

# Micro-spectrometer



C12880MA

## Finger-tip sized, ultra-compact spectrometer head supporting high sensitivity and long wavelength region

The C12880MA is a high-sensitivity, ultra-compact (finger-tip sized) spectrometer head that supports the long wavelength region (up to 850 nm). Hermetically sealed packaging provides improved humidity resistance. This product is suitable for integration into a variety of compact devices.

### Features

- **Finger-tip size: 20.1 × 12.5 × 10.1 mm**
- **Weight: 5 g**
- **Spectral response range: 340 to 850 nm**
- **High sensitivity**
- **Spectral resolution: 15 nm max.**
- **Supports synchronized integration (electronic shutter function)**
- **Hermetic package: high reliability against humidity**
- **For integration into mobile measurement equipment**
- **Wavelength conversion factors\*1 are listed on final inspection sheet.**

\*1: Conversion factors 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.

### Applications

- **Food inspection**
- **Biometry (POC)**
- **Tester for lights, LEDs, etc.**
- **Water quality control monitors and other environment measuring instruments**
- **Various light level measurements**

### Structure

Parameter	Specification	Unit
Image sensor	High-sensitivity CMOS linear image sensor with slit	-
Number of pixels	288	pixels
Pixel size (H × V)	14 × 200	μm
Slit*2 (H × V)	50 × 500	μm
NA*3	0.22	-
Dimensions (W × D × H)	20.1 × 12.5 × 10.1	mm
Weight	5	g

\*2: Entrance slit aperture size

\*3: Numeric aperture (solid angle)

### Absolute maximum ratings (Ta=25 °C unless otherwise noted)

Parameter	Symbol	Condition	Value	Unit
Supply voltage	Vs max		-0.3 to +6	V
Clock pulse voltage	V(CLK)		-0.3 to +6	V
Start pulse voltage	V(ST)		-0.3 to +6	V
Operating temperature	Topr	No dew condensation*4	+5 to +50	°C
Storage temperature	Tstg	No dew condensation*4	-20 to +70	°C

\*4: 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.

### ▣ Recommended terminal voltage (Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max	Unit
Supply voltage	Vs	4.75	5	5.25	V
Clock pulse voltage	High level	Vs - 0.25	Vs	Vs + 0.25	V
	Low level	0	-	0.3	
Start pulse voltage	High level	Vs - 0.25	Vs	Vs + 0.25	V
	Low level	0	-	0.3	

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

Parameter	Symbol	Min.	Typ.	Max	Unit
Clock pulse frequency	f(CLK)	0.2	-	5	MHz
Video rate	VR	-	f(CLK)	-	Hz
Output impedance*5	Zo	-	150	-	Ω
Current consumption*6	I	-	20	-	mA

\*5: Video signal output terminal (10-pin)

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 to the video output terminal so that the current flow is minimized.

\*6: f(CLK)=5 MHz

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

Parameter	Symbol	Min.	Typ.	Max	Unit
Conversion efficiency	CE	-	50	-	μV/e <sup>-</sup>
Dark output voltage*7	Vd	-	0.8	-	mV
Saturation output voltage*8	Vsat	-	4.3	-	V
Readout noise	Nr	-	1.8	-	mV rms
Output offset voltage	Vo	0.3	0.5	0.9	V
Spectral response range	λ	-	340 to 850	-	nm
Spectral resolution (FWHM)	-	-	12	15	nm
Wavelength reproducibility*9	λr	-0.5	-	+0.5	nm
Wavelength temperature dependence	λTd	-0.1	-	+0.1	nm/°C
Spectral stray light*10	SL	-	-	-25	dB

\*7: Integration time=10 ms

\*8: Relative value in reference to output offset voltage Vo

Example: When output offset voltage Vo is 0.5 V and saturation output voltage Vsat is 4.3 V, the saturation voltage at the video signal output terminal is 4.8 V.

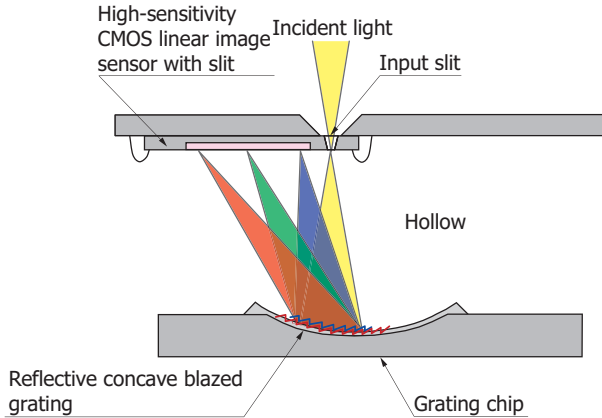
\*9: Measured under constant light input conditions

\*10: The ratio of the count measured when a light spectrum (655 nm) is input to the count measured at that wavelength ± 40 nm.

Optical component layout

Besides a CMOS image sensor chip integrated with an optical slit by etching technology, the C12880MA 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 C12880MA, making it extremely compact.

