

HAMAMATSU

MINI-SPECTROMETERS

TG-COOLED Series (C9913GC, C9914GB) **HARDWARE INSTRUCTION MANUAL**

Doc Version 1.10



To use the product safely

To use this product correctly and safely, always comply with the precautions listed below. We are not liable for any damage resulting from failure to comply with the precautions and instructions in this manual.

The following safety alert symbols and signal words are used in this manual to indicate degree of hazard.



DANGER

"DANGER" indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



WARNING

"WARNING" indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



CAUTION

"CAUTION" indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury or damage to the equipment.

Introduction

Thank you for purchasing a Hamamatsu TG-COOLED series mini-spectrometer (also called "this product"). This instruction manual explains how you can use this product and how to install, connect and operate it. To use this product safely and correctly, read this manual carefully before use and comply with the instructions.

Before using the TG series mini-spectrometer

- When using this product please be sure to stay within the maximum ratings and comply with all caution items to avoid possible trouble or accidents. We are constantly making every effort to improve product quality and reliability but this does not guarantee complete safety when using this product. In particular, when this product is to be used in equipment or systems which might cause personal injury, fatal accident or damage to property if handled improperly, be sure to implement safety measures that take potential problems fully into account. In such applications, we bear no responsibility for problems or damage arising from use of this product.
- After unpacking, first check that all items are included (see the list below). If an item is missing or damaged, contact us immediately without using this product.
- The contents of this manual are subject to change without prior notice due to product improvement, etc.
- Reproduction or copying of this manual is prohibited without permission of Hamamatsu Photonics.
- If this manual is lost or damaged, immediately contact our sales office to ask for an additional copy.

This product is supplied with the following items:

Mini-spectrometer main unit	1
CD-ROM	1
USB cable (1.5m)	1
Connector for external power supply	1
Inspection Sheet	1
Software license agreement	1
'About handling manual for HAMAMATSU miniature spectrometer' 1	



WARNING

■ **Stop using if an abnormal condition occurs.**

If smoke, unusual odors, abnormal noise or heat are noticed while operating this product, immediately stop using it. Continuous operation under such abnormal conditions may cause fire or electrical shock. Immediately turn off the PC connected to this product and then unplug the USB cable. After making sure that no abnormal condition has disappeared, contact our sales office. Never attempt to repair on your own since it is dangerous.

■ **Do not apply vibrations or shocks to this product.**

Excessive shocks or vibrations may damage the internal components or adversely affect their adjustments, causing fire or electrical shock.

■ **Always connect this product to a USB port.**

This product is designed to connect to a USB port on a PC. Fire or electrical shock may result if used at a voltage higher than the USB voltage.

■ **Do not disassemble this product.**

Do not remove any covers on this product. Touching the internal parts or changing their adjustments may cause malfunctions, fire or electrical shock.

■ **Do not allow any object or water to penetrate inside.**

If flammable objects, pieces of metal or water penetrate inside this product, they may cause fire or electrical shock.

■ **Handle the cables properly.**

Avoid placing any heavy objects on the cable or bringing a heater close to the cable. Do not pull on the cable itself when disconnecting it. Doing so might damage the cable and cause fire or electrical shock.

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CAUTION

Before using this product, be sure to read the following precautions to ensure correct and safe use.

■ This product is high-precision optical equipment !

Do not apply any excessive vibrations or shocks to this product.

Avoid storing or using this product in outdoor locations exposed to excessive dust or dampness.

The optical connector has an open aperture through which dust and damp might directly enter and affect the internal optical components. To prevent this, a cap is attached to the optical connector when shipped from our factory. Keep this cap attached until you connect an optical fiber cable to this connector. When connecting the optical fiber cable, clean the ferrule of the optical fiber cable.

Never insert any pointed or protruding object into the optical connector, since the internal optical components might be damaged.

■ Do not use organic solvent such as thinner and acetone for cleaning.

Use a soft dry cloth to wipe the surface of this product clean.

Keep the optical connector away from dust and dampness as explained above, so that you do not have to clean it.

■ Always use this product within the specified operating temperature range.

Avoid using this product in locations where the ambient temperature may exceed the specified operating temperature range. This product has a cooling fan. **Do not block the air intake and discharge vents during operation.**

If the temperature inside this product rises too high, the built-in safety circuit stops operation. However, breakdown might occur in some cases.

