SA30 Series Fabry-Pérot Interferometers

User Guide

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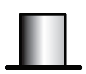
Chapter 1 Warning Symbol Definitions

Below is a list of warning symbols you may encounter in this manual or on your device.

Symbol	Description
	Direct Current
	Alternating Current
	Both Direct and Alternating Current
	Earth Ground Terminal
	Protective Conductor Terminal
	Frame or Chassis Terminal
	Equipotentiality
	On (Supply)
	Off (Supply)
	In Position of a Bi-Stable Push Control
	Out Position of a Bi-Stable Push Control
	Caution: Risk of Electric Shock
	Caution: Hot Surface
	Caution: Risk of Danger
	Warning: Laser Radiation
	Caution: Spinning Blades May Cause Harm

Chapter 2 Safety

WARNING
Take appropriate measures for eye safety. **Never look directly into the beam, not even at the output of the SA30.**

SHOCK WARNING
Never touch the output of the SA201 PZT driving unit.

Chapter 3 Description

The SA30 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 near-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 SA30 allows the time-base of an oscilloscope to be calibrated to facilitate quantitative measurements of a laser line shape. With a resolution of below 1 MHz, the fine structure resulting from multiple longitudinal modes of a laser line can be resolved.

For discussions on the spatial mode structure, transmission spectrum, and finesse of a Fabry-Pérot interferometer, please see the full web presentation at **www.thorlabs.com.**

Chapter 4 Setup

4.1. Optical Setup

WARNING

Take appropriate measures for eye safety.
Never look directly into the beam, not even at the output of the SA30.

The SA30 should be mounted so that it can be easily aligned to the incoming beam. It is recommended that Thorlabs' **KM200** Ø2" Kinematic Mount be used to mount the interferometer at the 2-inch diameter flange. Also, it is recommended that a fold mirror is used to direct the beam into the Fabry-Pérot interferometer. For the SA30 series, the EFL and position of the lens depend on the beam parameters before the lens and have to be chosen in a way to obtain the recommended waist diameter. The recommended waist diameter of the incident lens is given by

$$w_0^{inc} = \frac{\lambda f}{\pi w_0^{rec}} \frac{1}{\sqrt{1+\frac{f^2}{(z_0^{inc})^2}}}, \quad (1)$$

where w_0^{inc}, w_0^{rec}, z_0^{inc}, λ, and f are the beam waist size of the beam incident on the lens, the recommended beam waist diameter at the center of the instrument, the Rayleigh range of the incident beam on the lens, the wavelength of the incident light, and the focal length of the lens. For a well-collimated beam, i.e., when the Rayleigh range of the incident beam on the lens is much larger than the focal length of the lens and the beam is only weakly diverging, Equation (1) reduces to

$$w_0^{inc} = \frac{\lambda f}{\pi w_0^{rec}} \quad (2).$$

The lens should be placed at a distance D

$$D = \frac{f}{1+\frac{f^2}{(z_0^{inc})^2}} \quad (3)$$

away from the center groove. This reduces to $D = f$ for a well collimated beam[1]. Please note that the Rayleigh range of a Gaussian beam is given by

$$z_0 = \frac{\pi w_0^2}{\lambda}, \quad (4)$$

where w_0 is the beam waist diameter and λ is the wavelength of the incident light.

The recommended waist diameter for the SA30 series is given by

$$w_0^{rec} = \sqrt{\frac{\lambda}{2\pi}\sqrt{d(2R-d)}}, \quad (5)$$

where R is the radius of curvature of the mirrors (50 mm), d is the distance between the two resonator mirrors (50 mm), and λ is the wavelength of the incident beam[2].

[1] *P. W. Milonni and J. H. Eberly, Lasers (John Wiley & Sons, Inc., 2010) p. 290.*
[2] *H. Kogelnik and T. Li, "Laser Beams and Resonators," Applied Optics, vol. 5, no. 10, 1966.*

