

TLP2370

1. Applications

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

2. General

The TLP2370 is a 20-Mbps low-power photocoupler in the small SO6 package.

The TLP2370 consumes supply current (I_{DDL}/I_{DDH}) of only 0.4 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 1.3 mA for minimum, allowing direct drive by a microcontroller.

The detector has a totem-pole output stage with current sourcing and sinking capabilities. The TLP2370 has an internal Faraday shield that provides a guaranteed common-mode transient immunity of ± 20 kV/ μ s.

3. Features

- (1) Package: SO6
- (2) Data transfer rate: 20 MBd (typ.) (NRZ)
- (3) Supply current: 0.4 mA (max)
- (4) Threshold input current: 1 mA (max)
- (5) Supply voltage: 2.7 to 5.5 V
- (6) Operating temperature range: -40 to 125 °C
- (7) Propagation delay time: 60 ns (max)
- (8) Pulse width distortion: 25 ns (max)
- (9) Isolation voltage: 3750 Vrms (min)
- (10) Safety standards

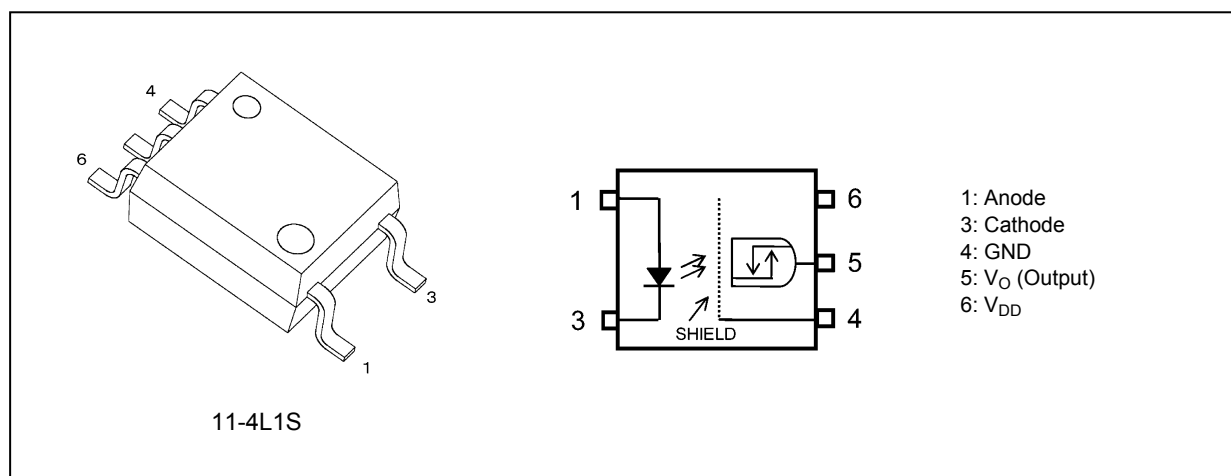
UL-approved: UL1577, File No.E67349

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

VDE-approved: EN60747-5-5 (**Note 1**)

Note 1: When an EN60747-5-5 approved type is needed, please designate the **Option (V4)**.

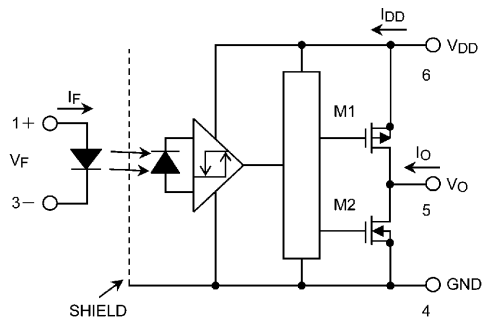
4. Packaging and Pin Assignment



Start of commercial production

2015-10

5. Internal Circuit (Note)



Note: A 0.1-μF 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	Min	Unit
Creepage distances	5.0	mm
Clearance	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 derating ($T_a \geq 110\text{ }^{\circ}\text{C}$)	$\Delta I_F / \Delta T_a$		-0.32	mA/ $^{\circ}\text{C}$
	Peak transient input forward current	I_{FPT}	(Note 1)	1	A
	Peak transient input forward current derating ($T_a \geq 110\text{ }^{\circ}\text{C}$)	$\Delta I_{FPT} / \Delta T_a$		-40	mA/ $^{\circ}\text{C}$
	Input reverse voltage	V_R		5	V
	Input power dissipation	P_D		20	mW
	Input power dissipation derating ($T_a \geq 110\text{ }^{\circ}\text{C}$)	$\Delta P_D / \Delta T_a$		-0.8	mW/ $^{\circ}\text{C}$
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 ($T_a \geq 110\text{ }^{\circ}\text{C}$)	$\Delta P_O / \Delta T_a$		-0.8	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)	1.3	—	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 data sheet should also be considered.

Note: A ceramic capacitor (0.1 μF) 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 μs .

When a peaking capacitor is placed at input side, V_{IN} should be less than 5.5 V, R_{IN} should be less than 2.7 k Ω , C_{IN} should be less than 22 pF.

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

9. Electrical Characteristics (Note)

(Unless otherwise specified, $T_a = -40$ to $125\text{ }^{\circ}\text{C}$, $V_{DD} = 2.7$ to 5.5 V)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input forward voltage	V_F		$I_F = 1.3\text{ mA}$	1.15	—	1.85	V
			$I_F = 1.3\text{ mA}$, $T_a = 25\text{ }^{\circ}\text{C}$	1.35	1.5	1.65	
Input forward voltage temperature coefficient	$\Delta V_F / \Delta T_a$		$I_F = 1.3\text{ mA}$	—	-1.58	—	mV/ $^{\circ}\text{C}$
Input reverse current	I_R		$V_R = 5\text{ V}$, $T_a = 25\text{ }^{\circ}\text{C}$	—	—	10	μA
Input capacitance	C_t		$V = 0\text{ V}$, $f = 1\text{ MHz}$, $T_a = 25\text{ }^{\circ}\text{C}$	—	26	—	pF
Low-level output voltage	V_{OL}	Fig. 12.1.1	$I_O = 20\text{ }\mu\text{A}$, $V_F = 0.8\text{ V}$	—	0.0013	0.1	V
			$I_O = 3.2\text{ mA}$, $V_F = 0.8\text{ V}$	—	0.15	0.4	
High-level output voltage	V_{OH}	Fig. 12.1.2	$I_O = -20\text{ }\mu\text{A}$, $I_F = 1.3\text{ mA}$	$V_{DD} - 0.1$	$V_{DD} - 0.01$	—	V
			$I_O = -3.2\text{ mA}$, $I_F = 1.3\text{ mA}$	$V_{DD} - 1.0$	$V_{DD} - 0.25$	—	
Low-level supply current	I_{DDL}	Fig. 12.1.3	$I_F = 0\text{ mA}$	—	0.3	0.4	mA
High-level supply current	I_{DDH}	Fig. 12.1.4	$I_F = 1.3\text{ mA}$	—	0.28	0.4	mA
Threshold input current (L/H)	I_{FLH}		$I_O = -3.2\text{ mA}$, $V_O > V_{DD} - 1\text{ V}$	—	0.42	1	mA

