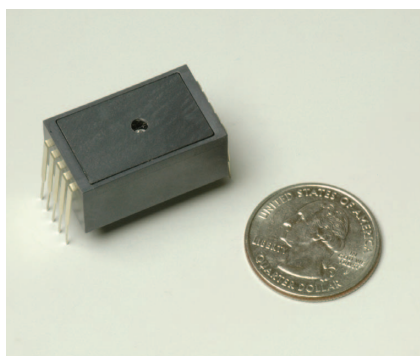


# Mini-spectrometers



[ **MS series** ] | C10988MA-01 C11708MA

## Ultra-compact mini-spectrometer integrating MEMS and image sensor technologies

The MS series are thumb-sized (27.6 × 16.8 × 13 mm) spectrometer heads developed for installation into mobile measurement equipment by merging our MEMS and image sensor technologies. The MS series uses a CMOS image sensor integrated with a light receiving slit. The internal optical system is comprised of a convex lens on which a grating is formed by nanoimprint. The result is a remarkably small size less than one-third the volume of the RC series mini-spectrometers that have already been marketed.

### Features

- **Thumb size: 27.6 × 16.8 × 13 mm**
- **Weight: 9 g**
- **Spectral response range: 340 to 750 nm (C10988MA-01)  
640 to 1050 nm (C11708MA)**
- **Spectral resolution: 14 nm (C10988MA-01)  
20 nm (C11708MA)**
- **Installation into mobile measurement equipment**
- **Wavelength conversion factor\*1 is listed on final inspection sheet.**

### Applications

- |  |
|--|
| C10988MA-01  |
| → <b>Color monitoring for printers and printing machines</b>         |
| → <b>Installation into large size display (Color control device)</b> |
| C11708MA   |
| → <b>Fruit sugar content measurement / cereal taste test</b>         |
| → <b>Component analysis</b>  |

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

### Optical characteristics

Parameter	C10988MA-01	C11708MA	Unit
Spectral response range	340 to 750	640 to 1050	nm
Spectral resolution (FWHM)*2	14 max.	20 max.	nm
Wavelength reproducibility*3	-0.5 to +0.5		nm
Wavelength temperature dependence	-0.05 to +0.05		nm/°C
Spectral stray light*2 *4	-25 max.		dB

\*2: Depends on the slit opening. Values were measured with the slit listed in the table "Structure / Absolute maximum ratings".

\*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.

C10988MA-01: 550 nm, C11708MA: 850 nm

### 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*5	-	Ω

\*5: 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 / Absolute maximum ratings**

Parameter	Value	Unit
Dimensions (W × D × H)	27.6 × 16.8 × 13	mm
Weight	9	g
Number of pixels	256	pixels
Pixel size (H × V)	12.5 × 1000	μm
Image sensor	CMOS linear image sensor	-
Slit*6 (H × V)	75 × 750	μm
NA*7	0.22	-
Operating temperature*8	+5 to +50	°C
Storage temperature*8	-20 to +70	°C

\*6: Entrance slit aperture size

\*7: Numeric aperture (solid angle)

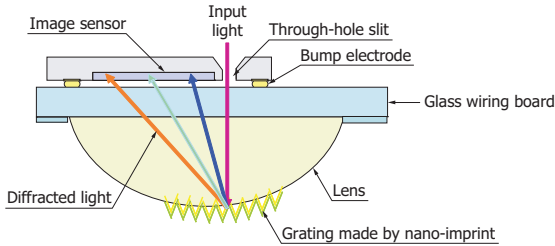
\*8: No dew condensation

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.

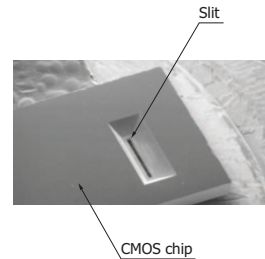
**Optical component layout (C10988MA-01)**

Besides a CMOS image sensor chip integrated with an optical slit by etching, the C10988MA-01 employs a grating that is formed on a convex lens by nano-imprint. This has made the unit very compact.



