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April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (<http://www.renesas.com>)

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7400 PIXELS CCD LINEAR IMAGE SENSOR

The μ PD3747 is a high-speed and high sensitive CCD (Charge Coupled Device) linear image sensor which changes optical images to electrical signal.

The μ PD3747 is a 2-output type CCD sensor with 2 rows of high-speed charge transfer register, which transfers the photo signal electrons of 7400 pixels separately in odd and even pixels. And it has reset feed-through level clamp circuits and voltage amplifiers. Therefore, it is suitable for 600 dpi/A3 high-speed digital copiers, multi-function products and so on.

FEATURES

- Valid photocell : 7400 pixels
- Photocell pitch : 4.7 μ m
- Photocell size : 4.7 \times 4.7 μ m²
- Resolution : 24 dot/mm (600 dpi) A3 (297 \times 420 mm) size (shorter side)
- Data rate : 44 MHz MAX. (22 MHz/1 output)
- Output type : 2 outputs in phase
- High sensitivity : 19.0 V/lx \cdot s TYP. (Light source: Daylight color fluorescent lamp)
- Low image lag : 1 % MAX.
- Power supply : +12 V
- Drive clock level : CMOS output under 5 V operation
- On-chip circuits : Reset feed-through level clamp circuits
- : Voltage amplifiers

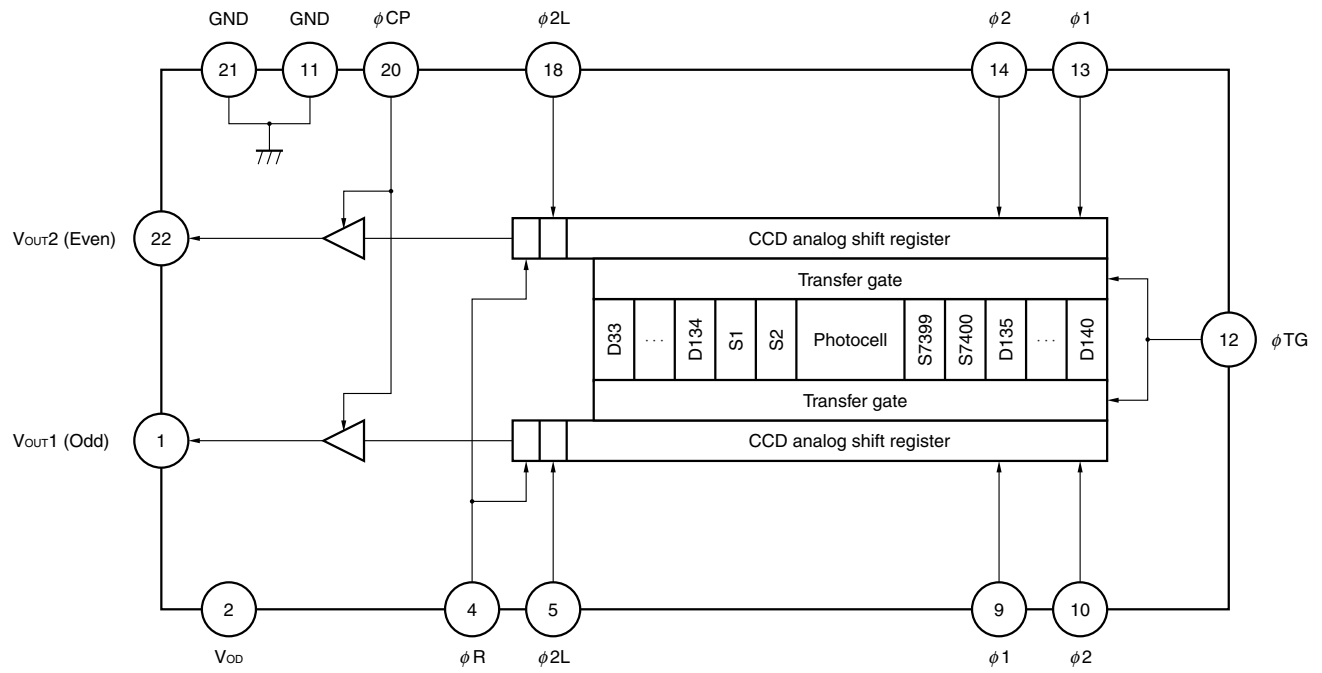
ORDERING INFORMATION

Part Number	Package
<R> μ PD3747D-A	CCD linear image sensor 22-pin ceramic DIP (CERDIP) (10.16 mm (400))

Remark The μ PD3747D-A is a lead-free product.

