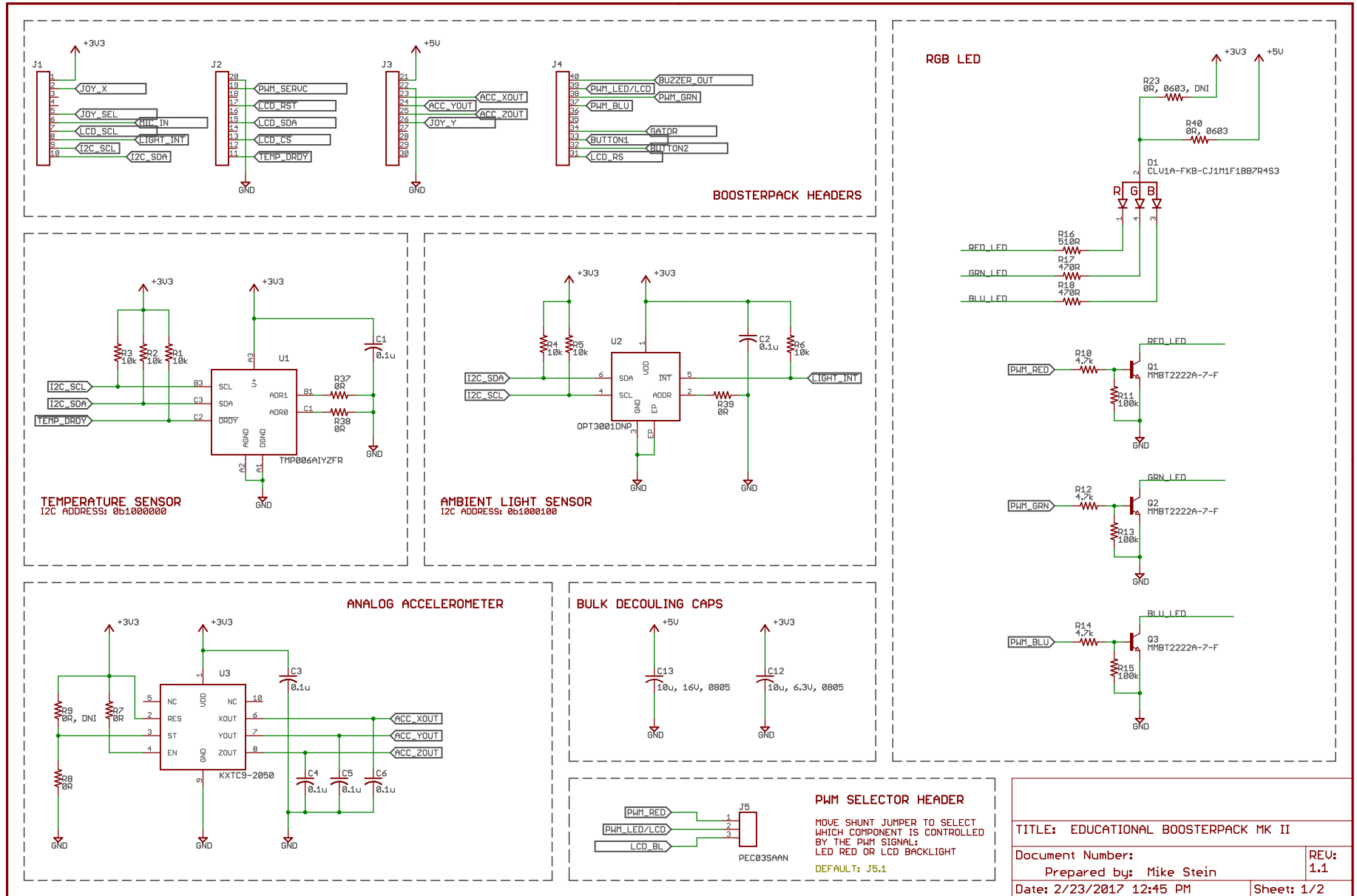


Figure 10. Schematics (1 of 2)