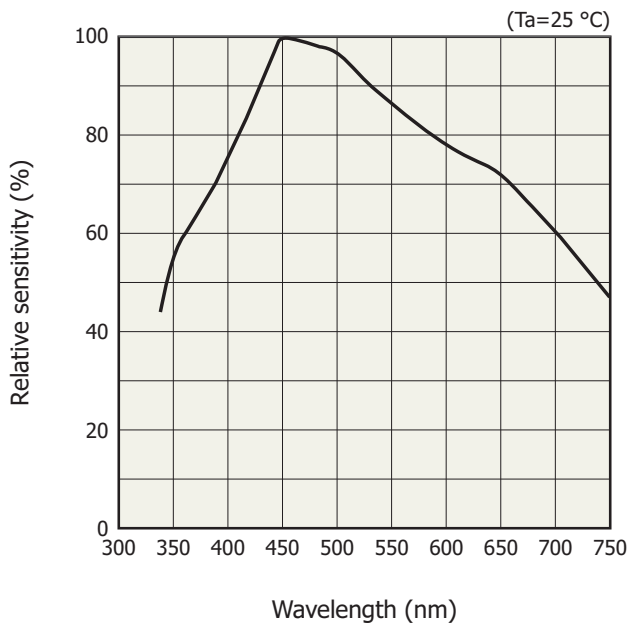
KACCC0458EA

**CMOS chip (back)**

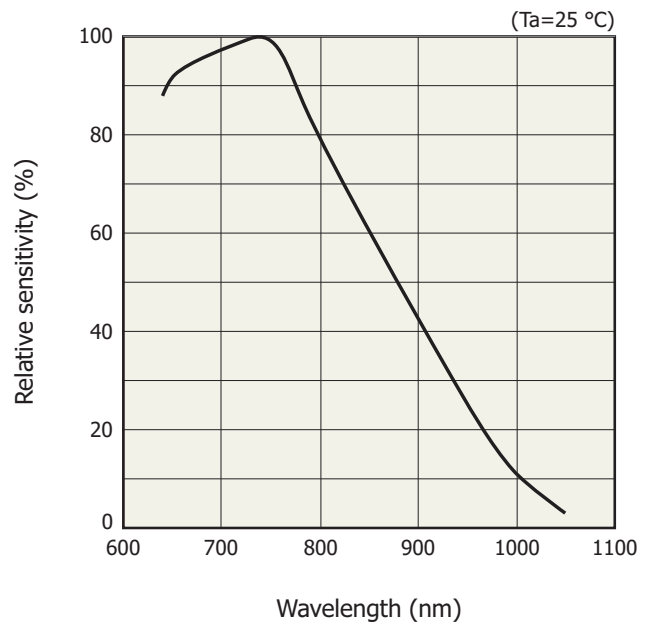


**Spectral response (typical example)**

C10988MA-01



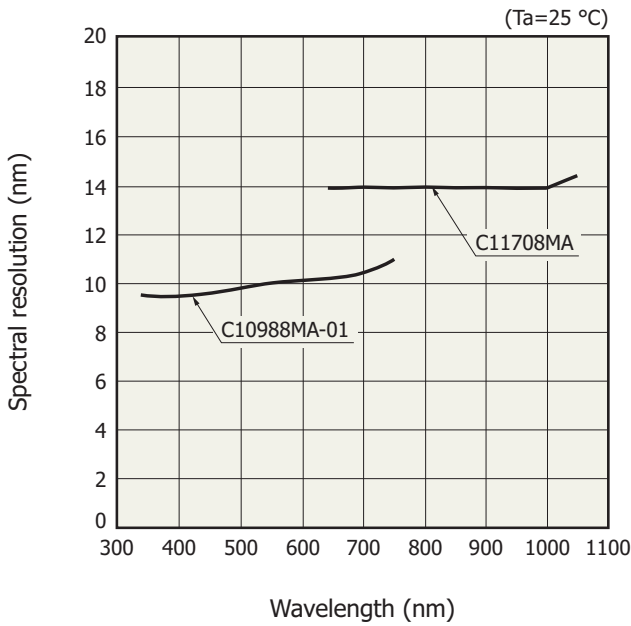
C11708MA



KACCB0209EC

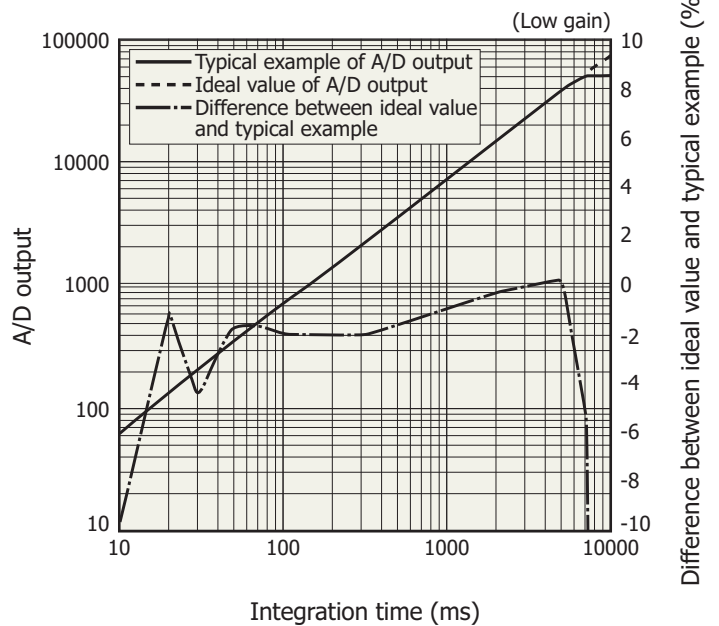
KACCB0225EB

