TOSHIBA CCD Linear Image Sensor CCD (Charge Coupled Device)

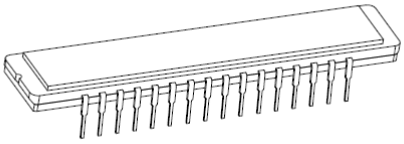
TCD2400DG

TOSHIBA Linear Image Sensor CCD (Charge Coupled Device)

TCD2400DG

The TCD2400DG is a high sensitive and low dark current 4096 elements × 3 lines CCD color linear image sensor.

The device contains a row of 4096 elements × 3 lines photodiodes are for automated optical inspection. The device is operated by 3.3 V pulse and 3.3 V & 10.0 V power supply.

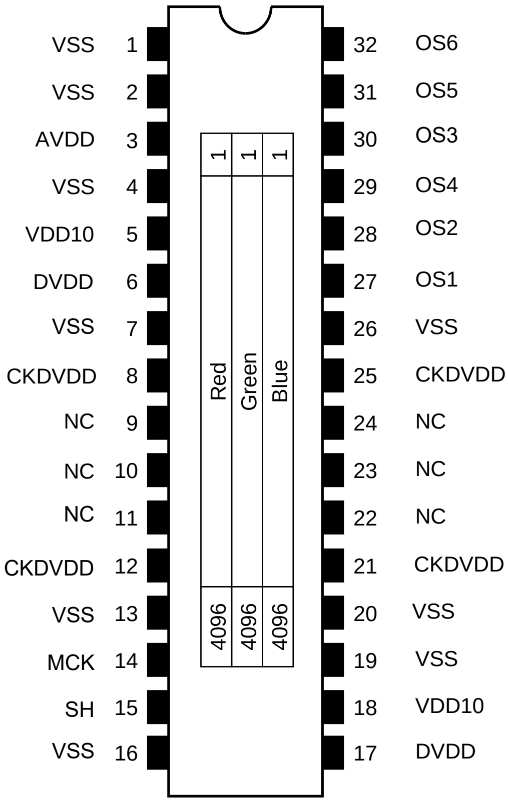


WDIP32-G-400-2.54

Features

Number of Image Sensing Elements: 4096 elements × 3 lines
Image Sensing Element Size: 7 μm by 7μm on 7 μm center
Photo Sensing Region: High sensitive PN photodiode
Power Supply Voltage: 3.3 V & 10.0 V (typ.)
Distance between Photodiode Array: 28 μm (4 lines) B array – G array, G array – R array
Internal Circuit: Timing generator circuit, Clamp circuit, Sample and hold circuit
Package: 32 pin CERDIP
Color Filter: Red, Green, Blue

Pin Connections (top view)



