TOSHIBA CCD Linear Image Sensor CCD (Charge Coupled Device)

TCD2724DG-1

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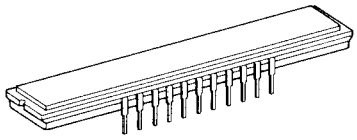
The TCD2724DG-1 is a high sensitive and low dark current 7450 elements × 3 lines CCD color image sensor.

The sensor is designed for color scanner.

The device contains a row of 7450 elements × 3 lines photodiodes which provide 24 lines/mm across a A3 size paper. The device is operated by 3.3 V (Pulse), and 10V power supply.



WDIP22-G-400-2.54

Weight: 4.4 g (typ.)

Features

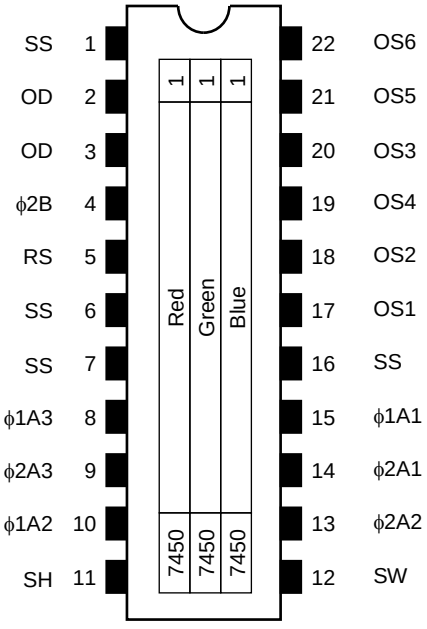
- Number of image sensing pixels: 7450 elements × 3 lines
- Image sensing pixels size: 4.7 μm by 4.7 μm on 4.7 μm center
- Photo sensing: High sensitive pn photodiode
- Clock: 2 phase (3.3 V)
- Distance between photodiode array: Pixel R to pixel G, and pixel G to pixel B = 18.8 μm (4 lines)
- Internal circuit: Clamp circuit, Sample and Hold Circuit, Low capacitance input
- Package: 22 pin CERDIP
- Color filter: Red, Green, Blue

ABSOLUTE MAXIMUM RATINGS (Note 1)

