

# **OL Series 770 and OL Series 771 Multi-Channel Spectroradiometer**

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**Applies to OL 77X Application Software (C000114)  
Application Version: 6.12  
CD Version: 130626  
and later.**



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# OL Series 770 and OL Series 771 Multi-Channel Spectroradiometer

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## INTRODUCTION

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The OL Series 770 Multi-Channel Spectroradiometer is a high-speed spectral measurement tool for a variety of scientific and industrial applications. The OL 770 is an array-based multi-channel spectroradiometer with an internal spectrograph, detector, and all control electronics housed in one rugged, portable enclosure. The OL 770 Multi-Channel Spectroradiometer is completely computer controlled via either RS-232 or Universal Serial Bus (USB) interface. The included Windows®-based OL 770 Application Software provides for all setup, measurement, data, and control functions. The user-friendly software is Microsoft® Word and Microsoft® Excel® compatible. An ActiveX® control is available for custom programming.

The internal spectrograph of the OL 770 is based on an aberration corrected, concave, flat field grating. The precision optics of the spectrograph delivers low stray light, high spectral resolution, and excellent wavelength accuracy. The standard grating operates over the 380 nm to 780 nm wavelength range. Other wavelength range gratings are available for the ultraviolet and near infrared regions. Optical input into the spectrograph is made via fiber optic connector. An interchangeable slit is provided in the entrance port on the front panel of the OL 770. The standard slit size is 100 microns (0.10 mm). Other slit sizes are available for varying the optical bandwidth.

OL 771  
☞

The OL 771 Multi-Channel Spectroradiometer is a high-speed, photodiode array based version of the OL 770. The OL 771 is specifically designed for fast spectroradiometric measurement of high-brightness LEDs. Differences in the use, performance and application software for the OL 771 are noted throughout this manual.

InGaAs  
☞

The OL 770 InGaAs Multi-Channel Spectroradiometer is a high-speed, two channel, photodiode array based version of the OL 770. The OL 770 InGaAs is specifically designed for accurate measurements of NIR LED and other NIR sources. Differences in the OL 770 InGaAs are noted throughout this manual.

*OL Series 770 Multi-Channel Spectroradiometer  
Shown with Optional Accessories*



## DESCRIPTION

The OL Series 770 Multi-Channel Spectroradiometers include a spectrograph, thermoelectrically cooled CCD array sensor (standard configuration), internal reference lamp<sup>1</sup>, power supply, and control electronics packaged in a convenient, portable enclosure. The spectrograph is factory aligned for optimum spectral performance and calibrated for wavelength, total spectral flux and averaged spectral intensity – conditions A & B<sup>2</sup>. The internal reference lamp will enable the end user to perform routine system calibrations and create new calibration files for each LED package and holder used with the integrating sphere.

Light from the various optical accessories (integrating sphere, luminous intensity receptor or goniometer) is transmitted to the OL 770 via a fiber optic connection. The standard fiber optic provided with the OL 770UV/VIS, OL 770VIS and OL 770VIS/NIR is a 1-meter long by 3-mm diameter fiber bundle. Gooch & Housego can provide other types and sizes of fiber optic probes to meet the particular application. Contact the factory for further information.

The front panel consists of the power switch, LED status indicators, and connection to the internal reference tungsten lamp source. The Optical Input Port has a removable collar holding the 1 meter long fiber optic and interchangeable slit. The user interchangeable slit is placed between the fiber optic ferrule and the entrance port to the internal spectrograph.

The OL 770UV/VIS Multi-Channel Spectroradiometer employs a 190 nm to 800 nm optimized f/2 concave diffraction grating with a dispersion of 24 nm/mm. Second order diffraction components are removed using a linear variable long wavelength pass filter.

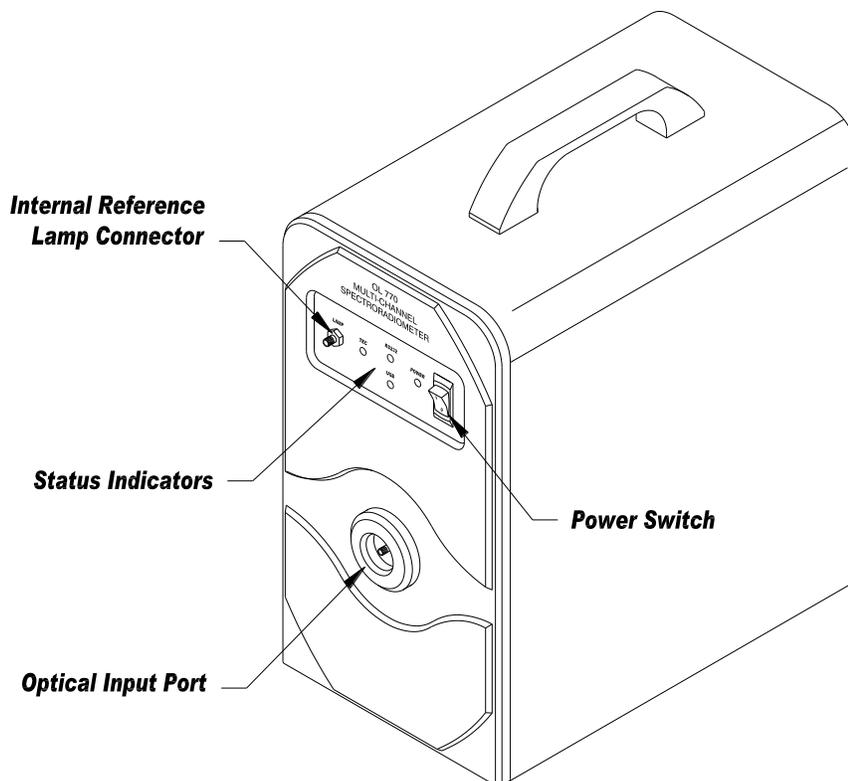
The OL 770VIS Multi-Channel Spectroradiometer employs a 380 nm to 780 nm optimized f/2 concave diffraction grating with a dispersion of 16.7 nm/mm.

The OL 770VIS/NIR Multi-Channel Spectroradiometer employs a 380 nm to 1100 nm optimized f/2 concave diffraction grating with a dispersion of 30 nm/mm. Second order diffraction components are removed using a linear variable long wavelength pass filter.

**OL 771**  The OL 771 Multi-Channel Spectroradiometer employs a 380 nm to 780 nm optimized f/2 concave diffraction grating with a dispersion of 16.7 nm/mm.

**InGaAs**  The OL 770 InGaAs Multi-Channel Spectroradiometer employs a 850 nm to 1700 nm optimized f/2 concave diffraction grating with a dispersion of 70.75 nm/mm.

*OL Series 770 Multi-Channel Spectroradiometer*



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<sup>1</sup> Some OL Series 770 Multi-Channel Spectroradiometer systems do not include the internal reference lamp.

<sup>2</sup> CIE 127-1997 Measurement of LEDs.

## OL SERIES 770 HIGH-SPEED TEST AND MEASUREMENT SYSTEMS

The OL Series 770 High-Speed Test and Measurement Systems are specially packaged versions of the OL 770 that includes accessories specifically for measuring various photometric, radiometric and colorimetric properties of LEDs, displays, etc. Each turnkey system includes all the hardware and software (except for a PC) for the following measurements:

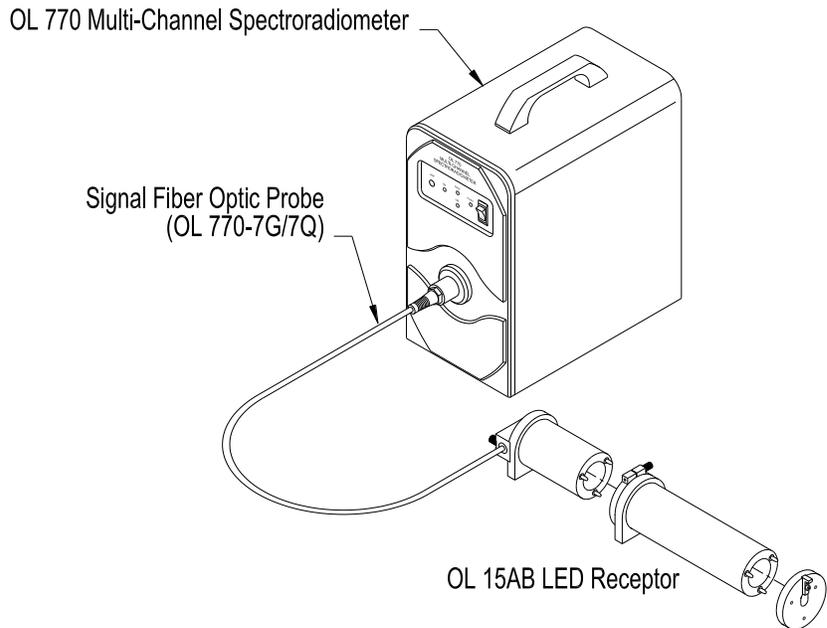
- total spectral flux [W/nm]
- total luminous flux [lm]
- spectral purity
- spectral bandwidth (FWHM)
- peak wavelength
- spectral radiant intensity [W/sr nm]
- averaged LED intensity [cd]
- dominant wavelength
- color temperature
- color rendering indices

### The OL Series 770 Configured for Averaged LED Intensity / Spectral Radiant Intensity Measurements

The OL Series 770 includes an OL 15AB LED Receptor so that averaged LED intensity measurements can be made per CIE publication 127 guidelines for Conditions A and B.

The OL 15AB Cal Adapter is also included for system calibration with the internal reference lamp.

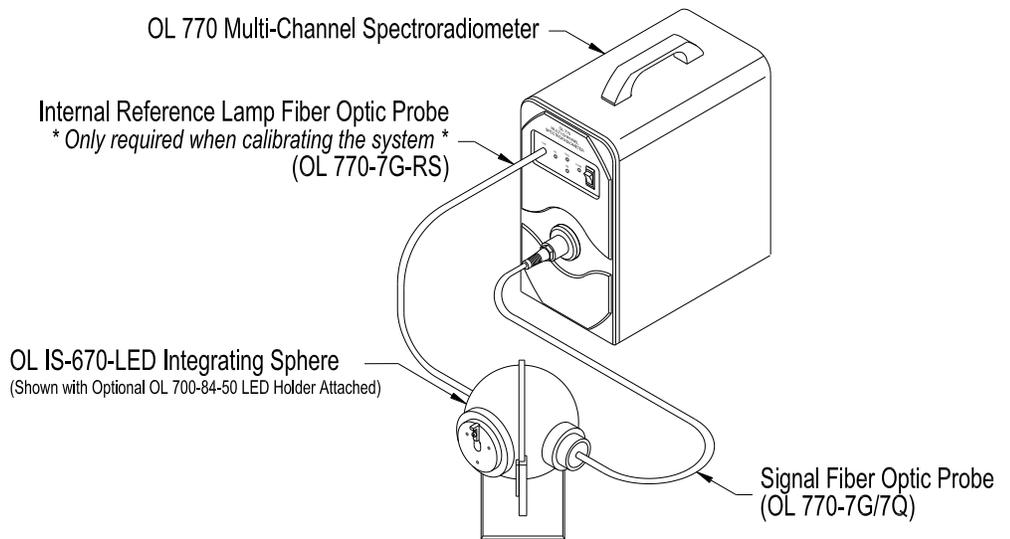
In addition to calculating the averaged LED intensity & radiant intensities of the LED with each spectral measurement the application software also calculates the radiant spectral bandwidth, peak wavelength, dominant wavelength, 60 chromaticity values and 15 color rendering indices.



### The OL Series 770 Configured for Total Luminous Flux / Total Spectral Flux Measurements

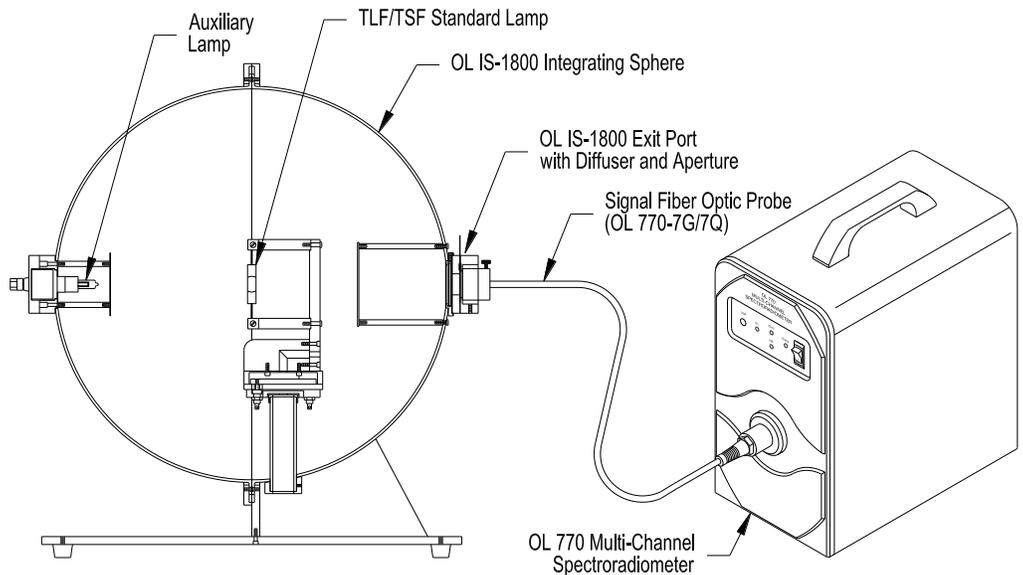
The OL Series 770 also includes an OL IS-670-LED Integrating Sphere for total luminous and spectral flux measurements of LEDs and small sources.

A unique feature of the OL 770 is its internal reference lamp, which allows the user to quickly and conveniently recalibrate the system using a second fiber optic probe shown. This is especially important since the OL IS-670-LED can be calibrated for use with a specific LED and LED holder in place. Thus, higher accuracy measurements are achieved since this effectively compensates for changes due to differences in LED package, holder geometries, and self-absorption.



The OL 770 Multi-Channel Spectroradiometer can also be configured for Total Luminous and Spectral Flux measurements with a larger integrating sphere. Gooch & Housego offers a variety of larger spheres such as the model OL IS-1800 18-inch, OL IS-3900 39-inch, or OL IS-7600 76-inch diameter integrating spheres.

These spheres use a NIST-traceable calibration standard (Gooch & Housego's model numbers OL 245-TSF or OL 220-TSF) and an internal auxiliary lamp to perform accurate system response calibrations for a variety of test lamps. Thereafter, the OL 770 spectroradiometer can perform accurate measurements on a test lamp's photometric, radiometric, and color parameters.

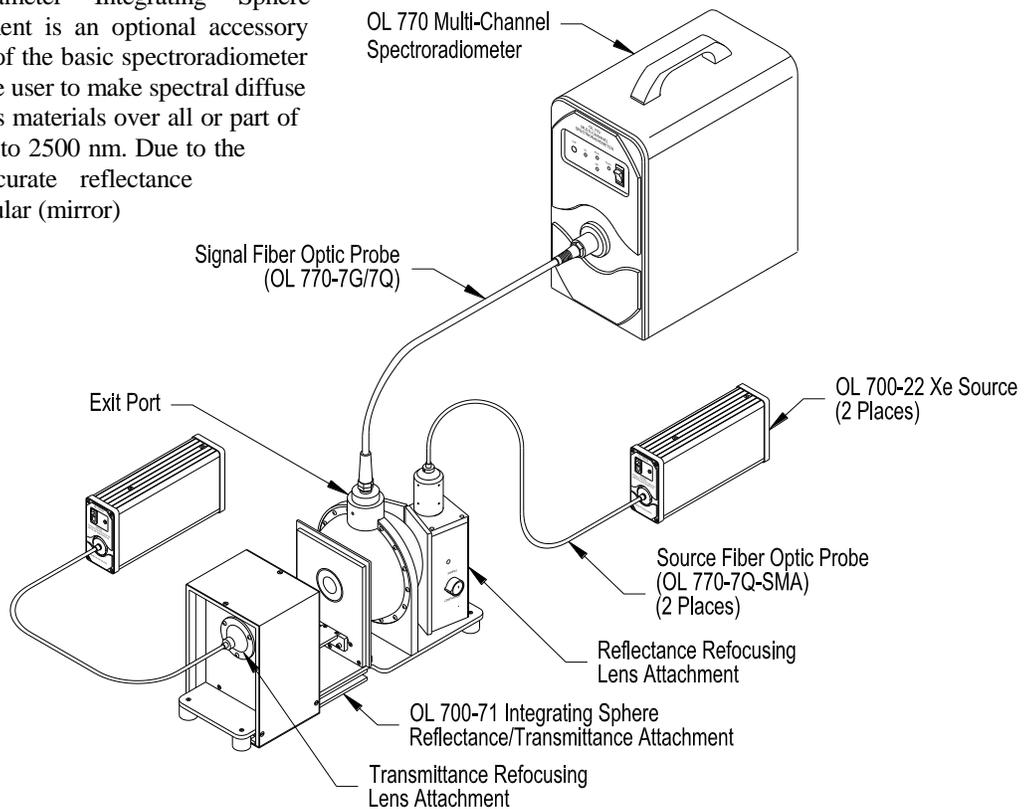


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**The OL Series 770 Configured for Total and Diffuse Reflectance/Transmittance Measurements**

The OL 700-71 6-Inch Diameter Integrating Sphere Reflectance/Transmittance Attachment is an optional accessory designed to enhance the versatility of the basic spectroradiometer measurement system by enabling the user to make spectral diffuse reflectance measurements of various materials over all or part of the wavelength range from 250 nm to 2500 nm. Due to the sophisticated optical design, accurate reflectance measurements can be made of specular (mirror) samples with the specular component included or excluded. Transmittance measurements can be made on a wide variety of sample materials and sizes.

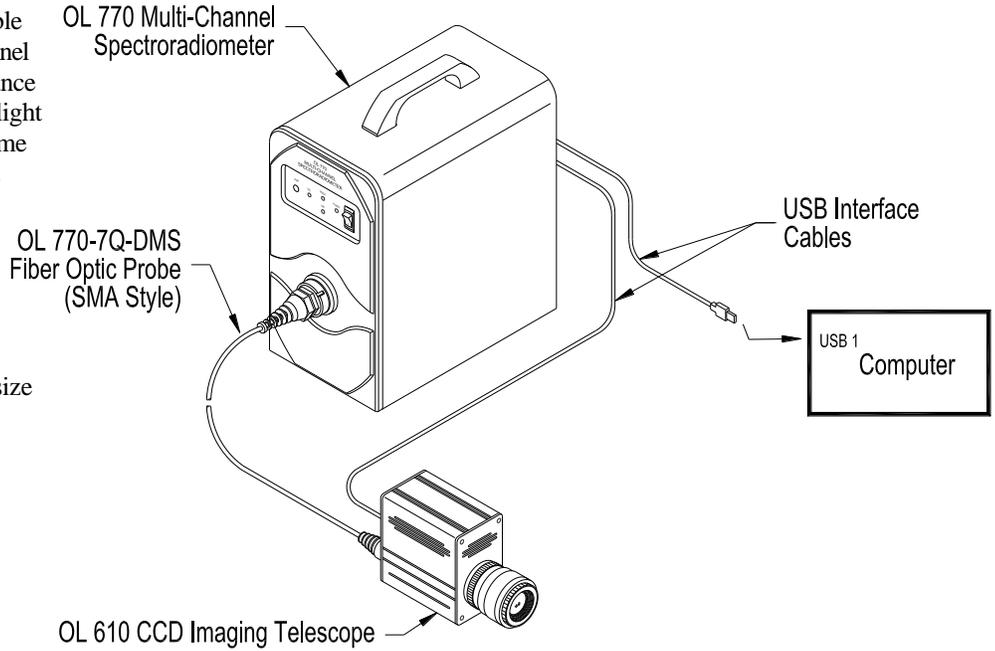
The OL 700-71 is designed to use fiber optics for the optical coupling to the spectroradiometer system, which creates the flexibility allowing the sphere to be positioned in remote locations simplifying the testing of large samples. The light beam from either input fiber optic is coupled into the integrating sphere via a Refocusing Lens Attachment and imaged at the sample port's aperture.



P001882

The OL Series 770 Configured for Spectral Radiance Measurements

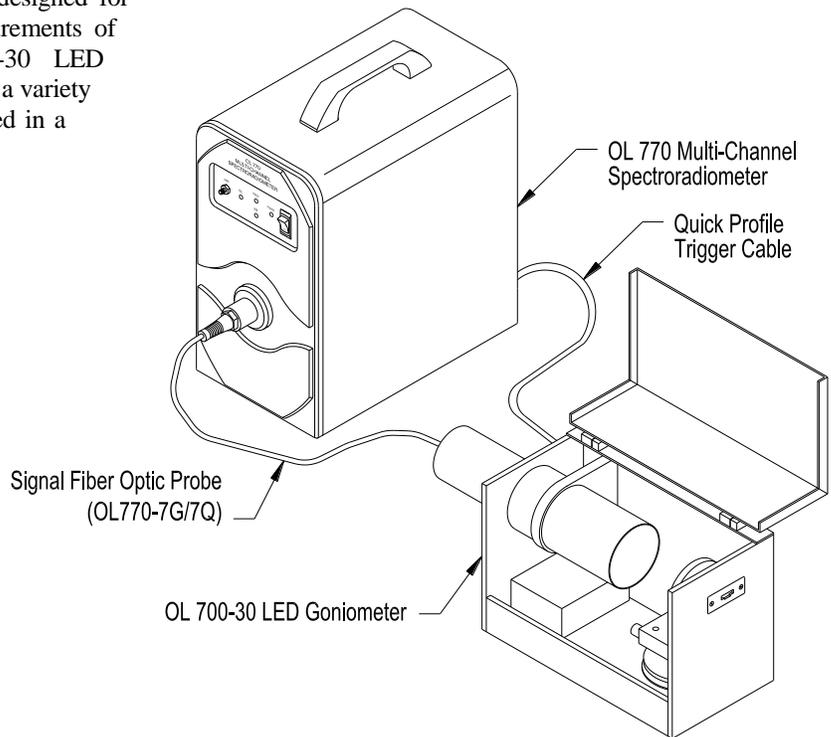
The OL 610 CCD Imaging Telescope is an optional accessory designed to enable the OL Series 770 Multi-Channel Spectroradiometer make spectral radiance measurements on displays or other light sources. The OL 610 provides real-time viewing of the measurement spot and surrounding image area for focus and alignment. The OL 610 is small and portable for use in both laboratory and manufacturing environments. A variety of field-of-view apertures and objective lenses are available to meet specific spot size and working distance requirements.



P001528D

The OL Series 770 Configured for Goniometric Measurements

The OL 700-30 LED Goniometer accessory is designed for performing automated spatial distribution measurements of LEDs and miniature lamps. The OL 700-30 LED Goniometer can be used to characterize sources in a variety of angle dependent measurements and is packaged in a small, fully enclosed, lightweight design.



P001390C

## **SPECIFICATIONS**

### OL 770UV/VIS Spectrograph General Specifications

Wavelength Range (standard)	200 nm to 780 nm
Wavelength Accuracy	± 0.75 nm
Optical Bandwidth (with 100 micron slit minimum binning)	3.5 nm
Spectral Resolution	0.6 nm
Slits (user interchangeable)	100 micron (standard) 50 micron, 200 micron, and 350 micron (optional)
Optical Focal Length	140 mm
Optical Aperture	f/2
Spectrograph Input Optics (standard OL 770-7Q)	3 mm $\phi$ x 1 meter UV-grade fused silica fiber optic probe

### OL 770VIS Spectrograph General Specifications

Wavelength Range (standard)	380 nm to 780 nm
Wavelength Accuracy	± 0.5 nm
Optical Bandwidth (with 100 micron slit minimum binning)	3.0 nm
Spectral Resolution	0.4 nm
Slits (user interchangeable)	100 micron (standard) 50 micron, 200 micron, and 350 micron (optional)
Optical Focal Length	140 mm
Optical Aperture	f/2
Spectrograph Input Optics (standard OL 770-7G)	3 mm $\phi$ x 1 meter glass fiber optic probe

### OL 770VIS/NIR Spectrograph General Specifications

Wavelength Range (standard)	380 nm to 1100 nm
Wavelength Accuracy	± 1.0 nm
Optical Bandwidth (with 100 micron slit minimum binning)	5.0 nm
Spectral Resolution	0.75 nm
Slits (user interchangeable)	100 micron (standard) 50 micron, 200 micron, and 350 micron (optional)
Optical Focal Length	140 mm
Optical Aperture	f/2
Spectrograph Input Optics (standard OL 770-7G)	3 mm $\phi$ x 1 meter glass fiber optic probe

### OL 770 InGaAs Spectrograph General Specifications

Wavelength Range (standard)	850 nm to 1700 nm
Wavelength Accuracy	± 1.0 nm
Optical Bandwidth (with 100 micron slit minimum binning)	10 nm
Spectral Resolution	1.8 nm
Slits (user interchangeable)	100 micron (standard) 50 micron and 200 micron (optional)
Optical Focal Length	140 mm
Optical Aperture	f/2
Spectrograph Input Optics (standard OL 770-7G)	1 mm $\phi$ x 1 meter glass fiber optic probe

### OL Series 771 Spectrograph General Specifications

Wavelength Range (standard)	380 nm to 780 nm
Wavelength Accuracy	± 0.5 nm
Optical Bandwidth	2.0 nm
Spectral Resolution	0.4 nm
Slits (user interchangeable)	100 micron (standard) 50 micron and 200 micron (optional)
Optical Focal Length	140 mm
Optical Aperture	f/2
Detector Technology	photodiode array
Spectrograph Input Optics (standard OL 771-7G)	1.5 mm $\phi$ x 1 meter glass fiber optic probe

## OL Series 770 Detector

Detector Technology .....	TE-cooled back-thinned 2-dimensional CCD array (other detectors optional)
Detector Cooling Temperature.....	-10 °C
Quantum Efficiency .....	> 90 % at 650 nm

## OL Series 770 System

Operating Temperature .....	0 °C to 30 °C
Operating Humidity .....	0 % to 90 % non-condensing
Chromaticity Accuracy (OL 770VIS only).....	± 0.002 x, y
Chromaticity Repeatability (temp. stabilized blue LED) (OL 770VIS only).....	± 0.00015 x, ± 0.0002 y
Integration Time .....	.20 ms to 600 s 1 ms to 60 s (InGaAs)
A/D Resolution.....	16 bits
A/D Rate.....	250 kHz
Power Input .....	100/115/230 VAC, 0.75/0.75/0.5 A, 50/60 Hz
Interface.....	USB, RS-232
Dimensions.....	7 ¼" (18.4 cm) W x 13 ¼" (33.6 cm) H x 13" (33.0 cm) D
Weight .....	22.5 lbs. (10.2 kg)

## OL Series 770 Optional Internal Reference Lamp (OL 700-20-X)

The OL 700-20 Internal Reference Lamp provides an easy and accurate means to maintain the OL 770 calibration accuracy, and is especially useful when performing total spectral flux measurements utilizing the OL IS-670-LED as it allows for compensation of spectral self-absorption properties of the devices positioned at the sphere measurement port. The source consists of a well regulated power supply operating a 5-watt tungsten lamp in constant current mode. A separate 600 µm fiber is supplied for coupling the lamp to the input optic utilized for measurement of the test devices.

Lamp type.....	5-watt tungsten halogen lamp
Calibration Range:	
OL 770UV/VIS .....	380 nm to 780 nm (only)
OL 770VIS .....	380 nm to 780 nm
OL 770VIS/NIR .....	380 nm to 1100 nm
Calibration Options:	
OL 700-20U .....	Uncalibrated
OL 700-20-1 .....	Calibrated for use with OL 15AB
OL 700-20-2 .....	Calibrated for use with OL IS-670-LED
OL 700-20-3 .....	Calibrated for use with OL 15AB and OL IS-670-LED
Stability .....	Better than 0.1 % / hour
Fiber Optic Probe (OL 770-7G-RS).....	600 µm diameter x 1.5 meter glass fiber bundle, SMA 905 terminated

## OL Series 770 InGaAs Optional External Reference Lamp (OL 700-20-X)

The OL 770 InGaAs External Reference Lamp provides an easy and accurate means to maintain the OL 770 calibration accuracy, and is especially useful when performing total spectral flux measurements utilizing the OL IS-670-LED as it allows for compensation of spectral self-absorption properties of the devices positioned at the sphere measurement port. The source consists of a 5-watt tungsten lamp mounted in a small heatsink assembly that installs on the OL IS-670-LED Auxiliary Lamp Port. The lamp connects via a cable to a 2-pin connector on the front panel of the OL 770 InGaAs. Power for the lamp is supplied by a well regulated, constant current mode, power supply inside the OL 770 InGaAs.

## OL Series 771 Optional External Reference Lamp (OL 701-20-X)

The OL 771 External Reference Lamp provides an easy and accurate means to maintain the OL 771 calibration accuracy, and is especially useful when performing total spectral flux measurements utilizing the OL IS-671-LED as it allows for compensation of spectral self-absorption properties of the devices positioned at the sphere measurement port. The source consists of a 9-watt tungsten lamp mounted in a small heatsink assembly that installs on the OL IS-671-LED Auxiliary Lamp Port. The lamp connects via a cable to a 2-pin connector on the front panel of the OL 771. Power for the lamp is supplied by a well regulated, constant current mode, power supply inside the OL 771.

**OL 770 Application Software Features**

- ◆ Real-time graphics utility
- ◆ Data input into custom Excel and Word templates
- ◆ Display, log, and store resultant data
- ◆ Auto save data in Text, Word or Excel files.
- ◆ Comparison cursors
- ◆ Cursor snap to peak / valley
- ◆ Expandable CIE high resolution plots
- ◆ Value monitor with pass & fail settings
- ◆ UV calibration utilities for OL 770UV/VIS
- ◆ Accumulation graphs for time studies
- ◆ Tristimulus- 2° XYZ, 10° XYZ
- ◆ 1931 Chromaticity- 2° xyz, 10° xyz
- ◆ 1960 Chromaticity- 2° uv, 10° uv
- ◆ 1976 Chromaticity- 2° u'v', 10° u'v'
- ◆ Lab Luv- Illuminants A,B,C,D65; 2° Labuv; 10° Labuv
- ◆ CRI (Color Rendering Index)
- ◆ Full spectral measurements at all goniometric angles
- ◆ Polar plots of intensity and chromaticity values

**OL 770-15Q Optional Neutral Density Filter Holder**

Mounting ..... Installs onto OL 770 Optical Input Port using a supplied locking collar

Input Port ..... Accepts standard OL Series 770 FOP

Filter Size ..... 1.00 inch (25.4 mm) diameter, 0.13 inch (3.5 mm) max. thickness

Dimensions ..... 2.0 inches (5.0 cm) Diameter x 3.31 inches (8.4 cm) Long

Weight ..... 13 oz. (0.37 kg)

**OL 770-15Q-A Optional Automated Neutral Density Filter Holder**

Operating Temperature ..... 0 °C to 30 °C

Operating Humidity ..... 0 % to 90 % non-condensing

Power Input ..... External 12 VDC / 800 mA main adapter (supplied)

Interface ..... USB

Mounting ..... Installs onto OL 770 Optical Input Port using supplied two-piece adapter

Input Port ..... Accepts standard OL Series 770 FOP

Filter Size ..... 1.00 inch (25.4 mm) diameter, 0.13 inch (3.5 mm) max. thickness

Number of Filter Positions ..... 5 total (OPEN plus 4 filters max.)

Internal Focusing Optics: ..... UV-grade quartz lenses

Optical Ratio (input port to exit port)..... 1:1 imaging

Filter Positioning Time (adjacent position)..... 0.8 second

Dimensions ..... 4.63 inches (11.8 cm) W x 6.50 inches (16.5 cm) H x 3.90 inches (9.9 cm) D

Weight ..... 3.3 lbs. (1.5 kg)

**NOTE:**

For a listing of optional optical accessories, refer to Appendix E.

OL 770 Packaged Systems for LED Measurement (380 nm to 780 nm)

OL 770 Model #	OL 770XX	Software	OL IS-670-LED	OL 15AB	Internal Ref. Source	OL 700-30
OL 770VIS-LED-3	OL 770VIS	OL 770-423-LED	✓	✓	OL 700-20-3	
OL 770VIS-LED-1	OL 770VIS	OL 770-423-LED		✓	OL 700-20-1	
OL 770VIS-LED-2	OL 770VIS	OL 770-423-LED	✓		OL 700-20-2	
OL 770VIS-LED/G-3	OL 770VIS	OL 770-423-LED	✓	✓	OL 700-20-3	✓
OL 770VIS-LED/G-1	OL 770VIS	OL 770-423-LED		✓	OL 700-20-1	✓

OL 770 Packaged Systems for LED Measurement (200 nm to 780 nm)

OL 770 Model #	OL 770XX	Software	OL IS-670-LED	OL 15AB	Internal Ref. Source	OL 700-30
OL 770UV/VIS-LED-3	OL 770 UV/VIS	OL 770-423-LED	✓	✓	OL 700-20-3	
OL 770UV/VIS-LED-1	OL 770 UV/VIS	OL 770-423-LED		✓	OL 700-20-1	
OL 770UV/VIS-LED-2	OL 770 UV/VIS	OL 770-423-LED	✓		OL 700-20-2	
OL 770UV/VIS-LED/G-3	OL 770 UV/VIS	OL 770-423-LED	✓	✓	OL 700-20-3	✓
OL 770UV/VIS-LED/G-1	OL 770 UV/VIS	OL 770-423-LED		✓	OL 700-20-1	✓

OL 770 Packaged Systems for LED Measurement (380 nm to 1100 nm)

OL 770 Model #	OL 770XX	Software	OL IS-670-LED	OL 15AB	Internal Ref. Source	OL 700-30
OL 770VIS/NIR-LED-3	OL 770VIS/NIR	OL 770-423-LED	✓	✓	OL 700-20-3	
OL 770VIS/NIR -LED-1	OL 770VIS/NIR	OL 770-423-LED		✓	OL 700-20-1	
OL 770VIS/NIR -LED-2	OL 770VIS/NIR	OL 770-423-LED	✓		OL 700-20-2	
OL 770VIS/NIR -LED/G-3	OL 770VIS/NIR	OL 770-423-LED	✓	✓	OL 700-20-3	✓
OL 770VIS/NIR -LED/G-1	OL 770VIS/NIR	OL 770-423-LED		✓	OL 700-20-1	✓

OL 770 Packaged Systems for Display Measurement

OL 770 Model #	OL 770XX	Spectral Range (nm)	Software	OL 610-1.0	OL 610-L-100	Internal Ref. Source
OL 770VIS-DMS	OL 770VIS	380 to 780	OL 770-423	✓	✓	No
OL 770VIS/NIR-DMS	OL 770VIS/NIR	380 to 1100	OL 770-423	✓	✓	No

OL 770 Packaged System for Night Vision Display Test and Measurement

OL 770 Model #	OL 770XX	Spectral Range (nm)	Software	OL 620-NVS	Objective Lens	Internal Ref. Source
OL 770-NVS	OL 770VIS/NIR	380 to 1100	OL 770-423-NVS	✓	✓	No

## OL 770 FRONT PANEL CONTROLS AND INDICATORS

### Power Switch

Push to apply power to the OL 770 after connecting to the appropriate AC voltage supply.

### Power Indicator

Glow red when power is applied to the unit.

### RS232 Indicator

When RS232 communication is being utilized, glows red for receive mode and green for transmit mode.

### USB Indicator

When USB communication is being utilized, glows red for receive mode and green for transmit mode.

### TEC Indicator

Lamp does not light during initial cool down of CCD sensor when power is first applied to the unit. After several seconds, the indicator will glow green indicating that the CCD sensor has reached its stable operating temperature.

#### IMPORTANT:

If the lamp glows red at any time other than during startup, then the cooler has failed. Turn off power to the OL 770 and consult the factory for service information.

### LAMP Connector

#### (OL Series 770)

This is an SMA905 fiber optic connection to the internal reference lamp source. Connect this lamp to the OL IS-670-LED integrating sphere with the SMA fiber to calibrate the system for Total Spectral Flux (TSF) or to the OL 15AB LED Receptor for spectral radiant intensity calibration. The lamp may also be used as a source for transmittance and reflectance measurements with the appropriate optional accessories

*Front Panel Controls and Indicators*



OL 771



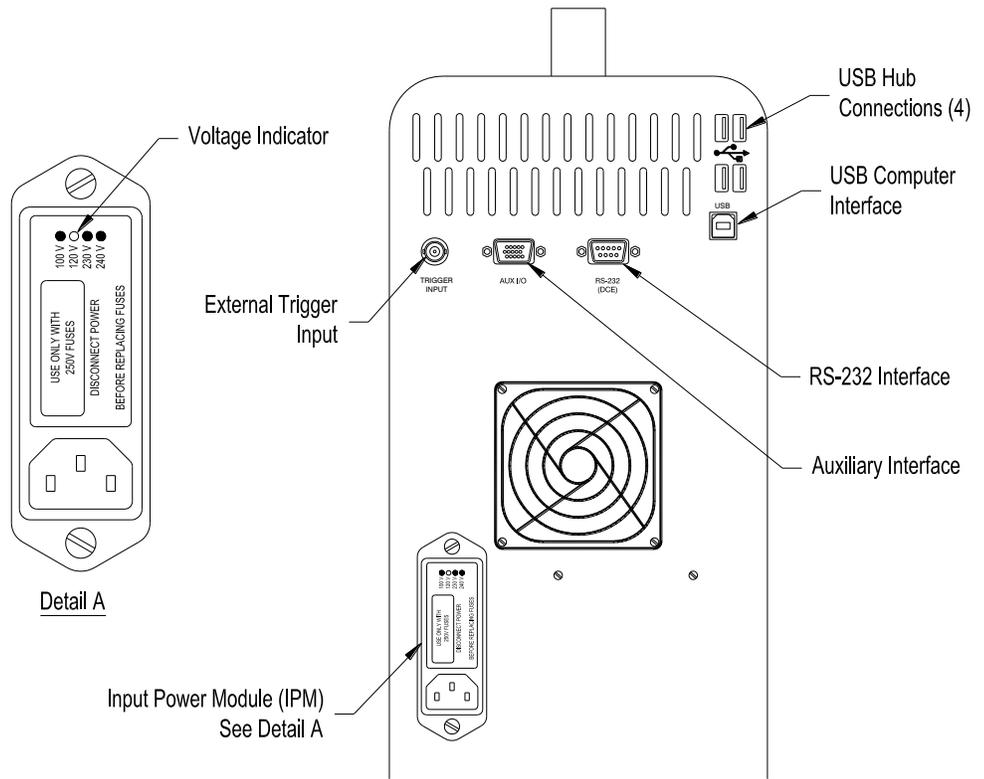
#### (OL Series 771 & OL 770 InGaAs)

**InGaAs** This is a 2-pin connector that provides power to the reference lamp source. Connect to the OL IS-671-LED Integrating Sphere reference lamp via the supplied cable (OL IS-670-LED for OL 770 InGaAs).



## OL 770 REAR PANEL CONNECTIONS

The rear panel has two communications connectors: one that provides for USB (recommended) interface to the computer, and one for the RS232 interface to the computer. Additionally, there are four USB Hub Connectors for use with various OL 770 accessories that require USB interface. The power cord is connected to the Input Power Module (IPM).



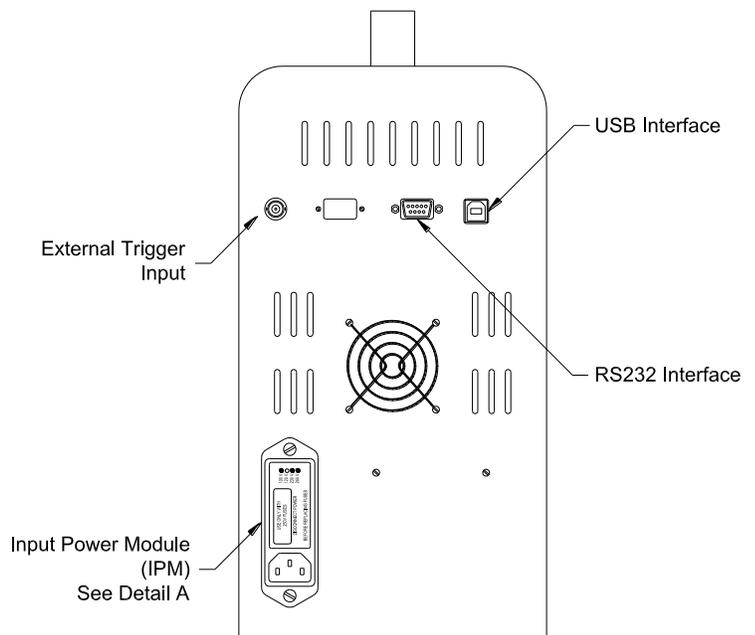
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### \* Notice \*

**OL 771** The OL Series 771 and older versions (listed below) of the OL 770 Multi-Channel Spectroradiometer rear panel do not include a USB hub or internal USB flash drive. With these versions, the USB accessory is connected to your computer instead of the rear of the OL 770.

Versions of OL 770 that do not include a USB hub:

- ◆ OL 770UV/VIS Rev 207 or lower
- ◆ OL 770VIS Rev 208 or lower
- ◆ OL 770VIS/NIR Rev 209 or lower



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### Internal USB 2.0 Compliant Hub and USB 2.0 Flash Drive

The OL 770 has been equipped with a seven port bus powered USB 2.0 compliant hub and a 512 megabyte USB 2.0 flash drive. The USB 2.0 hub will add convenience to the operation of the OL 770 instrument. Four ports are available for connection to Gooch & Housego's accessories (i.e. OL 700-30 Goniometer, OL 770-15QA Automated ND Filter Wheel, OL 610 CCD Imaging Telescope, etc). The 512 megabyte USB 2.0 flash drive is installed in the OL 770 chassis for operation through the USB hub. This flash drive is permanently mounted in one of the USB ports accessible only from within the chassis. Two other USB hub ports are only accessible from within the chassis, one is for the OL 770 instrument and the other is a spare port.

### Internal USB 2.0 Compliant Hub

After connection of a computer to the OL 770 USB connector, several devices will be detected by the Windows operating system as a new device after the USB 2.0 hub has completed the enumeration. First time operation of the device will require the Windows operating system to load the necessary drivers to operate the USB hub and flash drive components. The operating system may also load drivers for the OL 770 as well as any other devices connected to the OL 770 downstream USB connectors.

### Internal USB 2.0 Flash Drive

The flash drive will appear in Windows Explorer as a system Removable Disk resource. The drive letter assignment will vary depending on the number of available system drive resources. In the event the Windows operating system assigns a conflicting drive letter to the USB flash drive, the Administrative Tools may be used to manually correct the conflict. To change the USB flash drive letter, access the Windows Control Panel, then select Administrative Tools > Computer Management > Storage > Disk Management. From the frame on the right side of the window, select the flash drive that needs to be changed. This can be done from the list at the top right corner. Highlight the drive to be changed, right click on the selected item, and select Change Drive Letter and Path. Select Edit from the Change Drive Letter and Path window. Select an appropriate drive letter from the Assign a Drive Letter list. Once the drive assignment is selected the Flash Drive will be assigned that drive letter provided it is used with the same PC. If another flash drive of the same type is operated on the system it has the potential to assume that drive assignment as well.

The USB 2.0 flash drive may be used to store copies of system sensitive files such as OL 770 configuration files (.cfg), calibration files (.cal), and standard files (.std and .st7). Additionally, template files and any other data required to increase the portability of the OL 770 system outside of a local network may be included on the USB flash drive. Multiple OL 770 system operation within the same network is also more convenient.

Since the USB 2.0 hub is bus powered, power available to each port is limited by the downstream port power limit. If the OL 770 is connected to the root hub of the PC, the OL 770 will have 100 mA per port maximum, 500 mA total. Any attempt to exceed this current limit will result in Windows USB power limit violation. This may also result in a hardware shutdown of the USB port from the current protection limit responsible for the overload.

Operation of the OL 770 hub from a separate bus powered hub is not possible. This will cause the same Windows power violation described above. Operation of OL 770 hub is possible from a powered hub. The USB system should be 2.0 compliant to obtain the optimum performance from the USB flash drive and any other USB 2.0 devices connected to the OL 770 hub. Operation is possible from the USB 1.1 system, however, the user should be aware of the reduced performance. You may be prompted to select High Speed USB port for best performance.

### OL 770 Application Software Automatic Detection of OL 770 Flash Memory

As of version 4.2 of the OL 770 application software, the software now supports automatic setting storage and detection from the OL 770 Flash Memory. This allows the user to carry the OL 770 from computer to computer and maintain all the settings necessary for operation such as wavelength coefficients, calibration files, and report templates. Since there can be multiple USB Flash drives on a computer system, a method is needed to distinguish the flash located inside the OL 770. This is done through the OL770Flash.txt file. If this file is located on the Flash drive, the OL 770 Application Software will recognize it as an OL 770 specific flash drive. This file need not contain any information, just the detection of the existence of the file is all that is necessary. If more than one flash drive on the computer is detected with this file, the application will choose the first one found. Running the OL 770 application software at this point will cause the OL 770 to detect the Flash drive. If there is a file named default.cfg on the Flash, the OL 770 Application Software will attempt to load those settings. Depending on the settings, it may load appropriate CFG, CAL, XLT, or DOT files from the Flash as well. If the Save Settings to Flash on Exit is selected under the Modified Setting Dialog/Flash Tab, the application will automatically store any configuration changes out to the Flash drive back to the default.cfg file. If any pertinent files (XLT, DOT, CAL, STD, etc.) are linked to the hard drive, the application software will prompt the user to reroute these links and files to the flash drive if configured so under the Modified Setting Dialog/Flash tab. For advanced users who edit the default.cfg file, you will notice that file links located on the flash drive are denoted with a drive designation \$. This informs the application that the file is located on the flash. This prevents the application from assigning a specific drive for the flash, which might change from computer to computer depending on how the operating system wishes to assign it.

It is possible to use a flash with the OL 770 on an older OL 770 that doesn't support the new internal flash. To create a flash for the OL 770 to be recognized by the OL 770 Application Software, do the following:

1. Create a file called OL770Flash.txt on the Flash drive. (An empty file is fine.)
2. Run the OL 770 Application Software with the flash drive connected to your computer. This will cause the application to detect the flash drive but load settings from the registry.
3. Ensure the Save Settings to Flash on Exit is selected under the Modified Settings Dialog/Flash tab is checked.
4. Exit the OL 770 Application Software. You should be prompted with a message saying that pertinent files are linked to the hard drive and would you like to copy them and link them to the flash. Answer yes.

At this point, the flash will be set up. If you view the flash drive from the file explorer, you will see the new files that have been copied over. Now, whenever you execute the software, make sure the flash is plugged in beforehand. The system will behave like a newer OL 770 with an internal flash drive.

## GETTING STARTED

The OL 770 Multi-Channel Spectroradiometer has been designed to be a user-friendly measurement tool, in addition to being a highly accurate and dependable scientific instrument. But to maintain the integrity of the unit, it is imperative that particular steps are followed in the setting up process.

### STEP 1 – VERIFY OL 770 VOLTAGE SELECTION

Verify that the correct AC line voltage is selected on the Input Power Module (IPM) located on the OL 770 rear panel (Refer to page 8). The white voltage indicator on the IPM shows the voltage currently selected. (If the AC line voltage needs to be changed, refer to the following *AC Input Voltage Selection* section.) If the correct AC line voltage is selected, then attach the AC power cable to the IPM and to the power source. The OL 770 IPM accepts a standard IEC power line connector (a power cable is supplied).

### AC Input Voltage Selection

The rear panel of the OL 770 Multi-Channel Spectroradiometer contains the Input Power Module (IPM). The OL 770 can be configured to operate at one of four different AC line voltages: 100, 120, 230 or 240 volts AC ( $\pm 10\%$ ) at either 50 or 60 Hz. The white voltage indicator on the IPM shows the voltage currently selected.

The following procedure should be used to change the OL 770 voltage setting:

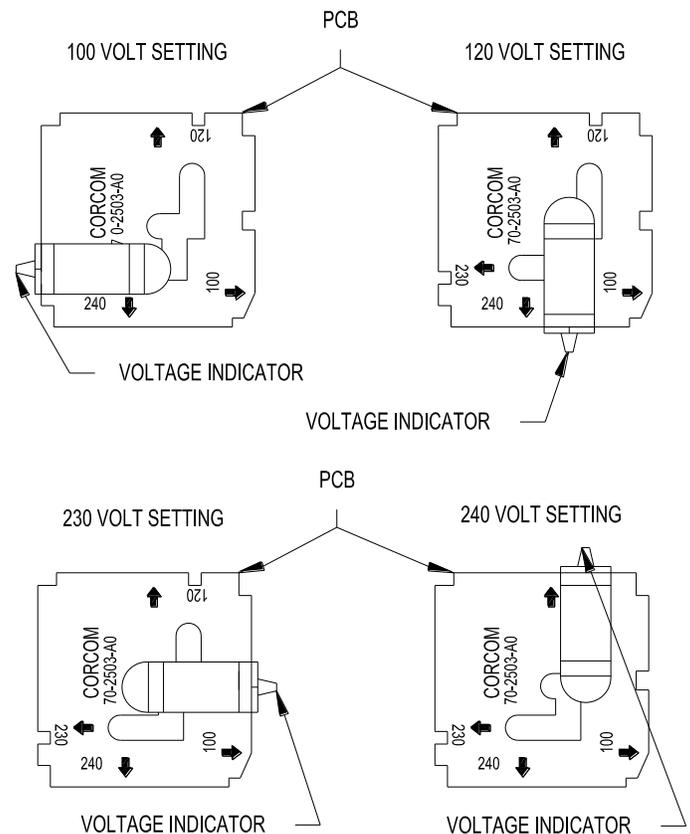
1. Unplug the power cord.
2. Pry off the plastic front cover of the IPM by inserting a small flat blade screwdriver or similar tool into the slot at the bottom.
3. Use a small pair of pliers to remove the small PCB located inside. It is important to note the direction and orientation of the PCB so that it can be re-inserted in the same manner. Note that the lettering is located on the bottom of the PCB.

#### NOTE:

Once the indicator is seated properly in the notch, its pointer will align with the corresponding voltage label on the front cover.

4. Slide the white plastic voltage indicator around the PCB until it is opposite of the desired voltage setting. The indicator should be seated in the notch on the side/edge of the PCB.
5. Re-insert the PCB with the text again on the bottom. A positive snap will indicate that the PCB is seated properly.
6. Verify the correct fuse(s) is/are installed (refer to the *Changing the Fuse(s) in the Input Power Module* section).
7. Align the front cover with the indicator and snap it back into place.
8. Plug the power cord into the IPM and test the OL 770 for proper operation.

IPM AC Input Voltage PCB



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### Changing the Fuse(s) in the Input Power Module

The proper fuse(s) are already installed in the OL 770 IPM according to the white voltage indicator on the IPM. In the event that the fuse(s) needs replacing, note the following fuse(s) that complies with IEC 127:

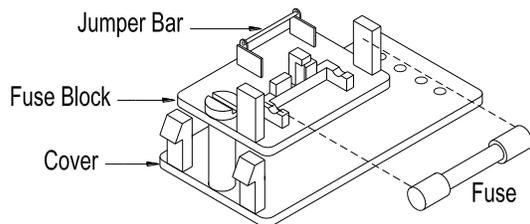
100 / 120 V operation: One, 1¼ inch, 1.0 A, Time Delay

230 / 240 V operation: Two 5 x 20 mm, 0.63 A, Time Delay

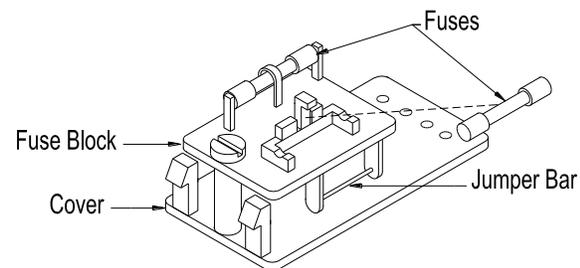
To change from North American to European fusing, the following procedure should be used to change the fuses in the Input Power Module.

1. Remove the power cord and pry off the plastic front cover/fuse block of the IPM by inserting a small flat blade screwdriver or similar tool into the slot at the bottom.
2. Loosen the Phillips screw on the fuse block a few turns, then remove the fuse block by sliding it away and up from the Phillips screw.
3. Orient the fuse block for the configuration to be used (note that two fuses are required for European fusing) and reinstall the fuse block assembly. Tighten the Phillips screw to secure it.
4. Install the proper fuses, then reinstall the cover/fuse block onto the IPM.

North American Fuse Arrangement



European Fuse Arrangement



P001126

## STEP 2 - CONNECT THE COMMUNICATION CABLE

Connect the USB communications cable to the host computer and the OL 770 USB interface connector. For maximum speed and performance, USB communications is recommended. If a USB interface is not available on the host computer, attach a RS-232 null modem cable to the RS-232 port on the host computer and the OL 770 RS-232 interface connector. Refer to the *OL 770 Rear Panel Connections* section for further clarification if necessary.

### NOTE:

In order to comply with EN 61326 EMC requirements, the RS-232 cable length should be limited to 1 meter.

If the RS-232 communication interface is used, the internal USB hub connections on the OL 770 rear panel are nonfunctional.

**STEP 3 – CONNECT THE SIGNAL FIBER OPTIC PROBE TO THE OL 770**

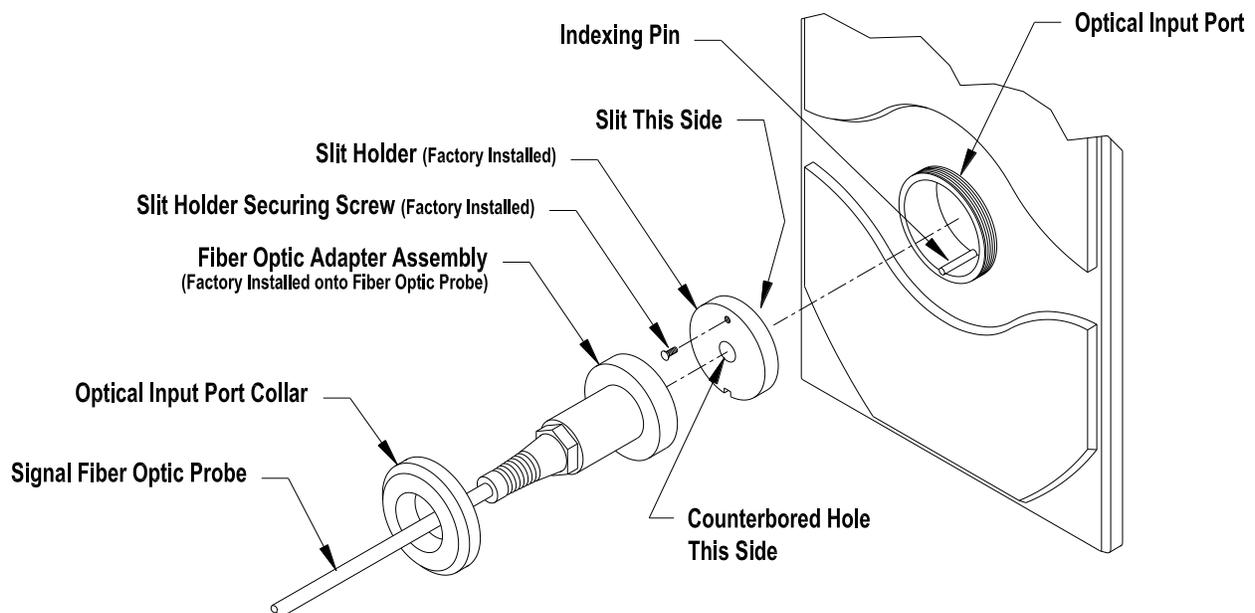
1. Unscrew the Optical Input Port Collar on the front of the OL 770. The pre-installed slit holder will remain inside the port.

**NOTE:**

Optional slit sizes are available for varying the optical bandwidth. To change the slit, refer to *Appendix D, Changing the Optical Input Slit*.

2. Install the Fiber Optic Adapter Assembly into the Optical Input Port. (Note: The fiber optic probe is pre-aligned to the fiber optic adapter – **do not** separate) Slide the collar over the free end of the fiber optic probe and screw the collar onto the Optical Input Port to secure the slit and fiber optic in place. **Do not overtighten.**
3. Attach the appropriate measurement accessory adapter supplied to the free end of the fiber optic probe and secure with its setscrew. Connect this end to the appropriate measurement accessory.

*OL 770 Standard Fiber Optic Probe Installation into the Optical Input Port*



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## STEP 4 – CONNECT THE SIGNAL FIBER OPTIC PROBE TO THE OPTICAL ACCESSORY

The OL 770 Multi-Channel Spectroradiometer can be used with a variety of optional Gooch & Housego accessories. For detailed information regarding the accessory, refer to the specified tutorial and accessory manual.

- Installation of the OL 15AB LED Receptor When Performing CIE Condition A and B Measurements (OL Series 770 Spectroradiometer System)
- Installation of the OL 16AB –SW LED Receptor When Performing CIE Condition A and B Measurements (OL Series 771 Spectroradiometer System)
- Installation of the OL IS-670-LED Integrating Sphere (OL Series 770 Spectroradiometer System)
- Installation of the OL IS-671-LED Integrating Sphere (OL Series 771 Spectroradiometer System)
- Installation of the OL IS-1800 Integrating Sphere
- Installation of the OL 610 CCD Imaging Telescope
- Installation of the OL 770-ND Neutral Density Filters (Refer to *Tutorial III - Optional OL 770-ND Neutral Density Filters* section.)
- Installation of the OL 700-30 LED Goniometer (Refer to *Tutorial IV - Goniometer* section.)
- Installation of the OL 700-70 Integrating Sphere Reflectance Accessory (Refer to *Tutorial V - Reflectance Measurements* section.)
- Installation of the OL 600 Telescope (Refer to *Tutorial VI - Spectral Radiance Measurements* section.)
- Installation of the OL IS-270 Integrating Sphere (Refer to *Tutorial VII - Spectral Irradiance Measurements* section.)
- Installation of the OL 700-10 LED Power Supply (Refer to *Tutorial VIII - OL 700-10 Programmable Precision Power Supply* section.)

### Installation of the OL 15AB LED Receptor

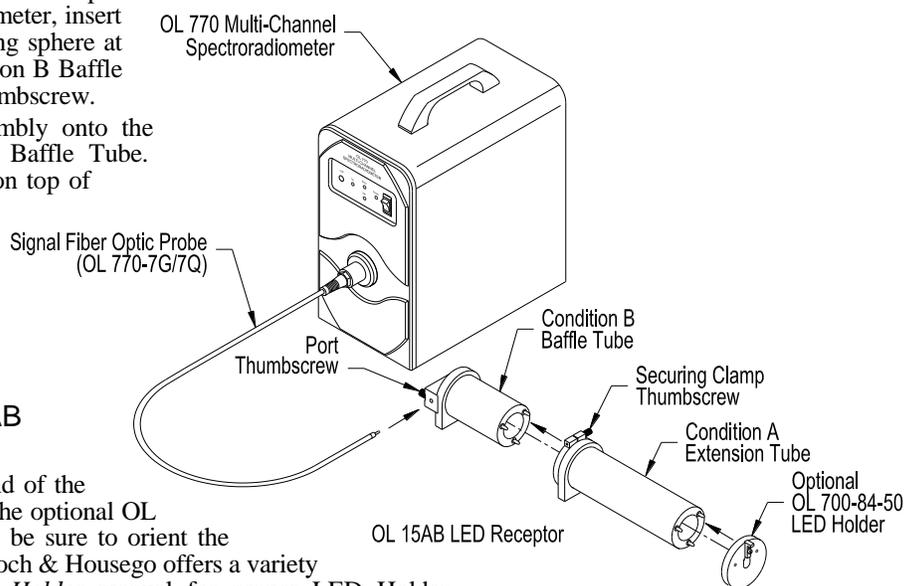
(Averaged LED Intensity Measurements with the OL Series 770 Spectroradiometer)

The OL 770 Multi-Channel Spectroradiometer can be combined with the OL 15AB LED Receptor to make fast, accurate measurements of the intensity of Light Emitting Diodes (LED's). The OL 15AB has been designed in accordance with the CIE Publication 127 measurement recommendations for “**Averaged LED Intensity.**” The geometries of the OL 15AB LED Receptor meet CIE Standard Conditions A and B for “near-field” conditions. The versatile assembly easily adapts to either Condition A or Condition B measurements with a single set of parts. Refer to the *OL 15AB LED Receptor* manual for additional information.

### Installation of the OL 15AB When Performing CIE Condition A Measurements

With one end of the fiber optic probe attached to the Input Port of the OL 770 Multi-Channel Spectroradiometer, insert the other end into the 1-inch diameter integrating sphere at the end of the OL 15AB LED Receptor Condition B Baffle Tube. Secure the probe in place with the port thumbscrew.

Place the Condition A Extension Tube Assembly onto the opposite end of the OL 15AB Condition B Baffle Tube. Secure in place by tightening the thumbscrew on top of the securing clamp. It is not necessary to overtighten the thumbscrew.



### Install the LED Holder onto the OL 15AB LED Receptor

Attach the appropriate LED Holder onto the end of the OL 15AB Condition A or B tube assembly. If the optional OL 700-84-50 Rear Mounted LED Holder is used, be sure to orient the LED Holder with its LED clamp at the top. (Gooch & Housego offers a variety of LED Holders, refer to the *Optional LED Holder* manual for proper LED Holder installation.) Insert the LED to be measured into the LED Holder and secure it in place.

P001359F

### Changing from Condition A to Condition B Measurements

1. Remove the LED Holder (and adapter) from the end of the Condition A Extension Tube.
2. Loosen the securing clamp thumbscrew and remove the Condition A Extension Tube assembly.
3. Reconnect the LED Holder (and adapter) to the end of the Condition B Baffle Tube.



## Installation of the OL 16AB-SW LED Receptor

(Averaged LED Intensity Measurements with the OL Series 771 and OL 770 InGaAs Spectroradiometer) \_\_\_\_\_

The OL 771 and OL 770 InGaAs Multi-Channel Spectroradiometer can be combined with the OL 16AB-SW LED Receptor to make fast, accurate measurements of the intensity of Light Emitting Diodes (LED's). The OL 16AB-SW has been designed in accordance with the CIE Publication 127 measurement recommendations for “**Averaged LED Intensity.**” The geometries of the OL 16AB-SW LED Receptor meet CIE Standard Conditions A and B for “near-field” conditions. The versatile assembly easily adapts to either Condition A or Condition B measurements with a single set of parts. Refer to the *OL 16AB-SW LED Receptor* manual for additional information.

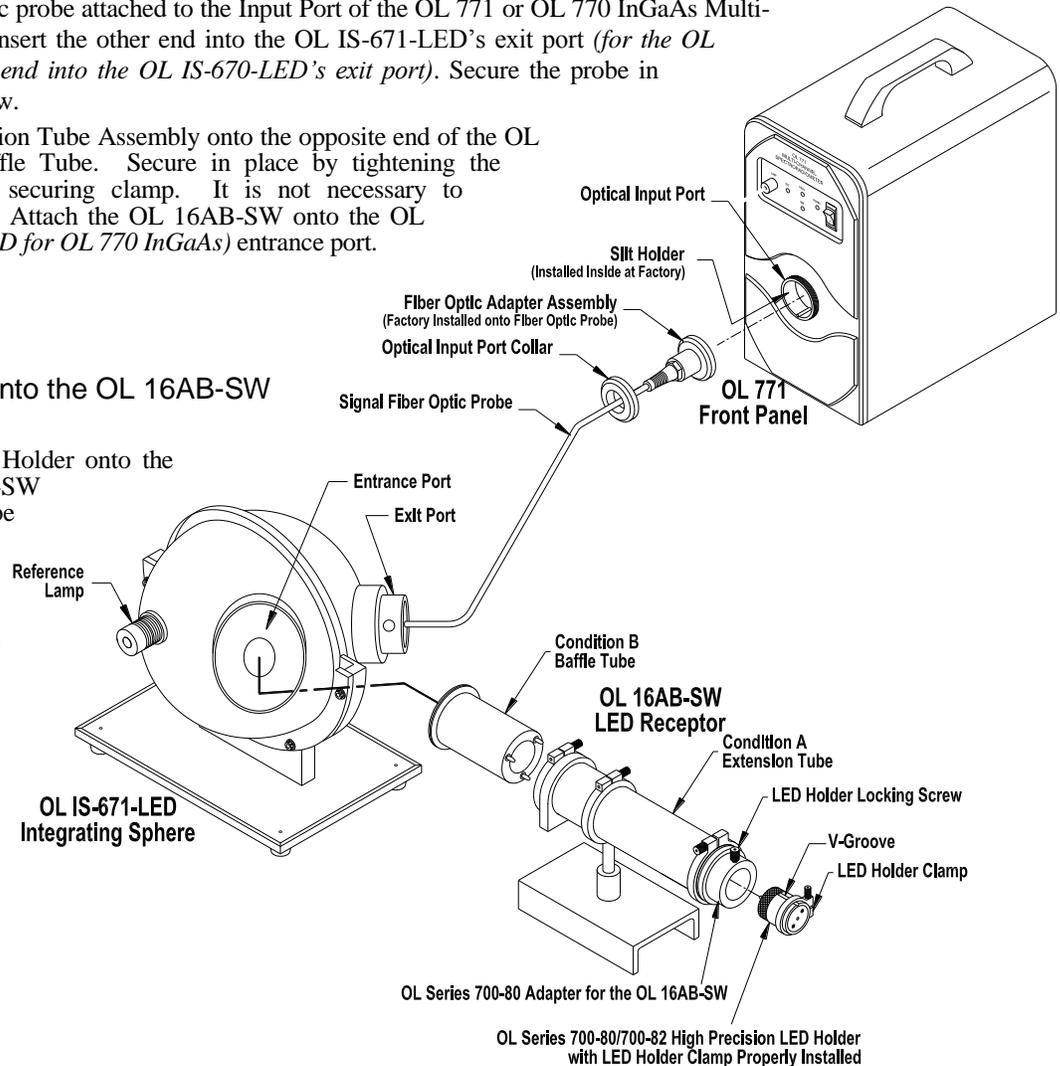
### Installation of the OL 16AB-SW When Performing CIE Condition A Measurements

With one end of the fiber optic probe attached to the Input Port of the OL 771 or OL 770 InGaAs Multi-Channel Spectroradiometer, insert the other end into the OL IS-671-LED's exit port (*for the OL 770 InGaAs insert the other end into the OL IS-670-LED's exit port*). Secure the probe in place with the port thumbscrew.

Place the Condition A Extension Tube Assembly onto the opposite end of the OL 16AB-SW Condition B Baffle Tube. Secure in place by tightening the thumbscrew on top of the securing clamp. It is not necessary to overtighten the thumbscrew. Attach the OL 16AB-SW onto the OL IS-671-LED's (*OL IS-670-LED for OL 770 InGaAs*) entrance port.

### Install the LED Holder onto the OL 16AB-SW LED Receptor

Attach the appropriate LED Holder onto the end of the OL 16AB-SW Condition A or B tube assembly. If the optional OL 700-84-50 Rear Mounted LED Holder is used, be sure to orient the LED Holder with its LED clamp at the top. (Gooch & Housego offers a variety of LED Holders, refer to the *Optional LED Holder* manual for proper LED Holder installation.) Insert the LED to be measured into the LED Holder and secure it in place.



P0011896B

### Changing from Condition A to Condition B Measurements

1. Remove the LED Holder (and adapter) from the end of the Condition A Extension Tube.
2. Loosen the securing clamp thumbscrew and remove the Condition A Extension Tube assembly.
3. Reconnect the LED Holder (and adapter) to the end of the Condition B Baffle Tube.

## Installation of the OL IS-670-LED Integrating Sphere

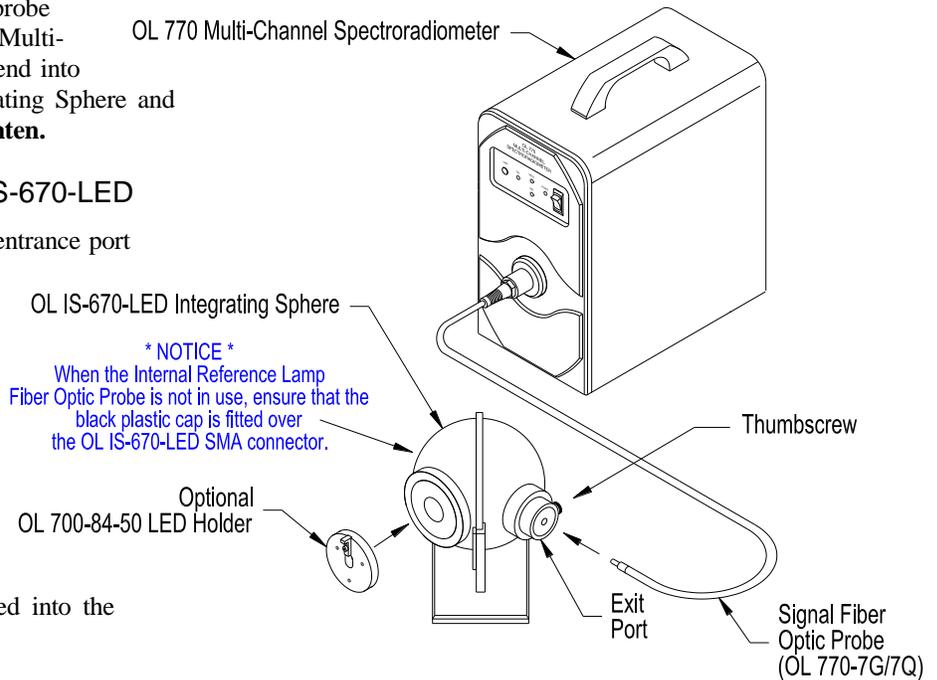
(Total Spectral and Luminous Flux Measurement with the OL Series 770 Spectroradiometer)

The OL IS-670-LED Integrating Sphere can be used with the OL 770 Multi-Channel Spectroradiometer for measuring the total spectral and luminous flux of LEDs in accordance with CIE and NIST recommendations. The system permits the user to make color measurements such as chromaticity, color rendering index, peak and dominant wavelength, half bandwidth, and purity. The OL IS-670-LED consists of a six-inch (150 mm) diameter, coated integrating sphere, mounted in a convenient tabletop stand. The sphere has a 90° entrance port to exit port configuration. The sphere also includes a reference lamp port with an SMA style fiber optic connector. Refer to the *OL IS-670-LED 6-Inch Diameter Integrating Sphere* manual for additional information.

With one end of the signal fiber optic probe attached to the Input Port of the OL 770 Multi-Channel Spectroradiometer, insert the other end into the exit port of the OL IS-670-LED Integrating Sphere and secure with the thumbscrew. **Do not overtighten.**

### Install the LED Holder onto the OL IS-670-LED

Install the appropriate LED Holder into the entrance port of the OL IS-670-LED. If the optional OL 700-84-50 Rear Mounted LED Holder is used, be sure to orient the LED Holder with its LED clamp at the top. The OL 700-84-50 LED holder inserts into the counterbore of the entrance port of the sphere and is secured in place with the setscrews on the outer diameter of the port. (Gooch & Housego offers a variety of LED Holders, refer to the *Optional LED Holder* manual for proper LED Holder installation.) Insert the LED to be measured into the LED Holder and secure it in place.

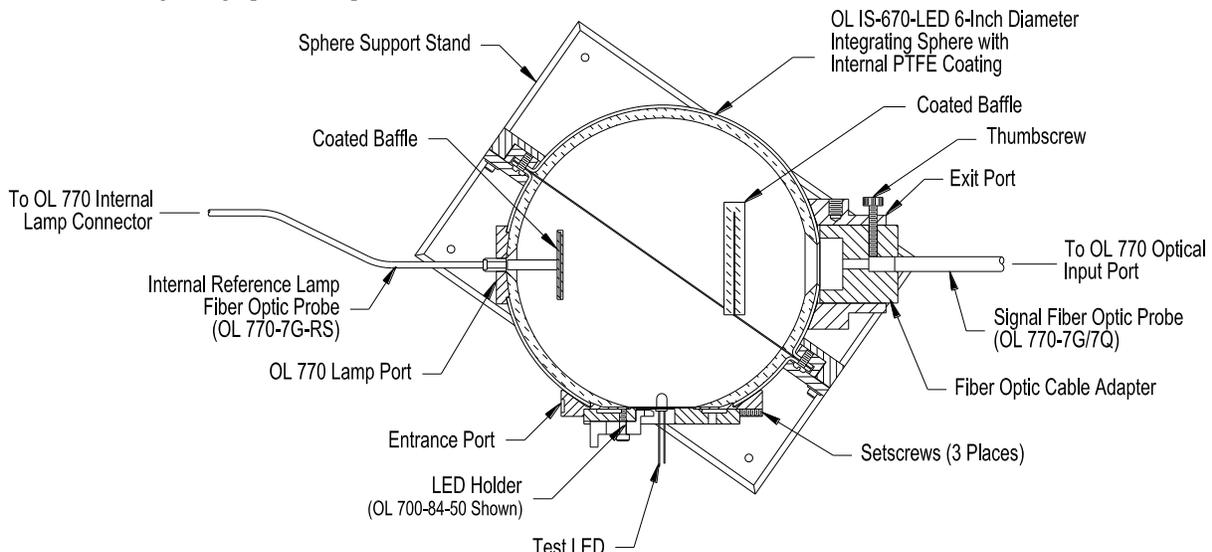


P001361C

### NOTE:

For routine measurements do not remove the plastic cap from the OL 770 Lamp Port on the OL IS-670-LED Sphere. It is only necessary to attach the supplied SMA style fiber optic probe between the OL 770 Lamp Port on the OL IS-670-LED and to the "LAMP" port on the front panel of the OL 770 during system calibration.

### OL IS-670-LED Integrating Sphere (Top View)



P001362B

## OL 771 Installation of the OL IS-671-LED Integrating Sphere

(Total Spectral and Luminous Flux Measurement with the OL Series 771 Spectroradiometer & OL 770 InGaAs)



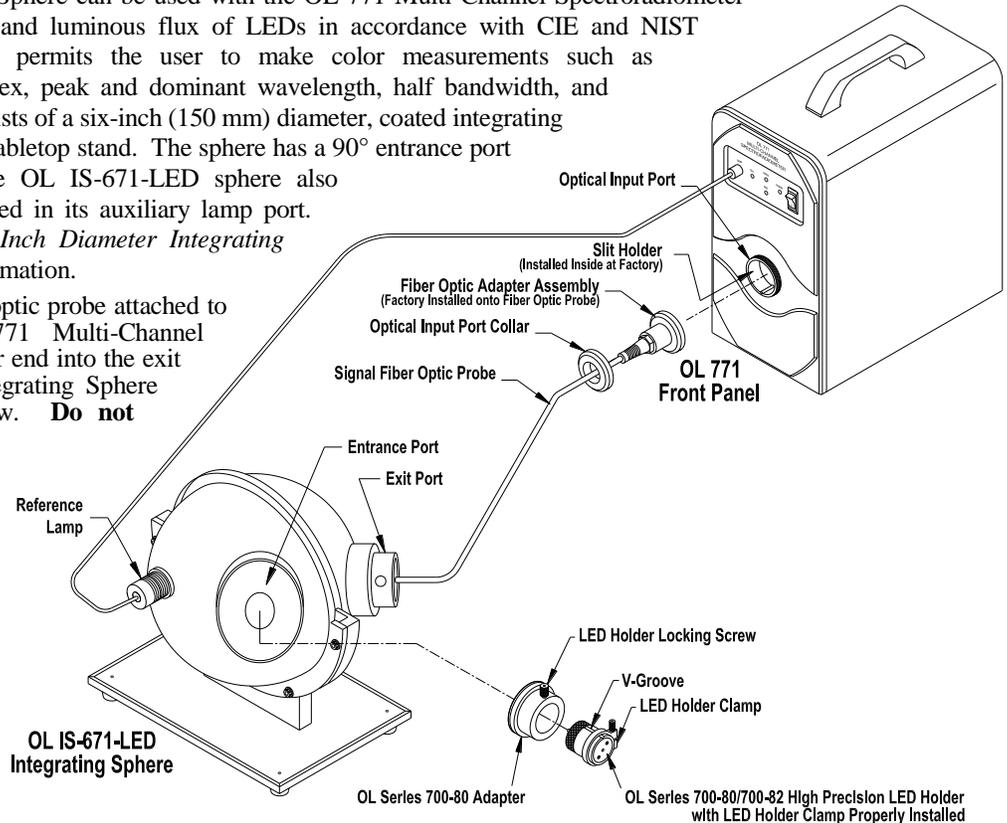
The OL 770-InGaAs is used with an OL IS-670-LED which has the reference lamp mounted to the sphere's auxiliary lamp port. All references in this section to the OL IS-671-LED should be replaced with OL IS-670-LED and OL 771 with OL 770 InGaAs.

