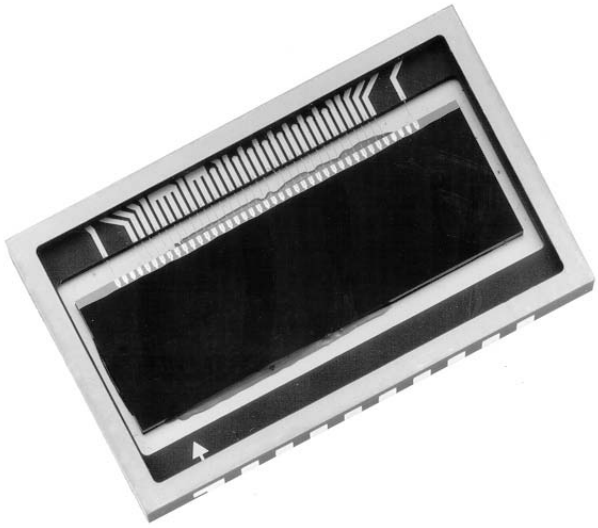
e2v technologies

CCD42-10 Back Illuminated High Performance AIMO CCD Sensor

FEATURES

- 2048 by 512 Pixel Format
- 13.5 μm Square Pixels
- Image Area 27.6 x 6.9 mm
- Wide Dynamic Range
- Symmetrical Anti-static Gate Protection
- Back Illuminated Format for Enhanced Quantum Efficiency
- 3 Standard Anti-reflection Coatings
- Advanced Inverted Mode Operation (AIMO)
- Dump Gate on Readout Register
- Zero Light Emitting Output Amplifier



APPLICATIONS

- Spectroscopy
- Scientific Imaging
- TDI Operation

INTRODUCTION

This version of the CCD42 series of CCD sensors has full-frame architecture. Back illumination technology, in combination with an extremely low noise amplifier, make the device well suited to the most demanding applications, such as spectroscopy. To improve the sensitivity further, the CCD is manufactured without anti-blooming structures. This variant of the CCD42-10 operates in advanced inverted mode (AIMO) for use at Peltier temperatures. e2v technologies' AIMO structures give a 100 times reduction in dark current with minimum reduction in full-well capacity.

The output amplifier is designed to give excellent noise levels at low pixel rates, and can match the noise performance of most conventional scientific CCDs at pixel rates as high as 3 MHz.

The readout register has a gate controlled dump drain to allow fast dumping of unwanted data. The register is designed to accommodate four image pixels of charge, and a summing well capable of holding six image pixels is provided. The output amplifier has a feature enabling the responsivity to be reduced to allow the reading of such large charge packets.

Designers are advised to consult e2v technologies should they be considering using CCD sensors in abnormal environments or if they require customised packaging.

TYPICAL PERFORMANCE

(Low noise mode)

Pixel readout frequency	20 - 3000	kHz
Output amplifier sensitivity	4.5	$\mu V/e^-$
Peak signal	100	ke^-/pixel
Dynamic range	33 333:1	
Spectral range	200 - 1060	nm
Readout noise (at 233 K, 20 kHz)	3	e^- rms

GENERAL DATA

Format

Image area	27.6 x 6.9	mm
Active pixels (H)	2048	
(V)	515 (usable)	
Pixel size	13.5 x 13.5	μm

Package

Package size	32.89 x 20.07 mm
Number of pins	20
Inter-pin spacing	2.54 mm
Inter-row spacing	15.24 mm
Window material	quartz or removable glass

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PERFORMANCE

	Min	Typical	Max	
Peak charge storage (see note 1)	80k	100k	-	e^-/pixel
Peak output voltage (unbinned)	-	450	-	mV
Dark signal at 293 K (see note 2)	-	250	500	e^-/pixel/s
Charge transfer efficiency (see note 3):				
parallel	-	99.9999	-	%
serial	-	99.9993	-	%
Output amplifier sensitivity:				
low noise mode	-	4.5	-	$\mu V/e^-$
high signal mode	-	1.5	-	$\mu V/e^-$
Readout noise at 233 K (see note 4):				
low noise mode	-	3	4	rms e^-/pixel
high signal mode	-	6	-	rms e^-/pixel
Readout frequency (see note 5)	-	20	3000	kHz
Dark signal non-uniformity at 293 K (std. deviation)	-	60	125	e^-/pixel/s
Binned column dark signal non-uniformity at 293 K (std. deviation)	-	7	15	e^-/pixel/s
Output node capacity relative to image section:				
low noise mode	-	1.5	-	
high signal mode	-	6.0	-	

Spectral Response

Wavelength (nm)	Minimum Response (QE)						Response Non-uniformity (1σ)	
	Enhanced Process			Basic Process				
	Broadband Coated	Midband Coated	UV Coated	Broadband Coated	Midband Coated	Uncoated		
300	-	-	45	-	-	-	-	%
350	50	25	45	25	15	10	5	%
400	80	50	55	55	40	25	3	%
500	80	85	60	75	85	55	3	%
650	75	85	60	75	85	50	3	%
900	30	30	30	30	30	30	5	%

