# SRI-RL-6000
# PAR ILLUMINANCE SPECTROPHOTOMETER

## SRI-PL-6000 Spectrometer
## Optimized for Plant Growth

### 1.3 General Description

SRI-PL-6000 spectrometer uses a compact, high-performance Czerny-Turner design allowing users accurately to test key illuminance and photometry parameters of all varieties of lamps including SSL modules, luminaires and general lighting systems. The SRI-PL-6000 is hand-held and easily portable so it can perform measurements wherever and whenever they are needed.

Parameters that can be measured include Illuminance (lx), Spectral Irradiance(mW/m$^2$), Chromaticity Coordinates CIE1931 (x,y), CIE1976 (u",v"), Correlated Colour Temperature (CCT), Dominant Wavelength (λd), Half-Width Wavelength (FWHM), Peak Wavelength (λp), Purity, PPFD and YPFD.

### 1.4 Main Features

- Compact Czerny-Turner design with a **2048 element** linear **Sony CCD array**
- Superior cosine collector using **29mm diameter integrating sphere** as light entrance port
- Collects light with **180° field of view**
- Provides accurate measurements of narrow bandwidth light sources including Specialized Grow lights
- **0.5 nm resolution** for intensity and colour (data resolution)
- **1 nm FWHW** (Full Wave Half Wave) resolution (data resolution)
- Different wavelength range variants available depending on required application:
- Standard:          **350 nm to 780 nm          (model# SRI-2000)**
- Extended:          **350 nm to 950 nm          (model#SRI-2000+)**
- UV:                    **250 nm to 850 nm          (model#SRI-2000UV)**
- 5" LCD colour touchscreen for user input and control
- Large on-board memory - up to **500,000 spectrums storage**
- Computer software analysis and data transfer via USB (mini USB port)
- Export in either Excel spreadsheet and pdf report format

## 2  Product Use

### 2.1 Battery Charging

On receipt of a new SRI-PL-6000 it may have some residual charge. However, a full charge before first use is recommended. For more details see section 4.3 regarding the Power Light Indicator colours and battery details.

For Charging, only use the provided mains adaptor and plug into the power socket on the right side of the product. Standard charging time is **6 hours** when the product is switched off, this time will increase if the product is switched on during charging. Battery life of a fully charged battery is ~**5 hours**.

### 2.2 Home Screen

The SRI-PL-6000 is Powered up by sliding the power button, boot time is ≤ **50 seconds** after which you will see the ***home screen*** as shown below:

Two selection buttons are offered on the *home screen*:

<div align="center"><b>Home Screen</b></div>

**Trans & MIX mode –** For measuring either Transmittance (Trans) or combining the spectrums of two lamps (MIX).

**Grow Light mode –** For immediate measurement of a Grow Light and all associated parameters as LED illuminance and photometry parameters.

### 2.3 **Grow Light Measurement**

*Grow Light function* immediately calculates all parameters commonly used in agricultural and horticultural applications. From the *Home Screen* select the 'Grow Light' button and the **Grow Light Screen** will display as below:
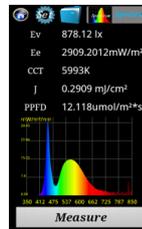
**Grow Light Screen**

Measurements are made immediately on entering Grow Light mode and the *Grow Light Screen* will display the following parameters:

- Ee     -  lluminance (lx)
- Ev     - Spectral Irradiance (mW/m$^2$)
- CCT    - Correlated Colour Temperature
- J      - Energy Density (mJ/cm$^2$)
- PPFD   - Photosynthetic Photon Flux Density (µmol/m$^2$ *s)
- YPFD   - Yield Photon Flux Density (umol/m2*s)

*Grow Light Screen* contains the following buttons:

 **Home button** – returns user to *Home Screen*

 **Set button** – access to settings, read on for more details

 **Folder button** – for saving data or retrieving old data (see section '2.6 Saving and retrieving data')

 **Measure button**   re-measures lighting conditions

 **Current display and change display dropdown selector**   indicates current display mode.

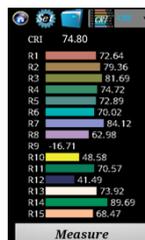Selecting this button will display the following dropdown menu:



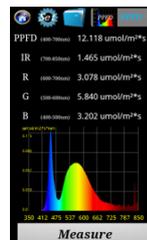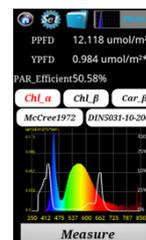From the dropdown menu, the following screens can be accessed:

