

ICX642BKA

Description

The ICX642BKA is an interline CCD solid-state image sensor suitable for NTSC color video cameras with a diagonal 4.5mm (Type 1/4) system. Compared with the conventional product ICX226AK, ICX226AZ, basic characteristics such as sensitivity are improved drastically. This chip features a field period readout system and an electronic shutter with variable charge-storage time. (Applications: Surveillance cameras, etc.)

Features

- ◆ High sensitivity (Approximately +6dB over ICX226AK, ICX226AZ)
- ◆ High resolution and low dark current
- ◆ Excellent anti-blooming characteristics
- ◆ Ye, Cy, Mg, and G complementary color mosaic filters on chip
- ◆ Continuous variable-speed shutter function
- ◆ No voltage adjustments
(Reset gate and substrate bias need no adjustment.)
- ◆ Supply voltage: 12V
- ◆ Reset gate: 3.3V drive
- ◆ Horizontal register: 3.3V drive
- ◆ Recommended range of exit pupil distance: -20 to -100mm

Package

14-pin DIP (Plastic)

Super HAD CCD II™

* "Super HAD CCD II" is a trademark of Sony Corporation. The "Super HAD CCD II" is a version of Sony's high performance CCD HAD (Hole-Accumulation Diode) sensor with realized sensitivity (typical) of 1000mV or more per 1 μ m² (Color: F5.6/BW: F8 in 1s accumulation equivalent).

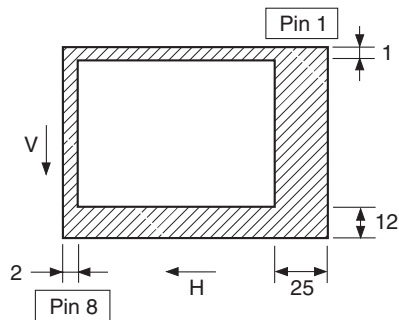
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Device Structure

- ◆ Interline CCD image sensor
- ◆ Image size : Diagonal 4.5mm (Type 1/4)
- ◆ Number of effective pixels : 510 (H) × 492 (V) approx. 0.25M pixels
- ◆ Total number of pixels : 537 (H) × 505 (V) approx. 0.27M pixels
- ◆ Chip size : 4.34mm (H) × 3.69mm (V)
- ◆ Unit cell size : 7.15 μ m (H) × 5.55 μ m (V)
- ◆ Optical black : Horizontal (H) direction: Front 2 pixels, rear 25 pixels
Vertical (V) direction : Front 12 pixels, rear 1pixel
- ◆ Number of dummy bits : Horizontal: 16
Vertical : 1 (even fields only)
- ◆ Substrate material : Silicon

Optical Black Position

(Top View)



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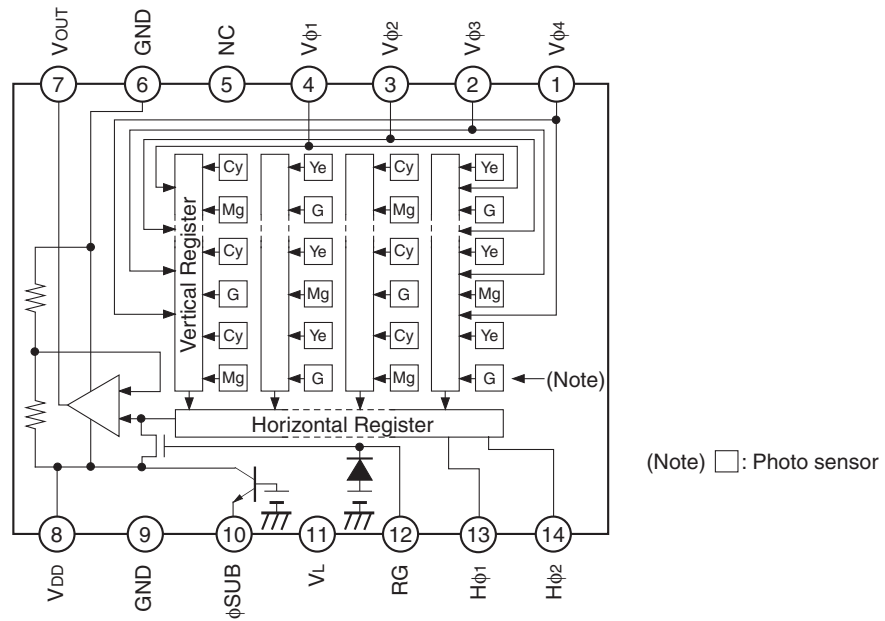
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Block Diagram and Pin Configuration

(Top View)



Pin Description

Pin No.	Symbol	Description	Pin No.	Symbol	Description
1	Vφ4	Vertical register transfer clock	8	VDD	Supply voltage
2	Vφ3	Vertical register transfer clock	9	GND	GND
3	Vφ2	Vertical register transfer clock	10	φSUB	Substrate clock
4	Vφ1	Vertical register transfer clock	11	VL	Protective transistor bias
5	NC		12	RG	Reset gate clock
6	GND	GND	13	Hφ1	Horizontal register transfer clock
7	VOUT	Signal output	14	Hφ2	Horizontal register transfer clock

Absolute Maximum Ratings

Item		Ratings	Unit	Remarks
Against ϕ SUB	V_{DD} , V_{OUT} , $RG - \phi$ SUB	-31 to +10	V	
	$V\phi_1$, $V\phi_3 - \phi$ SUB	-36 to +14	V	
	$V\phi_2$, $V\phi_4$, $V_L - \phi$ SUB	-36 to +0.3	V	
	$H\phi_1$, $H\phi_2$, $GND - \phi$ SUB	-31 to +0.3	V	
Against GND	V_{DD} , V_{OUT} , $RG - GND$	-0.3 to +17	V	
	$V\phi_1$, $V\phi_2$, $V\phi_3$, $V\phi_4 - GND$	-7 to +14	V	
	$H\phi_1$, $H\phi_2 - GND$	-7 to +4.2	V	
Against V_L	$V\phi_1$, $V\phi_3 - V_L$	-0.3 to +20	V	
	$V\phi_2$, $V\phi_4$, $H\phi_1$, $H\phi_2$, $GND - V_L$	-0.3 to +11	V	
Between input clock pins	Potential difference between vertical clock input pins	to +12	V	*1
	$H\phi_1 - H\phi_2$	-5 to +5	V	
	$H\phi_1$, $H\phi_2 - V\phi_4$	-11 to +11	V	
Storage temperature		-30 to +80	°C	
Operating temperature		-10 to +60	°C	

*1 When the clock width is less than 10 μ s and clock duty factor is less than 0.1%, voltages up to 20V are guaranteed.

Bias Conditions

Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
Supply voltage	V_{DD}	11.64	12.0	12.36	V	
Protective transistor bias	V_L		*1			
Substrate clock	ϕ SUB		*2			
Reset gate clock	ϕ RG		*2			

*1 For the V_L setting, use the V_{VL} voltage of the vertical clock waveform or the same voltage as the V_L power supply of the V driver.

*2 Do not apply a DC bias to the substrate clock and reset gate clock pins, because a DC bias is generated internally.

