# C2000 LED BoosterPack

# User's Guide

TEXAS INSTRUMENTS

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# C2000 LED BoosterPack

## 1 C2000™ LED BoosterPack Overview

### 1.1 Overview

The LED BoosterPack is an add-on board designed to fit the C2000 LaunchPad and the other 40-pin based LaunchPads. This BoosterPack provides users with a way to accurately control a series of LED strings while efficiently controlling the power stages needed to make the LEDs work. This user's guide discusses the LED BoosterPack kit contents, the board hardware details, and also explains the functions and locations of jumpers and connectors present on the board. Step-by-step instructions for two demo examples are also included.



**Figure 1. LED BoosterPack (BOOSTXL-C2KLED)**

## 2    Getting Familiar With the Kit

### 2.1    Kit Contents

The kit consists of:
*   LED BoosterPack
*   AC/DC Power Adapter (12 V 1A)
*   Quick Start Guide

### 2.2    Kit Specifications

The LED BoosterPack has the following specifications:
*   Power Input:
    –   6 V minimum @ 1.2A
    –   20 V maximum @ 360 mA
*   Boost Stages (each):
    –   Input
        *   6 V minimum @ 400 mA
        *   20 V maximum @ 120 mA
    –   Output
        *   24 V nominal @ 100 mA

## 3    Hardware Overview

Figure 2 illustrates a LED lighting system running from DC power.
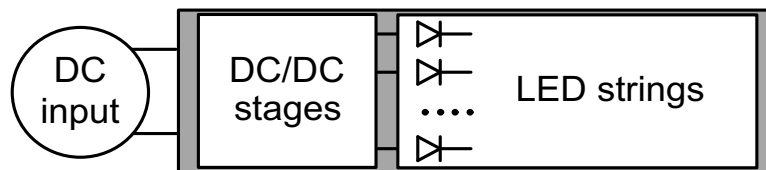


**Figure 2. Lighting System Topology**

There are multiple ways of controlling LEDs. This board uses the C2000 devices to control a separate DC supply for each of the LED strings. Brightness control is accomplished using the C2000 devices by independently varying the output power of each DC/DC stage. This allows the user to control the average current passing through each LED string. Since average current is roughly proportional to lumen output, each LED string's brightness is controlled. Figure 3 shows the circuit diagram for the LED BoosterPack.

**Figure 3. LED BoosterPack Circuit Diagram**

## 3.1 Subsystems

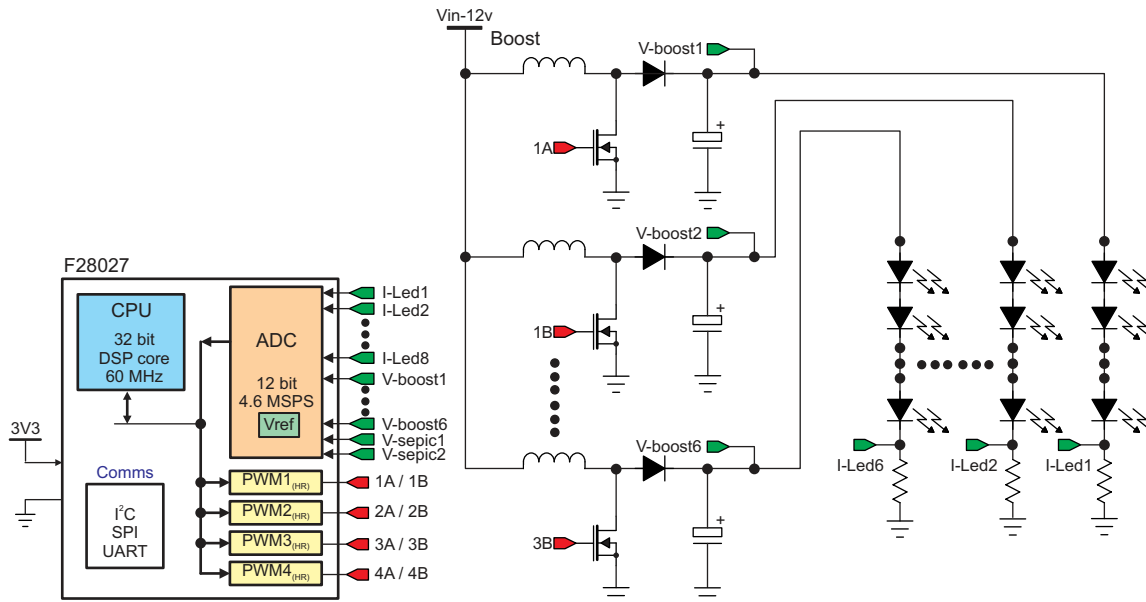The LED BoosterPack board is divided into functional groups referred to as subsystems. The following is a list of the subsystems present on the board and brief descriptions of each:

