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Micro-spectrometer

C12666MA

Finger-tip size, ultra-compact spectrometer head integrating MEMS and image sensor technologies

The C12666MA is an ultra-compact (Finger-tip size) spectrometer head developed based on our MEMS and image sensor technologies. The adoption of a newly designed optical system has achieved a remarkably small size, less than half the volume of the previous mini-spectrometer MS series (C10988MA-01). In addition, the employment of hermetic packaging has improved humidity resistance.
This product is suitable for integration into a variety of devices, such as integration into printers and hand-held color monitoring devices that require color management. It is also suitable for applications that collaborate with portable devices, such as smartphones and tablets.

Features

- **Finger-tip size: 20.1 × 12.5 × 10.1 mm**
- **Weight: 5 g**
- **Spectral response range: 340 to 780 nm**
- **Spectral resolution: 15 nm max.**
- **Hermetic package: High reliability against humidity**
- **Installation into mobile measurement equipment**
- **Wavelength conversion factor*1 is listed on final inspection sheet**

Applications

- **Color monitoring for printers and printing machines**
- **Testers for lights and LEDs**
- **Color adjustment of various large size displays**
- **Water quality control monitors and other environment measuring instruments**
- **Measuring instruments that use portable devices such as smartphones and tablets**

*1: A conversion factor for converting the image sensor pixel number into a wavelength. A calculation factor for converting the A/D converted count into the input light level is not provided.

Optical characteristics

Parameter	Value	Unit
Spectral response range	340 to 780	nm
Spectral resolution (FWHM)	15 max.	nm
Wavelength reproducibility*2	-0.5 to +0.5	nm
Wavelength temperature dependence	-0.1 to +0.1	nm/°C
Spectral stray light*3	-25	dB

*2: Measured under constant light input conditions
*3: Spectral stray light = 10 × log (Tl/Th)
Th: count measured when light at a certain wavelength is input
Tl: count measured at a wavelength 40 nm longer or shorter than the input light wavelength

Electrical characteristics

Parameter	Min.	Typ.	Max.	Unit
Supply voltage	4.75	5	5.25	V
Power consumption	-	30	-	mW
Video rate	0.25	-	200	kHz
Output impedance	-	150 *4	-	Ω

*4: An increase in the current consumption at the video output terminal also increases the chip temperature and so causes the dark current to rise. To avoid this, connect a buffer amplifier for impedance conversion to the video output terminal so that the current flow is minimized. As the buffer amplifier, use a JFET or CMOS input operational amplifier of optical input impedance.

Structure

Parameter	Specification	Unit
Dimensions (W × D × H)	20.1 × 12.5 × 10.1	mm
Weight	5	g
Slit*5 (H × V)	50 × 750	µm
NA*6	0.22	-
Image sensor (H × V)	CMOS linear image sensor with a slit	-
Number of pixels	256	pixels
Pixel size (H × V)	12.5 × 1000	µm

*5: Entrance slit aperture size
*6: Numeric aperture (solid angle)

Absolute maximum ratings

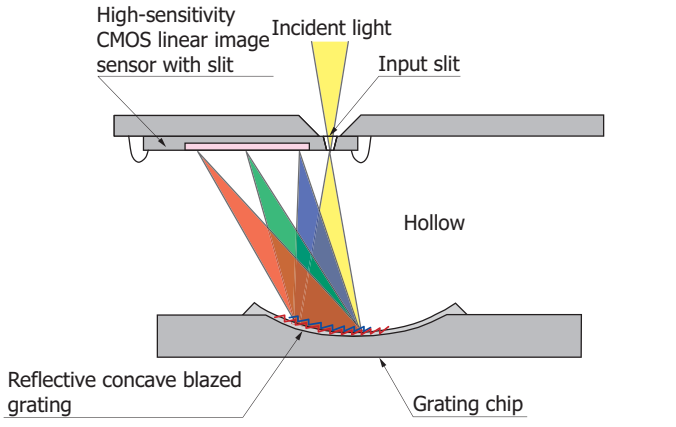
Parameter	Value	Unit
Operating temperature*7	+5 to +50	°C
Storage temperature*7	-20 to +70	°C

*7: No dew condensation
When there is a temperature difference between a product and the surrounding area in high humidity environment, dew condensation may occur on the product surface. Dew condensation on the product may cause deterioration in characteristics and reliability.
Note: Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

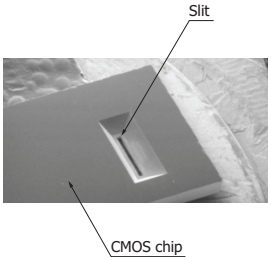
Optical component layout

Besides a CMOS image sensor chip integrated with an optical slit by etching technology, the C12666MA employs a reflective concave blazed grating formed by nanoimprint. In addition, the glass used in the light path of the previous C10988MA-01 is not used in the C12666MA, making it extremely compact.