DC Characteristics

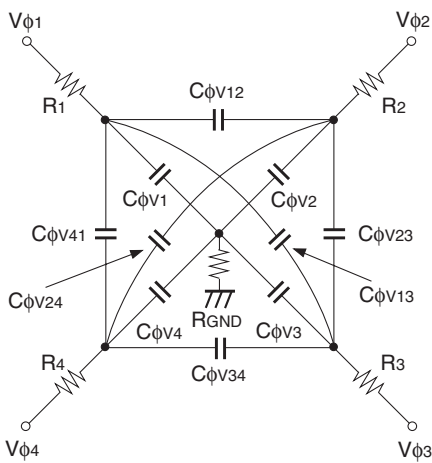
Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
Supply current	I_{DD}		2.5	5	mA	


Clock Voltage Conditions

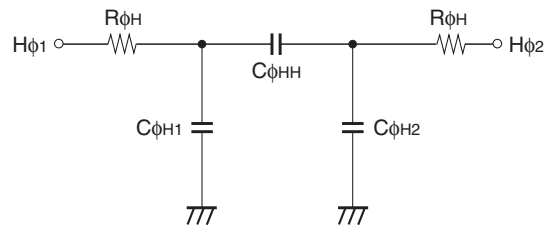
Item	Symbol	Min.	Typ.	Max.	Unit	Waveform diagram	Remarks
Readout clock voltage	V _{VT}	11.64	12.0	12.36	V	1	
Vertical transfer clock voltage	V _{VH1} , V _{VH2}	-0.05	0	0.05	V	2	$V_{VH} = (V_{VH1} + V_{VH2})/2$
	V _{VH3} , V _{VH4}	-0.2	0	0.05	V	2	
	V _{VL1} , V _{VL2} , V _{VL3} , V _{VL4}	-5.5	-5.0	-4.5	V	2	$V_{VL} = (V_{VL3} + V_{VL4})/2$
	V _{φV}	4.3	5.0	5.55	V	2	$V_{φV} = V_{VHn} - V_{VLn}$ (n = 1 to 4)
	V _{VH3} - V _{VH}	-0.25		0.1	V	2	
	V _{VH4} - V _{VH}	-0.25		0.1	V	2	
	V _{VHH}			0.3	V	2	High-level coupling
	V _{VHL}			0.3	V	2	High-level coupling
	V _{VLH}			0.3	V	2	Low-level coupling
	V _{VLL}			0.3	V	2	Low-level coupling
Horizontal transfer clock voltage	V _{φH}	3.0	3.3	3.6	V	3	
	V _H L	-0.05	0	0.05	V	3	
Reset gate clock voltage	V _{φRG}	3.0	3.3	3.6	V	4	Input through 0.1μF capacitance
	V _{RGLH} - V _{RGLL}			0.4	V	4	Low-level coupling
	V _{RGL} - V _{RGLM}			0.5	V	4	Low-level coupling
Substrate clock voltage	V _{φSUB}	16.14	17.0	17.86	V	5	

Clock Equivalent Circuit Constants

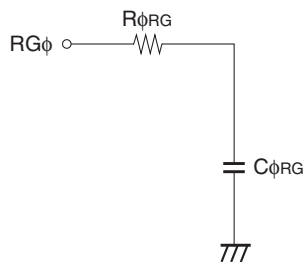
Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
Capacitance between vertical transfer clock and GND	$C\phi V1, C\phi V3$		560		pF	
	$C\phi V2, C\phi V4$		270		pF	
Capacitance between vertical transfer clocks	$C\phi V12, C\phi V34$		180		pF	
	$C\phi V23, C\phi V41$		100		pF	
	$C\phi V13$		100		pF	
	$C\phi V24$		100		pF	
Capacitance between horizontal transfer clock and GND	$C\phi H1, C\phi H2$		33		pF	
Capacitance between horizontal transfer clocks	$C\phi HH$		15		pF	
Capacitance between reset gate clock and GND	$C\phi RG$		5		pF	
Capacitance between substrate clock and GND	$C\phi SUB$		110		pF	
Vertical transfer clock series resistance	$R1, R2, R3, R4$		110		Ω	
Vertical transfer clock ground resistance	R_{GND}		15		Ω	
Horizontal transfer clock series resistance	$R\phi H$		15		Ω	
Reset gate clock series resistance	$R\phi RG$		39		Ω	



Vertical transfer clock equivalent circuit



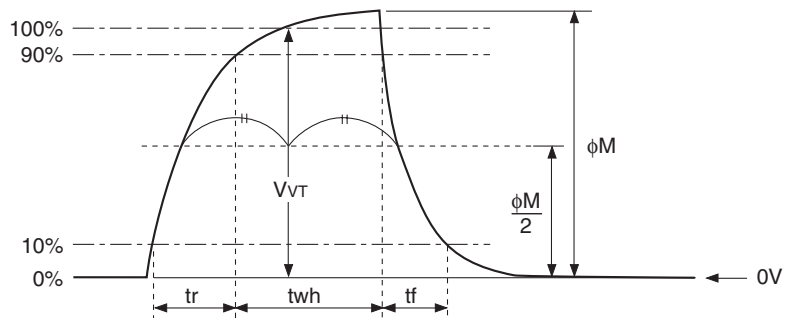
Horizontal transfer clock equivalent circuit



