

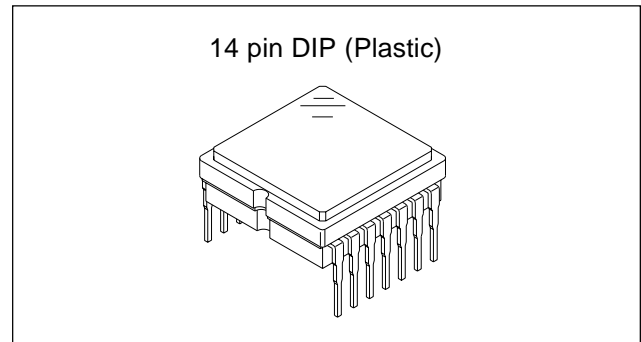
Diagonal 4.5mm (Type 1/4) CCD Image Sensor for EIA B/W Video Cameras

Description

The ICX278AL is an interline CCD solid-state image sensor suitable for EIA B/W video cameras with a diagonal 4.5mm (Type 1/4) system. Compared with the current product ICX208AL, basic characteristics such as sensitivity, smear and dynamic range are improved drastically from visible light region to near infrared light region through the adoption of EXview HAD CCD™ technology.

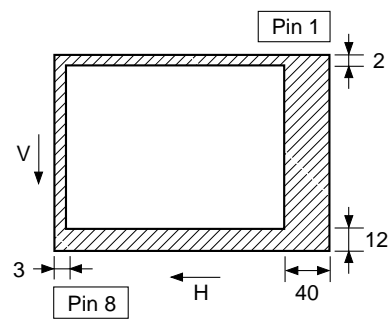
This chip features a field period readout system and an electronic shutter with variable charge-storage time.

The package is a 10mm-square 14-pin DIP (Plastic).



Features

- Sensitivity in near infrared light region (+5dB compared with the ICX208AL, $\lambda = 945\text{nm}$)
- High sensitivity (+6dB compared with the ICX208AL, no IR cut filter)
- Low smear (-20dB compared with the ICX208AL)
- High D range (+2dB compared with the ICX208AL)
- Horizontal register: 3.3 to 5V drive
- Reset gate: 3.3 to 5V drive
- No voltage adjustment (Reset gate and substrate bias are not adjusted.)
- High resolution and low smear
- Excellent antiblooming characteristics
- Continuous variable-speed shutter
- Recommended range of exit pupil distance: -20 to -100mm



**Optical black position
(Top View)**

Device Structure

- Interline CCD image sensor
- Image size: Diagonal 4.5mm (Type 1/4)
- Number of effective pixels: 768 (H) \times 494 (V) approx. 380K pixels
- Total number of pixels: 811 (H) \times 508 (V) approx. 410K pixels
- Chip size: 4.43mm (H) \times 3.69mm (V)
- Unit cell size: 4.75 μm (H) \times 5.55 μm (V)
- Optical black: Horizontal (H) direction: Front 3 pixels, rear 40 pixels
Vertical (V) direction: Front 12 pixels, rear 2 pixels
- Number of dummy bits: Horizontal 22
Vertical 1 (even fields only)
- Substrate material: Silicon

EXview HAD CCD™

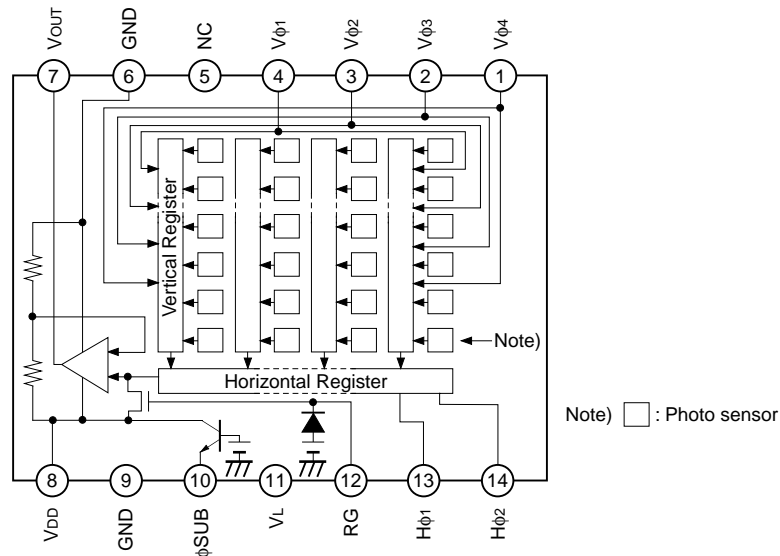
* EXview HAD CCD is a trademark of Sony Corporation.

EXview HAD CCD is a CCD that drastically improves light efficiency by including near infrared light region as a basic structure of HAD (Hole-Accumulation-Diode) sensor.

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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 φSUB | VDD, VOUT, RG – φSUB | -40 to +8 | V | |
| | Vφ1, Vφ3 – φSUB | -50 to +15 | V | |
| | Vφ2, Vφ4, VL – φSUB | -50 to +0.3 | V | |
| | Hφ1, Hφ2, GND – φSUB | -40 to +0.3 | V | |
| Against GND | VDD, VOUT, RG – GND | -0.3 to +18 | V | |
| | Vφ1, Vφ2, Vφ3, Vφ4 – GND | -10 to +18 | V | |
| | Hφ1, Hφ2 – GND | -10 to +6 | V | |
| Against VL | Vφ1, Vφ3 – VL | -0.3 to +28 | V | |
| | Vφ2, Vφ4, Hφ1, Hφ2, GND – VL | -0.3 to +15 | V | |
| Between input clock pins | Voltage difference between vertical clock input pins | to +15 | V | *1 |
| | Hφ1 – Hφ2 | -5 to +5 | V | |
| | Hφ1, Hφ2 – Vφ4 | -13 to +13 | V | |
| Storage temperature | | -30 to +80 | °C | |
| Operating temperature | | -10 to +60 | °C | |

*1 +24V (Max.) when clock width < 10μs, clock duty factor < 0.1%.

