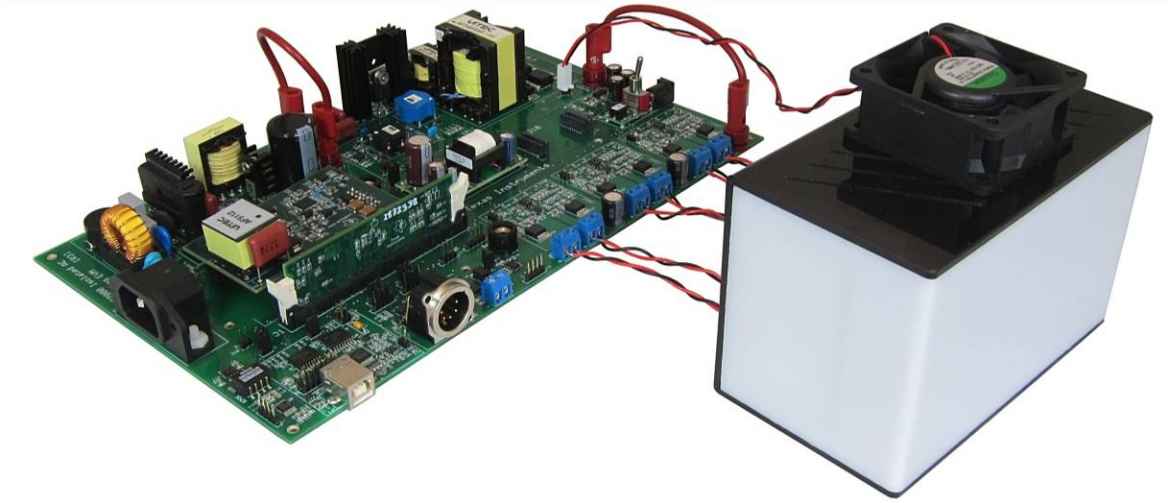
# AC LED Lighting & Communications Quick Start Guide

Version 1.1 – November 2011



The document provides instructions to run a GUI that controls the AC LED Lighting & Communications Developer's Kit board using the Piccolo F28027 microcontroller.

**Contents of the DC/DC LED Lighting Developer's Kit:**

- AC LED Lighting & Communication motherboard
- Piccolo F28027 controlCARD
- LED panel
- AC power cable
- 2 red banana plug cables
- 12V DC/DC power supply
- USB cable
- USB Flash drive with GUI executable and CCS installer

