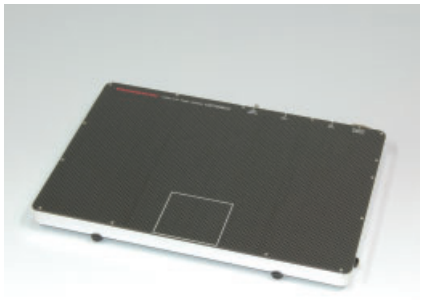
HAMAMATSU
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Flat panel sensor



C9728DK-10

For diffraction, cassette type with USB 2.0 interface
Photodiode area: 52.8 × 52.8 mm

The C9728DK-10 is a high detection capability digital X-ray image sensor newly developed as a key device for X-ray diffractometers less than 18 keV. The device shape is thin cassette which incorporates on-chip high-resolution scintillator and a control board. An on-board USB 2.0 interface can realize fast data transfer with the C9728DK-10.

Features

- **Active pixels readout *1**
- **Low noise: 80 electrons**
- **1032 × 1032 pixels (50 µm pitch)**
- **High resolution**
- **14-bit digital output (USB 2.0 interface)**
- **High-speed imaging: 3 frames/s**
- **Compatible with HAMAMATSU API (DCAM-API)**

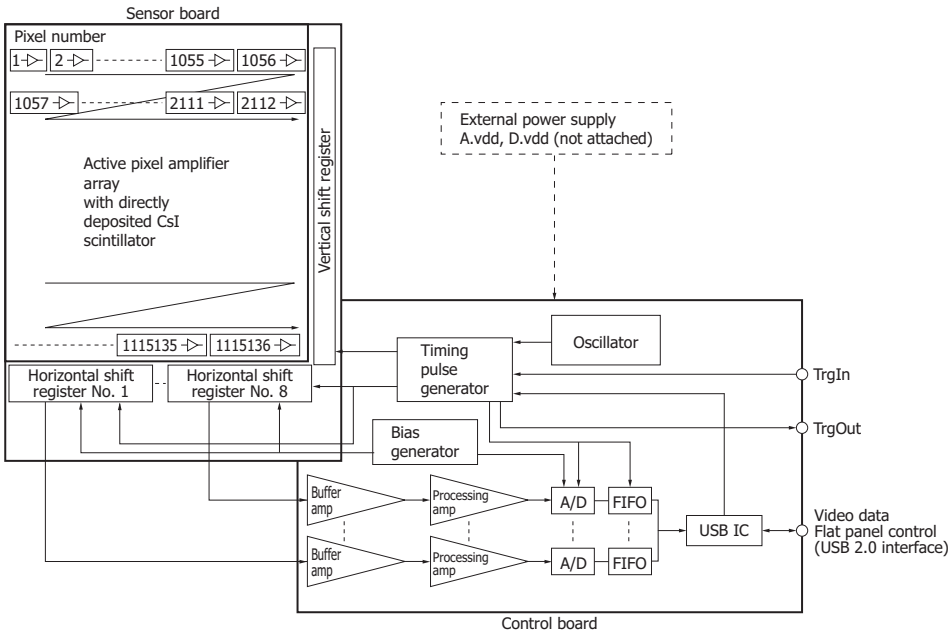
Applications

- **Diffraction**
- **Radiography**

*1: The amplifier integrated in each pixel converts charge to voltage. Since the amplifier input capacitance is small compared to the passive pixel type, imaging can be made with low noise and high sensitivity.

Structure

The C9728DK-10 is comprised of a sensor board and a control board. Mounted on the sensor board is a CMOS image sensor chip made up of a two-dimensional active pixel amplifier array, row-scanning vertical shift register, and 8 shift register blocks.
CsI scintillator is directly deposited on the two-dimensional photodiode array. X-rays incident on the scintillator are converted to fluorescence, which then enters the two-dimensional photodiode array where electric charge is accumulated in each pixel according to the light intensity. Each pixel has a low noise active pixel amplifier. The analog video signal from each pixel is held by the 1056 ch sample-and-hold circuit with a CDS (correlated double sampling) circuit added, and is then output from each amplifier array by scanning the horizontal shift register.
The control board converts the analog signal into a 14-bit digital signal, which is then output to a PC through the USB 2.0 interface.



Note: Signals are read out in order of pixel number.

