BabelColor®

Application Note #13

Adding DMX512 control to the high quality illumination lamp of AN-12

1. Introduction

This Application Note is a follow-up to a previous note, AN-12,[1] in which it was shown how to build and test a variable-CCT[2] illumination lamp based on a bi-color LED strip consisting of 432 LEDs in twelve rows manufactured by **Yujileds**. In this strip, half of the LEDs have a CCT of 2700 K (nominally), which are identified as **WW** (Warm White), and the other half a CCT of 6500 K (nominally) identified as **CW** (Cool White).

Bi-color tunable LED strip:	**YJ-VTC-12HRB-2835L-24-2765**	Copy/Paste a link in browser if not opened by clicking!
Yujileds store site:	**https://store.yujiintl.com/**	

With the remote control presented in AN-12 you can select either the WW or the CW LED bank and adjust its brightness. You can also set intermediate CCTs between WW and CW with a touch sensitive color ring and adjust the brightness of this mix. Adjusting the CCT to a predetermined value requires a measuring instrument, a spectrocolorimeter, plus trial and error with the finger position on the ring. In this document we add precise numeric control to each LED bank by using the DMX512 protocol; this addition enables selection of preset CCT values without the need for a measuring instrument.

The LED strip we use is similar to other LED products dedicated to entertainment venues and architectural lighting. There are a wide variety of accessories available to control such lamps, including stand-alone light consoles, computer-based control software or room light control panels. Of course, with a variety of technologies also comes a variety of control protocols and the abundance of options and combinations rapidly becomes overwhelming when you jump into this subject as a neophyte!

What is presented here is a personal selection primarily based on achieving our goal, selecting preset CCT values. In other words, any features which could be essential for theatre lighting or for large projects with hundreds of luminaires were not considered. The product selection is based on popular, readily available, and reasonably priced products which can be integrated with minimal system complexity.

[1] AN-12 Design and test of a high quality illumination lamp for color samples and prints https://www.babelcolor.com/tutorials.htm

[2] CCT: Correlated Color Temperature, in kelvin.

The first decision was to select DMX512 as the control protocol for the lamp. This decision was greatly facilitated by the availability of a DMX512 LED decoder from the LED strip manufacturer; this decoder acts as a physical interface between the DMX512 signals and the LED strip. The second decision, how to generate and send the DMX512 signals to the decoder, took much more time. A basic light console used by DJs could work but its input sliders remain analog and setting a precise numerical value is possible only in very high end (and cost-prohibitive) models. Also, it was important to find a control method which could provide fine control on the decoder, i.e. with 16-bit resolution (65536 levels) instead of the default 8-bit (256 levels) resolution of the DMX 512 protocol. This is why the attention was focused on small controllers which can be attached to a computer via a USB port or an Ethernet link. The selected decoder and controller are:

LED decoder
5 Channels DMX512 Decoder
YujiElecs YJ-DMX-5C-G01
https://store.yujiintl.com/

DMX512 controller
Ethernet/USB DMX Controller
DMXking ultraDMX2 PRO
https://dmxking.com/distributors

These products are presented with more details in the following sections which also discuss alternate offerings.

The third decision was to select software for the controller. Here again many options are available, with many of them being free. If you never used lighting control software, be ready for a steep learning curve. Light control is a specialty and it has evolved from an analog-only world to full computer control while keeping its language and process steps. You do not need to understand ALL the concepts and procedures required in mounting and controlling lights to use such software for our illumination lamp but you should reserve some time for self-training. The two programs used in this project are:

FreeStyler V-3.6.51: **http://www.freestylerdmx.be/**
Q Light Controller+ (QLC+) V-4.12.3: **https://www.qlcplus.org/**

FreeStyler is available for Windows OS only while QLC+ is available for Windows, macOS and Linux. The files used to define the lamp, i.e. fixtures in the DMX world, as well as the project files for these two software packages are provided within this document zip package. These files should help flatten the learning curve.

Please note that while this application note does not go into the details of the DMX512 protocol, specific DMX512 settings and characteristics will be discussed when it helps understanding the decisions. For more information on the DMX512 protocol, please start with this Wikipedia entry: https://en.wikipedia.org/wiki/DMX512 .

Here are shortcuts to jump at other sections of this document:

- LED driver and control
- DMX512 protocol and components
- DMX512 control software
- Deriving the LED inputs for the CCT presets
- Checking the CCT presets
- Conclusion

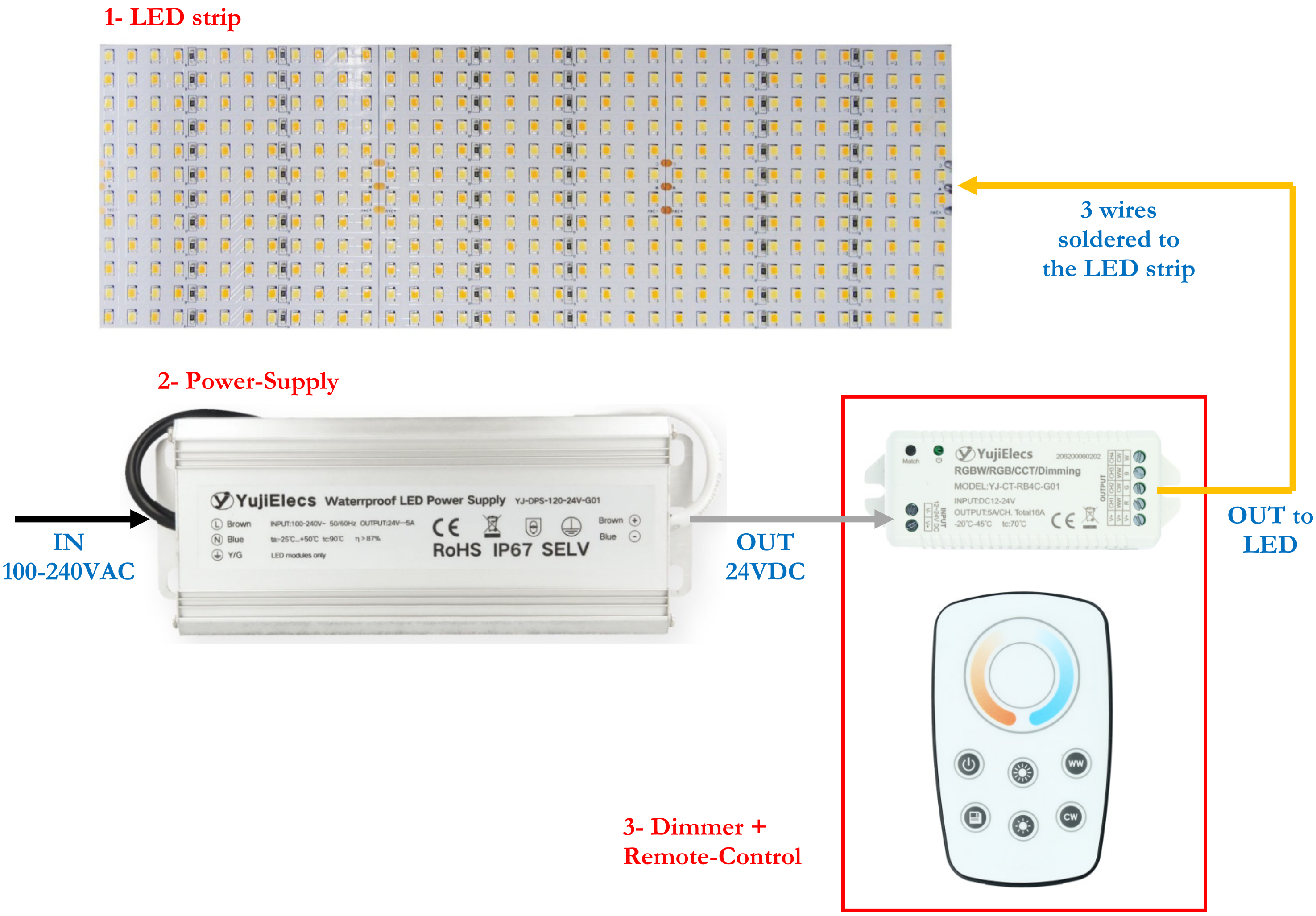
You will find additional information in these appendices:

- Appendix A: Components list and cost
- Appendix B: Revised lamp base

2. LED driver and control

2.1 With the remote-control kit (as used in AN-12)

The diagram below shows how the lamp was configured with the remote-control[3] used in application note AN-12 **before** we added the components for DMX512 control.



Components

1- **LED strip: Yujileds model [YJ-VTC-12HRB-2835L-24-2765]**
Full Spectrum CRI 98 Dynamic Tunable White Multirow.

2- **Power-Supply: YujiElecs [YJ-DPS-120-24V-G01]**
IN: 100-240VAC, 50-60Hz; OUT: 24VDC, 5A, 120W; IP67 Waterproof
This power supply is available in 24V and 12V versions. Make sure you select the 24V model.

3- **Dimmer + Remote-Control kit: YujiElecs [YJ-RCT-RB2C-G01]**
For Single Color/Bi-color LED Strips.

Please consult this Yujileds store Web page for a short video on how to match/pair the remote control to the dimmer:

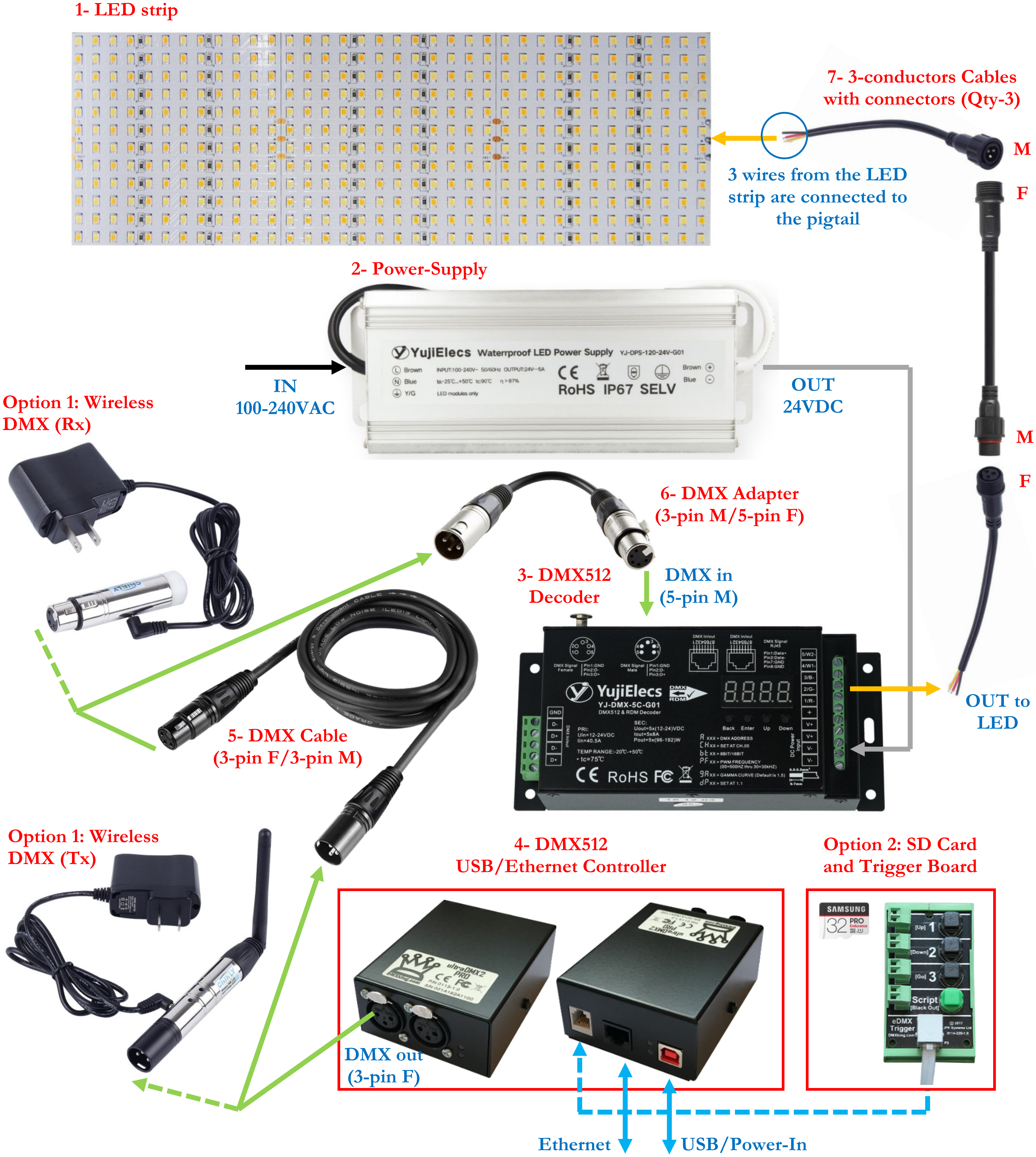
https://store.yujiintl.com/products/yujielecs-remote-control-dimmer-kit-for-single-color-bi-color-led-strips

The video is also available on YouTube: https://www.youtube.com/watch?v=DvVu62gDQXs

[3] Please refer to Yujileds documentation for proper connection instructions.

2.2 With DMX512 control

The diagram below shows the lamp with the DMX512 control components.



Components

1- **LED strip: Yujileds model YJ-VTC-12HRB-2835L-24-2765**
Full Spectrum CRI 98 Dynamic Tunable White Multirow.

2- **Power-Supply: YujiElecs YJ-DPS-120-24V-G01**
IN: 100-240VAC, 50-60Hz; OUT: 24VDC, 5A, 120W; IP67 Waterproof
This power supply is available in 24V and 12V versions. Make sure you select the 24V model.

3- **DMX512 Decoder: YujiElecs YJ-DMX-5C-G01**
DMX512 and RDM compatible; 5 channels (RGBWW); 500 Hz to 30 kHz PWM; 8 bit or 16 bit; 12V-24V DC output; 8 A/channel; I/O: 5 pin XLR, RJ45, terminal posts

4- **DMX512 Controller: DMXking.com ultraDMX2 PRO**
USB/Ethernet DMX controller; DMX In/Out; 2 XLR ports assignable as In/Out; available with 3-pin or 5-pin XLR sockets; Art-Net and sACN support; record and playback to microSD [4] card (not included); accessory port for external trigger (see Option2).

5- **DMX Cable: Sescom DMX-3M3F-10**
DMX cable with 3-pin Male to 3-pin Female XLR connectors; 120 ohm impedance; 10 ft (3 m).
Note 1: **Do not use XLR cables!** They may have the same connectors but the impedance will differ.
Note 2: This link is given as an example since we used another brand; this item was not specifically tested.

6- **DMX Adapter: Chauvet DJ DMX5F3M**
5-pin Female to 3-pin Male DMX cable; 6 in (154 mm).

7- **3-conductors cables: BTF-LIGHTING 3.3 ft (1 m), 3-pin, 18 AWG** (5 pcs, one end M, one end F)
3-conductors *pigtails*: BTF-LIGHTING 7.9 in (20 cm), 3-pin, 18 AWG (5 pairs, i.e. 5 M and 5 F)
Hint: You can be buy only cables and cut them to get pigtails.

Option 1: Wireless DMX: CHINLY DMX512 2.4 GHz, 1 Tx with 3 Rx kit
DMX512 wireless receiver (Qty-3)/transmitter (Qty-1). Uses the 2.4 GHz ISM band.
Transmitter: 3-pin Male XLR connector. Receiver: 3-pin Female XLR connector.
This option replaces the DMX Cable (Item 5).
Hint: Debug your setup with a cable first!

Option 2: SD Card: Samsung MB-MJ32G (PRO Endurance microSDHC-I Card; 32 GB)
Important: Use only the approved microSD cards listed in the eDMX PRO Recorder Manual.
Trigger Board: DMXking.com eDMX Trigger
Connects to the RJ12 accessory port of the ultraDMX2 PRO Controller (Item 4).
Use the card and trigger board to record and replay lighting sequences or recall presets.

[4] Trademark of SD-3C.

3. DMX512 protocol and components

3.1 DMX512 protocol

DMX512 is the name of a serial digital communication protocol used to control lamps and other devices in entertainment and architecture lighting applications. It is also the name of the cable standard used for this control. It is not the only protocol or cable used for lighting applications but it is widely supported because of its simplicity and low cost.

In one of its simplest implementation, the DMX512 protocol is used as a dimmer to remotely control the output of a lamp. The "512" in the name refers to the maximum number of channels a DMX "universe" can control; multiple universes can be defined for very large projects. One channel may be enough for a tungsten lamp for instance, or could be used to control many similar lamps connected together on the same channel. A lamp made of three separate LED colors, quite often R, G, and B, would require three separate channels to individually control each color and may even require a fourth channel to control the intensity of the three colors simultaneously.

The pictures below is an example of a basic DMX512 system consisting of a four channel DMX controller, a stage lamp, and a DMX512 cable to connect the controller to the lamp.

The DMX cable in the image above has 3-pin XLR connectors which correspond to the controller and lamp connectors. It is worth nothing that the DMX512 standard (ANSI E1.11-2008 (R2018)) strictly prohibits using 3-pin XLR connectors, first to prevent using XLR cables which have different electrical characteristics, and even more so to prevent the connection of audio components to lighting components. Yet, many commercial products are only available with 3-pin connectors.

The lamp shown on the preceding page can be set in two modes, one with 3 channels and the other one with seven channels. The 3-channel mode enables control of the individual R, G, and B channels. The 7-channel mode adds preset colors, strobe effects, sound-sensitivity modes, and a global dimmer. With the 4-channel controller shown in the image, we would thus have to set the lamp to its 3-channel mode.

We also need to set the starting channel for the lamp. DMX512 channel numbering starts at 1 but any number up to 512 is valid. In any case, the starting address of the controller and the lamp should match. The image on the right shows the back of the lamp and the numeral display used to set the address is highlighted in red.

The simplest setup is to set the controller and lamp starting address at “1”. For the controller in our example, this leaves one channel unused (Ch. 4). We could use this channel to control a single channel lamp, a white spotlight for example. This could be done by connecting a second DMX512 cable between the 3-channel lamp and the 1-channel lamp; you will notice that a DMX compatible device has two DMX connectors labeled DMX-IN and DMX-OUT specifically designed to do this kind of daisy chain (highlighted in yellow in the image). There is no need to have all cables connected directly into the controller. Of course, if you use the fourth channel, you need to properly set the starting DMX512 address on the 1-channel lamp; here it would be “4”.

You will realize that channel addressing can become complex when you have dozens or hundreds of lamps, and replacing a lamp in a setup could be a delicate shuffling exercise, especially if each lamp has a different number of channels. Such re-assignations are made easier by dedicated software associated with a computer-attached DMX512 controller. Please note that address shuffling is not the reason why we are using a computer attached controller in this project, since we are essentially controlling only two LED banks! The real reasons are that we want more than 8-bit precision for each LED bank and that we want many presets. 16-bit precision is possible if we use two 8-bit channels per bank; of course, both the controller, i.e. the computer software in our case, and the LED decoder/driver must support 16-bit resolution. Controlling two LED banks at 16-bit thus requires four DMX512 channels.

Here are a few important things you should be aware when using DMX512 cables:

i- Always use approved DMX512 cables. This is particularly important if you are using “prohibited” 3-pin cables since their XLR connectors are identical to the XLR connectors of XLR cables (seems logical!). The difference is that DMX cables have an impedance of 110 to 120 ohm while XLR cables have an impedance between 45 and 75 ohm and a higher capacitance.

ii- Connect a termination, usually just a connector with a 120 ohm resistor, at the end of the DMX512 daisy chain. Some fixtures may have an automatic or selectable terminator.

iii- If using more than 32 fixtures you should use a repeater/booster between fixtures 32 and 33, and again at the next 32 multiple (between fixture 64 and 65).

iv- Keep the maximum cabling length between the controller and the last fixture under 300 m.

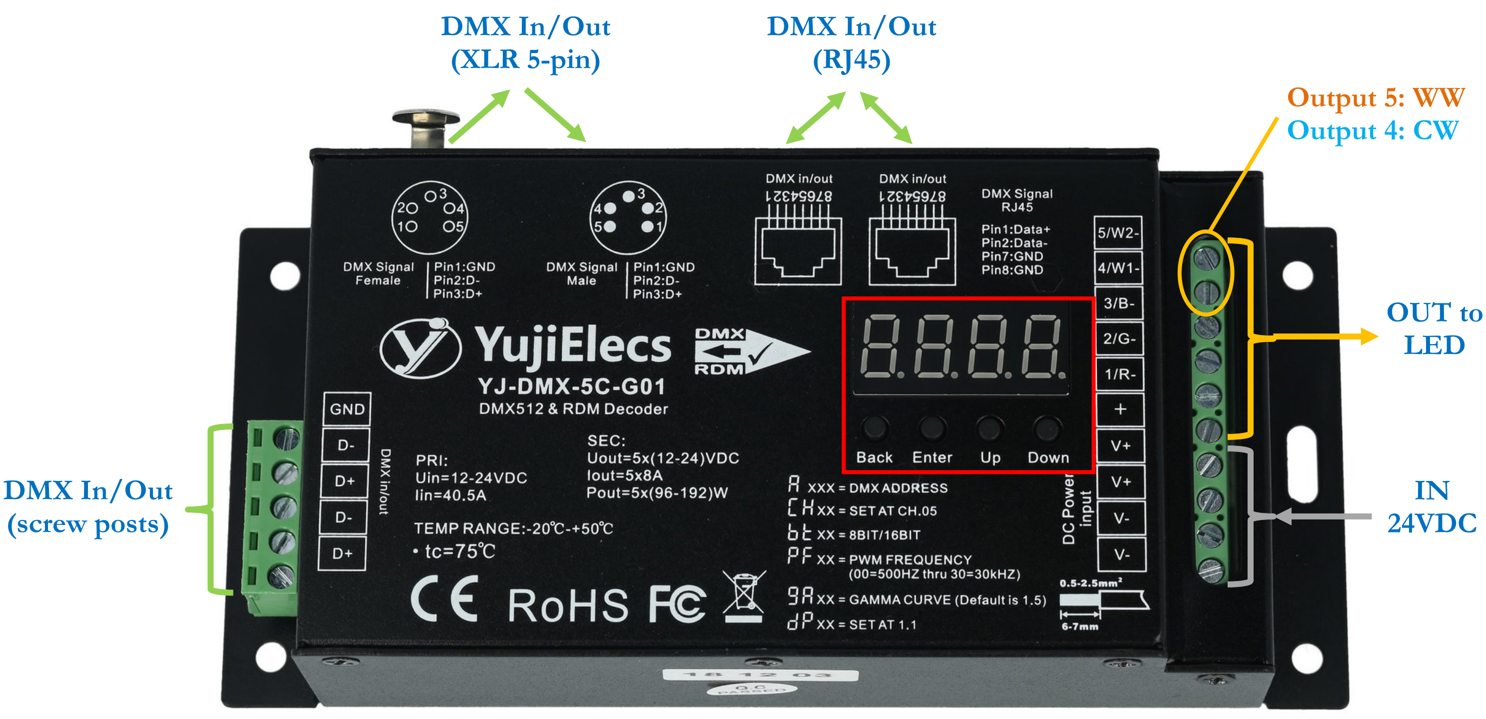
Note: While DMX512 data exchange is essentially unidirectional, from the controller to the fixtures, data can also be sent in the other direction using the RDM (Remote Device Management) protocol, a recent addition to the DMX512 protocol. Among its capabilities, the RDM protocol can be used for fixture identification and diagnostic. Not all controllers and fixtures support RDM.

