LEDCube

ANY SPD SIMULATOR

User Manual

Thousand Lights Lighting (Changzhou) Limited
Add: Room 3-410, 18thHuashan Road, Xinbei District,
Changzhou, Jiangsu, China, 213022
Tel: +86 (0519) 85289860
Fax:+86 (0519) 85289870
Email: service@thouslite.com
Web: www.thouslite.com

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1. INTRODUCTION

Based on our proprietary optimization algorithm and more than 10 carefully selected high power LEDs，THOUSLITE LEDCube can easily and accurately simulate any lighting environment having different Spectral Power Distribution (SPD). Currently, LEDCube is one of the best commercialized spectral tunable lighting devices in the world. The target applications include **lighting research, surface color visual assessment standard lighting, camera & sensor evaluation & calibration lighting**, such as daylight simulator, healthy lighting, medical lighting, non-visual effect of light, color rendering, whiteness evaluation, large test chart illumination etc. In addition, LEDCube can create a **large or customized standard lighting environment** for color visual assessment and camera sensor calibration.

Fig. 1.1 The applications of LEDCube

1.1 LEDCube Features

- **Reproducing high quality daylight illuminant**

To reproduce any phase of daylight with highest quality on the market in terms of Color Rendering Index (CRI) 99 and Metamerism Index (MI) Grade A

- **Blackbody locus simulator**

To accurately produce a range of sources from tungsten to daylight varying Correlated Color Temperature (CCT) from 2000K to 20000K with user-defined CIE Ra and Duv

- **SPD match**

To accurately reproduce any measured or imported SPD to record any light you want. It is easy to spread SPD files between different locations for light communication

- **Luminance adjustable**

The light is dimmable while keeping the same light quality

- **Faster change between illuminants**

Same illuminant properties during illuminant changes

- **Single-channel control**

Arbitrarily control the intensity of each channel in LEDCube to design any light wanted

- **Dynamic lighting**

Programmable illuminant light sequence and interval

- **Fast & accurate feedback**

Maintain the same light quality, compensating for age and variable environments with external color sensor. It is much more consistent over conventional lighting

- **User-friendly software**

Provide an easy and user-friendly software LEDNavigator- LC, and can be further customerized

- **No flicker**

It provides a uniform and flicker free lighting environment.

- **Longer life time and excellent long term stability**

Much longer lifetime compared to fluorescent technology, and optimized heat management resulting in excellent long term stability

- **Flexible installation**

Provide flexible installation methods for different applications, such as viewing cabinet, lifting, customerized support etc

- **LED channel wavelength selection service**

Provide LED channel wavelength selection service from UV, VIS to NIR

- **Wireless control**

Up to 256 LEDCubes can be controlled separately or simultaneously via Zigbee technology, easy to build large standard lighting space

- **36 hours customer response**

If customers report any problems or issues related to the products in working day, we will response in 36 hours for both domestic and international customers

Currently, there are three versions of LEDCube hardwares, including 11 LED channels (general lighting research application), 15 LED channels (surface color visual assessment application) and 14 LED channels (camera & sensor evaluation & calibration application). The differences among

these versions are LED layout and LED chips used in the hardware, but usage method and software control are all the same.

	LEDCube-11	LEDCube-C15	LEDCube-I14
LED channels	11 channel	15 channel	14 channel
Spectral range	400-700nm	350-700nm	400-730nm
LED channel drive method	Amplitude Modulation		
Resolution	10 bit (1024 steps dimmable for each channel)		
Warm up time	No		
LED Lifetime	>10,000 hours		
Capacity	80 light source in LEDCube hardware, unlimited in software		
Predefined illuminants	Standard daylight D65, D50 CIE Ra: 99, MIvis: Grade A (<0.25)		
Tunable range	CCT: 2000~20000K, CIE Ra: 0~100, Duv: -0.02~+0.02		
Max flux and illuminance	1 LEDCube hardware D65: 1700lm, 1 meter: 850lux; D50: 2400lm, 1 meter: 1250lux Multiple LEDCube hardwares can achieve higher intensity		
Short-term stability	D65<±10K, D50<±5K; Luminance <±0.5%		
Long-term stability	D65<±25K, D50<±15K; Luminance <±1.5%		
Software instrument compatibility	X-Rite i1 Pro 2, Konica Minolta CL500A, THOUSLITE FS Spectrometer Jeti Specbos 1211UV spectroradiometer		
Electrical	110/230V, 50/60Hz, 180W Maximum		
Operating ambient temperature	0-30°C		
Connection	USB cable, wireless control, touch screen controller		
Dimensions(L/W/H) & Weight	300×300×200 mm, 7kg		
Scope of delivery	LEDCube light source, power cord, USB cable, wireless sender		
Supplementary accessories	Ceilling installation kit, measurement device, 50×50×60cm Munsell N7 viewing cabinet, customerized aluminium support, touch screen controller, transmission converter		
Software (optional)	Six modules in LEDNavigator: Blackbody locus simulator, SPD match, Feedback, Dynamic lighting, Single channel control, Single LEDCube control; SDK available on request		

2. LEDCube DIMENSION & SETUP

2.1 LEDCube Dimensions

The dimension of the LEDCube is shown in Fig 2.1. The weight of each LEDCube is approximately 7 kg.

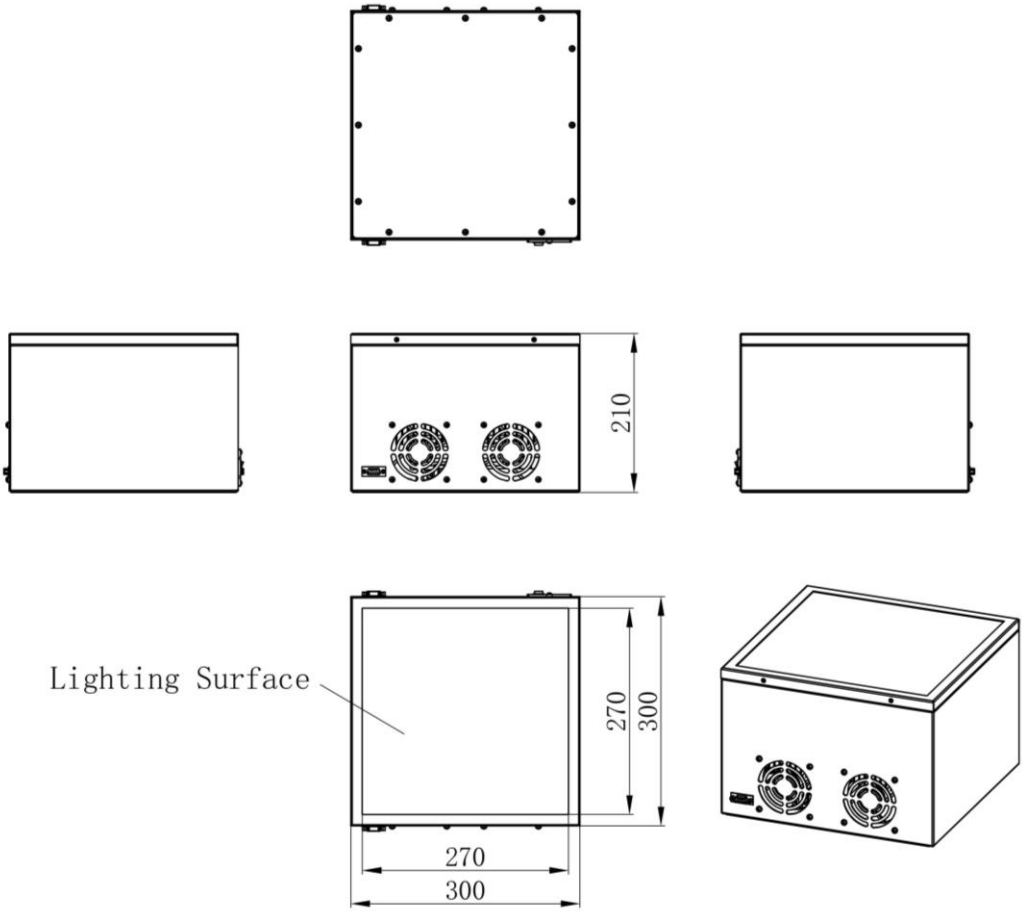
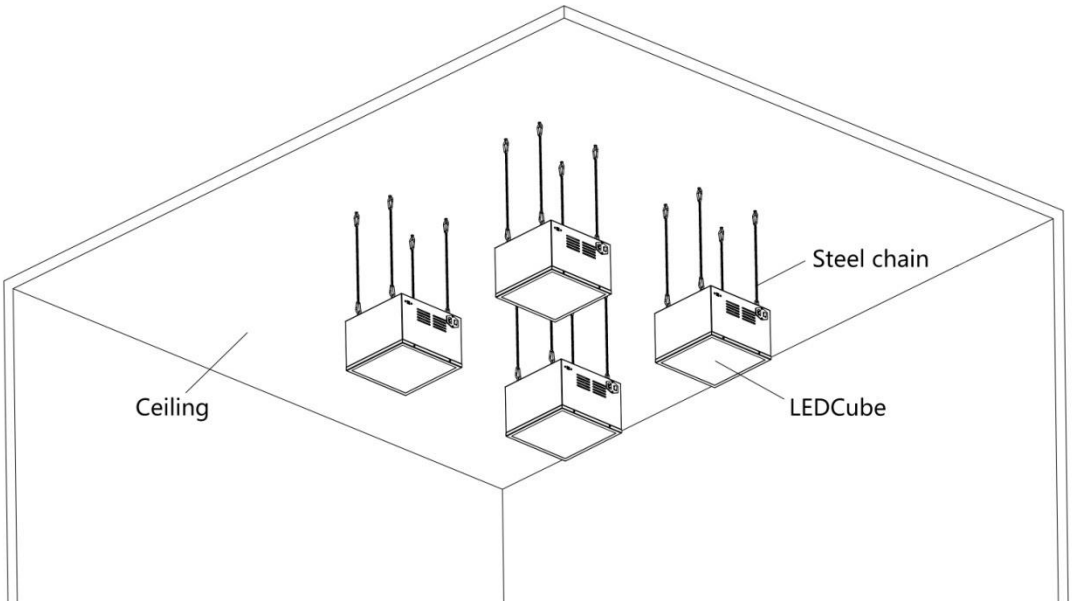


Fig. 2.1 LEDCube dimensions (in millimeters)

2.2 LEDCube Installation

LEDCube can be installed in different ways to fit different applications. The following ways of installation are provided as reference.

1. Simple installation. As shown in Fig 2.2, LEDCubes could be installed to the ceiling by hooking the LEDCubes to the customized steel chain. LEDCubes could be set into desired angle through adjusting the length of the hooks.



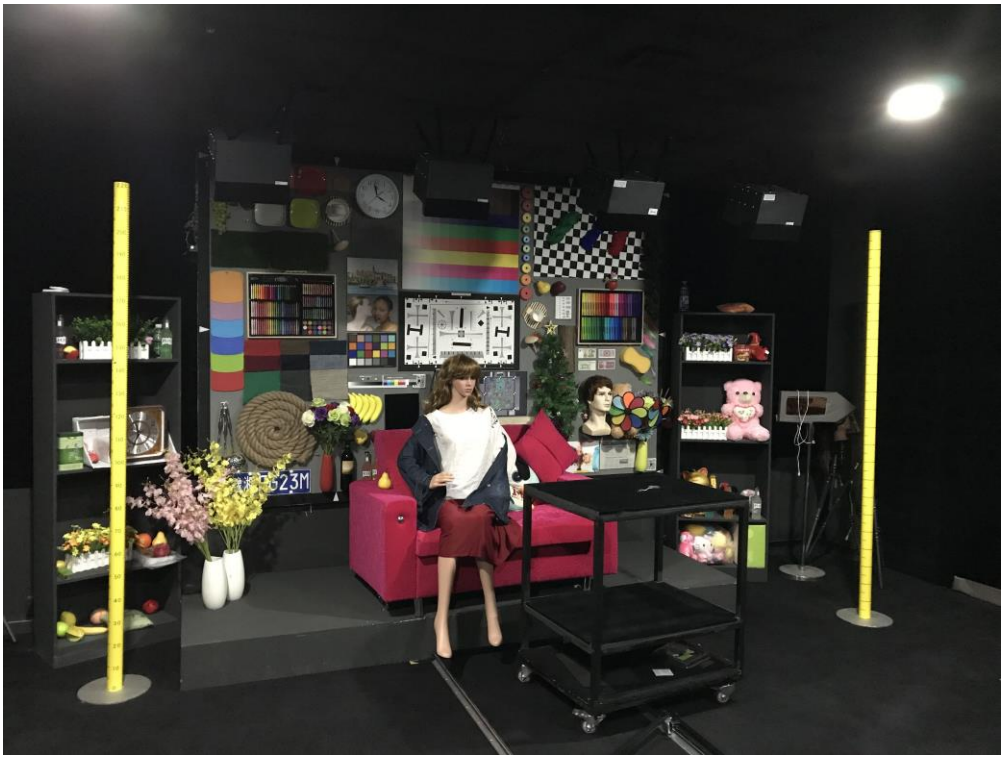


Fig. 2.2 Simple installation for LEDCubes

2. Customized aluminium framework. As shown in Fig 2.3, multi LEDCubes could be installed easily and firmly on the customized aluminium framework. The entire framework can be movable via its wheels.

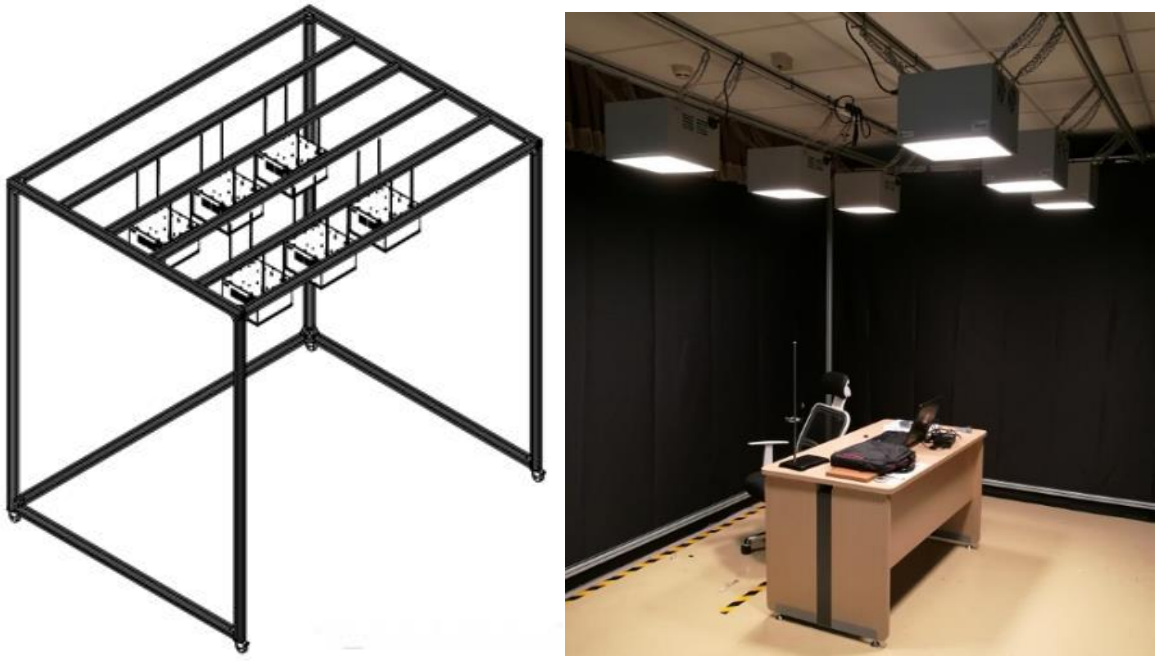


Fig. 2.3 Aluminium frame holder for LEDCubes

3. Customized aluminium frame rack for 45/0 illumination. As shown in Fig. 2.4. This solution is designed for the camera large test chart/model scene. High illumination uniformity (>90%) on the large test test chart is guaranteed.

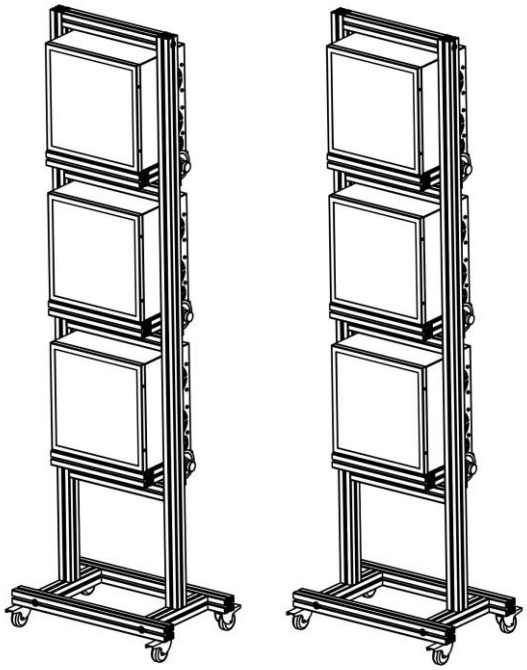


Fig. 2.4 Aluminium frame holder for 45/0 illumination

4. Munsell N7 standard viewing cabinet. As shown in Fig.2.5, THOUSLITE provides the standard viewing cabinet in dimension of 50×50×60cm, which is very convenient to setup a standard viewing environment. In addition, THOUSLITE also provide the customized dimension cabinet service as shown in Fig. 2.6.

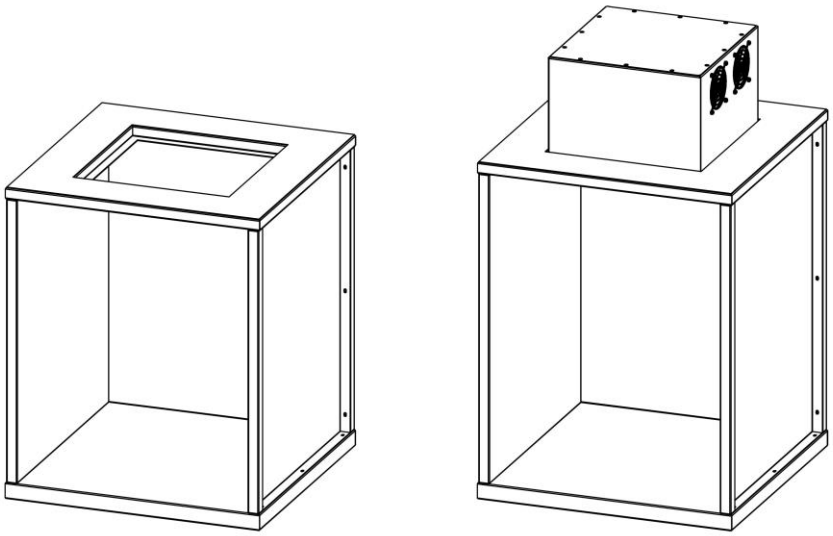


Fig. 2.5. LEDCube standard viewing cabinet

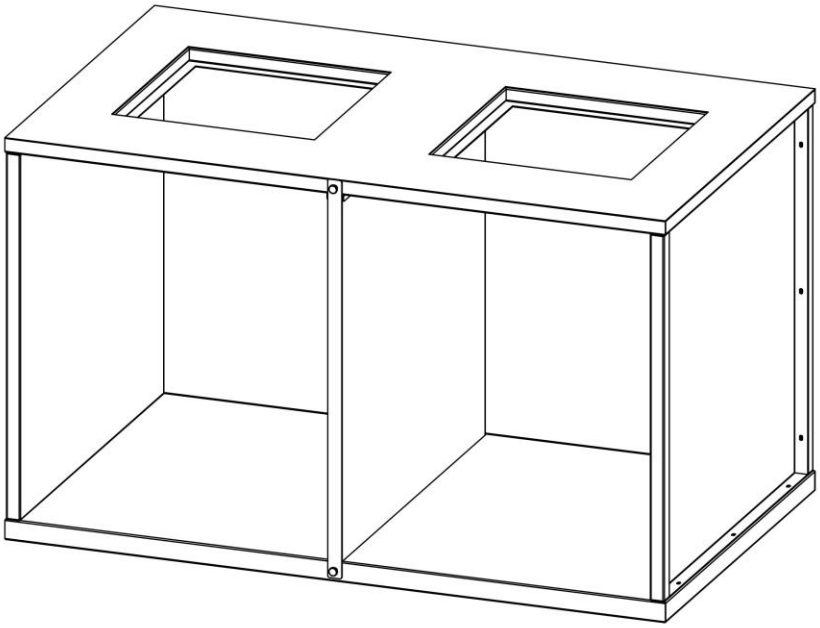


Fig. 2.6. LEDCube customized cabinet

2.3 LEDCube Hardware Interface & Optional Accessories

Fig. 2.7 shows the side view of LEDCube, indicating a power switch, a power socket, DB9 male and female. LEDCube hardwares can be connected one by one via DB9 cables. Optional

accessories include touch screen controller and transmission converter.

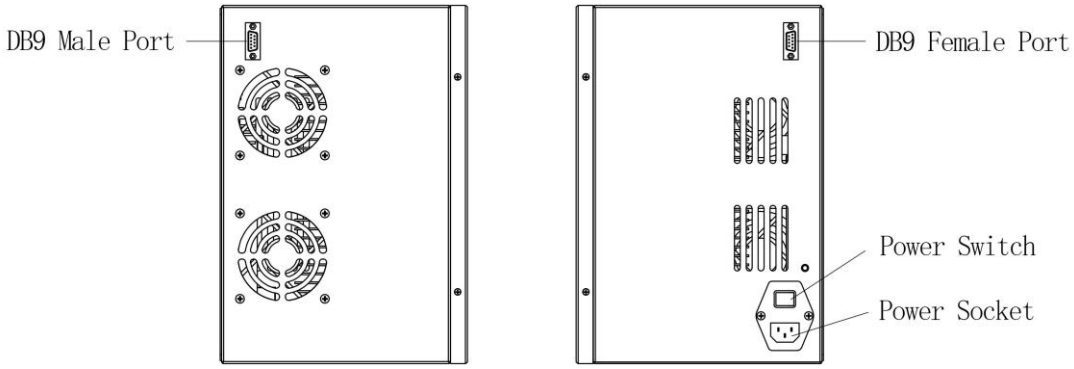


Fig. 2.7. Side view of LEDCube

2.3.1 Touch Screen Controller

When multiple LEDCube hardwares are connected via DB9cables, the DB9 female of last LEDCube hardware can be connected with touch screen controller. As shown below, the touch screen controller has one DB9 male and one USB port. The DB9 male is designed for LEDCube hardware connection, and the USB port is designed for PC connection.

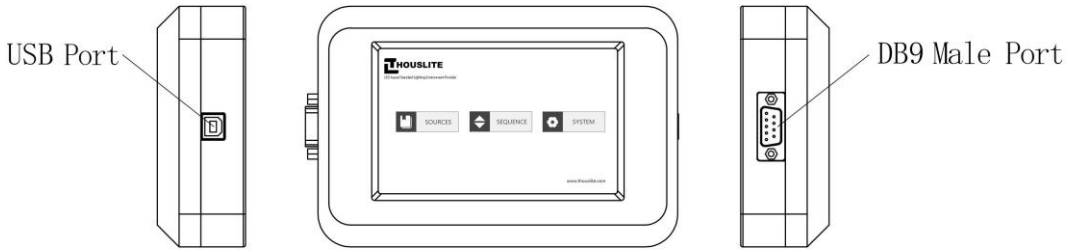
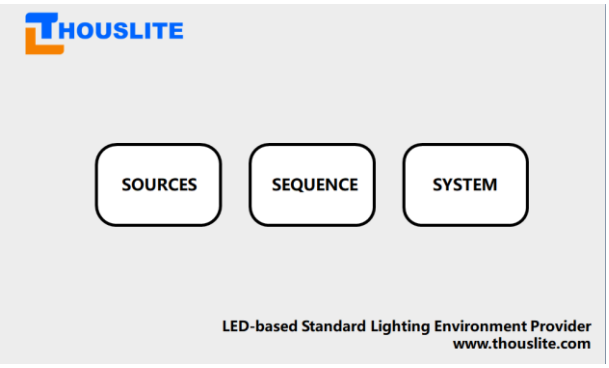


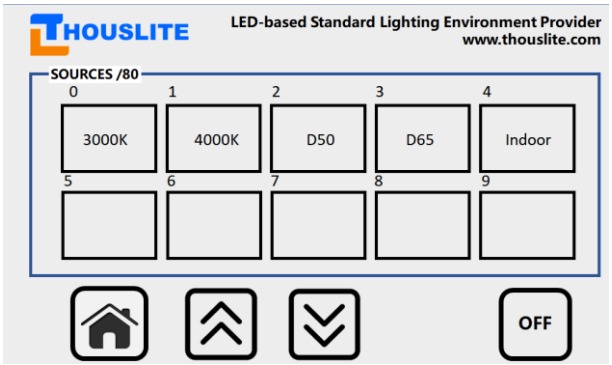
Fig. 2.8. LEDCube touch screen controller

Touch screen controller interface and features are introduced below:

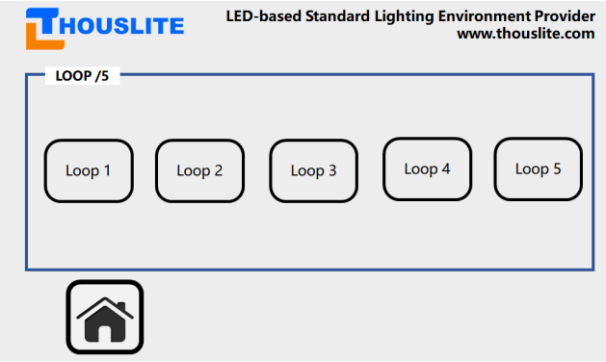
- Home interface: 3 buttons for 3 sub-interface, including *SOURCES*, *SEQUENCE*, *SYSTEM*, press each button to enter corresponding sub-interface.



