

# TLP2310

## 1. Applications

- Programmable Logic Controllers (PLCs)
- Battery Management System (BMS)
- Industrial Inverters

## 2. General

The TLP2310 is a 5-Mbps low-power photocoupler in the small SO6 package.

The TLP2310 consumes supply current ( $I_{DDL}/I_{DDH}$ ) of only 0.3 mA maximum over the entire operating temperature range of -40 °C to 125 °C and operates at a supply voltage as low as 2.7 V, contributing to a reduction in power consumption of various systems.

The input forward current can be less than 1 mA maximum, allowing direct drive by a microcontroller.

The detector has a totem-pole output stage with current sourcing and sinking capabilities. The TLP2310 has an internal Faraday shield that provides a guaranteed common-mode transient immunity of  $\pm 25$  kV/ $\mu$ s.

## 3. Features

- (1) Package: SO6
- (2) Data transfer rate: 5 MBd (typ.) (NRZ)
- (3) Supply current: 0.3 mA (max)
- (4) Threshold input current: 1.0 mA (max)
- (5) Supply voltage: 2.7 to 5.5 V
- (6) Operating temperature: -40 to 125 °C
- (7) Propagation delay time: 250 ns (max)
- (8) Pulse width distortion: 30 ns (max)
- (9) Isolation voltage: 3750 Vrms (min)
- (10) Safety standards

UL-approved: UL1577, File No.E67349

cUL-approved: CSA Component Acceptance Service No.5A File No.E67349

VDE-approved: EN60747-5-5, EN60065 or EN60950-1 (**Note 1**)

CQC-approved: GB4943.1, GB8898 Thailand Factory



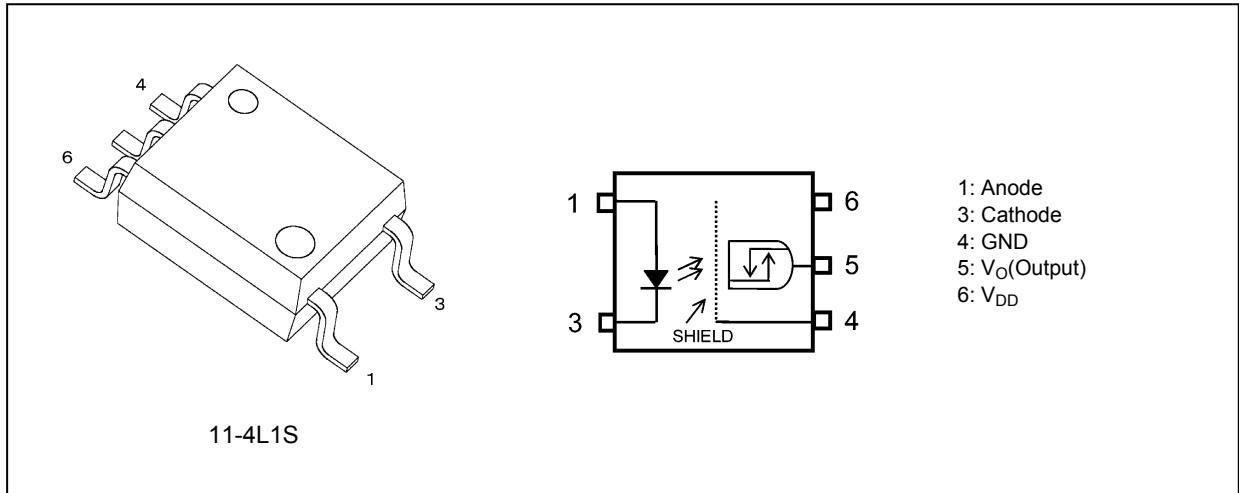
仅适用于海拔 2000m 以下地区安全使用

Note 1: When a VDE approved type is needed, please designate the **Option (V4)**.

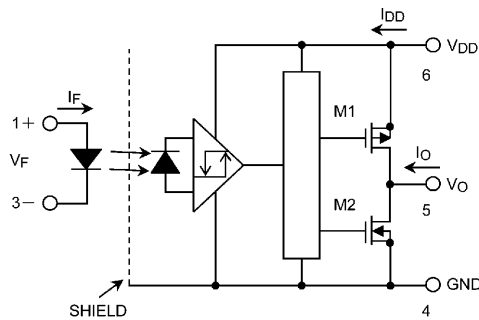
Start of commercial production

2015-04

**4. Packaging and Pin Assignment**



**5. Internal Circuit (Note)**



Note: A 0.1- $\mu$ F bypass capacitor must be connected between pin 6 and pin 4.

**6. Principle of Operation**

**6.1. Truth Table**

Input	LED	Output
H	ON	H
L	OFF	L

**6.2. Mechanical Parameters**

Characteristics	Dimension(Min)	Unit
Creepage distances	5.0	mm
Clearance distances	5.0	
Internal isolation thickness	0.4	

**7. Absolute Maximum Ratings (Note)**  
(Unless otherwise specified,  $T_a = 25\text{ }^\circ\text{C}$ )

	Characteristics	Symbol	Note	Rating	Unit
LED	Input forward current	$I_F$		8	mA
	Input forward current (pulsed)	$I_{FP}$		40	mA
	Input forward current derating (pulsed) ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta I_{FP}/\Delta T_a$		-1	mA/ $^\circ\text{C}$
	Peak transient input forward current	$I_{FPT}$	(Note 1)	1	A
	Peak transient input forward current derating ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta I_{FPT}/\Delta T_a$		-25	mA/ $^\circ\text{C}$
	Input power dissipation	$P_D$		20	mW
	Input power dissipation derating ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta P_D/\Delta T_a$		-0.5	mW/ $^\circ\text{C}$
	Input reverse voltage	$V_R$		5	V
Detector	Output current	$I_O$		10	mA
	Output voltage	$V_O$		6	V
	Supply voltage	$V_{DD}$		6	V
	Output power dissipation	$P_O$		20	mW
	Output power dissipation derating ( $T_a \geq 110\text{ }^\circ\text{C}$ )	$\Delta P_O/\Delta T_a$		-0.5	mW/ $^\circ\text{C}$
Common	Operating temperature	$T_{opr}$		-40 to 125	$^\circ\text{C}$
	Storage temperature	$T_{stg}$		-55 to 125	$^\circ\text{C}$
	Lead soldering temperature (10 s)	$T_{sol}$		260	$^\circ\text{C}$
	Isolation voltage (AC, 60 s, R.H. $\leq 60\%$ )	$BV_S$	(Note 2)	3750	Vrms

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc.).

Note 1: Pulse width (PW)  $\leq 1\text{ }\mu\text{s}$ , 300 pps

Note 2: This device is considered as a two-terminal device: Pins 1 and 3 are shorted together, and pins 4, 5 and 6 are shorted together.