ELECTRICAL INTERFACE CHARACTERISTICS

Electrode capacitances (measured at mid-clock level):

	Min	Typical	Max	
I∅/I∅ interphase	-	5	-	nF
R∅/R∅ interphase	-	80	-	pF
I∅/SS	-	15	-	nF
R∅/SS	-	150	-	pF
Output impedance	-	350	-	Ω

NOTES

1. Signal level at which resolution begins to degrade.
2. The typical average (background) dark signal at any temperature T (kelvin) between 230 and 300 K is given by:

   $$Q_d/Q_{d0} = 1.14 \times 10^6 T^3 e^{-9080/T}$$

   where Q_{d0} is the dark current at 293 K. Note that this is typical performance and some variation may be seen between devices. Below 230 K additional dark current components with a weaker temperature dependence may become significant.
3. CCD characterisation measurements made using charge generated by X-ray photons of known energy.
4. Measured using a dual-slope integrator technique (i.e. correlated double sampling) with a 10 μs integration period.
5. Readout above 3000 kHz can be achieved but performance to the parameters given cannot be guaranteed.

BLEMISH SPECIFICATION

Traps Pixels where charge is temporarily held. Traps are counted if they have a capacity greater than 200 e^- at 233 K.

Slipped columns Are counted if they have an amplitude greater than 200 e^-.

Black spots Are counted when they have a responsivity of less than 80% of the local mean signal.

White spots Are counted when they have a generation rate 125 times the specified maximum dark signal generation rate at 293 K (measured between 233 and 273 K). The typical temperature dependence of white spot blemishes is different from that of the average dark signal and is given by:

$$Q_d/Q_{d0} = 122T^3e^{-6400/T}$$

White column A column which contains at least 9 white defects.

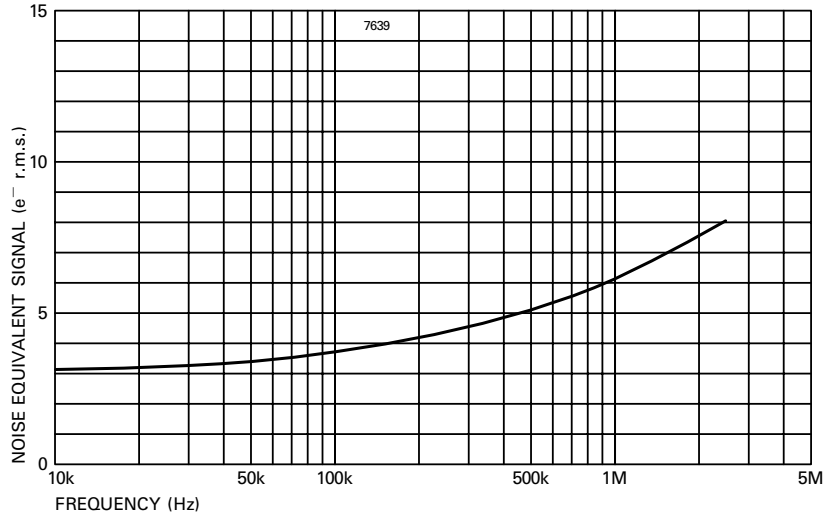
Black column A column which contains at least 9 black defects.

Spikes Are measured with the image fully binned into the register. Level 1 spikes are those above 50 ke^-/column. Level 2 spikes are those above 200 ke^-/column.

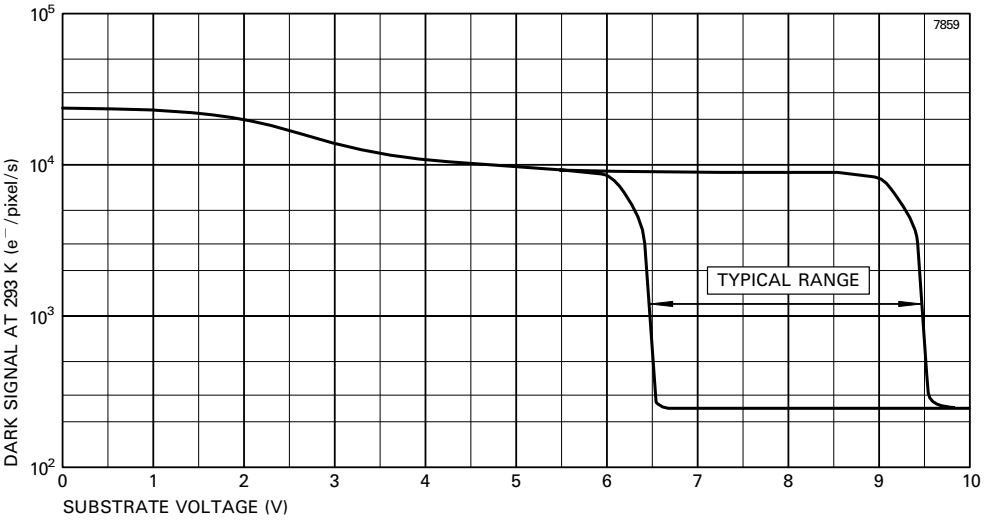
GRADE	0	1	2
Column defects:			
black or slipped	0	2	6
white	0	0	0
Black spots	40	80	200
Traps >200 e^-	1	2	5
White spots	20	30	50
Level 1 spikes	15	20	30
Level 2 spikes	3	4	6

Note The effect of temperature on defects is that traps will be observed less at higher temperatures but more may appear below 233 K. The amplitude of white spots and columns will decrease rapidly with temperature.

