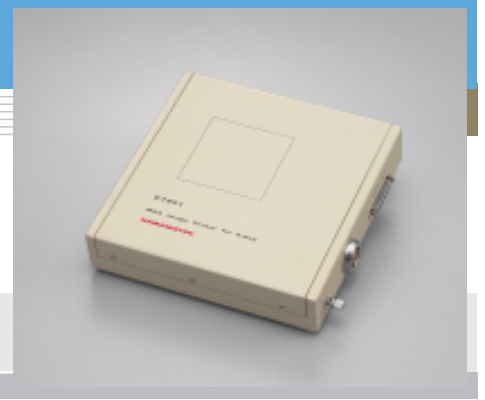## IMAGE SENSOR

Flat panel sensor
C7921CA

High resolution and high frame rate

Flat panel sensor C7921CA is a digital X-ray image sensor newly developed as key devices for non-destructive inspection, biomedical imaging, X-ray microscopy and other real-time X-ray imaging applications requiring high resolution and high image quality. C7921CA consists of a sensor board and a control board, both assembled in a thin, flat and compact package. The sensor board contains a CsI scintillator plate, a two-dimensional photodiode array with FET switches and a signal processing IC chip. The photodiode array has a 1056 × 1056 pixel format with minimized blooming and is highly sensitive to bluish green light emitted from the CsI scintillator. Each row of pixels is addressed in sequence by the vertical shift register connected to the gate line.

Light emission occurs when X-rays are absorbed in the CsI scintillator. This light emission enters directly into the two-dimensional photodiode array where an electric charge is stored in each pixel according to the light intensity. This charge is then transferred to the corresponding data line by applying a control signal to the vertical shift register.

The sensor board also has 8 charge sensitive amplifier arrays each having 132 channel amplifiers with a horizontal shift register. These amplifiers with a total of 1056 channels are connected to a CDS (Correlated Double Sampling) circuit that senses the charge on each video line and sends it as the analog video signal from each amplifier array. The control board converts the analog video signal into a 12-bit digital signal and outputs it to an external frame grabber from a 12-bit parallel port.

C7921CA delivers a frame rate of 16 frames per second using 4 × 4 binning and is ideal for high frame rate applications, also ideal for applications requiring high resolution because of its 50 μm pixel size. Massive digital image data can easily be monitored on a display unit by using a frame grabber board and video memory installed in the PC. C7921CA will prove ideal tools for real-time X-ray imaging and processing where easy-to-use, high-resolution X-ray digital image sensors are needed.
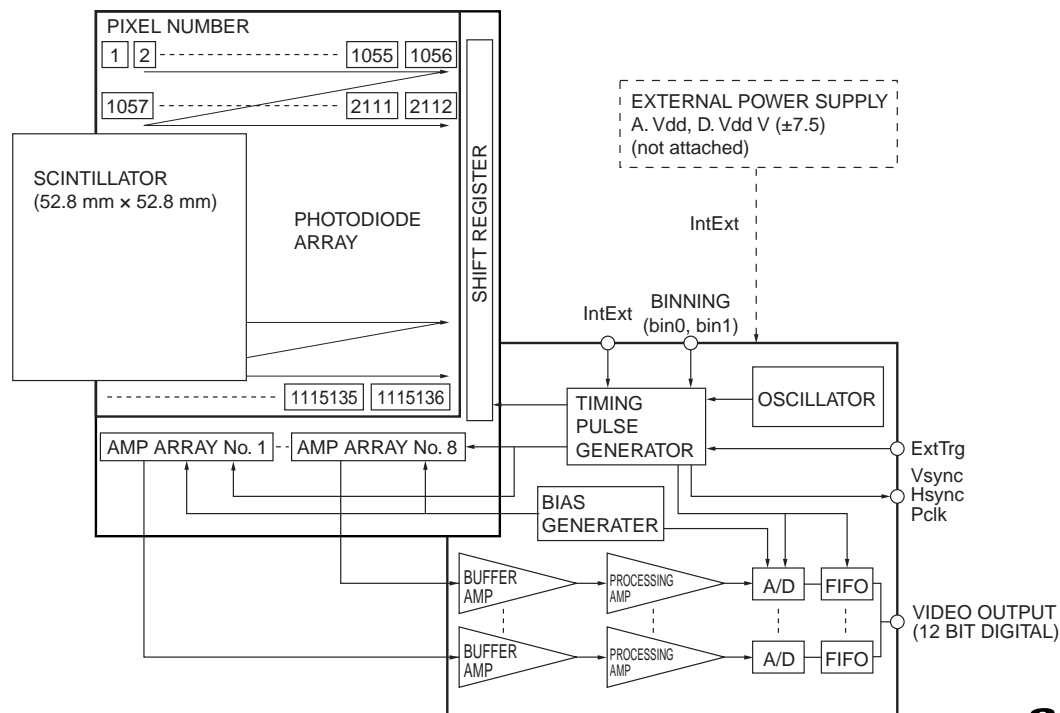
Applications

