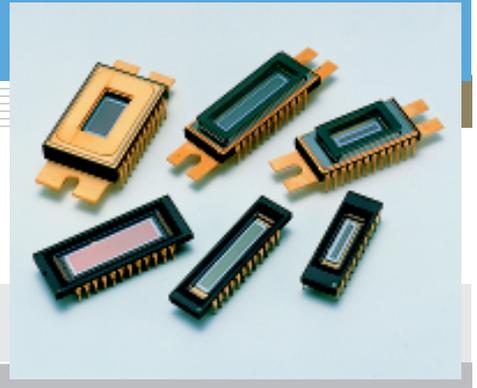


# CCD area image sensor S7010/S7011/S7015 series

## Front-illuminated FFT-CCD



S7010/S7011/S7015 series are families of FFT-CCD image sensors specifically designed for low-light-level detection in scientific applications. By using the binning operation, S7010/S7011/S7015 series can be used as a linear image sensor having a long aperture in the direction of the device length. This makes S7010/S7011/S7015 series ideally suited for use in spectrophotometry. The binning operation offers significant improvement in S/N and signal processing speed compared with conventional methods by which signals are digitally added by an external circuit. S7010/S7011/S7015 series also feature low noise and low dark signal (MPP mode operation). This enables low-light-level detection and long integration time, thus achieving a wide dynamic range.

S7010/S7011/S7015 series have an effective pixel size of  $24 \times 24 \mu\text{m}$  and are available in image areas ranging from  $12.288 \text{ (H)} \times 1.44 \text{ (V)} \text{ mm}^2$  ( $512 \times 60$  pixels) up to a large image area of  $24.576 \text{ (H)} \times 6.048 \text{ (V)} \text{ mm}^2$  ( $1024 \times 252$  pixels).

### Features

- $512 \text{ (H)} \times 60 \text{ (V)}$  to  $1024 \text{ (H)} \times 252 \text{ (V)}$  pixel format
- Pixel size:  $24 \times 24 \mu\text{m}$
- Line/pixel binning
- 100 % fill factor
- Wide dynamic range
- Low dark signal
- Low readout noise
- MPP operation

### Applications

- Fluorescence spectrometer, ICP
- Raman spectrometer
- Industrial inspection requiring
- Semiconductor inspection
- DNA sequencer
- Low-light-level detection

### Selection guide

Type No.	Cooling	Number of total pixels	Number of active pixels	Active area [mm(H) × mm(V)]	Suitable multichannel detector Head
S7010-0906	Non-cooled	$532 \times 64$	$512 \times 60$	$12.288 \times 1.440$	C7020
S7010-0907		$532 \times 128$	$512 \times 124$	$12.288 \times 2.976$	
S7010-0908		$532 \times 256$	$512 \times 252$	$12.288 \times 6.048$	
S7010-1006		$1044 \times 64$	$1024 \times 60$	$24.576 \times 1.440$	
S7010-1007		$1044 \times 128$	$1024 \times 124$	$24.576 \times 2.976$	
S7010-1008		$1044 \times 256$	$1024 \times 252$	$24.576 \times 6.048$	
S7011-0906	One-stage TE-cooled	$532 \times 64$	$512 \times 60$	$12.288 \times 1.440$	C7021
S7011-0907		$532 \times 128$	$512 \times 124$	$12.288 \times 2.976$	
S7011-1006		$1044 \times 64$	$1024 \times 60$	$24.576 \times 1.440$	
S7011-1007		$1044 \times 128$	$1024 \times 124$	$24.576 \times 2.976$	
S7015-0908	C7025	$532 \times 256$	$512 \times 252$	$12.288 \times 6.048$	
S7015-1008		$1044 \times 256$	$1024 \times 252$	$24.576 \times 6.048$	

### General ratings

Parameter	Specification
Pixel size	$24 \text{ (H)} \times 24 \text{ (V)} \mu\text{m}$
Vertical clock phase	2 phase
Horizontal clock phase	2 phase
Output circuit	One-stage MOSFET source follower
Package	24 pin ceramic DIP (refer to dimensional outlines)
Window *1	S7010 series: quartz glass S7011 series: sapphire glass S7015 series: quartz glass *2

\*1: Window-less is available upon request.

\*2: Sapphire glass is available upon request.

### ■ Absolute maximum ratings (Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operating temperature	Topr	-50	-	+30	°C
Storage temperature	Tstg	-50	-	+70	°C
OD voltage	Vod	-0.5	-	+25	V
RD voltage	VRD	-0.5	-	+18	V
ISV voltage	Visv	-0.5	-	+18	V
ISH voltage	Vish	-0.5	-	+18	V
IGV voltage	VIG1V, VIG2V	-10	-	+15	V
IGH voltage	VIG1H, VIG2H	-10	-	+15	V
SG voltage	VSG	-10	-	+15	V
OG voltage	VOG	-10	-	+15	V
RG voltage	VRG	-10	-	+15	V
TG voltage	VTG	-10	-	+15	V
Vertical clock voltage	VP1V, VP2V	-10	-	+15	V
Horizontal clock voltage	VP1H, VP2H	-10	-	+15	V

