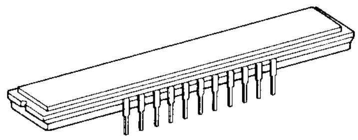
TOSHIBA CCD Linear Image Sensor CCD (Charge Coupled Device)

TCD2707D

The TCD2707D is a high sensitive and low dark current 7450 elements × 4 line CCD color image sensor.

The sensor is designed for color scanner.

The device contains a row of 7450 elements × 4 line photodiodes which provide a 24 lines/mm across a A3 size paper. The device is operated by 5-V pulse, and 10-V power supply.



WDIP22-G-400-2.54D

Weight: 5.2 g (typ.)

Features

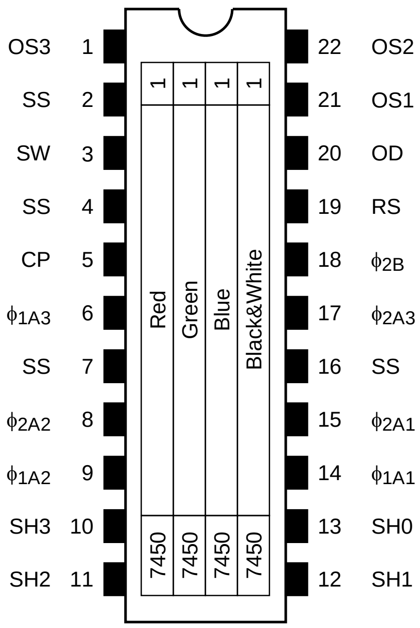
- Number of image sensing pixels: 7450 elements × 4 lines
- Image sensing pixels size: 4.7 μm by 4.7 μm on 4.7 μm center
- Photo sensing region: High sensitive pn photodiode
- Clock: 2-phase (5 V)
- Distance between photodiode array: Pixel R to pixel G, and pixel G to pixel B = 37.6 μm (8 lines)
  Pixel B to pixel B/W = 56.4 μm (12 lines)
- Internal circuit: Clamp circuit
- Package: 22-pin CERDIP
- Color filter: Red, green, blue

Maximum Ratings (Note 1)

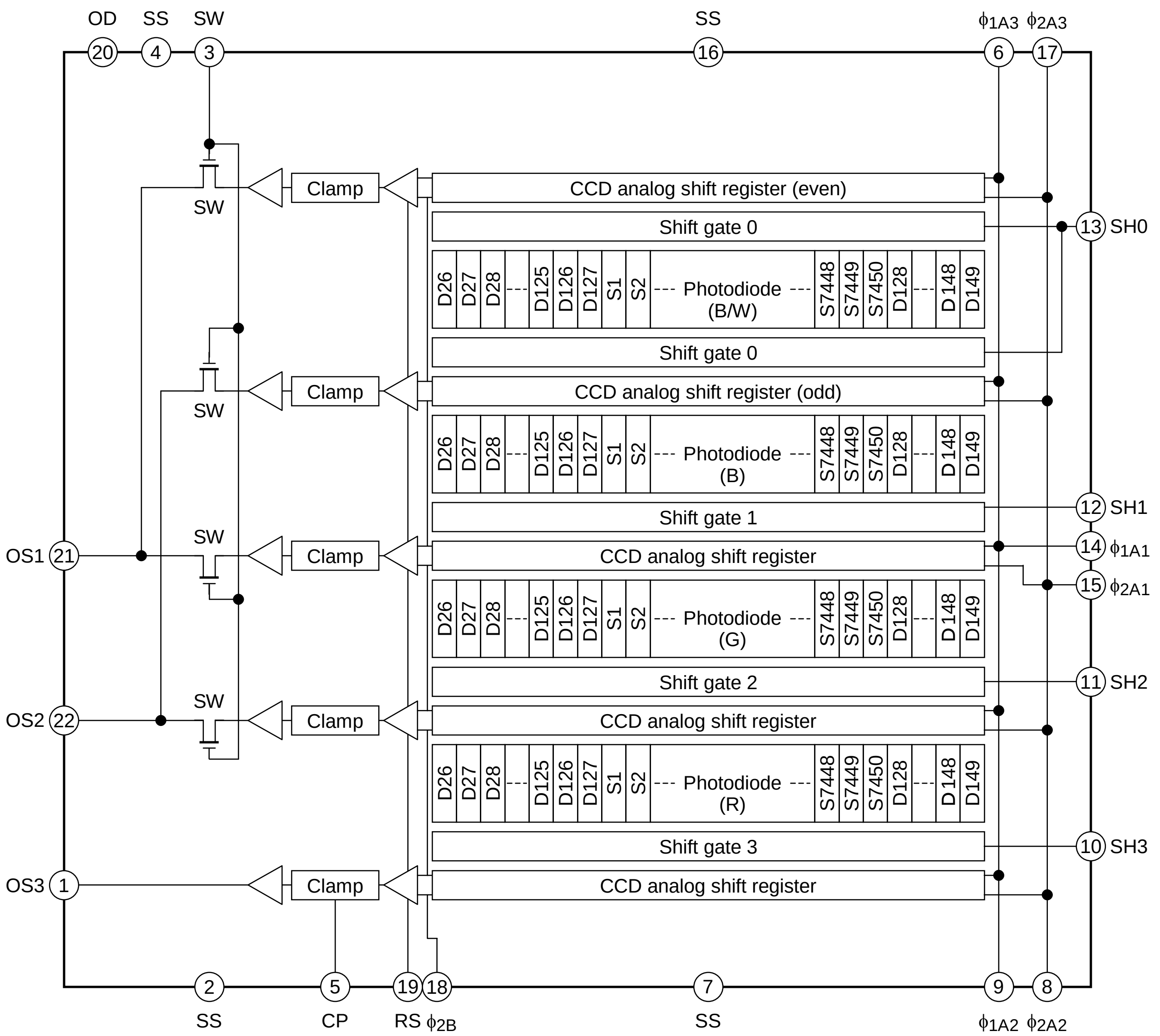
Characteristics	Symbol	Rating	Unit
Clock pulse voltage	$V_{\phi A}$	−0.3~8.0	V
Last stage clock pulse voltage	$V_{\phi B}$		V
Shift pulse voltage	V_{SH}		V
Reset pulse voltage	V_{RS}		V
Clamp pulse voltage	V_{CP}		V
Switch pulse voltage	V_{SW}		V
Power supply voltage	V_{OD}	−0.3~15	V
Operating temperature	T_{opr}	0~60	°C
Storage temperature	T_{stg}	−25~85	°C