**8. Recommended Operating Conditions (Note)**

Characteristics	Symbol	Note	Min	Typ.	Max	Unit
Input on-state current	$I_{F(ON)}$	(Note 1)	2	—	6	mA
Input off-state voltage	$V_{F(OFF)}$	(Note 1)	0	—	0.8	V
Supply voltage	$V_{DD}$	(Note 2)	2.7	3.3 / 5	5.5	V
Operating temperature	$T_{opr}$	(Note 2)	-40	—	125	$^\circ\text{C}$

Note: The recommended operating conditions are given as a design guide necessary to obtain the intended performance of the device. Each parameter is an independent value. When creating a system design using this device, the electrical characteristics specified in this datasheet should also be considered.

Note: A ceramic capacitor (0.1  $\mu\text{F}$ ) should be connected between pin 6 and pin 4 to stabilize the operation of a high-gain linear amplifier. Otherwise, this photocoupler may not switch properly. The bypass capacitor should be placed within 1 cm of each pin.

Note 1: The rise and fall times of the input on-current should be less than 0.5  $\mu\text{s}$ .

Note 2: Denotes the operating range, not the recommended operating condition.

**9. Electrical Characteristics (Note)**  
 (Unless otherwise specified,  $T_a = -40$  to  $125$  °C,  $V_{DD} = 2.7$  to  $5.5$  V)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input forward voltage	$V_F$		$I_F = 2$ mA	1.2	—	1.9	V
			$I_F = 2$ mA, $T_a = 25$ °C	1.4	1.53	1.7	
Input forward voltage temperature coefficient	$\Delta V_F/\Delta T_a$		$I_F = 2$ mA	—	-1.58	—	mV/°C
Input reverse current	$I_R$		$V_R = 5$ V, $T_a = 25$ °C	—	—	10	μA
Input capacitance	$C_t$		$V = 0$ V, $f = 1$ MHz, $T_a = 25$ °C	—	20	—	pF
Low-level output voltage	$V_{OL}$	Fig. 12.1.1	$I_O = 20$ μA, $V_F = 0.8$ V	—	—	0.1	V
			$I_O = 3.2$ mA, $V_F = 0.8$ V	—	—	0.4	
High-level output voltage	$V_{OH}$	Fig. 12.1.2	$I_O = -20$ μA, $I_F = 2$ mA	$V_{DD} - 0.1$	$V_{DD} - 0.01$	—	
			$I_O = -3.2$ mA, $I_F = 2$ mA	$V_{DD} - 1.0$	$V_{DD} - 0.25$	—	
Low-level supply current	$I_{DDL}$	Fig. 12.1.3	$I_F = 0$ mA	—	—	0.3	mA
High-level supply current	$I_{DDH}$	Fig. 12.1.4	$I_F = 2$ mA	—	—	0.3	
Threshold input current (L/H)	$I_{FLH}$		$I_O = -3.2$ mA, $V_O > V_{DD} - 1$ V	—	—	1.0	

Note: All typical values are at  $V_{DD} = 5$  V,  $T_a = 25$  °C, unless otherwise noted.

**10. Isolation Characteristics**  
 (Unless otherwise specified,  $T_a = 25$  °C)

Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
Total capacitance (input to output)	$C_S$	(Note 1)	$V_S = 0$ V, $f = 1$ MHz	—	0.8	—	pF
Isolation resistance	$R_S$	(Note 1)	$V_S = 500$ V, R.H. ≤ 60 %	$1 \times 10^{12}$	$10^{14}$	—	Ω
Isolation voltage	$BV_S$	(Note 1)	AC, 60 s	3750	—	—	Vrms
			AC, 1s, in oil	—	10000	—	
			DC, 60 s, in oil	—	10000	—	Vdc

Note 1: This device is considered as a two-terminal device: Pins 1 and 3 are shorted together, and pins 4, 5 and 6 are shorted together.

**11. Switching Characteristics (Note)**  
 (Unless otherwise specified,  $T_a = -40$  to  $125$  °C,  $V_{DD} = 2.7$  to  $5.5$  V)

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Propagation delay time (L/H)	$t_{pLH}$	(Note 1)	Fig. 12.1.5	$V_{IN} = 3.3$ V, $R_T = 820$ $\Omega$	80	—	250	ns
Propagation delay time (H/L)	$t_{pHL}$				60	—	250	
Pulse width distortion	$ t_{pHL} - t_{pLH} $				—	—	50	
Propagation delay skew (device to device)	$t_{psk}$	(Note 1), (Note 2)			-65	—	65	
Propagation delay time (L/H)	$t_{pLH}$	(Note 1)		$V_{IN} = 5$ V, $R_T = 1.6$ k $\Omega$	80	—	250	
Propagation delay time (H/L)	$t_{pHL}$				60	—	250	
Pulse width distortion	$ t_{pHL} - t_{pLH} $				—	—	50	
Propagation delay skew (device to device)	$t_{psk}$	(Note 1), (Note 2)			-65	—	65	
Propagation delay time (L/H)	$t_{pLH}$	(Note 1)	Fig. 12.1.6	$I_F = 2$ mA, $R = 100$ $\Omega$	80	—	250	
Propagation delay time (H/L)	$t_{pHL}$				60	—	250	
Pulse width distortion	$ t_{pHL} - t_{pLH} $				—	—	30	
Propagation delay skew (device to device)	$t_{psk}$	(Note 1), (Note 2)			-65	—	65	
Rise time	$t_r$	(Note 1)	Fig. 12.1.5	$V_{IN} = 0 \rightarrow 3.3$ V, $R_T = 820$ $\Omega$ , $V_{DD} = 5$ V	—	11	—	
Fall time	$t_f$			$V_{IN} = 3.3 \rightarrow 0$ V, $R_T = 820$ $\Omega$ , $V_{DD} = 5$ V	—	13	—	
Common-mode transient immunity at output high	$CM_H$		Fig. 12.1.7	$V_{IN} = 3.3$ V / $5$ V, $V_{DD} = 3.3$ V / $5$ V, $V_{CM} = 1000$ V <sub>p-p</sub> , $T_a = 25$ °C	$\pm 25$	$\pm 40$	—	kV/ $\mu$ s
Common-mode transient immunity at output low	$CM_L$							

Note: All typical values are at  $V_{DD} = 5$  V,  $T_a = 25$  °C, unless otherwise noted.

Note: Recommendation input resistance conditions

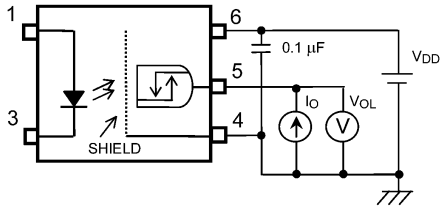
- $V_{IN} = 3.3$  V :  $R_1 = R_2 = 430$   $\Omega$
- $V_{IN} = 5$  V :  $R_1 = R_2 = 820$   $\Omega$

Note 1:  $f = 250$  kHz, duty = 50 %, input current  $t_r = t_f = 5$  ns,  $C_L$  is approximately 15 pF which includes probe and stray wiring capacitance.