Bias Conditions

| Item | Symbol | Min. | Typ. | Max. | Unit | Remarks |
|----------------------------|------------------|-------|------|-------|------|---------|
| Supply voltage | V _{DD} | 14.55 | 15.0 | 15.45 | V | |
| Protective transistor bias | V _L | *1 | | | | |
| Substrate clock | φ _{SUB} | *2 | | | | |
| Reset gate clock | φ _{RG} | *2 | | | | |

*1 V_L setting is the V_{VL} voltage of the vertical transfer clock waveform, or the same power supply as the V_L power supply for the V driver should be used.

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

DC Characteristics

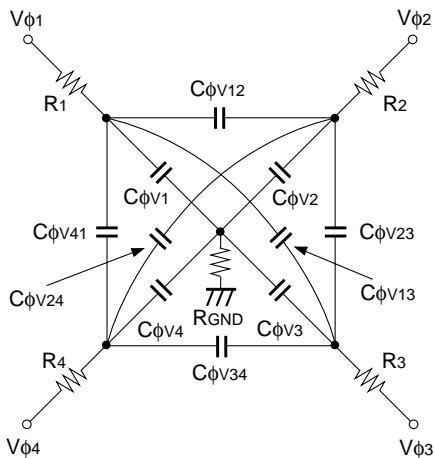
| Item | Symbol | Min. | Typ. | Max. | Unit | Remarks |
|----------------|-----------------|------|------|------|------|---------|
| Supply current | I _{DD} | | 4 | 6 | mA | |

Clock Voltage Conditions

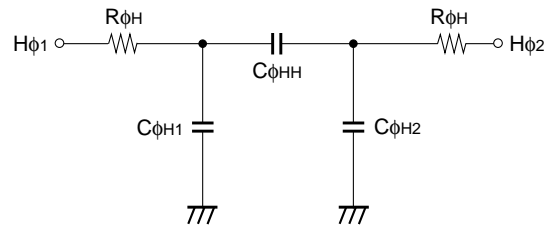
| Item | Symbol | Min. | Typ. | Max. | Unit | Waveform diagram | Remarks |
|-----------------------------------|------------------------------------------------------------------------------|-------|------|-------|------|------------------|----------------------------------------------------|
| Readout clock voltage | V _{VT} | 14.55 | 15.0 | 15.45 | 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} | -8.0 | -7.0 | -6.5 | V | 2 | $V_{VL} = (V_{VL3} + V_{VL4})/2$ |
| | V _{φV} | 6.3 | 7.0 | 8.05 | V | 2 | $V_{φV} = V_{VHn} - V_{VLn} (n = 1 \text{ to } 4)$ |
| | 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 | 5.25 | V | 3 | |
| | V _H L | -0.05 | 0 | 0.05 | V | 3 | |
| Reset gate clock voltage | V _{φRG} | 3.0 | 3.3 | 5.5 | 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} | 21.0 | 22.0 | 23.5 | V | 5 | |

Clock Equivalent Circuit Constant

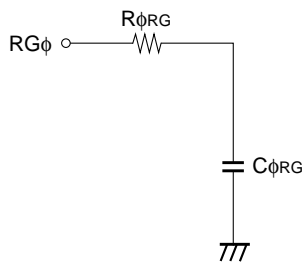
| Item | Symbol | Min. | Typ. | Max. | Unit | Remarks |
|-------------------------------------------------------|------------------------|------|------|------|----------|---------|
| Capacitance between vertical transfer clock and GND | $C\phi V1, C\phi V3$ | | 1200 | | pF | |
| | $C\phi V2, C\phi V4$ | | 560 | | pF | |
| Capacitance between vertical transfer clocks | $C\phi V12, C\phi V34$ | | 220 | | pF | |
| | $C\phi V23, C\phi V41$ | | 120 | | pF | |
| | $C\phi V13$ | | 82 | | pF | |
| | $C\phi V24$ | | 75 | | pF | |
| Capacitance between horizontal transfer clock and GND | $C\phi H1, C\phi H2$ | | 22 | | pF | |
| Capacitance between horizontal transfer clocks | $C\phi HH$ | | 36 | | pF | |
| Capacitance between reset gate clock and GND | $C\phi RG$ | | 5 | | pF | |
| Capacitance between substrate clock and GND | $C\phi SUB$ | | 180 | | pF | |
| Vertical transfer clock series resistor | $R1, R2, R3, R4$ | | 82 | | Ω | |
| Vertical transfer clock ground resistor | R_{GND} | | 15 | | Ω | |
| Horizontal transfer clock series resistor | $R\phi H$ | | 12 | | Ω | |
| Reset gate clock series resistor | $R\phi RG$ | | 51 | | Ω | |