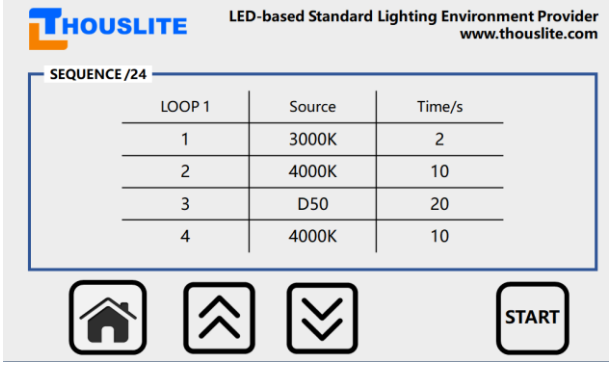
- SOURCES sub-interface: users can switch 80 light sources stored in the LEDCube hardware. If no light source is saved to the corresponding buttons, LEDCube won't do switch light by pressing these buttons, such as No.5-9 buttons in the following image. The method to rewrite or write the light source into the buttons are described in section 4.8.1. *UP* and *DOWN* arrow button can switch the pages of light sources. *OFF* button can switch off the light source.



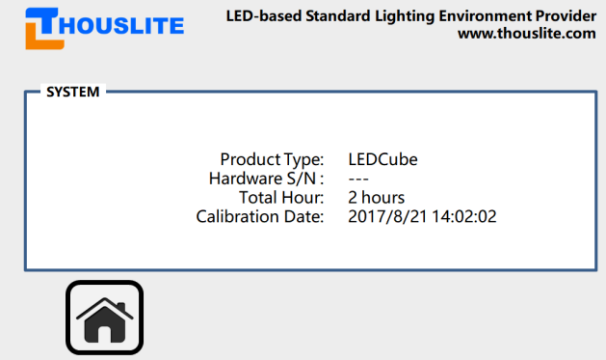
- SEQUENCE sub-interface: user can save up to 5 loops in this function, as shown below.



Press the button of any loop to enter the detail of that loop. In each loop, user can set max up to 24 light sources of the 80 light sources in the LEDCube hardware with specified sequence and time interval. Press button *Source* to set the light source number, and press button *Time/s* to set the time interval between light source switch. Press button *START* to start a loop. Loop setup can also be written or rewritten via software LEDNavigator, please refer to section 4.9 for detail.



- SYSTEM sub-interface: shows the product type, Hardware S/N, Total Hour and Calibration Date.



If PC is connected to touch screen controller (connection mode is detailed in section 2.4) successfully, the touch screen controller will shows “Device is connected to PC”. Please do switch to **home interface** when the controller is connected to PC.

2.3.2 Transmission Converter

Transmission Converter can transform the LEDCube to a transmissive lighting box for transparent test chart illumination. It is shown in Fig. 2.9. Fig. 2.10 shows the way to install the converter to LEDCube. User should unscrews the four screws, remove the diffusor, and then fix the converter by the same 4 screws.

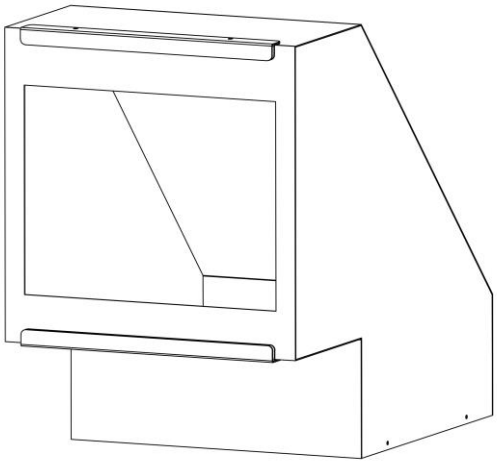


Fig. 2.9. LEDCube transmission converter

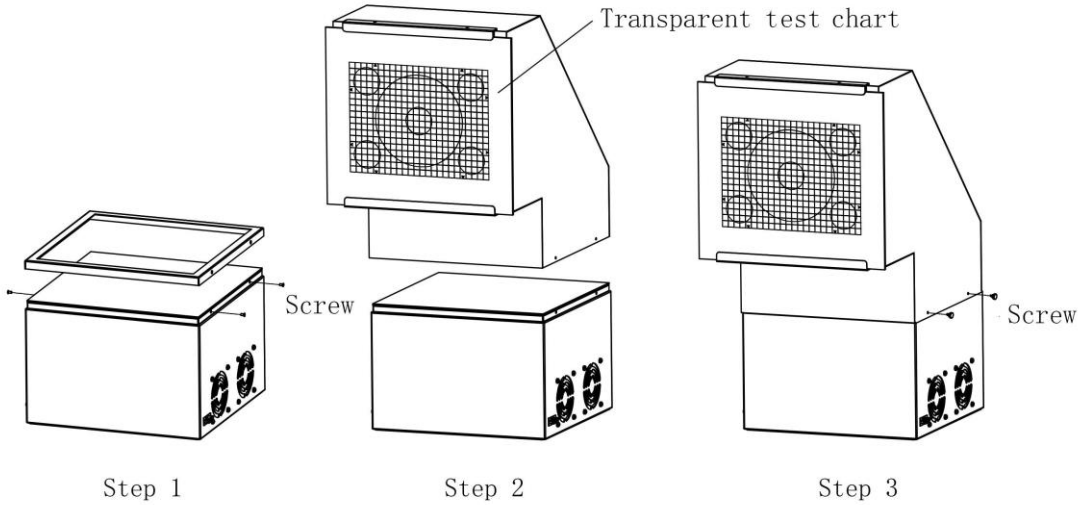
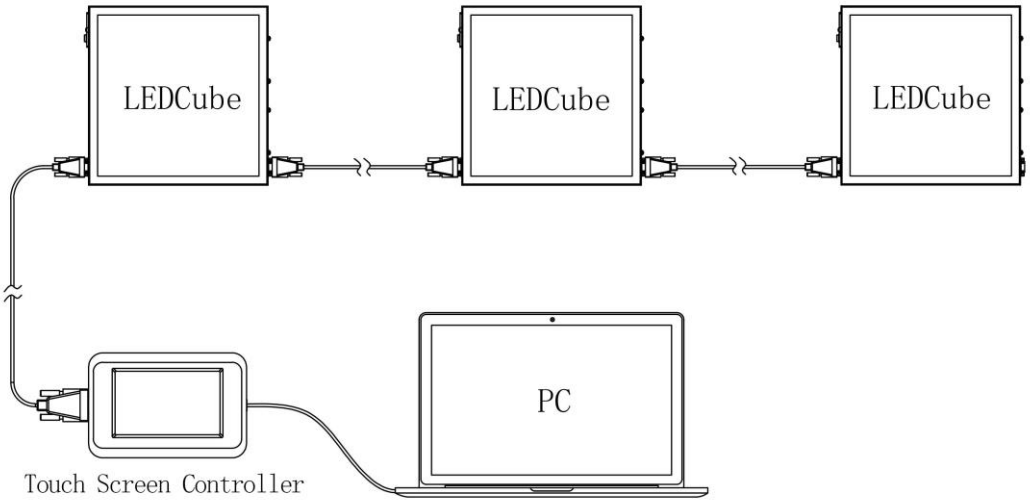


Fig. 2.10. LEDCube diffusor removal & installation

2.4 LEDCube Connection Modes

LEDCube hardware has three connection modes with the PC.

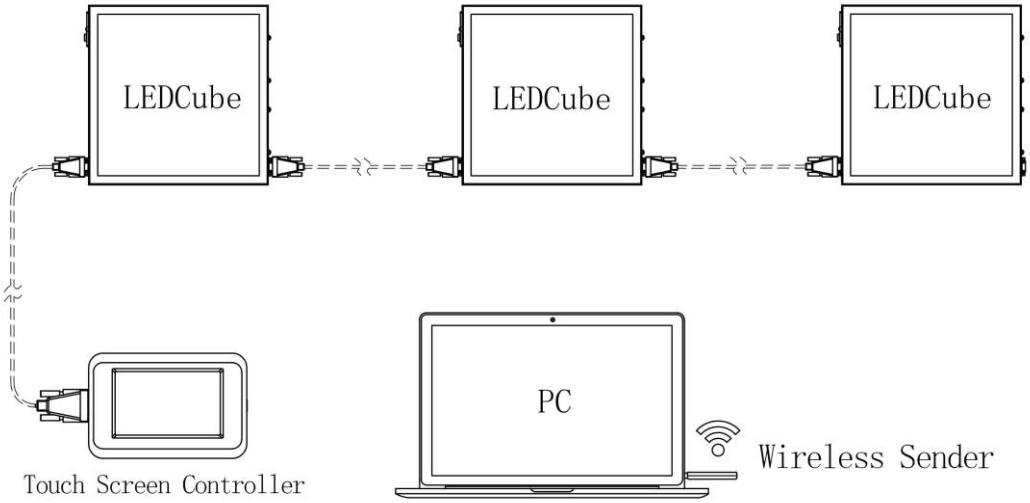
- **LEDCube hardware-Touch Screen Controller-PC**



In this mode, single or multiple LEDCube hardwares are connected one by one via DB9 cables, and the last LEDCube hardware is connected with touch screen controller via DB9 cable, and then to PC via USB cable.

In this mode, the connection is stable, and controller can switch light source in LEDCube hardware without PC.

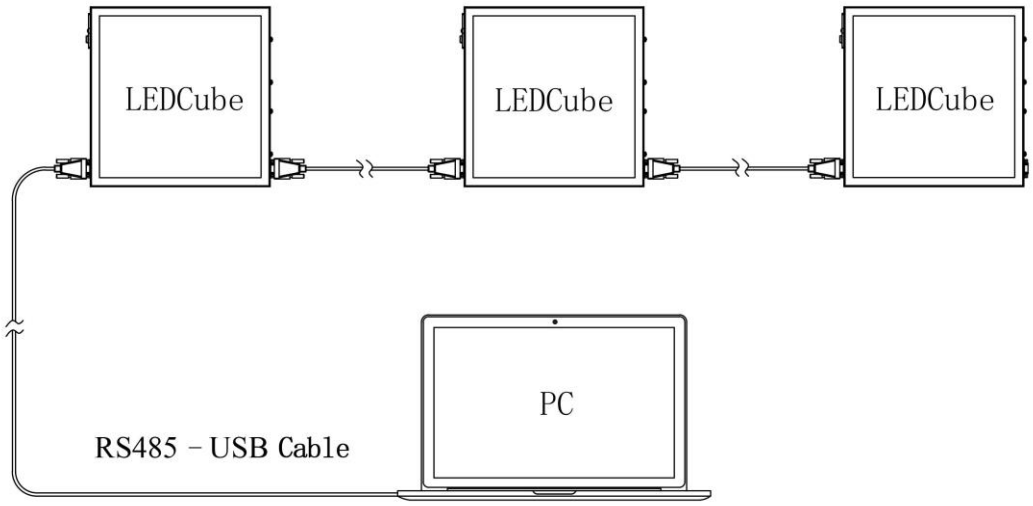
- **LEDCube hardware-Wireless sender-PC**



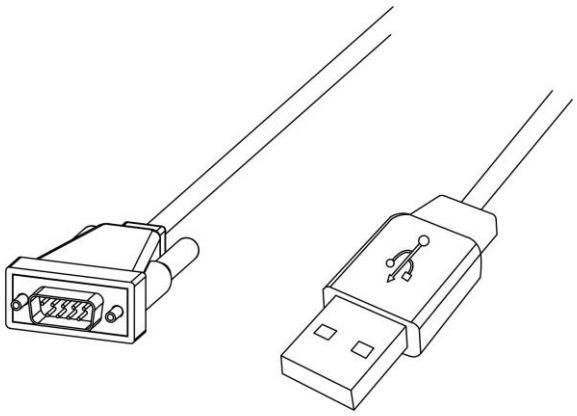
In this mode, wireless sender builds the Zigbee wireless network between PC and LEDCube hardwares. Users only need to plug the wireless sender into the PC. The cable connections between LEDCube hardwares and touch screen controller are optional, which is indicated by broken line in the above image.

In this mode, the DB9 cables are not necessary. However, the connection is not stable sometimes.

- **LEDCube hardware-PC**



In this mode, single or multiple LEDCube hardwares are connected one by one via DB9 cables, and the last LEDCube hardware is connected with PC via RS485-USB cable. The example of RS485-USB cable is shown below:



In this mode, the connection is table, but it requires unusual RS485-USB cable, and the PC is necessary to switch to light source.

If multiple LEDCube hardwares are used, the **mode 1 (LEDCube hardware-Touch Screen Controller-PC)** and **2 (LEDCube hardware-Wireless sender-PC)** are recommended, especially mode 1.

2.5 Hardware Preparation

Preparation work before using software LEDNavigator is listed below:

- Connect the LEDCube with electric supply through the power cable. The default voltage and frequency is 110V/230V and 50-60Hz, depending on the country;
- Refer to the connection modes in section 2.4, build connection between LEDCube, touch screen controller (optional) and PC;
- Turn on the LEDCube by pressing power switch;
- Plug in the software dongle in the PC;
- Connect measure device with PC through USB cable if measurement is necessary;

- Install the drivers and environment in first use, refer to chapter 3 for detail
- Double click to open the software LEDNavigator as shown in Fig. 3.11. The software features are detailed in chapter 4.

There are total three connections in the PC as shown in Fig. 3.12 and Fig. 3.13, including measure device, LEDCube USB cable or wireless sender or touch screen controller (depends on the LEDCube connection modes in section 2.4), dongle. Please note that if USB hub is used, it is strongly recommended that the **measure device is connected directly to the computer's motherboard rather than USB hub** to ensure stable power supply.

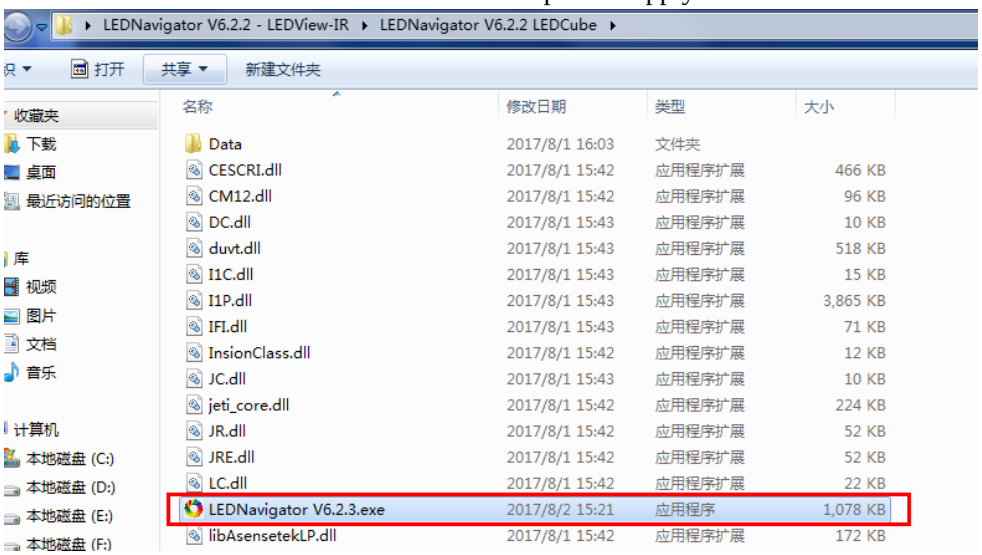


Fig. 3.11. LEDNavigator

Fig. 3.12 Wireless sender (left) and software dongle (right)

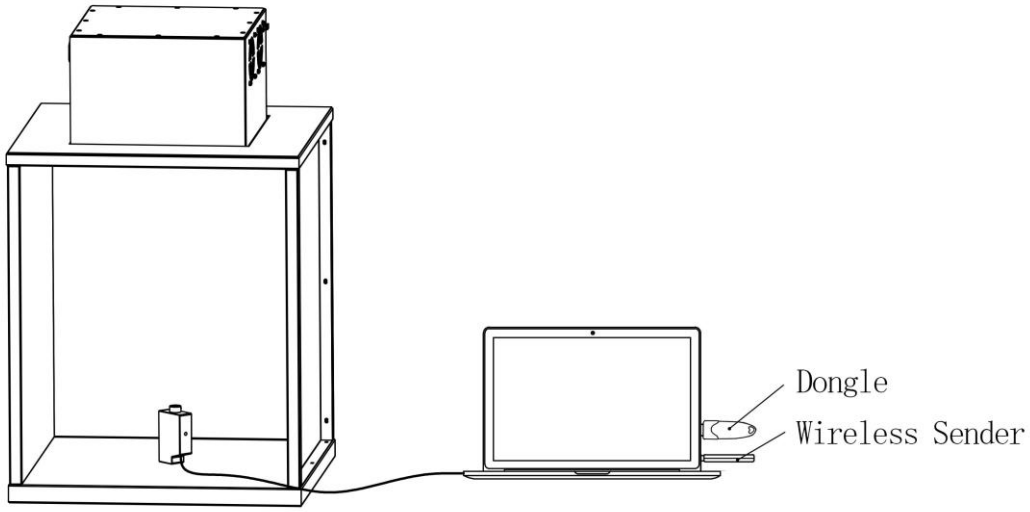


Fig. 3.13 Typical setup – three connections

3 DEVICE DRIVER & ENVIRONMENT INSTALLATION

3.1 LEDCube & Wireless Sender & Touch Screen Controller Driver

LEDCube, wireless sender, and touch screen controller use the same driver. When LEDCube hardware is connected to PC via USB cable or wireless sender in first use and the power is connected, a yellow symbol can be found in Device Manager of the PC, as indicated in Fig. 3.1.

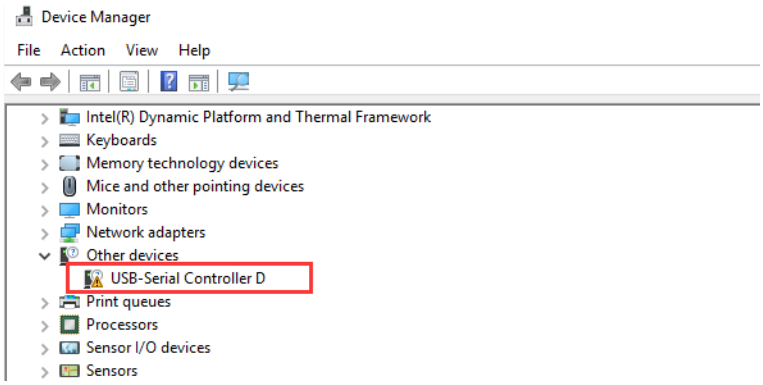


Fig. 3.1 LEDCube driver installation yellow symbol

Please install the LEDCube driver after antivirus software closed. The driver file "USBDriverInstaller.exe" is provided by THOUSLITE in the folder *Prerequisites\Drivers* for Windows Vista/7/Windows8/8.1/10. After driver installation, the yellow symbol disappears in device manager, which indicates the LEDCube driver is successfully installed, as shown in Fig. 3.2.

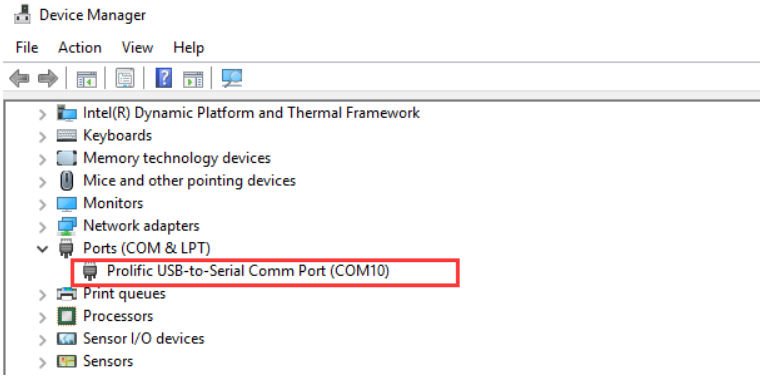


Fig. 3.2 LEDCube driver installation success

3.2 Measure Device Supported and Driver Installation

Currently, LEDNavigator-LC software is compatible with 3 spectral measure devices, including X-Rite i1 Pro2, THOUSLITE FS, and Konica Minolta CL500A.

As for Konica Minolta CL500A, the driver will be installed automatically when connected with PC in first use, In terms of THOUSLITE FS and X-Rite i1 Pro2, they require manually driver installation in first use. **The device calibration and setup geometry are described in section 4.5.**

If you need to integrate other spectral measure device, please contact us.

Fig. 3.3. X-Rite i1 Pro2(left),THOUSLITE FS (middle), Konica Minolta CL500A (right)

3.2.1 X-Rite i1 Pro2

- Connect the i1 Pro2 with the PC through USB cable;
- Find the “eye-one” in the device manager of the PC, as shown in Fig. 3.4;
- Right click, select “Properties”, and then “Update Driver” of eye-one, as shown in Fig. 3.5;
- Select “Browse my computer for driver software”, as shown in Fig. 3.6;
- Set the file location of file *Prerequisites/Drivers/ i1 Pro2 driver* provided by THOUSLITE, and complete the whole procedure.

