819C/D Series

Integrating Sphere Detectors

User's Manual

Newport®

Experience | Solutions

Warranty

Newport Corporation warrants that this product will be free from defects in material and workmanship and will comply with Newport's published specifications at the time of sale for a period of one year from date of shipment. If found to be defective during the warranty period, the product will either be repaired or replaced at Newport's option.

To exercise this warranty, write or call your local Newport office or representative, or contact Newport headquarters in Irvine, California. You will be given prompt assistance and return instructions. Send the product, freight prepaid, to the indicated service facility. Repairs will be made and the instrument returned freight prepaid. Repaired products are warranted for the remainder of the original warranty period or 90 days, whichever first occurs.

Limitation of Warranty

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Newport Corporation
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Part No. 90053518 rev A

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Service Information

This section contains information regarding factory service for the source. The user should not attempt any maintenance or service of the system or optional equipment beyond the procedures outlined in this manual. Any problem that cannot be resolved should be referred to Newport Corporation.

Technical Support Contacts

North America

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Newport Corporation Calling Procedure

If there are any defects in material or workmanship or a failure to meet specifications, promptly notify Newport's Returns Department by calling 1-800-222-6440 or by visiting our website at www.newport.com/returns within the warranty period to obtain a **Return Material Authorization Number (RMA#)**. Return the product to Newport Corporation, freight prepaid, clearly marked with the RMA# and we will either repair or replace it at our discretion. Newport is not responsible for damage occurring in transit and is not obligated to accept products returned without an RMA#.

E-mail: rma.service@newport.com

When calling Newport Corporation, please provide the customer care representative with the following information:

- Your Contact Information
- Serial number or original order number
- Description of problem (i.e., hardware or software)

To help our Technical Support Representatives diagnose your problem, please note the following conditions:

- Is the system used for manufacturing or research and development?
- What was the state of the system right before the problem?
- Have you seen this problem before? If so, how often?
- Can the system continue to operate with this problem? Or is the system non-operational?
- Can you identify anything that was different before this problem occurred?

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1 General Information

This user manual contains information necessary for using model 819C and 819D Series Integrating Sphere Detectors. Please read through the guide before attempting to make optical power measurements.

1.1 Unpacking and Inspection

The 819C and 819D Series sphere detectors are shipped in a foam padded cardboard box, along with this user's manual and the calibration report. The calibration report is unique to each detector and should be archived for future reference. The calibration interval recommended for these detectors is 12 months. Please make sure that these items are received in good condition.

NOTE

Fragile parts are contained. Use caution when handling. There is no user serviceable part for this product.

1.2 Product Models

Model	Sphere Size	Input Port Size	Detector Type
819C-UV-2-CAL	2 in.	0.5 in.	UV-enhanced Silicon
819C-UV-5.3-CAL	5.3 in.	1.0 in.	
819C-SL-2-CAL2	2 in.	0.5 in.	Silicon
819C-SL-5.3-CAL2	5.3 in.	1.0 in.	
819C-IG-2-CAL	2 in.	0.5 in.	InGaAs
819C-IG-5.3-CAL	5.3 in.	1.0 in.	
819D-UV-2-CAL	2 in.	0.5 in.	UV-enhanced Silicon
819D-UV-5.3-CAL	5.3 in.	1.0 in.	
819D-SL-2-CAL2	2 in.	0.5 in.	Silicon
819D-SL-5.3-CAL2	5.3 in.		
819D-IG-2-CAL	2 in.		InGaAs
819D-IG-5.3-CAL	5.3 in.		

Table 1 819C and 819D Series Models. Check with Newport for the full product offering.

1.3 Benefits of Using Sphere Detectors

Newport's calibrated integrating sphere detectors consist of the 819C and 819D series integrating spheres, configured to measure diverging or collimated light sources, respectively, and either a Si, UV-enhanced or an InGaAs sensor. The integrating sphere is an ideal tool for measuring high power or diverging light sources using a photodiode. The available sphere sizes are between 2" and 5.3".