Note: DMX512 data can also be sent on an Ethernet based network. Two popular protocols are Art-Net and sACN.

3.2 LED Decoder

In the example of the preceding section the DMX512 controller is connected directly to a lamp/fixture which incorporates the electronic components required to decode the signal and drive the light emitting components. In comparison, the LED strip used in our project is just like a bare bulb. So we need additional components between the controller and the lamp in order to perform light control. With LED strips becoming almost a commodity, such decoder/drivers are now readily available. In fact, for our LED strip, Yujileds proposes the YujiElecs model [YJ-DMX-5C-G01](), a DMX512 decoder with professional characteristics:

- i- 5 physical output channels preferentially dedicated to R, G, B plus two separate Whites (W1 and W2).
- ii- Support of 8-bit or 16-bit per output channel. Internally this means that two DMX512 channels must be assigned for each output channel.
- iii- Adjustable high frequency (500 Hz to 30 kHz) Pulse Width Modulation (PWM) for dimming.
- iv- Adjustable gamma curve for dimming (0.1 to 9.9). Setting the gamma to 1.0 provides a linear output.
- v- Selectable decoding modes which can assign two or more outputs to a single DMX512 channel, one or two DMX512 channels to a single output (for 16-bit support), and DMX512 channels dedicated to strobe effects and master dimming.
- vi- DMX512 connectors (IN-OUT): 5-pin XLR, RJ45, screw posts.
- vii- Input: 12-24 VDC. Output: 5X (12-24 VDC) @ 8A per channel.
  Note: 24 V required for our LED strip.



Using the four buttons and the four-digit display, highlighted in red above, we assign the following settings:

- DMX starting address: **A001** (Address 001; default)
- DMX channel quantity *: **CH05** (5 channels; default)
- Bits per channel: **bt16** (16-bit; default)
- PWM frequency: **PF01** (1 kHz; default)
- Gamma curve: **gA10** (1.0; NOT default)
- DMX decoding mode: **dP21** (dp 2.1; NOT default)

* A confusing term! It is equal to or less than the number of DMX channels that are available for a given **decoding mode** (see table on next page). You must select **CH05** if you want to individually control the **five** LED outputs.

The following table describes the **decoding modes** (**dp x.x**) and the **DMX channels** available when the decoder is set to **CH05**. Other tables are available for 1 to 4 DMX channel quantities (**CH01** to **CH04**); please refer to the manufacturer *Spec Sheet and User Manual* for more details (This info is available in the "YJ-DMX-5C.pdf" document located in the "Section_3" folder of the zipped package which contains this application note).

DMX starting address: 001; CH05

DMX console slider number (DMX channel)	**dp 1.1**	**dp 2.1**	**dp 6.5**	**dp 7.5**
1	for output 1 dimming	**for output 1 dimming**	for output 1 dimming	for output 1 dimming
2	for output 2 dimming	**for output 1 micro-dimming**	for output 2 dimming	for output 2 dimming
3	for output 3 dimming	**for output 2 dimming**	for output 3 dimming	for output 3 dimming
4	for output 4 dimming	**for output 2 micro-dimming**	for output 4 dimming	for output 4 dimming
5	for output 5 dimming	**for output 3 dimming**	for output 5 dimming	for output 5 dimming
6		**for output 3 micro-dimming**	for all outputs master dimming	for all outputs master dimming
7		**for output 4 (CW) dimming**		strobe effects
8		**for output 4 (CW) micro-dimming**		
9		**for output 5 (WW) dimming**		
10		**for output 5 (WW) micro-dimming**		

By selecting **CH05** and the **dp 2.1** decoding mode we can control **output 4 (CW)** and **output 5 (WW)** with 16-bit precision using **two DMX512 channels per output**. DMX channels **7 and 8** are assigned to **CW** and DMX channels **9 and 10** to **WW**. All channels are adjustable between 0 and 255; however, in this mode, the full range of a **micro-dimming** channel corresponds to one step of a dimming channel, thus providing the increased resolution.

As we can see in the table, we could use these settings to also control the first three LED outputs of the decoder which are usually assigned to R, G, and B channels. Since we do not need these outputs we can simply ignore them.

We will see in the DMX512 control software section how this table is used to create the light fixtures files.

Note: If you search the Internet for LED decoders and compare their characteristics, you will realize that the model sold by Yujileds offers top-of-the line features at a reasonable price. You may also find devices from other companies which look extremely similar, if not identical, apart from the brand name. The reason is most likely because they are manufactured by the same company, Sunricher, which offers rebranding services; so we are not dealing with cheap copies here, but clones. Some models have different features, 3-pin XLR connectors for example or a different PWM frequency range, or even a master mode (no controller required). Some of these clones can be found with the following links: Environmental Lights (USA), Green Image Tech (Canada), LED World Inc./Hueda (Canada), Waveform Lighting (USA).

3.3 USB/Ethernet Controller

A stand-alone lighting console such as the one shown as an example in the DMX512 protocol section can be both cost-effective and more than sufficient for a small project like ours. However, here we want a controller with fine resolution and the capability for many presets. This is why we looked at the various basic computer-connected controllers on the market. While you can find such a controller for much less than 100 US$, you have to consider that it has to be attached to a computer and that it requires a software that you have to minimally understand, so this also involves an investment in time.

There are two major categories for computer-connected DMX controllers (at least in the lower end of the market): **USB to DMX** and **Ethernet to DMX** devices. Some controllers offer both USB and Ethernet ports and the number of XLR connectors and supported DMX universes can vary. The table below shows a few models currently available and some of their distinguishing features.

Manufacturer	Model	DMX ports/univ.	USB control	Ethernet control	Price US$	Notes
DMXking.com	ultraDMX2 PRO	2(F-F)/2	Yes	Yes	199.00	USB port used for control + PS or for Power-Supply only. Accessory port for trigger. Can accept microSD card. 3-pin or 5-pin XLR option.
DMXking.com	ultraDMX Micro	1(F)/1	Yes	No	65.00	Power-Supply from USB port. 3-pin XLR.
DMXking.com	eDMX1 PRO	1(F)/1	No	Yes	139.00	USB port for Power-Supply only. 3-pin or 5-pin XLR option.
ENTTEC	DMX USB Pro	2(M-F)/1	Yes	No	170.00	USB port used for control + PS. 5-pin XLR.
ENTTEC	Open DMX USB	1(F)/1	Yes	No	70.00	USB port used for control + PS. 5-pin XLR.
ENTTEC	ODE MK2	2(M-F)/1	No	Yes	275.00	7.5 to 24 VDC Power-Supply. 5-pin XLR.

The **ultraDMX2 PRO** from **DMXking.com** was purchased because of its numerous features which enable all kinds of control configurations at a very reasonable price. While not tested, the other controllers should also work with the selected LED decoder. The **ultraDMX2 PRO** ports are identified below.

USB FTDI drivers
Note: These drivers should be installed before plugging the controller to the computer USB port.

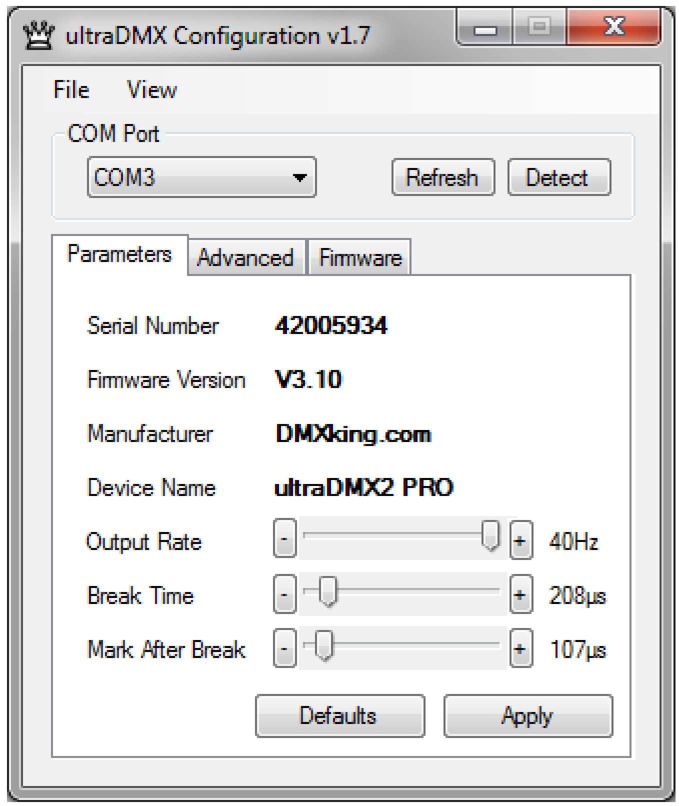
If you intend to use the controller from the USB port, you need the FTDI (Future Technology Devices International) **D2XX** drivers as well as Virtual COM Port (**VCP**) drivers. The D2XX drivers allow direct access to a USB device from the application software through a series of DLL (Dynamic Link Library) function calls. The VCP drivers cause the USB device to appear as an additional COM port on your computer. Expressed otherwise, the VCP driver emulates a standard PC serial port such that the USB device may communicate with a standard RS232 device. Depending on OS and OS version, some or all of the required drivers may already be installed. For more information, please refer to the **ultraDMX2 PRO** controller help manual and the installation guides available on the FTDI site.

Once installed, connect the controller to the computer USB port and proceed to the configuration steps.

USB configuration check (with the **ultraDMX Configuration** utility)
First install the **ultraDMX Configuration** program available from the DMXking.com download page. Once installed and launched you will see a simple dialog with a "COM port" menu; this menu may be blank (i.e. empty). If there is a COM port in the menu, select it. A screenshot of this dialog is shown on the right.

There are many parameters which can be set using this dialog but here there is no need to edit any of them. We just use this utility to confirm that the controller is assigned to a COM port and properly recognized.

You can now close the program.



Controller configuration (with the **eDMX Configuration** utility)
First install the **eDMX Configuration** program available from the DMXking.com download page. The **eDMX configuration** utility is dedicated to the settings and options which are available when the controller is operated through the Ethernet port. In fact, the controller can be connected with both the USB and the Ethernet ports at the same time with both configuration programs opened.

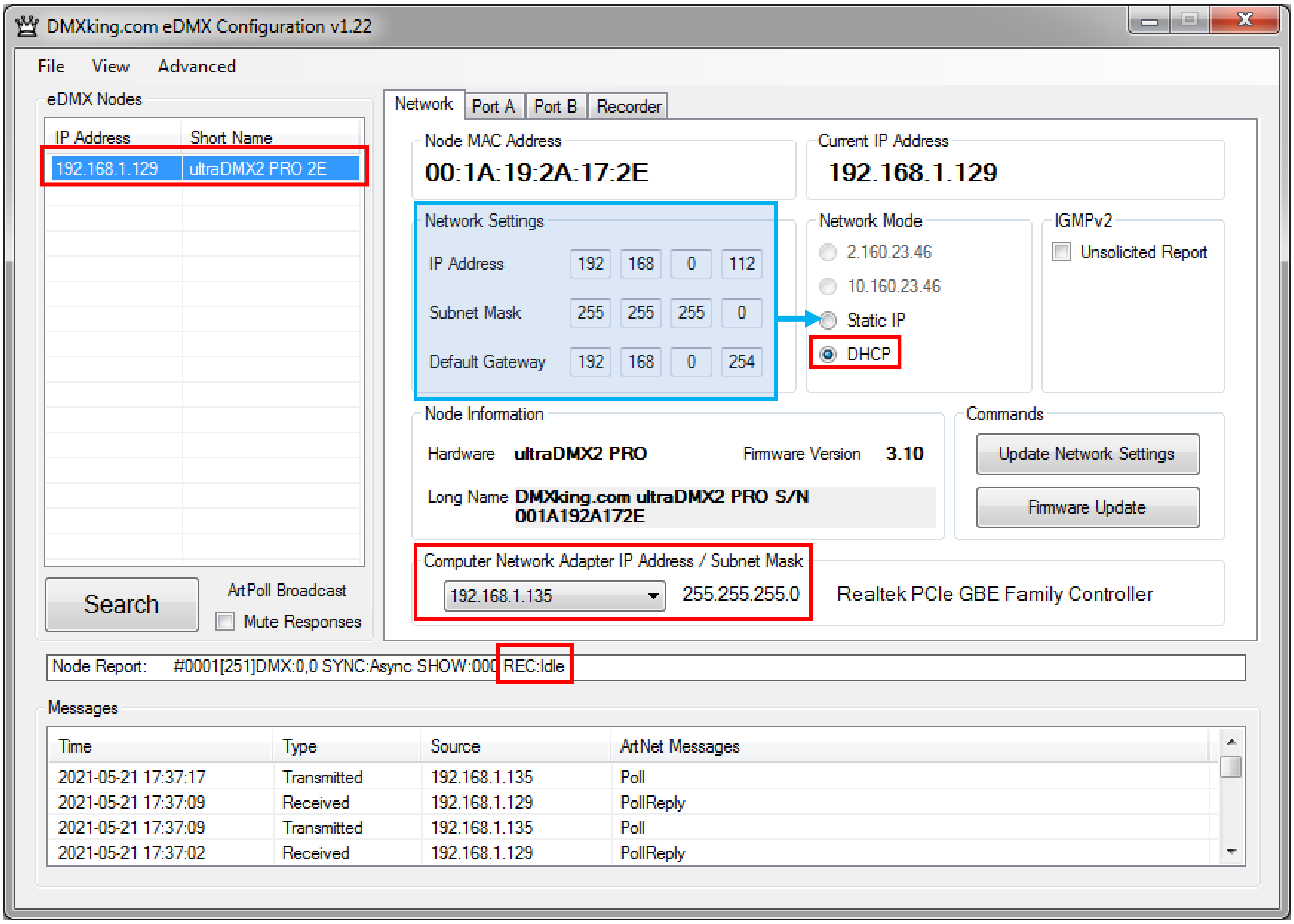
You can connect the controller Ethernet port to the output of a router or to the Ethernet port of a computer. If connecting into a computer, you should use a network crossover cable instead of standard cable. Crossover cables are sometimes yellow (but do not base your selection on the cable jacket color alone!), and sometimes will be labeled as such, with an "X/O" tag for example. The best way to identify a crossover cable is to look at the color of the wires when the connectors are side-by-side; if the order is different, then this is a crossover cable.

Note: The recording and playback capabilities of the controller can only be accessed with the eDMX Configuration utility. To enable these capabilities a compatible microSD card must be purchased and installed.

The dialog below is shown when the **eDMX Configuration** utility is opened. We first selected the "**DHCP**" Network Mode and then clicked on the **eDMX node** identified as "**192.168.1.129 ultraDMX2 PRO 2E**" in the table on the top-left of the screenshot.

Here the ultraDMX2 PRO controller is connected to a router and the IP address assigned to the **controller** is **192.168.1.129**. The IP address of the **computer** on which the utility was launched is **192.168.1.135**. These addresses are required to configure the control software later on.

We could also assign the network settings manually by selecting a "**Static IP**" and filling the network settings within the light-blue zone (Note: the numbers shown in this zone are irrelevant when DHCP is selected).



In the "**Node Report**" data field, we see "**SHOW 000 REC:Idle**"; this is a confirmation that a microSD card is installed and recognized (the field would display "**REC: No SD**" if no card was present).

Screenshots of the "**Port A**", "**Port B**", and "**Recorder**" tabs are shown on the next page.

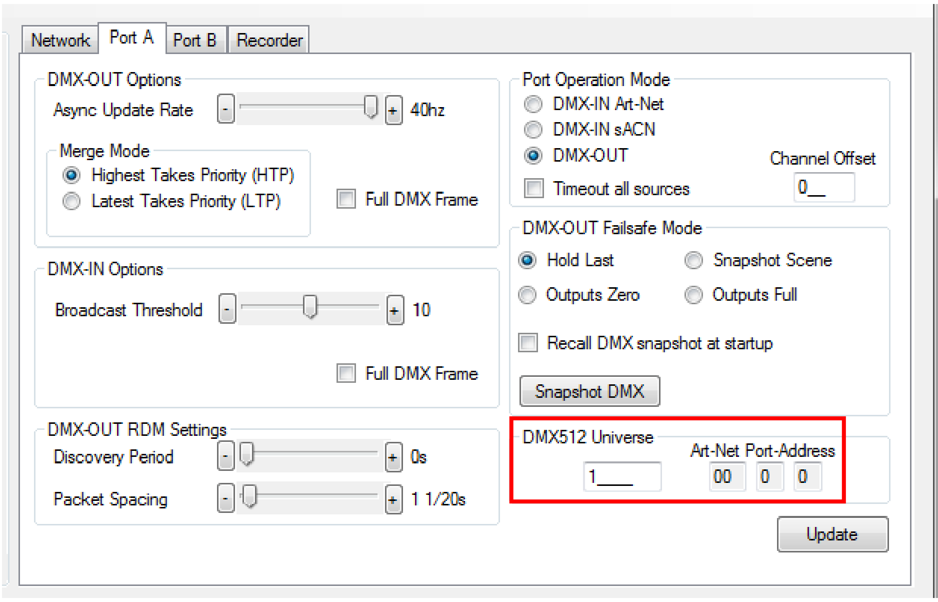
Here are various notes associated to these screenshots:

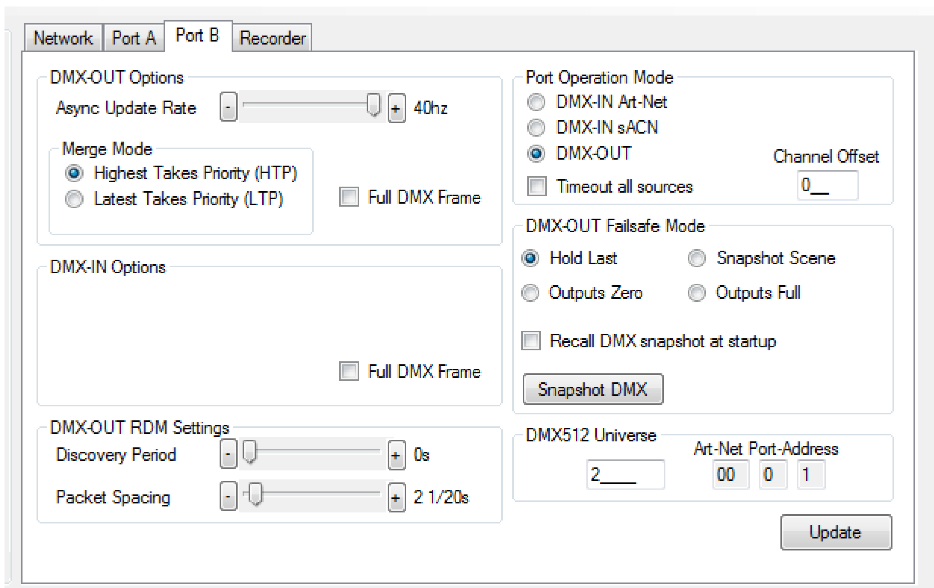
i- "Port A" is assigned as "Universe 1". This is shown as "1___" in the "DMX512 Universe" field , with a corresponding "Art-Net Port-Address" of "00 0 0". You should use the same Art-Net addresses in the control software setups (FreeStyler Art-Net setup, QLC+ Art-Net setup).

ii- "Port B" settings are essentially default values since we use only "Port A", and one universe.

iii- In "Port A" and "Port B", the "Discovery Period" of the "DMX-OUT RDM Settings" is set to "0s". We have noted that non-zero values interfered with the proper operation of the Wireless DMX512 link.

iv- The "Recorder" tab settings are meaningful only if a microSD card is inserted in the controller.