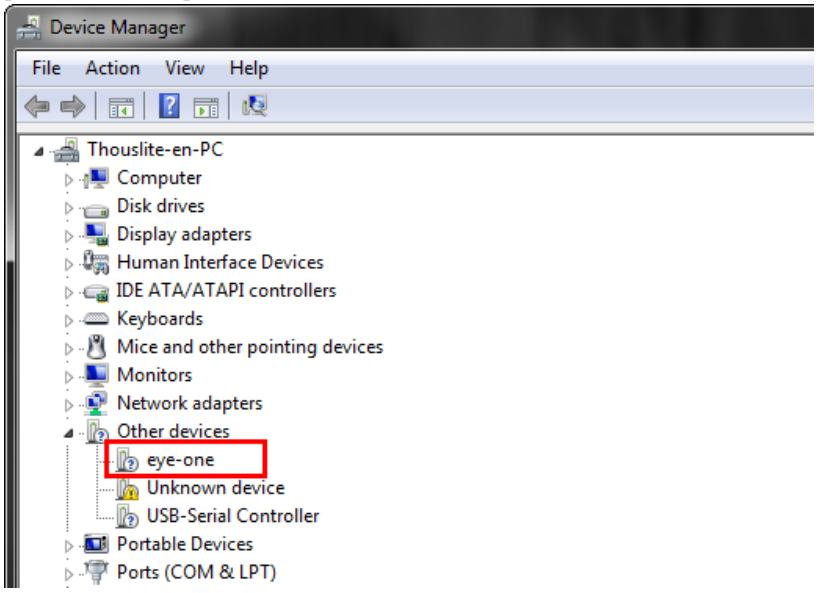


Fig. 3.4 i1 Pro2 in device manager

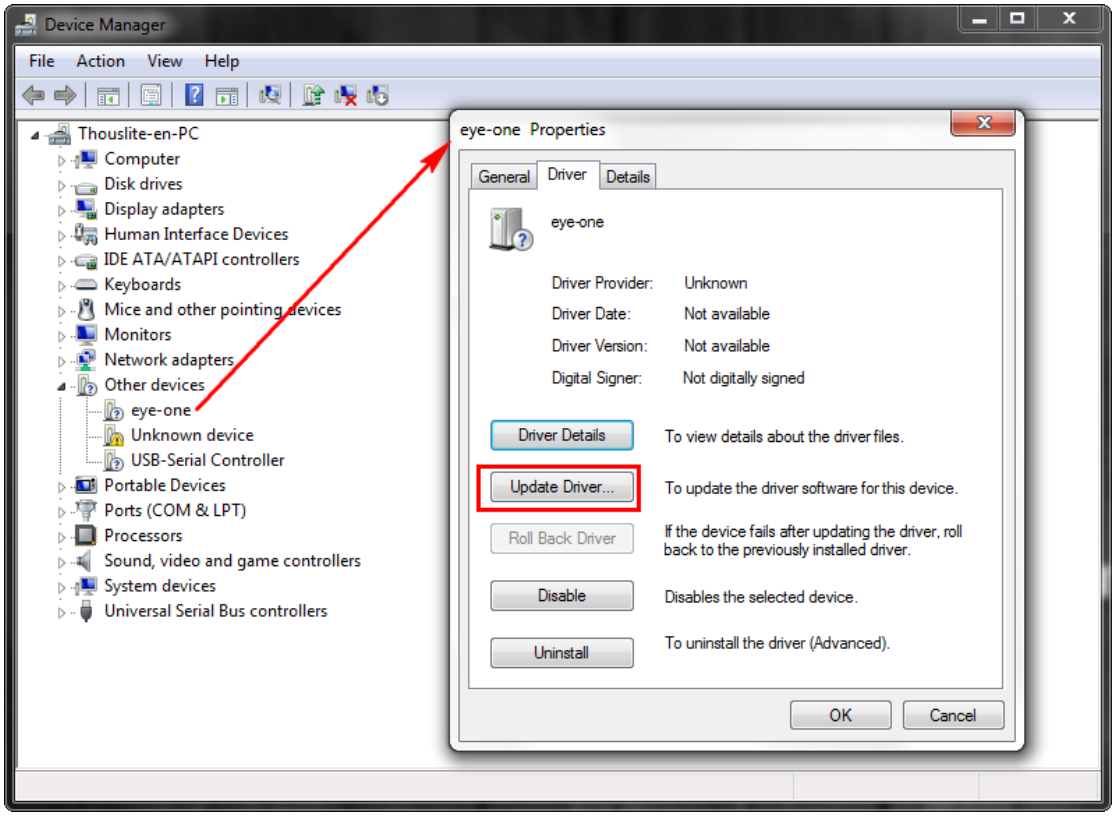


Fig. 3.5 Update the driver of i1 Pro2

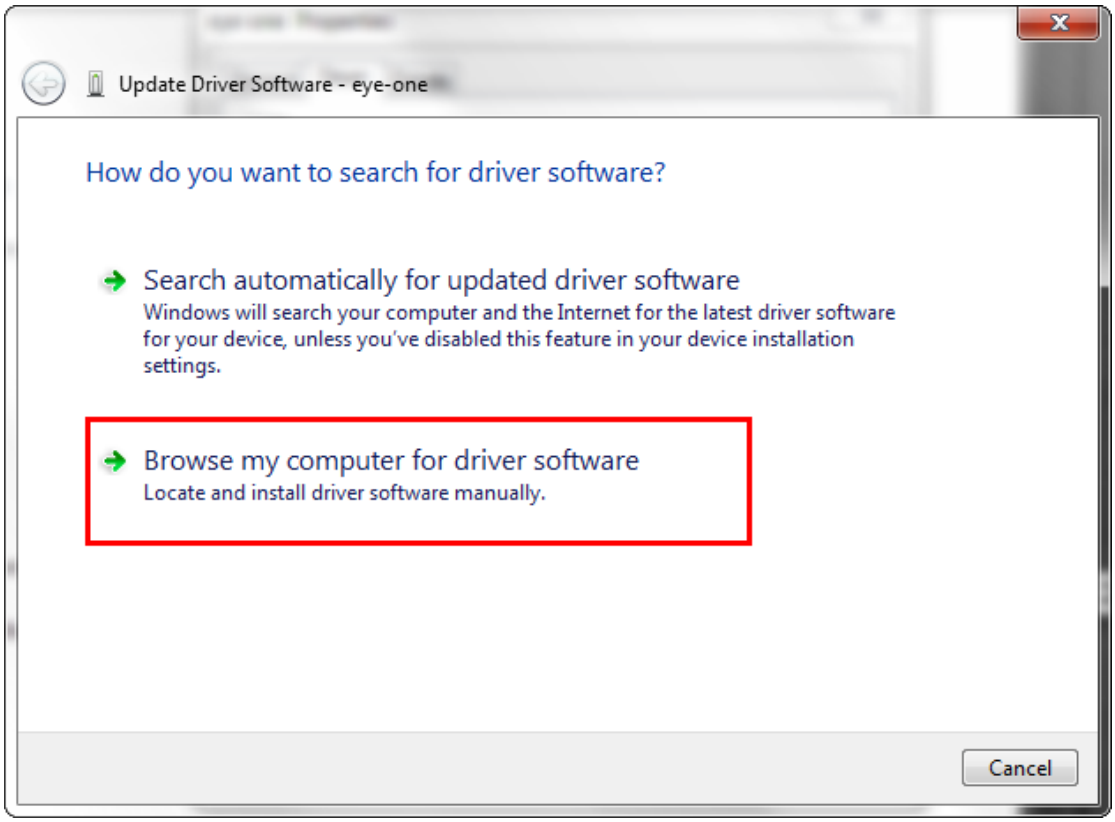


Fig.3.6 i1 Pro2 driver location setup

3.2.2 THOUSLITE FS

- Please open the folder *Prerequisites/Drivers/FS Spectrometer Driver.* If your system is 32 bit, please install DPInst.exe. If your system is 64 bit, then DPInst64.exe should be installed. As shown in Fig. 3.7.
- Follow the instructions until the installation is succeeded.

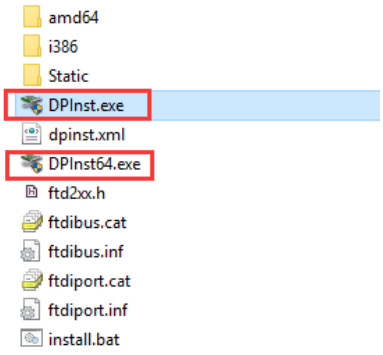
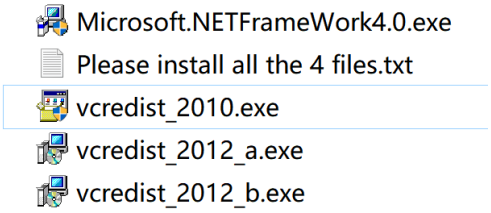


Fig. 3.7 Install DPInst.exe or DPInst64.exe

3.3 Software Environment Installation

Software LEDNavigator requires NETFrameWork environment and VC library. If the software cannot be properly opened in the first use, it will pop up a message about missing Dll file, say **Unable to load DLL 'SDCM.dll'.** Please install all the 4 environment files in *Prerequisites\Environment* folder provided by THOUSLITE before running the software again. If the OS reminds the environment files are already installed or cannot be installed, ignore these environment files installation.

- Microsoft.NETFrameWork4.0.exe <- most of win 7 & win 10 PC already has installed this file
- vcredist_2010.exe
- vcredist_2012_a.exe
- vcredist_2012_b.exe



4. SOFTWARE LEDNAVIGATOR-LC

4.1 Self Test before Main Interface

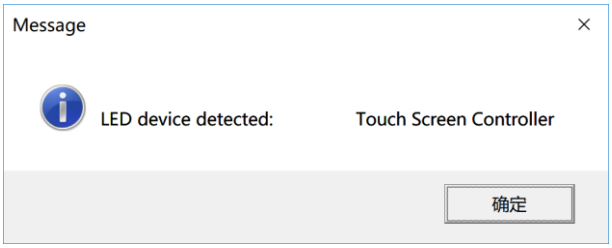
After the preparation work in section 2.5 are done, double click the software icon to open the software LEDNavigator. Before the main interface pop up, the software will searching for hardware connections and software local file information. It is described below:

- Check the dongle is connected or not. If not, the software cannot open.

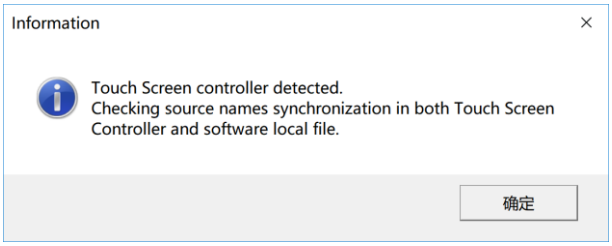
- Check the LEDCube connections. The pop up message information depends on different LEDCube connection modes in section 2.4. Detail is shown in section 4.1.1-4.1.3.
- Check the measure device is connected or not.

4.1.1 LEDCube hardware-Touch Screen Controller-PC

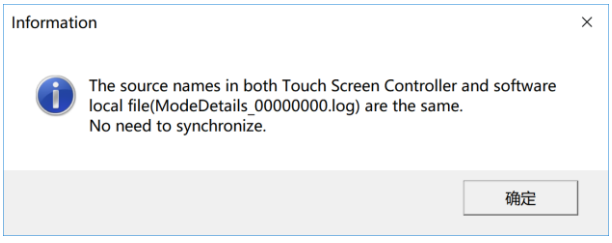
In this mode, the software will pop up the following information if connection is success.



Afterwards, the software will compare the source names in both touch screen controller and software local file. It takes 5-10 seconds.



If it is the same, the synchronization of sources name is not necessary.

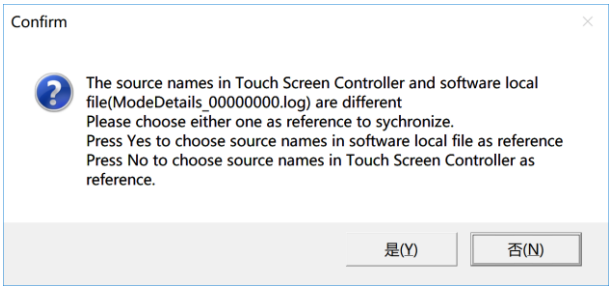


If it is different, users have to choose one as reference.

Choose Y, set the source name in software local file as reference, rewrite the corresponding names

in touch screen controller;

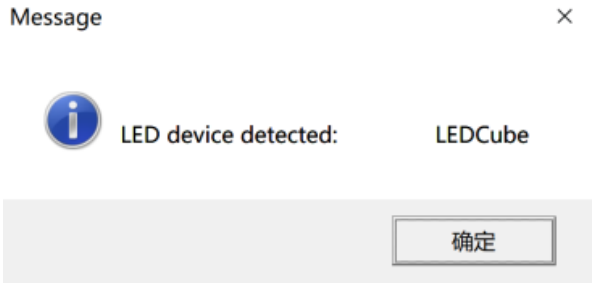
Choose N, set the source name in touch screen controller as reference, rewrite the corresponding names in software local file.



The sources names in the hardware is stored in touch screen controller, and the corresponding names in the software is stored in the *Data/ModeDetails_00000000*. If user switch to LEDCube connection mode 2 (LEDCube hardware-Wireless sender-PC), maybe they will save light source to LEDCube hardware, and modify the source name in the software local file, resulting in the different source names in touch screen controller and software local file.

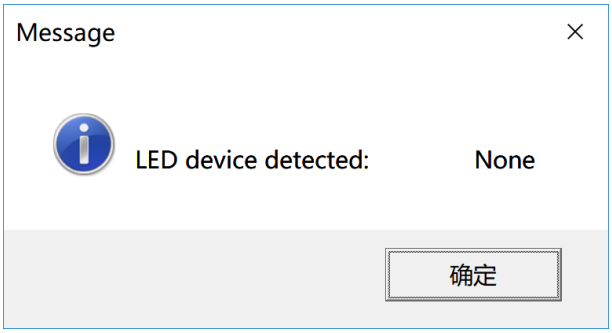
4.1.2 LEDCube hardware-Wireless sender-PC

In this mode, software will automatically search all LEDCube hardwares in the network, and the message will show below.



4.1.3 LEDCube hardware-PC

In this mode, the software will find the LEDCube if only one LEDCube is connected. If multiple LEDCube hardwares are connected, the software will show no LEDCube is found. However, **the software can control the LEDCube**.



After self test, LEDNavigator-LC software interface will pop up, as shown below, including Menu, Graphics, Single channel control, Database, Match, Lighting, Measure, Dynamic lighting. **Menu** and **Lighting** parts are slightly different depending on different LEDCube connection modes.

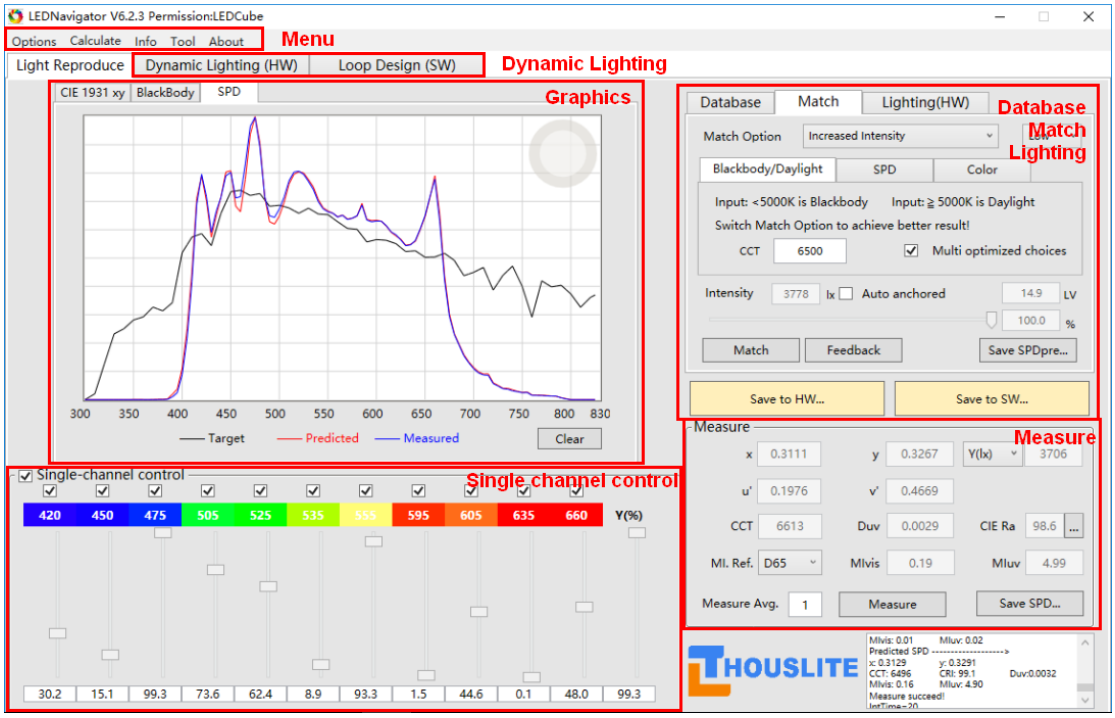


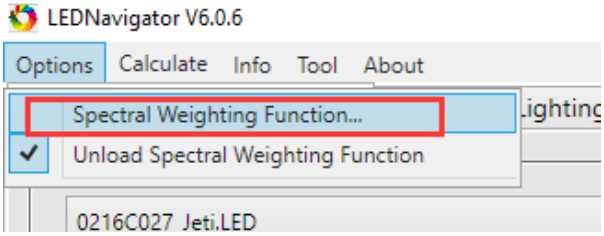
Fig. 4.1 LEDNavigator-LC software interface

4.2 Menu

LEDNavigator-LC has five submenu in Menu bar, which will be introduced as follow.

4.2.1 Menu/Options

This function is for the *Spectral Weighting Function(SWF)*.



If an **illuminance measure device (unit: lux)** adopted, then *SWF* is unnecessary, please switch to *Unload Spectral Weighting Function.*

If a **luminance measure device (unit: cd/m^2)** adopted, then it would be necessary to use *SWF* to compensate the standard white tile's reflectance from the measured data. The standard white tile needs to be purchased separately, as shown in Fig. 4.2. Fig. 4.3 shows the typical *SWF* curve of a white tile. The *SWF* is the reciprocal of the spectral reflectance(1/Ref). Load the *SWF* by clicking the *Menu/Options/Spectral Weighting Function…* .

Fig. 4.2 An example of THOUSLITE standard white tile

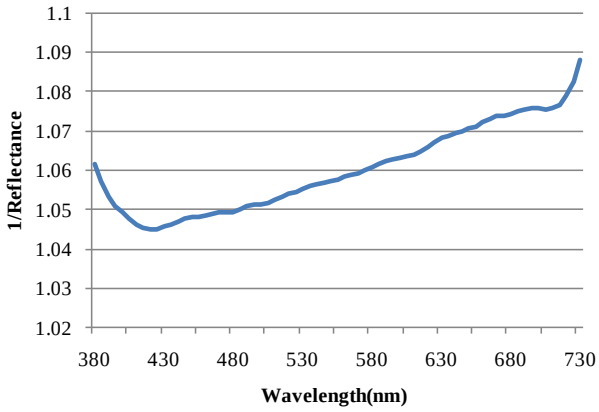
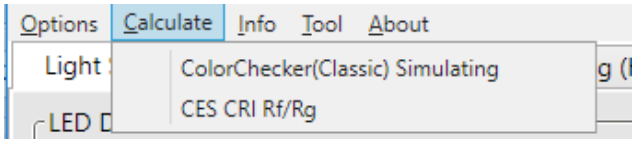


Fig. 4.3 Spectral weighting function curve

4.2.2 Menu/Calculate



a) ColorChecker(Classic) Simulating

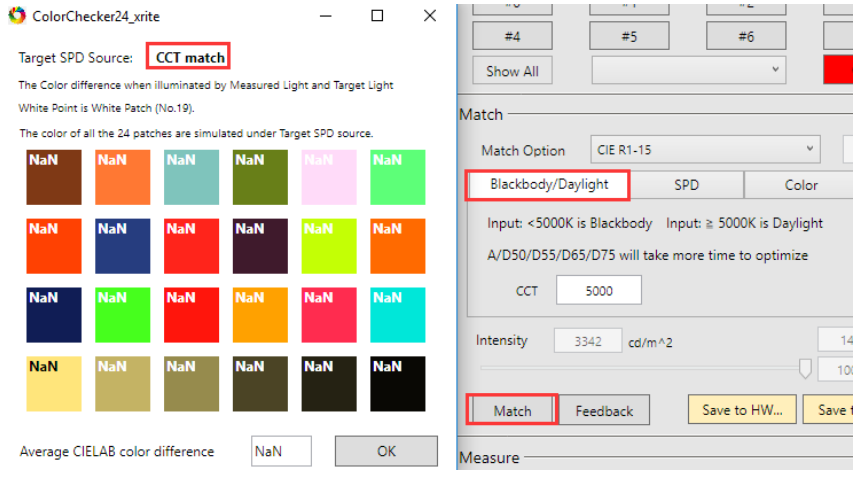


Fig. 4.4 ColorChecker(Classic) Simulating

The software will simulate the 24 color checker (X-Rite color checker/Classic) viewed under the simulated and target illuminant. The CIELAB color difference will be shown on the upper corner of each color patch. The average color difference will be shown on the bottom of the window.

b) CESCRI Rf/Rg

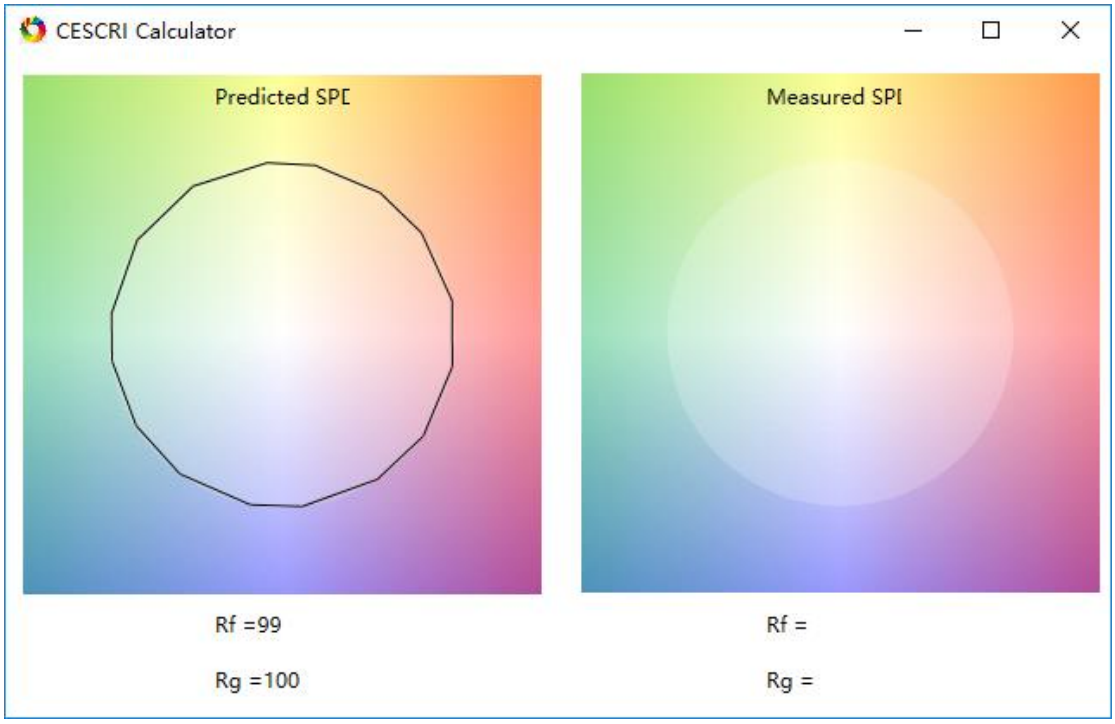
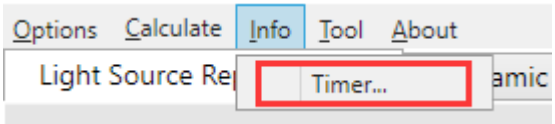


Fig. 4.5 CES CRI Parameters

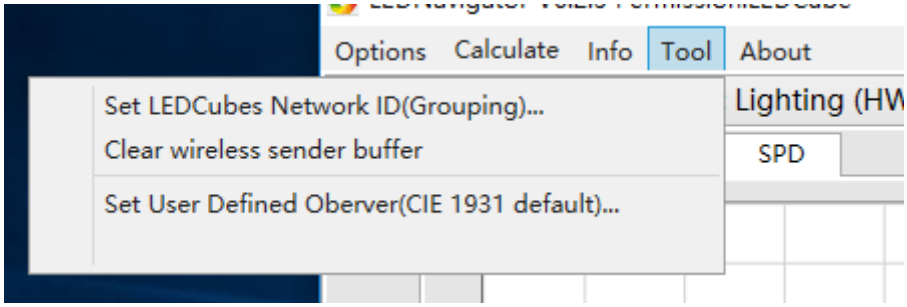
This button shows the CES Color Rendering Index (CES CRI) defined in TM-30-15, including Fidelity index Rf and Gamut index Rg. For the details, please refer to https://energy.gov/sites/prod/files/2015/12/f27/tm-30_fact-sheet.pdf. The CES CRI parameters Rf/Rg will be calculated respectively for the predicted and measured SPD.

4.2.3 Menu/Info

This submenu shows the running time for the current LED device. Please switch to single LEDCube control to use this function.



4.2.4 Menu/Tool



This submenu includes three items,

a) *Set LEDCubes Network ID(Grouping)...* Users can set multi LEDCube hardwares in one group, for the details please refer to Chapter 5 "LEDCube Wireless Connection Grouping"

b) *Clear wireless sender buffer.* When the working environment has strong signal interference, the Zigbee network may be jammed, resulting in the poor connection between LEDCube and PC. This function will increase the connection quality.