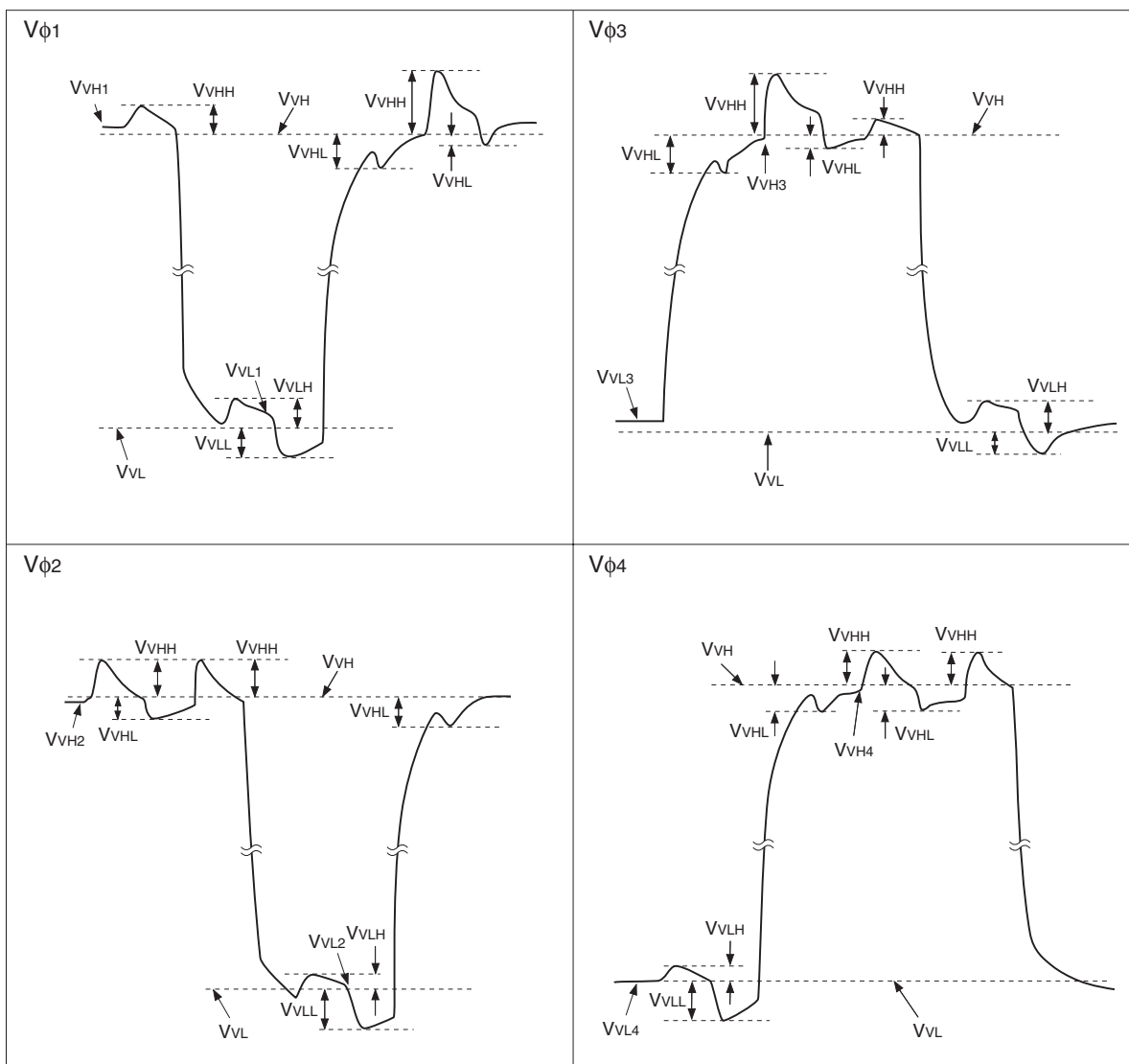
Reset gate clock equivalent circuit

Drive Clock Waveform Conditions

1. Readout clock waveform



2. Vertical transfer clock waveform

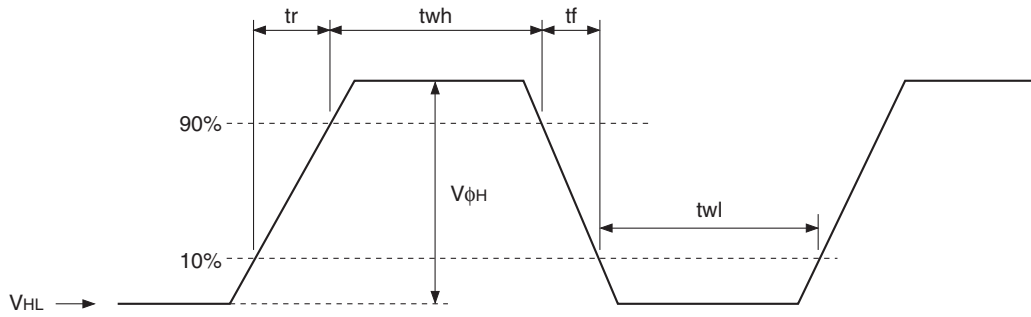


$$V_{VH} = (V_{VH1} + V_{VH2})/2$$

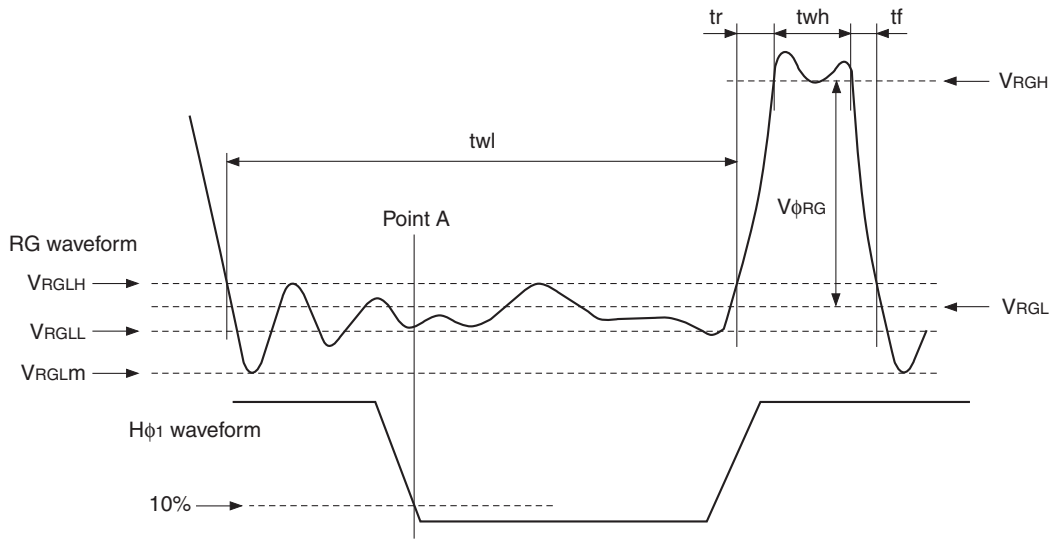
$$V_{VL} = (V_{VL3} + V_{VL4})/2$$

$$V_{\phi V} = V_{VHn} - V_{VVLn} \quad (n = 1 \text{ to } 4)$$

3. Horizontal transfer clock waveform



4. Reset gate clock waveform



V_{RGLH} is the maximum value and V_{RGLL} is the minimum value of the coupling waveform during the period from Point A in the above diagram until the rising edge of RG.

In addition, V_{RGL} is the average value of V_{RGLH} and V_{RGLL} .

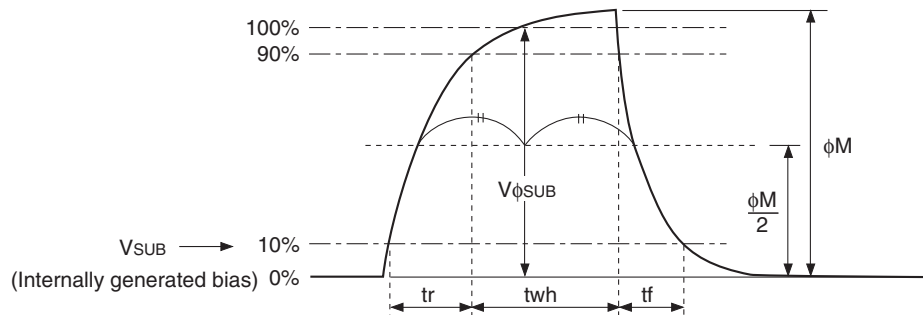
$$V_{RGL} = (V_{RGLH} + V_{RGLL})/2$$

V_{RGH} is the minimum value during the interval t_{wh} ,

$$V_{\phi RG} = V_{RGH} - V_{RGL}$$

V_{RGLM} is the negative overshoot level during the falling edge of RG.

5. Substrate clock waveform




Clock Switching Characteristics

Item	Symbol	twh			twl			tr			tf			Unit	Remarks
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
Readout clock	V_T	2.3	2.5						0.1			0.1		μ s	During readout
Vertical transfer clock	$V_{\phi 1}, V_{\phi 2}, V_{\phi 3}, V_{\phi 4}$										5		250	ns	*1
Horizontal transfer clock	During a video period	H_{ϕ}	41	46		41	46		6.5	9.5		6.5	9.5	ns	*2
	During parallel-to-serial conversion	$H_{\phi 1}$		5.6					0.007			0.007		μ s	
		$H_{\phi 2}$					5.6		0.007			0.007			
Reset gate clock	ϕ_{RG}	11	14		76	80		6.0			5.0		ns		
Substrate clock	ϕ_{SUB}	1.5	1.65						0.5			0.5	μ s	When draining charge	

*1 When vertical transfer clock driver CXD1267AN is used.

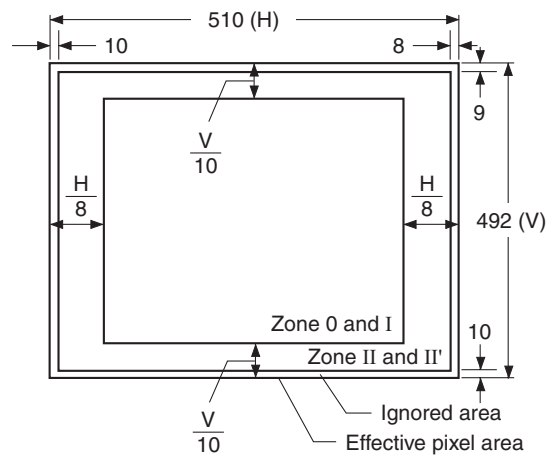
*2 When $V_{\phi H} = 3.0V$. $t_f \geq t_r - 2ns$, and the cross-point voltage (V_{CR}) for the $H_{\phi 1}$ rising side of the $H_{\phi 1}$ and $H_{\phi 2}$ waveforms must be at least $V_{\phi H}/2$ [V].