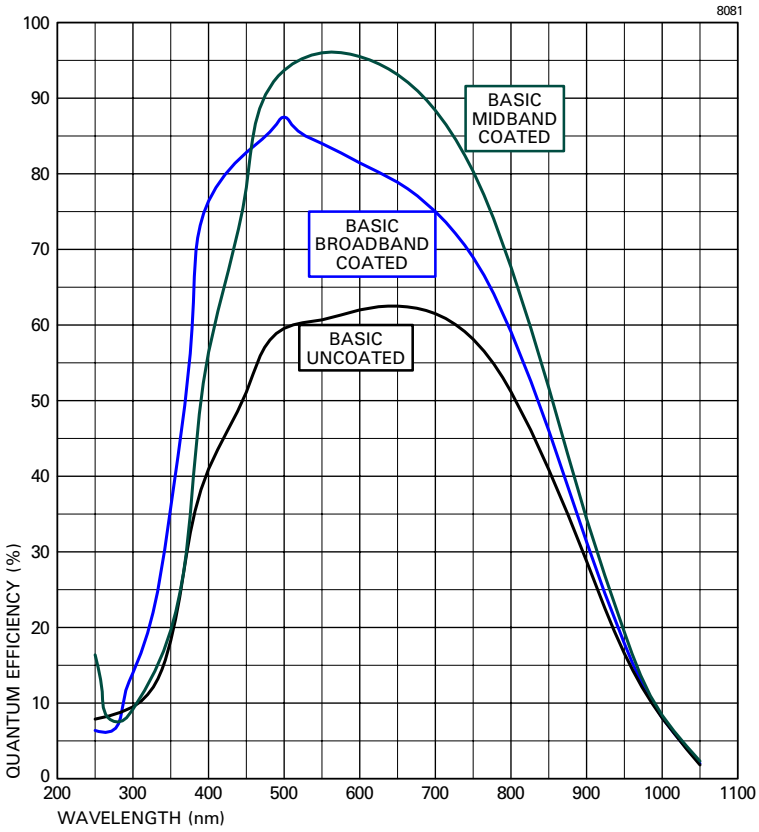
TYPICAL OUTPUT CIRCUIT NOISE (Measured using clamp and sample)