If the operation is interrupted by the safety circuit, immediately turn off the external power supply and disconnect the USB cable from this product. Then eliminate the cause and make sure that the temperature of this product has dropped to room temperature before restarting.

■ Install the evaluation software in your PC only after you accept the terms in the "Software license agreement".

Never connect this product to the PC before installing the evaluation software. Otherwise, the software installation may fail. (See the description of "Installing the software" in the separate "Mini Spectrometer Software Instruction Manual" for how to install the software.)

■ Power to this product is supplied from the USB port on the PC.

Typical current consumption of the Hamamatsu TG-COOLED series mini-spectrometers is shown below.

Mini-spectrometer model	Current consumption (mA)
TG-COOLED NIR-I (C9913GC)	250
TG-COOLED NIR-II (C9914GB)	250

Due to the USB specifications, the maximum power that can be supplied from one USB port is limited to 5 V, 500mA. **If connecting two or more units to one USB port through a hub, use a hub with power supply.**

■ Power saving function and screensaver

Depending on the PC model, the power supplied from the USB port might be interrupted when the power saving function or screensaver is activated. In this case, this product also stops operation and might create problems when the PC returns from power saving or screensaver mode.

If power to your PC is interrupted in this same way while connected to this product, **disable the power saving function and screensaver.** (For PC functions and settings, see the PC operation manual.)

■ Precautions on handling the acquired data

This product uses a 256 or 512-pixel linear image sensor that detects the light spectrum formed by the grating. The data acquired with the PC is A/D converted data that corresponds to the analog output from each pixel of the image sensor. **The evaluation software (supplied on the CD-ROM) saves the same A/D conversion data that corresponds to each pixel.** To calibrate each pixel of the image sensor according to the wavelength axis, see the description of "Notes on the saved text data" in the separate "Mini Spectrometer Software Instruction Manual".

■ This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Overview

Hamamatsu TG-COOLED series mini-spectrometers are compact polychromators integrated with optical elements and an image sensor circuit. Two models of the TG-COOLED series are available to cover different spectral ranges: TG-COOLED NIR-I and TG-COOLED NIR-II. The table below shows the TG-COOLED series model names and spectral response range.

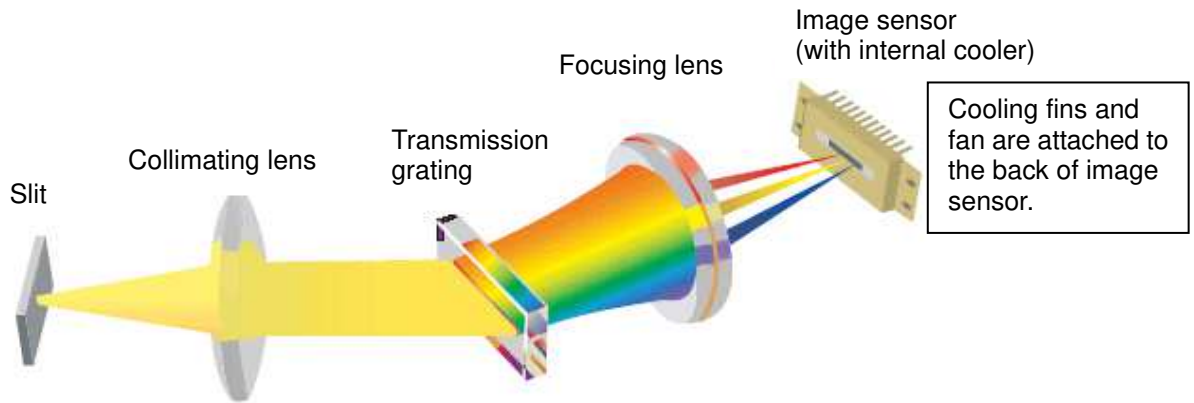
Mini-spectrometer model	Spectral response range (nm)
TG-COOLED NIR-I (C9913GC)	900 to 1700
TG-COOLED NIR-II (C9914GB)	1100 to 2200

Light to be measured is guided into the entrance port of the mini-spectrometer through an optical fiber and the spectrum is detected with the built-in image sensor. The spectrum data is then output from the USB port to a PC for data acquisition and analysis. Parameter information such as coefficients for converting the image sensor pixel numbers to the wavelengths is internally stored in the module. This can also be taken into the PC via the USB cable. The TG-COOLED series mini-spectrometer comes with evaluation software that lets you set measurement conditions, acquire and save spectrum data, and display it graphically. Basic measurements can be easily and quickly carried out with this software. Also supplied are a driver software package and a DLL file usable with Visual C++ and Visual Basic, allowing you to develop your own measurement programs.



