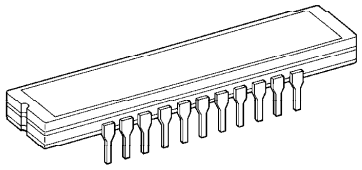
TOSHIBA CCD LINEAR IMAGE SENSOR CCD(Charge Coupled Device)

# TCD2251D

The TCD2251D is a high sensitive and low dark current 2700 elements × 3 line CCD color image sensor.
The sensor is designed for color scanner.
The device contains a row of 2700 elements × 3 line photodiodes which provide a 12 lines / mm across a A4 size paper. The device is operated by 5V pulse, and 12V power supply.



WDIP22-G-400-2.54A

Weight : 4.5g (Typ.)

**FEATURES**

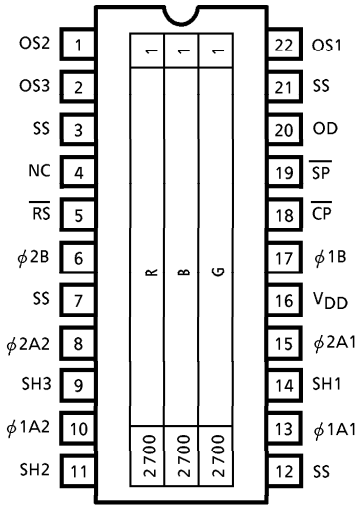
- Number of Image Sensing Elements : 2700 elements × 3 line
- Image Sensing Element Size : 8$\mu$m by 8$\mu$m on 8$\mu$m centers
- Photo Sensing Region : High sensitive pn photodiode
- Distance Between Photodiode Array : 64$\mu$m (8 Lines)
- Clock : 2 phase (5V)
- Internal Circuit : Sample and Hold circuit, Clamp circuit
- Package : 22 pin Cerdip
- Color Filter : Red, Green, Blue

**MAXIMUM RATINGS** (Note 1)

| CHARACTERISTIC | SYMBOL | RATING | UNIT |
|---|---|---|---|
| Clock Pulse Voltage | $V_\phi$ | −0.3~8 | V |
| Shift Pulse Voltage | $V_{SH}$ | | V |
| Reset Pulse Voltage | $V_{\overline{RS}}$ | | V |
| Sample and Hold Pulse Voltage | $V_{\overline{SP}}$ | | V |
| Clamp Pulse Voltage | $V_{\overline{CP}}$ | | V |
| Power Supply Voltage | $V_{OD}$ $V_{DD}$ | −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).

