

High Power/High Brightness LED, DALI & DMX512A-RDM enabled, Lighting Reference Design
Quick Start Guide

Version 1.0

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Acknowledgements

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The aim of this document is to provide an easy to follow guide as to the set up and usage of the Freescale High Power/High Brightness Lighting Reference Design (LRD).

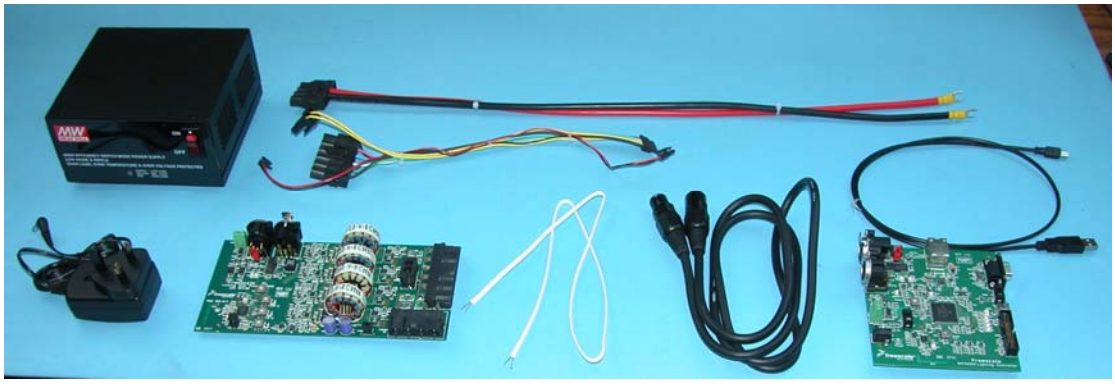
There are two versions of the LRD, a high power version capable of delivering 12A per LED with up to 4 LEDs/Channels per High Power (HP) LED Driver board. The second version of the LRD uses a 4 LED/Channel Low Power (LP) LED Driver board capable of delivering up to 1.5A per LED/Channel. The reason for these two versions is that the HP LED Driver board targets high current LEDs like those from Luminus Inc., in particular their CBM380 product that offers red, green blue & white LEDs in one package. This package is capable of sinking a maximum of 32A. The LP LED driver board targets high brightness LEDs from a range of manufacturers - Avago, Cree, Osram, Philips Lumileds and Seoul Semiconductor for example. As such the LP LED driver board has a daughter-card arrangement so that different manufacturers LEDs can be driven with a simple re-spin of just the LED daughter-card.

Each Lighting Reference Design kit is contained in a flight case and consists of either a High Power (HP) LED Driver board or two Low Power (LP) LED driver boards. These boards can be interconnected using either DALI or DMX512A lighting communication protocols and are interfaced to a Windows PC via an LED Controller board using a USB2.0 interface. Supplied with the kit is a Windows based (either Windows XP or Vista) Graphical User Interface (GUI). This GUI allows the user to control the colour balance and luminance of multiple LEDs using either DALI or DMX512A communications.

Throughout the rest of this document, photographs of the equipment used in the LRD, and screen shots of the GUI, will be used to provide the reader with a simple set of steps to follow to both connect and power the equipment and then invoke and use the GUI.

Hardware Components

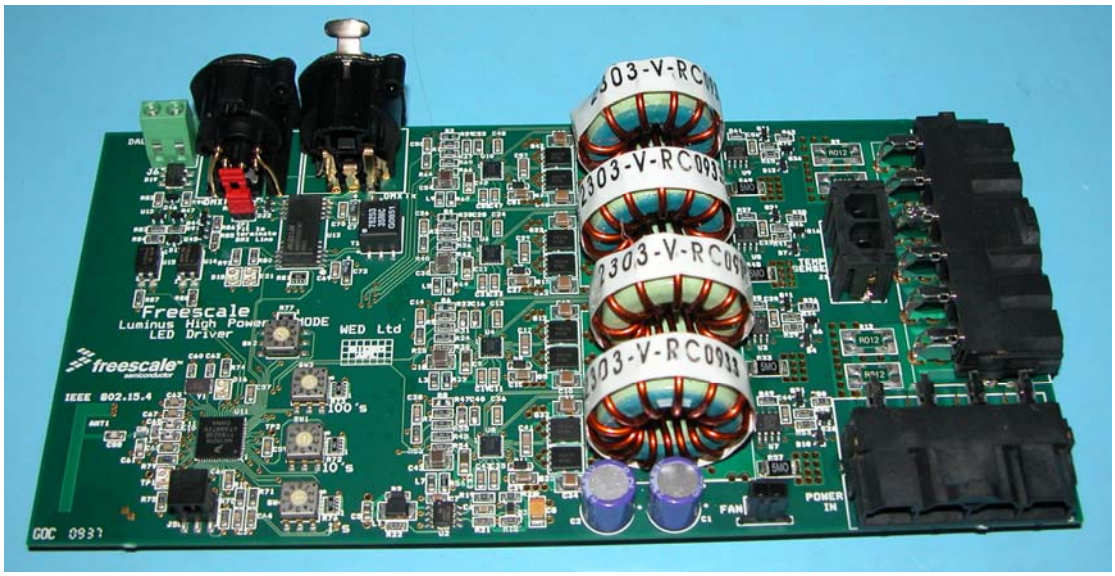
Shown below are the component parts of the HP LED driver kit



Taken from the top left hand corner in a clockwise direction these are –

1. A high current (~39A at max. LED forward voltage) isolated 12V DC power supply (PSU).
2. The black/red 12V supply cable for the HP LED driver board.
3. USB cable for connection between a PC and the LED Controller board, supplying both power and data to the LED Controller board.
4. A 0.5m long XLR5 DMX512A data cable for connection between the LED Controller board and HP LED Driver board.
5. A white two way DALI data cable, deliberately not colour coded as DALI works on potential difference and so the connections can be made either way round.
6. An HP LED Driver board.
7. An encapsulated 12V 0.8A power supply for connection to the LED Controller board to supply the DALI interface on the board. **Note: only required if the DALI interface is going to be used.**
8. In the centre of the photograph is the wiring loom used to connect the HP LED Driver board to the Luminus CBM380 LED assembly. This loom is supplied by Luminus Inc. and modified in terms of connector for the HP LED Driver board.