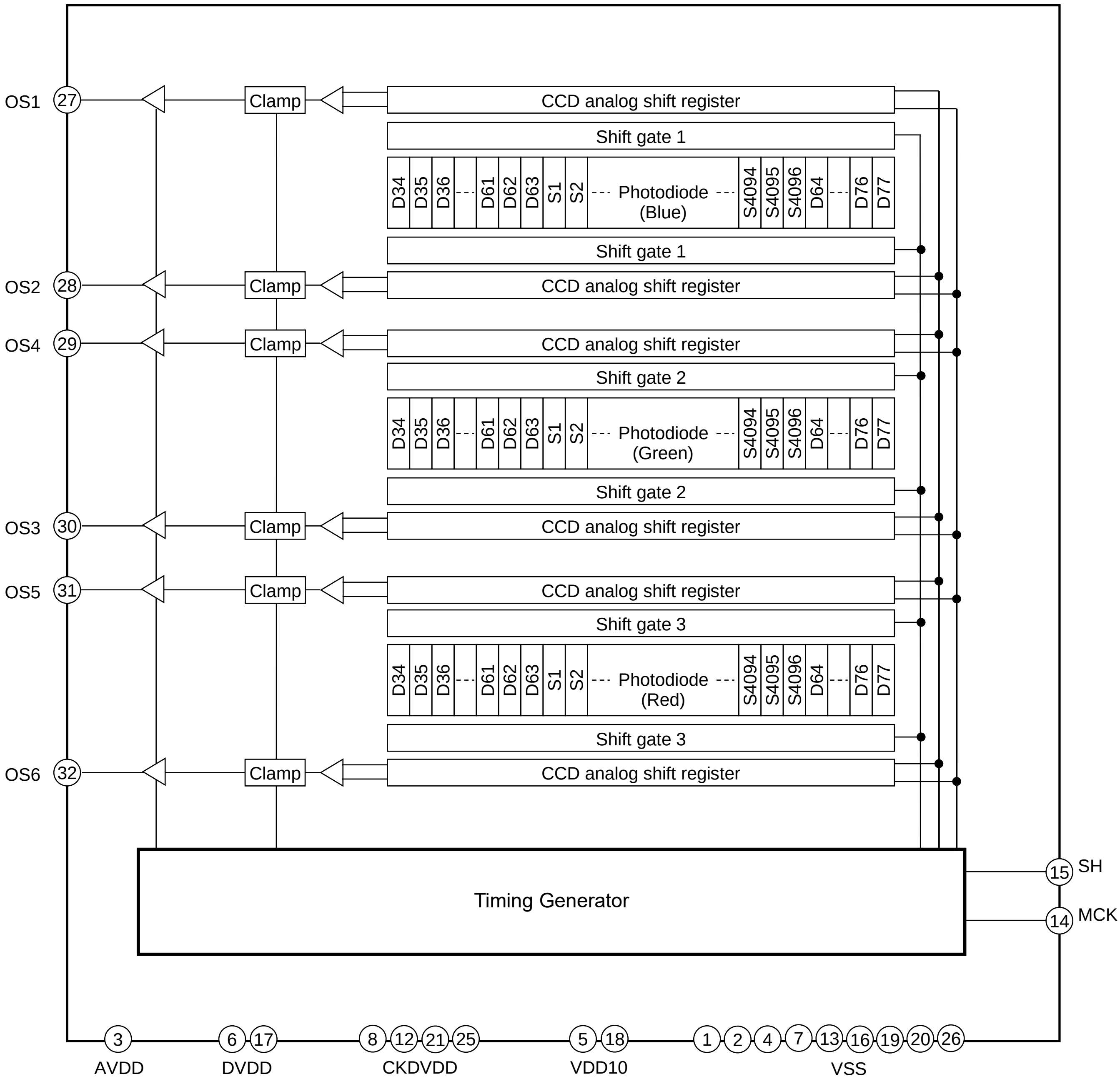
ABSOLUTE MAXIMUM RATINGS (Note 1)

Characteristics	Symbol	Rating	Unit
MCK Clock pulse voltage	V_{MCK}	−0.3 to +5.0	V
SH Clock pulse voltage	V_{SH}		
3.3 V Power supply voltage	V_{AVDD}	−0.3 to +5.0	
	V_{DVDD}	−0.3 to +5.0	
	V_{CKDVDD}	−0.3 to +5.0	
10.0 V Power supply voltage	V_{VDD10}	−0.3 to +13.5	
Operating temperature	T_{opr}	0 to 60	°C
Storage temperature	T_{stg}	−25 to +85	

Note 1: All voltages are with respect to VSS 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.

Start of commercial production
2025-09

Circuit Diagram



Pin Names

Pin No.	Symbol	Name	Pin No.	Symbol	Name
1	VSS	Ground	32	OS6	Output signal 6 (Red(Even))
2	VSS	Ground	31	OS5	Output signal 5 (Red(Odd))
3	AVDD	3.3 V Power supply (Analog)	30	OS3	Output signal 3 (Green(Odd))
4	VSS	Ground	29	OS4	Output signal 4 (Green(Even))
5	VDD10	10.0 V Power supply	28	OS2	Output signal 2 (Blue(Even))
6	DVDD	3.3 V Power supply (Digital)	27	OS1	Output signal 1 (Blue(Odd))
7	VSS	Ground	26	VSS	Ground
8	CKDVDD	3.3 V Power supply (Digital, for internal driver)	25	CKDVDD	3.3 V Power supply (Digital, for internal driver)
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	CKDVDD	3.3 V Power supply (Digital, for internal driver)	21	CKDVDD	3.3 V Power supply (Digital, for internal driver)
13	VSS	Ground	20	VSS	Ground
14	MCK	Master clock	19	VSS	Ground
15	SH	Shift pulse	18	VDD10	10.0 V Power supply
16	VSS	Ground	17	DVDD	3.3 V Power supply (Digital)