Internal configuration

The following illustration shows the schematic diagram of a Hamamatsu TG-COOLED series mini-spectrometer. The function of each element used in the TG-COOLED series is explained below.



■ slit

This is an aperture through which light to be measured is guided. (with internal cooler) light to be measured is guided by an optical fiber connected to the slit.

■ Collimating lens

The light passing through the slit usually spreads at a definite angle. The collimating lens collimates this light and guides it onto the transmission grating.

■ Transmission grating

The Transmission grating disperses the light guided through the collimating lens according to the wavelength and lets light of the same wavelength pass at the same diffraction angle. This is the so-called wavelength dispersing element.

■ Focusing lens

This lens forms an image of the light, which has passed through the transmission grating while being dispersed at the specific diffraction angles according to the wavelengths, onto the linearly arranged pixels of the image sensor that sequentially cover a spectral range from short to long wavelengths.

■ Image sensor

Converts the spectral data of light, which has been produced in the path between the slit and the focusing lens, into electrical signals. A thermoelectric cooler (Peltier cooler) is incorporated to reduce noise that generates during the light-to-electrical signal conversion.

■ Cooling fins and cooling fan

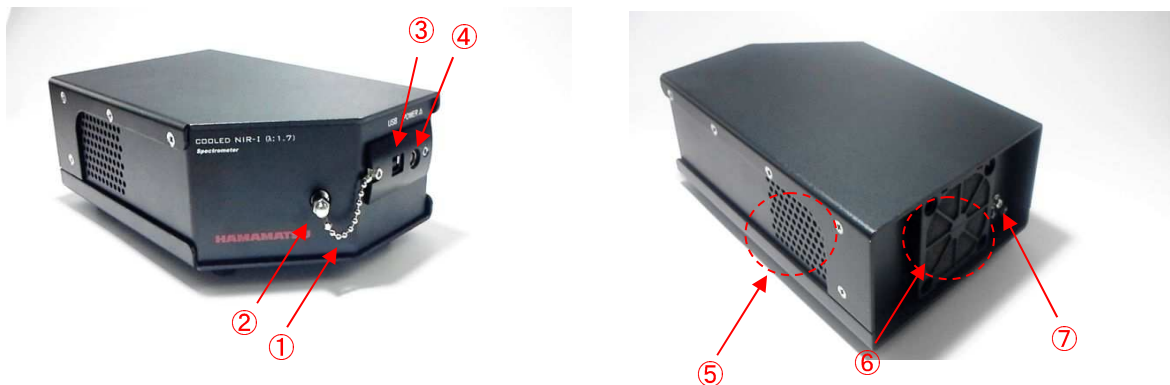
Radiates heat from the thermoelectric cooler in the image sensor.

Part name and description

Part names and functions of this product are described below.

■ Mini-spectrometer main body

Contains optical elements used to disperse light into a spectrum, an image sensor circuit and a cooler.



① Optical connector

This is the SMA905D receptacle. The optical fiber cable for guiding measurement light into the mini-spectrometer plugs in here. The entrance slit is located just inside this optical connector. A cap is attached to this optical connector when shipped.

② Optical connector cap

This cap should be attached to the optical connector when not in use.

③ USB connector

This is a USB B receptacle for connection to a PC. Use the supplied USB cable to make the connection.

④ Power supply connector

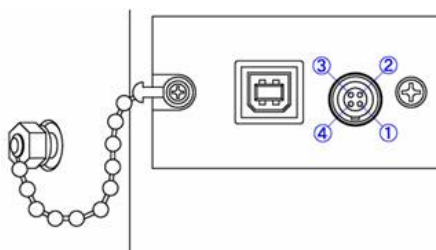
This is a multi-pin receptacle for connection to an external power supply.

Using the connector that comes with this product, make connection to an external power supply. Use a low-noise power supply (dropper type).