The photograph below shows the HP LED driver board in more detail –

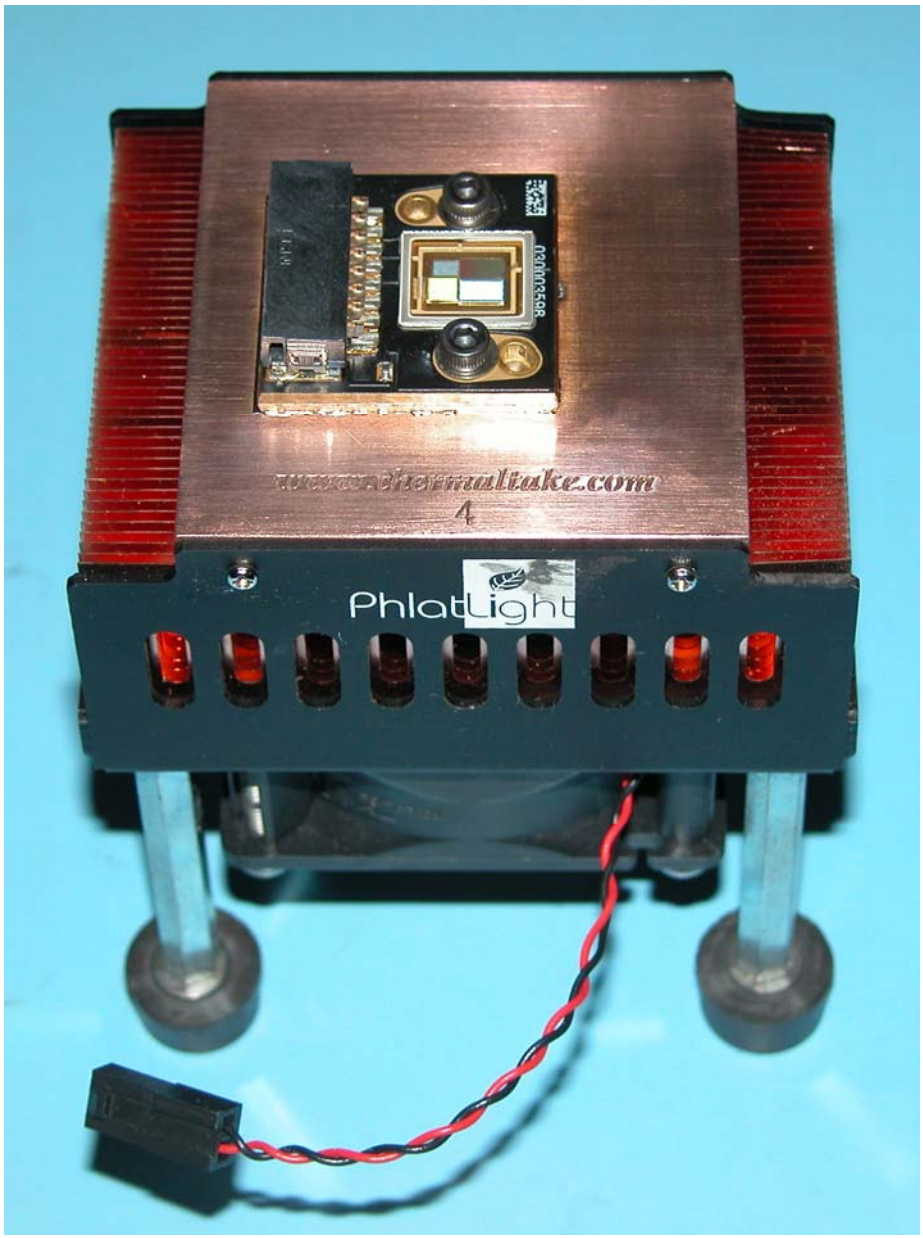


From the top left hand corner in a clockwise direction –

1. The green two way screw terminal connector is the DALI connector.
2. Next the two circular black connectors are 5-way XLR DMX512A connectors. The connector on the left hand side is DMX512A Rx and on the right hand side is DMX512A Tx. The red jumper behind the DMX512A Rx. connector is DMX termination, which must be fitted on the last HP LED driver board in the DMX512A chain of LEDs. The DMX512A interface includes electrical isolation from the DMX512A bus, which in simple hardware terms is a multi-drop (a max. of 512 LEDs can exist in one network, hence the protocol's name) RS-485 current loop based system.
3. The four large components near the centre of the board are high current inductors, if you look carefully you can see four repeated circuits each of which drive a separate LED with up to 12A.
4. Immediately to the right of the inductors is a 2-way connector that accepts a cable that connects to the thermistor on the CBM380 LED assembly.
5. On the right hand end of the board is the 6-way connector that connects to the Luminus wiring loom and delivers power to the four LEDs of the CBM380.
6. Immediately below this is a 4-way power connector where 12V is applied from the high current PSU. From this a 3.3V supply is derived for the Freescale MCU (MC13213) and interface circuitry.

7. In the bottom left hand corner of the board is the Freescale MCU and address/mode select switches. On the far left-hand side of the board embedded in the copper of the board is an IEEE 802.15.4 F-antenna. As the MC13213 contains a Zigbee transceiver as well as a MC9S08GB60 MCU in a system in a package (SiP). The MC13213 was used such that wireless control of the system via IEEE 802.15.4 could be added at some future date.

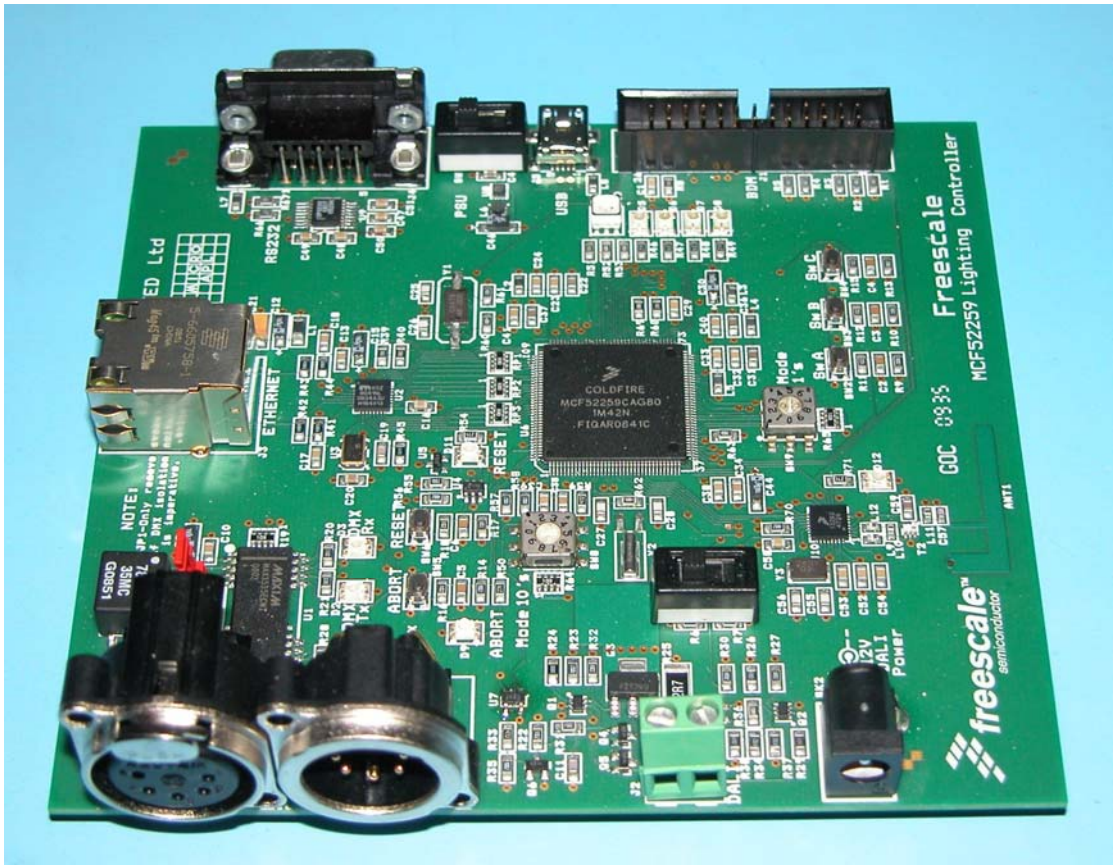
The High Power (HP) LED Driver board drives the Luminus Phlatlight CBM380 LED shown below in more detail –



This assembly connects to the HP LED driver board via the black ERNI connector to the left of the LED and the wiring loom shown in the initial

photograph of the complete kit on page 3. This loom is immediately below the red/black power lead at the top of the photograph.

The photograph below shows the LED Controller board that utilises a Freescale MCF52259 MCU running the MQX RTOS with USB communications stack. This board acts as the interface between a PC loaded with the GUI software and the LED Driver boards connected using either DALI or DMX512A cabling –



From the top left hand corner of the board –

1. An RS232 serial port used only for debug purposes at data rate of 115200bps 8N1.
2. The ON/OFF switch for the 5V USB power to the board.
3. A USB mini A/B connector.
4. The ColdFire MCF52259 microprocessor debug connector.

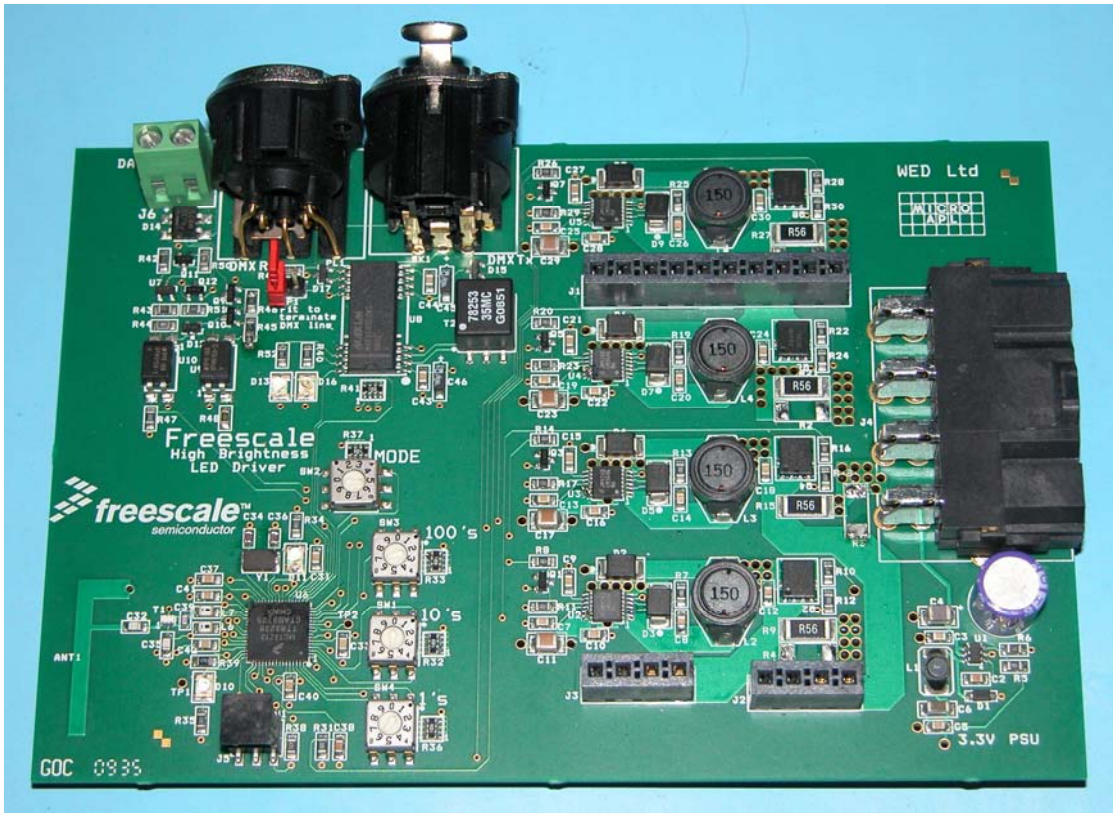
On the bottom side of the board from the right –

5. The DALI +12V power connector. To act as a DALI controller this board must be able to source 250mA and in our design swing a data voltage from 0V to between +10 & 11V to meet the DALI definition of high and low data levels.
6. Immediately to the left of the DALI power connector is the DALI data connector, the green connector with two screw terminals.

