Preliminary

TOSHIBA CCD Image Sensor
CCD (charge coupled device)

TCD2953CF

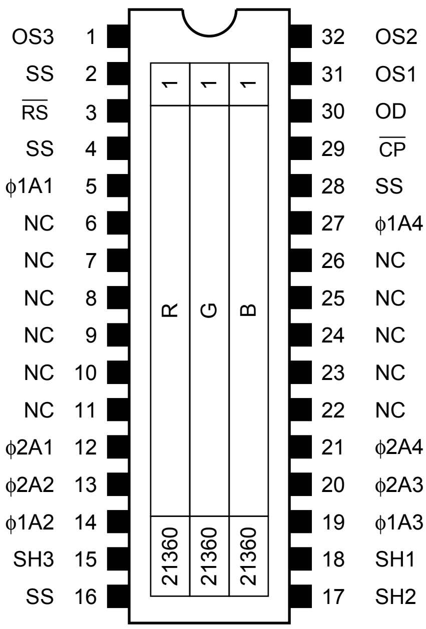
The TCD2953CF is a high sensitive and low dark current 10680 elements × 6 line CCD color image sensor which includes CCD drive circuit and clamp circuit. The sensor is designed for scanner.

The device contains a row of 10680 elements × 6 line staggered photodiodes which provide a 96 lines/mm (2400DPI) across a A4 size paper. The device is operated by 5 V pulse, and 12 V power supply.

Features

- Number of image sensing elements: 10680 elements × 6 line
- Image sensing element pitch: 4 μm
- Photo sensing region: High sensitive and low dark current PN photodiode
- Distance between photodiode array: 64 μm (16 lines), Red line-Green line, Green line-Blue line
  8 μm (2 lines), Odd line-Even-line
- Clock: 2 phase (5 V)
- Power supply: 12 V power supply voltage
- Internal circuit: Clamp circuit
- Package: 32 pin CLCC package
- Color filter: Red, green, blue
- Overflow drain for antiblooming

Pin Connections (top view)