The OL IS-671-LED Integrating Sphere can be used with the OL 771 Multi-Channel Spectroradiometer for measuring the total spectral and luminous flux of LEDs in accordance with CIE and NIST recommendations. The system permits the user to make color measurements such as chromaticity, color rendering index, peak and dominant wavelength, half bandwidth, and purity. The OL IS-671-LED consists of a six-inch (150 mm) diameter, coated integrating sphere, mounted in a convenient tabletop stand. The sphere has a 90° entrance port to exit port configuration. The OL IS-671-LED sphere also includes a reference lamp mounted in its auxiliary lamp port. Refer to the *OL IS-671-LED 6-Inch Diameter Integrating Sphere* manual for additional information.

With one end of the signal fiber optic probe attached to the Input Port of the OL 771 Multi-Channel Spectroradiometer, insert the other end into the exit port of the OL IS-671-LED Integrating Sphere and secure with the thumbscrew. **Do not overtighten.**

### Install the LED Holder onto the OL IS-671-LED

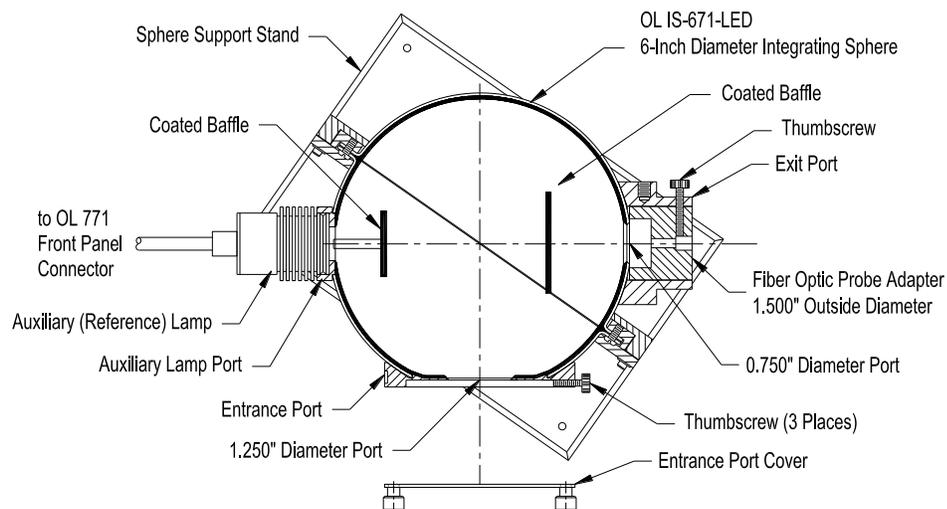
Install the appropriate LED Holder into the entrance port of the sphere. If the optional OL 700-84-50 Rear Mounted LED Holder is used, be sure to orient the LED Holder with its LED clamp at the top. The OL 700-84-50 LED holder inserts into the counterbore of the entrance port of the sphere and is secured in place with the setscrews on the outer diameter of the port. (Gooch & Housego offers a variety of LED Holders, refer to the *Optional LED Holder* manual for proper LED Holder installation.) Insert the LED to be measured into the LED Holder and secure it in place.



### NOTE:

It is only necessary to attach the supplied Reference Lamp Power Cable between the OL 771 Lamp Port Connectors on the front panel of the OL 771 during system calibration (i.e. when changing the LED holder).

### OL IS-671-LED Integrating Sphere (Top View)



## Installation of the OL IS-1800 Integrating Sphere

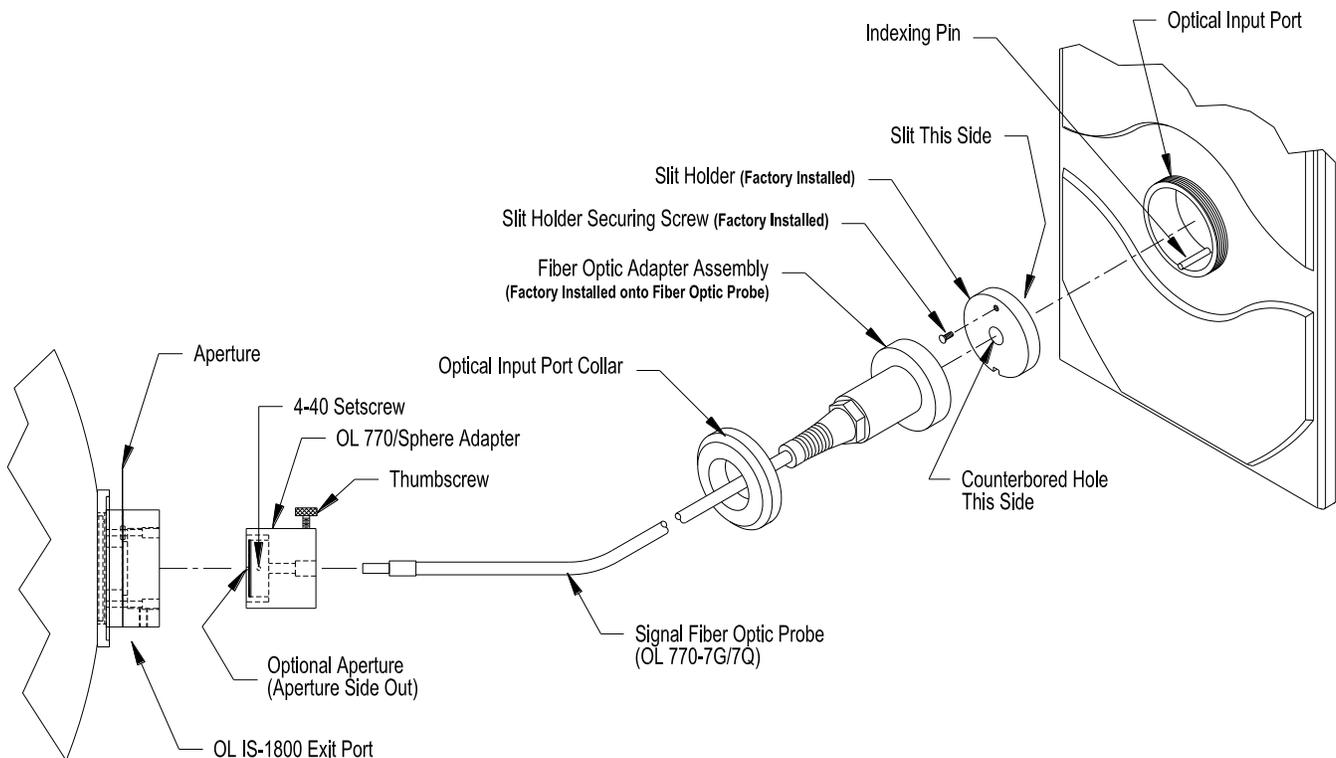
The OL 770 Multi-Channel Spectroradiometer can also be configured for Total Luminous and Spectral Flux measurements with larger integrating sphere such as the 18-inch or 39-inch diameter integrating spheres, models OL IS-1800 or OL IS-3900 available from Gooch & Housego.

These spheres use a NIST-traceable calibration standard (Gooch & Housego's model numbers OL TSF-245 or OL TSF-220) and an internal auxiliary lamp to perform accurate system response calibrations for a variety of test lamps. Thereafter, the OL 770 spectroradiometer can perform accurate measurements on a test lamp's photometric, radiometric and color parameters.

The following installation instructions will permit use of the OL 770 Multi-Channel Spectroradiometer with the OL IS-1800 18-Inch Diameter Integrating Sphere. The instructions describe how to couple the supplied fiber optic probe between the exit port of the OL IS-1800 and the optical input port of the OL 770.

1. Insert the Fiber Optic Adapter end of the Fiber Optic Probe into the Optical Input Port of the OL 770.
2. Slide the Optical Input Port Collar over the free end of the Fiber Optic Probe and screw onto the Optical Input Port to secure. **Do not overtighten.**
3. Insert the free end of the Fiber Optic Probe into the supplied OL 770/Sphere Adapter and secure by tightening the thumbscrew. **Do not overtighten.**
4. Insert the OL 770/Sphere Adapter into the Exit Port of the OL IS-1800 Integrating Sphere and secure in place with the port thumbscrew.
5. If necessary to attenuate the intensity at the exit port of the OL IS-1800 (e.g. reduce signal levels), install one of the supplied Apertures (0.5 mm, 1.5 mm, or 3.0 mm) into the slot on the exit port.
6. Refer to the *OL 770 Calibration Manual* for details on creating system calibration files with the auxiliary and standard lamps.

### *OL IS-1800 Fiber Optic Probe Installation*



P001407

## Installation of the OL 610 (or OL 620-NVS) CCD Imaging Telescope

### NOTE:

The OL 620-NVS CCD Imaging Telescope may be supplied in place of the OL 610. Use these installation instructions as a guide for installing the drivers and Fiber Optic Probe.

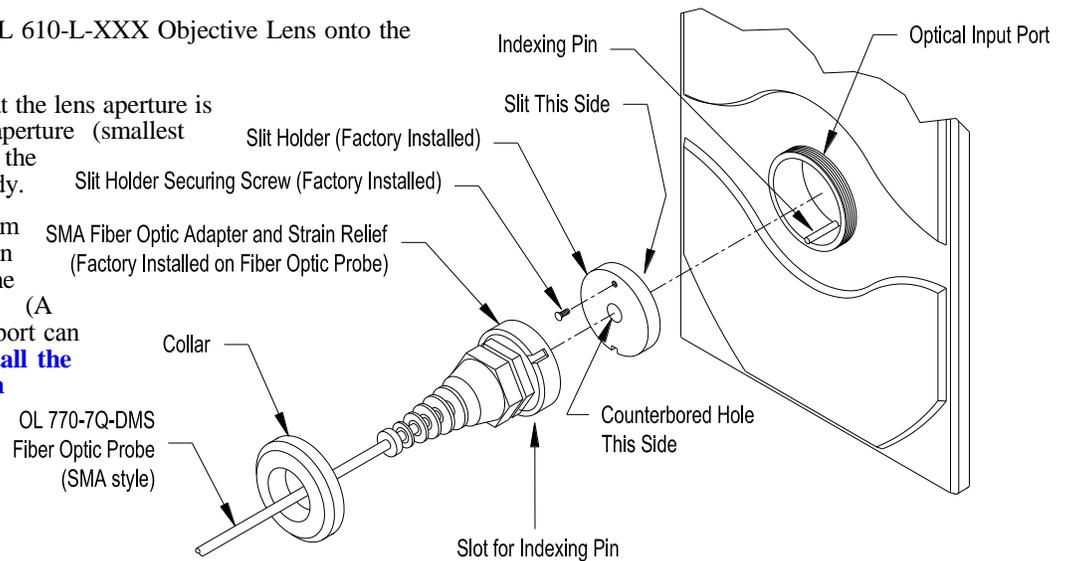
The OL 610 CCD Imaging Telescope is useful for measuring the spectral radiance of displays and other light sources. The OL 610 is designed for use with the OL 770 Multi-Channel Spectroradiometer to instantly provide accurate color, luminance, and spectral information. The OL 610 also provides real-time viewing of the measurement spot and surrounding image area for focus and alignment. A “snapshot” of the image area may be saved with the measurement data. The OL 610 is small and portable for use in both laboratory and manufacturing environments. A variety of field-of-view (FOV) apertures and objective lenses are available to meet specific spot size and working distance requirements. Refer to the *OL 610 CCD Imaging Telescope* manual for additional information.

1. Install the desired Series OL 610-L-XXX Objective Lens onto the front of the OL 610.

2. It is important to ensure that the lens aperture is set to its largest open aperture (smallest numerical value) by turning the aperture ring on the lens body.

3. Connect the USB cable from the rear of the OL 610 to an available USB port on the rear of the OL 770. (A computer’s USB interface port can also be used.) **Notice: Install the drivers before plugging in the USB cable - refer to the OL 610 (or OL 620-NVS) manual.**

4. Remove the Collar from the OL 770 Optical Input Port. (The Collar is supplied attached to the OL 770 from the factory.) Slide the Collar over the free end of the OL 770-7Q-DMS Fiber Optic Probe. Install the OL 770-7Q-DMS FOP with its Adapter into the Optical Input Port, aligning the slot to the indexing pin.

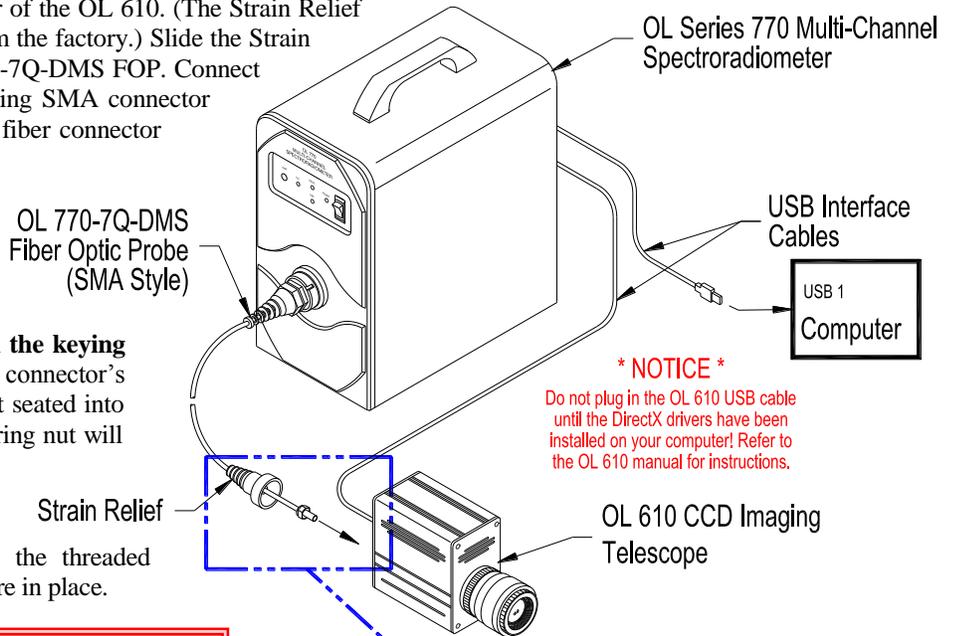


P001356

**NOTE:**

The OL 610 may be supplied with an optional OL F770-IRS.30SS1.5 300  $\mu\text{m}$  FOP (1.5-meter length standard). When the optional FOP is supplied, the strain relief on the OL 610 is a modified two-piece clamp assembly. Refer to *Appendix H* for installation of the OL 610 if the optional OL F770-IRS.30SS1.5 300  $\mu\text{m}$  FOP is supplied.

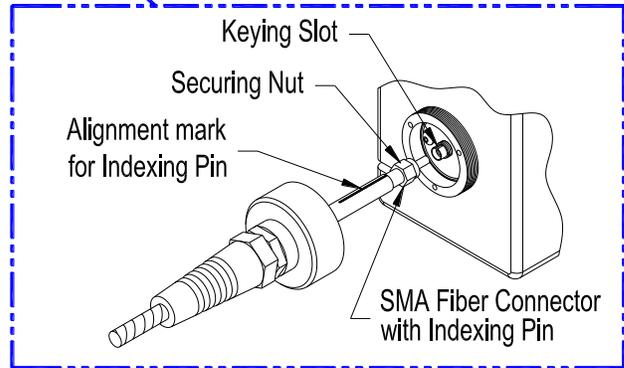
- Remove the Strain Relief from the rear of the OL 610. (The Strain Relief is supplied attached to the OL 610 from the factory.) Slide the Strain Relief over the free end of the OL 770-7Q-DMS FOP. Connect the OL 770-7Q-DMS FOP to the mating SMA connector on the rear of the OL 610. The SMA fiber connector contains an indexing pin that mates with a keying slot on the OL 610 rear connector. **Be sure the indexing pin inserts into the keying slot on the OL 610 rear SMA connector. An alignment mark on the FOP must line up with the keying slot.** Gently tighten the SMA fiber connector's securing nut. (If the indexing pin is not seated into the keying slot, the threads of the securing nut will not engage the threads of the mating SMA connector.) Slide the Strain Relief over the SMA connector. Gently screw the Strain Relief onto the threaded collar on the rear of the OL 610 to secure in place.



**\* CAUTION \***

Avoid excessive bending of the OL 770-7Q-DMS Filter Optic Probe. Bending of the fiber may cause change's in its transmittance properties. Excessive bends may permanently damage the fiber.

- Connect a USB cable from the rear of the OL 770 to one of your computer's USB ports.



## STEP 5 – INSTALL THE OL 770 APPLICATION SOFTWARE & USB DRIVER

### \* Notice \*

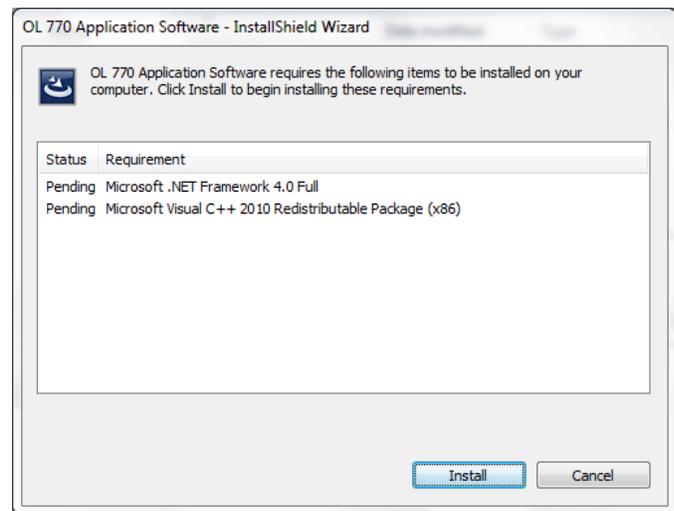
The OL 770 Application Software is designed to be used with the OL 770 and OL 771 Multi-Channel Spectroradiometers. The screen shot examples in the following instructions reflect the OL 770 Spectroradiometer and are identical if installing the software for the OL 771 Spectroradiometer.

An OL 770 Application Software installation program is provided that will install and register the OL 770 Application Software, calibration and configuration files. (Refer to *Appendix A* for the recommend computer configuration.)

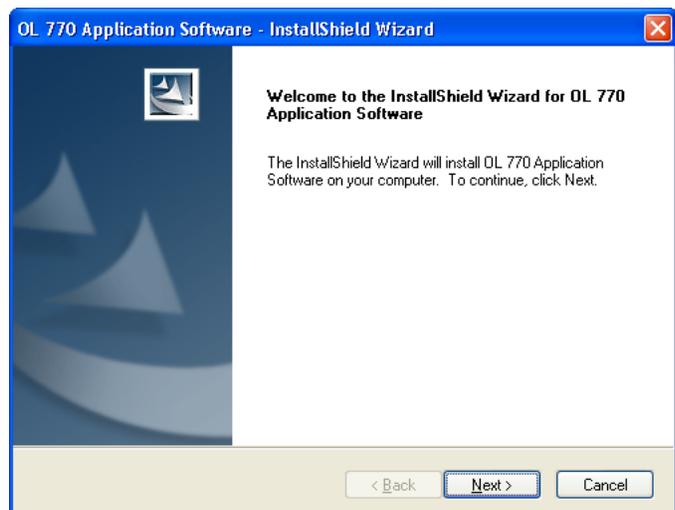
#### Important Notice to Users Upgrading to OL770 Application Software Application Version 3.2 and higher

Before installing the OL 770 Application Software (Application Ver: 3.2 and higher), you must first uninstall your existing OL 770 Application Software. This is due to a change of installation programs from InstallShield® to Wise Installation Wizard® Installer. Before removing the OL 770 Application Software, save the current system settings using the File/Export Setting File feature in the OL 770 application software. The existing OL 770 Application Software must be removed by using the Add or Remove Program feature of the Windows operating system or the Uninstall feature on the new OL 770 application software installation CD. Once the new OL 770 application software is installed, import the system settings using the File/Import Settings File feature.

1. Make sure the OL 770 power switch is in the OFF position.
2. Run the **setup.exe** program that is located on the OL 77X Application Software Installation CD.
3. The first screen will be the redistributable package screen. This screen appears if the necessary packages have not been installed for the OL 77X Software. Select **Install**.

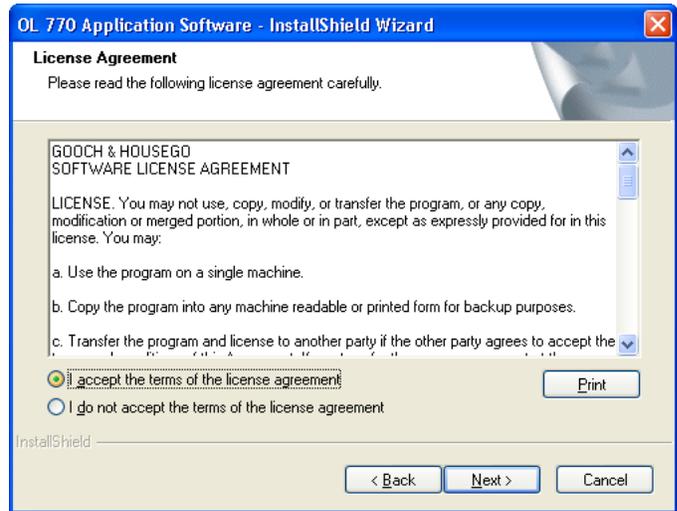


4. The next software installation screen to appear is the “Welcome to the OL770 Application Software Installation Wizard.” Review the contents of this screen, then click **Next** to continue the software installation.

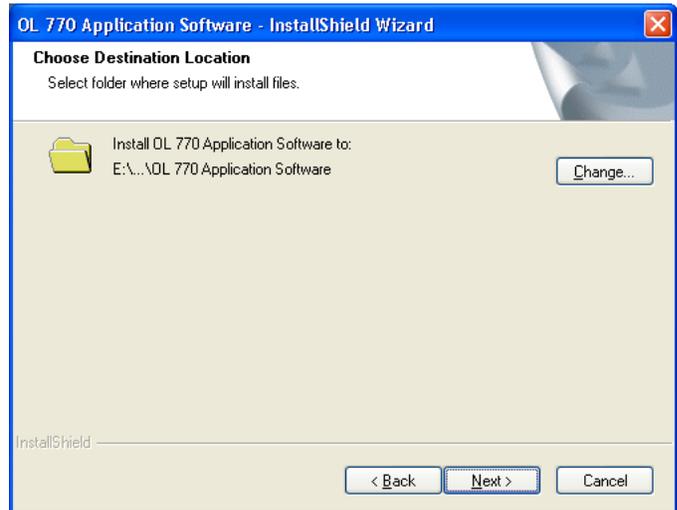


- The next screen to appear is the “License Agreement.” Scroll through the Software License Agreement to review the contents. The user must agree to the license agreement in order to proceed with the installation of the software.

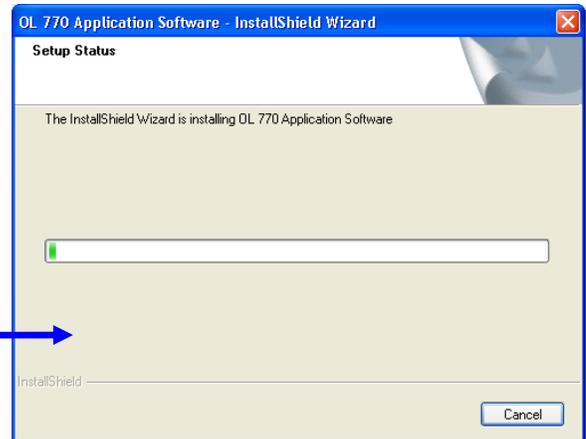
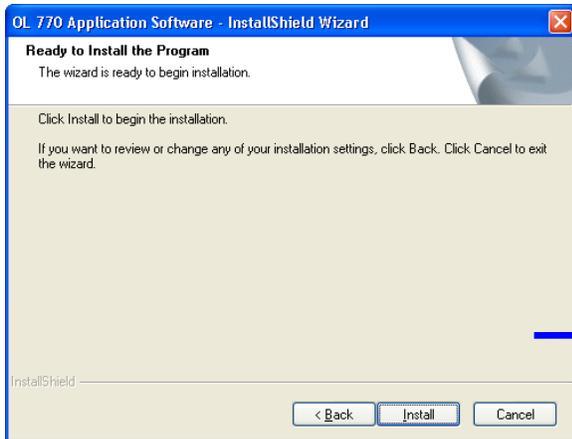
Once the user has selected “I accept the license agreement,” then click **Next** to continue the software installation.



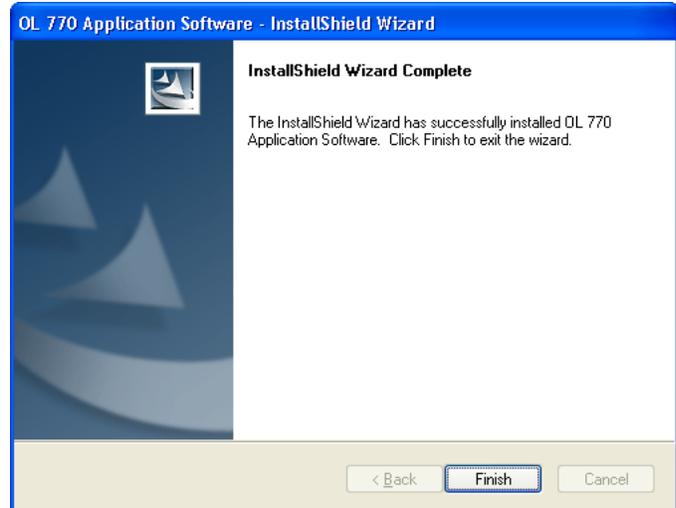
- The user now defines the Destination Folder where the application will be installed. **Browse** to select a new destination folder or leave the default target folder as stated. Click **Next** to continue the software installation.



- The OL 770 Application Software is now ready to be installed. The user has the option to go **Back** to change any settings. Click **Install** to begin installing the software.



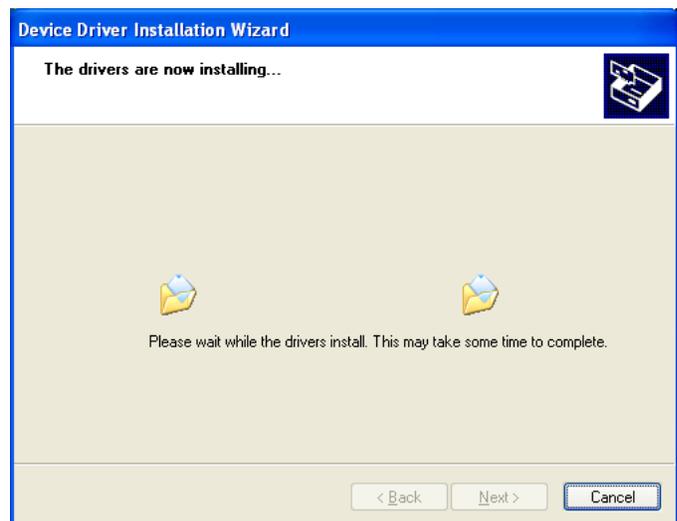
- The user will be informed when the OL 770 Application Software has been successfully installed. Click **Finish** to exit the software installation.



- OL 770/771 USB Driver installation will start after the application software installation. (This step can be cancelled if drivers already were installed.)

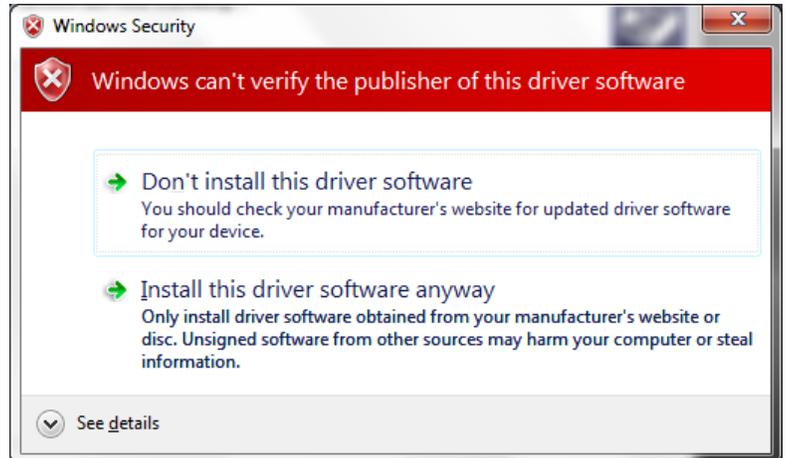


- Click **Next** to begin the OL 770/771 driver installation. The user will be prompted when the drivers are installing.



**Note:**

You may be prompted with a Windows Security warning. Click **Install this driver software anyway** to proceed.



11. The user will be prompted when the USB drivers have been successfully installed. The **Status** will display "Ready for use." Click **Finish** to exit the USB driver installation.

**Note:**

If the installation of the OL 770/771 USB Drivers is unsuccessful, refer to *Appendix I* for manual installation of the drivers.



12. After the OL 770 Application Software and USB driver have been installed, shut down your computer. The OL 770/OL 771 Multi-Channel Spectroradiometer must be turned on first before starting the OL 770 Application Software.
13. Restart your computer and run the application by selecting the OL 770 program from the Start Menu folder (default path: /Program Files/GoochandHousego/OL770) specified during installation.
14. The application software will initially attempt to communicate with the OL 770/OL 771 through a USB port. After the software has determined the OL 770/OL 771 hardware configuration, the application software will open. The USB Indicator light on the OL 770/OL 771 front panel will glow red during the receiving mode and glow green during the transmitting mode.

## STEP 6 – THE TUTORIALS

Now that all necessary components are in place and setups have been completed, proceed to the *Tutorials* section of this manual for the OL 770 Application Software operating instructions.

## TUTORIAL I – BASIC OPERATIONS

### NOTE:

Tutorial I should be performed in the software “demo” mode to avoid issues with passwords for measurement packages. To run the OL 770 Application Software in demo mode, ensure that the OL 770 is turned off and disconnect the USB cable between the OL 770 and computer. After the OL 770 Application Software is executed, you will be prompted to select “Switch to Demo.” When you are ready to perform working measurements, exit the OL 770 Application Software and reconnect the USB cable between the OL 770 and computer.

In the following example, the OL 770-423-LED Source Spectral Analysis Software for LEDs is used to demonstrate some of the basic operations of the OL 770 Application Software. Refer to other tutorials for specific measurement details when using other optical accessories and software packages.

### Introduction to the Tutorials

Welcome to the OL 770 software tutorials. These sections are designed to familiarize the user with the basics of the program and allow for quick progression to making measurements.

- ❑ While reading this tutorial, text presented in this manner will indicate instruction to be followed for execution of a given task.

Explanatory text will be presented in an unsegregated manner.

### Part 1 – The Main Screen

What we'll do:

- Start the OL 770 Application Software.
- Get Acquainted with the Main Screen.

### Starting the Application

- ❑ Double click on the OL 770 desktop icon or locate the file OL770.exe in the C:\Program Files\GoochandHousego\OL770\ folder.

The dialog box “ Searching For the OL 770 Instrument” will appear for a few seconds followed by the Main Screen.

### Getting Acquainted with the Main Screen

The Main Screen is the backbone of the OL 770 Application Software. All of its functionality originates from operations done on the main screen.

The Main Screen has two major parts:

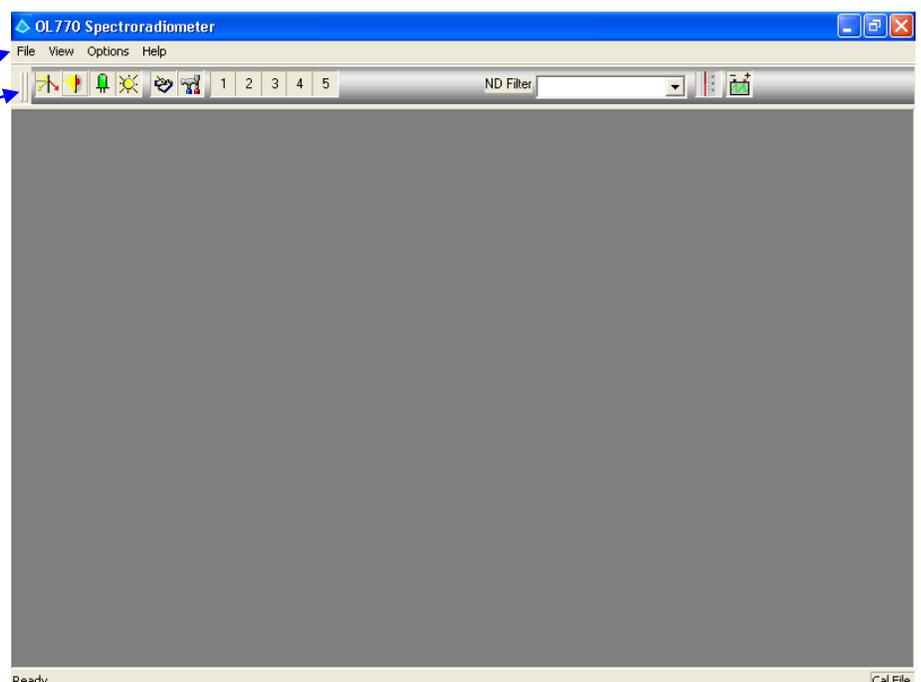
1. The Main Menu
2. The Main Toolbar

All functions of this software originate at these two points.

The Main Menu allows for basic operations such as opening and saving a file, opening and closing toolbars, as well as selecting security operating modes for user or manager.

The Main Toolbar allows for opening of a new Acquisition View or defining settings for the program.

An Acquisition View opens when a type of reading to be performed is selected from the Main Toolbar. This view provides all the functionality needed to take a measurement and view all data calculated from that measurement. The Acquisition View will be discussed further in later sections of the manual.



## Part 2 – Preparing the Application for Measurements

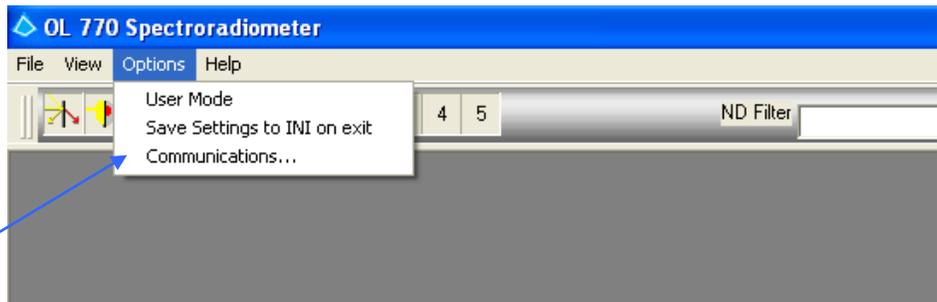
What we'll do:

- Accessing the Communications Dialog.
- Open the Modify Settings Dialog.
- Configure System Settings.
- Discuss Security Operating Modes: User and Manager.
- Set the Security Operating Mode to User.
- Change the Manager Mode Password.
- Setting the Save Settings to INI on Exit
- Configuring the Flash Drive

### Accessing the Communications Dialog

The Communications Dialog can be accessed in two ways. The first involves a failed attempt to connect to the instrument or to its peripherals at the start up of the OL 770 Application Software.

The second method is via the Options Menu, then selecting the Communications... menu item.

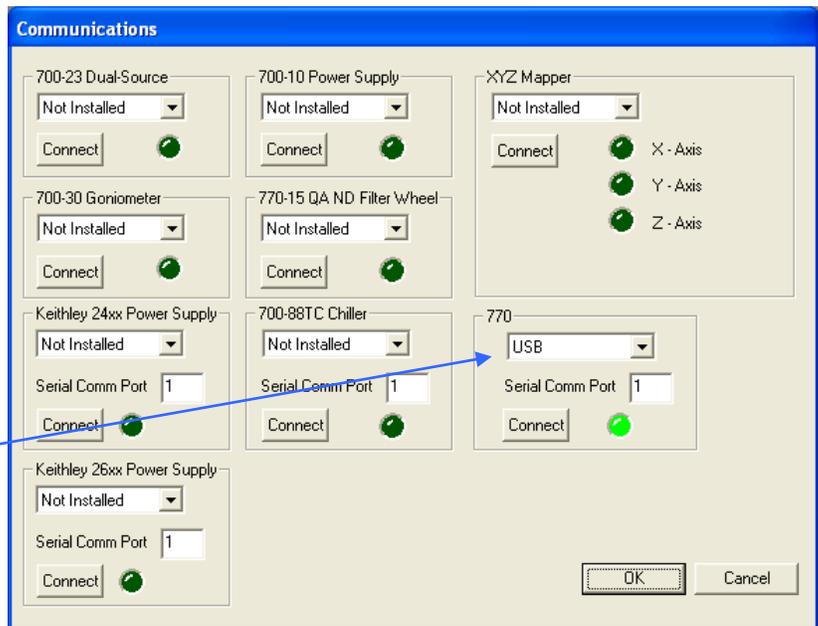


- ❑ **Select the Options menu from the Main Menu, then select Communications...**

The communications dialog allows the connectivity of all OL 770 peripherals to be centrally controlled which will allow for more efficient usage of the peripherals, and also increase the boot up speed of the software as disabled peripherals will not undergo a connection attempt.

The communications dialog will allow each peripheral to be connected separately and also serve to show the connected peripherals. Connected peripherals will show a bright green light and those that failed will show a blinking red light.

- ❑ **When you desire to use the OL 770/771 in the demonstration mode, select Demo from the drop-down list. Or, choose the type of interface for the OL 770/771; USB or serial (USB is recommended). If serial is selected, the Serial Communication Port must be defined.**



**Ensure that a bright green light displays to indicated the OL 770/771 is connected. If the connect light is not lit, click the Connect button.**

- ❑ **For this tutorial, select Demo from the drop-down list.**

## Opening the Modify Settings Dialog

The Modify Settings Dialog permits configuration of all settings for the applications. Tab pages separate the data. Each large block of related configuration data has its own page.



- ❑ Click on the **Modify Settings** button on the Main Toolbar to open the **Modify Settings Dialog**.
- ❑ Enter the default Password **1234** (if required) in order to switch from User Mode to Manager Mode to access the **Modify Settings Dialog**.

## Configuring System Settings

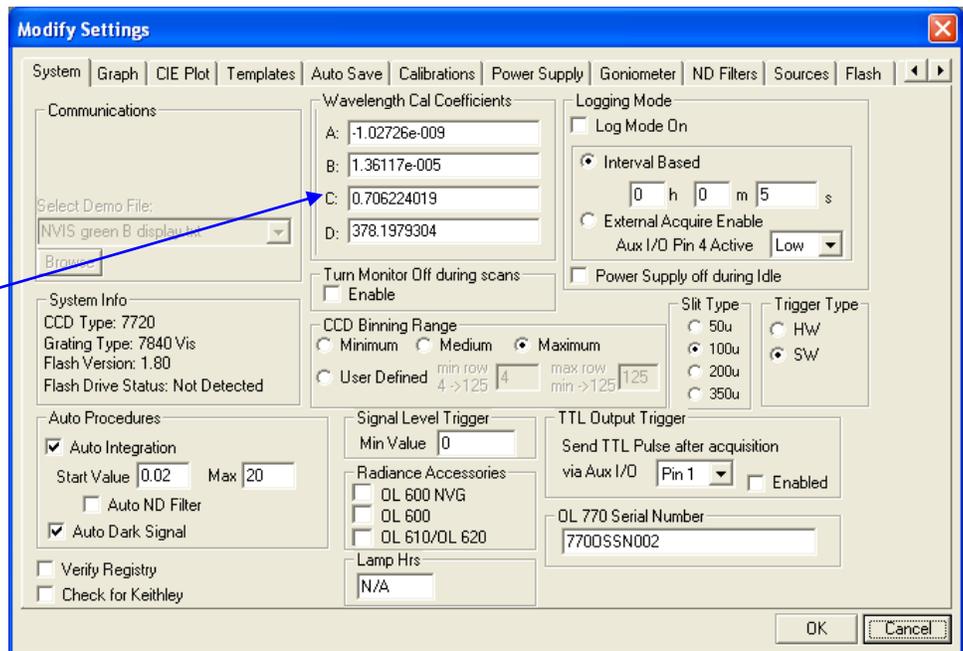
- ❑ Locate the **System** tab, located on the left of the **Modify Settings Dialog**. The page corresponding to this tab is responsible for the manner in which the OL 770 system will interact with the software.

### CAUTION:

Do not change these settings unless you completely understand the function or are instructed to do so by Gooch & Housego. These settings typically will not need modification after the initial setup.

- ❑ If the **System** tab is not currently active, click on the **System** tab to activate it.

Wavelength Cal Coefficients.



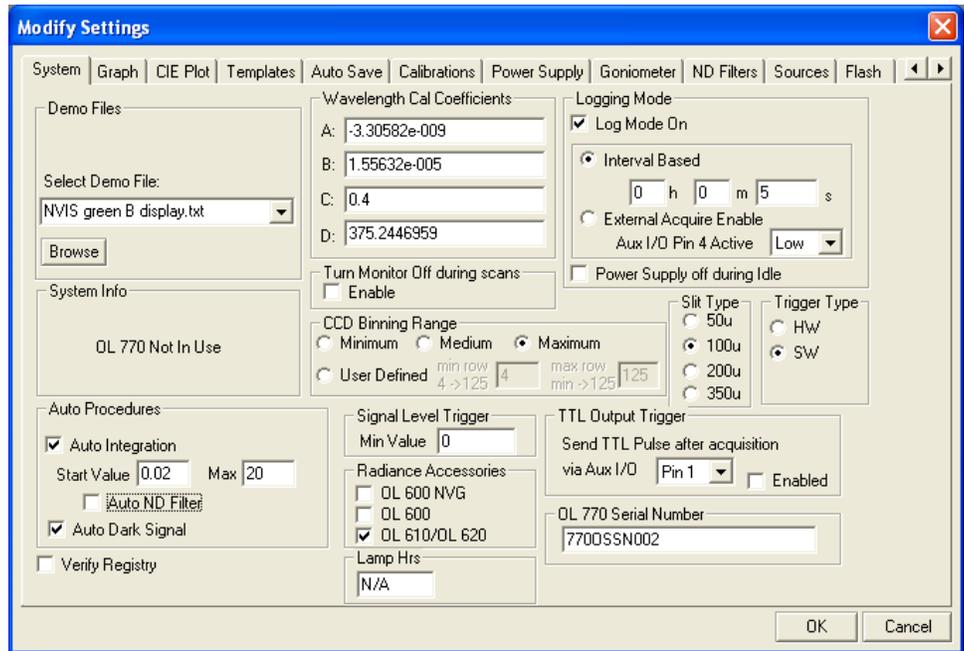
The default values for the Wavelength Cal. Coefficients A – D are 0, 0, 0.4 and 380, respectively. These are not the factory settings. If the Modify Settings / System page shows the default values, it will be necessary to load a previous \*.cfg file or contact Gooch and Housego for technical assistance.

Click **OK** to close the **Modify Settings Dialog**.

- ❑ Click on **File** on the Main Menu and select **Import Settings File**. Browse for the \*.cfg file in the program directory and open the \*.cfg file to load the settings into the software.

If no OL 770 is currently attached to the computer, readings may be acquired in demo mode. If the demo mode is active, a demo file in the **Select Demo File** box must be selected. To select a file, click the **Browse** button and browse to the desired file, or leave the default file (\*.txt) selected.

- ❑ If using demo mode, click the **Browse** button next to the **Select Demo File** box, and select the path and filename of the desired demo file or leave the default selected.



Communication has now been established with some form of an OL 770 device (OL 770 or demo). If an actual OL 770 is connected, the System Info box will be filled with four parameters of your OL 770: the CCD type, the grating type, the flash memory version, and the flash drive status. Otherwise, it will indicate “OL770 Not In Use” indicating the application software is running in demo mode.

The Wavelength Cal Coefficients boxes hold the unique calibration coefficients for your OL 770. These values are supplied by Gooch & Housego within the OL 770.INI file and on the OL 770 System Information Sheet located in the *OL 770 System Information Manual*. **The values must be an exact match as the values provided on the Information Sheet.**

- ❑ **Confirm that the Wavelength Cal Coefficient boxes (A, B, C, D) match with the values provided on the OL 770 System Information Sheet.**
- ❑ **The Turn Monitor Off during scans selection will be not be checked for this tutorial.** This selection allows the user to turn of the monitor display when a measurement is being done. The display will reappear when the measurement is complete or when the mouse is moved.

### Optimizing CCD Binning

The OL 770 achieves high sensitivity by simultaneously detecting spectra across its two-dimensional CCD array. Up to 122 individual pixel rows are summed together to produce the final reading. This method is termed “binning”. In the CCD Binning Range box of the System page there are four possible selections; Minimum, Medium, Maximum and User Defined. When Minimum is selected only the center three rows of the possible 122 rows in the CCD are binned when acquiring a reading. With Medium there are twelve rows binned and with Maximum all the 122 rows are binned. A User Defined option is also included, where the min row you can bin is row 4, and the max row is 125. The row 4 to 125 setting will yield maximum sensitivity for the system. This setting will bin the maximum CCD image height area equivalent to the input slit’s 3 mm image height. Medium and Minimum binning have factors of approximately 10 and 40 less sensitivity than Maximum (full) binning. The user can adjust the binning lines for several advantages. To decrease the system sensitivity where signal levels are saturating the CCD, reduce the number of binning lines. Always, reduce the number of binning lines by increasing the minimum row and decreasing the maximum row by the same amount, i.e. enter a minimum row of 24 and a maximum row of 105. For optimum bandwidth, the center 1mm of the CCD should be used. Set the minimum row to 44 and the maximum row to 85. The system response calibrations are dependent on the binning range specified. The binning range entered for measurement must be the same as the binning range specified for the calibration. Any change to this range will require a new calibration.

OL 771

When using the OL 770 Application Software with the OL 771 Spectroradiometer, binning is limited to one row, thus the controls to select binning will be disabled.

InGaAs

When using the OL 770 Application Software with the OL 770 InGaAs Spectroradiometer, binning is limited to one row, thus the controls to select binning are replaced with Sensitivity Settings. See Appendix J of this manual for additional information on Sensitivity Settings.

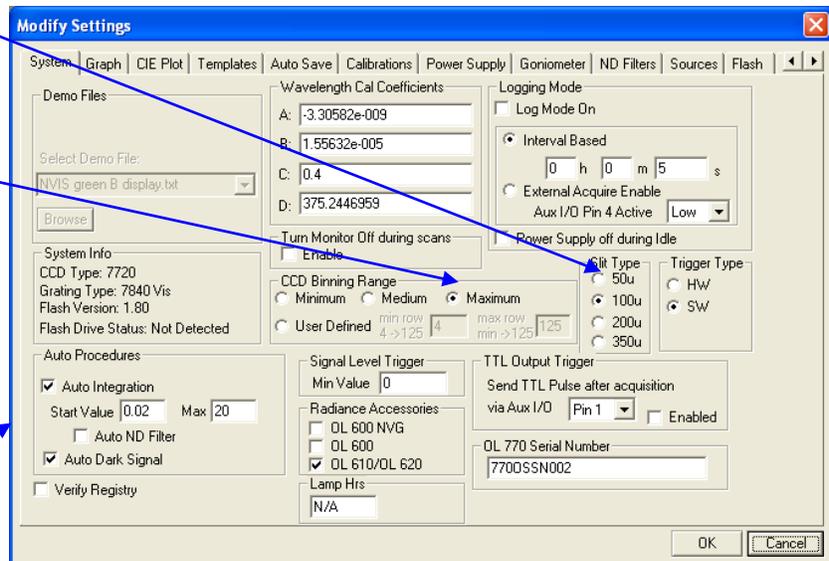
**NOTE:**

Changing the CCD binning may generate a Warning Dialogue Box indicating that the Quick Mode Integrating Time has to be adjusted. Refer to the *Tutorial IV / Quick Profile Mode* section.

The binning rows selected must match the values in the calibration files. A warning message will appear if the CCD Binning Range does not match the values recorded in the chosen calibration (CALX) file. Select OK to the warning message to automatically match binning ranges. The binning range for the supplied calibration (CALX) files are listed on the OL 770 System Information Sheet located in the *OL 770 System Information Manual*.

100µ input slit size (standard) selected

Maximum (full) binning range selected



The Auto Procedures box allows the selection of operations to be done before each reading in single reading mode and before continuous readings begin in continuous mode. The Auto Integration procedure will obtain the best fit for the integration time for the light source and set this value as the integration time. The Auto Dark Signal procedure will take a dark signal reading and subtract this reading from the source readings that follow. The Auto ND Filter selection is used with the OL 770-15Q-A Automated ND Filter Holder and discussed in the *Optional OL 770-ND1-ND4 Neutral Density Filters* section.

- ❑ Select both the Auto Integration and Auto Dark Signal now.

**NOTE:**

The Auto Procedures features are not active in Demo mode.

## TUTORIAL I / PART 2 – PREPARING THE APPLICATION FOR MEASUREMENTS

The Trigger Type radio buttons allow the choice of SW (software) or HW (hardware) device to be used to trigger taking the measurement.

- ❑ Make sure **SW** is selected for Trigger Type.

The Level Trigger box selects a minimum value that the highest point on the spectral data returned must achieve to be displayed. To turn the level trigger on, the Level Trigger button on the Measurement Toolbar must be depressed.

### NOTE:

Simply entering a value in Signal Level Trigger box does not turn the level trigger on. Rather, it only allows a value to be set for use when the trigger is on. The Level Trigger button on the Measurement Toolbar must also be depressed to activate this feature.

- ❑ Leave the Signal Level Trigger value at 0 for now.
- ❑ To activate the Signal Level Trigger feature, the Level Trigger button on the Measurement Toolbar must be depressed before measurements are taken. When the reading values are within the minimum value, the Level Trigger button will turn green, otherwise it will be displayed as gray.
- ❑ Leave all other settings at their default values.



Log Mode - unchecked

Trigger Type set to SW

Signal Trigger Level set to 0

### Internal Lamp Hours Counter

For OL 770 Spectroradiometer systems that have an internal lamp, an important item saved to the flash drive is the internal **Lamp Hours**. Every time the internal lamp is used, its usage time is tracked. Additionally, the OL 770 Serial Number is updated from the flash drive.



Note that the lamp hours indicate an "N/A" when the application is started in DEMO mode or if the OL770's flash drive has been disabled or if the flash drive does not exist as in the OL 771 and older OL 770 models.



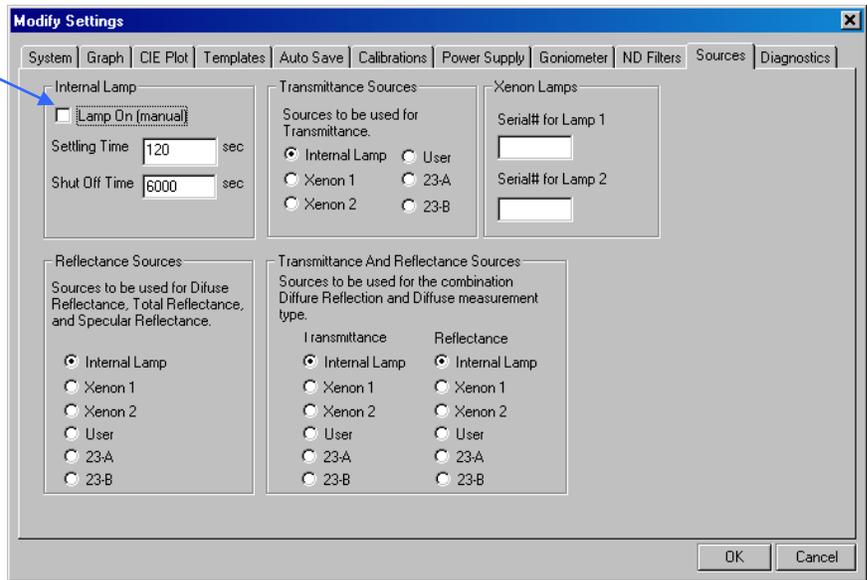
The file stored out to the flash for the lamp hours is lamp.txt. This file will consist of date/time segments of time. These segments are accumulated to present the Lamp Hrs seen on the dialog above. **Do not edit or delete the lamp.txt file from the flash!** This information is important to the factory to determine the integrity of the lamp and editing this file will alter the technician's ability to assure correlation of the integrity of lamp output with the lamp calibration. An example of contents of a lamp.txt is:

```
12/21/06 07:30:24 - 12/21/06 09:30:33
12/21/06 15:16:23 - 12/21/06 15:16:25
12/21/06 15:25:34 - 12/21/06 15:25:47
12/21/06 15:29:38 - 12/21/06 15:29:48
01/02/07 12:51:04 - 01/02/07 12:51:23
```

- ❑ Open the Sources tab.
- ❑ Ensure the Lamp On (manual) box is not checked.

The Lamp On (manual) check box allows the operator to manually turn the internal reference lamp off and on. The Settling Time is the amount of time the lamp will be on before a measurement begins (a count-down timer will display). The Shut Off Time is the amount of time the lamp will be on during measurements.

The Internal Lamp feature is commonly used when creating \*.st7 file or doing transmittance or reflectance measurements.



- ❑ Click OK to close the Modify Settings dialog and accept the settings.

### Discuss Security Operating Modes: User and Manager

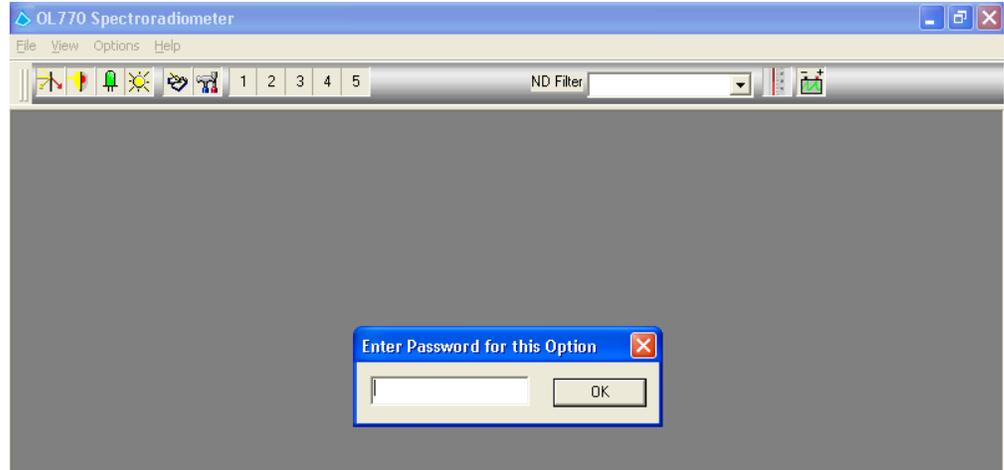
The OL 770 Application Software has two security modes:

- 1) User Mode: Locks out the user from accessing system settings.
- and 2) Manager Mode: Requires a password to access and change the system settings.

When the OL 770 Application Software is running in User Mode, a password is required to access the Modify Settings Dialog or import settings.

Once a password is entered, the application software switches to operate in the Manager Mode allowing system settings to be changed. After settings have been changed, in order to lock out a user from changing these settings, the security mode must be switched back to User Mode.

New installation will open with the application in Manager Mode. However, updates on existing installations may result in the application opening in User Mode. While in User Mode, whenever the Modify Settings button is selected, you will be prompted to enter the password. (The Default Password is 1234.) Once the password is entered, the application software will then run in Manager Mode, allowing changes to be made to the system settings.

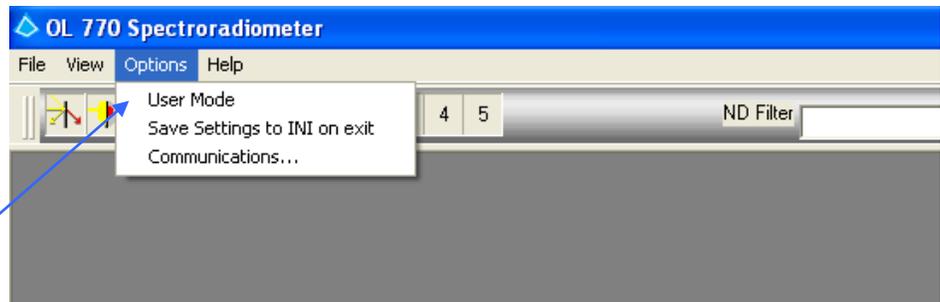


The application software will run in Manager Mode until User Mode is selected from the Options Menu. Changing to User Mode will be discussed later in this tutorial, as well as changing the password.

### Set the Security Operating Mode to User

Now that the system settings have been verified, you may choose to switch the security operating mode to User in order to lock out any user from accessing the system settings.

- **Select the Options menu from the Main Menu. If you desire to lock out users from the Modified Settings Dialog, click Manager Mode selection, it will then toggle to User Mode.**



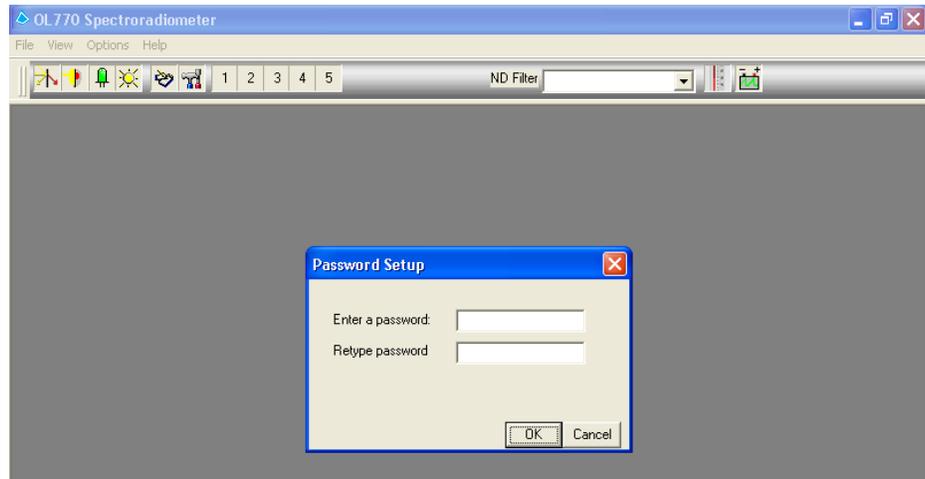
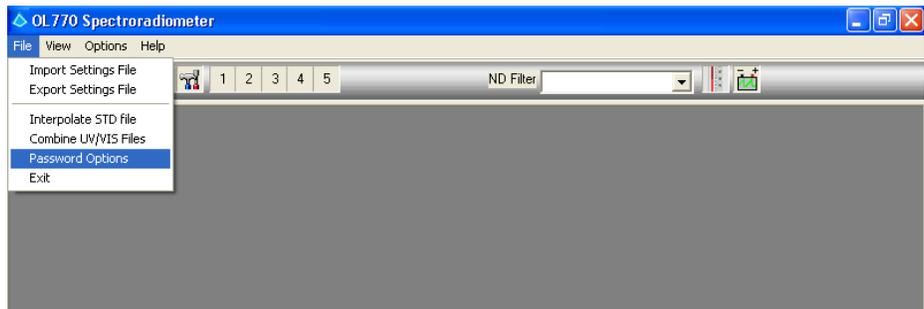
#### NOTE:

When the security operating mode is set for User, whenever the Modify Settings Dialog button is selected, the user will be prompted to enter a password to access any system settings.

## Changing the Manager Mode Password

The password for Manager Mode can be changed.

- ❑ **Select File from the Main Menu, then select Password Options.**
- ❑ **You will first be prompted to enter the existing password (1234 is the default).**
- ❑ **After entering the correct password, the next screen will appear to allow you to enter the new password. You must re-type the password in order for it to be accepted.**



### NOTICE:

You can contact Gooch & Housego, Orlando, Florida for all emergency access passwords.

Email: sales@goochandhousego.com

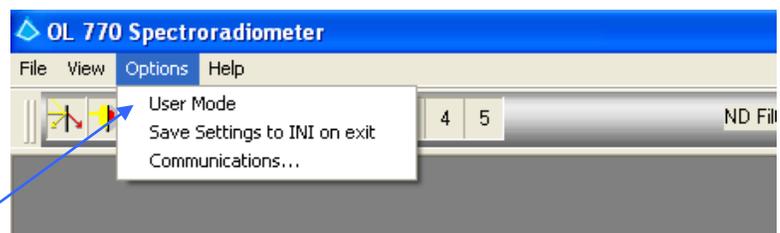
Telephone: +1 407 422 3171

Fax: +1 407 648 5412

## Setting the Save Settings to INI on Exit

An option to always automatically save the system settings to the .INI file on exit is available under the Options menu. If the option is selected, the user will not be prompted when the settings are saved.

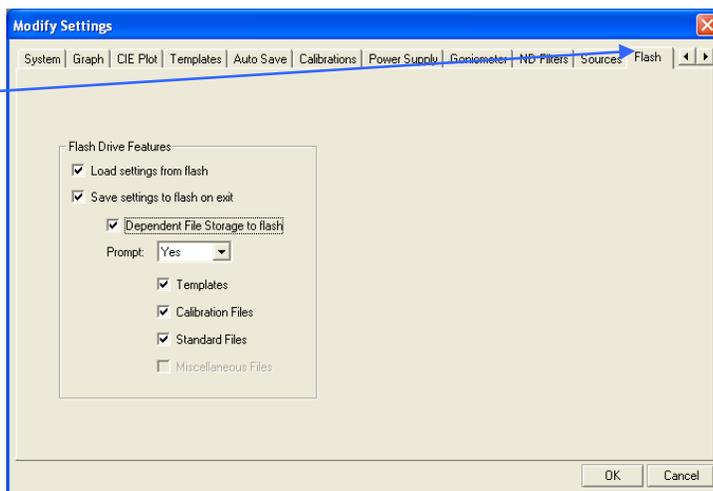
- ❑ **Select the Options menu from the Main Menu. If you desire to have the system settings that are configured under the Modified Setting Dialog to be saved when exiting the application software, then select Save Setting to INI on exit. A check mark will then appear beside the selection.**



## Configuring the Flash Drive

The flash settings have been modified and expanded from previous versions of the OL 770 Application Software. This has led to the addition of the OL 770's flash setting into the **Modify Settings** dialogue **Flash** tab.

The old method of saving system data from the application was through the Windows operating system registry. However, if the OL 770 Spectroradiometer contains the built-in flash drive, the system settings can be saved to the flash drive. This enables the settings to be system dependent instead of computer dependent. Enabling the saving out to the flash requires configuring the settings under the Modified Setting Dialogue/Flash tab. Note that selecting Save to Flash Storage on exit creates a file named default.cfg on the flash drive. When the software is exited with this feature enabled, the user will be prompted to confirm rerouting calibration files, templates, and standard files to the flash as well. Once the settings are saved out to the flash drive, the application will load the settings from the OL 770 flash drive. This feature enables the user to take the OL 770 to a completely different computer and all the settings and files will be intact in the OL 770.



*Note: The features in the flash tab will be grayed out if the flash drive is not attached.*

### Load Settings from Flash

If enabled, settings will be loaded from the flash drive when the OL 770 application software is started.

### Save Settings to Flash on Exit

If enabled, settings will be saved to the flash drive upon exit of the OL 770 application software.

### Dependent File Storage to flash

If enabled, files that are referenced on the hard drive by the application will be saved to the flash drive without erasing the copy on the computer's hard drive. Once the Dependent File Storage to Flash is selected, then the Prompt and types of files will be available for selection.

#### Prompt

If set to YES, the application will prompt the user if the user wants the file to be saved to the flash. If set to NO, the file will be copied without user approval.

#### Templates

If checked, the Word and Excel templates will be copied over to the flash drive.

#### Calibration Files

If checked, the OL 770 calibration files will be copied over to the flash drive.

#### Standard Files

If checked, the referenced STD and ST7 files will be copied over to the flash drive.

#### Miscellaneous Files

If checked, any other file referenced by the application will be copied over to the flash drive.

## Using the OL770 Application Software with an Off-the-Shelf Flash Drive and an Old OL 770 Multi-Channel Spectroradiometer

It is possible to create a flash drive system with an OL 770 that does not have the flash drive installed. This will allow any user to carry a flash drive with an OL 770 and contain all the settings for that OL 770 with the instrument. Here is the procedure to accomplish this.

1. Plug in the flash drive you would like to associate with an OL 770 into a USB port on your computer.
2. Create a file on the flash drive called *OL770Flash.txt*. It is irrelevant what is written in the file.
3. Make sure you have an application version 4.30 (or higher) of the OL 770 Application Software installed. Run the application with the OL 770 powered and attached.
4. Access the Modified Setting Dialogue and select the Flash tab. Turn on the **Save Setting to flash on exit** option.
5. Exit the software. Confirmations will appear about relocating files to the flash. Click the 'Yes' button on each screen to send the files to the flash drive.
6. That's it! Restart the application and it will load the settings from the flash. Just make sure to keep that flash drive with the OL 770 and plug in the flash before running the OL 770 Application Software.

## Part 3 – Acquiring a Measurement

What we'll do:

- Introduce the various measurement types.
- Learn how to open an Acquisition View.
- Discuss Dockable Dialog Bars.
- Acquire a Measurement.
- Change the Integration Time.
- Change the Number of Scans to Average.
- Save a Measurement File.
- Discuss the Clear Measurement Data button.
- Open a Measurement File.

## Various Measurement Types

The measurement types that are supported are:

Measurement Package		Measurement Type	OL 770 Accessories
OL 770-423-LED		Source Spectral Analysis for LEDs, includes: <ul style="list-style-type: none"> <li>- Goniometric</li> <li>- Averaged LED Intensity - Condition A</li> <li>- Averaged LED Intensity - Condition B</li> <li>- Total Luminous Flux</li> <li>- Electrical Characterization - Condition A</li> <li>- Electrical Characterization - Condition B</li> <li>- Electrical Characterization - TLF</li> </ul>	<p>Goniometric - Spatial distribution measurements require the OL 700-30 LED Goniometer.</p> <p>Averaged LED Intensity - Condition A or B – Requires the OL 15AB LED Receptor.</p> <p>Total Luminous Flux – Requires an integrating sphere such as the OL IS-670-LED, OL IS-1272-LED, or OL IS-1800, etc.</p> <p>Electrical Characterization – May be performed with the OL 15AB or an integrating sphere using the Keithley SourceMeter in Sweep or Pulse Mode.</p>
OL 770-423  - OR- OL 770-423-NVS		Source Spectral Analysis, includes <ul style="list-style-type: none"> <li>- Spectral Radiance</li> <li>- Spectral Irradiance</li> <li>- Spectral Radiant Intensity</li> <li>- Total Spectral Flux</li> </ul> - OR- Source Spectral Analysis for NVS Measurements, includes <ul style="list-style-type: none"> <li>- Spectral Radiance</li> </ul>	<p>Spectral Radiance – Requires an imaging optic such as the OL 610 CCD Imaging Telescope or other suitable imaging optic.</p> <p>Spectral Irradiance – Requires an integrating sphere, or may be performed with the combination of an imaging optic and diffuse reflectance standard.</p> <p>Spectral Radiant Intensity – Requires an integrating sphere, an imaging optic, or a combination of an imaging optic and diffuse reflectance standard.</p> <p>Total Spectral Flux – Requires a suitable integrating sphere, determined by source geometry.</p>
OL 770-424		Linear, includes: <ul style="list-style-type: none"> <li>- Transmittance</li> <li>- Specular Reflectance</li> </ul>	<p>Linear Transmittance – Requires a transmittance measurement attachment or may be performed using an imaging optic.</p> <p>Specular Reflectance – Requires a reflectance measurement attachment or may be performed using an imaging optic.</p>
OL 770-427		Diffuse, includes: <ul style="list-style-type: none"> <li>- Diffuse Transmittance/Reflectance Measurements</li> </ul>	<p>Diffuse Reflectance/Transmittance – Requires an OL 700-70 Diffuse Reflectance Attachment, or the OL 700-71 Diffuse Transmittance/Reflectance Attachment.</p>

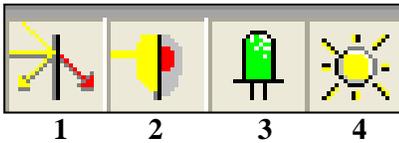
### Opening an Acquisition View

---

#### NOTICE

A password granting access to each measurement package is supplied with the OL 770 Application Software installation CD. The first time a measurement package is used, the user will be prompted to enter the password. Thereafter, the software will access the password in the computer system registry.

An Acquisition View affords all the functionality needed to take a reading and retrieve information about that reading. Clicking on one of the first four buttons on the Main Toolbar opens an Acquisition View.



1. Opens a Linear Measurement Menu:
  - Transmittance
  - Specular Reflectance
2. Opens a Diffuse Measurement Menu:
  - Total Reflectance/Transmittance
  - Diffuse Reflectance/Transmittance
3. Opens an LED Menu:
  - Goniometric
  - Averaged LED Intensity - Condition A
  - Averaged LED Intensity - Condition B
  - Total Luminous Flux
  - Electrical Characterization - Condition A
  - Electrical Characterization - Condition B
  - Electrical Characterization - TLF
4. Opens a Source Spectral Analysis Menu.
  - Spectral Radiance
  - Spectral Irradiance
  - Spectral Radiant Intensity
  - Total Spectral Flux

- ❑ For the purpose of this tutorial, press the LED button, and a menu will drop-down.

The items on the menu represent the optical attachments available for the OL 770.

- ❑ Choose the menu item that describes the item currently attached to the OL 770.

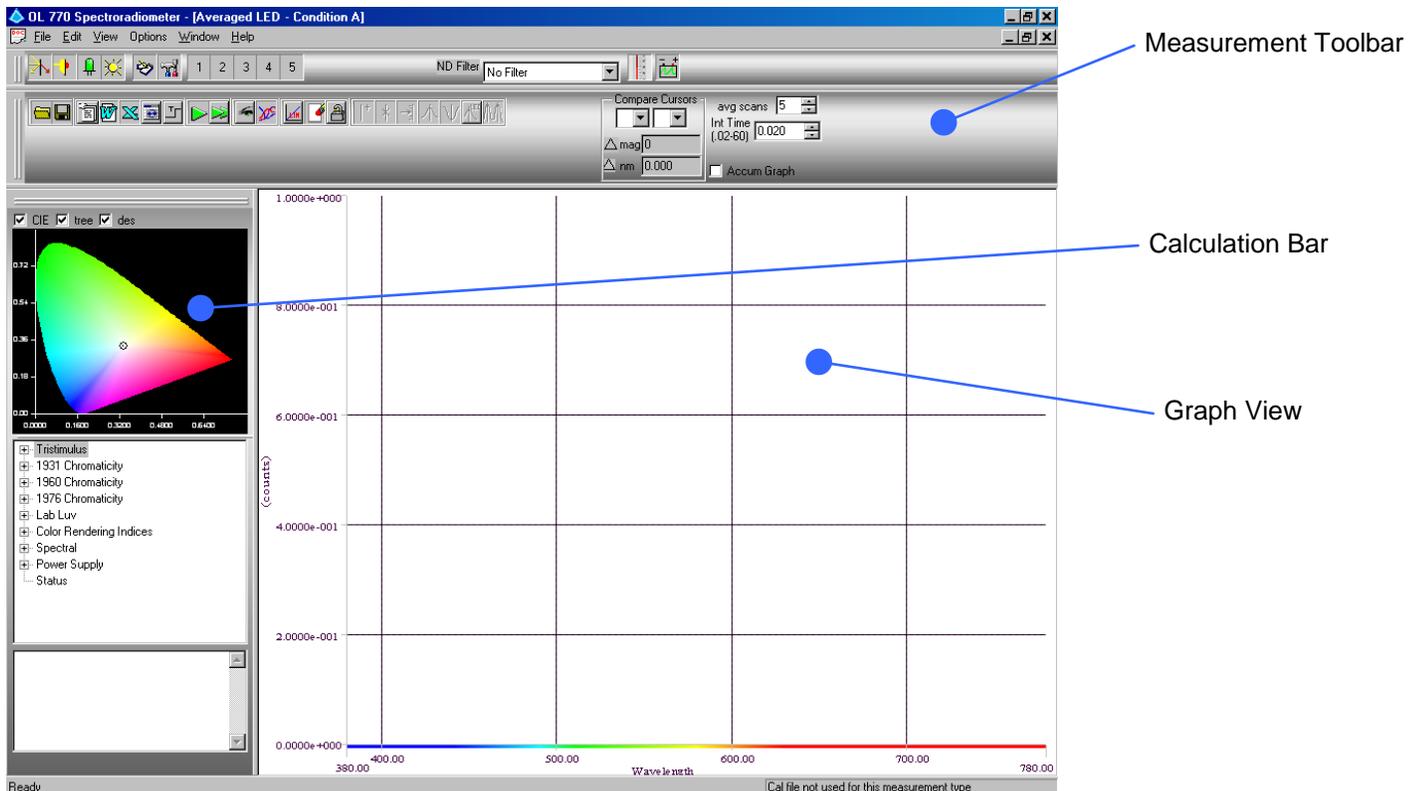
Choose the Averaged LED Intensity – Condition A selection if the OL 15AB LED Receptor setup for Condition A measurements is configured to the OL 770.

Choose the Averaged LED Intensity – Condition B selection if the OL 15AB LED Receptor setup for Condition B measurements is configured to the OL 770.

Choose the Total Luminous Flux selection if the OL IS-670-LED Integrating Sphere is configured to the OL 770.

Choose the Goniometric selection if the OL 700-30 is configured to the OL 770.

Once a selection is made, a new window will open inside of the main screen. This is the Acquisition View. This view contains three main items: the Measurement Toolbar on the top, the Calculation Bar on the left, and the Graph View that consumes the remaining space unoccupied by either of the two bars.



The Measurement Toolbar and the Calculation Bar are Dockable Dialog bars.

### What are Dockable Dialog Bars?

A Dockable Dialog Bar is a window that can be “docked” to a portion of the screen. Dockable dialogs are dialogs that are floating but can be dragged to integrate with the main window.

There are three Dockable Dialog bars that will appear in this application: the Main Toolbar, the Measurement Toolbar, and the Calculation Bar. These bars can be “docked” to either the top or bottom of the application for horizontal bars, or the right or left of the application for vertical bars. In other words, they can be moved or dragged around to any space within the application. But if they are dragged too close to either of these locations, the bar will snap itself to this location and fill a portion of the screen relating to where it is snapped.

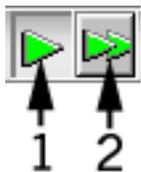
To undock a Dockable Dialog bar, click on the two thin 3D lines at either the far left or very top of the bar. Then, while holding the left mouse button down, drag the bar to the center of the screen. If the bar is far enough away from any other dockable region of the screen, the bar will undock. Otherwise it will dock to the closest dockable region.

Dockable Dialog bars can be closed and reopened in the main menu’s view/ toolbar section. Clicking on the bar’s title will toggle between closed and open.

## Measurement Acquisition

Now that there is an Acquisition View open, and the settings are properly configured in the System tab, the system is ready to begin acquiring measurements.

On the Measurement Toolbar, located at the top of the new view that was opened, are two buttons. The first is a single right directional arrow, and the second has two overlapping right directional arrows. These are the buttons used to acquire readings from the OL 770 device.



1. Used to acquire single measurements
2. Used to begin and end continuous measurements

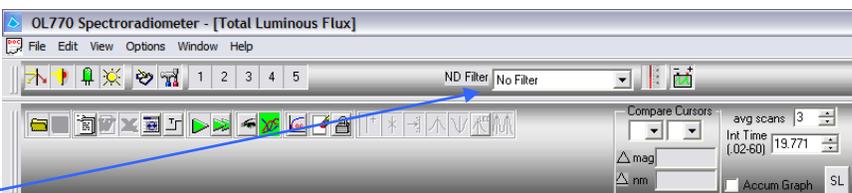
Begin by acquiring a single reading from the device.

- Provide an input source, such as an LED, to the optical input attachment.
- Ensure the ND Filter text box in the Main Toolbar is set to 'No Filter'.

### \* NOTICE \*

A new feature was added in the OL 770 Application Software version 4.43 and above. The ND filters are no longer used in measurements only. The new software allows the use of ND filters in all measurement types. To eliminate confusion, the ND filters are only selected in the main screen of the application software. The configuration settings are usually saved when exiting the software. If an ND was last used, it is remembered the next time the software is initiated.

*It is important that users confirm the desired ND selection before entering the Modified Setting window to perform any measurement.*



- Press the **Single Measurement**  button.

If either or both of the auto procedures (Auto Integration, Auto Dark Signal) have been checked and the software is not in demo mode, these procedures will be performed before a single reading is taken. If auto integration is operating, the system will adjust the integration time appropriately for that light level. (*This may take up to one minute.*)

When the reading is acquired, notice that many items on the view change. The most noticeable is the data that has been drawn on the graph. The data on the graph is drawn with the wavelength values across the x-axis and the intensity of the reading along the y-axis. The CIE Plot on the top part of the leftmost dialog bar named the Calculations Bar. The CIE plot will display a data point relative to the calculated x- and y-chromaticity coordinates. The tree below that, called the Value Tree, will be updated to show all of the variable's actual values calculated from the recently acquired data.