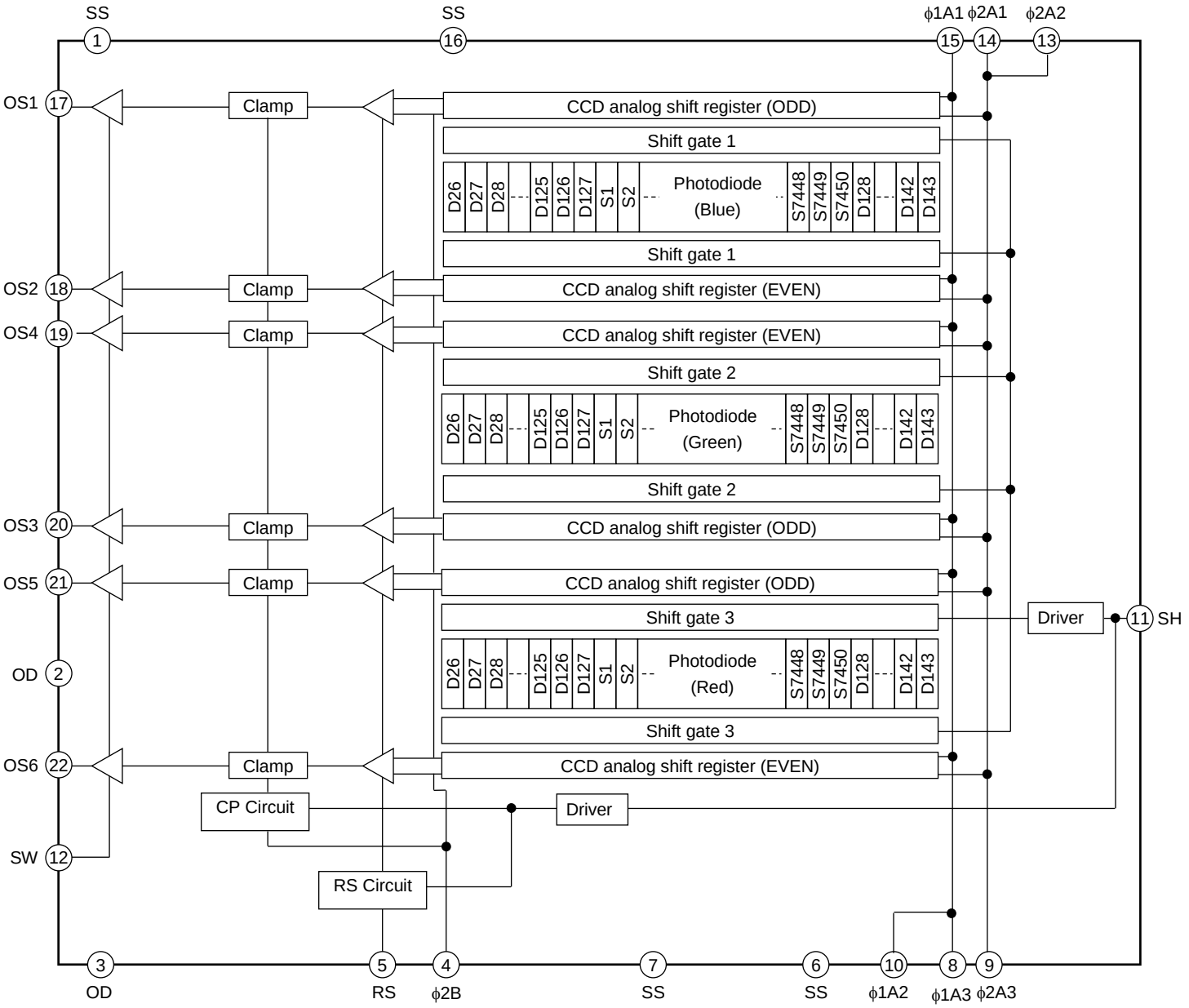
Characteristics	Symbol	Rating	Unit
Clock pulse voltage	$V_{\phi A}$	−0.3 to +8.0	V
Last stage clock pulse voltage	$V_{\phi B}$		
Shift pulse voltage	V_{SH}		
Reset pulse voltage	V_{RS}		
Switch pulse voltage	V_{SW}		
Power supply voltage	V_{OD}	−0.3 to +13.5	V
Operating temperature	T_{opr}	0 to 60	°C
Storage temperature	T_{stg}	−25 to +85	°C

Note 1: All voltages are with respect to SS 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.

Pin connection (top view)



Circuit Diagram



Pin Names

No.	Name	Description	No.	Name	Description
1	SS	Ground	22	OS6	Signal Output 6 (Red-EVEN)
2	OD	Power supply	21	OS5	Signal Output 5 (Red-ODD)
3	OD	Power supply	20	OS3	Signal Output 3 (Green-ODD)
4	ϕ2B	Last stage transfer clock (phase 2)	19	OS4	Signal Output 4 (Green-EVEN)
5	RS	Reset gate	18	OS2	Signal Output 2 (Blue-EVEN)
6	SS	Ground	17	OS1	Signal Output 1 (Blue-ODD)
7	SS	Ground	16	SS	Ground
8	ϕ1A3	Transfer clock 3 (phase 1)	15	ϕ1A1	Transfer clock 1 (phase 1)
9	ϕ2A3	Transfer clock 3 (phase 2)	14	ϕ2A1	Transfer clock 1 (phase 2)
10	ϕ1A2	Transfer clock 2 (phase 1)	13	ϕ2A2	Transfer clock 2 (phase 2)
11	SH	Shift Gate	12	SW	Switch gate (Sample and hold output select)

Optical/Electrical Characteristics

Ta=25°C, V_{OD}=10V, $V_{\phi}=V_{RS}=V_{SH}$=3.3V(pulse), f_{ϕ}=1.0 MHz, t_{INT}(integration time)=10ms, light source=light source A+CM500S(t=1.0 mm)