● Non-destructive inspection
● Digital X-ray photography

Features

● High quality image: 1056 × 1056 pixels
● Pixel size: 50 × 50 μm
● No image distortion
● Digital output (12 bits)
● High-speed imaging by binning operation:
  16 frames/s (4 × 4 binning)
● Wide dynamic range
● High cost performance

■ Block diagram

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SOLID STATE DIVISION

■ Functional specification

Parameter	Specification
Readout	Charge amplifier array
Feedback capacitance of each amplifier	0.15 pF
Video output (Data1 - 12)	RS-422 (differential) 12 bit
Output data rate	6.25 MHz
Synchronous signal (Vsync, Hsync, Pclk)	RS-422 (differential)
bin0, 1, ExtTrg, IntExt	TTL

■ Absolute maximum ratings (Ta=25 °C)

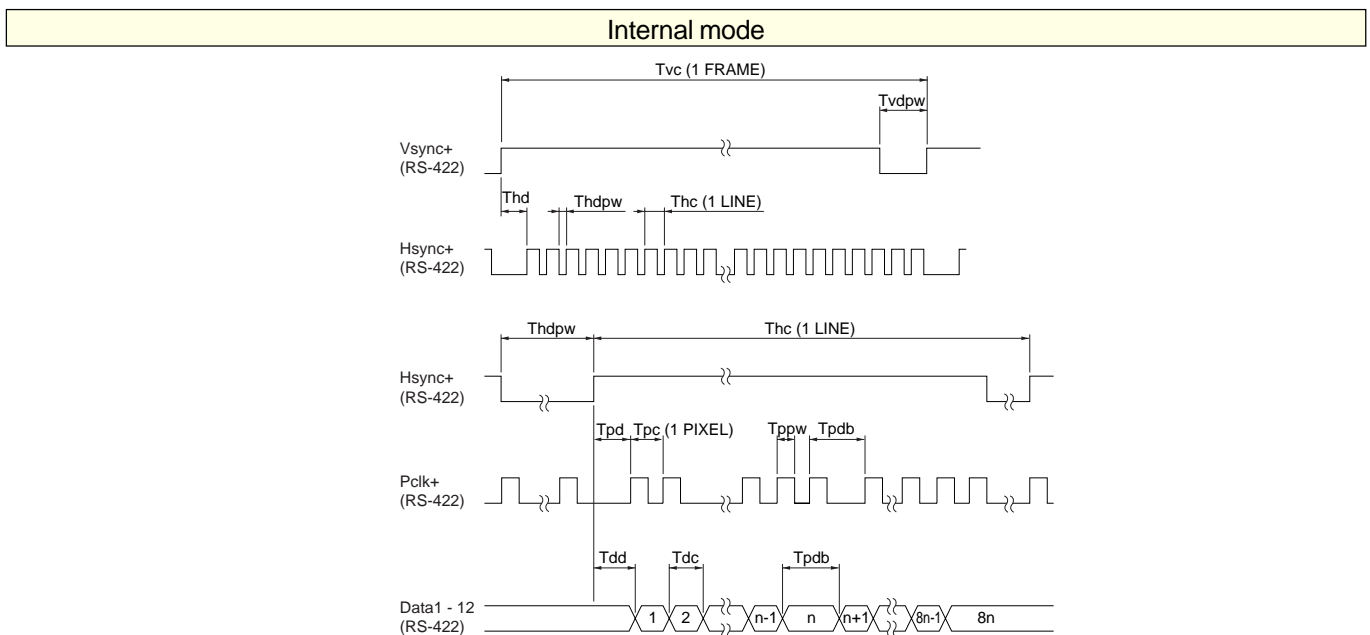| Parameter	Symbol	Value	Unit
Supply voltage for digital circuitry (+5 V)	D.vdd	+6.0	V
Supply voltage for analog circuitry (+5 V)	A.vdd	+6.0	V
Supply voltage for analog circuitry (±7.5 V)	V(+/-7.5)	±12	V
Input voltage (bin0, 1, ExtTrg, IntExt)	Vin	0 to 6.0	V
Operating temperature (not condensed)	Topr	0 to +35	°C
Storage temperature (not condensed)	Tstg	0 to +50	°C