#### NOTE:

The units on the 'y' axis scale on the graph change to reflect the measurement type and calibration options selected. Refer to Tutorial I / Part 5 of this manual.

- Press the **Continuous Measurement**  button.

After pressing this button, notice that the button remains depressed. It is a toggle button. While the button is depressed, continuous readings are taken. To cease continuous measurements once they have started, press the button a second time.

- Press the **Continuous Measurement button a second time now to toggle continuous measurements off and halt acquisitions.**

## OL 770 Signal Saturation

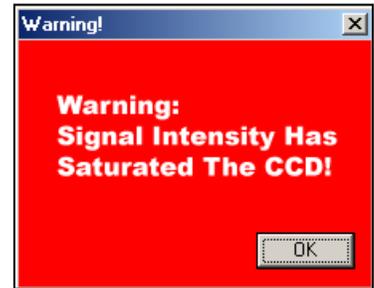
The OL 770 system has three methods for preventing signal saturation:

1. **Integration Time:** This can be set manually or automatically for any time between 0.02 and 60 seconds.
2. **CCD Binning:** (Reference Tutorial 1/ Part 2.) Minimum binning has < 3 % of the maximum (full) binning signal.
3. **Neutral Density Filters:** Gooch & Housego offers a range of calibrated neutral density filters for use with the OL 770 and its accessories. (Refer to Appendix E.)

The OL 770 application software will display a warning dialog when the peak spectral intensity exceeds the CCD or ADC range and the integration time is at its minimum or the Auto Integration procedure is disabled.

List of options to correct for CCD signal saturation:

1. Reduce the integration time or check the Auto Integration procedure.
2. If using the OL 600, reduce the OL 600 aperture size – select a new system response calibration file.
3. Change the CCD binning range – requires system calibration.
4. Add an ND filter to the fiber optic probe – and select ND filter # in measurement toolbar.

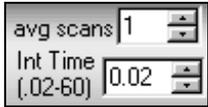


### NOTE:

The OL 770 signal saturation is reflected in the **Status** flag on the Value Tree. Refer to the *Value Tree Status Value* section on page 54 for more information.

## Manually Setting the Integration Time

The Integration Time box is used to set the integration time (in seconds) for the measurement reading. This value can be changed by “spinning” the value, which is done by clicking the up or down arrows. It can also be accomplished by clicking on the value, changing the value, then pressing enter to set the new value. Manual control of the integration time is only possible when the auto integration procedure is disabled (Modify Settings Dialog/System Tab/Auto Integration - Unchecked).



The Integration Time and Number of Scans to Average spin controls are located on the Measurement Toolbar.

- Click on the value in the Integration Time box.**

The numbers become bold, indicating they are ready to be edited.

-   **Type a new value (between 0.02 and 60.0) for the new integration time. Press enter to accept this value.**  
**Note: When using the OL 770 Application Software with the OL 771 Spectroradiometer, the integration time can range from 0.005 to 60.0 seconds. Newer OL 770/OL 771 systems can reach up to 600.0 seconds.**



- Type a new value (between .001 and 60.0) for the new integration time. Press enter to accept this value.**

### NOTE:

Pressing enter is very important. The new value will not be set if enter is not pressed.

The Auto Integration (Modify Settings Dialog/System Tab) option must be unchecked in order to implement the entered integrating time.

The Int Time box will display the integration time at the start of the measurement in either Auto Integration or Manually set integration modes.

If the integration time is edited during continuous measurements, the new integration time will not be implemented until measurements are stopped and started again.

The integration time has now been changed. All further readings will be taken with this integration time until changed again, or over written by Auto Integration.

## Change the Number of Scans to Average

The Ave Scans spin control is used to set the number of dark readings and scans that will be taken and averaged before data is calculated and displayed. This value is changed the same way as the Integration Time.

- Change this value to 3 in the same manner that the integration time was changed. Take a single measurement.**

Three dark readings and measurement scans will each be taken with the new integration time. The averaged dark spectrum will be subtracted from the averaged measurement data before applying the spectral calibration factors and displaying the graph.

- Set the averaging scans value back to 1.**

## Saving a Measurement File

The Save button is used to save readings.



- Press the Save button now to save the last acquisition's data to a file.**

A dialog box will appear, asking for a designation for the file. A designation is a user-specified comment included in the file.

- Enter a designation, if desired, then press OK.**

Next, a dialog box will appear, asking for a path and filename for the file to be saved.

**NOTE:**

The data can be saved where each binned pixel will have a unique wavelength and spectral data value:  
 <Data>  
 379.7825, 1.76703e-008  
 380.1675, 1.89951e-008  
 380.5526, 1.77141e-008 ....(1024 data points)

If the Interpolate Data to 1nm Increments box is checked, the data will be reduced to 401 data points from 380 to 780nm.  
 <Data>  
 380.0000, 1.76703e-008  
 381.0000, 1.92189e-008  
 382.0000, 1.78116e-008 ....(401 data points) (VIS systems)

- ❑ **Select a path and a filename from the dialog (e.g. C:\Program Files\...\OL770\OLIData). Click OK.**

The file extension “.OLI” is automatically added to the spectral data filename. The file is now saved. If you are interested in the way information is stored in a file, open Word Pad, Notepad, or some other text-editing program. Then use this program to open the file just saved.

### The Clear Measurement Data Button

The Clear Measurement Data button is used to clear all of the displayed current data. It will clear the graph, the CIE Plot, and the Value Tree.



- ❑ **Press the Clear Measurement Data button now.**

The graph disappears and the graph’s dimensions return to their default values. All CIE plot X’s will disappear, as well as all values in the Value Tree.

### Opening a Measurement File

The Open A File button opens a file that has been saved in a choice of Gooch & Housego spectral data formats:

- .oli for OL 770 measurement data
- .st7 for the internal lamp standard data
- .cal for the OL 770 spectral calibration data files
- .dat for OL 750 or OL 754 data files
- .std for OLI Standard Files
- .elt for Electrical Characterization files (used in the LED/Electrical Characterization Cond A, Cond B and TLF measurement packages)
- .grc for General Reflectance Calibration file (used in the Diffuse Transmittance/Reflectance and Linear Specular Reflectance measurement packages)
- .gtc for General Transmittance Calibration file (used in the Diffuse Transmittance/Reflectance measurement package)
- .scl for Sample Calibration file (used in the Diffuse Transmittance/Reflectance and Linear Specular Reflectance measurement packages)



- ❑ **Open the reading just taken by pressing the Open button and selecting the path and filename of the reading that you just saved.**

Notice that the graph, CIE Plot, and Value Tree are filled with the same information as when the reading was first taken.

**NOTE:**

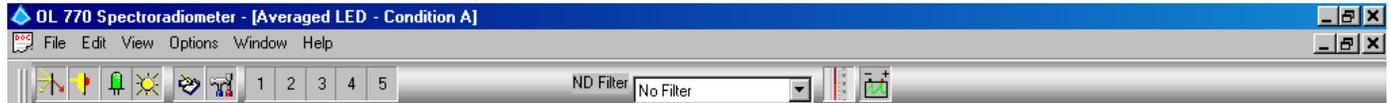
The file headers for ST7 and OLI data files contain information on the measurement type. If the file is opened into a different measurement window, a warning dialog will appear. If you choose to continue with opening the file, the units and values may be incorrect.

## Part 4 – Defining a User Configuration Button

What we'll do:

- Introduce the User Configuration Button.
- Save current settings to a User Configuration Button.
- Rename User Configuration Button to Reflect the Settings.

### User Configuration Buttons

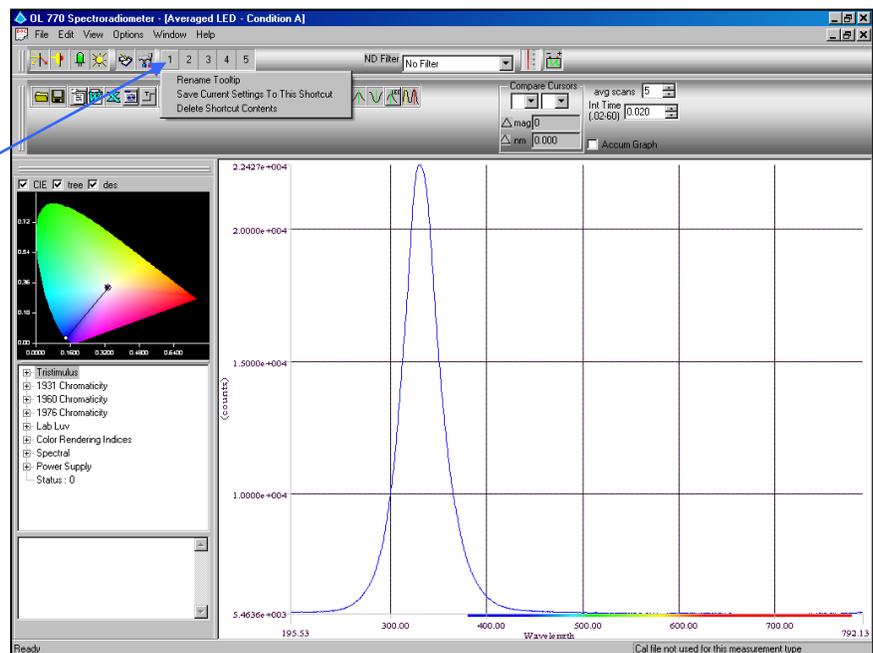


The OL 770 Application Software has five User Configuration Buttons located on the Main Toolbar. These can be used to quicken and simplify the process of changing the system settings. Each user button can memorize all the current system settings including the measurement type, calibration file selected, ND Filter selection, CCD binning, auto procedures, number of scans, Savitzky-Golay smoothing settings, graph colors, template file names, autosave paths and names, etc.

### Save Current Settings to a User Configuration Button

- ❑ **Adjust all the OL 770 settings to suit your measurement requirements. Keep the measurement window open.**
- ❑ **Place the mouse pointer over the User Configuration Button and right click to open a menu.**
- ❑ **Highlight the option Save Current Settings To This Shortcut and left click the mouse. A dialog will open to indicate the Current Settings Have Been Saved.**
- ❑ **Click OK to close dialog.**

A new file CFG1.CFG file will be saved to the OL 770 directory containing all the system settings. Each button has its own CFG file.



### Rename User Configuration Button to Reflect the Settings

- ❑ **Place the mouse pointer over the User Configuration Button that has been defined as a shortcut and right click to open a menu.**
- ❑ **Highlight the option Rename Tooltip and left click the mouse. A window will open Enter String For New Tooltip.**
- ❑ **Add text that best describes the measurement settings. Click OK to save the tooltip and close the window.**
- ❑ **Hover the mouse over the button to display the tooltip.**

Repeat the process for each User Configuration button as required.

To change the system configuration settings to each of the saved User Configuration Settings, simply click on the required button.

**NOTE:**

The application software will remind the user that all current settings will be replaced and all measurement windows will be closed prior to opening the new User Configuration Measurement Window.

## Part 5 – The Graph View

What we'll do:

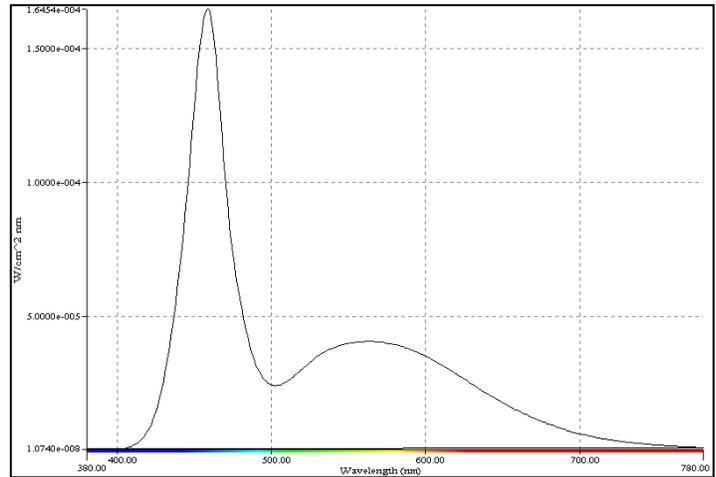
- Discuss the information provided by the Graph View.
- Show how to Zoom In and Out of the Graph.
- Locking the Graph's Axes.
- Discuss the Log Plot Button.
- Explain Graph Modes.

### Information Provided by the Graph View

The Graph View graphically displays the data that is read into the program. The wavelength values are plotted along the x-axis, and the intensity values are along the y-axis. As a reading is taken, the axis values change to accommodate for minimum and maximum values of the reading. The graph can be manipulated in many ways to make it more informative.

**NOTE:**

The wavelength scale is dependent upon the model of the spectroradiometer being used.



### Zooming In and Out of the Graph View

Zooming into the graph is accomplished by right clicking at the top left-hand corner of the area to be zoomed in to. Then, while holding the mouse button down, drag the cursor to the bottom right hand corner of the section to be zoomed in to.

- ❑ **Right click somewhere on the graph. Hold the right mouse button down, and drag the cursor down and to the right to draw a selection box around a portion of the graph. Release the right mouse button.**

The graph's dimensions change to the dimensions of the area of the box created. That portion of the graph in the box now fills the entire screen.

To zoom out, press the left mouse button anywhere on the graph except on one of the graph's cursors (explained in the next section). The view will zoom out to the previous view.

- ❑ **Click the left button somewhere on the graph area. The graph changes back to its previous look and dimensions.**
- ❑ **Try zooming in multiple times and zooming out to previous views.**

### Locking the Graph's Axis

Locking the axes of the graph allows viewing of future acquisitions at the present x and y dimensions.



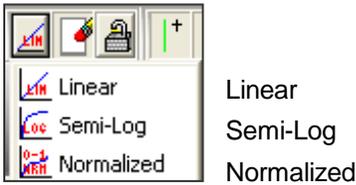
- ❑ **Press the Lock Graph button to lock the graph.**

The Lock Graph button will lock the graph's dimensions and display all further graphs using these same dimensions. Use this function to make comparisons without changing the graph scale on sequential measurements.

- ❑ **Take another reading. The graph's dimensions stay the same. The new graph is drawn to fit the old x and y axes values.**
- ❑ **Press the Lock Graph button to unlock the dimensions.**
- ❑ **Take another reading. Now the graph dimensions conform to minimum and maximum values of the graph.**

## The Graph Y Axis Plot Button

The Y Axis Plot button produces a pop-down menu for three graph plots (Note that only Linear and Normalized are available for Goniometric measurements):



- Take a single measurement. Now select the **Semi-Log** plot mode and observe how the graph looks with the Y-axis drawn using a logarithmic scale.
- Take another measurement. Notice that the following measurement is also graphed in **Semi-Log Plot** mode.
- Likewise, select the **Normalized** plot and finally return to the **Linear** plot.

## Graph Mode

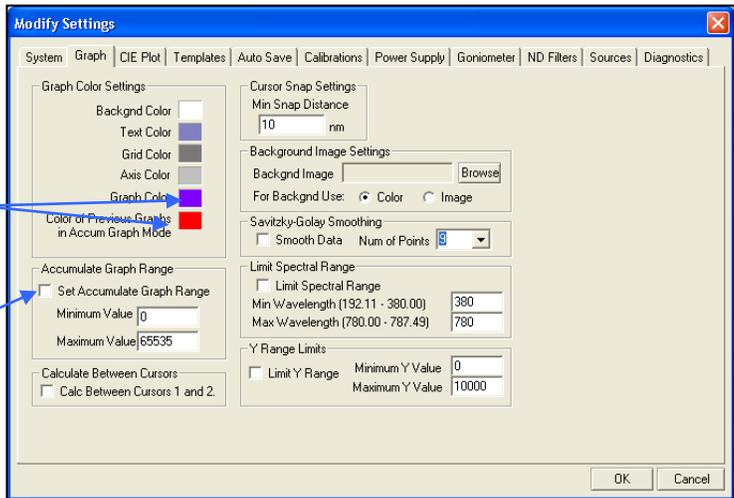


The Accum Graph check box is used to set the graph to accumulate graphs. In other words, the old graph will not be erased when the new graph is drawn. This mode will continue to accumulate graphs until the check is released. You can manually set the minimum and maximum graph values for the accumulate graphs option before measurements begin in the Modify Settings/Graph page.

Before changing to the Accum Graph mode, it will be necessary to check the settings of the Accumulate Graph Range.



- Click on the **Modify Settings** button on the Main Toolbar to open the dialog.
- Select the **Graph** tab.
- Confirm the **Color of the Current Graph is different from the Graph Color.** (Refer to the Tutorial II / Part I to change graph colors.)
- Ensure the **Set Accumulate Graph Range** box is not checked to enable the Y-axis to be scaled automatically.



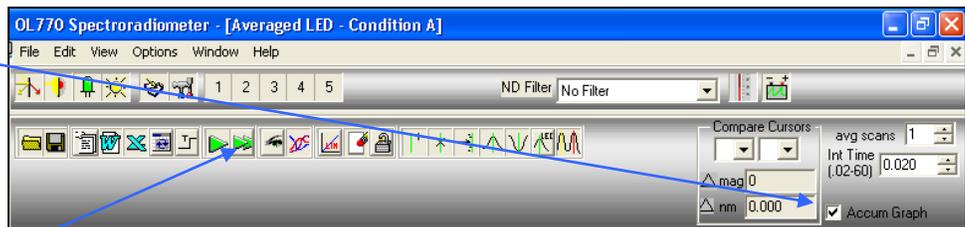
During Accumulate Graph mode, acquisition the scaling of the Y-axis is automatically set by the data in the first spectral scan. If the LED intensity is increasing, the graph range will not display the higher values.

When the Set Accumulate Graph Range box is checked, the graph range can be manually set using the Minimum and Maximum Values. Note the Maximum and Minimum Values reflect the type of measurement and can be [counts], [count / second], [Watts / nm], etc.

- Click **OK** to close the Modify Settings dialog and accept the settings.

- Click the **Accum Graph** check box on the Measurement Toolbar.

**Note:** Whenever the Accum Graph button is checked, the current graph display will be cleared.



- Click on the **Continuous Measurements** button again to begin taking continuous measurements. The graphs accumulate.



The graphs accumulate on top of all previous graphs taken after this button was checked. To clear the graph, press the **Clear Measurement Data** button.

- Click the **Accum Graph** check box to turn off the accumulate mode.
- Click the **Continuous Measurements** button to stop the measurements.

**NOTE:**  
The Accumulate Graph Mode is a “view only” mode. This data cannot be saved or retrieved later. The graph image, however, can be saved to the Windows clipboard by using the PC’s print screen button and copying into a suitable image-processing program.

## Part 6 - Cursors

What we'll do:

- Discuss Cursors.
- Discuss Cursor Property Blocks.
- Explain how to Add and Delete Multiple Cursors.
- Show how to Compare Two Cursors' Values.
- Discuss Snapping Cursors.
- Discuss Cursor Modes.

### Cursors

Cursors are vertical bars that can be added to the graph and moved to any location to view specific values of the graph at that location. A cursor defines a specific x-value on the graph and gives information about properties of the graph at the x-value that it represents.

#### NOTE:

Cursors are not available until after the first measurement has been performed.

Cursors are added to the graph by clicking the Add A New Cursor button on the Measurement Toolbar. A cursor is subtracted by selecting the cursor and clicking Delete Selected Cursor on the Measurement Toolbar.



Once a cursor is added, it can be moved to any x-location on the graph by left clicking on the cursor and holding the left mouse button down while dragging the cursor to a new location. To release the cursor at this location, release the left mouse button. A maximum of seven cursor can be added to the graph.

- ❑ **Click on the Add a Cursor button on the Measurement Toolbar to add a cursor.**

Notice that a vertical bar appears on the graph, as well as some new items. These new items define a Cursor Property Block, which will be explained in the next section.

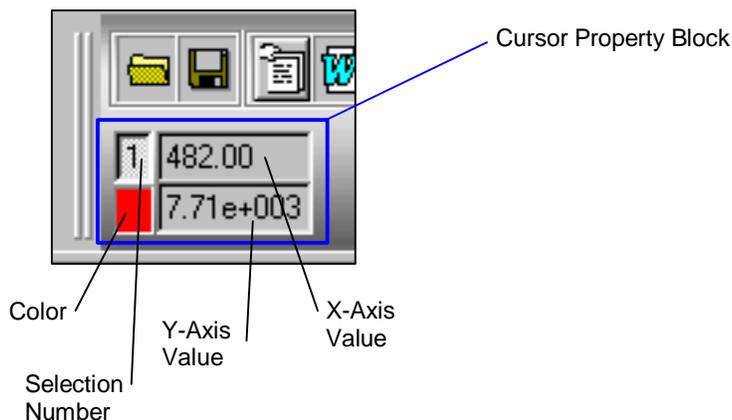
- ❑ **Position the mouse cursor directly over the vertical line. Left-click the mouse and hold the left mouse button down while dragging the cursor around the graph.**

As the cursor moves, notice that the values in the Cursor Property Block change.

### Cursor Property Block

Once the Add A Cursor button is selected, a Cursor Property Block is created. A Cursor Property Block displays information about the numbered cursor. There are four main parts to the Cursor Property Block:

1. The color
2. The selection number
3. The x-axis value display (wavelength in nanometers)
4. The corresponding y-axis value (intensity)



The Selection Number is also printed near the top of the cursor on the graph. This number, as well as the cursor's color, allows each cursor to be matched with its Cursor Property Block.

When a cursor is moved, its corresponding X-Axis Value (wavelength value) and Y-Axis Value (Intensity Value) will change. The Cursor Property Block will update to show the new x- and y- axis values relative to the cursor's position.

In order to select a cursor for deletion or other cursor manipulation, click on the Selection Number button of the cursor. This will depress the Cursor's Selection Number, thus selecting it.

## Adding and Deleting Multiple Cursors

We have learned that cursors are added and deleted by using the Add A Cursor and Delete a Selected Cursor buttons shown in the previous section. We will now discuss the use of multiple cursors in the application.



- ❑ Click the **Add A Cursor** button four more times so there are five cursors displayed.

Four new cursors were added to the graph and four new Cursor Property Blocks were added to the Measurement Toolbar. Try manipulating some of these Cursors and watch how each Cursor's Property Block is affected.

- ❑ Click on one of the five cursor **Selection Number** to select a cursor.

The cursor Selection Number button is depressed and all other buttons are in their normal state. This indicates that this cursor number is toggled on.

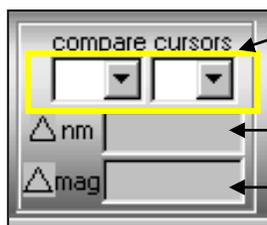


- ❑ Click on the **Delete A Selected Cursor** button.

The vertical bar that represents the cursor will be removed from the graph, and the Cursor Property Block will be erased.

## Comparing Two Cursors' Values

The Compare Cursors Block selects two cursors and shows the difference between these two cursors' x-axis values (wavelength) and y-axis values (magnitude).



The drop-down boxes are used to select any two cursors. When selected, the difference in the cursor's values will appear in the respective boxes.

Displays the difference between the two cursors' wavelength values

Displays the difference between the two cursors' magnitudes

- ❑ Make sure there are at least two cursors on the graph. Select a cursor from the left drop-down box, and a different cursor from the right drop-down box.

The "Δ mag" box displays the difference in magnitude, and the "Δ nm" box displays the wavelength value difference in nanometers.

- ❑ Try moving either of the cursors named in these two boxes and observe these values change.

## Moving Cursors with Graph Zoom View

The Bring The Cursor Into View moves the selected cursor into the zoomed graph view to enable it to be manually positioned or selected for snapping to a minor peak or valley.



- ❑ Zoom into the graph to show only the area with two peaks between 500 and 600 nm, or part of the graph where Cursor 1 is not visible.
- ❑ Select Cursor 1 by clicking on its Selection Number in the Property Block to depress it.
- ❑ Click on the **Bring The Cursor Into View** button. Cursor 1 is now visible on the zoomed graph and can be manually positioned or snapped.
- ❑ Zoom out to full graph view by left clicking the mouse until the full spectrum is plotted.

### Snapping Cursors

Cursors can be snapped to a peak (highest point) or valley (lowest point) on the current graph by selecting the cursor's Selection Number and clicking on either Snap Selected Cursor to Peak or Snap Selected Cursor to Valley buttons.



- ❑ If there are no cursors currently displayed, add a cursor. Select the cursor and then click on the **Snap Selected Cursor to Peak** button.

The cursor moves from its current position to the x-position where the corresponding y-value is the highest peak on the graph in the current view.



- ❑ Press the **Snap Selected Cursor to Valley** button

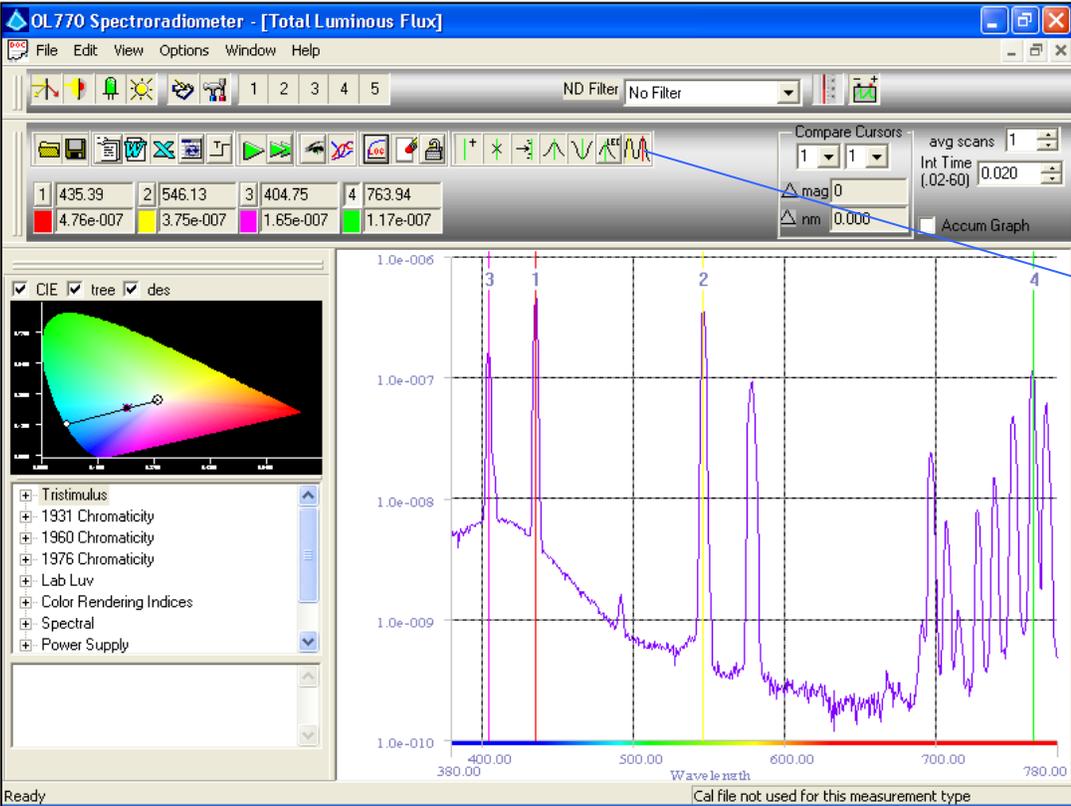
The cursor will move to the lowest valley on the graph in the present view.

To snap to a peak or valley that is not the highest or lowest on the current graph, zoom into an area that will make the desired peak or valley the highest or lowest in the view. Click the Snap Selected Cursor to Peak or Valley button.

The right cursor button moves the current cursors to Snap All Cursors to Peaks. This takes into account the number of cursors that are presently available in the view, and snaps these to the highest peaks in the view.



- ❑ Add or delete cursors from your graph until there are four cursors on the graph. Then, click the **Snap All Cursors to Peaks** button.



Snap All Cursors to Peaks button

There were four cursors in the view before this button was pressed. Now all four have been snapped to the four highest peaks in the view, and their Cursor Property Blocks have updated accordingly.

- ❑ Take a couple of readings and notice that the Cursor's wavelength values will not change as snap peaks do not update as consecutive readings are taken, yet the y-values will update.

**NOTE:**

Snap operates on the current graph, so if a new reading is taken after snap to valley or snap to peak is executed, the cursor's wavelength value will not move.

The minimum distance between cursors when snapping all cursors to peak can be set in the Modify Setting/Graph page. Change the Min. Snap Distance in the Cursor Snap Settings box to 20 nm if the cursors do not snap to the individual peaks.

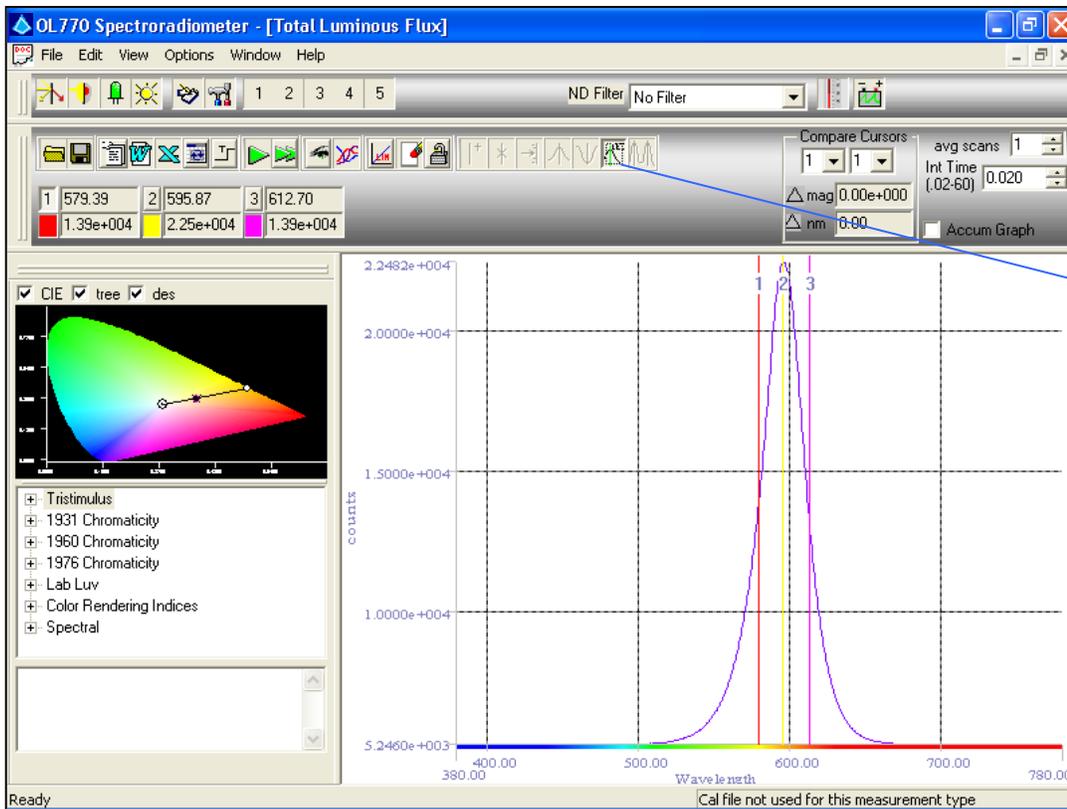
## LED Cursor Mode

To place the cursors into the LED Cursor Mode, press the LED Cursors toggle button. To release the mode, simply toggle the button off again.

When in LED Mode, the graph hides any current cursors that may be open, and adds three new Cursors that will represent the Left Half-Bandwidth, Max Signal, and Right Half-Bandwidth, respectively. Actual values for Half-Bandwidth and Max Signal are located in the Value Tree that will be discussed later.



❑ Click on the Snap Cursors to LED Values button.



Snap Cursors to LED button is depressed

All cursors are hidden, and three new cursors, as well as corresponding Cursor Property Blocks, appear. These represent the three values mentioned above. Also notice that while the LED Mode is on, all of the other cursor manipulation buttons are grayed out. When the cursors are in LED Mode, no other operations can be done on the cursors.

In LED Mode, the snap function is active with each new reading.

- ❑ Take a single reading. The three cursors snap to the new graph's LED values. Click the LED Mode button a second time to toggle the LED Mode off.

## Part 7 – The Calculation Bar

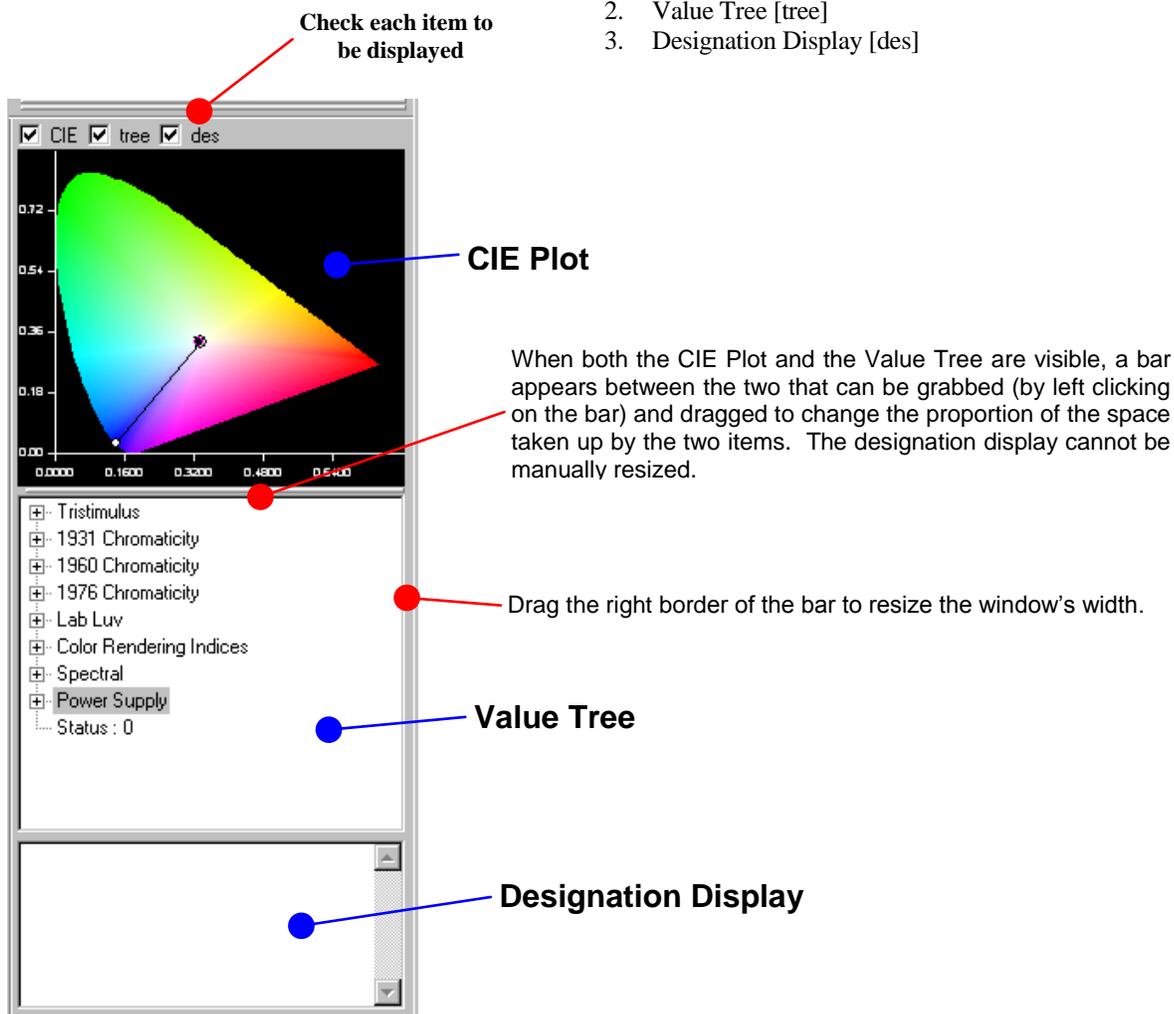
What we'll do:

- Discuss the Information Provided by the Calculation Bar.
- Show How to Change the Appearance of the Calculation Bar.
- Show How to Configure CIE Plot Settings.
- Introduce the CIE Plot.
- Discuss the Value Tree.
- Discuss the Calculate Between Cursors 1 and 2 selection.

### Information Provided by the Calculation Bar

The Calculation Bar is made up of three main parts:

1. CIE Plot [CIE]
2. Value Tree [tree]
3. Designation Display [des]



The CIE Plot responds to new readings by plotting a data point represented by an “X.” The Value Tree displays the variables that are calculated for each measurement in the application, and their current value, if any. The Designation Display shows the current file’s designation, if any. This designation is set when saving a file.

## Changing the Appearance of the Calculation Bar

The Calculation Bar will initially appear vertically on the left-hand side of the acquisition view. There are three check boxes in the upper left area of the Calculation Bar. These check boxes determine whether or not either of the “CIE” Plot, the Value “Tree”, or the “Des”ignation Display will be visible. If the check is set, its respective item is visible. If it is unchecked, it is hidden.

- ❑ **Move the mouse to hover over the center bar. The cursor will change to a North-South directional arrow. Left-click on the center bar and hold the mouse button while dragging the cursor up and down to see the bar’s outline move. When released, the bar will be placed at its current location, and the proportion of the two items will change accordingly. The horizontal size may be changed in the same manner by dragging the right border.**

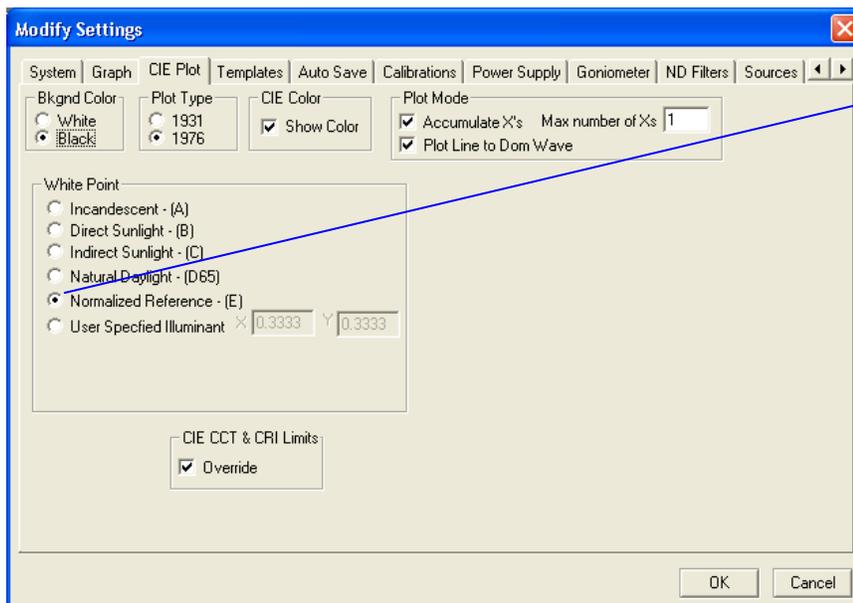
## Configuring CIE Plot Settings

The CIE Plot tab in the Modify Settings dialog sets up various properties of the CIE Plot.



- ❑ **Click the Modify Settings button .**

- ❑ **Then choose the CIE Plot tab.**



**IMPORTANT**

Set the White Point to the Normalized Reference (E) for all LED Dominant Wavelength measurements.

The Background Color box offers the option of a black or a white background on the CIE Plot.

- ❑ **Choose a background color.**

The Plot Type box allows the choice of displaying the CIE Plot in either the 1931 or 1976 form.

- ❑ **Select the type of CIE Plot to be worked with.**

The White Point box determines the type and position of the White Point on the graph. The selections are:

1. Incandescent – [A]
2. Direct Sunlight – [B]
3. Indirect Sunlight – [C]
4. Natural Daylight – [D65]
5. Normalized Reference – [E]
6. User Defined

- ❑ **Select the type of White Point to be displayed on the CIE Plot. If User Defined is selected, the user must enter the X and Y coordinates. Set the White Point to Normalized Reference – (E) for all LED dominant wavelength calculations, refer to Appendix B – Dominant Wavelength. Note the chromaticity coordinates of the Normalized Reference – (E) are (0.3333, 0.3333).**

The Plot Mode box chooses whether the data points will accumulate or be singular. If they are to accumulate, it sets a maximum number of Xs to accumulate on the CIE Plot before the oldest point is erased. The Plot Mode box also has the selection of Plot Line to Dom Wave. When checked, a plot line is added from the White Point through the data point to the dominant wavelength on the CIE locus.

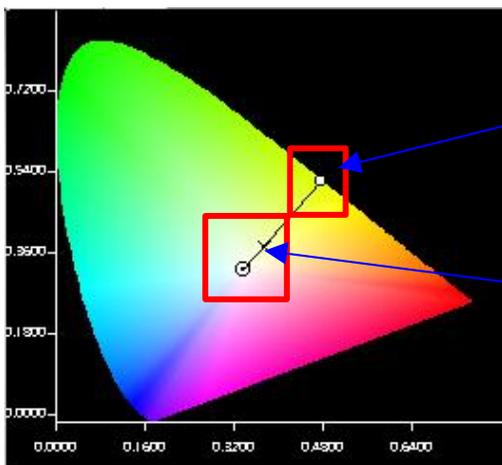
- Choose the option of accumulating or not accumulating X's. If so, indicate how many.
- Choose whether or not to plot the line to the dominant wavelength.

The limits set for calculating the CIE, CCT and CRI values can be overridden when the Override box is checked. With the Override box checked, the values that exceed the limits will be displayed in red in the Value Tree. If the box is not checked, the values that exceed the limits will display as "Exceeds Limits" in the Value Tree.

- Check the Override box to display exceeded limits in the Value Tree as red.

## Introducing the CIE Plot

When a reading is taken, a new data point is added to the CIE Plot.



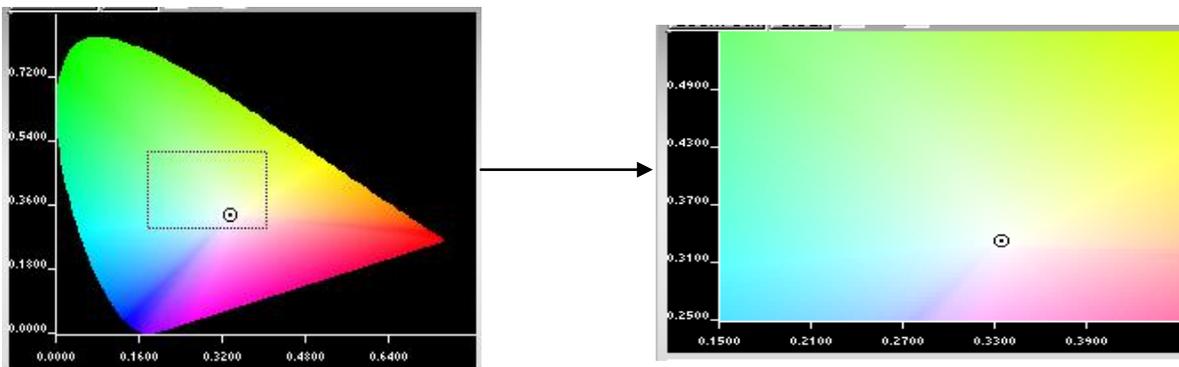
The Plot Line to Dom Wave selection in the Modify Setting Dialog/CIE Plot Page/Plot Mode draws a line to this point's dominant wavelength on the CIE locus

The data point appears as an "X" on the diagram corresponding to the current reading's X and Y chromaticity coordinates.

Zooming into the plot is done in a similar manner as zooming into the graph view. To zoom, right click at the upper-left hand portion of the graph to be zoomed in to, and hold the button down while dragging the cursor to the lower right-hand portion of the graph to zoom in to. A dotted line box will appear on the plot as a box is dragged around the area to be zoomed. Release the button to zoom in to the graph.

- Right click on an area of the CIE Plot. Hold the mouse button down and drag to the right and downward to create a selection box around the area to be zoom into. Release the right mouse button.

The CIE Plot changes to display the dimensions of the graph zoomed into.



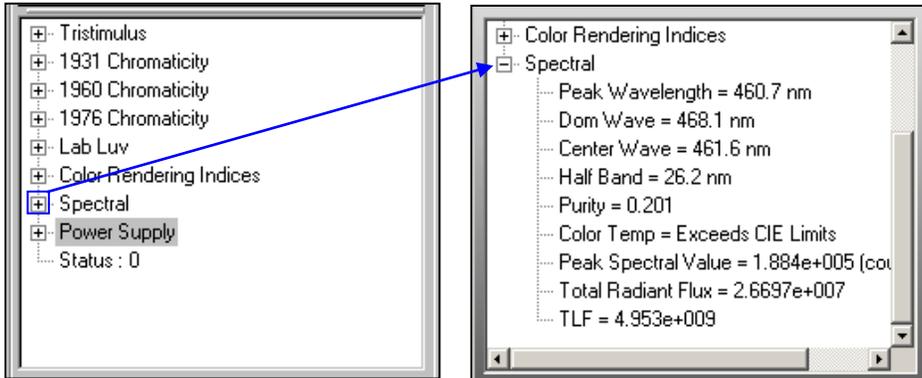
Once a particular area has been zoomed into, left click on the plot to zoom back out to the previous view.

- Click the left mouse button somewhere on the CIE Plot. The plot returns to its previous view.

The Clear Measurement Data button on the Measurement Toolbar that was introduced earlier will also clear the data point X's that have been placed on the CIE Plot. To enlarge the graph text, simply drag the window bars to a larger size.

## The Value Tree

The Value Tree contains branches that can be expanded or collapsed to view or hide values by clicking on the node [+] to the left of the branch.



**NOTE:**

Values will only appear in the value tree if a measurement has been taken or a data file is opened.

If “Calculate Between Cursors 1 and 2” has been checked in the Modify Settings/Graph page, the values reported will only relate to the data between Cursors 1 and 2. To display data over the complete spectrum, either remove cursors 1 or 2 or uncheck the Calculate Between Cursors 1 and 2 from the Modify Settings/Graph page.

- ❑ Expand the **Spectral** branch by clicking the plus sign to the left of the respective title.

A new list expands from the Spectral label as in the pictures above.

The variables are fixed and set up by the program relative to the measurement type that is open. Once a reading is either opened or taken, the tree will be automatically filled in with values.

## Value Tree Status Value

An OL 770 Signal Saturation status flag is available with each acquisition. It is reported as the **STATUS** value on the Value Tree. The value will be “0,” if the signal is not saturated. The value will be “1”, and displayed in red, when the signal is saturated. The OL 770 system has three methods of preventing signal saturation, and this is covered under the *OL 770 Signal Saturation* section on page 41.

**NOTE:**

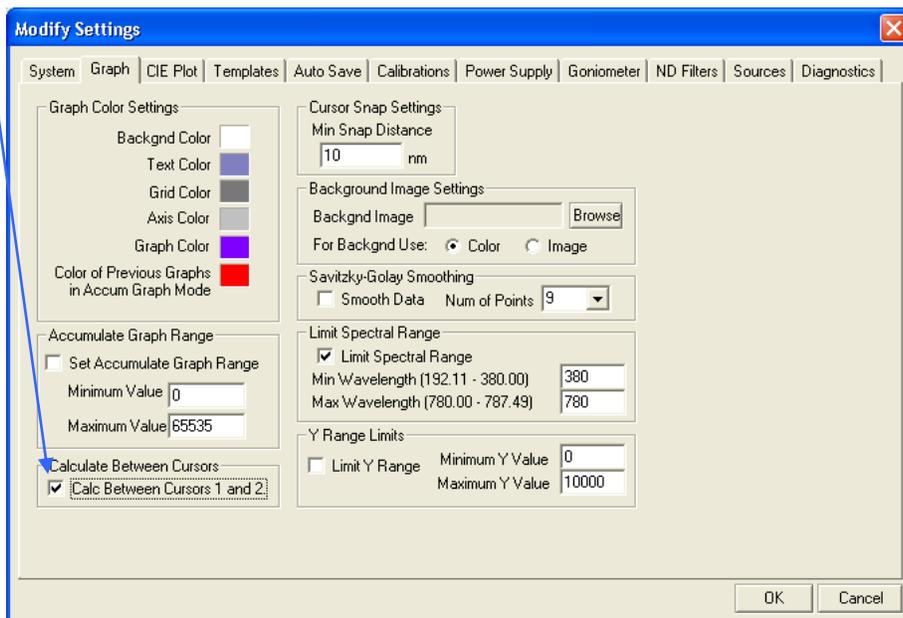
The Status flag was added to the list of variables for the Continuous Excel Value Data Reporting feature in the OL 770 Application Software version 4.46 and later. If using an older Excel template with the Continuous Excel Value Data Reporting feature, verify that the location specified for Status does not interfere with any pervasively defined locations used for other values.

## Calculate Between Cursors 1 and 2

When the Calculate Between Cursors 1 and 2 box is checked in the Modify Settings/Graph page, the value tree only displays the calculated values using data from between Cursors 1 and 2 positions. Refer to the previous section, Adding and Deleting Multiple Cursors, to display two cursors on the graph. Position Cursor 1 and 2 at the desired locations.

### NOTE:

Zooming into a section of the graph will neither exclude Cursor 1 or 2, nor set the spectral range for the value tree.



## Part 8 – The Value Monitor

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What we'll do:

- Explain the Value Monitor's Purpose
- How to Open and Close the Value Monitor and the Monitor Slide
- Show How to Add Variables to the Value Monitor
- Show How to Change Variable Settings

### The Value Monitor's Purpose

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The Value Monitor is a dialog used to monitor specific variable values and see if they remain in a set range. The Value Monitor button is located on the Measurement Toolbar and toggles the visibility of the Value Monitor. The Value Monitor is used to monitor the values of variables that are inserted into it. This provides an easy view of specific values and can alert the user to pass/fail conditions for each measurement. There are six value containers, which hold information about variables that have been added to it. The Value Monitor can be moved around the screen by clicking anywhere on the title (the area that says "Value Monitor") and dragging the dialog to a new position.

### Opening and Closing the Value Monitor and Monitor Slide

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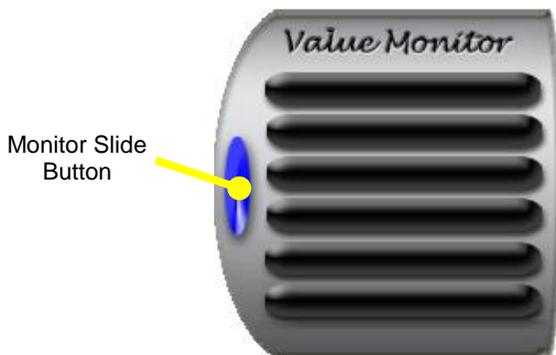
Pressing the toggle button on the Measurement Toolbar opens and closes the Value Monitor .



- Press the Value Monitor button to open the Value Monitor

While the button is toggled on, the Value Monitor will be shown. When the button is toggled off, the Value Monitor is hidden. To open and close the Monitor Slide, press the blue elliptical button on the left of the Value Monitor.

- Press the Monitor Slide button



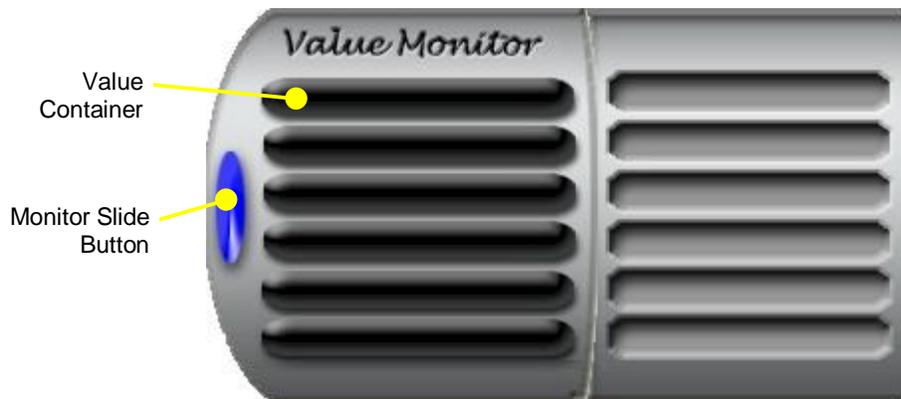
**NOTE:**

The Value Monitor can not be edited when performing Continuous Measurements.

A new section of the Value Monitor will slide out and lock into place to the right of the Value Monitor. The Monitor Slide window contains six wells, adjacent to the six containers in the Value Monitor. When this window is open, it will display the actual values of variables that have been added to the Value Monitor.

## Adding Variables to the Value Monitor

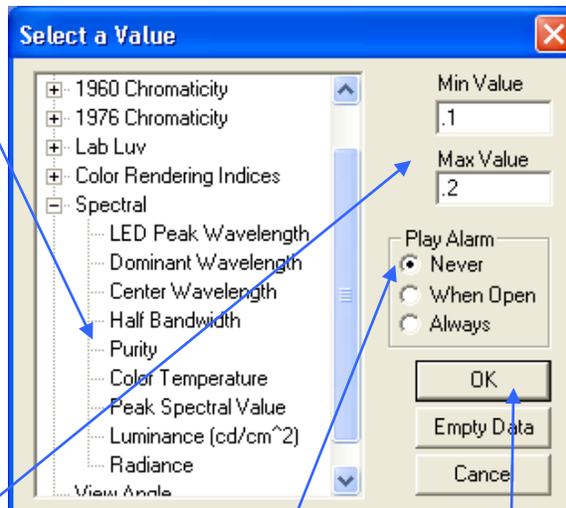
- To insert a variable, click on one of the Value Monitor's Value Containers.



The Select a Value window appears to set properties for the Value Container.

- **1. Select the desired variable to add to the Value Container from the Value Tree.**

Choose the variable "Purity" from the tree by clicking on it.



- **2. Set the "min"imum and "max"imum range values for the variable.**

Enter the min and max values for the variable by typing their values into their respective edit boxes. The maximum value must be larger than the minimum value.

- **3. Choose when the Alarm sound will be played.**

If **Never** is chosen, the alarm sound will never play. If **When Open** is chosen, the alarm will sound when the variable goes out of range and the Value Monitor is visible. If **Always** is selected, the alarm will sound anytime the variable goes out of its designated bounds, even if the Value Monitor is hidden. Your PC must be equipped with sound features to use the alarm monitor mode.

- **4. Press the OK button to close the window and add the designated information to the container. If all parameters are not set correctly, the window will not close.**

- ❑ **5. When the Empty Data button is pressed, all parameters for that container will be cleared and the window will close. The Value Container will return to the empty state.**
- ❑ **Click OK to accept all data entered and close the Select a Value window.**



The Value Container selected will change its color from black to either green or red. The name of the variable that was selected, in this case Purity, will be written on top of the Value Container. The Value Container's color signifies the state of the variable's value. If the variable's value is within the specified range, it will appear green. Otherwise it will appear red. The variable's actual value appears in the well directly to the right of the Value Container.

### Changing Variable Settings

---

To change the settings of a Value Container that has already been added, click on the desired Variable Container. When the Select a Value window appears, simply alter the settings and click OK. The new settings will be saved.

## Part 9 – Selecting and Using Calibration Files

### NOTE:

The instructions of performing a system response calibration are found in the *OL Series 770/771 Multi-Channel Spectroradiometer Calibration Manual*.

What we'll do:

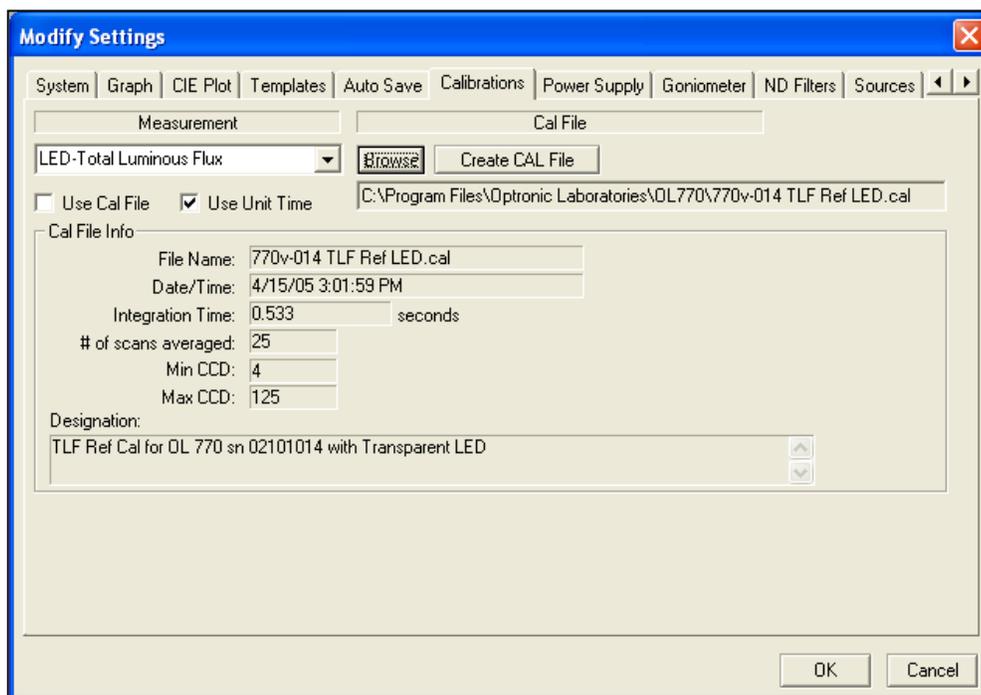
- Configure Calibration Settings.
- Select a Calibration File for a Specific Measurement Type.

## Configuring Calibration Settings



- ❑ Click the **Modify Settings** button.

- ❑ Choose the **Calibrations** tab.



The Measurement drop-down box selects the measurement file type to be edited. The Measurement types include:

- |  |   |
|--|---|
| 1. Transmittance                                   | 15. OL 610 (or OL 620 for OL 770-423-NVS Measurement Package) |
| 2. Diffuse Reflectance                             | 16. Spectral Irradiance                                       |
| 3. Total Reflectance                               | 17. Spectral Radiant Intensity                                |
| 4. Specular Reflectance                            | 18. Total Spectral Flux                                       |
| 5. LED-Condition A                                 |   |
| 6. LED-Condition B                                 |   |
| 7. LED-Total Luminous Flux                         |   |
| 8. LED-Goniometric                                 |   |
| 9. Spectral Radiance                               |   |
| 10. OL 600 0.3 (OL 600 DVIOM with 0.3 mm aperture) |   |
| 11. OL 600 0.5 (OL 600 DVIOM with 0.5 mm aperture) |   |
| 12. OL 600 1.0 (OL 600 DVIOM with 1.0 mm aperture) |   |
| 13. OL 600 3.0 (OL 600 DVIOM with 3.0 mm aperture) |   |
| 14. OL 600 5.0 (OL 600 DVIOM with 5.0 mm aperture) |   |

The **Cal File** box displays the calibration file that is currently selected for this measurement type. The **Browse** button to the right of this selects a new calibration file to associate with the current measurement type.

- ❑ **For each calibration setup ordered, select it from the Measurement drop-down box. Click the Browse button to select the appropriate calibration file supplied by Gooch & Housego or recently created.**

**NOTE:**

The calibration file selection for each measurement type is part of the system settings. The factory settings are installed with the 770.INI file. User settings can be exported for later retrieval.

Opening a measurement acquisition view will automatically match the Measurement type and Cal File.

The **Use Cal File** check box allows the choice of whether or not a calibration file will be used with future readings.

- ❑ **Check the Use Cal File box.**

The **Use Unit Time** check box is only available if the Use Cal File check box is off, meaning a calibration file will not be used for the next measurement. Checking the Use Unit Time box means that data will be represented in unit time per second. Clearing this option will cause data to be presented in raw counts and dependent upon integration time.

**NOTE:**

The use of a CAL file that requires a change in the CCD binning range may result in a Warning Dialogue Box indicating that the Quick Mode Integrating Time has to be adjusted. Refer to the *Tutorial V / Quick Mode* section.

The **Cal File Info** box displays the description information stored in the calibration file that has been selected for this measurement type. If the CCD binning rows, Min CCD, and Max CCD do not match the system settings, a warning dialogue will appear when closing the **Modify Settings** dialog to allow the user to change the CCD Binning Range to match the calibration file.

The **Create CAL File** button spawns a new window that will create a new calibration file. Details of calibrating the system are outlined in the *OL 770 Calibration Manual*.

**CAUTION:**

**Do not calibrate the system without the proper setup and instruction!**

You may return your OL 770 Multi-Channel Spectroradiometer to Gooch & Housego, Orlando, Florida, for internal reference lamp recalibration. The following items must be returned to the factory to assure proper recalibration:

1. OL 770 Multi-Channel Spectroradiometer
2. Signal Fiber Optic Probe (3 mm  $\phi$ ) (OL 770-7G/7Q)
3. 100  $\mu$ m Slit Holder (include any additional slit holders)
4. OL IS-670-LED Integrating Sphere
5. 600  $\mu$ m Internal Reference Lamp Fiber Optic Cable (OL 770-7G-RS)
6. OL 15AB LED Receptor (Condition A and B Baffle Tubes)
7. OL 15AB-CAL Calibration Adapter
8. LED Mounting Adapters
9. An estimation of lamp usage since last calibration.
10. Configuration Disk with the following files:
  - Latest system configuration file (770.ini) with the wavelength coefficients, etc.
  - Set of your calibration files
  - Existing ST7X files

### Diagnostics Page \_\_\_\_\_

This area is for Gooch & Housego manufacture and service use ONLY and should not be modified without instruction from Gooch & Housego.

## TUTORIAL II – ADVANCED FEATURES

### Part 1 – Advanced Graph Features

What we'll do:

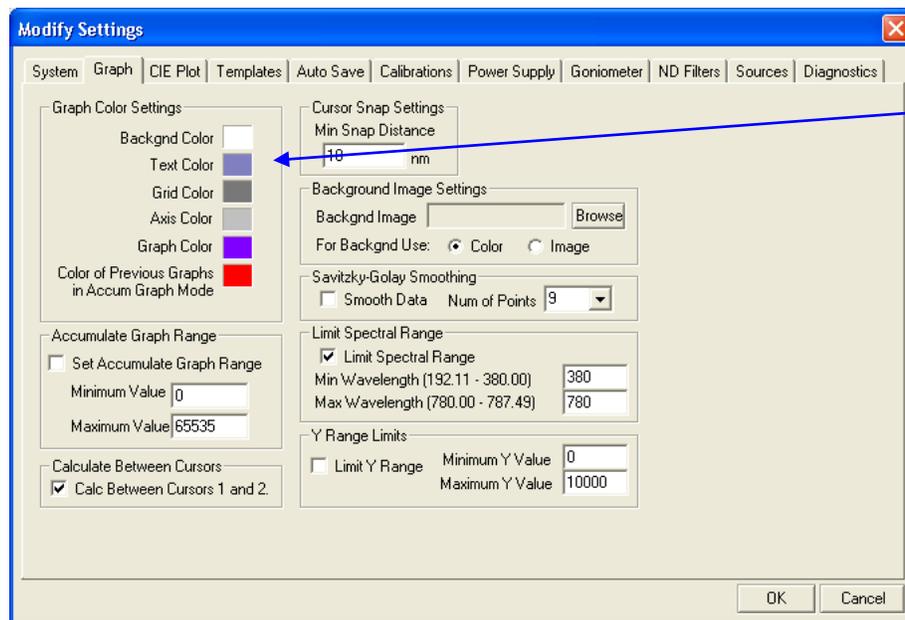
- Configure Graph Settings.
- Add graphs to background.

#### Configuring Graph Settings

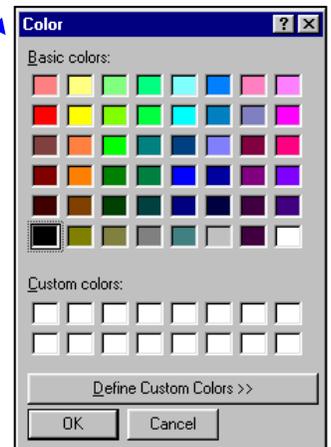


- ❑ Click the **Modify Settings** button.
- ❑ Then choose the **Graph** tab.

The Modify Settings' Graph tab configures the Graph Color Settings.



The **Background Color** button displays the current color that will be applied to the background. When this button is pressed, it opens a **Color Palette** where a new color can be selected.



The **Text Color**, **Grid Color**, **Axis Color**, and **Graph Color** buttons are similar to the **Background Color** button. They display the color of an item and can be pressed to change the item's color.

- ❑ **To change the colors of any of these Graph Color Settings, click on their respective color and the Color Palette will appear. Select the new color to use and click OK.**

The **Accumulate Graph Range** box allows the setting of the minimum and maximum values for the graph when in accumulate graph mode; the **Set Accumulate Graph Range** button must be checked to use these values as minimum and maximum – reference *Tutorial I / Part 5 – The Graph View* section of this manual.

- ❑ **Leave the Set Accumulate Graph Range box unchecked at this stage.**

The Cursor Snap Settings box is set to determine the minimum wavelength distance between each Cursor when the Snap All Cursors to Peaks option is selected.

- ❑ **Change the Cursor Snap Setting value if so desired.**

The graph and measurement values can have Savitzky-Golay Smoothing applied to them. Savitzky-Golay Smoothing can give more accurate and repeatable values for LED bandwidth and peak intensity. The number of points should be less than twice the bandwidth of the narrowest peak in the spectrum. For example, an LED with an FWHM of 10 nm can have up to 19 point smoothing. To ensure the data integrity, the Savitzky-Golay Smoothing is not applied to any saved data file.

- ❑ **Leave the Smooth Data box unchecked at this stage.**

The Limit Spectral Range applies to OL 770UV or 770UV/VIS spectroradiometer systems that are configured for measurements below 380 nm. When the Limit Spectral Range is checked, graphs will displayed in the wavelength range as specified as the Min and Max Wavelength entries. The minimum wavelength can not be lower than the Wavelength Cal Coefficient D.

- ❑ **Leave the Limit Spectral Range box unchecked at this stage.**

The Y Range Limit allows the user to specify a range for the y-axis. The y-axis will be displayed in the Minimum and Maximum Y value.

- ❑ **Leave the Y Range Limit box unchecked at this stage.**

The background of the graph can be either a color (selected in the Graph Color Settings) or a bitmap image. The Background Image Settings box contains the Color or Image selection buttons and the filename for the current background image. To change this, press the Browse button to the right of this box. An Open File dialog will appear to select the path and name of the new file. Only bitmap files (.bmp) may be used as a background image. The For Backgnd Use radio buttons beneath this box determines whether the graph will use the selected “image” or the selected Background “Color” for the graph background.

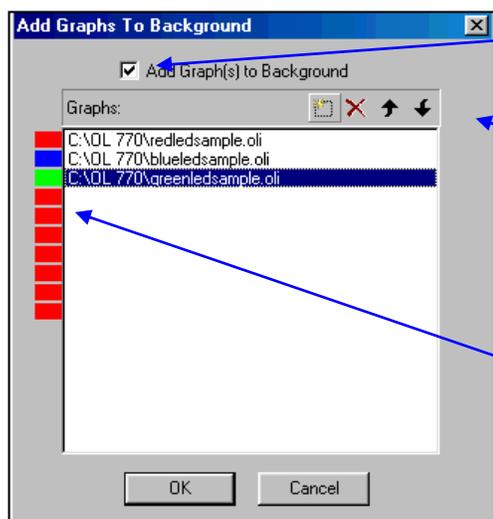
- ❑ **Ensure the For Backgnd Use - Color radio button is selected.**
- ❑ **Click OK in the Modify Settings window to accept all changes.**

### Adding Graphs to Background

The Add Graphs to Background button allows selection of files (\*.oli) that contain graphs to be drawn in the background of the current graph. When this button is pressed, a new dialog will appear to add filenames to a list, and choose whether or not this option should be turned on.



- ❑ **Press the Add Graphs to Background button to select the graphs you wish to display in the background.**



This check box determines whether or not the graphs that appear in the list below will be drawn in the background.

The **New** button adds a filename box to the list. A maximum of ten graphs can be added to the list.

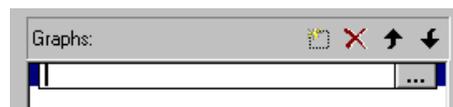
The **Delete** button removes a filename from the list.

The **Move Up** and **Move Down** buttons move the filenames around within the list.

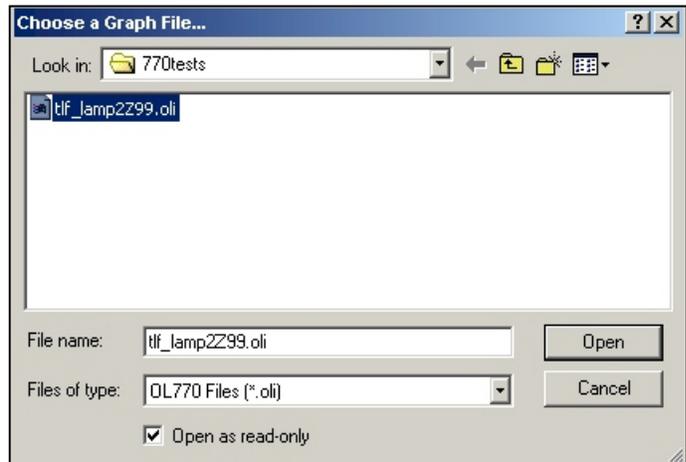
Change the color of the graph by clicking on the colored box.



- ❑ **To add a filename to the list, press the New button, which will add a filename box to the list.**



- ❑ Choose the Browse button (labeled ...) to open the **Choose a Graph File** window and select an **.oli** file that has been saved previously. Select **Open** to add the filename to the list.



- ❑ Turn **Add Graph(s) to Background** on by adding a check mark. Select **OK** to close the dialog and accept the setup.



When the Add Graph(s) to Background option has been turned on, the background of the button will turn green and the graphs that have been added to the list will be drawn in the background of the graph.

- ❑ Take a single reading and notice the new graph drawn as well as the graph(s) that have been added to the background.

#### NOTE:

The data in the Value Tree, as well as the CIE Plot, will refer to the newly taken data and will not reflect the data of the graphs drawn in the background.

- ❑ Click the **Add Graphs to Background** button again to toggle the Add Graphs off. Select **OK**. The background graphs will disappear from the display, and the background of the Add Graphs button will return to its default color.

## Part 2 – Report Generation

What we'll do:

- Create Microsoft Word & Excel templates.
- Configure the Templates Page.
- Discuss the Send Data to Excel and Word buttons.
- Perform Continuous Excel Report Generation.
- Configure the Auto Save Page.
- Discuss the Logging Mode

### Creating Word & Excel Templates

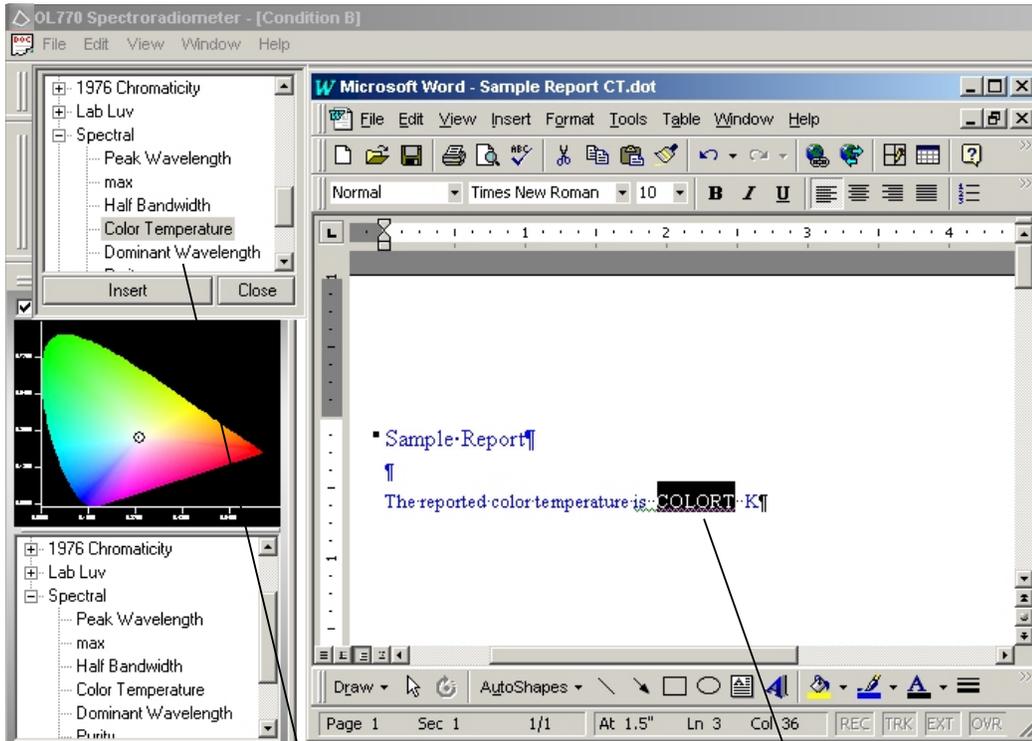
#### The Word Template Builder

The Word Template Builder button inserts OL 770 generated values that are found in the Calculations Bar and a graph or CIE snapshot into a Microsoft Word template file. The Microsoft Word Application Program must be installed on your computer in order to perform this feature.



- ❑ Press the **Word Template Builder** button to design a report to be used for report generation.

Once the Word Template Builder button on the Main Toolbar is selected, the Microsoft Word Application Program opens along with the OL 770 Variables Insertion Window. It may be necessary to resize and position the Word window to give access to the file menus and toolbars in Word.



OL 770 Variables Insertion Window

Color Temperature Variable Inserted into the Word Template Document

- ❑ Create a Word template document by typing the text you desire in your report or open and edit the Word template supplied with the OL 770 installation disk - **OL770DefaultWordTemplate.dot**
- ❑ At the positions where the values should be inserted, highlight the desired variable from the **OL 770 Variable Insertion Window** tree and click on **Insert**

These variables will be replaced by the variable's calculated value when a reading is taken and the Word document is generated. After typing the report and inserting all desired variables, save the report as a Word "template" document with a ".dot" file extension. Note the location of the Word template – MS Word defaults templates to a different directory from the Word documents. This Word template file name (.dot) can then be entered in the Word Document Report section of the Modify Setting/Templates tab.

- ❑ Click the **Close** button on the **OL 770 Variable Insertion Window** to close the window as well as **Microsoft Word**.

**CAUTION:**

You must click the Close button on the Template Builder to close Word. Manually closing Word will cause an OL 770 Application Software error message.

**Creating an Excel Spectral Data Template**

When using the Excel Spectral Data Report generator, the measurement spectral data is inserted in two columns into the Excel template. The complete spectral data set of 1024 points at approximately 0.4 nm intervals can be used, or a reduced data set of 401 points interpolated to 1 nm intervals from 380 nm to 780 nm can be selected.

The template for the Excel Spectral Data Report is created in Microsoft Excel. The Excel template file can be a simple template designed with a heading of “Wavelength” in cell A1 and “Intensity” in cell B1. Using cells A1 and B1 coincides with Beginning Cell for Wavelength Values “A2” and Beginning Cell for Intensity Values “B2”, as this data is inserted into the designated Excel column.

- ❑ **Open the sample template OL770DefaultExcelTemplate.xlt in Microsoft Excel.**

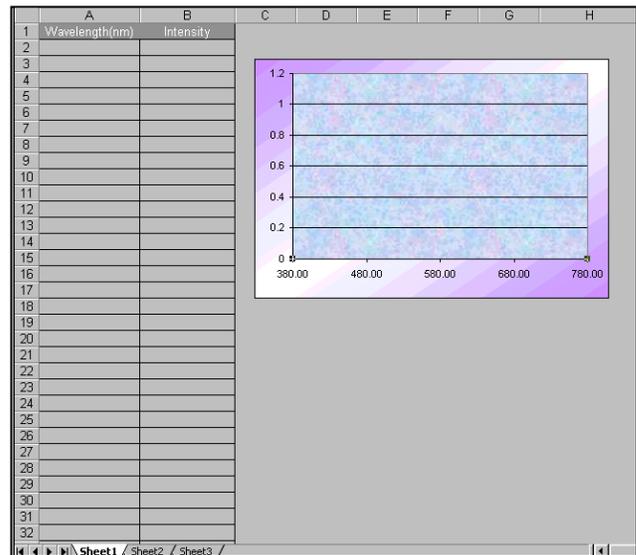
This template is configured to take the complete data set and plot a graph.

- ❑ **Customize the template to suit your needs.**

It is probably easier to generate a complex template with some real spectral data listed in the Excel spreadsheet. Proceed through the rest of Tutorial II / Part 2 to export and save data to the sample template, then return to customize the Excel spreadsheet into a template. The spectral data may be removed from the template before saving.

- ❑ **Save this template in Excel, by selecting the “Template” in the “Save as Type” selection.**

Note: Microsoft may change the path and directory when saving a template file.



**Creating a Continuous Excel Value Data Template**

The Continuous Excel Value Data Report is a powerful tool for collecting the important measurement values from one or hundreds of samples into a single spreadsheet. The measurement data includes over 80 of the values listed in the value tree together with the seven cursor wavelengths and spectral values.