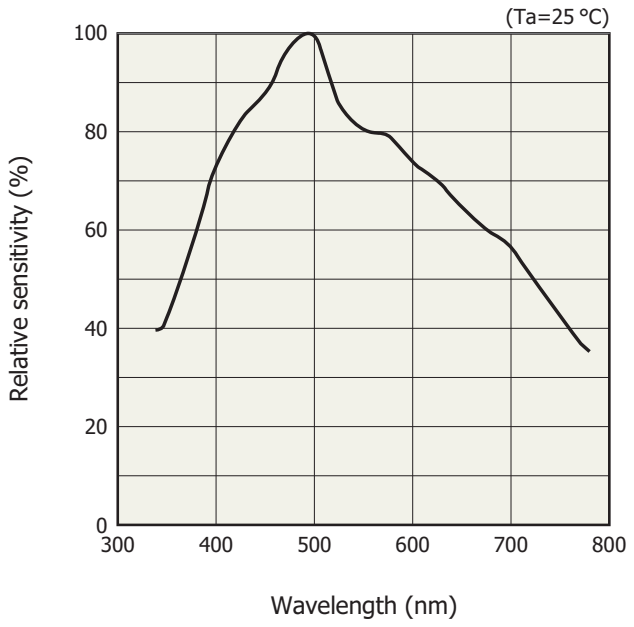
Structure



CMOS linear image sensor with a slit [Incident light side (back of chip)]



Spectral response (typical example)



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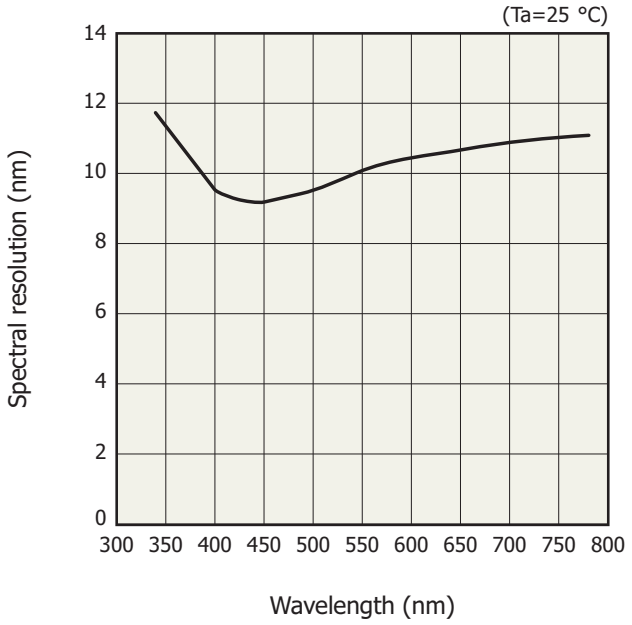
Spectral resolution vs. wavelength (typical example)



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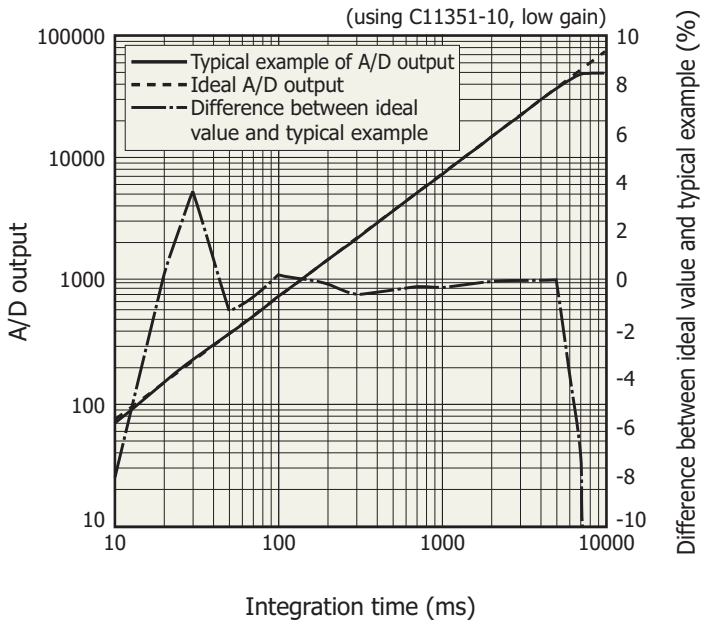
Linearity (typical example)



A/D output is the output with dark output is subtracted when light is input. The difference between the ideal value and typical example contains a measurement error. The smaller the A/D output, the larger the measurement error.

