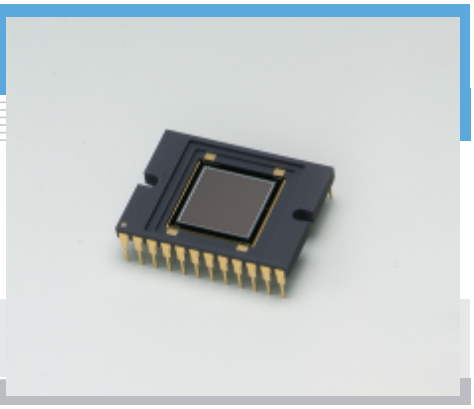
CCD area image sensor
S9978



Front-illuminated FFT-CCDs, high IR sensitivity

S9978 is FFT-CCD area image sensor specifically designed for low-light-level detection in scientific applications. S9978 also features low noise and low dark current (MPP mode operation). These enable low-light-level detection and long integration time, thus achieving a wide dynamic range.
S9978 is pin compatible with S9736-01. (Operating conditions and characteristics are a little bit changed from S9736-01.)

Features

- High IR sensitivity
- 512 (H) × 512 (V) pixel format
- Pixel size: 24 × 24 µm
- 100 % fill factor
- Wide dynamic range
- Low dark current
- Low readout noise
- MPP operation

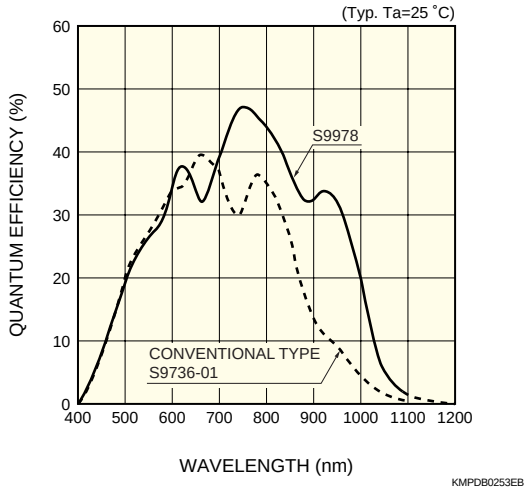
Applications

- Astronomy
- Scientific measuring instrument
- Fluorescence spectrometer
- Raman spectrophotometer
- Optical and spectrophotometric analyzer
- For low-light-level detection requiring

■ General ratings

Parameter	Rating
CCD structure	Full frame transfer
Fill factor	100 %
Number of active pixels	512 (H) × 512 (V)
Pixel size	24 (H) × 24 (V) µm
Active area	12.288 (H) × 12.288 (V) mm
Vertical clock phase	2 phase
Horizontal clock phase	2 phase
Output circuit	One-stage MOSFET source follower
Package	24-pin ceramic DIP
Window	None

■ Spectral response (without window)



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■ 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	V_{OD}	-0.5	-	+25	V
RD voltage	V_{RD}	-0.5	-	+18	V
ISV voltage	V_{ISV}	-0.5	-	+18	V
ISH voltage	V_{ISH}	-0.5	-	+18	V
IGV voltage	V_{IG1V}, V_{IG2V}	-15	-	+15	V
IGH voltage	V_{IG1H}, V_{IG2H}	-15	-	+15	V
SG voltage	V_{SG}	-15	-	+15	V
OG voltage	V_{OG}	-15	-	+15	V
RG voltage	V_{RG}	-15	-	+15	V
TG voltage	V_{TG}	-15	-	+15	V
Vertical clock voltage	V_{P1V}, V_{P2V}	-15	-	+15	V
Horizontal clock voltage	V_{P1H}, V_{P2H}	-15	-	+15	V

