HAMAMATSU
PHOTON IS OUR BUSINESS

NEW

CMOS area image sensor

S15589

CMOS area image sensors for X-ray imaging (USB interface type)

The S15589 is a CMOS area image sensor developed for X-ray imaging. FOP (fiber opitc plate) used as the input window ensures high image quality and long sensor life even under exposure to X-rays. The sensor area is about twice as large as that of the conventional product, making it possible to obtain images over a wider area. It supports USB 2.0.

Features

- **Pixel size: 20 × 20 µm**
- **Effective pixels: 2580 (H) × 1700 (V)**
- **High resolution: 20 Lp/mm typ.**
- **Frame rate: 0.46 fps**
- **USB 2.0 interface**
- **Three sensors can be connected to one PC at a time.**
- **Automatically calibrated X-ray images**
  Conditions of calibration data: Tube voltage=70 kV, total filtration is equivalent to 2 mm Al.

Applications

- **Non-destructive inspection**
- **General X-ray imaging**

Structures

Parameter	Specification	Unit
Image size (H × V)	51.6 × 34	mm
Pixel size (H × V)	20 × 20	µm
Pixel pitch	20	µm
Number of total pixels (H × V)	2580 × 1706	pixels
Number of effective pixels (H × V)	2580 × 1700	pixels
Number of light-shielded pixels	Upper part: 756, 758, 760 × 2 Lower part: 2580 × 3	pixels
Scintillator type	CsI(Tl)	-
Interface	USB 2.0	-
Cable length	2	m

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

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	V_{BUS}		4.75	5	5.25	V
Operating temperature	Topr	No dew condensation*1	0	-	35	°C
Operating pressure	Popr		700	-	1060	hPa
Storage temperature	Tstg	No dew condensation*1	-20	-	70	°C
Storage pressure	Pstg		700	-	1060	hPa
Tensile strength	TS	*2	-	-	100	N
X-ray tube voltage	Ex-ray		-	70	90	kV
Total dose irradiation	D	*3	-	-	57.6	Gy

*1: When there is a temperature difference between a product and the surrounding area in high humidity environments, dew condensation may occur on the product surface. Dew condensation on the product may cause deterioration in characteristics and reliability.
*2: Connection between the CMOS sensor and the cable
*3: Tube voltage=60 kV, no Al added filter
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 and optical characteristics (image sensor, Ta=25 °C, VBUS=5 V)

Parameter			Symbol	Min.	Typ.	Max.	Unit
X-ray sensitivity*4			Sx-ray	13	19	25	LSB/μGy
Saturation output			Dsat	3280	4900	-	LSB
Saturation dose*4			Lsat	130	260	380	μGy
X-ray response nonuniformity*4 *5 *6			XRNU	-	-	±30	%
Dark output effective pixels*5			Ddark	-	350	900	LSB/s
Readout noise			DNread	-	7	21	LSB rms
Dynamic range*7			DR	44	57	-	dB
X-ray resolution*4			RESOx-ray	15	20	-	Lp/mm
Contrast transfer function*8			CTF	0.15	0.23	-	-
Blemish*4	Point defect*9	White spot	-	-	0	40	-
		Black spot	-	-	0	40	-
	Cluster defect*10		-	-	0	6	-
	Column defect*11		-	-	0	0	-
Defect line*4 *12			DL	-	0	0	lines
X-ray life*13			-	-	-	144000	shots

*4: Tube voltage=70 kV, tube current=6 mA, SID (source to image-receptor distance)=510 mm, no Al added filter
*5: Average value excluding defective pixels
*6: XRNU (%)=(ΔS/S) × 100
S is the average value of X-ray output signals.
ΔS is the difference between S and the maximum or the minimum value of X-ray output signals.
ΔS is calculated from an X-ray image corrected by dark subtraction excluding any defect.
XRNU specification is not applied to 5 pixels from the edge of effective pixels.
*7: DR=20 × log (Dsat/DNread)
*8: 10 line pairs/mm
*9: White spot > 9000 LSB/s of dark output
Black spot > 50% reduction in response relative to the average value of the effective pixels measured at half of saturation output
*10: Continuous 2 to 9 point defects
*11: Continuous 10 or more point defects excluding a defect line
*12: A defect line consists of 10 or more point defects in 1 pixel width.
*13: 400 μGy/shot, tube voltage=60 kV, no Al added filter