- ❑ **Open into Microsoft Excel the sample template OL770ContinuousExcelTemplate.xlt**

This template is configured to record the measurement values; chromaticity x & y, peak & dominant wavelengths and the purity into five columns. The graphs on the right hand side display the variations in these values with each measurement.

At this stage the values have not been assigned, for example chromaticity x could be the 2° or 10° values.

- ❑ **Change the titles in cells B1 to F1 to suit your requirements.**
- ❑ **Save the changes to create a template (\*.xlt) with a new file name.**

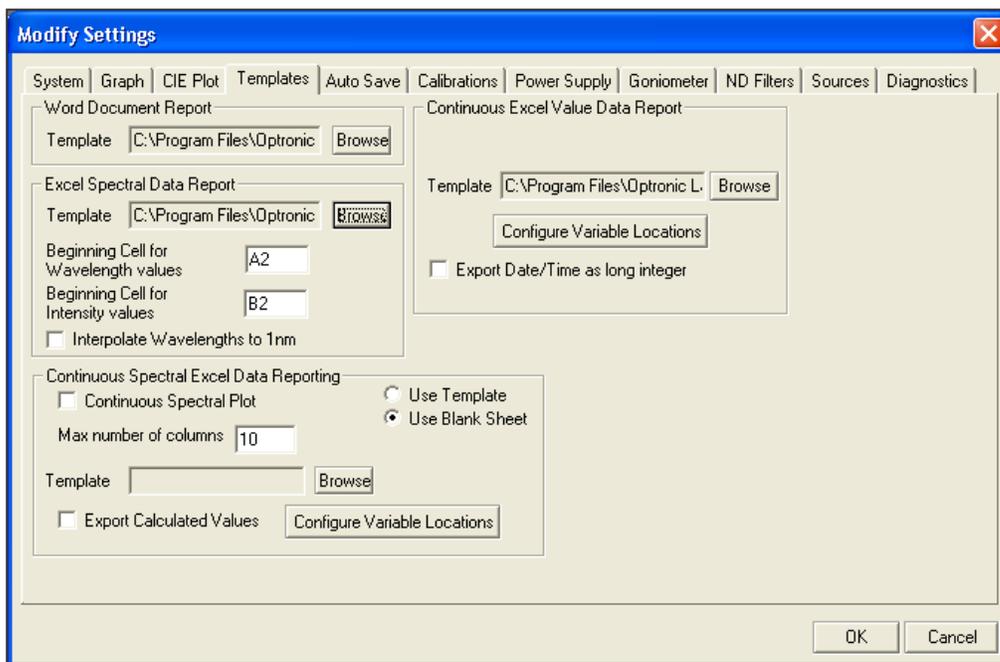


## Configuring the Templates Page



- ❑ Click the **Modify Settings** button.
- ❑ Choose the **Templates** tab.

The Modify Settings' Templates page configures template names used when generating reports.



There are three types of report templates that can be defined on this page:

1. Microsoft Word Document Report
2. Microsoft Excel Spectral Data Report
3. Continuous Microsoft Excel Value Data Report

### Selecting the Word Document Template

At the beginning of Tutorial II / Part 2, we created a Word template. This template can now be selected for creating Word documents with real data and graphs.

- ❑ To generate Word Document Reports, use the Browse button to choose the path and filename of the Word Template (\*.dot) that was created using the Word Template Builder.
- ❑ Select the new template or the one supplied with the installation disk - OL770DefaultWordTemplate.dot

A sample of the document created from the DefaultWordTemplate is shown at the end of Tutorial II / Part 2.

### Selecting the Excel Spectral Data Template

Before data can be exported to an Excel template using the Auto Save or Report generators, it is necessary to point to the Excel template.

- ❑ To generate Excel Spectral Data Reports, click the “Modify Settings,” “Template” tab, and enter the Excel Template filename (\*.xlt) that was previously designed and saved. Use the Browse button and choose the path and filename.
- ❑ Enter the Beginning Cell for Wavelength Values. It is recommended to enter A2 (Column A, Row 2). The wavelength values will be entered into the designated “column”.
- ❑ Enter the Beginning Cell for Intensity Values. It is recommended to enter B2 (Column B, Row 2). The intensity values will be entered into the designated “column”.
- ❑ To have the data interpolated at every 1-nm interval, check mark the box for Interpolate Wavelengths to 1 nm.

## Selecting & Configuring the Continuous Spectral Excel Data Reporting

The setup of the Continuous Spectral Excel Data Reporting does not require an Excel template, but the option for including an Excel template exists. (Gooch & Housego did not supply a sample Excel template for Continuous Spectral Excel Data Reporting.)

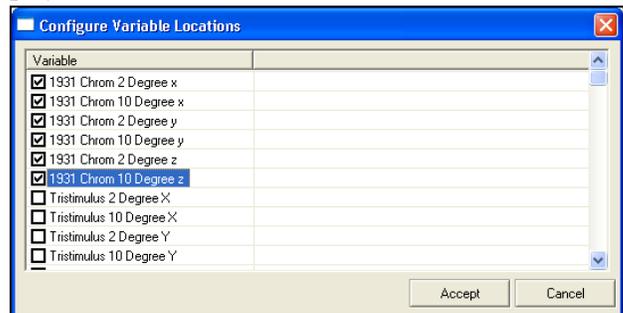
- ❑ **Select Use Blank Sheet to send data to a blank Excel spreadsheet (or Browse to select an Excel template).**

In order for the software to determine to use Continuous Spectral Excel or Continuous Value Excel reporting, the Continuous Spectral Plot must be enabled. The Continuous Spectral Excel reports the spectral data while the Continuous Value Excel reports user chosen data from the value tree, such as Chromaticity, radiometric values, photometric values, etc.

- ❑ **Check the box for Continuous Spectral Plot.**

Enter a number, up to 255, for the Maximum amount of columns to be displayed. Once the number of measurements displayed reaches the maximum number of columns, Excel will prompt the user whether to save the file, and then will exit Excel.

- ❑ **Enter the Maximum number of columns to be displayed.**
- ❑ **Click on Configure Variable Locations button to open the variable selection dialog. Select which variables to send to the Excel template. When using the Continuous Spectral Excel Data Reporting, the user does not have the option of selecting the column, row, or sheet for the location of the variable will be sent to; the data will sequentially be added to the template.**
- ❑ **Select if you desire to Export Calculated Values. This allows the spectral data to follow underneath the calculated value.**



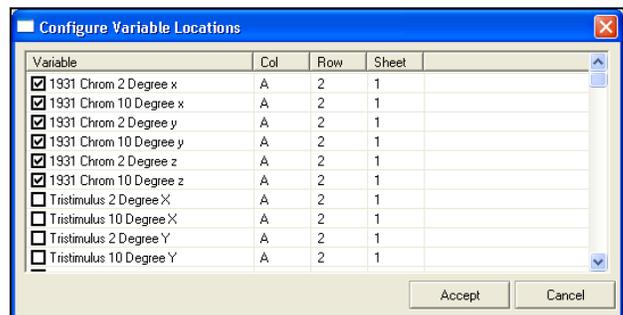
## Selecting & Configuring the Continuous Excel Value Data Template

The setup of the Continuous Excel Value Data Report requires both an Excel template (\*.xlt) and variable locations file (\*.cdt). Selecting the template will also select the variable locations file, if it exists.

- ❑ **Enter the Excel Template filename (\*.xlt) that was previously designed and saved or the sample supplied with the installation disk. Use the Browse button and choose the path and filename.**

In order to match the data cells in the template with the measurement values, it is necessary to Configure Variable Locations file.

- ❑ **Click on Configure Variable Locations button to open the variable selection dialog. From the Variable Location window, choose the data that you wish to report.**
- ❑ **Match the variable to the data cells in the sample template by checking the Variable boxes.**
- ❑ **Click or double click on the Col letter to the right of the desired Variable. Enter the column that corresponds to the template location. Always use capitals letters for column identifications.**
- ❑ **The row can remain at the default setting of 2. This will define the beginning cell that the value for each variable will be displayed in. During readings, each new variable value will appear directly below the one before it; filling in consecutively down the column. It is recommended that the desired Variable have its own column assigned to it and not share a column with two or more variables.**
- ❑ **Enter the Sheet that the variable will be sent to. Enter the Sheet number that corresponds to the template location.**



### NOTE:

The Status flag was added to the list of variables in the OL 770 Application Software version 4.46 and later. If using an older Excel template, verify that the location specified for Status does not interfere with any previously defined locations used for other values.

- ❑ **When all desired variables are checked and their cell locations defined, select Accept.**

The Configurations Variable Locations file (\*.cdt) will be saved with the same name as the template selected.

- ❑ **If desired, select Export Date/Time as long integer to export the date and time at a higher resolution.**

## Sending Data to Excel

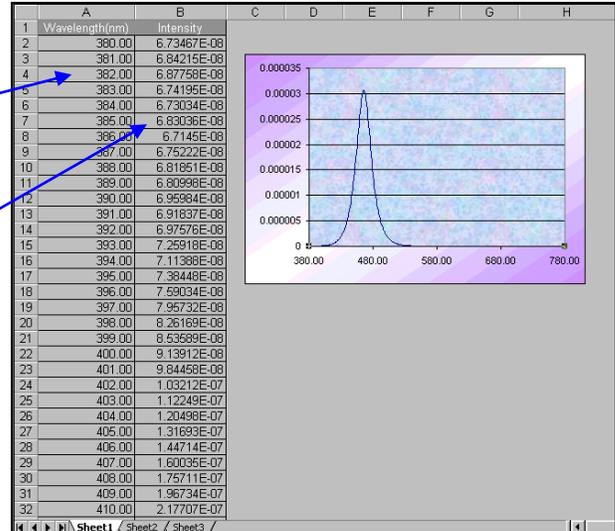


The Send Data to Excel button will update the data for the Excel “Spectral Data” Report feature only. Before using the Send Data to Excel button, an Excel Spectral Data Report template must be created and the template must be defined in the Modify Settings/Template Tab under Excel Spectral Data Report. After a measurement is taken, the Send Data to Excel button can be selected to update the Excel template. The Excel application will be opened, and the two columns defined in the template will be filled in with their appropriate values.

Sample Excel Spectral Data Spreadsheet

Wavelength Data  
(reduced to 1nm intervals)

Spectral Intensity recalculated to  
match the 1nm wavelength interval.



## Continuous Spectral Excel Data Report Generation

The Continuous Spectral Excel Data Report feature is done in real time while the measurement is occurring rather than after the measurement is complete. This is especially useful during continuous measurements where all the readings are desired. The only information sent to Excel will consist of the wavelength in the first column followed by multiple columns of signal values. Refer to the *Selecting & Configuring the Continuous Spectral Excel Data Reporting* section for information on this feature.

- ❑ Open the Modify Settings/Templates page and confirm that the Continuous Spectral Plot box has been checked and the Use Blank Sheet is selected.
- ❑ Depress the Continuous Excel Value Data Reporting button located on the Measurement Toolbar to toggle this feature on. An Excel blank sheet will appear without any data values.
- ❑ Switch back to the OL 770 Application Software.
- ❑ Take a Single Measurement.
- ❑ Switch to Windows Excel to review the report.



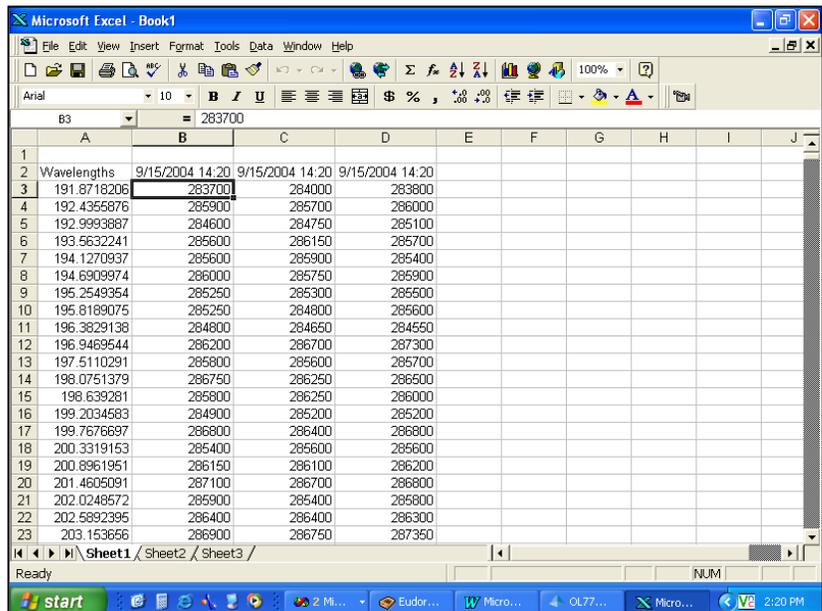
Once the reading is complete, the spreadsheet will be updated with the wavelength and its corresponding spectral values. (Sample shown using a blank sheet and after three measurements.) At this point you can save the spreadsheet with a new name, although subsequent readings will be added to the spreadsheet.



- ❑ Discontinue the continuous report by releasing the Continuous Excel Value Data Reporting button.

**CAUTION:**

You must disable / release the Continuous Excel Value Data Reporting button if the Excel report has been closed first.



## Continuous Excel Value Data Report Generation

The Continuous Excel Value Data Report feature will generate a report using an Excel template and measurement values taken from the Value Tree that have been defined in the Configure Variable Location file. Refer to the *Creating a Continuous Excel Value Data Template* and *Selecting & Configuring the Continuous Excel Value Data Template* sections for information on creating the Excel Template used with this feature.



- ❑ Open the **Modify Settings/Templates** page and confirm that the **Continuous Spectral Plot** box **IS NOT** checked.
- ❑ Depress the **Continuous Excel Value Data Reporting** button located on the **Measurement Toolbar** to toggle this feature on. The Excel Continuous Data Report will appear without any data values.
- ❑ Switch back to the **OL 770 Application Software**.
- ❑ Take a **Single Measurement**.

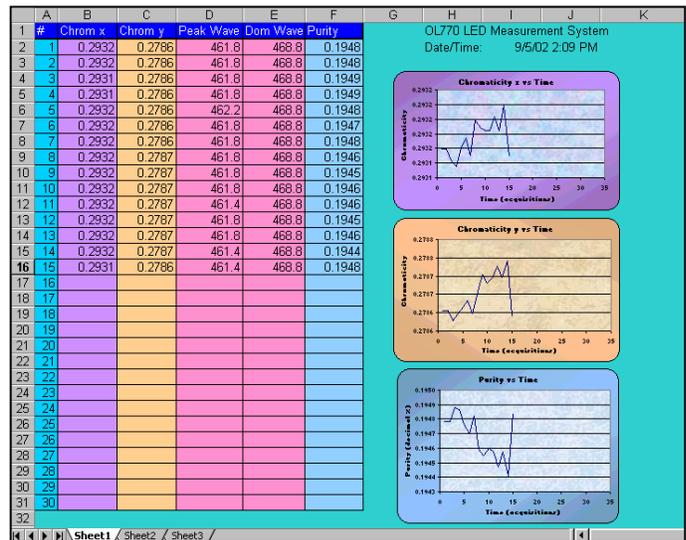
Once the reading is complete, the spreadsheet will be updated with the desired variable values in the first data row. Switch over to Excel to view the data. At this point you can save the spreadsheet with a new name, although subsequent readings will be added to the spreadsheet.



- ❑ Return to the **OL 770 Application Software** and take a number of readings using the **Continuous Measurement** button.
- ❑ Stop the measurements, then switch to view the Excel report.
- ❑ Save the report if required and return to the **OL 770 Application Software**.
- ❑ Discontinue the continuous report by releasing the **Continuous Excel Value Data Reporting** button.

**CAUTION:**

You must disable / release the Continuous Excel Value Data Reporting button if the Excel report has been closed first.

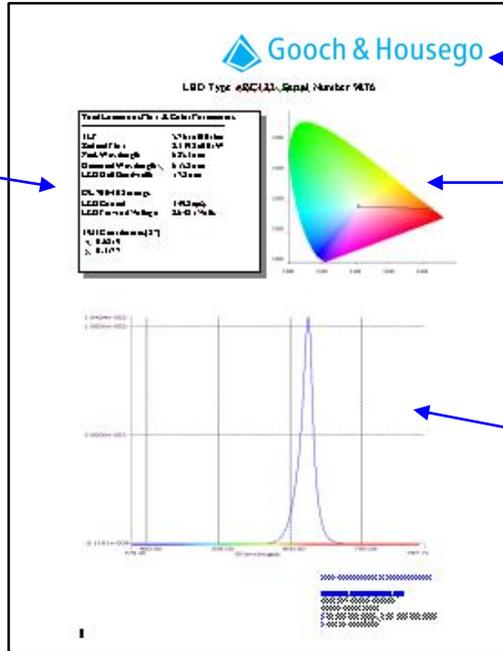


## Sending Data to Word



Before using the Send Data to Word button, a Word template must be created and the template must be defined in the Modify Settings/Template tab under the Word Document Report. After a measurement is taken, the Send Data to Word button can be selected to update the Word template. The template will be filled in with their appropriate values and then saved (if Auto Save selected) to the location defined in the Auto Save Prefix.

Measurement data taken from the Value Tree



Template Graphics

CIE Plot Snapshot

Graph Snapshot

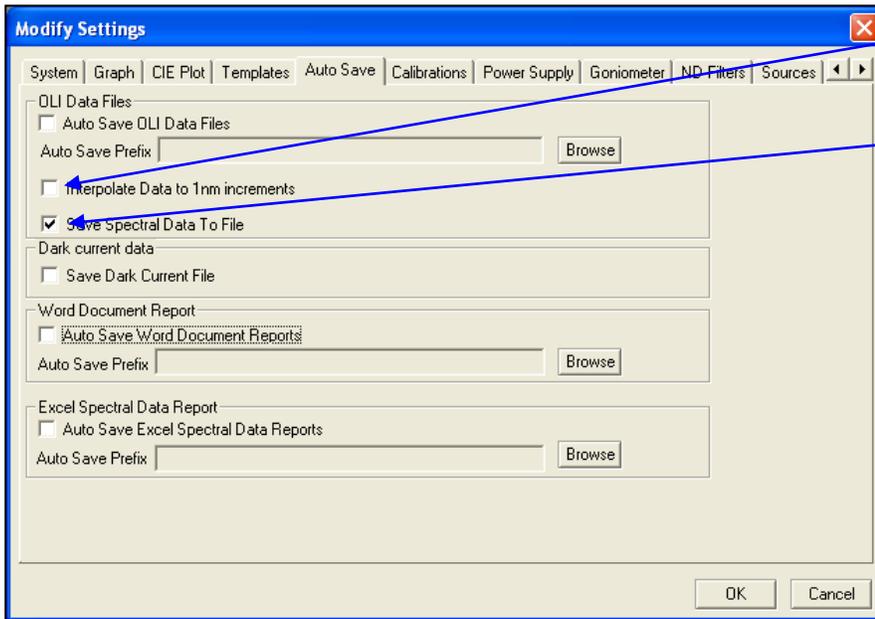
## Configure the Auto Save Page

Each report type can be turned on or off by checking its respective box. As many of these report types can be turned on as desired. In order to perform the report generating, the Auto Save button on the Measurement Toolbar must also be depressed.



Click the **Modify Settings** button.

Then choose the **Auto Save** tab.



Check this box to reduce the data to 1nm wavelength increment.

Check this box to add the calculated spectral data values to the end of the OLI data files as shown:

```
...
779.0000, 3.46359e-008
780.0000, 3.38044e-008
<EndData>
Peak Wavelength = 461.7 nm
Max Intensity= 6.88e-006 W/nm
Half Band = 26.2 nm
Color Temp = 3.287e+004 K
Dom Wave = 469.9 nm
Purity = 0.347
Power = 4.3381e-004 W
CenterWave = 462.0 nm
TLF = 1.013e-001 lm
```

### NOTE:

When opening modified data files, the spectral values are always recalculated.

## Saving Dark Current

Enabling this feature will allow the saving of the dark current data used for the measurement. The dark current file will be saved when the measurement is saved. The file saved will be named after the saved measurement file name except the extension will be a \*.darx format. The file can be renamed to an \*.oli file and opened in the application.

## Auto Save OLI Data Files

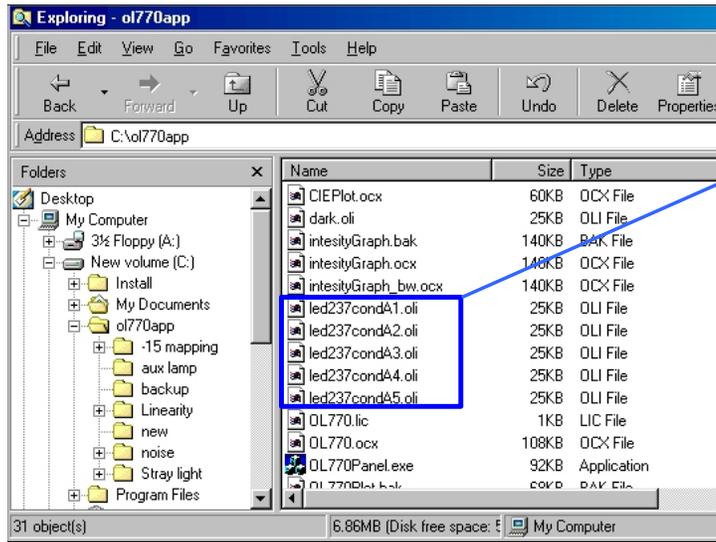
The Auto Save OLI Data Files feature only saves the following data obtained from a reading to a file:

File Title, Date and Time, Measurement Type, Designation, Calibration File Used, Unit Time Used, CCD Type, Grating Type, Flash Version, Reading Coefficients, Integration Time, CCD Min and Max Rows, Number Of Scans Averaged, and the Data with each wavelength and corresponding value.

The OLI Data File is in ASCII format and is saved to a file with the extension \*.oli. To obtain the values that are reported in the Calculations Bar, you must first open the saved \*.oli file and then view the Calculations Bar Value Tree.

- ❑ Enter the Auto Save Prefix for OLI Data File (s) by selecting the Browse button and choosing a path and a prefix for the auto save files.

Each subsequent reading taken is saved at the location designated in the Auto Save Prefix with the next consecutive number automatically added to the end of the filename.



Example of saved filenames for five subsequent readings with an Auto Save Prefix of "LED237condA"

- ❑ To automatically save OLIX Data File (s) after each reading, check mark the Auto Save OLI Data File box. Select the OK button on the Modify Settings window to accept the settings.



- ❑ Before any data files are saved, the Auto Save button on the Measurement Toolbar must be depressed.

- ❑ Once the Single or Continuous Measurement button is selected, and readings are complete, the OLI Data file is saved to the location defined in the Auto Save Prefix.

### Auto Save Microsoft Word Documents

The Word Document Report feature will generate a report with all items that are available from the Calibrations Bar as well as a snapshot of the Graph and CIE Plot.

- ❑ Ensure that the Word Document Report (Modify Settings / Templates) points to the required Word template.
- ❑ Enter the Auto Save Prefix for reports generated with Word by selecting the Browse button and choosing a path and a prefix for the auto save files.
- ❑ To automatically save the report generated with Word after each reading, check mark the Auto Save Word Documents box. Select the OK button on the Modify Settings window to accept the settings.



- ❑ Before the Word report is generated, the Auto Save button on the Measurement Toolbar must also be depressed.
- ❑ Once the Single or Continuous Measurement button is selected, and readings are complete, the Word Report document will appear updated with the desired variable values and saved to the location defined in the Auto Save Prefix.

### Auto Save Excel Spectral Data Report

The Excel Spectral Data Report feature will generate a report with only the wavelength and intensity values.

- ❑ Ensure that the Excel Spectral Data Report (Modify Settings / Templates) points to the required Excel template.
- ❑ Enter the Auto Save Prefix for reports generated with Excel by selecting the Browse button and choosing a path and a prefix for the auto save files.
- ❑ To automatically save the report generated with Excel after each reading, check mark the Auto Save Excel Spectral Data Report box. Select the OK button on the Modify Settings window to accept the settings.

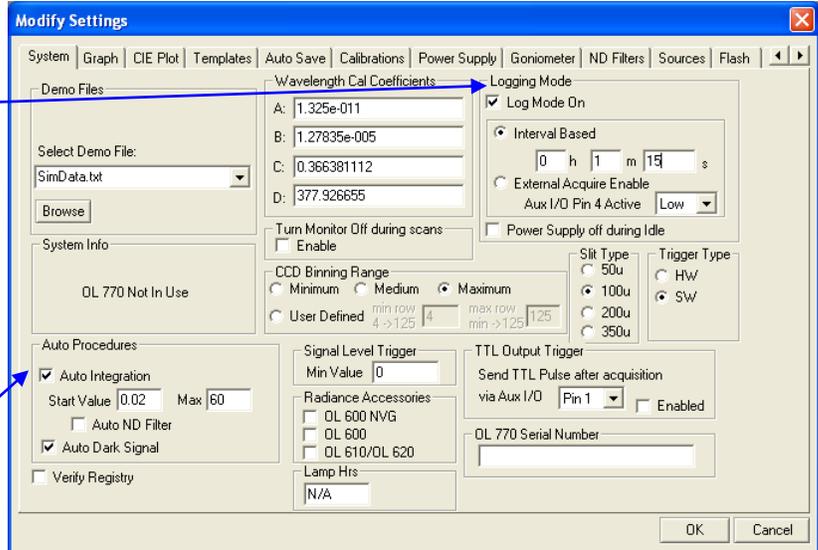


- ❑ Before the Excel report is generated, the Auto Save button on the Measurement Toolbar must also be depressed.
- ❑ Once the Single or Continuous Measurement button is selected, and readings are complete, the Excel Report document will appear updated with the wavelength and spectral values and saved to the location defined in the Auto Save Prefix.

## Logging Mode

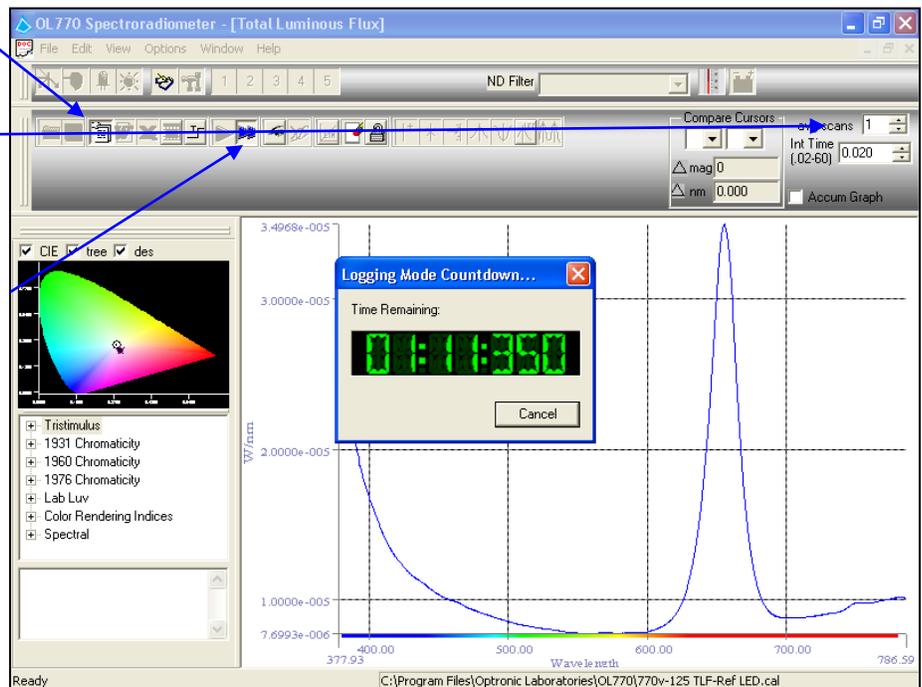
The OL 770 Multi-Channel Spectroradiometer can be configured to record and save spectral data or calculated values over prolonged periods using the Logging Mode setting in the Modify Settings / System dialog.

- 
  - ❑ **Open the Modify Settings/System dialog.**
  - ❑ **Check the Log Mode On box.**
  - ❑ **Select the interval between measurements. For this example enter 1 minute and 15 seconds.**
  - ❑ **If desired, check the box Power Supply off during idle if you want to turn off the power supply during count down.**
- ❑ **Confirm both Auto Procedure boxes are checked. This will ensure that each measurement has the optimum integration time and a fresh dark signal file for subtraction.**
- ❑ **Choose the option of how the logged data will be saved (i.e. OLI Data File, Word, or Excel) by configuring the Auto Save tab (refer to page 71) and/or Templates tab (refer to page 66).**
- ❑ **Click on OK to close the Modify Settings dialog.**



Note the Continuous Measurements icon on the measurement tool bar is now colored blue to indicate that Logging Mode is selected.

- ❑ **From the taskbar, select the Auto Save and/or Continuous Values Excel Template icons as required.**
- ❑ **Set the number of scans (avg scans) per measurement to desired number.**
- ❑ **Setup measurement test source and click on the blue Continuous Measurements icon to start the logging.**
- ❑ **After the first measurement, a count down timer will appear on the screen. Pressing Cancel here will stop the logging acquisition. Reset (click-on) the Continuous Measurements icon to stop the logging during a scan.**



The logged data will be available now for review.

## TUTORIAL III – OPTIONAL OL 770-ND1 – ND4 NEUTRAL DENSITY FILTERS

A range of attenuation filters are available for the OL 770 Multi-Channel Spectroradiometer to extend the measurement range to include high brightness LEDs.

OL 770 Model Number	Calibrated Spectral Range	ND1 Filter Model Number (~10%)	ND2 Filter Model Number (~1%)	ND3 Filter Model Number (~0.1%)	ND4 Filter Model Number (~0.01%)
OL 770UV/VIS	240 nm to 780 nm	OL 770-ND1-UV/VIS	OL 770-ND2-UV/VIS	OL 770-ND3-UV/VIS	OL 770-ND4-UV/VIS
OL 770VIS	380 nm to 780 nm	OL 770-ND1-VIS	OL 770-ND2-VIS	OL 770-ND3-VIS	OL 770-ND4-VIS
OL 770VIS/NIR	380 nm to 1100 nm	OL 770-ND1-VIS/NIR	OL 770-ND2-VIS/NIR	OL 770-ND3-VIS/NIR	OL 770-ND4-VIS/NIR

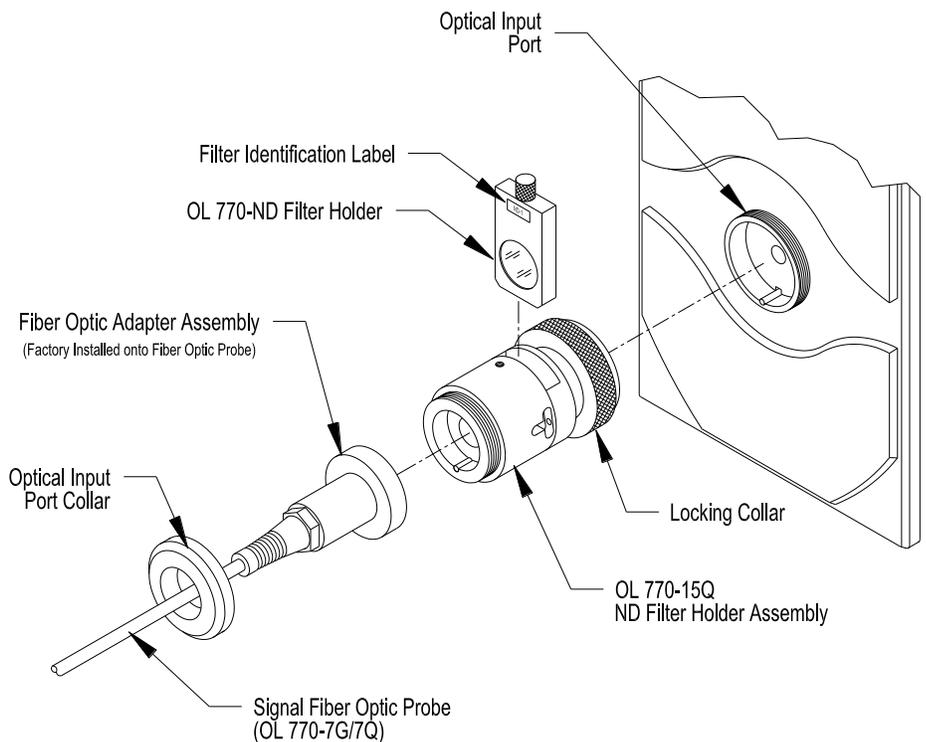
The OL 770-15Q ND Filter Holder Assembly is used to manually introduce a Neutral Density (ND) filter into the input optical path of the OL 770 Multi-Channel Spectroradiometer. The OL 770-15Q is mounted to the Optical Input Port of the OL 770. Each includes a set of focusing lenses to collimate the output of the fiber optic probe through the ND filter and then refocus onto the entrance slit of the spectroradiometer. The OL 770-15Q uses UV-grade quartz lenses and can be used over the 200 nm to 1100 nm UV-Visible-NIR wavelength range.

The OL 770-15Q-A Automated ND Filter Holder Assembly is controlled by the OL 770 Application Software to automatically introduce the Neutral Density (ND) filters into the input optical path of the OL 770 Multi-Channel Spectroradiometer. The OL 770-15Q-A is mounted to the Optical Input Port of the OL 770. Each includes a set of focusing lenses to collimate the output of the fiber optic probe through the ND filter and then refocus onto the entrance slit of the spectroradiometer. The OL 770-15Q-A uses UV-grade quartz lenses and can be used over the 200 nm to 1100 nm UV-Visible-NIR wavelength range. Each includes a motorized, 5-position filter wheel that accommodates an “open” position and up to 4 different ND filters.

### Part 1A - Installing the OL 770-15Q ND Filter Holder and ND Filters

The OL 770-15Q ND Filter Holder Assembly is installed onto the OL 770 Multi-Channel Spectroradiometer with a blank filter holder installed prior to performing a system calibration. The desired OL 770-ND Neutral Density Filter is not installed during system calibration to avoid extending the measurement cycle. Instead, each filter is supplied with a spectral transmission curve in the form of a polynomial function. The attenuation filters can therefore be used in combination with reduced CCD binning or with full binning without re-calibrating the system.

- ❑ **Remove the Optical Input Port Collar from the Optical Input Port on the front of the OL 770 Multi-Channel Spectroradiometer.**
- ❑ **Insert the OL 770-15Q into the Optical Input Port and secure with its Locking Collar.**
- ❑ **Place the Fiber Optic Probe into the entrance port of the ND Filter Holder Assembly and secure with the Optical Input Port Collar. (Do not overtighten.)**
- ❑ **Place the supplied blank ND Filter Holder into the slot in the top of the OL 770-15Q to perform either a system calibration or a measurement without the use of an attenuation filter.**
- ❑ **Replace the blank ND Filter Holder with the appropriate OL 770-ND Neutral Density Filter to achieve the desired attenuation.**



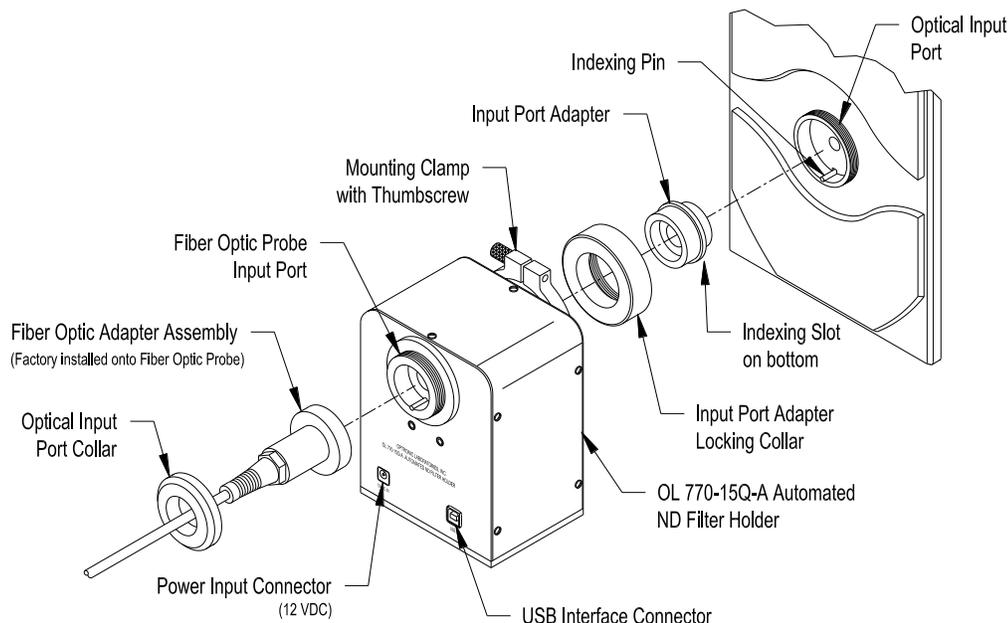
**NOTE:**  
The Filter Holder is designed with a slot on one side to correctly orientate the filter.

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## Part 1B - Installing the OL 770-15Q-A Automated ND Filter Holder and ND Filters

The OL 770-15Q-A Automated ND Filter Holder Assembly is installed onto the OL 770 Multi-Channel Spectroradiometer. Upon power up, the OL 770-15Q-A homes the internal filter wheel to the OPEN position. This OPEN (no ND filter) position is used in performing a system calibration. An OL 770-ND Neutral Density Filter is not selected during system calibration to avoid extending the measurement cycle. Instead, each filter is supplied with a spectral transmission curve in the form of a polynomial function. The attenuation filters can therefore be used in combination with reduced CCD binning or with full binning without re-calibrating the system.

- ❑ **Remove the Optical Input Port Collar from the Optical Input Port on the front of the OL 770 Multi-Channel Spectroradiometer.**
- ❑ **Insert the supplied Input Port Adapter into the OL 770 Optical Input Port. The slot in the bottom of the adapter aligns with the indexing pin in the port. Secure with the supplied Input Port Adapter Locking Collar.**
- ❑ **Install the OL 770-15Q-A onto the Input Port Adapter Locking Collar. Press the OL 770-15Q-A flush against the front plate of the OL 770. When properly installed, the OL 770-15Q-A**



should be level and its base plate extension tab is flush to the OL 770. While holding in place with one hand, tighten the thumbscrew on the OL 770-15Q-A Mounting Clamp. (A 1/8 hex wrench can be used if desired.)

- ❑ **Place the Fiber Optic Probe into the Input Port of the OL 770-15Q-A and secure with the Optical Input Port Collar.**
- ❑ **Insert the plug from the supplied external 12 VDC power adapter into the mating connector (12VDC IN) on the OL 770-15Q-A. Plug the adapter into the correct AC power outlet. The unit will HOME to the OPEN position.**
- ❑ **Connect the OL 770-15Q-A to an available USB port on the rear of the OL 770. (A computer's USB interface port can also be used.)**
- ❑ **The Windows operating system should bring up the "Add New Hardware Wizard." The OL 770-15Q-A USB device driver is typically part of the Windows operating system. Allow the wizard to search for the best driver in its driver database on the main drive only. When the "USB Human Interface Device" driver is found, the Wizard can install the software. Finish the Add New Hardware Wizard.**
- ❑ **Install (boot) the OL 770 Applications Software.**

P001692

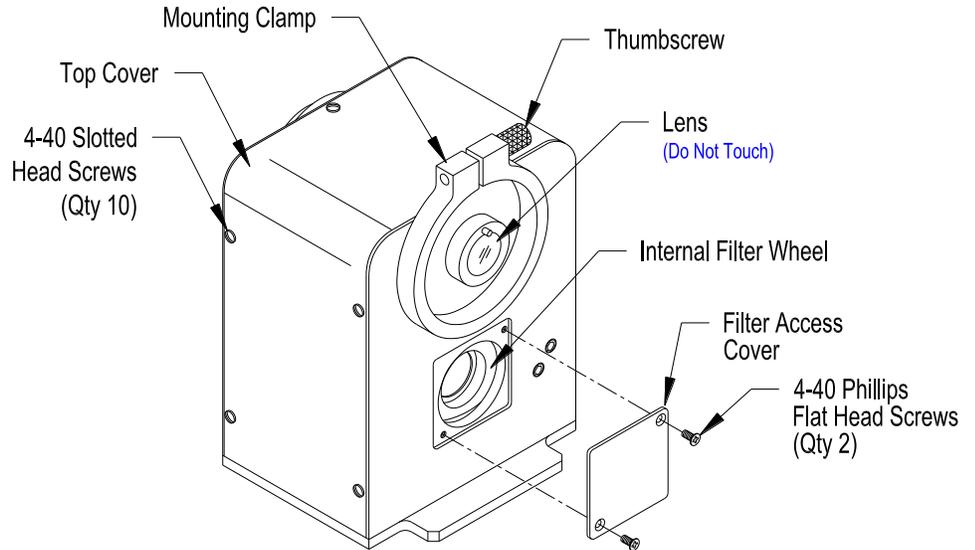
### Installing the ND Filters into the OL 770-15Q-A

The OL 770-15Q-A Automated ND Filter Holder Assembly has an internal five position filter wheel. The 0 position is the OPEN position. Positions 1 through 4 will include ND filters as ordered from the factory. Additional filters can be ordered from Gooch & Housego and installed by the user. An access cover is provided on one side of the OL 770-15Q-A to permit installation of new filters into the internal filter wheel.

- ❑ Turn off the OL 770. Disconnect the power input and USB cables from the OL 770-15Q-A.
- ❑ Loosen the thumbscrew on the Mounting Clamp and remove the OL 770-15Q-A from the OL 770 Multi-Channel Spectroradiometer.

**CAUTION**

Do not touch the quartz lens located in the center of the Mounting Clamp.



- ❑ Remove the top cover by removing the ten 4-40 slotted head screws and set aside.
- ❑ Gently lay the OL 770-15Q-A on its back side (connector side). Remove the Filter Access Cover by removing the two 4-40 Phillips flat head screws and set aside.
- ❑ There are blank, black discs installed in the unused filter wheel positions. Manually rotate the wheel until the appropriate numbered filter position is visible through the filter access opening. The appropriate filter must be inserted in the proper position as indicated in the table.
- ❑ Remove the retaining ring, o-ring, and the black disc from the appropriate filter position. Install the new ND filter into the filter wheel opening and gently secure in place with the o-ring and retaining ring.
- ❑ Replace the Filter Access Cover and the top cover. Re-install the OL 770-15Q-A onto the OL 770 Multi-Channel Spectroradiometer. Reconnect the power input and USB cables. Note: The unit will HOME to the OPEN position after the power is applied.
- ❑ Add the new ND Filter file information to the configuration settings in the OL 770 Applications Software. See *Configuring the OL 770-ND Filter Settings for the OL 770-15Q-A Automated ND Filter Holder* section of this manual.

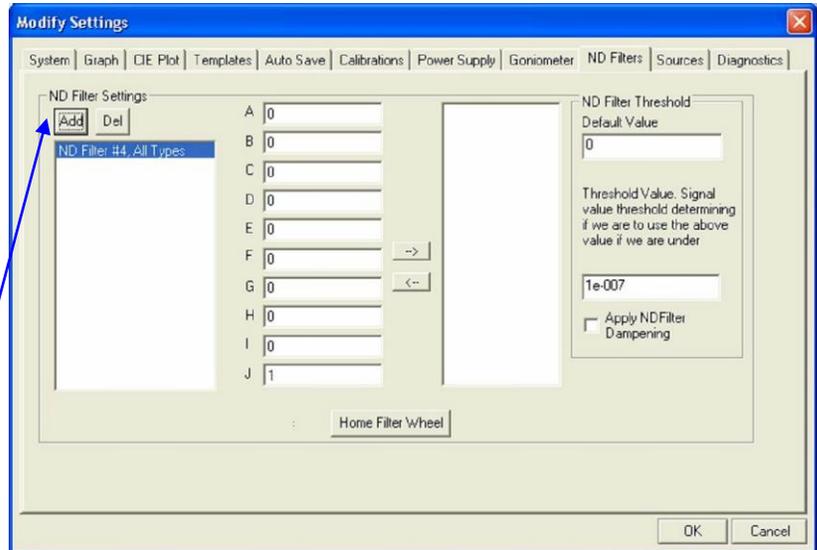
Position Marking	Filter
0	OPEN
1	ND1
2	ND2
3	ND3
4	ND4

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**Part 2A - Configuring the OL 770-ND Filter Settings for the OL 770-15Q ND Filter Holder \_**

The OL 770-ND1 - ND4 filters are supplied with a text file (located in the System folder on the OL 770 Application Software Installation CD) which contains the coefficients for the polynomial. This represents the spectral transmission of the filter in each of its optical accessories.

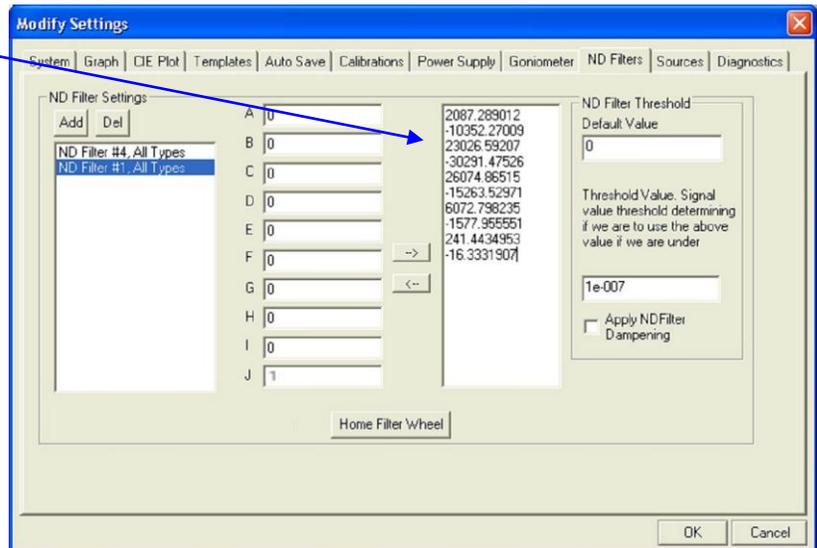
- ❑  **Click on the Modify Settings button on the Main Toolbar to open the Modify Settings Dialog.**
- ❑ **Locate the ND Filters tab. This page contains the selections for configuring a ND filter with the optical accessory and the corresponding coefficients for the transmission polynomial.**
- ❑ **To create a ND Filter Setting, select the Add button.**



- ❑ **From the Add a New Filter screen, select the ND Filter from the ND Filter drop-down list.**  
**Selecting All, will apply the ND filter coefficients to all types of optical accessory.**  
**Select OK after the type is chosen.**

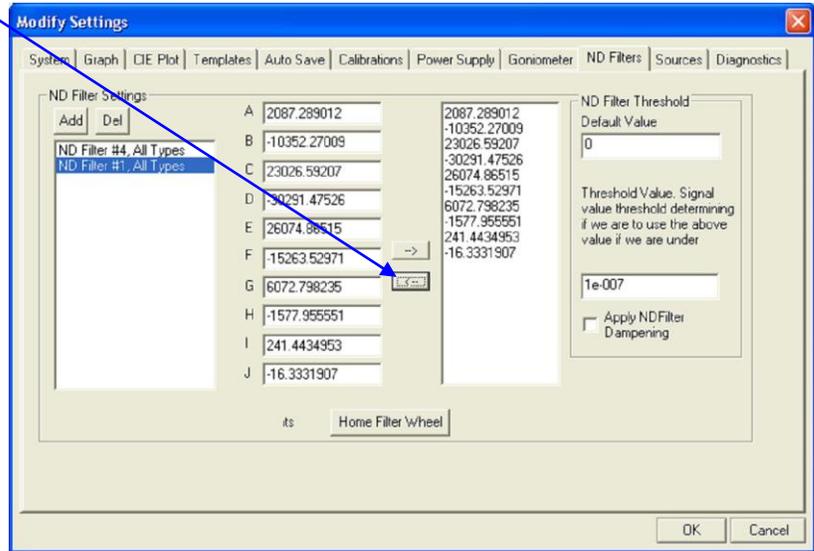


- ❑ **Copy and Paste the polynomial coefficients from the text file to the empty box located on the right.**



- Then click on the arrow left (-) to move the coefficients to their proper locations to the left. Note that the arrow right (->) can be used to copy the coefficients to the right to be copied to another location.

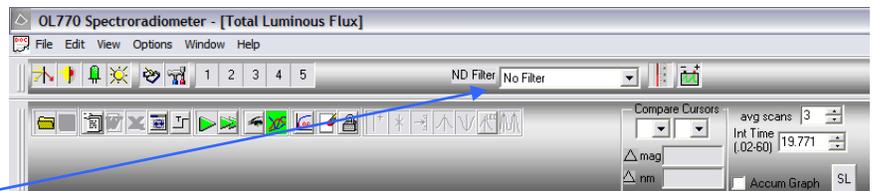
**NOTE:**  
When the attenuation filters are supplied with a new OL 770 system, the polynomial coefficient values are automatically imported with the factory configuration file, 770.INI. Refer to the OL 770 manual Tutorial 1, Part 2.



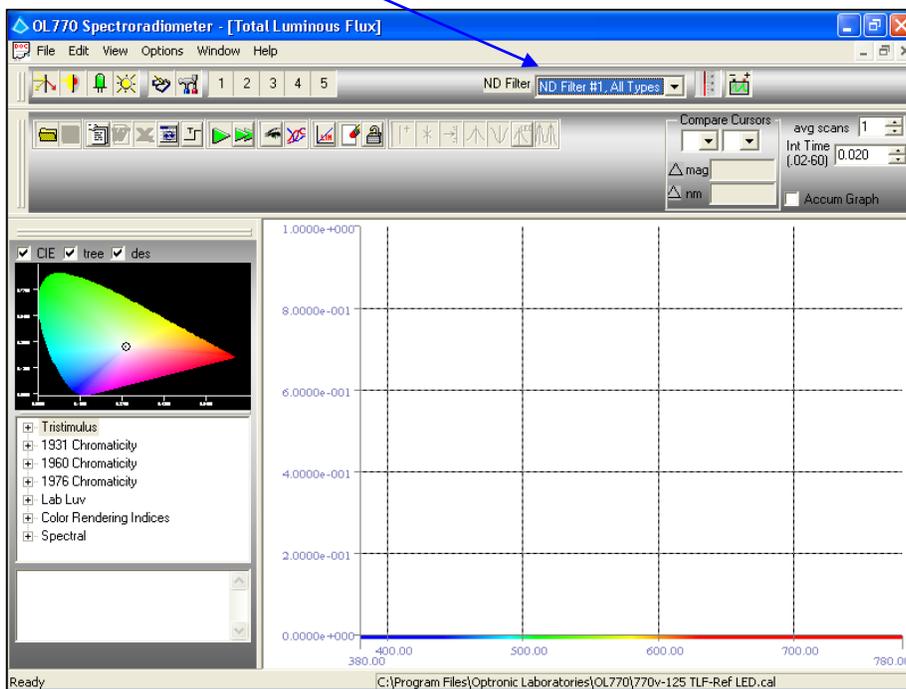
- The Default Value entry allows you to enter the signal value to use if the data point is below the threshold value. For this tutorial we will leave the default value of zero.
- The Threshold Value is the lower limit on the ND filter curve. If at a particular wavelength, the ND filter curve is below this value, then the program will use the default value as the signal. For this tutorial we will leave the value at 1e-007.
- The Apply ND Filter Dampening checkbox allows you to enable or disable the ND Filter Threshold feature.

**\* NOTICE \***

A new feature was added in the OL 770 Application Software version 4.43 and above. The ND filters are no longer used in measurements only. The new software allows the use of ND filters in all measurement types. To eliminate confusion, the ND filters are only selected in the main screen of the application software. The configuration settings are usually saved when exiting the software. If an ND was last used, it is remembered the next time the software is initiated. *It is important that users confirm the desired ND selection before entering the Modified Setting window to perform any measurement.*



- When performing measurements using the desired OL 770-ND Filter, select the appropriate ND Filter Setting from the drop-down list on the main toolbar.



## Part 2B - Configuring the OL 770-ND Filter Settings for the OL 770-15Q-A Automated ND Filter Holder

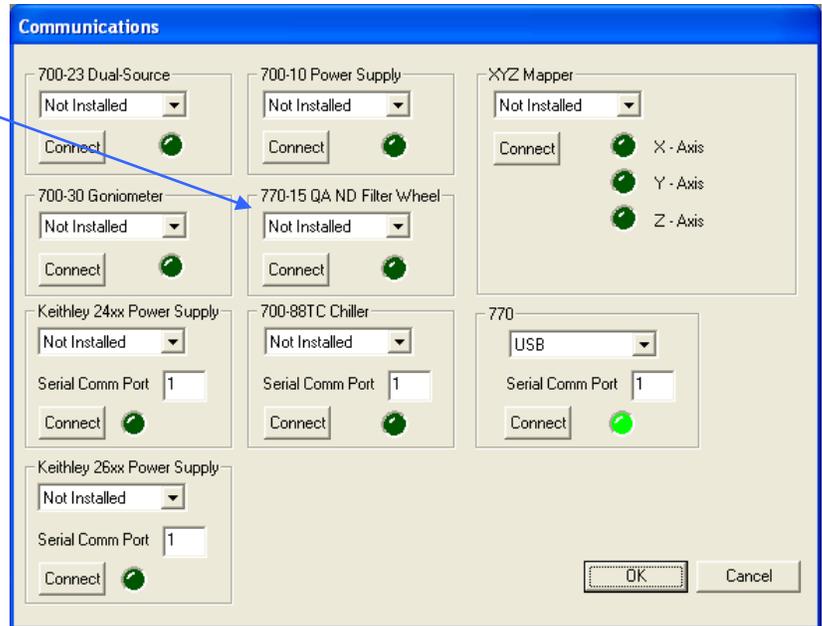
Access the Communications Dialog to configure the communications interface to the OL 770-15Q-A.

- ❑ Select the **Options** menu from the Main Menu, then select **Communications...**



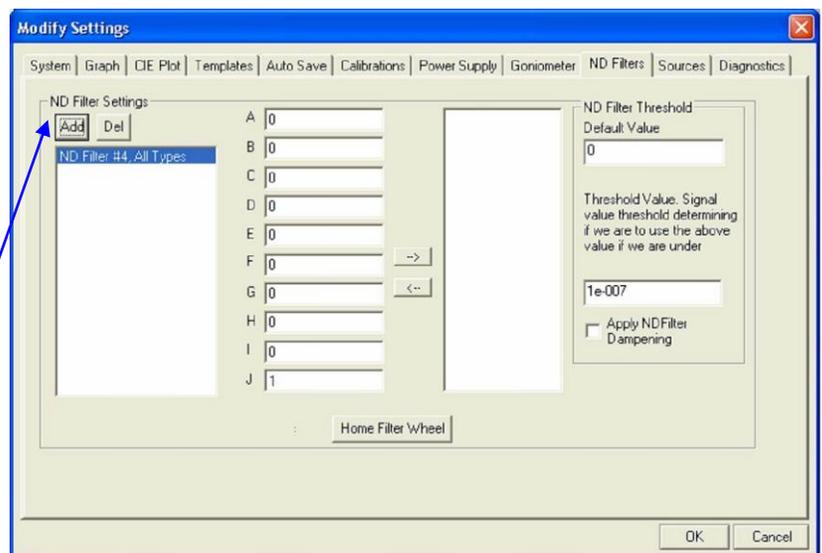
The Communications Dialog will open. Select USB connection from the drop-down list.

- ❑ When the **Communications Dialog** opens, select **USB** from the drop-down list of the **OL 770-15QA ND Filter Wheel** selection. Click the **Connect** button to initiate the communication. Ensure that a bright green light displays to indicated the **OL 770-15Q-A** is connected.



The OL 770-ND1 – ND4 filters are supplied with a text file which contains the coefficients for the polynomial. This represents the spectral transmission of the filter in each of its optical accessories.

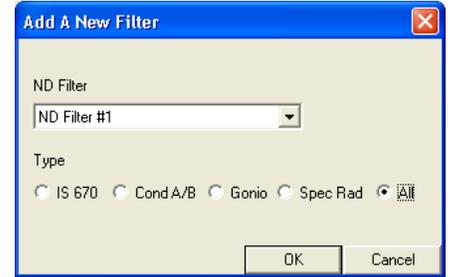
- ❑  Click on the **Modify Settings** button on the Main Toolbar to open the **Modify Settings Dialog**.
- ❑ Locate the **ND Filters** tab. This page contains the selections for configuring a ND filter with the optical accessory and the corresponding coefficients for the transmission polynomial.
- ❑ To create a ND Filter Setting, select the **Add** button.



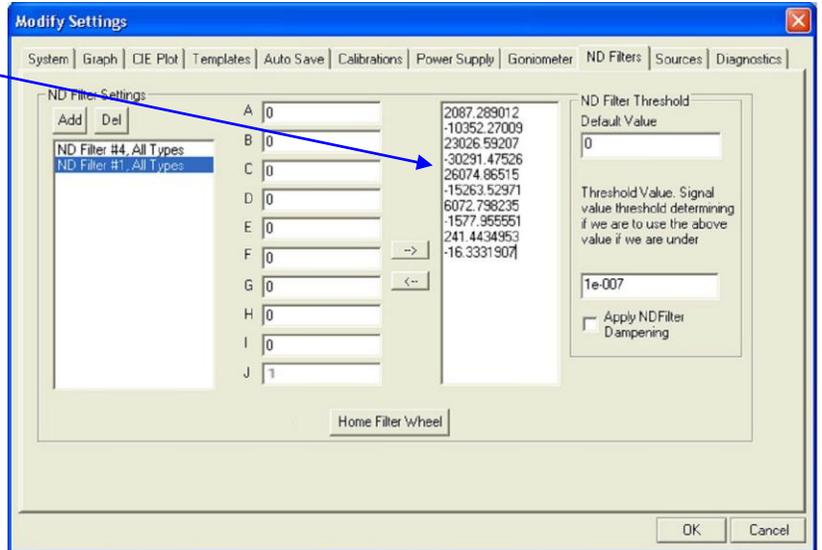
- From the Add a New Filter screen, select the ND Filter from the ND Filter drop-down list and also select the Type of optical accessory this ND filter will be used with.

Selecting All, will apply the ND filter coefficients to all types of optical accessory.

Select OK after the type is chosen.

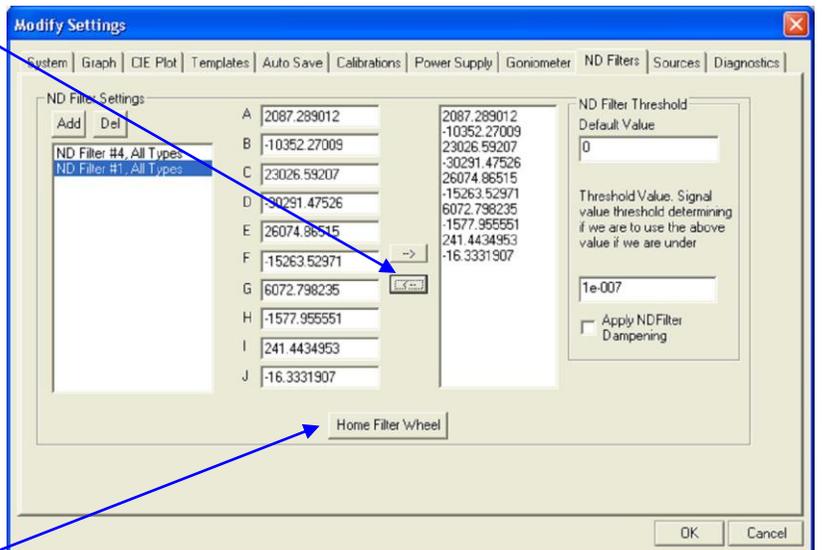


- Copy and Paste the polynomial coefficients from the text file to the empty box located on the right.



- Then click on the arrow left (<-) to move the coefficients to their proper locations to the left. Note that the arrow right (->) can be used to copy the coefficients to the right to be copied to another location.

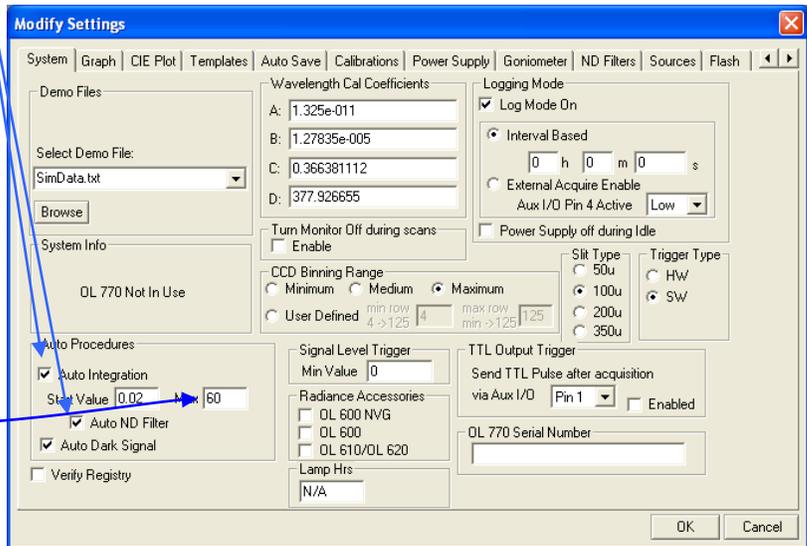
**NOTE:**  
When the attenuation filters are supplied with a new OL 770 system, the polynomial coefficient values are automatically imported with the factory configuration file, 770.INI. Refer to the OL 770 manual Tutorial 1, Part 2.



- When it is desired to home the ND filter wheel, select the Home Filter Wheel button.

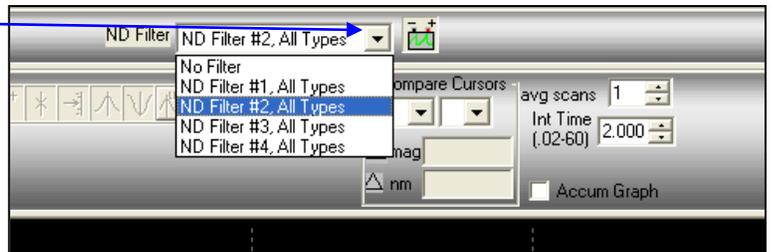
- The Default Value entry allows you to enter the signal value to use if the data point is below the threshold value. For this tutorial we will leave the default value of zero.
- The Threshold Value is the lower limit on the ND filter curve. If at a particular wavelength, the ND filter curve is below this value, then the program will use the default value as the signal. For this tutorial we will leave the value at 1e-007.
- The Apply ND Filter Dampening checkbox allows you to enable or disable the ND Filter Threshold feature.

- Click on the **System** tab and check the **Auto ND Filter** check box, along with **Auto Integration** check box. This will allow the OL 770 Application Software to automatically select the best filter to use from available filters in the filter wheel. If the saturation occurs during auto integration, a denser filter will be selected, when available, until the light levels are no longer saturated. Conversely, when max integration time is reached, a less dense filter will be selected, when available, until the light levels are strong enough.



Setting the max integration too short may cause a filter loop condition. If this occurs, an error message will display instructing an increase of max integration.

- If the Auto ND Filter option is not checked and a particular ND is desired, select the desired OL 770-ND Filter from the drop-down list on the main toolbar. The filter wheel will move the desired ND filter into position.

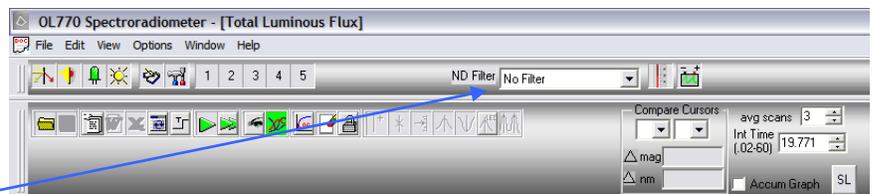


**NOTE:**

An appropriate calibration file must be enabled for the ND filters to work properly. Refer to the Modify Settings / Calibrations tab / Use Cal File selection.

**\* NOTICE \***

A new feature was added in the OL 770 Application Software version 4.43 and above. The ND filters are no longer used in measurements only. The new software allows the use of ND filters in all measurement types. To eliminate confusion, the ND filters are only selected in the main screen of the application software. The configuration settings are usually saved when exiting the software. If an ND was last used, it is remembered the next time the software is initiated.



*It is important that users confirm the desired ND selection before entering the Modified Setting window to perform any measurement.*

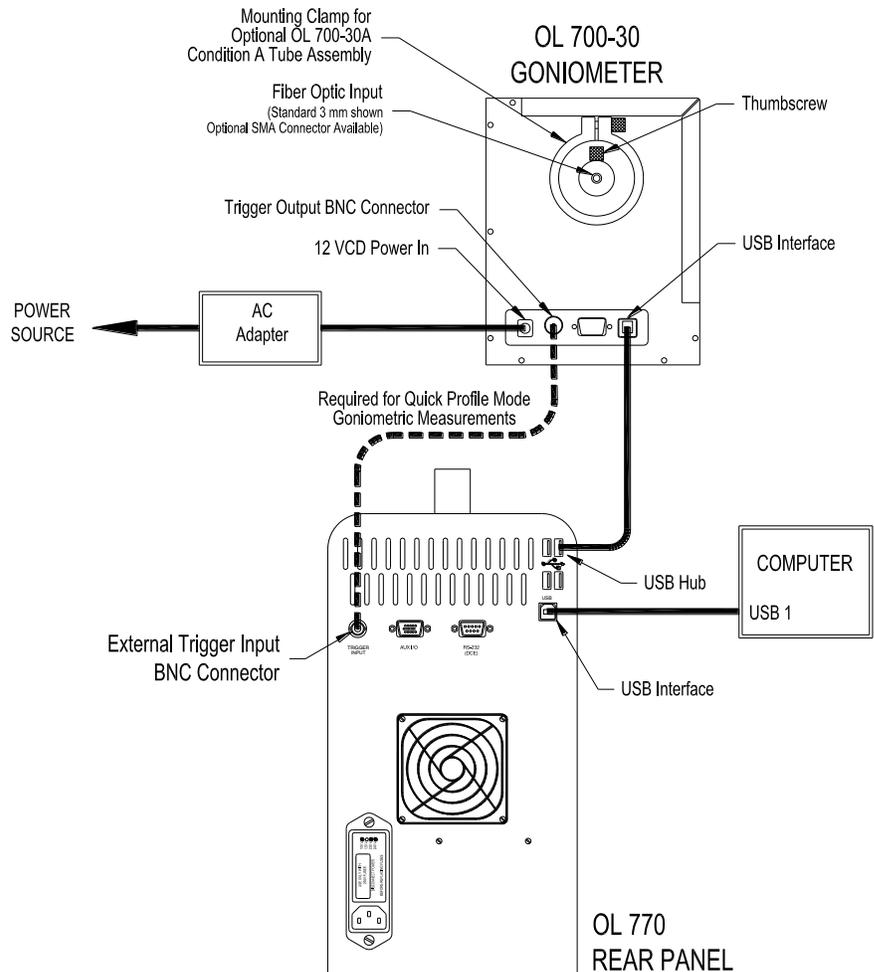
## TUTORIAL IV - GONIOMETER OPERATION

### NOTE:

Be sure you have completed Tutorial I – Basic Operations before starting this section!

### Part 1 - Installing the OL 700-30 LED Goniometer and HID Driver for the OL 770

- Place the OL 700-30 LED Goniometer on a flat, level surface within 3 feet of the OL 770 Multi-Channel Spectroradiometer.
- Insert the plug from the supplied external 12 VDC power adapter into the mating connector on the side of the OL 700-30 LED Goniometer. Plug the adapter into the correct AC power outlet.
- Connect the supplied coaxial cable between the Trigger Output BNC connector on the OL 700-30 LED Goniometer and External Trigger Input connector on the rear panel of the OL 770 Multi-Channel Spectroradiometer.
- Connect the supplied USB cable between the OL 700-30 and an available USB port on the rear of the OL 770. (A computer's USB interface port can also be used.)
- The Windows operating system should bring up the "Add New Hardware Wizard." The OL 700-30 USB device driver is typically part of the Windows operating system. Allow the Wizard to search for the best driver in its driver's database on the main drive only. When the "USB Human Interface Device" driver is found, the Wizard can install the software. Finish the Add New Hardware Wizard.
- Insert the 3-mm fiber optic probe from the OL 770 fully into the end of the external baffle tube on the OL 700-30 and secure with the thumbscrew. Do not overtighten.
- Open the top cover of the unit. Insert the OL 700-84-50 LED Holder onto the internal LED mount by pressing the holder onto the three nylon pins until it snaps in place.



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### NOTE:

If an optional LED Holder is being used, refer to the *Optional LED Holder* manual for proper LED installation and LED Holder configuration.

- Insert the LED to be measured into the holder and make the appropriate electrical connections onto the internal LED Electrical Connectors located on the OL 700-30 rear panel. Connect the appropriate electrical connections from the external LED Electrical Connectors to the LED power supply. Close the OL 700-30 top cover.
- Refer to the *Test OL 700-30 LED Alignment* section in the OL 700-30 manual to perform an LED alignment before making a measurement.

## Part 2 - Setting Up the Application's Goniometer Mode Settings

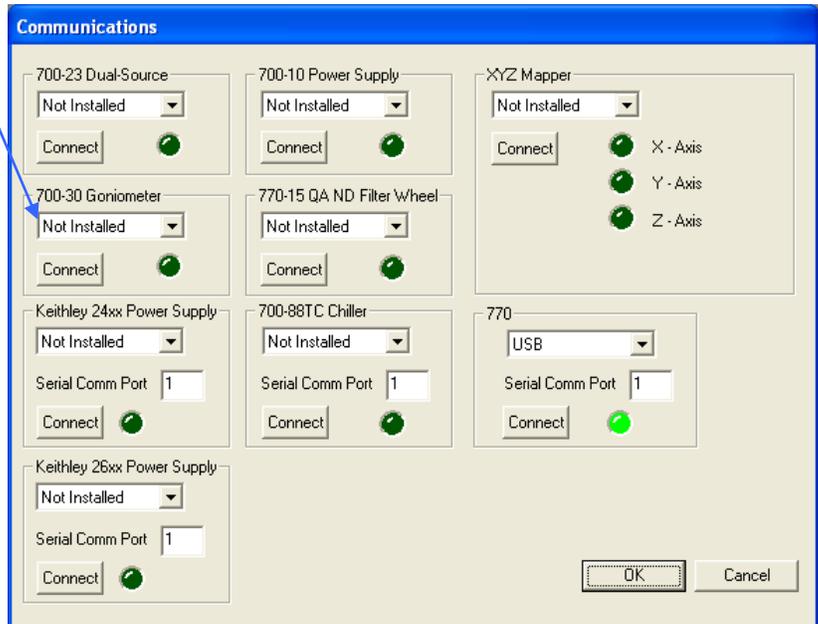
Access the Communications Dialog to configure the communications interface to the OL 700-30.

- ❑ Select the **Options** menu from the Main Menu, then select **Communications...**



The Communications Dialog will open. Select USB connection from the drop-down list.

- ❑ When the **Communications Dialog** opens, select **USB** from the drop-down list of the **OL 700-30 Goniometer** selection. Click the **Connect** button to initiate the communication. Ensure that a bright green light displays to indicated the **OL 700-30** is connected.



There are three different modes for performing measurements with the OL 700-30 LED Goniometer: Quick Profile Mode, Normal Mode, and Manual Mode.

1. **Quick Profile Mode** allows for quick measurements taken over a range of angles. This mode sets restrictions on the integration time that can be used depending on the number of degrees between each angle. The movement of the angle is continuous while optical sampling is at 1 degree angles or greater.
2. **Normal Mode** allows selection of integration time and increment angle independent of each other. The movement of the angle stops at each position for optical sampling.
3. **Manual Mode** allows movement of the OL 700-30 LED Goniometer to a specified angle. Measurements can be performed while at that angle.

The application's Goniometer Mode is selected in the Modify Settings/Goniometer tab in the OL 770 Application Software.

### NOTE:

If the OL 770 Application Software is set to User Mode, you will be required to enter a password before opening the Modify Settings dialog. Refer to Tutorial I, Part 2 for information on Security Operating Modes. Tutorial I, Part 2 will also provide further details on the Modify Settings / System dialog.

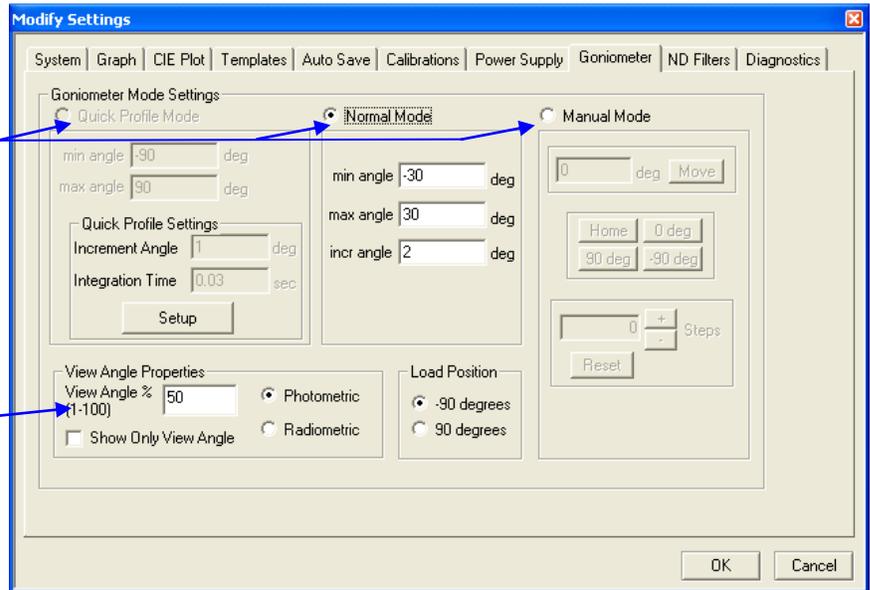


- Open the Modify Settings Dialog and click on the Goniometer tab.

Goniometer mode selection buttons.

**Note: that the Quick Profile Mode will be grayed when the OL 700-30 Goniometer is not connected.**

View Angle Percentage box



View Angle Percentage box: Used to set the percentage of the max intensity that will be used to find the left and right boundaries of the view angle based upon the formula:

- Intensity at view angle boundary = (max intensity-min intensity)\*percentage
- The percentage must be a number between one and one hundred.
- The Show Only View Angle check box only graphs the data within the boundaries of the view angle.
- Select either Photometric or Radiometric to determine how the view angle will be calculated.

Load Position: The position of the OL 700-30 linear stage when the goniometer is turned on and finished with the measurement. Select the position that would be the most convenient in order to install an LED between measurements.

The mode is selected with the radio buttons at the top of the page. Once a mode is selected, its setup parameters will be enabled, while all others will be disabled. We will learn how to use these parameters in the following sections.

Quick Profile Mode

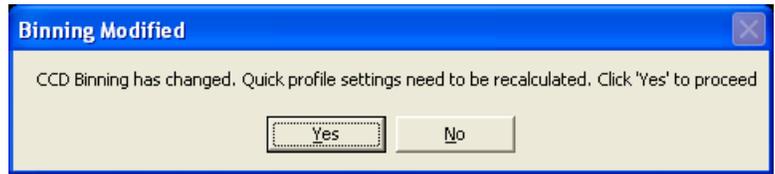
**NOTE:**

The Sweep and Pulse Modes of the Keithley SourceMeter are not possible when using the Quick Profile Mode of the OL 700-30 Goniometer. An error message will appear when trying to perform a Quick Profile Mode measurement.

- ❑ When Quick Profile Mode is desired, select the Quick Profile Mode radio button.
- ❑ Select the Setup button to begin the Quick Profile Mode Wizard.

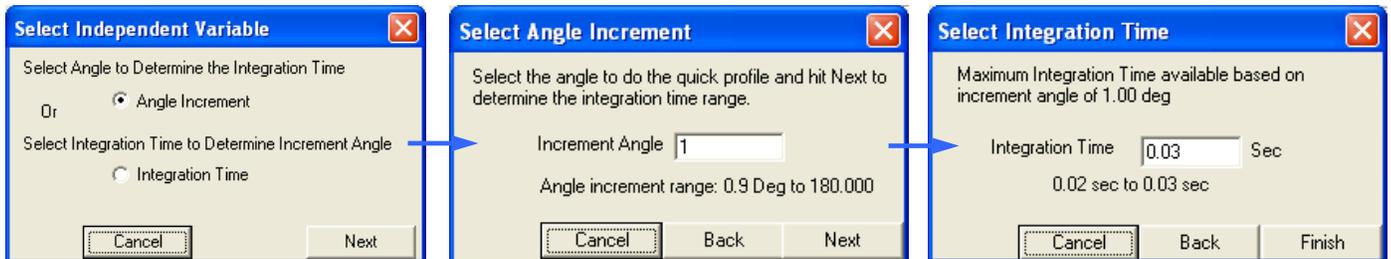
The goniometric Quick Profile Setup wizard is used to prevent errors associated with the setup of parameters necessary to goniometric Quick Profile measurements. Quick Profile measurements are based on an integration time and increment angle depending on the CCD binning type. Changing the binning will require recalculations of the quick profile settings.