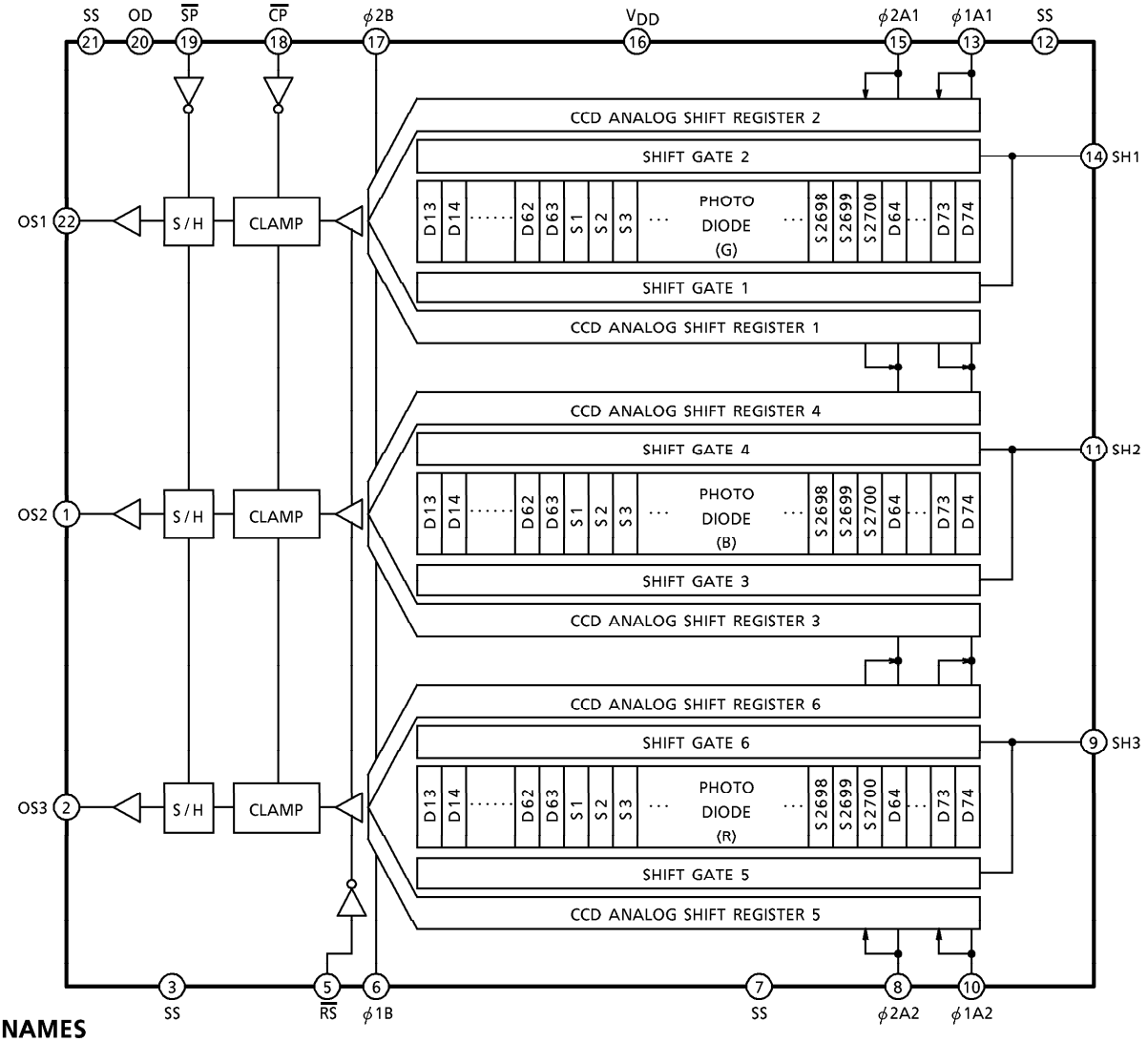
**PIN CONNECTIONS**




(TOP VIEW)

961001EBA2

## CIRCUIT DIAGRAM




## PIN NAMES

| | | | |
|---|---|---|---|
| $\phi$1A1 | Clock 1 (Phase 1) | SH2 | Shift Gate 2 |
| $\phi$2A1 | Clock 1 (Phase 2) | SH3 | Shift Gate 3 |
| $\phi$1A2 | Clock 2 (Phase 1) | $\overline{RS}$ | Reset Gate |
| $\phi$2A2 | Clock 2 (Phase 2) | $\overline{SP}$ | Sample and Hold Gate |
| $\phi$1B | Final Stage Clock (phase 1) | $\overline{CP}$ | Clamp Gate |
| $\phi$2B | Final Stage Clock (phase 2) | OS1 | Signal Output 1 (Green) |
| SS | Ground | OS2 | Signal Output 2 (Blue) |
| OD | Power (Analog) | OS3 | Signal Output 3 (Red) |
| $V_{DD}$ | Power (Digital) | NC | Non Connection |
| SH1 | Shift Gate 1 | | |

961001EBA2'

**OPTICAL / ELECTRICAL CHARACTERISTICS**

(Ta = 25°C, $V_{OD}$ = 12V, $V_\phi = V_{\overline{RS}} = V_{SH} = V_{\overline{CP}}$ = 5V (PULSE), $f_\phi$ = 0.5MHz, $f_{\overline{RS}}$ = 1.0MHz,
LOAD RESISTANCE = 100kΩ, $t_{INT}$ (INTEGRATION TIME) = 10ms,
LIGHT SOURCE = A LIGHT SOURCE + CM500S FILTER (t = 1.0mm) )

