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Model 918D Series

Photodiode Detectors

User's Manual

Newport®
Experience | Solutions

Model 918D Series
Photodiode Detectors

Dear Customer,

This User Manual contains essential information, including safety precautions and start up procedures, needed to get your new instrument up and running. Please review it prior to unpacking and powering up the instrument.

In an effort to keep the Newport instruments optimized for your applications, Newport will on occasion update existing and add new features and documents. You can find the latest User Manual, application software, Start-up Guide, or firmware at the product page on the Newport website (www.newport.com). Call your local Newport application specialist if you need support with locating or downloading these files.

Enjoy your new product!

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

The above warranties do not apply to products which have been repaired or modified without Newport's written approval, or products subjected to unusual physical, thermal or electrical stress, improper installation, misuse, abuse, accident or negligence in use, storage, transportation or handling. This warranty also does not apply to fuses, batteries, or damage from battery leakage.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. NEWPORT CORPORATION SHALL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, OR CONSEQUENTIAL DAMAGES RESULTING FROM THE PURCHASE OR USE OF ITS PRODUCTS.

First printing 2006

This manual has been provided for information only and product specifications are subject to change without notice. Any change will be reflected in future printings.

Newport Corporation
1791 Deere Avenue
Irvine, CA, 92606, USA
Part No. 44640-02, Rev. D

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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 & Asia
Newport Corporation Service Dept.
1791 Deere Ave. Irvine, CA 92606
Telephone: (949) 253-1694
Telephone: (800) 222-6440 x31694

Europe
Newport/MICRO-CONTROLE S.A.
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45340 Beaune la Rolande, FRANCE
Telephone: (33) 02 38 40 51 56

Asia

253 Aidu Road, Bld #3, Flr 3, Sec C
Shanghai 200131, China
Telephone: +86-21-5046 2300
Fax: +86-21-5046 2323

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?

Table of Contents

General Information

This guide contains information necessary for using model 918D series photodetectors. Please read through the guide before attempting to make optical power measurements or energy measurements.

1.1 Unpacking and Inspection

The 918D photodetectors are shipped in a foam padded cardboard box. The user's manual and the calibration report are also included. 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

The only user serviceable part of this detector is the cleaning of the internal attenuator filter and detector window. See Section 1.6 for a description on how to clean these parts.

1.2 Photodetector Features

918D series detectors utilize Silicon, extended Silicon, Germanium, and InGaAs photodiodes covering a broad wavelength range from 200nm to 1800nm. These highly sensitive, low-noise semiconductor photodiodes enable measurements from the milli-Watt down to the femto-Watt regime. The built-in attenuator extends this range up into the 200mW to 10W range.

The 918D detectors are terminated with a 15-pin D-Sub type connector and are designed for use with Newport's optical meter families:

- 1928-C, 1935/2935-C, 1936/2936-C Series High Performance Optical Power/Energy Meters (Including the 1935T-C, 2935T-C and 2935T-C-1)
- 1931/2931-C Series High Performance Optical Power Meters
- 1918-C High-Performance Handheld Optical Power/Energy Meter
- 842-PE Handheld Optical Power/Energy Meter
- 1916-C Handheld Optical Power Meter

The 918D-IG-C1 cooled InGaAs detector can only be used with the 1935T-C, 2935T-C and 2935T-C-1 optical meters, which include a Thermo-Electric Cooler (TEC) Controller card. The detector has an additional cable, terminated with a 9-pin D-Sub type connector, for driving the TEC inside the detector head.

Photodetector Specifications

Model	918D-UV	918D-SL
Spectral Range (µm)	0.2–1.1	0.4–1.1
Power, Average Max w/ Attenuator (W/cm^2)(1)	0.2	2
Power, Average Maximum w/o Attenuator (mW/cm^2)(1)	0.2	2
Pulse Energy, Maximum - w/ Attenuator ($\mu J/cm^2$)(2)	0.1	1
Pulse Energy, Maximum - w/o Attenuator (nJ/cm^2)(2)	0.1	1
Calibration Uncertainty (Without Attenuator)	4% @ 200-219nm, 2% @ 220-349nm, 1% @ 350-949nm, 4% @ 950-1100nm	1% @ 400-940nm, 4% @ 941-1100nm,
Calibration Uncertainty (With Attenuator)	8% @ 200-219nm, 2% @ 220-349nm, 1% @ 350-949nm, 4% @ 950-1100nm	1% @ 400-940nm, 4% @ 941-1100nm
Uniformity (%)(3)	±2	±2
Linearity (%)	±0.5	±0.5
Rise Time (µs)	≤5.9	≤2
Shunt Resistance (MΩ) (typ)	≥10	≥10
Reverse Bias, Maximum (V)	5	3
NEP (W/√Hz)	4.5×10^{-13}	2.0×10^{-13}
Material	Silicon-Uv Enhanced	Silicon
Active Area (cm^2)	1	1
Active Diameter (cm)	1.13	1.13
Shape	Cylinder	Cylinder
Attenuator	Built-In OD3(4)	Built-In OD1, OD2 or OD3(4)
Calibration	Stored Internally	