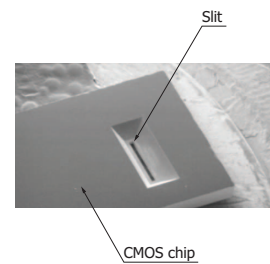
Structure



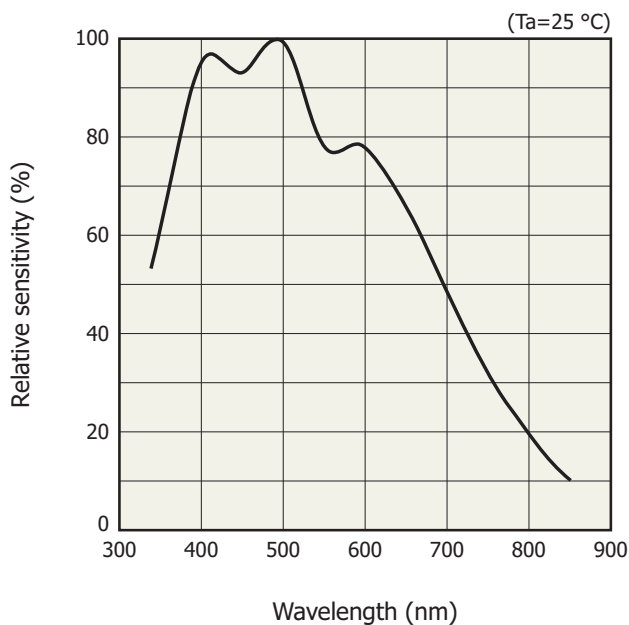
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High-sensitivity CMOS linear image sensor with a slit [Incident light side (back of chip)]

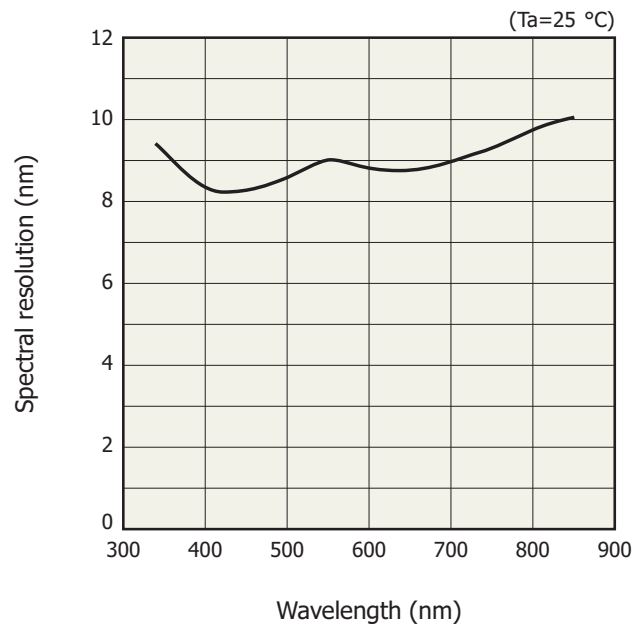


Spectral response (typical example)



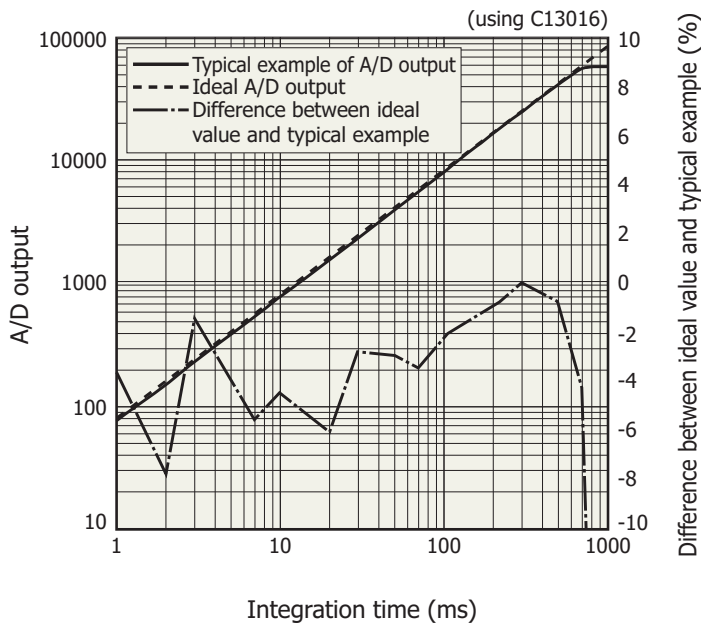
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Spectral resolution vs. wavelength (typical example)