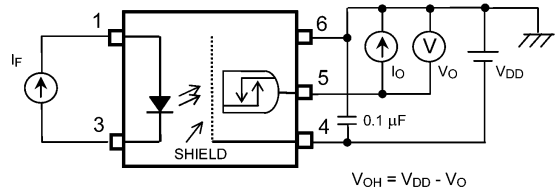
Note 2: The propagation delay skew,  $t_{psk}$ , is equal to the magnitude of the worst-case difference in  $t_{pHL}$  and/or  $t_{pLH}$  that will be seen between units at the same given conditions (supply voltage, input current, temperature, etc).

**12. Test Circuits**

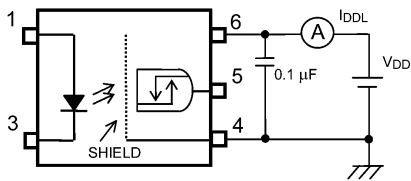
**12.1. Test Circuits**



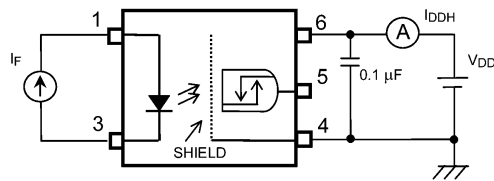
**Fig. 12.1.1  $V_{OL}$  Test Circuit**



**Fig. 12.1.2  $V_{OH}$  Test Circuit**

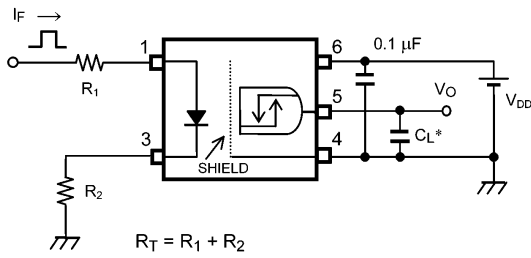


**Fig. 12.1.3  $I_{DDL}$  Test Circuit**



**Fig. 12.1.4  $I_{DDH}$  Test Circuit**

$V_{IN} = 3.3\text{ V} / 5\text{ V (P.G.)}$   
 $(f = 250\text{ kHz, duty} = 50\%, \text{less than } t_r = t_f = 5\text{ ns})$



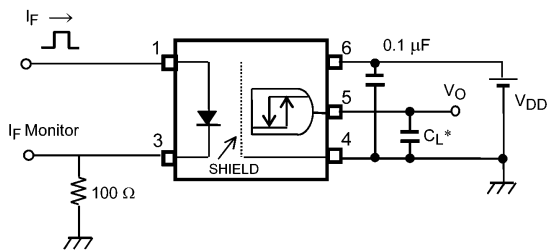
$R_T = R_1 + R_2$

P.G. : Pulse generator

\* $C_L$  is approximately 15 pF which includes probe and stray wiring capacitance.

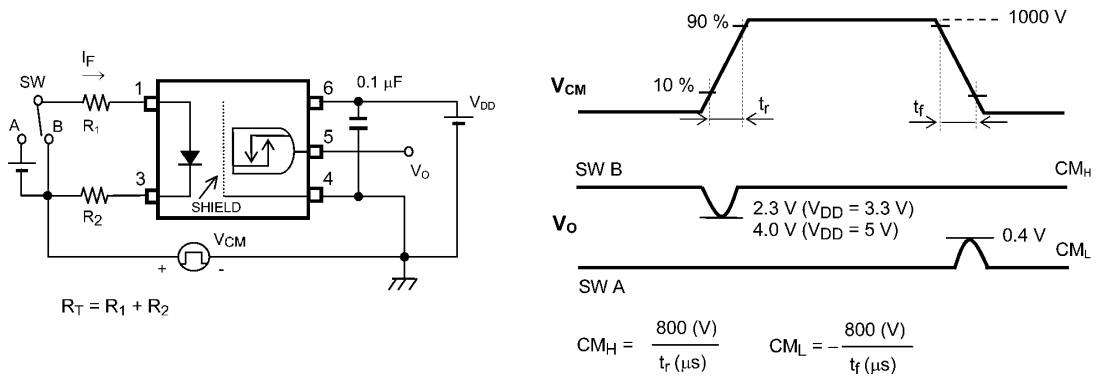
**Fig. 12.1.5 Switching Time Test Circuit and Waveform**

$I_F = 2\text{ mA}$   
 $(f = 250\text{ kHz, duty} = 50\%, \text{less than } t_r = t_f = 5\text{ ns})$



\* $C_L$  is approximately 15 pF which includes probe and stray wiring capacitance.

