

**LC9997M**

## 1/5-Inch Frame Transfer CCD NTSC Color Image Sensor

### Preliminary

### Overview

The LC9997M is a 1/5-inch optical size frame transfer CCD solid-state image sensor.

### Features

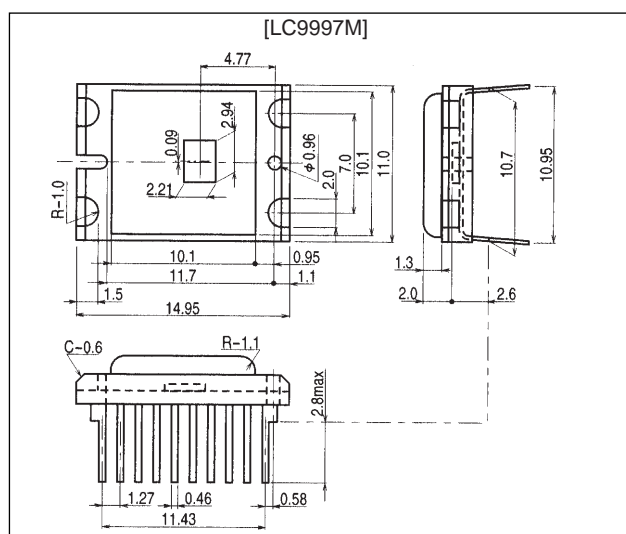
- Effective pixels [total pixels]:  $508 \times 246$  [ $532 \times 250$ ] (H  $\times$  V)
- Number of optical black pixels:  
Horizontal: 2 in front, 22 in back  
Vertical: 2.5 above, 1.5 below
- Dummy bits: Horizontal: 4 pixels
- Horizontal resolution: 330 TV lines
- Small form factor supports compact application products
- 20-pin half-pitch transparent DIP package
- Horizontal shift register operates at 5 V.
- Supports variable-speed electronic shutter operation.

### Device Structure

- 1/5-inch optical size frame transfer CCD image sensor
- Unit cell size:  $5.8 \mu\text{m} \times 9.0 \mu\text{m}$  (H  $\times$  V)
- Chip size:  $4.18 \text{ mm} \times 5.10 \text{ mm}$  (H  $\times$  V)
- Parallel gate CCD sensor
- Built-in high-sensitivity output amplifier
- Cy-G-Ye-W mosaic complementary color filters

### Package Dimensions

unit: mm

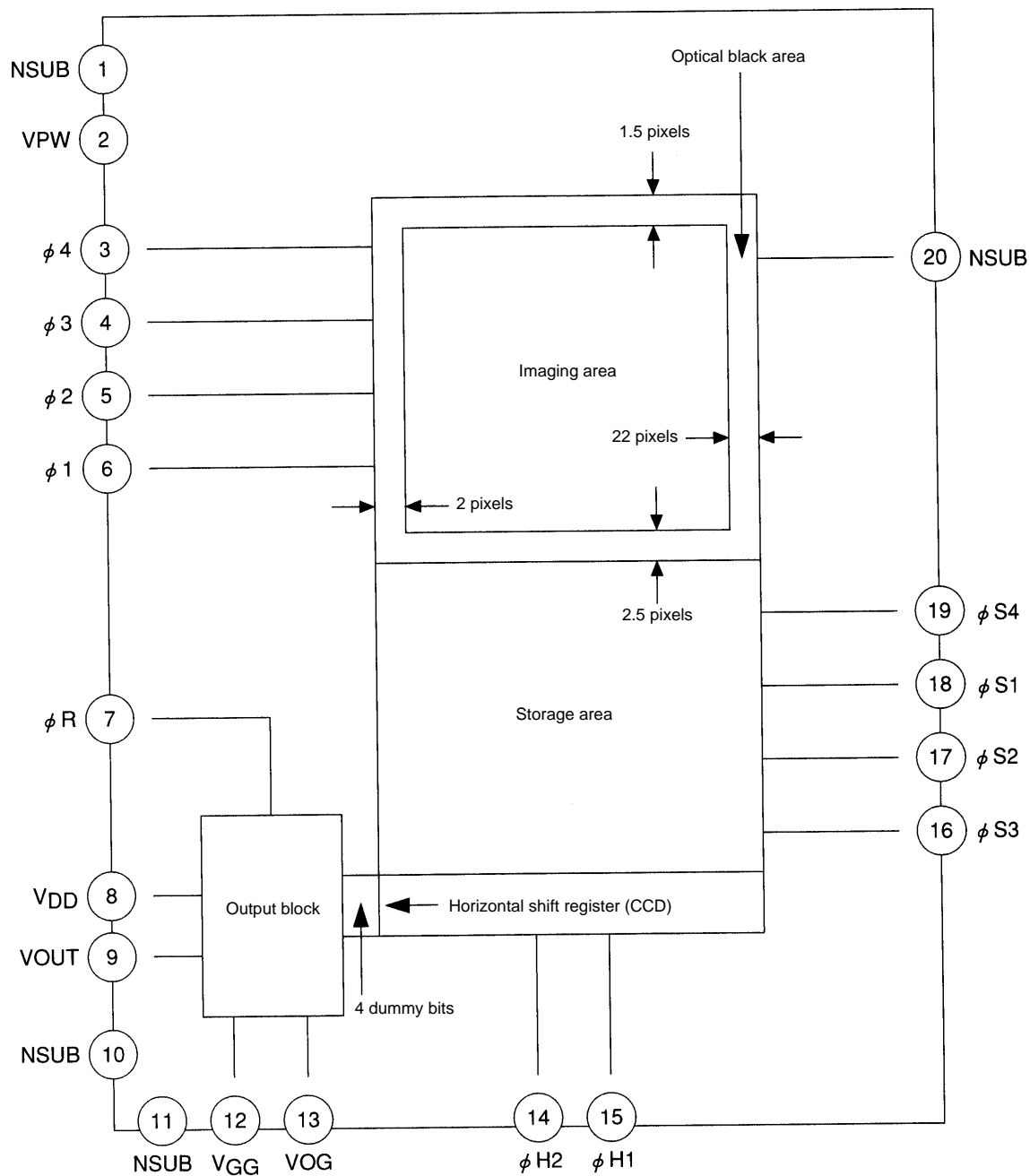
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### Specifications

#### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

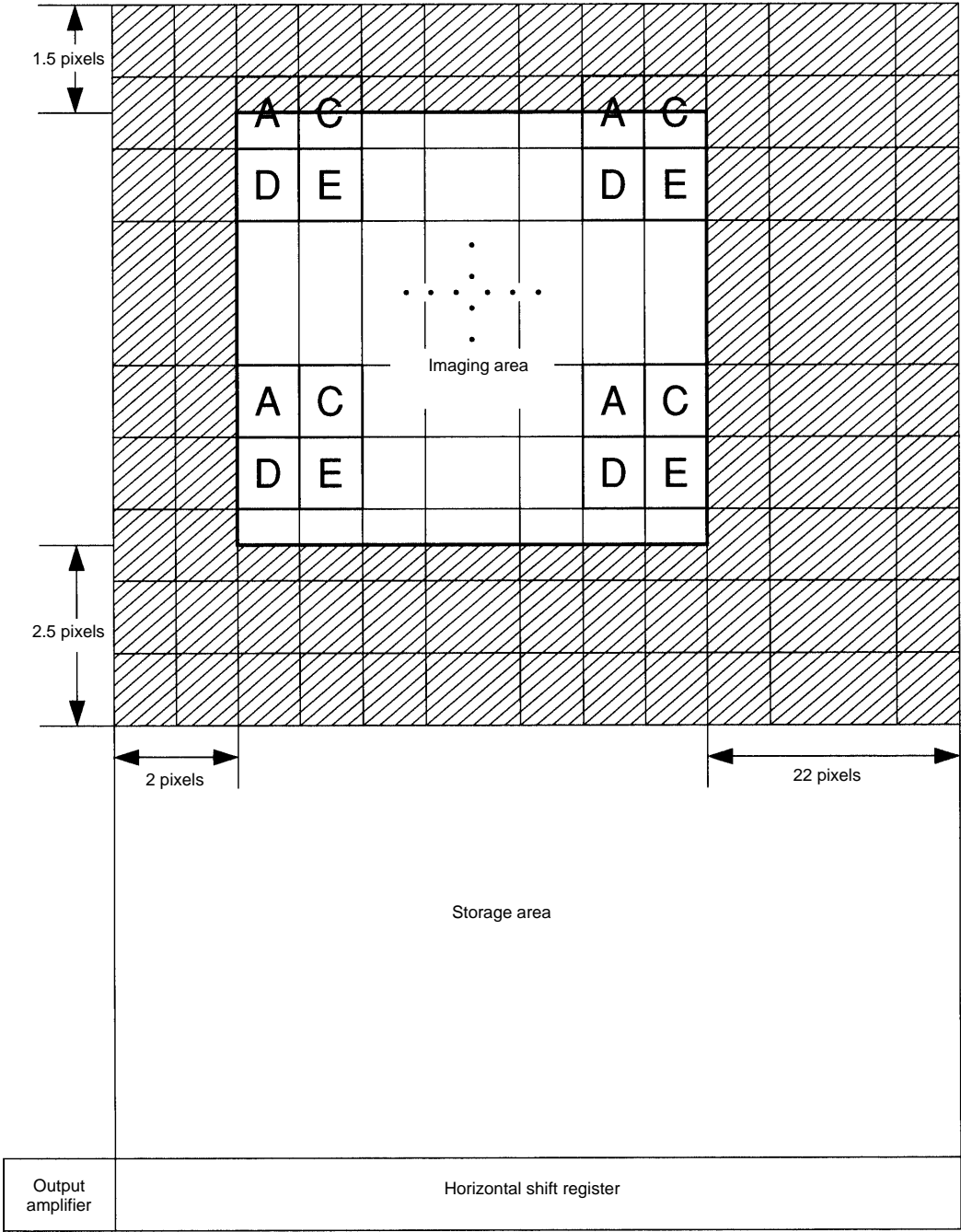
Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	$V_{DD}$	$V_{PW} = 0 \text{ V}$	-0.3 to +18	V
Load gate voltage	$V_{GG}$	$V_{PW} = 0 \text{ V}$	-0.3 to +5	V
N substrate - p-well voltage		NSUB-VPW	-0.3 to +50	V
N substrate - image and storage area voltage		NSUB- $\phi 1$ to $\phi 4$ , $\phi S1$ to $\phi S4$	-0.3 to +55	V
Pin voltage		Horizontal clock pin, $\phi R$ : $V_{PW} = 0 \text{ V}$	-0.3 to +18	V
		Other clock pins: $V_{PW} = 0 \text{ V}$	-15 to +18	V
		Other pins: $V_{PW} = 0 \text{ V}$	-0.3 to +10	V
Operating temperature	$T_{opr}$		-10 to +60	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-30 to +80	$^\circ\text{C}$