**a) Data**     **b) CRI**     **c) PPFD**     **d) Photosynthesis**



a) **Data screen** displays a list of key photometric parameters, scroll to the bottom to view all
b) **CRI screen** displays 'Colour Rendering Index', R1 R15
c) **PPFD screen** displays the full PPFD (Photosynthetic Photon Density, 400 nm to 700 nm) along with IR, Red, Green, and Blue wavelength ranges. Also R(red) / IR, and R / B(blue) ratio.
d) **Photosynthesis screen** displays the measured spectrum overlaid with a selectable plot (in white colour) of absorption spectrums for **Chl-α (chlorophyll a), Chl-β (chlorophyll b), Car-β (β-Carotene)** as well as the **McCree1972** and **DIN5031-10-2000** standards.

## 2.4 Transmittance Function

Transmittance function enables the user to determine the transmittance of a translucent object or medium, referred to below as the **transmittance object**, using a light source of their choice. The Field of View of the light collector is 180° so stray light should be considered when performing this measurement.

From the *home screen* select the 'Trans & MIX' button. This displays the following *transmittance test screen*:
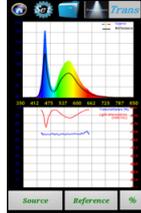


**Transmittance Screen**

From the *transmittance screen* the user has the following options:

 **Home button** – returns user to *Home Screen*

 **Set button** – access to settings, read on for further details

 **Folder button** – for saving data or retrieving old data (see section '2.6 Saving and retrieving data')

 **Current mode and change mode selector** – indicates the current measurement mode.
Selecting this button will change the measurement mode to 'Mix' mode (see section '2.4 Combined spectrums    Mix')

 **Source button**    to measure source as reference (i.e. without *transmittance object* present)

 **Reference button** – to complete transmittance calculation press this button after placing *transmittance object* above light collector and using the same light source in the same configuration and orientation

 **Percentage button** – displays percentage raw data in 0.5 nm steps. Pressing again will revert to *transmittance screen*

The transmittance function test has 2 steps:

**Step 1**



**Step 2**
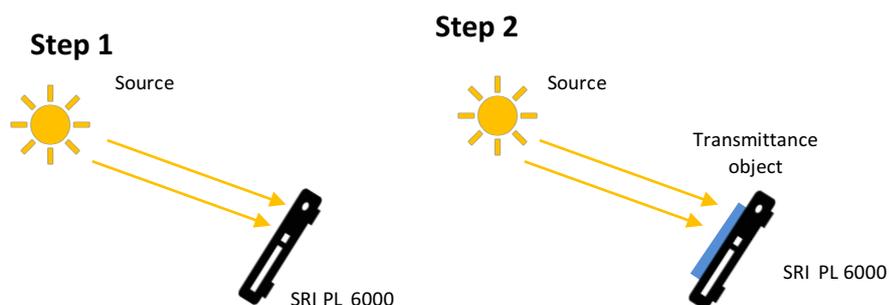
1. Source is measured without *transmittance object*
Press *Source button* once SRI-PL-6000 is in the correct position relative to the source making sure there is >10cm between source and the device.

2. Measurement is performed with the source observed through the *transmittance object.*
Press *Reference button* to complete transmittance measurement.
On completion of Step 2 the device will calculate the difference between step 1 and step 2 spectral measurements and display the results, see below for an example **transmittance results screen:**
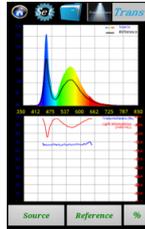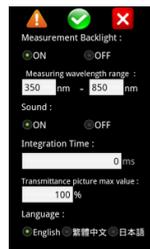


**Transmittance Results Screen**

The left-hand results axis (blue) shows the Transmittance as percentage of light from the source.
The red results axis (red) shows the light attenuation in mW/m$^2$.
Use *Set button* to change the settings, below is the **Transmittance Settings Screen**:
(note that the *settings screen* is different for each measuring mode)



**Transmittance Settings screen**

*Transmittance Settings Screen* allows the user to change the following settings:
**Measurement backlight** – turns off LCD screen backlight while performing measurements
**Measuring wavelength range** – must select within the limits of the purchased device
**Sound** – controls the sound when touching buttons on touch screen
**Integration time** – if set to '0' this sets the integration time to "automatic"
**Transmittance picture max value** – the max percentage value for graph (left-hand vertical axis)
**Language** allows selection between languages, English
Settings will be saved and will remain in place even when the device is powered down.

