CY3263-ColorLock EZ-Color™ Evaluation Kit Guide

Doc. # 001-44081 Rev. *A

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Contents

1. Introduction

WARNING: HIGH BRIGHTNESS LEDs CAN CAUSE PERMANENT EYE DAMAGE!

Do not look at the LEDs if they are not covered by the protective enclosure. The LEDs illuminate at a very high intensity and can cause permanent eye damage if they are viewed without the protective enclosure.

1.1   Purpose

The CY3263-ColorLock EZ-Color Evaluation Kit demonstrates the ability of a EZ-Color controller to use real-time optical feedback to control three primary, high brightness LEDs and create accurate, mixed-color output. The three LEDs on the CY3263 evaluation board use the primary colors red, green, and blue, although any three primary color LEDs can be used in a design, depending upon the application and the desired color gamut.

Right out of the box, CY3263-ColorLock EZ-Color Evaluation kit can be used to evaluate and demonstrate EZ-Color functionality, including color mixing and optical feedback. See the quick start on how to use the kit with the factory installed firmware.

The next step is to develop a ColorLock application using this kit as a platform. Use PSoC Express, Cypress's revolutionary visual embedded design tool, to quickly design powerful lighting applications.

This guide serves three main purposes:

1. Chapter 1. Introduction, on page 5 discusses kit contents, installation instructions, adding drivers and valuators to designs, MiniProg installation, and programming instructions for PSoC Express Projects.

2. Chapter 2. on page 13 discusses the ColorLock Monitor application. The ColorLock Monitor application is used to demonstrate the functionality of ColorLock by displaying important information as it controls the ColorLock evaluation board. Connect the board via a USB cable to a personal computer running the Windows Vista or Windows XP operating system. Use this application with the default factory program discussed in the CY3263-ColorLock EZ-Color Quick Start. Note that the ColorLock Monitor application is not compatible with PSoC Express projects. The board must have the factory installed firmware (available on the CD) to work with the ColorLock Monitor application. A PDF of the quick start is available on the Tools CD in the \documents folder.

3. Chapter 3. on page 25 though Chapter 5. on page 53 contains detailed PSoC Express example projects for the CY3263-ColorLock EZ-Color Evaluation Kit. Review Section 1.4 Introduction to PSoC Express, on page 8 before starting a project. Use these projects as the first step to learning how to create a custom design using PSoC Express.

1.2 Install Software

1.2.1 Install PSoC Express Development Software

1. Insert the Tools CD.
2. Wait for the installer to start.
3. Install the following software in the order listed:
   a. Install PSoC Programmer
   b. Install .NET Framework 2.0
   c. Install PSoC Express
   d. Install ColorLock Express Pack
   e. Install ColorLock Kit Documentation

1.2.2 Install the CY3263-ColorLock EZ-Color Kit Software

1. Insert the CY3263-ColorLock EZ-Color Kit CD.
2. Open *CY3263-ColorLock Setup.msi*.
3. Follow the Setup Wizard instructions.

1.2.3 Install the Latest Version of PSoC Programmer

To ensure you have the latest version of PSoC Programmer:

1. Launch PSoC Programmer.
2. Select **Help → About PSoC Programmer**.
3. Note the version number and click **OK**.
4. Click **Check for Updates**. PSoC Programmer launches your web browser and opens the PSoC Programmer web site.
5. Compare the PSoC Programmer version number you noted in Step 3. to the latest version available on the web site. If the version on the web site is newer, click **Download**, and download and install the newest version.

1.2.4 Install the PSoC MiniProg

1. Ensure all content on the Tools CD is installed.
2. Plug the MiniProg into your PC via the USB cable. If this is the first time you have connected the PSoC MiniProg, the Windows Found New Hardware Wizard opens. If the Windows Found New Hardware Wizard does not open, then the PSoC MiniProg software is already installed and you do not need to continue with these instructions.
3. Select the **No, not this time** option button, and click **Next**.
4. Select the **Install from a list or specific location (Advanced)** option button and click **Next**.
5. Select the **Don't search. I will choose the driver to install** option button, and click **Next**.
6. Select the **USB Mini Programmer (x.x.x.x)** driver and click **Next**.
7. When prompted that the USB Mini Programmer (x.x.x.x) software has not passed Windows Logo Testing, click **Continue Anyway**.
8. When Windows has completed the installation, click **Finish**.

1.3   Board Layout

1.3.1   The On/Off Button

The CY3263-ColorLock EZ-Color evaluation hardware has two buttons and a liquid crystal display. These allow the board to be demonstrated without using a personal computer to control the board. When held properly for use, the buttons liquid crystal display face upward. When held in this orientation, the right-most button alternately turns the high brightness LEDs on and off. The default setting when power is applied is off; pressing this right-most button will illuminate the LEDs.

1.3.2   The Color Selection Button

The left-most button along the bottom edge cycles between seven preset colors. The initial color is white (all three LEDs are illuminated at high intensity). Pressing this button changes to the next color of the seven preset colors. The color sequence cycles through white, red, green, blue, yellow, magenta and cyan.

Note If the board has been controlled from a personal computer using the USB interface, the color displayed upon powering the board and pressing the On/Off button will be the last color setting selected when using the monitor application. If the board has never been controlled from a personal computer, or the last color selected could not be displayed at the selected intensity, the LEDs will not illuminate (an impossible color and intensity combination has been selected). Pressing the color selection button will select a valid color for display from the seven preset colors and the LEDs will illuminate with that color.

1.3.3   The Liquid Crystal Display

The liquid crystal display displays the currently selected color using CIE 1931 color coordinates. The values displayed on the top line of the LCD represent the CIE x, y coordinates for the currently selected color, whether chosen from the seven preset colors or selected from the ColorLock Monitor application (if using the factory firmware). The two values on the bottom line of the display represent the CIE x, y coordinate currently being sensed by the integrated color sensor. The difference between these two values represents the error. The coordinates for the currently sensed color are displayed in real-time and are continuously varying as the EZ-Color continually senses and corrects for the error in the displayed color.

If the LEDs are illuminated, an asterisk ('*') is displayed on the left end of the top row of the liquid crystal display (this is useful if the last color selected cannot be displayed with the given LEDs, resulting in the LEDs being turned off).

Figure 1-1. ColorLock Board
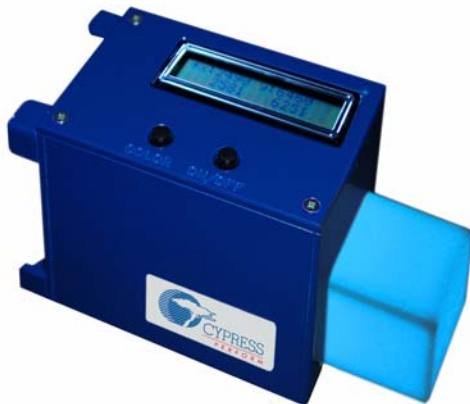
1.4 Introduction to PSoC Express

PSoC Express is a revolutionary tool that enables the engineer to go from concept to embedded custom ASIC in an hour or less. PSoC Express is a code-free visual design interface that employs drag-and-drop drivers in lieu of writing code. Designers have access to libraries of sensors, switches, potentiometers, High Brightness LEDs, and more.

With PSoC Express, users can drag and drop Inputs, Outputs, Valuators, and Interfaces from a menu of typical analog and digital devices (see Figure 1-2 on page 9). The driver blocks are then connected graphically with appropriate logic that determines their behavior. PSoC Express automatically places and routes the hardware and uses firmware to create actual chip functions. Before programming, you can use the simulation tool to verify the design. This free tool generates a data sheet, schematic, and bill of materials along with a hex file for programming. Once the part is programmed with the hex file, use the powerful PSoC Express Monitor feature to control and observe the behavior of the drivers in the project.

Chapters 3 through 5 walk you step-by-step through three PSoC Express ColorLock EZ-Color example projects. The following sections provide the necessary background information to successfully complete the projects. If you are new to PSoC Express, review these sections before starting the example projects.

1.4.1 Add Drivers and Valuators to a Design

It is very easy to add drivers and valuators to a design in PSoC Express 3. Throughout this guide, when a driver or valuator needs to be added to a design, a small table displays the required information. See Table 1-1 for an example. The table is broken into three sections:

- Driver/Valuator: Shows the actual name of the driver or valuator.
- Location: Shows the path to the device in the Driver Catalog.
- Properties: Lists all properties associated with a device. In the User Input column, default values are labeled as such. Manually enter any data not labeled as default.

Table 1-1. Example of an Add Driver or Valuator Table

Driver/Valuator	Banked Output	
Location	Outputs Tab ↳ Digital Output ↳ Banked Output	
Properties	**Field**	**User Input**
	Name	XLeds
	Number of output pins	4
	DriveMode	Strong (default)

Note: To add a driver to a design, you must open a new or existing project. Adding new drivers does not work in the Start Page in PSoC Express.

To add drivers and valuators to your design:

1. Ensure the Driver Catalog pane (Figure 1-2) is visible. If it is not visible, select **View** → **Driver Catalog**.

Figure 1-2. Driver Catalog Pane
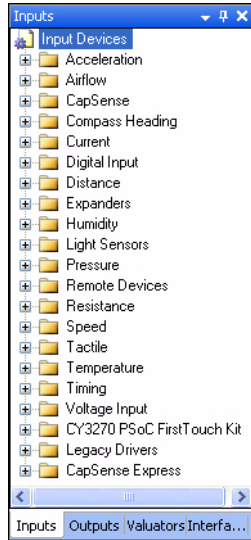
2. Each driver and valuator has certain properties associated with it. For the purposes of this tutorial, ensure **View** → **Use Add Driver Dialog** is checked.

Note: Some of the projects in this guide will not work unless the Add Driver Dialog option is selected.

Figure 1-3. Use Add Driver Dialog Menu Option is Selected

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A 9
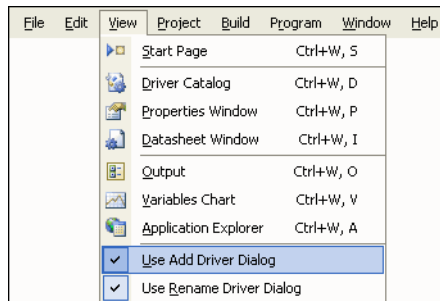
3. In PSoC Express, there are three ways to add drivers and valuators to a design. In the Driver Catalog pane, navigate to the driver or valuator you want to add, and either drag-and-drop the item to your design (Figure 1-4), double-click the item, or right-click on the item and select **Add to Design** (Figure 1-5).

Figure 1-4. Adding a Driver Via Drag and Drop
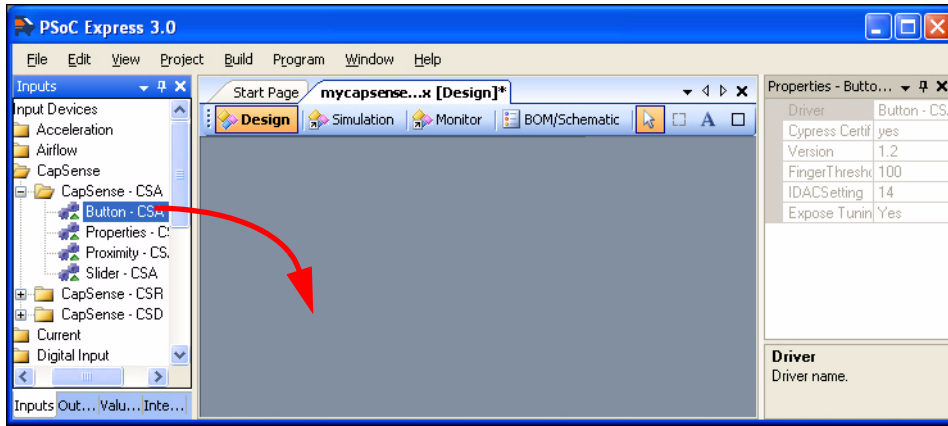
Figure 1-5. Adding a Driver Via the Contextual Menu
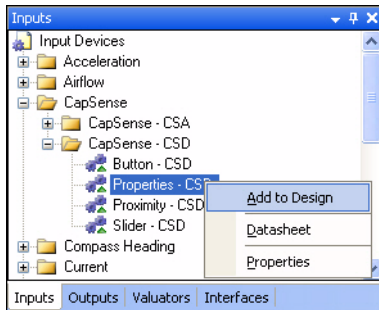
4. When drivers and valuators are added to a design, the Add Driver window opens (Figure 1-6). Name the item and enter the properties required for the design.

Figure 1-6. Add Driver Window
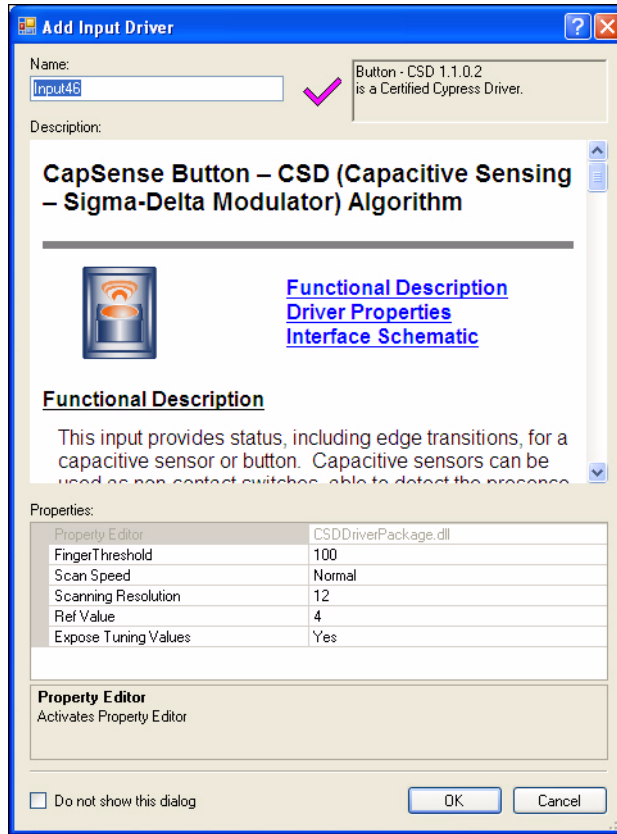
5. Click **OK**.

1.4.2 Program Parts with PSoC Express Projects

> **WARNING: Disconnect all power sources from the board**. Damage to the board may occur if you program the board while leaving a wall adapter connected.

1. Connect the USB cable to the MiniProg and to the PC.
2. Connect the MiniProg to the programming header specified by the lab instructions.
3. Select **Program** → **PSoC Programmer** from PSoC Express. The following three actions are automatically accomplished:
   a. PSoC Programmer starts.
   b. The executable firmware is loaded into PSoC Programmer.
   c. The EZ-Color device to be programmed is specified in PSoC Programmer.

Note: If the Actions column in the PSoC Programmer status box indicates "Firmware update required at...", the MiniProg's firmware is out of date. Before attempting to program the target EZ-Color chip, go to **Utilities** → **Upgrade Firmware** to update the MiniProg's firmware.

4. In PSoC Programmer:
   a. Select the **MiniProg** from the Port list.
   b. Select the **Power Cycle** option button.
   c. Click the **Program** button in the toolbar.
   d. Wait until the Actions column of PSoC Programmer's status window indicates either Programming Succeeded or Programming Terminated. If the Programming Terminated message appears, troubleshoot the problem, and re-attempt to program the device.
   e. Exit PSoC Programmer.
5. Disconnect the MiniProg from the board.

1.5 Document Revision History

Table 1-2. Revision History

Revision	PDF Creation Date	Origin of Change	Description of Change
**	04/24/2008	SFVTMP3	New Guide
*A	05/06/2008	AESA	Updated device to EZ-Color

1.6 Documentation Conventions

Table 1-3. Document Conventions for Guides

Convention	Usage
Courier New	Displays file locations, user entered text, and source code: `C:\...cd\icc\`
Italics	Displays file names and reference documentation: Read about the *sourcefile.hex* file in the *PSoC Designer User Guide*.
[**Bracketed, Bold**]	Displays keyboard commands in procedures: [**Enter**] or [**Ctrl**] [**C**]
File → Open	Represents menu paths: File → Open → New Project
Bold	Displays commands, menu paths, and icon names in procedures: Click the **File** icon and then click **Open**.
Times New Roman	Displays an equation: $2 + 2 = 4$
Text in gray boxes	Describes Cautions or unique functionality of the product.