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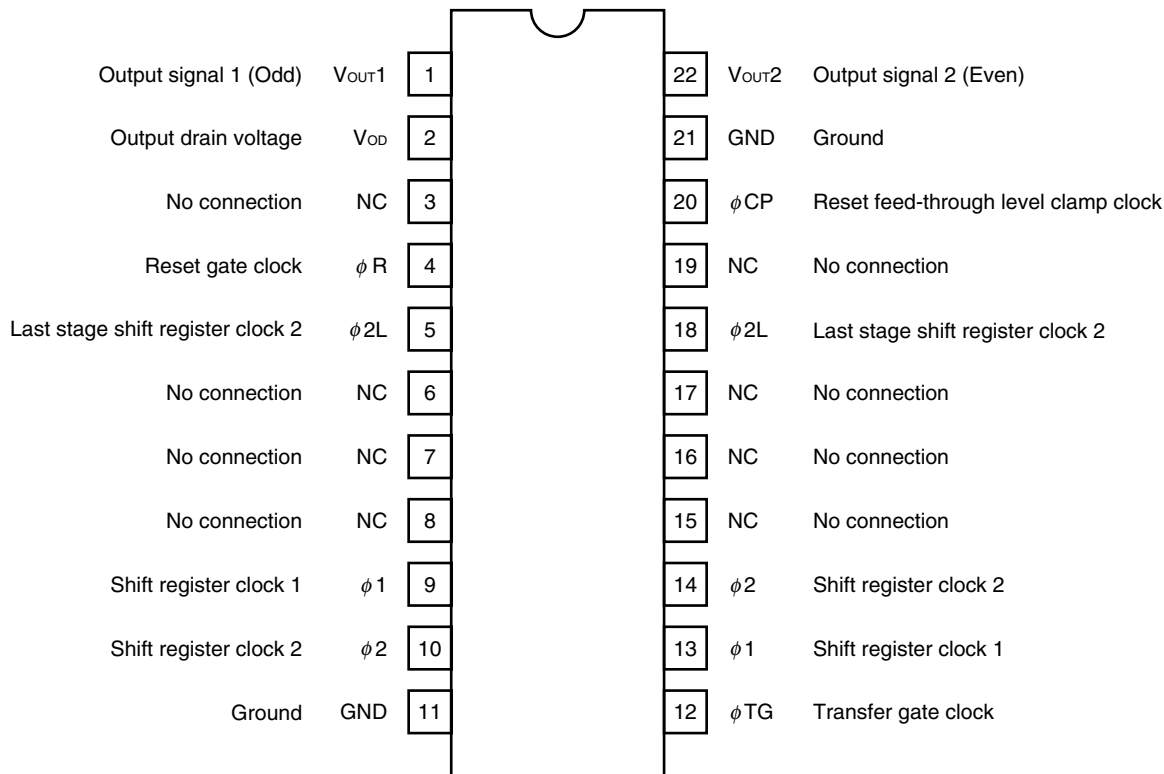
BLOCK DIAGRAM



PIN CONFIGURATION (Top View)

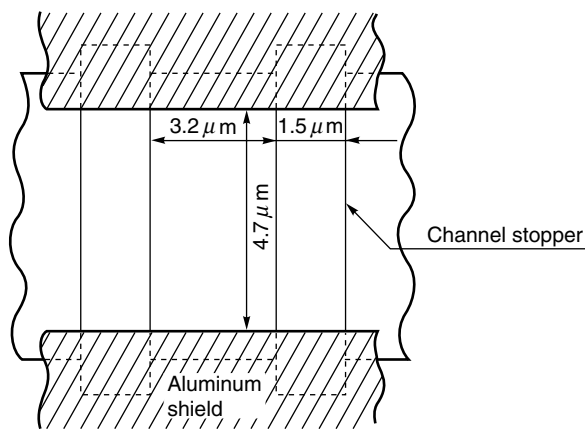
CCD linear image sensor 22-pin ceramic DIP (CERDIP) (10.16 mm (400))

• μPD3747D-A



Caution Connect the No connection pins (NC) to GND.

PHOTOCELL STRUCTURE DIAGRAM



ABSOLUTE MAXIMUM RATINGS (T_A = +25°C)

Parameter	Symbol	Ratings	Unit
Output drain voltage	V _{OD}	-0.3 to +14	V
Shift register clock voltage	V _{φ1} , V _{φ2} , V _{φ2L}	-0.3 to +8	V
Reset gate clock voltage	V _{φR}	-0.3 to +8	V
Reset feed-through level clamp clock voltage	V _{φCP}	-0.3 to +8	V
Transfer gate clock voltage	V _{φTG}	-0.3 to +8	V
Operating ambient temperature ^{Note}	T _A	-25 to +55	°C
Storage temperature	T _{stg}	-40 to +100	°C

Note Use at the condition without dew condensation.

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

RECOMMENDED OPERATING CONDITIONS (T_A = +25°C)

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Output drain voltage	V _{OD}	11.4	12.0	12.6	V
Shift register clock high level	V _{φ1H} , V _{φ2H} , V _{φ2LH}	4.5	5.0	5.5	V
Shift register clock low level	V _{φ1L} , V _{φ2L} , V _{φ2LL}	-0.3	0	+0.5	V
Reset gate clock high level	V _{φRH}	4.5	5.0	5.5	V
Reset gate clock low level	V _{φRL}	-0.3	0	+0.5	V
Reset feed-through level clamp clock high level	V _{φCPH}	4.5	5.0	5.5	V
Reset feed-through level clamp clock low level	V _{φCPL}	-0.3	0	+0.5	V
Transfer gate clock high level	V _{φTGH}	4.5	5.0	5.5	V
Transfer gate clock low level	V _{φTGL}	-0.3	0	+0.5	V
Data rate	2f _{φR}	1	2	44	MHz

