

# TLP2309

## 1. Applications

- Industrial Inverters
- Switching Power Supplies
- High-Speed Digital Interfacing

## 2. General

The Toshiba TLP2309 consists of a high-output infrared LED coupled with a high-speed photo-diode-transistor chip. It is housed in the SO6 package. The TLP2309 guarantees operation at up to 110 °C and on supplies both 3.3 V and 5 V. Also, since the TLP2309 guarantees a creepage / clearance distance  $\geq 5.0$  mm and internal isolation thickness  $\geq 0.4$  mm, this product is in the reinforced insulation class according to international safety standards.

## 3. Features

- (1) Inverter logic type (open collector output)
- (2) Package: SO6
- (3) Operating temperature: -40 to 110 °C
- (4) Supply voltage: 3.3 V / 5 V
- (5) Data transfer rate: 1 Mbit/s (typ.) (NRZ)
- (6) Common-mode transient immunity:  $\pm 15$  kV/ $\mu$ s (min)
- (7) Isolation voltage: 3750 Vrms (min)
- (8) Safety standards

UL-recognized: UL 1577, File No.E67349

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

VDE-approved: EN IEC 60747-5-5, EN IEC 62368-1 (**Note 1**)

CQC-approved: GB4943.1 Thailand Factory

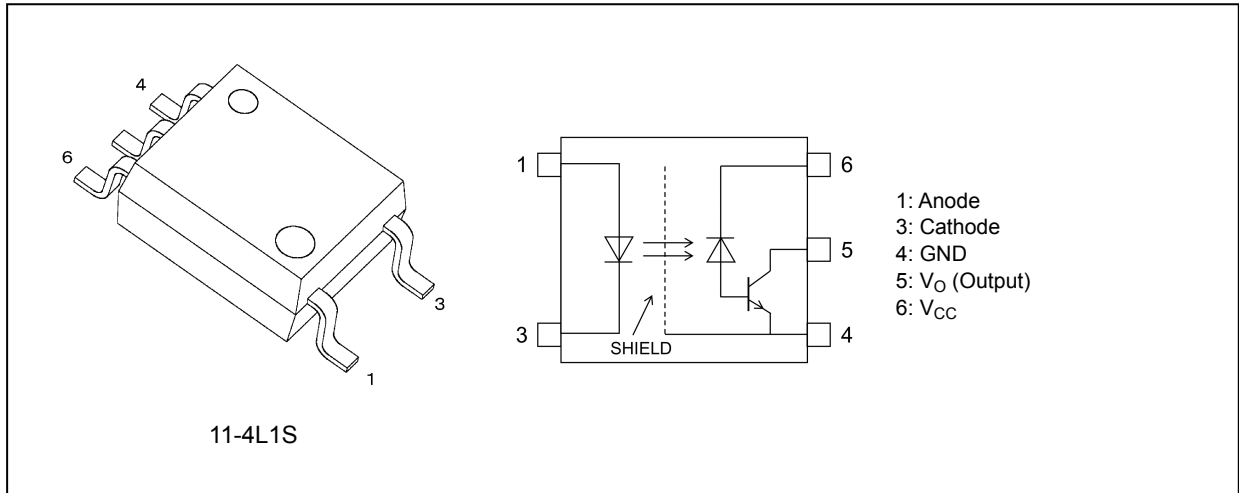


Can only be safely used in areas below 2000m above sea level.

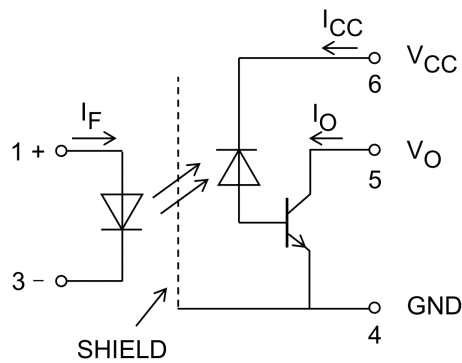
Note 1: When a VDE approved type is needed, please designate the **Option (V4)**.

Start of commercial production  
2011-04

## 4. Packaging and Pin Configuration



## 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	L
L	OFF	H

### 6.2. Mechanical Parameters

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

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

	Characteristics	Symbol	Note	Rating	Unit
LED	Input forward current	$I_F$		25	mA
	Input forward current derating ( $T_a \geq 100\text{ °C}$ )	$\Delta I_F/\Delta T_a$		-1.0	mA/°C
	Input forward current (pulsed)	$I_{FP}$	(Note 1)	50	mA
	Input forward current derating (pulsed) ( $T_a \geq 100\text{ °C}$ )	$\Delta I_{FP}/\Delta T_a$		-2.0	mA/°C
	Peak transient input forward current	$I_{FPT}$	(Note 2)	1	A
	Peak transient input forward current derating ( $T_a \geq 85\text{ °C}$ )	$\Delta I_{FPT}/\Delta T_a$		-25	mA/°C
	Input power dissipation	$P_D$		40	mW
	Input power dissipation derating ( $T_a \geq 100\text{ °C}$ )	$\Delta P_D/\Delta T_a$		-1.6	mW/°C
	Input reverse voltage	$V_R$		5	V
Detector	Output current	$I_O$		8	mA
	Peak output current	$I_{OP}$		16	
	Supply voltage	$V_{CC}$		-0.5 to 30	V
	Output voltage	$V_O$		-0.5 to 20	
	Output power dissipation	$P_O$		100	mW
	Output power dissipation derating ( $T_a \geq 100\text{ °C}$ )	$\Delta P_O/\Delta T_a$		-4.0	mW/°C
Common	Operating temperature	$T_{opr}$		-40 to 110	°C
	Storage temperature	$T_{stg}$		-55 to 125	
	Lead soldering temperature (10 s)	$T_{sol}$		260	
	Isolation voltage (AC, 60 s, R.H. $\leq 60\%$ )	$BV_S$	(Note 3)	3750	

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)  $\leq 1\text{ ms}$ , duty = 50 %

Note 2: Pulse width (PW)  $\leq 1\text{ }\mu\text{s}$ , 300 pps

Note 3: 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	$I_{F(ON)}$		10	—	20	mA
Input off-state voltage	$V_{F(OFF)}$		0	—	0.8	V
Supply voltage	$V_{CC}$		2.7	3.3 / 5	20	
Operating temperature	$T_{opr}$	(Note 1)	-40	—	110	°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  $\mu\text{F}$ ) 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: Denotes the operating range, not the recommended operating condition.