- Power Supplies – Power is supplied to the board via a 12 V AC/DC wall adapter. This power is stepped down using the Buck regulator to generate 5 V. The 5 V is used to power a 3.3 V LDO that supplies power to the 3.3 V device present on the BoosterPack. Both the 3.3 V and 5 V power domains can be selectively jumpered (via J2 and J8, respectively) to supply power to the LaunchPadXL headers.

- Boost Converters – Boost converters are used to step up the 12 V input voltage to a voltage high enough to forward bias the LEDs. The boost converters are driven by the EPWM peripheral present on the F28027 device on the C2000 LaunchPad™.

- Current Feedback – Shunt resistors at the base of each LED string are used to convert the LED current into a voltage that can be measured. The voltage from the sense resistors is passed to a set of op-amps to amplify and filter the current feedback signal. They also serve the purpose of driving the analog-to-digital converter (ADC) inputs.

- MSP430 Capacitive Touch – The LED BoosterPack includes an MSP430 device and headers such that a Capacitive Touch BoosterPack can be plugged into the LED BoosterPack and used to control the LEDs. Switch S1 can be used to connect or disconnect the MSP430's serial peripheral to the F28027 device's serial peripheral present on the C2000 LaunchPad. If the user wishes to use the capacitive touch demo, ensure S1 is in the up position while S4 on the LaunchPad is in the down position.
  - Advanced users can reprogram the MSP430 present on the LED BoosterPack by using J5.