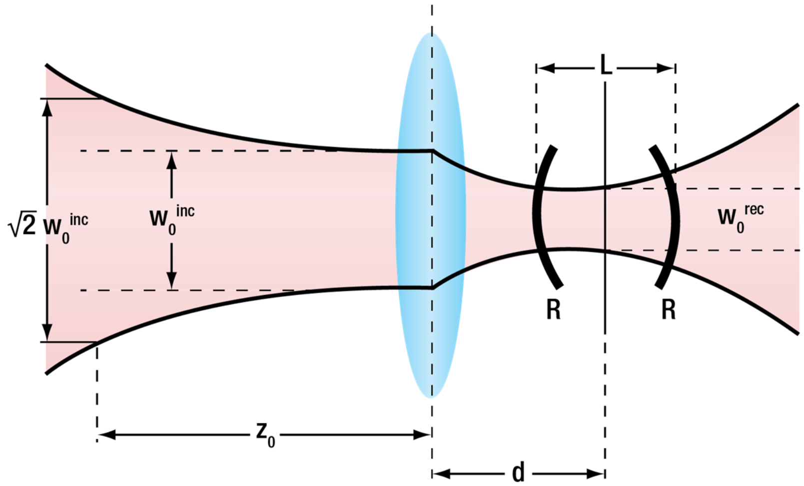


Figure 1 Schematic showing the incident beam waist and recommended beam waist.

4.2. Driving Electronics and Oscilloscope

CAUTION

Caution is given when the SA30 is used with another driver than the SA201.
Please make sure to never apply voltages below 0 V or above 150 V.

In a typical application, the SA30 interferometer is used in conjunction with a signal generator and an oscilloscope, as shown in Figure 2. The signal generator must produce either a triangle or saw-tooth wave with an adjustable frequency, amplitude, rise time, and offset; please refer to the Thorlabs SA201 Fabry-Pérot controller manual for details. Please note that the Thorlabs SA201 Fabry-Pérot controller was used to generate the scan signals required for obtaining the data in this document.

The signal generator is used to repetitively scan the length of the cavity in order to sweep through one full spectral range (FSR) of the interferometer. An oscilloscope is typically used to view the spectrum and make quantified measurements of spectral features. The offset adjustment on the SA201 is conveniently used to center a mode on the scope. If the detector is connected directly to the scope, a 5 kΩ terminator is needed.