## 9. Electrical Characteristics (Note) (Unless otherwise specified, $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input forward voltage	$V_F$		$I_F = 10\text{ mA}$	1.45	1.55	1.7	V
Input forward voltage temperature coefficient	$\Delta V_F / \Delta T_a$		$I_F = 10\text{ mA}, T_a = -40\text{ }^\circ\text{C to } 110\text{ }^\circ\text{C}$	—	-2.0	—	mV/°C
Input reverse current	$I_R$		$V_R = 5\text{ V}$	—	—	10	$\mu\text{A}$
Input capacitance	$C_t$		$V = 0\text{ V}, f = 1\text{ MHz}$	—	60	—	pF
High-level output current	$I_{OH}$	Fig. 12.1.1	$I_F = 0\text{ mA}, V_O = 5.5\text{ V}, V_{CC} = 5.5\text{ V}$	—	3	500	nA
			$I_F = 0\text{ mA}, V_O = 20\text{ V}, V_{CC} = 30\text{ V}$	—	—	5	$\mu\text{A}$
			$I_F = 0\text{ mA}, V_O = 20\text{ V}, V_{CC} = 30\text{ V}, T_a = 110\text{ }^\circ\text{C}$	—	—	50	
Low-level output voltage	$V_{OL}$	Fig. 12.1.2	$I_F = 16\text{ mA}, V_{CC} = 4.5\text{ V}, I_O = 2.4\text{ mA}$	—	—	0.4	V
High-level supply current	$I_{CCH}$	Fig. 12.1.3	$I_F = 0\text{ mA}, V_{CC} = 30\text{ V}$	—	0.01	1	$\mu\text{A}$
Current transfer ratio	$I_O / I_F$	Fig. 12.1.4	$I_F = 10\text{ mA}, V_O = 0.4\text{ V}, V_{CC} = 3.3\text{ V}$	15	—	—	%
			$I_F = 16\text{ mA}, V_O = 0.4\text{ V}, V_{CC} = 4.5\text{ V}$	15	—	—	

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

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

Characteristics	Symbol	Note	Test Conditions	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)	$V_S = 500\text{ V}, R.H. \leq 60\%$	$10^{12}$	$10^{14}$	—	$\Omega$
Isolation voltage	$BV_S$	(Note 1)	AC, 60 s	3750	—	—	Vrms

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, $T_a = -40\text{ to } 110\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Note	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Propagation delay time (H/L)	$t_{pHL}$		Fig. 12.1.5	$I_F = 0 \rightarrow 10\text{ mA}, R_L = 1.9\text{ k}\Omega, V_{CC} = 3.3\text{ V}, C_L = 15\text{ pF}$	—	—	1	$\mu\text{s}$
Propagation delay time (L/H)	$t_{pLH}$			$I_F = 10 \rightarrow 0\text{ mA}, R_L = 1.9\text{ k}\Omega, V_{CC} = 3.3\text{ V}, C_L = 15\text{ pF}$	—	—	1	
Propagation delay time (H/L)	$t_{pHL}$		Fig. 12.1.5	$I_F = 0 \rightarrow 16\text{ mA}, R_L = 1.9\text{ k}\Omega, V_{CC} = 5\text{ V}, C_L = 15\text{ pF}$	—	—	0.8	
Propagation delay time (L/H)	$t_{pLH}$			$I_F = 16 \rightarrow 0\text{ mA}, R_L = 1.9\text{ k}\Omega, V_{CC} = 5\text{ V}, C_L = 15\text{ pF}$	—	—	0.8	
High-level common-mode transient immunity	$CM_H$	(Note 1)	Fig. 12.1.6	$I_F = 0\text{ mA}, V_{CC} = 3.3\text{ V} / 5\text{ V}, V_{CM} = 400\text{ V}_{p-p}, R_L = 4.1\text{ k}\Omega, T_a = 25\text{ }^\circ\text{C}$	15	20	—	kV/ $\mu\text{s}$
Low-level common-mode transient immunity	$CM_L$	(Note 1)		$I_F = 10\text{ mA}, V_{CC} = 3.3\text{ V} / 5\text{ V}, V_{CM} = 400\text{ V}_{p-p}, R_L = 4.1\text{ k}\Omega, T_a = 25\text{ }^\circ\text{C}$	-15	-20	—	

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

Note 1:  $CM_H$  is the maximum rate of rise of the common mode voltage that can be sustained with the output voltage in the logic high state ( $V_O > 2.0\text{ V}$ ).

$CM_L$  is the maximum rate of fall of the common mode voltage that can be sustained with the output voltage in the logic low state ( $V_O < 0.8\text{ V}$ ).