Vertical transfer clock equivalent circuit



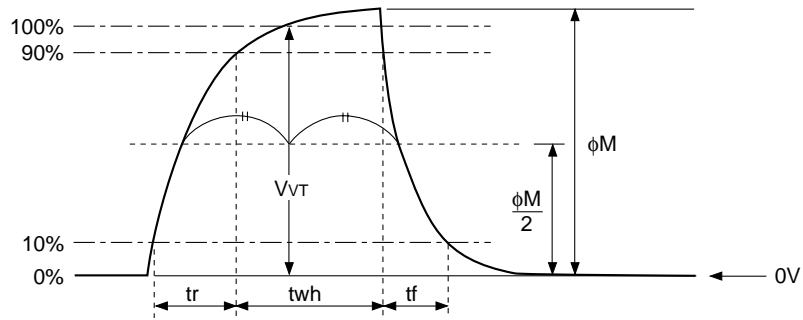
Horizontal transfer clock equivalent circuit



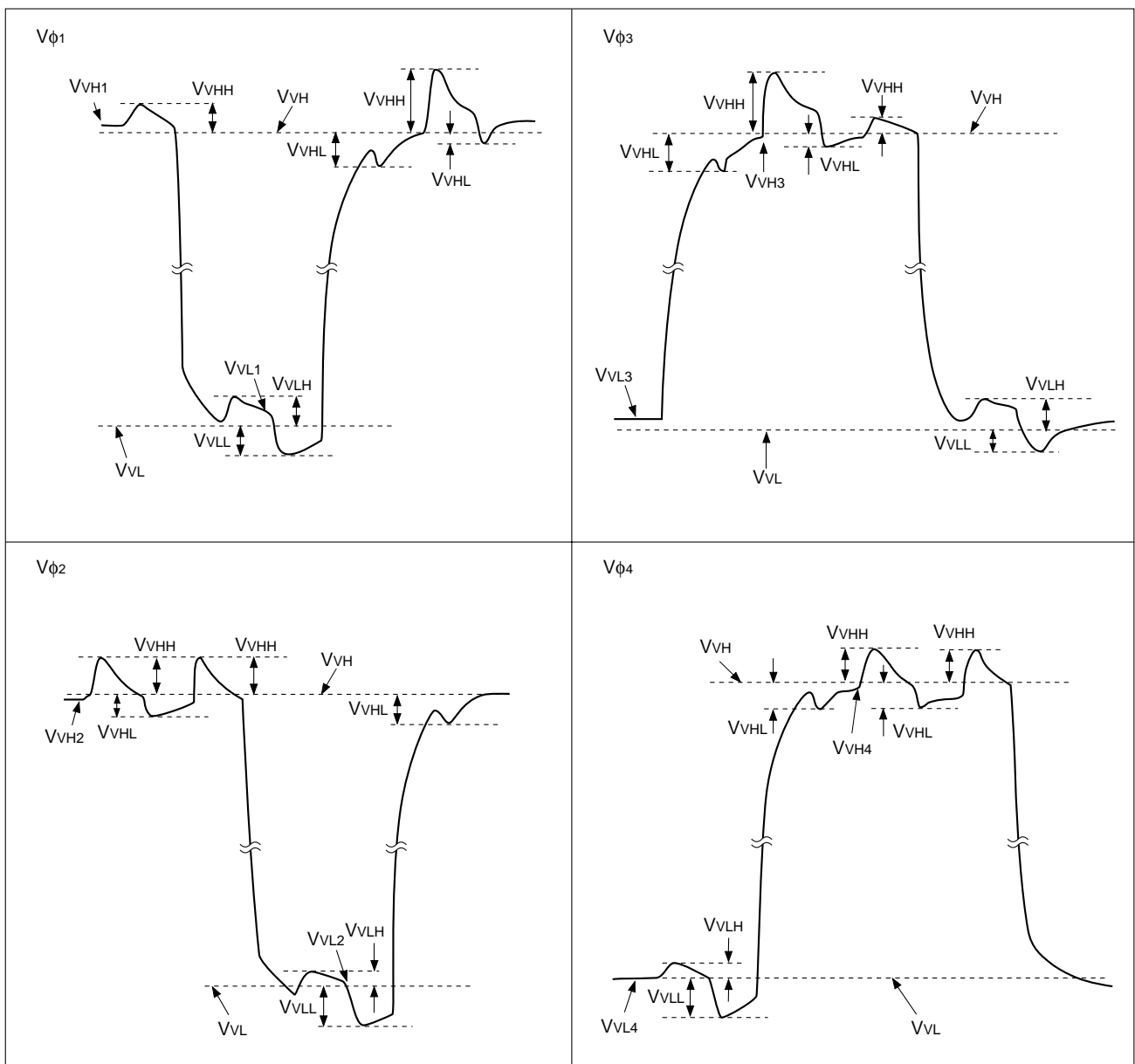
Reset gate clock equivalent circuit

Drive Clock Waveform Conditions

(1) Readout clock waveform



(2) Vertical transfer clock waveform

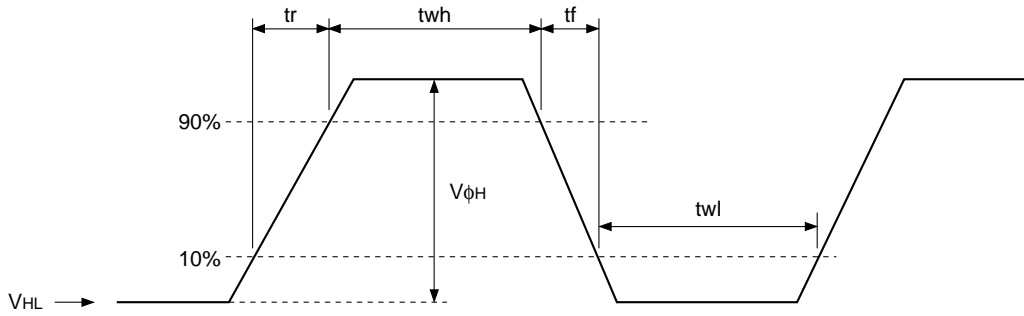


$$V_{vH} = (V_{vH1} + V_{vH2})/2$$

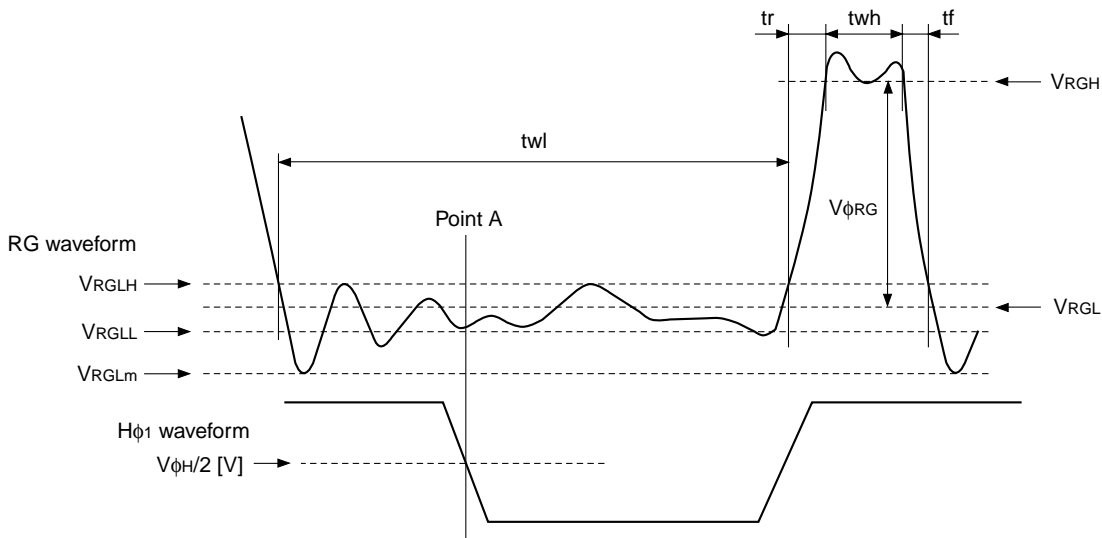
$$V_{vL} = (V_{vL3} + V_{vL4})/2$$

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

(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} .

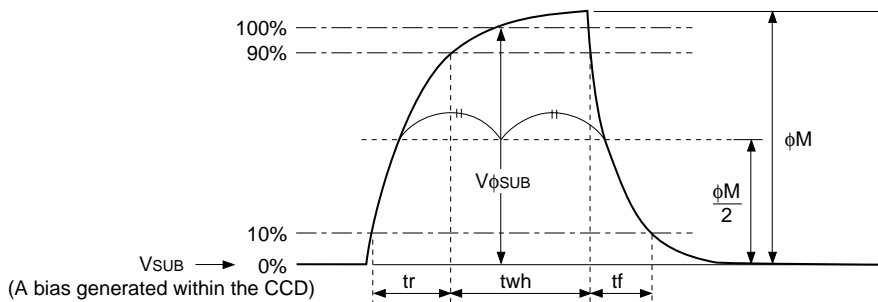
$$V_{RGL} = (V_{RGLH} + V_{RGLL})/2$$

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

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

Negative overshoot level during the falling edge of RG is V_{RGLm} .

(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 | | | | | | 0.5 | | | 0.5 | | μ s | During readout | |
| Vertical transfer clock | $V_{\phi 1}, V_{\phi 2}, V_{\phi 3}, V_{\phi 4}$ | | | | | | | | | | 15 | | 250 | ns | *1 | |
