NEC

MOS INTEGRATED CIRCUIT

μ**PD3778**

10600 PIXELS × 3 COLOR CCD LINEAR IMAGE SENSOR

The μPD3778 is a color CCD (Charge Coupled Device) linear image sensor which changes optical images to electrical signal and has the function of color separation.

The μPD3778 has 3 rows of 10600 pixels, and each row has a double-sided readout type of charge transfer register. And it has reset feed-through level clamp circuits and voltage amplifiers. Therefore, it is suitable for 1200 dpi/A4 color image scanners and so on.

FEATURES

- Valid photocell   : 10600 pixels × 3
- Photocell's pitch : 4 μm
- Photocell size   : 4×4 μm^2
- Line spacing   : 48 μm (12 lines) Red line-Green line, Green line-Blue line
- Color filter   : Primary colors (red, green and blue), pigment filter (with light resistance 10^7 lx•hour)
- Resolution   : 48 dot/mm A4 (210 × 297 mm) size (shorter side)
                     1200 dpi US letter (8.5" × 11") size (shorter side)
- Drive clock level : CMOS output under 5 V operation
- Data rate   : 5 MHz MAX.
- Power supply   : +12 V
- On-chip circuits : Reset feed-through level clamp circuits
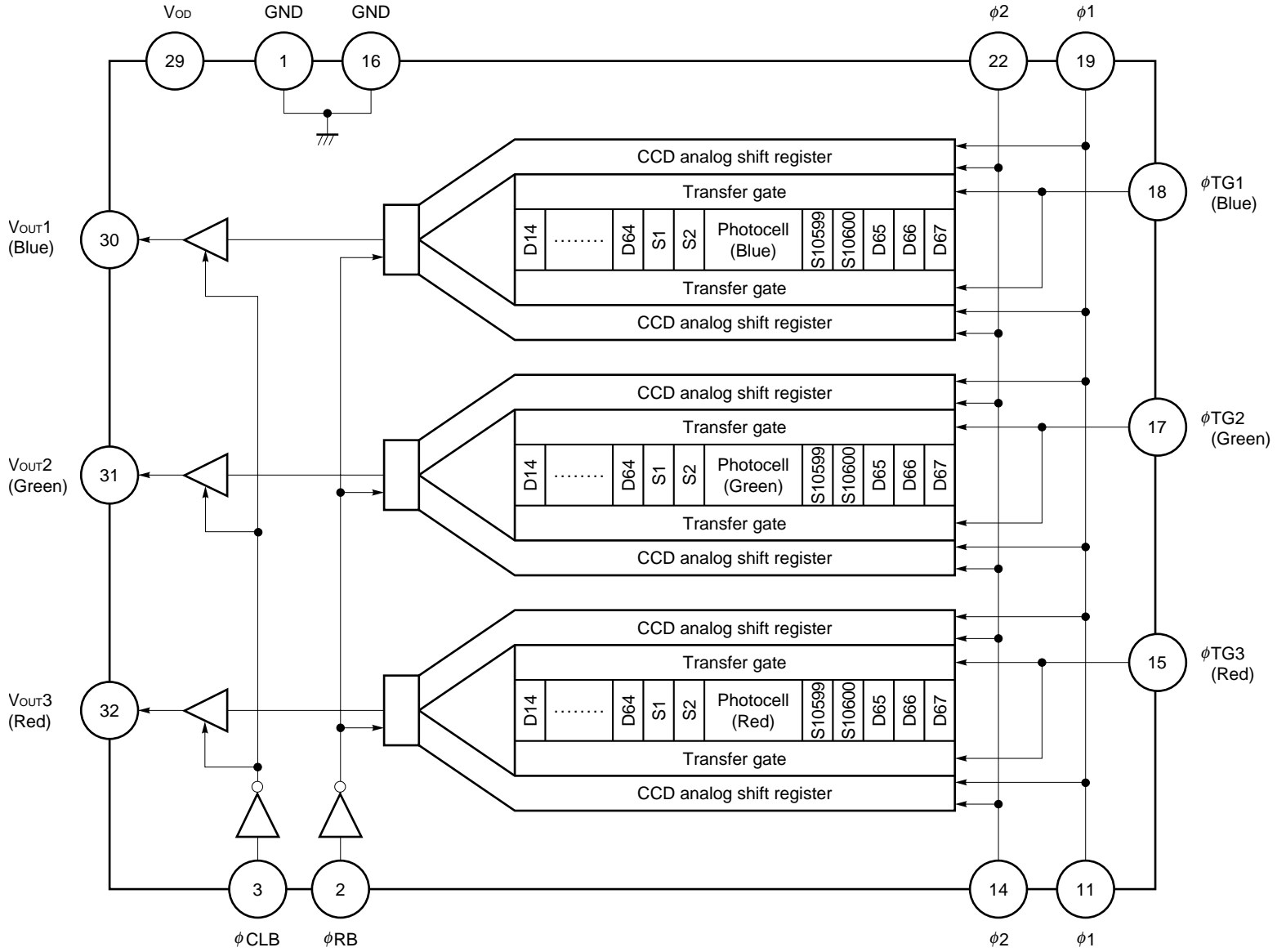   Voltage amplifiers

ORDERING INFORMATION

Part Number	Package
μPD3778CY	CCD linear image sensor 32-pin plastic DIP (400 mil)

BLOCK DIAGRAM

V_OD GND GND φ2 φ1

29 1 16 22 19

CCD analog shift register

Transfer gate

18 φTG1 (Blue)

V_OUT1 (Blue) 30

D14 .... D64 S1 S2 Photocell (Blue) S10599 S10600 D65 D66 D67

Transfer gate

CCD analog shift register

CCD analog shift register

Transfer gate

17 φTG2 (Green)