Figure 4 illustrates the position of these subsystems on the board. The use of a subsystem approach, for different power stages, enables easy debug and testing of one stage at a time.
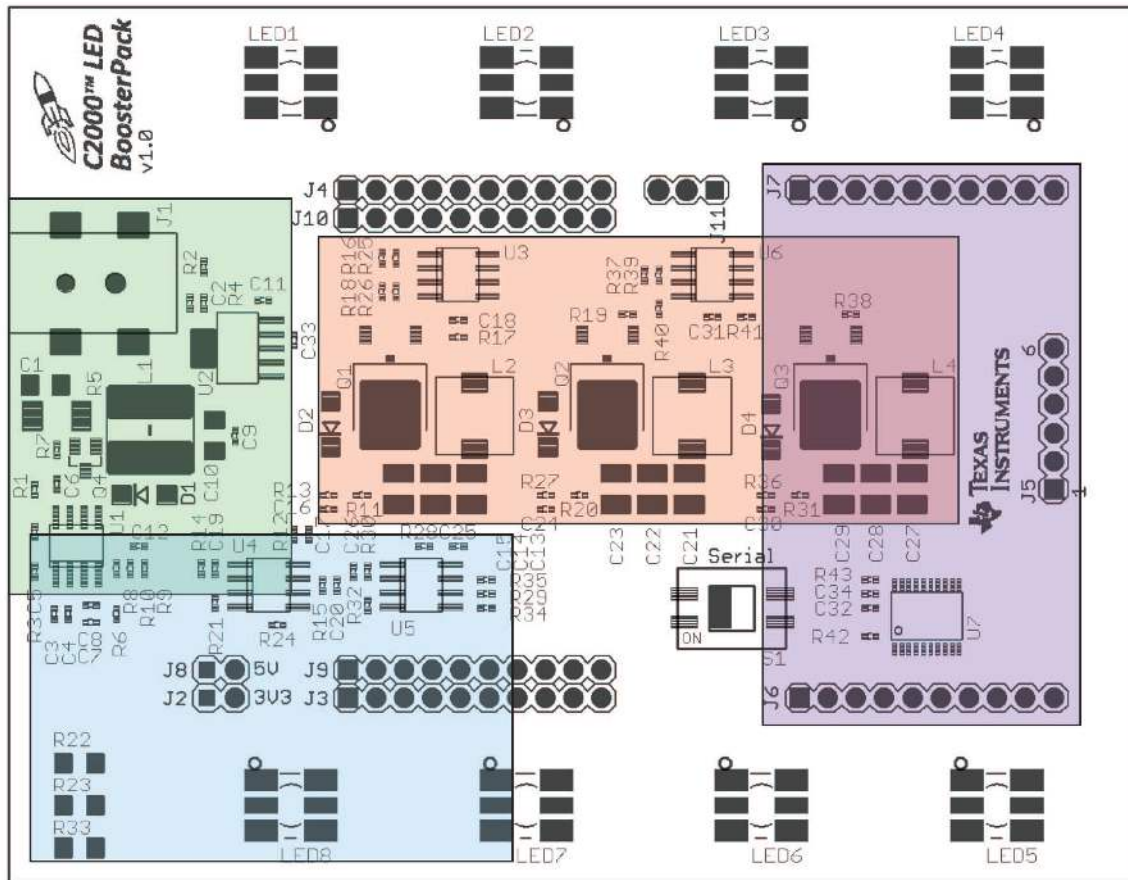


**Figure 4. LED BoosterPack Subsytem Locations**

## 3.2 Powering the Board

The LED BoosterPack has three separate power domains and two major modes of operation: two power domains are the primary power rails that feeds the three DC/DC power stages and the auxiliary power supply rails that power all of the support chips, and is used to power the LaunchPad. The question of which mode of operation should be used depends on whether the board is being used for evaluation or for experimentation.

- Non-Isolated – Used to quickly show how the boards function with the supplied firmware. Power for the LaunchPad is supplied via the USB. Power for the LED BoosterPack is supplied via the included 12 V AC/DC adapter. With this configuration, your PC's USB port is connected to the same ground as both the LaunchPad and LED BoosterPack.
    - Jumpers JP1, JP2, and JP3 on the LaunchPad should have jumpers placed on each post.
    - Jumpers J2 and J8 on the LED BoosterPack should NOT have jumpers placed on each post.
    - Connect the USB to the LaunchPad.
    - Connect the included power adapter to the LED BoosterPacks' J1.

- Isolated/Standalone – Used to protect the host PC while debugging the application, which may present dangerous voltages to a PC or when the user wants to run a standalone application with a single supply. Power for the entire system (both LaunchPad and LED BoosterPack) is supplied from the 12 V AC/DC wall adapter. The USB can be optionally connected if the user wants to debug the application; in this case, power for the emulator is supplied via USB. This mode provides the user with 2500 Vrms of isolation to protect the computer in the event that dangerous transient voltages are present on the board.
  - Jumpers JP1, JP2, and JP3 on the LaunchPad should NOT have jumpers placed on each post.
  - Jumpers J2 and J8 on the LED BoosterPack should have jumpers placed on each post.
  - Connect the USB (optional, only used for debugging) to the LaunchPad.
  - Connect the included power adapter to the LED BoosterPacks' J1.

## 3.3 Boot Modes

Table 1 describes the switch settings that are needed for emulation boots as well as booting from FLASH or SCI for the board.