| Horizontal transfer clock | During imaging | $H_{\phi 1}$ | 26 | 28.5 | | 26 | 28.5 | | | 6.5 | 9.5 | | 6.5 | 9.5 | ns | *2 |
| | | $H_{\phi 2}$ | 26 | 28.5 | | 26 | 28.5 | | | 6.5 | 9.5 | | 6.5 | 9.5 | | |
| | During parallel-serial conversion | $H_{\phi 1}$ | | 5.38 | | | | | | 0.01 | | | 0.01 | | μ s | |
| | | $H_{\phi 2}$ | | | | | 5.38 | | | 0.01 | | | 0.01 | | | |
| Reset gate clock | ϕ_{RG} | 11 | 13 | | | 51 | | | 3 | | | 3 | | ns | | |
| Substrate clock | ϕ_{SUB} | 1.5 | 1.8 | | | | | | | 0.5 | | | 0.5 | μ s | During drain 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].

| Item | Symbol | two | | | Unit | Remarks |
|---------------------------|--------------------------|------|------|------|------|---------|
| | | Min. | Typ. | Max. | | |
| Horizontal transfer clock | $H_{\phi 1}, H_{\phi 2}$ | 22 | 26 | | ns | *3 |

*3 The overlap period for twh and twl of horizontal transfer clocks $H_{\phi 1}$ and $H_{\phi 2}$ is two.

