ATTONICS Systems

ATTO^3 Spectrometer

Atto^3 Manual 1.6
Jun 2020

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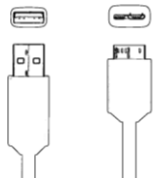
Manual Revision History

Ver	Release Date	Notes	Affected Sections
1.0	08/07/2019	First Formal Release	
1.3	04/11/2019	Updated Software look and feel and added technical notes	
1.4	04/12/2019	Added new software features, application notes	
1.5	12/03/2020	Added White lid referencing procedure to the appendix AN1.	
1.6	2/6/2020	Added the section for App3: Recording	

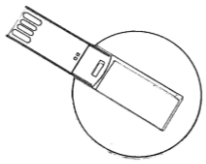
What's Inside the Box

1 Attonics Spectrometer

2 USB3.0 interface cable



3 Flash drive



Before you start

Hardware Requirements	
CPU	Intel Core 2 Duo or higher
RAM	4 GB or higher
Hard Drive Space	1 GB for the software
USB Port	USB 3.0 port(preferred) USB 2.0 port compatible

Software Requirements	
Operating System	Windows 10

Caution

Mechanical Shock

This product is sensitive to mechanical shock, improper handling can cause permanent damage to the product. Do not handle or expose to shock while product is in operation. Handle with great care.

Heat Build-up

It is recommended to disconnect the device when not in use. The electronic components inside may cause a heat build-up inadvertently leading to partial damage or failure.

Install Software before Connecting

Be sure to install the software BEFORE connecting the spectrometer to your PC. The software installs the drivers required for spectrometer installation. If you do not install the software first, the computer will not properly recognize the spectrometer.

Safety from dirt and liquid

To ensure the optimal performance of the device, please ensure that no solids or liquids enter. the spectrometer through the input port.

Active Illumination based Devices

Beware of the illumination light sources at the entrance of the spectrometer. The light sources are very bright for normal viewing and should not be directly viewed at any point of time. Bright light exposure can cause temporary blindness.

Device Features

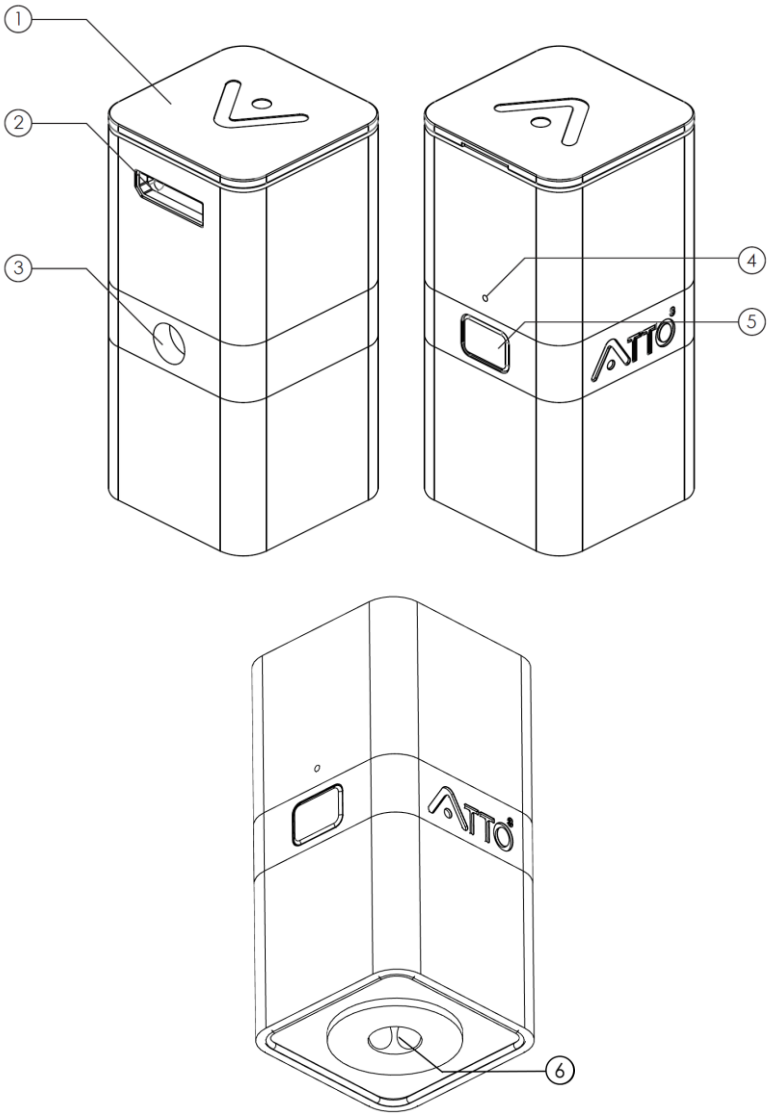


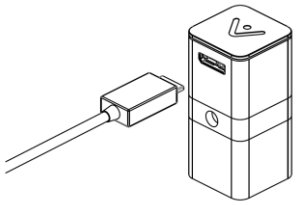
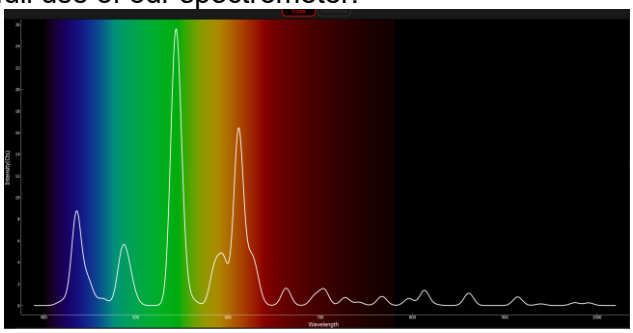
Figure 2.