**Table 1. Boot Options**

|  | Emulation Boot | Boot From FLASH | Boot From SCI |
|---|---|---|---|
| F2802x | SW1 on LaunchPad<br>Position 1 = up<br>Position 2 = up<br>Position 3 = up | SW1 on LaunchPad<br>Position 1 = up<br>Position 2 = up<br>Position 3 = down | SW1 on LaunchPad<br>Position 1 = up<br>Position 2 = down<br>Position 3 = down |

## 4 Getting Started

## 4.1 PC GUI Demo

The LED BoosterPack experimenter's kit comes with a GUI that provides a convenient way to evaluate the functionality of this kit and the F28027 device without having to learn and configure the underlying project software. The interactive interface using sliders, buttons, and textboxes allows LED lighting with the C2000 device to be demonstrated quickly and easily.

### 4.1.1 Hardware Setup for PC GUI Demo

Perform or verify the following steps to prepare the LED BoosterPack for use with the included GUI:

1. Verify the following jumper and switch settings on the LED BoosterPack.
   - (a) A jumper is not placed on J2.
   - (b) A jumper is not placed on J8.
   - (c) The switch S1 is in the down position.
2. Verify the following jumper and switch settings on the C2000 LaunchPad:
   - (a) A jumper is placed on JP1.
   - (b) A jumper is placed on JP2.
   - (c) A jumper is placed on JP3.
   - (d) Switches in S1 are all in the up position.
   - (e) The switch S4 is in the up position.
3. Insert a C2000 LaunchPad into the header marked J3, J9 and J4, J10.
4. Connect the LED BoosterPack to the included power adapter and plug in the adapter to the mains power.
5. Connect the LaunchPad to the PC using the USB cable included with the C2000 LaunchPad.

### 4.1.2 Software Setup for PC GUI Demo

The GUI for evaluating this kit is named *LED_BOOST_PC_GUI.exe* and can be found in the C2000 LaunchPad controlSUITE™ package. This GUI is all the software necessary to do a quick evaluation of this kit. To explore deeper, the underlying reference software can be found within controlSUITE.

> **NOTE:** The GUI requires Microsoft® .NET framework 3.0 to run. Please ensure that this software is installed prior to running this program.
>
> If this demo is being used on a computer that uses a decimal comma, the regional settings of the computer may need to be changed to English for this demo to run correctly.

Follow these instructions to run the GUI included with the LED BoosterPack:

1. Start Code Composer Studio™ version 5.
2. In TI Resource Explorer, look for an entry called controlSUITE and expand the Development Tools section.
3. Expand the entry for *BOOSTXL-C2KLED* and look for the PC GUI application project. Follow the steps in the right pane of Resource Explorer to import, compile, program, and run the embedded half of this example.
4. Browse to and run the *LED_BOOST_PC_GUI.exe* GUI. The program shown in Figure 5 should appear. This executable resides next to the embedded example application in Resource Explorer.
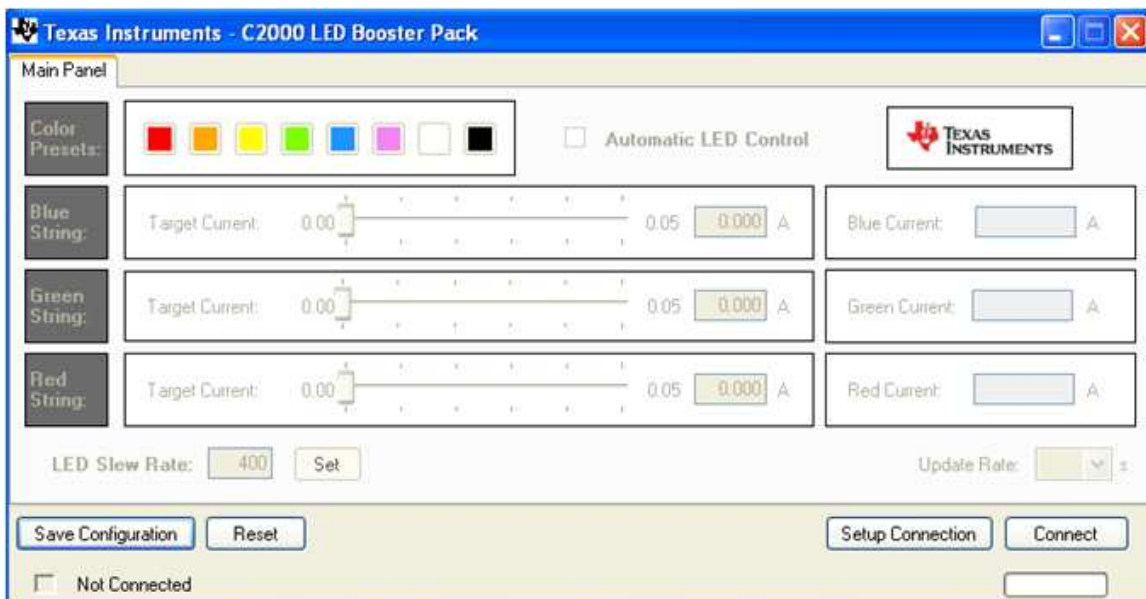