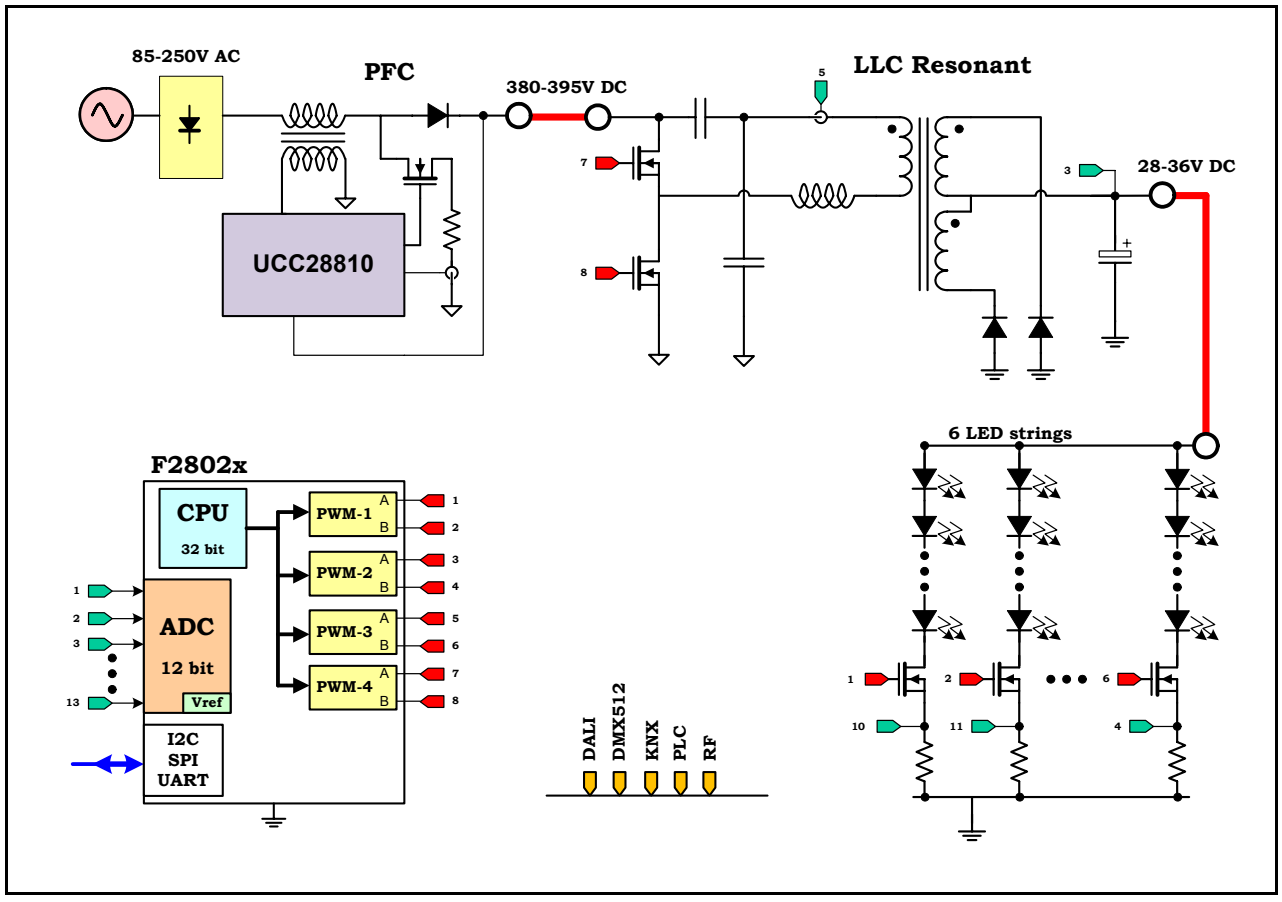
**Features of the AC LED Lighting Developer's Kit:**

- Independent closed-loop brightness control of 6 LED strings with PWM dimming
- Closed-loop voltage control of the LED bus with a LLC Resonant converter
- On-board isolated JTAG emulation
- Over-current and over-voltage protection for the LLC resonant stage using the F28x on-chip comparators
- Several communications options available for host-control which are often used in the LED market. These include support for DALI, DMX512 and PLC. Different application notes describe these options:
  - DALI – TMDSIACLEDCOMKIT-DALIGuide.pdf
  - DMX512 – TMDSIACLEDCOMKIT-DMX512Guide.pdf
  - Power Line Communications – TMDSIACLEDCOMKIT-PLCQSG.pdf – to demonstrate PLC, 1 TMDSPLCMOD-P3X add-on module and 1 TMDSPLCKIT-V3 kit will be needed.
  - Hardware support for other communication options exist as well
- Hardware Developer's Package is available and includes schematics, bill of materials, Gerber files, etc.

## Overview

The AC LED Lighting Developer's Kit takes in universal (85-250Vac) input. This AC input then goes through a PFC stage in order to increase the power factor of the downstream power stages. A PFC stage, as shown here, helps the board to meet IEC61000-3-2 and other on-line regulations. At the output of the PFC stage, the voltage will be roughly 395V DC. To meet the LED string voltage that is required for each LED string to light, a LLC resonant DC/DC stage is used. The LLC provides isolation between the mains and the LED output and its turns ratio is chosen such that it can output approximately 29-36V. The LLC resonant output is then connected to each of the LED strings. In order to perform independent LED string dimming, a MOSFET is placed in series with each string, The "on" time of each string's MOSFET will control the average current through the LED string. Since the brightness of an LED is roughly proportional to the LED current, we use the duty cycle of each string's PWM to control the average current drawn.

In this board, a UCC28810 transition-mode PFC controller is used to manage the PFC stage and the C2000 controls the LLC resonant and lumen output of each LED string. In addition, spare bandwidth on the MCU allows communications and system supervisory tasks to also be done by the C2000 device. The figure below illustrates the hardware present on the AC LED Lighting & Communications Developer's Kit.



