

HAMAMATSU

MINI-SPECTROMETERS

TG Series (C9406GC)

HARDWARE INSTRUCTION MANUAL

Doc Version 1.9



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 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
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 using or storing 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.

■ 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.

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

Mini-spectrometer model	Current consumption (mA)
TG-NIR (C9406GC)	250

■ 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.)

The evaluation software contained on the supplied CD-ROM has a function that allows you to temporarily change the PC settings when the software starts up.

■ Precautions on handling the acquired data

This product uses a 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 series mini-spectrometers are palmtop-size polychromators integrated with optical elements and an image sensor circuit into a compact module. The table below shows the TG-NIR model names and spectral response range.

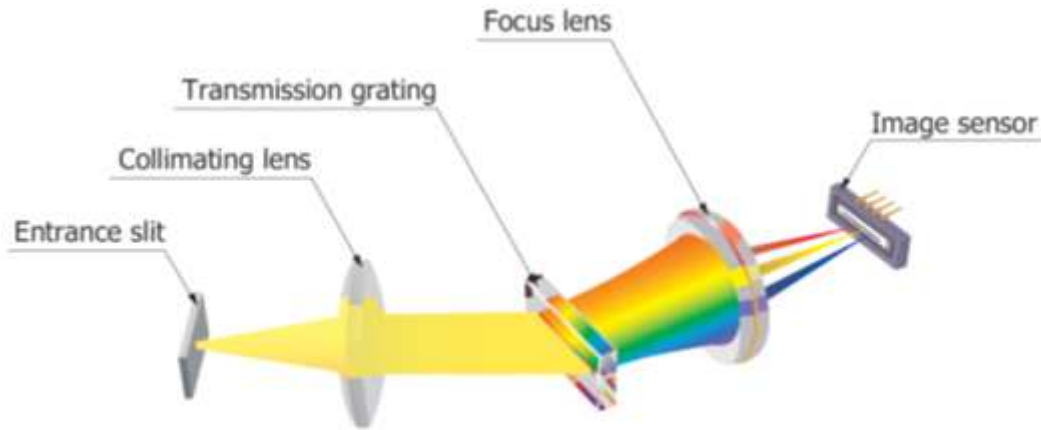
Mini-spectrometer model	Spectral response range (nm)
TG-NIR (C9406GC)	900 to 1700

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 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 series mini-spectrometer. The function of each element used in the TG series is explained below.



■ Entrance slit

This is an aperture through which light to be measured is guided inside. In most cases, the light to be measured is guided by an optical fiber connected to the entrance slit.

■ Collimating lens

The light passing through the entrance 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.

■ Focus 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

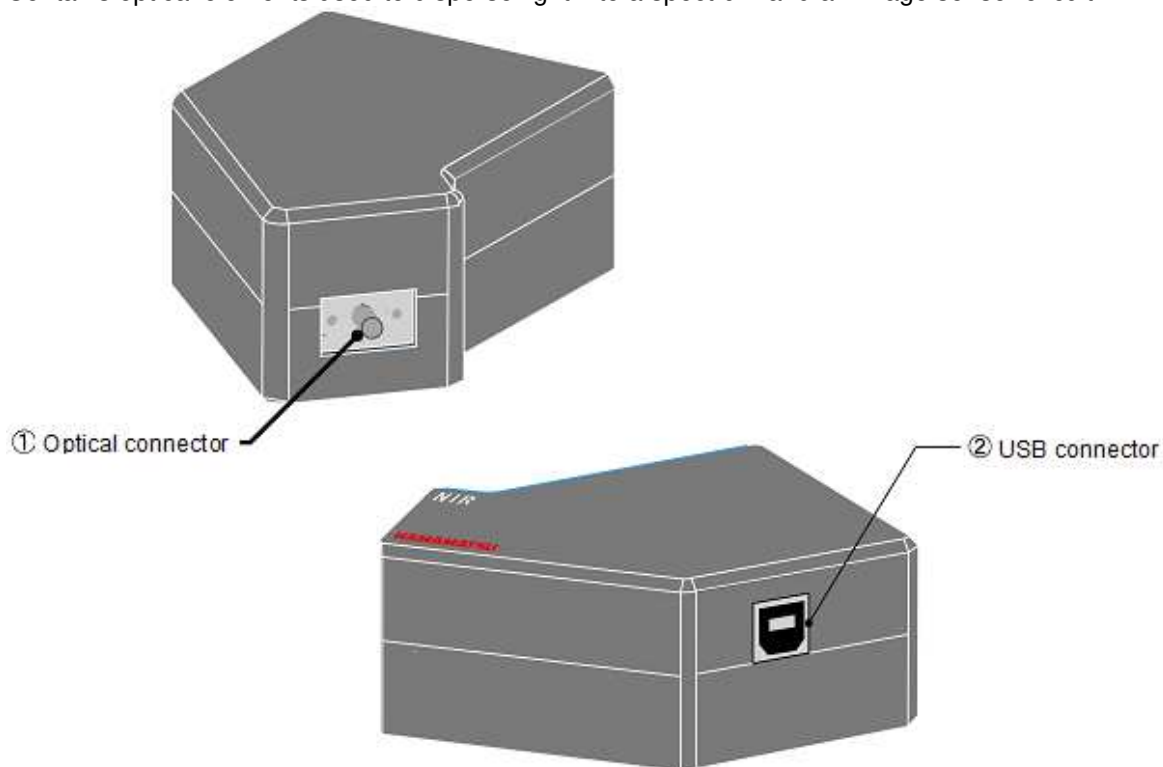
Converts the spectral data of light, which has been produced in the path between the entrance slit and the focus lens, into electrical signals.