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General ratings

Parameter	Specification	Unit
Pixel size	50 × 50	µm
Photodiode area	52.8 × 52.8	mm
Number of pixels	1056 × 1056	pixels
Number of active pixels	1032 × 1032	pixels
Readout	Active pixel readout	-
Video output	USB 2.0, 14-bit	-
TrgIn, TrgOut	TTL	-
Scintillator	Direct deposition CsI	-

Absolute maximum ratings (Ta=25 °C)

Parameter	Symbol	Value	Unit
Supply voltage for digital circuitry (+5 V)	D.vdd	+6.0	V
Supply voltage for analog circuitry (+5 V)	A.vdd	+6.0	V
Input voltage	Vin	0 to 6.0	V
Operating temperature *2	Topr	0 to +35	°C
Storage temperature *2	Tstg	0 to +50	°C
Incident X-ray energy	-	18	keV

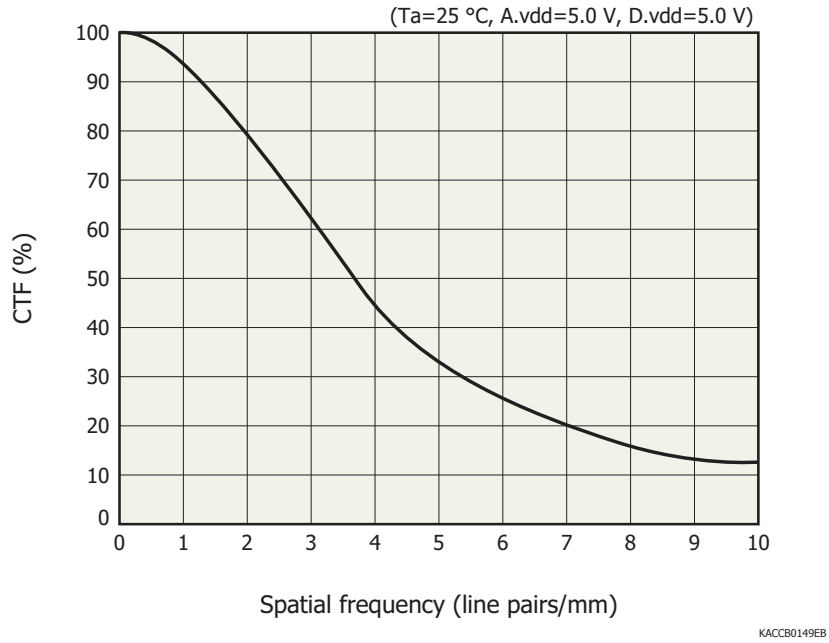
*2: No condensation

Specifications (Ta=25 °C, A.vdd=5.0 V, D.vdd=5.0 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Frame rate max.	Sf(max)	2.85	3	-	frames/s
Frame rate	Sf	-	0.1 to Sf(max)	-	frames/s
Noise (rms) *3	N(rms)	-	80	-	electrons
Sensitivity *4	S	360	450	-	LSB/mR
Saturation charge	Csat	-	0.45	-	M electrons
Resolution *5	Reso	9	10	-	line pairs/mm
Dynamic range	-	-	5600	-	-
Defect line *6	-	-	-	10	lines
Blemish *7	-	-	-	600	µm
Non-uniformity of sensitivity *7	-	-	-	4	%
Defect cluster *7	-	Not allowed			-
Bright line output adjacent to a defect line *7	-	-	-	120	%
Output offset *8	-	-	260	800	LSB

*3: Internal trigger mode at Sf(max)
*4: 25 kVp (Mo target X-ray source), without filter
*5: Spatial frequency at CTF=5 %
*6: A defect line is a horizontal or vertical line containing 4 or more cosecutive pixels located at the opposite side of an amplifier array or a shift register, that produce 1/8 of the average sensitivity of the surrounding pixels.
Adjacent defect lines are not allowed in the vertical or horizontal directions.
*7: See P. 5, "Description of terms"
*8: Average of all active pixels at Sf(max)
Note: X-ray energy range is less than 18 keV.

Resolution



Accessories

- Power cable (terminated with a JSTJ-C9-2C plug at one end and open at the other end; 2 m; see Table 1.)
- Trigger cable (terminated with an FGG.0B.304.CLAD56 plug at one end and open at the other end; 5 m; see Table 2.)
- Earth cable (AWG; 4 m)

System requirements

To operate the C9728DK-10 at full performance, the following system and peripherals are required.