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

10. Isolation Characteristics (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$)

Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
Total capacitance (input to output)	C_S	(Note 1)	$V_S = 0\text{ V}$, $f = 1\text{ MHz}$	—	0.8	—	pF
Isolation resistance	R_S	(Note 1)	$V_S = 500\text{ V}$, R.H. $\leq 60\%$	1×10^{12}	10^{14}	—	Ω
Isolation voltage	BV_S	(Note 1)	AC, 60 s	3750	—	—	V_{rms}
			AC, 1 s 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 $125\text{ }^{\circ}\text{C}$, $V_{DD} = 2.7$ 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	$V_{IN} = 3.3\text{ V}$ $R_{IN} = 1.3\text{ k}\Omega$ $C_{IN} = 22\text{ pF}$	—	39	60	ns
Propagation delay time (H/L)	t_{pHL}				—	35	60	
Pulse width distortion	$ t_{pHL} - t_{pLH} $				—	4	25	
Propagation delay skew (device to device)	t_{psk}	(Note 1), (Note 2)			-30	—	30	
Propagation delay time (L/H)	t_{pLH}	(Note 1)	Fig. 12.1.5	$V_{IN} = 5\text{ V}$ $R_{IN} = 2.7\text{ k}\Omega$ $C_{IN} = 12\text{ pF}$	—	33	60	ns
Propagation delay time (H/L)	t_{pHL}				—	35	60	
Pulse width distortion	$ t_{pHL} - t_{pLH} $				—	2	25	
Propagation delay skew (device to device)	t_{psk}	(Note 1), (Note 2)			-30	—	30	
Rise time	t_r	(Note 1)	Fig. 12.1.5	$V_{IN} = 0 \rightarrow 5\text{ V}$, $R_{IN} = 2.7\text{ k}\Omega$, $C_{IN} = 12\text{ pF}$	—	3	—	ns
Fall time	t_f			$V_{IN} = 5 \rightarrow 0\text{ V}$, $R_{IN} = 2.7\text{ k}\Omega$, $C_{IN} = 12\text{ pF}$	—	2	—	
Common-mode transient immunity at output high	CM_H		Fig. 12.1.6	$V_{IN} = 3.3\text{ V} / 5\text{ V}$, $V_{DD} = 3.3\text{ V} / 5\text{ V}$, $V_{CM} = 1000\text{ V}_{p-p}$, $T_a = 25\text{ }^{\circ}\text{C}$	± 20	± 35	—	kV/ μs
Common-mode transient immunity at output low	CM_L				± 20	± 35	—	

Note: All typical values are at $V_{DD} = 5\text{ V}$, $T_a = 25\text{ }^{\circ}\text{C}$, unless otherwise noted.Note 1: $f = 5\text{ MHz}$, duty = 50 %, input current $t_r = t_f = 5\text{ ns}$, 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).