■ Specification (Unless otherwise noted, Typ. Ta=25 °C A.vdd= 5.0 V, D.vdd= 5.0 V, V (±7.5)= ±7.5 V)

Parameter	Symbol	Specification	Unit
Pixel size	-	50	µm
Active area	-	52.8 × 52.8	mm
Pixel number	-	1056 × 1056	pixels
Number of active pixels	-	1032 × 1032	pixels
Frame speed (single operation)	Sf (int)	4	frame/s
Frame speed (2 × 2 binning)	-	8	frame/s
Frame speed (4 × 4 binning)	-	16	frame/s
Frame speed external (single operation)	Sf (ext)	Sf (int) to 0.1	frame/s
Noise (rms.)	N (rms.)	1000	electrons
Saturation charge	Csat	2.9	M electrons
Resolution	Reso	8	line pairs/mm
Dynamic range	-	2900	-
Defect line *	-	10 Max.	lines
Scintillator	-	CsI	-

* Without a couple of adjacent defect line that has no response.
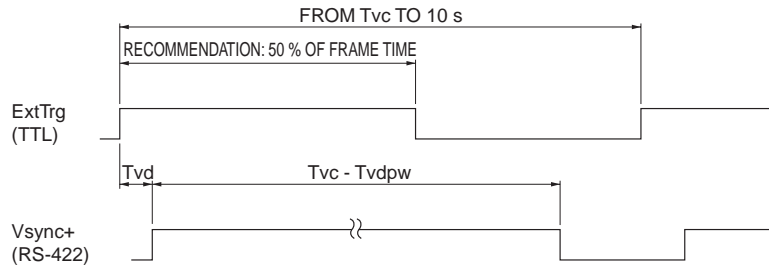
■ Timing chart

To acquire images through an image grabber board, parameters that match the following timing chart should be described in the software program or parameter file.

Internal mode

The number of n is 132

External mode

FROM Tvc TO 10 s

RECOMMENDATION: 50 % OF FRAME TIME

ExtTrg
(TTL)

Tvd   Tvc - Tvdpw

Vsync+
(RS-422)

Hsync+, Pclk and Data 1-12 are the same as internal trigger mode.

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1 × 1 mode (Typ.)

	Parameter	Symbol	Value	Unit
Vsync	Delay time (only external trigger mode)	Tvd	450	µs
	Cycle time	Tvc	243	ms
	Dummy pulse width	Tvdpw	920	µs
Hsync	Delay time	Thd	2.8	µs
	Cycle time	Thc	230	µs
	Dummy pulse width	Thdpw	59	µs
Pclk	Delay time	Tpd	150	ns
	Cycle time	Tpc	160	ns
	Pulse width	Tppw	85	ns
	Delay time between each block	Tpdb	480	ns
Data1-12	Delay time	Tdd	50	ns
	Cycle time	Tdc	160	ns

2 × 2 mode (Typ.)

