Photocouplers Infrared LED & Photo IC

# TLP2301

## 1. Applications

- Industrial Inverters
- Communications Equipment
- Home Electric Appliances

## 2. General

The Toshiba TLP2301 consists of a high-speed detector based on the photo-transistor optically coupled to infrared LED. It is housed in the SO6 package. The TLP2301 has realized the early switching characteristics by several kΩ resistance. The TLP2301 correspond to the transmission rate of 20 kbps, and has become a product which fills between a general-purpose transistor coupler and IC couplers corresponding to 1 Mbps.

## 3. Features

(1) Collector-emitter voltage: 40 V (min)

(2) Current transfer ratio: 50% (min) (@$I_F$ = 1 mA, $V_{CE}$ = 5 V)
GB Rank: 100% (min) (@$I_F$ = 1 mA, $V_{CE}$ = 5 V)

(3) Isolation voltage: 3750 Vrms (min)

(4) Propagation delay time: $t_{pHL}$ = 30 μs (max), $t_{pLH}$ = 30 μs (max) @ $I_F$ = 1 mA, $R_L$ = 10 kΩ, $T_a$ = 25 °C

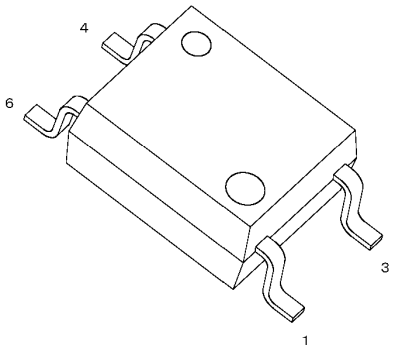
(5) Operating temperature: -55 to 125 °C

(6) 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 Japan and Thailand Factory

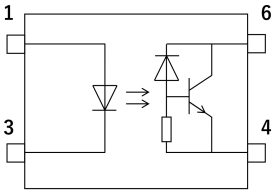
Can only be safely used in areas below 2000m above sea level.

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

## 4. Packaging and Pin Assignment




11-4M1S




1: Anode
3: Cathode
4: Emitter
6: Collector

Start of commercial production
2013-03

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# 5. Principle of Operation

## 5.1. Mechanical Parameters

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

# 6. Absolute Maximum Ratings (Note) (Unless otherwise specified, $T_a$ = 25 °C)

| | Characteristics | | Symbol | Note | Rating | Unit |
|---|---|---|---|---|---|---|
| LED | Input forward current | | $I_F$ | | 50 | mA |
| | Input forward current derating | ($T_a \geq 90$ °C) | $\Delta I_F/\Delta T_a$ | | -1.11 | mA/°C |
| | Input forward current (pulsed) | | $I_{FP}$ | (Note 1) | 1 | A |
| | Input reverse voltage | | $V_R$ | | 5 | V |
| | Input power dissipation | | $P_D$ | | 100 | mW |
| | Input power dissipation derating | ($T_a \geq 90$ °C) | $\Delta P_D/\Delta T_a$ | | -2.22 | mW/°C |
| | Junction temperature | | $T_j$ | | 135 | °C |
| Detector | Collector-emitter voltage | | $V_{CEO}$ | | 40 | V |
| | Emitter-collector voltage | | $V_{ECO}$ | | 7 | V |
| | Collector current | | $I_C$ | | 50 | mA |
| | Collector power dissipation | | $P_C$ | | 150 | mW |
| | Collector power dissipation derating | ($T_a \geq 25$ °C) | $\Delta P_C/\Delta T_a$ | | -1.36 | mW/°C |
| | Junction temperature | | $T_j$ | | 135 | °C |
| Common | Operating temperature | | $T_{opr}$ | | -55 to 125 | |
| | Storage temperature | | $T_{stg}$ | | -55 to 125 | |
| | Lead soldering temperature | (10 s) | $T_{sol}$ | | 260 | °C |
| | Total power dissipation | | $P_T$ | | 200 | mW |
| Common | Isolation voltage | AC, 60 s, R.H. ≤ 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) ≤ 0.1 ms, f = 100 Hz

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

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## 7. Electrical Characteristics (Unless otherwise specified, $T_a$ = 25 °C)

| | Characteristics | Symbol | Note | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| LED | Input forward voltage | $V_F$ | | $I_F$ = 10 mA | 1.1 | 1.25 | 1.4 | V |
| | Input reverse current | $I_R$ | | $V_R$ = 5 V | — | — | 10 | μA |
| | Input capacitance | $C_t$ | | V = 0 V, f = 1 MHz | — | 30 | — | pF |
| Detector | Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | | $I_C$ = 0.1 mA | 40 | — | — | V |
| | Emitter-collector breakdown voltage | $V_{(BR)ECO}$ | | $I_E$ = 0.1 mA | 7 | — | — | |
| | Dark Current | $I_{DARK}$ | | $V_{CE}$ = 40 V | — | 0.01 | 0.08 | μA |
| | | | | $V_{CE}$ = 40 V, $T_a$ = 85 °C | — | 2 | 50 | |
| | Collector-emitter capacitance | $C_{CE}$ | | V = 0 V, f = 1 MHz | — | 10 | — | pF |