Image Sensor Characteristics

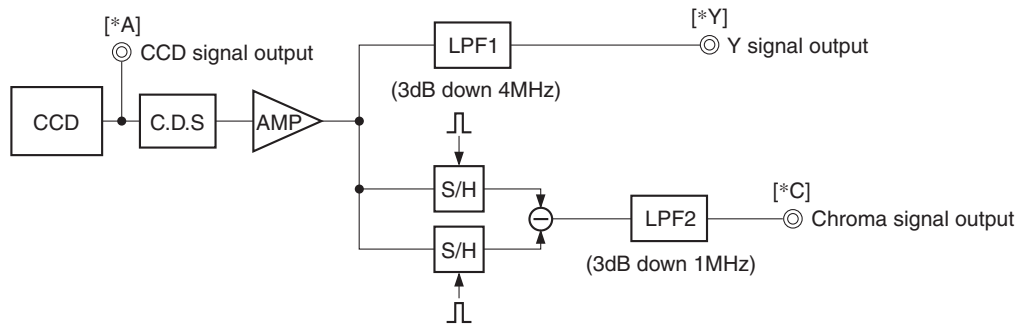
(Ta = 25°C)

Item	Symbol	Min.	Typ.	Max.	Unit	Measurement method	Remarks
Sensitivity	S	1470	1950		mV	1	
Sensitivity ratio	RMgG	1.08		1.48		2	
	RYeCy	1.2		1.6		2	
Saturation signal	Ysat	1000			mV	3	Ta = 60°C
Smear	Sm		-105	-95	dB	4	
Video signal shading	SHy			20	%	5	Zone 0 and zone I
				25	%	5	Zone 0, zone I, zone II and zone II'
Uniformity between video signal channels	ΔSr			10	%	6	
	ΔSb			10	%	6	
Dark signal	Ydt			2	mV	7	Ta = 60°C
Dark signal shading	ΔYdt			1	mV	8	Ta = 60°C
Flicker Y	Fy			2	%	9	
Flicker R – Y	Fcr			5	%	9	
Flicker B – Y	Fcb			5	%	9	
Line crawl R	Lcr			3	%	10	
Line crawl G	Lcg			3	%	10	
Line crawl B	Lcb			3	%	10	
Line crawl W	Lcw			3	%	10	
Lag	Lag			0.5	%	11	

Zone Definition of Video Signal Shading



Measurement System



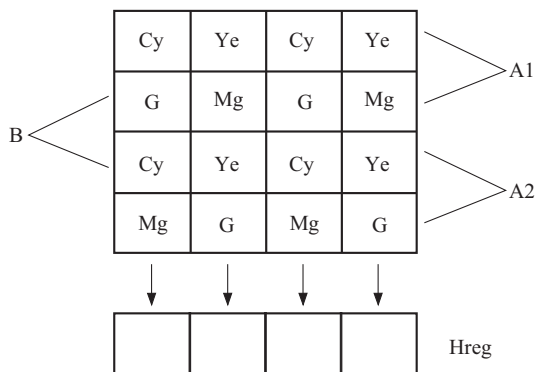
Note) Adjust the amplifier gain so that the gain between [*A] and [*Y], and between [*A] and [*C] equals 1.

Image Sensor Characteristics Measurement Method

Measurement conditions

1. In the following measurements, the device drive conditions are at the typical values of the bias and clock voltage conditions.
2. In the following measurements, the value of the Y signal output or the chroma signal output of the measurement system is used as the signal output based on the optical black level (OB) except spot pixels unless otherwise specified.

Color coding of this image sensor and Composition of luminance (Y) and chroma (color difference) signals



Color Coding Diagram

As shown in the figure on the left, fields are read out. The charge is mixed by pairs such as A1 and A2 in the A field (pairs such as B in the B field). As a result, the sequence of charges output as signals from the horizontal shift register (Hreg) is, for line A1, (G + Cy), (Mg + Ye), (G + Cy), and (Mg + Ye).

These signals are processed to form the Y signal and chroma (color difference) signal. The Y signal is formed by adding adjacent signals, and the chroma signal is formed by subtracting adjacent signals. In other words, the approximation:

$$Y = \{(G + Cy) + (Mg + Ye)\} + 1/2$$

$$= 1/2 \{2B + 3G + 2R\}$$

is used for the Y signal, and the approximation:

$$R - Y = \{(Mg + Ye) - (G + Cy)\}$$

$$= \{2R - G\}$$

is used for the chroma (color difference) signal. For line A2, the signals output from Hreg in sequence are (Mg + Cy), (G + Ye), (Mg + Cy), (G + Ye)

The Y signal is formed from these signals as follows:

$$Y = \{(G + Ye) + (Mg + Cy)\} \times 1/2$$

$$= 1/2 \{2B + 3G + 2R\}$$

This is balanced since it is formed in the same way as for line A1.

Similarly, the chroma (color difference) signal is approximated as follows:

$$- (B - Y) = \{(G + Ye) - (Mg + Cy)\}$$

$$= - \{2B - G\}$$

In other words, the chroma signal can be retrieved according to the sequence of lines from R - Y and - (B - Y) in alternation. This is also true for the B field.

Definition of Standard Imaging Conditions

- ◆ Standard imaging condition I:
Use a pattern box (luminance: 706 cd/m², color temperature of 3200K halogen source) as a subject. (Pattern for evaluation is not applicable.) Use a testing standard lens with CM500S (t = 1.0mm) as an IR cut filter and image at F5.6. The luminous intensity to the sensor receiving surface at this point is defined as the standard sensitivity testing luminous intensity.
- ◆ Standard imaging condition II:
Image a light source (color temperature of 3200K) with a uniformity of brightness within 2% at all angles. Use a testing standard lens with CM500S (t = 1.0mm) as an IR cut filter. The luminous intensity is adjusted to the value indicated in each testing item by the lens diaphragm.
- ◆ Standard imaging condition III:
Image a light source (color temperature of 3200K) with a uniformity of brightness within 2% at all angles. Use a testing standard lens (exit pupil distance –33mm) with CM500S (t = 1.0mm) as an IR cut filter. The luminous intensity is adjusted to the value indicated in each testing item by the lens diaphragm.

1. Sensitivity

Set the measurement condition to standard imaging condition I. After setting the electronic shutter mode with a shutter speed of 1/500s, measure the Y signal (Y_s) at the center of the screen, and substitute the value into the following formula.

$$S = Y_s \times (500/60) \text{ [mV]}$$

2. Sensitivity ratio

Set the measurement condition to standard imaging condition II. Adjust the luminous intensity so that the average value of the Y signal output is 200mV, measure the M_g signal output (S_{Mg} [mV]) and G signal output (S_G [mV]), and Y_e signal output (S_{Ye} [mV]) and C_y signal output (S_{Cy} [mV]) at the center of the screen with frame readout method. Substitute the values into the following formula.

$$\begin{aligned} R_{MgG} &= S_{Mg}/S_G \\ R_{YeCy} &= S_{Ye}/S_{Cy} \end{aligned}$$

3. Saturation signal

Set the measurement condition to standard imaging condition II. After adjusting the luminous intensity to 10 times the intensity with average value of the Y signal output, 200mV, measure the minimum value of the Y signal.