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 and an image sensor circuit.



① Optical connector

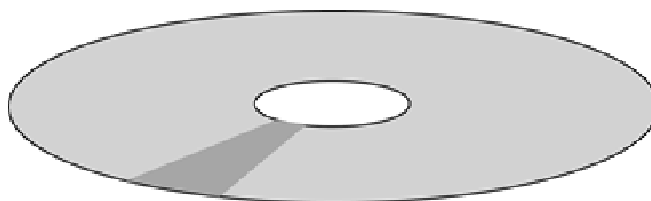
This is the SMA905D receptacle. The optical fiber cable for guiding measurement light into the mini-spectrometer plugs in here. The entrance slit is located just inside this optical connector. A cap is attached to this optical connector when shipped.

② USB connector

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

■ CD-ROM

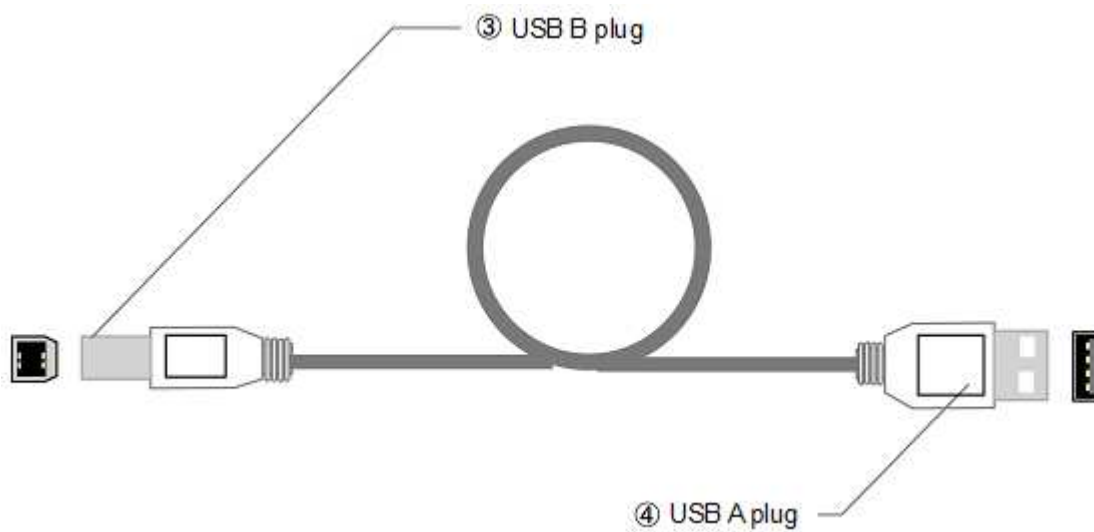
Contains related software and documents such as this instruction manual.



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.



③ USB B plug

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

④ USB A plug

Connect this plug to the USB port of the PC.