**Spectral resolution vs. wavelength  
(typical example)**



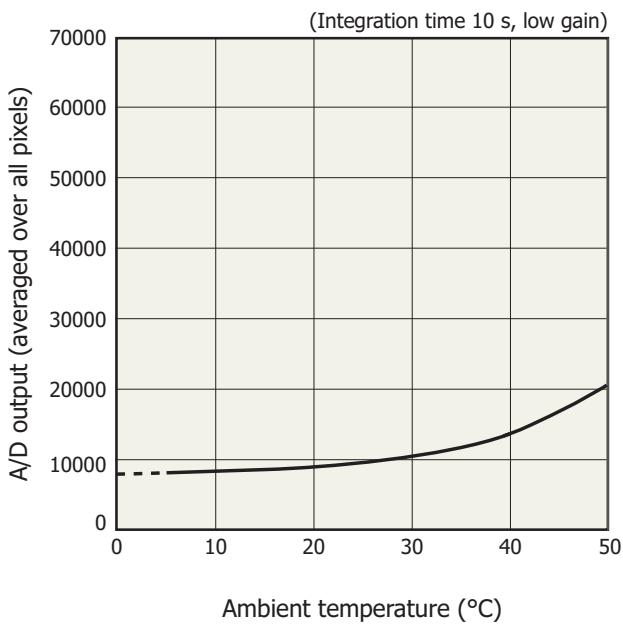
KACCB0211ED

**Linearity  
(measured with C11351, typical example)**



KACCB0230EA

**Dark output vs. ambient temperature  
(measured with C11351, typical example)**

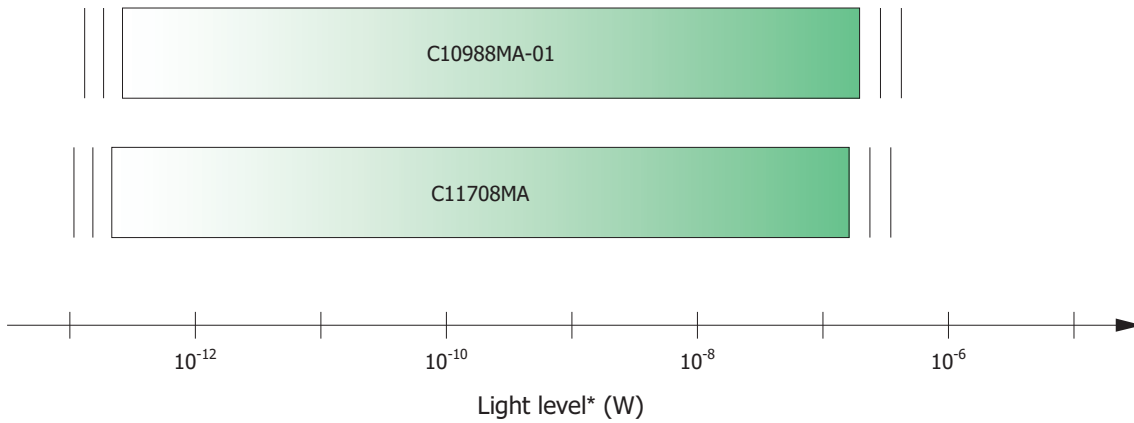


KACCB0233EB