Optical/Electrical Characteristics

Ta = 25°C, V_{AVDD} = V_{DVDD} = V_{CKDVDD} = 3.3 V, V_{VDD10} = 10.0 V,
V_{MCK} = V_{SH} = 3.3 V (pulse), f_{MCK} = 25 MHz, t_{INT} (integration time) = 10 ms,
light source = A light source + CM500S filter (t = 1.0 mm)

Characteristics		Symbol	Min	Typ.	Max	Unit	Note
Sensitivity	Red	R_R	10.2	14.7	19.2	V/(lx･s)	(Note 2)
	Green	R_G	11.6	16.6	21.6		
	Blue	R_B	4.8	6.9	9.0		
Photo response non uniformity		PRNU (1)	—	5	20	%	(Note 3)
		PRNU (3)	—	6	17	mV	(Note 4)
Saturation output voltage		V_{SAT}	0.8	0.95	—	V	(Note 5)
Dark signal voltage		V_{DRK}	—	1.8	6.0	mV	(Note 6)
Dark signal non uniformity		DSNU	—	4	15	mV	(Note 7)
AVDD DC power dissipation		P_{AVDD}	—	145	263	mW	(Note 8)
CKDVDD DC power dissipation		P_{CKDVDD}	—	290	455	mW	(Note 8)
DVDD DC power dissipation		P_{DVDD}	—	132	196	mW	(Note 8)
VDD10 DC power dissipation		P_{VDD10}	—	150	273	mW	(Note 8)
Total transfer efficiency		TTE	92	97	—	%	(Note 9)
Output impedance		Z_O	—	95	250	Ω	—
DC output signal voltage		V_{OS}	1.3	1.85	2.4	V	(Note 10)
Random noise		$N_{D\sigma}$	—	1.7	—	mV	(Note 11)
Difference of output voltage as next pixel in OS		V_{diff}	—	7	30	mV	(Note 12)

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 400 mV of signal output.

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

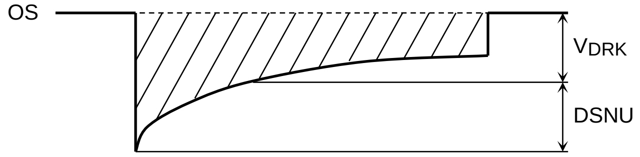
$\overline{X}$: Average of total signal outputs
ΔX: The maximum deviation from $\overline{X}$

Note 4: PRNU (3) is defined as 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: V_{DRK} is defined as average dark signal voltage of all effective pixels.

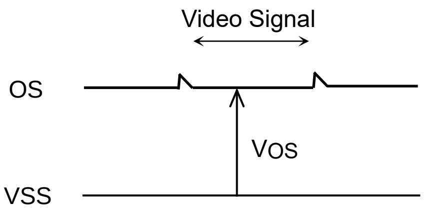
Note 7: DSNU is defined by the difference between average value (V_{DRK}) and the maximum value of the dark voltage.



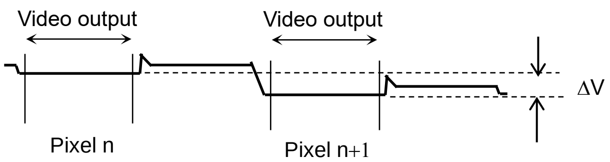
Note 8: DC power dissipations are defined on below condition.
f_{MCK} = 50 MHz
V_{AVDD} = V_{DVDD} = V_{CKDVDD} = 3.5 V
V_{VDD10} = 10.5 V

Note 9: TTE is measured approximately 400 mV of signal output.

Note 10: DC output signal voltage is defined as follows.
Video signal with sample and hold represents the dummy outputs period.



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.
$f_{MCK} = 50$ MHz



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 4 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).