### ■ Operating conditions (MPP mode, Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max.	Unit	
Output transistor drain voltage	Vod	18	20	22	V	
Reset drain voltage	VRD	11.5	12	12.5	V	
Output gate voltage	VOG	1	3	5	V	
Substrate voltage	VSS	-	0	-	V	
Test point (vertical input source)	Visv	-	VRD	-	V	
Test point (horizontal input source)	Vish	-	VRD	-	V	
Test point (vertical input gate)	VIG1V, VIG2V	-8	0	-	V	
Test point (horizontal input gate)	VIG1H, VIG2H	-8	0	-	V	
Vertical shift register clock voltage	High	VP1VH, VP2VH	4	6	8	V
	Low	VP1VL, VP2VL	-9	-8	-7	
Horizontal shift register clock voltage	High	VP1HH, VP2HH	4	6	8	V
	Low	VP1HL, VP2HL	-9	-8	-7	
Summing gate voltage	High	VSGH	4	6	8	V
	Low	VSGL	-9	-8	-7	
Reset gate voltage	High	VRGH	4	6	8	V
	Low	VRGL	-9	-8	-7	
Transfer gate voltage	High	VTGH	4	6	8	V
	Low	VTGL	-9	-8	-7	

### ■ Electrical characteristics (Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Signal output frequency	fc	-	-	1	MHz
Vertical shift register capacitance *3	CP1V, CP2V	-	3,000	-	pF
Horizontal shift register capacitance *3	CP1H, CP2H	-	120	-	pF
Summing gate capacitance	CSG	-	7	-	pF
Reset gate capacitance	CRG	-	7	-	pF
Transfer gate capacitance	CTG	-	120	-	pF
Charge transfer efficiency *4	CTE	0.99995	0.99999	-	-
DC output level *5	Vout	12	15	18	V
Output impedance *5	Zo	-	3	-	kΩ
Power consumption *5 *6	P	-	15	-	mW

\*3: S7010/S7011-1007

\*4: Charge transfer efficiency per pixel, measured at half of the full well.

\*5: The values depend on the load resistance. (typical, VOD=20 V, load resistance=22 kΩ)

\*6: Power consumption of the on-chip amplifier.

### ■ Electrical and optical characteristics (Ta=25 °C, unless otherwise noted)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Saturation output voltage	Vsat	-	Fw × Sv	-	V
Full well capacity	Vertical	150,000	300,000	-	e <sup>-</sup>
	Horizontal *7	300,000	600,000	-	
CCD node sensitivity	Sv	1.8	2.2	-	μV/e <sup>-</sup>
Dark current *8 MPP mode (tentative data)	25 °C	-	400	3000	e <sup>-</sup> /pixel/s
	0 °C	-	20	150	
Readout noise *9	Nr	-	8	12	e <sup>-</sup> rms
Dynamic range *10	Line binning	25,000	75,000	-	-
	Area scanning	12,000	37,500	-	-
Photo response non-uniformity *11	PRNU	-	±3	±10	%
Spectral response range	λ	-	400 to 1,100	-	nm

\*7: Large horizontal full well for vertical binning operation.

\*8: Dark current nearly doubles for every 5 to 7 °C increase in temperature.

\*9: -40 °C, operating frequency is 150 kHz.

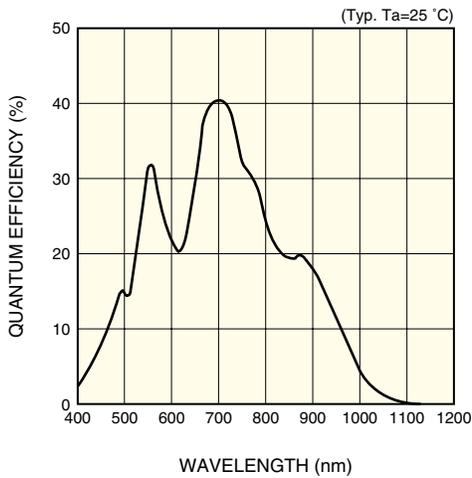
\*10: Dynamic range: DR = Full well/Readout noise.

\*11: Measured at half of full well capacity.

Photo response non-uniformity:

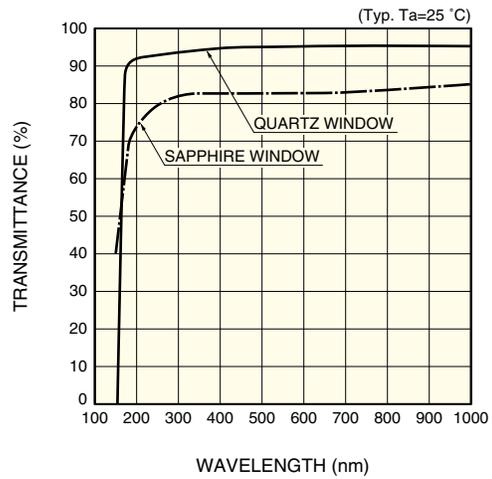
$$\text{PRNU (\%)} = \frac{\text{Fixed pattern noise (peak to peak)}}{\text{Signal}} \times 100$$

■ Spectral response (without window)



