THORLABS

SA210 Series
Fabry-Pérot Interferometers

User Guide



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Chapter 1 Safety



Warning

Take appropriate measures for eye safety.

Never look directly into the beam, not even at the output of the SA210.



Shock Warning

Never touch the output of the SA201B Fabry-Pérot Controller.

Chapter 2 Fabry-Pérot Interferometry

The SA210 is a high finesse Spectrum Analyzer used to examine the fine structures of the spectral characteristics of CW lasers. The spectrum analyzer consists of a confocal cavity that contains two high reflectivity mirrors; by varying the mirror separation with a piezoelectric transducer, the cavity acts as a very narrow bandpass filter. Knowing the free spectral range of the SA210 allows the time-base of an oscilloscope to be calibrated to facilitate quantitative measurements of a laser line shape. The confocal cavity design, for which the mirror spacing, d, and radius, r, are identical, allows for an easy alignment procedure. Mirrors shown below are AR coated on the outer surfaces and HR coated on the inner surfaces.

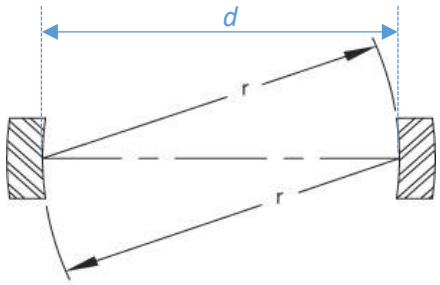


Figure 1 Illustration of the confocal cavity design, where the mirror spacing is chosen equal to the radius of curvature of the mirrors.

2.1 Free Spectral Range

To scan the spectra of the laser beam entering the Scanning Fabry-Perot interferometer, a small displacement is applied to one of the cavity mirrors mounted on the piezoelectric transducers. This is done by fine tuning the ramp voltage applied to the piezoelectric elements using the controller SA201B. When the mirror spacing becomes equal to an integral number of half the wavelength of the laser, constructive interferences occur. That spectral response of the signal can be visualized with a scope. A series of periodical peaks appear on the screen of the scope. The distance between consecutive peaks is called the free spectral range (FSR) of the instrument.

From a user's perspective, the free spectral range of a confocal cavity is given by

$$FSR = c/4d,$$

Where *c* is the speed of light and *d* is the cavity length, instead of *c/2d* as would be the case for a plano-plano cavity; the factor of 2 in the denominator can be understood by inspecting the ray trace shown in Figure 2 below. Note that a ray entering the cavity at the height '*H*' parallel to the optical axis of the cavity makes a triangular figure eight pattern as it traverses the cavity. From this pattern it is clear that the ray makes four reflections from the cavity mirrors instead of the two that would result in a plano-plano cavity. Hence the total round-trip path through the cavity is given as *4d* instead of *2d*.

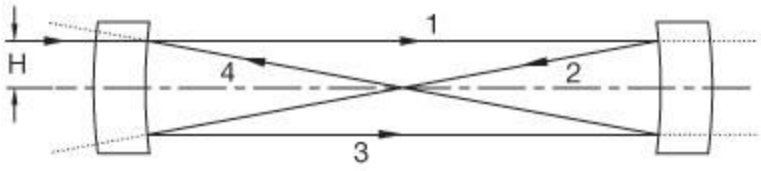


Figure 2 This figure shows a simplified ray-trace for a ray entering the cavity at height 'H'. The curvature of the mirrors 'r' and the separation being set precisely to 'r' ensures that the input ray is imaged back onto itself after traveling a distance of approximately 4r.

Additionally, in this configuration if a paraxial ray is traced through the system as shown in Figure 2, it is apparent that in the confocal configuration each mirror serves to image the other mirror back onto itself so that a ray entering the cavity will, after four traverses of the cavity, fall back onto itself (keep in mind that the focal length of a spherical mirror is *r/2*). This imaging of the beam back onto itself greatly simplifies the alignment of the cavity; just align your input to within a few tenths of a millimeter to the center of the mirror set and restrict you input angles to less than a few degrees. The SA200 series interferometer has two iris diaphragms that simplify this alignment requirement.