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

Pin Connections (top view)



Circuit Diagram



Pin Names

OS3	Output signal 3 (red)	OS2	Output signal 2 (green, B/W (odd))
SS	Ground	OS1	Output signal 1 (blue, B/W (even))
SW	Mode switch input (color or B/W)	OD	Power supply
SS	Ground	RS	Reset gate
CP	Clamp gate	ϕ_{2B}	Last stage transfer clock
ϕ_{1A3}	Transfer clock 3 (phase 1)	ϕ_{2A3}	Transfer clock 3 (phase 2)
SS	Ground	SS	Ground
ϕ_{2A2}	Transfer clock 2 (phase 2)	ϕ_{2A1}	Transfer clock 1 (phase 2)
ϕ_{1A2}	Transfer clock 2 (phase 1)	ϕ_{1A1}	Transfer clock 1 (phase 1)
SH3	Shift gate 3	SH0	Shift gate 0
SH2	Shift gate 2	SH1	Shift gate 1

Optical/Electrical Characteristics

(Ta = 25°C, V_{OD} = 10 V, V_{ϕ} = V_{RS} = V_{SH} = V_{CP} = 5 V (pulse), f_{ϕ} = 1.0 MHz, load resistance = 100 kΩ, t_{INT} (integration time) = 10 ms, light source = light source A + CM500S (t = 1.0 mm))

Characteristics		Symbol	Min	Typ.	Max	Unit	Note
Sensitivity	Black and white	$R_{B/W}$	10.2	12.8	15.4	V/(lx・s)	(Note 2)
	Red	R_R	3.8	5.5	7.2		
	Green	R_G	5.9	8.5	11.1		
	Blue	R_B	2.9	4.2	5.5		
Photo response non uniformity		PRNU (1)	—	10	20	%	(Note 3)
		PRNU (3)	—	3	12	mV	(Note 4)
Saturation output voltage		V_{SAT}	1.0	1.5	—	V	(Note 5)
Saturation exposure	Black and white	SE (B/W)	0.06	0.12	—	lx・s	(Note 6)
	Color	SE (color)	0.09	0.18	—		
Dark signal voltage		V_{DRK}	—	2	5	mV	(Note 7)
Dark signal non uniformity		DSNU	—	8	12	mV	(Note 8)
DC power dissipation		P_D	—	400	600	mW	—
Total transfer efficiency		TTE	92	97	—	%	—
Output impedance		Z_O	—	0.2	0.5	kΩ	—
DC signal output voltage	Black and white	V_{OS} (B/W)	4.0	5.5	7.0	V	(Note 9)
	Color	V_{OS} (color)	3.0	4.5	6.0		
Random noise	Black and white	$N_{D\sigma}$ (B/W)	—	0.7	—	mV	(Note 10)
	Color	$N_{D\sigma}$ (color)	—	1.4	—		