The Quick Profile wizard can be accessed in two ways. The first is inside of the Modify Settings/Goniometer page (used in this tutorial) and the second is during a Quick Profile measurement. If the application detects some change with the binning vs. the integration time or angle, a message box with the following will be displayed to alert the user that the settings need to be recalculated.



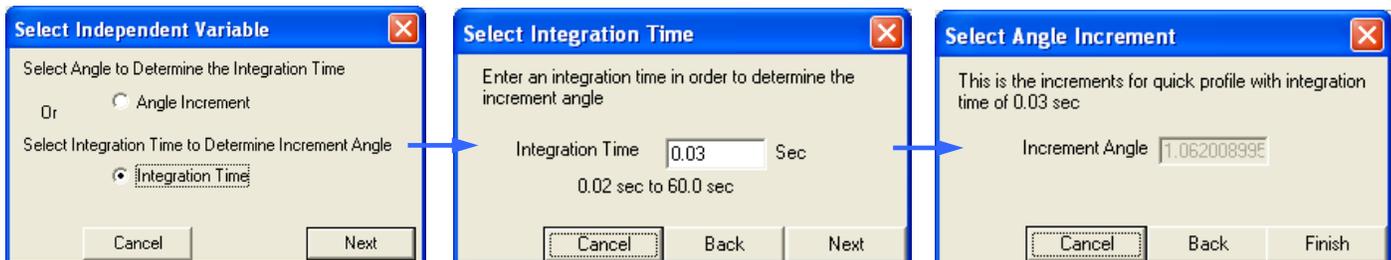
Calculations Using Increment Angle

The wizard begins by determining what independent variable to use. When the increment angle is selected, the possible integration time ranges are listed based on the chosen CCD binning type.



Calculations Using Integration Time

When the integration time is selected as the independent variable, the increment angle necessary for the measurement would be calculated.



At any time, the user can go back and forth through the wizard. The settings would not apply until the user clicks on the Finish button.

Once the Quick Profile Mode wizard is finished, the Quick Profile Settings will be displayed. The increment angle and integration time settings can be altered only by using the Quick Profile Wizard. The following items are included in the Quick Profile Mode settings:

1. **Min Angle:** The degree angle where the first measurement will be taken.
2. **Max Angle:** The degree angle where the last measurement will be taken.
3. **Increment Angle:** The number of degrees to be between each consecutive measurement, the smallest increment being one degree.
4. **Integration Time:** The integration time for each measurement taken. This number must be within the specified range that appears in its label. This range is dynamic and changes according to the increment angle and the CCD binning.

## Normal Mode

---

- When Normal Mode is desired, select the Normal Mode radio button.**

The following items will be enabled:

1. **Min Angle:** The degree angle where the first measurement will be taken.
2. **Max Angle:** The degree angle where the last measurement will be taken.
3. **Incr Angle:** The number of degrees, to the nearest hundredth of a degree, to be between each consecutive measurement.

## Manual Mode

---

- When Manual Mode is desired, select the Manual Mode radio button.**

The following items will be enabled:

**Move Button:** This button will allow you to move to the angle specified in the edit box to the left.

- Select the Manual Mode radio button.**
- Enter a value between -90 and 90 into the deg edit box.**
- Click the Move button to move to this angle.**

The OL 700-30 LED Goniometer will move to the specified angle and stop. Once the OL 700-30 LED Goniometer completes the move, feel free to take measurements at this angle.

Other features of Manual Mode:

1. **Home Button:** Moves the OL 700-30 LED Goniometer to the home position.
2. **Zero Button:** Moves the OL 700-30 LED Goniometer to zero degrees.
3. **Negative Ninety Button:** Moves the OL 700-30 LED Goniometer to negative ninety degrees.
4. **Ninety Button:** Moves the OL 700-30 LED Goniometer to ninety degrees.
5. **Plus Button:** Moves the OL 700-30 LED Goniometer one step,  $0.01^\circ$  in the positive direction and adds one to the number in the edit box to its direct left.
6. **Minus Button:** Moves the OL 700-30 LED Goniometer one step,  $0.01^\circ$  in the negative direction and subtracts one from the number in the edit box to its direct left.
7. **Reset Button:** Resets the offset button to zero, but does not reset the actual OL 700-30 LED Goniometer in any way.

### Part 3 – Goniometer Optical Setup Options

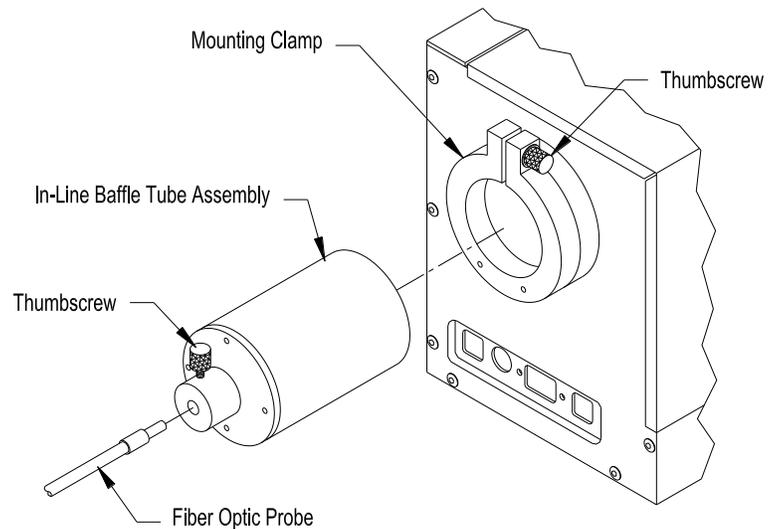
The OL 700-30 LED Goniometer is supplied with an interchangeable in-line extension tube for high sensitivity for uncalibrated measurements. However, it can be exchanged with the short tube from the OL 15AB LED Receptor (i.e. OL 700-30A) for calibrated Averaged LED Intensity - Condition A measurements. Note that the OL 15AB LED Receptor may not be supplied with your system.

#### OL 700-30 In-Line Baffle Tube Measurements

The short In-Line Baffle Tube supplied with the OL 700-30 can be used for spatial distribution measurements of LED's and small sources. System response calibration files are not available for this accessory. It is therefore not possible to measure the photometric, radiometric and chromaticity values. The In-Line Baffle Tube gives accurate measurements of an LED's View Angle and relative spatial distribution.

#### Installation

The In-Line Baffle Tube is supplied attached to the OL 700-30 Goniometer from the factory. Insert the fiber optic probe into the fiber optic input and secure with the thumbscrew. When the In-Line Baffle Tube is used, ensure the Use Cal File box is not checked in the Modify Settings / Calibration dialog for LED-Goniometric Measurements.



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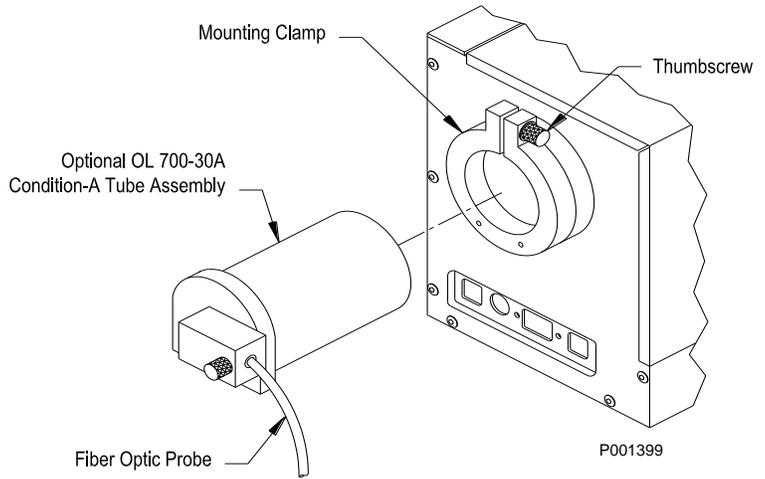
## Optional OL 700-30A Condition A Tube Assembly

The optional OL 700-30A Condition A Tube Assembly can be used with the OL 700-30 LED Goniometer to perform “Average LED Intensity” measurements in accordance with CIE Publication 127 Condition A recommendations.

### Installation

Remove the existing standard fiber optic probe tube assembly by loosening the thumbscrew on the external mounting clamp. Insert the OL 700-30A Tube Assembly into the mounting clamp. Gently tighten the thumbscrew to close the clamp. Insert the fiber optic probe into the 1-inch diameter integrating sphere exit opening and secure the thumbscrew. Set the measurement angle to 0°. Ensure the tip of the LED to be measured is aligned with the LED Alignment Tool. Refer to the OL 700-30 Manual for further details on installation and LED alignment.

*Installation of the Optional OL 700-30A Condition A Tube Assembly*



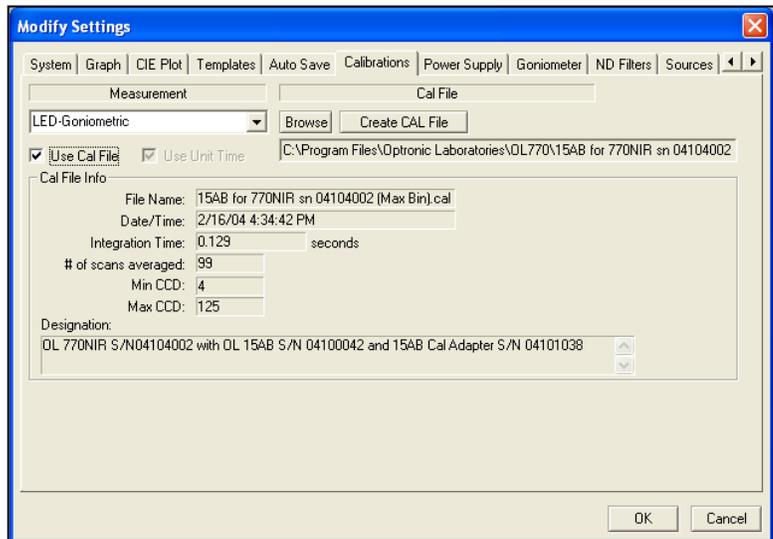
### Calibration

Open the Modify Settings / Calibration dialog and select the LED-Goniometric from the Measurement drop-down menu.

Browse and select the system response calibration file for Averaged LED Intensity –Condition A/B.

Ensure the Use Cal File box is checked.

Click OK to close the Modify Settings and confirm the correct calibration file is displayed in the status bar.



## Part 4 – Changing the Polar Plot Parameter

The polar plot can be switched to represent the spatial distribution of a number of different measurement values.

- ❑ Ensure the LED-Goniometer measurement window is open and a polar plot graph is visible.

### NOTE:

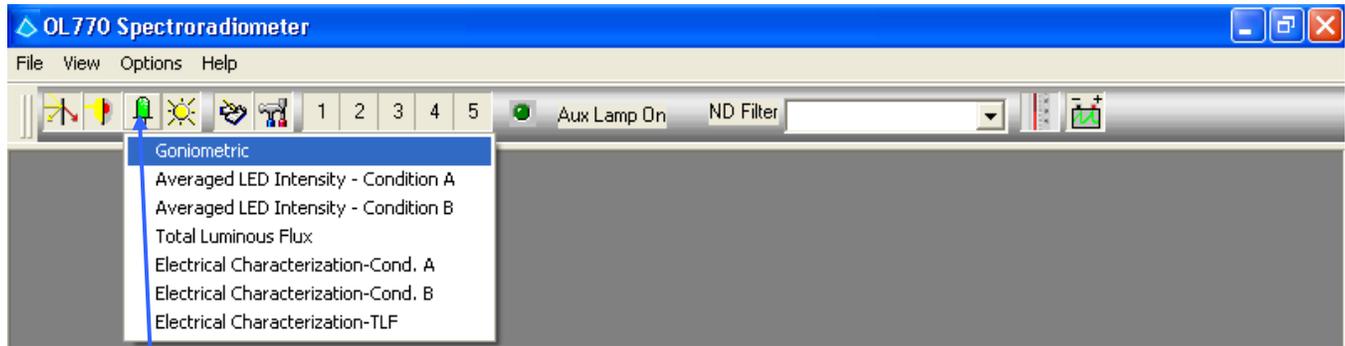
If a polar plot graph is not visible, check that the Modify Settings / Goniometer dialog is set for Normal or Quick Profile Mode.

- ❑ Use the mouse to highlight a measurement value in the value tree, for example 1931 Chromaticity / 2 degree x
- ❑ Right click the mouse and click on the dialog, Set as Polar Plot Radial Value

The polar plot will now be drawn for the spatial distribution of the chromaticity x value versus angle. The radial value can be changed as required after the scan.

## Part 5 - Taking Goniometric Measurements

Make sure the OL 700-30 LED Goniometer is properly attached. If the OL 770 Application Software is not running, run the application software now.



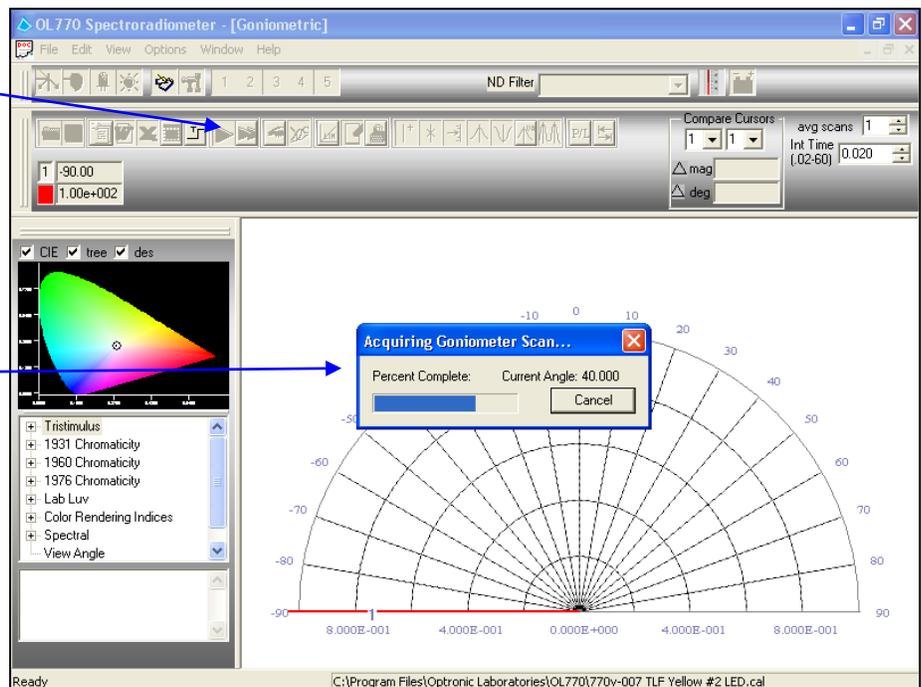
Click on the **LED** button and select **Goniometric** from the list. This will open a window for taking Goniometer Measurements. A password granting access to each module is stored in a bin file and is automatically saved to the appropriate location during installation.

### Quick Profile Mode

- ❑ Select **Quick Profile Mode** from the **Modify Settings/Goniometer** page.
- ❑ Enter **-90** as the **min angle**.
- ❑ Enter **90** as the **max angle**.
- ❑ Select **Setup** to activate the wizard. Select **Angle Increment** as the **independent variable**, then enter **1** as the **Increment Angle**. Continue through the wizard entering the **integration time** within the range that is calculated, and then select **Finish**.
- ❑ Click **OK** to close the **Goniometer** page.

Click Single Reading arrow to start a Quick Scan

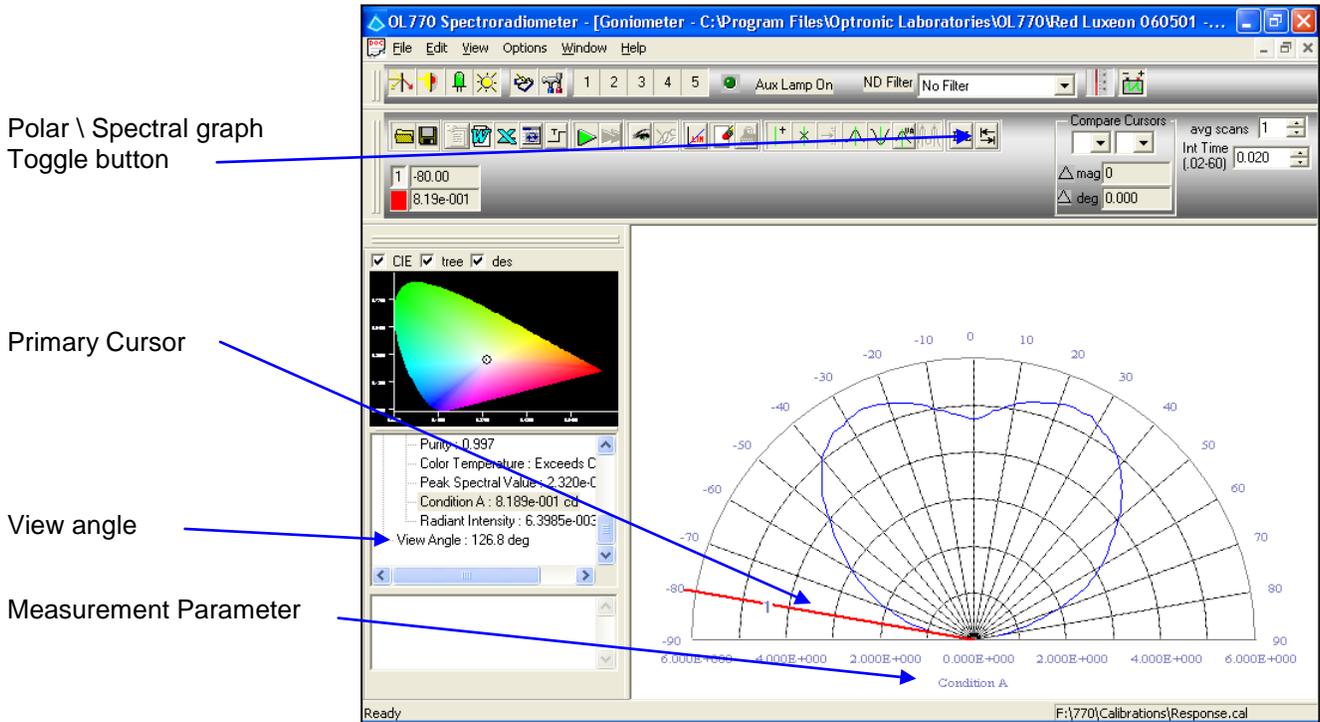
Scanning in progress box



- ❑ Click the **single reading** button to take a **Quick Mode Goniometric** measurement.

This angular rotation will take 12 seconds to complete. When finished, data will be plotted on the polar plot from -90 to 90 degrees with a data point at each angle. Notice that the variable tree has been updated. The values shown are the variable's values at the currently selected angle.

Notice that a polar plot is drawn in the graph window. This is the default graph that data taken in either Quick or Normal Goniometer Mode will be displayed on. Also notice a single red cursor on this graph. This is the primary cursor in Goniometric Mode, which is used to select an angle at which to display various calculations. There is also a new variable added to the Spectral branch of the variable tree called View Angle. This variable is only shown in Quick or Normal Goniometer Mode.



 The Toggle Between Polar and Spectral Plot button is used to toggle between polar and spectral plot mode. When depressed, the polar plot will change to a spectral plot to display counts per wavelength data at the currently selected angle denoted by the primary cursor. When pressed a second time, it will switch back to the polar plot.

- ❑ Click and drag the primary cursor to a new location and watch the values on the variable tree update to reflect the data at the new angle.
- ❑ Click on the **Toggle Between Polar and Spectral Plot** button to see a spectral plot of the data at the selected angle.

 The Toggle Between Polar and Linear Plot button is used to toggle between polar and linear plot mode. When depressed, the polar plot will change to a linear plot to display counts per wavelength data at the currently selected angle denoted by the primary cursor. When pressed a second time, it will switch back to the polar plot.

## Changing the Polar Plot Parameter

The polar plot can be switched to represent the spatial distribution of a number of different measurement values.

- ❑ Use the mouse to highlight a measurement value in the value tree, for example **1931 Chromaticity \ 2 degree x**
- ❑ Right click the mouse and click on the dialog, **Set as Polar Plot Radial Value**.

The polar plot will now be redrawn showing the spatial distribution of the chromaticity x value with angle.

## Normal Mode

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- ❑ **Open the Modify Settings dialog box and choose the Goniometer tab.**
- ❑ **Select Normal Mode.**
- ❑ **Set the min angle to -30 the max angle to 30, and the increment angle to 1.**
- ❑ **Change to the Systems tab and uncheck the Auto Integration box.**
- ❑ **Click OK to close the dialog.**
- ❑ **If using a different integration time than the one specified on the Cursors Bar, make changes now. The integration time should be set for the maximum signal level encountered during the scan.**
- ❑ **Click the single measurement button to begin a scan.**

Notice that this scan takes a longer amount of time to complete than the quick mode scan. Also notice that the graph will be displayed the same as the graph in quick profile mode. The only difference between the two modes is the way scans are taken.

## Manual Mode

---

The Manual Mode moves the OL 700-30 LED Goniometer to a desired position. The user can then take measurements at these angles if preferred.

- ❑ **Open the Modify Settings Dialog, and click on the Goniometer page.**
- ❑ **Click the Manual Mode radio button.**

Three sections under this radio button will be enabled. The first allows the user to type in an angle in hundredths of degrees and click the move button to move there. The second section permits clicking one of four buttons to move to a predefined angle. The third radio button allows the user to increment or decrement by a single step, which is a hundredth of a degree. The value displayed in the box is the offset of steps from the initial value. Clicking reset only sets this value back to zero and does not reset the actual OL 700-30 LED Goniometer in any way.

- ❑ **Enter a number between -90 and 90 into the deg edit box in the top section.**
- ❑ **Click the Move button. The OL 700-30 LED Goniometer will move to that degree.**
- ❑ **Click on the 0 degrees button in the second section. If different than the number typed in the edit box, the OL 700-30 LED Goniometer move to this position.**
- ❑ **Click the + step button. The plus and minus buttons will gray out while the OL 700-30 LED Goniometer is performing the step, and re-enable when it has finished the step.**

These functions may be used in any way to move the OL 700-30 LED Goniometer to your desired angle. By clicking OK on the Setup Dialog, the OL 700-30 LED Goniometer will remain at that angle. Measurements may now be taken at that angle.

## TUTORIAL V – LINEAR TRANSMITTANCE MEASUREMENTS

**NOTE:**

Be sure you have completed Tutorial I – Basic Operations before starting this section!

The OL Series 454 Integrating Sphere Calibration Source can be used to perform linear transmittance measurements with the OL 770 and the OL 610 Telescope.

This tutorial will cover using the OL 454 and the OL 610 with the OL 770, however it will be necessary to refer to their manuals for further details and specifications.

### Part 1 - Typical Optical Setup and System Configuration

#### OL 610 Telescope / Camera Setup

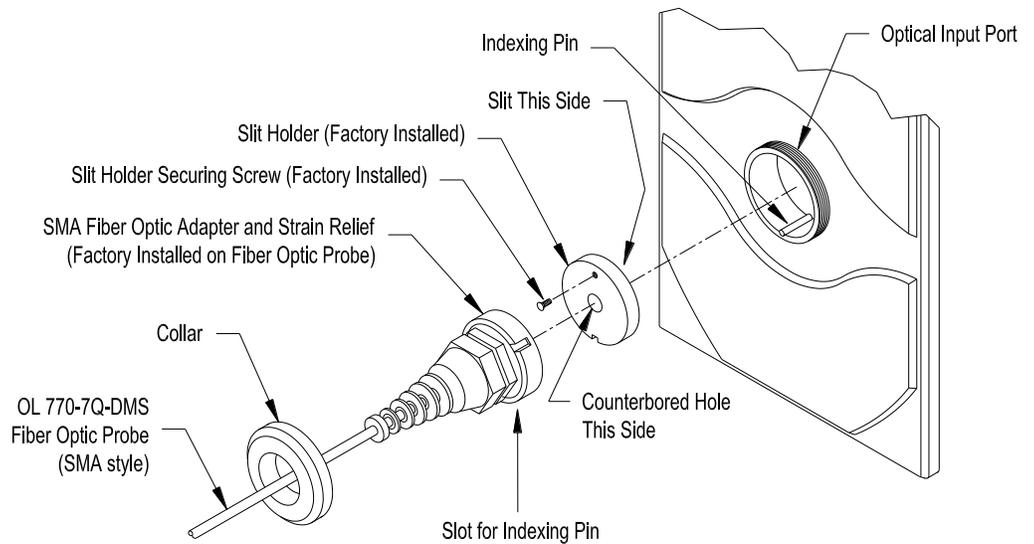
The OL 610 comprises of a 35 mm camera lens, direct viewing optics mirror with integral field-of-view aperture, and an internal CCD imaging camera for object viewing and allows the CCD image to be stored with the measurement data.

1. Install the desired Series OL 610-L-XXX Objective Lens onto the front of the OL 610.
2. It is important to ensure that the lens aperture is set to its largest open aperture (smallest numerical value) by turning the aperture ring on the lens body.

**\* CAUTION \***

Changing the lens aperture to a setting other than the one the instrument was calibrated at invalidates the calibration applied to the measurement. Always ensure that the appropriate aperture setting on the lens is selected for a given calibration.

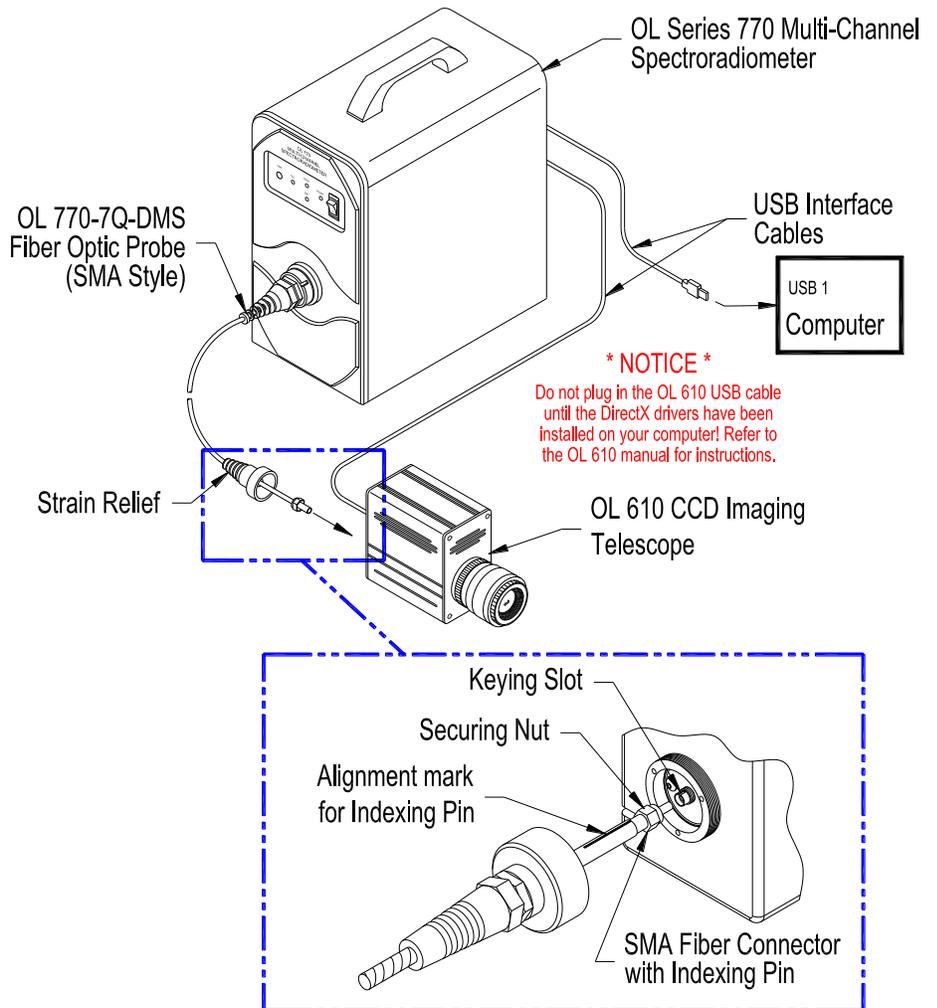
3. Connect the USB cable from the rear of the OL 610 to an available USB port on the rear of the OL 770. (A computer’s USB port can also be used.) **Notice: Install the drivers before plugging in the USB cable - refer to the OL 610 manual.**
4. Remove the Collar from the OL 770 Optical Input Port. (The Collar is supplied attached to the OL 770 from the factory.) Slide the Collar over the free end of the OL 770-7Q-DMS Fiber Optic Probe. Install the OL 770-7Q-DMS FOP with its Adapter into the Optical Input Port, aligning the slot to the indexing pin.



**NOTE:**

The OL 610 may be supplied with an optional OL F770-IRS.30SS1.5 300  $\mu\text{m}$  FOP (1.5-meter length standard). When the optional FOP is supplied, the strain relief on the OL 610 is a modified two-piece clamp assembly. Refer to *Appendix H* for installation of the OL 610 if the optional OL F770-IRS.30SS1.5 300  $\mu\text{m}$  FOP is supplied.

5. Remove the Strain Relief from the rear of the OL 610. (The Strain Relief is supplied attached to the OL 610 from the factory.) Slide the Strain Relief over the free end of the OL 770-7Q-DMS FOP. Connect the OL 770-7Q-DMS FOP to the mating SMA connector on the rear of the OL 610. The SMA fiber connector contains an indexing pin that mates with a keying slot on the OL 610 rear connector. **Be sure the indexing pin inserts into the keying slot on the OL 610 rear SMA connector. An alignment mark on the FOP must line up with the keying slot.** Gently tighten the SMA fiber connector's securing nut. (If the indexing pin is not seated into the keying slot, the threads of the securing nut will not engage the threads of the mating SMA connector.) Slide the Strain Relief over the SMA connector. Gently screw the Strain Relief onto the threaded collar on the rear of the OL 610 to secure in place.
6. Connect a USB cable from the rear of the OL 770 to one of your computer's USB ports.
7. Mount the OL 610 on a camera tripod or optical bench.
8. Turn on "power" to the OL 770 Multi-Channel Spectroradiometer.



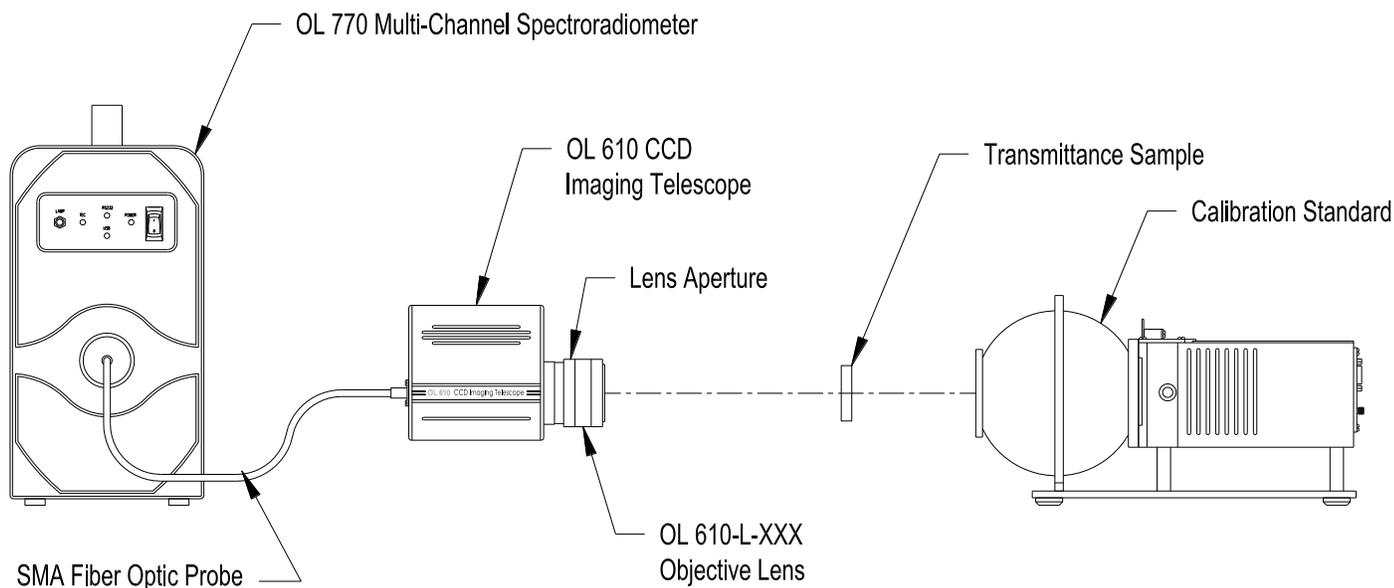
**\* CAUTION \***

Avoid excessive bending of the OL 770-7Q-DMS Filter Optic Probe. Bending of the fiber may cause change's in its transmittance properties. Excessive bends may permanently damage the fiber.

## System Configuration

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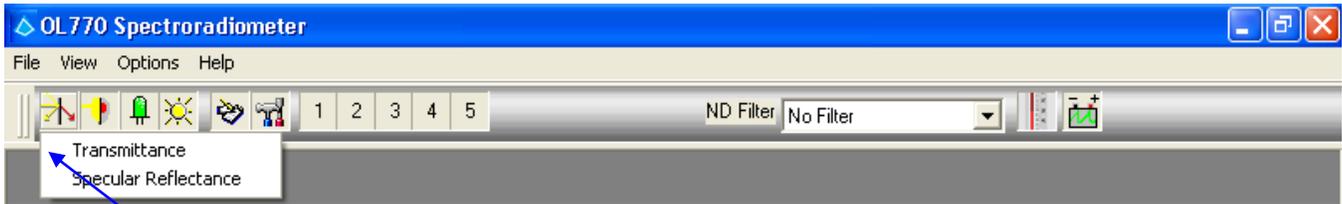
1. Align the OL 610 Telescope and focus the objective lens on the output port of the calibration source.
2. Select the maximum OL 610 objective lens aperture.
3. Switch on the stabilized current source.
4. Switch on the lamp and allow it to warm up and stabilize for the required time.
5. Adjust the calibration sphere source's variable aperture to set the output at the required level.
6. Position the transmittance test sample to the desired distance. Note: Samples can interact with the sphere if placed too close to the port. Also, samples may be heated if the source intensity is high.



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### Part 2 - Open the Linear Transmittance Measurement Software Module \_\_\_\_\_

Within the OL 770 Application Software are packages for the various spectral measurement configurations including transmittance, reflectance, radiance and the optical parameters of LEDs. Each package is accessed via a button on the Main Toolbar. A password granting access to each measurement package is stored in a bin file and is automatically saved to the appropriate location during installation.



- ❑ Click on the **Linear** icon on the Main Toolbar and then select **Transmittance**. (A password access dialog will open if the software package was not purchased.) For information on purchasing additional OL 770 software packages, contact Gooch & Housego, Orlando, Florida. You will only need to enter the password provided when using the module for the first time. During normal use, the password dialog box does not appear.

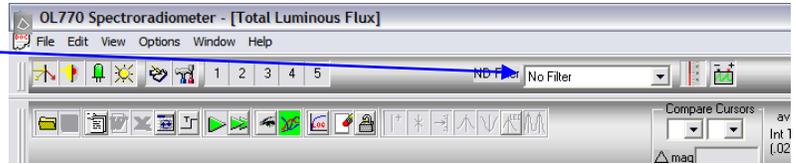
#### NOTE:

When the application software is run in Demo mode, access is given to all the measurement modules without password intervention.

## Configuring the OL 770 for Transmittance Measurements

The configuration file for your OL 770 spectroradiometer and sample calibration files are supplied in the System folder located on the OL 770 Application Software Installation CD supplied with your system. The contents of this folder are installed with the application program, refer to *Installing the OL 770 Application Software & USB Driver* section in this manual.

- ❑ Confirm the desired ND selection on the Main Toolbar before entering the Modified Settings window.

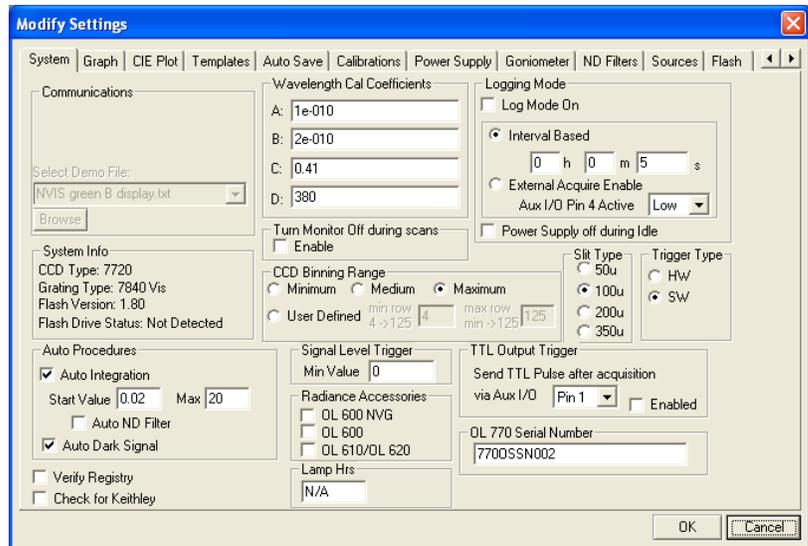


### NOTE:

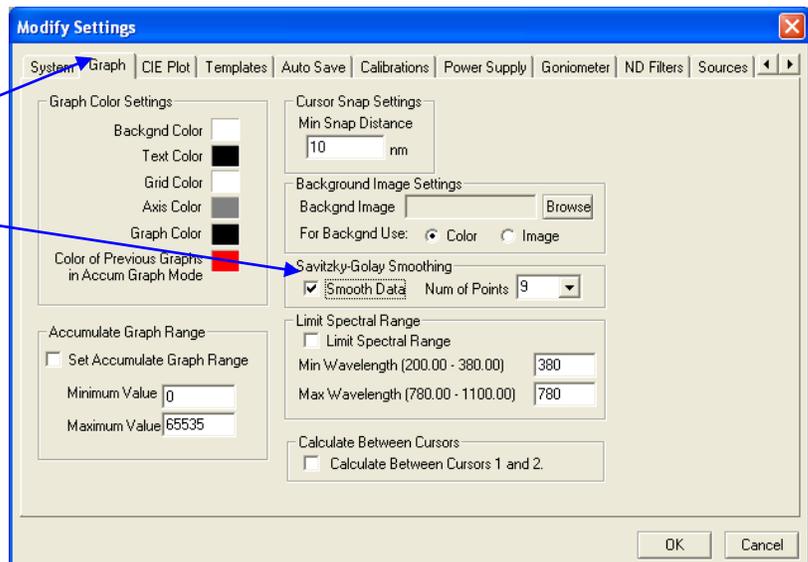
If the OL 770 Application Software is set to User Mode, you will be required to enter a password before opening the Modify Settings dialog. Refer to Tutorial I, Part 2 for information on Security Operating Modes. Tutorial I, Part 2 will also provide further details on the Modify Settings / System dialog.



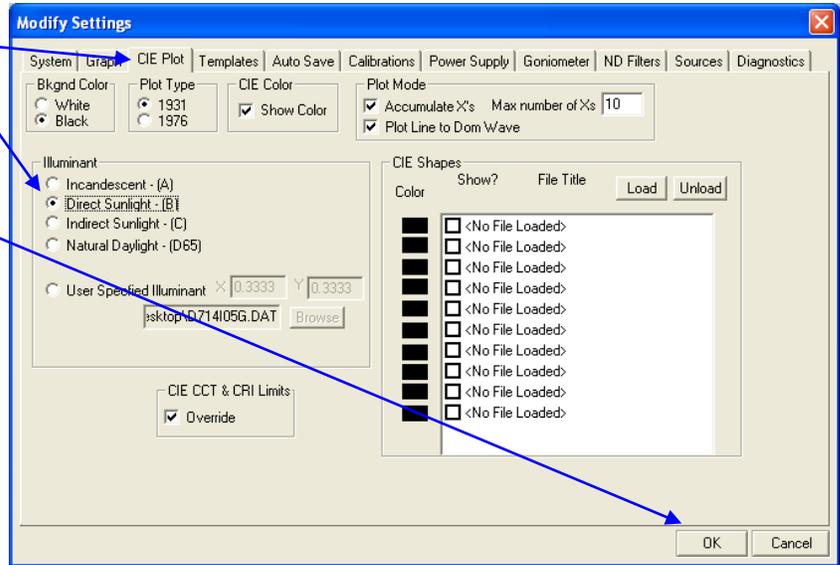
- ❑ Select the **Modify Settings** button on the Main Toolbar. Refer to the OL 770 manual Tutorial I / Part 2 for an introduction to the Modify Settings / System dialog.
- ❑ Go to the **System** page and confirm both the Auto Procedure boxes are checked.
- ❑ Ensure the **CCD Binning Range** is set to **Maximum**.
- ❑ Confirm the **Wavelength Coefficients** and **Slit Type** are correct.



- ❑ Select the **Graph** tab.
- ❑ Check the **Smooth Data** box to enable Savitzky-Golay Smoothing.
- ❑ Set the Num of points to the required level.

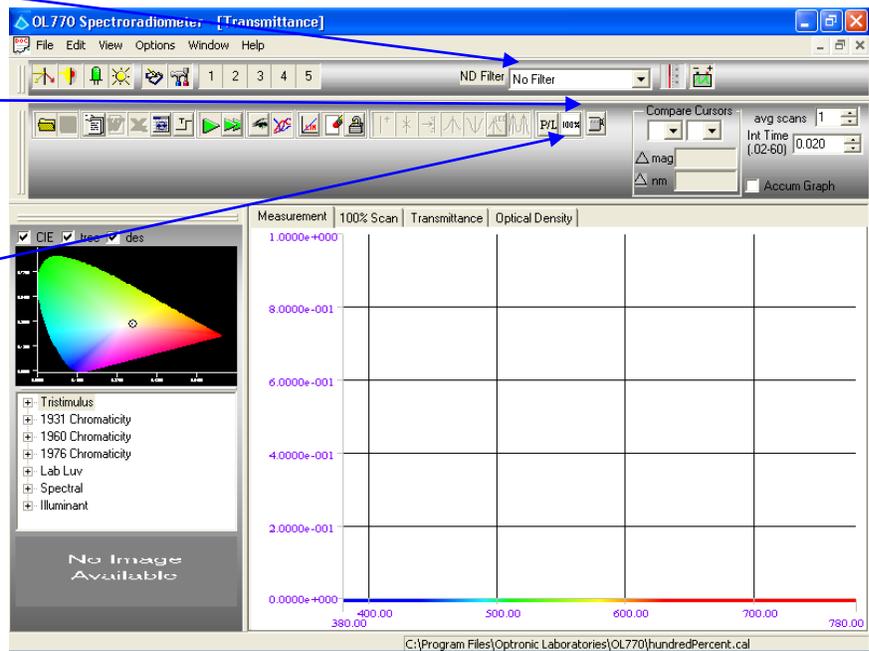


- ❑ Select the **CIE Plot** tab.
- ❑ Select the desired **Illuminant**.
- ❑ Click **OK** to close the **Modify Settings** dialog.

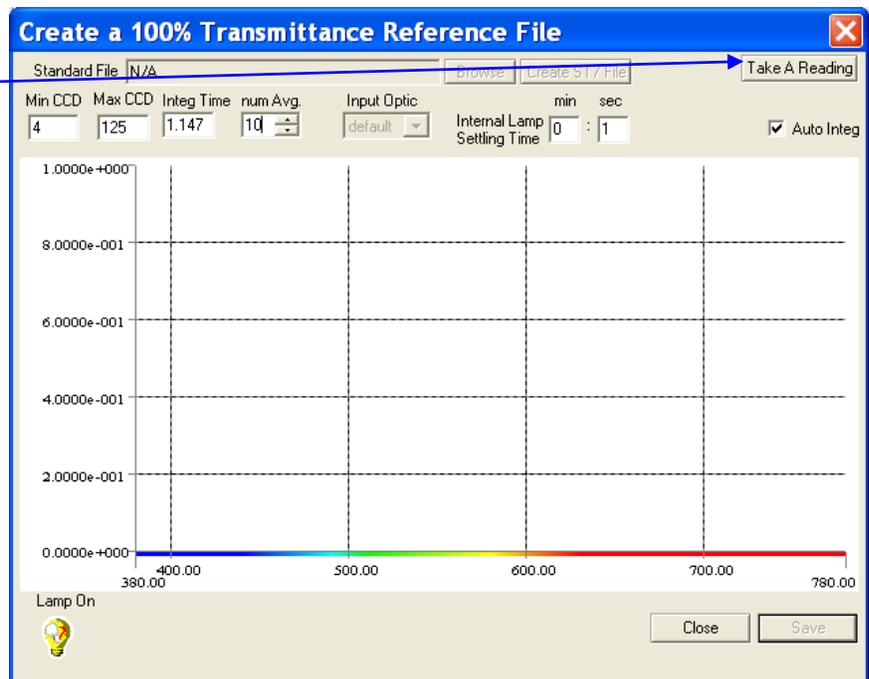


Performing a Transmittance Measurement Scan

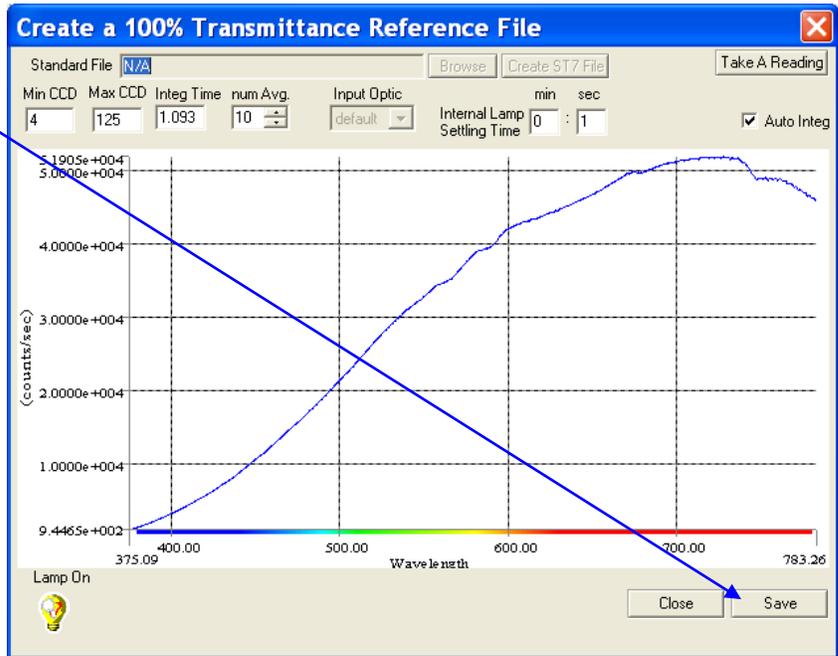
- ❑ It is important to confirm the desired ND selection before performing any measurement.
- ❑ Before the test sample has been properly positioned and aligned, click the OL 610 camera button to display the view.
- ❑ Click the Take a 100% Measurement button.



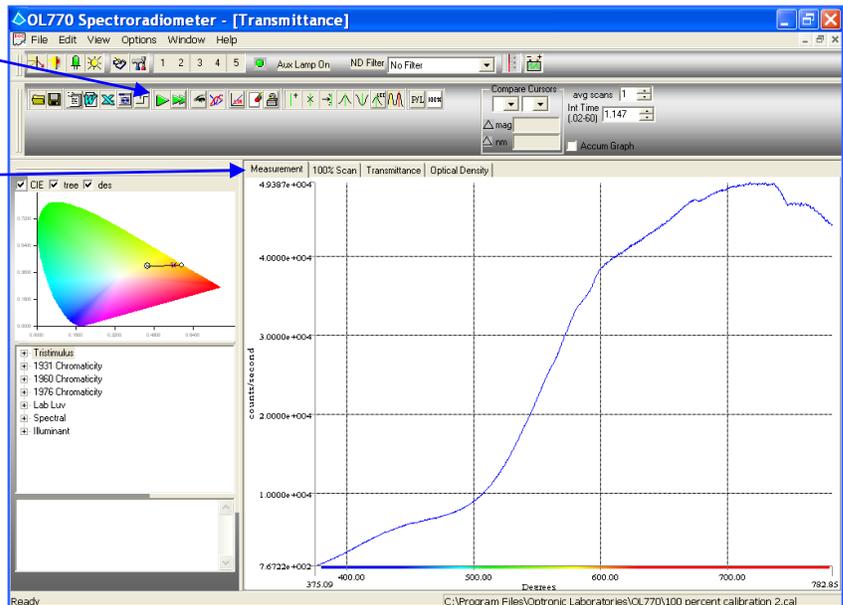
- ❑ The Create a 100% Transmittance Reference File dialog will appear. Click the Take a Reading button.



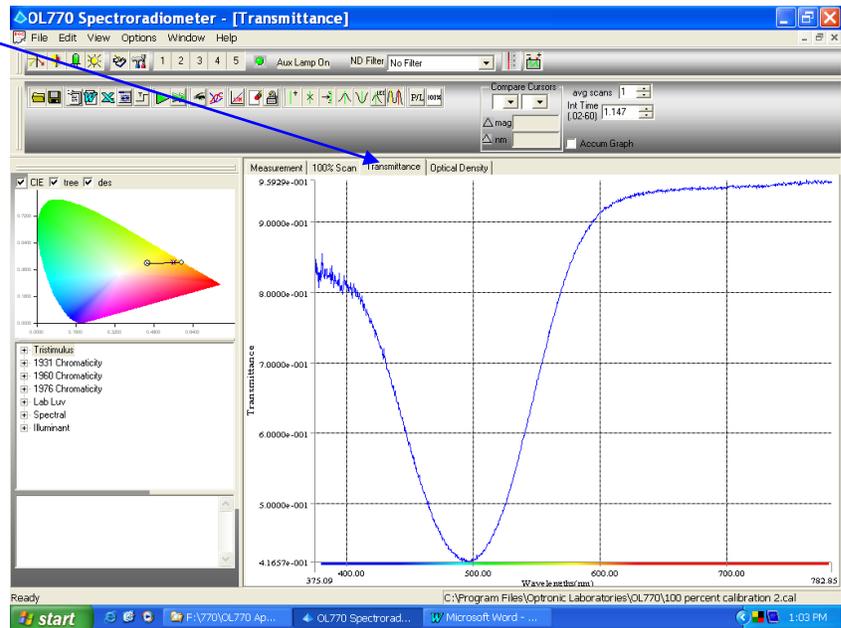
- ❑ After the 100% transmittance scan data is complete, save the 100% measurement file to the default cal file location.



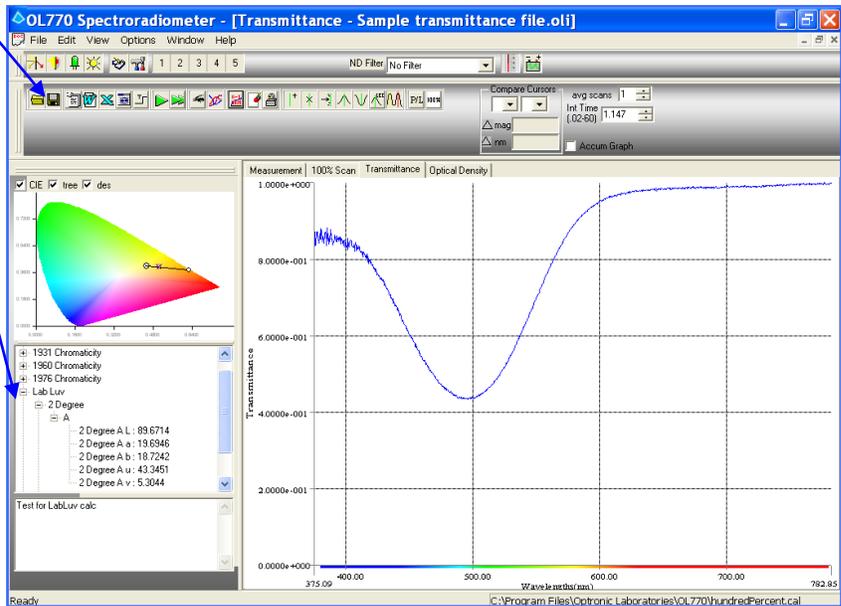
- ❑ Position and align the test sample, and click the Single Measurement button.
- ❑ A graph of the measurement scan will display on the Measurement tab.
- ❑ You can toggle through the Measurement, 100% Scan, Transmittance, and Optical Density graphs by selecting the respective tab.



- ❑ The transmittance scan plot can be displayed when selecting the Transmittance tab.



- ❑ Save the data by selecting the Save icon.
- ❑ Expand the value tree to display the LAB/LUV values.



### Part 3 – Calculations and Formulas for Transmittance Measurements Using the Comparison Method

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Identified below are the parameters used to determine the spectral transmittance of a test sample:

- $i$  : dark reading (measured while source is shuttered before scan) [A or V].
- $\lambda$  : wavelength [nm].
- $S_{100\%}(\lambda)$  : calibration signal. Stabilized averaged reading, without test sample [A or V] with dark current ( $i$  [A or V]) subtracted.
- $S_T(\lambda)$  : average signal reading with test sample [A or V] with dark current ( $i$  [A or V]) subtracted.
- $\tau(\lambda)$  : test sample spectral transmittance.

The test sample spectral transmittance,  $\tau(\lambda)$ , is calculated as follows:

$$\tau(\lambda) = S_T(\lambda) / S_{100\%}(\lambda)$$

#### Optical Density

This data reduction option will convert transmittance data to optical density for each wavelength included in the data set. The following equation is applied:

$$OD(\lambda) = \text{LOG}_{10}(1/T(\lambda))$$

- Where,
- $T(\lambda)$  = Transmittance
  - $OD(\lambda)$  = Optical density

## TUTORIAL VI – DIFFUSE REFLECTANCE/TRANSMITTANCE MEASUREMENTS (USING THE OL 700-71)

### NOTE:

Be sure you have completed Tutorial I – Basic Operations before starting this section!

The OL 700-71 6-Inch Diameter Integrating Sphere Reflectance/Transmittance Attachment is designed to enhance the versatility of the basic spectroradiometer measurement system by enabling the user to make spectral diffuse reflectance measurements of various materials over all or part of the wavelength range from 250 nm to 2500 nm. Due to the sophisticated optical design, accurate reflectance measurements can be made of specular (mirror) samples with the specular component included or excluded. Transmittance measurements can be made on a wide variety of sample materials and sizes.

The OL 700-71 is designed to use fiber optics for the optical coupling to the spectroradiometer system, which creates the flexibility allowing the sphere to be positioned in remote locations simplifying the testing of large samples. The light beam from either input fiber optic is coupled into the integrating sphere via a Refocusing Lens Attachment and imaged at the sample port's aperture.

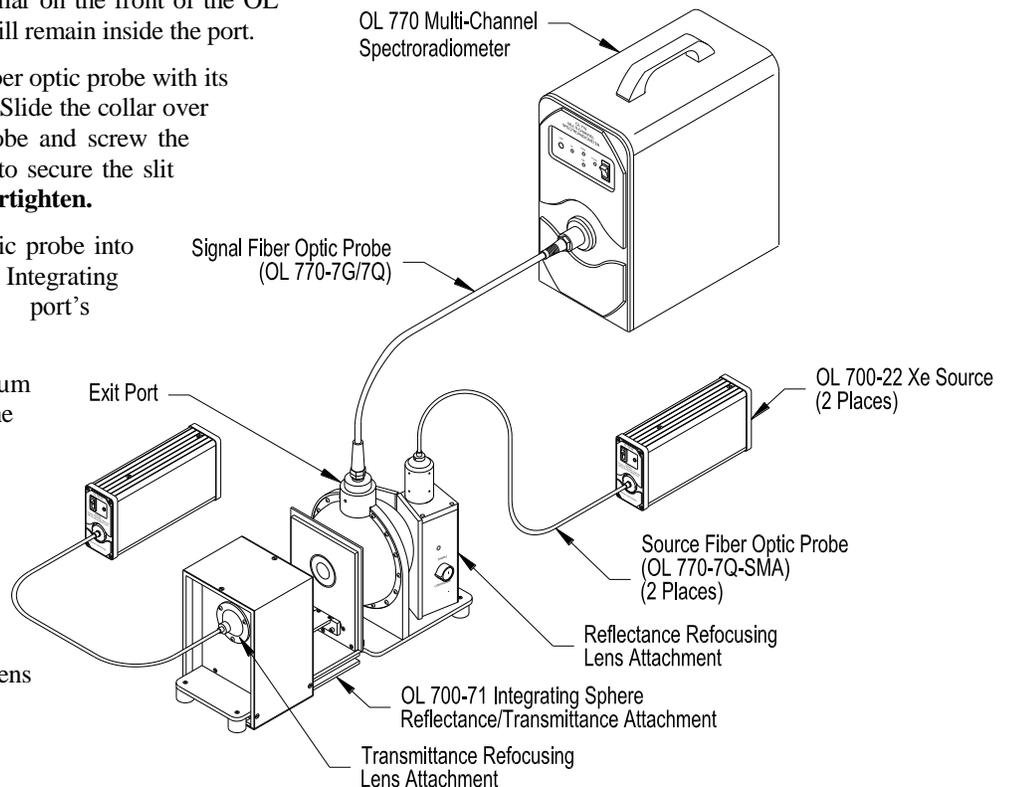
This tutorial will cover using the OL 700-71 Integrating Sphere Reflectance/Transmittance Attachment and two OL 700-22 Pulsed Xenon Flash Sources with the OL 770, however it will be necessary to refer to the OL 770, OL 700-22, and OL 700-71 manuals for further details and specifications.

### Part 1 - Typical Optical Setup and System Configuration with Dual Light Source

What we'll do:

- Connect the OL 770 to the OL 700-71 Integrating Sphere and the OL 700-71 to each of the OL 700-22 Xenon Sources.
- Discuss Diffuse or Total Reflectance Measurement options.
- Open the OL 770 Reflectance Measurement Software Module.
- Configure the OL 770 for Reflectance/Transmittance Measurements.

1. Unscrew the Optical Input Port collar on the front of the OL 770. The pre-installed slit holder will remain inside the port.
2. Install the OL 770-7G/7Q signal fiber optic probe with its adapter into the Optical Input Port. Slide the collar over the free end of the fiber optic probe and screw the collar onto the Optical Input Port to secure the slit and fiber optic in place. **Do not overtighten.**
3. Place the free end of the fiber optic probe into the Exit Port of the OL 700-71 Integrating Sphere. Gently tighten the port's thumbscrew.
4. Using an OL 770-7Q-SMA 600  $\mu\text{m}$  fiber optic probe, connect one of the OL 700-22 Xenon Source to the Reflectance Refocusing Lens Attachment on the OL 700-71.
5. Using the other OL 770-7Q-SMA 600  $\mu\text{m}$  fiber optic probe, connect the other OL 700-22 Xenon Source to the Transmittance Refocusing Lens Attachment on the OL 700-71.



### Diffuse or Total Reflectance Measurements Overview \_\_\_\_\_

The OL 700-71 Integrating Sphere is supplied with a Specular Light Trap Assembly and a Total Reflectance Plug, either of which may be fitted to the Light Trap Port on the sphere. When the Light Trap is fitted, the specular component of the reflected beam is removed from the measurement leaving only the diffuse reflectance component. The choice of whether to measure the total or diffuse only reflectance will depend on the area on interest and the materials. For example, a highly scattering material such as matte paper or skin will have no obvious specular reflectance component. It therefore should have the Total Reflectance Plug fitted to the Light Trap Port to ensure all the reflected light is measured. However, when measuring gloss or semi gloss surfaces, the proportion of the diffuse light in the total reflection may be the critical parameter. This will require measurements with the Total reflectance Plug and the Specular Light Trap fitted.

### Open the OL 770 Reflectance/Transmittance Measurement Software Module \_\_\_\_\_

Within the OL 770 Application Software are packages for the various spectral measurement configurations including transmittance, reflectance, radiance and the optical parameters of LEDs. Each package is accessed via a button on the Main Toolbar. A password granting access to each measurement package is stored in a bin file and is automatically saved to the appropriate location during installation.



- Click on the Diffuse icon on the Main Toolbar. (A password access dialog will open if the software package was not purchased.) For information on purchasing additional OL 770 software packages, contact Gooch & Housego, Orlando, Florida. You will only need to enter the password provided when using the module for the first time. During normal use, the password dialog box does not appear.

#### NOTE:

When the application software is run in Demo mode, access is given to all the measurement modules without password intervention.

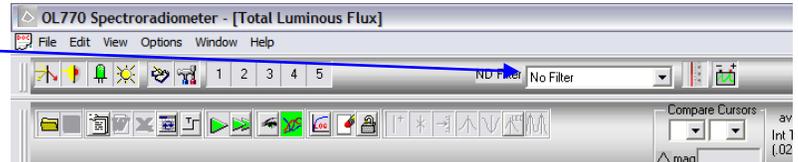
## Configuring the OL 770 for Reflectance/Transmittance Measurements

The configuration file for your OL 770 spectroradiometer and sample calibration files are supplied in the System folder located on the OL 770 Application Software Installation CD supplied with your system. The contents of this folder are installed with the application program, refer to *Installing the OL 770 Application Software & USB Driver* section in this manual. If required, you may manually copy the files from the System folder into the OL 770 application directory by performing the following:

- ❑ From the **File** menu select **Import Settings File**.
- ❑ Locate and **Open** the **770.INI** file from the **System** folder.

Opening the 770.ini file will load into memory all the settings and parameters for the OL 770. These are saved to the computer system registry each time the OL 770 application is closed.

- ❑ **Confirm** the desired **ND** selection on the **Main Toolbar** before entering the **Modified Settings** window.



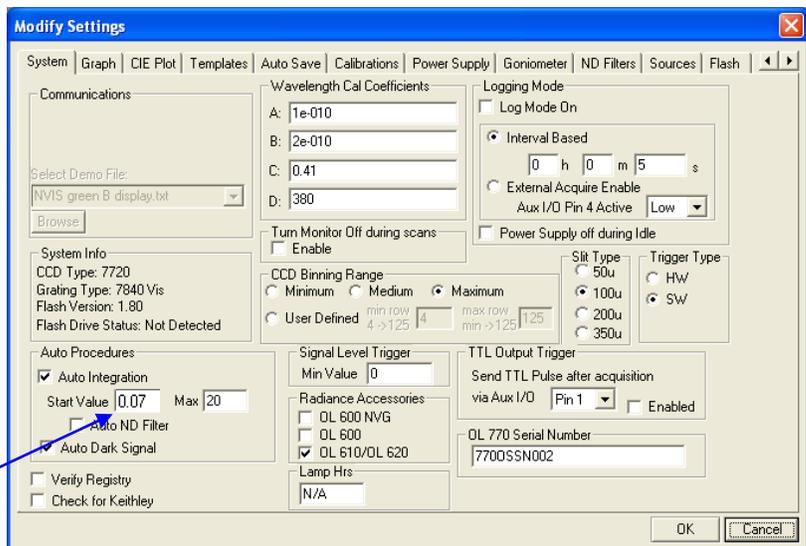
### NOTE:

If the OL 770 Application Software is set to User Mode, you will be required to enter a password before opening the Modify Settings dialog. Refer to Tutorial I, Part 2 for information on Security Operating Modes. Tutorial I, Part 2 will also provide further details on the Modify Settings / System dialog.

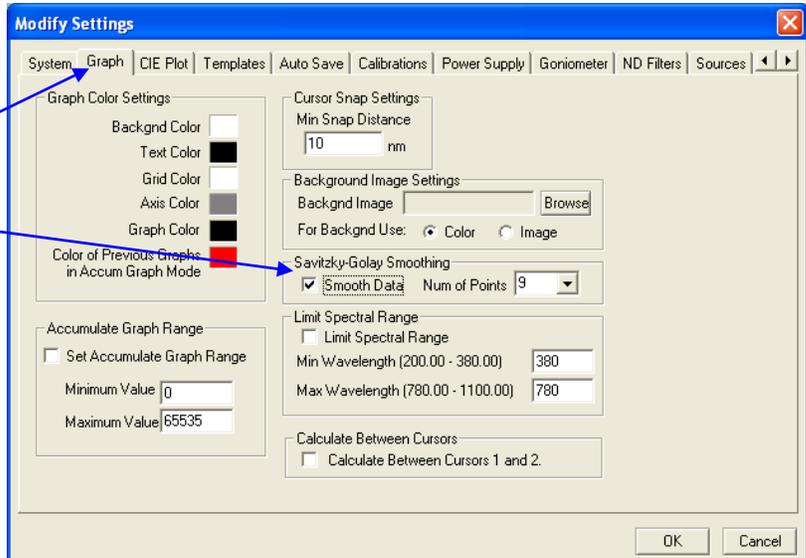


- ❑ Select the **Modify Settings** button on the **Main Toolbar**. Refer to the **OL 770** manual **Tutorial I / Part 2** for an introduction to the **Modify Settings / System** dialog.
- ❑ Go to the **System** page and confirm both the **Auto Procedure** boxes are checked.
- ❑ Confirm the **Wavelength Coefficients** and **Slit Type** are correct.
- ❑ Ensure the **CCD Binning Range** is set to **Maximum**.

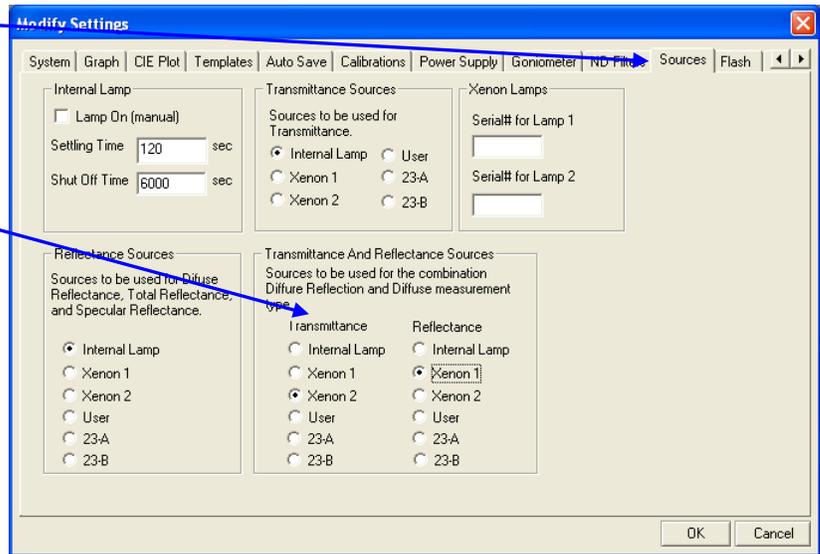
**Note:** When using the OL 700-22 or OL 700-23 Xenon Source, it is recommended to start the Auto Integration at 0.07 seconds.



- ❑ Select the **Graph** tab.
- ❑ Check the **Smooth Data** box to enable **Savitzky-Golay Smoothing**.
- ❑ Set the **Num** of points to the required level.
- ❑ Click **OK** to close the **Modify Settings** dialog.



- ❑ Select the **Sources** tab.
- ❑ Select the **reflectance and transmittance source that will be used for the OL 700-71. For this tutorial, we will use the OL 700-22 Pulsed Xenon Flash Source utilizing Xenon 1 for the Reflectance Refocusing Lens Attachment and Xenon 2 for the Transmittance Refocusing Lens Attachment.**



**Note:**

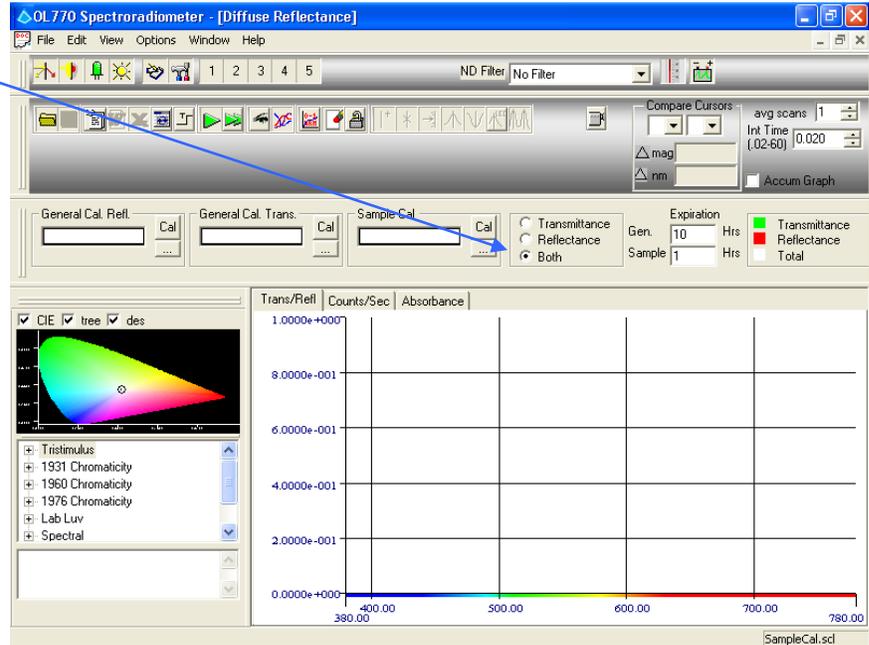
Ensure that the bifurcated control cable from the OL 770 to both of the OL 700-22's is properly connected. The connectors marked XENON 1 and XENON 2 should be properly connected to the appropriate OL 700-22 that is coupled to the Transmittance Refocusing Lens Attachment Port and the Reflectance Refocusing Lens Attachment Port.

For diffuse reflectance/transmittance measurements, the calibrations are done in the main screen of the application. There are three calibrations, a general calibration for reflectance, a general calibration for transmittance and also a sample calibration. This tutorial will illustrate the basics of performing measurement for both diffuse reflectance and transmittance. The following steps include the creation of a general calibration file for the reflectance and transmittance, and then a sample calibration file for either a transmittance or reflectance sample:

Choose the Measurement Type

- Choose what type of measurement to perform. For this tutorial we will select Both transmittance and reflectance.

Notice when Both is selected, General Cal. Refl, General Cal. Trans., and Sample Cal are all active. When selecting the radio button for Transmittance or Reflectance, the General Cal for the selected measurement type will be active only.

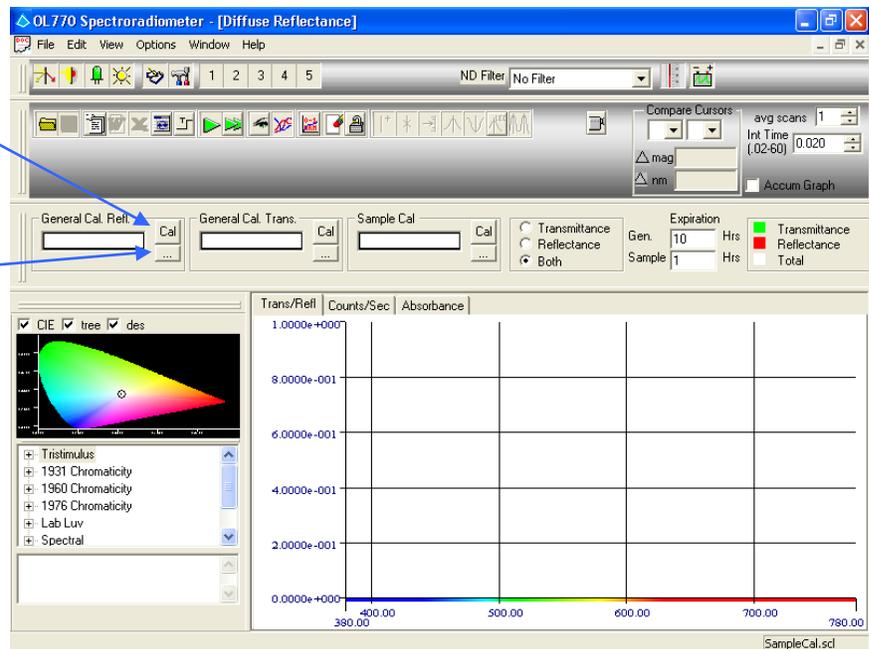


Create a General Reflectance Calibration File

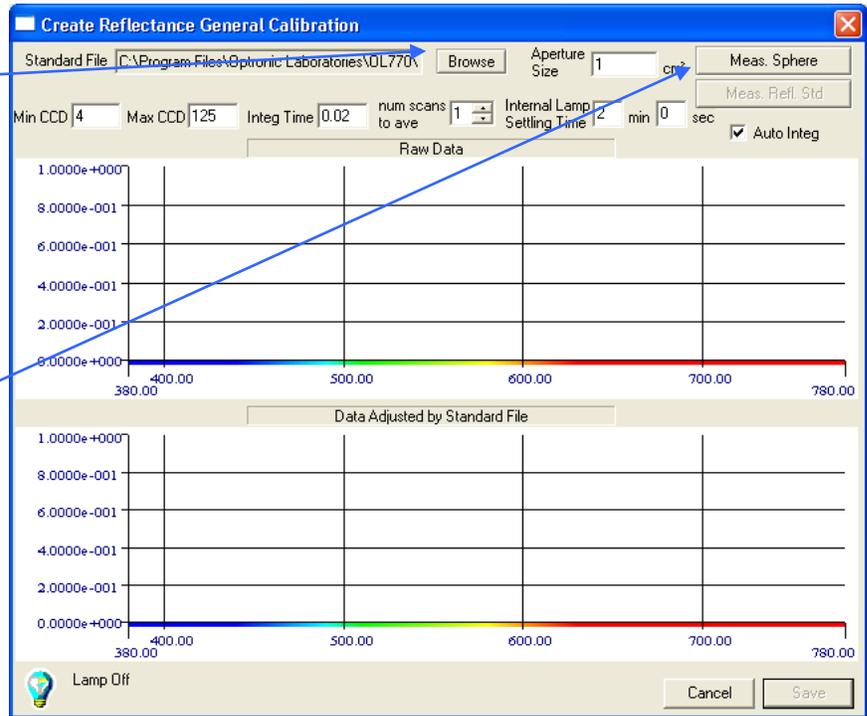
The completed measurement for the general reflectance calibration file has a file extension of \*.grc extension.

- Click on the Cal button under the General Cal. Refl.

Note that if the general calibration file (\*.grc) was previously performed, the file can be loaded by selecting the browse [...] button.

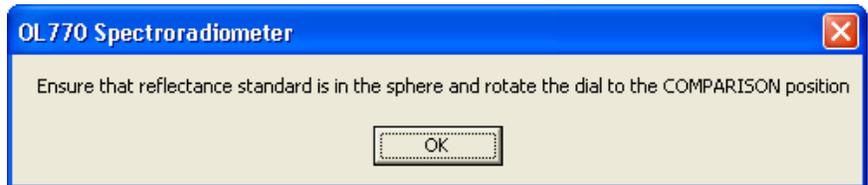


- From the Create Reflectance General Calibration dialog, choose the Browse button to select the reflectance standard file (typically the file is supplied as an \*.std extension with the reflectance standard) to create the general reflectance calibration.



- Install the reflectance standard onto the Sample Port and select the Comparison Position on the OL 700-71. Click on the Meas. Sphere button.

- You will be prompted to ensure that the reflectance standard is installed and the light beam is rotated to the Comparison Position.

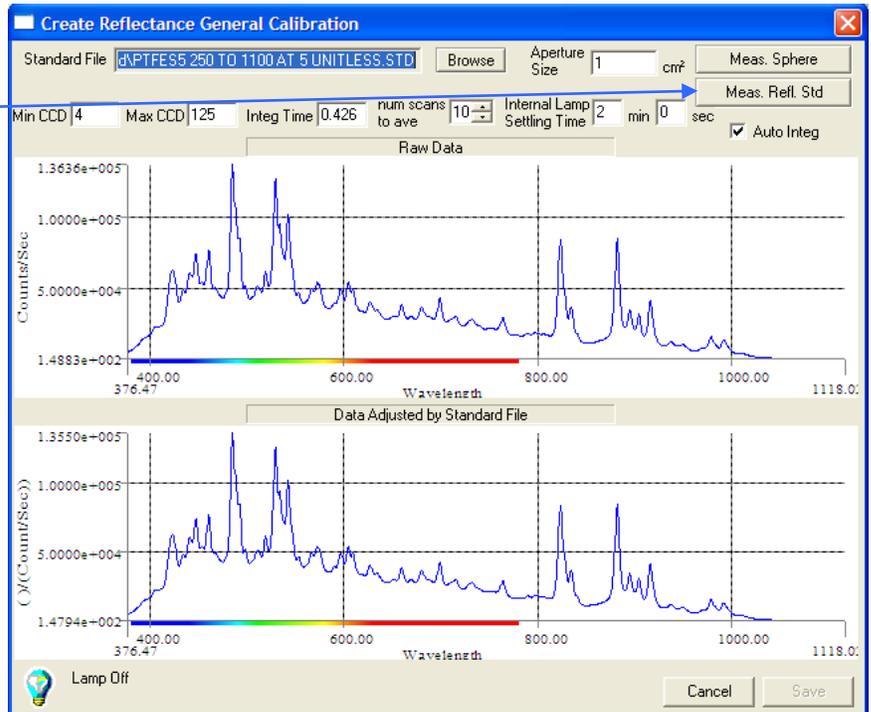


**CAUTION:**

The inner surface of the OL 700-71 integrating sphere is lined with a high reflectance pressed PTFE powder. Take care to prevent and contamination or damage to the coating.