A typical power conversion board is made up of several power stages. On the AC LED Lighting & Communications board, each of these power stages is organized into distinct macro blocks for ease of development. Each of these macro sections is bounded by its own silkscreen area. Below is a list of all the macro blocks' names and a short description of its function. Refer to the image on the next page for placement of macro areas.

| | | |
|---|---|---|
| **AC LED Lighting & Communications Main Board** | **[Main]** | Consists of controlCARD socket, a few communications jumpers and the routing of signals between the controlCARD and the macro blocks. This section is all of the area outside of the macro blocks. |
| **PFC Stage Macro** | **[M1]** | A single-phase PFC boost stage |
| **LLC Resonant Stage Macro** | **[M2]** | A step-down DC/DC LLC Resonant stage |
| **LED Dimming Stage Macros** | **[M3-M5]** | Stages used to individually dim each individual LED string |
| **Isolated DC/DC converter Module** | **[M6]** | Converts a 400V DC input into 18V DC for the primary side and 12V for the secondary side |
| **DC Power Entry Macro** | **[M7]** | Generates the 12V, 5V, and 3.3V DC rails |
| **Isolated USB-to-JTAG Emulation Macro** | **[M8]** | Provides on-board isolated JTAG connection through USB to the host. Is also used to provide isolated SCI (UART) communcation for connection with the GUI. |

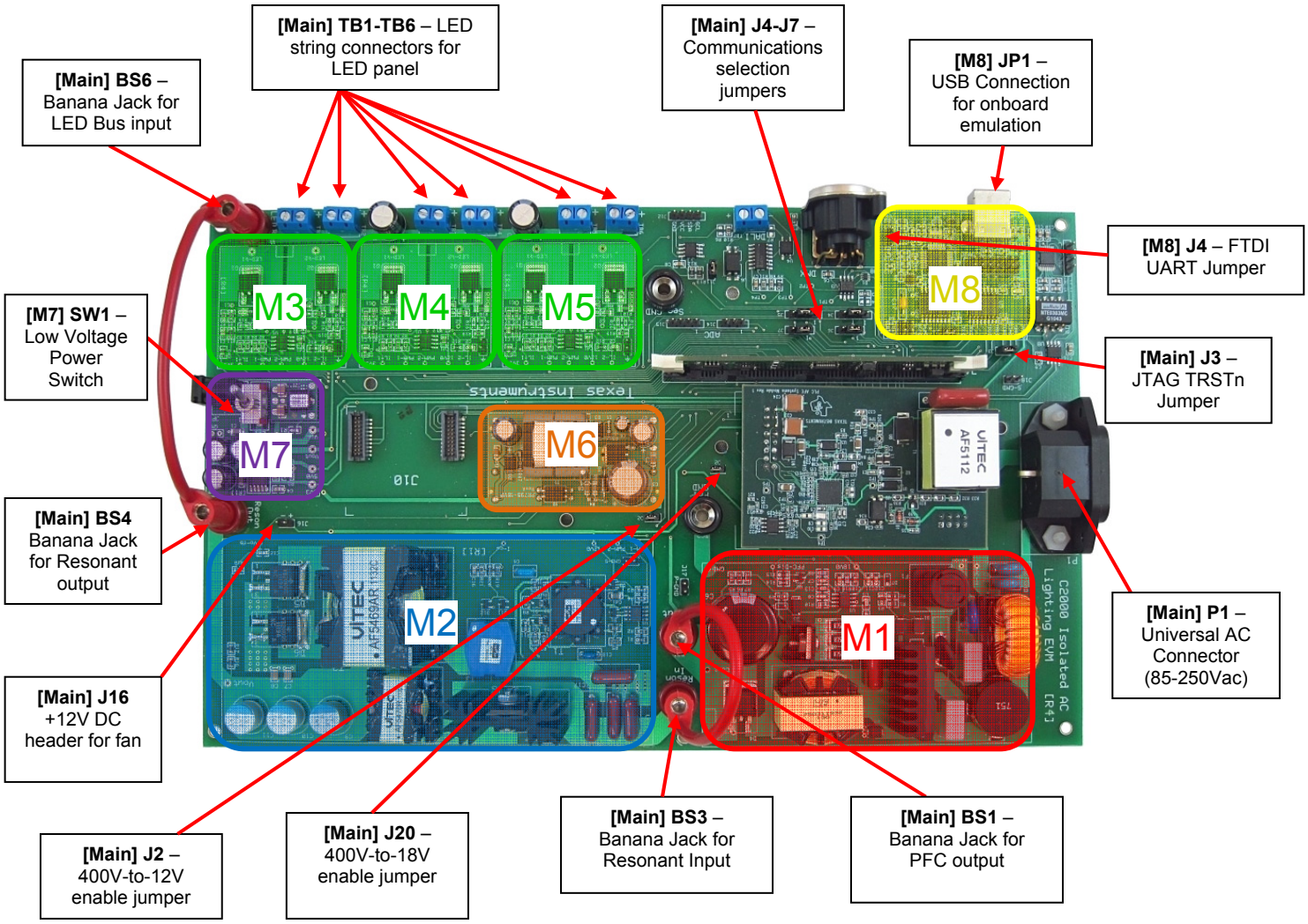
In this guide, each component is named first with their macro number followed by the reference name. For example, [M2]-J1 would refer to the jumper J1 located in the macro M2 and [Main]-J1 would refer to the jumper J1 located on the main board, outside of the other defined macro blocks.