1. Reference Standard / Safety Cover
2. Female USB 3.0 Micro B port
3. Tripod Socket
4. LED Indicator
5. Snap Button
6. Spectrometer Entrance Port

Technical Specs

Wavelength Range	**380 nm – 1020 nm**
Peak Repeatability	**< 1 nm**
FWHM	**12 nm (customisable to 2 nm)**
SNR	**> 1000:1**
Dynamic Range	**12 bit**
Integration Time	**10 µs to 1 s**
Numerical Aperture	**0.3 ***
Measurement Speed	**50 frames per sec***
LED*	**White High CRI LED UV LED(398 nm),**
Supply Voltage	**5 V, USB based connection**
Power Consumption	**0.4 W (CMOS) 0.1 to 1 W (LEDs) ***
Operation Temperature	**–30°C to +70°C**
Size / Dimensions	**32 mm x 32 mm x 64 mm**
*** based on configuration, customisable**	

Quick Startup Guide

1	Install the software located inside the flash-drive provided by Attonics. Run the **attonicssetup1.X.X.exe** using administrator privileges. Password for the setup is “atto3”. In case of an error during auto-launch of Attoview.exe, please ignore and open it manually from the installed location. *Tip: check the check box - place a shortcut on desktop*
2	Launch the Attonics software AttoView.
3	Locate the USB cable provided with the spectrometer. Connect the USB type-A end to the computer and USB type-micro B end to the Attonics spectrometer. 
4	The software detects the device as soon as it is connected.
5	Once it is connected, all the features based on the spectrometer are activated. 
6	You can capture the spectrum in the following modes: 1. **Acquire Live** 2. **Acquire a Snap** 3. **Acquire Snap using HW trigger**
7	Place your spectrometer bottom side up looking at any ceiling light. Click **Snap** icon to get a single shot spectrum of the light source.
8	If you see a spectrum in the spectral window, you have now been initiated into the black magic of spectroscopy. You are welcome! Go ahead and explore all the features to make full use of our spectrometer.  Typical spectrum recorded by our spectrometer for a fluorescence lamp

General Introduction

Attonics Systems is disrupting the field of spectroscopy. Our innovative spectrometers are based on a novel interferometer design that allows the spectrometer to be as compact as possible yet comparable to a lab grade spectrometer. Our patented manufacturing technique enables a new platform for spectroscopy based on interferometry instead of conventional gratings. By realizing a spectrometer conveniently held within your palm and yet have research grade precision is a revolution. Our compact, rugged spectrometers are easily adaptable to any existing optical setup for spectral monitoring.

Unique Features

- Compact Size
- Low Cost
- Interferometer based sensor: High resolution, high throughput as opposed to high resolution low throughput for grating based spectrometers
- Wide range spanning the entire CMOS range (380-1020)
- 1 nm repeatability
- 12 nm FWHM (customizable down to 2 nm)

Cost effectiveness and compactness

High resolution and lab grade spectrometers and spectrophotometers are expensive with a price tag in excess of US$ 20k and difficult to maintain. The cost for using spectrometers as detectors is, therefore, cost-prohibitive and many applications can't afford precise spectral monitoring. We overcome the cost disadvantage while providing high spectral resolution for process monitoring. The dimensions of the active device are 32 x 32 x 66 mm^3 making it ultra-compact and suitable for applications hitherto impossible. Compact size means it can be easily adapted to any viewport.