	Parameter	Symbol	Value	Unit
Vsync	Delay time (only external trigger mode)	Tvd	450	µs
	Cycle time	Tvc	122	ms
	Dummy pulse width	Tvdpw	920	µs
Hsync	Delay time	Thd	2.8	µs
	Cycle time	Thc	230	µs
	Dummy pulse width	Thdpw	140	µs
Pclk	Delay time	Tpd	150	ns
	Cycle time	Tpc	160	ns
	Pulse width	Tppw	85	ns
	Delay time between each block	Tpdb	480	ns
Data1-12	Delay time	Tdd	50	ns
	Cycle time	Tdc	160	ns

4 × 4 mode (Typ.)

	Parameter	Symbol	Value	Unit
Vsync	Delay time (only external trigger mode)	Tvd	450	µs
	Cycle time	Tvc	62	ms
	Dummy pulse width	Tvdpw	920	µs
Hsync	Delay time	Thd	2.8	µs
	Cycle time	Thc	230	µs
	Dummy pulse width	Thdpw	190	µs
Pclk	Delay time	Tpd	150	ns
	Cycle time	Tpc	160	ns
	Pulse width	Tppw	85	ns
	Delay time between each block	Tpdb	480	ns
Data1-12	Delay time	Tdd	50	ns
	Cycle time	Tdc	160	ns

Note) The numbers of siginificant figures is two. (except Tvc)

■ System requirements

To operate C7921CA at full performance, the following system and peripherals are required.

PC: IBM compatible PC running on Windows 98 or later operating system

Digital frame grabber card: Monochrome 16 bits or more, pixel clock 7 MHz or more, RS-422 interface synchronous signal (See the frame grabber manual.)

The National Instruments IMAQ PCI-1424 (NI parts No. 777662-01) frame grabber has been verified to successfully acquire 12-bit digital images from C7921CA. The IMAQ PCI-1422 (NI pats No. 777959-01) also acquires satisfactory images from C7921CA. You can utilize the demonstration software that comes with the frame grabber as a simple viewer, to acquire and save an image. To do so, refer to the frame grabber user's guide for how to use the camera information file for the demonstration software.

Power source: A. Vdd = +5.0 ± 0.1 V (700 mA), D. Vdd = +5.0 ± 0.1 V (800 mA), V (±7.5) = ±7.5 ± 0.5 V (±100 mA). Use of a series power supply is recommended. (Avoid using a switching power supply.) A power cable (terminated with an FGG.2B.307.CLAD92Z plug at one end and open at the other end; 2 m; see Table 2.) comes supplied with C7921CA. An optional 36-pin cable for interface with the 36-pin receptacle (see Table 1) on C7921CA is also available for synchronous signal input, video output and external control.

The voltages described above are specified at the flat panel sensor side. The impedance of the power cable attached with the flat panel sensor is low enough but it causes 0.1 V approx. drop. Therefore the voltage at the power source side should be set 0.1 V higher than the voltage specified above.

Table 1   Pin assignment of 36-pin receptacle

Pin No.	Signal	Pin No.	Signal
1	Data1+ (MSB)	19	Data1- (MSB)
2	Data2+	20	Data2-
3	Data3+	21	Data3-
4	Data4+	22	Data4-
5	Data5+	23	Data5-
6	Data6+	24	Data6-
7	Data7+	25	Data7-
8	Data8+	26	Data8-
9	Data9+	27	Data9-
10	Data10+	28	Data10-
11	Data11+	29	Data11-
12	Data12+(LSB)	30	Data12- (LSB)
13	bin0 (TTL)	31	Gnd
14	bin1 (TTL)	32	Gnd
15	ExtTrg (TTL)	33	IntExt (TTL)
16	Vsync+	34	Vsync-
17	Hsync+	35	Hsync-
18	Pclk+	36	Pclk-

Unless otherwise noted, signal level is RS-422.