**Fig. 12.1.6 Switching Time Test Circuit and Waveform**



**Fig. 12.1.7 Common-Mode Transient Immunity and Waveform**

12.2. Characteristics Curves (Note)

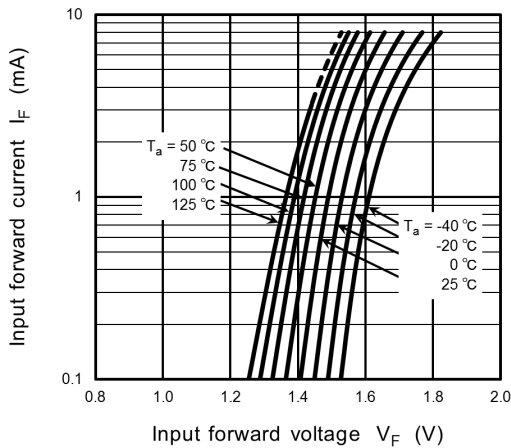


Fig. 12.2.1  $I_F - V_F$

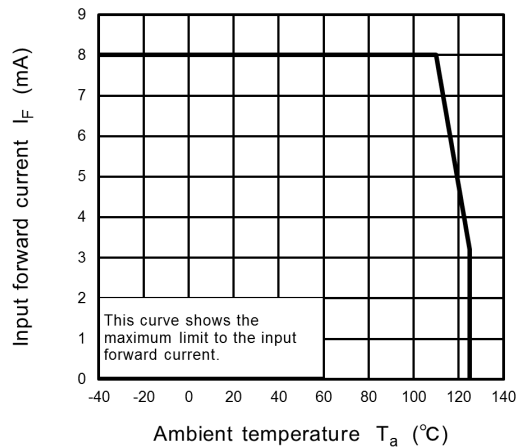


Fig. 12.2.2  $I_F - T_a$

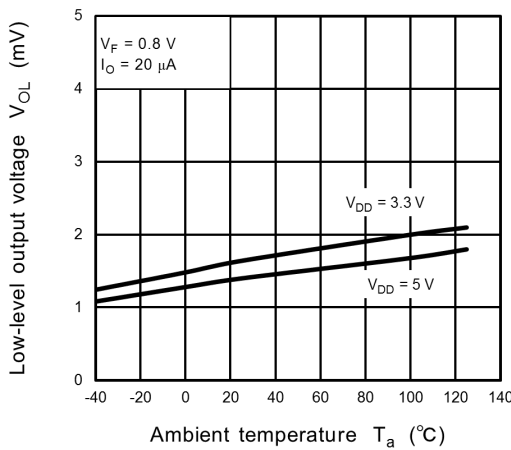


Fig. 12.2.3  $V_{OL} - T_a$

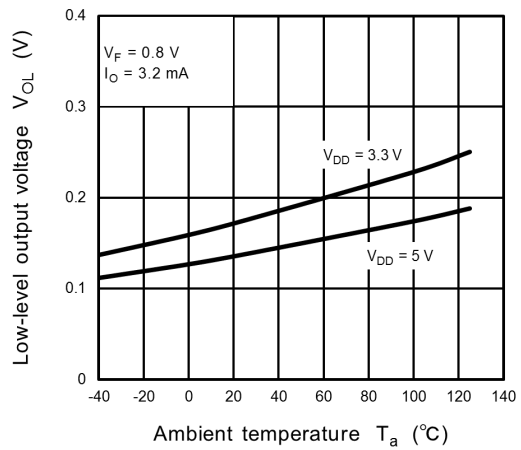


Fig. 12.2.4  $V_{OL} - T_a$

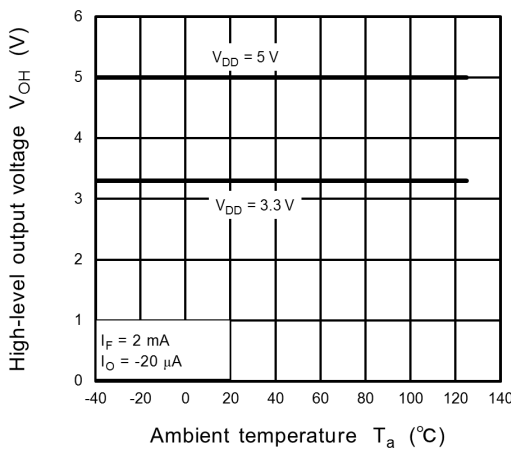


Fig. 12.2.5  $V_{OH} - T_a$

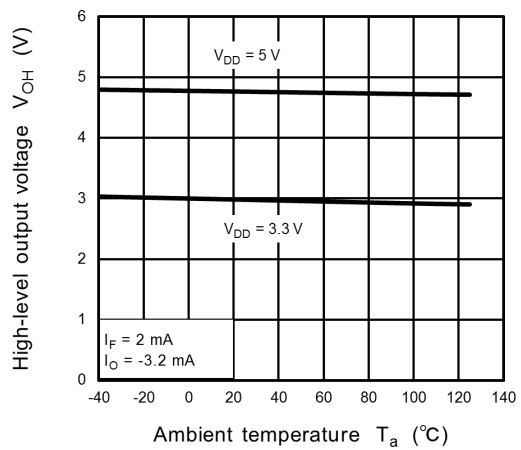


Fig. 12.2.6  $V_{OH} - T_a$



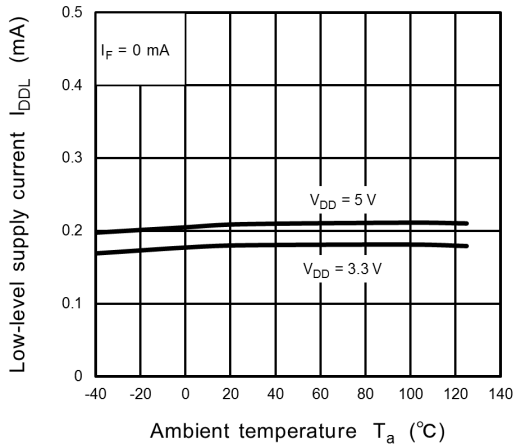


Fig. 12.2.7  $I_{CCL} - T_a$

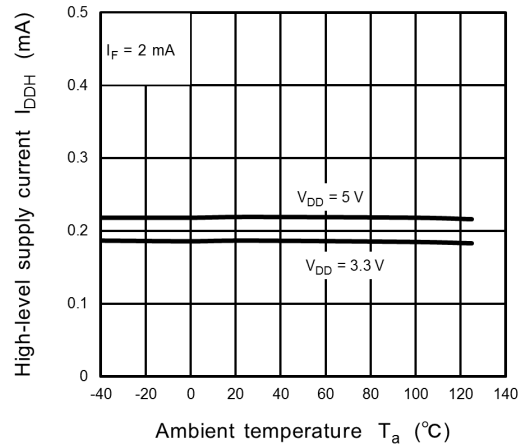


Fig. 12.2.8  $I_{CCH} - T_a$

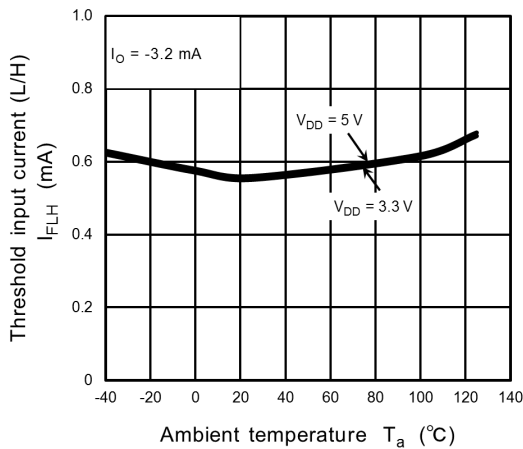


Fig. 12.2.9  $I_{FLH} - T_a$

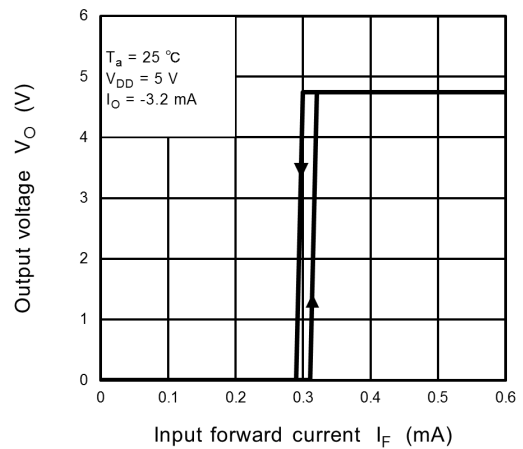


Fig. 12.2.10  $I_F - V_O$

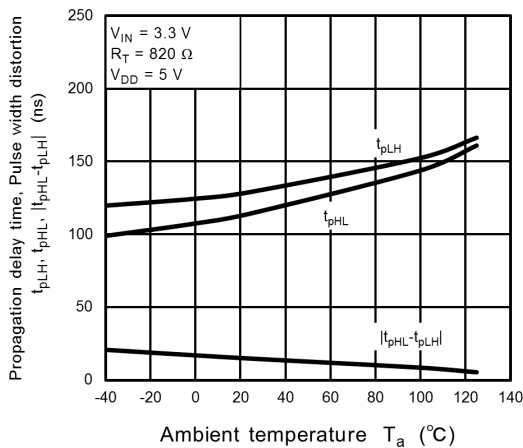


Fig. 12.2.11  $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - T_a$

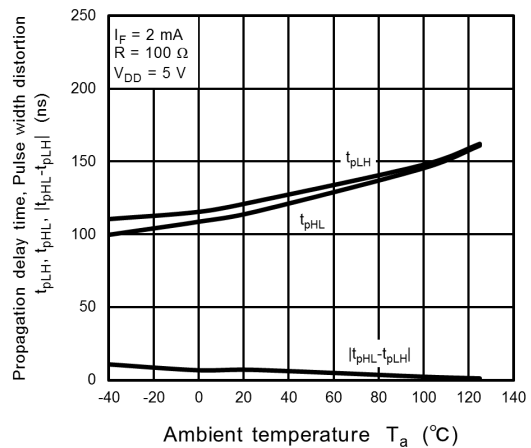
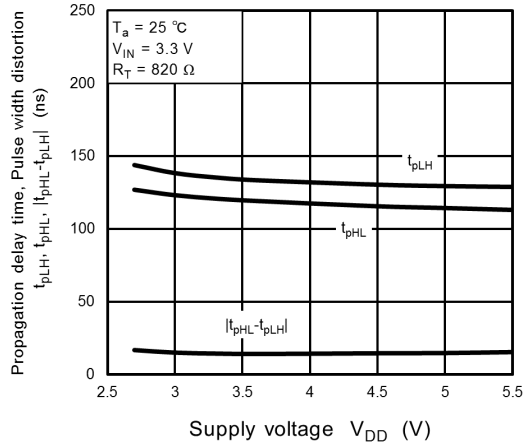
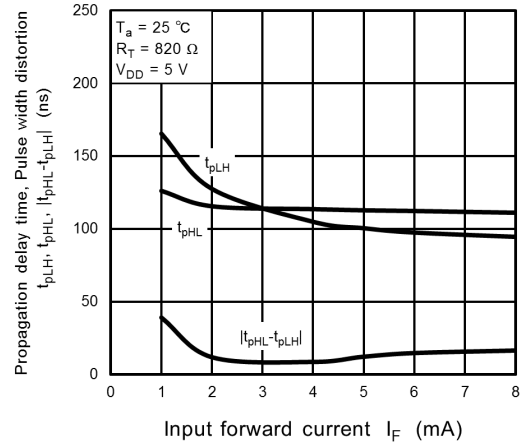


Fig. 12.2.12  $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - T_a$



**Fig. 12.2.13**  $t_{pHL}$ ,  $t_{pLH}$ ,  $|t_{pHL} - t_{pLH}| - V_{DD}$



**Fig. 12.2.14**  $t_{pHL}$ ,  $t_{pLH}$ ,  $|t_{pHL} - t_{pLH}| - I_F$

Note: The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

**13. Soldering and Storage**

**13.1. Precautions for Soldering**

The soldering temperature should be controlled as closely as possible to the conditions shown below, irrespective of whether a soldering iron or a reflow soldering method is used.

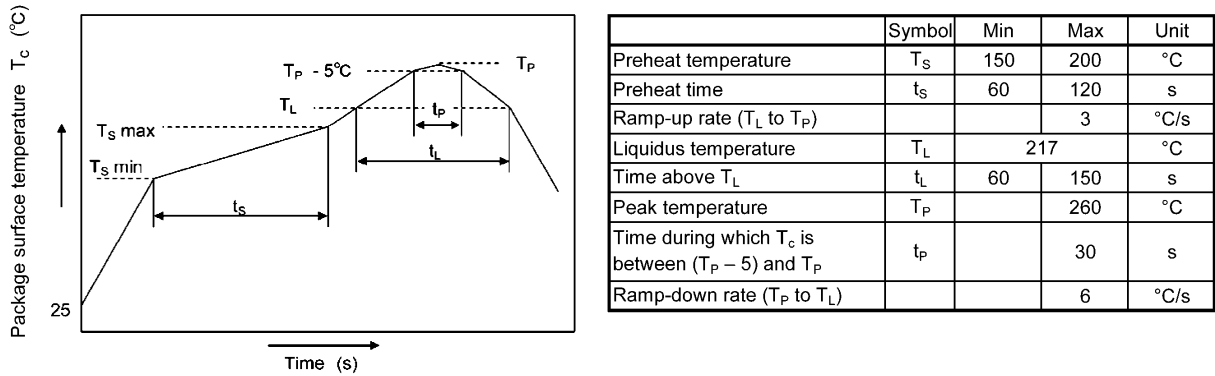
- When using soldering reflow.

The soldering temperature profile is based on the package surface temperature.