Network
Port A
Port B
Recorder
DMX-OUT Options
Async Update Rate
40hz
Merge Mode
Highest Takes Priority (HTP)
Latest Takes Priority (LTP)
Full DMX Frame
Port Operation Mode
DMX-IN Art-Net
DMX-IN sACN
DMX-OUT
Channel Offset
Timeout all sources
0
DMX-OUT Failsafe Mode
Hold Last
Snapshot Scene
Outputs Zero
Outputs Full
Recall DMX snapshot at startup
Snapshot DMX
DMX-IN Options
Broadcast Threshold
10
Full DMX Frame
DMX-OUT RDM Settings
Discovery Period
0s
Packet Spacing
1 1/20s
DMX512 Universe
Art-Net Port-Address
1
00
0
0
Update


Network
Port A
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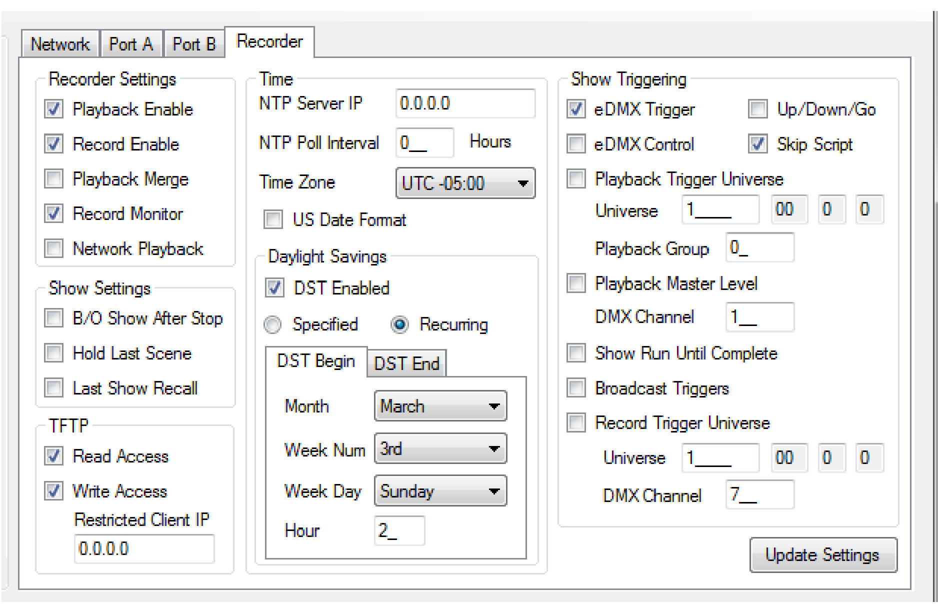
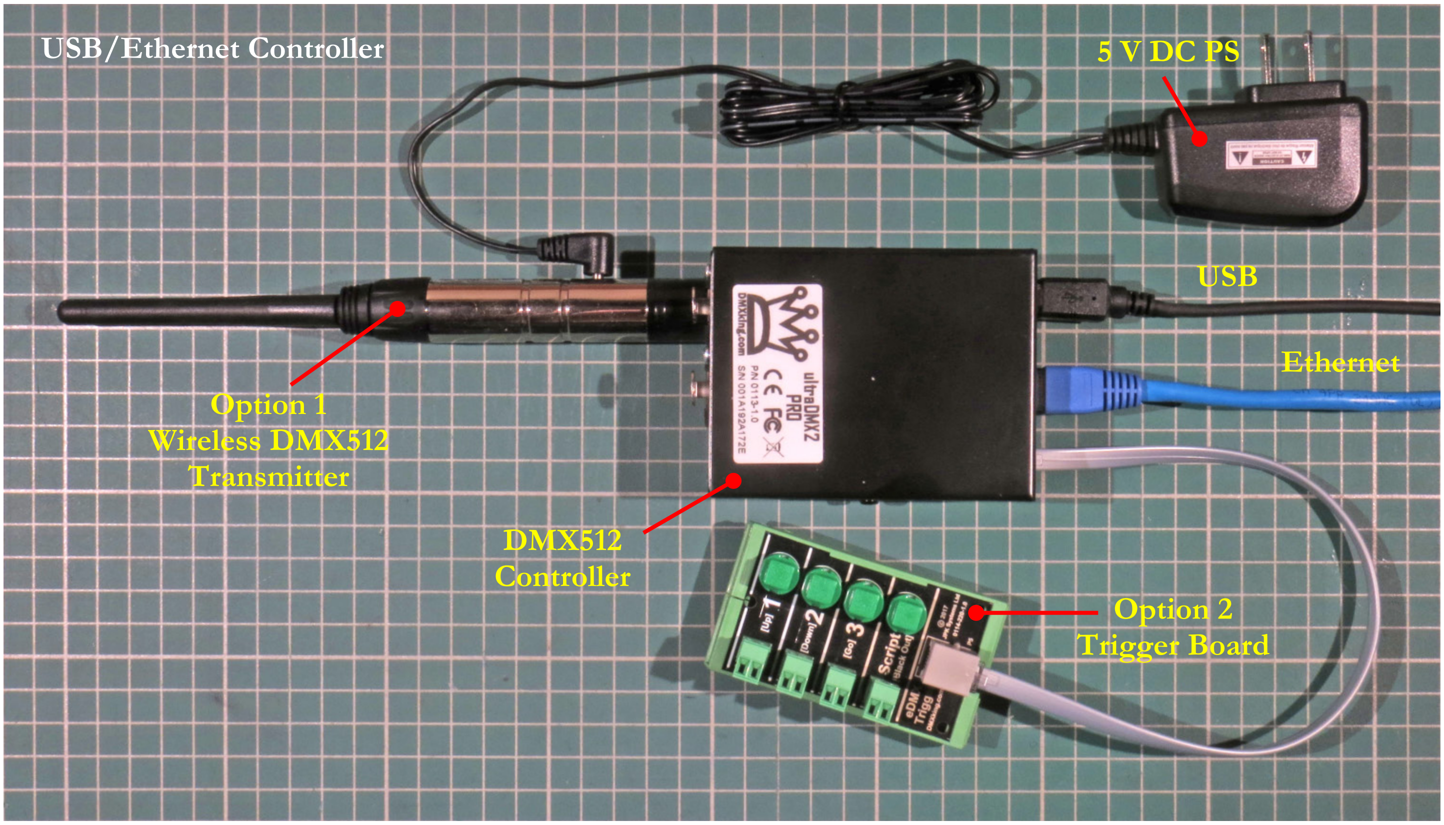
0
DMX-OUT Failsafe Mode
Hold Last
Snapshot Scene
Outputs Zero
Outputs Full
Recall DMX snapshot at startup
Snapshot DMX
DMX-IN Options
Full DMX Frame
DMX-OUT RDM Settings
Discovery Period
0s
Packet Spacing
2 1/20s
DMX512 Universe
Art-Net Port-Address
2
00
0
1
Update


Network
Port A
Port B
Recorder
Recorder Settings
Playback Enable
Record Enable
Playback Merge
Record Monitor
Network Playback
Show Settings
B/O Show After Stop
Hold Last Scene
Last Show Recall
TFTP
Read Access
Write Access
Restricted Client IP
0.0.0.0
Time
NTP Server IP
0.0.0.0
NTP Poll Interval
0
Hours
Time Zone
UTC -05:00
US Date Format
Daylight Savings
DST Enabled
Specified
Recurring
DST Begin
DST End
Month
March
Week Num
3rd
Week Day
Sunday
Hour
2
Show Triggering
eDMX Trigger
Up/Down/Go
eDMX Control
Skip Script
Playback Trigger Universe
Universe
1
00
0
0
Playback Group
0
Playback Master Level
DMX Channel
1
Show Run Until Complete
Broadcast Triggers
Record Trigger Universe
Universe
1
00
0
0
DMX Channel
7
Update Settings

The picture below shows the controller in its final testing configuration. The USB connector is connected to a USB port of the control computer and the Ethernet connector is connected to a router. We this configuration, we can switch between USB and Art-Net control by software. The controller DMX512 output is connected directly into a wireless DMX512 Transmitter (Option 1) instead of into a DMX512 cable. Pre-recorded light-control sequences can be replayed using the attached Trigger Board (Option 2).

The optional devices are further discussed in the next sections:

- Wireless DMX512
- microSD Card and Trigger Board



3.4 Wireless DMX512

In a DMX512 network, it is possible to replace a DMX512 cable by a wireless link. This can facilitate system installation if the controller and the lamp need to be in separate rooms, and reduce the installation time and cost since you are not limited by the availability of cables. The wireless range can go up to several 100 meters in open spaces but is of course more limited in crowded indoor environments.

In its most simple embodiment a wireless DMX512 system consists of one Transmitter (Tx), usually connected on the controller DMX output, and one Receiver (Rx) connected to the decoder DMX input. One transmitter can communicate with more than one receiver. The fixture connected to a receiver can be daisy-chained to many other fixtures with standard DMX512 cable. Up to 512 DMX channels can be addressed. A transmitter and its receivers can be assigned to seven (7) different groups/universes to control even more fixtures.

There are few industry wide standards and the various offers are usually not compatible with the products from other companies. On the positive side, there are several options if you are looking for decent entry level systems. Here are three "brand names" we have identified (Note: Only the Chinly system was tested):

i- Chinly (search for "Chinly" on eBay)
ii- Donner
iii- Gidderwel

These wireless systems are usually available as kits with one transmitter and one to seven receivers. It is much more difficult to find offers for a single transmitter or a single receiver. The transmitter and the receiver require a separate power input, usually 5 V DC from a provided AC adapter (1 AC adapter per receiver or transmitter). Most brands also offer receivers with built-in rechargeable batteries with enough reserve for an evening usage. The transmitters are generally fitted with an antenna while receivers can be found with or without antennas. The receivers without antennas often have a rounded translucent illuminated dome whose light beats when receiving data; this may or may not be annoying depending on your needs!

We have selected a Chinly system with one transmitter and three receivers (i.e. with two spares!) for 73.00 US$. The transmitter has an antenna and the receiver a light dome; the receiver has no rechargeable battery.

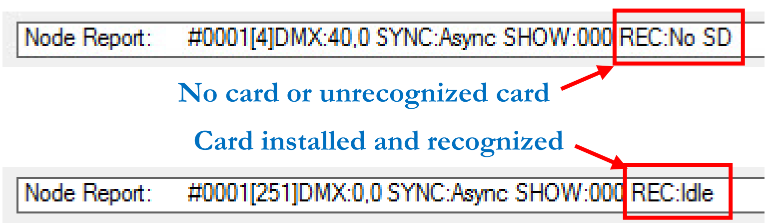
Hint: Install the wireless system only after you have successfully controlled your luminaire using a physical DMX512 cable.

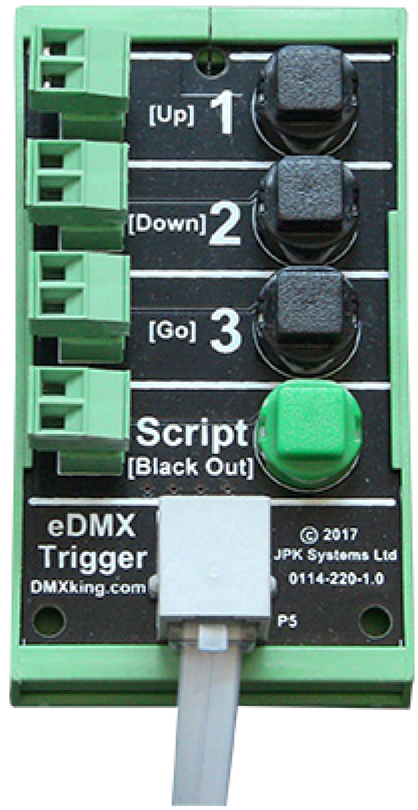
Note: When configuring the controller using the eDMX software, you should set the "Discovery Period" of the "DMX-OUT RDM Settings" to "0s". We have noted that non-zero values interfered with the proper operation of the Wireless DMX512 link.

3.5 microSD Card and Trigger Board

The ultraDMX2 PRO USB/Ethernet DMX512 controller has an accessory RJ12 jack[5] that can be used as an input to trigger/replay pre-recorded DMX512 data streams. The data stream to record may be manually controlled or automatically produced from a predefined sequence in control software. Two optional components are required in order to perform this task in a stand-alone manner, i.e. without a computer: the **eDMX Trigger** board, and a **microSD card**. These components are shown below on the right.

The microSD card shown here is a Samsung model MB-MJ32G (PRO Endurance microSDHC-I Card; 32 GB). This card has to be installed within the controller. It is important to use only one of the approved microSD cards listed in the eDMX PRO Recorder Manual. Please follow the instructions of the manual for proper installation. In particular, you should disconnect the power (USB cable) and the other cables from the controller before disassembly and you should take appropriate anti-static precautions when inserting the card in the controller socket. Proper installation and recognition of the microSD card can be confirmed by looking at the "Node Report" data field in the main dialog of the **eDMX Configuration** utility.





The eDMX Trigger board connects to the RJ12 accessory port of the ultraDMX2 PRO Controller with the provided RJ12 cable. This board can be used to select and start pre-recorded data streams. It has two operating modes. In the first mode, pressing the buttons identified by 1, 2, and 3 replays pre-recorded "Shows" of the same number and the 4th button can start a script or replay "Show 4" (with the "Skip Script" option selected). In the second mode, the buttons act on the entire recorded list; their functions are (Up - in the list), (Down - on the list), (Go – i.e. run the current list number), and (Black Out – all OFF). The modes are selected in the "Recorder" tab of eDMX Configuration utility (see next page).

Note: The eDMX Trigger board is not required to record a data stream. It is only required if you intend to control your lamp without a connected computer.

Important: While the ultraDMX2 PRO Controller can record Art-Net, sACN, and DMX-IN sources simultaneously, it cannot record the controller's own USB DMX-OUT source. This feature is actually written and crossed-out in the features section (p. 1) of the eDMX PRO Recorder Manual:

~~• Record USB DMX sources (ultraDMX2 PRO and eDMX2 PRO only)~~

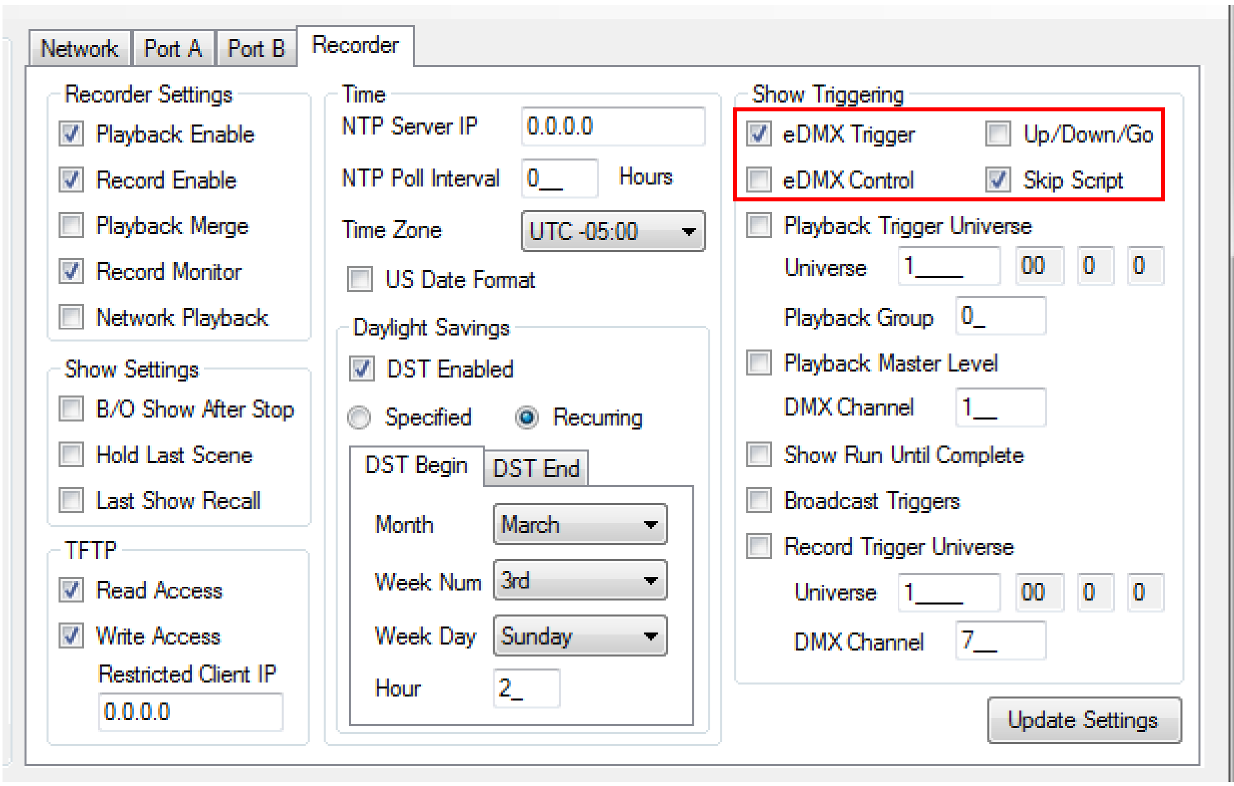
What appears as a major shortcoming at first sight has a simple solution. We just have to use Art-Net via the controller's Ethernet port instead of controlling it with its USB port; when set this way, the USB port only function is to power the controller.

Since recording is possible when using the Ethernet port, you should not be a surprised to learn that recording is done with the same program used for Ethernet configuration, the eDMX Configuration utility presented in the USB/Ethernet Controller section. The recording procedure is presented on the following page.

[5] RJ12 and RJ11 connectors and sockets have the same dimensions and both have six available connection positions. RJ11 usually have 2 or 4 connections/wires while RJ12 use all 6 connections.

DMX512 recording procedure

1- Connect the ultraDMX2 PRO controller Ethernet port to a router or directly to your computer Ethernet port. Connect the controller USB port to a USB AC power adapter or to a USB port on your computer (the USB port is used ONLY as a Power-Supply in this procedure).
2- Start the **eDMX Configuration** utility. Select the "DHCP" "Network Mode" and make sure that the controller is properly detected as an eDMX node. The "Computer Network Adapter IP Address" should correspond to the computer on which the configuration utility is running, and, if you are trying to make everything simple, this should also be the computer on which you are running the DMX512 control software.
3- In the configuration utility, select the "Recorder" tab (which becomes visible once an eDMX node is selected). Set the tab as shown below; it is important to click on the "Update Settings" button when done.

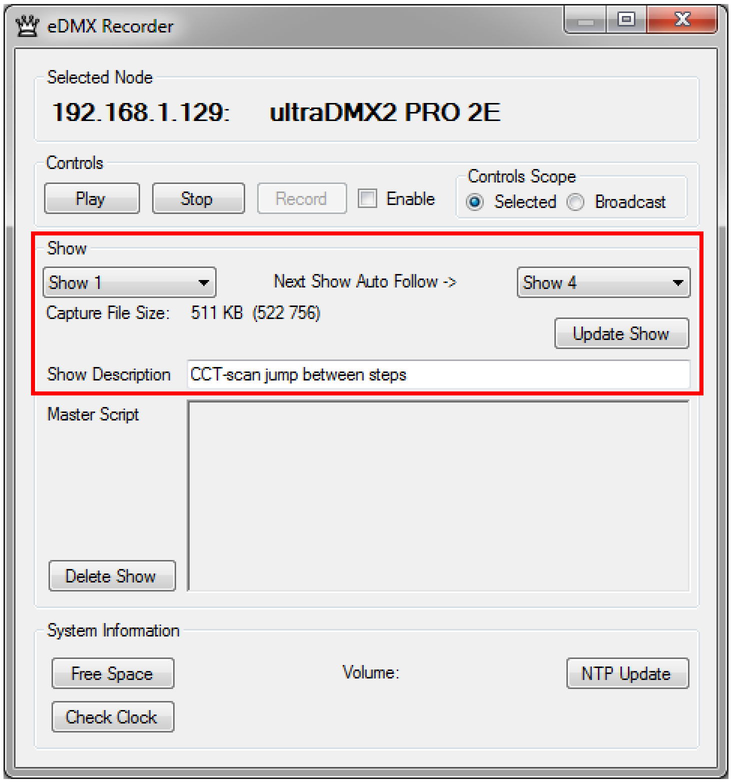


4- In the configuration utility, open the "eDMX Recorder" dialog from the "View/ eDMX Recorder" menu. The Recorder dialog is shown on the next page. Leave the "Enable" check-box deselected for now.
5- Start your DMX512 control software. If using FreeStyler make sure that the proper Location/fixture file is opened and that the required Sequences and Presets are available. If using QLC+, open a Workspace file which has the proper "Functions", i.e. Chasers, Scenes, Sequences, etc.
6- In your DMX512 control software set the interface to Art-Net; use the eDMX node address and the computer IP address determined in Step 2 for your interface settings. Do a quick test of your setup by manually adjusting a channel or selecting a preset/scene. You may need to quit and restart your DMX control software after changing the interface if your quick test does not work.
7- In the "eDMX Recorder" dialog select the "Enable" check-box. Select the "Show" number in the drop-down menu. When ready to record, click on the "Record" button and start a sequence in the DMX512 control software. You can also do manual adjustments or select various scenes/presets in a manual sequence; they will be recorded as well.
8- When the recording is complete, click on the "Stop" button and fill in the "Show Description". Click on the "Update Show" button to record the description.

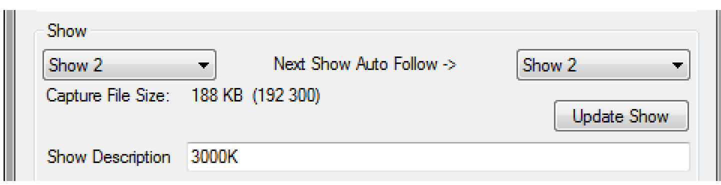
Recordings can be replayed and tested in the eDMX Recorder until you are satisfied with the results. They can also be launched by the eDMX Trigger board if you have this optional accessory.

In our Trigger board the four buttons are assigned to Shows 1 to 4. The fourth button, labeled “Script” is not used for a script (the “Skip Script” checkbox is selected in the “Recorder” tab screenshot on the previous page) but for a scene in which we shut-off the lamp, i.e. we do a “Black Out”. Here are more settings for each recording.

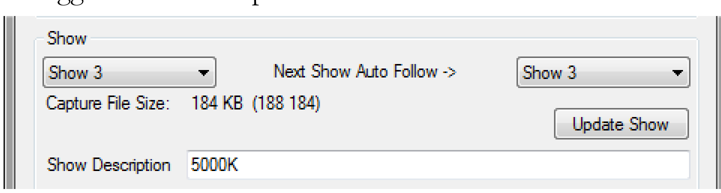
Show 1: A scan between 3000 K and 6500 K at fixed 500 K steps. Each CCT is shown for about 5 seconds. Show 4 is automatically called at the end of the recording (Show 4 is a Black Out).



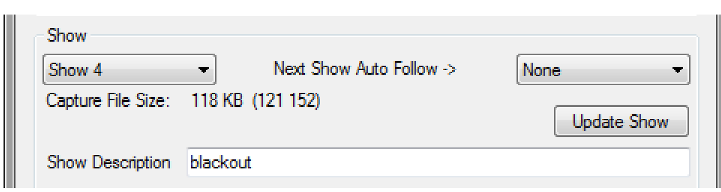
Show 2: A fixed 3000 K output at the maximum brightness possible. The recording time was short, a few seconds, but the same show is called once the recording is finished, i.e. the show goes in an infinite loop. We need to press on button 4/Show 4 of the Trigger board to stop it.