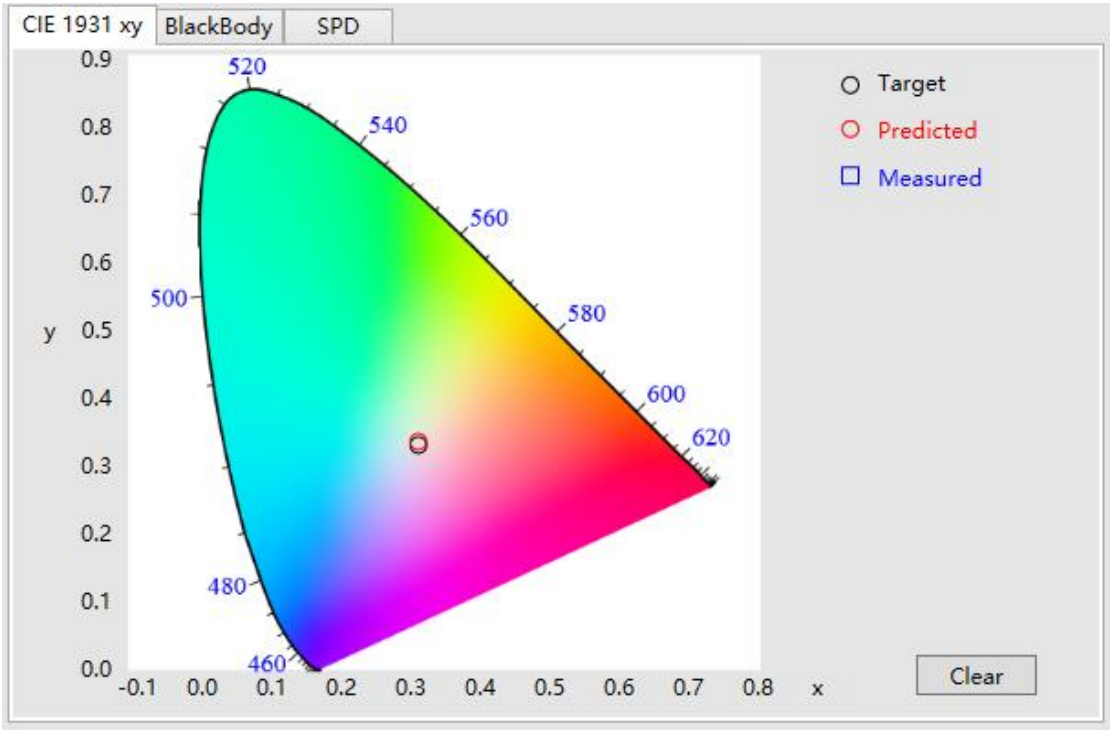
c) *Set User Defined Observer (CIE 1931 default)*: the default setting is CIE 1931 standard color matching functions. Users can choose CIE 1964 standard color matching functions, spectral sensitivity curves of one typical camera sensor, or customized curves. The file is located in *Data/system*.

4.2.5 Menu/About

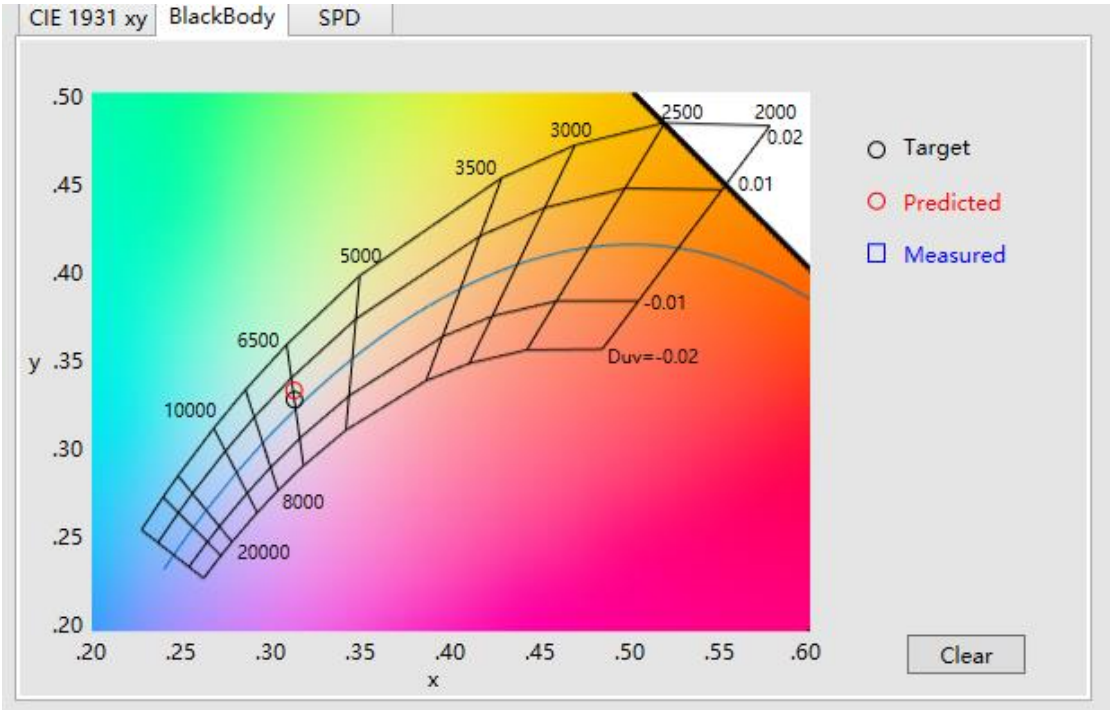
This option shows the general information about the software.

4.3 Graphics

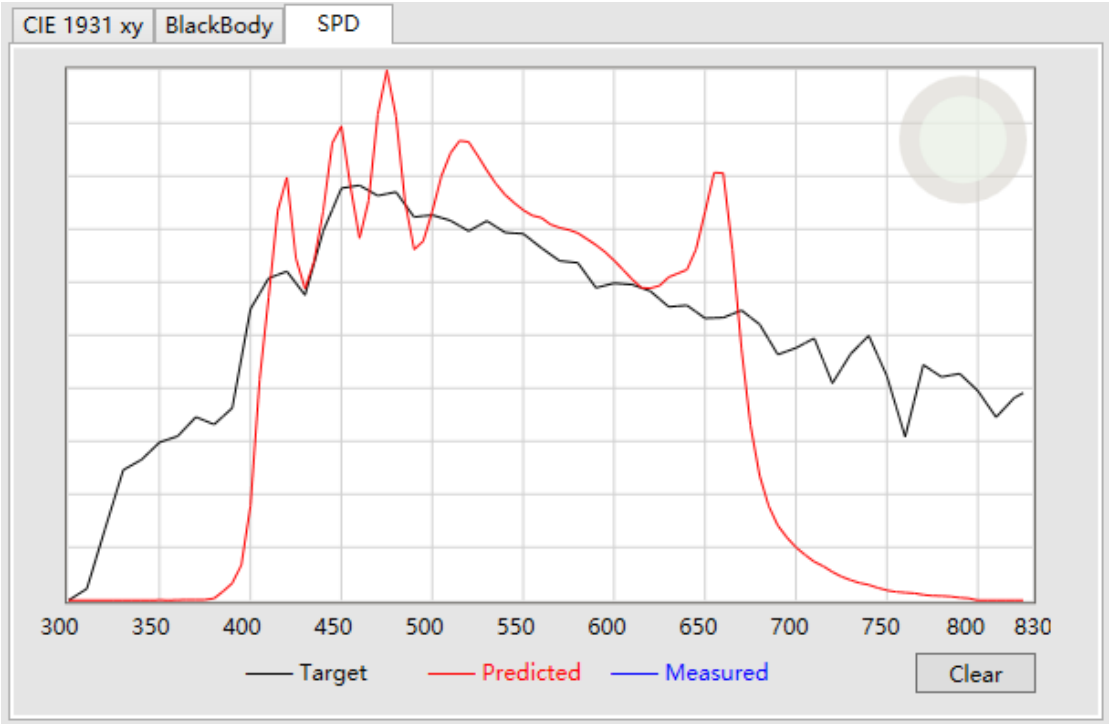
Graphics area in Fig. 4.6(a) ~ (c) demonstrates the target, predicted and measured light data. It has 3 tabs, i.e. CIE1931 chromaticity diagram, blackbody locus area enlarged CIE1931 chromaticity diagram and SPD diagram. Button *Clear* can clear the curve and points in the Graphic area.



(a) CIE1931 chromaticity diagram



(b). Blackbody locus area enlarged CIE1931 chromaticity diagram



(c). SPD diagram

Fig. 4.6 Graphics area

4.4 Single-channel Control

Single Channel Control allows users to set the intensity drive current of each LED channel in LEDCube, as shown in Fig.4.7. Users could adjust the drive current of each channel by sliding the bars or input the drive value directly. The corresponding SPD curves and color will change correspondingly. The range is from 0-100 with resolution 0.1.

The slider *Y%* is used to adjust the drive current of each LED channel simultaneously at the percentage of Y%. The left & right arrow keys on the keyboard are used to fine adjust the drive value. **Please note that the light quality of the output light will shift due to the nonlinearity between the LED intensity and its drive current**.

In section 4.7 lightness adjustment, we will introduce the way to linearly adjust the LED intensity.

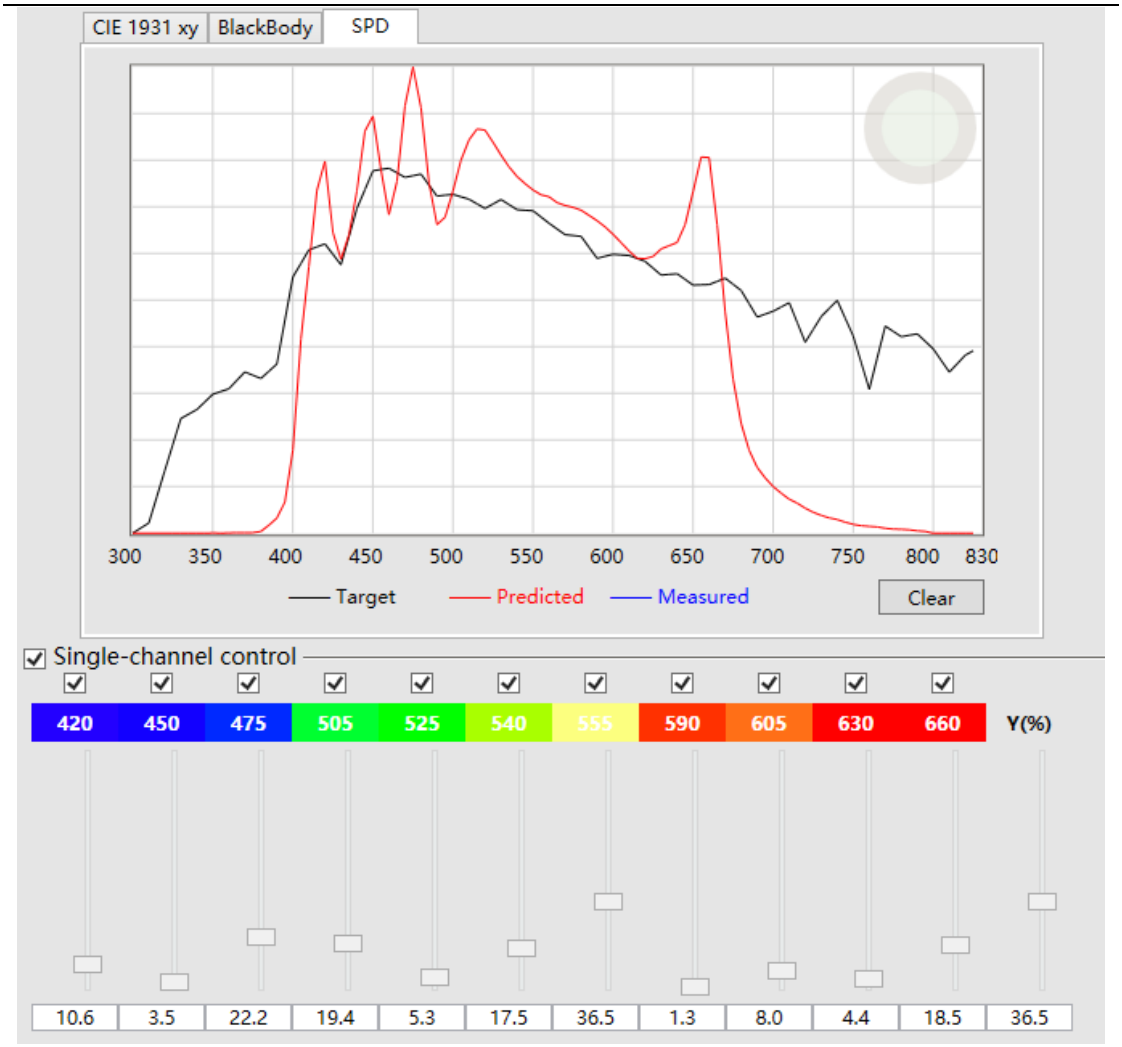


Fig. 4.7 Interface of Single-channel Control Module

The Single-channel control can be activated by ticking the check box near the words "Single-channel control". User can choose LED channels included or excluded in the optimization algorithm by ticking the check box above corresponding LED channel. The excluded channel will be set 0 during optimization. However, users can still adjust the intensity of excluded channels manually, as show in Fig. 4.8.

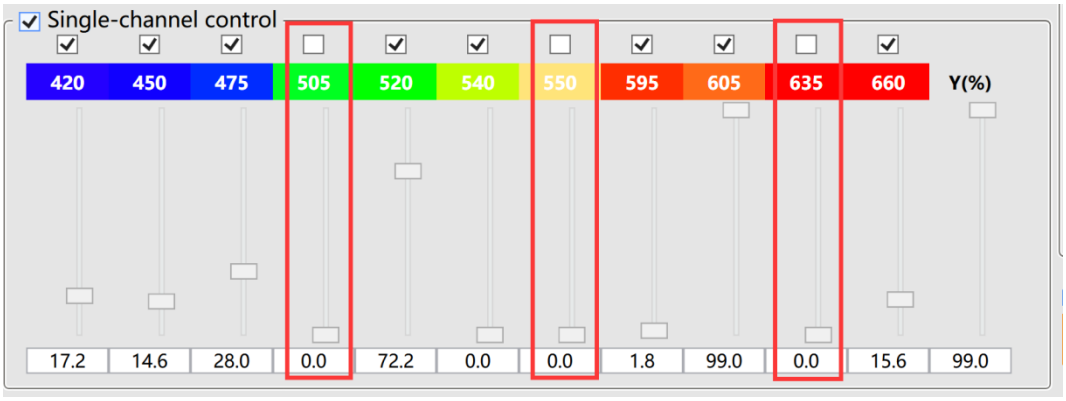


Fig. 4.8 LED channel selection in optimization algorithms

4.5 Measurement

Currently, LEDNavigator-LC software is compatible with three spectral measure devices, including X-Rite i1 Pro2, THOUSLITE FS, and Konica Minolta CL500A. The device calibration and setup geometry are described separately as follows:

- When the **X-Rite i1 Pro2** is connected, it requires calibration when the button *Measure* is first pressed. Please remove the slider on the calibration white tile and place i1 Pro2 on it, as shown in Fig. 4.9. The calibration will be finished in several seconds.

Fig. 4.9 i1 Pro 2 calibration

After calibration, please put the i1 Pro2 on the support holder. Fig. 4.10 shows the support holder of i1 Pro2. The i1 Pro 2 can be easily held by inserting into the two pillars of the holder.

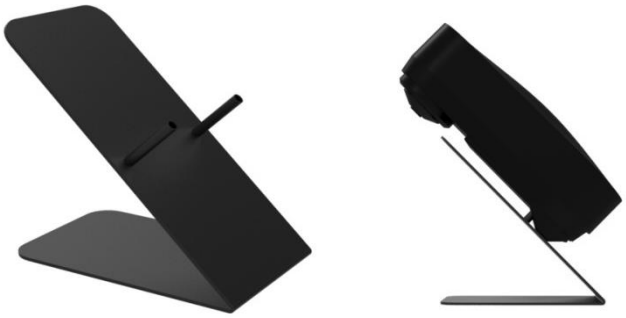


Fig. 4.10 i1 Pro2 holder

Fig. 4.11 shows the geometry of i1 Pro 2 and white tile during measurement and database rebuild.

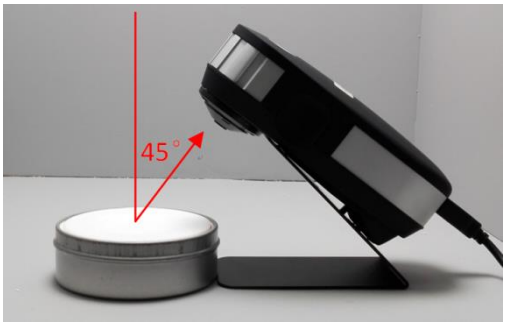


Fig. 4.11 THOUSLITE white tile (left) and i1 Pro2 measurement geometry

The white tile and i1 Pro2 can be placed at any user desired position to measure, as shown in Fig. 4.12. Please note that the white tile's *SWF* should be loaded as described in section 4.1.1, and the data measured by i1 Pro2 in this setup is luminance (cd/m^2).

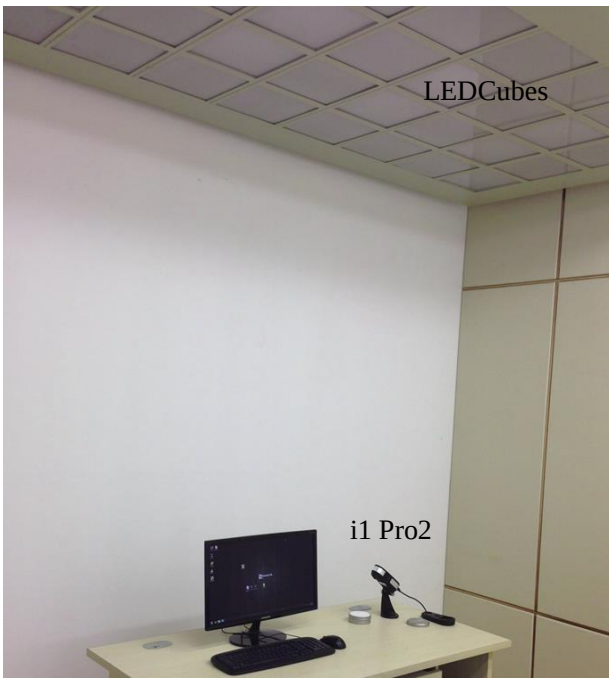


Fig. 4.12 THOUSLITE i1 Pro2 and white tile measurement position

If illuminance head of i1 Pro2 is purchased, as shown in Fig. 4.13, please install it after calibration, as shown in Fig. 4.14. Typical measurement geometry is shown in Fig. 4.15. **Please note it is not necessary to load the white tile SWF in this setup**, and the data measured by i1 Pro2 is illuminance (lx).

Fig. 4.13. i1 Pro2 illumination head

Fig. 4.14 i1 Pro2 with illumination head

Fig. 4.15 i1 Pro2 with illumination head measurement position

- When the **THOUSLITE FS** is connected, it requires dark calibration before first measurement. Firstly please screw the protection head as shown in Fig. 4.16, and then start the calibration. It is not necessary to load the white tile *SWF* in this setup, and the data measured by THOUSLITE FS spectrometer is illuminance (lx).

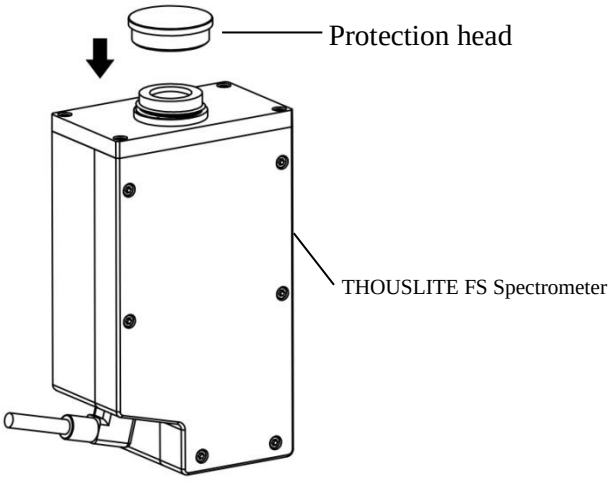
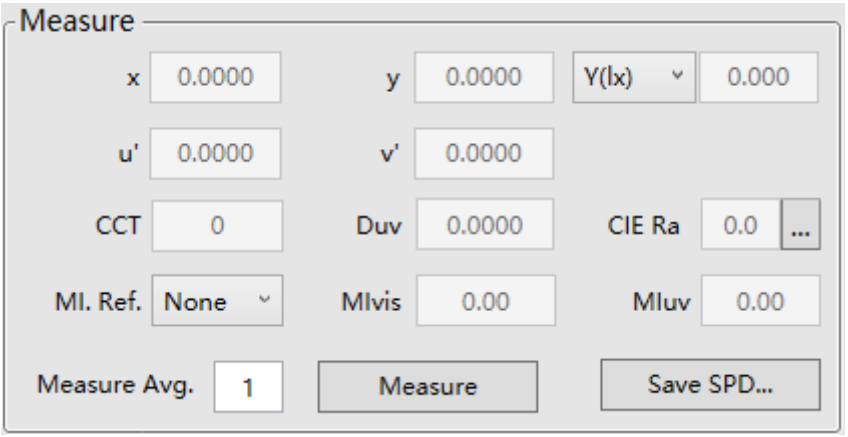


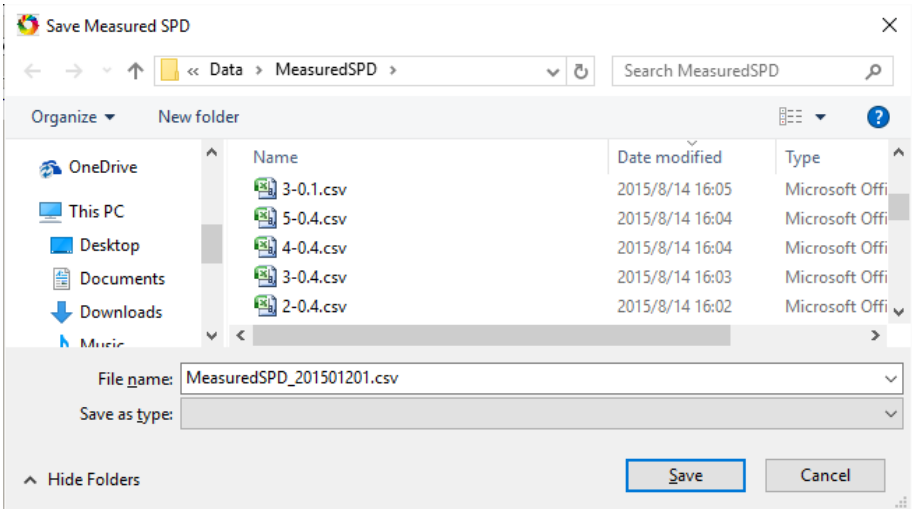
Fig. 4.16 Screw THOUSLITE FS spectrometer protection head before dark calibration

- When the **Konica Minolta CL500A** is connected, no calibration is required before first measure. Please place the CL500A at any user desired position to measure, same as Fig. 4.15.

Once the measure device is calibrated and setup, measurement could be conducted by pressing *Measure*. The result will be shown in the below image. Meanwhile, the SPD curve will be illustrated in the Graphics area. The detailed R1 ~ R15 parameters can be shown after pressing the button ... near to *CIE Ra*. To calculate the metamerism index, the corresponding reference illuminant should be chosen firstly.



The measured SPD data, which could be loaded as SPD source file in *Match* in section 4.7, could be saved by pressing *Save SPD*..., as shown in the below image.



4.6 LED Database

LED database file stores the characteristic of each LED channel in LEDCube in specified environment. The database file is located in the folder *Data/Database*, the suffix name is LED. It is the foundation to perform the optimization algorithm. Users can select the database built previously or build new database (Fig. 4.17). The new database rebuild requires 15~30 minutes (depends on the measure device and setup). During database rebuild, the software will light the each channel at drive value from 5%-100% with 5% interval sequentially, and the measure device will record the SPD and intensity at each drive value. Users can customize the name of new database after rebuild. **Make sure the whole procedure conducted in the dark environment.** The LED Database is located in folder *Data/Database*.

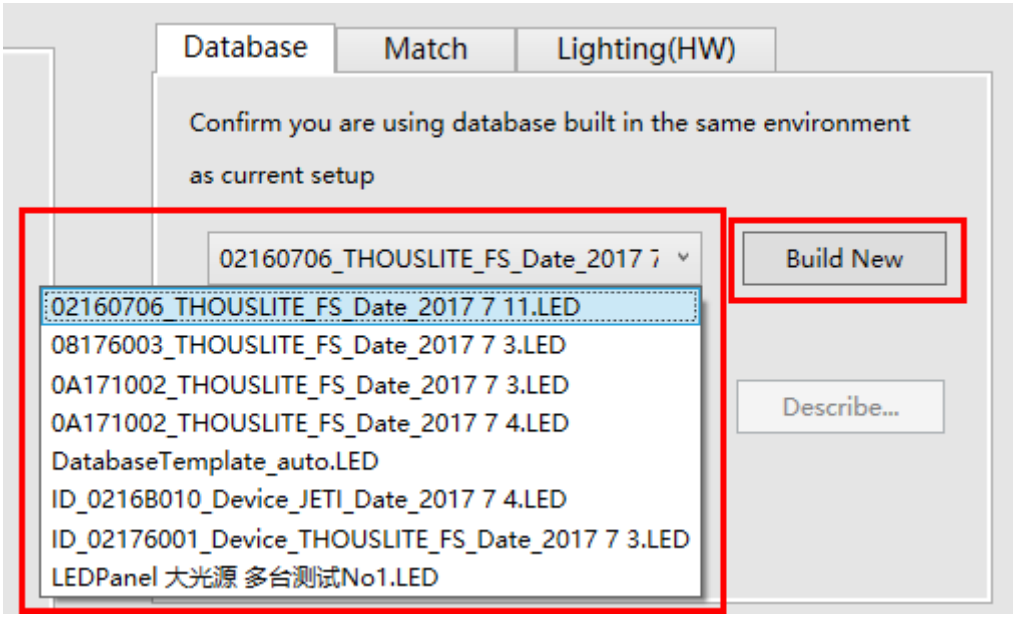


Fig. 4.17 LED Database selection or Build new database

If there are multiple LEDCube hardwares in current network, users can control a specific single LEDCube as shown in Fig. 4.18. Moreover, the name can be user-defined for each LEDCube, as shown in Fig. 4.19.