918D-IR	918D-IG	918D-IG-C1 (Obsolete)
0.78–1.8	0.8–1.65	1.2–2.55
2	2	2
3	3	3
0.35	0.35	0.35
0.35	0.35	0.35
2% @ 780-910nm, 2% @ 911-1700nm, 4% @ 1701-1800nm	2% @ 800-900nm 2% @ 901-1650nm	5% @ 1200-1390nm, 4% @ 1400-2520nm, 8% @ 2530-2540nm
5% @ 780-910nm, 2% @ 911-1700nm, 4% @ 1701-1800nm	5% @ 800-900nm, 2% @ 901-1650nm	5% @ 1200-1390nm, 4% @ 1400-2520nm, 8% @ 2530-2540nm
±2	±2	±2
±0.5	±0.5	±0.5
≤2	≤2	≤100 (ns)
≥35 (kΩ)	≥20	≥60 (kΩ)
0.25	2	2
0.6×10^{-12}	4.0×10^{-14}	5×10^{-13}
Germanium	Indium Gallium Arsenide	Indium Gallium Arsenide w/ built-in 2-stage T.E. cooler
0.071	0.071	0.0079
0.3	0.3	0.1
Cylinder	Cylinder	Cylinder
Built-In OD1, OD2 or OD3(4)	Built-In OD1, OD2 or OD3(4)	Built-In OD1, OD2 or OD3(4)
	Stored Internally	

1) Applies to entire spectral response

2) 15 ns pulse width

3) Uniformity specification applies to detector only

4) Selected at time of ordering

1.4 Making Measurements

918D series photodetectors are terminated with a 15-pin D-Sub connector, which needs to be attached to the back or side panels of Newport's optical meters. 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 detector body. Calibration data is provided for the detector with and without the optical attenuator. Newport's 1936/2936 series of optical meters read the EEPROM data not only during initial power-up, but at any time a detector is connected to, and subsequently sensed by the optical meter.

The 918D series photodetectors have a built-in optical attenuator, which can be manually switched into or out of the optical path using a thumb-wheel located on top of the detector housing. Attenuator 'ON' and 'OFF' markings indicate the turning direction. A built-in sensor automatically detects the attenuator position, signaling the instrument to use the appropriate responsivity for the detector/attenuator combination.

The 918D-IG-C1 cooled InGaAs detector is terminated with two cables. The first one is identical to the cable on the standard 918D series detectors, and is terminated with a 15-pin D-Sub connector. The second cable is terminated with a 9-pin D-Sub connector and needs to be attached to the TEC Controller card of the 1935T-C, 2935T-C or 2935T-C-1 optical meters. Upon turning on the power meter, the TEC inside the detector head will start cooling down the photodiode to the factory preset temperature. A temperature sensor inside the photodiode housing provides the actual temperature reading back to the controller card, which will maintain the temperature at the optimal level. The instrument front panel display will indicate when the optimal temperature level is attained, at which point the detector is ready for taking measurements. The detector temperature will typically settle within a few seconds after the detector is plugged into the instrument.

- 918D series detectors are available with one of several built in optical attenuators – OD1, OD2 or OD3 - which are mounted on a slide internal to the detector housing. The On/Off position of the attenuator is automatically detected by the optical meter.

- 918D series detectors have a built-in EEPROM which stores the responsivity data for the detector. The 918D 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.

- 918D series detectors include a thermistor which measures the temperature of the detector and allows the optical meter to make numerical corrections of the responsivity as a function of temperature.

- 918D series detectors were designed to position the optical axes of the internal photodiode, directly over the mounting hole located on the bottom surface of the detector. This should provide a more accurate alignment of the laser beam onto to the photodiode, in the event the detector is rotated around its axis. The location of the optical axis is maintained for all detector types. 8-32 and M4 threaded holes are provided on the detector housing perimeter for post mounting to an optical table.

- 918D series detectors can be post mounted or mounted to an optional base plate, allowing the positioning of the detector on a flat surface or bolting it to an optical table.

- The 918D-IG-C1 cooled InGaAs detector includes a thermistor which measures the temperature of the photodiode and provides feedback to the TEC controller card inside the 1935T-C, 2935T-C and 2935T-C-1 optical meters.

Figure 1 – Model 918D attenuator 'ON/OFF' dial

NOTE

You must manually set the optical meter to the correct wavelength for the light source you are measuring to obtain accurate power measurements.

1.5 Optional Accessories

Base Plate
A base plate kit (Model 918D-Base-Kit), consisting of the plate and mounting screws, is available for using the detector on a flat surface or optical table. A total of 5 screws are provided: 1 set screw to attach the base plate to the detector and 4 screws for attaching the plate to an optical table (2 Metric and 2 English)

Figure 2 – Model 918D mounted on Base

1.6 Cleaning

The 918D series detector head must not be disassembled for cleaning purposes. The attenuator optics can be cleaned by placing the internal filter in the 'ON' position and accessing it from the front.