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.

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

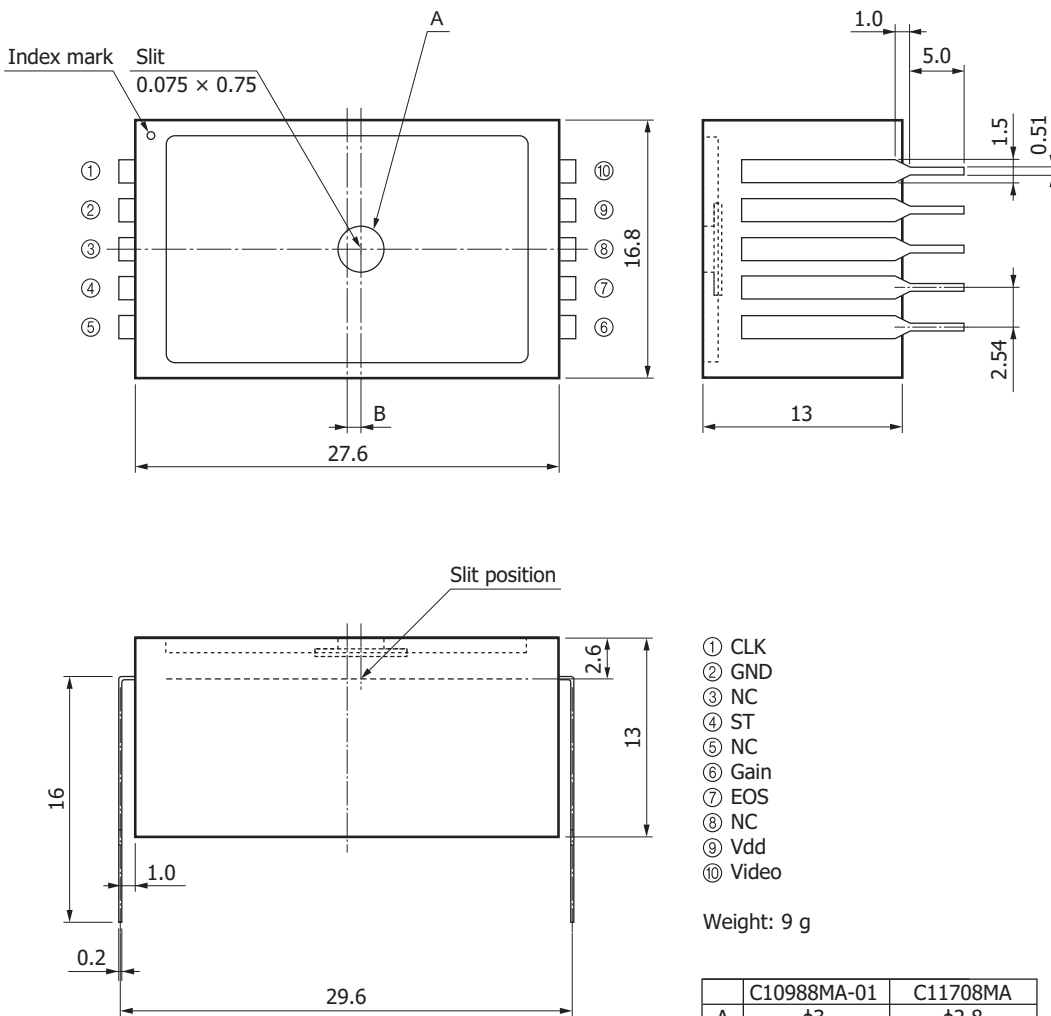
Measurable optical power



\* Input spot diameter: 800  $\mu\text{m}$  (C10988MA-01:  $\lambda=550\text{ nm}$ , C11708MA:  $\lambda=850\text{ nm}$ )