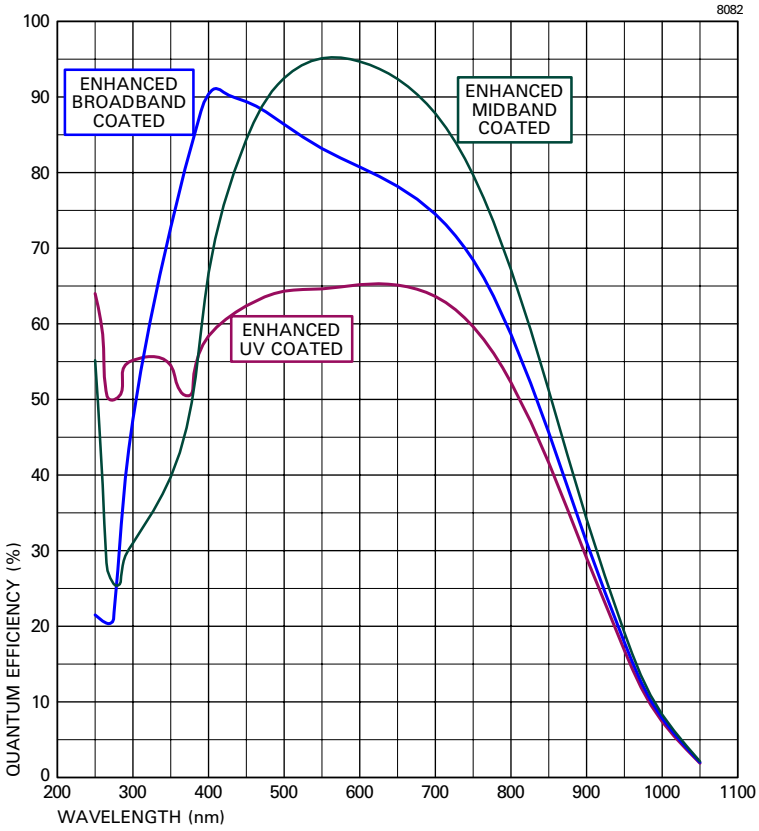


TYPICAL VARIATION OF DARK SIGNAL WITH SUBSTRATE VOLTAGE

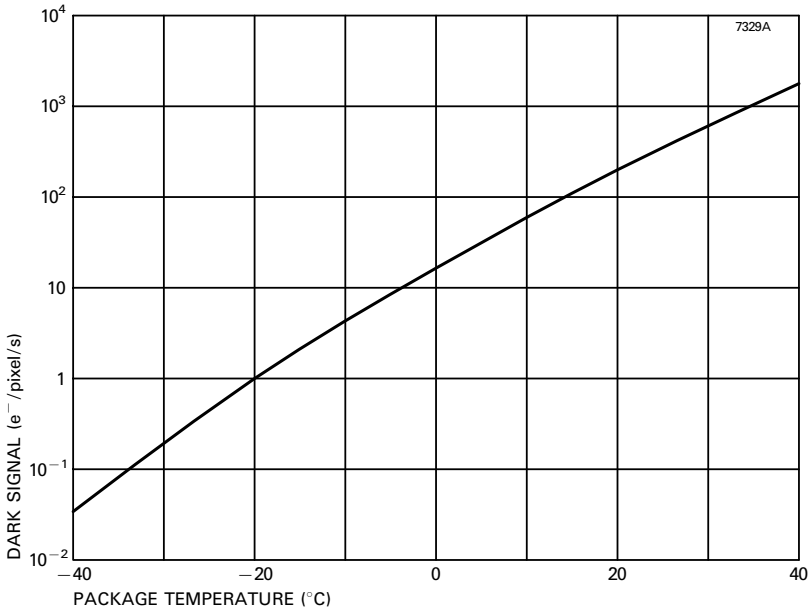


TYPICAL SPECTRAL RESPONSE (At −20 °C, no window)