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 mini-spectrometer is supplied from the PC through the USB cable. No other power is needed.

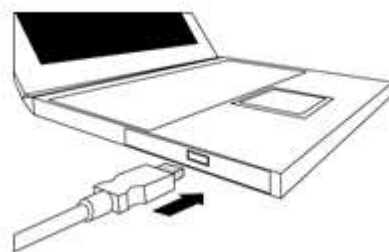
■ Connecting the cables

CAUTION:

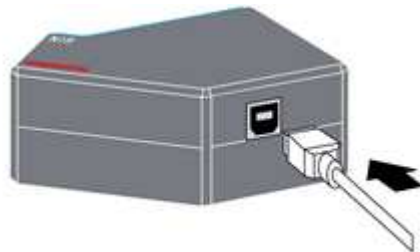
Always first install the evaluation software before connecting the mini-spectrometer to the PC. Otherwise, the software may not be installed.

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

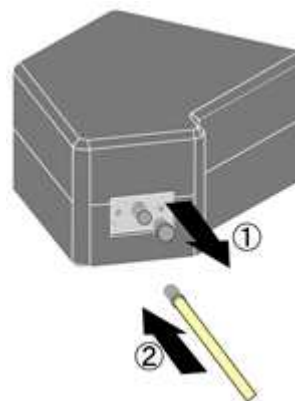
- (1) Insert the USB A plug of the USB cable (supplied) into the USB port of the PC.



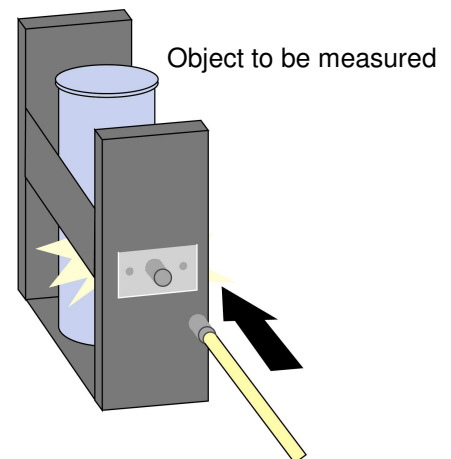
- (2) Insert the USB B plug of the USB cable (supplied) into the USB connector on the mini-spectrometer.



- (3) 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. 16) for selecting an optical fiber cable.

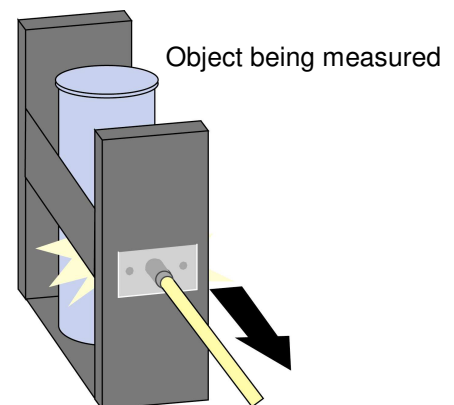


- (4) Connect the other end of the optical fiber cable to the object (light) to be measured.

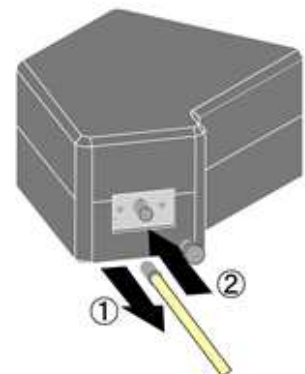


■ Disconnecting the cables

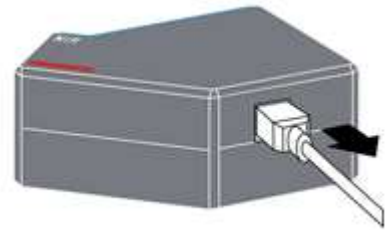
- (1) Quit the mini-spectrometer software (evaluation software installed from the CD-ROM or user's own software).
- (2) Remove the optical fiber from the object (light) being measured.



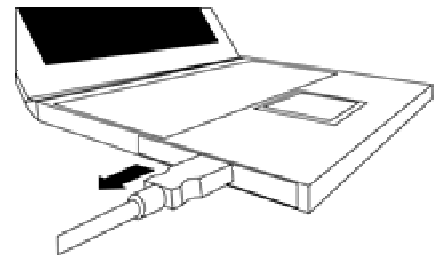
- (3) Remove the optical fiber cable from the optical connector of the mini-spectrometer and reattach the cap to the optical connector.