## 8. Coupled Electrical Characteristics (Unless otherwise specified, $T_a$ = 25 °C)

| Characteristics | Symbol | Note | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Current transfer ratio | $I_C/I_F$ | (Note1) | $I_F$ = 1 mA, $V_{CE}$ = 5 V, Blank Rank | 50 | — | 600 | % |
| | | | $I_F$ = 1 mA, $V_{CE}$ = 5 V, GB Rank | 100 | — | 600 | |
| Saturated current transfer ratio | $I_C/I_{F(sat)}$ | | $I_F$ = 1 mA, $V_{CE}$ = 0.3 V | — | 100 | — | |
| | | | $I_F$ = 1 mA, $V_{CE}$ = 0.3 V, GB Rank | 50 | — | — | |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | $I_C$ = 2.4 mA, $I_F$ = 8 mA | — | — | 0.3 | V |
| | | | $I_C$ = 0.2 mA, $I_F$ = 1 mA | — | 0.2 | — | |
| | | | $I_C$ = 0.2 mA, $I_F$ = 1 mA, GB Rank | — | — | 0.3 | |
| OFF-state collector current | $I_{C(off)}$ | | $V_F$ = 0.7 V, $V_{CE}$ = 40 V | — | 1 | 10 | μA |

Note1: See Table 8.1 for current transfer ratio.

**Table 8.1 Current Transfer Ratio (CTR) Rank (Note) (Unless otherwise specified, $T_a$ = 25 °C)**

| Rank | Test Condition | Current transfer ratio $I_C/I_F$ Min | Current transfer ratio $I_C/I_F$ Max | Marking of classification | Unit |
|---|---|---|---|---|---|
| Blank | $I_F$ = 1 mA, $V_{CE}$ = 5 V | 50 | 600 | Blank, GB | % |
| GB | | 100 | 600 | GB | |

Note: Specify both the part number and a rank in this format when ordering.
Example: TLP2301(GB)
For safety standard certification, however, specify the part number alone.
Example: TLP2301(GB,E: TLP2301

## 9. 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% | $10^{12}$ | $10^{14}$ | — | Ω |
| Isolation voltage | $BV_S$ | (Note 1) | AC, 60 s | 3750 | — | — | Vrms |

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

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## 10. Switching Characteristics (Unless otherwise specified, $T_a$ = 25 °C)

| Characteristics | Symbol | Note | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Propagation delay time (H/L) | $t_{pHL}$ | | See figure 10.1<br>$V_{CC}$ = 5 V, $I_F$ = 1 mA, $R_L$ = 10 kΩ | — | 8 | 30 | μs |
| Propagation delay time (L/H) | $t_{pLH}$ | | See figure 10.1<br>$V_{CC}$ = 5 V, $I_F$ = 1 mA, $R_L$ = 10 kΩ | — | 15 | 30 | μs |