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, and the incident light is 50% of SH (typ.).

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

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

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

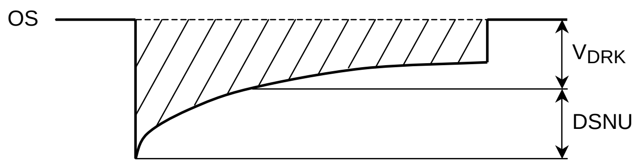
Note 5: V_{SAT} is defined as minimum saturation output voltage of all effective pixels.

Note 6: Definition of SE:

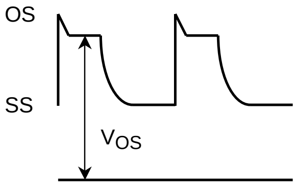
$$\mathrm{SE}_{\ (B/W)} = \frac{V_{SAT}}{R_{B/W}}\ ,\quad \mathrm{SE}_{\ (color)} = \frac{V_{SAT}}{R_G}$$

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

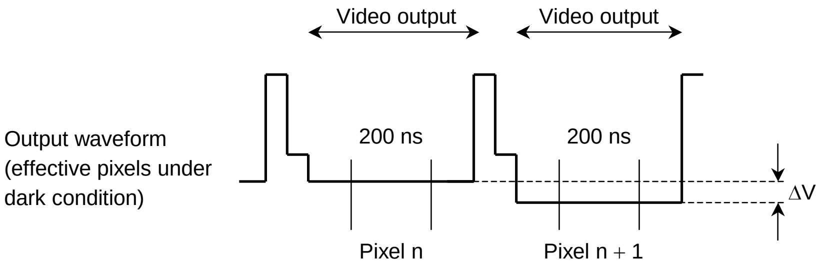
Note 8: DSNU is defined by the difference between average value (V_{DRK}) and the maximum value of the dark voltage.



Note 9: DC signal output 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. 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 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).

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

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

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

(6) $\overline{\sigma}$ 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.

$$N_{D\sigma} = \frac{1}{\sqrt{2}}\overline{\sigma}$$

Operating Condition (Ta = 25°C)

