DALI Communication on the AC LED Lighting & Communications Developer's Kit

Version 1.1 – December 2011 *C2000 Systems and Applications Team*

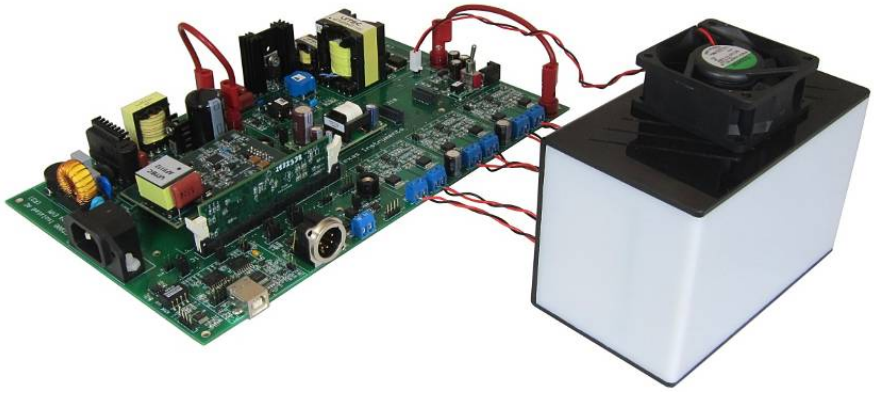

Figure 1: TMDSIACLEDCOMKIT

1 Introduction

The AC LED Lighting & Communications Developer's Kit provides a great way to learn and experiment with using a single MCU to accurately control a series of LED strings and efficiently control the power stages needed to make the LEDs work. This document explains how to use the TMDSIACLEDCOMKIT to communicate via the DALI protocol. The accompanying Code Composer Studio project enables the MCU to control the kit's power stages, LED strings, and serves as a DALI slave. The MCU used to perform all these tasks is a Piccolo F28027 microcontroller.

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.

2 DALI Summary

DALI (Digital Addressable Lighting Interface) is a common lighting standard that is used primarily to control lighting in building and home networks. It is often used as a more feature rich alternative to 0-10V dimmers. DALI has the ability to control up to 64 single units, control 16 groups and create 16 scenes. DALI has a full set of more the 250 commands which can be used to do things from changing dimming values, editing ballast addresses, and querying the status of various ballasts.

DALI is defined first in IEC 60929 Annex E and updated in IEC 62386. The major reason for the update was to include support for LED modules and color control. The DALI software given in the below application note shows how to use DALI as specified in IEC 60929 Annex E and performs a subset of the full instruction set.

The DALI protocol is a half-duplex digital communications interface composed of forward and backward frames. The forward frames consists of one start bit, one address byte, one data byte, and two stop bits. The backward frame (the response) consists of one start bit, one data byte, and two stop bits.

DALI uses Manchester encoding, which means that within a bit frame, and low-to-high transition is defined as a “1” whereas a high-to-low transition is defined as a “0”. See Figure 2.

Figure 2: Manchester Encoding

3 Implementation

A hardware interface and a Code Composer Studio (CCS) project were developed to control the LLC resonant stage, control the LED stages, and receive DALI commands on a F28027 device. The driver software for DALI communications is found within the DALI folder of the CCS project.

The DALI driver and project are meant to be used as an aid in developing a DALI system.

This project can be found at:
C:\TI\controlSUITE\development_kits\IsoACLighting_vX.X\IsoACLighting-F28027-DALI

3.1 Hardware interface

Optoisolators and a schmitt-trigger inverter convert the DALI signal into unipolar signals which can be converted to DALI commands by the Piccolo C2000 microcontroller. See Figure 3.