## 12. Test Circuits and Characteristics Curves

### 12.1. Test Circuits

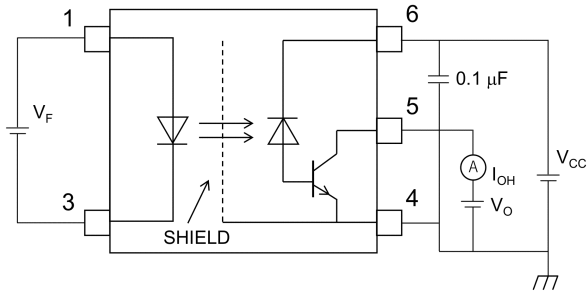


Fig. 12.1.1  $I_{OH}$  Test Circuit

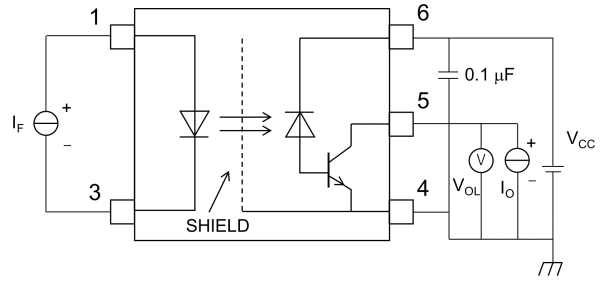


Fig. 12.1.2  $V_{OL}$  Test Circuit

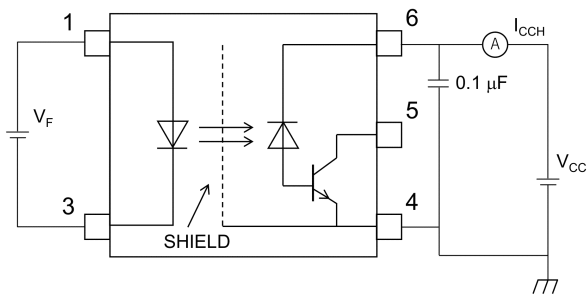


Fig. 12.1.3  $I_{CCH}$  Test Circuit

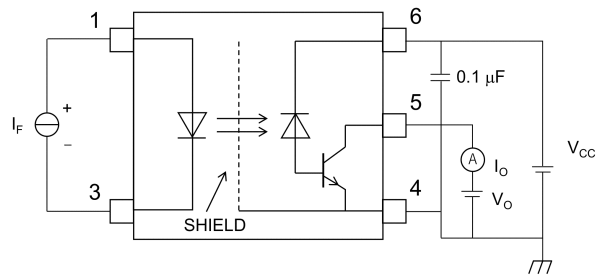
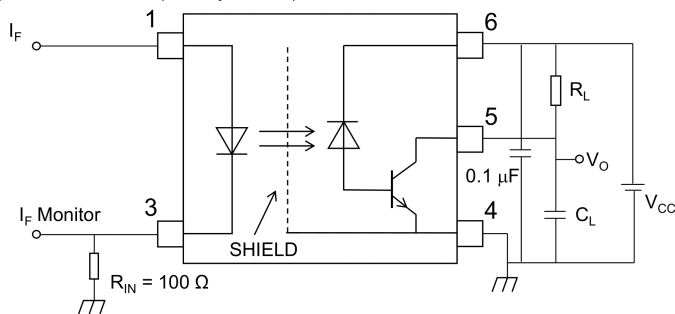


Fig. 12.1.4  $I_O$  Test Circuit

$I_F = 10 \text{ mA}$  (Pulse Generator)  
(Pulse Width = 100  $\mu\text{s}$ , duty = 10 %)



$C_L$  is less than 15 pF which includes probe and stray wiring capacitance.

Fig. 12.1.5 Switching Time Test Circuit and Waveform

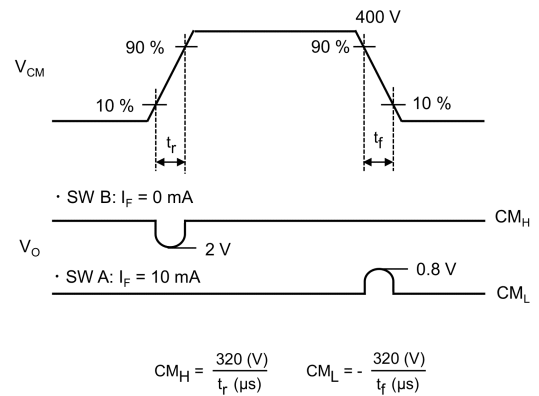
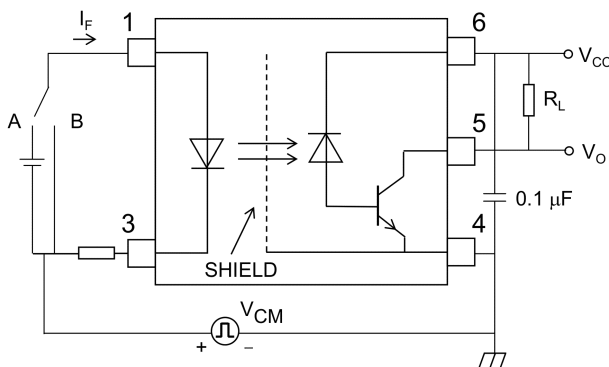