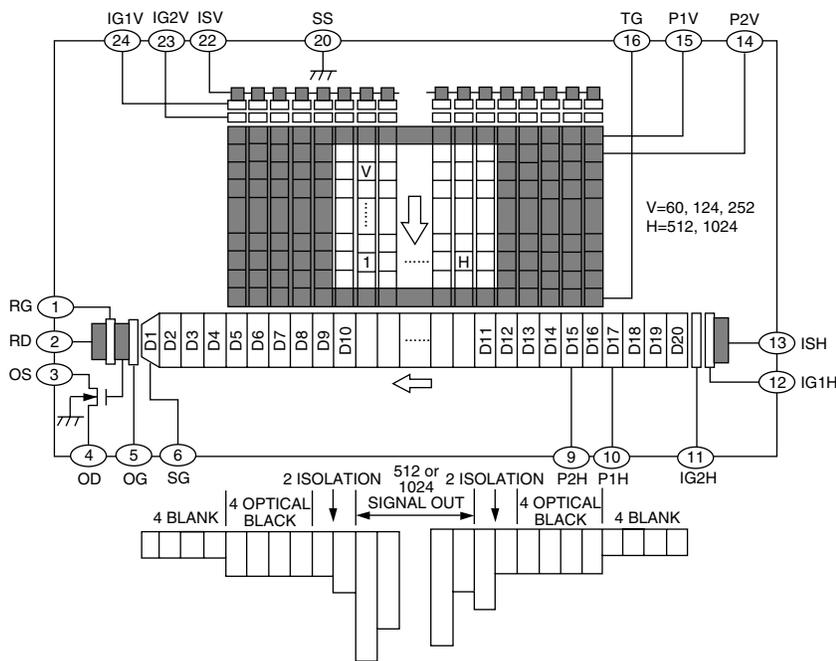
KMPDB0051EA

■ Spectral transmittance characteristics



KMPDB0101EA

■ Device structure, line output format



KMPDC0015EB

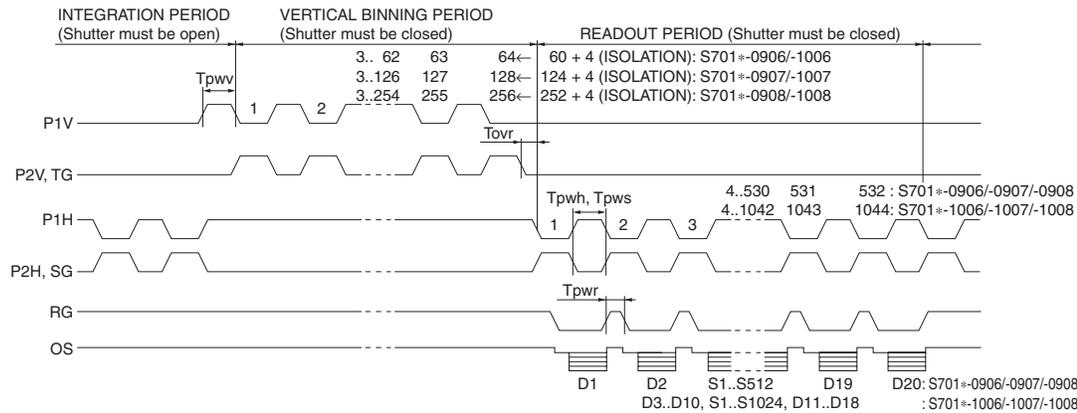
Pixel format

Left ← Horizontal Direction → Right						
Blank	Optical Black	Isolation	Effective	Isolation	Optical Black	Blank
4	4	2	512 or 1024	2	4	4

Top ← Vertical Direction → Bottom		
Isolation	Effective	Isolation
2	60, 124 or 252	2

