

# TLP2405

## 1. Applications

- High-Speed Digital Interfacing for Instrumentation and Control Devices
- Communications Equipment
- Intelligent Power Module Signal Isolation

## 2. General

The Toshiba TLP2405 consists of a GaAs light-emitting diode coupled with a high-gain, high-speed photo detector.

It is housed in the 8-pin SO8 package.

The detector has a totem-pole output stage with current sourcing and sinking capabilities.

The TLP2405 has an internal Faraday shield that provides a guaranteed common-mode transient immunity of  $\pm 15$  kV/ $\mu$ s.

The TLP2405 has a logic buffer output. An inverter output version, the TLP2408, is also available.

## 3. Features

- (1) Buffer logic type (totem pole output)
- (2) Package: SO8
- (3) Supply voltage: 4.5 to 20 V
- (4) Threshold input current: 1.6 mA (max)
- (5) Propagation delay time: 250 ns (max)
- (6) Common-mode transient immunity:  $\pm 15$  kV/ $\mu$ s (min)
- (7) Operating temperature range: -40 to 100 °C
- (8) Isolation voltage: 3750 Vrms (min)
- (9) Safety standards

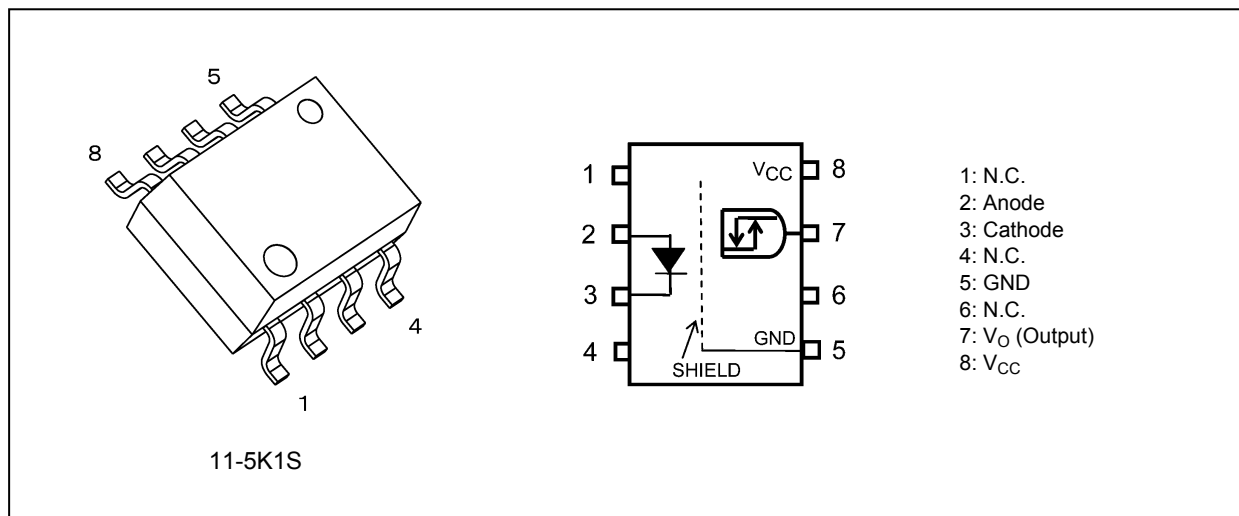
UL-approved: UL1577, File No.E67349

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)**.

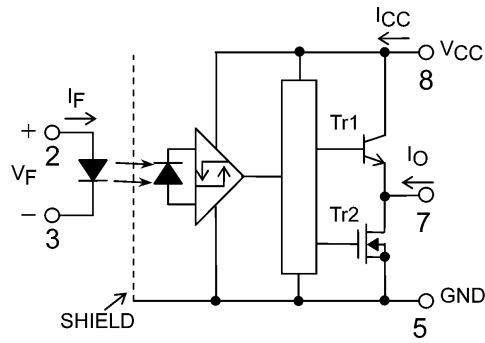
## 4. Packaging and Pin Assignment



Start of commercial production

2010-03

**5. Internal Circuit (Note)**



Note: A 0.1- $\mu$ F bypass capacitor must be connected between pin 8 and pin 5.

**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	4.0	mm
Clearance	4.0	
Internal isolation thickness	—	

**7. Absolute Maximum Ratings (Note) (Unless otherwise specified, T<sub>a</sub> = 25 °C)**

	Characteristics	Symbol	Note	Rating	Unit
LED	Input forward current (T <sub>a</sub> ≥ 85 °C)	I <sub>F</sub>		25	mA
	Input forward current derating (T <sub>a</sub> ≥ 85 °C)	ΔI <sub>F</sub> /ΔT <sub>a</sub>		-0.67	mA/°C
	Input reverse voltage	V <sub>R</sub>		5	V
	Input power dissipation	P <sub>D</sub>		40	mW
	Input power dissipation derating (T <sub>a</sub> ≥ 85 °C)	ΔP <sub>D</sub> /ΔT <sub>a</sub>		-1.0	mW/°C
Detector	Output current (T <sub>a</sub> ≥ 25 °C)	I <sub>O</sub>		25 / -15	mA
	Output current (T <sub>a</sub> = 100 °C)	I <sub>O</sub>		5 / -5	mA
	Output voltage	V <sub>O</sub>		-0.5 to 20	V
	Supply voltage	V <sub>CC</sub>		-0.5 to 20	V
	Output power dissipation	P <sub>O</sub>		75	mW
	Output power dissipation derating (T <sub>a</sub> ≥ 25 °C)	ΔP <sub>O</sub> /ΔT <sub>a</sub>		-0.75	mW/°C
Common	Operating temperature	T <sub>opr</sub>		-40 to 100	°C
	Storage temperature	T <sub>stg</sub>		-55 to 125	°C
	Lead soldering temperature (10 s)	T <sub>sol</sub>		260	°C
	Isolation voltage AC, 60 s, R.H. ≤ 60 %	BV <sub>S</sub>	(Note 1)	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: This device is considered as a two-terminal device: Pins 1, 2, 3 and 4 are shorted together, and pins 5, 6, 7 and 8 are shorted together.