V_OUT2 (Green) 31

D14 .... D64 S1 S2 Photocell (Green) S10599 S10600 D65 D66 D67

Transfer gate

CCD analog shift register

CCD analog shift register

Transfer gate

15 φTG3 (Red)

V_OUT3 (Red) 32

D14 .... D64 S1 S2 Photocell (Red) S10599 S10600 D65 D66 D67

Transfer gate

CCD analog shift register

3 2 14 11

φCLB φRB φ2 φ1

PIN CONFIGURATION (Top View)

CCD linear image sensor 32-pin plastic DIP (400 mil)

- μPD3778CY

Left label	Pin name	Pin		Pin	Pin name	Right label
Ground	GND	1		32	VOUT3	Output signal 3 (Red)
Reset gate clock	φRB	2		31	VOUT2	Output signal 2 (Green)
Reset feed-through level clamp clock	φCLB	3		30	VOUT1	Output signal 1 (Blue)
No connection	NC	4		29	VOD	Output drain voltage
No connection	NC	5		28	NC	No connection
Internal connection	IC	6		27	IC	Internal connection
Internal connection	IC	7		26	IC	Internal connection
No connection	NC	8		25	NC	No connection
No connection	NC	9		24	NC	No connection
No connection	NC	10		23	NC	No connection
Shift register clock 1	φ1	11		22	φ2	Shift register clock 2
Internal connection	IC	12		21	IC	Internal connection
Internal connection	IC	13		20	IC	Internal connection
Shift register clock 2	φ2	14		19	φ1	Shift register clock 1
Transfer gate clock 3 (for Red)	φTG3	15		18	φTG1	Transfer gate clock 1 (for Blue)
Ground	GND	16		17	φTG2	Transfer gate clock 2 (for Green)

(Package markings: Red, Green, Blue columns each labeled "1" at top and "10600" at bottom.)

Caution Leave pins 6, 7, 12, 13, 20, 21, 26, 27 (IC) unconnected.

PHOTOCELL STRUCTURE DIAGRAM
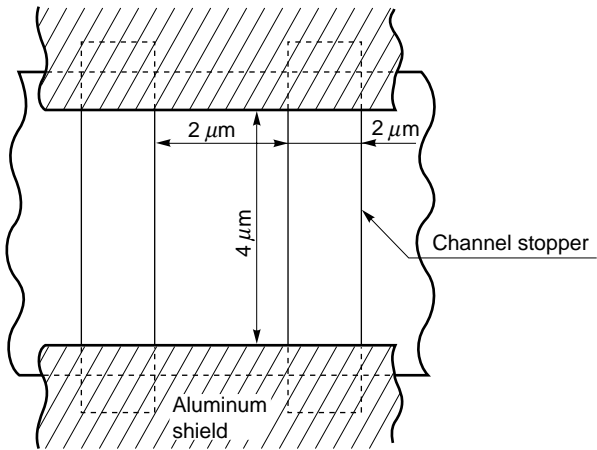
PHOTOCELL ARRAY STRUCTURE DIAGRAM (Line spacing)
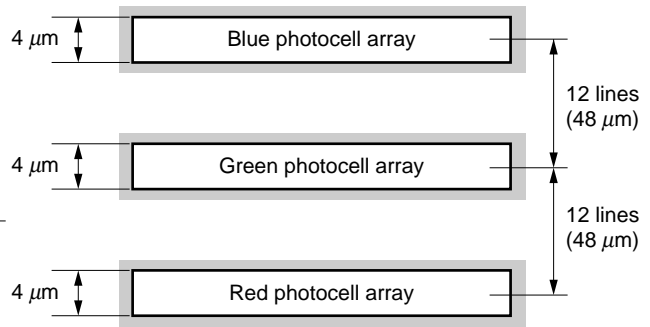
ABSOLUTE MAXIMUM RATINGS (T$_A$ = +25 °C)

Parameter	Symbol	Ratings	Unit
Output drain voltage	V$_{OD}$	−0.3 to +15	V
Shift register clock voltage	V$_{\phi 1}$, V$_{\phi 2}$	−0.3 to +8	V
Reset gate clock voltage	V$_{\phi RB}$	−0.3 to +8	V
Reset feed-through level clamp clock voltage	V$_{\phi CLB}$	−0.3 to +8	V
Transfer gate clock voltage	V$_{\phi TG1}$ to V$_{\phi TG3}$	−0.3 to +8	V
Operating ambient temperature	T$_A$	−25 to +60	°C
Storage temperature	T$_{stg}$	−40 to +70	°C

Caution   **Exposure to ABSOLUTE MAXIMUM RATINGS for extended periods may affect device reliability; exceeding the ratings could cause permanent damage. The parameters apply independently.**

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$_{\phi 1H}$, V$_{\phi 2H}$	4.5	5.0	5.5	V
Shift register clock low level	V$_{\phi 1L}$, V$_{\phi 2L}$	−0.3	0	+0.5	V
Reset gate clock high level	V$_{\phi RBH}$	4.5	5.0	5.5	V
Reset gate clock low level	V$_{\phi RBL}$	−0.3	0	+0.5	V
Reset feed-through level clamp clock high level	V$_{\phi CLBH}$	4.5	5.0	5.5	V
Reset feed-through level clamp clock low level	V$_{\phi CLBL}$	−0.3	0	+0.5	V
Transfer gate clock high level	V$_{\phi TG1H}$ to V$_{\phi TG3H}$	4.5	V$_{\phi 1H}$[Note]	V$_{\phi 1H}$[Note]	V
Transfer gate clock low level	V$_{\phi TG1L}$ to V$_{\phi TG3L}$	−0.3	0	+0.5	V
Data rate	f$_{\phi RB}$	−	1.0	5.0	MHz

Note   When Transfer gate clock high level (V$_{\phi TG1H}$ to V$_{\phi TG3H}$) is higher than Shift register clock high level (V$_{\phi 1H}$), Image lag can increase.