# Quick Start GUI

This kit comes with a user-friendly graphical user interface (GUI) which provides a convenient way to evaluate the functionality of this kit and the F28027 microcontroller, without having to learn and configure the underlying project software or install Code Composer Studio. The interactive interface using sliders, buttons, and textboxes allows LED lighting with the C2000 device to be demonstrated quickly and easily.

## Hardware Setup

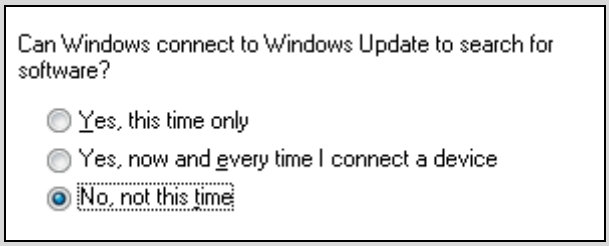
Listed below are some of the major connectors and features of the AC LED Lighting & Communications board.



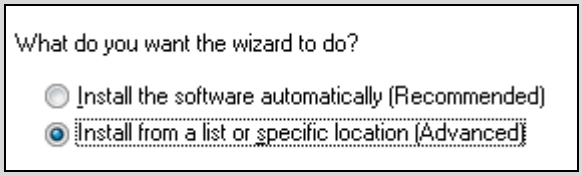
1) On the Piccolo F28027 controlCARD, check the following switches:
   - SW1, make sure position 1 and 2 are both in the “on” (up) position.
   - SW2, SW3, and SW4 should all be in the default down position.
   - There should be no jumper at R10 (if applicable)
2) Put a F28027 control card into the socket on the AC LED Lighting and Communications board and connect a cable from the USB connector on the board to the computer. [M8]-LD1, near the AC LED Lighting board’s USB connector, should turn on.

**NOTE**: If Code Composer Studio has never been installed, it may be necessary to install drivers to make the board work correctly. If a popup comes up when the USB cable is connected from the board to the computer, have the install wizard install drivers from the XDS100v1 directory of the USB drive included with this kit.

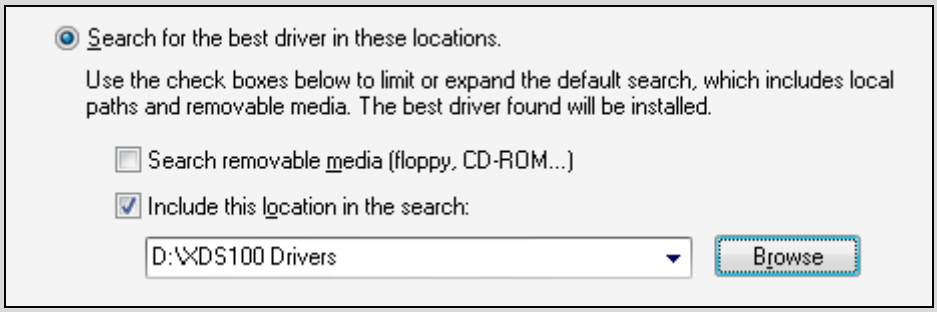
1) When Windows asks to search Windows Update, select “No, not at this time” and click Next




2) On the next screen select “Install from specific location” and click Next




3) Select “Search for Best Driver”, uncheck search removable media, and check include specific location and browse to [USB Drive]:\XDS100 Drivers




4) Click next and the drivers will be installed. The driver install screen will appear three times, repeat this procedure each time.