| CHARACTERISTIC | SYMBOL | MIN. | TYP. | MAX. | UNIT | NOTE |
|---|---|---|---|---|---|---|
| Sensitivity (Red) | $R_R$ | 4.1 | 5.8 | 7.5 | V / lx·s | (Note 2) |
| Sensitivity (Green) | $R_G$ | 5.3 | 7.6 | 9.8 | V / lx·s | (Note 2) |
| Sensitivity (Blue) | $R_B$ | 1.9 | 2.7 | 3.5 | V / lx·s | (Note 2) |
| Photo Response Non Uniformity | PRNU (1) | — | 10 | 20 | % | (Note 3) |
| | PRNU (3) | — | 3 | 12 | mV | (Note 4) |
| Register Imbalance | RI | — | — | 3 | % | (Note 5) |
| Saturation Output Voltage | $V_{SAT}$ | 2.0 | 2.5 | — | V | (Note 6) |
| Saturation Exposure | SE | 0.20 | 0.33 | — | lx·s | (Note 7) |
| Dark Signal Voltage | $V_{DRK}$ | — | 3.0 | 9.0 | mV | (Note 8) |
| Dark Signal Non Uniformity | DSNU | — | 4.0 | 12.0 | mV | (Note 9) |
| Total Transfer Efficiency | TTE | 92 | — | — | % | |
| Output Impedance | $Z_O$ | — | 0.3 | 1.0 | kΩ | |
| DC Power Dissipation | $P_D$ | — | 300 | 400 | mW | |
| DC Signal Output Voltage | $V_{OS}$ | 3.0 | 6.0 | 8.0 | V | (Note 10) |
| Random Noise | ND$\sigma$ | — | 1.0 | — | mV | (Note 11) |

(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.

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

Where $\overline{\chi}$ is average of total signal outputs and $\Delta\chi$ is the maximum deviation from $\overline{\chi}$. The amount of the incident light is shown below.

$$\text{Red} = \frac{1}{2}\ \text{SE}$$

$$\text{Green} = \frac{1}{2}\ \text{SE}$$

$$\text{Blue} = \frac{1}{4}\ \text{SE}$$

(Note 4) PRNU (3) is defined as maximum voltage difference between two adjacent pixels, where measured at 50mV (Typ.).

(Note 5) RI 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.

$$RI = \frac{\sum_{n=1}^{2699} |\chi n - \chi n + 1|}{2699 \cdot \overline{\chi}} \times 100\ (\%)$$

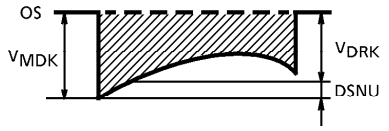
Where $\chi n$ and $\chi n + 1$ are signal outputs of each pixel. $\overline{\chi}$ is average of signal outputs of all effective pixels.

(Note 6) $V_{SAT}$ is defined as minimum Saturation Output Voltage of all effective pixels.

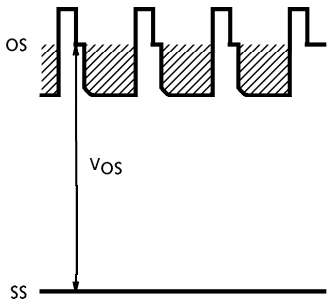
(Note 7) Definition of SE : $SE = \frac{V_{SAT}}{R_G}$

(Note 8) $V_{DRK}$ is defined as average dark signal voltage of all effective pixels.

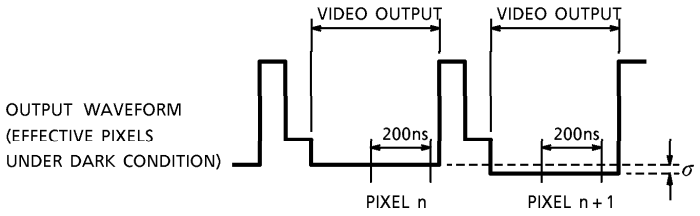
(Note 9) DSNU is defined as different voltage between $V_{DRK}$ and $V_{MDK}$, when $V_{MDK}$ is maximum dark voltage.




(Note 10) DC Signal Output Voltage is defined as follows:



(Note 11) 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 nanosecond period to get Vn and Vn + 1.
3) Vn + 1 is subtracted from Vn to get $\Delta V$.

$$\Delta V = Vn - Vn + 1$$

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

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

5) Procedure 2), 3) and 4) are repeated 10 times to get 10 sigma values.
6) 10 sigma values are averaged.