ELECTRICAL CHARACTERISTICS

T_A = +25 °C, V_{OD} = 12 V, data rate ($f_{\phi RB}$) = 2 MHz, storage time = 5.5 ms, input signal clock = 5 V_{P-p},
light source: 3200 K halogen lamp +C-500S (infrared cut filter, t = 1mm) + HA-50 (heat absorbing filter, t = 3 mm)

Parameter		Symbol	Test Conditions	MIN.	TYP.	MAX.	Unit
Saturation voltage		V_{sat}		2.0	2.5	–	V
Saturation exposure	Red	SER			0.694		lx•s
	Green	SEG			0.757		lx•s
	Blue	SEB			1.250		lx•s
Photo response non-uniformity		PRNU	V_{OUT} = 1.0 V		6	20	%
Average dark signal		ADS	Light shielding		0.2	4.0	mV
Dark signal non-uniformity		DSNU	Light shielding		1.5	4.0	mV
Power consumption		P_W			400	600	mW
Output impedance		Z_O			0.5	1	kΩ
Response	Red	R_R		2.52	3.60	4.68	V/lx•s
	Green	R_G		2.31	3.30	4.29	V/lx•s
	Blue	R_B		1.40	2.00	2.60	V/lx•s
Image lag		IL	V_{OUT} = 1.0 V		2.0	10.0	%
Offset level **Note1**		V_{OS}		4.0	6.0	7.0	V
Output fall delay time **Note2**		t_d	V_{OUT} = 1.0 V		50		ns
Total transfer efficiency		TTE	V_{OUT} = 1.0 V, data rate = 5 MHz	92	98		%
Register imbalance		RI	V_{OUT} = 1.0 V	0	1.0	4.0	%
Response peak	Red				630		nm
	Green				540		nm
	Blue				460		nm
Dynamic range		DR1	V_{sat} /DSNU		1666		times
		DR2	V_{sat} /σ CDS		2500		times
Reset feed-through noise **Note1**		RFTN	Light shielding	−1000	−300	+500	mV
Random noise (CDS)		σ CDS	Light shielding	–	1.0	–	mV

Notes 1. Refer to **TIMING CHART 2**.
    2. When each fall time of ϕ1 and ϕ2 (t2, t1) is the TYP. value (refer to **TIMING CHART 2**).

INPUT PIN CAPACITANCE (T$_A$ = +25 $^\circ$C, V$_{OD}$ = 12 V)

Parameter	Symbol	Pin name	Pin No.	MIN.	TYP.	MAX.	Unit
Shift register clock pin capacitance 1	C$_{\phi 1}$	ϕ1	11		400		pF
			19		400		pF
Shift register clock pin capacitance 2	C$_{\phi 2}$	ϕ2	14		400		pF
			22		400		pF
Reset gate clock pin capacitance	C$_{\phi RB}$	ϕRB	2		15		pF
Reset feed-through level clamp clock pin capacitance	C$_{\phi CLB}$	ϕCLB	3		15		pF
Transfer gate clock pin capacitance	C$_{\phi TG}$	ϕTG1	18		120		pF
		ϕTG2	17		120		pF
		ϕTG3	15		120		pF

Remark   Pins 11 and 19 (ϕ1), 14 and 22 (ϕ2) are each connected inside of the device.

TIMING CHART 1 (for each color)

φTG1 to
φTG3

φ1

1 2 3 4 5 6 7 8

φ2

φRB

φCLB

Note

10663 10664 10665 10666 10667 10668 10669

Vout1 to
Vout3

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

61 62 63 64 65 66

Note

Optical black
(49 pixels)

Invalid photocell
(2 pixels)

Valid photocell
(10600 pixels)

Invalid photocell
(3 pixels)
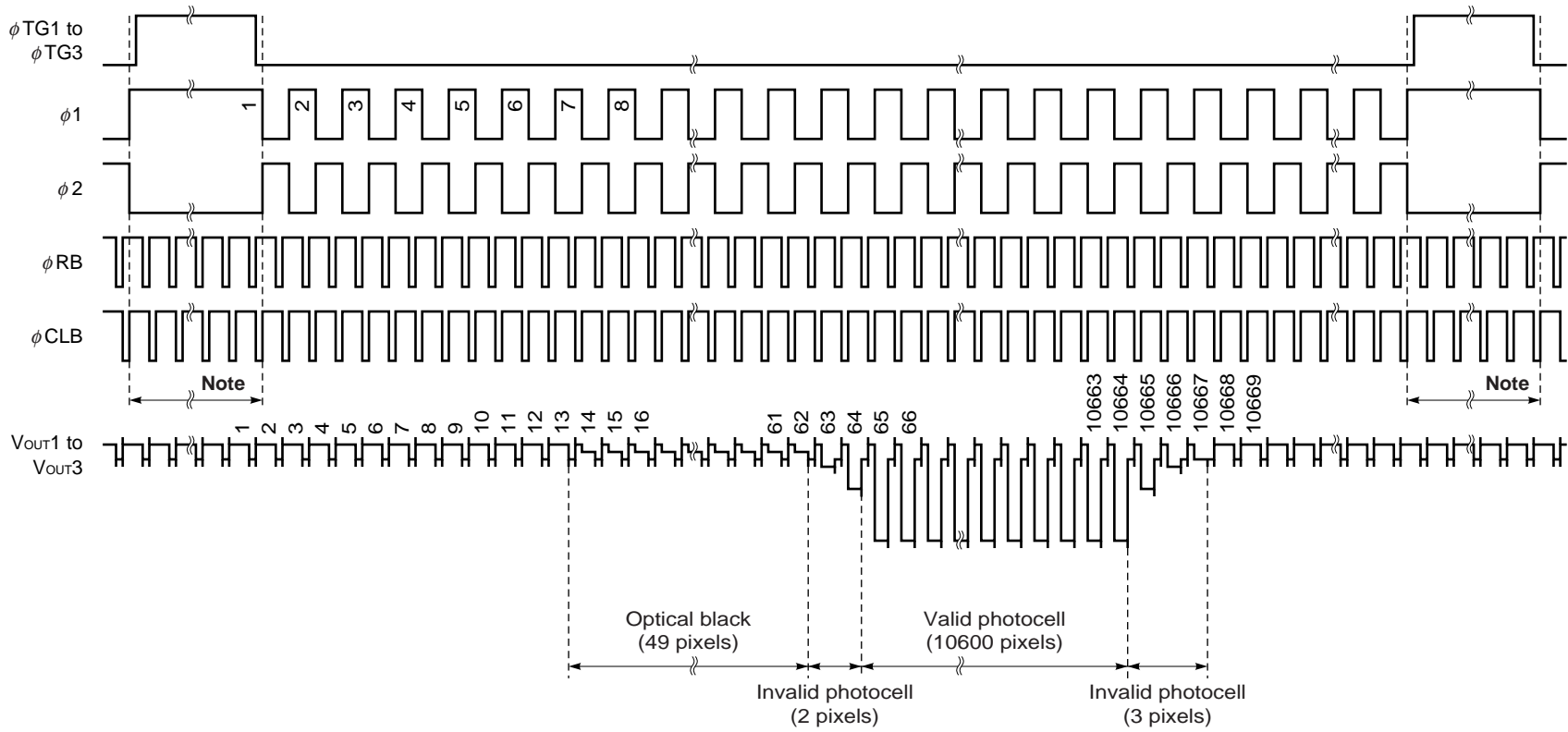
Note Input the φRB and φCLB pulses continuously during this period, too.

