TOSHIBA CCD Linear Image Sensor CCD (Charge Coupled Device)

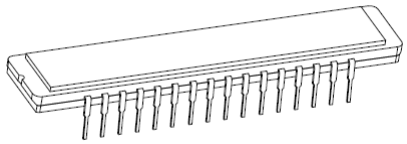
TCD2728DG

TOSHIBA Linear Image Sensor CCD (Charge Coupled Device)

TCD2728DG

The TCD2728DG is a high sensitive and low dark current 7500 elements × 3 lines CCD color linear image sensor.

The device contains a row of 7500 elements × 3 lines photodiodes which provide 24 lines/mm across a A3 size paper. The device is operated by 3.3 V pulse and 3.3 V & 10.0 V power supply.

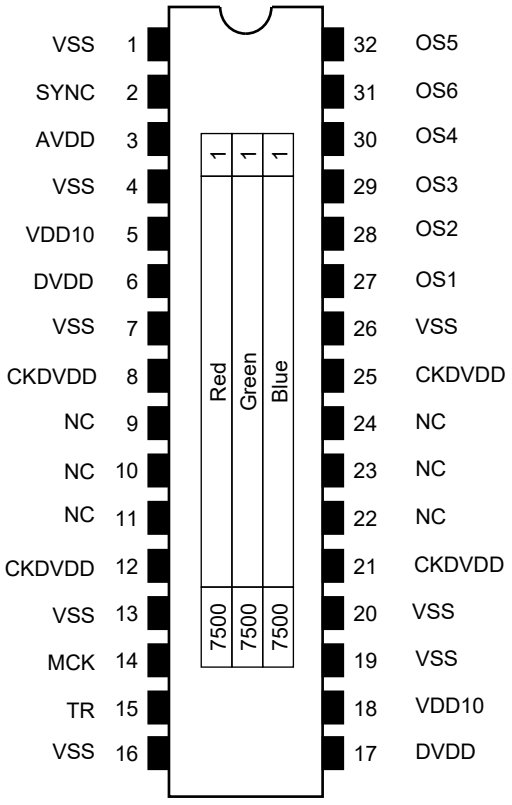


WDIP32-G-400-2.54

Features

Number of Image Sensing Elements: 7500 elements × 3 lines
Image Sensing Element Size: 4.7 μm by 4.7 μm on 4.7 μm center
Photo Sensing Region: High sensitive PN photodiode
Power Supply Voltage: 3.3 V & 10.0 V (typ.)
Distance between Photodiode Array: 9.4 μm (2 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)