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

7) $\overline{\sigma}$ 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.

$$\text{Random noise} = \frac{1}{\sqrt{2}}\overline{\sigma}$$

**OPERATING CONDITION**

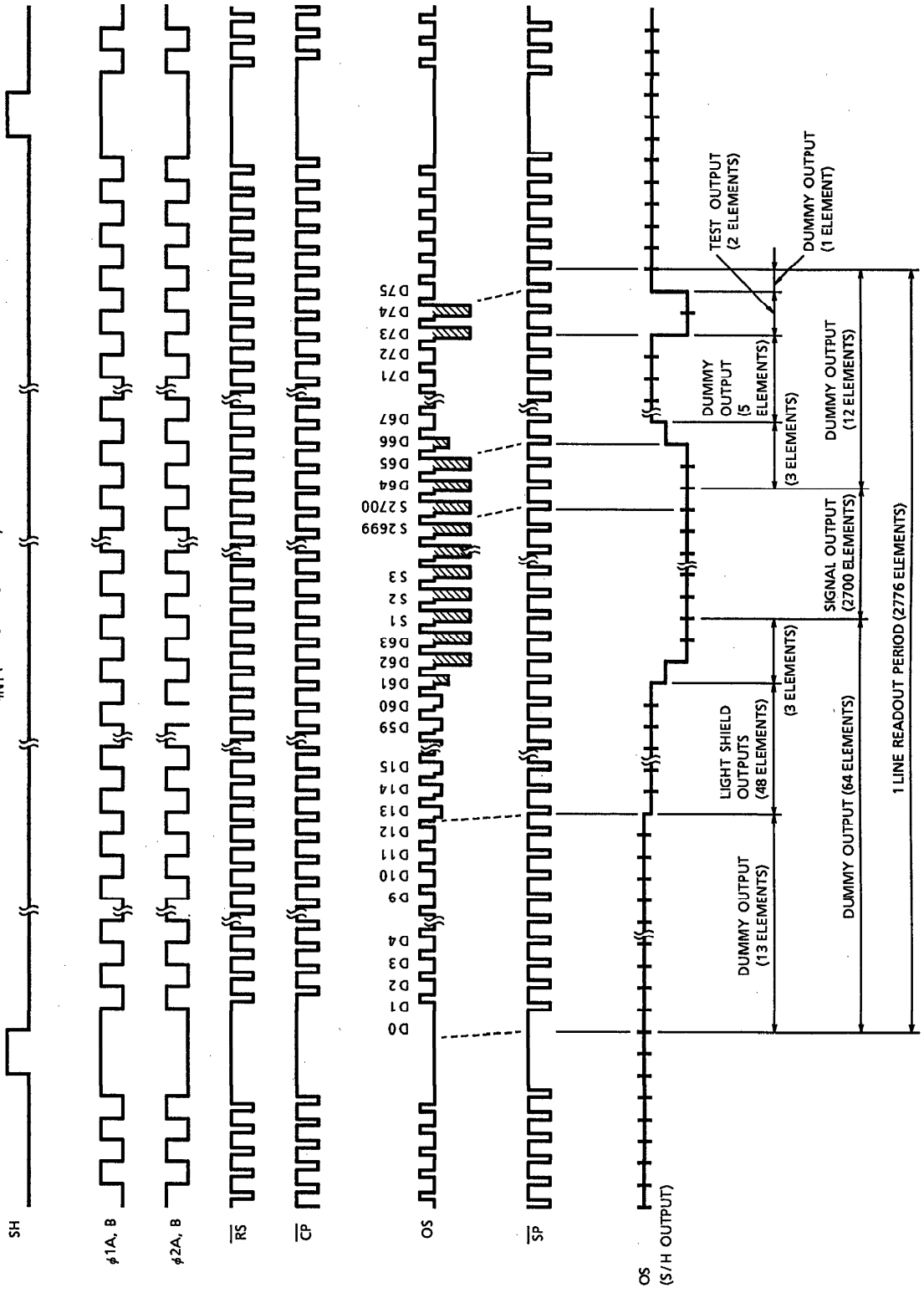
| CHARACTERISTIC | | SYMBOL | MIN. | TYP. | MAX. | UNIT | NOTE |
|---|---|---|---|---|---|---|---|
| Clock Pulse Voltage | "H" Level | $V_{\phi A}$ | 4.5 | 5.0 | 5.5 | V | |
| | "L" Level | | 0.0 | 0.0 | 0.5 | | |
| Final Stage Clock Pulse Voltage | "H" Level | $V_{\phi B}$ | 4.5 | 5.0 | 5.5 | V | |
| | "L" Level | | 0.0 | 0.0 | 0.5 | | |
| Shift Pulse Voltage | "H" Level | $V_{SH}$ | $V\phi A$"H" – 0.5 | $V\phi A$"H" | $V\phi A$"H" | V | (Note 12) |
| | "L" Level | | 0.0 | 0.0 | 0.5 | | |
| Reset Pulse Voltage | "H" Level | $V_{\overline{RS}}$ | 4.5 | 5.0 | 5.5 | V | |
| | "L" Level | | 0.0 | 0.0 | 0.5 | | |
| Sample and Hold Pulse Voltage | "H" Level | $V_{\overline{SP}}$ | 4.5 | 5.0 | 5.5 | V | (Note 13) |
| | "L" Level | | 0.0 | 0.0 | 0.5 | | |
| Clamp Pulse Voltage | "H" Level | $V_{\overline{CP}}$ | 4.5 | 5.0 | 5.5 | V | |
| | "L" Level | | 0.0 | 0.0 | 0.5 | | |
| Power Supply Voltage | | $V_{OD}$, $V_{DD}$ | 11.4 | 12.0 | 13.0 | V | |