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A

2.   ColorLock Monitor

WARNING: HIGH BRIGHTNESS LEDs CAN CAUSE PERMANENT EYE DAMAGE!

Do not look at the LEDs if they are not covered by the protective enclosure. The LEDs illuminate at a very high intensity and can cause permanent eye damage if they are viewed without the protective enclosure.

Note The ColorLock Monitor application is for demonstration purposes only and is completely separate from the Tuner in PSoC Express, which is a design tool, and will not function while PSoC Express is open.

The CY3263-ColorLock EZ-Color Evaluation Kit board demonstrates the ability of a EZ-Color controller to provide closed-loop, high accuracy control for three primary, high brightness LEDs to create mixed-color output. To provide the closed-loop capability, a TAOS TSC-230 color sensor is used to determine the current color being produced by the LEDs. This information is fed to the EZ-Color LED16 controller to determine the correct brightness for each of three primary, high brightness LEDs. The three LEDs are the colors red, green, and blue. The application described in this chapter controls the ColorLock evaluation board through a USB port on a personal computer that is using the Windows Vista or Windows XP operating system.

2.1   Representing Colors

The application can represent either of two standard color coordinate systems: CIE 1931 x, y or CIE 1976 u', v'. These two modes are available under the Settings > Color Space pull-down on the application tool-bar. The CIE 1931 coordinate system is automatically selected when the application is started. The CIE Color Mix Mode displays the 1931 CIE Color chart. This chart represents the range of colors visible to the human eye. The interior portion of the triangle displayed on the color chart represents the range of colors that can be represented by the LEDs on the ColorLock board. All synthetic light sources, such as LEDs or incandescent lights, produce some limited range of the spectrum of colors the human eye can see. The triangle shows the colors that can be displayed by mixing the light from the three LEDs on the evaluation board. Clicking anywhere within the triangle will place a dot at the selected point. The corresponding CIE coordinates for that color are transmitted to the ColorLock board, where the selected color is displayed by adjusting the three LEDs to brightness levels that create the mixed color. The resulting coordinates are shown numerically in the Color panel displayed below the color chart. If the CIE 1931 chart is selected, the x, y coordinates are shown. If the CIE 1976 chart is selected, the u', v' coordinates are displayed.

The Manual Control Mode is an alternative to specifying colors using CIE coordinates. This mode displays three slider controls, one for each LED on the board. Moving a slider from left-to-right causes the corresponding LED to light from zero to one-hundred percent of this maximum brightness. To control the LEDs manually, check Disable Feedback below the three horizontal slider controls displayed on the bottom right portion of the application display. Notice that all controls related to

selecting color or brightness using the color-lock feature are disabled when the Disable feedback box is checked. These controls have no meaning when setting the individual LED brightness levels manually.

The colors that can be displayed are determined by the choice of LEDs used on the board. The colors produced by individual LEDs are referred to as primary colors. All other colors are created by mixing various intensities of the primary colors. Such mixed colors appear the same to the eye as if produced by an LED producing that color as its primary color. The colors that can be selected are called the evaluation board's color gamut. Once the primary LED colors are determined, as they are on the evaluation board, the color gamut is defined by those choices. Thus, the bounding triangle defines the color gamut for the board. Colors outside of the color gamut cannot be represented by the given LEDs and the user cannot select colors outside of the color gamut. For any coordinate selected outside of the color gamut, the LEDs turn off.

Note The triangle is an approximate gamut boundary. For points adjacent to the triangle edges, especially close to the LED coordinates (i.e., the corners), it is possible to select a point that falls outside of the color gamut.

2.2   Installation Requirements

In order to use the ColorLock Monitor application, a personal computer running Window's Vista or Window's XP is required. The computer must have the minimum amount of memory required to run the desired version of Windows, as well as at least 1.5 megabytes of available hard disk space. In addition, one available USB port is needed to connect the evaluation board to the computer using an A to mini B USB cable. This port can be provided by using an expansion hub connected to one of the host computer's USB ports.

2.3   Using the ColorLock Monitor Application

2.3.1   Initial Application Displays

Figure 2-1 shows the ColorLock Monitor window that appears when the ColorLock Monitor application is started. As long as the ColorLock evaluation unit is not connected to the PC with a USB cable, the USB Link Status box located in the bottom right corner of the window shows the status Not Connected, with a red background. When the unit is connected to the host PC and the host recognizes the hardware is present, the status changes to Connected to ColorLock Demonstration, along with the version of the ColorLock unit's firmware. The status box background changes to green to indicate that communication has been established (see Figure 2-2).

Figure 2-1. The ColorLock Startup Display
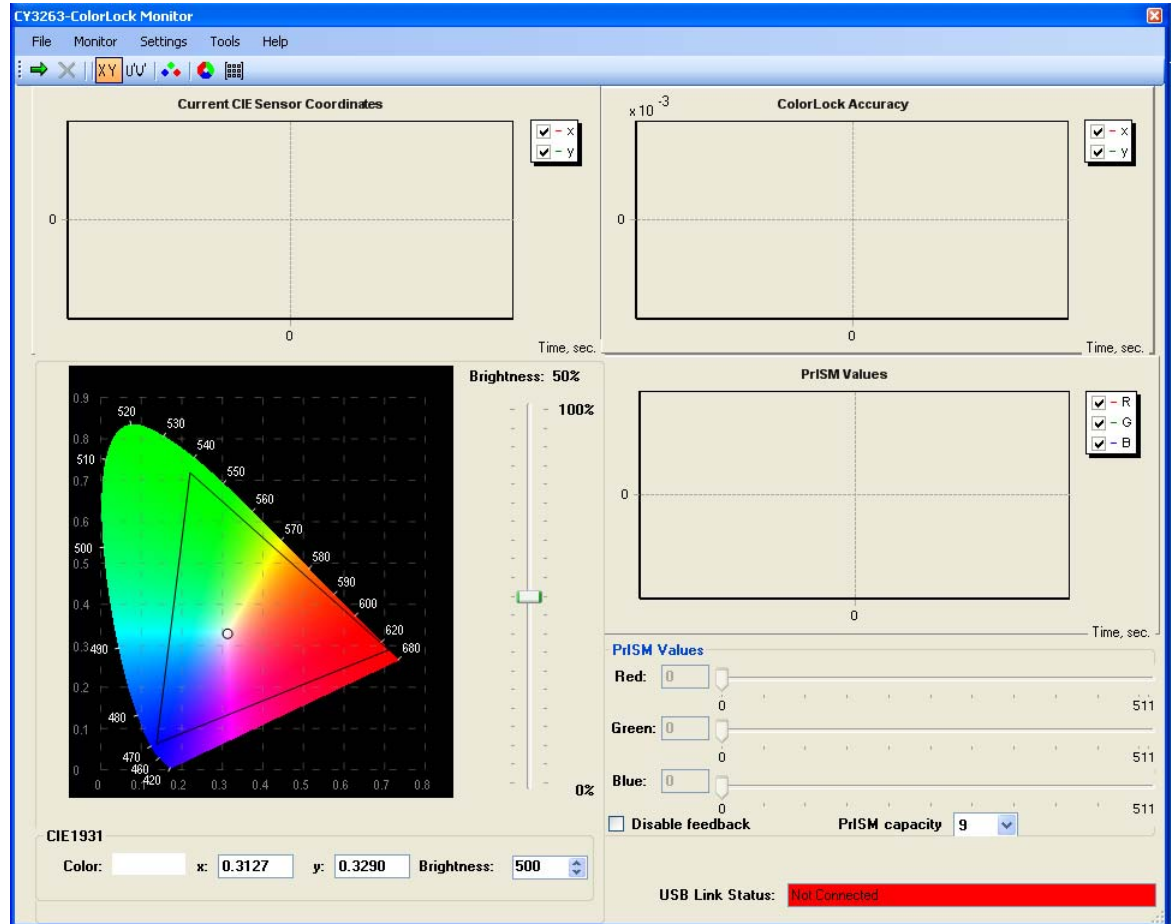
In addition to displaying colors, the application turns the LEDs on or off. The LEDs are turned on whenever the real-time color-lock is running (i.e., the green, right-pointing arrow on the left end of the tool-bar has been clicked.) If color-lock has been turned off (i.e., the red 'X' to the right of the green arrow) the LEDs are also turned off.

Figure 2-2. Connected to the ColorLock Hardware

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A
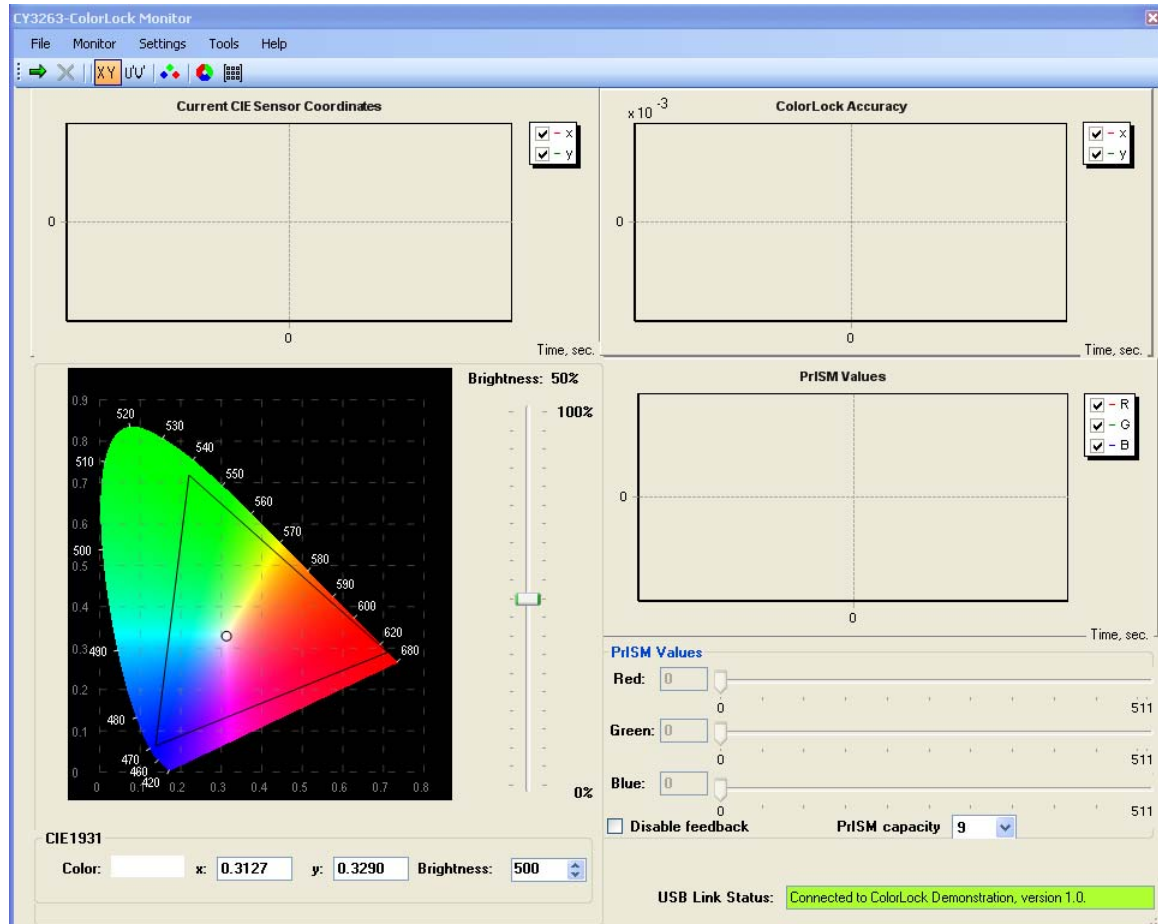
The ColorLock Monitor window is divided into five panes. The upper two panes are graphs that show the current CIE coordinates for the color output being sensed on the left and the corresponding error, or deviation from the selected color on the right. Below these two graphs, the currently selected CIE color chart (initially the CIE 1931 chart) and brightness slider are displayed in the bottom left quarter of the monitor's window. Below the color chart and brightness slider, the currently selected color is displayed as CIE coordinates (x, y for CIE 1931 or u', v' for CIE 1976, Figure 2-3). Finally, the current brightness setting is displayed numerically, with a range of 0 (LEDs off) to 1000 (LEDs at maximum intensity). The bottom right quarter contains two panes: a real-time graph showing the current dimming values for each of the three LEDs, and below that a pane containing the horizontal manual control intensity sliders for each LED.

For each graph, any of the parameters shown can be selectively enabled or disabled. For example, for the graph PrISM Values, the graph of the current PrISM value for the blue LED can be turned off by unchecking **B** (Figure 2-3). When turned off, the corresponding graph trace is removed from the graph. Checking **B** causes the graph for the blue LED to display again. There is no information loss when a particular trace is disabled: checking the selected graph trace will cause it's charted values to be displayed again.

Figure 2-3. CIE 1976 Color Display
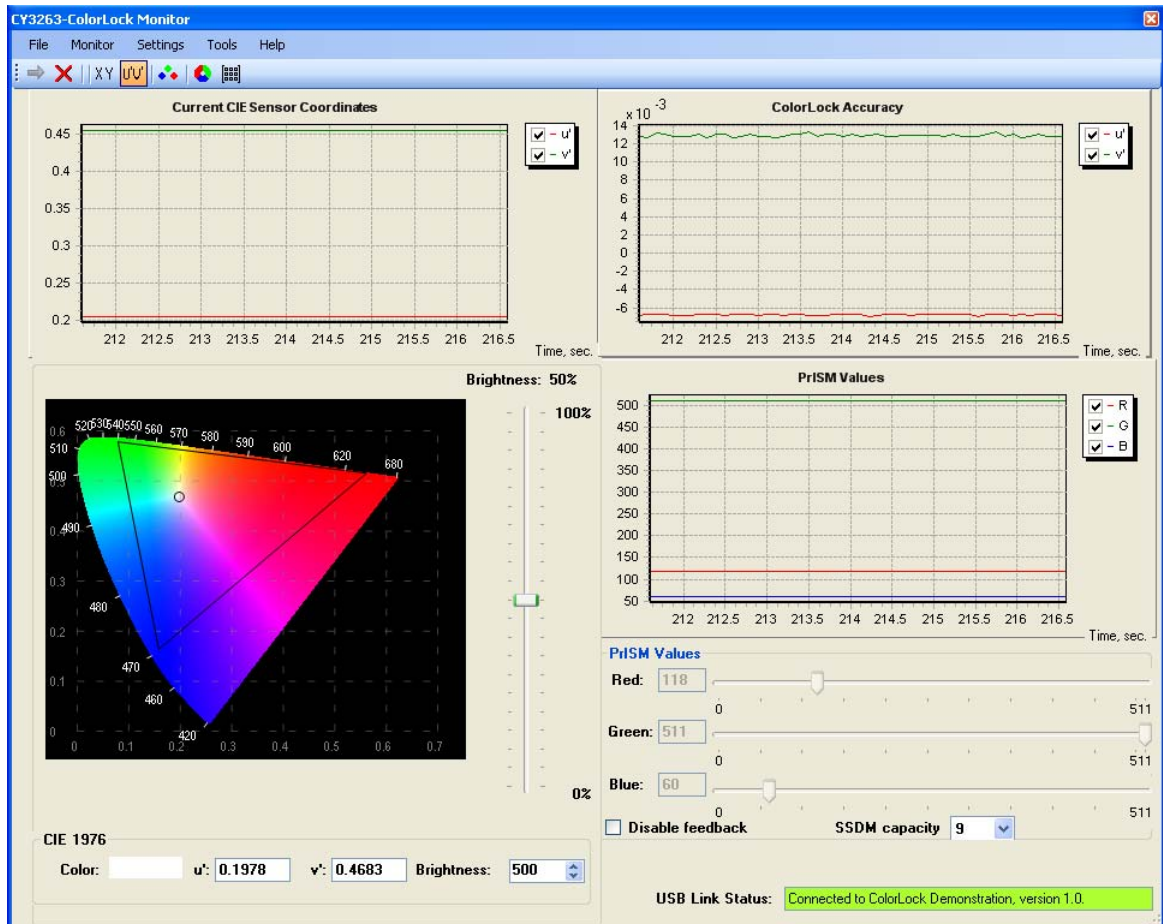
As shown in Figure 2-2, all of the graphs remain blank, displaying only the coordinate axes, without an associated graph, until the monitor is placed in run mode. The monitor can be run by either clicking the right-pointing green arrow icon ⮕ in the tool bar (see Section 2.3.2 Toolbar Icons and Menubar Options on page 14), or by selecting the pull-down labeled Monitor and clicking and selecting the Run option. Upon selecting Run, the monitor will enable the ColorLock evaluation board and begin charting the graphed parameters representing the currently sensed coordinates, the current error and the three current PrISM values. The monitor updates in real time, showing the EZ-Color color-lock function as the EZ-Color continually corrects the currently generated color relative to the currently selected color. As the EZ-Color more closely approximates the requested color, the error graph dynamically changes scale to provide a higher resolution graph of the error correction. Similarly, the scales of the other graphs automatically update to graph only the range of values currently displayed. When run is selected, the monitor renders the arrow icon in gray to indicate that the monitor is running. See Figure 2-4.