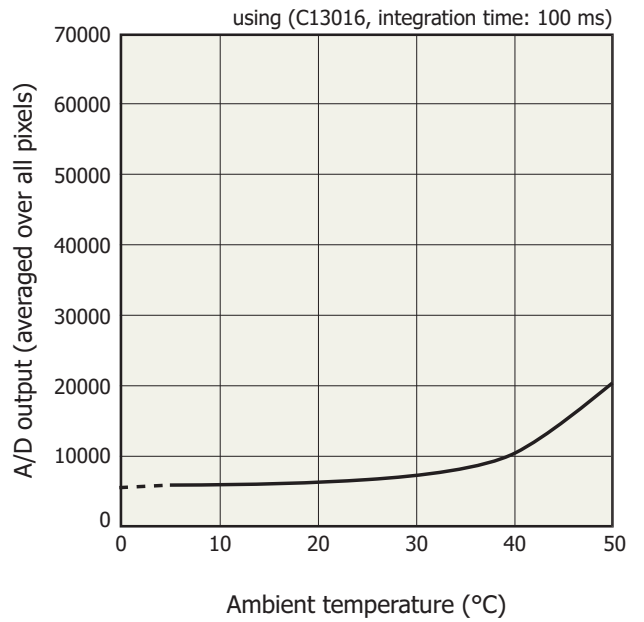
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▣ Linearity (typical example)



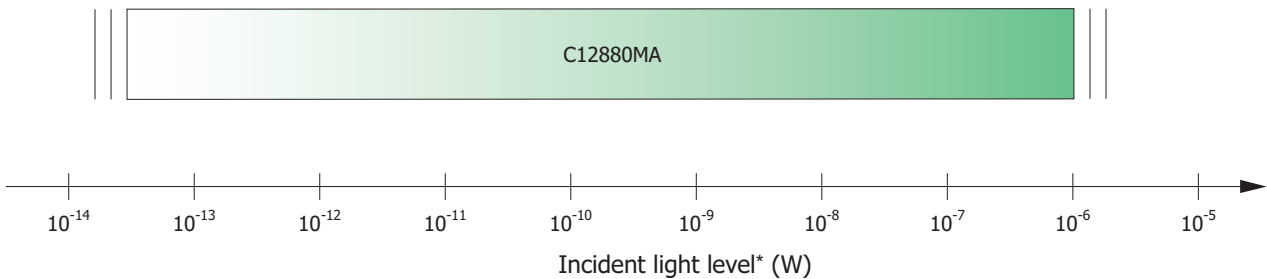
A/D output is the output with dark output is subtracted when light is input. The difference between the ideal value and typical example contains a measurement error. The smaller the A/D output, the larger the measurement error.

▣ Dark output vs. ambient temperature (typical example)



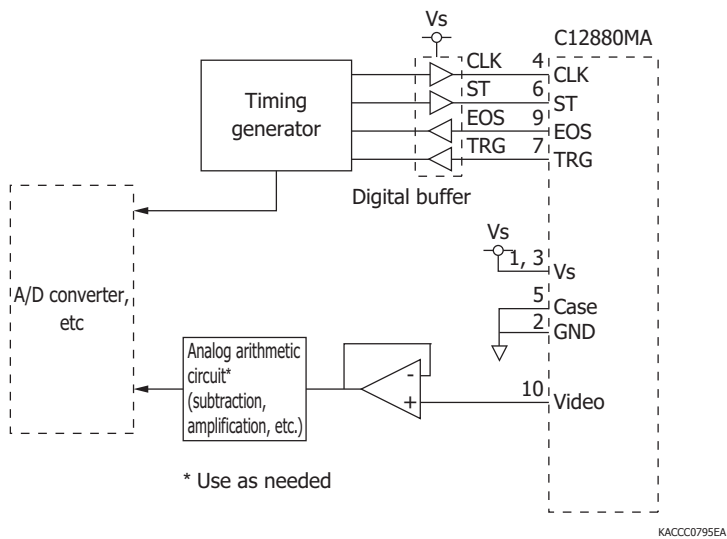
A/D output is the sum of the sensor and circuit offset outputs and the sensor dark output.

▣ Measurable incident light level



\* Using C13016, input spot diameter 800 μm (λ=600 nm)