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

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 the random noise as follows.
   $$ND\sigma = \frac{1}{\sqrt{2}}\bar{\sigma}$$

Note 12: Vdiff is defined as follows at dark condition.

$$\mathrm{Vdiff} = \frac{1}{2047}\sum_{n=1}^{2047}\left|V_n - V_{(n+1)}\right|$$

Recommended Operating Conditions (Ta = 25°C)

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

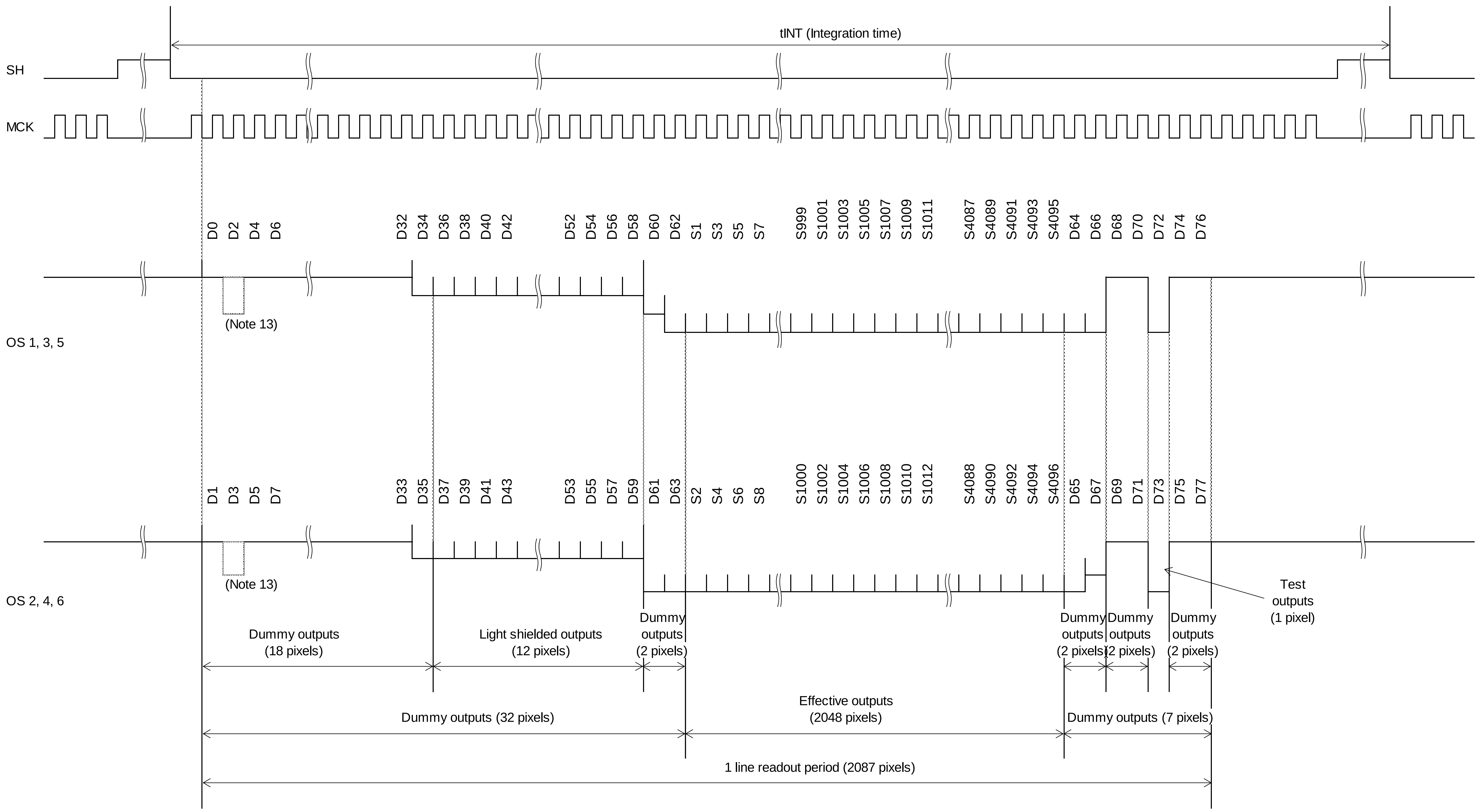
Characteristics		Symbol	Min	Typ.	Max	Unit
Master clock pulse voltage	"H" level	V_{MCK}	2.4	3.3	V_{DVDD}	V
	"L" level		0	0	0.8	
Shift pulse voltage	"H" level	V_{SH}	2.4	3.3	V_{DVDD}	V
	"L" level		0	0	0.8	
3.3 V Power supply voltage (Digital)		V_{DVDD}	3.1	3.3	3.5	V
		V_{CKDVDD}	3.1	3.3	3.5	
3.3 V Power supply voltage (Analog)		V_{AVDD}	3.1	3.3	3.5	V
10.0 V Power supply voltage		V_{VDD10}	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
Master clock fleqency	f_{MCK}	10	—	50	MHz
Master clock capacitance	C_{MCK}	—	10	—	pF
Line start capacitance	C_{SH}	—	10	—	pF

