TOSHIBA CCD Linear Image Sensor　CCD (Charge Coupled Device)

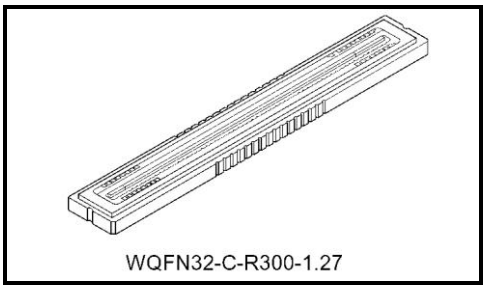
# TCD2720BFG

TOSHIBA CCD Linear Image Sensor　CCD (Charge Coupled Device)

# TCD2720BFG

The TCD2720BFG is a high sensitive and low dark current 7500 elements × 3 lines output CCD color linear image sensor with 7500 elements × 1 line output CCD B/W linear image sensor.

The device contains a row of 7500 elements × 4lines photodiodes which provide 24 lines/mm across a A3 size paper. The device is operated by 5.0 V pulse and 10 V power supply.


WQFN32-C-R300-1.27

## Features

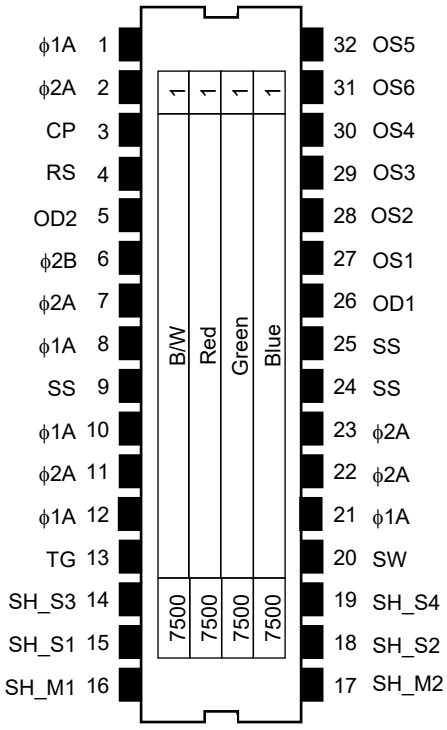
- Number of Image Sensing Elements: 7500 elements × 3 lines for Color
  7500 elements × 1 line for B/W
- Image Sensing Element Size: 4.7 μm by 4.7 μm on 4.7 μm center for Color
  4.7 μm by 4.7 μm on 4.7 μm center for B/W
- Photo Sensing Region: High sensitive PN photodiode
- Clock: 2-phase (5 V)
- Power Supply Voltage: 10 V (typ.)
- Distance between Photodiode Array: 9.4 μm (2 lines) B array – G array, G array – R array
  56.4 μm (12 lines) R array – B/W array
- Internal Circuit: Clamp circuit
- Package: 32 pin CLCC
- Color Filter: Red, Green, Blue

## ABSOLUTE MAXIMUM RATINGS (Note 1)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Clock pulse voltage | $V_{\phi A}$ | −0.3 to +8.0 | V |
| Last stage clock pulse voltage | $V_{\phi B}$ | | |
| Shift pulse voltage | $V_{SH}$ | | |
| Reset pulse voltage | $V_{RS}$ | | |
| Clamp pulse voltage | $V_{CP}$ | | |
| Transfer pulse voltage | $V_{TG}$ | | |
| Switch pulse voltage | $V_{SW}$ | | |
| Power supply voltage | $V_{OD}$ | −0.3 to +13.5 | V |
| Operating temperature | $t_{opr}$ | 0 to 60 | °C |
| Storage temperature | $t_{stg}$ | −25 to +85 | °C |

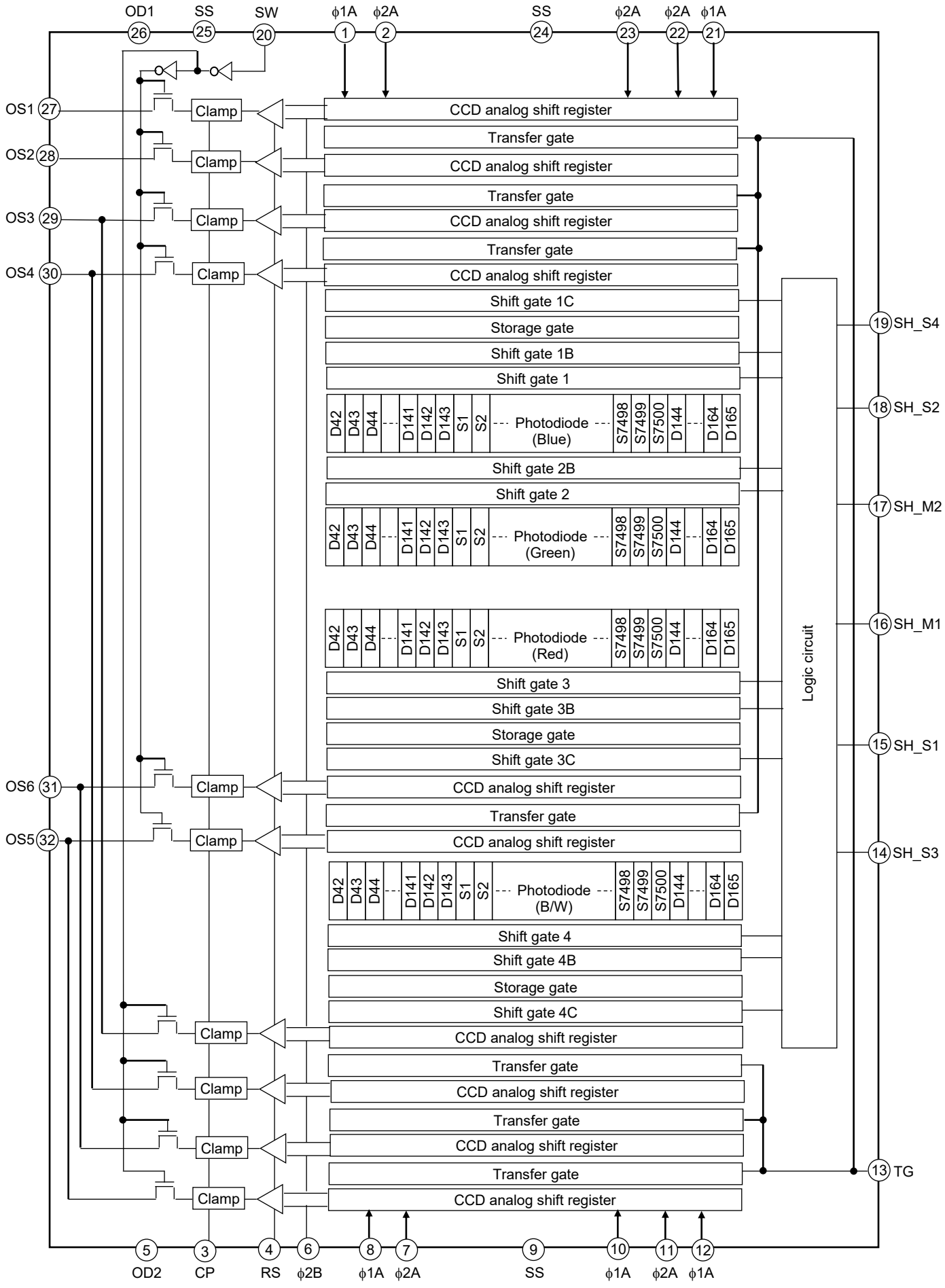
Note 1: All voltages are with respect to SS terminals (ground).
None of the ABSOLUTE MAXIMUM RATINGS must be exceeded, even instantaneously.
If any one of the ABSOLUTE MAXIMUM RATINGS is exceeded, the electrical characteristics, reliability and life time of the device cannot be guaranteed. If the ABSOLUTE MAXIMUM RATINGS are exceeded, the device can be permanently damaged or degraded. Create a system design in such a manner that any of the ABSOLUTE MAXIMUM RATINGS will not be exceeded under any circumstances.