KACCB0210ED

Dimensional outline (unit: mm, tolerance unless otherwise noted:  $\pm 0.2$ )



	C10988MA-01	C11708MA
A	$\phi 3$	$\phi 2.8$
B	0.75	0.5

KACCA0257EC

### Electrical connections with an external circuit

Make electrical connections to an external circuit using the lead pins.

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

### Precaution for use

- If external force is repeatedly applied to the lead pins, this may damage the lead pins.  
When installing this product in locations subject to vibration, secure it with resin or a holder, etc.  
(Recommended resin: KE347B, etc. made by Shin-Etsu Chemical Co., Ltd.)
- The sensor may be damaged by soldering, so be careful of the soldering temperature and time.  
As a general guide, finish soldering within 3.5 seconds at 370 °C or less when soldering by hand, or within 10 seconds at 260 °C or less when using a solder bath.

CMOS image sensor

### Recommended terminal voltage

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	Vdd	4.75	5	5.25	V
Gain selection terminal voltage	High gain	0	-	0.4	V
	Low gain	Vdd - 0.25	Vdd	Vdd + 0.25	V
Clock pulse voltage	High level	Vdd - 0.25	Vdd	Vdd + 0.25	V
	Low level	0	-	0.4	V
Start pulse voltage	High level	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	-	-	60	mW
	Low gain	-	-	60	

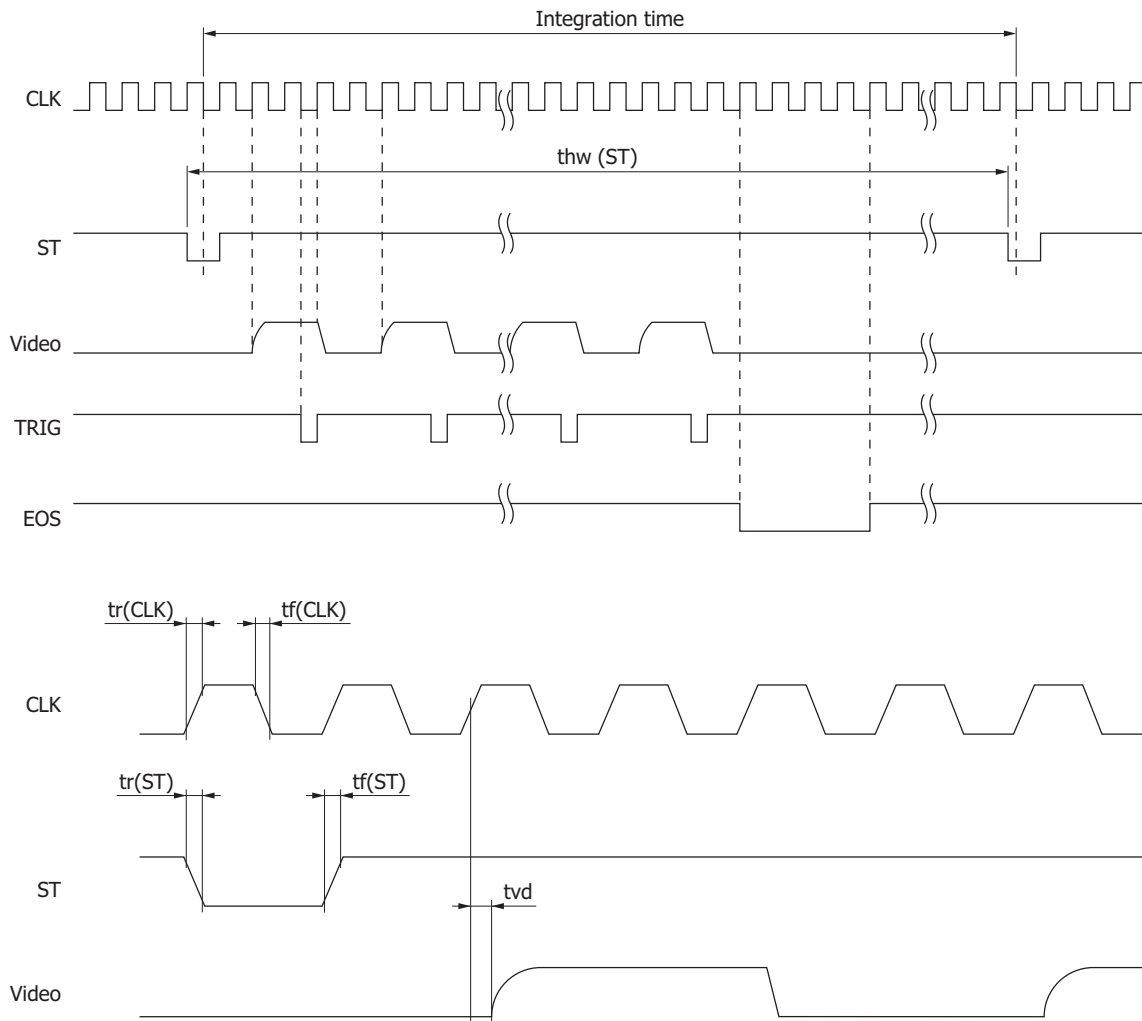
### Electrical and optical characteristics [Ta=25 °C, Vdd=5 V, V(CLK)=V(ST)=5 V]