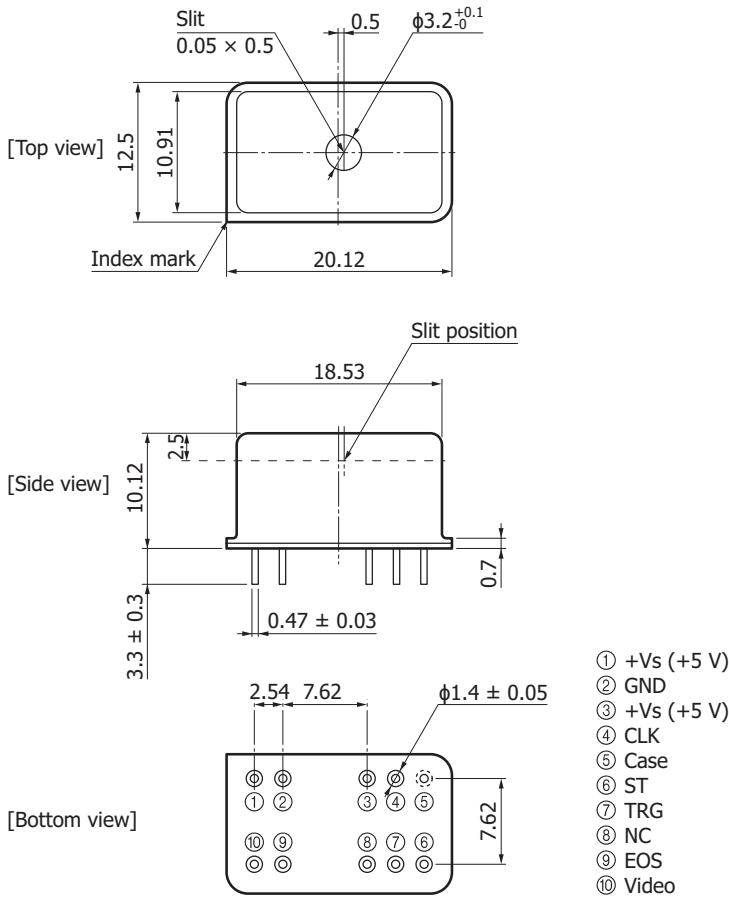
Recommended driver circuit example



Precautions

- The packaging of the C12880MA 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)**



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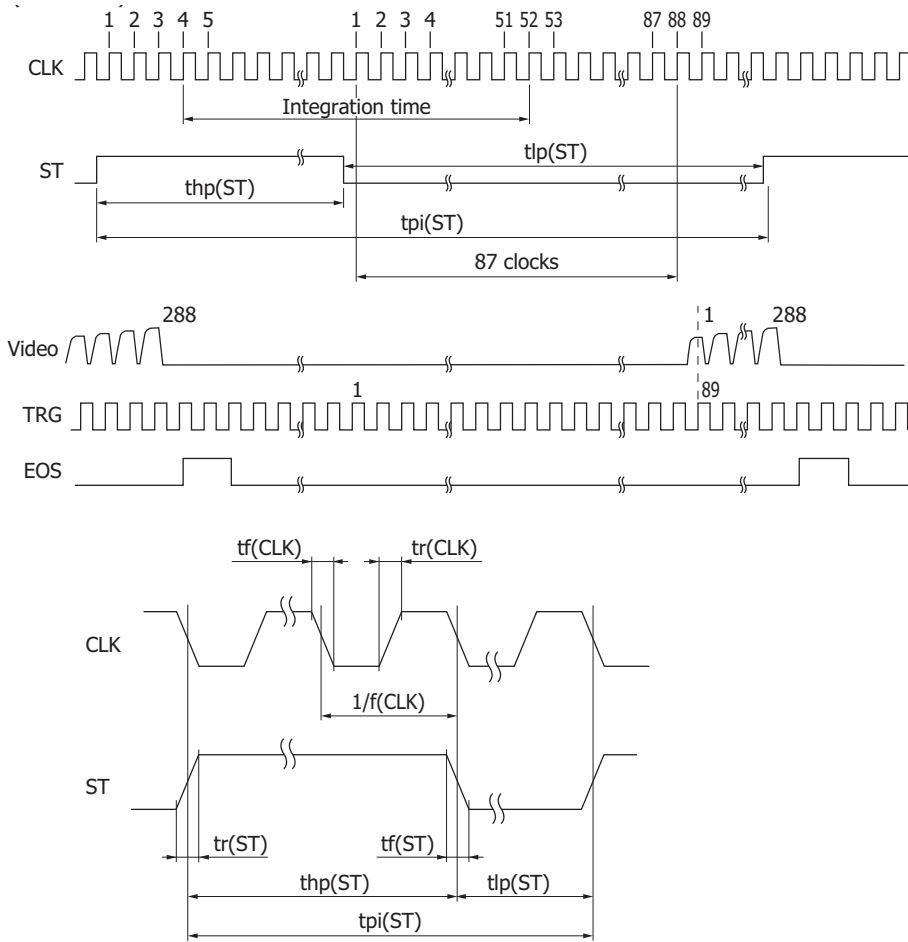
**Pin connections**

Make electrical connections to an external circuit using leads.

Pin no.	Symbol	Name	I/O	Description
1	+Vs	Supply voltage	I	Sensor power supply: 5 V
2	GND	Ground	-	Sensor ground
3	+Vs	Supply voltage	I	Sensor power supply: 5 V
4	CLK	Clock pulse	I	Sensor clock pulse
5	Case	Case	-	Case connection
6	ST	Start pulse	I	Sensor start pulse
7	TRG	Trigger pulse	O	Pulse for capturing sensor video signals
8	NC		-	No connection
9	EOS	End of scan	O	Sensor scan end
10	Video	Video output	O	Sensor video output

Note: Pin no. 5 and the case of the micro-spectrometer are at the same potential. Ensure that the case is not in contact with other potentials during use. Parts coming in contact with the case must be set at the same potential as pin no. 5 or insulated from other potentials.