The spheres with a silicon detector are suitable for the measurements ranging from 400 – 1100 nm, while the models with an InGaAs detector are suitable for approximately 800 – 1650 nm range. The UV detector is optimized for wavelengths between 200 - 400 nm, but it is calibrated up to 1100 nm. All the spheres come with an SMA fiber optic connector on the North pole as a standard feature, allowing a small amount of light pickoff for wavelength measurement or any further analysis without affecting the overall system calibration.

Key Features

- Competitive calibration uncertainty
- Calibrated and traceable to NIST standards
- Measurements are less sensitive to exact detector positioning, compared to a photodiode or a thermopile detector
- The models that end with –CAL2 utilize a 918D-SL-OD1 detector with a built-in OD1 optical attenuator, improving the dynamic range and the high power handling capability. The thermal sensor near the sensor head allows correction of the optical power measurement as a function of temperature when used with by the optical meter Models 1918-R, 1936-R/2936-R, and 1830-R. The On/Off position of the attenuator is automatically detected and the temperature reading of the detector as well.

Figure 1 Attenuator 'ON/OFF' Switch is on the photodiode head

- The detectors have a built-in EEPROM which stores the responsivity data, measured for every 10 nm step within the specified spectral range, for the detector. The responsivity data is stored for both with and without the attenuator filter in the beam path. The detectors are “hot-pluggable”, enabling this data to be uploaded onto the power meter when the detector is first connected to the instrument, allowing for corrections of the responsivity as a function of the wavelength selected by the user.

1.4 Specifications

The following table summarizes the performance specifications of the 819C and 819D Series detectors. Specifications may change without notice.

Model	Spectral Range	Calibration Uncertainty	Power Range
819C-UV-2-CAL	200 to 1100 nm	4% @ 200 - 250 nm 2.5% @ 251 - 950 nm 5% @ 951 – 1100 nm	100 nW - 100 mW @ 350 nm
819C-UV-5.3-CAL	220 to 1100 nm	3% @ 220 - 830 nm 3.5% @ 831 – 960 nm 3% @ 961 - 1100 nm	100 nW - 500 mW @ 350 nm
819C-SL-2-CAL2	400 to 1100 nm	2.5% @ 400 - 1000 nm 3% @ 1001 – 1100 nm	100 nW – 2.0 W
819C-SL-5.3-CAL2			100 nW – 4.0 W
819C-IG-2-CAL	800 to 1650 nm	5% @ 800 - 910 nm 2% @ 911-1650	100 nW - 1.5 W
819C-IG-5.3-CAL	860 to 1650 nm	5% @ 860 - 920 nm 2% @ 921-1650	1 µW - 4.5 W
819D-UV-2-CAL	200 to 1100 nm	4% @ 200 - 250 nm 2.5% @ 251 - 950 nm 5% @ 951 - 1100	100 nW - 100 mW @ 350 nm
819D-UV-5.3-CAL	220 to 1100 nm	3% @ 220 - 830 nm 3.5% @ 831 – 960 nm 3% @ 961 - 1100 nm	100 nW - 500 mW @ 350 nm
819D-SL-2-CAL2	400 to 1100 nm	2.5% @ 400 - 1000 nm 3% @ 1001 – 1100 nm	100 nW - 2 W
819D-SL-5.3-CAL2	400 to 1100 nm		100 nW - 10 W
819D-IG-2-CAL	910 to 1650 nm	5% @ 910-960 nm 2% @ 961-1650	100 nW – 2.5 W
819D-IG-5.3-CAL	930 to 1650 nm	5% @ 930-950 nm 2% @ 951-1650	1 µW – 9.0 W

Table 2 Specifications Table

1.5 Making Measurements

Attach the connector of an integrating sphere detector to a compatible Newport optical power meter (Refer to the power meter user manual for details on how to operate the meter). In order to assure good electrical connectivity, it is recommended that the thumbscrews located on both sides of the connector be hand-tightened.

Each detector comes with its unique calibrated responsivity data encoded in an EEPROM built into the connector. When the detector is connected to a power meter for the first time, manually set up the wavelength from the power meter. Calibration data is provided for the detector with and without the optical attenuator. Newport's 1830-R, 1918-R, 1928-C, and 1936/2936-R optical meters read the EEPROM data, not only during initial power-up, but any time a detector is connected, and subsequently sensed by the optical meter. To ensure an accurate measurement, it is recommended that the detector be mounted securely on an optical table.