7. To the left of the DALI connector are the two DMX512A connectors for Rx and Tx respectively. Note the red jumper behind the DMX connectors, this allows the Controller board to be completely isolated from the DMX interface, the default setting for this jumper is fitted i.e. non-isolated.
8. On the left hand side of the board is an Ethernet RJ45 connector, which is connected to the FEC module of the MCF52259. Currently this Ethernet connection is unused.
9. Finally, immediately above the green DALI connector is a second slide switch that allows the user to select between DALI or DMX512A lighting protocols.

The Controller board, like the slave boards, is Zigbee (IEEE 802.15.4) enabled, the Zigbee PCB antenna can be seen on the right hand edge of the board just above the Freescale silkscreen logo. This would allow the controller board to wirelessly control slave LED driver boards, which will be implemented at some future date.

The photograph below shows the lower power (LP) version of the LED driver board in more detail –



From the top left hand corner of the board –

1. The two way DALI data connector.

2. The two DMX512A connectors for Rx and Tx respectively, immediately behind these two DMX connectors is a red DMX termination jumper. This should only be fitted to the last board in a DMX network, to terminate the DMX bus.
3. Immediately to the right of the DMX connectors is the first of the 4 driver circuits for each LED supplying up to a maximum of 1.5A per channel/LED. Within this circuitry you can see 3 connectors that will be used to connect and support the LED daughter card.
4. On the right hand edge of the board is the +12V power connector for the LP LED driver board, this supplies both the LED driver circuitry as well as the microcontroller, MC13213.
5. In the bottom left hand corner of the board is the MC13213 microcontroller, to the right of which are the LED selection and DALI/DMX selection switches, which on this board are 4 rotary BCD switches. Immediately to the left of the microcontroller is a Zigbee (IEEE 802.15.4) PCB antenna, ready for future wireless connectivity.

The final PCB is used only with the LP LED driver board, it is the LED daughter card, see below. This example happens to use 4 Philips Lumileds Luxeon Rebel LEDs – Red, Green, Blue and Cool White. These are covered by an optical diffuser. The last thing to note about this board is the large area of copper around the LEDs as well as the large number of through board vias. These are to dissipate heat away from the LEDs, combined with a heatsink on the underside of the PCB.



When assembled to the LP LED driver board they look like this –



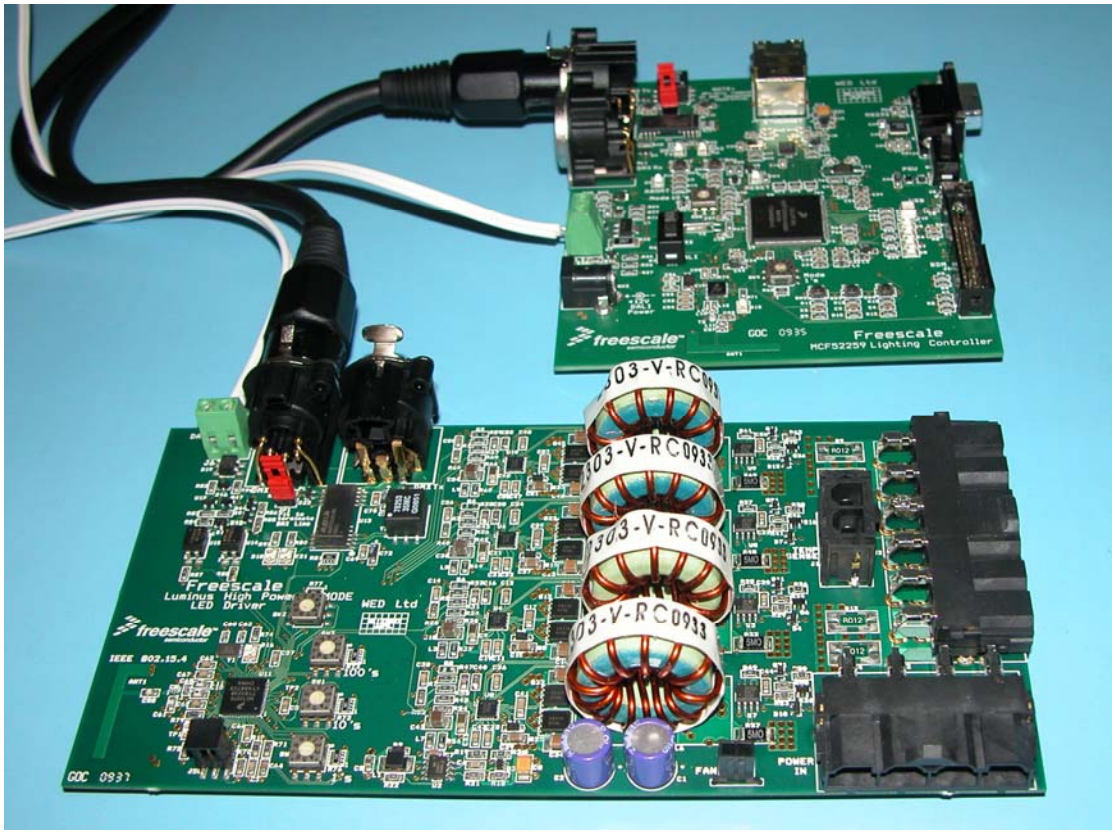
Cabling

Now that we have looked at the key components of the Lighting Reference Design let us look at how they should be cabled together.

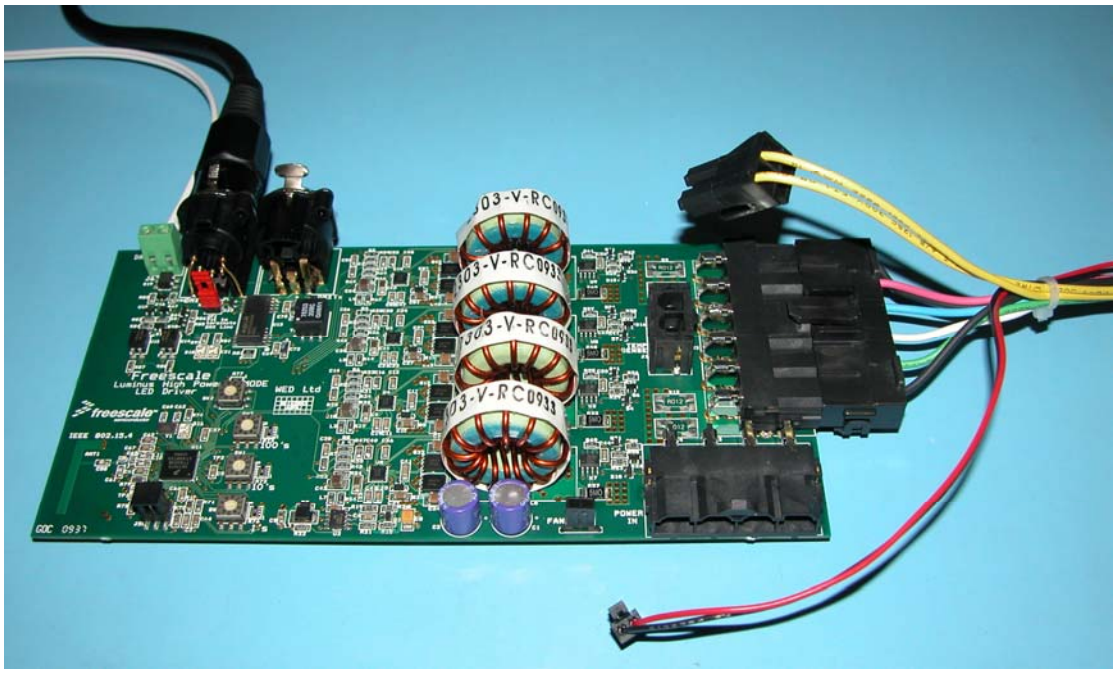
Taking a high power set up as our first kit assembly, below the photograph shows the LED Controller board connected to the HP LED driver board using a black DMX cable, in that the DMX Tx (LED Controller) connector of the LED controller board is connected to the DMX Rx connector of the HP LED Driver board –



We now add a white DALI cable between the LED controller and HP LED driver board. The cable is deliberately not colour coded as the DALI connections can be made either way round. The DALI interface offering isolation for the MCU from the DALI cable/data –



Next the Luminus wiring loom is connected to the HP LED Driver board and LED CBM380 assembly –



The main signal/power connector is attached.