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

Characteristics	Symbol	Note	Min	Typ.	Max	Unit
Input on-state current	I <sub>F(ON)</sub>		2	—	10	mA
Input off-state voltage	V <sub>F(OFF)</sub>		0	—	0.8	V
Supply voltage	V <sub>CC</sub>	(Note 1)	4.5	—	20	
Operating temperature	T <sub>opr</sub>		-40	—	100	°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 8 and pin 5 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: Denotes the operating range, not the recommended operating condition.

**9. Electrical Characteristics (Note)**  
 (Unless otherwise specified,  $T_a = -40$  to  $100\text{ }^\circ\text{C}$ ,  $V_{CC} = 4.5$  to  $20\text{ V}$ )

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input forward voltage	$V_F$			$I_F = 10\text{ mA}$ , $T_a = 25\text{ }^\circ\text{C}$	1.40	1.57	1.80	V
Input forward voltage temperature coefficient	$\Delta V_F/\Delta T_a$			$I_F = 10\text{ mA}$	—	-1.8	—	mV/ $^\circ\text{C}$
Input reverse current	$I_R$			$V_R = 5\text{ V}$ , $T_a = 25\text{ }^\circ\text{C}$	—	—	10	$\mu\text{A}$
Input capacitance	$C_t$			$V = 0\text{ V}$ , $f = 1\text{ MHz}$	—	60	—	pF
Low-level output voltage	$V_{OL}$		Fig. 12.1.1	$I_O = 3.5\text{ mA}$ , $V_F = 0.8\text{ V}$	—	0.2	0.6	V
High-level output voltage	$V_{OH}$	(Note 1)	Fig. 12.1.2	$V_{CC} = 4.5\text{ V}$ , $I_O = -2.6\text{ mA}$ , $I_F = 5\text{ mA}$	2.7	3.5	—	V
				$V_{CC} = 20\text{ V}$ , $I_O = -2.6\text{ mA}$ , $I_F = 5\text{ mA}$	17.4	19	—	
Low-level supply current	$I_{CCL}$		Fig. 12.1.3	$V_{CC} = 5.5\text{ V}$ , $V_F = 0\text{ V}$	—	—	3.0	mA
				$V_{CC} = 20\text{ V}$ , $V_F = 0\text{ V}$	—	—	3.0	
High-level supply current	$I_{CCH}$		Fig. 12.1.4	$V_{CC} = 5.5\text{ V}$ , $I_F = 5\text{ mA}$	—	—	3.0	mA
				$V_{CC} = 20\text{ V}$ , $I_F = 5\text{ mA}$	—	—	3.0	
Low-level short-circuit output current	$I_{OSL}$	(Note 2)	Fig. 12.1.5	$V_{CC} = V_O = 5.5\text{ V}$ , $V_F = 0\text{ V}$	15	80	—	mA
				$V_{CC} = V_O = 20\text{ V}$ , $V_F = 0\text{ V}$	20	90	—	
High-level short-circuit output current	$I_{OSH}$	(Note 2)	Fig. 12.1.6	$V_{CC} = 5.5\text{ V}$ , $I_F = 5\text{ mA}$ , $V_O = \text{GND}$	-5	-15	—	mA
				$V_{CC} = 20\text{ V}$ , $I_F = 5\text{ mA}$ , $V_O = \text{GND}$	-10	-20	—	
Threshold input current (L/H)	$I_{FLH}$			$I_O = -2.6\text{ mA}$ , $V_O > 2.4\text{ V}$	—	0.4	1.6	mA
Threshold input voltage (H/L)	$V_{FHL}$			$I_O = 3.5\text{ mA}$ , $V_O < 0.6\text{ V}$	0.8	—	—	V
Input current hysteresis	$I_{HYS}$			$V_{CC} = 5\text{ V}$	—	0.05	—	mA

Note: All typical values are at  $T_a = 25\text{ }^\circ\text{C}$ .

Note 1:  $V_{OH} = V_{CC} - V_O$  (V)

Note 2: Duration of output short circuit time should not exceed 10 ms.

**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)	$V_S = 0\text{ V}$ , $f = 1\text{ MHz}$	—	1.0	—	pF
Isolation resistance	$R_S$	(Note 1)	$V_S = 500\text{ V}$ , R.H. $\leq 60\%$	$1 \times 10^{12}$	$10^{14}$	—	$\Omega$
Isolation voltage	$BV_S$	(Note 1)	AC, 60 s	3750	—	—	Vrms
			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, 2, 3 and 4 are shorted together, and pins 5, 6, 7 and 8 are shorted together.

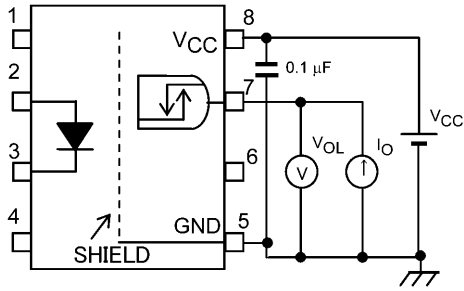
**11. Switching Characteristics (Note)**  
 (Unless otherwise specified,  $T_a = -40$  to  $100\text{ }^\circ\text{C}$ ,  $V_{CC} = 4.5$  to  $20\text{ V}$ )

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Propagation delay time (L/H)	$t_{pLH}$		Fig.12.1.7, Fig.12.1.8	$I_F = 0 \rightarrow 3\text{ mA}$	30	90	250	ns
Propagation delay time (H/L)	$t_{pHL}$			$I_F = 3 \rightarrow 0\text{ mA}$	30	120	250	
Pulse width distortion	$ t_{pHL} - t_{pLH} $			—	—	—	220	
Rise time	$t_r$			$I_F = 0 \rightarrow 3\text{ mA}$ , $V_{CC} = 5\text{ V}$	—	30	75	
Fall time	$t_f$			$I_F = 3 \rightarrow 0\text{ mA}$ , $V_{CC} = 5\text{ V}$	—	30	75	
Common-mode transient immunity at output high	$CM_H$		Fig.12.1.9	$V_{CM} = 1000\text{ V}_{p-p}$ , $I_F = 5\text{ mA}$ , $V_{CC} = 20\text{ V}$ , $T_a = 25\text{ }^\circ\text{C}$	-15	—	—	kV/ $\mu\text{s}$
Common-mode transient immunity at output low	$CM_L$			$V_{CM} = 1000\text{ V}_{p-p}$ , $I_F = 0\text{ mA}$ , $V_{CC} = 20\text{ V}$ , $T_a = 25\text{ }^\circ\text{C}$	15	—	—	

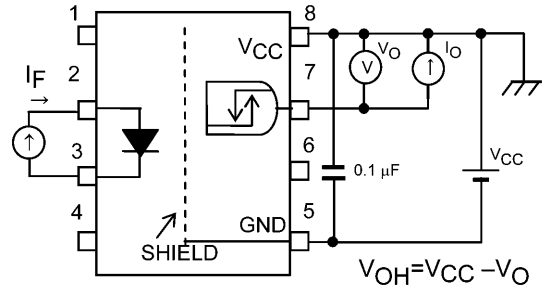
Note: All typical values are at  $T_a = 25\text{ }^\circ\text{C}$ .