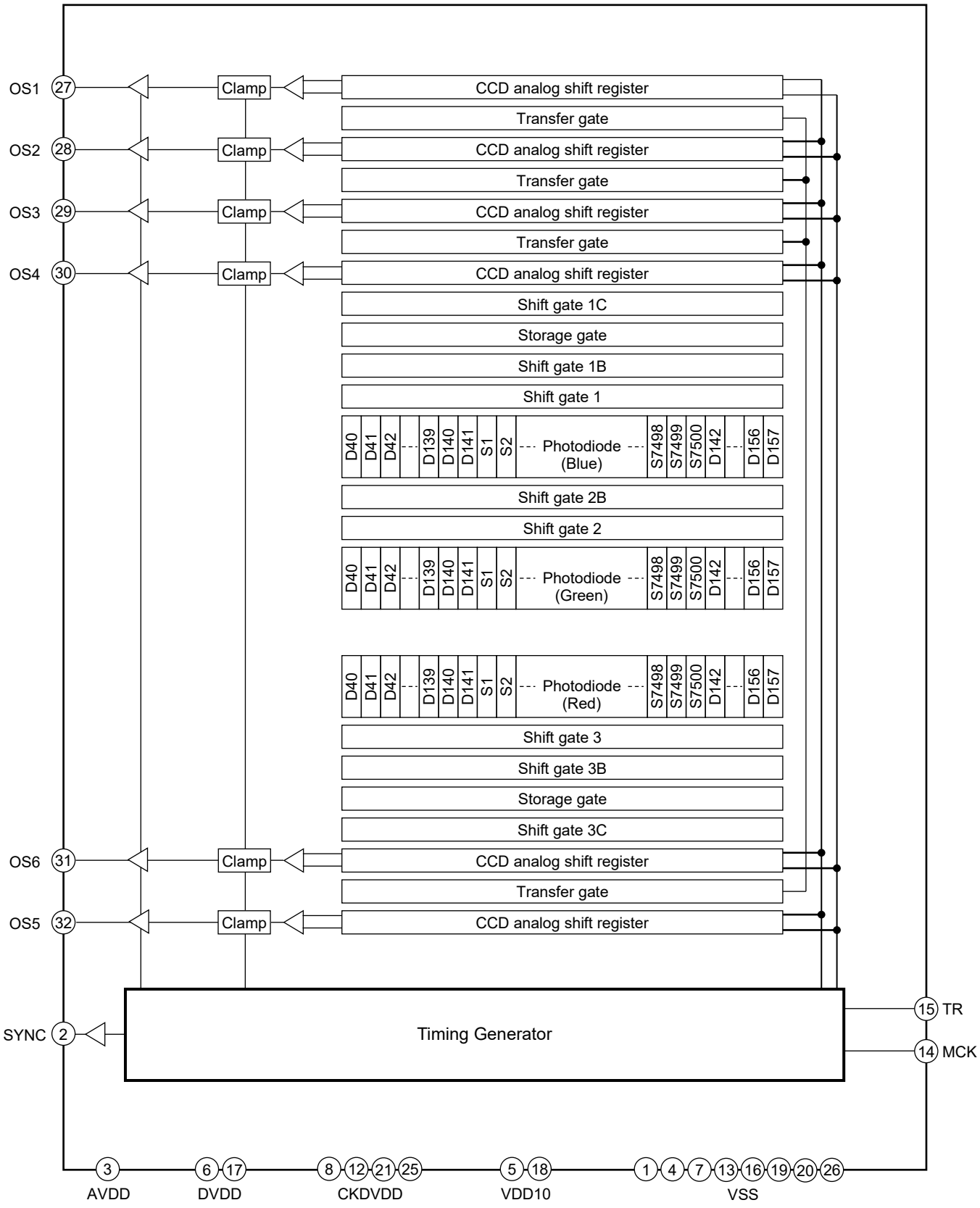
ABSOLUTE MAXIMUM RATINGS (Note 1)

Characteristics	Symbol	Rating	Unit
MCK Clock pulse voltage	V_{MCK}	−0.3 to +5.0	V
TR Clock pulse voltage	V_{TR}		
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 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.

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Circuit Diagram



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Pin Names

Pin No.	Symbol	Name	Pin No.	Symbol	Name
1	VSS	Ground	32	OS5	Output signal 5 (Red(Odd))
2	SYNC	Synchronized signal for OS	31	OS6	Output signal 6 (Red(Even))
3	AVDD	3.3 V Power supply (Analog)	30	OS4	Output signal 4 (Green(Even))
4	VSS	Ground	29	OS3	Output signal 3 (Green(Odd))
5	VDD10	10 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	TR	Line start pulse	18	VDD10	10 V Power supply
16	DVSS	Ground	17	DVDD	3.3 V Power supply (Digital)

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Optical/Electrical Characteristics

Ta = 25°C, V_{AVDD} = V_{DVDD} = V_{CKDVDD} = 3.3 V, V_{VDD10} = 10.0 V, V_{MCK} = V_{TR} = 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	5.0	6.7	8.3	V/(lx·s)	(Note 2)
	Green	R_G	6.4	8.5	10.6		
	Blue	R_B	2.3	3.1	3.8		
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}	—	160	263	mW	(Note 8)
CKDVDD DC power dissipation		P_{CKDVDD}	—	315	455	mW	(Note 8)
DVDD DC power dissipation		P_{DVDD}	—	130	196	mW	(Note 8)
VDD10 DC power dissipation		P_{VDD10}	—	180	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	1.9	2.5	V	(Note 10)
Random noise (Enable sample and hold)		$N_{D\sigma}$	—	1.9	—	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.

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

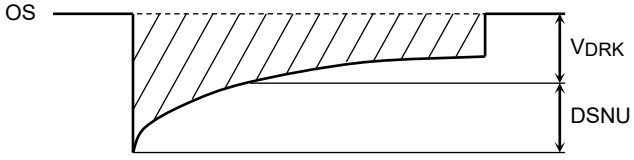
$\overline{X}$: Average of total signal outputs
ΔX: The maximum deviation from $\overline{X}$

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.