**Timing chart**



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Parameter	Symbol	Min.	Typ.	Max.	Unit
Start pulse cycle* <sup>11</sup>	$t_{pi}(ST)$	$381/f(CLK)$	-	-	s
Start pulse high period* <sup>12</sup>	$t_{hp}(ST)$	$6/f$	-	-	s
Start pulse low period	$t_{lp}(ST)$	$375/f$	-	-	s
Start pulse rise and fall times	$t_r(ST), t_f(ST)$	0	10	30	ns
Clock pulse duty	-	45	50	55	%
Clock pulse rise and fall times	$t_r(CLK), t_f(CLK)$	0	10	30	ns

\*11: The shortest period required to output the video signals from all pixels.

\*12: The integration time equals the high period of ST plus 48 CLK cycles.

The shift register starts operation at the rising edge of CLK immediately after ST goes low.

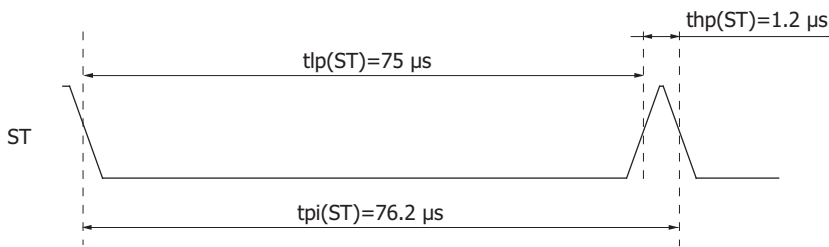
The integration time can be changed by changing the ratio of the high and low periods of ST.

If the first TRG pulse after ST goes low is counted as the first pulse, the Video signal should be acquired at the rising edge of the 89th TRG pulse.

**Operation example**

This is an operating example when the clock pulse frequency is set to maximum (video data rate is also set to maximum), the time per scan to minimum, and the integration time to maximum.

- Clock pulse frequency [f(CLK)] = Video data rate  
= 5 MHz
- Start pulse cycle [t<sub>pi</sub>(ST)] = 381/f(CLK)  
= 381/5 MHz  
= 76.2 μs
- Low period of start pulse min. [t<sub>lp</sub>(ST)] = 375/f(CLK)  
= 375/5 MHz  
= 75 μs
- High period of start pulse [t<sub>hp</sub>(ST)] = Start pulse cycle [t<sub>pi</sub>(ST)] - Low period of start pulse min. [t<sub>lp</sub>(ST)]  
= 76.2 μs - 75 μs  
= 1.2 μs

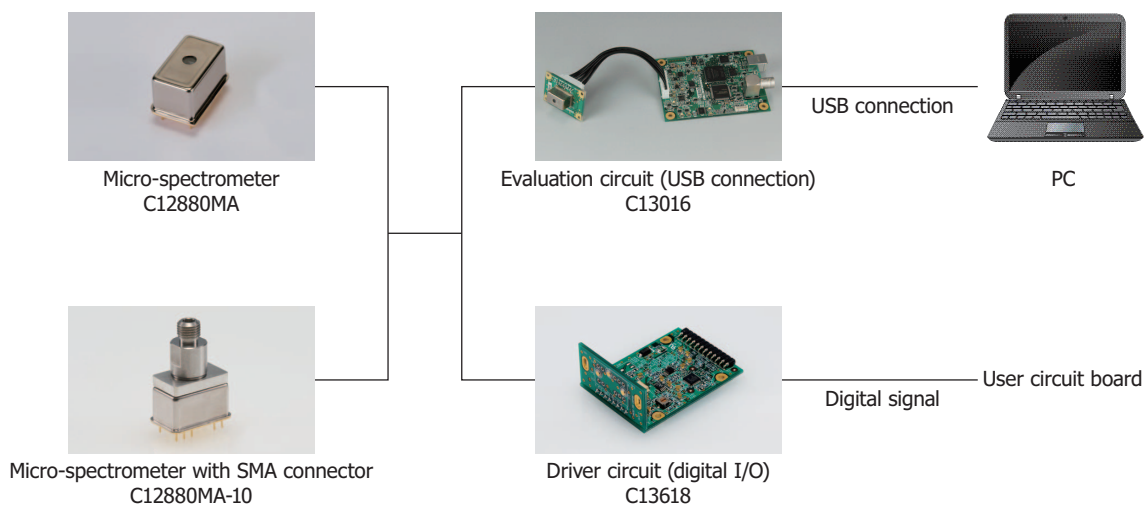


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Integration time is equal to the high period of start pulse + 48 cycles of clock pulses, so it will be 1.2 μs + 9.6 μs = 10.8 μs.

**Selection chart**

A micro-spectrometer with SMA connector (for optical fiber connection), an evaluation circuit, and a driver circuit are available as related products for the micro-spectrometer.