Fig. 4.18 Single LEDCube control

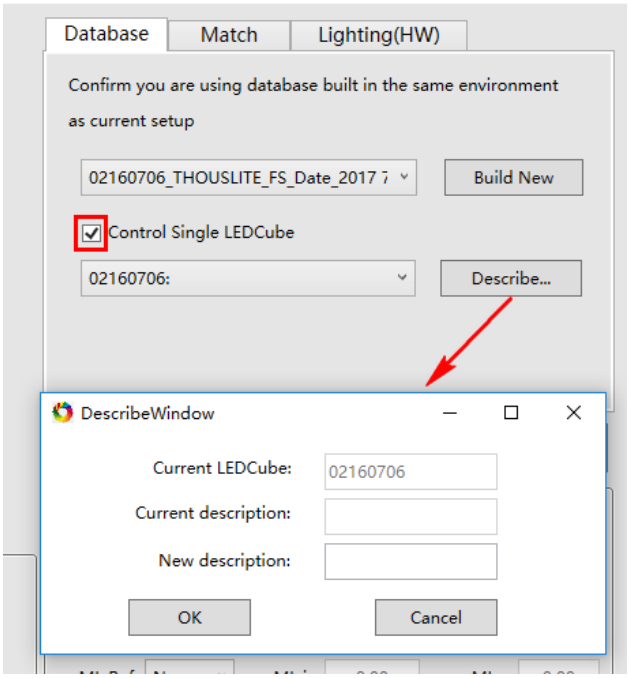


Fig. 4.19 Single LEDCube description

4.7 Match

Match is the key feature for optimization algorithm, including *Blackbody/Daylight*, *SPD*, and *Color*.

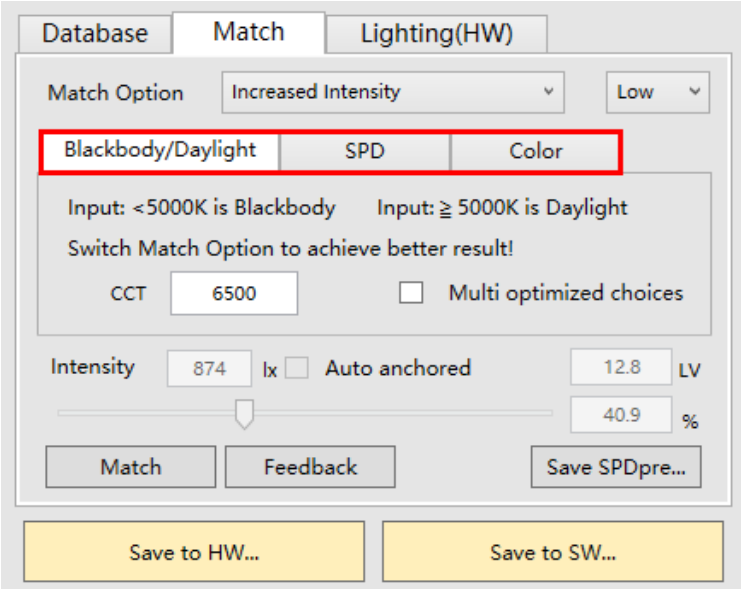
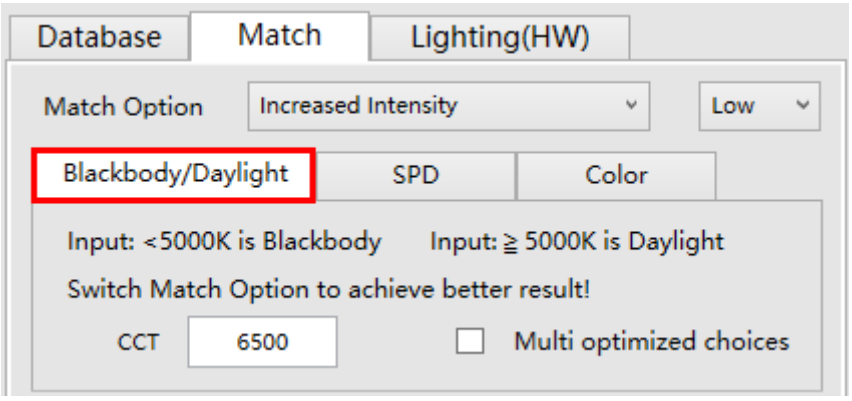
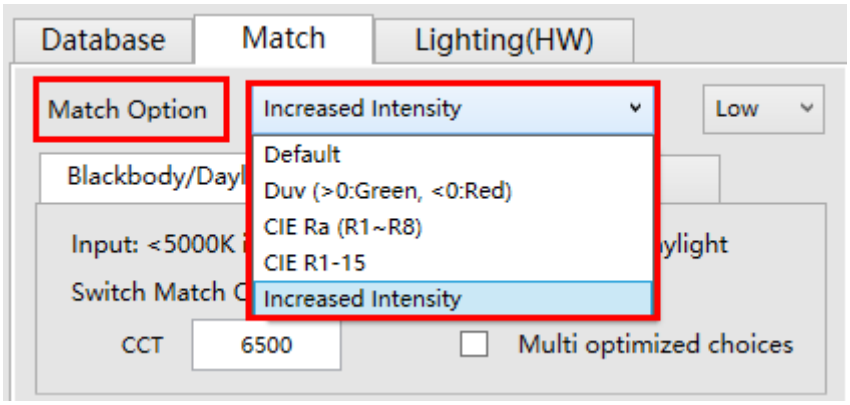


Fig. 4.20 Match interface

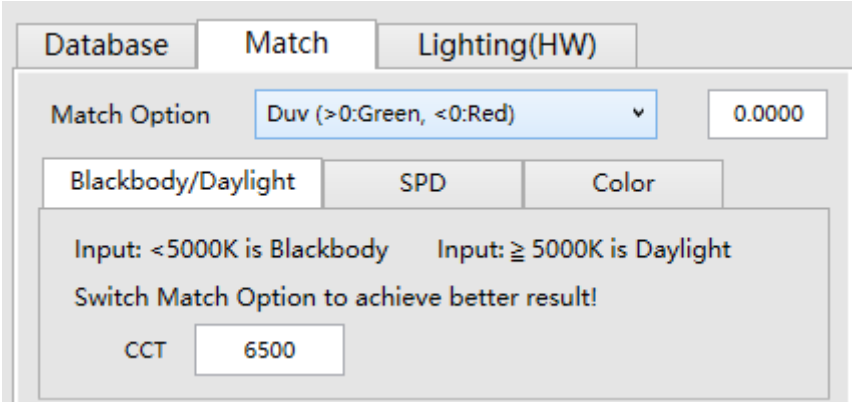
- **Module *Blackbody/Daylight.*** The software will optimize the output SPD to match Blackbody (<5000K) or CIE Daylight (>=5000K) standard SPD. When **5000/5500/6500/7500** is input, the software will consider the target SPD as **D50/D55/D65/D75** and optimize the output light. The input CCT range is from 2000K to 20000K.



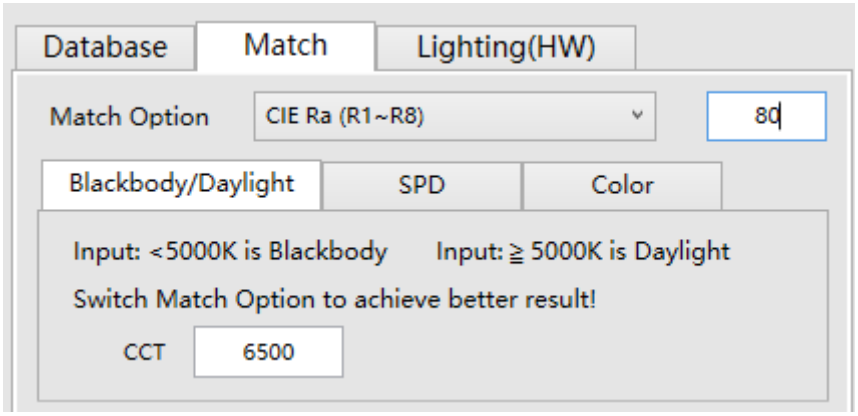
In this module, users could choose one of the 5 match options according to applications. In general, the ***CIE R1-R15*** and ***Increased Intensity Low*** options.



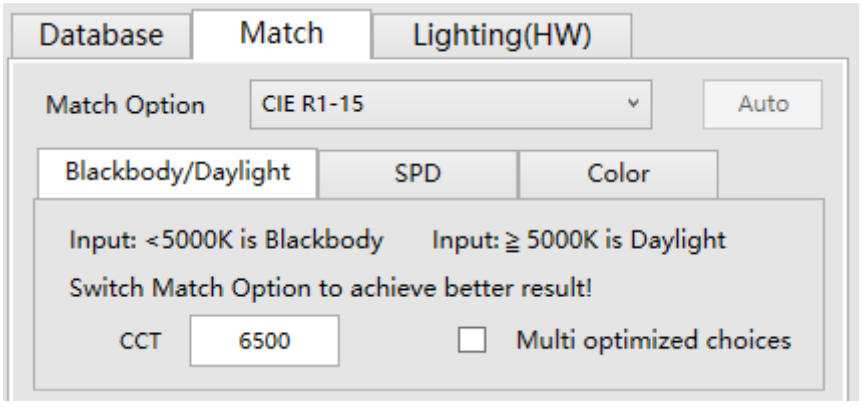
- ✓ When *Default* is chosen, balanced weights of SPD/CCT/xy/CIE Ra will be assigned during optimization.
- ✓ When *Duv* is chosen, users can set Duv value from -0.02 to +0.02. For example when 0.01 was input, then a greenish light will be output while the CCT will remain the same.



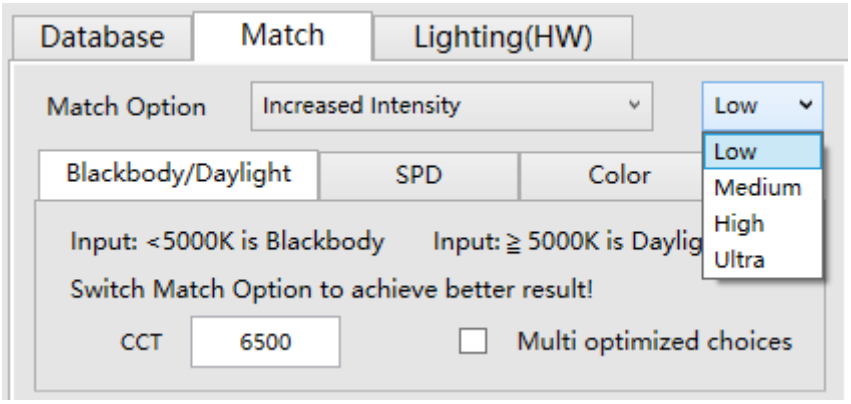
- ✓ If *CIE Ra* is chosen, users can set CIE Ra value from 0 to 100.



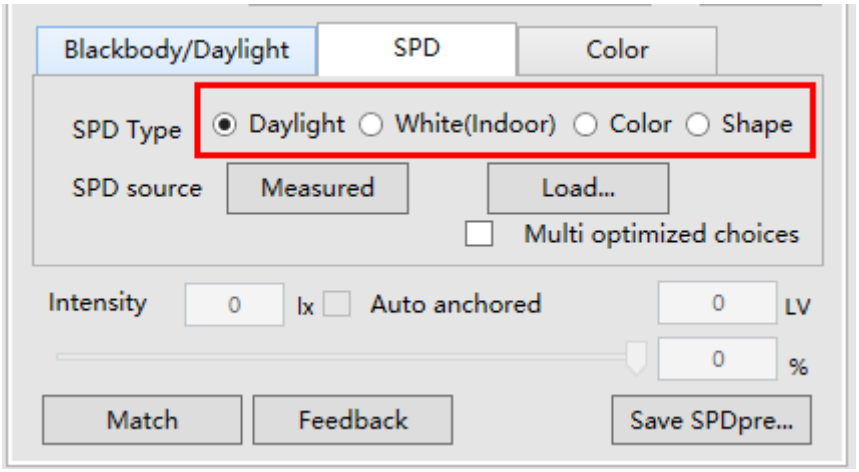
- ✓ If *CIE R1-15* is chosen, balanced weights among SPD/CCT/CIE R1~R15 will be assigned during optimization.



- ✓ If *Increased Intensity* is chosen, the software will optimize the output SPD based on *CIE R1~R15* method but at the same time increase the output intensity at the cost of potential degradation of light quality. There are 4 levels available for the intensity increase degree.

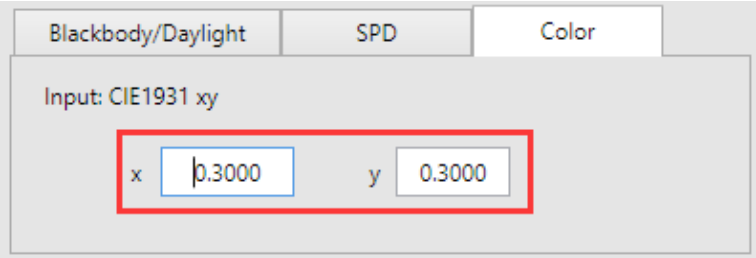


- **Module *SPD*.** The software will optimize the output light according to the target SPD. Users need to set the *SPD type* for the target SPD, and load in the SPD by *Measure* or *Load*… buttons.



  - ✓ **Type *Daylight***: the input SPD is assumed daylight, balanced weights of SPD/CCT/xy/CIE Ra will be assigned during optimization. However, the algorithm will give more weights to CCT and CIE Ra during optimization compared to "***White(Indoor)***"
  - ✓ **Type *White(Indoor)***: The input SPD will be considered as indoor white light, which means parameters like CCT, CIE Ra, together with input SPD Curve, will be considered during optimization.
  - ✓ **Type *Color***. The input SPD will be considered as colorful, the parameters like CCT or Ra will be ignored. The software only considers CIE 1931 chromaticity coordinates x/y and SPD curve during optimization.
  - ✓ **Type *Shape***. The output light will minimize the root mean square error (RMSE) for the SPD curve through 380nm-730nm.

  After setting the *SPD Type*, press *Measured* or *Load*…to load in the target SPD. Press *Measured* to get the target SPD by measurement. Press *Load*… to get it from presaved SPD file. The SPD file is located in folder *Data/MeasuredSPD*, and the SPD file could be created by button *Save SPD*… in section 4.5 Measure.
- **Module *Color***. Users could set CIE 1931 x, y coordinates as target parameters. The LEDNavigator-LC will optimize the output light to match the x, y value.



- ***Multi optimized choices***

  Before pressing *Match*, users can choose "Multi optimized choices" by ticking the check box. If the "Multi optimized choices" is selects, the software will offer 8 candidate results for user to select. The option is available for both module *Blackbody/Daylight* and *SPD*.

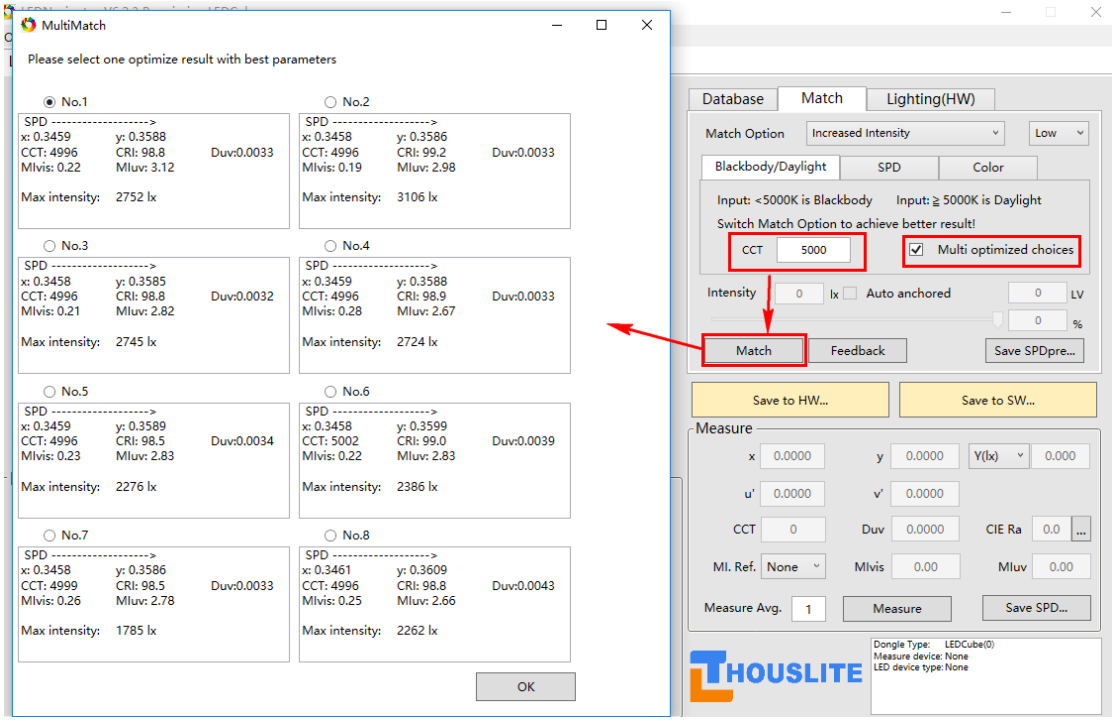
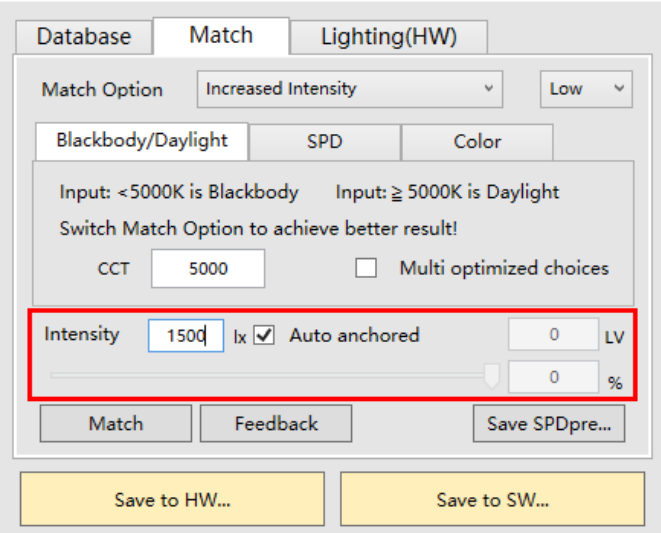


Fig. 4.21. Multi optimized choices

- **Lightness adjustment**

  After pressing *Match*, users could adjust the intensity slider as shown in below image. The adjust range is 0%-100% and the minimum resolution is 0.1%, which could also be fine adjusted by pressing the left & right arrow keys on the keyboard. During the adjustment, the software will also show the predicted intensity and the LV value.

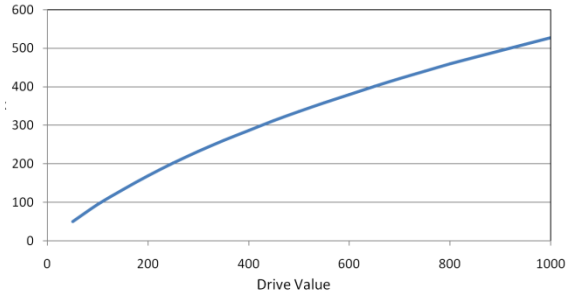
  In addition, users can set target light intensity by enabling the "Auto anchored" feature. By ticking the check box of "Auto anchored", user can input the target light intensity, say 1500lux, and then the software will optimize the result to achieve the target intensity. If the final measured result has a large difference compared to the predicted one, *Feedback* can be used to compensate the difference. The option is available for both module *Blackbody/Daylight* and *SPD*.



When the intensity slider is set below 5%, it may will result in relatively large difference between LEDCube hardwares, because the consistency of LED chips at low intensity is relatively poor, and the adjustment range of each LED channel is small at low intensity. For example, the below image shows two LEDCube at same color temperature 5000K and same intensity 1%. Apparently, they are visually different. If users have multiple LEDCube hardwares to build lighting environment, **we strongly recommend users not to set the intensity slider below 5%**. Instead, **user can use two white LED channels in LEDCube to create low intensity illumination**, say 1or 2 lux.

Please note the slider in this module is different from Y% in section 4.4.

- In section 4.4, the slider *Y%* is used to adjust the **drive current** of each LED channel simultaneously at the percentage of Y%, but the relationship between the LED intensity and its drive current are non-linear. The below image show a typical relationship between drive value of LED channel and its intensity. Obviously, it is non-linear.

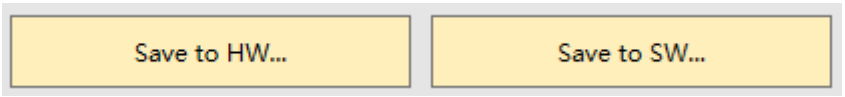


- The slider in this module will adjust the light intensity at the specified percentage rather than drive value, and the software will calculate the drive value for the specified percentage of the light intensity based on the data in the database.

- ***Match* and *Feedback* button**

Press *Match* button to simulate the target light. The software will generate optimized result, and then press *Measure* button to obtain the measured result. If there is a considerable difference (say ΔCCT>100K) between measured result and target light, the *Feedback* button could be performed to compensate the difference. After *Feedback*, the lightness percentage will remain the same, while the absolute intensity will slightly change. In general, 1-2 *Feedback* process is enough to compensate the difference. If more than 3 *Feedback* process cannot close to the target, different "Match Options" selection or database rebuild is recommended. In addition, **make sure press *Measure* to obtain the difference between predicted and measured result before using *Feedback*.**

- ***Save to HW…* and *Save to SW…***



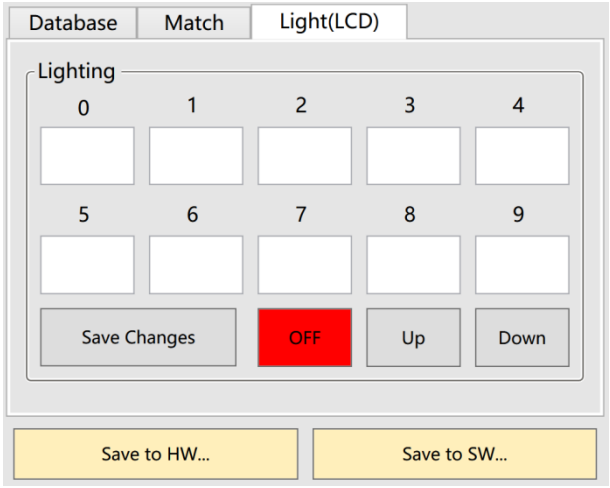
Press *Save to HW…* to save the current light into LEDCube hardware. Press *Save to SW…* to save the light into software local loop file. Please refer to section 4.10 for details. The saved light sources are easy for users to recall the light source in the future or to design the dynamic lighting.

4.8 Lighting

LEDCube can save up to 80 light sources in its hardware. The Lighting interface are different depending on different LEDCube connection modes in section 2.4

4.8.1 LEDCube hardware-Touch Screen Controller-PC

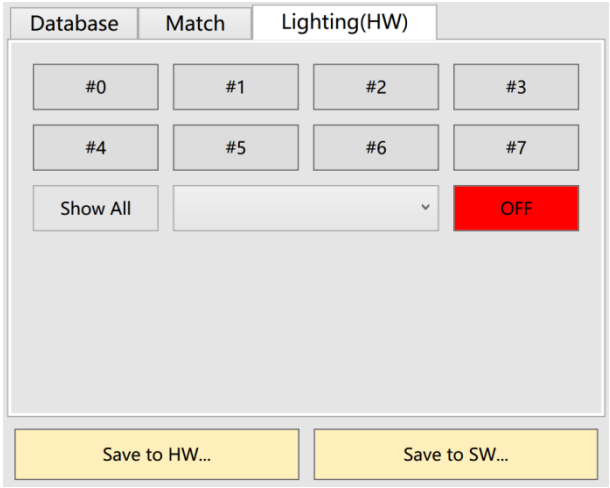
In this mode, the Lighting interface is shown below.



