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# SA200-Series Scanning Fabry Perot Interferometer


## DESCRIPTION:

The SA200 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 band-pass filter. Knowing the free spectral range of the SA200 allows the time-base of an oscilloscope to be calibrated to facilitate quantitative measurements of a laser line shape.

## SPECIFICATIONS:

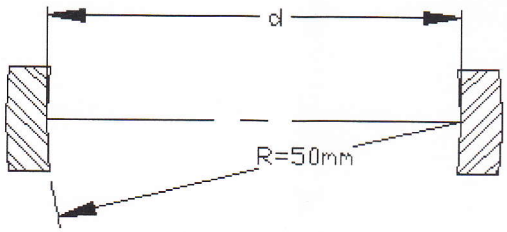
| | |
|---|---|
| **Free Spectral Range[1] (FSR)** **Measured in milliseconds:** | 5,4 |
| **FWHM** **Measured in microseconds:** | 25,8 |
| **(FSR/FWHM)** | |
| **Actual Calculated Finesse:** | 209 |
| | |
| **Maximum Input Voltage:** | 150V |
| **Free Spectral Range:** | 1.5Ghz |
| **Minimum Finesse:** | >200 |
| **Resolution:** | 7.5MHz |
| **Outer Housing Material:** | Black Anodized Aluminum |
| **Fabry Perot Cavity Material[2]:** | Low thermal expansion Invar ® |
| **Dimensions:** | Ø 2" Flange<br>Total Length: 5.85" |

## Confocal Cavity Configuration

Mirrors shown below are AR coated on the outer surfaces and HR coated on the inner surfaces.

[1] FSR is set by the length of the confocal cavity and is given by: FSR=c/4d. Where d= the radius of curvature of the mirrors; in this case d=50mm. (see drawing on next page)

[2] 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.




FSR=c/4d

**Other mirror sets are available for this instrument:**

- **350nm - 535nm**
- **535nm - 820nm**
- **820nm - 1275nm**
- **1275nm - 2000nm**

## SETUP:

- Knowing the FSR of the SA200 allows the time-base of an oscilloscope to be calibrated to facilitate quantitative measurements of laser line shape. With a resolution of 7.5MHz, the fine structure resulting from multiple longitudinal modes of a laser line can be resolved. Note: A saw tooth wave (0-20V) would provide approximately 2 Free Spectral Ranges.
- The SA200 should be mounted, so that it can be easily adjusted. It is recommended that Thorlabs 2-inch Kinematic Mount **KM200** be used to mount the interferometer at the 2-inch diameter flange.
- The apparent beam size should be approximately 4mm. It is recommended that a fold mirror be used to direct the beam into the Fabry-Perot interferometer. A lens with focal length of 250mm can be used, with the focus set roughly at the center of the housing, approximately 30mm in from the flange.
- The maximum voltage on the piezo (ramp in) is not to exceed 150V.
- If the detector is connected directly to the scope, a 5kΩ terminator is needed. Offset adjustment (SA201) is used to center the output on the scope.

## OPERATION:

To set up the SA200-Series Fabry-Perot you should first mount the unit into a tip/tilt mirror mount (Thorlabs part# KM200). Attach all of the connection according the drawing on page 4. Next you should remove the detector from the back of the unit and mount it in it's own mount, this will aid in the initial alignment. Then close the input iris and center your beam on the iris opening. Leave the back iris completely open and start to scan the unit. Now using the tip/tilt adjustment until the beam is center through the body of the SA200. Adjust the scope gain to maximum sensitivity, position the detector close to the rear opening and slowly close the back iris as you correct the 2 angular adjustments on the mirror mount. Once the beam is centered you can the replace the detector on the main body and start to use the unit for measurements.

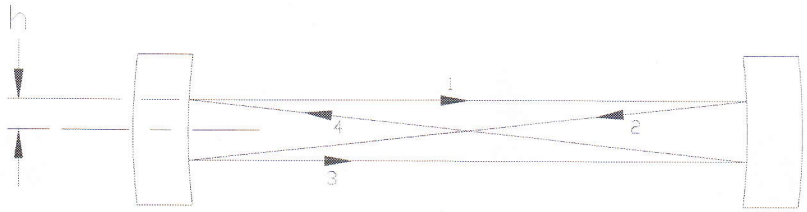
## OVER VIEW:

### Free Spectral Range

To scan the spectra of the laser beam entering the Scanning Fabry–Perot interferometer small displacement is applied to one of the cavity mirror mounted on piezoelectric transducers. This operation is done by fine tuning the ramp voltage applied to the Piezoelectric elements using the controller SA201. 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 users perspective a confocal cavity has a FSR that is given by c/4d 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 below in Figure II. Note that a ray entering the cavity at a 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 II

**Figure II: 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 II, 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, (note 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 of the center of the mirror set and restrict your input angles to less than a few degrees. The SA200 series interferometer has two iris diaphragms that simplify this alignment requirement.