## Pin Connections (top view)




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## Circuit Diagram




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## Pin Names

| Pin No. | Symbol | Name | Pin No. | Symbol | Name |
|---|---|---|---|---|---|
| 1 | ϕ1A | Transfer clock (phase 1) | 32 | OS5 | Output signal 5 (Red(Odd) or B/W1) |
| 2 | ϕ2A | Transfer clock (phase 2) | 31 | OS6 | Output signal 6 (Red(Even) or B/W3) |
| 3 | CP | Clamp gate | 30 | OS4 | Output signal 4 (Green(Even) or B/W2) |
| 4 | RS | Reset gate | 29 | OS3 | Output signal 3 (Green(Odd) or B/W4) |
| 5 | OD2 | Power supply | 28 | OS2 | Output signal 2 (Blue(Even)) |
| 6 | ϕ2B | Last stage transfer clock (phase 2) | 27 | OS1 | Output signal 1 (Blue(Odd)) |
| 7 | ϕ2A | Transfer clock (phase 2) | 26 | OD1 | Power supply |
| 8 | ϕ1A | Transfer clock (phase 1) | 25 | SS | Ground |
| 9 | SS | Ground | 24 | SS | Ground |
| 10 | ϕ1A | Transfer clock (phase 1) | 23 | ϕ2A | Transfer clock (phase 2) |
| 11 | ϕ2A | Transfer clock (phase 2) | 22 | ϕ2A | Transfer clock (phase 2) |
| 12 | ϕ1A | Transfer clock (phase 1) | 21 | ϕ1A | Transfer clock (phase 1) |
| 13 | TG | Transfer gate | 20 | SW | Switch gate for color or B/W |
| 14 | SH_S3 | Shift gate (select 3) | 19 | SH_S4 | Shift gate (select 4) |
| 15 | SH_S1 | Shift gate (select 1) | 18 | SH_S2 | Shift gate (select 2) |
| 16 | SH_M1 | Shift gate (master 1) | 17 | SH_M2 | Shift gate (master 2) |

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## Optical/Electrical Characteristics 1 (Color mode)

**Ta = 25°C, $V_{OD}$ = 10 V, $V_{SW}$ = 5 V, $V_{\phi}$ = $V_{SH}$ = $V_{RS}$ = $V_{CP}$ = $V_{TG}$ = 5 V (pulse), $f_{\phi}$ = 1.0 MHz, $t_{INT}$ (integration time) = 10 ms, light source = A light source + CM500S (t = 1.0 mm)**

| Characteristics | | Symbol | Min | Typ. | Max | Unit | Note |
|---|---|---|---|---|---|---|---|
| Sensitivity | Red | $R_R$ | 5.6 | 8.0 | 10.4 | V/lx·s | (Note 2) |
| | Green | $R_G$ | 5.0 | 7.2 | 9.4 | | |
| | Blue | $R_B$ | 3.7 | 5.4 | 7.1 | | |
| Photo response non uniformity | | PRNU (1) | — | 10 | 20 | % | (Note 3) |
| | | PRNU (3) | — | 6 | 12 | mV | (Note 4) |
| Saturation output voltage | | $V_{SAT}$ | 1.5 | 2.0 | — | V | (Note 5) |
| Saturation exposure | | SE | 0.15 | 0.27 | — | lx·s | (Note 6) |
| Dark signal voltage | | $V_{DRK}$ | — | 1 | 6 | mV | (Note 7) |
| Dark signal non uniformity | | DSNU | — | 6 | 12 | mV | (Note 8) |
| DC power dissipation | | $P_D$ | – | 800 | 970 | mW | — |
| Total transfer efficiency | | TTE | 92 | 98 | — | % | — |
| Output impedance | | $Z_O$ | — | 0.2 | 0.5 | kΩ | — |
| DC output signal voltage | | $V_{OS}$ | 4.0 | 5.0 | 6.0 | V | (Note 9) |
| Random noise | | $N_{D\sigma}$ | — | 0.8 | — | mV | (Note 10) |

## Optical/Electrical Characteristics 2 (B/W mode)

**Ta = 25°C, $V_{OD}$ = 10 V, $V_{SW}$ = 0 V, $V_{\phi}$ = $V_{SH}$ = $V_{RS}$ = $V_{CP}$ = $V_{TG}$ = 5 V (pulse), $f_{\phi}$ = 1.0 MHz, $t_{INT}$ (integration time) = 10 ms, light source = A light source + CM500S (t = 1.0 mm)**

| Characteristics | Symbol | Min | Typ. | Max | Unit | Note |
|---|---|---|---|---|---|---|
| Sensitivity | $R_{B/W}$ | 9.2 | 11.5 | 13.8 | V/lx·s | (Note 2) |
| Photo response non uniformity | PRNU (1) | — | 10 | 20 | % | (Note 3) |
| | PRNU (3) | — | 3 | 12 | mV | (Note 4) |
| Saturation output voltage | $V_{SAT}$ | 1.5 | 2.0 | — | V | (Note 5) |
| Saturation exposure | SE | 0.10 | 0.17 | — | lx·s | (Note 6) |
| Dark signal voltage | $V_{DRK}$ | — | 1 | 6 | mV | (Note 7) |
| Dark signal non uniformity | DSNU | — | 6 | 12 | mV | (Note 8) |
| DC power dissipation | $P_D$ | — | 800 | 970 | mW | — |
| Total transfer efficiency | TTE | 92 | 98 | — | % | — |
| Output impedance | $Z_O$ | — | 0.2 | 0.5 | kΩ | — |
| DC output signal voltage | $V_{OS}$ | 4.0 | 5.0 | 6.0 | V | (Note 9) |
| Random noise | $N_{D\sigma}$ | — | 0.6 | — | mV | (Note 10) |

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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, where measured approximately 750 mV of signal output.

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

$\overline{X}$ : Average of total signal outputs
$\Delta X$: The maximum deviation from $\overline{X}$

Note 4: PRNU (3) is defined as the maximum voltage with next pixel, where measured approximately 50 mV of signal output.