Electrical and optical characteristics (monitoring photodiode, Ta=25 °C, VBUS=5 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit
X-ray sensitivity*14	S_MPD	-	38	-	LSB*15
Saturation output*14	Dsat_MPD	-	-	1023	LSB
A/D converter offset*16	Offset_MPD	426	432	438	LSB
Random noise*17	Nmd_MPD	0.1	0.4	1	LSB rms

*14: Tube voltage=70 kV, tube current=6 mA, SID=510 mm, no Al added filter
*15: The unit means the output of the monitoring photodiode when the dose rate is 1 μGy/ms.
*16: An A/D converter offset is a "mode" value of monitoring photodiode data without X-ray irradiation. "Mode" is a statistic term and the number that appears the most often in a set of numbers. This value is dependent on the PC and surrounding environment, and varies per sensor.
*17: Random noise is a standard deviation of a series of monitoring photodiode data without X-ray irradiation.

Electrical characteristics (Ta=25 °C, VBUS=5 V)

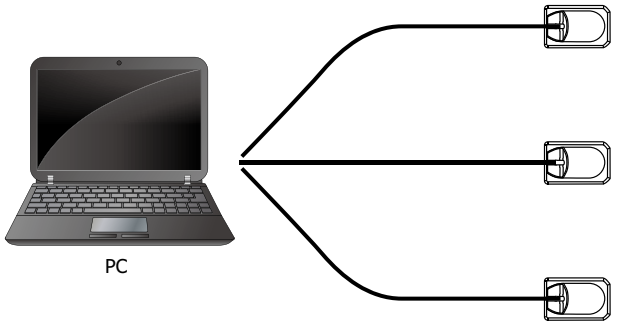
Parameter		Symbol	Min.	Typ.	Max.	Unit
Frame rate*18		FR	-	-	0.46	fps
Readout time		tread	-	2.2	-	s
Integration time		tint	0.001	-	10	s
Consumption current	Image sensor (readout mode)	Ic	-	190	240	mA
	Monitoring photodiode		-	115	165	

*18: The frame rate does not include an integration time and the time for displaying an image after readout.

Feature 01 Set-up example

Up to three sensors can be connected to one PC at a time.

Connection example



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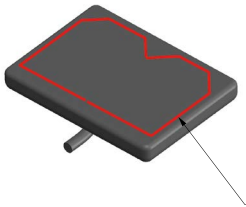
Feature 02 Monitoring photodiode

The monitoring photodiode is arranged along the entire circumference of the effective pixel area and this will monitor dose rates. When you get an image, if the output of the monitoring photodiode gets higher than a certain threshold, you can get an image automatically. You need to get the output of the monitoring photodiode in order to set an appropriate threshold. However, you cannot get the output of monitoring photodiode while you get an image. You can get the output of the monitoring photodiode by calling the function prepared in DLL. The function is described in the CD-ROM attached to the product.