Fig. 12.1.6 Common-Mode Transient Immunity Test Circuit and Waveform

## 12.2. Characteristics Curves (Note)

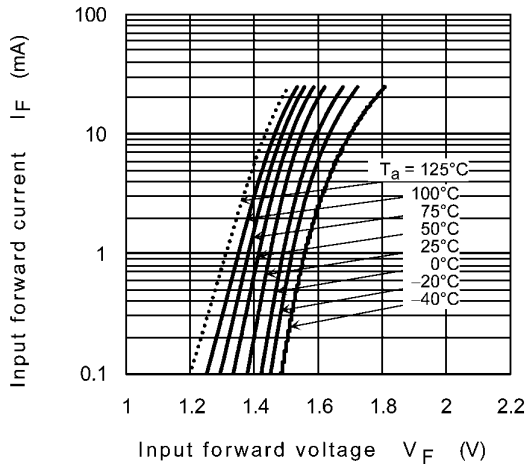


Fig. 12.2.1  $I_F - V_F$

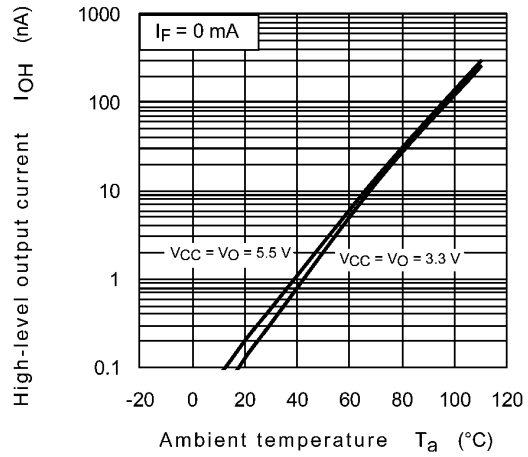


Fig. 12.2.2  $I_{OH} - T_a$

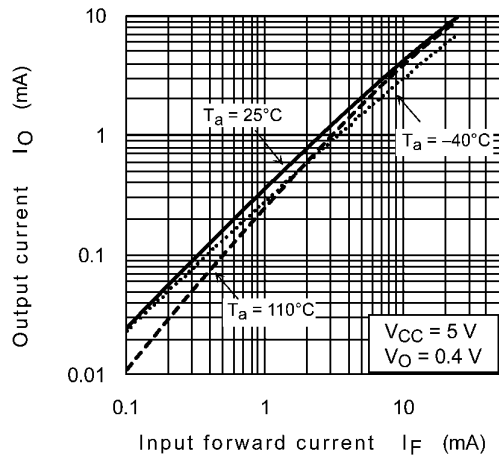


Fig. 12.2.3  $I_O - I_F$

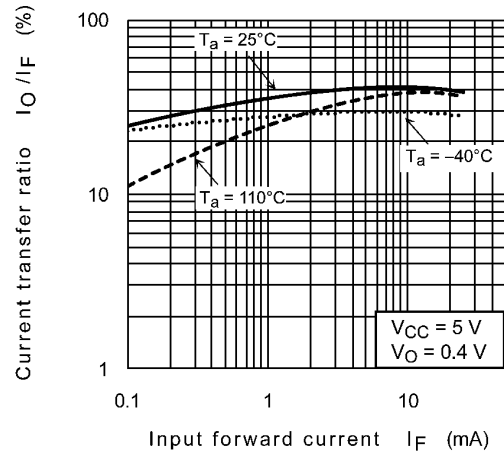


Fig. 12.2.4  $I_O/I_F - I_F$

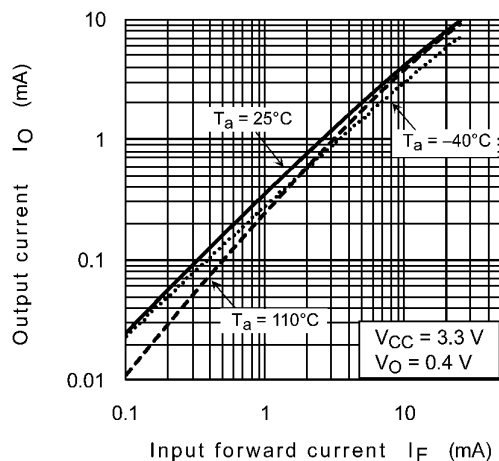


Fig. 12.2.5  $I_O - I_F$

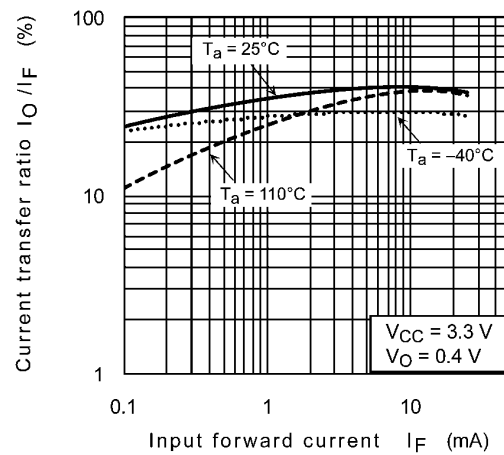


Fig. 12.2.6  $I_O/I_F - I_F$

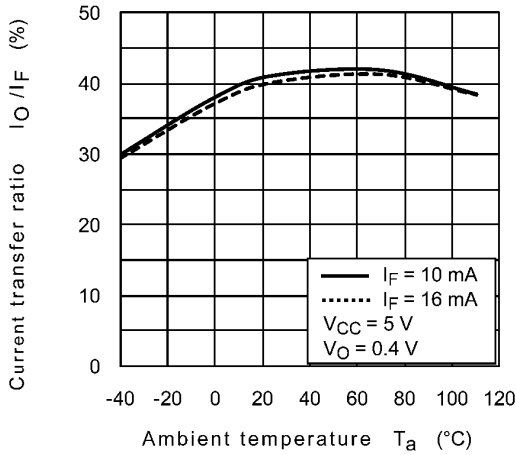


Fig. 12.2.7  $I_O/I_F - T_a$

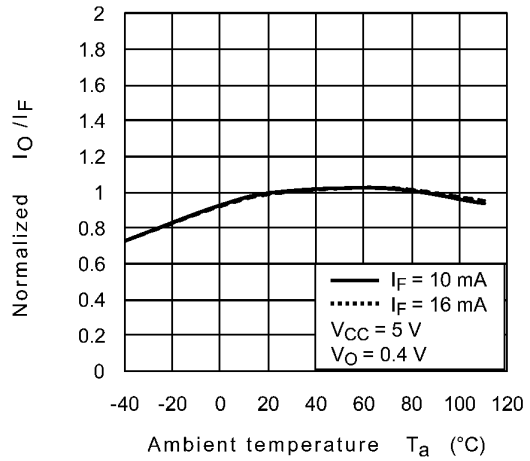


Fig. 12.2.8  $I_O/I_F - T_a$

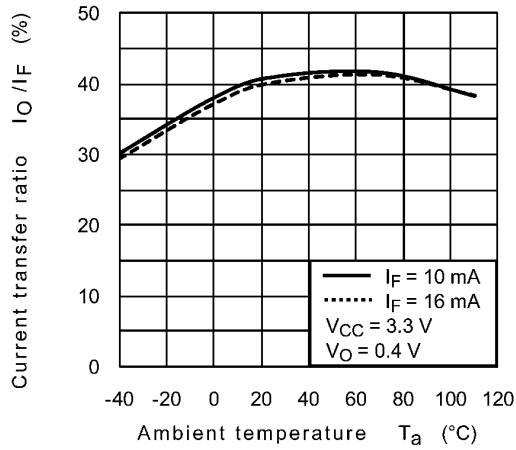


Fig. 12.2.9  $I_O/I_F - T_a$

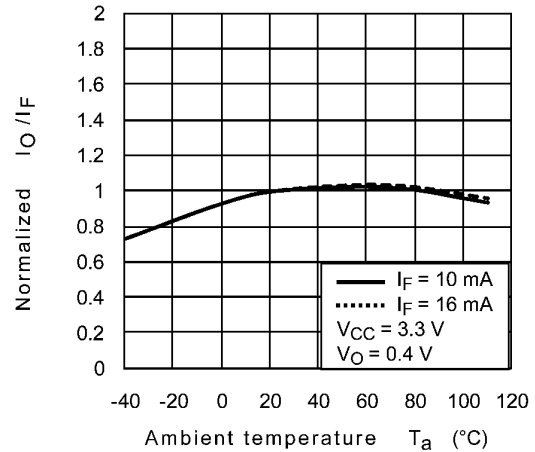


Fig. 12.2.10  $I_O/I_F - T_a$

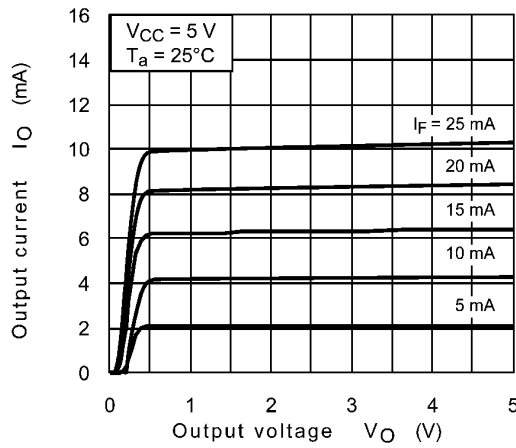


Fig. 12.2.11  $I_O - V_O$

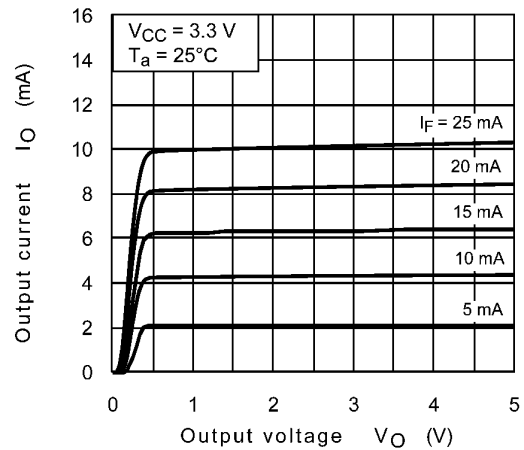


Fig. 12.2.12  $I_O - V_O$

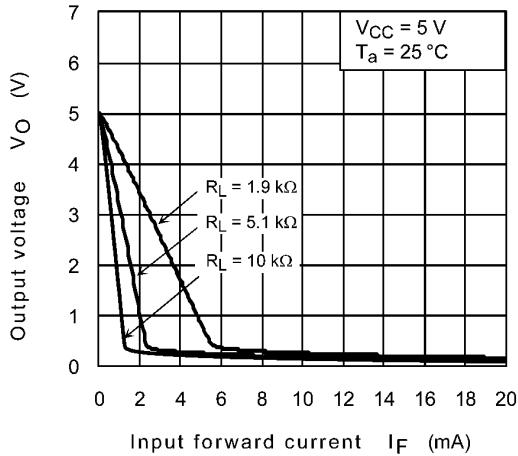


Fig. 12.2.13  $V_O - I_F$

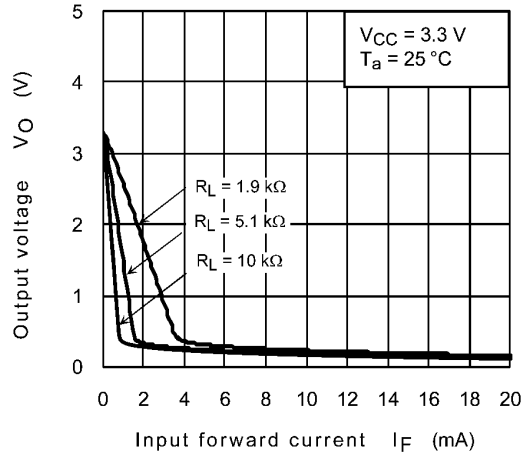


Fig. 12.2.14  $V_O - I_F$

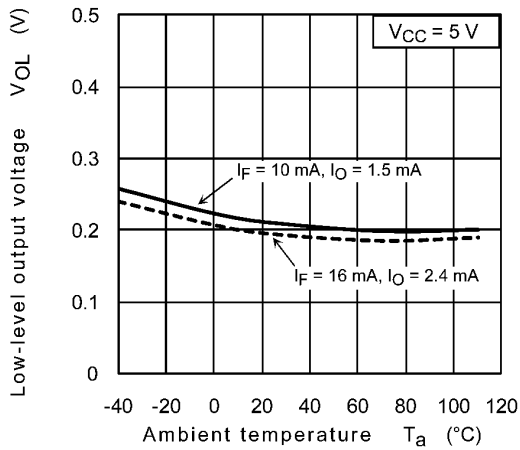


Fig. 12.2.15  $V_{OL} - T_a$

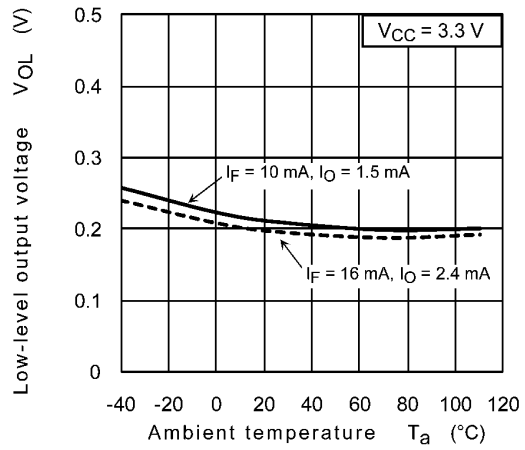


Fig. 12.2.16  $V_{OL} - T_a$

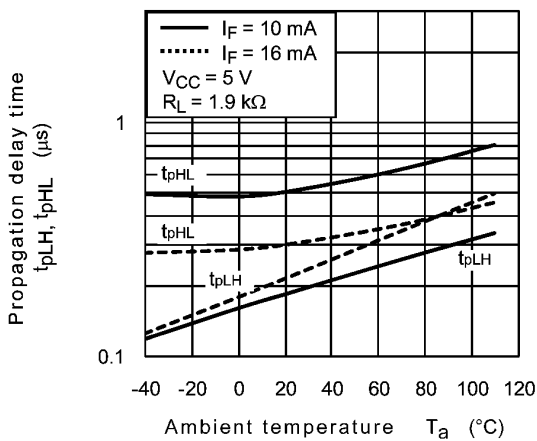