Note: If you use a commercially available external power supply, Teccio Technologies, Inc. (model number: PW18-1.3ATS) is recommended. When creating an external power supply, +5V is a TDK-Lambda linear power supply (model No.: NNS15-5) to + 12V, we recommend COSEL 's unit power supply (model number: PBA10F12-N).

Connector Pin No.	Signal	Function	TG-COOLED NIR-I	TG-COOLED NIR-II
1	VEC+	Thermoelectric cooler	5V 1.8A	5V 2.8A
2	VEC-			
3	VFAN+	Fan	12V 0.2A	12V 0.2A
4	VFAN-			

Connector pin number
(Viewed from the outside of case)



⑤ Air discharge vents for cooling fan

Air discharge vents for the internal cooling fan.

⑥ Air intake opening for cooling fan

This is an air intake opening for the internal cooling fan.

[Exchange of a cooling fan's filter]

The filter is attached to the cooling fan suction mouth so that the dust from the outside may not be inhaled in equipment. If a filter becomes dirty, please exchange in the following procedures.

- Exchange of a filter is performed after removing connection with an external power and PC
- The cover of the fan of a cooling fan suction mouth is removed.
(It is being fixed by the up-and-down nail)
- The filter in a cover is exchanged
Conformity filter : The filter for resin filter kit exchange. Five sheet is entered
Part number 109-1003m30 SANYO Electric Co.,Ltd.
- A cooling fan's cover is inserted in the original position.



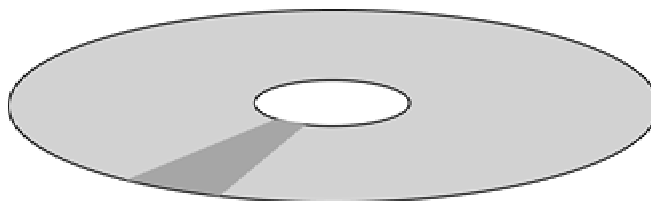
⑦ Ground terminal

This is a functional ground terminal.

Ground the mini-spectrometer using this terminal to remove noise if needed.

■ CD-ROM

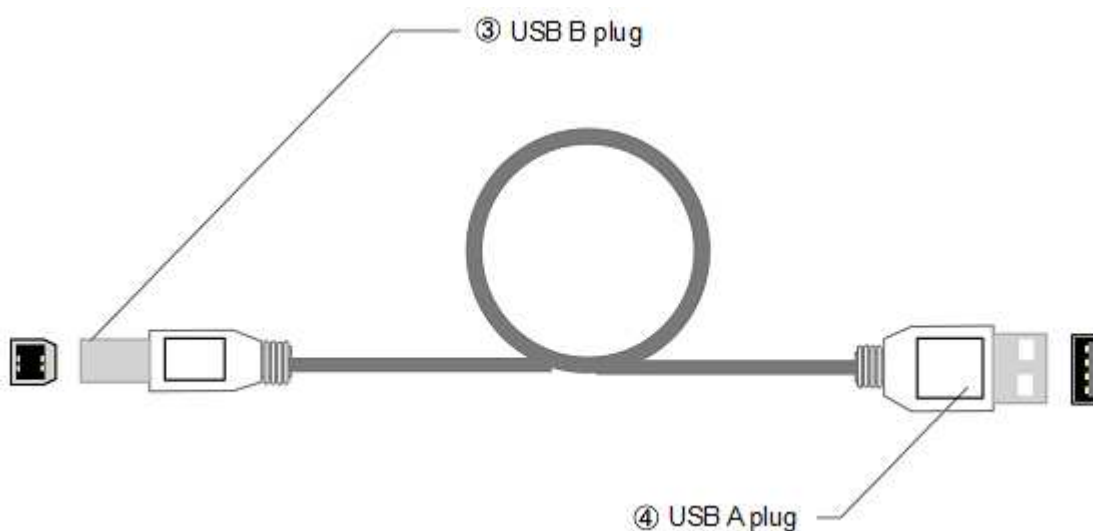
Contains related software and documents such as this instruction manual.



See the description of "Installing the software" in the separate "Mini Spectrometer Software Instruction Manual " for how to install the software.

■ USB cable (1.5 m)

Use this USB cable to connect the mini-spectrometer to the PC.