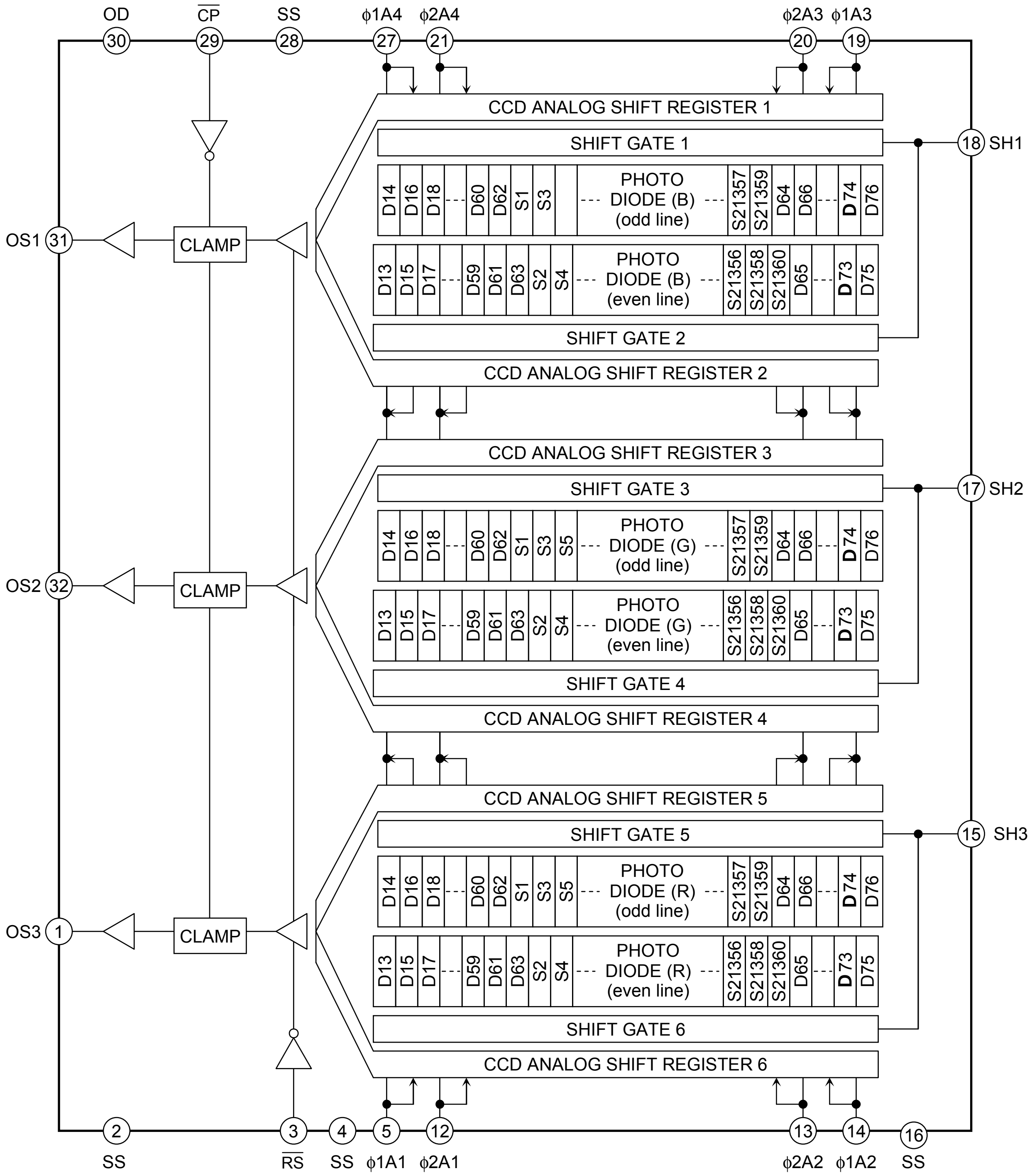


Maximum Ratings (Note1)

Characteristics	Symbol	Rating	Unit
Clock pulse voltage	V_{ϕ}	−0.3~8.0	V
Shift pulse voltage	V_{SH}		
Reset pulse voltage	$V_{\overline{RS}}$		
Clamp pulse voltage	$V_{\overline{CP}}$		
Power supply voltage	V_{OD}	−0.3~15	V
Operating temperature	T_{opr}	0~60	°C
Storage temperature	T_{stg}	−25~85	°C

Note 1: All voltage are with respect to SS terminals (ground).

Circuit Diagram



Pin Names

Pin No.	Symbol	Name	Pin No.	Symbol	Name
1	OS3	Signal output 3 (red)	32	OS2	Signal output 2 (green)
2	SS	Ground	31	OS1	Signal output 1 (blue)
3	$\overline{RS}$	Reset gate	30	OD	Power
4	SS	Ground	29	$\overline{CP}$	Clamp gate
5	ϕ_{1A1}	Clock 1 (phase 1)	28	SS	Ground
6	NC	Non connection	27	ϕ_{1A4}	Clock 4 (phase 1)
7	NC	Non connection	26	NC	Non connection
8	NC	Non connection	25	NC	Non connection
9	NC	Non connection	24	NC	Non connection
10	NC	Non connection	23	NC	Non connection
11	NC	Non connection	22	NC	Non connection
12	ϕ_{2A1}	Clock 1 (phase 2)	21	ϕ_{2A4}	Clock 4 (phase 2)
13	ϕ_{2A2}	Clock 2 (phase 2)	20	ϕ_{2A3}	Clock 3 (phase 2)
14	ϕ_{1A2}	Clock 2 (phase 1)	19	ϕ_{1A3}	Clock 3 (phase 1)
15	SH3	Shift gate 3	18	SH1	Shift gate 1
16	SS	Ground	17	SH2	Shift gate 2

Optical/Electrical Characteristics

(Ta = 25°C, V_{OD} = 12 V, V_{ϕ} = V_{SH} = $V_{\overline{RS}}$ = $V_{\overline{CP}}$ = 5 V (pulse), f_{ϕ} = 1 MHz, $f_{\overline{RS}}$ = 2 MHz, t_{INT} = 11 ms, LIGHT SOURCE = A LIGHT SOURCE + CM500S FILTER (t = 1 mm), LOAD RESISTANCE = 100 kΩ)

Characteristics		Symbol	Min	Typ.	Max	Unit	Note
Sensitivity	Red	$R_{(R)}$	1.0	1.5	2.0	V/lx・s	(Note 2)
	Green	$R_{(G)}$	1.4	2.0	2.6		
	Blue	$R_{(B)}$	0.9	1.4	1.9		
Photo response non uniformity		PRNU (1)	—	15	20	%	(Note 3)
		PRNU (3)	—	3	12	mV	(Note 4)
Register imbalance		RI	—	1	3	%	(Note 5)
Saturation Output Voltage		V_{SAT}	3.2	3.6	—	V	(Note 6)
Saturation Exposure		SE	1.23	1.80	—	lx・s	(Note 7)
Dark signal Voltage		V_{DRK}	—	0.5	2.0	mV	(Note 8)
Dark Signal Non Uniformity		DSNU	—	2.0	7.0	mV	(Note 8)
DC Power Dissipation		P_D	—	420	585	mW	—
Total Transfer Efficiency		TTE	92	98	—	%	—
Output Impedance		Z_O	—	0.3	1.0	kΩ	—
DC Compensation Output Voltage		V_{OS}	5.0	6.0	7.0	V	(Note 9)
Random Noise		$N_{D\sigma}$	—	0.8	—	mV	(Note 10)
Reset Noise		V_{RSN}	—	0.3	1.0	V	(Note 9)
Masking Noise		V_{MS}	—	0.2	1.0	V	(Note 9)

Note 2: Sensitivity is defined for each color of signal outputs average when the photosensitive surface is applied with the light of uniform illumination and uniform color temperature.