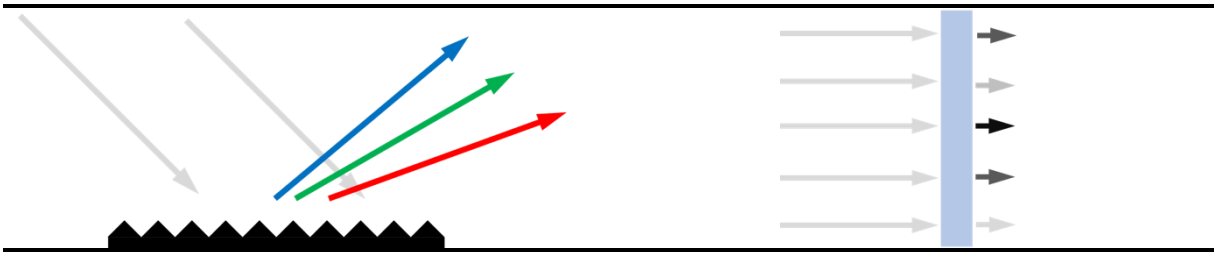
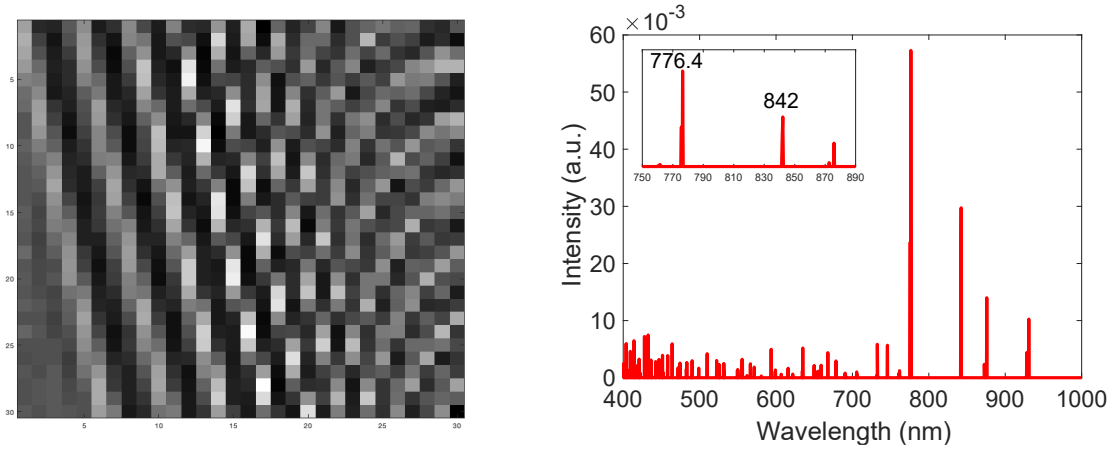


Fig. 1: *a) Schematic of a grating spectrometer dispersing a collimated beam of light impinging on the grating into its spectral components. A detector downstream the grating reads the individual wavelengths as a function of angle or location. Spectral separation depends on collimation, dispersion and distance from the grating. b) Schematic of the Attonics Systems interferometer. A collimated beam of light transmits through a 3-dimensionally structured micro/nano textured surface. Light rays interfere and form a unique fringe pattern on an array detector in proximity. The forming fringe pattern are mathematically translated into spectral information. Spectral separation depends on the maximum phase delay generated in the textured surface.*



(a) (b)

Fig. 2: *a) Typical interference pattern for oxygen plasma, b) Spectra computed from the interference pattern. The oxygen plasma is maintained with a 20 SCCM gas flowrate at a pressure of 150 mTorr and 100 W RF Power. The inset of the figure shows a magnified view of oxygen emission lines in the spectral band ranging from 750 to 890 nm.*

Interference vs Dispersion

Contrary to conventional UV-VIS spectrometers which rely on the dispersion of a collimated beam of electromagnetic radiation into its spectral elements by a high precision, finely ruled and costly grating, we utilize a static array of unique interferometer channels producing a distinctive wavelength dependent interference pattern on a detector array (Fig. 1). Each interference pattern is unique to a given wavelength and can be mathematically translated into spectral information. Fig. 2(a) demonstrates a typical interference pattern recorded by our spectrometer capturing the oxygen plasma emission.
Unlike the dispersion of light e.g. by a grating (requiring a wave to travel comparably long distances until it separates into spectral components), the interference allows us to construct extremely compact spectral solutions thereby saving cost and space. Furthermore, our interferometer array allows large field of views while offering the multiplexing advantage known for conventional Fourier transform interferometers.

The interferometer chip is placed in front of a CCD or CMOS array detector into a collimated beam of light coming from the plasma source. In its essence, our interferometer chip converts a standard monochrome camera into a spectrometer engine. The spectral working band of the camera thereby determines the spectral bandwidth of the device. Its spectral resolution is tailored by the design of the chip and mainly governed by the maximum optical path difference generated in the interference structure of the chip. In the current device, the peak full-width-half-maximum is 12 nm. Its spectral bandwidth is determined by the sensitivity curve of the CMOS detector and ranges from 380 nm to 1000 nm whereby our chip enables a 1 nm wavelength interval throughout. Neither order sorting filters nor long collimators are required further reducing the complexity of the optical system to a bare minimum.

Spectroscopy Introduction

What is spectroscopy?

Spectroscopy in its broadest sense is the study of the interaction between matter and electromagnetic radiation. Spectroscopy involves separating light into its constituent wavelengths and reading out the intensity distribution versus wavelength. Different methodologies of spectroscopy provide information of the sample based on its interaction with electromagnetic radiation. Measurement of scattering, reflection of incident radiation from a surface/sample provides its scattering properties. One can also measure the transmission of electromagnetic radiation and estimate its absorbance that unravels the molecular fingerprints of the constituents of the sample be it solid, liquid or gas.