– Clean attenuator surface when in 'On' position

– Clean Photodiode surface when in 'Off' position

Figure 3 – Cleaning Detector Optics on Model 918D

The front surface of the glass window or attenuator window can be accessed through the opening in the detector.

The photodiode surface does not need to be cleaned as it is positioned in a sealed environment, behind the window. Use the proper optics grade lint-free cotton swabs and organic solvent, such as optical-grade isopropyl alcohol, reagent-grade acetone, or lens cleaning solution.

NOTE

Kleenex and Kim-wipes contain wood and fiber glass (respectively) and will scratch optical surfaces.

CAUTION

Fragile parts contained. Use caution when handling

Care should be taken not to touch the photodiode window or attenuator with bare fingers. Contaminants may cause inaccurate measurements, particularly at ultraviolet wavelengths where absorption is common.

Potentially large measurement errors can be induced by scratches, digs and damage to the optical surfaces of the attenuator or detector. For dust removal, use pressurized gas (filtered dry nitrogen) and lint-free cotton swabs dabbed in an organic solvent.

Temperature and Humidity

The temperature range of +5 to +50°C should not be exceeded and the detector should not be exposed to humidity levels greater than 70%. The photodiode sensitivity increases with temperature, mainly for wavelengths longer than the peak response wavelength. The temperature of the 918D series detectors is monitored with a thermistor and the responsivity is numerically compensated to keep the calibration accurate within specification throughout the operating temperature for certain wavelengths.

2 Calibration Accuracy 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.

2.2 Calibration Accuracy and Service

Statement of Calibration: The accuracy and calibration of this photodetector are traceable to National Institute of Standards and Technology (NIST) and/or National Research Council of Canada (NRC) through equipment which is calibrated at planned intervals 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 accuracy 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 one year intervals to ensure confidence in the accuracy of the measurement.

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

2.3 Uniformity

Fabrication processes may cause the response of the detector to vary slightly over the detector surface. Calibration involves illumination of approximately 70% of the detector's central active diameter. Optical signals being measured should illuminate approximately this same area. Care should be taken not to overfill the detector if accuracy is to be maintained.

2.4 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, it is possible to locally saturate the detector by subjecting it to high power densities (power per unit area). 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 are a complex phenomenon, when using pulsed lasers 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.

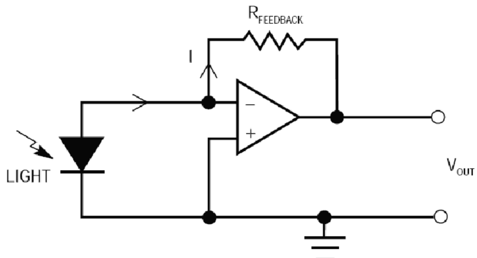
2.6 Reflections

The photodetector surface, window material and the attenuator all reflect light. The amount of reflected light depends upon the angle of incidence and the polarization of the beam. Reflected light does not get absorbed by the detector, and therefore is not included in the detector signal. The Newport detector and attenuator calibration include the loss due to reflection for incoherent light incident normal to the detector. For accurate power measurements the detector should therefore be used at near normal incidence.

2.7 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

Op-Amp Circuit
Photovoltaic Mode



2.8 Low Power Measurement Considerations

Measurements of very low power optical sources are possible with 918D series photodetectors. To use the detector properly and achieve accurate results requires the understanding of a number of effects that limit the device performance which are discussed below.

2.8.1 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:

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

Ideally an input amplifier connected as in Figure 4 would have no offset 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:

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

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, λ, the noise frequency, f, and bandwidth, ∅f.

Noise and dark current generally increase exponentially with detector temperature so it is best to keep the temperature close to 25°C.

2.8.2 Ambient Light and Electrical Offsets

Good measurement technique dictates that the effects of ambient light should be reduced as much as possible when using photodiodes. 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.

All 918D series photodetectors have a threaded aperture for the attachment of accessories. When measurements of power in fiber optics are being made, the effects of ambient lighting can be minimized by using the Model 818-FA Fiber Adapter Holder with the appropriate FP3 or FP4 series fiber adapters. If free space beam measurements are desired, using an attenuator will reduce stray light and often improve the ratio of signal to background noise. Wavelength specific filters, such as optical cutoff, bandpass, or spike filters can also be used if the signal wavelength spectrum permits. Other techniques to reduce stray light include using apertures to admit only the laser beam, placing the detector in a box to shield the surface and turning off external lighting.

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 Service Form

Newport Corporation
USA Office 800-222-6440
FAX: 949-253-1479

Name ____________________________ **Return Authorization #** ____________________

(Please obtain RA# prior to return of item)

Company ____

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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Newport Corporation, Irvine, California, has been certified compliant with ISO 9001 by the British Standards Institution.