Show 3: A fixed 5000 K output at the maximum brightness possible. The recording time was short, a few seconds, but the same show is called once the recording is finished, i.e. the show goes in an infinite loop. We need to press on button 4/Show 4 of the Trigger board to stop it.



Show 4: A scene where we set all channels to zero, i.e. a Black Out. Nothing is done (no other show is called) at the end of the recording.



4. DMX512 control software

There is quite a wide offering of software dedicated to light control, with capabilities extending from simple party setups to stadium based shows. We are fortunate enough to have access to many free and low-cost solutions which, you will readily realize, offer way too much features for our application. The problem is more in finding software with simple basic features and which is tolerant to DMX-dummies; in other words, the learning curve should ideally have a mild slope!

The manufacturers of USB and Ethernet based controllers usually propose a list of software compatible with their products. If you select a product from ENTTEC or DMXking.com, or a product which advertises itself as "ENTTEC DMX USB PRO" compatible, then most software will handle it.

After much reading on DMX512 forums and quite a few YouTube videos, the first selection was **FreeStyler** (Version 3.6.51), a popular software which has been available for many years. The learning journey was a bit rough but with trial and error it was possible to define a fixture corresponding to the Yujileds decoder and control it as required, which means 16-bit control, use of presets and sequences, and recording of presets and sequences.

Afterwards, we installed the **Q Light Controller Plus** software, better known as **QLC+** (Version 4.12.3), and restarted the learning process. Progress was faster this time, partly because of the familiarity with lighting terminology and processes, partly because the interface and features better corresponded to our needs, and partly because of the numerous and detailed video tutorials.

A fixture definition file and a program file (a Location in FreeStyler and a Workspace in QLC+) are provided for each program. If you are not familiar with either program, we recommend starting with QLC+.

Click on a link to jump to a specific section or sub-section:

- FreeStyler
  - Install procedure
  - Fixture definition
  - Program setup
  - Location file example

- Q Light Controller Plus (QLC+)
  - Install procedure
  - Fixture definition
  - Program setup
  - Workspace file example
  - QLC+ Virtual Console
  - QLC+ Fixtures tab
  - QLC+ Functions tab

4.1 FreeStyler

Like the name says, this is freeware; donations are accepted (from the download page). This software is available for the Windows OS only. Here are essential links:

FreeStyler home: http://www.freestylerdmx.be/

Download: https://www.freestylersupport.com/fsforum/viewforum.php?f=1
To download, use the link in the first forum message, just over the "Donate" button.

FreeStyler Wiki (on-line user guide): https://www.freestylersupport.com/wiki/Welcome

Install procedure

1- If not already done, first install the USB FTDI drivers before installing FreeStyler.

2- Install FreeStyler. If, during install, you receive a message indicating that "**.net 3.5**" is missing (this happened with Windows 10), cancel the FreeStyler install and install ".net 3.5". To locate the .net install file, look for "**.net 3.5 installer**" on Google. We have found the file at this link:
https://docs.microsoft.com/en-us/dotnet/framework/install/dotnet-35-windows
Once .net is installed, you can restart the FreeStyler install.

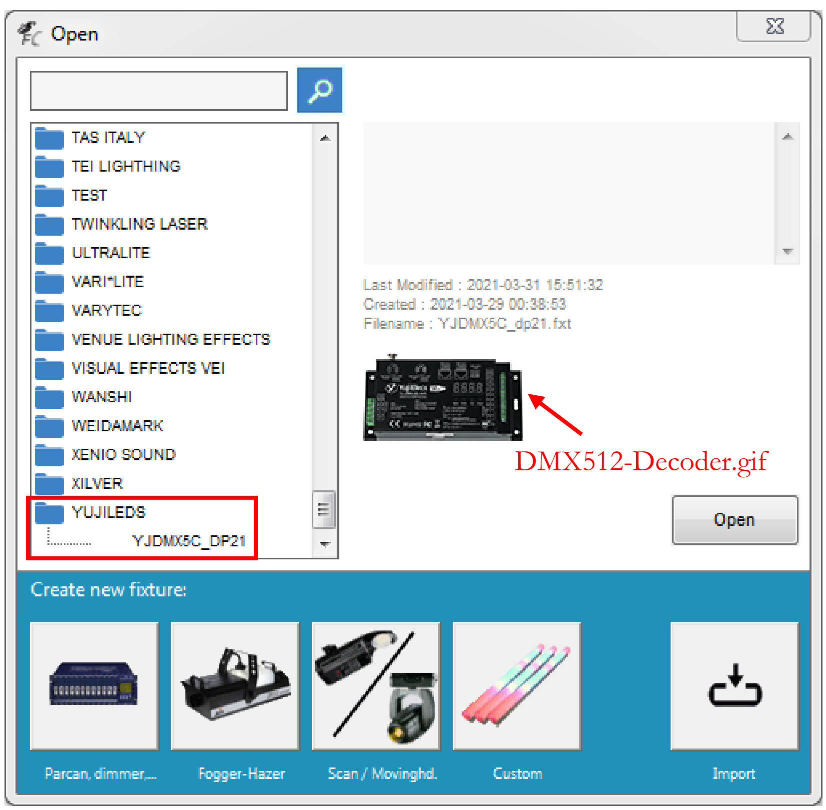
3- **Do not launch FreeStyler after installation!**
Note: If you have launched FreeStyler anyway, it is not dramatic; just exit. The first time you launch FreeStyler you may receive a security alert advising that the Windows Defender Firewall has blocked some program functions. You should authorize FreeStyler to have access to private networks.

Fixture definition

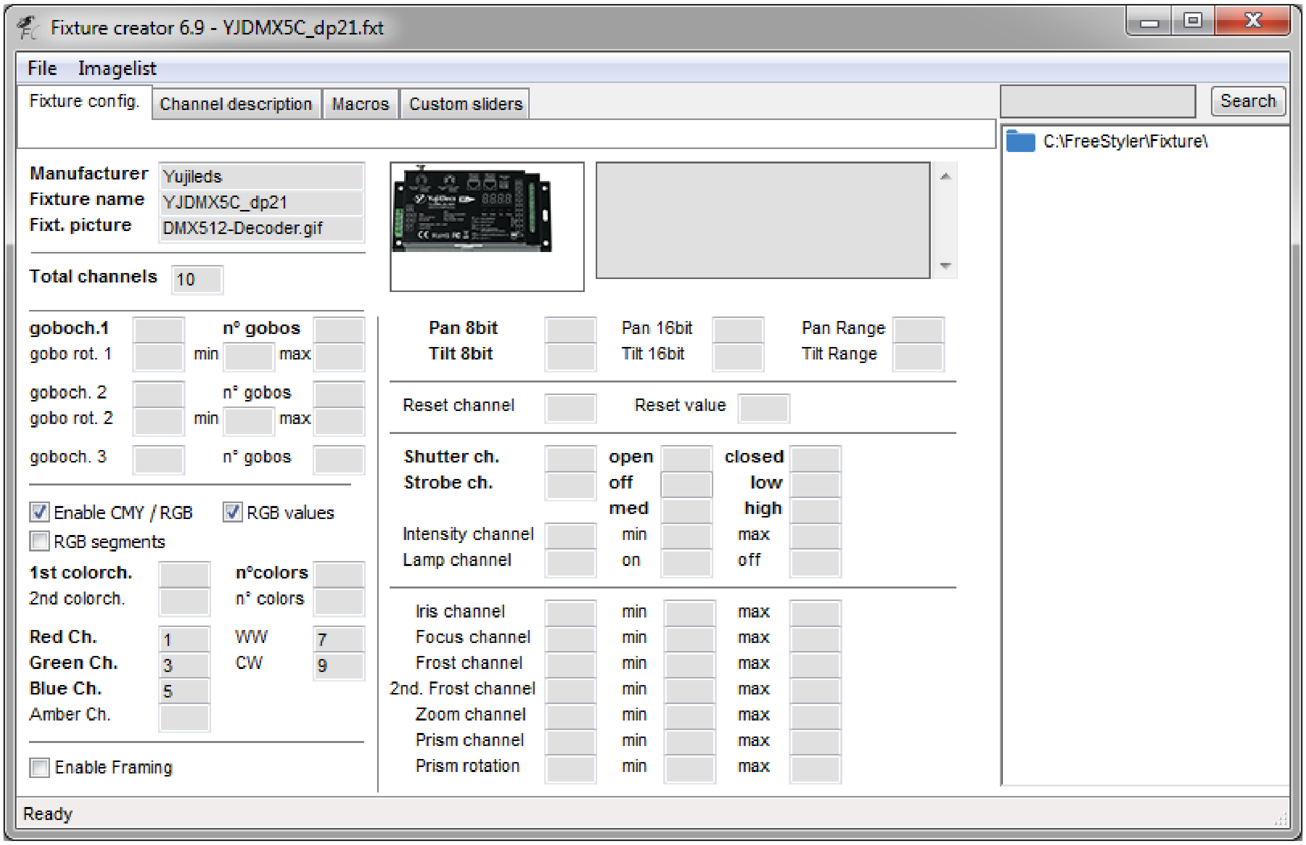
1- Add the fixture image and fixture definition files to the FreeStyler fixture folder.
Fixture folder: C:\FreeStyler\Fixtures (default location)
Fixture image: **DMX512-Decoder.gif**
Fixture definition: **YJDMX5C_dp21.fxt**
The fixture files are part of the zipped package which contains this application note.

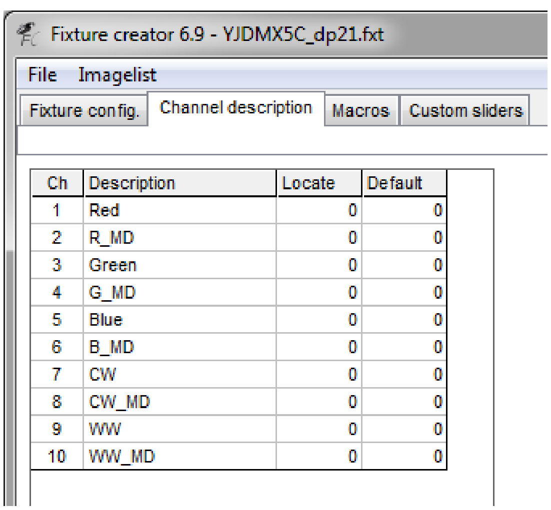
2- Launch the "**FixtureCreator**" application which is bundled with FreeStyler.

Locate the "YUJILEDS" folder on the left pane of the dialog and double-click on it. You should see the **YJDMX5C_DP21** fixture; click on the fixture name and then click on the "Open" button.

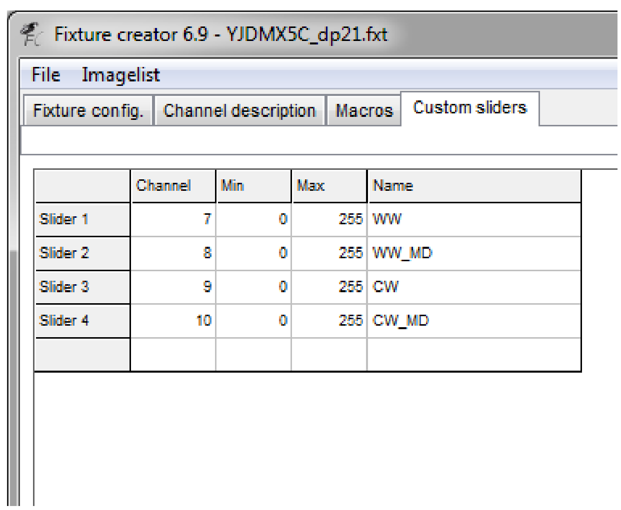


3- The "Fixture config.", "Channel description" and "Custom sliders" tabs are shown below. The DMX channels of the "Channel description" tab match those of the LED Decoder set to **CH05** and to the **dp 2.1** decoding mode.





Ch	Description	Locate	Default
1	Red	0	0
2	R_MD	0	0
3	Green	0	0
4	G_MD	0	0
5	Blue	0	0
6	B_MD	0	0
7	CW	0	0
8	CW_MD	0	0
9	WW	0	0
10	WW_MD	0	0



	Channel	Min	Max	Name
Slider 1	7	0	255	WW
Slider 2	8	0	255	WW_MD
Slider 3	9	0	255	CW
Slider 4	10	0	255	CW_MD

4- You can edit this fixture definition if you wish. Alternately, you can define your fixture from scratch with the same application. You should close the fixture editor when satisfied with the fixture definition.

Program setup

1- Add the **Location** file to the FreeStyler folder.

FreeStyler folder:	**C:\FreeStyler\Locations** (default location)
Location file:	**Yujileds_YJDMX5C_2021-05-04.qxw**

Add the **Sequence** files to the FreeStyler folder:

FreeStyler folder:	**C:\FreeStyler\Chases** (default location)
Sequence files:	**CCT-jump_fixed-steps.chb**
	CCT-ramp_fixed-steps.chb

Replace the following files in the FreeStyler **root** folder:
Note: These files' purpose is to define the fixture presets and the program interface. There is no obligation to replace them! However, if you don't, you will have to define the presets from scratch.
Warning: If you have assigned presets in FreeStyler previously, you should do a backup of the current files before replacing them.

FreeStyler folder:	**C:\FreeStyler** (default location)				
Files:	**chasers.set**	**cstcol.dat**	**data.fsd**	**fixts.fsd**	**freestyler.ini**
	groups.set	**keyb.fsd**	**midi.fsd**	**obtns.fsd**	**pres.dat**
	presa.bin	**presb.bin**	**udp.fsd**		

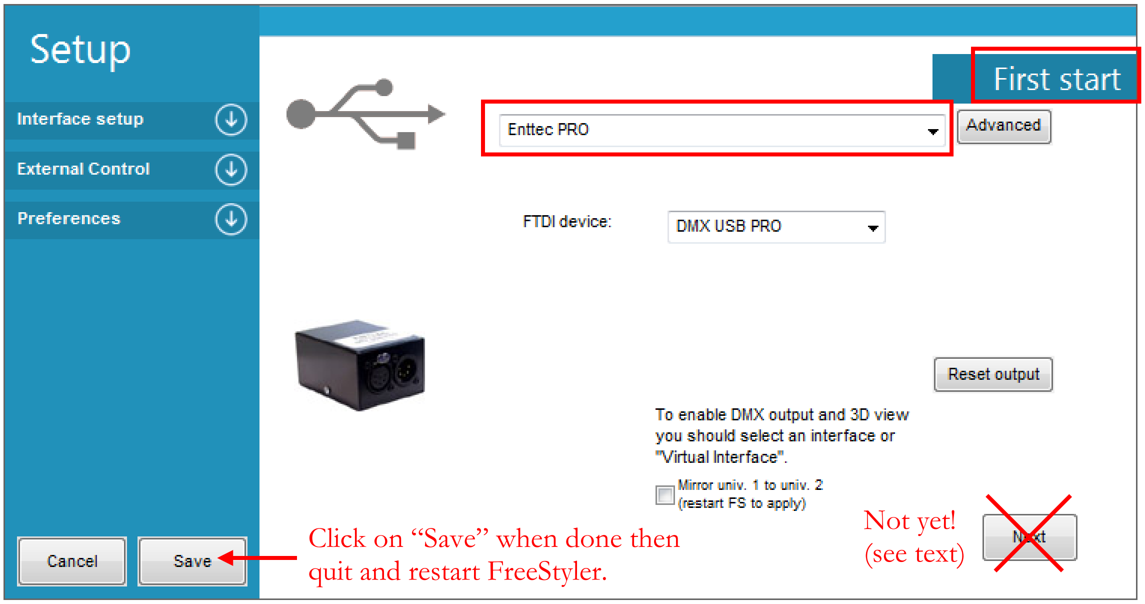
The above files can be found in the zipped package which contains this application note.

2- Power and connect the DMX512 controller. For this first try we recommend connecting the controller USB port to your computer USB port and not just powering the controller to an AC adapter with a USB power output plug. You should also connect your controller Ethernet port to an output on your router.
Note: In this procedure we assume that the controller is the ultraDMX2 PRO presented in the USB/Ethernet Controller section.

3- **Launch the FreeStyler application.**
The first time you launch FreeStyler you may receive a security alert advising that the Windows Defender Firewall has blocked some program functions on private and public networks. You should authorize access to private networks if your intent is to use this program locally.

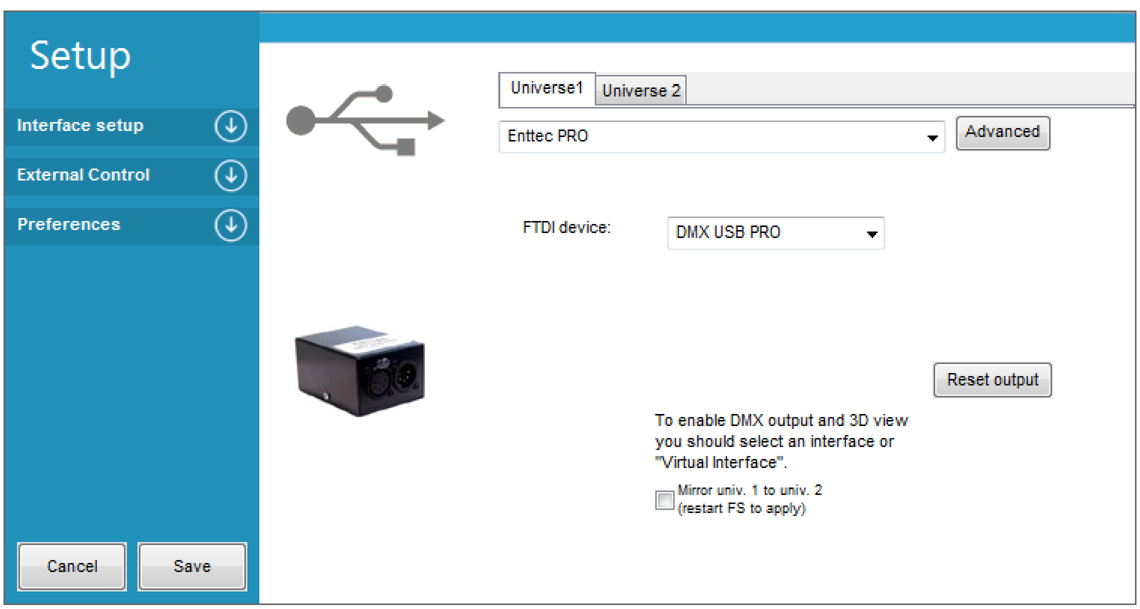
For FreeStyler "**First start**" you will also get a "Setup" dialog with a "Welcome to FreeStyler" message. Click on the "Next" button and you will be asked to "**Select your interface**." If, instead of the welcome words you get a question dialog asking "**No interface selected for universe 1. Continue in demo mode?**," answer "**No**", and this will also bring you to the setup dialog. Finally, if the setup dialog does not open automatically or is not opened for whatever reason, you can open it with the "Setup/FreeStyler setup" menu.

USB setup
The screenshot below shows the setup dialog as it appears during a "**First start**".



You should select "Enttec PRO" in the interface menu and then click the "Save" button. Clicking on the "Next" button will open the fixture selection dialog; this is not required yet and will be done automatically when we open the "**Location**" file in the next step.

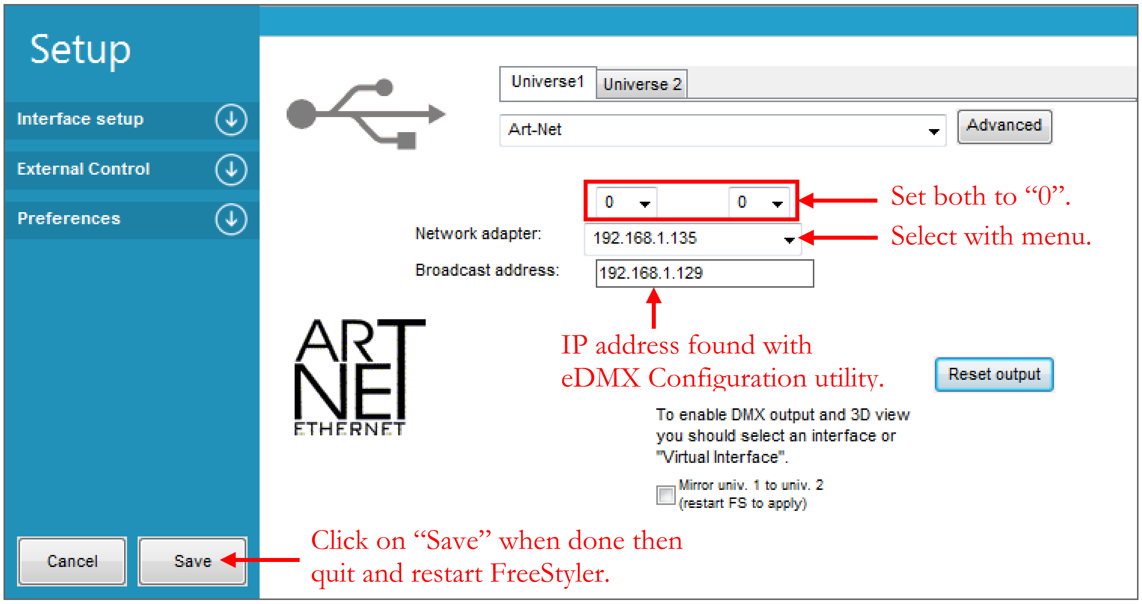
The screenshot below shows the setup dialog which appears when you answer "No" to the question asking "No interface selected for universe 1. Continue in demo mode?" or when you open the setup manually. In this dialog the two universes of our controller are already shown as separate tabs. Select "Enttec PRO" for the "Universe 1"; you can leave "Universe 2" set at "No interface". Click on the "Save" button to close the setup dialog.



Hint: Quit and restart FreeStyler after an interface change! This simple trick helps in applying the changes.

Art-Net setup

If required, re-open the "Setup" dialog with the "Setup/FreeStyler setup" menu. Select "Art-Net" as the interface and set the network as shown in the screenshot.