Image Sensor Characteristics

(Ta = 25°C)

| Item | Symbol | Min. | Typ. | Max. | Unit | Measurement method | Remarks |
|----------------------|--------------|------|------|------|------|--------------------|---------------|
| Sensitivity 1 | S1 | 640 | 800 | | mV | 1 | |
| Sensitivity 2 | S2 | 2200 | 3200 | | mV | 2 | |
| Saturation signal | Vsat | 1000 | | | mV | 3 | Ta = 60°C |
| Smear | Sm | | -108 | -100 | dB | 4 | |
| Video signal shading | SH | | | 20 | % | 5 | Zone 0 and I |
| | | | | 25 | % | 5 | Zone 0 to II' |
| Dark signal | Vdt | | | 2 | mV | 6 | Ta = 60°C |
| Dark signal shading | ΔVdt | | | 1 | mV | 7 | Ta = 60°C |
| Flicker | F | | | 2 | % | 8 | |
| Lag | Lag | | | 0.5 | % | 9 | |

Zone Definition of Video Signal Shading

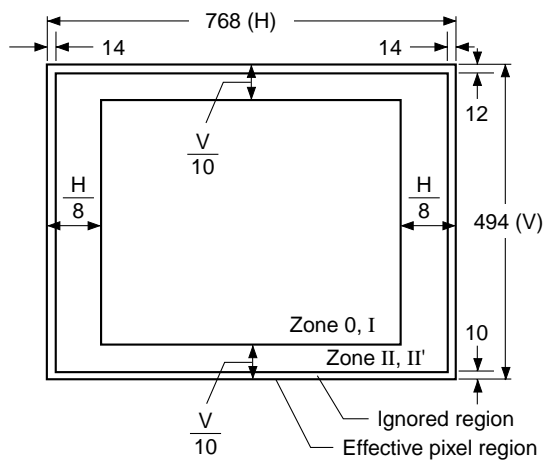


Image Sensor Characteristics Measurement Method

◎ 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, spot blemishes are excluded and, unless otherwise specified, the optical black (OB) level is used as the reference for the signal output, and the value measured at point [*A] in the drive circuit example is used.

◎ Definition of standard imaging conditions

- 1) Standard imaging condition I:
Use a pattern box (luminance: 706cd/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 F8. The luminous intensity to the sensor receiving surface at this point is defined as the standard sensitivity testing luminous intensity.
- 2) Standard imaging condition II:
Indicate the state which removes an IR cut filter of standard imaging condition I.
- 3) 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 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.
- 4) Standard imaging condition IV:
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 1

Set to standard imaging condition I. After selecting the electronic shutter mode with a shutter speed of 1/250s, measure the signal output (V_{S1}) at the center of the screen and substitute the value into the following formula.

$$S1 = V_{S1} \times \frac{250}{60} \text{ [mV]}$$

2. Sensitivity 2

Set to standard imaging condition II. After selecting the electronic shutter mode with a shutter speed of 1/1000s, measure the signal output (V_{S2}) at the center of the screen and substitute the value into the following formula.

$$S2 = V_{S2} \times \frac{1000}{60} \text{ [mV]}$$

3. Saturation signal

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

4. Smear

Set to standard imaging condition III. With the lens diaphragm at F5.6 to F8, adjust the luminous intensity to 500 times the intensity with average value of the signal output, 200mV. When the readout clock is stopped and the charge drain is executed by the electronic shutter at the respective H blankings, measure the maximum value YSm [mV] of the signal output and substitute the value into the following formula.

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

5. Video signal shading

Set to standard imaging condition IV. With the lens diaphragm at F5.6 to F8, adjust the luminous intensity so that the average value of the signal output is 200mV. Then measure the maximum (Vmax [mV]) and minimum (Vmin [mV]) values of the signal output and substitute the values into the following formula.

$$SH = (V_{max} - V_{min})/200 \times 100 \text{ [%]}$$

6. Dark signal

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

7. Dark signal shading

After measuring 6, measure the maximum (Vdmax [mV]) and minimum (Vdmin [mV]) values of the dark signal output and substitute the values into the following formula.

$$\Delta V_{dt} = V_{dmax} - V_{dmin} \text{ [mV]}$$

8. Flicker

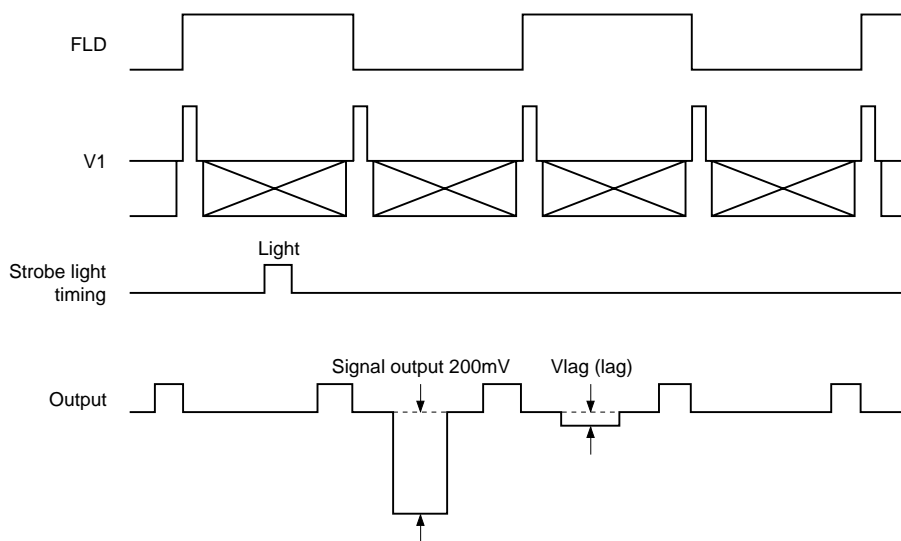
Set to standard imaging condition III. Adjust the luminous intensity so that the average value of the signal output is 200mV, and then measure the difference in the signal level between fields (ΔV_f [mV]). Then substitute the value into the following formula.