NEC

μ**PD3778**

TIMING CHART 2 (for each color)
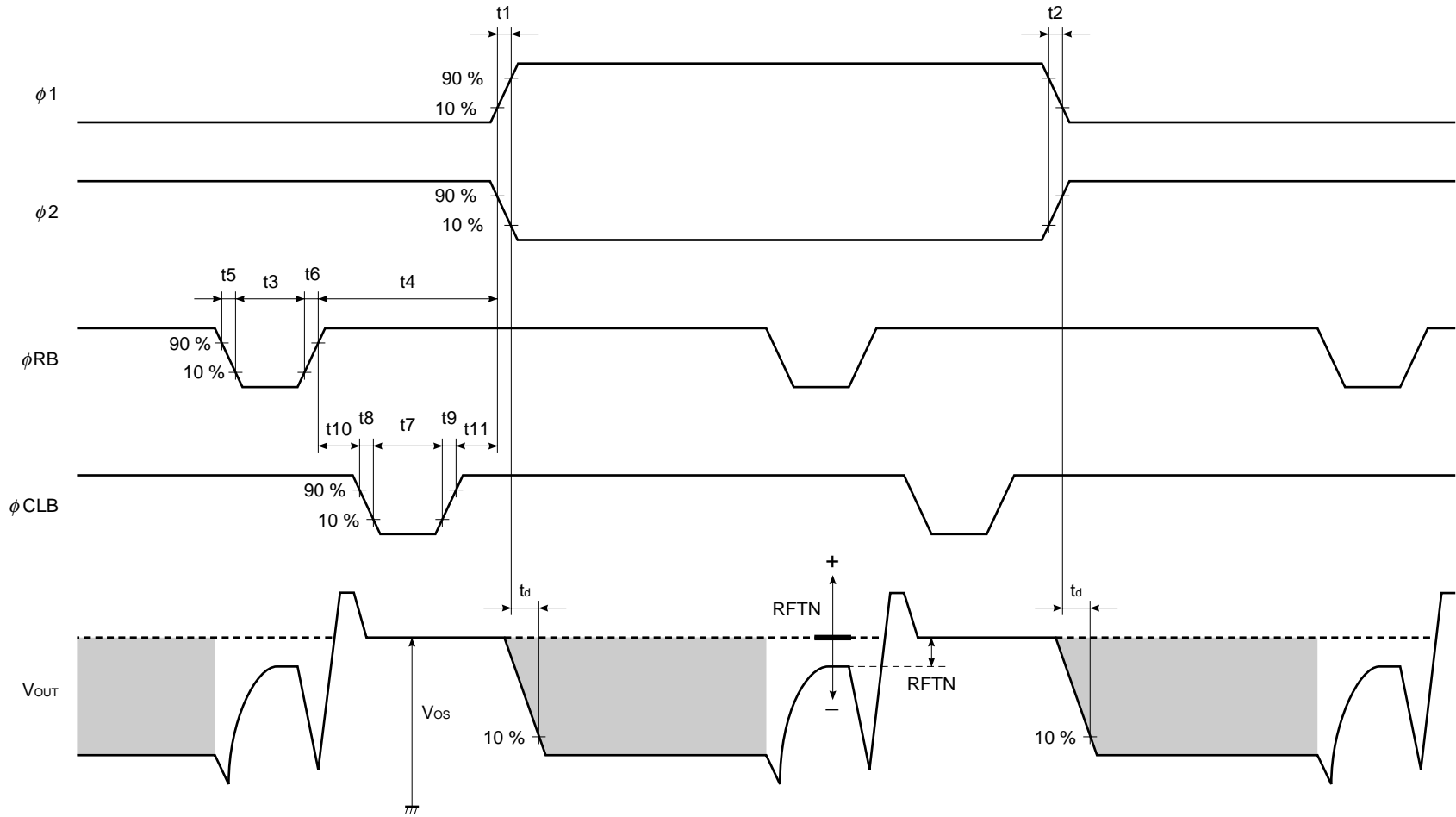
ϕ**TG1 to ϕTG3, ϕ1, ϕ2 TIMING CHART**
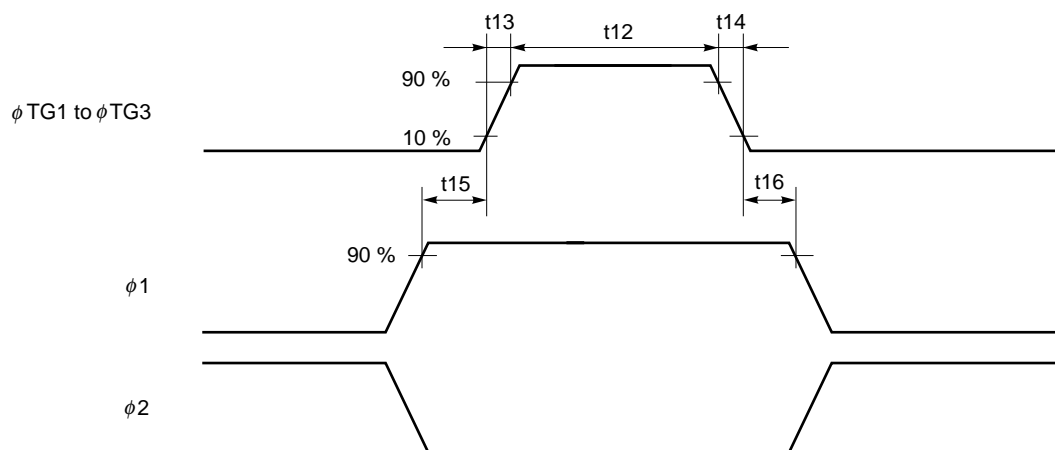
Symbol	MIN.	TYP.	MAX.	Unit
t1, t2	0	25	–	ns
t3	20	50	–	ns
t4	70	250	–	ns
t5, t6	0	25	–	ns
t7	30	50	–	ns
t8, t9	0	25	–	ns
t10	30	50	–	ns
t11	5	15	–	ns
t12	5000	10000	–	ns
t13, t14	0	50	–	ns
t15, t16	900	1000	–	ns