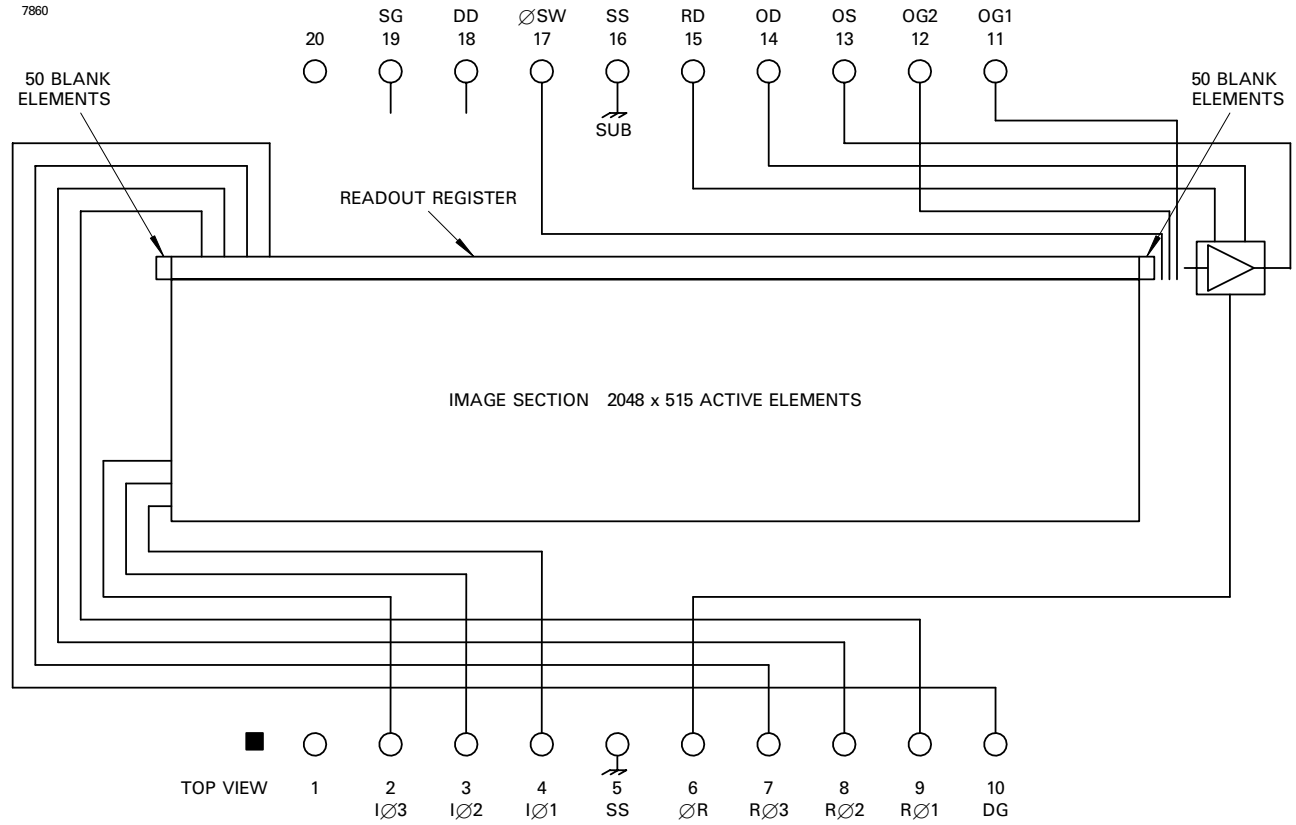




TYPICAL VARIATION OF DARK SIGNAL WITH TEMPERATURE



DEVICE SCHEMATIC



CONNECTIONS, TYPICAL VOLTAGES AND ABSOLUTE MAXIMUM RATINGS

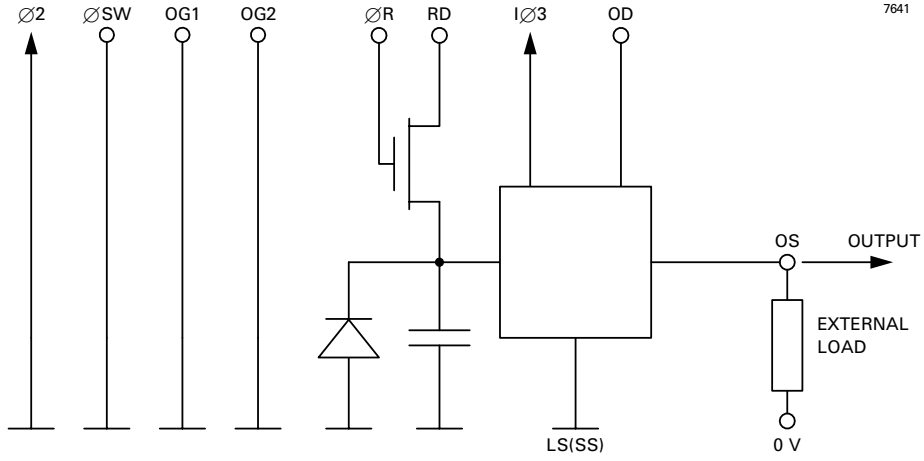
PIN	REF	DESCRIPTION	PULSE AMPLITUDE OR DC LEVEL (V) (see note 6) Min	Typical	Max	MAXIMUM RATINGS with respect to V_{SS}
1	-	No connection		-		-
2	I∅3	Image section, phase 3 (clock pulse)	8	12	15	±20 V
3	I∅2	Image section, phase 2 (clock pulse)	8	12	15	±20 V
4	I∅1	Image section, phase 1 (clock pulse)	8	12	15	±20 V
5	SS	Substrate	8	9.5	11	-
6	∅R	Output reset pulse	8	12	15	±20 V
7	R∅3	Readout register, phase 3 (clock pulse)	8	12	15	±20 V
8	R∅2	Readout register, phase 2 (clock pulse)	8	12	15	±20 V
9	R∅1	Readout register, phase 1 (clock pulse)	8	12	15	±20 V
10	DG	Dump gate (see note 7)	-	0	-	±20 V
11	OG1	Output gate 1	2	3	4	±20 V
12	OG2	Output gate 2 (see note 8)	-	OG1 + 1 V	-	±20 V
13	OS	Output transistor source		see note 9		−0.3 to +25 V
14	OD	Output drain	27	29	32	−0.3 to +25 V
15	RD	Reset transistor drain	15	17	19	−0.3 to +25 V
16	SS	Substrate	8	9.5	11	-
17	∅SW	Summing well (see note 10)	8	12	15	±20 V
18	DD	Diode drain	22	24	26	−0.3 to +25 V
19	SG	Spare gates	0	0	V_{SS} + 19	±20 V
20	-	No connection		-		-

If all voltages are set to the 'typical' values, operation at or close to specification should be obtained. Some adjustment within the minimum - maximum range specified may be required to optimise performance.

Voltage between pairs of pins: OS to OD ± 15 V.

Maximum current through any source or drain pin: 10 mA.