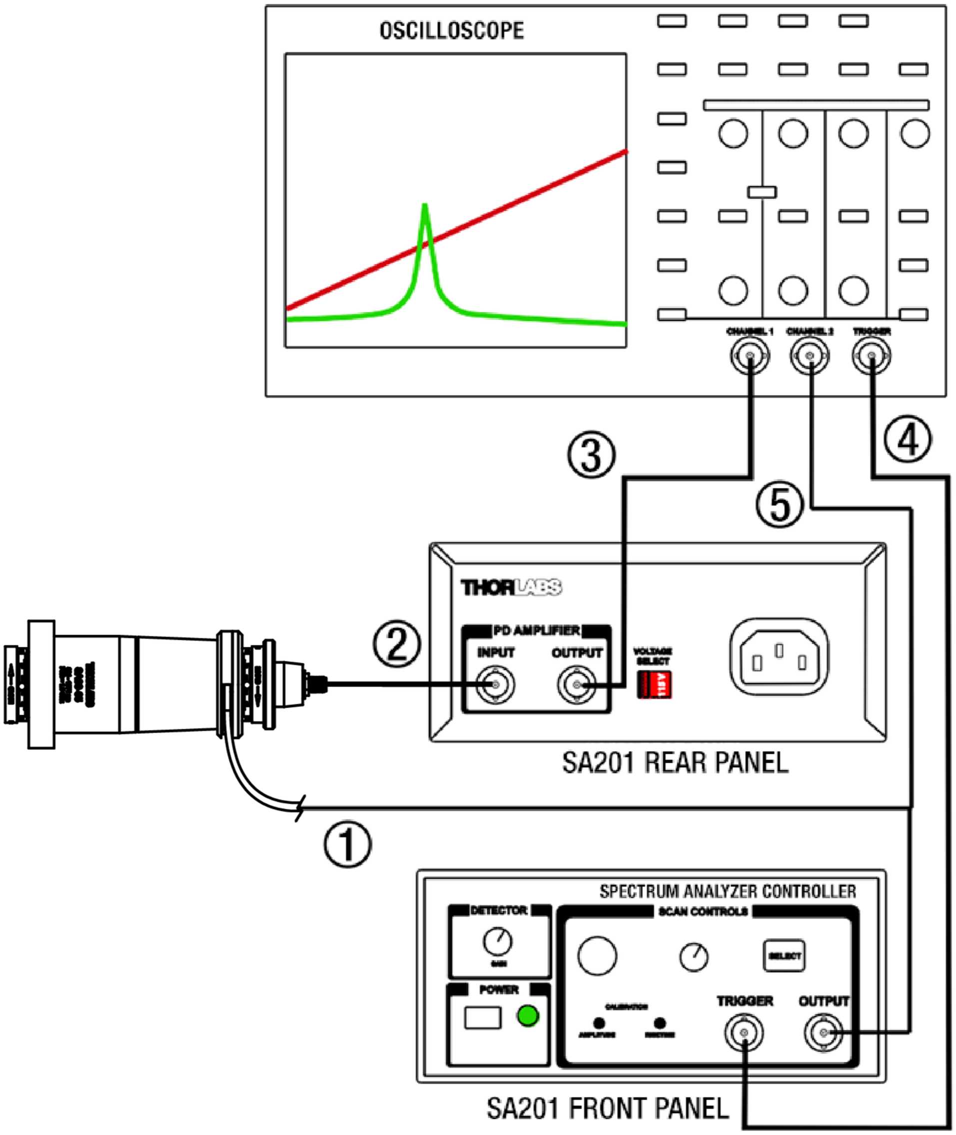


Figure 2 Schematic of a recommended setup for using an SA30 series interferometer in combination with a SA201 controller

Connection	Description
1	Controller (BNC) to Piezo (Cable is Attached to FP Interferometer)
2	Photodiode (SMA) to Controller (BNC) Cable (Included with FP Interferometer)
3	Amplified Photodiode Output (BNC) to Oscilloscope Cable (Not Included)
4	Trigger Output of Controller (BNC) to Oscilloscope Cable (Not Included)
5	Optional Connection that Allows the User to Monitor the Signal used to Drive the Piezoelectric Transducers (Not Included)

Chapter 5 Operation

WARNING

Take appropriate measures for eye safety.
Never look directly into the beam, not even at the output of the SA30.

To set up the SA30 series Fabry-Pérot interferometer, mount the unit in a KM200 mirror mount and make the connections according to the description in the SA201 manual or the PZT driver and detector amplifier you are using. Then, use the iris aperatures to align the incoming beam to the optical axis of the SA30. Note that the detector from the back of the unit can be removed and mounted on its own to aid in the initial alignment. To align the beam along the optical axis, 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, use the tip/tilt adjustment until the beam is centered through the body of the SA30. Adjust the scope gain to maximum sensitivity, position the detector close to the rear opening, and slowly close the back iris while simultaneously correcting the two angular adjustments on the mirror mount. The beam is close to an overlap with the optical axis when each second mode in the spectrum becomes somewhat smaller. Once the beam is centered, mount the detector back on the main body. For this alignment sequence it is convenient to have the oscilloscope triggered by the PZT scan; the SA201 does provide such a trigger signal.

Compared to the models in the SA200 and SA210 series, the SA30 instruments require more sophisticated alignment. Therefore, once initial alignment has been established according to the above description, zoom in on a transmission mode and optimize the alignment for maximum suppression of higher order modes, which typically occur within a few MHz around the fundamental transmission modes. For this, it is very convenient to set the trigger on the oscilloscope to one of the larger transmission modes visible in the spectrum. Now, fine tune the alignment of the SA30 with respect to the incident beam. Also, it might be necessary to fine tune the distance between the lens and the SA30 within a few centimeters around its initial 25 cm distance described in the previous chapter. Once higher order modes are suppressed, the unit is ready for measurements. The left oscilloscope panel in the figure below shows an alignment that can be improved. Since the higher order transverse modes are still visible, the lens position or beam alignment needs to be changed. In contrast, the right panel shows a perfectly mode-matched alignment.

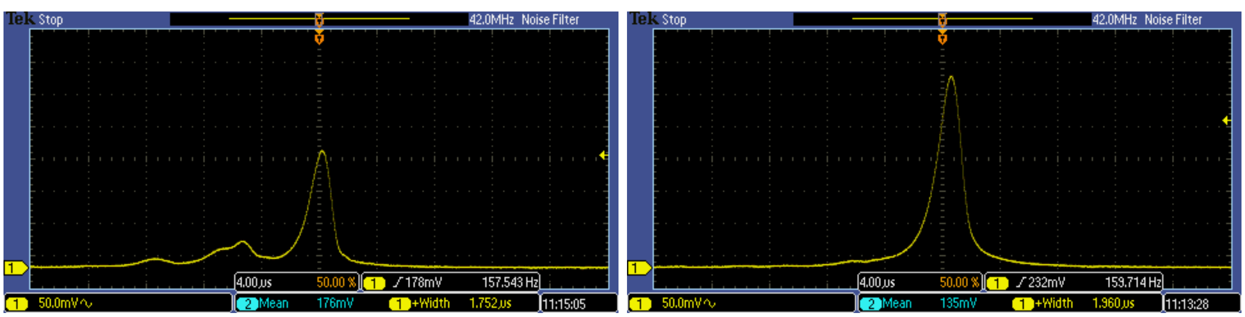


Figure 3** **Left: Higher order transverse modes are still visible and the alignment has to be improved. Right: Good alignment, higher order transverse modes are not evoked.