**Figure 5. LED BoosterPack GUI**

5. Click Setup Connection and make sure the baud rate is set to 57600 and that the Boot on Connect box is unchecked.
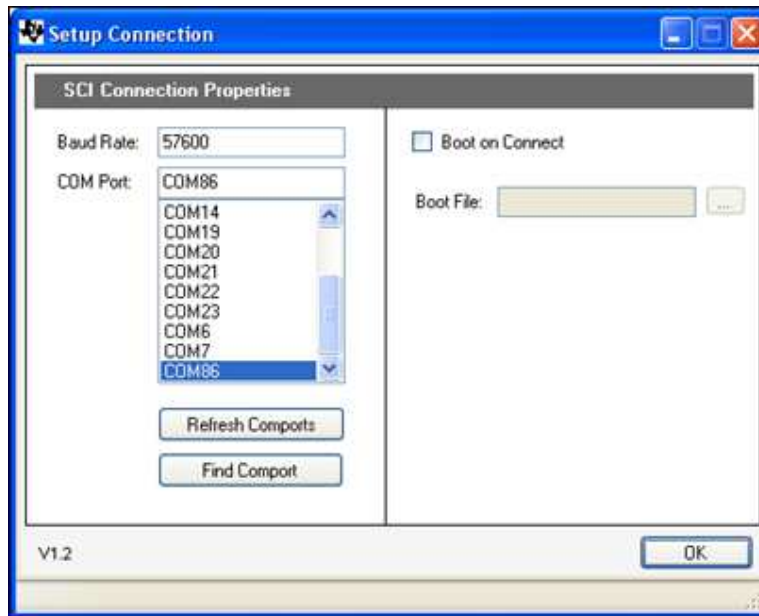


**Figure 6. GUI Setup Connections Window**

6. Select the serial COM port. This can be found by going to:

   Control Panel → System → Hardware tab → Device Manager → Ports(COM and LPT)

   Look for the COM port that is named USB Serial Port (or similar) and note the number. Select this COM port in the Setup Connection window and click OK to close the window. Hint: Try selecting the largest number or refreshing the list while connecting or disconnecting the USB cable to or from the board to see which one changes.

7. Click Connect in the GUI main window. The status bar at the bottom left corner of the GUI turns green and says Connected once the GUI is connected.

8. Use the Color Presets provided or manually adjust the current level for each LED string to vary the color generated by each LED array.

9. When finished, set each LED string's Target Current to 0.00A and press Disconnect to terminate the connection.

## 4.2 Capacitive Touch Demo

The LED BoosterPack experimenter's kit comes with an MSP430 device and headers such that a user can connect the Capacitive Touch BoosterPack and use it to control the LEDs. This interface is meant to demonstrate how an OEM lighting company might implement touch-based control of LED lighting applications.