⑦ USB B plug

Connect this plug to the USB port of the mini-spectrometer.

⑧ USB A plug

Connect this plug to the USB port of the PC.

■ Connector for external power supply

FGG0B304CLAD56 (LEMO)

Use this connector to connect the mini-spectrometer to an external power supply.



Connecting/disconnecting the mini-spectrometer

The following procedures explain how to make connections to the mini-spectrometer.

Use the USB cable to connect the mini-spectrometer to your PC. Spectral data of the light that entered the mini-spectrometer through the optical fiber cable is transferred to the PC via this USB cable.

Power to the internal cooler circuit is supplied from an external power supply. Power to the other circuits is all supplied from the PC through the USB cable.

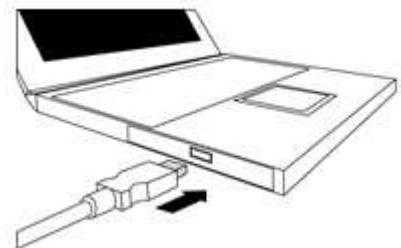
■ Connecting the cables

CAUTION:

- Always first install the evaluation software before connecting the mini-spectrometer to the PC. Otherwise, the software may not be installed.
(See the description of "Installing the software" in the separate "Mini Spectrometer Software Instruction Manual" for how to install the software.)
 - If the cables are connected in the wrong order, the built-in safety circuit may prevent the mini-spectrometer from starting operation. If this happens, disconnect all cables and then reconnect them from the beginning.
- (1) Using the power supply connector that comes supplied, connect the mini-spectrometer to the external power supply. Then turn on the external power supply.



- (2) Insert the USB A plug of the USB cable (supplied) into the USB port of the PC running on Windows.



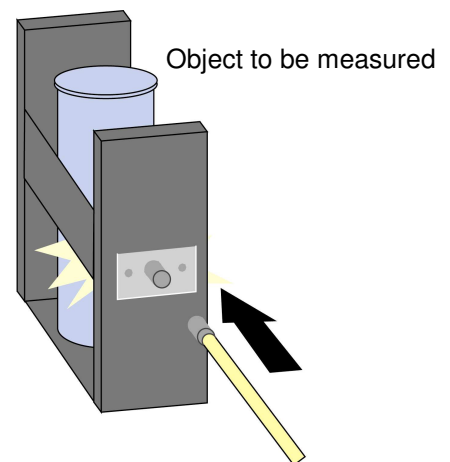
- (3) Insert the USB B plug of the USB cable (supplied) into the USB connector on the mini-spectrometer.



- (4) Remove the cap from the optical connector and attach one end of an optical fiber cable to the optical connector. (The end of the optical fiber cable should be cleaned before making this connection.) See the description in "[C. Suitable optical fiber cables](#)" in Appendix (p. 18) for selecting an optical fiber cable.



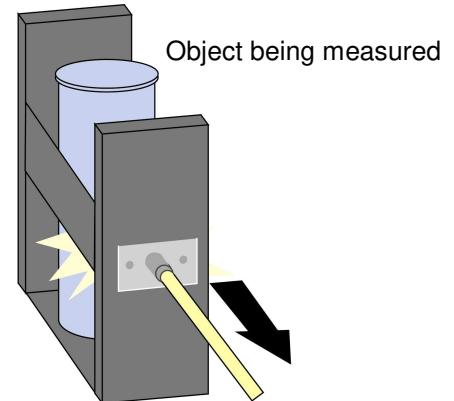
- (5) Connect the other end of the optical fiber cable to the object (light) to be measured.



- (6) Start the measurement software (evaluation software installed from the CD-ROM or user-developed software) on your PC. In actual measurement, the mini-spectrometer starts sending spectral data to the PC when the preset temperature is reached and stabilized by the thermoelectric cooler.

■ Disconnecting the cables

- (1) Quit the mini-spectrometer software (evaluation software installed from the CD-ROM or user's own software).
- (2) Remove the optical fiber from the object (light) being measured.



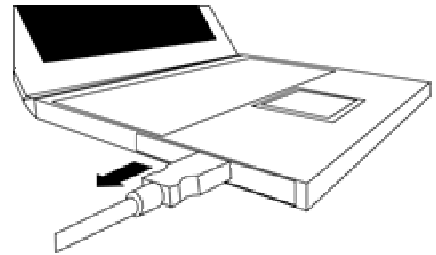
- (3) Remove the optical fiber cable from the optical connector of the mini-spectrometer and reattach the cap to the optical connector.