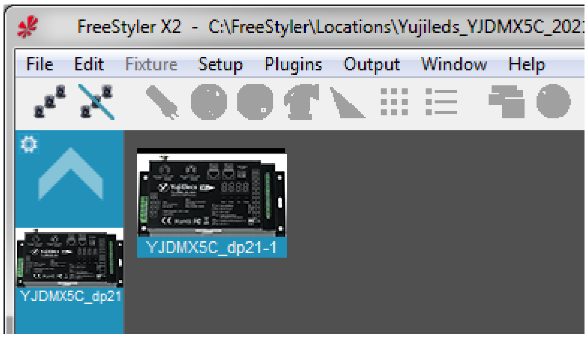
The "**Network adapter**" is the IP address of the computer on which the program is installed. The "**Broadcast address**" is the IP address of the DMX512 as determined with the eDMX Configuration utility; it could be left to x.255.255.255 but it is our understanding that this means broadcasting to all addresses, an unnecessary action.

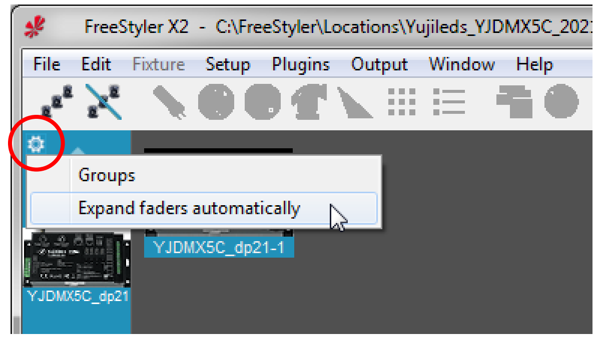
4- The LED decoder **power input** should be connected to the 24 V DC Power Supply, with power OFF for the moment, and its outputs should be connected to the LED strip. Now connect the controller to the LED decoder with a DMX512 cable. A 5-pin to 3-pin adapter may be required (our controller has 3-pin XLR connectors while our LED decoder has 5-pin connectors).

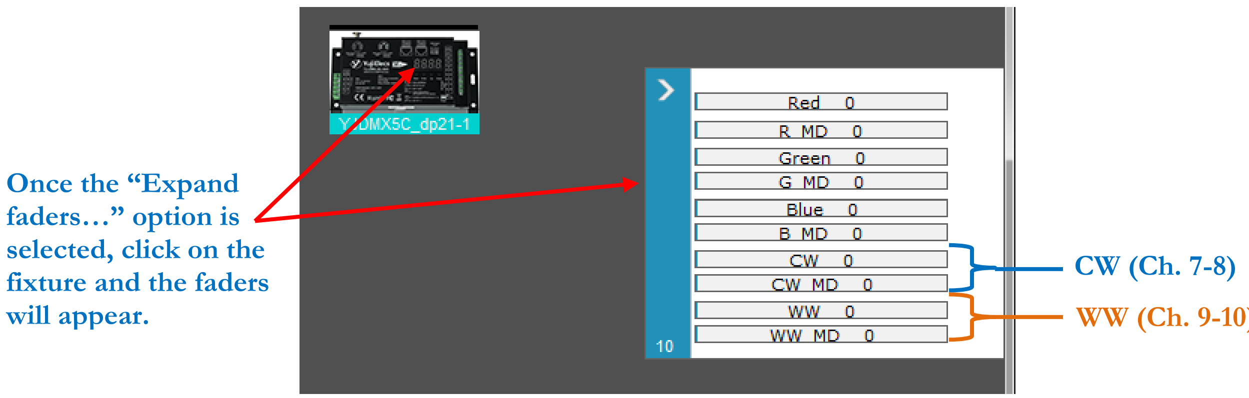
5- With all connections checked, apply power to the LED decoder. Make sure that the LED decoder settings shown on the four-digit display are correct.

Location file example

1- Select the "File/Open Location" menu. Select the **location** file you added in Step 1 of the FreeStyler setup procedure. You should see the fixture in the main program window as shown below on the left. Do a mouse click on the little tool icon and select "Expand faders automatically". Once selected, the faders on the right of the main window will expand whenever you select the fixture.





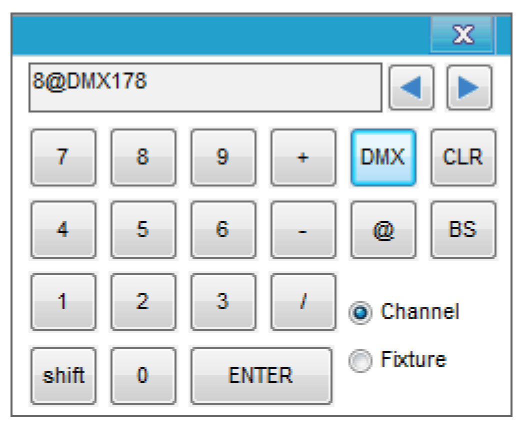


If everything is properly set, making changes in the four CW and WW sliders/faders should affect the LED strip. All channels are 8-bit, accepting values between 0 and 255 (0 and 100%). Two channels are associated to each output, the secondary channels, identified with "MD" are used for micro-dimming where the entire range corresponds to a change of 1 in the non-micro-dimmed channels.

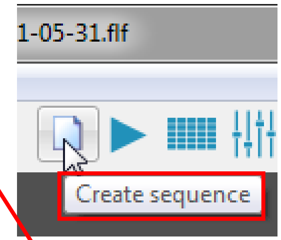
2- An alternate method to assign channel values is through a dedicated keypad which is shown by clicking on the "Go" icon. This keypad is shown on the right. The keypad accepts short one line commands in the format

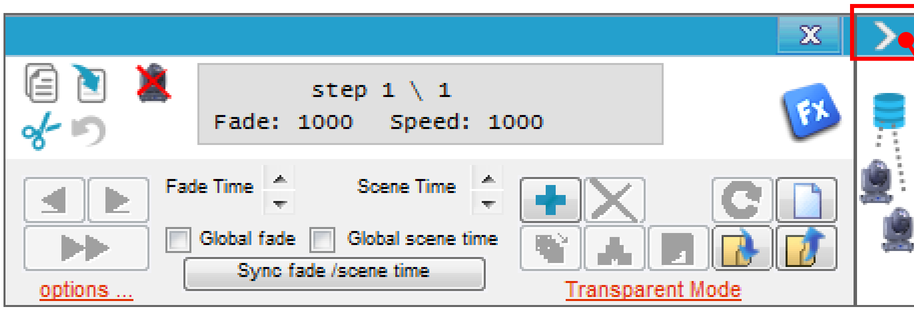
"Ch#" @DMX "xxx"

where "Ch#" is the channel number and "xxx" is an 8-bit integer value (0 to 255). It can also accept percentage inputs if you do not include DMX in the line. For example, assigning 178 to the CW micro-dimming channel is done by entering "**8@DMX178**" and the ENTER key.

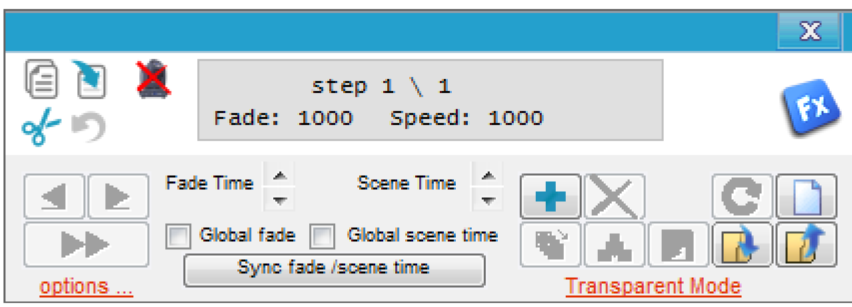


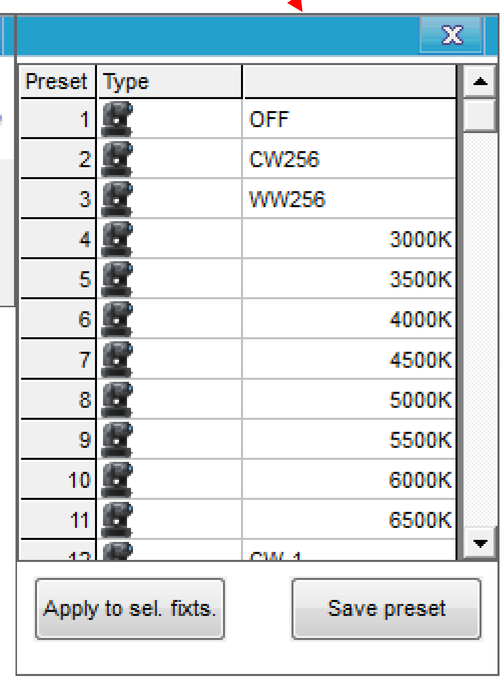
3- Click on the “Create sequence” icon shown on the right to open the interface used to create **sequences** and **presets**. The interface is shown below as it initially opens.





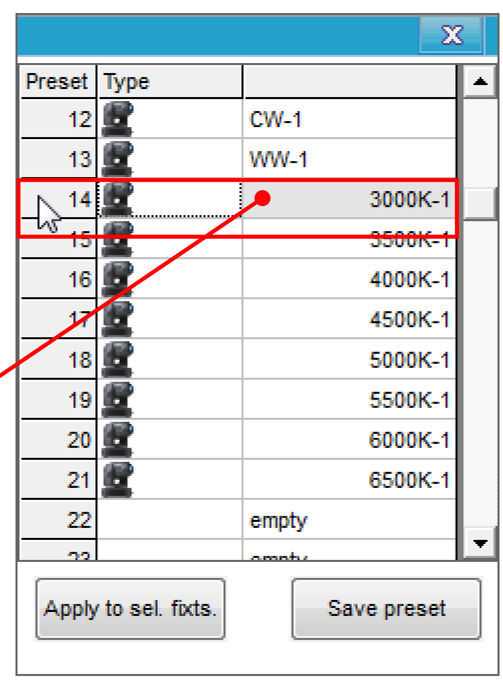
The above dialog is used to create and play sequences. Click on the arrow (**>**) on the top-right corner to expand the dialog used to create and assign presets, as shown just below on the right.





The presets in this table are those contained in the files copied in Step 1 of the FreeStyler setup section. To apply a preset, first click on a preset number and then click on the “**Apply to sel. fixts.**” button. You will see the values assigned to each channel in the sliders panel.

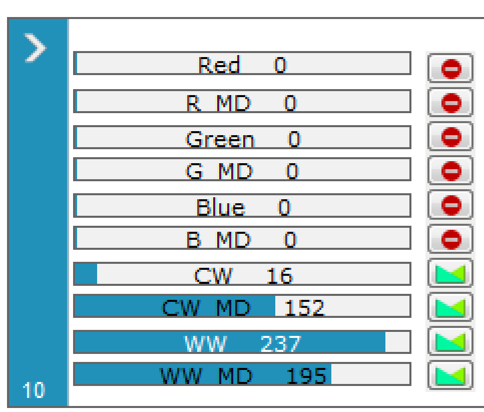
For example, the CW256 preset maximizes both channels (dimming + micro-dimming) controlling the CW LED bank. The 3000K to 6500K presets can be used to assign specific CCTs with the maximum brightness achievable by mixing the two LED banks; this also means that the brightness differs for each CCT.



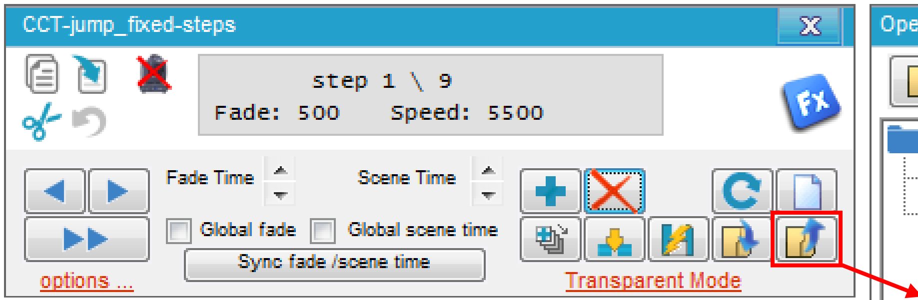
Going down in the list, the CW-1 and WW-1 presets as well as the 3000K-1 to 6500K-1 presets can be seen. The “-1” presets were defined to assign specific CCTs with **constant brightness**. The channel outputs for the “**3000K-1**” preset are shown below. You will see that these settings correspond to those we computed using the spreadsheet (and also to those of the "3000K Y-fix" QLC+ channels). Of course your lamp will likely require different settings for all the presets that we have here and you will have to change them accordingly.

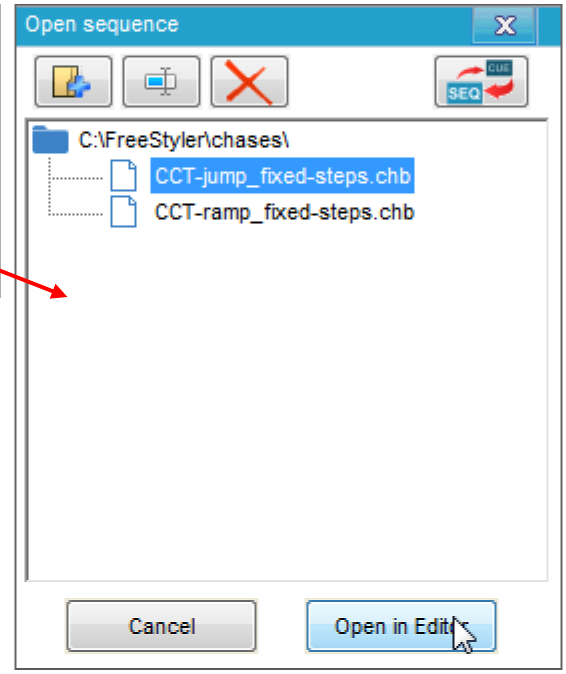
To change a preset:

i- Select a preset.
ii- Click on the “Apply to sel. Fixts.” button.
iii- Edit the channels.
iv- Click the “Save preset” button and confirm the change.

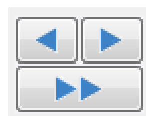


4- To open a sequence, click on the "Open" button of the sequence dialog. 





In the "**Open sequence**" dialog you should see the two sequence files copied in Step 1 of the FreeStyler setup procedure. We have selected and opened the first file and we see that the sequence dialog now shows "**step 1\9**" of the sequence.

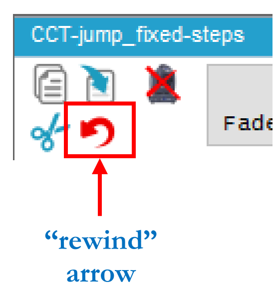


In the channels/faders display you should see the intensity levels associated to the current step. To see the next step, click on the forward arrow button. To play the sequence, click on the double-forward-arrows button; click a second time to stop the sequence.

To change a step in a sequence:

i- Make sure the fixture is selected.
ii- Move to a step with the forward or backward arrows.
iii- Change the channels values directly with the faders, with the "Go" Run Command keypad, or by selecting a preset.
iv- Adjust the "Fade" time and the "Scene" time (also called "Speed") if required.
v- You can also delete, add, or insert a step (also called a "scene").
vi- Test your sequence and save it (under the same name or another name).

Warning: Be extremely careful when editing a sequence since it is the last channels values that you set, or preset that you select, that will be used in the current sequence step. Check the "rewind" arrow; if colored red, then you may have changed the sequence level unknowingly. Just click on the arrow to undo the change.



4.2 Q Light Controller Plus (QLC+)

QLC+ is free and cross-platform software; donations are accepted (from the home page). This software is available for Windows OS, macOS, and Linux 64bit DEB. Here are essential links:

QLC+ home: https://www.qlcplus.org/

Download: https://www.qlcplus.org/downloads.html

Video tutorials: https://www.qlcplus.org/tutorials.html

Install procedure

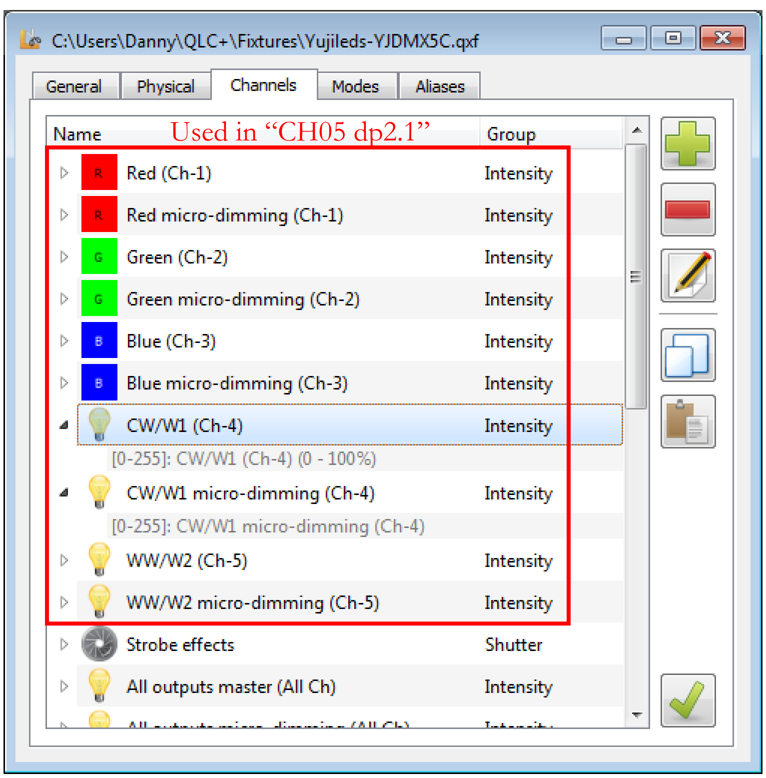
1- If not already done, first install the USB FTDI drivers before installing QLC+.

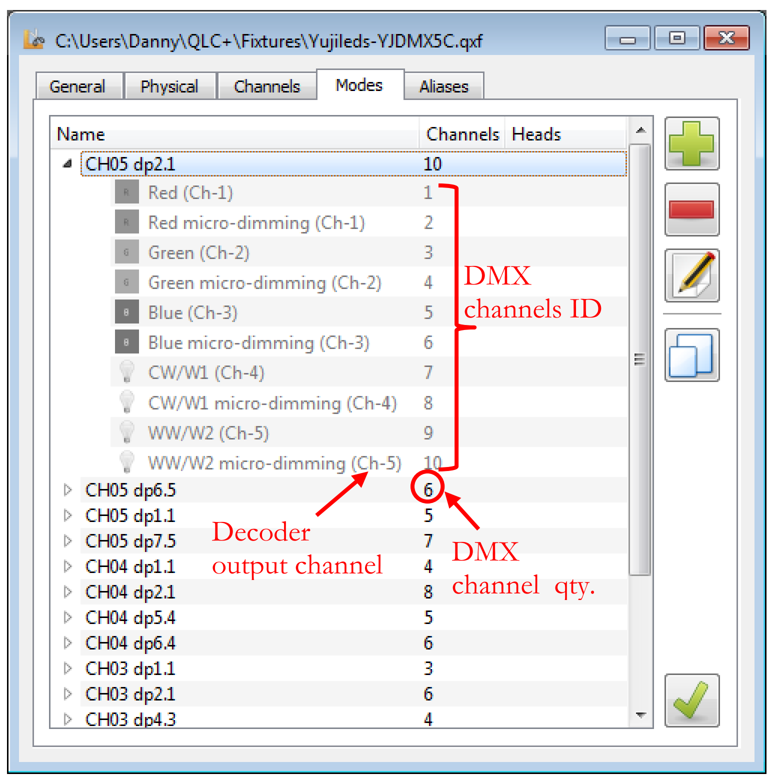
2- Install QLC+. **Do not launch QLC+ yet!**
Note: If you have launched QLC+ anyway, it is not dramatic! The first time you launch QLC+ you may receive a security alert advising that the Windows Defender Firewall has blocked some program functions. You should authorize QLC+ to have access to private networks.

Fixture definition

1- Add the fixture definition file to the QLC+ fixture folder.
Fixture folder: **C:\Users\UserName\QLC+\Fixtures** (default location)
Fixture definition: **Yujileds-YJDMX5C.qxf**
The fixture file is part of the zipped package which contains this application note.

2- Launch the "**Fixture definition Editor**" application which is bundled with QLC+. Click on the "Open" icon (the second from the left) and the "Open a fixture definition" dialog should contain the fixture definition file you added in Step 1; select and open this file. You will notice that the "General", "Physical", "Channels", and "Modes" tabs are filled. The "Channels" tab presents the DMX channels available for all decoding modes (**dp X.X**) and output channel quantity settings (**CH01 to CH05**). For instance, the "All outputs master (All Ch)" and "Strobe effects" channels are not used in all decoding modes. You will also see that the "Modes" tab identifies which channels are used in the decoding modes of **CH01 to CH05**.





3- You can edit this fixture definition if you wish. Alternately, you can define your fixture from scratch with the same application. You should close the fixture editor when satisfied with the fixture definition.