No external hardware is required to run this demo, which makes it a great demo to show when one is away from a PC. To explore deeper, the underlying reference software can be found within controlSUITE.
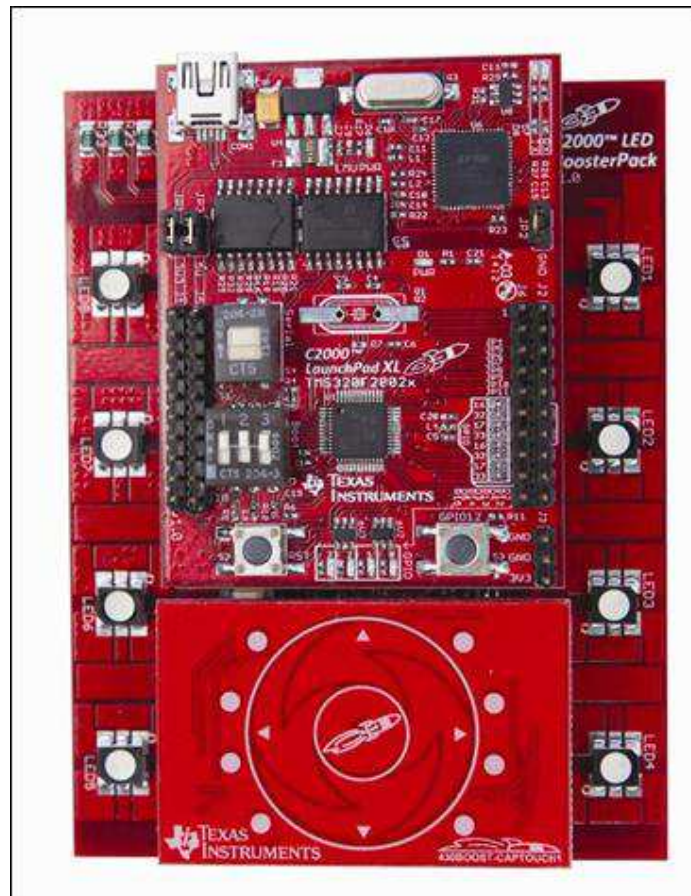
**Figure 7. LED BoosterPack With C2000 LaunchPad and MSP430 Capacitive Touch BoosterPack**

### 4.2.1 Hardware Setup for Capacitive Touch Demo

Perform or verify the following steps to prepare the LED BoosterPack for use with the MSP430 Capacitive Touch BoosterPack.

1. Verify the following jumper and switch settings on the LED BoosterPack:
   (a) A jumper is not placed on J2.
   (b) A jumper is not placed on J8.
   (c) The switch S1 is in the up position.
2. Verify the following jumper and switch settings on the C2000 LaunchPad:
   (a) A jumper is placed on JP1.
   (b) A jumper is placed on JP2.
   (c) A jumper is placed on JP3.
   (d) Switches in S1 are all in the up position.
   (e) The switch S4 is in the down position.
3. Insert a C2000 LaunchPad into the header marked J3, J9 and J4, J10 on the LED BoosterPack.
4. Insert an MSP430 Capacitive Touch BoosterPack onto the headers marked J6 and J7.
5. Connect the LED BoosterPack to the included power adapter and plug in the adapter to the mains power.
6. Connect the LaunchPad to the PC using the USB cable included with the C2000 LaunchPad.

### 4.2.2 Software Setup for Capacitive Touch Demo

1. Start Code Composer Studio version 5.
2. In the TI Resource Explorer, look for an entry called controlSUITE and expand the Development Tools section.
3. Expand the entry for *BOOSTXL-C2KLED* and look for the capacitive touch demo application project. Follow the steps in the right pane of Resource Explorer to import, compile, program, and run the example.
4. After the example is running, the LEDs can be controlled as follows:

   (a) Press the Center button twice to initially turn the LEDs ON.
   (b) Spinning one's finger around the touch wheel, while the LEDs are ON, cycles through the color spectrum.
   (c) Pressing the Center button again turns the LEDs OFF.
   (d) Subsequent (single) presses of the Center button turns the LEDs ON or OFF.