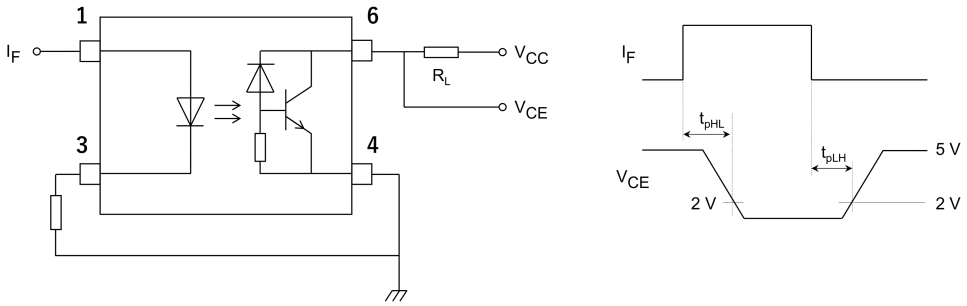



**Fig. 10.1 Propagation delay Time Test Circuit and Waveform**

## 11. Characteristics Curves (Note)

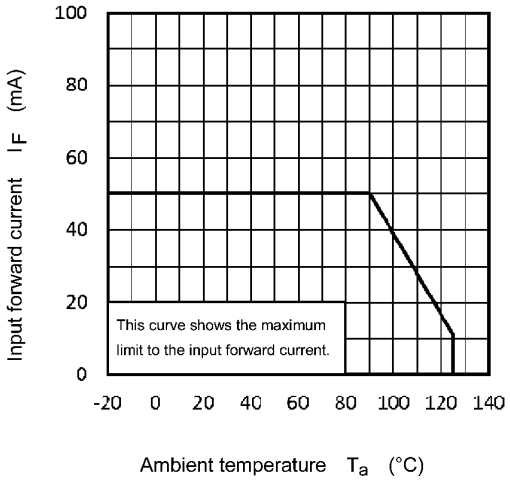



**Fig. 11.1 $I_F$ - $T_a$**

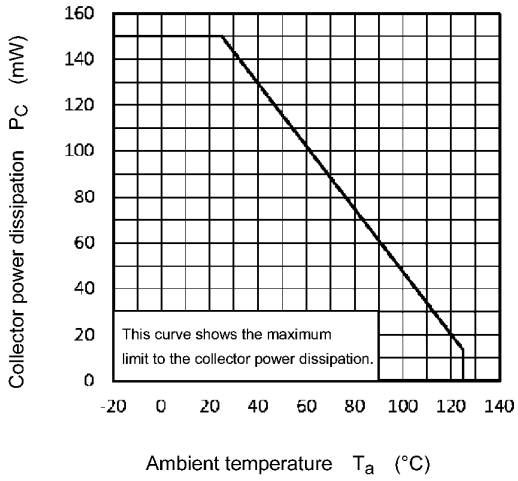



**Fig. 11.2 $P_C$ - $T_a$**

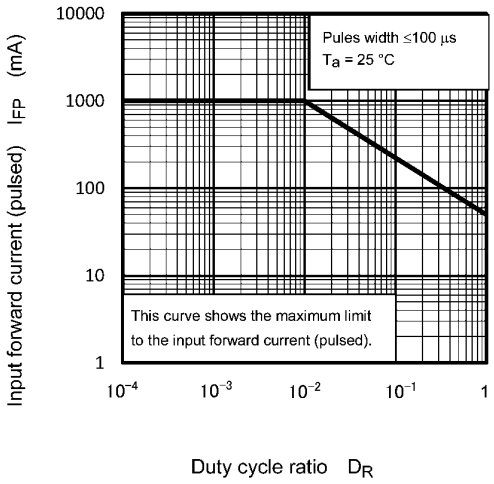