36-pin receptacle: TX20A-36R-D2GF1-A1L made by JAE (Japan Aviation Electronics Industry limited)

36-pin mating plug: TX20A-36PH1-D2P1-D1 made by JAE (Japan Aviation Electronics Industry limited)

Table 2   Power pin assignment and cable color

Pin No.	Color	Signal
1	Brown	+7.5 V
2	Red	Analog GND
3	Orange	-7.5 V
4	Yellow	Analog GND
5	Green	Analog +5 V
6	Blue	Digital GND
7	Purple	Digital +5 V
Shield	-	Analog GND

7-pin power plug: FGG.2B.307.CLAD92Z made by LEMO S. A. (http://www.lemo.ch)

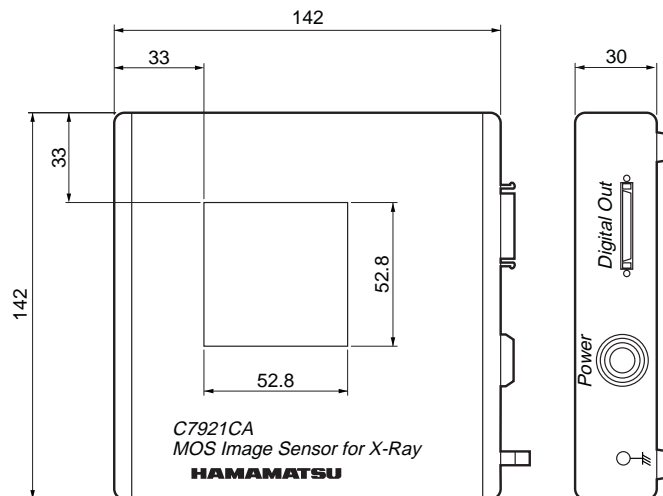7-pin power receptacle: ECG.2B.307.CLV made by LEMO S. A.

■ Connection

Install the frame grabber board into the PC by following the manufacturer's instructions. When a general-purpose frame grabber board is used, binning or trigger operation for bin0, bin1, IntExt and ExtTrig can be controlled with its digital I/O control.
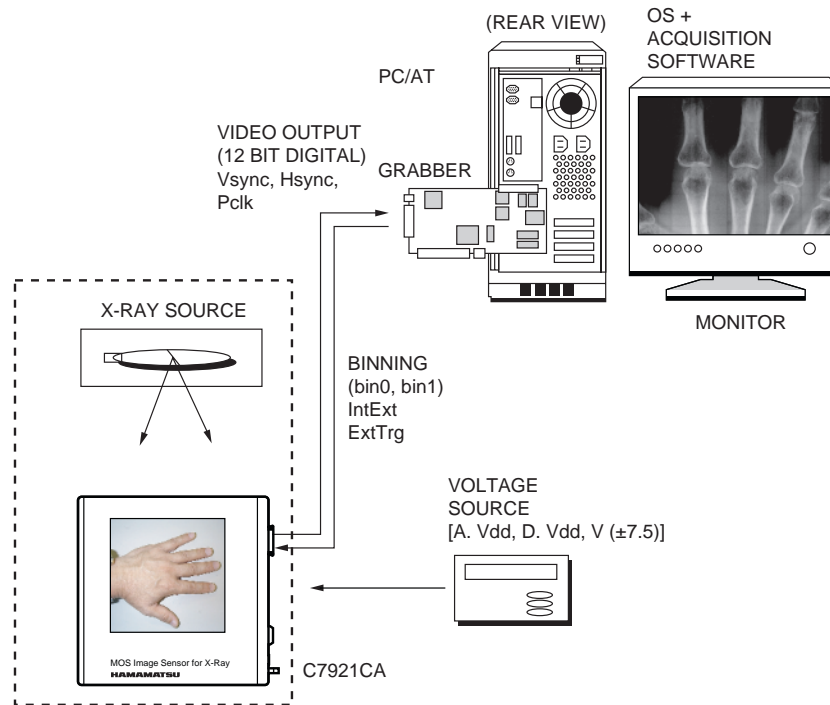
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■ Dimensional outline (unit: mm)