All Newport optical detectors are calibrated with the input port surface normal to the incident beam, with the reflectivity from the detector-air interface and from the attenuator already taken into account during calibration.

The models that end with –CAL2 have a built-in optical attenuator, which can be manually switched into or out of the optical path using a slider. Attenuator 'ON' and 'OFF' markings indicate the attenuator position (see Figure 1). A built-in sensor automatically detects the attenuator position, signaling the power meter to use the appropriate responsivity for the detector/attenuator combination.

1.6 Temperature and Humidity

The temperature range of +5 to +50°C and the humidity levels greater than 70% should not be exceeded to avoid permanent damages for the photodiode sensor. The photodiode sensitivity increases with temperature, mainly for wavelengths longer than the peak response wavelength. The temperature of the models ending with –CAL2 can be monitored with the built-in thermistor and the responsivity is numerically compensated to keep the calibration accurate within specification throughout the operating temperature for a given wavelength.

2 Calibration Uncertainties and Limitations

2.1 Spectral Response

The response of the detector depends on the wavelength of the incident light. The photodiode is transparent for photon energies less than the band gap, which determines the long wavelength infrared sensitivity limit. The short wavelength limit is determined by the photodiode manufacturing process and possibly, in the case of silicon photodiodes, by strong window absorption. The photodiode response is commonly measured in amps of photocurrent per watt of incident optical power. The response curves for the photodetector are shown on the calibration report, shipped with each detector.

2.2 Divergent vs. Collimating Beam Input Considerations

One of the major advantages of using an integrating sphere is to diffuse the input beam so that the detector readings are less sensitive to errors caused by detector positioning or problems associated with overfilling, or saturation of the active area of the detector. The detector should see a completely diffused input field. Then, a key technical consideration, when deciding which configuration one has to choose, is whether the input beam will directly hit the detector, influencing the optical power at the detector. For this purpose, each integrating sphere includes a baffle.

The 819D series integrating sphere detectors, ideal for measuring divergent light sources, are configured as shown in Figure 2. The 819C series integrating sphere detectors, ideal for measuring collimated light sources, are configured as shown in Figure 3. If the light source is diverging with a small angle, either configuration will work.

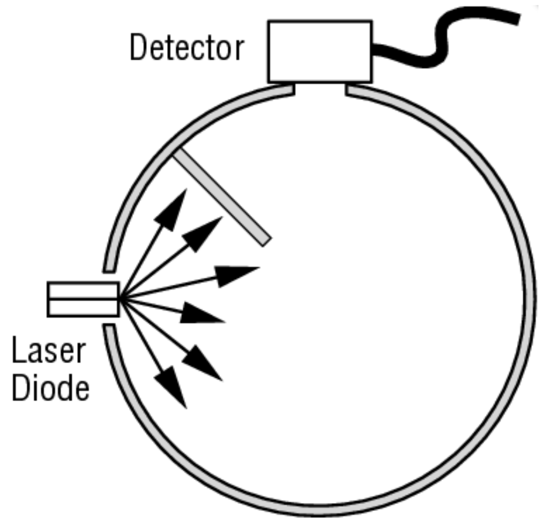

Figure 2 819D integrating sphere configuration.

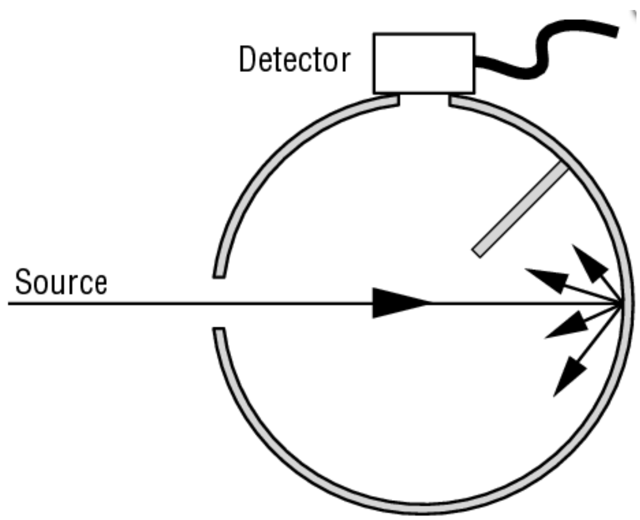

Figure 3 819C integrating sphere configuration.