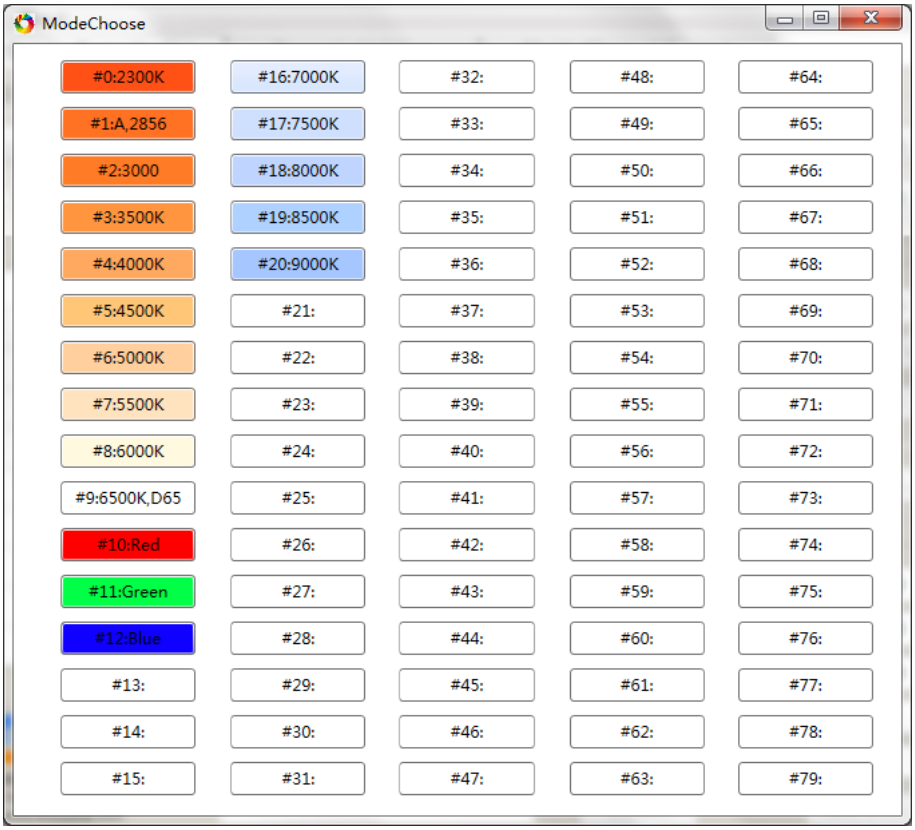
This Lighting interface is the same as the SOURCES sub-interface on touch screen controller in section 2.3. It includes 8 pages which can be selected by *Up* and *Down* button, and each page has 10 buttons. **Press the number above each rectangle space can turn on the corresponding light source**. User can type the source name in the rectangle space, and then press *Save Changes* to save the source name to the touch screen controller. Please note, ***Save Changes* only save the source names in controller**, and saving light source is done by pressing *Save to HW…* in section 4.7 *"Save to HW…* and *Save to SW…"*.

4.8.2 LEDCube hardware-Wireless sender-PC

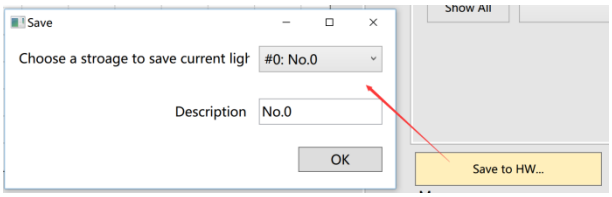
In this mode, the Lighting interface is shown below.



The above interface has 8 buttons which is the shortcuts for light number 0 ~ 7. Users could also select the light source from drop-list button, or just click the *Show All* button. The light source name should be defined by users when save the light. The background color of each button is color of the saved light.



If user want to save a new light source, user can click *Save to HW…* , type the source name, and press *OK*. The source name will be stored in the software local file *Data/ModeDetails_00000000*, which may results in the different source names in touch screen controller and software local file.



4.8.3 LEDCube hardware-PC

In this mode, the Lighting interface is exactly same as section 4.8.2.

4.9 Dynamic Lighting (HW)

Fig. 4.22 shows the interface of *Dynamic Lighting (HW)*. Totally, users can select max 24 presaved light sources within one loop. Users can set the switch interval between light sources in the loop. The minimum interval is 1 second. If the time is set to 0, the corresponding light source will be skipped in the loop. Press *Start* or *Stop* button to start or stop a loop. In addition, users could save the current setting into a loop by pressing *Save to Loop* as shown in Fig. 4.23.

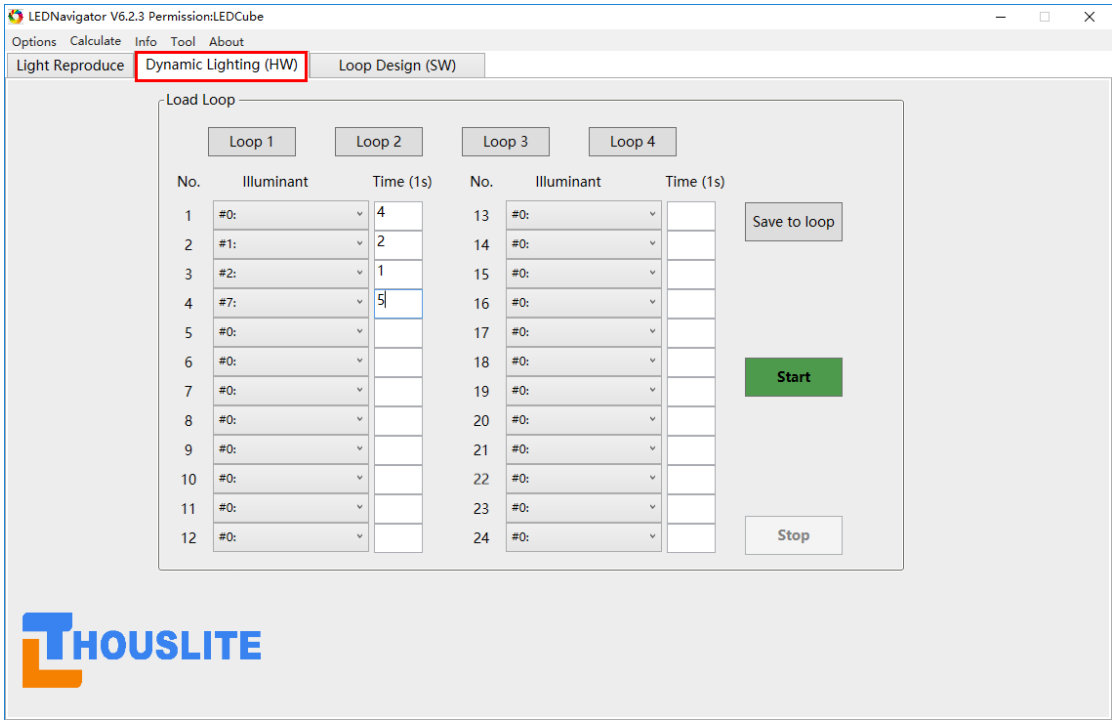


Fig. 4.22 Interface of Dynamic Lighting

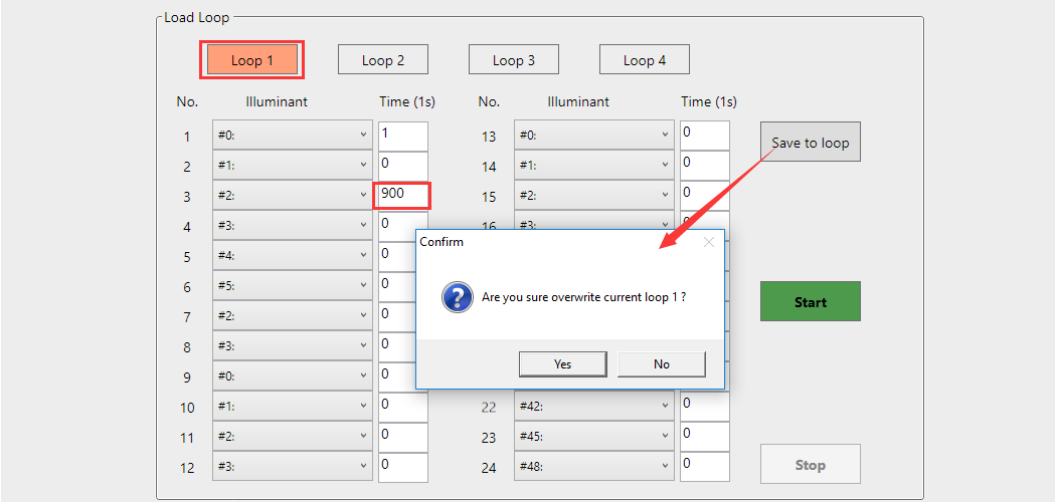


Fig. 4.23 Save changes to current loop

In the LEDCube connection mode 1(LEDCube hardware-Touch Screen Controller-PC), the “Save current loop to touch screen controller” is enabled as shown in Fig. 4.24, and press Save button can save the loop into one of five loop in SEQUENCE sub-interface of touch screen controller.

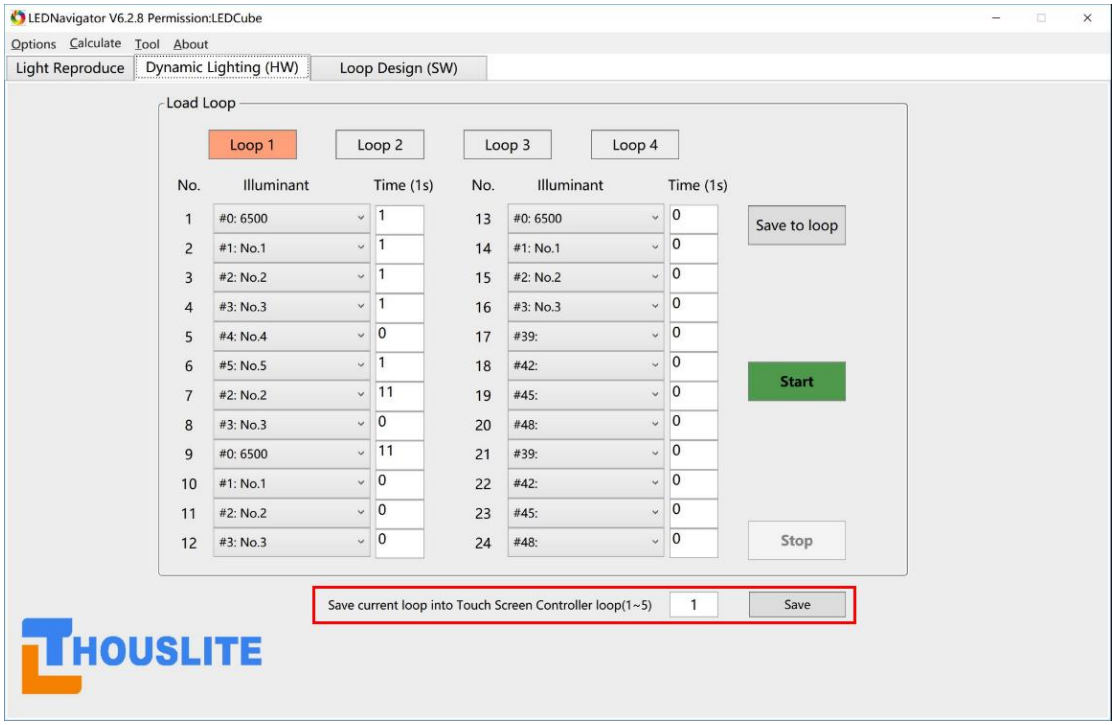


Fig. 4.24 Save the loop to touch screen controller

4.10 Loop Design (SW)

The saved light sources via *Save to SW…* in section 4.7 is shown in the *Loop Design (SW)* page. In the *Loop Design (SW)*, users could save unlimited light sources into software. Press *Load…* button to open a history Loop file, as shown in Fig. 4.25. Press *Clear* to clear previously loaded loop file.

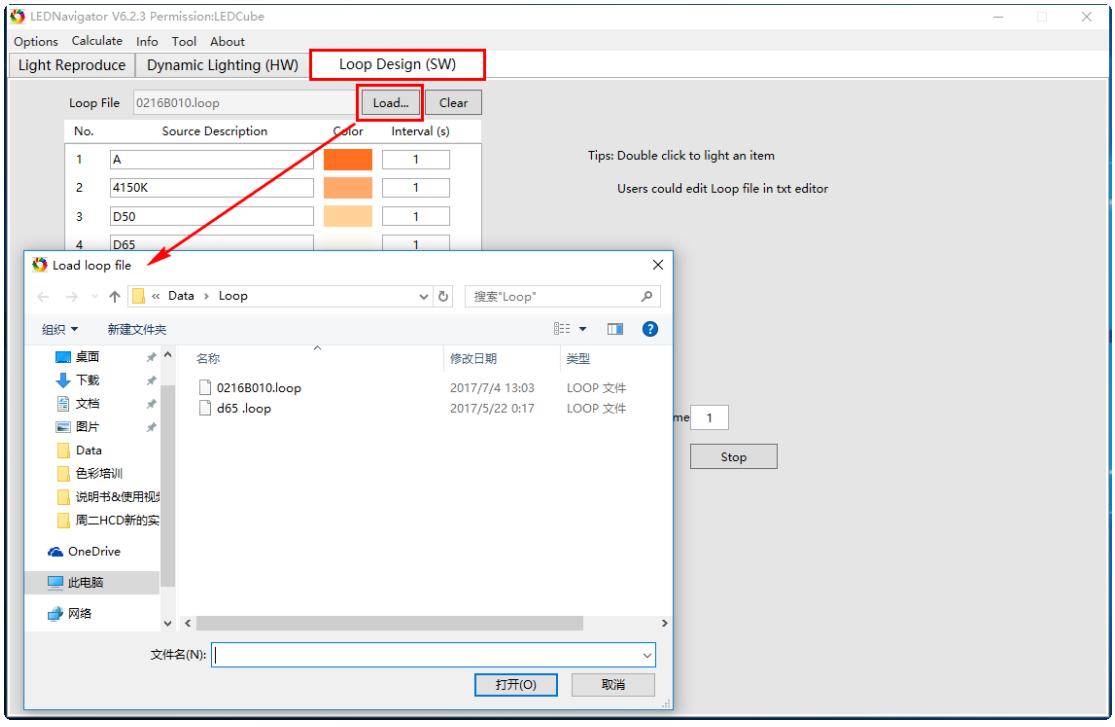


Fig. 4.25 Load in a history loop file

After the loop file is loaded, users could edit the *Source Description* and the *Interval* parameter, as shown in Fig. 4.26. Up and down arrow button allows user to modify the sequence of light source in the loop. Press *Delete* to remove a light source.

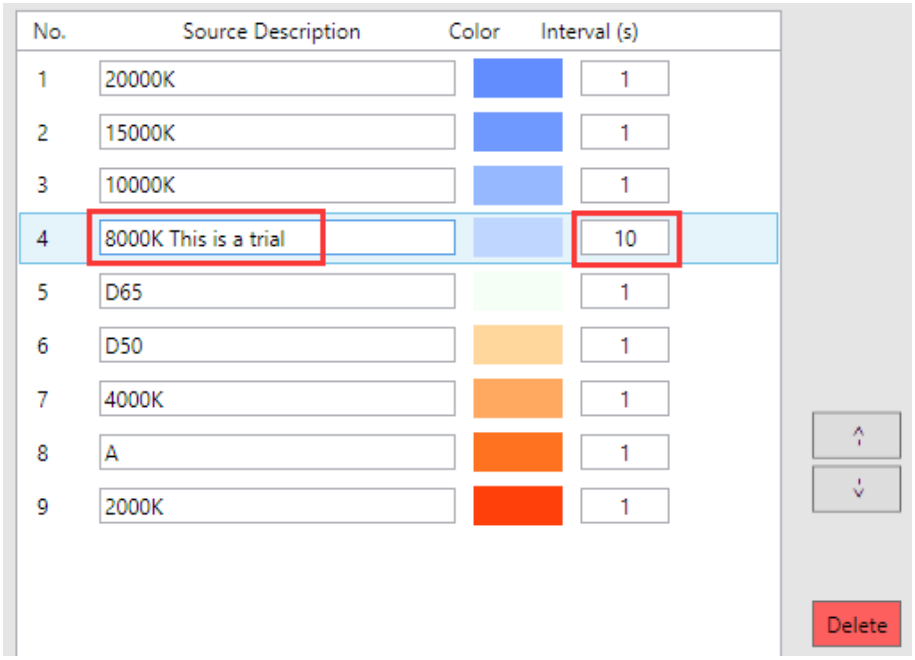
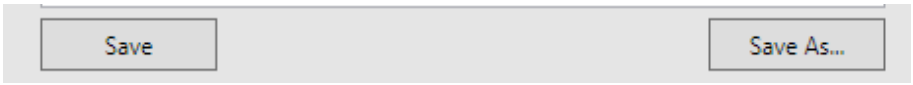
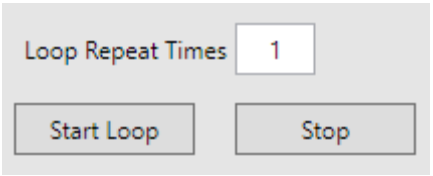


Fig. 4.26 Edit a light source in a loop

It should be noticed that all the changes will not be saved unless users press the *save* button. Press *Save As…* to save the current working loop as a new loop file.

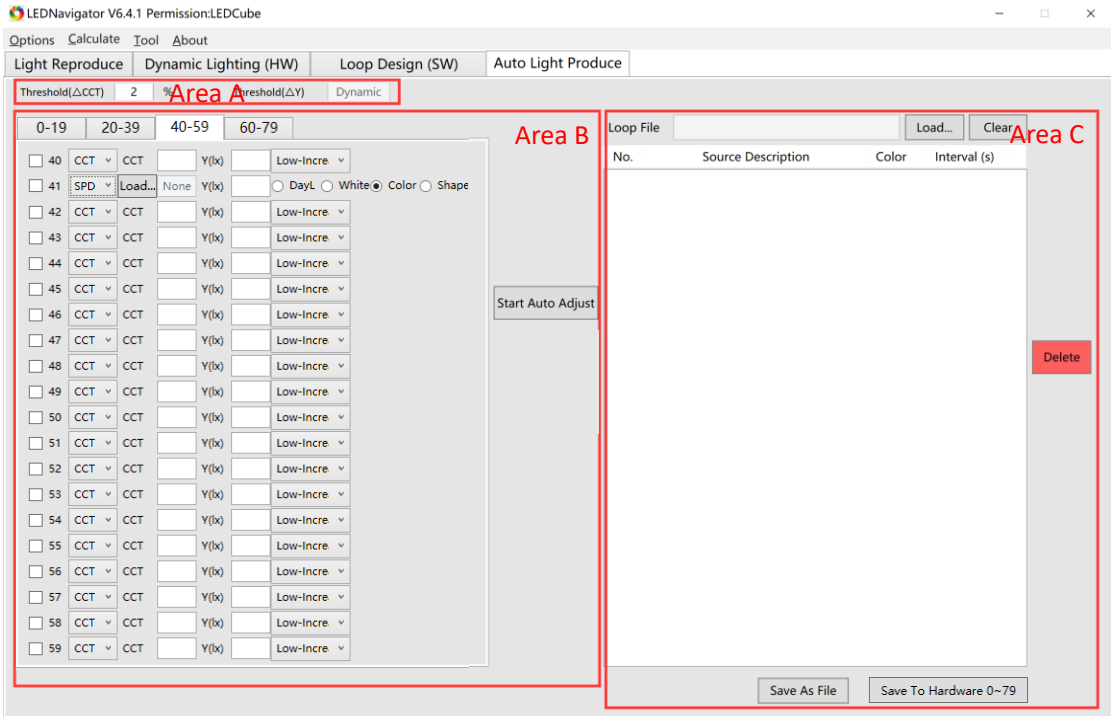


Set the *Loop Repeat Times* to change the loop times for the entire loop.



4.11 Auto Light Produce

This module is applicable when users need to produce multi light source at once to save energy and time. Users could input up to 80 kinds of light specs at once into this module. It will handle the light producing procedure automatically. The whole module is shown in the following image.

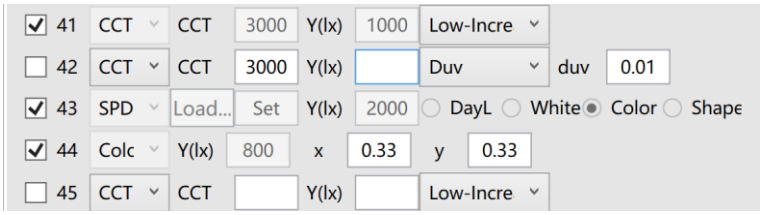


The area A in up-left controls the threshold of CCT error (△CCT) and light intensity error(△Y). The automatic light producing procedure will come to a stop when the CCT error and light intensity error fulfills the threshold. If the error always exceeds the threshold, the procedure will repeat and come to a stop automatically after several times of “Feedback”.

The left red area B enables users to input light specs for each light item. There are 4 tabs in this area, each contains up to 20 light items. The order in front of each light specs correspond to the order of the button users intend to store the light. As for the light specs, there are 3 kinds of modes, which has been introduced in detail in section 4.7. Users could define the target CCT (Blackbody/Daylight mode), SPD, or Color.

The area C in the right will show the lights generated after the light producing procedure is over. After users press button “Start Auto Adjust”, the software will start to produce light according to the corresponding spec. After this procedure finished, users could decide whether to accept the result or not. Through button “Save As File” or “Save to Hardware 0-79”, the result light could be saved as a file or into the hardware buttons.

4.11.1 Set Specs for Each Light Item

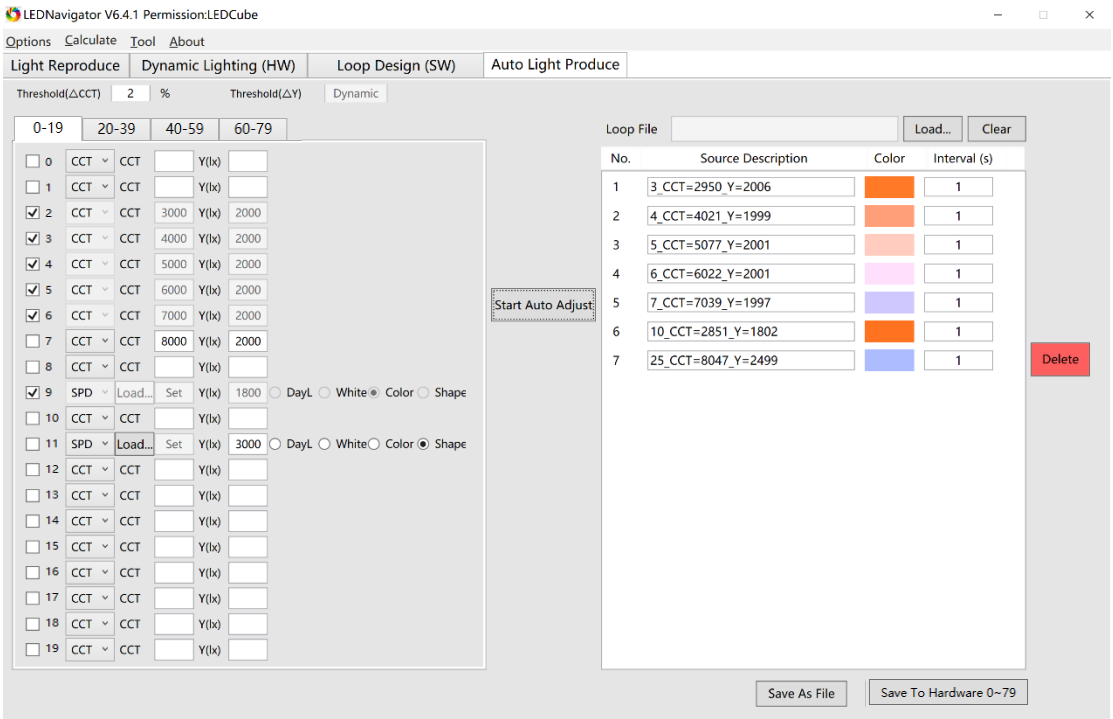


Let's see the example shown in the up image. No. 41~44 light items have been set to some specs. In No.41 light item, the target CCT is set to 3000K, target intensity is 1000lx, match option set as "Low-Incre…". In No.42, the intensity is vacant, which is why the checkbox in front could not be checked. As for No.43, users loaded an SPD file as target, the intensity is set to 2000lx, SPD type is "Color". In No.44, the match type is Color, so the color coordinates x/y could be set.