**Fig. 11.3 $I_{FP}$ - $D_R$**

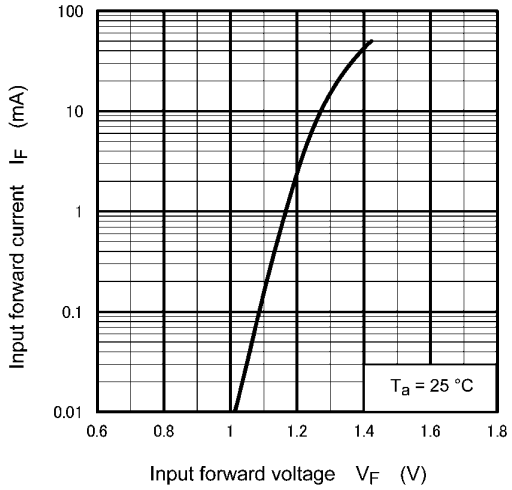



**Fig. 11.4 $I_F$ - $V_F$**

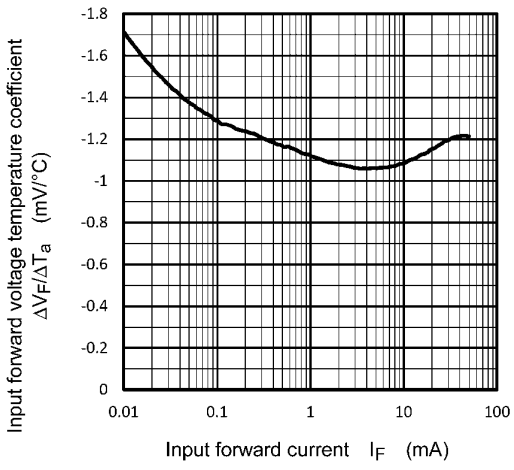



**Fig. 11.5 $\Delta V_F/\Delta T_a$ - $I_F$**

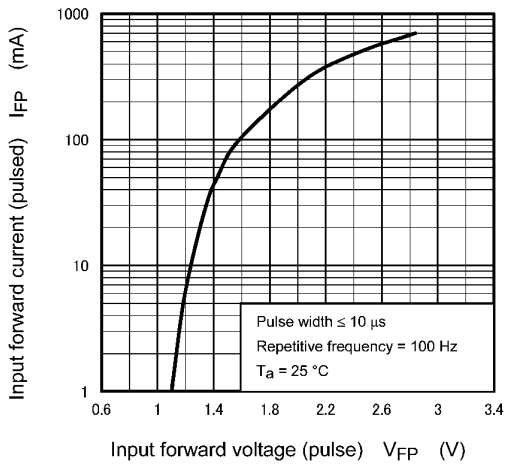



**Fig. 11.6 $I_{FP}$ - $V_{FP}$**

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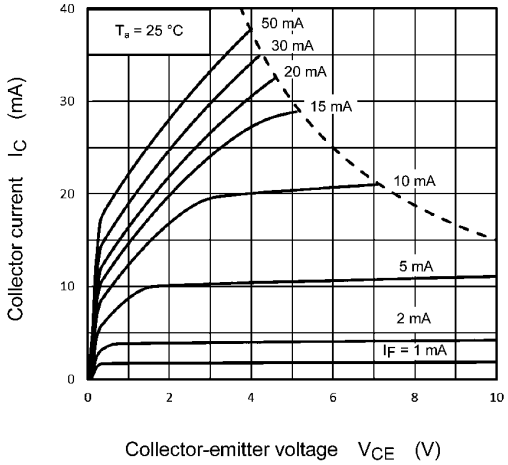