12.1. Test Circuits

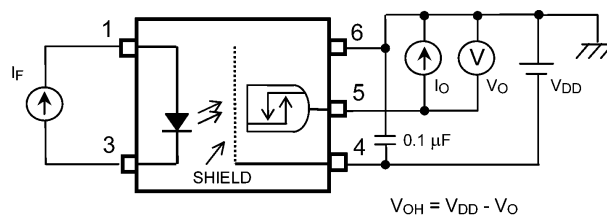


Fig. 12.1.2 V_{OH} Test Circuit

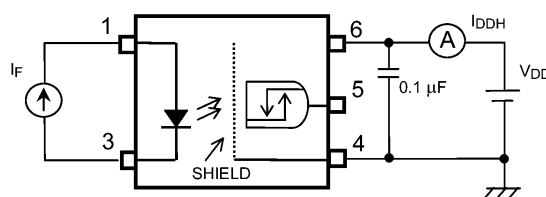


Fig. 12.1.4 I_{DDH} Test Circuit

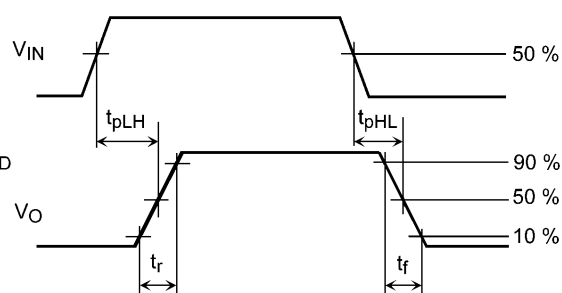


Fig. 12.1.5 Switching Time Test Circuit and Waveform

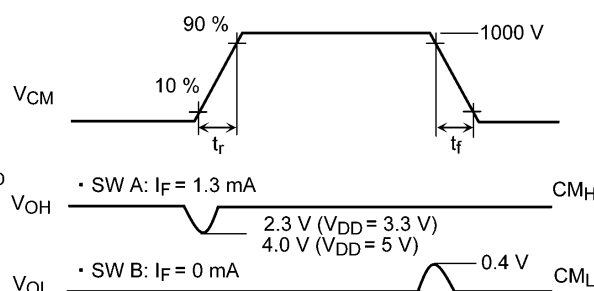


Fig. 12.1.6 Common-Mode Transient Immunity Test Circuit and Waveform

12.2. Characteristics Curves (Note)

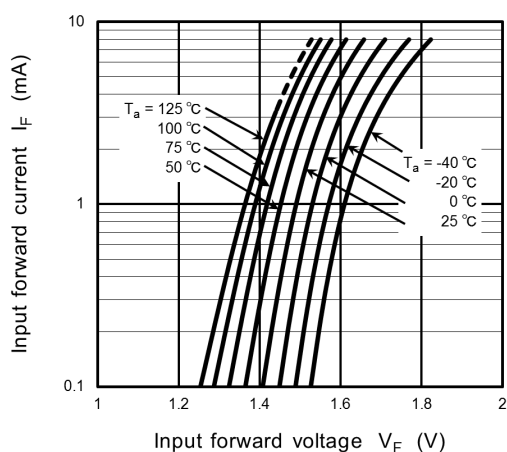


Fig. 12.2.1 $I_F - V_F$

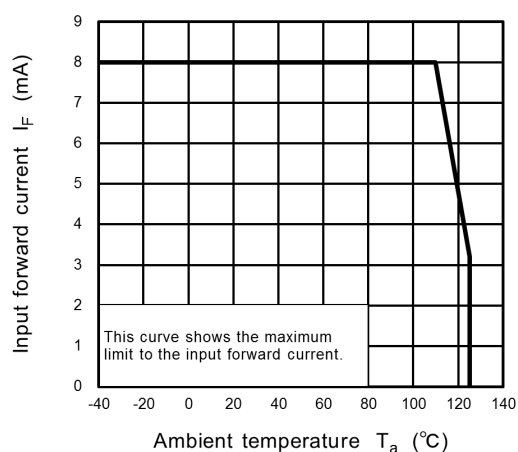


Fig. 12.2.2 $I_F - T_a$

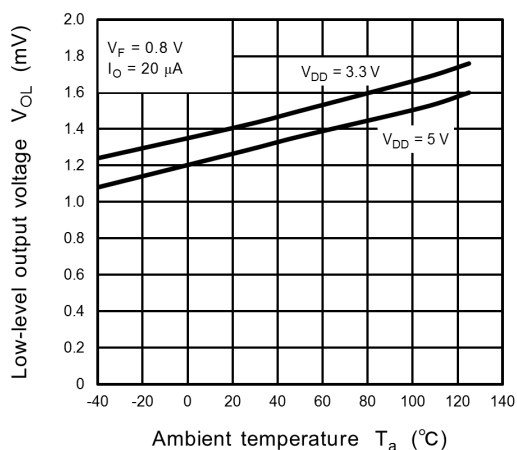


Fig. 12.2.3 $V_{OL} - T_a$

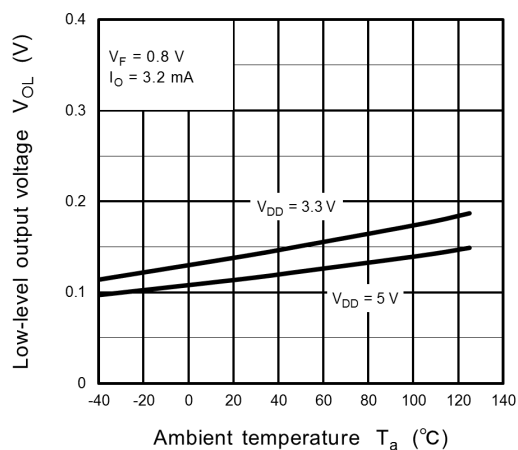


Fig. 12.2.4 $V_{OL} - T_a$

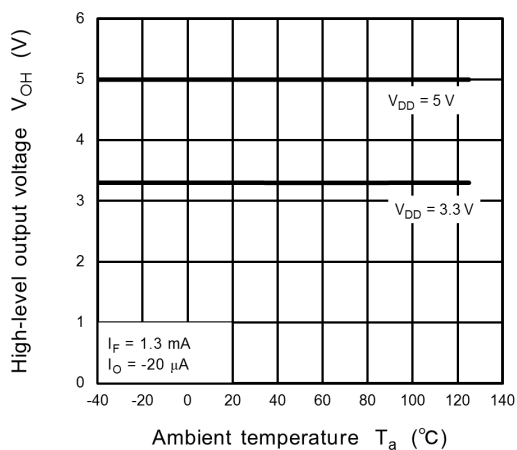


Fig. 12.2.5 $V_{OH} - T_a$

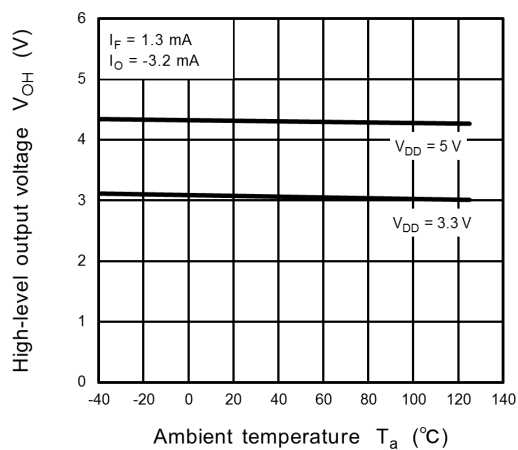


Fig. 12.2.6 $V_{OH} - T_a$

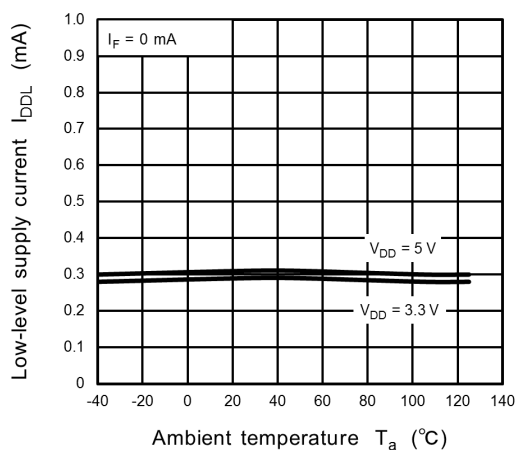


Fig. 12.2.7 $I_{DDL} - T_a$

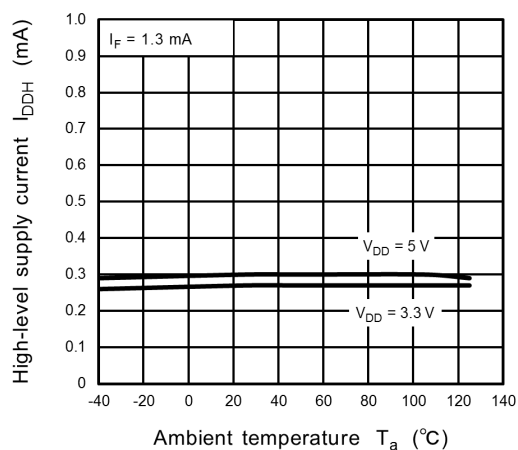


Fig. 12.2.8 $I_{DDH} - T_a$

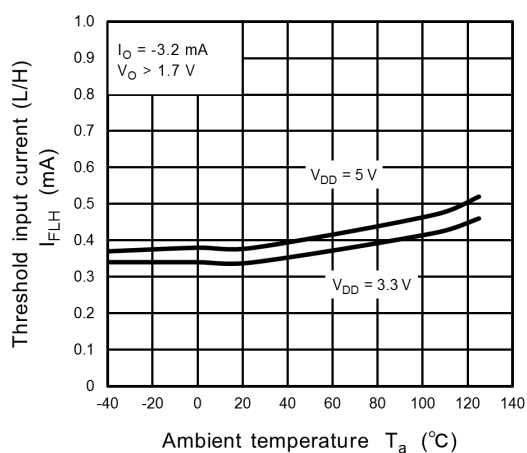


Fig. 12.2.9 $I_{FLH} - T_a$