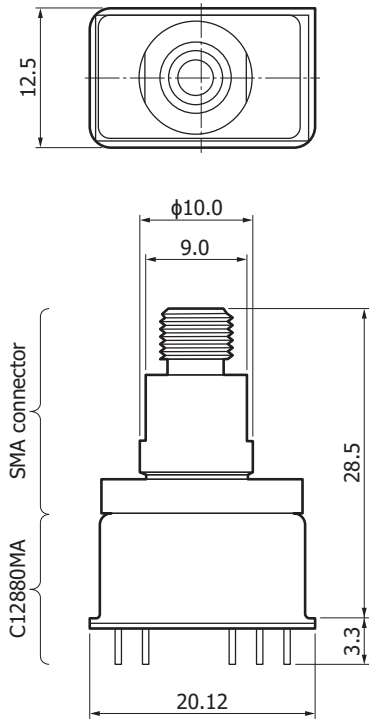
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Micro-spectrometer with SMA connector C12880MA-10

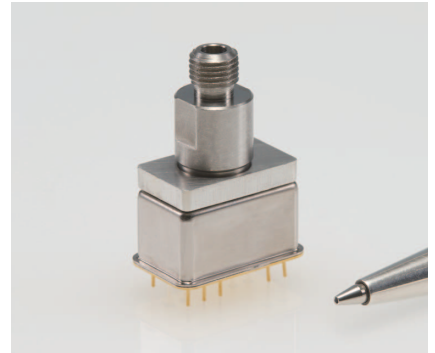
The C12880MA-10 is a product in which an SMA connector is attached to the C12880MA. It has an optical system inside the connector that can be connected with an optical fiber (single core, NA=0.22) with an SMA connector. The specifications of the C12880MA-10 is the same as those of the C12880MA except the connector section.

**Dimensional outline (unit: mm)**



Tolerance unless otherwise noted: ±0.5

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**Options**

Product name	Type no.	Core diameter (μm)	Specification
Fiber for UV/visible range (resistance to UV)	A9762-01	600	NA=0.22, length=1.5 m With SMA905D connector on each end
	A9762-05	400	

Driver circuit for micro-spectrometer C13618

The C13618 is a driver circuit that the C12880MA or C12880MA-10 can be mounted on. It has an A/D converter that can be used to obtain digital data (16-bit) by applying an external power supply and drive signal. Using this driver circuit with the user's circuit board having LVDS level and 3.3 V level I/O ports eliminates the need for designing analog circuits and video output conversion circuits.



Structure

Parameter	Specification	Unit
Applicable micro-spectrometers (sold separately)	C12880MA, C12880MA-10	-
A/D converter	AD7961 by Analog Devices	-
I/O terminal	Connector 801-87-012-20-002101 by PRECI-DIP	-
Number of I/O terminals	12	-
Dimensions	50 × 40 × 21.6	mm
Weight	14.3	g

Absolute maximum ratings

Parameter	Symbol	Condition	Value	Unit
Operating temperature	Topr	No dew condensation*13	+5 to +40	°C
Storage temperature	Tstg	No dew condensation*13	-20 to +70	°C

\*13: 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.

Electrical characteristics (Ta=25 °C, Vs=SENSOR\_ST=SENSOR\_CLK=3.3 V)

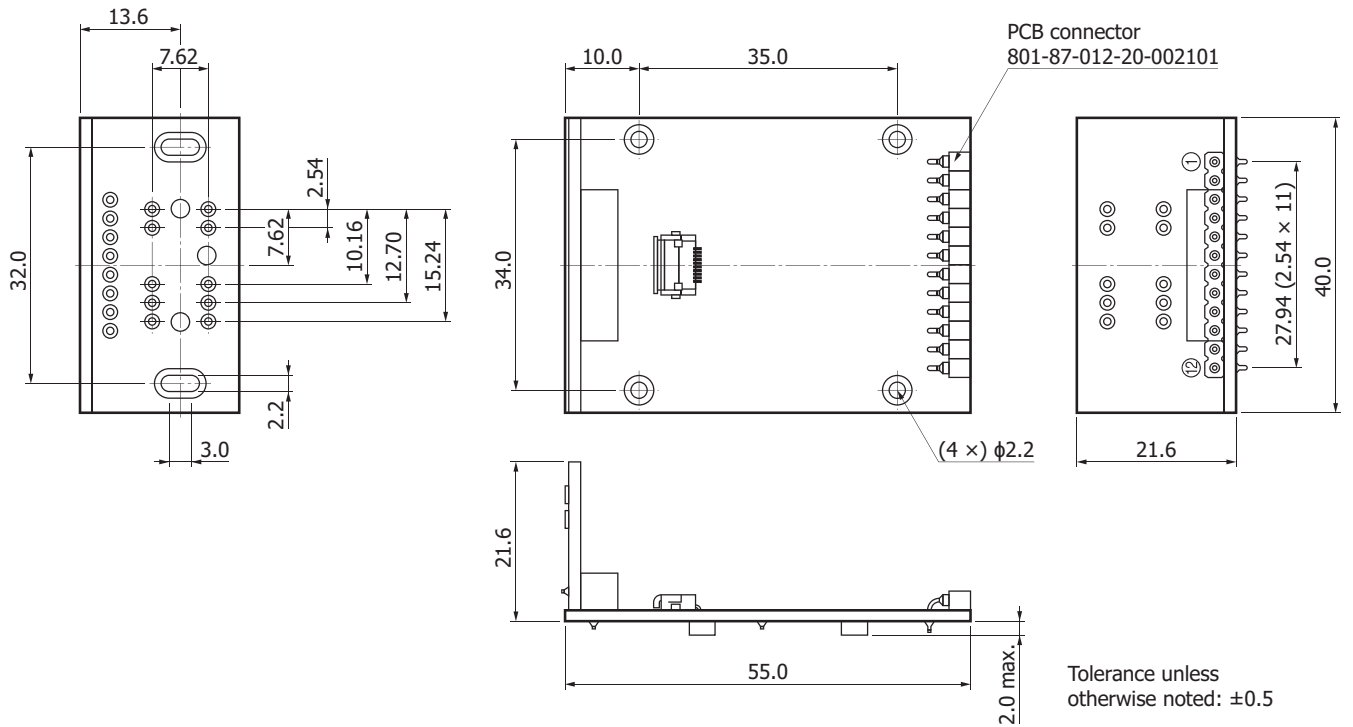
Parameter	Symbol	Min.	Typ.	Max.	Unit
Sensor clock frequency	SENSOR_CLK	0.2	-	5	MHz
A/D converter clock frequency	AD_CLK	-	250	300	MHz
Current consumption	Ic	-	150	200	mA