(Note 12) $V\phi A$"H" means the high level voltage of $V\phi A$ when SH pulse is high level.
(Note 13) Supply "L" Level to $\overline{SP}$ terminal when sample and hold circuit is not used.

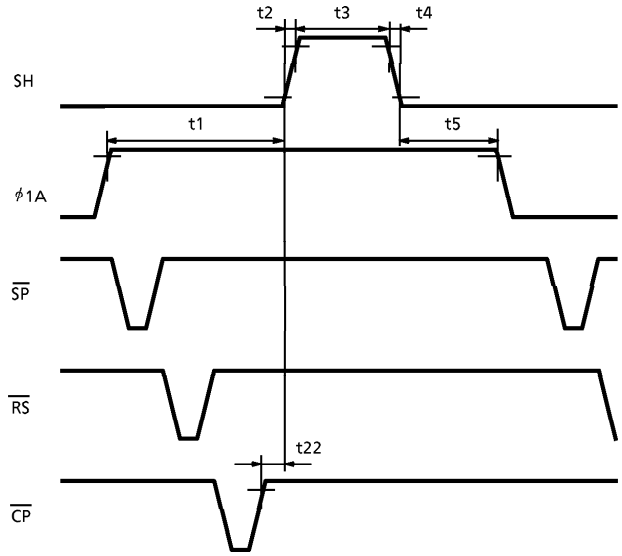
**CLOCK CHARACTERISTICS** (Ta = 25°C)

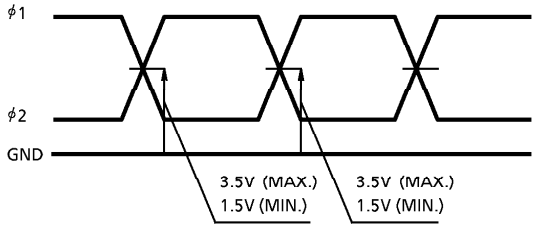
| CHARACTERISTIC | SYMBOL | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| Clock Pulse Frequency | $f_{\phi}$ | — | 0.5 | 2.5 | MHz |
| Reset Pulse Frequency | $f_{\overline{RS}}$ | — | 1.0 | 5.0 | MHz |
| Sample and Hold Pulse Frequency | $f_{\overline{SP}}$ | — | 1.0 | 5.0 | MHz |
| Clamp Pulse Frequency | $f_{\overline{CP}}$ | — | 1.0 | 5.0 | MHz |
| Clock Capacitance | $C_{\phi A}$ | — | 250 | 350 | pF |
| Final Stage Clock Capacitance | $C_{\phi B}$ | — | 10 | 20 | pF |
| Shift Gate Capacitance | $C_{SH}$ | — | 20 | 40 | pF |
| Reset Gate Capacitance | $C_{\overline{RS}}$ | — | 10 | 20 | pF |
| Sample and Hold Gate Capacitance | $C_{\overline{SP}}$ | — | 10 | 20 | pF |
| Clamp Gate Capacitance | $C_{\overline{CP}}$ | — | 10 | 20 | pF |