## ■ Timing chart

### Line binning



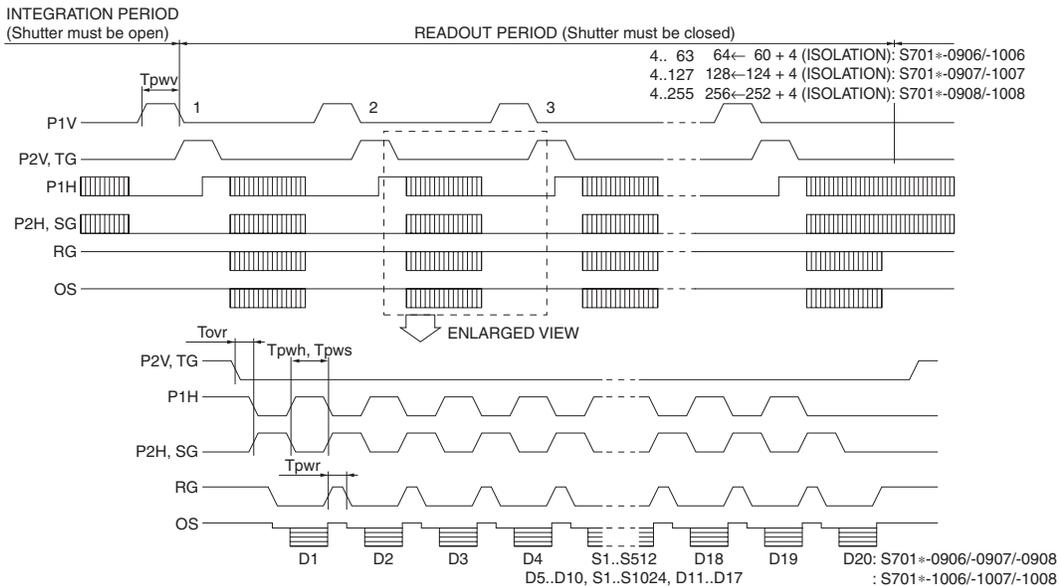
KMPDC0122EA

Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
P1V, P2V, TG	Pulse width	$T_{pww}$	*12	6 *13	-	-	$\mu$ s
	Rise and fall time	$T_{prv}$ , $T_{pfv}$		200	-	-	ns
P1H, P2H	Pulse width	$T_{pwh}$	*12	500	-	-	ns
	Rise and fall time	$T_{prh}$ , $T_{pfh}$		10	-	-	ns
	Duty ratio	-		-	50	-	%
SG	Pulse width	$T_{pws}$	-	500	-	-	ns
	Rise and fall time	$T_{prs}$ , $T_{pfs}$		10	-	-	ns
	Duty ratio	-		-	50	-	%
RG	Pulse width	$T_{pwr}$	-	100	-	-	ns
	Rise and fall time	$T_{prr}$ , $T_{pfr}$		5	-	-	ns
TG - P1H	Overlap time	$T_{ovr}$	-	3	-	-	$\mu$ s

\*12: Symmetrical pulses should be overlapped at 50 % of maximum amplitude.

\*13: In case of S701\*-0908/-1007.

### Area scanning 1: low dark current mode



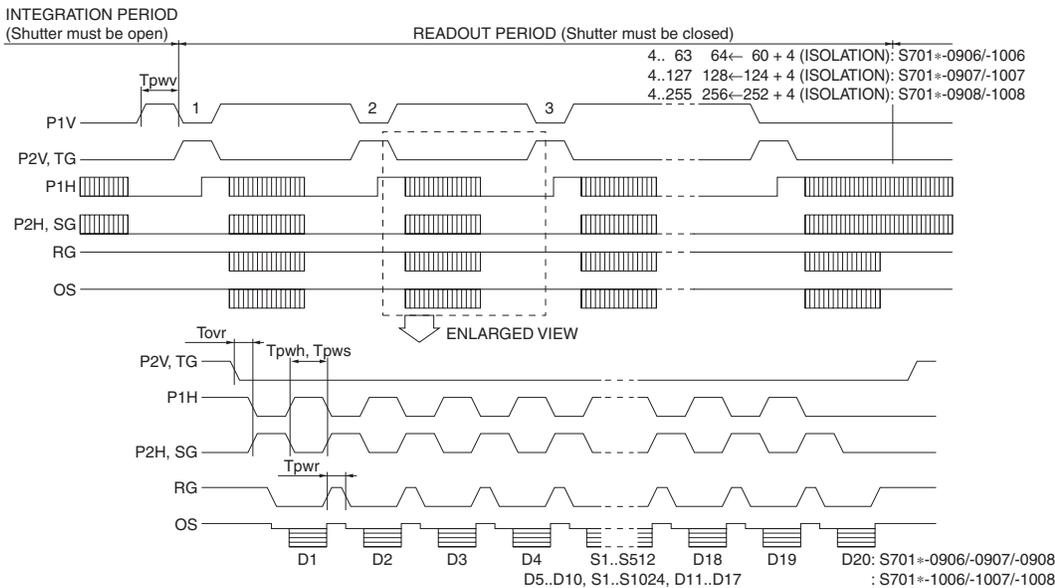
KMPDC0123EA

Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
P1V, P2V, TG	Pulse width	Tp <sub>pwv</sub>	*14	6 *15	-	-	μs
	Rise and fall time	Tp <sub>rv</sub> , Tp <sub>fv</sub>		200	-	-	ns
P1H, P2H	Pulse width	Tp <sub>wh</sub>	*14	500	-	-	ns
	Rise and fall time	Tp <sub>rh</sub> , Tp <sub>fh</sub>		10	-	-	ns
	Duty ratio	-		-	50	-	%
SG	Pulse width	Tp <sub>ws</sub>	-	500	-	-	ns
	Rise and fall time	Tp <sub>rs</sub> , Tp <sub>fs</sub>		10	-	-	ns
	Duty ratio	-		-	50	-	%
RG	Pulse width	Tp <sub>wr</sub>	-	100	-	-	ns
	Rise and fall time	Tp <sub>rr</sub> , Tp <sub>fr</sub>		5	-	-	ns
TG - P1H	Overlap time	To <sub>vr</sub>	-	3	-	-	μs

\*14: Symmetrical pulses should be overlapped at 50 % of maximum amplitude.

\*15: In case of S701\*-0908/-1007.

### Area scanning 2: large full well mode



KMPDC0124EA

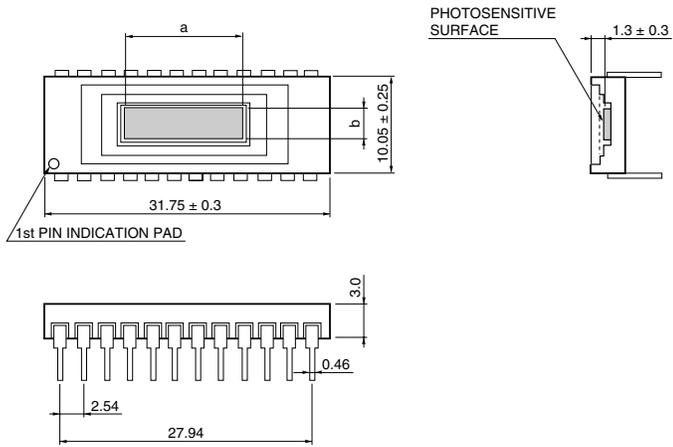
Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
P1V, P2V, TG	Pulse width	Tp <sub>pwv</sub>	*16	6 *17	-	-	μs
	Rise and fall time	Tp <sub>rv</sub> , Tp <sub>fv</sub>		200	-	-	ns
P1H, P2H	Pulse width	Tp <sub>wh</sub>	*16	500	-	-	ns
	Rise and fall time	Tp <sub>rh</sub> , Tp <sub>fh</sub>		10	-	-	ns
	Duty ratio	-		-	50	-	%
SG	Pulse width	Tp <sub>ws</sub>	-	500	-	-	ns
	Rise and fall time	Tp <sub>rs</sub> , Tp <sub>fs</sub>		10	-	-	ns
	Duty ratio	-		-	50	-	%
RG	Pulse width	Tp <sub>wr</sub>	-	100	-	-	ns
	Rise and fall time	Tp <sub>rr</sub> , Tp <sub>fr</sub>		5	-	-	ns
TG - P1H	Overlap time	To <sub>vr</sub>	-	3	-	-	μs