ELECTRICAL CHARACTERISTICS

($T_A = +25^{\circ}\text{C}$, $V_{OD} = 12\text{ V}$, $f_{\phi R} = 1\text{ MHz}$, data rate = 2 MHz, storage time = 10 ms, input signal clock = 5 V_{p-p} ,
light source : 3200 K halogen lamp + C-500S (infrared cut filter, t = 1 mm) + HA-50 (heat absorbing filter, t = 3 mm))

Parameter	Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Saturation voltage	V_{sat}		1.5	2.0	–	V
Saturation exposure	SE	Daylight color fluorescent lamp	–	0.10	–	$\text{lx}\cdot\text{s}$
Photo response non-uniformity	PRNU	$V_{OUT} = 500\text{ mV}$	–	5	10	%
Average dark signal	ADS	Light shielding	–	0.5	3.0	mV
Dark signal non-uniformity	DSNU	Light shielding	–	8.0	14.0	mV
Power consumption	P_w		–	350	600	mW
Output impedance	Z_o		–	0.2	0.3	$k\Omega$
Response	R_F	Daylight color fluorescent lamp	13.3	19.0	24.7	$\text{V}/\text{lx}\cdot\text{s}$
Image lag	IL	$V_{OUT} = 500\text{ mV}$	–	0.5	1.0	%
Offset level ^{Note 1}	V_{OS}		3.7	4.7	5.7	V
Output fall delay time ^{Note 2}	t_d	$V_{OUT} = 500\text{ mV}$	–	14	–	ns
Register imbalance	RI	$V_{OUT} = 500\text{ mV}$	0	1.0	4.0	%
Total transfer efficiency	TTE	$V_{OUT} = 1\text{ V}$, data rate = 44 MHz	94	98	–	%
Response peak			–	550	–	nm
Dynamic range	DR1	V_{sat}/DSNU	–	250	–	times
	DR2	V_{sat}/σ_{bit}	–	1000	–	times
Reset feed-through noise ^{Note 1}	RFTN	Light shielding	–300	+300	+900	mV
Random noise	σ_{bit}	Light shielding, bit clamp mode	–	2.0	–	mV
	σ_{line}	Light shielding, line clamp mode	–	8.0	–	mV
Shot noise	σ_{shot}	$V_{OUT} = 500\text{ mV}$, bit clamp mode	–	8.0	–	mV

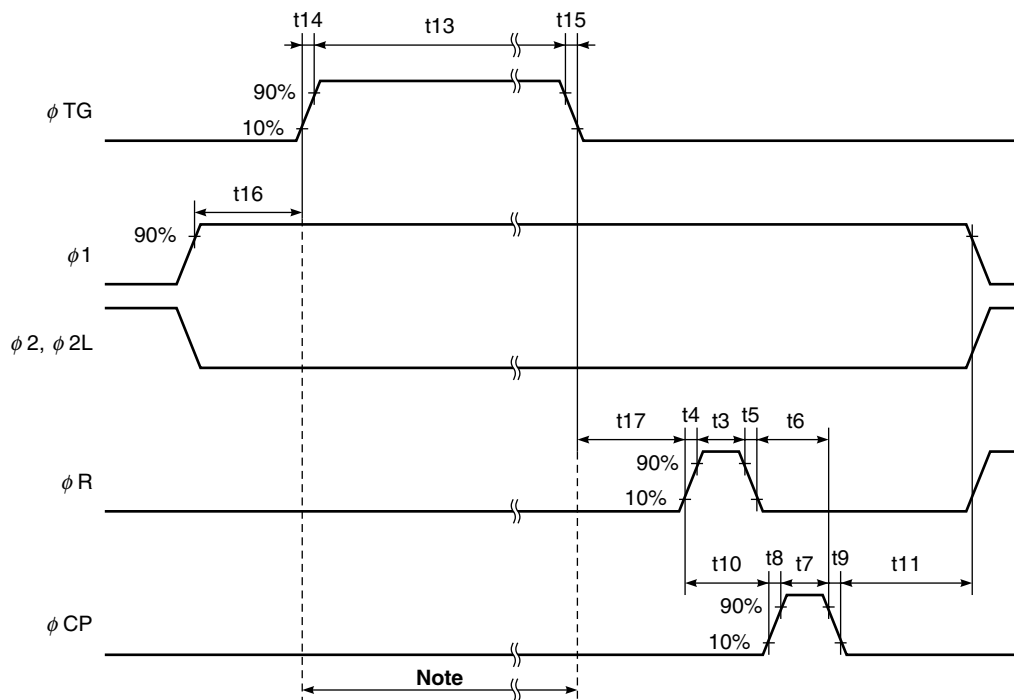
Notes 1. Refer to **TIMING CHART 2, 3.**

2. When the fall time of $\phi 2L$ (t_2') is the TYP. value (refer to **TIMING CHART 2, 3**). Note that V_{OUT1} and V_{OUT2} are the outputs of the two steps of emitter-follower shown in **APPLICATION CIRCUIT EXAMPLE.**

INPUT PIN CAPACITANCE (T_A = +25°C, V_{OD} = 12 V)