Characteristics		Symbol	Min	Typ.	Max	Unit	Note
Sensitivity Enable sample and hold	Red	R_R	9.0	12.8	16.6	V/(lx·s)	(Note 2)
	Green	R_G	10.5	15.0	19.5		
	Blue	R_B	3.6	5.2	6.8		
Sensitivity Disable sample and hold	Red	R_R	10.0	14.3	18.6		
	Green	R_G	11.8	16.9	22.0		
	Blue	R_B	4.0	5.8	7.5		
Photo response non uniformity		PRNU (1)	—	5	20	%	(Note 3)
		PRNU (3)	—	3	12	mV	(Note 4)
Saturation output voltage		V_{SAT}	1.2	1.8	—	V	(Note 5)
Saturation exposure		SE	0.05	0.1	—	lx·s	(Note 6)
Dark signal voltage		V_{DRK}	—	0.5	6	mV	(Note 7)
Dark signal non uniformity		DSNU	—	10	12	mV	(Note 8)
DC power dissipation		P_D	—	700	1050	mW	—
Total transfer efficiency		TTE	92	97	—	%	—
Output impedance		Z_O	—	0.2	0.5	kΩ	—
DC signal output voltage		V_{OS}	3.7	5.2	6.7	V	(Note 9)
Random noise (Enable sample and hold)		$N_{D\sigma}$	—	1.4	—	mV	(Note 10)
Random noise (Disable sample and hold)			—	1.1	—		

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 Vsat (Min.).

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

$\bar{\chi}$: Average of total signal outputs
$\Delta\chi$: The maximum deviation from $\bar{\chi}$.

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

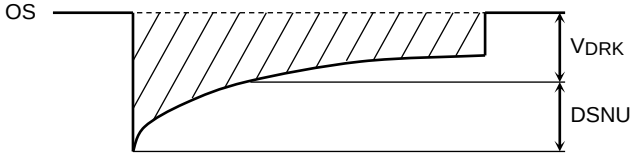
Note 5: V_{SAT} is defined as minimum saturation output voltage of all effective pixels.

Note 6: Definition of SE:

$$SE = \frac{V_{SAT}}{R_G}$$

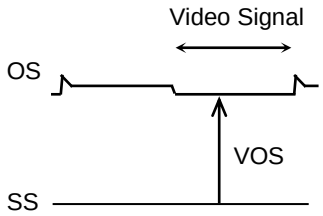
Note 7: V_{DRK} is defined as average dark signal voltage of all effective pixels.

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

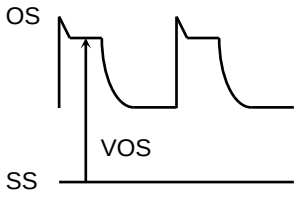


Note 9: DC signal output voltage is defined as follows:
Video Signal with Sample and hold represents the Dummy outputs period.

Enable sample and hold

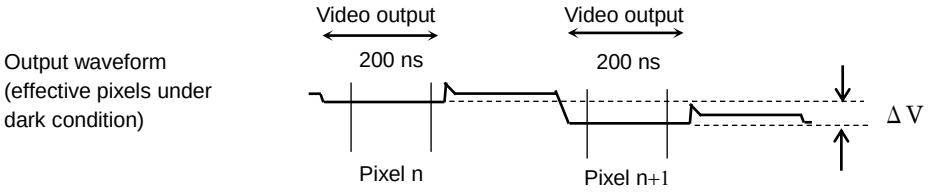


Disable sample and hold

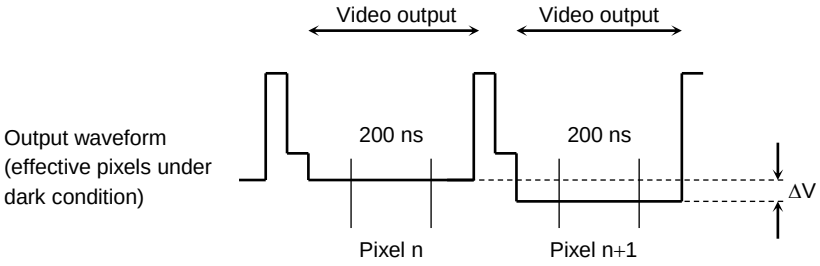


Note 10: Random noise is defined as the standard deviation (sigma) of the output level difference between two adjacent effective pixels under no illumination (i.e. dark condition) calculated by the following procedure.