Fig. 11.7 $I_C$ - $V_{CE}$

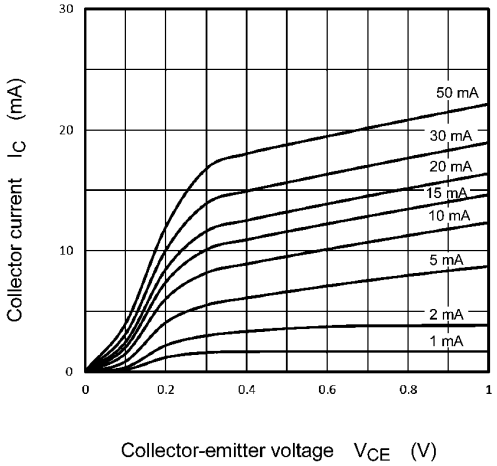



Fig. 11.8 $I_C$ - $V_{CE}$

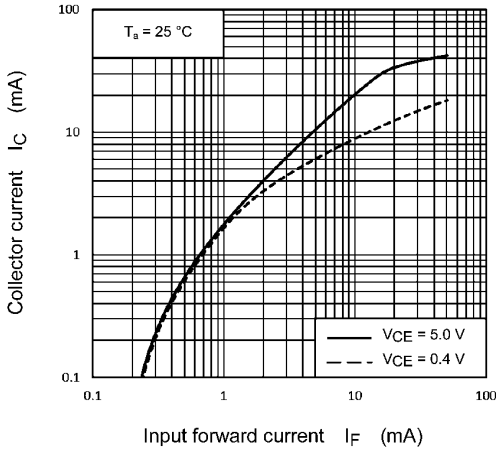



Fig. 11.9 $I_C$ - $I_F$

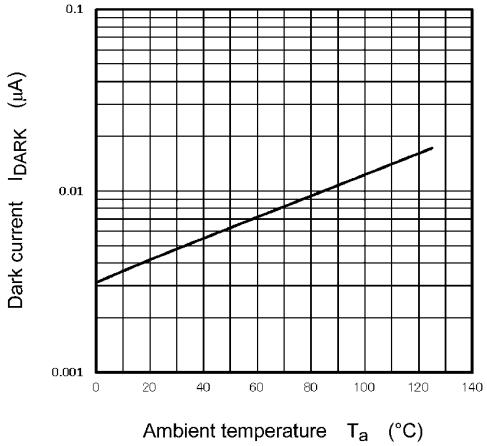



Fig. 11.10 $I_{DARK}$ - $T_a$

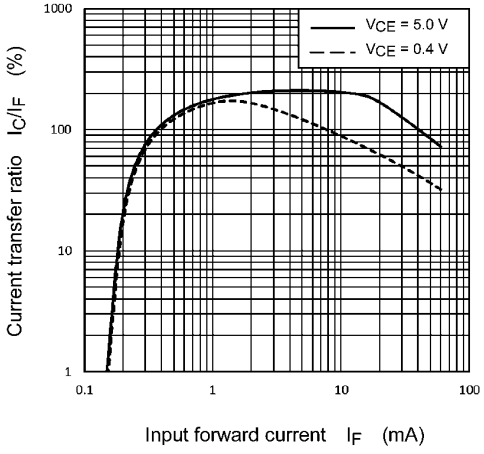



Fig. 11.11 $I_C/I_F$ - $I_F$

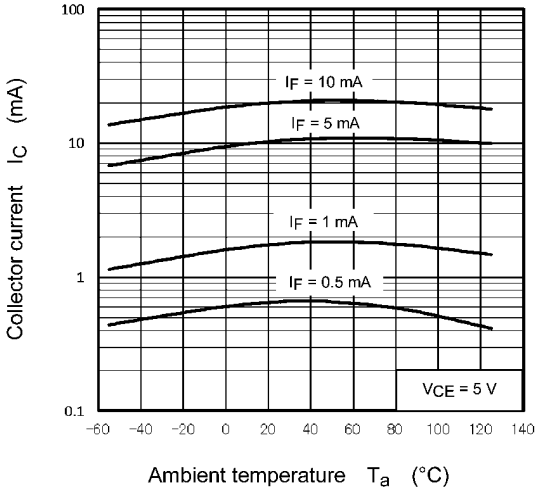



Fig. 11.12 $I_C$ - $T_a$

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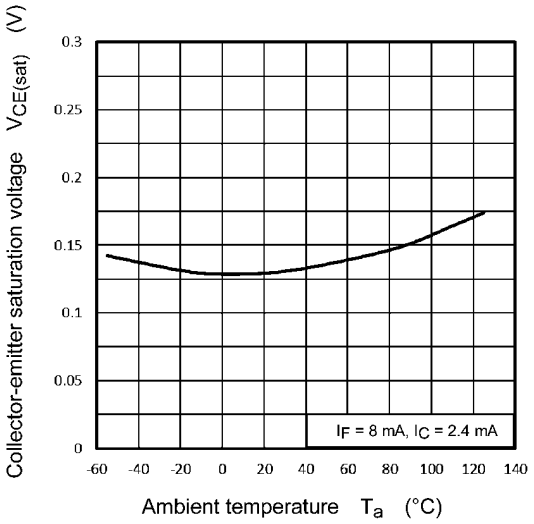