- (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.



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-NIR	Unit
	C9406GC	
Number of pixels ^{*1}	512	-
Spectral response range	900 to 1700	nm
Wavelength resolution (FWHM) ^{*2}	7max.	nm
Wavelength reproducibility ^{*3}	-0.2 to +0.2	nm
Wavelength temperature dependence	-0.02 to +0.02	nm/°C
Spectral stray light ^{*2, *4}	-35max.	dB
Slit ^{*5}	70 (H) × 500 (V)	μm
A/D conversion	16	bit
Integration time	5 to 10000	msec
Optical NA ^{*6}	0.22	-
Image sensor	InGaAs linear image sensor (G9204-512D)	-
Optical fiber connector	SMA905	-
Interface	USB 1.1	-
Current consumption (USB bus power)	250max.	mA
Storage temperature range ^{*7}	-20 to +70	°C
Operating temperature range ^{*7}	+5 to +40	°C
Dimensions	86 × 40 × 106	mm
weight	270	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 (C9406GC).
C9406GC: 1300 nm

*5: Entrance slit aperture size

*6: Numerical aperture (solid angle)

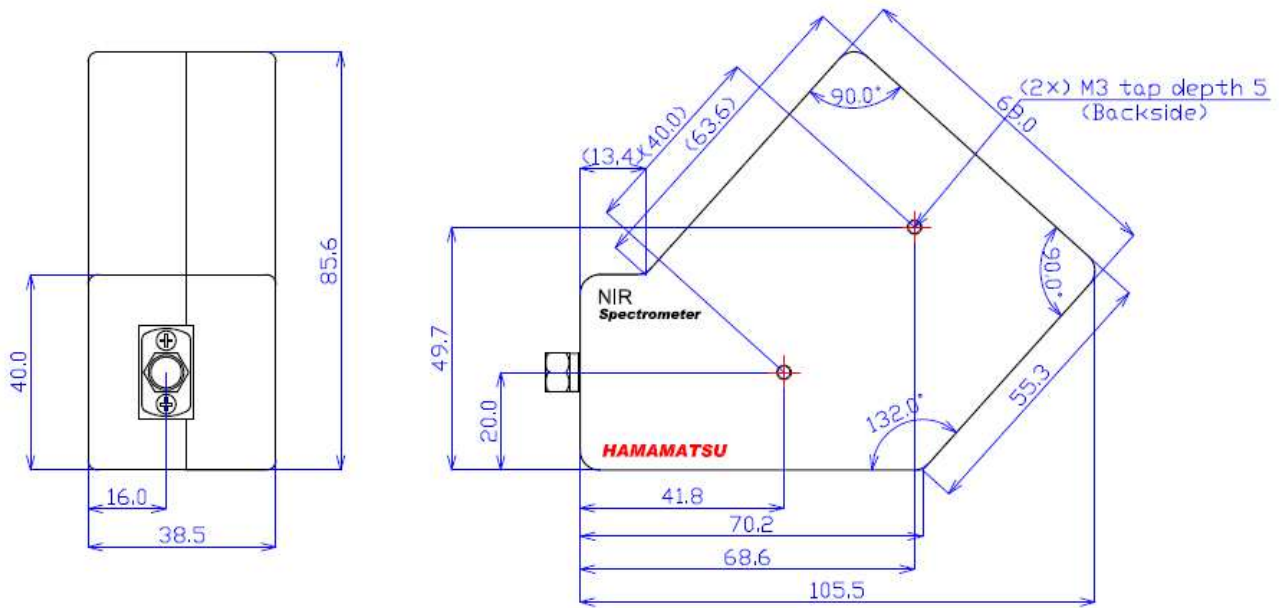
*7: No condensation. Avoid storing or using this product at high temperatures and humidity.

Applicable standards

EMC	EN61326-1:2006 Group 1 Class B
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NOTE: Use the USB cable (1.5 m) that comes with this product.