Top cover is made of aluminum 1.0 mm thickness.
Weight: 1.37 kg

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Optional 36-pin cables

Two types of 36-pin cables are provided as options for connecting to the frame grabber.
Type A (A8406-01): General-purpose interface cable for digital flame grabber.
Type B (A8406-02): Interface cable for IMAQ PCI-1424 grabber board.

Type	Cable type No.	Cable length	Cable end	Cable end
A	A8406-01	5 m	TX20A-36PH1-D2P1-D1 *1	open
	A8406-06	7 m		
	A8406-07	10 m		
	A8406-08	12 m		
B	A8406-02	5 m		PCS-XE100MA *2
	A8406-03	7 m		
	A8406-04	10 m		
	A8406-05	12 m		

*1: Made by JAE (Japan Aviation Electronics Industry, Limited)
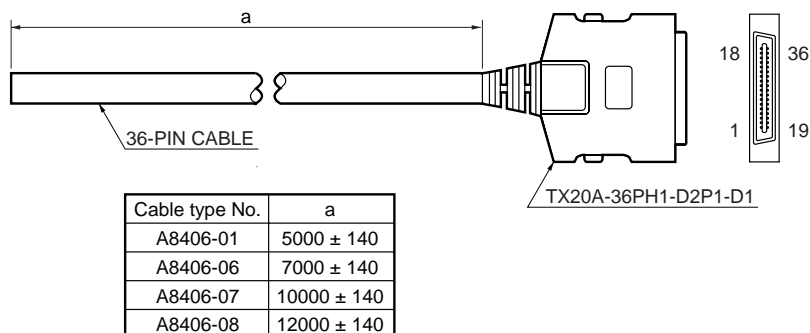*2: Made by Honda Tsushin Kogyo Co. Ltd.

A8406-01/-06/-07/-08 cable for general frame grabber

A8406-01/-06/-07/-08 is a cable that connects the flat panel sensor (C7921CA, etc.) to a general frame grabber. One end of this cable has a 36-pin plug mating with the C7921CA digital output receptacle, but the other end is left open. Connect the open end to a plug that mates with the frame grabber to be used. Cable color coding and specifications are shown in the table below.

■ Cable color coding and specifications

Pin No.	Signal	Cable color	Marking color	Pin No.	Signal	Cable color	Marking color
1	Data1+ (MSB)	blue	-	19	Data1- (MSB)	orange	-
2	Data2+	green	-	20	Data2-	brown	-
3	Data3+	gray	-	21	Data3-	red	-
4	Data4+	black	-	22	Data4-	yellow	-
5	Data5+	pink	-	23	Data5-	purple	-
6	Data6+	white	-	24	Data6-	blue	red
7	Data7+	orange	white	25	Data7-	green	white
8	Data8+	brown	white	26	Data8-	gray	white
9	Data9+	red	white	27	Data9-	black	white
10	Data10+	yellow	black	28	Data10-	pink	black
11	Data11+	purple	white	29	Data11-	white	blue
12	Data12+ (LSB)	blue	red	30	Data12- (LSB)	orange	white
13	bin0 (TTL)	green	white	31	Gnd	brown	white
14	bin1 (TTL)	gray	white	32	Gnd	red	white
15	ExtTrg (TTL)	black	white	33	IntExt (TTL)	yellow	black
16	Vsync+	pink	black	34	Vsync-	purple	white
17	Hsync+	white	blue	35	Hsync-	blue	black
18	Pclk+	orange	black	36	Pclk-	green	black