**2.5 Mix Function (combined spectrums)**
*Mix function* enables the user to calculate the result of combining two spectrums from two different light sources. Both light sources should be measured from >10cm away.
From the *Home Screen* first select the 'Trans & MIX' button to bring up the *Transmittance Screen*. From the *Transmittance Screen* select the *Trans button* and the following **Mix Mode Screen** will display:
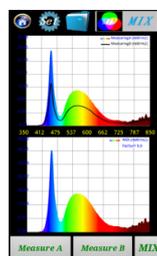
## Mix Mode Screen

*Mix mode screen* contains similar buttons to the *Transmittance Screen*.

**Home button** – returns user to *Home Screen*

**Set button** – access to settings, read on for further details

**Folder button** – for saving data or retrieving old data (see section '2.6 Saving and retrieving data')

**Current mode and change mode selector** indicates the current measurement mode.
Selecting this button will change the measurement mode to transmittance mode (see section '2.3 Transmittance measurement')

**Measure A button** – measures first source

**B button** – measures second source

**Mix button** – combines the two spectrums on the lower graph

To perform a mix calculation each source is measured one after the other using the Measure A (for measuring **Source A**) and Measure B (for measuring **Source B**) buttons. The calculation follows the following formula:

MIX = Measure A + (Measure B * Magnification factor)

*Set button* is used to change the settings and brings users to the following **mix settings screen**:
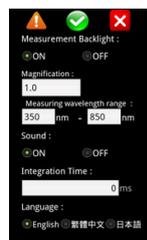
Device Information
see section 2.7

Save Settings

Cancel

**Mix Settings Screen**

*Mix Settings Screen* allows the user to change the following:
**Measurement backlight** – turns off LCD screen backlight while performing measurements
**Magnification** Magnification factor, multiplies *Source B* input by inputted value

**New select** – selects previously saved settings (can be deleted using the 'trash' icon)
**Save File** – save settings, new filename can be inputted. Clicking the 'disk' icon will save the information.
**Ev**, **Ee**, **PPFD**, **YPFD** – Controls multiplier for each parameter
**Sound** – controls the sound when touching buttons on touch screen
**Spectral scale mW max value** – controls maximum value of the y-axis
**Language** – allows selection between languages

**Measuring wavelength range**   must select within the limits of the purchased device



**Sound** − controls the sound when touching buttons on touch screen

**Integration time** − if set to '0' this sets the integration time to automatic

**Language** − allows selection between languages

Settings will be saved and will remain in place even when the device is powered down.

Use *Set Button* to change the settings, below is the **Grow Light Settings screen**:

**Measurement type –** select between a single spot measurement or continuously updated. Note that when 'Continuous' is select spectrum will not be displayed and only *Grow Light screen* can be viewed.

**Measurement Backlight**   turns off LCD screen backlight while performing measurements. Backlight can only be turned off when using 'Single' *measurement type* (see above).

**J Sets the exposure seconds** − only available using 'Continuous' *measurement type.* '0' sets the device to automatic update.

**Auto save file name** − not available on my device

**Delay time**   not available on my device

**End time**   not available on my device

**Measuring wavelength range** − defaults to the limits of the device. If an out of range selection is made an error message will show and the selection shall revert to the default range

**2.6 Saving and Retrieving Data**
For any of the measurement modes data can be saved using the *folder button*
Which brings up the following screen **Saving and Retrieving Screen**



 Save
Settings

 Cancel
discard changes

**Saving and Retrieving Screen**

**Saving**

Select the **Save File** button, this will open the **File Name** text entry box. Any name can be chosen using the pop up keyboard. Selecting the **Save Settings** button will save data with the selected file name.

**Retrieving**

Select **Load File** button, previously saved data files can then be selected from the list. In the example screen above the only previously saved data has the name 'MeasureData 0001.csv'.

Selecting the  button from any *Settings Screen* displays detailed device information including serial

number and software versions.
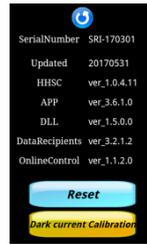


The **Reset** button can be used to revert back to factory default settings.

The **Dark current calibration** button should be used if readings spectrum is not smoothly curve, especially in 350-380 nm, or after 780 nm. Then the collector cap should be in place before performing the calibration.