Enable sample and hold



Disable sample and hold



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.
   $\Delta V = Vn - Vn + 1$
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 10 sigma values.

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

6) $\bar{\sigma}$ 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.

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

Operating Condition (Ta=25°C)

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

Characteristics		Symbol	Min	Typ.	Max	Unit
Clock pulse voltage	High level	$V_{\phi 1A}$	3.1	3.3	5.5	V
	Low level	$V_{\phi 2A}$	0	—	0.1	
Last stage clock pulse voltage	High level	$V_{\phi 2B}$	3.1	3.3	5.5	V
	Low level		0	—	0.1	
Shift pulse voltage	High level	V_{SH}	3.1	3.3	5.5	V
	Low level		0	—	0.1	
Reset pulse voltage	High level	V_{RS}	3.1	3.3	5.5	V
	Low level		0	—	0.1	
Switch pulse voltage	High level	V_{SW}	3.1	3.3	5.5	V
	Low level		0	—	0.1	
Power supply voltage		V_{OD}	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.

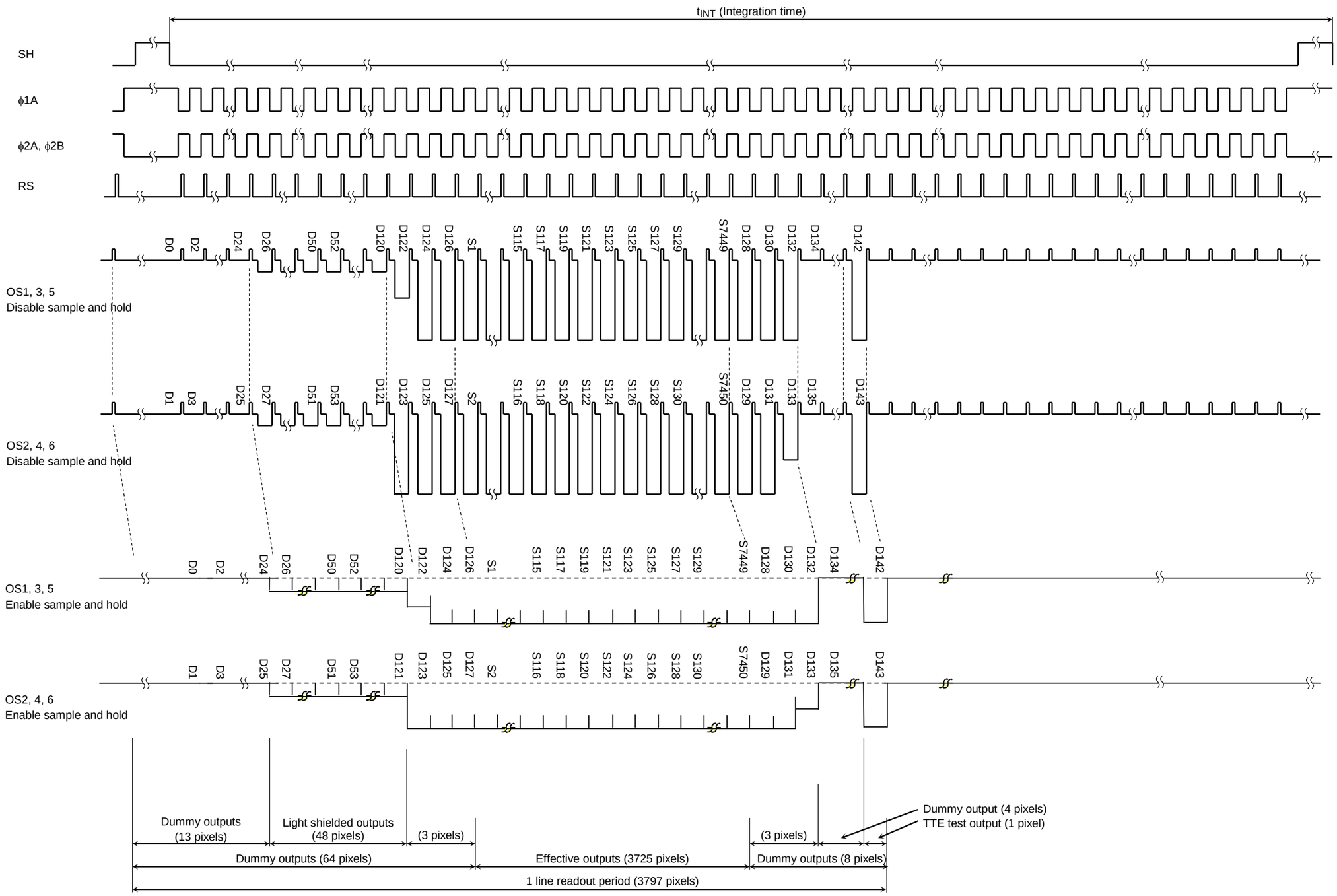
Characteristics	Symbol	Min	Typ.	Max	Unit
Clock pulse frequency	f_{ϕ}	1.0	1.0	35,0	MHz
Reset pulse frequency	f_{RS}	1.0	1.0	35,0	MHz
Clock capacitance (Note 11)	$C_{\phi A}$	—	65	—	pF
Last stage clock capacitance	$C_{\phi B}$	—	7	—	pF
Shift gate capacitance	C_{SH}	—	20	—	pF
Reset gate capacitance	C_{RS}	—	7	—	pF