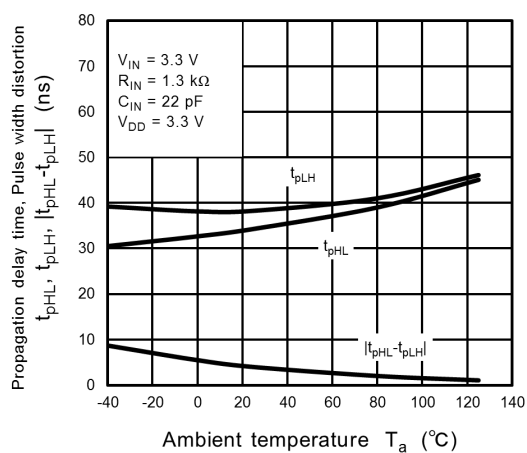


Fig. 12.2.10 $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - T_a$

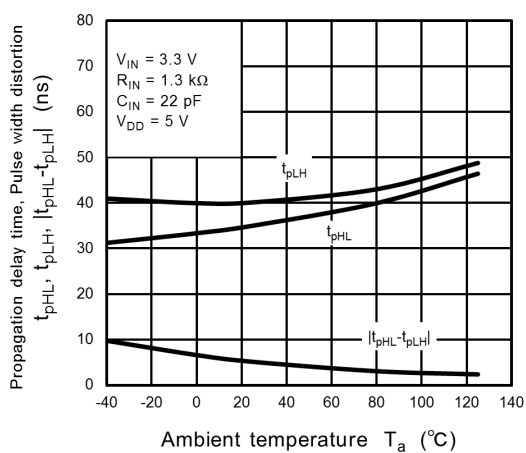


Fig. 12.2.11 $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - T_a$

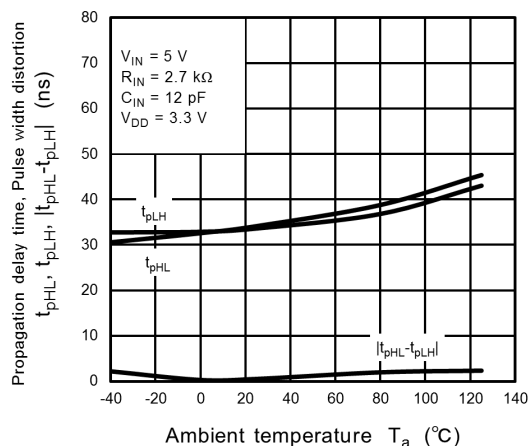


Fig. 12.2.12 t_{pHL} , t_{pLH} , $|t_{pHL} - t_{pLH}|$ - T_a

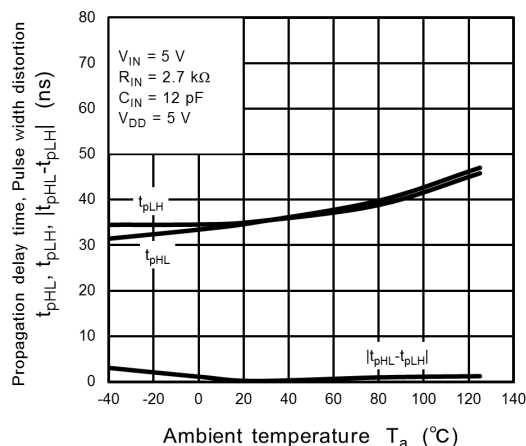


Fig. 12.2.13 t_{pHL} , t_{pLH} , $|t_{pHL} - t_{pLH}|$ - T_a

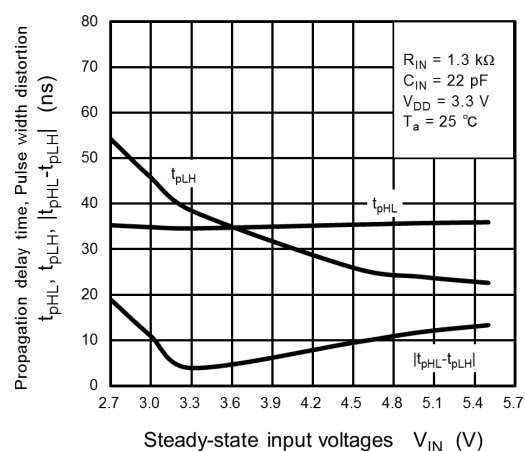


Fig. 12.2.14 t_{pHL} , t_{pLH} , $|t_{pHL} - t_{pLH}|$ - V_{IN}

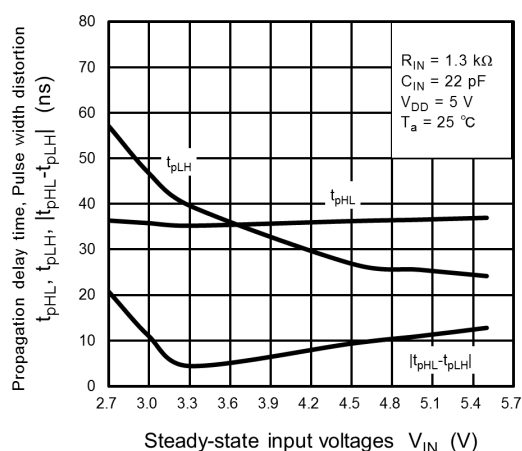


Fig. 12.2.15 t_{pHL} , t_{pLH} , $|t_{pHL} - t_{pLH}|$ - V_{IN}

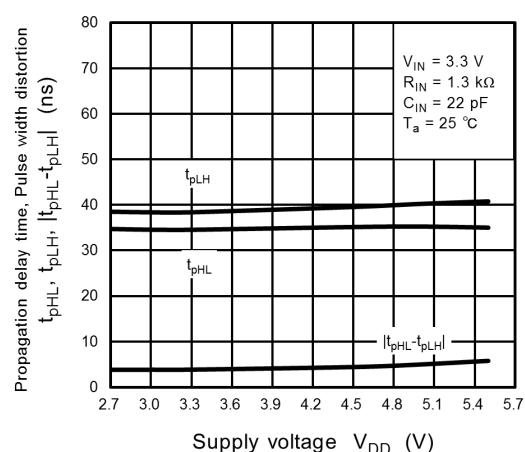


Fig. 12.2.16 t_{pHL} , t_{pLH} , $|t_{pHL} - t_{pLH}|$ - V_{DD}

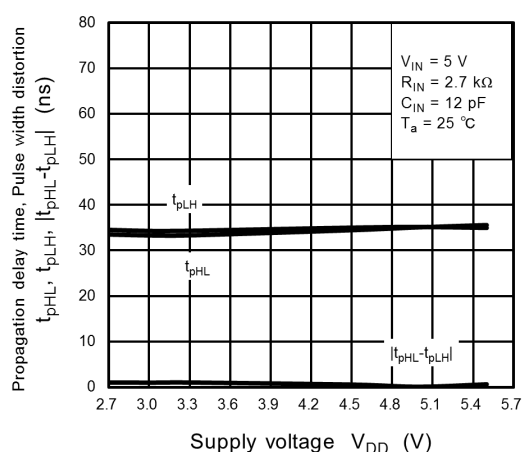


Fig. 12.2.17 t_{pHL} , t_{pLH} , $|t_{pHL} - t_{pLH}|$ - V_{DD}

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.

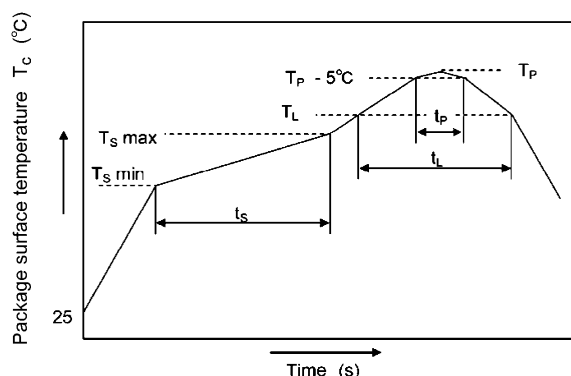
- When using soldering reflow.

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.