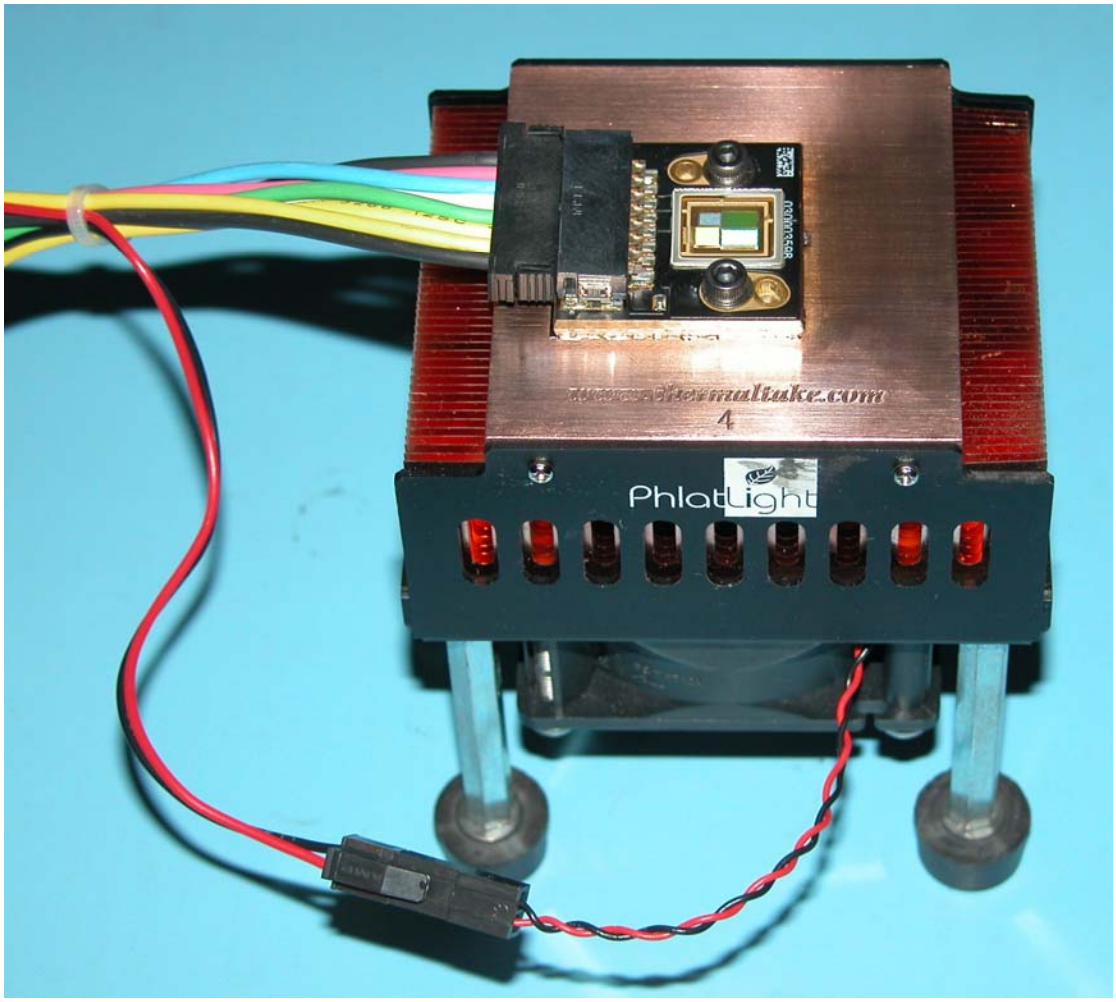


The yellow thermistor cable is attached to allow the system to monitor the temperature of the CBM380 assembly and hence calculate the junction temperatures of each LED in the package.

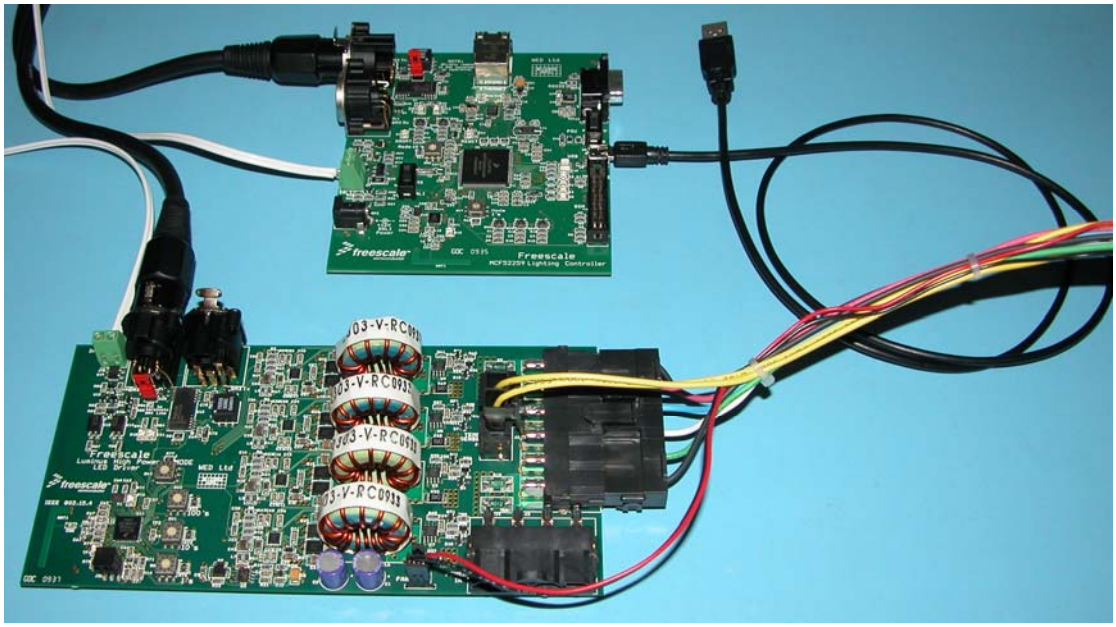


Finally the red/black power connector for the fan on the CBM380 assembly is attached.

The other end of the Luminus wiring loom connects to the CDM380 assembly as shown below –