Recommended operating conditions (Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max.	Unit	
Power supply	Vs	3.15	3.3	3.45	V	
Sensor clock input signal	High level	SENSOR_CLK	3.15	3.3	3.45	V
	Low level		0	-		
Sensor start input signal	High level	SENSOR_ST	3.15	3.3	3.45	V
	Low level		0	-		
A/D converter output signal*14	Input voltage range	AD_CLK+, AD_CLK-	0.8	-	1.575	V
	Differential input voltage		0.1	-		

\*14: AD\_CLK+ and AD\_CLK- are a pair of LVDS signals.

**Dimensional outline (unit: mm)**



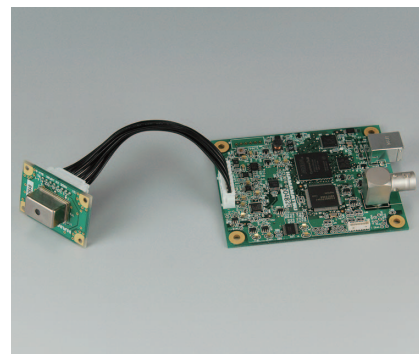
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**Pin connections**

Pin no.	Symbol	Input/Output	Function
1	Vs	Input	Supply voltage
2	NC	-	-
3	SENSOR_CLK	Input	Clock pulse for C12880MA and C12880MA-10
4	SENSOR_ST	Input	Start pulse for C12880MA and C12880MA-10
5	SENSOR_TRG	Output	Trigger pulse for C12880MA and C12880MA-10
6	AD_CLK+	Input	Clock pulse for A/D converter
7	AD_CLK-		
8	AD_DCO+	Output	Buffered clock pulse of A/D converter
9	AD_DCO-		
10	AD_D+	Output	Data of A/D converter
11	AD_D-		
12	GND	-	Ground

### Micro-spectrometer evaluation circuit C13016 (sold separately)

The C13016 is a circuit board designed to simply evaluate the characteristics of the micro-spectrometer C12880MA. The characteristics of the C12880MA can be evaluated using the evaluation software by connecting the C12880MA to a PC with a USB cable A9160 (AB type, sold separately)\*15.



### Features

- Initial evaluation circuit for micro-spectrometer C12880MA
- Wavelength conversion factors of the micro-spectrometer can be input from a PC.\*16
- High A/D resolution (16-bit)
- USB powered

\*15: Compatible OS:

Microsoft® Windows® 7 Professional SP1 (32-bit, 64-bit), Microsoft Windows 8 Professional (32-bit, 64-bit)

\*16: Typical wavelength conversion factors are entered at the time of shipment of the C13016. To measure a spectrum with higher wavelength accuracy, it is necessary to input the wavelength conversion factors listed in the final inspection sheet that comes with each micro-spectrometer.

Note: 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	5	MHz
Video rate	5	MHz
Integration time	11 to 1000000	μs

### Structure

Parameter	Specification	Unit
Applicable spectrometer	C12880MA	-
Dimensions	Control board	90 × 70
	Sensor board	30 × 44