	Symbol	Min	Max	Unit
Preheat temperature	T_S	150	200	°C
Preheat time	t_S	60	120	s
Ramp-up rate (T_L to T_P)			3	°C/s
Liquidus temperature	T_L	217		°C
Time above T_L	t_L	60	150	s
Peak temperature	T_P		260	°C
Time during which T_c is between ($T_P - 5$) and T_P	t_P		30	s
Ramp-down rate (T_P to T_L)			6	°C/s

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

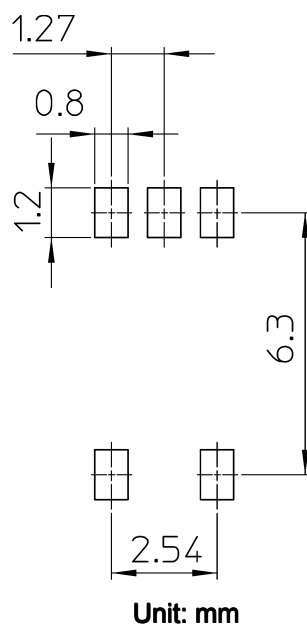
Complete soldering within 10 seconds for lead temperature not exceeding 260 °C or within 3 seconds not exceeding 350 °C

Heating by soldering iron must be done only once per lead.

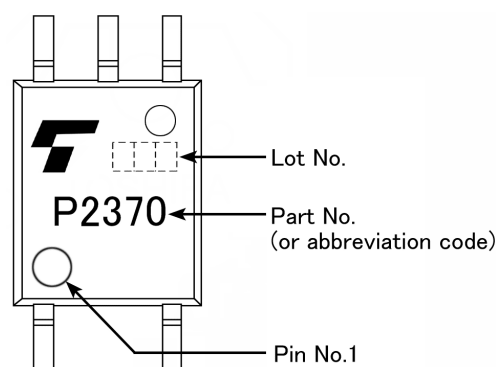
13.2. Precautions for General Storage

- 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: TLP2370 (**Note 1**)
- The following part naming conventions are used for the devices that have been qualified according to option (V4) of EN60747.

Example: TLP2370(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., TLP2370(V4-TPL,E(T → TLP2370

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 electronic equipment.