2.2 Finesse and Resolution

The finesse, F, of the Scanning Fabry-Perot interferometer is a quantity which characterizes the ability of the interferometer to resolve closely spaced spectral features, and it is determined solely by the reflectivity of the mirrors involved. For an infinitely narrow input spectrum, the finesse determines the width of the measured spectrum. In combination with the mirror spacing and its resulting free spectral range, the finesse defines the resolution of the instrument by

$$\Delta = FSR/F.$$

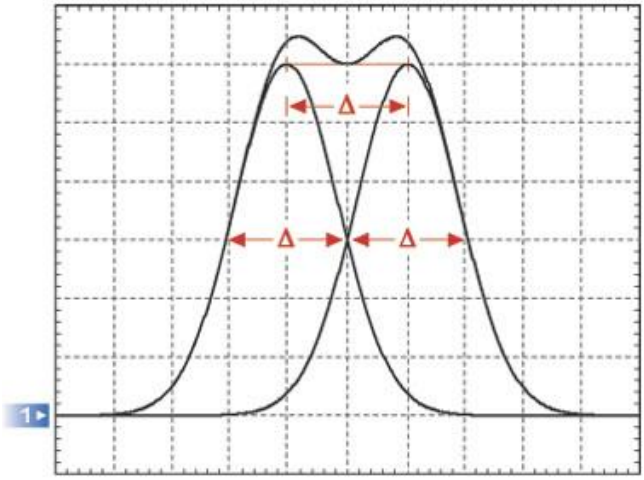


Figure 3 ***When two equal Gaussian lineshapes just meet the Taylor criteria for being resolvable, they are separated by their common FWHM (Δ) as shown in the plot.***

High finesse means high resolution capability, and high finesse is obtained by increasing the reflectivity of the cavity mirrors. However, highly reflective mirrors reduce the transmission of the interferometer. Still, typical peak-transmission values are in the range from 20-60% of the input power, depending on both the SA210 model and the set of mirrors used.

Chapter 3 Setup and Procedures

3.1 Recommended Setup

The SA210 should be mounted in a Ø1" kinematic mirror mount, such as Thorlabs' KM100, so that it can be easily adjusted. The apparent beam size should be approximately 1 mm. It is recommended that a fold mirror be used to direct the beam into the Fabry-Perot interferometer. A lens with focal length of 100 mm can be used, with the focus set roughly at the center of the housing, approximately 25 mm past the flange. If the detector is connected directly to the scope, a 5 kΩ terminator is needed. Offset adjustment (SA201B) is used to center the output on the scope.

In a typical application, the SA210 Interferometer is used in conjunction with a signal generator and an oscilloscope, as shown below. The signal generator should be able to produce either a triangle or saw-tooth wave with an adjustable frequency (5 to 50 Hz), an adjustable amplitude, and an adjustable offset (Thorlabs SA201B Fabry-Perot Controller is used for generating the required scan signals for obtaining the data in this document). The maximum voltage on the piezo (ramp in) is not to exceed 150 V. The signal generator is used to repeatedly scan the length of the cavity to sweep through the transmission spectrum of the interferometer. An oscilloscope is typically used to view the spectrum and make quantified measurements of spectral features.