3) Connect the LED panel to [Main]-TB1 to [Main]-TB6 on the AC LED Lighting and Communication board. For each twisted cable from the LED panel, make sure to connect the red wire to the positive, “+”, terminal and the black wire to the negative, “-“, terminal.
4) Connect or verify the following:
   - Connect a jumper on [Main]-J2
   - Connect a jumper on [Main]-J20.
   - Connect a jumper on [M8]-J4.
   - Remove any jumpers placed on [Main]-J3
   - Switch [M7]-SW1 to the internal position (switched away from “Ext”)
5) Connect a banana-to-banana plug cable that came with the kit between the PFC Output Connector ([Main]-BS1) and the Resonant Input Connector ([Main]-BS3)
6) Connect the other banana-to-banana plug cable that came with the kit between the Resonant Output Connector ([Main]-BS4) and the LED Bus Input Connector ([Main]-BS6)
7) Connect the fan’s power cable to [Main]-J16. Connect the red wire toward “+”.

## Software Setup

The GUI used to conveniently evaluate the kit can be found on the USB drive that is included with this kit. It is named TMDSIACLEDCOMKIT_GUI.exe. This .exe is all the software necessary to do a quick evaluation of this kit. To explore deeper, the underlying reference software can be found as a Code Composer Studio project within controlSUITE.

**NOTE**: The GUI requires Microsoft .NET framework 3.5 to run. Please ensure that this software is installed prior to running this program.

To install the CCS4 project built to run with this kit, use the most up-to-date software, and find all reference material for the C2000 MCU, please install controlSUITE. The “AC LED Lighting and Communications Kit” option will download this kit’s software. controlSUITE can be downloaded at:

http://www.ti.com/controlSUITE

Once controlSUITE is installed, the GUI mentioned in this guide can be found at the following location:
*controlSUITE/development_kits/TMDSIACLEDCOMKIT_vX.X/~GUI/TMDSIACLEDCOMKIT_GUI.exe*

The source code for this GUI was written in C# using Microsoft Visual Studio .NET and can be found at:
*controlSUITE/development_kits/TMDSIACLEDCOMKIT_vX.X/~GUI/~Source/*

The kit ships with a F28027 controlCARD that has been pre-flashed with the code that enables it to run with the GUI that comes with this kit. If for any reason, the software needs to be reflashed so that it works with the GUI again, this flash image can be found at:

*controlSUITE/development_kits/TMDSIACLEDCOMKIT_vX.X/~GUI/*
*TMDSIACLEDCOMKIT-FlashImage_v1.0.out*

The underlying Code Composer Studio project documentation and how to run guide can be found at:
*controlSUITE/development_kits/TMDSIACLEDCOMKIT_vX.X/~Docs/*
*TMDSIACLEDCOMKIT_CCS.pdf*

## WARNING

**This EVM is meant to be operated in a lab environment only and is not considered by TI to be a finished end-product fit for general consumer use.**