$$F = (\Delta V_f/200) \times 100 \text{ [%]}$$

9. Lag

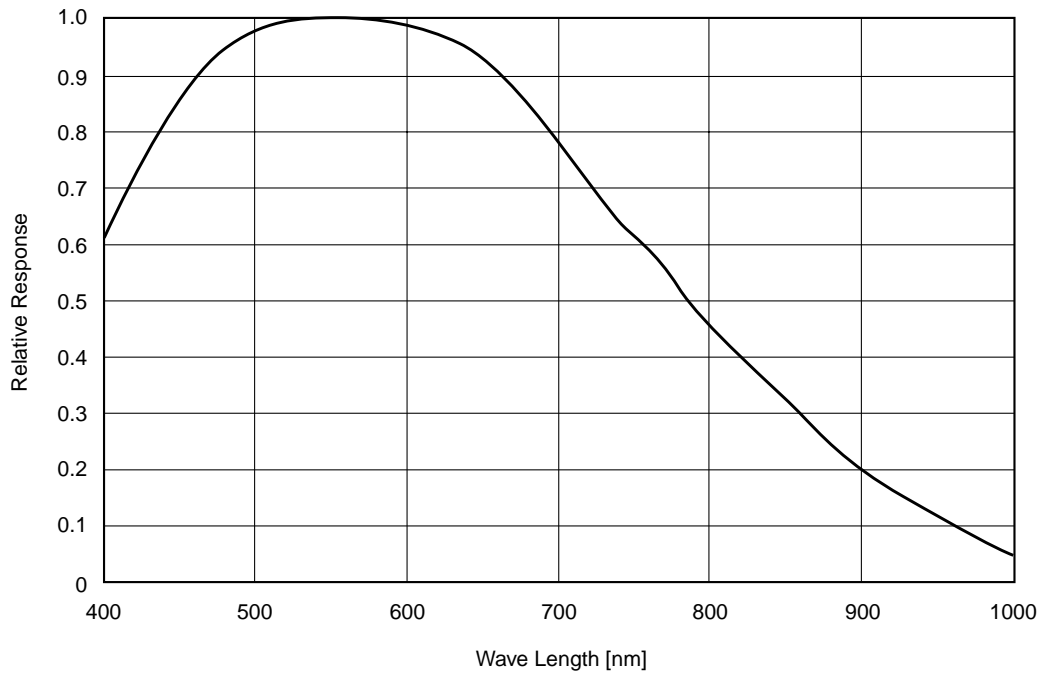
Adjust the signal output value generated by strobe light to 200mV. After setting the strobe light so that it strobos with the following timing, measure the residual signal (Vlag). Substitute the value into the following formula.