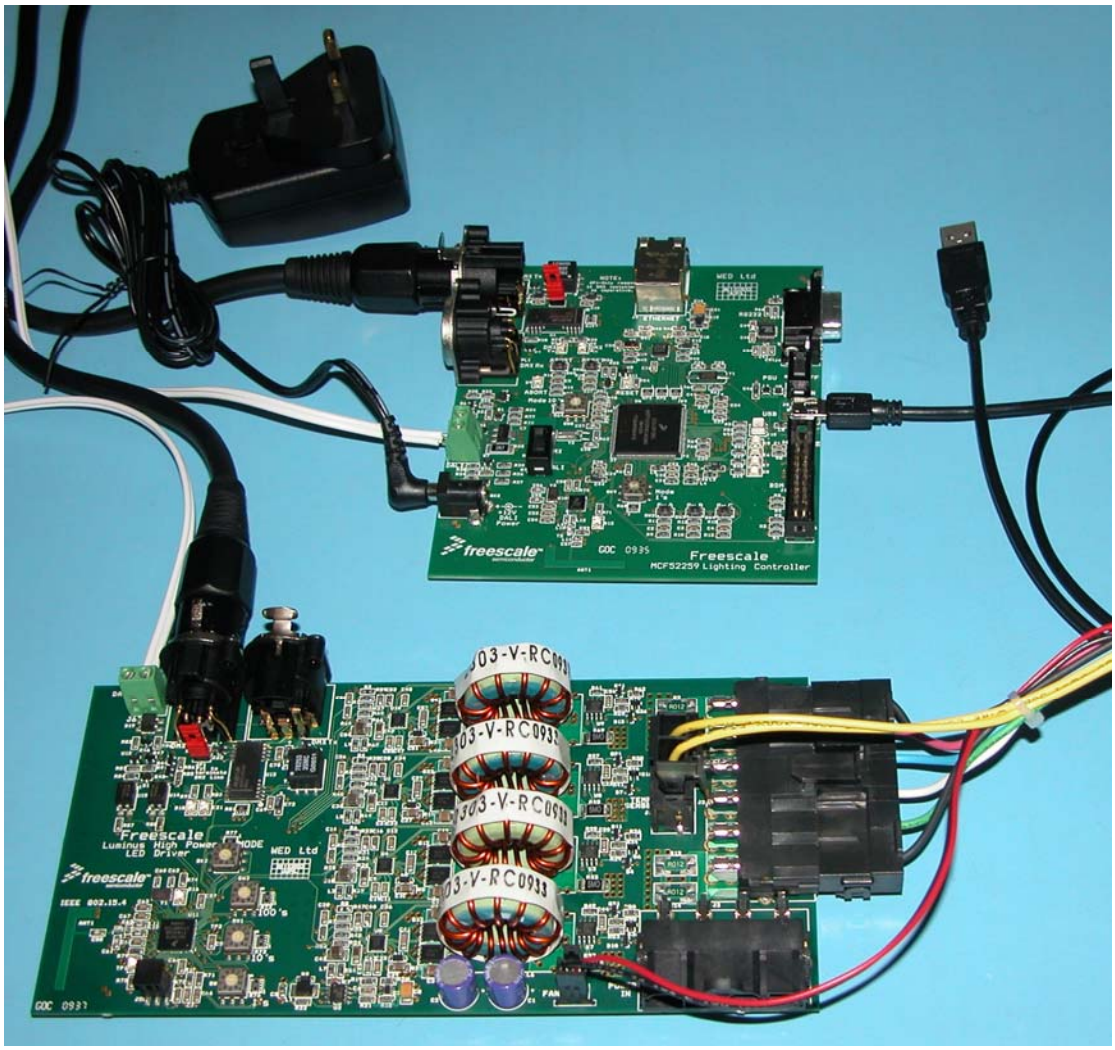


The next step is to connect a USB cable to the LED Controller card –



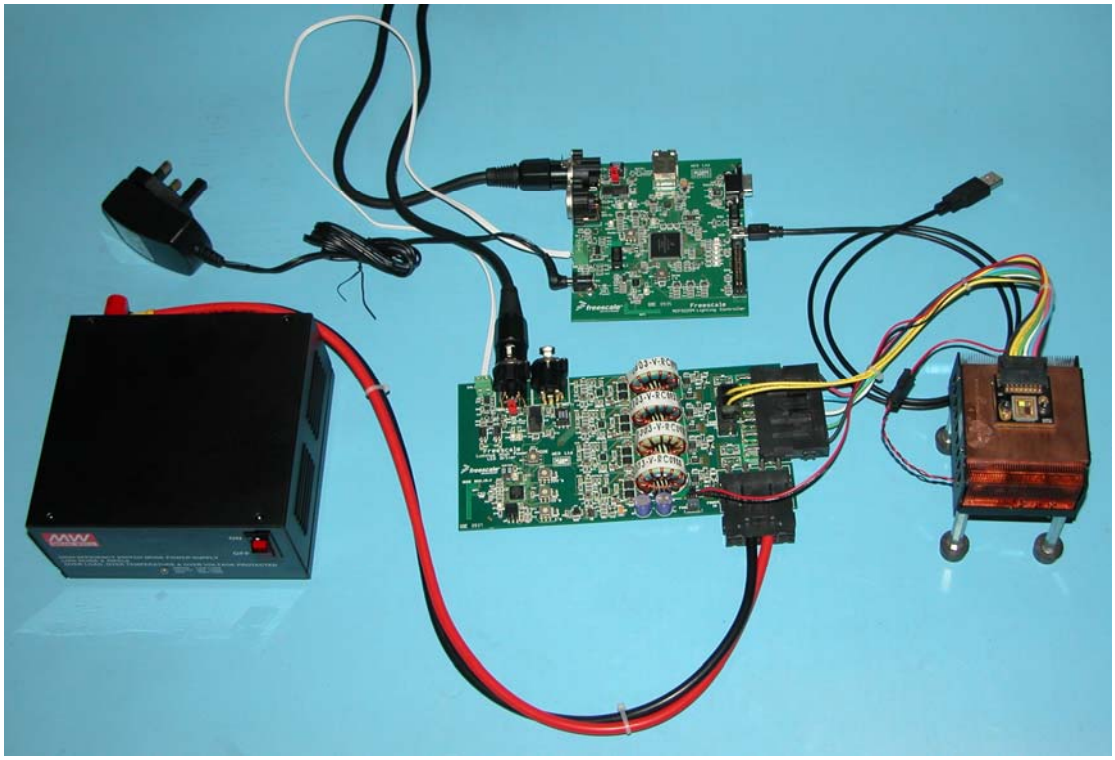
The USB cable provides both data and power to the LED Controller card.
Please do not power the LED Controller board just yet.

The encapsulated DALI power supply is connected –



The encapsulated DALI power supply comes with multiple mains connectors, shown here with a U.K. mains plug.

Finally the high current +12V DC isolated power supply is attached –

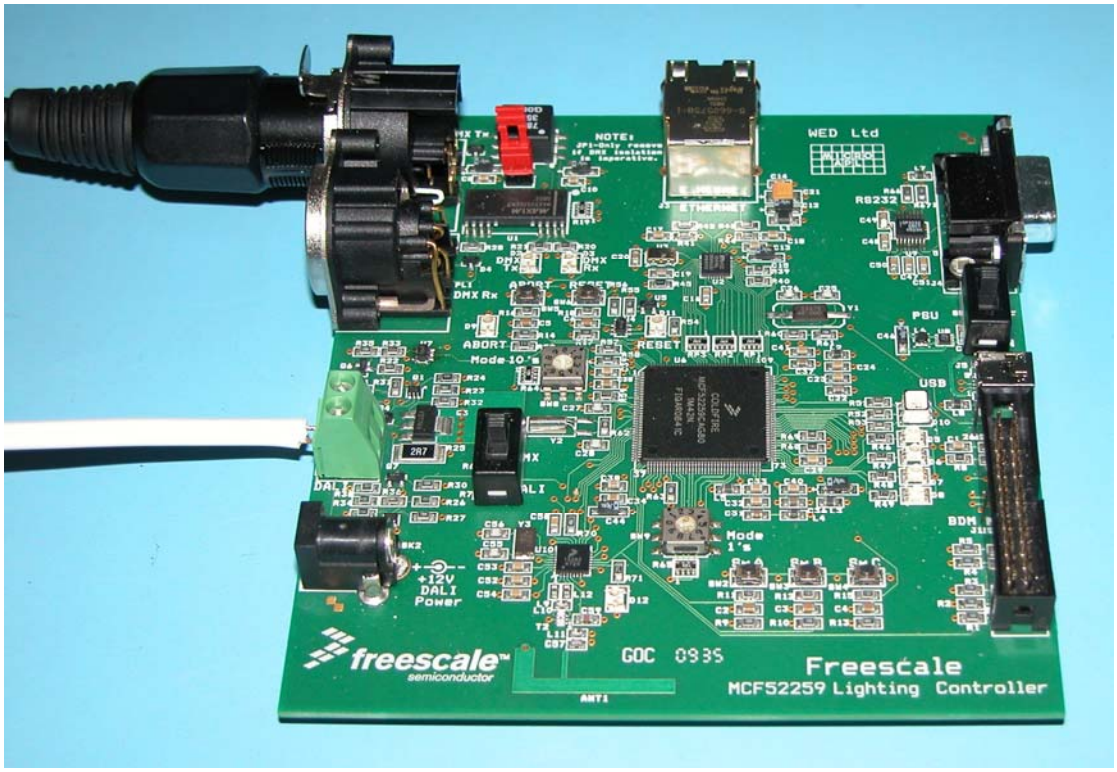


The heavy gauge cable between the +12V power supply and HP LED Driver board ensures little drop in either current or voltage. The lead is supplied with spade terminals, which connect as shown below using screw terminals on the +12V power supply –

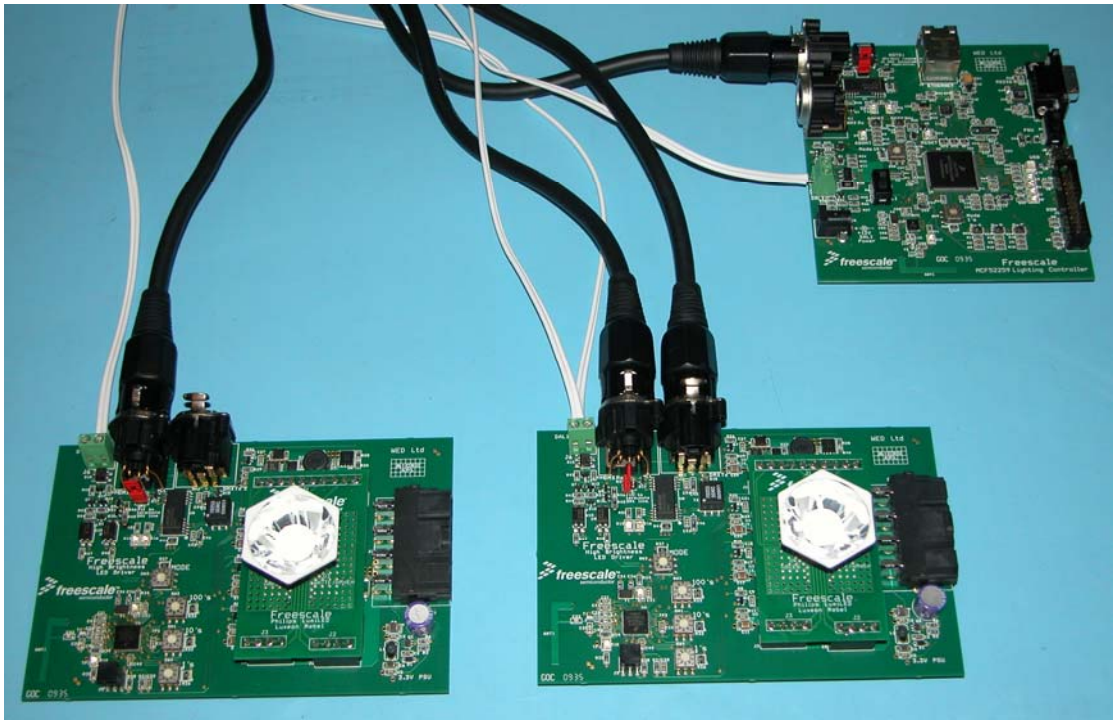


Please note the high current +12V DC supply supports both 120V & 240V AC input operation via the red selector switch shown above, please make sure that the correct AC input voltage is selected for your region.