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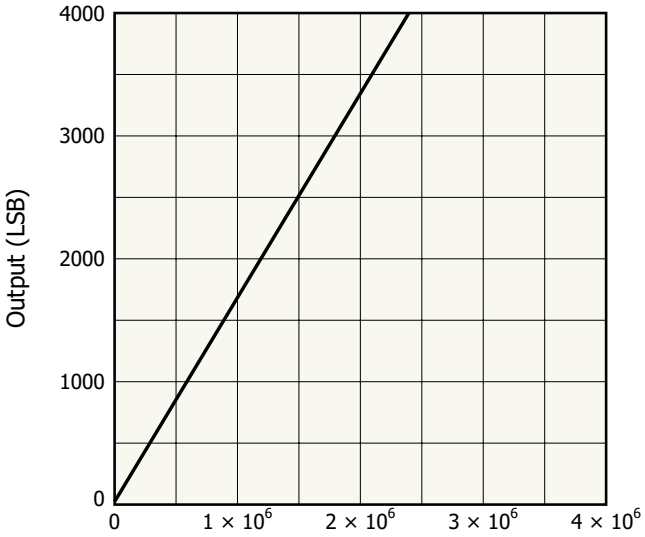
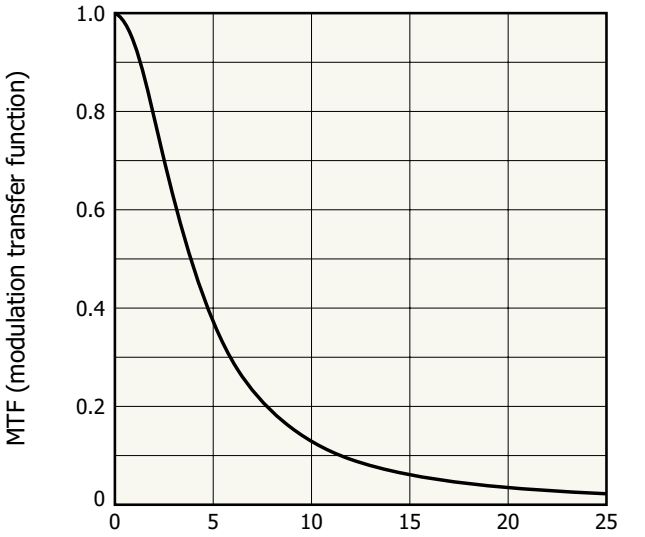
Output vs. number of input photons (typical example)*19



KMPDB0662EA

MTF vs. spatial frequency (typical example)*19



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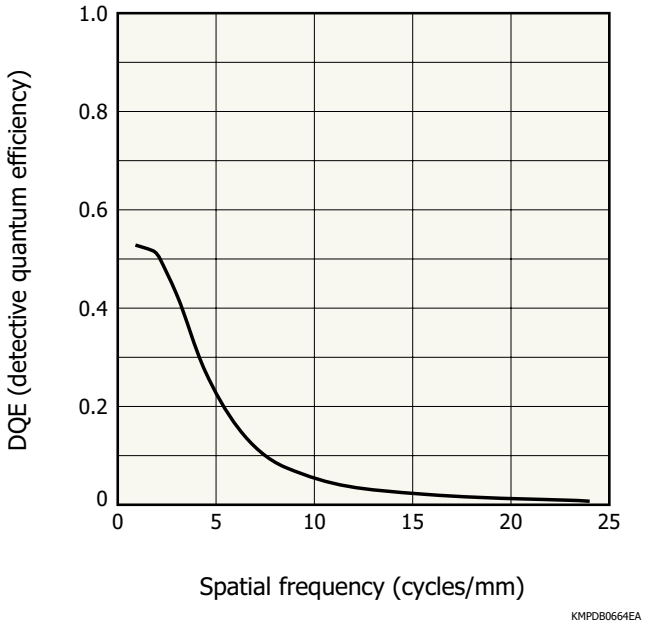
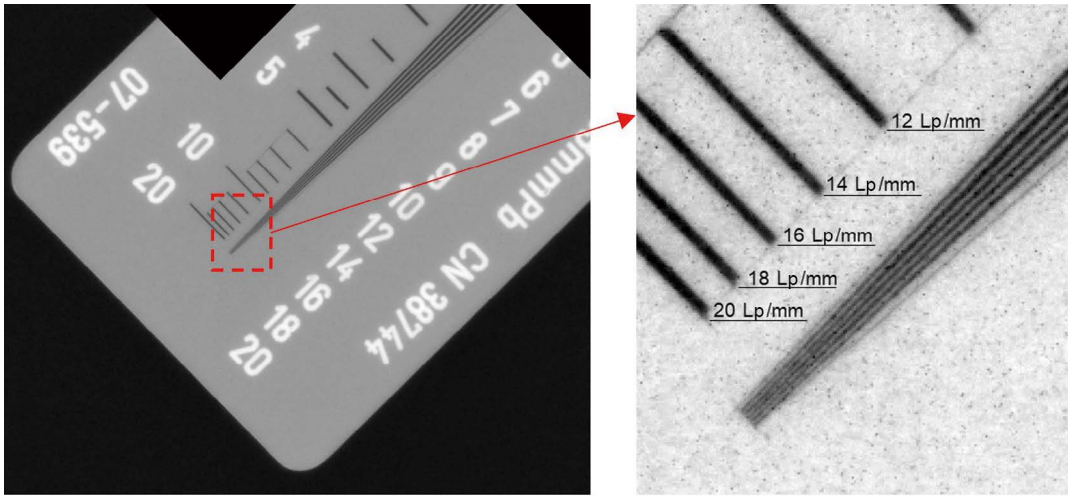
*19: X-ray radiation quality=RQA5, tube current=6 mA, SID=375 mm