\*16: Symmetrical pulses should be overlapped at 50 % of maximum amplitude.

\*17: In case of S701\*-0908/-1007.

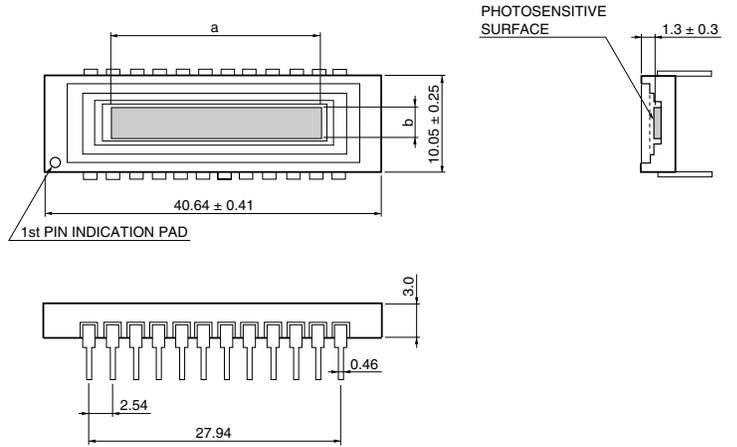
■ Dimensional outlines (unit: mm)

S7010-0906/-0907



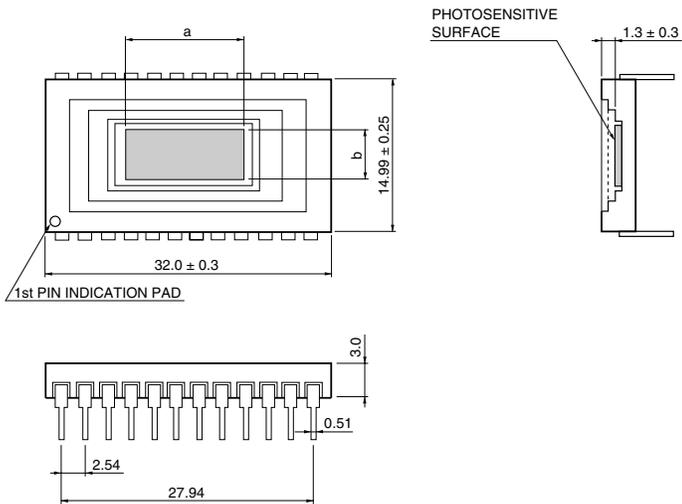
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S7010-1006/-1007



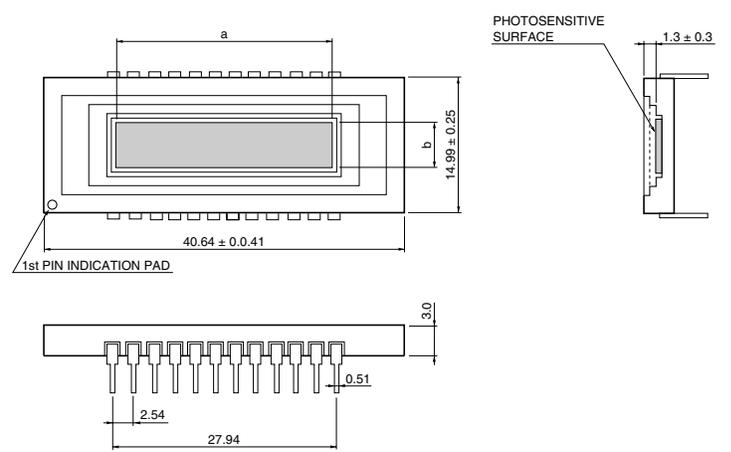
KMPDA0054EA

S7010-0908



KMPDA0055EA

S7010-1008

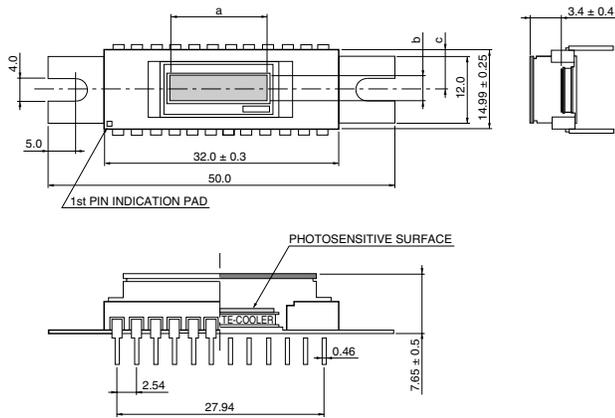


KMPDA0056EA

Type No.	Active area	
	a	b
S7010-0906	12.288 (H)	1.440 (V)
S7010-0907	12.288 (H)	2.976 (V)
S7010-0908	12.288 (H)	6.048 (V)
S7010-1006	24.576 (H)	1.440 (V)
S7010-1007	24.576 (H)	2.976 (V)
S7010-1008	24.576 (H)	6.048 (V)