Note 3: PRNU (1) is defined for each color on a single chip by the expressions below when the photosensitive surface is applied with the light of uniform illumination and uniform color temperature.

$$\text{PRNU (1)} = \frac{\Delta x}{\overline{x}} \times 100\ (\%)$$

Where $\overline{x}$ is average of total signal output and ΔX is the maximum deviation from $\overline{x}$.
The amount of incident light is shown below.
Red = 1/2·SE
Green = 1/2·SE
Blue = 1/4·SE

Note 4: PRNU (3) is defined as maximum voltage with next pixels, where measured at 5% of SE (typ.).

Note 5: Register imbalance is defined as follows.

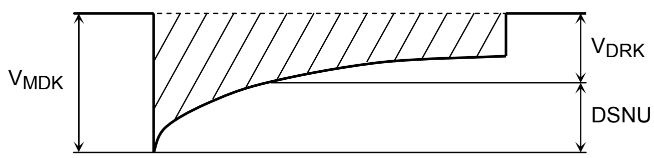
$$\text{RI} = \frac{\sum_{n=1}^{21359} \left| xn - x\,(n+1) \right|}{21359 \times \overline{x}} \times 100\ (\%)$$

Note 6: VSAT is defined as minimum saturation output of all effective pixels.

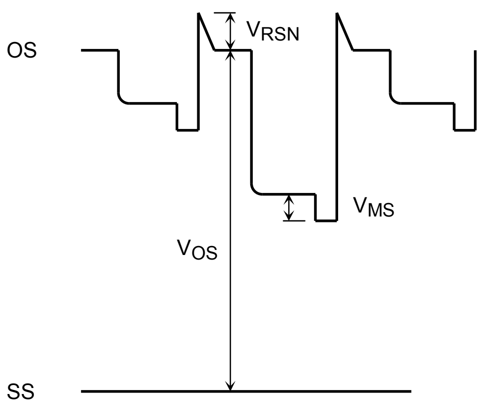
Note 7: Definition of SE

$$\text{SE} = \frac{V_{SAT}}{R_G}\ (\text{lx}\cdot\text{s})$$

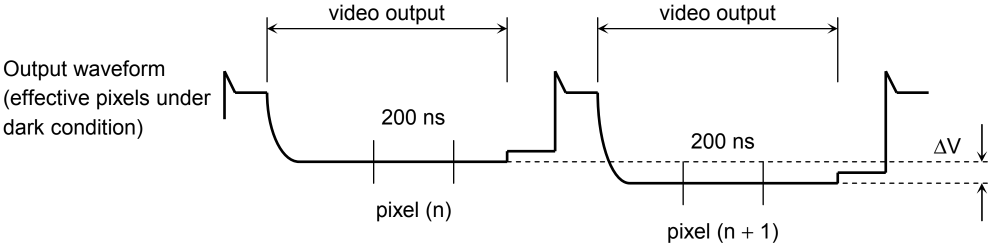
Note 8: V_{DRK} is defined as average dark signal voltage of all effective pixels.
DSNU is defined as different voltage between V_{DRK} and V_{MDK} when V_{MDK} is maximum dark signal voltage.



Note 9: DC signal output voltage is defined as follows. Reset noise voltage is defined as follows.
Masking noise voltage is defined as follows.



Note 10: Random noise is defined as the standard deviation (sigma) of the output level difference between two adjacent effective pixels under no illumination (i.e. darkconditions) calculated by the following procedure.



(1) Two adjacent pixels (pixel n and n + 1) in one reading are fixed as measurement points.

(2) Each of the output level at video output periods averaged over 200 ns period to get V (n) and V (n + 1).

(3) V (n + 1) is subtracted from V (n) to get ΔV.

$\Delta V = V(n) - V(n+1)$

(4) The standard deviation of ΔV is calculated after procedure (2) and (3) are repeated 30 times (30 readings).

$$\overline{\Delta V} = \frac{1}{30}\sum_{i=1}^{30}|\Delta V_i| \qquad \sigma = \sqrt{\frac{1}{30}\sum_{i=1}^{30}\left(|\Delta V_i| - \overline{\Delta V}\right)^2}$$

(5) Procedure (2), (3) and (4) are repeated 10 times to get sigma value.

(6) 10 sigma values are averaged.

$$\bar{\sigma} = \frac{1}{10}\sum_{j=1}^{10}\sigma_j$$

(7) $\bar{\sigma}$ value calculated using the above procedure is observed $\sqrt{2}$ times larger than that measured relative to the ground level. So we specify random noise as follows.