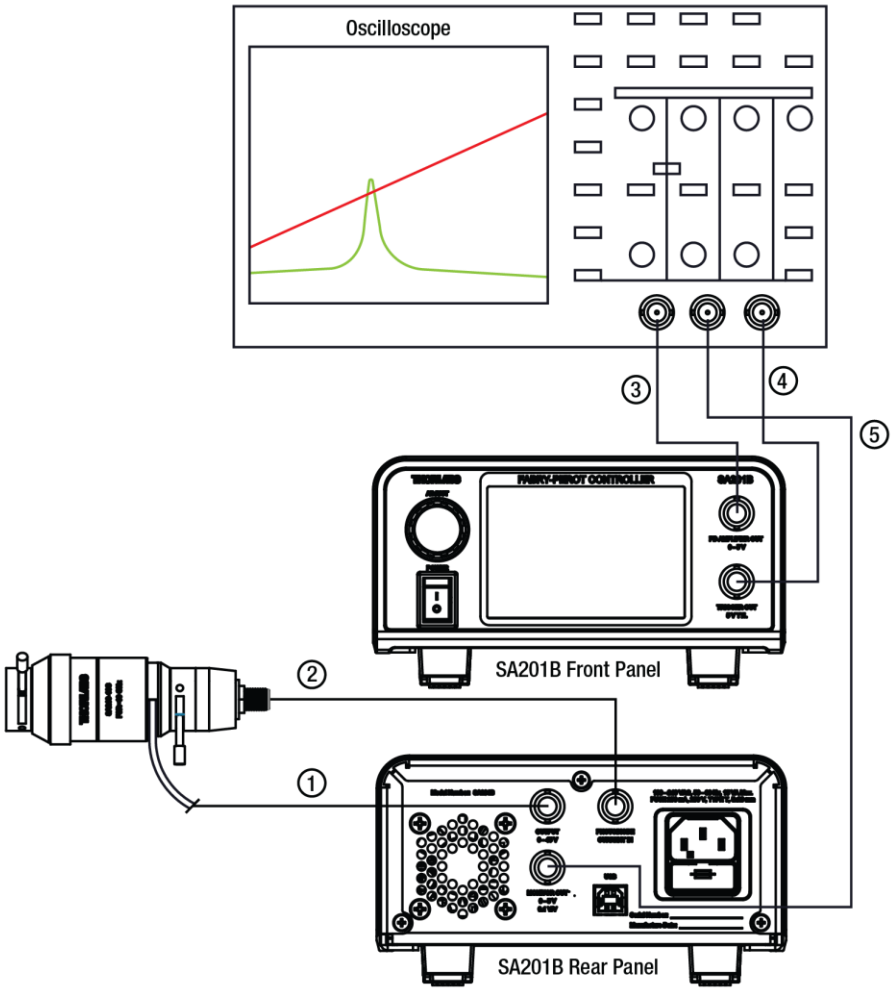


Figure 4 Schematic of a recommended setup for using an SA210 series interferometer in combination with a SA201B controller.

3.2 Alignment

To align the SA210 Series Fabry-Perot interferometer, first mount the unit into a tip/tilt mirror mount (item # KM100). Attach all the connections according to the Figure 4 on Page 4. Next, remove the detector from the back of the unit and mount it in a separate mount; this will aid in the alignment. Close the input iris to its minimum aperture and center the beam on the iris opening. Leave the back iris completely open and start to scan the unit. Use the mirror mount's tip/tilt adjustment until the beam is centered through the body of the SA210.

Adjust the oscilloscope gain to maximize sensitivity, position the detector close to the rear opening, and slowly close the back iris while adjusting the mirror mount to keep the beam in the center of the device. Once the beam is centered, attach the detector to the main body once more. The interferometer will then be ready for measurements.

3.3 Calibration of the time scale

Knowing the free spectral range (FSR) of the SA210 allows the time-base of an oscilloscope to be calibrated to facilitate quantitative measurements of laser line shape. With a resolution of 67 MHz, the fine structure resulting from multiple longitudinal modes of a laser line can be resolved. Note: A saw tooth wave (0 – 20 V) would provide approximately 2 FSR.

3.4 Spectrum Analyzer Controller and Other Accessories

- The **SA201B** controller generates a voltage ramp, which is used to scan the separation between the two cavity mirrors. A photodiode is used to monitor transmission of the cavity. Using the Trigger Out signal from the controller, an oscilloscope can be used to display the spectrum of the input laser. The controller provides adjustment of the ramp amplitude (0 to 30 V) and scan-time (10 ms to 10 s) to allow the user to choose the scan range and speed. An DC offset control (0 to 15 V) is provided to allow the spectrum displayed on the oscilloscope to be shifted right- or leftwards, and zoom capability provides up to 100X increase in spectral resolution.
- Thorlabs' **KM100**, Ø1" kinematic mount can be used to mount the SA210 Scanning Fabry-Perot Interferometer

Chapter 4 Specifications

Optical Performance Specifications	
Maximum Input Voltage	150 V
Free Spectral Range[a]	10 GHz
Minimum Finesse	>150
Resolution	67 MHz
Outer Housing Material[b]	Black Anodized Aluminum
Fabry-Pérot Cavity Material	Low Thermal Expansion Invar®
Dimensions	Ø1” Flange Total Length: 2.93”

a. FSR is set by the length of the confocal cavity and is given by: *FSR = c/4d*, where *d* is the radius of curvature of the mirrors; in this case *d = 7.5 mm*.

b. A thermal design balances the small coefficient of thermal expansion of the Invar body with the negative coefficient of thermal expansion of the piezo actuators.