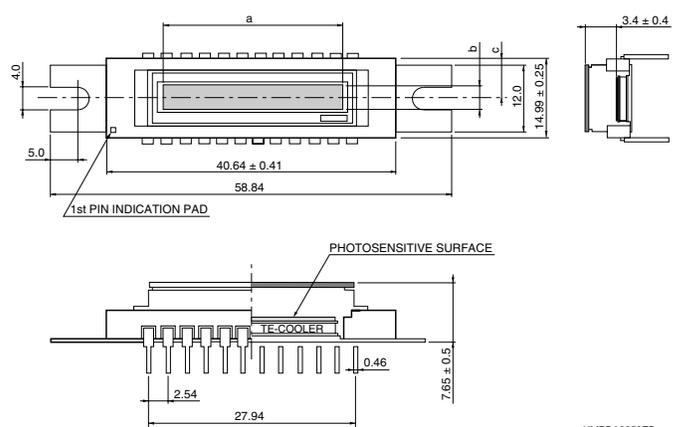
# CCD area image sensor S7010/S7011/S7015 series

S7011-0906/-0907



KMPDA0057EB

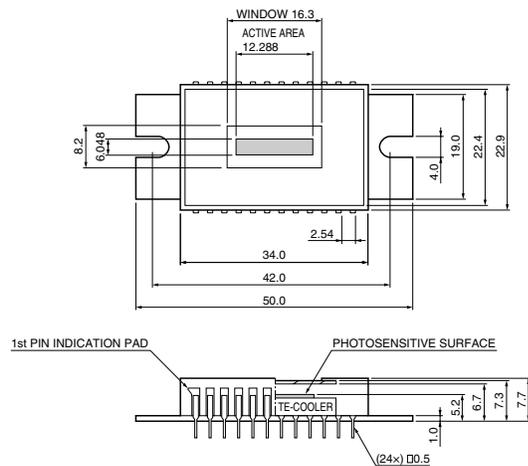
S7011-1006/-1007



KMPDA0058EB

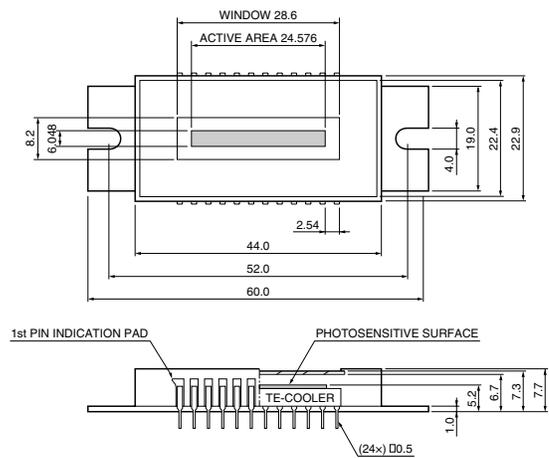
Type No.	Active area		
	a	b	c
S7011-0906	12.288 (H)	1.440 (V)	7.5
S7011-0907	12.288 (H)	2.976 (V)	7.1
S7011-1006	24.576 (H)	1.440 (V)	7.5
S7011-1007	24.576 (H)	2.976 (V)	7.1

S7015-0908



KMPDA0044EC

S7015-1008



KMPDA0045EB

■ Pin connections

Pin No.	S7010 series		S7011 series		S7015 series		Remark
	Symbol	Description	Symbol	Description	Symbol	Description	
1	RG	Reset gate	RG	Reset gate	RG	Reset gate	
2	RD	Reset drain	RD	Reset drain	RD	Reset drain	
3	OS	Output transistor source	OS	Output transistor source	OS	Output transistor source	
4	OD	Output transistor drain	OD	Output transistor drain	OD	Output transistor drain	
5	OG	Output gate	OG	Output gate	OG	Output gate	
6	SG	Summing gate	SG	Summing gate	SG	Summing gate	=P2H
7	NC		Th1	Thermistor	Th1	Thermistor	
8	NC		Th2	Thermistor	Th2	Thermistor	
9	P2H	CCD horizontal register clock-2	P2H	CCD horizontal register clock-2	P2H	CCD horizontal register clock-2	
10	P1H	CCD horizontal register clock-1	P1H	CCD horizontal register clock-1	P1H	CCD horizontal register clock-1	
11	IG2H	Test point (horizontal input gate-2)	IG2H	Test point (horizontal input gate-2)	IG2H	Test point (horizontal input gate-2)	0 V
12	IG1H	Test point (horizontal input gate-1)	IG1H	Test point (horizontal input gate-1)	IG1H	Test point (horizontal input gate-1)	0 V
13	ISH	Test point (horizontal input source)	ISH	Test point (horizontal input source)	ISH	Test point (horizontal input source)	=RD
14	P2V	CCD vertical register clock-2	P2V	CCD vertical register clock-2	P2V	CCD vertical register clock-2	
15	P1V	CCD vertical register clock-1	P1V	CCD vertical register clock-1	P1V	CCD vertical register clock-1	
16	TG *18	Transfer gate	TG *18	Transfer gate	TG *18	Transfer gate	=P2V
17	NC		NC		NC		
18	NC		P-	TE-cooler-	P-	TE-cooler-	
19	NC		P+	TE-cooler+	P+	TE-cooler+	
20	SS	Substrate (GND)	SS	Substrate (GND)	SS	Substrate (GND)	
21	NC		NC		NC		
22	ISV	Test point (vertical input source)	ISV	Test point (vertical input source)	ISV	Test point (vertical input source)	=RD
23	IG2V	Test point (vertical input gate-2)	IG2V	Test point (vertical input gate-2)	IG2V	Test point (vertical input gate-2)	0 V
24	IG1V	Test point (vertical input gate-1)	IG1V	Test point (vertical input gate-1)	IG1V	Test point (vertical input gate-1)	0 V