Now it is time to look at the set up of equipment for the low power (LP) LED driver board. There are similarities with the HP set up so I will keep comments to a minimum. All the connections to the LED controller card are the same as for the HP set up, below we see the initial DALI and DMX512A connections



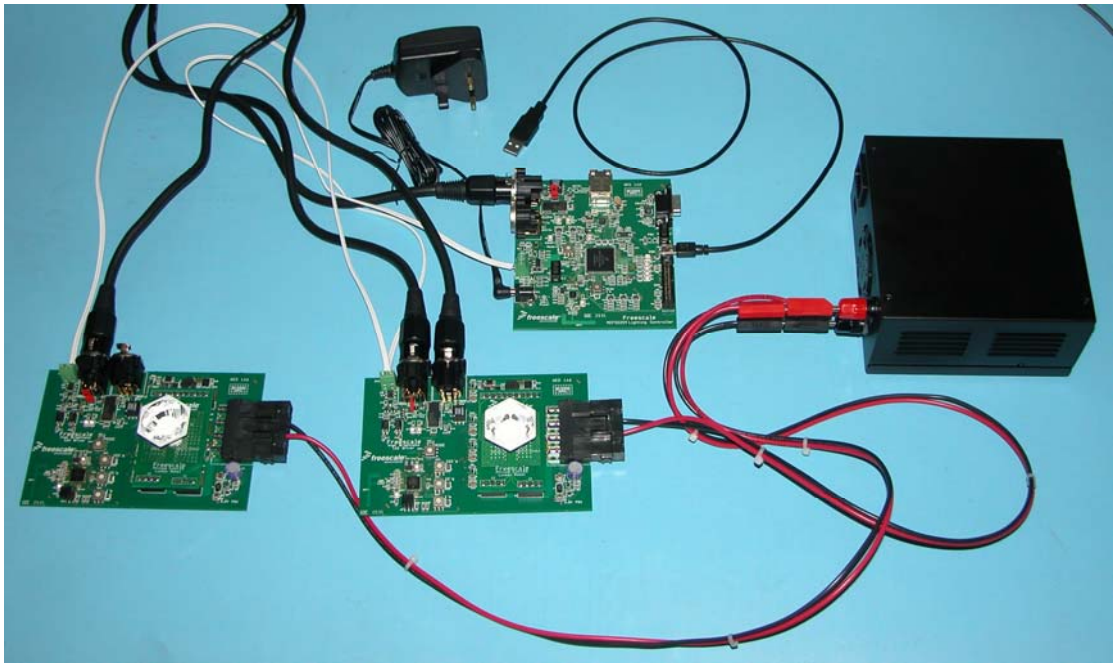
The LED controller is connected to two LP LED driver boards connected via both DALI & DMX512A cabling. Note how the second LP LED driver board has the DMX termination jumper fitted and first has it removed. Both lighting protocols have their slave LEDs connected in series.



The next photograph shows the addition of the USB cable to the LED controller ready for connection to a PC.

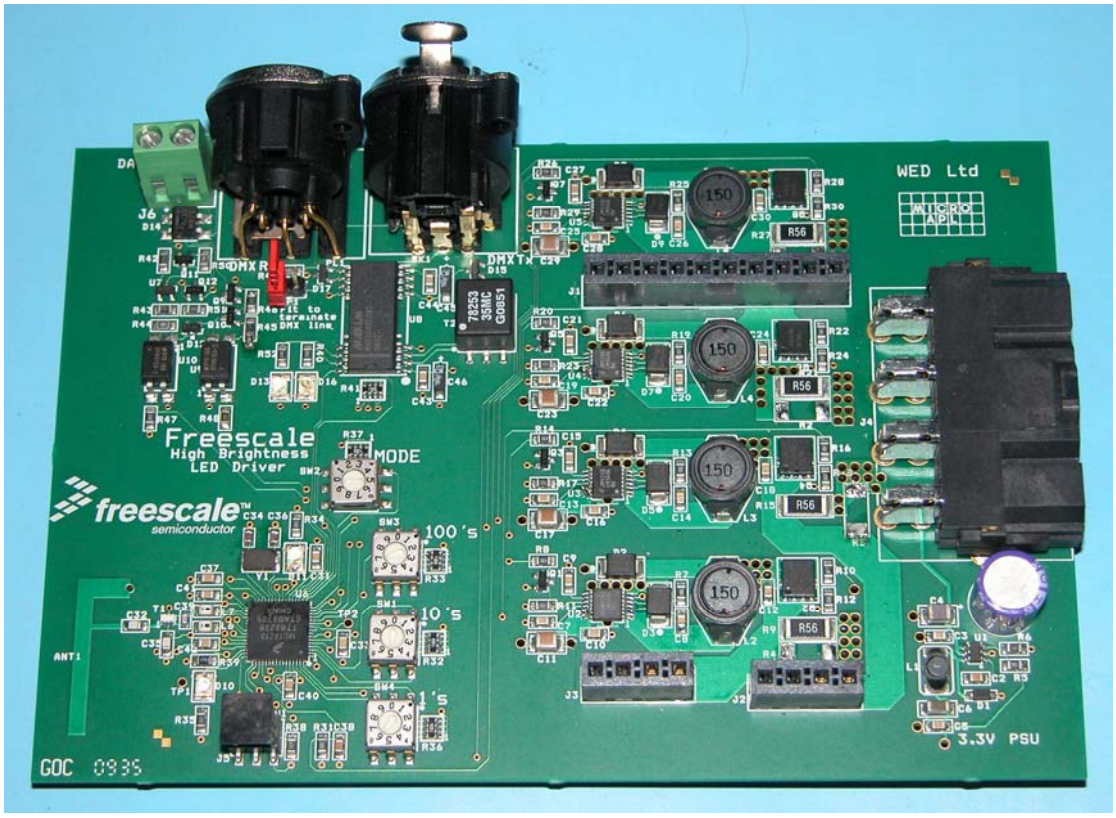


This is followed by connection of the DALI and +12V high current power supply. Note each LP LED driver board consumes far less current than the HP set up, so stackable cables are used with the high current power supply to allow several boards to be connected in series.



This represents the complete set up for a LP LED reference design kit as delivered in one flight case.

The BCD rotary switch configuration is the same for both the HP and LP LED driver boards. Below is a photograph showing the LP LED Driver board, without LED daughter card fitted, in more detail.



The top rotary switch labelled MODE on the silkscreen, selects whether the HP or LP LED driver board is in DALI or DMX512A mode –

MODE switch set to 1 = DALI
MODE switch set to 2 = DMX512A

The next switch labelled 100's on the silkscreen selects the DMX512A RDM address. This is only required during DMX512A operation and limits the size of the DMX512A network to 10 LEDs i.e. 0 to 9. In a real DMX512A network these addresses would be assigned by the LED Controller board and stored in MC13213's Flash memory.

100's switch = DMX512A RDM address from 0 to 9

The final two switches labelled 10's and 1's select the LED type allowing for up to 100 LED types to be supported. So far only two LED types have been assigned.

10's switch = 0, 1's switch = 1 – Philips Lumileds Luxeon Rebel LEDs R,G,B & CW
10's switch =0, 1's switch =2 – Luminus Phlatlight LED CBM380 R,G,B & W

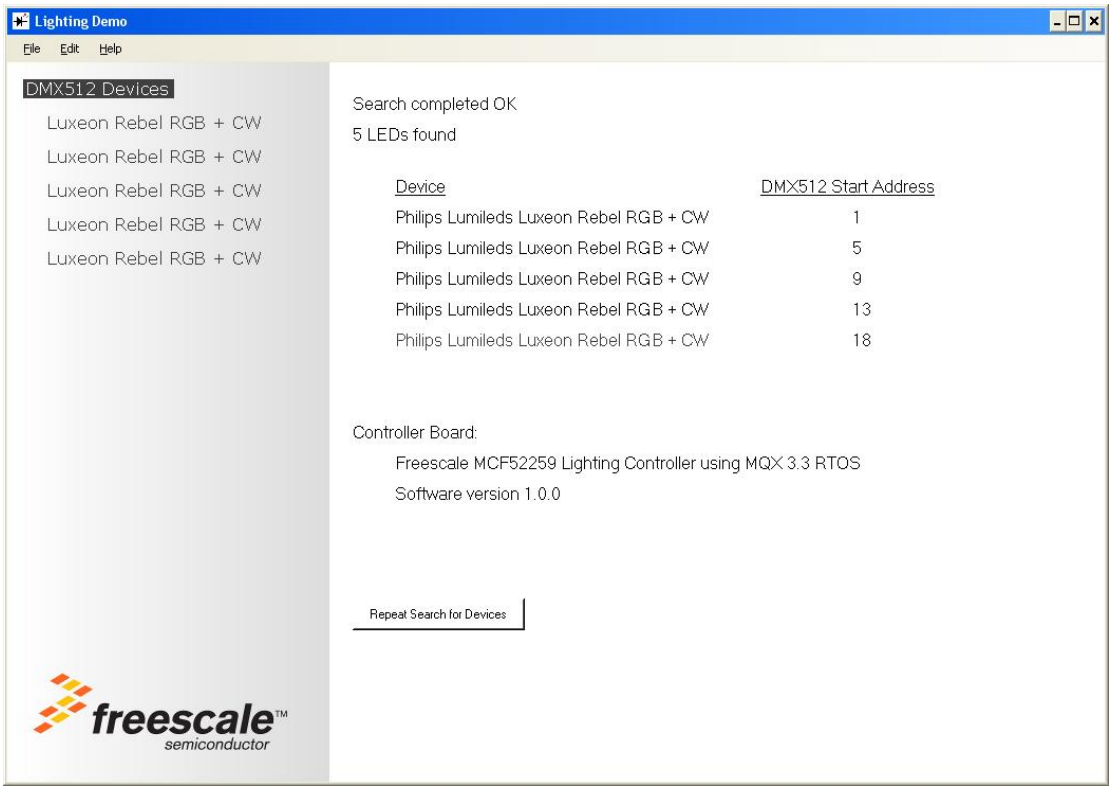
Currently any other switch combination will appear in the PC GUI as unknown LED manufacturer after a search of the network via either DALI or DMX512A. The set of supported LEDs will of course be added to as more LED daughter cards are created to support other LED manufacturers.