Parameter	Symbol	Pin name	Pin No.	MIN.	TYP.	MAX.	Unit
Shift register clock pin capacitance 1	C _{φ1}	φ 1	9	–	250	300	pF
			13	–	250	300	pF
Shift register clock pin capacitance 2	C _{φ2}	φ 2	10	–	250	300	pF
			14	–	250	300	pF
Last stage shift register clock pin capacitance	C _{φL}	φ 2L	5	–	10	20	pF
			18	–	10	20	pF
Reset gate clock pin capacitance	C _{φR}	φ R	4	–	10	20	pF
Reset feed-through level clamp clock pin capacitance	C _{φCP}	φ CP	20	–	10	20	pF
Transfer gate clock pin capacitance	C _{φTG}	φ TG	12	–	250	300	pF

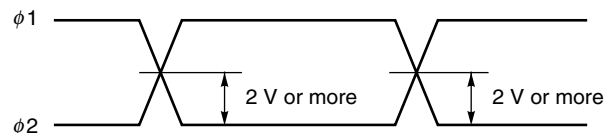
TIMING CHART 4 (Bit clamp mode, Line clamp mode)



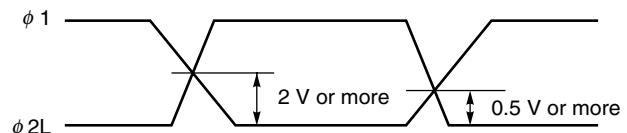
Note Set the ϕ R and ϕ CP to low level during this period.

Symbol	MIN.	TYP.	MAX.	Unit
t3	10	125	–	ns
t4, t5	0	5	–	ns
t6	0	125	–	ns
t7	5	125	–	ns
t8, t9	0	5	–	ns
t10	t3	125	–	ns
t11	0	250	–	ns
t13	1000	1500	–	ns
t14, t15	0	50	–	ns
t16, t17	200	300	–	ns

ϕ 1, ϕ 2 cross points



ϕ 1, ϕ 2L cross points



Remark Adjust cross points of (ϕ 1, ϕ 2) and (ϕ 1, ϕ 2L) with input resistance of each pin.

DEFINITIONS OF CHARACTERISTIC ITEMS

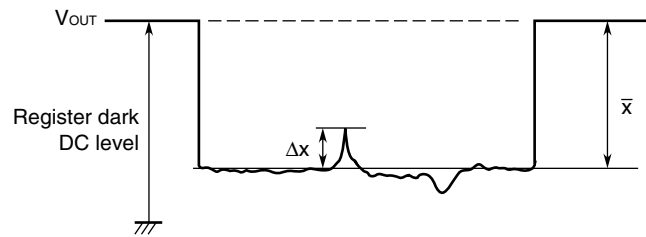
1. Saturation voltage : **V_{sat}**
Output signal voltage at which the response linearity is lost.
2. Saturation exposure : **SE**
Product of intensity of illumination (lx) and storage time (s) when saturation of output voltage occurs.
3. Photo response non-uniformity : **PRNU**
The output signal non-uniformity of all the valid pixels when the photosensitive surface is applied with the light of uniform illumination. This is calculated by the following formula.

$$PRNU (\%) = \frac{\Delta x}{\bar{x}} \times 100$$

Δx: maximum of $|x_j - \bar{x}|$

$$\bar{x} = \frac{\sum_{j=1}^{7400} x_j}{7400}$$

x_j: Output voltage of valid pixel number j



4. Average dark signal : **ADS**
Average output signal voltage of all the valid pixels at light shielding. This is calculated by the following formula.

$$ADS (mV) = \frac{\sum_{j=1}^{7400} d_j}{7400}$$

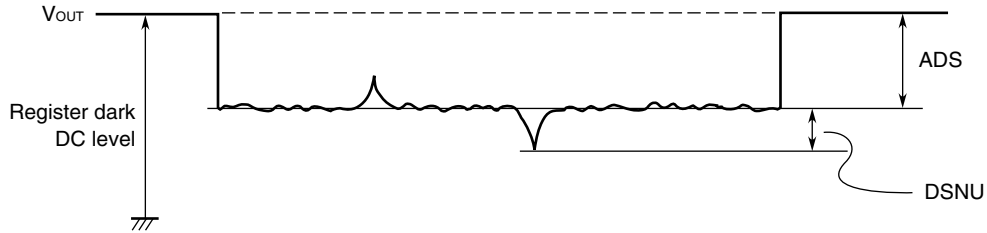
d_j: Dark signal of valid pixel number j

5. Dark signal non-uniformity : **DSNU**

Absolute maximum of the difference between ADS and voltage of the highest or lowest output pixel of all the valid pixels at light shielding. This is calculated by the following formula.

DSNU (mV): maximum of $|d_j - ADS|$ $|_{j = 1 \text{ to } 7400}$

d_j : Dark signal of valid pixel number j



6. Output impedance : **Zo**

Impedance of the output pins viewed from outside.

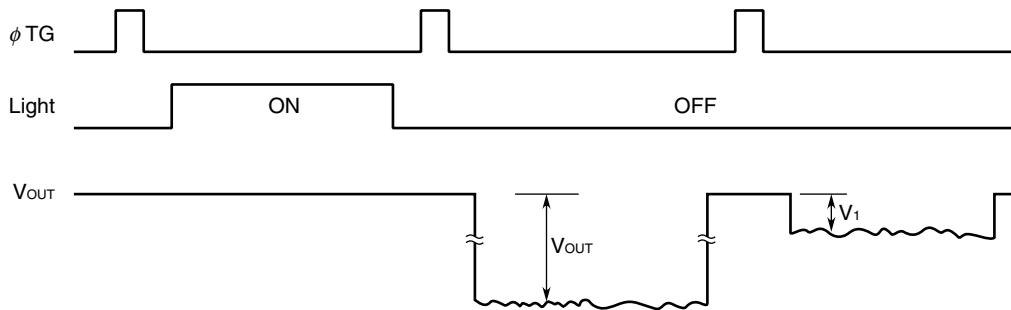
7. Response : **R**

Output voltage divided by exposure ($lx \cdot s$).