## Block Diagram



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Pixel Arrangement

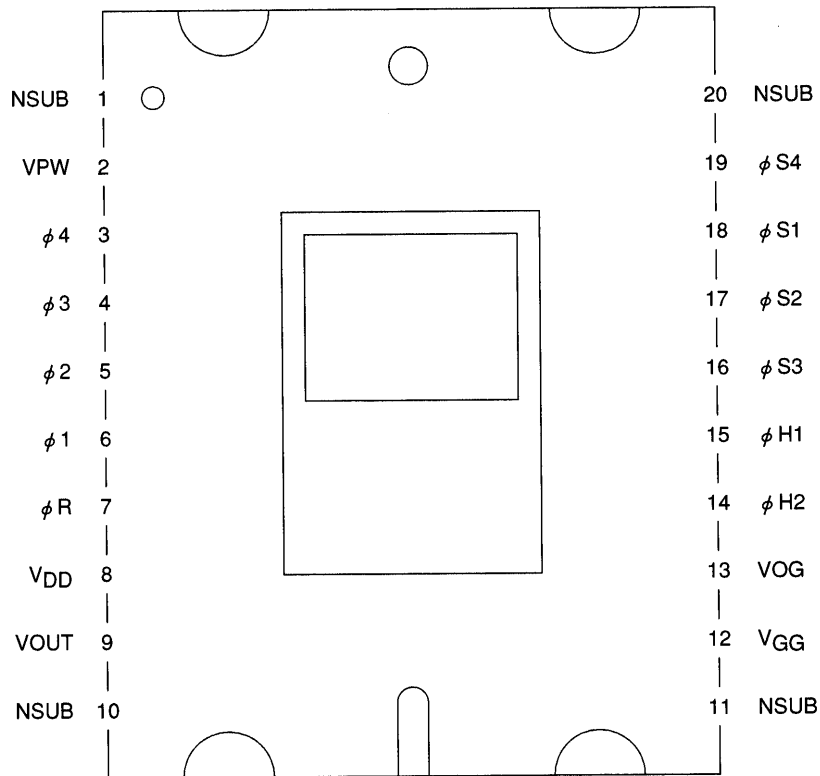


A	C
D	E

Ye : Yellow       $A = Cy + W$   
Cy : Cyan         $C = Ye + G$   
G : Green         $D = Cy + G$   
W : White         $E = Ye + W$

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## Pin Assignment



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## Pin Functions

Pin No.	Symbol	Function	Pin No.	Symbol	Function
1	NSUB	N substrate	20	NSUB	N substrate
2	WPW	P-well	19	$\phi$ S4	Storage area clocks
3	$\phi$ 4	Imaging area clock	18	$\phi$ S1	
4	$\phi$ 3		17	$\phi$ S2	
5	$\phi$ 2		16	$\phi$ S3	
6	$\phi$ 1	Reset gate	15	$\phi$ H1	Horizontal block clocks
7	$\phi$ R		14	$\phi$ H2	
8	V <sub>DD</sub>	Supply voltage	13	V <sub>OG</sub>	CCD output gate
9	V <sub>OUT</sub>	CCD output	12	V <sub>GG</sub>	Load gate
10	NSUB	N substrate	11	NSUB	N substrate