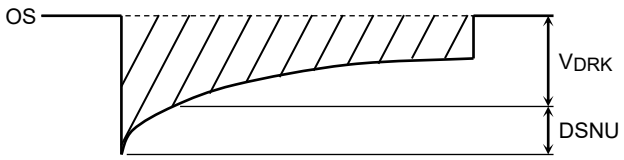
Note 5: $V_{SAT}$ is defined as the minimum saturation output voltage of all effective pixels.

Note 6: Definition of SE:

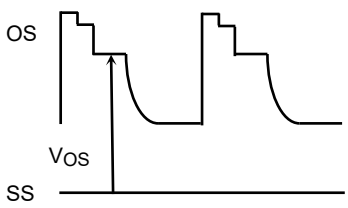
$$SE_{(B/W)} = \frac{V_{SAT}}{R_{B/W}} \qquad SE_{(Color)} = \frac{V_{SAT}}{R_G}$$

Note 7: $V_{DRK}$ is defined as average dark signal voltage of all effective pixels.

Note 8: DSNU is defined by the difference between average value ($V_{DRK}$) and the maximum value of the dark voltage.

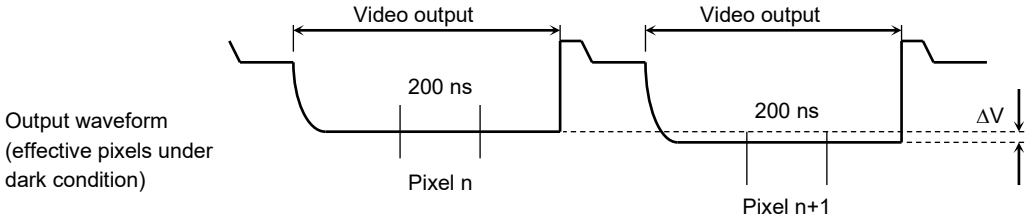



Note 9: DC output signal voltage is defined as follows.




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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. dark condition) 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 levels 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).
   $\overline{\Delta V} = \frac{1}{30}\sum_{i=1}^{30}|\Delta Vi|$ $\sigma = \sqrt{\frac{1}{30}\sum_{i=1}^{30}(|\Delta Vi| - \overline{\Delta V})^2}$
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 the random noise as follows.
   $N_{D\sigma} = \frac{1}{\sqrt{2}}\bar{\sigma}$

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## Recommended Operating Conditions (Ta = 25°C)

For best performance, the device should be used within the Recommended Operating Conditions.

| Characteristics | | Symbol | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Clock pulse voltage | "H" level | $V_{\phi 1A}$ | 4.75 | 5.0 | 5.5 | V |
| | "L" level | $V_{\phi 2A,}$ | 0 | 0 | 0.25 | |
| Last stage clock pulse voltage | "H" level | $V_{\phi 2B}$ | 4.75 | 5.0 | 5.5 | V |
| | "L" level | | 0 | 0 | 0.25 | |
| Shift pulse voltage | "H" level | $V_{SH}$ | 4.75 | 5.0 | 5.5 | V |
| | "L" level | | 0 | 0 | 0.25 | |
| Reset pulse voltage | "H" level | $V_{RS}$ | 4.75 | 5.0 | 5.5 | V |
| | "L" level | | 0 | 0 | 0.25 | |
| Clamp pulse voltage | "H" level | $V_{CP}$ | 4.75 | 5.0 | 5.5 | V |
| | "L" level | | 0 | 0 | 0.25 | |
| Transfer pulse voltage | "H" level | $V_{TG}$ | 4.75 | 5.0 | 5.5 | V |
| | "L" level | | 0 | 0 | 0.25 | |
| Switch pulse voltage | "H" level | $V_{SW}$ | 4.75 | 5.0 | 5.5 | V |
| | "L" level | | 0 | 0 | 0.25 | |
| Power supply voltage | | $V_{OD}$ | 9.5 | 10.0 | 10.5 | V |

## Clock Characteristics (Ta = 25°C)

For best performance, the device should be used within the Recommended Operating Conditions.

| Characteristics | | Symbol | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Clock pulse frequency | | $f_{\phi}$ | 0.5 | 1.0 | 35.0 | MHz |
| Reset pulse frequency | | $f_{RS}$ | 0.5 | 1.0 | 35.0 | MHz |
| Clamp pulse frequency | | $f_{CP}$ | 0.5 | 1.0 | 35.0 | MHz |
| Clock capacitance | (Note 11) | $C_{\phi A}$ | — | 120 | — | pF |
| Last stage clock capacitance | | $C_{\phi B}$ | — | 10 | — | pF |
| Shift gate capacitance | (Note 11) | $C_{SH}$ | — | 20 | — | pF |
| Reset gate capacitance | | $C_{RS}$ | — | 10 | — | pF |
| Clamp gate capacitance | | $C_{CP}$ | — | 10 | — | pF |
| Transfer gate capacitance | | $C_{TG}$ | — | 20 | — | pF |
| Switch gate capacitance | | $C_{SW}$ | — | 10 | — | pF |

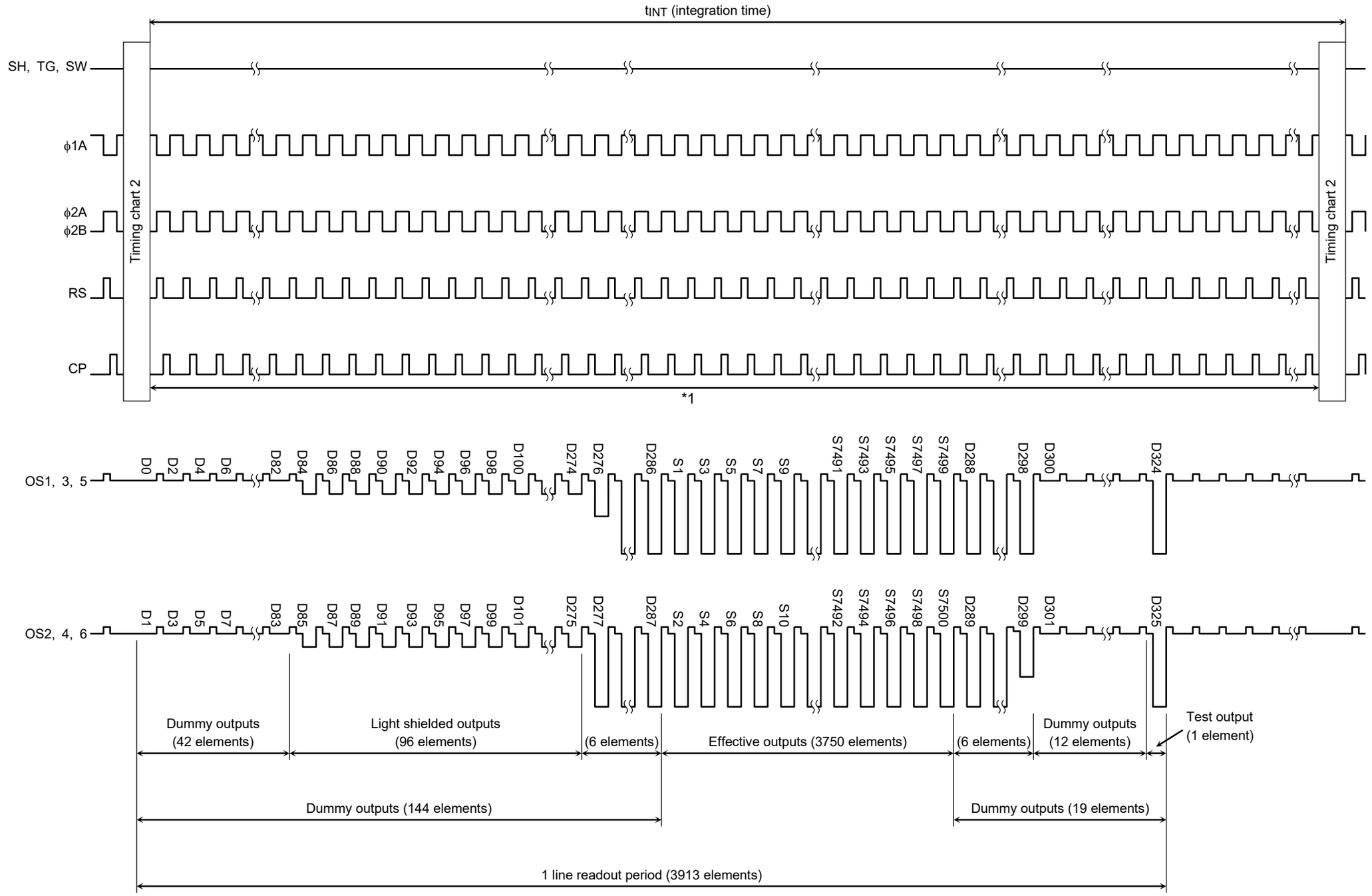
Note 11 : $V_{OD}$ = 10 V, Input capacitance per a pin.