Fig. 12.2.17  $t_{pLH}, t_{pHL} - T_a$

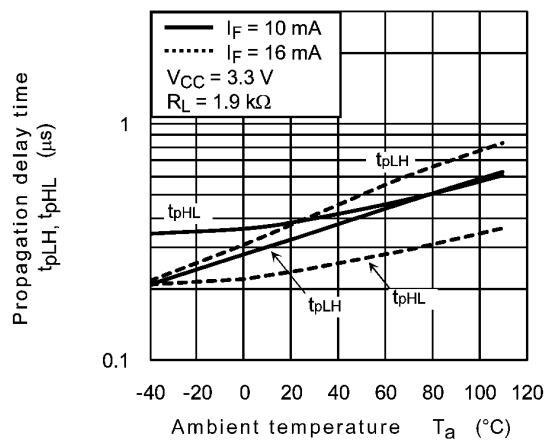
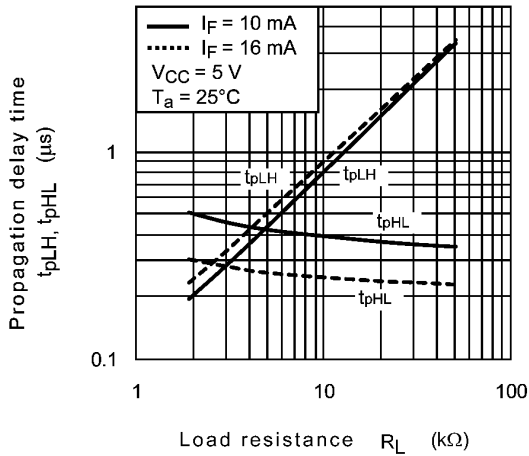
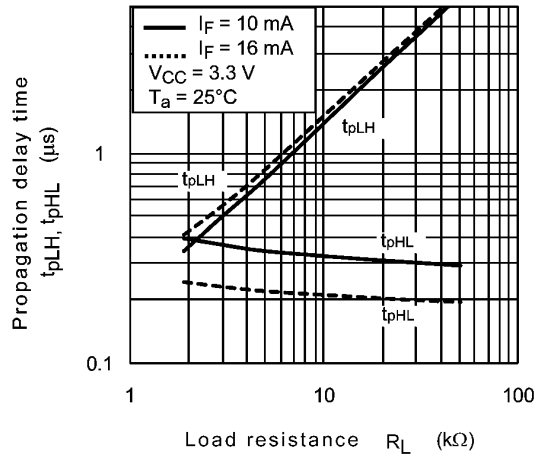


Fig. 12.2.18  $t_{pLH}, t_{pHL} - T_a$



**Fig. 12.2.19**  $t_{pLH}$ ,  $t_{pHL}$  -  $R_L$



**Fig. 12.2.20**  $t_{pLH}$ ,  $t_{pHL}$  -  $R_L$

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.

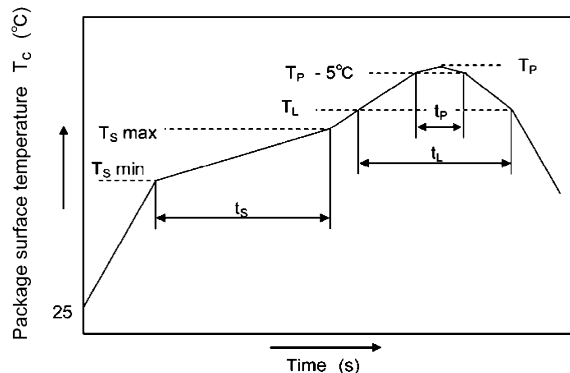
- When using soldering reflow.

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

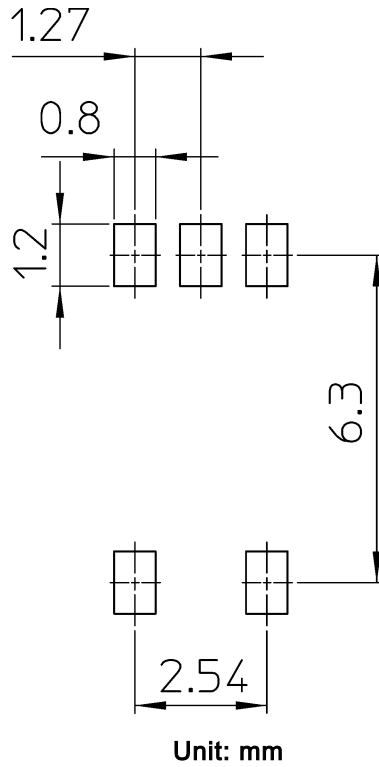
**An Example of a Temperature Profile When Lead(Pb)-Free Solder Is Used**

- 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.

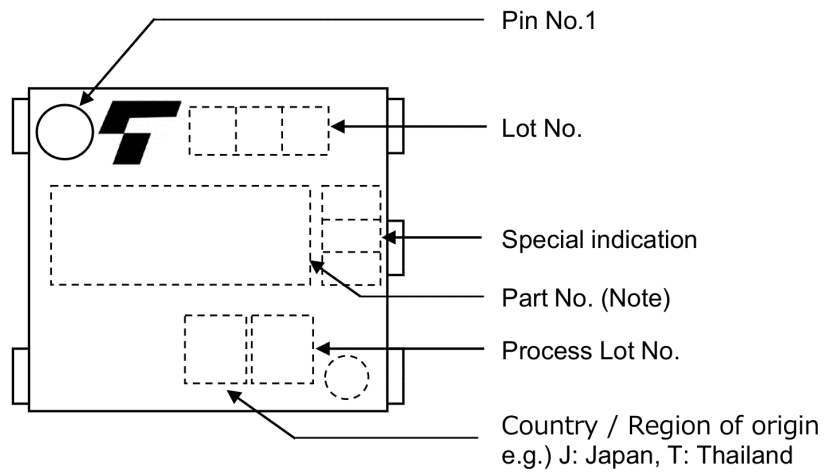
### 13.2. Precautions for General Storage

- 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 devices in locations with poisonous gases (especially corrosive gases) or in dusty conditions.
- Store the devices 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.

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



## 15. Marking



Note: P2309(Abbreviation code)

## 16. EN IEC 60747-5-5 Option (V4) Specification

- Part number: TLP2309 (Note 1)
- The following part naming conventions are used for the devices that have been qualified according to option (V4) of EN IEC 60747.