(See the figure shown below, which is based on the package surface temperature.)

Reflow soldering must be performed once or twice.

The mounting should be completed with the interval from the first to the last mountings being 2 weeks.



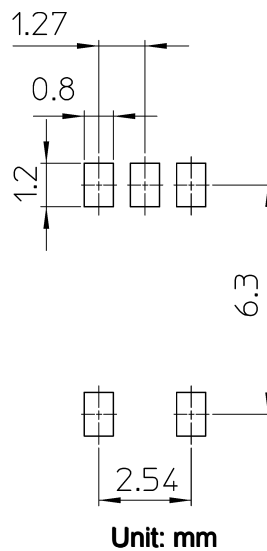
**Fig. 13.1.1 An Example of a Temperature Profile When Lead(Pb)-free Solder Is Used**

- When using soldering flow  
Preheat the device at a temperature of 150 °C (package surface temperature) for 60 to 120 seconds.  
Mounting condition of 260 °C within 10 seconds is recommended.  
Flow soldering must be performed once.
- When using soldering Iron  
Complete soldering within 10 seconds for lead temperature not exceeding 260 °C or within 3 seconds not exceeding 350 °C  
Heating by soldering iron must be done only once per lead.

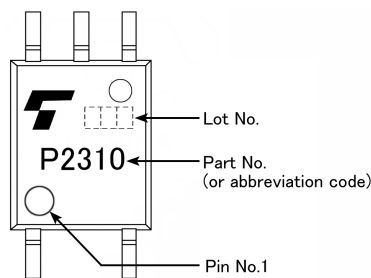
**13.2. Precautions for General Storage**

- Avoid storage locations where devices may be exposed to moisture or direct sunlight.
- Follow the precautions printed on the packing label of the device for transportation and storage.
- Keep the storage location temperature and humidity within a range of 5 °C to 35 °C and 45 % to 75 %, respectively.
- Do not store the products in locations with poisonous gases (especially corrosive gases) or in dusty conditions.
- Store the products in locations with minimal temperature fluctuations. Rapid temperature changes during storage can cause condensation, resulting in lead oxidation or corrosion, which will deteriorate the solderability of the leads.
- When restoring devices after removal from their packing, use anti-static containers.
- Do not allow loads to be applied directly to devices while they are in storage.
- If devices have been stored for more than two years under normal storage conditions, it is recommended that you check the leads for ease of soldering prior to use.