## 5 Hardware Resource Mapping

### 5.1 Resource Allocation

Figure 8 shows the various stages of the board in a circuit diagram format and illustrates the major connections and feedback values being mapped to the C2000 MCU. Table 2 lists these resources. For more detailed information, see the schematics and the device-specific data sheets.

**Table 2. PWM and ADC Resource Allocation**

| Net Name | PWM/ADC Channel | Description |
|----------|-----------------|-------------|
| VDCIN | ADC-B6 | Input voltage sense |
| PWM-1A | PWM-1A | Boost 1 PWM signal |
| PWM-1B | PWM-1B | Boost 2 PWM signal |
| VBLUE | ADC-B1 | Boost 1 output voltage sense |
| VGREEN | ADC-B2 | Boost 2 output voltage sense |
| IBLUE | ADC-A2 | Boost 1 output current sense |
| IGREEN | ADC-A1 | Boost 2 output current sense |
| PWM-2A | PWM-2A | Boost 3 PWM signal |
| VRED | ADC-B4 | Boost 3 output voltage sense |
| IRED | ADC-A6 | Boost 3 output current sense |
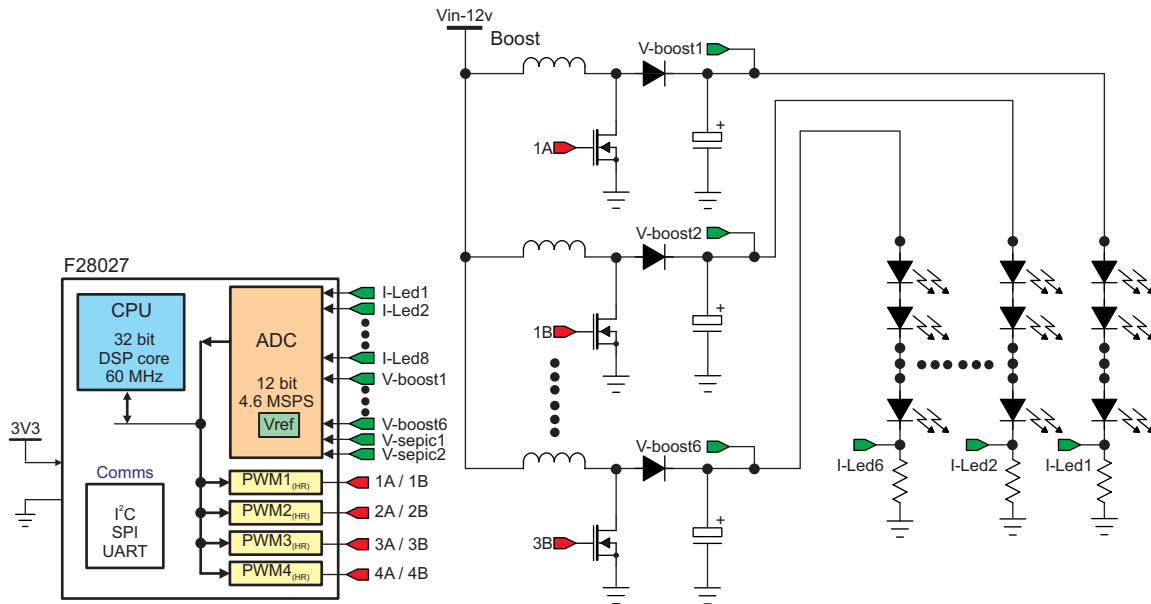
**Figure 8. LED BoosterPack Circuit Diagram**

## 5.2 Jumpers, Connectors, and Switches

Table 3 lists the jumpers, connectors, and switches available on the board. Figure 9 shows the location of these items with help of a board image.