Example: TLP2309(V4-TPL,E)

V4: EN IEC 60747 option

TPL: Tape type

E: [[G]]/RoHS COMPATIBLE (Note 2)

Note 1: Use TOSHIBA standard type number for safety standard application.

e.g., TLP2309(V4-TPL,E → TLP2309

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 $\leq 150$ Vrms for rated mains voltage $\leq 300$ Vrms		I-IV I-III	—
Climatic classification		40 / 110 / 21	—
Pollution degree		2	—
Maximum operating insulation voltage	VIORM	707	Vpeak
Input to output test voltage, Method A $V_{pr} = 1.6 \times VIORM$ , type and sample test $t_p = 1$ s, partial discharge $< 5$ pC	Vpr	1131	Vpeak
Input to output test voltage, Method B $V_{pr} = 1.875 \times VIORM$ , 100 % production test $t_p = 10$ s, partial discharge $< 5$ pC	Vpr	1325	Vpeak
Highest permissible overvoltage (transient overvoltage, $t_{pr} = 60$ s)	VTR	6000	Vpeak
Safety limiting values (max. permissible ratings in case of fault, also refer to thermal derating curve) current (input current $I_F$ , $P_{so} = 0$ ) power (output or total power dissipation) temperature	$I_{si}$ $P_{so}$ $T_s$	250 400 150	mA mW °C
Insulation resistance $V_{IO} = 500$ V, $T_a = 25$ °C $V_{IO} = 500$ V, $T_a = 100$ °C $V_{IO} = 500$ V, $T_a = T_s$	Rsi	$\geq 10^{12}$ $\geq 10^{11}$ $\geq 10^9$	$\Omega$