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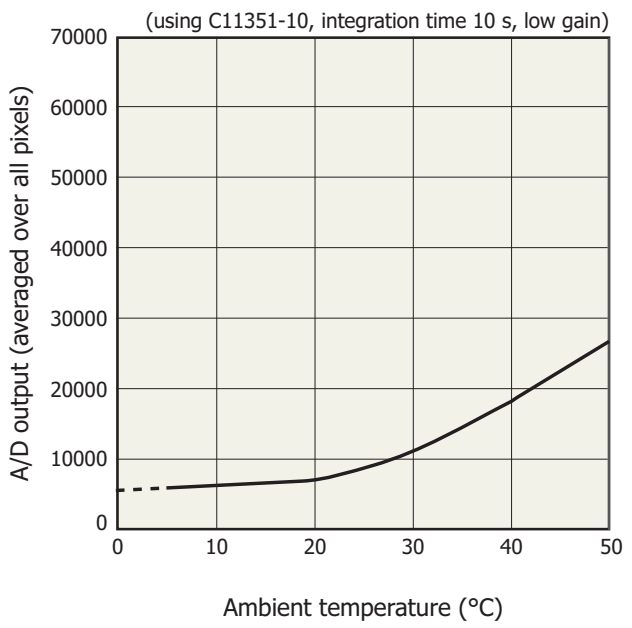
Dark output vs. ambient temperature (typical example)



A/D output is the sum of the sensor and circuit offset outputs and the sensor dark output.

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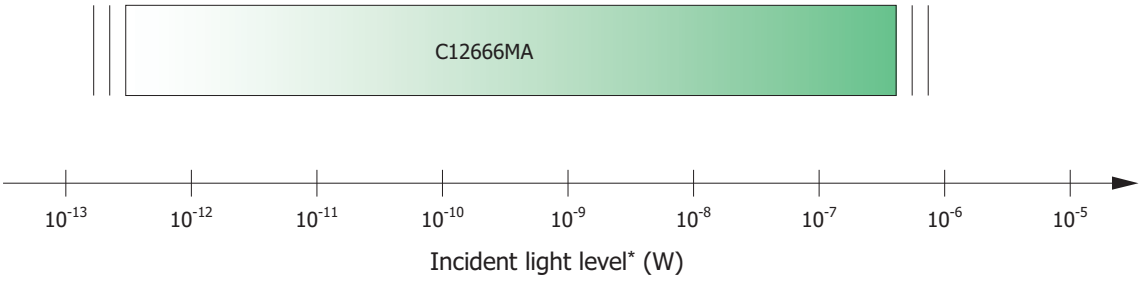
Measurable incident light level



* Input spot diameter: 800 µm (λ=550 nm)

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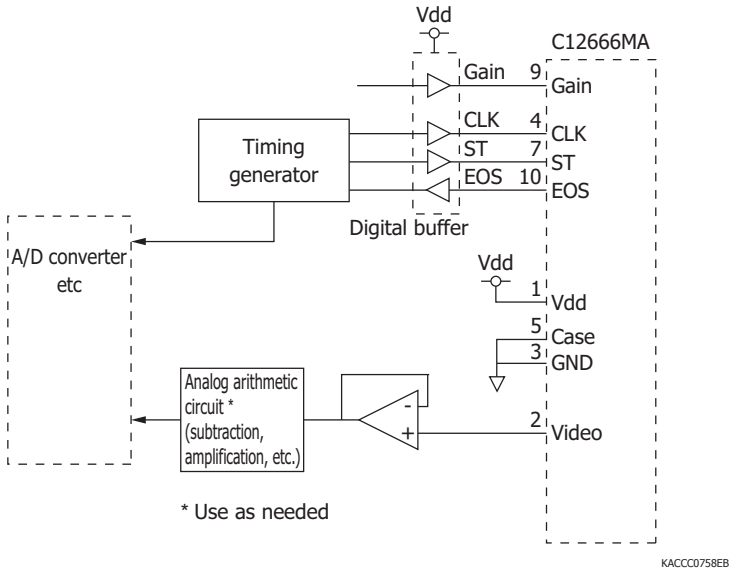
Recommended driver circuit example



