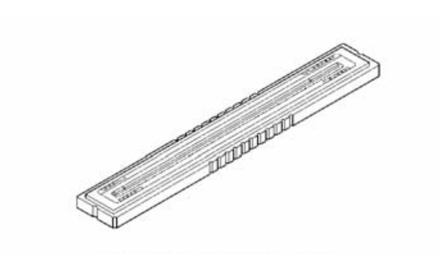
Preliminary

TOSHIBA CCD Image Sensor CCD (charge coupled device)

TCD2915BFG

The TCD2915BFG is a high sensitive and low dark current 10680 elements × 3 line CCD color image sensor. The sensor is designed for scanner.

The device contains a row of 10680 elements × 3 line photodiodes which provide a 48 lines/mm (1200 dpi) across a A4 size paper. The device is operated by 5.0V pulse and 12V power supply.

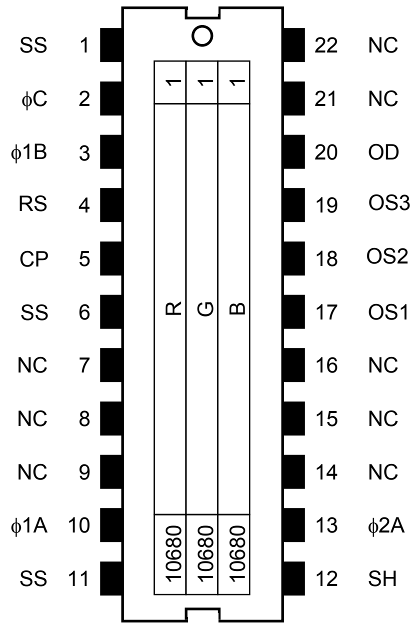


Weight: 2.0g (typ.)

Features

- Number of Image Sensing Elements: 10680 elements × 3 line
- Image Sensing Element Size: 2.625 μm by 8.4 μm on 2.625 μm centers
- Photo Sensing Region: High sensitive and low dark current PN photodiode
- Distanced Between Photodiode Array: 42 μm (16 lines) R array – G array, G array – B array
- Clock: 2 phase (5.0V)
- Power Supply:12V Power Supply Voltage
- Internal Circuit: Clamp Circuit
- Package: 22 pin CLCC Package
- Color Filter: Red, Green, Blue

Pin Connections (top view)

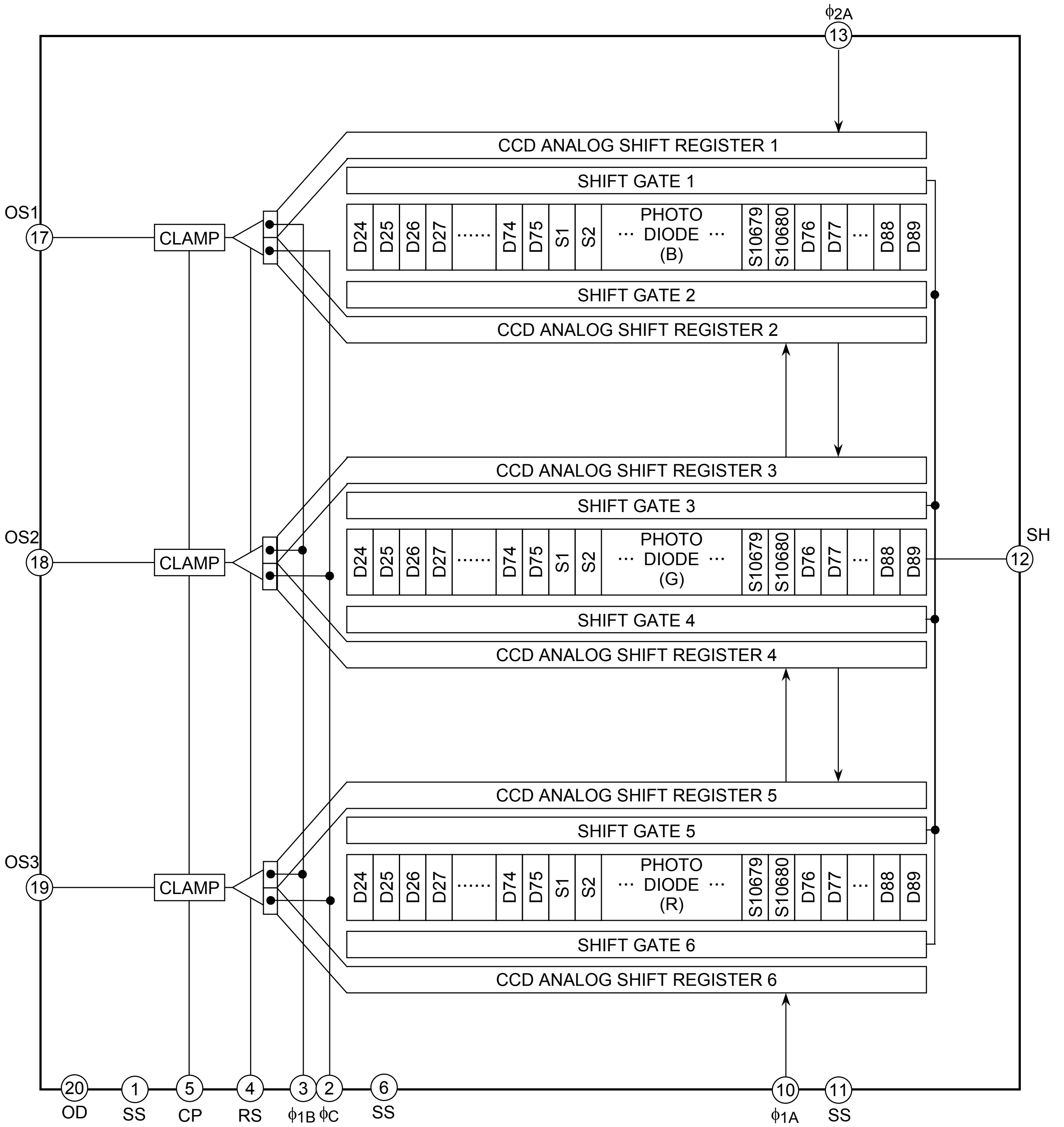


Maximum Ratings (Note1)

Characteristic	Symbol	Rating	Unit
Clock pulse voltage	$V_{\phi A}$, $V_{\phi B}$, $V_{\phi C}$	−0.3~8.0	V
Shift pulse voltage	V_{SH}		
Reset pulse voltage	V_{RS}		
Clamp pulse voltage	V_{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).