Figure 2-4. Running Monitor Showing the Three Graphs Actively Charting
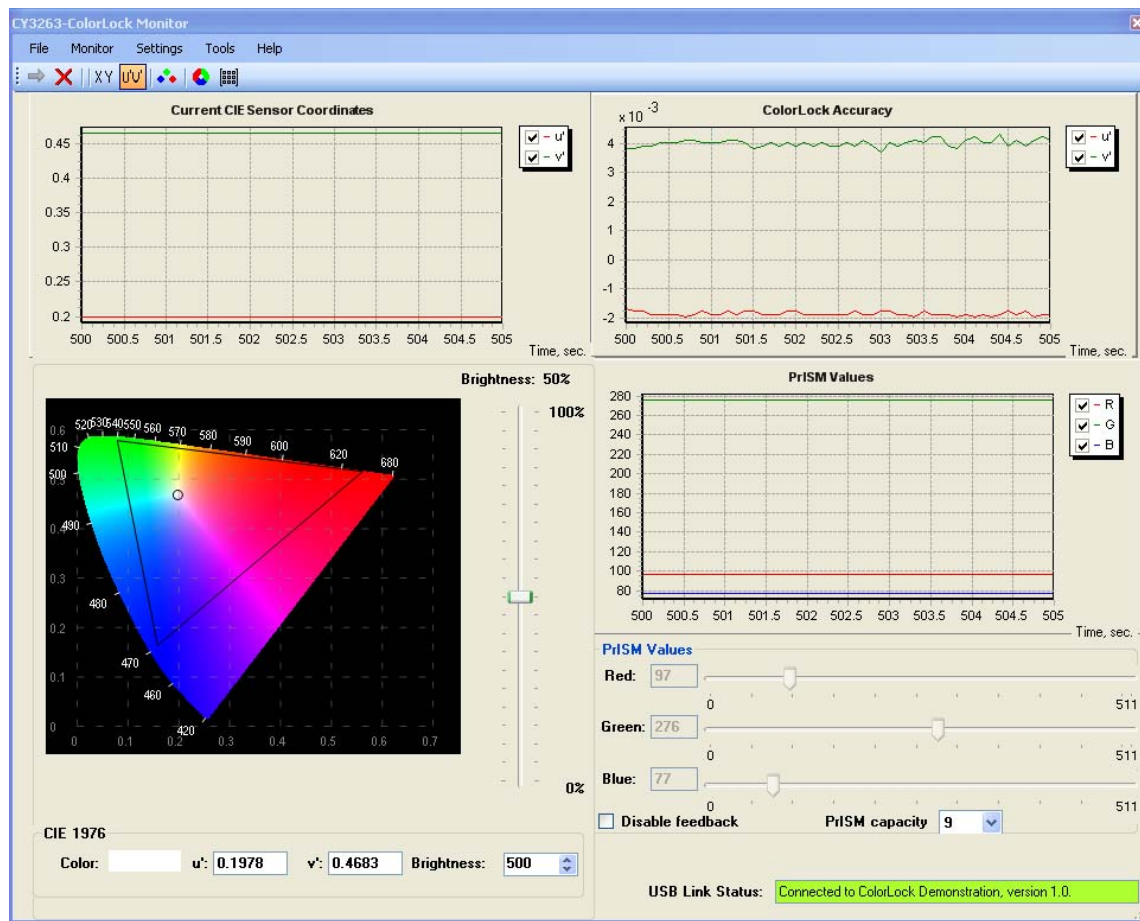
The manual control sliders in the bottom right pane are enabled if the Disable feedback checkbox is checked, otherwise they are set automatically, based upon the current CIE color coordinate and the color-lock firmware on the ColorLock unit. If Disable feedback is checked, the Red, Green and Blue sliders become active. Simultaneously, all ColorLock related controls, including the graphs and the CIE related controls, become inactive. The LEDs are controlled by setting the PrISM values directly using the slider for each LED so ColorLock functionality no longer applies. See Figure 2-5.

Figure 2-5. Feedback Disabled
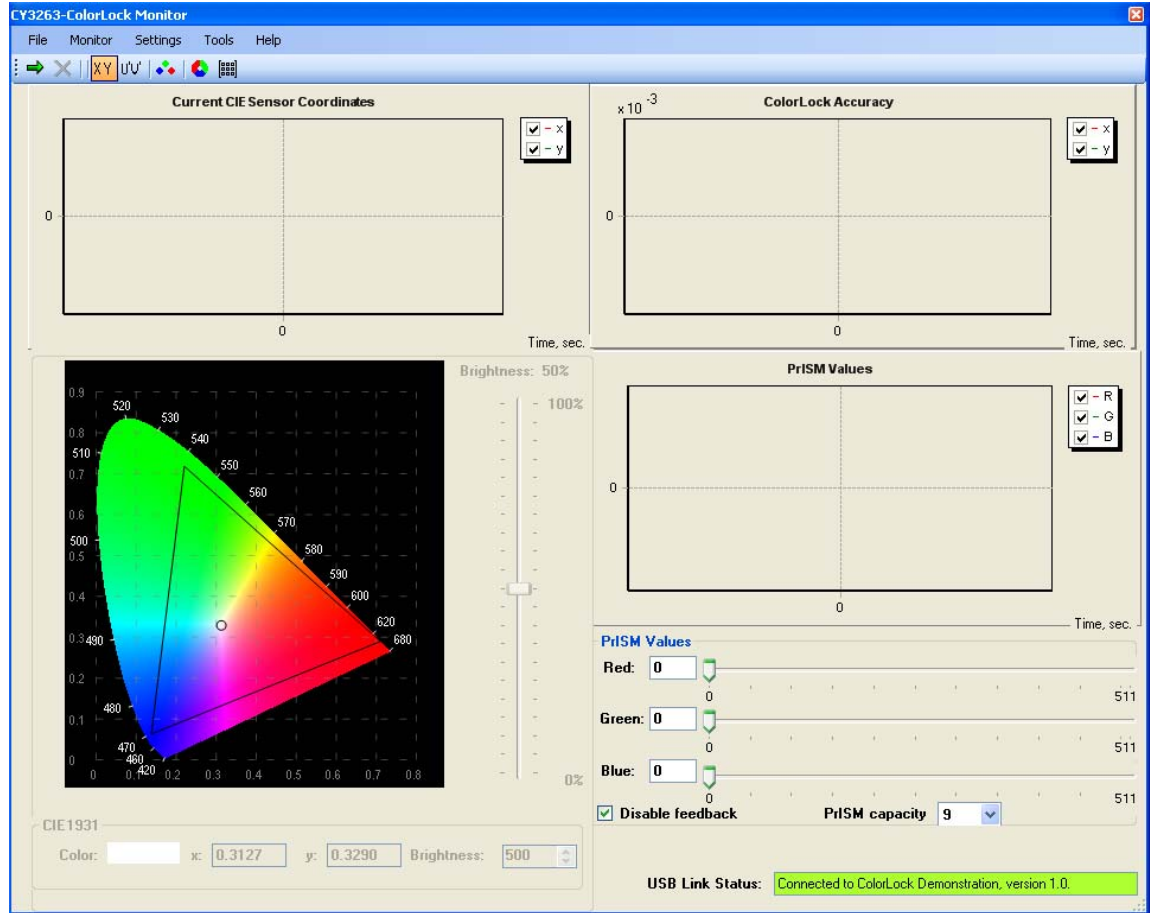
2.3.2 Toolbar Icons and Menubar Options

The ColorLock monitor application can be controlled using the toolbar icons or by using menu bar options. Both provide the complete set of control options available in the monitor. This section describes each icon and the corresponding menu-bar selection. In the descriptions that follow, each icon is shown, followed by the corresponding menu selection path on the menu bar, followed by a description of the use and function of the control.

(Monitor → Run) When selected, this icon starts the monitor. The charts begin displaying real-time information about the current state of the ColorLock unit. Once selected, the Run control is rendered inactive and is "grayed out," as the monitor is now running.

(Monitor → Stop) This control stops the monitor. All charting stops, but the graphical information recorded in the charts is preserved. Once selected, the Stop control is rendered inactive and is "grayed out," as the monitor is now stopped.

(Settings → ColorSpace → CIE1931) This icon causes the monitor to use CIE 1931 color coordinates. This is the default coordinate system when the monitor is started. When selected, the CIE 1931 color chart is displayed in the lower left pane and the charts display data using the x, y coordinate values used in the CIE 1931 coordinate system.

(Settings → ColorSpace → CIE1976) This icon causes the monitor to use CIE 1976 color coordinates. When selected, the CIE 1976 color chart is displayed in the lower left pane and the charts display data using the u', v' coordinate values used in the CIE 1976 coordinate system.

(Settings → LED Color Coordinates) This icon results in a pop-up menu that shows the current CIE 1931 x, y coordinates for the LEDs being used in the ColorLock unit. These values represent the primary colors that define the color gamut being displayed by the ColorLock unit. The values in this window are measured from the existing LEDs on the board. New values can be entered, which will only change the color gamut in the window, it does not change the capability of the LEDs to create different colors. In general there is no reason to change these settings unless the LED board in the ColorLock unit is being changed. If the system is calibrated using the calibration tool, these values will be overwritten with the new gamut information.

(Tools → Calibration) This control results in a pop-up menu that allows for the calibration of the ColorLock unit's optical feedback system. Each of the sensor's three color channels must be calibrated with values obtained from an external color meter. The first menu displayed calibrates the red color channel of the sensor, the second menu the green channel, and the third menu the blue sensor. Each menu requires three color values from the color meter, corresponding to the red, green and blue components for the given channel. Upon completion, the monitor sends the calibration information to the ColorLock unit, where it is stored. The calibration information is stored in non-volatile flash, unless the contents of flash memory is overwritten.

(Tools → Show Calibration Matrices) This control results in a pop-up window that displays the values of the current calibration matrices. The values shown cannot be changed using this window, only the calibration menu can change the values of the three matrices displayed. The ColorLock firmware uses the contents of these matrices to transform the current sensor readings into PrISM values for each of the three LEDs. For more calibration information for this system, refer to Application Note 44533 ColorLock Optical Feedback for EZ-Color.

(Help → About) This menubar selection results in a pop-up window that displays the application version and copyright information. Clicking the OK button closes the About window.

2.3.3   Error Messages

There are several situations that will result in error windows being displayed. These result from situations where the monitor cannot communicate with the ColorLock unit and are related to situations where the monitor needs to read or change matrix values on the unit. Figure 2-6 shows the result of attempting to show the calibration matrix values when the ColorLock unit is not attached.

Figure 2-6. Error Reading Calibration Matrices
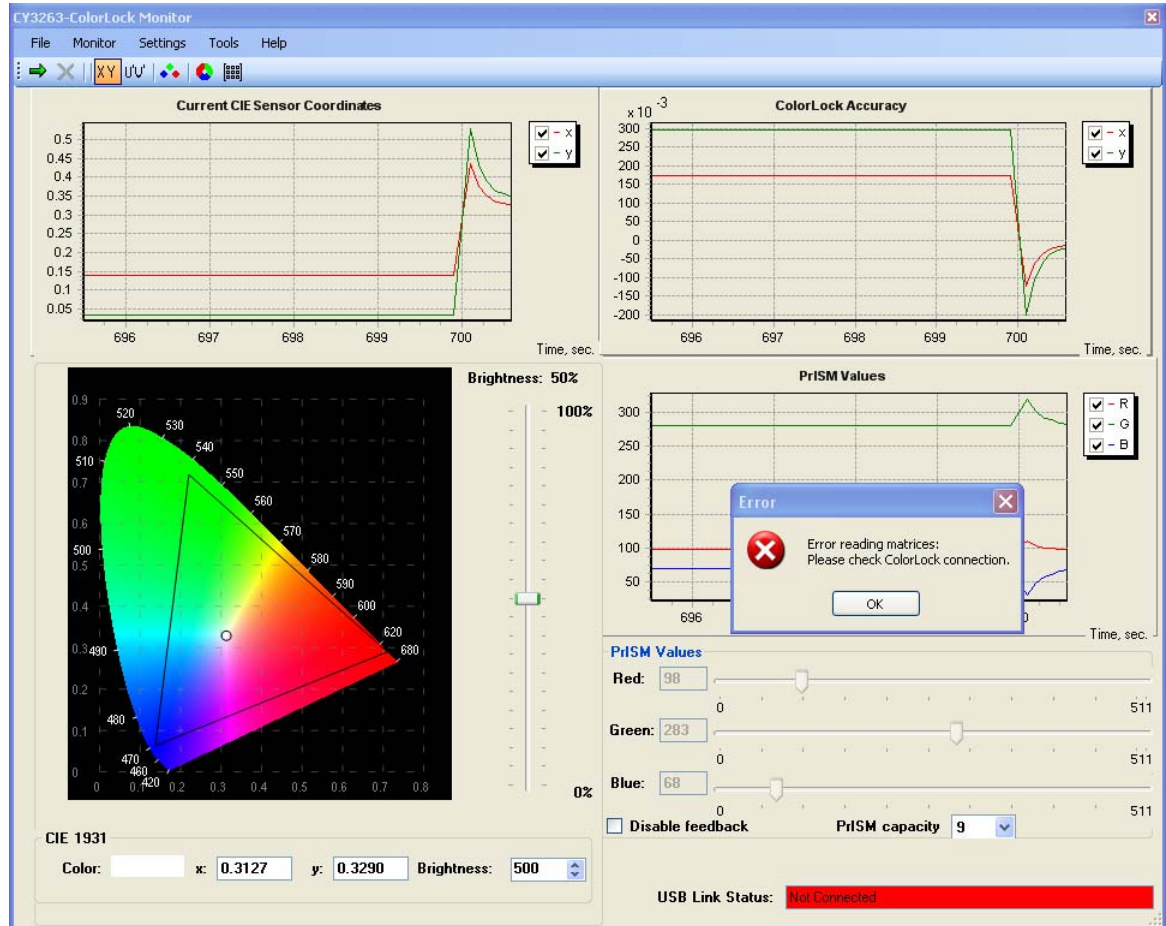
A similar error occurs if sensor calibration is attempted without an attached ColorLock unit. See Figure 2-7. If this error occurs, the ColorLock unit can be attached and the calibration values are retained so that the calibration can be completed without entering the values again.