$$ND\sigma = \frac{1}{\sqrt{2}}\bar{\sigma}$$

Operating Condition

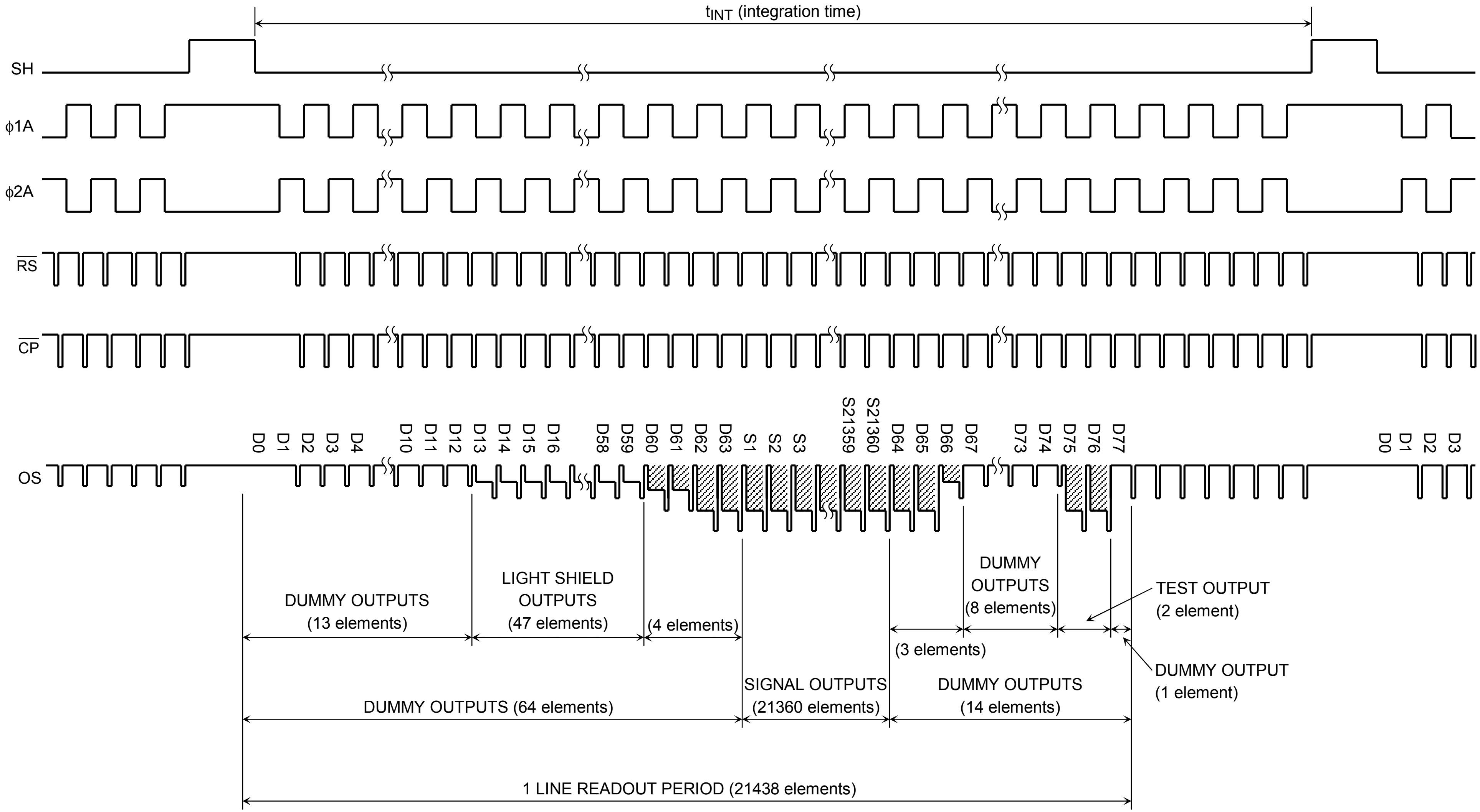
Characteristics		Symbol	Min	Typ.	Max	Unit	Note
Clock pulse voltage	"H" level	$V_{\phi A}$	4.5	5.0	5.5	V	
	"L" level		0	—	0.3		
Shift pulse voltage	"H" level	V_{SH}	4.5	5.0	5.5	V	
	"L" level		0	—	0.5		
Reset pulse voltage	"H" level	$V_{\overline{RS}}$	4.5	5.0	5.5	V	
	"L" level		0	—	0.5		
Clamp pulse voltage	"H" level	$V_{\overline{CP}}$	4.5	5.0	5.5	V	
	"L" level		0	—	0.5		
Power supply voltage		V_{OD}	11.4	12.0	13.0	V	

Clock Characteristics (Ta = 25°C)