Please be careful that the output spectrum of the SA201 control box is not affected by the internal filters. The smallest possible time-based FWHM mode width is 4 µs for all gain settings. If you start to approach this value, you either have to change to a lower amplification level, or change the PZT settings (amplitude, rise time, or sweep expansion) on the SA201 to achieve a slower sweep.

Chapter 6 Spectrum Analyzer Controller and 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 30 V) and scan-time (10 ms to 10 s) to allow the user to choose the scan range and speed. An offset control (0 to 15 V) is provided to allow the spectrum displayed on the oscilloscope to be shifted right- or leftwards.

- Thorlabs' **KM200** Ø2" kinematic mount can be used to mount the SA30 Scanning Fabry-Pérot Interferometer.

Chapter 7 Specifications

Optical Performance Specifications	
Piezoelectric Transducer Input Voltage	0 to 150 V
Free Spectral Range[3]	1.5 GHz
Minimum Finesse	1500
Resolution	<1 MHz
Cavity Length[4]	50 mm
On-Resonance Transmission	10% to 20% (Typical)
Outer Housing Material	Black Anodized Aluminum
Fabry-Pérot Cavity Material[5]	Low Thermal Expansion Invar
Dimensions	Ø2" Flange; Total Length: 5.85"

Available Wavelength Ranges for the SA30 Instrument	
SA30-47	400 - 535 nm
SA30-52	488 - 545 nm
SA30-73	630 - 824 nm
SA30-95	824 - 1071 nm
SA30-120	1060 - 1350 nm
SA30-144	1250 - 1625 nm

Please refer to the Fabry-Pérot Interferometers product catalog page on **www.thorlabs.com** for a complete and updated list of available models.

[3] FSR is set by the length of the near-confocal cavity and is given by FSR=c/4R, where R is the radius of curvature of the mirrors; in this case R = 50 mm.
[4] Nominal distance between mirrors
[5] The athermal design balances the small coefficient of thermal expansion of the Invar body with the negative coefficient of thermal expansion of the piezo actuators