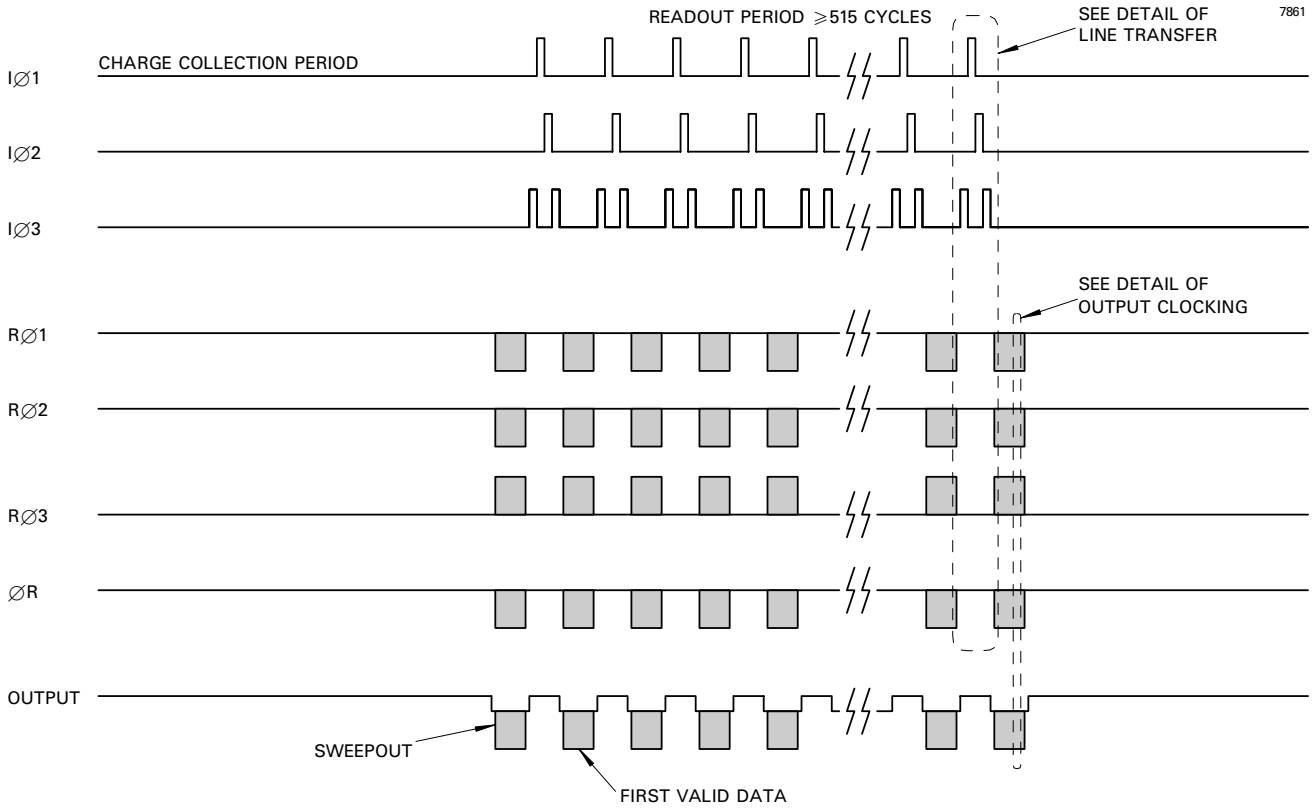
OUTPUT CIRCUIT



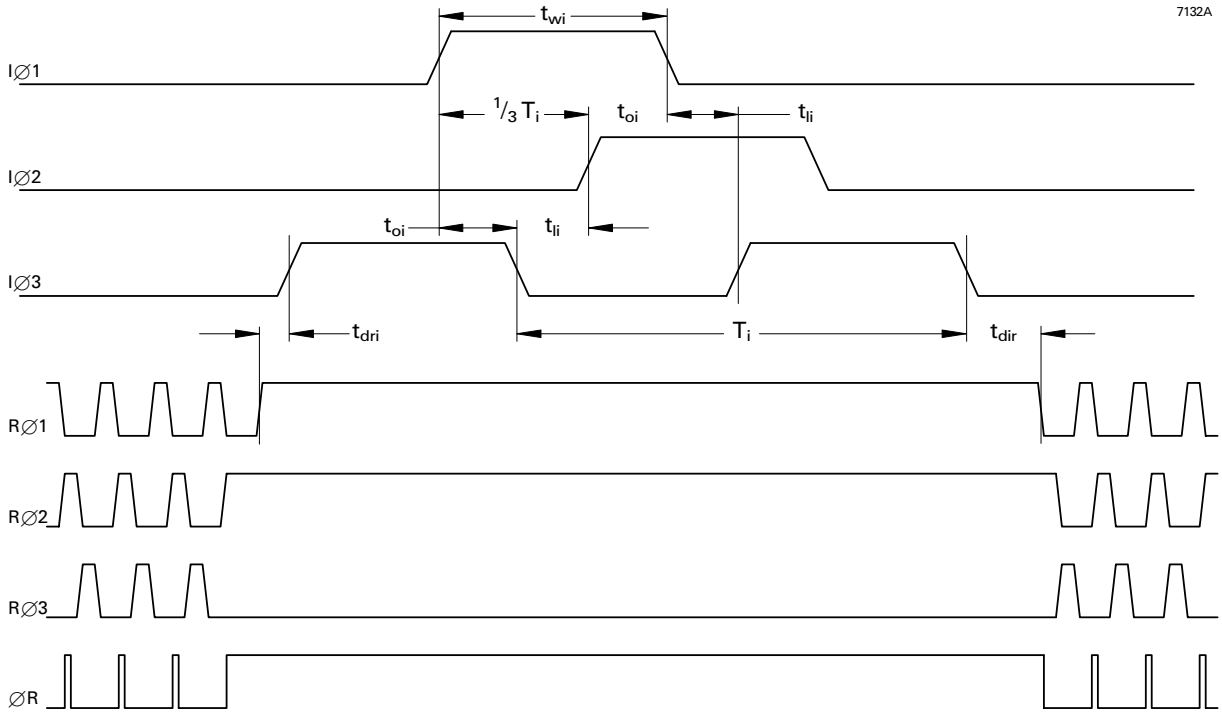
NOTES

6. Readout register clock pulse low levels + 1 V; other clock low levels 0 ± 0.5 V.
7. Non-charge dumping level shown. For charge dumping, DG should be pulsed to 12 ± 2 V.
8. Use OG2 = OG1 + 1 V for normal, low noise mode, or 20 V for low responsivity, high signal mode.
9. Not critical; can be a 1 - 5 mA constant current source, or 5 - 10 kΩ resistor.
10. For normal operation, the summing well should be clocked as R∅3.
11. The amplifier has a DC restoration circuit, which is activated internally whenever I∅3 is pulsed high.