# 3 Interfacing with a PC

## 3.1 Software Installation

1) Insert  USB flash drive into a USB port on the PC  and open the flash drive in Windows folder explorer. The following window will display:

2) Double-click on the *dotNetFx40_Full_x86_x64.exe* application file and accept the installation request

3) After the installation is complete, connect the *SRI-PL-6000* to the PC using the mini USB cable included in the pack and power on the device

4) Go back to the flash drive folder, and double-click *Data Recipients_ver_3_3_1_1.exe* (note that the numbers of this file change depending on the version that is being installed)

5) Double-click on the above icon to open the 'Data Recipients' software. This software enables data on the USB connected *SRI-PL-6000* to be viewed and downloaded. See next section (3.2) for further details.

Note that the 'Data Recipients' software can only be opened if the *SRI-PL-6000* is connected to the PC via USB and powered on.

## 3.2 Data Handling and Report Generation

Opening the 'Data Recipients' software will open the following screen:

Selecting *Data Type* in the toolbar provides the following options:

- Transmittance – saved data from *Transmittance mode* and *Mix mode*
- LED Plant Light Spectrometer   saved data from *Grow Light mode*

The File List will update with all files saved on the device. Clicking on the desired filename will highlight the filename and display the saved data and associated spectrum.

Selecting *File* in the toolbar provides the list below  for  saving  selected  or  all  data.  A printable  report  can  also  be  generated  by  selecting *Print Report*
.

## 4.1 Specifications

| | Property | Description |
|---|---|---|
| **Physical** | Detector Type | Compact Czerny-Turner design |
| | Sensor array | 2048 element linear Sony CCD array |
| | Cosine collector | 6.6 ± 0.1mm aperture<br>29mm diameter integrating sphere |
| | Measurable distance | >10cm |
| | Display | 5" color LCD touchscreen, 400x800 resolution |
| | Data output port | Mini USB 2.0 |
| | Size (LWH) | 200mm x 92mm x 30mm |
| | Weight | 660g ± 20g |
| **Photometry** | Wavelength range[1] | Standard: 380nm to 780nm<br>Extended: 350nm to 850nm<br>UV: 250nm to 780nm |
| | Wavelength accuracy | ± 0.3nm |
| | Resolution | 0.5nm |
| | FWHM | 1nm |
| | Illuminance range | 10 lx to 50,000 lx or<br>50 lx to 250,000 lx |
| | Illuminance accuracy | ± 2%<br>± 4% |
| | Color accuracy | x,y: ± 0.0015 (Source A / other light source) |
| | Color repeatability | x,y: ± 0.001 (illuminance at > 200 lx) |
| | CCT accuracy | ± 1% / ± 2% (CIE 1931) |
| | CRI accuracy @ Ra | ± 0.8% / ± 1.5% (CIE 1931) |

| | | |
|---|---|---|
| | Stray ight | 0.001% |
| | Exposure time | 1 to 4,000 ms |
| | Capture mode | Single/Continuous |
| | Digital resolution | 16 bit |
| **Software** | Data output format | CSV (compatible with Microsoft Excel) |
| | Data storage | Up to 500,000 files stored on device |
| **Operating** | Temperature range | 0°C to 35/50°C |
| | Battery life | 3/5 hours, 3000/3500 mAh |
| | Charging time[2] | 6 hours |

## 4.2 Measurable Parameters

The following parameters can be measured using the SRI-PL-6000:

1. Illuminance
2. Luminance
3. Spectral Irradiance
4. mW/m2
5. Peak Wavelength(
6. Dominant Wavelength
7. CCT – Corelated Color Temperature
8. CRI – Color Rendering Index, R1-R15
9. Chromaticity x,y Coordinates (CIE 1931)
10. Transmittance
11. PPFD – Photosynthetic Photon Flux Density
12. YPFD – Yield Photon Flux Density

## 4.3 Power Light Indicator and Battery Maintenance

When the SRI-PL-6000 is turned on the Power Indicator Light will have one of the following colors:

| ON | Good Battery | Low Battery |
|---|---|---|
| **Not Charging** | Green | Cyan |
| **Charging** | Yellow | White |

When the SRI-PL-6000 is turned off, the Power Indicator Light will only be illuminated when charging:

| OFF | Good Battery | Low Battery |
|---|---|---|
| Not Charging | - | - |
| Charging | Red | Blue |

The battery used is Li-ion which does not suffer from memory effect so it can accept regular charging. The user does not need to wait for low battery indication before charging.

Generally, it is always good to keep the battery well charged, as soon as the Power light Indicator shows low battery the device should be charged immediately to avoid damage to the battery.

The device should also not be left in direct sunlight as this will shorten the life of the battery and could lead to battery overheating and exploding.

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