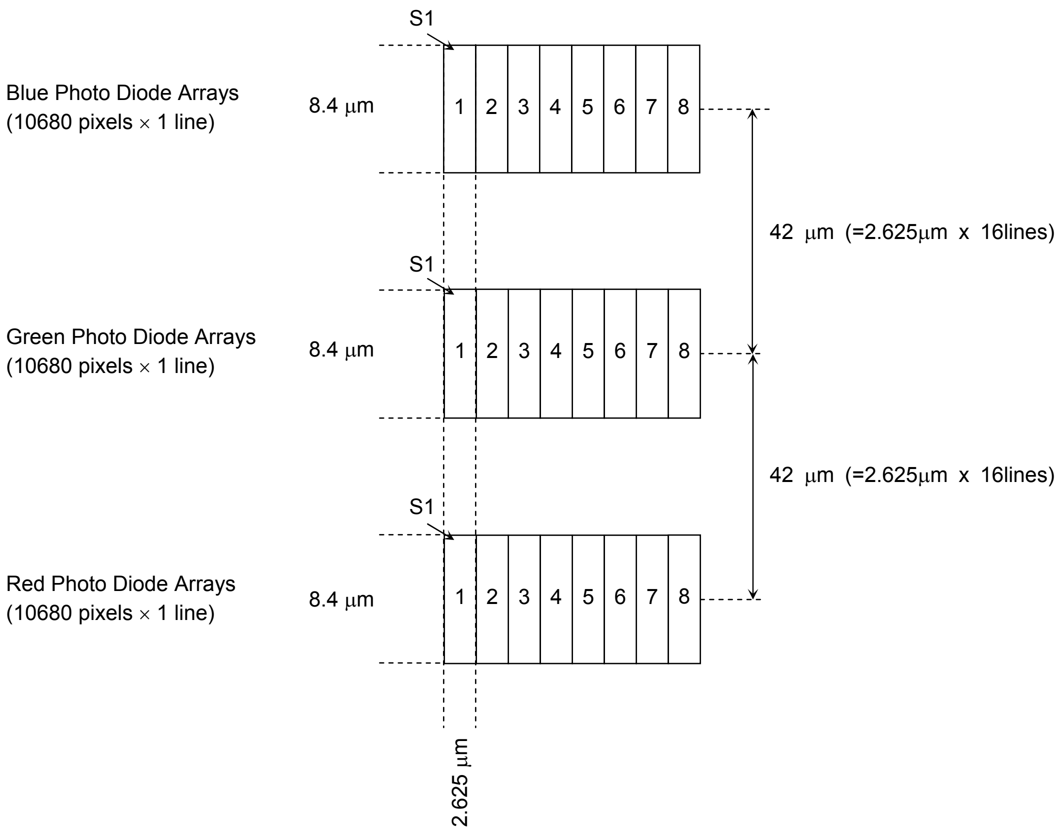
Block Diagram



Pin Names

Pin No.	Symbol	Name	Pin No.	Symbol	Name
1	SS	Ground	22	NC	Non Connection
2	ϕC	Last stage transfer Clock C	21	NC	Non Connection
3	ϕ1B	Last stage transfer Clock B (phase 1)	20	OD	Power
4	RS	Reset Gate	19	OS3	Signal Output 3 (red)
5	CP	Clamp Gate	18	OS2	Signal Output 2 (green)
6	SS	Ground	17	OS1	Signal Output 1 (blue)
7	NC	Non Connection	16	NC	Non Connection
8	NC	Non Connection	15	NC	Non Connection
9	NC	Non Connection	14	NC	Non Connection
10	ϕ1A	Clock A (phase 1)	13	ϕ2A	Clock A (phase 2)
11	SS	Ground	12	SH	Shift Gate

Arrangement of The 1st Effective Pixel (S1)



Optical/Electrical Characteristics (1200dpi Mode)

(Ta = 25°C, V_{OD} = 12V, V_{ϕ} = V_{SH} = V_{RS} = V_{CP} = 5.0V (pulse), f_{ϕ} = 2.5 MHz, f_{RS} = 5 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)	3.8	5.5	7.2	V/lx・s	(Note2)
	Green	R (G)	4.4	6.3	8.2		
	Blue	R (B)	2.3	3.4	4.5		
Photo response non uniformity		PRNU (1)	—	10	20	%	(Note3)
		PRNU (3)	—	3	12	mV	(Note4)
Register imbalance		RI	—	1	—	%	(Note5)
Saturation output voltage		V_{SAT}	2.4	3.0	—	V	(Note6)
Saturation exposure		SE	—	0.47	—	lx・s	(Note7)
Dark signal voltage		V_{DRK}	—	0.3	2.0	mV	(Note8)
Dark signal non uniformity		DSNU	—	2.0	7.0	mV	
DC power dissipation		PD	—	400	580	mW	
Total transfer efficiency		TTE	92	98	—	%	
Output impedance		Z_O	—	80	500	Ω	
DC output voltage		V_{OS}	5.2	6.2	7.2	V	(Note9)
Reset noise		V_{RSN}	—	0.6	—	V	
Random noise		$N_{D\sigma}$	—	0.8	—	mV	(Note10)

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 pixel, where measured 5% of SE (typ.)

Note 5: Register imbalance is defined as follows.

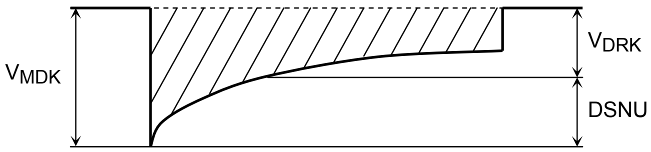
$$\text{RI} = \frac{\sum_{n=1}^{10679} |X_n - X_{(n+1)}|}{10679 \times \overline{X}} \times 100(\%)$$

Note 6: V_{SAT} is defined as minimum saturation output of all effective pixels.

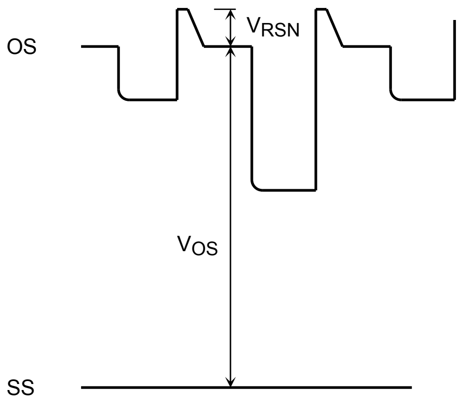
Note 7: Definition of SE

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

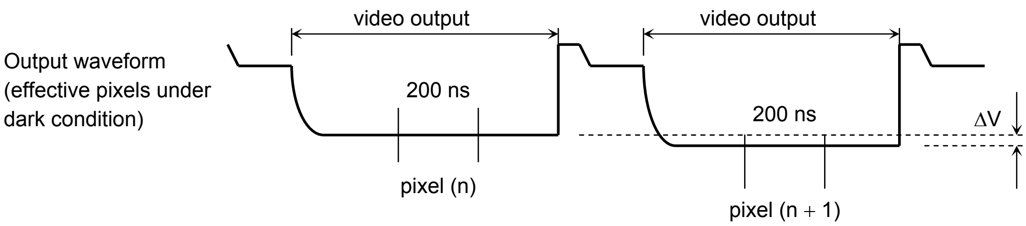
Note 8: V_{DRK} is defined as average dark signal voltage of all effective pixels.
DSNU is defined as different voltage between V_{DRK} and V_{MDK} when V_{MDK} is maximum dark signal voltage.



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



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 conditions) calculated by the following procedure.



(1) Two adjacent pixels (pixel n and n + 1) after reference level clamp 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).

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

(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 random noise as follows.

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

Operating Condition

Characteristics		Symbol	Min	Typ.	Max	Unit
Clock pulse voltage	"H" Level	$V_{\phi A}$	4.5	5.0	5.5	V
	"L" Level		0	0	0.5	
Final Stage Clock voltage	"H" Level	$V_{\phi 1B}$, $V_{\phi C}$	4.5	5.0	5.5	V
	"L" Level		0	0	0.5	
Shift pulse voltage	"H" Level	V_{SH}	2.7	3.3	5.5	V
	"L" Level		0	0	0.8	
Reset pulse voltage	"H" Level	V_{RS}	4.5	5.0	5.5	V
	"L" Level		0	0	0.5	
Clamp pulse voltage	"H" Level	V_{CP}	4.5	5.0	5.5	V
	"L" Level		0	0	0.5	
Power supply voltage		V_{OD}	11.4	12.0	12.6	V

Clock Characteristics (Ta = 25°C)