Software

PC GUI Software Installation

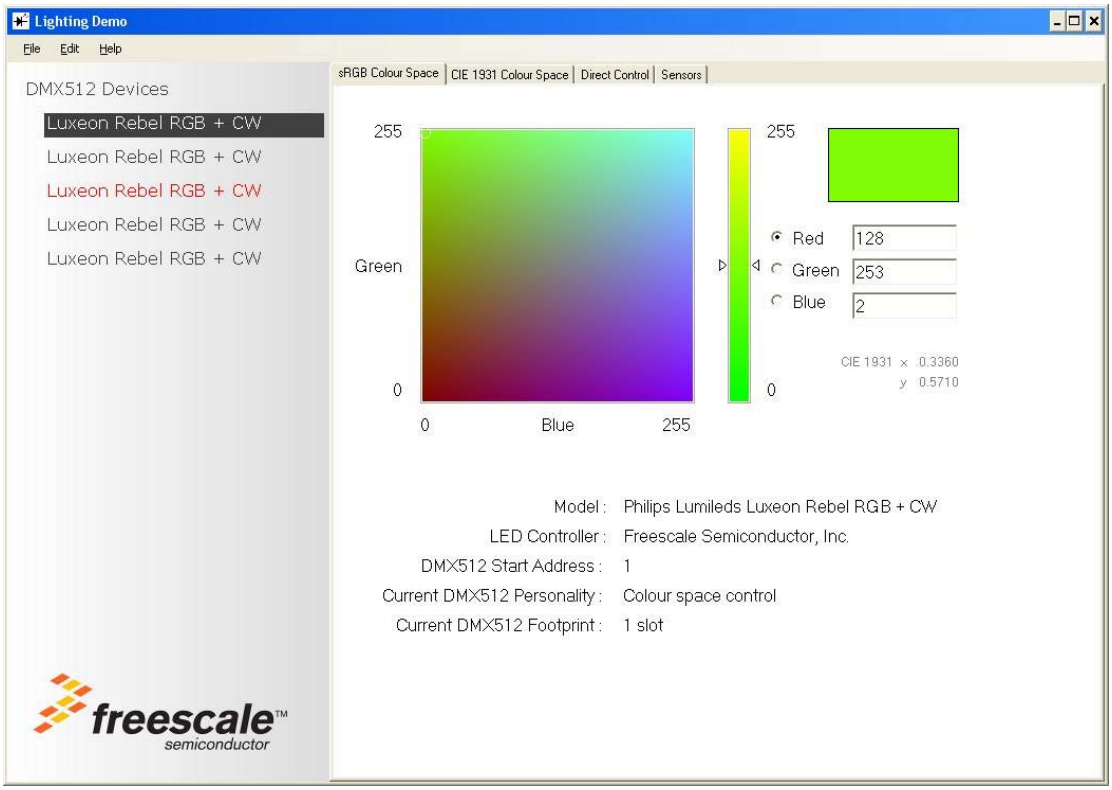
Before powering up the reference design the PC Graphical User Interface (GUI) software must be loaded onto a PC. This software, via the USB port, will control the LED(s) in the system. The CD supplied with the reference design has an auto installer. Please follow the installation windows that appear when the CD is loaded (the installation has been tested on Windows XP SP2 & SP3, as well as Windows Vista). When prompted to do so please connect the USB cable from the LED Controller board to the PC and power up the board using the on/off slide switch. The installation will install a USB driver for the Lighting Reference Design and one way to check if the installation has been successful is to check within the Control Panel of the PC where, under the System Properties/Hardware/Device Manager settings you

should find a Freescale Lighting Controller device. Also within the Programs pop up menu you should see – DMX-DALI Lighting Demo. Invoke this program and the following start up screen should appear –

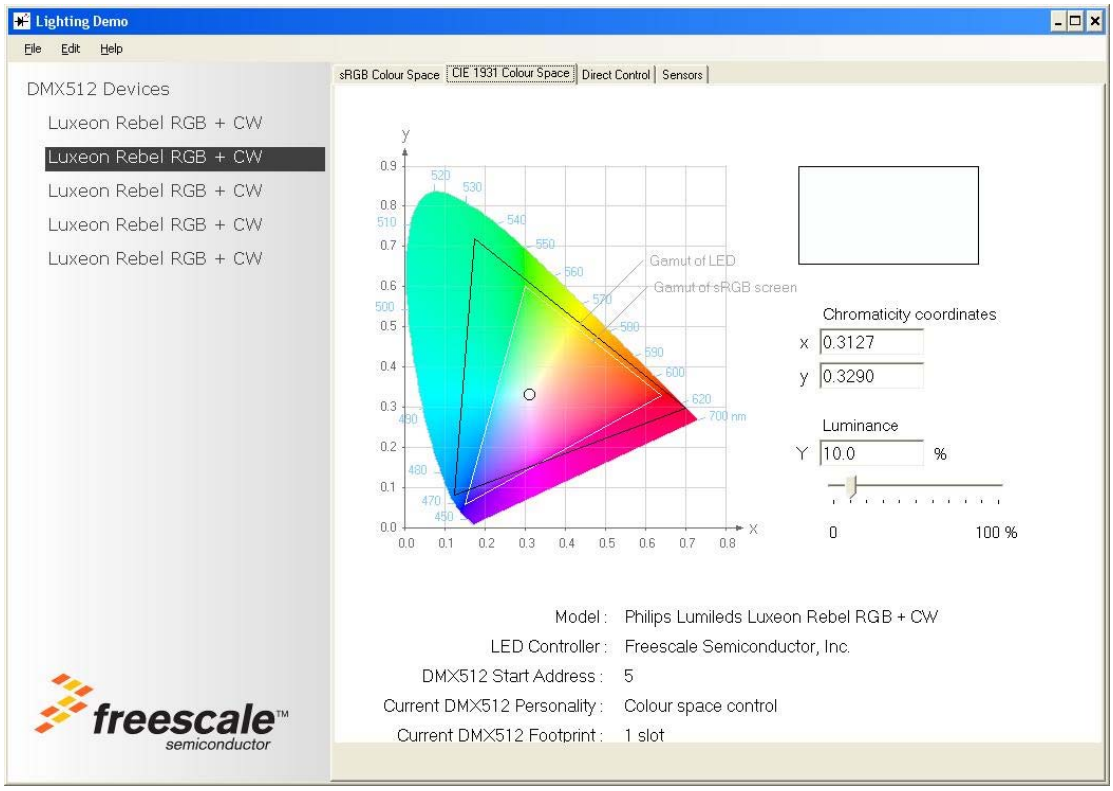


The Lighting Demo software will communicate via USB to the LED controller board. The LED controller will then read the setting of the DALI/DMX512A switch and automatically scan either the DALI or DMX512A network as a result of this switch setting. Users will note that a DALI scan takes far longer than a DMX512A scan. This is mainly due to the fact that DMX512A is operating at 250Kbps whereas DALI is operating at 1200 bps. This allows DMX512A data to be sent over 200 times faster through the lighting network than DALI data. The screen shot above was taken with 5x Philips Lumileds LEDs connected. In this instance using DMX512A as a communications protocol. To select one of the LEDs, click the mouse pointer on either the left hand column or the right hand list, where the LEDs are shown with their DMX addresses.

Once an LED has been selected the following screen appears –

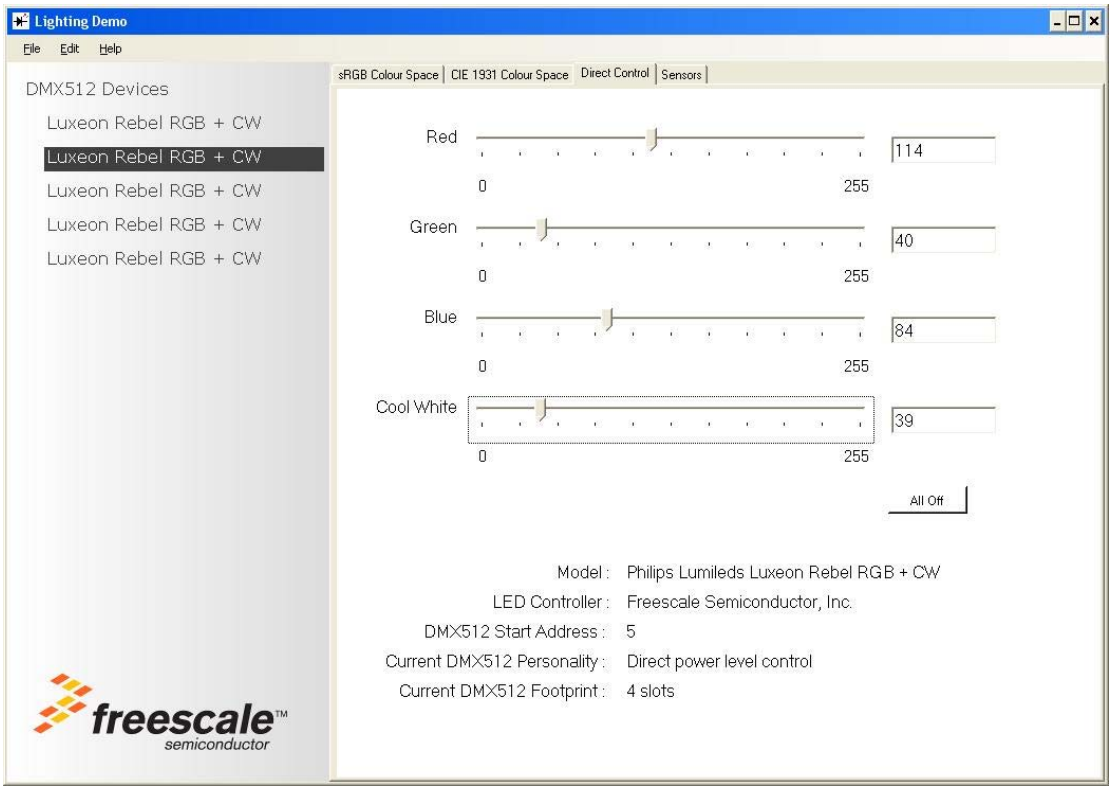


This is the first screen to display once and LED has been selected and shows colour space control. This colour space control is known as sRGB and colours can be selected by clicking the mouse pointer within the colour square and using the colour slider to the right of the colour square. sRGB colour space values can also be entered directly in the Red, Green & Blue boxes to the right of the colour slider. Once selected the colour details are sent via the USB port to the LED controller card and then out into the lighting system via either DALI or DMX512A lighting protocols. The HP or LP LED driver boards then decode these colour selection messages and adjust the colour balance accordingly. Finally, it is important to note that the colour selected is also shown as CIE 1931 colour space x,y values in grey text below the R.G & B values. As we will see from the next screen CIE 1931 is an alternative colour space method of colour selection. To use CIE 1931 click the tab at the top of the window labelled CIE 1931, the following window will appear –