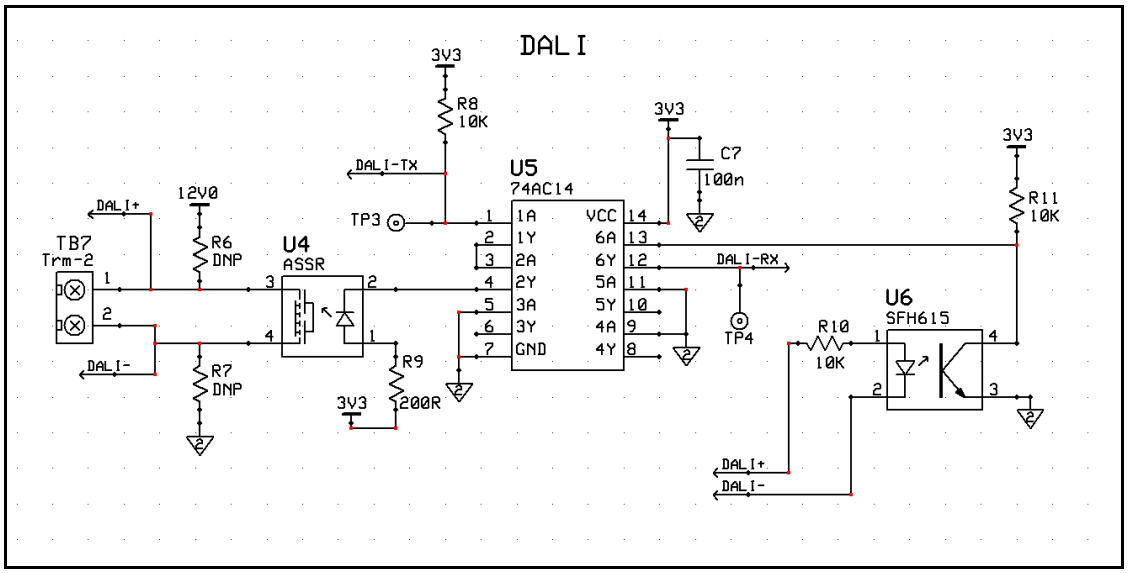

Figure 3: DALI hardware interface

The DALI-RX net terminal in Figure 3 connects to GPIO-19 on the F28027 device. GPIO-19 is then configured to be an eCAP peripheral input in the initialization phase of the device startup. The C2000 microcontroller's eCAP Capture unit is able to count cycles between transitions, which allows the C2000 device to translate the Manchester encoding to DALI commands (with the help of software).

DALI-TX is attached to GPIO-18 which is used directly as a GPIO. The state of the GPIO is governed by software and the timing is governed by a counter within the eCAP peripheral. Note that above TX and RX are relative to the fixture controlled by the Piccolo F28027.

Although the DALI standard recommends allowing incorrect connection of + and -, it has not been done in this version of hardware. To resolve this, one would need to add a diode bridge at the input to U6, such that U6 will only ever see a unipolar input.

Although not tried by TI, R6 and R7 could be populated with 10K resitors if the TMDSIACLEDCOMKIT is to be used as a DALI master. This provides the pull-up and pull-downs needed such that the two signals are made differential.

3.2 DALI Software Driver

The DALI.c file primarily defines the DALI driver, whereas the DALI_command.c and DALI_special_command.c define what each specific command should do.

The software driver assumes that the C2000 device (and light device) is the slave in a DALI network. The software driver uses the C2000 device's eCAP peripheral to decode the DALI communication input as well as to give the timing for the DALI transmissions which are needed to answer the master's query commands. The reason that the eCAP can be used in this way is because the eCAP has two modes of operation.

In capture mode the eCAP will trigger on a particular edge and record the timestamp of a given transition. In this way, the eCAP can be used to measure the time between two edges. Knowing that the DALI bit period is about 416us long, a Manchester encoded bitstream can be interpreted in 1s and 0s to find the correct DALI command. This DALI bitstream is then translated into changing the actual_level, which is the light output for the DALI slave.

The other mode of the eCAP peripheral is APWM mode. In this mode a certain period is defined and the eCAP peripheral will fire an interrupt when the period value is reached. The eCAP peripheral's timer then restarts at 0. This allows the DALI transmit function to have a known timebase from which to transmit a DALI packet.

The C2000 device's GPIO18 is used as a GPIO to transmit DALI and GPIO19 is configured as an eCAP to receive DALI commands.