\*18 TG: Isolation gate between vertical register and horizontal register. In standard operation, TG should be applied the same pulse as P2V.

■ Specifications of built-in TE-cooler (Typ.)

Parameter	Symbol	Condition	S7011-0906/ -0907	S7011-1006/ -1007	S7015-0908	S7015-1008	Unit
Internal resistance	Rint	Ta=25 °C	2.8	6.0	2.5	1.2	Ω
Maximum current *19	I <sub>max</sub>	T <sub>c</sub> *20=T <sub>h</sub> *21=25 °C	1.5	1.5	1.5	3.0	A
Maximum voltage	V <sub>max</sub>	T <sub>c</sub> *20=T <sub>h</sub> *21=25 °C	4.4	8.8	3.8	3.6	V
Maximum heat absorption *22	Q <sub>max</sub>		3.4	6.7	3.4	5.1	W
Maximum temperature of heat radiating side	-		70				°C

\*19: Maximum current I<sub>max</sub>:

If the current greater than this value flows into the thermoelectric cooler, the heat absorption begins to decrease due to the Joule heat. It should be noted that this value is not the damage threshold value. To protect the thermoelectric cooler and maintain stable operation, the supply current should be less than 60 % of this maximum current.

\*20: Temperature of the cooling side of thermoelectric cooler.

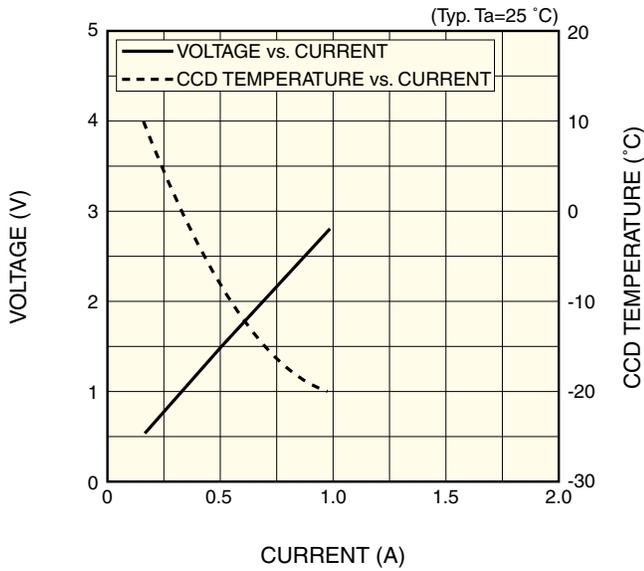
\*21: Temperature of the heat radiating side of thermoelectric cooler.

\*22: Maximum heat absorption Q<sub>max</sub>.

This is a heat absorption when the maximum current is supplied to the TE-cooler.