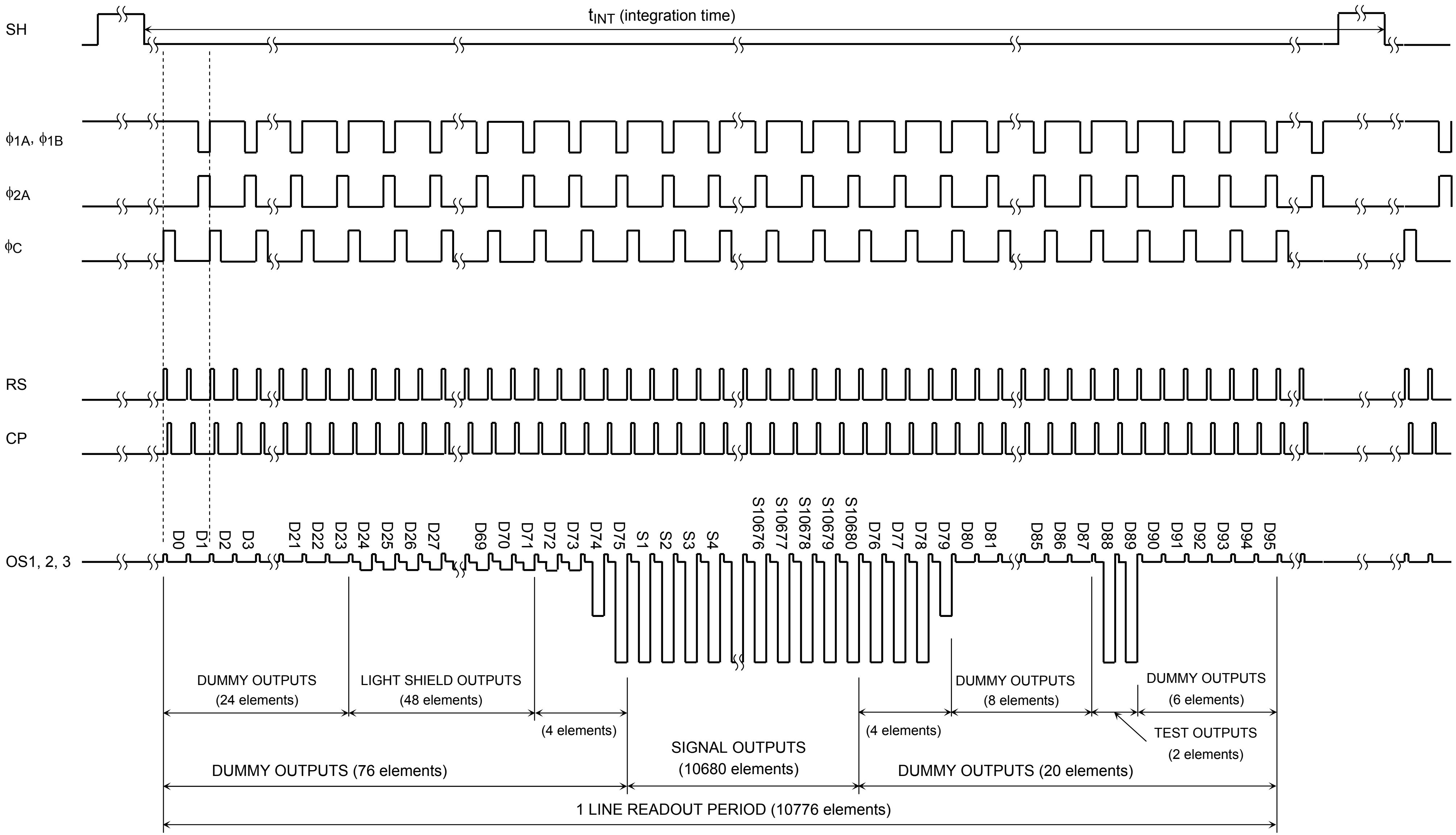
Characteristics	Symbol	Min	Typ.	Max	Unit
Clock pulse frequency	f_{ϕ}	—	5.0	20.0	MHz
Reset pulse frequency	f_{RS}	—	5.0	20.0	MHz
Clamp pulse frequency	f_{CP}	—	5.0	20.0	MHz
Clock(1A) capacitance (Note 11)	$C_{\phi 1A}$	—	250	—	pF
Clock(2A) capacitance (Note 11)	$C_{\phi 2A}$	—	270	—	pF
Final Stage Clock capacitance (Note 11)	$C_{\phi 1B}$, $C_{\phi C}$	—	6	—	pF
Shift gate capacitance	C_{SH}	—	12	—	pF
Reset gate capacitance	C_{RS}	—	7	—	pF
Clamp gate capacitance	C_{CP}	—	7	—	pF

Note 11: V_{OD} = 12V

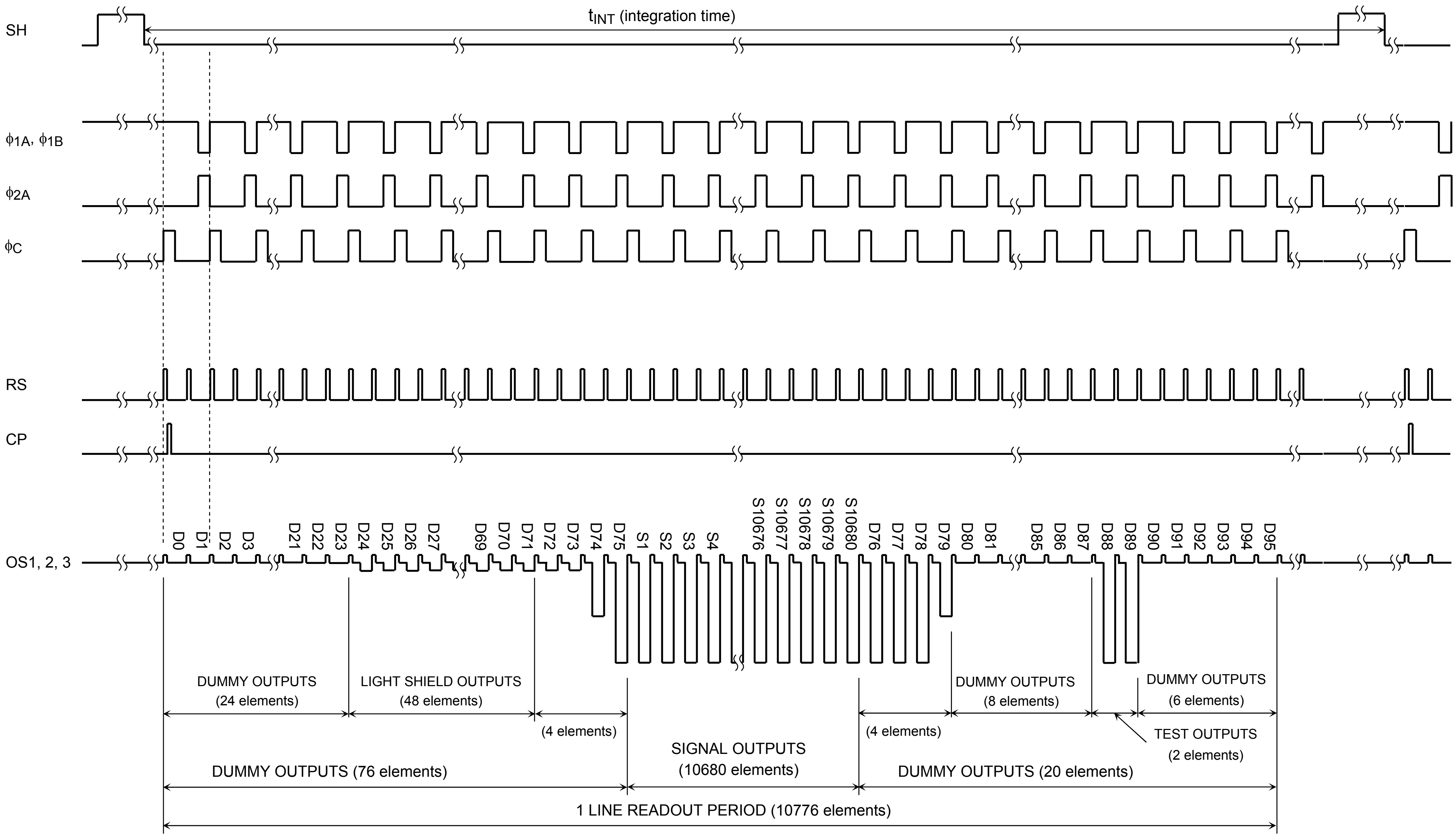
Clocking Mode

<table>
<tr><th colspan="2">Mode</th><th>SH</th><th>φ1A,
φ2A</th><th>φ1B</th><th>φC</th><th>RS</th><th>CP</th></tr>
<tr><td rowspan="2">Bit Clamp
/ Line Clamp</td><td>1200DPI</td><td rowspan="2">Pulse</td><td rowspan="2">Pulse</td><td>φ1A</td><td>Pulse</td><td rowspan="2">Pulse</td><td rowspan="2">Pulse</td></tr>
<tr><td>600DPI</td><td colspan="2">φ1A</td></tr>
</table>