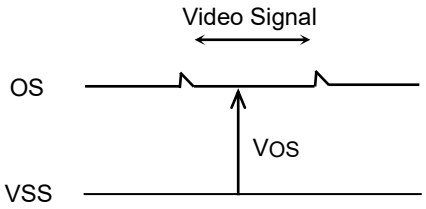


Note 8: DC power dissipations are defined on below condition.
f_{MCK} = 50 MHz
VAVDD = VDVDD = VCKVDD = 3.5 V
VVDD10 = 10.5 V

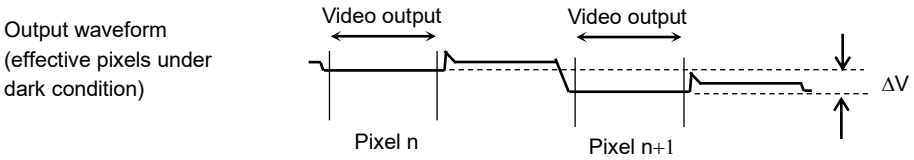
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Note 9: TTE is measured approximately 400 mV of signal output. f_{MCK} = 10 MHz

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 40 times of 4.0ns 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).

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

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.

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

Note 12: V_{diff} is defined as follows at dark condition.

$$Vdiff = \frac{1}{3749}\sum_{n=1}^{3749}|V_n - V_{(n+1)}|$$

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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
Master clock pulse voltage	“H” level	V_{MCK}	3.1	3.3	3.5	V
	“L” level		0	0	0.1	
Line start pulse voltage	“H” level	V_{TR}	3.1	3.3	3.5	V
	“L” level		0	0	0.1	
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

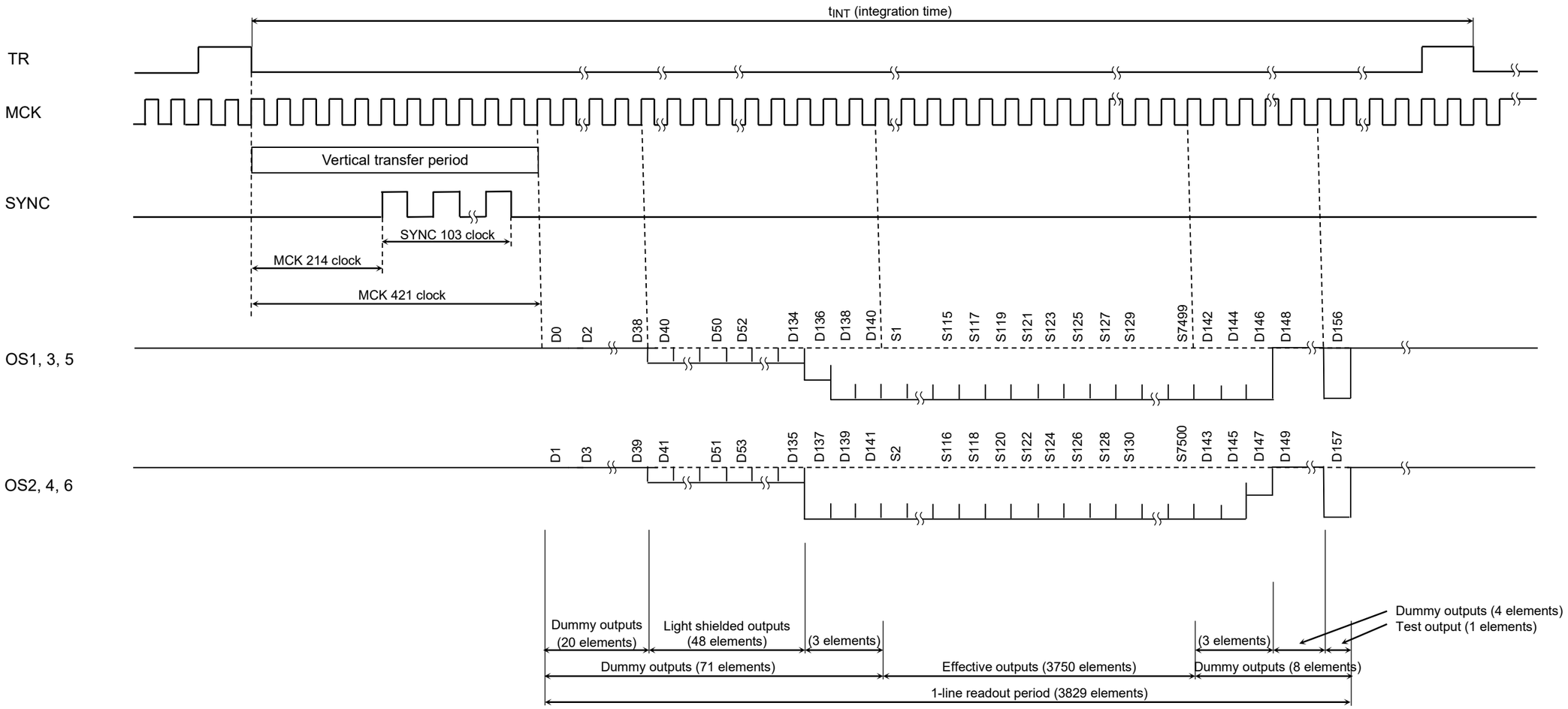
Clock Characteristics (Ta = 25°C)