Reflectance, Transmittance & Absorbance

The reflectance (**R(λ)**) of an object is measured as follows:

- Measure Dark Spectrum(optional)
- Measure the spectrum of the illuminant also known as bright spectrum (**B(λ)**)
- Optionally subtract the dark spectrum (**D(λ)**)
- Divide the measured spectrum (**S(λ)**) by the bright spectrum (**B(λ)**)

$$R(\lambda) = \frac{S(\lambda) - D(\lambda)}{B(\lambda) - D(\lambda)}$$

The transmittance (**T(λ)**) of an object is measured as follows:

- Measure Dark Spectrum(optional)
- Measure the spectrum of the illuminant also known as bright spectrum (**B(λ)**)
- Optionally subtract the dark spectrum (**D(λ)**)
- Divide the measured spectrum (**S(λ)**) by the bright spectrum (**B(λ)**)

$$T(\lambda) = \frac{S(\lambda) - D(\lambda)}{B(\lambda) - D(\lambda)}$$

Absorbance is typically derived as follows:

$$A(\lambda) = 1 - T(\lambda) - R(\lambda)$$

Typically, Beer's law is used for the calculation of absorbance for liquid/solution samples. According to Beer's Law (also known as Beer-Lambert law) that the absorbance of a solution will depend directly on the concentration (**c**) of the absorbing molecules and the pathlength (**l**) travelled by light through the solution.

$$A(\lambda) = \varepsilon(\lambda)cl$$

where $\varepsilon(\lambda)$ is the molar absorptivity of the sample. By measuring the transmittance also given as $T(\lambda) = \frac{I(\lambda)}{I_0(\lambda)} = e^{-\varepsilon cl}$, we can estimate the absorbance as follows: $A(\lambda) = -\log T = \varepsilon(\lambda)cl$ where A(λ) is dimensionless.

Fluorescence

Fluorescence is a very important technique to resolve single molecules and commonly used to understand the electronic structure of a molecule or an atom. Fluorescence is the light emitted by an electron that is excited from ground state to excited state by a photon. The emitted light typically has longer wavelength than the wavelength of excitation.

Most of the dyes generally have an absorption peak in the UV (360-400 nm) region of the electromagnetic spectrum. Attonics spectrometers can be customized to UV LED or any desired illumination for measuring fluorescence. For example, if a sample is excited at UV, the UV light is filtered using a long pass filter above the excitation wavelength to avoid saturation of the detector caused by the UV light source.

Colorimetry

As for every spectroscopy system, the Atto^3 sample measurement consists of two independent measurements, a reference and a sample spectrum measurement: First, a bright spectrum must be taken. The bright spectrum measures the emission of the spectrometers light source alone. To take the bright spectrum the device is placed onto, e.g. a white reference surface meant for colorimetry and the bright or reference spectrum is recorded. This measurement is commonly referred to as the source spectrum $I_{0\,(\lambda)}$. The user confirms the measurement of the white standard by pressing "collect bright spectrum".

Second, the sample measurement is taken $I_{S\,(\lambda)}$ by placing the device onto the sample surface.

The device then computes the sample reflectance spectrum $R_{(\lambda)}$ by:

$$R_{(\lambda)} = \frac{I_{0\,(\lambda)}}{I_{S\,(\lambda)}}$$

In the Atto^3 software, once the bright spectrum is taken, the computation of reflectance spectrum $R_{(\lambda)}$ is automatically implemented, subsequent spectra are compared against the bright spectrum. To be able to see the reflectance spectrum, please enable the Reflectance Tab on the plot. This disables the Scope tab. Reflectance is plotted as a normalized spectrum ranging from 0 to 1. Since the

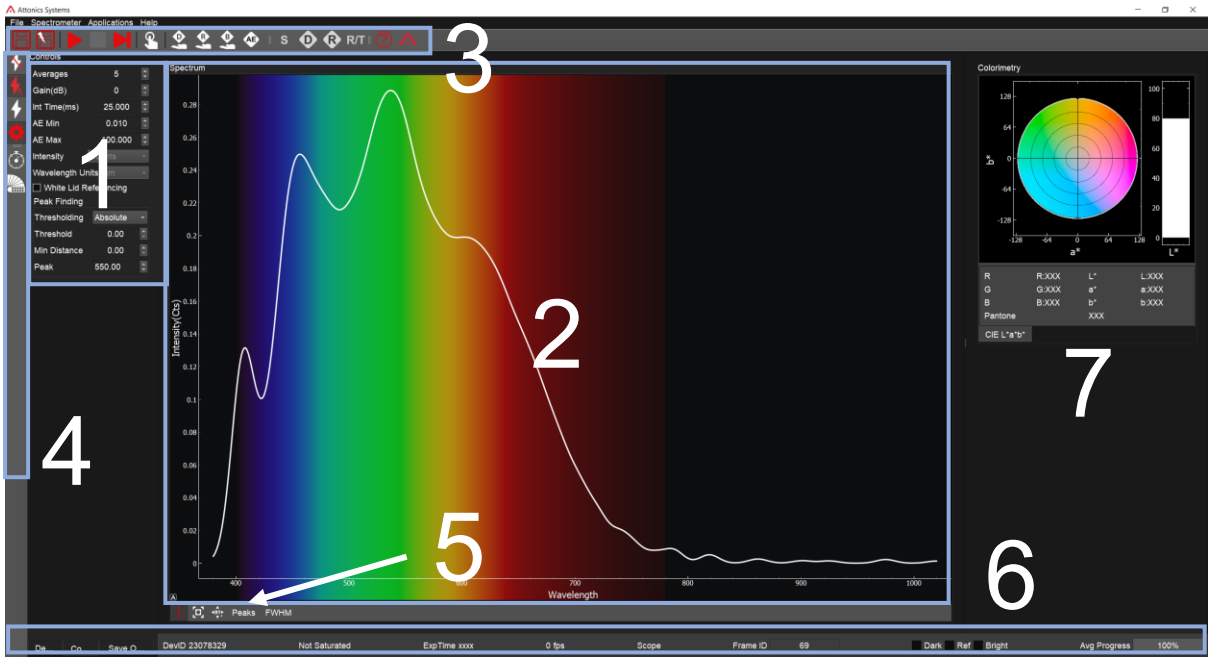
source spectrum spans from 400 to 750 nm, hence the reflectance plot is only plotted from 400 to 750 nm.