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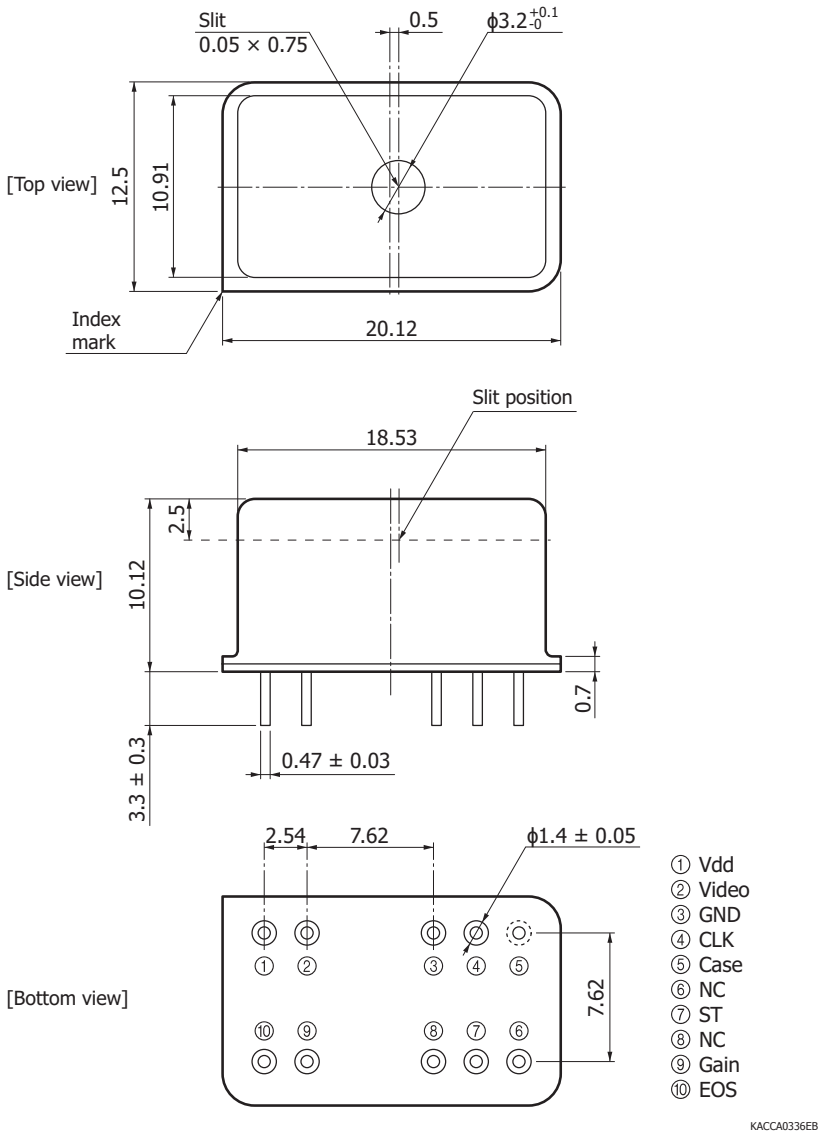
Precautions

- The packaging of C12666MA is electrically conductive, so be careful when designing the circuit to avoid short circuit caused by contact with a circuit pattern.
- If external force is repeatedly applied to the lead pins, this may damage the lead pins.
- To prevent damage due to soldering, be careful of the soldering temperature and time.
  As a general guide, finish soldering within 3.5 seconds at 350 °C or less when soldering by hand, or within 10 seconds at 260 °C or less when using a solder bath.

Dimensional outline (unit: mm, tolerance unless otherwise noted: ±0.2)



Pin connections

Make electrical connections to an external circuit using leads.

Pin no.	Symbol	Name	I/O	Description
1	Vdd	Supply voltage	I	Image sensor power supply: 5 V
2	Video	Video output	O	Video output signal
3	GND	Ground	-	Sensor ground
4	CLK	Clock pulse	I	Sensor scan sync signal
5	Case	Case	-	Case connection terminal
6	NC		-	No connection
7	ST	Start pulse	I	Start pulse
8	NC		-	No connection
9	Gain	Gain	I	Image sensor: Gain setting
10	EOS	End of scan	O	Sensor scan end signal

Note: Pin no. 9 is pulled up internally to Vdd via 10 kΩ.
Do not pull-up or pull-down the gain setting using an external circuit. For low gain, leave the pin open or connect to Vdd. For high gain, connect to GND.