Note that the response varies with a light source (spectral characteristic).

8. Image lag : **IL**

The rate between the last output voltage and the next one after read out the data of a line.

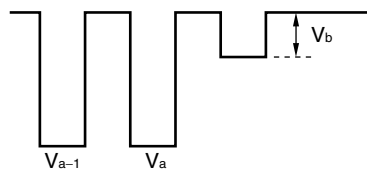


$$IL (\%) = \frac{V_1}{V_{OUT}} \times 100$$

9. Total transfer efficiency : **TTE**

The total transfer rate of CCD analog shift register. This is calculated by the following formula, it is defined by each output.

$$TTE (\%) = (1 - V_b / \text{average output of all the valid pixels}) \times 100$$



V_{a-1} : The last pixel output - 1 (Odd pixel: 7537th pixel)

V_a : The last pixel output (Odd pixel: 7539th pixel)

V_b : The split pixel output (Odd pixel: 7541st pixel)

10. Register imbalance : **RI**

The rate of the difference between the averages of the output voltage of Odd and Even pixels, against the average output voltage of all the valid pixels.

$$RI (\%) = \frac{\frac{2}{n} \left| \sum_{j=1}^{\frac{n}{2}} (V_{2j-1} - V_{2j}) \right|}{\frac{1}{n} \sum_{j=1}^n V_j} \times 100$$

n : Number of valid pixels

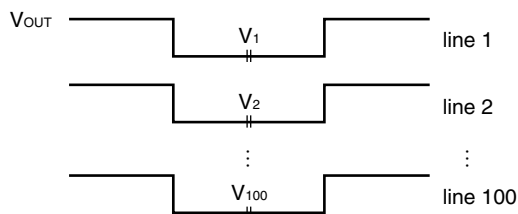
V_j: Output voltage of each pixel

11. Random noise : **σ**

Random noise σ is defined as the standard deviation of a valid pixel output signal with 100 times (= 100 lines) data sampling at dark (light shielding).

$$\sigma (mV) = \sqrt{\frac{\sum_{i=1}^{100} (V_i - \bar{V})^2}{100}}, \quad \bar{V} = \frac{1}{100} \sum_{i=1}^{100} V_i$$