- (4) Unplug the USB cable from the USB connector on the mini-spectrometer.



- (5) Unplug the USB cable from the USB port of the PC.



- (6) Turn off the external power supply and then disconnect the power supply cable from the mini-spectrometer.



Warranty and repair

■ Warranty

When using this product please be sure to stay within the maximum ratings and comply with all caution items to avoid possible trouble or accidents. We are constantly making every effort to improve product quality and reliability but this does not guarantee complete safety when using this product. In particular, when this product is to be used in equipment or systems which might cause personal injury, fatal accident or damage to property if handled improperly, implement safety measures that take potential problems fully into account.

This product is warranted for a period of one year from the date of delivery. If you should find any failure in the workmanship and notify us within this warranty period, we will repair or replace it at our option, free of charge. (The warranty is limited to repair or replacement.) However, even if within the warranty period the warranty shall not apply to failures in cases where the product has been damaged by accidents such as natural or man-made disasters, or misused (including modification, incorrect handling without regard to the precautions, installation locations, applications, usage, storage and disposal described in this manual). Please acknowledge that we bear no liability for any problems caused by these cases.

■ Repair

If a failure is found or you suspect possible trouble, contact us with the specific problem and detailed description of the trouble, as well as the product model number and production number (serial number). We will make every effort to repair the product in as short a time as possible. In the following cases, however, the repair might require additional time and extra costs or might be refused.

- (1) The product was purchased a long time ago.
- (2) The maintenance parts used in the product are not in current production.
- (3) The product was modified or altered.
- (4) The product was severely damaged.

Appendix

A. Specifications

Parameter	TG-COOLED NIR-I	TG-COOLED NIR-II	Unit
	C9913GC	C9914GB	
Number of pixels ^{*1}	512	256	-
Spectral response range	900 to 1700	1100 to 2200	nm
Wavelength resolution (FWHM) ^{*2}	7Max.	8Max.	nm
Wavelength reproducibility ^{*3}	-0.2 to +0.2	-0.4 to +0.4	nm
Wavelength temperature dependence	-0.02 to +0.02	-0.04 to +0.04	nm/°C
Spectral stray light ^{*2, *4}	-35max.	-35max.	dB
Slit ^{*5}	70(H) × 500(V)	70(H) × 500(V)	um
A/D conversion	16		bit
Integration time	5 to 10000	5 to 1000	msec
Optical NA ^{*6}	0.22	0.22	-
Image sensor	InGaAs linear image sensor (G9204-512S)	InGaAs linear image sensor (Maximum wavelength sensitivity 1.95um) electronic cooling type	-
Image sensor cooling temperature	-5	-20	°C
Optical fiber connector	SMA905D		-
Interface	USB 1.1		-
Current consumption (USB bus power)	250max.	250max.	mA
Peltier element power ^{*7}	5/1.8 (max.)	5/2.8 (max.)	V/A
Cooling fan power ^{*7}	12/0.2		V/A
Operating temperature range ^{*8}	+5 to +35 (+5 to +30 ^{*9})		°C
Storage temperature range ^{*8}	-20 to +70		°C
Dimensions	218 × 142 × 80		mm
weight	1700		g

*1: A defective pixel doesn't exist. (When low gain is set)

According to our rule, defective pixel has non standard electrical and optical properties.

*2: Measured with the slit specified in this table. The wavelength resolution depends on the slit size.

*3: Measured under constant light input conditions.

*4: When monochromatic light of the following wavelengths is input, spectral stray light is defined as the ratio of the count measured at the input wavelength, to the count measured in a region of the input wavelength ± 40 nm.

C9913GC: 1300 nm, C9914GB: 1650 nm

*5: Entrance slit aperture size

*6: Numerical aperture (solid angle)

*7: Maximum power in normal state. Note that in-rush current flows at start-up.

*8: For controllable cooling temperature.