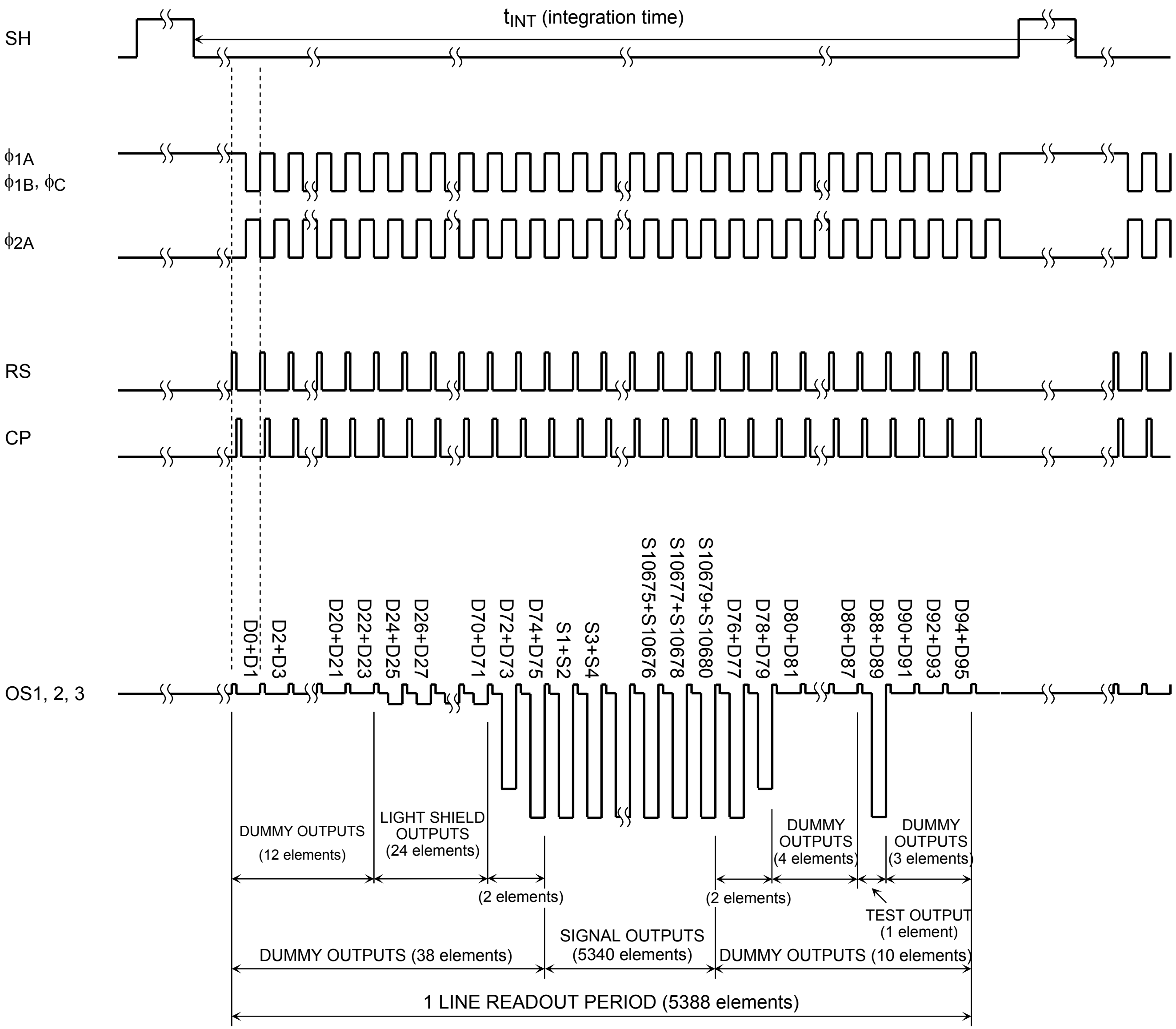
Timing Chart 1: Color 1200DPI Mode (Bit Clamp Mode)



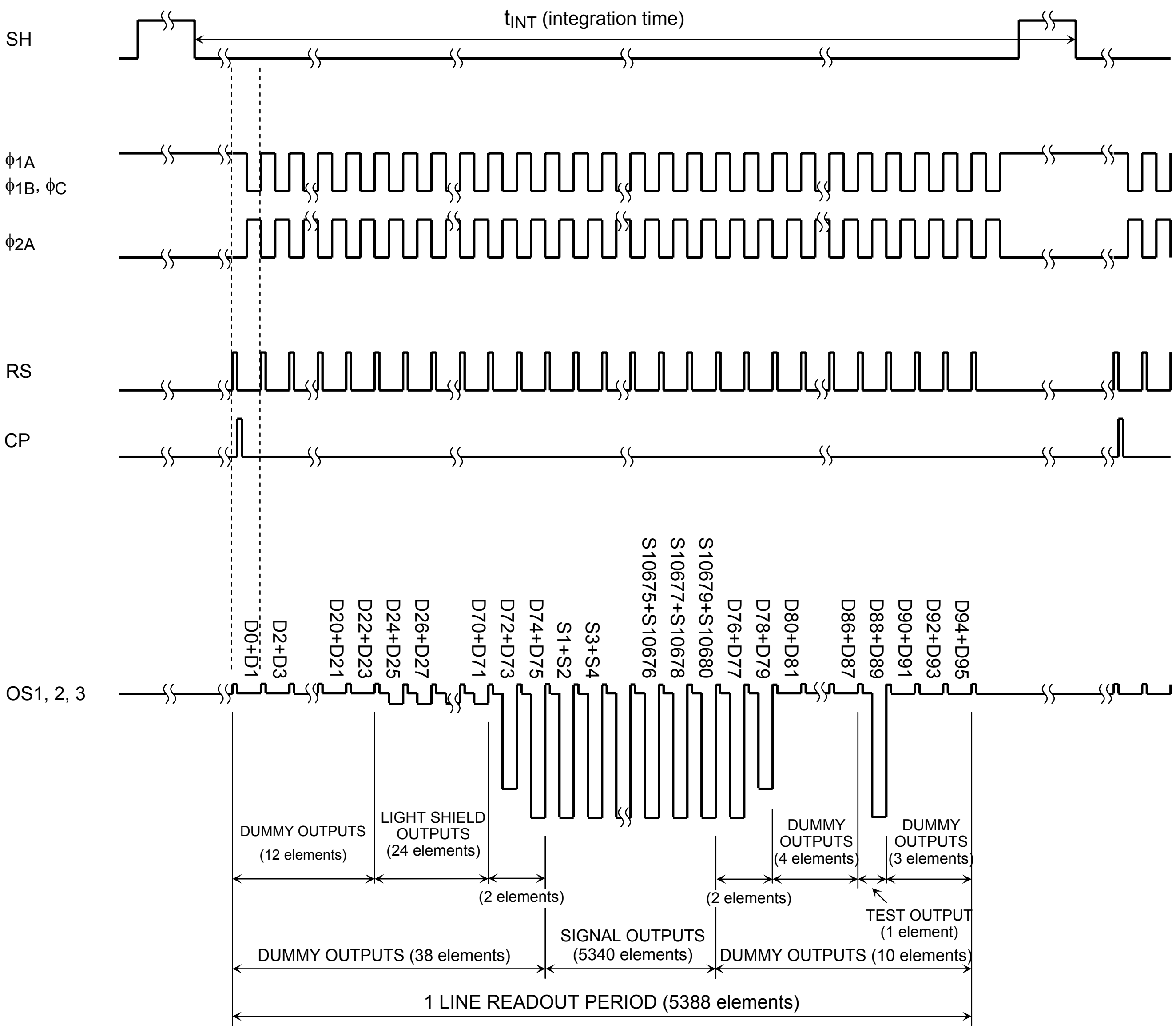
Timing Chart 2: Color 1200DPI Mode (Line Clamp Mode)



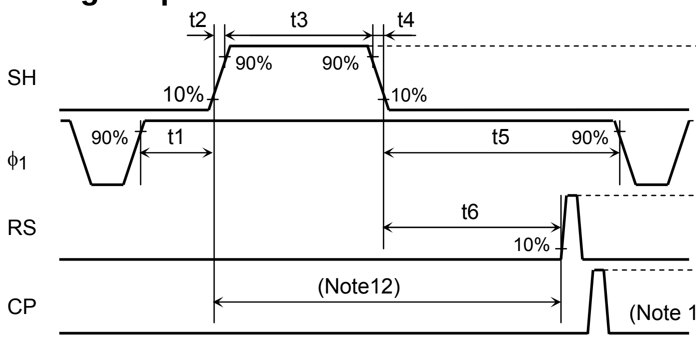
Timing Chart 3: Color 600DPI Mode (Bit Clamp Mode)

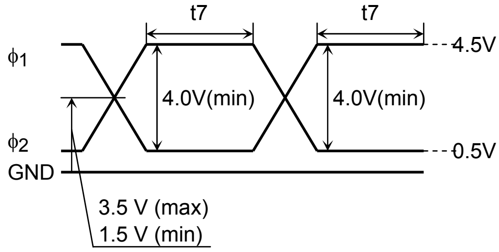


Timing Chart 4: Color 600DPI Mode (Line Clamp Mode)