**12. Test Circuits and Characteristics Curves**

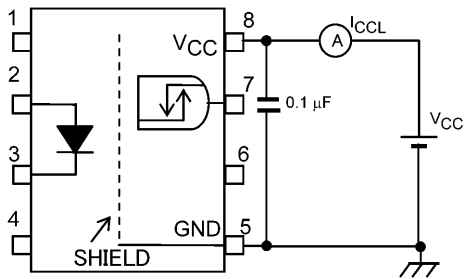
**12.1. Test Circuits**



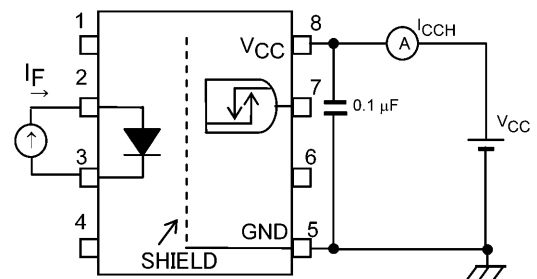
**Fig. 12.1.1 VOL Test Circuit**



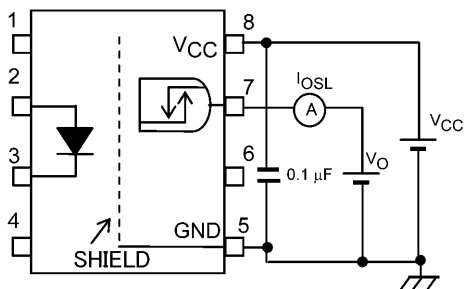
**Fig. 12.1.2 VOH Test Circuit**



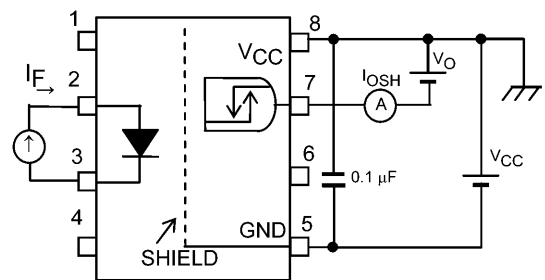
**Fig. 12.1.3 ICCL Test Circuit**



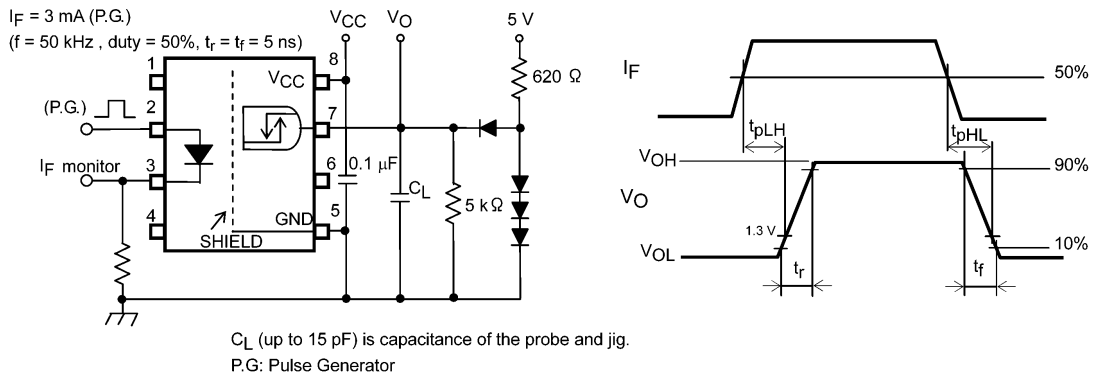
**Fig. 12.1.4 ICCH Test Circuit**



**Fig. 12.1.5 IOSL Test Circuit**



**Fig. 12.1.6 IOSH Test Circuit**



**Fig. 12.1.7 Switching Time Test Circuit and Waveform**

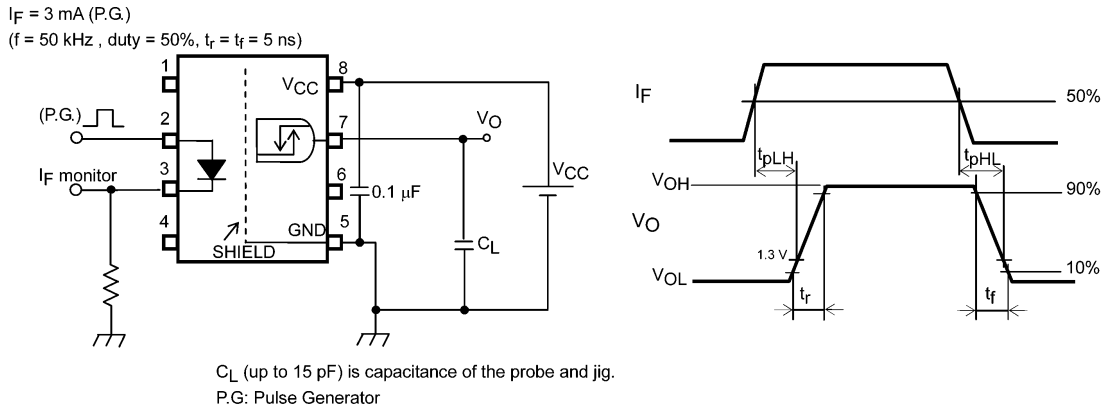


Fig. 12.1.8 Switching Time Test Circuit and Waveform

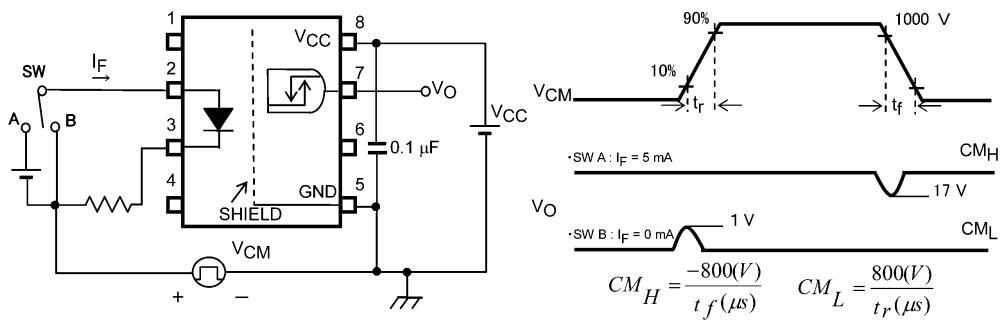


Fig. 12.1.9 Common-Mode Transient Immunity Test Circuit and Waveform

12.2. Characteristics Curves (Note)

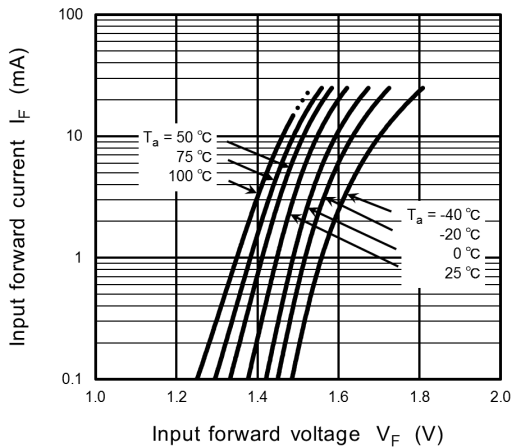


Fig. 12.2.1  $I_F - V_F$