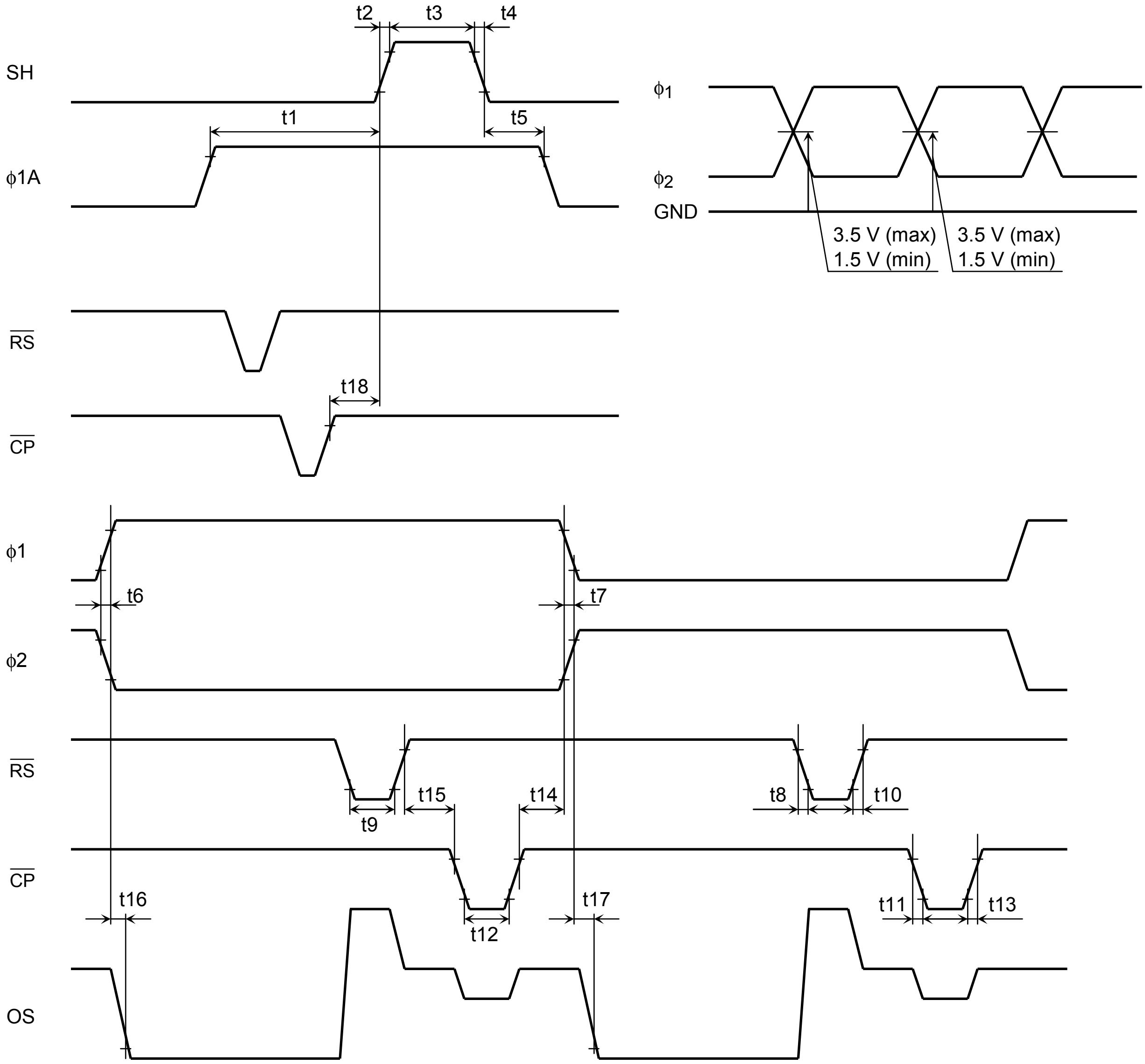
Characteristics	Symbol	Min	Typ.	Max	Unit
Clock pulse frequency	$f_{\phi A}$	0.15	1.0	10	MHz
Reset pulse frequency	$f_{\overline{RS}}$	0.3	2.0	10	MHz
Clamp pulse frequency	$f_{\overline{CP}}$	0.3	2.0	10	MHz
Clock capacitance (Note 11)	$C_{\phi A}$	—	400	—	pF
Shift gate capacitance	C_{SH}	—	50	—	pF
Reset gate capacitance	$C_{\overline{RS}}$	—	10	—	pF
Clamp gate capacitance	$C_{\overline{CP}}$	—	10	—	pF

Note 11: V_{OD} = 12 V

Timing Chart (bit clamp mode)