**Fig. 11.13 $V_{CE(sat)}$ - $T_a$**

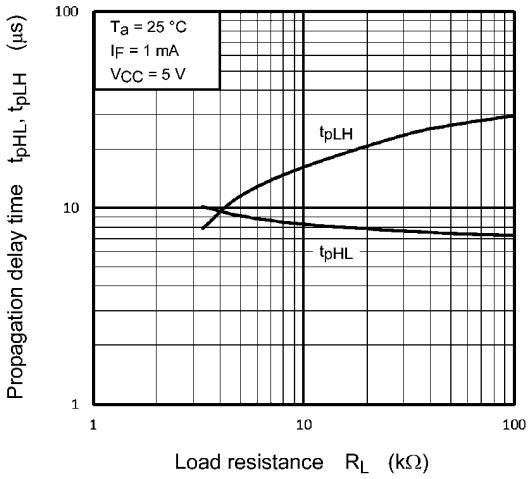



**Fig. 11.14 $t_{pHL}$,$t_{pLH}$ - $R_L$**

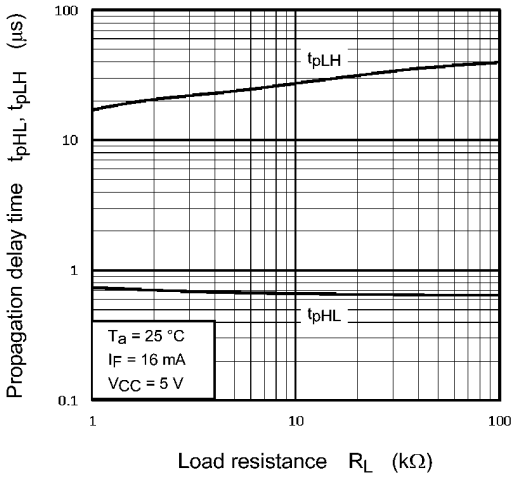



**Fig. 11.15 $t_{pHL}$,$t_{pLH}$ - $R_L$**

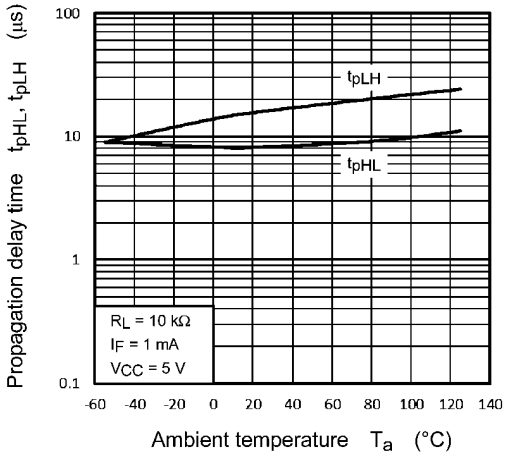



**Fig. 11.16 $t_{pHL}$,$t_{pLH}$ - $T_a$**

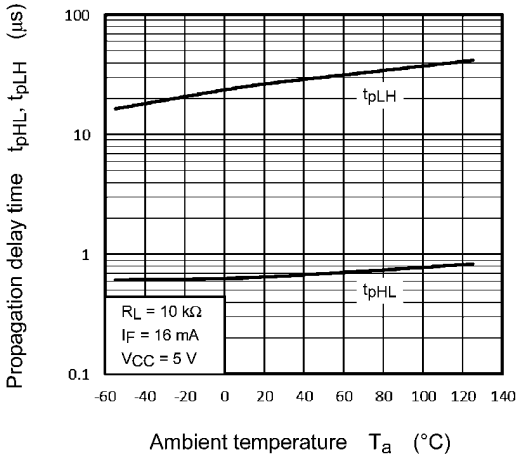



**Fig. 11.17 $t_{pHL}$,$t_{pLH}$ - $T_a$**

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

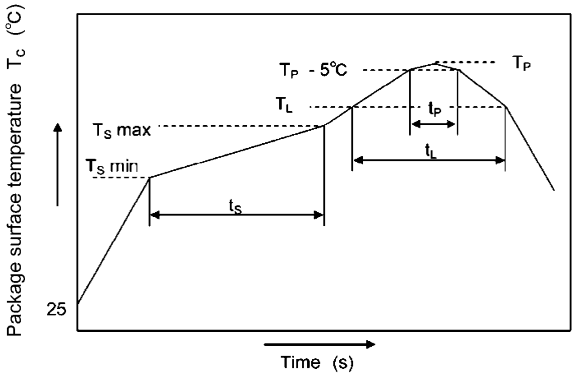
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# 12. Soldering and Storage

## 12.1. 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.

## 12.2. 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.

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## 13. Marking

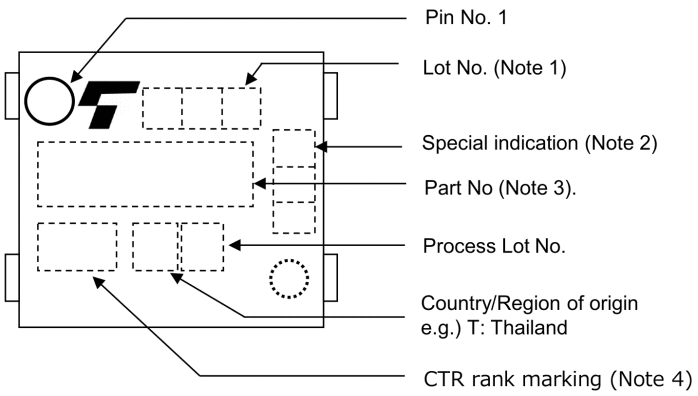



**Fig. 13.1 Marking Example**

Note 1: If the lot number is expressed with three characters, it indicates "manufacturing year (1 character) + manufacturing week (2 characters)".
For example, if the lot number shown on the product is "841", it means the product was manufactured in the 41st week of a year ending in 8.

Note 2: Special indication is put for the traceability enhancement.
Information of special indication
e.g. A01
A: Factory administration number
01: A counting of the number is started on every week from 01.
and reset when Lot No or weekly code is changed.

Note 3: P2301 (Abbreviation code)

Note 4: For the CTR rank mark, please refer to the marking of classification in table 8.1 CTR rank table.

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

- Part number: TLP2301 **(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: TLP2301(V4GBTL,E

  V4: EN IEC 60747 option
  GB: CTR rank
  TL: Tape type
  E: [[G]]/RoHS COMPATIBLE **(Note 2)**

Note 1: Use TOSHIBA standard type number for safety standard application.
e.g., TLP2301(V4GBTL,E → TLP2301