Parameter	Symbol	Min.	Typ.	Max.	Unit
Dark current	High gain	-	0.02	0.08	pA
	Low gain	-	0.02	0.08	
Output offset voltage	High gain	0.15	0.35	0.55	V
	Low gain	0.15	0.35	0.55	
Feedback capacitance of charge amplifier*9	High gain	-	1.4	-	pF
	Low gain	-	4.8	-	
Saturation output voltage*10	High gain	2.3	2.8	3.3	V
	Low gain	1.4	1.7	2.0	
Readout noise	High gain	-	0.3	0.5	mV rms
	Low gain	-	0.2	0.4	

\*9: Gain=5 V (low gain), Vg=0 V (high gain)

\*10: Difference from Vo

## Timing chart



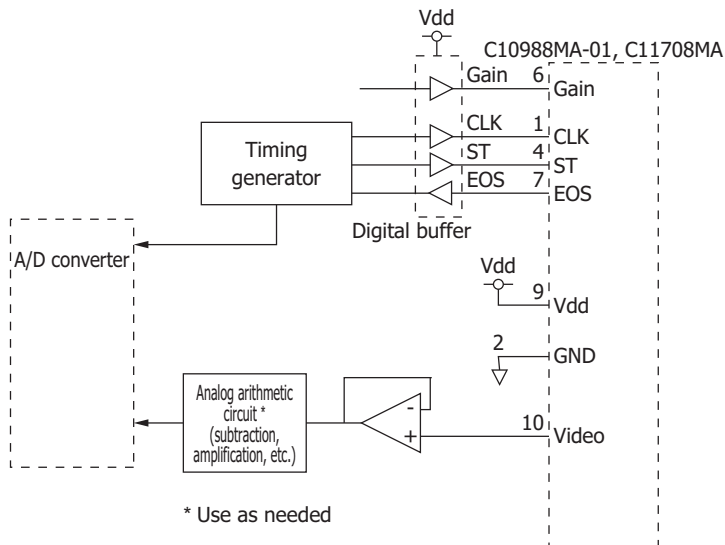
KACCC0493EB

Parameter	Symbol	Min.	Typ.	Max.	Unit
Start pulse high period	thw(ST)	$1030/f(\text{CLK})$	-	-	s
Start pulse rise and fall times	tr(ST), tf(ST)	0	20	30	ns
Clock pulse duty ratio	-	45	50	55	%
Clock pulse rise and 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.