Internal CMOS image sensor specifications

Recommended terminal voltage

Parameter		Symbol	Min.	Typ.	Max.	Unit
Supply voltage		Vdd	4.75	5	5.25	V
Gain selection terminal voltage	High gain	Gain	0	-	0.4	V
	Low gain		Vdd - 0.25	Vdd	Vdd + 0.25	V
Clock pulse voltage	High level	V(CLK)	Vdd - 0.25	Vdd	Vdd + 0.25	V
	Low level		0	-	0.4	V
Start pulse voltage	High level	V(ST)	Vdd - 0.25	Vdd	Vdd + 0.25	V
	Low level		0	-	0.4	V

Electrical characteristics [Ta=25 °C, Vdd=5 V, V(CLK)=V(ST)=5 V]

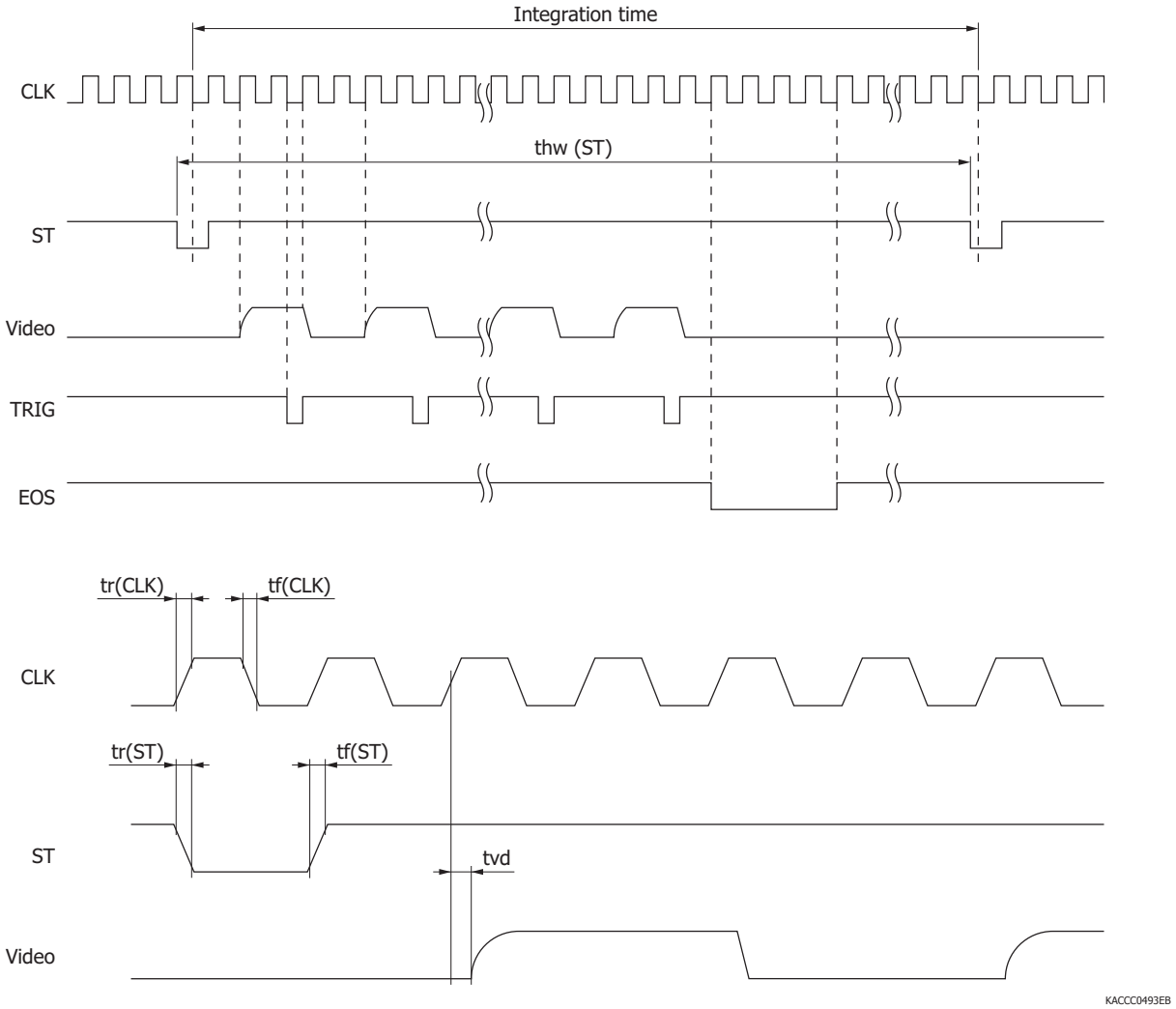
Parameter		Symbol	Min.	Typ.	Max.	Unit
Clock pulse frequency		f(CLK)	1	-	800	kHz
Power consumption	High gain	P	-	-	60	mW
	Low gain		-	-	60	