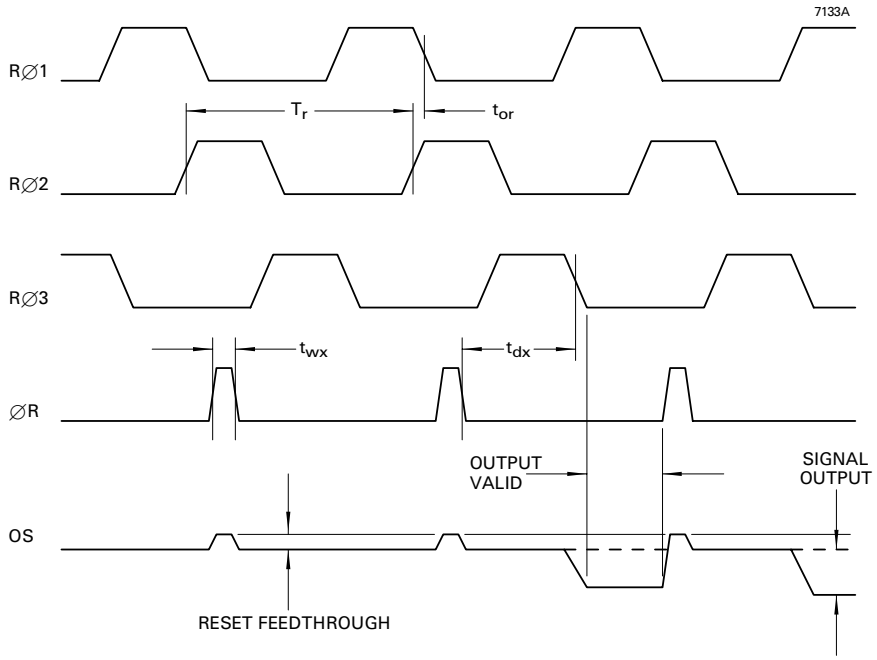
FRAME READOUT TIMING DIAGRAM



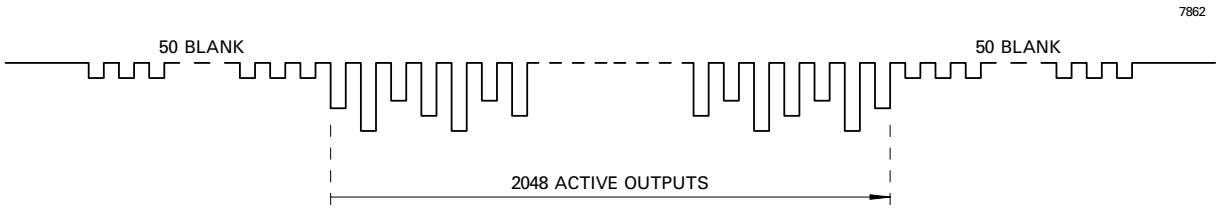
DETAIL OF LINE TRANSFER



DETAIL OF OUTPUT CLOCKING



LINE OUTPUT FORMAT



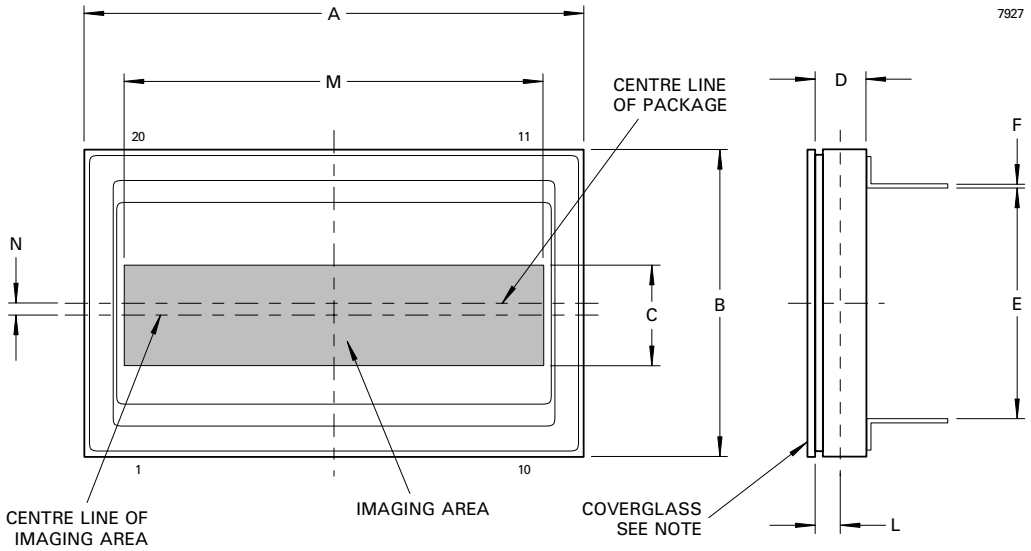
CLOCK TIMING REQUIREMENTS

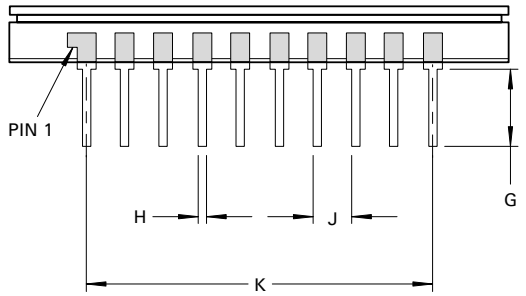
Symbol	Description	Min	Typical	Max	
T_i	Image clock period	15	30	see note 12	µs
t_{wi}	Image clock pulse width	7	15	see note 12	µs
t_{ri}	Image clock pulse rise time (10 to 90%)	0.5	2	$0.5t_{oi}$	µs
t_{fi}	Image clock pulse fall time (10 to 90%)	t_{ri}	2	$0.5t_{oi}$	µs
t_{oi}	Image clock pulse overlap	3	5	$0.2T_i$	µs
t_{li}	Image clock pulse, two phase low	3	5	$0.2T_i$	µs
t_{dir}	Delay time, IØ stop to RØ start	3	5	see note 12	µs
t_{dri}	Delay time, RØ stop to IØ start	1	2	see note 12	µs
T_r	Output register clock cycle period	333	see note 13	see note 12	ns
t_{rr}	Clock pulse rise time (10 to 90%)	50	$0.1T_r$	$0.3T_r$	ns
t_{fr}	Clock pulse fall time (10 to 90%)	t_{rr}	$0.1T_r$	$0.3T_r$	ns
t_{or}	Clock pulse overlap	20	$0.5t_{rr}$	$0.1T_r$	ns
t_{wx}	Reset pulse width	30	$0.1T_r$	$0.2T_r$	ns
t_{rx}, t_{fx}	Reset pulse rise and fall times	20	$0.5t_{rr}$	$0.2T_r$	ns
t_{dx}	Delay time, ØR low to RØ3 low	30	$0.5T_r$	$0.8T_r$	ns

NOTES

12. No maximum other than that necessary to achieve an acceptable dark signal at the longer readout times.
13. As set by the readout period.

OUTLINE
(All dimensions without limits are nominal)





Outline Note

The device is normally supplied with a temporary glass window for protection purposes. It can also be supplied with a fixed, quartz or fibre-optic window where required.

Ref	Millimetres
A	32.89 ± 0.38