Available Coating Ranges for the SA210 series	
Item #	**Coating Wavelength Range**
SA210-3B	350 – 535 nm
SA210-5B	535 – 820 nm
SA210-8B	820 – 1275 nm
SA210-12B	1275 – 2000 nm
SA210-18C	1800 – 2600 nm

Chapter 5 Mechanical Drawings

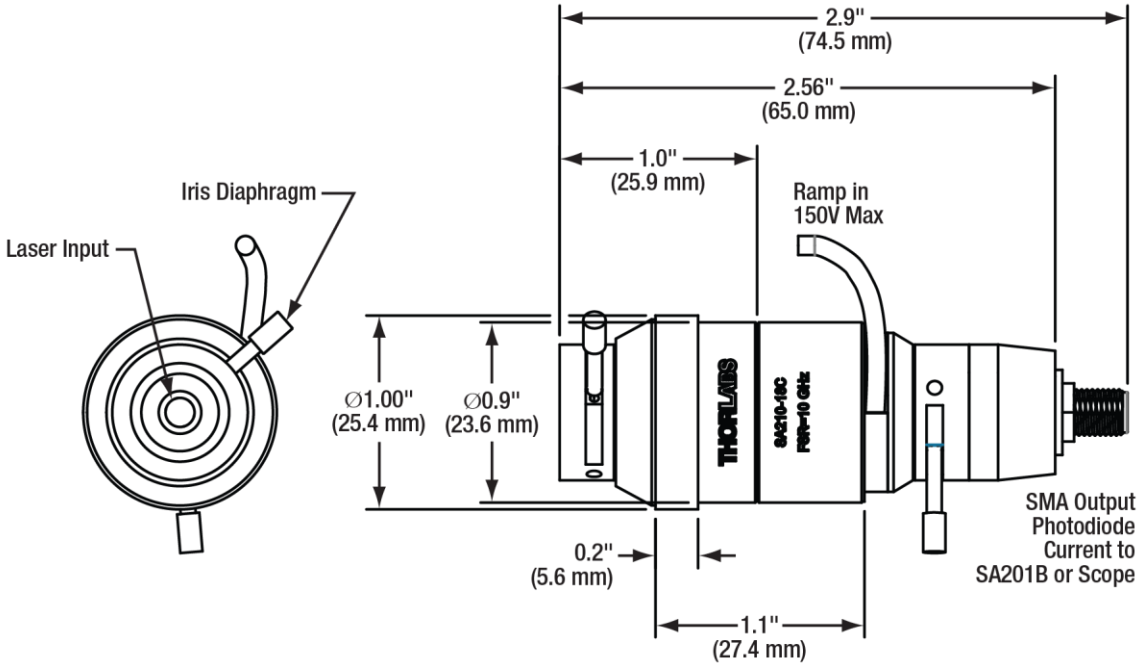
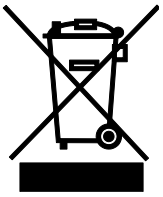


Figure 5 Mechanical Drawing for SA210-3B, SA210-5B, SA210-8B, SA210-12B, SA210-18C

Chapter 6 Warranty and RMA Information



Annex I

Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site. It is the user's responsibility to delete all private data stored on the device prior to disposal.

6.1 Return of Devices

This precision device is only serviceable if returned and properly packed into the complete original packaging including the complete shipment plus the cardboard insert that holds the enclosed devices. If necessary, ask for replacement packaging. Refer servicing to qualified personnel.

Chapter 7 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at **www.thorlabs.com/contact** for our most up-to-date contact information.



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