Electrical and optical characteristics [Ta=25 °C, Vdd=5 V, V(CLK)=V(ST)=5 V]

Parameter		Symbol	Min.	Typ.	Max.	Unit
Dark current	High gain	ID	-	0.02	0.08	pA
	Low gain		-	0.02	0.08	
Output offset voltage	High gain	Vo	0.15	0.35	0.55	V
	Low gain		0.15	0.35	0.55	
Charge amplifier feedback capacitance*8	High gain	Cf	-	1.4	-	pF
	Low gain		-	4.8	-	
Saturation output voltage*9	High gain	Vsat	2.3	2.8	3.3	V
	Low gain		1.4	1.7	2.0	
Readout noise	High gain	Nr	-	0.3	0.5	mV rms
	Low gain		-	0.2	0.4	

*8: Gain=5 V (low gain), Vg=0 V (high gain)
*9: Voltage difference relative to Vo

Timing chart

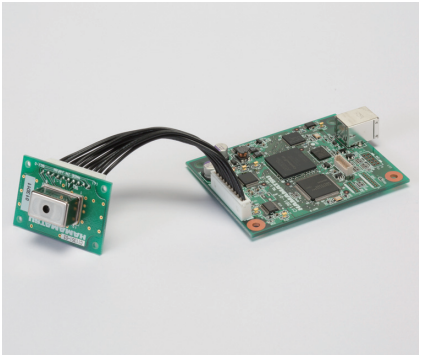


Parameter	Symbol	Min.	Typ.	Max.	Unit
Start pulse high period	thw(ST)	1030/f(CLK)	-	-	s
Start pulse rise/fall times	tr(ST), tf(ST)	0	20	30	ns
Clock pulse duty ratio	-	45	50	55	%
Clock pulse rise/fall times	tr(CLK), tf(CLK)	0	20	30	ns
Video delay time	tvd	-	20	-	ns

Note: The clock pulse should be set from high to low just once when the start pulse is low. The internal shift register starts operating at this timing.
The integration time is determined by the start pulse intervals. However, since the charge integration of each pixel is carried out between the signal readout of that pixel and the next signal readout of the same pixel, the start time of charge integration differs depending on each pixel. In addition, the next start pulse cannot be input until signal readout from all pixels is completed.
Video output is 1/4 of the clock pulse frequency.

Micro-spectrometer evaluation circuit C11351-10 (sold separately)

The C11351-10 is a circuit board designed to simply evaluate the characteristics of the micro-spectrometer. The characteristics of the micro-spectrometer can be evaluated using the evaluation software by connecting the micro-spectrometer to a PC with a USB cable A9160 (AB type, sold separately)*10.



Features

- **Initial evaluation circuit for micro-spectrometer*11**
- **Wavelength conversion factors of the micro-spectrometer can be input from a PC.*12**
- **High A/D resolution (16-bit)**
- **USB powered**

*10: Compatible OS:
Microsoft® Windows® 7 Professional SP1 (32-bit, 64-bit), Microsoft® Windows® 8 Professional (32-bit, 64-bit)

*11: The C11351-10 is a modified version of the C11351 evaluation circuit for the previous mini-spectrometer MS series (C10988MA-01, C11708MA). Only the sensor board has been modified. If you already have the C11351, you only have to purchase the C11351-03 (the sensor board for micro-spectrometers) to evaluate C12666MA micro-spectrometers.

*12: A typical wavelength conversion factor is entered at the time of shipment of the C11351-10. To measure a spectrum with higher wavelength accuracy, it is necessary to input the wavelength conversion factor listed in the final inspection sheet that comes with each micro-spectrometer.

Note: Since the C11351-10 is an evaluation circuit for the micro-spectrometer, the DLL function specifications are not available to users.
Microsoft and Windows are registered trademarks of Microsoft Corporation in the United States and/or other countries.