2.3 Calibration Uncertainties and Services

STATEMENT OF CALIBRATION

The uncertainty and calibration of this photodetectors are traceable to National Institute of Standards and Technology (NIST) or an equivalent body, through equipment which is calibrated at planned intervals, and by comparison to certified standards maintained at Newport Corporation.

Newport Corporation calibrates its detectors using secondary standards directly traceable to NIST and/or NRC. The absolute uncertainty of the photodetector calibration is indicated on the calibration report. Detector response can change with time at different wavelengths, especially in the ultraviolet, and should be returned for recalibration at 12 month intervals to ensure confidence in the accuracy of the measurement.

Note that the system calibration is no longer valid if any component is changed from the original calibrated configuration. For a very high power level, elevated temperature of the integrating sphere system can affect the measurement accuracy, so the sphere must be temperature controlled. We recommend that the system be calibrated every year, along with the optical power meter.

For recalibration services, contact Newport Corporation at 800-222-6440.

2.4 Detector Saturation

For low optical power, the photocurrent is linearly proportional to the optical signal incident on the photodiode. For high optical powers, saturation of the detector begins to occur and the response signal is no longer linearly proportional to the incident power. Optical power measurements must be made in the linear region to be valid. Newport's optical meters measure the current coming from the detector and will let you know before the detector is near its saturation point. However, even with low total power, it is possible to locally saturate the detector by subjecting it to high power densities (power per unit area), i.e., a very small beam size. This is why it is important to fill the central portion of the detector's active area as much as possible.

NOTE

The saturation is "soft", i.e. the detector output does not suddenly stop increasing, but the rate of increase slows. For Gaussian and other signals with spatially varying intensities, local saturation may occur. The onset of saturation is not always obvious and is a common source of inaccurate measurements.

To determine if the detector is saturating, follow the steps below:

1. Measure the photodetector current (or power), and record this value (A).
2. Place a filter or attenuator of known transmission (T) in the beam path. Record the current again (B). A filter transmission of 0.001 is a convenient choice.
3. The power with the filter in place should be the product of the power measured without the filter and the transmission of the filter, i.e. B = A x T.

If the transmission (T) of the filter is not known, it can be determined by following the steps below:

1. Reduce the optical power to a level low enough to avoid saturation, but high enough that, when it is reduced by the filter it can still be accurately measured.
2. Follow steps 1 and 2 in the procedure above.
3. Calculate the ratio T = B/A to determine the transmission of the filter at the wavelength of light used for the measurement.

The calibrated filter (or attenuator) can be used with the detector to measure the power of higher power beams.

2.5 Saturation with Pulsed Power Measurements

Saturation effects, when using pulsed lasers, are a complex phenomenon and depend upon the wavelength, peak power, pulse shape, average power, repetition rate, and on the type of detection circuit. However, the test for saturation described immediately above should be used whenever pulsed power measurements are being made.

2.6 Photodiode Operation

When a photon is absorbed in the photodiode, an electron-hole pair is formed within the device and a voltage is developed across the diode junction. If the photodiode terminals are connected a photocurrent proportional to the light intensity will be generated. Measuring this photocurrent provides a measurement of the optical power incident upon the detector. Newport's power meters utilize an Op Amp to enable unbiased photocurrent measurement. Operation with zero bias is called the Photovoltaic Mode.