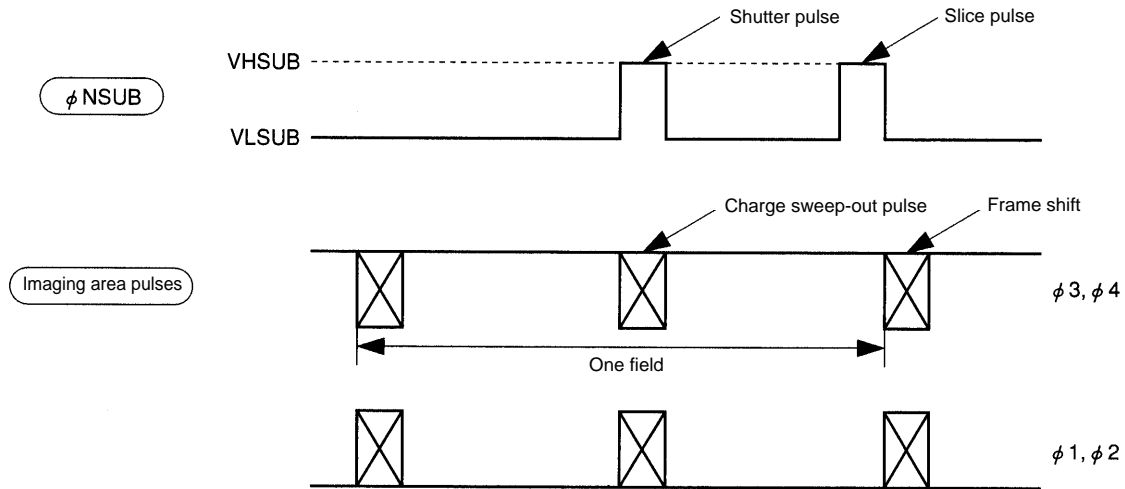
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### Clock Voltage Conditions at a frame shift frequency of 3.58 MHz

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Imaging area pulse signals: $\phi 1$ , $\phi 2$ , $\phi 3$ , $\phi 4$						
Pulse amplitude	$V_{PIF}$	*1	14.0	14.5	15.0	V
Low level	$V_{LIF}$	*1	−10.0	−9.5	−9.0	V
Storage area pulse signals: $\phi S1$ , $\phi S2$						
Pulse amplitude	$V_{PSL}$		14.0	14.5	15.0	V
Low level	$V_{LSL}$		−8.0	−7.5	−7.0	V
Storage area pulse signals: $\phi S3$ , $\phi S4$						
Pulse amplitude	$V_{PSL}$		14.0	14.5	15.0	V
Low level	$V_{LSL}$		−9.0	−8.5	−8.0	V
Horizontal transfer pulse signals: $\phi H1$ , $\phi H2$						
Pulse amplitude	$V_{PH}$		4.5	5.0	5.5	V
Low level	$V_{LH}$		0	0	0.5	V
Reset gate: $\phi R$						
Pulse amplitude	$V_{PR}$		4.5	5.0	5.5	V
Low level	$V_{LR}$		4.2	4.5	4.8	V
Substrate pulse: $\phi NSUB$						
Pulse amplitude	$V_{HSUB}$	*2. See Figure 1.	30.0		40.0	V
Low level	$V_{LSUB}$	See Figure 1.	17.5	18.0	18.5	V

Notes: 1. Insert 47-pF capacitance as shown in Figure 2.

2.  $V_{HSUB}$  must be adjusted so that the saturated output is maximum within the range where image degradation does not occur.



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Figure 1

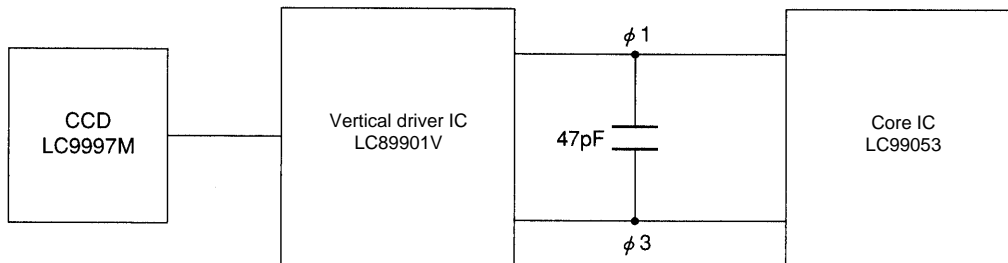


Figure 2

### Bias Conditions

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
P - well	$V_{PW}$			0		V
Output circuit voltage	$V_{DD}$	*3	14.5	15.0	15.5	V
	$V_{GG}$	*4	1.2	1.5	1.8	V
OG bias	$V_{OG}$	*4	4.5	5.0	5.5	V