Electrical characteristics

Parameter	Specification	Unit
Interface	USB 2.0	-
A/D conversion	16	bit
Clock pulse frequency	800	kHz
Video rate	200	kHz
Integration time	5 to 10000	ms

Structure

Parameter		Specification	Unit
Applicable spectrometer		C12666MA	-
Dimensions	Control board	80 × 60	mm
	Sensor board	30 × 44	mm

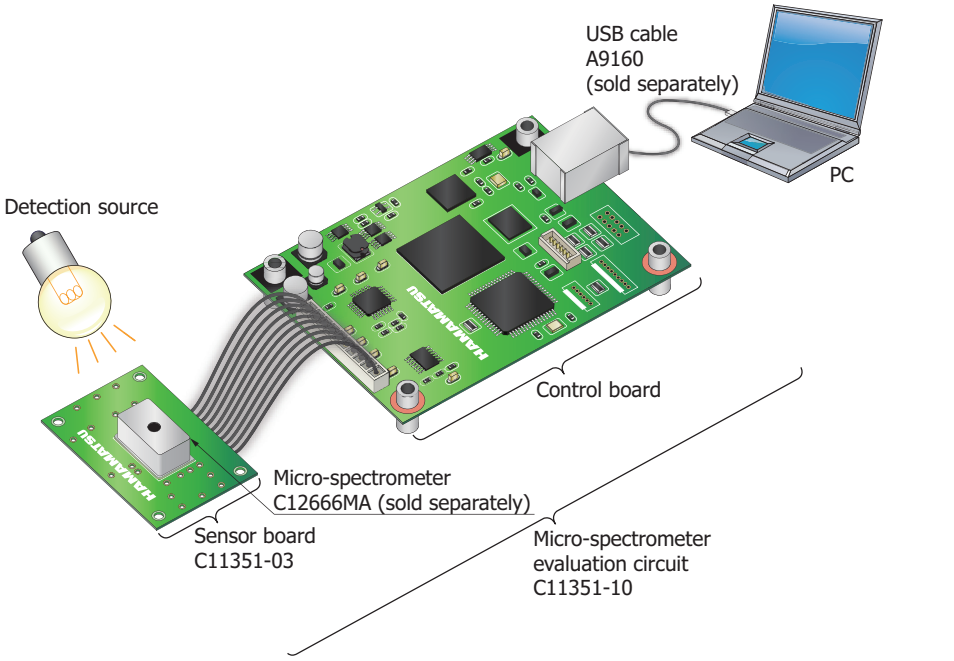
Absolute maximum ratings

Parameter	Value	Unit
Operating temperature*13	+5 to +40	°C
Storage temperature*13	-20 to +70	°C

*13: No dew condensation
When there is a temperature difference between a product and the surrounding area in high humidity environment, dew condensation may occur on the product surface. Dew condensation on the product may cause deterioration in characteristics and reliability.

Note: Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

Connection example



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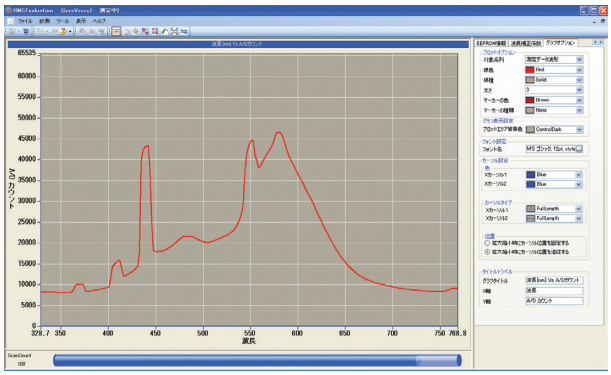
Evaluation software display example