- PC: IBM compatible PC with USB 2.0 running on Windows XP
- Power source: A.vdd = +5.0 ± 0.1 V (600 mA), D.vdd = +5.0 ± 0.1 V (900 mA)
  - · The voltages described above are specified at the flat panel sensor side.
  - · Please use a low noise series power supply. (Avoid using a switching power supply.)
  - · Install a noise filter on the AC power input line to prevent surges on the AC line.
  - · Always ground the ground terminal to avoid the effects of noise from peripheral devices.
- DCAM-API (digital camera application programming interface): produced by HAMAMATSU
  - · The driver software, DLL and sample software are included in DCAM-API.
  - · The latest version of DCAM-API can be downloaded from "http://www.dcamapi.com".
- USB cable: mini-B type

[Table 1] Pin assignment and cable color for 9-pin power receptacle

Pin No.	Color	Signal
1	Yellow	Digital GND
2	Blue	Digital GND
3	Gray	Analog GND
4	Black	Analog GND
5	Red	Analog GND
6	Green	Digital +5 V
7	Purple	Digital +5 V
8	White	Analog +5 V
9	Brown	Analog +5 V

9-pin receptacle: DE-9PF-N made by JAE (Japan Aviation Electronics Industry, Limited)
Mating plug: JST J-C9-2C made by J.S.T Mfg. Co., Ltd.

[Table 2] Pin assignment and color cable for 4-pin trigger cable

Pin No.	Color	Signal	Note
1	Blue	TrgIn	Twist pair
2	Orange	Digital GND	
3	Green	TrgOut	Twist pair
4	Brown	Digital GND	

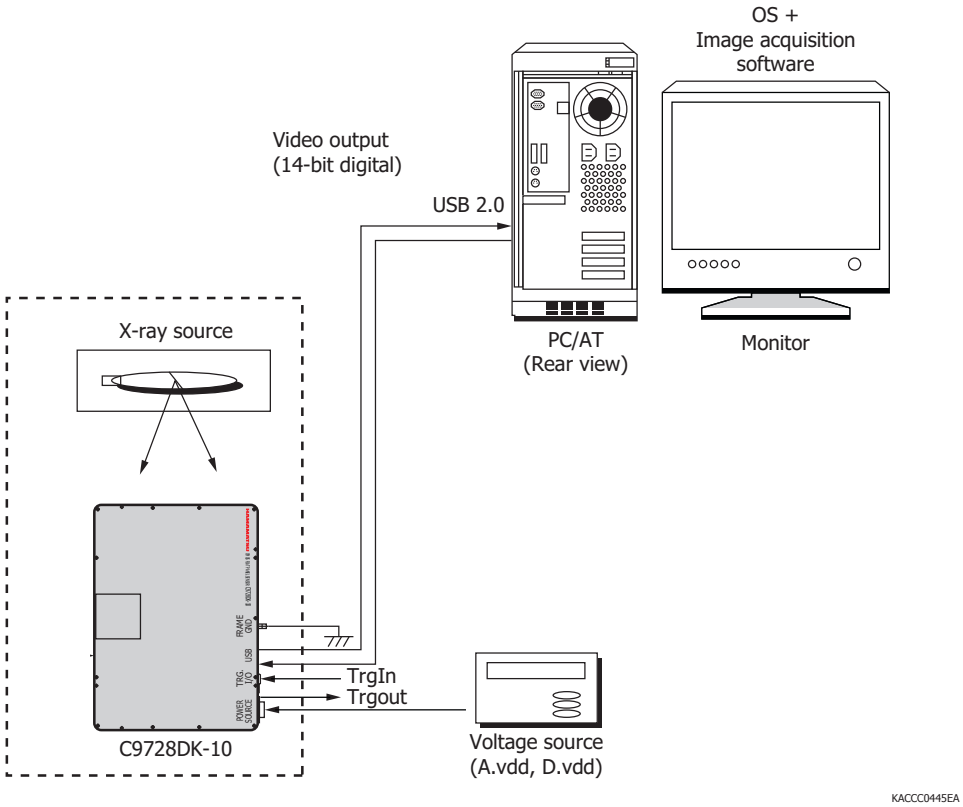
4-pin receptacle: ECG. 0B. 304. CLL made by LEMO S.A.
Mating plug: FGG. 0B. 304. CLAD56 made by LEMO S.A.