DQE vs. spatial frequency (typical example)*19



*19: X-ray radiation quality=RQA5, tube current=6 mA, SID=375 mm

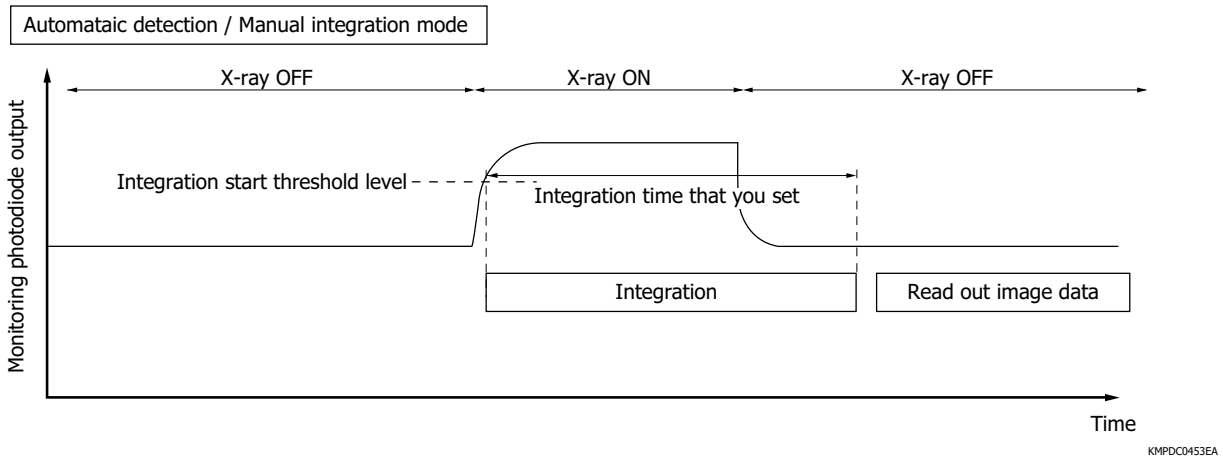
Acquired images of resolution chart

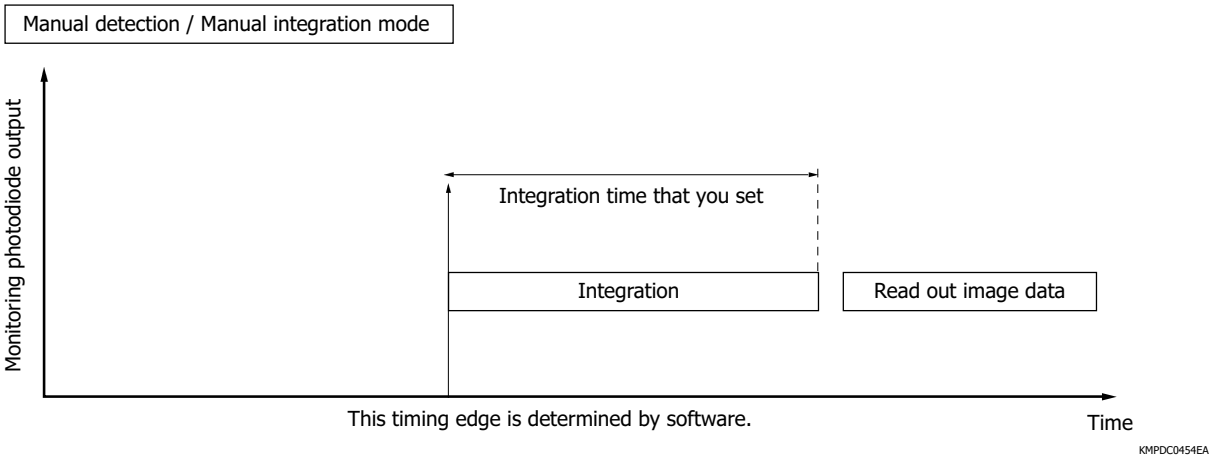


Detection modes

There are following two modes to start integration. In both case, an integration time is determined by an operator.