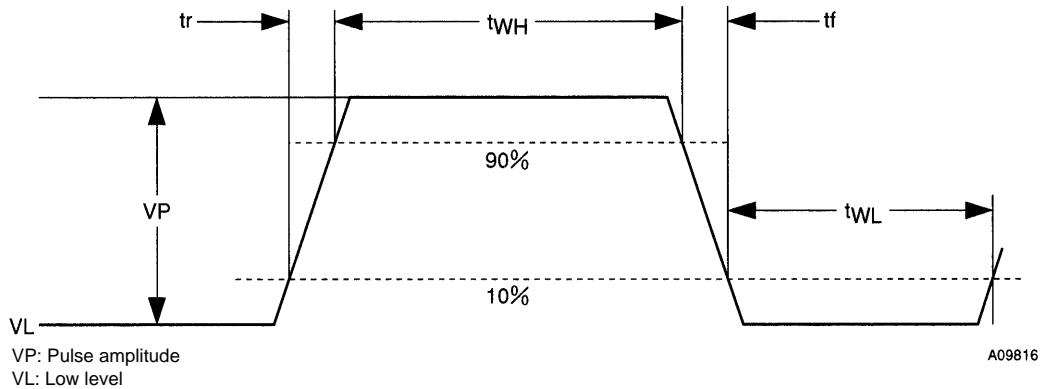
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Notes: 3. This voltage must not exceed the substrate pulse low level  $V_{LSUB}$ .  
4. These input pins are high-impedance inputs.

### DC Characteristics

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
DC operating current	$I_{DD}$		4.5	7.0	11.0	mA

### Drive Pulse Waveform Stipulations



### Pulse Waveform Figure

Symbol	tWH	tWL	tr	tf	Unit	Notes
	typ	typ	typ	typ		
$\phi 1$	166	100	6.5	6.5	ns	Frame transfer time When the frame shift frequency is 3.58 MHz
$\phi 2$	141	116	11	11		
$\phi 3$	166	100	6.5	6.5		
$\phi 4$	141	116	11	11		
$\phi S1$	141	116	11	11	ns	Frame transfer time When the frame shift frequency is 3.58 MHz
$\phi S2$	141	116	11	11		
$\phi S3$	141	116	11	11		
$\phi S4$	141	116	11	11		
$\phi S1$	1.36	62.1	30	30	ns	Vertical transfer time for a single horizontal line Values in the box enclosed in the darker lines <span style="border: 1px solid black; padding: 0 2px;"> </span> are in microseconds.
$\phi S2$	1.36	62.1	30	30		
$\phi S3$	62.1	1.36	30	30		
$\phi S4$	62.1	1.36	30	30		
$\phi R$	11	86	4	4	ns	Reset pulse
$\phi H1$	50	49	3	3		Horizontal transfer time
$\phi H2$	50	49	3	3		
$\phi NSUB$	9.9	16.59*	0.07	1	$\mu s$	Slice pulse
$\phi NSUB$	4.2	16.59*	0.07	1	$\mu s$	Shutter pulse

Note: The item marked with an asterisk (\*) is in milliseconds.

### Imaging Characteristics (storage time = 1/60 s) at $T_a = 25^\circ C$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
[Sensitivity]						
Luminance signal	S	Test method 1		130		mV
R gain	G <sub>R</sub>	Test method 1	0.7		2.4	
B gain	G <sub>B</sub>	Test method 1	2.0		4.4	
Image signal uniformity	VF	Test method 2			15	%
Saturation signal	Vsat	Test method 3, *5	600			mV
Smear	SM	Test method 4, *6		0.04		%
Dark signal	Vdrk	Test method 5. Ta = 55°C			7	mV
Color irregularity (mura)	Vcs	Test method 6			50	mV
Gamma characteristics	γ			1		

Notes: 5. When the substrate pulse  $V_{HSUB}$  is used fixed at  $40 \pm 2$  V, the minimum saturation output is 450 mV.

6. When the frame shift frequency is 3.58 MHz and the storage time is 1/60 s.

## Test Methods

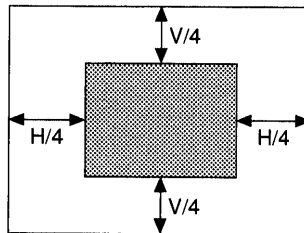
The following tests are to be performed using the evaluation unit made by Sanyo Electric Co., Ltd.

### 1. Sensitivity

Using the CCD-SY1 light source (made by Wakasa Optical Co., Ltd.) illuminate the pixel surface with an intensity of 7 lux. Measure the CCD outputs (G, Ye, Cy, and W) at the center of the screen in that state with the T8331 tester (made by Advantest, Inc.). The sensitivity is the average value for four pixels.