■ Dimensional outline (unit: mm)

Cable type No.	a
A8406-01	5000 ± 140
A8406-06	7000 ± 140
A8406-07	10000 ± 140
A8406-08	12000 ± 140

36-PIN CABLE

TX20A-36PH1-D2P1-D1

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A8406-02/-03/-04/-05 cable for IMAQ PCI-1424 frame grabber

A8406-02/-03/-04/-05 cable is designed to connect the flat panel sensor (C7921CA, etc.) to the National Instrument IMAQ PCI-1424 and PCI-1422 digital frame grabber board. Both ends of this cable have connectors. One end is a 36-pin plug mating with the C7921CA digital output receptacle, while the other end is a 100-pin plug for the IMAQ PCI-1424 and PCI-1422.

■ Pin connection for A8406-02

TX20A-36PH1-D2P1-D1 Pin No.	Signal	PCS-XE100MA Pin No.	TX20A-36PH1-D2P1-D1 Pin No.	Signal	PCS-XE100MA Pin No.
1	Data1+ (MSB)	23	19	Data1- (MSB)	24
2	Data2+	21	20	Data2-	22
3	Data3+	19	21	Data3-	20
4	Data4+	17	22	Data4-	18
5	Data5+	15	23	Data5-	16
6	Data6+	13	24	Data6-	14
7	Data7+	11	25	Data7-	12
8	Data8+	9	26	Data8-	10
9	Data9+	7	27	Data9-	8
10	Data10+	5	28	Data10-	6
11	Data11+	3	29	Data11-	4
12	Data12+ (LSB)	1	30	Data12- (LSB)	2
13	bin0 (TTL)	33	31	Gnd	99
14	bin1 (TTL)	35	32	Gnd	100
15	ExtTrg (TTL)	37	33	IntExt (TTL)	39
16	Vsync+	41	34	Vsync-	42
17	Hsync+	43	35	Hsync-	44
18	Pclk+	49	36	Pclk-	50

■ Dimensional outline (unit: mm)
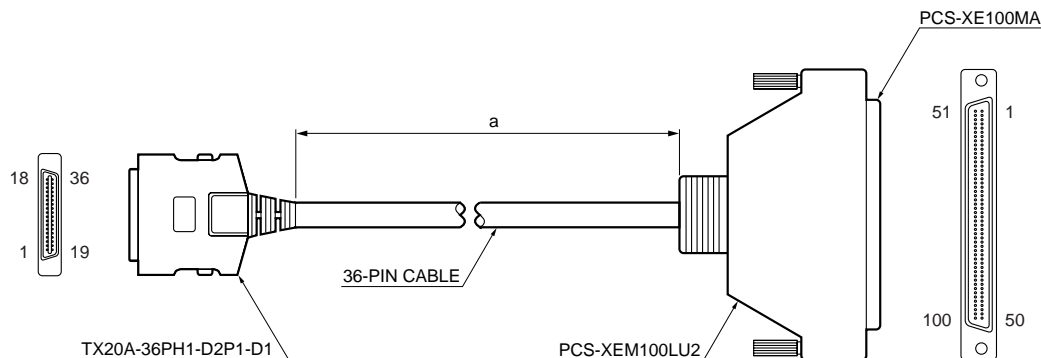
KACCA0097EB

Cable type No.	a
A8406-02	5000 ± 140
A8406-03	7000 ± 140
A8406-04	10000 ± 140
A8406-05	12000 ± 140

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.
· This product was not designed and manufactured for use as a medical X-ray device. System manufacturers must take responsibility for obtaining MHW or FDA approval when incorporating this product into a medical diagnostics system.
· This product is warranted for a period of 12 months after the date of the shipment.
The warranty is limited to make a replacement or repair of any defective material due to defects in workmanship or materials used in manufacture. It does not cover loss or damage of the product due to natural calamity, misuse or total radiation dose over 1 million Roentgen (80 kV) even within the warranty period.