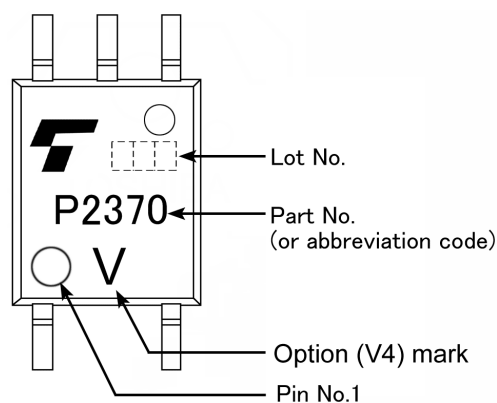
Description	Symbol	Rating	Unit
Application classification			
for rated mains voltage ≤ 150 Vrms		I-IV	—
for rated mains voltage ≤ 300 Vrms		I-III	—
Climatic classification		40 / 125 / 21	—
Pollution degree		2	—
Maximum operating insulation voltage	V_{IORM}	707	Vpeak
Input to output test voltage, Method A $V_{pr} = 1.6 \times V_{IORM}$, type and sample test $t_p = 10$ s, partial discharge < 5 pC	V_{pr}	1131	Vpeak
Input to output test voltage, Method B $V_{pr} = 1.875 \times V_{IORM}$, 100 % production test $t_p = 1$ s, partial discharge < 5 pC	V_{pr}	1325	Vpeak
Highest permissible overvoltage (transient overvoltage, $t_{pr} = 60$ s)	V_{TR}	6000	Vpeak
Safety limiting values (max. permissible ratings in case of fault, also refer to thermal derating curve)			
current (input current I_F , $P_{SO} = 0$)	I_{Si}	250	mA
power (output or total power dissipation)	P_{SO}	400	mW
temperature	T_s	150	°C
Insulation resistance $V_{IO} = 500$ V, $T_a = 25$ °C $V_{IO} = 500$ V, $T_a = 100$ °C $V_{IO} = 500$ V, $T_a = T_s$	R_{Si}	$\geq 10^{12}$ $\geq 10^{11}$ $\geq 10^9$	Ω

Fig. 16.1 EN60747 Insulation Characteristics

Table Insulation Related Specifications (Note)

Insulation Related Parameters	Symbol	TLP2370
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

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. 16.2 Marking on Packing for EN60747

Fig. 16.3 Marking Example (Note)

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

Figure 1 Partial discharge measurement procedure according to EN60747
Destructive test for qualification and sampling tests.

Method A

(for type and sampling tests,
destructive tests)

t_1, t_2	= 1 to 10 s
t_3, t_4	= 1 s
t_p (Measuring time for partial discharge)	= 10 s
t_b	= 12 s
t_{ini}	= 60 s

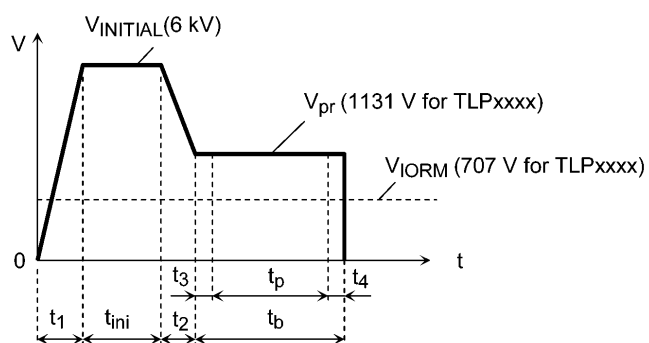


Figure 2 Partial discharge measurement procedure according to EN60747
Non-destructive test for 100 % inspection.

Method B

(for sample test, non-
destructive test)

t_3, t_4	= 0.1 s
t_p (Measuring time for partial discharge)	= 1 s
t_b	= 1.2 s

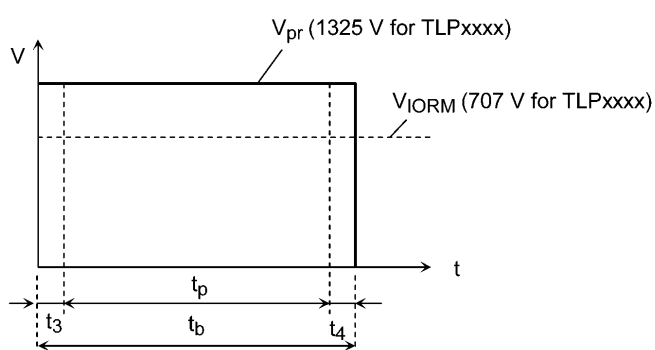


Figure 3 Dependency of maximum safety ratings on ambient temperature

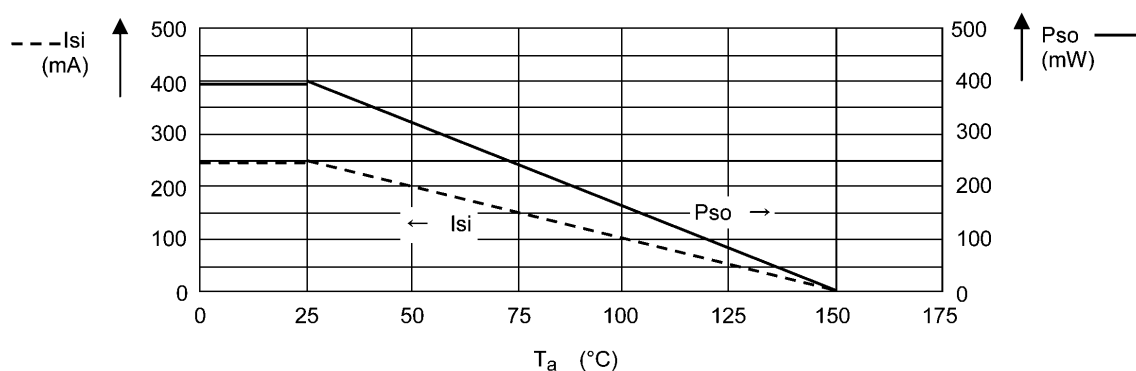


Fig. 16.4 Measurement Procedure

17. Specifications for Embossed-Tape Packing

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) TLP2370(TPL,E(T

Part number: TLP2370

Tape type: TPL

[[G]]/RoHS COMPATIBLE: E (Note 1)

Domestic ID (Country/Region of origin: Thailand): T

Note 1: Please contact your Toshiba sales representative for details on environmental information such as the product's RoHS compatibility.