**14. Land Pattern Dimensions (for reference only)**



**15. Marking**



**16. EN60747-5-5 Option (V4) Specification**

- Part number: TLP2310 (**Note 1**)
- The following part naming conventions are used for the devices that have been qualified according to option (V4) of EN60747.  
 Example: TLP2310(V4-TPL,E(T)  
 V4: EN60747 option  
 TPL: Tape type  
 E: [[G]]/RoHS COMPATIBLE (**Note 2**)  
 T: Domestic ID (Country / Region of origin: Thailand)

Note 1: Use TOSHIBA standard type number for safety standard application.  
 e.g., TLP2310(V4-TPL,E(T → TLP2310

Note 2: Please contact your Toshiba sales representative for details on environmental information such as the product's RoHS compatibility.  
 RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronics equipment.

Description	Symbol	Rating	Unit
Application classification  for rated mains voltage ≤150 Vrms for rated mains voltage ≤300 Vrms		I-IV I-III	—
Climatic classification		40 / 125 / 21	—
Pollution degree		2	—
Maximum operating insulation voltage	V <sub>IORM</sub>	707	V <sub>peak</sub>
Input to output test voltage, Method A V <sub>pr</sub> = 1.6 × V <sub>IORM</sub> , type and sample test t <sub>p</sub> = 10 s, partial discharge < 5 pC	V <sub>pr</sub>	1131	V <sub>peak</sub>
Input to output test voltage, Method B V <sub>pr</sub> = 1.875 × V <sub>IORM</sub> , 100 % production test t <sub>p</sub> = 1 s, partial discharge < 5 pC	V <sub>pr</sub>	1325	V <sub>peak</sub>
Highest permissible overvoltage (transient overvoltage, t <sub>pr</sub> = 60 s)	V <sub>TR</sub>	6000	V <sub>peak</sub>
Safety limiting values (max. permissible ratings in case of fault, also refer to thermal derating curve)  current (input current I <sub>F</sub> , P <sub>SO</sub> = 0) power (output or total power dissipation) temperature	I <sub>si</sub> P <sub>so</sub> T <sub>s</sub>	250 400 150	mA mW °C
Insulation resistance V <sub>IO</sub> = 500 V, T <sub>a</sub> = 25 °C V <sub>IO</sub> = 500 V, T <sub>a</sub> = 100 °C V <sub>IO</sub> = 500 V, T <sub>a</sub> = T <sub>s</sub>	R <sub>si</sub>	≥ 10 <sup>12</sup> ≥ 10 <sup>11</sup> ≥ 10 <sup>9</sup>	Ω

**Fig. 16.1 EN60747 Isolation Characteristics**

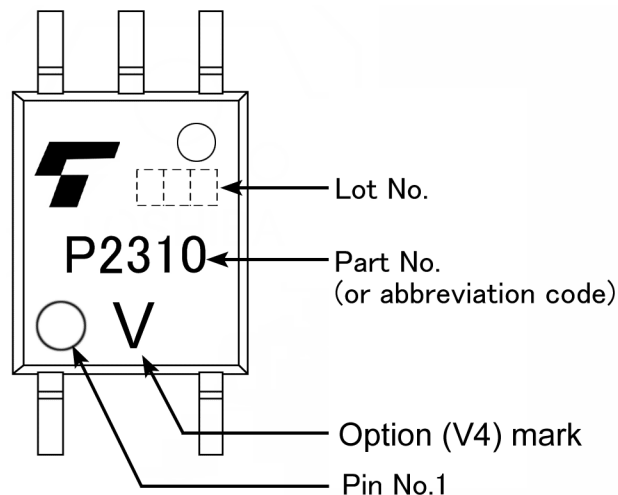
Minimum creepage distance	Cr	5.0 mm
Minimum clearance	Cl	5.0 mm
Minimum insulation thickness	ti	0.4 mm
Comparative tracking index	CTI	175

**Fig. 16.2 Insulation Related Specifications (Note)**

Note: This photocoupler is suitable for **safe electrical isolation** only within the safety limit data. Maintenance of the safety data shall be ensured by means of protective circuits.