## Select Mode of B/W and Color

| Mode | SW input pulse |
|---|---|
| Color | "H" |
| B/W | "L" |

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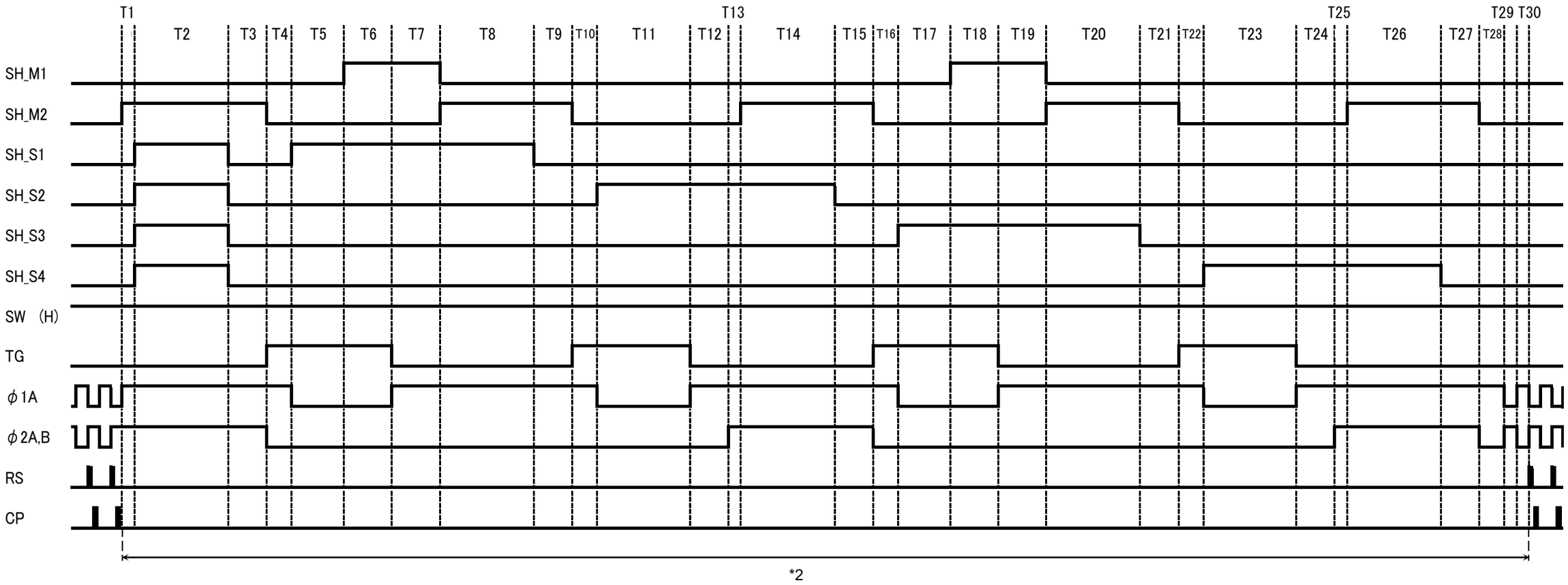
**Timing Chart 1: Color Mode (Refer to the Timing Chart 2)**




*1: Keep the SH and TG pins “L” level and keep the SW pin “H” level.

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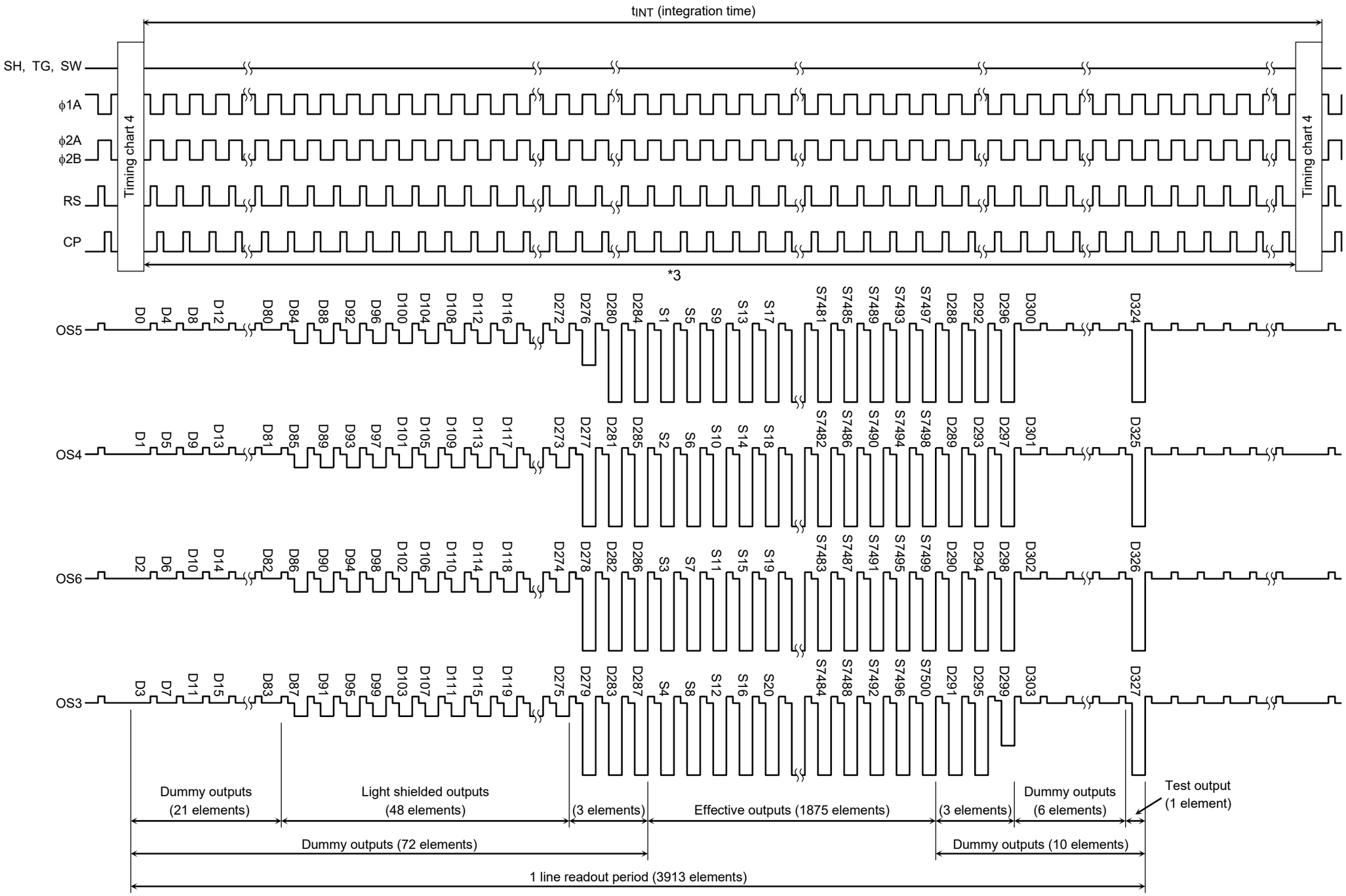
**Timing Chart 2: Color Mode (Vertical Transfer Period)**