Chapter 8 Mechanical Drawing

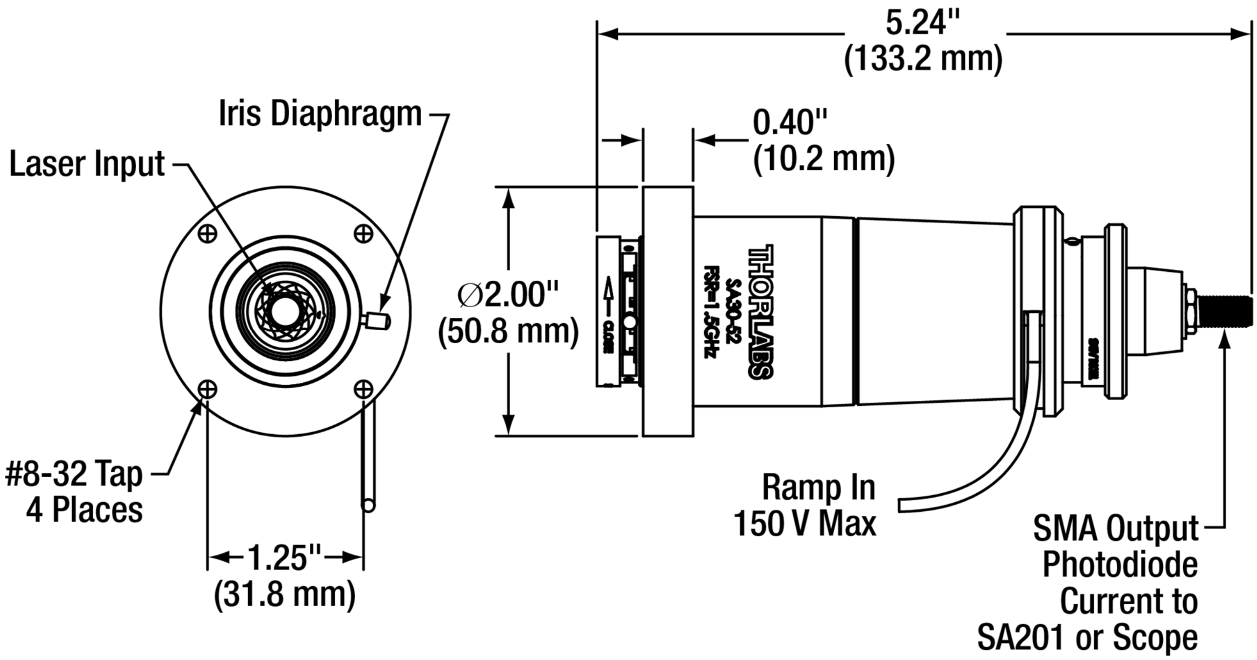


Figure 4 Mechanical Drawing for SA30-52

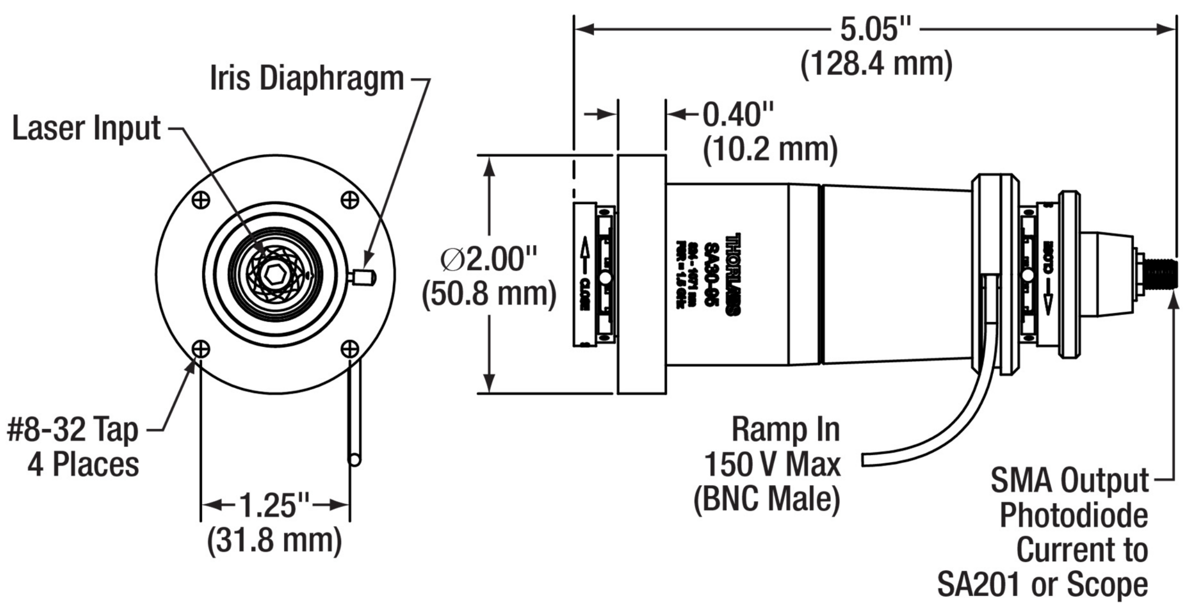


Figure 5 Mechanical Drawing for SA30-47, SA30-73, SA30-95, SA30-120, and SA30-144

Chapter 9 Regulatory

As required by the WEEE (Waste Electrical and Electronic Equipment Directive) of the European Community and the corresponding national laws, Thorlabs offers all end users in the EC the possibility to return "end of life" units without incurring disposal charges.

- This offer is valid for Thorlabs electrical and electronic equipment:
- Sold after August 13, 2005
- Marked correspondingly with the crossed out "wheelie bin" logo (see right)
- Sold to a company or institute within the EC
- Currently owned by a company or institute within the EC
- Still complete, not disassembled and not contaminated

Wheelie Bin Logo

As the WEEE directive applies to self-contained operational electrical and electronic products, this end of life take back service does not refer to other Thorlabs products, such as:

- Pure OEM products, that means assemblies to be built into a unit by the user (e. g. OEM laser driver cards)
- Components
- Mechanics and optics
- Left over parts of units disassembled by the user (PCB's, housings etc.).

If you wish to return a Thorlabs unit for waste recovery, please contact Thorlabs or your nearest dealer for further information.

Waste Treatment is Your Own Responsibility

If you do not return an "end of life" unit to Thorlabs, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end of life products will thereby avoid negative impacts on the environment.

Chapter 10 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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