Figure 2-7. Calibration Failure

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A
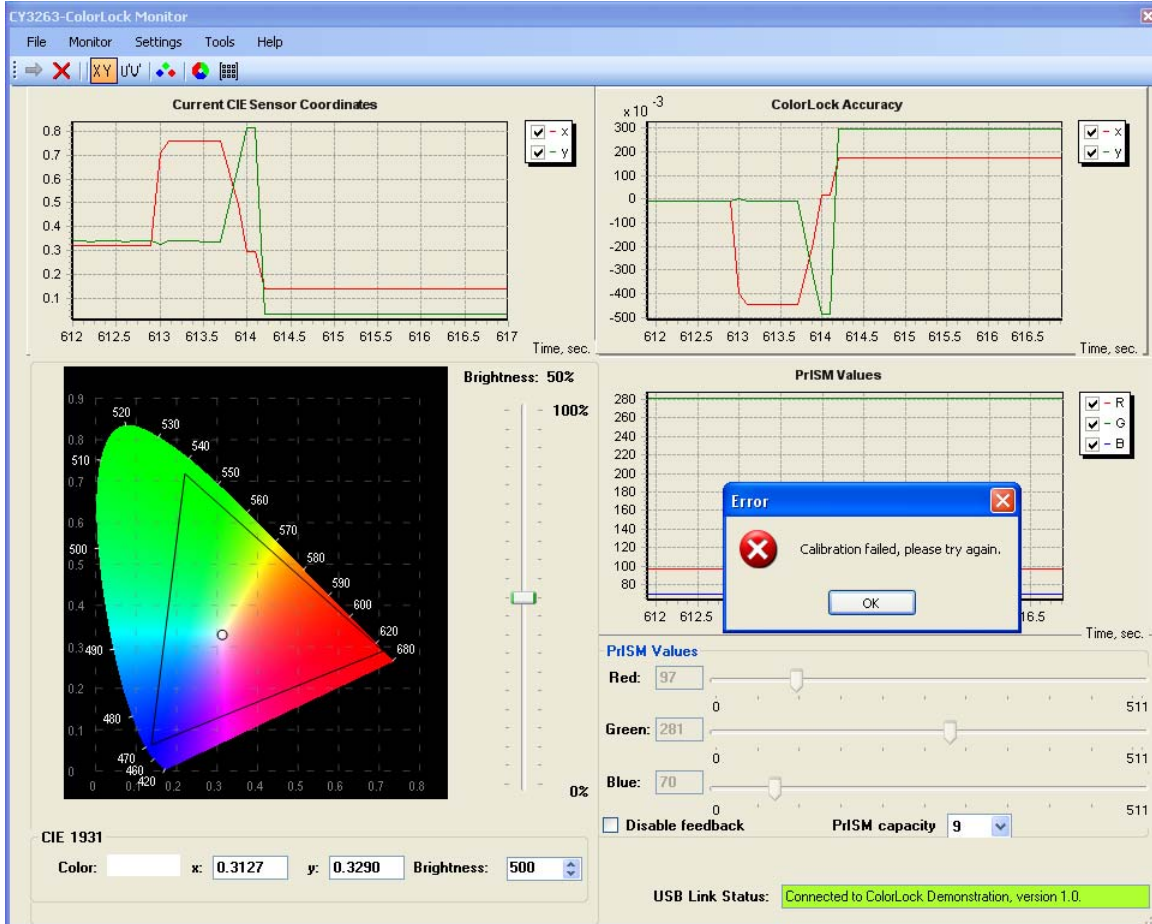
2.3.4   Dynamic Update

The ColorLock evaluation board has two buttons that allow the board to be demonstrated without using this application. One button is used to turn the LEDs on and off. The second button is used to cycle between seven preset colors. At any time the user can use the buttons to control the evaluation board.

2.3.5   Shutting Down the Application

Select **Exit** from the **File** menu to close the ColorLock Monitor application.

2.3.6   Reset the Board to the Original Factory Programming

Follow these steps if you wish to reset the board to the original factory installed programming:

1. Locate the *CY3263-ColorLock CY8CLED16.hex* file on the ColorLock CD included with this kit, it is in the following directory:

   ```
   D:\Firmware\Hex Files\CY3263-ColorLock CY8CLED16.hex
   ```

2. To reset the board to the factory conditions, connect your computer to the Color-Lock main board ISSP Connector (J4) using the PSoC MiniProg and a USB cable.

3. Open **PSoC Programmer** by going to the **Windows Start** menu → **All Programs** → **Cypress MicroSystems** → **PSoC Programming** → **PSoC Programmer**

4. Click **File Load**, navigate to, and open the *cy3263-ColorLock CY8CLED16.hex* file.

5. From the Device Family menu, select **CY8CLED16**.

6. From the Device menu, select **CY8CLED16-48LFXI**.

7. Click **Program**. "Programming Succeeded..." appears in the Actions pane when programming is complete.
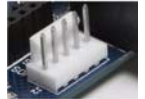
3. Tuner Project

WARNING: HIGH BRIGHTNESS LEDs CAN CAUSE PERMANENT EYE DAMAGE!

Do not look at the LEDs if they are not covered by the protective enclosure. The LEDs illuminate at a very high intensity and can cause permanent eye damage if they are viewed without the protective enclosure.

3.1   Description

This project creates firmware that color mixes three primary high-brightness LEDs to a specific color and introduces optical feedback into the system using a color sensor.

The user can then choose the Tuner to select other desired colors mapped along the 1931 CIE XYZ Color Space.

The tuner enables turning ON/OFF the LEDs and adjusting the resultant flux output, over an I2C interface. By default, the firmware will automatically generate a single color output within the defined color gamut.

The project utilizes five different Interface (Communication) Valuators. Each set a specific register which can be modified using the available tuner. The LEDEnable controls the 3LED ColorLock Driver, the LEDTrigger controls the optical feedback loop, the LEDBrightness valuator controls a set flux value and the final two valuators set the specific color. In turn, the 3-LED ColorLock Driver controls the LM3404 Switching Regulators to power the LEDs.

3.2   EZ-Color Device

CY8CLED16, 48-Pin MLF

3.3   Start a New Project

1. Select **File → New Project**.
2. Name the project **Tuner**.
3. If needed, click **Browse** to save the project in a different location.
4. Click **OK**.
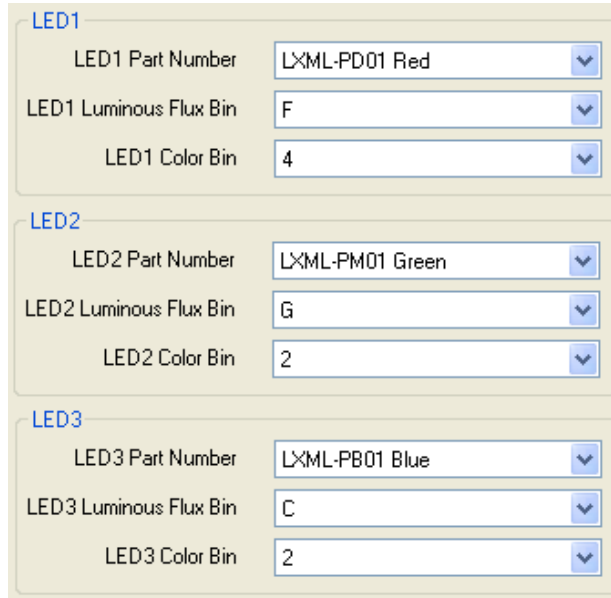
3.4　Add an Output Driver

Table 3-1. Luxeon Rebel® with LM3402

Driver/Valuator	Lumileds™ Luxeon® Rebel 3-LED Color Mixing Driver with Color-Lock™ Closed Loop Optical Feedback and LM3402 External Constant Current Source **Note**: When you click OK to close the Add Output Driver window, the ColorLock (Luxeon Rebel® with LM3402) Properties window opens.		
Location	Outputs Tab ↳ High Brightness LED 　↳ 3-LED Color Mixing 　　↳ ColorLock™ Optical Feedback 　　　↳ Lumileds™ 　　　　↳ Luxeon® Rebel, 350mA 　　　　　↳ Luxeon Rebel® with LM3402		
Properties	**Field**	**User Input**	
	Name	ColorLock	
	ClockFrequency	20000	(Default)
	Color Space	1931 XYZ Color Space	(Default)
	LED1 Part Number	LXML-PD01 Red	(Default)
	LED2 Part Number	LXML-PM01 Green	(Default)
	LED3 Part Number	LXML-PB01 Blue	(Default)
	LED1 Luminous Flux Bin	G	(Default)
	LED2 Luminous Flux Bin	G	(Default)
	LED2 Luminous Flux Bin	G	(Default)
	LED1 Color Bin	1	(Default)
	LED2 Color Bin	1	(Default)
	LED3 Color Bin	1	(Default)
	Expose Tuning Values	Yes	(Default)

1. The ColorLock (Luxeon Rebel® with LM3402) Properties window opens. Set the following values:

■　Set LED1 Luminous Flux Bin to **F**, and the LED1 Color Bin to **4**.

■　Set LED2 Luminous Flux Bin to **G**, and the LED2 Color Bin to **2**.

■　Set LED3 Luminous Flux Bin to **C**, and the LED3 Color Bin to **2**.

Figure 3-1. LED Settings in the ColorLock (Luxeon® Rebel with 3402) Properties Window

2. Click **OK** when finished.

3.5   Add Five Interface Valuators

Note: These steps must be performed in the Add Valuator dialog box that appears when the Discrete Interface Valuator is initially placed in the design.

Table 3-2. Discrete Interface Valuator

Driver/Valuator	Discrete	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Discrete	
Properties	**Field**	**User Input**
	Name	LEDEnable
	Default Value	0x1
	States	(Default)

Table 3-3. Continuous Interface Valuator

Driver/Valuator	Continuous	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Continuous	
Properties	**Field**	**User Input**
	Name	LEDBrightness
	Min	-32767 (Default)
	Max	32767 (Default)
	Scale	1 (Default)
	Default Value	750

Table 3-4. Discrete Interface Valuator

Driver/Valuator	Discrete	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Discrete	
Properties	**Field**	**User Input**
	Name	LEDTrigger
	Default Value	0x1
	States	(Default)

Table 3-5. Continuous Interface Valuator

Driver/Valuator	Continuous	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Continuous	
Properties	**Field**	**User Input**
	Name	xValuator
	Min	-32767 (Default)
	Max	32767 (Default)
	Scale	1 (Default)
	Default Value	2000

Table 3-6. Continuous Interface Valuator

Driver/Valuator	Continuous	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Continuous	
Properties	**Field**	**User Input**
	Name	yValuator
	Min	-32767 (Default)
	Max	32767 (Default)
	Scale	1 (Default)
	Default Value	2000

3.6   Define Output Behavior

1. Right-click the **ColorLock** driver icon and select **Transfer Function**.
2. Set the following fields:
    - Set Enable to **LEDEnable**
    - Set Target x to **xValuator**
    - Set Target y to **yValuator**
    - Set Relative Flux to **LEDBrightness**
    - Set ColorLock Trigger to **LEDTrigger**

Figure 3-2. ColorLock Transfer Function Window
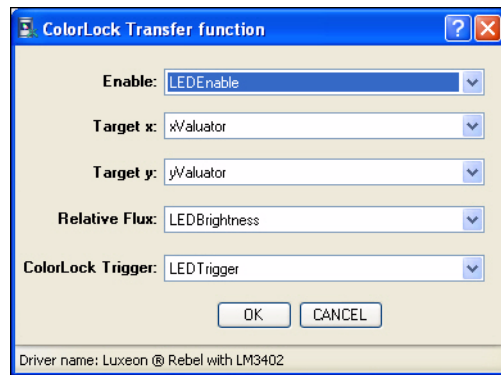
3. Click **OK** when done.

3.7　Add an Interface Driver

Table 3-7. Slave Driver

Driver/Valuator	I2C Slave Interface	
Location	Interfaces Tab ↳ Communication 　↳ I2C 　　↳ Slave	
Properties	**Field**	**User Input**
	Name	Interface1
	I2C_Address	4　　　　　(Default)

With a little rearranging, your workspace should look like the example below.

Figure 3-3. Tuner Project Design View Pane
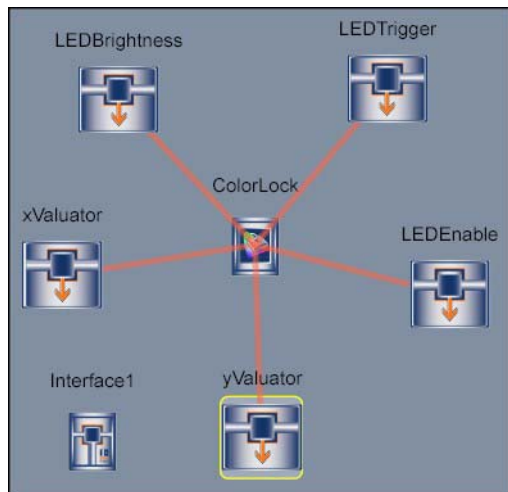
3.8　Build project

3.8.1　Build the Project

1. Select **Build → Generate\Build 'Tuner' Project**.
2. In the Available Device Configurations pane, select **CY8CLED16 → CY8CLED16, 48-Pin MLF**.
3. In the Device Configurations Properties pane, set the following parameters:
   - Sample Rate　→　8 Hz
   - Flash Interface　→　Enable
4. Ensure the **Assign pins automatically** check box is **not** selected.
5. Click **Next**.
6. In the User Pin Assignment window, click **Unassign All Pins**.

7. Assign drivers to pins by dragging and dropping the blue rectangles from the Unassigned Drivers list to the pins listed in the following table.

> **WARNING: Assign pins in the order listed in Table 3-8**. Assign drivers according to the Order of Assignment column in Table 3-8, not the order of appearance in the User Pin Assignment window.

Table 3-8. Tuner Pinouts

Order of Assignment	Order of Appearance	Function	Pin	Notes
0	0	ColorLock_ColorSensor	Port 2_5	
1	7	TCS230SHARED_0 S0	Port 2_0	←The these four drivers are assigned automatically when the ColorLock_ColorSensor driver is assigned. You must reassign them before assigning the rest of the pins.
2	8	TCS230SHARED_0 S1	Port 2_1	
3	9	TCS230SHARED_0 S2	Port 2_2	
4	10	TCS230SHARED_0 S3	Port 2_3	
5	1	ColorLock_Dim1	Port 1_2	
6	2	ColorLock_Dim2	Port 1_3	
7	3	ColorLock_Dim3	Port 1_4	
8	4	ColorLock_Enable	Port 4_0	
9	6	Interface1 I2CSDAPin	Port 1_5	←The I2CSCLPin driver is assigned automatically when the I2CDAPPin driver is assigned.
10	5	Interface1 I2CSCLPin	Port 1_7	

Figure 3-4. Tuner Pinout Diagram

8. Select **Lock Pins**, and click **Next**. PSoC Express builds your project.

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A

31
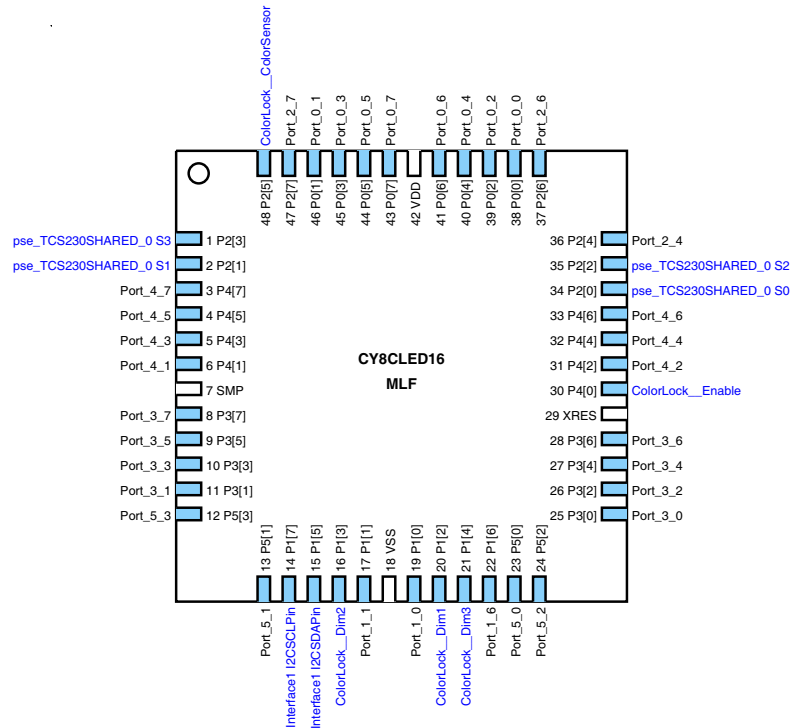
3.9   Program the EZ-Color Part

1. Disconnect any power sources from the evaluation board and connect the MiniProg to your PC using a USB cable.

2. Connect the Miniprog to the 5-pin ISSP header.

3. Program the part via J1 as described in the Program Parts with PSoC Express Projects section on page 11.

3.10   Tune Your Project

1. Apply power to the board using the supplied wall adapter.

2. Connect the board to your PC via a USB cable.

3. Select **Monitor** in PSoC Express.

Figure 3-5. PSoC Express Monitor Pane
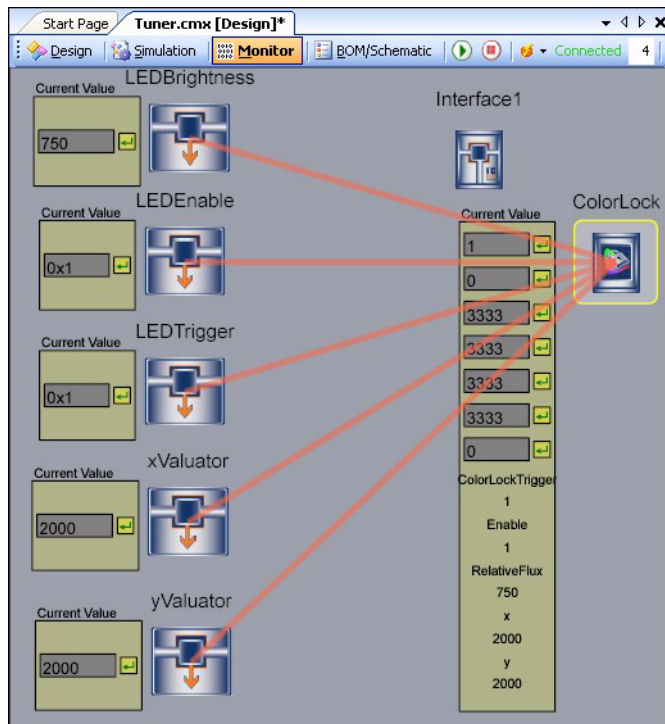
4. Click **Play** . The Monitor toolbar will change from Connected , to Running .