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_{TR}	—	10	—	pF

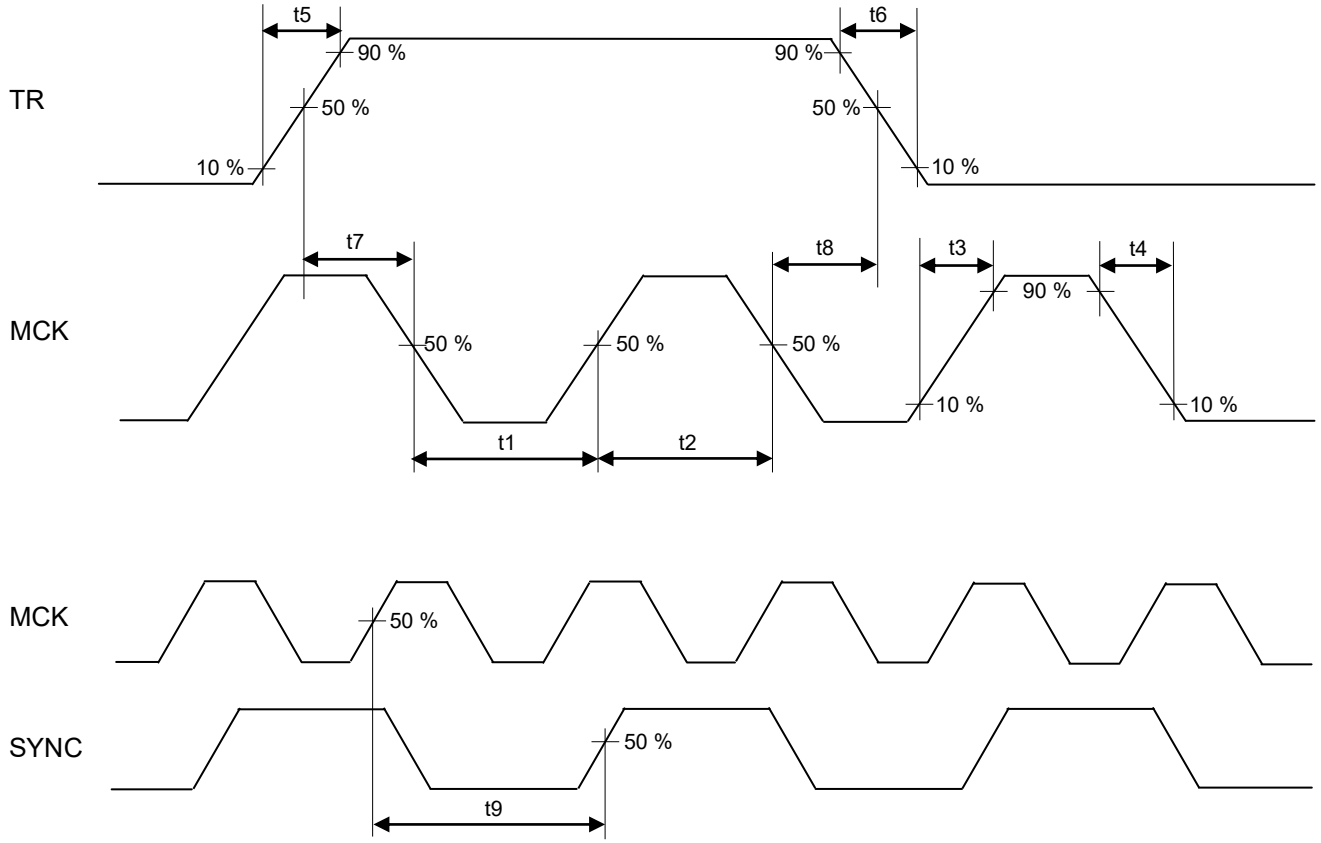
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Timing Chart:

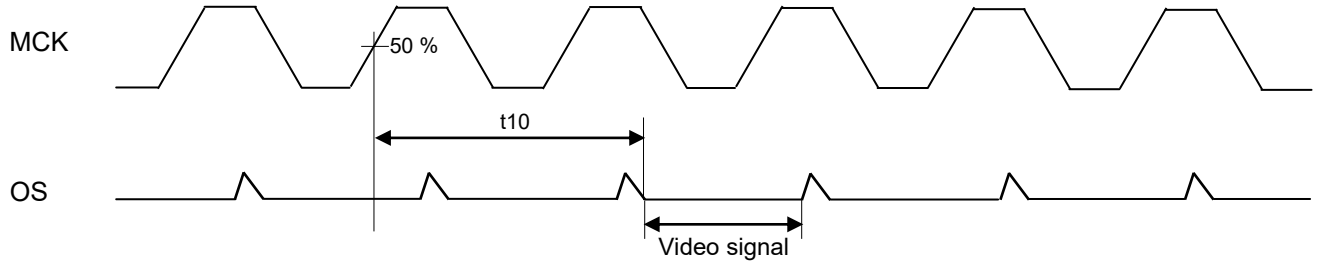


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Timing Requirements



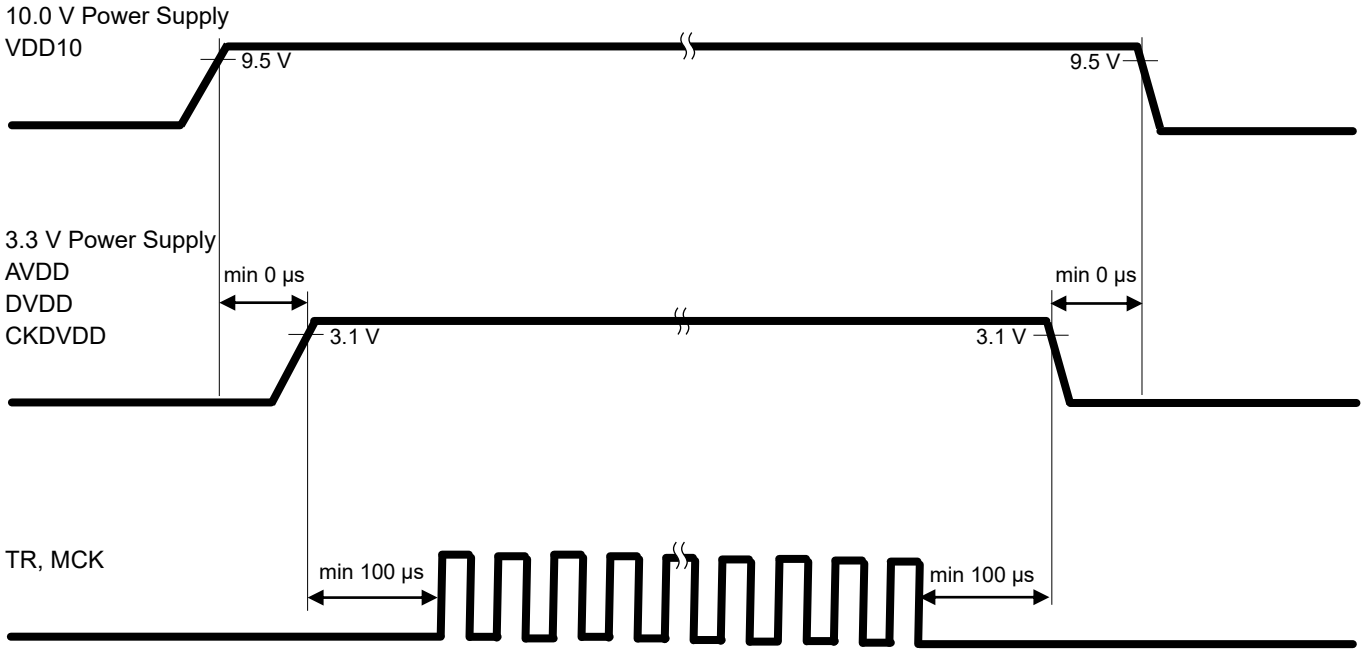
SYNC is a trigger timing signal to capture the video signal of OS.
It outputs only in the Vertical transfer period, but not in the Effective outputs period.