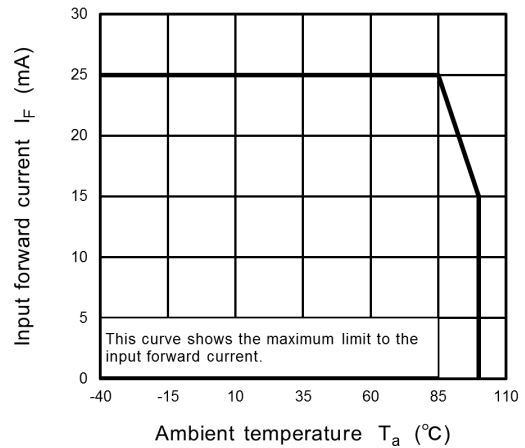


Fig. 12.2.2  $I_F - T_a$

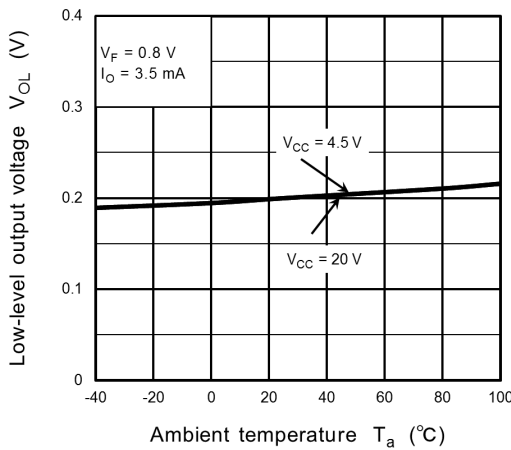


Fig. 12.2.3  $V_{OL} - T_a$

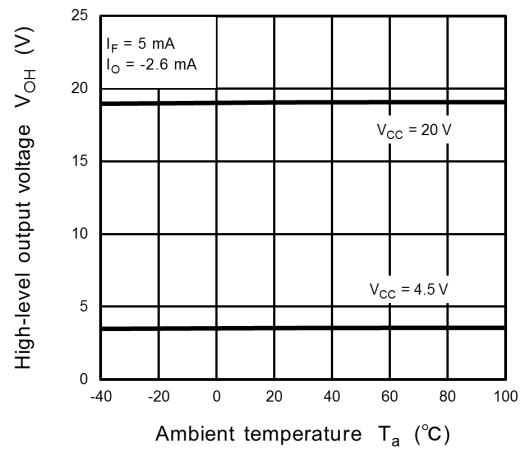


Fig. 12.2.4  $V_{OH} - T_a$

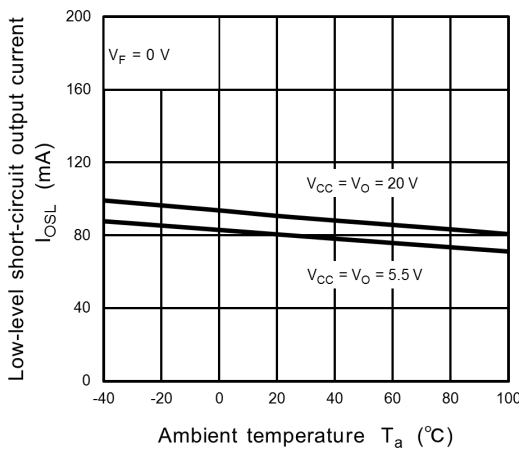


Fig. 12.2.5  $I_{OL} - T_a$

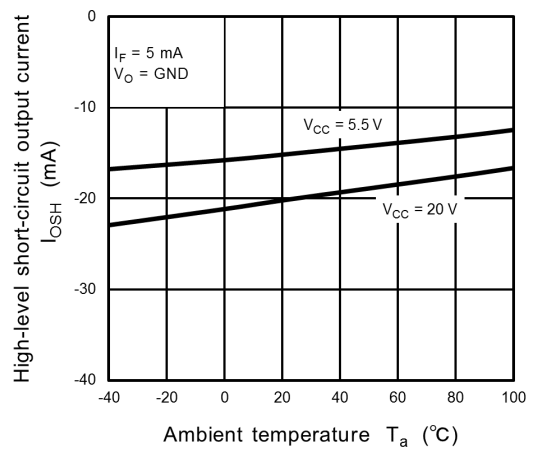


Fig. 12.2.6  $I_{OSH} - T_a$



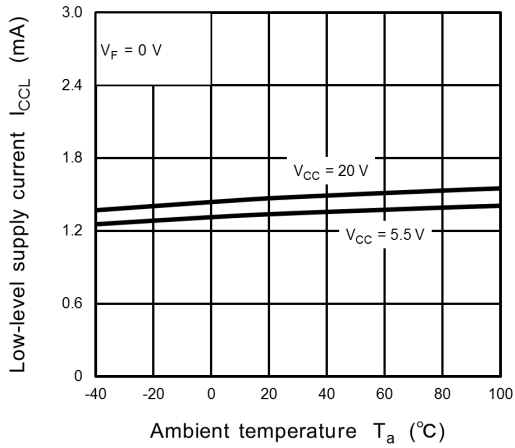


Fig. 12.2.7  $I_{CCL} - T_a$

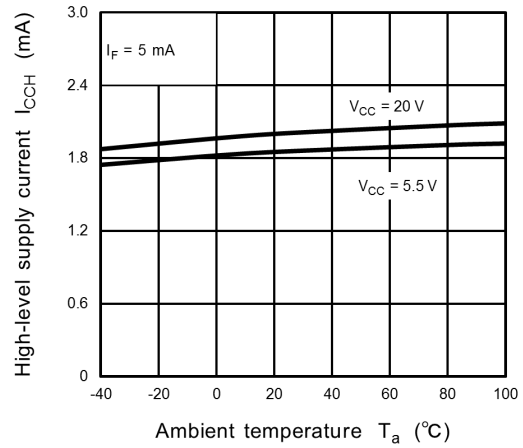


Fig. 12.2.8  $I_{CCH} - T_a$

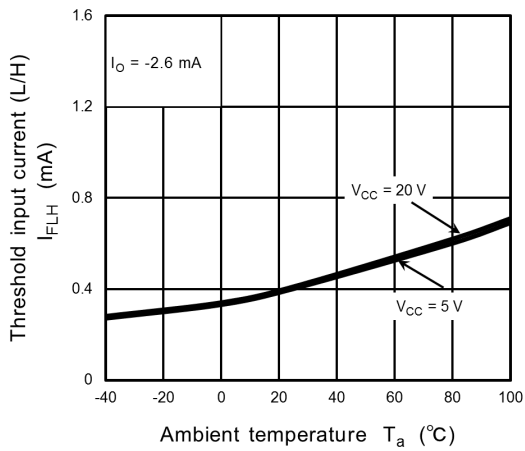


Fig. 12.2.9  $I_{FLH} - T_a$

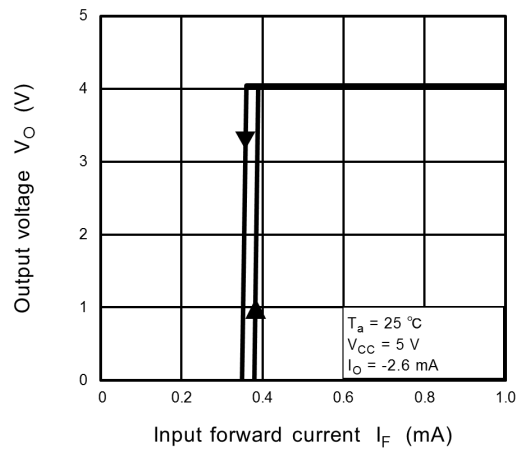


Fig. 12.2.10  $V_O - I_F$

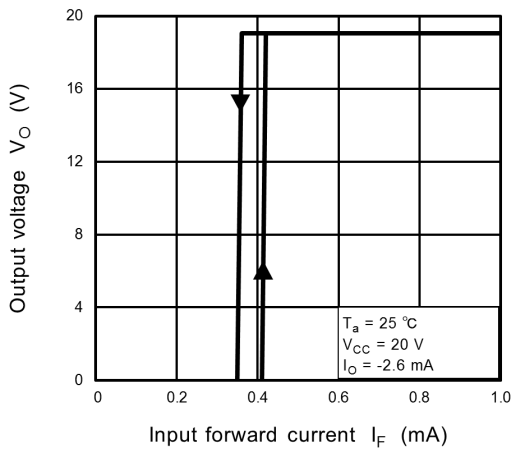


Fig. 12.2.11  $V_O - I_F$

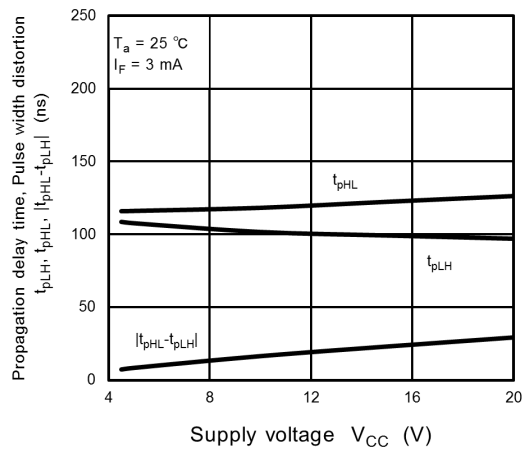


Fig. 12.2.12  $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - V_{CC}$

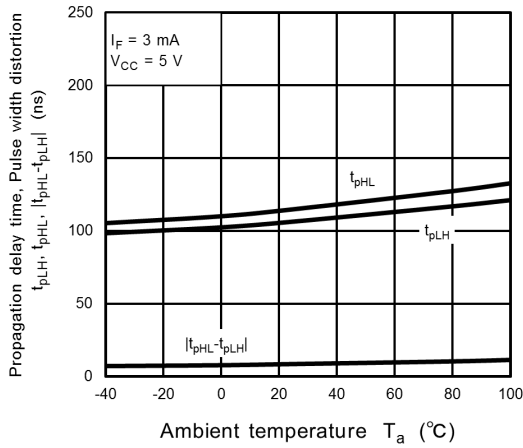