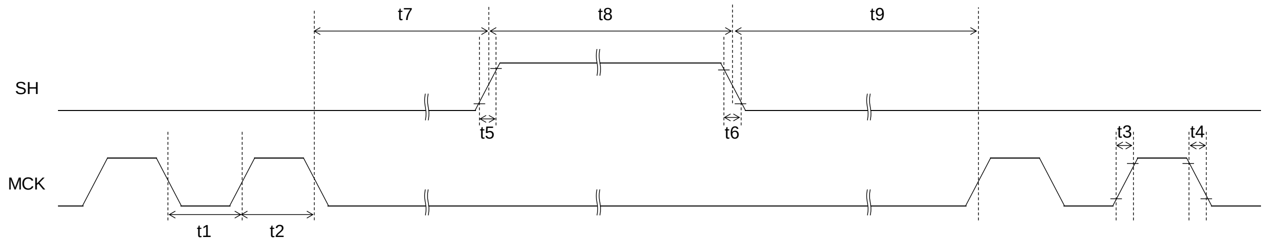
Timing Chart:



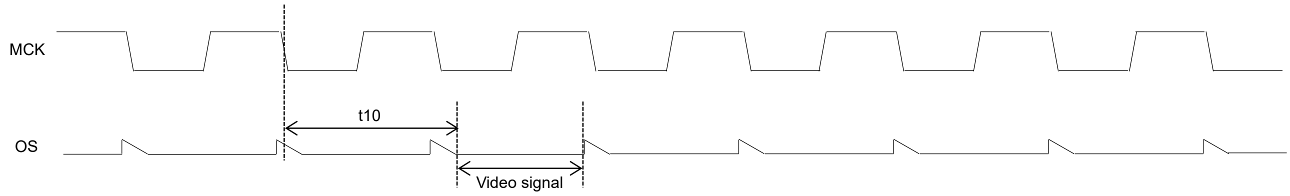
Note 13 : When the number of MCK during the tINT period is even, the DC level decreases (it does not decrease when it is odd).

Timing Requirements

< MCK to SH pulse timing >



< OS delay time >

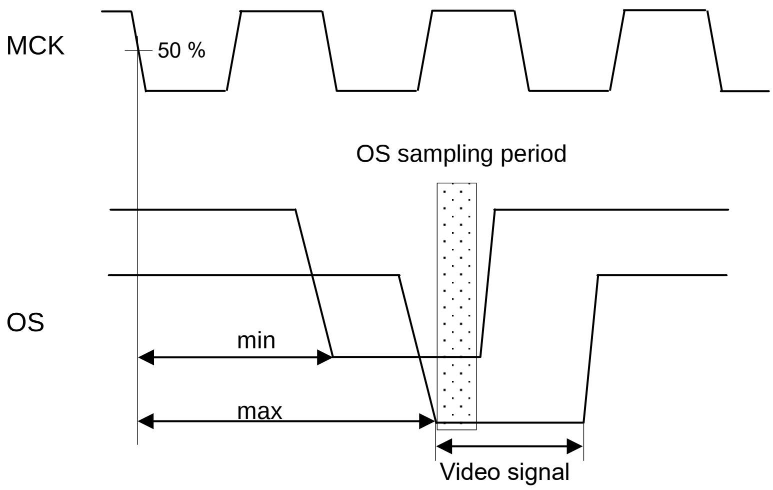


Characteristics	Symbol	Min	Typ.	Max	Unit
MCK pulse “L”, “H” period	t1, t2	9	—	—	ns
MCK pulse Duty	—	45	—	55	%
MCK pulse rise time, fall time	t3, t4	—	—	3	ns
SH pulse rise time, fall time	t5, t6	—	—	3	ns
MCK to SH pulse timing	t7	140	—	—	ns
SH pulse “H” period	t8	1000	—	—	ns
SH pulse “L” period	t9	1000	—	—	ns
OS delay time	t10	—	26	—	ns