5. Right-click on the **ColorLock** driver icon and select **Show Tuner**.

Figure 3-6. ColorLock (Luxeon® Rebel with LM3402) Tuner
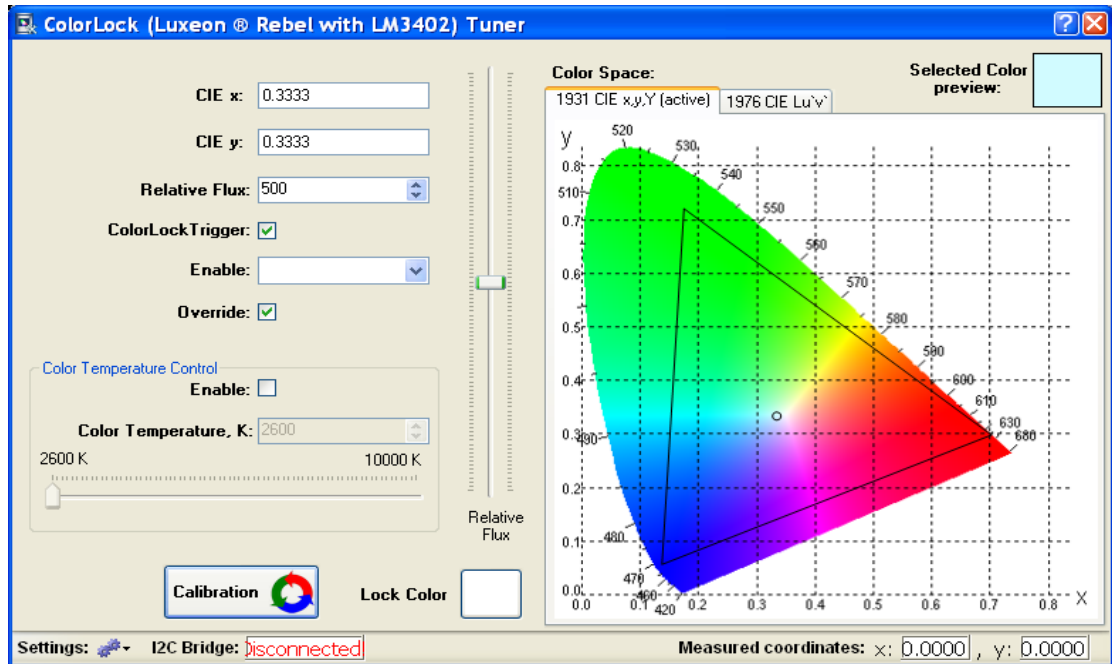
3.11 Calibrate the LEDs

1. Select **Calibration**.
2. Select **Set LED1 to Maximum**.
3. Select **Set LED2 to Maximum**.
4. Select **Set LED3 to Maximum**.
5. Select **Calibrate**.
6. Select **OK** to reenter Tuner.
7. Adjust the brightness of the LED using the slider and turn the LED on and off.
8. Enter coordinates directly into the x and y fields.
9. Click directly within color gamut.
10. Click **Lock Color**.
11. Click any other point inside color gamut and watch optical feedback response.

4.   Traffic Light Project

WARNING: HIGH BRIGHTNESS LEDs CAN CAUSE PERMANENT EYE DAMAGE!

Do not look at the LEDs if they are not covered by the protective enclosure. The LEDs illuminate at a very high intensity and can cause permanent eye damage if they are viewed without the protective enclosure.

4.1   Description

This project creates firmware that color mixes three primary high-brightness LEDs to the three cycled colors found in a traffic light and introduces optical feedback into the system using a color sensor.

The user can then choose the Tuner to select other desired colors mapped along the 1931 CIE XYZ Color Space.

The tuner enables turning ON/OFF the LEDs and adjusting the resultant flux output, over an I2C interface. By default, the firmware will automatically generate a red, green, and yellow color inside the defined color gamut. The LCD display will generate text dependent on the state the program is in.

The project utilizes three different Interface (Communication) Valuators. Each set a specific register which can be modified using the available tuner. The LEDEnable controls the 3LED ColorLock Driver, the LEDTrigger controls the optical feedback loop and the LEDBrightness valuator controls a set flux value. Also utilized are two priority encoders to cycle through the traffic signal colors based on x,y coordinates in the 1931 CIE XYZ Color Space. Next, the program contains a timing element and three different priority encoders that feed a state machine. This timing element controls the length of time Red, Green, and Yellow are displayed. Finally, the 3-LED ColorLock Driver controls the LM3404 Switching Regulators to power the LEDs.

4.2   EZ-Color Device

CY8CLED16, 48-Pin MLF

4.3   Start a New Project

1.   Select **File** → **New Project**.
2.   Name the project **TrafficLight**.
3.   If needed, click **Browse** to save the project in a different location.
4.   Click **OK**.
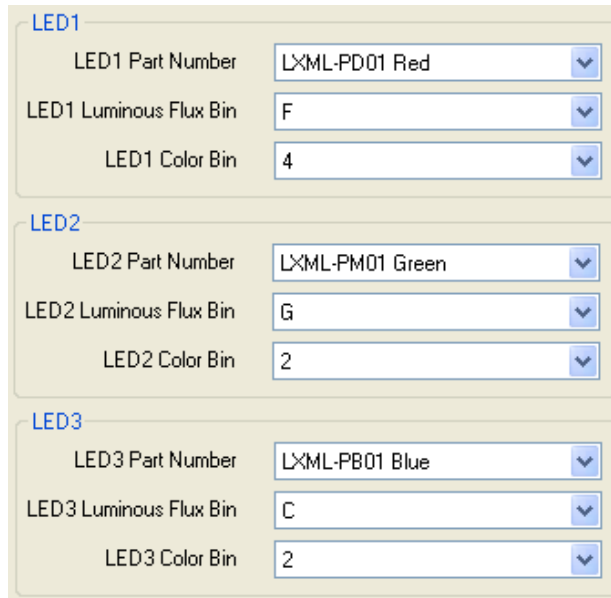
4.4　Add an Output Driver

Table 4-1. Luxeon Rebel® with LM3402

Driver/Valuator	Lumileds™ Luxeon® Rebel 3-LED Color Mixing Driver with Color-Lock™ Closed Loop Optical Feedback and LM3402 External Constant Current Source **Note**: When you click OK to close the Add Output Driver window, the ColorLock (Luxeon Rebel® with LM3402) Properties window opens.	
Location	Outputs Tab ↳ High Brightness LED 　　↳ 3-LED Color Mixing 　　　　↳ ColorLock™ Optical Feedback 　　　　　　↳ Lumileds™ 　　　　　　　　↳ Luxeon® Rebel, 350mA 　　　　　　　　　　↳ Luxeon Rebel® with LM3402	
Properties	**Field**	**User Input**
	Name	ColorLock
	ClockFrequency	20000　　　　　　　(Default)
	Color Space	1931 XYZ Color Space　(Default)
	LED1 Part Number	LXML-PD01 Red　　　(Default)
	LED2 Part Number	LXML-PM01 Green　　(Default)
	LED3 Part Number	LXML-PB01 Blue　　　(Default)
	LED1 Luminous Flux Bin	G　　　　　　　　　(Default)
	LED2 Luminous Flux Bin	G　　　　　　　　　(Default)
	LED2 Luminous Flux Bin	G　　　　　　　　　(Default)
	LED1 Color Bin	1　　　　　　　　　(Default)
	LED2 Color Bin	1　　　　　　　　　(Default)
	LED3 Color Bin	1　　　　　　　　　(Default)
	Expose Tuning Values	Yes　　　　　　　　(Default)

1. The ColorLock (Luxeon Rebel® with LM3402) Properties window opens. Set the following values:

   ■ Set LED1 Luminous Flux Bin to **F**, and the LED1 Color Bin to **4**.

   ■ Set LED2 Luminous Flux Bin to **G**, and the LED2 Color Bin to **2**.

   ■ Set LED3 Luminous Flux Bin to **C**, and the LED3 Color Bin to **2**.

Figure 4-1. LED Settings in the ColorLock (Luxeon® Rebel with 3402) Properties Window

2. Click **OK** when finished.

4.5   Add Three Interface Valuators

Note: These steps must be performed in the Add Valuator dialog box that appears when the Discrete Interface Valuator is initially placed in the design.

Table 4-2. Discrete Interface Valuator

Driver/Valuator	Discrete	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Discrete	
Properties	**Field**	**User Input**
	Name	LEDEnable
	Default Value	0x1
	States	(Default)

Table 4-3. Continuous Interface Valuator

Driver/Valuator	Continuous	
Location	Valuators Tab ↳ Interface (Communication) Valuators 　　↳ Continuous	
Properties	**Field**	**User Input**
	Name	LEDBrightness
	Min	-32767　　　　　　　　　　(Default)
	Max	32767　　　　　　　　　　(Default)
	Scale	1　　　　　　　　　　　　(Default)
	Default Value	1000

Table 4-4. Discrete Interface Valuator

Driver/Valuator	Discrete	
Location	Valuators Tab ↳ Interface (Communication) Valuators 　　↳ Discrete	
Properties	**Field**	**User Input**
	Name	LEDTrigger
	Default Value	0x1
	States	(Default)

4.6　　　Add Three Transfer Function Valuators

Note: These steps must be performed in the Add Valuator dialog box that appears when the Discrete Interface Valuator is initially placed in the design.

4.6.1　　Add the TrafficState StateMachine Transfer Function Valuator

Table 4-5. StateMachine Valuator

Driver/Valuator	StateMachine	
Location	Valuators Tab ↳ Transfer Function Valuators 　　↳ StateMachine	
Properties	**Field**	**User Input**
	Name	TrafficState

1. In the State Machine Transfer Function TrafficState window:
    a. Click **Add State**, set the Name to **Red**, and click **OK**.
    b. Click **Add State**, set the Name to **Green**, and click **OK**.
    c. Click **Add State**, set the Name to **Yellow**, and click **OK**.

Figure 4-2. State Machine Transfer Function TrafficState Window
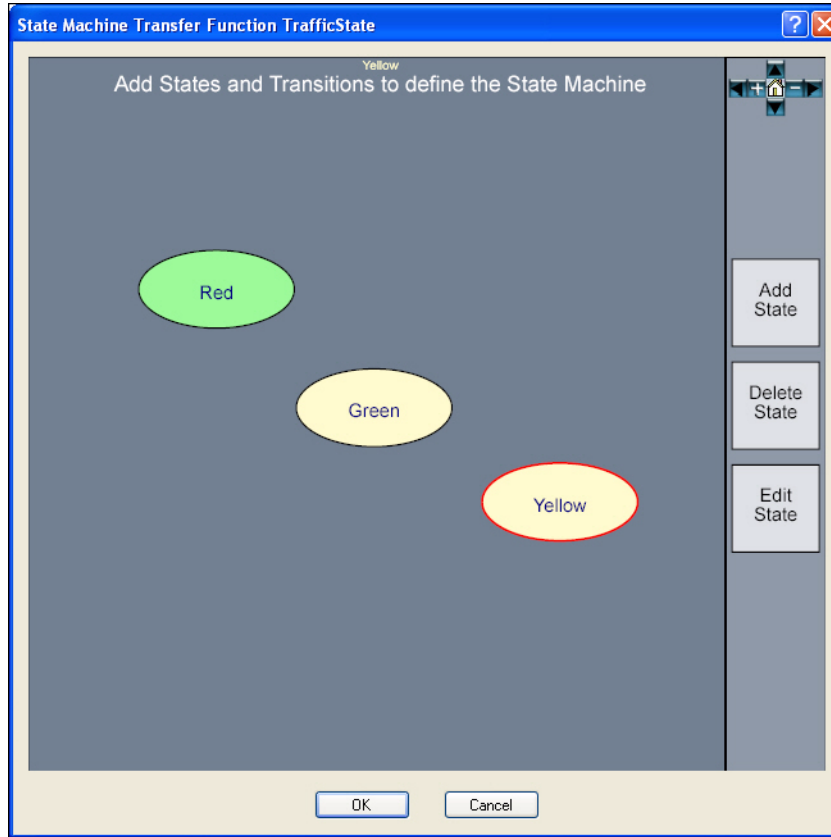
2. Click **OK** to close State Machine Window.

4.6.2   Add the xValuator Priority Encoder Transfer Function Valuator

Table 4-6. Priority Encoder Valuator

Driver/Valuator	Priority Encoder	
Location	Valuators Tab ↳ Transfer Function Valuators ↳ PriorityEncoder	
Properties	**Field**	**User Input**
	Name	xValuator

1. The Priority Encoder Transfer Function - xValuator window opens. Set the If/Else statements to the values in Table 4-7.

Table 4-7. xValuator Priority Encoder Transfer Function Values

Else/If	Then xValuator =
TrafficState_state==TrafficState_state__Green	2000
TrafficState_state==TrafficState_state__Red	6800
TrafficState_state==TrafficState_state__Yellow	5300

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A   39

2. Select **Continuous**.

Figure 4-3. Priority Encoder Transfer Function - xValuator Window

3. Click **OK**.

4.6.3 Add the yValuator Priority Encoder Transfer Function Valuator

Table 4-8. Priority Encoder Valuator

Driver/Valuator	Priority Encoder	
Location	Valuators Tab ↳ Transfer Function Valuators ↳ PriorityEncoder	
Properties	**Field**	**User Input**
	Name	yValuator

1. The Priority Encoder Transfer Function - yValuator window opens. Set the If/Else statements to the values in Table 4-9.