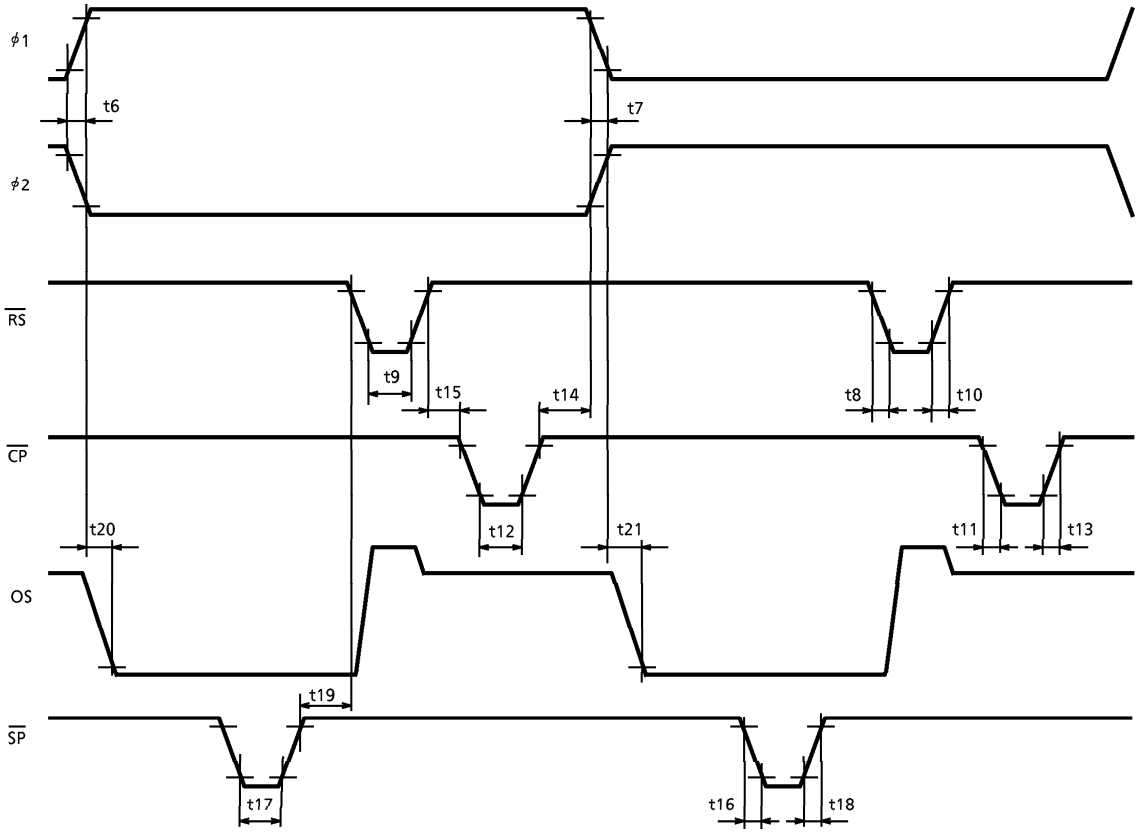
## TIMING CHART



## TIMING REQUIREMENTS



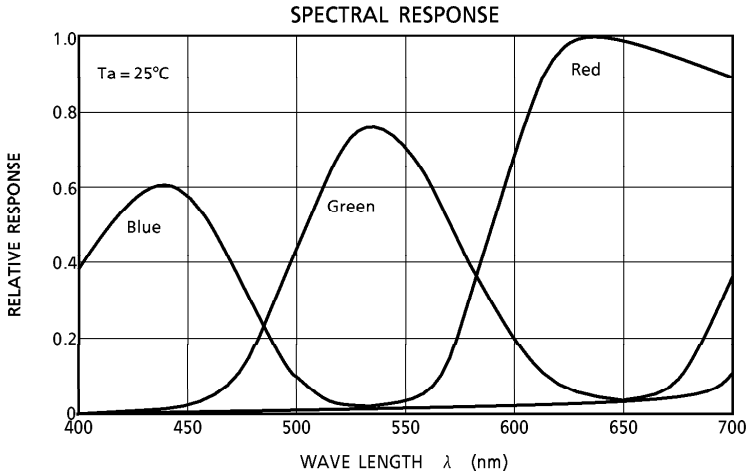



**TIMING REQUIREMENTS (Cont'd)**

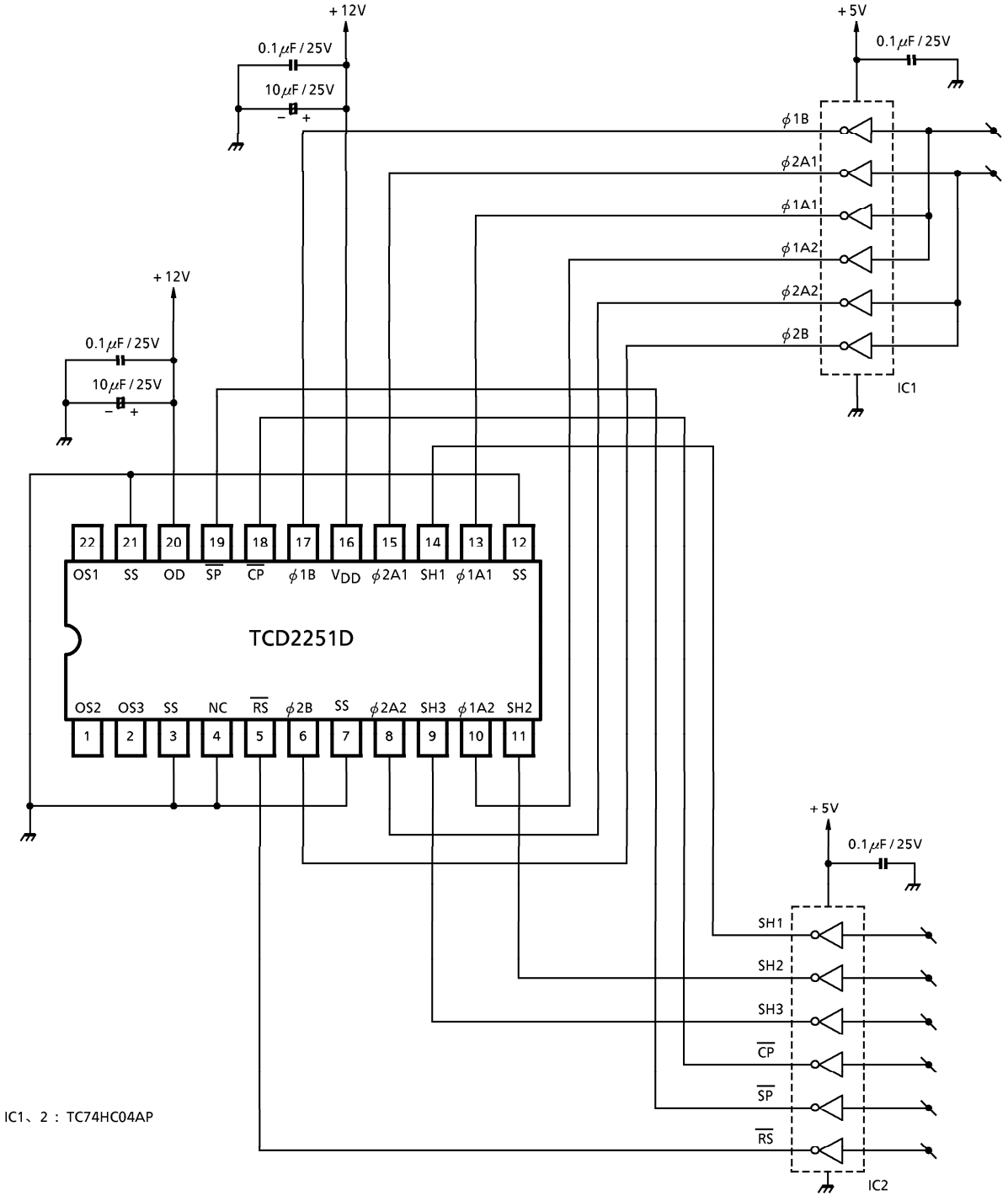
| CHARACTERISTIC | SYMBOL | MIN. | TYP. (Note 14) | MAX. | UNIT |
|---|---|---|---|---|---|
| Pulse Timing of SH and $\phi$1A | t1 | 120 | 1000 | — | ns |
| | t5 | 200 | 1000 | — | ns |
| SH Pulse Rise Time, Fall Time | t2, t4 | 0 | 50 | — | ns |
| SH Pulse Width | t3 | 1000 | 2000 | — | ns |
| $\phi$1, $\phi$2 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 | t9 | 30 | 100 | — | ns |
| $\overline{CP}$ Pulse Rise Time, Fall Time | t11, t13 | 0 | 20 | — | ns |
| $\overline{CP}$ Pulse Width | t12 | 30 | 100 | — | ns |
| Pulse Timing of $\phi$1B, $\phi$2B and $\overline{CP}$ | t14 | 20 | 40 | — | ns |
| Pulse Timing of $\overline{RS}$ and $\overline{CP}$ | t15 | 0 | 20 | — | ns |
| $\overline{SP}$ Pulse Rise Time, Fall Time | t16, t18 | 0 | 20 | — | ns |
| $\overline{SP}$ Pulse Width | t17 | 40 | 100 | — | ns |
| Pulse Timing of $\overline{RS}$ and $\overline{SP}$ | t19 | 0 | 20 | — | ns |
| Video Data Delay Timing (Note 15) | t20, t21 | — | 60 | — | ns |
| Pulse Timing of SH and $\overline{CP}$ | t22 | 0 | 500 | — | ns |