4. Smear

Set the measurement condition to standard imaging condition II. With the lens diaphragm at F5.6 to F8, adjust the luminous intensity to 500 times the intensity with average value of the Y signal output, 200mV. Stop the readout clock and drain charges at the respective H blankings using the electronic shutter. Then measure the maximum value of the Y signal output (Y_{Sm} [mV]) and substitute the value into the following formula.

$$S_m = 20 \times \log \{ (Y_{Sm}/200) \times (1/500) \times (1/10) \} \text{ [dB]} \text{ (1/10V method conversion value)}$$

5. Video signal shading

Set the measurement condition to standard imaging condition III. With the lens diaphragm at F5.6 to F8, adjust the luminous intensity so that the average value of the Y signal output is 200mV. Then measure the maximum (Y_{max} [mV]) and minimum (Y_{min} [mV]) values of the Y signal, and substitute the values into the following formula.

$$S_{Hy} = (Y_{max} - Y_{min})/200 \times 100 \text{ [%]}$$

6. Uniformity between video signal channels

Set the measurement condition to standard imaging condition II. Adjust the luminous intensity so that the average value of the Y signal output is 200mV. Then measure the maximum (Crmax, Cbmax [mV]) and minimum (Crmin, Cbmin [mV]) values of the R – Y and B – Y channels of the chroma signal, and substitute the values into the following formula.

$$\Delta Sr = | (Crmax - Crmin) / 200 | \times 100 [\%]$$

$$\Delta Sb = | (Cbmax - Cbmin) / 200 | \times 100 [\%]$$

7. Dark signal

Measure the average value of the Y signal output (Ydt [mV]) at the device ambient temperature of 60°C and the device in the light-obstructed state using the horizontal idle transfer level as a reference.

8. Dark signal shading

After measuring 7, measure the maximum (Ydmax [mV]) and minimum (Ydmin [mV]) values of the dark signal output, and substitute the values into the following formula.

$$\Delta Ydt = Ydmax - Ydmin [\text{mV}]$$

9. Flicker

(1) Fy

Set the measurement condition to standard imaging condition II. After adjusting the average value of the Y signal output to 200mV, measure the difference in the signal level between fields (ΔYf [mV]), and substitute the value into the following formula.

$$Fy = (\Delta Yf / 200) \times 100 [\%]$$

(2) Fcr, Fcb

Set the measurement condition to standard imaging condition II. After adjusting the average value of the Y signal output to 200mV, insert an R or B filter, and then measure both the difference in the signal level between fields of the chroma signal (ΔCr , ΔCb) as well as the average value of the chroma signal output (CAr, CAb). Substitute the values into the following formula.

$$Fci = (\Delta Ci / CAi) \times 100 [\%] \quad (i = r, b)$$

10. Line crawl

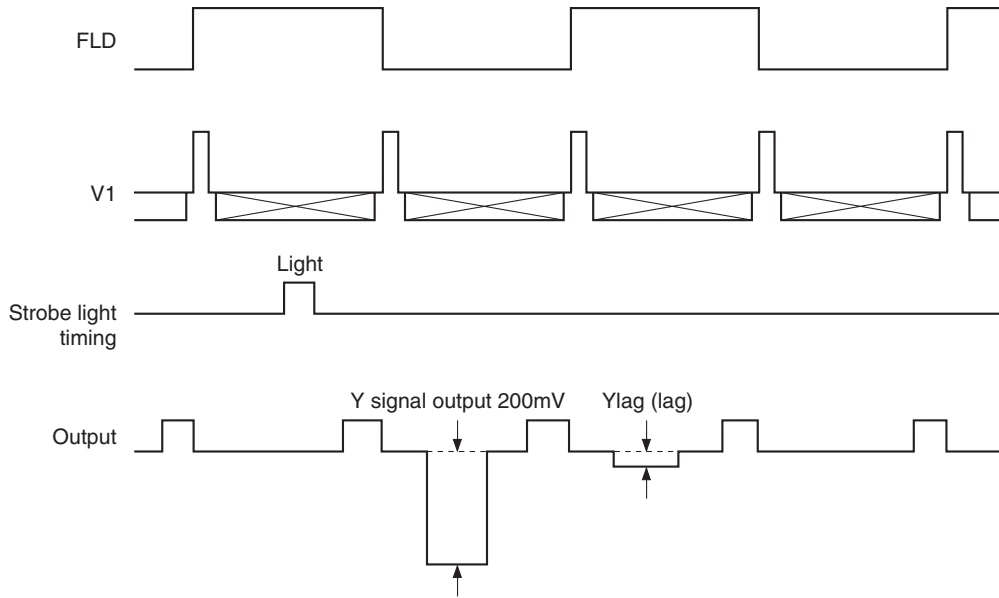
Set the measurement condition to standard imaging condition II. After adjusting the average value of the Y signal output to 200mV, and then insert a white subject and R, G, and B filters and measure the difference between Y signal lines for the same field (ΔYlw , ΔYlr , ΔYlg , ΔYlb [mV]). Substitute the values into the following formula.

$$Lci = (\Delta Yli / 200) \times 100 [\%] \quad (i = w, r, g, b)$$

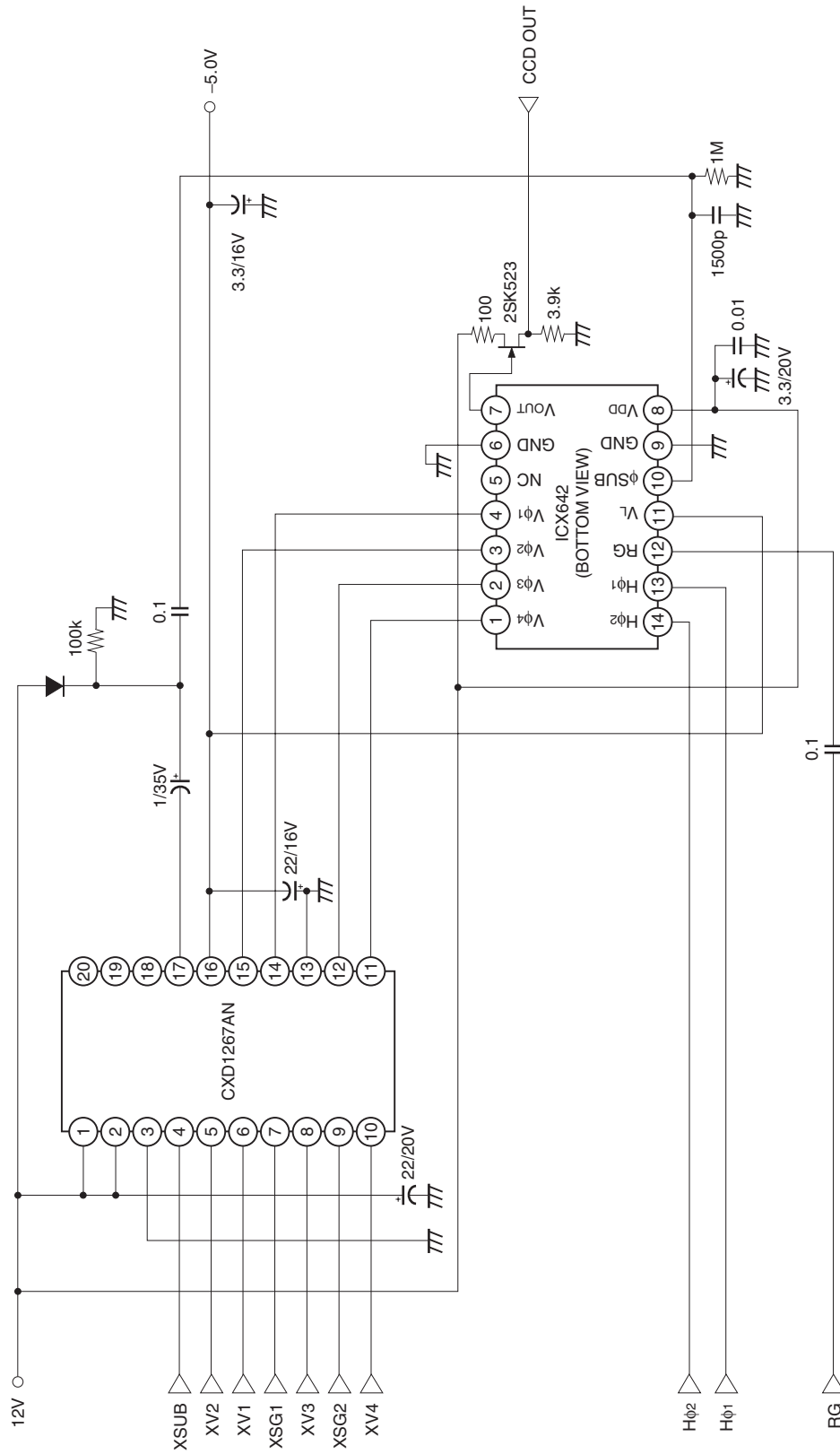
11. Lag

Adjust the Y signal output value generated by strobe light to 200mV. After setting the strobe light so that it strobos with the following timing, measure the residual signal (Ylag), and substitute the value into the following formula.