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

Parameter		Symbol	Min.	Typ.	Max.	Unit
Output transistor drain voltage		V_{OD}	18	20	22	V
Reset drain voltage		V_{RD}	12	13	14	V
Output gate voltage		V_{OG}	-0.5	0	2	V
Substrate voltage		V_{SS}	-	0	-	V
Test point (vertical input source)		V_{ISV}	-	V_{RD}	-	V
Test point (horizontal input source)		V_{ISH}	-	V_{RD}	-	V
Test point (vertical input gate)		V_{IG1V}, V_{IG2V}	-8	0	-	V
Test point (horizontal input gate)		V_{IG1H}, V_{IG2H}	-8	0	-	V
Vertical shift register clock voltage	High	V_{P1VH}, V_{P2VH}	0	4	6	V
	Low	V_{P1VL}, V_{P2VL}	-9	-8	-7	
Horizontal shift register clock voltage	High	V_{P1HH}, V_{P2HH}	0	4	6	V
	Low	V_{P1HL}, V_{P2HL}	-9	-8	-7	
Summing gate voltage	High	V_{SGH}	0	4	6	V
	Low	V_{SGL}	-9	-8	-7	
Reset gate voltage	High	V_{RGH}	0	4	6	V
	Low	V_{RGL}	-9	-8	-7	
Transfer gate voltage	High	V_{TGH}	0	4	6	V
	Low	V_{TGL}	-9	-8	-7	

■ Electrical characteristics (Ta=25 °C)

Parameter	Symbol	Remark	Min.	Typ.	Max.	Unit
Signal output frequency	fc	-	-	0.1	1	MHz
Vertical shift register capacitance	C_{P1V}, C_{P2V}	-	-	3500	-	pF
Horizontal shift register capacitance	C_{P1H}, C_{P2H}	-	-	60	-	pF
Summing gate capacitance	C_{SG}	-	-	5	-	pF
Reset gate capacitance	C_{RG}	-	-	5	-	pF
Transfer gate capacitance	C_{TG}	-	-	70	-	pF
Transfer efficiency	CTE	*1	0.99995	0.99999	-	-
DC output level	Vout	*2	12	15	18	V
Output impedance	Zo	*2	-	3	-	kΩ
Power dissipation	P	*2, *3	-	15	-	mW

*1: Charge transfer efficiency per pixel, measured at half of the full well capacity.
*2: The values depend on the load resistance. (V_{OD}=20 V, Load resistance=10 kΩ)
*3: Power dissipation of the on-chip amplifier.

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

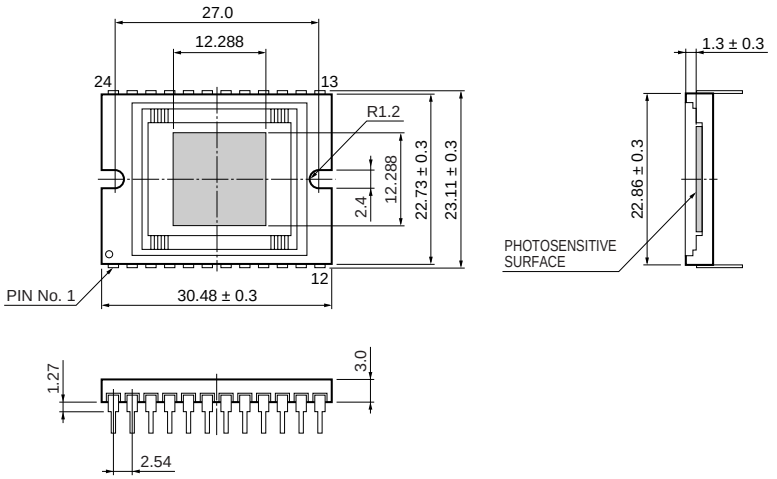
Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
Saturation output voltage		Vsat	-	-	Fw × Sv	-	V
Full well capacity	Vertical	Fw	-	120	240	-	ke⁻
	Horizontal			-	280	-	
CCD node sensitivity		Sv	*4	-	2.8	-	μV/e⁻
Dark current (MPP mode)	+25 °C	DS	*5	-	1000	15000	e⁻/pixel/s
	0 °C			-	100	1500	
Readout noise		Nr	*6	-	4	18	e⁻rms
Dynamic range	Area scanning	-	*7	6667	60000	-	-
Spectral response range		λ	-	-	400 to 1100	-	nm
Photo response non-uniformity		PRNU	*8	-	-	±10	%
Blemish	Point defects	-	*9	-	-	0	-
	Cluster defects		*10	-	-	0	
	Column defects		*11	-	-	0	