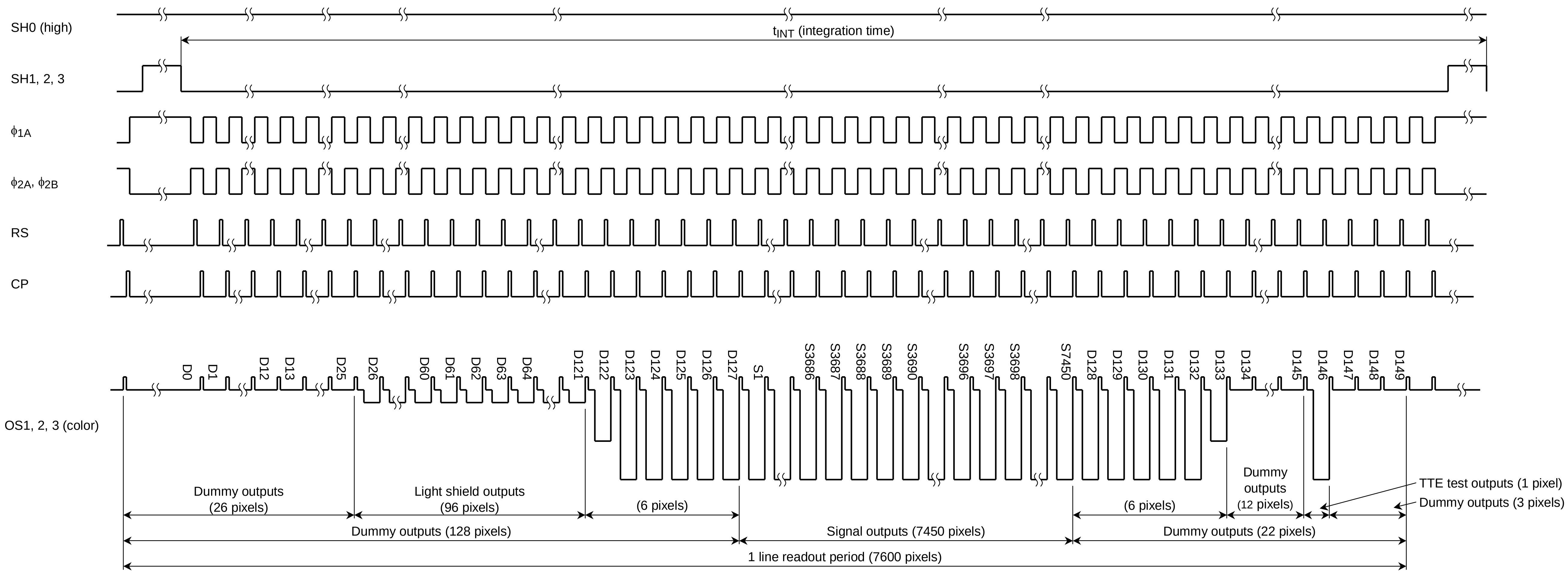
Characteristics		Symbol	Min	Typ.	Max	Unit
Clock pulse voltage	High level	$V_{\phi 1A}$	4.75	5.0	5.5	V
	Low level	$V_{\phi 2A}$	0	—	0.25	
Last stage clock pulse voltage	High level	$V_{\phi 2B}$	4.75	5.0	5.5	V
	Low level		0	—	0.25	
Shift pulse voltage	High level	V_{SH}	4.75	5.0	5.5	V
	Low level		0	—	0.25	
Reset pulse voltage	High level	V_{RS}	4.75	5.0	5.5	V
	Low level		0	—	0.25	
Clamp pulse voltage	High level	V_{CP}	4.75	5.0	5.5	V
	Low level		0	—	0.25	
Switch pulse voltage	High level	V_{SW}	4.75	5.0	5.5	V
	Low level		0	—	0.25	
Power supply voltage		V_{OD}	9.5	10.0	11.0	V

Clock Characteristics (Ta = 25°C)