DALI Commands Supported

Commands Fully Supported	Commands that are Partially Supported *	Commands Not Supported	Commands Not Tested	Reserved Commands
Standard Commands				
0-8	42-47	129	9	10-15
16-33	64-128	156-157	228	34-41
144-155		194-197	237-241	48-63
160-165		224-227	242-251	130-143
176-193			252-255	158-159
				166-175
				198-223
				229-236
Special Commands				
256-258		259	260-261	262-263
264-266		267	269	
268		271		
270		273-275		
272				

* Commands listed as partially supported do work, but do not store data to non-volatile memory as required

3.3 DALI Project

Before working with this project it will be useful to have already run and experimented with the IsoACLighting-F28027 project found at:

C:\TI\controlSUITE\development_kits\TMDSIACLEDCOMKIT_v1.0\IsoACLighting-F28027

That project and its documentation thoroughly explain the TMDSIACLEDCOMKIT and how the F28027 controls the kit's power stages. The IsoACLighting-F28027-DALI project builds on the knowledge found there.

Hardware-wise the only change that may need to be done to make the DALI project work is that the jumpers at [Main]-J4 and [Main]-J5 both need to be moved and placed to connect positions 2 and 3.

The key software difference between the IsoACLighting-F28027 project and the IsoACLighting-F28027-DALI project is that the IsoACLighting-Comms.c file has changed and now interfaces and calls functions in the DALI.c file. The Comms.c file also initializes and turns on the Resonant stage so that the DALI interface can directly change the brightness of the LED strings without needing to do anything with the LLC resonant stage. This DALI.c file contains the DALI driver. Figure 8 gives some details on the major files used in the DALI project.

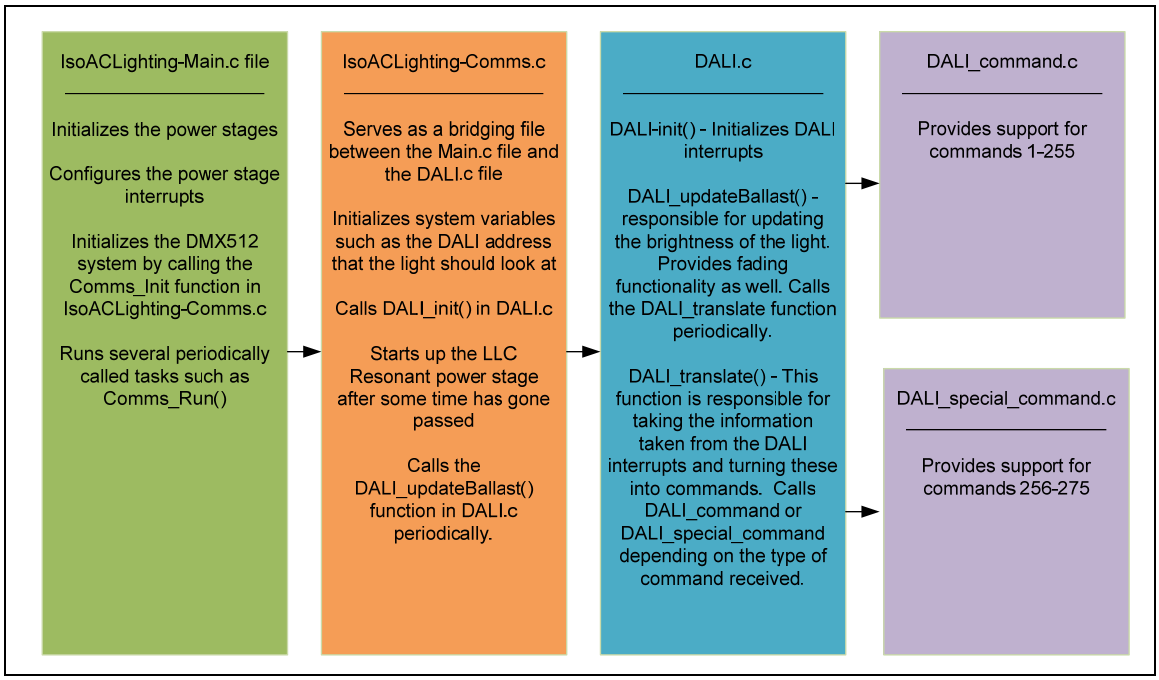

Figure 4: Major Files in the DALI Project

To run the project and have DALI communications work you will need a DALI master such as the Tridonic DALI-BM RS-232 (with winDIM 4.0) or other DALI master.