Timing Requirements



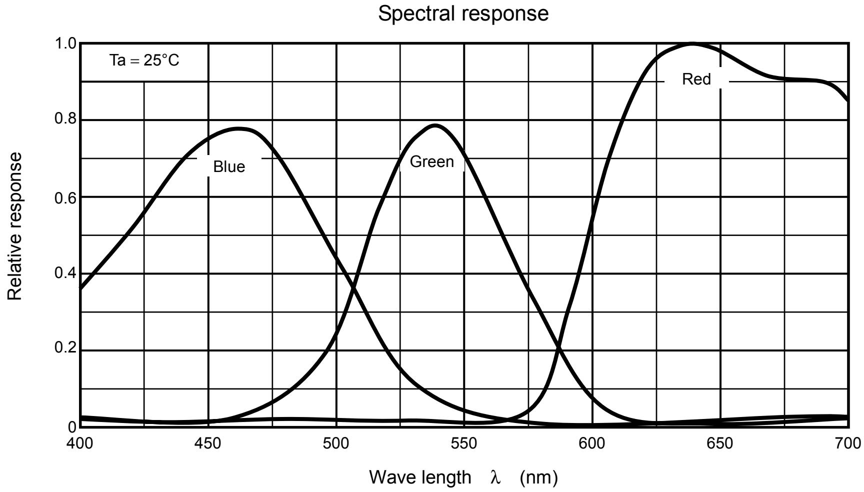
Timing Requirements

Characteristics	Symbol	Min	Typ. (Note11)	Max	Unit
Pulse timing of SH and ϕ1A	t1	110	1000	—	ns
	t5	200	1000	—	
SH pulse rise time, fall time	t2, t4	0	50	—	ns
SH pulse width	t3	1000	2000	—	ns
ϕ1, ϕ2 pulse rise time, fall time	t6, t7	0	50	—	ns
$\overline{RS}$ pulse rise time, fall time	t8, t10	0	20	—	ns
$\overline{RS}$ pulse width (Note 12)	t9	15	100	—	ns
$\overline{CP}$ pulse rise time, fall time	t11, t13	0	20	—	ns
$\overline{CP}$ pulse width	t12	20	100	—	ns
Pulse timing of ϕ_{1A}, ϕ_{2A} and $\overline{CP}$	t14	10	40	—	ns
Pulse timing of $\overline{RS}$ and $\overline{CP}$	t15	0	100	—	ns
Video data delay time (Note 13)	t16, t17	—	15	—	ns
Pulse timing of SH and $\overline{CP}$	t18	0	500	—	ns

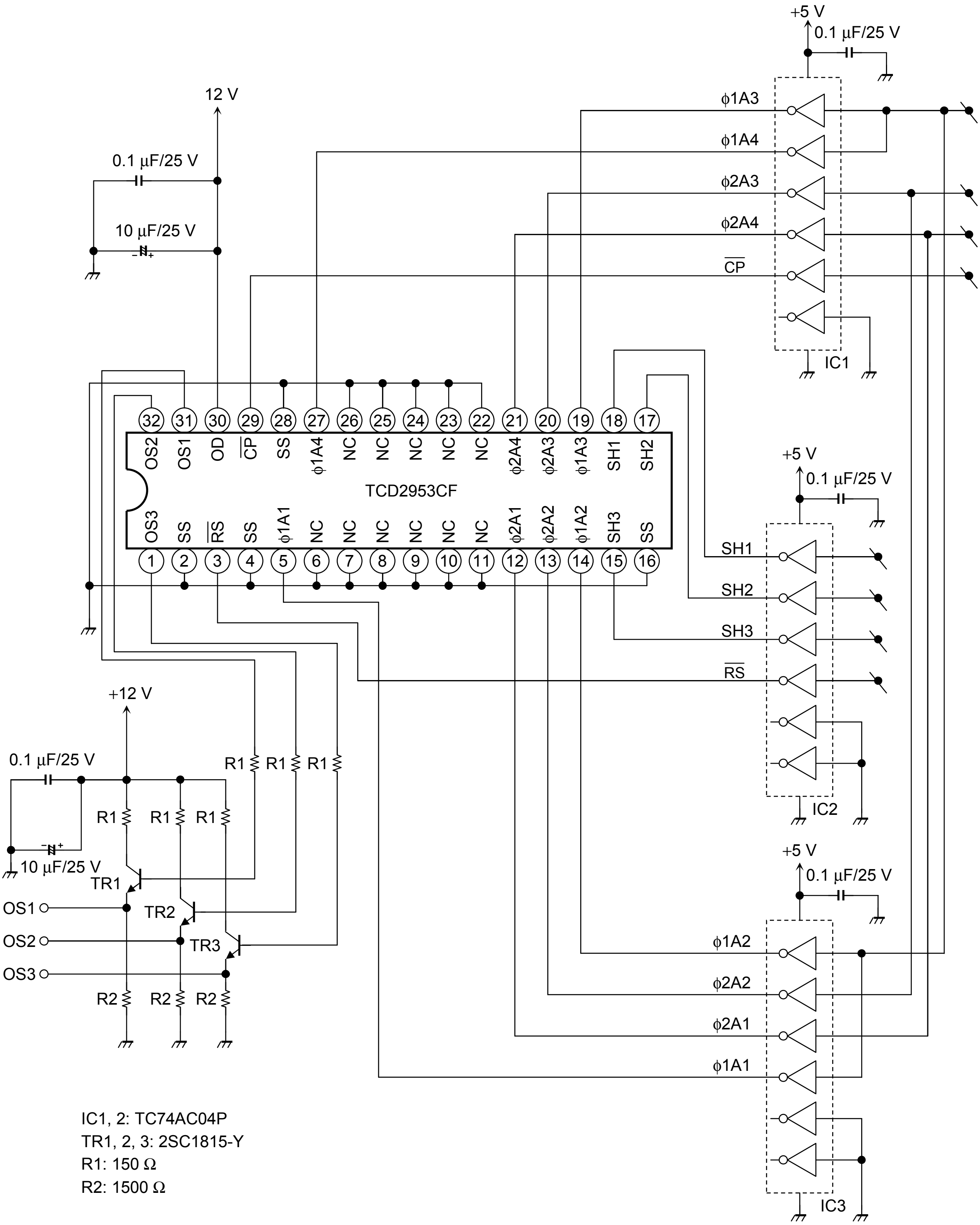
Note 12: TYP is the case of $f_{\overline{RS}} = 2.0$ MHz.