Fig. 16.1 EN IEC 60747 Isolation Characteristics

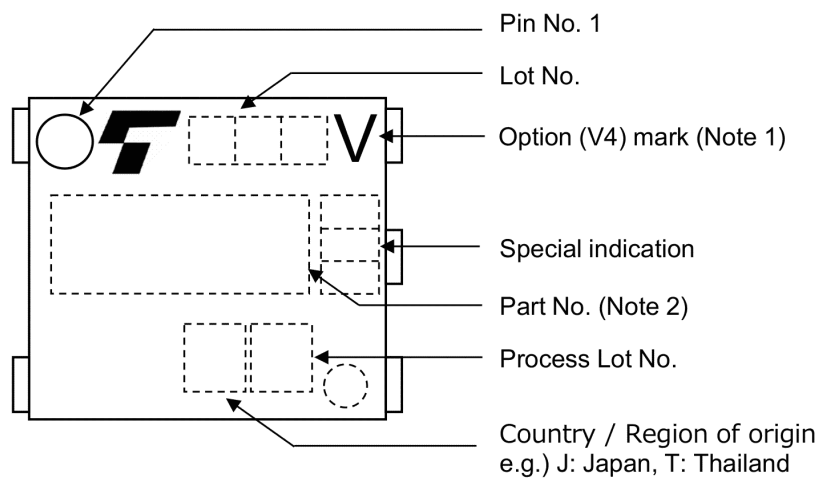
Minimum creepage distance	Cr	5.0 mm
Minimum clearance	Cl	5.0 mm
Minimum insulation thickness	ti	0.4 mm
Comparative tracking index	CTI	500

**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)**

Note1: The above marking is applied to the photocouplers that have been qualified according to option (V4) of EN IEC 60747.

Note2: P2309(Abbreviation code)

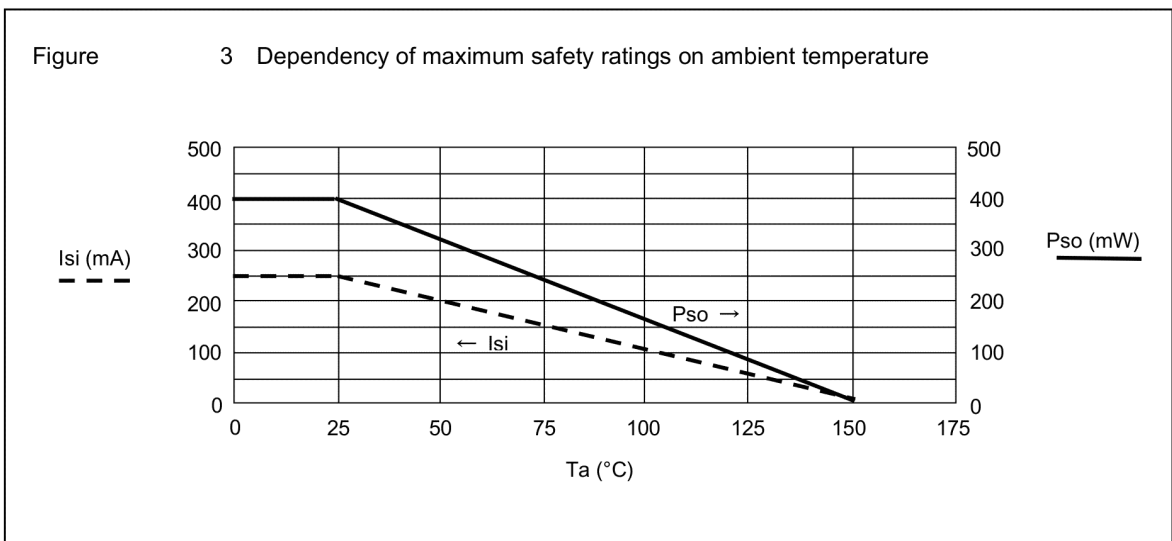
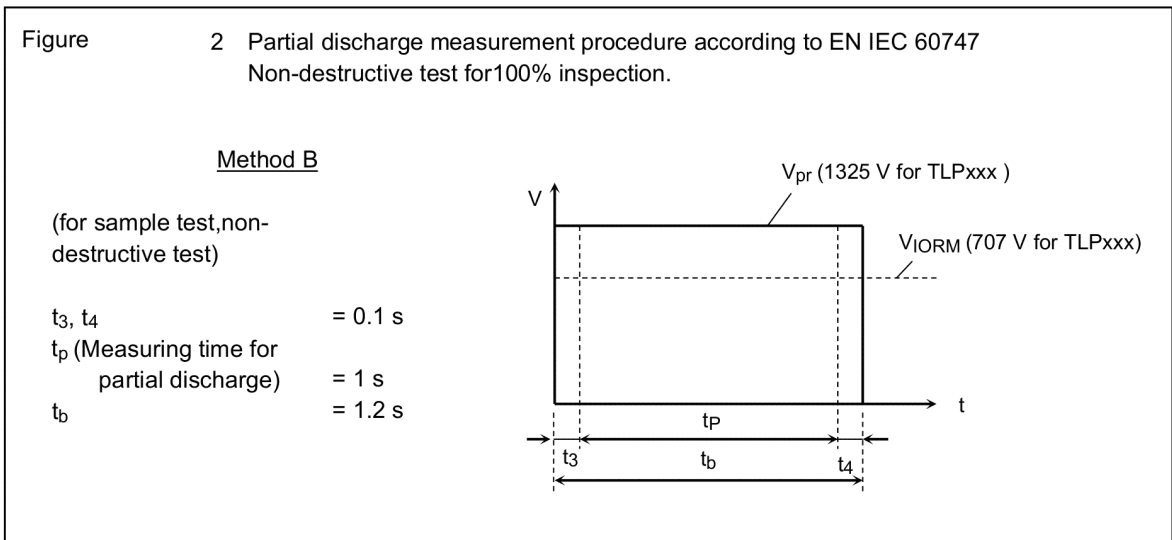
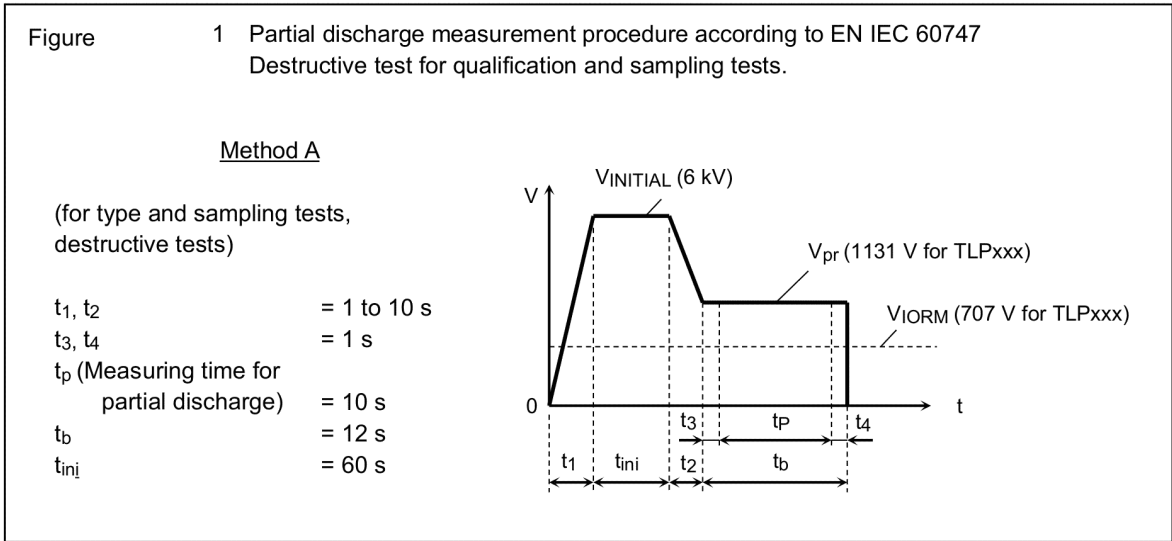