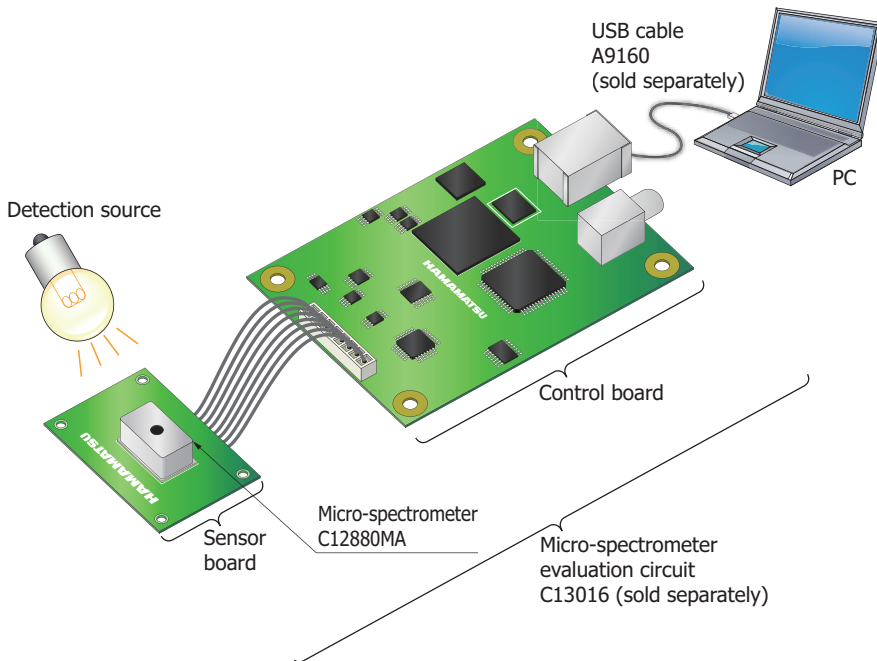
### Absolute maximum ratings

Parameter	Condition	Value	Unit
Operating temperature	No dew condensation*17	+5 to +40	°C
Storage temperature	No dew condensation*17	-20 to +70	°C

\*17: 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.

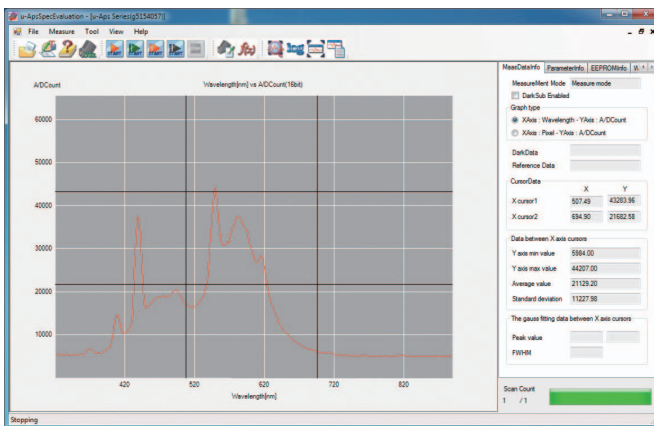
Note: Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

Connection example



KACCC0800EA

Evaluation software display example



Mini-spectrometer/micro-spectrometer lineup

Type no.	Type	Spectral response range (nm)													Spectral resolution max. (nm)	Image sensor			
		200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600					
C10082CA	TM-UV/VIS-CCD High sensitivity																	6	Back-thinned CCD image sensor
C10082CAH	TM-UV/VIS-CCD High resolution		200 to 800															1*	
C10082MD	TM-UV/VIS-MOS Wide dynamic range																	6	CMOS linear image sensor
C10083CA	TM-VIS/NIR-CCD High sensitivity																	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	TG-UV-CCD High sensitivity		200 to 400															3	Back-thinned CCD image sensor
C9404CAH	TG-UV-CCD High resolution		200 to 400															1*	
C9405CB	TG-SWNIR-CCD-II IR-enhanced																	5 (λ=550 to 900 nm)	IR-enhanced back-thinned CCD image sensor
C11713CA	TG-RAMAN-I High resolution																	0.3*	Back-thinned CCD image sensor
C11714CB	TG-RAMAN-II High resolution																	0.3*	IR-enhanced back-thinned CCD image sensor
C11482GA	TG2-NIR Non-cooled type																	7	InGaAs linear image sensor
C9913GC	TG-cooled NIR-I Low noise (cooled type)																	7	
C9914GB	TG-cooled NIR-II Low noise (cooled type)																	8	
C11118GA	TG-cooled NIR-III Low noise (cooled type)																	20	
C13053MA	TF-SWIR-MOS-II Compact, thin case																	3.5	High-sensitivity CMOS linear image sensor
C13054MA	TF-RAMAN Compact, thin case																	0.4*	
C13555MA	TF-VIS-MOS-II Compact, thin case																	3	
C11007MA	RC-VIS-MOS Spectrometer module																	9	
C11008MA	RC-SWNIR-MOS Spectrometer module																	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			
		200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600					
C11009MA	RC-VIS-MOS Spectrometer head																	9	CMOS linear image sensor
C11010MA	RC-SWNIR-MOS Spectrometer head																	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			
		200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600					
C11708MA	MS-SWNIR-MOS Spectrometer head																	20	CMOS linear image sensor
C12666MA	Spectrometer head																	15	CMOS linear image sensor
C12880MA	Spectrometer head																	15	High-sensitivity CMOS linear image sensor

## Related information

[www.hamamatsu.com/sp/ssd/doc\\_en.html](http://www.hamamatsu.com/sp/ssd/doc_en.html)

### ■ Precautions

- Disclaimer

### ■ Technical information

- Mini-spectrometers

Information described in this material is current as of January 2017.

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# HAMAMATSU

[www.hamamatsu.com](http://www.hamamatsu.com)

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