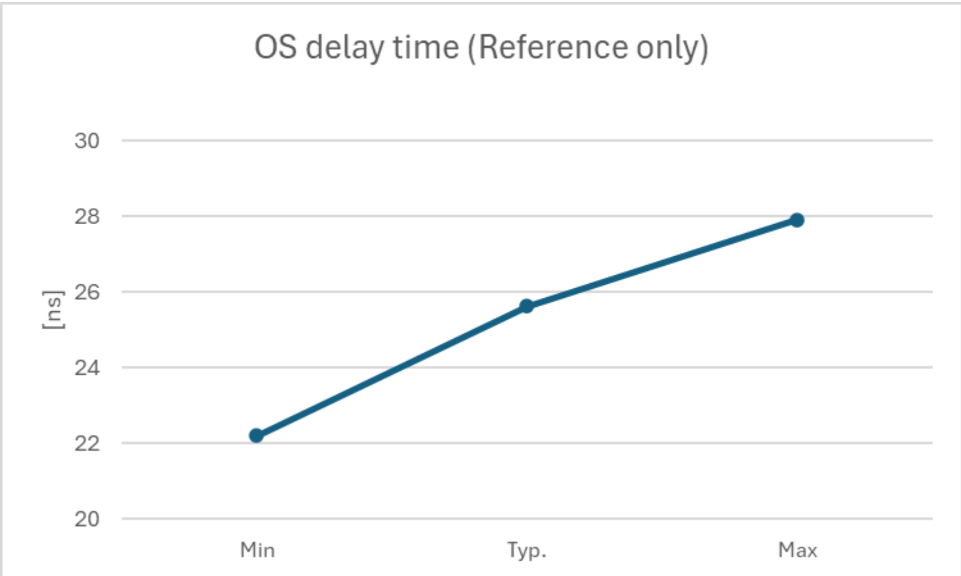
OS delay time

OS delay time (from MCK) has variance like below figure.
So in case that the OS signal is sampled, the sample timing is necessary to achive both max and min OS delay times.
It's recommended that the customer's machine adjusts the sample timing for each sensor device.