B	20.07 ± 0.25
C	6.9
D	3.30 ± 0.33
E	15.24 ± 0.25
F	$0.254^{+\ 0.051}_{-\ 0.025}$
G	5.2
H	0.46 ± 0.05
J	2.54 ± 0.13
K	22.86 ± 0.13
L	1.65 ± 0.56
M	27.6
N	0.8

ORDERING INFORMATION

Options include:

- Temporary Quartz Window
- Permanent Quartz Window
- Temporary Glass Window

For further information on the performance of these and other options, please contact e2v technologies.

HANDLING CCD SENSORS

CCD sensors, in common with most high performance MOS IC devices, are static sensitive. In certain cases a discharge of static electricity may destroy or irreversibly degrade the device. Accordingly, full antistatic handling precautions should be taken whenever using a CCD sensor or module. These include:

- Working at a fully grounded workbench
- Operator wearing a grounded wrist strap
- All receiving socket pins to be positively grounded
- Unattended CCDs should not be left out of their conducting foam or socket.

Evidence of incorrect handling will invalidate the warranty. All devices are provided with internal protection circuits to the gate electrodes (pins 2, 3, 4, 6, 7, 8, 9, 12, 19) but not to the other pins.

HIGH ENERGY RADIATION

Device parameters may begin to change if subject to an ionising dose of greater than 10^4 rads.

Certain characterisation data are held at e2v technologies. Users planning to use CCDs in a high radiation environment are advised to contact e2v technologies.

TEMPERATURE LIMITS

	Min	Typical	Max	
Storage	153	–	373	K
Operating	153	233	323	K

Operation or storage in humid conditions may give rise to ice on the sensor surface on cooling, causing irreversible damage.

Device heating/cooling . . . . . 5 K/min max