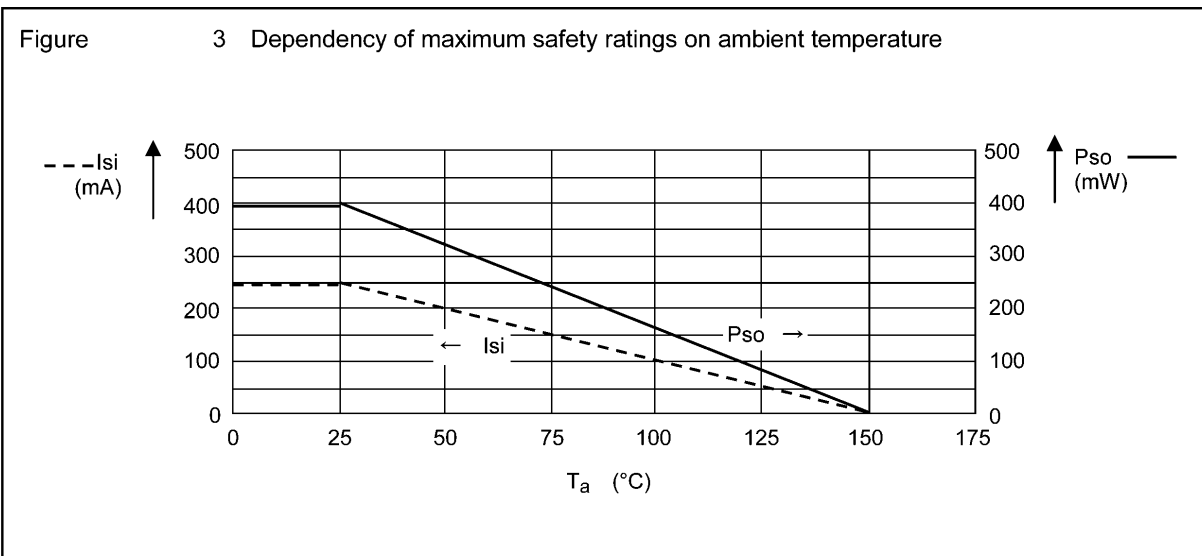
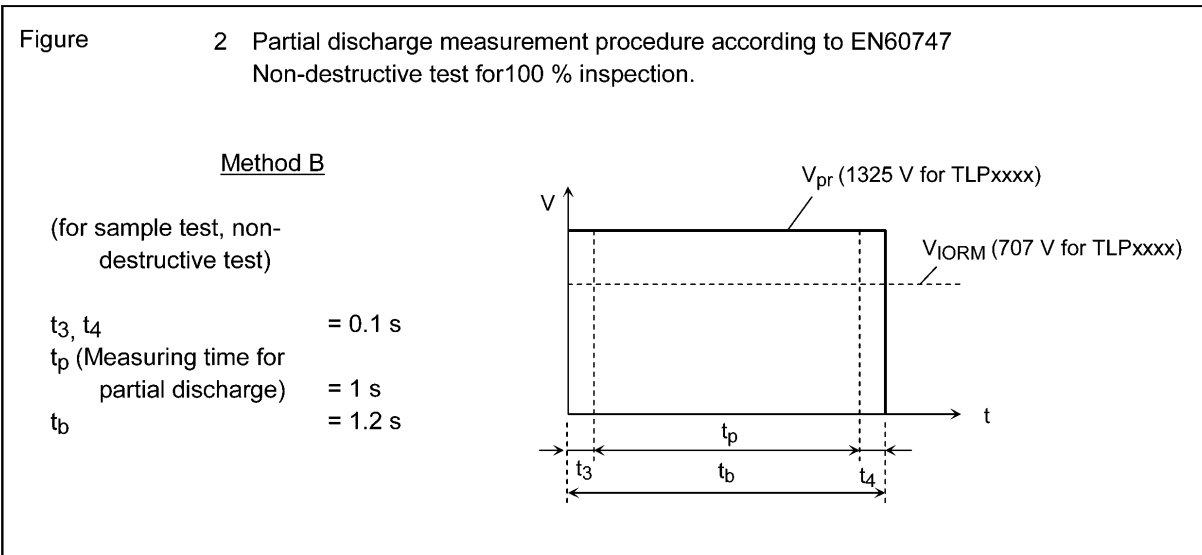
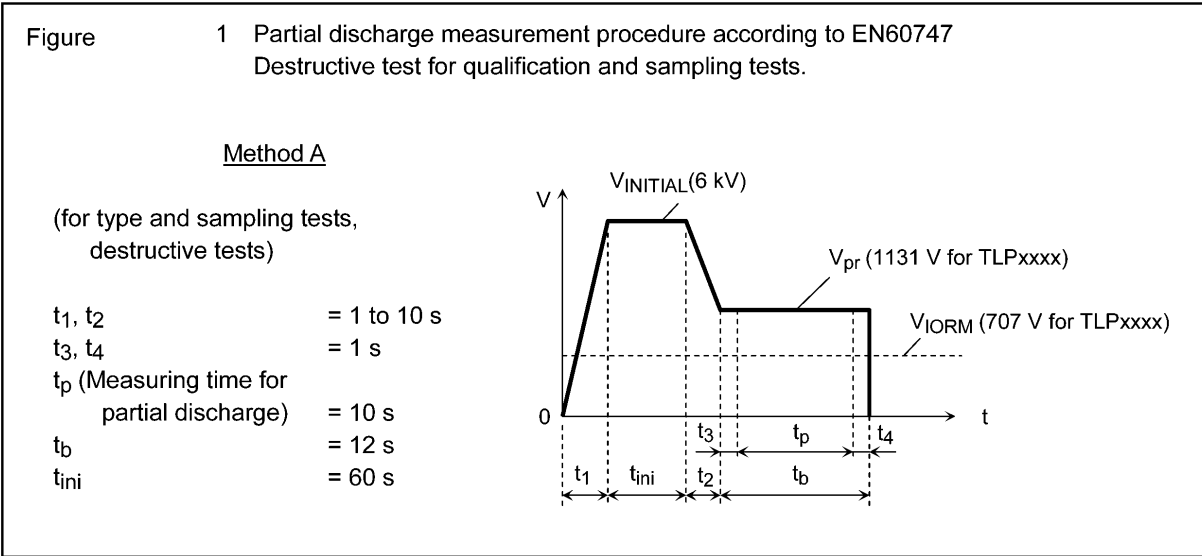


**Fig. 16.3 Marking on Packing**



**Fig. 16.4 Marking Example (Note)**

Note: The above marking is applied to the photocouplers that have been qualified according to option (V4) of EN60747.



**Fig. 16.5 Measurement Procedure**

**17. Specifications for Embossed-Tape Packing (TPL) (TPR)for SO6 Coupler**

**17.1. Applicable Package**

Package Name	Product Type
SO6	Mini flat coupler

**17.2. Product Naming Conventions**

Type of package used for shipment is denoted by a symbol suffix after a part number. The method of classification is as below.

Example) TLP2310(TPL,E(T

- Part number: TLP2310
- Tape type: TPL
- [[G]]/RoHS COMPATIBLE: E (**Note**)
- T: Domestic ID (Country / Region of origin: Thailand)

**Note:** Please contact your Toshiba sales representative for details on environmental information such as the product's RoHS compatibility.

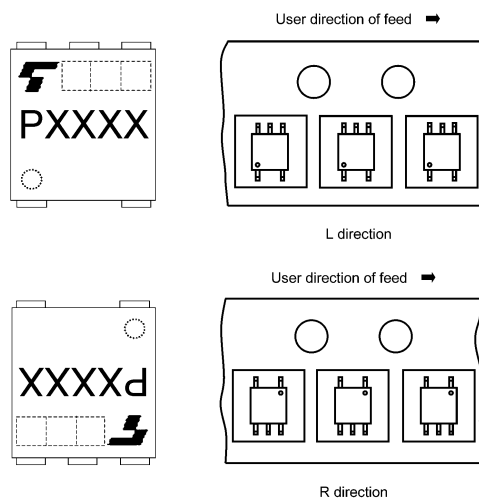
RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronics equipment.

**17.3. Tape Dimensions Specification**

Specification	Division	Packing Amount (A unit per reel)
TPL	L direction	3000
TPR	R direction	3000

**17.3.1. Orientation of Device in Relation to Direction of Feed**

Device orientation in the carrier cavities as shown in the following figure.



**Fig. 17.3.1.1 Orientation of Device in Relation to Direction of Tape Movement**

per reel: 3000 pcs



**17.3.2. Empty Device Recesses**

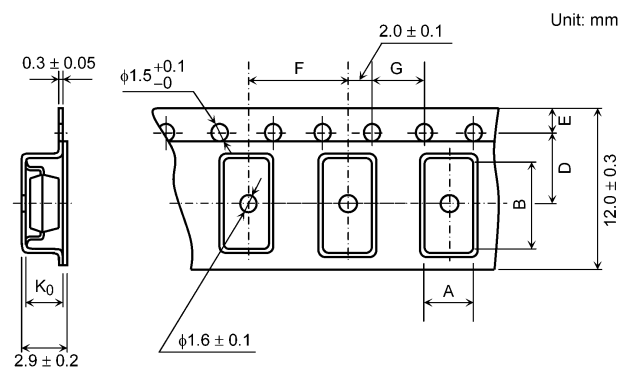
Characteristics	Standard	Remarks
occurrences of 2 more successive empty cavities	0	Within any given 40-mm section of tape, not including leader and trailer
Single empty cavity	6 devices (max) per reel	Not including leader and trailer

**17.3.3. Tape Leader and Trailer**

The start of the tape has 14 or more empty holes. The end of the tape has 34 or more empty holes and more than 30mm only for a cover tape.