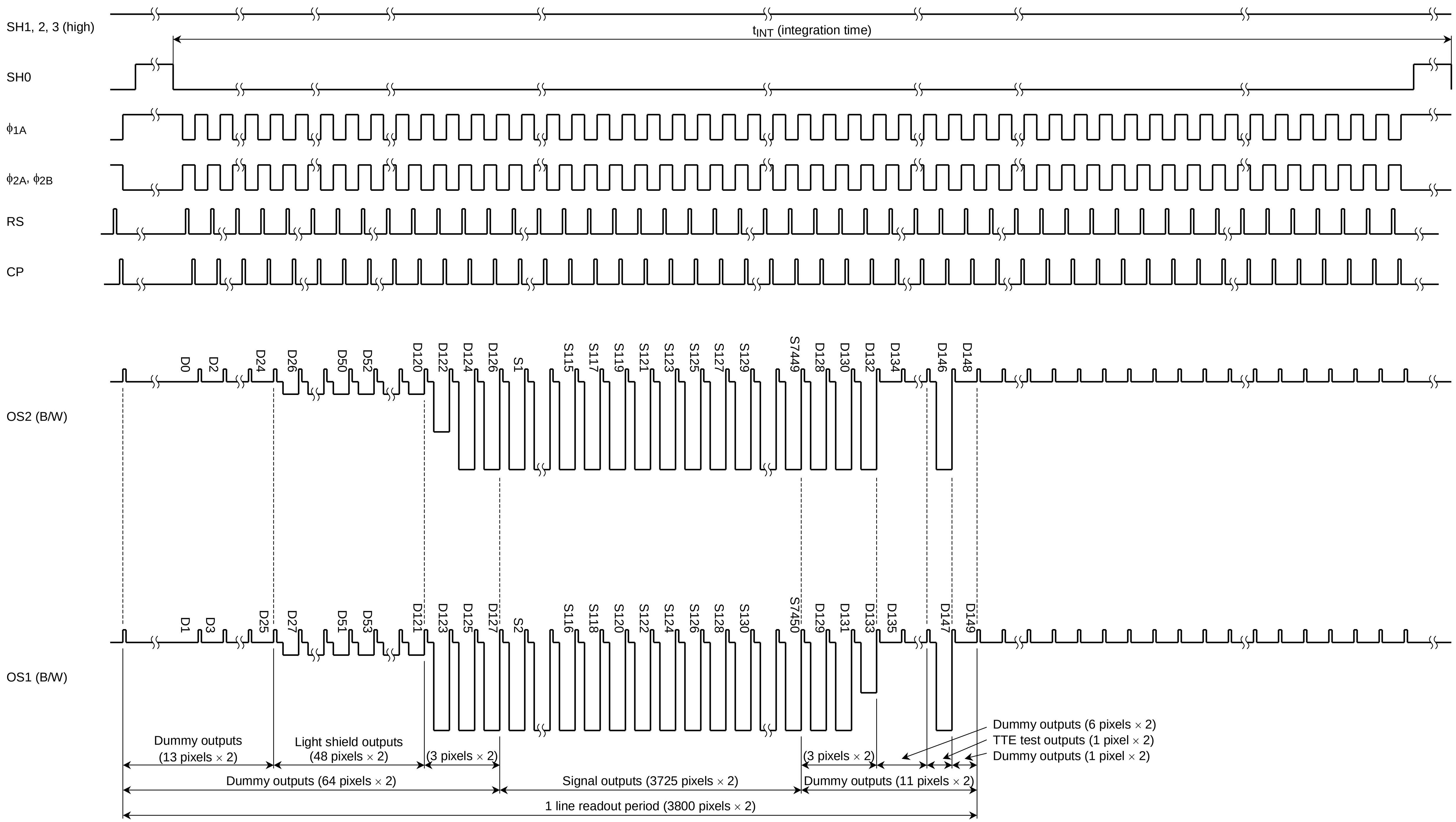
Characteristics	Symbol	Min	Typ.	Max	Unit
Clock pulse frequency	f_{ϕ} (B/W)	—	1.0	25	MHz
	f_{ϕ} (color)	—	1.0	20	
Reset pulse frequency	f_{RS}	—	1.0	25	MHz
Clamp pulse frequency	f_{CP}	—	1.0	25	MHz
Clock capacitance (Note 11)	$C_{\phi 1A}$	—	260	—	pF
	$C_{\phi 2A}$	—	220	—	
Last stage clock capacitance	$C_{\phi B}$	—	20	—	pF
Shift gate capacitance	C_{SH} (SH0, SH3)	—	20	—	pF
	C_{SH} (SH1, SH2)	—	10	—	
Reset gate capacitance	C_{RS}	—	20	—	pF
Clamp gate capacitance	C_{CP}	—	15	—	pF
Switch gate capacitance	C_{SW}	—	10	—	pF