Note 13: Load resistance is 100 kΩ.

Typical Spectral Response



Typical Drive Circuit



IC1, 2: TC74AC04P
TR1, 2, 3: 2SC1815-Y
R1: 150 Ω
R2: 1500 Ω

Caution

1. Electrostatic Breakdown

Store in shorting clip or in conductive foam to avoid electrostatic breakdown.

CCD Image Sensor is protected against static electricity, but inferior puncture mode device due to static electricity is sometimes detected. In handing the device, it is necessary to execute the following static electricity preventive measures, in order to prevent the trouble rate increase of the manufacturing system due to static electricity.

a. Prevent the generation of static electricity due to friction by making the work with bare hands or by putting on cotton gloves and non-charging working clothes.
b. Discharge the static electricity by providing earth plate or earth wire on the floor, door or stand of the work room.
c. Ground the tools such as soldering iron, radio cutting pliers of or pincer.
   It is not necessarily required to execute all precaution items for static electricity.
   It is all right to mitigate the precautions by confirming that the trouble rate within the prescribed range.
d. Ionized air is recommended for discharge when handling CCD image sensors.

2. Incident Light

CCD sensor is sensitive to infrared light. Note that infrared light component degrades resolution and PRNU of CCD sensor.

3. Moisture-proof Packing

CCD surface mount products may have a haze on the inside of glass when thermal stress is applied during surface mount assembly after they absorb atmospheric moisture. However, since a haze will disappear if time passes even if a haze happens on the inside of glass, there is no problem in quality, If you are worrisome such a haze, please observe the following precautions:

a. This moisture barrier bag may be stored unopened 12 months at or below 30°C/90% RH.
b. After opening this moisture proof bag, the packages should be assembled within 5 days in an environment less than 30°C/60% RH.
c. If upon opening, the moisture indicator card shows humidity above 30% or the expiration date has passed, they may still be used with the addition of a bake of 3 hours at 125°C. After baking the packages, it should be assembled with 5 days in an environment less than 30°C/60% RH.
d. Expiration date; 12 months from sealing date, which is imprinted near the heat-seal.

4. Ultrasonic Cleaning

Ultrasonic cleaning should not be used with such hermetically-sealed ceramic package as CCD because the bonding wires can become disconnected due to resonance during the cleaning process.

5. Mounting

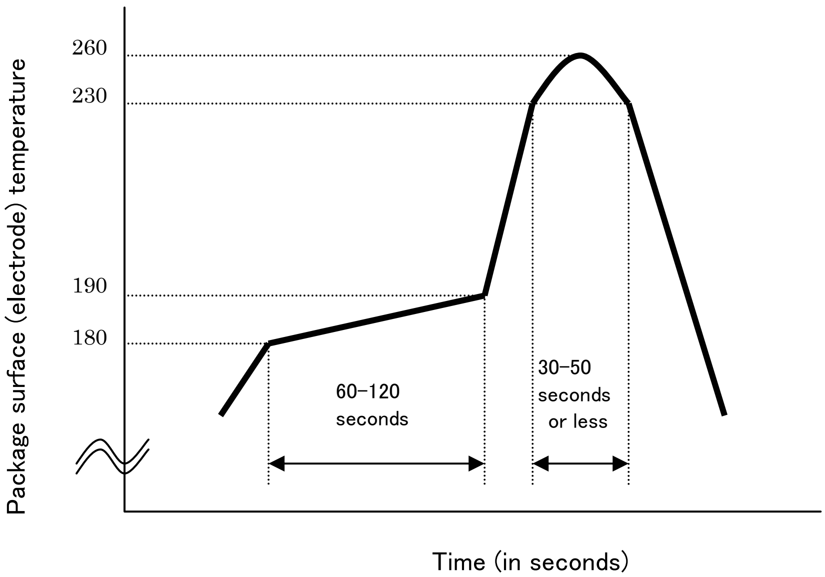
In the case of solder mounting, the devices should be mounted with the window glass protective tape in order to avoid dust or dirt included in reflow machine.

6. Soldering Temperature Profile for Pb free

Good temperature profile for each soldering method is as follows. In addition, in case of the repair work accompanied by IC removal, since the degree of parallel may be spoiled with the left solder, please do not carry out and in case of the repair work not accompanied by IC removal, carry out with a soldering iron or , in reflow, carry out at once.

a. Using a soldering iron
   Complete soldering within ten seconds for lead temperatures of up to 260°C, or within three seconds for lead temperatures of up to 350°C.

b. Using long infrared rays reflow/hot air reflow
   Complete the infrared ray reflow process within between 30 seconds and 50 seconds at a package surface (electrode) temperature of between 230°C and 260°C.
   Refer to the following Figure for an example of a good temperature profile for long infrared rays or hot air reflow.