*2: Keep the RS and CP pins “L” level.

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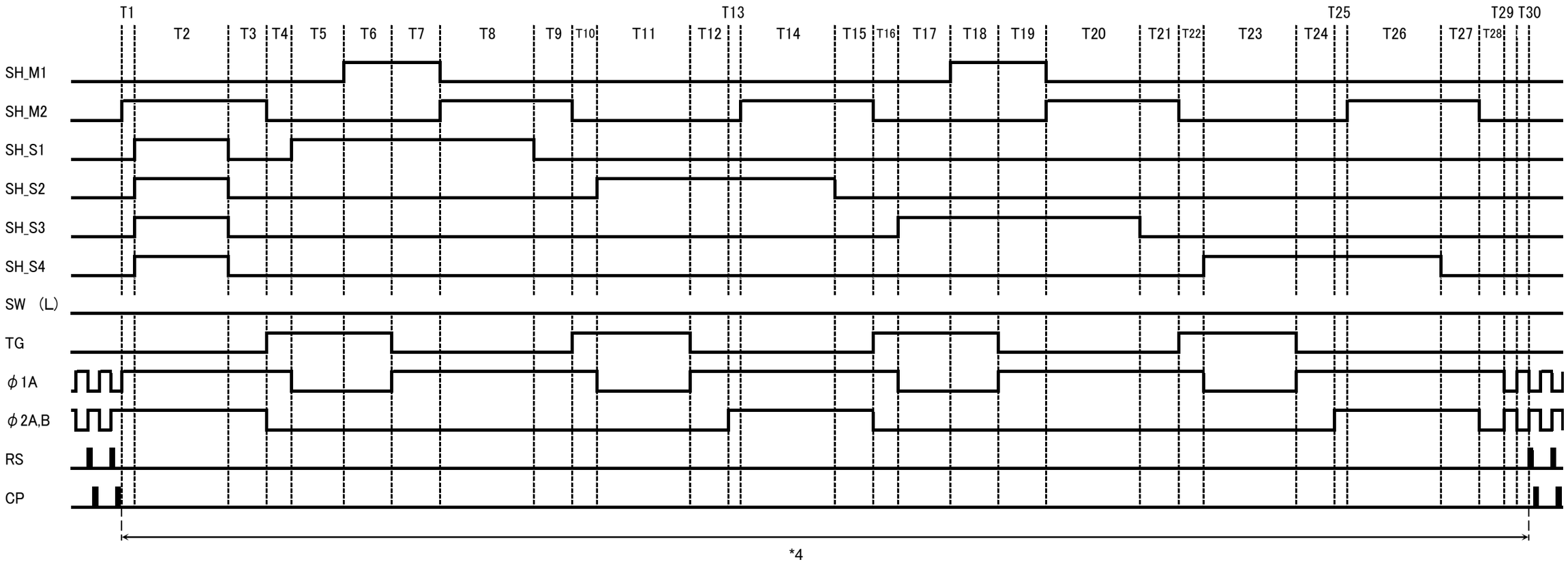
## Timing Chart 3: B/W Mode (Refer to the Timing Chart 4)




*3: Keep the SH, TG and SW pins “L” level.

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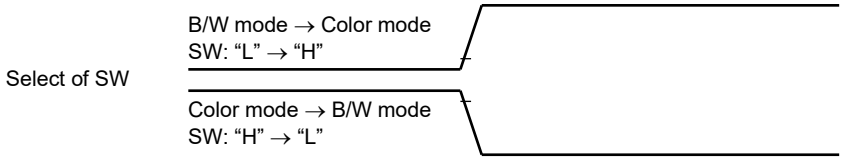
## Timing Chart 4: B/W Mode (Vertical Transfer Period)



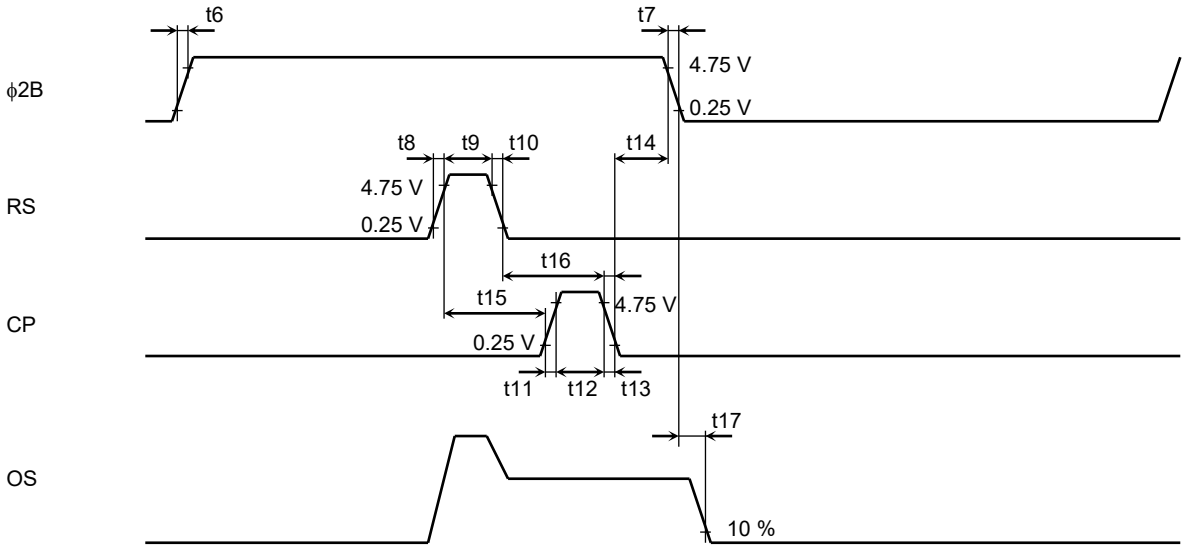

*4: Keep the RS and CP pins “L” level.