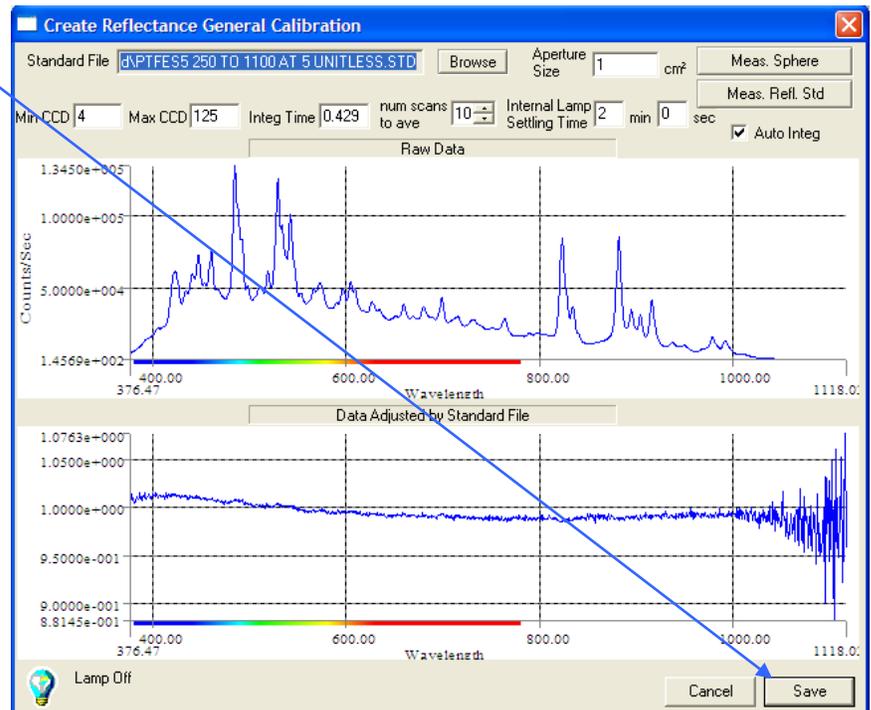
To clean, carefully blow off any loose dirt using low pressure, clean, dry air. Damage to the coating can occur if the air pressure is too high.

- After the OL 770 has completed the sphere measurement scan, now set the OL 700-71 to the Sample Position. Click on the **Meas Refl Std** button. You will be prompted to ensure that the light beam is rotated to the Sample Position.



- After the OL 770 has completed the reflectance standard measurement scan, **Save** the completed general reflectance calibration file (\*.grc).

After the file is saved, the file name will populate the **General Cal. Refl** entry in the next screen.

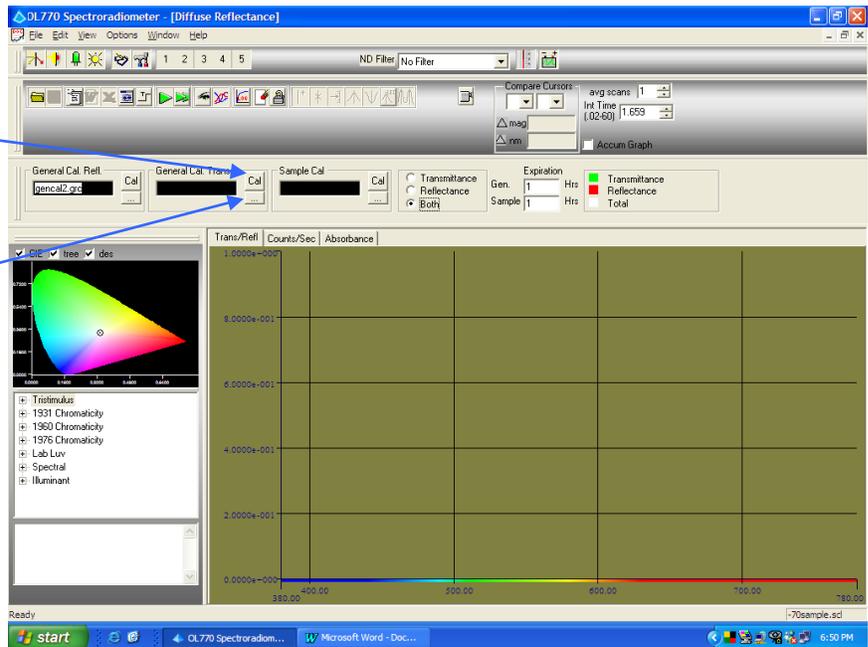


Create a General Transmittance Calibration File

The completed measurement for the general transmittance calibration file has a file extension of \*.gtc extension.

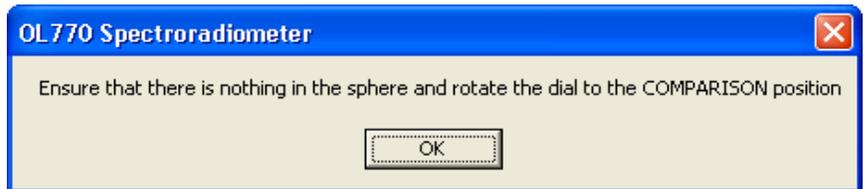
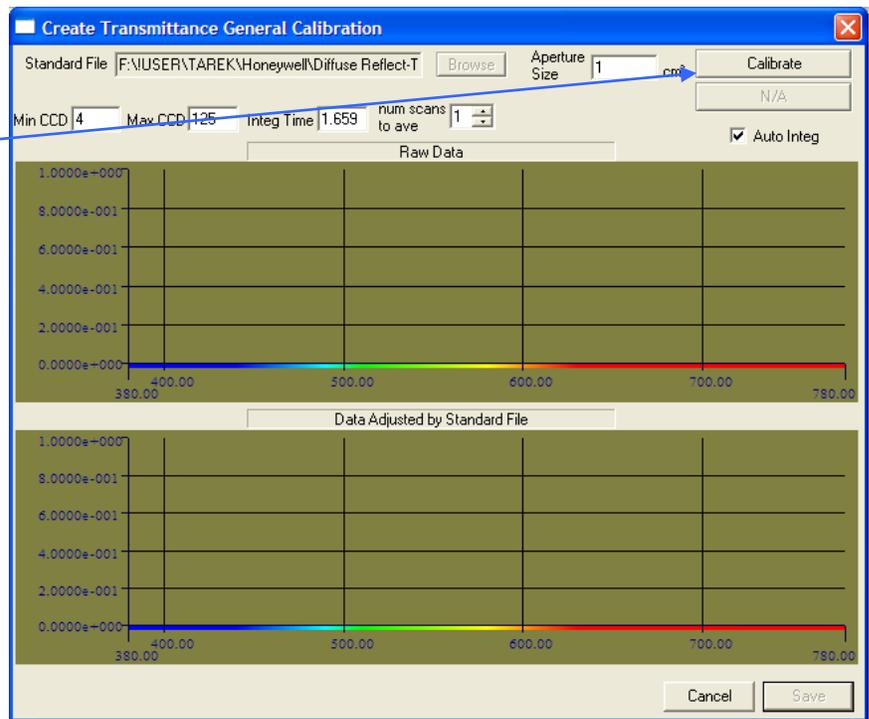
- Click on the Cal button on under the General Cal. Trans.

Note that if the general transmittance calibration file (\*.gtc) was previously performed, the file can be loaded by selecting the browse [...] button.



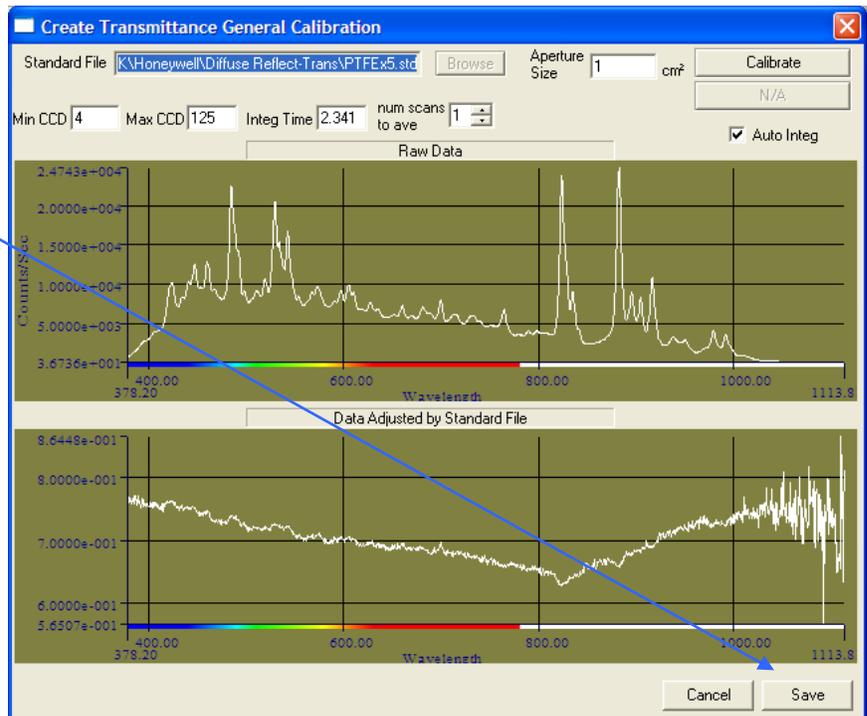
- Remove the reflectance standard from the sphere and select the Comparison Position on the OL 700-71. Click on the Calibrate button. You will be prompted to ensure that there is no reflectance standard or sample installed and the light beam is rotated to the Comparison Position and the Transmittance Port is capped.

**CAUTION:**  
 The inner surface of the OL 700-71 integrating sphere is lined with a high reflectance pressed PTFE powder. Take care to prevent and contamination or damage to the coating.  
 To clean, carefully blow off any loose dirt using low pressure, clean, dry air. Damage to the coating can occur if the air pressure is too high.



- After the OL 770 has completed the measurement scan from the reflectance source, the program will automatically switch to make the measurement from the transmittance source. After the OL 770 has completed the scans, Save the completed general transmittance calibration file (\*.gtc).

After the file is saved, the file name will populate the **General Cal. Trans** entry in the next screen.

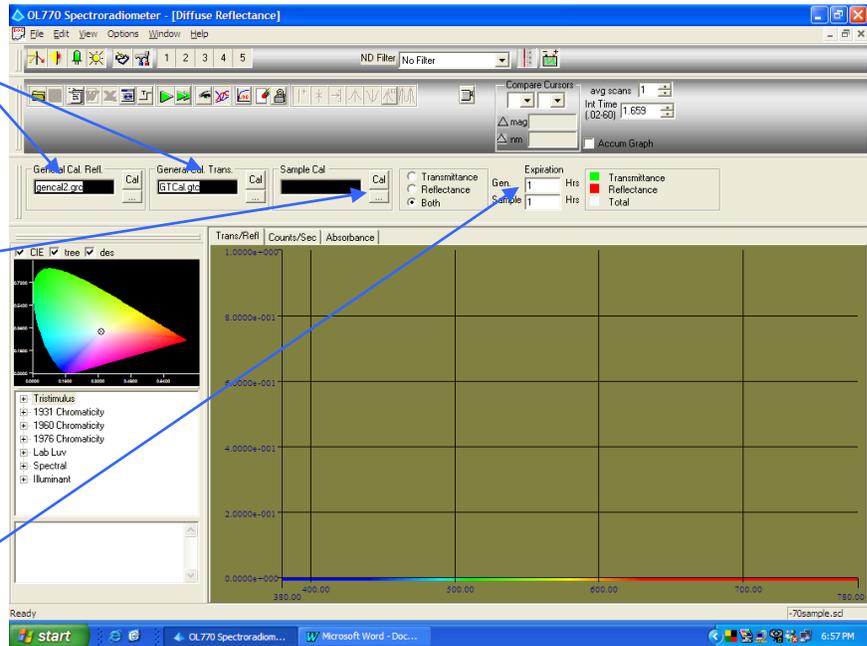


Create a Sample Calibration .

Sample calibration files (file extension \*.scl) are created with the test sample or a sample representative of the items that you will be measuring.

- Ensure that the General Cal. Refl and General Cal. Trans files are loaded.

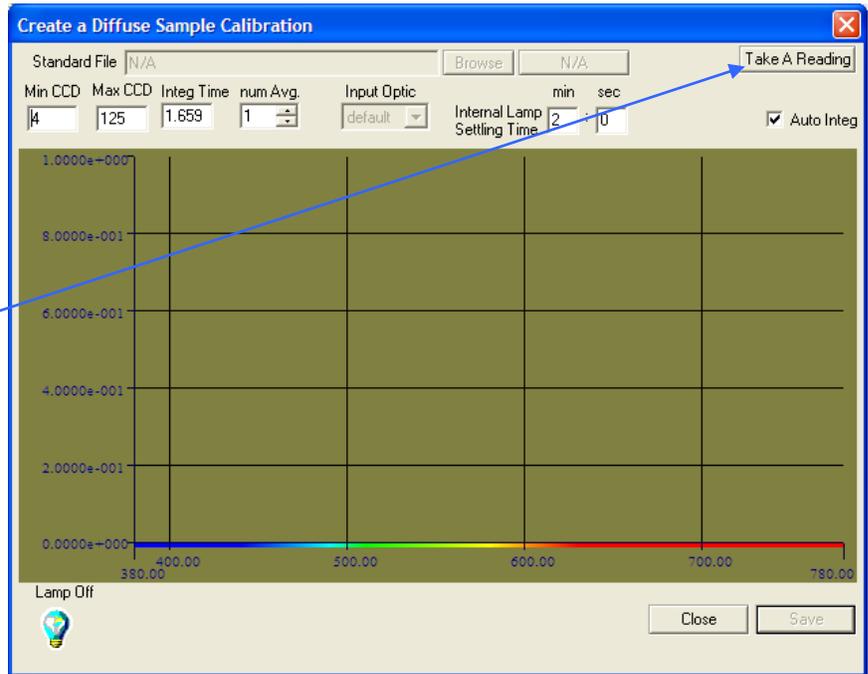
Note that if the sample calibration file (\*.scl) was previously performed, the file can be loaded by selecting the browse [...] button.



- The OL 770 Application Software has a feature to check how old a selected General Cal. Refl and Trans file is. The user enters the desired amount of time, in hours, in the Expiration Gen entry to check the age of the general calibration files. If the files are older than the amount entered, they will display in red.

- Click on the Cal button under Sample Cal. This will open the Sample Cal File Creation dialog.

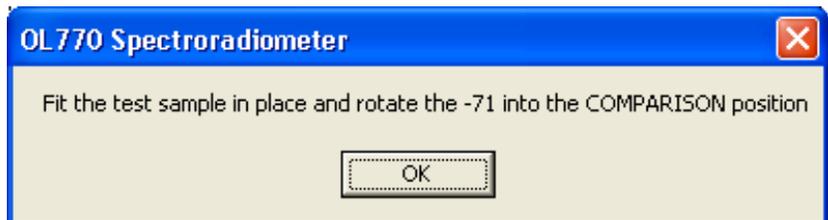
- Install the test sample onto the Sample Port and select the Comparison Position on the OL 700-71. Click on the Take A Reading button. You will be prompted to ensure that the test sample is installed and the light beam is rotated to the Comparison Position.



**CAUTION:**

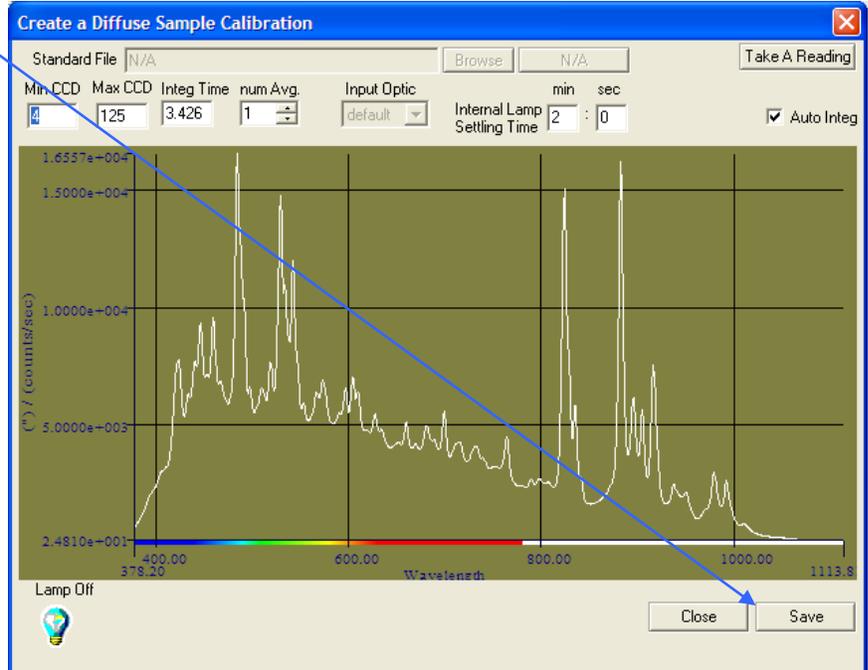
The inner surface of the OL 700-71 integrating sphere is lined with a high reflectance pressed PTFE powder. Take care to prevent and contamination or damage to the coating.

To clean, carefully blow off any loose dirt using low pressure, clean, dry air. Damage to the coating can occur if the air pressure is too high.



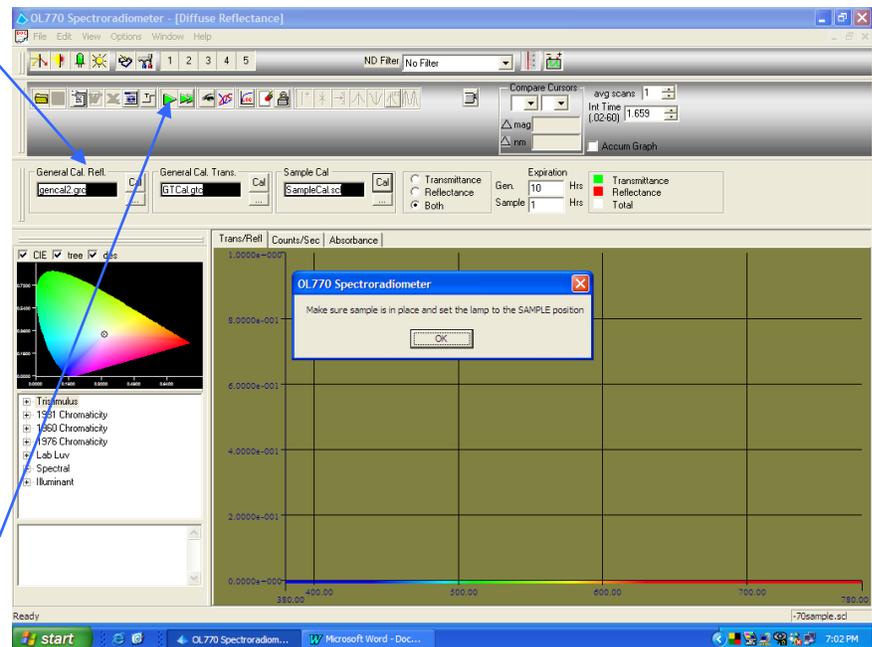
After the OL 770 has completed the measurement scan, **Save** the sample calibration file (\*.scl file). You will be prompted to enter a designation and file name.

After the file is saved, the file name will populate the **Sample Cal.** entry in the next screen.



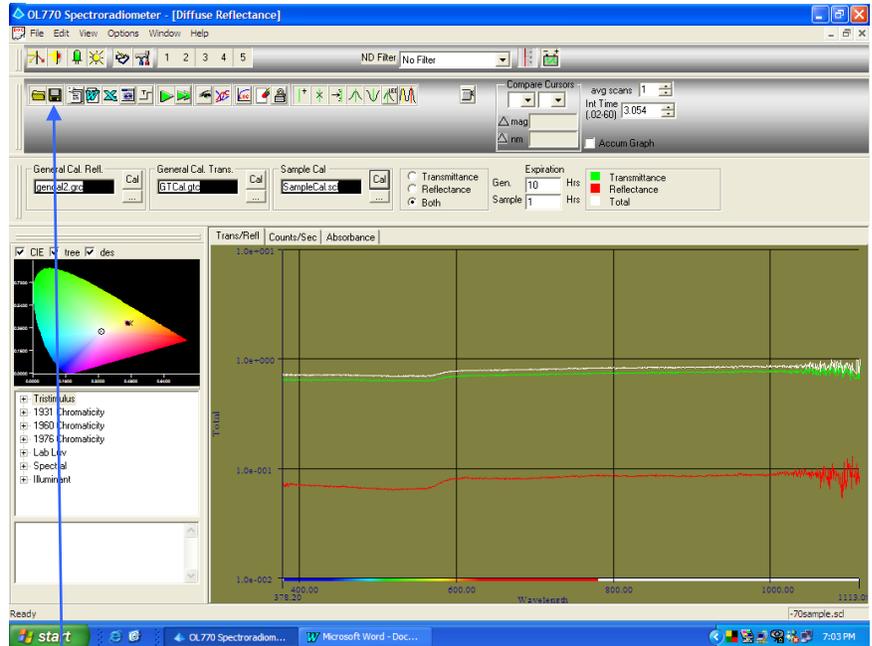
### Start the Measurement

- ❑ When a General Cal Refl. file, General Cal. Trans, and Sample Cal file are loaded, you can then perform reflectance and transmittance measurements on additional samples. Install another sample and rotate the light beam onto the Sample Position.
- ❑ The OL 770 Application Software has a feature to check how old a selected Sample Cal. file is. The user enters the desired amount of time, in hours, in the Expiration Sample entry to check the age of the sample calibration file. If the file is older than the amount entered, it will display in red.
- ❑ Click the single measurement button. You will be prompted to ensure that the test sample is installed and the light beam is rotated to the Sample Position.



In this tutorial, two separate lamp sources were selected for reflectance and transmittance under the Modify Setting/Sources tab (ie: Xenon 1 & Xenon 2), thus the OL 770 will automatically measure the sample using the reflectance source and the transmittance source. If User or Internal Lamp were selected as a source, you would be prompted to connect the source at the appropriate time.

- ❑ Once the measurement is complete, the plot will display. The user can view the plots on the Trans/Refl tab according to their color. The user can also view the Counts/Sec and Absorbance plot by clicking on the respective tab. (Note that when the measurement selection is set for “both,” the Absorbance tab is present. When “transmittance” or “reflectance” is only selected the Absorbance tab is replaced with an Optical Density tab.)
- ❑ Verify that your data is acceptable and **Save** the file (\*.oli). Since **Both** was selected for the measurement type, you will be prompted to enter a designation for both the transmittance and reflectance measurements and when the file is saved there will be two separate files with the same name but a suffix of \_refl and \_trans representing which file.
- ❑ If multiple samples need to be measured, replace the test sample and click the single measurement button again.

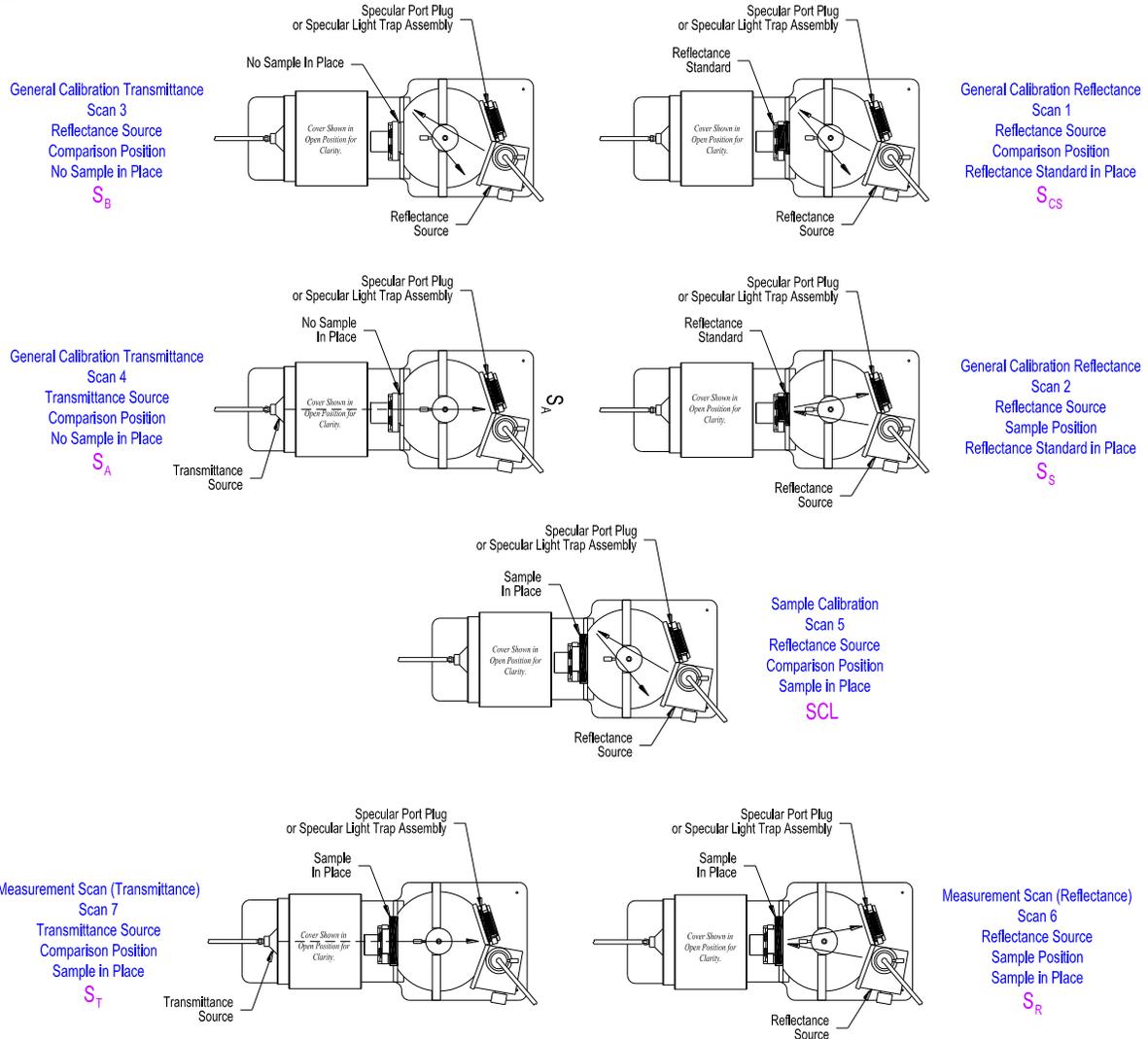


**NOTE:**

For the greatest accuracy, the Sample Calibration file (\*.scl) should only be re-used with other test samples if they have a similar spectral reflectance values.

## Part 2 – Calculations and Formulas for Reflectance/Transmittance Measurements Using the Comparison Method

The instructions in this manual for measuring the total or diffuse reflectance/transmittance using the comparison method follow the sequence given below. In practice the user will take scan 6 and 7 for each sample, scan 5 less frequently and scans 1 to 4 only occasionally. This is because the measurement taken with scans 1 to 4 will only change if the sphere or the standard have been contaminated or if the reflectance properties of the sphere have aged. Scan 5 should in theory be taken for each different sample but this can be reduced if the samples have similar reflectance and the light source is stable.



### Transmittance Measurements

$$GTC(\lambda) = S_B(\lambda) / S_A(\lambda)$$

- where:
- $GTC(\lambda)$  = the spectral calibration factor for the transmittance attachment
  - $S_B(\lambda)$  = the signal with the Reflectance Source/Switch in Comparison Position (no sample in place)
  - $S_A(\lambda)$  = the signal with the Transmittance Source/Switch in Comparison Position (no sample in place)

$$T(\lambda) = (GTC(\lambda)) \cdot (S_T / S_{CL}(\lambda))$$

- where:
- $T(\lambda)$  = the spectral transmittance of the test sample
  - $GTC(\lambda)$  = the spectral calibration factor for the transmittance attachment
  - $S_T(\lambda)$  = the signal with the Transmittance Source/Switch in the Comparison position (sample in place)
  - $S_{CL}(\lambda)$  = the signal with the Reflectance Source/Switch in Comparison Position (sample in place)

### Reflectance Measurements

$$GRC(\lambda) = R_S(\lambda) \cdot S_{CS}(\lambda) / S_S(\lambda)$$

- where:
- $GRC(\lambda)$  = the spectral calibration factor for the reflectance attachment
  - $S_{CS}(\lambda)$  = the signal with the Reflectance Source/Switch in the Comparison position (reflectance standard in place)
  - $S_S(\lambda)$  = the signal with the Reflectance Source/Switch in the Sample position (reflectance standard in place)
  - $R_S(\lambda)$  = the reflectance of the Reflectance Standard

$$R(\lambda) = GRC(\lambda) \cdot (S_R(\lambda) / S_{CL}(\lambda))$$

- where:
- $R(\lambda)$  = the spectral reflectance of the test sample
  - $GRC(\lambda)$  = the spectral calibration factor for the reflectance attachment
  - $S_R(\lambda)$  = the signal with the Reflectance Source/Switch in the Sample position (sample in place)
  - $S_{CL}(\lambda)$  = the signal with the Reflectance Source/Switch in the Comparison position (sample in place)

## TUTORIAL VII – RADIANCE MEASUREMENTS

The OL 770 Multi-Channel Spectroradiometer can be coupled to various optical accessories for specific optical measurements. This tutorial will discuss the use of spot-measuring telescopes (radiance telescopes), the OL 600 Direct Viewing Imaging Optics Module (DVIOM) and the OL 610 telescope / camera. The OL 600 telescope can be supplied with a number of interchangeable objective lens assemblies, which together with the aperture wheel, give a wide choice of field of views. The OL 610 uses a fixed aperture, 1.0 or 0.5 mm diameter with a choice of lenses and lens accessories.

Lens Model No.	Lens (Type)	Spectral Range	Working Range	Spot Size @ Min. Focus
OL 600-L-100	200 mm f/5 (Achromat)	360 to 1100 nm	80 cm to infinity	~ 1.4 <sup>①</sup> mm / 0.9 <sup>②</sup> mm
OL 600-L-110	100mm f/3.4 (Quartz)	200 to 2500 nm	28.5 cm to infinity	~ 0.9 <sup>①</sup> mm / 0.5 <sup>②</sup> mm
OL 600-L-112	200 mm f/5.2 (Quartz)	200 to 2500 nm	80 cm to infinity	~ 1.4 <sup>①</sup> mm / 0.9 <sup>②</sup> mm
OL 600-L-130	65 mm f/3 Macro (Achromat)	360 to 1100 nm	8.5 cm to 12.5 cm	0.5 <sup>①</sup> mm / 0.3 <sup>②</sup> mm

OL 610-L-100	50 mm f/1.8 (Achromat)	360 to 1100 nm	33 cm to infinity	~ 6.0 <sup>③</sup> mm / 3.0 <sup>④</sup> mm	
OL 610-L-110	60 mm f/2.8 Macro (Achromat)	360 to 1100 nm	7 cm to infinity	~ 1.0 <sup>③</sup> mm / 0.5 <sup>④</sup> mm	
OL 610-L-210	60 mm f/2.8 with Close Up Lens Kit	+1	360 to 1100 nm	6 cm to infinity	0.95 <sup>③</sup> mm / 0.48 <sup>④</sup> mm
		+2	360 to 1100 nm	5.7 cm to infinity	0.9 <sup>③</sup> mm / 0.45 <sup>④</sup> mm
		+4	360 to 1100 nm	5.5 cm to infinity	0.75 <sup>③</sup> mm / 0.38 <sup>④</sup> mm

- ① Image size with 0.5 mm  $\phi$  aperture selected on the OL 600 DVIOM.
- ② Image size with 0.3 mm  $\phi$  aperture selected on the OL 600-NVG DVIOM.
- ③ Image size with 1.0 mm  $\phi$  aperture installed in the OL 610
- ④ Image size with 0.5 mm  $\phi$  aperture installed in the OL 610

The OL 600 DVIOM can be supplied with a choice of two aperture wheels:

DVIOM	Aperture #1	Aperture #2	Aperture #3	Aperture #4	Aperture #5
OL 600	0.5 mm	1.5 mm	3.0 mm	5.0 mm	8.75 mm
OL 600-NVG	0.3 mm	0.5 mm	1.0 mm	3.0 mm	5.0 mm

This tutorial will cover all the new aspects of using the OL 600 and OL 610 telescopes with the OL 770, however it may be necessary to refer to their manuals for further details and specifications.

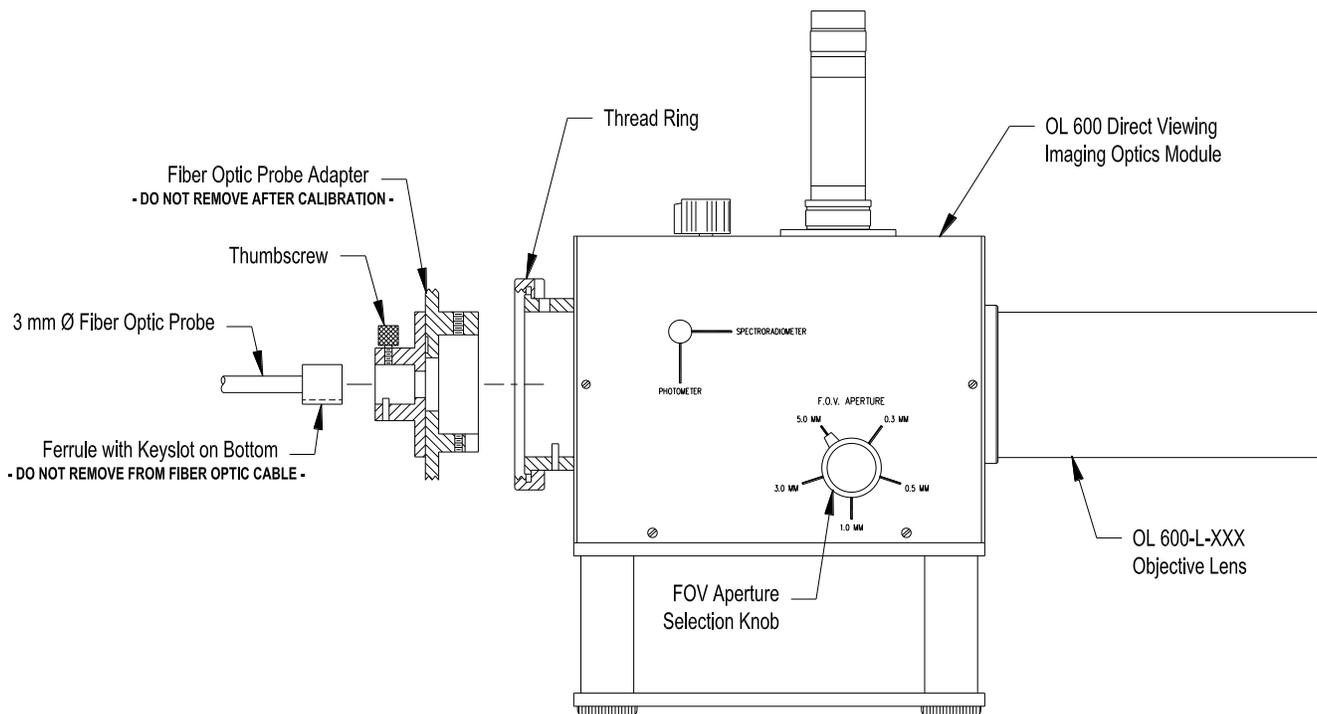
## Part 1 - Typical Optical Setup and System Configuration

What we'll do:

- Connect the OL 770 to the OL 600 DVIOM or the OL 610 CCD Imaging Telescope
- Spectral Radiance Measurement Overview
- Align the Telescope onto the Test Source and Select a Field-Of-View Aperture.
- Open the OL 770 Spectral Radiance Measurement Software Module.
- Configure the OL 770 for Spectral Radiance Measurements

### OL 600 Telescope Setup

1. The OL 600 DVIOM comprises of an interchangeable objective lens, mirrored aperture wheel with selection knob for the five aperture diameters, viewfinder with 25X magnification eyepiece and reticle. A fiber optic probe (FOP) with adapter is supplied to optically couple the light through the measurement aperture of the OL 600 telescope to the input port of OL 770 Multi-Channel Spectroradiometer. The FOP adapter mounts into the exit port of the OL 600 DVIOM and is secured via the thread ring. The FOP inserts into the adapter and is secured by the thumbscrew. Indexing pins are provided for aligning the adapter and the FOP in the proper orientation.

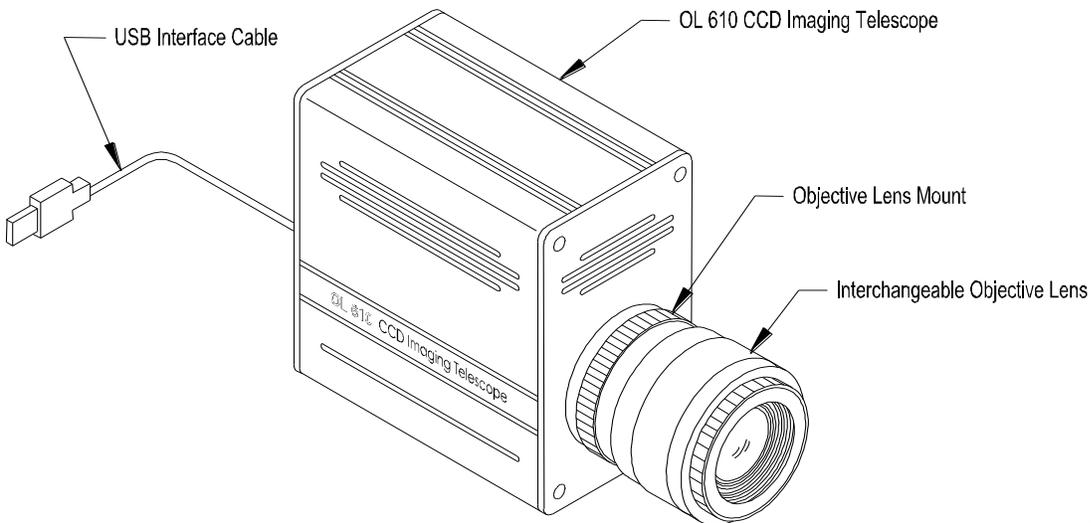


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2. Place the FOP adapter onto the output port of the OL 600 and secure tightly in place with the large thread ring. Once installed this adapter should not be removed.
3. Install the larger adapter fitted to the 3 mm  $\phi$  FOP (supplied with the OL 600) into the optical input port of the OL 770 spectroradiometer. Slide the collar over the free end of the FOP and screw the collar onto the optical input port to secure the slit and fiber optic in place. **Do not overtighten.**
4. Place the free end of the FOP with its *keyed* ferrule into the FOP adapter on the OL 600 telescope and secure using the thumbscrew. **Do not overtighten.**

## OL 610 Telescope / Camera Setup

The OL 610 comprises of a 35 mm camera lens, direct viewing optics mirror with integral field-of-view aperture, and an internal CCD imaging camera for object viewing and allows the CCD image to be stored with the measurement data.



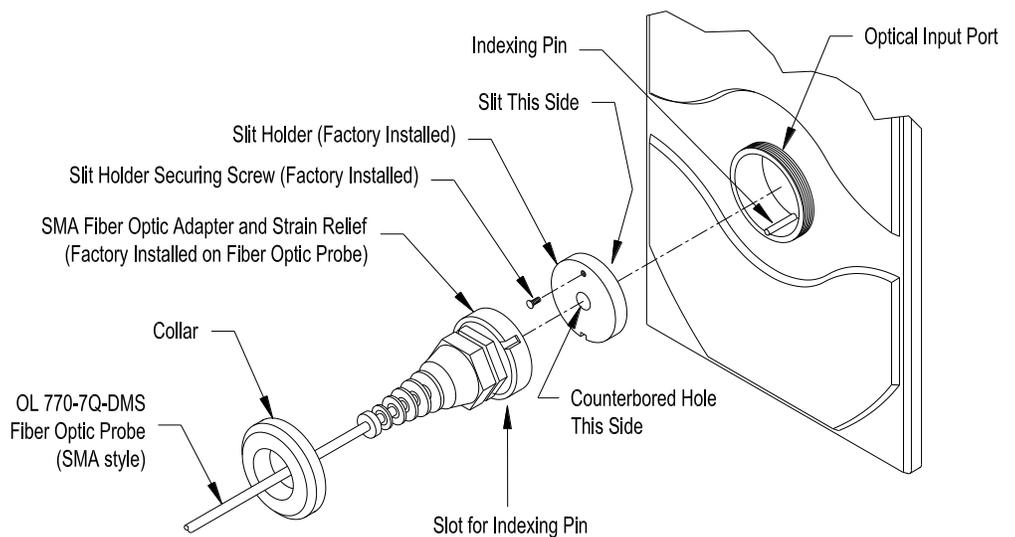
P001526

1. Install the desired Series OL 610-L-XXX Objective Lens onto the front of the OL 610.
2. It is important to ensure that the lens aperture is set to its largest open aperture (smallest numerical value) by turning the aperture ring on the lens body.

**\* CAUTION \***

Changing the lens aperture to a setting other than the one the instrument was calibrated at invalidates the calibration applied to the measurement. Always ensure that the appropriate aperture setting on the lens is selected for a given calibration.

3. Connect the USB cable from the rear of the OL 610 to an available USB port on the rear of the OL 770. (A computer's USB port can also be used.) **Notice: Install the drivers before plugging in the USB cable - refer to the OL 610 manual.**
4. Remove the Collar from the OL 770 Optical Input Port. (The Collar is supplied attached to the OL 770 from the factory.) Slide the Collar over the free end of the OL 770-7Q-DMS Fiber Optic Probe. Install the OL 770-7Q-DMS FOP with its Adapter into the Optical Input Port, aligning the slot to the indexing pin.

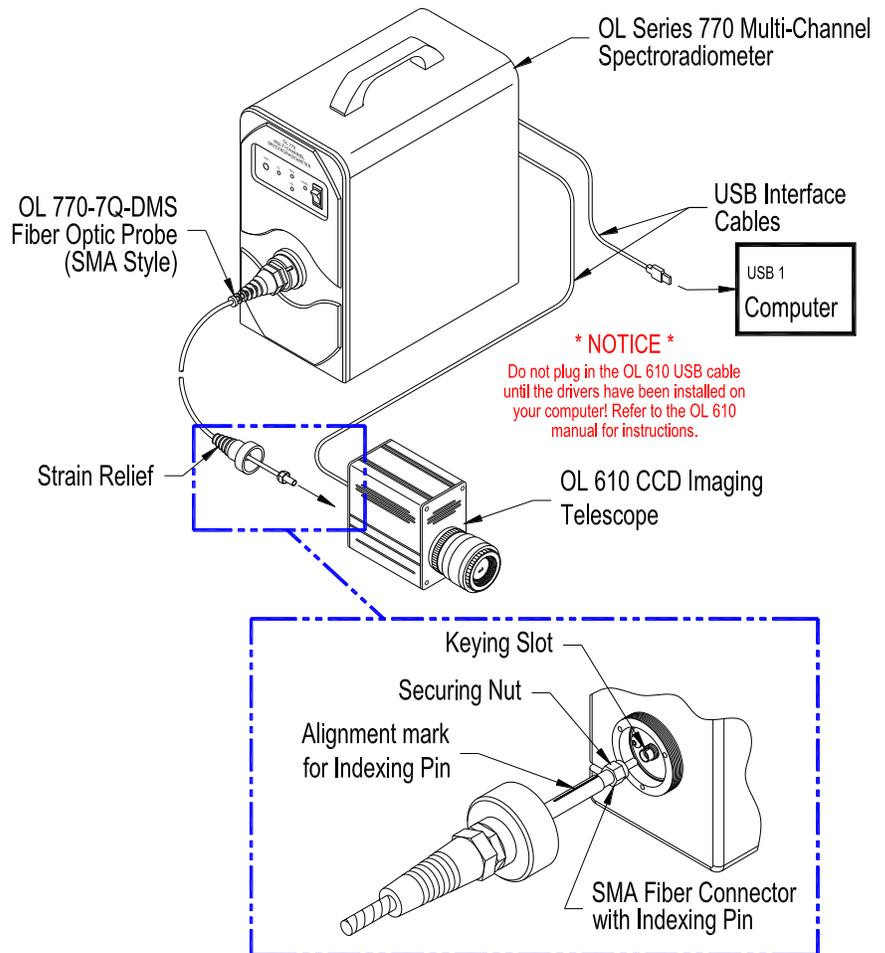


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**NOTE:**

The OL 610 may be supplied with an optional OL F770-IRS.30SS1.5 300  $\mu\text{m}$  FOP (1.5-meter length standard). When the optional FOP is supplied, the strain relief on the OL 610 is a modified two-piece clamp assembly. Refer to *Appendix H* for installation of the OL 610 if the optional OL F770-IRS.30SS1.5 300  $\mu\text{m}$  FOP is supplied.

5. Remove the Strain Relief from the rear of the OL 610. (The Strain Relief is supplied attached to the OL 610 from the factory.) Slide the Strain Relief over the free end of the OL 770-7Q-DMS FOP. Connect the OL 770-7Q-DMS FOP to the mating SMA connector on the rear of the OL 610. The SMA fiber connector contains an indexing pin that mates with a keying slot on the OL 610 rear connector. **Be sure the indexing pin inserts into the keying slot on the OL 610 rear SMA connector. An alignment mark on the FOP must line up with the keying slot.** Gently tighten the SMA fiber connector's securing nut. (If the indexing pin is not seated into the keying slot, the threads of the securing nut will not engage the threads of the mating SMA connector.) Slide the Strain Relief over the SMA connector. Gently screw the Strain Relief onto the threaded collar on the rear of the OL 610 to secure in place.
6. Connect a USB cable from the rear of the OL 770 to one of your computer's USB ports.
7. Mount the OL 610 on a camera tripod or optical bench.
8. Turn on "power" to the OL 770 Multi-Channel Spectroradiometer.

**\* CAUTION \***

Avoid excessive bending of the OL 770-7Q-DMS Filter Optic Probe. Bending of the fiber may cause change's in its transmittance properties. Excessive bends may permanently damage the fiber.

## Definitions and Measurement Overview

- Radiance :** Radiant power per unit source area per unit solid angle. Usually expressed in  $W/(m^2 sr)$  or  $W/(cm^2 sr)$ .
- Spectral Radiance :** Radiant power per unit source area per unit solid angle per unit wavelength. Usually expressed in  $W/(m^2 sr nm)$  or  $W/(cm^2 sr nm)$ .
- Luminance :** Luminous flux emitted from a surface per unit solid angle per unit area projected onto a plane normal to the direction of propagation. Usually expressed in lumens per unit solid angle per unit area ( $(lm/sr)/m^2$ ), candela per square meter ( $cd/m^2$ ), and footlambert ( $(lm/sr)/ft^2$ ).

The measurement of spectral radiance or luminance of an extended source requires a telescope or baffle attachment to form a Field of View (FOV). The OL 600 uses direct viewing optics to view the source with the aperture also visible in the image plane defining the area of the source to be measured. In general it is not necessary to know the distance from the source to the telescope or baffle, although the telescope optics should be focused at the plane of the source.

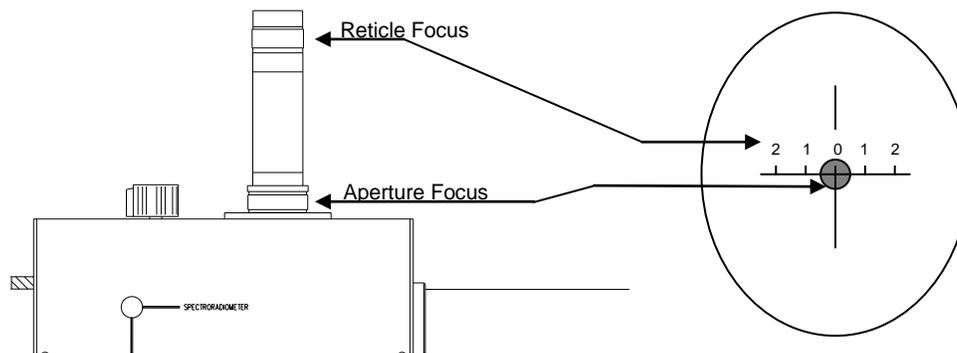
Calibration of the OL 770 spectroradiometer with the OL 600 telescope requires an integrating sphere calibration standard. A system response calibration is required for each aperture used. When the larger apertures are used, it may be necessary to fit the optional holographic diffusers or integrating sphere between the end of the 3 mm FOP and the aperture.

## Align the OL 600 Telescope and Select a Field-of-View Aperture

**NOTE:**

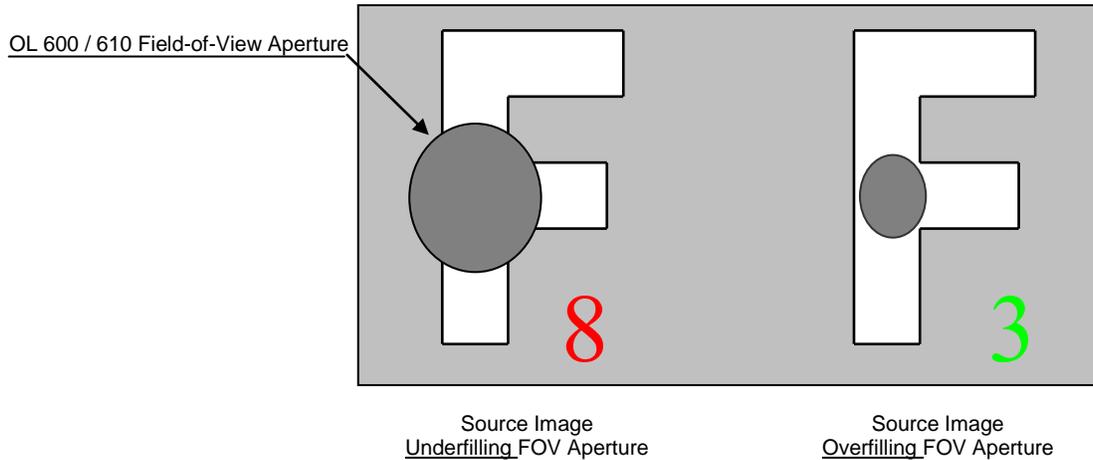
Start the OL 770 application software in order to view the OL 610 camera image for alignment and objective lens focus.

1. Before the telescope is used it will be necessary to first adjust the OL 600 viewfinder eyepiece to focus on the reticle. Place a blank sheet of paper in front of the OL 600 telescope objective lens to reflect light in. Adjust the eyepiece focus for a sharp image of the reticle as shown below.
2. Set the OL 600 to its smallest aperture and adjust the telescope focus to bring the aperture into focus. For larger apertures, it will not be possible to have both the top and bottom edges of the aperture simultaneously in focus, so use the left and right edges to judge correct focus.



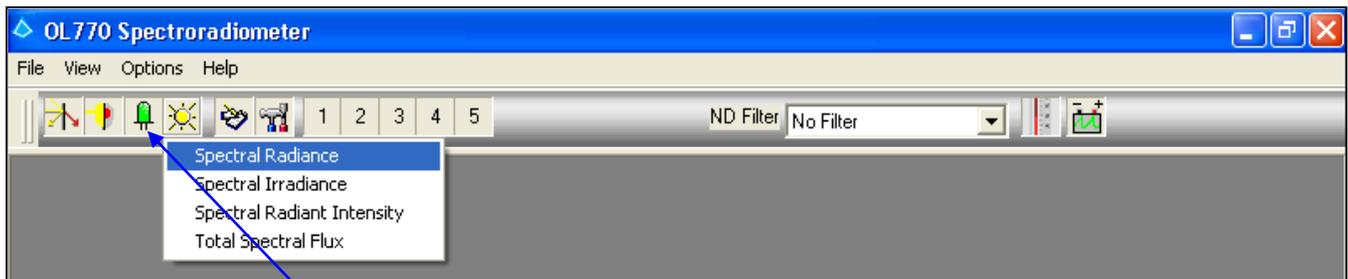
3. Align the telescope on the source to be measured. When the test source is compact and easily moved, the alignment and focus of the telescope can be very straightforward. If the test source is large or very small, a motorized stage may be required for either the telescope or the test source. Adjust the focus of the OL 600 objective lens for a sharp image of the test source. If the test source is featureless, place a ruler in the plane of the source and focus on the ruler.

4. Spectral radiance measurements require the source to overflow the field-of-view aperture. Ensure the selected aperture is smaller than the source.



### Open the OL 770 Spectral Radiance Measurement Software Module

Within the OL 770 Application Software are packages for the various spectral measurement configurations including transmittance, reflectance, spectral radiance, spectral irradiance and the optical parameters of LEDs. Each package is accessed via a button on the Main Toolbar. A password granting access to each measurement package is stored in a bin file and is automatically saved to the appropriate location during installation.



- ❑ Click on the **Source Spectral Analysis** icon on the Main Toolbar, and then select **Spectral Radiance**. (A password access dialog will open if the software package was not purchased.) For information on purchasing additional OL 770 software packages, contact Gooch & Housego, Orlando, Florida. You will only need to enter the password provided when using the module for the first time. During normal use, the password dialog box does not appear.

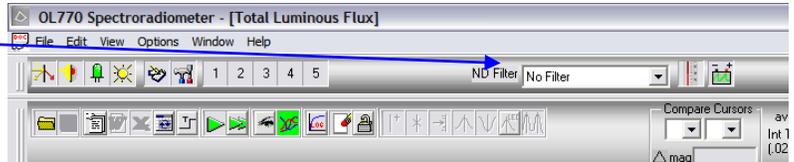
#### NOTE:

When the application software is run in Demo mode, access is given to all the measurement modules without password intervention.

## Configuring the OL 770 for Spectral Radiance Measurements

The configuration file for your OL 770 spectroradiometer and calibration files are supplied in the System folder located on the OL 770 Application Software Installation CD supplied with your system. The contents of this folder are installed with the application program, refer to *Installing the OL 770 Application Software & USB Driver* section in this manual.

- ❑ Confirm the desired ND selection on the Main Toolbar before entering the Modified Settings window.

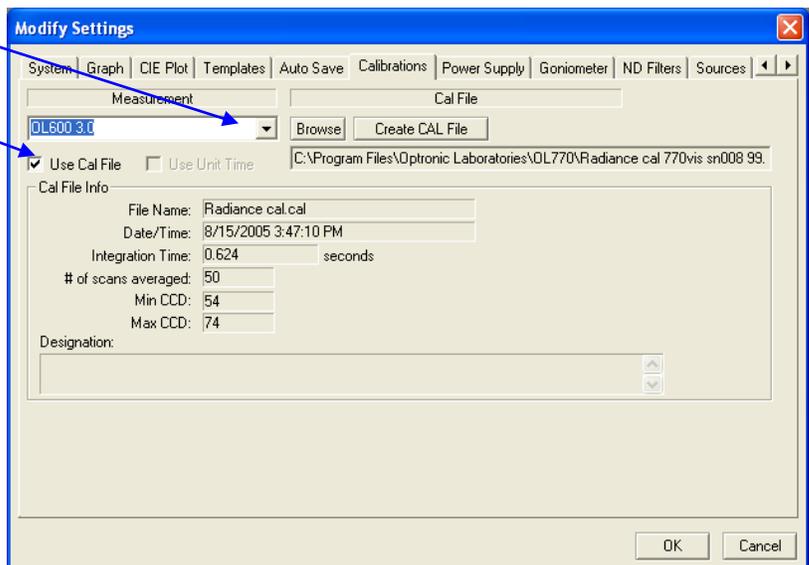
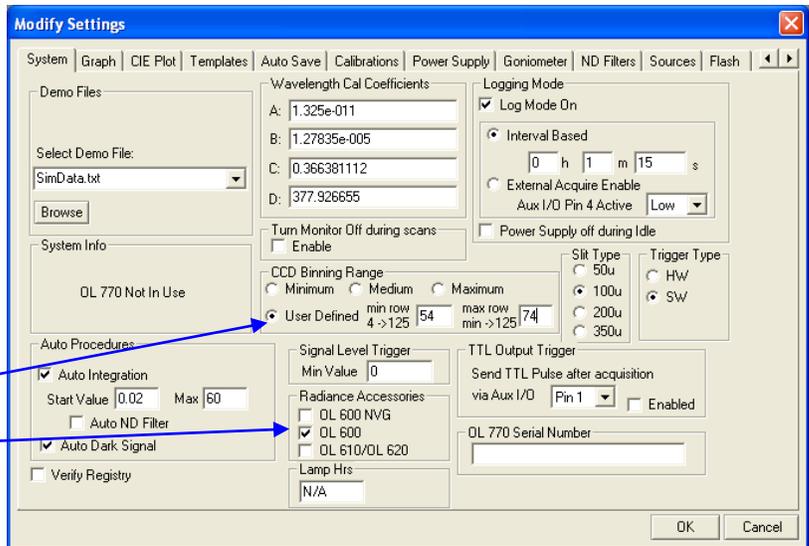


**NOTE:**

If the OL 770 Application Software is set to User Mode, you will be required to enter a password before opening the Modify Settings dialog. Refer to Tutorial I, Part 2 for information on Security Operating Modes. Tutorial I, Part 2 will also provide further details on the Modify Settings / System dialog.



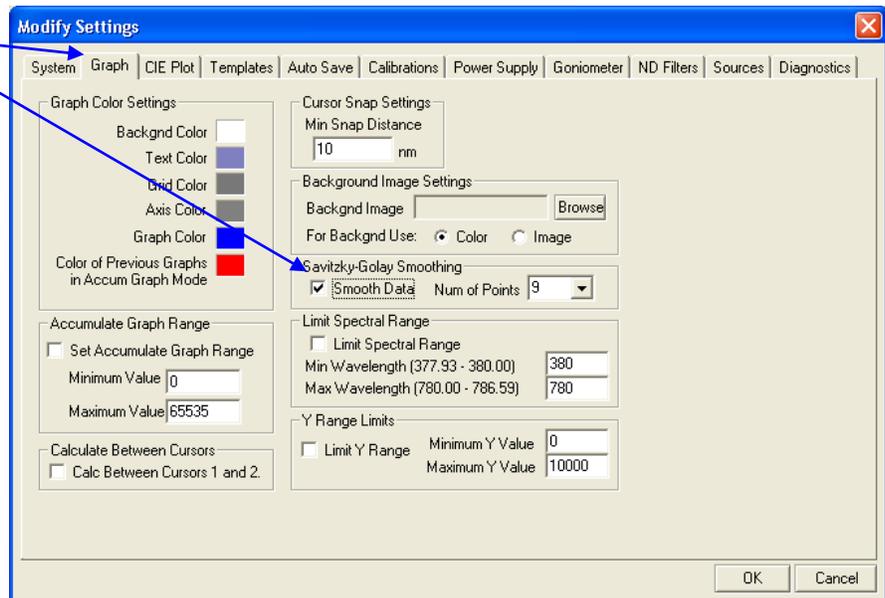
- ❑ Select the **Modify Settings** button on the Main Toolbar. Refer to the OL 770 manual Tutorial I / Part 2 for an introduction to the Modify Settings / System dialog.
- ❑ Confirm both of the Auto Procedure boxes are checked.
- ❑ Confirm the **Wavelength Coefficients** and **Slit Type** are correct by comparing these values to your System Information Sheet.
- ❑ Binning should be set to **User Defined**, with the **Min Row: 54** and **Max Row: 74**.
- ❑ Ensure the correct radio button is selected for the telescope attached.
- ❑ Select the **Calibrations** tab.
- ❑ From the drop-down menu select **OL 600** and aperture size or Spectral Radiance (when using the OL 610).
- ❑ Check the **Use Cal File** box.
- ❑ **Browse** and select the calibration file for telescope (and aperture size) selected.
- ❑ Click **Open** to load the selected calibration file.
- ❑ Repeat for all the OL 600 aperture sizes.



**Note:**

The OL 770 Application will check to confirm the Selected Slit Size matches the data stored in the calibration file header.

- ❑ Select the **Graph** tab.
- ❑ Check the **Smooth Data** box to enable Savitzky-Golay Smoothing. This will reduce the noise on the spectral plots. The smoothing can be switched on or off without effecting the stored data.
- ❑ Set the **Num of Points** to the required level. Spectral plots with narrow (FWHM <4 nm) emission lines should have no smoothing applied.
- ❑ Click **OK** to close the **Modify Settings** dialog.



## Save the OL 770 Settings to the Computer Registry

Save the new system settings and the password to the computer registry by closing and opening the OL 770 application.

- ❑ **Close the OL 770 application.**
- ❑ **Restart the OL 770 application.**

The system settings can also be exported to a configuration file using the **File / Export System Settings** on the Main Menu.

## Part 2A – Spectral Radiance Measurements with the OL 600 Telescope

What we'll do:

- Select the Calibration File.
- Check the Sensitivity and Take the Spectral Radiance Measurement.
- Save the System Settings to a CFG Button.

### Select the Calibration File

**Note:**

If it is required to create a system calibration file or no valid calibration file exists, refer to the *OL 770 Calibration Manual*.

A system response calibration file is required for each aperture, fiber optic probe or lens fitted to the telescope. The OL 770 application software allows you to match the calibration files to the aperture size and load the correct file when you change the telescope aperture.



- Open a **Spectral Radiance** measurement window.



- Click on the **OL 600 Aperture** icon on the Measurement Toolbar to open the **F.O.V. Aperture** window.

- Select the correct aperture size by clicking the mouse on the image beside the aperture diameter.



- Click on the **Aperture** icon to close the **F.O.V. Aperture** window.



The file name on the status bar will indicate which system response calibration file is being used during the measurements.

## Check the System Sensitivity

---

The OL 770 CCD detector integrates the light induced charge to create a signal dependent on both the light intensity and the exposure time. The OL 770/600 has four options to ensure the optimum signal level is measured: -adjust the integration time from 20 ms up to 60 seconds; reduce the aperture diameter; change the CCD binning range; insert neutral density filters in the optical path. In many applications, however, the light levels are low and maximum sensitivity is required.

With the system setup as detailed above, proceed with the measurement.



### □ Take a Single Measurement.

The OL 770 will take a test exposure at 0.02 s or the **Start Value**. The data values from this test measurement will be compared to the full scale of the ADC within the spectroradiometer. A new integration time will be estimated for an optimum exposure. A second measurement is taken and saved if its peak value is within range. A dark spectrum is recorded at the same integration time and subtracted from the second measurement. Finally the spectrum is multiplied by the selected calibration file before being plotted.

The radiometric ( $W/sr/cm^2$ ) and photometric ( $cd/cm^2$ ) values for the measurement are displayed in the Value Tree. The Calculation Bar also includes the tristimulus and color parameters for the source.

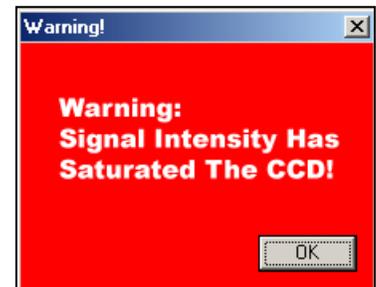
Refer to Tutorials I and II for further details on the Calculation Bar, Graphs & Cursors, File Saving and Word & Excel reports.

## Signal Saturation

The OL 770 application software will display a warning dialog when the peak spectral intensity exceeds the CCD or ADC range and the integration time is at its minimum or the Auto Integration procedure is disabled.

List of options to correct for CCD signal saturation:

5. Reduce the integration time or check the **Auto Integration** procedure.
6. Reduce the OL 600 aperture size – select a new system response calibration file.
7. Change the CCD binning range – requires system calibration.
8. Add an ND filter to the fiber optic probe – and select ND filter # in measurement toolbar.



## Save the System Settings to a CFG Button

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The complete OL 770 settings and the selected calibrations file names can be exported to a system configuration file (File\ Export Settings File) or saved to the one of the five user CFG preset buttons on the Measurement Toolbar. Refer to Tutorial I-/ Part 4 for a complete description of the User Configuration Buttons.

## Part 2B – Spectral Radiance Measurements with the OL 610 Telescope

What we'll do:

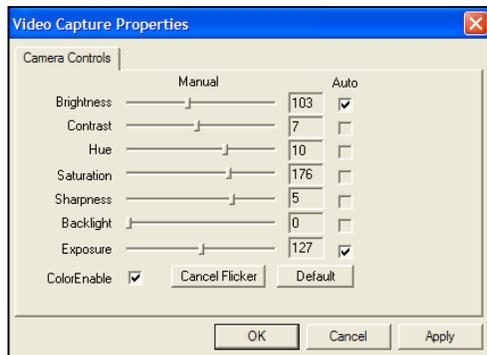
- Switch on and align the OL 610's camera.
- Check the Sensitivity and Take the Spectral Radiance Measurement.
- Save the System Settings to a CFG Button.

### Switching on the OL 610 Camera

The OL 610 has a fixed aperture diameter. System response calibration files are required for each objective lens aperture setting and for each slit size selected. The file name on the status bar will indicate which system response calibration file is being used during the measurements.



- Open a **Spectral Radiance** measurement window.
  - Click on the OL 610 **“View and Capture Streaming Video”** icon on the Measurement Toolbar to open an OL 610 camera image window.
  - Move the mouse cursor over the edge or corner of the image window to resize and position the image on your screen.
  - Adjust the objective lens to focus on the display under test.
  - Align the black measurement spot over the required part of the display.
- 
- Select **Edit Properties** on the OL 610 Video Preview window to open manual adjustment of the camera image settings as required.
  - Click **Apply** and **OK** to save settings and close the **Video Capture Properties** dialog.



**Note:**

The video capture properties do not affect the spectral radiance measurement.

### Check the System Sensitivity

The OL 770 CCD detector integrates the light induced charge to create a signal dependent on both the light intensity and the exposure time. The OL 770/610 has four options to ensure the optimum signal level is measured:-adjust the integration time from 20 ms up to 60 seconds; reduce the aperture diameter; change the CCD binning range; insert neutral density filters in the optical path. In many applications, however, the light levels are low and maximum sensitivity is required.

With the system setup as detailed above, proceed with the measurement.



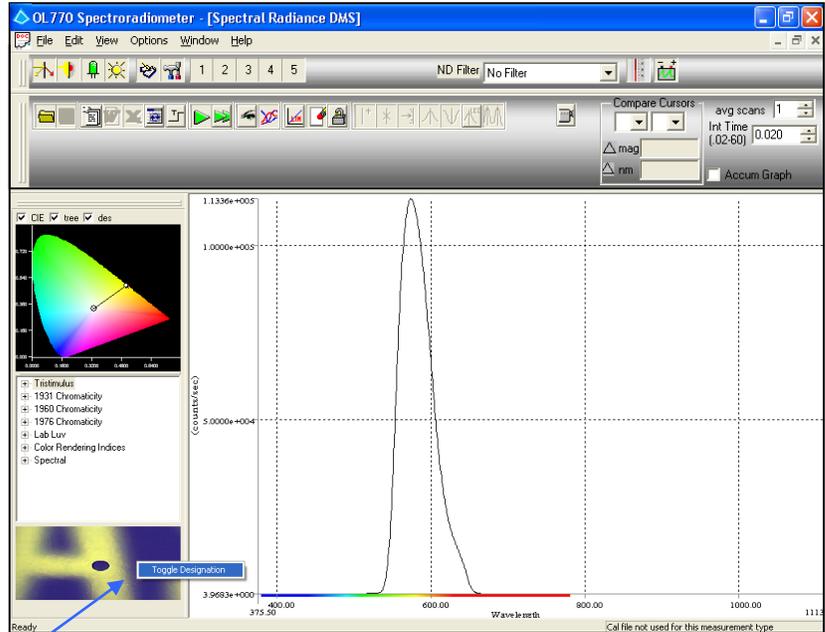
□ **Take a Single Measurement.**

The OL 770 will take a test exposure at 0.02 s or the **Start Value**. The data values from this test measurement will be compared to the full scale of the ADC within the spectroradiometer. A new integration time will be estimated for an optimum exposure. A second measurement is taken and saved if its peak value is within range. A dark spectrum is recorded at the same integration time and subtracted from the second measurement. Finally the spectrum is multiplied by the selected calibration file before being plotted.

An image from the OL 610 camera is recorded into the designation box on the value tree. This will be saved as a bitmap image with the same name as the saved OLI data file.

Toggle Between Designation and Image

In certain modes of measurement, the designation box becomes an image viewer to view the image captured using an OL 610 (or OL 620). In order to view the designation of the loaded \*.oli file, simply right-click on the image and then select **Toggle Designation** or **Toggle Image**



The radiometric ( $W/sr/cm^2$ ) and photometric ( $cd/cm^2$ ) values for the measurement are displayed in the Value Tree. The Calculation Bar also includes the tristimulus and color parameters for the source.

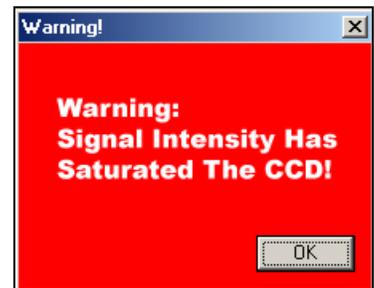
Refer to Tutorials I and II for further details on the Calculation Bar, Graphs & Cursors, File Saving and Word & Excel reports.

**Signal Saturation**

The OL 770 application software will display a warning dialog when the peak spectral intensity exceeds the CCD or ADC range and the integration time is at its minimum or the Auto Integration procedure is disabled.

List of options to correct for CCD signal saturation:

1. Reduce the integration time or check the **Auto Integration** procedure.
2. Close the OL 610 objective lens aperture a number of stops – requires a new system response calibration file.
3. Change the CCD binning range – requires system response calibration.
4. Add an ND filter to the fiber optic probe – and select ND filter # in measurement toolbar.



**Save the System Settings to a CFG Button**

The complete OL 770 settings and the selected calibrations file names can be exported to a system configuration file (File\ Export Settings File) or saved to the one of the five user CFG preset buttons on the Measurement Toolbar. Refer to Tutorial I-/ Part 4 for a complete description of the User Configuration Buttons.

## TUTORIAL VIII - SPECTRAL IRRADIANCE MEASUREMENTS

### NOTE:

Be sure you have completed Tutorial I – Basic Operations before starting this section!

It will be necessary to return to Tutorial II for information on the advanced features of the OL 770 application software.

If you do not have password access to the LED Measurements, in order to follow Tutorial I, then switch to demo mode (by turning off the OL 770 power) and open the LED measurements window.

### Definitions and Measurement Overview

Irradiance :	Radiant flux (power) incident per unit area upon a surface. Also known as radiant flux density. The S.I. units for irradiance are $W/m^2$ however it is often expressed in units of $W/cm^2$ , $mW/cm^2$ , $\mu W/cm^2$ etc.
Spectral Irradiance :	The radiant flux density that is incident on a surface per unit of wavelength. Usually expressed in $W/(m^2 nm)$ or $W/(cm^2 nm)$ .
Illuminance :	Illuminance is a measure of luminous flux incident per unit area upon a surface. Illuminance is typically expressed in lux, lx (lumens per square meter), $lm/cm^2$ (lumens per square centimeter) or footcandles, fc (lumens per square foot).
Point Source:	Light emitted from a point source appears to have all its rays originating from a single point in space. <i>A source can be considered an approximate point source if the largest dimension of its emitting area is small (&lt;10%) compared to distance between the source and the measurement plane. Collimated sources are point sources originating from an infinite distance. Sources with lens optics may appear to originate from a virtual point behind the source.</i>
Extended Source:	Light from an extended source does not come from a single point in space. <i>Light reflected from a surface can also be considered as an extended source.</i>
Angular Response:	Angular response is the normalized change in the system sensitivity to a source as it is rotated to different points on a hemisphere subtended above and centered on the input port. The $0^\circ$ measurement directly above the input port is typically used as the reference value.
Cosine Response:	A system has a Cosine Response when the angular response follows that of the cosine function. The cosine error is defined as the ratio of the normalized angular response to cosine at the measurement angle.

The OL 770 Multi-Channel Spectroradiometer can be coupled to various optical accessories for specific optical measurements. When an integrating sphere such as the OL IS-270 is connected to the OL 770 fiber optic input probe, the system can be configured and calibrated for spectral irradiance measurements. The OL 770 can be supplied with various lengths of fiber optic probe allowing the integrating sphere input optics to be located remotely from the spectroradiometer for on-line high speed production or remote testing applications.

Using the Radiance (Source Spectral Analysis) software module within the OL 770 application, measurements include:

- spectral irradiance graphs & data
- chromaticity and tri-stimulus values
- illuminance value
- CCT & CRI values
- peak spectral and source bandwidth data
- data logging

It should be noted that all radiometric measurements are restricted to the spectral range of the instrument. For many sources, the full spectral irradiance will extend beyond the wavelength range of the spectroradiometer. Measurements of irradiance should be accompanied by the instruments spectral range of the instrument, e.g. 1.220 mW/cm<sup>2</sup> [380 nm to 1100 nm].

Spectral irradiance measurements require the careful orientation and position of the input optics (integrating sphere). It is essential that the end user understand the properties of the input optics accessory and cosine angular response and minimizing the *cosine error*.

#### EXTENDED SOURCE

- Input optics with a cosine angular response is necessary. Integrating spheres can have an angular response, which closely matches the cosine function over a wide spectral range. Transmission diffusers will only have a cosine angular response over a more limited spectral range.
- The optical axis is normal to and centered at the input port of the sphere.
- The optical axis is typically on a horizontal or vertical plane when measuring extended sources.
- The measurement or calibration plane is at the aperture of the input port. For well designed integrating spheres the input port and apertures are coplanar . (Refer to Gooch & Housego's Application Note #9: *Improving Integrating Sphere Designs for Near-perfect Cosine Response*.)
- The integrating sphere's blind spot should be orientated to minimize the measurement error. (Refer to Gooch & Housego's Application Note #9.)
- The Inverse Square Law does not apply.

#### POINT SOURCES

- The optical axis is normal to and centered at the input port of the sphere. The sphere orientation is not bound to horizontal or vertical planes.
- The Inverse Square Law applies when the source is a point sources or an approximate point source.
- It is not necessary for the input optics to have a cosine angular response. However, input optics with a narrow angular response can be more difficult to align on the source and more difficult to calibrate.
- Integrating sphere input optics will be sensitive to scattered light. Careful baffling may be required to eliminate scattered light or light reflected from surfaces.

#### Calibration

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Calibration of the OL 770 spectroradiometer with the OL IS-270 integrating sphere requires a spectral irradiance calibration lamp such as the OL 245 or OL 345 standards. A system response calibration is required for each CCD binning range used and any additional apertures fitted to the input port of the integrating sphere.

Full details of the procedure for creating a system response calibration files and verifying their accuracy are discussed in the *OL 770 Calibration Manual*.