All related colour information such as colour coordinates (CIE, CIE LAB, sRGB) are computed from the reflectance spectrum $R_{(\lambda)}$.

Consequently, the correct measurement of $I_{0\ (\lambda)}$ by appropriate selection of a reference surface are of paramount importance, particularly when accurate colour data is required. This is further discussed in the appendix note AN1.

Software Description

AttoView Software Main Screen



1	**Controls**	Spectrometer's settings such as gain and integration time are set here.
2	**Spectrum Window**	This is where the spectrum appears.
3	**Main toolbar**	Acquisition Modes, Collect Dark, Reference, Bright And Post processing of spectra can be done here: Scope, Dark Correction (DC), Reference Correction (RC), Reflectance/Transmittance Mode (R/T)
4	**Side toolbar**	Toolbar for Flash Settings, Trigger, Colour and Time Series
5	**Plot features**	Plot scale settings, peak finder and FWHM
6	**Indicators**	Device details and status indicators from the connected spectrometer are displayed here
7	**Colorimetry charts**	RGB values and CIE Lab, xy charts

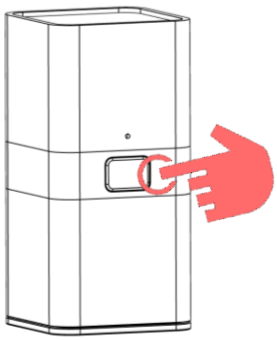
Software Features

Acquisition Modes

Live Acquire: This is a continuous (free run) acquisition mode. The spectra are collected as rapidly as permissible by the spectrometer. For continuous or transient monitoring, this acquisition method is recommended.

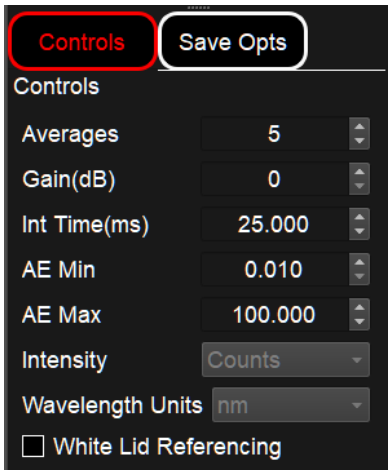
Snap: This mode enables software triggered single shot spectrum acquisition. The spectrum is collected only once. For single shot evaluation of your sample, this method is recommended.

HW trigger Snap: This enables HW triggered acquisition mode. The spectrum is collected only once when the switch on top of the spectrometer is clicked. For single shot evaluation of your samples, this method is recommended.



Spectrometer Controls :

Integration Time	Sets the integration time, the time over which the detector captures incident light. At the end of the integration time the accumulated signal is read from the detector by the electronics. Minimum is 10 us. Maximum is 1s.
Gain	Sets the gain on the device to capture low level light signals. Use only in case of low light. High gain can lead to nonlinear spectral/intensity inaccuracies. Maximum setting allowed is 18.
Averages	Signal, especially at low levels, is significantly impacted by noise. Averaging several spectra together reduces the impact of noise and improves the accuracy of the result. Maximum averages are limited to 100. Use higher integration times to record low light spectra. Please note that, at long integration times, averaging can increase the total time of a measurement significantly.

AE min	Sets the minimum exposure time limit for AE mode.
AEmax	Sets the maximum exposure time limit for AE mode.
Units	Intensity is set in counts. Wavelength is set in nm. Presently, the units are fixed and in future versions, the units can easily be changed by user.
White Lid Referencing	Enables referencing the bright spectrum with the white lid provided with spectrometer. Please refer to Appendix Note AN 1 for more details.
Controls Widget	

Indicator Bar

DevID	This shows the device ID of the spectrometer connected to the computer.
Saturation Flag	Detects saturation in the detector and turns red to indicate the user that spectrometer is saturated.
ExpTime	Displays current exposure time in milliseconds.
Frame Rate	Frame rate in spectra per second for live mode.
Mode	Shows the present mode of spectrometer with applied spectral corrections. For example, Scope DC is displayed when the mode is set to Scope and Dark correction is applied.
Spectra ID	Identification number (ID) of the spectra recorded. Resets after ever Live mode ends.
Dark Collected Reference Collected Bright Collected	These flags indicate whether the user has already collected the dark, reference and bright spectra. Dark Correction (DC), Reference Correction(RC), and Reflectance/Transmittance(R/T) modes are not allowed until their respective spectra are collected. These are described in spectral processing section.