Only after the specs are set, users can check the checkbox in front of each light item. Only those light items with checkbox checked will be taken into account during the light produce procedure. Otherwise this light item will be ignored.

4.11.2 Generate Light Automatically

After all the light items are set, press "Start Auto Adjust" to start the automatic light producing procedure. The time consumption depends on the numbers of the light to be produced and the type of the measure device used. Generally speaking, each light will take 20 seconds to 2 minutes. After the producing procedure is finished, the result would be shown in the result area,

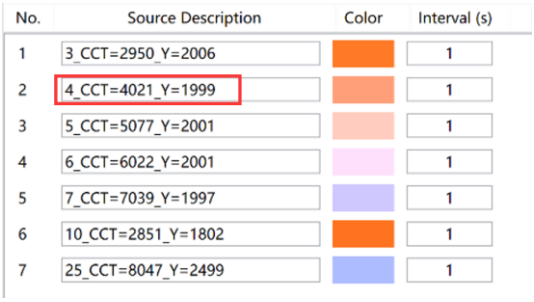


Please be noted that No.7 and No.11 are not shown in the right because users did not check the checkbox of these two light items.

4.11.3 Understand Description of Light

Each light generated will be shown with an automatic description. Please refer to the following image. The description of No.2 light is “4_CCT=4021_Y=1999”, in which ”_” is a separate sign, “4” means this light source is intended to be stored into button No.4. If users press “Save To Hardware 0~79” then this light will be stored into No.4 button. “CCT=4021” means the measured CCT is 4021K. While “Y=1999” means measured illumination is 1999lx. Users should check the parameters like CCT and Y to decide whether to accept this light.

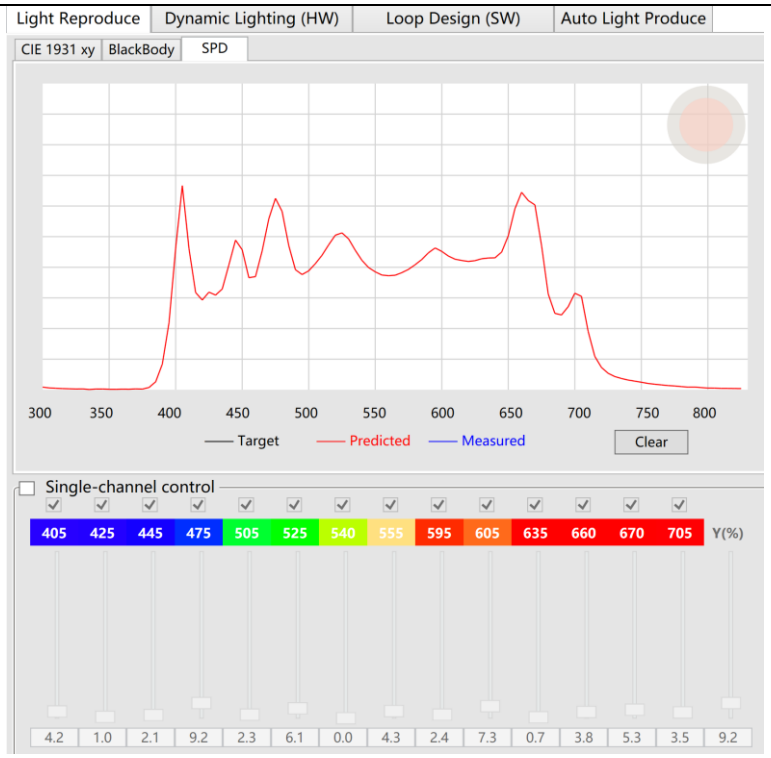
Please be noted that the numbers before the first separate sign “_” represents the button to be stored. So do not edit the numbers unless necessary. Or the software will report failure when press “Save to Hardware 0-79”.



No.	Source Description	Color	Interval (s)
1	3_CCT=2950_Y=2006		1
2	4_CCT=4021_Y=1999		1
3	5_CCT=5077_Y=2001		1
4	6_CCT=6022_Y=2001		1
5	7_CCT=7039_Y=1997		1
6	10_CCT=2851_Y=1802		1
7	25_CCT=8047_Y=2499		1

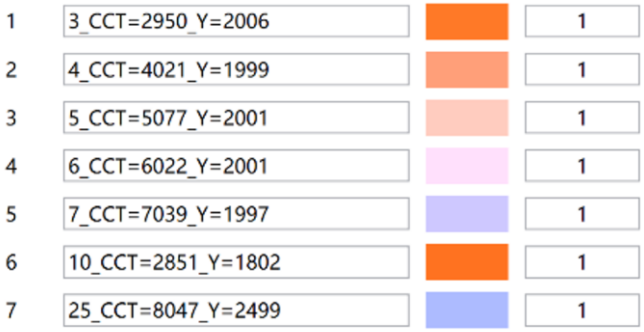
In this example, the No.3 light has a target CCT of 5000K, but the measured CCT is 5077K. If an error of 77K is unacceptable, then users should rematch this light again. One way to solve this problem is to change the threshold to 1%, then perform auto match. Another way is to match this light manually as described in section 4.7.

Double click each item could lit up the corresponding light. Users could examine the intensity of each LED channel after switching to the first tab “Light Reproduce”, as shown in the following image. For operation details please refer to section 4.10.



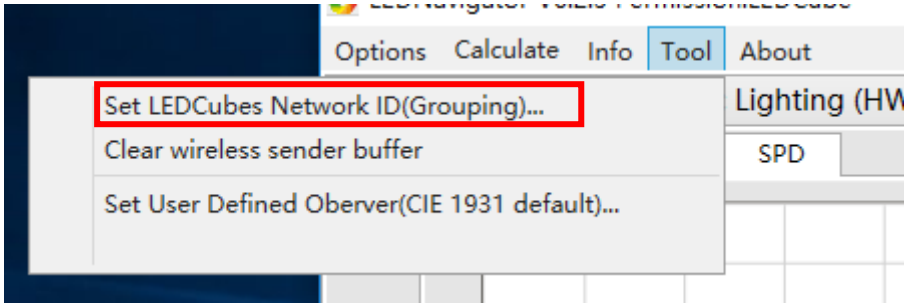
4.11.4 Save Light

Press “Save As File” to save the current result lights into a file. This file could be loaded in in module “Loop Design(SW)”. Press “Save To Hardware 0~79” would save current lights into corresponding buttons. Be caution that if the current button already contains a light source, this operation would cover it with new light. Take the following image as example. Users set specs for light 3、4、5、6、7、10 and 25. After press “Save to Hardware 0-79”, the No. 3、4、5、6、7、10 and 25 buttons will be re-write with these lights.



5. LEDCube WIRELESS GROUPING

5.1 Brief Introduction



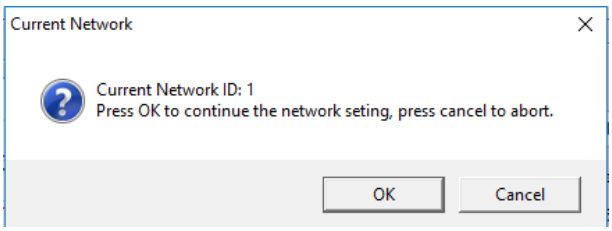
If users have multiple LEDCube hardwares, "LEDCube wirelss grouping" allows users to separate these hardwares into several groups. For example, if users have 10 LEDCubes and want to separate them into 2 groups (4 and 6 units), *Set LEDCubes Network ID(Grouping)* could be used to set the first 4 LEDCubes network ID as #2 and set the other 6 LEDCubes' network ID as #3. In this example, two wireless senders, with network ID #2 and #3, can be used to control corresponding LEDCube hardware with the same network ID.

The grouping principles for LEDCube Network ID

- All the LEDCubes and wireless senders are set as #1 in default settings
- Each LEDCube and each wireless sender has its own wireless network ID
- Users can modify the network ID of LEDCube hardware or wireless sender via software
- Only the same network ID wireless sender and LEDCube hardware can communicate
- The network ID options is 1~9, which means users could only separate LEDCubes into max 9 groups
- Only those LEDCubes and wireless sender produced after March 2017 supports network grouping

5.2 Grouping Operation

After clicking *Tool/Set LEDCubes Network ID (Grouping),* a message will show up to indicates the current network ID. Press *OK* to continue the grouping and press *Cancel* to quit.



Press *OK* and continue to grouping interface, as shown in Fig. 5.1.

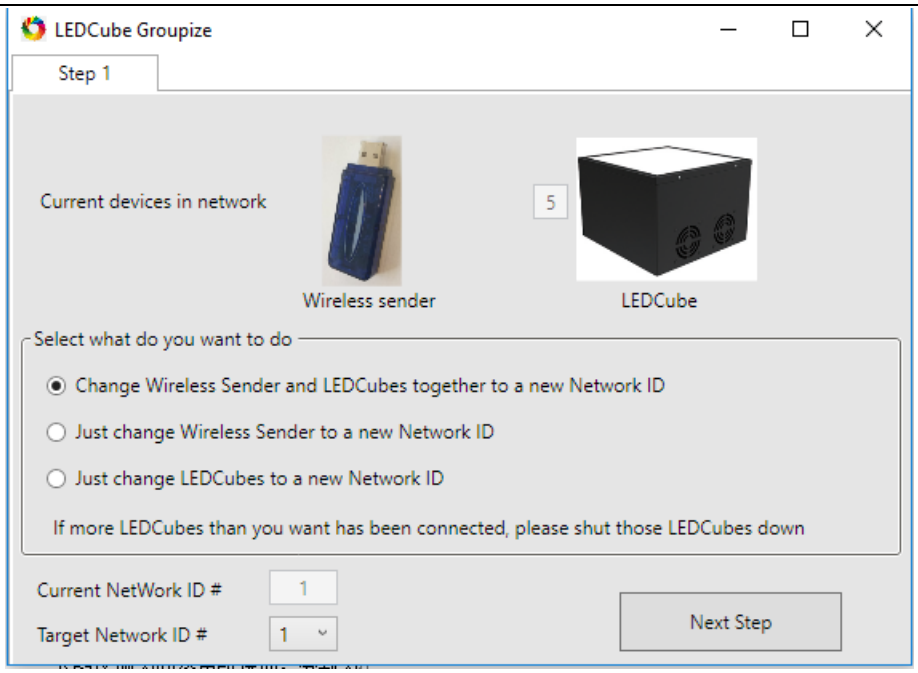
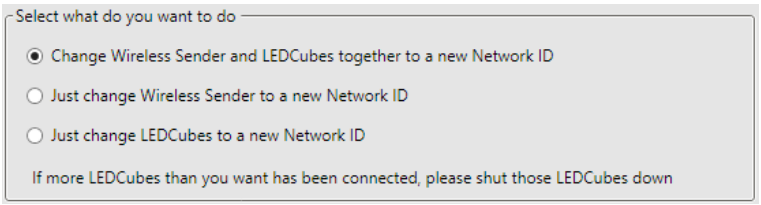


Fig. 5.1 Grouping interface

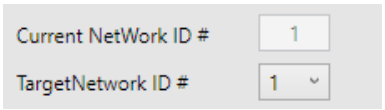
The following figure shows the hardware unit in current network, i.e. a wireless sender and 5 LEDCubes.

The next step is the option of grouping,

- Change wireless sender and LEDCubes together to a new Network ID
- Just change wireless sender to a new network ID
- Just change LEDCubes to a new network ID

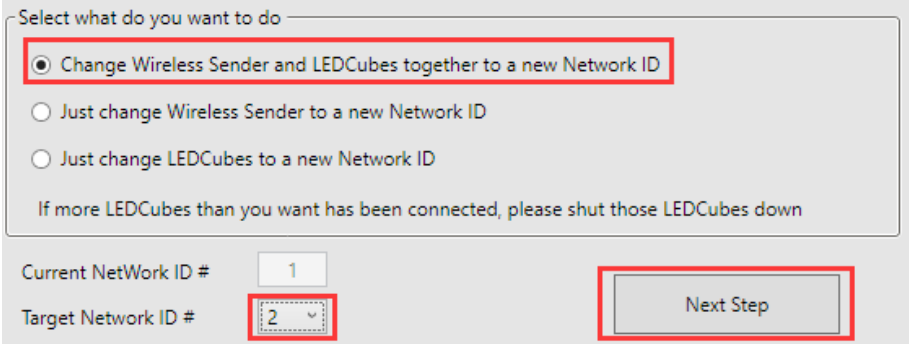


The following figure shows the current network ID and the target network ID.

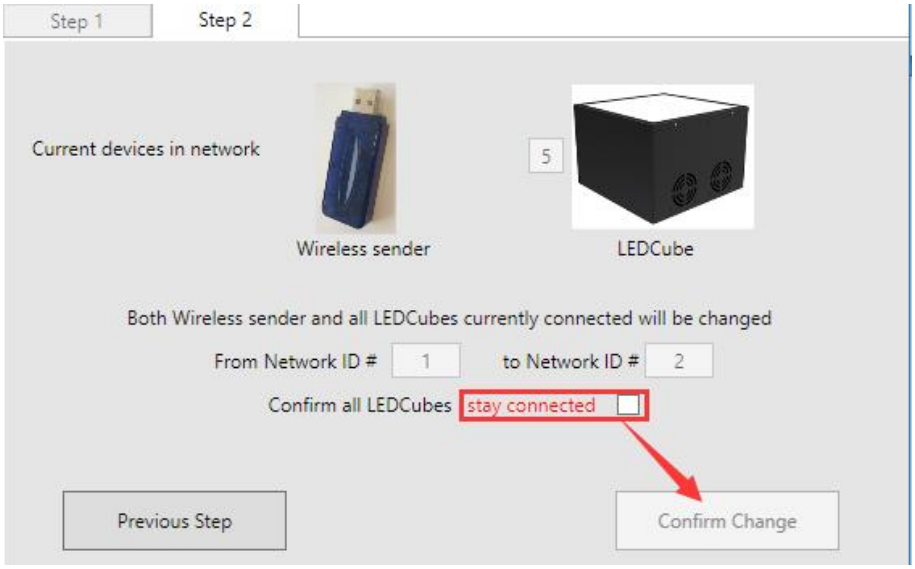


5.2.1 Grouping both LEDCube and Wireless Sender

Select the first option and set the target network ID, then press *Next Step*, as shown below.



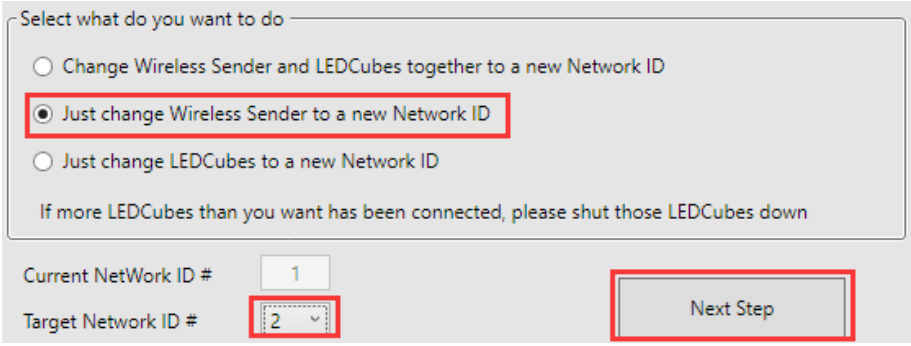
In the second step, please confirm the connection of LEDCubes in one group and then press *Confirm Change*.



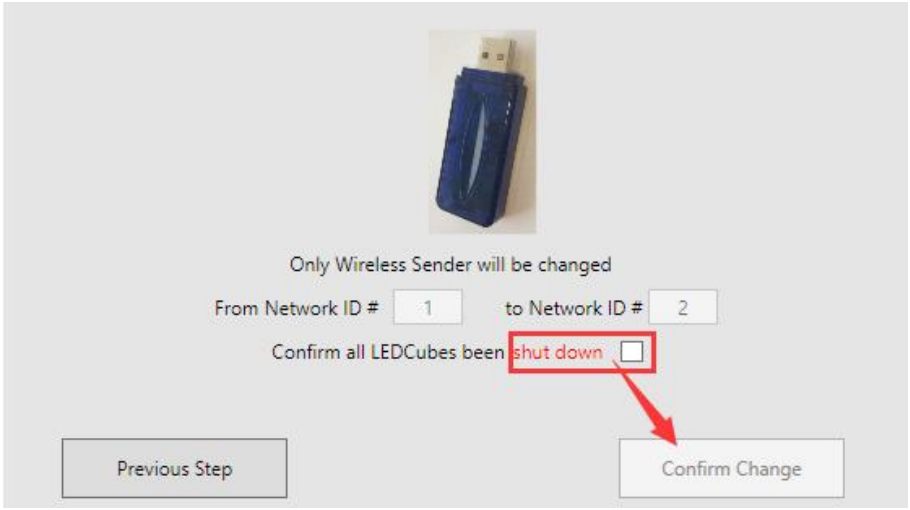
The following message will show up if the grouping is finished.

5.2.2 Grouping Wireless Sender only

Select the second option and set the target network ID, then press *Next Step*, as shown bellow.



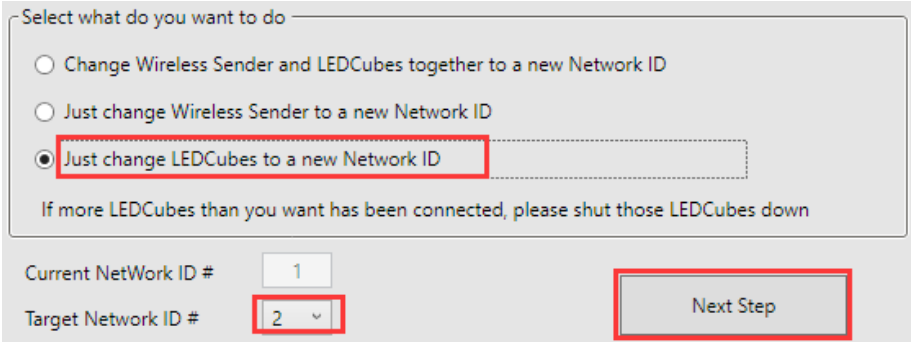
In the second step, please confirm all the LEDCubes shut down (no power connection) and then press *Confirm Change*.



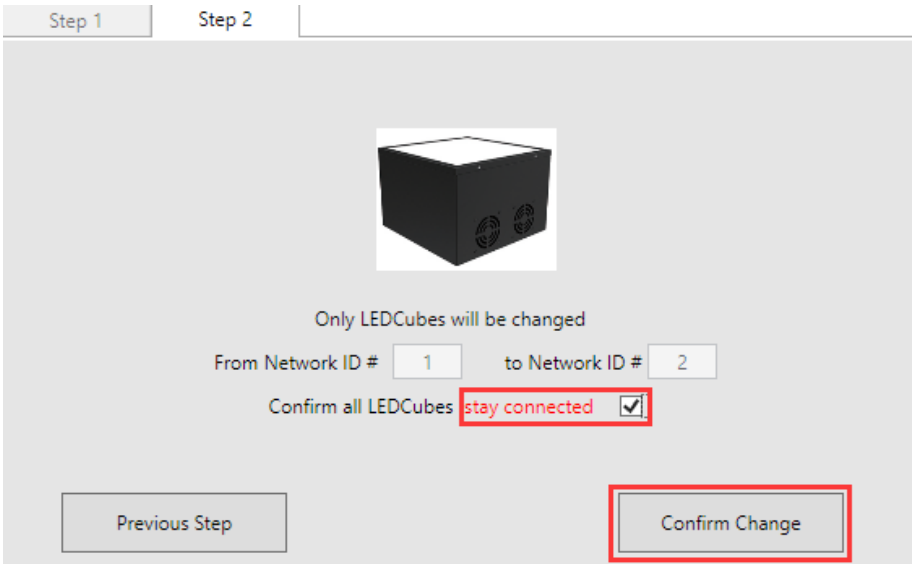
The following message will show up if the grouping finished.

5.2.3 Grouping LEDCubes only

Select the third option and set the target network ID, then press *Next Step*, as shown bellow.



In the second step, please confirm all the LEDCubes in one group stay connected and then press *Confirm Change*.



In the third step, please confirm all the LEDCubes shut down and press *Confirm Change* again.

The following message will show up if the process is finished.

6. MATCH EXAMPLE

6.1 Auto Anchored Based Match Example

In this auto anchored based match example, we will take the CIE D65, 1000lux as an example. As shown in Fig. 6.1, the procedure is described below:

1) Select the LED channels used in the optimization;
2) Select *Match Option*, we use *Increased Intensity Low* in this example;
3) Set *CCT* 6500;
4) Tick the check box of *Multi optimized choice*, user can decide to enable or disable this function;
5) Tick the check box of *Auto anchored*, set the target intensity 1000lux;
6) Press *Match*, the software will provide 8 candidate results, choose no. 1 result, because its excellent predicted performance (CCT=6496K, CIE Ra=99.1, MI=0.16, Max intensity=3778lx, see Fig. 6.2 for detail;
7) Press *Measure*, the measured result is shown in Fig. 6.3, CCT=6118K, CIE Ra=97.8, which is relatively far from predict performance;
8) Press *Feedback*, Fig. 6.4 shows the measured CCT=6502K, CIE Ra=98.9, MI=0.18, Intensity=1001lx, which is really excellent light quality;
9) Press *Save to HW…* or *Save to SW…*to save the light source to the software or LEDCube hardware, as shown in Fig. 6.5.