OS timing image

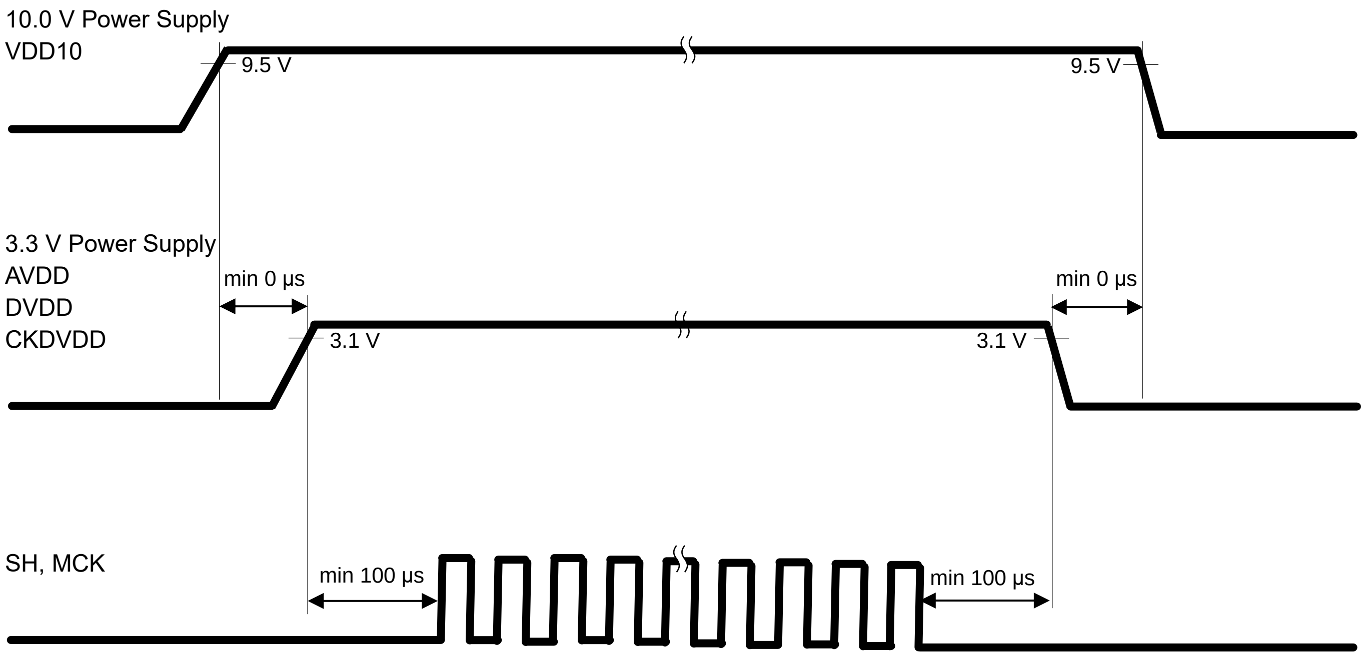


Reference data

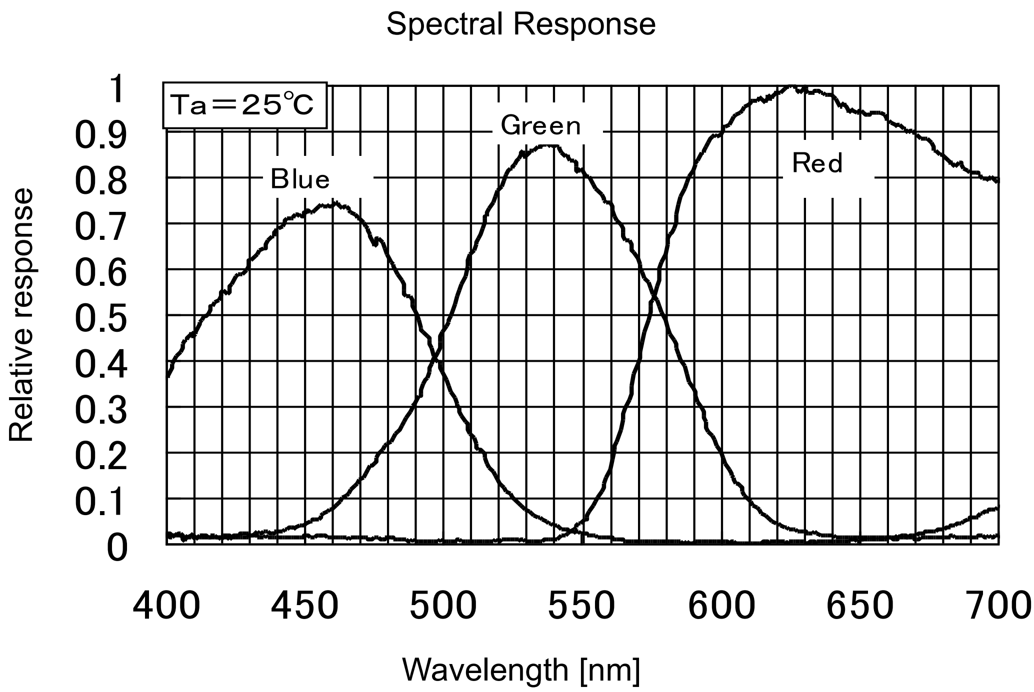


Condition : OS output is open. f_{MCK} = 50 MHz, $V_{AVDD} = V_{DVDD} = V_{CKDVDD}$ = 3.3 V, V_{VDD10} = 10.0 V,
Signal output = 800 mV

Power Sequence



Typical Spectral Response (Reference only)



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. 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.