Note 11: V_{OD} = 10 V, input capacitance per a pin.

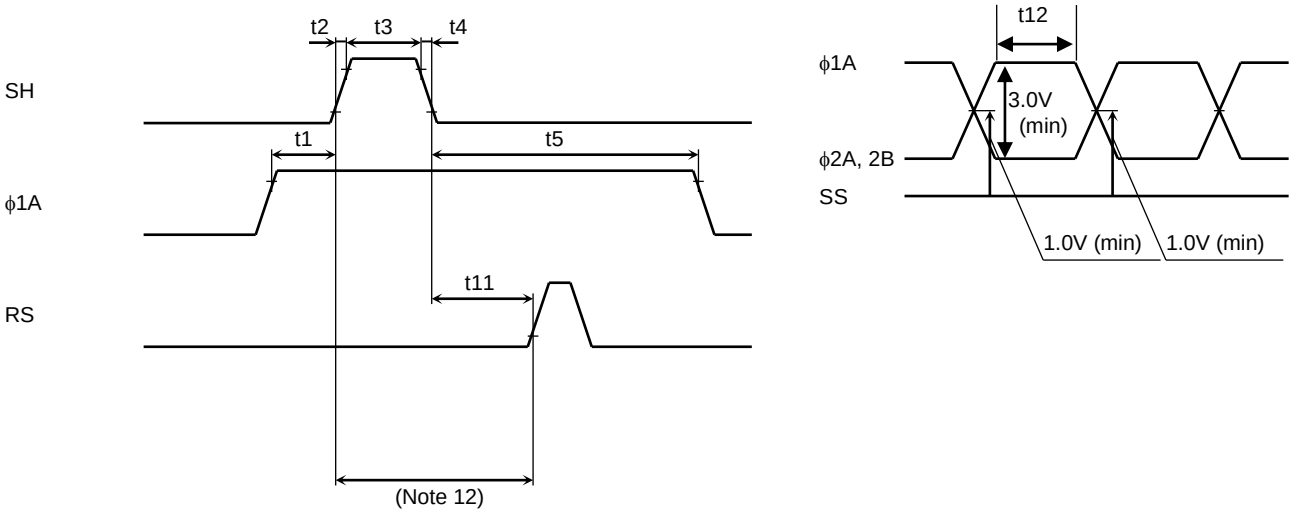
Mode select (selection sample and hold)