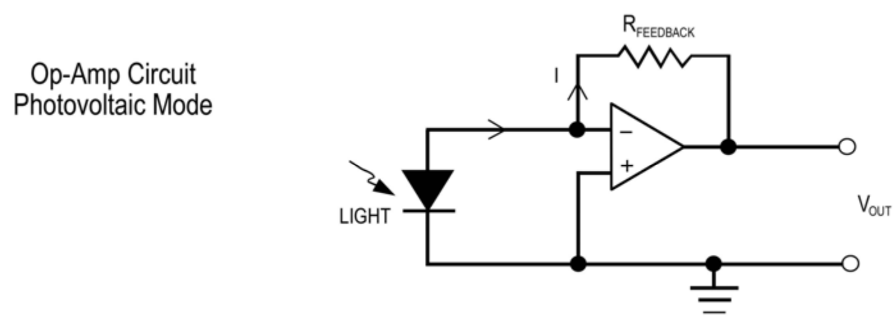

Figure 4 Newport detector circuitry used in photovoltaic mode

2.7 Low Power Measurement Considerations

Proper detector usage in the low light measurement situations and achievement of accurate results requires the understanding of a number of effects that limit the device performance which are discussed below.

2.7.1 Noise Characteristics

The lower limits of optical detection are determined by the noise characteristics of the detector and/or amplifier. Theory predicts that the photodiode noise is largely thermal (Johnson) noise associated with the effective resistance of the photodiode and shot noise from dark current. Additionally, there is Johnson noise contributed by the resistance of the amplifier's feedback resistor. The dark current at a 10mV bias voltage is measured and used to define the effective resistance of the photodiode, known as the shunt resistance:

$$R_{shunt} = V_{bias} / I_{dark} \text{ where } V_{bias} = 10mV$$

Ideally an input amplifier connected as in Figure 4 would have no off- set voltage and there would be no dark current. In practice though, a small bias usually exists. For non-CW measurements the light detection limit is more generally expressed as the intensity of light required to produce a current equal to the noise current, i.e. a signal-to-noise level of 1. This is called the noise equivalent power (NEP) and is expressed as:

$$NEP = \text{Noise Current/Sensitivity} (W/\sqrt{Hz})$$

with sensitivity defined as the current generated by the photodiode for a given incident power, at a specific wavelength. NEP varies inversely with the spectral response of the photodiode and depends on the wavelength, the noise frequency, f, and bandwidth, Δf.
Noise and dark current generally increase exponentially with detector temperature so it is best to keep the temperature close to 25°C.

2.7.2 Ambient Light and Electrical Offsets

Due to the reduced detector responsivity, caused by the signal diffusion of light inside the sphere, the ambient light should be reduced as much as possible when using the detector. It is recommended that the measurement setup be constructed in a light tight box.

Although the photocurrent generated by ambient light can be easily zeroed out, the shot noise associated with the photocurrent will not be zeroed, nor will any changes in the ambient light levels, which might be caused by people moving around in the room. A small electronic offset will always be present with semiconductor detectors, caused by an interaction of the detector shunt resistance with voltage offsets in the amplifier circuitry. The offset can be removed by use of the optical meter's zero function. Please note, however, that the offset is a function of the temperature of both the photodiode and the amplifier inside the optical meter.

When measuring very low light levels, it is best to re-zero the meter whenever you think that the temperature of the detector or the optical meter may have changed. For instance, it is good practice to re-zero the meter after a warm-up period of about 30 minutes. Refer to your optical meter manual for details regarding the zeroing procedure.

2.8 High Power Measurement Considerations

Integrating sphere detectors are often used in high power measurements, due to the natural signal attenuation due to diffusion of the signal inside the sphere. Newport's 819D-SL-5.3-CAL2 can measure up to 10 watts of optical power at its peak responsivity wavelength, around 980 nm. The main mechanism that limits the high power measurement of a sphere detector is the detector saturation. The InGaAs detectors start to saturate at approximately 10 mA current, the Si detectors at 2 mA, and the UV detectors at 100 uA. Because the responsivity is wavelength dependent, the maximum optical power at which the photodiode saturates is also wavelength dependent.

Figure 5 shows a typical responsivity curve of a 819D-SL-5.3-CAL2 (shown in blue, if viewed in color). The maximum power before saturation becomes higher at the wavelengths with lower detector responsivity.