Fig. 12.2.13  $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - T_a$

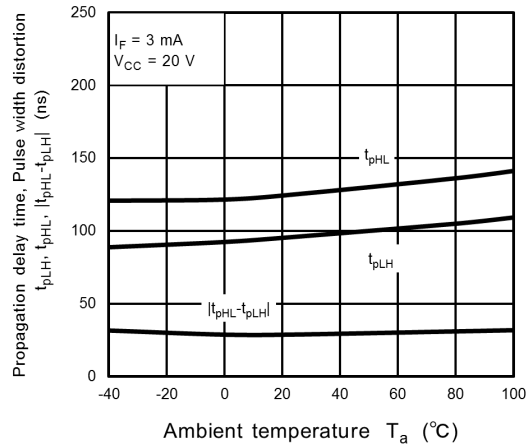


Fig. 12.2.14  $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - T_a$

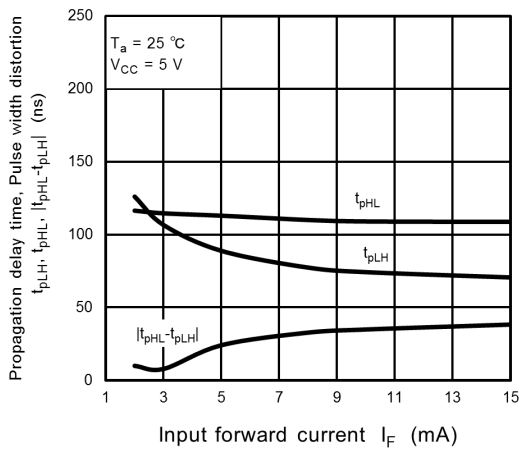


Fig. 12.2.15  $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - I_F$

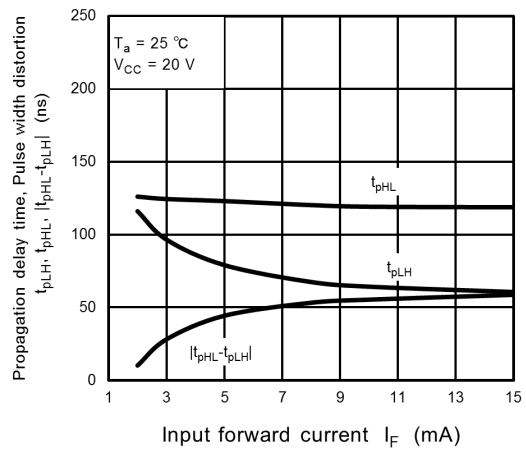


Fig. 12.2.16  $t_{pHL}, t_{pLH}, |t_{pHL} - t_{pLH}| - I_F$

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.

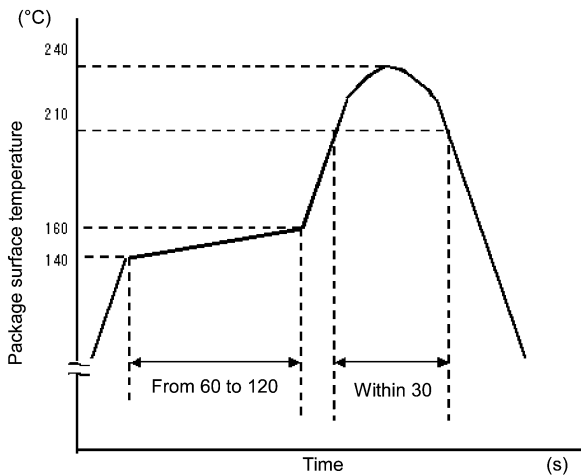
- When using soldering reflow.

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

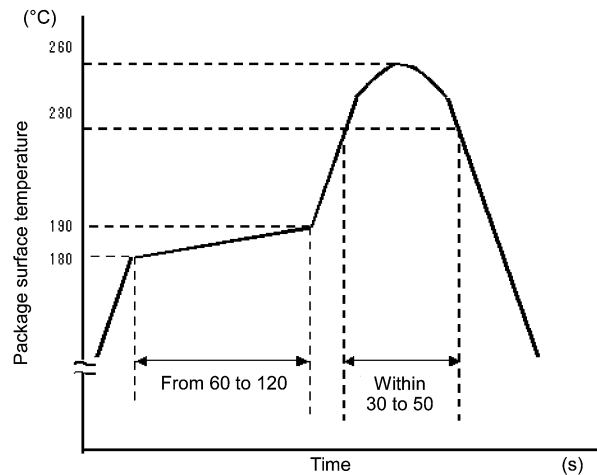
(See the figure shown below, which is based on the package surface temperature.)

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 Sn-Pb Eutectic Solder Is Used**



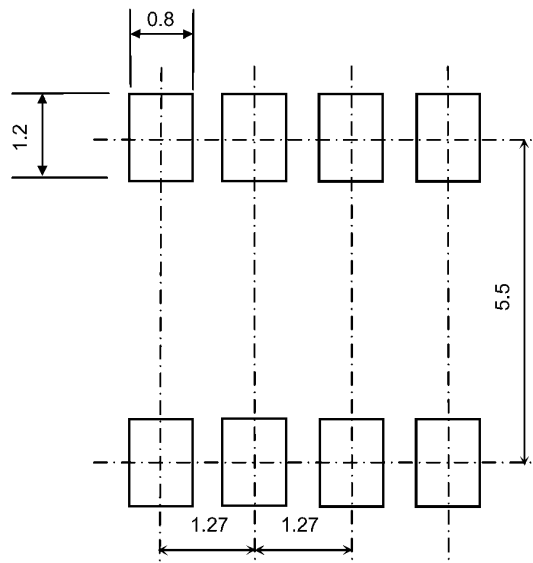
**Fig. 13.1.2 An Example of a Temperature Profile When Lead(Pb)-Free Solder Is Used**

- When using soldering flow (Applicable to both eutectic solder and Lead(Pb)-Free solder)  
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

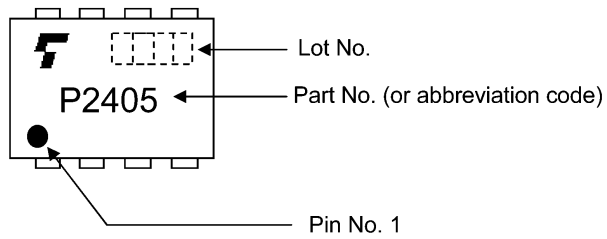
- Avoid storage locations where devices may be exposed to moisture or direct sunlight.
- Follow the precautions printed on the packing label of the device for transportation and storage.
- Keep the storage location temperature and humidity within a range of 5 °C to 35 °C and 45 % to 75 %, respectively.
- 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)



Unit: mm

15. Marking



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

- Part number: TLP2405 (**Note 1**)
- The following part naming conventions are used for the devices that have been qualified according to option (V4) of EN60747.