Fig. 16.5 Measurement Procedure

## 17. Ordering Information

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

Example) TLP2309(TPL,E 3000 pcs

Part number: TLP2309

Tape type: TPL

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

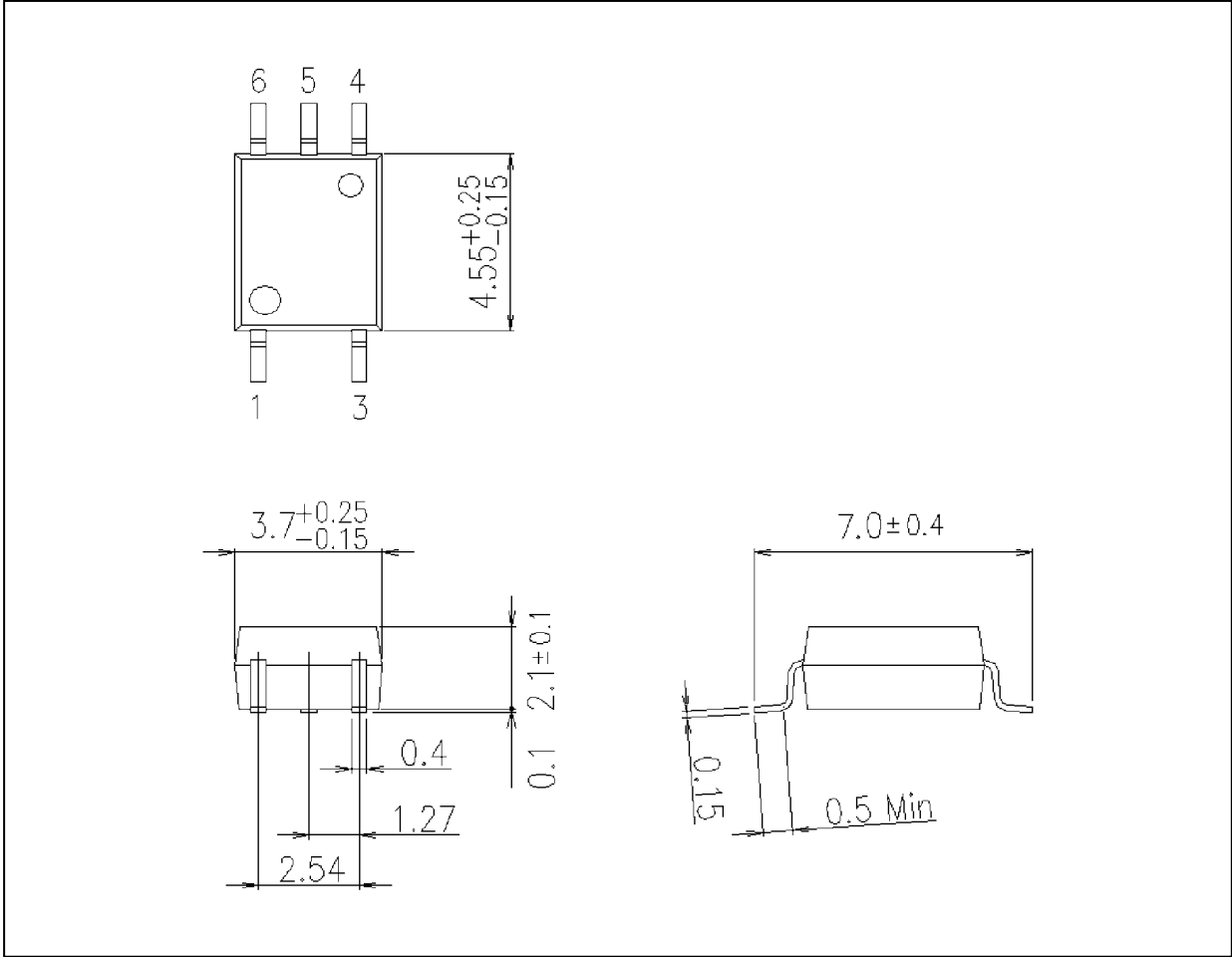
Quantity (must be a multiple of 3000): 3000 pcs

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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