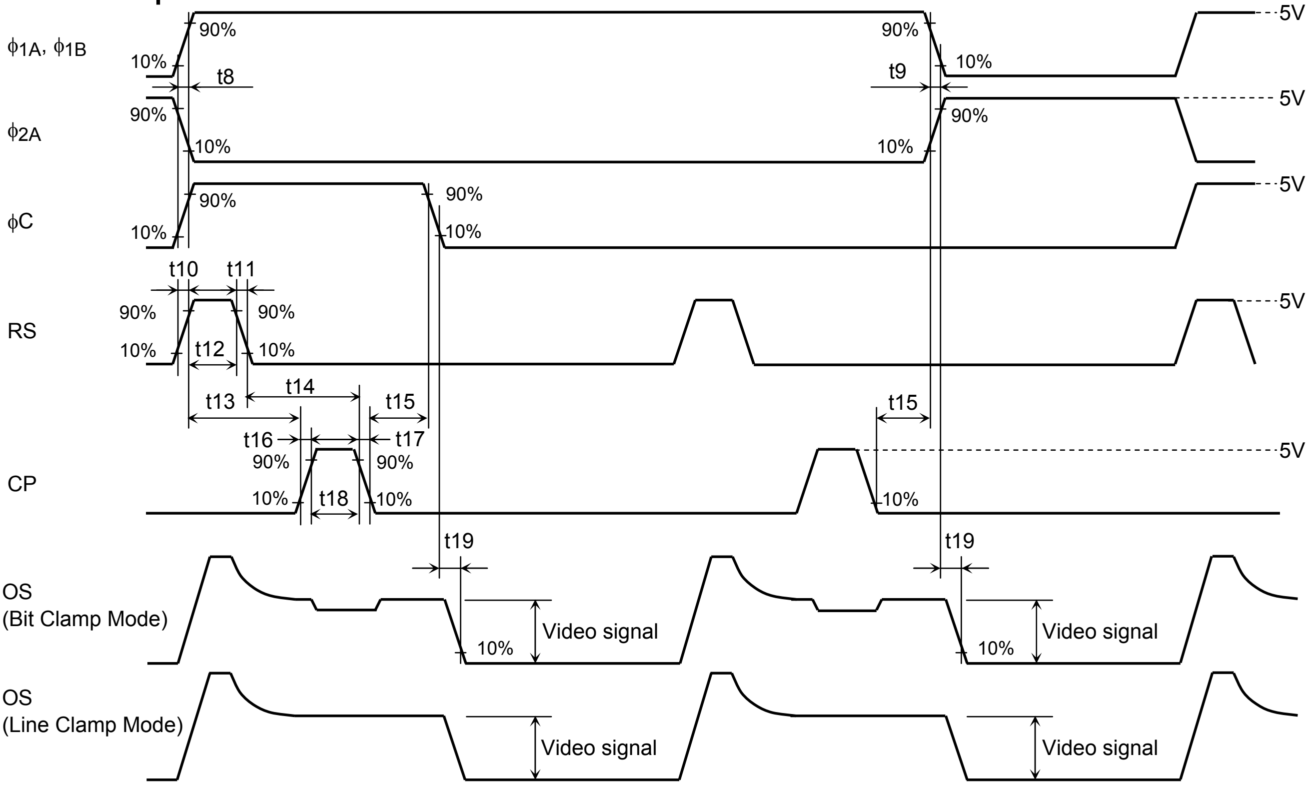
Timing Requirements



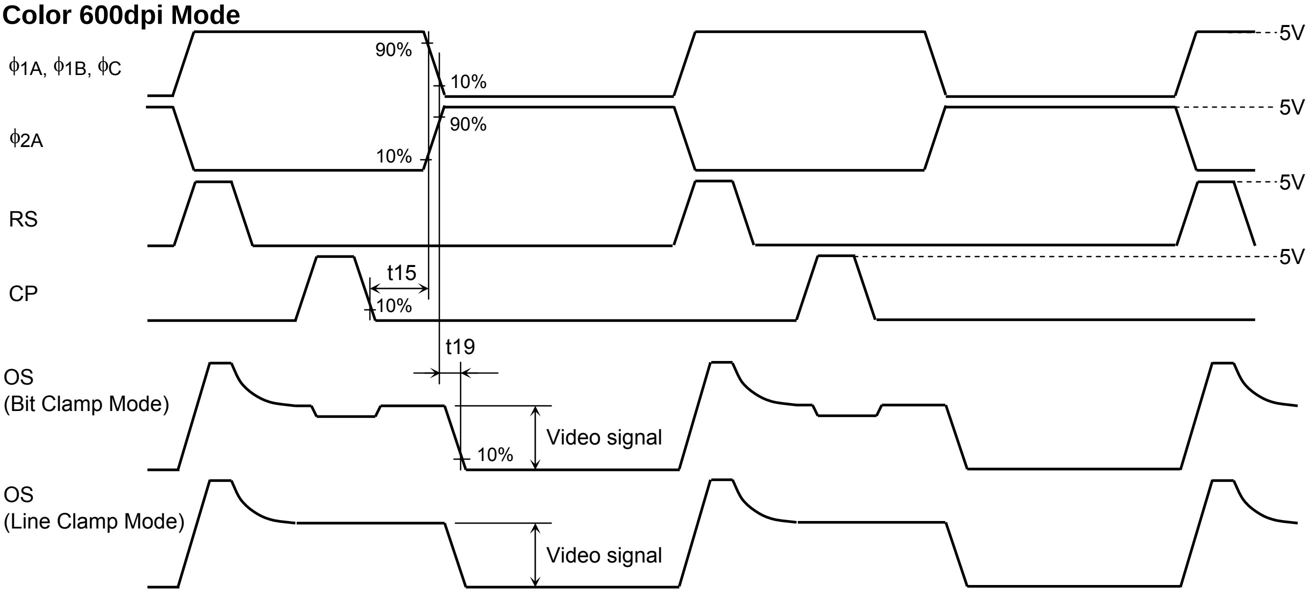


(Note 12) Set the voltage level of RS and CP to "L" level.

Color 1200dpi Mode



Color 600dpi Mode



Timing Requirements (cont.)

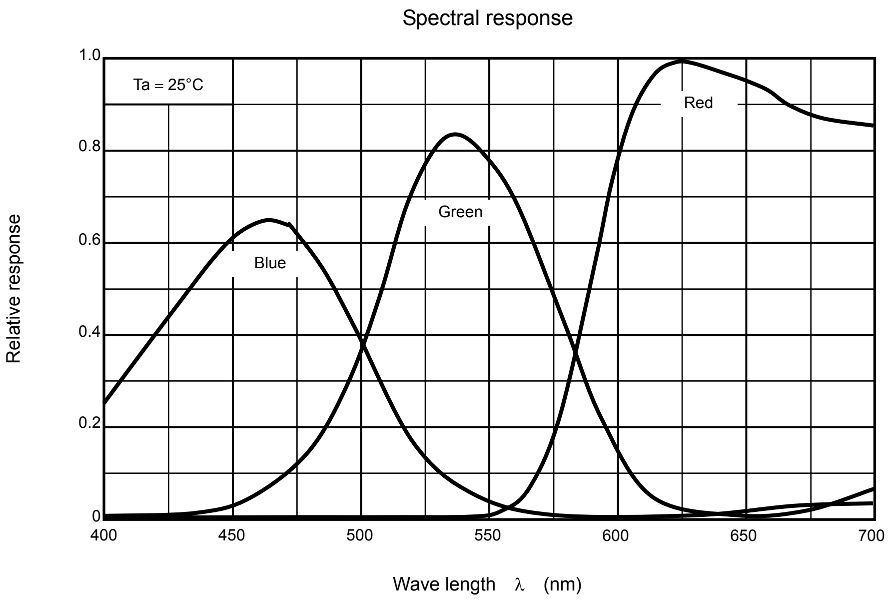
Characteristics	Symbol	Min	Typ. (Note 13)	Max	Unit
Pulse timing of SH and ϕ1	t1	120	200	—	ns
	t5	1000	1075	—	
SH pulse rise time, fall time	t2, t4	0	50	—	ns
SH pulse width	t3	3000	4000	—	ns
Pulse timing of SH and CP	t6	975	—	—	ns
ϕ1A, ϕ2A pulse width (Note 14)	t7	(15)	90	—	ns
ϕ1A, ϕ2A pulse rise time, fall time	t8, t9	0	15	—	ns
RS pulse rise time, fall time	t10, t11	0	10	—	ns
RS pulse width	t12	10	15	—	ns
Pulse timing of RS and CP	t13	0	0	—	ns
	t14	10	50	—	ns
Pulse timing of ϕ_{1B} and CP	t15	0	40	—	ns
Pulse timing of ϕ_C and CP					
CP pulse rise time, fall time	t16, t17	0	10	—	ns
CP pulse width	t18	10	40	—	ns
Video data delay time (Note 15)	t19	—	10	—	ns

Note 13: Typ. is the case of f_{RS}= 5.0 MHz.