Table 4-9. yValuator Priority Encoder Transfer Function Values

Else/If	Then yValuator =
TrafficState_state==TrafficState_state__Green	5000
TrafficState_state==TrafficState_state__Red	3000
TrafficState_state==TrafficState_state__Yellow	4200

2. Select **Continuous**.

Figure 4-4. Priority Encoder Transfer Function - yValuator Window
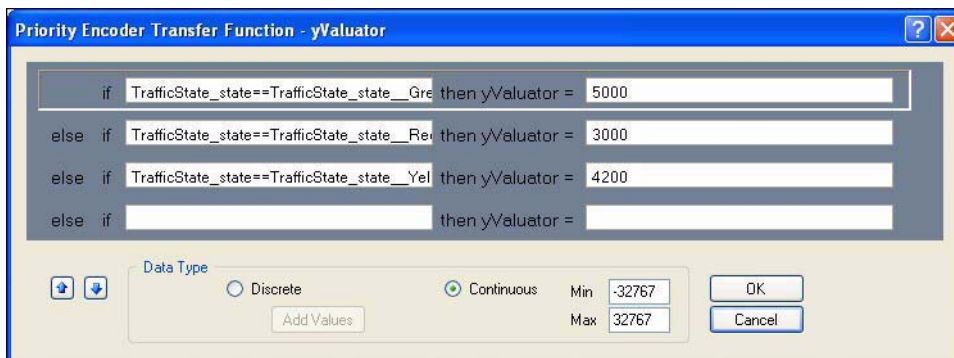
3. Click **OK**.

4.7 Add an Input Driver

Table 4-10. Interval Generator Driver

Driver/Valuator	Interval Generator	
Location	Inputs Tab ↳ Timing ↳ Interval Generator	
Properties	**Field**	**User Input**
	Name	Count100ms
	IntervalTime	100 (Default)
	IntervalMode	PULSE (Default)

4.8 Add Three Valuators

4.8.1 Add the RedCount PriorityEncoder Transfer Function Valuator

Table 4-11. PriorityEncoder Valuator

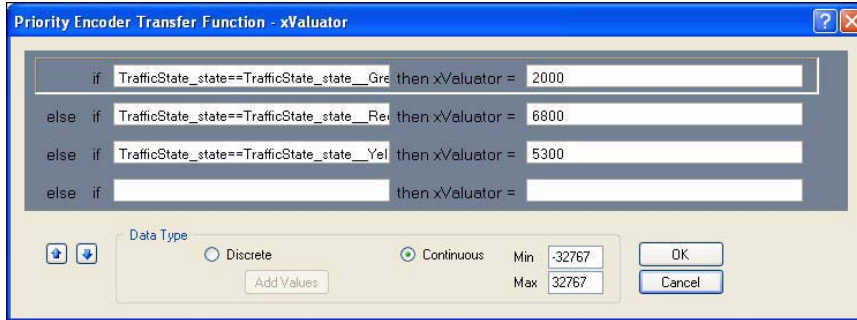| Driver/Valuator	Priority Encoder	
Location	Valuators Tab ↳ Transfer Function Valuators ↳ PriorityEncoder	
Properties	**Field**	**User Input**
	Name	RedCount

1. The Priority Encoder Transfer Function - RedCount window opens. Set the If/Else statements to the values in Table 4-12.

Table 4-12. RedCount Priority Encoder Transfer Function Values

Else/If	Then RedCount =
(TrafficState_state==TrafficState_state__Red) && (Count100ms==Count100ms__Triggered)	RedCount+1
TrafficState_state!=TrafficState_state__Red	0

Figure 4-5. Priority Encoder Transfer Function - RedCount
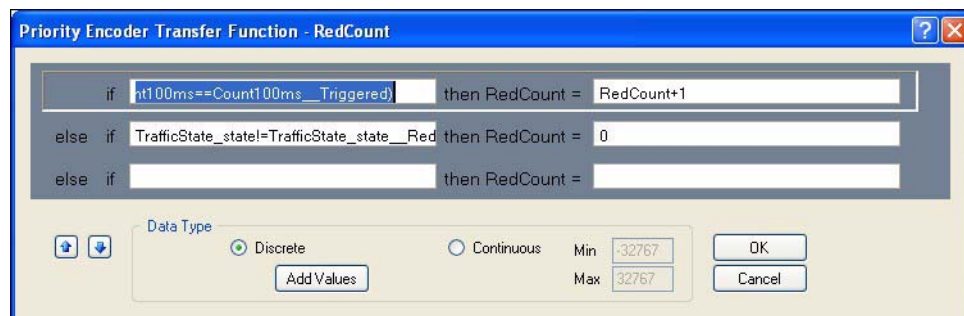
2. Click **OK** when finished.

4.8.2 Add the GreenCount PriorityEncoder Transfer Function Valuator

Table 4-13. PriorityEncoder Valuator

Driver/Valuator	Priority Encoder	
Location	Valuators Tab ↳ Transfer Function Valuators ↳ PriorityEncoder	
Properties	**Field**	**User Input**
	Name	GreenCount

1. The Priority Encoder Transfer Function - GreenCount window opens. Set the If/Else statements to the values in Table 4-14.

Table 4-14. GreenCount Priority Encoder Transfer Function Values

Else/If	Then GreenCount =
(TrafficState_state==TrafficState_state__Green) && (Count100ms==Count100ms__Triggered)	GreenCount+1
TrafficState_state!=TrafficState_state__Green	0

Figure 4-6. Priority Encoder Transfer Function - GreenCount

2. Click **OK** when finished.

4.8.3 Add the YellowCount PriorityEncoder Transfer Function Valuator

Table 4-15. PriorityEncoder Valuator

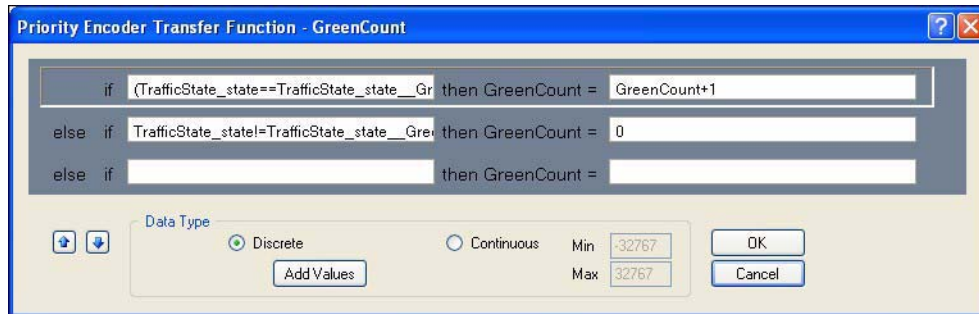| Driver/Valuator	Priority Encoder	
Location	Valuators Tab ↳ Transfer Function Valuators 　↳ PriorityEncoder	
Properties	**Field**	**User Input**
	Name	YellowCount

1. The Priority Encoder Transfer Function - YellowCount window opens. Set the If/Else statements to the values in Table 4-16.

Table 4-16. YellowCount Priority Encoder Transfer Function Values

Else/If	Then YellowCount =
(TrafficState_state==TrafficState_state__Yellow) && (Count100ms==Count100ms__Triggered)	YellowCount+1
TrafficState_state!=TrafficState_state__Yellow	0

Figure 4-7. Priority Encoder Transfer Function - YellowCount
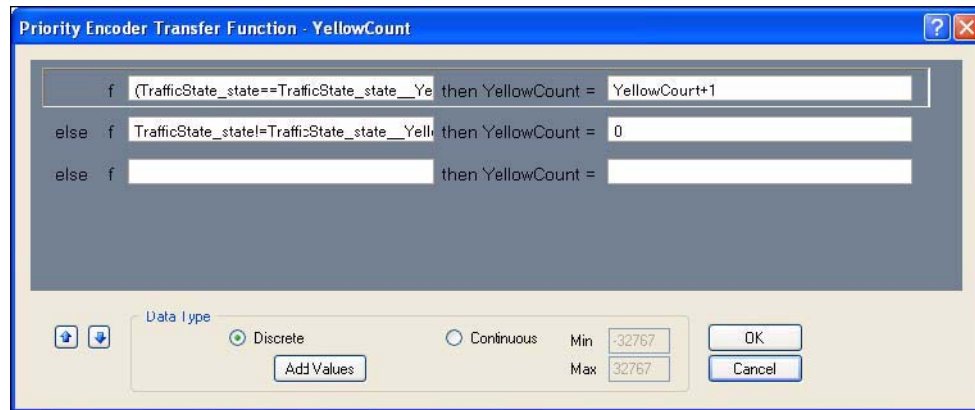
2. Click **OK** when finished.

4.9 Add an Output Driver

Table 4-17. LCD Selectable Scrolling Text - Full Line

Driver/Valuator	LCD Selectable Scrolling Text – Full Line	

Location	Outputs Tab
	↳ Display
	    ↳ LCD
	        ↳ LCD Selectable Scrolling Text - Full Line	

Properties	**Field**	**User Input**
	Name	LCDText
	Initial Value	No_Text (Default)
	Row Location	Row 0 (Default)
	Text 1	Stop
	Text 2	Go
	Text 3	Slow Down!
	Text 4	(Leave Blank)
	Text 5	(Leave Blank)
	Text 6	(Leave Blank)
	Text 7	(Leave Blank)
	Step_time	100 (Default)

4.10 Define Output Behavior

1. Right-click on the **LCD Text** driver icon and select **Transfer Function**.
2. Select **TableLookup** in the list of transfer functions, and click **OK**.
3. Select **TrafficState_state** in the Select Input(s) list.
4. Click **Next**.
5. Drag the TrafficState_state Input values to the following LCD state columns:
   - Red   →   Text1
   - Green   →   Text2
   - Yellow   →   Text3

Figure 4-8. TrafficLight Table Lookup

6. Click **OK**.

    CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A

4.11 Add State Machine Transitions

4.11.1 Add the Red State Machine Transition

1. Right-click on the **TrafficState** driver icon and select **Transfer Function**.
2. Right-click **Red** and select **Edit**.
3. Click **Add**.
4. In the Name field, enter **RedGreen**.
5. In the Expression field, enter **RedCount>=50**.
6. Set Transition From field to **Red**, and Transition To field to **Green**.
7. Click **OK** to close the Add Transition window.

Figure 4-9. Add Transition Window
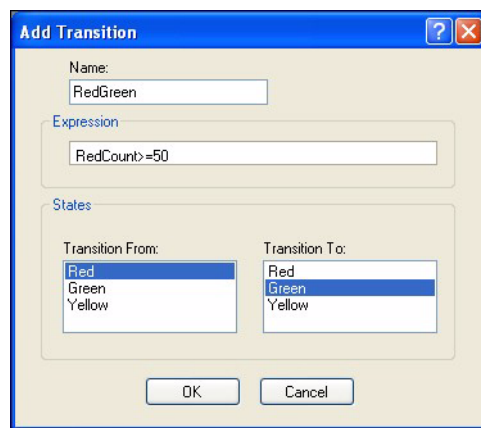
8. Click **OK** to close the Add State window.

4.11.2 Add the Green State Machine Transition

1. Right Click **Green** and select **Edit**.
2. Click **Add**.
3. In the Name field, enter **GreenYellow**.
4. In the Expression field, enter **GreenCount>=50**.
5. Set Transition From field to **Green**, and Transition To field to **Yellow**.
6. Click **OK** to close the Add Transition window.

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A

Figure 4-10. Add Transition Window

7. Click **OK** to close the Add State window.

4.11.3   Add the Yellow State Machine Transition

1. Right Click **Yellow** and select **Edit**.
2. Click **Add**.
3. In the Name field, enter **YellowRed**.
4. In the Expression field, enter **YellowCount>=30**.
5. Set Transition From field to **Yellow**, and Transition To field to **Red**.
6. Click **OK** to close the Add Transition window.
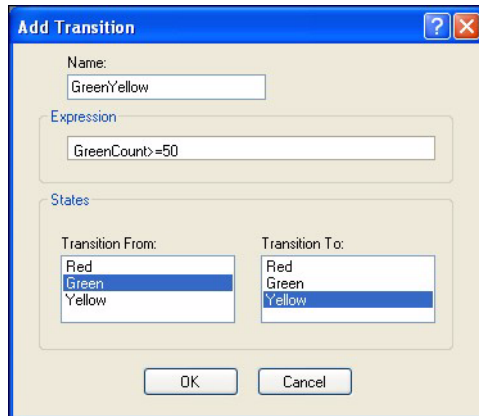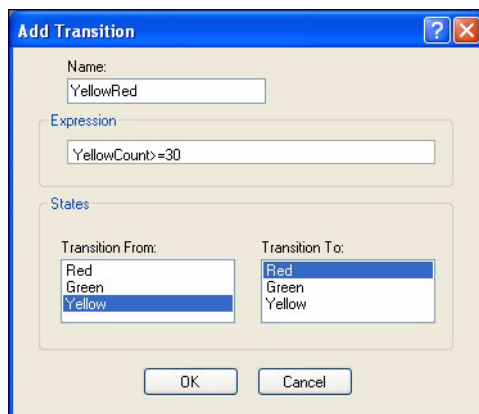
Figure 4-11. Add Transition Window

7. Click **OK** to close the Add State window.
8. Click **OK** to close the State Machine Transfer Function TrafficState window.

4.12   Define Output Behavior

1. Right-click on the **ColorLock** driver icon and select **Transfer Function**.
2. Set the following fields:

   ■ Set Enable to **LEDEnable**

   ■ Set Target x to **xValuator**

   ■ Set Target y to **yValuator**

   ■ Set Relative Flux to **LEDBrightness**

   ■ Set ColorLock Trigger to **LEDTrigger**

Figure 4-12. ColorLock Transfer Function Window
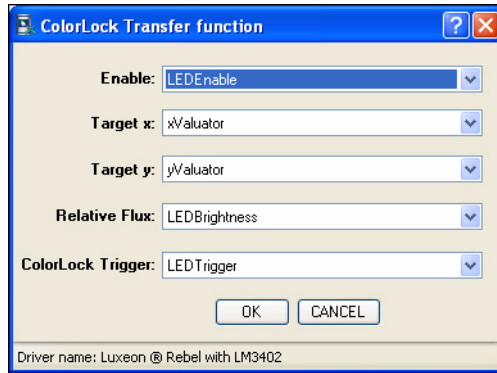
3. Click **OK** when done.

4.13   Add an Interface Driver

Table 4-18. Slave Driver

Driver/Valuator	I2C Slave Interface	

Location	Interfaces Tab
	↳ Communication
	   ↳ I2C
	      ↳ Slave	

Properties	**Field**	**User Input**
	Name	Interface1
	I2C_Address	4 (Default)

With a little rearranging, your workspace should look like the example in Figure 4-13.

Figure 4-13. PSoC Express Design View Pane

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A
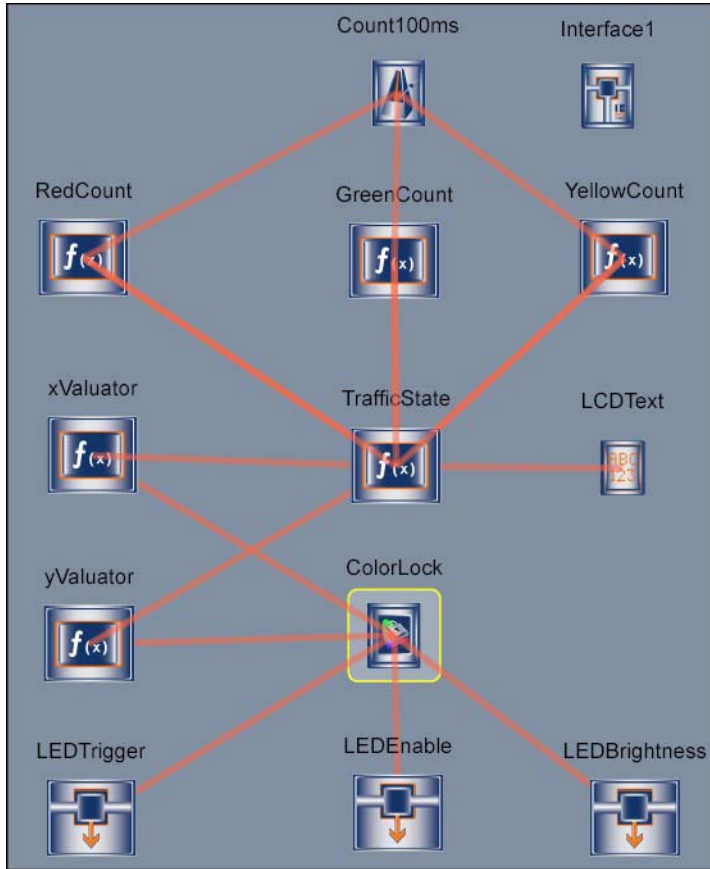
4.14   Build project

1. Select **Build → Generate\Build 'TrafficLight' Project**.
2. In the Available Device Configurations pane, select **CY8CLED16 → CY8CLED16, 48-Pin MLF**.
3. In the Device Configurations Properties pane, set the following parameters:
    ■   Sample Rate   →   8 Hz
    ■   Flash Interface →   Enable
4. Ensure the **Assign pins automatically** check box is **not** selected.
5. Click **Next**.
6. In the User Pin Assignment window, click **Unassign All Pins**.
7. Assign drivers to pins by dragging and dropping the blue rectangles from the Unassigned Drivers list to the pins listed in the following table.