ϕ**1, ϕ2 cross points**
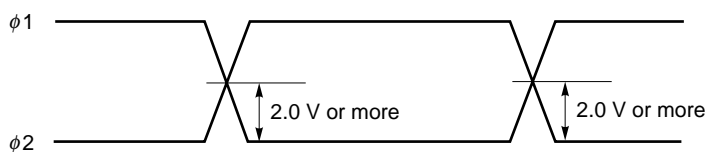
Remark   Adjust cross points of ϕ1 and ϕ2 with input resistance of each pin.

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 (I_X) 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.

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

   Δx : maximum of $|x_j - \overline{x}|$

   $$\overline{x} = \frac{\displaystyle\sum_{j=1}^{10600} x_j}{10600}$$

   x_j : Output voltage of valid pixel number j
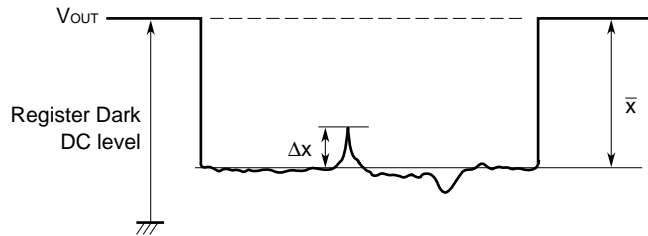
4. Average dark signal: ADS

   Average output signal voltage of all the valid pixels at light shielding. This is calculated by the following formula.

   $$ADS\ (mV) = \frac{\displaystyle\sum_{j=1}^{10600} d_j}{10600}$$

   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 $|d_j - ADS|_{j\ =\ 1\ to\ 10600}$

   d_j : Dark signal of valid pixel number j
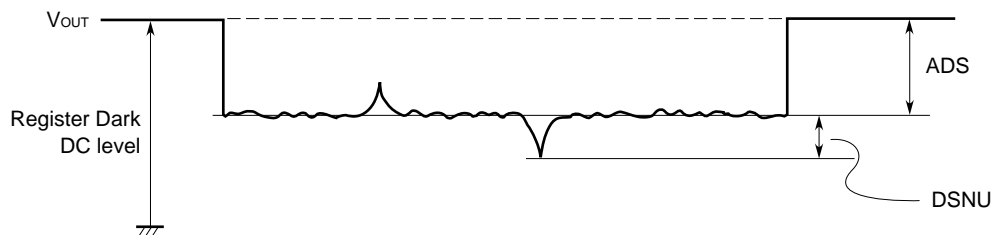
6. Output impedance: Z_O

   Impedance of the output pins viewed from outside.

7. Response: R

   Output voltage divided by exposure (lx•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.

$$IL\ (\%) = \frac{V_1}{V_{OUT}} \times 100$$
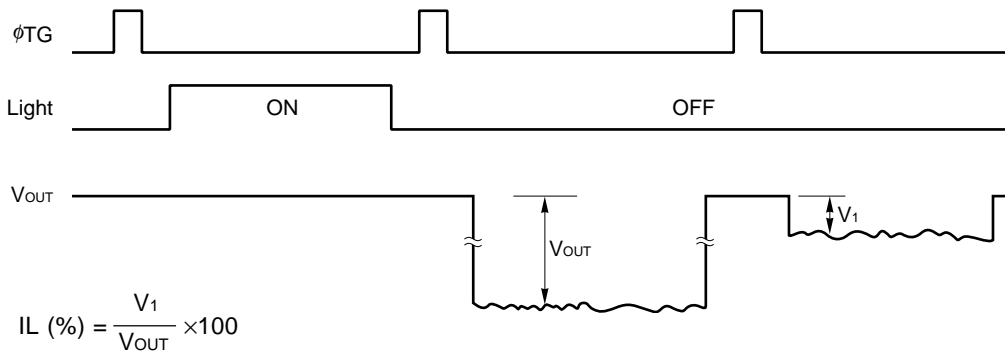
9. Register imbalance: RI

   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.