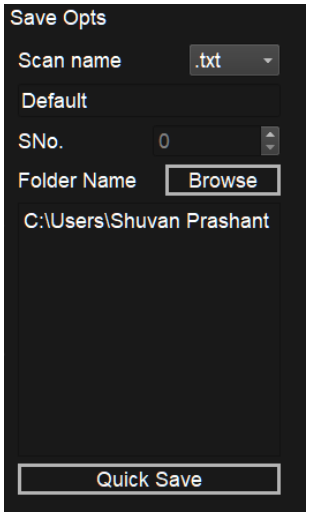
Progress Bar During averaging, the progress bar updates from 0 to 100 as it captures entire sequence.

Saving Data

Save spectrum: This icon opens a save file dialog for user to save the current spectrum in a folder.

Quick Save saves the file instantly without opening a file dialog to a preassigned file path in the scan opts widget.

Scan Opts widget



This widget helps in saving spectra with a defined scan name in a preassigned folder. To use this feature, type in the scan name for your dataset, add a folder name using browse. Quick Save saves the file instantly without opening a file dialog. It uses the **Scan name** and adds a rolling number to keep saving multiple files without having to rename.

Spectral Processing

Collect Dark, Reference and Bright spectrum

Collect Dark spectrum: Any detector has a constant dark noise arising due to various factors such as fixed pattern noise, etc. It is important to remove the dark noise to get correct spectrum. Dark spectrum, as the name suggests, is captured only when the light source is OFF to remove any background from the ambient environment.

Collect Reference spectrum – Reference spectrum is useful for subtracting out the contribution of a background arising due to fluorescence of the substrate or due to ambient lighting.

Collect Bright spectrum – Bright spectrum is captured to make the spectrum signal relative to it. It is a normalization of the signal against the bright spectrum. Typically, this is taken with a reference sample and the light source turned on.

The following applies to all the above collection modes. In Live Capture Mode, the next spectrum is set as Dark/Reference/Bright spectrum as soon as the user clicks the respective icon. If the spectrometer is not acquiring, a snap is initiated and spectrum is captured. For HW triggered Snap, the user needs to press the switch to capture the spectrum.

Spectral View Modes

Scope **Scope Mode(S):** Shows only raw spectrum with no post processing.

Reflectance **Reflectance:** Divides the processed spectrum with bright spectrum yielding reflectance based on the measurement methodology.

Spectral Processing

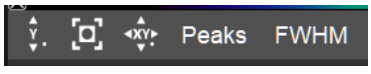
Dark Correction(DC): Subtracts the dark spectrum collected before. Here, icon denotes that it is enabled. Ensure that the correction is on to get the right spectrum.

Reference Correction(RC): Subtracts the reference spectrum. Here, icon denotes that it is enabled. Ensure that the correction is on to get the right spectrum.

Auto Exposure Mode(AE): In this mode, the spectrum captured is divided by the exposure time and exposure time is automatically varied to get the maximum signal. This mode is very useful for measurements which need high dynamic range, have low light collection. For example, dark colour measurements suffer from low light reflected back and hence suffer from higher measurement error. AE mode takes care of low light collection by increasing the integration time to the appropriate amount to boost the signal-to-noise ratio.

Other Features

Plotting Features

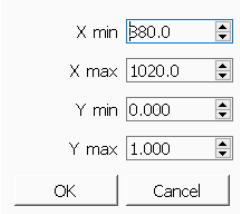


Plot Toolbar

Autoscale Y: Set the Y scale automatically based on the live spectrum.

Rescale XY: Rescale XY axes to maximum limits once. After that it returns to the manual or Autoscale Y mode.

Manual Scale: Set the manual scale as per user's requirement to specific plot limits. Opens a dialog box as seen on the right.

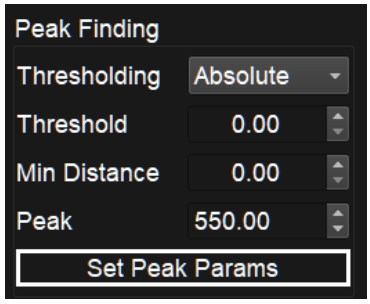


Peaks

Peaks: Peak Finding allows a user to see the values of peaks on data. The threshold can be set to absolute or relative. The peak threshold and minimum distance is set using the Peak Finding Controls within the Controls widget in the Settings bar. Enable peak finding by clicking Peaks on plot toolbar.

FWHM

FWHM: FWHM or Full Width Half Maximum is a measure of the width of the peak and used for many spectral measurements. For computing FWHM, set the Peak in Peak Finding params to the wavelength of your desired peak and then click the FWHM button on the plot toolbar. The FWHM is displayed as a number on the plot toolbar.



Applications

Colorimetry: Opens a new widget showcasing the colour of any surface based on CIE Lab colour scale and sRGB. The colour is computed using the reflectance spectra recorded with our device. It is recommended that a bright measurement using a white standard is done before enabling the colour measurement. This application is only available for devices with High CRI white LED illumination.

Time Series: This application allows the user to record time series of spectra for monitoring a transient behaviour. It will store spectra and a user specified metric such as area under the curve, intensity at a particular wavelength or peak ratio at two separate wavelengths. The data is recorded between user-defined time intervals for a fixed duration of the recording. Minimum time interval is 1 s.