Use the following formulas to determined the R and G gains.

$$\begin{aligned} R &= E - D \\ B &= A - C \\ G &= (C+D)/2 \\ GR &= G/R \\ GB &= G/B \end{aligned}$$



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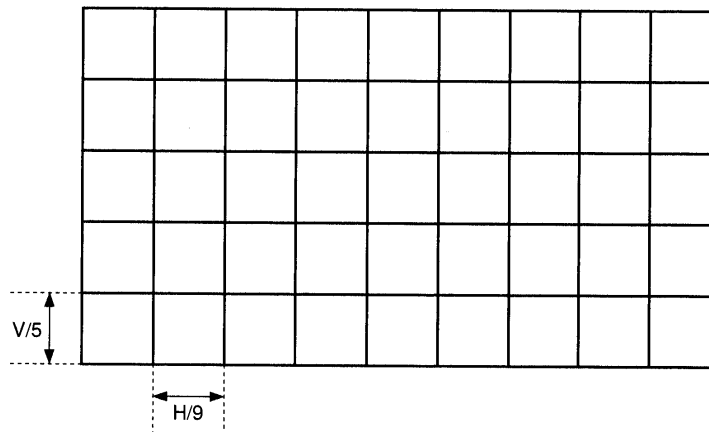
### 2. Image signal uniformity

Measure the uniformity under the following conditions

- The standard drive state (See the specifications document.)
- Using a halogen lamp with a color temperature of 3200 °K as the light source
- Using an IR cutting filter (C-500, 1mmt)

Illuminate the CCD surface with an intensity of 7 lux. Divide the surface of the CCD into 45 sections as shown in the figure and measure the average value for each block. Determine the maximum, minimum, and mean of those measurements, and determine the ratio of the difference with respect to the block average.

$$VF = \frac{\langle \text{Maximum of the block averages} \rangle - \langle \text{Minimum of the block averages} \rangle}{\langle \text{Mean of the block averages} \rangle}$$



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### 3. Saturation signal

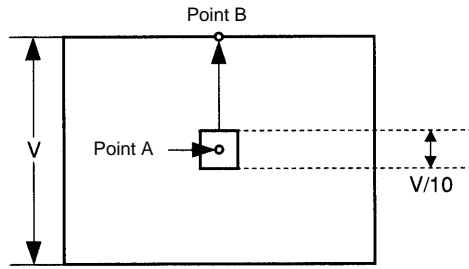
Set up the following conditions using the Sanyo evaluation unit.

- The standard drive state (See the specifications document.)
- Light source: The LV-2001 pattern box (made by Kyoritsu Electronics, intensity: 870 NITS, color temperature: 3100 °K)
- Lens: HF 16A (made by Fujinon) with the aperture fully open.

Measure the CCD output signal from the center of the screen under these conditions.

### 4. Smear

- Place the 1/10-V chart described below in front of the halogen light source and image it.
- Using neutral density filters, adjust the incident illumination such that the CCD output signal at point A becomes 250 mV.
- Remove the neutral density filters and measure the value of the CCD output signal for the first line (i.e. at point B).



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$$SM = \frac{VB \cdot TND}{250} \times 100 [\%]$$

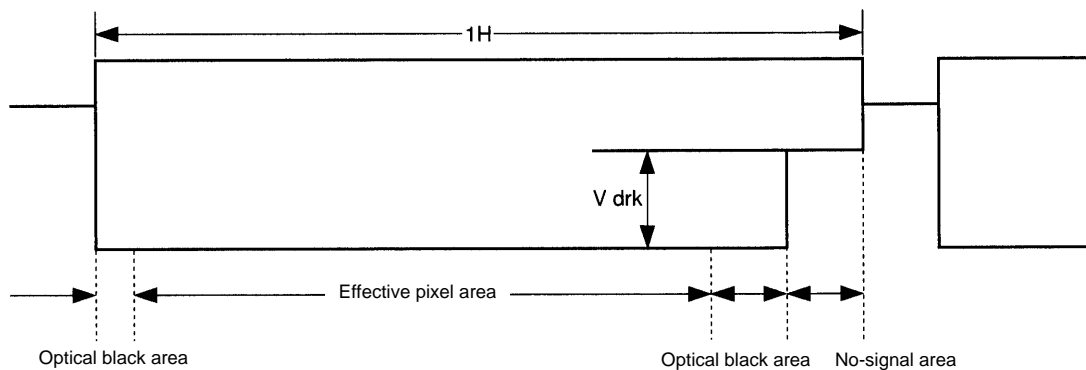
VB: The amount of smear at point B (mV)

TND: The transmittance of the neutral density filters used.

##### 5. Dark signal

Block all light from the surface of the CCD element, and measure the CCD output signal at the center of the screen. For this measurement, do not measure the difference between the signal level and the optical black area level, but rather, read out the difference with the no-signal level at a point where there is no pixel information. (See the figure.)