Steps:

1. Run the software and configure the hardware as instructed in build 1 & 2 of the TMDSIACLEDCOMKIT-CCS guide.
2. Attach the USB cable to [M8]-JP1
3. Ensure that [Main]-J3 is populated
4. Put jumpers across positions 2 & 3 of [Main]-J4 and [Main]-J5
5. Attach a DALI master to TB7. Attach the "+" terminal of the master to the "+" terminal of TB7.
6. Setup the DALI master and software as instructed in the master's user manuals and guides.
7. Connect a 12V DC supply to [M7]-JP1
8. Switch [M7]-SW1 to the "Ext" position.
9. Open CCS.
10. Import the IsoACLighting-F28027-DALI project found at:
    C:\TI\controlSUITE\development_kits\TMDSIACLEDCOMKIT_vX.X\
    IsoACLighting-F28027-DALI
11. Compile the software
12. Connect and flash the code by clicking the "bug" button.
13. In CCS, reset the processor and then click restart (so that the program starts at the beginning of main)
14. In CCS, enable real-time mode and enable continuous refresh of the watch window.
15. Click the green play button to run the software. (Step 16 should be done shortly after this step is complete.)
16. Carefully plug the AC cable into the wall. **Once this step is complete, the board will be dangerous to touch.**

Note that the LLC resonant power supply is automatically set to turn on about 10 seconds after the board is powered.

17. Use the DALI master's software to communicate brightness information to the kit. By default the ballast will have no group or scenes assigned to it. The controlCARD's LED LD3 should toggle when any DALI command is received by the F28027 MCU.
18. From a CCS watchwindow, you can look at the below variables (and many more). Each of these is defined as a character, but should be viewed as a integer in the watch window:
    - actual_level – the brightness value reference given by the DALI
    - Gui_IsetLed[0-5] – the brightness level for each LED string (provided by the actual_level variable). This variable is Q14.
    - short_address – the address of the DALI light; 0xFF (broadcast only) by default
    - min_level – the minimum value that the light can output; set as 90
    - max_level – the maximum value that the light can output; set as 254
    - group_0_7 and group_8_f – 8-bit variables in which each bit corresponds to whether the light is in a particular group or not.
    - scene – an array that corresponds to the light's defined value in a particular scene.
19. Once done, use the DALI master to turn off the LEDs on the TMDSIACLEDCOMKIT.
20. Unplug the power cable from the wall.
21. Wait at least 60 seconds before touching the board.

Note: This demo can also be run without the external DC/DC power supply connected and without CCS. However, it is safer to use the external power supply first. Once the DALI code is flashed into the device (which is done in the procedure above), you can rerun the above with the following exceptions: remove the DC/DC supply, switch [M7]-SW1 away from "Ext", and skip steps 10-12 & 16.