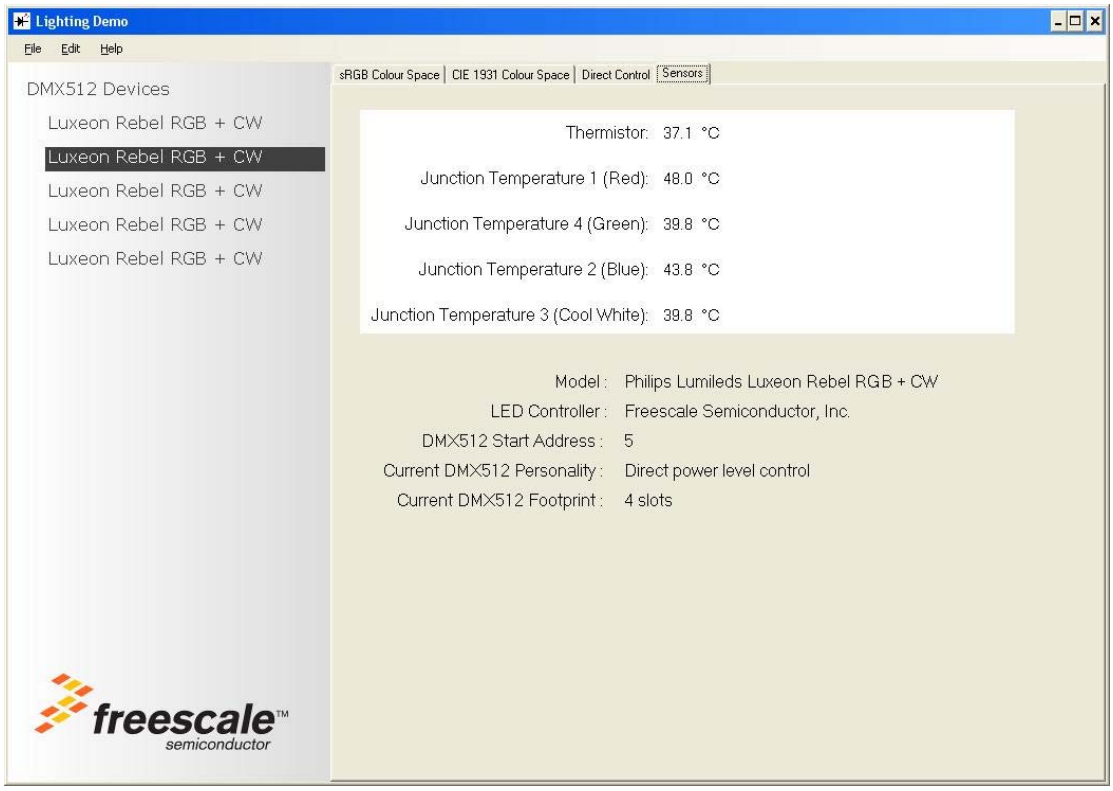


The horseshow shape represents all the colours to which the human eye is sensitive. Again to select a colour click the mouse pointer within the colour space. It is important to note that the two triangles within the colour space represent the colour gamut available to the PC screen and the LEDs being used in the lighting reference design. In most cases the LEDs have a wider gamut of colours that they can create/display. The default setting for this screen is the white point, represented by the x,y and Y (luminance) values on the right of the screen. The x,y colour coordinates can be entered manually in the boxes to the right of the screen if required and the luminance of the LEDs is controlled by the horizontal slider. Details of the LED being controlled are shown at the bottom of the window. If a colour outside the gamut of the LED(s) is selected the control software will attempt to colour match as closely as possible. The LED binning information from the manufacturer for each particular make of LED has been entered into the control software and so the colour balancing should be relatively accurate.

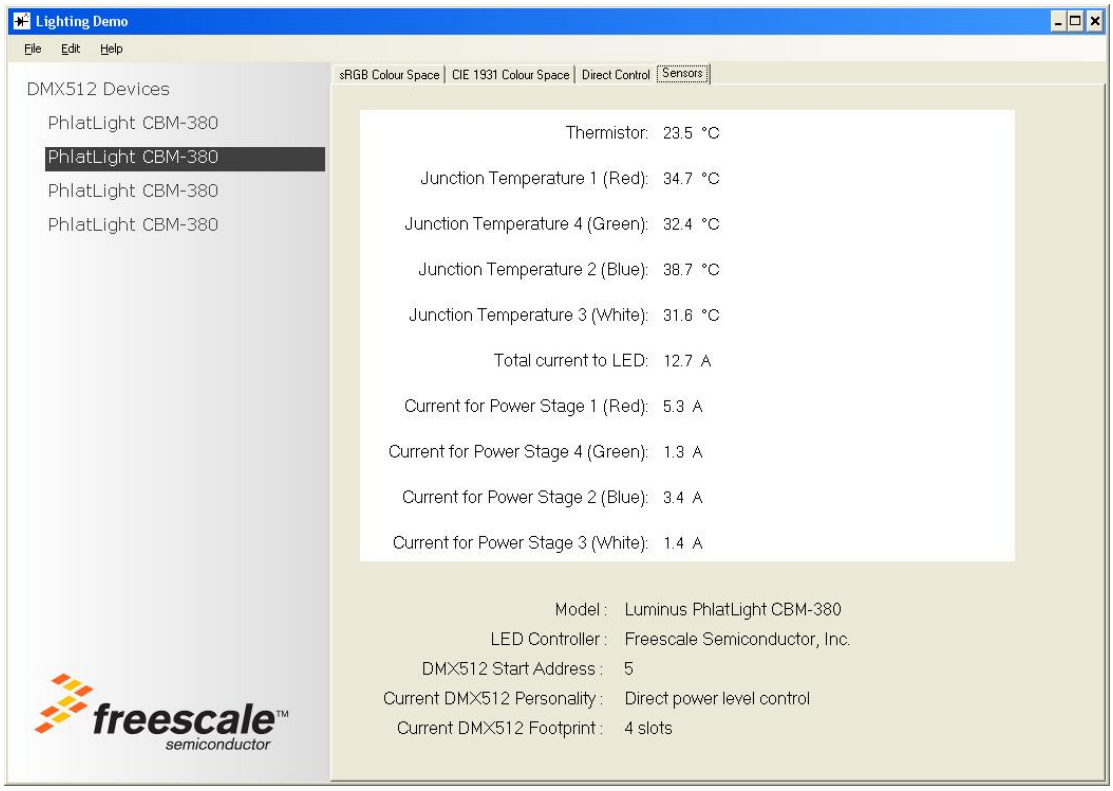
The next tab at the top of the window allows direct colour control of each LED making up the lighting module. In this case we have four LEDs – red, green, blue and cool white. By clicking the Direct Control tab you will see the following window –



The number of sliders appearing in this window will depend on the number of LEDs within the slave. In this case we have four. Each LED luminance can be directly controlled using either a slider or directly typing a value in the box to the right of each slider. The values run from 0 to 255, although the intensity of each LED is controlled via a 16-bit PWM value so the resolution of the luminance is a lot finer. To allow the lights to be extinguished quickly, quite useful with the Luminus LED, an "All Off" button is also available. This window and the last tab selected window, Sensors, are only available when using the DMX512A protocol. This is mainly because the most recent DMX512A specification includes RDM – Remote Device Management, not available when using DALI communications. This allows values to be passed back to the LED Controller by each of the DMX512A slaves and hence allows real time (in this case ~ once per second) updates of the sensor data received from the DMX512A slave selected, see the following Sensor window screen shot –



This screen is showing sensor data as a result of the previous Direct Control screen and, as you can see, the temperature values extrapolated from the thermistor close to the LED array do indeed follow the luminance settings from the previous screen shot. There is an extra set of values that can be read back for the Luminus Phlatlight design, as current sense circuitry was added to the HP LED driver board, both in terms of individual channel monitoring of current as well as overall current, see the screen shot below –



This window was generated using the same Direct Control settings used with the LP LED Driver board driving the Philips Lumileds LEDs and show the same variation in temperature and now current being supplied to each individual LED.

Finally for those users interested in seeing what sort of DALI and DMX512A data is being passed between the HP/LP LED driver boards and the LED controller board. Under the Help menu at the top of the GUI window is a diagnostics option. When selected this outputs all the data passing through the lighting system in a separate text window, see below –



This is a paused output and shows a DMX512A RDM command being acknowledged.

For any further information regarding the Lighting Reference Design please contact – R19296@freescale.com