Recording: This application allows the user to record spectra for monitoring a fast-transient behaviour at the maximum permissible frame rate of the detector. It will store the spectra in a folder defined by user after the recorded raw data is post-processed. The data is recorded at time intervals specified by 1/FPS where FPS is the frame rate of the detector.

Illumination Control

Active Illumination for active spectrometers includes three different exclusively enabled modes: Flash Off, Flash Auto, Flash On.

Flash Off: This mode renders the spectrometer to act as a passive device. The lights provided by our spectrometer are switched OFF and spectrometer collects the spectrum of external light sources.

Flash Auto: This mode switches flash ON only while spectrum is captured. This is the default mode for hardware trigger mode.

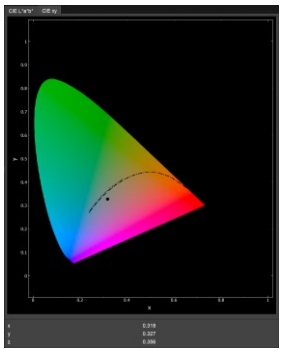
Flash On: This mode is used for keeping the light on while capturing spectra continuously.

App 1: Colorimetry

In AttoView, Colorimetry is done based on D65 illuminant and 1931, 2 degree observer data for colour matching functions. Please follow the steps below to get the best results.

Standard Procedure

1	Set the Integration Time to 25 ms and Averages to 5. Please increase the integration times and averages to get more stable data. But for the beginning, you can start with this setting.	
2	Initiate a dark mode collection on a black surface. It automatically switches LED off for the dark collection if the LED was on previously.	
3	Enable DC on the right toolbar by clicking once.	
4	Switch on the Light and place the spectrometer on a white paper/white standard. Click on “Collect Bright Spectrum”.	
5	Unless there is a bright spectrum, Reflectance mode is not enabled. After Bright Spectrum is collected, the Reflectance mode is enabled. Please click on that to see the divided spectrum.	
6	Once Reflectance Mode is clicked, AutoScale Y function is automatically disabled, and scale is set to Y: 0-1.1. You can also change to desired plot region by clicking “Manual Scale” setting the desired range on X and Y spectrum.	
7	After Reflectance is clicked, you should see a straight line along the x-axis with intensity around 1. If the colour chart on right is already present, then colours are displayed based on the measurement of the reflectance surface. If the colour chart is unavailable on the right, click the Colorimetry icon to get the colour chart and read the colour measurements.	
8	Please note that it is a good practice to take bright spectrum measurement, every new set of measurements to ensure flat profile. After every 10 to 20 minutes, please collect a bright spectrum to ensure there are no changes.	
9	Once the colour tab is available, the RGB and CIE L*a*b* values are displayed beneath the colour chart. The CIE xyz values are displayed in the CIE xyz tab along with the CIE xy plot.	
10	The figures for different charts are shown as under.	

		
	CIE Lab plot showing the wheel with a,b values and L on the side bar.	CIE xy plot with x, y values plotted on the colour gamut.

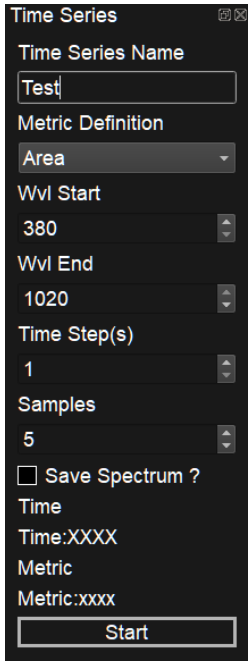
App 2: Time Series

In many scientific measurements, processes need to be monitored as a function of time to obtain new insights about the nature of the process. The time dependent spectral or colour change of an evolving process can be captured with the help of time series measurements. Time series measurements record spectra and/or colors at a fixed time interval for certain duration of time span.

Standard Procedure

To initiate time series measurements, please follow the steps listed as under.

1	Check if Atto^3 is in Live Acquire mode. If yes, then click on stop and disable the live mode.
2	Click on the Time Series icon.
3	This opens up a new dock on the right side of the software window which has controls related to time series.
4	Provide a name for time series.
5	Define a metric of choice for the time series. There are three kinds of metrics, namely, Area, Peak Ratio and Peak. Area metric computes the area of the curve from Start Wavelength(Wvl Start) to End Wavelength(Wvl End). Peak Ratio provides the computed ratio between the wavelength end points namely Wvl End and Wvl Start. Peak metric captures the intensity data for a given wavelength.
6	Please specify the time step in seconds. It ranges from 1 to 3600s. This is the interval between two consecutive measurements.
7	Choose the number of samples you want to record. The duration, D, of entire time series is given as D = time step x number of samples
8	Check the option of Save spectrum to ensure that every interval the spectrum and colour data is saved. For colour data to be saved, please ensure that colour window is open when capturing the time series.
9	When the settings are in order, please initiate the time series measurement by clicking on Start button and wait for it to finish. At the end of the measurement, the spectrum files and the time series data for the specified metric is saved in the folder specified in Save Opts docked widget on the left.