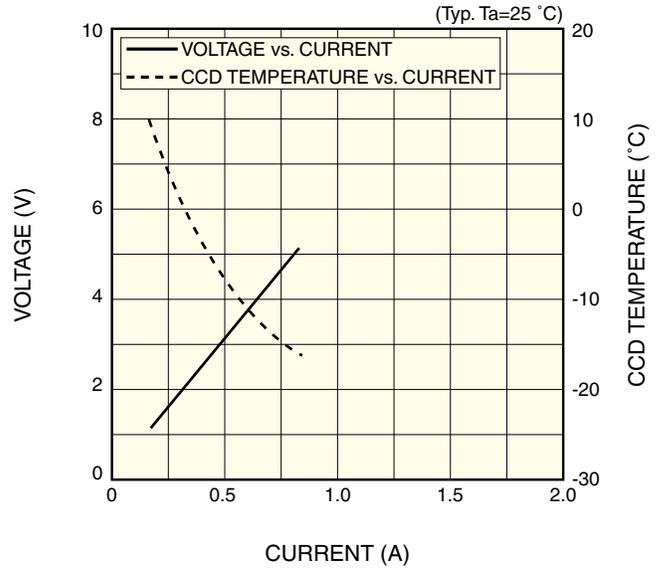
■ TE-cooler characteristics

S7011-0906/-0907



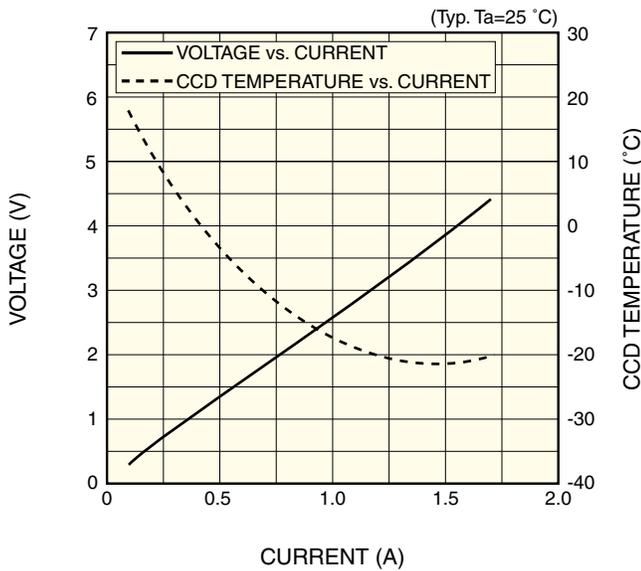
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S7011-1006/-1007



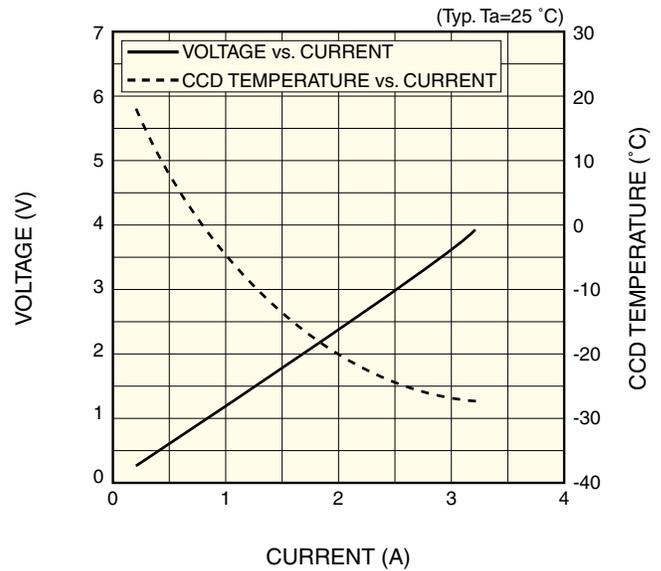
KMPDB0177EB

S7015-0908



KMPDB0178EA

S7015-1008



KMPDB0179EA

### ■ Specifications of built-in temperature sensor

A chip thermistor is built in the same package with a CCD chip, and the CCD chip temperature can be monitored with it. A relation between the thermistor resistance and absolute temperature is expressed by the following equation.

$$R1 = R2 \times \exp B (1 / T1 - 1 / T2)$$

where R1 is the resistance at absolute temperature T1 (K)

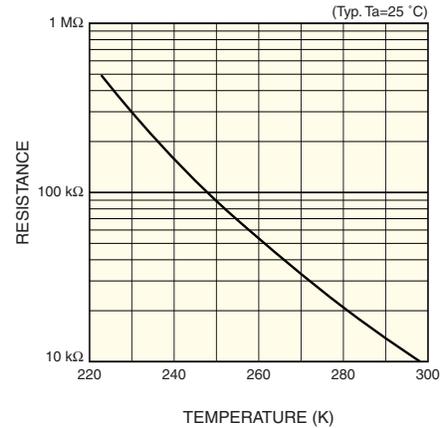
R2 is the resistance at absolute temperature T2 (K)

B is so-called the B constant (K)

The characteristics of the thermistor used are as follows.

$$R (298K) = 10 \text{ k}\Omega$$

$$B (298K / 323K) = 3450 \text{ K}$$



KMPD80111EA

### ■ Precaution for use (Electrostatic countermeasures)

- Handle these sensors with bare hands or wearing cotton gloves. In addition, wear anti-static clothing or use a wrist band with an earth ring, in order to prevent electrostatic damage due to electrical charges from friction.
- Avoid directly placing these sensors on a work-desk or work-bench that may carry an electrostatic charge.
- Provide ground lines or ground connection with the work-floor, work-desk and work-bench to allow static electricity to discharge.
- Ground the tools used to handle these sensors, such as tweezers and soldering irons.

It is not always necessary to provide all the electrostatic measures stated above. Implement these measures according to the amount of damage that occurs.

### ■ Element cooling/heating temperature incline rate

Element cooling/heating temperature incline rate should be set at less than 5 K/min.

## Multichannel detector head (C7020, C7021, C7025)

### Features

- C7020: for S7010 series  
C7021: for S7011 series  
C7025: for S7015 series
- Area scanning or full line-binning operation
- Readout frequency: 250 kHz
- Readout noise: 20 e<sup>-</sup>rms
- ΔT=50 °C (ΔT changes by radiation method.)



Input	Symbol	Value
Supply voltage	VD1	+5 Vdc, 200 mA
	VA1+	+15 Vdc, +100 mA
	VA1-	-15 Vdc, -100 mA
	VA2	+24 Vdc, 30 mA
	VD2	+5 Vdc, 30 mA (C7021, C7025)
	Vp	+5 Vdc, 2.5 A (C7021, C7025)
	VF	+12 Vdc, 100 mA (C7021, C7025)
Master start	φms	HCMOS logic compatible
Master clock	φmc	HCMOS logic compatible, 1 MHz

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