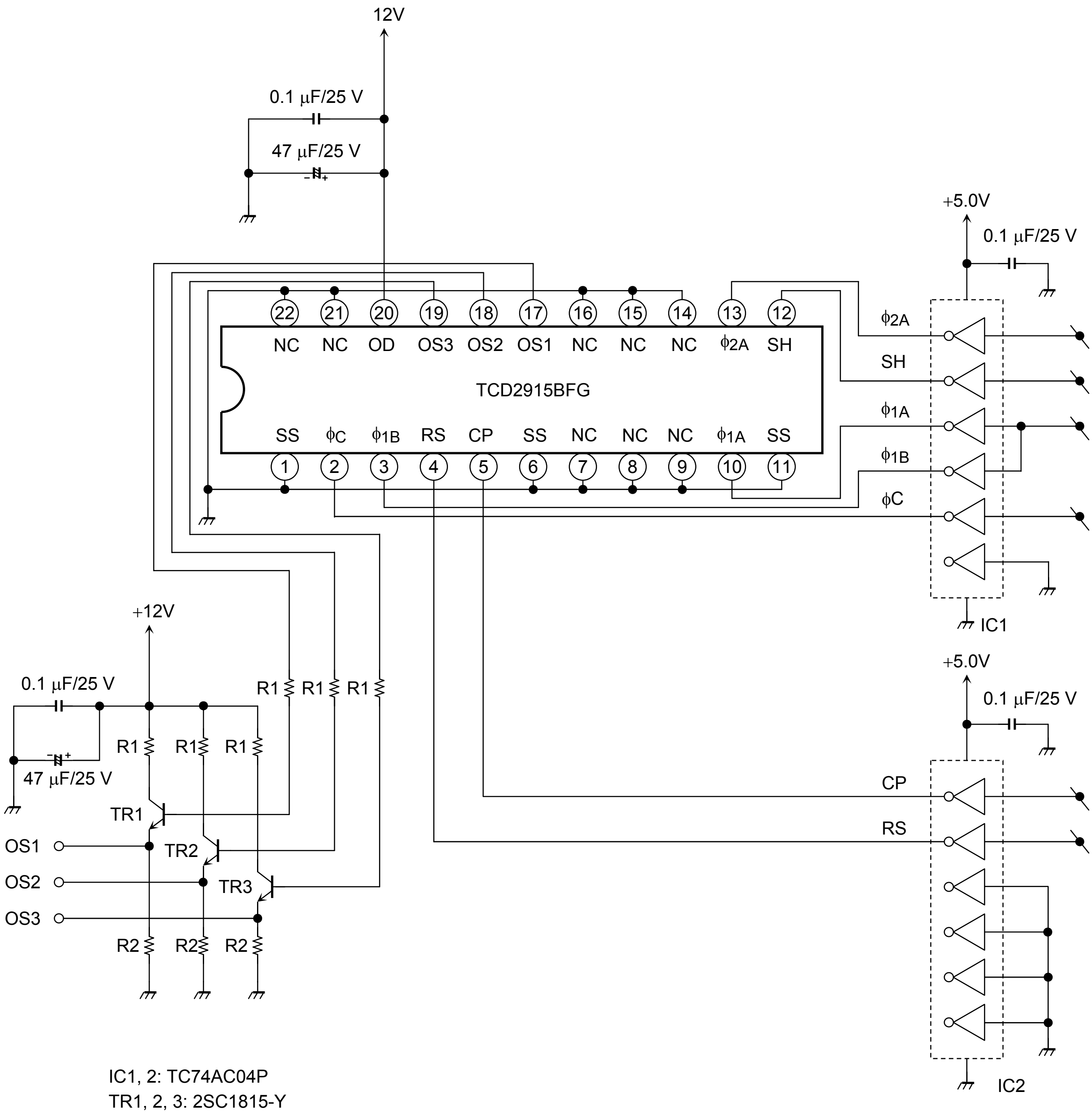
Note 14: Pulse width is the period when voltage difference between ϕ1 and ϕ2 is over 4.0V. Observe the specification strictly because of normal transfer efficiency.

Note 15: Load Resistance is 100 kΩ.

Typical Spectral Response

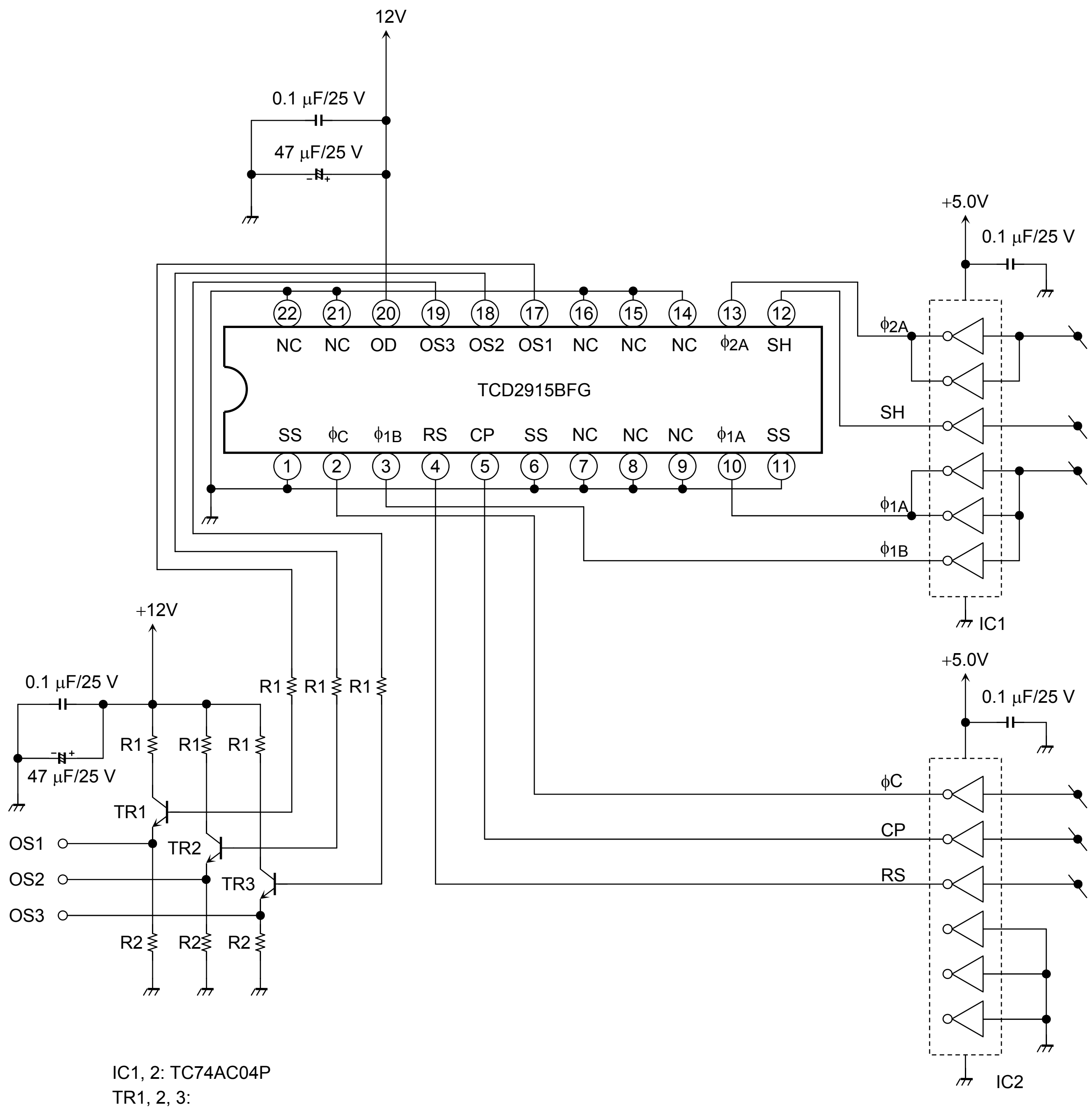


Typical Drive Circuit (at fϕ=10MHz or lower)



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

Typical Drive Circuit



IC1, 2: TC74AC04P
TR1, 2, 3:
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. 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℃90%RH. And after the aluminum bag is opened, please keep the products in the environment below 30℃60%RH .
・ Please mount the products within 12month from sealed date and within 6 month 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.

7. 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, only one time.

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℃.

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℃ or less.
2. Time to keep high temperature : 220～250℃, 30～40sec.
3. Pre. heat : 150～190℃, 60～120sec

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.

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.

Recommended wiping cloth is as follow;
- MK cloth (Toray Industries)

Cleaner

Recommended cleaning liquid of window glass are as follow;
- EE-3310 (Olympus)

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.

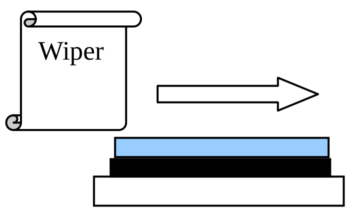
Next, the surface of window glass wipes with the dry wiping cloth. Please wipe down the surface of window glass at least 3 times or more.

Finally, blow cleaning is performed by dry N2 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.



10. Foot Pattern on the PCB

We recommend fig1 's foot pattern for your PCB(Printed circuit Board).