$$\text{Lag} = (\text{Ylag}/200) \times 100 [\%]$$

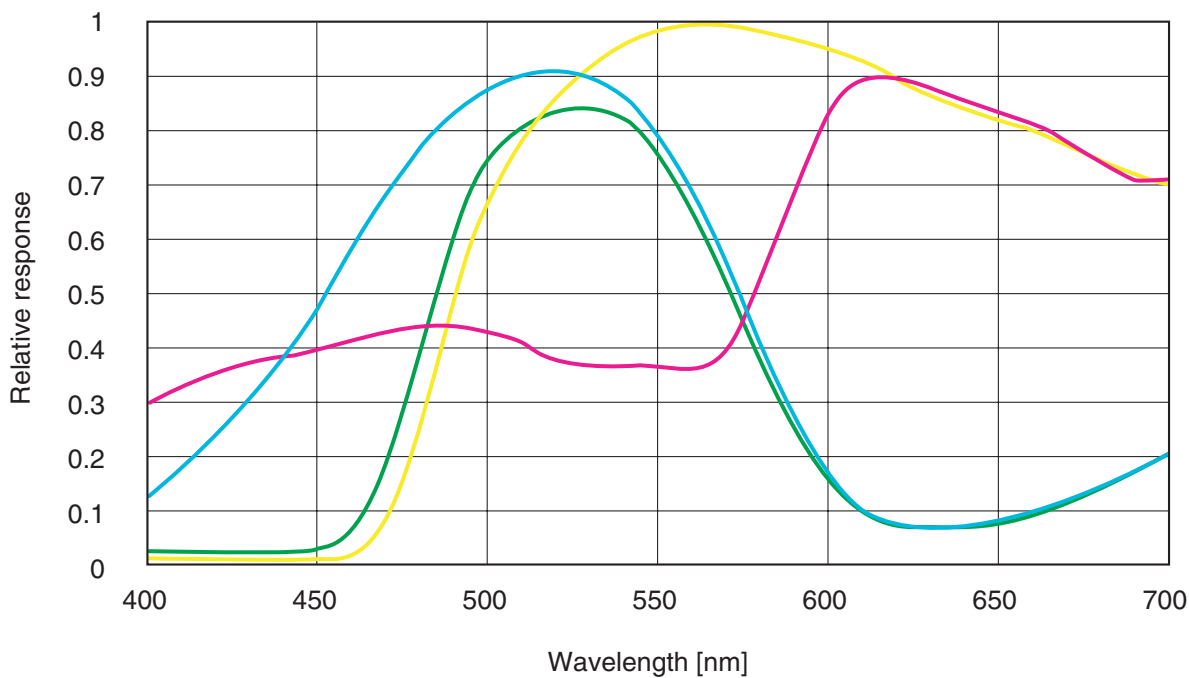


Drive Circuit

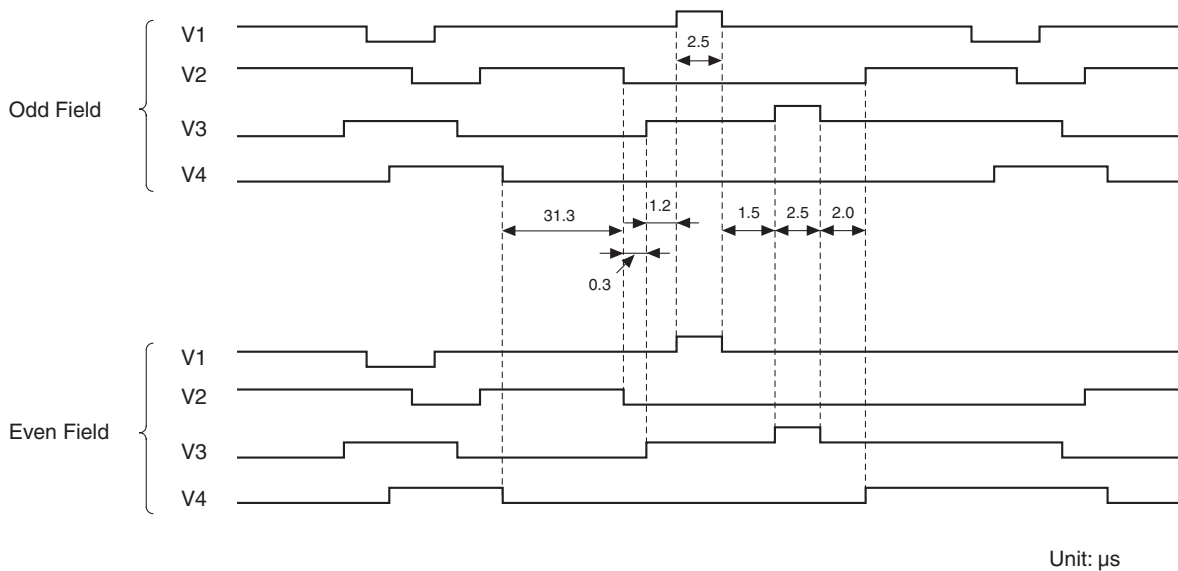


Spectral Sensitivity Characteristics

(Excludes lens characteristics and light source characteristics)