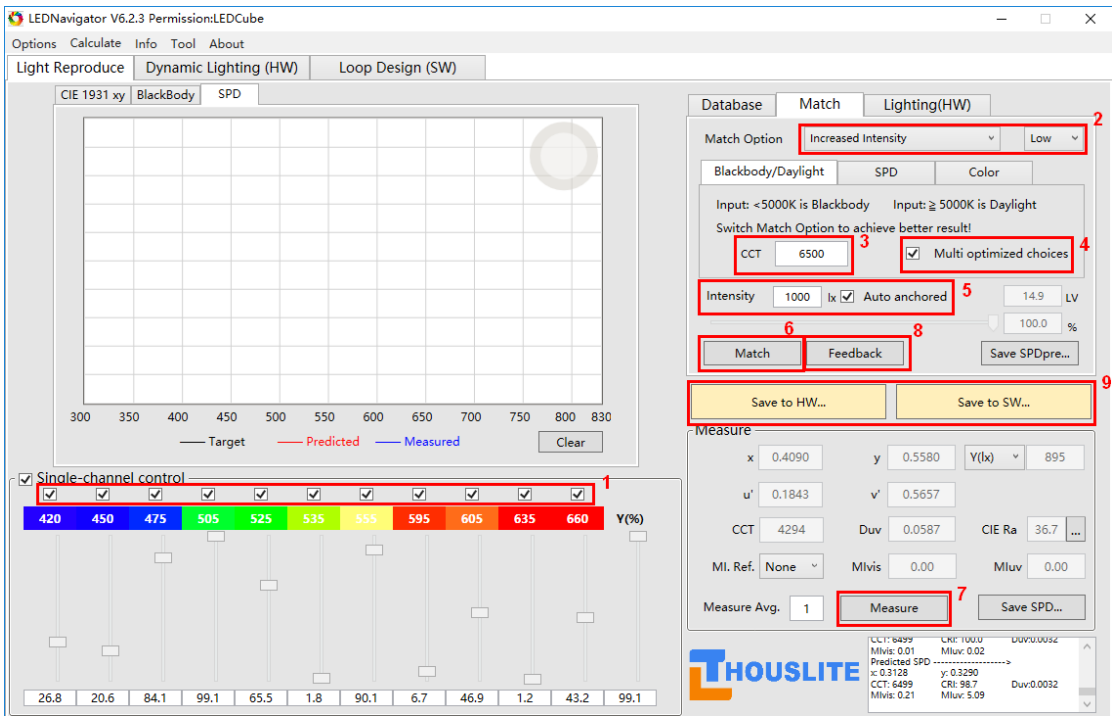


Fig. 6.1 Auto anchored based match procedure

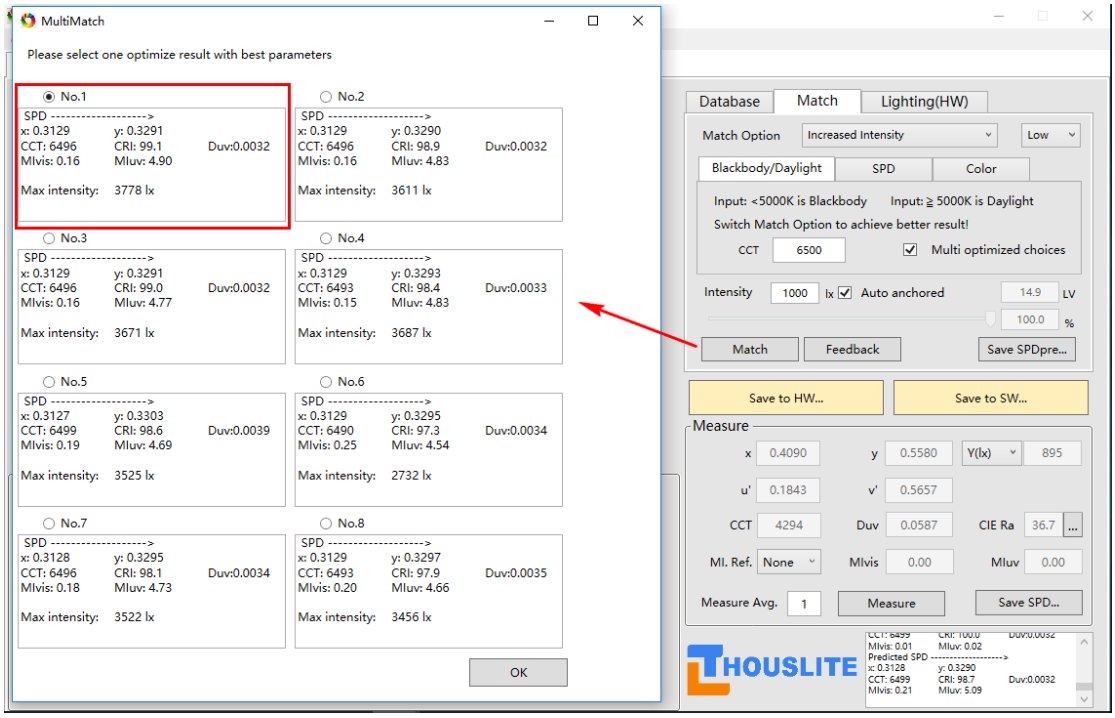


Fig. 6.2 8 candidate results

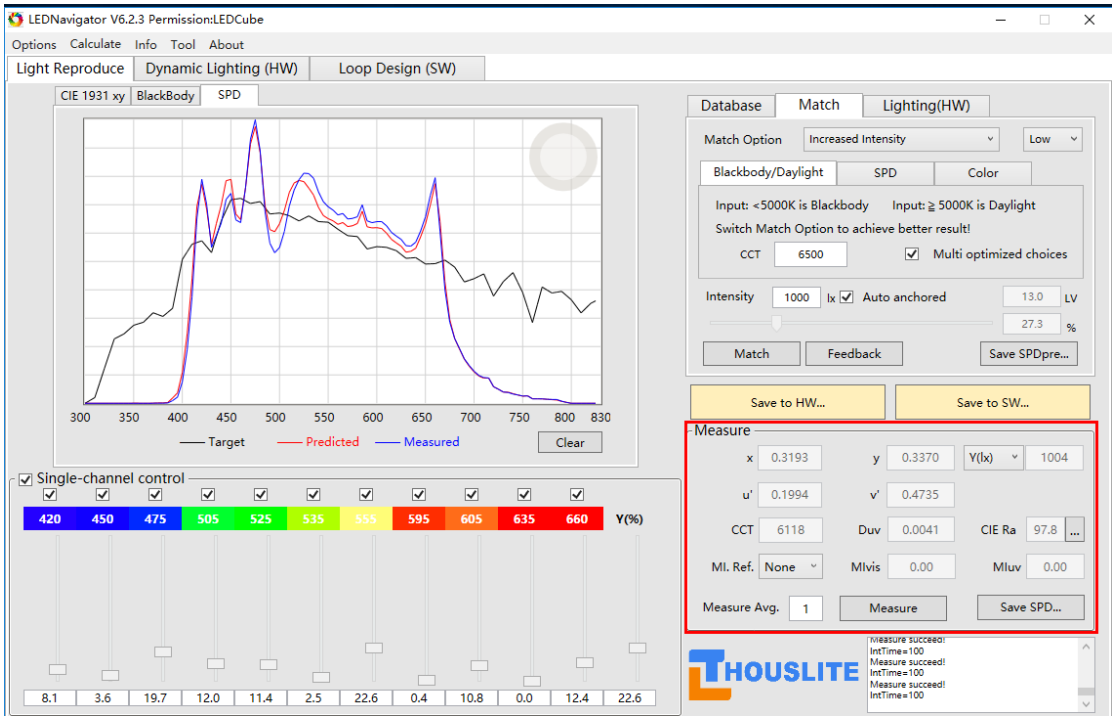


Fig. 6.3 Measured result after first measurement

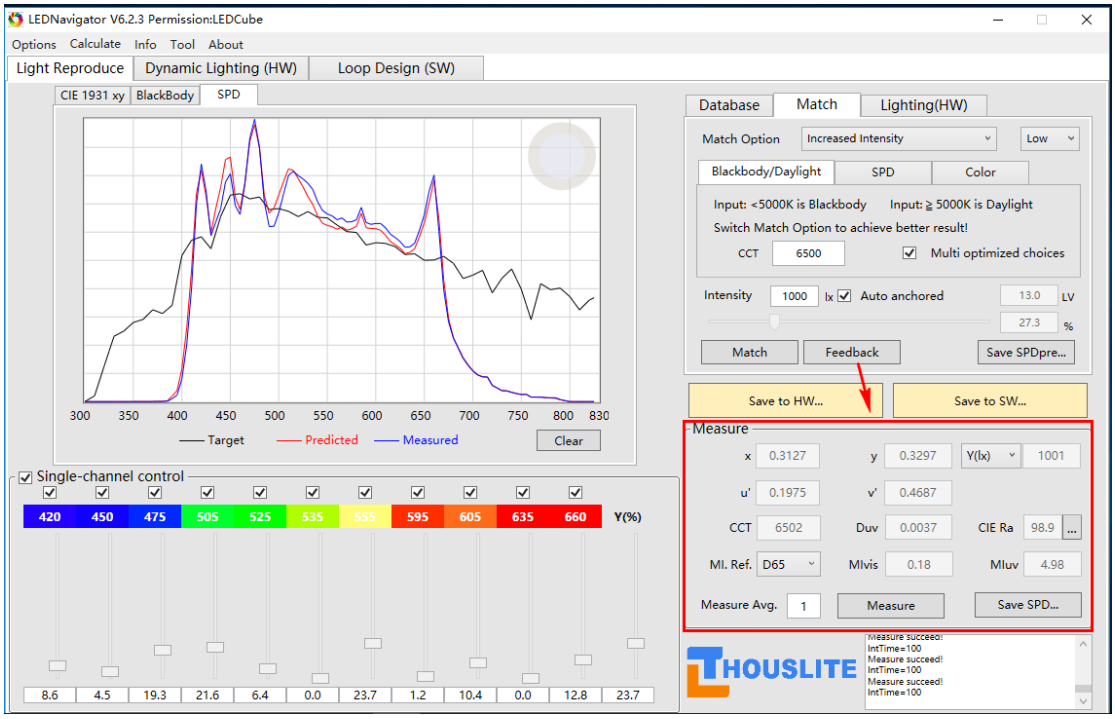


Fig. 6.4 Measured result after first *Feedback*

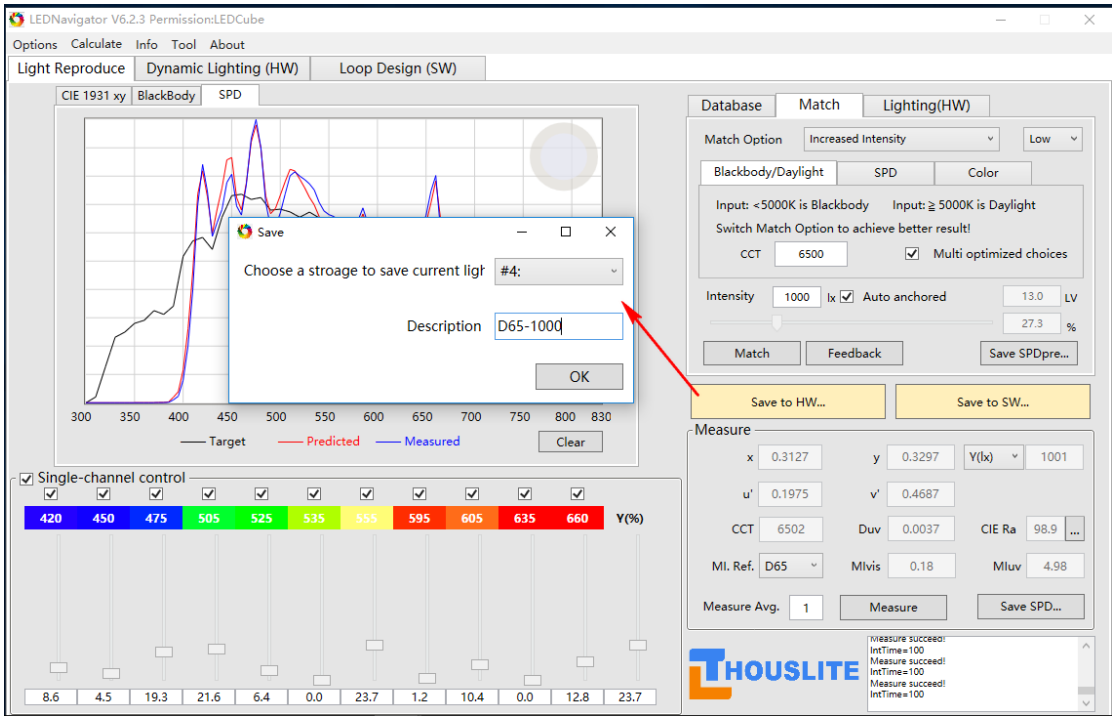


Fig. 6.5 Save the light source

6.2 Manually Intensity Adjustment Based Match Example

In this manually intensity adjustment based match example, we will take the CIE D65, 1000lux as an example. As shown in Fig. 6.6, the procedure is described below:

1) Select the LED channels used in the optimization;

2) Select *Match Option*, we use *Increased Intensity Low* in this example;

3) Set *CCT* 6500;

4) Tick the check box of *Multi optimized choice*, user can decide enable or disable this function;

5) Press *Match*, the software will provide 8 candidate results, choose no. 1 result, because its excellent predicted performance (CCT=6496K, CIE Ra=99.1, MI=0.16, Max intensity=3778lx, see Fig. 6.2 for detail;

6) Press *Measure*, the first measured result is shown in Fig. 6.6, CCT=6613K, CIE Ra=98.6, Y(lx)=3706; adjust the intensity bar to the predicted intensity close to 1000lux (986lx in Fig. 6.7), and then Press *Measure*, the measured result after first intensity adjustment is shown in Fig. 6.7, CCT=6115K, CIE Ra=97.8, Y(lx)=958lx;

7) Press *Feedback*, Fig. 6.8 shows the measured CCT=6415K, CIE Ra=99.1, Y(lx)=707; and adjust the intensity bar again to the predicted intensity close to 1000lux (1002 lx in Fig. 6.9); Press *Measure*, Fig. 6.9 shows the measured result after second intensity adjustment, CCT=6481K, CIE Ra=98.7, Y(lx)=979lx; and then increase the intensity bar (1027lx in Fig. 6.10); Press *Measure*, Fig. 6.10 shows the measured result after third intensity adjustment, CCT=6502K, CIE Ra=98.7, MI=0.19, Y(lx)=1000lx, which is really excellent light quality; If the measured CCT is far from the target after third intensity adjustment, use *Feedback* again, and adjust the intensity until the target is achieved.

8) Press *Save to HW…* or *Save to SW…*to save the light source to the software or LEDCube

hardware.

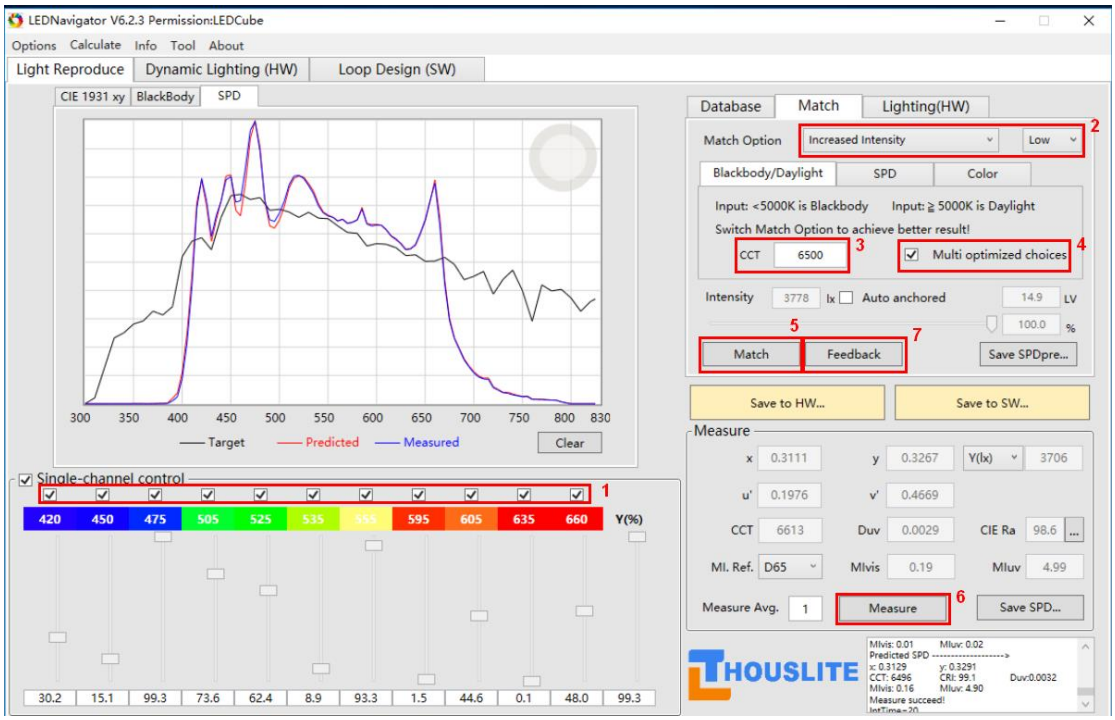


Fig. 6.6 manually intensity adjustment based match procedure

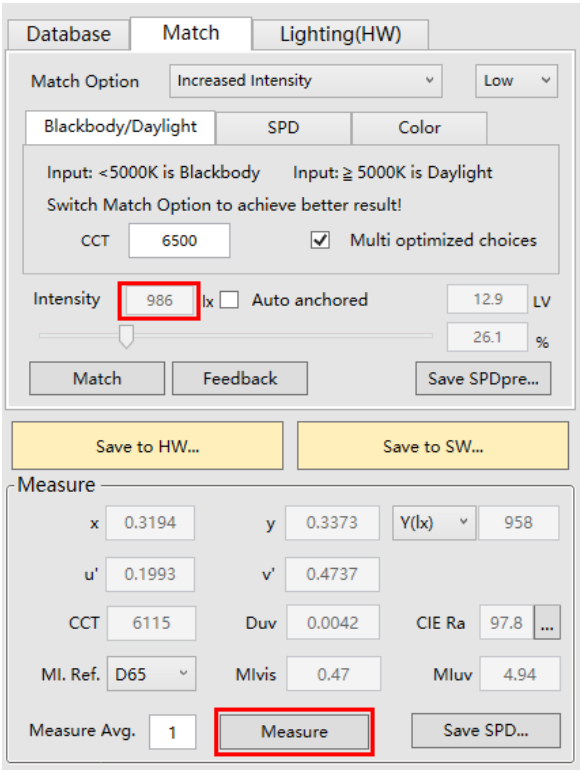


Fig. 6.7 the measured result after first intensity adjustment

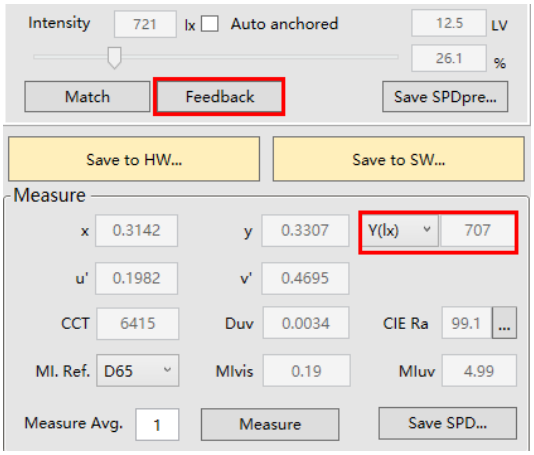


Fig. 6.8 the measured result after first *Feedback*

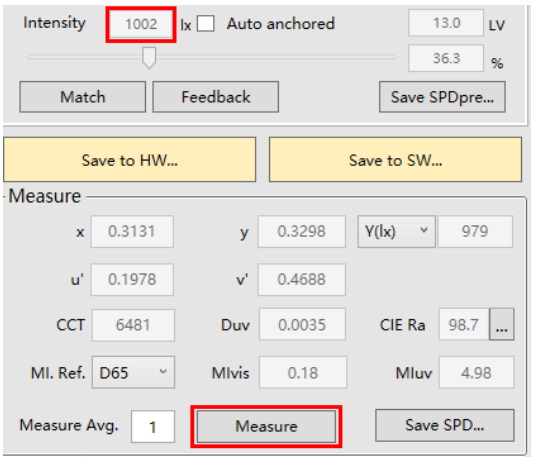


Fig. 6.9 the measured result after second intensity adjustment

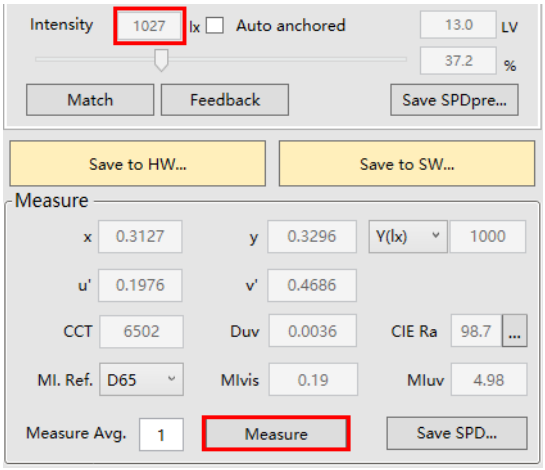


Fig. 6.10 the measured result after third intensity adjustment

6.3 SPD File Based Match Example

In this SPD file based match example, we will take *Load* SPD file as an example. As shown in Fig. 6.11, the procedure is described below:

1) Select the LED channels used in the optimization;
2) Select *SPD Type*, each option is detailed in section 4.7;
3) Press *Load…* to load the SPD file, or Press *Measured* to measure the target light.

4) Tick the check box of *Multi optimized choice*, user can decide to enable or disable this function;

5) Tick the check box of *Auto anchored*, user can decide enable or disable this function;

6) Press *Measure*;

Other steps refer to section 6.1 and 6.2.

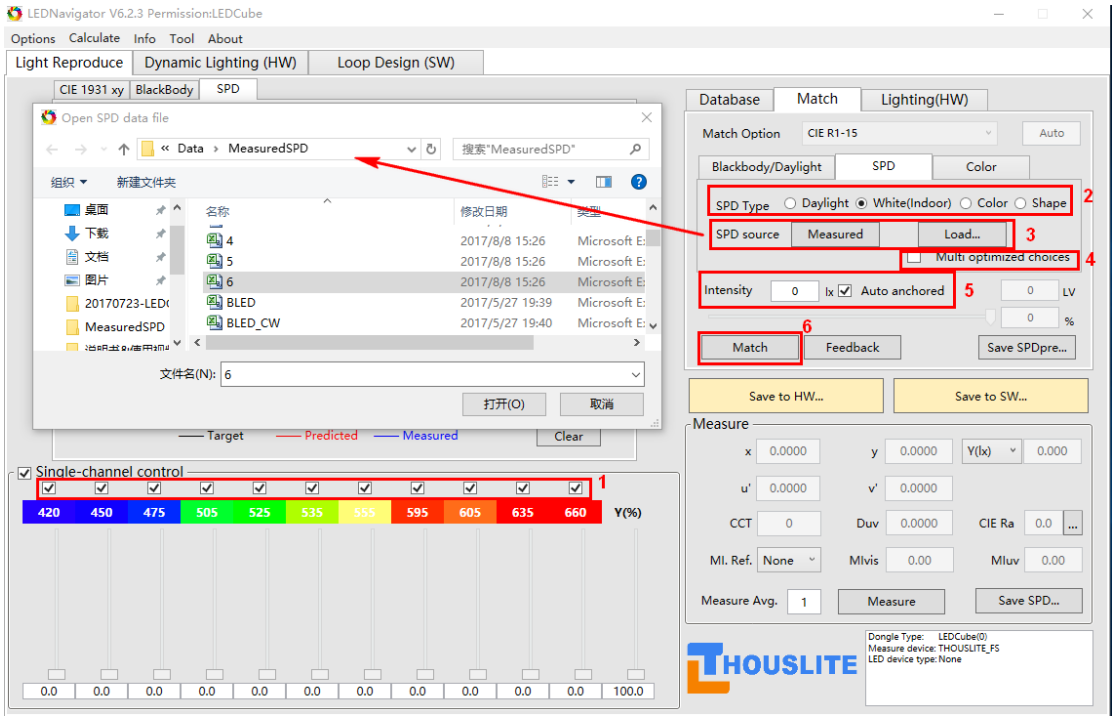


Fig. 6.11 SPD file based match procedure

7. SOFTWARE UPGRADE

In future, the software LEDNavigator-LC will be upgraded, THOUSLITE will provide the updated version of software to customers. We take the LEDNavigator V6.1.2 (current version) and LEDNavigator V6.2.4 (new version) as an example.

When users receive the new version software LEDNavigator V6.2.4, Copy all the files in the *Data* folder in the current version software LEDNavigator V6.1.2, and then replace the all files in the *Data* folder in the new version software LEDNavigator V6.2.4, resulting in the same setting as the current software (same Database, same light source name, etc).

Fig. 7.1 LEDNavigator V6.1.2 folder

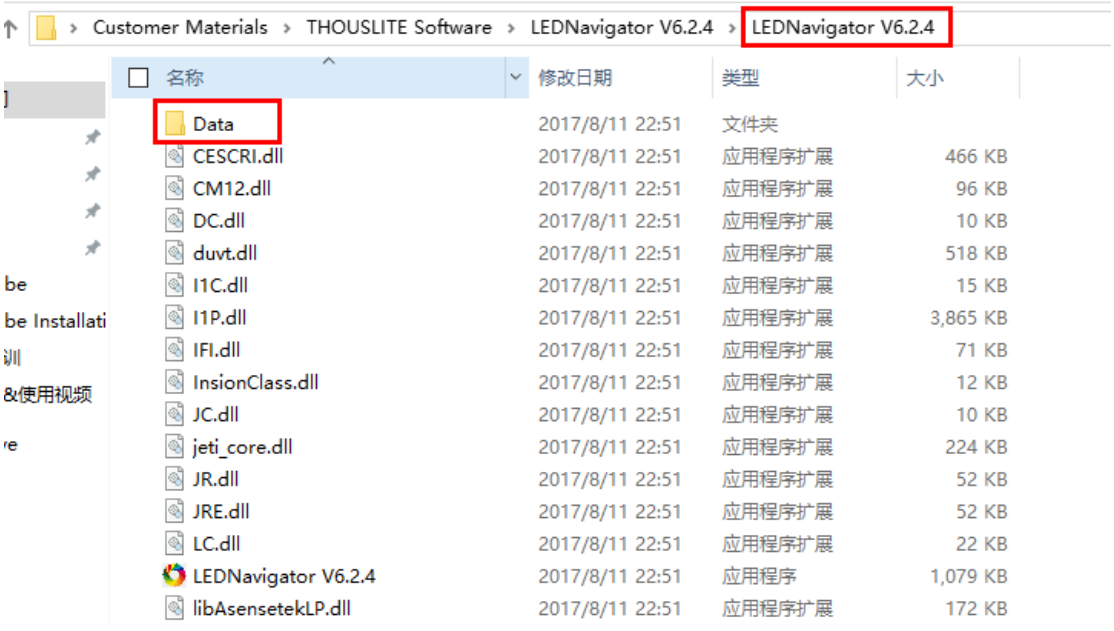


Fig. 7.2 LEDNavigator V6.2.4 folder