> **WARNING: Assign pins in the order listed in Table 4-19**. Assign drivers according to the Order of Assignment column in Table 4-19, not the order of appearance in the User Pin Assignment window.

Table 4-19. TrafficLight Pinouts

Order of Assignment	Order of Appearance	Function	Pin	Notes
0	0	ColorLock_ColorSensor	Port 2_5	
1	7	TCS230SHARED_0 S0	Port 2_0	←The these four drivers are assigned automatically when the ColorLock_ColorSensor driver is assigned. You must reassign them before assigning the rest of the pins.
2	8	TCS230SHARED_0 S1	Port 2_1	
3	9	TCS230SHARED_0 S2	Port 2_2	
4	10	TCS230SHARED_0 S3	Port 2_3	
5	1	ColorLock_Enable	Port 4_0	
6	2	ColorLock_Dim1	Port 1_2	
7	3	ColorLock_Dim2	Port 1_3	
8	4	ColorLock_Dim3	Port 1_4	
9	6	Interface1 I2CSDAPin	Port 1_5	
10	5	Interface1 I2CSCLPin	Port 1_7	←The I2CSCLPin driver is assigned automatically when the I2CDAPPin driver is assigned
11	7	pse_LCD_SHARED_0 LCDPin11	Port 3_0	
12	8	pse_LCD_SHARED_0 LCDPin12	Port 3_1	←The these six drivers are assigned automatically when the pse_LCD_SHARED_0 LCDPin11 driver is assigned.
13	9	pse_LCD_SHARED_0 LCDPin13	Port 3_2	
14	10	pse_LCD_SHARED_0 LCDPin14	Port 3_3	
15	11	pse_LCD_SHARED_0 LCDPin6	Port 3_4	
16	12	pse_LCD_SHARED_0 LCDPin4	Port 3_5	
17	13	pse_LCD_SHARED_0 LCDPin5	Port 3_6	

Figure 4-14. TrafficLight Pinout Diagram
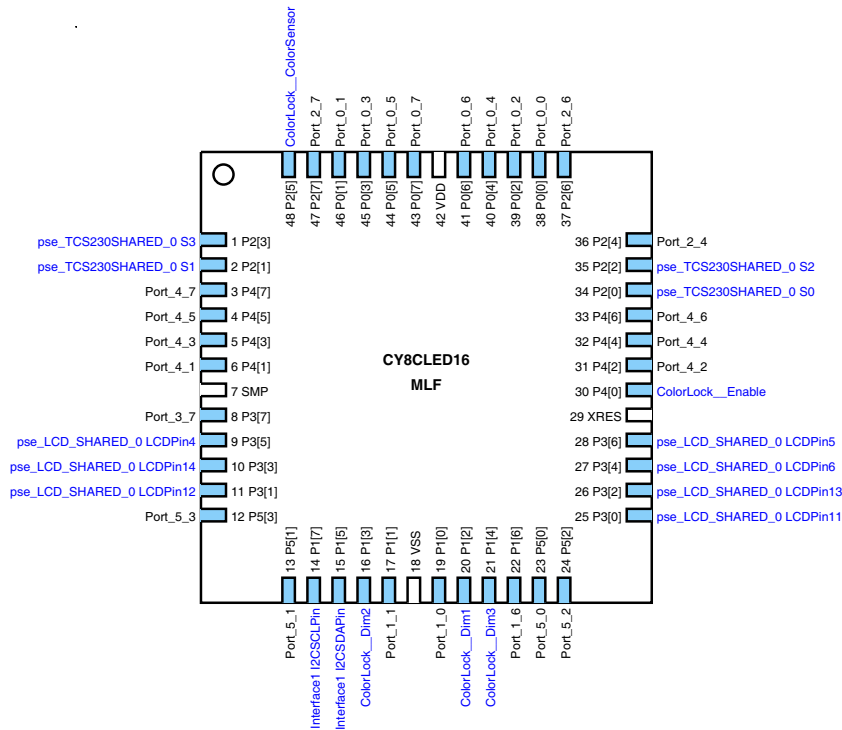
8. Select **Lock Pins** and click **Next**. PSoC Express builds your project.

4.15   Program the EZ-Color Device

1. Disconnect any power sources from the evaluation board and connect the MiniProg to your PC using a USB cable.

2. Connect the Miniprog to the 5-pin ISSP header.

3. Program the part via J1 as described in the Program Parts with PSoC Express Projects section on page 11.

4.16　Tune Your Project

1. Apply power to the board using the supplied wall adapter.
2. Connect the board to your PC via a USB cable.
3. Select **Monitor** in PSoC Express.
4. Click **Play** ▶. The Monitor toolbar will change from Connected Connected, to Running Running.
5. Right-click on the **ColorLock** driver icon and select **Show Tuner**.

Figure 4-15.　ColorLock (Luxeon Rebel® with LM3402) Tuner Window
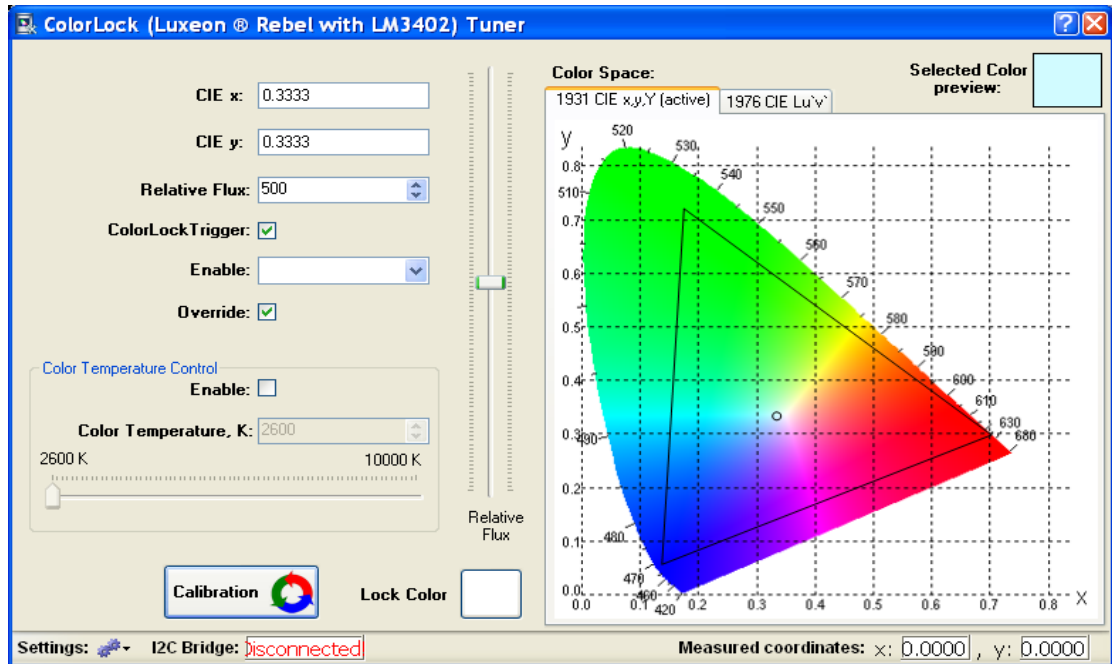
4.17　Calibrate LEDs

1. Select **Calibration**.
2. Select **Set LED1 to Maximum**.
3. Select **Set LED2 to Maximum**.
4. Select **Set LED3 to Maximum**.
5. Select **Calibrate**.
6. Click **OK** to return to the Tuner.

4.18　Run Program

Uncheck **Override** to observe the TrafficLight program. After closing the tuner window, power cycle the evaluation board before continuing with monitoring or tuning the design.

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A   51

5.   Modulated Dimmer Project

WARNING: HIGH BRIGHTNESS LEDs CAN CAUSE PERMANENT EYE DAMAGE!

Do not look at the LEDs if they are not covered by the protective enclosure. The LEDs illuminate at a very high intensity and can cause permanent eye damage if they are viewed without the protective enclosure.

5.1   Description

This project creates firmware that color mixes three primary high-brightness LEDs to a single color, modulates the brightness and introduces optical feedback into the system using a color sensor.

The user can then choose the Tuner to select other desired colors mapped along the 1931 CIE XYZ Color Space.

The tuner enables turning ON/OFF the LEDs and adjusting the resultant flux output, over an I2C interface. By default, the firmware will automatically generate a single color inside the defined color gamut and modulate the brightness.

The project utilizes four different Interface (Communication) Valuators. Each set a specific register which can be modified using the available tuner. The LEDEnable controls the 3LED ColorLock Driver, the LEDTrigger controls the optical feedback loop and the xValuator and yValuator registers create a color based on x,y coodinates in the 1931 CIE XYZ Color Space. Also utilized are a priority encoder named LEDBrightness valuator which controls a modulated flux value. Next, the program contains a timing element which feeds a state machine. This timing element controls the length of time it takes to dim the LEDs from full intensity to OFF. Finally, the 3-LED ColorLock Driver controls the LM3404 Switching Regulators to power the LEDs.

5.2   EZ-Color Device

CY8CLED16, 48-Pin MLF

5.3   Start a New Project

1. Select **File → New Project**.
2. Name the project **ModulatedDimmer**.
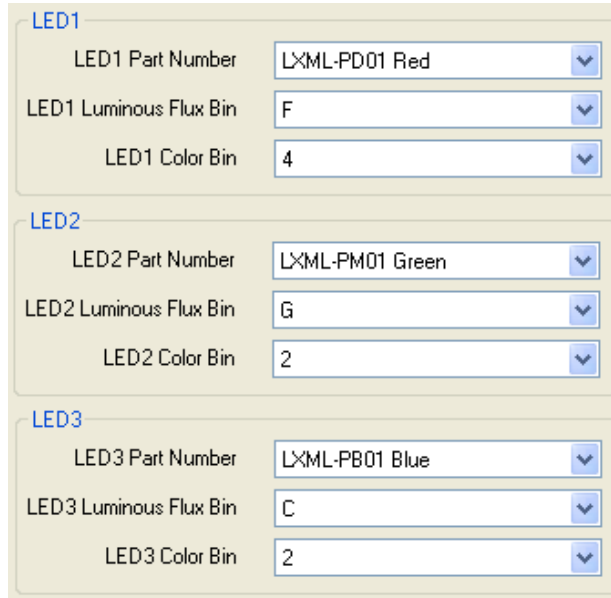3. If needed, click **Browse** to save the project in a different location.
4. Click **OK**.

5.4　Add an Output Driver

Table 5-1. Luxeon Rebel® with LM3402

Driver/Valuator	Lumileds™ Luxeon® Rebel 3-LED Color Mixing Driver with Color-Lock™ Closed Loop Optical Feedback and LM3402 External Constant Current Source **Note**: When you click OK to close the Add Output Driver window, the ColorLock (Luxeon Rebel® with LM3402) Properties window opens.
Location	Outputs Tab ↳ High Brightness LED 　↳ 3-LED Color Mixing 　　↳ ColorLock™ Optical Feedback 　　　↳ Lumileds™ 　　　　↳ Luxeon® Rebel, 350mA 　　　　　↳ Luxeon Rebel® with LM3402

	Field	User Input	
Properties	Name	ColorLock	
	ClockFrequency	20000	(Default)
	Color Space	1931 XYZ Color Space	(Default)
	LED1 Part Number	LXML-PD01 Red	(Default)
	LED2 Part Number	LXML-PM01 Green	(Default)
	LED3 Part Number	LXML-PB01 Blue	(Default)
	LED1 Luminous Flux Bin	G	(Default)
	LED2 Luminous Flux Bin	G	(Default)
	LED2 Luminous Flux Bin	G	(Default)
	LED1 Color Bin	1	(Default)
	LED2 Color Bin	1	(Default)
	LED3 Color Bin	1	(Default)
	Expose Tuning Values	Yes	(Default)

1. The ColorLock (Luxeon Rebel® with LM3402) Properties window opens. Set the following values:

    ■　Set LED1 Luminous Flux Bin to **F**, and the LED1 Color Bin to **4**.

    ■　Set LED2 Luminous Flux Bin to **G**, and the LED2 Color Bin to **2**.

    ■　Set LED3 Luminous Flux Bin to **C**, and the LED3 Color Bin to **2**.

Figure 5-1. LED Settings in the ColorLock (Luxeon® Rebel with 3402) Properties Window

2. Click **OK** when finished.

5.5   Add Four Interface Valuators

Note: These steps must be performed in the Add Valuator dialog box that appears when the Discrete Interface Valuator is initially placed in the design.

Table 5-2. Discrete Interface Valuator

Driver/Valuator	Discrete	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Discrete	
Properties	**Field**	**User Input**
	Name	LEDEnable
	Default Value	0x1
	States	(Default)

Table 5-3. Discrete Interface Valuator

Driver/Valuator	Discrete	
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Discrete	
Properties	**Field**	**User Input**
	Name	LEDTrigger
	Default Value	0x1
	States	(Default)

Table 5-4. Continuous Interface Valuator

Driver/Valuator	Continuous		
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Continuous		
Properties	**Field**	**User Input**	
	Name	xValuator	
	Min	-32767	(Default)
	Max	32767	(Default)
	Scale	1	(Default)
	Default Value	5000	

Table 5-5. Continuous Interface Valuator

Driver/Valuator	Continuous		
Location	Valuators Tab ↳ Interface (Communication) Valuators ↳ Continuous		
Properties	**Field**	**User Input**	
	Name	yValuator	
	Min	-32767	(Default)
	Max	32767	(Default)
	Scale	1	(Default)
	Default Value	2500	

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A

5.6   Add a Transfer Function Valuator

Note: These steps must be performed in the Add Valuator dialog box that appears when the Discrete Interface Valuator is initially placed in the design.

Table 5-6. StateMachine Valuator

Driver/Valuator	Discrete	
Location	Valuators Tab ↳ Transfer Function Valuators ↳ StateMachine	
Properties	**Field**	**User Input**
	Name	TickState

In the State Machine Transfer Function TickState window:

1. Click **Add State**. The Add State window opens.
2. Set the Name to **State0**.
3. Click **OK**.
4. Repeat Step 1 through Step 3, naming the states State1 through State7.

Figure 5-2. State Machine Transfer Function TickState
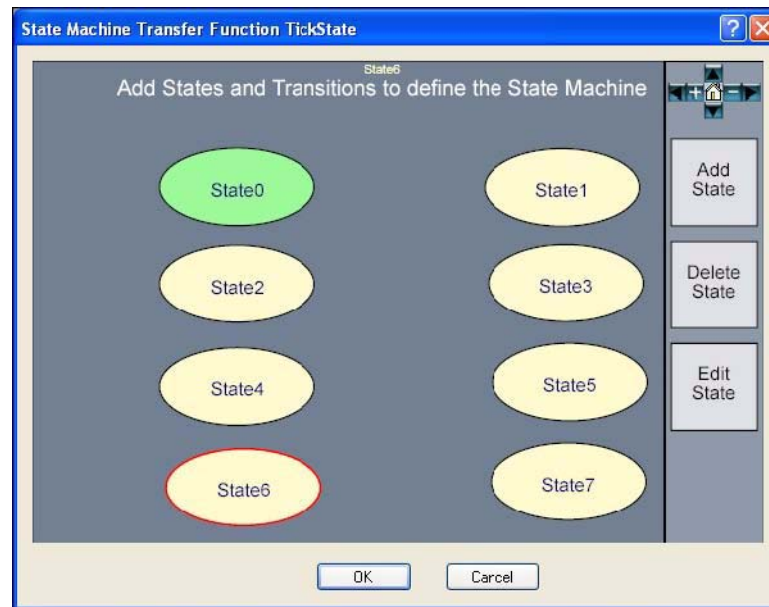
5. Click **OK** when finished.