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<br><br>for rated mains voltage ≤ 150 Vrms<br>for rated mains voltage ≤ 300 Vrms | | <br><br>I-IV<br>I-III | — |
| Climatic classification | | 55 / 125 / 21 | — |
| Pollution degree | | 2 | — |
| Maximum operating insulation voltage | $V_{IORM}$ | 707 | Vpeak |
| Input to output test voltage, Method A<br>$V_{pr}$ = 1.6 × $V_{IORM}$, type and sample test<br>$t_p$ = 10 s, partial discharge < 5 pC | $V_{pr}$ | 1131 | Vpeak |
| Input to output test voltage, Method B<br>$V_{pr}$ =1.875 × $V_{IORM}$, 100 % production test<br>$t_p$ = 1 s, partial discharge < 5 pC | $V_{pr}$ | 1330 | Vpeak |
| Highest permissible overvoltage<br>(transient overvoltage, $t_{pr}$ = 60 s) | $V_{TR}$ | 6000 | Vpeak |
| Safety limiting values (max. permissible ratings in case of fault,<br>also refer to thermal derating curve)<br>current (input current $I_F$, $P_{so}$ = 0)<br>power (output or total power dissipation)<br>temperature | <br><br>$I_{si}$<br>$P_{so}$<br>$T_s$ | <br><br>250<br>400<br>150 | <br><br>mA<br>mW<br>°C |
| Insulation resistance<br><br><br> | $V_{IO}$ = 500 V, $T_a$ = 25 °C<br>$V_{IO}$ = 500 V, $T_a$ = 100 °C<br>$V_{IO}$ = 500 V, $T_a$ = $T_s$ | $R_{si}$ | ≥ $10^{12}$<br>≥ $10^{11}$<br>≥ $10^9$ | Ω |

**Fig. 14.1 EN IEC 60747 Insulation Characteristics**

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| | | |
|---|---|---|
| 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. 14.2 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. 14.3 Marking on Packing for EN IEC 60747**

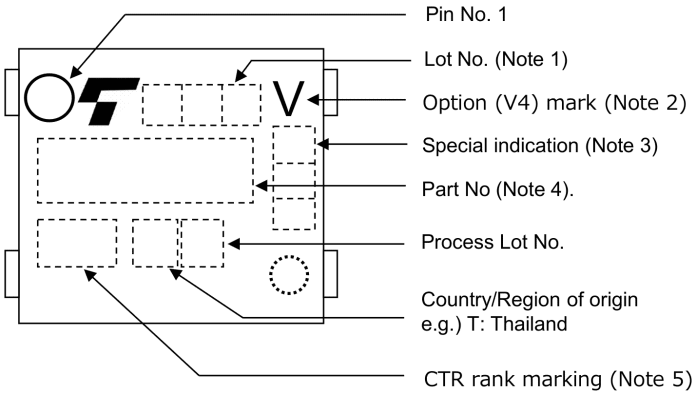



**Fig. 14.4 Marking Example**

Note 1: If the lot number is expressed with three characters, it indicates "manufacturing year (1 character) + manufacturing week (2 characters)".
For example, if the lot number shown on the product is "841", it means the product was manufactured in the 41st week of a year ending in 8.

Note 2: The above marking is applied to the photocouplers that have been qualified according to option (V4) of EN IEC 60747.

Note 3: Special indication is put for the traceability enhancement.
Information of special indication
e.g. A01
A: Factory administration number
01: A counting of the number is started on every week from 01.
and reset when Lot No or weekly code is changed.

Note 4: P2301 (Abbreviation code)

Note 5: For the CTR rank mark, please refer to the marking of classification in table 8.1 CTR rank table.

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Figure 1 Partial discharge measurement procedure according to EN IEC 60747
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 |

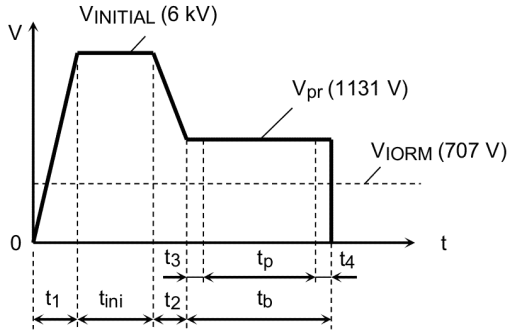



Figure 2 Partial discharge measurement procedure according to EN IEC 60747
Non-destructive test for 100 % inspection.