*4: V_{OD}=20 V , Load resistance=10 kΩ
*5: Dark current nearly doubles for every 5 to 7 °C increase in temperature.
*6: -40 °C, operating frequency is 80 kHz.
*7: DR = Fw / Nr
*8: Measured at half of the full well capacity. PRNU = noise / signal × 100 [%], noise: fixed pattern noise (peak to peak)
*9: White spots > 3 % of full well at 0 °C after Ts=1 s
Black spots
Pixels whose sensitivity is lower than one-half of the average pixel output. (Measured with uniform light producing one-half of the saturation charge)
*10: 2 to 9 contiguous defective pixels
*11: 10 or more contiguous defective pixels

■ Pin connections

Pin No.	Symbol	Description	Remark
1	RG	Reset gate	-
2	RD	Reset drain	-
3	OS	Output source	-
4	OD	Output transistor drain	-
5	OG	Output gate	-
6	SG	Summing gate	-
7	P2H	CCD horizontal register clock-2	-
8	NC	No connection	-
9	P1H	CCD horizontal register clock-1	-
10	NC	No connection	-
11	IG2H	Test point (horizontal input gate-2)	Shorted to ground
12	IG1H	Test point (horizontal input gate-1)	Shorted to ground
13	ISH	Test point (horizontal input source)	Shorted to RD
14	TG	Transfer gate	-
15	P2V	CCD vertical register clock-2	-
16	NC	No connection	-
17	P1V	CCD vertical register clock-1	-
18	NC	No connection	-
19	NC	No connection	-
20	SS	Substrate (GND)	-
21	NC	No connection	-
22	ISV	Test point (vertical input source)	Shorted to RD
23	IG2V	Test point (vertical input gate-2)	Shorted to ground
24	IG1V	Test point (vertical input gate-1)	Shorted to ground

■ Dimensional outline (unit: mm)



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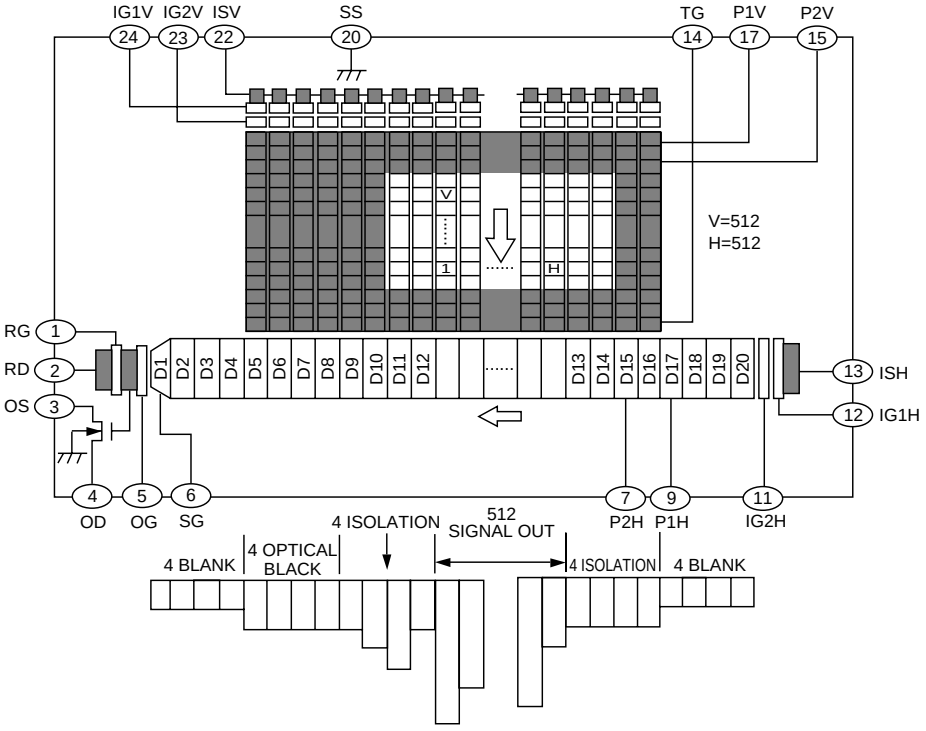
■ Device structure, line output format