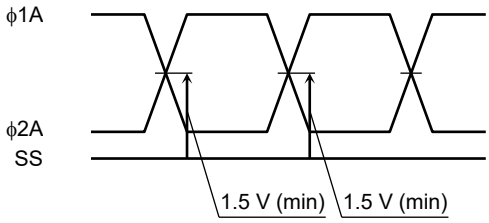
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## Timing Requirements 1




Note 12: Please scan the dummy more than 4 lines after the change of the mode.




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| Characteristics | Symbol | Min | Typ. (Note 13) | Max | Unit |
|---|---|---|---|---|---|
| $\phi$2B pulse rise time, fall time | t6, t7 | 0 | 50 | — | ns |
| RS pulse rise time, fall time | t8, t10 | 0 | 20 | — | ns |
| RS pulse width | t9 | 6 | 100 | — | ns |
| CP pulse rise time, fall time | t11, t13 | 0 | 20 | — | ns |
| CP pulse width | t12 | 6 | 200 | — | ns |
| Pulse timing of $\phi$2B and CP | t14 | 0 | 40 | — | ns |
| Pulse timing of RS and CP | t15 | 0 | 0 | — | ns |
| | t16 | 6 | 100 | — | ns |
| Video data delay time | t17 | — | 7 | — | ns |

Note 13: Measured with $f_{RS}$ = 1 MHz

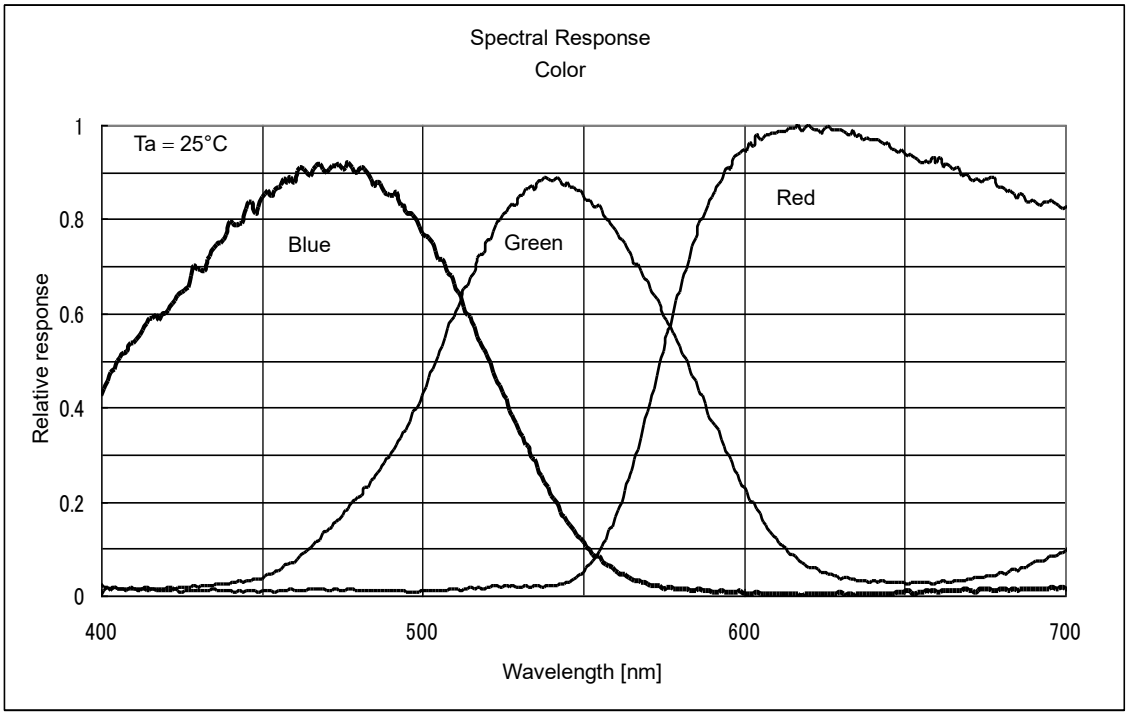
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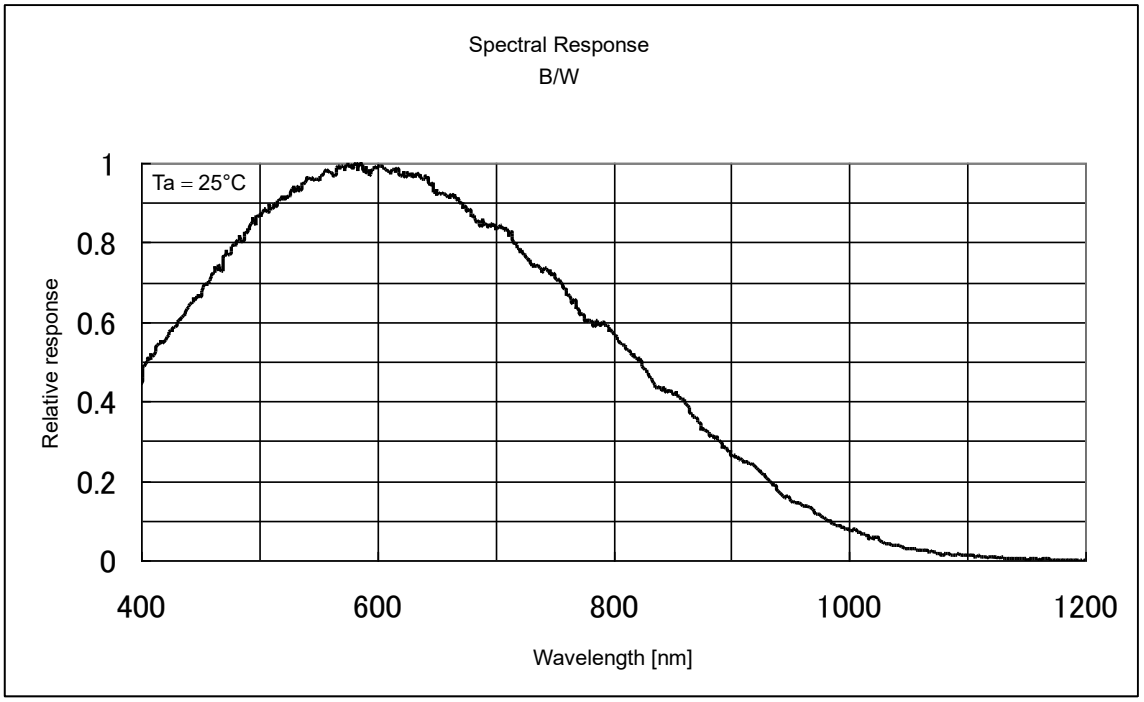
## Timing Requirements 2 (Vertical Transfer Period)