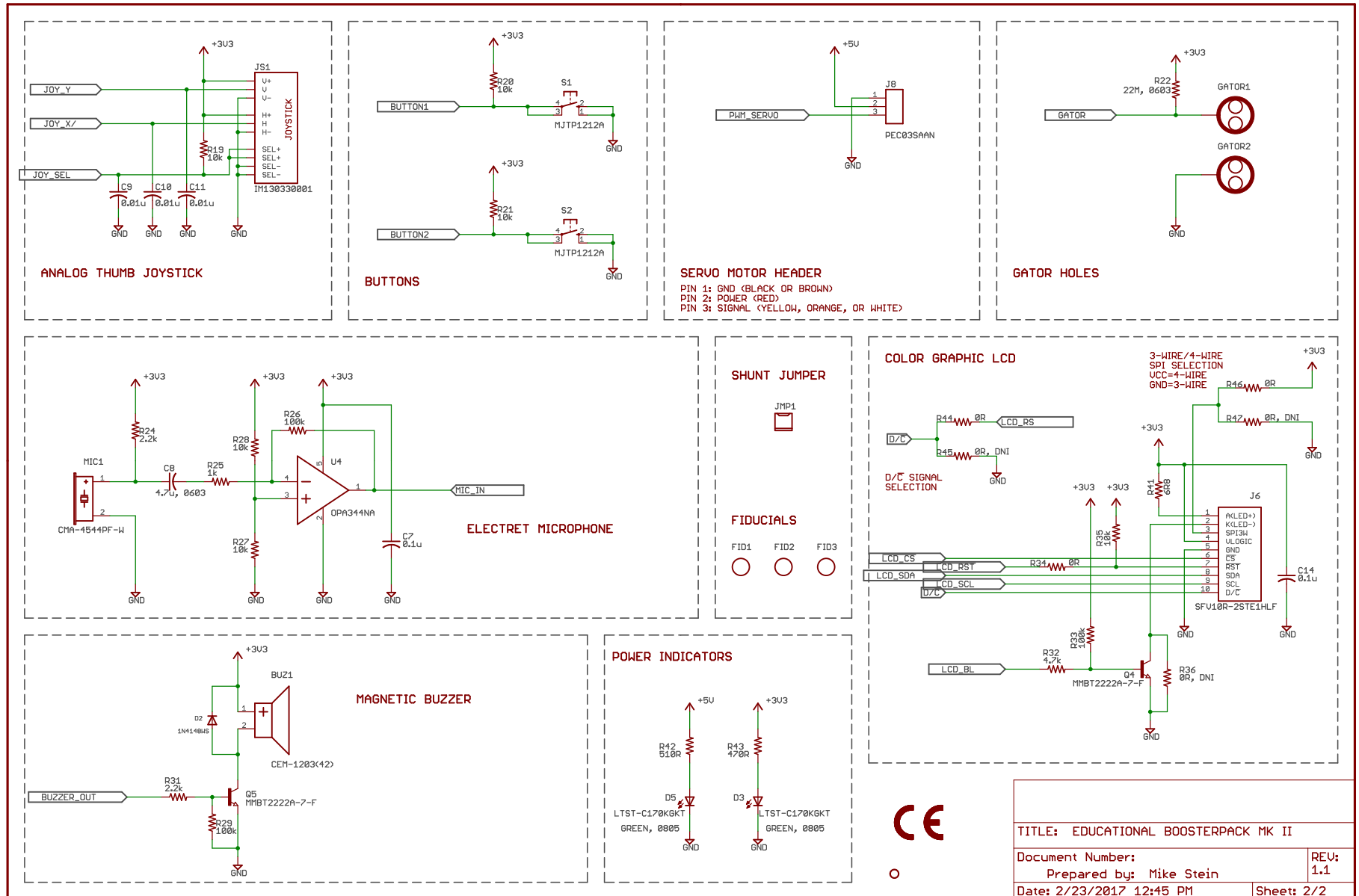


Figure 11. Schematics (2 of 2)

## Revision History

### Changes from August 22, 2015 to March 6, 2017

**Page**

- 
- Added Rev 1.1 to [Table 11](#), *Hardware Change Log*..... 9
  - Updated the required versions in [Table 13](#), *IDE Minimum Requirements for MSP-EXP432P401R*..... 9
  - Throughout document, changed "MSPWare" to "SimpleLink MSP432 SDK" ..... 10
  - Updated all content in [Section 4.3](#), *SimpleLink MSP432 SDK and TI Resource Explorer*..... 15
  - Updated all figures in [Section 5](#), *Schematics* ..... 17
-

## IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2018, Texas Instruments Incorporated