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.
- Adequate performance cannot be obtained if the NA differs significantly from these values.
- 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 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	C9406GC (TG-NIR)	Core diameter 600 μm , N.A.=0.22 Length 1.5 m, with SMA905D connector at both ends
A15363-02	Optical fiber for visible/near infrared range	C9406GC (TG-NIR)	Core diameter 800 μm , N.A.=0.22 Length 1.5 m, with SMA905D connector at both ends

Refer to the following recommendations when selecting accessory optical fibers.

■ **C9406GC (TG-NIR)**

We recommend using A15363-01 for most applications.

Use the A15363-02 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 series uses an image sensor specifically designed for spectrophotometry based on our long experience in image sensor technologies.

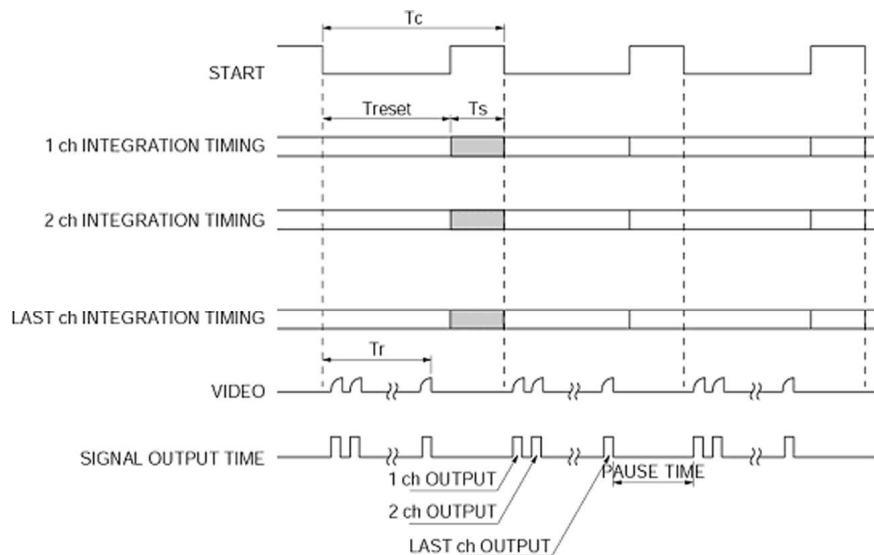
The image sensor outputs a photoelectric signal from each pixel at a certain time interval. This time interval is called "integration time" during which the photoelectric signal is accumulated in each pixel. The output signal level can therefore be optimized by adjusting the integration time. For example,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

(1) 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 G6204-512D (installed in TG-NIR: C9406GC).

The integration time (T_s) of the InGaAs image sensor G9204-512D 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 C9406GC (TG-NIR) 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 period (T_{reset}) for TG-NIR is 2.066 ms, the repetition time (T_c) will be "integration time + 2.066 msec". Please note that this is different from the time-series integration method explained in (1). Information on light entering within the reset period is ignored, so use caution with measurement timing when pulsed light is input.



$$\text{REPETITION TIME (} T_c \text{)} = \text{INTEGRATION TIME (} T_s \text{)} + \text{RESET TIME (} T_{reset} \text{)}$$

Timing chart (simultaneous integration method)

Release Notes

Version number	Revision date	Description
K29-B60910 Doc Version 1.0	Nov. 2010	First Edition
K29-B60910A Doc Version 1.1	Mar. 2011	Changed Dimensional outlines (Unit: mm)
K29-B60910B Doc Version 1.2	Jun. 2011	Changed A. Specifications
K29-B60910C Doc Version 1.3	Feb. 2012	Deleted the part of words such as class I apparatus "of" IEC61010 " To use the product safely".
K29-B60910D Doc Version 1.4	Dec. 2012	Changed A. Specifications applicable standards
K29-B60910E Doc Version 1.5	Jun. 2013	Changed address
K29-B60910F Doc Version 1.6	Sep. 2014	Changed cover Changed Internal configuration Changed supplied with the following items Deleted C9404MC,C9405MC Changed A. Specifications applicable standards Changed C. Suitable optical fiber cables Changed D. Image sensors
K29-B60910G Doc Version 1.7	Dec. 2016	Changed address
K29-B60910H Doc Version 1.8	May. 2019	Changed C. Suitable optical fiber cables
K29-B60910I Doc Version 1.9	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.

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