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 |

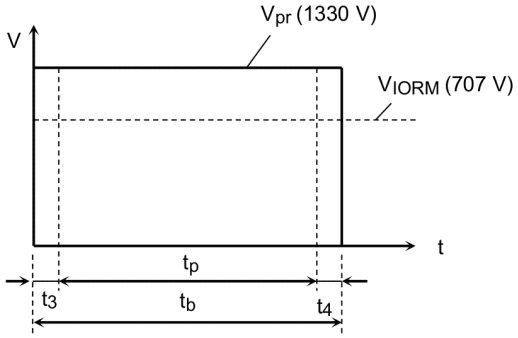



Figure 3 Dependency of maximum safety ratings on ambient temperature

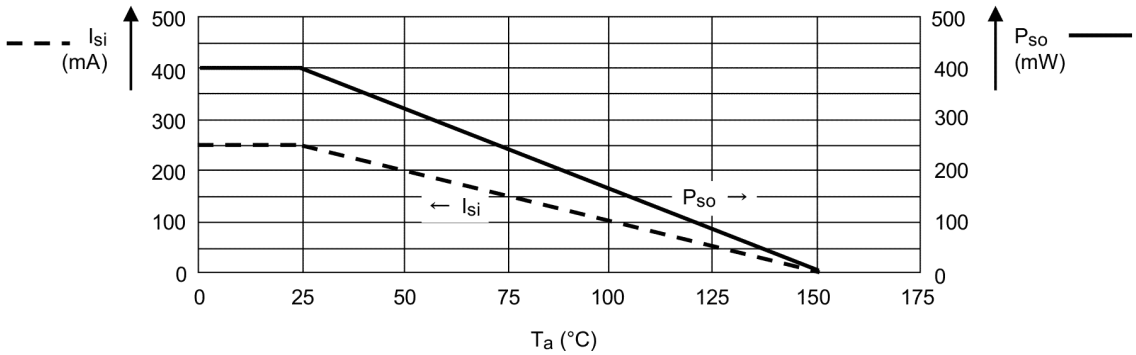
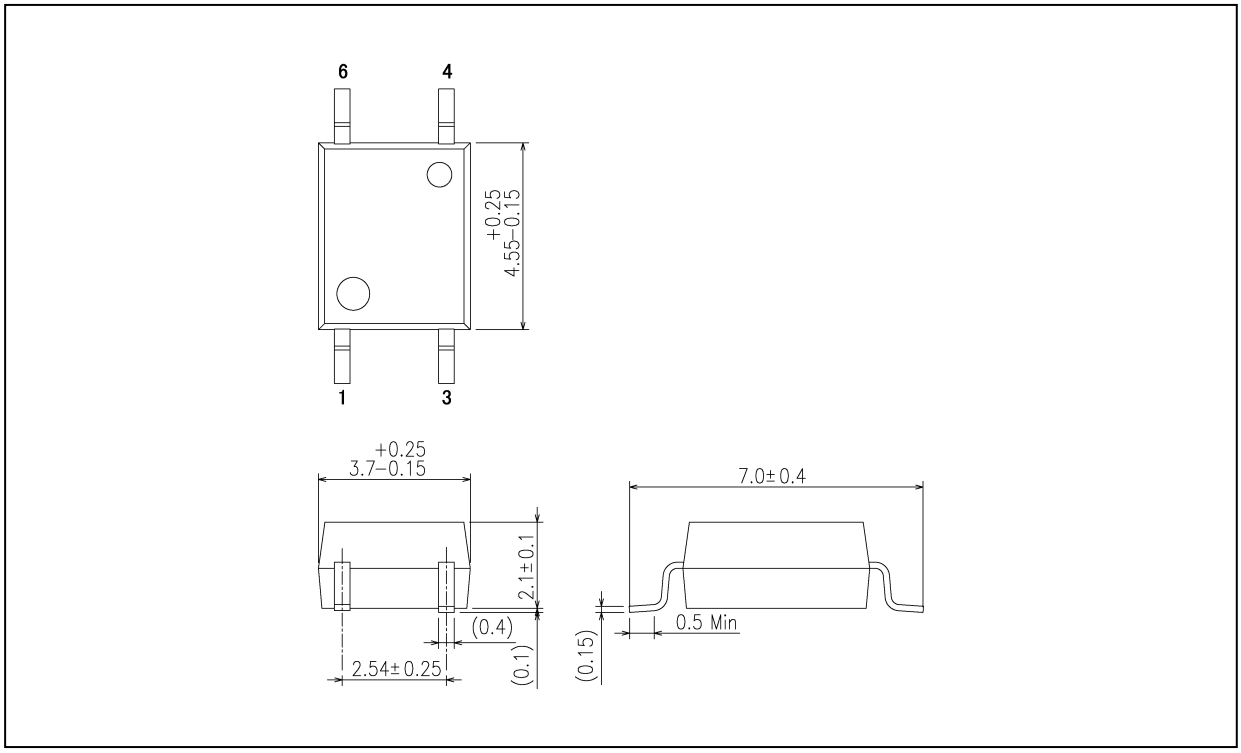



**Fig. 14.5 Measurement Procedure**

## Package Dimensions

Unit: mm




Weight: 0.08 g (typ.)

| Package Name(s) |
| --- |
| TOSHIBA: 11-4M1S |

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