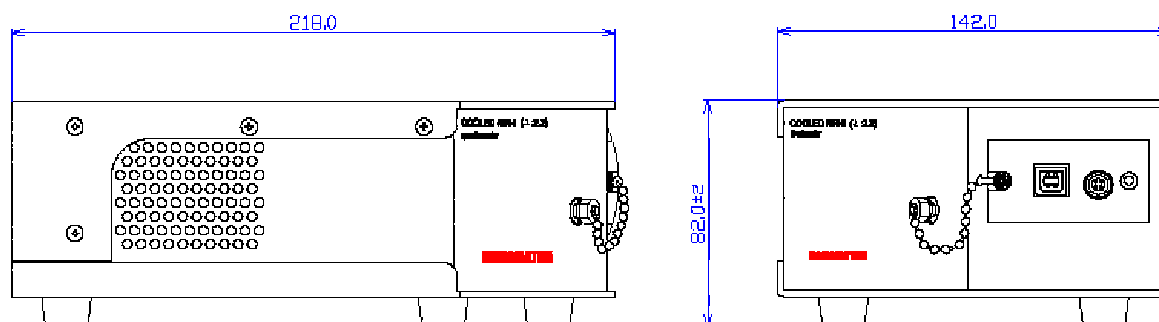
*9: No condensation. Avoid storing or using this product at high temperatures and high humidity.

Applicable standards

EMC	EN61326-1:2006 Group 1 Class B
-----	--------------------------------

NOTE: Use the USB cable (1.5 m) In the power cable side, it is at the ferrite core use time.

B. Dimensional outlines (Unit: mm)



C. Suitable optical fiber cables

The following conditions are required for optical fiber cables used to connect to mini-spectrometers.

- Optical fiber cables should have high transmittance in the spectral response range of the mini-spectrometer to be used or the spectral output range of the object (light) to be measured. This ensures more efficient and reliable measurement.
- Optical fiber cables should have an optical NA (numerical aperture) of about 0.2 that optically matches the TG-COOLED series mini-spectrometers. Adequate performance cannot be obtained if the NA differs significantly from these values.
- Optical fiber should have a core diameter sufficiently larger than the width of the input slit of the mini-spectrometer. Measurement reproducibility is adversely affected if the core diameter is less than 3 times the width of the input slit.
- The protective tube surrounding the optical fiber should have a good light shielding.
If the protective tube does not have good light shielding, then ambient light might penetrate inside the optical fiber as stray light and adversely affect measurement.

As optional accessories for the TG-COOLED series mini-spectrometers, Hamamatsu provides optical fiber cables carefully selected to meet the above-mentioned conditions.

Type No.	Product name	Mini-spectrometer	Specifications
A15363-01	Optical fiber for visible/near infrared range	TG-COOLED NIR-I (C9913GC) TG-COOLED NIR-II (C9914GB)	Core diameter 600 μm , N.A.=0.22 Length 1.5 m, with SMA905D connector at both ends

Use the A15363-02 (core diameter: 800 μm) if a larger core diameter is needed due to the light source, object to be measured or the measurement system.

D. Image sensors

Optical information is dispersed into a spectrum by the grating. The spectrum is then linearly focused by the focusing lens onto a linear image sensor that converts light into an electrical signal at each wavelength of the spectrum.

The TG-COOLED series uses an image sensor specifically designed for spectrophotometry based on our long experience in image sensor technologies.

The image sensor outputs a photoelectric signal from each pixel at a certain time interval. This time interval is called "integration time" during which the photoelectric signal is accumulated in each pixel. The output signal level can therefore be optimized by adjusting the integration time. For example, even at low light levels, lengthening the integration time increases the output signal to a level where the signal can be easily processed.

Image sensors used with the TG-COOLED series mini-spectrometers use the simultaneous integration method for charge integration.