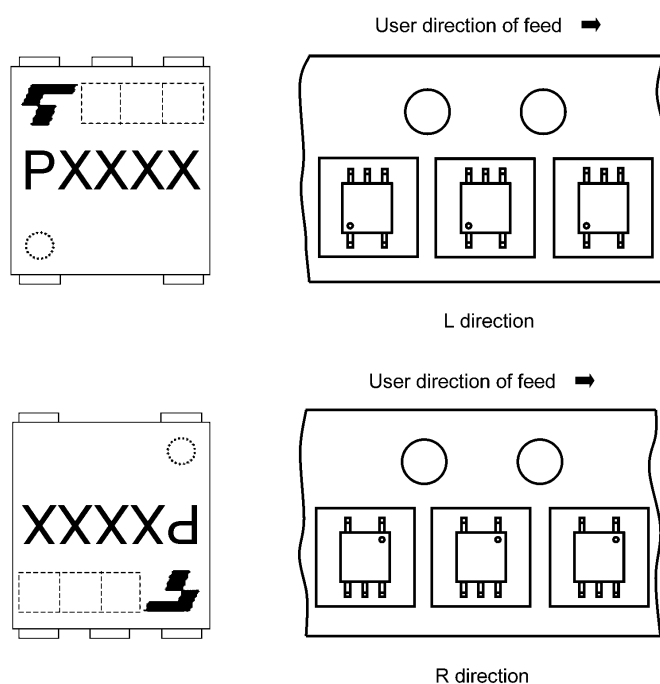
RoHS is the Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

17.3. Tape Dimensions Specification

Tape Type	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.

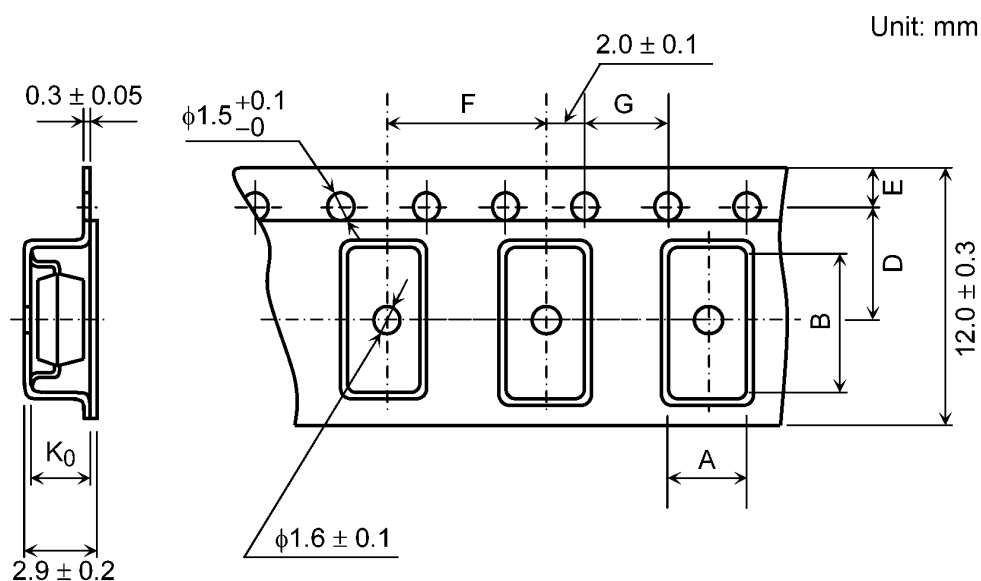


Device Orientation

Characteristics	Criterion	Remarks
Occurrences of 2 or more successive empty cavities	0 device	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

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

Tape material: Plastic (for protection against static electricity)



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 ₀	2.6	Internal space

17.3.5. Reel Specification

Material: Plastic (for protection against static electricity)

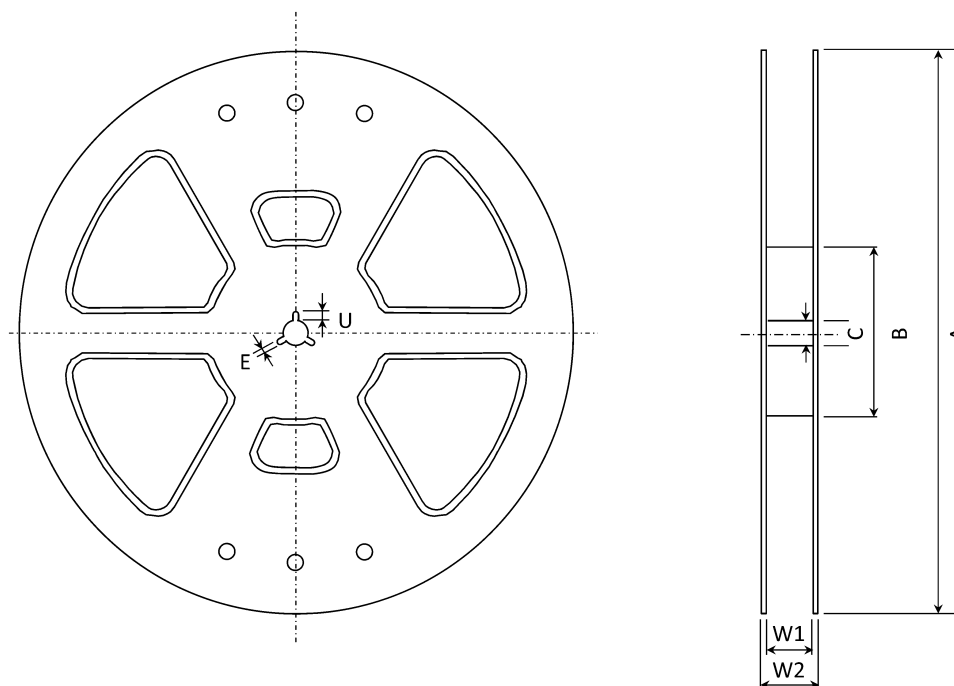
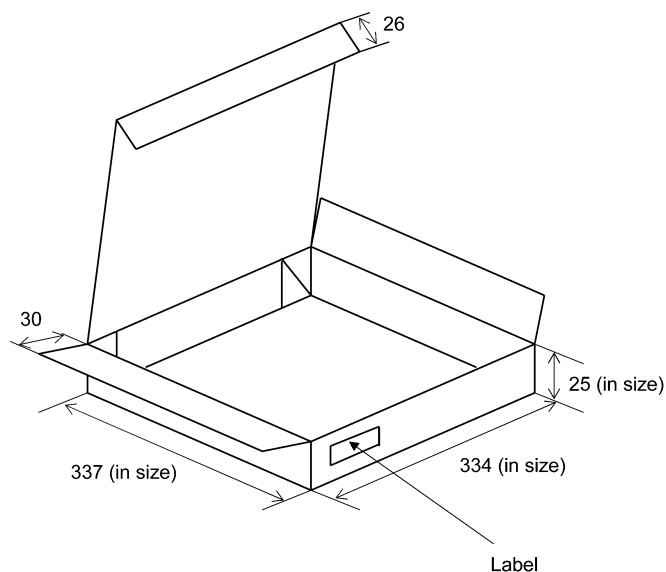