Mini-spectrometer/micro-spectrometer lineup

Type no.	Type		Spectral response range (nm)	Spectral resolution max. (nm)	Image sensor
C10082CA	Mini-spectrometer TM series	TM-UV/VIS-CCD High sensitivity	200 to 800	6	Back-thinned CCD image sensor
C10082CAH		TM-UV/VIS-CCD High resolution		1*	
C10082MD		TM-UV/VIS-MOS Wide dynamic range		6	CMOS linear image sensor
C10083CA		TM-VIS/NIR-CCD High sensitivity	320 to 1000	8 (λ=320 to 900 nm)	Back-thinned CCD image sensor
C10083CAH		TM-VIS/NIR-CCD High resolution		1* (λ=320 to 900 nm)	
C10083MD		TM-VIS/NIR-MOS Wide dynamic range		8	CMOS linear image sensor
C11697MB		TM-VIS/NIR-MOS-II Trigger-compatible		8	High-sensitivity CMOS linear image sensor
C9404CA	Mini-spectrometer TG series	TG-UV-CCD High sensitivity	200 to 400	3	Back-thinned CCD image sensor
C9404CAH		TG-UV-CCD High resolution		1*	
C9405CB		TG-SWNIR-CCD-II IR-enhanced	500 to 1100	5 (λ=550 to 900 nm)	IR-enhanced back-thinned CCD image sensor
C11713CA		TG-RAMAN-I High resolution	500 to 600	0.3*	Back-thinned CCD image sensor
C11714CB		TG-RAMAN-II High resolution	790 to 920	0.3*	IR-enhanced back-thinned CCD image sensor
C11482GA	Mini-spectrometer TG series	TG2-NIR Non-cooled type	900 to 1700	7	InGaAs linear image sensor
C9913GC		TG-cooled NIR-I Low noise (cooled type)		7	
C9914GB		TG-cooled NIR-II Low noise (cooled type)	1100 to 2200	8	
C11118GA		TG-cooled NIR-III Low noise (cooled type)	900 to 2550	20	
C13053MA	Mini-spectrometer TF series	TF-SWIR-MOS-II Compact, thin case	500 to 1100	3.5	High-sensitivity CMOS linear image sensor
C13054MA		TF-RAMAN Compact, thin case	790 to 920	0.4*	
C13555MA		TF-VIS-MOS-II Compact, thin case	340 to 830	3	
C11007MA	Mini-spectrometer RC series	RC-VIS-MOS Spectrometer module	340 to 780	9	CMOS linear image sensor
C11008MA		RC-SWNIR-MOS Spectrometer module	640 to 1050	8	IR-enhanced CMOS linear image sensor

* Typ.

For installation into mobile measuring equipment

Type no.	Type		Spectral response range (nm)	Spectral resolution max. (nm)	Image sensor
C11009MA	Mini-spectrometer RC series	RC-VIS-MOS Spectrometer head	340 to 780	9	CMOS linear image sensor
C11010MA		RC-SWNIR-MOS Spectrometer head	640 to 1050	8	IR-enhanced CMOS linear image sensor

For installation into mobile measuring equipment (ultra-compact)

Type no.	Type		Spectral response range (nm)	Spectral resolution max. (nm)	Image sensor
C11708MA	Mini-spectrometer MS series	MS-SWNIR-MOS Spectrometer head	640 to 1050	20	CMOS linear image sensor
C12666MA	Micro-spectrometer	Spectrometer head	340 to 780	15	CMOS linear image sensor
C12880MA		Spectrometer head	340 to 850	15	High-sensitivity CMOS linear image sensor

Related information

www.hamamatsu.com/sp/ssd/doc_en.html

■ Precautions
· Disclaimer

■ Technical information
· Mini-spectrometers

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HAMAMATSU PHOTONICS K.K., Solid State Division
1126-1 Ichino-cho, Higashi-ku, Hamamatsu City, 435-8558 Japan, Telephone: (81) 53-434-3311, Fax: (81) 53-434-5184
U.S.A.: Hamamatsu Corporation: 360 Foothill Road, Bridgewater, N.J. 08807, U.S.A., Telephone: (1) 908-231-0960, Fax: (1) 908-231-1218
Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, Germany, Telephone: (49) 8152-375-0, Fax: (49) 8152-265-8
France: Hamamatsu Photonics France S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: 33-(1) 69 53 71 00, Fax: 33-(1) 69 53 71 10
United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, United Kingdom, Telephone: (44) 1707-294888, Fax: (44) 1707-325777
North Europe: Hamamatsu Photonics Norden AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46) 8-509-031-00, Fax: (46) 8-509-031-01
Italy: Hamamatsu Photonics Italia S.r.l.: Strada della Moia, 1 int. 6, 20020 Arese (Milano), Italy, Telephone: (39) 02-93581733, Fax: (39) 02-93581741
China: Hamamatsu Photonics (China) Co., Ltd.: B1201, Jiaming Center, No.27 Dongsanhuan Beilu, Chaoyang District, Beijing 100020, China, Telephone: (86) 10-6586-6006, Fax: (86) 10-6586-2866

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