[Table 3] Control mode

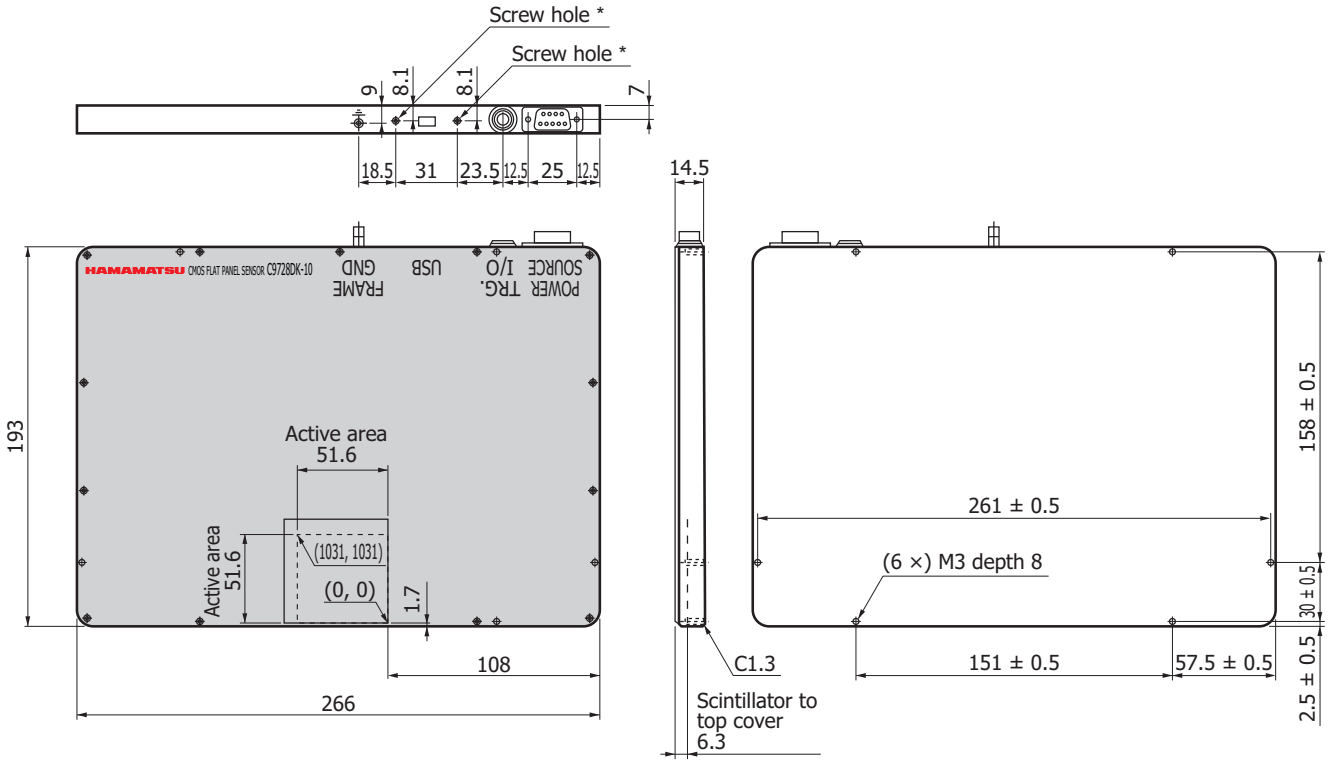
Mode	TrgIn (See Table 2)	Note
External control (DCAM_TRIGMODE_SYNCREADOUT)	Rectangular signal	The integration time is controlled through Lemo 4-pin trigger cable.
Internal control (DCAM_TRIGMODE_INTERNAL)	High or Open	The integration time is controlled by DCAM command without Lemo 4-pin trigger cable.

Connection

After installing DCAM-API in a PC with a USB 2.0 port, connect the C9728DK-10 to that PC.