Table Reel Dimensions (unit: mm)

Symbol	Dimension
A	$\phi 330 \pm 2.0$
B	$\phi 80 \pm 1.0$
C	$\phi 13 \pm 0.5$
E	2.0 ± 0.5
U	4.0 ± 0.5
W1	13.5 ± 0.5
W2	17.5 ± 1.0

17.4. Packing (Note)



1 reel/carton (unit: mm)

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

17.5. Label Format

- (1) Carton: The label provides the part number, quantity, lot number, the Toshiba logo, etc.
- (2) Reel: The label provides the part number, the taping name, quantity, lot number, 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) TLP2370(TPL,E(T 3000 pcs

Part number: TLP2370

Tape type: TPL

[[G]]/RoHS COMPATIBLE: E (**Note 1**)

Domestic ID (Country/Region of origin: Thailand): T

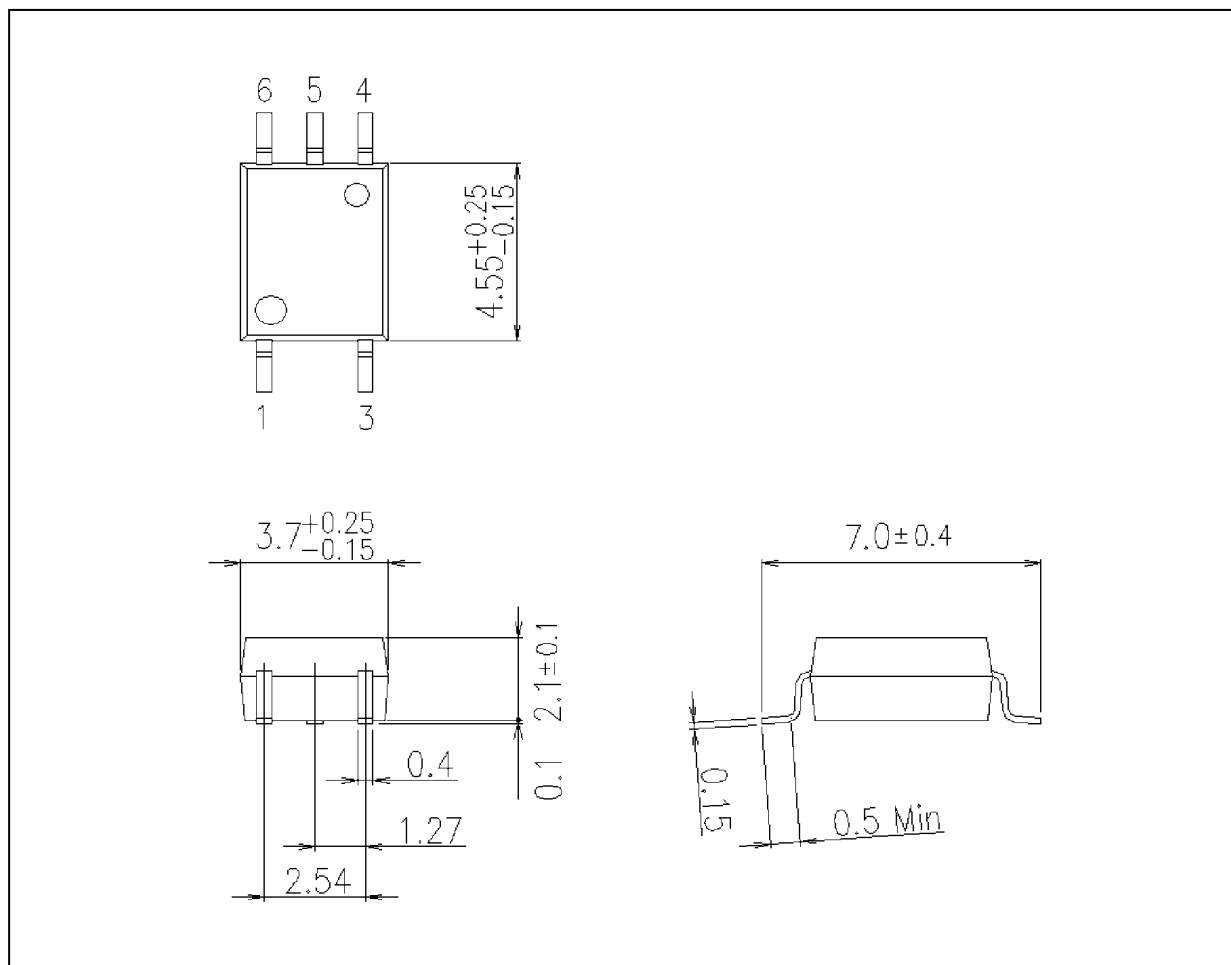
Quantity (must be a multiple of 3000): 3000 pcs

Note 1: 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 electronic equipment.

Package Dimensions

Unit: mm



Weight: 0.08 g (typ.)

Package Name(s)
TOSHIBA: 11-4L1S

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