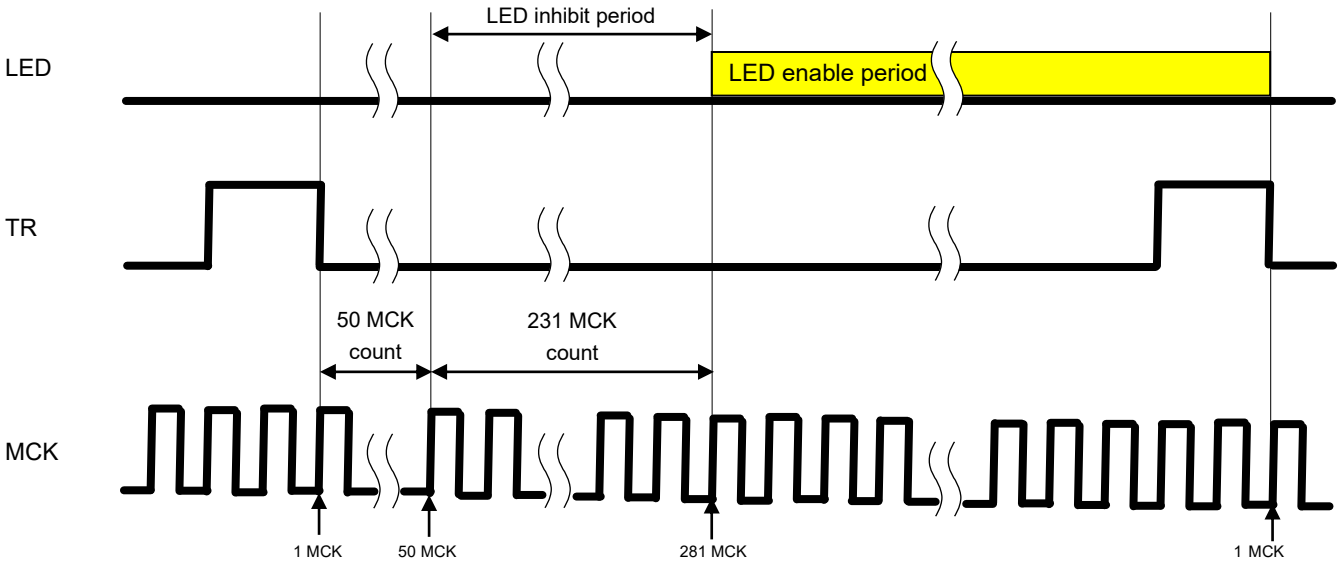
Characteristics	Symbol	Min	Typ.	Max	Unit
MCK pulse “L”, “H” period	t1, t2	9	—	—	ns
MCK pulse Duty	—	45	—	55	%
MCK pulse rise time, fall time	t3, t4	—	—	3	ns
TR pulse rise time, fall time	t5, t6	—	—	3	ns
TR, MCK pulse timing	t7	6	—	—	ns
TR, MCK pulse timing	t8	—	—	t1+t2-6	ns
SYNC delay time	t9	—	25	—	ns
OS delay time	t10	—	33	—	ns