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

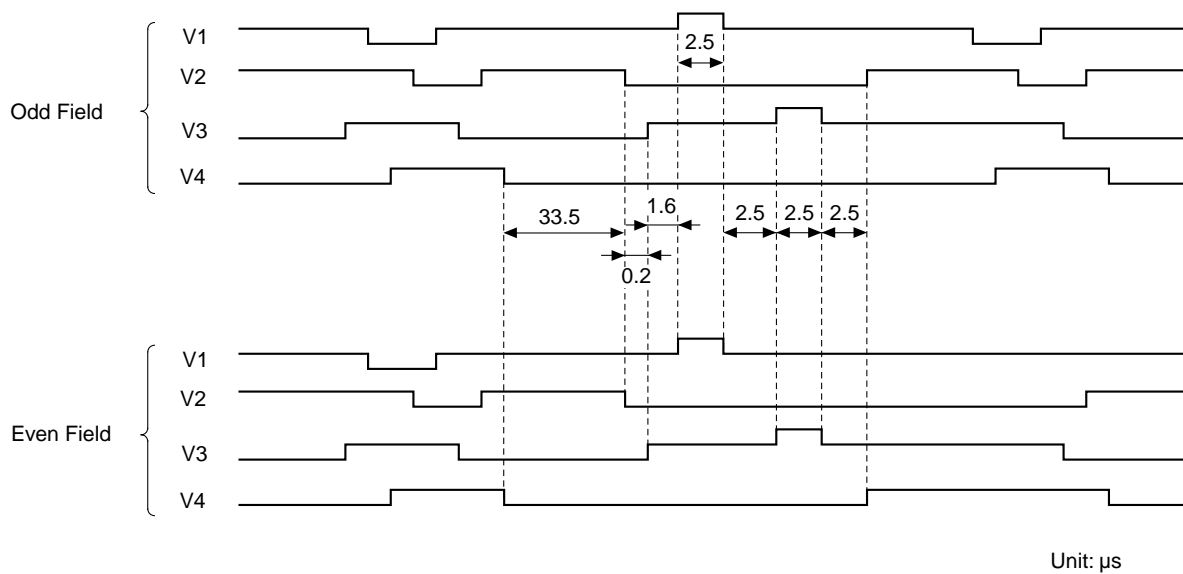


Spectral Sensitivity Characteristics

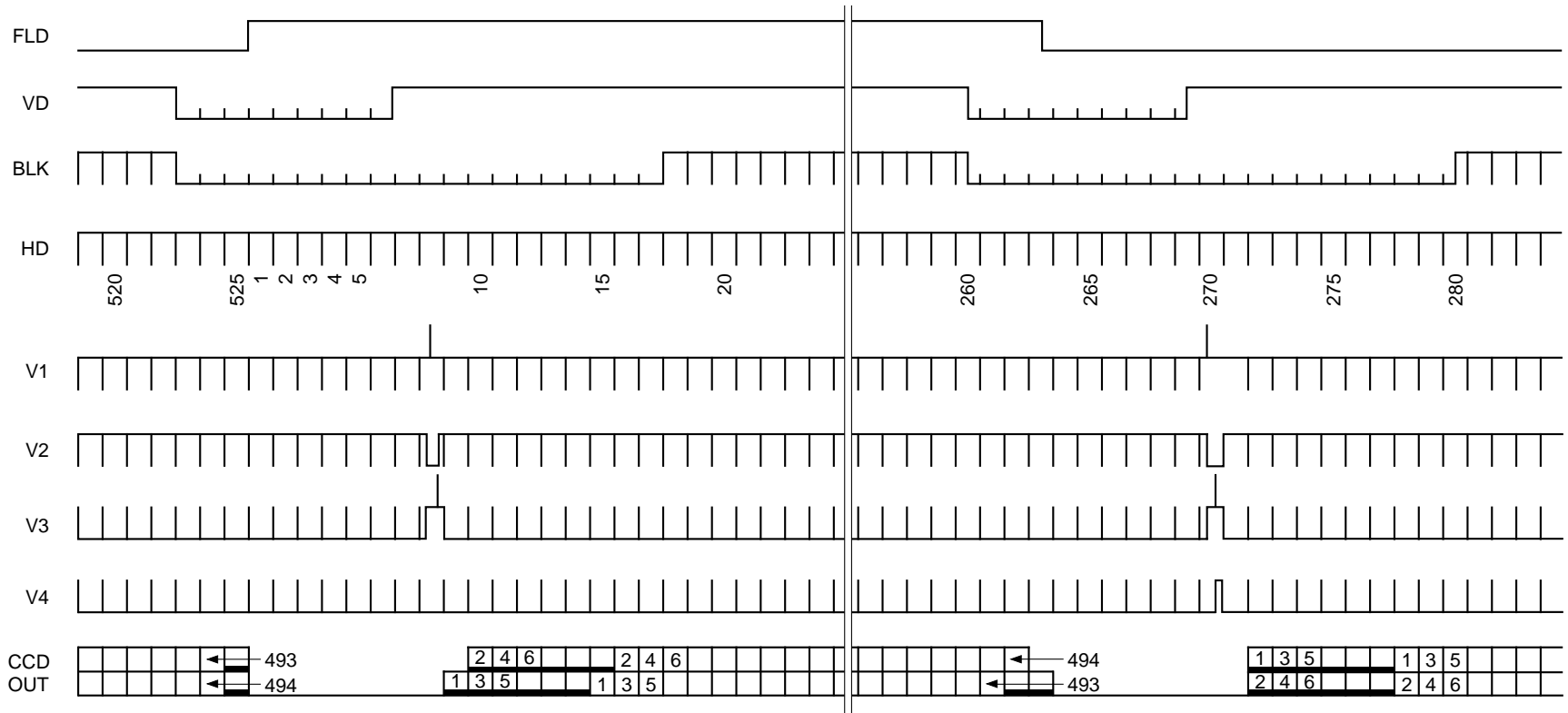
(excludes both lens characteristics and light source characteristics)



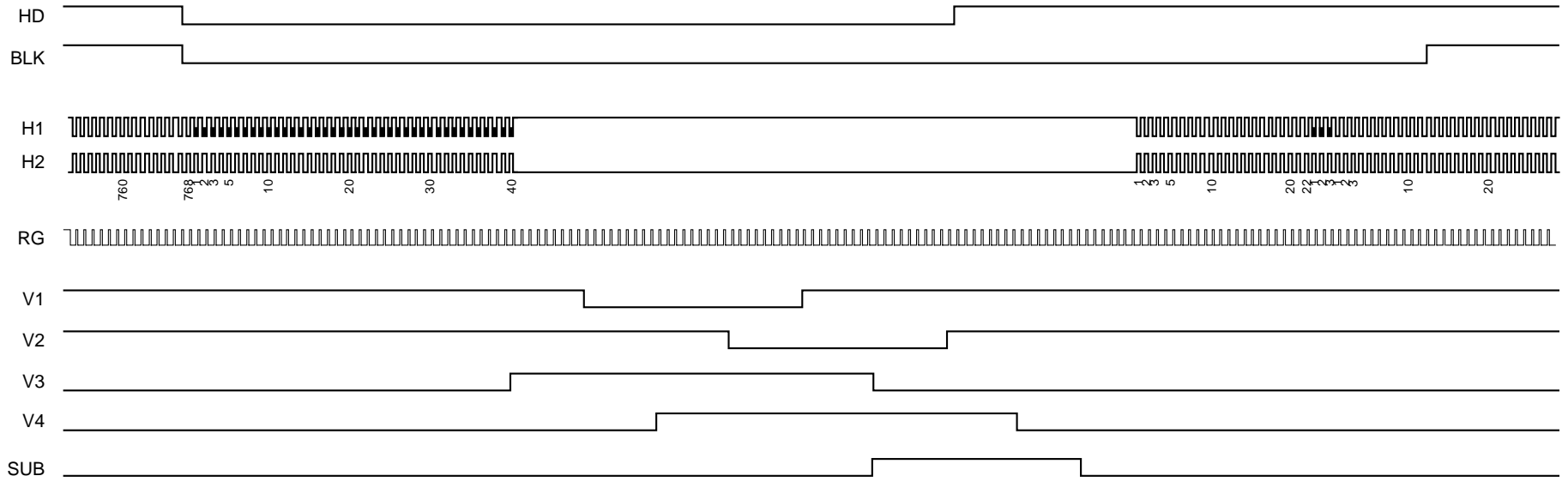
Sensor Readout Clock Timing Chart



Drive Timing Chart (Vertical Sync)



Drive Timing Chart (Horizontal Sync)



Notes on Handling

1) Static charge prevention

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

- a) Either handle bare handed or use non-chargeable gloves, clothes or material.
Also use conductive shoes.
- b) When handling directly use an earth band.
- c) Install a conductive mat on the floor or working table to prevent the generation of static electricity.
- d) Ionized air is recommended for discharge when handling CCD image sensor.
- e) For the shipment of mounted substrates, use boxes treated for the prevention of static charges.