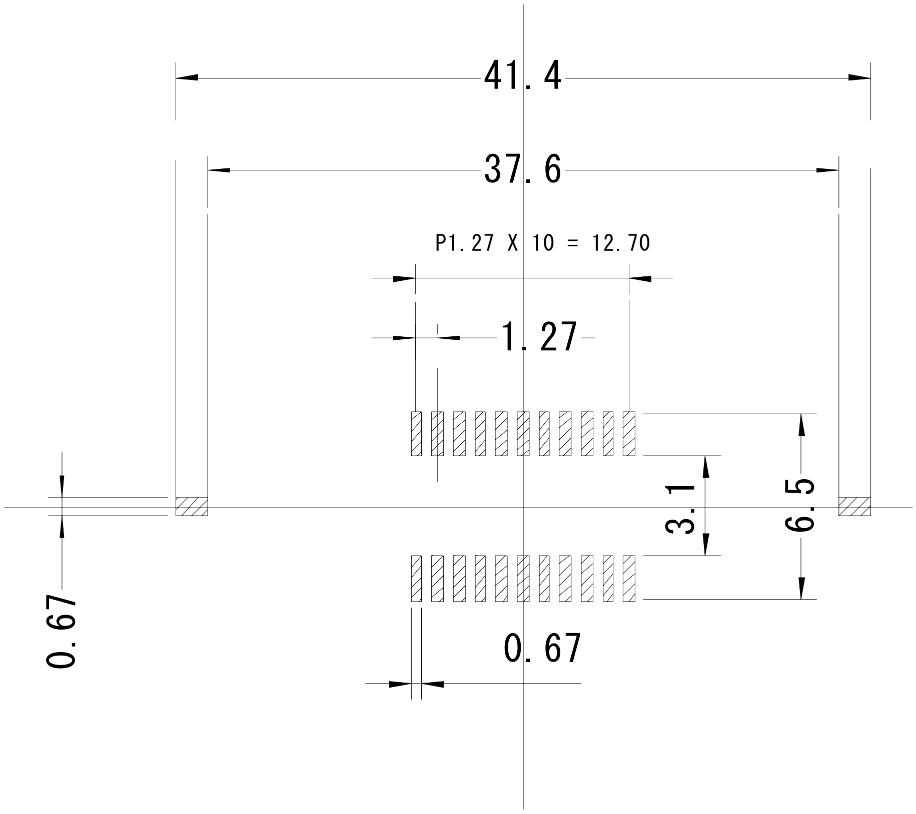


fig1

11. Mask for Solder Paste Application

We recommend metal mask that have the following thickness.
・TCD****BFG(Pad material : Au) : a thickness of 0.2mm.
And we recommend that the size of the pattern of the metal mask is 95% to 100% of recommended foot pattern at fig1.

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, underfil 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.

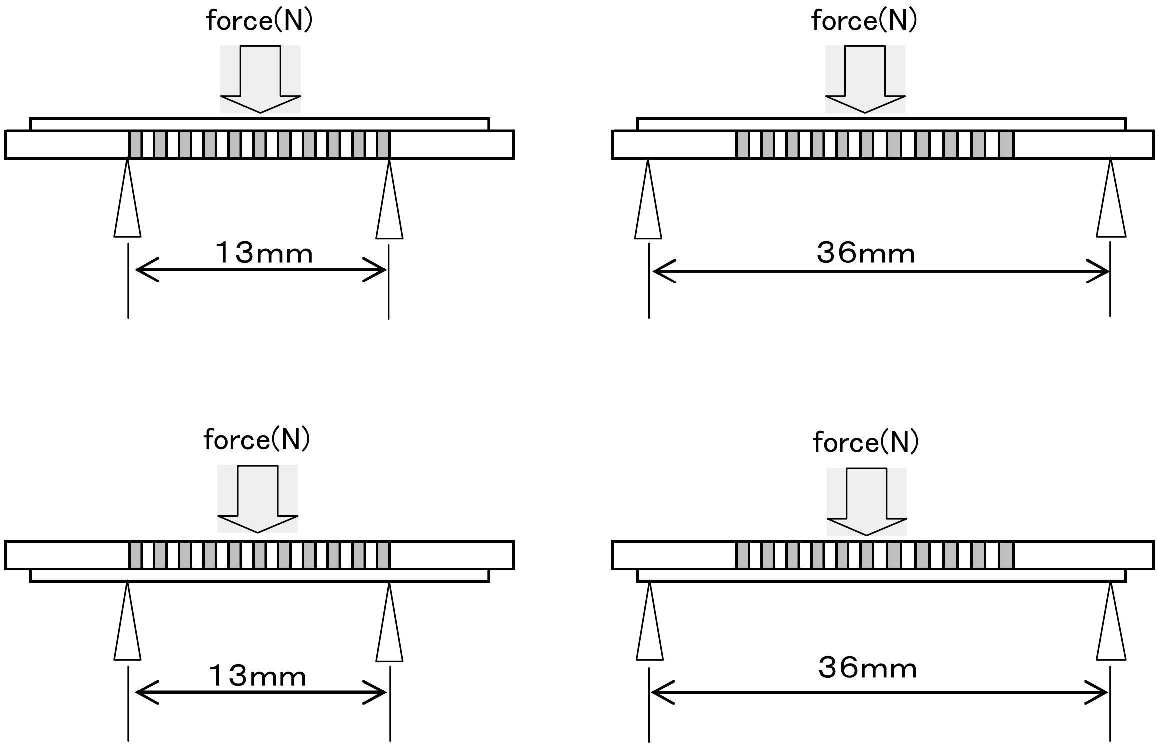
14. Caution for Package Handling

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.