- Automatic detection / Manual integration mode
  The start of integration is determined by the sensor automatically, but an integration time has to be set by an operator. This mode will be available for both AC and DC type X-ray source.
- Manual detection / Manual integration mode
  You will be able to take images without X-ray irradiation. Therefore, this mode is useful when you would like to take dark images as a background image. The integration time has to be set by an operator.

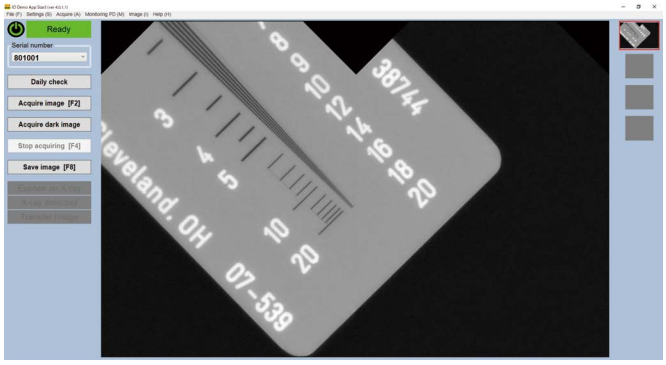




For details, please see a function manual attached to the CD-ROM.

Evaluation software*20

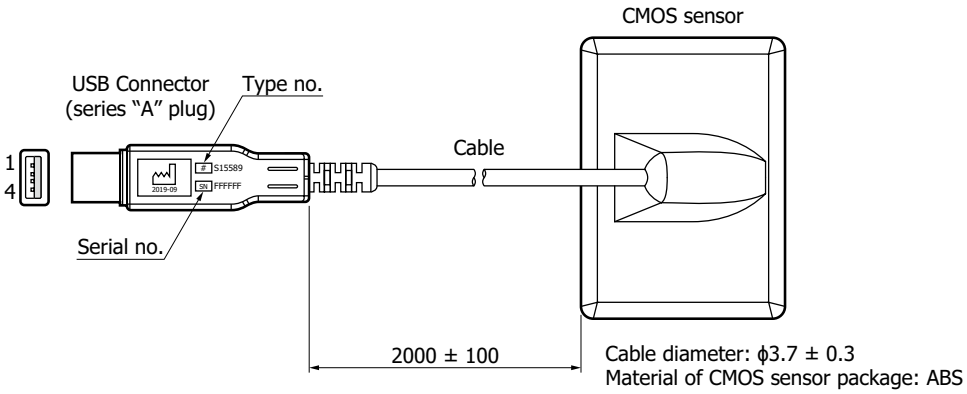
You can acquire and save images with attached evaluation software. Dark subtraction and flat field correction are automatically applied to X-ray images.



*20: The evaluation software is not designed for medical use. You should use this software only for evaluating the sensor and must not use for medical use.