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Power Sequence



LED flash timing

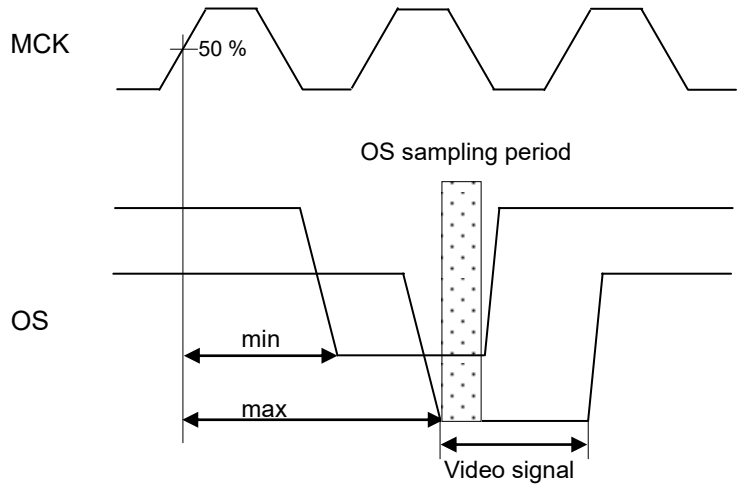


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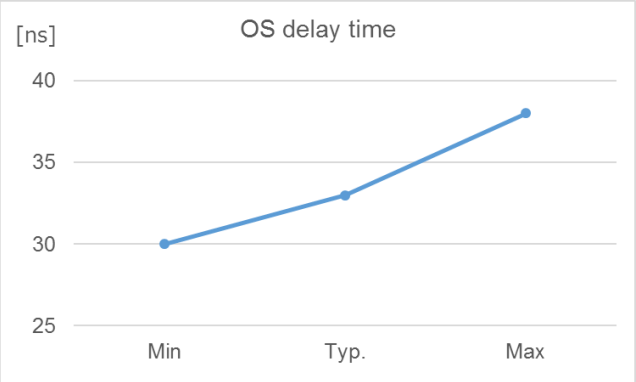
OS delay time

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.
Or it's recommended to sample OS signal by using AFE (Analog Front End device) which can set the sample timing by SYNC (Synchronized signal for OS).