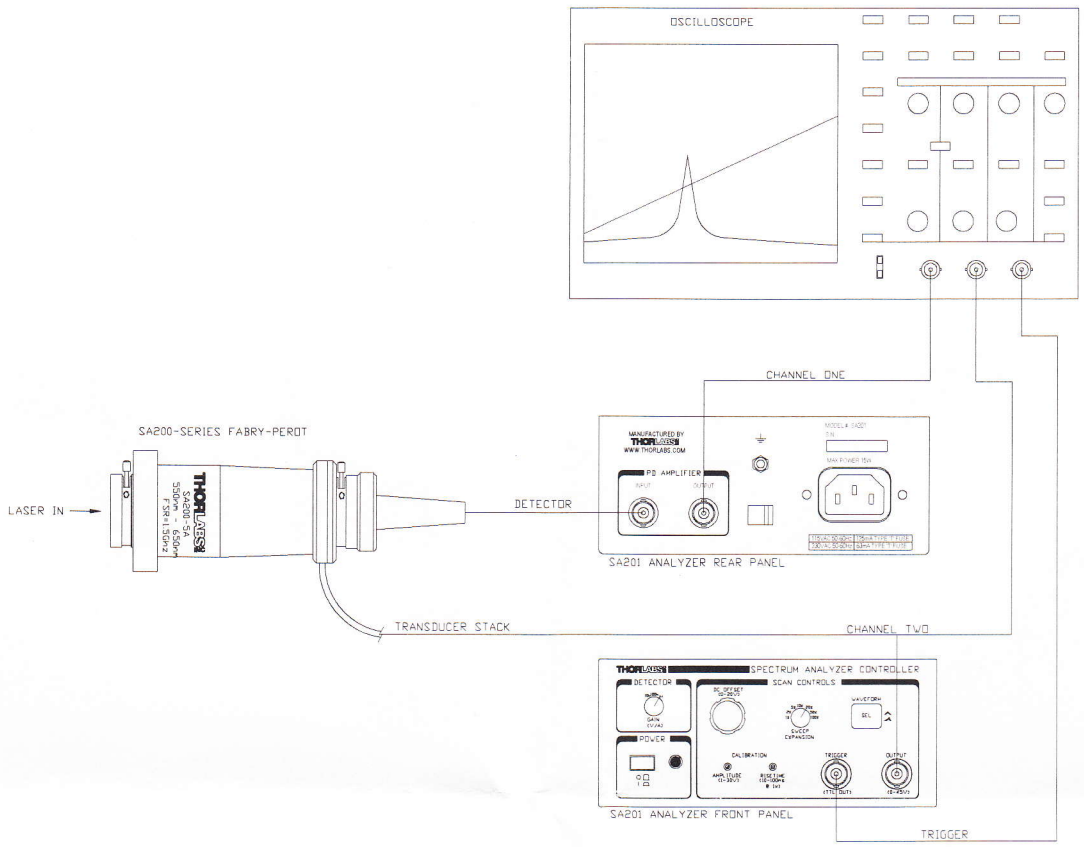
### Finesse

The finesse of the Scanning Fabry-Perot interferometer is a quantity which characterizes the ability of the interferometer to resolve closely spaced spectral features, it defines the resolution of the instrument. For an infinitely narrow input spectrum, the finesse determines the width of the measured spectrum.

High finesse means high resolution capability, high finesse is obtained by increasing the reflectivity of the cavity mirrors. However, high reflective mirrors reduce the transmission of the interferometer.

In a typical application the SA200 Interferometer is used in conjunction with a signal generator and an oscilloscope, as shown below in figure III. A signal generator (Thorlabs SA201 Fabry-Perot Controller is used for generating the required scan signals for obtaining the data in this document) that can produce either a triangle or saw-tooth wave with an adjustable frequency (5 to 50 Hz), an adjustable amplitude (15 to 40 volts), and an adjustable offset. The signal generator is used to repetitively scan the length of the cavity by $\lambda/4$ in order to sweep through one FSR of the interferometer. An oscilloscope is typically used to view the spectrum and make quantified measurements of spectral features.

## Recommended Set-up




## Figure III

**Figure III: This figure shows a schematic diagram of a typical setup that is used to measure the spectrum of a laser source. Please note that for this device to be useful the linewidth of the source must be less than the FSR of the interferometer.**

## SPECTRUM ANALYZER CONTROLLER AND OTHER ACCESSORIES:

- The **SA201** 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 output sync signal from the controller, an oscilloscope can be used to display the spectrum of the input laser. The controller provides adjustment of the ramp voltage (0 to 20V) and scan-time (1ms to 5s) to allow the user to choose the scan range and speed. An offset control is provided to allow the spectrum displayed on the oscilloscope to be shifted right or left, zoom capability provides up to 100X increase in spectral resolution.
- Thorlabs' **KM200,** 2" kinematic mount can be used to mount the SA200 Scanning Fabry Perot Interferometer.

## TECHNICAL SUPPORT:

For further questions, or if you suspect a problem with your SA200, please contact Tech Support. An Applications Engineer will gladly assist you.

## Technical Drawing