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

n : Number of valid pixels

V_j : Output voltage of each pixel

10. Random noise (CDS): σCDS

Random noise (CDS) σCDS is defined as the standard deviation of a valid pixel output signal with 100 times (= 100 lines) data sampling at dark (light shielding). This is measured by the following procedure.

1. One valid photocell in one reading is fixed as measurement point.
2. The output level is measured during the Reset feed-through period which is averaged over 100 ns to get "VD_i".
3. The output level is measured during the Video output time averaged over 100 ns to get "VO_i".
4. The correlated double sampling output is defined by "$VCDS_i = VD_i - VO_i$".
5. Repeat the above procedure (1 to 4) for 100 times (= 100 lines).
6. Calculate the standard deviation σCDS using the following formula.

$$\sigma\text{CDS (mV)} = \sqrt{\frac{\displaystyle\sum_{i=1}^{100} (\text{VCDS}_i - \overline{V})^2}{100}} \quad , \quad \overline{V} = \frac{1}{100}\sum_{i=1}^{100} \text{VCDS}_i$$
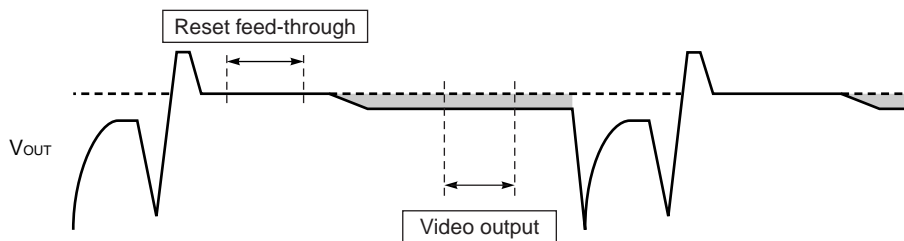
STANDARD CHARACTERISTIC CURVES (Nominal)

**DARK OUTPUT TEMPERATURE
CHARACTERISTIC**

Relative Output Voltage vs Operating Ambient Temperature T$_A$(°C)

**STORAGE TIME OUTPUT VOLTAGE
CHARACTERISTIC (T$_A$ = +25 °C)**

Relative Output Voltage vs Storage Time (ms)
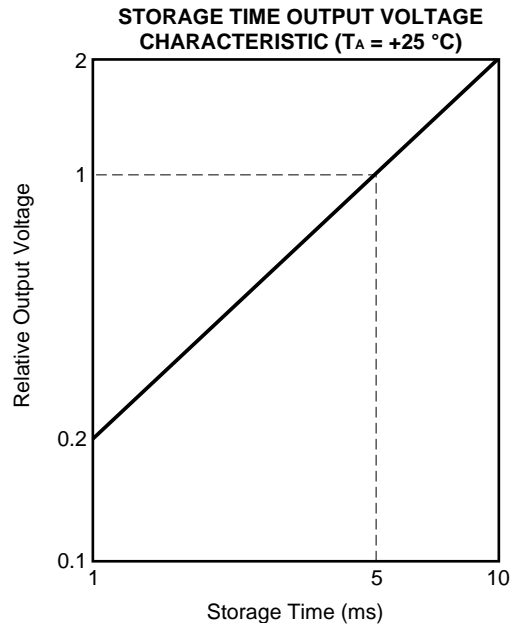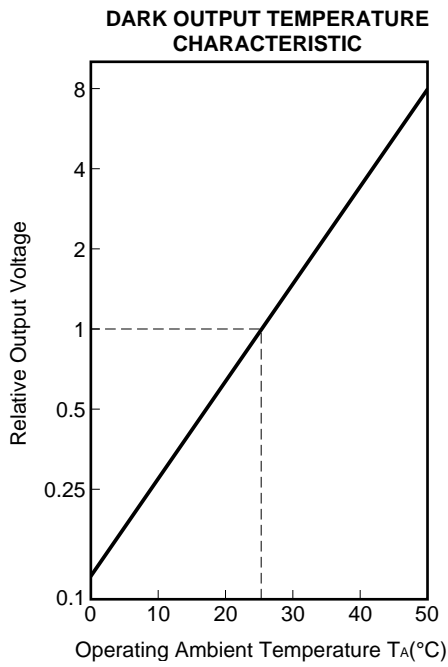
**TOTAL SPECTRAL RESPONSE CHARACTERISTICS
(without infrared cut filter and heat absorbing filter) (T$_A$ = +25 °C)**

Response Ratio (%) vs Wavelength (nm)