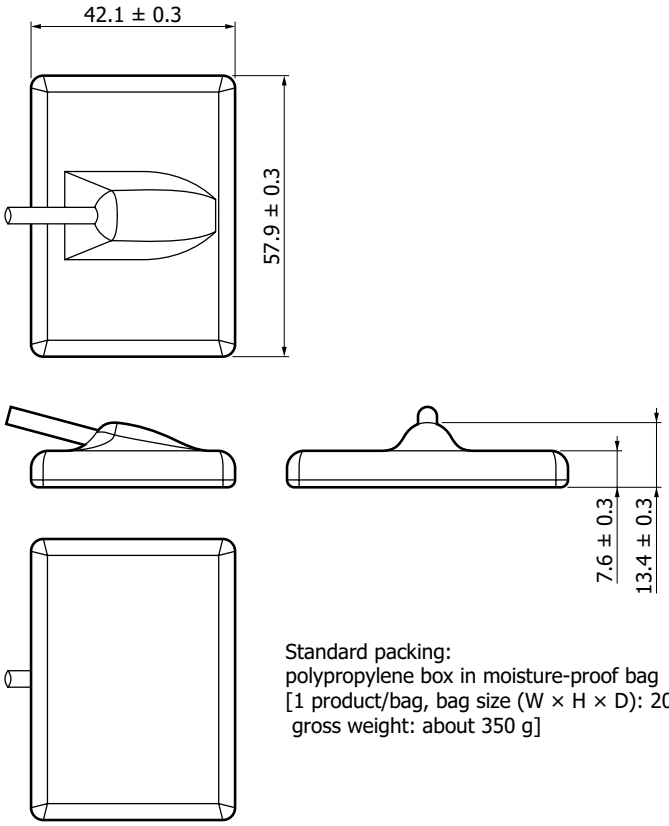
Dimensional outlines (unit: mm)

Entire view



Cable diameter: ϕ3.7 ± 0.3
Material of CMOS sensor package: ABS
Material of cable sheath: PVC
Weight: 85 g

CMOS sensor



Standard packing:
polypropylene box in moisture-proof bag
[1 product/bag, bag size (W × H × D): 200 × 50 × 150
gross weight: about 350 g]

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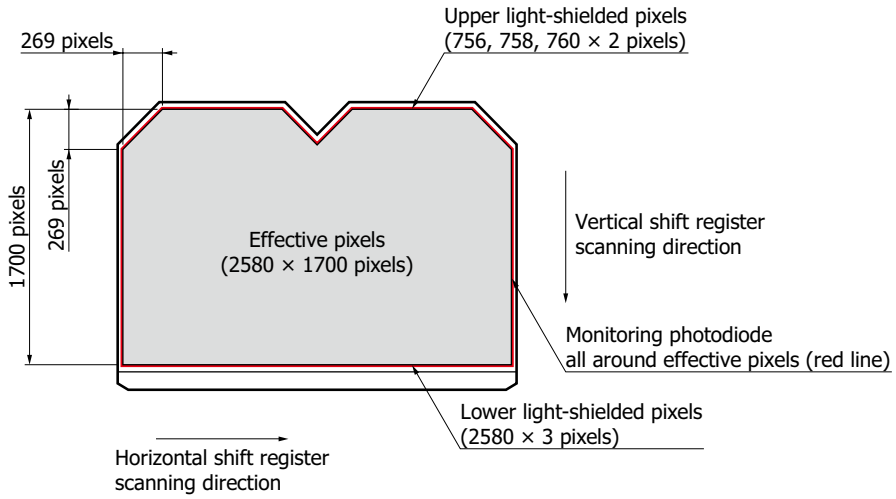
Pin connections

Pin no.	Description
1	V_{BUS}
2	D-
3	D+
4	GND

Effective photosensitive area



Labelings

· CD-ROM
(Evaluation software, USB driver, DLL, function manual)
· Documents (precautions for using image sensors, user's guide, final inspection sheet)

Recommended system requirements

Users must use Intel-based PCs.

· Windows
CPU: Intel core i5-2520M 2.5 GHz or higher
Memory: 8 GB or higher
Operating system: Microsoft® Windows® 10 64-bit

Note: Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

Notice

This product is warranted for a period of 12 months after the date of the shipment.
The warranty is limited to replacement or repair of any defective product due to defects in workmanship or materials used in manufacture. The warranty does not cover loss or damage caused by natural disaster, misuse (including modifications and any use not complying with the environment, application, usage and storage conditions described in this datasheet), or total radiation dose over 57.6 Gy (tube voltage=60 kV) even within the warranty period.

Estimated useful life*21

5 years
(if you keep the product safely according to this datasheet)

*21: Estimated useful life does not mean a warranty period.

Related information

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

■ Precautions
· Disclaimer

Information described in this material is current as of December 2021.
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.
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