##### Structure of the Horizontal Period



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##### 6. Color irregularity (mura)

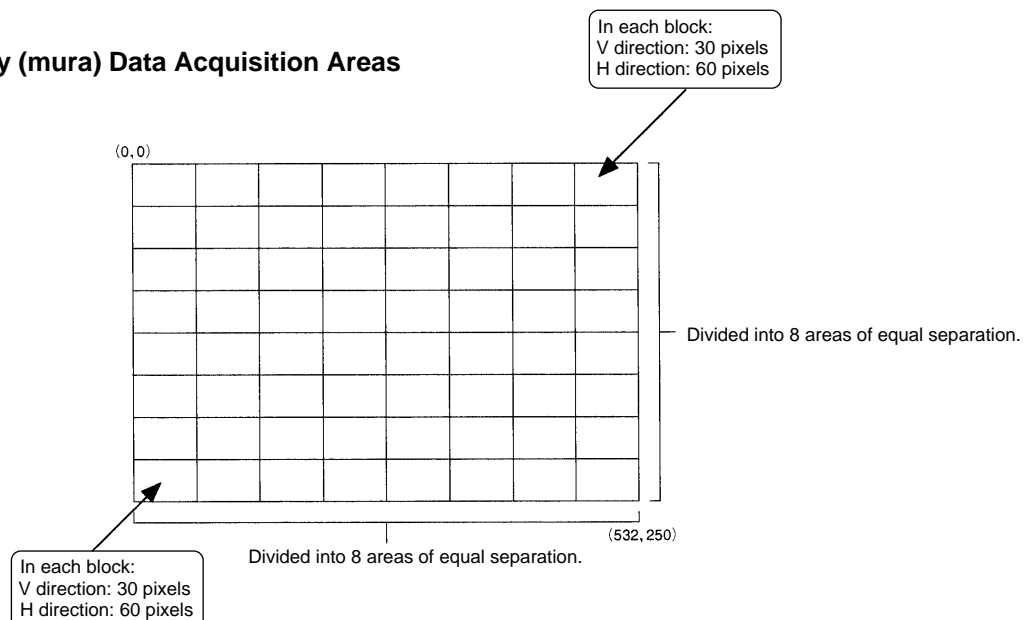
With no pattern in the LV-2001 pattern box, image the pattern box with a C-500 1-mm thick IR cut filter and a 7% neutral density filter over the whole surface of the 1/5-inch standard lens used for measurement. Verify that the CCD average output at this time is over 200 mV. Calculate the color difference signals RY and BY from the following formula from the average output of post-image processing R, G, and B signals. The color irregularity (mura) CS is defined as the distance between the two points for which the data (RY and BY) is separated the most for all the areas.

$$RY = \{(\text{red-green}) - (\text{blue-green}) \times 0.25\} \times 101/64$$

$$BY = \{(\text{blue-green}) - (\text{red-green}) \times 0.125\} \times 50/64$$

$$CS = \{(RY1-RY2)^2 + (BY1-BY2)^2\}^{1/2}$$

##### Color Irregularity (mura) Data Acquisition Areas



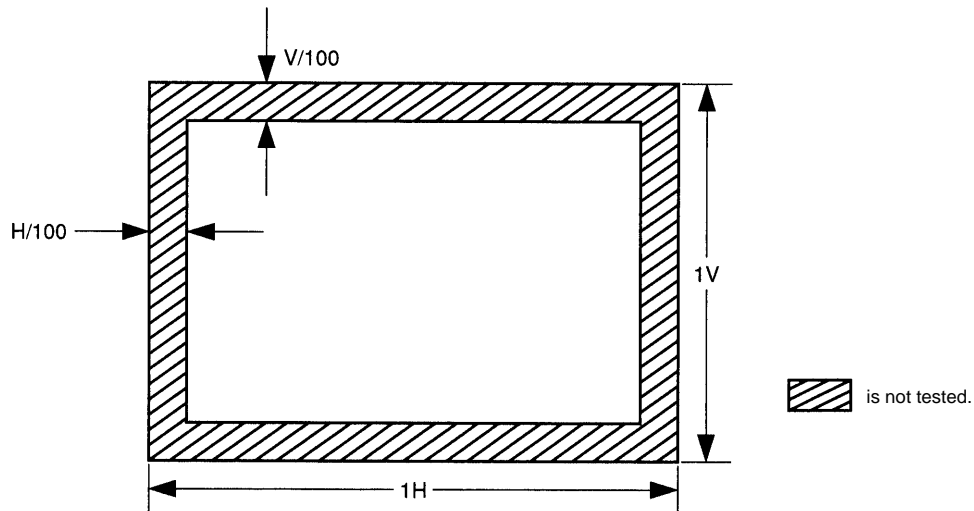


## Image Defect Standards

Test temperature	Test item	Allowable defects	Notes
55°C	White defects	At most 5 per zone	1
		No white defects that cover 2 or more pixels in the horizontal direction or 2 or more lines in the vertical direction.	
25°C	Black defects	At most 10 per zone	2
		No black defects that cover 2 or more pixels in the horizontal direction or 2 or more lines in the vertical direction.	
	Molding debris	No defects	3

## Test Conditions

Defect position are classified on the monitor as shown below.