App 3: Recording

Some measurements are very time critical and need fast sampling of data. Since Atto3 measures and computes the spectrum, the computation could delay the measuring rate of an experiment. This app allows you to record the raw data in the maximum allowed frame rate from the detector. The frame rate is determined by the exposure time. After the raw data is captured, it is post-processed to obtain the spectra files in the desired file format. The time interval between data recorded in the file is given by (1/FPS) where FPS is the frame rate as displayed on the app interface.

Standard Procedure

To initiate recording measurements, please follow the steps listed as under.

1	Please make sure that the spectrometer settings are in correct range before starting the recording.
2	Check if Atto^3 is in Live Acquire mode. If yes, then click on stop and disable the live mode.
3	Click on the Recording icon. 
4	This opens a new dialog box for the recording app.
5	Select a folder where the data will be finally stored.
6	Provide a scan name for the measurement to identify it uniquely. Default name is set to “Recording”.
7	Enter the file format for the final output.
8	Enter the Number of Samples. Number of samples are the number of data points considered for the measurement. At present, the maximum number of samples is set to 10000.
9	Enter the Capture Every **x** Frame parameter. The parameter **x** allows the recording to skip (**x**-1) frames and sample for a longer measurement.
10	When the settings are in order, please initiate the recording by clicking on Start button and wait for it to finish. At the end of the measurement, the post

	processing occurs, and the spectrum files are saved in the folder specified. The progress bar keeps track of the recording and the post-processing.
11	If anything is amiss, you can abort the recording by clicking on Abort button.

Appendix Notes

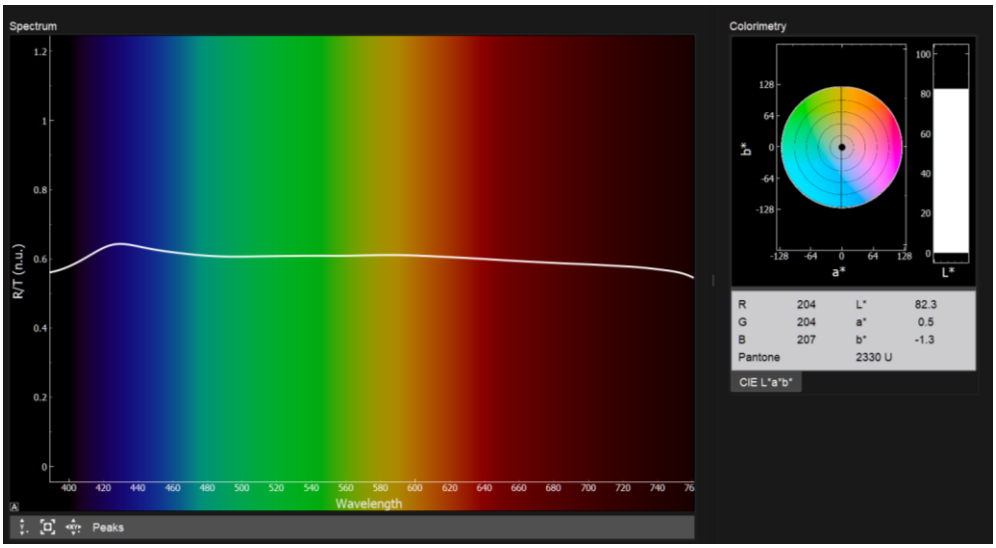
AN1. Choosing the correct white standard for Colorimetry

Conventionally, pure white reference surfaces are used in spectroscopy. These surfaces, however, are highly expensive and prone to discoloration or aging. While, we recommend the use of pure white reference surfaces (not supplied in our standard package), the Atto^3 spectrometer provide a supplementary “white standard” in its lid for reference measurements.

The white lid is calibrated against a standard white reference and can be used for reference spectrum measurements. This setting is enabled within the software by checking “white lid referencing”. If this setting is disabled, the reflectance is based on the actual spectrum measured against white surface provided by user. In this case, the responsibility of using the correct white standard lies with the user for proper colour measurement. On the other hand, when the lid white reference option is enabled, the reflectance spectrum is based on the bright spectrum offset with respect to the reflectance of the white lid provided with the Atto^3 spectrometer.

In case, a pure white reflectance reference surface is not available, we recommend the user to enable “white lid referencing” in the settings menu and use the white reference in the lid as a reference surface.

Please note when using “white lid referencing” in reflectance spectrum measurement mode, reference corrected spectrum of the “white lid referencing” will appear as a line ranging between 60% and 100%. A sample reference corrected spectrum of the lid white reference presents a 60% line as illustrated below:



Following are the steps to execute in AttoView software to perform colorimetry using Atto^3 white lid referencing:
Tip: Ensure a dark spectrum is collected and all spectra are compensated using the "Subtract Dark Spectrum" button in the software toolbar

1. Switch the device into either of the flash ON modes.
2. Enable "White Lid Referencing" option present under the tab Settings → Controls.
3. Place the white lid provided along with the device firmly onto the spectrometer entrance port (please refer to section "Device Features to see an illustration of the entrance port").
4. Press on "Collect bright spectrum for reflectance".
5. Remove the white lid from the entrance port.
6. Ultimately, intended sample colours can be measured with spectrometer port placed firmly on to the sample.

Troubleshooting

ATTONICS Systems

Please contact us for further enquires via info@attonics-systems.com.