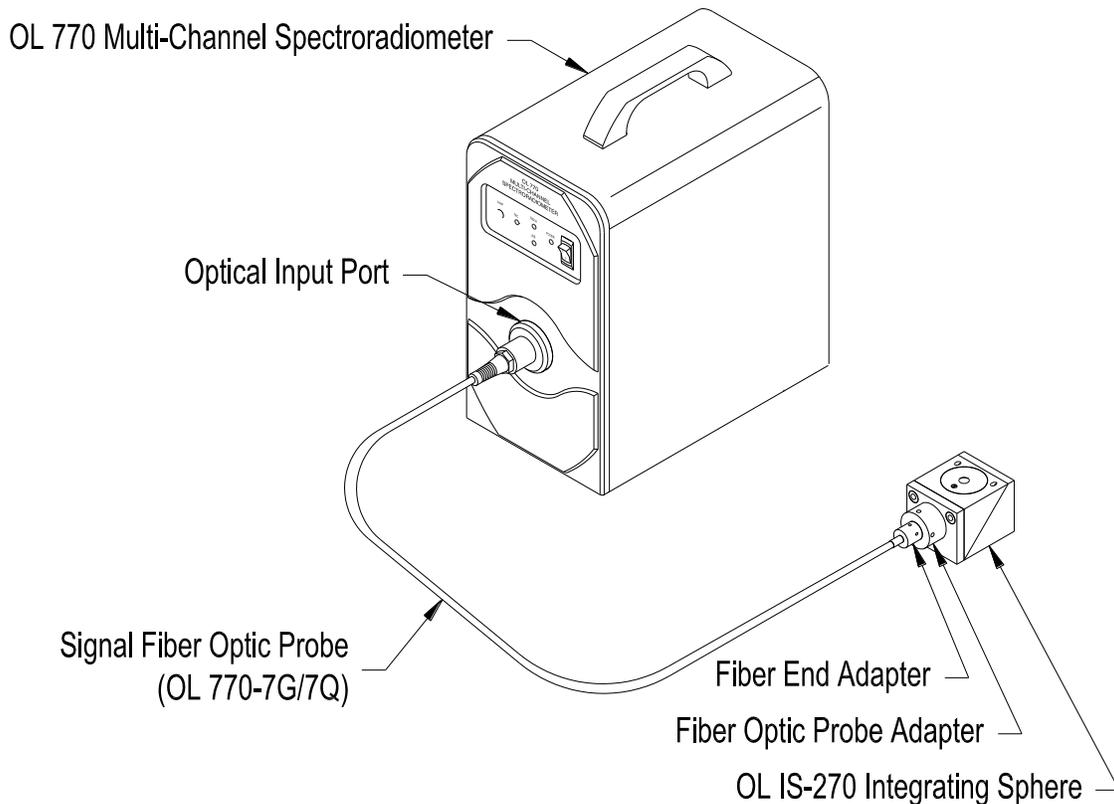
## Part 1 - Typical Optical Setup and System Configuration

What we'll do:

- Connect the OL IS-270 to the OL 770 Multi-Channel Spectroradiometer
- Measurement Setup for Extended and Point Sources
- Open the OL 770 Spectral Irradiance Measurement Software Module
- Configure the OL 770 for Spectral Irradiance Measurements
- Take a Spectral Irradiance Measurement

### Connect the OL IS-270 Integrating Sphere to the OL 770 Multi-Channel Spectroradiometer

1. Place the Fiber Optic Probe Adapter onto the OL IS-270 Integrating Sphere and secure with the two supplied 6-32 cap head screws. (The adapter may be supplied from the factory already attached.)
2. Attach the Fiber End Adapter to the free end of the OL 770-7 Fiber Optic Probe and secure by tightening the two setscrews.
3. Insert the Fiber Optic Probe into the Adapter on the OL IS-270 and secure by tightening the two setscrews.
4. Insert the opposite end of the OL 770-7 Fiber Optic Probe into the entrance port of the OL 770 Multi-Channel Spectroradiometer.



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## Measurement Setup for Extended and Point Sources

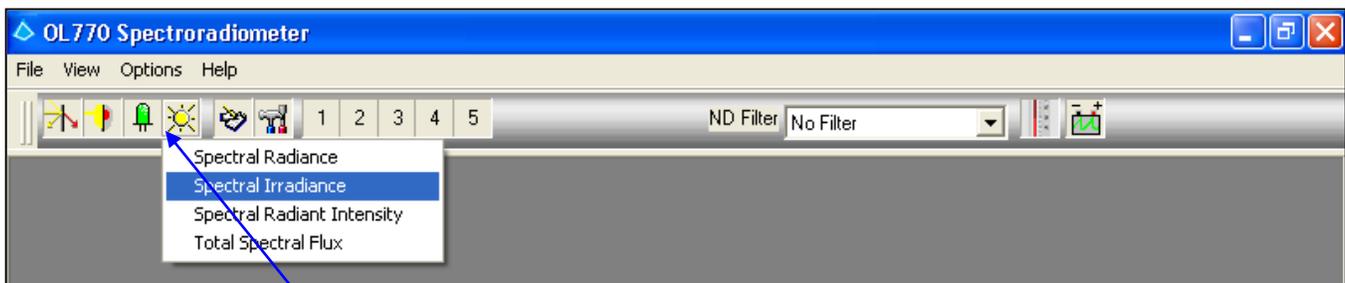
The measurement plane for the OL IS-270 passes through the entrance port of the integrating sphere. It is therefore important to note that the spectral irradiance and illuminance values are for a plane, which is 2.31 inches (5.86 cm) above the *table* surface. In addition the integrating sphere will measure light, incident on its input port that originates from any source within the hemisphere above the port aperture. Therefore, the position and orientation of the sphere is critical to the recorded measurement values.

For example, the spectral irradiance and illuminance values within an environmental test chamber will depend on the shelf height, the number and distribution of the light sources, the position of the sources with respect to the integrating sphere input port, the reflectance properties of the walls and other fittings and the position of the integrating sphere with respect to the chamber walls. Where possible, lower the shelf to compensate for the height of the integrating sphere. Map the light distribution across the table to record minimum, maximum and average irradiance / illuminance values for each shelf height.

The measurement setup is simpler for point sources. Here we do not wish to measure the reflected or scattered light. Our first concern is to know that the measurement distance is sufficiently great for the source to be considered a point source. A single measurement on axis could be sufficient to allow for the calculation of the irradiance or illuminance values at different distances, positions and orientations. In practice, however, it is necessary to verify some of the calculated values with measurements.

## Open the OL 770 Spectral Irradiance Measurement Software Module

Within the OL 770 Application Software are packages for the various spectral measurement configurations including transmittance, reflectance, spectral radiance, spectral irradiance and the optical parameters of LEDs. Each package is accessed via a button on the Main Toolbar. A password granting access to each measurement package is stored in a bin file and is automatically saved to the appropriate location during installation.



- ❑ Click on the **Source Spectral Analysis** icon on the Main Toolbar, and then select **Spectral Irradiance**. (A password access dialog will open if the software package was not purchased.) For information on purchasing additional OL 770 software packages, contact Gooch & Housego, Orlando, Florida. You will only need to enter the password provided when using the module for the first time. During normal use, the password dialog box does not appear.

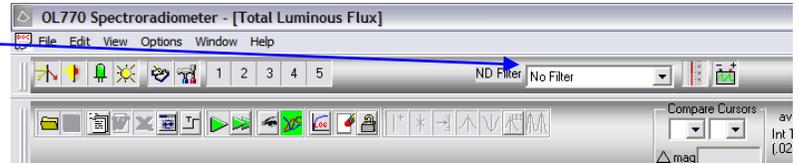
### NOTE:

When the application software is run in Demo mode, access is given to all the measurement modules without password intervention.

## Configuring the OL 770 for Spectral Irradiance Measurements

The configuration file for your OL 770 spectroradiometer and calibration files are supplied in the System folder located on the OL 770 Application Software Installation CD supplied with your system. The contents of this folder are installed with the application program, refer to *Installing the OL 770 Application Software & USB Driver* section in this manual.

- ❑ Confirm the desired ND selection on the Main Toolbar before entering the Modified Settings window.

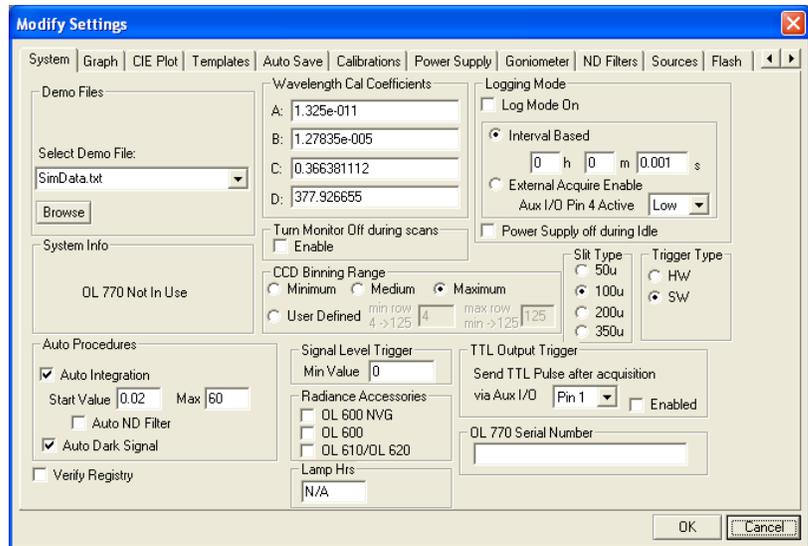


### NOTE:

If the OL 770 Application Software is set to User Mode, you will be required to enter a password before opening the Modify Settings dialog. Refer to Tutorial I, Part 2 for information on Security Operating Modes. Tutorial I, Part 2 will also provide further details on the Modify Settings / System dialog.

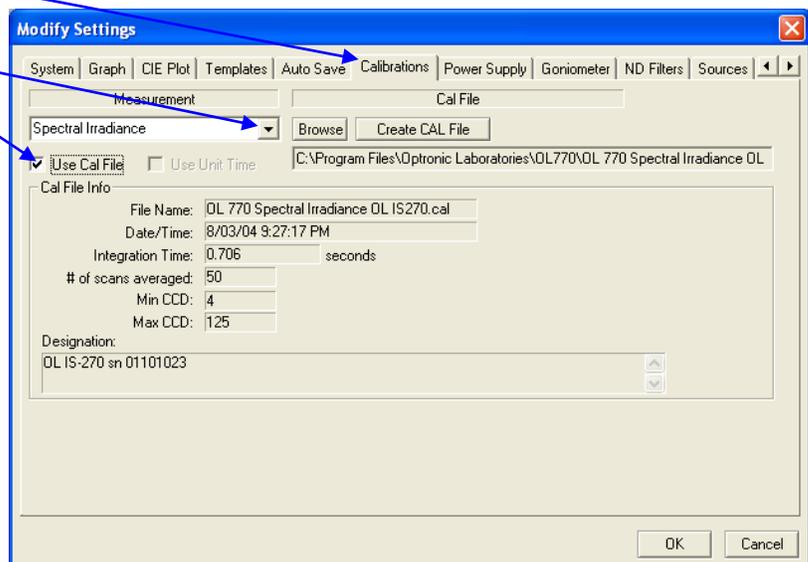


- ❑ Select the **Modify Settings** button on the Main Toolbar.
- ❑ On the System tab, confirm the **Wavelength Coefficients** and **Slit Type** are correct by comparing these values to your System Information Sheet.
- ❑ Confirm both of the **Auto Procedure** boxes are checked.

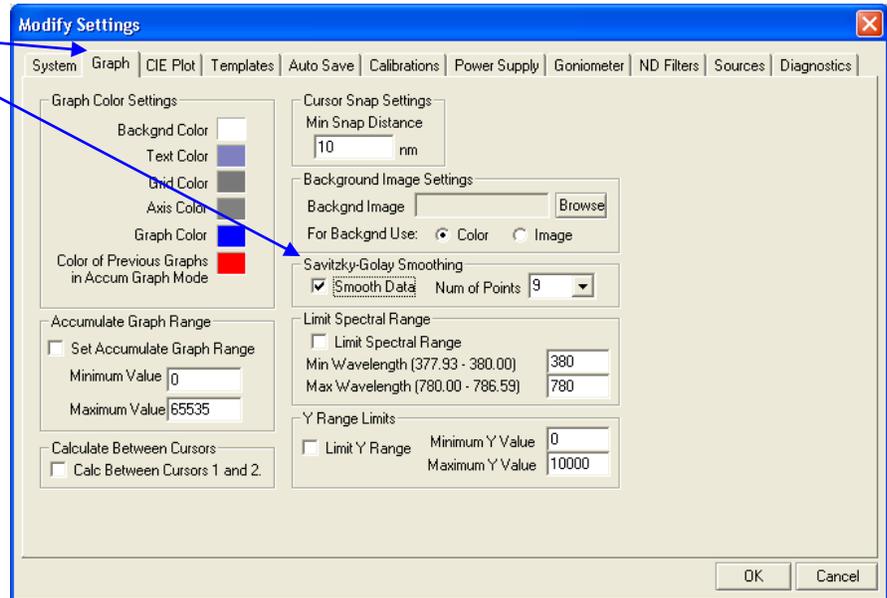


- ❑ Select the **Calibrations** tab.
- ❑ From the Measurement drop-down menu **Spectral Irradiance**.
- ❑ Check the **Use Cal File** box.
- ❑ Browse and select the calibration file for the Spectral Irradiance with the OL IS-270 Integrating Sphere.
- ❑ Click **Open** to load the selected calibration file.

**Note:**  
The OL 770 Application will check to confirm the Selected Slit Size and CCD Binning Range match the data stored in the calibration file header.



- ❑ Select the **Graph** tab.
- ❑ Check the **Smooth Data** box to enable Savitzky-Golay Smoothing. This will reduce the noise on the spectral plots. The smoothing can be switched on or off without effecting the stored data.
- ❑ Set the **Num of Points** to the required level. Spectral plots with narrow (FWHM <4 nm) emission lines should have no smoothing applied.
- ❑ Click **OK** to close the **Modify Settings** dialog.



### Save the OL 770 Settings to the Computer Registry

Save the new system settings and the password to the computer registry by closing and opening the OL 770 application.

- ❑ **Close the OL 770 application.**
- ❑ **Restart the OL 770 application.**

The system settings can also be exported to a configuration file using the File / Export System Settings on the Main Menu.

## Part 2 – Spectral Irradiance Measurements with the OL IS-270 Accessory

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What we'll do:

- Confirm the *Selected* Calibration File.
- Check the Sensitivity and Take the Spectral Irradiance Measurement.
- Save the System Settings to a CFG Button.

### Confirm the Calibration File

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A selected system response calibration file is displayed on the bottom right of the status bar. If the status bar is not visible, check the **Status Bar** option in the **View** menu.



- Open a Spectral Irradiance measurement window.**
- Confirm the correct spectral irradiance calibration file is displayed on the status bar.**

### Check the System Sensitivity

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The OL 770 CCD detector integrates the light induced charge to create a signal dependent on both the light intensity and the exposure time. The OL 770 has three methods to ensure the optimum signal level is measured:-

- adjust the integration time from 20 ms up to 60 seconds.
- change the CCD binning range.
- insert optional calibrated neutral density filters into the OL 770-15Q holder.

With the system setup as detailed above, proceed with the measurement.



- Take a Single Measurement.**

The OL 770 will take a test exposure at 0.02 s or the **Start Value**. The data values from this test measurement will be compared to the full scale of the ADC within the spectroradiometer. A new integration time will be estimated for an optimum exposure. A second measurement is taken and saved if its peak value is within range. A dark spectrum is then recorded at the same integration time and subtracted from the second measurement. Finally, the spectrum is multiplied by the selected calibration file before being plotted.

The radiometric ( $W/cm^2$ ) and photometric ( $lm/cm^2$ ) values for the measurement are displayed in the Value Tree. The Calculation Bar also includes the tristimulus and color parameters for the source.

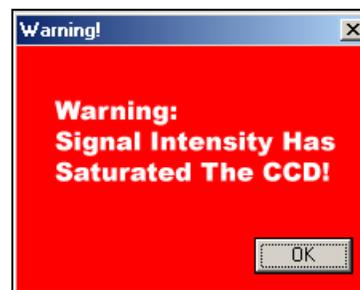
Refer to Tutorials I and II for further details on the Calculation Bar, Graphs & Cursors, File Saving and Word & Excel reports.

### Signal Saturation

The OL 770 Application Software will display a warning dialog when the peak spectral intensity exceeds the CCD or ADC range and the integration time is at its minimum or the Auto Integration procedure is disabled.

List of options to correct for CCD signal saturation:

1. Reduce the integration time or check the Auto Integration procedure.
2. Change the CCD binning range – requires system calibration.
3. Insert an optional calibrated ND filter into the optional OL 770-15Q holder – and select ND filter # in measurement toolbar.



### Save the System Settings to a CFG Button

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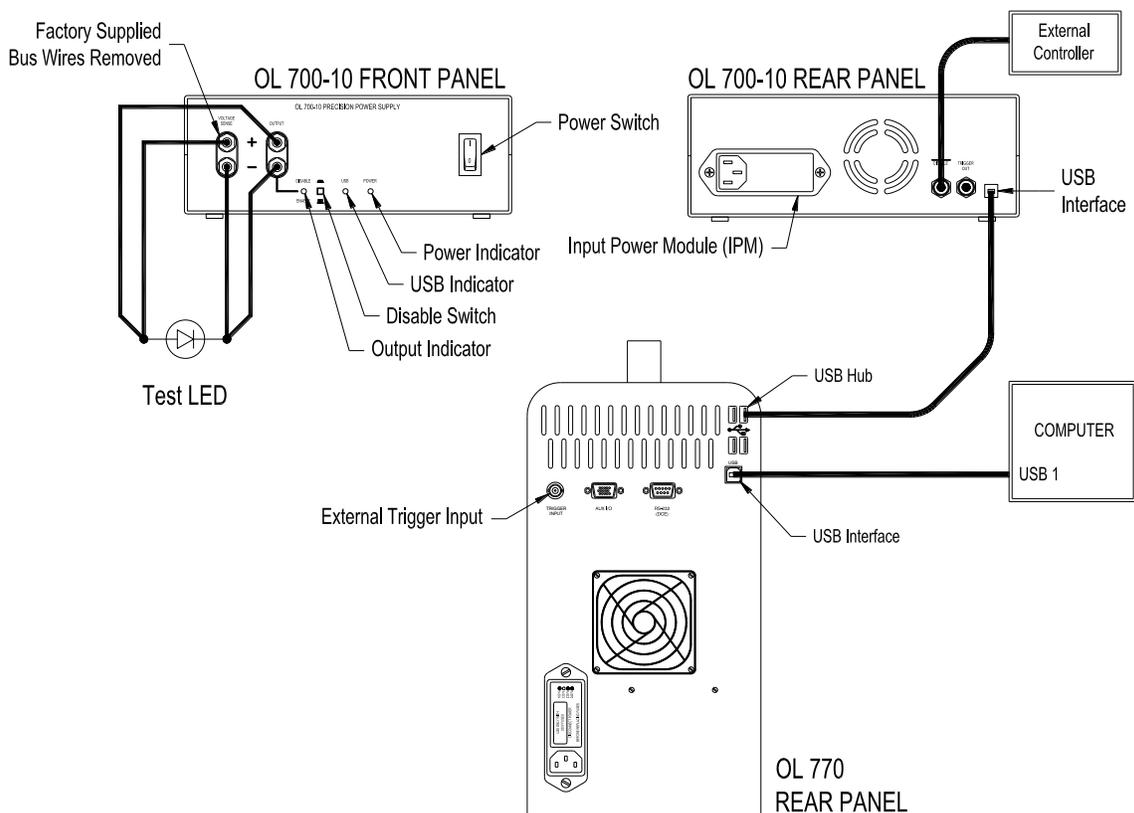
The complete OL 770 settings and the selected calibrations file names can be exported to a system configuration file (**File\ Export Settings File**) or saved to the one of the five user CFG preset buttons on the **Measurement Toolbar**. Refer to Tutorial I / Part 4 for a complete description of the User Configuration Buttons.

## TUTORIAL IX – OL 700-10 PROGRAMMABLE PRECISION POWER SUPPLY

**NOTE:**

Be sure you have completed Tutorial I – Basic Operations before starting this section!

### Part 1 - Typical Setup for OL 700-10 Programmable Precision Power Supply



P001462F

1. Connect the AC power cable to the OL 700-10 Input Power Module and then to the power source.
2. With the OL 770 and host computer running, connect the USB cable from the OL 700-10 Rear Panel to an available USB port on the rear of the OL 770. (A computer's USB interface port can also be used.) The Windows operating system should bring up the "Add New Hardware Wizard." The OL 700-10 USB device driver is typically part of the Windows operating system. Allow the Wizard to search for the best driver in its driver's database on the main drive only. When the "USB Human Interface Device" driver is found, the Wizard can install the software. Finish the Add New Hardware Wizard.
3. Connect the Test LED to the Output Terminals on the OL 700-10 Front Panel. Note proper polarity.

**CAUTION:**

DO NOT disconnect or connect an LED to the Output Terminals while the Disable Switch is "Enabled."

4. Turn the OL 700-10 power on. It is recommended to have the Disable Switch in the "Disabled" position (pressed down) until measurements are to be performed. For additional front and rear panel information, refer to the *OL 700-10 Programmable Precision Power Supply* manual.

## Part 2 - Setting Up the OL 770 Application Software for Operating the OL 700-10 Power Supply

The OL 700-10 Programmable LED Power Supply can be configured and controlled using the OL 770 Application Software. When first executed, the OL 770 Application Software automatically searches for the OL 700-10 power supply and uploads the calibration factors from its non-volatile memory to the operating system.

The integration of the LED power supply includes the following features and controls:

- ◆ Measures and records the power supply's ADC and DAC offsets
- ◆ Choice of voltage or current regulation modes
- ◆ Auto power on / off sequence
- ◆ Settling time delay
- ◆ Record current and forward voltage with the spectral data files

What we'll do:

- Verify the OL 700-10 Power Supply communication interface.
- Review the Power Supply Tab.
- Review the Power Supply Settings Panel.
- Review the Amplitude Control Dial to Change Settings.
- Change the operating mode of the OL 700-10 Power Supply.
- Switch between Driving Current or Driving Voltage.
- Set the Over Voltage and Current.
- Set the Settling Time.
- Configure the OL 700-10 Tolerance Settings.
- Disable the Amplitude Control Knob.

### Verify the OL 700-10 Power Supply Communication Interface

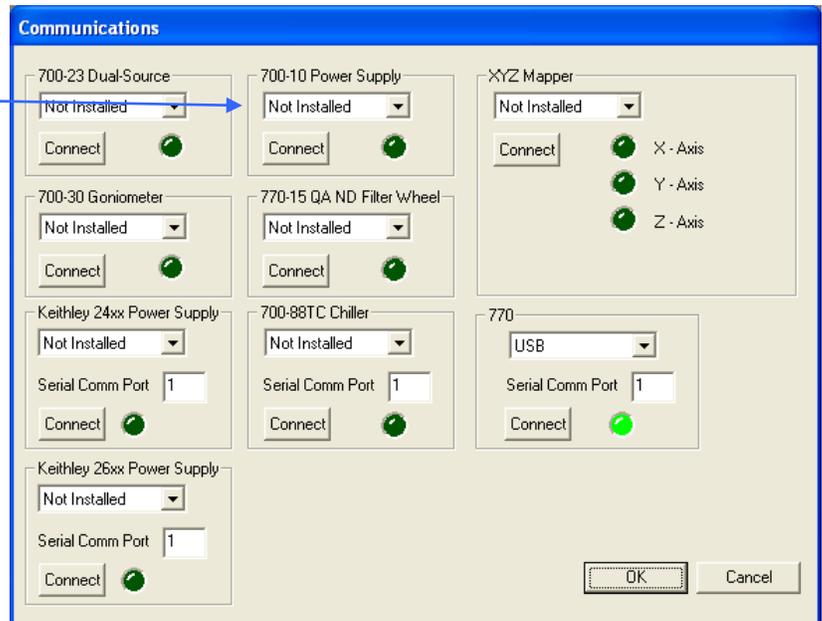
Access the Communications Dialog to configure the communications interface to the OL 700-10.

- ❑ **Select the Options menu from the Main Menu, then select Communications...**



The Communications Dialog will open. Select USB connection from the drop-down list.

- ❑ **When the Communications Dialog opens, select USB from the drop-down list of the OL 700-10 Power Supply selection. Click the Connect button to initiate the communication. Ensure that a bright green light displays to indicated the OL 700-10 is connected.**



## Review the Power Supply Tab

The Modify Setting/Power Supply tab contains five separate tabs to configure the power supply: 1. General, 2. Keithley 24xx, 3. 700-10, 4. Pulse/Sweep, and 5. Keithley 26xx.

### Power Supply / General Tab

The Power Supply/General tab in the Modify Settings dialog allows you to select and configure the following:

#### Output

The Output radio buttons allow you to specify when the power supply sets the current or voltage that is specified.

**ON:** The voltage or current value will be set on the power supply as soon as the OK button is pressed.

**Off:** The output of the power supply is disabled as soon as the OK button is pressed.

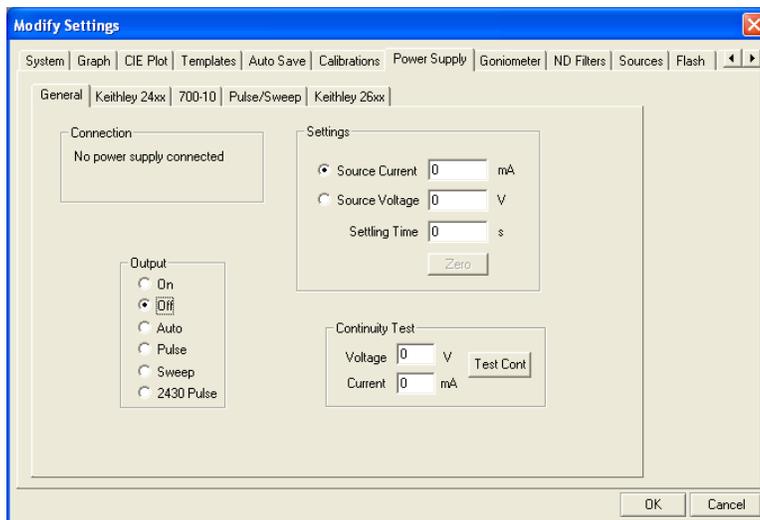
**Auto:** The voltage or current value will be set just before the spectral measurement is taken. At the end of the measurement the power supply output is disabled.

**Pulse:** Similar to Auto except the triggering of the measurement is done by the Keithley SourceMeter with more precise LED warmup and exposure times. Configuration parameters are entered on the Pulse tab.

– *This output is used for Keithley 2400 Series SourceMeter only.*

**Sweep:** Applies to electrical characterization only. Measurements are made across a voltage or current range incrementally. Configuration parameters are entered on the Pulse tab. – *This output is used for Keithley 2400 Series SourceMeter only.*

**2430 Pulse:** Configures the Keithley SourceMeter for Pulse Mode Operation (Model 2430 only). Configuration parameters are entered on the Pulse tab. – *This output is used for Keithley SourceMeter Model 2430 only.*



#### Settings

Current Mode or Voltage Mode radio buttons can be selected, which will determine which of these values are set. The value boxes to the right of these modes allow you to enter the set voltage (in Volts) or current (in milliamperes).

The Settling Time is the delay, in seconds, between switching on the LED and the start of the spectral measurement.

To reset the values to zero, click the **Zero** button.

#### Continuity Test

The Continuity Test enables the user to set a low level of current or voltage to test whether an LED has been connected properly to its LED holder. This will allow the user to detect visually whether an LED is connected without powering up the LED, thus increasing its temperature. After the Voltage or Current is entered, click the **Test Cont** button to test the LED.

### Power Supply / Keithley 24xx or Keithley 26xx Tabs

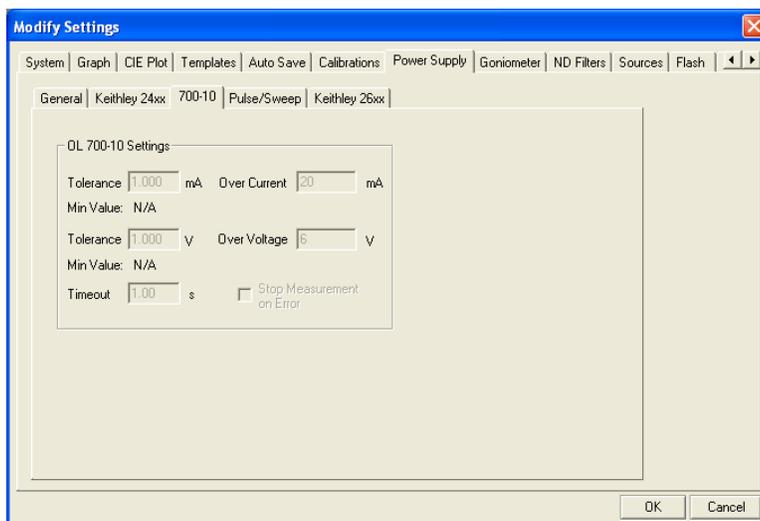
*These tabs pertain to the Keithley SourceMeters, thus they are explained in detail in the 'Using the OL 770 Application Software for Operating the Keithley 2400 (or 2600) Series SourceMeter' manuals.*

### Power Supply / 700-10 Tab

To accurately source out the correct amperage and voltage during **Auto** mode scans, the power supply settings include an amperage tolerance and a voltage tolerance. The user has the ability to set a **Tolerance** based on the specifications of the power supply. The low level feedback that the tolerance settings require will slow the acquisition of a measurement by a factor of about 4. The user also needs to set a **Timeout** value, which would stop the OL 700-10 power supply from trying to attain the target amperage or voltage. If the **Stop Measurement on Error** option is unchecked, the measurement will complete even if the sourcing exceeds the timeout value.

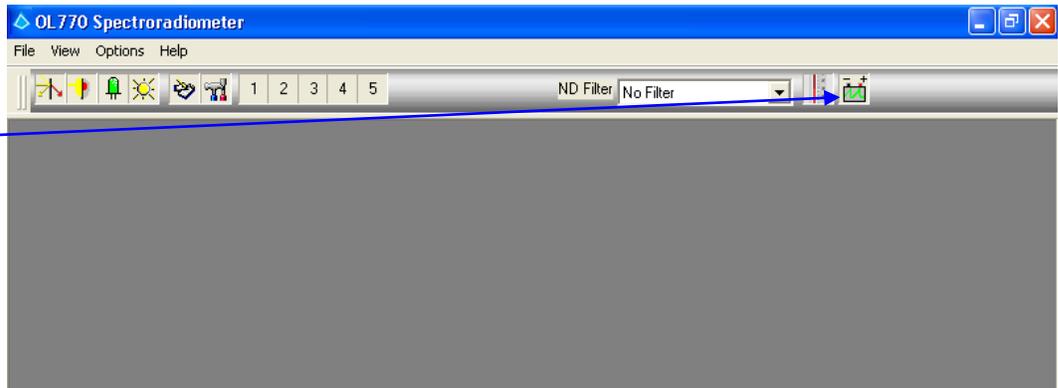
### Power Supply / Pulse/Sweep Tab

*This tab pertains to the Keithley 2400 Series SourceMeter, thus it is explained in detail in the 'Using the OL 770 Application Software for Operating the Keithley 2400 Series SourceMeter' manual.*



Review the Power Supply Settings Panel

The Power Supply Settings Panel can be accessed from the Main Toolbar by selecting the Power Supply Settings button.



- Press the Power Supply Settings button to bring up the Power Supply Settings Panel. (Pressing this button again will hide the power supply dialog.)

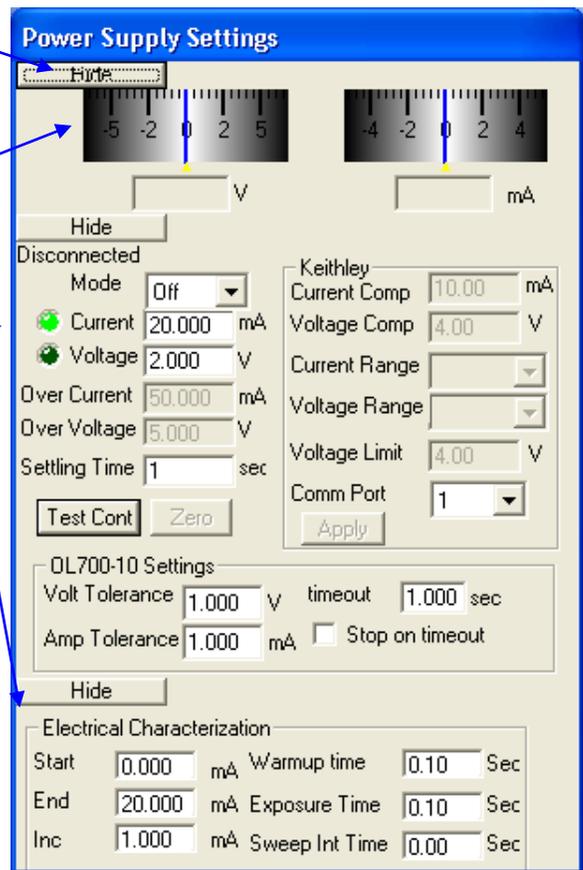
The Power Supply Settings Panel contains three different sections with three **Show/Hide** buttons in order to display or hide the section.

**Section 1** displays information concerning the output of the power supply. It contains two sliding gauges that display the real time current and voltage information. The real time numerical values are also displayed.

**Section 2** contains information on the settings of the OL 700-10 Power Supply.

**Section 3** contains settings concerning the electrical characterization measurement type such as starting and ending currents or voltages, exposure time and warm-up time, etc., used primarily for the Sweep Mode.

When all three Sections are hidden from view, the result will be the following:



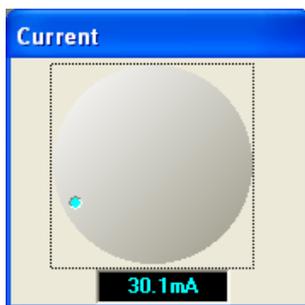
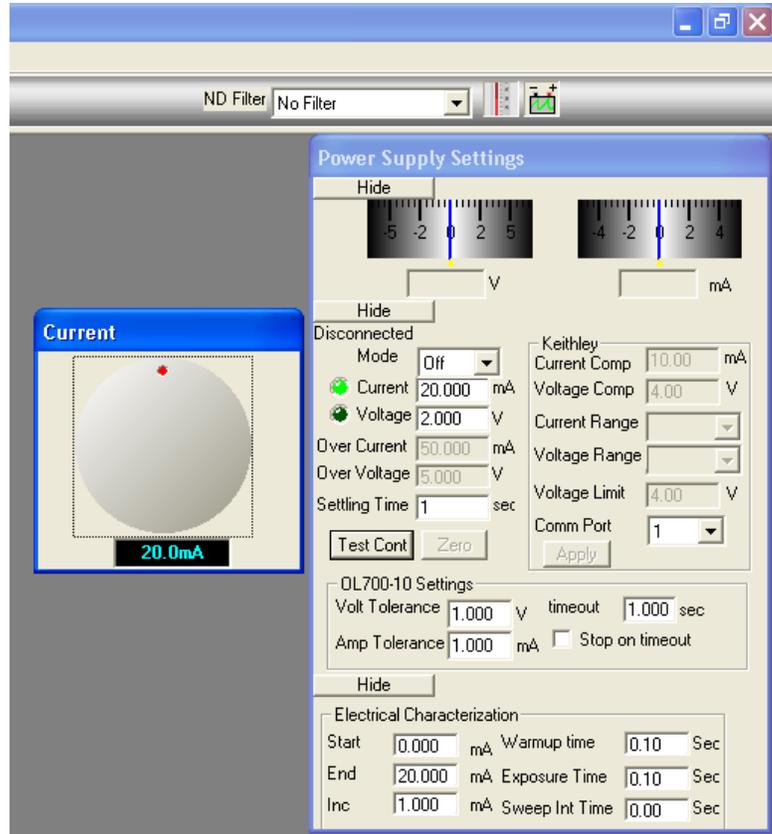
SECTION 1    SECTION 2    SECTION 3

To expand a section, click on the appropriate Show button for that Section.

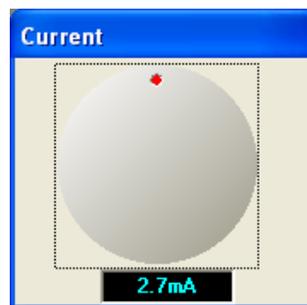
## Review the Amplitude Control Dial for Changing Settings

The settings on the Power Supply Settings Panel can be changed in two ways: typing with the keyboard or using the mouse. To use the keyboard, for entries without a drop-down box, click inside the edit box and type the desired entry. The following describes changing a setting using the mouse.

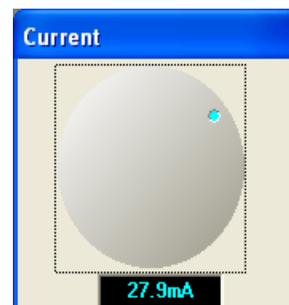
- ❑ To change the settings using a mouse, hover over the edit box for the setting you desire to change. In this example, the mouse hovered over the **Current** edit box. A small dialog box appeared with an **Amplitude Control Dial**, which is used to change the setting.
- ❑ The Amplitude Control Dial changes the settings by rotating to the left or to the right of the rest position. The numeric value is displayed below the dial. Position the mouse on the dial, then press the left mouse button and move clockwise to the right, to obtain a positive change. Moving the dial more to the right will cause a faster positive change to occur. Similarly, the more the dial is moved to the left, the more of a negative change is seen. The dial will return to the rest position by releasing the left mouse button.



Fastest negative change



Rest position



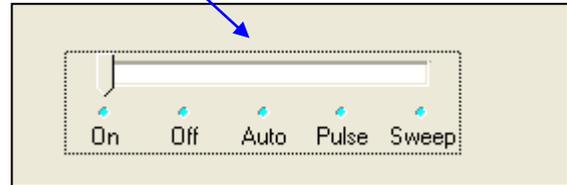
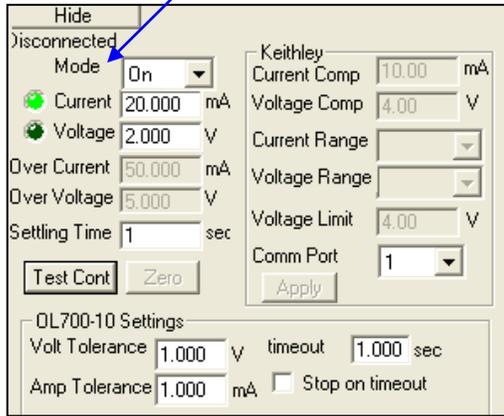
Slow positive change

The Amplitude Control Dial will close when the user leaves the area of the dial or if the user clicks elsewhere on the dialog box. The dial will also close if another dial is opened.

## Changing the Operating Mode of the Power Supply

When changing the Operating Mode, be certain that a power supply is connected prior to starting the application.

- Hover the mouse over the **Mode** setting to display the **Mode Selection Slide Switch**. Slide the switch to the desired mode. Note that Sweep mode will work only under the new measurement type.



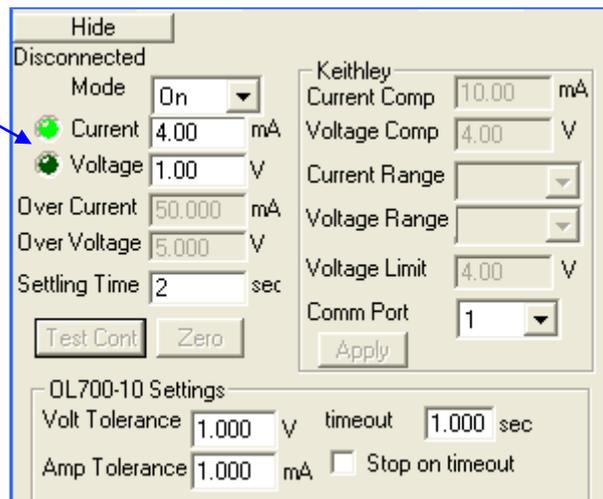
Mode:	Function:
On	Manually turn power supply on.
Off	Manually turn power supply off.
Auto	The voltage or current value will be set just before the spectral measurement is taken. At the end of the measurement, the power supply output is disabled.
Pulse	Similar to Auto except the triggering of the measurement is done by the power supply with more precise LED exposure times.
Sweep	Electrical characterization only. Measurements are made across a voltage or current range incrementally.

**NOTE:**

The OL 700-10 Power Supply does not support the **Pulse** and **Sweep** Modes at this time.

### Switching Between Driving Current or Driving Voltage

- ❑ To switch between sourcing current and voltage by the power supply, click on the appropriate radio button next to the **Current** and **Voltage** edit boxes. The green colored radio button indicates which driving mode is sourcing. In this example, the power supply will drive the Current to 4.0 mA when the power supply is turned on.
- ❑ Next, hover over the **Voltage** or **Current** edit boxes to display the Amplitude Control Dial. The maximum limit of these dials are determined by the model and type of power supply. In this example, the OL 700-10-2000 is a 2 A power supply. Therefore, the dial to control amperage will allow up to 2.0 A of output. Voltage for the OL 700-10 line of power supplies have a maximum of 6.0 V. The current and voltage can be changed while the power supply is applying current or voltage.



**Table A**

Note the current and voltage specification according to the OL Series 700-10 Power Supply model number:

Model	Current Range	Accuracy (0.02%)	ADC Resolution	Display Range <sup>①</sup>	Display Resolution <sup>②</sup>
OL 700-10-2000	± 2 A	± 0.4 mA	± 0.061 mA	± 1999.9 mA	0.1 mA
OL 700-10-200	± 200 mA	± 0.04 mA	± 0.006 mA	± 199.99 mA	0.01 mA
OL 700-10-50	± 50 mA	± 0.01 mA	± 0.0015 mA	± 49.992 mA	0.002 mA

Model	Voltage Range	Accuracy (0.02%)	ADC Resolution	Display Range <sup>①</sup>	Display Resolution <sup>②</sup>
All Models	±6 V	± 0.0012 V	± 0.0003 V	6.000 V	0.001 V

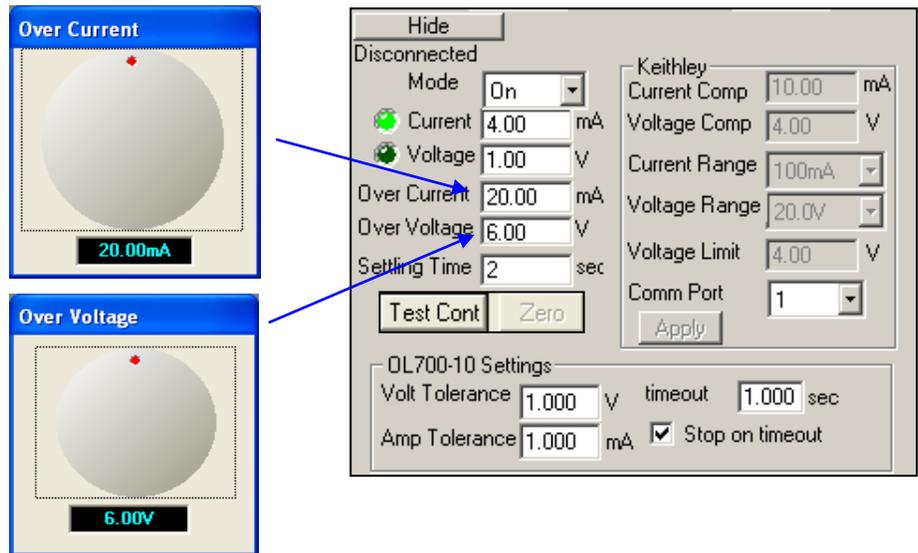
① Current display range and resolution within the OL 770 application software.

② Voltage display range and resolution within the OL 770 application software.

### Setting the Over Voltage and Current

The Over Voltage and Over Current settings are used to prevent overloading an LED or other sensitive light source. When the power supply is set to source out current, the over voltage is checked to prevent the voltage from going over a preset level. For the OL 700-10, the maximum voltage is set to 6.0 V. In the case of voltage being driven, the current is checked as to not exceed the over current level. If at any time, the voltage and current are exceeded, the power supply will be set to the OFF position in order to protect the light source attached to the power supply.

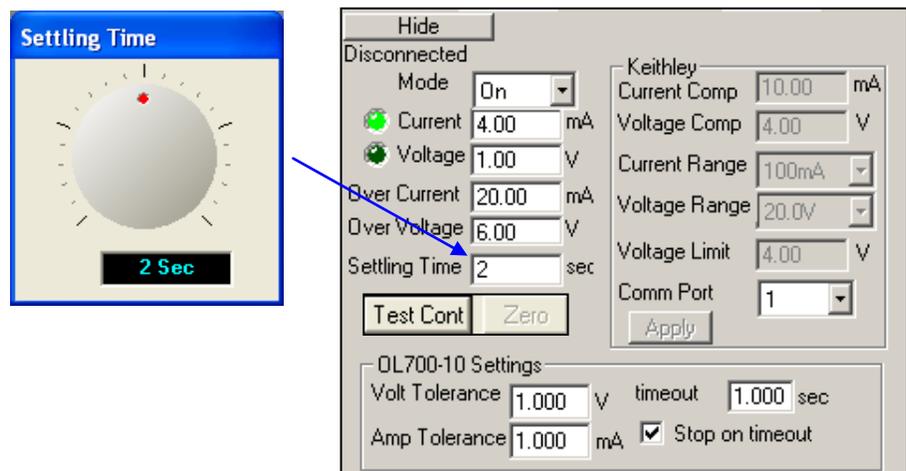
- By hovering the mouse over the Over Current and Over Voltage edit boxes, the Amplitude Control Dial will appear to allow you to set the desired value.



### Setting the Settling Time

The settling time is the delay, in seconds, between switching on the LED and the start of the spectral measurement, primarily when the power supply is set on Auto mode. The power supply will remain in an off state and will ramp up only when a measurement is made. The power supply will remain on for the specified duration and then shut off after the measurement is made. The settling time is in integer seconds. There is no upper limit on the settling time.

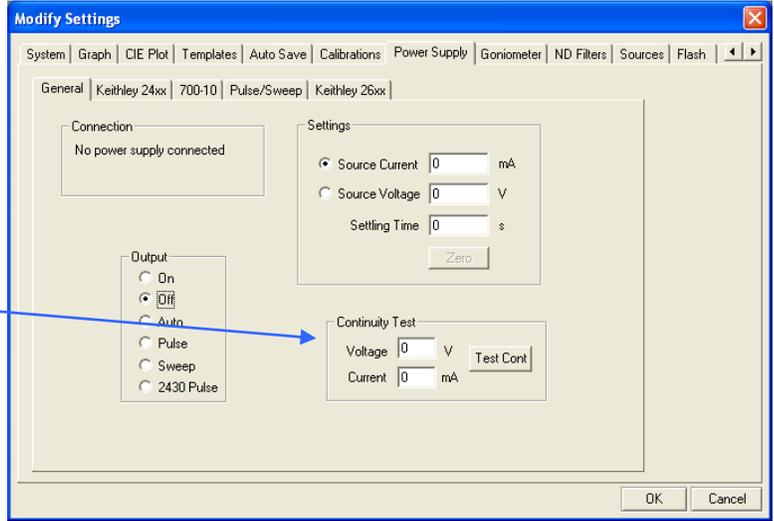
- By hovering the mouse over the Settling Time edit box, the Amplitude Control Dial will appear to allow you to set the desired value



### Setting the Continuity Test

The Continuity Test enables the user to set a low level of current or voltage to test whether an LED has been connected properly to its LED holder. This will allow the user to detect visually whether an LED is connected without powering up the LED that might increase its temperature.

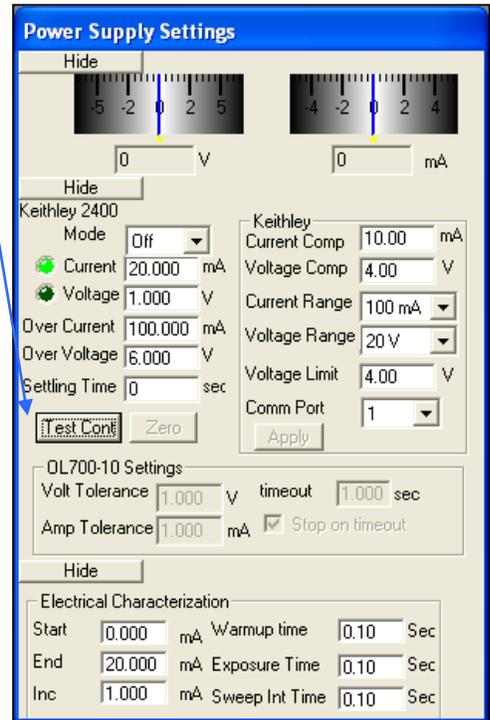
- ❑ In the Modify Settings/Power Supply/General tab, enter the desired **Continuity Voltage** and **Continuity Current** values in the appropriate box. The voltage and current are used based on which driving mode is selected.



- ❑  Close the Modify Setting dialog and access the Power Supply Settings Panel.
- ❑ From the Power Supply Setting Panel, select the **[Test Cont]inuity** button to test the LED. The test will be performed for approximately 2 seconds.

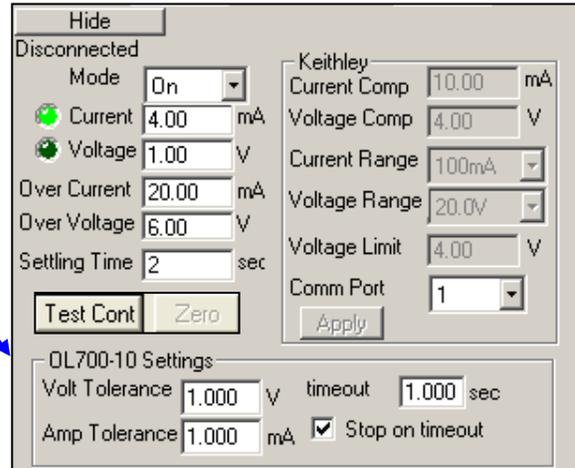
**NOTE:**

You can perform the Continuity Test from the Modify Settings/Power Supply/General tab or from the Power Supply Setting Panel.



### Configure the OL 700-10 Tolerance Settings

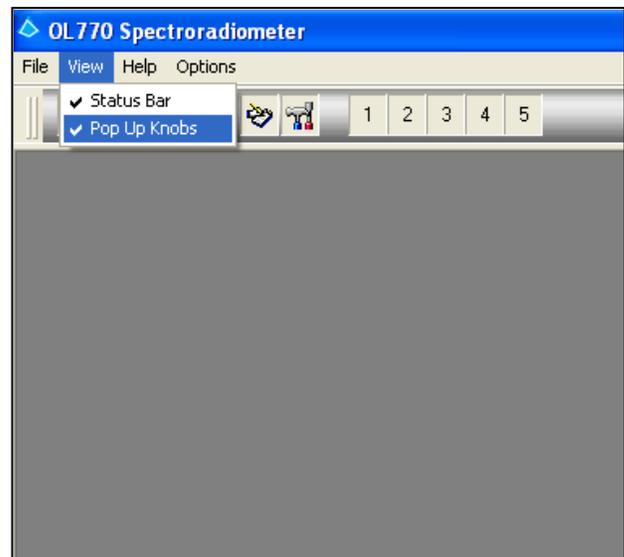
To accurately source out the correct amperage and voltage during **Auto** mode scans, the power supply settings include an amperage tolerance and a voltage tolerance. The user has the ability to set a tolerance based on the specifications of the power supply. The low level feedback that the tolerance settings require will slow the acquisition of a measurement by a factor of about 4. The user also needs to set a time out value, which would stop the OL 700-10 power supply from trying to attain the target amperage or voltage. If the **Stop on timeout** option is unchecked, the measurement will complete even if the sourcing exceeds the timeout value.



Setting:	Description:
Amperage Tolerance	When sourcing out amperage, the power supply will source to within +/- the amperage tolerance from the target amperage.
Voltage Tolerance	When sourcing out voltage, the power supply will source to within +/- the voltage tolerance from the target voltage.
Time out	Maximum amount of time to allow the power supply to reach the target amperage or voltage based on the tolerances.
Stop on timeout	Stops the measurement upon the timeout value exceeding during the process of the power supply achieving the desired voltage or current within its tolerance value.

### Disabling the Amplitude Control Dial

The Amplitude Control Dial can be disabled or enabled by selecting the View menu and clicking on the Pop Up Knobs selection. A check mark indicates the Amplitude Control Dial will display. When the Amplitude Control Dial is not activated, the edit boxes for the Power Supply Setting Panel can be selected by using the Tab key to move throughout the panel.



## TUTORIAL X – OL 700-88TC TEMPERATURE CONTROLLER INSTRUMENT CONTROL USING THE OL 770 APPLICATION SOFTWARE

The OL 700-88TC Temperature Controlled can be controlled manually using the digital controller or controlled using the OL 770 Application Software. The following describes how to control and adjust the OL 700-88TC using the OL 770 Application Software when taking measurements.

### Verify the OL 700-88TC Temperature Controller Communication Interface \_\_\_\_\_

Ensure that the OL 700-88TC Temperature Controller and LED Holder with test LED are properly assembled and connected. Connect the RS-232 cable from the OL 700-88TC to your computer.

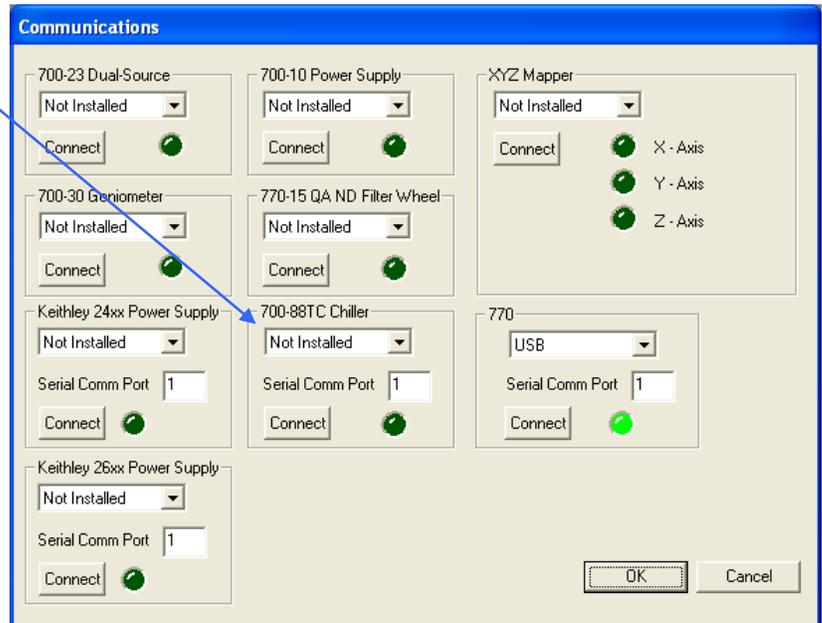
Access the Communications Dialog to configure the communications interface to the OL 700-88TC.

- ❑ Select the **Options** menu from the Main Menu, then select **Communications...**



The Communications Dialog will open. Select USB connection from the drop-down list.

- ❑ When the **Communications Dialog** opens, select **RS-232** from the drop-down list of the **OL 700-88TC Power Supply** selection. Click the **Connect** button to initiate the communication. Ensure that a bright green light displays to indicated the OL 700-88TC is connected.



### Open the Temperature Controller Instrument Panel \_\_\_\_\_



- ❑ Click the **Change Settings** button.
- ❑ The **Temperature Controller Instrument Panel** will appear.

Adjust the Temperature Controller Parameters

The screenshot shows the 'Temperature Controller' window. It features a digital display showing '+25.30' in green. To the right of the display is a 'degrees' section with radio buttons for 'C' (Celsius) and 'F' (Fahrenheit). Below the display is a numeric input field containing '25.3' and an 'Update' button. At the bottom left, there is a 'Port' dropdown menu set to 'COM 1' and a 'Connected' status indicator.

Callout boxes provide the following instructions:

- Choose temperature scale. C - Celsius; F - Fahrenheit
- Actual temperature of the instrument will be reported here.
- Set the target temperature and press the **Update** button to activate this number.
- Select the Serial Port that the Temperature Controller is connected to.
- View the instrument connection status.

Take a Measurement with the Temperature Controller Attached

- Click the **Take A Reading** button to perform a measurement with the OL 770.

The temperature at the time of measurement is reported in the value tree.

The value tree shows a hierarchy of nodes. The 'Temperature Controller' node is expanded, revealing a sub-node 'Temperature : 25.0 deg C'. A callout box points to this sub-node with the text: 'Temperature at time of measurement.'





## Appendix A

### OL 770 Multi-Channel Spectroradiometer Recommended Computer Configuration

	<b><u>For optimum performance, use the following configuration:</u></b>	<b><u>The following configuration is adequate, but there will be a noticeable decrease in response time and system performance <sup>/1</sup>:</u></b>
<b>Computer:</b>	Intel® Pentium® III or AMD Athlon® - based IBM® - compatible personal computer or laptop, 1 GHz or faster.	Pentium II - based IBM - compatible personal computer or laptop, 500 MHz.
<b>Memory:</b>	128 Mb RAM or greater	64 Mb RAM
<b>Operating System:</b>	Windows® XP, Windows Vista™, and Windows 7.	SAME
<b>Monitor:</b>	SVGA capable of displaying 1024x768 or greater in 24 bit color.	SVGA capable of displaying 800x600 in 16 bit color.
<b>Mass Storage:</b>	Hard Drive > 1 Gb	> 20 Mb free space
<b>Mouse:</b>	Microsoft® compatible	SAME
<b>Printer:</b>	Windows operating system supported printer	SAME
<b>Interface (standard):</b>	USB – USB port 1.1 or 2.0 <sup>/2</sup>	Serial port – RS232
<b>Software:</b>	Microsoft Office	SAME

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*Microsoft, Windows, and Windows Vista, are registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.*

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<sup>/1</sup> Use of the minimum system configuration will limit transfer rates in USB mode.  
Use of serial port vs. USB port will significantly reduce transfer rates.

<sup>/2</sup> Additional USB ports are available on the rear panel of the OL 770 for use with the OL 700-10 Programmable Precision Power Supply for LEDs, OL 700-30 LED Goniometer, or the OL 770-15QA accessories when used with the OL 770. Note: The OL 700-30 Goniometer Quick Profile Mode is not supported when using an RS232 port to interface with the OL 770.



## APPENDIX B

### Calculations and Formulas

Chromaticity Calculations .....	B - 1
X, Y & Z Tristimulus Values Calculations for Sources .....	B - 1
X, Y & Z Tristimulus Values Calculations for Objects .....	B - 1
Photometric Output Calculations .....	B - 2
CIE 1931 Chromaticity Calculations .....	B - 2
Dominant Wavelength .....	B - 2
UCS 1976 u, v, u', and v' Coordinates Calculations .....	B - 2
CIE LAB/LUV Color Space Calculations .....	B - 3
Color Rendering Calculations .....	B - 4
X-bar Spectral Tristimulus Values from 1931 CIE Standard Observer .....	B - 6
Y-bar Spectral Tristimulus Values from 1931 CIE Standard Observer .....	B - 7
Z-bar Spectral Tristimulus Values from 1931 CIE Standard Observer .....	B - 8
Measurement of Correlated Color Temperature .....	B - 9
Luminous Intensity Measurement Theory .....	B - 10
Averaged LED Intensity .....	B - 10
Savitzki-Golay Smoothing .....	B - 11



The following are calculations and formulas performed by the OL 770 Application Software utilities/data reduction and measurement routines.

### Chromaticity Calculations

Chromaticity values may be calculated for sources (data file in radiometric units) or objects (data file in fractional transmittance or reflectance). For objects, values represent the color as seen under a standard illuminant (A, B, C or D65).

#### X, Y & Z Tristimulus Values Calculations for Sources

The X, Y and Z tristimulus values for sources are calculated using the CIE 1931 spectral tristimulus values,  $\bar{x}(\lambda)$ ,  $\bar{y}(\lambda)$  and  $\bar{z}(\lambda)$  as follows:

$$\begin{aligned} X &= \sum_{\lambda=380}^{780} E(\lambda) \bar{x}(\lambda) \Delta(\lambda) \\ Y &= \sum_{\lambda=380}^{780} E(\lambda) \bar{y}(\lambda) \Delta(\lambda) \\ Z &= \sum_{\lambda=380}^{780} E(\lambda) \bar{z}(\lambda) \Delta(\lambda) \end{aligned} \quad (1)$$

Where:

$$\begin{aligned} E(\lambda) &= \text{Spectral values of the data file} \\ \bar{x}(\lambda), \bar{y}(\lambda) \text{ and } \bar{z}(\lambda) &= \text{CIE 1931 spectral tristimulus values} \\ \Delta(\lambda) &= \text{Wavelength interval of the data file [nm]} \end{aligned}$$

See this appendix for the  $\bar{x}(\lambda)$ ,  $\bar{y}(\lambda)$  and  $\bar{z}(\lambda)$  values which are automatically called up by this data reduction routine.

#### X, Y & Z Tristimulus Values Calculations for Objects

The X, Y and Z tristimulus values for objects are calculated using the CIE 1931 spectral tristimulus values,  $\bar{x}(\lambda)$ ,  $\bar{y}(\lambda)$  and  $\bar{z}(\lambda)$  as follows:

$$\begin{aligned} X &= k \sum_{\lambda=380}^{780} \bar{E}(\lambda) R(\lambda) \bar{x}(\lambda) \Delta(\lambda) \\ Y &= k \sum_{\lambda=380}^{780} \bar{E}(\lambda) R(\lambda) \bar{y}(\lambda) \Delta(\lambda) \\ Z &= k \sum_{\lambda=380}^{780} \bar{E}(\lambda) R(\lambda) \bar{z}(\lambda) \Delta(\lambda) \end{aligned} \quad (2)$$

$$k = \frac{100}{\sum \bar{E}(\lambda) \bar{y} \Delta \lambda} \quad (3)$$

Where:

$$\begin{aligned} \bar{E}(\lambda) &= \text{Relative spectral power of an illuminant} \\ R(\lambda) &= \text{Spectral Reflectance or transmittance data} \\ \bar{x}(\lambda), \bar{y}(\lambda) \text{ and } \bar{z}(\lambda) &= \text{CIE 1931 spectral tristimulus values} \\ \Delta(\lambda) &= \text{Wavelength interval of the data file [nm]} \end{aligned}$$

See this appendix for the  $\bar{x}(\lambda)$ ,  $\bar{y}(\lambda)$  and  $\bar{z}(\lambda)$  values which are automatically called up by this data reduction routine. These tables refer to a 2° field-of-view observer. Equivalent X, Y & Z values for 10° field-of-view can be similarly calculated using the CIE 1964 supplementary spectral tristimulus values.

### Photometric Output Calculations

For sources, the photometric output (in this case illuminance,  $E_p$ ) is calculated by:

$$E_p [lm / cm^2] = Y [W / cm^2] * 683 [lm / W] \quad (4)$$

For objects, the value of Y is expressed in percent and is the photometric transmittance or reflectance.

### CIE 1931 Chromaticity Calculations

The x, y and z chromaticity coordinates of the data file are calculated from the tristimulus values X, Y, Z as follows:

$$\begin{aligned} x &= \frac{X}{X + Y + Z} \\ y &= \frac{Y}{X + Y + Z} \\ z &= \frac{Z}{X + Y + Z} \end{aligned} \quad (5)$$

### Dominant Wavelength

The human eye perceives light as generally additive in nature. This means that monochromatic light added to white light would give colors ranging from one to the other depending on the intensity proportions. The CIE 1931 x, y chromaticity diagram is bounded by the monochromatic locus. By mixing various proportions of white light with monochromatic light, a straight line between the two coordinates is described. Conversely, for any set of coordinates and a reference white (the equal energy point at coordinates  $x = 0.3333$ ,  $y = 0.3333$  is normally used) there is a corresponding monochromatic wavelength - the dominant wavelength. The dominant wavelength is calculated as the intersection of the monochromatic locus with the line from the equal energy point and through the source coordinates.

Calculations are initially performed using 1 nm interval values of the CIE 1931 monochromatic locus, and then linearly interpolated between neighboring values

### UCS 1976 u, v, u', and v' Coordinates Calculations

The UCS 1960 u, v coordinates are calculated:

$$\begin{aligned} u &= \frac{4x}{12y - 2x + 3} = u' \\ v &= \frac{6y}{12y - 2x + 3} = \frac{2}{3} v' \end{aligned} \quad (6)$$

The UCS 1976 u' and v' coordinates are calculated:

$$\begin{aligned} u' &= \frac{4x}{12y - 2x + 3} = u \\ v' &= \frac{9y}{12y - 2x + 3} = \frac{3}{2} v \end{aligned} \quad (7)$$

$$m = \frac{3}{2} m' \quad (8)$$

Where: m and m' are the isothermperature line slopes for 1960 and 1976, respectively.

## CIE LAB/LUV Color Space Calculations

CIE LAB Color Space Calculations are performed as per the recommended 1976 CIE formulas. For Source computations, X, Y and Z are normalized equally such that Y = 100. The equations are as follows:

$$\begin{aligned}
 L^* &= 116 \left( \frac{Y}{Y_n} \right)^{1/3} - 16 \\
 a^* &= 500 \left[ \left( \frac{X}{X_n} \right)^{1/3} - \left( \frac{Y}{Y_n} \right)^{1/3} \right] \\
 b^* &= 200 \left[ \left( \frac{Y}{Y_n} \right)^{1/3} - \left( \frac{Z}{Z_n} \right)^{1/3} \right]
 \end{aligned} \tag{9}$$

Here  $X_n$ ,  $Y_n$  and  $Z_n$  are tristimulus values of the reference white. The equations above are modified slightly when  $X/X_n$ ,  $Y/Y_n$  or  $Z/Z_n$  is less than 0.01. The modified equations are shown below:

$$\begin{aligned}
 L^* &= 116 \left[ f \left( \frac{Y}{Y_n} \right) - \frac{16}{116} \right] \\
 a^* &= 500 \left[ f \left( \frac{X}{X_n} \right) - f \frac{Y}{Y_n} \right] \\
 b^* &= 200 \left[ f \left( \frac{Y}{Y_n} \right) - f \frac{Z}{Z_n} \right]
 \end{aligned} \tag{10}$$

Where:  $f(Y/Y_n) = (Y/Y_n)^{1/3}$  for  $Y/Y_n$  greater than 0.008856 and  $f(Y/Y_n) = 7.787(Y/Y_n) + 16/116$  for  $Y/Y_n$  less than or equal to 0.008856;  $f(X/X_n)$  and  $f(Z/Z_n)$  are similarly defined.

$$\begin{aligned}
 u' &= 13L^*(u' - u'_n) \\
 v' &= 13L^*(v' - v'_n)
 \end{aligned} \tag{11}$$

For sources, values represent a comparison to a standard illuminant for an ideal white object. For objects, values represent a comparison to an ideal white object under a given standard illuminant.

## Color Rendering Calculations

The color rendering algorithm was written by C.J. Bartleson<sup>/1</sup>. Relevant sections are given below either quote or paraphrase Bartleson.

Two sources with the same color temperature or correlated color temperature will not necessarily yield the same chromaticities for reflecting or transmitting samples with spectrally selective relative radiance distributions. In short, we cannot assume that sources with equal chromaticities will render the same color appearances for a given sample illuminated by each. The CIE has developed a method for assessing the color-rendering properties of sources. This method is called the CIE 1995 Method of Measuring and Specifying Colour Rendering Properties Light Source (Publication CIE No. 13.3). The method consists of a series of "special color-rendering indices" and an average "general color-rendering index."

Each of the special color-rendering indices represents CIE 1964 color differences between the chromaticities for a specified sample under the test illuminant and a specified reference illuminant.

The test illuminant is represented by the datafile already chosen by the user. The reference illuminant is calculated by one of two methods depending on the value of the test illuminant's correlated color temperature:

If the correlated color temperature is less than 5000K, the reference illuminant will be a blackbody radiator:

$$M_{e\lambda}(\lambda, T) = c_1 \lambda^{-5} (e^{c_2/\lambda T} - 1)^{-1} Wm^{-1} \quad (12)$$

Where: the radiation constants are taken as

$$c_1 = 3.74150 * 10^{-16} Wm^2 \quad (13)$$

$$c_2 = 1.4388 * 10^{-2} mK$$

and the temperature T is set equal to

$$T = \left( \frac{1.4388}{1.4350} \right) 2848 K \cong 2856 K \quad (14)$$

If the correlated color temperature is 5000K or above, the reference illuminant will be a daylight radiator:

$$S(\lambda) = S_0(\lambda) + M_1 S_1(\lambda) + M_2 S_2(\lambda) \quad (15)$$

Where:  $S_0, S_1, S_2$  are "Values of Three Characteristic Vectors" from Table VIII<sup>/1</sup>.  
 $M_1$  and  $M_2$  are factors whose values are related to the chromaticity coordinates  $x, y$  of the illuminant as follows:

$$M_1 = \frac{-1.3515 - 1.7703x + 5.9114y}{0.0241 + 0.2562x - 0.7341y} \quad (16)$$

$$M_2 = \frac{0.0300 - 31.4424x + 30.0717y}{0.0241 + 0.2562x - 0.7341y}$$

Where:  $x$  (for temperatures < 7000K):

$$x = -4.6070 \left( \frac{10^9}{T_c^3} \right) + 2.9678 \left( \frac{10^6}{T_c^2} \right) + 0.09911 \left( \frac{10^3}{T_c} \right) + 0.244063 \quad (17)$$

$x$  (for temperatures  $\geq$  7000K):

$$x = -2.0064 \left( \frac{10^9}{T_c^3} \right) + 1.9018 \left( \frac{10^6}{T_c^2} \right) + 0.24748 \left( \frac{10^3}{T_c} \right) + 0.237040 \quad (18)$$

$y$  (all temperatures):

$$y = -3.000x^2 + 2.870x - 0.275 \quad (19)$$

<sup>/1</sup> Published in "Optical Radiation Measurements - Volume 2" by Academic Press.

Now having both the test illuminant data set and the computed reference illuminant data set, the CIE 1960 u, v coordinates of the two data files will be calculated. In addition, the u, v coordinates will be found for 14 test samples illuminated by each of the two sources.

The tristimulus values for each source and the 14 samples illuminated by each source are calculated by the equations below. The tristimulus values for either source are calculated by illuminating a unity test sample (all values = 1) by the source, as in equations (2) and (3).

The CIE 1960 u, v coordinates are calculated directly from the tristimulus data arrays by equation (6).

The  $u''$ ,  $v''$  chromaticities after adaptive color shift are computed using:

$$u''_{k,i} = \frac{10.872 + 0.404(c_r / c_k)c_{k,i} - 4(d_r \cdot d_k)d_{k,i}}{16.518 + 1.481(c_r / c_k)c_{k,i} - (d_r \cdot d_k)d_{k,i}} \quad (20)$$

$$v''_{k,i} = \frac{5.52}{16.518 + 1.481(c_r / c_k)c_{k,i} - (d_r \cdot d_k)d_{k,i}}$$

Where: k is the source, r is the reference source, i stands for samples 1 through 14,  $c = (4 - u - 10v)/v$ , and  $d = (1.708v + 0.404 - 1.481u)/v$ .

The CIE 1964 tristimulus differences  $U^*$ ,  $V^*$ ,  $W^*$  are computed using:

*Reference Illuminant*

$$W^*_{r,i} = 25(100Y_{r,i})^{1/3} - 17$$

$$U^*_{r,i} = 13W^*_{r,i} (u_{r,i} - u_r) \quad (21)$$

$$V^*_{r,i} = 13W^*_{r,i} (v_{r,i} - v_r)$$

and

*Test Illuminant*

$$W^*_{k,i} = 25(100Y_{k,i})^{1/3} - 17$$

$$U^*_{k,i} = 13W^*_{k,i} (u''_{k,i} - u_r) \quad (22)$$

$$V^*_{k,i} = 13W^*_{k,i} (v''_{k,i} - v_r)$$

Where: k is the source, r is the reference source, i stands for samples 1 through 14.

The resultant color shift ( $\Delta$ )E is computed for each of the test samples by:

$$(\Delta)E_i = [(U^*_{r,i} - U^*_{k,i})^2 + (V^*_{r,i} - V^*_{k,i})^2 + (W^*_{r,i} - W^*_{k,i})^2]^{1/2} \quad (23)$$

and the color rendering indices are computed and rounded to the nearest whole number by:

$$R_i = 100 - 4.6\Delta E_i \quad (24)$$

Finally, the first eight test samples are averaged to produce the single "General Color Rendering Index."