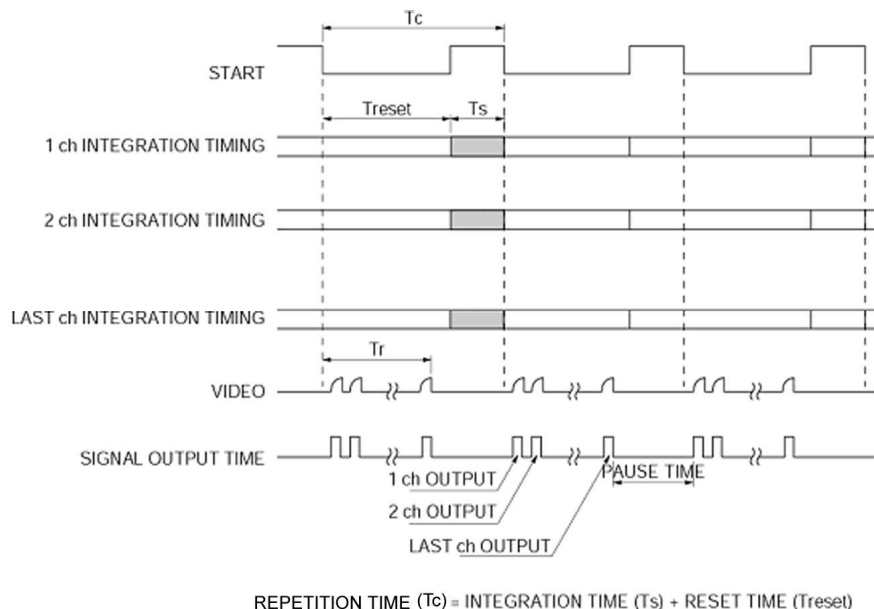
● Simultaneous integration method

In simultaneous integration, when a transfer pulse is input, the charges accumulated in the photodiode array are transported to the analog shift register from all pixels at one time. Each charge is then sequentially transferred to the readout section by a clock pulse. This method is used by the InGaAs image sensor G9204-512S and G9206-02 installed in the TG-COOLED series.

The integration time (T_s) of the InGaAs image sensor is controlled by the RESET signal level. Specifically, the sensor operation sets to the integration mode when the RESET signal level is "High" and sets to the reset mode when the RESET signal level is "Low". So the integration time (T_s) on image sensors using repetition time (T_c) will be the integration time (T_s) minus the reset period (T_{reset}).

When the TG-COOLED series is operated with the supplied evaluation software, the integration time (T_s) matches the software display, so the repetition time (T_c) will be the sum of the integration time (T_s) and the reset period (T_{reset}). Since the reset periods (T_{reset}) for TG-COOLED NIR-I and TG-COOLED NIR-II (C9914GB) are 2.066 msec, the repetition time (T_c) will be "integration time + 2.066 msec".

Information on light entering within the reset period is ignored, so use caution with measurement timing when pulsed light is input.



Timing chart (simultaneous integration method)

Release Notes

Version number	Revision date	Description
K29-B60912 Doc Version 1.0	Oct. 2010	First edition
K29-B60912A Doc Version 1.1	Jun. 2011	Changed A. Specifications
K29-B60912B Doc Version 1.2	Feb.2012	Deleted the part of words such as class I apparatus "of" IEC61010 " To use the product safely".
K29-B60912C Doc Version 1.3	Dec.2012	Changed A. Specifications Changed A. Specifications applicable standards
K29-B60912D Doc Version 1.4	Jun. 2013	Changed address Changed figure of external form dimensions Changed Air intake opening for cooling fan
K29-B60912E Doc Version 1.5	Oct. 2013	Changed Spectrometer picture Changed explanation of a cooling fan's suction mouth Changed A. Specifications Applicable standards
K29-B60912F Doc Version 1.6	Sep.2014	Changed supplied with the following items Changed Internal configuration Changed A. Specifications Applicable standards
K29-B60912G Doc Version 1.7	Dec.2016	Changed part name and description. Changed address.
K29-B60912H Doc Version 1.8	Nov.2017	Changed part name and description.
K29-B60912I Doc Version 1.9	May.2019	Changed recommended external power supply. Changed C. Suitable optical fiber cables.
K29-B60912J Doc Version 1.10	Aug.2020	Added explanation about FCC rules to "CAUTION".

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Product specifications are subject to change without prior notice due to improvements or other reasons. This document has been carefully prepared and the information contained is believed to be accurate. In rare cases, however, there may be inaccuracies such as text errors. Before using these products, always contact us for the delivery specification sheet to check the latest specifications.

The product warranty is valid for one year after delivery and is limited to product repair or replacement for defects discovered and reported to us within that one year period. However, even if within the warranty period we accept absolutely no liability for any loss caused by natural disasters or improper product use. Copying or reprinting the contents described in this material in whole or in part is prohibited without our prior permission.

HAMAMATSU

www.hamamatsu.com

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