Example: TLP2405(V4-TP,F)

V4: EN60747 option

TP: Tape type

F: [[G]]/RoHS COMPATIBLE (**Note 2**)

Note 1: Use TOSHIBA standard type number for safety standard application.  
e.g., TLP2405(V4-TP,F) → TLP2405

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 for rated mains voltage ≤ 300 Vrms		I-IV I-III	—
Climatic classification		40 / 100 / 21	—
Pollution degree		2	—
Maximum operating insulation voltage	V <sub>IORM</sub>	565	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>	904	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>	1059	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 Insulation Characteristics**

**Table Insulation Related Specifications (Note)**

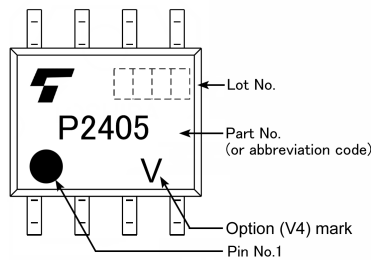
Insulation Related Parameters	Symbol	TLP2405
Minimum creepage distance	Cr	4.0 mm
Minimum clearance	Cl	4.0 mm
Minimum insulation thickness	ti	—
Comparative tracking index	CTI	175

Note: If a printed circuit is incorporated, the creepage distance and clearance may be reduced below this value. (e.g., at a standard distance between soldering eye centers of 3.5 mm). If this is not permissible, the user shall take suitable measures.

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.

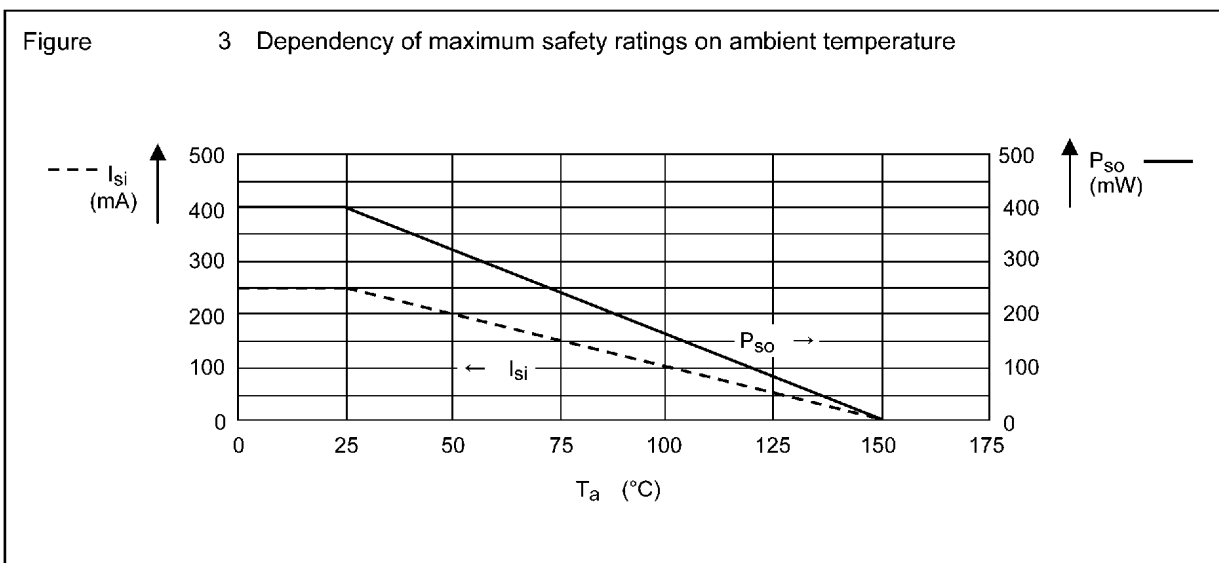
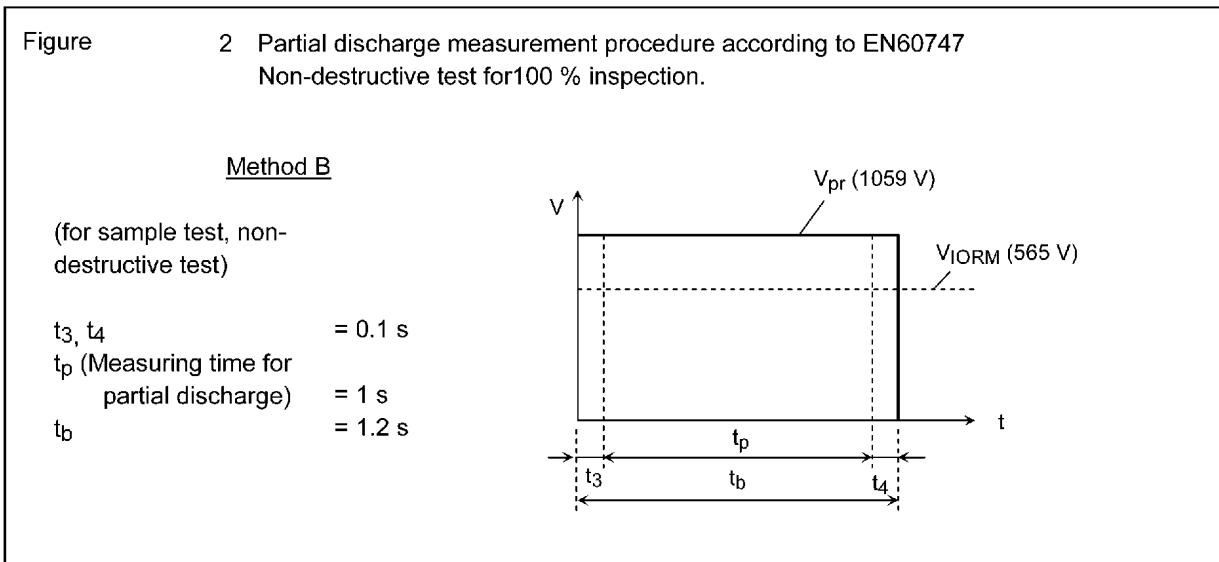
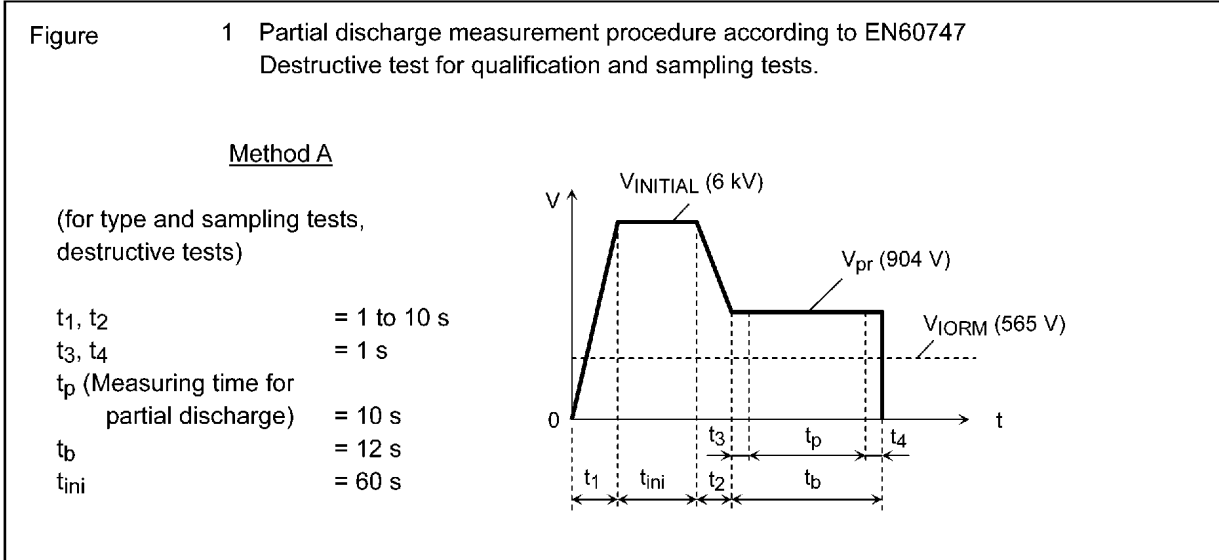