| Timing address | Min | Typ. | Max | Unit |
|---|---|---|---|---|
| T1 | 100 | 200 | — | ns |
| T2 | 800 | 1600 | — | ns |
| T3 | 300 | 600 | — | ns |
| T4 | 200 | 400 | — | ns |
| T5 | 400 | 800 | — | ns |
| T6 | 400 | 800 | — | ns |
| T7 | 400 | 800 | — | ns |
| T8 | 800 | 1600 | — | ns |
| T9 | 300 | 600 | — | ns |
| T10 | 200 | 400 | — | ns |
| T11 | 800 | 1600 | — | ns |
| T12 | 300 | 600 | — | ns |
| T13 | 100 | 200 | — | ns |
| T14 | 800 | 1600 | — | ns |
| T15 | 300 | 600 | — | ns |
| T16 | 200 | 400 | — | ns |
| T17 | 400 | 800 | — | ns |
| T18 | 400 | 800 | — | ns |
| T19 | 400 | 800 | — | ns |
| T20 | 800 | 1600 | — | ns |
| T21 | 300 | 600 | — | ns |
| T22 | 200 | 400 | — | ns |
| T23 | 800 | 1600 | — | ns |
| T24 | 300 | 600 | — | ns |
| T25 | 100 | 200 | — | ns |
| T26 | 800 | 1600 | — | ns |
| T27 | 300 | 600 | — | ns |
| T28 | 200 | 400 | — | ns |
| T29 | 50 | 100 | — | ns |
| T30 | 50 | 100 | — | ns |
| Vertical transfer time | 11.5 | 23.0 | — | μs |

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## Typical Spectral Response




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## Cautions

### 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.
d. Ionized air is recommended for discharge when handling CCD image sensors.

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.

### 2. Incident Light

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

### 3. Cloudiness of Glass Inside

CCD surface mount products may have a haze on the inside of glass, so be careful about following.
Even if the haze arises inside of glass, when it is not on the pixel area, there is no problem in quality.
Before the aluminum bag is opened, please keep the products in the environment below 30°C·90 %RH. And after the aluminum bag is opened, please keep the products in the environment below 30°C·60 %RH.
Please mount the products within 12 months from sealed date and within 6 months from opening the aluminum bag. (Sealed date is printed on aluminum bag.)

### 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. 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 or white flaws on the image, please wipe the window glass surface with the cloth into which the organic solvent was infiltrated. Then please attach CCD to a product.
Do not reuse the tape.

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## 7. Soldering Temperature Profile

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, only one time.

a. Using a soldering iron
   Complete soldering within three seconds for lead temperatures of up to 350°C.
b. Using long infrared rays reflow / hot air reflow
   Please do reflow at the condition that the package surface (electrode) temperature is on the solder maker's recommendation profile. And that reflow profile is within below condition 1 to 3.

   1. Peak temperature: 250°C or less.
   2. Time to keep high temperature: 220 to 250°C, 30 to 40 s.
   3. Pre. heat: 150 to 190°C, 60 to 120 s

## 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 $N_2$. Care should be taken to avoid mechanical or thermal shock because the glass window is easily to damage.

## 9. Cleaning Method of the Window Glass Surface

Wiping Cloth

a. Use soft cloth with a fine mesh.
b. The wiping cloth must not cause dust from itself.
c. Use a clean wiping cloth necessarily.

Cleaner

When using solvents, such as alcohol, unavoidably, it is cautious of the next.

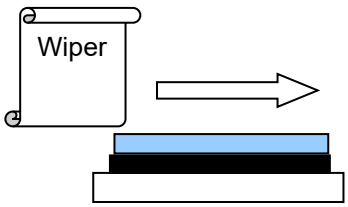
a. A clean thing with quick-drying.
b. After liquid dries, there needs to be no residual substance.
c. A thing safe for a human body.

And, please observe the use term of a solvent and use the storage container of a solvent to be clean.
Be cautious of fire enough.

Way of Cleaning

First, the surface of window glass is wiped with the wiping cloth into which the cleaner was infiltrated. Please wipe down the surface of window glass at least 2 times or more.
Next, the surface of window glass wipes with the dry wiping cloth. Please wipe down the surface of window glass at least 3 times or more.
Finally, blow cleaning is performed by dry $N_2$ filtered.
If operator wipes the surface of the window glass with the above-mentioned process and dirt still remains, TOSHIBA recommends repeating the clean operation from the beginning.
Be cautious of the next thing.

a. Don't infiltrate the cleaner too much.
b. A wiping portion is performed into the optical range and don't touch the edge of window glass.
c. Be sure to wipe in a long direction and the same direction.
d. A wiping cloth always uses an unused portion.




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## 10. Foot Pattern on the PCB

We recommend fig.1 's foot pattern for your PCB(Printed Circuit Board). Unit: mm

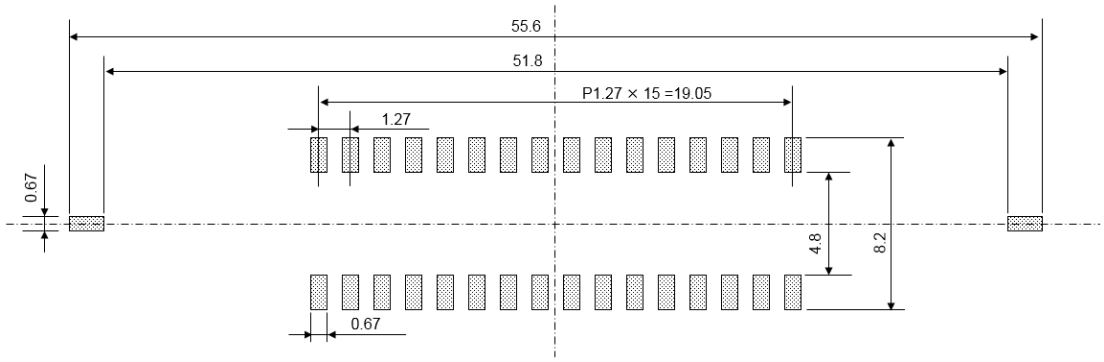



fig. 1

## 11. Mask for Solder Paste Application

We recommend metal mask that have the following thickness.
·Thickness : 0.2 mm.
And we recommend that the opened area size on the metal mask is 95 % to 100 % for pads on solder.

## 12. Temperature Cycle

After mounting, if temperature cycle stress is too much, CCD surface mount products have a possibility that a crack may arise in solder. As a method of preventing a solder crack, underfill is effective.