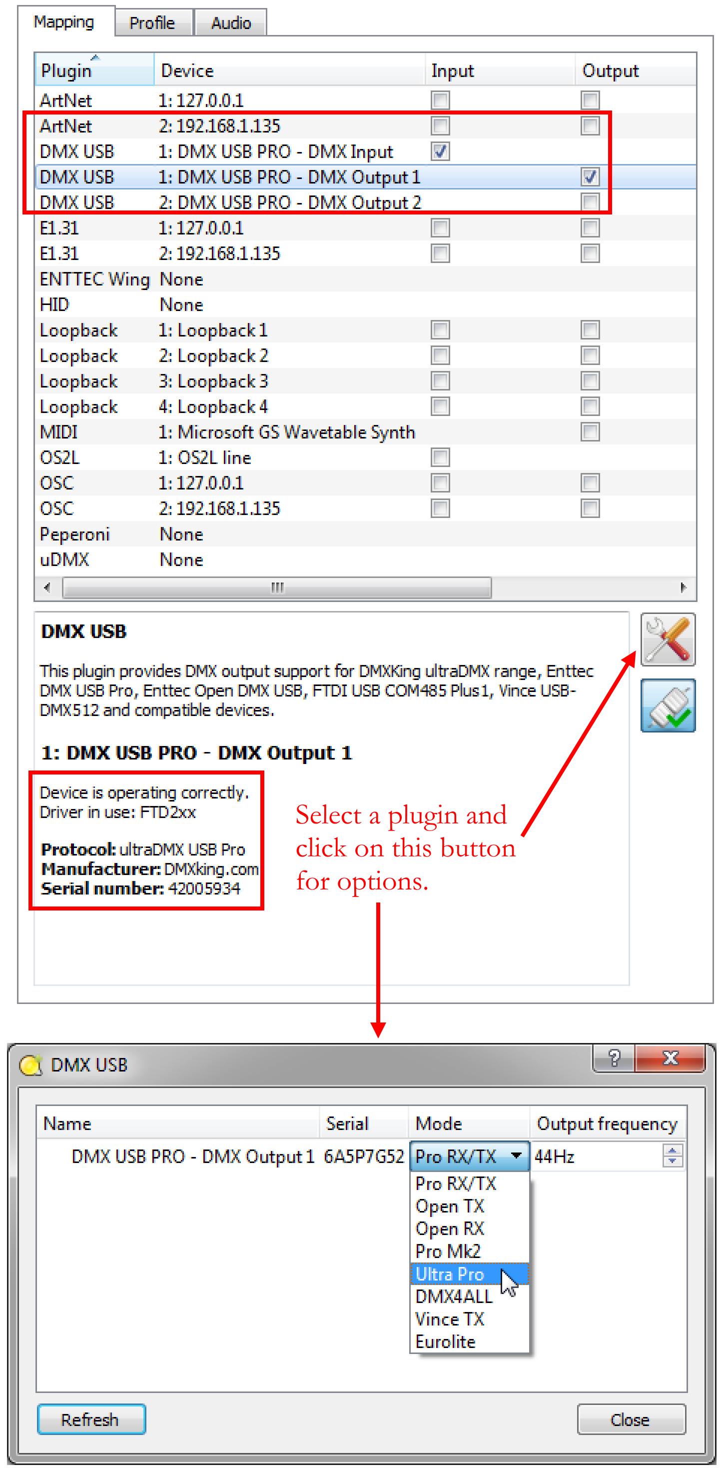
Program setup

1- Add the **Workspace** file to the QLC+ folder.
   QLC+ folder: **C:\QLC+** (default location)
   Workspace file: **Yujileds-WorkSpace_2021-05-11.qxw**
   The workspace file is part of the zipped package which contains this application note.

2- Power and connect the DMX512 controller. For this first try we recommend connecting the controller USB port to your computer USB port and not just powering the controller to an AC adapter with a USB power output plug. You should also connect your controller Ethernet port to an output on your router.
   Note: In this procedure we assume that the controller is the ultraDMX2 PRO presented in the USB/Ethernet Controller section.

3- **Launch the "QLC+" application.**
   Before we open a workspace file we will set the interface between the software and the DMX512 controller. Click on the "Inputs/Outputs" tab (the last tab) located on the bottom of the program window. In the "Mapping" table on the top-right of the program window you will see all the input and output options available with the connected/detected devices. We are principally interested in the options available for the "Art-Net" and "DMX USB" plugins.

   You will notice that the second Art-Net entry indicates the IP address (192.168.1.135) of our computer. This is of course the same address identified by the eDMX Configuration utility program we used earlier.



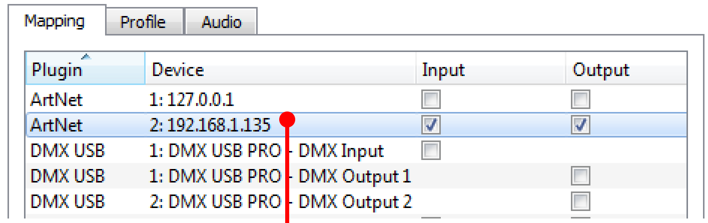
   USB setup

   As shown on the screenshot on the right we have selected the USB port for input and output. If the DMX USB plugins do not appear as shown, select any DMX USB entry (click on a plugin or device name, not in or on a checkbox!) and click on the "tools" button to configure the plugin. This will open a new dialog, shown on the bottom-right of this page. In the options mode menu, select "Ultra Pro" (the "Pro RX/TX" menu item will also work, but supports less features).

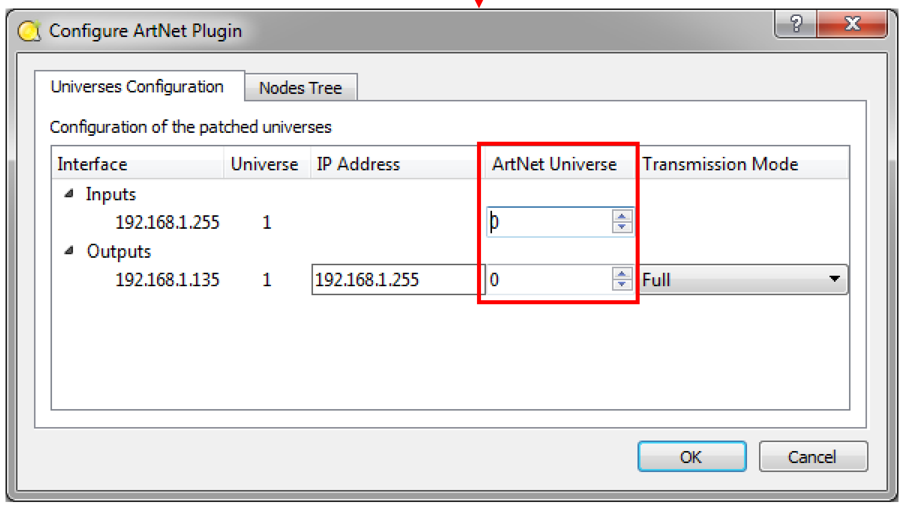
   The bottom of the "Mapping" tab also provides feedback on the device driver as well as the device protocol, manufacturer, serial number, and if it is operating properly.

   On the next page we will see on we can simply use these settings to control the device using the Art-Net protocol.

Art-Net setup

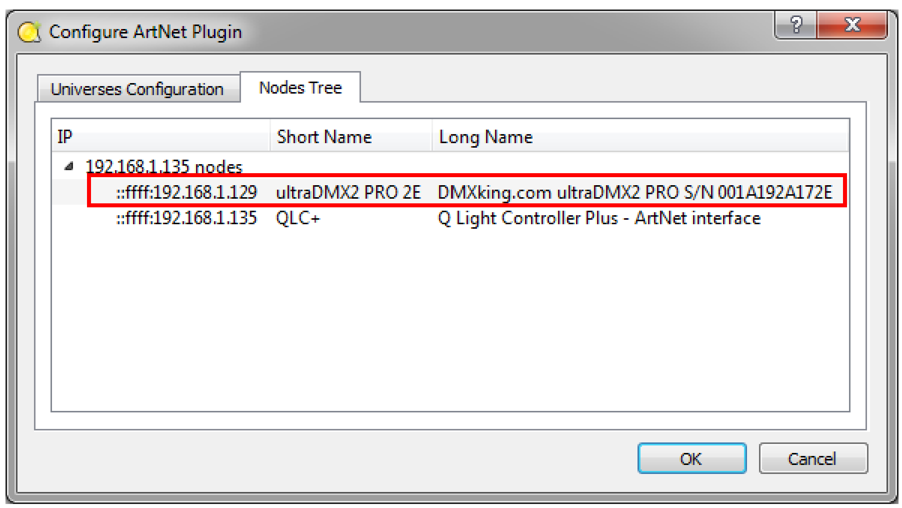


On the screenshot on the right showing the mapping info we have selected the second Art-Net plugin for both input and output. Once selected, click on the "tools" button; you should get a configuration dialog similar to the one shown just below. In the "Universe Configuration" tab, make sure that the input and output "ArtNet Universe" values match those (both =0) assigned in the controller [eDMX Configuration utility](#).



In the "Nodes Tree" tab we have expanded the nodes; we see that the ultraDMX2 PRO controller is recognized at the 192.168.1.129 IP address, the same address identified by the eDMX Configuration utility.

At this stage it is up to you to decide which protocol you will use to control the LED decoder, USB or Art-Net. With this interface you can easily switch to one or the other.



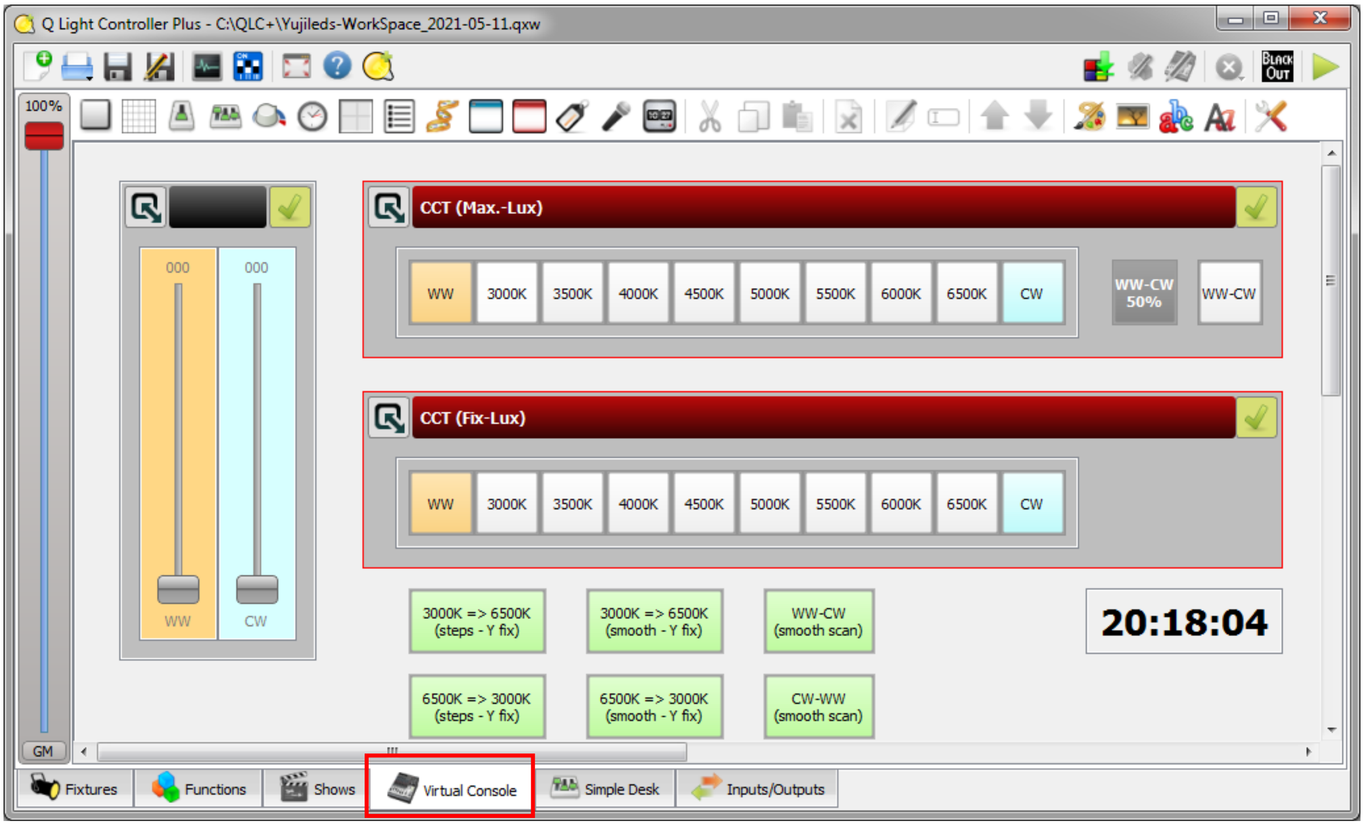
4- The [LED decoder](#) **power input** should be connected to the 24 V DC Power Supply, with power OFF for the moment, and its outputs should be connected to the LED strip. Now connect the controller to the LED decoder with a DMX512 cable. A 5-pin to 3-pin adapter may be required (our controller has 3-pin XLR connectors while our LED decoder has 5-pin connectors).

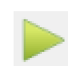
5- With all connections checked, apply power to the LED decoder. Make sure that the [LED decoder settings](#) shown on the four-digit display are correct.

Workspace file example

1- Click on the QLC+ "Open" icon (the second from the left). 

The "Open Workspace" dialog should contain the workspace file you added in Step 1 of the QLC+ setup procedure; select and open this file. The program window should appear as in the screenshot below; select the "**Virtual Console**" tab if it is not selected.

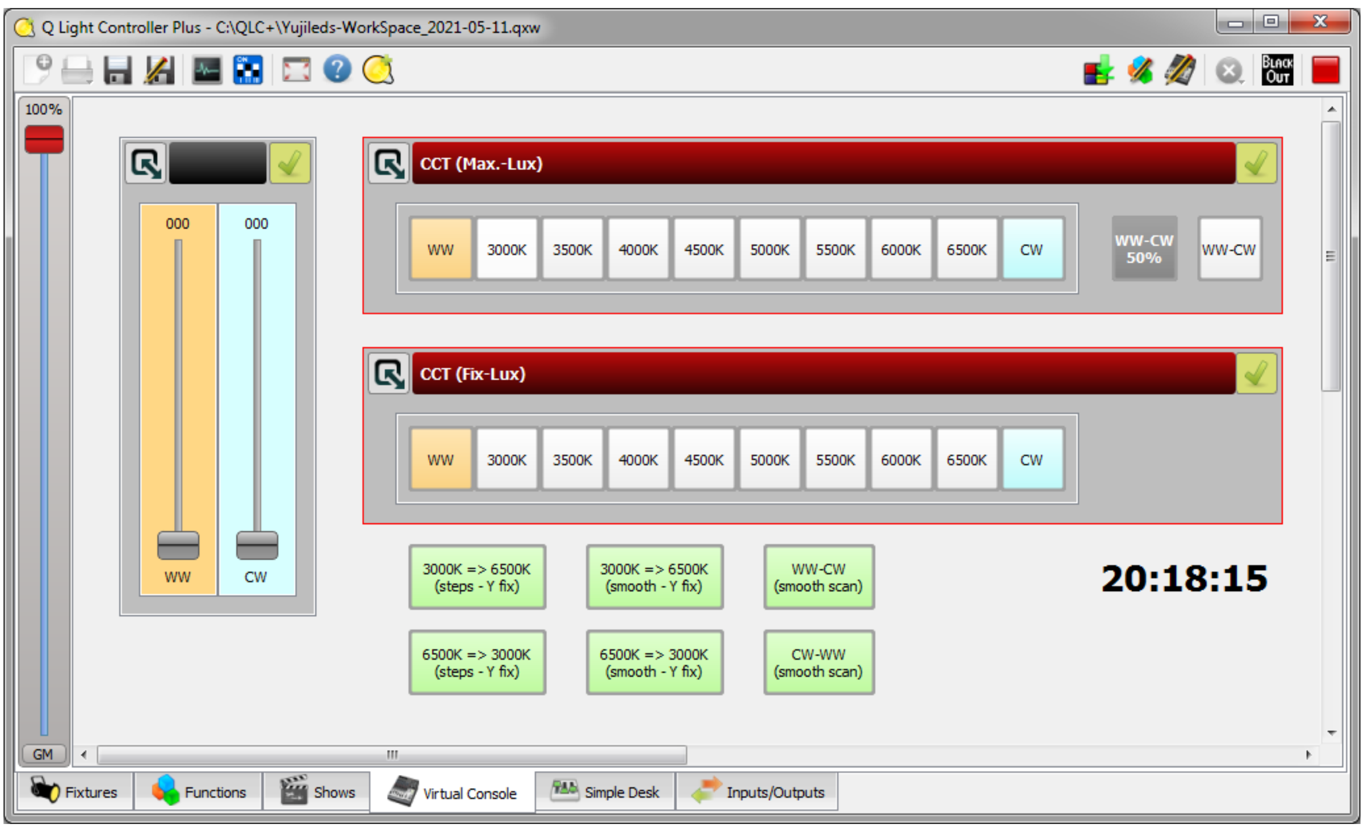


2- As shown above, the console is not operational but in "**Design mode**", a mode where you can add, edit or delete any interface element required in your project. This is also the mode in which the fixtures and functions are defined. The "Design mode" can rapidly be identified by the presence of a green triangle located on the upper-right corner of the program window. While in this mode you can see to which channels the sliders are linked and to which functions the buttons are associated. Just double-click on a control, or do a mouse right-click and select "Widget Properties," to open a configuration dialog. 

3- In order to use the console to control the LED strip, you need to switch to the "**Operate mode**." This is done by clicking on the green triangle which is then replaced by a red square (see the screenshot on the next page). In the remaining of this section we will present the various features of the "Virtual Console" and provide additional info on the "Fixtures" and "Functions" tabs.

QLC+ Virtual Console

- The GM slider (the Grand Master dimmer) on the left side of the window overrides all intensity channels.
- Apart from the GM slider, all other components of the virtual console interface are defined by the user. The console layout is saved within the workspace file.
- The WW and CW sliders' purposes are to manually control each LED bank. They assign the same 8-bit values to the regular and micro-dimmed channels, i.e. these are 8-bit sliders. You should bring both sliders to zero if you intend to use the other controls (i.e. the square and rectangular buttons).
- The square buttons are associated to fixed CCT outputs. Each CCT is associated with a "Function/Scene". The buttons regrouped under the "**CCT (Max.-Lux)**" box can be used to assign specific CCTs with the maximum brightness achievable by mixing the two LED banks; this also means that the brightness differs for each CCT. The button labeled "WW-CW" sets both LED banks at their maximum output, equivalent to moving the WW and CW sliders at their maximum position. The buttons regrouped under the "**CCT (Fix-Lux)**" box can be used to assign specific CCTs with constant brightness. **You should activate only one button at a time.** Press on an activated button to stop it.
- The green rectangular buttons are associated to scans at fixed CCT steps or smooth scans across CCT ranges. These scans are performed via a "Functions/Chaser" or a "Functions/Sequence". "Chasers" consists of a series of "Scenes" ordered in a time-line. "Sequences" directly control the fixture channels in a time-line. In our setup "Chasers" are associated with specific CCTs since they control scenes defined for each CCT. Sequences are not associated to specific CCTs and directly control the fixture channels; sequences are used for the WW-to-CW and CW-to-WW scans. Click on a button to start or stop a scan. **You should activate only one scan at a time.**

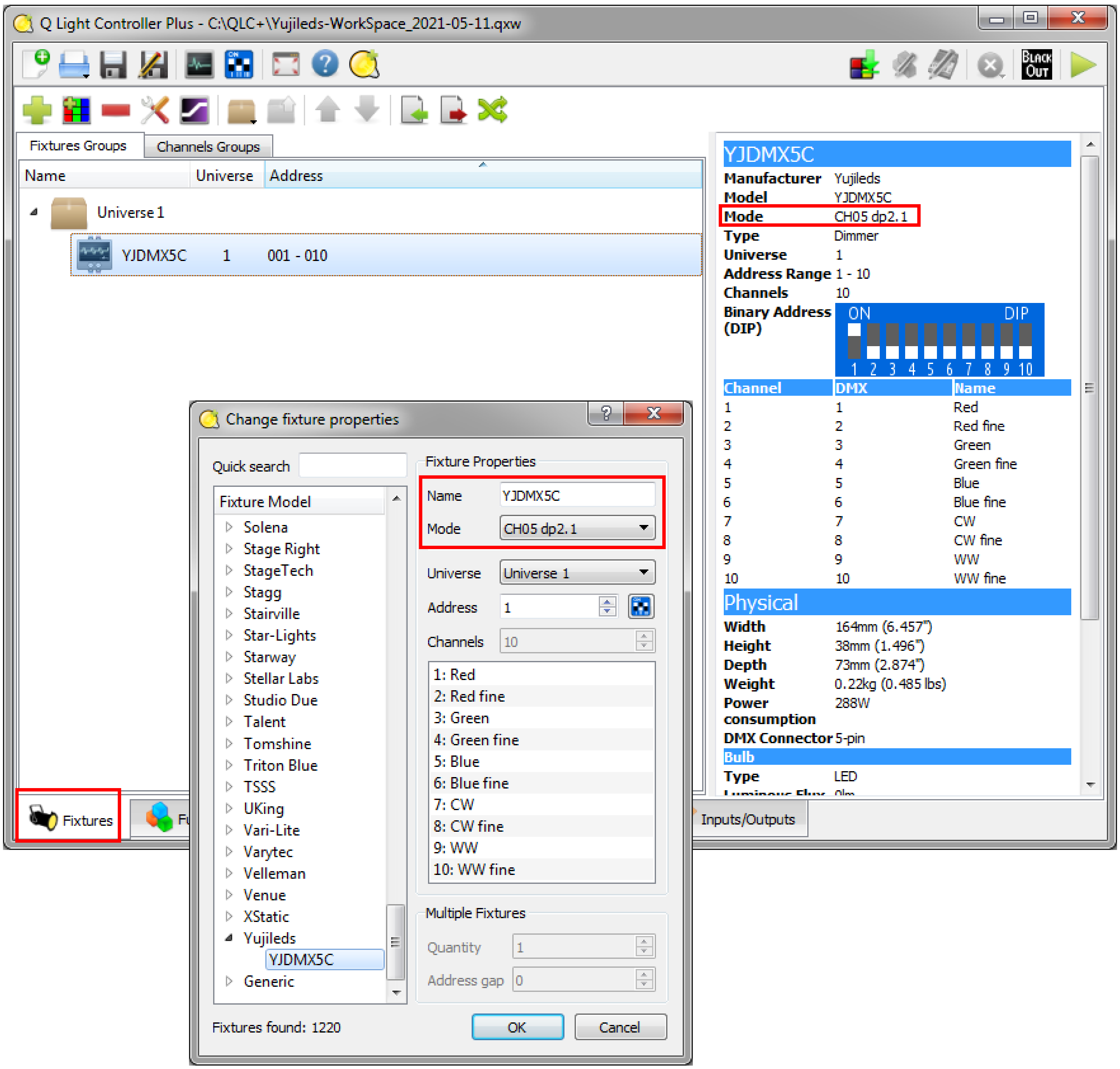


- Click on the red square located on the upper-right corner of the program window to get back to the "Design mode". 