APPLICATION CIRCUIT EXAMPLE

μ**PD3778**
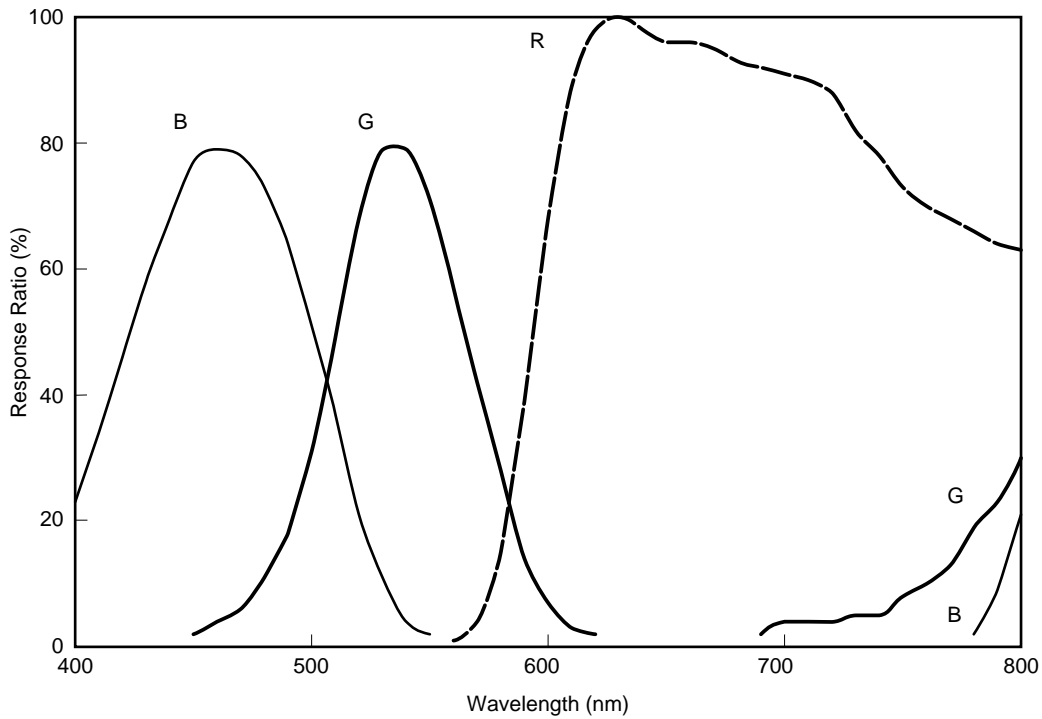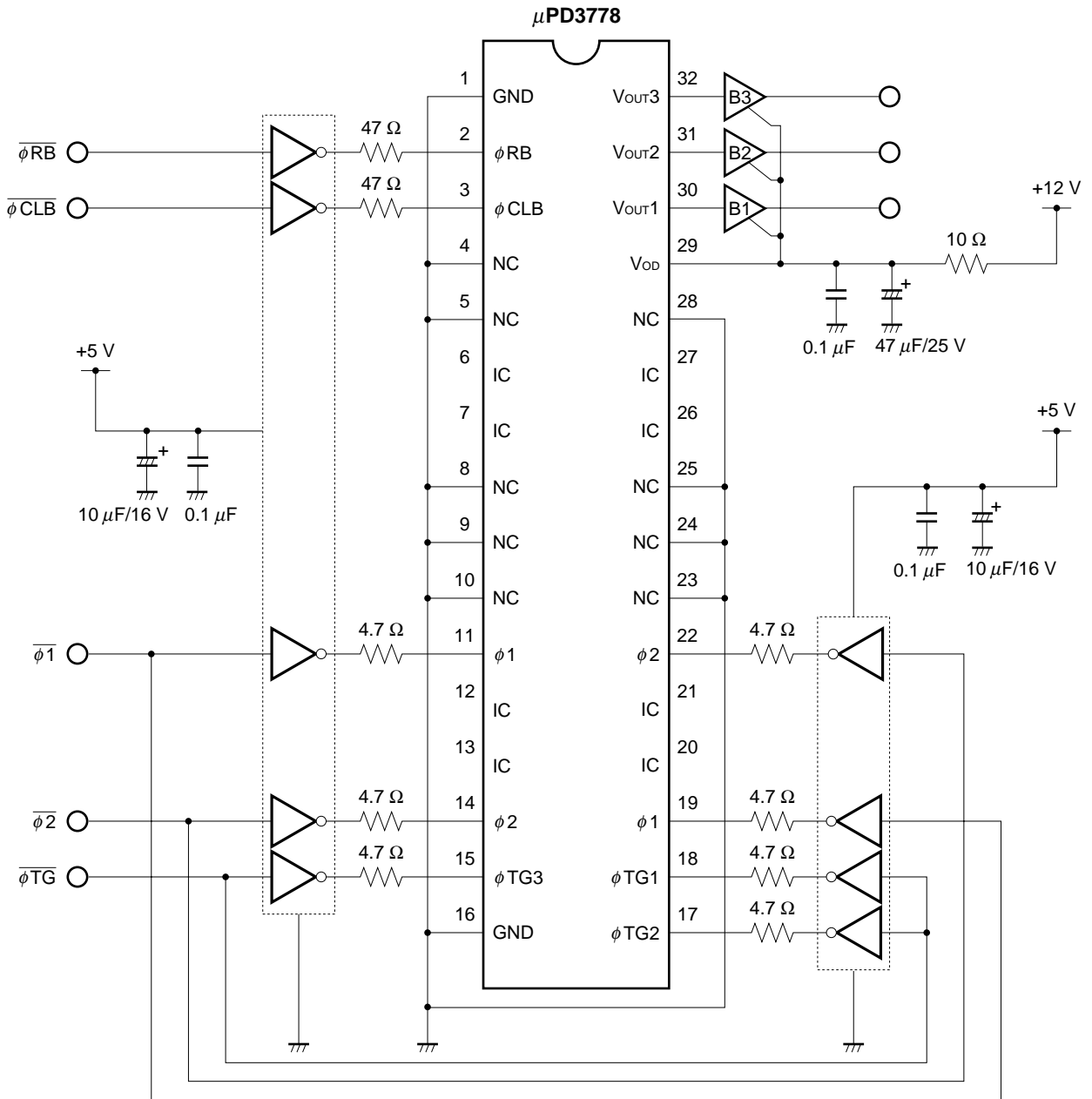
Caution **Leave pins 6, 7, 12, 13, 20, 21, 26, 27 (IC) unconnected.**

Remark The inverters shown in the above application circuit example are the 74HC04 or 74AC04.