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

5. Soldering

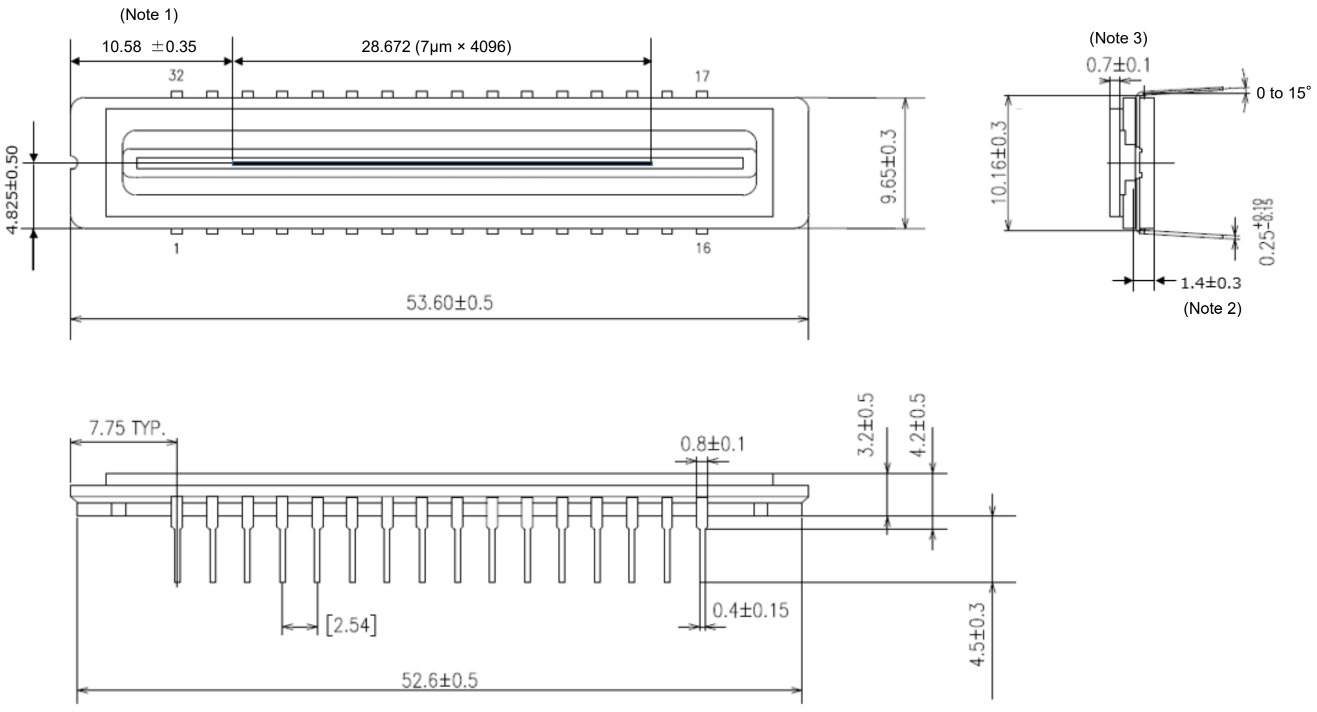
Soldering by the solder flow method cannot be guaranteed because this method may have deleterious effects on prevention of window glass soiling and heat resistance.
Using a soldering iron, complete soldering within three seconds for lead temperatures of up to 350°C.

6. Abnormal dark signal as time goes by

Image sensor has possibility to be damaged by cosmic rays as time goes by and have abnormal dark signal.

Package Dimensions

WDIP32-G-400-2.54



Unit: mm

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

RESTRICTIONS ON PRODUCT USE

Toshiba Corporation and its subsidiaries and affiliates are collectively referred to as “TOSHIBA”.
Hardware, software and systems described in this document are collectively referred to as “Product”.

- TOSHIBA reserves the right to make changes to the information in this document and related Product without notice.

- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.

- Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the "TOSHIBA Semiconductor Reliability Handbook" and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.**

- **PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT ("UNINTENDED USE").** Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. **IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT.** For details, please contact your TOSHIBA sales representative.

- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.

- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.

- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**

- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.

- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. **TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.**

TOSHIBA ELECTRONIC DEVICES & STORAGE CORPORATION

https://toshiba.semicon-storage.com/