### Recommended driver circuit example



KACCC0502ED

### Evaluation circuit C11351 for mini-spectrometer MS series

The C11351 is a circuit board designed to simply evaluate characteristics of mini-spectrometer MS series. By using the C11351 with the MS series (sold separately) and a USB cable A9160 (AB type; sold separately), the MS series characteristics can be evaluated with the evaluation software\*11.



### Features

- Initial evaluation circuit for mini-spectrometer MS series
- Wavelength conversion factors of MS series can be input from PC\*12
- High A/D resolution (16 bits)
- Powered only via USB port

\*11: Compatible OS: Microsoft® Windows® 7 Professional SP1 (32-bit, 64-bit)  
Microsoft® Windows® 8 Professional (32-bit, 64-bit)

\*12: A typical wavelength conversion factor for converting the image sensor pixel number into a wavelength is recorded in C11351. 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 C10988MA-01 or C11708MA.

Note: Since the C11351 is an evaluation circuit for the MS series, the DLL function specifications are not available to users.

Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and 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 / Absolute maximum ratings

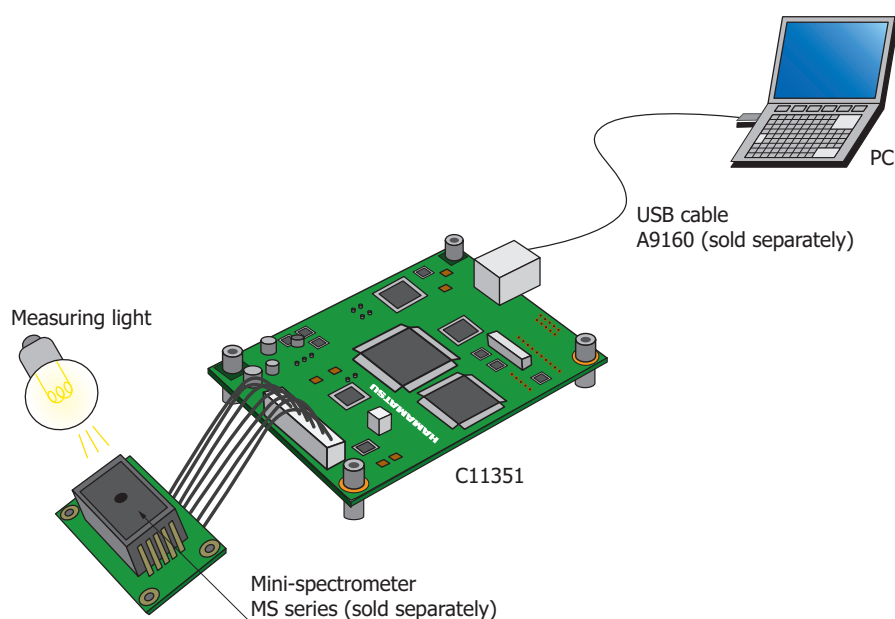
Parameter		Specification	Unit
Applicable mini-spectrometer		C10988MA-01, C11708MA	-
Dimensions	Control board	80 × 60	mm
	Sensor board	30 × 44	mm
Operation temperature*13		+5 to +40	°C
Storage temperature*13		-20 to +70	°C

\*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.

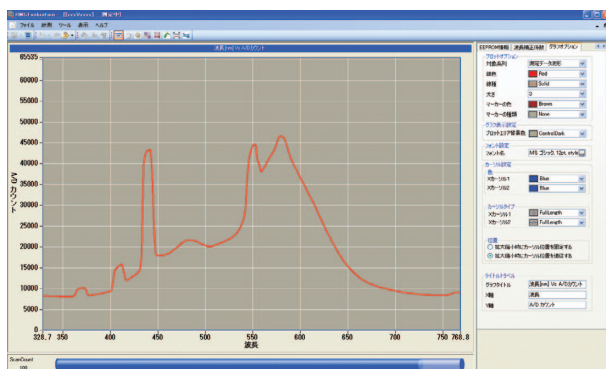
Note: Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

## Connection example



KACCC0494EC

## Evaluation software





Mini-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 February, 2016.

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