**Table 3. Description of Jumpers, Connectors, and Switches**

| J1 | Barrel Jack for main power connection (6 V-48 V) |
|----|--------------------------------------------------|
| J2 | Jumper to connect BoosterPack 3.3 V to LaunchPad Headers |
| J8 | Jumper to connect BoosterPack 5 V to LaunchPad Headers |
| J3, J9 and J4, J10 and J11 | LaunchPadXL Socket |
| J6 and J7 | Capacitive Touch BoosterPack Headers |
| S1 | MSP430 Serial Disconnect Switch |
| J5 | MSP430 Programming Header |

J2 and J8
Power Jumpers

J1
Power Input

J3,J9 and J4,J10 and J11
LaunchPadXL Socket

S1
MSP430 Serial
Disconnect
Switch

J6 and J7
Capacitive Touch
BoosterPack
Headers

J5
MSP430
Programming
Interface
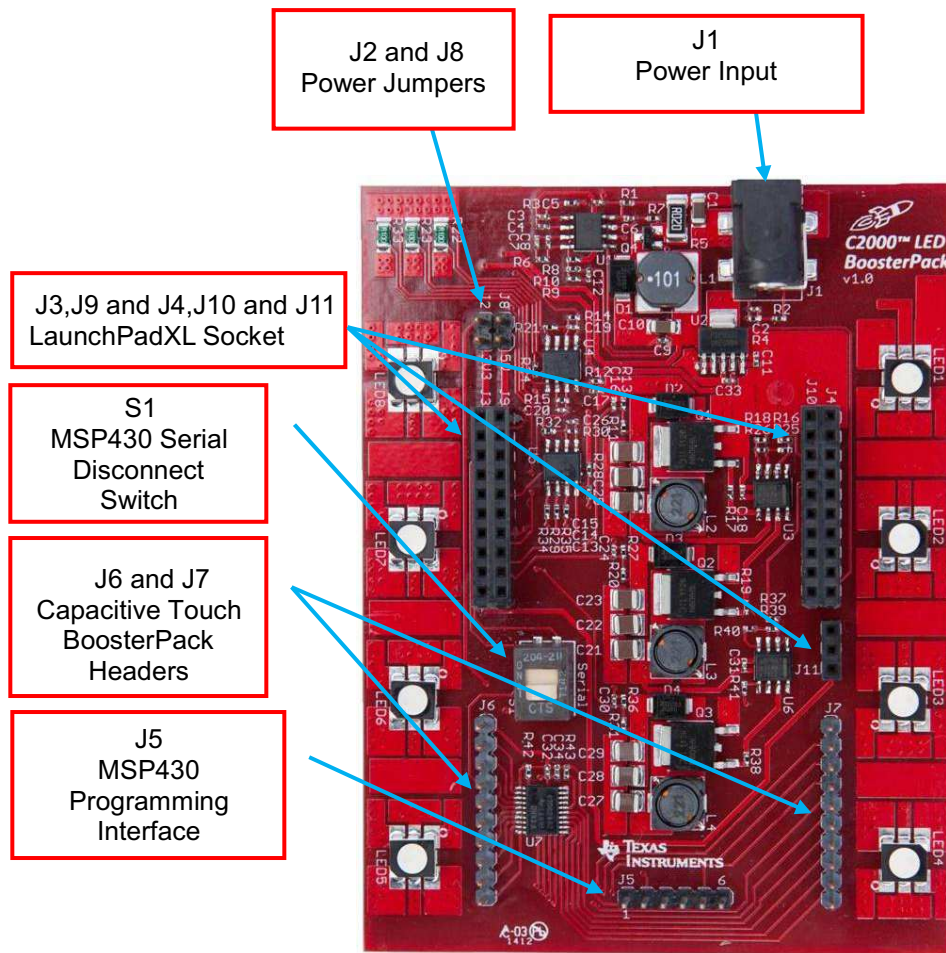
**Figure 9. LED BoosterPack Jumper, Connector, and Switch Locations**

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- 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.

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