V_i: A valid pixel output signal among all of the valid pixels



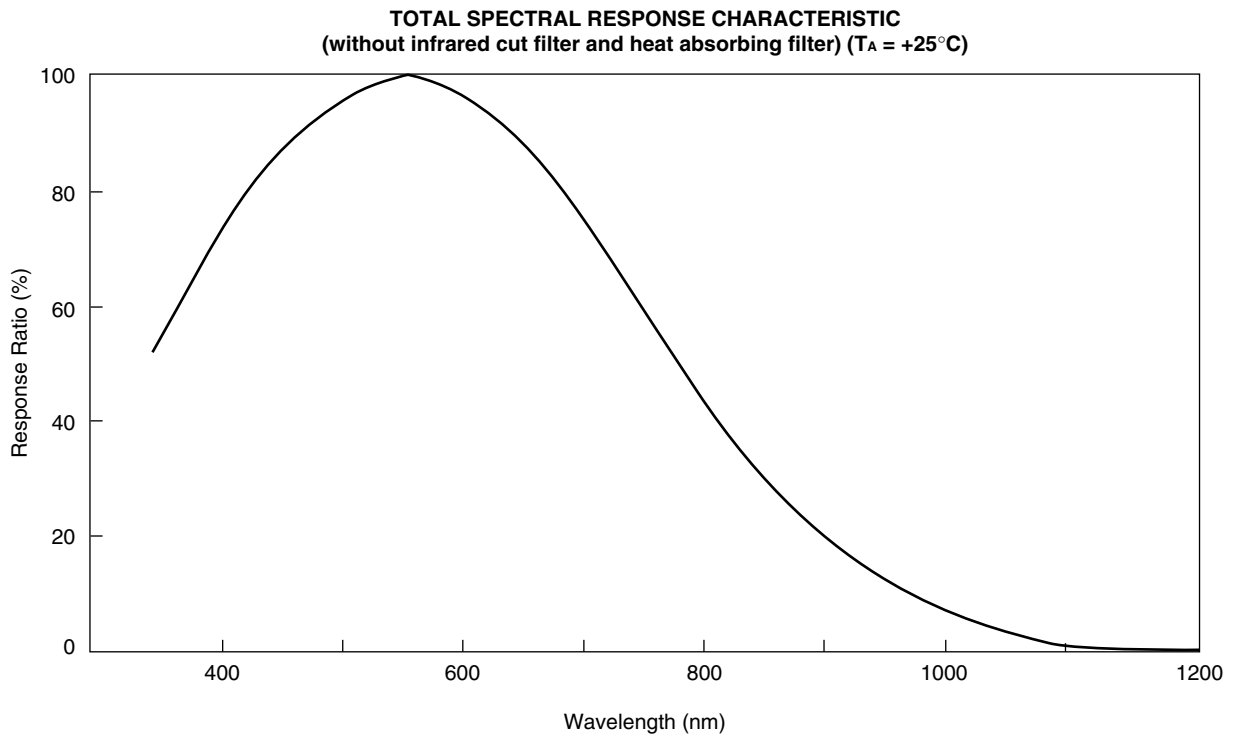
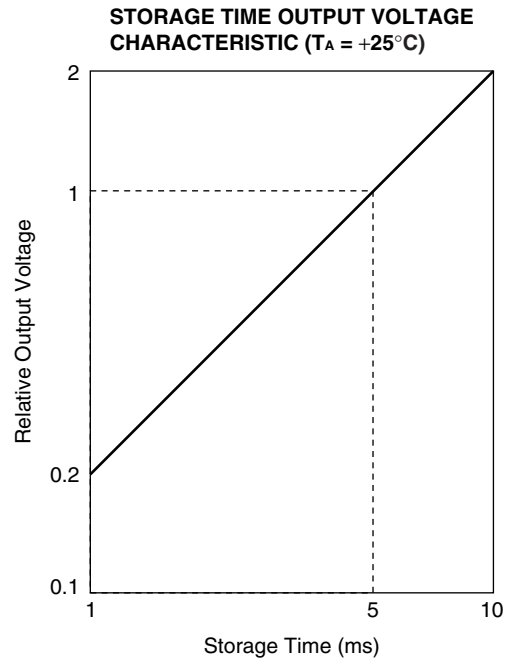
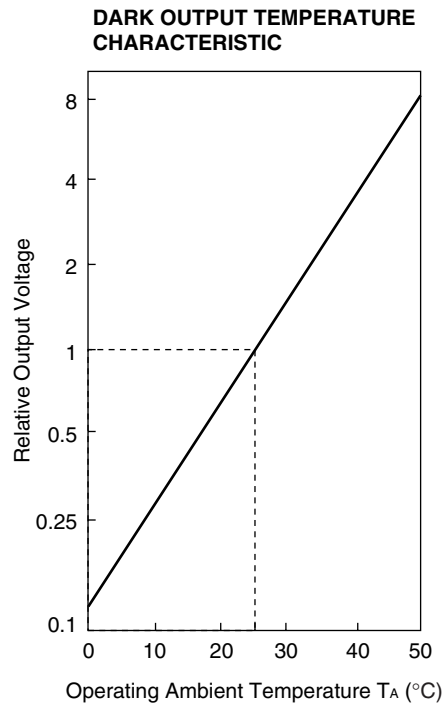
This is measured by the DC level sampling of only the signal level, not by CDS (Correlated Double Sampling).

12. Shot noise : **σ_{shot}**

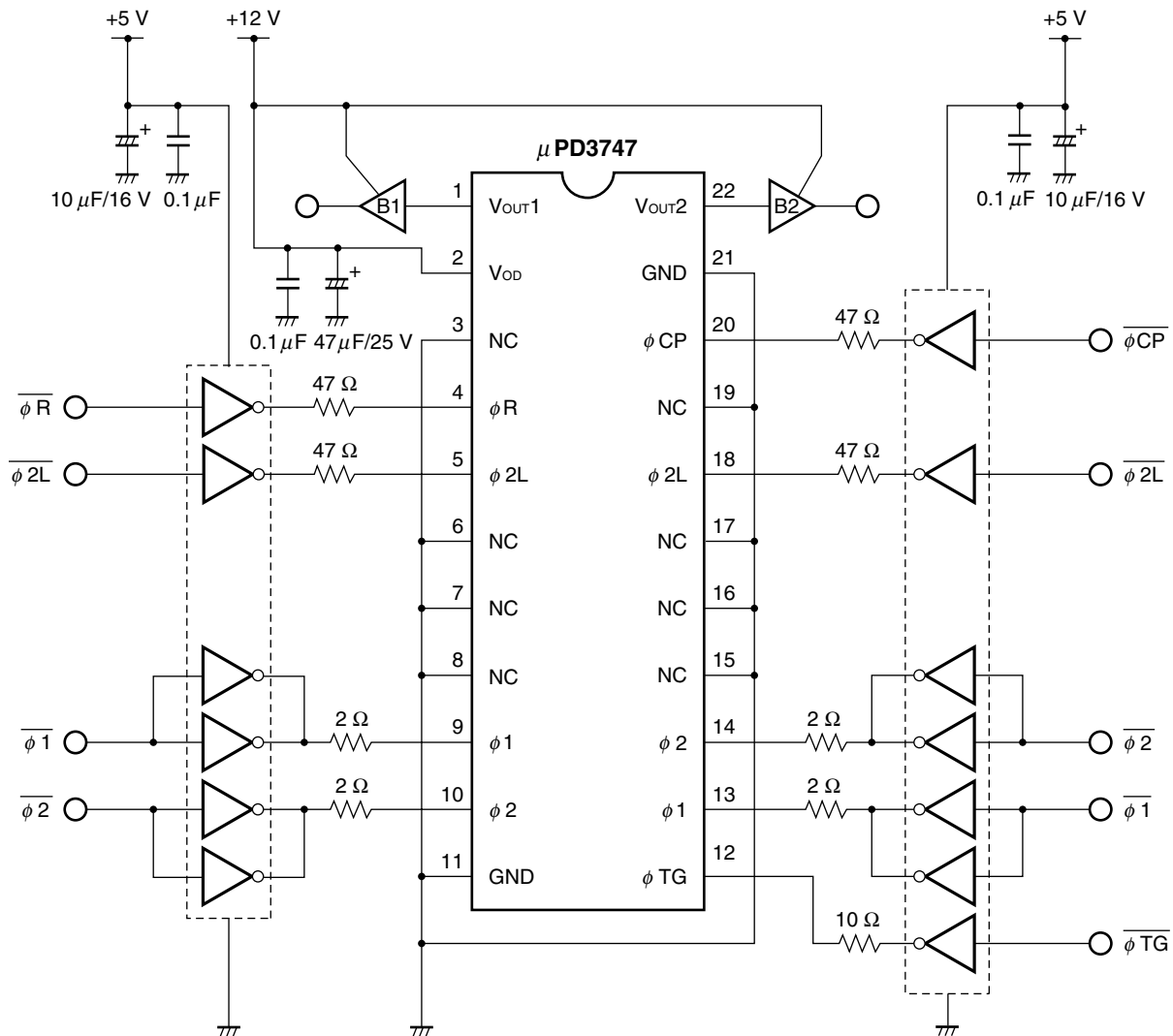
Shot noise is defined as the standard deviation of a valid pixel output signal with 100 times (= 100 lines) data sampling in the light. This includes the random noise.