Mode	SW
Enable sample and hold	H
Disable sample and hold	L

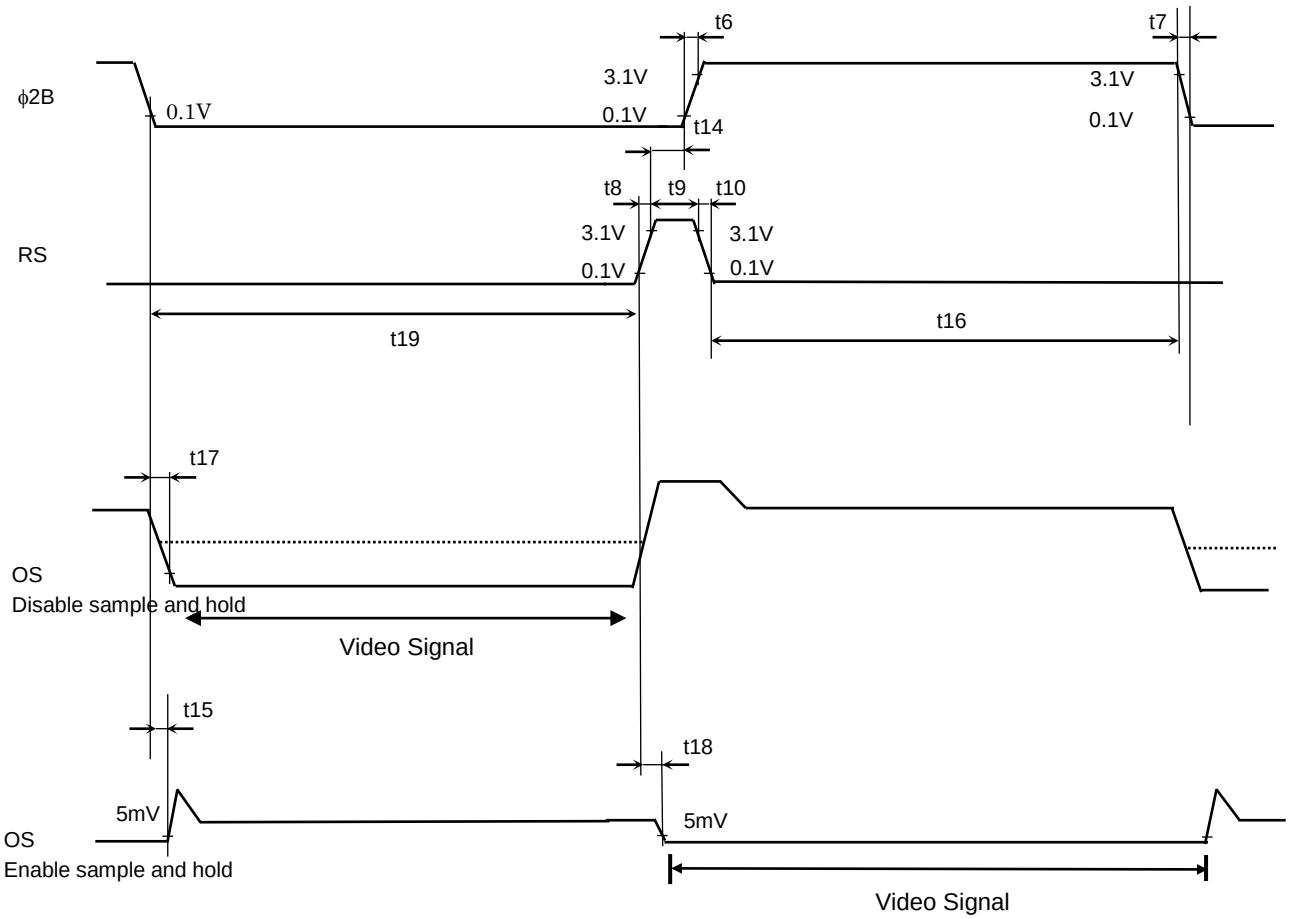
Timing Chart 1



Timing Requirements



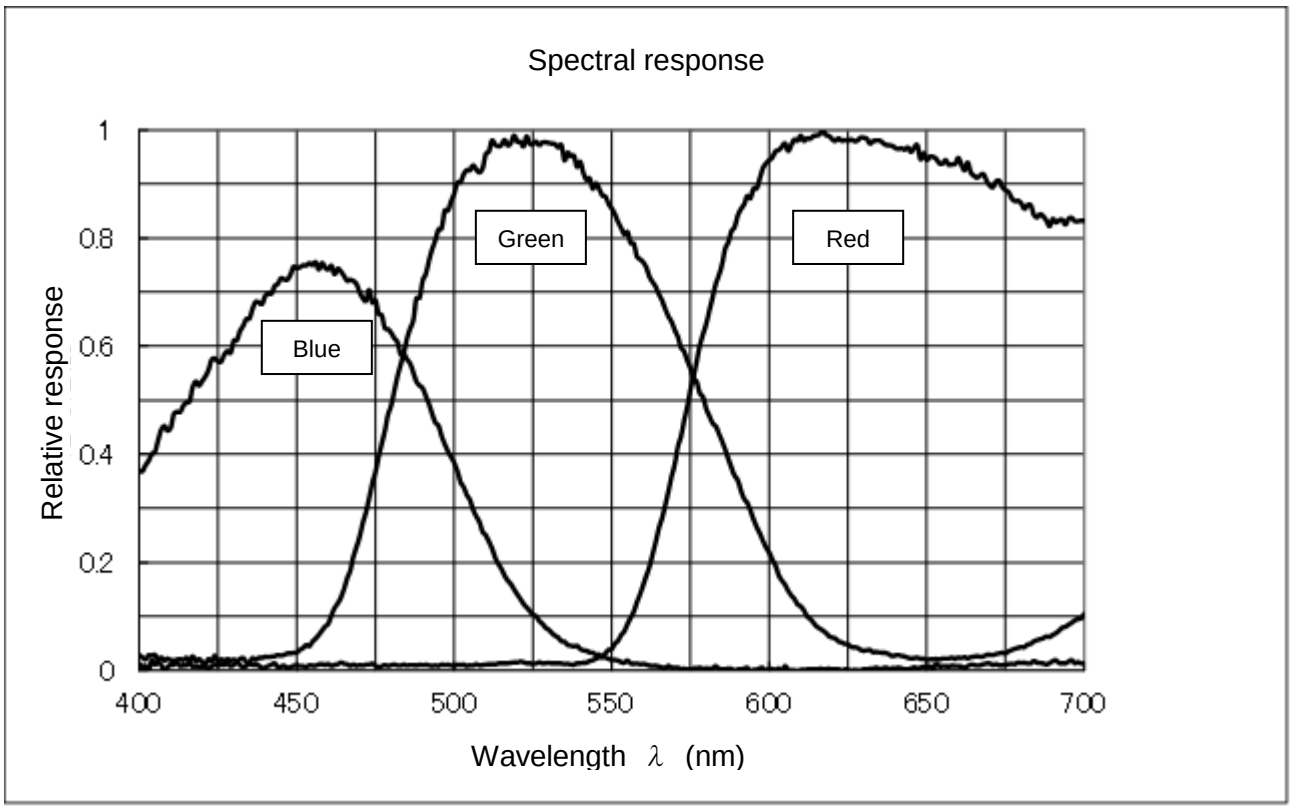
Note 12: Hold the RS pin at low during this period.



Characteristics	Symbol	Min	Typ (Note 13)	Max	Unit
Pulse timing of SH and ϕ1A	t1	120	1000	—	ns
	t5	1000	1200	—	
SH pulse rise time, fall time	t2, t4	0	50	—	ns
SH pulse width	t3	2000	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	6	100	—	ns
Pulse timing of SH and RS	t11	500	—	—	ns
ϕ1A, ϕ2A pulse width	t12	7	100	—	ns
Pulse timing of ϕ2B and RS	t14	0	0	—	ns
	t16	6	100	—	ns
	t19	8	100	—	ns
Video data delay time	t17	—	7	—	ns
Video data delay time Enable sample and hole	t18	—	7	—	ns
ϕ2B pulse timing of OS	t15	—	0	—	ns

Note 13: Measured with f_{RS} = 1 MHz.