2) Soldering

- a) Make sure the package temperature does not exceed 80°C.
- b) Solder dipping in a mounting furnace causes damage to the glass and other defects. Use a ground 30W soldering iron and solder each pin in less than 2 seconds. For repairs and remount, cool sufficiently.
- c) To dismount an image sensor, do not use a solder suction equipment. When using an electric desoldering tool, use a thermal controller of the zero cross On/Off type and connect it to ground.

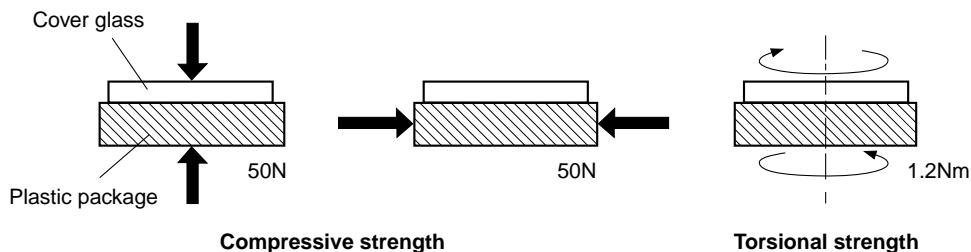
3) Dust and dirt protection

Image sensors are packed and delivered by taking care of protecting its glass plates from harmful dust and dirt. Clean glass plates with the following operation as required, and use them.

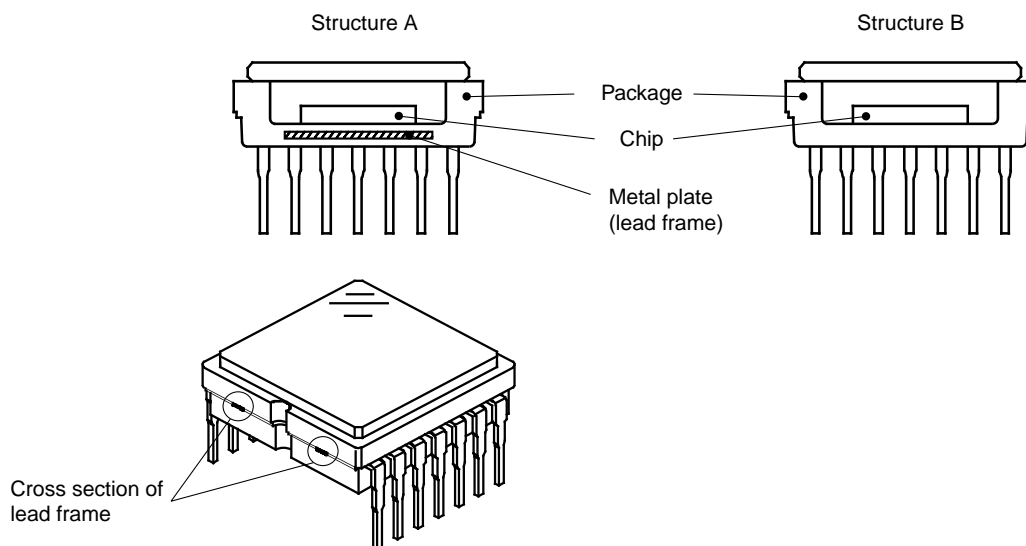
- a) Perform all assembly operations in a clean room (class 1000 or less).
- b) Do not either touch glass plates by hand or have any object come in contact with glass surfaces. Should dirt stick to a glass surface, blow it off with an air blower. (For dirt stuck through static electricity ionized air is recommended.)
- c) Clean with a cotton bud and ethyl alcohol if the grease stained. Be careful not to scratch the glass.
- d) Keep in a case to protect from dust and dirt. To prevent dew condensation, preheat or precool when moving to a room with great temperature differences.
- e) When a protective tape is applied before shipping, just before use remove the tape applied for electrostatic protection. Do not reuse the tape.

4) Installing (attaching)

- a) 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.)



- b) 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, or an adhesive.
 - c) 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.
 - d) 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.
 - e) If the lead bend repeatedly and the metal, etc., clash or rub against the package, the dust may be generated by the fragments of resin.
 - f) Acrylate anaerobic adhesives are generally used to attach CCD image sensors. In addition, cyano-acrylate instantaneous adhesives are sometimes used jointly with acrylate anaerobic adhesives. (reference)
- 5) Others
- a) Do not expose to strong light (sun rays) for long periods. For continuous using under cruel condition exceeding the normal using condition, consult our company.
 - b) Exposure to high temperature or humidity will affect the characteristics. Accordingly avoid storage or usage in such conditions.
 - c) The brown stain may be seen on the bottom or side of the package. But this does not affect the CCD characteristics.
 - d) This CCD image sensor has sensitivity in the near infrared area. Its focus may not match in the same condition under visible light/near infrared light because of aberration. Incident light component of long wavelength which transmits the silicon substrate may have bad influence upon image.
 - e) 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.