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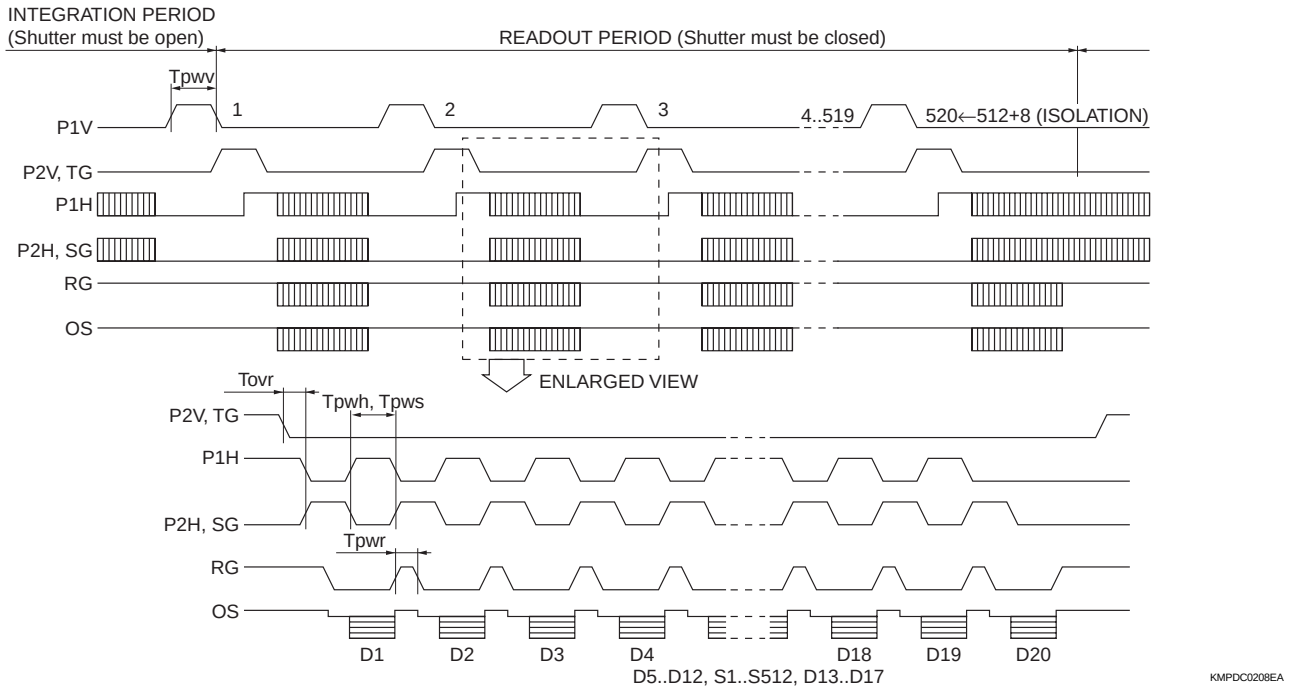
Pixel format

Left ← Horizontal Direction → Right						
Blank	Optical Black	Isolation	Effective	Isolation	Optical Black	Blank
4	4	4	512	4	-	4