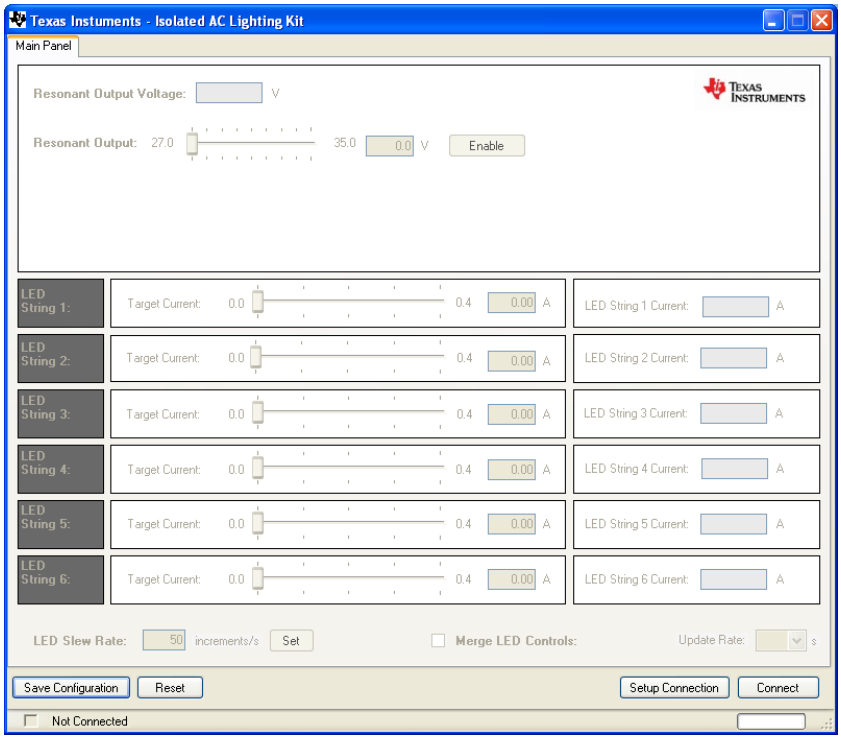
**This EVM must be used only by qualified engineers and technicians familiar with risks associated with handling high voltage electrical and mechanical components, systems and subsystems.**

**This equipment operates at voltages and currents that can result in electrical shock, fire hazard and/or personal injury if not properly handled or applied. Equipment must be used with necessary caution and appropriate safeguards employed to avoid personal injury or property damage.**

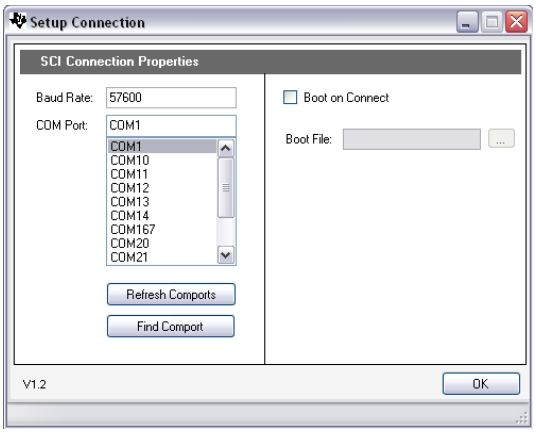
**It is the user's responsibility to confirm that the voltages and isolation requirements are identified and understood, prior to energizing the board and or simulation. When energized, the EVM or components connected to the EVM should not be touched.**

## Running the GUI

1) Browse to and double-click on TMDSIACLEDCOMKIT_GUI.exe. If this is the first time that the GUI is run, the GUI will ask the user to read a license agreement. Assuming that the license is accepted, the image below should be seen:




2) Click "Setup Connection" on the GUI and ensure the Baud Rate is set to 57600 and that the "Boot on Connect" Box is unchecked.




3) Next you will need to select your serial comport. This can be found by going to:

*Control Panel->System->Hardware tab->Device Manager->Ports(COM & LPT)*

Look for the comport that is named "USB Serial Port" or similar, then select this comport in the "Setup Connection" window.

4) Click "OK". This will close the "Setup Connection" window.
5) Plug one end of the AC cable into [Main]-P1.

**CAUTION: After the AC cable is plugged in, the board is considered live and has the potential for hazardous shock. Take all necessary precautions before completing this step.**