The formula is the same with that of random noise.

STANDARD CHARACTERISTIC CURVES (Reference Value)



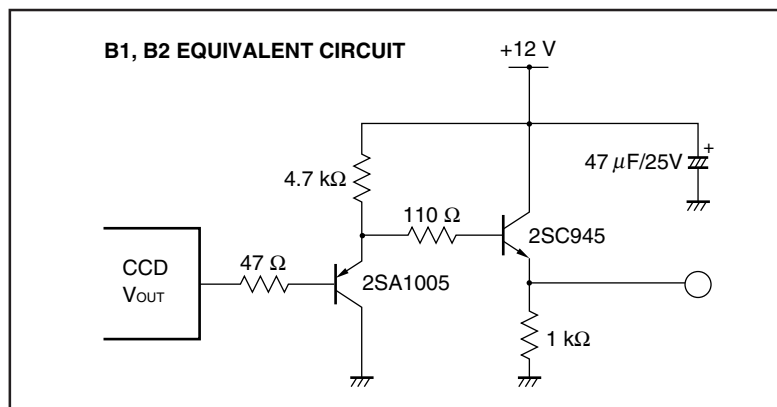
APPLICATION CIRCUIT EXAMPLE



Caution Connect the No connection pins (NC) to GND.

Remarks 1. It is recommended that pins 5 and 18 (ϕ 2L) are separately driven a driver other than that of pins 10, 14 (ϕ 2).

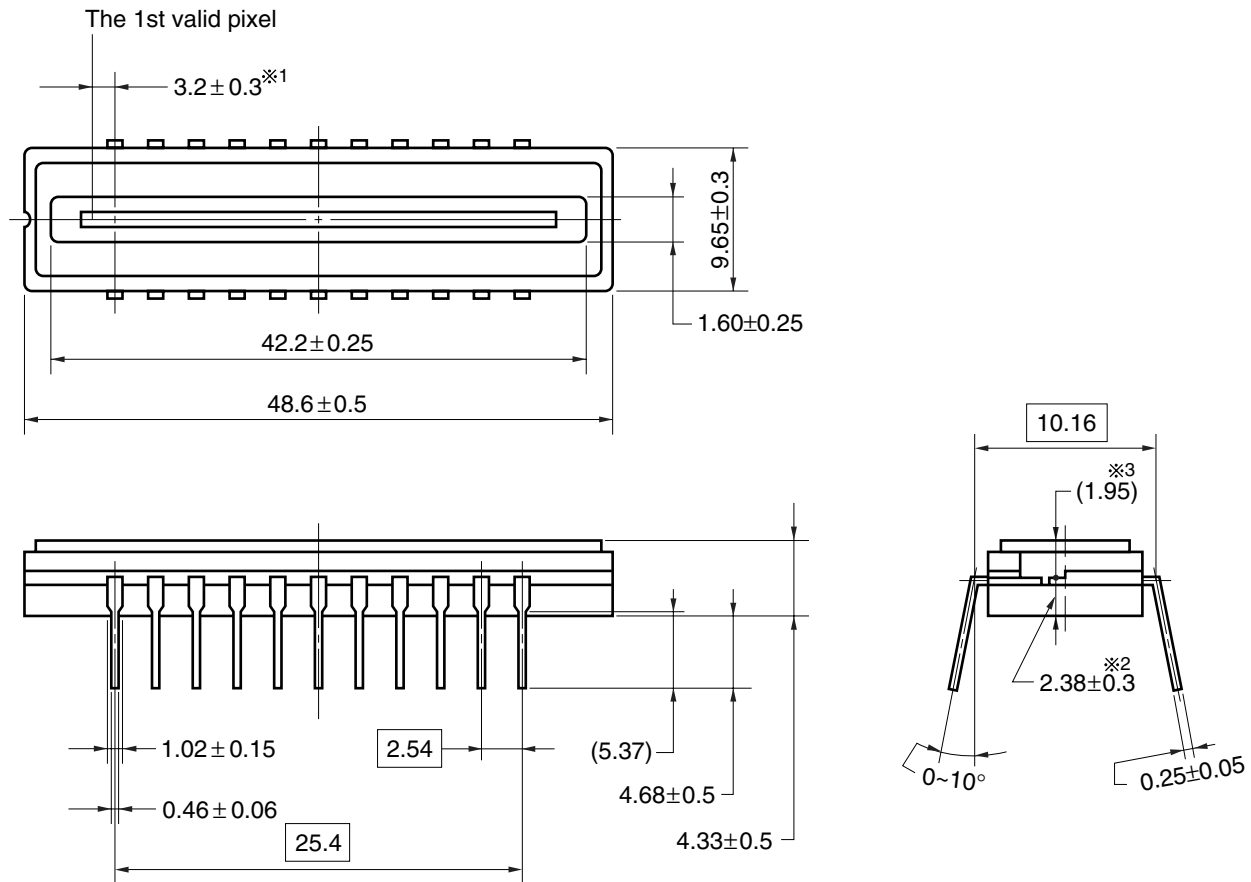
2. The inverters shown in the above application circuit example are the 74AC04.