5.7 Add an Input Driver

Table 5-7. Interval Generator Driver

Driver/Valuator	Interval Generator	
Location	Inputs Tab ↳ Timing ↳ Interval Generator	
Properties	**Field**	**User Input**
	Name	Tick
	IntervalTime	75
	IntervalMode	PULSE (Default)

5.8 Add a Priority Encoder Transfer Function Valuator

Table 5-8. PriorityEncoder Valuator

Driver/Valuator	Priority Encoder	
Location	Valuators Tab ↳ Transfer Function Valuators ↳ PriorityEncoder	
Properties	**Field**	**User Input**
	Name	LEDBrightness

1. The Priority Encoder Transfer Function - LEDBrightness window opens. Set the If/Else statements to the values in Table 5-9.

Table 5-9. LEDBrightness Priority Encoder Transfer Function Values

Else/If	Then LEDBrightness =
(TickState_state==TickState_state__State0)&& (LEDBrightness>=0) && (Tick==Tick__Triggered)	LEDBrightness-5
(TickState_state==TickState_state__State1)&&(LEDBrightness>=0) && (Tick==Tick__Triggered)	LEDBrightness-10
(TickState_state==TickState_state__State2) && (LEDBrightness>=0) && (Tick==Tick__Triggered)	LEDBrightness-20
(TickState_state==TickState_state__State3) &&(LEDBrightness>=0) && (Tick==Tick__Triggered)	LEDBrightness-50
(TickState_state==TickState_state__State4) && (LEDBrightness>=0) && (Tick==Tick__Triggered)	LEDBrightness-75
(TickState_state==TickState_state__State5) && (LEDBrightness>=0) && (Tick==Tick__Triggered)	LEDBrightness-100
(TickState_state==TickState_state__State6) && (LEDBrightness>=0)&& (Tick==Tick__Triggered)	LEDBrightness-150
(TickState_state==TickState_state__State7) && (LEDBrightness>=0) && (Tick==Tick__Triggered)	LEDBrightness-200
LEDBrightness<=0	1000

2. Select **Continuous**.

Figure 5-3. Priority Encoder Transfer Function - LEDBrightness


3. Click **OK** to close the Priority Encoder Transfer Function - LEDBrightness window.

5.9   Add Seven State Machine Transitions

1. Right-click **TickState** driver icon and select **Transfer Function**.
2. Right-click **State0** and select **Edit**.
3. Click **Add**.
4. In the Name field, enter **Dim1**.
5. In the Expression field, enter **LEDBrightness<=0**.
6. Set Transition From field to **State0**, and Transition To field to **State1**.
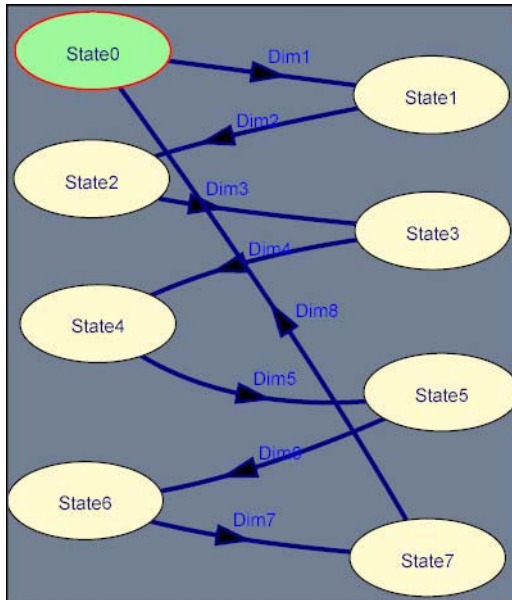7. Click **OK** to close the Add Transition window.

Figure 5-4. Add Transition Window
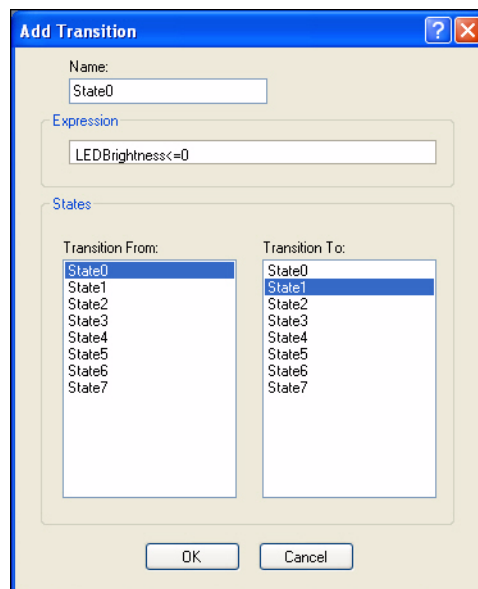
8. Click **OK** to close the Add State window.

9. Repeat for State 1 → 2, State 2 → 3, State 3 → 4, State 4 → 5, State 5 → 6, State 6 → 7, and State 7 → 0.
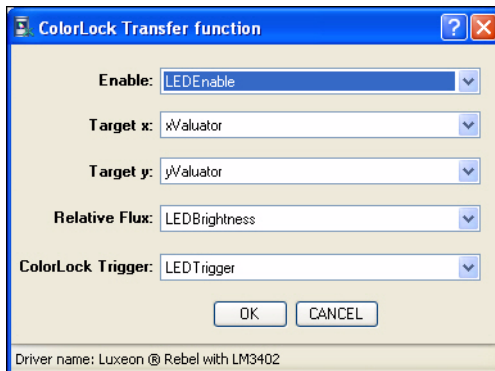
Figure 5-5. Add State Window

10. Click **OK**.

5.10   Define Output Behavior

1. Right-click on the **ColorLock** driver icon and select **Transfer Function**.
2. Set the following fields:
    ■   Set Enable to **LEDEnable**
    ■   Set Target x to **xValuator**
    ■   Set Target y to **yValuator**
    ■   Set Relative Flux to **LEDBrightness**
    ■   Set ColorLock Trigger to **LEDTrigger**

Figure 5-6. ColorLock Transfer Function Window
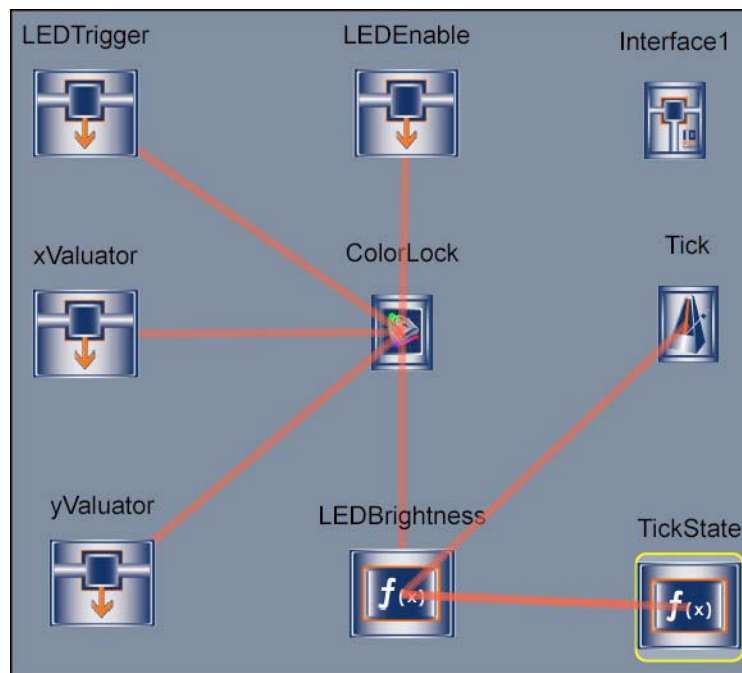

3. Click **OK** when done.

5.11 Add an Interface Driver

Table 5-10. Slave Driver

Driver/Valuator	I2C Slave Interface	

Location	Interfaces Tab
	↳ Communication
	  ↳ I2C
	    ↳ Slave	

Properties	**Field**	**User Input**
	Name	Interface1
	I2C_Address	4 (Default)

With a little rearranging, your workspace should look like the example below.

Figure 5-7. PSoC Express Design View Pane

5.12 Build project

1. Select **Build** → **Generate\Build 'ModulatedDimmer' Project**.
2. In the Available Device Configurations pane, select **CY8CLED16** → **CY8CLED16, 48-Pin MLF**.
3. In the Device Configurations Properties pane, set the following parameters:
   - Sample Rate   →   8 Hz
   - Flash Interface   →   Enable
4. Ensure the **Assign pins automatically** check box is **not** selected.
5. Click **Next**.
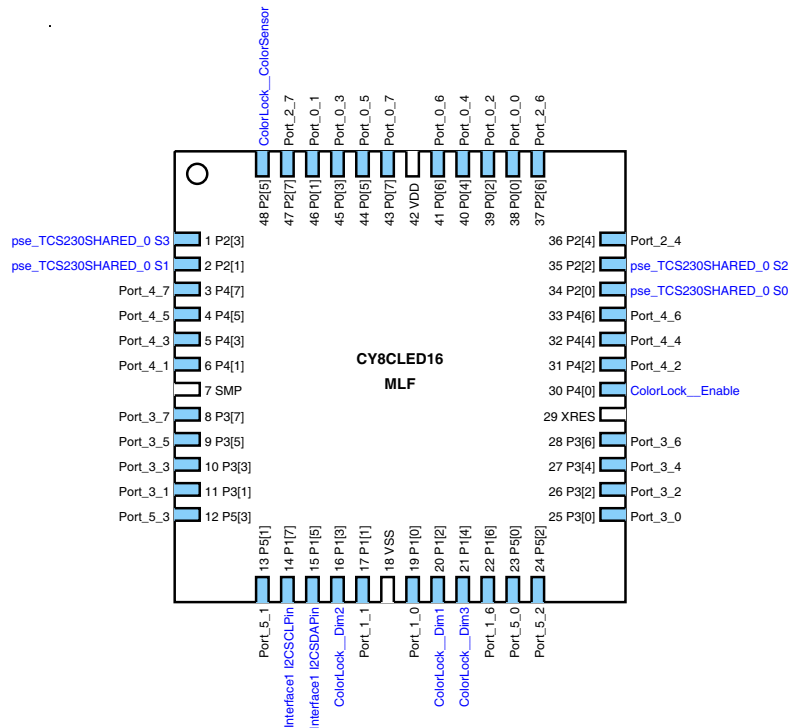6. In the User Pin Assignment window, click **Unassign All Pins**.

7. Assign drivers to pins by dragging and dropping the blue rectangles from the Unassigned Drivers list to the pins listed in the following table.

WARNING: Assign pins in the order listed in Table 5-5. Assign drivers according to the Order of Assignment column in Table 5-11, not the order of appearance in the User Pin Assignment window.

Table 5-11. ModulatedDimmer Pinouts

Order of Assignment	Order of Appearance	Function	Pin	Notes
0	0	ColorLock_ColorSensor	Port 2_5	
1	7	TCS230SHARED_0 S0	Port 2_0	←The these four drivers are assigned automatically when the ColorLock_ColorSensor driver is assigned. You must reassign them before assigning the rest of the pins.
2	8	TCS230SHARED_0 S1	Port 2_1	
3	9	TCS230SHARED_0 S2	Port 2_2	
4	10	TCS230SHARED_0 S3	Port 2_3	
5	1	ColorLock_Enable	Port 4_0	
6	2	ColorLock_Dim1	Port 1_2	
7	3	ColorLock_Dim2	Port 1_3	
8	4	ColorLock_Dim3	Port 1_4	
9	6	Interface1 I2CSDAPin	Port 1_5	←The I2CSCLPin driver is assigned automatically when the I2CDAPPin driver is assigned.
10	5	Interface1 I2CSCLPin	Port 1_7	

Figure 5-8. ModulatedDimmer Pinout Diagram

8. Select **Lock Pins**, and click **Next**. PSoC Express builds your project.

CY3263-ColorLock EZ-Color Evaluation Kit Guide, Doc. # 001-44081 Rev. *A

5.13   Program the EZ-Color Part

1. Disconnect any power sources from the evaluation board and connect the MiniProg to your PC using a USB cable.
1. Connect the Miniprog to the 5-pin ISSP header.
2. Program the part via J1 as described in the .
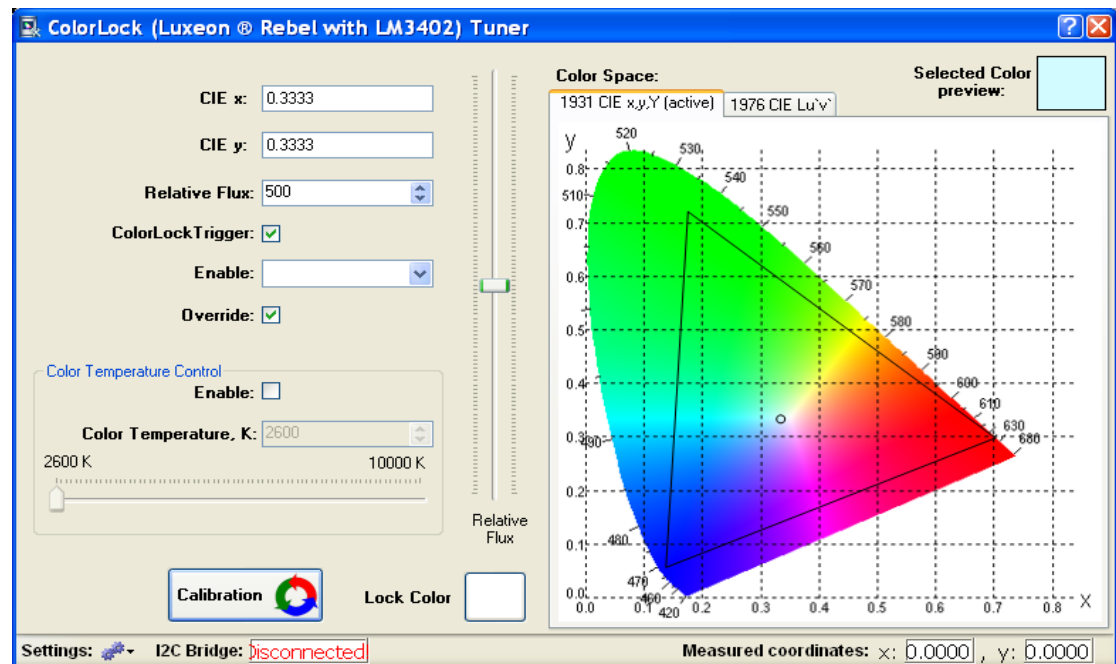
5.14   Tune Your Project

1. Apply power to the board using the supplied wall adapter.
2. Connect the board to your PC via a USB cable.
3. Select **Monitor** in PSoC Express.
4. Click **Play** . The Monitor toolbar will change from Connected , to Running .
5. Right-click the **ColorLock** driver icon and select **Show Tuner**.

Figure 5-9. ColorLock (Luxeon® Rebel with LM3402) Tuner

6. Click **OK** to return to the Tuner.

5.15   Calibrate LEDs

1. Select **Calibration**.
2. Select **Set LED1 to Maximum**.
3. Select **Set LED2 to Maximum**.
4. Select **Set LED3 to Maximum**.
5. Select **Calibrate**.

5.16   Run Program

Uncheck **Override** to observe the ModulatedDimmer program. After closing the tuner window, power cycle the evaluation board before continuing with monitoring or tuning the design.