Dimensional outline (unit: mm, tolerance: ±1 mm unless otherwise noted)



Top cover material including window is carbon fiber (1.0 mm thickness).
Weight: 1.3 kg
* M3 screw hole for fixing USB plug to flat panel sensor.
The depth of the hole: 7 mm

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Notice

- Do not subject the flat panel sensors to strong vibration or shock (Strong shock such as drop impacts may cause permanent damage to these sensors).
- Users must take responsibility for implementing X-ray shielding safety measures to avoid the risk of X-ray exposure.
- The specification listed in this datasheet is defined at the time of shipment. Characteristics may vary somewhat due to exposure to X-rays so take proper countermeasures such as making periodic image correction.
- 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 45000 Roentgen (incident X-ray energy: less than 18 keV) even within the warranty period.

CE

The C9728DK-10 conforms to European EMC directives:
EN61326-1 Class A.

Description of terms

Blemish

Length of pixel cluster which has less than 90 % of the average sensitivity of the surrounding pixels.

Bright line output adjacent to a defect line

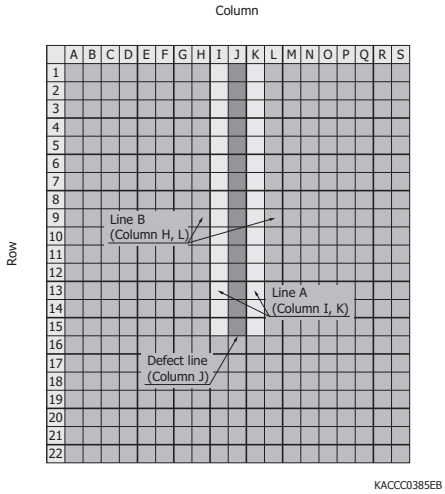
The relative sensitivity ratio "a/b" should be 120 % or less for both vertical and horizontal lines, where "a" and "b" are defined as follows:

a: Average sensitivity of bright line (Line A) adjacent to defect line
b: Average sensitivity of standard line (Line B) adjacent to Line A

Note that the average sensitivity of the bright line is calculated from the region adjacent to the defect region in the defect line.

Example: See the right figure

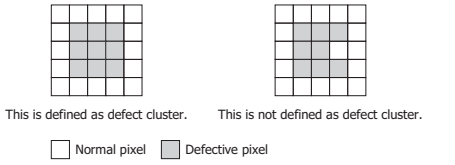
Defect region in defect line: From pixel (J, 1) to pixel (J, 15)
a: Average sensitivity from pixel (I, 1) to pixel (I, 15) or from pixel (K, 1) to pixel (K, 15)
b: Average sensitivity from pixel (H, 1) to pixel (H, 15) or from pixel (L, 1) to pixel (L, 15)



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Defect cluster

Formed with more than 3 × 3 pixels which have less than 1/8 of the average sensitivity of the surrounding pixels.



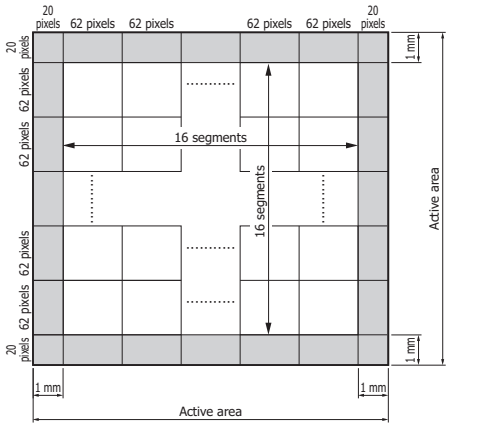
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Non-uniformity of sensitivity

16 × 16 segments are 16 × 16-divided active area excluded 1 mm from the whole edge. Xij is defined as the average sensitivity of each segment.
Uniformity of sensitivity is calculated as following equation.

$$\text{Non-unifomity of sensitivity} = \frac{\sigma}{\overline{x}}$$

σ: standard deviation of 16 × 16 "Xij"
$\overline{x}$: average value of 16 × 16 "Xij"



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Information described in this material is current as of March, 2011. Product specifications are subject to change without prior notice due to improvements or other reasons. Before assembly into final products, please contact us for the delivery specification sheet to check the latest information.
Type numbers of products listed in the delivery specification sheets or supplied as samples may have a suffix "(X)" which means preliminary specifications or a suffix "(Z)" which means developmental 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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