PACKAGE DRAWING

CCD LINEAR IMAGE SENSOR 22-PIN CERAMIC DIP (CERDIP) (10.16 mm (400))

(Unit : mm)



Name	Dimensions	Refractive index
Glass cap	47.5×9.25×0.7	1.5

- ※1 1st valid pixel ↔ Center of pin 1
- ※2 Photosensitive surface of CCD chip ↔ Bottom of package
- ※3 Photosensitive surface of CCD chip ↔ Top of glass cap

22D-1CCD-PKG10

RECOMMENDED SOLDERING CONDITIONS

When soldering this product, it is highly recommended to observe the conditions as shown below.

If other soldering processes are used, or if the soldering is performed under different conditions, please make sure to consult with our sales offices.

Type of Through-hole Device

μ PD3747D-A : CCD linear image sensor 22-pin ceramic DIP (CERDIP) (10.16 mm (400))

Process	Conditions
<R> Partial heating method	Pin temperature : 380°C or below, Heat time : 3 seconds or less (per pin)

- Cautions**
1. **During assembly care should be taken to prevent solder or flux from contacting the glass cap. The optical characteristics could be degraded by such contact.**
 2. **Soldering by the solder flow method may have deleterious effects on prevention of glass cap soiling and heat resistance. So the method cannot be guaranteed.**

NOTES ON HANDLING THE PACKAGES

① MOUNTING OF THE PACKAGE

The application of an excessive load to the package may cause the package to warp or break, or cause chips to come off internally. Particular care should be taken when mounting the package on the circuit board. Don't have any object come in contact with glass cap. You should not reform the lead frame. We recommended to use a IC-inserter when you assemble to PCB.

Also, be care that the any of the following can cause the package to crack or dust to be generated.

1. Applying heat to the external leads for an extended period of time with soldering iron.
2. Applying repetitive bending stress to the external leads.
3. Rapid cooling or heating

② GLASS CAP

Don't either touch glass cap surface by hand or have any object come in contact with glass cap surface. Care should be taken to avoid mechanical or thermal shock because the glass cap is easily to damage. For dirt stuck through electricity ionized air is recommended.

③ OPERATE AND STORAGE ENVIRONMENTS

Operate in clean environments. CCD image sensors are precise optical equipment that should not be subject to mechanical shocks. Exposure to high temperatures or humidity will affect the characteristics. So avoid storage or usage in such conditions.

Keep in a case to protect from dust and dirt. Dew condensation may occur on CCD image sensors when the devices are transported from a low-temperature environment to a high-temperature environment. Avoid such rapid temperature changes.

For more details, refer to our document "Review of Quality and Reliability Handbook" (C12769E)

④ ELECTROSTATIC BREAKDOWN

CCD image sensor is protected against static electricity, but destruction due to static electricity is sometimes detected. Before handling be sure to take the following protective measures.

1. Ground the tools such as soldering iron, radio cutting pliers or pincer.
2. Install a conductive mat or on the floor or working table to prevent the generation of static electricity.
3. Either handle bare handed or use non-chargeable gloves, clothes or material.
4. Ionized air is recommended for discharge when handling CCD image sensor.
5. For the shipment of mounted substrates, use box treated for prevention of static charges.
6. Anyone who is handling CCD image sensors, mounting them on PCBs or testing or inspecting PCBs on which CCD image sensors have been mounted must wear anti-static bands such as wrist straps and ankle straps which are grounded via a series resistance connection of about 1 MΩ.

NOTES FOR CMOS DEVICES

① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ PRECAUTION AGAINST ESD

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ STATUS BEFORE INITIALIZATION

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

⑤ POWER ON/OFF SEQUENCE

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current.

The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

⑥ INPUT OF SIGNAL DURING POWER OFF STATE

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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