QLC+ Fixtures tab

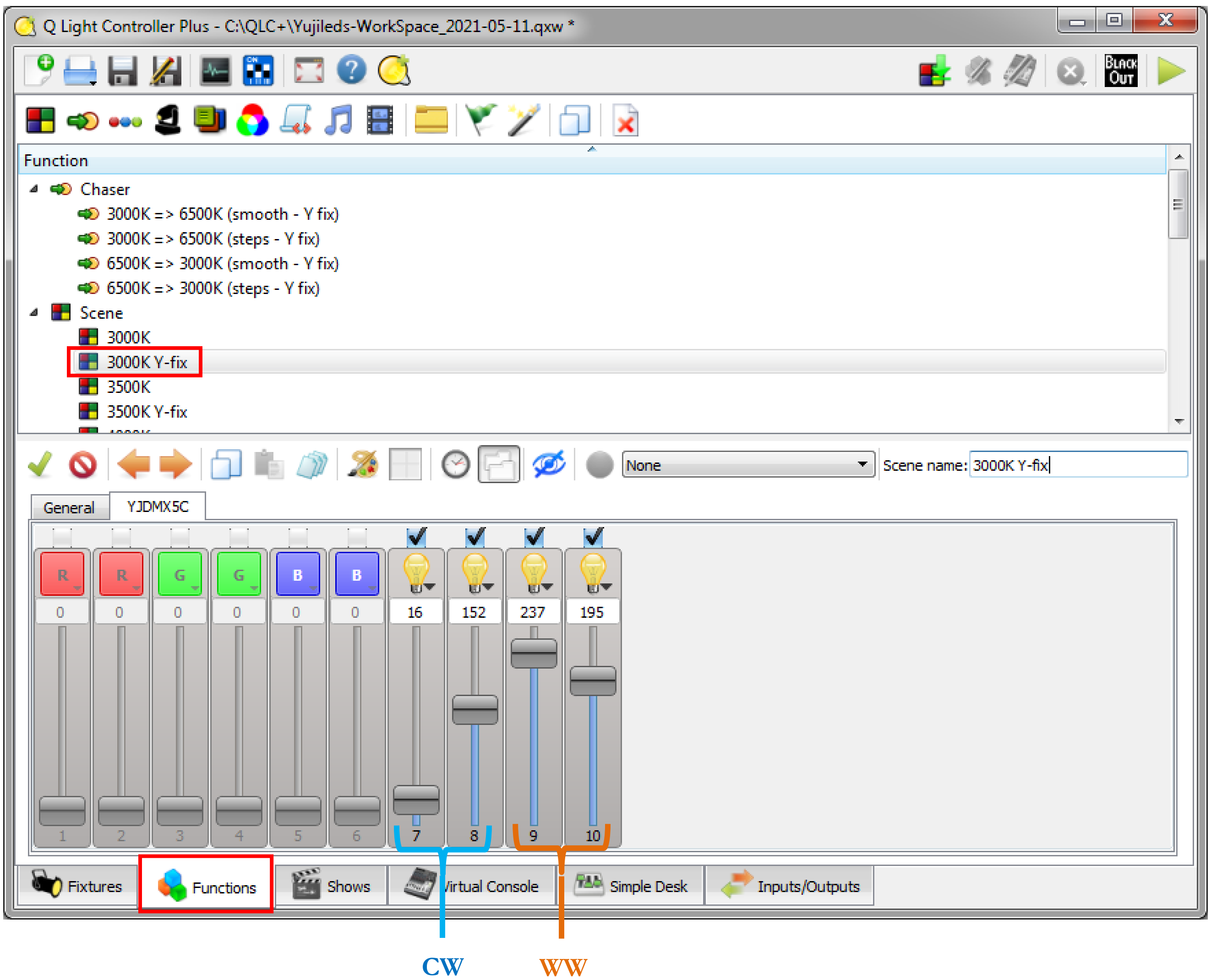
- Assuming the workspace file identified in Step 1 of the QLC+ setup sub-section is properly opened, the “Fixtures” tab should contain only one fixture as shown here. If you click on the fixture name (YJDMX5C) you will see the device details in the right pane of the Fixtures tab. Check that the “Mode” is “CH05 dp2.1” and that the channels are properly identified.

  To select another mode or even select another fixture you can either double-click on the device icon or do a right-click and select “Properties”; either action will open the “Change fixture properties” dialog shown below.



QLC+ Functions tab

- This tab contains the "Scenes", "Chasers" and "Sequences" associated to our fixture. A scene corresponds to fixed channels settings, i.e. a fixed CCT; this is equivalent to a preset in FreeStyler. For this project, we have defined chasers by joining scenes of increasing or decreasing CCTs. The scene transition can be smooth, with fade-in and fade-out durations and no hold time, or the transition can be fast with a hold time at every CCT step. We have also defined smooth sequences where the CW and WW LED banks are continuously mixed, either going from CW to WW or from WW to CW.
- The screenshot below shows the settings for the "**3000K Y-fix**" scene corresponding to a 3000 K CCT with the same (fixed) brightness as the other CCTs/scenes with the "Y-fix" suffix. You can verify that the channels values are those we computed using the spreadsheet (and also those of the "3000K-1" FreeStyler preset). The scenes without the "Y-fix" suffix correspond to CCTs with the maximum brightness achievable by mixing the two LED banks; this also means that the brightness differs for each CCT. Of course your lamp will likely require different settings for all the scenes that we have here and you will have to change them accordingly. On the plus side, the chasers and sequences do not need editing, and there is no change required either in the "Virtual Console".

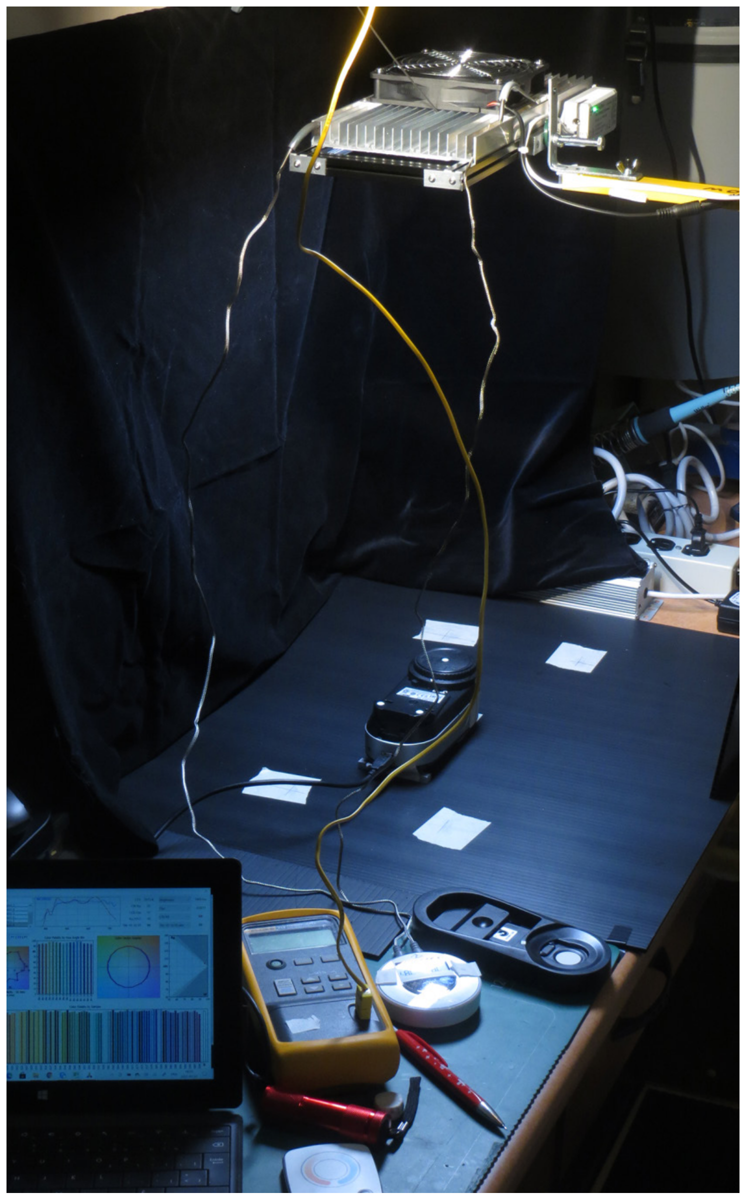


5. Deriving the LED inputs for the CCT presets

The preceding sections present all the components and software that we need in order to control our bi-color LED strip so that it accurately emits light at prescribed CCT values. What is missing at this point are numbers, more specifically the actual proportion of the WW and CW LED banks which we need to obtain a given CCT. We will also compute the proportions so that the illumination level, i.e. the lamp brightness, remains the same for all CCTs.

Of course we could find these proportions by trial and error, and some time... But we can automate this search by using a very useful feature of the Microsoft Excel spreadsheet software, its "Solver" add-in. You will find the actual spreadsheet used for computation in the zipped package which contains this application note. Look for a file named "**CCT-from_WW-CW_mix_2021-04-21_V1.xls**".

5.1 Test setup



The test setup is similar to the one used to characterize the lamp in AN-12, which is pictured here. For this setup you need to make sure that there is no light from an external source, either natural, such as through a window, or artificial, i.e. another lamp. In our case, the only other light source in the room was from a laptop whose display was oriented away from the measurement area.

A black velvet curtain was placed in front of the wall and partially on the sides of the test area. A black Coroplast® sheet was placed at the bottom of the area, under the measuring instrument (an i1Pro 3 spectrocolorimeter from X-Rite®). If your velvet curtain is big enough you could use it for the bottom area as well.

The lamp was positioned parallel with the measuring surface. You should place the detector at a distance which is likely to be used in practice and at the center of the emission field-of-view. The distance between the LED strip and the ambient diffuser input window on the instrument was around 500 mm. We do not recommend placing the lamp too close since it could heat the instrument.

The presence of potential parasitic reflections was verified using either a white or a black sheet of plastic which was positioned at different locations. For example, we positioned a black sheet on the sides not protected by the velvet and compared measurements with and without the sheet;[6] no variation was seen for the sides and this explains why the setup is opened. We also did a test with a white sheet on the bottom of the area; it did influence the measurements but only slightly since this is a "second order" effect where the light bounces back up to the LED strip circuit board and down again to the detector.

[6] Be careful with shiny black plastic since it can still reflect light; adjust its orientation so that the reflection of light emitted by the illuminator is directed away from the test area.

5.2 Measuring the reference spectrums

The minimal information we need to **measure** are the spectrums of the WW and CW LED banks between 380 nm and 730 nm at 5 nm intervals. If measured at 10 nm intervals, the spectrum shall be interpolated at 5 nm. These spectrums are then processed in the aforementioned spreadsheet to determine the proportion of each spectrum required to obtain a CCT anywhere between the WW and CW CCTs. The LED banks are measured at their maximum output and we refer to these spectrums as **WW256** and **CW256** in the processing spreadsheet.

We recommend also measuring the spectrums of the lamp when both LED banks are at their maximum output, which we refer to as **WWCW256**, and when both LED banks are at half their output, which we refer to as **WWCW128**. These last two measurements are used to check our data processing computations and to see if the hardware behaves linearly (more specifically in terms of dimming linearity!).

Measurements preparation
Here is a check-list to go through before making the measurements:

i- The LED strip is connected to the computer as illustrated in the DMX512 diagram.
ii- The LED decoder is set as described in the LED decoder section.
iii- If using the USB port: The DMX512 controller USB drivers are installed and the device is set as described in the USB/Controller section.
iv- A DMX512 software is installed and configured. **Presets/scenes are not required!**
v- All components are powered. The lamp fan should be set at a proper speed, as discussed in AN-12 Section 6.2.
vi- Before making any measurements the lamp output is set to its maximum, with the WW and CW channels at 256. Let the lamp stabilize for about 5 minutes.

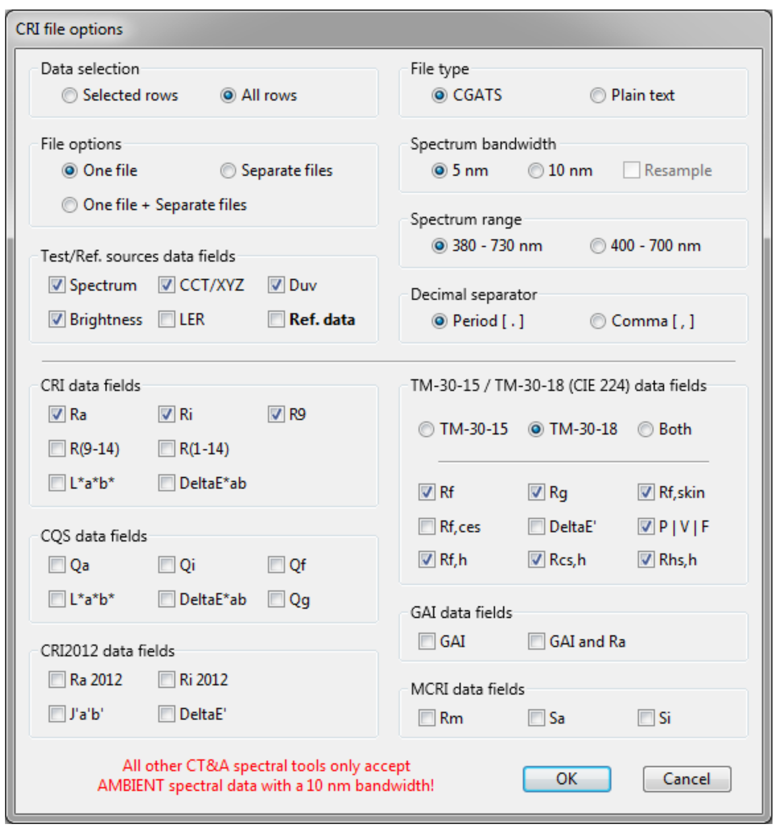
Making the measurements (The short version!)

i- Set the LED strip for maximum CW output; measure and record the spectrum.
ii- Set the LED strip for maximum WW output; measure and record the spectrum.
iii- Optionally set the LED strip for combined maximum CW and WW output (CWWW256) and half combined output (CWWW128).
iv- Jump to the next section and copy/paste the spectrums in the spreadsheet.

Making the measurements (A longer version!)

i- Use an i1Pro and BabelColor CT&A's CRI tool for measurements.
ii- With CT&A's CRI tool measure the maximum CW and WW output, CW and WW combined, and CW and WW combined at half level (i.e. 128 per channel). Make sure the measurements are named appropriately.
iii- Export the data with the settings shown in this screenshot (export is not possible with CT&A in demo mode). These results are processed in the spreadsheet presented in the next section.

Note: Here the measurements were taken with a 10 nm bandwidth instrument. They are interpolated to 5 nm for export. The interpolation method is selected in the "Math" tab of CT&A's Preference dialog (where we selected the **Lagrange** method).



5.3 Using Microsoft Excel to get the preset values

This procedure was developed using Microsoft Excel. The Excel file should open and work in spreadsheet applications which are compatible with ".xls" files. Please note that while the Excel "Solver" plugin is required for an automatic optimization procedure, it is feasible to achieve this optimization by trial and error without the plugin (but with more time!).

For this procedure you need to have at least the spectrums of the CW and WW LED banks in a file. You will find a sample measurement file in the zipped package which contains this application note. Look for a file named:

CRI_Report_2021-04-21_16h24_WW-and-CW_5-nm_Lagrange.txt

This is a simple text file where the data is Tab-delimited; it can be opened in any word processor if you do not have a spreadsheet application. The file can be opened in Microsoft Excel simply by dragging and dropping the file on an opened Excel window. You will see that this file has ten measurements, including the four we are looking for: CW256, WW256, WWCW256, and WWCW128.

You should now open the spreadsheet file used for data processing. Look for a file named:

CCT-from_WW-CW_mix_2021-04-21_V1.xls

in the zipped package which contains this application note.

With the measurement file and the processing spreadsheet both opened in the spreadsheet application, copy the measurements one-by-one from the measurement file to the processing spreadsheet. For a given measurement, **copy the spectral data and the processed data** in columns "C" to "CF" in the measurements file (from "nm380" to "Brightness") and **paste this line as a column** (i.e. transposed) in the processing spreadsheet. You will note that the processing spreadsheet already contains the data of the four measurements in the sample file.

Note: In the "CRI_Report…" measurements file, the additional data after the spectral values shows the **CCT, xyY, XYZ, u'v', Duv** and **Brightness** corresponding to the spectral data as computed by BabelColor CT&A. **This processed data is recomputed from spectral data in the spreadsheet** and appears in cells "L4" to "O15".

Note: If your measurement file only has spectral data, just copy and paste the spectral data and erase the **content** of cells "B75" to "E85" (11R x 4C) in the processing spreadsheet. Just erase the cell content; do not delete the cells!

Let's now see what we can do with the measurement data in the processing spreadsheet.

Manual WW-CW mix

In the spreadsheet, you can manually input the ratios of the WW and CW banks and see the resulting characteristics (CCT, xyY, XYZ, u'v', Duv, Brightness). The ratios can be set between zero and one for each LED bank. The interface is shown below on the left. On the right we see the processed data from the measured WWCW128 spectrum compared to the data from the predicted, mathematically mixed, spectrums.

Manual WW-CW mix	
CW:	0,500
WW:	0,500
QLC+ / FreeStyler values	
CW	128
CW-MD	0
WW	128
WW-MD	0

inputs

	Measured WWCW128	Manual WW-CW mix
CCT	4379	4366
XYY_X	0,36304	0,36344
XYY_Y	0,35605	0,35612
XYY_CAPY	1778,275	1845,212
XYZ_X	2484,474	2580,339
XYZ_Y	2436,689	2528,411
XYZ_Z	1922,413	1991,103
XYZ_X	**101,961**	**102,054**
XYZ_Y	**100**	**100**
XYZ_Z	**78,894**	**78,749**
Duv	**-0,0045**	**-0,0046**
Brightness	**1778,275**	**1845,212**

output

We observe a small difference in **CCT**, 4379 K for the measured spectrum and 4366 K for the mixed spectrum, a 13 K difference (-0,3%) which will not be perceived in practice. The **brightness** difference is more pronounced, 1845 lux vs 1778 lux (+3.8%). We have seen a similar difference when mixing the WW and CW banks at all signal levels; the measurement data can be found in the "CRI_Report_2021-04-21…" file presented at the start of this section and you can also see this data compared in the processing spreadsheet in a table located between the "L71" and "P84" cells (in the "Main" page). We cannot identify precisely the cause of the difference but we suspect it is an effect of the encoder Pulse Width Modulation (PWM) circuit which controls the brightness. We will take into consideration this difference when we adjust all CCTs to the same brightness in the next section.

Using the Solver to find the mix-ratios for a given CCT

We have just seen that we can manually adjust the proportions of the WW and CW LED banks to estimate the resulting CCT. By trial and error we could vary the mix to obtain a specific CCT, such as 3000 K or 4756 K. This manual method can take time but we can use the Excel "Solver" plugin to accelerate the process. In the spreadsheet you can just write the CCT target value, open the Solver dialog and launch it. The screenshot on the left shows the interface after we have entered the "**CCT Target**" (3000 K) and found a solution. The Solver computed target and its corresponding parameters are shown on the right.

Step 2 - Solver	
CCT Target	3000
CCT diff:	0
CW:	0,0698
WW:	1,0000
QLC+ / FreeStyler values	
CW	17
CW-MD	222
WW	255
WW-MD	255

Solver target (input)

Solver solution (output)

CCT	Solver CCT Target 3000
XYY_X	0,43421
XYY_Y	0,39845
XYY_CAPY	1831,848
XYZ_X	2735,346
XYZ_Y	2510,099
XYZ_Z	1054,185
XYZ_X	**108,974**
XYZ_Y	**100**
XYZ_Z	**41,998**
Duv	**-0,0019**
Brightness	**1831,848**

Computed target

The "**CCT diff:**" is zero, confirming that the CCT target was attained. The **CW and WW ratios** found by the Excel Solver **are 0.0698 and 1.000** respectively. We see that the WW bank is at its maximum output and that we need just a bit of output from the CW bank. The corresponding decoder channels values that we need to assign in our controller software are also shown. Because we control the LEDs with 16-bit precision two channels are required for each LED bank. Both channels are defined by 8-bit integers between 0 and 255; the low bit channel, used for precise adjustments, is identified with "MD" which stands for micro-dimming.

The tables on the right, which can also be found in the spreadsheet, compile the ratios and the channels values for a series of CCTs we want to use as presets. You will find these values in the FreeStyler presets and QLC+ scenes. They provide the maximum brightness feasible for a given CCT. If we want the same brightness for all CCTs we need to dim all channels to the lowest brightness measured. This procedure is presented in the next section.

CCT	Max brightness for each CCT ratios (Solver)		Max brightness for each CCT QLC+ / FreeStyler settings			
	CW	WW	CW	CW-MD	WW	WW-MD
CW	1	0	255	255	0	0
WW	0	1	0	0	255	255
3000K	0,0698	1,0000	17	222	255	255
3500K	0,3349	1,0000	85	184	255	255
4000K	0,6749	1,0000	172	195	255	255
4500K	1,0000	0,8754	255	255	224	25
5000K	1,0000	0,5421	255	255	138	197
5500K	1,0000	0,3287	255	255	84	41
6000K	1,0000	0,1794	255	255	45	237
6500K	1,0000	0,0693	255	255	17	189

Note: The Excel "Solver" parameters are already assigned in the processing spreadsheet. In the spreadsheet "Main" page you will also find a description of these parameters.

5.4 Adjusting the levels for a fixed brightness at all CCTs

In the preceding section we have seen how to derive the CCT by manually editing the ratios of the WW and CW LED banks and also how to get, with the Excel "Solver", the ratios corresponding to prescribed CCTs.

We have noted that while the match is quite good between the CCT obtained with predicted mixes of the WW and CW spectrums and the CCT of measured spectrums obtained with the same ratios, the predicted brightness is higher by 3 to 4%. Also, the Solver, as defined, provides the ratios for the maximum brightness achievable by mixing, and not a fixed brightness value. We could certainly adapt the Solver to provide ratios at a fixed brightness but this is made difficult by the non-linear relation between predicted and measured brightness. So, the solution we propose is to first measure the brightness obtained with the ratios obtained by the Solver, and then **tweak** the ratios to take into consideration both the fixed brightness target and the measured brightness. While this may sound complex, it involves only a linear compensation, which can easily be handled by the spreadsheet.

We also have to be careful in our measurement sequence. To determine the brightness compensation we need to **measure the brightness obtained with the Solver ratios**, and we also need the **minimum measured brightness of ALL CCT presets**. So it looks like we have to do all the brightness measurements once to get the minimum value before tweaking the brightness in a second pass. In fact we already know the minimum brightness; just look at the WW and CW brightness computed from the reference measurements. With our lamp we measured 1692 lux at maximum output for the WW bank and 1998 lux at maximum output for the CW bank; with this info, and because of the spectral content of each bank and how mixing works, we can say that the brightness will never be lower than the WW brightness.