7. Window Glass Protective Tape

The window glass protective tape is manufactured from materials in which static charges tend to build up. When removing the tape from CCD sensor after solder mounting, install an ionizer to prevent the tape from being charged with static electricity.

When the tape is removed, adhesives will remain in the glass surface. Since these adhesives appear as black flaws on the image, please wipe off it by a swab or cloth soaked in small amount of organic solution, such as volatile alcohol (ethanol etc.), before including in a product.

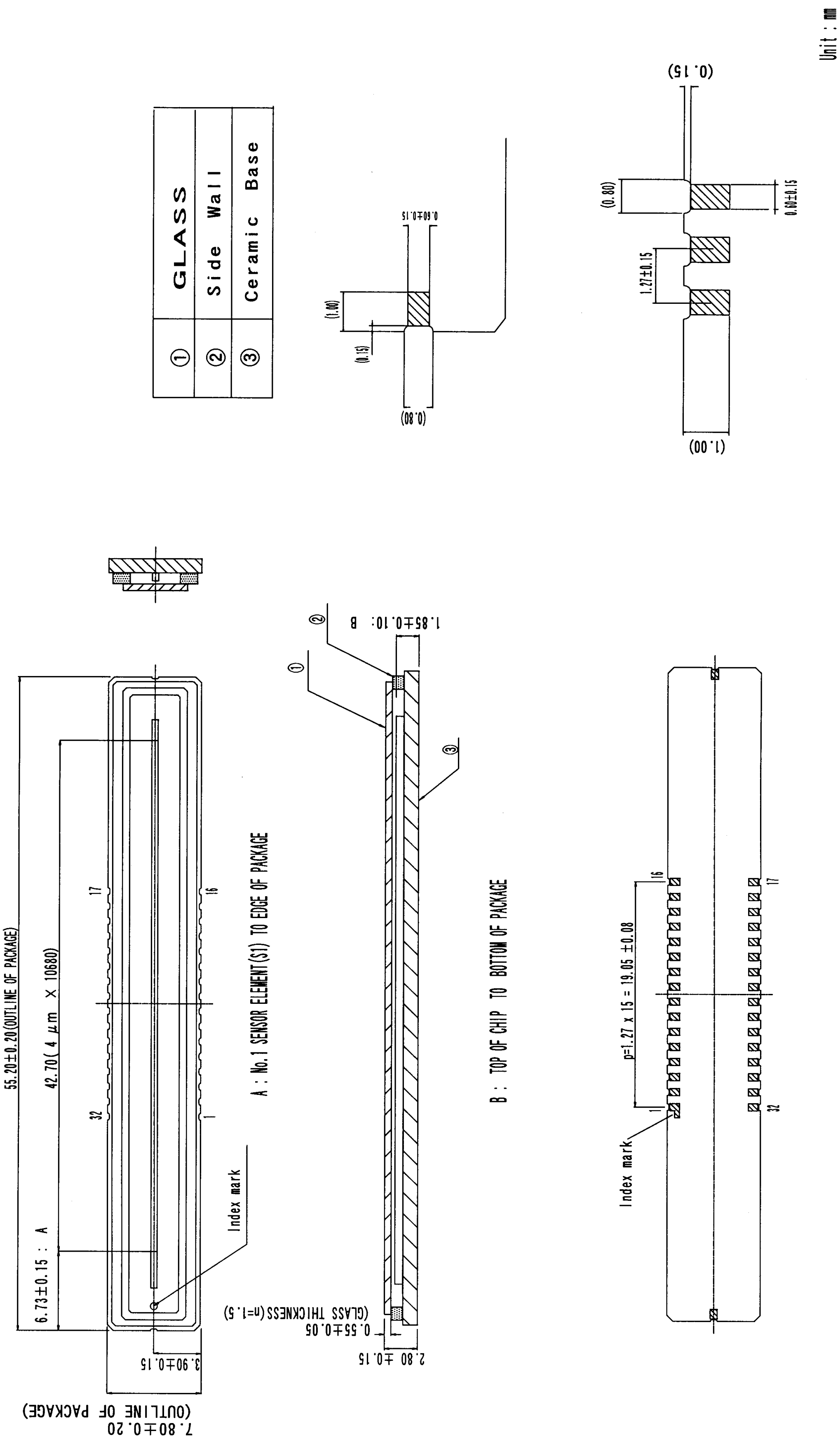
Do not reuse the tape.

8. Window Glass

The dust and stain on the glass window of the package degrade optical performance of CCD sensor.

Keep the glass window clean by saturating a cotton swab in alcohol and lightly wiping the surface, and allow the glass to dry, by blowing with filtered dry N2. Care should be taken to avoid mechanical or thermal shock because the glass window is easily to damage.

Package Dimensions



Weight: 2.8 g (typ.)

RESTRICTIONS ON PRODUCT USE

000707EBA

- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
  In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.
- The products described in this document are subject to the foreign exchange and foreign trade laws.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.
- The information contained herein is subject to change without notice.