Top ← Vertical Direction → Bottom		
Isolation	Effective	Isolation
4	512	4

■ Timing chart

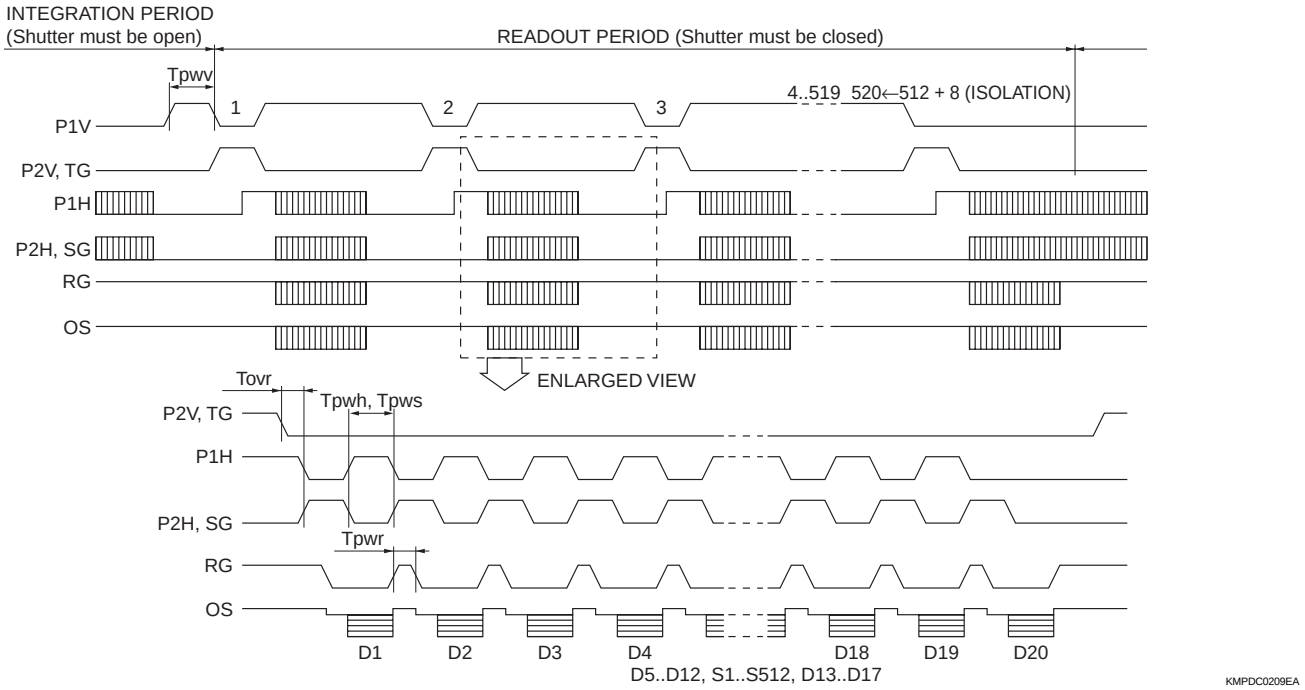
● Area scanning 1 (low dark current mode)



Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
P1V P2V, TG	Pulse width	Tpwv	*12	6	18	-	µs
	Rise and fall time	Tprv, Tpfv		200	-	-	ns
P1H, P2H	Pulse width	Tpwh	*12	500	5000	-	ns
	Rise and fall time	Tprh, Tpfh		10	-	-	ns
	Duty ratio	-		-	50	-	%
SG	Pulse width	Tpws	-	500	5000	-	ns
	Rise and fall time	Tprs, Tpfs		10	-	-	ns
	Duty ratio	-		-	50	-	%
RG	Pulse width	Tpwr	-	100	500	-	ns
	Rise and fall time	Tprr, Tpfr		5	-	-	ns
TG – P1H	Overlap time	Tovr	-	3	6	-	µs

*12: The clock pulses should be overlapped at 50 % of clock pulse amplitude.

● Area scanning 2 (large full well mode)



Parameter		Symbol	Remark	Min.	Typ.	Max.	Unit
P1V P2V, TG	Pulse width	Tpwv	*13	6	18	-	µs
	Rise and fall time	Tprv, Tpfv		200	-	-	ns
P1H, P2H	Pulse width	Tpwh	*13	500	5000	-	ns
	Rise and fall time	Tprh, Tpfh		10	-	-	ns
	Duty ratio	-		-	50	-	%
SG	Pulse width	Tpws	-	500	5000	-	ns
	Rise and fall time	Tprs, Tpfs		10	-	-	ns
	Duty ratio	-		-	50	-	%
RG	Pulse width	Tpwr	-	100	500	-	ns
	Rise and fall time	Tprr, Tpfr		5	-	-	ns
TG – P1H	Overlap time	Tovr	-	3	6	-	µs

*13: The clock pulses should be overlapped at 50 % of clock pulse amplitude.

■ 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 strap, 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

When cooling the CCD by an externally attached cooler, set the cooler operation so that the temperature gradient (rate of temperature change) for cooling or allowing the CCD to warm back is less than 5 K/minute.

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