Note: The actual brightness will vary with the lamp to detector distance so when you do a series of measurements where you are interested in brightness normalization you should do all your measurements at the same distance, **without modifying your setup**. If you changed the lamp to detector distance since you measured the reference spectrums you have to re-measure the WW brightness.

Measuring the brightness involves assigning the channels values, as derived by the Solver in the preceding section, in our control software. You can measure the lamp output immediately after adjusting the channels sliders but you should also record these values as presets (FreeStyler) or scenes (QLC+) so that they can be reused afterwards. And you should also record the spectrums for future analysis and quality control purposes. For example, you will find the **measured** CCTs corresponding to the brightness measurements shown here in the next section.

Measuring the brightness of the predicted mix is identified as "**Step 3**" in the processing spreadsheet and in the complete procedure of the next page. The table on the right shows the measured brightness for the ten presets we defined. These measurements confirm that the WW CCT has the minimum brightness (which we could also call the maximum brightness common to all CCTs!).

CCT	Step 3 measured brightness
CW	1999
WW	**1695**
3000K	1825
3500K	2326
4000K	2971
4500K	3391
5000K	2860
5500K	2521
6000K	2284
6500K	2109

We will see on the next page how we get the WW and CW ratios as well as the channels values for all CCTs set to minimum brightness. CCT and brightness measurements of the **tweaked presets** are shown in the next section.

Note: The CW and WW brightness shown in the table are slightly different than those in our reference measurements. They were made in a separate measurement session. This is one more proof that experimental measurements are subject to variations and errors!

Procedure to get a fixed brightness for all CCTs (the same Steps are shown in the spreadsheet):

Step 1- Paste the reference spectrums from measurements (done in the preceding section)

Step 2- Solver. Input the "CCT target" (3000 K in the tables below) and launch the Excel "Solver" to find the CW and WW ratios and the channels values. These ratios provide the **maximum brightness for each CCT**.

Step 3- Set the channels values from Step 2 in the LED control software and **measure the brightness**. Note: In order to perform Step 4 the **minimum brightness**, i.e. the "Lux Target," must be known.

Step 4- TWEAK. Insert the **measured brightness** (Meas. Lux) and the **Lux Target** in the yellow input fields. The Lux Target is the same for all target CCTs. Use the tweaked **channels values from Step 4** in your software to define the fixed brightness presets/scenes. See screenshots of these assignments in the FreeStyler (3000K-1 preset) and QLC+ (3000K Y-fix) sections. Redo Steps 2 to 4 for all target CCTs.

CCT	Solver CCT Target 3000
XYY_X	0,43421
XYY_Y	0,39845
XYY_CAPY	1831,848
XYZ_X	2735,346
XYZ_Y	2510,099
XYZ_Z	1054,185
XYZ_X	**108,974**
XYZ_Y	**100**
XYZ_Z	**41,998**
Duv	**-0,0019**
Brightness	**1831,848**

The TWEAK procedure uses the Measured and Target brightness to optimize the Solver CW and WW ratios. The tweaked ratios are then converted to channel values.

Predicted brightness @ 3000 K

Step 2 - Solver	
CCT Target	3000
CCT diff:	0
CW:	0,0698
WW:	1,0000
QLC+ / FreeStyler values	
CW	17
CW-MD	222
WW	255
WW-MD	255

Ratios to be tweaked

Channels values for maximum brightness

Step 4 - Lux TWEAK	
Meas. Lux:	1825
Lux Target:	1695
CW:	0,0648
WW:	0,9288
QLC+ / FreeStyler values	
CW	16
CW-MD	152
WW	237
WW-MD	195

Measured brightness @ 3000 K

Channels values for Lux Target brightness

CCT	Max brightness for each CCT ratios (Solver) CW	WW	Step 3 measured brightness	Max brightness for each CCT QLC+ / FreeStyler settings CW	CW-MD	WW	WW-MD	1695 lux for all CCTs (TWEAK) QLC+ / FreeStyler settings CW	CW-MD	WW	WW-MD
CW	1	0	1999	255	255	0	0	217	17	0	0
WW	0	1	1695	0	0	255	255	0	0	255	255
3000K	0,0698	1,0000	1825	17	222	255	255	16	152	237	195
3500K	0,3349	1,0000	2326	85	184	255	255	62	119	186	141
4000K	0,6749	1,0000	2971	172	195	255	255	98	144	146	13
4500K	1,0000	0,8754	3391	255	255	224	25	127	245	112	4
5000K	1,0000	0,5421	2860	255	255	138	197	151	184	82	62
5500K	1,0000	0,3287	2521	255	255	84	41	172	31	56	149
6000K	1,0000	0,1794	2284	255	255	45	237	189	251	34	21
6500K	1,0000	0,0693	2109	255	255	17	189	205	190	14	66

6. Checking the CCT presets

This section presents the measurements of a bi-color LED strip controlled with DMX512 hardware and software. Measurements were performed at prescribed CCT values located between the WW (≈2700 K) and CW (≈6500 K) LED banks of the LED strip.

A **first set** of measurements is done using LED decoder channels values which are predicted to match the prescribed CCTs while maximizing the lamp brightness for each CCT. These channels values were predicted using the Microsoft Excel "Solver" plugin; these predictions are also **Step 3 (of 4)** of the procedure used to adjust the decoder channels levels for a fixed brightness.

A **second set** of measurements is done using LED decoder channels values which are predicted to match the prescribed CCTs AND have the same brightness. These channels values were obtained **after Step 4** of the procedure used to adjust the decoder channels levels for a fixed brightness.

Note: The purpose of these measurements is not to prove the validity of the approach consisting of blending the two LED banks to get intermediate CCTs but to evaluate the accuracy of its predictions.

6.1 Test setup

The measurements were done with the same setup used to measure the WW and CW reference spectrums in the preceding section. However, even if using the same setup, there is a good chance that the lamp to detector distance may have changed, even slightly. This is why you should first measure the lamp brightness with its WW bank at full output (WW256); this brightness value will then be used as the **minimum brightness** or "**Lux Target**" in the processing spreadsheet.

6.2 Measuring the presets

This checking procedure only requires that we measure the **CCT** and the **brightness** level. If you have an X-Rite i1Pro series instrument you can get this data with BabelColor CT&A's CRI tool in demo/free mode. Please note that the demo mode does not allow saving the measurements and the processed data.

Measurements preparation

Here is a check-list to go through before making the measurements:

- i- The LED strip is connected to the computer as illustrated in the DMX512 diagram.
- ii- The LED decoder is set as described in the LED decoder section.
- iii- If using the USB port: The DMX512 controller USB drivers are installed and the device is set as described in the USB/Controller section.
- iv- A DMX512 software is installed and configured. **The presets (FreeStyler) or scenes (QLC+) should be defined**, ideally in two subsets, one subset for maximum brightness output for each CCT target and one subset for fixed brightness output for all CCT targets.
- v- All components are powered. The lamp fan should be set at a proper speed, as discussed in AN-12 Section 6.2.
- vi- Before making any measurements the lamp output is set to its maximum, with the WW and CW channels at 256. Let the lamp stabilize for about 5 minutes.

Making the measurements

- i- Use an i1Pro and BabelColor CT&A's CRI tool for measurements.
- ii- Assign the LED decoder channels values for every predefined CCTs using the DMX512 control software (or just select a preset!) and measure the light with the CRI tool. Make sure the measurements are named appropriately.
- iii- Export the data with the same settings used when measuring the reference spectrums. The CCT and brightness data is presented in a table on the next page.

You will find the measurement file for the table below in the zipped package which contains this application note. Look for a file named: **CRI_Report_2021-04-21_18h24_presets.txt**

	Maximum brightness*		**Fixed brightness****	
Target CCT (K)	**Meas. CCT (K)**	**Bright. (lux)**	**Meas. CCT (K)**	**Bright. (lux)**
CW	6881	1999	6917	1688
WW	2849	**1695**	2853	1692
3000	2994	1825	3001	1694
3500	3485	2326	3496	1689
4000	3987	2971	4002	1683
4500	4498	3391	4510	1679
5000	5009	2860	5019	1684
5500	5513	2521	5522	1687
6000	6011	2284	6021	1689
6500	6500	2109	6503	1691

*** The CCT and brightness were obtained by placing the instrument *about* 500 mm from the LED strip, in the center of the emission field-of-view.**

**** The fixed/minimum brightness was set at 1695 lux, the maximum output of the WW LED bank (WW256).**

We see that all measured CCTs are close to the target values, within -15 K (=3485-3500) to +22 K (=5522-5500), and the fixed brightness values are within a 15 lux span (1679 to 1694 lux), with an average (1688 lux) slightly lower than the 1695 lux set point.

It is certainly possible to manually (or mathematically) tweak the LED decoder channels even more in order to get nearly spot-on CCTs and brightness but these results are perfectly adequate for accurate color viewing purposes.

We have not made a detailed study on the long term stability of the settings but measurements made six weeks after those shown in the table above are within -2 K to +39 K of the target CCTs and the fixed brightness presets have the same brightness span of 15 lux (around a 1683 average brightness[7]).

[7] Even though much care was taken to reproduce the initial setup, the lamp to detector distance and the detector position may have changed during these six weeks…

7. Conclusion

This document presents how to integrate a computer based DMX512 controller to the variable-CCT illumination lamp built with a bi-color LED strip presented in a previous Application Note (AN-12). The measurements confirm that, once programmed, it is possible to accurately assign CCT presets with constant brightness without the need for a separate measuring instrument.

And, as a final thought, just think of what you could do next. Adding a second lamp to this setup only requires purchasing another DMX512 Decoder. The proposed controller and software can handle many more lamps and you already know how to configure the hardware and how to use the software (and you may already have a few Wireless DMX receivers available if you purchased them in a kit!).

You will find additional information in these appendices:

- Appendix A: Components list and cost
- Appendix B: Revised lamp base

Appendix A

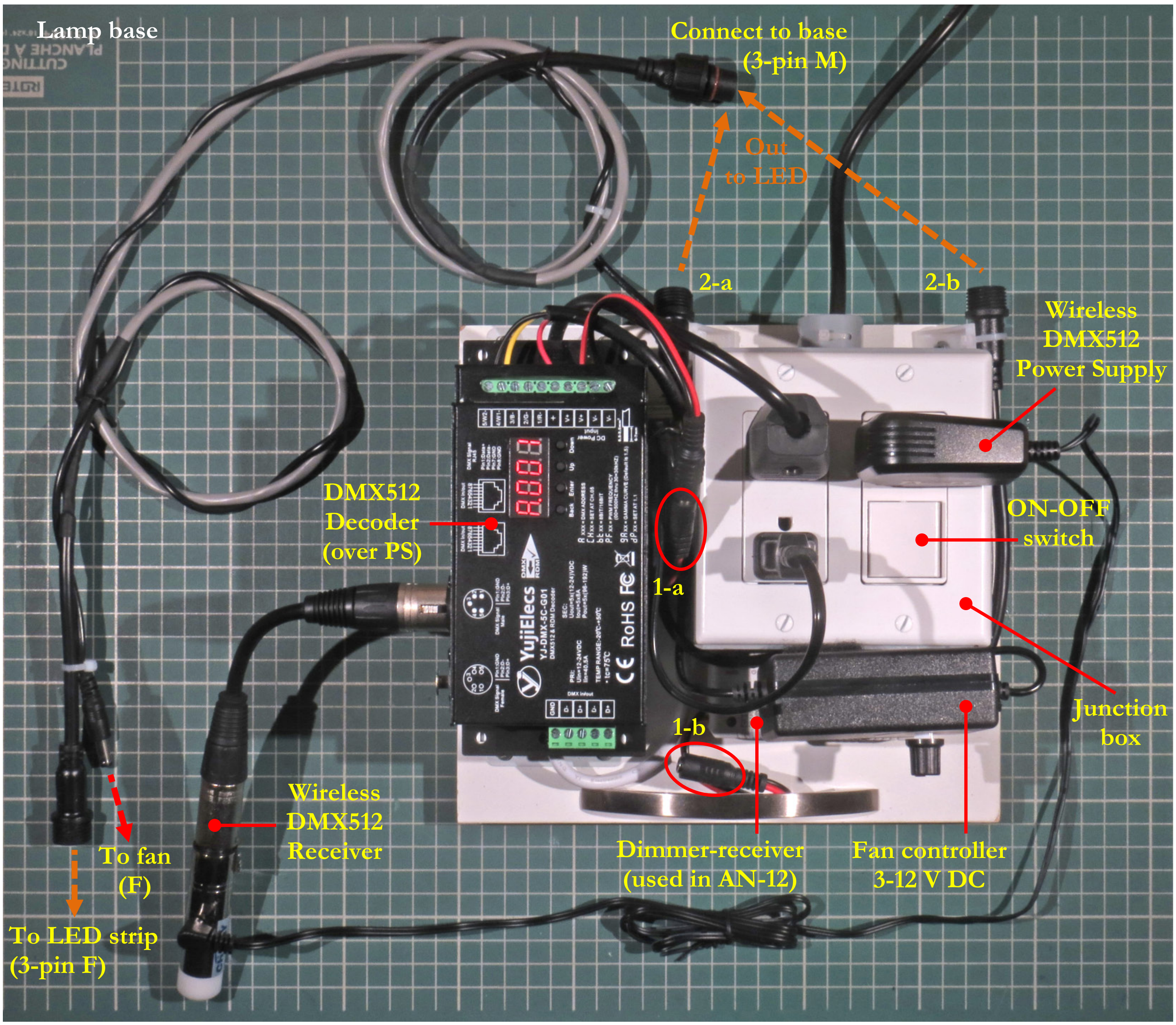
Components list and cost

Item	Model	Description	Vendor	Store	Price (US$)
DMX512 Decoder	YJ-DMX-5C-G01	DMX512 and RDM compatible; 5 channels (RGBWW); 500 Hz to 30 kHz PWM; 8 bit or 16 bit; 12V-24V DC output; 8 A/channel Description: see https://store.yujiintl.com/	YujiElecs (Yujileds)	Yujileds	139,00
DMX512 Controller	ultraDMX2 PRO	USB/Ethernet DMX controller; DMX In/Out; 2 XLR ports (F-F) assignable as In/Out; available with 3-pin or 5-pin XLR sockets; 2 universes; Art-Net and sACN support	DMXking.com	distributors	199,00
Cables / Adapters	DMX-3M3F-10	DMX cable with 3-pin Male to 3-pin Female XLR connectors; 10 ft	Sescom	markertek	28,49
	DMX5F3M	5-pin Female to 3-pin Male DMX cable; 6 in (154 mm).	Chauvet DJ	Amazon	14,99
	3-conductors cables	3.3 ft (1 m); 3-pin; 18 AWG; one end M, one end F (5 pcs)	BTF-LIGHTING	Amazon	16,99
Wireless DMX (Option 1)	DMX512 Rx/Tx	DMX512 wireless receiver (Qty-3)/transmitter (Qty-1). Uses the 2.4 GHz ISM band. Transmitter: 3-pin Male XLR connector. Receiver: 3-pin Female XLR connector; NO internal battery	CHINLY	Amazon	86,99
SD Card (Option 2)	Samsung MB-MJ32G	PRO Endurance microSDHC-I Card; 32 GB (Samsung info)	Samsung	DMX Pro Sales	15,99
Trigger Board (Option 2)	eDMX Trigger	Connects to the RJ12 accessory port of the ultraDMX2 PRO	DMXking.com	distributors	59,00
Alternate DMX512 Controllers	ultraDMX Micro	USB DMX controller; 1X 3-pin XLR socket (F)	DMXking.com	distributors	65,00
	eDMX1 PRO	Ethernet DMX controller; 1X 3-pin or 5-pin XLR socket (F);	DMXking.com	distributors	139,00
	DMX USB Pro	USB DMX controller; 2X 5-pin XLR sockets (M-F); 1 universe	ENTTEC	ENTTEC	170,00
	Open DMX USB	USB DMX controller; 1X 5-pin XLR socket (F)	ENTTEC	ENTTEC	70,00
	ODE MK2	Ethernet DMX controller; 2X 5-pin XLR sockets (M-F); 1 universe	ENTTEC	ENTTEC	275,00

Appendix B

Revised lamp base

Just as we did in the Application Note describing the lamp (AN-12), we do not go into the details of the lamp base assembly but here is a description of the major changes. First, we attached, with VELCRO® Brand[8] fasteners, the DMX512 Decoder on top of the Power Supply. We removed the remote-control dimmer-receiver used in AN-12 from the lamp bezel and installed it on the base under the fan controller; you can see, on the next page, a photo of the lamp after removing the dimmer-receiver. The reason we kept the old wireless dimmer is because we want to be able to go back to the previous system just by switching two cables. There are now two identical 3-pin connectors at the back of the base; one is for the DMX512 Decoder output (labeled **2-a**) and the other for the dimmer-receiver output (labeled **2-b**).



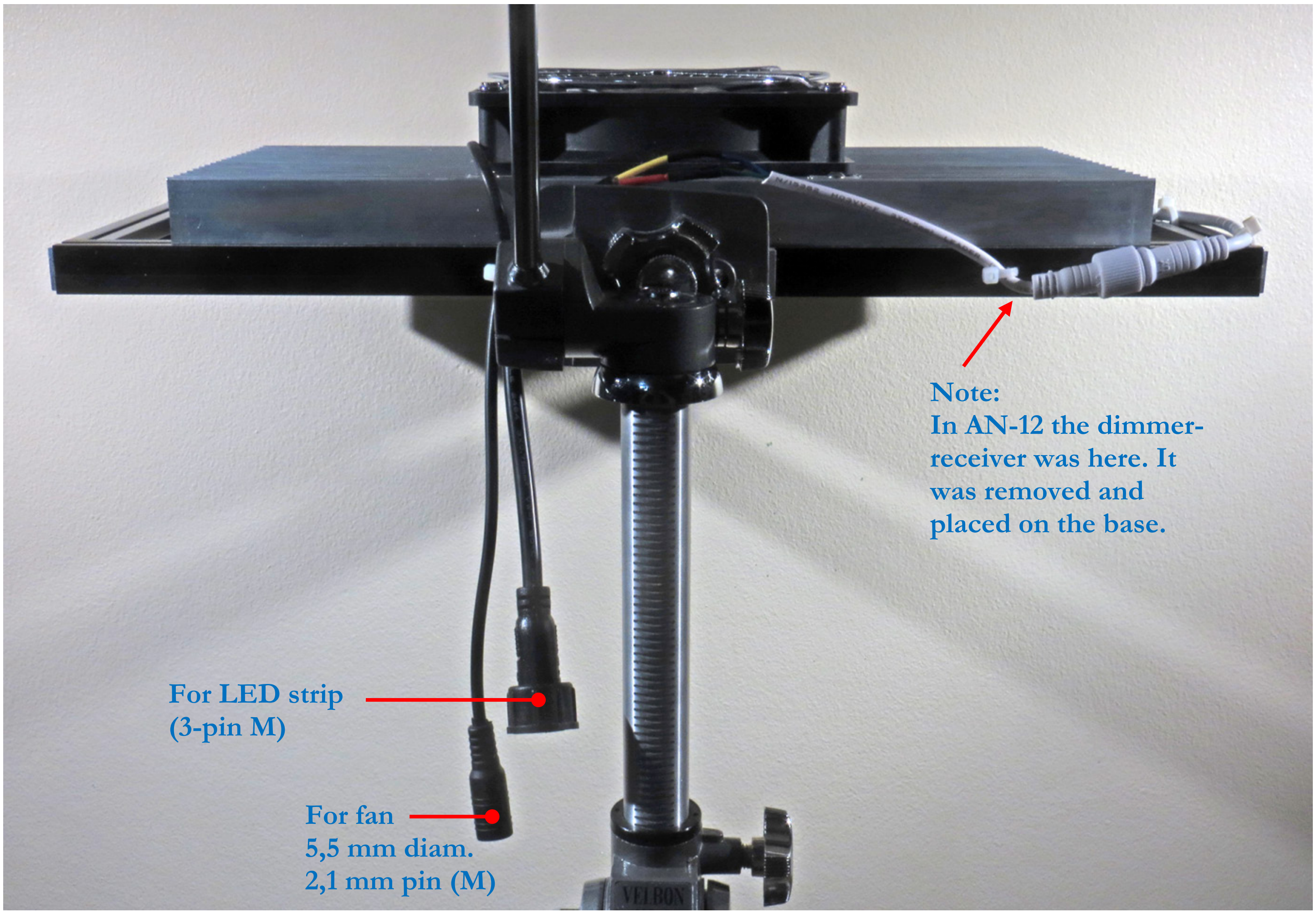
[8] VELCRO® is a registered trademark of Velcro IP Holdings LLC. Used with permission.

Switching between the DMX512 Decoder and the remote control dimmer-receiver is done as follow:

i- With Power OFF, connect the 24 V DC Power Supply cable–with black and red wires in the picture–to connector **1-a** to power the DMX512 Decoder **or** to connector **1-b** to power the dimmer-receiver.

ii- Connect the 3-pin power cable connected to the lamp to port **2-a** on the left of the base if the DMX512 Decoder is used **or** to port **2-b** on the right of the base if the dimmer-receiver is used.

Two cables link the base to the lamp bezel; these cables should be designed for DC power. Here, the cable with a 3-pin connector , connected to the LED strip, has 18 AWG[9] conductors; this gauge was selected by taking into consideration the maximum output current of the decoder, which is 8 A per channel. If you intend to use this decoder only with the LED strip of this project, which requires about 2 A in total, then you could use a cable with smaller diameter conductors, such as 20 AWG. The other cable, which came wuth the fan kit, powers the fan; if you extend it, we recommend a cable which has at least 20 AWG conductors.



[9] AWG: American Wire Gauge. Bigger AWG numbers correspond to smaller diameter conductors and thus to less current carrying capability. See https://en.wikipedia.org/wiki/American_wire_gauge .

The BabelColor Company

Founded in 2003, *The BabelColor Company* develops and sells software dedicated to the measurement and analysis of color.

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Revision History

2021-06-11: First release.

2022-06-11: New screenshots for the QLC+ software fixture definition dialog (Section 4.2).