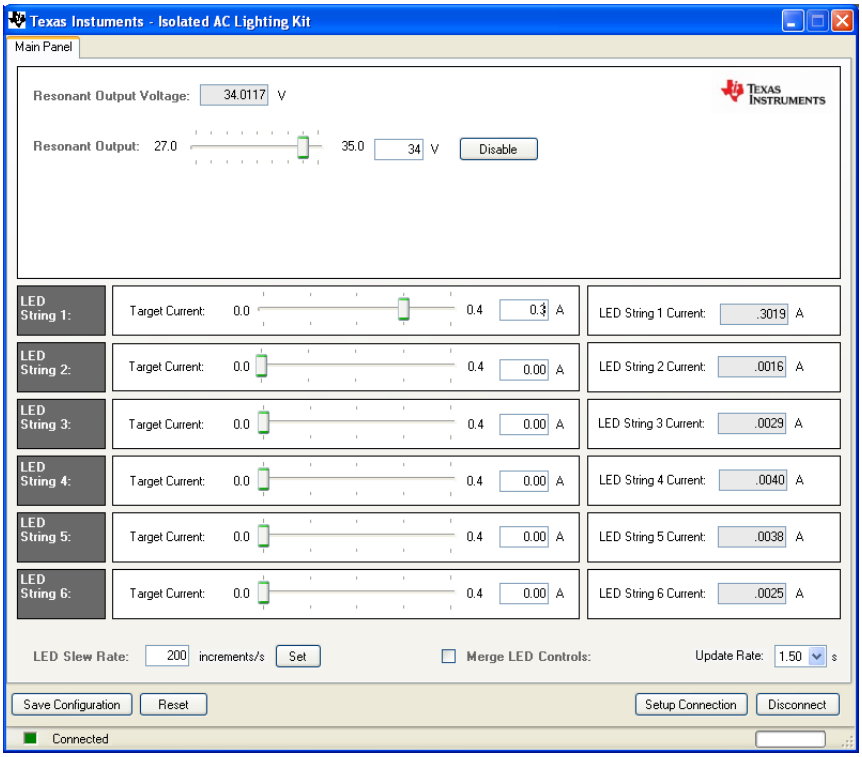
6) Carefully plug the other end of the AC cable into the wall outlet. Or (recommended) plug the AC cable into a power strip and then flip its switch to enable power.
7) Wait 5 seconds.
8) On the Main Window click "Connect". When connected the status bar at the bottom left of the GUI should say "Connected".
9) Enable the Resonant DC/DC converter by clicking the "Enable" button in the area labelled "Resonant Output".
10) Move the slider labelled "Resonant Output Voltage' to approximately 34V. This sets the reference that the controller will try to regulate the output of the Resonant DC/DC stage to.

**NOTE**: With no load, the Resonant DC/DC stage may not be able to regulate the output to exactly the reference given. Once loaded, the output will stay constant at the given reference voltage.

**WARNING**: **The LED panel is capable of driving the LEDs at a very high intensity. It is recommended to face the LED panel away from people and/or eye protection is recommended.**

11) Change the value of LED string 1's target current to 0.3A. Note that the "LED String 1 Current" will ramp until it reaches approximately 0.3A. The "Resonant Output Voltage" should also remain constant at about 34V.
12) Edit the other strings' target currents as desired. The average LED current draw is proportional to LED lumen output for most high brightness LEDs. Therefore, in this program, the brightness of the LEDs is being controlled.

**NOTE**: Near the bottom of the GUI there is a checkbox control named "Merge LED controls". This control enables/disables individual control of each LED string and has the controller try and output the same current for each string. This reference is set by LED string 1's slider.




13) When finished, click the resonant stage's "Disable" button then click "Disconnect".
14) Power off the board by unplugging the AC cable from the wall.
15) Please wait a minute before touching the board.

## References

For more information please see the following guides:

- **TMDSIACLEDCOMKIT_CCS –** provides detailed information on the IsoACLighting project within Code Composer Studio. The document goes through the project in an easy to use lab-style format.

  *C:\TI\controlSUITE\development_kits\TMDSIACLEDCOMKIT_vX.X\~Docs\TMDSIACLEDCOMKIT_CCS.pdf*

- **TMDSIACLEDCOMKIT-HWdevPkg** – a folder containing various files related to the hardware on the AC LED Lighting and Communications Developer's Kit board (schematics, bill of materials, Gerber files, PCB layout, etc).

  *C:\TI\controlSUITE\development_kits\TMDSIACLEDCOMKIT_vX.X *
  *~TMDSIACLEDCOMKIT-HwdevPkg[R4]*

- **TMDSIACLEDCOMKIT-HWGuide** – presents full documentation on the hardware found on the AC LED Lighting and Communications Developer's board.
  *C:\TI\controlSUITE\development_kits\TMDSIACLEDCOMKIT_vX.X\~Docs*
  *TMDSIACLEDCOMKIT -HWGuide.pdf*