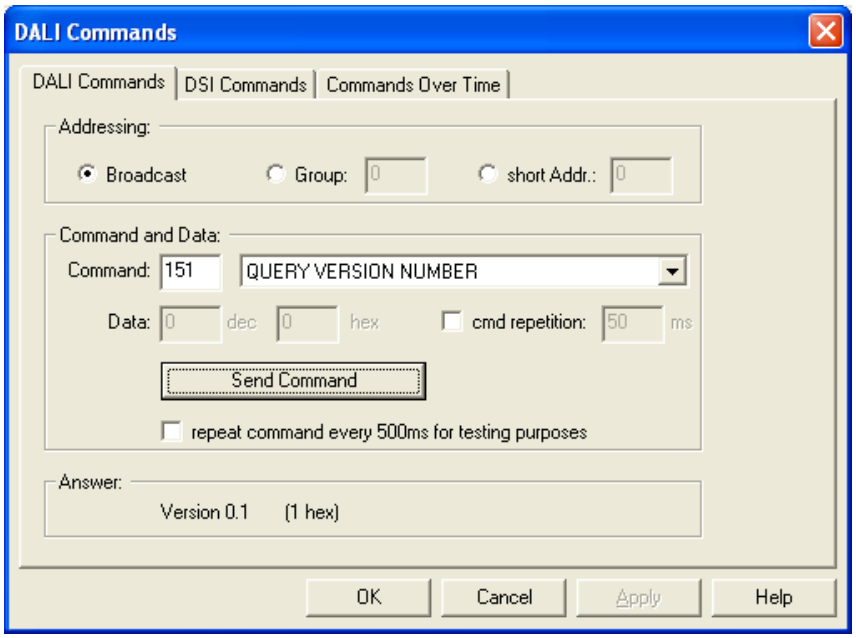

Figure 5: Example of DALI Host GUI

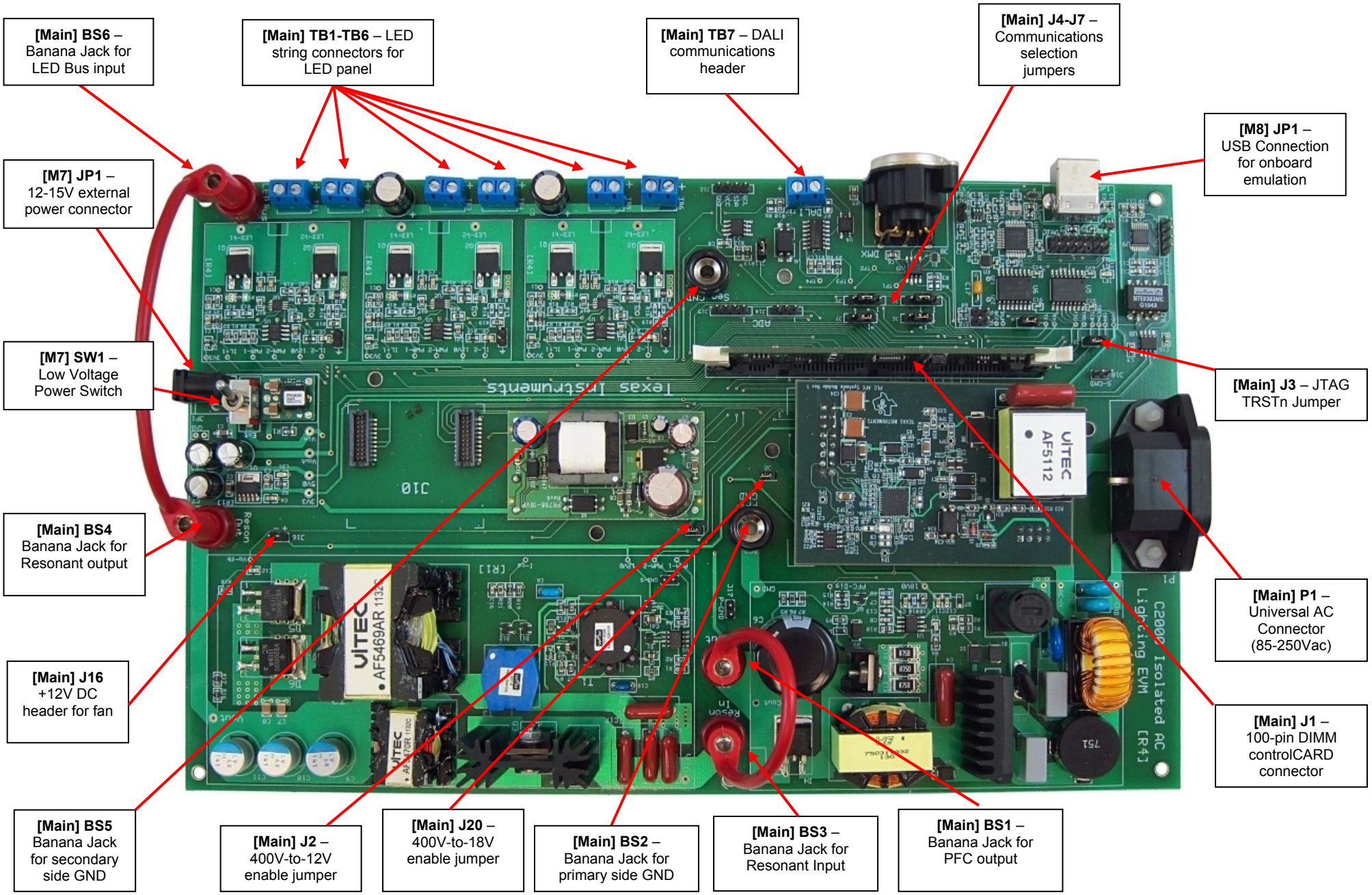

Fig5. AC LED Lighting and Communications Board Jumpers and Connectors Diagram

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

- **MSP430 DALI Application Note** – MSP430 software from which the C2000 DALI software has been based

  http://www.ti.com/lit/slaa422

- **DALI Manual** – Gives an overview of the DALI standard

  http://www.dali-ag.org/c/manual_gb.pdf