X-bar Spectral Tristimulus Values from 1931 CIE Standard Observer  
(380-780 nm @ 1 nm intervals)

380.00 nm	1.368E-003 1.502E-003 1.642E-003 1.802E-003 1.996E-003	475.00 nm	1.421E-001 1.322E-001 1.226E-001 1.133E-001 1.043E-001	570.00 nm	7.621E-001 7.785E-001 7.948E-001 8.109E-001 8.268E-001	665.00 nm	1.212E-001 1.136E-001 1.065E-001 9.969E-002 9.333E-002	760.00 nm	1.660E-004 1.550E-004 1.450E-004 1.350E-004 1.260E-004
385.00 nm	2.236E-003 2.535E-003 2.893E-003 3.301E-003 3.753E-003	480.00 nm	9.564E-002 8.730E-002 7.931E-002 7.172E-002 6.458E-002	575.00 nm	8.425E-001 8.579E-001 8.731E-001 8.879E-001 9.023E-001	670.00 nm	8.740E-002 8.190E-002 7.680E-002 7.208E-002 6.769E-002	765.00 nm	1.170E-004 1.100E-004 1.020E-004 9.500E-005 8.900E-005
390.00 nm	4.243E-003 4.762E-003 5.330E-003 5.979E-003 6.741E-003	485.00 nm	5.795E-002 5.186E-002 4.628E-002 4.115E-002 3.641E-002	580.00 nm	9.163E-001 9.298E-001 9.428E-001 9.553E-001 9.672E-001	675.00 nm	6.360E-002 5.981E-002 5.628E-002 5.297E-002 4.982E-002	770.00 nm	8.300E-005 7.800E-005 7.200E-005 6.700E-005 6.300E-005
395.00 nm	7.650E-003 8.751E-003 1.003E-002 1.142E-002 1.287E-002	490.00 nm	3.201E-002 2.792E-002 2.414E-002 2.069E-002 1.754E-002	585.00 nm	9.786E-001 9.894E-001 9.995E-001 1.009E+000 1.018E+000	680.00 nm	4.677E-002 4.378E-002 4.088E-002 3.807E-002 3.541E-002	775.00 nm	5.900E-005 5.500E-005 5.100E-005 4.800E-005 4.400E-005
400.00 nm	1.431E-002 1.570E-002 1.715E-002 1.878E-002 2.075E-002	495.00 nm	1.470E-002 1.216E-002 9.920E-003 7.967E-003 6.296E-003	590.00 nm	1.026E+000 1.034E+000 1.041E+000 1.047E+000 1.052E+000	685.00 nm	3.290E-002 3.056E-002 2.838E-002 2.635E-002 2.445E-002	780.00 nm	4.200E-005
405.00 nm	2.319E-002 2.621E-002 2.978E-002 3.388E-002 3.847E-002	500.00 nm	4.900E-003 3.777E-003 2.945E-003 2.425E-003 2.236E-003	595.00 nm	1.057E+000 1.060E+000 1.062E+000 1.063E+000 1.063E+000	690.00 nm	2.270E-002 2.108E-002 1.960E-002 1.824E-002 1.699E-002		
410.00 nm	4.351E-002 4.900E-002 5.502E-002 6.172E-002 6.921E-002	505.00 nm	2.400E-003 2.926E-003 3.837E-003 5.175E-003 6.982E-003	600.00 nm	1.062E+000 1.061E+000 1.058E+000 1.055E+000 1.051E+000	695.00 nm	1.584E-002 1.479E-002 1.383E-002 1.295E-002 1.213E-002		
415.00 nm	7.763E-002 8.696E-002 9.718E-002 1.084E-001 1.208E-001	510.00 nm	9.300E-003 1.215E-002 1.554E-002 1.948E-002 2.399E-002	605.00 nm	1.046E+000 1.039E+000 1.031E+000 1.023E+000 1.013E+000	700.00 nm	1.136E-002 1.063E-002 9.939E-003 9.288E-003 8.679E-003		
420.00 nm	1.344E-001 1.494E-001 1.654E-001 1.820E-001 1.986E-001	515.00 nm	2.910E-002 3.482E-002 4.112E-002 4.799E-002 5.538E-002	610.00 nm	1.003E+000 9.914E-001 9.793E-001 9.665E-001 9.528E-001	705.00 nm	8.111E-003 7.582E-003 7.089E-003 6.627E-003 6.195E-003		
425.00 nm	2.148E-001 2.302E-001 2.449E-001 2.588E-001 2.718E-001	520.00 nm	6.327E-002 7.164E-002 8.046E-002 8.974E-002 9.946E-002	615.00 nm	9.384E-001 9.232E-001 9.072E-001 8.905E-001 8.729E-001	710.00 nm	5.790E-003 5.410E-003 5.053E-003 4.718E-003 4.404E-003		
430.00 nm	2.839E-001 2.949E-001 3.049E-001 3.138E-001 3.216E-001	525.00 nm	1.096E-001 1.202E-001 1.311E-001 1.424E-001 1.539E-001	620.00 nm	8.545E-001 8.351E-001 8.149E-001 7.942E-001 7.730E-001	715.00 nm	4.109E-003 3.834E-003 3.576E-003 3.334E-003 3.109E-003		
435.00 nm	3.285E-001 3.344E-001 3.392E-001 3.431E-001 3.461E-001	530.00 nm	1.655E-001 1.773E-001 1.891E-001 2.012E-001 2.134E-001	625.00 nm	7.514E-001 7.296E-001 7.076E-001 6.856E-001 6.638E-001	720.00 nm	2.899E-003 2.704E-003 2.523E-003 2.354E-003 2.197E-003		
440.00 nm	3.483E-001 3.496E-001 3.501E-001 3.500E-001 3.493E-001	535.00 nm	2.258E-001 2.383E-001 2.511E-001 2.640E-001 2.771E-001	630.00 nm	6.424E-001 6.215E-001 6.011E-001 5.811E-001 5.614E-001	725.00 nm	2.049E-003 1.911E-003 1.781E-003 1.660E-003 1.546E-003		
445.00 nm	3.481E-001 3.464E-001 3.443E-001 3.418E-001 3.391E-001	540.00 nm	2.904E-001 3.039E-001 3.176E-001 3.314E-001 3.455E-001	635.00 nm	5.419E-001 5.226E-001 5.035E-001 4.847E-001 4.662E-001	730.00 nm	1.440E-003 1.340E-003 1.246E-003 1.158E-003 1.076E-003		
450.00 nm	3.362E-001 3.332E-001 3.300E-001 3.266E-001 3.229E-001	545.00 nm	3.597E-001 3.741E-001 3.886E-001 4.034E-001 4.183E-001	640.00 nm	4.479E-001 4.299E-001 4.121E-001 3.946E-001 3.775E-001	735.00 nm	1.000E-003 9.290E-004 8.620E-004 8.010E-004 7.430E-004		
455.00 nm	3.187E-001 3.140E-001 3.089E-001 3.033E-001 2.973E-001	550.00 nm	4.335E-001 4.488E-001 4.643E-001 4.801E-001 4.960E-001	645.00 nm	3.608E-001 3.445E-001 3.285E-001 3.130E-001 2.980E-001	740.00 nm	6.900E-004 6.410E-004 5.950E-004 5.520E-004 5.120E-004		
460.00 nm	2.908E-001 2.840E-001 2.767E-001 2.689E-001 2.604E-001	555.00 nm	5.121E-001 5.283E-001 5.447E-001 5.612E-001 5.778E-001	650.00 nm	2.835E-001 2.695E-001 2.561E-001 2.432E-001 2.307E-001	745.00 nm	4.760E-004 4.420E-004 4.120E-004 3.830E-004 3.570E-004		
465.00 nm	2.511E-001 2.408E-001 2.299E-001 2.184E-001 2.068E-001	560.00 nm	5.945E-001 6.112E-001 6.280E-001 6.448E-001 6.616E-001	655.00 nm	2.187E-001 2.071E-001 1.959E-001 1.852E-001 1.748E-001	750.00 nm	3.320E-004 3.100E-004 2.890E-004 2.700E-004 2.520E-004		
470.00 nm	1.954E-001 1.842E-001 1.733E-001 1.627E-001 1.523E-001	565.00 nm	6.784E-001 6.952E-001 7.121E-001 7.288E-001 7.455E-001	660.00 nm	1.649E-001 1.554E-001 1.462E-001 1.375E-001 1.291E-001	755.00 nm	2.350E-004 2.190E-004 2.050E-004 1.910E-004 1.780E-004		

Y-bar Spectral Tristimulus Values from 1931 CIE Standard Observer  
(380-780 nm @ 1 nm intervals)

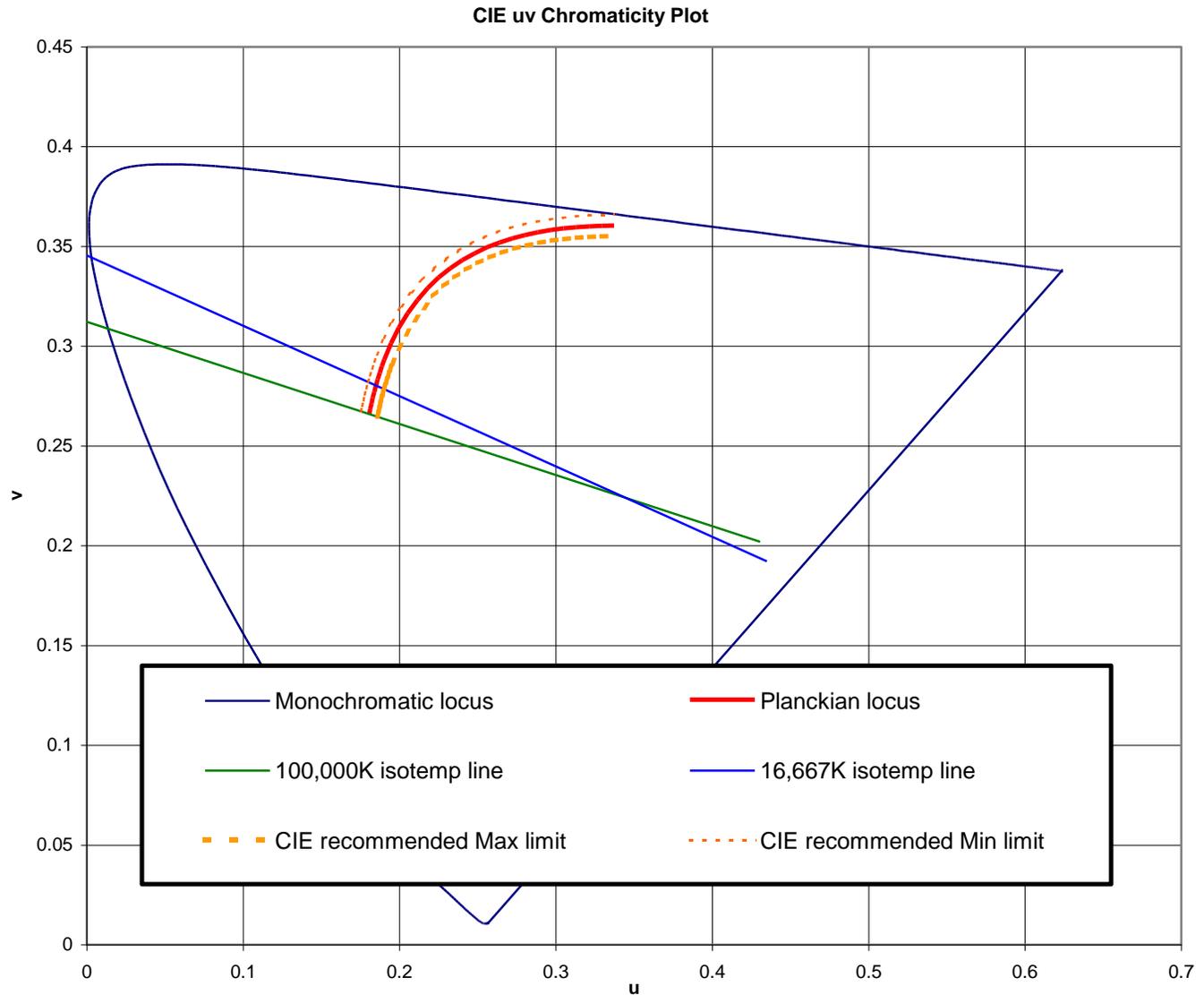
380.00 nm	3.900E-005 4.300E-005 4.700E-005 5.200E-005 5.700E-005	475.00 nm	1.126E-001 1.175E-001 1.227E-001 1.280E-001 1.335E-001	570.00 nm	9.520E-001 9.454E-001 9.385E-001 9.312E-001 9.235E-001	665.00 nm	4.458E-002 4.176E-002 3.909E-002 3.656E-002 3.420E-002	760.00 nm	6.000E-005 5.600E-005 5.200E-005 4.900E-005 4.500E-005
385.00 nm	6.400E-005 7.200E-005 8.200E-005 9.400E-005 1.060E-004	480.00 nm	1.390E-001 1.447E-001 1.505E-001 1.565E-001 1.627E-001	575.00 nm	9.154E-001 9.070E-001 8.983E-001 8.892E-001 8.798E-001	670.00 nm	3.200E-002 2.996E-002 2.808E-002 2.633E-002 2.471E-002	765.00 nm	4.200E-005 4.000E-005 3.700E-005 3.400E-005 3.200E-005
390.00 nm	1.200E-004 1.350E-004 1.510E-004 1.700E-004 1.920E-004	485.00 nm	1.693E-001 1.762E-001 1.836E-001 1.913E-001 1.994E-001	580.00 nm	8.700E-001 8.599E-001 8.494E-001 8.386E-001 8.276E-001	675.00 nm	2.320E-002 2.180E-002 2.050E-002 1.928E-002 1.812E-002	770.00 nm	3.000E-005 2.800E-005 2.600E-005 2.400E-005 2.300E-005
395.00 nm	2.170E-004 2.470E-004 2.810E-004 3.190E-004 3.570E-004	490.00 nm	2.080E-001 2.171E-001 2.267E-001 2.369E-001 2.475E-001	585.00 nm	8.163E-001 8.048E-001 7.931E-001 7.812E-001 7.692E-001	680.00 nm	1.700E-002 1.590E-002 1.484E-002 1.381E-002 1.284E-002	775.00 nm	2.100E-005 2.000E-005 1.800E-005 1.700E-005 1.600E-005
400.00 nm	3.960E-004 4.340E-004 4.730E-004 5.180E-004 5.720E-004	495.00 nm	2.586E-001 2.702E-001 2.823E-001 2.951E-001 3.086E-001	590.00 nm	7.570E-001 7.448E-001 7.324E-001 7.200E-001 7.075E-001	685.00 nm	1.192E-002 1.107E-002 1.027E-002 9.533E-003 8.846E-003	780.00 nm	1.500E-005
405.00 nm	6.400E-004 7.250E-004 8.260E-004 9.410E-004 1.070E-003	500.00 nm	3.230E-001 3.384E-001 3.547E-001 3.717E-001 3.893E-001	595.00 nm	6.949E-001 6.822E-001 6.695E-001 6.567E-001 6.438E-001	690.00 nm	8.210E-003 7.624E-003 7.085E-003 6.591E-003 6.138E-003		
410.00 nm	1.210E-003 1.362E-003 1.531E-003 1.720E-003 1.935E-003	505.00 nm	4.073E-001 4.256E-001 4.443E-001 4.634E-001 4.829E-001	600.00 nm	6.310E-001 6.182E-001 6.053E-001 5.925E-001 5.796E-001	695.00 nm	5.723E-003 5.343E-003 4.996E-003 4.676E-003 4.380E-003		
415.00 nm	2.180E-003 2.455E-003 2.764E-003 3.118E-003 3.526E-003	510.00 nm	5.030E-001 5.236E-001 5.445E-001 5.657E-001 5.870E-001	605.00 nm	5.668E-001 5.540E-001 5.411E-001 5.284E-001 5.156E-001	700.00 nm	4.102E-003 3.838E-003 3.589E-003 3.354E-003 3.134E-003		
420.00 nm	4.000E-003 4.546E-003 5.159E-003 5.829E-003 6.546E-003	515.00 nm	6.082E-001 6.293E-001 6.503E-001 6.709E-001 6.908E-001	610.00 nm	5.030E-001 4.905E-001 4.780E-001 4.657E-001 4.534E-001	705.00 nm	2.929E-003 2.738E-003 2.560E-003 2.393E-003 2.237E-003		
425.00 nm	7.300E-003 8.087E-003 8.909E-003 9.768E-003 1.066E-002	520.00 nm	7.100E-001 7.282E-001 7.455E-001 7.620E-001 7.778E-001	615.00 nm	4.412E-001 4.291E-001 4.170E-001 4.050E-001 3.930E-001	710.00 nm	2.091E-003 1.954E-003 1.825E-003 1.704E-003 1.590E-003		
430.00 nm	1.160E-002 1.257E-002 1.358E-002 1.463E-002 1.571E-002	525.00 nm	7.932E-001 8.081E-001 8.225E-001 8.363E-001 8.495E-001	620.00 nm	3.810E-001 3.689E-001 3.568E-001 3.448E-001 3.328E-001	715.00 nm	1.484E-003 1.384E-003 1.291E-003 1.204E-003 1.123E-003		
435.00 nm	1.684E-002 1.801E-002 1.921E-002 2.045E-002 2.172E-002	530.00 nm	8.620E-001 8.738E-001 8.850E-001 8.955E-001 9.054E-001	625.00 nm	3.210E-001 3.093E-001 2.979E-001 2.866E-001 2.756E-001	720.00 nm	1.047E-003 9.770E-004 9.110E-004 8.500E-004 7.930E-004		
440.00 nm	2.300E-002 2.429E-002 2.561E-002 2.696E-002 2.835E-002	535.00 nm	9.149E-001 9.237E-001 9.321E-001 9.399E-001 9.472E-001	630.00 nm	2.650E-001 2.548E-001 2.449E-001 2.353E-001 2.261E-001	725.00 nm	7.400E-004 6.900E-004 6.430E-004 5.990E-004 5.580E-004		
445.00 nm	2.980E-002 3.131E-002 3.288E-002 3.452E-002 3.623E-002	540.00 nm	9.540E-001 9.603E-001 9.660E-001 9.713E-001 9.760E-001	635.00 nm	2.170E-001 2.082E-001 1.995E-001 1.912E-001 1.830E-001	730.00 nm	5.200E-004 4.840E-004 4.500E-004 4.180E-004 3.890E-004		
450.00 nm	3.800E-002 3.985E-002 4.177E-002 4.377E-002 4.584E-002	545.00 nm	9.803E-001 9.841E-001 9.874E-001 9.903E-001 9.928E-001	640.00 nm	1.750E-001 1.672E-001 1.596E-001 1.523E-001 1.451E-001	735.00 nm	3.610E-004 3.350E-004 3.110E-004 2.890E-004 2.680E-004		
455.00 nm	4.800E-002 5.024E-002 5.257E-002 5.498E-002 5.746E-002	550.00 nm	9.950E-001 9.967E-001 9.981E-001 9.991E-001 9.997E-001	645.00 nm	1.382E-001 1.315E-001 1.250E-001 1.188E-001 1.128E-001	740.00 nm	2.490E-004 2.310E-004 2.150E-004 1.990E-004 1.850E-004		
460.00 nm	6.000E-002 6.260E-002 6.528E-002 6.804E-002 7.091E-002	555.00 nm	1.000E+000 9.999E-001 9.993E-001 9.983E-001 9.969E-001	650.00 nm	1.070E-001 1.015E-001 9.619E-002 9.112E-002 8.627E-002	745.00 nm	1.720E-004 1.600E-004 1.490E-004 1.380E-004 1.290E-004		
465.00 nm	7.390E-002 7.702E-002 8.027E-002 8.367E-002 8.723E-002	560.00 nm	9.950E-001 9.926E-001 9.897E-001 9.864E-001 9.827E-001	655.00 nm	8.160E-002 7.712E-002 7.283E-002 6.871E-002 6.477E-002	750.00 nm	1.200E-004 1.120E-004 1.040E-004 9.700E-005 9.100E-005		
470.00 nm	9.098E-002 9.492E-002 9.905E-002 1.034E-001 1.079E-001	565.00 nm	9.786E-001 9.741E-001 9.692E-001 9.639E-001 9.581E-001	660.00 nm	6.100E-002 5.740E-002 5.396E-002 5.067E-002 4.755E-002	755.00 nm	8.500E-005 7.900E-005 7.400E-005 6.900E-005 6.400E-005		

Z-bar Spectral Tristimulus Values from 1931 CIE Standard Observer  
(380-780 nm @ 1 nm intervals)

380.00 nm	6.450E-003 7.083E-003 7.745E-003 8.501E-003 9.415E-003	475.00 nm	1.042E+000 9.942E-001 9.473E-001 9.015E-001 8.566E-001	570.00 nm	2.100E-003 2.018E-003 1.948E-003 1.890E-003 1.841E-003	665.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	760.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000
385.00 nm	1.055E-002 1.197E-002 1.366E-002 1.559E-002 1.773E-002	480.00 nm	8.130E-001 7.705E-001 7.294E-001 6.899E-001 6.521E-001	575.00 nm	1.800E-003 1.766E-003 1.738E-003 1.711E-003 1.683E-003	670.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	765.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000
390.00 nm	2.005E-002 2.251E-002 2.520E-002 2.828E-002 3.190E-002	485.00 nm	6.162E-001 5.823E-001 5.504E-001 5.203E-001 4.920E-001	580.00 nm	1.650E-003 1.610E-003 1.564E-003 1.514E-003 1.459E-003	675.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	770.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000
395.00 nm	3.621E-002 4.144E-002 4.750E-002 5.412E-002 6.100E-002	490.00 nm	4.652E-001 4.399E-001 4.162E-001 3.939E-001 3.729E-001	585.00 nm	1.400E-003 1.337E-003 1.270E-003 1.205E-003 1.147E-003	680.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	775.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000
400.00 nm	6.785E-002 7.449E-002 8.136E-002 8.915E-002 9.854E-002	495.00 nm	3.533E-001 3.349E-001 3.176E-001 3.013E-001 2.862E-001	590.00 nm	1.100E-003 1.069E-003 1.049E-003 1.036E-003 1.021E-003	685.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	780.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000
405.00 nm	1.102E-001 1.246E-001 1.417E-001 1.613E-001 1.833E-001	500.00 nm	2.720E-001 2.588E-001 2.465E-001 2.348E-001 2.235E-001	595.00 nm	1.000E-003 9.690E-004 9.300E-004 8.870E-004 8.430E-004	690.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
410.00 nm	2.074E-001 2.337E-001 2.626E-001 2.948E-001 3.308E-001	505.00 nm	2.123E-001 2.012E-001 1.901E-001 1.792E-001 1.686E-001	600.00 nm	8.000E-004 7.610E-004 7.240E-004 6.860E-004 6.450E-004	695.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
415.00 nm	3.713E-001 4.162E-001 4.655E-001 5.197E-001 5.795E-001	510.00 nm	1.582E-001 1.481E-001 1.384E-001 1.290E-001 1.201E-001	605.00 nm	6.000E-004 5.480E-004 4.920E-004 4.350E-004 3.830E-004	700.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
420.00 nm	6.456E-001 7.185E-001 7.967E-001 8.778E-001 9.594E-001	515.00 nm	1.117E-001 1.039E-001 9.667E-002 8.998E-002 8.385E-002	610.00 nm	3.400E-004 3.070E-004 2.830E-004 2.650E-004 2.520E-004	705.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
425.00 nm	1.039E+000 1.115E+000 1.188E+000 1.258E+000 1.324E+000	520.00 nm	7.825E-002 7.321E-002 6.868E-002 6.457E-002 6.079E-002	615.00 nm	2.400E-004 2.300E-004 2.210E-004 2.120E-004 2.020E-004	710.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
430.00 nm	1.386E+000 1.443E+000 1.495E+000 1.542E+000 1.585E+000	525.00 nm	5.725E-002 5.390E-002 5.075E-002 4.775E-002 4.490E-002	620.00 nm	1.900E-004 1.740E-004 1.560E-004 1.360E-004 1.170E-004	715.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
435.00 nm	1.623E+000 1.656E+000 1.685E+000 1.710E+000 1.730E+000	530.00 nm	4.216E-002 3.951E-002 3.694E-002 3.446E-002 3.209E-002	625.00 nm	1.000E-004 8.600E-005 7.500E-005 6.500E-005 5.700E-005	720.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
440.00 nm	1.747E+000 1.760E+000 1.770E+000 1.776E+000 1.780E+000	535.00 nm	2.984E-002 2.771E-002 2.569E-002 2.379E-002 2.199E-002	630.00 nm	5.000E-005 4.400E-005 3.900E-005 3.600E-005 3.300E-005	725.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
445.00 nm	1.783E+000 1.783E+000 1.782E+000 1.779E+000 1.776E+000	540.00 nm	2.030E-002 1.872E-002 1.724E-002 1.586E-002 1.459E-002	635.00 nm	3.000E-005 2.800E-005 2.600E-005 2.400E-005 2.200E-005	730.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
450.00 nm	1.772E+000 1.768E+000 1.764E+000 1.759E+000 1.752E+000	545.00 nm	1.340E-002 1.231E-002 1.130E-002 1.038E-002 9.529E-003	640.00 nm	2.000E-005 1.800E-005 1.600E-005 1.400E-005 1.200E-005	735.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
455.00 nm	1.744E+000 1.734E+000 1.721E+000 1.706E+000 1.689E+000	550.00 nm	8.750E-003 8.035E-003 7.382E-003 6.785E-003 6.243E-003	645.00 nm	1.000E-005 8.000E-006 5.000E-006 3.000E-006 1.000E-006	740.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
460.00 nm	1.669E+000 1.648E+000 1.623E+000 1.596E+000 1.565E+000	555.00 nm	5.750E-003 5.304E-003 4.900E-003 4.534E-003 4.202E-003	650.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	745.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
465.00 nm	1.528E+000 1.486E+000 1.440E+000 1.390E+000 1.339E+000	560.00 nm	3.900E-003 3.623E-003 3.371E-003 3.141E-003 2.935E-003	655.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	750.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		
470.00 nm	1.288E+000 1.237E+000 1.188E+000 1.139E+000 1.090E+000	565.00 nm	2.750E-003 2.585E-003 2.439E-003 2.309E-003 2.197E-003	660.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000	755.00 nm	0.000E+000 0.000E+000 0.000E+000 0.000E+000 0.000E+000		

## Measurement of Correlated Color Temperature

Correlated Color Temperature (CCT) can be calculated from  $u$  and  $v$  chromaticity coordinates. There are limits to this however, since applying an “equivalent blackbody temperature” to a source that is totally unlike a blackbody is not advisable. CCT values are determined from the coordinate location relative to isothermperature lines.



Two isothermperature lines are shown in the figure above. These lines cross the Planckian locus, and hence the CCT is really the temperature of the blackbody that is closest in color to the lamp.

Some of these isothermperature lines cross, and hence can give strange results if the method is used too far from the Planckian locus. This is generally considered acceptable, since the method is NOT intended for lamps that differ too much from a blackbody. CIE placed recommended limits on the  $uv$  coordinates so the method would not be mis-applied. This limit is 0.0054 units from the Planckian locus, and is specified in CIE Publication 13.3-1995.

Also, any source with  $uv$  coordinates below the yellow isothermperature line in the figure above cannot have a CCT value since there is no isothermperature line possible. This is condition commonly found in “blue” lamps.

Despite these restrictions, many lamp comparisons are still made on the basis of CCT, even when the chromaticity values are well away from the Planckian locus.

## Luminous Intensity Measurement Theory

Luminous Intensity is defined as the luminous flux per unit solid angle in a given direction. The units are candelas (cd) and related to illuminance by the equation:

$$I_v = E_v \cdot d^2 \quad (26)$$

Where:  $I_v$  is luminous intensity (cd),  $E_v$  is illuminance, and  $d$  is the distance from the emitting element to the detector.

The concept of luminous intensity measurement assumes a small sized source relative to the distance between the source and detector. Under such conditions, most sources obey the inverse square law. However, LEDs come in many packages, often incorporating lenses to produce a narrow beam. The lenses make the LEDs emitting elements appear as though they are much further away than their physical location. Because of the difficulties in assigning a physical location to the LED element, the normal definition of luminous intensity cannot be applied. However, historically the value of luminous intensity has been used as a primary parameter in specifying LEDs. The CIE therefore defined the practical term “averaged LED intensity” based on physical dimensions.

### Averaged LED Intensity

CIE Publication 127 solves the issues regarding the difficulties of luminous intensity by departing from the physically precise geometrical demands, and recommends this method of flux measurement for a fixed geometry. This recommendation is now the internationally accepted method of measurement of LED intensity. The recommendation defines a new term, **Averaged LED Intensity**, using the symbols:  $I_{LED A}$  for Condition A and  $I_{LED B}$  for Condition B.

The Averaged LED Intensity conditions as defined by CIE Publication 127 incorporates two measurement geometries. These are classified as CIE Condition A and CIE Condition B. Both conditions require the use of a detector with a circular aperture having an area of  $1 \text{ cm}^2$ . The distances from the tip of the LED to the detector entrance aperture are specified as follows.

CIE 127 Recommendation	Distance LED tip to detector	Approximate Plane Angle (degrees)	Solid Angle (steradians)
CIE Condition A	316 millimeters	2E	0.001 sr
CIE Condition B	100 millimeters	6.5E	0.01 sr

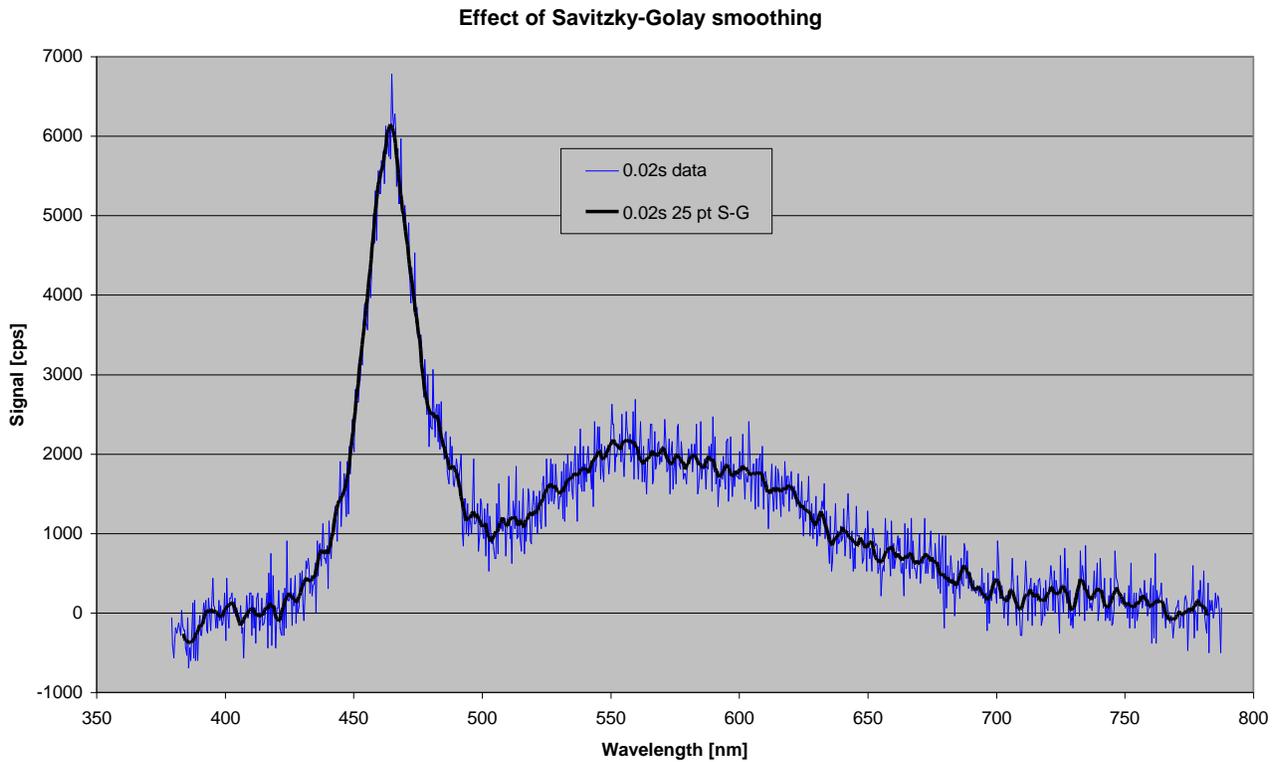
With the detector calibrated for illuminance, the Averaged LED Intensity is calculated from the formula:

$$I_{LED} = E_v \cdot d^2 \quad (26)$$

Where:  $E_v$  is the average illuminance in lux and  $d$  is the distance in meters.  
For Condition A,  $d = 0.316 \text{ m}$  and for Condition B,  $d = 0.100 \text{ m}$ .

## Savitzki-Golay Smoothing

At low signals, noise can be seen on plots. In these cases, smoothing the graphed curve can offer advantages. One method of smoothing is to use a Savitzki-Golay algorithm. This is especially useful since it tends to avoid distortion of the underlying features. To illustrate the effect, the measurement below (blue line) has been deliberately made with very short integration time to make it noisy.



A 25-point Savitzki-Golay smooth (black line) improves the graph without distorting the features.

A Savitski-Golay smoothing works by filtering out changes that are sharper than the number of points selected. As a rule-of-thumb, select the number of points within the Full-Width-at-Half-Maximum (FWHM) of the narrowest real feature to get the best effect. For instance, if there are very sharp peaks in your data, use a small number of points to avoid them being mistaken for noise and smoothed. In general, the higher the number of points selected the smoother the curve is.



## Appendix C

### Warranty

Gooch & Housego warrants that all goods supplied will be of the kind described or in any specification and drawings approved by Gooch & Housego and will be free from defects in material and workmanship for one (1) year from the date of purchase by the original Purchaser. During this period, Gooch & Housego will at its option either repair or replace any goods that are found to be defective in material or workmanship, provided the goods are returned to Gooch & Housego in Orlando, Florida, with all shipping, insurance, and delivery charge prepaid (DDU Orlando, Florida). This Warranty does not extend to batteries, fuses, and glass phototubes (if any), or other items of limited durability, nor does this warranty cover damage to goods caused by leaky or otherwise defective batteries, by Purchaser use of improper batteries and by misuse or abuse, unauthorized alteration, excessive line voltage, excessive temperatures (above 160 degrees F), extreme environmental conditions (such as extremely dusty or wet environment), corrosive atmospheres or servicing by unauthorized personnel. The items returned shall only be accepted when accompanied by a written statement setting forth the nature and suspected cause of the alleged deficiencies. After the initial one (1) year warranty, repairs performed by Gooch & Housego are covered under a limited ninety (90) day warranty. The warranty repaired (and/or replacement) items will be returned DDU to customer. THERE ARE NO OTHER WARRANTIES, EXPRESS OR IMPLIED, (INCLUDING THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR IMPLIED WARRANTY OF MERCHANTABILITY) OTHER THAN THE WARRANTY SET FORTH HEREIN.

### Technical Assistance

If there is any uncertainty about how to install and operate the OL 770 Multi-Channel Spectroradiometer in a safe manner, technical assistance can be received by contacting:

Gooch & Housego  
4632 36<sup>th</sup> Street,  
Orlando, FL 32811  
Phone: 407.422.3171  
Fax: 407.648.5412  
Website: [www.goochandhousego.com](http://www.goochandhousego.com)



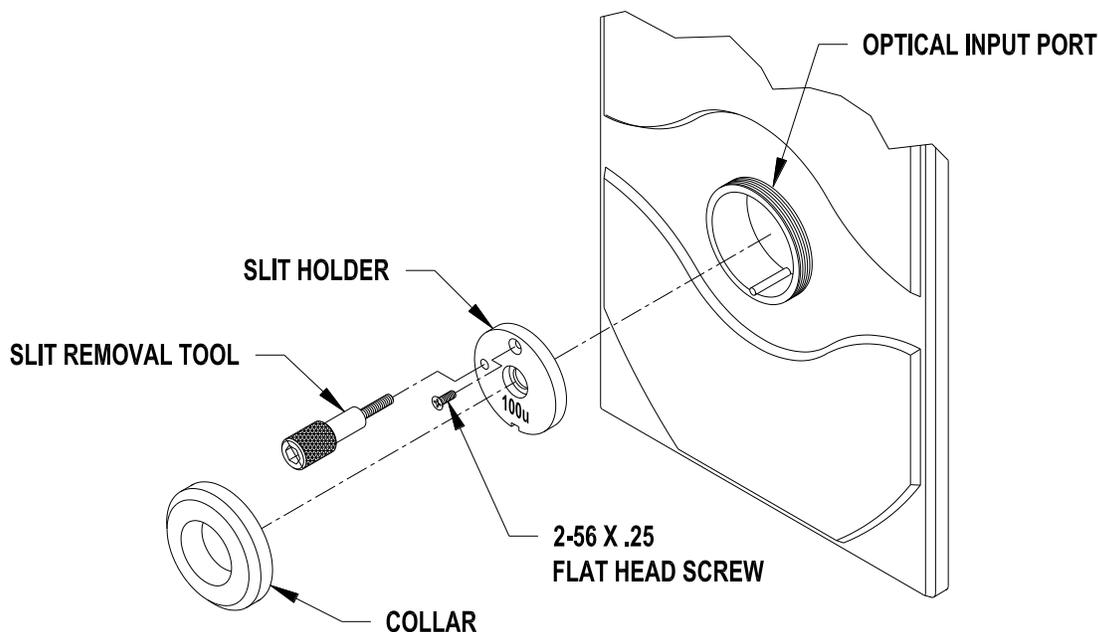
## Appendix D

### Changing the Optical Input Slit

The OL 770 Multi-Channel Spectroradiometer is supplied with a 100 micron slit that is installed into the Optical Input Port on the front panel. To change the slit size:

1. Unscrew the Optical Input Port collar on the front of the unit.
2. Remove the Fiber Optic Probe from the port.
3. Using a small Phillips head screwdriver, remove the 2-56 x 0.25 inch long flat head screw at the top of the slit holder.
4. Remove the existing slit holder from the port using the supplied slit removal tool (see Figure 1D). Screw the threaded end of the tool into the 4-40 tapped hole on the side of the slit holder. Carefully slide the slit holder out of the port.
5. Install the new size slit holder into the port opening with the “slit” side first and the notch in the bottom of the slit holder aligned with the indexing pin in the port opening. The counterbored hole must be facing the outside of the unit.
6. Re-install the 2-56 x 0.25 inch long flat head screw to secure the new size slit holder in place.
7. Install the appropriate Fiber Optic Probe into the port opening.
8. Re-install the Optical Input Port collar to secure in place. Do not overtighten.

Figure 1D – OL 770 Slit Installation/Removal



P001358



## Appendix E

### OL 770 Multi-Channel Spectroradiometer Optional Accessories

The following are optional accessories for use with the OL 770 Multi-Channel Spectroradiometer:

#### ◆ Software Packages:

##### OL 770-423-LED Source Spectral Analysis for LEDs

Provides Spectral Radiant Intensity for Averaged LED Intensity (Condition A and Condition B), Total Spectral Radiance and Luminous Flux, and Goniometric Measurements

##### OL 770-423 Source Spectral Analysis Software

Provides Spectral Radiance and Luminance, Spectral Irradiance and Illuminance, Spectral Radiant Intensity and Candela, and Total Spectral Radiance and Luminous Flux Measurements

##### OL 770-423-LED-Plus Source Spectral Irradiance/Radiance & LED Analysis Software

Combination of the OL 770-423 and OL 770-423-LED Software packages

##### OL 770-423-LED-KI Remote Software for Controlling the Keithley Model 2400/2420/2440/2600

Provides remote control of Keithley Model 2400/2420/2440/2600 series of SourceMeters. Also includes KEITHLEY-SDK Software Development Kit (*SDK does not support the Keithley 2600 Series SourceMeter at this time*) including:

- A sample Keithley SourceMeter® Panel Application Software
- An ActiveX® control
- C++ source code for the sample Keithley SourceMeter Panel Application
- Software Support

##### OL 770-423-NVS Software for Source NVG Goggle Compatibility

OL 770-423 Software with the addition of Pass/Fail results for chromaticity and radiance per MIL-L-85762A, and chromaticity Pass/Fail results for external aviation lighting per SAE AS25050 and SAE A58037

##### OL 770-424 Spectral Linear Transmittance & Specular Reflectance Software

Provides Spectral Linear Transmittance Measurements and Specular Reflectance Measurements

##### OL 770-427 Diffuse Spectral Transmittance & Reflectance Software

Provides Diffuse Spectral Transmittance or Reflectance Measurements

##### OL 770-420 Software Development Kit

Provides:

- Sample Source Code utilizing DLL
- Software Support

#### ◆ Fiber Optic Probes

Optional fiber optic input probes are available (available in other lengths):

- OL 770-7G-1: 3-mm  $\phi$  x 1 meter glass fiber optic probe
- OL 770-7G-2: 3-mm  $\phi$  x 2 meter glass fiber optic probe
- OL 770-7G-3: 3-mm  $\phi$  x 3 meter glass fiber optic probe
- OL 770-7Q-1: 3-mm  $\phi$  x 1 meter UV-grade fused silica fiber optic probe
- OL 770-7Q-2: 3-mm  $\phi$  x 2 meter UV-grade fused silica fiber optic probe
- OL 770-7Q-3: 3-mm  $\phi$  x 3 meter UV-grade fused silica fiber optic probe

#### ◆ Neutral Density Holders and Filters

A range of attenuation filters are available for the OL 770 Multi-Channel Spectroradiometer to extend the measurement range to include high brightness LEDs.

OL 770 Model Number	Calibrated Spectral Range	ND1 Filter Model Number (~10%)	ND2 Filter Model Number (~1%)	ND3 Filter Model Number (~0.1%)	ND4 Filter Model Number (~0.01%)
OL 770UV/VIS	240 nm to 780 nm	OL 770-ND1-UV/VIS	OL 770-ND2-UV/VIS	OL 770-ND3-UV/VIS	OL 770-ND4-UV/VIS
OL 770VIS	380 nm to 780 nm	OL 770-ND1-VIS	OL 770-ND2-VIS	OL 770-ND3-VIS	OL 770-ND4-VIS
OL 770VIS/NIR	380 nm to 1100 nm	OL 770-ND1-VIS/NIR	OL 770-ND2-VIS/NIR	OL 770-ND3-VIS/NIR	OL 770-ND4-VIS/NIR

The OL 770-15Q and OL 770-15Q-A Neutral Density (ND) Filter Holders are used to introduce the ND Filters into the input optical path of the OL 770. The OL 770-15Q-A is an automated ND Filter Holder. The OL 770-15Q and OL 770-15Q-A use UV-grade quartz lenses and can be used over the 200 nm to 800 nm UV-visible wavelength range.

## ◆ LED Holders, Alignment and Adapter Kit

Below is a partial listing of LED Holders that are available from Gooch & Housego. For additional information on standard and custom LED Holders, contact Gooch & Housego, Orlando, Florida.

### OL 700-84-50 Rear Mounted LED Holder:

The OL 700-84-50 accommodates 5 mm, T1¼ flanged LEDs. It provides a simple interface between the LED and the OL 15AB LED Receptor, OL IS-670-LED Integrating Sphere, and the OL 700-30 Goniometer.

### OL 700-80-20/-30 High Precision LED Holder:

- OL 700-80-20 for 2-pin LED packages
- OL 700-80-30 for 3-pin LED packages

These LED Holders are designed to hold leaded 3 mm to 10 mm diameter LEDs. The OL 700-80 series LED holder includes a self-centering clamp to ensure the LED is positioned on the mechanical axis and, if the LED is flanged, pulled down onto its mounting surface.

### OL 700-82-20/-30/-40 Front Mount Socketed LED Holder:

- OL 700-82-20 for 2-pin LED packages
- OL 700-82-30 for 3-pin LED packages
- OL 700-82-40 for 4-pin square LED packages

When the position of the LED is not critical, such as with total luminous flux measurements, the OL 700-82 series LED holder offers a lower cost option to the self-centering high precision holders. The OL 700-82 series is available for two or three pin LED on a 0.1 inch (2.54 mm) lead pitch or four-pin square LED package on a 0.2 inch x 0.2 inch (5.08 mm) lead pitch.

### OL 700-86 Vacuum Chuck LED Holder:

With OL 700-86-XX Mask for Surface Mount/Chip LEDs  
And Optional OL 700-86VP Vacuum Pump

The OL 700-86 LED holder is available with optional interchangeable masks to accommodate the large number of surface mount LED sizes available today. Masks are available separately for specific size LEDs. The OL 700-86 is suitable for forward emitting surface mount LEDs.

When the LED is placed into the mask, a vacuum pump holds the LED securely onto the electrical contacts. Gooch & Housego offers an OL 700-86VP Vacuum Pump Assembly to work in conjunction with the OL 700-86 Vacuum Chuck LED Holder.

### OL 700-88 LED Holder for Luxeon® -style Emitters and LEDs:

- OL 700-88-20 for 2-pin Luxeon-style Emitter LEDs
- OL 700-88-26 for Luxeon-shaped PCB LEDs

The OL Series 700-88 LED Holders are cylindrical assemblies that allow the precise holding and alignment of Luxeon-style emitters and LEDs.

### OL 700-80 Alignment and Adapter Kit

The OL 700-80 Alignment and Adapter Kit is used with the OL Series 700-80/700-82/700-86 LED Holders. The kit consists of:

1. Condition AB Alignment Jig
2. Adapter for the OL 15AB LED Receptor
3. Adapter for the OL IS-670-LED Integrating Sphere
4. Adapter for the OL 700-30 Goniometer

## ◆ OL 700-88TC Temperature Controller

The OL 700-88TC Temperature Controller is designed to provide a method to maintain a stable temperature setting of the LED contact area on applicable Gooch & Housego's series OL 700-88-XXTC LED holders. A selected temperature is controlled by circulating a liquid coolant, in a closed loop system, through a heat sink inside the LED holder. A thermocouple installed in the heat sink is connected to the OL 700-88TC's control circuitry to provide accurate temperature monitoring. The following LED Holders are available for use with the OL 700-88TC:

- ◆ OL 700-88-20TC 2-pin Luxeon-style Emitter LEDs
- ◆ OL 700-88-26TC Luxeon-shaped PCB LEDs

## ◆ OL 700-10 Programmable Precision Power Supply for LEDs

The OL 700-10 Programmable Precision Power Supply for LEDs is a small, self-contained, programmable current or voltage source for use in powering lamps and other loads. It has special features that make it particularly useful for powering LED's. The OL 700-10 is completely controlled by a remote computer via a USB interface.

#### ◆ OL 15AB LED Receptor

The OL 15AB LED Receptor is a convenient accessory designed to measure the intensity of Light Emitting Diodes (LED's). The OL 15AB has been designed in accordance with the CIE Publication 127 measurement recommendations for "Averaged LED Intensity." The geometries of the OL 15AB LED Receptor meet CIE Standard Conditions A and B for "near-field" conditions. The versatile assembly easily adapts to either Condition A or Condition B measurements with a single set of parts.

#### ◆ OL 700-30 LED Goniometer

The OL 700-30 LED Goniometer is designed for performing automated spatial distribution measurements of LEDs and miniature lamps. The OL 700-30 LED Goniometer can be used to characterize sources in a variety of angle dependent measurements and is packaged in a small, fully enclosed, lightweight design.

Measurements that can be performed as a function of angle utilizing the OL 700-30 LED Goniometer and OL 770-LED System include:

- |                     |                            |
|---------------------|----------------------------|
| - Maximum intensity | - Power                    |
| - Chromaticity      | - Tristimulus              |
| - Color temperature | - Purity                   |
| - Lab/Luv           | - CRI                      |
| - Peak wavelength   | - Dominant wavelength      |
| - Relative power    | - Half bandwidth vs. angle |

#### ◆ OL 700-70 Diffuse Reflectance Attachment

The OL 700-70 6-Inch Diameter Integrating Sphere Diffuse Reflectance Attachment is designed to enhance the versatility of the basic OL 770 spectroradiometer measurement system by enabling the user to make spectral diffuse reflectance measurements of various materials over all or part of the wavelength range from 200 nm to 2500 nm. Due to the sophisticated optical design, accurate measurements can be made of specular (mirror) samples as well as diffuse samples with the specular component included or excluded.

#### ◆ OL 700-71 Reflectance/Transmittance Attachment

The OL 700-71 6-Inch Diameter Integrating Sphere Reflectance/Transmittance Attachment is designed to enhance the versatility of the basic spectroradiometer measurement system by enabling the user to make spectral diffuse reflectance and transmittance measurements of various materials over all or part of the wavelength range from 350 nm to 1100 nm. Due to the sophisticated optical design, accurate reflectance measurements can be made of specular (mirror) samples with the specular component included or excluded. Transmittance measurements can be made on a wide variety of sample materials and sizes.

#### ◆ OL 700-73 Solids Transmission Attachment

The OL 700-73 Solids Transmission Attachment (STA) is utilized in conjunction with the OL 770 Multi-Channel Spectroradiometer for performing spectral transmission measurements of samples in solid form. The OL 700-73 STA has a slide-in sample holder that accommodates both 1-inch by 1-inch, and 2-inch by 2-inch square samples, as well as 1-inch diameter and 2-inch diameter round samples. Samples can be up to ½-inch in thickness.

#### ◆ OL 600 Direct Viewing Imaging Optics Module

The OL 600 Direct Viewing Imaging Optics Module is useful for measuring the luminance, radiance or spectral radiance of uniform, diffusely emitting light sources. The OL 600 features:

- Direct viewing (see-through) optical design.
- A 5-position, reflective field-of-view (FOV) aperture wheel that directs the unmeasured portion of the light beam to a viewer eyepiece. Standard FOV aperture diameters are 0.5 mm, 1.5 mm, 3.0 mm, 5.0 mm and 8.75 mm.
- A multi-element, viewer eyepiece with focusing (relay) lens, which yields an approximate 25X magnification (with 200 mm objective lens).
- A 5-position filter wheel for inserting shutter or optional filters in the optical path.
- A relay lens for 1:1 imaging of the target aperture onto the detector or monochromator entrance port.
- Optional interchangeable objective lens mounted in a lens barrel with focus adjustment.

*NOTE: Achromatic telephoto and macro lenses are available for visible photometric measurement applications and fused silica lenses are available for operating up to 2500 nm.*

#### ◆ **OL 610 CCD Imaging Telescope**

The OL 610 CCD Imaging Telescope is useful for measuring the spectral radiance of displays and other light sources.

The OL 600 features:

- Direct viewing (see through) optical design.
- Real time image viewing of the measurement area, seen as a pop-up window in the applications software.
- Choice of either 1mm or 0.5 mm diameter, factory installed field-of-view (FOV) apertures.
- USB interface.
- SMA fiber optical interface to the OL 770 Multi-Channel Spectroradiometer.
- Nikon® F-mount objective lens mounting adapter.
- Interchangeable objective lenses.
- Tripod mounting capability.

#### ◆ **OL 620-NVS CCD Imaging Telescope**

The OL 620-NVS is small, portable and easy to use making it ideal for laboratory, manufacturing, and remote applications. The objective lens is pre-focused to meet the requirements of MIL-L-85762A. The OL 620-NVS incorporates an internal 0.5 mm field-of-view (FOV) aperture. Combined with the 3:1 magnification of the objective lens, the FOV aperture yields a <0.17 mm (<0.0069 inch) measured spot size at 100 mm (approx. 4-inch) focal distance.

OL 620-NVS features:

- Direct viewing (through the lens) optical design
- Real-time image viewing of the measurement area, seen as a pop-up window in the applications software.
- USB interface
- SMA fiber optic interface to OL 770VIS/NIR Multi-Channel Spectroradiometer
- Compact, portable design
- Tripod mounting capability

#### ◆ **OL IS-1800, OL IS-3900, or OL IS-7600 Integrating Spheres**

This series of large integrating spheres is designed for total luminous flux and/or total spectral flux measurement applications. The IS-1800, IS-3900, and IS-7600 have diameters of 18, 39 and 76 inches, respectively, and are coated with the rugged, washable Optolon 2™ Integrating Sphere Spray Coating. The large integrating spheres consist of two hemispheres mounted in a rugged frame equipped with locking casters. The hemisphere separate for ease of opening for installing or interchanging lamps. The sphere design makes provision for using an optional auxiliary lamp. Also, located inside the sphere assembly is a lamp holder mounting plate. The lamp holder plate facilitates the mounting of various types of lamp holders and sockets. A number of commonly used lamp holders, as well as custom lamp holders, are available from Gooch & Housego.

#### ◆ **OL IS-670-LED 6-Inch Diameter Integrating Spheres**

The OL IS-670 6-Inch Diameter Integrating Sphere is designed for measuring the total spectral and luminous flux of LEDs in accordance with CIE and NIST recommendations. The OL IS-670-LED consists of a six-inch diameter, PTFE coated integrating sphere, mounted in the convenient tabletop stand, OL ISA-670-Mount . The sphere has a 90° entrance port to exit port configuration. The sphere also includes an auxiliary (reference) lamp port with an SMA style fiber optic connector.

#### ◆ **OL IS-270 2-Inch Diameter Integrating Spheres**

The OL IS-270 2-Inch Diameter Integrating Sphere is designed for measuring spectral measurements. The OL IS-270 consists of a two-inch diameter, PTFE coated integrating sphere. The sphere has a 90° entrance port to exit port configuration. Four 8-32 tapped holes are provided on the bottom of the OL IS-270 to facilitate mounting the sphere to a fixture.

#### ◆ **OL 770-IS-1 1-inch Diameter Integrating Spheres**

The OL 770-IS-1 1-Inch Diameter Integrating Sphere is designed to replace transmitting cosine diffusers in various source measurement applications. The miniature 1-inch diameter integrating sphere lends itself to applications which require an efficient, wide wavelength range, cosine collector to be positioned in difficult to reach locations. The sphere is OPTOLON 2™ coated and has a 90° entrance port to exit port configuration. The OL 770-IS-1 contains two #4-40 counterbore holes for either front or rear face mounting.





Appendix F  
 OL 770 Multi-Channel Spectroradiometer  
 Rear Panel  
 Auxiliary Interface Input/Output Connector  
 and  
 External Enabled Log Mode Acquisitions

Auxiliary Interface Input/Output Connector

**NOTICE**

This appendix applies to OL 770 Multi-Channel Spectroradiometers that are provided with a 15-pin, female, high-density, D-subminiature I/O connector (HD15F) only. If your OL 770 spectroradiometer is supplied with a different I/O connector, contact Gooch & Housego, Orlando, Florida for auxiliary interface information.

The rear panel I/O connector provides a method to connect the OL 770 to other Gooch & Housego's equipment for the purposes of control and synchronization. Many pins are reserved for future use and are not defined, nor controlled in the software.

**CAUTION**

Do not connect any equipment or cabling to these pins without specific instructions from Gooch & Housego, Orlando, FL.

There are four TTL inputs that are each pulled up to 5 volts with a 10 kilohm resistor. They may be driven by a TTL, open-collector or open-drain output, or by a mechanical switch to ground.

The Integration Trigger (pin 1), is directly wired to the Trigger Input BNC connector on the rear panel, so that the OL 770 may be triggered by either connector. The trigger functions occur upon the falling edge of the trigger input. If the application software settings are configured for hardware triggering, this input will activate a measurement at each falling edge. The maximum trigger rate will depend upon the speed of the host PC and the integration time of the measurement. If triggered again once a measurement is in process, it will be ignored. If triggered before communications resulting from the last measurement are complete, some measurements may be ignored.

The Shutter Enable is active-high (or disconnected). Driving the Shutter Enable pin low prevents the shutter from opening.

There are two Exposure Trigger Output pins that indicate when the shutter is fully open. These pins are both tied to an open-emitter, active-high output.

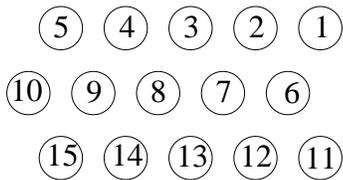
There are four TTL outputs for controlling external accessory equipment. They can drive TTL inputs and other small loads such as opto-isolators.

There are four ground pins and one 5V pin for providing a small amount of power for external circuitry, such as opto-isolators.

**OL 770 Auxiliary I/O Specifications**

	<u>MIN</u>	<u>MAX</u>	<u>UNIT</u>
Input voltage range	0	5.0	V
High-level Input Voltage	2.0	5.0	V
Low-level Input Voltage	0	0.8	V
High-level Input Current		0.001	mA
Low-level Input Current (10 kOhm pull-up)		0.5	mA
Output Voltage Range	0	5.0	V
High-level Output Voltage (at -6 mA)	3.8	5.0	V
Low-level Output Voltage (at +6 mA)	0	0.4	V
Output Current		±20.0	mA
5 V Supply voltage (pin 10)	4.5	5.5	V
5 V Supply Current	0	100	mA

## OL 770 TTL I/O Pinout



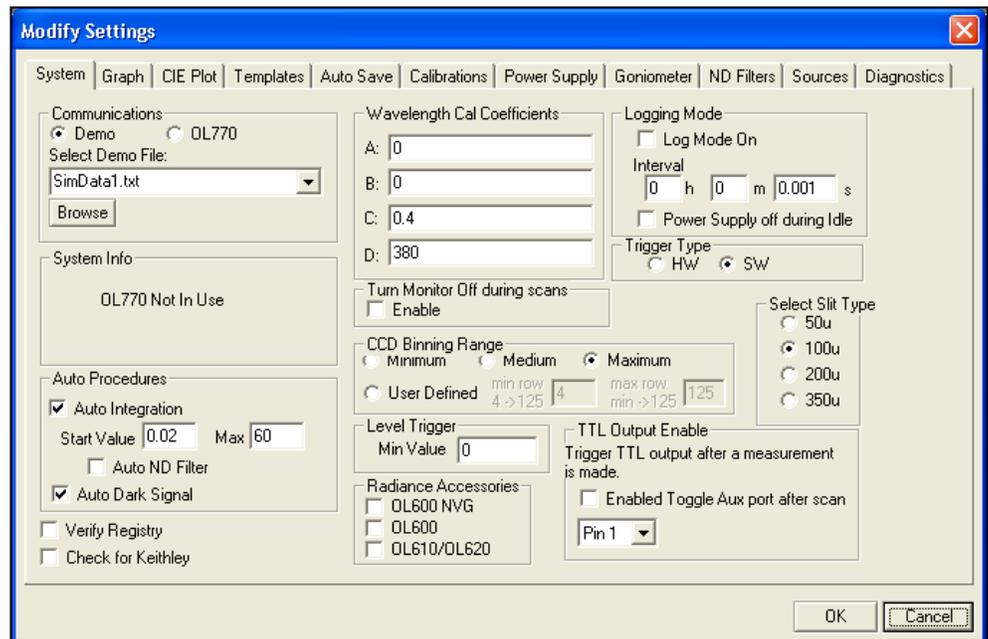
Pin	Signal
1	Input 0 - Integration Trigger (same as BNC input)
2	Input 1 - Read Trigger (not supported / for multiple exposures)
3	Input 2 - Shutter Enable (to inhibit shutter operation)
4	Input 3 - not supported
5	Exposure Trigger Output – active high while shutter is open
6	Ground
7	Ground
8	Ground
9	Ground
10	+5 Volts output – 100 mA max.
11	Output 0 – not supported
12	Output 1 – not supported
13	Output 2 – not supported
14	Output 3 – not supported
15	Exposure Trigger Output – same as pin 5

The OL 770 Application Software has a special feature located under the Modify Settings tab that allows to TTL trigger a pin after a measurement is complete. Check the **Enabled Toggle Aux Port after scan** to use this feature.

Note the software selection that corresponds to the connector pin:

SW      Connector

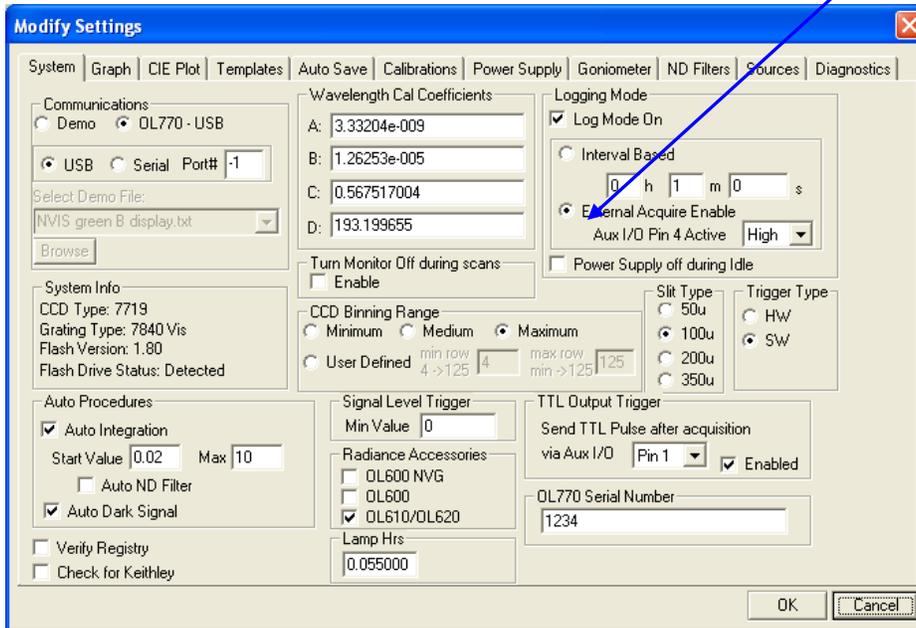
- Pin 1 = Pin 11 Output 0
- Pin 2 = Pin 12 Output 1
- Pin 3 = Pin 13 Output 2
- Pin 4 = Pin 14 Output 3



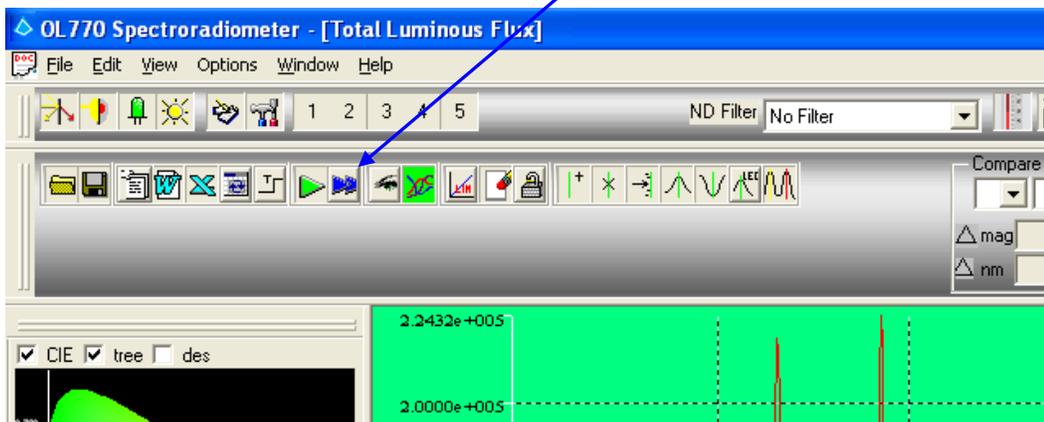
## External Enabled Log Mode Acquisitions

The externally enabled log mode allows a separate device to take control when the OL 770 takes measurements.

To set up the system, open the Modify Settings/ System tab and make sure that the check box labeled **Log Mode On** is checked. **Trigger Type** should be set for **SW** (software trigger). Additionally, select the radio button labeled **External Acquire Enable**. If active **High** is selected, a +5V level on Input pin 4 will allow a measurement. A setting of active **Low** will allow a measurement when the level on pin 4 is zero.

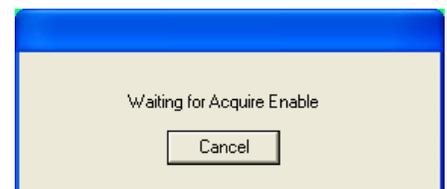


After exiting the System settings tab, the main application will have the following change. Notice that the double arrows once green for continuous mode acquisition are now blue, indicating that the system is ready for *log mode acquisition*.



### Taking Log Mode measurements with External Acquire Enable active:

 Upon clicking the **Log Measurement** button, the OL 770 will begin a measurement sequence. If the TTL state of Aux I/O pin 4 matches your selection (High or Low) under External Acquire Enable, then an acquisition will occur immediately. If the state of pin 4 does not match, a dialog will appear signaling that it is waiting for Acquire Enable to allow a measurement to take place. (This dialog appears in place of the countdown timer dialog used in the time interval log mode.)



Selecting the **Cancel** button will terminate the log sequence and return the software to its original state.

Optionally, once an acquisition is complete, you may use the TTL Output Trigger to signal the same external device to do something prior to the next OL 770 acquisition.



Appendix G  
OL 770 Multi-Channel Spectroradiometer  
RS-232 Serial Port Pin Definition

Wired for DTE operation : Use null modem cable

<u>Pin</u>	<u>Definition</u>
1	DCD
2	RXD
3	TXD
4	DTR
5	GND
6	DSR
7	RTR
8	CTS
9	RIH



## Appendix H

### Installation of the OL 610 CCD Imaging Telescope with Optional OL F770-IRS.30SS1.5 300 $\mu$ m Fiber Optic Probe

The OL 610 CCD Imaging Telescope may be supplied with an optional OL F770-IRS.30SS1.5 300  $\mu$ m Fiber Optic Probe (FOP). The FOP is a 300  $\mu$ m diameter x 1.5 meter<sup>1/</sup> VIS/NIR silica fiber optic probe. When the optional FOP is supplied, the strain relief on the OL 610 is a modified two-piece clamp assembly. Refer to the following instructions for installation of the optional FOP to the OL 610:

1. Install the desired Series OL 610-L-XXX Objective Lens onto the front of the OL 610.
2. It is important to ensure that the lens aperture is set to its largest open aperture (smallest numerical value) by turning the aperture ring on the lens body.

**\* CAUTION \***

Changing the lens aperture to a setting other than the one the instrument was calibrated at invalidates the calibration applied to the measurement. Always ensure that the appropriate aperture setting on the lens is selected for a given calibration.

3. Connect the USB cable from the rear of the OL 610 to an available USB port on the rear of the OL 770. (A computer's USB interface port can also be used.) **Notice:** Install the drivers before plugging in the USB cable - refer to the OL 610 manual.
4. Remove the Collar from the OL 770 Optical Input Port. (The Collar is supplied attached to the OL 770 from the factory.) Slide the Collar over the free end of the OL F770-IRS.30SS1.5 FOP. Install the FOP with its Adapter into the Optical Input Port, aligning the slot to the indexing pin.

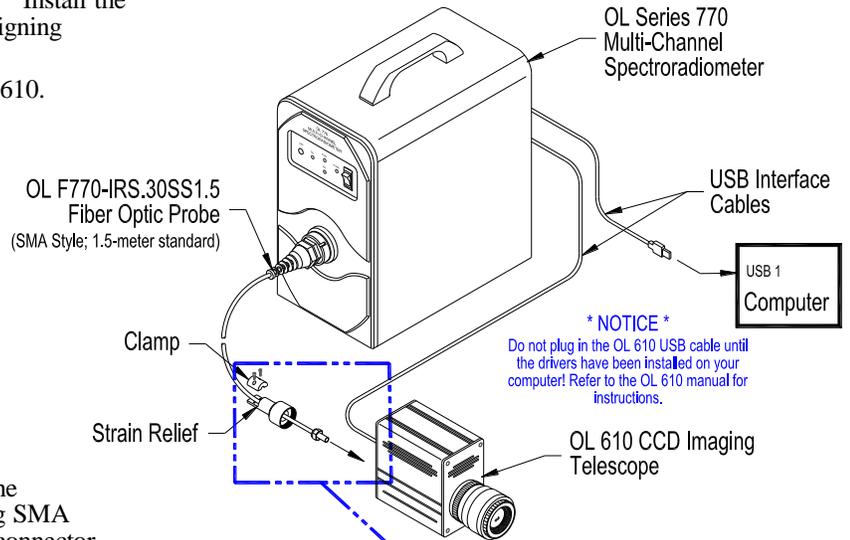
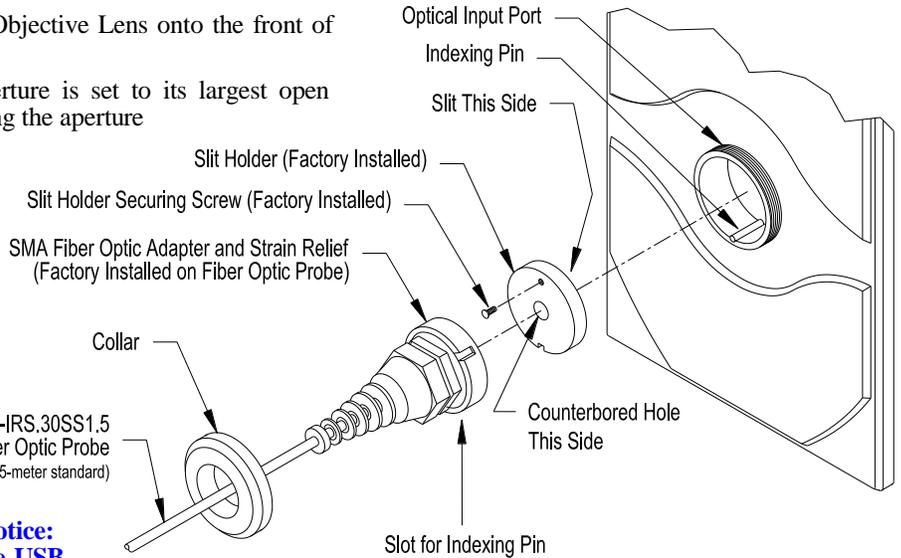
5. Remove the Strain Relief from the rear of the OL 610. (The Strain Relief is supplied attached to the OL 610 from the factory.) Remove the clamp from the Strain Relief. Slide the Strain Relief over the free end of the OL F770-IRS.30SS1.5 FOP. Connect the FOP to the mating SMA connector on the rear of the OL 610. The SMA fiber connector contains an indexing pin that mates with a keying slot on the OL 610 rear connector. **Be sure the indexing pin inserts into the keying slot on the OL 610 rear SMA connector. An alignment mark on the FOP must line up with the keying slot.** Gently tighten the SMA fiber connector's securing nut. (If the indexing pin is not seated into the keying slot, the threads of the securing nut will not engage the threads of the mating SMA connector.) Slide the Strain Relief over the SMA connector. Gently screw the Strain Relief onto the threaded collar on the rear of the OL 610 to secure in place. Replace the clamp and secure with the supplied cap screws. **Do not overtighten.**

**\* CAUTION \***

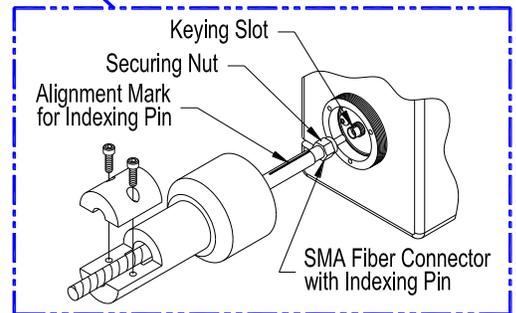
Avoid excessive bending of the OL F770-IRS.30SS1.5 Fiber Optic Probe. Bending of the fiber may cause changes in its transmittance properties. Excessive bends may permanently damage the fiber.

**NEVER** remove the FOP without removing the clamp first. Severe damage to the FOP will occur if the clamp is not removed first.

6. Connect a USB cable from the rear of the OL 770 to one of your computer's USB ports.
7. Turn on "power" to the OL 770 Multi-Channel Spectroradiometer.



**\* NOTICE \***  
Do not plug in the OL 610 USB cable until the drivers have been installed on your computer! Refer to the OL 610 manual for instructions.



P001356A/P001528J

<sup>1/</sup> The OL F770-IRS.30SS1.5 1.5-meter length is standard, other lengths are available: OL F770-IRS.30SS2.0 2-meter and OL F770IRS.30SS3.0 3-meter.







# Appendix I

## Manual Installation of OL 770 Spectroradiometer USB Drivers

The following instructions describe installing the OL 770 USB drivers manually:

1. Ensure the USB cable is connected between the OL 770 spectroradiometer and the computer. The computer should be turned on and the Windows operating system should be running.
2. Turn ON the power switch on the OL 770 Spectroradiometer front panel. When switching ON the OL 770 for the first time, the Windows operating system will automatically open a New Hardware Wizard. From this screen, choose **No, not at this time** in the response to *Can Windows connect to Windows Update to search for software?*

Click **Next** to continue the wizard.

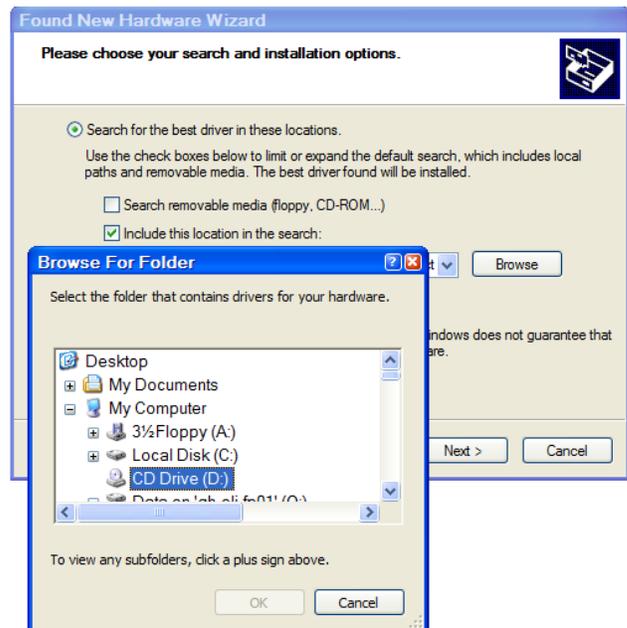


3. The next screen will prompt *What do you want the wizard to do?* Choose **Install from a list of specific location (Advanced)**.

Click **Next** to continue the wizard.



4. On the next screen, choose the radio button **Search for the best driver in these locations**. Then check the box next to **Include this location in the search**. Click the **Browse** button and select the drive for the OL 77X Installation CD, then click **OK**. The following screen will show the files being copied.



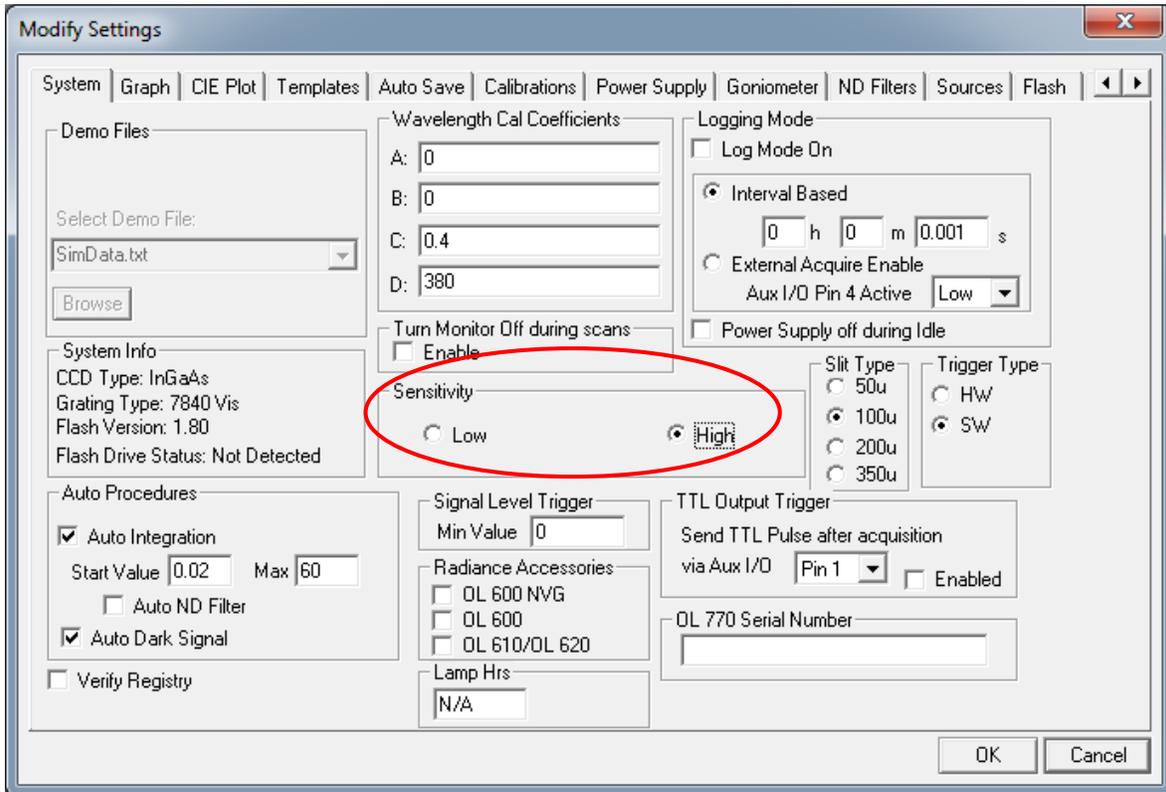
5. After the files have installed, you will be greeted with the final screen declaring the wizard has finished installing the software. The click **Finish** to close the wizard.



## Appendix J InGaAs Sensitivity Setting

The OL 770 InGaAs Spectroradiometer has an additional setting available for signal sensitivity. The options are low and high. This setting is stored in the data, CALX and ST7X calibration files. The settings must agree between the calibration file and the current measurement being performed, if the settings conflict the user will be prompted.

Use of the low sensitivity mode is intended for measurements of sources with moderate to high output intensity. The user may wish to select high sensitivity when low sensitivity measurements require long integration times. A calibration is required for each setting of each measurement type. This is necessary to retain pixel to pixel gain correlation.









# ***DECLARATION OF CONFORMITY***

(In accordance with EN 45014)

*We,*

**Optronic Laboratories, LLC  
DBA Gooch & Housego  
4632 36<sup>th</sup> Street  
Orlando, Florida 32811**

*declare under our sole responsibility that the product,*

- OL 770 Multi-Channel Spectroradiometer
- OL 700-30 Goniometer Accessory

*to which this declaration relates is in conformity with the following standards or other normative documents:*

**EMC: EN 61326: 1997 / A1: 1998  
EN 55011: 1998 / A1: 1999 Group 1, Class A  
FCC Part 15 / Class A  
IEC 1000-4-2: 1995  
IEC 1000-4-3: 1995  
IEC 1000-4-4: 1995 / EN 61000-4-4: 1995  
IEC 1000-4-5: 1995 / EN 61000-4-5: 1995  
IEC 1000-4-6: 1996 / EN 61000-4-6: 1996  
IEC 1000-4-11: 1994 / EN 61000-4-11: 1994  
IEC 1000-3-2: 1995 / EN 61000-3-2: 1995  
IEC 1000-3-3: 1994 / EN 61000-3-3: 1995**

*following the provision of EMC Directive 89/336/EEC and Low Voltage Directive 2006/95/EC.*

**LVD: EN 61010-1: 1995**

*Orlando, Florida 32811 U.S.A.*

 3/16/10  
Signature and Date

**Bob Bronson, VP of Engineering**  
*Typed Name and Title*







**DO NOT DISCARD – KEEP THIS SHEET WITH PRODUCT**

## China RoHS Disclosure Report OL 770 Multi-Channel Spectroradiometer

This report provides product information required by the People's Republic of China Electronic Industry Standard SJ/T11364-2006 to report certain hazardous substances that an electronic product may contain. The "40" in the symbol means the product will not have a negative impact on the environment for 40 years when used and stored as directed. The date of manufacture can be determined from the product serial number – contact Optronic Laboratories for information when needed.



Hazardous Substance						
Component Name	Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Hexavalent Chromium (Cr6+)	Polybrominated Biphenyls (PBB)	Polybrominated Diphenyl Ethers (PBDE)
Chassis (plastic/rubber)	0	0	0	0	0	0
Chassis (metal)	0	0	0	0	0	0
Power Supply Components	X	0	0	0	0	0
Printed Circuit Assemblies	X	0	0	0	0	0
Wire and Cable	0	0	0	0	0	0
Connectors	0	0	0	0	0	0
Fasteners	0	0	0	0	0	0
Accessories	X	0	0	0	0	0

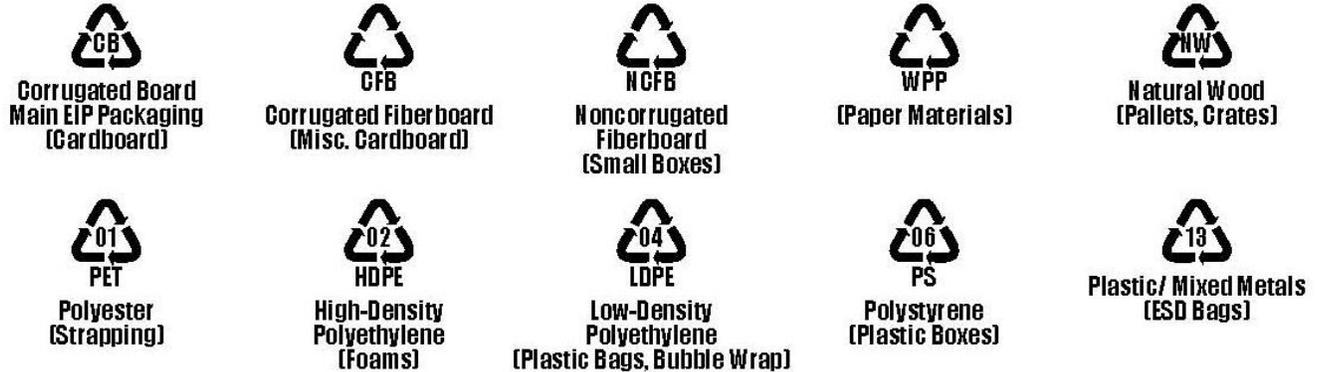
**Notes:**

- In the table, "0" indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.
- In the table, "X" indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T11363-2006.

### Packaging Recycling Marks

EIP packaging is marked in accordance with the needs and requirements for recycling, reuse, and regeneration, as defined in standard GB 18455-2001, *Packaging Recycling Marks*.

As specified in SJ/T 11364-2006, the following packaging information may be used for instances in which it is not possible to provide recycling marks on the packaging material.



The crossed out "wheelie bin" symbol on the product means the product must not be placed in the trash, but must be re-cycled as electronic waste according to the European Union directive: 2002/96/EC.



Gooch & Housego has taken reasonable steps to provide representative and accurate information, but makes no representation of warranty as to the accuracy of such information. In no event shall Gooch & Housego liability arising out of such information exceed the warranty and limitation of liability in Gooch & Housego standard warranty statement.

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