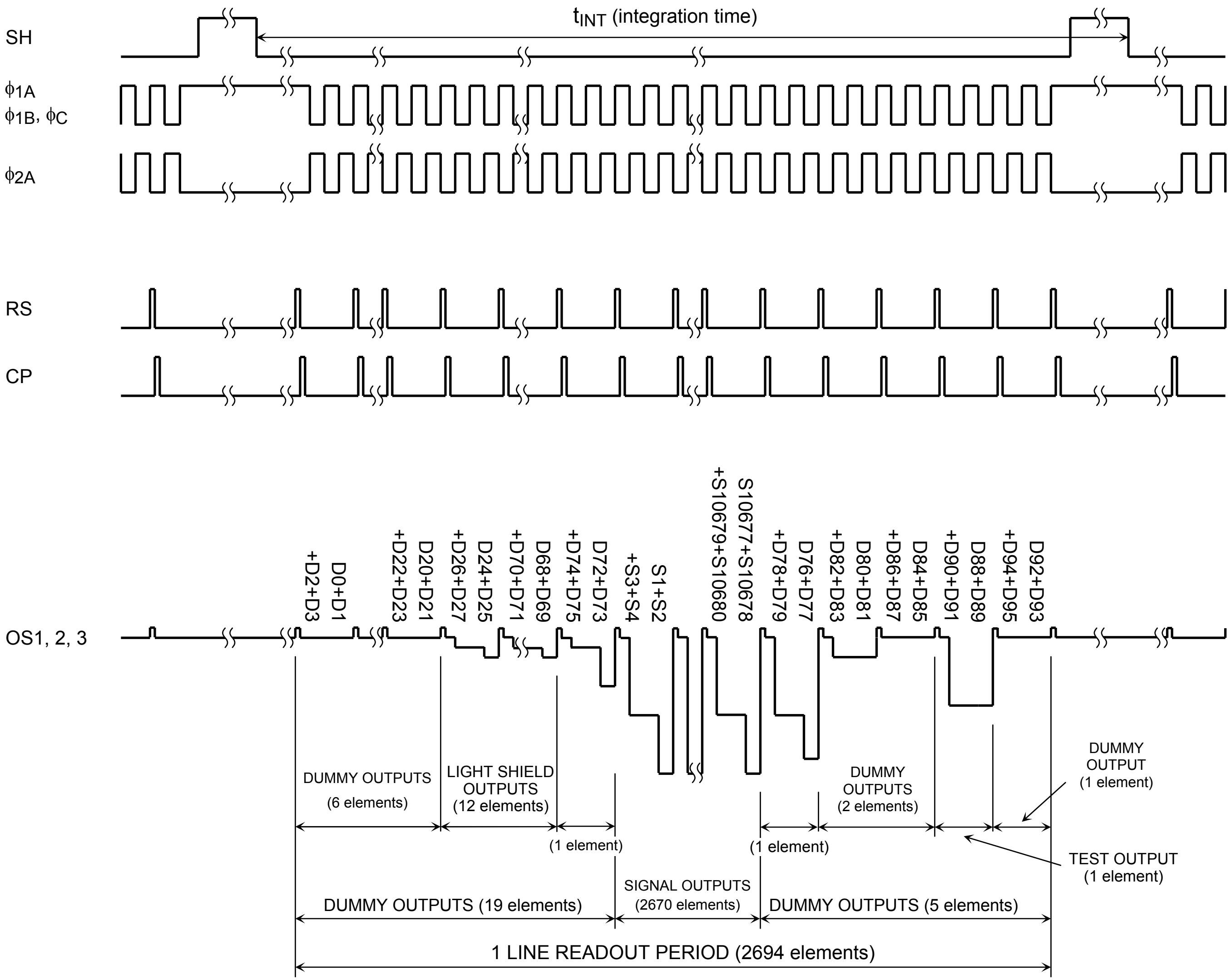
Bending Test



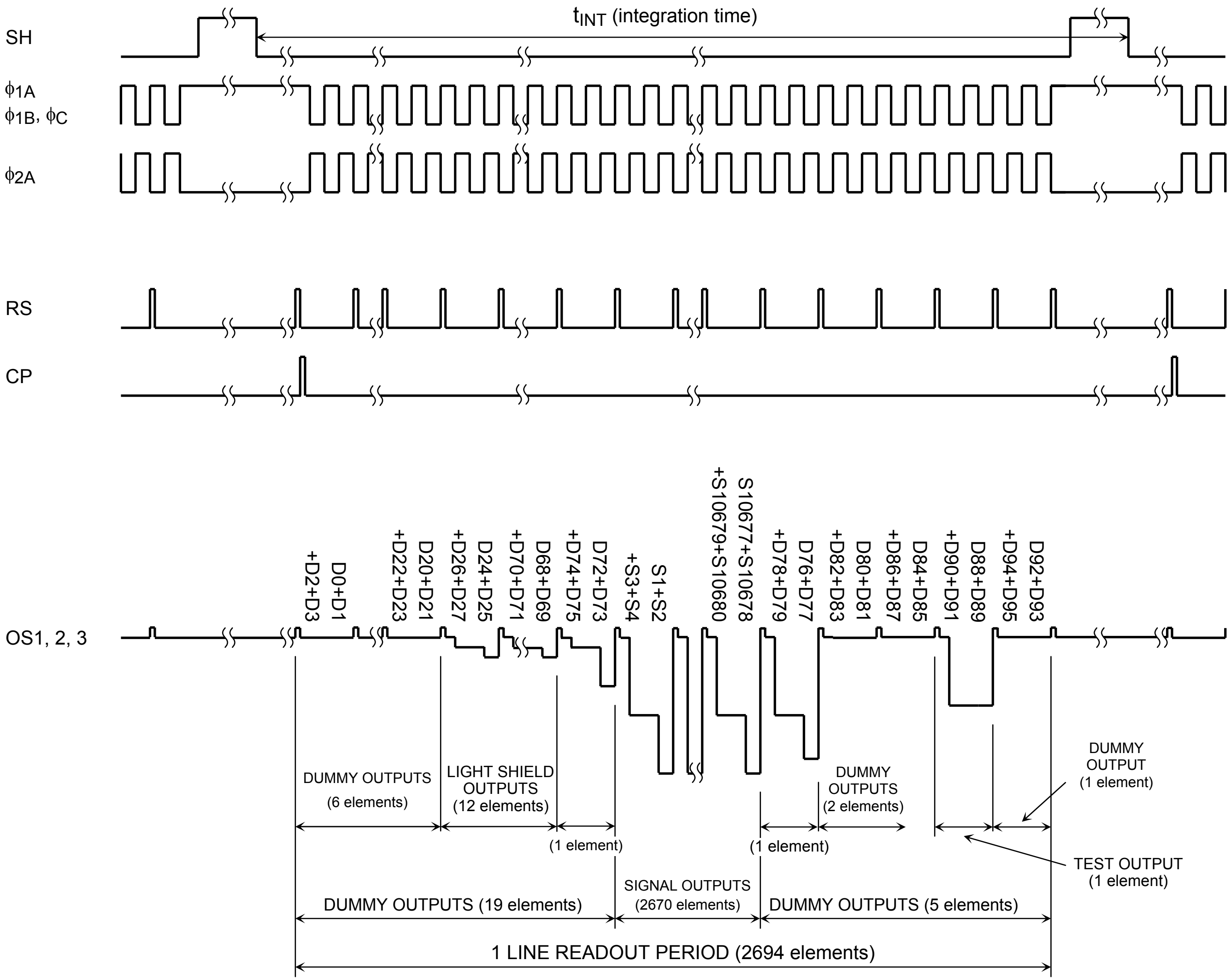
・22CLCC

Bearing length 13mm :	The force from upside : 300[N]
	The force from downside : 200[N]
Bearing length 36mm :	The force from upside : 150[N]
	The force from downside : 80[N]

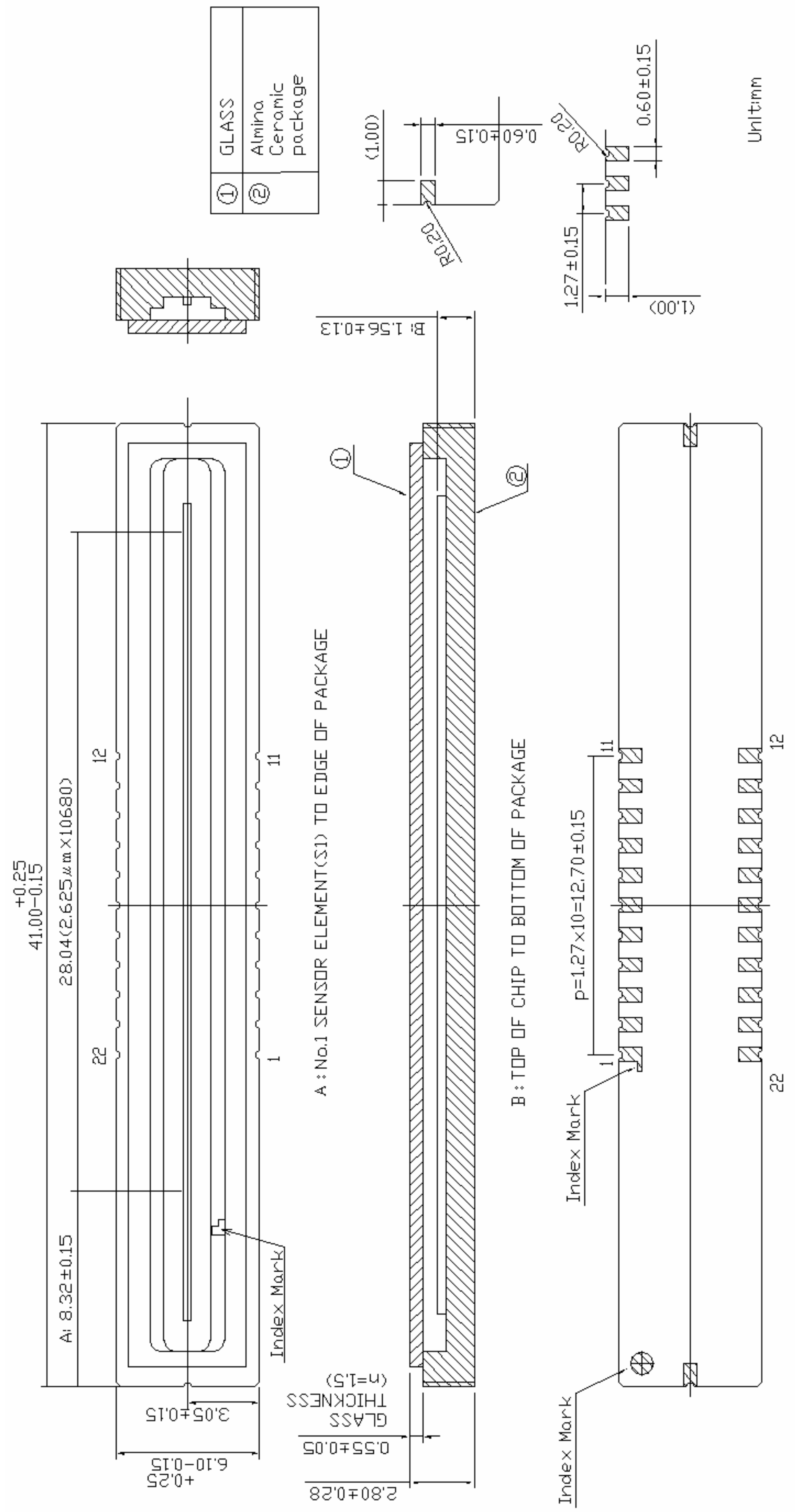
Application Note : Timing Chart (300DPI Bit Clamp mode)



Application Note : Timing Chart (300DPI Line Clamp mode)



Package Dimensions



Weight: 2.0g (typ.)

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