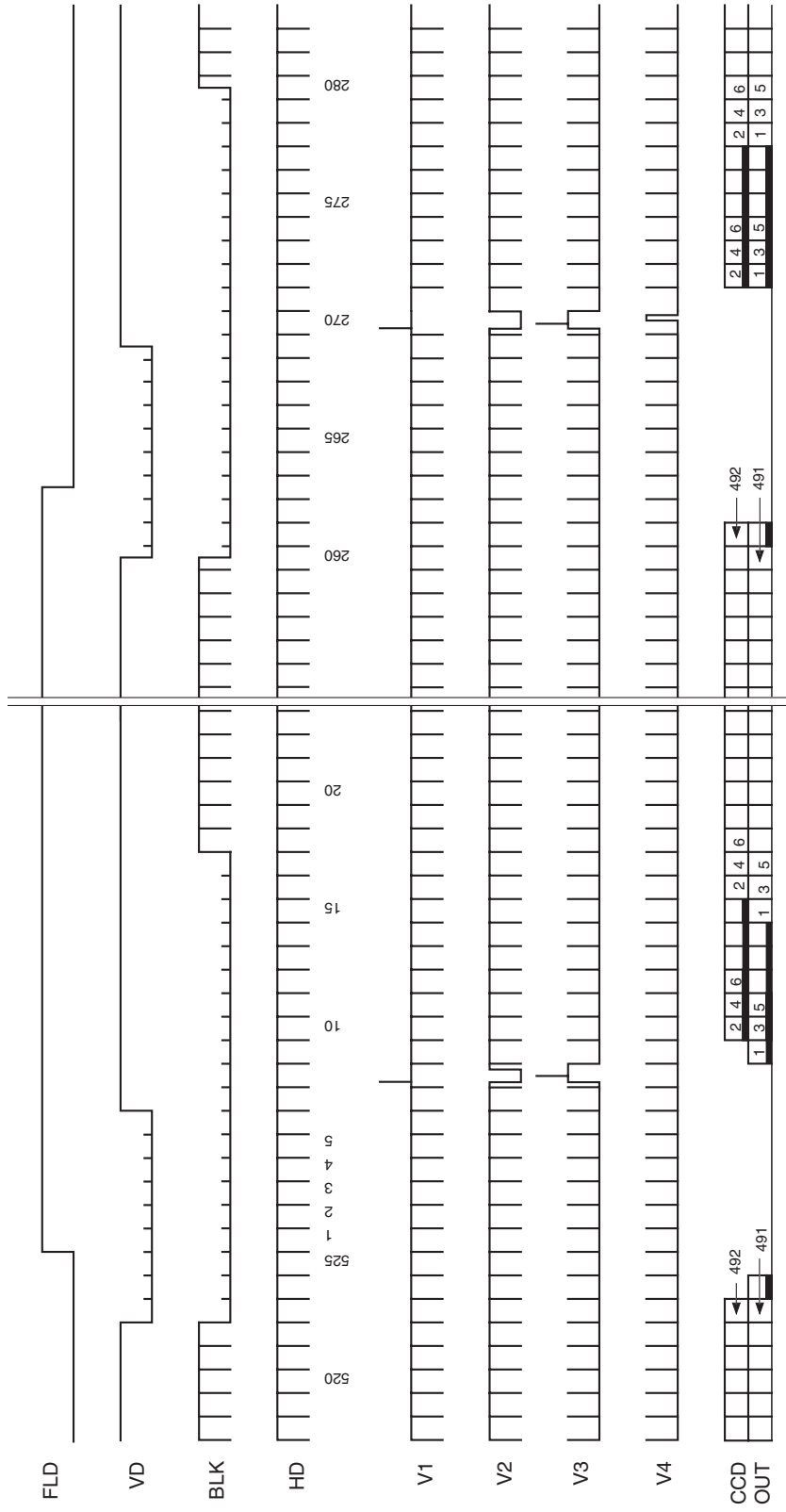


Center Readout Clock Timing Chart

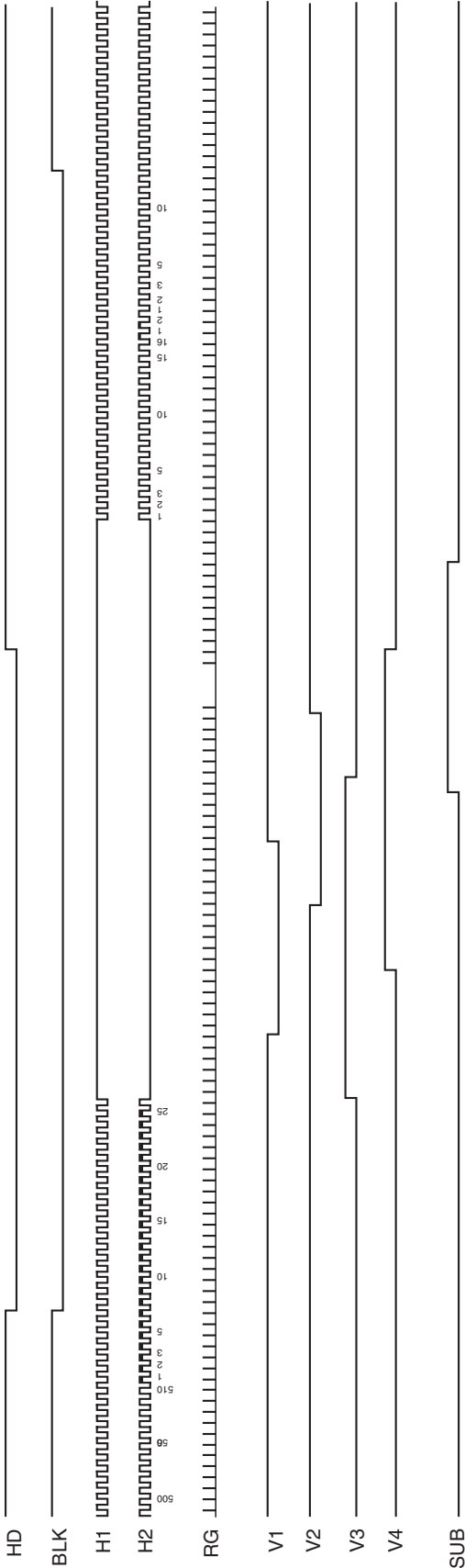


Drive Timing Chart

Vertical Sync



Horizontal Sync



Notes On Handling

1. Static charge prevention

Image sensors are easily damaged by static discharge. Before handling be sure to take the following protective measures.

- (1) Either handle bare handed or use non-chargeable gloves, clothes or material. Also use conductive shoes.
- (2) Use a wrist strap when handling directly.
- (3) Install grounded conductive mats on the floor and working table to prevent the generation of static electricity.
- (4) Ionized air is recommended for discharge when handling image sensors.
- (5) For the shipment of mounted boards, use boxes treated for the prevention of static charges.

2. Soldering

- (1) Make sure the temperature of the upper surface of the seal glass resin adhesive portion of the package does not exceed 80°C.
- (2) Solder dipping in a mounting furnace causes damage to the glass and other defects. Use a 30W soldering iron with a ground wire and solder each pin in 2 seconds or less. For repairs and remount, cool sufficiently.
- (3) To dismount an image sensor, do not use solder suction equipment. When using a desoldering tool, use a zero-cross ON/OFF type for the temperature control system and ground the controller.

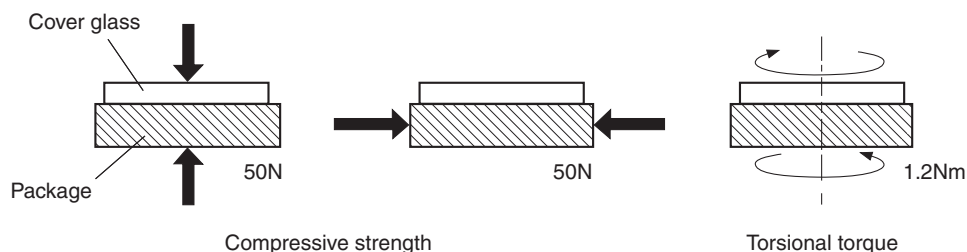
3. Protection from dust and dirt

Image sensors are packed and delivered with care taken to protect the element glass surfaces from harmful dust and dirt. Clean glass surfaces with the following operations as required before use.

- (1) Perform all lens assembly and other work in a clean room (class 1000 or less).
- (2) Do not touch the glass surface with hand and make any object contact with it. If dust or other is stuck to a glass surface, blow it off with an air blower. (For dust stuck through static electricity, ionized air is recommended.)
- (3) Clean with a cotton swab with ethyl alcohol if grease stained. Be careful not to scratch the glass.
- (4) Keep in a dedicated case to protect from dust and dirt. To prevent dew condensation, preheat or precool when moving to a room with great temperature differences.
- (5) When a protective tape is applied before shipping, remove the tape applied for electrostatic protection just before use. Do not reuse the tape.

4. Installing (attaching)

- (1) Remain within the following limits when applying a static load to the package. Do not apply any load more than 0.7mm inside the outer perimeter of the glass portion, and do not apply any load or impact to limited portions. (This may cause cracks in the package.)