OS timing image



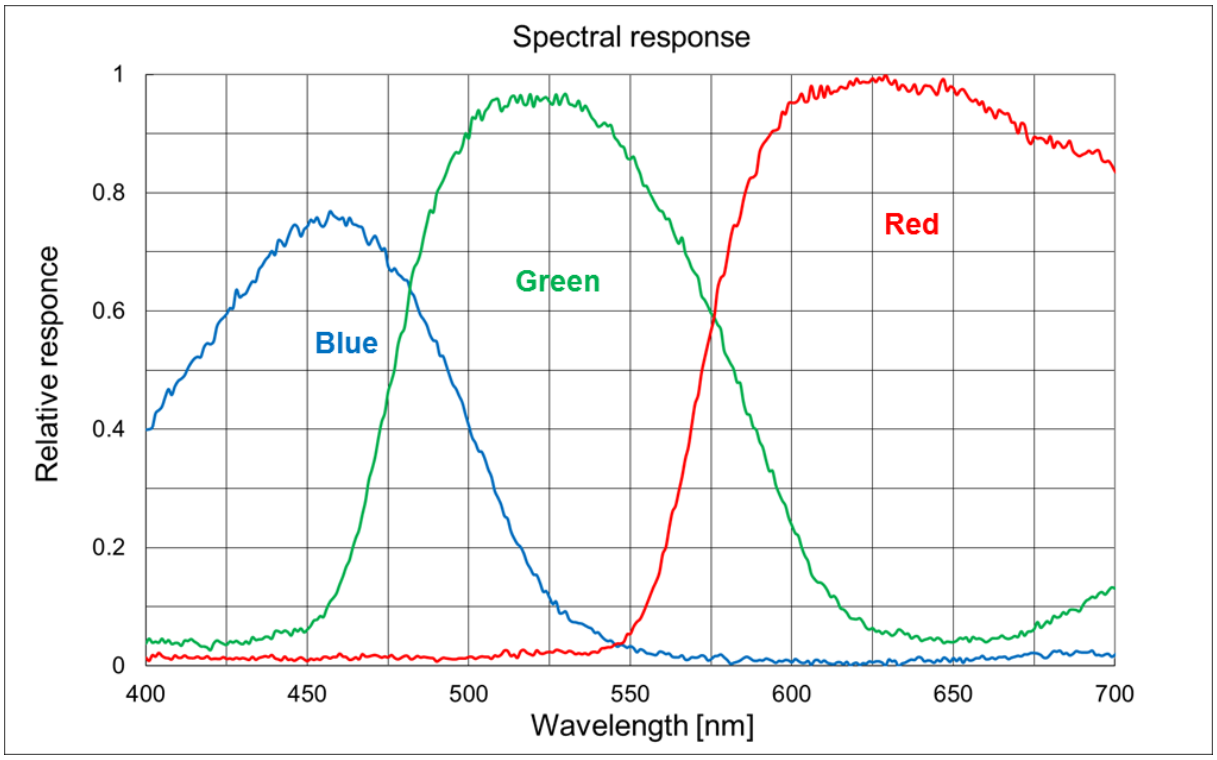
Reference data



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

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Typical Spectral Response (Reference only)



Ta=25 °C

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.

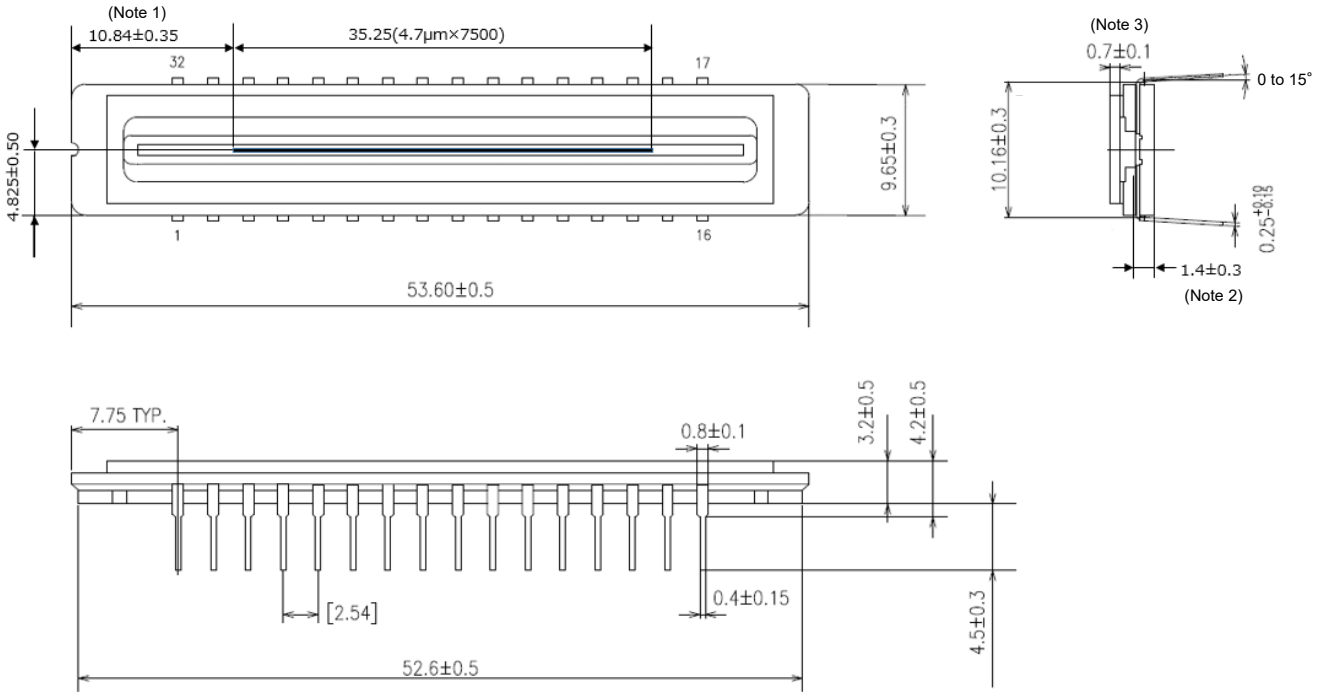
6. Abnormal dark signal as time goes by

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

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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)

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