(Note 14) TYP. is the case of $f_{\overline{RS}}$ = 1.0MHz.
(Note 15) Load Resistance is 100k$\Omega$.

**TYPICAL SPECTRAL RESPONSE**



## TYPICAL DRIVE CIRCUIT



**CAUTION**

1. 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.

2. Electrostatic Breakdown

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

3. Incident Light

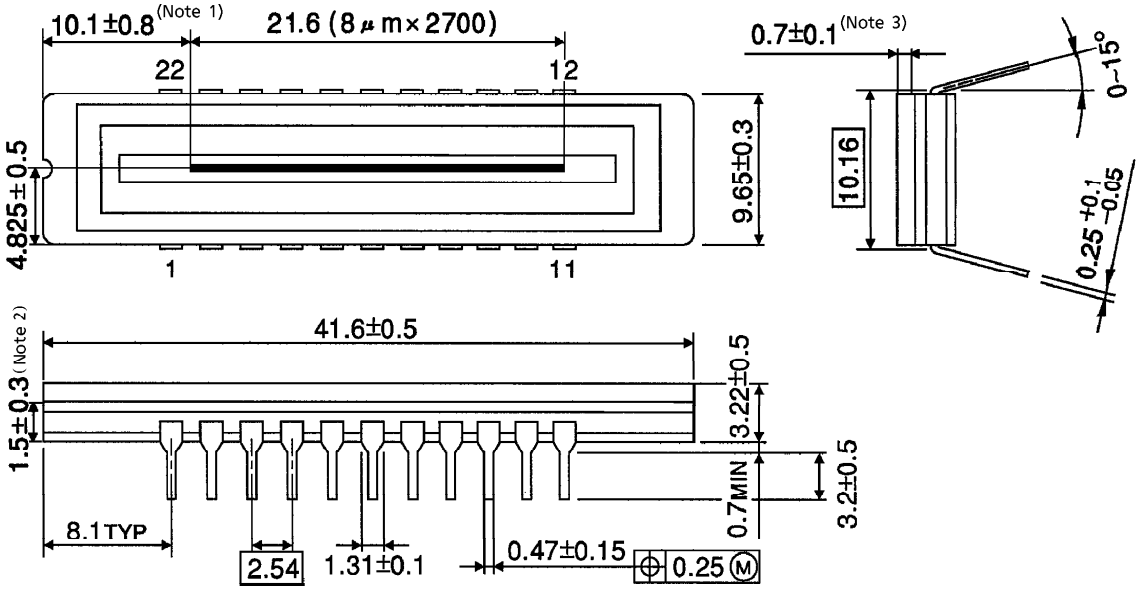
   CCD sensor is sensitive to infrared light.
   Note that infrared light component degrades resolution and PRNU of CCD sensor.

4. Lead Frame Forming
   Since this package is not strong against mechanical stress, you should not reform the lead frame.
   We recommend to use a IC-inserter when you assemble to PCB.

**OUTLINE DRAWING**

WDIP22-G-400-2.54A

Unit : mm




(Note 1) No. 1 SENSOR ELEMENT (S1) TO EDGE OF PACKAGE.
(Note 2) TOP OF CHIP TO BOTTOM OF PACKAGE.
(Note 3) GLASS THICKNES (n = 1.5)

Weight : 4.5g (Typ.)