B1 to B3 EQUIVALENT CIRCUIT
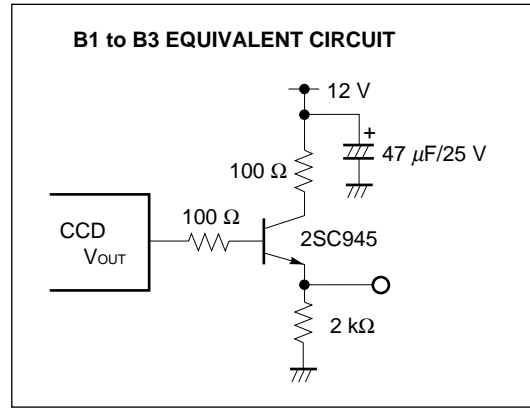
PACKAGE DRAWING

CCD LINEAR IMAGE SENSOR 32-PIN PLASTIC DIP (400 mil)

(Unit : mm)
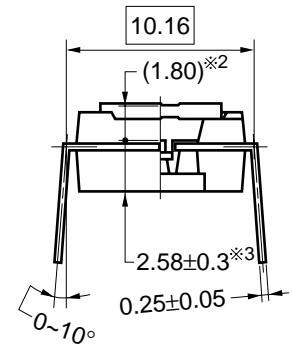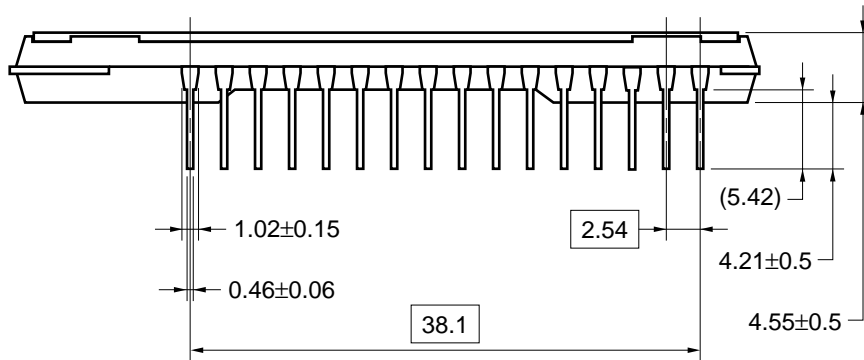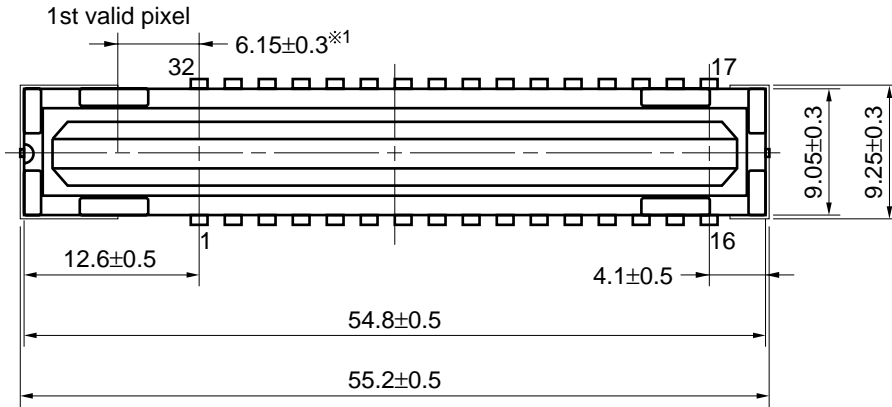
Name	Dimensions	Refractive index
Plastic cap	52.2×6.4×0.7[※4]	1.5

※1 The 1st valid pixel ◄──► The center of the pin1

※2 The surface of the chip ◄──► The top of the cap

※3 The bottom of the package ◄──► The surface of the chip

※4 Thickness of plastic cap over CCD chip

32C-1CCD-PKG3

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.

For more details, refer to our document **"Semiconductor Device Mounting Technology Manual"(C10535E)**.

Type of Through-hole Device

μ**PD3778CY : CCD linear image sensor 32-pin plastic DIP (400 mil)**

Process	Conditions
Partial heating method	Pin temperature: 300 °C or below, Heat time: 3 seconds or less (per pin)

Caution   During assembly care should be taken to prevent solder or flux from contacting the plastic cap. The optical characteristics could be degraded by such contact.

NOTES ON CLEANING THE PLASTIC CAP

① CLEANING THE PLASTIC CAP

Care should be taken when cleaning the surface to prevent scratches.
The optical characteristics of the CCD will be degraded if the cap is scratched during cleaning.

We recommend cleaning the cap with a soft cloth moistened with one of the recommended solvents below. Excessive pressure should not be applied to the cap during cleaning. If the cap requires multiple cleanings it is recommended that a clean surface or cloth be used.

② RECOMMENDED SOLVENTS

The following are the recommended solvents for cleaning the CCD plastic cap. Use of solvents other than these could result in optical or physical degradation in the plastic cap. Please consult your sales office when considering an alternative solvent.

Solvents	Symbol
Ethyl Alcohol	EtOH
Methyl Alcohol	MeOH
Isopropyl Alcohol	IPA
N-methyl Pyrrolidone	NMP

─── **NOTES FOR CMOS DEVICES** ───

① **PRECAUTION AGAINST ESD FOR SEMICONDUCTORS**

Note:

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 once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build 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 bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② **HANDLING OF UNUSED INPUT PINS FOR CMOS**

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_DD or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ **STATUS BEFORE INITIALIZATION OF MOS DEVICES**

Note:

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

[MEMO]

[MEMO]

[MEMO]

[MEMO]