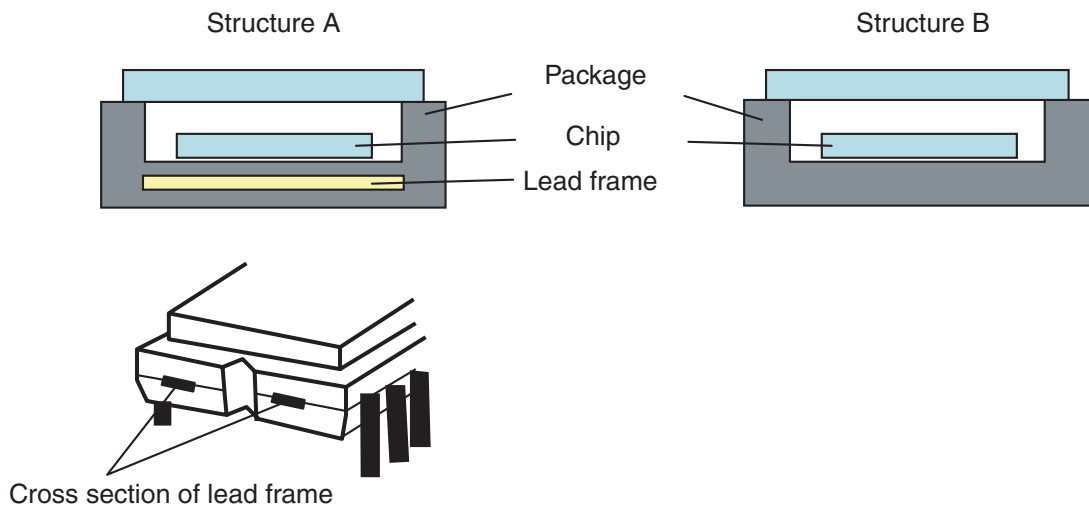


- (2) If a load is applied to the entire surface by a hard component, bending stress may be generated and the package may fracture, etc., depending on the flatness of the bottom of the package. Therefore, for installation, use either an elastic load, such as a spring plate.
- (3) The adhesive may cause the marking on the rear surface to disappear, especially in case the regulated voltage value is indicated on the rear surface. Therefore, the adhesive should not be applied to this area, and indicated values should be transferred to the other locations as a precaution.

- (4) The notch of the package is used for directional index, and that can not be used for reference of fixing. In addition, the cover glass and seal resin may overlap with the notch of the package.
- (5) If the leads are bent repeatedly or metal, etc., strikes or rubs against the package surface, the plastic may chip or fragment and generate dust.
- (6) Acrylate anaerobic adhesives are generally used to attach this product. In addition, cyanoacrylate instantaneous adhesives are sometimes used jointly with acrylate anaerobic adhesives to hold the product in place until the adhesive completely hardens. (reference)
- (7) Note that the sensor may be affected when using visible light other than ultraviolet ray and infrared ray etc. on mounting it.

5. Others

- (1) Do not expose to strong light (sun rays) for long periods, as color filters will be discolored.
- (2) Exposure to high temperature or humidity will affect the product characteristics. Accordingly avoid storage or use in such conditions.
- (3) Brown stains may be seen on the bottom or side of the package. But this does not affect the characteristics.
- (4) This product is precision optical parts, so care should be taken not to apply excessive mechanical shocks or force.
- (5) This package has 2 kinds of internal structure. However, their package outline, optical size, and strength are the same.

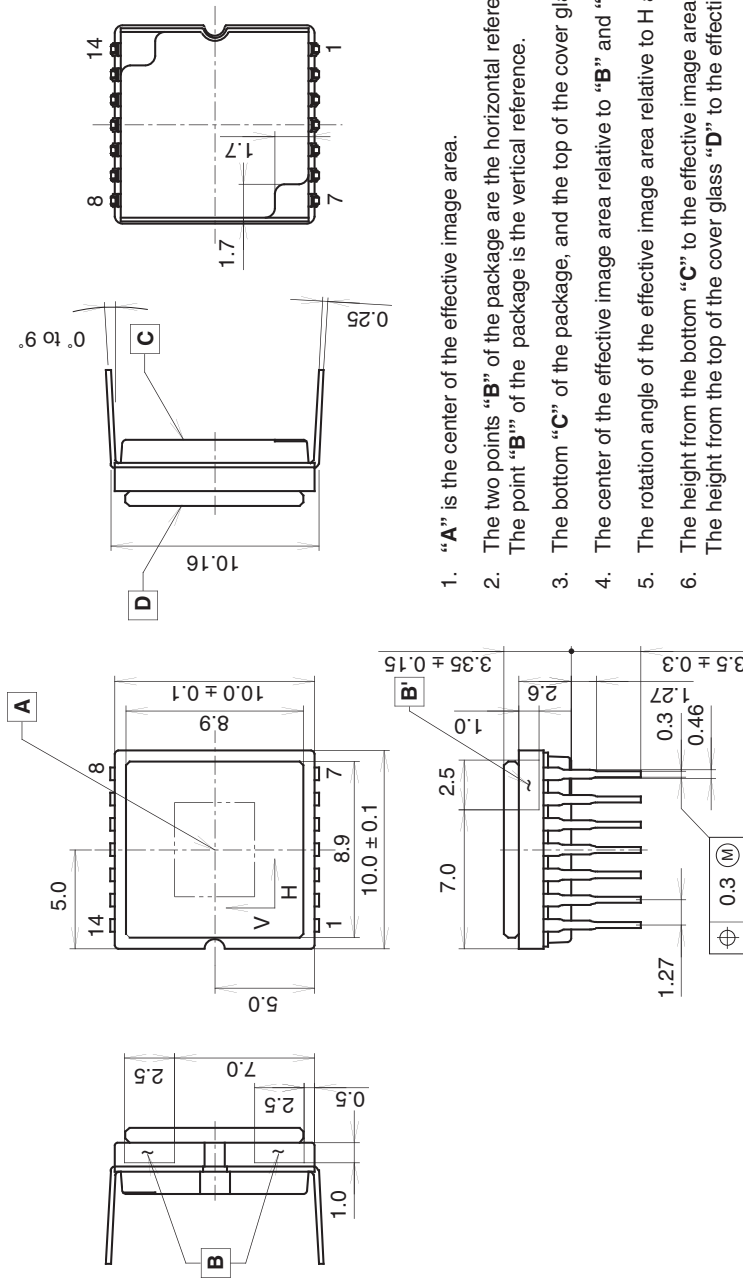


The cross section of lead frame can be seen on the side of the package for structure A.

Package Outline

(Unit: mm)

14 pin DIP (400mil)



1. "A" is the center of the effective image area.
2. The two points "B" of the package are the horizontal reference. The point "B'" of the package is the vertical reference.
3. The bottom "C" of the package, and the top of the cover glass "D" are the height reference.
4. The center of the effective image area relative to "B" and "B'" is $(H, V) = (5.0, 5.0) \pm 0.15\text{mm}$.
5. The rotation angle of the effective image area relative to H and V is $\pm 1^\circ$.
6. The height from the bottom "C" to the effective image area is $1.41 \pm 0.10\text{mm}$. The height from the top of the cover glass "D" to the effective image area is $1.94 \pm 0.15\text{mm}$.
7. The tilt of the effective image area relative to the bottom "C" is less than $25\mu\text{m}$. The tilt of the effective image area relative to the top "D" of the cover glass is less than $25\mu\text{m}$.
8. The thickness of the cover glass is 0.75mm, and the refractive index is 1.5.
9. The notch of the package is used only for directional index, that must not be used for reference of fixing.
10. Cover glass defect
Edge part
Length : no matter, Width : less than 0.5mm, Depth : less than the thickness of the glass.
Corner part
Length : less than 1.5mm, Depth : less than the thickness of the glass.

PACKAGE STRUCTURE

PACKAGE MATERIAL	Plastic
LEAD TREATMENT	GOLD PLATING
LEAD MATERIAL	42 ALLOY
PACKAGE MASS	0.60g
DRAWING NUMBER	AS-D3-02(E)