Note 11: V_{OD} = 10 V

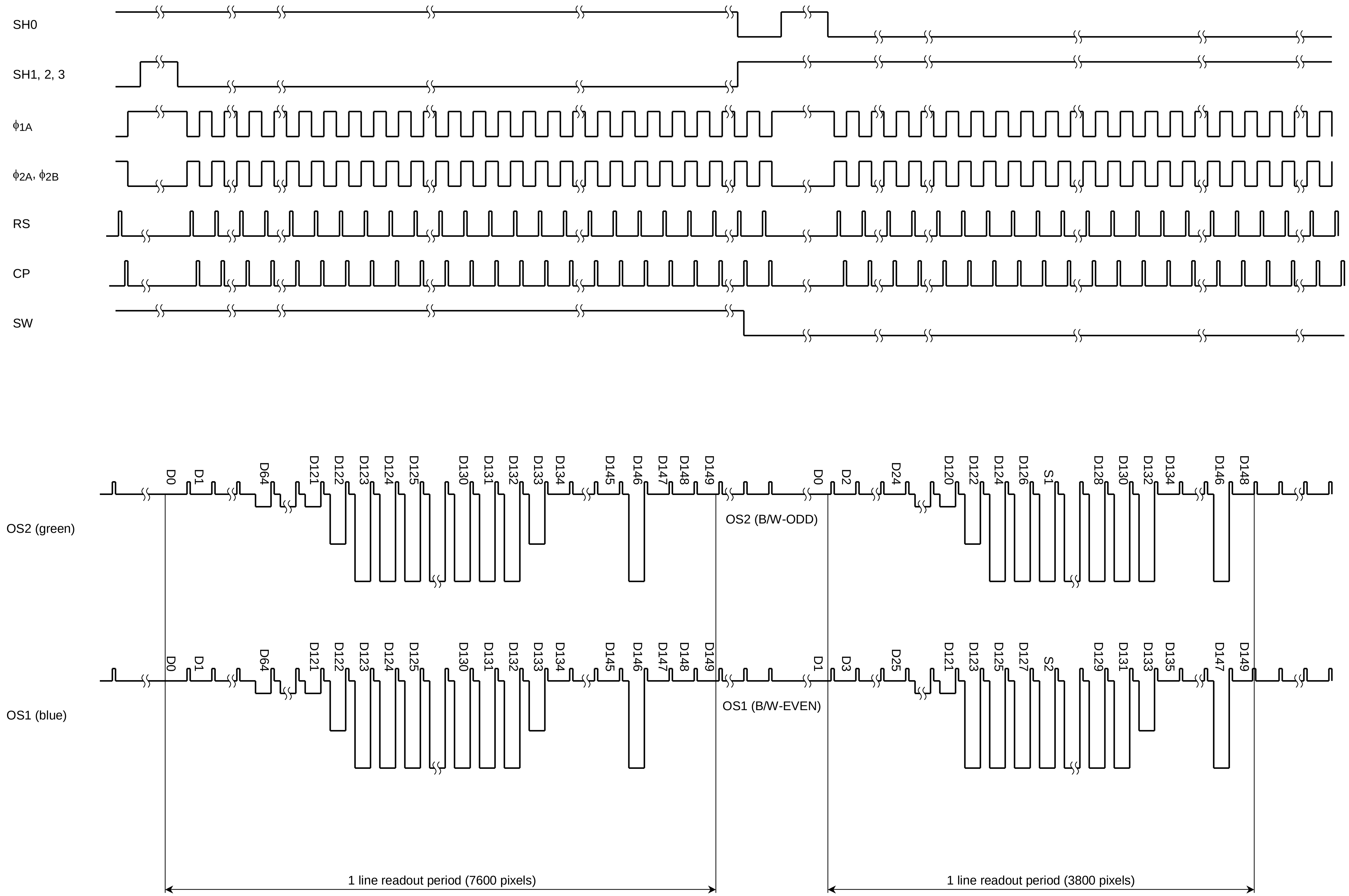
Timing Chart 1 (color mode)



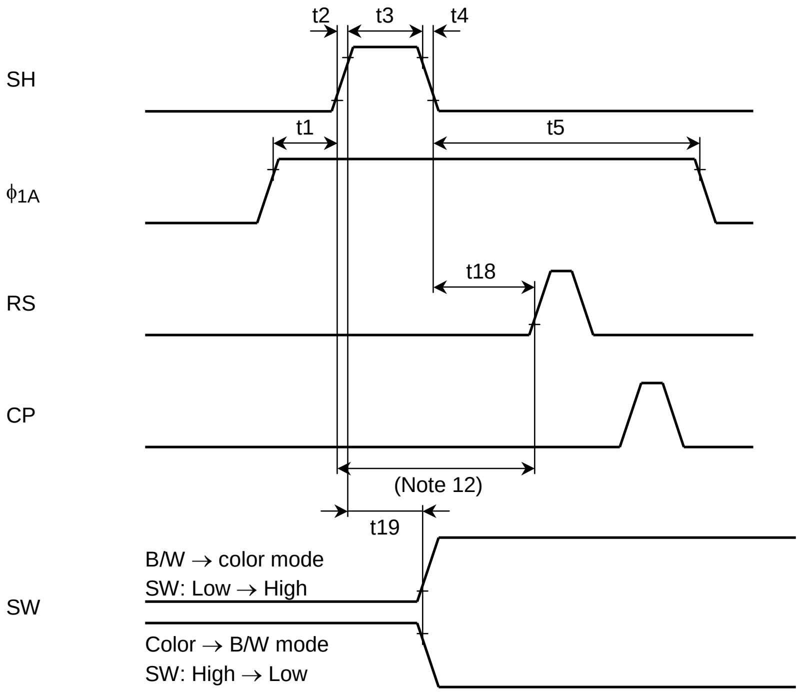
Timing Chart 2 (B/W mode)