**Fig. 16.2 Marking on Packing for EN60747**



**Fig. 16.3 Marking Example (Note)**

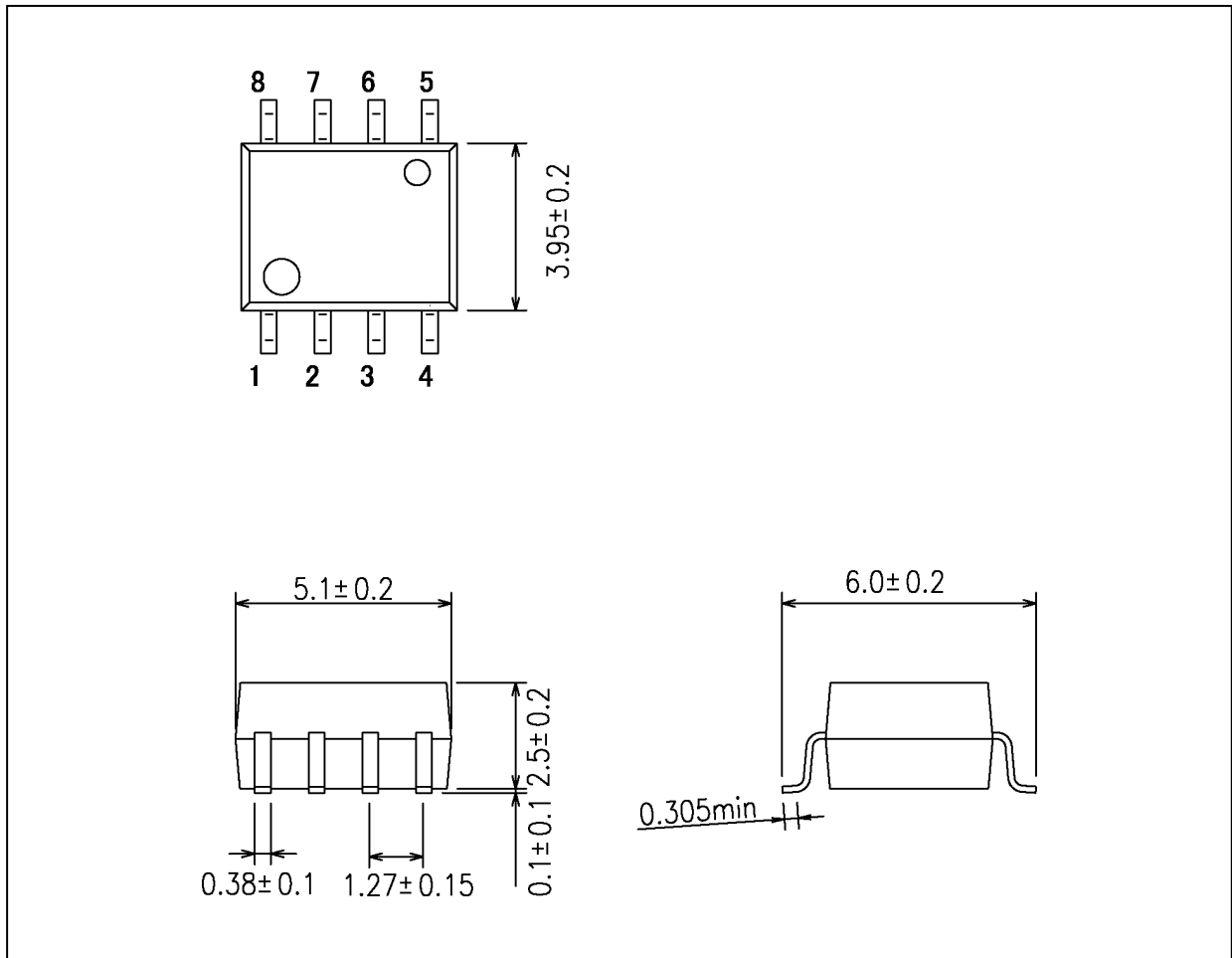
Note: The above marking is applied to the photocouplers that have been qualified according to option (V4) of EN60747.



**Fig. 16.4 Measurement Procedure**

Package Dimensions

Unit: mm



Weight: 0.11 g (typ.)

Package Name(s)
TOSHIBA: 11-5K1S



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