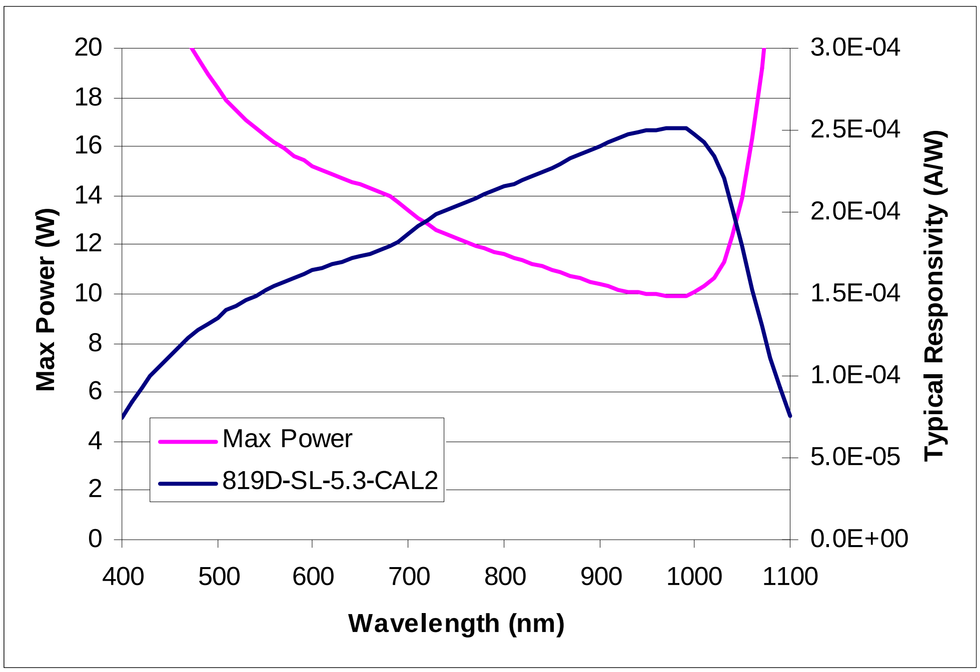

Figure 5 Typical responsivity curve of 819D-SL-5.3-CAL2

When making high power measurements, ensure that proper cooling is applied, especially at the detector.

2.9 Using the Detector for Non-CW Measurements

When the photodetector is used with a Newport optical meter, it is operated essentially without bias voltage, as depicted in Figure 4. The effective time constant of the detector/amplifier combination may be much slower than the characteristic time of the signal. Nonetheless, if the detector/amplifier combination does not become saturated, effective integration of the signal will occur, and accurate power measurements of very short pulses can be made. Additionally, if the repetition rate or duty cycle is sufficiently high, good average power measurements can be made. Usually it is helpful to turn on the analog filter (5Hz low- pass) to smooth the DC component so that the optical meter will make consistent measurements of the average power.

3 Factory Service

3.1 Introduction

This section contains information regarding obtaining factory service for the products. The user should not attempt any maintenance or service of this product. Contact Newport Corporation or your Newport representative for assistance. The detector calibration uncertainty is warranted for a period of 1 year with a normal use.

3.2 Obtaining Service

To obtain information concerning factory service, contact Newport Corporation or your Newport representative. Please have the following information available:

1. Product model number
2. Product serial number
3. Description of the problem.

If the instrument is to be returned to Newport Corporation, you will be given a Return Authorization Number, which you should reference in your shipping documents. Please fill out a copy of the service form, located on the following page, and have the information ready when contacting Newport Corporation. Return the completed service form with the instrument.

3.3 Service Form

Newport Corporation U.S.A.
Office: 800-222-6440
FAX: 949/253-1479

Name ________________________________ Return Authorization #__________________
(Please obtain RA# prior to return of item)

Company ____
(Please obtain RA # prior to return of item)

Address _________________________________ ____________________Date _________________

Country ________________________ Phone Number _______________________________________

P.O. Number ___________________ FAX Number ____

Item(s) Being Returned:

Model # ________________________ Serial # ___________________________

Description ____

Reason for return of goods (please list any specific problems):

____

____

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