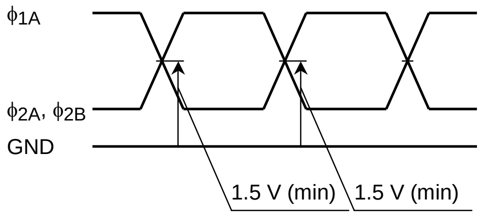


Timing Chart 3 (color → B/W mode)

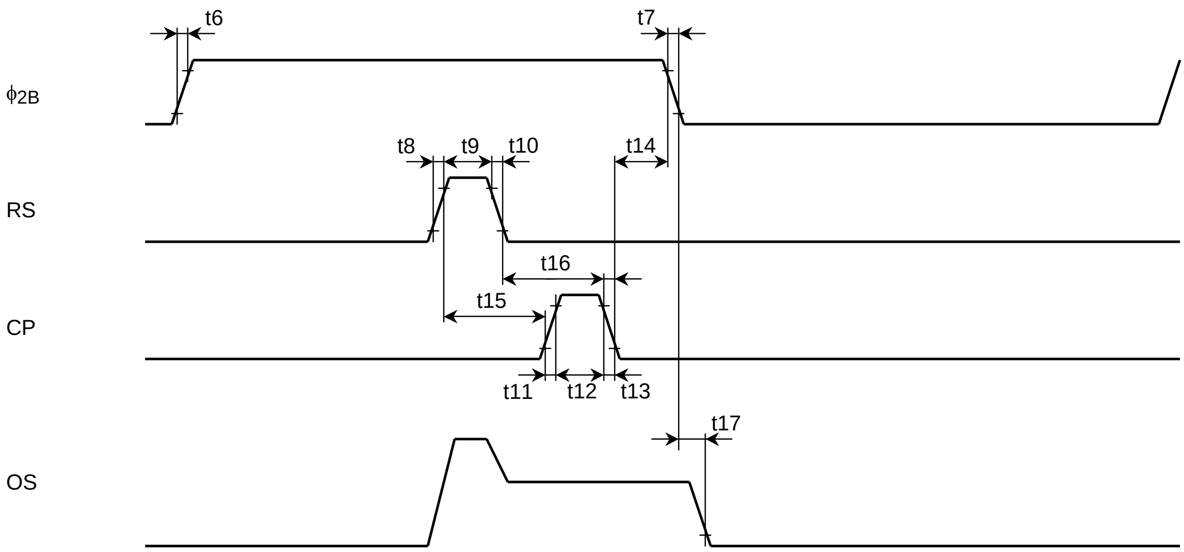


Timing Requirements

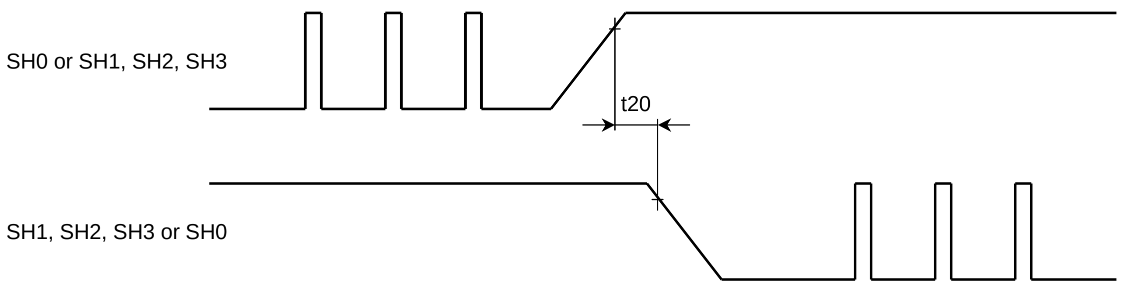




Note 12: Hold the RS and CP pins at low during this period.



SH Input



Prohibited Combination of SH Inputs

SH1, SH2, SH3: "L"
SH0: "L"

Characteristics	Symbol	Min	Typ. (Note 12)	Max	Unit
Pulse timing of SH and ϕ_{1A}	t1	120	1000	—	ns
	t5	1000	1200	—	
SH pulse rise time, fall time	t2, t4	0	50	—	ns
SH pulse width	t3	3000	5000	—	ns
ϕ1, ϕ2 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	10	100	—	ns
CP pulse rise time, fall time	t11, t13	0	20	—	ns
CP pulse width	t12	10	200	—	ns
Pulse timing of ϕ_{2B} and CP	t14	0	40	—	ns
Pulse timing of RS and CP	t15	0	0	—	ns
	t16	10	100	—	
Video data delay time (Note 14) B/W	t17	—	10	—	ns
Video data delay time (Note 14) Color		—	15	—	
Pulse timing of SH and RS	t18	1000	—	—	ns
Pulse timing of SH and SW	t19	100	500	t3 − 100	ns
Mode switching (color ↔ B/W) timing of SH pulse	t20	3000	5000	—	ns