**17.3.4. Tape Dimensions**

Tape material: Plastic (for protection against static electricity)

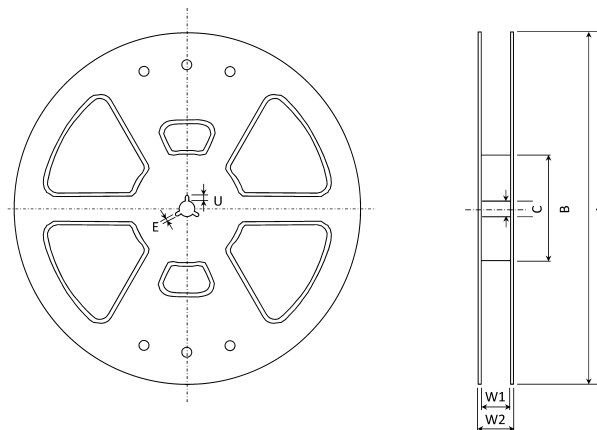


**Table Tape Dimensions (unit: mm, tolerance: ±0.1)**

Symbol	Dimension	Remark
A	4.0	—
B	7.6	—
D	5.5	Center line of embossed cavity and sprocket hole
E	1.75	Distance between tape edge and sprocket hole center
F	8.0	Cumulative error +0.1/-0.3 (max) per 10 empty cavities holes
G	4.0	Cumulative error +0.1/-0.3 (max) per 10 sprocket holes
K <sub>0</sub>	2.6	Internal space

**17.3.5. Reel Specification**

Material: Plastic



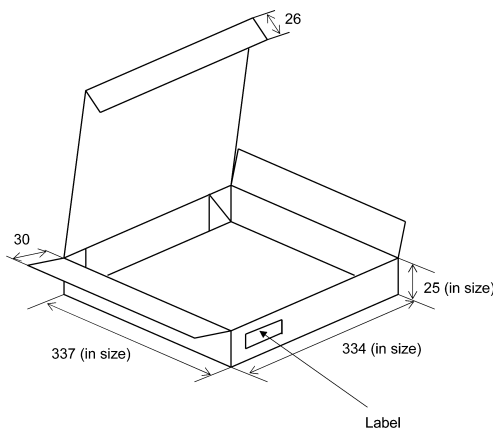
**Reel Forms**

**Table Reel Dimensions (unit: mm)**

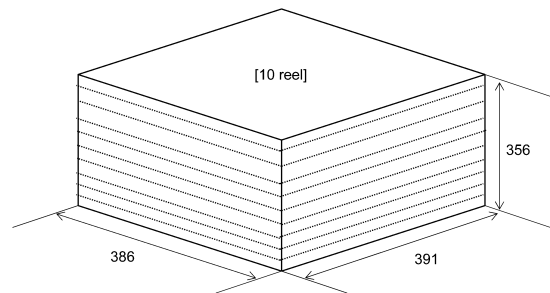
Symbol	Dimension
A	$\phi 330 \pm 2.0$
B	$\phi 100 \pm 1.0$
C	$\phi 13 \pm 0.5$
E	$2.0 \pm 0.5$
U	$4.0 \pm 0.5$
W1	$17.4 \pm 1.0$
W2	$214 \pm 1.0$

**17.4. Packing (Note)**

Either one reel or ten reels of photocouplers are packed in a shipping carton.



**1 reel/carton (unit: mm)**



**10 reel/carton (unit: mm)**

Note: Taping reel diameter:  $\phi 330$  mm

**17.5. Label Format**

The label on each carton provides the part number, quantity, lot number, the Toshiba logo, etc.

**17.6. Ordering Information**

When placing an order, please specify the part number, tape type and quantity as shown in the following example.

Example) TLP2310(TPL,E 3000 pcs

Part number: TLP2310

Tape type: TPL (12-mm pitch)

[[G]]/RoHS COMPATIBLE: E (**Note**)

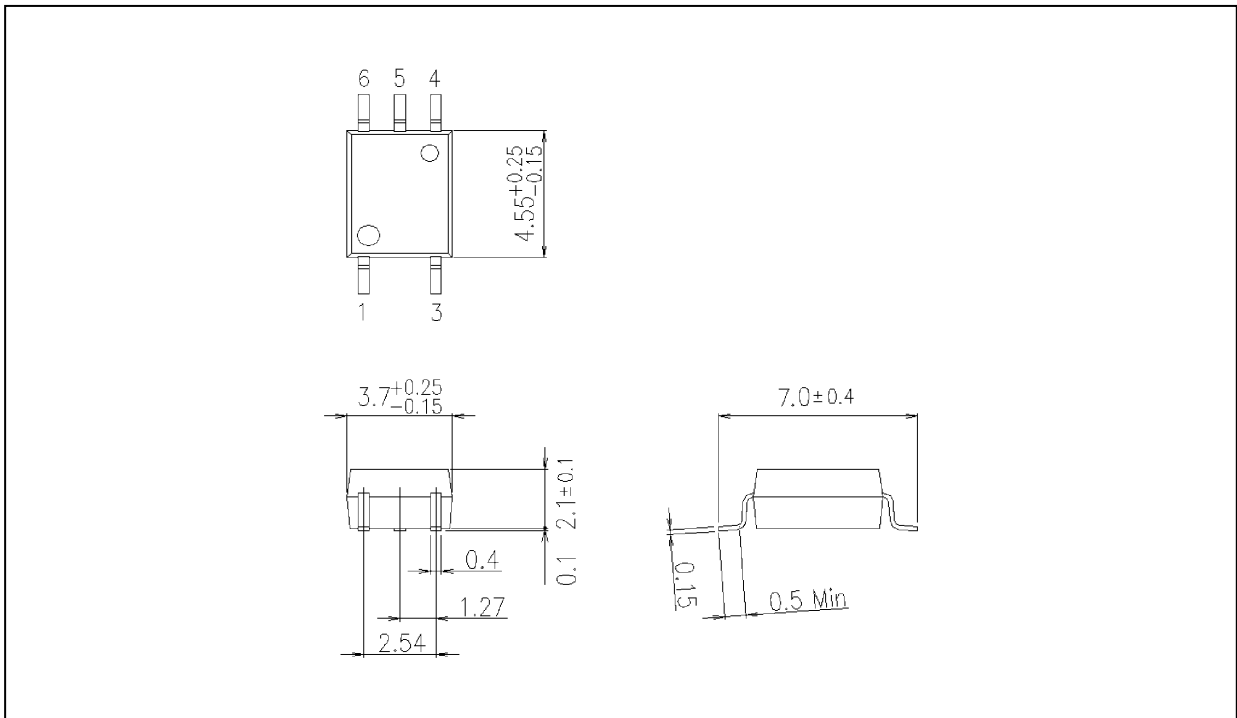
Quantity (must be a multiple of 3000): 3000 pcs

**Note:** Please contact your Toshiba sales representative for details on environmental information such as the product's RoHS compatibility.

RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronics equipment.

**Package Dimensions**

Unit: mm



Weight: 0.08 g (typ.)

Package Name(s)
TOSHIBA: 11-4L1S

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