Typical Spectral Response



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.

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

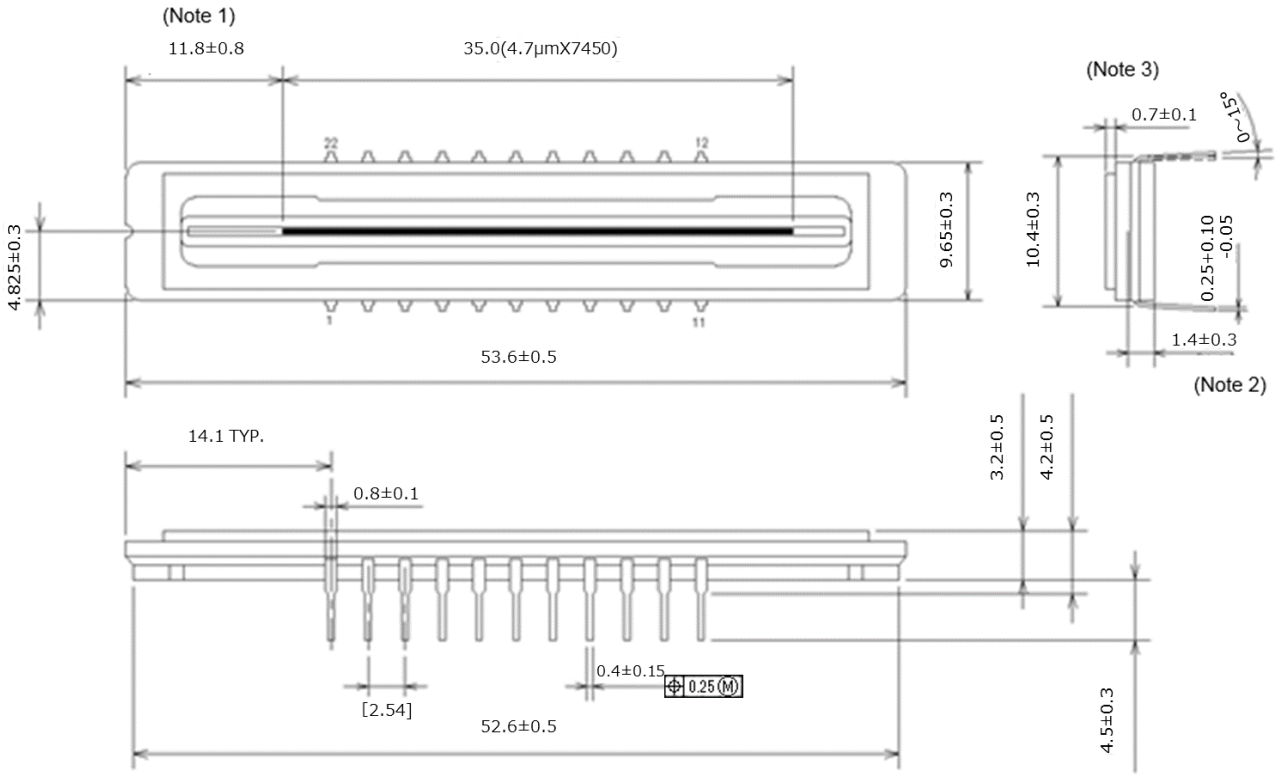
This package is sensitive to mechanical stress.
TOSHIBA recommends using IC inserters for mounting, instead of using lead forming equipment.
Since this package is not strong against mechanical stress, you should not reform the lead frame.
We recommend to use an IC-inserter when you assemble to PCB.

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.

Package Dimensions

WDIP22-G-400-2.54



Note 1 : Nn.1 Sensor element (S1) to edge of package.
Note 2 : Top of chip to bottom of package.
Note 3 : Glass thickness (n = 1.5)

Unit : mm

Weight: 4.4 g (typ.)

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