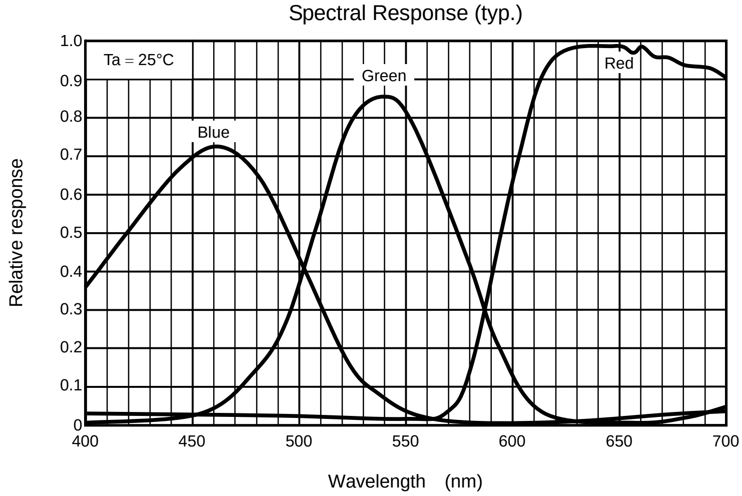
Note 12: Measured with f_{RS} = 1 MHz.

Note 13: Load resistance is 100 kΩ.

Mode Switch Input

Output Type	SW Input Pulse
Color	High
B/W	Low

Typical Spectral Response



Cautions

1. Electrostatic Breakdown

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.

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.

2. 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.

3. Incident Light

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

4. Mounting on a PCB

This package is sensitive to mechanical stress.
Toshiba recommends using IC inserters for mounting, instead of using lead forming equipment.

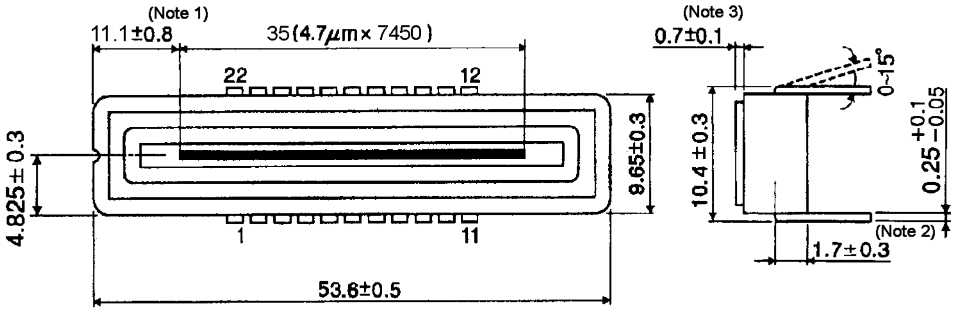
5. Soldering

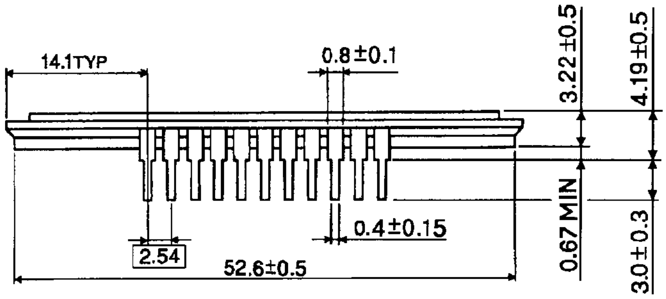
Soldering by the solder flow method cannot be guaranteed because this method may have deleterious effects on prevention of window glass soiling and heat resistance.

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.

Package Dimensions

WDIP22-G-400-2.54D Unit: mm





Note 1: Distance between the edge of the package and the first pixel (S1)
Note 2: Distance between the of chip and bottom of the package.
Note 3: Glass thickness (n = 1.5)

Weight: 5.2 g (typ.)

RESTRICTIONS ON PRODUCT USE

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