## 13. Reuse of a Tray

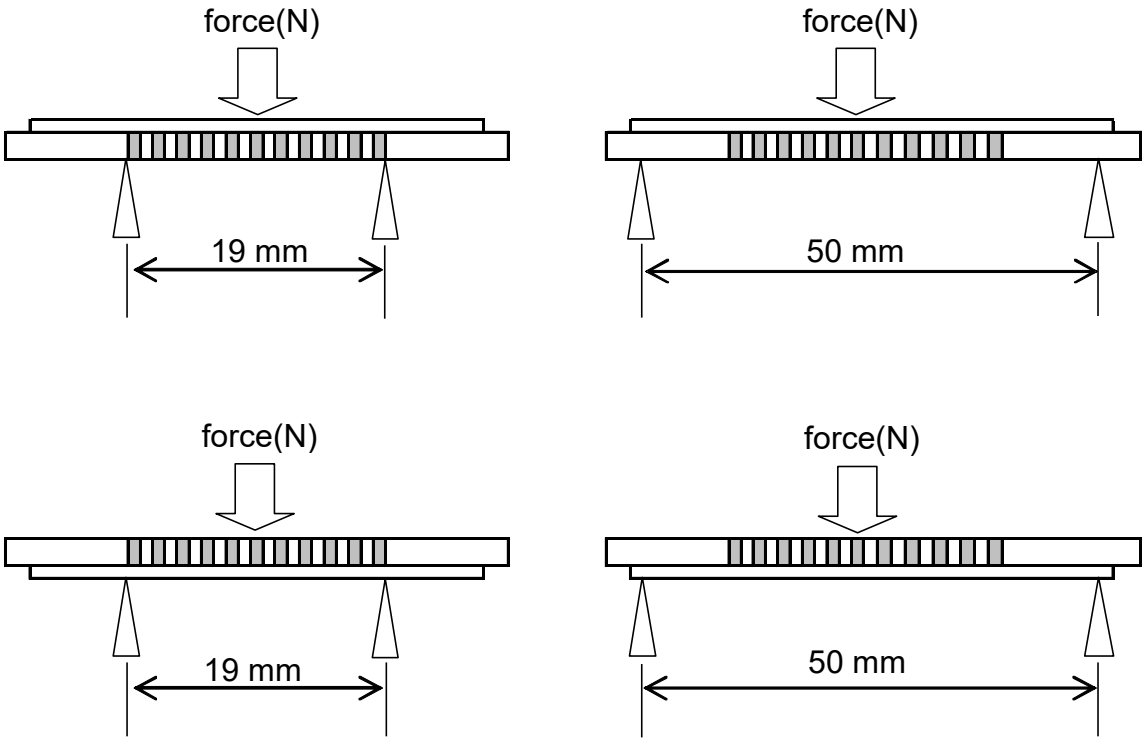
We reuse tray in order to reduce plastic waste as we can. Please cooperate with us in reusing for ecology.

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## 14. Caution for Package Handling

Over force on CCD products may cause crack and chip removing on the product. The three point bending strength of this product is the following. (Reference data)
If the stress is loaded far from a fulcrum, the stress on the package will be increase.
When you will treat CCD on every process, please be careful particularly. For example, soldering on PCB, cutting PCB, wiping on the glass surface, optical assemble and so on.

Bending Test



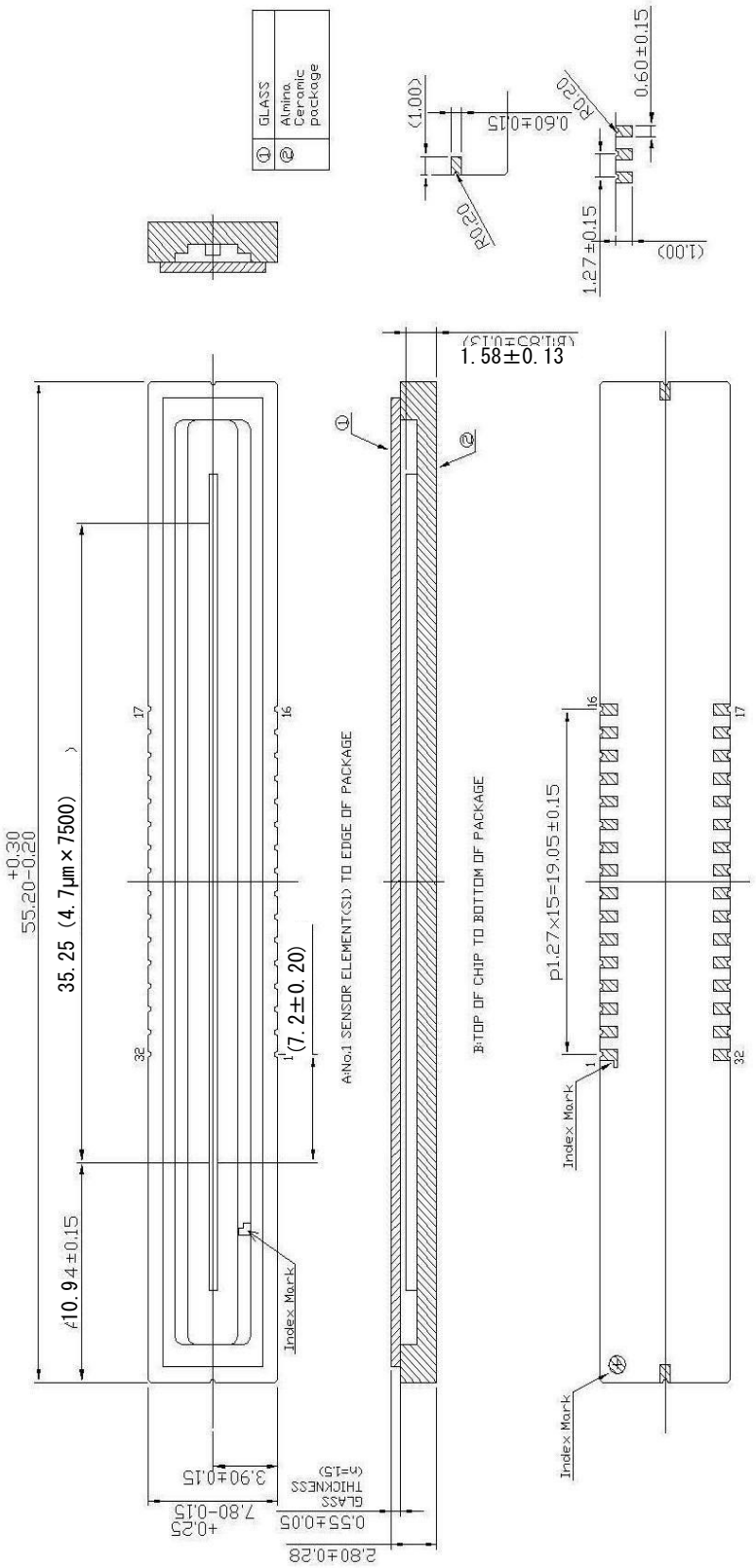

•32CLCC
Bearing length 19 mm: The force from upside: 250 [N]
The force from downside: 150 [N]
Bearing length 50 mm: The force from upside: 120 [N]
The force from downside: 60 [N]

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## Package Dimensions

WQFN32-C-R300-1.27

Unit: mm



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