### Notes

1. A white defect is a 10 mV or more higher than the CCD output optical black area for a black image. The CCD device is defective if any such level is 20 mV or more above the optical black level.
2. A black defect is a level that is 10% or more below the average level when the CCD is illuminated so that the average level is about 400 mV.
3. Using the Fujinon TV zoom lens H6 × 12.5R 1:1.2/12.5-75 stopped down to f 5.6 and with a 20% neutral density filter mounted, no dusts in the resin should be visible on the image screen.

**Notes on Handling****1. ESD prevention**

This CCD image sensor is easily damaged by ESD (electrostatic discharge). The following ESD prevention measures must be taken when handling this device.

- All personnel and all equipment must be grounded when handling this CCD device. For safety, personnel should be grounded through a resistor of about 1 M $\Omega$ . (We recommend using wrist straps.)
- This device should be handled with either bare hands or hands wearing antistatic gloves. Personnel should wear antistatic clothing. Conductive shoes must be worn.
- Spread conductive mats on floors and benches in the work areas to prevent static charges from accumulating.
- We recommend using ionized air blowers to minimize static charges in areas where CCD sensors are handled.
- Antistatic boxes must be used for transporting substrate mounting materials.
- Packing materials, boxes, and other items made from plastics, such as styrofoam, that easily accumulate static charges must not be placed on tables where CCD sensors are handled or in the vicinity of CCD handling operations.
- Tools, including testers, conveyors, and soldering irons, used in operations on CCD sensors must be grounded. Furthermore, the quality of that grounding must be tested periodically.
- Do not handle this IC in the vicinity of TV monitors or other devices that generate high static charges. If unavoidable, apply antistatic measures, such as covering the TV monitor screen with an antistatic filter.
- Since static charges accumulate more easily at a low relative humidity, the work environment must be maintained at a relative humidity of 50% or higher.

**2. Soldering**

- The package temperature must not exceed 80°C.
- In addition to ESD, CCD sensors are easily damaged by thermal stress. When mounting on a printed circuit board, the soldering iron temperature must never exceed 300°C, and the soldering time for each pin should be about 2 seconds.
- Only use soldering irons that include a temperature controller that holds the soldering tip at a fixed temperature.
- Be especially careful to avoid heating the device to over 80°C when repairing solder joints by hand and when removing CCDs sensors from printed circuit boards.

**3. Debris and contamination**

- Handle CCD sensors in a clean location only.
- Do not touch the package surface with bare hands. Also, do not allow the package surface to come in contact with any objects. If any foreign matter gets onto the package surface, remove it with an air blower. (We recommend using an ionized air blower if possible.)
- Remove oil or grease contamination from the CCD package surface with a cotton swab dipped in ethyl alcohol. Be careful not to damage the package surface.
- To prevent foreign matter and contamination from occurring, use dedicated cases to hold the CCD sensors, and also equalize temperatures gradually when moving CCD sensors between rooms with radical temperature differences to prevent condensation.

**4. Storage**

- Do not leave CCDs exposed to strong light, such as direct sunlight, for extended periods.
- Since high temperatures and high humidity can degrade device characteristics, avoid storing or using these devices in such environments. The temperature and humidity of locations used to store samples must always be within normal ranges (5 to 35°C and 45 to 75% RH).
- Since CCD sensors are precision optical instruments, be extremely careful not to apply mechanical shocks to these devices.
- Avoid locations with corrosive atmospheres or high dust levels.
- Avoid locations subject to rapid temperature changes.
- Do not stack heavy objects on top of containers holding CCD sensors during storage.
- Containers used to hold sample must be made from materials with good antistatic properties.
- Be extremely careful not to apply mechanical shocks to these devices, since that could lead to bent pins and reduced reliability during mounting.

5. Notes on mounting

- Use of lenses with optical sizes in excess of 1/5 inch can lead to flare. Consult your Sanyo representative when selecting lenses for use with this product.
- This product is mounted in a completely transparent plastic package, and thus is easily affected by light transmitted from the back through the printed circuit board on which the device is mounted. Accordingly, applications must provide adequate light shielding.

6. Transport

- Do not throw or drop packages containing CCD sensors.
- Protect CCD sensors from moisture when transporting during rain or snow.
- Minimize mechanical vibration and shock as much as possible when transporting CCD sensors.

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